WATER CONTROL MANUAL

FOR

McNARY LOCK AND DAM

COLUMBIA RIVER

OREGON AND WASHINGTON

U.S. ARMY CORPS OF ENGINEERS

WALLA WALLA DISTRICT

AUGUST 1989

NOTICE TO USERS OF THIS MANUAL

Regulations specify that this Water Control Manual be published in a looseleaf form, and only those sections, or parts thereof, requiring changes will be revised and printed. Therefore, this copy should be pre-served in good condition so that inserts can be made to keep the manual current.

As a continuing program, it will be necessary to revise portions of this manual annually in order to keep it up-to-date. Revisions to this manual will be made by the Walla Walla District's Planning Division (Hydrology Branch). Whenever revisions are necessitated, new pages containing the revised material will be printed with the date of revision and issued to each person having a copy of the manual so that substitution may be made.

Emergency procedures are used if physical and/or structural failures occur at the McNary project and emergency coordination and action may be necessary to prevent loss of life or property. Emergency coordination and action required will be dependent upon the nature and severity of the emergency. Possible emergencies have been divided into the following categories: (1) catastrophic failures, (2) equipment failures, (3) project function emergencies (power generation and navigation), and (4) national type emergencies. The following paragraphs provide guidance on action required by operators and engineers dealing with these four categories of emergency conditions.

Catastrophic failures include:

(1) Flooding resulting from failures at McNary Dam.

(2) Flooding resulting from failures at upstream dams.

(3) Assumed spillway design floods.

(4) Flooding and damage caused by earthquakes, sabotage, cracking, equipment malfunction, leakage, and foundation failures.

Catastrophic failures should be coordinated according to existing criteria within the Flood Emergency Subplans - McNary Lock and Dam - Columbia River, Washington, U.S. Army Engineer District, Walla Walla, October 1982.

Equipment failures that would prevent the controlled discharge of water passing through the project powerhouse or spillway would be an emergency and should be coordinated according to "Call-Out Procedures for McNary Emergencies," which is in the McNary Project Standing Orders.

Project function emergencies affecting power generation and/or navigation are the responsibility of the McNary Project Manager or his representative. Emergencies affecting power generation should be coordinated according to "Call-Out Procedures for McNary Emergencies," which is in the McNary Project Standing Orders. If the nature of the emergency is such as to require immediate action, the Project Manager may take necessary action and report to Walla Walla District's Chief of Operations Division as soon as possible. The Bonneville Power Administration dispatcher will also be notified of any emergency which may affect power production. Table B-1 in exhibit 8-1 of this manual shows a notification list for unscheduled lock closures or other navigation matters.

National type emergencies should be coordinated according to annex K, appendix 3 of the Walla Walla District Continuity of Operations Plan, which describes actions to be taken at McNary project under various types of national emergencies (terrorist attack, sabotage, nuclear war, etc.).

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McNARY LOCK AND DAM
PERTINENT DATA

1. GENERAL.

Location:
State .... Washington and Oregon
County .... Benton, Franklin, Walla Walla, and Umatilla
River .... Columbia
River Mile 292.0
Township 5N
Range 28E
Section 10
Latitude .... 45° 56' 09"
Longitude .... 119° 17' 47"

River miles upstream from John Day Dam 76.4
River miles downstream from Ice Harbor Lock and Dam 42.7

Owner .... U.S. Army, Corps of Engineers, Walla Walla District

Authorized Purpose .... Power generation and inland navigation

Other Uses .... Fishery, recreation, irrigation, and water quality

Type of Project .... Run-of-River

Real Estate: Fee acquisition land above pool elevation
340, acres 15,372

2. RESERVOIR.

Name .... Lake Wallula 1/

Elevations (feet msl):
Maximum at dam for spillway design flood 356.5
Normal operating range 340-335
Maximum at dam for standard project flood 340

Length, miles (at normal pool elevation 340) 61.6
Length of Shoreline (normal pool, including islands), miles 242.0
Average width, miles 1.0
Maximum width, miles 4.6

1/ For the purpose of continuity with existing McNary Lock and Dam documents, the use of the terms "pool" or "reservoir" are used interchangeably. The term "lake" is used to designate a geographical body of water.

2. RESERVOIR (Continued).

Surface area at elevation 340 (low flow, .60,000 cfs), acres 38,800

Reservoir Storage for Riverflows, cfs 100,000
Storage below flatpool elevation 340, acre-feet 1,350,000
Storage below flatpool elevation 335, acre-feet 1,165,000
Storage between elevation 340 and 335, acre-feet 185,000

Drawdown for power, feet 5
Height: (normal highpool, elevation 340,
to normal tailwater, elevation 265), feet 75

3. LEVEES.

Richland:
Number 3
Top width, feet 12
Slopes:
Waterside ....1V on 2.5H to 1V on 3H
Landside .... 1V on 2H to 1V on 3H
Materials ....Gravel and earth fill with impervious core
Top elevation... 7 to 12 feet above backwater profile for standard project flood

Embankment length, miles 3.72

Installed pumping capacity, cfs 163

Pasco:
Number 6
Top width, feet 12
Slopes:
Waterside and landside .... 1V on 2H
Materials ....Gravel and earth fill with impervious core
Top elevation... 8 to 13 feet above backwater profile for standard project flood

Embankment length, miles 5.38

Installed pumping capacity, cfs 135

PERTINENT DATA (Continued)

3. LEVEES (Continued)

Kennewick:
- Number 8
- Top width, feet 12
- Slopes:
  - Waterside and landside .... 1V on 2H
- Materials .... Gravel and earth fill with impervious core
- Top elevation .... 6 to 12 feet above backwater profile for standard project flood

- Embankment length, miles 7.68

- Installed pumping capacity, cfs 284

4. DAM (GENERAL).

Axis (Lambert) .... N10° 33' 11.8"W

Length and widths (in feet):
- Dam total length at crest 7,365

Spillway overall length 1,310

Powerhouse overall length 1,422

Abutments:
- North embankment 1,620
- South embankment 2,495

Nonoverflow areas:
- Spillway to powerhouse 93
- Spillway to navigation lock 255

Concrete heights (in feet):
- Maximum overall concrete height (Powerhouse sump deck to deck) 191

Elevations of some features (feet msl):
- North and South abutment embankment 365
- Intake, spillway bridge, nonoverflow sections 361
- Upstream end of navigation lock 348
- Downstream end of navigation lock 342

PERTINENT DATA (Continued)

5. SPILLWAY.

Number of bays	22
Overall length, feet	1,310
Deck elevation, feet msl	361
Ogee crest elevation, feet msl	291
Flip lip elevation, feet msl	256

Control gates:

Type	Fixed-wheel vertical lift
Remote-controlled gates, number	21
Size {2 split-leaf sections):	
Top, feet	50'W x 27.25'H
Bottom, feet	50'W x 24.55'H
Combined, feet	50'W x 51.80'H

Gantry cranes (joint use with powerhouse):

Number of cranes	2
Capacity, tons	200

Stilling Basin:

Stilling basin, type	Horizontal Baffle
Stilling basin length, feet	248.05
Stilling basin elevation, feet msl	228

Maximum design capacity at elevation 356.5, cfs	2,200,000
Maximum spillway capacity at elevation 340, cfs	1,368,000

6. POWERHOUSE.

Length overall, feet	1,422

Spacing, feet:

Units (1 through 14)	86
Erection and service bay	86

Width overall, transverse section, feet	248
Intake deck elevation, feet msl	361
Tailrace deck elevation, feet msl	287
Maximum height (draft tube invert to intake deck), feet	191

PERTINENT DATA (Continued)

6. POWERHOUSE (Continued).

Turbines:

Type	Kaplan, automatic adjustable, 6-blade
Runner diameter, inches	280
Revolutions per minute	85.7
Rating horsepower	111,300
Distributor centerline elevation	239.5

Generators:

Rating (nameplates), kilowatts	70,000
Power factor	0.95
Kilovolt ampere rating	73,684
Units installed complete initially	14
Total units now installed	14
Plant capacity, nameplate rating, megawatts (14 @ 70 MW)	980
Overload capacity, megawatts (14 @ 80.5 MW)	1,127
Station service units, megawatts (2 @ 3 MW)	6
Hydraulic capacity, cfs	232,000

Crane capacities, tons:

Intake (joint use with spillway)	140
Tailrace gantry, 2 - capacity in tons	30
Bridge crane, 2 - capacity in tons	350

7. NAVIGATION LOCK AND CHANNELS:

Type .... Single lift
Net clear length, lock chamber, feet 675
Net clear width, lock chamber, feet 86

Upstream gate:
Type .... Miter
Height, feet 24

Downstream gate:
Type .... Miter
Height, feet 106

Operating water surface elevations in chamber, feet msl 257-340
Maximum operating lock lift, feet (forebay elevation 340 and
tailwater elevation 257) 83

Length of guidewalls (from face of gate), feet:
Upstream (floating) 1,417
Downstream 1,520

Downstream approach channel:
Minimum width, feet 250
Moorage dock, feet .... 870 X 16.5

Downstream sill: ....
Sill elevation, feet msl 236
Depth over sill at tailwater elevation 265, feet 29
Depth over sill at tailwater elevation 257, feet 21

Upstream sill:
Sill elevation, feet msl 320
Depth over sill at forebay elevation 340, feet 20
Depth over sill at forebay elevation 335, feet 15

PERTINENT DATA (Continued)

8. LEFT ABUTMENT.

Material ....Impervious core with rock shells
Length (not including upstream blanket), feet 2,495
Height of maximum section 103
Embankment elevation, feet msl... 365
Embankment top width, feet .... Variable, 30 to 50
Slope, upstream .... 1V on 1.5H
Slope, downstream....................................... Variable, 1V on 1.3H to 1V on 1.5H
Freeboard over maximum pool (elevation 356.5), feet 8.5
Freeboard over normal pool (elevation 340), feet.. 25

9. RIGHT ABUTMENT.

Material ....Impervious core with rock shells
Length, feet 1,620
Height of maximum section 110
Embankment elevation, feet msl... 365
Slope, upstream .... IV on 1.5H
Slope, downstream.. 1V on 2H
Freeboard over maximum pool (elevation 356.5), feet 8.5
Freeboard over normal pool (elevation 340), feet.. 25

10. FISH FACILITIES.

Upstream Migrants - Adult Fish Ladder:
Number of fish ladders 2
Slope .... 1V on 20H
Ladder clear width, feet... 30
North shore ladder design capacity, cfs 180
South shore ladder design capacity, cfs.. 210

Operating elevations (Washington & Oregon):

Design range:

Pool elevations, feet msl.. 335 to 340
Tailwater elevations, feet msl .... 257 to 275
River flow, cfs .... 12,500 to 510,000

Maximum operating range:

Pool elevations, feet msl.. 334 to 341
Tailwater elevations, feet msl .... 257 to 279 ±
River flow, cfs .... 12,500 to 800,000

PERTINENT DATA (Continued)

10. FISH FACILITIES (Continued).

Fishway system attraction water:
- Powerhouse collection system, pumps 3
- South shore .... Gravity & Diffusion Chambers
- North shore .... Gravity & Diffusion Chambers

Downstream Migrant - Juvenile Bypass System:
- Design pool range, feet msl .... 340 to 335
- Design capacity, cfs .... 200 to 250
- Submersible traveling fish screens 42
- Vertical barrier fish screens 42
- Gatewell orifices from bulkhead:
  - Number 84
  - Size (diameter in inches) 12
- Juvenile collection channel 1

Juvenile transportation pipe 1

Juvenile Holding and Sampling Facility 1
- Water supply pipe 1

Juvenile transportation facilities:
- Truck loading facility 1
- Barge loading facility 1

11. HYDROLOGIC DATA (based on streamflow data for McNary Reservoir inflow).

Drainage area, square miles 214,000
Period of record (14 years) .... Oct 1973 - Sep 1986
Average annual regulated inflow volume, acre-feet 128,100,000

Discharges in cubic feet per second:
- Mean daily maximum of record, 21 June 1974, cfs 580,400*
- Average annual flow, cfs 176,800*
- Average annual maximum mean daily flow, cfs 361,000*
- Average annual minimum mean daily flow, cfs 68,400*

Note: * Reflects regulation by Libby, Dworshak, and other existing projects since 1973.

Extreme outside period of record:
- Flood of June 1894 (Columbia R. at The Dalles), cfs 1,240,000
- Flood of June 1894, controlled by existing projects, cfs 668,000

11. HYDROLOGIC DATA (Continued)

Probable maximum flood (1969 computation regulated by existing system at The Dalles) 2,060,000

Standard project flood (controlled by existing projects):

- Columbia River below Priest Rapids, cfs 540,000
- Columbia River above Snake River, cfs 570,000
- Columbia River at McNary Dam, cfs 810,000

Spillway design flood, cfs 2,200,000

Major Reservoir Tributaries:

- Walla Walla River (mouth at RM) 313.9
- Snake River (mouth at RM) 324.2

Yakima River (mouth at RM) 335.2

I - INTRODUCTION

1-01. Authorization. This Water Control Manual has been prepared according to authority contained in Section 7 of ER 1110-2-240, "Engineering and Design - Water Control Management," dated 8 October 1982. The format and content of this manual are in accordance with criteria set forth in EM 1110-2-3600, dated 25 May 1959, and ETL 1110-2-251, "Engineering and Design - Preparation of Water Control Manuals," dated 14 March 1980.

1-02. Purpose and Scope. The purpose of this manual is to present information pertinent to the regulation of McNary project and to provide a reference source for higher authority and personnel responsible for the regulation of McNary project. Items discussed within this manual are as follows:

a. History of project.

b. Description of project.

c. Basin characteristics.

d. Data collection and communication networks.

e. Water control management.

f. Streamflow forecasts.

g. Water control plan.

h. Effect of water control plan.

Section VI, Water Control Management, outlines responsibilities of the Corps of Engineers, Bonneville Power Administration (BPA), and other agencies involved indirectly with the regulation of the McNary project. Section VIII, Water Control Plan, contains information necessary for under-standing the objectives of the project and instructions to implement the regulation of the reservoir. The Master Water Control Manual for the Columbia River Basin, dated December 1984, contains policies and procedures for system regulation and coordination of major water control projects in the basin.

1-03. Related Manuals and Reports. A list of published design memorandums is provided in exhibit 1-1 of this manual. The following list outlines manuals and reports which contain information and data pertinent to the operation of McNary project, Columbia River, Oregon and Washington.

a. Definite Project Report on McNary Dam, 6 May 1946.

b. Letter Report, Fish Passing Facilities, McNary Dam - December I949.

c. Design Memorandum No. 4, McNary Lock and Dam - Kennewick Levees 4A and 6B, Seepage Control, 21 October 1954.

d. Design Memorandum No. 7, McNary Lock and Dam - Pasco Levee 12, Seepage Control, 19 September 1955.

e. McNary Lock and Dam Operation and Maintenance Manual (Seven Volumes), 1956.

f. Design Memorandum No. 26, McNary Lock and Dam - Remote Operation of Spillway Gates, July 1959.

g. Design Memorandum No. 30, John Day Lock and Dam - Modifications to McNary Fish Facilities, 15 June 1962.

h. McNary Dam - Turbine Rating by the Current Meter Method, U.S. Army Corps of Engineers, North Pacific Division, March 1967.

i. Design Memorandum No. 29, McNary Lock and Dam - Reservoir Recreation Facilities, 16 May 1967, revised 21 November 1968.

j. Design Memorandum No. 30, McNary Lock and Dam - Pumping Plant 12-1A, 10 October 1967.

k. Tri-City Levees, McNary project - Inspection Report No. 1, August 1969.

l. Final Environmental Impact Statement, McNary Lock and Dam, April 1976.

m. McNary Lock and Dam, Reconnaissance Report, July 1980.

n. McNary Lock and Dam, Inspection Report No. 4, August 1980.

o. Design Memorandum No. 29.1, McNary Lock and Dam - Expansion of Lake Wallula Recreation Facilities, October 1980.

p. Fish Facilities Manual, U.S. Army Corps of Engineers, North Pacific Division, March 1981.

q. McNary Repair and Modernization Studies and Recommendations, December 1981.

r. Design Memorandum No. 24, McNary Lock and Dam - Master Plan, 1982.

s. Flood Emergency Subplans - Identification, Operation, Repair, Notification, and Inundation Maps - McNary Lock and Dam Project, October 1982.

t. McNary Lock and Dam - Dam Safety Assurance Report, November 1983.

u. McNary Lock and Dam, Inspection Report No. 5, March 1984.

v. Columbia River Basin - Master Water Control Manual, December 1984.

w. Project Data & Operating Limits, Columbia River and Tributaries Review Study, U.S. Army Corps of Engineers, North Pacific Division, May 1985.

x. Columbia River Water Management Report for Water Year 1987, U.S. Army Corps of Engineers, North Pacific Division, March 1988.

y. 1986 Dissolved Gas Monitoring for the Columbia and Snake Rivers, U.S. Army Corps of Engineers, North Pacific Division, December 1986.

z. Juvenile Fish Bypass Program for Corps of Engineers Projects, U.S. Army Corps of Engineers, North Pacific Division, Published Annually by CENPD-EN-WM.

1-04. Project Owner and Operator. The Federal Government owns the McNary project. The Walla Walla District Corps of Engineers is responsible for the operation and maintenance of the McNary project and its facilities.

1-05. Regulating Agencies. Functional day-to-day water regulation at McNary is the responsibility of the U.S. Army Corps of Engineers, North Pacific Division, Reservoir Control Center (RCC). The RCC coordinates the regulation of existing projects with other agencies in order to provide maximum benefits to the public. The Walla Walla District Corps of Engineers is responsible for reviewing and updating the Water Control Plan for the regulation of McNary and upon request from North Pacific Division RCC, aids in its regulation by providing technical advice. The BPA is authorized to market electrical energy generated at McNary and other Federal projects within the Columbia Basin system. Section VI, Water Control Management, outlines the responsibilities of the key agencies connected with the management of McNary and other Corps of Engineers, North Pacific Division projects.

II - HISTORY OF PROJECT

2-01. Authorization. In 1945, acting on recommendations in House Document 704 and the desires of the people of the Pacific Northwest, Congress enacted Public Law 14, dated 2 March 1945, authorizing construction of McNary Dam. The following partial quotation of Public Law 14 contains statements authorizing the project:

"...Be it enacted by the Senate and the House of Representatives of the United States of America in Congress assembled...."

Section 2. "The following works of improvement of rivers, harbors, and other waterways are hereby adopted and authorized...."

"Columbia River, Oregon and Washington: The construction of the Umatilla Dam for purposes of navigation, power development, and irrigation in accordance with the plan submitted in House Document Number 704, Seventy-fifth Congress; Provided, that surplus electric energy generated at said dam shall be delivered to the Secretary of Interior for disposition in accordance with existing laws relating to the disposition of power at Bonneville Dam. Provided further, that nothing in this paragraph shall be construed as conferring the power of condemnation of transmission lines. Provided further, that said dam shall be so constructed as to provide a pool elevation of three hundred and forty feet above sea level if a dam of that height is found feasible. In the design, construction, and operation of Umatilla Dam adequate provision shall be made for the protection of anadromous fishes by affording free access to their natural spawning grounds or by other appropriate means. Studies and surveys necessary for fish protection shall be made by the Fish and Wildlife Service of the Department of the Interior, and designs for structures and facilities required for fish protection shall be prepared in cooperation with that agency. Funds appropriated for the design, construction, or operation of said dam shall be available for transfer to the Department of the Interior for the foregoing purposes. The aforesaid dam heretofore referred to as the Umatilla Dam shall when completed be named the McNary Dam in honor of the late Senator Charles L. McNary, and shall be dedicated to his memory as a monument to his distinguished public service...."

The purpose of coordinated planning for development of Columbia River Basin was to assure attainment of optimum beneficial use of the water resources. In such planning, McNary project is one of the major basic projects primarily required for provision of slack water navigation and for power generation. The many other uses of that reservoir and of water taken from the reservoir at or near McNary Dam will be in accordance with coordinated system planning and operation. McNary project was not planned, authorized, or designated for use as a flood control reservoir.

2-02. Early History. A need existed for a dam on the Columbia River in the vicinity of Umatilla Rapids. Pioneers in the Pacific Northwest, whose principal means of travel was by boats, were forced to portage around the hazardous rapids. Later, riverboats managed to navigate the rapids but with considerable difficulty.

About 1912, engineering investigations resulted in a proposal to build a series of low head dams on Columbia River below Pasco for the benefit of navigation including one at Umatilla Rapids. After the construction of The Dalles-Celilo Canal in 1917, Umatilla Rapids was one of the most difficult remaining reaches of the lower river to navigate.

In 1921, because of the apparent need for improvement of navigation conditions in lower Columbia River and the possibility of expansion of power production facilities, the Umatilla Rapids Association was organized at Umatilla and Pendleton, Oregon, to promote authorization and construction of a dam and powerplant at Umatilla Rapids. In 1923 and 1924, the Bureau of Reclamation investigated a project at Umatilla Rapids and pro-posed a dam with a pool elevation of 310.5 feet above sea level, a power-plant, and a pumping installation for irrigation of adjacent lands. As a result of these activities and other requests to Congress for projects on the Columbia River, the Corps of Engineers, Portland, Oregon, District Office prepared a report, dated 29 November 1927, proposing a series of dams on lower Columbia River including one at Umatilla Rapids, river mile (RM) 292, with alternate pool elevations of 282 and 295 feet above sea level. In House Document 103, 73rd Congress, 1934, the Corps of Engineers recommended a project with a pool elevation of 330.0. House Document 704, 75th Congress, 3rd Session, 1938, contained a proposal by the Corps of Engineers to build a series of four dams on lower Columbia River including one at Umatilla Rapids to pool elevation 310.5. In this document it was recommended that Umatilla Dam be constructed before undertaking slack water improvements on Columbia River below Umatilla. A preliminary report on further engineering studies recommended, in 1942, a dam with a normal pool elevation of 340 feet. Results of these studies were confirmed in 1945 by a special report to determine the McNary pool elevation and the 340-foot elevation was adopted.

2-03. <u>Significant Construction Dates</u>. Construction of McNary Dam began in April 1947, the first work being excavation for the navigation lock and installation of Washington shore cofferdam which enclosed the area occupied by the navigation lock, Washington shore fish ladder, gate repair pit, spillway bays 1 to 13, and corresponding portion of the spillway stilling basin. This cofferdam was completed in May 1948 and immediately thereafter was overtopped by the unusually high 1948 flood which interrupted work in the area until early in August 1948 and caused $135,000 damages to the cofferdam. With virtual completion of the lock and with the spillway bays within the area raised to elevation 250 feet, the Washington shore coffer-dam was breached in April 1950 and removed in subsequent weeks.

Construction on the south side of the river began in the fall of 1949 with the erection of the junior cofferdam containing the area in which units 1 and 2 and the station and assembly service bay portions of the powerhouse and appurtenant facilities and Oregon shore abutment were built. In November 1950, the Oregon shore second step cofferdam closure was made by placing concrete tetrahedrons in the main channel of Columbia River. The second step cofferdam enclosed the area of the junior cofferdam, the remainder of the powerhouse, a nonoverflow section of the dam north of the powerhouse, and spillway bays 14 to 22. The second step cofferdam area was dewatered in February 1951 and the junior cofferdam was removed in July 1951. During 1951 and 1952, the major part of heavy concrete construction within the second step cofferdam area was accomplished and the cofferdam was breached in February 1953.

The flow of the river was passed through the powerhouse during early 1953 until 24 April, during which period spillway bays 1 to 13 were raised to design crest elevation at 291 feet. Water was forced over the completed spillway bays on 24 April by closing the powerhouse intakes and the pool was raised to an elevation of 310 feet on 26 April. From then until 1 October 1953, pool elevations between 310 and 319 feet were maintained while difficulties encountered in construction of Kennewick levees were overcome and work on the navigation lock gates, fish facilities, and other facilities at the dam was accomplished.

During October 1953, the pool was raised to 335 feet in elevation, the navigation lock upstream gate was installed in its permanent position, and baffles in the upper ends of the fish ladders were installed. The 340-foot elevation pool was attained on 6 December 1953. Power unit 1 first produced line power on 6 November 1953, and the last completed unit (14) produced line power on 8 February 1957.

Major contracts for repairs and rehabilitation on McNary since construction of the project are listed in the following tabulation.

MAJOR REHABILITATION AND MODIFICATION CONTRACTS
McNARY LOCK AND DAM

Contract No.	Title
DA-45-164-CIVENG-64-281	Modifications to Powerhouse
DACW68-67-C-0024	Revisions to McNary Fish Facilities
67-86	Modification of Powerhouse Air-Conditioning System
67-88	Replacement and Additions - Underground Sprinkler Systems
68-27	Revisions to McNary Fish Facilities, Category 3
68-103	Construction of Pasco Levees Pumping Plant 12-1A
71-236	Navigation Lock Modification
72-248	Beach Comfort Station, Recreation Facilities and Public Use Areas

Contract No.	Title
73-69	Modifications to South Shore Fish Ladder
73-158	Riprap Repair, Kennewick Levee 6-B
73-254	Lock Monolith Prestressing, Lock Curb Replacement, and Spillway Bridge Pier Concrete Repair
74-59	Modification of North Shore Fish Ladder
74-248	Spillway Gate Hoist Units, McNary
74-249	Electrical Facilities for Operation of Spillway Gate Hoist Units
75-159	Drilling Water Well, Hood Park
75-167	Exit Road Paving at Columbia Park, Kennewick, and Paving at Boat Basin, Pasco
75-168	Modify Maintenance Shop, Big Pasco
75-171	Additional Sanitary Facilities, Hood Park and Wallula Junction
76-15	Spillway Deflectors (Flip Lips)
76-262	Paving, McNary Beach
77-45	Paving, Columbia Park - Exit Road
77-145	Additional Sanitary Facilities, Sand Station and McNary Wildlife Area
77-151	Bulkhead Fish Screens, Traveling Fish Screen, Bearing Pads, and Handrail
77-186	Fingerling Facilities
78-61	Bulkhead Fish Screens and Traveling Fish Screening Pads, McNary Powerhouse
78-136	Sanitary Facilities, Cold Springs and Madame Dorion Sites

Contract No.	Title
79-37	Fingerling Facilities Completion and Miscellaneous Modifications
80-149	Transformer Cell Drain Modification, McNary Powerhouse
80-157	Intake Bulkhead Slot Handrail
80-174	Repair North Shore Fish Ladder
80-177	Electrostatic Filter and Coil Replacement
81-36	Power for Traveling Fish Screens
81-145	Modify and Repair Traveling Fish Screens, Lower Granite, Little Goose, and McNary
82-11	Modification of Drainage Pump Discharge, Powerhouse
82-65	Rehabilitate Protective Relays
82-73	Furnishing Generator Thrust Bearing Oil Coolers and Repairing Generator Air Coolers
82-106	Battery Chargers
82-131	Powerhouse Bridge Crane Rehabilitation 2-5
82-133	Oil Pumps and 3-D Cams
82-141	Modification and Fire Protection System, Power-house
82-151	Air Compressor and Air Dryer Installation, Powerhouse
83-04	Neutral Grounding Transformer
83-20	Cathodic Protection for Navigation Lock Gates, McNary, Little Goose, and Lower Granite
83-25	Modifications at Levee Pumping Plants
83-43	Modernize Generator Controls

Contract No.	Title
83-44	Repair and Modernization of Elevator Controls at Powerhouse
83-53	Modification of Intake Gates and Intake Gantry Crane, Powerhouse
83-72	Paint Navigation Lock Stoplogs
83-78	Replace Pratt Crane
83-79	Emergency Generator Building
83-81	Erosion Protection of Strawberry Island
83-83	Fire Detection System
83-84	Navigation Lock Guidewall Timber Replacement
83-122	Paving, Parking Areas and Boat Ramps, Hood Park
85-72	Paving for Public Use and Project Work Areas
85-76	Beach Access Road and Beach Area Paving
85-81	Madame Dorion Park Sanitary Lift Station and Drainage Field
87-22	Amphitheater Facility at Hood Park
87-37	Heating and Cooling Coil Freeze Protection

Modernization work on the McNary project, primarily in the power-house area, began in 1982 and is planned for completion in 1988. Under consideration for improvement at McNary Dam is the installation of structures to reduce the mortality of migrating anadromous fish under the fishery improvement program for the Columbia-Snake River system. Second Powerhouse General Design Memorandum No. 1, Phase II - Project Design with Appendixes - Two Volumes, dated November 1983, includes a plan of development for a second powerhouse. This second powerplant for the McNary project would be constructed in the future when the need for expansion of power facilities was demonstrated.

III - PROJECT DESCRIPTION

3-01. Protect Location. McNary Dam is located on the Columbia River 292 miles above its mouth. The Columbia River in this region forms the boundary between southeastern Washington and northeastern Oregon. The dam is approximately 2-1/2 miles upstream from the town of Umatilla, Oregon, and 161 miles east of Portland, Oregon, the largest city in the Columbia River Basin. Backwater effects extend about 61.6 miles upstream on the Columbia River, 6 miles up Yakima River, 10 miles up Snake River, and 9 miles up Walla Walla River. Plate 3-1 is a regional map showing the general location of McNary Lock and Dam.

3-02. Protect Purposes. The primary purposes of the project are inland navigation and hydroelectric power generation. In addition, it provides irrigation, fish and wildlife, and recreation benefits. Flood control is not a designated or planned project function.

3-03. Physical Components.

a. General. The following paragraphs provide a general description of the physical components of the McNary project. Design memorandums and project reports provide details on planning, design, and construction of the project (refer to paragraph 1-03., Related Manuals and Reports).

b. Dam. Plate 3-2 shows a general plan of the dam and the relative locations of principal features. Principal McNary Dam features include: (1) a powerhouse, (2) a concrete overflow spillway section, (3) a navigation lock, (4) Oregon shore and Washington shore adult fish passage facilities, (5) juvenile fish facilities, and (6) nonoverflow sections (flanking Washington and Oregon shore earth embankments and north and south concrete sections). The dam is 7,365 feet in length including embankments. Concrete sections have a maximum height of 191 feet from foundation to top of the deck at elevation 361 feet. The crest elevation of earth embankments is 365 feet and the maximum height in these sections is 110 feet. Normal pool elevation at the dam is 340 feet above sea level and maximum pool elevation is 356.5 feet. Freeboards above maximum pool are 4.5 feet for concrete sections and 8.5 feet for earth embankments. Extreme tailwater elevations are 257 feet above sea level for low flow of 60,000 cfs or less, and 303 feet for the spillway design flood discharge of 2,200,000 cfs.

(1) Powerhouse. The powerhouse consists of 14 generator bays, a station service bay, an assembly bay, control room, and project office. The powerhouse, adjoining the Oregon shore embankment, has an overall length of 1,422 feet and a maximum width of 248 feet. The 14 generator units are numbered 1 through 14 right to left, looking upstream. Plate 3-2 shows a typical transverse section through the powerhouse. Table 3-1 and plate 3-3 show mean unit performance information in terms of power output, discharge, and gross head.

(a) Generators. Fourteen main units of the vertical shaft, water wheel, synchronous generator type driven by Kaplan type turbines were installed on 86-foot centers in the remaining space of the powerhouse. Generator nameplate ratings are 70 megawatts (MW) each and can be operated continuously at 115 percent of rated capacity with a maximum power output of 80.5 MW. Continuous minimum power generation is limited to 40 MW because of excessive generator-turbine vibrations when operated at less than 40 MW. The 14 generators have a total rated capacity of 980,000 kW and total overload capacity of 1,127,000 kW.

(b) Turbines. Each of the turbines has a 280-inch-diameter automatic adjustable six-blade propeller and will revolve at 85.7 revolutions per minute, developing 111,300 hp at a design head of 80 feet. At generator rated capacity and with an 80-foot head, each turbine will discharge approximately 11,500 cfs.

(c) Main Unit Transformers. Seven main unit transformers banks are located on the intake deck at elevation 361. Each bank consists of three single-phase, three winding transformers. Each single-phase unit is rated at 56,500 kVA, 60 cycles, and 55 degree C temperature rise and is of the oil-immersed, inert gas filled, forced oil-cooled with forced water coolers type. Each bank of transformers serves two main unit trans-formers. Banks 1 through 6 steps up the voltage from 13.8 kV to 230 kV and bank 7 steps up the voltage from 13.8 kV to 115 kV.

(d) Station Service Power. Two station service generators are located in the service station bay at the south end of the powerhouse and serve the project power needs. These station service generators are of the vertical shaft, water wheel driven type (rated at 3,750 kVA, 0.8 pF, 4,160 volts between phases, 60 cycles, 3-phase, 277 rpm). Each generator is driven by a Francis type turbine (rated output - 4,500 hp at 80-foot design head and 90 percent efficiency).

(2) Spillway. The spillway has a total length of 1,310 feet and consists of 22 bays each 50 feet in width that are separated by piers 10 feet in width. Spillway bays have ogee crests at elevation 291 feet. Spillway discharges are controlled by two-piece, 50- by 51.8-foot, fixed-wheel vertical lift gates. The design capacity of the spillway is 2,200,000 cfs at reservoir pool elevation 356.5 and 1,368,000 cfs at the normal pool elevation of 340 feet. Energy of the water discharged through the spillway is dissipated by a hydraulic jump in a horizontal baffled apron type stilling basin which is designed to contain the jump for all discharges up to 2,200,000 cfs. Plate 3-2 shows a transverse section of the spillway. Spillway bays are numbered 1 through 22, left to right, looking upstream.

Table 3-2 shows spillway discharge rating for split-leaf operation (flow between upper and lower leaves). Table 3-3 shows spillway discharge rating for undershot operation (flow under lower leaf) and free-flow operation (flow over ogee). Plate 3-4, Spillway Discharge Rating Curve, shows the total free-flow capacity for the 22 bays. Plate 3-5 shows tailwater rating curves for conditions below McNary Dam (RM 292), which are based on backwater profiles from John Day Dam (RM 215.6).

(a) Gate Slot Heaters. Gate slot heaters were originally provided in the top leaves of six gates (bays 1, 3, 11, 12, 20, and 22). Only four (now in bays 11, 13, 15, and 19) of the six gate slot heaters are in working condition. Two gate slot heaters have not worked since the fifth periodic inspection was conducted in October 1983 because of electrical shorting. The purpose of gate slot heaters is to prevent the top leaves of spillway gates from freezing shut during extremely cold weather.

(b) Gate Hoists and Gantry Cranes. Nineteen gate hoists and two gantry cranes are used for remote control operation of 21 gates from the powerhouse. Gate operation with hoists and gantry cranes is as follows:

1. Three old hoists can lift the top leaf only a distance of 22 feet.

2. Sixteen new hoists can lift one or both leaves a distance of 20 feet.

3. Two spillway gantry cranes are used to operate the gates on three bays.

Old hoists are in place on gates 1, 2, and 20. New hoists were installed on gates 4 through 19 in 1974. Gates 3, 21, and 22 are operated by two spillway gantry cranes.

(c) Spillway Deflectors (Flip Lips). Flip lips were provided in bays 3 through 20 at elevation 256 in 1976. The purpose of the flip lips is to minimize nitrogen supersaturation in spilled water. Nitrogen supersaturation in the water is a potentially fatal condition for fish and is similar to the "bends" experienced by human divers.

(3) Navigation Lock. Plate 3-6.1 shows a general plan and sections for the navigation lock. The single-lift navigation lock on the northern end of the concrete structure adjoining the Washington shore embankment has a clear width of 86 feet, length of 675 feet, maximum lift of 83 feet, and minimum water depth of 21 feet over lower sill and 20 feet over the upper sill with pool elevation at 340. Average lockage time for McNary will vary from 30 to 40 minutes depending upon pool and tailwater elevations. The lock gates are 106 feet in height at the lower end and 24 feet in height at the upper end and is filled and emptied through wall culverts with floor laterals and ports. Guard walls extend 1,417 feet upstream and 1,520 feet downstream from the lock. A 16.5-foot by 870-foot moorage dock is constructed downstream of the lock. Lock facility controls are located on panels on the north side of the lock near each gate. Lock operation is normally suspended when discharge is above 800,000 cfs.

Two stoplog derricks are located on the navigation lock deck; one at each of the upstream and downstream gates. These derricks' primary usage involves the placement of the navigation lock stoplogs, for either dewatering the lock for routine maintenance or emergency conditions when McNary Reservoir may surcharge above the pool elevation of 340.5 feet msl.

Two basic types of stoplogs, regular and auxiliary, are used in the navigation lock. Fifteen regular stoplogs are used for normal maintenance. Two auxiliary stoplogs would only be used when the pool is forecasted to exceed elevation 345. The installation of these two auxiliary stoplogs, one positioned on each side of the regular stoplogs in the auxiliary stoplog slots and across the upstream lock deck (elevation 348), form an extension of the regular stoplog slot. This allows the placement of upstream stoplogs 7U, 8U, and 9U and seals the navigation lock from deck elevation 348 up to a maximum elevation of 358.

Plate 3-6.2 shows plans and sections for regular stoplogs (Types I, II, III, and IV). Plate 3-6.3 shows plan and sections for auxiliary stoplogs. Plate 3-6.4 shows plan and sections for regular and auxiliary stoplogs storage pits. For details on the navigation lock and equipment, refer to the Operation and Maintenance Manual, Volume 3 of 7, Chapter 3.

(4) Adult Fish Passage Facilities. The adult fish passage facilities at McNary include two fish ladders, one on the Washington shore and one on the Oregon shore, with a powerhouse fish collection system as shown on figure 3-1 on page 3-15.

(a) Washington Shore Facilities. Fish facilities for the Washington shore consist of four entrances, a fish ladder with a counting station, and gravity-flow auxiliary water supply system.

1. Fish Ladder Entrances. The entrance system has three lateral and one longitudinal approach channels, cut through a rock ledge to provide effective passage of adult migrants from a natural deep hole in the center of the channel below the spillway. Four large overflow weir entrances (WFE-1, WFE-2, WFE-3, and WFE-4) provided downstream access to the fish ladder. WFE-1 and WFE-2 are normally opened and WFE-3 and WFE-4 are closed.

2. Fish Ladder. The fish ladder, which lies mostly downstream of the axis of the dam, is 30 feet wide, 2,190 feet in length, and has a 5 percent slope. Each pool is 20 feet long and separated by a 6-foot concrete weir. There is a drop of 1 foot between successive weir crests. Diffusion chambers located in the ladder provide the necessary attraction water when rising tailwater tends to drown the lower end of the ladder. The gravity-flow auxiliary water supply system permits the introduction of water through the diffusion chambers. Total discharge from the ladder varies depending on the tailwater elevation.

3. Auxiliary Water Supply System. The gravity-flow auxiliary water supply system takes water from the forebay through a series of conduits and distributes it through diffusers at the bottom of the ladder and in the transportation channel. There are four main conduits numbered 1 to 4, with conduits 1 and 4 providing the required flow. Conduits 2 and 3 were sealed off when the fish lock was deactivated and are not available for use. Conduit 1 supplies water for diffusers 5 through 12 and

conduit 4 supplies water for diffusers 1, 2A, 2B, 2C, 3, 4, and the auxiliary manifold.

(b) Oregon Shore Facilities. The facility consists of spillway to powerhouse nonoverflow entrances, Oregon shore entrances, a powerhouse collection system with entrances across the downstream face of the powerhouse, and a fish ladder with counting station, and a dual auxiliary water supply system.

1. Fish Ladder Entrances. The north powerhouse non-overflow entrances are (NFE-1, NFE-2, NFE-3, and NFE-4) located at the north end of the powerhouse. All four entrances use telescoping overflow-type entrance weirs. Three entrances (NFE-1, NFE-2, and NFE-3) discharge downstream and one entrance (NFE-4) discharges toward the spillway. Presently, only two downstream entrances (NFE-2 and NFE-3) are operated.

The Oregon shore entrances consist of two 15-foot-wide overflow weir entrances (SFE-1 and SFE-2) at the south end of the powerhouse. Presently, the operational range for the gates varies from elevation 251 to 268. This range allows for proper main entrance operations from minimum tailwater elevation 257 to above tailwater elevation 275, which occurs at a riverflow of approximately 510,000 cfs.

There are 44 orifice gate slots (OG-1 through OG-44) along the face of the powerhouse of which 30 are floating orifice gate entrances. Presently, 12 floating orifices with openings 2 feet high by 6 feet wide are installed and being operated in the vertical slots. The 18 floating orifice entrances are closed off by steel plates or steel bulk-heads rather than concrete.

2. Powerhouse Collection System. The main collection channel extends from the nonoverflow entrance at the north end of the powerhouse to the junction pool at the south end of the powerhouse. The invert elevation is constant at elevation 242. The channel width is 17.5 feet across the powerhouse with varying channel transition widths connecting the main entrances with the main collection channel. A back channel located on the upstream side of the main collection channel is no longer used. This back channel was to provide fish entering the north powerhouse nonoverflow entrances access to the junction pool on the south end of the powerhouse. The junction pool, located at the south end of the power-house, is where the main collection channel extending across the powerhouse joins the Oregon shore entrance collection channel to connect to the fish ladder.

3. Fish Ladder. The Oregon shore fish ladder is 2,270 feet long and 30 feet wide. It has a 5-percent slope and weirs like the Washington shore ladder and provides passage over the dam for fish entering the north powerhouse fish ladder entrance, the powerhouse collecting system, and the Oregon fish ladder entrance.

An underwater fish counting station is located at the upper end of the south shore ladder immediately below the tilting weirs (seven weirs that adjust to control water surface elevations in the ladder) and the flow-regulating weir (one weir that controls the volume of water passing down the ladder by telescoping leaves).

4. Auxiliary Water Supply System. The dual water supply system is for the fish collection system. Auxiliary water is taken from both the forebay through a gravity-flow system and from the tailrace by three large low head pumps. The system is designed to use both forebay and pumped water simultaneously. The gravity-flow auxiliary water is provided by one conduit from the forebay and supplies the diffusers at the bottom of the ladder at tailwater level. The pumped auxiliary water is supplied by three electric pumps with variable-pitched blades. Two pumps are operated to supply the required attraction flow at the various entrances and maintain the directional or transportational flow in the collection channels, with a third pump held on standby.

(5) Juvenile Fish Facilities. The juvenile fish facilities at McNary Dam divert fish from the turbine intakes into collection facilities for transportation or for bypass to the tailrace. Juvenile fish entering the 14 turbines swim near the ceilings. Traveling fish screens (plate 32) inserted into the 42 intakes through the bulkhead slots divert the fish up into common galleries between the bulkhead slots and emergency operating gate slots. Vertical barrier screens divide the galleries and confine fish to the bulkhead slots. Orifices near the top of the bulkhead slots allow fish to egress into the ice and trash sluiceway. While there are two orifices per slot, or a total of 84 orifices, only the northern ones, or 42 orifices, are used.

After passing through each orifice, a 12-inch elbow directs flow to the north in a plastic impregnated plywood flume (plate 3-2) suspended from the ceiling of the ice and trash sluiceway. The northern orifices are equipped with air-operated valves for ease in closing when they are cycled for debris removal. The south orifices have manual valves. As more and more orifices from the bulkhead slots empty into the flume, excess water spills out through screened weirs into the sluiceway. Fish and transport water proceed north to a downwell at the end of the flume. From there, they go through a 20-inch pipe that goes down below the separator, then bends up into the upwell box. An air-pressure operated pinch valve throttles flow through the pressurized pipe.

The juvenile fish sorting and holding facility is located between the north end of the powerhouse and the spillway (plate 3-7). At the upwell, excess water is removed and piped to the raceways or returned to the outfall of the sluiceway. Fish are separated from water as they spill into the wet separator. Upwelling jets between separator bars keep the fish in water except for the fraction of a second when they enter the separator. Small spacings in the front half of the separator allow small fish to swim down between bars into a collection chamber. Larger smolts swim clown through wider spaced bars in the back half of the separator. Larger fish (adult steelhead, salmon, shad, and suckers) go over the end of the separator and into the outfall of the sluiceway.

From the collection chamber in the separator, large and small fish flumes carry smolts to five holding raceways or into nonpressurized pipes to two temporary raceways. Passively induced transponder (PIT) tag detectors on flumes to the holding tanks and raceways monitor all fish for PIT tags. Sample gates, automatically timed, divert a small percentage of fish to sample holding tanks. These fish are crowded into preanesthetic tanks where they are preanesthetized before being netted and lifted into the laboratory sorting troughs. They are further anesthetized in the laboratory where they are sorted by species; inspected for injuries, descaling, and marks; and are measured and weighed. When research is conducted, sample fish are used; and sample sizes may be increased to provide enough fish for research. Sample fish are returned to Raceway No. 1 to recover after they have been anesthetized and handled. Sample fish are transported along with normally collected fish unless they are used for research purposes. Sample numbers are used to estimate total collection, and sample weights are used to regulate truck and barge loading.

When fish numbers are low, or when barges arriving from Lower Granite/Little Goose collection facilities are full, fish are crowded from raceways into a flume and into a waiting transport truck parked between the raceways and end of the powerhouse. When barges are used, they dock in spillway bay 22, and fish are loaded by pipeline from raceways into the barge compartments.

Collection and transportation begin in late March and continue into October at McNary Dam. Barges from the Snake River projects pick up fish from McNary on most trips. When barges are full they bypass McNary, and fish are trucked. After barging ends in mid-June on the Snake River, it continues into August at McNary Dam. After the majority of the summer outmigration has been barged to Bonneville tailrace, trucks are used for the smaller number of fish that continue migrating into the fall.

Section VIII of this manual provides information on the water control plan at McNary Dam, including adult and juvenile fish passage requirements.

(6) Embankments. The embankments are impervious cores with rock shells and have a maximum height of 110 feet, crest widths of 30 to 72 feet, crest elevation of 365 feet, upstream slopes of 1 on 1.5, and down-stream slopes of 1 on 1.5 or flatter. Freeboard heights are 25 feet above normal pool and 8.5 feet above maximum design pool elevation. The Washing-ton shore embankment is 1,620 feet long. The Oregon shore embankment is 2,495 feet in length. A seepage cutoff blanket about 400 feet in width and 2 to 30 feet in thickness extends about 1,000 feet upstream from the axis of the dam at the Oregon shore.

(7) Concrete Nonoverflow Sections. The north nonoverflow concrete section is 255 feet in length and is located between the navigation lock and the spillway. This section contains the DS1 power center, an elevator, air compressor room, spillway gate repair room and storage pit, and a fishway valve house. The deck across the section is at elevation 361, which is the same as the spillway deck and the spillway crane track.

The south nonoverflow concrete section is 93 feet in length and is located between the south end of the spillway and the north end of the powerhouse. This section gives access to the powerhouse at the 346.0 level, the tailrace deck at the 287.0 level, and the drainage gallery. A substation room for power center DS2, entrance gate room, and control room are located in this section. Passage from one level to another is by stairways.

c. Reservoir. McNary Reservoir has a length of 61.6 miles measured along the channel of Columbia River, an average width of approximately 1 mile, a surface area of 38,800 acres, and a maximum depth of about 100 feet along the channel bottom of the river just upstream from the dam. In addition to the riverbed and floodplain between RMs 292 and 353.6, the reservoir occupies bordering strips of low lands. Backwater from the dam extends about 18 miles upstream from Richland, Washington, 9 miles up Walla Walla River, 10 miles up Snake River, and 6 miles up Yakima River. Some lowlands along these streams outside the natural streambeds are also in the reservoir area. Acquisition of lands for McNary Reservoir necessitated purchase of some public and private properties and relocations of consider-able mileages of public utility facilities. Some lands in the vicinity of Pasco, Kennewick, and Richland had been developed to the extent that protection of these properties by levees was more economical than acquisition; therefore, a number of levees were constructed. Plate 3-8 (five sheets) is a land use map of the McNary project, which shows the general features of the reservoir and uses of adjacent land.

(1) Elevations and Storage. Backwater profiles on McNary Reservoir for several discharges in the range of probable riverflow fluctuations are shown on plate 3-9. In general, elevations will be only slightly above 340 feet throughout practically the entire length of the reservoir for low flow conditions (60,000 cfs at the dam). Slopes will increase for high flows, but it is estimated that water surface elevations at Richland, 46 miles upstream from McNary Dam, will remain between elevations of 341 and 347 feet, when riverflows are between 185,000 and 276,000 cfs for the Columbia River and above the Yakima River and will attain an elevation of 356 feet only with the occurrence of the standard project flood (512,000 cfs) for the Columbia River below Priest Rapids Dam.

Total power pondage for McNary Reservoir is 185,000 acre-feet. The entire storage capacity for Lake Wallula at elevation 340 is 1,350,000 acre-feet. The total impoundment of water behind McNary Dam would be 1,980,000 acre-feet if the maximum pool elevation of 356.5 is reached. Plate 3-4 shows the storage capacity curves for McNary Reservoir.

(2) Drawdown. The normal operating range is elevation 335 to 340 for McNary. Power operations usually keep the reservoir in its top 3 feet (elevations 337 and 340, measured at the dam). Drafts into the lower 2 feet are relatively infrequent, but do occur and are coordinated with affected parties when foreseen. The following tabulation gives the amount of acre-feet of pondage removed for total feet of drawdown:

Feet of Drawdown	Acre-Feet of Pondage
1	37,900
2	75,300
3	112,300
4	148,900
5	185,000

Reservoir pondage may be used on a regular schedule for peak power production, and weekly and diurnal fluctuations of the pool elevation should be expected and planned for during the annual low stream-flow period. Regulation for power is described further in Section VIII of this manual. McNary Reservoir storage is not likely to be used in cycles longer than a week because the active capacity between pool elevations of 335 feet and 340 feet is relatively small, amounting to approximately 185,000 acre-feet under low flow conditions. This storage quantity is equivalent to the volume for a mean daily inflow of 92,500 cfs. Plate 3-10 shows the difference between inflow and outflow required to change reservoir storage for a given amount of time; for example, an increase in discharge for drawdown and decrease in discharge for refill. The following tabulation summarizes the reservoir elevation data:

McNARY RESERVOIR

Forebay Elevation at Dam (RM 292)	Feet msl
Spillway Design Flood (2,200,000 cfs) Maximum Pool	356.5
Standard Project Flood (Regulated, 839,000 cfs)	340
Power Pool Elevation	
Full Pool	340
Minimum Pool	335

d. Levees. Levees of about 17 miles in length were built along McNary Reservoir to protect areas of urban and rural lands in the vicinity of Richland, Kennewick, and Pasco, Washington, from inundation. These levees are trapezoidal earth embankments, with 12-foot-wide crests and slopes of 1 on 2, aboveground and, where necessary, have impervious cores extending below natural ground. Levees protecting landward areas have 6 to 12 feet of freeboard above the backwater profile of the Spring Standard Project Flood. The levees are riprapped on the riverside to prevent erosion. Pumping plants are required to reduce water levels behind the levees resulting from seepage through and under the levees and irrigation waste-water and rain and snowmelt runoff that would otherwise accumulate landward of the levees. Plate 3-11 shows the locations of the levees and pumping plants in the Tri-Cities area. Table 3 4 lists pertinent details of the levees on page 3-12, and table 3-5, page 3-13, provides general information about the pumping plants located near some of the levees

TABLE 3-4

McNARY LEVEES

Levee No.	Location (RM)	Length (feet)	General Top (el. feet)	Freebboard [1/]
Protection for areas on right bank of Columbia River at and near Richland.				
2A [2/]	2.4- 4.0	6,208	366.8 to 368.5	8
2B [3/]				
2C [4/]	337.7-339.2	8,076	364.0 to 369.7	8 & 12
Protection for areas on right bank of Columbia River in vicinity of Kennewick.				
4A	334.4-335.1	2,860	362.3	10
5D [5/]	328.8-330.2	12,123	359.0 to 360.6	11
6B	325.3-327.9	15,286	358.3 to 359.0	12
7	323.2-323.4	1,072	352.3	7
15C	320.1-321.0	2,880	350.5 to 350.7	7
15D	321.0-322.1	6,050	350.7 to 351.2	6
15E	322.2-322.5	2,400	351.2 to 351.4	7
20	326.0-326.2	744	355.5	8
Protection for areas on left bank of Columbia River in vicinity of Pasco.				
11B-1 [6/]	327.1-327.2	400	355.7	8
11B-2 [6/]	325.6-325.8	3,100	355.0	8
12-1	328.1-330.5	14,250	358.9 to 361.0	11
12-2	331.4-332.8	7,416	358.7 to 361.1	8
17A	333.8-334.0	865	361.4	9
17B	332.0-332.1	1,700	364.1	13

1/ Freeboard above Spring Standard Project Flood Water Surface Profile.
2/ On Yakima River.
3/ This levee protected the old sewage plant and was removed in 1988.
4/ Approximately 5,675 feet of levee have 8 feet of freeboard.
5/ Two separate sections, one 7,123 feet in length with an average height of 16 feet and the other 5,000 feet in length with an average height of 30 feet.
6/ Operation and maintenance of the 11B embankments and the pumping plant at levee 11B-2 were assumed by the Port of Pasco in July 1964. (Reference Inspection Report No. 1, Tri-City Levees, August 1969.)

TABLE 3-5

CALIBRATION OF TRI-CITIES LEVEES PUMP PLANTS
Measured Capacities (GPM)

Pumping Plant No.	Without Siphon - GPM Pump 1	Without Siphon - GPM Pump 2	Without Siphon - GPM Pump 3	Total Without Siphon GPM	Total Without Siphon CFS	With Siphon - GPM Pump 1	With Siphon - GPM Pump 2	With Siphon - GPM Pump 3	Total With Siphon GPM	Total With Siphon CFS
2B * 8/	-	-	-	-	-	-	-	-	-	-
2C	4/	5/	6/	-	-	4/	6/	6/	-	-
4A	2,000	2,000	-	4,000	9	7/	7/	7/	-	-
5D	13,233	11,056	11,819	36,108	80	14,963	14,488	14,916	44,367	99
6B	8,536	8,728	8,371	25,635	57	10,402	10,963	9,990	31,355	70
11B-2	5,000	5,000	5,000	15,000	33	2/	2/	-	-	-
12-1	6,601	6,232	5,350	18,183	40	8,304	8,387	8,459	25,150	56
12-1A	16,676	15,367	-	32,043	71	20,423	18,396		38,819	87
12-2	6,445	5,839	1/	12,284	27	8,996	7,822	9,078	25,896	58
15C	6,150	6,890	-	13,040	29	7,212	8,070		15,282	34
15D	2,519	3,797	3,092	9,408	21	5,753	5,325	4,767	15,845	35
15E	-	-	10,533	10,533	23	13,403/	7/	10,806	24,209	53
15E-1	-	-	-	-	-	13,016	-	-	13,016	29
17A 8/	3,750	3,750	-	7,500	16.7	-	-	7,650	7,650	17

* Plant dismantled and land currently considered for turnover to city of Richland for a pumping site.

** Rated capacity without benefit of siphon or effects of varying pool and tailwater conditions.
1/ Could not open lock on siphon breaker housing.
2/ No known calibration data available.
3/ Manual air release valve would not open fully.
4/ Meter adapter did not fit pipe access hole.
5/ One measurement made but not verified due to insufficient water available in the sump.
6/ Insufficient water for measurement.
7/ Meter repeatedly became blocked by moss and vegetation.
8/ Were not measured because of insufficient flows available for measurement.

e. Debris Disposal. Removal of debris from the powerhouse intake area is accomplished by a mobile crane, trashrack rake system, and a dump truck. Trashracks are provided for each of the three power intakes for each unit and intakes for each station service unit. Trashracks are located near the upstream end of the piers and prevent larger debris from entering the turbine scroll cases. The trashrack rakes mechanically clean the trashracks and the debris is removed and placed in a dump truck then transported to a north shore disposal area for burning. Floating debris that is too large to be handled by the trashrack rakes will be removed by a mobile crane operating on the powerhouse intake deck.

3-04. Project Lands. Of the total 23,000 acres of original project lands above elevation 340, approximately 7,600 acres have been transferred from Federal ownership for railroad and highway right-of-ways or sold for port or industrial development. Project lands above elevation 340 total 15,372 acres at the present time. Lake Wallula at elevation 340 has a surface area of 38,800 acres.

Project land use allocation has been broken into categories to assure utilization of various resources with the objective of maximum sustained benefits to the greatest number of people. These allocations include project operations with three subcategories of project structures, public port terminal, and industrial use and access (approximate acreage total of 1,000); recreation with subcategories of intensive use and low density use (approximate acreage of 3,000); fish and wildlife with sub-categories of intensive management and moderate management (approximate acreage of 11,000); and natural areas for which no, or limited, development as preservation is the primary objective (approximate acreage of 500 acres). There are presently 8,426 land acres in use as wildlife lands (along with 5,660 water acres) in a total of 11 management units or nature areas and one refuge. Plate 3-8, Reservoir Land Use Map, details the land use allocation for McNary project.

3-05. Recreation Facilities. McNary project is located close to the population centers of Kennewick, Pasco, and Richland and within 50 miles of Pendleton and Walla Walla. The combined population of the five-county area surrounding McNary project is 236,038 (preliminary 1980 Census). There are a total of 26 different recreational sites located in the McNary project area comprising 8,276.6 acres of which 692.5 are developed for various recreational activities. Most sites have the capacity for expansion or improvement of facilities as needs are defined. These recreational sites are owned or operated by Federal, state, county, or city agencies. Table 3-6 on page 3-14 lists the recreation sites and the facilities available.

TABLE 3-6
McNARY RECREATION FACILITIES

SITE		RM	Swimming Beach	Boat Launch	Boat Docks	Rest-rooms	Picnic Facilities	Marina	Camping	Trailer Facilities	Trailer Dump Facilities	Power Hookups	Drinking Water	Showers
1.	McNary Wildlife Nature Area	291				X								
2.	McNary Dam	292		X	X	X	X						X	
3.	McNary Beach Park	293	X			X	X						X	X
4.	Hat Rock State Park	298		X	X	X	X						X	X
5.	McNary Yacht Club	298		X	X			X						
6.	Cold Springs Rec. Area	299				X	X							
7.	Sand Station Rec. Area	300				X	X							
8.	Walla Walla Yacht Club	312		X	X			X						
9.	Madame Dorion Memorial Park	315				X	X		X	X			X	
10.	Wallula HM Unit	315							X					
11.	Hover Park	317.5												
12.	McNary National Wildlife Refuge	319				X								
13.	Peninsula HM Unit	321												
14.	Two Rivers HM Unit	321												
15.	Two Rivers Park	325	X	X	X	X	X						X	
16.	Sacajawea State Park	325	X	X	X	X	X						X	
17.	Pasco Boat Basin	328		X	X	X	X	X					X	
18.	Columbia Park	330	X	X	X	X	X	X	X	X	X	X	X	X
19.	Wye Park	336		X	X	X	X						X	

SITE		RM	Swimming Beach	Boat Launch	Boat Docks	Rest-rooms	Picnic Facilities	Marina	Camping	Trailer Facilities	Trailer Dump Facilities	Power Hookups	Drinking Water	Showers
20.	Chiawana Park and Road 54 Park	334	X	X	X	X	X						X	
21.	Yakima River Delta Wildlife Nature Area	YR1												
22.	Howard Amon Park	337.5		X	X	X	X	X					X	
23.	Leslie R. Groves Park	339		X	X	X	X						X	
24.	Hood Park	2.5	X	X	X	X	X		X	X	X	X	X	X
25.	Burbank Island	5.0												
26.	Locust Grove	5.5												

Detailed information on existing recreation sites can be found in the "Walla Walla District Recreation Facilities guide," dated March 1987 (revised April 1988).

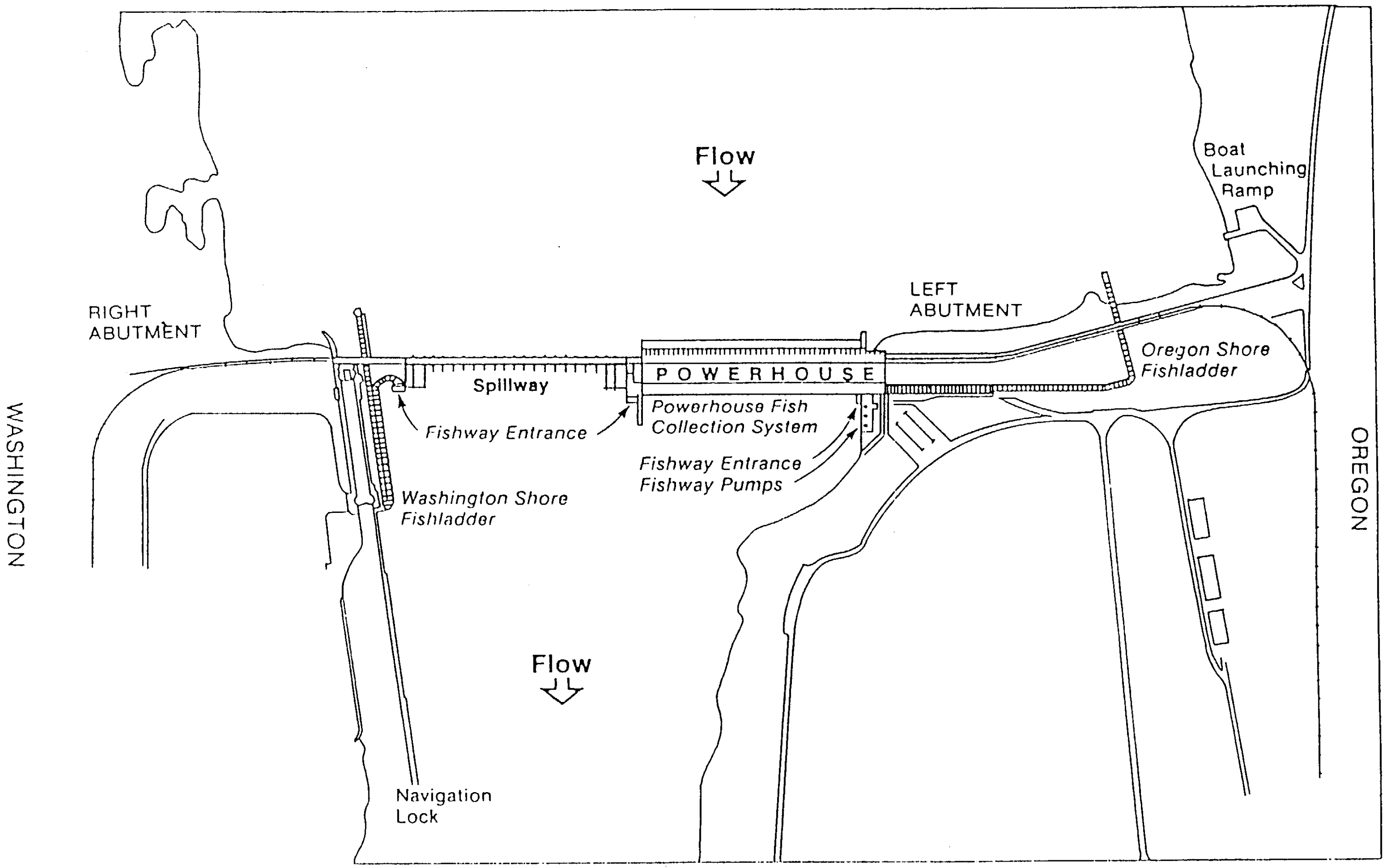


FIGURE 3-1 McNary Dam

IV - BASIN CHARACTERISTICS

4-01. General. The Columbia River Basin above McNary Dam comprises an area of 214,000 square miles of land in northwestern United States and western Canada between the Rocky Mountains on the east and the Cascade Mountain Range on the west. About 39,500 square miles of the area are in western Canada; the remainder comprises nearly all of the State of Idaho; large parts of the States of Montana, Oregon, and Washington; and smaller areas in Utah, Nevada, and Wyoming.

The Columbia River originates in British Columbia on the western slopes of the Canadian Rockies. From its origin, the stream flows north-west, then south to the international boundary, south and west across the State of Washington to the Oregon-Washington boundary, and generally west along that boundary to the Pacific Ocean. The total length of the river is 1,215 miles. The length of the stream above McNary Dam is 923 miles. Principal tributaries of Columbia River upstream of the dam are listed in the following tabulation:

Stream	Location	Drainage Area Square Miles
Kootenai River	British Columbia, western Montana, and northern Idaho	19,450
Clark Fork	Montana and northern Idaho and Washington	25,820
Kettle River	British Columbia and northern Washington	4,260
Spokane River	Idaho and eastern Washington	6,600
Okanogan River	British Columbia and northern Washington	8,200
Yakima River	Central Washington	5,970
Snake River	Western Wyoming, Idaho, northern Utah and Nevada, eastern Oregon, and southeastern Washington	109,000
Walla Walla River	Northern Oregon and southern Washington	1,720

Of these, the Yakima, Snake, and Walla Walla Rivers enter the parent stream in the reach covered by McNary Reservoir. Plate 4-1 illustrates Columbia River Basin climatic characteristics.

4-02. Topography. The topography of the basin is characterized by numerous mountain ranges, large rolling plateaus, and broad valleys. More important mountain ranges are the Cascades and Rockies which are roughly parallel and in approximately north-south lines across several of the western states and Canada. Several smaller ranges between these two major ranges comprise the rough terrain of eastern Oregon and much of Idaho. The mountain ranges are steep with deep narrow canyons, sharp ridges, and towering peaks, many of which exceed 10,000 feet in elevation. Separating the mountain ranges are two principal plains areas. One of these, known as the Inland Empire, is an area of broad river valleys and sloping plateau lands extending from central Oregon through central and eastern Washington into British Columbia. The other is the Snake River Plains which occupy most of southern Idaho.

Mean, maximum, and minimum elevations in the basin upstream from McNary Dam are, respectively, 4,550, 13,766, and 253 feet above sea level. The following tabulation illustrates distribution by elevation of lands in the basin:

Elevation Range (feet)	Area (square miles)	Percent
Below 1,000	14,000	6.5
1,000-2,000	17,000	8.0
2,000-3,000	27,000	12.6
3,000-4,000	37,000	17.3
4,000-5,000	42,000	19.6
5,000-6,000	31,000	14.5
6,000-7,000	25,000	11.7
7,000-8,000	16,000	7.5
over 8,000	5,000	2.3
Total	214,000	100.0

Steep rocky slopes rising abruptly from the reservoir shorelines in the reach from Sand Station to Wallula Gap preclude, with only minor exceptions, development of any port terminal or industrial facilities or park and recreational facilities. There are short segments of steep shoreline terrain at the upper reaches of the pool on both Snake and Columbia River arms.

4-03. Geology and Soils.

a. Columbia River Basin. Columbia River basalt underlies the area and is the most prominent rock formation in the Columbia Plateau physiographic province. As a part of a series of immense lava flows, mostly of a middle Miocene period, this formation covers over 250,000 square miles. The formation ranging in total thickness to over 5,000 feet is made up of numerous individual flows, commonly 25 to 100 feet thick, extending later-ally for miles. The rock is typically fine-grained, dark gray, dense basalt in the massive parts of the flows, but may be scoriaceous (cindery lava) in the upper parts. The upper parts of the flow are commonly oxidized and partly weathered; thus, shades of red and brown are common. Vertical columnar structures of polygonal cross sections formed as the lava cooled.

Throughout the area, much of the basalt bedrock is overlain by sedimentary deposits composed of several formations. These deposits, consisting of silt, sand, gravel, and volcanic ash of the Pliocene or Holocene periods, were deposited by the glacier-swollen Columbia River at the close of the Pleistocene epoch.

Recent alluvium, represented by narrow ribbons of river-washed gravels and reworked loess of volcanic ash, borders the Columbia River and many of the smaller streams in the area. This alluvium covers many larger areas along the Columbia River. With a high ratio of silt to gravel, this material displays limited permeability.

The Columbia River basalt is generally associated with the later sedimentary deposits. Basalt provides a good building or foundation material and also serves as a principal ground-water aquifer due to the water bearing ability of the upper flows. Much of the area is overlain in varying degrees by a veneer of loess. These Pleistocene to Holocene silts were derived in part by wind action.

b. <u>McNary Dam Region</u>. The Columbia River flows through the Sentinel Gap and into the Pasco Basin. In the Pasco Basin, which is a structural and topographic low point of eastern Washington and the Columbia River Plateau, McNary Dam impounds the river to an altitude of about 340 feet, causing the slack water of Wallula Lake to reach upstream about halfway through the basin.

The region is underlain by three major geologic units--the bed-rock of basaltic lavas of Miocene and Pliocene Age and their associated sedimentary interbeds which constitute the Columbia River basalt; the Pleistocene Age Ringold Formation; and the Pasco (glaciofluvial) gravels and associated sediments of late Pleistocene Age at the surface.

The Columbia River basalt forms the bedrock in the Pasco Basin and is encountered at depths greater than 100 feet. The basalt ranges in thickness from 5,000 to 12,000 feet, is exposed in the ridges and at a few knobs which project above terrace lands, and is permeable mainly along the contact zones between some of the lava flows, but its overall permeability is much less than that of the material overlying it.

In the Pasco Basin region, the alluviation appears to have been particularly effective throughout the lowlands between Priest Rapids Dam and Richland and also from the Pasco-Kennewick area to Wallula Gap. These deposits form a mantle overlying the eroded surface of the Ringold which ranges from 20 to 100 feet in thickness. The mantle of glaciofluvial deposits contains mostly gravel of granule or pebble size. Where the glaciofluvial mantle lies below the water table, wells can produce copious amounts of water.

The lower reach of the river between the dam and Wallula Gap is flanked by basalt ledges rising 500 to 1,000 feet above the pool surface to grazing and dryland wheat farms. Upstream of the gap, the shoreline changes abruptly to a broad, flat river plain extending from Wallula to a few miles above Richland.

4-04. Sediment. Some siltation occurs at the mouths of the Yakima and Walla Walla Rivers or draws entering the pool, but this would not result in significant loss of storage in the main reservoir.

4-05. Water Quality.

a. General. Water quality in McNary Reservoir is dependent on numerous factors and varies seasonally. It is determined primarily by the water quality of inflows from the Columbia and Snake Rivers and smaller tributaries including the Yakima and Walla Walla Rivers. There is little potential for internal water column processes to occur because of the run-of-river type of reservoir operations at this project. Other human-related activities that may impact water quality in the reservoir include (1) industrial and urban activities in the Tri-Cities area, (2) agriculture, and (3) localized point sources of contaminant loading.

The reservoir is generally considered mesotrophic. Occasional algal blooms do occur, however, probably resulting from Snake River loading of nutrients. Although the Snake River is of less pristine quality than the Columbia River in regards to nutrient levels, the Columbia River may be higher in toxic contaminants from urban loading as it passes through the Tri-Cities. Some recent encroachment of the aquatic macrophyte water mil-foil has been observed in the reservoir moving in from other upstream reservoirs on the Columbia River.

Other water quality problems exist with (1) the presence of the Tri-Cities urban area at the headwaters of the reservoir, (2) the discharge of pulp mill effluent from the Boise Cascade plant, and (3) the unknown discharge of radionuclides from the Hanford Nuclear Reservation that may be related to radioactive iodine found in the water and ground water of the Columbia River.

Overall, water quality for designated uses is adequate. Standards are achieved for swimming and recreation activities and although the water temperature and dissolved gas concentrations are sometimes relatively high, only minimal impacts from reaching these levels have been observed.

b. Water Temperature. The water column in McNary Reservoir is essentially homogeneous, and well-mixed isothermal temperature conditions generally prevail. During summer heating and/or low flow years, however, a slight temperature stratification of 1 to 2 degrees from surface to bottom may be established. This may inhibit complete mixing. Water temperatures had exceeded 20 degrees C, which is considered fatal to salmonid fish. High water temperatures have contributed to disease and increased stress levels for migrating salmonids, especially the outmigrating juveniles. Table 4-1 shows monthly water temperature data at McNary Dam (Oregon and Washington sides) from 1983 through 1986. The annual maximum water temperatures vary from 20 to 25 degrees C, and minimum water temperatures from 0 to 4 degrees C.

Although vertically well-mixed, the reservoir frequently exhibits lateral differences caused by the incomplete mixing of the Columbia and Snake Rivers. Downstream from the confluence, the waters of the two rivers maintain their characteristics and are often visible with the Columbia water mass moving along the right bank and the Snake water mass along the left bank (this is especially during spring runoff with the Snake River being typically much more turbid). The lateral differences are noted through the entire reservoir and to the dam, as evidenced by the daily temperature readings taken from two locations at the face of the dam. Temperature differences of as much as 9 degrees C from shore to shore had been observed. By contrast, transects which have been run upstream in the reservoir only show longitudinal water temperature differences of 1 degree C.

During low flow, high air temperature periods in the summer, distinct variances in water temperature (as much as 5 to 6 degrees centigrade) occur between gatewell orifice discharge points. Juvenile fall Chinook salmon experience significantly high mortality as they are exposed to rapid temperature fluctuations in the bypass flume. The exact source of the warmer and cooler water is unknown, and studies are currently being conducted to determine the source and the optimal operating procedure to minimize these mortalities. It was previously believed that the temperature fluctuations resulted from the incomplete mixing between the Snake and Columbia Rivers, with the Columbia River inflow (along the north side of the channel) typically being cooler than the Snake River inflow. To minimize the thermal shocking of the smolts, a special powerhouse loading is implemented (for details, see Section 8, Water Control Plan, paragraph 8-04.c., Juvenile Fish Transportation Program).

c. Dissolved Oxygen. Variations in dissolved oxygen levels in McNary Reservoir are associated with the seasons. Water temperature deter-mines the potential maximum dissolved oxygen concentration, and phytoplankton activity in summer and fall can create peaks and depressions in those concentrations. Dissolved oxygen concentrations measured at the dam typically range from a low of about 7.0 mg/L (approximating 70 percent saturation) in the late summer and into fall to a high of about 14 mg/L (110 to 120 percent saturation) during the winter months and during spring runoff. Spill increases the dissolved oxygen levels. Also, some deviation from these concentrations could occur in localized areas of the reservoir, such as in quiescent shallow water areas, and near point sources of effluent, such as the Boise Cascade pulp mill effluent. However, very little variation with depth or distance upstream occurs as flow rates are sufficient to prevent longitudinal gradients from establishing. Bottom dissolved oxygen levels were never less than 5.0 mg/L.

d. Dissolved Gas. Dissolved gas levels in McNary Reservoir have often exceeded the 110 percent saturation standard established by the States of Oregon and

Washington. Data collected at the dam since 1983 (first year of dissolved gas monitoring) have indicated that maximum total dissolved gas saturation in McNary Reservoir is typically about 130 percent. Dissolved gas saturation correlates directly with amount of spill: with the occurrence of any spill at all (April through June), percentages are consistently greater than 110 percent, and typically range from 110 to 120 percent. Following cessation of spill, percentages drop to a range of 100 to 110 percent. Table 4-2 shows daily spill at McNary Dam from 1983 through 1986. Table 4-3 summarizes April through September dissolved gas readings at McNary Dam for that same period.

Despite relatively high level of dissolved gas saturation, a study conducted by the National Marine Fisheries Service during 1985-86 indicated that the impacts of gas supersaturation on juvenile fish were minimal and that there was little reported damage to fish. The following tabulation shows a comparison of maximum and minimum levels of total dissolved gas saturation at the McNary Dam Oregon and Washington stations.

TOTAL DISSOLVED GAS READINGS
Annual Maximum/Minimum Values in Percent of Saturation

Stations	1982	1983	1984	1985	1986	1987
McNary (OR)	132/105	133/105	120/100	134/97	119/100	
McNary (WA)	129/107	127/102	128/106	121/100	126/98	118/99

Data Source: CENPD 1987 Dissolved Gas Monitoring for the Columbia and Snake Rivers (December 1987).

4-06. Climate.

a. General. The climate of the Columbia River Basin is characterized by generally moderate temperatures and precipitation although wide variations in both occur because of the vast size of the area and extreme variations of topographical features. See plate 4-1 for graphical information on temperatures and precipitation.

b. Temperatures. Temperatures above freezing prevail for as much as 220 days per year on the average in some of the lower elevation areas, but the frost-free period reduces with elevation and latitude so that the average in high mountain valleys is less than 100 days per year. Temperature extremes of over 110 degrees and minus 60 degrees have been recorded in the basin, but extremely hot or cold weather in the valleys and plains does not occur frequently and does not usually exist for more than a few days at a time. Protracted periods of subfreezing weather are common in the high elevation areas; and, as a result, much of the precipitation there falls in the form of snow.

c. Precipitation. The mean annual precipitation above McNary Dam averages 24.1 inches but ranges from less than 7 inches in south central Washington to over

120 inches in the mountains along the western rim of the basin. In general, the plains areas are semiarid; but because of the lifting of the maritime air masses in passing over the mountain ranges, annual precipitation increases with elevation and amounts over 30 inches are common in the mountainous areas.

Tables 4-4 and 4-5 show regional climatological data for McNary Dam.

4-07. Storms and Floods.

a. Lower Columbia River. Maximum annual flood peak discharges in excess of 800,000 cfs occurred in Columbia River near The Dalles in 1859, 1862, 1866, 1871, 1876, 1880, 1882, 1887, 1894, and 1948. The largest flood observed at The Dalles gaging station occurred in June 1894 with a maximum discharge of 1,240,000 cfs. The 1876 flood was second highest with 1,020,000-cfs peak discharge, and the 1948 flood had a peak of 1,010,000 cfs at the gaging station. The existing upstream reservoir system reduces the peak discharges of these large historical floods in the Columbia River near The Dalles to nondamaging levels. Little is known of the causes of the 1876 flood. Floods of 1894 and 1948 resulted from greater than normal accumulated snowpacks, subnormal temperatures that retarded the runoff during the early part of the runoff season, heavy spring precipitation creating runoff from saturated lands, and prolonged high temperatures in the latter part of May and early June that caused rapid melting of the snowpack.

Frequencies of unregulated and regulated annual flood peaks are shown for the Snake River at Lower Granite Dam on plate 9-1, for Columbia River at Trinidad (known now as Columbia River below Priest Rapids) on plate 9-2, and for the Columbia River near The Dalles, on plate 9-3. Refer to section IX, paragraph 9-08 for details.

b. Standard Project Flood (SPF). The SPF was derived for McNary project by simulating the maximum possible adverse meteorological conditions that could be reasonably expected to occur from contributing upstream basins. The SPF unregulated and regulated peak discharges for (1) Snake River at Lower Granite, (2) Columbia River below Priest Rapids, (3) Columbia River above Snake River, and (4) Columbia River at McNary are summarized in the following tabulation:

Location	Unregulated Peak Discharge (cfs)	Regulated Peak Discharge (cfs)
Snake River at Lower Granite	575,000	420,000
Columbia River below Priest Rapids	960,000	540,000
Columbia River above Snake River	975,000	570,000
Columbia River at McNary	1,490,000	810,000

c. Spillway Design Flood. The spillway design flood's peak discharge is 2,200,000 cfs. Under this flood condition, the forebay would increase in elevation from the normal high pool of 340 to elevation 356.5. The tailrace water elevation would increase to elevation 303.

The probable maximum floods for key control points on the lower Columbia River were recomputed in 1969 and are summarized in the following tabulation:

LOCATION	Natural Discharge (cfs)	Regulated Discharge (cfs)
McNary Dam	2,610,000	2,100,000
The Dalles	2,660,000	2,060,000

NOTE: For details on the derivation of Lower Columbia River probable maxi-mum floods, refer to Memorandum Report, *Columbia River Basin - Lower Columbia River Standard Project Flood and Probable Maximum Flood,* September 1969, U.S. Army Engineer Division, North Pacific, Portland, Oregon.

4-08. Runoff Characteristics.

a. General. The normal pattern of streamflow for the Columbia River consists of low flows from October through February and increasing flows from March through May or June, and decreasing flows from July through September. At McNary Dam the peak inflow usually occurs in May or June and is primarily the result of snowmelt, sometimes augmented by rainfall. Regulation by upstream projects has a significant effect on peak discharges at McNary. Daily discharge hydrographs on plate 4-2 illustrates the characteristic runoff pattern and the year-to-year variations for the Lower Columbia River at McNary. Table 4-6 summarizes the annual computed inflow volumes and mean daily maximum and minimum inflows from 1954-1986 for McNary reservoir. McNary reservoir inflows have been computed since 1954. Table 4-7 summarizes McNary computed monthly inflow volumes by water years. The maximum historical flood peak was approximately 1,200,000 cfs in June 1894 which is outside of the 1954-1986 period. The minimum mean daily discharge was 48,500 cfs in July 1977 and the maximum mean daily discharge was 754,600 cfs in June 1956.

With regulation by Libby, Dworshak, and other existing projects since 1973, the computed mean annual runoff of McNary reservoir inflow for water years 1973-1986 is 128,053,000 acre-feet. Annual runoff volumes ranged from a minimum of 86,526,000 acre-feet in the 1977 water year to a maximum of 164,698,000 acre-feet in the 1974 water year. In average depths of water over the drainage area of 214,000 square miles above the McNary gage the mean, minimum, and maximum annual runoffs are 11.2 inches, 7.6 inches and 14.4 inches, respectively. The mean annual discharge is approximately 177,000 cfs. Mean daily maximum and minimum discharges averaged 361,300 cfs and 68,400 cfs, respectively, for the 1973-1986 water year period. Plate 4-3 shows summary hydrographs for McNary reservoir inflow.

Runoff contribution and distribution above McNary Dam is shown in the following tabulation:

AVERAGE MONTHLY AND ANNUAL 1980 LEVEL
MODIFIED STREAMFLOW FOR 1928-1978

	Columbia River below Priest Rapids		Snake River below Ice Harbor		Yakima and Walla Walla Rivers 1/		McNary Reservoir Inflow	
Month	Cfs	% of Total	Cfs	% of Total	Cfs	% of Total	Total Cfs	(100 %)
OCT	53,030	65.7	24,360	30.2	3,320	4.1	80,710	100
NOV	50,560	60.2	28,270	33.7	5,160	6.1	83,990	100
DEC	47,900	54.6	33,420	38.1	6,410	7.3	87,730	100
JAN	42,260	50.4	34,320	40.9	7,200	8.6	83,780	100
FEB	45,520	48.5	41,030	43.7	7,400	7.9	93,950	100
MAR	55,200	48.9	50,830	45.1	6,670	5.9	112,700	100
APR	126,300	59.7	80,490	38.1	4,610	2.2	211,400	100
MAY	291,800	71.4	117,90	28.9	-1,100		408,600	100
JUN	349,100	76.0	108,50	23.6	1,700	0.4	459,300	100
JUL	199,300	82.4	39,410	16.3	3,290	1.4	242,000	100
AUG	102,100	80.6	20,160	15.9	4,440	3.4	126,700	100
SEP	63,630	72.3	20,280	23.0	4,140	4.7	88,050	100
TOTAL	119,100	68.7	49,760	28.7	4,440	2.6	173,300	100

1/ Value computed by: ((McNary Reservoir Inflow) minus (Columbia River below Priest Rapids Dam plus Snake River below Ice Harbor Dam)).

Source: 1980 Level Modified Streamflow, 1928-1978, July 1980, Depletions Task Force of the Columbia River Water Management Group.

For information on the modified flows at selected projects or project sites, based on the 1980 level of irrigation development for the 50 year period 1928-1978, refer to the 1980 Level Modified Streamflow, 1928-1978, July 1983, prepared by the Depletions Task Force of the Columbia River Water Management Group. The next report, "2030 Level Modified Streamflow, 1928-1978", will document procedures for computation of irrigation depletion adjustments and will present 2030 level modified flow for each of the selected projects or project sites.

b. Streamflow Records. Streamflow data records have been maintained at key gaging stations on the Columbia River, Snake River, and the Yakima River by the U.S. Geological Survey (USGS) and published in the *USGS Water Resources Data - Washington.* Major gaging stations above McNary Dam include; (1) Snake River below

Ice Harbor Dam, (2) Columbia River below Priest Rapids Dam, and (3) Yakima River at Kiona.

c. Basin Runoff.

(1) Snake River below Ice Harbor Dam. Plate 4-4 shows regulated discharge summary hydrographs for the Snake River below Ice Harbor. Table 4-8 summarizes annual runoff volumes and extreme discharges, by water years, for the Snake River below Ice Harbor Dam.

(2) Columbia River below Priest Rapids Dam. This gaging station measures virtually all of the runoff of the Columbia River above its confluence with the Yakima River. Plate 4-5 shows regulated discharge summary hydrographs for the Columbia River below Priest Rapids Dam. Table 4-9 summarizes annual runoff volumes and extreme discharges, by water years, for the Columbia River below Priest Rapids.

(3) Yakima River at Kona. This gaging station measures runoff from 5,615 square miles of drainage area, which represents most of the runoff of the Yakima River above its confluence with the Columbia River. Plate 4-6 shows regulated discharge summary hydrographs for the Yakima River at Kiona. Table 4-10 summarizes annual runoff volumes and extreme discharges, by water years, for the Yakima River at Kiona.

4-09. Upstream and Downstream Structures.

a. General. The Columbia River, and to a lesser extent the Snake River, is regulated above McNary by a number of dams operated by the Corps, Bureau of Reclamation, Idaho Power Company, utility districts, and private irrigation companies. Regulation by upstream projects has a great effect on the flows at McNary, and coordination between the agencies and companies involved is necessary. Corps of Engineers structures downstream of McNary Dam on the Columbia River include: (1) John Day Dam, (2) The Dalles Dam, and (3) Bonneville Dam. These major projects, along with McNary, are operated for multiple purposes on a system basis.

b. Travel Time. The travel time in terms of velocity in the Columbia has also been significantly affected by the construction of dams and reservoirs, but in a manner entirely different from their effect on storage travel times. This effect is most pronounced on the main stem Columbia and Snake River projects, where many run-of-river projects below Grand Coulee Dam on the Columbia River and below Lewiston, Idaho, on the Snake River have been constructed. While these reservoirs have only minor amounts of storage, the water contained in inactive storage provides much reduced mean water velocities as compared with the velocities in the natural river channels that occurred before the project was constructed. The major reservoir storage projects, such as Grand Coulee, Mica, Libby, and Dworshak projects have even greater effects on the reduction of mean flow velocities compared with natural conditions. Overall, the particle travel times are greatly reduced from those which prevailed under natural conditions.

The following tabulation shows estimates of particle travel times for the main stem Columbia and lower Snake Rivers under normal flow conditions.

PARTICLE TRAVEL TIMES

Reach	Estimated Particle Travel Time, Days Flow in 1,000 cfs	Controlled
Columbia River from Snake River	200	12.2
Confluence to Bonneville Dam (178 miles)	400	6.3
Snake River from Lewiston, Idaho	100	9.3
to the mouth (140 miles)	200	4.6

Source: Columbia River Master Water Control Plan, December 1984.

While particle travel time is reduced, the effect of discharges from projects upstream of McNary occurs much sooner for storage travel time. For most conditions, changes in discharge at Priest Rapids and Ice Harbor can be measured in about 11 hours and 1 hour, respectively, through wave effects. Likewise, McNary discharges reach the John Day forebay in about 3 hours.

4-10. Water Supplies. McNary Dam and Reservoir is an integral part of the major multiple-purpose project system. Section VIII of this manual describes the Water Control Plan for McNary project including in part how it will be coordinated with other existing, authorized, and proposed projects of the comprehensive plan for producing power.

Since 1973 with Libby, Dworshak, and other existing projects above McNary Dam, the effect has been a higher magnitude of base flows and a lengthening of the duration for the moderately low runoff period. During the October through March period, mean monthly runoff has increased due to the winter and spring evacuation of storage reservoirs. Lower runoff has occurred during the May and June period because of the spring refill of storage reservoirs, which allows the runoff to be regulated. The following tabulation shows how runoff has been distributed throughout the water year since the completion of major storage and run-of-river projects.

COLUMBIA RIVER AT THE DALLES (Mean Monthly Runoff Volume) Acre-Feet

Month	Unregulated 1890-1950 Mean	Percent	Regulated [1/] 1973-1985 Mean	Percent
Oct	5,860,712	4.27	7,376,942	5.53
Nov	5,725,207	4.17	7,985,647	5.99
Dec	5,969,343	4.35	9,783,309	7.34
Jan	5,722,895	4.17	11,285,031	8.46
Feb	5,414,620	3.94	10,635,557	7.97
Mar	7,384,336	5.38	12,559,156	9.42
Apr	11,522,382	8.39	12,903,705	9.68
May	22,188,829	16.16	16,783,599	12.58
Jun	28,545,979	20.79	16,753,877	12.56
Jul	20,539,370	14.96	11,643,633	8.73
Aug	11,244,695	8.19	8,619,391	6.46
Sep	7,173,893	5.23	7,036,695	5.28
Mean Annual Runoff	137,292,263	100.00	133,366,541	100.00

1/ Runoff timing and distribution reflect the effects of system regulation by major reservoirs since the completion of Libby Dam on the Kootenai River and Dworshak Dam on the North Fork of the Clearwater River.

4-11 Economic Data.

a. Population. Five counties in Oregon and Washington border the reservoir created by the construction of McNary Dam. The tabulation for county population surrounding the McNary project from 1950 to 1980 follows:

COUNTY POPULATION

Year	Washington: Benton	Washington: Franklin	Washington: Walla Walla	Oregon: Morrow	Oregon: Umatilla
1950	51,370	13,563	40,135	4,783	41,703
1960	62,070	23,342	42,195	4,871	44,352
1970	67,540	25,816	42,176	4,465	44,923
1980	109,444	35,025	47,435	7,519	58,861

Note: Information obtained from Oregon and Washington 1980 Census of Population, U.S. Department of Commerce, Bureau of the Census.

b. Industry and Agriculture.

(1) Morrow and Umatilla Counties, Oregon. Agriculture has been, is, and probably will remain the mainstay of the Morrow and Umatilla Counties economics. Annual estimates released by the Oregon Extension Service indicate that Morrow and Umatilla Counties consistently rank among the top ten Oregon counties in annual agricultural production.

Many of the other economic sectors of the two counties originally developed in response to the needs of agriculture--transportation, financial institutions, government agencies, food processing industries, agri-business, services, and retail trade outlets. In both counties, wheat has until recently been the primary farm crop. With the development of large-scale irrigation, other crops have come into heavy production. These include potatoes, sweet corn, and alfalfa. In Morrow County, in 1973 receipts from potato production surpassed those from grain.

(2) Benton, Franklin, and Walla Walla Counties, Washington. Machinery, fabricated metals, printing and publishing industries, nuclear industry with scientific research (Hanford Project), and the Boise Cascade pulp mill are some of the main contributors to the economy of Benton, Franklin, and Walla Walla Counties. In addition, the viable agriculture sector furnishes a direct stimulus to the economy's industrial growth via the continuous development of numerous food processing plants and chemical fertilizer facilities.

c. Irrigation. There are 7 irrigation pumping plants on the Oregon shore and 14 pumping plants on the Washington shore of Lake Wallula. Of these 21 pumps, 2 are on the Snake River below Ice Harbor Dam and another 2 on the Yakima River, which are considered to be on Lake Wallula. The combined capacity of these pumping plants are 1,194.1 cfs and their horsepower ranges from one 25-hp pump plant to 25 pumps, totaling 30,000 hp.

d. Navigation. Most of the navigation activities in Columbia River Basin are carried on along the Columbia River between its mouth and Pasco, Washington, 328 miles upstream; the lower reaches of Willamette River; and other coastal tributaries. However, considerable transportation of logs and some movement of ores and small boats, principally pleasure craft, exist further inland on Columbia River and a number of tributary streams and lakes. Portland, Oregon, is an important West Coast port for transocean shipping. Principal products moved through the navigable reaches of Columbia River upstream of Portland are grain, logs, and petroleum products. In 1953 about 1,522,000 tons of these and miscellaneous commodities were moved through the locks at Bonneville Dam. At McNary Dam in 1975, 3,507,571 tons and in 1986, 5,712,321 tons of commodities and approximately 6,200 water craft (tows, barges, and pleasure and miscellaneous craft) passed through the locks. In addition, over half of the tonnage that passes through McNary lock either originates or is destined for the Snake River locks and dams.

e. Flood Damages. The following tabulation is a summary of the effects of reservoir regulation on flood peaks for the lower Columbia River below McNary Dam and total Columbia Basin:

EFFECTS OF RESERVOIR REGULATION ON FLOOD PEAKS
COLUMBIA RIVER BASIN

	Maximum Annual Mean Daily Flood Peak at The Dalles, Oregon (1,000 cfs)		Damage Prevented (millions of dollars)	
WaterYear	Unregulated	Observed	Lower Columbia 1/	Total Columbia Basin 2/
1957	820	705	6.60	11.11
1958	735	593	3.55	7.83
1959	642	555	.88	2.60
1960	493	470	.08	.58
1961	789	699	6.50	7.70
1962	503	460	.09	1.79
1963	481	437	.03	.65
1964	764	662	7.60	22.91
1965	669	520	1.44	7.18
1966	455	396	None	.43
1967	781	622	14.21	20.80
1968	533	404	.26	1.07
1969	628	449	2.61	5.51
1970	634	426	1.16	6.34
1971	740	557	8.49	25.73
1972	1,053	618	213.10	260.49
1973	402	221	0.00	.52
1974	1,010	590	239.73	306.36
1975	669	423	9.41	40.97
1976	637	419	15.65	43.08
1977	276	183	0.00	0.00
1978	565	313	6.00	30.61 3/
1979	482	306	1.50	4.65
1980	544	341	5.16	15.15
1981	579	436	10.91	49.12
1982	759	422	15.22	78.62
1983	732	400	18.48	127.00
1984	628	376	10.71	107.29
1985	550	274	10.45	23.46
1986	719	338	15.66	87.49
1987	439	284	0.00	9.09

1/ Damages are for the Columbia River below McNary Dam.
2/ Totals are damages prevented by major projects above The Dalles during the spring and summer runoff. Damage prevented in Canada and/or by levees and channel improvements are not included.
3/ Damages were based on the flood of December 1977.
Source: 1987 Columbia River Water Management Report.

V - DATA COLLECTION AND COMMUNICATION NETWORKS

5-01. Data Collection.

a. General. McNary project data is collected to report the operation status of the project, to evaluate streamflow and reservoir conditions, and to schedule daily and long-term regulations for the McNary project and other projects in the Columbia and Snake River systems. McNary Dam is also the center for the remote operation and reporting of hydropower related functions from Ice Harbor Dam, Lower Monumental Dam, Little Goose Dam, Lower Granite Dam, and Dworshak Dam.

b. Project Gages. Project data is collected by recorded observations on gages at the dam for reporting reservoir elevations (forebay and tailwater), project inflow and discharge, power generation, and other miscellaneous data (fish counts, navigation lockages, and power unit status).

(1) Reservoir Elevation Gages. There are four reservoir water surface elevation gages on the McNary pool: (1) the forebay gage at McNary Dam, (2) Columbia River at Finley, Washington, (3) Columbia River at Clover Island at Kennewick, Washington, and (4) Columbia River at Richland, Washington. Of these four, only the forebay gage is used on a daily basis to assist in controlling the pool elevation of McNary Reservoir. The gage at Clover Island can be used to obtain information by telephone if the need arises.

(a) Forebay Gage. The McNary Dam forebay gage is located in a still-well house on the upstream side of the dam. The measuring equipment includes a float on a slide wire attached to a galvanometer, with continuous readouts on a strip chart in the control room. Readings are noted by the operators and reported hourly on the Columbia Basin Telecommunications (CBT) network. The forebay gage can be used in conjunction with discharge data for project regulation in the event that all communications to the dam are lost.

(b) Columbia River on Clover Island at Kennewick, Washington. This gage records reservoir elevations at RM 328.5 in the vicinity of Pasco and Kennewick and is upstream of the Snake River confluence. A water-stage recorder and telemark telephone equipment are installed in a gage house at the old Coast Guard Station on the east end of Clover Island.

(c) Columbia River at Finley, Washington. This gage records reservoir elevations at RM 323.0, near the Finley and Hedges port sites. The site is equipped with a standard water-stage recorder mounted near the southwest end of the Union Pacific Railroad-Columbia River crossing, downstream of the Snake River confluence.

(d) Columbia River at Richland, Washington. This gage records water surface elevations at RM 338 in the vicinity of Richland, upstream of the Yakima River confluence. The gage house is located near the outlet of the Corps of Engineers pumping plant for levee 2C. This site is equipped with a water-stage recorder only.

(2) Tailwater Elevation Gage. The McNary Dam tailwater gage is located in a still-well house on the tailrace adjacent to the powerhouse. The measuring equipment includes a float on a slide wire attached to a galvanometer, with continuous readouts on a strip chart in the control room. Readings are noted by the operators and reported hourly on the CBT network.

c. Reporting. Project data is transmitted on a scheduled basis to the Columbia River Operational Hydromet Management System (CROHMS) data-base, in Portland, Oregon, via the CBT network. The data from Columbia River at Clover Island at Kennewick, Washington, Columbia River at Finley, Washington, and Columbia River at Richland, Washington, gages are gathered approximately every 3 months by the USGS and entered into the WATSTORE database.

d. Maintenance. The forebay and tailwater elevation gages maintenance is performed by the maintenance personnel at McNary Dam. The other gages are maintained by personnel from USGS office in Pasco.

5-02. CBT Network (Corps of Engineers). The CBT network, operated by the Corps of Engineers, is basically a manual input system used for: (1) transmitting project data on an hourly basis and (2) issuing day-to-day operating instructions and schedules to the project. Data is transmitted to CROHMS either by manually typing data on the teletype keyboard or by manually attaching a prepunched paper tape. The CBT is also used to pro-vide instructions and information from McNary, RCC, and other stations on the CBT network to the project. Commercial land-line facilities are used exclusively in this system. The Mid-Columbia Project Controller System is operated by Douglas, Grant, and Chelan County public utility districts, and provides data for the CBT from the five mid-Columbia projects. The CBT network does not have inquiry capability to the remote stations. Refer to CBT Users Manual, revised 15 September 1980, for details on the CBT net-work.

5-03. CROHMS (Corps of Engineers).

a. General. CROHMS is a real-time water resources data management system. A computer system is used for data reduction, system modeling, forecasting, and data base support functions. The data acquisition for these functions is supported through the CROHMS Automated Front End (CAFE). Figure 5-1 on page 5-6 shows the CROHMS network diagram. Details on the CROHMS data collection system are contained in the Columbia River Basin, Master Water Control Manual, December 1984.

In addition, the CBT network, operated by the Corps of Engineers, is now merged with CAFE. The CAFE computer performs the polling functions for the CBT circuit.

b. Use of CROHMS Data. The real-time data are used for the operational management and forecasting of the Columbia River system. The output system is designed to be flexible and easy to use in carrying out the water management responsibilities on a day-to-day basis or for special operating conditions, for maintaining surveillance of the river and reservoir system, and for developing forecasts or operating plans for future regulation.

5-04. Sedimentation Stations. For monitoring the amount and pattern of sediment deposition in McNary Reservoir, 28 sedimentation ranges have been established beginning at RM 293.5 and extending to RM 344.0. Plate 5-1 shows the location of sedimentation ranges in McNary Reservoir for the Columbia, Walla Walla, and Yakima Rivers. There are also 23 sedimentation ranges on the lower reaches of the Walla Walla River and 11 on the lower reaches of the Yakima River regularly monitored by the Corps of Engineers. Sedimentation ranges have not been established officially on the Snake River below Ice Harbor Dam reach.

Data from the sedimentation range surveys is used to calibrate a one-dimensional sediment deposition model and to update reservoir flow models. These computer programs are used in determining water surface profiles for flood control purposes and to study the effects of various reservoir projects.

5-05. Water Quality.

a. General. The Walla Walla District Environmental Resources Branch is responsible for collecting water quality data. Water quality data is collected quarterly at three stations (two at RM 295 and one at RM 324) within McNary Reservoir. The parameters collected in profile are temperature, pH, DO, and conductivity. Graft composite samples for selected chemical, physical, and biological parameters are also collected at these stations. In addition to the reservoir water quality sampling, project personnel take monthly bacteriological samples at swim beaches.

Dissolved gas data has been collected seasonally during the downstream migration of the salmon and steelhead smolts. Two permanent tensionometer stations, station 814-Washington side and station 820-Oregon side (see figure 5-2 on page 5-7), have five-channel units which are capable of monitoring water temperature, atmospheric barometric, total dissolved gas, dissolved oxygen, and nitrogen + argon gas pressures.

b. Reporting. Data from these tensionometer stations are inter-faced with a Data Collection Platform (DCP) which is programmed to record and store hourly instrument readings. These data are transmitted every 4 hours via the GOES-WEST satellite through the Corps of Engineers, North Pacific Division down-link in Portland, Oregon, into the CROHMS database (see figure 5-3 on page 5-8).

c. Maintenance. COMMON SENSING, INC. is contracted yearly for the maintenance and repairs of the tensionometers, which they manufactured, and SUTRON CORPORATION is also contracted yearly for the maintenance and repairs of the Data Collection Platforms.

5-06. Communications. Direct communication between the project and the District Office is normally by telephone via a leased line between McNary and Walla Walla. A commercial telephone line is used for communication between Walla Walla District and North Pacific Division.

A large amount of river, reservoir, weather, and related operating data is transmitted via the CBT network. The CBT network connects the North Pacific Division and the Walla Walla, Portland, and Seattle District Offices with all major projects in the Columbia River Basin system. The network also includes BPA, Portland, Oregon; Bureau of Reclamation and Weather Bureau Offices, Boise, Idaho; and the Geological Survey Northwest Regional Water Data Center in Portland, Oregon.

An elaborate radio, microwave radio, and telephone system connects all District projects except Lucky Peak. McNary Dam is the control center for this system. Radio communication to commercial floating craft and the U.S. Coast Guard utilizes assigned Marine Channel 14 for working traffic, and Marine Channel 16 for contacting and emergencies. Radio communication between mobile and portable units and the District Office or a project control room is on the Corps operating frequency 163.4125 Megahertz (MHz). Two relay stations, one near Kennewick and one near Pomeroy in the Blue Mountains, are provided to increase mobile and portable units radio cover-age. Microwave radio channels link the project control rooms and the District Office.

When an operator at one of the lower Snake River Dams leaves the control room, McNary can switch the microwave radio system and rebroadcast over the mobile or portable frequency, 163.4125 MHz, and reach the operator anywhere on the project. The operator can monitor and answer the navigation radio on Marine Channel 14 by activating the rebroadcasting feature when he leaves the control room. The operator must return to the control room to conduct any radio traffic on Marine Channel 16.

A microwave telephone system provides an additional link between the District Office, McNary, and the lower Snake River projects. With the microwave radio and telephone system available, it is possible to communicate between a mobile radio and any project or District telephone extension via McNary control room.

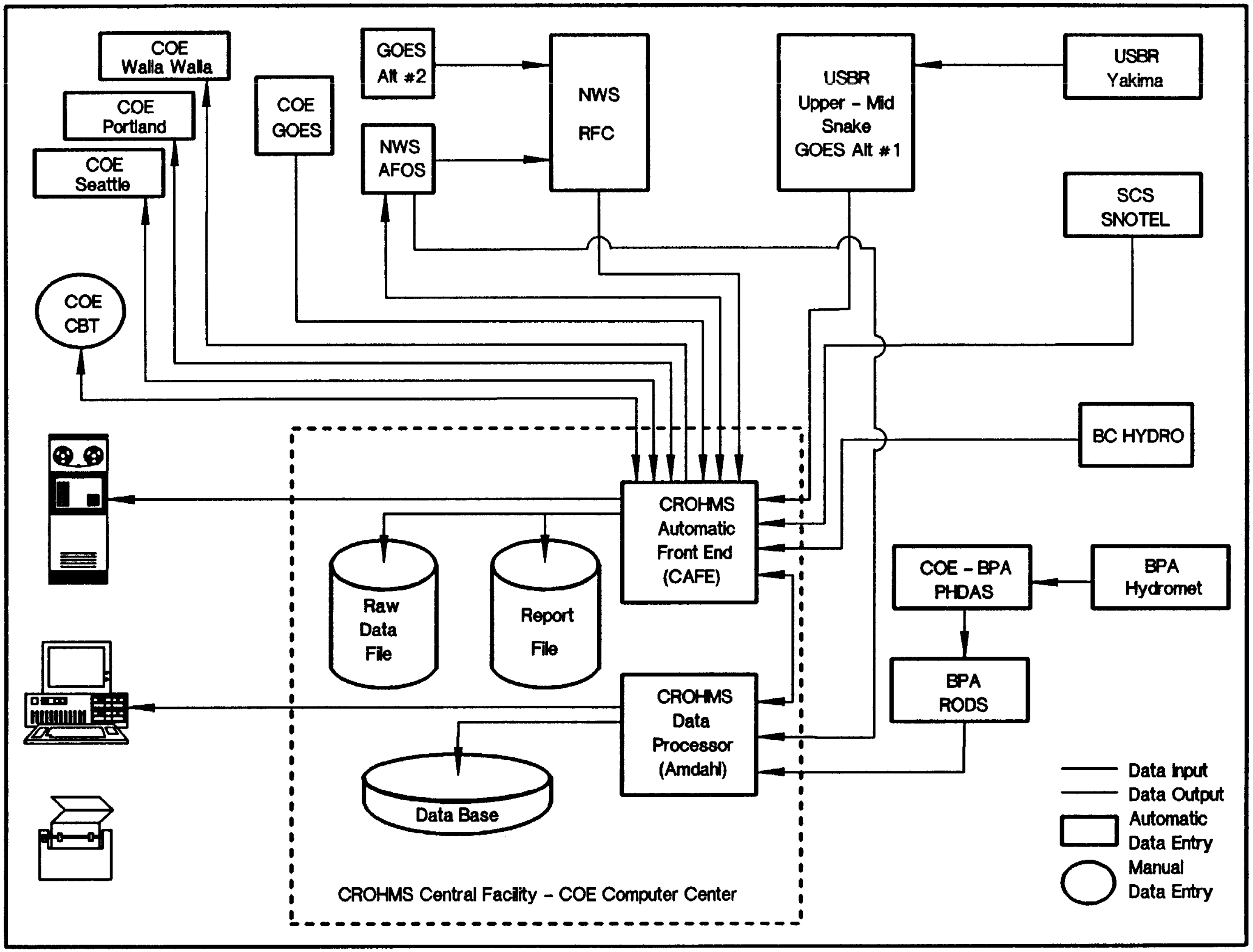
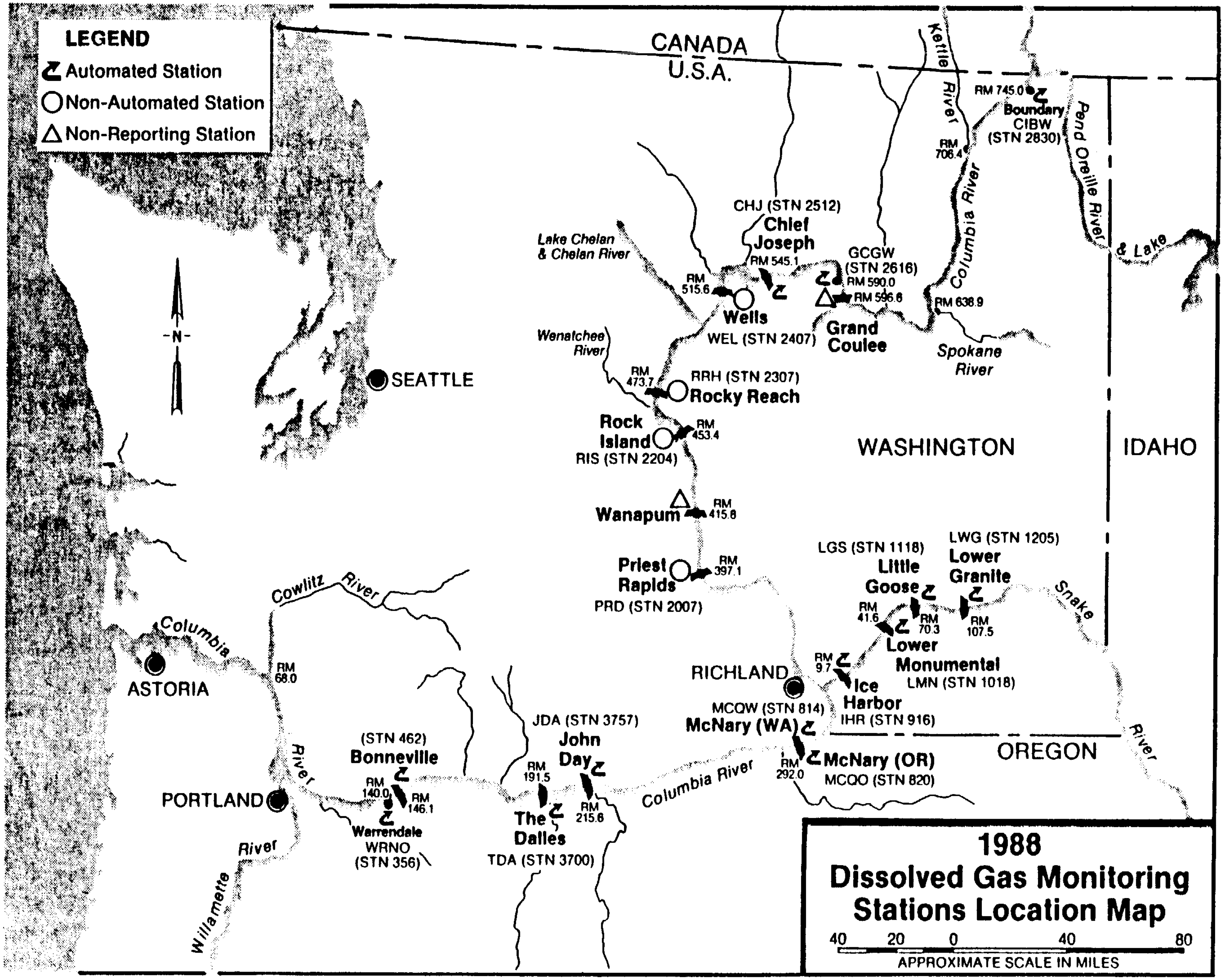

COE Walla Walla
COE Portland
COE Seattle
COE GOES
GOES Alt #2
NWS AFOS
NWS RFC
USBR Upper - Mid Snake GOES Alt #1
USBR Yakima
SCS SNOTEL
COE CBT
BC HYDRO
CROHMS Automatic Front End (CAFE)
Raw Data File
Report File
CROHMS Data Processor (Amdahl)
Data Base
COE - BPA PHDAS
BPA Hydromet
BPA RODS
CROHMS Central Facility - COE Computer Center
Data Input
Data Output
Automatic Data Entry
Manual Data Entry

Figure 5-1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Automated Station
Non-Automated Station
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CANADA
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SEATTLE
ASTORIA
PORTLAND
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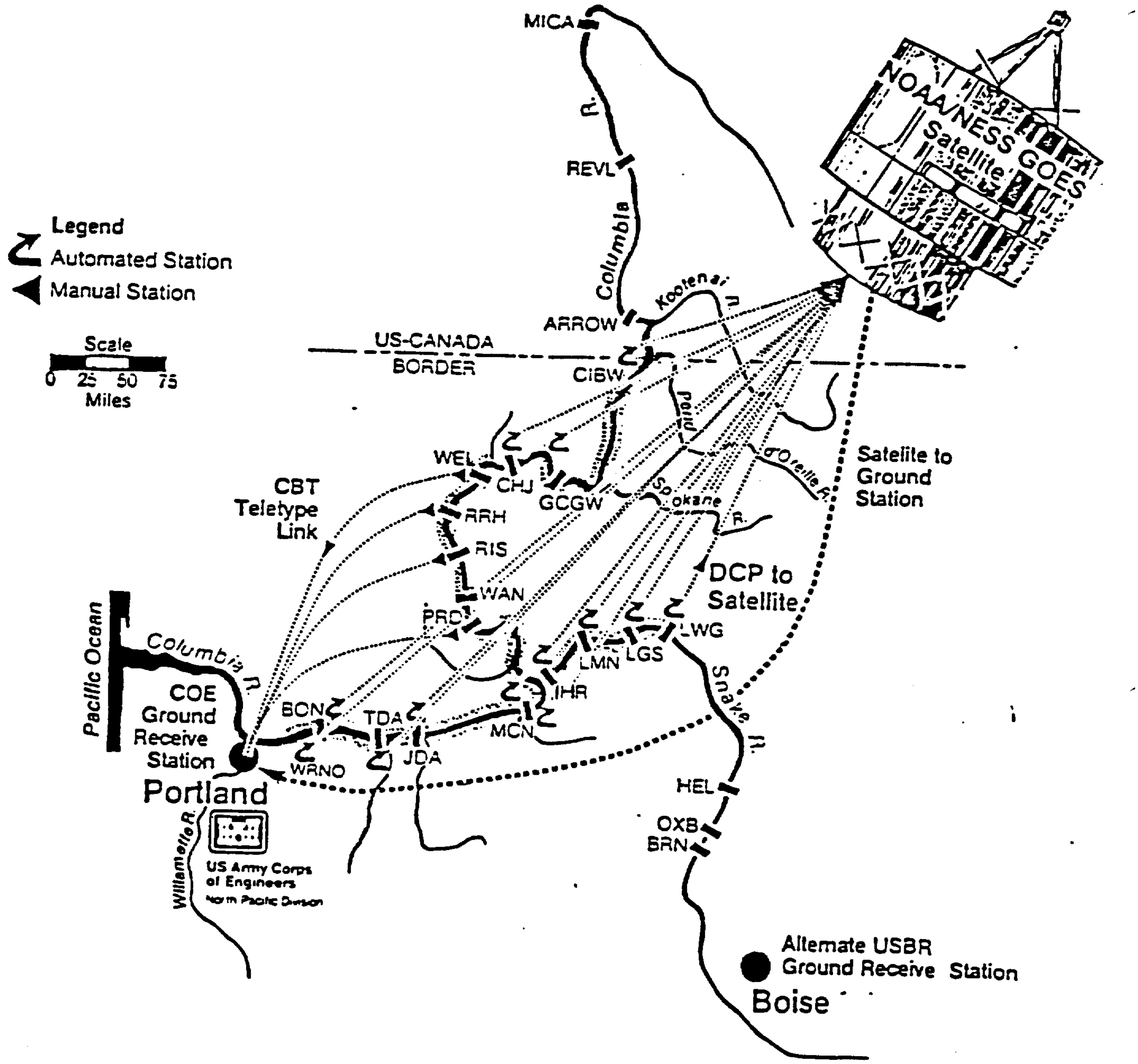
IDAHO
OREGON
Kettle River
Pend Oreille River
& Lake
Columbia River
Spokane River
Lake Chelan & Chelan River
Wenatchee River
Cowlitz River
Willamette River
Snake River
RM 745.0
Boundary
CIBW
(STN 2830)
RM 706.4
CHJ (STN 2512)
Chief Joseph
RM 545.1
GCGW
(STN 2616)
RM 590.0
RM 596.6
RM 638.9
Grand Coulee
RM 515.6
Wells
WEL (STN 2407)
RM 473.7
RRH (STN 2307)
Rocky Reach
Rock Island
RM 453.4
RIS (STN 2204)
Wanapum
RM 415.8
Priest Rapids
RM 397.1
PRD (STN 2007)
LGS (STN 1118)
Little Goose
LWG (STN 1205)
Lower Granite
RM 41.6
RM 70.3
RM 107.5
Lower Monumental
LMN (STN 1018)
RM 9.7
Ice Harbor
IHR (STN 916)
MCQW (STN 814)
McNary (WA)
RM 292.0
McNary (OR)
MCQO (STN 820)
JDA (STN 3757)
John Day
RM 191.5
RM 215.6
The Dalles
TDA (STN 3700)
(STN 462)
Bonneville
RM 140.0
RM 146.1
Warrendale
WRNO
(STN 356)
RM 68.0
1988
Dissolved Gas Monitoring
Stations Location Map
40 20 0 40 80
APPROXIMATE SCALE IN MILES

Figure 5-2



Legend
Automated Station
Manual Station
Scale
0 25 50 75
Miles
MICA
REVL
Columbia R.
ARROW
Kootenai R.
US-CANADA BORDER
CIBW
NOAA/NESS GOES Satellite
Satellite to Ground Station
Pend Oreille R.
Spokane R.
WEL
CHJ
GCGW
CBT Teletype Link
RRH
RIS
WAN
PRD
DCP to Satellite
LWG
LGS
LMN
IHR
Pacific Ocean
Columbia R.
COE Ground Receive Station
BON
TDA
MCN
WRNO
JDA
Snake R.
Portland
HEL
OXB
BRN
Willamette R.
US Army Corps of Engineers
North Pacific Division
Alternate USBR Ground Receive Station
Boise

Figure 5-3

VI - WATER CONTROL MANAGEMENT

6-01. Responsibilities and Organization. The complex system of reservoirs in the Columbia River Basin and their diverse ownership requires a high degree of cooperation and coordination between Federal, state, municipal, and other public and private organizations which have interests in the reservoir regulation activities of the Columbia River system. McNary is a part of this system. Functional water regulation at McNary Project is the responsibility of the Engineering Division of the North Pacific Division. Physical operation and maintenance are the responsibility of the Operations Division of the Walla Walla District. Project responsibility is assigned to the McNary Project Engineer, who reports to the Chief, Operations Division, Walla Walla District. Details of organization and responsibilities, liaison with other agencies, coordinated regulation of reservoirs on a system basis, and related matters are described in the Master Water Control Manual for the Columbia River Basin dated December 1984.

a. Corps of Engineers. In general, the North Pacific Division Reservoir Control Center (CENPD-RCC) plans and directs the regulation of CENPD reservoirs and certain non-Corps reservoirs that have space allocated for flood control. The CENPD-RCC coordinates the regulation of CENPD, non-Corps, and Canadian reservoirs in the Columbia River Basin in order to increase the effectiveness of the system operation under routine and critical conditions.

The real-time daily regulation of McNary is the direct responsibility of the CENPD-RCC. For special reservoir operations, the CENPD-RCC collaborates with the Hydrology Branch of the Walla Walla District. The Hydrology Branch provides assistance and support to the CENPD-RCC by participating in reservoir regulation studies, supplying hydrometeorological data, and providing reservoir regulation manuals for District projects. Final regulation plans are approved and administered by the CENPD-RCC. Physical operation and maintenance of the McNary project is the responsibility of the project engineer who is under the supervision of the Operations Division, Walla Walla District. Pages 6-8 through 6-11 show organizational charts, corresponding personnel names and telephone numbers pertinent to the operation of McNary for the Corps of Engineers and Bonneville Power Administration.

b. Portland River Forecast Center (RFC). The Portland RFC is the official office responsible for issuing coordinated runoff volume forecasts, peak flow forecasts, and flood stage forecasts for key gaging stations within the Columbia River Basin. See Section VII of this manual for details on hydrologic forecasts. A formal agreement in 1963 between the Corps of Engineers and the National Weather Service formed the Cooperative Columbia River Forecasting Service. In 1971, this agreement was amended to include Bonneville Power Administration. A three-member technical committee provides technical advice and guidance to the Columbia River Forecasting Service. The three committee members are as follows:

Chief, Hydrologic Engineering Section, CENPD
Hydrologist In Charge, National Weather Service, Portland RFC Chief
Hydrometeorology Branch, Bonneville Power Administration

c. Bonneville Power Administration (BPA). The BPA is the marketing agency for electric power produced at Federal hydroelectric projects throughout the Columbia River Basin system. This group of Federal hydroelectric plants along with BPA's transmission facilities is known as the Federal Columbia River Power System. McNary is a unit of this system. The Chief of the CENPD-RCC coordinates with the BPA Chief of Division of Power Supply and Chief of Power Scheduling Branch on significant regulation decisions that affect power generation. Routine power scheduling is accomplished by BPA's Power Scheduling Branch within operating limits established by CENPD-RCC. BPA dispatchers coordinate power production from the Federal projects on a real-time basis.

A Memorandum of Understanding, entered into on 8 October, 1956 and revised on 16 November 1970, between the CENPD and the BPA documents the policies and procedures to be followed in the operation of the Corps of Engineers projects. The objective of this Memorandum of Understanding is to maximize power generation by coordinated operations within the normal and special operating limits of CENPD projects.

d. Other Agencies. Other entities with which the CENPD-RCC coordinates and exchanges information in the process of carrying out reservoir regulation activities include the Bureau of Reclamation, U.S. Geological Survey, Soil Conservation Service, Federal Energy Regulatory Commission, Northwest Power Planning Council, the Fish Passage Center representing Federal and state fish and wildlife agencies and the Indian tribes, Federal and state water quality agencies, non-Federal public utilities, private power utilities, and navigation interests. Details on coordination of reservoir regulation activities with other agencies on a system basis are provided in the CENPD-RCC Guidance Memorandum dated January 1972 and the Master Water Control Manual for the Columbia River Basin dated December 1984.

6-02. Coordination Committees and Agreements. The principal organizations which have been formed to coordinate the planning and operation of the Columbia River system projects are the Northwest Power Pool, the Pacific Northwest Coordination Contract Committee, the Columbia River Treaty Operating Committee, and the Columbia River Water Management Group.

a. Northwest Power Pool. The Northwest Power Pool is a voluntary organization whose primary function is to coordinate the operation and maintenance of the power systems of the Pacific Northwest. It also serves as a coordinating group for the solution of a variety of system operating problems.

The membership of the Northwest Power Pool Operating Committee includes 20 utilities and agencies as follows:

- Bonneville Power Administration
- Bureau of Reclamation
- British Columbia Hydro and Power Authority
- Chelan County PUD
- Corps of Engineers
- Douglas County PUD
- Eugene Water and Electric Board
- Grant County PUD
- Idaho Power Company
- Montana Power Company
- Pacific Power and Light Company
- Portland General Electric Company
- Puget Sound Power and Light Company
- Seattle City Light
- Sierra Pacific Company
- Tacoma City Light
- Transalta Utilities Corporation
- Utah Power and Light Company
- Washington Water Power
- West Kootenay Power and Light Company

The functions of the pool are carried out by means of an Operating Committee and a Coordinating Group:

(1) Operating Committee. The Operating Committee consists of one member from each participating system through whom all pool matters are handled. Implementation of any pool action requires unanimous approval by the Operating Committee. The Operating Committee has three continuous subcommittees: Relaying, Communications, and Maintenance.

(2) Coordinating Group. The Coordinating Group, head-quartered in Portland, Oregon, consists of six full-time professionals who are sup-ported by a clerical staff. It acts as a staff for the Operating Committee and the Coordination Contract Committee of the Pacific Northwest Coordination Agreement and provides a clearinghouse for all pool utilities. The group initiates telephone conference calls, chairs Operating Committee meetings, prepares numerous load-resource analyses, takes a lead in coordinating operation with the pool and with adjacent areas, and makes other operating studies and reports. A considerable amount of time is spent on making load-resource analyses for both the Coordinated System of the Pacific Northwest Coordination Agreement and the Northwest Power Pool. Utilizing digital computers, these analyses are made from load and resource data supplied by the utilities. The Northwest Power Pool does not maintain a centralized group to schedule and dispatch

the combined resources of the members of the pool. Rather, each member system remains autonomous, scheduling and dispatching its own resources to serve its own load. The Northwest Power Pool is a member of the North American Power Systems Interconnection Committee which coordinates energy interchange between 10 regional systems.

b. Pacific Northwest Coordination Agreement. The utilities of the Pacific Northwest have long recognized the need for coordinated operation. Through the years the Northwest Power Pool and other inter-utilities arrangements have accomplished much toward this end. These efforts culminated in the Pacific Northwest Coordination Agreement, a formal contract for coordinating the seasonal operation of the generating resources of the member systems for the best utilization of their collective reservoir storage. Finalized in mid-August 1964, the agreement (Contract No. 14-02-4822) became effective on 4 January 1965 and terminates on 30 June 2003. The following 18 agencies and utilities have ratified the agreement:

- Bonneville Power Administration
- Bureau of Reclamation
- Corps of Engineers
- Chelan County PUD
- Colockum Transmission Company
- Cowlitz County PUD
- Douglas County PUD
- Eugene Water and Electric Board
- Grant County PUD
- Montana Power Company
- Pacific Power and Light Company
- Pend Oreille County PUD
- Portland General Electric Company
- Puget Sound Power and Light Company
- Seattle City Light
- Snohomish County PUD
- Tacoma City Light
- Washington Water Power Company

A fundamental concept of the Coordination Agreement is "Firm Load Carrying Capability," commonly abbreviated as FLCC. For the coordinated system of all 18 parties, the FLCC is the aggregate firm load that the system could carry under coordinated operation with critical period streamflow conditions and with the use of all reservoir storage.

In order to accomplish such coordinated operation, the combined power facilities of the parties are operated to produce optimum firm load-carrying ability.

Each party is entitled to a Firm Energy Load Carrying Capability (FELCC) equal to its capability in the critical streamflow period with full upstream storage release, except for reimbursement of Canadian Treaty benefits and restoration of capability to parties which suffer loss in critical period energy capability as a result of the Canadian Treaty storage. FELCC's are sustained by exchange of energy between parties.

Prior to the start of a contract year, a reservoir operating and storage schedule is developed to provide the optimum FELCC of the coordinated system within nonpower constraints. This schedule is melded with a schedule that provides adequate assurance of reservoir refill. The resulting schedule, called an Energy Content Curve (ECC), is used to determine system energy generation capability. Generation in excess of FELCC resulting from draft to ECC is used to serve secondary load. If draft below ECC is required to carry FELCC, then secondary load is not served.

The above discussion refers primarily to the procedures followed to ensure meeting FELCC during periods of critical streamflow. However, the same basic procedures are used to ensure optimum utilization of reservoir storage during years of plentiful streamflow as well.

Representatives of the participants in the agreement are members of the Coordination Contract Committee. This committee makes studies and analyses and rules on any actions concerning the agreement. Most of its work is delegated to the Northwest Power Pool Coordinating Group. However, some of the work is delegated to one or more of the participants. If, as may frequently happen, the best operation for the coordinated system requires a utility to cut back on releases and to hold storage for later use thereby reducing its present generation below its FELCC and perhaps below its load requirements, it has the right to call for and receive interchange energy from a party with excess capability. Later, when the first party's storage is scheduled for release, it will be able to return the energy. Provision is made to pay for any imbalances in such interchange energy exchange accounts that may remain at the end of a contract year.

The agreement provides that, upon request, a utility is entitled to the energy that it could generate at its plants if upstream reservoirs released all water above their ECCs. The upstream party can either release the water or, if it has surplus energy and wishes to conserve its storage for later use, it may deliver energy "in lieu" of the water. The upstream party is not required to spill water to satisfy demands of a down-stream utility.

Other provisions of the agreement include the following: (1) each party shall accept for storage in available reservoir space energy surplus to other parties' needs; (2) equitable compensation shall be made for the benefits from reservoir storage; (3) the obligation to reimburse treaty power to Canada shall be shared by the projects which benefit from treaty storage in proportion to their benefits; (4) interconnecting transmission facilities shall be made available for coordination use subject to the owners' prior requirements; and (5) equitable charges shall be made for capacity, energy, transmission, storage, and other services. Nothing in the agreement is intended to conflict with project constraints for other functions such as flood control, recreation, fish, irrigation, etc.

c. Columbia River Treaty. In 1964, the Columbia River Treaty for the international development of the Columbia River was ratified by the governments of Canada and the United States. The treaty provided for Canada to build and operate three reservoirs presently known as Duncan Lake, Arrow Lake, and Kinbasket Lake. These three reservoirs have a combined usable storage of 20.5 million acre-feet. Under the treaty, Canada operates these reservoirs in a manner which increases downstream power generation and reduces flood damage in the United States. In return for the benefits received, the United States gives Canada half of the dependable capacity and half the energy gain in the United States as a result of Canadian storage and pays Canada an amount equal to half the value of flood damages prevented.

In carrying out the functions required under the Columbia River Treaty, each country has set up a working organization. The treaty working organization is comprised of a permanent engineering board; United States and Canadian entities, United States coordinators; Manager, Canadian Entity Service; and two international committees. The North Pacific Division RCC Guidance Memorandum dated January 1972 provides details on functions and responsibilities of these working organizations.

d. Columbia River Water Management Group. The Columbia River Water Management Group acts as a committee to consider problems relating to operation and management of water control facilities in the Columbia River Basin. Upon review and discussion of the problems, the group makes tentative recommendations for consideration of the individual agencies having primary responsibilities in these areas. The basic function of the group is coordination of river systems operations including the efficient operation of the hydrometeorological system required for each operation. The Water Management Group prepares an annual report which summarizes hydro-meteorological, reservoir regulation activities, and activities and accomplishments of member agencies as related to the Columbia River and tributaries.

The membership of the Columbia River Management Group is composed of representatives from the following state and Federal agencies:

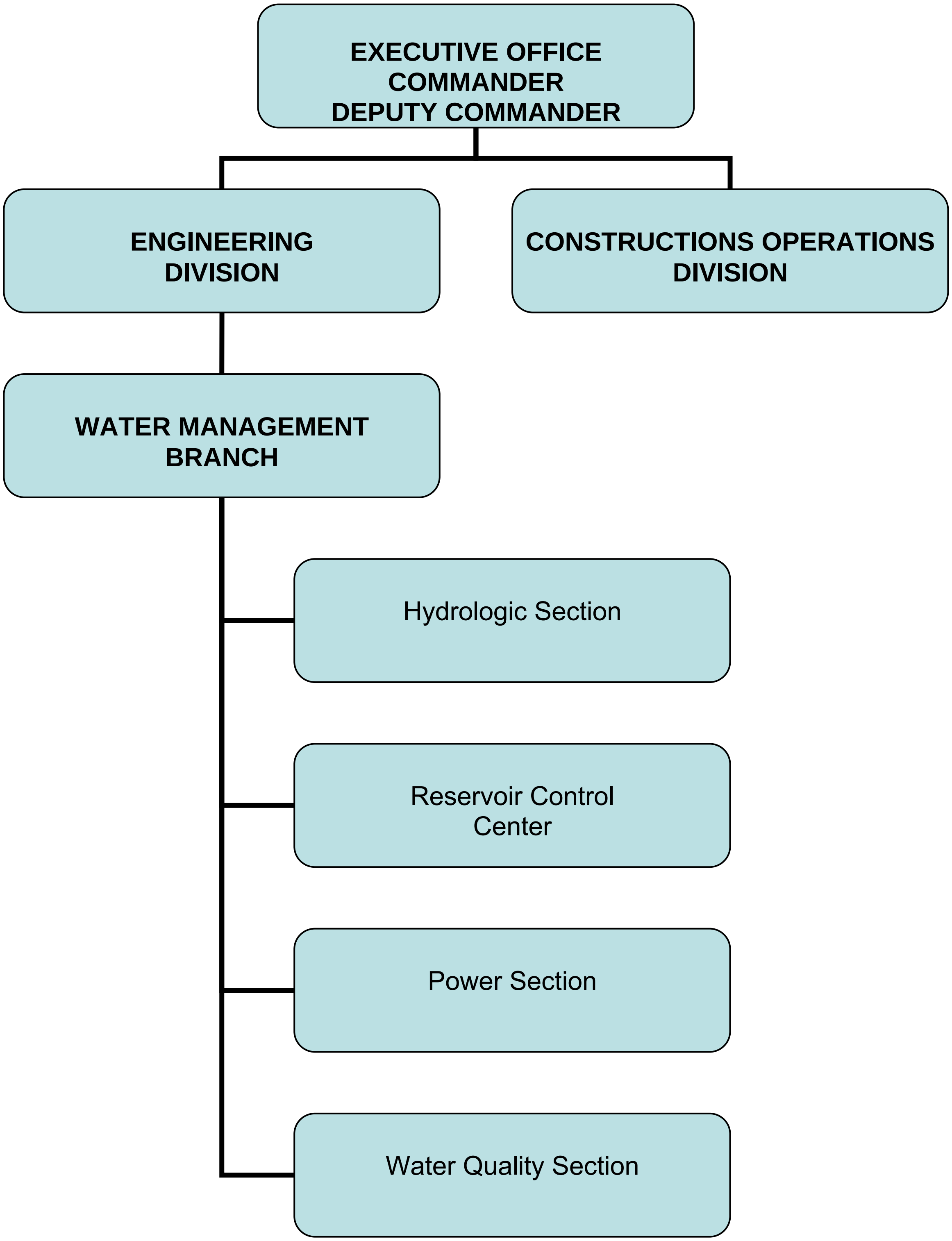
- Bureau of Reclamation
- Bonneville Power Administration
- Corps of Engineers
- National Weather Service
- United States Geological Survey
- Environmental Protection Agency--Water Quality Office
- U.S. Forest Service
- Soil Conservation Service
- Bureau of Land Management • Federal Energy Regulatory Commission
- Fish and Wildlife Service

- National Marine Fisheries Service
- Oregon Water Resources Department
- Washington Department of Ecology
- Idaho Department of Ecology
- Nevada State Engineer
- Department of Natural Resources and Conservation (Montana)
- Wyoming State Engineer

6-03. Regulation Decisions and Records. The North Pacific Division RCC is responsible for making regulation decisions which affect project discharge rates and storage. The goal of the North Pacific Division RCC is to effectively and efficiently schedule project operations in order to maximize benefits for project purposes. A daily log noting pertinent conversations and discussions leading to regulation decisions will be kept current both at the project and the North Pacific Division RCC. Regulation decisions and instructions are discussed with appropriate project personnel and confirmed both on the CBT and the CROHMS (Report Number 42--Project Regulation Messages). Details and completeness of the daily log will be as necessary for after-the-fact review and analysis of regulation plans.

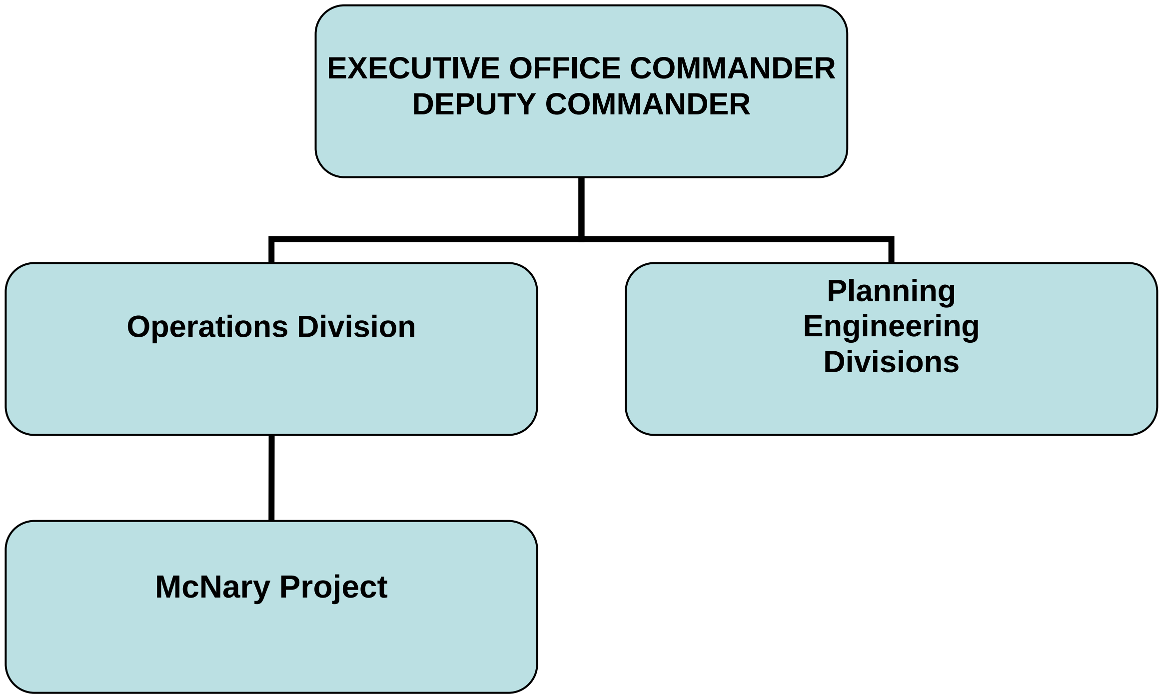
ORGANIZATION CHART

CORPS OF ENGINEERS – NORTH PACIFIC DIVISION



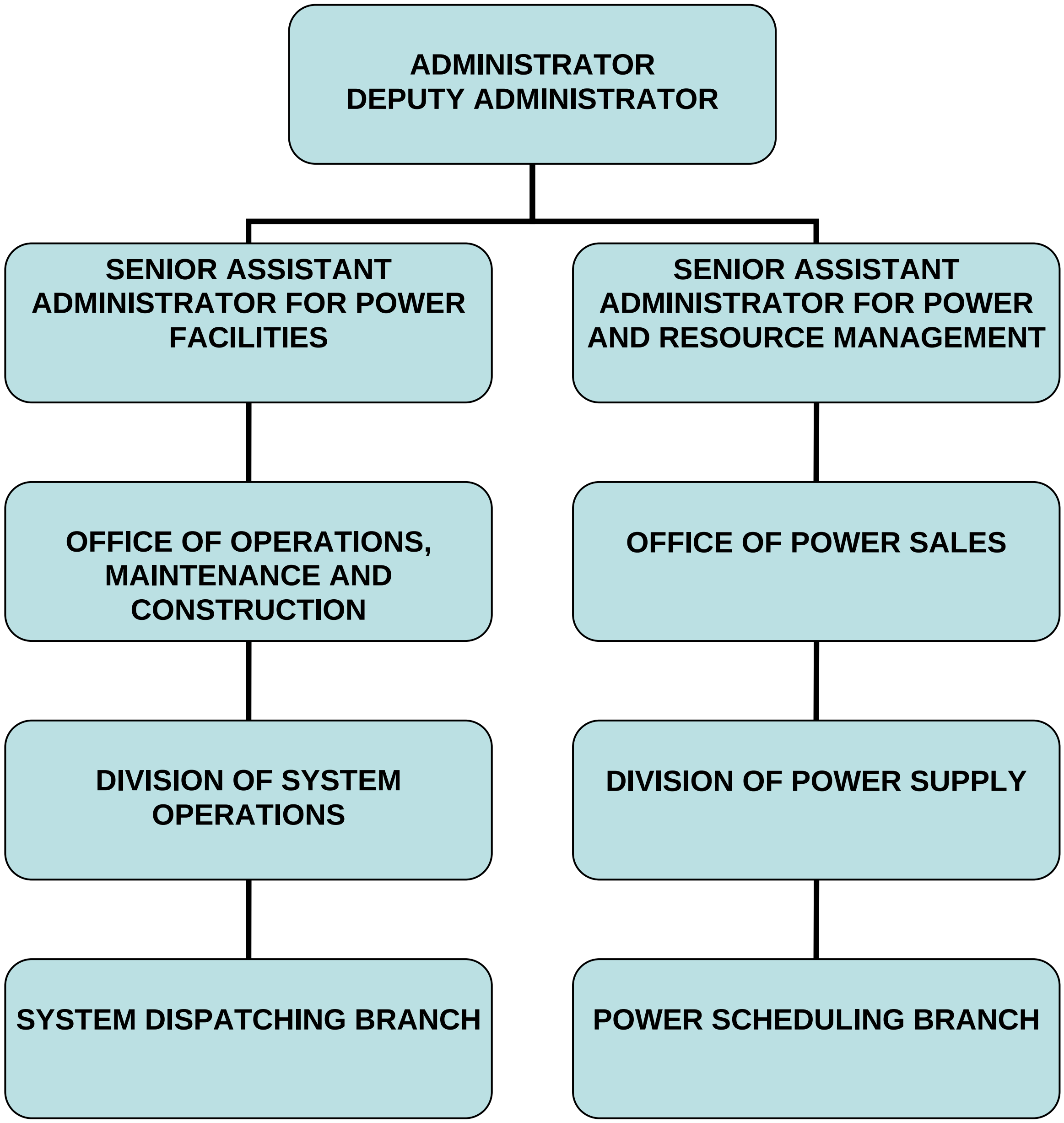
ORGANIZATION CHART

CORPS OF ENGINEERS – WALLA WALLA DISTRICT



ORGANIZATION CHART

BONNEVILLE POWER ADMINISTRATION



VII - STREAMFLOW FORECASTS

7-01. General. The development of reservoir regulation plans for the McNary project is based primarily on power operations and daily streamflow forecasts. The North Pacific Division RCC is directly responsible for coordination of operational planning and regulation of Corps of Engineers reservoirs. The Northwest RFC of the National Weather Service is responsible for issuing coordinated water supply forecasts for the Columbia River Basin system based on forecasts from B.C. Hydro, BPA, Bureau of Reclamation, Corps of Engineers, SCS, and the Northwest RFC. RFC also makes peak discharge estimates for key gaging stations in the Columbia River Basin based on 1 April runoff volume forecasts. These peak flow forecasts are based on statistical relationships between peak flow and runoff volume.

For real-time short-range daily regulation, the North Pacific Division RCC uses the Streamflow Synthesis and Reservoir Regulation (SSARR) model. The SSARR model utilizes routing procedures, snowmelt, and precipitation data to simulate streamflows. The storage effects of lakes and reservoirs can also be evaluated with specified streamflow and reservoir conditions. The RFC and the North Pacific Division RCC develop SSARR forecasts cooperatively and use results to carry out daily service and daily operational responsibilities. Refer to the Master Water Control Manual dated December 1984 for more information on use of the SSARR model.

7-02. SSARR Forecasts. The SSARR model is comprised of three basic components:

a. A generalized watershed model for synthesizing runoff from snow-melt, rainfall, or a combination of the two as drainage basin outflows.

b. A river system model for routing streamflows from upstream points to downstream points through channel and lake storage. Streamflows may be routed as a function of multivariable relationships involving back-water effects from tides or reservoirs.

c. A reservoir regulation model whereby reservoir outflow and con-tents may be analyzed in accordance with predetermined or synthesized inflow and free flow or any of several modes of operation.

SSARR forecasts normally begin about 1 April and continue until the flood potential becomes minimal, which is usually sometime in July. During the early part of the spring flood season, the frequency of these forecasts is 3 days per week on Monday, Wednesday, and Friday. The Monday and Friday forecasts are short-range forecasts for 10 days in advance. The Wednesday forecast is a long-range forecast which covers the period from the initial forecast date through July. During the peak flow and recession flow period, long-term extended forecasts are made every day. These extended forecasts continue until the danger of flooding is past and the reservoirs are filled. Since weather forecasts are usually reliable for no more than 3 to 5 days in advance, the hydrometeorological factors affecting runoff must be extended during the forecast period on the basis of average and extreme snowmelt conditions in order to compare probable flows with the most severe flows likely to occur.

VIII - WATER CONTROL PLAN

8-01. General Objectives. The objective of this Water Control Plan is to define reservoir regulation procedures and practices which provide maximum benefits from authorized project uses when the project is regulated as a part of the Columbia River Basin system. For maximum benefits, the McNary project will be regulated as a run-of-river project within the normal reservoir forebay operating limits of 335 to 340 for primary project functions. Primary project functions include navigation and hydroelectric power generation, while other project uses include fish and wildlife, recreation, irrigation, and water quality. Flood control is not an authorized or planned function because of the limited amount of usable reservoir storage (185,000 acre-feet) between elevations 335 to 340. However, if reservoir elevation 340 cannot be maintained, it is possible for the pool to rise above the 340 normal limit. Unless certain actions are taken the possible consequences include: (1) Overtopping features at the dam, and (2) the Tri-City levees located near the cities of Kennewick, Pasco, and Richland. Paragraph 8-03.e. summarizes actions to be taken for various reservoir surcharge conditions.

8-02. Major Constraints.

a. Lake Elevation Limits. McNary Reservoir will normally be operated between elevations 335.0 and 340.0. A tolerance of up to 0.5 foot above or below those limits is permissible to allow for forecast error or other unanticipated events, but the 0.5-foot tolerance will not be utilized on a planned basis. The 334.5 to 340.5 elevation range will not be violated without prior District Office approval except in an emergency. District Office approval will be coordinated through the Chief, Operations Division. If major flooding occurs, the increased flows will be passed through the spillway with the pool in the normal operating range, elevation 335 to 340, insofar as possible. At normal pool elevation 340.0 with 22 bays in operation, the spillway discharge will be 1,368,000 cfs. For inflows greater than 1,368,400 cfs, the forebay elevation at McNary Dam will rise as shown on plate 3-4 for the free-flow spillway condition when total inflow is passed through the spillway. For example, the spillway design flood of 2,200,000 cfs has a corresponding maximum pool elevation of 356.5.

b. Minimum Discharge. Minimum project discharge limits ensure the safe passage of anadromous fish during their migration to spawning grounds. From December to February, a 12,500 cfs minimum project discharge is permitted. From March to November, the minimum project discharge will be 50,000 cfs for power generation and fishery purposes. The minimum discharge of 12,500 cfs is the approximate design discharge of one power unit operated at the continuous generation of 80 MW.

c, Rate of Change of Discharge. The maximum rate of change per hour for project discharge will normally be limited to 150,000 cfs, which is based on a 1.5 feet per hour rate of change for tailwater elevation. Plate 3-5 shows tailwater discharge rating curves.

d. Spillway Operation.

(1) General. The McNary spillway will be opened to pass flood waters in excess of the powerplant's current hydraulic capacity, which has a maximum of 232,000 cfs at pool elevation 340. During the fish passage season (1 March through 31 December), a specific spill pattern will be used for spillway discharges less than or equal to 606,400 cfs at pool elevation 340. This spill pattern, illustrated in table 8-1, on pages 8-4 to 8-6, provides optimum hydraulic conditions in the stilling basin, particularly at the fish ladder entrances.

The existing spillway system is adequate for the regulation of spring snowmelt floods and winter floods (when nonfreezing weather conditions prevail) provided all the existing facilities work properly and effective actions are taken. Spring flood forecasting procedures and winter flood magnitudes should provide sufficient time to remove three crane operated gates and the 19 gates with hoists as needed with the two gantry cranes in order to provide the required spillway discharge. However, concerns of spillway inadequacy arise, which may cause surcharge pool levels. These concerns emerge primarily as a result of the relatively long time it will take to fully open most gates because of spillway hoists and gate manipulation, and also frozen gate conditions. Inclement weather conditions may cause: (a) Severe icing problems that prevent normal equipment operations; (b) restricted activities of personnel because of wind, rain, darkness, ice, etc.; or (c) a powerplant load rejection causing loss of powerhouse hydraulic capacity because of the loss of transmission lines, etc. The following paragraphs outline spillway operation criteria:

(2) Normal Operation. The spillway gates will normally be operated remotely and in accordance with criteria in the Walla Walla District - Fish Facility Operation and Maintenance Plan, Appendix C - Operating Standards For Adult Fish Passage Facilities. Table 8-1, on pages 8-4 to 8-6, shows the spill pattern based on current criteria for a 20-spillway gate operation during the fish passage season from 1 March through 31 December, with gates numbered 1 to 22 from left to right looking upstream.

If the desired spill becomes greater than the capacity of 20 gates for the spill pattern shown in table 8 1, repeat the gate operating sequence shown in table 8-1 until the maximum gate opening for bays #3 through #19, except for #14 (undershot), reach 20 feet and the maximum gate opening for bays #1, #2, #20, and #21 reach 22 feet. At these maximum gate openings, the spillway discharge will be 606,400 cfs at a reservoir elevation of 340.

The foregoing procedure is a guide rather than a firm rule. Additional experience and further testing of various other combinations may result in modifications of the above plan. Table 3-2 shows the discharge rating for one spillway gate for flow between leaves and free flow over the lower leaf. Table 3-3 shows the spillway discharge rating for flow under the lower leaf and free flow over the ogee. Plate 3-4 shows spillway rating curve for free flow over the ogee.

TABLE 8-1
MCNARY SPILL PATTERN
20 Bay Operation
(1 March to 31 December)

Gate Numbers																					
1*	2*	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20*	20*	Total Discharge (cfs)
OPENINGS IN FEET																					
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,500
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	(1)	4,500
1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	(1)	1	8,000
1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	(1)	1	1	12,000
1	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	(2)	14,200
1	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	(1)	1	1	2	18,200
1	2	1	1	1	1	0	0	0	0	0	0	0	0	0	0	(1)	1	1	1	2	22,200
1	2	1	1	1	1	1	0	0	0	0	0	0	0	0	(1)	1	1	1	1	2	26,200
1	2	1	1	1	1	1	1	0	0	0	0	0	0	(1)	1	1	1	1	1	2	30,200
1	2	1	1	1	1	1	1	(1)	0	0	0	0	0	1	1	1	1	1	1	2	32,200
2	2	1	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	1	2	33,300
2	2	1	1	1	1	1	1	1	(1)	0	0	1	0	1	1	1	1	1	1	2	37,300
2	2	1	1	1	1	1	1	1	1	(1)	1	1	0	1	1	1	1	1	1	2	41,300
2	2	1	1	1	1	1	1	1	1	1	(2)	2	0	1	1	1	1	1	1	2	44,900
2	2	1	1	1	1	1	(2)	1	1	1	2	2	0	2	1	1	1	1	1	2	48,500
2	2	1	1	1	(2)	1	2	1	1	1	2	2	0	2	1	2	1	1	1	2	52,100
2	3	1	1	1	2	1	2	1	1	1	2	2	0	2	1	2	1	1	1	(3)	54,300
2	3	1	(2)	1	2	1	2	1	1	1	2	2	0	2	1	2	1	2	1	3	57,900
2	3	1	2	1	2	1	2	1	(2)	2	2	2	0	2	1	2	1	2	1	3	61,500
2	3	1	2	1	2	1	2	(2)	2	2	2	2	0	2	1	2	1	2	1	3	62,300
3	3	1	2	1	2	1	2	2	2	2	2	2	0	2	1	2	1	2	1	3	64,400
3	3	1	2	1	2	(2)	2	2	2	2	2	2	0	2	2	2	1	2	1	3	68,000
3	4	1	2	1	2	2	2	2	2	2	2	2	0	2	2	2	1	2	1	(4)	70,200
3	4	1	2	1	2	2	2	2	2	2	3	(3)	0	2	2	2	1	2	1	4	73,600
3	4	(2)	2	1	2	2	2	2	2	2	3	3	0	2	2	2	1	2	1	4	75,400

Notes:
1. Values in parenthesis may be 1 foot less than value shown. For example: (1) means 0 or 1 foot; (2) means 1 or 2 feet.
2. Gate 14 is not used for normal spill operation.
3. Gate 22 is closed for the use of bay as loading area by juvenile transport barge.

*Gates 1, 2, 20, and 21 are split-leaf openings. 1/ Forebay Elevation 340.

TABLE 8-1. MCNARY SPILL PATTERN
20 Bay Operation
(1 March to 31 December)

Gate Numbers																					
1*	2*	3*	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20*	21*	Total Discharge (cfs)
OPENINGS IN FEET																					
3	4	2	2	1	2	2	2	2	(3)	3	3	3	0	2	2	2	1	2	14	4	78,800
3	4	2	2	(2)	2	2	2	2	3	3	3	3	0	2	2	2	2	2	1	4	82,400
3	4	2	2	2	2	2	(3)	2	3	3	3	3	0	2	2	3	2	2	1	4	85,800
3	4	2	2	2	2	2	3	(3)	3	3	3	3	0	3	2	3	2	2	1	4	89,200
3	4	2	2	2	(3)	2	3	3	3	3	3	3	0	3	3	3	2	2	1	4	92,600
3	4	2	2	2	3	3	3	3	3	3	3	3	0	(4)	3	3	2	2	1	4	96,100
3	5	2	2	2	3	3	3	3	3	3	3	3	0	4	3	3	2	2	(2)	(4	98,200
3	5	2	2	3	3	3	3	3	3	(4)	3	3	0	4	3	3	2	2	2	4	101,600
4	5	2	2	3	3	3	3	3	3	4	3	3	0	4	3	3	2	2	2	4	102,800
4	5	2	2	3	3	3	3	3	3	4	3	3	0	4	3	3	3	2	2	4	104,500
4	5	2	2	3	3	3	3	3	(4)	4	3	3	0	4	3	3	3	2	2	5	107,300
4	5	2	2	3	3	3	3	3	4	4	3	3	0	4	3	3	3	3	2	5	109,000
4	5	2	2	3	3	3	3	(4)	4	4	3	3	0	4	4	3	3	3	2	5	112,400
4	5	2	2	3	3	3	3	4	4	4	3	4	0	4	4	(4)	3	3	2	5	115,800
4	5	2	2	3	3	3	3	4	4	4	3	4	0	4	4	4	3	3	(3)	6	118,000
4	5	2	2	3	3	3	3	4	4	4	4	4	0	4	4	4	3	(4)	3	6	121,400
5	5	2		3	3	3	3	4	4	4	4	4	0	4	4	4	3	4	3	6	124,200
5	5	2		3	3	3	4	4	4	4	4	4	0	4	4	4	3	4	3	6	125,900
5	(6)	2		3	3	3	4	4	4	4	4	4	0	4	4	4	3	4	4	6	128,200
5	6	3		3	4	3	4	4	4	4	4	4	0	4	4	4	3	4	4	6	131,600
6	(6)	3		3	4	3	4	4	4	4	4	4	0	4	4	4	3	4	4	6	134,400
6	6	3		3	4	3	4	4	4	(5)	4	5	0	4	4	4	3	4	4	6	137,600
6	(7)	3		3	4	3	4	4	4	5	4	5	0	4	4	4	3	4	4	7	139,800
6	7	3		3	4	(4)	4	4	4	5	4	5	0	4	4	4	3	4	4	7	141,400
(7)	7	3		3	4	4	4	4	4	5	4	5	0	4	4	4	3	4	4	7	142,500

Notes:
1. Values in parenthesis may be 1 foot less than value shown. For example: (1) means 0 or 1 foot; (2) means 1 or 2 feet.
2. Gate 14 is not used for normal spill operation.
3. Gate 22 is closed for the use of bay as loading area by juvenile transport barge.

* Gates 1, 2, 20, and 21 are split-leaf openings.

1/ Forebay Elevation 340.

TABLE 8-1. MCNARY SPILL PATTERN
20 Bay Operation
(1 March to 31 December)

Gate Numbers																					
1*	2*	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20*	20*	Total Discharge (cfs)
OPENINGS IN FEET																					
7	7	3	4	3	4	4	(5)	4	4	5	4	5	0	5	4	4	3	4	4	7	145,700
7	7	3	4	3	4	4	5	4	(5)	5	5	5	0	5	4	4	3	4	4	7	148,900
7	7	(4)	4	3	4	4	5	4	5	5	5	5	0	5	4	4	4	4	4	7	152,300
7	(8)	4	4	3	4	4	5	4	5	5	5	6	0	5	4	4	4	4	4	7	155,000
7	8	4	4	3	4	4	5	(5)	5	5	5	6	0	5	4	5	4	4	4	7	158,300
7	8	4	4	4	4	4	5	5	5	6	6	6	0	5	4	5	4	4	4	7	161,600
7	8	4	4	4	(5)	4	5	5	5	6	6	6	0	5	4	5	4	4	4	7	164,900
(8)	8	4	4	4	5	4	5	5	6	6	6	6	0	5	4	5	4	4	4	7	167,600
8	8	4	4	4	5	4	5	(6)	6	6	6	6	0	5	4	5	4	4	4	7	169,300
8	8	4	4	4	5	4	5	6	6	6	(7)	6	0	5	4	5	4	4	4	8	171,900
8	8	4	4	4	5	4	5	6	6	(7)	7	7	0	5	4	5	4	4	4	8	175,100
8	8	4	4	4	5	5	5	6	6	7	7	7	0	5	(5)	5	4	4	4	8	178,300
8	8	4	4	4	5	5	5	6	7	7	7	7	0	(6)	5	5	4	4	4	8	181,600
8	9	4	4	4	5	5	(6)	6	7	7	7	7	0	6	5	5	4	4	4	8	184,300
8	9	4	4	4	5	5	6	7	7	7	(8)	7	0	6	5	5	4	4	4	8	187,600
8	9	4	(5)	4	5	5	6	7	7	7	8	7	0	6	5	5	4	5	4	8	190,800
(9)	9	4	5	4	5	5	6	7	7	7	8	7	0	6	5	5	4	5	4	8	191,800
9	10	4	5	5	6	5	6	7	8	8	9	9	0	7	6	5	5	5	4	9	210,300
10	11	5	6	5	6	6	6	7	8	9	10	10	0	9	8	6	5	6	5	10	234,000

Notes: 1 Values in parenthesis may be 1 foot less than value shown
For example: (1) means 0 or 1 foot; (2) means 1 or 2 feet
2. Gate 14 is not used for normal spill operation
3. Gate 22 is closed for the use of bay as loading area by juvenile transport barge

* Gates 1, 2, 20, and 21 are split-leaf openings J Forebay Elevation 340

(3) Emergency Operation.

(a) Load Resection. During extremely cold periods a load rejection could occur because of the loss of transmission facilities. In addition, freezing conditions at the dam could cause the spillway gates to remain frozen shut during at least the first portion of the flood. If the 16 gates without heaters were frozen shut and the six existing gate slot heaters located only on the upper leaves of bays 11, 13, 15, 19, 20, and 22 were operable, the McNary spillway capacity at pool elevation 340 would be as follows:

Gate Hoists in Place (6 X 21,200)	127,200 cfs
Gate Hoists Removed (6 X 62,200)	373,200 cfs*

* Assumes lower gate section is not frozen.

Note: With a constant inflow of 350,000 cfs, spillway gates need to be opened within 3 hours in order to limit reservoir surcharge to elevation 342 and prevent uncontrolled flow over the spillway gates.

Four post-project (water years 1954-87) winter floods during December through February have exceeded 300,000 cfs. The project would be extremely vulnerable with inadequate spillway capacity during frozen gate conditions. If frozen gate conditions should occur with load rejection, the initial effect would be to cause surcharge of the McNary Reservoir above the maximum power pool level of elevation 340. If emergency activities are not successful, the effects of extreme surcharge of McNary Reservoir could include: (1) Overtopping upstream navigation miter gate, sluiceway regulating gates with extensive damage to the juvenile fish bypass system, navigation lock deck, and railroad cut; (2) interruption of navigation and rail use because of installation of emergency stoplogs required at the navigation lock and railroad; and (3) severe flooding. Emergency actions to be taken are summarized in paragraph 8-03.e., Reservoir Surcharge. The ultimate effect of severe frozen gate conditions with inoperable spillway gates would be overtopping of the dam and possible failure with catastrophic effects downstream.

(b) Catastrophic Floods. Man-made floods, such as an upstream dam failure, may occur too suddenly to have full spillway capacity. Refer to the Flood Emergency Subplans for McNary Lock and Dam dated October 1982 for instructions and information on catastrophic flood emergencies. In addition, the Operations Division will also provide assistance and guidance for implementing emergency action plans.

Time requirements for opening spillway gates as a result of an upstream dam failure are summarized below:

1. Brownlee. A dam failure at Brownlee generates a peak flood inflow of 1,540,000 cfs. All 22 bays need to be opened for free flow in 41 hours.

2. Dworshak. A dam failure at Dworshak generates a peak flood inflow of 1,665,000 cfs. All 22 bays need to be opened for free flow in 28 hours.

3. Ice Harbor. A dam failure at Ice Harbor generates a

peak flood inflow of 1,112,000 cfs. 18 bays would need to be in free-flow mode in 18 hours.

4. Chief Joseph. A dam failure at Chief Joseph generates a peak flood inflow of 868,000 cfs. All 22 bays will be used as follows in 37 hours:

14 gates @	32,600 cfs	(undershot)	456,400
2 gates @	21,200 cfs	(split-leaf)	42,400
6 gates @	62,200 cfs	(free flow)	373,200
	Total Spillway Discharge =		872,000

8-03 Flood Control Plan.

a. General. McNary is a run-of-river project and flood control is not an authorized function. However, a flood control plan during a flood period will provide guidance for maintaining a reservoir elevation of 340 at the dam which assures adequate freeboard at the dam and at the Tri-City levees. The intent of the flood control plan is to allow RCC some flexibility and judgment in the operation of the McNary project during a flood period.

b. Flood Period. A flood period will be defined as a period when inflow is greater than 450,000 cfs at The Dalles and when these flows have the potential to increase substantially and to remain above the indicated levels for at least 24 hours because of past or forecasted near future meteorological events. Any rising flood hydrograph because of rain and/or snowmelt with flows exceeding 450,000 cfs and increasing more than 5 per-cent per day should be considered a flood period.

For the purposes of this flood control plan, a nonflood period exists when McNary inflows are predictable and high because of large discharges from upstream reservoirs and relatively stable natural flows from gradually changing snowmelt. Also, major flooding on the lower Columbia River is not a consideration.

c Flood Operation. The RCC will direct the flood operations for the McNary project during flood periods and will notify key personnel associated with operation and regulation of the project A flood operation will be initiated during a flood period as defined above in paragraph 8-03b. Accurate flood forecasting will be required to determine whether the flood can be passed by the project without special procedures to remove spillway hoists, as outlined in paragraph 8-03d.

(1) Rising Inflow Hydrograph. During a flood period, McNary will be operated to maintain a pool elevation of not more than 340 feet at the dam by increasing spillway gate openings to pass inflows in excess of the powerplant's hydraulic capacity (232,000 cfs). If all spillways gates are open, discharges greater than 1,368,400 cfs will cause the pool to rise above elevation 340 feet. When the reservoir elevation is predicted to rise above 340, the Project Manager will take preparatory action for reservoir surcharge conditions (refer to paragraph 8-03.e. for details).

In general, lowering of McNary Reservoir to provide storage for regulation of floods is not contemplated. However, lowering the pool (within normal 335 to 340 operating limits) may be requested to provide additional buffer storage for emergency actions, which would provide additional time to open the spillway gates for free-flow operation Facilities along the reservoir generally are designed to function effectively for 1894 flood conditions. Lowering of the pool at the dam during flood stage would have little effect on water surface elevations at or above Pasco; for example, the 1894 flood backwater profile would differ by less than 2 feet from the 1894 flood natural profile at Pasco, Washington.

(2) Summary. The flood control plan provides guidance for the interruption of normal operation, but does not change the limitations and procedures of preceding paragraphs. The flood control plan requires preparatory action 3 to 5 days before inflows are forecasted to be greater than 1,368,400 cfs to allow emergency actions at the dam, such as spillway operation.

d. Extremely High Inflows. The project was designed to pass an inflow of 1,368,000 cfs and still maintain a 340 elevation at the forebay gage. The possibility exists that the project may lose outside communications during extremely high inflows. If the project becomes isolated and the inflow is judged to be 639,000 cfs, or greater, the spillway gates will be opened to free flow as needed to maintain a stable pool.

Free-flow operation of the spillway gates is required to achieve the full capacity of 1,368,400 cfs at pool elevation 340 and 2,200,000 cfs at pool elevation 356.5 for 22 gates. The following summarizes actions that must be taken to accomplish free-flow operation:

(1) Gate hoists must be removed and stored, probably on the spillway deck.

(2) The upper leaf must be removed and stored in the upstream storage slot.

(3) The lower leaf must be raised and dogged off at its maximum upper position.

These procedures to provide full spillway capacity are estimated to take about 42 hours barring difficulties such as equipment failure, accidents, inclement weather conditions, etc. (Reference - DF, dated 15 July 1980, From: Project Engineer, McN, To: Chief, Operations Division.) This time would be considerable longer if delays from such difficulties occurred.

Under extremely high inflows, the RCC may also consider drawing down John Day, The Dalles, and Bonneville Reservoirs on the lower Columbia River in advance of increasing discharges from McNary Dam, if such a system regulation plan would significantly reduce the flood peak at downstream locations on the Columbia River.

The following summarizes spill schedules for spillway discharges greater than 639,000 cfs [17 at 32,600 cfs (undershot); 4 at 21,200 cfs (split-leaf)]:

CASE I (Q > 639,000 S 668,600 cfs):

Conditions:

1 Forebay Elevation 340

2 21 Bay Operation

3 Open gate #3 as needed to free flow

Spill Schedule Operation		Spillway Flow (cfs)
1	16 gates (#4-19) @ 32,600 cfs (undershot)	521,600
2	4 gates (#1, 2, 20, 21) @ 21,200 cfs (split-leaf)	84,800
3	Gate #3 (free flow)	62,200
4	Gate #22 (no flow)	0
	Total Spillway Discharge =	668,600

CASE II (Q > 668,600 S 709,600 cfs):

Conditions:

1 Forebay Elevation 340

2. 21 Bay Operation

3. Gate #3 (free flow), open #21 as needed to free flow

Spill Schedule Operation		Spillway Flow (cfs)
1	16 gates (#4-19) @ 32,600 cfs (undershot)	521,600
2	3 gates (#1, 2, & 20) @ 21,200 cfs (split-leaf)	63,600
3	Gates #3 & 21 (free flow)	124,400
4	Gate #22 (no flow)	0
	Total Spillway Discharge =	709,600

CASE III (Q > 709,600 S 771,800 cfs):

Conditions:

1 Forebay Elevation 340

2 22 Bay Operation

3. Gates #3 & 21 (free flow), open #22 as needed to free flow

Spill Schedule Operation		Spillway Flow (cfs
1	16 gates (#4-19) @ 32,600 cfs (undershot)	521,600
2	3 gates (#1, 2, & 20) @ 21,200 cfs (split-leaf)	63,600
3	Gates #3, 21, & 22 (free flow)	186,600
4		
	Total Spillway Discharge =	771,800

CASE IV (Q > 771,800 S 1,368,400 cfs)
Conditions:
1 Forebay Elevation 340
2. 22 Bay Operation
3. Gates #3, 21, & 22 (free flow)
4. Open other 19 gates (#4-19, #1, 2, & 20) as needed to free flow
(removal of spillway hoists required to open these gates to free flow)

Increased Discharge Per Gate		Spillway Flow (cfs
1	16 new hoist gates #4-19 (62,200-32,600)	29,600
2	3 old hoist gates #1, 2, & 20 (62,000-21,200)	41,000

TYPICAL SPILL SCHEDULE FOR FREE FLOW:

No. of Hoist Gates Opened To Free Flow	Accumulated Number of Hoist Gates Opened To Free Flow	Total Number of Gates Opened To Free Flow	Hoist Gates Discharge Change (cfs) 1/	Spillway Discharge (cfs)
0	0	3	0	771,800
1*	1	4	29,600	801,400
5*	6	9	148,000	949,400
4*	10	13	118,400	1,067,800
4*	14	17	118,400	1,186,200
5**	19	22	182,200**	1,368,400 2/

1/ All 19 hoist gates opened to maximum limits: discharge change is difference between free-flow discharge and maximum limit discharge.
2/ All gates at free flow, 22 gates @ 62,200 cfs = 1,368,400 cfs.
* New hoist gates.
** 2 new and 3 old hoist gates (59,200 + 123,000 = 182,200 cfs).

e Reservoir Surcharge. The surcharge storage volume of the McNary Reservoir, elevations 340 to 356, is about 630,000 acre-feet, or a 1-day nominal inflow rate of about 315,000 cfs. The reservoir storage versus pool elevation is shown on plate 3-4.

Any surcharge of McNary Reservoir is considered serious because of impact of various facilities at the dam and along the reservoir, such as fish bypass equipment, fish ladders, navigation lock, port facilities, irrigation pump plants, etc. The following presents elevations of some features at the dam:

Location	Elevation
Top of spillway gate (closed)	342.00
Upper navigation lock gate operating arm port	343.83
Top of upper navigation miter gate	344.00
Top of sluiceway gate	346.00 *
Navigation lock deck	348.00
North shore railroad cut at bulkhead slot	350.11
Intake deck	361.00
Powerhouse tailrace deck	287.00

* Sluiceway contains fish bypass facilities that would receive extensive damage if gates were overtopped

For various conditions of reservoir surcharge barriers (stoplogs or fill materials) must be placed at the following locations: (1) Across the navigation lock and fish ladder exits, (2) in the railroad cut, and (3) at various cuts through the Tri-City levees.

The following paragraphs summarize actions to be taken during various reservoir surcharge conditions:

(1) At McNary Dam:

(a) Pool Elevation ≥ 340.5 and < 341.0:

1. The RCC will provide up-to-date stream-flow forecasts and instructions to the project, and will also monitor hydrometeorological conditions.

2. Project personnel will make preparations for the installation of upstream stoplogs for the navigation lock, including arrangements to transport stoplogs stored at the lower navigation lock deck level to the upper deck level.

(b) Pool Elevation ≥ 341 0 < 350.0:

When the 5-day forecast by the RCC shows that the reservoir will rise to elevation 341.0 or greater, project personnel must make preparation to install upstream stoplogs for the navigation lock. Without stoplogs in place, water will begin to enter the upstream water machine rooms at pool elevations greater than 343.83.

Note: The structural design of the various types of stoplogs requires placement as shown in the installation diagram below. Each stoplog is marked with an identification number, "U" for upstream and "D" for down-stream, for placement in a specific order during usage and storage.

Stoplog Installation Diagram

Upstream Stoplog Slot				Downstream Stoplog Slot	
Emergency Usage		Current Usage Stoplog		Current Usage Stoplog	
No.	Elev.	No.	Elev.	No.	Elev.
9U	357.99	9U	345.46	6D	273.83
8U	353.92 *	5U	341.23	8U	269.76**
7U	349.69 *	4U	336.58	7U	265.53**
6U	345.46,	3U	331.94	6U	261.30**
5U	341.23	2U	327.29	5D	257.07
4U	336.58	1U	322.65	4D	252.84
3U	331.94	Sill	318.00	3D	248.61
2U	327.29			2D	244.38
1U	322.65			ID	240.15
Sill	318.00			Sill	235.15

* Requires placement of two auxiliary stoplogs before installation.

** With the rise in tailwater elevation due to the John Day Dam and Reservoir, stoplogs 6U, 7U, and 8U are currently in use at the down-stream navigation lock miter gate for routine maintenance.

Under emergency reservoir surcharge (pool elevation above 340.5), the following actions at the dam need to be accomplished when it is predicted that the river flow will increase beyond 1,390,000 cfs. This river flow will produce an uncontrolled pool elevation of 340.5 with all 22 spillway bays open for free flow.

- Pool elevation above 340.5 and below 345. Place stoplogs 1U to 6U as needed.

- Pool elevation above 345. Place two auxiliary stoplogs across upstream lock deck and then add stoplogs 7U, 8U, and 9U as needed up to a maximum elevation of 358.

When pool surcharge is forecasted to exceed elevation 345, stop-logs 6U, 7U, and 8U would have to be transported from the downstream stop-log slots to the upstream stoplog slots by barge or low-boy carrier.

- During extremely high river flows, steps must be taken to protect the Washington shore and Oregon shore fish facilities from damage due to flooding. Normal spring floods do not require any protective measures. However, preparatory actions for protection of the fish facilities must be accomplished prior to reaching pool elevation 342 or a river flow of 1,500,000 cfs. Refer to 0 & M Manual, Volume 3 of 7, 1956, Chapter 4 - Fishway Facilities and Equipment, Section 15 (page 83) and Section 45 (page 259) for details on emergency operation of the fish facilities.

(c) Pool Elevation ≥ 350.0:

1. Project personnel will make preparation to block off the north shore railroad cut with stoplogs or fill materials. The Walla Walla District will provide instructions and assistance.

2. The cut through the right embankment for the Burlington Northern Railway tracks will allow flood waters to flow through when the forebay elevation exceeds 350. As the three stanchions and the stoplogs are no longer available, the railroad cut will be filled with random earthfill material in an emergency. Seven hundred cubic yards of material should be stockpiled near the cut to close it off from elevations 350 to 365 when needed. The fill will be made under the supervision of the Chief, Geotechnical Branch. (Source: Flood Emergency Subplans for Identification, Operations, Repair, Notification, and Inundation Maps, McNary Lock and Dam, October 1982, page 26.) Plate 8-1.1 shows railroad cut and stoplog structure location in the right abutment, and plate 8-1.2 show plan, elevation, and sections for the railroad stoplog structure.

(d) Tailwater Elevation > 282.0:

1. When flows are forecasted to exceed 880,000 cfs and a tailwater elevation of 282, the powerhouse is in danger of flooding.

2. Emergency actions to be performed by project personnel are described in the *Flood Emergency Subplans for Identification Operations, Repair, Notification, and Inundation Maps*, McNary Lock and Dam, October 1982, page 27.

(2) At Tri-City Levees:

(a) Levee 5D, RM 328.8 to 330.2 (El. ≥ 348.0):

Kennewick Area. Ice Harbor personnel will install flood barriers in the slot through levee 5D when an elevation of 348.0 or greater is forecasted. Flood barriers are in a storage building adjacent to the slot. Access to the Port of Kennewick is provided by this slot just east of the extension of Ivy Street. Refer to 0 & M Manual, Volume 4 of 7, page 161, 1956, for details on the erection of the flood barrier Plate 8-2 shows plan and profile of levee 5D.

(b) Levee 12-1, RM 328.1 to 330.5 (El. ≥ 350.0):

Pasco Area. Two openings are located in the Pasco Levee (levee 12-1) to permit both vehicular and railroad access to the Port of Pasco facilities. The sill of both openings is at elevation 352 It is necessary to install the flood barriers at these locations to prevent both failure of the levee and flooding of a portion of the city of Pasco for river stages in excess of elevation 352. Upon notification that river stages in excess of elevation 350 are forecast in the following 48 hours the barriers should be installed. Refer to 0 & M Manual, Volume 4 of 7, page 164, 1956, for details on the erection of flood barriers. Plate 8-3 shows plan and profile of levee 12-1

(c) Levee 2C, RM 337.7 to 339.2 (El. > 360.0):

Richland Area. Within two reaches of levee 2C, from stations 13+16 to 52+50 and stations 64+16 to 80+70, the top of the levee varies from 2 6 feet to 4 feet lower than the normal levee crest elevations of 364.0 to 369.7. (Refer to plates 8-4.1 and 8-4.2 for details.) In the event that the pool elevation is forecasted to be 360.0 or greater at levee 2C, Ice Harbor personnel will be responsible for implementing action to raise the two low areas on levee 2C in order to accommodate the forecasted pool elevation. The Walla Walla District will provide instructions and assistance in raising the levee. There should be ample time to accomplish the task of raising the levee because the rate of rise of the Columbia River was no more than 1 foot per day for both the 1894 and 1948 floods. For the Columbia River above the Snake River, mean daily peak discharges were 840,000 cfs (1894) and 725,000 cfs (1948).

f. Spillway Design Flood Operations. The Project Manager will secure the powerhouse for the pending flood and plan for probable evacuation The Project Manager will receive instructions from the Walla Walla District Chief, Operations Division, the Walla Walla District or North Pacific Division Emergency Operations Manager, and the North Pacific Division RCC. The actions required are outlined in the Flood Emergency Subplan for Identification, Operations, Repair, Notification, and Inundation Maps, for McNary Lock and Dam, dated October 1982.

8-04. Fish and Wildlife Plan.

a. Background. Every spring juvenile salmon and steelhead smolts leave spawning grounds and hatcheries on the Columbia and Snake Rivers and begin their downstream migration to the Pacific Ocean. These young fish depend on river currents to guide them downstream. The many hydroelectric dams constructed on these rivers have resulted in adverse survival conditions for these smolts due to: (1) increased travel times to the ocean caused by slower flows in reservoirs, and (2) restricted downstream fish movement past the dams.

The spring runoff of 1973, which was one of the lowest runoff volumes of record, brought about a heightened awareness of the problems facing juvenile fish during their migration past Columbia and Snake River dams. During the 1973 spring runoff period, migrating juvenile fish suffered heavy mortalities as a result of (1) the extended transit time through the system and (2) greater numbers of fish passing through the turbine units of the dams. A Committee on Fishery Operations (COFO) was established in 1975 to coordinate the effort to provide for the protection of juvenile fish within a balance of reduced firm power and adverse impacts on other uses of the water resource. Definitive steps were taken to assist juvenile fish passage during the 1977 drought which was more severe than the one in 1973. The COFO continued to coordinate the annual juvenile fish passage program through 1982.

In November 1982, the Northwest Power Planning Council, under guidelines of the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (Regional Act, PL 96-501), developed the first regional Fish and Wildlife Program for the Columbia River and its tributaries. The Fish and Wildlife Program, amended in 1984 and 1987, proposes development of an interim regional plan to coordinate, refine, and develop operations and facilities for protecting these migrating fish and improving migration conditions. The North Pacific Division, Corps of Engineers is responsible for implementing the Juvenile Fish Passage Plan for Corps of Engineers projects.

b. Columbia River Fish and Wildlife Program. The Water Budget is a recommended amount of water specifically reserved for the enhancement of flows to aid in the spring migration of smolts through Lower Granite Dam and the Lower Snake River reservoir system, and Priest Rapids Dam and the mid-Columbia River reservoir system. This Water Budget may be used during the 15 April to 15 June period when the major smolt migration is occurring in the Lower Snake and mid-Columbia River systems Hence, the Water Budget approach rather than a minimum flow requirement to enhance spring migration conditions. A total Water Budget of 78 kcfs-months (4.64 MAF), divided into 20 kcfs-months (1.19 MAF) at Lower Granite and 58 kcfs-months (3.45 MAF) at Priest Rapids, has been recommended for shaping spring flows under the Columbia River Basin Fish and Wildlife Program developed by the Pacific Northwest Power Planning Council in 1982 and amended in 1984 and 1987. If the Snake River flows at Lower Granite Dam and Columbia River flows at Priest Rapids are not adequate to move fish quickly through the reservoir, additional water may be released from upstream reservoirs.

A Coordinated Plan of Operation (CPO) is developed annually by the North Pacific Division, Corps of Engineers in cooperation with Fish Passage Managers, fishery agencies and tribes, BPA, Bureau of Reclamation, utility companies, and others for Water Budget implementation during the 15 April to 15 June juvenile fish passage period. The purpose of the CPO is to meet, insofar as possible, the Section 304 measures in the Northwest Power Planning Council's Fish and Wildlife Program relating to the Water Budget. The CPO relates only to the Water Budget period {15 April to 15 June) and does not include other aspects of operation for fishery. A fish passage plan for juvenile passage at specific Corps of Engineers projects is implemented under a separate document.

Water Budget flows at McNary will be an operational consideration whenever requested during the 15 April to 15 June period. Requests for Water Budget flows will originate from fish and wildlife agencies and tribes through two Fish Passage Managers. These managers will be the primary points of contact between the power system operators and the fish and wildlife agencies and tribes on matters concerning the Water Budget and fish passage. The flow request must be greater than average weekly firm power flows and less than 140 kcfs for both Lower Granite and Priest Rapids. For Water Budget accounting purposes, the Power Planning Council has used firm power flows for Lower Granite Dam and Priest Rapids as follows:

Period	Average Weekly Firm Power Flows (kcfs)	
	Lower Granite	Priest Rapids
15 April to 30 April	50	76
1 May to 31 May	65	76
1 June to 15 June	60	76

Because Lower Granite and Priest Rapids Dams are run-of-river projects, the Water Budget flows provided at these projects are passed through the lower Columbia reservoir system, which includes McNary, John Day, The Dalles, and Bonneville project. The RCC will be responsible for coordinating releases from upstream storage to the extent that water is available for shaping fish flows at Lower Granite and Priest Rapids. The regulation objectives will be to provide well-timed flows from upstream reservoirs in addition to the uncontrolled spring runoff to aid and enhance migration. The RCC and Fish Passage Managers will jointly monitor the runoff and juvenile migration and may by mutual agreement modify the minimum level of flow at Lower Granite, if necessary. Use of the Water Budget approach during the spring runoff season will be based on the following criteria:

(1) Lower Snake Water Budget at Lower Granite Dam. During a year when the Lower Granite runoff volume inflow forecast for April to July is 23.0 MAF or less, the use of upstream reservoir storage for providing Water Budget flows at Lower Granite will be coordinated by the North Pacific Division Corps of Engineers, RCC.

(2) Mid-Columbia Water Budget at Priest Rapids Dam. Federal reservoirs above Priest Rapids have adequate storage capability to provide the Water Budget in all but extremely low runoff years.

Although runoff forecasts greater than 23.0 MAF at Lower Granite would eliminate lower Snake River Water Budget regulation, there will still be regulation for a mid-Columbia Water Budget.

c. Juvenile Fish Transportation Program. In addition to the juvenile fish passage facilities for bypassing juveniles around the turbine units, McNary has facilities for collecting and holding juvenile salmonids for the juvenile fish transportation program.

For the juvenile fish transportation program, juvenile fish are collected at Lower Granite, Little Goose, and McNary projects; loaded into trucks or barges; and transported to below Bonneville Dam. The peak migration period begins when total collection at an individual project reaches 20,000 fish per day. Migration peaks at McNary Dam vary, but major migrations of spring and summer fish occur between May and mid-August. This program is to minimize travel time for juvenile salmonids on their downstream migration and to increase survival related to passage at downstream projects.

The juvenile fish passage facilities are described in paragraph 3-03.b(5). From approximately 1 April to the end of the transport season, McNary's juvenile fish passage facilities will be operated according to criteria in the *Walla Walla District's Fish Facility Operation and Maintenance Plan*, Appendix E - *Fish Transportation Oversight Team's (FTOT) Annual Work Pla*n for Transport Operations at Lower Granite, Little Goose, and McNary Dams. The FTOT Annual Work Plan provides guidelines on facility operation and project operations for juvenile fish to maximize survival of fish collected and transported during the spring and summer migrations.

(1) Facility Operations. The facilities at McNary are normally operated for the collection and transportation of juveniles with bypassing back to the river being done only under certain flow conditions; for research fish; when numbers of fish collected exceed facility holding capacity; or when there is a malfunction to the facility that prohibits the collection, holding, or transportation of juveniles. The FTOT Annual Work Plan requires that when spring river flows exceed 220 kcfs, fish will be separated by size as long as yearling salmon predominate in the collection Smaller fish (primarily yearling salmon) will be returned to the river to migrate downriver on their own The larger fish (primarily steelhead trout) are to be transported. When subyearling salmon numbers exceed yearling salmon numbers, all collected fish will be transported. Transportation will continue until numbers of fish collected are 1,000 or less for 5 consecutive days.

(2) Project Operations.

(a) Turbine Operations/Generation. In order to reduce mortality to juvenile fish passing through turbines, normal powerhouse unit loading should be as near to 70 MW (peak efficiency) as possible.

(b) Unit Priority and Operation. Research has shown that certain powerhouse units collect more fish than others Units with higher collections are referred to as "priority units." The priority of unit operation at McNary will proceed from units 1, 2, 14, 4-10, 3, 11, 12, and 13 consecutively.

Generally during July, surface forebay water temperatures at McNary usually increase to a level which cause higher than normal fish mortality in the collection system. At such time when mortality exceeds 4 percent of fish collected, or there is evidence of daily peak in juvenile mortality due to thermal stress, a special powerhouse operation will be implemented as follows:

1. Unit Priority:

a. Unit 1. (for adult attraction), then

b. Units 14, 13, 12, 11, 10, 9, and 8.

2 Unit Loading:

Units should be operated near best efficiency but may be operated between 50 and 80 MW to minimize starting and stopping them. If additional generation is needed beyond 80 MW per each above unit then additional units may be brought on line beginning with unit 7 and continuing through unit 5. Units 4, 3, or 2, should not be operated when thermal stress related mortality is occurring at the project.

(c) Special Spill Operation. Spillway releases may be required during the outmigration period to facilitate juvenile fish passage past the project if problems develop with the bypass system, juvenile collection system, or transport operations. This is separate from the Water Budget, which is only intended to facilitate migration downstream between the dams.

d. Wildlife Regulation.

(1) Geese Nesting Operation. McNary's pool elevation will be regulated to at least 339 every third day during the geese nesting season from 15 March through 15 May. The intent of this regulation plan is to encourage the geese to nest above the normal operating range of 335 to 340.

(2) Waterfowl Hunting. In the fall and winter season, McNary's pool will be regulated between elevations 339 to 340, if possible, to allow hunter access to waterfowl habitat areas from 5 a.m. to 5 p.m. on Wednesdays, weekends, and Federal holidays between 15 October and 15 January.

8-05. Power Plan. McNary project will be operated for power within the foregoing pondage and release limitations and in accordance with a working agreement between the Corps of Engineers and BPA, the marketing agency for federally generated power in the Pacific Northwest. Power scheduling for McNary will be accomplished by BPA in coordination with the North Pacific Division Corps of Engineers. To implement scheduling and maintain optimum operating conditions, close coordination between the McNary and McNary powerplant operators and the BPA dispatchers will be essential. Routine power operations for Ice Harbor, Lower Monumental, Little Goose, and Lower Granite will be remotely controlled from McNary through the system optimizer controller. Discussion of overall coordinated operation of the Northwest Federal Power System is presented in the Columbia River Basin Master Water Control Manual dated December 1984.

Load factoring may be accomplished by making use of the 185,000 acre-feet of storage between elevations 335 and 340 when the reservoir inflow is less than powerplant hydraulic capacity and downstream projects can accommodate the extra flow. The discharge capacity of the 14 existing power units is about 232,000 cfs in the range of normal operating head.

Generally, the power units will be operated to provide maximum over-all powerplant efficiency. This will be in the interest of smooth and efficient turbine operation and also will provide more satisfactory conditions for any downstream migrating fingerling fish which pass through the turbines. Paragraph 8-04.c.(2), Project Operations, summarizes criteria for unit priority and operation. All operations will be within the safe limitations of the equipment as set forth in the Operations and Maintenance Manual.

In the event of a transmission system breakup which would leave McNary project the only major generating facility on an isolated segment of the BPA system, a maximum effort will be made to carry the load. Under such conditions, it may be justified on a short-time basis to load the generators above the normal 15 percent overload, and to utilize somewhat more than the normal 5-foot reservoir operating range. If at all possible, at least one generator will be kept in operation throughout an emergency which has isolated or threatens to isolate the project from other power sources. If no other power is available, the spillway gates may be operated with emergency power supplied by a diesel-generator set.

When inflows are forecasted to be increasing above 880,000 cfs and a tailwater elevation of 282, the Project Manager must implement actions to prevent flooding of the powerhouse and appurtenances. Refer to the Flood Emergency Subplans for McNary Lock and Dam, dated October 1982 for details. With a discharge of 1,150,000 cfs into the tailrace, the reservoir elevation can be maintained at 340 but the tailwater will increase to the tailrace deck elevation of 287.

8-06. Navigation Plan. The Columbia-Snake barge channel extends from the head of deep water navigation at Vancouver to the Pasco-Kennewick area on the Columbia River and to Lewiston on the Snake, 465 miles from the Pacific Ocean. The lower Snake River navigation channel (mouth of the Snake River to Lewiston) accounts for 140 miles of the Columbia-Snake barge channel and is an important link in the Columbia-Snake barge channel system because it connects interior agricultural areas with the Columbia River for the transport of major commodities to world market places. This element of the Water Control Plan will discuss reservoir regulation procedures and practices, which pertain to the navigation purposes of (1) barge lockages and (2) slackwater navigation in the reservoir.

a. Barge Lockages. The lock facilities are operable at the full range of normally experienced river flows. However, at 800,000 cfs, the navigation lock will be closed to all navigation. The navigation regulations and procedures are set forth in exhibit 8-1. The lock facilities will be closed periodically for maintenance; however, these closures will be scheduled in advance and public notices will be issued. Water which is passed through the dam by lockages is accounted for and reported . A lockage requires approximately 15 to 30 minutes, varying somewhat with head and other factors.

b. Slackwater Navigation in the Reservoir. The McNary project is designed to operate within the normal water surface levels of 335 to 340. As a result, navigation requirements are fully met under normal multi-purpose project operation. Minor conflicts may arise with regard to special regulation for a particular shipment, use of port facilities, shoaling problems along reservoir reaches, or other special navigation functions on the reservoir or at a downstream location. Special regulations of this type will generally be accommodated by either advance scheduling whereby the system operation can be adjusted, or by imposing a soft constraint for a temporary period on the operation of McNary pool to meet the particular need The RCC will be responsible for the coordination and implementation of special regulations for navigation. Table B-1, exhibit 8-1, shows a list of personnel and companies that should be notified in the event of any unscheduled navigation lock closures or situations which may impede lock usage or navigation in the reservoir.

8-07. Recreation Plan. The Water Control Plan for the McNary project does not specifically provide regulation criteria for recreation because the recreational facilities at McNary are developed to accommodate normal reservoir fluctuation between elevations 340.0 and 335.0. Under special conditions and when clearly not detrimental to other interests, the RCC may consider regulation for recreation interests activities on the reservoir for short periods. Recreation facilities are fully described in the McNary Master Plan for management of natural and manmade resources . This publication was prepared by the Walla Walla District Corps of Engineers and published in 1982. Additional information on recreation facilities may also be obtained by referring to the Walla Walla District, Recreation Facilities Guide, dated March 1987.

8-08. Special Operations. Special reservoir regulation activities, which are not considered normal reservoir regulation activities, will be required from time to time. Such reservoir regulation plans for special activities (i.e., hydroplane races, construction, etc.) would be developed within the normal operating limits and constraints of the project, which are explained in paragraph 8-02., Major Constraints. Requests for special operations that are not within the normal operating criteria of the project will be evaluated and approved or denied by RCC in consideration of real-time or current conditions.

8-09. Public Notices. Public notices will be issued only when there is a pronounced departure from normal operating procedure or an unusual development which will require scheduled special reservoir operations that will be of concern to public activities. Public notices will not be issued for conditions which are of little significance to the public or navigation interests. Public notices pertaining to McNary project will be issued by the Operations Division of the Walla Walla District. Public information releases to newspapers, radio stations, and television stations will normally be issued by the Public Affairs Officer of the Walla Walla District and/or McNary Project Manager.

8-10 Standing Instructions. The following is a list of standing instructions for reservoir regulation under normal conditions, emergency conditions, and communication outage.

a. Normal Conditions. McNary will be regulated according to criteria and procedures in this Water Control Manual. The following tabulation lists key paragraphs in this Water Control Plan Section for normal operation.

Paragraph .... Page

8-02 Major Constraints
a. Lake Elevation Limits 8-1
b. Minimum Discharge 8-1
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8-04 Fish and Wildlife Plan
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8-05 Power Plan 8-22

8-06 Navigation Plan
a. Barge Lockages *** 8-23
b. Slackwater Navigation in the Reservoir 8-23

*** Instructions and procedures for lockage of vessels are contained in exhibit 8-1, Navigation Regulations Table B-1, exhibit 8-1, shows a list of personnel and companies to notify in the event of unscheduled navigation matters.

b Preparation of Gates for Winter Operation.

(1) Background. Some gates have been latched together for a long period of time and corrosion of the latching device that locks the two gate leaves together has caused seizure of the locking mechanism to various degrees. Under severe freezing

conditions, it is necessary to ensure that gates provided with gate slot heaters on the upper leaves can be opened to pass split-leaf flow.

(2) Preparatory Action. Gates with slot heaters should be prepared for split-leaf (flow between leaves) operation. It will be necessary to free up latching mechanism on spillway gates equipped with slot heaters and test upper-leaf operation prior to the December to February winter flood period to ensure that the top and bottom leaves can be separated. The operation to separate the gate leaves requires lowering someone (by crane or other means to the gate top, 18 feet below the spill-way deck) where the latching mechanism is located During icing conditions this operation may be impractical because of ice build-up on the mechanism, corrosion, and safety considerations. Therefore, latching devices for gates with slot heaters should be released for split-leaf mode operation during the December to February winter flood period.

c. Emergency Conditions. Emergency conditions are unforeseen and cannot be provided for in this Water Control Manual. Should an emergency occur or appear to be developing, the Project Manager or his representative should contact his immediate supervisor. If the nature of the emergency requires immediate action to prevent loss of life and property, the Project Manager will take the necessary action and report all circumstances to the Walla Walla District Chief, Operations Division, as soon as possible. If the emergency affects power or downstream water conditions, the RCC will be notified immediately

Note: Refer to pages iv to v (pink sheets in the front of this manual) for telephone numbers and guidelines on emergency conditions.

d. Communications Outage. In the event of normal telephone and CBT systems outage, communication between the project and the RCC will be established via the Walla Walla District radio system.

IX - EFFECT OF WATER CONTROL PLAN

9-01. General. The various water control plans are intended as a means of outlining project regulation and/or management practices that maximize benefits derived from project functions. These water control plans provide for navigation, power generation, irrigation, flood control, recreation, and fish and wildlife. Overall benefits and effects from the project include:

a. Enhancement of economic productivity in the region with slack water navigation up the Columbia River and Snake River to Lewiston, Idaho.

b. Production of hydroelectric power.

c. Water oriented recreational opportunities for the public.

d. Impact upon fish and wildlife habitat by altering 62 miles of free-flowing river and associated canyon bottom lands.

e. Flood protection for the cities of Kennewick, Pasco, and Richland during extreme flood conditions.

f. Coordinated plan to minimize flood damage on lower Columbia River.

The benefits and effects of the various water control plans will be discussed in the following paragraphs.

9-02. Flood Control. Flood control, though not an authorized project function, is an important consideration in the Water Control Plan for McNary. Under the Flood Control Plan, regulation of the project is effective in maintaining existing freeboards that range from 6 to 13 feet for the McNary levees at SPF flow of 810,000 cfs at McNary Dam on the Columbia River. As a result, the cities of Kennewick, Pasco, and Richland are protected from flood damage.

Since McNary is operated as a run-of-river project, usable reservoir storage is small compared to the volume of flow in the river, and as a result, river flow passing the dam would not be significantly reduced by reservoir routing. However, the cumulative effect of drawing down McNary and downstream reservoirs in advance of flood peaks would have some moderating effect on the flood peak at downstream locations on the Columbia River.

During an extreme flood, the forebay at McNary will be maintained as close to elevation 340 as possible but the spillway gates will be opened to accommodate higher discharges and maintain the design freeboard, if possible, at the various levees around the Tri-Cities area.

9.03. Recreation. The McNary project has greatly improved the recreation opportunities for the major population centers of Kennewick, Pasco, and Richland, nearby Pendleton and Walla Walla areas. The relatively stable pool levels provided by operation between elevations 335 and 340 for primary project functions of power generation and navigation provide excellent conditions for reservoir recreation activities. Project recreation activities include boating, water skiing, swimming, picnicking, and camping. These recreation opportunities enhance the quality of life for people in the region.

9-04. Fish and Wildlife.

a. Fish Passage. The two major fish migration events in the life cycle of anadromous fish include the downstream migration to the ocean and the upstream migration to spawning grounds. McNary Dam is a major physical barrier that anadromous fish must move past when migrating both up and down the Columbia River. As a result, fish facilities were provided at the project to aid migrating adults and juveniles. Two fish ladders located on both the Oregon (South) and Washington (North) shores at the project are effective in providing passage past the dam for upstream migrating fish. A bypass system is also effective in moving juveniles rapidly through the dam during their downstream migration. The juveniles that do not go through the bypass system will either pass over the spillway if water is being spilled or be drawn through the turbines. Juvenile passage through the turbines is hazardous because juveniles are subjected to extreme pressure differences and impacts in the turbines that can easily result in injury or death. A mechanical device called a submersible traveling screen is used to divert fish out of turbine intakes and into gatewells from where they continue their passage through the bypass system. Physical transport by truck or barge is another method of helping juveniles downstream and improving survival rates. Juveniles' survival rates will increase with improvements to the fish bypass/collection facilities and physical trans-port methods.

b. Flow Augmentation for Downstream Migrants. In addition to fish passage facilities and physical transport, well-timed and increased flows through the Snake River and Columbia River dams and reservoirs will also contribute to greater survival rates for outmigrating fish. The effects of the slow-moving current through the McNary Reservoir on juveniles include increased migration time, increased stress, favorable conditions for predators, and warmer water conditions. Flow augmentation from upstream projects will help to shape the flow pattern on the Columbia River during the critical migration period (15 April to 15 June) in order to move juveniles quickly and safely downstream.

Implementation of the Water Budget for flow augmentation on the Snake or Columbia Rivers may require McNary to spill water in excess of the rated hydraulic capacity of the powerplant (approximately 232,000 cfs). Flow augmentation may occur at Lower Granite or Priest Rapids, and as McNary Lock and Dam is a run-of-river project, these flows will be passed through the McNary Reservoir and Dam. If problems develop with the juvenile bypass and collection facilities, spill specifically separate from the Water Budget flow may be required to aid juvenile passage at the dam. The Water

Budget's objective is to provide the requested flow in the Columbia River during the critical downstream period. The Water Budget is not used to provide water for intentional spill at McNary Dam. The volume of water required for Water Budget flow will be drawn from storage reservoirs on the Snake or Columbia Rivers, if available. The effect on upstream dams is a reduction of the FELCC, which will also affect the FELCC of the entire Federal Columbia River Power System.

9-05. Water Quality. The water quality in McNary Reservoir is influenced mainly by the following factors:

a. The water quality, including nutrient and sediment inputs, of the inflows from the Columbia and its major tributaries of the Snake, Walla Walla, and Yakima Rivers.

b. The ability of the cities of Kennewick, Richland, and Pasco to meet state and Federal effluent treatment standards.

The regulation of McNary Reservoir to provide optimum conditions for primary project functions of power generation, and navigation, while providing the best possible conditions for other project purposes of fish and wildlife, irrigation, and recreation, has not resulted in prolonged adverse effects on the water quality of the reservoir to date.

The nutrient rich character of McNary Reservoir is a result of agricultural and urban activities both adjacent to and upstream of the reservoir. For portions of the year, principally late fall and winter, algal nutrient values in the upper reservoir are below or near those nutrient values considered minimum for algal blooms. As the Columbia gains the inputs from tributary nutrient sources and passes through the population area of the Tri-Cities, sufficient algal nutrient is present in the river to contribute to noxious algal blooms of blue-green algae; however, noxious blooms have not yet been observed. Turbidity does occur during spring high flows and are largely transitory in nature and extremely variable in intensity and duration. The effects of intermittent high levels of dissolved gas, due to spill, have been minimal to the juvenile and adults salmonids during the 1985-86 fish passage seasons.

Water contact activities such as water skiing, swimming, and fishing have not been seriously affected as a result of the water quality in the reservoir. The water quality of McNary Reservoir will improve as the nutrient levels in river inflows are reduced by improved waste treatment facilities for municipal and industrial sources and by controlling the animal waste sources upstream of the dam.

9-06. Hydroelectric Power. Power produced by McNary goes into the Northwest Power Pool where it is used to meet system needs. This power generation helps to meet the power needs of the Pacific Northwest region at a cost considerably lower than would be possible using fossil fuels. The addition of McNary to the system also produces more dependability in the system, since it can help meet power demands in the event that the generating ability of another facility is impaired.

9-07. Navigation. The regulation of McNary for navigation has a consider-able effect on the economy of the Tri-Cities area. Prior to the building of the lower Snake River navigation system, it was possible though difficult to navigate the river as far up as Lewiston. In the last few years before the system was finished, water traffic had almost ceased, since it was more economical to ship commodities by railway or truck. However, completion of the system made it possible to easily and economically transport commodities to and from interior areas of the basin by water. Major shipping facilities in the Tri-Cities area handle bulk commodities such as grain and fertilizer, which are considerably cheaper to transport by barge.

9-08. Flood Frequencies.

a. Snake River at Lower Granite. Plate 9-1 shows frequency curves for natural peak discharges and regulated peak discharges for the Snake River at Lower Granite Dam. These frequencies were computed by CENPD-EN-WM-HES in May 1978. The frequency curve for natural discharges is based on the station record form 1894-1975 (81 years) which is adjusted for irrigation depletion and storage and extended by correlation with 1858-1975 (117 years) Columbia River at the Dalles station record. The frequency curve for regulated discharge is based on the 1975 level of storage development and 1985 level of irrigation depletions. Regulated discharges are from regulation studies for 1894, 1929 through 1958, and in addition the high runoff years of 1972 and 1974. Data from Plate 9-1, Snake River at Lower Granite Frequency curves, are summarized in the following tabulation:

Maximum Annual Peak Daily Discharge Frequencies

Exceedence Probability (Percent)	Average Recurrence Interval (years)	Unregulated Discharge (cfs)	Regulated Discharge (cfs)
Standard Project Flood		575,000	420,000
1	100	426,000	319,000
2	50	403,000	300,000
5	20	367,000	270,000
10	10	334,000	244,000
20	5	298,000	214,000
50	2	231,000	163,000

b. Columbia River below Priest Rapids Dam. Plate 9-2 shows frequency curves for natural and regulated peak discharges for the Columbia River below Priest Rapids - USGS STA NO. 12472800 - drainage area = 96,000 square miles. These curves were computed by CENPD-EN-WM-HES in May, 1978. Curve 1 is for unregulated flows, except for natural lake storage, prior to the construction of storage projects on the Columbia River. Curve 2 is for regulated discharge and is based on the 1975 level of storage development and 1985 level of irrigation depletions. Data from Plate 9-2, Columbia River at Trinidad, frequency curves are summarized in the following:

Maximum Annual Peak Daily Discharge Frequencies

Exceedence Probability (Percent)	Average Recurrence Interval (Years)	Unregulated Discharge (cfs)	Regulated Discharge (cfs)
Standard Project Flood		960,000	540,000
1	100	680,000	440,000
2	50	650,000	415,000
5	20	590,000	360,000
10	10	560,000	325,000
20	5	510,000	285,000
50	2	415,000	215,000

Note: Columbia River below Priest Rapids Dam, Washington (Columbia river mile 394.5) period of record, January 1917 to present. January 1917 to September 1930, at site 3.4 miles downstream, published as "at Vernita". October 1930 to July 27, 1959, at site 46.5 miles upstream, published as "at Trinidad."

c. Columbia River at The Dalles. Plate 9-3 shows frequency curves for natural and regulated peak discharges for the Columbia River at The Dalles. These curves were computed by CENPD-EN-WM-HES in June 1987. The frequency curve for natural discharges is based on the 1858-1985 (127) years) period. Observed flows have been adjusted for irrigation depletion and storage. The frequency curve for regulated discharges is based on 1985 level of storage development and 1985 level of irrigation depletions. Regulated discharges are from regulation studies for 1894, 1929 through 1958, and in addition the high runoff years of 1972 and 1974. Data from Plate 9-3, Columbia River at the Dalles, frequency curves are summarized in the following:

Maximum Annual Peak Daily Discharge Frequencies

Exceedence Probability (Percent)	Average Recurrence Interval (years)	Unregulated Discharge (cfs)	Regulated Discharge (cfs)
Standard Project Flood		1,550,000	840,000
1	100	1,060,000	680,000
2	50	993,000	635,000
5	20	890,000	567,000
10	10	813,000	515,000
20	5	732,000	461,000
50	2	580,000	360,000

MCNARY LOCK AND DAM - WATER CONTROL MANUAL

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TABLE 3-1

MEAN UNIT PERFORMANCE TABULATION

DISCHARGE IN CFS

POWER OUTPUT (MW)	Gross Head in Feet: 62	63	64	65	66	67	68	69	70	71	72
20	5656	5592	5531								
21	5819	5752	5687	5627	5568	5511					
22	5983	5912	5843	5780	5719	5658	5600	5549	5500		
23	6147	6072	5999	5934	5869	5804	5742	5690	5638	5588	5540
24	6311	6232	6155	6087	6020	5951	5884	5830	5777	5723	5672
25	6475	6392	6311	6241	6171	6098	6027	5970	5915	5859	5804
26	6638	6552	6467	6394	6322	6245	6169	6111	6053	5994	5936
27	6802	6712	6623	6548	6472	6391	6311	6251	6192	6129	6067
28	6966	6872	6779	6701	6623	6538	6454	6392	6330	6264	6199
29	7130	7032	6935	6854	6774	6685	6596	6532	6469	6400	6331
30	7292	7191	7091	7007	6924	6832	6740	6673	6607	6535	6463
31	7452	7349	7247	7159	7072	6981	6890	6818	6746	6668	6592
32	7611	7507	7402	7311	7220	7130	7041	6963	6885	6802	6719
33	7771	7664	7558	7462	7367	7280	7192	7108	7024	6935	6847
34	7931	7822	7713	7614	7515	7429	7343	7252	7162	7069	6975
35	8090	7980	7870	7767	7665	7574	7484	7392	7299	7204	7109
36	8249	8138	8027	7920	7814	7718	7623	7529	7435	7341	7247
37	8407	8296	8184	8074	7963	7863	7762	7667	7571	7478	7385
38	8566	8454	8341	8227	8113	8007	7901	7804	7708	7615	7522
39	8745	8624	8505	8386	8268	8156	8045	7945	7845	7752	7660
40	8936	8805	8675	8555	8434	8320	8206	8101	7996	7897	7798
41	9132	8991	8850	8724	8600	8483	8366	8257	8148	8041	7935
42	9339	9194	9050	8916	8783	8657	8532	8417	8302	8190	8079
43	9560	9407	9255	9116	8977	8840	8704	8583	8462	8346	8230
44	9785	9624	9465	9318	9172	9029	8886	8758	8631	8509	8389
45	10016	9846	9678	9521	9366	9221	9077	8946	8816	8687	8559
46	10256	10077	9901	9740	9580	9428	9277	9136	8998	8866	8733
47	10510	10318	10130	9961	9795	9637	9481	9327	9177	9045	8913
48	10766	10563	10363	10186	10010	9849	9688	9530	9373	9237	9101
49	11021	10808	10597	10410	10225	10060	9896	9733	9571	9432	9294
50	11277	11060	10843	10645	10449	10279	10110	9941	9773	9629	9486
51	11533	11312	11092	10884	10679	10507	10335	10160	9986	9835	9685
52	11788	11563	11340	11123	10908	10734	10560	10379	10199	10041	9885
53	12040	11810	11581	11360	11140	10961	10783	10597	10412	10247	10084
54	12293	12056	11822	11598	11374	11187	11002	10813	10624	10456	10288
55	12545	12303	12062	11835	11608	11414	11221	11028	10836	10664	10493
56	12797	12549	12303	12072	11842	11640	11440	11244	11048	10872	10697
57	13049	12795	12544	12309	12076	11866	11659	11459	11261	11081	10902
58	13304	13044	12786	12547	12310	12093	11878	11675	11473	11289	11106
59	13560	13294	13030	12788	12547	12323	12101	11893	11686	11498	11311
60	13816	13544	13275	13029	12784	12554	12326	12113	11902	11708	11516
61	14072	13794	13519	13270	13021	12785	12551	12334	12117	11919	11721
62	14327	14045	13764	13511	13259	13016	12776	12554	12333	12129	11926
63	14583	14295	14009	13751	13496	13247	13001	12774	12549	12339	12131
64	14839	14545	14253	13992	13733	13478	13226	12995	12764	12550	12336
65	15101	14798	14499	14233	13970	13710	13451	13215	12980	12760	12541
66	15364	15054	14747	14474	14204	13940	13678	13437	13197	12971	12747
67	15628	15309	14994	14715	14439	14171	13905	13661	13418	13187	12958
68	15921	15575	15244	14956	14673	14402	14132	13885	13639	13403	13169
69	16219	15852	15498	15202	14910	14632	14358	14108	13860	13619	13380
70	16549	16142	15754	15448	15148	14862	14579	14327	14076	13831	13589
71		16454	16039	15711	15393	15096	14802	14545	14291	14043	13796
72		16778	16338	15979	15643	15340	15041	14770	14505	14254	14004
73			16667	16282	15914	15594	15282	14996	14717	14466	14214
74			16995	16585	16192	15858	15531	15232	14938	14680	14424
75				16898	16483	16126	15781	15467	15161	14896	14633
76					16781	16404	16040	15712	15390	15113	14842
77					17111	16705	16311	15958	15623	15335	15051
78						17016	16610	16234	15872	15565	15265
79							16907	16514	16132	15809	15495
80							17226	16803	16396	16056	15725
81								17109	16681	16320	15967
82									16966	16589	16220
83									17281	16871	16478
84										17161	16739
85										17484	17044

DISCHARGE IN CFS

POWER OUTPUT (MW)	Gross Head in Feet: 73	74	75	76	77	78	79	80	81	82	83
20											
21											
22											
23											
24	5622	5575	5525								
25	5751	5701	5648	5597	5554	5512					
26	5880	5826	5772	5719	5672	5627	5586	5545	5508		
27	6009	5951	5896	5841	5791	5743	5700	5658	5620	5582	5535
28	6138	6077	6019	5962	5910	5859	5815	5771	5731	5692	5643
29	6267	6202	6143	6084	6029	5975	5929	5883	5842	5802	5751
30	6395	6327	6266	6206	6148	6091	6044	5996	5954	5912	5859
31	6523	6455	6392	6329	6268	6207	6157	6107	6063	6020	5966
32	6651	6583	6518	6453	6388	6323	6270	6216	6171	6127	6072
33	6779	6711	6644	6577	6508	6440	6382	6325	6279	6233	6178
34	6907	6839	6770	6701	6628	6556	6495	6434	6387	6340	6284
35	7037	6965	6893	6822	6747	6673	6609	6545	6497	6449	6391
36	7169	7091	7015	6940	6866	6791	6725	6659	6610	6561	6501
37	7300	7216	7138	7059	6984	6909	6841	6773	6722	6672	6611
38	7432	7342	7260	7178	7102	7027	6957	6887	6835	6784	6721
39	7563	7467	7382	7296	7220	7145	7072	7000	6948	6895	6832
40	7697	7596	7506	7417	7340	7263	7187	7110	7058	7005	6941
41	7830	7725	7631	7537	7460	7383	7300	7219	7166	7113	7049
42	7968	7858	7761	7664	7581	7498	7416	7333	7276	7220	7157
43	8114	7998	7899	7801	7704	7607	7537	7467	7394	7322	7258
44	8268	8149	8045	7942	7843	7745	7660	7577	7509	7440	7376
45	8437	8316	8207	8098	7993	7890	7798	7707	7632	7559	7493
46	8607	8483	8371	8258	8148	8038	7944	7851	7763	7677	7609
47	8779	8648	8536	8425	8310	8196	8097	7998	7906	7815	7738
48	8964	8826	8711	8596	8477	8358	8252	8147	8053	7960	7873
49	9156	9019	8896	8774	8653	8531	8423	8315	8214	8114	8021
50	9349	9211	9081	8952	8828	8705	8593	8482	8375	8269	8169
51	9542	9400	9267	9134	9008	8881	8766	8651	8538	8425	8319
52	9735	9587	9452	9318	9190	9062	8942	8822	8707	8593	8481
53	9928	9774	9638	9502	9372	9243	9118	8993	8877	8761	8642
54	10127	9967	9826	9687	9554	9422	9293	9164	9046	8928	8804
55	10327	10163	10017	9872	9735	9598	9467	9336	9215	9095	8971
56	10527	10359	10208	10058	9916	9774	9640	9507	9384	9261	9137
57	10728	10555	10399	10244	10097	9951	9814	9679	9553	9427	9303
58	10928	10751	10589	10429	10278	10127	9988	9850	9722	9594	9470
59	11128	10946	10780	10615	10459	10303	10162	10021	9891	9760	9636
60	11330	11146	10975	10804	10644	10484	10338	10194	10060	9927	9802
61	11533	11345	11170	10996	10832	10669	10520	10371	10232	10094	9967
62	11735	11545	11366	11187	11021	10855	10701	10548	10405	10262	10131
63	11938	11745	11561	11379	11210	11041	10882	10725	10577	10430	10295
64	12140	11945	11757	11570	11398	11227	11064	10901	10749	10597	10460
65	12342	12144	11953	11762	11587	11413	11245	11078	10921	10765	10624
66	12545	12344	12148	11953	11776	11599	11426	11255	11093	10932	10788
67	12753	12548	12347	12147	11966	11785	11608	11433	11266	11100	10953
68	12960	12753	12547	12343	12157	11972	11793	11614	11446	11277	11124
69	13168	12957	12747	12538	12348	12159	11977	11795	11625	11455	11296
70	13373	13158	12946	12733	12539	12346	12161	11977	11804	11632	11468
71	13574	13354	13141	12927	12730	12533	12345	12157	11983	11809	11641
72	13776	13550	13336	13121	12920	12720	12529	12338	12161	11984	11813
73	13983	13752	13532	13314	13110	12908	12712	12518	12338	12159	11986
74	14189	13955	13729	13505	13300	13095	12895	12696	12515	12334	12158
75	14397	14162	13932	13703	13492	13284	13079	12875	12692	12509	12331
76	14605	14369	14134	13901	13686	13472	13265	13059	12875	12691	12508
77	14811	14573	14334	14097	13879	13662	13452	13243	13058	12873	12686
78	15018	14776	14533	14292	14073	13855	13640	13426	13235	13044	12857
79	15230	14972	14727	14483	14263	14044	13828	13610	13411	13214	13026
80	15448	15176	14924	14674	14446	14220	14008	13794	13594	13394	13199
81	15672	15385	15129	14876	14642	14410	14191	13974	13773	13572	13374
82	15906	15600	15340	15081	14838	14598	14376	14154	13948	13743	13548
83	16143	15816	15551	15287	15034	14784	14559	14335	14127	13920	13722
84	16390	16049	15772	15498	15235	14973	14744	14516	14306	14097	13896
85	16656	16287	15995	15712	15440	15171	14937	14705	14486	14270	14068

DISCHARGE IN CFS

POWER OUTPUT (MW)	Gross Head in Feet: 84	85	86	87	88	89	90	91	92	POWER OUTPUT (MW)
20										20
21										21
22										22
23										23
24										24
25										25
26										26
27										27
28	5595	5564	5535							28
29	5702	5667	5634	5597	5560	5530	5500			29
30	5808	5770	5733	5697	5660	5628	5597	5571	5545	30
31	5913	5874	5834	5798	5761	5728	5694	5666	5639	31
32	6017	5977	5937	5901	5864	5829	5793	5764	5735	32
33	6122	6081	6040	6004	5967	5930	5892	5862	5832	33
34	6227	6185	6143	6106	6070	6030	5991	5959	5928	34
35	6333	6289	6246	6209	6172	6131	6090	6058	6025	35
36	6441	6396	6350	6312	6274	6233	6192	6158	6125	36
37	6550	6502	6454	6415	6376	6335	6294	6259	6224	37
38	6659	6609	6559	6518	6477	6436	6395	6359	6324	38
39	6768	6715	6663	6621	6579	6538	6497	6460	6423	39
40	6877	6823	6770	6725	6681	6640	6599	6559	6520	40
41	6985	6933	6880	6832	6783	6742	6700	6655	6610	41
42	7093	7042	6990	6938	6885	6843	6802	6751	6700	42
43	7195	7142	7090	7038	6985	6939	6893	6861	6828	43
44	7311	7255	7200	7147	7094	7044	6994	6957	6921	44
45	7427	7366	7305	7253	7200	7149	7098	7050	7002	45
46	7540	7470	7400	7348	7295	7247	7199	7148	7097	46
47	7662	7588	7514	7456	7398	7348	7299	7245	7191	47
48	7787	7714	7641	7574	7508	7452	7396	7339	7283	48
49	7928	7852	7775	7702	7629	7567	7506	7449	7391	49
50	8070	7991	7911	7831	7752	7686	7621	7564	7507	50
51	8213	8129	8046	7961	7875	7805	7736	7680	7624	51
52	8369	8282	8195	8105	8014	7940	7866	7801	7738	52
53	8525	8435	8345	8251	8157	8079	8002	7926	7851	53
54	8681	8588	8495	8398	8300	8219	8139	8051	7964	54
55	8846	8749	8652	8550	8449	8364	8280	8185	8090	55
56	9013	8912	8811	8706	8602	8513	8424	8329	8235	56
57	9179	9074	8969	8862	8754	8661	8569	8474	8379	57
58	9346	9236	9128	9017	8907	8810	8714	8618	8523	58
59	9512	9399	9287	9173	9059	8959	8859	8763	8667	59
60	9678	9561	9445	9328	9212	9107	9003	8907	8811	60
61	9840	9721	9602	9483	9365	9258	9151	9053	8956	61
62	10001	9880	9759	9638	9517	9410	9302	9203	9104	62
63	10162	10039	9916	9793	9670	9562	9453	9352	9251	63
64	10323	10198	10073	9948	9823	9713	9604	9501	9399	64
65	10484	10356	10229	10102	9976	9865	9755	9650	9546	65
66	10645	10515	10386	10257	10129	10017	9906	9800	9694	66
67	10806	10674	10543	10412	10281	10169	10057	9949	9841	67
68	10972	10834	10698	10566	10434	10320	10207	10097	9988	68
69	11138	10995	10852	10719	10587	10471	10355	10245	10135	69
70	11305	11155	11007	10873	10740	10621	10502	10392	10282	70
71	11473	11317	11161	11027	10892	10771	10650	10539	10429	71
72	11644	11483	11322	11185	11047	10923	10799	10687	10576	72
73	11814	11649	11484	11343	11202	11075	10949	10835	10722	73
74	11984	11817	11650	11503	11358	11228	11099	10984	10869	74
75	12153	11986	11819	11666	11514	11383	11253	11134	11016	75
76	12326	12155	11985	11827	11670	11538	11405	11284	11163	76
77	12499	12324	12150	11987	11826	11691	11557	11437	11317	77
78	12670	12493	12316	12151	11986	11847	11708	11589	11470	78
79	12839	12662	12485	12320	12156	12008	11862	11743	11623	79
80	13006	12829	12652	12487	12323	12169	12015	11896	11777	80
81	13174	12994	12815	12644	12474	12326	12177	12052	11929	81
82	13352	13168	12986	12814	12642	12488	12335	12210	12084	82
83	13525	13340	13156	12983	12811	12652	12493	12367	12242	83
84	13696	13510	13324	13148	12973	12813	12654	12526	12398	84
85	13865	13679	13492	13314	13135	12975	12816	12684	12553	85

TABLE 3-2

McNARY DAM SPILLWAY RATING TABLE
FLOW BETWEEN LEAVES IN 1,000 CFS FOR ONE GATE

POOL EL. M.S.L.	GATE OPENINGS IN FEET ABOVE TOP OF LOWER LEAF - ELEVATION 314.75 M.S.L.																					FREE FLOW CONDITIONS	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Discharge over Lower Leaf	Gate Opening for Free Flow
341.0	1.5	2.9	4.1	5.3	6.3	7.4	8.5	9.5	10.5	11.5	12.4	13.4	14.2	15.1	16.1	17.0	17.9	18.8	19.8	20.7	21.7	22.6	22.08
340.8	1.5	2.9	4.1	5.2	6.3	7.4	8.4	9.4	10.5	11.4	12.4	13.4	14.1	15.0	16.0	16.9	17.7	18.7	19.6	20.5	21.5	22.4	
340.6	1.5	2.8	4.1	5.2	6.3	7.3	8.4	9.4	10.4	11.4	12.3	13.3	14.1	15.0	15.9	16.8	17.6	18.6	19.5	20.4	21.4	22.1	
340.4	1.5	2.8	4.1	5.2	6.3	7.3	8.4	9.3	10.4	11.3	12.2	13.2	14.0	14.9	15.8	16.7	17.5	18.5	19.4	20.3	21.3	21.8	
340.2	1.4	2.8	4.1	5.2	6.2	7.3	8.3	9.3	10.3	11.3	12.2	13.1	13.9	14.8	15.7	16.6	17.4	18.4	19.3	20.2	21.2	21.2	
340.0	1.4	2.8	4.0	5.2	6.2	7.2	8.3	9.3	10.3	11.2	12.1	13.1	13.8	14.7	15.6	16.5	17.3	18.3	19.2	20.1	21.0	21.2	21.20
339.8	1.4	2.8	4.0	5.1	6.2	7.2	8.2	9.2	10.2	11.1	12.1	13.0	13.8	14.6	15.5	16.4	17.2	18.2	19.1	20.1	21.0	21.1	
339.6	1.4	2.8	4.0	5.1	6.1	7.2	8.2	9.2	10.2	11.1	12.0	12.9	13.7	14.5	15.4	16.3	17.1	18.1	19.0	20.0		20.8	
339.4	1.4	2.8	4.0	5.1	6.1	7.1	8.2	9.1	10.1	11.0	11.9	12.8	13.6	14.5	15.3	16.2	17.0	18.0	18.9	19.9		20.6	
339.2	1.4	2.8	4.0	5.1	6.1	7.1	8.1	9.1	10.0	11.0	11.9	12.8	13.5	14.4	15.2	16.1	17.0	17.9	18.8	19.8		20.3	
339.0	1.4	2.7	3.9	5.0	6.1	7.1	8.1	9.0	10.0	10.9	11.8	12.7	13.5	14.3	15.1	16.0	16.9	17.8	18.7	19.7		20.1	20.32
338.8	1.4	2.7	3.9	5.0	6.0	7.0	8.0	9.0	9.9	10.9	11.8	12.6	13.4	14.2	15.0	16.0	16.9	17.8	18.7			19.8	
338.6	1.4	2.7	3.9	5.0	6.0	7.0	8.0	9.0	9.9	10.8	11.7	12.6	13.3	14.1	14.9	15.9	16.8	17.7	18.6			19.6	
338.4	1.4	2.7	3.9	5.0	6.0	7.0	8.0	9.0	9.8	10.8	11.6	12.5	13.2	14.1	14.9	15.9	16.7	17.6	18.5			19.4	
338.2	1.4	2.7	3.9	4.9	5.9	6.9	7.9	8.9	9.8	10.7	11.6	12.4	13.2	14.0	14.8	15.8	16.7	17.5	18.4			19.1	
338.0	1.4	2.7	3.9	4.9	5.9	6.9	7.9	8.8	9.7	10.6	11.5	12.3	13.1	13.9	14.7	15.7	16.6	17.5	18.4			18.9	19.44
337.8	1.4	2.7	3.8	4.9	5.9	6.9	7.8	8.8	9.7	10.6	11.4	12.3	13.0	13.8	14.6	15.7	16.5	17.5				18.6	
337.6	1.4	2.7	3.8	4.9	5.9	6.8	7.8	8.7	9.6	10.5	11.4	12.2	12.9	13.8	14.5	15.6	16.4	17.4				18.4	
337.4	1.4	2.7	3.8	4.8	5.8	6.8	7.8	8.7	9.6	10.5	11.3	12.1	12.9	13.7	14.5	15.5	16.3	17.3				18.2	
337.2	1.3	2.6	3.8	4.8	5.8	6.8	7.7	8.6	9.5	10.4	11.2	12.0	12.8	13.6	14.4	15.4	16.2	17.2				17.9	
337.0	1.3	2.6	3.8	4.8	5.8	6.7	7.7	8.6	9.5	10.3	11.2	12.0	12.7	13.5	14.3	15.4	16.2	17.2				17.7	18.56
336.8	1.3	2.6	3.7	4.8	5.7	6.7	7.6	8.5	9.4	10.3	11.1	11.9	12.7	13.5	14.2	15.3	16.2					17.4	
336.6	1.3	2.6	3.7	4.8	5.7	6.7	7.6	8.5	9.4	10.2	11.0	11.8	12.6	13.4	14.2	15.2	16.1					17.2	
336.4	1.3	2.6	3.7	4.7	5.7	6.6	7.5	8.5	9.3	10.2	11.0	11.8	12.5	13.3	14.1	15.1	16.0					17.0	
336.2	1.3	2.6	3.7	4.7	5.6	6.6	7.5	8.4	9.3	10.1	10.9	11.7	12.5	13.3	14.0	15.0	15.9					16.8	
336.0	1.3	2.6	3.7	4.7	5.6	6.6	7.5	8.4	9.2	10.0	10.8	11.6	12.4	13.2	14.0	15.0	15.9					16.5	17.68
335.8	1.3	2.5	3.6	4.7	5.6	6.5	7.4	8.3	9.1	10.0	10.7	11.6	12.3	13.1	14.0	14.9						16.3	
335.6	1.3	2.5	3.6	4.6	5.6	6.5	7.4	8.3	9.1	9.9	10.7	11.5	12.3	13.1	13.9	14.8						16.1	
335.4	1.3	2.5	3.6	4.6	5.5	6.5	7.3	8.2	9.0	9.9	10.6	11.4	12.2	13.0	13.8	14.7						15.8	
335.2	1.3	2.5	3.6	4.6	5.5	6.4	7.3	8.2	9.0	9.8	10.5	11.3	12.1	12.9	13.8	14.6						15.6	
335.0	1.3	2.5	3.6	4.6	5.5	6.4	7.3	8.1	8.9	9.7	10.5	11.3	12.1	12.9	13.7	14.6						15.4	16.80
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21		

Source: McNary Operation and Maintenance Manual, Volume 2 of 7, 1956

TABLE 3-3

McNARY DAM SPILLWAY RATING TABLE

FLOW UNDER LOWER LEAF IN 1,000 C.F.S. FOR ONE GATE

POOL EL. M.S.L.	GATE OPENING IN FEET																																					FREE FLOW	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	Q: 1,000 C.F.S.	Gate Opening
341.0	2.0	4.0	5.7	7.4	9.0	10.7	12.3	14.1	15.7	17.3	18.9	20.6	22.2	23.8	25.3	26.8	28.3	29.9	31.4	33.0	34.4	35.8	37.5	38.9	40.4	41.9	43.4	44.8	46.2	47.8	49.4	51.0	52.7	54.4	56.3	58.4	60.8	64.2	37.7
340.8	2.0	4.0	5.7	7.4	9.0	10.7	12.3	14.0	15.6	17.3	18.8	20.5	22.1	23.7	25.2	26.8	28.3	29.8	31.3	32.9	34.3	35.7	37.4	38.9	40.3	41.8	43.3	44.7	46.2	47.7	49.4	51.0	52.6	54.4	56.3	58.4			
340.6	2.0	4.0	5.7	7.4	9.0	10.6	12.3	14.0	15.6	17.2	18.8	20.4	22.0	23.6	25.2	26.7	28.2	29.7	31.2	32.8	34.2	35.7	37.3	38.8	40.2	41.7	43.2	44.6	46.1	47.6	49.3	50.9	52.5	54.3	56.2	58.4			
340.4	2.0	4.0	5.7	7.3	9.0	10.6	12.3	13.9	15.5	17.2	18.7	20.3	21.9	23.6	25.1	26.6	28.2	29.6	31.2	32.7	34.1	35.6	37.2	38.7	40.2	41.6	43.1	44.5	46.0	47.6	49.2	50.8	52..	54.2	56.1	58.5			
340.2	2.0	4.0	5.6	7.3	9.0	10.6	12.2	13.9	15.5	17.1	18.7	20.3	21.9	23.5	25.1	26.6	28.1	29.6	31.1	32.6	34.0	35.5	37.1	38.6	40.1	41.5	43.0	44.5	45.9	47.5	49.2	50.8	52.3	54.2	56.0	58.5			
340.0	2.0	4.0	5.6	7.3	8.9	10.6	12.2	13.8	15.4	17.0	18.6	20.2	21.8	23.4	25.0	26.5	28.0	29.5	31.0	32.6	34.0	35.4	37.0	38.5	40.0	41.4	42.9	44.4	45.8	47.4	49.1	50.7	52.2	54.1	56.0	58.5		62.2	36.8
339.8	2.0	4.0	5.6	7.3	8.9	10.5	12.2	13.8	15.4	17.0	18.6	20.2	21.8	23.3	24.9	26.4	28.0	29.4	30.9	32.5	33.9	35.3	36.9	38.4	39.9	41.3	42.8	44.3	45.7	47.3	49.0	50.6	52.1	54.0	56.0				
339.6	2.0	4.0	5.6	7.3	8.9	10.5	12.1	13.8	15.4	17.0	18.5	20.1	21.7	23.3	24.9	26.4	27.9	29.4	30.9	32.4	33.8	35.2	36.8	38.3	39.8	41.2	42.7	44.2	45.6	47.2	48.9	50.5	52.0	54.0	56.0				
339.4	2.0	4.0	5.6	7.3	8.9	10.5	12.1	13.7	15.3	16.9	18.5	20.1	21.7	23.2	24.8	26.3	27.8	29.3	30.8	32.3	33.7	35.1	36.7	38.2	39.7	41.1	42.6	44.1	45.6	47.2	48.8	50.4	52.0	53.9	56.0				
339.2	2.0	3.9	5.6	7.3	8.9	10.5	12.1	13.7	15.3	16.9	18.5	20.1	21.6	23.2	24.7	26.3	27.8	29.2	30.7	32.2	33.6	35.0	36.b	38.1	39.6	41.1	42.5	44.0	45.5	47.1	48.7	50.3	51.9	53.8	56 0				
339.0	2.0	3.9	5.6	7.2	8.8	10.4	12.0	13.7	15.3	16.9	18.4	20.0	21.6	23.1	24.7	26.2	27.7	29.2	30.6	32.1	33.6	35.0	36.6	38.1	39.5	41.0	42.4	43.9	45.4	47.0	48.6	50.2	51.9	53.8	56.0			60.2	35.9
338.8	2.0	3.9	5.6	7.2	8.8	10.4	12.0	13.6	15.2	16.8	18.4	20.0	21.5	23.1	24.6	26.1	27.6	29.1	30.6	32.0	33.5	34.9	36.5	38.0	39.4	40.9	42.3	43.9	45.3	46.9	48.5	50.1	51.8	53.7	56.4				
338.6	2.0	3.9	5.6	7.2	8.8	10.4	12.0	13.6	15.2	16.8	18.3	19.9	21.5	23.0	24.6	26.1	27.6	29.0	30.5	32.0	33.4	34.8	36.4	37.9	39.3	40.8	42.2	43.8	45.2	46.9	48.4	50.0	51.7	53.6	56.8				
338.4	2.0	3.9	5.6	7.2	8.8	10.4	12.0	13.6	15.1	16.7	18.3	19.9	21.4	23.0	24.5	26.0	27.5	29.0	30.4	31.9	33.3	34.7	36.3	37.8	39.2	40.7	42.2	43.7	45.1	46.8	48.3	49.8	51.6	53.5	56.2				
338.2	2.0	3.9	5.5	7.2	8.8	10.4	11.9	13.5	15.1	16.7	18.2	19.8	21.4	22.9	24.4	25.9	27.5	28.9	30.3	31.8	33.2	34.6	36.2	37.7	39.2	40.6	42.1	43.6	45.1	46.7	48.2	49.7	51.5	53.4	56.6				
338.0	2.0	3.9	5.5	7.2	8.7	10.3	11.9	13.5	15.1	16.7	18.2	19.8	21.3	22.8	24.4	25.9	27.4	28.8	30.2	31.7	33.2	34.5	36.1	37.6	39.1	40.5	42.0	43.5	45.0	46.6	48.1	49.6	51.4	53.4				58.2	35.0
337.8	2.0	3.9	5.5	7.1	8.7	10.3	11.9	13.5	15.0	16.6	18.2	19.7	21.3	22.8	24.3	25.8	27.3	28.8	30.2	31.6	33.1	34.4	36.0	37.5	39.0	40.4	41.9	43.4	44.9	46.6	48.0	49.6	51.4	53.9					
337.6	2.0	3.9	5.5	7.1	8.7	10.3	11.9	13.4	15.0	16.6	18.1	19.7	21.2	22.7	24.2	25.8	27.3	28.7	30.1	31.5	33.0	34.4	35.9	37.4	38.9	40.3	41.8	43.4	44.8	46.5	47.9	49.6	51.4	54.5					
337.4	2.0	3.9	5.5	7.1	8.7	10.3	11.8	13.4	15.0	16.5	18.1	19.6	21.2	22.7	24.2	25.7	27.2	28.6	30.0	31.4	32.9	34.3	35.8	37.3	38.8	40.2	41.7	43.3	44.8	46.4	47.8	49.5	51.4	55.0					
337.2	2.0	3.9	5.5	7.1	8.7	10.2	11.8	13.4	14.9	16.5	18.0	19.6	21.1	22.6	24.1	25.6	27.1	28.5	29.9	31.3	32.8	34.2	35.8	37.2	38.7	40.1	41.6	43.2	44.7	46.3	47.8	49.5	51.4	55.6					
337.0	2.0	3.8	5.5	7.1	8.6	10.2	11.8	13.3	14.9	16.5	18.0	19.5	21.1	22.6	24.1	25.6	27.1	28.5	29.9	31.3	32.8	34.1	35.7	37.2	38.6	40.1	41.5	43.1	44.6	46.3	47.8	49.5	51 4					56.2	34.0
336.8	2.0	3.8	5.5	7.1	8.6	10.2	11.7	13.3	14.9	16.4	18.0	19.5	21.0	22.5	24.0	25.5	27.0	28.4	29.8	31.2	32.7	34.0	35.6	37.1	38.5	40.0	41.4	43.0	44.5	46.2	47.7	49.5	51.7						
336.6	2.0	3.8	5.4	7.0	8.6	10.2	11.7	13.3	14.8	16.4	17.9	19.4	21.0	22.4	23.9	25.4	27.0	28.3	29.7	31.1	32.6	33.9	35.5	37.0	38.4	39.9	41.3	42.9	44.4	46.1	47.7	49.5	52.0						
336.4	2.0	3.8	5.4	7.0	8.6	10.1	11.7	13.2	14.8	16.3	17.9	19.4	20.9	22.4	23.9	25.4	26.9	28.3	29.6	31.0	32.5	33.8	35.4	36.9	38.3	39.8	41.2	42.8	44.4	46.0	4/.7	49.6	52.3						
336.2	2.0	3.8	5.4	7.0	8.6	10.1	11.7	13.2	14.7	16.3	17.8	19.3	20.8	22.3	23.8	25.3	26.8	28.2	29.6	30.9	32.4	33.8	35.3	36.8	38.2	39.7	41.1	42.8	44.3	46.0	47.6	49.6	52.6						
336.0	2.0	3.8	5.4	7.0	8.5	10.1	11.6	13.2	14.7	16.3	17.8	19.3	20.8	22.3	23.8	25.2	26.8	28.1	29.5	30.8	32.3	33.7	35.2	36.7	38.1	39.6	41.0	42.7	44.2	45.9	47.6	49.6	53.0					54.2	33.1
335.8	1.9	3.8	5.4	7.0	8.5	10.1	11.6	13.1	14.7	16.2	17.7	19.2	20.7	22.2	23.7	25.2	26.7	28.0	29.4	30.8	32.2	33.6	35.1	36.6	38.0	39.5	40.9	42.6	44.1	45.8	47.6	49.8							
335.6	1.9	3.8	5.4	7.0	8.5	10.1	11.6	13.1	14.6	16.2	17.7	19.2	20.7	22.2	23.6	25.1	26.6	28.0	29.3	30.7	32.2	33.5	35.0	36.5	37.9	39.4	40.9	42.5	44.0	45.8	47.6	50.0							
335.4	1.9	3.8	5.4	6.9	8.5	10.0	11.5	13.1	14.6	16.1	17.6	19.1	20.6	22.1	23.6	25.1	26.6	27.9	29.2	30.6	32.1	33.4	34.9	36.4	37.8	39.3	40.8	42.4	44.0	45.7	47.5	50.2							
335.2	1.9	3.8	5.4	6.9	8.5	10.0	11.5	13.0	14.6	16.1	17.6	19.1	20.6	22.0	23.5	25.0	26.5	27.8	29.2	30.5	32.0	33.3	34.8	36.3	37.8	39.2	40.7	42.4	43.9	45.7	47.5	50.4							
335.0	1.9	3.8	5.3	6.9	8.4	10.0	11.5	13.0	14.5	16.1	17.6	19.0	20.5	22.0	23.4	24.9	26.5	27.7	29.1	30.4	31.9	33.2	34.7	36.2	37.7	39.1	40.6	42.3	43.8	45.6	47.4	50.7						52.2	32.2
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37		

Note: Flows to right of the heavy line are not considered reliable.

Source: McNary Operation and Maintenance Manual, Volume 2 of 7, 1956.

TABLE 4-1

Water Temperature at McNary Dam (Forebay)
In Degrees Centigrade
Station 814 - Washington Side Fishladder, Upstream - MSL 340

WATER YEAR 1983
April 1 to July 28

MONTH	Avg	Min (day)	Max (day)
APR	10.1	7.5 (Apr04)	12.5 (Apr26)
MAY	13.7	11.7 (May01)	17.3 (May29)
JUN	16.5	14.7 (Jun03)	18.5 (Jun28)
JUL	19.0	17.2 (Jul02)	20.9 (Jul18)
YEARLY	14.5	7.5 (Apr04)	20.9 (Jul18)

WATER YEAR 1984
April 17 to July 31

MONTH	Avg	Min (day)	Max (day)
APR	9.8	9.1 (Apr27)	10.4 (Apr29)
MAY	12.1	9.1 (May05)	15.5 (May29)
JUN	15.4	13.5 (Jun01)	18.3 (Jun25)
JUL	19.7	16.7 (Jul01)	23.0 (Jul30)
YEARLY	15.0	9.1 (Apr27)	23.0 (Jul30)

WATER YEAR 1985
April 2 to August 31

MONTH	Avg	Min (day)	Max (day)
APR	8.9	5.9 (Apr02)	12.3 (Apr14)
MAY	12.5	10.1 (May01)	15.4 (May28)
JUN	16.0	14.2 (Jun02)	18.7 (Jun16)
JUL	21.5	17.9 (Jul01)	26.3 (Jul26)
AUG	21.2	19.8 (Aug24)	23.2 (Aug04)
YEARLY	16.0	5.9 (Apr02)	26.3 (Jul26)

WATER YEAR 1986
April 1 to September 24

MONTH	Avg	Min (day)	Max (day)
APR	8.8	7.0 (Apr02)	10.3 (Apr20)
MAY	11.7	9.5 (May01)	15.9 (May31)
JUN	16.5	14.4 (Jun01)	21.2 (Jun23)
JUL	18.8	17.3 (Jul19)	22.6 (Jul31)
AUG	21.3	19.5 (Aug01)	23.0 (Aug19)
SEP	19.8	18.1 (Sep19)	22.1 (Sep05)
YEARLY	16.1	7.0 (Apr02)	23.0 (Aug19)

Note: 1983 information obtained when gage was at 10 ft. depth. All other years data obtained from a 15 ft. depth.

Data Source: CROHMS Database, North Pacific Division, Water Management Branch (Water Quality).

TABLE 4-1

Water Temperature at McNary Dam (Forebay)
In Degrees Centigrade
Station 820 - Oregon Side, Powerhouse 1 - MSL 340

WATER YEAR 1983
May 27 to June 30

YEARLY	Avg	Min (day)	Max (day)
	15.7	12.7 (May27)	19.8 (Jun28)

WATER YEAR 1984
April 17 to July 31

MONTH	Avg	Min (day)	Max (day)
APR	8.9	8.3 (Apr20)	10.6 (Apr29)
MAY	11.1	8.8 (May07)	14.4 (May27)
JUN	14.2	12.4 (Jun01)	17.2 (Jun30)
JUL	18.8	15.4 (Jul01)	22.3 (Jul20)
YEARLY	13.9	8.3 (Apr20)	22.3 (Jul20)

WATER YEAR 1985
April 2 to August 31

MONTH	Avg	Min (day)	Max (day)
APR	9.1	6.0 (Apr02)	13.1 (Apr13)
MAY	12.6	9.7 (May01)	18.4 (May22)
JUN	16.7	13.8 (Jun03)	21.0 (Jun22)
JUL	23.4	17.6 (Jul01)	30.4 (Jul27)
AUG	22.6	20.0 (Aug21)	29.0 (Aug24)
YEARLY	17.0	6.0 (Apr02)	30.4 (Jul27)

WATER YEAR 1986
April 1 to September 4

MONTH	Avg	Min (day)	Max (day)
APR	8.7	6.7 (Apr03)	19.7 (Apr21)
MAY	11.9	9.6 (May01)	18.7 (May27)
JUN	17.0	14.0 (Jun01)	22.0 (Jun22)
JUL	19.6	17.3 (Jul20)	23.3 (Jul21)
AUG	22.5	19.8 (Aug02)	24.7 (Aug15)
SEP	22.6	21.5 (Sep03)	23.8 (Sep04)
YEARLY	16.1	6.7 (Apr03)	24.7 (Aug15)

Note: 1983 information obtained when gage was at 10 ft. depth. All other years data obtained from a 15 ft. depth.

Data Source: CROHMS Database, North Pacific Division, Water Management Branch (Water Quality).

TABLE 4-2

Mean Daily Spill at McNary Dam
In 1,000 Cfs

WATER YEAR 1983

MONTH	Avg	# of: Days	Min (day)	Max (day)
OCT	0.0	0	-	-
NOV	0.0	0	-	-
DEC	0.0	0	-	-
JAN	77.8	3	2.9 (Jan12)	122.0 (Jan14)
FEB	181.3	12	2.7 (Feb05)	267.7 (Feb23)
MAR	204.4	31	111.0 (Mar26)	271.5 (Mar21)
APR	97.6	30	25.5 (Apr09)	179.7 (Apr27)
MAY	134.1	31	48.5 (May17)	207.8 (May31)
JUN	110.7	23	4.4 (Jun23)	209.8 (Jun02)
JUL	16.1	3	3.1 (Jul19)	39.1 (Jul17)
AUG	0.0	0	-	-
SEP	0.0	0	-	-
OCT to SEP	138.5	133	2.7 (Jan05)	271.5 (Mar21)
APR to SEP	111.3	87	4.4 (Jun23)	209.8 (Jun02)

WATER YEAR 1984

MONTH	Avg	# of: Days	Min (day)	Max (day)
OCT	0.0	0	-	-
NOV	0.0	0	-	-
DEC	0.0	0	-	-
JAN	0.0	0	-	-
FEB	11.5	1	11.5 (Feb10)	11.5 (Feb10)
MAR	27.7	18	6.5 (Mar08)	57.2 (Mar23)
APR	84.8	28	8.5 (Apr01)	150.8 (Apr23)
MAY	121.8	31	60.9 (May05)	230.7 (May31)
JUN	160.1	30	118.6 (Jun02)	210.3 (Jun18)
JUL	61.7	20	0.3 (Jul15)	143.4 (Jul03)
AUG	0.0	0	-	-
SEP	0.0	0	-	-
OCT to SEP	99.2	128	0.3 (Jul15)	230.7 (May31)
APR to OCT	111.8	109	0.3 (Jul15)	230.7 (May31)

Data Source: Corps of Engineers, Walla Walla District, Hydrology Branch.

TABLE 4-2

Mean Daily Spill at McNary Dam
In 1,000 Cfs

WATER YEAR 1985

MONTH	Avg	Days # of:	Min (day)	Max (day)
OCT	0.0	0	-	-
NOV	25.0	5	6.4 (Nov21)	38.1 (Nov17)
DEC	0.0	0	-	-
JAN	25.2	10	5.1 (Jan25)	42.7 (Jan09)
FEB	10.3	4	1.5 (Feb06)	20.3 (Feb05)
MAR	0.0	0	-	-
APR	18.2	5	4.2 (Apr21)	27.3 (Apr17)
MAY	28.5	17	5.3 (May15)	53.7 (May09)
JUN	0.0	0	-	-
JUL	0.0	0	-	-
AUG	0.0	0	-	-
SEP	0.0	0	-	-
OCT to SEP	107.2	41	1.5 (Feb06)	53.7 (May09)
APR to SEP	26.2	22	4.2 (Apr21)	53.7 (May09)

WATER YEAR 1986

MONTH	Avg	Days # of:	Min (day)	Max (day)
OCT	0.0	0	-	-
NOV	0.0	0	-	-
DEC	0.0	0	-	-
JAN	0.0	0	-	-
FEB	88.7	5	33.7 (Feb24)	139.8 (Feb27)
MAR	83.1	28	7.9 (Mar21)	197.9 (Mar02)
APR	42.4	26	3.7 (Apr30)	82.9 (Apr04)
MAY	45.0	28	1.5 (May25)	130.3 (May28)
JUN	90.1	20	2.3 (Jun20)	181.5 (Jun07)
JUL	0.0	0	-	-
AUG	0.0	0	-	-
SEP	0.0	0	-	-
OCT to SEP	64.8	107	1.5 (May25)	181.5 (Jun07)
APR to SEP	56.3	74	1.5 (May25)	181.5 (Jun07)

Data Source: Corps of Engineers, Walla Walla District, Hydrology Branch.

TABLE 4-3

Total Dissolved Gases at McNary Dam (Forebay)
In Percentage of Satuarization of Nitrogen (N2)
Station 814 - Washington Side Fishladder, Upstream - MSL 340

WATER YEAR 1983
April 1 to July 28

MONTH	Avg N2%	Min N2% (day)	Max N2% (day)
APR	114.1	107.5 (Apr12)	121.5 (Apr29)
MAY	116.7	110.3 (May09)	126.6 (May30)
JUN	113.4	104.7 (Jun25)	123.6 (Jun07)
JUL	108.8	101.6 (Jul10)	119.8 (Jul23)
YEARLY	113.8	101.6 (Jul10)	126.6 (May30)

WATER YEAR 1984
April 17 to July 31

MONTH	Avg N2%	Min N2% (day)	Max N2% (day)
APR	114.3	109.0 (Apr20)	116.5 (Apr29)
MAY	115.9	108.2 (May06)	125.8 (May29)
JUN	118.4	111.4 (Jun08)	127.7 (Jun18)
JUL	113.0	105.8 (Jul26)	123.0 (Jul04)
YEARLY	115.6	105.8 (Jul26)	127.7 (Jun18)

WATER YEAR 1985
April 2 to August 31

MONTH	Avg N2%	Min N2% (day)	Max N2% (day)
APR	107.2	102.4 (Apr24)	114.5 (Apr14)
MAY	112.5	105.8 (May30)	120.6 (May17)
JUN	109.2	105.1 (Jun30)	117.3 (Jun12)
JUL	107.7	101.9 (Jul31)	112.5 (Jul09)
AUG	101.2	97.2 (Aug21)	106.6 (Aug17)
YEARLY	15.0	9.1 (Apr27)	23.0 (Jul30)

WATER YEAR 1986
April 1 to September 24

MONTH	Avg N2%	Min N2% (day)	Max N2% (day)
APR	112.3	106.2 (Apr13)	119.2 (Apr07)
MAY	114.6	108.1 (May07)	124.4 (May31)
JUN	115.0	102.3 (Jun30)	125.9 (Jun02)
JUL	105.1	98.4 (Jul19)	113.7 (Jul22)
AUG	107.0	98.9 (Aug31)	114.2 (Aug03)
SEP	102.4	97.6 (Sep02)	111.4 (Sep05)
YEARLY	16.1	7.0 (Apr02)	23.0 (Aug19)

Note: 1983 information obtained when gage was at 10 ft. depth. All other years data obtained from a 15 ft. depth.

Data Source: CROHMS Database, North Pacific Division, Water Management Branch (Water Quality).

TABLE 4-3

Total Dissolved Gases at McNary Dam (Forebay)
In Percentage of Saturization of Nitrogen (N2)
Station 820 - Oregon Side, Powerhouse 1 - MSL 340

WATER YEAR 1983
May 27 to June 30

YEARLY	Avg N2%	Min N2% (day)	Max N2% (day)
	115.7	104.6 (Jun30)	132.3 (Jun07)

WATER YEAR 1984
April 17 to July 31

MONTH	Avg N2%	Min N2% (day)	Max N2% (day)
APR	115.0	112.4 (Apr20)	121.0 (Apr29)
MAY	116.9	108.7 (May06)	128.6 (May29)
JUN	121.9	112.6 (Jun08)	132.7 (Jun19)
JUL	113.9	105.5 (Jul28)	124.3 (Jul07)
YEARLY	117.2	105.5 (Jul28)	132.7 (Jun19)

WATER YEAR 1985
April 2 to August 31

MONTH	Avg N2%	Min N2% (day)	Max N2% (day)
APR	107.4	103.7 (Apr24)	115.0 (Apr13)
MAY	112.2	105.9 (May30)	119.8 (May22)
JUN	109.2	104.0 (Jun30)	117.5 (Jun12)
JUL	108.8	100.6 (Jul10)	116.0 (Jul03)
AUG	102.3	98.0 (Aug08)	116.4 (Aug25)
YEARLY	108.0	98.0 (Aug08)	119.8 (May22)

WATER YEAR 1986
April 1 to September 4

MONTH	Avg N2%	Min N2% (day)	Max N2% (day)
APR	113.1	107.6 (Apr13)	120.8 (Apr03)
MAY	115.9	108.8 (May07)	133.1 (May31)
JUN	117.8	106.1 (Jun24)	134.1 (Jun01)
JUL	107.1	100.2 (Jul19)	121.2 (Jul21)
AUG	108.4	100.5 (Aug31)	114.6 (Aug03)
SEP	101.6	97.4 (Sep02)	107.2 (Sep04)
YEARLY	112.2	97.4 (Sep02)	134.1 (Jun01)

Note: 1983 information obtained when gage was at 10 ft. depth. All other years data obtained from a 15 ft. depth.

Data Source: CROHMS Database, North Pacific Division, Water Management Branch (Water Quality).

TABLE 4-4

McNARY DAM AND RESERVOIR
AVERAGE REGIONAL PRECIPITATION
(INCHES)

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
McNARY DAM, WA. (ELEVATION 361)	0.19	1.17	1.40	0.98	1.21	1.22	0.00	0.16	0.60	0.42	1.94	0.51	9.80
RICHLAND, WA. (ELEVATION 373)	1.03	0.69	0.50	0.42	0.53	0.44	0.14	0.32	0.28	0.46	0.91	1.06	6.78
PENDLETON, OR. WSO AP (ELEVATION 1482)	1.73	1.11	1.06	0.99	1.09	0.70	0.30	0.55	0.58	0.95	1.48	1.66	12.20
MORO, OR. (ELEVATION 1868)	1.83	1.04	1.01	0.73	0.85	0.65	0.24	0.42	0.47	0.77	1.63	1.74	11.38
WALLA WALLA, WA. 13 ESE (ELEVATION 2400)	6.29	4.08	4.49	3.68	2.74	2.29	0.59	1.23	1.93	3.62	5.15	5.82	42.65
ELGIN, OR. (ELEVATION 2655)	3.22	2.37	2.22	1.71	1.79	1.39	0.54	0.78	1.14	1.94	3.02	3.66	23.78

Notes:

1. Average precipitation values based on 30 year time period (1951-1980), except McNary Dam (1955-1984).
2. Source: Climatological Data, Oregon and Washington, 1985.

TABLE 4-5

McNARY DAM AND RESERVOIR
AVERAGE REGIONAL TEMPERATURES
(DEGREES F.)

STATION		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
McNARY DAM, WA.	MAX	40.0	47.1	57.5	62.6	68.9	77.9	90.5	90.2	76.1	62.7	50.2	38.9	63.6
(ELEVATION 361)	MIN	27.2	33.2	38.5	40.7	45.5	52.2	59.1	60.0	50.4	41.3	36.6	25.2	42.5
	AVG	33.6	40.2	48.0	51.7	57.2	65.1	74.8	75.1	63.3	52.0	43.4	32.1	53.0
RICHLAND, WA.	MAX	41.1	49.5	58.0	66.9	75.9	83.6	91.6	89.5	81.4	67.9	51.7	43.8	66.7
(ELEVATION 373)	MIN	25.9	31.3	34.6	40.8	48.3	55.1	59.8	58.6	51.1	41.3	33.6	29.3	42.5
	AVG	33.5	40.4	46.3	53.9	62.1	69.4	75.7	74.0	66.3	54.7	42.7	36.6	54.6
PENDLETON, OR.	MAX	39.4	46.9	53.4	61.4	70.6	79.6	88.9	85.9	77.1	63.7	48.7	42.5	63.2
WSO AP	MIN	26.3	31.8	34.4	39.2	46.1	52.9	58.6	57.5	50.5	41.3	33.4	29.5	41.8
(ELEVATION 1482)	AVG	32.8	39.4	43.9	50.3	58.4	66.2	73.8	71.7	63.8	52.5	41.1	36.0	52.5
MORO, OR.	MAX	37.1	44.1	50.2	57.5	66.1	74.1	83.1	81.3	74.1	61.7	46.7	40.2	59.7
(ELEVATION 1868)	MIN	23.0	28.6	30.8	35.1	41.2	48.1	53.4	52.3	45.8	37.0	30.3	26.5	37.7
WALLA WALLA, WA.	MAX	35.0	41.5	48.5	57.9	67.0	74.5	84.0	81.8	72.7	58.8	42.6	37.1	58.5
13 ESE	MIN	23.9	28.0	29.4	33.5	38.8	44.2	46.3	45.9	41.5	36.1	30.2	26.7	35.4
(ELEVATION 2400)	AVG	29.4	34.7	38.9	45.7	52.9	59.4	65.1	63.9	57.1	47.5	36.4	31.9	46.9
	AVG	30.1	36.4	40.5	46.3	53.7	61.1	68.3	66.9	59.9	49.4	38.5	33.4	48.7

NOTES: 1. Average Temperature Values Based on 30 Year Time Period (1951-1980), except McNary Dam (1955-1984).

2. Source: Climatological Data, Oregon and Washington.

TABLE 4-6

SUMMARY OF RUNOFF AND DISCHARGE DATA
(McNary Reservoir Computed Inflows)

Water Year	Annual Runoff KAF	Annual Runoff Inches 1/	Mean Daily Discharge Maximum Cfs	Mean Daily Discharge Maximum Date	Mean Daily Discharge Minimum Cfs	Mean Daily Discharge Minimum Date
1954	145,093	12.71	537,500	MAY 22	75,700	NOV 23
1955	123,586	10.83	526,700	JUN 26	80,200	DEC 29
1956	163,756	14.35	754,600	JUN 2	85,300	OCT 21
1957	128,965	11.30	648,000	MAY 21	75,000	SEP 9
1958	118,814	10.41	553,000	MAY 30	69,400	DEC 27
1959	144,616	12.67	531,900	JUN 23	78,900	NOV 3
1960	136,890	11.99	442,200	JUN 6	82,600	SEP 7
1961	130,850	11.46	670,700	JUN 7	73,100	SEP 19
1962	115,596	10.13	436,600	JUN 4	68,300	JAN 1
1963	119,042	10.43	422,500	JUN 17	82,400	SEP 8
1964	130,672	11.45	668,200	JUN 17	63,300	NOV 3
1965	153,490	13.45	503,800	JUN 13	77,100	NOV 22
1966	113,759	9.97	392,000	JUN 12	61,800	SEP 5
1967	133,052	11.66	610,100	JUN 21	62,400	SEP 5
1968	121,596	10.65	442,600	JUN 12	68,500	OCT 2
1969	142,064	12.45	446,000	MAY 21	63,000	SEP 7
1970	114,282	10.02	429,900	JUN 5	67,100	OCT 5
1971	156,193	13.69	558,400	MAY 30	71,600	SEP 19
1972	169,234	14.83	619,000	JUN 12	70,500	OCT 17
1973	94,811	8.31	207,900	DEC 13	55,100	AUG 26
1974	164,698	14.43	580,400	JUN 21	69,200	OCT 14
1975	131,521	11.52	381,600	JUN 4	77,800	AUG 17
1976	156,672	13.73	428,800	MAY 12	65,300	OCT 5
1977	86,526	7.58	186,200	MAY 27	48,500	JUL 10
1978	122,775	10.76	318,500	JUN 8	60,900	OCT 16
1979	106,928	9.37	292,600	MAY 24	65,600	SEP 23
1980	110,451	9.68	324,900	JUN 17	67,500	OCT 7
1981	130,313	11.42	421,900	JUN 9	65,000	SEP 7
1982	155,783	13.65	441,900	JUN 23	80,100	OCT 3
1983	147,860	12.96	407,400	MAY 30	85,100	SEP 5
1984	143,322	12.56	402,600	MAY 31	82,700	SEP 30
1985	111,201	9.74	276,400	MAY 10	69,900	SEP 2
1986	129,883	11.38	382,700	JUN 1	64,900	SEP 1
1954 - 1986						
Average	131,948	11.56	462,045		70,148	
Maximum	169,234	14.83	754,600	1956	85,300	1956
Minimum	86,526	7.58	186,200	1977	48,200	1970
1973 - 1986						
Average	128,053	11.22	360,986		68,400	
Maximum	164,698	14.43	580,400	1974	85,100	1983
Minimum	86,526	7.58	186,200	1977	48,500	1977

1/ 1.0 basin inches = 11,413 KAF for a drainage area of 214,000 square miles above McNary Dam.

Note: Data source U.S. Army Corps of Engineers, Walla Walla District, Hydrology Branch.

TABLE 4-7
SUMMARY OF MONTHLY RUNOFF
MCNARY RESERVOIR
COMPUTED MONTHLY INFLOW VOLUME IN 1,000 ACRE-FEET

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1954	6002.7	5491.1	5955.3	6381.5	6247.5	7535.1	8946.2	22625.6	28954.1	25228.9	12889.0	8836.3
1955	6449.9	6240.3	5997.1	5769.0	5582.0	6729.4	8014.9	11775.8	26172.7	24050.9	10703.8	6100.3
1956	5759.3	6712.4	8170.2	8031.6	6563.2	9192.1	19133.6	30997.1	35705.0	18376.1	9062.0	6052.7
1957	5989.4	5754.7	6100.3	6284.5	6030.4	7853.9	9886.0	30399.9	26670.7	11810.0	7111.6	5073.4
1958	5366.0	4932.8	5085.9	5237.6	6773.3	8174.0	11199.4	22877.3	25289.4	12009.3	6741.9	5127.0
1959	5428.2	5800.9	6944.2	8126.4	7291.3	8938.2	11806.2	20682.0	29319.5	21228.6	10127.0	8923.8
1960	10435.4	9331.4	8387.0	6906.3	6733.2	7645.6	14818.9	17841.4	22632.3	17285.4	9031.9	5840.8
1961	5650.8	5868.8	5423.3	5868.4	8522.5	9272.7	9947.5	19869.1	34120.2	13725.4	7316.7	5264.6
1962	5421.3	5086.1	5096.2	6351.2	6666.9	6379.5	12262.4	17590.1	22048.6	13983.7	9239.1	5470.5
1963	6416.2	6491.2	7848.9	7346.7	8220.0	7337.8	9234.8	14932.8	22512.7	14829.8	8146.0	5724.6
1964	5351.7	5012.1	5533.8	5488.9	6072.9	6023.3	7842.2	17335.2	34358.4	21731.8	9772.3	6149.6
1965	7279.2	6133.8	8869.2	9451.2	11541.8	10444.7	13725.2	23865.1	27820.0	17542.7	10135.3	6681.8
1966	6255.6	6152.4	6704.6	6745.5	6425.2	7562.7	8515.0	15973.5	19896.5	15734.9	8066.1	5726.6
1967	5643.9	5598.8	6637.6	7257.0	6659.6	8005.6	8191.9	15128.4	33630.2	20897.4	9192.3	6209.5
1968	6302.6	6500.1	7761.6	7343.1	8142.1	10099.2	8982.5	12464.5	21874.2	16132.0	8769.3	7225.1
1969	6964.1	7307.4	8209.7	10197.6	9459.9	11015.8	18786.5	23456.9	19492.6	13802.8	7544.6	5825.9
1970	6789.1	6863.1	7691.4	8638.5	7331.6	8151.4	8520.5	15461.2	20059.5	10900.1	7591.6	6167.1
1971	6559.8	6617.2	7407.6	8554.4	10303.1	12681.5	14394.7	28380.7	28182.0	17266.6	9725.1	6120.5
1972	6593.6	7051.1	8482.6	8830.9	10107.3	18488.2	16485.9	23980.1	32642.7	18218.1	11037.4	7316.5
1973	7127.3	7190.4	9147.7	8902.5	7515.5	8560.8	8012.0	8649.6	8346.6	8050.8	7434.8	5872.9
1974	6251.8	6472.4	9222.9	14420.4	12586.1	13116.9	17268.0	21089.8	28201.2	18060.8	10137.7	7870.5
1975	7693.0	7720.2	8067.3	9310.7	9550.2	12706.3	11932.1	18166.1	19563.1	12306.8	8203.8	6301.2
1976	7173.7	8668.5	11761.4	11886.3	11876.6	13019.3	15323.9	21300.4	17468.5	14696.1	13871.8	9624.9
1977	8410.8	7637.1	8106.2	8885.5	6889.1	7562.9	6028.5	8382.1	7106.7	5696.0	5835.3	5986.0
1978	5749.6	6888.3	9096.3	9773.9	8995.6	10565.1	13708.8	16025.7	14325.6	11470.6	7670.0	8505.2
1979	7735.1	8314.8	8711.7	9903.0	8554.4	9579.7	9653.9	14242.9	10405.4	7441.5	6664.8	5720.4
1980	6401.7	7803.3	7918.7	9008.3	7817.6	7923.1	8582.6	15183.9	16859.8	9762.2	7158.1	6031.8
1981	6059.4	7203.7	10218.4	12407.4	10364.2	9102.7	8824.4	14551.0	21213.5	13842.6	9876.2	6649.7
1982	7166.0	7149.5	8928.3	10324.9	11794.3	18627.8	15951.7	20247.0	21855.6	16937.5	9586.7	7213.6
1983	7340.7	8522.1	8985.1	11164.3	12111.3	19396.3	15190.0	18561.8	17019.4	12715.6	9864.7	6988.5
1984	6590.4	8419.6	10809.7	11343.2	11431.7	12715.4	15464.8	18722.9	20477.7	12394.7	8329.1	6622.5
1985	7323.3	7626.0	9055.3	11962.3	10787.9	9950.5	11216.1	14278.6	10960.0	6564.0	5604.0	5872.9
1986	7336.2	9015.0	10018.1	7484.5	9917.5	16326.8	15180.9	15903.3	15312.4	9307.4	7402.2	6679.0
1987	7235.4	8191.1	8906.5	9828.4	7348.3	7518.9	8379.5	13768.3	8884.7			
STATISTICS												
N	34	34	34	34	34	34	34	34	34	33	33	33
AVERAGE	6654.5	6934.3	7978.2	8688.7	8594.5	10241.3	11806.2	18373.8	22040.6	14666.7	8783.1	6538.7
MAXIMUM	10435.4	9331.4	11761.4	14420.4	12586.1	19396.3	19133.6	30997.1	35705.0	25228.9	13871.8	9624.9
MINIMUM	5351.7	4932.8	5085.9	5237.6	5582.0	6023.3	6028.5	8382.1	7106.7	5696.0	5604.0	5073.4

Notes:
1. Data Source U.S. Army Corps of Engineers, Walla Walla District, Hydrology Branch.
2. Period of Record: October 1953 to present.

TABLE 4-8

SUMMARY OF RUNOFF AND DISCHARGE DATA
(Snake River below Ice Harbor Discharges)

Water Year	Annual Runoff KAF	Annual Runoff Inches 1/	Mean Daily Discharge Maximum Cfs	Mean Daily Discharge Maximum Date	Mean Daily Discharge Minimum Cfs	Mean Daily Discharge Minimum Date
1973	25,905	4.48	88.700	MAY 19	9.900	AUG 12
1974	56,520	9.77	305.000	JUN 19	8.900	SEP 2
1975	43,795	7.57	185.000	JUN 8	14.600	FEB 15
1976	49,153	8.49	191.300	MAY 15	8.100	AUG 31
1977	19,620	3.39	61.900	JUN 8	3.300	JUL 31
1978	39,774	6.87	148.100	JUN 9	6.300	OCT 23
1979	30,772	5.32	143.000	MAY 24	2.700	FEB 4
1980	32,600	5.63	138.100	JUN 14	3.100	DEC 30
1981	33,696	5.82	187.100	JUN 9	8.800	AUG 30
1982	50,777	8.77	203.000	JUN 19	10.900	NOV 1
1983	48,296	8.35	197.500	MAY 29	15.800	AUG 7
1984	54,431	9.41	248.000	MAY 31	11.300	OCT 2
1985	35,260	6.09	132.200	JUN 9	11.800	JUL 23
1986	44,653	7.72	214.100	MAY 31	10.100	DEC 15
AVERAGE	40,375	6.98	174.500		8.971	
MAXIMUM	56,520	9.77	305.000	1974	15.800	1983
MINIMUM	19,620	3.39	61.900	1977	2.700	1979

1/ 1.0 basin inches = 5,787 KAF for a drainage area of 108,500 square miles above gaging station Snake River below Ice Harbor Dam.

Notes: Data reflects the effect of irrigation and upstream storage developments.

Data source U.S. Army Corps of Engineers, Walla Walla District, Hydrology Branch.

TABLE 4-9

SUMMARY OF RUNOFF AND DISCHARGE DATA
(Priest Rapids Computed Regulated Discharges)

Water Year	Annual Runoff		Mean Daily Discharge			
			Maximum		Minimum	
	KAF	Inches 1/	Cfs	Date	Cfs	Date
1973	66,458	12.98	174,000	DEC 13	38,000	DEC 25
1974	102,769	20.07	351,000	JUN 30	37,800	NOV 11
1975	83,442	16.30	212,000	MAY 24	43,500	AUG 16
1976	102,471	20.01	243,000	JUL 20	39,300	APR 10
1977	65,398	12.77	146,000	JAN 29	38,400	JUL 10
1978	77,207	15.08	182,000	APR 15	39,000	DEC 25
1979	74,384	14.53	152,000	JAN 1	50,500	AUG 19
1980	75,026	14.65	208,000	JUN 18	42,900	SEP 14
1981	94,684	18.49	281,000	JUN 5	47,500	OCT 12
1982	100,545	19.64	246,000	JUN 24	54,000	SEP 29
1983	94,031	18.37	240,000	MAR 23	45,600	SEP 11
1984	83,566	16.32	207,000	JUN 29	49,000	SEP 23
1985	74,010	14.46	179,000	FEB 5	39,000	AUG 4
1986	81,834	15.98	197,000	APR 16	44,900	SEP 28
AVERAGE	83,987	16.40	215,571		43,529	
MAXIMUM	102,769	20.07	351,000	1974	54,000	1982
MINIMUM	65,398	12.77	146,000	1977	37,800	1974

1/ 1.0 basin inches = 5,120 KAF for a drainage area of 96,000 square miles above gaging station Columbia River below Priest Rapids Dam.

Notes: Discharges reflect the effects of irrigation and upstream storage developments.

Data source U.S. Army Corps of Engineers, Walla Walla District, Hydrology Branch.

TABLE 4-10

SUMMARY OF RUNOFF AND DISCHARGE DATA
(Yakima River at Kiona Observed Regulated Discharges)

Water Year	Annual Runoff KAF	Annual Runoff Inches 1/	Mean Daily Discharge Maximum Cfs	Mean Daily Discharge Maximum Date	Mean Daily Discharge Minimum Cfs	Mean Daily Discharge Minimum Date
1934	4,405	14.71	59.400	DEC 24	0.732	JUN 24
1935	2,896	9.67	17.900	JAN 28	1.140	AUG 15
1936	2,449	8.18	13.900	MAY 16	1.100	AUG 8
1937	1,943	6.49	16.800	JUN 24	1.100	JAN 31
1938	3,063	10.23	14.900	APR 21	1.270	AUG 12
1939	1,552	5.18	7.140	MAR 27	1.140	AUG 7
1940	1,705	5.69	8.660	MAY 13	1.030	JUN 29
1941	1,335	4.46	4.520	APR 4	0.840	APR 26
1942	1,456	4.86	4.520	DEC 5	1.060	APR 30
1943	2,748	9.18	13.200	APR 18	1.360	OCT 13
1944	1,192	3.98	3.720	DEC 6	0.730	APR 20
1945	1,463	4.88	8.280	JUN 2	1.030	APR 29
1946	2,492	8.32	15.300	MAY 29	1.360	OCT 14
1947	2,723	9.09	14.800	DEC 16	1.260	AUG 17
1948	3,499	11.68	36.800	MAY 31	1.550	AUG 14
1949	3,152	10.52	15.200	MAY 17	1.290	FEB 13
1950	3,648	12.18	14.700	JUN 22	1.660	JAN 16
1951	4,200	14.02	20.200	FEB 13	1.550	JUL 19
1952	2,014	6.73	6.140	MAR 28	1.390	JUL 17
1953	2,193	7.32	11.400	JUN 15	1.240	APR 17
1954	3,091	10.32	11.560	MAY 21	1.650	OCT 16
1955	2,221	7.42	17.800	JUN 14	1.180	APR 20
1956	5,121	17.10	19.800	MAY 22	1.760	AUG 16
1957	2,798	9.34	19.300	MAY 12	1.060	JUN 21
1958	2,141	7.15	9.760	FEB 26	0.914	JUL 14
1959	3,118	10.41	10.700	JAN 26	1.050	JUL 17
1960	2,919	9.74	16.700	NOV 25	0.959	JUL 23
1961	3,053	10.19	12.900	MAY 23	0.860	JUL 22
1962	1,992	6.65	10.600	APR 9	1.030	JUL 14
1963	2,449	8.18	13.300	FEB 6	0.850	JUN 21
1964	1,796	6.00	8.540	JUN 12	1.280	MAY 9

1/ 1.0 basin inches = 299 KAF for a drainage area of 5,615 square miles above gaging station Yakima River at Kiona, Washington.

Notes: Discharges reflect the effects of irrigation and upstream storage projects.

Data source U.S. Army Corps of Engineers, Walla Walla District, Hydrology Branch.

TABLE 4-10

SUMMARY OF RUNOFF AND DISCHARGE DATA
(Yakima River at Kiona Observed Regulated Discharges)

Water Year	Annual Runoff KAF	Annual Runoff Inches 1/	Mean Daily Discharge Maximum Cfs	Mean Daily Discharge Maximum Date	Mean Daily Discharge Minimum Cfs	Mean Daily Discharge Minimum Date
1965	3,051	10.19	21.900	FEB 1	1.300	JUL 9
1966	1,626	5.43	6.820	APR 3	1.240	AUG 5
1967	2,126	7.10	10.300	JUN 23	1.230	JUL 16
1968	2,502	8.35	14.800	FEB 25	0.870	JUL 12
1969	2,919	9.74	14.200	MAY 27	1.110	JUL 24
1970	1,897	6.33	7.350	JAN 24	0.930	JUL 13
1971	3,054	10.20	14.100	MAY 14	1.150	AUG 5
1972	4,861	16.23	20.100	MAR 20	1.460	AUG 9
1973	1,614	5.39	8.270	DEC 28	0.554	JUL 20
1974	4,195	14.01	37.400	JAN 18	1.240	OCT 1
1975	3,034	10.13	12.700	MAY 17	1.260	JUL 30
1976	3,707	12.38	27.200	DEC 6	1.480	JUL 30
1977	936	3.12	3.250	OCT 20	0.225	APR 4
1978	3,108	10.38	24.000	DEC 5	1.280	JUL 27
1979	1,212	4.05	4.400	MAR 9	0.497	SEP 29
1980	2,463	8.22	12.500	MAY 1	0.497	OCT 1
1981	2,299	7.68	25.400	DEC 28	0.933	APR 17
1982	3,046	10.17	21.100	FEB 23	1.500	JAN 7
1983	3,372	11.26	16.600	MAR 12	1.620	AUG 3
1984	2,877	9.61	16.900	JAN 27	1.200	JUL 29
1985	1,713	5.72	7.150	APR 16	1.040	JUL 11
1986	2,160	7.21	15.600	FEB 28	1.080	JUN 27
AVERAGE	2,615	8.73	15.103		1.134	
MAXIMUM	5,121	17.10	59.400	1934	1.760	1956
MINIMUM	936	3.12	3.250	1977	0.225	1977

1/ 1.0 basin inches = 299 KAF for a drainage area of 5,615 square miles above gaging station Yakima River at Kiona, Washington.

Notes: Discharges reflect the effects of irrigation and upstream storage projects.

Data source U.S. Army Corps of Engineers, Walla Walla District, Hydrology Branch.

TABLE 5-1

McNARY SEDIMENTATION RANGES

	MONUMENT DESIGNATION	RIVER MILES	ELEVATION	NORTHING	EASTING	STATION LEFT TO RIGHT
	Columbia River					
1	CR-21-LB	293.40	372.74	220414.60	2314233.69	5+00.00
	CR-21-LA		359.50	220514.73	2314203.35	6+04.63
	CR-21-RA		349.53	226352.72	2312434.31	67+04.76
	CR-21-RB		362.52	226536.54	2312378.61	68+96.83
2	CR-20-LB	298.32	371.81	217199.83	2338842.16	5+00.00
	CR-20-LA		350.20	217250.20	2338837.79	5+50.56
	CR-20-RA		351.28	222149.40	2338413.17	54+68.13
	CR-20-RB		366.24	222223.46	2338406.75	55+42.47
3	CR-19-LB	311.93	341.16	256145.28	2396295.61	5+00.00
	CR-19-LA		350.83	256174.33	2396255.08	5+49.87
	CR-19-RA		352.56	259180.95	2392060.62	57+10.61
	CR-19-RB		373.83	259226.84	2391996.60	57+89.38
4	RGLB	314.11	352.01	266255.56	2397504.54	0+00.00
	RGLA		344.55	266286.41	2397411.97	0+97.58
	RGRA		352.64	267738.42	2393054.77	46+90.72
	RGRB		367.87	267770.52	2392958.44	47+92.27
5	RHLB	314.38	351.00	267307.24	2398510.94	0+00.00
	RHLA		347.68	267332.99	2398438.42	0+76.95
	RHRA		355.08	269152.13	2393314.40	55+14.78
	RHRB		364.87	269198.40	2393184.06	56+52.92
6	RJLB	314.88	376.44	271613.78	2404145.28	0+00.00
	RJLA		365.64	271605.60	2404026.15	1+19.47
	RJRA		362.18	270858.46	2393556.98	106+16.39
	RJRB		364.00	270849.98	2393438.13	107+35.07
7	RKLB	315.28	369.30	274996.95	2404218.11	0+00.00
	RKLA		361.67	274956.20	2404031.47	1+91.05
	RKRA		351.59	272571.69	2393111.29	113+69.23
	RKRB		379.04	272546.74	2392997.04	114+86.18
8	RLLB	315.82	354.21	278143.40	2403595.68	0+00.00
	RLLA		351.61	278100.99	2403437.33	1+65.08
	RLRA		343.79	275326.84	2392957.54	110+06.52
	RLRB		351.59	275284.13	2392798.09	111+70.46
9	RMLB	316.20	359.31	283260.56	2401538.68	0+00.00
	RMLA		345.02	283232.39	2401498.80	0+48.82
	RMRA		351.19	276738.87	2392305.40	113+04.58
	RMRB		370.52	276635.98	2392159.72	114+82.94
10	RNLB	317.37	347.26	288773.52	2399775.73	0+00.00
	RNLA		353.34	288697.24	2399643.62	1+52.56
	RNRA		352.87	282309.88	2388581.42	129+27.09
	RNRB		349.17	282253.10	2388483.08	130+40.66
11	CR-18-LC	318.80	353.49	296244.75	2396772.49	5+00.00
	CR-18-LB		341.16	295564.51	2395720.73	17+52.57
	CR-18-LA		341.40	295286.32	2395290.59	22+64.83
	CR-18-RA		342.33	290062.79	2387214.23	118+83.19
	CR-18-RB		367.30	289094.07	2385716.46	136+66.93

TABLE 5-1

McNARY SEDIMENTATION RANGES

	MONUMENT DESIGNATION	RIVER MILES	ELEVATION	NORTHING	EASTING	STATION LEFT TO RIGHT
12	CR-17-LG	320.53	353.24	305344.83	2394659.41	5+00.00
	CR-17-LF		342.63	305275.61	2394551.01	6+28.62
	CR-17-LE		352.95	304258.83	2392958.67	25+17.90
	CR-17-LD		341.72	302685.36	2390494.54	54+41.55
	CR-17-LC		352.05	301852.74	2389190.61	69+88.64
	CR-17-LB		352.67	301436.70	2388537.96	77+62.62
	CR-17-LA		349.68	301185.47	2388145.63	82+28.50
	CR-17-RA		342.16	295747.68	2379629.75	183+32.44
	CR-17-RB		354.07	295570.43	2379352.19	186+61.77
13	CR-16-LB	322.03	388.59	309780.89	2384879.66	5+00.00
	CR-16-LA		342.12	309438.47	2384471.93	10+32.44
	CR-16-RA		352.29	304353.47	2378416.98	89+39.38
	CR-16-RB		352.11	304227.39	2378266.85	91+35.43
14	CR-15-LC		393.77	315658.27	2378238.50	2+26.26
	CR-15-LB	323.53	387.20	315452.61	2378057.84	5+00.00
	CR-15-LA		347.61	313825.06	2376628.11	26+66.34
	CR-15-RA		353.21	311358.58	2374461.27	59+49.44
	CR-15-RB		366.33	311270.15	2374383.58	60+67.15
15	CR-14-LB	325.50	345.30	320285.47	2368014.80	5+00.00
	CR-14-LA		345.22	320169.66	2367949.29	6+33.06
	CR-14-RA		341.54	317380.65	2366371.87	38+37.25
	CR-14-RB		359.03	317506.20	2366442.88	39+81.49
16	CR-13-LB	327.67	357.53	325952.19	2357946.19	5+00.00
	CR-13-LA		347.95	325763.91	2357832.83	7+19.77
	CR-13-RA		359.35	323031.10	2356187.55	39+09.63
	CR-13-RB		344.63	322906.28	2356112.40	40+55.33
17	CR-12-LB	329.05	333.31	327955.61	2350751.71	5+00.00
	CR-12-LA		359.05	327876.26	2350699.45	5+95.01
	CR-12-RA		360.15	325000.23	2349439.87	37+34.77
	CR-12-RB		344.44	324858.07	2349377.94	38+89.83
18	CR-11-LB	330.55	352.27	330264.61	2342962.09	5+00.00
	CR-11-LA		342.29	330120.28	2342952.12	6+44.67
	CR-11-RA		343.83	327543.62	2342773.26	32+27.53
	CR-11-RB		344.56	327442.04	2342766.21	33+29.35
19	CR-10-LB	331.44	353.56	330997.60	2338860.43	5+00.00
	CR-10-LA		351.21	330878.00	2338829.76	6+23.47
	CR-10-RA		344.34	328019.60	2338096.76	35+74.36
	CR-10-RB		347.26	327918.30	2338070.78	36+78.94
20	CR-9-LB	332.64	345.30	332176.10	2333395.07	5+00.00
	CR-9-LA		360.84	332063.42	2333307.37	6+42.79
	CR-9-RA		344.75	330133.57	2331805.67	30+88.08
	CR-9-RB		348.20	330004.36	2331704.91	32+51.93
21	CR-8-LB	333.70	348.93	334302.94	2328317.10	5+00.00
	CR-8-LA		342.86	334215.68	2328248.90	6+10.75
	CR-8-RA		347.40	331924.07	2326457.92	35+19.20
	CR-8-RB		348.60	331819.18	2326375.96	36+52.31

TABLE 5-1

McNARY SEDIMENTATION RANGES

	MONUMENT DESIGNATION	RIVER MILES	ELEVATION	NORTHING	EASTING	STATION LEFT TO RIGHT
22	CR-7-LB	336.40	370.15	343720.07	2317305.22	5+00.00
	CR-7-LA		356.91	343624.20	2317287.33	5+97.53
	CR-7-RA		350.31	342034.26	2316991.85	22+14.69
	CR-7-RB		351.98	341841.70	2316955.74	24+10.61
23	CR-6-LC		370.67	345631.78	2314188.73	3+57.93
	CR-6-LB	337.30	350.23	345573.54	2314059.15	5+00.00
	CR-6-LA		342.87	345377.12	2313622.14	9+79.12
	CR-6-RA		353.79	344672.95	2312055.26	26+96.96
	CR-6-RB		354.16	344601.76	2311896.75	28+70.73
24	CR-5-LB	338.73	354.50	351841.39	2313976.32	5+00.00
	CR-5-LA		352.70	351850.72	2313935.19	5+42.18
	CR-5-RA		353.38	352416.12	2311442.79	30+97.90
	CR-5-RB			352428.32	2311388.99	31+53.07
25	CR-4-LB	340.34	378.07	359879.49	2316596.18	5+00.00
	CR-4-LA		357.38	359882.03	2316530.41	5+65.82
	CR-4-RA		342.60	360000.59	2313475.38	36+23.15
	CR-4-RB		354.61	360002.77	2313408.32	36+90.24
26	CR-3-LB	341.95	418.87	368585.71	2315624.08	5+00.00
	CR-3-LA		359.69	368544.09	2315501.43	6+29.52
	CR-3-RA		363.08	367574.64	2312649.04	36+42.15
	CR-3-RB		368.71	367519.93	2312488.06	38+12.18
27	CR-2-LB	342.98	397.76	373563.40	2314487.68	5+00.00
	CR-2-LA		355.47	373540.58	2314378.84	6+11.20
	CR-2-RA		362.03	372994.61	2311775.09	32+71.58
	CR-2-RB		378.58	372964.70	2311632.46	34+17.31
28	CR-1-LB	343.94	397.52	378464.65	2313701.29	5+00.00
	CR-1-LA		360.02	378452.68	2313543.18	6+58.56
	CR-1-RA		350.51	378262.74	2311034.73	31+74.20
	CR-1-RB		367.26	378257.61	2310966.99	32+42.13
	Walla Walla River					
29	RIFLB	300	350.20	267121.07	2398278.62	0+00.00
	RIFLA		347.68	267332.99	2398438.42	2+65.42
	R1FRA1		363.32	274774.62	2404049.96	95+85.68
	R1FRA		369.30	274997.08	2404217.71	98+85.68
	R1FRB		375.64	275275.97	2404428.01	102+13.59
30	R1ELB	325	362.70	267943.32	2400114.32	0+00.00
	R1ELA		354.41	268201.36	2400307.65	3+22.43
	R1ERA		368.24	273245.25	2404086.78	66+25.02
	R1ERB		385.80	273532.63	2404302.10	69+84.12
31	R1DLB	350	354.80	269114.01	2402080.64	3+27.01
	R1DLA		351.28	269301.52	2402227.06	5+64.91
	R1DRA		346.78	271348.68	2403825.54	31+62.22
	R1DRB		365.64	271605.60	2404026.15	34+88.18

TABLE 5-1

McNARY SEDIMENTATION RANGES

	MONUMENT DESIGNATION	RIVER MILES	ELEVATION	NORTHING	EASTING	STATION LEFT TO RIGHT
32	R1CLB	3.60	381.30	268636.12	2402468.69	0+00.00
	R1CLA		368.04	268812.12	2402603.91	2+21.94
	R1CRA		352.05	270421.01	2403840.00	22+50.85
	R1CRB		386.53	270641.06	2404239.55	29+06.66
33	R1BLB	3.70	377.34	269087.65	2403579.98	0+00.00
	R1BRB		377.37	269376.43	2403801.46	3+63.93
34	R1ALB	3.80	378.82	268975.38	2403981.88	0+00.00
	R1ARB		377.02	269333.28	2404064.41	3+67.29
35	R1LD	3.85	358.07	268383.71	2404303.51	-1+39.38
	R1LC		352.55	268515.20	2404319.41	-0+06.93
	R1LB		352.55	268521.64	2404320.19	0+00.00
	R1LA		350.51	268560.96	2404324.94	0+39.61
	R1RA		350.08	269380.72	2404424.03	8+65.34
	R1RB		347.92	269497.08	2404438.10	9+82.63
36	R2LB	4.00	371.90	268113.37	2405006.44	0+00.00
	R2LA		361.88	268156.82	2405009.48	0+43.55
	R2RA		345.61	269403.17	2405095.94	12+92.90
	R2RB		356.67	269611.94	2405110.42	15+02.35
37	R3LB	4.85	418.21	268689.01	2407563.57	0+00.00
	R3LA		396.54	268759.01	2407572.18	0+70.68
	R3RB		367.14	272684.40	2408055.27	40+25.69
38	R4LB	5.35	394.06	267868.24	2410144.42	0+00.00
	R4LA		390.04	267926.52	2410148.41	0+58.42
	R4RA		360.98	269616.86	2410263.99	17+52.71
	R4RB		360.74	269715.53	2410270.74	18+51.61
39	R5LB	6.00	421.24	268114.87	2413364.74	0+00.00
	R5LA		377.44	268169.61	2413365.99	0+54.79
	R5RA		359.37	271956.21	2413452.10	38+42.37
	R5RB		367.03	272024.45	2413453.65	39+10.63
40	R6LB	6.55	409.54	267984.88	2416304.85	0+00.00
	R6LA		350.48	268049.78	2416289.71	0+66.66
	R6RA		370.60	271147.25	2415567.55	32+47.20
	R6RB		409.19	271383.27	2415512.52	34+89.61
41	R7LA	7.25	362.40	271624.77	2418245.34	1+38.16
	R7RA		396.56	272407.02	2417027.20	16+39.96
	R7RB		396.31	272441.01	2416974.28	17+02.86
42	R8LB	7.85	381.20	273522.04	2419572.50	0+00.00
	R8LA		363.85	273619.97	2419553.41	0+99.91
	R8RA		368.37	274286.61	2419423.46	7+79.10
	R8RB		375.71	274348.74	2419411.35	8+42.48
43	R9LA	8.22	402.83	274110.71	2421836.64	0+00.00
	R9RA		398.47	274649.63	2421532.49	6+18.82
44	R10LB	8.72	403.59	274332.75	2424083.67	0+00.00
	R10LA		393.82	274441.86	2424110.83	1+12.44
	R10RA		428.87	275270.17	2424317.02	9+66.03
	R10RB		489.10	275458.46	2424363.89	11+58.96

TABLE 5-1

McNARY SEDIMENTATION RANGES

	MONUMENT DESIGNATION	RIVER MILES	ELEVATION	NORTHING	EASTING	STATION LEFT TO RIGHT
45	R11LB1		410.45	271582.55	2424483.51	-0+71.90
	R11LB2		427.01	272806.21	2424272.36	12+02.88
	R11LA		374.18	272651.11	2424299.04	10+12.49
	R11LB		404.47	271653.38	2424471.27	0+00.00
	R11LA1		384.33	271833.78	2424440.13	1+83.07
46	R12LB(R)	9.20	404.48	271585.33	2424266.21	-0+87.42
	R12LA(R)		384.33	271833.78	2424440.13	2+15.85
	R12RA		380.75	273746.94	2425779.37	25+51.18
	R12RB		386.23	273824.40	2425833.60	26+45.76
47	R13LB	10.38	432.22	272655.50	2429271.46	0+00.00
	R13LA(R)		426.40	272721.17	2429258.21	0+67.00
	R13RB		386.18	274487.62	2428902.33	18+68.85
48	R14LA	11.40	404.47	274445.50	2432780.25	0+77.13
	R14RA		412.23	275529.34	2432595.41	11+76.62
	R14RB		419.26	275650.13	2432574.81	12+99.15
49	R15LB(R)	12.18	378.65	274235.69	2435301.74	0+00.00
	R15LA		382.31	274231.34	2435323.34	0+22.03
	R15RA		382.70	274179.98	2435578.30	2+82.11
Snake River						
50	SR-11R		344.48	318887.89	2370155.95	**
51	SR-10R		347.55	324033.53	2372425.77	**
52	SR-9L			326736.13	2377506.26	**
53	SR-8L		344.47	329232.87	2381822.08	**
54	SR-7R		356.61	334819.62	2387002.64	**
55	SR-6R		352.44	334906.70	2391562.34	**
56	SR-5R		355.98	335301.63	2393675.17	**
57	SR-4R		361.03	335906.91	2396467.47	**
58	SR-3R		358.08	336510.03	2399087.85	**
59	SR-2R		354.42	336969.98	2401133.48	**
60	SR-1R		359.68	338232.33	2405618.85	**
Yakima River						
61	R1LD	334.32	368.63	335148.84	2329020.42	10+00.00
	R1LC		361.17	335155.90	2328095.85	19+24.60
	R1LB		358.32	335159.60	2327611.46	24+09.00
	R1LA		355.25	335161.16	2327392.07	26+28.40
	R1RA		362.78	335244.08	2316550.68	134+70.10
	R1RB		363.58	335248.92	2315916.41	141+04.39
62	R2LB	335.74	383.06	341554.19	2320391.56	10+00.00
	R2LA		378.01	341448.47	2320307.73	11+35.18
	R2RA		362.09	336012.18	2316010.68	80+64.42
	R2RB		363.50	335631.78	2315709.98	85+49.31

** Sedimentation ranges have not been established officially.

TABLE 5-1

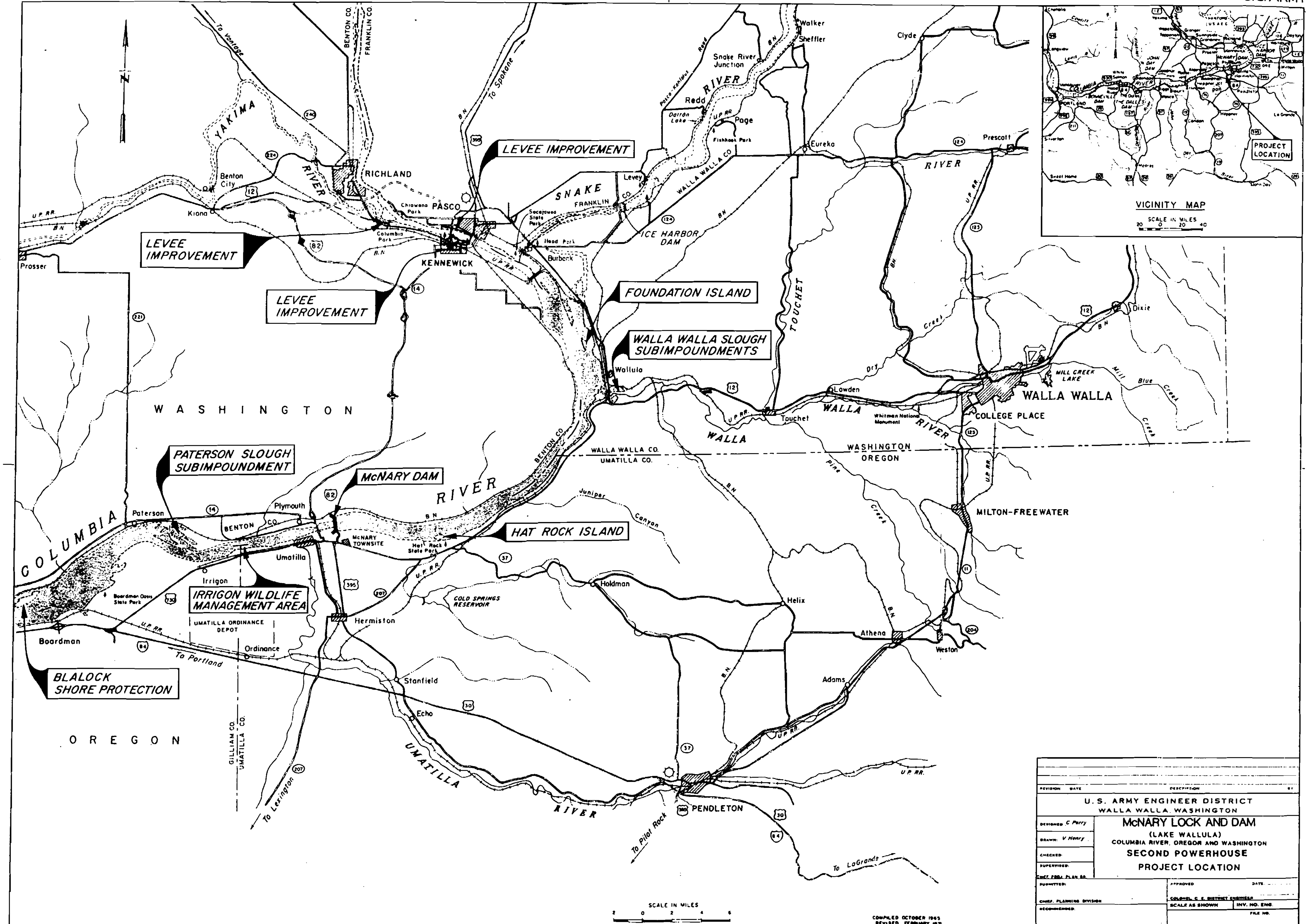
McNARY SEDIMENTATION RANGES

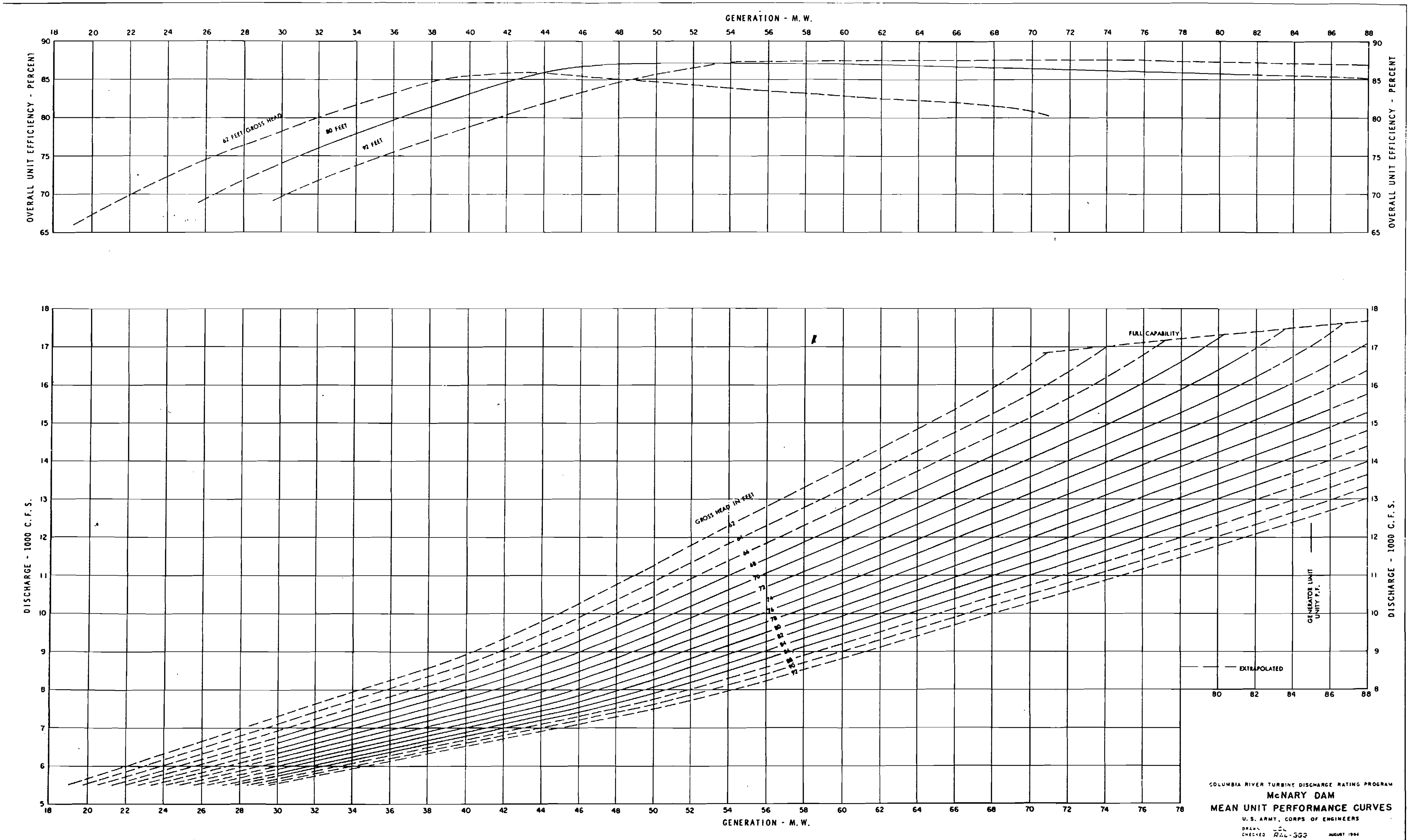
	MONUMENT DESIGNATION	RIVER MILES	ELEVATION	NORTHING	EASTING	STATION LEFT TO RIGHT
63	R1ALA			336001.44	2321458.18	0+00.00
	R1ARA			337150.00	2319350.00	24+00.75
64	R2ALA	334.93		338000.00	2323100.00	0+00.00
	R2ARA			337000.00	2321800.00	16+40.12
65	R3LB		371.90	340805.38	2316761.47	10+00.00
	R3LA		368.51	340604.55	2316681.97	12+15.99
	R3RA		364.40	337081.35	2315287.23	50+05.22
	R3RB		363.91	336696.84	2315135.02	54+18.76
66	R4LB		368.09	338382.24	2312660.85	10+00.00
	R4LA		365.63	337722.46	2312596.36	16+62.92
	R4RA		378.95	334509.98	2312282.36	48+90.71
	R4RB		393.31	334392.70	2312270.90	50+08.55
67	R5LB		364.15	338904.82	2310312.04	10+00.00
	R5LA		367.44	338235.62	2310070.34	17+11.51
	R5RA		375.33	336156.85	2309319.57	39+21.70
	R5RB		393.57	336054.86	2309282.74	40+30.14
68	R6LB		370.84	339376.18	2307529.64	10+00.00
	R6LA		367.59	339306.42	2307460.55	10+98.18
	R6RA		365.45	338397.32	2306560.18	23+77.69
	R6RB		388.45	338370.12	2306533.24	24+15.97
69	R7LB		399.70	341129.71	2305594.15	10+00.00
	R7LA		392.67	341038.25	2305524.06	11+15.23
	R7RA		381.73	339635.67	2304449.20	28+82.30
	R7RB		402.67	339536.25	2304373.01	30+07.56
70	R8LC		395.34	343397.97	2302824.26	10+00.00
	R8LB		376.85	342403.81	2302393.57	20+83.44
	R8LA		366.91	342320.73	2302357.57	21+73.99
	R8RA		385.60	341633.04	2302059.65	29+23.44
	R8RB		402.53	341608.07	2302048.83	29+50.65
71	R9LC		387.34	344590.85	2301130.92	10+00.00
	R9RB		403.94	344519.61	2299512.26	26+20.23
72	R10LC		406.58	347201.31	2301765.43	10+00.00
	R10LB		401.09	347155.62	2301597.32	11+74.21
	R10LA		375.87	347139.50	2301538.01	12+35.67
	R10RA		378.26	346435.54	2298948.02	39+19.62
	R10RC		405.98	346263.30	2298314.35	45+56.20
	R10RD		416.44	346215.51	2298138.52	47+38.41
73	R11LB		382.65	350657.55	2301462.95	10+00.00
	R11LA		373.22	350585.21	2301373.35	11+15.16
	R11RA		381.29	348012.58	2298187.46	52+10.07
	R11RB(DES)			347964.76	2298128.23	52+86.20
	R11RC		405.25	347703.89	2297805.18	57+01.42
	R11RD		417.12	347634.78	2297719.60	58+11.43

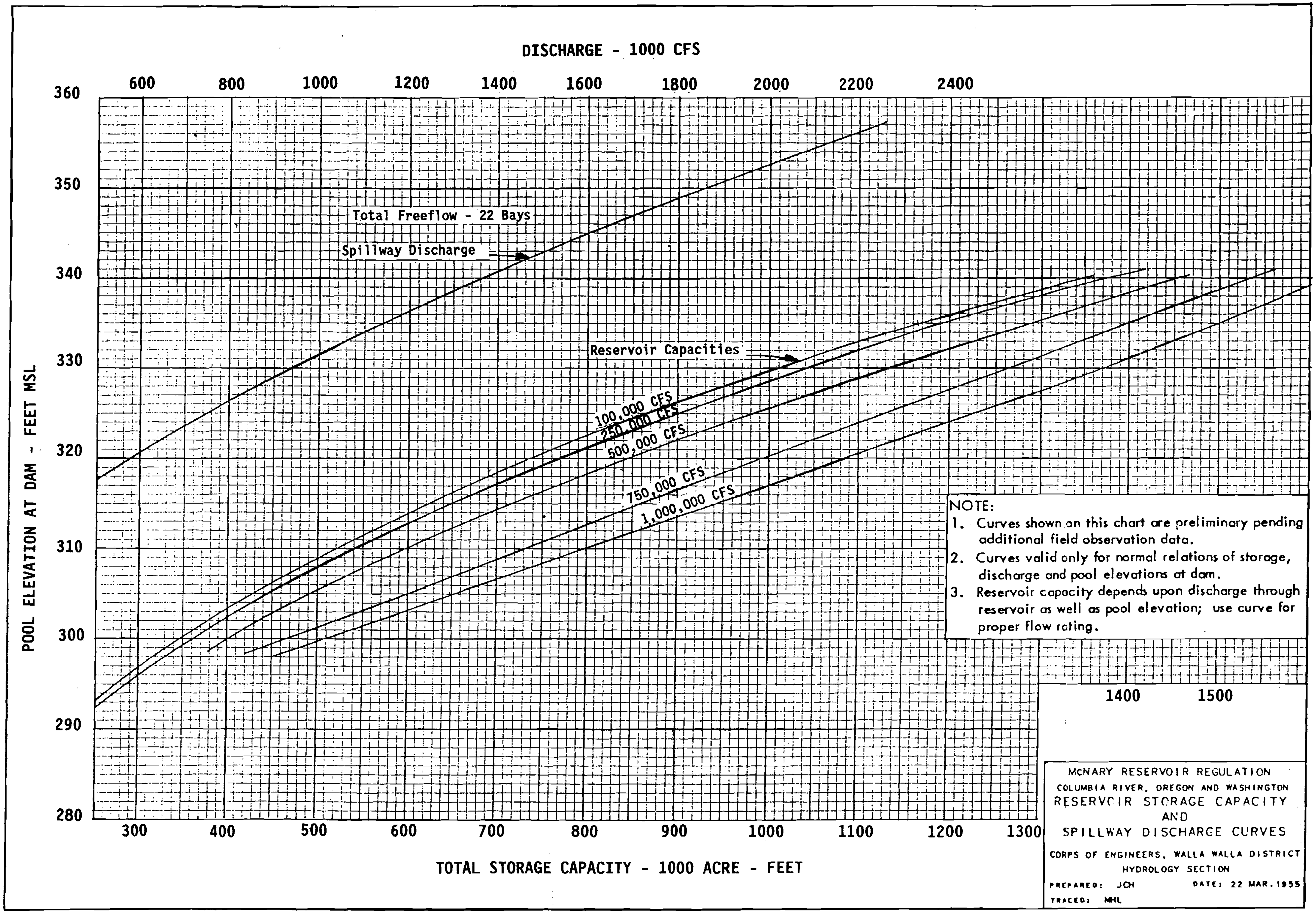
McNARY LOCK AND DAM - WATER CONTROL MANUAL

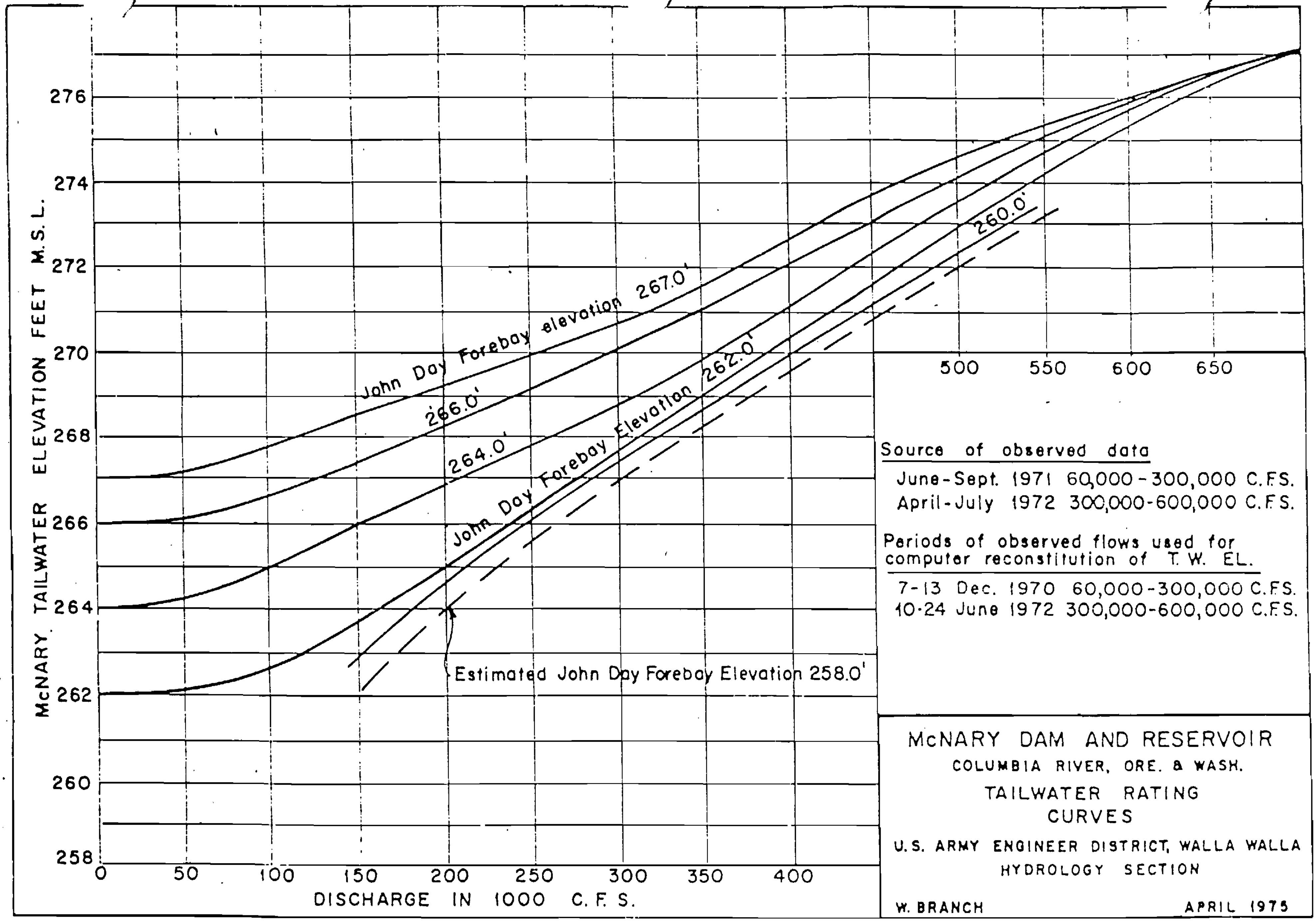
PLATES

3-1 McNary Lock and Dam Project Location Map
3-2 McNary Lock and Dam Project Plan
3-3 Mean Unit Performance Curves
3-4 Reservoir Storage Capacity and Spillway Discharge Curves
3-5 Tailwater Rating Curves
3-6.1 Navigation Lock, General Plan and Sections
3-6.2 Stoplogs Types I, II, III, & IV, Plan and Sections
3-6.3 Auxiliary Stoplogs Plan and Sections
3-6.4 Stoplog Storage Pits Plan and Sections
3-7 Fingerling Facility, General Plan and Sections
3-8 McNary Land Use Map (5 Sheets)
3-9 McNary Lock and Dam, Lake Water Surface Profiles
3-10 Pondage Drawdown - Refill Versus Time
3-11 McNary Levee System - General Plan
4-1 Columbia River Basin - Climatic Characteristics
4-2 Daily Discharge Hydrographs - McNary Reservoir Computed Regulated Inflow (2 Sheets)
4-3 Summary Hydrographs - McNary Reservoir Computed Regulated Inflow
4-4 Summary Hydrographs - Snake River below Ice Harbor Dam
4-5 Summary Hydrographs - Columbia River below Priest Rapids Dam
4-6 Summary Hydrographs - Yakima River at Kiona, Washington
5-La McNary Reservoir - Sedimentation Ranges (Index Sheet)
5-1 McNary Reservoir - Sedimentation Ranges (6 Sheets)
8-1.1 Right Abutment - Detailed Plan
8-1.2 Right Abutment - Railroad Stoplog Structure
8-2 Levee 5D, Kennewick, Washington - Plan and Profile
8-3 Levee 12-1, Pasco, Washington - Plan and Profile
8-4.1 Levee 2C, Richland, Washington - Plan, Profile, and Details
(Station 00+50 to Station 25+00)
8-4.2 Levee 2C, Richland, Washington - Plan, Profile, and Details (Station 25+00 to Station 80+76)
9-1 Flood Frequency Curves - Snake River at Lower Granite Dam
9-2 Flood Frequency Curves - Columbia River at Trinidad (Columbia River below Priest Rapids Dam)
9-3 Flood Frequency Curves - Columbia River at The Dalles

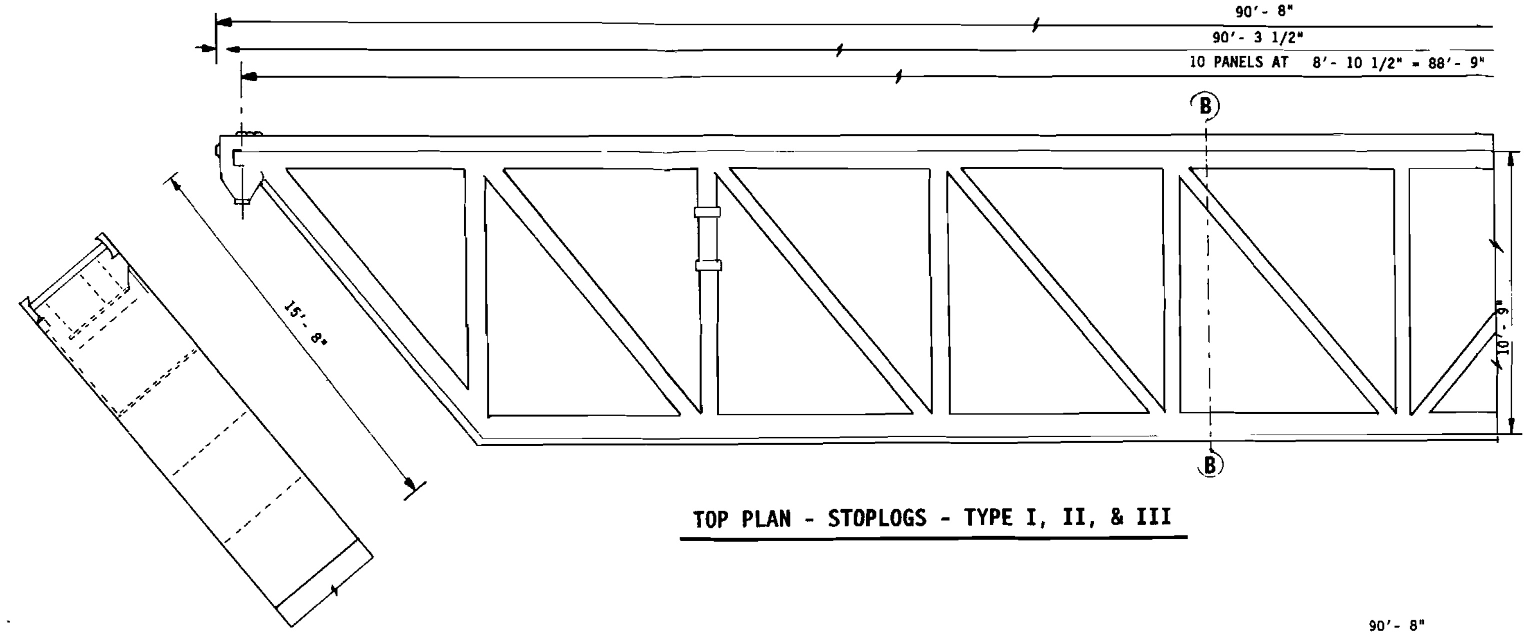

LEVEE IMPROVEMENT
LEVEE IMPROVEMENT
LEVEE IMPROVEMENT
FOUNDATION ISLAND
WALLA WALLA SLOUGH SUBIMPOUNDMENTS
PATERSON SLOUGH SUBIMPOUNDMENT
McNARY DAM
HAT ROCK ISLAND
IRRIGON WILDLIFE MANAGEMENT AREA
BLALOCK SHORE PROTECTION
YAKIMA RIVER
SNAKE RIVER
COLUMBIA RIVER
WALLA WALLA RIVER
TOUCHET RIVER
UMATILLA RIVER
WASHINGTON
OREGON
RICHLAND
PASCO
KENNEWICK
WALLA WALLA
COLLEGE PLACE
MILTON-FREEWATER
PENDLETON
Prosser
Benton City
Kiona
Paterson
Plymouth
Umatilla
Irrigon
Boardman
Hermiston
Stanfield
Echo
Holdman
Helix
Athena
Weston
Adams
Wallula
Touchet
Lowden
Dixie
Eureka
Prescott
Clyde
Walker
Sheffler
Burbank
ICE HARBOR DAM
MILL CREEK LAKE
COLD SPRINGS RESERVOIR
UMATILLA ORDINANCE DEPOT
Ordinance
McNARY TOWNSITE
To Vantage
To Spokane
To Portland
To Lexington
To Pilot Rock
To LaGrande
WALLA WALLA CO.
UMATILLA CO.
BENTON CO.
FRANKLIN CO.
GILLIAM CO.
VICINITY MAP
PROJECT LOCATION
SCALE IN MILES
COMPILED OCTOBER 1965
REVISED FEBRUARY 1975
U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON
McNARY LOCK AND DAM
(LAKE WALLULA)
COLUMBIA RIVER, OREGON AND WASHINGTON
SECOND POWERHOUSE
PROJECT LOCATION


GENERATION - M.W.
OVERALL UNIT EFFICIENCY - PERCENT
62 FEET GROSS HEAD
80 FEET
92 FEET
DISCHARGE - 1000 C.F.S.
FULL CAPABILITY
GROSS HEAD IN FEET
62
64
66
68
70
72
74
76
78
80
82
84
86
88
90
92
GENERATOR LIMIT
UNITY P.F.
EXTRAPOLATED
GENERATION - M.W.
COLUMBIA RIVER TURBINE DISCHARGE RATING PROGRAM
McNARY DAM
MEAN UNIT PERFORMANCE CURVES
U. S. ARMY, CORPS OF ENGINEERS
AUGUST 1964

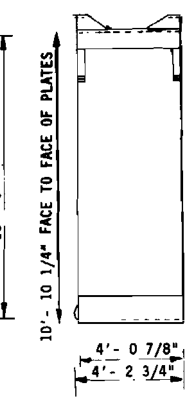

DISCHARGE - 1000 CFS
600
800
1000
1200
1400
1600
1800
2000
2200
2400
360
350
340
330
320
310
300
290
280
POOL ELEVATION AT DAM - FEET MSL
Total Freeflow - 22 Bays
Spillway Discharge
Reservoir Capacities
100,000 CFS
250,000 CFS
500,000 CFS
750,000 CFS
1,000,000 CFS
NOTE:
1. Curves shown on this chart are preliminary pending additional field observation data.
2. Curves valid only for normal relations of storage, discharge and pool elevations at dam.
3. Reservoir capacity depends upon discharge through reservoir as well as pool elevation; use curve for proper flow rating.
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
TOTAL STORAGE CAPACITY - 1000 ACRE - FEET
MCNARY RESERVOIR REGULATION
COLUMBIA RIVER, OREGON AND WASHINGTON
RESERVOIR STORAGE CAPACITY
AND
SPILLWAY DISCHARGE CURVES
CORPS OF ENGINEERS, WALLA WALLA DISTRICT
HYDROLOGY SECTION
PREPARED: JCH
DATE: 22 MAR. 1955
TRACED: MHL



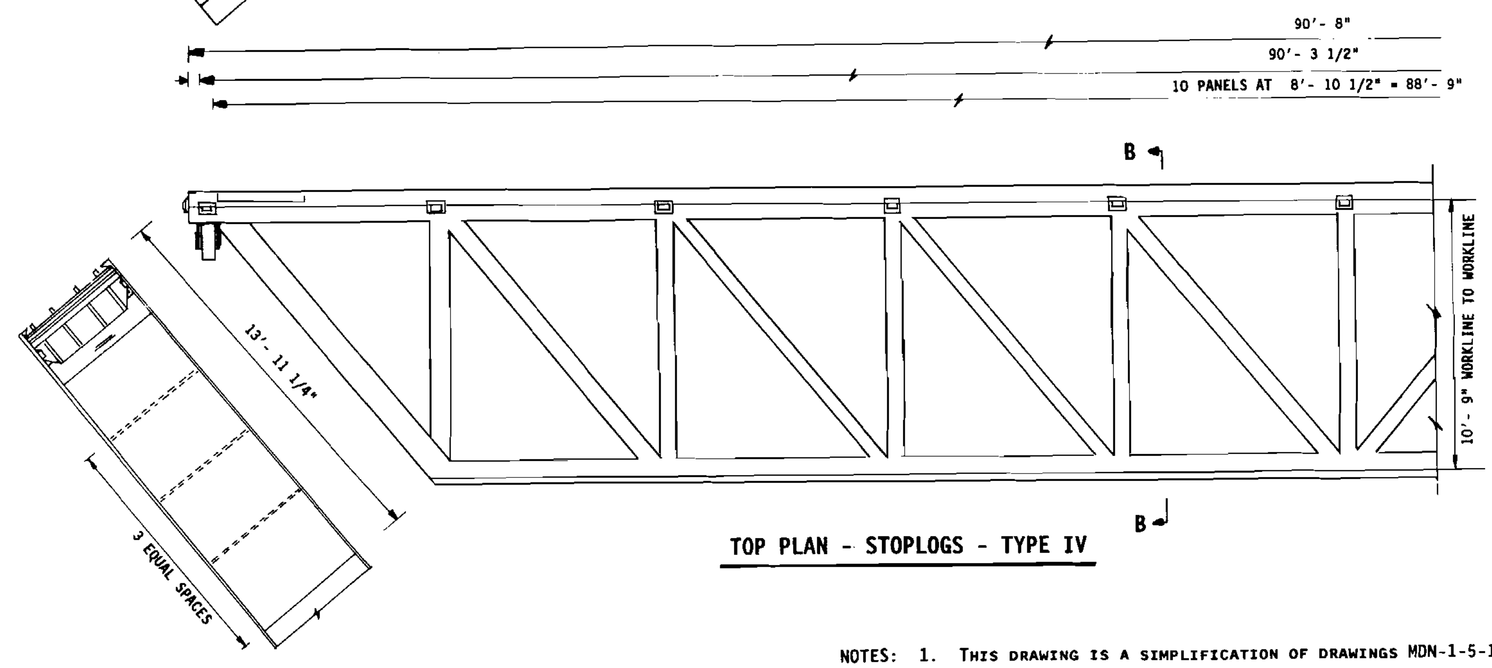
McNARY TAILWATER ELEVATION FEET M.S.L.
DISCHARGE IN 1000 C.F.S.
258
260
262
264
266
268
270
272
274
276
0
50
100
150
200
250
300
350
400
500
550
600
650
John Day Forebay elevation 267.0'
266.0'
264.0'
John Day Forebay Elevation 262.0'
260.0'
Estimated John Day Forebay Elevation 258.0'
Source of observed data
June-Sept. 1971 60,000-300,000 C.F.S.
April-July 1972 300,000-600,000 C.F.S.
Periods of observed flows used for computer reconstitution of T. W. EL.
7-13 Dec. 1970 60,000-300,000 C.F.S.
10-24 June 1972 300,000-600,000 C.F.S.
McNARY DAM AND RESERVOIR
COLUMBIA RIVER, ORE. & WASH.
TAILWATER RATING CURVES
U.S. ARMY ENGINEER DISTRICT, WALLA WALLA
HYDROLOGY SECTION
W. BRANCH
APRIL 1975



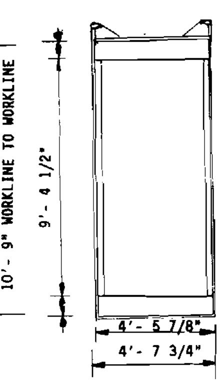
TOP PLAN - STOPLOGS - TYPE I, II, & III



SECTION B-B



TOP PLAN - STOPLOGS - TYPE IV

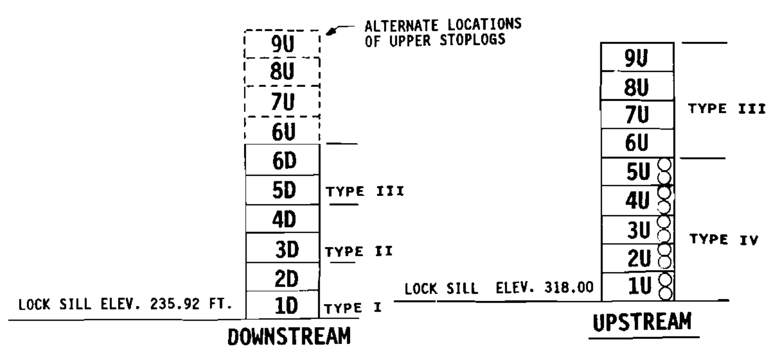


SECTION B-B

FOR INFORMATION ONLY

NOTES: 1. This drawing is a simplification of drawings MDN-1-5-10/2.1 (contract No. 85, sheet 35) and MDN-1-5-10/3 (contract No. 85, sheet 36) for the arrangement and location of Navigation Lock Stoplogs - Type I, II, III, and IV.
2. Drawing MDN-1-5-10/2.1 is no longer an active number and is drawing is no longer on file at McNary.
3. Source of drawings MDN-1-5-10/2.1 and MDN-1-5-10//3 is the Walla Walla District Support Services Branch Reprographics Section - microfilm files.

SCALE IN FEET



LOCATION DIAGRAM

FURNISH TWO STOPLOGS TYPE I - NA 1D, 2D
FURNISH TWO STOPLOGS TYPE II - NA 3D, 4D
FURNISH SIX STOPLOGS TYPE III - NA 5D, 6D, 6U, TO 9U INCL
FURNISH FIVE STOPLOGS TYPE IV - NA 1U TO 5U INCL

NOTE: STOPLOGS No 1U AND 1D HAVE BOTTOM SEAL - SEE MDN-1-5-10/4 & 5

REVISION	DATE	DESCRIPTION	CHKD	APPR

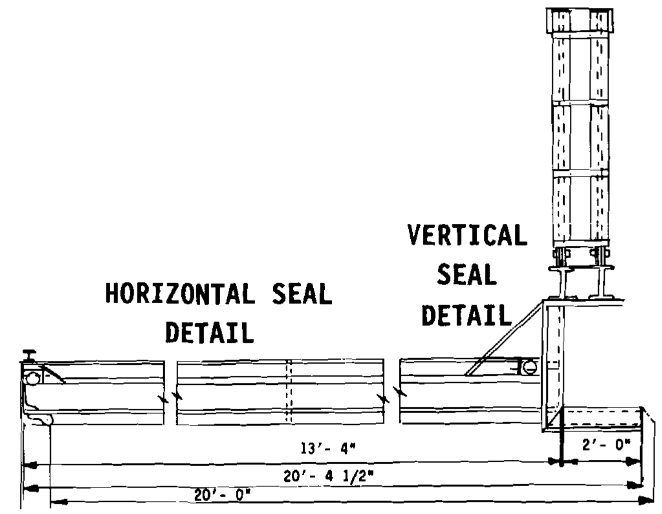
U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

DESIGNED BY
DRAWN BY A. Roberts
CHECK BY E. Kim
CHECKED BY
SUBMITTED Mark Lindgren
CHIEF Hydrology B.
SUBMITTED
J. P. Armacost, P.E.
CHIEF Planning Division

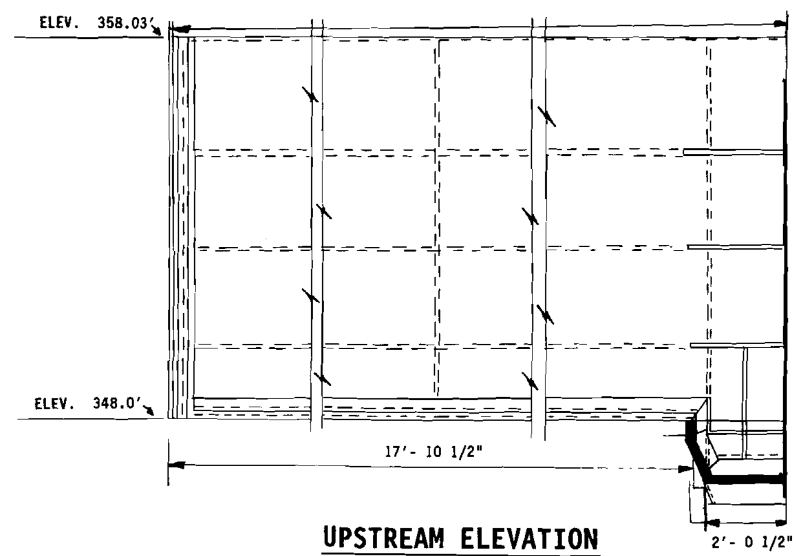
Mc Nary Dam Project
COLUMBIA RIVER, OREGON - WASHINGTON
NAVIGATION LOCK
STOPLOGS - TYPE I, II, III, & IV

DATE July 1989
SCALE AS SHOWN | INV. NO.
SHEET NO. | FILE NO.

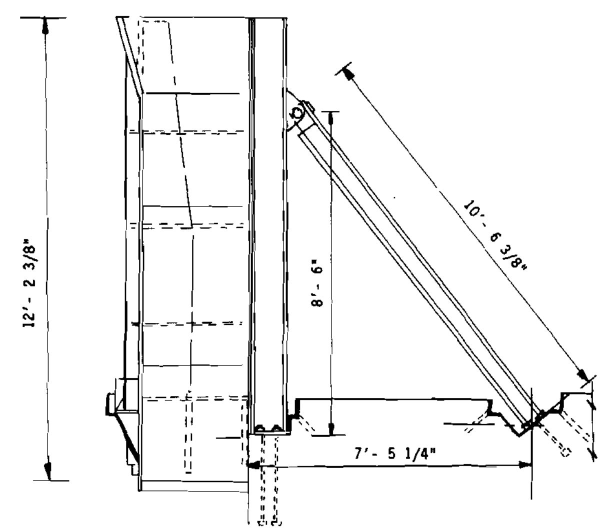
WATER CONTROL MANUAL PLATE 3-6.2



PLAN



UPSTREAM ELEVATION



END VIEW

NOTES:
1. THIS DRAWING IS A SIMPLIFICATION OF DRAWING MDN-1-5-10/6 (CONTRACT NO. 85, SHEET 39) FOR THE ARRANGEMENT OF NAVIGATION LOCK AUXILIARY STOPLOG.
2. SOURCE OF DRAWING MDN-1-5-10/6 IS THE WALLA WALLA DISTRICT SUPPORT SERVICES BRANCH REPROGRAPHICS SECTION - MICROFILM FILES.

FOR INFORMATION ONLY

SCALE IN FEET

2 1 0 1

REVISION	DATE	DESCRIPTION	CHKD	APPR

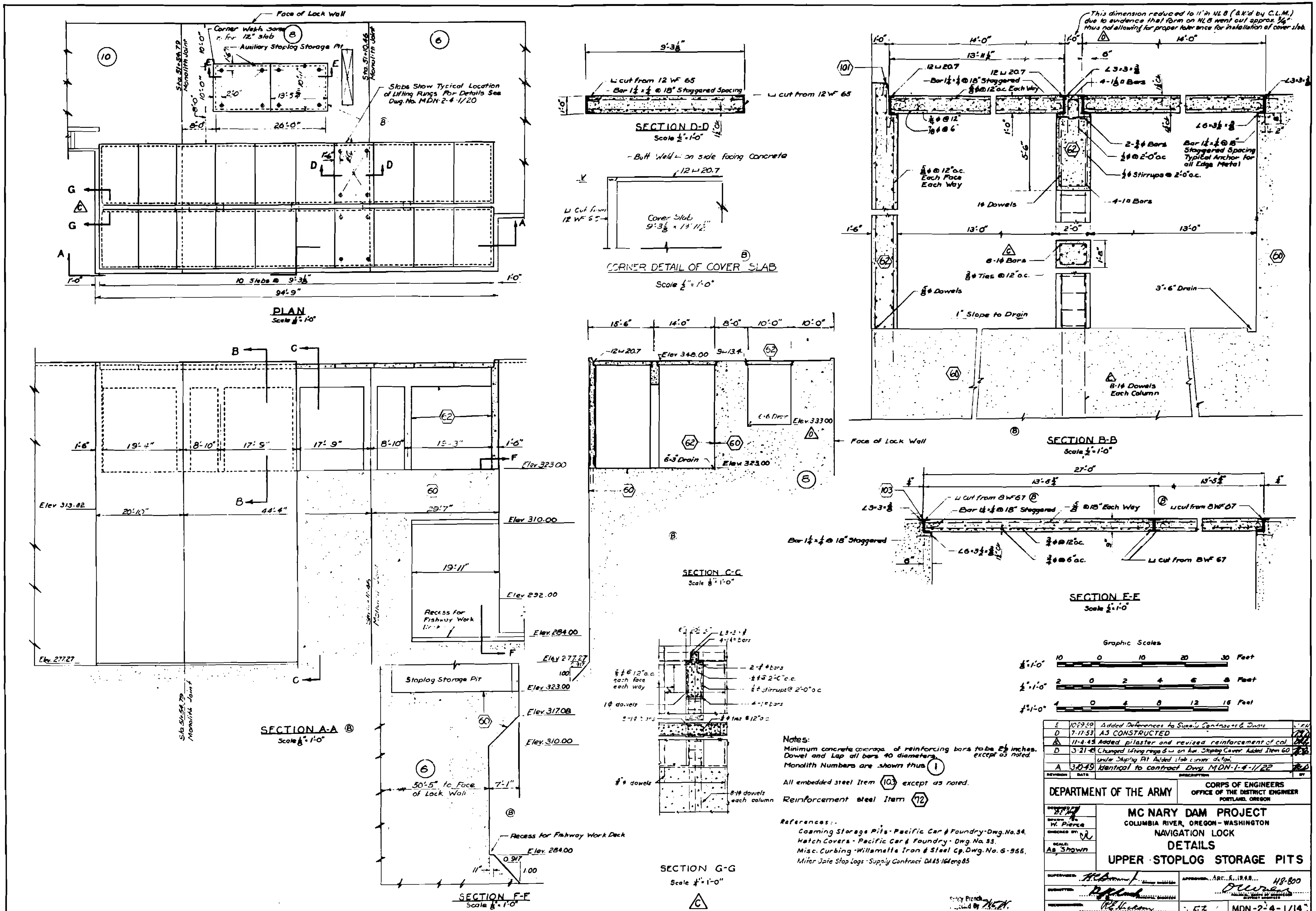
U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

DESIGNED BY A. Roberts
DRAWN BY E. Kim
CHECKED BY
CHIEF Hydrology B.
SUBMITTED
CHIEF Planning Division

MC NARY DAM PROJECT
COLUMBIA RIVER, OREGON - WASHINGTON
NAVIGATION LOCK
AUXILIARY STOPLOG

DATE: July 1989

SCALE AS SHOWN | INV. NO.
SHEET NO. | FILE NO.



Notes:
Minimum concrete coverage of reinforcing bars to be 2 1/2 inches, except as noted.
Dowel and Lap all bars 40 diameters.
Monolith Numbers are shown thus (1)
All embedded steel Item (103) except as noted.
Reinforcement steel Item (72)

References:-
Coaming Storage Pits - Pacific Car & Foundry - Dwg. No. 34.
Hatch Covers - Pacific Car & Foundry - Dwg. No. 33.
Misc. Curbing - Willamette Iron & Steel Co. Dwg. No. G-966.
Miter Gate Stop Logs - Supply Contract DA45-164eng85

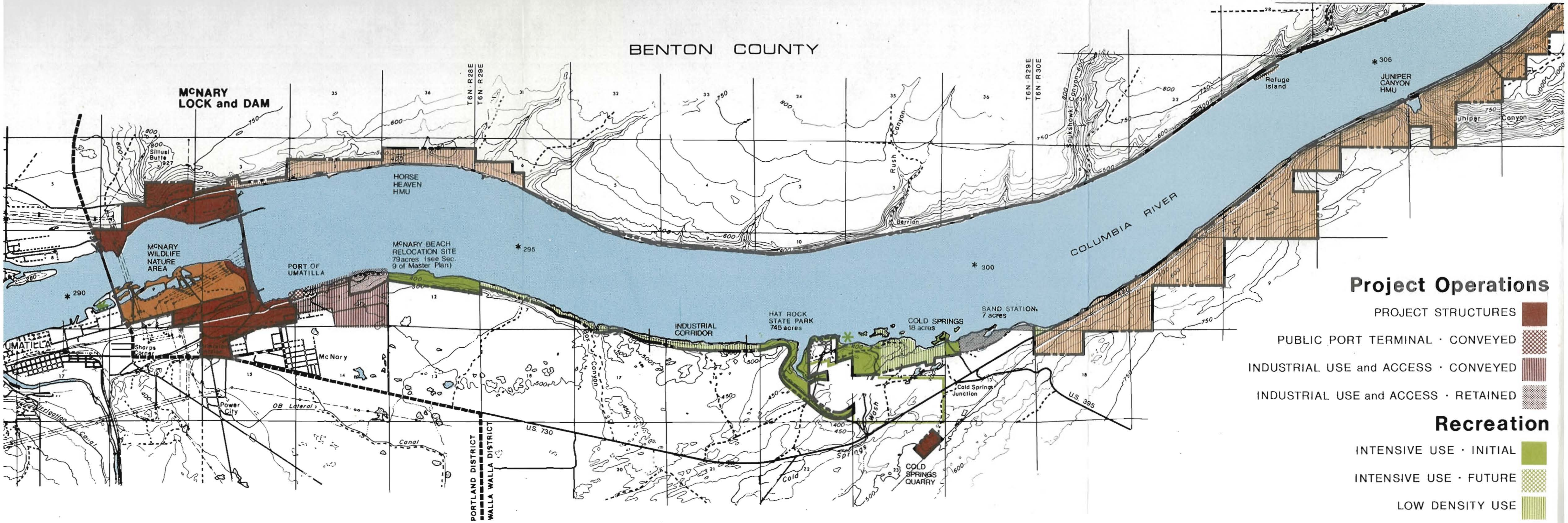
Revision	Date	Description	By
E	10-29-59	Added References to Supply Contracts & Dwgs	
D	7-17-53	AS CONSTRUCTED	
△	11-4-49	Added pilaster and revised reinforcement of col.	
D	3-21-49	Changed lifting rings 6-⊔ on Aux. Stoplog Cover. Added Item 60 under Stoplog Pit. Added slab corner detail.	
A	3-10-49	Identical to contract Dwg. MDN-1-4-1/22	

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
OFFICE OF THE DISTRICT ENGINEER
PORTLAND, OREGON

MC NARY DAM PROJECT
COLUMBIA RIVER, OREGON-WASHINGTON
NAVIGATION LOCK
DETAILS
UPPER STOPLOG STORAGE PITS

Drawn: W. Pierce
Scale: As Shown
Approved: Apr. 6, 1948
48-800
53 | MDN-2-4-1/14

Cont 5108 FILMED P. Vol I



Project Operations

PROJECT STRUCTURES

PUBLIC PORT TERMINAL · CONVEYED

INDUSTRIAL USE and ACCESS · CONVEYED

INDUSTRIAL USE and ACCESS · RETAINED

Recreation

INTENSIVE USE · INITIAL

INTENSIVE USE · FUTURE

LOW DENSITY USE

MARINA

Fish and Wildlife

INTENSIVE MANAGEMENT

MODERATE MANAGEMENT

Other

NATURAL AREA

FLOWAGE EASEMENT LANDS

uncolored areas within the project boundary are either railroads or highway rights-of-way

MAJOR ROADS

RAILROADS

PROJECT BOUNDARY

LAKE WALLULA
normal pool · 340 m.s.l.

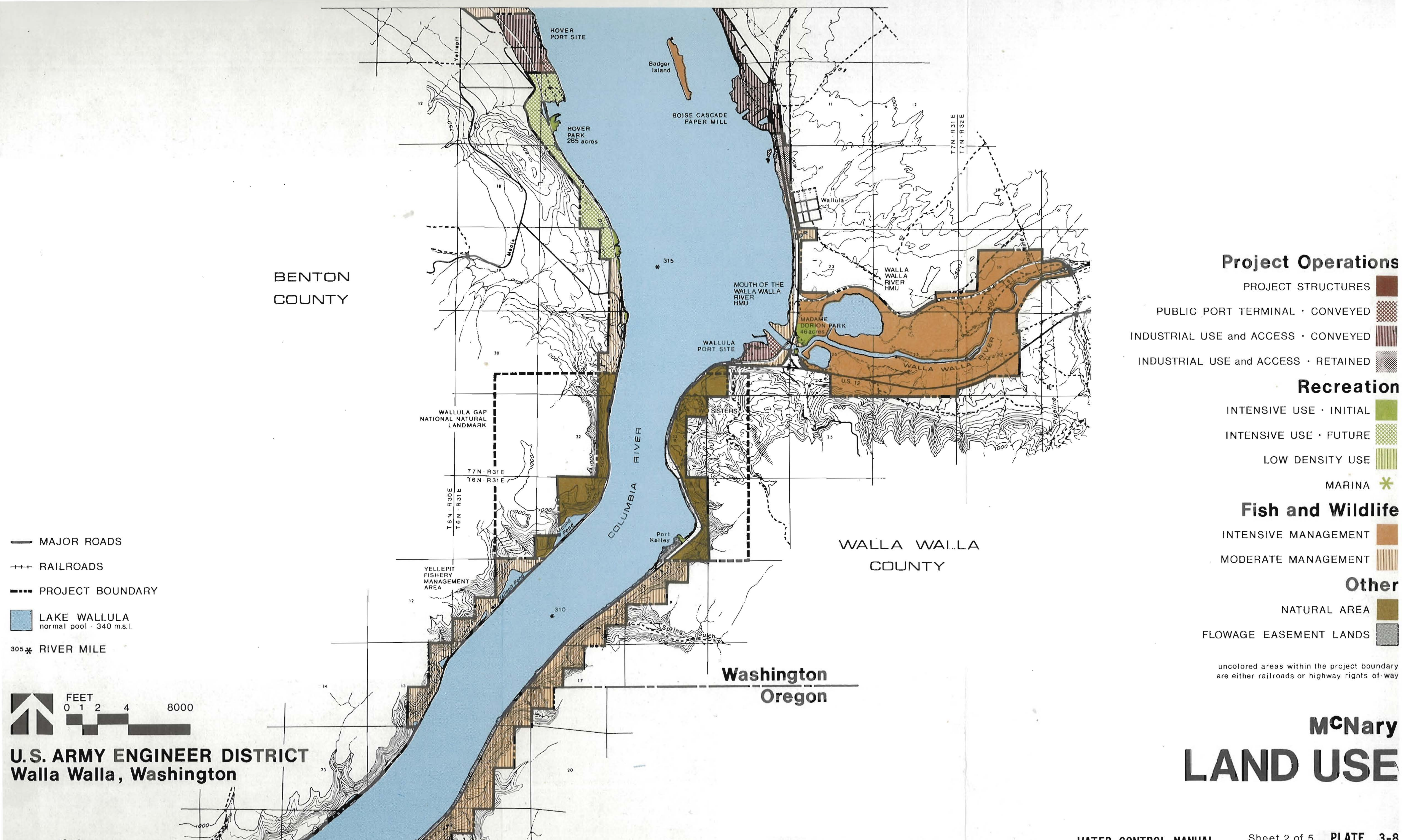
05 * RIVER MILE

FEET
0 1 2 4 8000

J.S. ARMY ENGINEER DISTRICT
Walla Walla, Washington

McNary
LAND USE

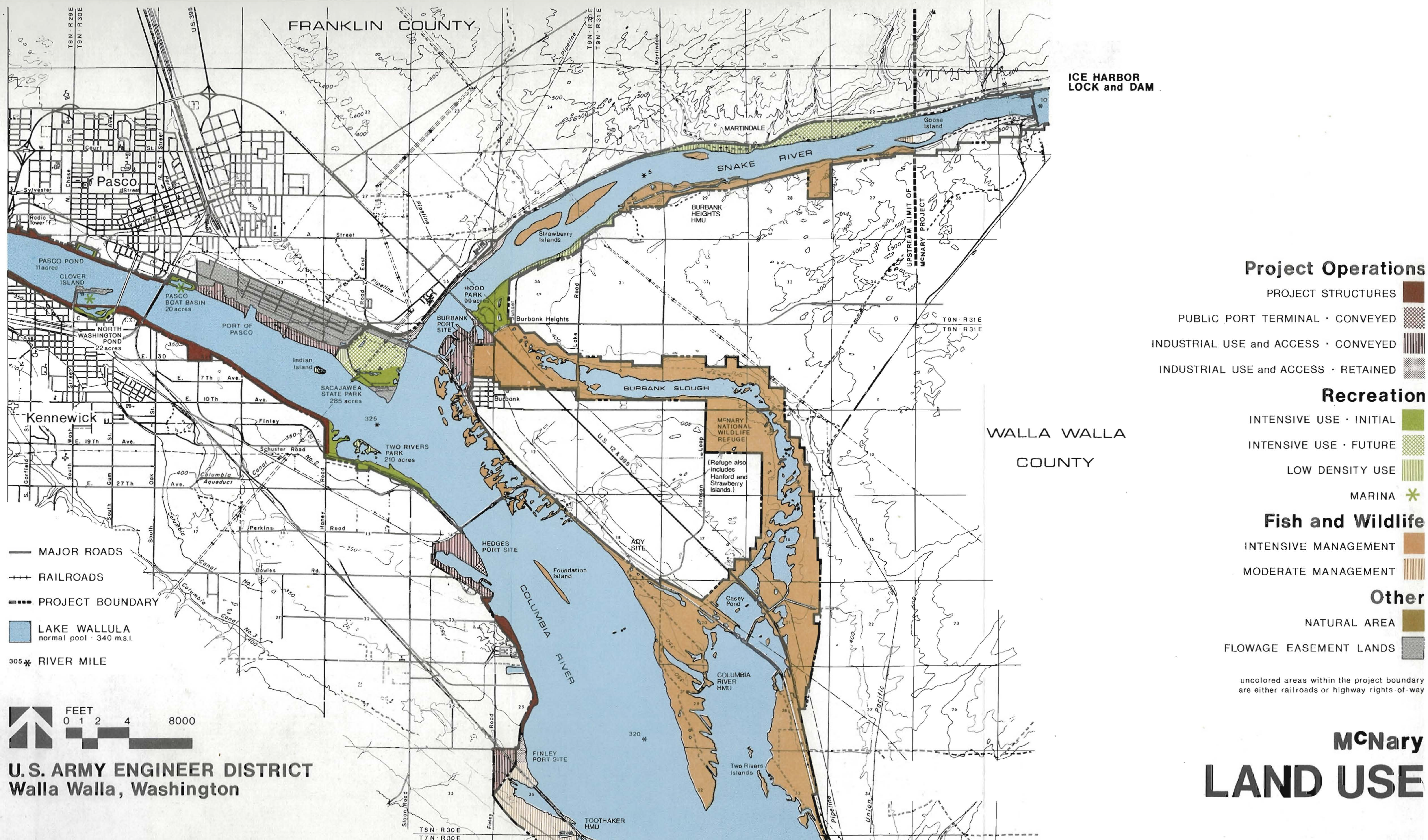
1982

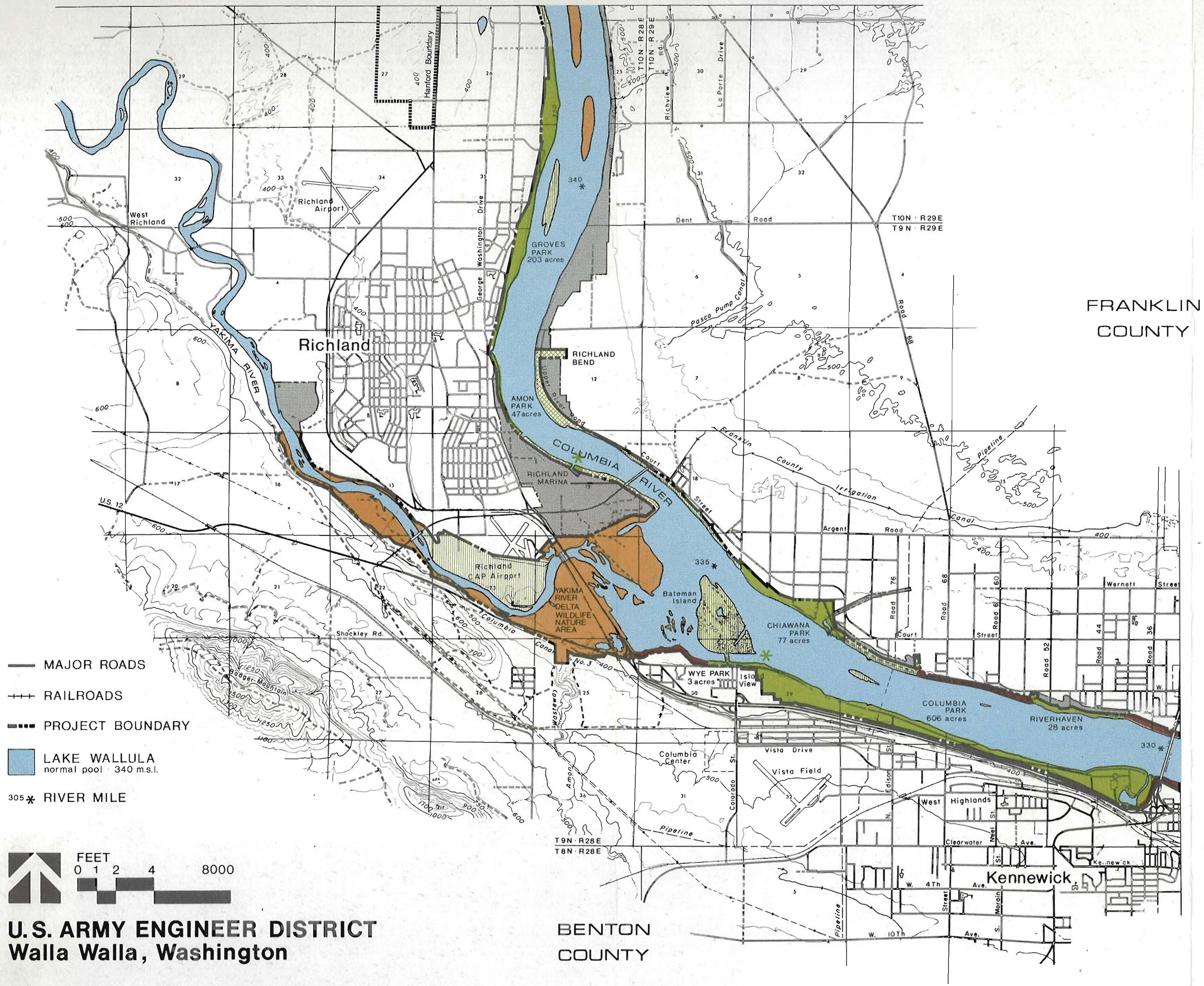


U.S. ARMY ENGINEER DISTRICT
Walla Walla, Washington

1982

McNary
LAND USE


FRANKLIN COUNTY
ICE HARBOR LOCK and DAM
WALLA WALLA COUNTY
Pasco
Kennewick
SNAKE RIVER
COLUMBIA RIVER
MARTINDALE
Goose Island
Strawberry Islands
BURBANK HEIGHTS HMU
UPSTREAM LIMIT OF McNARY PROJECT
HOOD PARK 99 acres
BURBANK PORT SITE
Burbank Heights
Burbank
BURBANK SLOUGH
McNARY NATIONAL WILDLIFE REFUGE
(Refuge also includes Hanford and Strawberry Islands.)
PASCO POND 11acres
CLOVER ISLAND
PASCO BOAT BASIN 20 acres
NORTH WASHINGTON POND 22 acres
PORT OF PASCO
Indian Island
SACAJAWEA STATE PARK 285 acres
TWO RIVERS PARK 210 acres
HEDGES PORT SITE
Foundation Island
ADY SITE
Casey Pond
COLUMBIA RIVER HMU
Two Rivers Islands
FINLEY PORT SITE
TOOTHAKER HMU
T9N · R29E
T9N · R30E
T9N · R31E
T8N · R31E
T8N · R30E
T7N · R30E
MAJOR ROADS
RAILROADS
PROJECT BOUNDARY
LAKE WALLULA normal pool · 340 m.s.l.
305 * RIVER MILE
FEET
0 1 2 4 8000
U.S. ARMY ENGINEER DISTRICT
Walla Walla, Washington
1982
Project Operations
PROJECT STRUCTURES
PUBLIC PORT TERMINAL · CONVEYED
INDUSTRIAL USE and ACCESS · CONVEYED
INDUSTRIAL USE and ACCESS · RETAINED
Recreation
INTENSIVE USE · INITIAL
INTENSIVE USE · FUTURE
LOW DENSITY USE
MARINA
Fish and Wildlife
INTENSIVE MANAGEMENT
MODERATE MANAGEMENT
Other
NATURAL AREA
FLOWAGE EASEMENT LANDS
uncolored areas within the project boundary are either railroads or highway rights-of-way
McNary
LAND USE



U.S. ARMY ENGINEER DISTRICT
Walla Walla, Washington

1982

Project Operations
PROJECT STRUCTURES
PUBLIC PORT TERMINAL · CONVEYED
INDUSTRIAL USE and ACCESS · CONVEYED
INDUSTRIAL USE and ACCESS · RETAINED

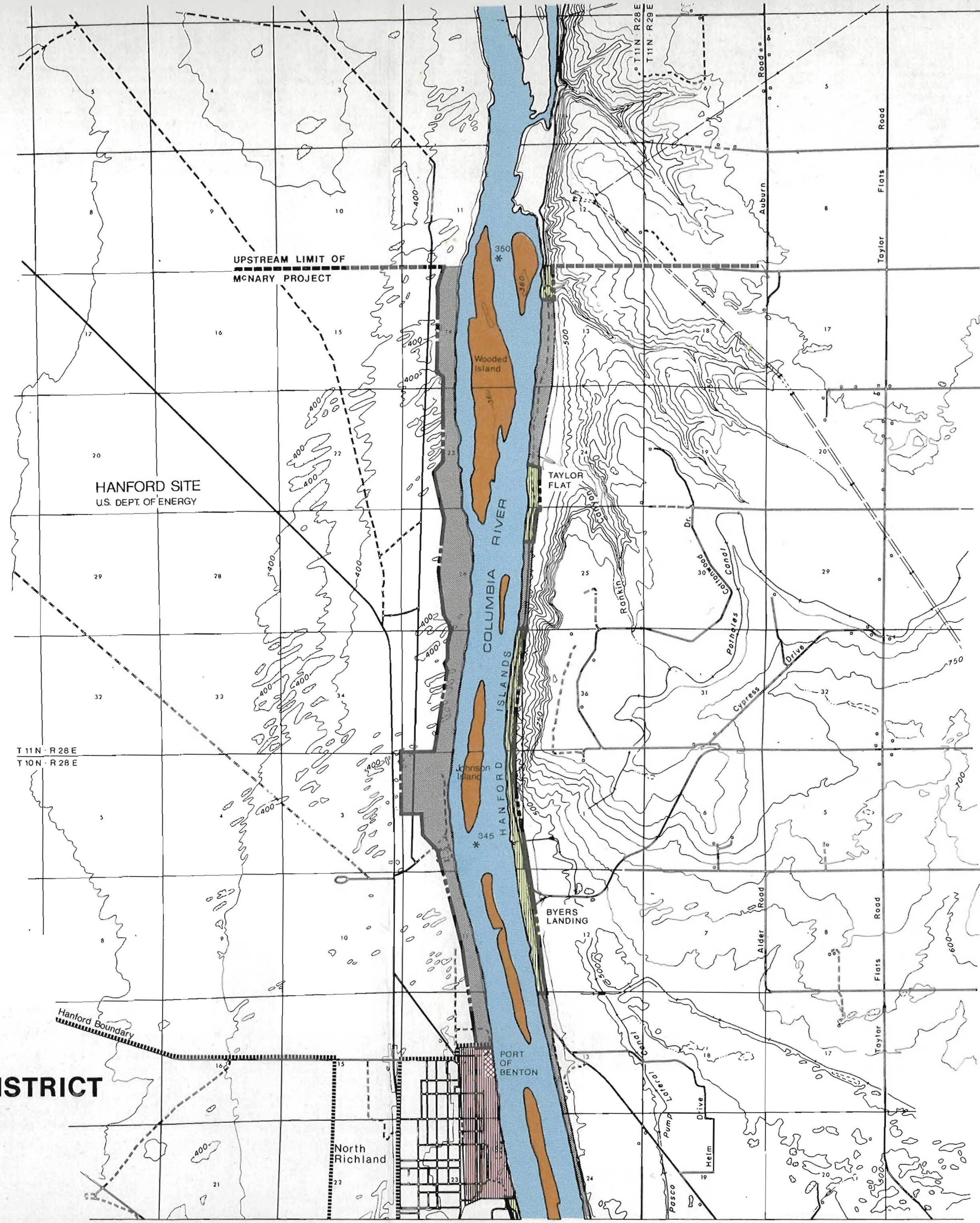
Recreation
INTENSIVE USE · INITIAL
INTENSIVE USE · FUTURE
LOW DENSITY USE
MARINA

Fish and Wildlife
INTENSIVE MANAGEMENT
MODERATE MANAGEMENT

Other
NATURAL AREA
FLOWAGE EASEMENT LANDS

uncolored areas within the project boundary are either railroads or highway rights-of-way

McNary
LAND USE



— MAJOR ROADS

-+-+- RAILROADS

---- PROJECT BOUNDARY

LAKE WALLULA
normal pool · 340 m.s.l.

305 * RIVER MILE

FEET
0 1 2 4 8000

Project Operations

PROJECT STRUCTURES

PUBLIC PORT TERMINAL · CONVEYED

INDUSTRIAL USE and ACCESS · CONVEYED

INDUSTRIAL USE and ACCESS · RETAINED

Recreation

INTENSIVE USE · INITIAL

INTENSIVE USE · FUTURE

LOW DENSITY USE

MARINA *

Fish and Wildlife

INTENSIVE MANAGEMENT

MODERATE MANAGEMENT

Other

NATURAL AREA

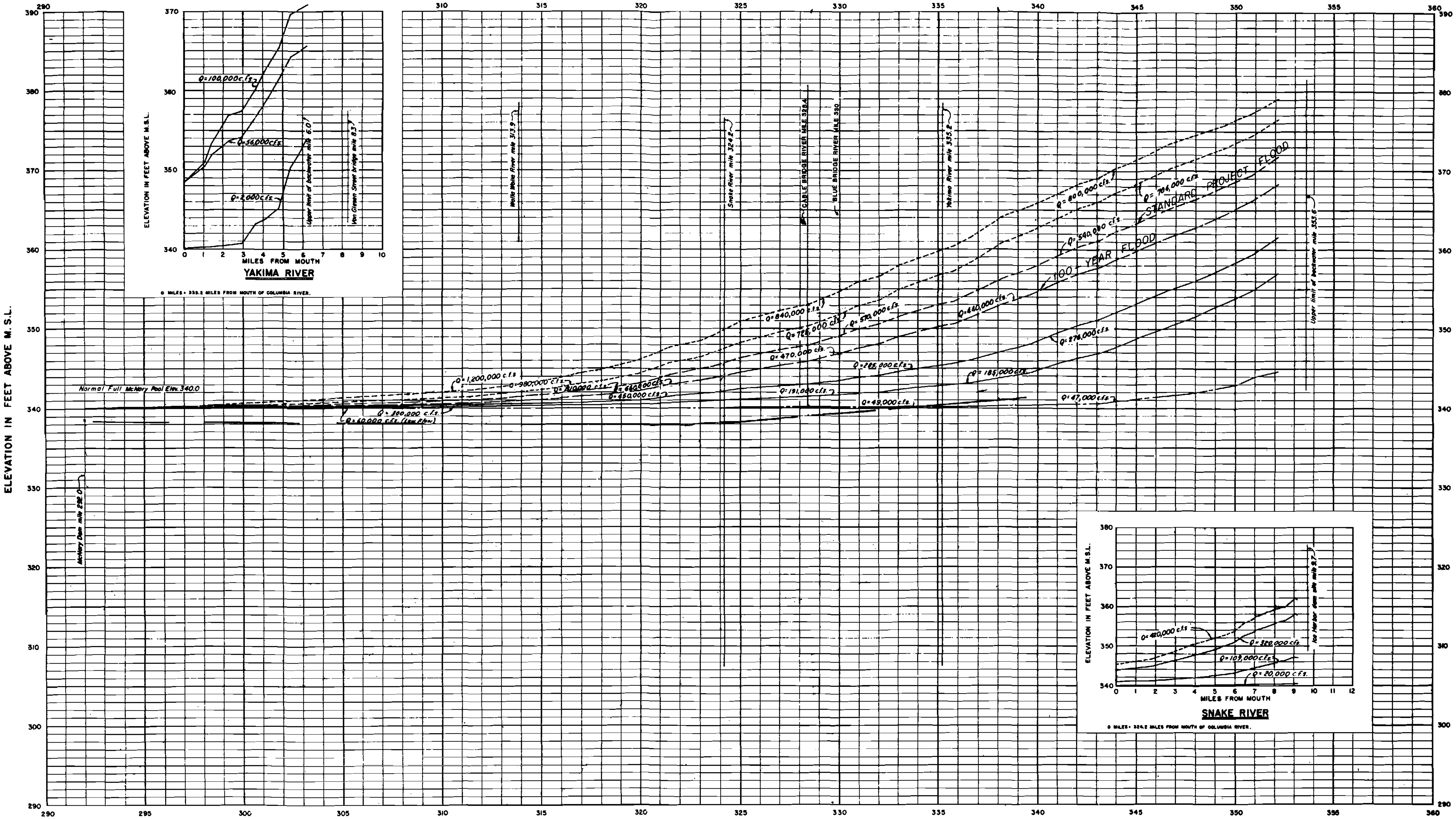
FLOWAGE EASEMENT LANDS

uncolored areas within the project boundary are either railroads or highway rights of way

U.S. ARMY ENGINEER DISTRICT
Walla Walla, Washington

1982

McNary
LAND USE



COLUMBIA RIVER MILEAGE FROM MOUTH

FLOOD	COLUMBIA RIVER REACHES		
COLUMBIA RIVER	AT McNARY DAM	ABOVE SNAKE RIVER	ABOVE YAKIMA RIVER
	C.F.S.	C.F.S.	C.F.S.
1894	1,200,000	840,000	800,000
1948	980,000	725,000	704,000
SPF 7/	810,000	570,000	540,000
1% 8/	660,000	470,000	440,000
LOW FLOW	60,000	49,000	47,000

FLOOD SNAKE RIVER	COLUMBIA RIVER BELOW SNAKE RIVER	SNAKE RIVER
	C.F.S.	C.F.S.
SPF	810,000	420,000
1%	660,000	320,000
I.H. DAM PLANT CAPAC	300,000	109,000
LOW FLOW	60,000	20,000

FLOOD YAKIMA RIVER	COLUMBIA RIVER BELOW YAKIMA RIVER	YAKIMA RIVER
	C.F.S.	C.F.S.
SPF	470,000	100,000
1%	450,000	56,000
LOW FLOW	49,000	2,000

NOTES:

1. ALL PROFILES SHOWN ARE MEAN WATER SURFACE PROFILES OF THE TRANSVERSE RIVER SECTION.
2. ALL ELEVATIONS ARE IN FEET ABOVE MEAN SEA LEVEL AND ARE REFERRED TO THE 1929 DATUM PLANE.
3. COMPUTATIONS FOR THE BACKWATER PROFILES ON COLUMBIA RIVER ARE BASED ON ADJUSTED HYDRAULIC COEFFICIENTS DERIVED FOR THE OBSERVED PROFILE OF 7 - 8 JUNE, 1978 AND FIELD SURVEYS OF FORTY FOUR SEDIMENT RANGE CROSS SECTIONS EXTENDING FROM RIVER MILE 293 TO 352. THE BACKWATER PROFILES FOR SNAKE RIVER ARE BASED ON EIGHTEEN SEDIMENT RANGE CROSS SECTIONS EXTENDING FROM THE MOUTH TO RIVER MILE 9. BACKWATER PROFILES FOR YAKIMA RIVER WERE BASED ON ELEVEN SEDIMENT RANGE CROSS SECTIONS EXTENDING FROM THE MOUTH TO RIVER MILE 6.2.
4. THE BACKWATER PROFILES HAVE AN ORIGIN AT THE McNARY NORMAL FULL POOL ELEVATION OF 340 M.S.L.
5. RIVER DISCHARGES OF 60,000 C.F.S. ON COLUMBIA RIVER AND 20,000 C.F.S. ON SNAKE RIVER WERE SELECTED TO ILLUSTRATE BACKWATER CONDITIONS AT LOW STAGES.
6. ALL BACKWATER PROFILES WERE COMPUTED WITH CONSIDERATION OF EXISTING LEVEES IN THE McNARY RESERVOIR.
7. THE SPF (STANDARD PROJECT FLOOD) FOR THE REACHES ON THE COLUMBIA RIVER ARE INTERIM VALUES PROVIDED BY NPD. PENDING A MORE DETAILED ANALYSIS OF THE EFFECTS OF CURRENT UPSTREAM REGULATION.
8. THE 1% (HUNDRED YEAR FLOOD) FOR THE REACHES ON THE COLUMBIA RIVER ARE INTERIM VALUES GIVEN IN CORRESPONDENCE DATED 28 AUG AND 25 SEPT 1974 BETWEEN NORTH PACIFIC DIVISION AND SEATTLE DISTRICT AND IN STUDIES BY THE DIVISION OFFICE.

REVISION	DATE	DESCRIPTION	BY

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

DESIGNED: J Jones
DRAWN: F. Spaulding
CHECKED: C. French
SUPERVISED: R.E. Riebel

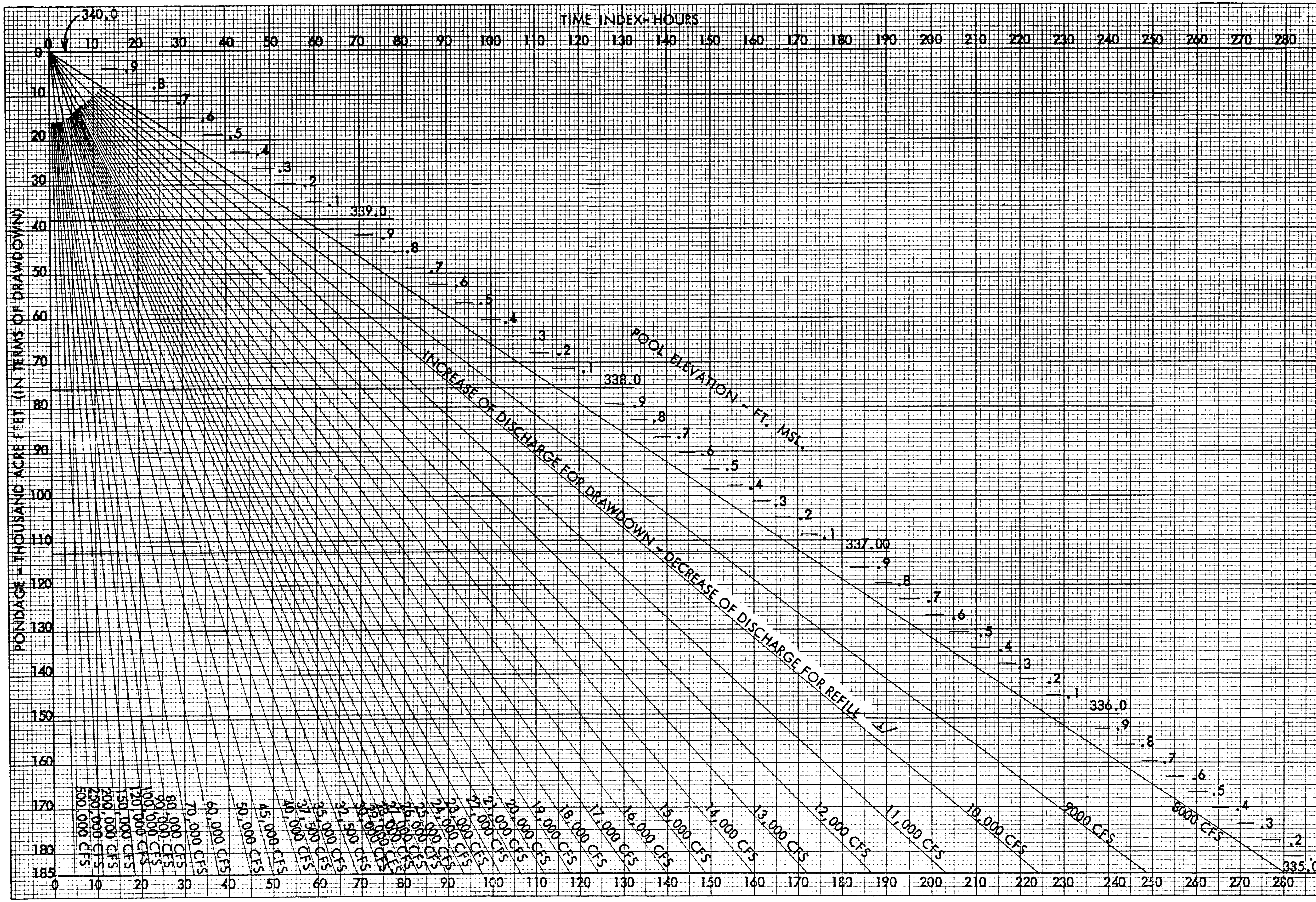
McNARY LOCK AND DAM
(LAKE WALLULA)
COLUMBIA RIVER, OREGON AND WASHINGTON

LAKE WATER SURFACE PROFILES

SUBMITTED: L.V. Armacost, P.E.
CHIEF, PLANNING DIVISION

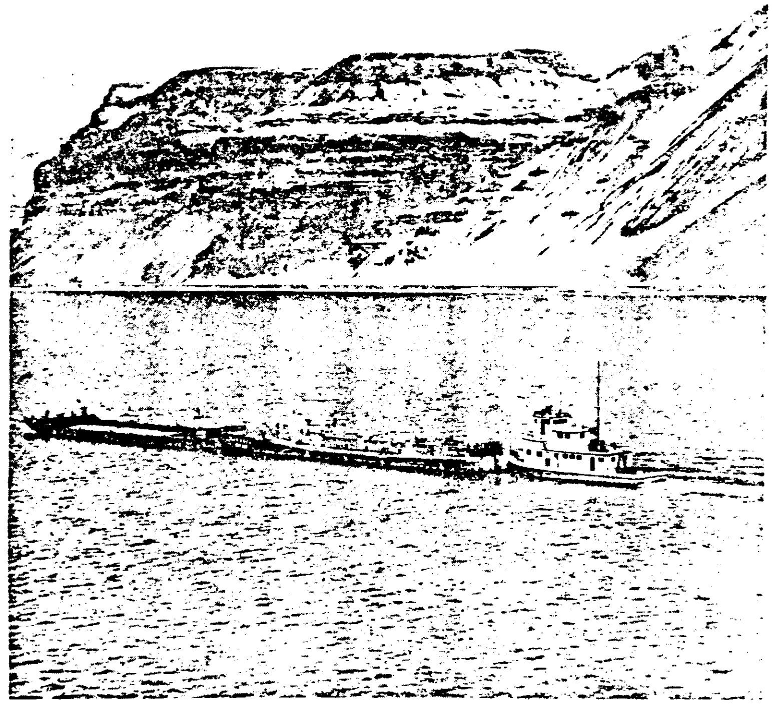
DATE May 1982

SCALE AS SHOWN | INV. NO.
FILE NO.
SHEET



NOTE:

1. Increase or decrease of discharge represents difference in river inflow to reservoir over downstream flow release from reservoir.

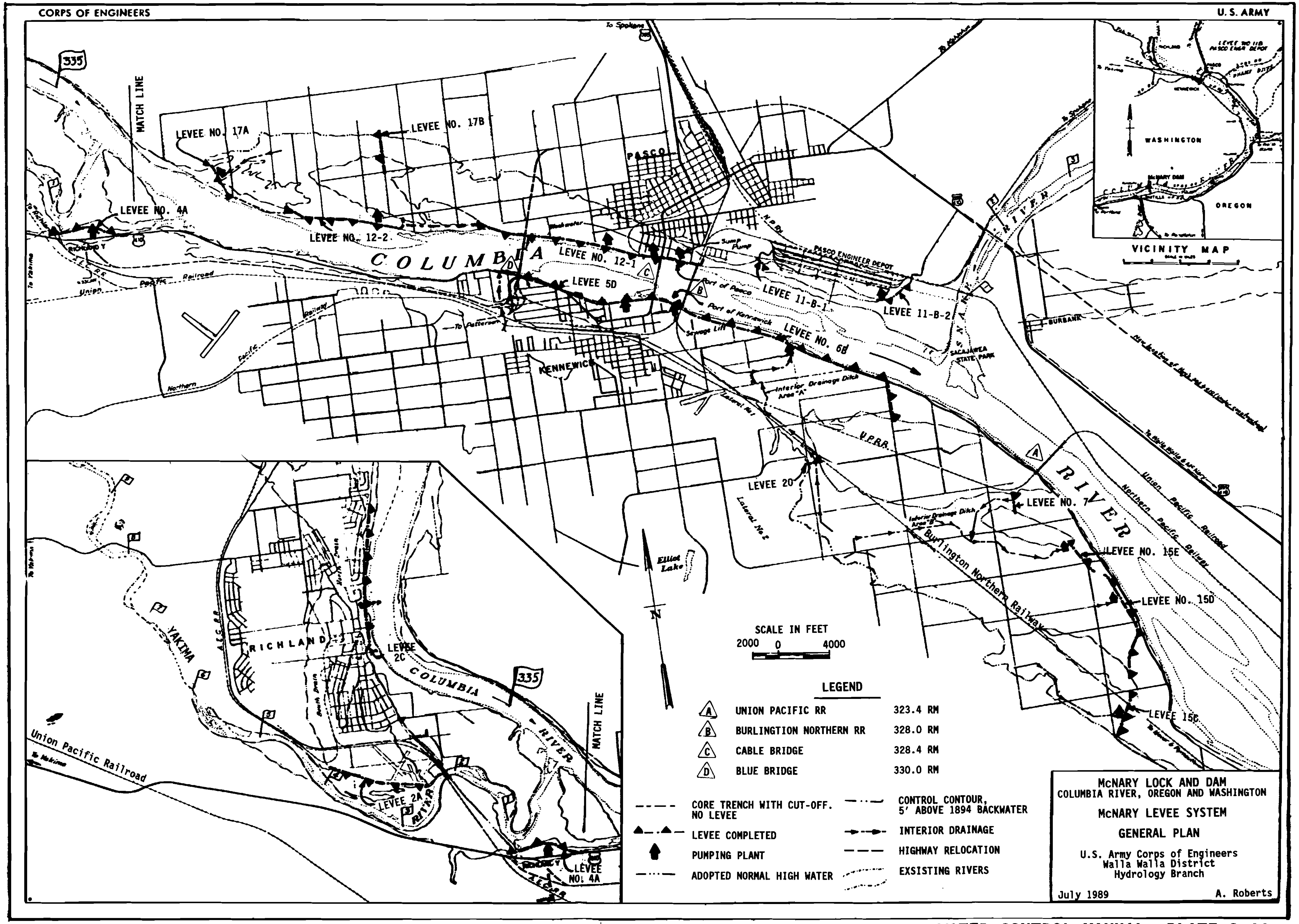


Slackwater navigation on reservoir.

MCNARY RESERVOIR REGULATION
COLUMBIA RIVER, OREGON AND WASHINGTON
PONDAGE DRAWDOWN - REFILL
VERSUS TIME
POOL ELEVATION 335.0 TO 34.0

CORPS OF ENGINEERS, WALLA WALLA DISTRICT
POWER SECTION

PREPARED: B.F.S. DATE: 22 OCT. 1954
TRACED: W.J.V.



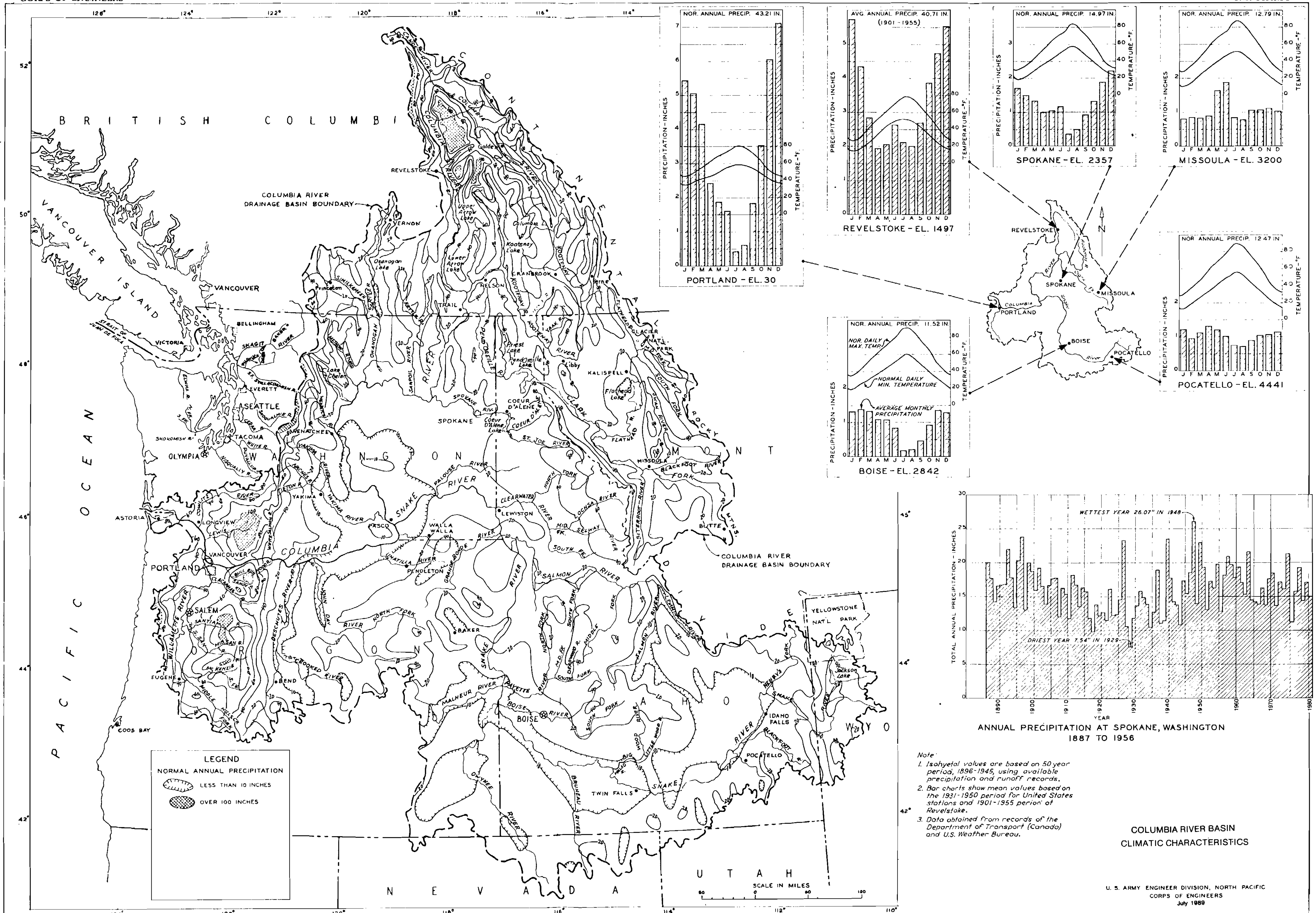
McNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON

McNARY LEVEE SYSTEM

GENERAL PLAN

U.S. Army Corps of Engineers
Walla Walla District
Hydrology Branch

July 1989 A. Roberts

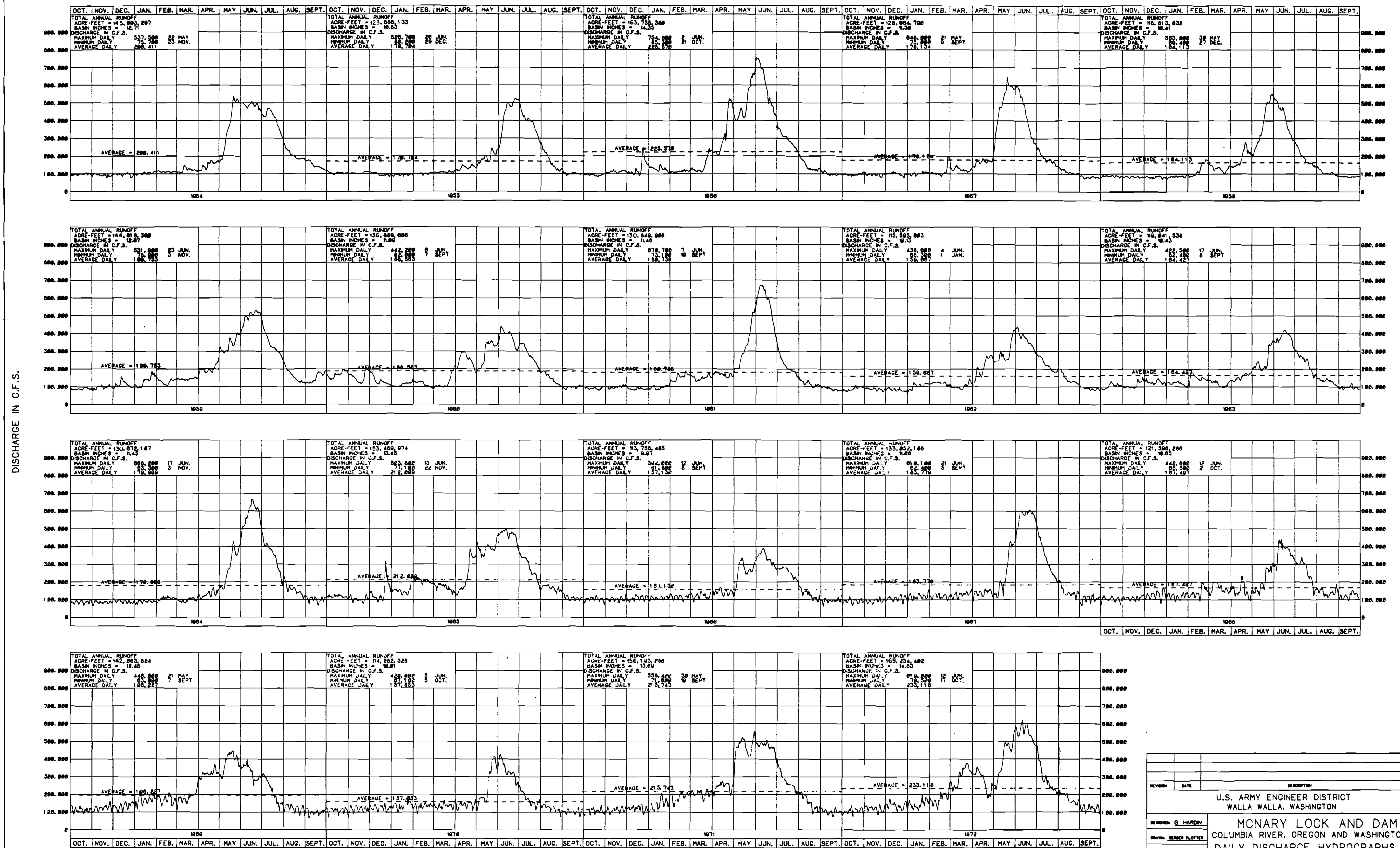


ANNUAL PRECIPITATION AT SPOKANE, WASHINGTON
1887 TO 1956

Note:
1. Isohyetal values are based on 50 year period, 1896-1945, using available precipitation and runoff records.
2. Bar charts show mean values based on the 1931-1950 period for United States stations and 1901-1955 period of Revelstoke.
3. Data obtained from records of the Department of Transport (Canada) and U.S. Weather Bureau.

COLUMBIA RIVER BASIN
CLIMATIC CHARACTERISTICS

U. S. ARMY ENGINEER DIVISION, NORTH PACIFIC
CORPS OF ENGINEERS
July 1989



U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

DESIGNED: G. HARDIN
DRAWN: BENSON PLOTTER
CHECKED: E. KIM

MCNARY LOCK AND DAM

COLUMBIA RIVER, OREGON AND WASHINGTON

DAILY DISCHARGE HYDROGRAPHS
COMPUTED REGULATED INFLOWS
1954-1988

DATE July 1989

SCALE AS SHOWN | INV. NO. ENG.

SHEET 1 OF 2

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

DESIGNED: G. HARDIN
DRAWN: GERBER PLOTTER
CHECKED: E. KIM
PREPARED:

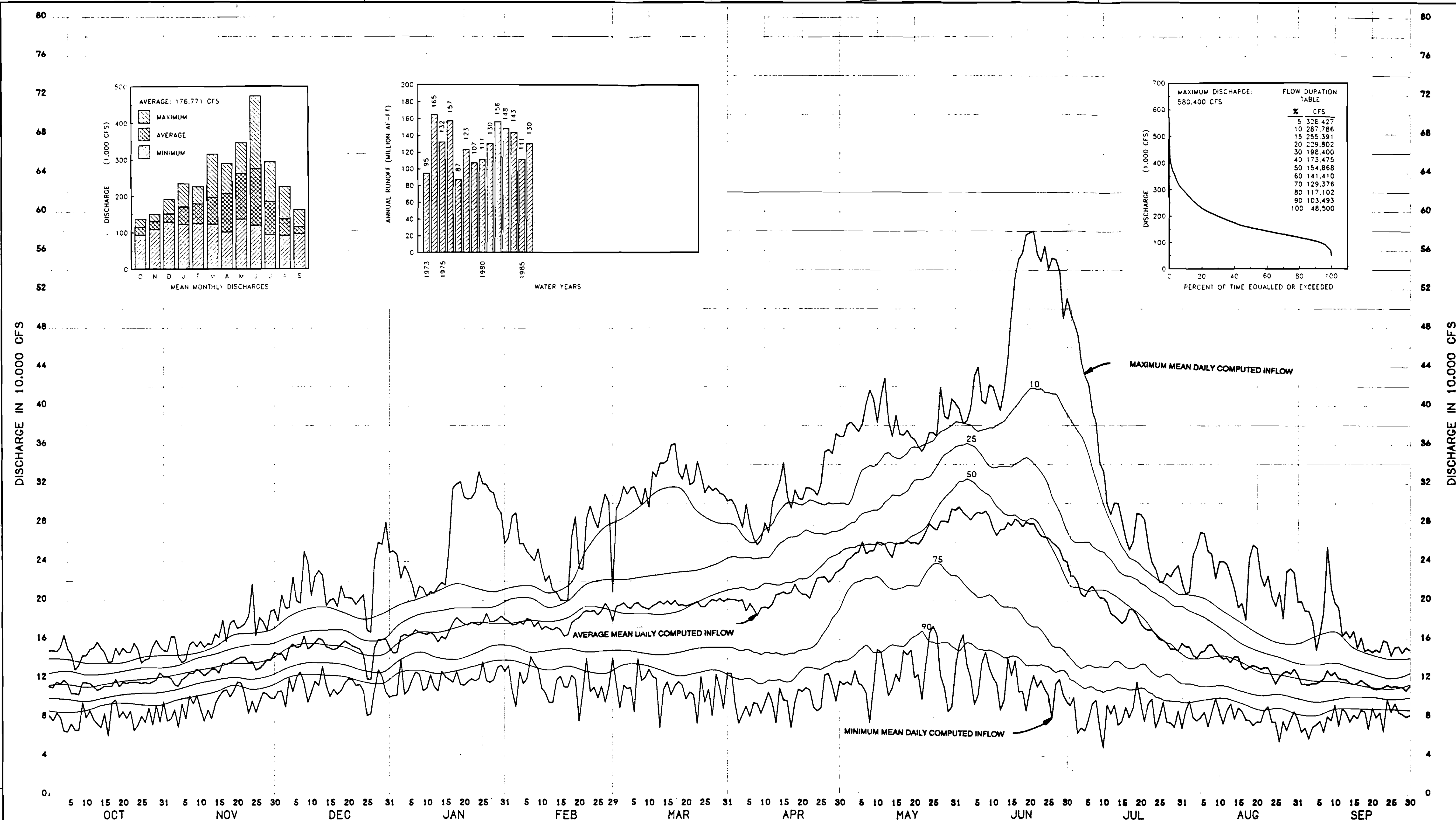
MCNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
DAILY DISCHARGE HYDROGRAPHS
COMPUTED REGULATED INFLOWS
1954-1986

SUPERVISED:
CHIEF, HYDROLOGY BRANCH
SUBMITTED:
CHIEF, PLANNING DIVISION

APPROVED: DATE July 1989

SCALE AS SHOWN | INV. NO. ENG.

SHEET 2 OF 2



NOTES:

1. RECORDS USED:
   WATER YEARS 1973–1986. OBSERVED DISCHARGES FOR COLUMBIA RIVER AT MCNARY DAM, OREGON AND WASHINGTON. DISCHARGE RECORDS USED ARE FROM DATA PUBLISHED BY U.S.G.S.
2. DRAINAGE AREA IS 214,000 SQUARE MILES.
3. DISCHARGES USED REFLECT THE EFFECTS OF IRRIGATION AND RESERVOIR STORAGE DEVELOPMENTS.
4. CURVES OF PERCENT CHANCE OF OCCURRENCE REPRESENT THE AVERAGE FLOW FOR THAT DAY. A POINT ON AN EXCEEDENCE CURVE REPRESENTS THE AVERAGE DAILY DISCHARGE FOR A SPECIFIC DAY WHICH HAS BEEN EXCEEDED THE GIVEN PERCENTAGE ON TIME.

MAXIMUM ANNUAL MEAN DAILY DISCHARGES

WATER YEAR	DATE	CFS		WATER YEAR	DATE	CFS
1973	DEC 13	207,900				
1974	JUN 21	580,400				
1975	JUN 04	381,600				
1976	MAY 12	428,800				
1977	MAY 27	186,200				
1978	JUN 08	318,500				
1979	MAY 24	292,600				
1980	JUN 17	324,900				
1981	JUN 09	421,900				
1982	JUN 23	441,900				
1983	MAY 30	407,400				
1984	MAY 31	402,600				
1985	MAY 10	276,400				
1986	JUN 01	382,700				

REVISION	DATE	DESCRIPTION	CHKD	APPR

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

G. HARDIN — DESIGNED BY
GERBER PLOTTER — DRAWN BY
E. KIM — CHECKED BY
SUPERVISED: CHIEF

McNARY LOCK AND DAM

COLUMBIA RIVER, OREGON AND WASHINGTON

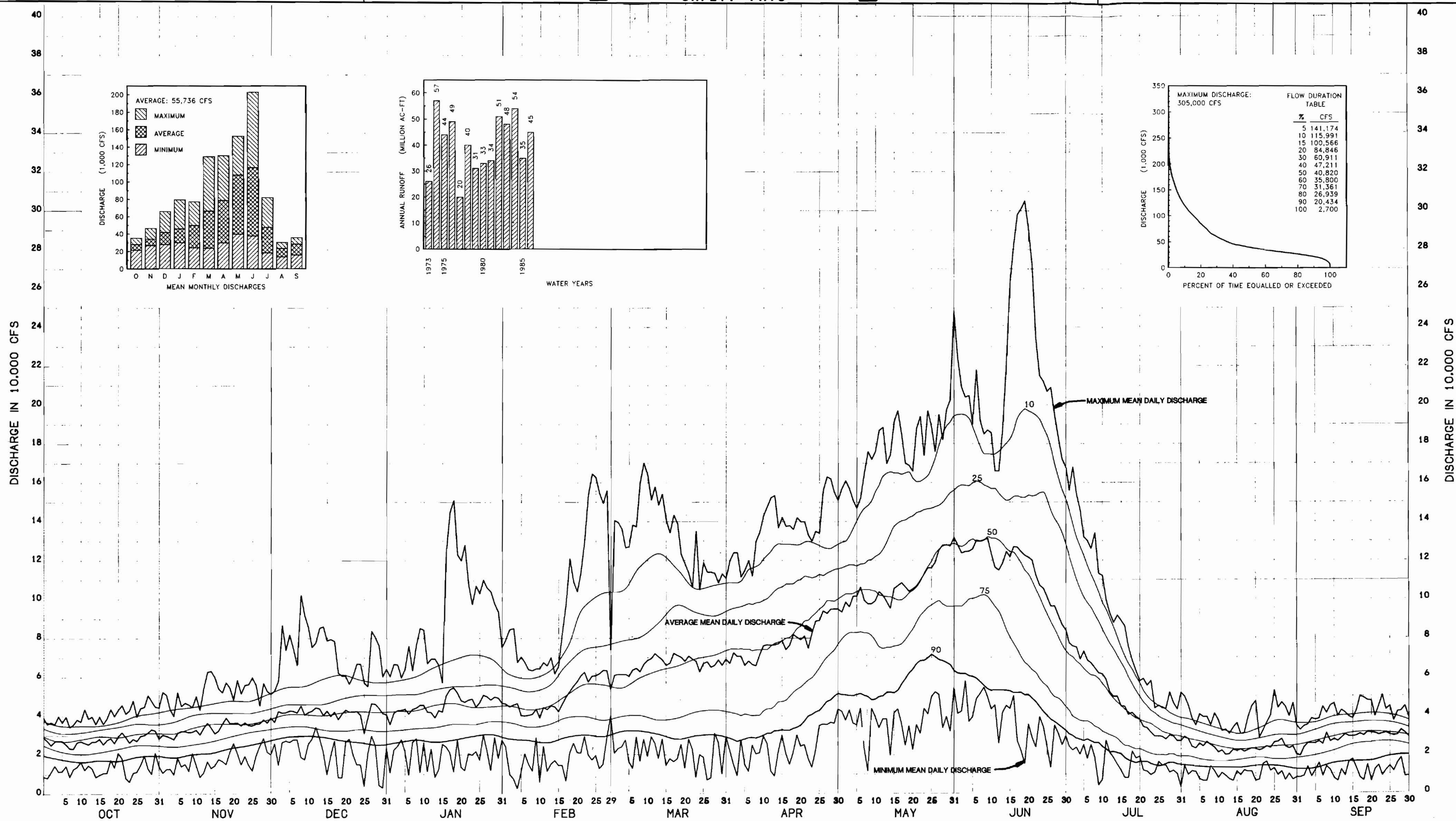
SUMMARY HYDROGRAPHS

COLUMBIA RIVER AT McNARY DAM, ORE & WASH.

COMPUTED REGULATED INFLOW

SUBMITTED: CHIEF
APPROVED — DATE July 1989
RECOMMENDED: CHIEF
SCALE AS SHOWN — INV. NO.
SHEET NO — FILE NO

U.S. GOVERNMENT PRINTING OFFICE



NOTES:

1. RECORDS USED:

   a. WATER YEARS 1973-1986, DISCHARGE RECORDS FOR SITE AT ICE HARBOR DAM (RIVER MILE 9.7).

   b. DISCHARGE RECORDS PUBLISHED BY U.S.G.S., RECORDS FURNISHED BY U.S. CORPS OF ENGINEERS.

2. DRAINAGE AREA IS 108,500 SQUARE MILES, APPROXIMATELY.

3. DISCHARGES USED REFLECT THE EFFECTS OF IRRIGATION AND RESERVOIR STORAGE DEVELOPMENTS.

4. CURVES OF PERCENT CHANCE OF OCCURRENCE REPRESENT THE AVERAGE FLOW FOR THAT DAY. A POINT ON AN EXCEEDENCE CURVE REPRESENTS THE AVERAGE DAILY DISCHARGE FOR A SPECIFIC DAY WHICH HAS BEEN EXCEEDED THE GIVEN PERCENTAGE ON TIME.

MAXIMUM ANNUAL MEAN DAILY DISCHARGES

WATER YEAR	DATE	CFS		WATER YEAR	DATE	CFS
1973	MAY 19	88,700				
1974	JUN 19	305,000				
1975	JUN 08	185,000				
1976	MAY 15	191,300				
1977	JUN 08	61,900				
1978	JUN 09	148,100				
1979	MAY 24	143,000				
1980	JUN 14	138,100				
1981	JUN 09	187,100				
1982	JUN 19	203,000				
1982	MAY 29	197,500				
1984	MAY 31	248,000				
1985	JUN 09	132,200				
1986	MAY 31	214,100				

REVISION	DATE	DESCRIPTION	CHKD	APPR

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

G. HARDIN — DESIGNED BY
GERBER PLOTTER — DRAWN BY
E. KIM — CHECKED BY

McNARY LOCK AND DAM

SNAKE RIVER, OREGON, WASHINGTON, & IDAHO

SUMMARY HYDROGRAPHS

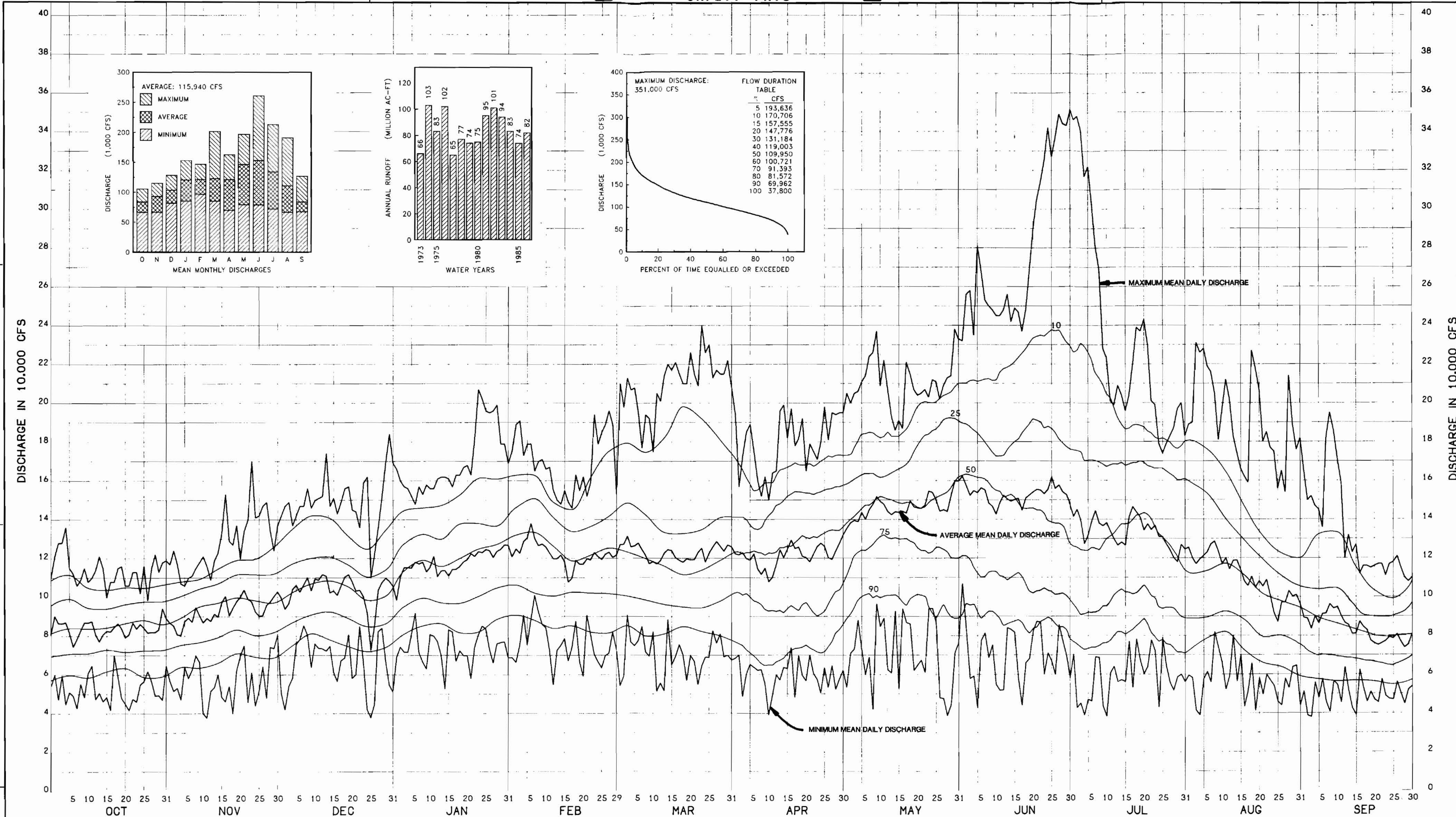
SNAKE RIVER BELOW ICE HARBOR DAM, WASH.

REGULATED DISCHARGE

APPROVED — DATE July 1989

SCALE AS SHOWN — INV. NO.

U.S. GOVERNMENT PRINTING OFFICE



NOTES:

1. RECORDS USED:

   a. WATER YEARS 1973–1986, OBSERVED DISCHARGES FOR COLUMBIA RIVER BELOW PRIEST RAPIDS, WASHINGTON.

   b. DATA FOR WATER YEARS 1985–1986 PROVISIONAL.

   c. DISCHARGE RECORDS USED ARE FROM DATA PUBLISHED BY U.S.G.S.

2. DRAINAGE AREA IS 96,000 SQUARE MILES.

3. DISCHARGES USED REFLECT THE EFFECTS OF IRRIGATION AND RESERVOIR STORAGE DEVELOPMENTS.

4. CURVES OF PERCENT CHANCE OF OCCURRENCE REPRESENT THE AVERAGE FLOW FOR THAT DAY. A POINT ON AN EXCEEDENCE CURVE REPRESENTS THE AVERAGE DAILY DISCHARGE FOR A SPECIFIC DAY WHICH HAS BEEN EXCEEDED THE GIVEN PERCENTAGE ON TIME.

MAXIMUM ANNUAL MEAN DAILY DISCHARGES

WATER YEAR	DATE	CFS		WATER YEAR	DATE	CFS
1973	DEC 13	174,000				
1974	JUN 30	351,000				
1975	MAY 24	212,000				
1976	JUL 20	243,000				
1977	JAN 29	146,000				
1978	APR 15	182,000				
1979	JAN 01	152,000				
1980	JUN 18	208,000				
1981	JUN 05	281,000				
1982	JUN 24	246,000				
1982	MAY 23	240,000				
1984	JUN 29	207,000				
1985	FEB 05	179,000				
1986	APR 16	197,000				

REVISION	DATE	DESCRIPTION	CHKD	APPR

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

G. HARDIN
DESIGNED BY
GERBER PLOTTER
DRAWN BY
E. KIM
CHECKED BY
SUPERVISED:
CHIEF

McNARY LOCK AND DAM

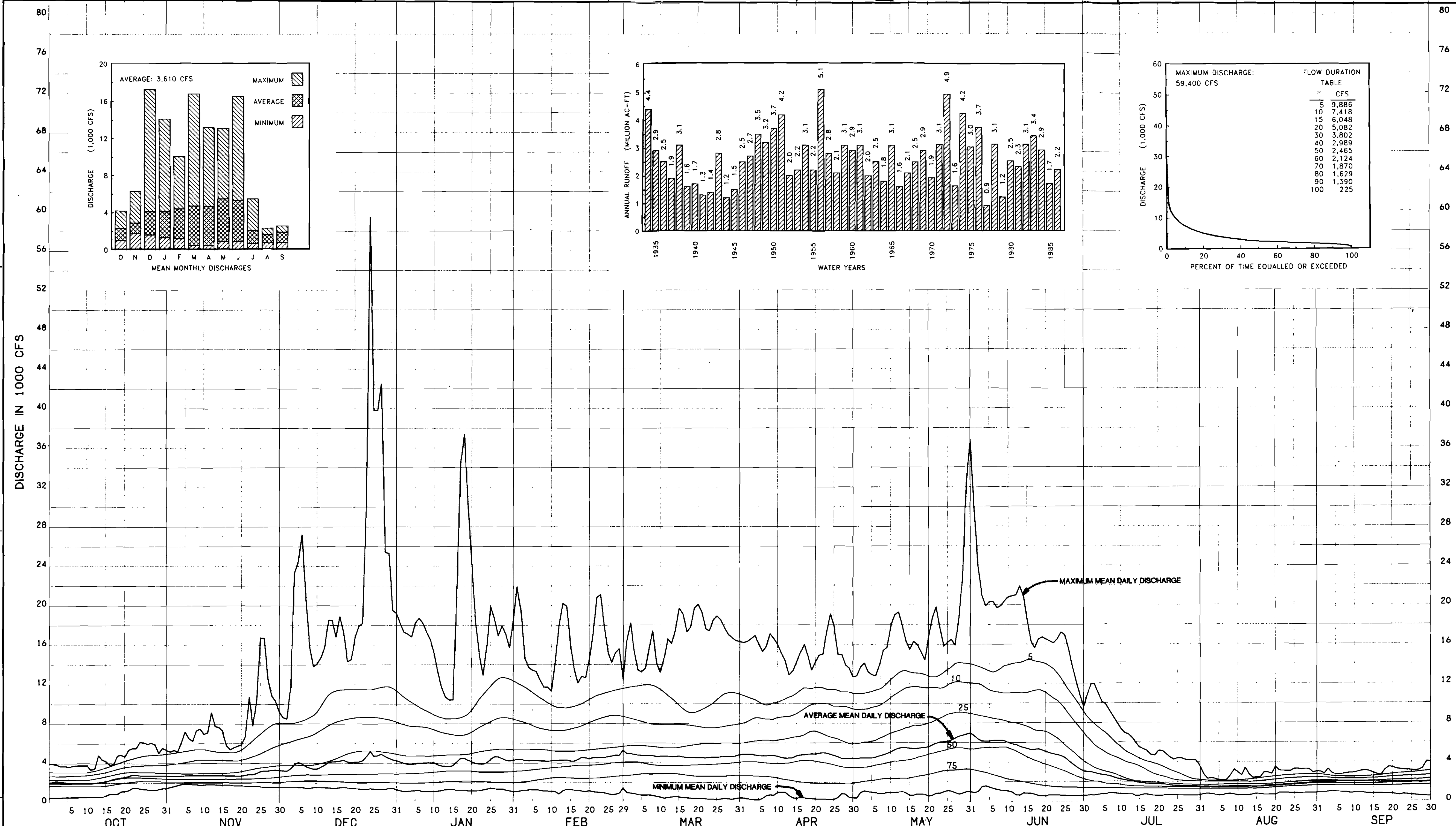
COLUMBIA RIVER, OREGON AND WASHINGTON

SUMMARY HYDROGRAPHS

COLUMBIA RIVER BELOW PRIEST RAPIDS, WASH.
REGULATED DISCHARGE

SUBMITTED:
CHIEF
RECOMMENDED
CHIEF
APPROVED
DATE July 1989
SCALE AS SHOWN
INV. NO.
SHEET NO
FILE NO

U S GOVERNMENT PRINTING OFFICE · 1984-798-107



NOTES:

1. RECORDS USED:
   a. WATER YEARS 1934–1986, OBSERVED DISCHARGES FOR YAKIMA RIVER AT KIONA, WASHINGTON.
   b. DATA FOR WATER YEARS 1985–1986 PROVISIONAL.
   c. DISCHARGE RECORDS USED ARE FROM DATA PUBLISHED BY U.S.G.S.
2. DRAINAGE AREA IS 5,615 SQUARE MILES.
3. DISCHARGES USED REFLECT THE EFFECTS OF IRRIGATION AND RESERVOIR STORAGE PROJECTS.
4. CURVES OF PERCENT CHANCE OF OCCURRENCE REPRESENT THE AVERAGE FLOW FOR THAT DAY. A POINT ON AN EXCEEDENCE CURVE REPRESENTS THE AVERAGE DAILY DISCHARGE FOR A SPECIFIC DAY WHICH HAS BEEN EXCEEDED THE GIVEN PERCENTAGE ON TIME.

MAXIMUM ANNUAL MEAN DAILY DISCHARGES

WATER YEAR	DATE	CFS	WATER YEAR	DATE	CFS	WATER YEAR	DATE	CFS
1934	DEC 24	59,400	1954	MAY 21	11,560	1974	JAN 18	37,400
1935	JAN 28	17,900	1955	JUN 14	17,800	1975	MAY 17	12,700
1936	MAY 16	13,900	1956	MAY 22	19,800	1976	DEC 06	27,200
1937	JUN 24	16,800	1957	MAY 12	19,300	1977	OCT 20	3,250
1938	APR 21	14,900	1958	FEB 26	9,760	1978	DEC 05	24,000
1939	MAR 27	7,140	1959	JAN 26	10,700	1979	MAR 09	4,400
1940	MAY 13	8,660	1960	NOV 25	16,700	1980	MAY 01	12,500
1941	APR 04	4,520	1961	MAY 23	12,900	1981	DEC 28	25,400
1942	DEC 05	4,520	1962	APR 09	10,600	1982	FEB 23	21,100
1943	APR 18	13,200	1963	FEB 06	13,300	1983	MAR 12	16,600
1944	DEC 06	3,720	1964	JUN 12	8,540	1984	JAN 27	16,900
1945	JUN 02	8,280	1965	FEB 01	21,900	1986	APR 16	7,150
1946	MAY 29	15,300	1966	APR 03	6,820	1986	FEB 28	15,600
1947	DEC 16	14,800	1967	JUN 23	10,300			
1948	MAY 31	36,800	1968	FEB 25	14,800			
1949	MAY 17	15,200	1969	MAY 27	14,200			
1950	JUN 22	14,700	1970	JAN 24	7,350			
1951	FEB 13	20,200	1971	MAY 14	14,100			
1952	MAR 28	6,140	1972	MAR 20	20,100			
1953	JUN 15	11,400	1973	DEC 28	8,270			

REVISION	DATE	DESCRIPTION	CHKD	APPR

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

G. HARDIN — DESIGNED BY
GERBER PLOTTER — DRAWN BY
E. KIM — CHECKED BY
SUPERVISED:
CHIEF

McNARY LOCK AND DAM

YAKIMA RIVER, WASHINGTON

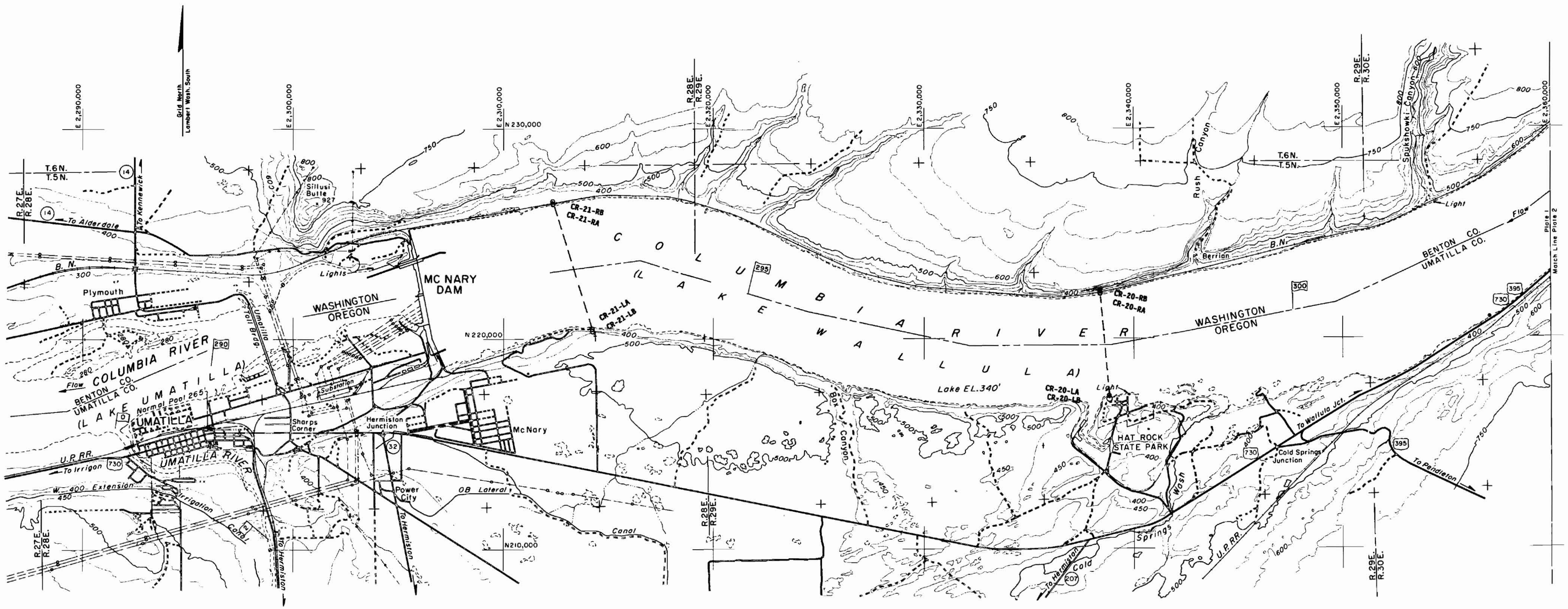
SUMMARY HYDROGRAPHS

YAKIMA RIVER AT KIONA, WASH.

REGULATED DISCHARGE

SUBMITTED:
CHIEF
RECOMMENDED
CHIEF
APPROVED DATE July 1989
SCALE AS SHOWN | INV. NO.
SHEET NO FILE NO

☆U S GOVERNMENT PRINTING OFFICE - 1984 - 796 - 107



McNary Sedimentation Ranges

MONUMENT DESIGNATION	RIVER MILES	ELEVATION
CR21	293.40	372.74
CR20	298.32	371.81

SCALE IN FEET

2000 0 2000 4000 6000

NOTE:
Basic Topography compiled from Quadrangle Maps 1:24,000 dated 1964 & 1962.
Contour Interval 50'.
Coordinates are Lambert Washington South.

REVISION	DATE	DESCRIPTION	BY

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

McNARY LOCK AND DAM
(LAKE WALLULA)
SNAKE RIVER, OREGON, WASHINGTON AND IDAHO

LAND USE ALLOCATION PLAN

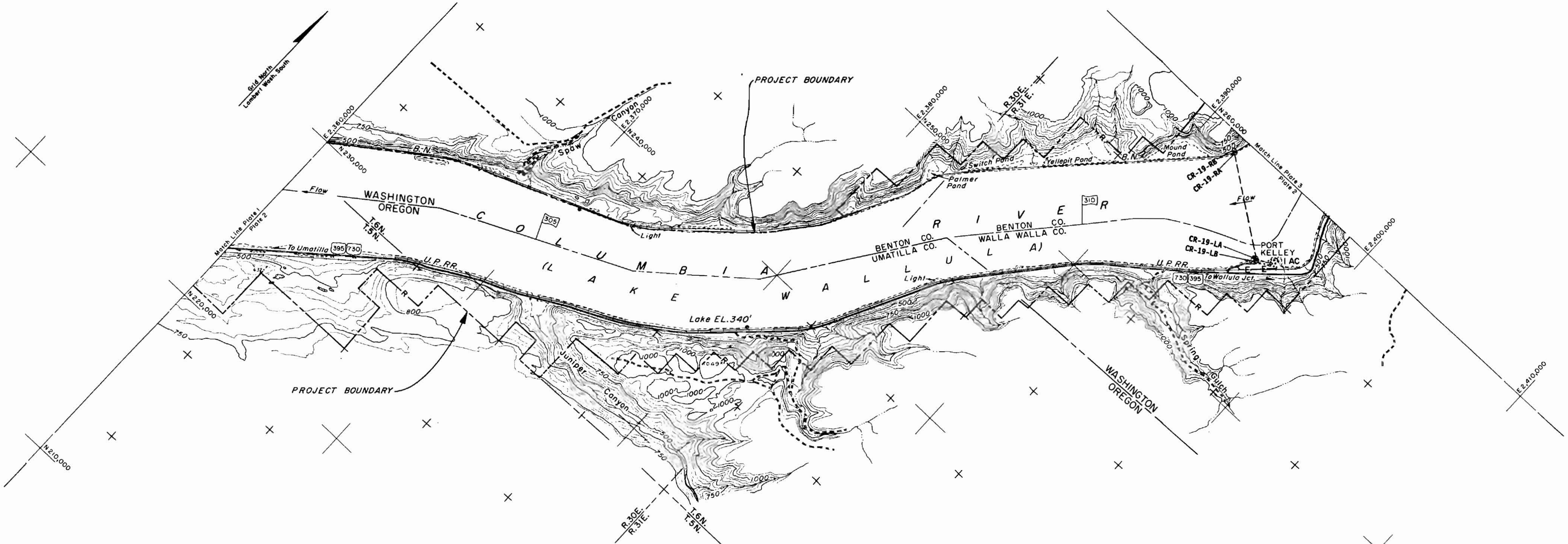
SEDIMENTATION RANGES

DESIGNED:
DRAWN:
CHECKED:
SUPERVISED:
SUBMITTED:
CHIEF.

DATE July 1989

SCALE AS SHOWN | INV. NO.

SHEET 1 OF 6 | FILE NO. MD-05-44/1



McNary Sedimentation Ranges

Monument Designation	River Miles	Elevation
CR19	311.93	341.16

SCALE IN FEET
2000 0 2000 4000 6000

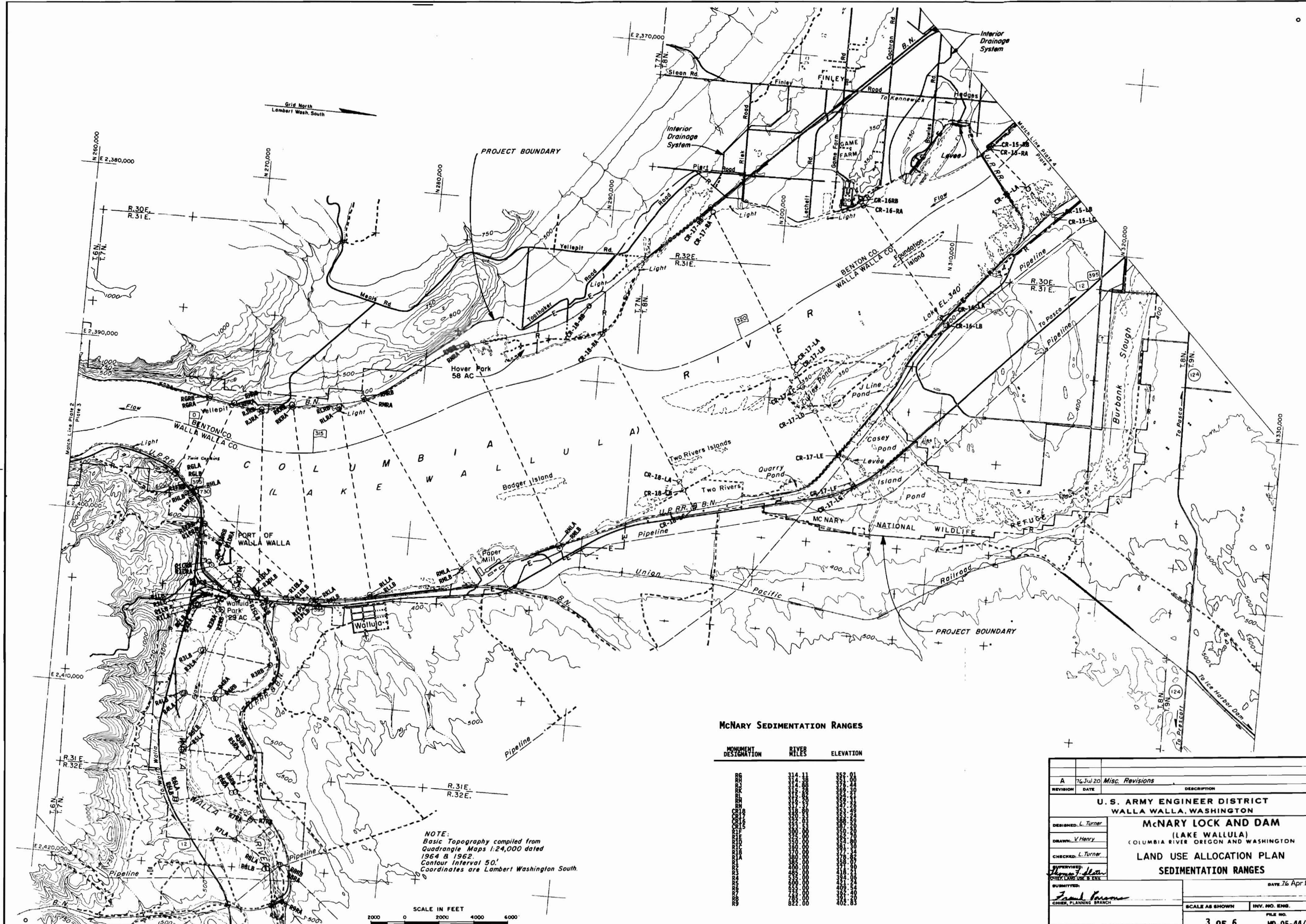
NOTE:
Basic Topography compiled from Quadrangle Maps 1:24,000 dated 1964 & 1962.
Contour Interval 50'.
Coordinates are Lambert Washington South.

REVISION	DATE	DESCRIPTION
A	76 Jul 20	Added Island

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

McNARY LOCK AND DAM
(LAKE WALLULA)
COLUMBIA RIVER OREGON AND WASHINGTON
LAND USE ALLOCATION PLAN
SEDIMENTATION RANGES

DESIGNED: L. Turner
DRAWN: V Henry
CHECKED: L. Turner
SUPERVISED: [signature] CHIEF LAND USE & ENV.
SUBMITTED: Frank Parsons CHIEF, PLANNING BRANCH
DATE 76 Apr 12
SCALE AS SHOWN
INV. NO. ENG.
FILE NO. MD-05-44/2
SHEET 2 OF 6



McNARY SEDIMENTATION RANGES

MONUMENT DESIGNATION	RIVER MILES	ELEVATION
RG	314.11	352.01
RH	314.38	351.00
RJ	314.88	376.44
RK	315.28	369.30
RL	315.82	354.21
RM	316.20	359.31
RN	317.37	347.26
CR18	318.80	353.49
CR17	320.53	353.24
CR16	322.03	388.59
CR15	323.53	387.20
R1F	300.00	350.20
R1E	325.00	362.70
R1D	350.00	354.80
R1C	360.00	381.30
R1B	370.00	377.34
R1A	380.00	378.82
R1	385.00	358.07
R2	400.00	371.90
R3	485.00	418.21
R4	535.00	394.06
R5	600.00	421.24
R6	655.00	409.54
R7	725.00	362.40
R8	785.00	391.20
R9	822.00	402.83

REVISION	DATE	DESCRIPTION
A	76 Jul 20	Misc. Revisions

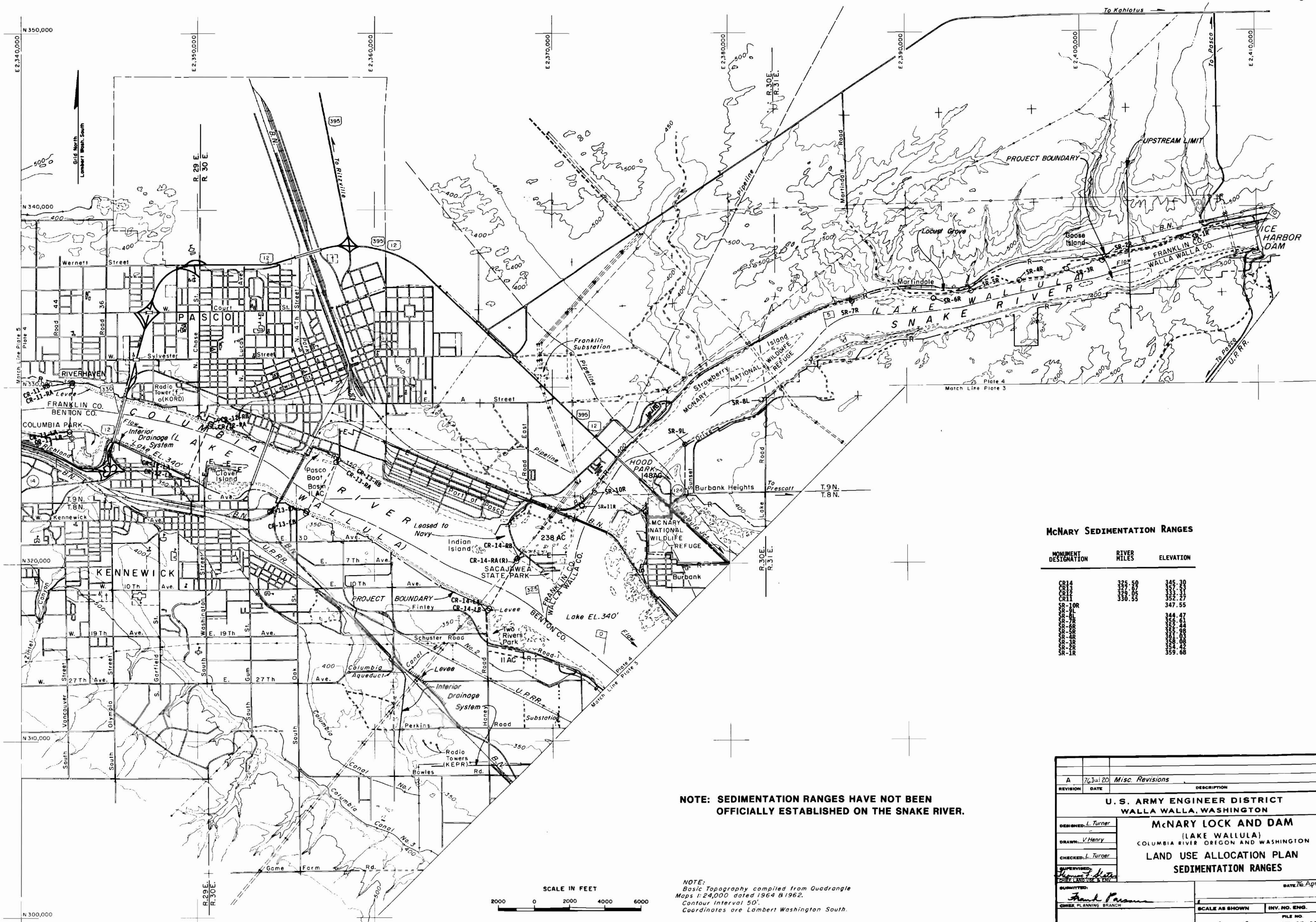
U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

DESIGNED: L. Turner
DRAWN: V Henry
CHECKED: L. Turner
SUPERVISED: [signature] CHIEF, LAND USE & ENV.
SUBMITTED: Frank Parsons CHIEF, PLANNING BRANCH

McNARY LOCK AND DAM
(LAKE WALLULA)
COLUMBIA RIVER OREGON AND WASHINGTON

LAND USE ALLOCATION PLAN
SEDIMENTATION RANGES

DATE 76 Apr 12
SCALE AS SHOWN
INV. NO. ENG.
FILE NO. MD-05-44/3
SHEET 3 OF 6



McNARY SEDIMENTATION RANGES

MONUMENT DESIGNATION	RIVER MILES	ELEVATION
CR14	325.50	345.30
CR13	327.67	357.53
CR12	329.05	333.31
CR11	330.55	352.27
SR-10R		347.55
SR-9L		
SR-8L		344.47
SR-7R		356.61
SR-6R		352.44
SR-5R		355.98
SR-4R		361.03
SR-3R		358.08
SR-2R		354.42
SR-1R		359.68

NOTE: SEDIMENTATION RANGES HAVE NOT BEEN OFFICIALLY ESTABLISHED ON THE SNAKE RIVER.

SCALE IN FEET

2000 0 2000 4000 6000

NOTE:
Basic Topography compiled from Quadrangle Maps 1:24,000 dated 1964 & 1962.
Contour Interval 50'.
Coordinates are Lambert Washington South.

REVISION	DATE	DESCRIPTION
A	76 Jul 20	Misc. Revisions

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

McNARY LOCK AND DAM
(LAKE WALLULA)
COLUMBIA RIVER OREGON AND WASHINGTON

LAND USE ALLOCATION PLAN
SEDIMENTATION RANGES

DESIGNED: L. Turner
DRAWN: V Henry
CHECKED: L. Turner
SUPERVISED: [signature]
CHIEF, LAND USE & ENV.
SUBMITTED: Frank Parsons
CHIEF, PLANNING BRANCH

DATE 76 Apr 12

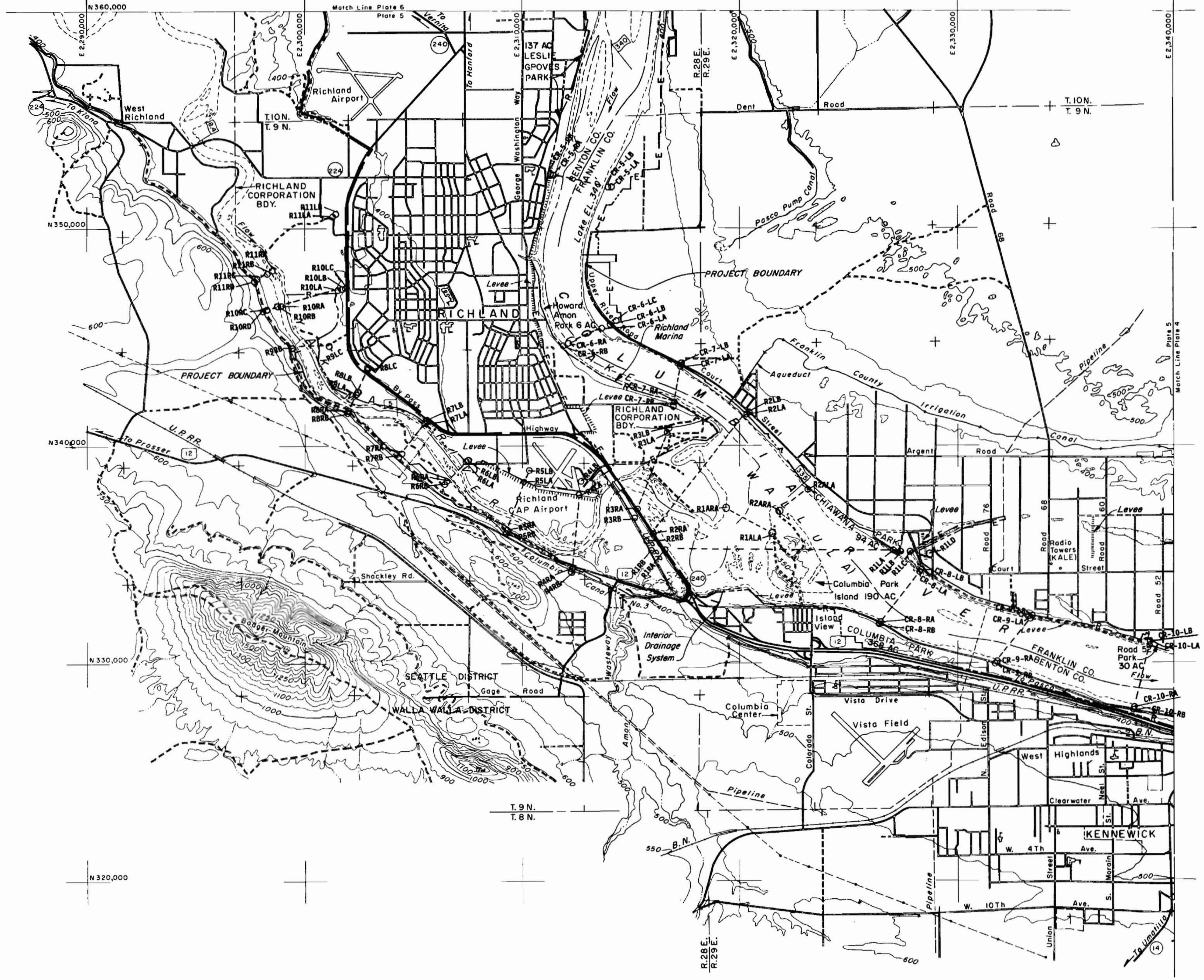
SCALE AS SHOWN

INV. NO. ENG.

FILE NO. MD-05-44/4

SHEET 4 OF 6

CORPS OF ENGINEERS · U. S. ARMY



McNary Sedimentation Ranges

MONUMENT DESIGNATION	RIVER MILES	ELEVATION
CR10	331.44	353.56
CR9	332.64	345.30
CR8	333.70	348.93
CR7	336.40	370.15
CR6	337.30	350.23
CR5	338.73	354.50
R1A		
R2A	334.93	
R1	334.32	368.63
R2	335.74	383.06
R3		371.90
R4		368.09
R5		364.15
R6		370.84
R7		399.70
R8		385.34
R9		387.34
R10		406.58
R11		382.65

SCALE IN FEET
2000 0 2000 4000 6000

NOTE:
Basic Topography compiled from Quadrangle Maps 1:24,000 dated 1964 & 1962.
Contour Interval 50'.
Coordinates are Lambert Washington South.

REVISION	DATE	DESCRIPTION
A	76 Jul 20	Misc. Revision

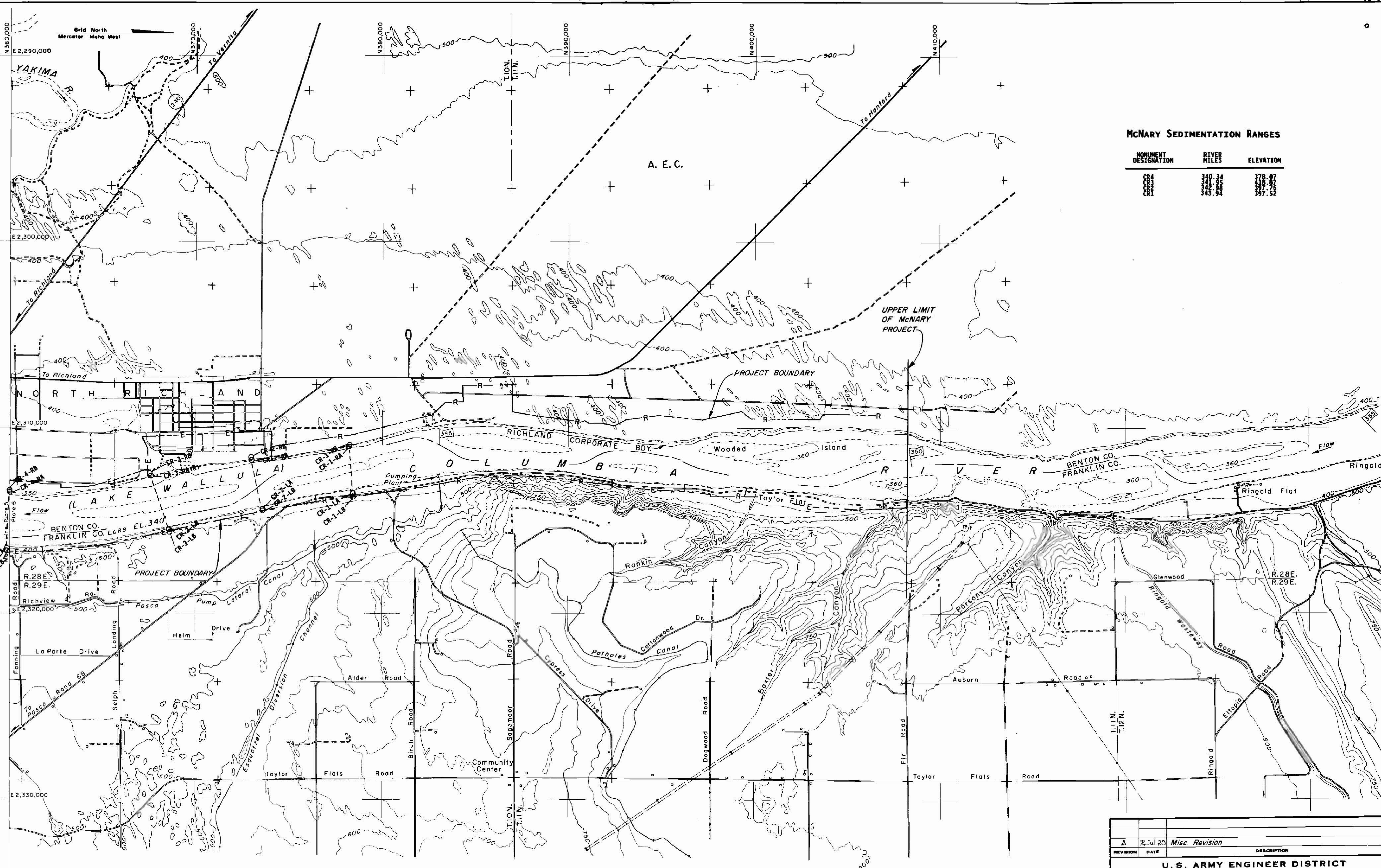
U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

DESIGNED: L. Turner
DRAWN: V. Henry
CHECKED: L. Turner
SUPERVISED: [signature] CHIEF, LAND USE & ENV.
SUBMITTED: [signature] CHIEF PLANNING BRANCH

McNARY LOCK AND DAM
(LAKE WALLULA)
COLUMBIA RIVER OREGON AND WASHINGTON

LAND USE ALLOCATION PLAN
SEDIMENTATION RANGES

DATE 76 Apr 12
SCALE AS SHOWN
INV. NO. ENG.
SHEET 5 OF 6
FILE NO. MD-05-44/5



McNARY SEDIMENTATION RANGES

MONUMENT DESIGNATION	RIVER MILES	ELEVATION
CR4	340.34	378.07
CR3	341.95	418.87
CR2	342.98	397.76
CR1	343.94	397.52

SCALE IN FEET
2000 0 2000 4000 6000

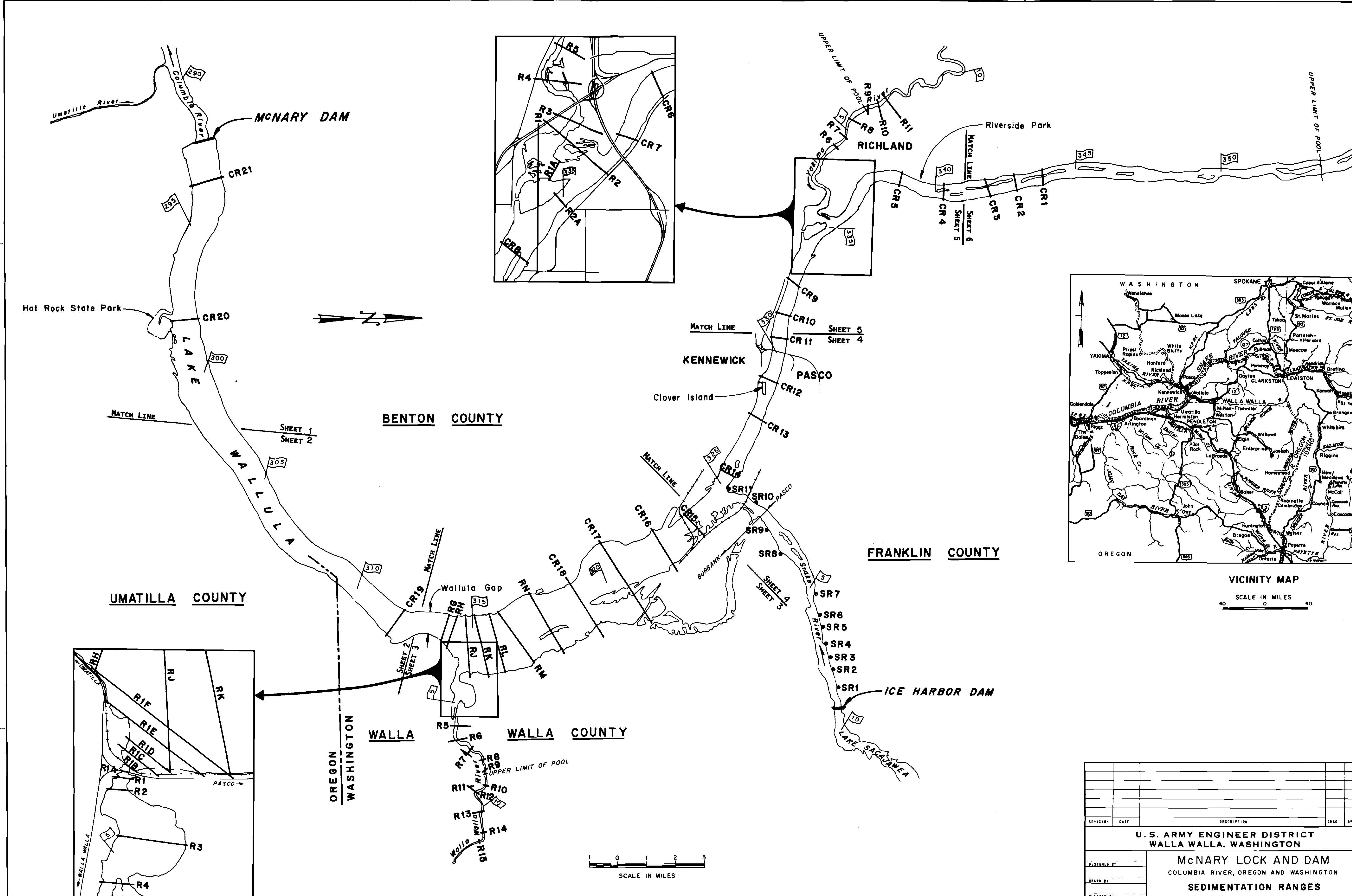
NOTE:
Basic Topography compiled from Quadrangle Maps 1:24,000 dated 1964 & 1962.
Contour Interval 50'.
Coordinates are Lambert Washington South.

REVISION	DATE	DESCRIPTION
A	7 Jul 20	Misc Revision

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

McNARY LOCK AND DAM
(LAKE WALLULA)
COLUMBIA RIVER OREGON AND WASHINGTON
LAND USE ALLOCATION PLAN
SEDIMENTATION RANGES

DESIGNED: L. Turner
DRAWN: V. Henry
CHECKED: L. Turner
SUPERVISED: [signature] CHIEF LAND USE & ENV.
SUBMITTED: Frank Parsons CHIEF, PLANNING BRANCH
DATE 76 Apr 12
SCALE AS SHOWN
INV. NO. ENG.
FILE NO. MD-05-44/6
SHEET 6 OF 6



REVISION	DATE	DESCRIPTION	CHKD	APPR

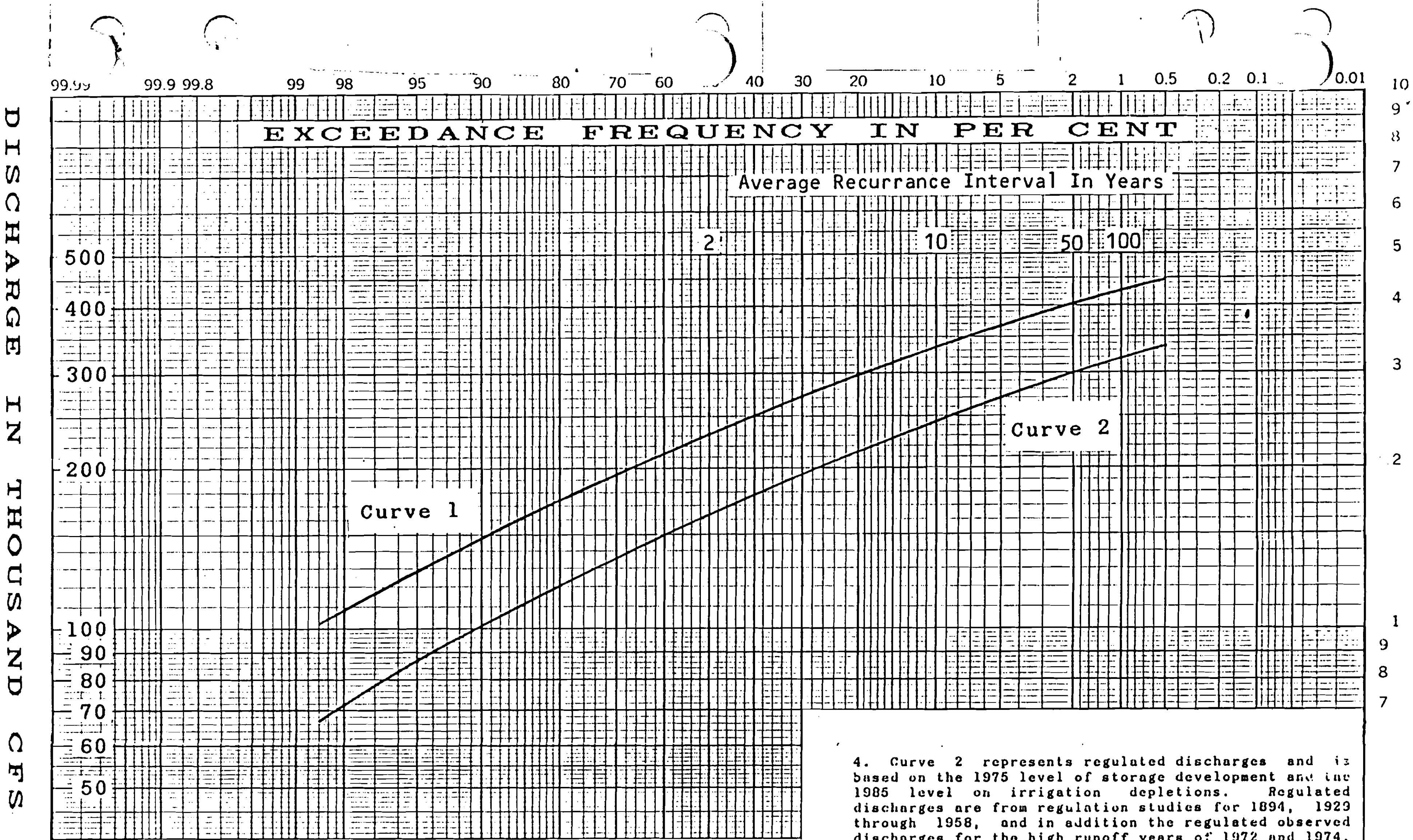
U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

McNARY LOCK AND DAM
COLUMBIA RIVER, OREGON AND WASHINGTON

SEDIMENTATION RANGES
INDEX SHEET

DATE July 1989

SCALE AS SHOWN | INV. NO.



4. Curve 2 represents regulated discharges and is based on the 1975 level of storage development and the 1985 level on irrigation depletions. Regulated discharges are from regulation studies for 1894, 1929 through 1958, and in addition the regulated observed discharges for the high runoff years of 1972 and 1974. The plotting positions for the regulated event years are for the natural frequency curve. Curve 2 is a graphical fit of the regulated data.

NOTES

1. Drainage area equals 103,200 sq. mi.

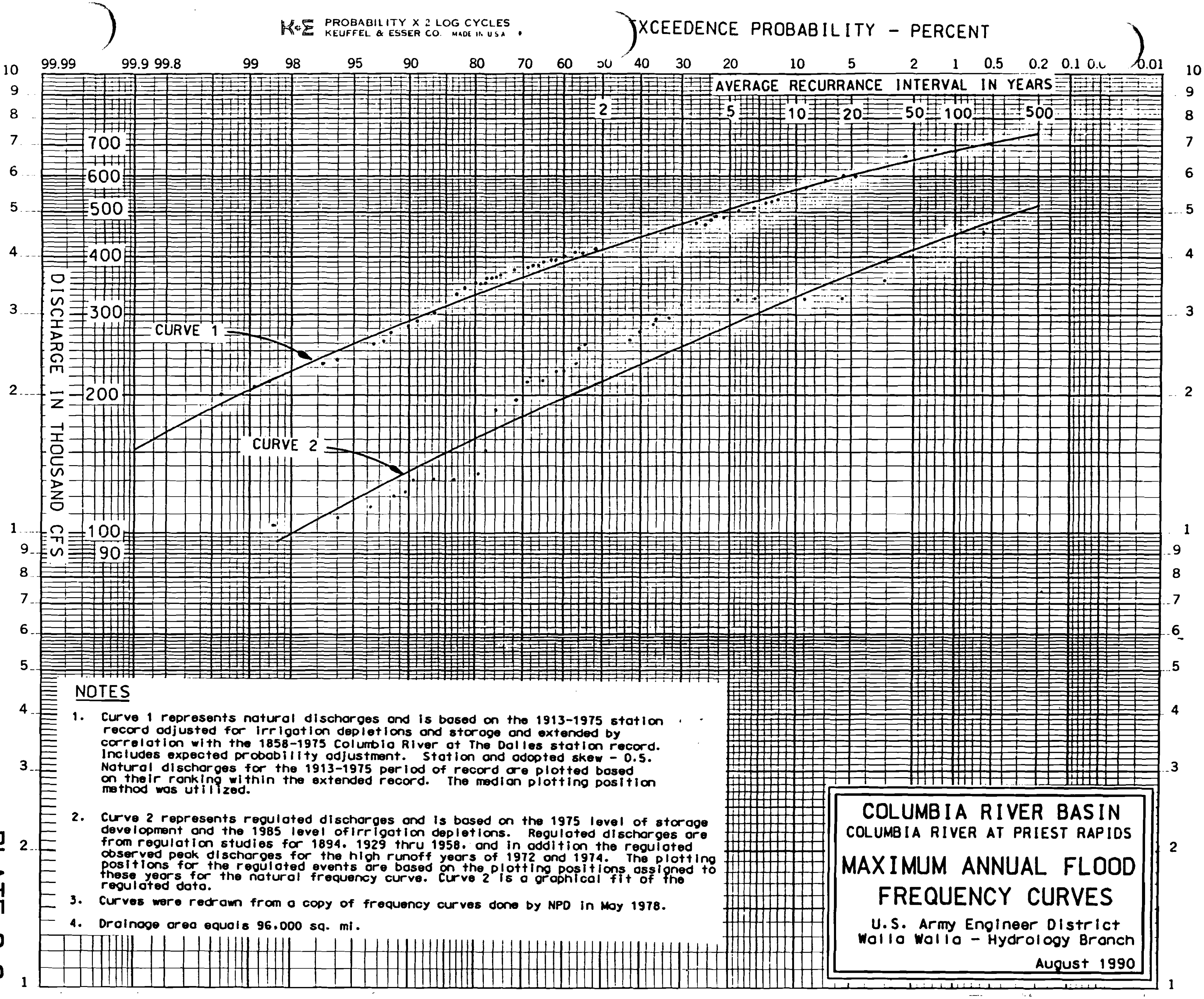
2. This is a preliminary graph subject to revision.

3. Curve 1 represents natural discharges and is based on the 1894-1975 station record adjusted for irrigation depletions and storage and extended by correlation with the 1858-1975 Columbia River at The Dalles station record. It includes an expected probability adjustment. The station and adopted skew is -0.5. Natural discharges for the 1894-1975 period of record are plotted based on their ranking within the extended record. The median plotting position method was utilized.

SNAKE RIVER, WASHINGTON

ANNUAL PEAK DISCHARGE FREQUENCIES
Snake River At Lower Granite Dam

U.S. Army Engineer Division, N.P.
NPDEN-WM-HES May 1978



NOTES

1. Curve 1 represents natural discharges and is based on the 1913-1975 station record adjusted for irrigation depletions and storage and extended by correlation with the 1858-1975 Columbia River at The Dalles station record. Includes expected probability adjustment. Station and adopted skew - 0.5. Natural discharges for the 1913-1975 period of record are plotted based on their ranking within the extended record. The median plotting position method was utilized.

2. Curve 2 represents regulated discharges and is based on the 1975 level of storage development and the 1985 level ofirrigation depletions. Regulated discharges are from regulation studies for 1894, 1929 thru 1958, and in addition the regulated observed peak discharges for the high runoff years of 1972 and 1974. The plotting positions for the regulated events are based on the plotting positions assigned to these years for the natural frequency curve. Curve 2 is a graphical fit of the regulated data.

3. Curves were redrawn from a copy of frequency curves done by NPD in May 1978.

4. Drainage area equals 96,000 sq. mi.

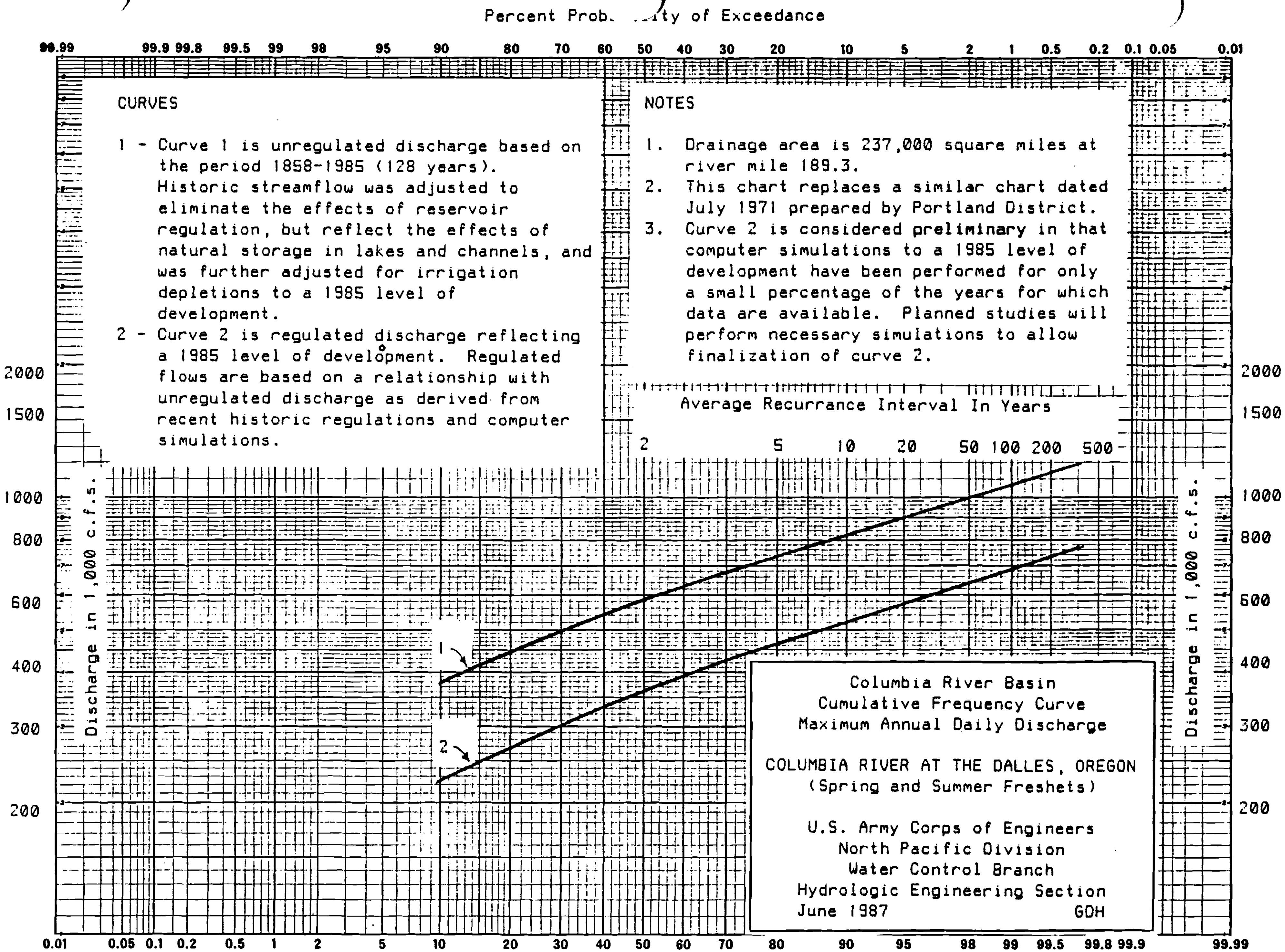
COLUMBIA RIVER BASIN
COLUMBIA RIVER AT PRIEST RAPIDS

MAXIMUM ANNUAL FLOOD FREQUENCY CURVES

U.S. Army Engineer District
Walla Walla - Hydrology Branch

August 1990

PLATE 9-2


Percent Probability of Exceedance
99.99
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
CURVES
1 - Curve 1 is unregulated discharge based on the period 1858-1985 (128 years). Historic streamflow was adjusted to eliminate the effects of reservoir regulation, but reflect the effects of natural storage in lakes and channels, and was further adjusted for irrigation depletions to a 1985 level of development.
2 - Curve 2 is regulated discharge reflecting a 1985 level of development. Regulated flows are based on a relationship with unregulated discharge as derived from recent historic regulations and computer simulations.
NOTES
1. Drainage area is 237,000 square miles at river mile 189.3.
2. This chart replaces a similar chart dated July 1971 prepared by Portland District.
3. Curve 2 is considered preliminary in that computer simulations to a 1985 level of development have been performed for only a small percentage of the years for which data are available. Planned studies will perform necessary simulations to allow finalization of curve 2.
Average Recurrance Interval In Years
2
5
10
20
50
100
200
500
2000
1500
1000
800
600
400
300
200
Discharge in 1,000 c.f.s.
1
2
Columbia River Basin
Cumulative Frequency Curve
Maximum Annual Daily Discharge
COLUMBIA RIVER AT THE DALLES, OREGON
(Spring and Summer Freshets)
U.S. Army Corps of Engineers
North Pacific Division
Water Control Branch
Hydrologic Engineering Section
June 1987
GDH
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.5
99.8
99.9
99.99

MCNARY LOCK AND DAM – WATER CONTROL MANUAL

EXHIBITS

No.

1-1 McNary Lock and Dam Design Memorandums
8-1 Part 207 – Navigation Regulations

EXHIBIT 1-1

McNARY LOCK AND DAM
LAKE WALLULA, OREGON AND WASHINGTON

DESIGN MEMORANDUMS

		Cover Date
1	Levee Operations and Maintenance Building; Paint and Oil Storage Shed; Pumping Plants Warning System	2 September 1955
2	Preliminary Cost Allocation Studies	November 1954
	Revised	4 February 1955
2.1	Cost Allocation Studies	14 March 1961
3	Kennewick Levees 15D and 5D, Interior Drains	15 October 1954
4	Kennewick Levees 4A and 6B, Seepage Control	October 1954
5	Navigation Lock Gate Fender	December 1954
	Revised	15 September 1958
6	Revetment Repair	6 May 1955
7	Pasco Levee 12, Seepage Control	September 1955
8	Security Building and Fire Station	23 March 1956
9	Irrigation Development Plan, Project Area	7 December 1956
	Revised	17 December 1958
10	Permanent Water Supply	15 March 1957
11	Landscaping and Grounds Development	1 February 1957
	Revised	2 January 1959
12	Recreation Facilities	24 April 1957
	Supplement to Recreation Facilities	5 February 1960
13	Fencing Ponding Area, Kennewick Levee 5D	24 June 1955
14	Project Maintenance Roads and Parking Facilities	28 March 1956

McNARY LOCK AND DAM
DESIGN MEMORANDUMS
(CONTINUED)

No.		Cover Date
15	Security Floodlighting, Warehouse Area	7 July 1955
16	Sand Blasting Facilities	7 May 1958
17	Deleted	
18	Visitors' Shelter	15 April 1957
19	Deleted	
20	Synchronization of Lock Filling Valves	21 December 1955
21	Security Floodlighting, Project Area	24 April 1956
22	Bank Protection, Richland Park	10 December 1957
23	Deleted	
24	Master Plan	1982
25	Modification of Main Unit Controls and Annunciation	7 July 1959
	Letter Report No. 1 Modification of Main Unit Controls and Annunciation	31 July 1973
26	Remote Operation of Spillway Gates	31 July 1959
27	Modification of Station Service Controls	
28	and Annunciation Revised Revised Modification of Northern Pacific Railway	3 October 1960
29	Bridge No. 3, Snake River Reservoir Recreation Facilities Revised Letter Supplement No. 1 - Replacement of Lake Wallula Recreation Facilities, Hood Park	December 1966 16 May 1967 21 November

MCNARY LOCK AND DAM
DESIGN MEMORANDUMS (CONTINUED)

No.		Cover Date
29.1	Expansion of Lake Wallula Recreation Facilities Revised	7 May 1971
	Supplement No. 1 - Recreation Cost Sharing, City of Richland, WA	October 1980
30	Pumping Plant 12-1A	10 October 1967
31	Data Acquisition and Control System	October 1987

EXHIBIT 8-1

PART 207 - NAVIGATION REGULATIONS

207.718 Navigation Locks and Approach Channels, Columbia and Snake Rivers, Oregon and Washington.

a. General. All locks, approach channels, and all lock appurtenances, shall be under the jurisdiction of the District Engineer, Corps of Engineers, United States Army, in charge of the locality. The District Engineer may, after issuing a public notice and providing a 30-day opportunity for public comment, set (issue) a schedule for the daily lockage of recreation vessels. Recreational vessels are pleasure boats such as a row, sail, or motor boats used for recreational purposes. Commercial vessels include licensed commercial passenger vessels operating on a published schedule or regularly operating in the "for hire" trade. Any recreation schedule shall provide for a minimum of one scheduled recreation lockage upstream and downstream (two lockages) each day. At the discretion of the District Engineer, additional lockages may be scheduled. Each schedule and any changes to the schedule will be issued at least 30 days prior to implementation. Prior to issuing any schedule or any changes to the schedule, the District Engineer will consider all public comments and will evaluate the expected energy situation, water supply, and recreation use of the lock to determine the seasonal need for the schedule or change in schedule. The District Engineer's representative at the locks shall be the Project Engineer, who shall issue orders and instructions to the Lock Master in charge of the lock. Hereinafter, the term "Lock Master" shall be used to designate the person in immediate charge of the lock at any given time. In case of emergency and on all routine work in connection with the operation of the lock, the Lock Master shall have authority to take action without waiting for instructions from the Project Engineer.

b. Lockage Control. The Lock Master shall be charged with the immediate control and management of the lock, and of the area set aside as the lock area, including the lock approach channels. Upstream and downstream approach channels extend to the end of the wing or guide wall, whichever is longer. At Bonneville Lock, the upstream approach channel extends to the upstream end of Bradford Island and the downstream approach channel extends to the downstream end of the lower moorage. The Lock Master shall demand compliance with all laws, rules, and regulations for the use of the lock and lock area and is authorized to issue necessary orders and directions, both to employees of the Government or to other persons within the limits of the lock or lock area, whether navigating the lock or not. Use of lock facilities is contingent upon compliance with regulations, Lock Master instructions, and the safety of people and property.

c. No one shall initiate any movement of any vessel in the lock or approaches except by or under the direction of the Lock Master. ("Vessel" as used herein includes all connected units, tugs, barges, tows, boats, or other floating objects.)

d. Signals.

(1) Radio. All locks are equipped with two-way FM radio operating on channel 14, frequency of 156.700 MHz, for both the calling channel and the working channel. Vessels equipped with two-way radio desiring a lock-age shall call WUJ 33 Bonneville, WUJ 34 The Dalles, WUJ 35 John Day, WUJ 41 McNary, WUJ 42 Ice Harbor, WUJ 43 Lower Monumental, WUJ 44 Little Goose, or WUJ 45 Lower Granite, at least one-half hour in advance of arrival since the Lock Master is not in constant attendance of the locks. Channel 14 shall be monitored constantly in the vessel pilot house from the time the vessel enters the approach channel until its completion of exit. Prior to entering the lock chamber, the commercial freight or log-tow vessel operator shall report the nature of any cargo; the maximum length, width and draft of the vessel; and whether the vessel is in any way hazardous because of its condition or the cargo it carries or has carried.

(2) Pull-cord Signal Stations. Pull-cord signal stations marked by large instructional signs and located near the end of the upstream and downstream lock entrance walls may be used in place of radios to signal the Lock Master for a lockage.

(3) Entering and Exit Signals. Signal lights are located outside each lock gate. When the green (go) light is on, all vessels will enter in the sequence prescribed by the Lock Master except at Bonneville where freight and log-tow vessels will enter on the amber light. When the red {stop) light is on, the lock is not ready for entrance and vessels shall stand clear. In addition to the above visual signals, the Lock Master will signal that the lock is ready for entrance by sounding one long blast on the lock air horn. The Lock Master will signal that the lock is ready for exit by lighting the green exit light and sounding one short blast on the air horn.

e. Permissible Dimensions of Vessels. Nominal overall dimensions of vessels allowed in the lock chamber are 84 feet wide and 650 feet long, except at Bonneville where these dimensions are 74 feet wide and 500 feet long. Depth of water in the lock depends upon river levels which may vary from day to day. Staff gauges showing the minimum water level depth over gate sills are located inside the lock chamber near each lock gate and outside the lock chamber near the end of both upstream and downstream guide walls. Vessels which do not have a draft of at least 1 foot less than a gauge reading shall not pass that gauge. Information concerning allowable draft for vessel passage through the locks may be obtained from the Lock Master. Minimum lock chamber water level depth is 15 feet except at

Ice Harbor where it is 14 feet and at Bonneville where it is 24.2 feet. The riverflow at Lower Granite exceeds 330,000 cubic feet per second; the normal minimum 15-foot depth may be decreased to as little as 8 feet. At Bonneville, a tow may be rearranged to less than clear lock dimensions (74 feet by 500 feet) prior to entering the lock and may be passed in one lock-age. Such rearrangements at Bonneville may be done at the moorage in the downstream lock approach channel or above the upstream guide wall and with the Lock Master's permission at the upstream guide wall. In consideration of river and swing bridge traffic at Bonneville, the Lock Master may authorize rearrangement of vessels within the lock chamber only when both miter gates at the open end of the lock are in their recesses in the lock walls and rearrangement will not be hazardous to them. Vessels wider than 50 feet will not be permitted to enter the Bonneville Lock during extreme high water when tailwater at the lock is higher than 35 feet above msl since the downstream guide wall will be inundated.

f. Precedence at Lock. Subject to the order of precedence, the vessel or tow arriving first at the lock will be locked through first; however, this precedence may be modified at the discretion of the Lock Master. If immediate passage is required, lockage of vessels owned or operated by the United States shall take precedence. The precedence of all other vessels shall be as follows:

(1) When a recreational vessel lockage schedule is in effect at the appointed time for lockage of recreation craft, recreation craft shall take precedence; however, commercial vessels may be locked through with recreational craft if safety and space permit. At other than the appointed time, the lockage of commercial and tow vessels shall take precedence and recreational craft may (only) lock through with commercial vessels as provided in paragraph h. of this section.

(2) If a recreational vessel lockage schedule is not in effect, commercial and tow vessels shall take precedence. Recreational craft may be locked through with commercial craft. If no commercial vessels are scheduled to be locked through within a reasonable time, not to exceed 1 hour after the arrival of the recreational vessel at the lock, the recreational vessel may be locked through separately. If a combined lockage cannot be arranged, the recreational craft shall be locked through after waiting three commercial lockages.

g. Loss of Turn. Boats that fail to enter the lock with reasonable promptness, after being authorized to do so, shall lose their turn.

h. Lockage.

(1) Multiple Lockages. The Lock Master shall decide whether one or more vessels or tows may be locked through at the same time. Vessels with flammable or highly hazardous cargo will be passed separately from all

other vessels. Hazardous materials are described in Part 171, Title 49, Code of Federal Regulations. Flammable materials are defined in the National Fire Code of the National Fire Protection Association.

(2) Recreational Craft. By mutual agreement of (all parties) the Lock Master and the captains of the vessels involved, recreational vessels may be locked through with commercial vessels. Under the recreational vessel schedule, separate lockage will not be made by recreational vessels except in accordance with the recreational lockage schedule or when circumstances warrant, such as in an emergency. When recreational craft are locked simultaneously with commercial vessels, the recreational vessel will enter the lock chamber after the commercial vessel is secured in the chamber and when practicable will depart while the commercial vessel remains secured.

(3) Special Schedules. Recreational boating groups may request special schedules by contacting the District Engineer. The schedule for the daily lockage of recreational vessels will indicate the number of boats required in order to arrange a special schedule.

i. Mooring in Approaches Prohibited. Mooring or anchoring in the approaches to the lock is prohibited where such mooring will interfere with navigation.

j. Waiting for Lockage. Vessels waiting for lockage shall wait in the clear outside of the lock approach channel, or contingent upon permission by the Lock Master may, at their own risk, lie inside the approach channel at a place specified by the Lock Master. At Bonneville, vessels may, at their own risk, lay-to at the downstream moorage facility on the south shore downstream from the guide wall. Provided, that a 100-foot-wide open channel is maintained and vessels upstream may lay-to against the guide wall, at their own risk, provided they remain not less than 400 feet upstream of the upstream lock gate; or contingent upon prior radio clearance by the Lock Master they may, at their own risk, tie to the upstream guide wall.

k. Mooring in Lock. All vessels must be moored within the lock chamber so that no portion of any vessel extends beyond the lines painted on the lock walls. Moorage within the lock chamber will be to floating mooring bits only and will be accomplished in a proper no-slip manner. Small vessels will not be locked with a large vessel unless the large vessel is so moored two mooring bits) that no lateral movement is possible. The vessel operator will constantly monitor the position of his vessel and his mooring bit ties to assure that there is no fore-or-aft movement of his vessel and lateral movement is minimized. Propulsion by vessels within the lock chamber will not be permitted during closure operation of a lock chamber gate or as otherwise directed by the Lock Master.

l. Crew to Move Craft. During the entire lockage, the vessel operator shall constantly attend the wheelhouse, be aware of the vessel's position, and monitor radio channel 14 on frequency 156.700 MHz, or otherwise be constantly able to communicate with the Lock Master. At a minimum, vessels shall be as vigilantly manned as if underway.

m. Speed. Vessels shall be adequately powered to maintain a safe speed and be under control at all times. Vessels shall not be raced or crowded alongside another in the approach channels. When entering the lock, speed shall be reduced to a minimum consistent with safe navigation. As a general rule, when a number of vessels are entering the lock, the following vessel shall remain at least 200 feet astern of the vessel ahead.

n. Delay in Lock. Vessels shall not unnecessarily delay any operation of the locks.

o. Landing of Freight. No freight, baggage, personnel, or passengers shall be landed on or over the walls of the lock, except by permission and direction of the Lock Master.

p. Damage to Lock or Other Structures. The regulations in this section shall not relieve the liability of the owners and/or operators of vessels from liability for any damage to the lock or other structures or for the immediate removal of any obstruction. No vessel in less than stable floating condition or having unusual sinking potential shall enter the locks or its approaches. Vessels must use great care not to strike any part of the lock, any gate or appurtenance thereto, or machinery for operating the gates, or the walls protecting the banks of the approach channels. All vessels with projecting irons or rough surfaces which may damage the gates or lock walls shall not enter the lock unless provided with suitable buffers and fenders. Vessels having chains, lines, or drags either hanging over the sides or ends or dragging on the bottom for steering or other purposes will not be permitted to pass.

q. Tows. Prior to a lockage, the person in charge of a vessel towing a second vessel by lines shall, at a safe distance outside of the incoming approach channel, secure the second vessel to the towing vessel and keep it secured during the entire course of a lockage and until safely clear of the outgoing approach channel.

r. Violation of Regulations. Any violation of these regulations may subject the owner or master of any vessel to any or all of the following: (1) Penalties prescribed by law of the United States Government (33 U.S.C. 1); (2) report of violation to the titled owner of the vessel; (3) report of the violation to the U.S. Coast Guard; and/or (4) refusal of lockage at the time of violation.

s. Refuse in Locks. No material of any kind shall be thrown or discharged into the lock or be deposited in the lock area. Vessels leaking or spilling cargo will be refused lockage and suitable reports will be made to the U.S. Coast Guard. Deck cargo will be so positioned so as not to be subject to falling overboard.

t. Handling Valves, Gates, Bridges, and Machinery. No person, unless authorized by the Lock Master, shall open or close any bridge, gate, valve, or operate any machinery in connection with the lock. However, the Lock Master may call for assistance from the master of any vessel using the lock, should such aid be necessary, and when rendering such assistance, the men so employed shall be directly under the orders of the Lock Master. Masters of boats refusing to give such assistance when it is requested of them may be denied the use of the lock by the Lock Master.

u. Statistics. On each passage through the lock, masters or pursers of vessels shall furnish to the Lock Master a written statement of passengers, freight, and registered tonnage and other information as indicated on forms furnished to boat operators by the Lock Master.

v. Hazardous Areas. At McNary, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite Dams, all water from the downstream face of the dam to a line straight across the river at the downstream end of the down-stream lock guide wall is considered hazardous and vessels may enter only at their own risk.

w. Restricted Areas. No vessel shall enter or remain in any restricted area at any time without first obtaining permission from the District Engineer, U.S. Army Corps of Engineers, or his duly authorized representative.

(1) At Bonneville Dam. The waters restricted to only Government vessels are described as all waters of the Columbia River and Bradford Slough within 1,000 feet above and 2,000 feet below the powerhouse. The restricted areas will be designated by signs.

(2) At The Dalles Dam. The waters restricted to only Government vessels are described as all downstream waters other than those of the navigation lock downstream approach channel which lie between the Pasco County Bridge and the project axis, including those waters between the powerhouse and the Oregon shore and all upstream waters other than those of the navigation lock upstream approach channel which lie between the project axis and a line projected from the upstream end of the navigation lock guide wall to the junction of the concrete structure with the earthfill section of the dam near the upstream end of the powerhouse.

(3) At John Day Dam. The waters restricted to only Government vessels are described as all of the waters within a distance of about 1,000 yards above the dam lying south of the navigation channel leading to the lock and bounded by a line commencing at the upstream end of the guide wall, and running in a direction 54°01'37" true for a distance of 771 yards, thence 144°01'37" true across the river to the south shoreline. The downstream limit is marked by orange and white striped monuments on the north and south shores.

(4) At McNary Dam. The waters restricted to only Government vessels are described as all of the waters within a distance of about 1,000 yards above the dam lying south of the navigation channel leading to the lock and bounded by a line commencing at the upstream end of the guide wall, and running in a direction 93^{0}30' true for a distance of 495 yards, thence 175°15' true for 707 yards, thence 179°00' true for 441 yards, thence 235^{0}00 true for 585 yards, thence 268º00 true for 146 yards to the head of the fish ladder.

(5) At Ice Harbor Dam. The waters restricted to only Government vessels are described as the waters within a distance of about 800 yards upstream of the dam lying south of the navigation channel leading to the lock and bounded by a line commencing at the upstream end of the guide wall, and running a direction 83º00' true for a distance of 600 yards, thence 175°00' true for a distance of 250 yards, thence 241°00' true to the upstream face of the dam.

(6) At Lower Monumental Dam. The waters restricted to only Government vessels are described as the waters within a distance of about 1,200 yards upstream of the dam lying north of the navigation channel leading to the lock and bounded by a line commencing at the upstream end of the fixed guide wall and running in a direction 48^{0}00' true for a distance of yards, thence 326°00' true for a distance of 366 yards, thence 260°00' true for a distance of 160 yards, thence 270°00' true to the north shore.

(7) At Little Goose Dam. The waters restricted to only Government vessels are described as those within a distance of 800 yards above the dam lying north of the guide wall and bounded by a line commencing at the upstream end of the guide wall and running in a direction 64°13' true for a distance of 567 yards, thence 349°03' true for a distance of 610 yards to the north shoreline.

(8) At Lower Granite Dam. The waters restricted to only Government vessels are described as those within a distance of 800 yards above the dam lying south of the guide wall and upstream end of the guide wall and running in a direction 136° true for a distance of ± 586 yards, thence 214° true for a distance of 250 yards to the south shoreline.

Drawings which depict the hazardous and restricted areas in paragraphs v. and w. of this section are available from the District Engineers for areas within their respective jurisdictions.

TABLE B-1

NOTIFICATION LIST IN CASE OF UNSCHEDULED LOCK CLOSURES
OR
OTHER NAVIGATION MATTERS

[redacted]

Who will in turn notify:

1. Chief, Project Operations Branch, Operations Division.

2. Public Affairs Office, Walla Walla District.

3. Chief, Project Operations Branch, North Pacific Division.

4. Columbia River Towboat Association.