Hydrology Section

US Army Corps
of Engineers
Walla Walla District

Water Control Manual For Ice Harbor Lock and Dam

Snake River, Washington

1985 WATER CONTROL MANUAL STATUS SHEET
ICE HARBOR LOCK and DAM, WASHINGTION

CHAPTER NUMBER	ITEM*	PRIORITY	STATUS	PLANNED ACTION
I	INTRODUCTION	3	3	
II	DESCRIPTION	3	3	
III	HISTORY	3	3	ALL MANUAL ITEMS WILL BE REVIEWED PERIODICALLY.
IV	WATERSHED CHARACTERISTICS	3	3	
V	DATA COLLECTION	2	3	
VI	HYDROLOGIC FORECASTS	2	NA	
VII	WATER CONTROL PLAN	1	1	
VIII	EFFECT OF WATER CONTROL PLAN	2	6	
IX	WATER CONTROL MGT.	2	3	
SUPPORTING INFORMATION:				
	PHOTO	3	1	
	PERTINENT DATA	2	3	

* Includes charts & tables associated with each chapter

STATUS CODES

APPROVED MANUALS:

1. TECHNICAL ASPECTS ADEQUATE AND APPROVED; FINISHED FORM (up-to-date).
2. TECHNICAL ASPECTS ADEQUATE AND APPROVED; DRAFT FORM (preliminary).
3. APPROVED, BUT SOME ASPECTS INCOMPLETE OR NEED REVISION.

MANUALS NOT APPROVED:

4. DRAFT FORM; NOT ALL ASPECTS APPROVED.
5. PORTIONS INCOMPLETE AND/OR OUTDATED.

6. INCOMPLETE CHAPTER (report published prior to ETL 1110-2-251, " Engineering and Design - Preparation of Water Control Manuals," dated 14 March 1980).

NA - Not applicable

REVISED SEPT. 1985

WATER CONTROL MANUAL REVISIONS
FOR ICE HARBOR LOCK AND DAM

The following revisions are provided for the updating of this Water Control Manual. This Manual will be reviewed annually and updated if necessary. Major revisions pertaining to format and content in accordance with references ETL 110-2-251 and ER 1110-2-240 will be accomplished as time and manpower becomes available.

FEBRUARY 2011 revisions include:

1. Emergency Regulation Assistance Procedures (Pink Sheet, Page iv)
2. Personnel and Telephone Numbers (Pages 6-9 and 6-10)
3. EXHIBIT 8-1 (Page 7 of 7)

DECEMBER 1988 revisions include:

1. Emergency Regulation Assistance Procedures (Pink Sheet, Page iv)
2. Personnel and Telephone Numbers (Pages 6-9 and 6- 0)
3. SECTION IX - EFFECT OF WATER CONTROL PLAN (Pages 9-3 and 9-4)
4. PLATE 9-2, Annual Peak Discharge Frequency - Columbia River at The Dalles.

JUNE AND DECEMBER 1987 revisions include:

1. TITLE PAGE (Green Sheet)
2. PHOTOGRAPH (Insert existing project photo for page ii)
3. NOTICE TO USERS (page iii)
4. EMERGENCY REGULATION ASSISTANCE PROCEDURES. (Pink Sheet, Pages iv-v)
5. TABLE OF CONTENTS (Yellow Sheet, Pages a-d)
6. PERTINENT DATA (Blue Sheet, Pages A-D)
7. SECTION I - Introduction (Pages 1-1 to 1-2)
8. SECTION VI - Water Control Management (Pages 6-1 to 6-10)
9. SECTION VII - Streamflow Forecasts (Page 7-1)
10. SECTION VIII - Water Control Plan (Pages 8-1 to 8-11)
11. SECTION IX - Effects of Water Control Plan (Pages 9-1 to 9-4)
12. TABLE 6 - Summary of Runoff and Discharge Data Snake River near Clarkston, Wash.
13. TABLE 6A - Summary of Runoff and Discharge Data Lower Granite Reservoir Computed Regulated Inflows
14. TABLE 13 - Ice Harbor Mean Unit Performance
15. CHART 3 - Power Unit Discharge Rating
16. CHART 12 - Regulation of Large Historical Snake River Floods
17. PLATE 2 - Reservoir Map (2 Sheets)
18. PLATE 8 - Daily Discharge Hydrographs - Snake River near Clarkston, Wash. (1948-1966)
19. PLATE 8A - Daily Discharge Hydrographs - Snake River near Clarkston, Wash.(1967-1972)
20. PLATE 8B - Daily Discharge Hydrographs - Lower Granite Reservoir Computed Regulated Inflows (1976- 1986)
21. PLATE 9 - Summary Hydrographs - Snake River near Clarkston, Washington
22. PLATE 9-1 - Annual Peak Discharge Frequencies Snake River at Lower Granite
23. PLATE 9-2 - Annual Peak Discharge Frequencies Columbia River at The Dalles

WATER CONTROL MANUAL INDORSEMENTS

S: 1 Feb 88

CENPW-PL-H (CENPW-PL-H/24 Jun 87) (1110-2-1150a) 2nd End
Mr. Kim/jm/434-6608
SUBJECT: Ice Harbor Lock and Dam, Water Control Manual Revisions

DA, Commander, Walla Walla District, Corps of Engineers, Walla Walla, WA 99362-9265 5 January 1988

FOR: Commander, North Pacific Division, ATTN: CENPD-EN-WM

1. Enclosed for your approval are five sets of revisions for Section VIII - Water Control Plan and other pertinent sections in the subject Water Control Manual which was published in March 1964 and approved on 4 May 1964. Review comments by your office and NPW Planning, Operations, Engineering Divisions, and Ice Harbor - Lower Monumental Project Office on the set of June 1987 revisions have been incorporated into the set of revisions to the subject Manual.

2. The items revised within the subject Manual include:

1. TITLE PAGE (Green sheet)

2. PHOTOGRAPH (Insert existing project photo for Page ii)

3. NOTICE TO USERS OF MANUAL (Page iii)

4. EMERGENCY REGULATION ASSISTANCE PROCEDURES (Pages iv-v, pink sheet)

5. TABLE OF CONTENTS (Pages a-d, yellow sheet)

6. PERTINENT DATA (Pages A-E, blue sheet)

7. I - INTRODUCTION (Pages 1-1 to 1-2)

8. VI - WATER CONTROL MANAGEMENT (Pages 6-1 to 6-10)

9. VII - STREAMFLOW FORECASTS (Page 7-1)

10. VIII - WATER CONTROL PLAN (Pages 8-1 to 8-12)

11. IX - EFFECTS OF WATER CONTROL PLAN (Pages 9-1 to 9-4)

12. TABLE 6 Summary of Runoff and Discharge Data - Snake River near Clarkston, Washington

13. TABLE 6A Summary of Runoff and Discharge Data - Lower Granite Reservoir Computed Regulated Inflows

14. TABLE 13 Ice Harbor Mean Unit Performance

15. CHART 3 Power Unit Discharge Rating

16. CHART 12 Regulation of Large Snake River Floods

17. PLATE 2 Reservoir Map (2 Sheets)

18. PLATE 8A Daily Discharge Hydrographs - Snake River near Clarkston, Washington (1967-1972)

19. PLATE 8B Daily Discharge Hydrographs - Lower Granite Reservoir Computed Regulated Inflows (1976-1986)

20. PLATE 9 Summary Hydrographs - Snake River near Clarkston, Washington

21. PLATE 9-1 Annual Peak Discharge Frequencies - Snake River at Lower Granite

22. PLATE 9-2 Annual Peak Discharge Frequencies - Columbia River at The Dalles

23. PLATE 10 Summary Hydrographs - Clearwater River at Spalding, Idaho (Regulated Discharge)

24. EXHIBIT 1-1 Design Memorandums

25. EXHIBIT 8-1 Part 207 - Navigation Regulations

3. We would appreciate your response by 1 February 1988. We plan to forward copies of the above set of revisions to other interested parties after approval is received from your office.

4. Questions concerning these revisions to the subject manual should be directed to Ed Kim, extension 6608.

FOR THE COMMANDER:

KIM/jm

RICKEL/PL-H

5 Encls

RONALD G. BARRETT,
Acting Chief, Planning Division

P.E.BARRETT/PL

IM-SM

EN

CENPD-EN-WM (CENPW-PL-H/24 Jun 87)(1110-2-1150a) Mr. Holmes/FTS 423-3761/dll
SUBJECT: Ice Harbor Lock and Dam, Water Control Manual Revisions

DA, North Pacific Division, Corps of Engineers, P. O. Box 2870, Portland, Oregon 97208-2870 3 August 1987

FOR: Commander, Walla Walla District, ATTN: CENPW-PL-H

One set of revisions which has been marked with our comments is enclosed.

FOR THE COMMANDER:

for Gary L. Fleighton [signature]
HERBERT H. KENNON, P.E.
Chief, Engineering Division

5 Encls
w/d 4 Encls

DEPARTMENT OF THE ARMY
WALLA WALLA DISTRICT, CORPS OF ENGINEERS
BUILDING 602, CITY-COUNTY AIRPORT
WALLA WALLA, WASHINGTON 99362

REPLY TO
ATTENTION OF:

CENPW-PL-H (1110-2-1150a) 24 June 1987

MEMORANDUM FOR: Commander, North Pacific Division, ATTN: CENPD-EN-WM

SUBJECT: Ice Harbor Lock and Dam, Water Control Manual Revisions

1. Enclosed for your review and comment are revisions of Section VIII - Water Control Plan and other pertinent sections in the subject Manual, which was published in March, 1964. We are requesting concurrent review of these revisions by CENPW Planning; Operations, Construction, and Readiness; Engineering Divisions; and Lower Monumental project Engineer.

2. The items revised within the subject Manual include:

a. TITLE PAGE (Page i)

b. PHOTOGRAPH (Insert existing project photo for Page ii)

c. NOTICE TO USERS OF MANUAL (Page iii, pink sheet)

d. EMERGENCY REGULATION ASSISTANCE PROCEDURES (Pages iv-v, pink sheet)

e. TABLE OF CONTENTS (Pages a-d, yellow sheet)

f. PERTINENT DATA (Pages A-E, blue sheets)

g. I - INTRODUCTION (Pages 1-1 to 1-2)

h. VI - WATER CONTROL MANAGEMENT (Pages 6-1 to 6-10)

i. VII - STREAMFLOW FORECASTS (Page 7-1)

j. VIII - WATER CONTROL PLAN (Pages 8-1 to 8-10)

k. IX - EFFECT OF WATER CONTROL PLAN (Pages 9-1 to 9-4)

l. PLATE 9-1 Maximum Annual Flood Frequency Curve
Snake River at Lower Granite

m. PLATE 9-2 Maximum Annual Flood Frequency Curve
Columbia River at the Dalles

n. EXHIBIT 1-1 Design Memorandums

o. EXHIBIT 8-1 Part 207 - Navigation Regulations

CENPW-PL-H
SUBJECT: Ice Harbor Lock and Dam, Water Control Manual Revisions

3. We would appreciate receiving any editorial comments your office may have by 31 July 1987. Review comments will be incorporated into the Water Control Manual, and final revisions to the Manual will be distributed to interested parties.

4. Questions concerning revisions to the subject manual should be directed to Ed Kim, Extension 6608.

FOR THE COMMANDER:

L. V. Armacost

L. V. ARMACOST, P.E.
Chief, Planning Division

5 Encl

ENGCW-EY (22 Apr 64) 1st Ind
SUBJECT: Ice Harbor Regulation Manual

HQ, DA, CofEngrs, Washington, D. C. 20315, 4 May 1964

TO: Division Engineer, U. S. Army Engineer Division, North Pacific

1. The reservoir regulation manual for Ice Harbor Lock and Dam is approved.

2. Two copies of the subject manual are returned as surplus to the needs of this office.

FOR THE CHIEF OF ENGINEERS:

Incl
1 cy w/d

WENDELL E. JOHNSON
Chief, Engineering Division
Civil Works

NPDEN-WC (22 Apr 64) 2nd Ind

U. S. Army Engr Div, North Pacific, Portland, Ore. 7 May 1964

TO: District Engineer, U. S. Army Engineer District, Walla Walla

1. To note approval.

2. The copies returned by the Office, Chief of Engineers, have been retained in this office.

FOR THE ACTING DIVISION ENGINEER:

Incl
w/d

GORDON H. FERNALD, JR.
Chief, Engineering Division

ADDRESS REPLY TO
THE DIVISION ENGINEER
(NOT TO INDIVIDUALS)

U. S. ARMY ENGINEER DIVISION, NORTH PACIFIC
CORPS OF ENGINEERS
210 CUSTOM HOUSE
PORTLAND, OREGON 97209

SYMBOL: NPDEN-WC

22 April 1964

SUBJECT: Ice Harbor Regulation Manual

TO: Chief of Engineers
ATTN: ENGCW

1. Reference letter dated 26 July 1963, NPD to OCE, subject as above.

2. Three copies of the Ice Harbor Regulation Manual are inclosed for your use and review.

3. Approval is recommended.

FOR THE DIVISION ENGINEER:

1 Incl
Reg. Man. (trip)

DON D. DeFORD
Colonel, Corps of Engineers
Deputy Division Engineer

NPWEN-PY

14 April 1964

SUBJECT: Reservoir Regulation Manual, Ice Harbor Project

TO: Division Engineer
U. S. Army Engineer Division, North Pacific

1. Inclosed are four copies of the Ice Harbor Reservoir Regulation Manual. It is requested that Copy No. 1 be forwarded to the Office, Chief of Engineers. Additional copies can be provided if desired.

2. Some of the information in the inclosed manual differs somewhat from that in the preliminary manual, dated May 1963, which should now be discarded. Among the significant revisions is the relationship between power unit output and turbine discharge, shown graphically on Charts 3 and 4. As stated in earlier correspondence to your office and as discussed at various times between members of our technical staffs, the revised power-discharge relationships are now in use in the day-to-day operation of Ice Harbor project.

3. We are providing Bonneville Power Administration with three copies of the manual for their use.

FOR THE DISTRICT ENGINEER:

1 Incl
Manual, Cy 1-4

E. J. WILLIAMS, JR.
Major, CE
Deputy District Engineer

cc: Water Control Section files

ML/hc
MJO
CVG
ECF
VB
EJW
M&R
ENGF

NPDEN-WC (26 Jul 63) 2nd Ind
SUBJECT: Ice Harbor Regulation Manual

U. S. Army Engr Div, North Pacific, Portland, Ore., 6 August 1963

TO: District Engineer
U. S. Army Engineer District, Walla Walla

Forwarded for your information.

FOR THE DIVISION ENGINEER:

Don D. DeFord
DON D. DEFORD
Colonel, Corps of Engineers
Assistant Division Engineer

ENGCW-EY (26 Jul 63) 1st Ind
SUBJECT: Ice Harbor Regulation Manual

HQ, DA, Office of the Chief of Engineers, Washington, D.C. 20315, 2 Aug 63

TO: Division Engineer, U. S. Army Engineer Division, North Pacific, Portland, Oregon

The subject draft reservoir regulation manual for the Ice Harbor project is approved as recommended.

FOR THE CHIEF OF ENGINEERS:

Incl
w/d

HORACE A. JOHNSON
Acting Chief, Engineering Division
Civil Works

ADDRESS REPLY TO
THE DIVISION ENGINEER
(NOT TO INDIVIDUALS)

U. S. ARMY ENGINEER DIVISION, NORTH PACIFIC
CORPS OF ENGINEERS
210 CUSTOM HOUSE
PORTLAND 9, OREGON

SYMBOL: NPDEN - WC

26 July 1963

SUBJECT: ICE HARBOR REGULATION MANUAL

TO: Chief of Engineers
ATTN: ENGCW

A draft copy of the Ice Harbor Regulation Manual is inclosed for your immediate reference. Your approval is recommended. Three copies of the Manual will be forwarded following final editing by the Walla Walla District.

FOR THE DIVISION ENGINEER:

Don D. DeFord

DON D. DeFORD
Colonel, Corps of Engineers
Assistant Division Engineer

1 Incl
as

WATER CONTROL MANUAL

FOR

ICE HARBOR LOCK AND DAM

SNAKE RIVER

WASHINGTON

U. S. ARMY CORPS OF ENGINEERS

WALLA WALLA DISTRICT

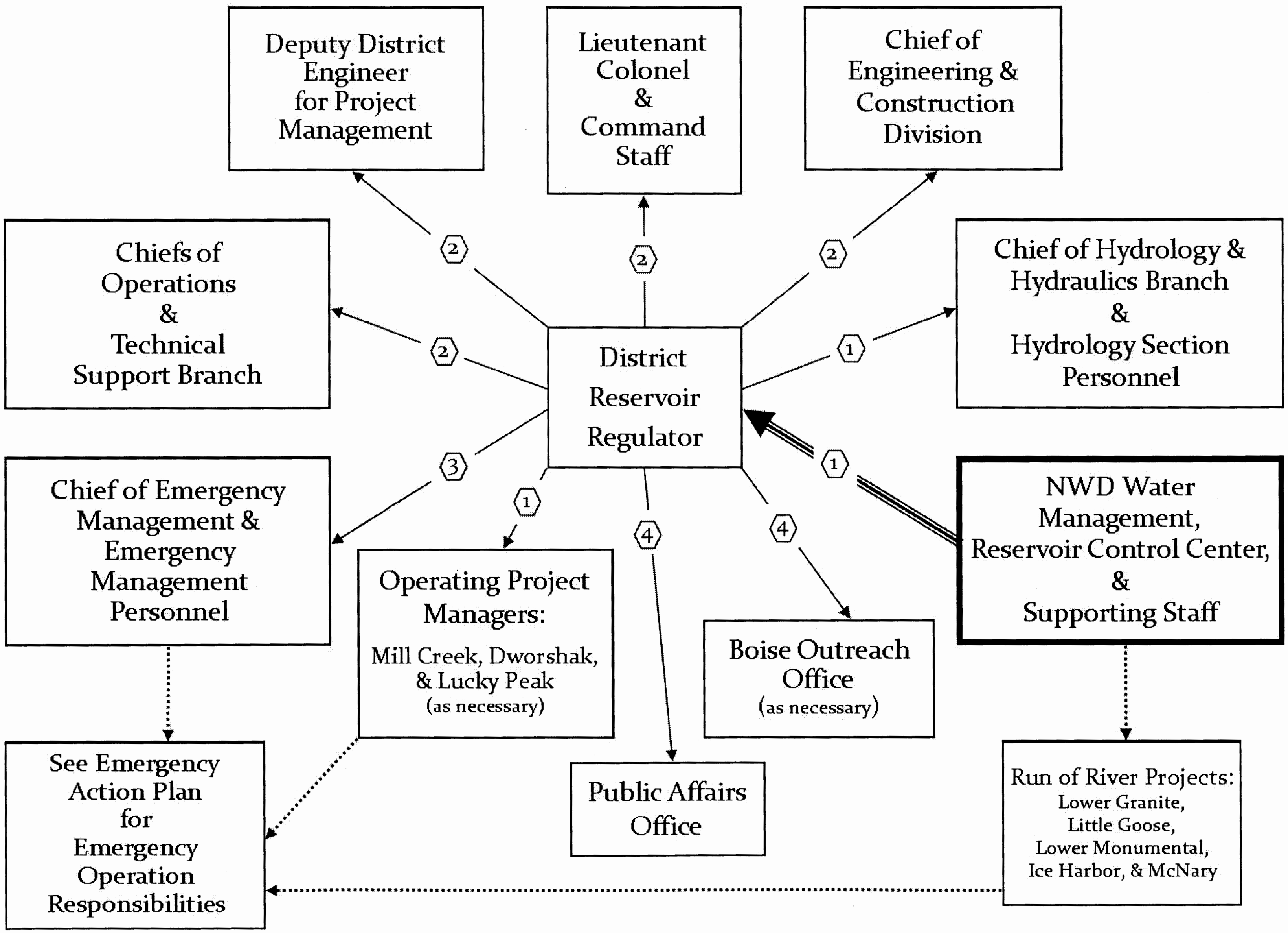
MARCH 1964

ICE HARBOR DAM

13 May 1963. Spillway discharge 38,000 cfs, powerhouse discharge 44,000 cfs, fish ladder discharge 200 cfs.

COMMUNICATION RESPONSIBILITIES for Flood Emergencies

Run of River Projects



NOTE: Numbers on the arrows indicate priority of contact. The highest priority contacts are denoted with 1 and the lowest priority contacts are denoted with 4.

NOTE: NWD Water Management initiates communication with the District Reservoir Regulator (large arrow) when the concern is with the Run of the River Projects.
District Reservoir Regulator sends the information to the interested parties (Solid Lines)
Communications that occur between the respective sources shown with Dashed lines

NOTICE TO USERS OF THIS MANUAL

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

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 structual failures occur at the Ice Harbor 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.

Castastrophic failures include:

(1) Flooding resulting from failures at Ice Harbor 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 - Ice Harbor Lock and Dam - Snake River, Washington, U.S. Army Engineer District, Walla Walla, August 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 Ice Harbor Emergencies", which is in the Ice Harbor Project Standing Orders.

Project function emergencies affecting power generation and/or navigation are the responsibility of the Ice Harbor - Lower Monumental Project Engineer or his representative. Emergencies affecting power generation should be coordinated according to "Call-Out Procedures for Ice Harbor Emergencies", which is in the Ice Harbor Standing Orders. If the nature of the emergency is such as to require immediate action, the Project Engineer may take necessary action and report to Walla Walla District's Chief of Operations as soon as possible. The Bonneville Power Administration (BPA) 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 Ice Harbor Project under various types of national emergencies (terrorist attack, sabotage, nuclear war, etc.).

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TABLE OF CONTENTS (CONTINUED)

IX - EFFECT OF WATER CONTROL PLAN

Tables

* DELETED BY REVISION
** ADDED BY REVISION

TABLE OF CONTENTS (CONTINUED)

TABLES (CONTINUED)

Charts

Plates

Exhibits

* DELETED BY REVISION
** ADDED BY REVISION

PERTINENT DATA

1. GENERAL:

Location:

State	Washington
County	Franklin and Walla Walla
River	Snake
River Mile	9.7

Drainage Area above Ice Harbor Dam, Sq. mi	109,000
River miles upstream from mouth of Snake River	9.7

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

Authorized Purpose: Power generation and inland navigation

Other Uses: Fishery and recreation

Type of Project: Run-of-river

Real Estate: Fee acquisition land above pool elev. 440, acres — 7,830

2. RESERVOIR:

Name	Sacajawea
Elevations (Feet Mean Sea Level):	
Maximum at dam for spillway design flood.	446.4
Normal operating range guaged at Dam	437- 440
Length, miles	31.9
Average width, miles	0.4
Maximum width, miles	1.0
Surface area at elevation, 440 (low flow-flat pool), acres	8,375
Storage between elev. 437 and 440 (acre feet)	24,900

3. DAM (General):

Powerhouse, overall length	671
Spillway, total length	590
Navigation lock, overall width	173
Concrete nonoverflow sections:	
Navigation lock to spillway, (length feet)	154
Spillway to powerhouse, (length feet)	40
Powerhouse to south shore embankment (length feet)	560

3. DAM (General, Cont.):

Earth embankment, north shore (length feet)	624
Total length of dam (feet)	2,822
Maximum height of concrete sections (foundations deck, feet)	213.0
Maximum height of abutment section (N.S. foundation to top)	123.0
Deck elevation	453 ft. msl

4. SPILLWAY:

Type	Ogee, concrete, gravity, gate controlled
Maximum width at base, elev. 392 feet msl (feet)	139
Maximum height, foundation to deck (feet)	141
Number of bays	10
Overall length, (feet) (abutment centerlines)	590
Clear length (feet)	500
Crest elevation, feet msl	391
Gate seal elevation, feet msl	389.07
Top of gate in closed position, elev	442
Deck elevation feet msl	453
Gate lip elevation at maximum opening, feet msl	436
Control gates:	
Type	Tainter
Size	50'W x 52.9'H
Method of operation:	Individual electric hoists, remote and manually controlled
Maintainance closure for spillway bays	stoplogs
Spillway design flood:	
Peak discharge	850,000 cfs
Pool elevation, feet msl	446.4
Tailwater elevation, feet msl	374.0
Gross head, feet	72.4
Maximum flood at normal pool, elev 440 discharge	685,000 cfs
Tailwater elevation, feet, msl	370.5
Gross head, feet	72.4

5. STILLING BASIN:

Type	Horizontal apron
Width, perpendicular to flow, feet	590
Length, parallel to flow, feet	168
Floor elevation, feet msl	304
Height of continuous end sill, feet	12

6. POWERHOUSE:

Number of generating units	6
Spacing, feet:	
Units 1 through 5	90

6. POWERHOUSE (Cont'd):

Unit 6	96
Erection and service bay	110
Turbines:	
Type	Kaplan, 6-blade
Runner diameter:	
Units 1 through 3, inches	280
Units 4 through 6, inches	300
Revolutions per minute:	
Units 1 through 3	90.0
Units 4 through 6	87.5
Generators:	
Rating (nameplates)	
Units 1 through 3, kilowatts	90,000
Units 4 through 6, kilowatts	111,000
Power factor	0.95
Kilovolt ampere rating	
Units 1 through 3	95,000
Units 4 through 6	117,000
Units installed complete initially	3
Skeleton units provided initially	3
Total units now installed	6
Plant capacity, nameplate rating, kilowatts	603,000
Crane capacities, tons:	
Intake (joint use with spillway)	85
Bridge	500
Draft tube gantry	35

7. NAVIGATION LOCK AND CHANNELS:

Type	Single lift
Net clear length, lock chamber, feet	675
Net clear width, lock chamber, feet	86
Minimum water depth over lower sill, feet	16
Upstream gate:	
Type	Radial
Height, feet	25
Downstream gate:	
Type	Vertical lift
Height, feet	91.0
Maximum operating lock lift, feet	105
Length of guidewalls (from face of gate), feet:	
Upstream (floating)	746
Downstream	696
Normal fill time	11 minutes
Normal emptying time	14 minutes

8. FISH FACILITIES

Number of fish ladders	2
Slope:	
North Shore	1V on 10H
South Shore	1V on 16H
Number of weirs (including orifice-control section)	103
Overflow weirs:	
Number	97
Height	6 feet
Orifice size:	
North Shore	18x18 inches
South Shore	21x23 inches
Exit of ladders, invert elevation, feet msl	431
Entrance of ladder, invert elevation, feet msl	332
Normal fishway flow, forebay to each ladder:	
North Shore, cfs	74
South Shore, cfs	142
Ladder clear width:	
North Shore, feet	16
South Shore, feet	24
Pumps for fish attraction water:	
Number:	
North Shore	3
South Shore	8
Type	turbine
Discharge:	
North Shore, cfs	250
South Shore, cfs	300
Fishway entrances:	
North shore	2
South shore	3
Nonoverflow	3
Powerhouse collection system:	
Number of orifice entrances	12
Length of channel, feet	661
Width of channel, feet	17.5
Downstream Migrants Bypass System:	
Ice and Trash Sluiceway	1
Hydraulic Capacity, cfs	2,700

9. HYDROLOGIC DATA (Based on streamflow data for Snake River near Clarkston, Washington):

Drainage area, square miles	103,200
Period of record: Oct 1915 - Sep 1972 Dec 1972 (discontinued)	
Discharges in cubic feet per second:	
Instantaneous maximum of record, 29 May 1948	369,000
Instantaneous minimum of record, 2 Sept. 1958	6,660
Average annual flow	48,840
Average annual mean daily peak flow	188,300
Extreme outside period of record:	
Flood of June 1894	409,000
Flood of June 1894, controlled by existing projects	295,000
Standard project flood (controlled by existing projects):	
Snake River below Clearwater River	420,000
Snake River above Clearwater River	295,000
Clearwater River above Snake River	150,000
Spillway design flood:	850,000

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 Oct. 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 Ice Harbor Project and to provide a reference source for higher authority and personnel responsible for the regulation of the project. Items discussed within this manual are as follows:

a. Basin Description.

b. Climatology and Hydrology

c. Project History.

d. Description of project.

e. Water control management.

f. Streamflow forecasts.

g. Water control plan.

h. Effect of water control plan.

Section VIII, Water Control Plan, contains information necessary for understanding the objectives of the project and instructions to implement the regulation of the reservoir. Section VI, Water Control Management, outlines responsibilities of the Corps of Engineers, Bonneville Power Administration, and other agencies involved indirectly with the regulation of the Ice Harbor Project. The Master Water Control Manual for the Columbia River Basin, dated Dec. 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 Ice Harbor Project, Snake River, Washington.

a. Design Memorandum No. 1 - General Design Memorandum (5 volumes), 5 October 1959.

b. Design Memorandum No. 7B Master Plan for Development of Lower Monumental Lock and Dam, 6 May 1966.

c. Ice Harbor Lock and Dam, Operation and Maintenance Manual (3 Volumes, Except Chapter 3, Powerhouse and Equipment), 1974.

d. Final Environmental Impact Statement, February 1976.

e. Ice Harbor Lock and Dam, Master Plan.

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

g. Flood Emergency Subplans, Identification, Operation, Repair, Notification, and Inundation Maps - Ice Harbor Lock and Dam, Snake River, Washington, August 1982..

h. Ice Harbor Lock and Dam, Operation and Maintenance Manual

i. Columbia River Basin - Master Water Control Manual, Dec. 1984.

j. Juvenile Fish Passage Plan For Corps of Engineers Projects, published annually by CENPD-EN-WM.

1-04. Project Ownership and Operation. The Federal government owns the Ice Harbor project. The Walla Walla District Corps of Engineers is responsible for the operation and maintenance of the Dam and its facilities.

1-05. Regulating Agencies. Functional day-to-day water regulation at Ice Harbor is the responsibility of the U.S. Army Corps of Engineers, North Pacific Division, Reservoir Control Center (RCC). 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 Ice Harbor and upon request from RCC aids in its regulation by providing technical advice. The Bonneville Power Administration is authorized to market electrical energy generated at Ice Harbor 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 Ice Harbor and other Corps of Engineers, North Pacific Division Projects.

SECTION II - BASIN DESCRIPTION

2-01. PROJECT LOCATION

Ice Harbor Dam is located in southeastern Washington on Snake River, 9.7 miles above its confluence with Columbia River. The dam is 334 river miles above the mouth of Columbia River and about 250 airline miles east of the Pacific Ocean. The frontispiece map shows the geographical location of Ice Harbor project in relation to the overall Columbia River system and to other major dam and reservoir development. Plate 1 gives further detail on the plan of development of lower Snake River.

2-02. DRAINAGE BASIN

Ice Harbor Dam has a tributary area of 109,000 square miles, comprising very nearly the entire Snake River basin. Most of Idaho, with lesser parts of Oregon, Washington, Wyoming, Nevada, and Utah, are within the Snake River watershed. The greatest overall dimensions of the basin are about 450 miles in both the north-south and east-west directions. The Master Reservoir Regulation Manual will describe the basin in greater detail.

2-03. STREAM SYSTEM

Snake River is 1,078 miles long and is the largest tributary of Columbia River. It originates in the high Yellowstone National Park area of western Wyoming and traverses the southern part of Idaho in a broad arc running from east to west. It then flows almost due north, forming part of the boundary between Idaho, Oregon, and Washington. Near Lewiston, Idaho, it turns westerly and joins Columbia River near Pasco, Washington. Total fall of Snake River from its source near Two Ocean Plateau, Wyoming, to Ice Harbor Dam is about 8,000 feet. The principal tributary streams are given in the following tabulation:

Stream	Drainage Area Sq. mi.	Snake River Mile
Palouse	2,900	60
Clearwater	9,640	139
Grande Ronde	4,070	169
Salmon	14,100	188
Powder	1,660	296
Weiser	1,660	352
Payette	3,240	368
Malheur	4,800	369
Boise	4,100	391
Owyhee	11,300	392
Bruneau	3,300	493
Big Wood	3,000	571
Portneuf	1,380	737
Blackfoot	1,300	751
Henrys Fork	3,010	837

2-04. RESERVOIRS AND LAKES

The numerous artificial reservoirs and partially controlled lakes in the Snake River basin have a substantial effect on the flow of lower Snake River. Total useable storage in the 50 largest reservoirs and lakes amounts to about 9,600,000 acre-feet. American Falls Reservoir has the greatest useable capacity, 1,700,000 acre-feet, followed by Palisades Reservoir with 1,202,000 acre-feet and Brownlee Reservoir with 980,000 acre-feet. Useable capacity of the under-construction Dworshak Reservoir will be 2,000,000 acre-feet initially.

SECTION II - BASIN DESCRIPTION

2-01. PROJECT LOCATION

Ice Harbor Dam is located in southeastern Washington on Snake River, 9.7 miles above its confluence with Columbia River. The dam is 334 river miles above the mouth of Columbia River and about 250 airline miles east of the Pacific Ocean. The frontispiece map shows the geographical location of Ice Harbor project in relation to the overall Columbia River system and to other major dam and reservoir development. Plate 1 gives further detail on the plan of development of lower Snake River.

2-02. DRAINAGE BASIN

Ice Harbor Dam has a tributary area of 109,000 square miles, comprising very nearly the entire Snake River basin. Most of Idaho, with lesser parts of Oregon, Washington, Wyoming, Nevada, and Utah, are within the Snake River watershed. The greatest overall dimensions of the basin are about 450 miles in both the north-south and east-west directions. The Master Reservoir Regulation Manual will describe the basin in greater detail.

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2-05. TOPOGRAPHY

Several complex systems of mountain ranges, with intervening valleys and plains, lie within the Snake River basin. Much of the southern part of the basin is included within the Columbia Plateau, a semiarid expanse formed by successive flows of basaltic lava. To the north of this plateau is a rugged area of mountain ridges and troughs, with deeply incised stream channels. Overall extremes of elevation are 13,766 feet, at Grand Teton Mountain in Wyoming, to 340 feet, which is normal McNary pool elevation, at the mouth of Snake River. The basin mean elevation is about 5,300 feet.

2-06. POPULATION

Overall, the Snake River basin is sparsely populated, with two-thirds of the people living on farms or in small towns. The 1960 census indicates a basin population of 643,000, which is equivalent to an average density of less than six persons per square mile. The largest cities are Boise and Idaho Falls, each with a metropolitan area population of approximately 50,000. Both rural and urban populations are concentrated along Snake River and major tributaries where the principal towns and agricultural areas are located.

2-07. INDUSTRY

Agriculture and associated processing and service industries constitute the primary economic base of the Snake River basin. Other important industries are based on forestry and wood products, mineral deposits, and the recreational resources of the region. More than 3.3 million acres of land in the Snake River basin are under irrigation, and it is expected that the acreage will increase substantially in the future. The effect of present and future irrigation water demands on the flow of Snake River at Ice Harbor Dam is discussed in the following section of this manual. House Document 403, 87th Congress, contains additional information on development of the agricultural and other resources.

SECTION III - CLIMATOLOGY AND HYDROLOGY

3-01. GENERAL CLIMATE

Basically, the climate of the Snake River basin is transitional between the maritime regimen west of the Cascade Range and the continental type climate of the northern Great Plains. Both maritime and continental air masses affect the basin, but since it is located in the zone of prevailing westerly flow the maritime air masses predominate. The Rocky Mountains to the north and east provide some protection against outbreaks of cold arctic air from Canada, but such incursions do occur occasionally in the winter season, particularly over the eastern part of the basin. Because of the irregular topography and large differences in elevation and exposure, there are pronounced differences of local climate.

3-02. TEMPERATURE

Air temperatures within the Snake River basin are controlled by elevation and distance from the Pacific Ocean, as well as by air mass and season of the year. An important aspect of basin temperature to the regulation of Ice Harbor project lies in the effect of temperature and solar radiation on snowmelt. The shape, timing, and peak discharge of the spring snowmelt runoff of lower Snake River are determined to considerable degree by the sequence of spring season basin temperatures. In addition, temperatures in the region have a pronounced effect on electric power demand and therefore on generation at Ice Harbor project and other hydroelectric projects which serve the area.

Normal summer maximum temperatures for most climatological stations are between 80 and 90 degrees Fahrenheit and normal winter minimums between zero and 20 degrees Fahrenheit. Extreme recorded temperatures are minus 66 degrees Fahrenheit at West Yellowstone, Montana, barely outside the upper Snake River basin boundary, and 118 degrees Fahrenheit at Ice Harbor Dam and at Orofino, Idaho. Average frost-free periods in agricultural areas vary with location from about 50 to 200 days, and some small high-elevation areas experience frost in every month of the year.

3-03. PRECIPITATION

The normal annual precipitation over the Snake River basin ranges from less than 8 inches in the vicinity of Ice Harbor Dam and in portions of the plains of southern Idaho to an estimated maximum of 70 inches in the Bitterroot Mountains. The normal annual precipitation averaged over the entire basin is estimated to be 20 inches. Much of the winter precipitation is in the form of snow, a factor of great hydrologic importance.

The climate of the immediate Ice Harbor project area is semi-arid, sometimes classified as middle-latitude steppe climate. The climatological record for Ice Harbor Dam is too short to be considered representative. Table 1 shows climatological data for other longer-period stations in the area which are considered reasonably representative of Ice Harbor Dam. Table 2 is a climatological summary for selected stations located throughout the Snake River basin, and Table 3 is a summary of representative snow course data for selected snow courses.

3-04. KEY STREAM GAGING STATION

A stream gaging station on Snake River 7 miles downstream from Clarkston, Washington, is of primary importance to Ice Harbor project. Runoff from 103,200 square miles of the 109,000 square miles above Ice Harbor Dam is gaged by this station. The contribution of the intervening area is very small because of its generally semiarid climate and the absence of major tributaries, so runoff volumes at the dam are only slightly more than at the gage. Records for this station, which will be inundated when the authorized Lower Granite Reservoir is raised, are published by the U. S. Geological Survey, and are rated as excellent by that agency. Table 4 is a discharge rating for the station.

3-05. RUNOFF CHARACTERISTICS

The normal pattern of stream flow for Snake River consists of low flows from August through February and high flows from March through July. At Ice Harbor Dam the peak usually occurs in May or June and is primarily the result of snowmelt, sometimes augmented by rainfall. Discharge hydrographs on Plates 6, 7, and 8 illustrate the characteristic runoff pattern and the year-to-year variations. Plate 9 shows mean monthly discharges, summary hydrographs, discharge-duration curves, maximum annual mean daily discharges, and annual runoffs for the Clarkston station. Plate 10 shows similar data for Clearwater River, a major contributor to lower Snake River which enters Snake River near Clarkston. Table 6 summarizes the annual runoff volumes and extremes of discharge, by years, for Snake River near Clarkston and Table 7 presents similar data for Clearwater River at Clarkston.

The observed mean annual runoff of Snake River at the gaging station near Clarkston for the period 1910-62 is 36,080,000 acre-feet. Annual runoff volumes ranged from a low of 20,600,000 acre-feet in the 1931 water year to 49,800,000 acre-feet in the 1921 water year. In average depths of water over the drainage area of 103,200 square miles above the Clarkston gage the mean, low, and high annual runoffs are 6.5 inches, 3.7 inches and 9.0 inches, respectively. The mean annual discharge is 49,800 cfs. Annual peak flows average about 190,000 cfs, and the maximum historical flood peak was 409,000 cfs on 5 June 1894. The extreme low flow, caused by emergency regulation of the upstream Brownlee Reservoir, was 6,660 cfs on 2 September 1958. Annual minimum flows have averaged 15,220 cfs, but as discussed in paragraph 3-09 the average low-water flow will probably be somewhat greater in the future.

The relation of the runoff of lower Snake River to the contribution of major sub-basins and also to runoff of Columbia River is shown in Table 8. During the period 1928-57 Snake River at Ice Harbor Dam derived 35 percent of its runoff volume from Snake River above Weiser, 22 percent from Salmon River, 30 percent from Clearwater River, and 13 percent from other lesser streams between Weiser and Ice Harbor Dam. Snake River contributes about 27 percent of the runoff of Columbia River at The Dalles. Columbia River above Snake River contributes about 66 percent, and miscellaneous streams below Snake River contribute about 7 percent.

3-06. FLOODS

Floods in lower Snake River are of two types: (a) Annual spring floods caused primarily by snowmelt but sometimes augmented by rainstorms, and (b) occasional winter or early spring floods resulting from rainstorms, low elevation snowmelt, or a combination of the two factors. The spring floods usually begin in March, culminate with the peak discharge for the year usually between late April and early June amid a succession of high fluctuating flows, and end with recession to low flows in late June and July as snow disappears from the principal contributing areas.

The average date of spring flood peaks at the stream gaging station near Clarkston is 14 May. Some 60 percent of the annual peaks of a 50-year period have occurred in May, 24 percent were in June, 12 percent were in April, and one peak or 2 percent occurred in December and in March. The winter or early spring floods are of shorter duration, seldom exceeding a week or 10 days, and usually consist of one peak preceded and followed by rapidly rising and receding flows. They normally occur with much lower base flows than exist between individual peaks of the spring snowmelt runoff season. Unregulated and regulated hydrographs of the 1894, 1948, and 1956 floods are shown on Chart 12.

Frequencies of annual flood peaks, analyzed in accordance with procedures in OCE publication "Statistical Methods in Hydrology," are shown in Chart 1. Natural peaks were computed by adjusting the observed peaks for storage changes in the larger upstream reservoirs and estimates of depletions for irrigation. Statistics for the natural peak frequencies were adjusted to the long-term record of peak flows of Columbia River near The Dalles. Chart 1 also shows the effects of regulation by existing projects and the additional effects of the under-construction Dworshak Reservoir.

3-07. STANDARD PROJECT FLOOD

The 1894 flood was adopted as the standard project flood for design studies on Ice Harbor Dam and Reservoir. It was by far the largest flood in both peak and volume on lower Columbia River and the largest known historical flood on lower Snake River. The 1894 flood had a peak discharge of 409,000 cfs and a 60-day runoff volume of about 27,000,000 acre-feet or 4.9 inches over the drainage area above the Clarkston gage. The peak discharge was 48 percent of the probable maximum peak discharge and 11 percent larger than that of any other recorded flood. The volume of runoff during the 60 days of highest flow of the 1894 flood is 45 percent of that applicable to a comparable period for the probable maximum flood, and 20 percent larger than that for any other recorded flood. The 1894 flood (standard project flood) hydrograph is shown on Chart 12.

3-08. SPILLWAY DESIGN FLOOD

The computed probable maximum flood has a peak discharge of 850,000 cfs and a 7-month runoff volume of 81,000,000 acre-feet. It was adopted without modification as the spillway design flood for Ice Harbor Dam. Derivation of the probable maximum flood, which was developed in cooperative studies with the Office, Chief of Engineers, was presented in the report on Selection of Sites, Lower Snake River, dated 14 March 1947.

3-09. WATER SUPPLIES

Stream flows of lower Snake River have been undergoing progressive modification during the entire period of recorded flows because of upstream irrigation and storage developments. The depletions above Ice Harbor Dam now amount to approximately 6,000,000 acre-feet per year. Modified stream flows for future conditions with anticipated irrigation and upstream irrigation reservoir developments as of the years 1960 and 2010 have been determined for the 20-year period July 1928 - June 1948, a period of subnormal flow. From these data, system studies were made as of the year 1985 (average of conditions for years 1960 and 2010) to show the effects of system regulation of reservoir projects on main streams for power, navigation, basic elements of flood control, and water conservation. Several systems were studied, each of which gave slightly different water supply conditions at Ice Harbor Dam. Results of Sequence IV-H studies for 1985 conditions, shown in the report entitled, "Water Resource Development Columbia River Basin," (Review of House Document 531, 81st Congress, 2nd Session) dated June 1958 are considered representative of regulated flow conditions for illustration of the regimen and changes in flows expected to occur. The following tabulation briefly summarizes the flows determined in these studies for Snake River at Ice Harbor Dam:

SUMMARY OF MEAN MONTHLY FLOWS, 1928-1948
1,000 cfs

	Average			Maximum			Minimum		
Mo.	Act 1/	Mod 2/	Reg 3/	Act 1/	Mod 2/	Reg 3/	Act 1/	Mod 2/	Reg 3/
O	21.4	21.7	31.4	30.6	29.2	38.3	16.6	17.5	27.2
N	25.6	25.4	37.3	36.2	35.0	45.4	17.6	18.5	24.7
D	29.2	27.8	46.6	52.4	57.6	74.6	16.9	17.6	34.2
J	27.8	26.8	50.3	55.5	54.7	75.0	14.9	14.9	29.3
F	29.5	28.1	52.7	46.7	43.5	81.2	19.1	17.5	27.0
M	43.8	42.4	61.2	63.9	65.1	93.5	28.0	27.7	39.5
A	79.6	73.6	47.6	158.4	158.3	86.5	48.8	43.4	19.8
M	108.4	100.2	44.8	179.1	172.6	99.7	69.0	66.0	17.7
J	93.1	85.2	50.3	191.6	183.2	123.2	33.9	32.0	15.1
J	33.9	32.0	30.1	85.0	75.7	75.1	15.3	16.6	13.6
A	18.8	18.8	21.7	28.5	26.9	26.8	11.1	13.0	18.0
S	18.4	19.6	26.0	24.5	25.4	32.1	12.7	14.9	21.4
Ave	44.1	41.8	41.6	79.4	77.3	71.0	25.3	25.0	24.0
Max	108.4	100.2	61.2	191.6	183.2	123.3	69.0	66.0	39.5
Min	18.4	18.8	21.7	24.5	25.4	26.8	11.1	13.0	13.6

1/ Actual historical.
2/ Discharges modified by irrigation, 1985 conditions.
3/ Discharges regulated by at-site and upstream power storage, Sequence IV-H, 1985 conditions.

Although emergency closure of Brownlee Dam caused Snake River near Clarkston to drop to 6,660 cfs on 2 September 1958, the discharge otherwise has fallen only as low as 10,600 cfs for the minimum mean daily flow and 11,000 cfs for the minimum mean monthly flow. With increasing development upstream from Ice Harbor project, it is not likely that minimum flows will be as low in the future as in the past. As regulation of the flows increases, the effect will be to raise the magnitude of the low base flow and to lengthen the duration of the moderately low-flow period. From the foregoing compilation of data on modified and regulated flow 1985 conditions, the dependable minimum mean monthly flows would be about 13,000 cfs without regulation by upstream projects. With regulation by these main stream projects, the corresponding discharge would be about 13,600 cfs.

3-10. SEDIMENTATION

Analysis of sediment in lower Snake River indicates that the average annual sediment load will be about 5,700 acre-feet per year. This figure is based on suspended sediment sampling on Snake River at Central Ferry, Snake River mile 83, for a 3-year period, theoretical adjustment of quantities measured to a value for an average year, and the assumption that the volume of bedload in the stream would be equal to 20 percent of the suspended sediment. It is also estimated that a reservoir on lower Snake River would trap 65 percent of the total sediment load entering that reservoir; hence the average yearly accumulation of sediment in Ice Harbor Reservoir, with no additional upstream reservoirs, is estimated to be roughly 3,700 acre-feet. Because of the short-period record used as a basis for the estimates, assumptions regarding the amount of bedload and trap efficiencies, and uncertainty as to major origins of sediment, it is not practical at this time to modify the estimate for effect of future upstream reservoirs, but the reduction probably will be considerable.

Both the above data and experience with run-of-river reservoirs on Columbia River suggest that sedimentation of Ice Harbor Reservoir will not be a major problem. It is expected that some silting may occur at the mouths of minor watercourses or draws entering the pool, but this would not result in significant loss of storage in the main reservoir.

3-11. ICING

Ice Harbor Reservoir may be expected to freeze over occasionally. A number of instances of extensive ice formation on reservoirs in the region have been noted, but relatively little difficulty has been experienced with ice at Columbia River dams that have been in operation during the last several years. Because of the low velocities ice that forms on the reservoirs melts with little or no tendency to jam, even during periods of relatively severe cold weather.

The most marked ice effects have occurred at the head of backwater or in the backwater reaches of tributary streams that enter the reservoirs where ice jams have a tendency to form, causing a considerable rise in the water surface. At the head of McNary backwater in Snake River, ice raised the river levels 13 to 14 feet at Ice Harbor Dam site during February 1956, and in February 1957 ice accumulated in the river for a period of 12 days and raised the water surface approximately 8 feet. Records show that there has been ice in Snake River at Lewiston an average of 8 days per year. Individual years show wide variations in durations of floating ice, with none shown for 16 years in a 36-year period and a maximum single duration of 48 days in 1937.

SECTION IV - PROJECT HISTORY

4-01. AUTHORIZATION AND PURPOSE

Ice Harbor Project was authorized by Public Law 14, 79th Congress, 1st Session, approved 2 March 1945. The applicable portion of the act reads as follows:

> ". . .Snake River, Oregon, Washington, and Idaho: The construction of such dams as are necessary, and open channel improvement for the purposes of providing slackwater navigation and irrigation in accordance with the plan submitted in House Document Numbered 704, Seventy-fifth Congress, with such modifications as do not change the requirement to provide slackwater navigation as the Secretary of War may find advisable after consultation with the Secretary of the Interior and such other agencies as may be concerned: Provided, that surplus electric energy generated at the dams authorized in this item shall be delivered to the Secretary of the 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;..."

The primary purposes of the project are inland navigation and hydroelectric power generation. In addition, it will provide irrigation and recreation benefits. Flood control is not a designated or planned project function.

4-02. EARLY HISTORY

Prior to the authorization of slackwater development of the lower Snake River in 1945, an existing project provided for open river improvements to obtain a 5-foot depth in the existing channel to Riparia (mile 68) and from that point a channel of the same depth and generally 60 feet wide to Lewiston, Idaho. Beyond that point removal of boulders and rock points was contemplated.

House Document 704, 75th Congress, 3rd Session, upon which authorization of the Lower Snake River Project was based, proposed an ultimate slackwater development between Pasco, Washington, and Lewiston, Idaho, by 10 locks and dams, with such power facilities as were feasible to develop at the time the work was undertaken. Subsequent to authorization, additional studies of the number of dams required for the project were made and reported in "Special Report on Selection of Sites, Lower Snake River, Oregon, Washington, and Idaho," dated 14 March 1947. This report recommended that development be accomplished by four dams with the downstream unit at Snake River mile 10.2. This report was approved and additional planning work on the entire four-dam development was authorized, including preparation of a letter report summarizing costs and benefits and of a definite project report on relocations and flowage. Planned locations of the other three dams, Lower Monumental, Little Goose, and Lower Granite, are shown on the lower Snake River map, Plate 1.

Detailed studies on Ice Harbor Project as a separate unit of the Lower Snake River Project were initiated in 1947. With more complete data on the proposed site locations, the final site location at river mile 9.7 was selected on the basis of geology and navigation channel excavation requirements.

4-03. SIGNIFICANT CONSTRUCTION DATES

Construction work on Ice Harbor Dam was initiated on 8 March 1956 with notice to proceed on Contract No. 56-113. Closure of the dam, at the downstream leg of the north shore cofferdam, was accomplished on 23 July 1959. Raising of the reservoir was started on 27 November 1961 by closing the powerhouse gates. The water surface was raised rapidly to elevation 400, which is 9 feet above spillway crest, at which level the entire river flow was passing through five spillway bays. Further raising of the reservoir was in a series of steps to insure a slow rate of saturation of foundations and relocation embankments. Advantage was taken of this method of raising the reservoir to conduct a series of powerplant index tests over a range of hydraulic heads. Operating levels were attained in late January 1962 but normal pool, elevation 440, was not reached until 27 April 1962.

The date of initial power on line (one unit) was 28 December 1961. Normal delivery of commercial power to Bonneville Power Administration started in March 1962. Commercial operation of the navigation lock began 5 October 1962. The south shore fish ladder was placed in service on 24 January 1962, the north shore ladder on 28 March 1962. Fish counting began 1 April 1962. The project was dedicated by Vice-President Lyndon B. Johnson on 9 May 1962.

The following tabulation of major construction contracts summarizes construction progress:

MAJOR CONSTRUCTION CONTRACTS

Ice Harbor

	Contract Item	Contractor	Awarded	Construction Began	Construction Complete	Final Payment Made
56-113	First-Step Cofferdam, Channel Diversion, Grading Roads & RR	Guy F. Atkinson Co.	23 Feb 56	Mar 56	Feb 57	$ 1,517,468
57-62	Powerhouse Structure, 7-1/2 Bays Spillway Dam, Left Abutment, Channel Dredging	Montag, Halvorson, Austin, and Associates	4 Jan 57	Jan 57	Oct 59	30,164,071
57-127	SP&S Railway Relocation and No. Shore Project Roads	R. A. Heintz Construction Company	22 Apr 57	May 57	Mar 58	1,086,573
57-40	Temp. Fish Facilities, First Step	Wayne Construction Co.	29 Oct 56	Nov 56	Nov 57	249,636
59-1	River Leg Second Step Cofferdam, Remove First Step Cofferdam Except River Leg, Powerhouse and Tailrace Excavation	Montag, Halvorson, Austin and Associates	9 Jul 58	Jul 58	Jul 59	850,510
59-38	Powerhouse Superstructure, Install Turbines and Misc. Powerplant Equipment, Install Fishway Pumps, Underground Duct Lines	Guy F. Atkinson Co.	27 Sep 58	Oct 58	-	-
57-88	Water Supply and Storage Tank	C. J. Montag and Sons	21 Feb 57	Mar 57	Sep 57	96,003

MAJOR CONSTRUCTION CONTRACTS

Ice Harbor (Cont'd)

	Contract Item	Contractor	Awarded	Construction Began	Construction Complete	Final Payment Made
56-86	South Shore Access Road	Grant Construction Co.	6 Dec 55	Dec 55	Apr 56	$ 85,291
59-81	SP&S Railway Embankment, Protection	R. A. Heintz Construction Company	19 Dec 58	Jan 59	Sep 60	2,501,109
59-89	Foundation Grouting & Drainage	Boyles Brothers	21 Jan 59	Feb 59	Mar 61	217,209
59-148	Dam, Lock, N. Shore Fish Facilities No. Shore Road Extension, Channel Exc. and Construction Facilities	Guy F. Atkinson Company	15 May 59	Jun 59	-	-
60-117	Grading and Bank Protection, Sec. I, UPRR Relocation, Walla Walla County Road Relocation, Construction of Reservoir and Recreation Access Roads	Peter Kiewit & Sons Co.	11 Sep 59	Oct 59	Jun 62	4,268,856
60-142	Grading and Bank Protection, Sec. II, UPRR Relocation, Walla Walla County Road Relocation & Construction of Reservoir Access Road	R. A. Heintz & Rogers Construction Co.	19 Nov 59	Dec 59	Nov 63	5,471,446
61-139	Embankment Protection, NP Railway, Relocation of Franklin County Road, Reservoir Clearing	Natt McDougall Co.	18 Nov 60	Nov 60	Sep 62	1,851,254

MAJOR CONSTRUCTION CONTRACTS

Ice Harbor (Cont'd)

	Contract Item	Contractor	Awarded	Construction Began	Construction Complete	Final Payment Made
60-284	Track Laying & Ballasting, UPRR	Franco Railroad Contractors Inc. and Verne W. Johnson	16 Jun 60	Jun 60	Jul 62	$ 366,520
61-114	Main Channel Completion, Sec. I	J. A. Jones Construction Co. & Osberg Constr. Co.	22 Aug 60	Sep 60	Jul 62	4,597,755
61-128	Main Channel Completion, Sec. II	General Construction Co.	5 Oct 60	Nov 60	Nov 61	580,069
61-267	Upstream Floating Guide Wall	General Construction Co.	21 Mar 61	Mar 61	Mar 63	664,446
62-321	Debris Disposal Boom, Foundation and Grading	Sime Construction Company	28 Jun 62	5 Jul 62	Mar 63	172,213
62-123	Levey Landing Area Recreation Facilities	Natt McDougall Company	2 Oct 61	6 Oct 61	Aug 62	112,870

NOTE: Does not include small construction contracts, supply contracts, or relocation agreements.

SECTION V - PROJECT DESCRIPTION

5-01. GENERAL

Main structures of the dam consist of a powerhouse, concrete spillway and stilling basin, navigation lock, concrete non-overflow sections, a rockfill embankment on the north shore, and fish passage and appurtenant facilities. The dam is 2,822 feet in length, including embankments. Concrete sections have a maximum height of 213 feet from elevation 240 at base of draft tube foundations to top of deck, elevation 453. One hole in bedrock under the draft tubes required treatment down to elevation 228. Plate 3 and the frontispiece photograph show the relative location of principal components of the dam. Data on various features are summarized in the front part of this manual, and more detailed descriptions of the equipment are contained in the Operation and Maintenance Manual.

5-02. POWERHOUSE

The powerhouse structure houses three complete generator bays, an erection bay, service bay, control room, project office space, and contains skeleton provisions for future completion and installation of three additional power units. The powerhouse floor plan is shown on Plate 11 and a transverse section of the generator bays is shown on ~~Chart~~ Plate 12. Plate 13 shows the main one-line diagram and Plate 14 the control room arrangement. The overall powerhouse length, including abutment piers, is 671 feet. Generator and skeleton bays are approximately 261 feet in width. The three completed generator bays and skeleton bays Nos. 4 and 5 are 86 feet in length. Skeleton bay No. 6 is 92 feet in length and the erection bay, located between the service bay and generator bay No. 1, is 83 feet in length. The service bay, located at the south end of the powerplant, is 66 feet in length. Power generation equipment is serviced by a 500-ton bridge crane.

5-03. GENERATORS

Each of the three installed generators, manufactured by General Electric Company, has a rated nameplate capacity of 90,000 kw. They are suitable for operation under varying load conditions and are capable of operating continuously at 115 percent of rated capacity. Guaranteed performance and operating data are as follows:

Capacity, kva	94,737
Power factor	0.95
Frequency, cycles	60
Number of phases	3
Voltage between phases, rated	13,800
Speed, rpm	90
Stator winding connection	Star, suitable both for grounded or ungrounded operation
Excitation voltage, nominal	375
Direction of rotation	Clockwise
Maximum runaway speed, rpm	198

The maximum temperature rise of both the armature and field windings is designed not to exceed 60 degrees Centigrade and the stator core 55 degrees Centigrade when delivering rated output continuously at rated voltage, power factor, and frequency, and with cooling air entering the generator at not more than 40 degrees Centigrade.

5-04. TURBINES

The installed turbines are of the Kaplan type with six adjustable blades. Synchronous speed is 90 rpm and runner throat diameter is 280 inches. They were built by the Allis-Chalmers Manufacturing Company (formerly S. Morgan Smith Company) and are designed to have good efficiencies throughout a wide range of load and the full range of head. Each will develop at least 143,000 horsepower at 89 feet of head and 124,400 horsepower at 78 feet of head. Centerline of the turbine distributor is set at elevation 321.0, and the tailrace water surface may vary from 14 to 57 feet above that elevation. Turbine design was based on the following basic criteria:

Forebay - Tailwater Elevations

Maximum pool elevation (850,000 cfs)	446.0
Normal pool elevation	440.0
Minimum pool elevation	437.0
Maximum tailwater (850,000 cfs)	378.0
Normal minimum tailwater	337.5

Head, Feet

Normal maximum	102.5
Mean operating	96.0
Normal minimum (350,000 cfs)	78.0
Rated (95,000 cfs)	89.0

Chart 2 shows turbine unit characteristics as developed from model performance and prototype index tests. Chart 3 shows the generating capability of one power unit under various conditions of head and discharge, with the power-discharge relationship determined in part by correlation with stream flow measurements at upstream and downstream gaging stations. The same data, modified in form to show power output per unit discharge, are shown in Chart 4. Chart 5 shows power plant capability in terms of river or plant discharge. The relationships are less refined than shown on Charts 3 and 4 but permit rapid determination of the approximate power output for various discharges and number of power units.

5-05. MAIN UNIT TRANSFORMERS

The transformers, furnished by Wagner Electric Corporation of St. Louis, Missouri, are located outside the powerhouse at elevation 368.5 between the powerhouse and intake structure. Each transformer is of the two-winding, oil-immersed, forced-oil-cooled with forced-water coolers, class FOW, inert gas-filled type suitable for outdoor operation. Each transformer is rated 115-13.2 kv, 109,000 kva.

5-06. STATION SERVICE POWER

To provide reliability consistent with the operating needs of Ice Harbor powerhouse, station service power is provided by means of two transformers. One station service transformer is tapped from the 115-kv bus section of unit 3, providing a primary source which can be made independent of all powerhouse equipment. The second station service transformer is supplied from the 13.8 kv isolated-phase bus of generator No. 1, providing a primary source which can be isolated from the transmission system and supplied from unit 1 only, or from generator No. 1 when it is on the transmission system.

The transformers will supply power at 4,160 volts for distribution to large motors and various power centers as required.

The station service transformers are of the two-winding, oil-immersed, self-cooled type (class OA) with automatic tap changing equipment suitable for outdoor operation. The transformer connected to the 115 kv bus is rated 115-4.16 kv, 5,000 kva, with delta-grounded wye connections. The transformer connected to main unit No. 1 is rated 13.8-4.16 kv, 5,000 kva.

5-07. ICE AND TRASH SLUICE

The upper or collecting portion of the ice and trash sluice is a concrete channel 16 feet wide, running longitudinally through the intake structures and beneath the upstream portion of the intake deck. This section terminates in a vertical shaft at the south end of the service bay monolith. The invert at the junction is curved vertically on a 6-foot radius to aid in passing long logs without jamming against the side of the shaft. Hatches in the intake deck over the sluice are provided for dumping trash collected in the trash rake and to facilitate dislodging of any jams that may occur by means of grappling hooks and the gantry crane. The bottom of the shaft is curved on a radius of 25 feet to aid in deflecting the ends of logs and to minimize the possibility of a jam at this point. The section through the powerhouse is a closed conduit at approximately the turbine floor level. Beyond the powerhouse the sluice is an open channel which discharges into the main river channel downstream of the fishway pumps.

The ice and trash sluice may receive discharge through any of the three 20-foot wide weirs provided between piers in each generator bay intake structure. No weirs are provided in the erection or service bay monoliths. Concrete sills of all weirs are at elevation 431, 6 feet below minimum power pool, elevation 437. The discharge over each weir is controlled by a gate which may be lowered until the top lies flush with the concrete weir lip, or fully raised so that the tops will be near elevation 440.5, 0.5 foot above normal pool level. In the raised position, gate seal will effectively block all flow of water but at other positions the bottom seal will be ineffective and some water will pass under the gates. Tops of gates may be set at any desired elevation by means of dogging devices which engage the chain supports. Table 9 gives the discharge rating for one gate.

5-08. SPILLWAY

The spillway has a total length of 590 feet, including nine intermediate piers, and consists of 10 gate-controlled bays, each 50 feet wide. Piers 10 feet wide separate the bays. Elevation of the spillway crest is 391. The spillway has a maximum height, foundation to deck, of 141 feet, with a 30-foot wide roadway on top at elevation 453. Spillway discharges are controlled by 10 tainter gates each 50 feet wide by 52.9 feet high. The gates are operated by electric hoist units mounted above the gates, with one motor and two hoist units per gate. Operation of the gates may be by manual control through push button stations located near each hoist, but normally gates 2 through 9 are remotely controlled from the powerhouse. One spare hoist motor is provided for maintenance and emergency use, and all spillway gates can be operated with emergency power supplied by a diesel-generator set. The gate seal is downstream of the spillway crest axis at elevation 389.07. Electric heating elements beneath the side plates prevent seal damage during gate movement in freezing temperatures.

The design capacity of the spillway is 850,000 cfs, with a corresponding maximum pool elevation of 446.4. At normal pool, elevation 440, the spillway will pass a maximum of 685,000 cfs. Table 10 and Chart 9 show the discharge for an individual bay at various gate openings and pool elevations. Table 11 shows the recommended maximum discharge per bay for a wide range of tailwater elevations.

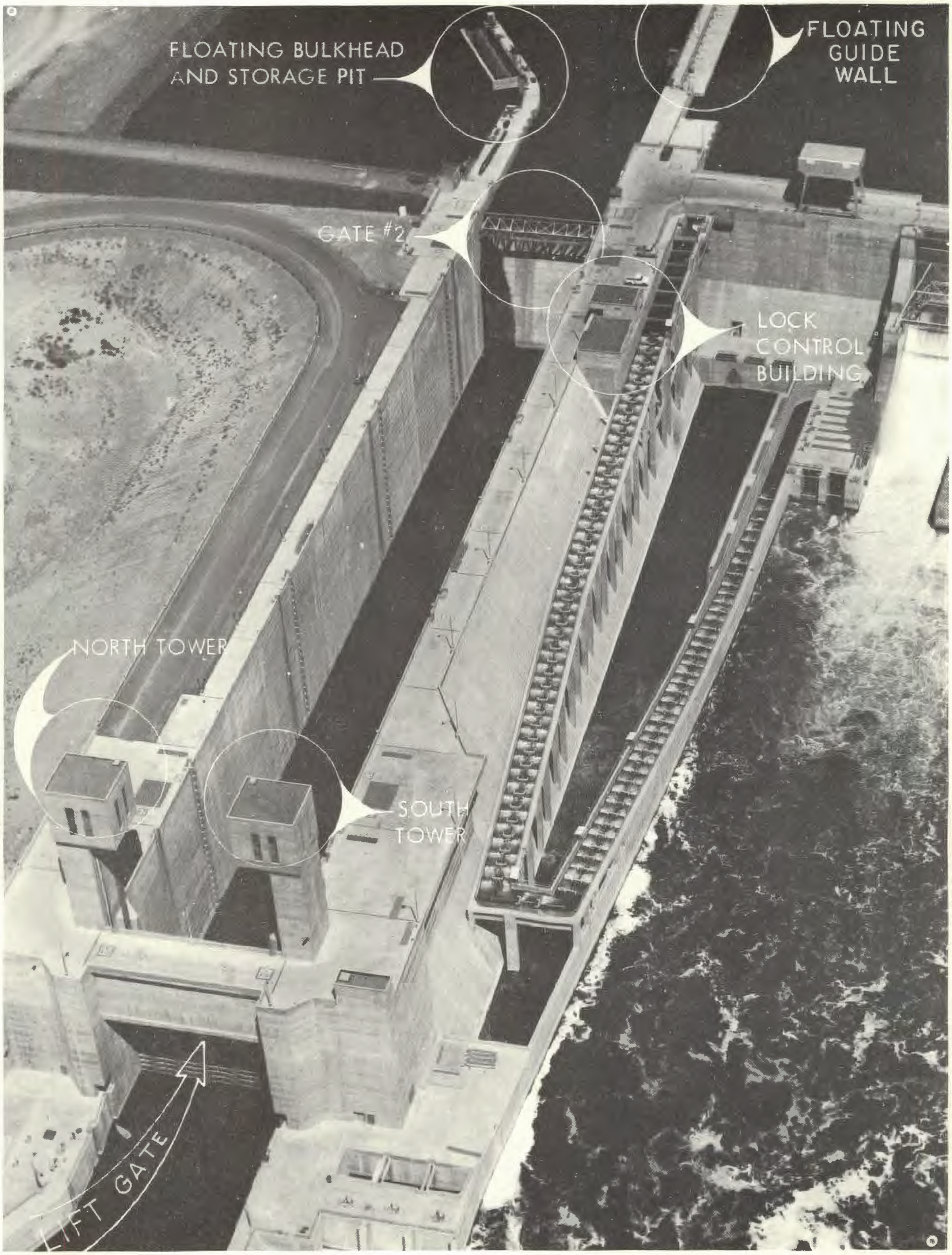
Energy of the water discharging through the spillway is dissipated by a hydraulic jump and baffles in a horizontal apron-type stilling basin. One row of baffles 8 feet high, 10.5 feet long and 10 feet wide, plus an end sill 12 feet high and 590 feet long, is used to assist in dissipating the energy. The stilling basin has been designed to contain the jump for all discharges up to 850,000 cfs.

5-09. NAVIGATION LOCK

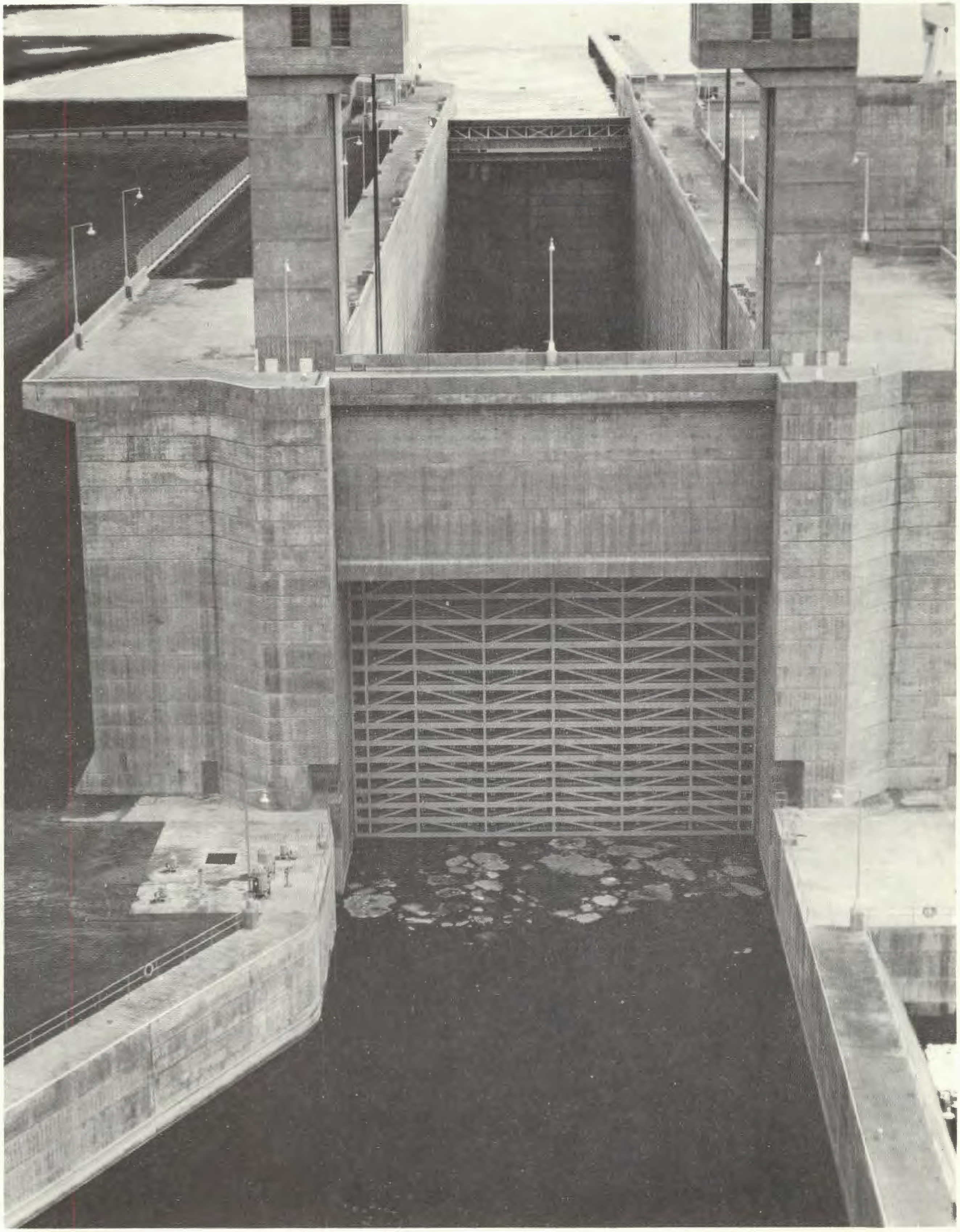
The single-lift navigation lock is located on the north side of the river. It has a clear inside width of 86 feet and a length of 675 feet. The maximum lift with McNary Reservoir at minimum elevation and zero Ice Harbor outflow is 105 feet. Other dimensions are given in the pertinent data tabulation.

The downstream lift gate is operated by hydraulic hoists which are automatically controlled to keep the gates level during travel. Provision is made for a floating bulkhead to be installed in the upstream and downstream ends of the lock chamber for maintenance and emergency use. Also, slots are provided for stoplogs downstream. Guard walls extend 746 feet upstream and 696 feet downstream from the gate to protect the 250-foot wide approach channel. The upstream guard wall opens into deep water but the downstream approach channel was dredged to elevation 322 for a distance of approximately 4 miles to deeper water in McNary pool. This channel will provide 15-foot depth except on rare occasions.

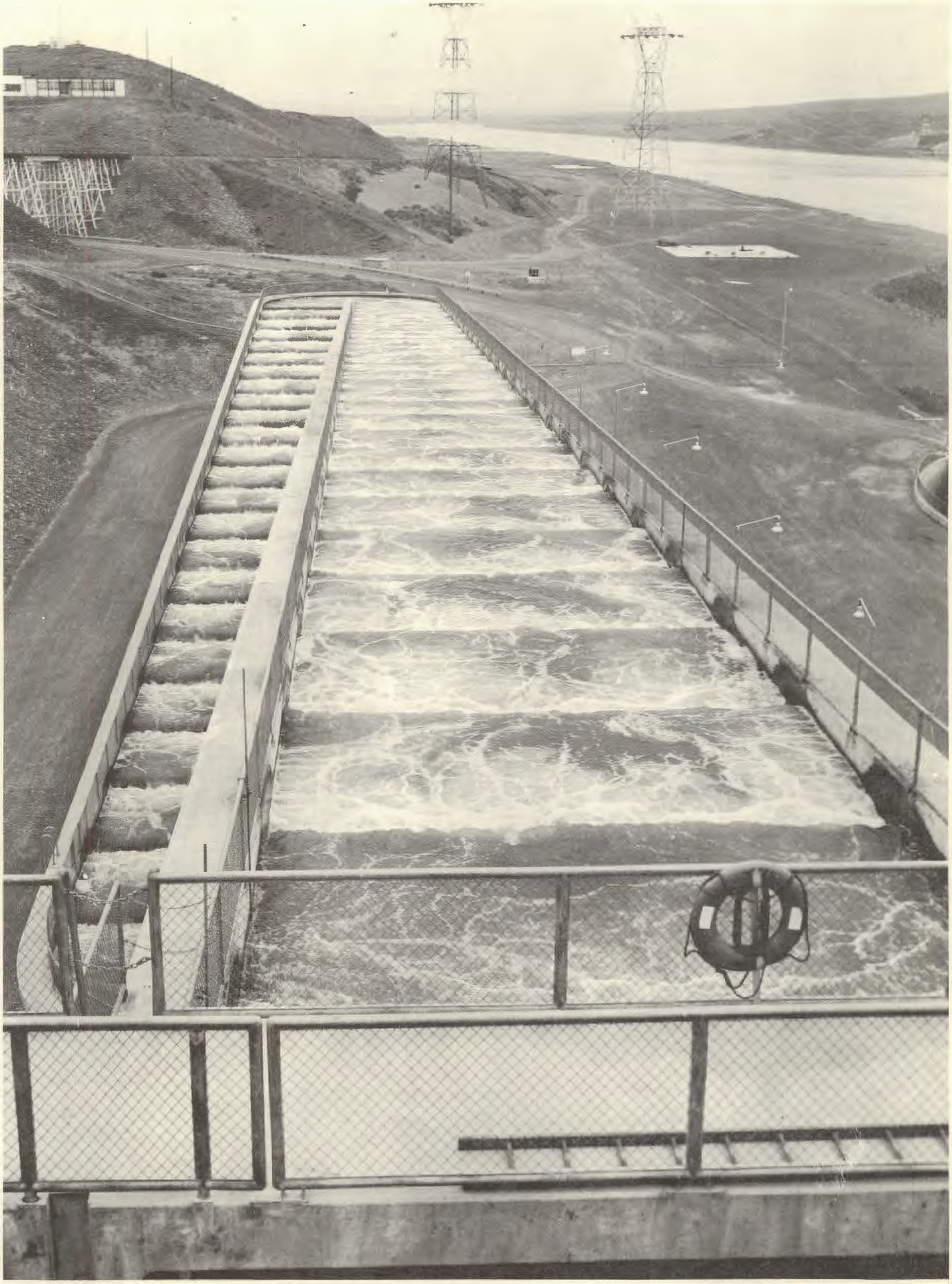
Lock control facilities are located in the operations building on the river wall of the lock, plus sheltered control stands adjacent to each gate. Air bubblers installed in the sill, guide slots, and bridge keep floating ice and debris away from the lift gate during freezing weather and during any gate operation. Navigation facilities are illustrated in the following photograph and in the frontispiece photograph.



Navigation lock and north shore fish ladder



Looking upstream at navigation lock, with downstream lift gate in lowered (closed) position. Reservoir in background is ice-covered.



Looking downstream at south shore fish ladder. Width 24 feet, slope 1 on 16, discharge 142 cfs.

5-10. FISH FACILITIES

The fish passing facilities at Ice Harbor Dam consist of north and south shore fish ladders, powerhouse collecting system and transportation channel, 11 fishwater pumps (8 south, 3 north), and a fish counting station on each ladder. Total normal discharge through the ladders from the forebay is approximately 216 cfs, 74 cfs north, and 142 cfs south.

The north shore fish ladder is located between the spillway and the navigation lock and is 16 feet wide. The normal flow in the ladder, 74 cfs, is regulated by an orifice-control section located at the upstream end of the ladder. Three 250-cfs pumps located near the downstream end of the ladder supply auxiliary water. Discharge of the auxiliary water system varies from 250 to 750 cfs in increments of 250 cfs, depending on the number of pumps operating. Weirs are fixed, with an 18 by 18-inch orifice on each side of the center non-overflow portion of the weir. See Plate 15.

The south shore fish ladder is located south of the powerhouse and includes the powerhouse collection and transportation system. The ladder is 24 feet wide and has fixed weirs with 21 by 23-inch orifices. Normal flow in the ladder from the forebay is approximately 142 cfs, controlled by an orifice control section at the ladder exit. The auxiliary water supply is provided by eight 300-cfs pumps located just downstream of the powerhouse on the left bank. The auxiliary water supply will vary from 1,200 to 2,400 cfs in increments of 300 cfs, depending on the number of pumps operating.

The powerhouse collection and transportation system consists of a 17.5-foot wide channel across the length of the powerhouse, with 12 submerged orifices through which water is released to the powerhouse tailrace. Entrances are also provided for collection of fish at the south end of the spillway and on the south between the powerhouse and the pump intake for the auxiliary water system. This powerhouse collection and transportation system joins the south shore fish ladder near the south end of the powerhouse.

5-11. NON-OVERFLOW SECTIONS

Ice Harbor Dam has three non-overflow concrete gravity sections. One is located between the navigation lock and the north end of the spillway, another extends from the south end of the spillway to the north end of the powerhouse, and the third section extends from the south end of the powerhouse to the south shore.

The section between the lock and spillway is 154 feet long and contains the north shore fish ladder exit structure, stoplog storage, and appurtenances. The non-overflow section between the spillway and the north end of the powerhouse is 40 feet long. The section between the south end of the powerhouse and the south shore is 580 feet long and contains the south shore fish ladder exit structure.

The north shore embankment extends from the navigation lock 624 feet to the right bank. The maximum height is 123 feet, the crest width is 25 feet, and the crest is at elevation 453. The embankment consists of a central impervious core flanked on both sides by substantial rockfill shells. Sand and gravel filter zones are provided for transition between the impervious core and the rockfill sections. Within the zone of wave action the upstream slope is protected by riprap. The upstream slope is 1 on 2 and the downstream slope is 1 on 1-1/2.

5-12. RESERVOIR

Ice Harbor Reservoir (Lake Sacajawea) is 31.9 miles in length from Ice Harbor Dam to Lower Monumental Dam. It has an average width of about 2,000 feet and a maximum depth of about 110 feet immediately upstream of the dam. The flat reservoir has a surface area of 8,375 acres at normal pool, elevation 440. Plate 2 shows a detailed reservoir and land use map, and Plate 3 shows the general shape and configuration of the reservoir on a small scale map.

Reservoir regulation at Ice Harbor project for power generation will normally be confined to the use of storage between elevations 437 and 440, measured at the dam. That storage amounts to about 24,900 acre-feet at low flows and about 23,000 acre-feet at a discharge of 300,000 cfs. For flows up to 30,000 cfs the pool is nearly level but at higher flows the slope of the pool increases, particularly at the upper end. Plate 4 shows water surface profiles for various significant river discharges with elevations 437 and 440 at Ice Harbor Dam. Plate 5 shows the river bottom profile and natural water surface profiles. Table 12 and Chart 6 show the storage-discharge relationship for a wide range of river flows.

5-13. REAL ESTATE ACQUISITION

The backwater elevation based on the 1894 flood discharge, 409,000 cfs, and a normal pool elevation of 440 at the dam were used to establish the control contour for real estate acquisition. For Ice Harbor project this control contour, the upper limit of flowage area, is the 1894 backwater elevation plus 5 feet. A flowage easement was obtained for all lands below the control contour and above the 5-year frequency flood (270,000 cfs) backwater profile. All lands between the 5-year frequency flood backwater profile and the natural normal high water (165,000 cfs) profile were purchased in fee. Total area acquired amounted to 7,830 acres. Lands below the natural normal high water profile, shown on Plate 5, are considered part of the river channel and not private property. Relocation and protection of railroads and roadways is based on the 1894 flood (409,000 cfs), regulated by Palisades, Boise River, and Cascade Reservoirs (360,000 cfs), backwater profile plus 7.5 feet of freeboard.

5-14. WATER SURFACE ELEVATION GAGES

Elevations of Ice Harbor Reservoir are recorded at three locations, two near the dam and one at river mile 19.3, which is 9.6 miles above Ice Harbor Dam. One of the gages near the dam is located on the landward wall of the navigation approach channel; the other is on the upstream face of the powerhouse on pier 1. The record obtained by the gage on the navigation channel wall is recorded in the control room on a 4-pen recorder and also by digital read-out. The record obtained by the gage on the powerhouse is telemetered to the control room and recorded on a strip chart in combination with a record of tailwater elevations. Each of the three recording gages is provided with a staff gage.

A tailwater gage is located near the north end of the existing 3-unit powerhouse at pier 3. Tailwater elevations at this gage are transmitted and recorded automatically in the powerhouse control room in combination with the forebay record. Two downstream recording gages 2.4 miles apart provide a means of determining the discharge through the dam on the basis of a slope-type rating, which evaluates McNary Reservoir backwater effects. The base station is located at river mile 8.7, the auxiliary station at river mile 6.3. Water surface elevations at these stations are recorded in the powerhouse control room on the 4-pen recorder on which pool elevations also are entered. Streamflow measurements are made from a cableway across the river located near the base station. Each of the recording gages is provided with a staff gage.

The two downstream gages and the cableway are operated and maintained jointly by the Corps of Engineers and the U. S. Geological Survey under the coöperative stream gaging program. Geological Survey personnel normally make the river measurements at the cableway and operate and maintain the servomanometers, records, and battery-operated cable car. Project personnel operate and maintain the powerhouse and forebay gages and the 4-pen recorder and other recording equipment in the control room. The gages on the navigation lock wall and at river mile 19.2 are serviced by the Water Control Section of the Engineering Division.

In addition to the recording water-surface elevation gages, a number of non-recording gages are installed at various locations at the project. Four staff gages are located in the landward wall of the navigation lock. Two staffs, reading from elevations 435 to 446, are installed immediately above and below the upstream lock gate. A corresponding pair of staff gages shortly above and below the downstream gate span the elevation range 335 to 363. Each of the two fish ladder systems is equipped with several float wells and staff gages located at the entrances, pumphouses, and diffuser pools.

Plate 3 shows the locations of the more important water-surface elevation gages at the dam, exclusive of those associated with fish-passing facilities. Plate 15 shows the locations of float wells and staff gages of the north shore fishway system. Upstream river gaging stations which are not directly a part of Ice Harbor project but which provide reports used for forecasting reservoir inflow are listed in Section VI.

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. Ice Harbor is a part of this system. Functional water regulation at Ice Harbor 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. 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 Regulation Manual for the overall Columbia River Basin dated December 1964.

a. Corps of Engineers. In general, the NPD Reservoir Control Center (RCC) plans and directs the regulation of NPD reservoirs and certain non-Corps reservoirs that have space allocated for flood control. The RCC coordinates the regulation of NPD, 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 Ice Harbor is the direct responsibility of the RCC. For special reservoir operations, the RCC collaborates with the Hydrology Branch of the Walla Walla District. The Hydrology Branch provides assistance and support to the 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 RCC. Physical operation and maintenance of the Ice Harbor project is the responsibility of the project engineer who is under the supervision of the Operations Division, Walla Walla District. Pages 6-7 through 6-10 show organizational charts, corresponding personnel names and telephone numbers pertinent to the operation of Ice Harbor for the Corps of Engineers and Bonneville Power Administration.

b. Portland River Forecast Center (RFC). The Portland RFC is authorized to issue 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, NPD
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. Ice Harbor is a unit of this system. The Chief of the 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 NPD/RCC in coordination with BPA's Power Scheduling Branch. 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 NPD 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 NPD projects.

d. Other Agencies. Other entities with which the 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 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 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:

1. Bonneville Power Administration
2. Bureau of Reclamation
3. British Columbia Hydro and Power Authority
4. Chelan County PUD
5. Corps of Engineers
6. Douglas County PUD
7. Eugene Water and Electric Board
8. Grant County PUD
9. Idaho Power Company

10. Montana Power Company
11. Pacific Power and Light Company
12. Portland General Electric Company
13. Puget Sound Power and Light Company
14. Seattle City Light
15. Sierra Pacific Company
16. Tacoma City Light
17. Transalta Utilities Corporation
18. Utah Power and Light Company
19. Washington Water Power
20. 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, headquartered in Portland, Oregon, consists of five full-time professionals. 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 (NAPSIC) 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:

1. Bonneville Power Administration
2. Bureau of Reclamation

3. Corps of Engineers
4. Chelan County PUD
5. Colockum Transmission Company
6. Cowlitz County PUD
7. Douglas County PUD
8. Eugene Water and Electric Board
9. Grant County PUD
10. Montana Power Company
11. Pacific Power and Light Company
12. Pend Oreille County PUD
13. Portland General Electric Company
14. Puget Sound Power and Light Company
15. Seattle City Light
16. Snohomish County PUD
17. Tacoma City Light
18. 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. 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 in the operation of the system to determine system energy generation capability. Generation in excess of FELCC resulting from draft to ECC can be used to serve secondary load. If draft below ECC is required to carry FELCC, then secondary load may not be served.

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

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 ECC's. 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 downstream utility. 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.

Other provisions of the agreement include the following: Each party shall accept for storage in available reservoir space energy surplus to other parties' needs. Equitable compensation shall be made for the benefits from reservoir storage. The obligation to reimburse treaty power to Canada shall be shared by the projects which benefit from treaty storage in proportion to their benefits. Interconnecting transmission facilities shall be made available for coordination use subject to the owners' prior requirements. 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 pay 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, U. S. and Canadian entities, U. S. coordinators, Manager - Canadian Entity Service, and two international committees. The RCC Guidance Memorandum dated January 1972 provides details on functions and responsibilities of these working organizations.

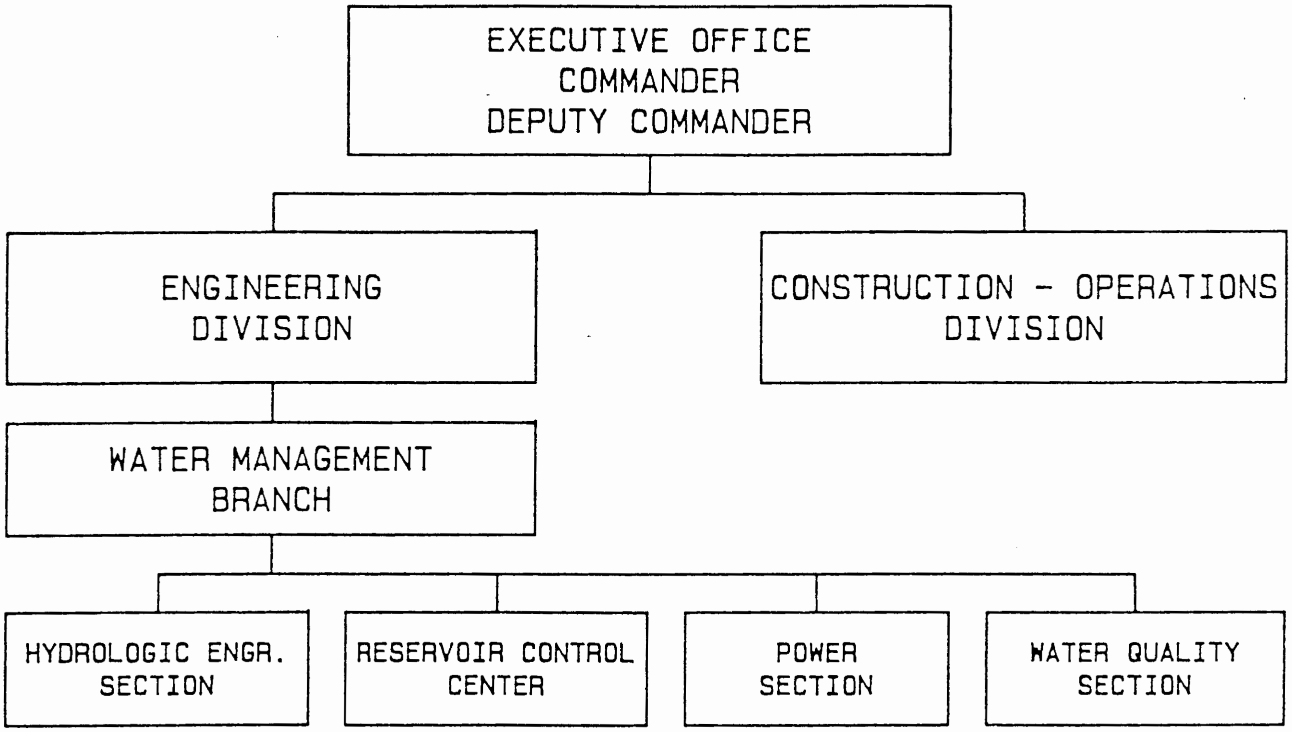
d. Columbia River Water Management Group. The Columbia River Water Management Group acts as a committee to consider problems relating to operation and management of water control facilities in the Columbia River Basin. Upon review and discussion of the problems, the group makes tentative recommendations 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 hydrometeorological, 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:

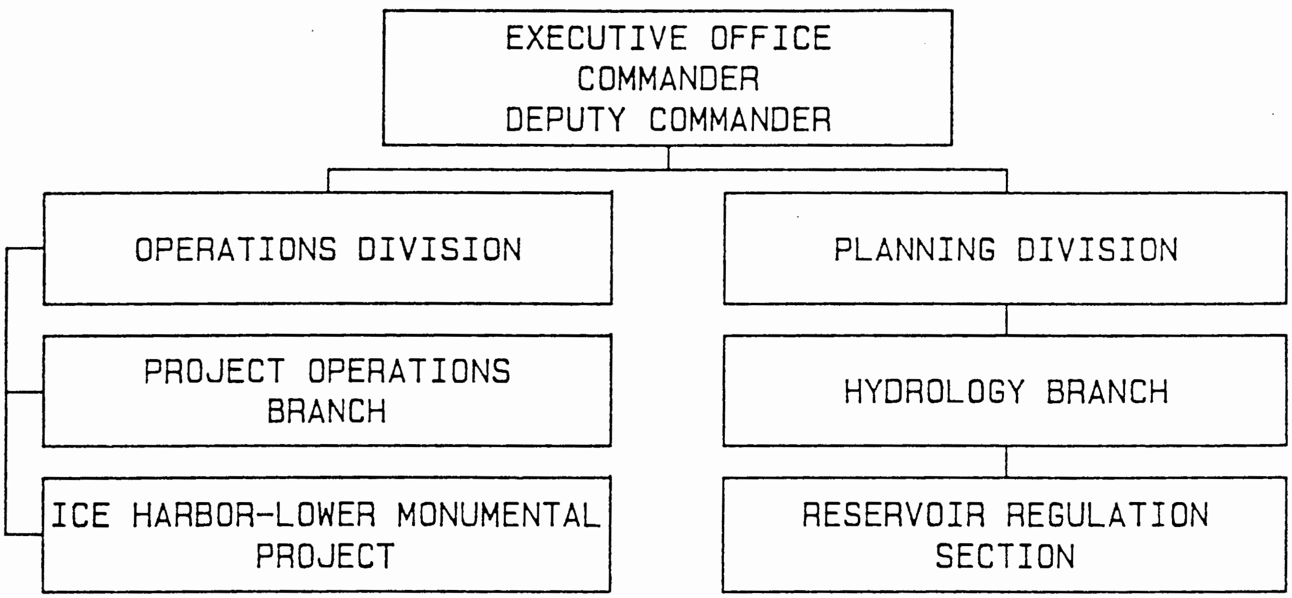
1. Bureau of Reclamation
2. Bonneville Power Administration
3. Corps of Engineers
4. National Weather Service
5. United States Geological Survey
6. Environmental Protection Agency - Water Quality Office
7. U.S. Forest Service
8. Soil Conservation Service
9. Bureau of Land Management
10. Federal Energy Regulatory Commission
11. Fish and Wildlife Service
12. National Marine Fisheries Service
13. Oregon Water Resources Department
14. Washington Department of Ecology
15. Idaho Department of Ecology
16. Nevada State Engineer
17. Department of Natural Resources and Conservation (Montana)
18. Wyoming State Engineer

6-03. Regulation Decisions and Records. The Reservoir Control Center (RCC) is responsible for making regulation decisions which affect project discharge rates and storage. The goal of the 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 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.

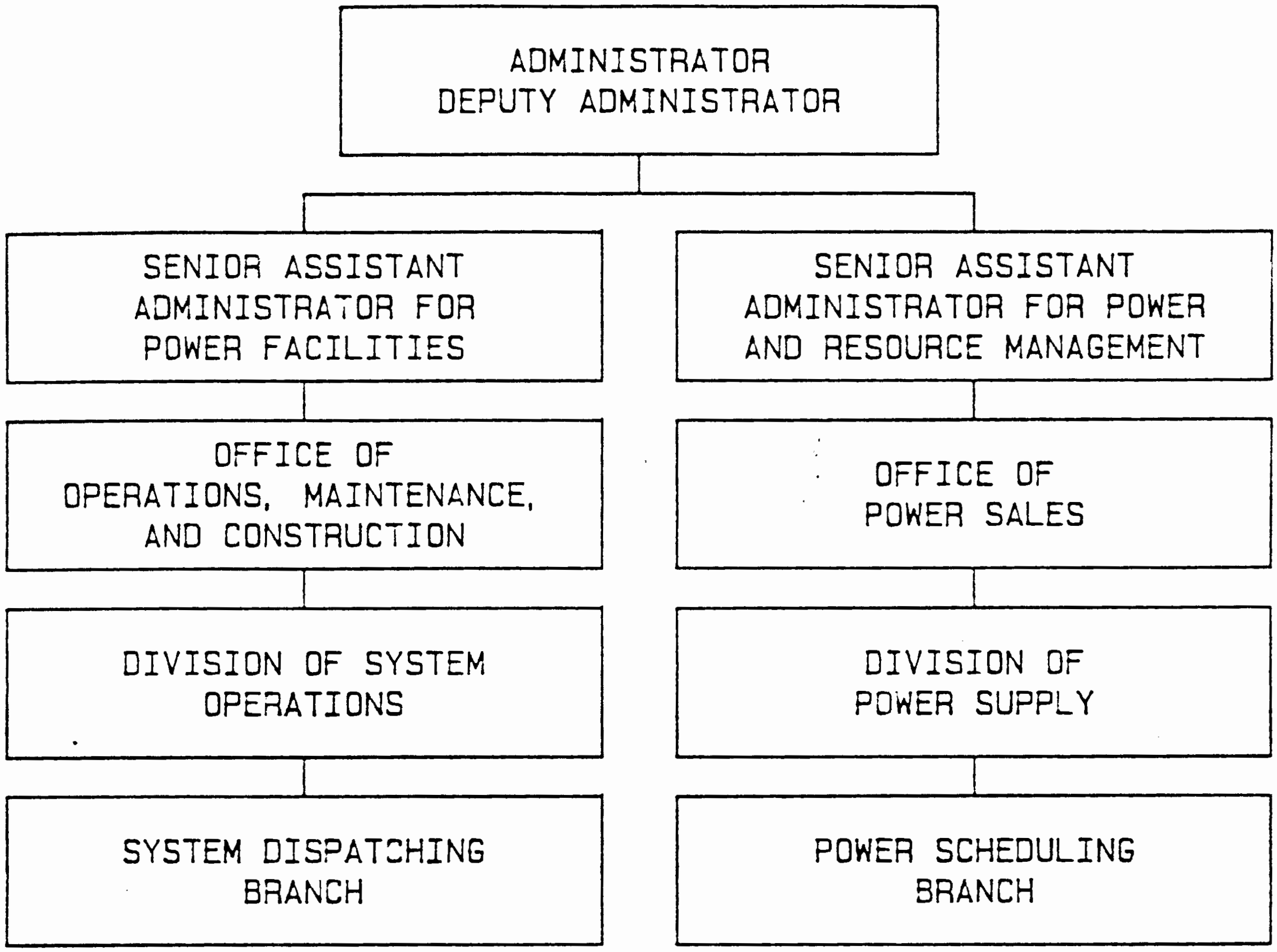
ORGANIZATION CHART
CORPS OF ENGINEERS - NORTH PACIFIC DIVISION



ORGANIZATION CHART
CORPS OF ENGINEERS - WALLA WALLA DISTRICT



ORGANIZATION CHART
BONNEVILLE POWER ADMINISTRATION



PERSONNEL AND TELEPHONE NUMBERS

CORPS OF ENGINEERS - NORTHWEST DIVISION

TITLE	NAME	OFFICE TELEPHONE COMMERCIAL
COMMANDER	BRIGADIER GENERAL JOHN R. MCMAHON	503-808-3700
DEPUTY COMMANDER	COL. ROBERT A. TRIPTON	503-808-3701
WATER MANAGEMENT DIVISION - CHIEF	JAMES BARTON	503-808-3930
RESERVOIR CONTROL CENTER BRANCH - CHIEF	STEVE BARTON	503-808-3945
HYDROLOGIC ENGINEERING TECHNICAL BRANCH - CHIEF	PETER BROOKS	503-808-3954

CORPS OF ENGINEERS - WALLA WALLA DISTRICT

TITLE	NAME	OFFICE TELEPHONE COMMERCIAL
COMMANDER	LT. COL. DAVID CALDWELL	509-527-7700
DEPUTY COMMANDER	MAJ. DECKER HAINS	509-527-7702
OPERATIONS DIVISION - CHIEF	RICHARD WERNER	509-527-7101
HYDRAULIC & HYDROLOGY BRANCH CHIEF	MARK LINDGREN	509-527-7530
HYDROLOGY SECTION - CHIEF	TRACY SCHWARZ	509-527-7522
RESERVOIR REGULATION - LEAD	STEPHEN HALL	509-527-7550
ICE HARBOR PROJECT O&M MANAGER	ROGER GOLLADAY	509-543-3251

PERSONNEL AND TELEPHONE NUMBERS

BONNEVILLE POWER ADMINSTRATION

TITLE	NAME	OFFICE TELEPHONE COMMERCIAL
ADMINISTRATOR AND CHIEF EXECUTIVE OFFICER	STEVE WRIGHT	503-230-5102
DEPUTY ADMINSTRATOR	DAVE ARMSTRONG	503-230-5103
CHIEF OPERATING OFFICER	ANITA DECKER	503-230-5105
POWER SERVICES	GREG DELWICHE, S.V.P.	503-230-4452
GENERATION ASSET MANAGEMENT	STEVE OLIVER, V.P.	503-230-4090
NORTHWEST REQUIREMENTS MARKETING	MARK GENDRON, V.P.	503-230-7640
TRANSMISSION FIELD SERVICES	ROBIN FURRER, V.P.	360-418-2245
SYSTEM OPERATIONS	RANDI THOMAS, MANAGER	360-418-2010

VII - STREAMFLOW FORECASTS

7-01. a. General. The development of reservoir regulation plans for the Ice Harbor project is based primarily on power operations and daily streamflow forecasts. The North Pacific Division Corps of Engineers Reservoir Control Center (RCC) is directly responsible for coordination of operational planning and regulation of Corps of Engineers reservoirs. The Northwest River Forecast Center 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, Bonneville Power Administration, Bureau of Reclamation, Corps of Engineers, Soil Conservation Service (SCS), and the Northwest River Forecast Center (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 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 RCC develop SSARR forecasts cooperatively and use results to carry out their public service and operational responsibilities. Refer to the Master Water Control Manual dated December 1984 for more information on use of the SSARR model.

b. SSARR Forecasts. The SSARR model is comprised of three basic components:

(1) A generalized watershed model for synthesizing runoff from snowmelt, rainfall, or a combination of the two as drainage basin outflows.

(2) 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 backwater effects from tides or reservoirs.

(3) A reservoir regulation model whereby reservoir outflow and contents 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 only for 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.

8-01. General Objectives. The objectives of this water control plan are to define regulation practices and procedures to maximize benefits from authorized project uses of providing water transportation lockages past the dam, slackwater navigation in the reservoir, and producing hydroelectric power. Regulation to optimize these authorized uses will also provide suitable conditions for secondary uses of recreation and fish and wildlife. Flood control is not an authorized or planned project function since the amount of reservoir storage is small compared to river flows.

8-02. Major Constraints.

a. Lake Elevation Limitations. Ice Harbor Reservoir will normally be operated between elevations 437.0 and 440.0. 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 436.5 - 440.5 elevation range will not be violated without prior District Office approval except in event of an emergency. District Office approval will be coordinated through the Chief of the Operations, Construction and Readiness Division. In the event of possible artificial flooding due to rupture of an upstream dam, the increased flows will be passed through the spillway with the pool in the normal operating range, elevation 437 to 440 insofar as possible. When fully open the 10 spillway gates will pass 685,000 cfs at pool elevation 440.0. Should the river flow exceed 685,000 cfs, elevation 440.0 will be exceeded even with all spillway gates fully open. Except in event of a definite emergency, elevation 440.5 will not be exceeded unless the pool is forced above that elevation by involuntary surcharge with exceptionally high river discharge.

b. Minimum Discharge. Minimum project discharge limits ensure the safe passage of anadromous fish during their migration to spawning grounds. From December through February, "zero" minimum project discharge is permitted on a limited basis. Under an agreement between the Corps of Engineers and the fishery agencies zero river flow is allowed for water storage during low power demand periods (at night and on weekends) when there are few if any actively migrating anadromous fish present in the Snake River. From March through July and August through November, the minimum project discharge will be 9,500 and 7,500 cfs, respectively, for power generation and conservation purposes. This minimum discharge is the approximate design discharge of one power unit operated at the continuous minimum generation limit of 70 MW at 9,500 cfs and 50 MW at 7,500 cfs. Special conditions may develop which make "zero" minimum project discharge desirable for a limited time during the March to November period. The Reservoir Control Center (RCC) will be responsible for coordinating such "zero" flow requests with the fishery agencies for approval. Water Stored under "zero" river flow conditions may maximize power production from the Columbia River Basin system, but "zero" river flow operations are not recommended at Ice Harbor when fish are actively migrating in the Snake River.

c. Rate of Change of Discharge. The maximum rate of change will normally be limited to 1.5 feet per hour for tailwater elevation. Coordination with upstream projects is required because the maximum rate of change per hour at Lower Monumental, Little Goose, and Lower Granite of 1.5 feet per hour is approximately 70,000 cfs per hour. Chart 11 shows tailwater discharge rating curves.

d. Spillway Operation. The spillway is operated to pass the desired discharge with the best practical hydraulic conditions in the area adjacent to the stilling basin, particularly at the fish ladder entrances. All spillway gate positions are remotely indicated and each gate is equipped for remote operation from the powerhouse control room or through the supervisory remote control system between McNary and Ice Harbor. The spillway bays and gates are numbered 1 to 10 from left to right looking downstream. Spillway gates are operated in accordance with criteria contained in the Walla Walla District - Fish Facility Operation and Maintenance Plan, Appendix C - Operating Standards for Adult Fish Passage Facilities. Table 8-1 on page 8-4 shows the spill pattern based on current criteria for spillway gate operation during the adult fish passage season from 1 March through 31 December. The variation in gate opening normally will not exceed one stop. This criteria for spillway pattern is a guide and may be modified with additional experience and tests. Table 10 is the discharge rating for one spillway gate and Chart 9 shows similar data in graphical form.

e. Sluiceway Operation. The ice and trash sluiceway is used for juvenile fish passage. Any appreciable amount of water passed through the dam for operation of the fish facilities is accounted for and reported. The juvenile fish facilities consist of 6-inch orifices, drilled through the concrete, leading from the gate wells into the ice trash sluiceway. In addition, the sluiceway operates as a surface bypass system with spill over its regulating gates. Six A-slot gates, equipped with electric hoists, operate automatically and maintain a 3.5 foot head above each A-slot gate, providing approximately 2,640 cfs through the sluiceway on a 24 hour basis. Hydralic control is maintained at the A-slot regulating gates with this automatic operation. Table 9 is a discharge rating for one gate as a function of head, which is the difference between the elevation of the top of the gate and the forebay elevation.

The sluice way has a design capacity of 3,450 cfs. Discharges greater than 3,450 cfs will produce violent waves, which would impinge upon the bridge over the sluiceway channel at the bend.

8-03. Flood Control Plan. Flood control is not a planned project function because Ice Harbor is operated as a run-of-river project with a small amount of usable storage. However, with extremely high forecasted inflow conditions at Lower Granite, the NPD Reservoir Control Center may consider drawing down Little Goose, Lower Monumental and Ice Harbor reservoirs in advance of increased discharges from Lower Granite in order to provide some space in the Lower Snake River system if such a system regulation plan provides benefits for flood control and power generation at downstream locations on the Snake and the Columbia Rivers.

A flood period on the Lower Snake River system is defined as a period when Lower Granite inflows will reach 120,000 cfs and when these flows have the potential to increase substantially and remain above 120,000 cfs for at least 24 hours because of past or forecasted meteorological events. The intent of the flood control plan is to allow the Reservoir Control Center some flexibility and judgment in the operation of the Lower Snake River system.

TABLE 8-1

ICE HARBOR SPILL PATTERN

(1 March - 31 December)

Gate Numbers 1	2	3	4	5	6	7	8	9	10	TOTAL OPENINGS (feet) 2/
Openings in Feet 1/										
(1)	0	0	0	0	0	0	0	0	1.5	2.5
1	(1)	0	0	0	0	0	0	1	1.5	4.5
1	1	(1)	0	0	0	0	1	1	1.5	6.5
1	(2)	1	0	0	0	0	1	2	1.5	8.5
1	2	1	(1)	0	0	1	1	2	1.5	10.5
1	2	1	1	(1)	1	1	1	2	1.5	12.5
1	2	(2)	1	1	1	1	2	2	1.5	14.5
1	2	2	(2)	1	1	2	2	2	1.5	16.5
1	2	2	2	(2)	2	2	2	2	1.5	18.5
1	2	2	2	(3)	3	2	2	2	1.5	20.5
1	2	2	(3)	3	3	3	2	2	1.5	22.5
1	2	(3)	3	3	3	3	3	2	1.5	24.5
1	2	3	3	(4)	4	3	3	2	1.5	26.5
1	2	3	3	4	4	4	3	2	1.5	28.5
1	2	3	3	(5)	5	4	3	2	1.5	30.5
1	2	3	(4)	5	5	4	3	3	1.5	32.5
1	(3)	3	5	5	5	4	3	3	1.5	34.5
1	3	(4)	5	6	5	4	3	3	1.5	36.5
(2)	3	4	(6)	6	5	4	4	3	1.5	38.5
2	3	4	6	6	(6)	5	4	3	1.5	40.5
2	3	(5)	6	6	6	5	4	3	1.5	41.5
2	3	5	6	(7)	6	5	5	3	1.5	43.5
2	3	5	(7)	7	6	6	5	3	1.5	45.5
2	3	(6)	7	8	6	6	5	3	1.5	47.5
2	(4)	6	7	8	6	6	5	4	1.5	50.0
2	4	6	7	8	(7)	7	5	4	2	52.0
2	4	6	(8)	8	7	7	6	4	2	54.0
2	4	6	8	(9)	8	7	6	4	2	56.0
2	4	(7)	8	9	9	7	6	4	2	58.0
2	4	7	(9)	10	9	7	6	4	2	60.0
2	4	7	(10)	10	9	8	6	4	2	62.0
2	4	7	10	11	9	8	(7)	4	2	64.0
2	4	7	(11)	11	10	8	7	4	2	66.0
2	4	(8)	11	12	10	8	7	4	2	68.0
2	4	8	11	13	10	(9)	7	4	2	70.0

1/ Values in parenthesis may be 1 foot less than values shown. For example: (1) means 0 or 1 foot; (2) means 1 or 2 feet.

2/ Note: Tentative Spilling Schedule at Ice Harbor Dam Adjusted for Expanded Powerhouse in 1976 (Openings in feet).

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 carry 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 droughts of record, brought about a heightened awareness of the problems facing juvenile fish during their migration past Columbia an 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) the passage of most fish 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, Public Law 96-501), developed the first regional fish and wildlife program for the Columbia River and its tributaries. The fish and wildlife program , amended in October 1984, 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 NPD Corps of Engineers is responsible for developing and implementing the juvenile fish passage plan for Corps of Engineers projects.

b. Lower Snake River Fish and Wildlife Program.

(1) Lower Granite Water Budget. The Lower Granite Water Budget is a recommended amount of water specifically reserved for the enhancement of flows at Lower Granite Dam to aid in the spring migration of smolts through the Lower Snake River reservoir system. This Water Budget may be used during the 15 April-15 June period when the major smolt migration is occurring at Lower Granite Dam, hence the water budget approach rather than a minimum flow requirement to enhance spring migration conditions. A total Water Budget of 20 Kcfs-months (1.19 MAF) 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.

In most years, the Water Budget flows will be the result of runoff from uncontrolled drainage basins above Lower Granite because of the limited amount of water available from storage in Dworshak and Brownlee reservoirs with which to control the Lower Snake River flows. If the Snake River flows at Lower Granite Dam are not adequate (less than 85 Kcfs) to move fish quickly through the reservoir, additional water may be released from upstream reservoirs (Dworshak and Brownlee), if available.

Under the Lower Granite Water Budget Implementation Procedure developed by the Engineering Division of the NPD Corps of Engineers, a sliding scale, based on the Lower Granite April-July runoff volume forecast, is used to determine the volume of water to be allocated from upstream reservoirs (Dworshak and Brownlee) for the Lower Granite Water Budget. Idaho Power Company's participation, use of Brownlee storage, in the Lower Granite Water Budget is still under negotiation with the Bonneville Power Administration.

Water Budget flows at Lower Granite 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 requests must be greater than average weekly firm power flows and less than 140 Kcfs. For Water Budget accounting purposes, the Power Planning Council has used firm power flows for Lower Granite Dam as follows:

Period	Average Weekly Firm Power Flows (Kcfs)
15-30 April	50
1-31 May	65
1-15 June	60

(2) Fishery Regulation. Since Lower Granite, Little Goose, Lower Monumental, and Ice Harbor are operated as run-of-river projects, The Water Budget flows provided at Lower Granite from the use of Dworshak and Brownlee storage will be passed through the Lower Snake River reservoir system and into the Lower Columbia River.

(a) Water Budget Regulation. During a year when the Lower Granite runoff volume inflow forecast for April-July is 23.0 MAF or less, the use of upstream reservoir storage for providing Water Budget flows will be coordinated by the NPD RCC. 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. 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. 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. Total water available for Water Budget requests above uncontrolled runoff is provided from Dworshak and Brownlee storage under the following conditions:

(1) Brownlee storage may be available to meet Lower Granite Water Budget requests if such releases are agreeable to Idaho Power Company.

(2) Water from Dworshak for shaping Water Budget flows at Lower Granite may be used to maintain average weekly flows of at least 85 Kcfs at Lower Granite. Additional water may be available from Dworshak to provide extended flows up to 140 Kcfs if Dworshak refill is not jeopardized and the Corps is not collecting and transporting juvenile fish at Lower Granite or Little Goose.

(3) A water Budget request may not be implemented if it conflicts with other non-power constraints at Dworshak. The severity of the conflict will be analyzed by the NPD-RCC and appropriate action taken, with documentation of the basis of the decision forwarded to the Fish Passage Managers.

(b) Non-water Budget Regulation. During a year when the Lower Granite runoff volume inflow forecast for April-July is greater than 23.0 MAF and the reservation of water for the Water Budget is not required at Dworshak, the RCC would still coordinate the regulation of releases from Dworshak and Brownlee to the extent that water is available for flow augmentation at Lower Granite.

c. Operations for Juvenile Fish Passage.

(1) General. Ice Harbor's juvenile bypass system is an ice and trash sluiceway, which was originally designed to pass floating debris and ice. At Ice Harbor, water and fish are skimmed into the ice and trash sluiceway by spill over A-slot regulating gates. See Paragraph 8-02. e. for details of sluiceway operation. Approximately 2,700 cfs will be routed through the ice and trash sluiceway for 24 hours-per-day during the juvenile fish passage season to provide a project survival rate of 92% or greater. Table 9 shows the discharge rating for the ice and trash sluiceway. The facilities at Lower Granite and Little Goose dams are used mostly for collection, with bypass capability being used only when flow conditions or fish numbers make transportation unfeasible, so the number of fish bypassed at Ice Harbor is small in comparison to the total fish count.

(2) Spill Criteria for Juvenile Passage. Criteria for spill patterns from 1 April to the end of the juvenile fish passage season are summarized as follows:

(a) Involuntary Spill Operation. Involuntary spill occurs when the powerplant's hydraulic capacity has been exceeded or low system power demands require part of the river flow to be spilled. The spill pattern for an involuntary spill operation will be in accordance with criteria contained in the Walla Walla District - Fish Facility Maintenance Plans, Appendix C - Operating Standards for Adult Fish Passage (Refer to Table 8-1 on page 8-4).

(b) Special Spill. Spill will be considered when other non-collector projects are spilling to exceed 92% survival rate for juvenile passage.

8-05. Power Plan. Ice Harbor Dam is operated for power within the foregoing pondage and release limitations and in accordance with a working agreement between the Corps of Engineers and Bonneville Power Administration, the marketing agency for Federally generated power in the Pacific Northwest. Power scheduling for Ice Harbor is accomplished by Bonneville Power Administration in coordination with the North Pacific Division of the Corps of Engineers. To implement scheduling and maintain optimum operating conditions, close coordination between the Ice Harbor and McNary powerplant operators and the Bonneville Power Administration dispatchers is essential. Routine power operations are controlled remotely from McNary through the system optimizer controller, which can also control Lower Monumental, Little Goose, and Lower Granite projects. Discussion of overall coordinated operation of the Northwest Federal Power System is presented in the Master Water Control Manual.

Load factoring may be accomplished by making use of the 24,900 acre-feet of storage between elevations 437 and 440 when the reservoir inflow is less than powerplant hydraulic capacity. The discharge capacity of the six power units is about 94,000 cfs in the range of normal operating head.

Generally, the power units will be operated to provide greatest overall 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. All operations will be within the safe limitations of the equipment as set forth in the Operations and Maintenance Manual. Table 13 and Chart 3 show mean unit performance data (power versus discharge relationships).

The Bonneville Power Administration dispatcher will be notified of any emergency which may affect power production and the estimated time to restore conditions to normal.

In the event of a transmission system break-up which would leave Ice Harbor Project the only major generating facility on an isolated segment of the Bonneville Power Administration 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 3-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.

8-06. Navigation Plan. Operation for navigation, a major project function, consists essentially of making the necessary lockages. Normally, navigation requirements are met with regulation of streamflows and pool levels for other project purposes. Occasionally, however, special requirements are met by special regulation of pool levels, but these do not significantly alter the Columbia River system regulation as a whole. The lock facilities are operable at the full range of normally experienced river flows, but should the discharge reach 300,000 cfs, it may be necessary to close the lock to some vessels because of restricted clearance under the downstream lift gate. In the raised position, the bottom of the gate is at elevation 410, the same as the bottom of the bridge. Tailwater elevation with a 300,000 cfs discharge is 358 feet msl, providing 52 feet of clearance. The navigation regulations and procedures are set forth in Exhibit 8-1.

The locks at the dams may be closed for brief periods every year for maintenance. Closures are scheduled far enough in advance and given sufficient publicity to provide minimum interference with navigation. A callout list for use in case of emergency closure of the lock facilities or other navigation emergencies is given in Table B-1, Exhibit 8-1.

Water which is passed through the dam by lockages is accounted for and reported. A lockage requires approximately 40 to 50 minutes, varying somewhat with head and other factors. The following tabulation shows the relationship between head and volume in a lockage expressed in acre-feet and equivalent cfs averaged over a one-hour period.

Head	Lockage Volume	
Ft.	Acre-Feet	Cfs-Hr
100	133	1625
96	128	1560
92	123	1484
88	117	1419
84	112	1355
80	107	1290

8-07. Recreation Plan. The plan of operation of Ice Harbor project does not specifically provide for special regulation of the reservoir in the interest of recreation. The recreation facilities are constructed to accommodate the three-foot reservoir fluctuations between elevations 437 and 440 measured at the dam. Under special conditions and when clearly not detrimental to other interests it may be permissible to regulate the reservoir in the special interest of recreation for short periods.

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 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

Reservoir Control Center 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 Ice Harbor 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 Ice Harbor - Lower Monumental Project engineer.

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. Ice Harbor 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.

*** Exhibit 8-1 contains guidelines for the lockage of vessels and a notification list in the event of unscheduled navigation matters.

b. Emergency Conditions. Emergency conditions are unforeseen and cannot be completely provided for in this Water Control Manual. General instructions are summarized as follows:

- o Refer to pages iv and v (pink sheets in the front of this Manual) for telephone numbers and guidelines on emergency conditions.

- o If the nature of the emergency requires immediate action to prevent loss of life and property, the Project Engineer will take the necessary action and report all circumstances to the Walla Walla District's Chief of Operations Division as soon as possible.

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

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, which is only available in the control room. Radio communication between mobile and portable units and the District office or a project control room will be on the Corps' operating frequency 163.4125 megahertz. Relay stations, one near Pomeroy in the Blue Mountains and one near Kennewick, are provided to increase mobile radio coverage. Microwave radio channels link the project control rooms and the District Office.

When the operator at Ice Harbor leaves the control room, McNary can switch the microwave radio system so that it is rebroadcast over the mobile or portable frequency, 163.4125 megahertz, and reach the operator anywhere on the project. The operator can monitor and answer the navigation radio, Marine channel 14, by activating the rebroadcasting feature when he leaves the control room. He 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 and the 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.

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 safe operation, power generation, recreation, fish and wildlife, and navigation. Overall benefits and effects from the project include:

1. Production of hydroelectric power.

2. Water oriented recreational opportunities for the public.

3. Enhancement of economic productivity in the region with slack water navigation to Lewiston.

4. Impact upon fish and wildlife habitat by altering 31.9 miles of free-flowing river and associated canyon bottom lands.

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

9-02. Flood Control. Ice Harbor is operated as a run of river project and as a result, river flow passing the dam would not be significantly reduced by reservoir routing. However, the cumulative effect of drawing down Ice Harbor and other run-of-river projects in advance of flood peaks would have some moderating effect on the flood peak at downstream locations on the Snake and Columbia Rivers.

9-03. 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 years later, the upstream migration to spawning grounds. Ice Harbor dam is a major physical barrier that anadromous fish must pass when migrating both up and down the Snake River. As a result, fish facilities were provided at the project to aid migrating adults and juveniles. The Two fish ladders at the project are effective in providing passage past the dam for upstream migrating fish. A bypass system also helps move juveniles rapidly past 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. Physical transport by truck or barge from facilities at Lower Granite and Little Goose dams is another method of helping juveniles downstream and survival rates have been found to be higher for transported fish. Juvenile survival rates will increase with improvements to the fish bypass/collection facilities and physical transport methods.

b. Flow Augmentation for Downstream Migrants. In addition to fish passage facilities and physical transport, well-timed and increased flows through Lower Monumental reservoir will also contribute to greater survival rates for outmigrating fish. The effects of the slow-moving current through the reservoir on juveniles include increased migration time which reduces the smolts ability to adapt to salt water, favorable conditions for predators, and warmer water conditions. Flow augmentation at Lower Granite by water budget releases from upstream storage reservoirs will help to shape the flow pattern on the Lower Snake River during the critical migration period (15 April to 15 June) in order to move juveniles quickly and safely downstream.

The Corps does not plan to augment flows at Lower Granite for implementation of the Water Budget where it would cause spill at Lower Granite and Little Goose in excess of the rated hydraulic capacity of the power plant. Hydraulic capacity of each power plant at Lower Granite and Little Goose is approximately 130,000 cfs. However, at Lower Monumental voluntary spill specifically separate from the water budget flow may be required to aid juveniles in passing the dam. The volume of water required for water budget flow may be drawn from storage in Dworshak and Brownlee if necessary. The effect on Dworshak and Brownlee is a reduction of the firm energy load carrying capability (FELCC), which will also affect the FELCC of the entire Federal Columbia River Power System.

9-04. Hydroelectric Power. Power produced by Ice Harbor 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 at a cost considerably lower than would be possible using fossil fuels. The addition of Ice Harbor to the system also produces more dependability in the power system, since it can help meet power demands in the event that the generating ability of another facility is impaired.

9-05. Navigation. The regulation of the Snake River for navigation has a considerable effect on the economy of the region and of the Lewiston - Clarkston 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 from interior areas of the basin by water. Major shipping facilities in Lewiston and Clarkston and along the reservoir handle bulk commodities such as grain and fertilizer, which are considerably cheaper to transport by barge.

9-06. Recreation. The Ice Harbor project has greatly improved the recreation opportunities of the region. The relatively stable pool levels provided by operation between elevations 437 and 440 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 opportunities enhance the quality of life for people in the region.

9-07. Water Quality. The regulation of Ice Harbor 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 and recreation has not resulted in prolonged adverse effects on the water quality of the reservoir to date. The growth of algae in Lower Granite reservoir has somewhat alleviated this problem in downstream reservoirs, by decreasing the nutrient levels passing the dam. Lower Granite also traps much of the sediment carried by the river, and thus improves water quality in Ice Harbor. 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.

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, which is immediately upstream of Little Goose. Since runoff between Lower Granite and Ice Harbor dams is insignificant, the runoff volume at Ice Harbor is essentially identical. 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 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 at the Dalles. Plate 9-2 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 (128) 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 9-2, Columbia River at The Dalles, frequency curves are summarized in the following:

Maximum Annual Peak 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

Tables

* DELETED BY REVISION
** ADDED BY REVISION

ICE HARBOR RESERVOIR REGULATION MANUAL

TABLE 1 - REPRESENTATIVE CLIMATOLOGICAL DATA

Ice Harbor Dam For Period Ending 1962

TEMPERATURE 1/	UNIT	YEARS OF RECORD	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Normal	°F.	54	31.8	37.5	46.1	54.5	62.3	68.3	75.1	72.4	64.6	53.7	41.2	36.0	53.6
Average Maximum	°F.	54	38.5	46.6	58.4	68.5	76.6	83.4	92.1	89.0	79.3	66.5	50.7	41.6	65.9
Average Minimum	°F.	54	24.1	29.1	34.3	39.5	47.4	53.5	59.0	56.8	49.0	40.5	32.5	27.8	41.1
Extreme Maximum	°F.	72	74	74	88	95	105	108	115	115	102	89	78	71	115
Extreme Minimum	°F.	72	-27	-23	-20	10	18	37	38	37	21	15	0	-29	-29
PRECIPITATION 1/															
Normal	In.	72	1.05	0.82	0.56	0.48	0.54	0.63	0.17	0.14	0.33	0.73	0.95	1.09	7.49
Maximum Monthly	In.	72	2.49	3.57	1.94	1.31	2.29	2.27	1.38	1.53	1.77	3.07	3.38	2.72	
Minimum Monthly	In.	72	0.18	0.11	0.02	0	T	0	0	0	0	0	T	0.23	
Maximum Year	In.	(1948)	1.50	1.13	0.24	1.30	2.05	2.27	1.38	0.07	0.16	0.72	0.92	1.16	12.90
Minimum Year	In.	(1898)	0.73	0.52	0.14	0.21	0.37	0.34	0	0.15	0.05	0.10	0.74	0.23	3.58
Maximum One-Day	In.	30	0.86	0.73	0.56	1.09	0.99	1.42	0.88	0.70	0.52	1.18	0.94	0.73	1.42
Avg. Days .01 or more	Day	65	7	7	5	4	4	3	1	2	3	5	7	7	55
SNOWFALL 1/															
Avg. Unmelted Depth	In.	63	5.8	3.0	0.1	0	0	0	0	0	0	0	1.5	2.8	13.2
Maximum Observed	In.	30	25.5	13.0	1.4	0.2	0	0	0	0	0	0	8.0	16.3	34.3
RELATIVE HUMIDITY 2/															
04:30 AM PST	%	84	83	82	76	70	69	66	56	55	65	74	79	83	72
04:30 PM PST	%	77	80	71	55	42	38	35	24	25	38	52	72	80	51
WIND															
Prevailing Direction 1/		32	SW	SW	SW	SW	SW	SW	SW	SW	W	SW	W	W	SW
Avg. Speed 3/	MPH	15	6	7	8	9	9	9	8	8	7	7	6	6	8
Highest Speed 3/	MPH	15	64	59	70	53	71	72	50	50	65	63	64	71	72

1/ Kennewick, Washington U.S. Weather Bureau Cooperative Station

2/ Based on USWB records, Spokane, Yakima and Walla Walla

3/ Hanford works meteorological station report H.W. - 57722 Nov. 1959

TABLE 2 - CLIMATOLOGICAL DATA

Snake River Basin above Ice Harbor Dam

Sta. No.	Station	Basin	Elevation	TEMPERATURE Length of record	TEMPERATURE Annual mean	TEMPERATURE Extremes Max.	TEMPERATURE Extremes Min.	PRECIPITATION Length of record	PRECIPITATION Normal	PRECIPITATION Wettest year 1/	PRECIPITATION Wettest Amount	PRECIPITATION Driest year 1/	PRECIPITATION Driest Amount	SNOWFALL Length of record	SNOWFALL Average depth
			Feet M.s.l.	Years	°F	°F	°F	Years	Inches		Inches 1/		Inches 1/	Years	Inches
	WASHINGTON														
1	Anatone	Snake	3,750	25	44.8	104	-30	34	22.6	1940	31.0	1935	12.8	30	89.5
2	Dayton	Columbia	1,610	57	50.9	109	-22	58	19.6	1948	26.8	1944	12.1	53	24.0
3	Kahlotus	Columbia	1,350	--	----	---	---	42	10.0	1940	15.5	1935	5.6	35	12.5
4	La Crosse 3 ESE	Snake	1,546	49	49.7	110	-30	49	14.2	1940	20.5	1944	8.6	44	20.1
5	Pomeroy	Snake	1,890	45	50.3	112	-24	57	17.2	1941	22.4	1952	9.3	44	23.2
6	Pullman	Palouse	2,545	4	48.1	104	-21	4	20.4	1933	26.6	1944	11.8	58	44.8
7	Walla Walla	Columbia	949	54	53.8	113	-16	54	16.1	1942	21.6	1935	10.1	44	20.6
	IDAHO														
8	Big Creek	Salmon	5,686	10	37.8	96	-43	16	23.0	1941	28.7	1952	16.3	6	122.4
9	Boise	Boise	2,842	59	51.3	109	-17	59	12.2	1938	16.4	1949	7.4	19	21.5
10	Burley	Snake	4,180	41	48.7	106	-35	41	9.4	1936	12.6	1939	3.5	35	28.8
11	Challis	Salmon	5,171	37	43.5	101	-33	42	7.3	1941	10.3	1935	2.6	50	20.4
12	Council	Snake	2,930	38	47.9	109	-23	40	25.9	1940	39.6	1935	16.8	35	70.0
13	Deadwood Dam	Payette	5,375	28	38.2	99	-48	29	32.9	1940	44.7	1935	19.4	21	185.1
14	Dubois CAA-AP	Lost	2,717	18	43.3	98	-23	18	11.1	1944	13.8	1943	7.0	12	41.6
15	Gooding CAA-AP	Snake	3,696	16	47.6	105	-18	17	9.3	1951	11.2	1949	5.9	9	38.1
16	Grangeville	Clearwater	3,355	34	46.8	108	-24	38	23.6	1941	27.2	1934	15.2	34	55.1
17	Hailey	Snake	5,322	48	43.5	109	-36	50	15.3	1941	22.0	1947	6.8	47	86.5
18	Idaho City	Boise	3,965	38	45.4	109	-38	41	21.5	1951	31.3	1935	12.5	41	94.0
19	Idaho Falls CAA-WB	Snake	4,730	28	44.3	104	-37	28	11.6	1940	14.2	1952	5.9	19	35.9
20	Kooskia	Clearwater	1,261	40	50.5	116	-30	50	23.4	1948	35.5	1936	15.8	38	25.9
21	Lewiston	Snake	1,436	52	51.0	106	-22	52	13.3	1940	21.3	1935	8.4	11	19.3
22	Obsidian	Snake	6,870	31	35.4	95	-44	37	16.1	1946	19.8	1952	8.2	41	85.7
23	Payette	Payette	2,110	57	50.5	113	-33	59	10.9	1940	18.6	1949	5.3	54	24.1
24	Pierce RS	Clearwater	3,175	17	43.9	107	-44	29	38.6	1948	59.2	1935	27.7	17	110.1
25	Pocatello WBAP	Snake	4,444	20	47.2	103	-31	59	10.8	1938	16.5	1939	6.4	20	37.1
26	Riggins RS	Salmon	1,801	29	52.7	110	-13	34	14.8	1941	22.4	1936	9.8	29	12.3
27	St. Anthony	Snake	4,968	11	42.5	98	-33	15	13.5	1951	17.9	1946	10.4	7	49.5
28	Salmon	Salmon	3,949	47	44.0	105	-37	47	8.6	1946	14.4	1935	3.6	38	24.0
	OREGON														
29	Baker	Snake	3,368	62	45.4	104	-25	62	11.2	1940	15.8	1939	5.8	59	40.4
30	Harper	Malheur	2,518	24	48.3	107	-41	4	10.5	1941	12.5	1935	4.2	24	21.1
31	Huntington	Snake	2,150	34	53.4	110	-17	43	10.8	1940	18.9	1949	5.4	38	37.6
32	La Grande	Grande Ronde	2,805	66	49.4	108	-34	67	20.1	1946	25.9	1935	13.7	61	41.7
33	Owyhee Dam	Owyhee	2,400	22	53.9	110	-18	23	9.6	1940	13.7	1939	4.8	17	13.0
34	Wallowa	Grande Ronde	2,923	44	47.6	108	-38	51	17.5	1948	21.2	1939	9.7	43	55.3
35	Warm Springs Res.	Malheur	3,332	21	49.2	109	-34	31	8.1	1940	13.1	1939	3.3	19	16.4
	WYOMING														
36	Moran	Snake	6,798	42	34.2	92	-63	43	21.6	1945	26.8	1952	13.5	40	143.0
	NEVADA														
37	Owyhee	Owyhee	5,396	20	47.9	108	-35	20	12.5	1945	19.4	1933	5.7	14	65.2

NOTE: 1/ From record of period 1931 - 1952 only

TABLE 3 - REPRESENTATIVE SNOW COURSE DATA

Snake River Basin

Map No.	Course	River Basin	Elevation in Ft.M.S.L.	Years of Record	Observed Snow Water Equivalent Depth in Inches: Average Jan. 1	Average Feb. 1	Average Mar. 1	Average Apr. 1	Average May 1	Maximum Recorded	Date	Minimum April 1	Year
1	Arizona, Wyo. 1/	Snake	6850	32	8.9	14.0	16.5	15.9	---	31.8	Mar. 1943	6.0	1931
2	Aster Creek, Wyo. 1/	Snake	7700	32	14.5	22.1	27.2	29.8	---	50.8	Apr. 1943	17.5	1931
3	Snake River Station, Wyo.	Snake	6780	32	9.8	15.1	18.5	18.3	---	32.6	Mar. 1943	7.0	1931
4	Blackrock, Wyo.	Snake	8600	29	---	12.3	22.3	22.6	25.3	34.6	Mar. 1943	14.1	1940
5	Afton Ranger Station, Wyo.	Snake	6200	17	2.3	4.0	4.9	2.1	---	10.2	Mar. 1936	0.0	1938
6	Bechler Ranger Station, Wyo.	Snake	6400	14	8.5	13.9	21.7	23.4	14.8	34.0	Mar. 1943	15.4	1944
7	West Yellowstone, Mont.	Snake	6700	19	5.0	7.8	10.3	11.7	3.6	18.9	Apr. 1952	7.1	1944
8	Magic Mountain, Idaho	Snake	6700	10	9.4	15.1	20.4	20.8	---	28.6	Apr. 1952	11.9	1944
9	Bear Creek Meadows, Nev.	Snake	7800	21	---	---	16.5	20.6	---	24.4	Apr. 1949	14.1	1941
10	White Knob, Idaho	Big Lost	7700	17	2.8	5.3	8.3	9.9	---	22.9	Apr. 1938	4.8	1939
11	Graham Ranch, Idaho	Big Wood	6200	17	5.3	8.8	12.3	13.3	---	23.2	Apr. 1938	5.9	1939
12	Mascot Mine, Idaho	Big Wood	7900	17	3.7	7.9	14.1	15.8	8.1	24.7	Mar. 1943	7.9	1944
13	Bogus Basin, Idaho	Boise	6400	11	10.6	16.0	20.9	27.1	24.5	39.6	Apr. 1943	14.8	1944
14	Couch Summit, Idaho	Boise	7000	5	---	19.9	19.8	25.0	22.0	38.4	Apr. 1952	14.3	1948
15	Lower Jack Creek, Idaho	Owyhee	6800	18	---	---	4.9	4.2	---	10.3	Apr. 1952	0.0	Several
16	South Mountain No. 2, Ida.	Owyhee	6340	12	4.8	9.1	11.9	11.5	---	23.8	Mar. 1952	3.6	1947
17	Crawford Ranger Station, Ida.	Payette	4800	16	2.7	5.8	7.4	5.8	0.0	13.8	Apr. 1936	0.0	Several
18	Deadwood River Dam, Idaho	Payette	5500	17	8.0	11.6	15.8	16.3	16.0	25.7	Apr. 1952	7.0	1944
19	Blue Mountain Springs, Ore.	Malheur	5900	23	6.0	9.8	15.2	15.2	4.2	23.1	Apr. 1952	4.1	1930
20	Rock Spring, Oregon	Malheur	5100	17	2.5	4.6	6.6	4.9	0.0	10.4	Mar. 1936	0.0	1940
21	Boulder Creek, Idaho	Weiser	5500	15	---	---	21.4	23.4	21.6	37.1	Apr. 1952	12.6	1944
22	Blue Mountain Summit, Ore.	Burnt	5100	17	3.7	6.2	9.1	7.7	0.5	13.6	Mar. 1952	1.0	1940
23	Williams Creek Summit, Idaho	Salmon	7800	16	---	5.0	10.9	13.2	10.6	20.2	Apr. 1950	7.1	1941
24	Mill Creek Summit, Idaho	Salmon	8870	16	---	---	---	20.8	16.2	35.5	Apr. 1943	11.3	1941
25	Eilertson Meadows, Ore.	Powder	5400	20	4.1	8.0	11.2	12.0	---	17.5	Apr. 1932	6.5	1944
26	Schneider Meadows, Ore.	Pine Creek	5400	16	---	20.3	34.6	29.9	---	45.4	Apr. 1952	17.4	1940
27	Aneroid Lake No. 1, Ore.	Imnaha	7480	22	---	21.2	31.4	36.2	35.4	47.3	Apr. 1938	21.0	1944
28	Moss Spring, Oregon	Grande Ronde	5850	15	9.9	15.5	21.0	25.1	---	34.6	Apr. 1943	16.7	1941
29	Nez Perce Pass, Idaho	Clearwater	6575	16	---	11.1	15.1	17.6	9.7	27.2	Mar. 1943	6.2	1941
30	Packers Meadow, Idaho	Clearwater	5700	16	5.3	13.2	18.0	21.7	13.4	34.4	Apr. 1949	8.4	1941

NOTE: 1/ Date of Survey about the 15th

DELETED

TABLE 4
DISCHARGE RATING TABLE - SNAKE RIVER NEAR CLARKSTON, WASHINGTON

DELETED

TABLE 5
DISCHARGE RATING TABLE - PALOUSE RIVER AT HOOPER, WASHINGTON

TABLE 6
SUMMARY OF RUNOFF AND DISCHARGE DATA
Snake River near Clarkston, Washington

Water Year	Station Name	Annual Runoff KAF	Annual Runoff Inches	Discharge Maximum c.f.s.	Discharge Maximum Date	Discharge Minimum c.f.s.	Discharge Minimum Date
1894	RIPARIA 2/	------	----	409,000 1/	5 JUN	------	------
1910	BURBANK 3/	49,000	8.43	252,000	23 MAR	11,800	26 AUG
1911	BURBANK	42,200	7.26	242,000	15 JUN	15,600	2 SEP
1912	BURBANK	49,100	8.45	289,000	10 JUN	15,000	6 JAN
1913	BURBANK	46,400	7.98	298,000	29 MAY	15,500	4 SEP
1914	BURBANK	36,300	6.24	175,000	25 MAY	13,000	4 SEP
1915	BURBANK	26,000	4.47	122,000	20 MAY	13,000	1 SEP
1916	RIPARIA	46,500	8.38	230,000	20 JUN	15,200	1 OCT
1917	RIPARIA	46,300	8.35	256,000	30 MAY	16,200	3 SEP
1918	RIPARIA	42,600	7.68	216,000	14 JUN	15,000	8 SEP
1919	RIPARIA	28,900	5.21	167,000	30 MAY	10,900	28 AUG
1920	RIPARIA	30,800	5.55	148,000	17 JUN	12,300	1 OCT
1921	RIPARIA	49,800	8.98	270,000	20 MAY	16,700	31 AUG
1922	RIPARIA	39,400	7.10	233,000	7 JUN	14,500	24 SEP
1923	4/	32,800	5.91	179,000	13 JUN	15,200	13 SEP
1924		24,100	4.34	136,000	14 MAY	9,800	29 AUG
1925		38,800	7.00	219,000	22 MAY	15,200	11 AUG
1926		25,400	4.58	91,000	20 APR	11,300	3 AUG
1927		41,500	7.48	245,000	9 JUN	16,800	29 AUG
1928		45,600	8.22	271,000	27 MAY	16,100	3 SEP
1929	RIPARIA	27,000	4.87	155,000	25 MAY	13,100	9 SEP
1930	RIPARIA	25,000	4.51	95,600	26 APR	13,100	2 SEP
1931	RIPARIA	20,600	3.71	107,000	2 APR	10,600	14 AUG
1932	RIPARIA	34,800	6.27	219,000	23 MAY	14,400	6 OCT
1933	RIPARIA	32,700	5.90	245,000	11 JUN	-----	-----
1934	RIPARIA	29,400	5.30	149,000	23 DEC	12,200	19 AUG
1935	RIPARIA	25,020	4.51	130,000	25 MAY	13,100	28 AUG
1936	CLARKSTON5/	31,460	5.72	219,000	16 MAY	12,200	20 DEC
1937	CLARKSTON	22,310	4.06	114,000	19 MAY	10,800	10 JAN
1938	CLARKSTON	37,540	6.82	219,000	29 MAY	15,200	1 OCT
1939	CLARKSTON	27,320	4.96	149,000	4 MAY	14,000	21 AUG
1940	CLARKSTON	28,810	5.23	126,000	12 MAY	13,000	24 AUG
1941	CLARKSTON	26,290	4.78	102,000	14 MAY	15,500	16 DEC
1942	CLARKSTON	34,490	6.27	162,000	27 MAY	16,800	26 AUG
1943	CLARKSTON	49,030	8.91	209,000	20 APR	17,900	11 OCT
1944	CLARKSTON	25,500	4.63	109,600	16 MAY	16,400	13 SEP
1945	CLARKSTON	30,800	5.60	149,000	7 MAY	16,100	14 DEC
1946	CLARKSTON	37,860	6.88	169,000	20 APR	17,800	20 AUG
1947	CLARKSTON	40,410	7.34	239,000	10 MAY	19,000	21 AUG
1948	CLARKSTON	46,390	8.43	369,000	29 MAY	20,200	16 SEP
1949	CLARKSTON	48,390	6.97	248,900	16 MAY	17,200	3 SEP
1950	CLARKSTON	42,730	7.76	212,000	17 JUN	19,200	5 JAN

TABLE 6 (CONTINUED)
SUMMARY OF RUNOFF AND DISCHARGE DATA
Snake River near Clarkston, Washington

Water Year	Station Name	Annual Runoff		Discharge Maximum		Minimum	
		1,000 ac.ft	Inches	c.f.s.	Date	c.f.s.	Date
1951	CLARKSTON	43,060	7.82	182,000	24 MAY	19,200	16 SEP
1952	CLARKSTON	46,590	8.46	250,000	29 APR	20,700	27 AUG
1953	CLARKSTON	37,710	6.85	232,000	13 JUN	15,600	30 NOV
1954	CLARKSTON	35,320	6.42	210,000	21 MAY	20,500	10 SEP
1955	CLARKSTON	30,890	5.61	204,000	13 JUN	17,500	10 SEP
1956	CLARKSTON	48,460	8.80	292,100	24 MAY	20,400	5 OCT
1957	CLARKSTON	42,700	7.76	322,900	20 MAY	18,300	31 JAN
1958	CLARKSTON	37,470	6.81	247,600	22 MAY	9,320	3 SEP
1959	CLARKSTON	36,760	6.68	171,400	6 JUN	13,400	8 OCT
1960	CLARKSTON	35,180	6.39	163,500	4 JUN	15,900	22 AUG
1961	CLARKSTON	30,000	5.45	174,500	27 MAY	13,000	15 AUG
1962	CLARKSTON	32,680	5.94	138,900	26 MAY	17,500	10 SEP
1963	CLARKSTON	34,940	6.35	150,400	25 MAY	18,100	2 SEP
1964	CLARKSTON	37,720	6.86	240,300	9 JUN	17,900	7 OCT
1965	CLARKSTON	53,130	9.66	227,000	21 APR	20,820	22 AUG
1966	CLARKSTON	27,110	4.93	111,000	8 MAY	14,400	22 AUG
1967	CLARKSTON	33,790	6.14	205,000	24 MAY	15,500	22 AUG
1968	CLARKSTON	31,100	5.65	134,000	4 JUN	15,200	11 OCT
1969	CLARKSTON	42,010	7.63	189,000	20 MAY	16,500	2 SEP
1970	CLARKSTON	38,180	6.94	233,000	7 JUN	17,900	31 AUG
1971	CLARKSTON	54,340	9.87	258,000	30 MAY	16,700	27 AUG
1972	CLARKSTON	50,660	9.20	240,000	2 JUN	19,300	11 SEP
1973	6/	25,750	4.68	96,000	19 MAY	14,850	26 AUG
1974		57,410	10.43	332,000	18 JUN	20,750	9 SEP
Average 8/		37,000	6.65	200,000		16,000	
Maximum		57,410	10.43	409,000	1894	24,100	1975
Minimum		20,600	3.71	91,000	1926	9,320 7/	1958

1/ Computed by the U.S. Geological Survey from high water marks.
2/ Drainage area at Riparia is 104,000 square miles.
3/ Drainage area at Burbank is 109,000 square miles.
4/ Estimated from discharge records of Snake River at Oxbow, Salmon River at Whitebird, and Clearwater River at Kamiah, and from stage Records at Lewiston for 1923-1928.
5/ Drainage area for Snake River near Clarkston is about 103,200 square miles.
6/ Estimated from Snake River at Anatone and Clearwater River at Spalding for 1973-1974 mean daily discharges.
7/ Minimum Extreme discharge is 6,660 cfs on 2 September 1958.
8/ Average for period 1910-1974.

Notes:
1. Data source U.S. Army Corps of Engineers, Walla Walla District, Hydrology Branch.
2. Gage discontinued December 1972.

TABLE 6A
SUMMARY OF RUNOFF AND DISCHARGE DATA
(Lower Granite Reservoir Computed Regulated Inflows) 1/

Water Year	Annual Runoff KAF	Annual Runoff Inches 3/	Mean Daily Discharge Maximum c.f.s.	Maximum Date	Minimum c.f.s.	Minimum Date
1975 2/			177,300	7 JUN	24,100	15 AUG
1976	50,780	9.20	192,800	11 MAY	22,000	5 SEP
1977	20,430	3.70	62,200	3 MAY	10,900	21 AUG
1978	40,370	7.31	148,800	9 JUN	18,700	3 SEP
1979	30,970	5.60	141,200	25 MAY	13,700	13 AUG
1980	32,810	5.94	133,200	13 JUN	16,100	1 SEP
1981	33,920	6.15	176,100	10 JUN	15,700	24 AUG
1982	51,000	9.24	205,600	18 JUN	17,400	25 OCT
1983	48,400	8.77	194,300	29 MAY	22,800	31 AUG
1984	54,750	9.92	244,800	31 MAY	19,400	2 OCT
1985	35,280	6.39	124,400	8 Jun	28,600	6 Aug
1986	44,320	8.03	211,000	1 Jun	23,800	30 Aug
Average	40,270	7.30	168,000		19,000	
Maximum	54,750	9.92	244,800	1984	28,600	1985
Minimum	20.430	3.70	62,200	1977	10,900	1977

1/ Inflows computed at Lower Granite Dam due to abandonment of Clarkston site in 1972 because of Lower Granite Dam construction.

2/ Water year 1975 data based on March - December 1975 period of record.

3/ 1.0 basin inches = 5,520 KAF for a drainage area of 103,500 sq. mi. above Lower Granite Dam.

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

TABLE 7 - SUMMARY OF RUNOFF AND DISCHARGE DATA

Clearwater River at Spalding, Idaho

Water Year	Annual runoff 1,000 ac.ft.	Annual runoff Inches	Extremes: Momentary maximum c.f.s.	Momentary maximum Date	Minimum day 1/ c.f.s.	Minimum day 1/ Date
1927	14,500	28.42	109,000	9 Jun	3,670	24 Aug
1928	17,600	34.47	107,000	26 May	2,450	5 Jan
1929	7,460	14.62	77,100	24 May	1,000	9 Feb
1930	7,430	14.56	52,600	25 Apr	950	15 Jan
1931	6,910	13.52	71,500	1 Apr	1,510	6 Sep
1932	12,100	23.70	121,000	14 May	1,570	24 Nov
1933	11,900	23.31	136,000	10 Jun	1,900	9 Feb
1934	13,880	27.19	172,000	23 Dec	1,660	8 Sep
1935	8,709	17.07	72,400	24 May	1,500	21 Jan
1936	10,260	20.12	107,000	15 May	1,000	20 Dec
1937	6,566	12.86	54,400	19 May	500	9 Jan
1938	10,110	19.81	134,000	19 Apr	1,790	14 Oct
1939	8,289	16.26	77,500	4 May	1,710	28 Sep
1940	8,166	16.00	56,200	12 May	1,500	3 Sep
1941	6,569	12.86	39,700	13 May	1,660	16 Dec
1942	9,280	18.18	53,500	26 May	2,040	30 Sep
1943	14,060	27.53	87,200	28 May	2,020	10 Oct
1944	6,212	12.13	50,900	16 May	1,680	30 Jan
1945	8,886	17.40	79,600	6 May	1,540	13 Dec
1946	10,740	21.05	65,600	6 May	2,380	16 Oct
1947	13,360	26.17	114,000	8 May	2,560	7 Sep
1948	16,290	31.93	177,000	29 May	2,840	17 Sep
1949	12,450	24.39	123,000	16 May	2,150	5 Sep
1950	14,290	28.01	100,700	17 Jun	2,400	5 Jan
1951	12,680	24.84	73,800	12 May	2,140	22 Sep
1952	11,250	22.05	89,900	28 Apr	1,980	28 Sep
1953	9,902	19.40	81,800	13 Jun	500	1 Dec
1954	11,320	22.19	104,000	20 May	1,960	16 Oct
1955	10,470	20.51	101,000	12 Jun	1,850	20 Dec
1956	14,850	29.10	121,000	24 May	2,630	20 Sep
1957	11,990	23.47	143,000	20 May	1,600	18 Jan
1958	9,910	19.41	91,200	22 May	2,190	1 Oct
1959	14,440	28.29	84,000	6 Jun	2,420	7 Oct
1960	12,750	24.98	79,000	13 May	2,200	22 Sep
1961	10,980	21.52	91,900	27 May	1,750	8 Dec
1962	10,740	21.03	75,800	7 Apr	1,530	18 Nov
Average	11,036	21.62	93,760	-	1,850	-
Maximum	17,600	34.47	177,000	-	3,670	-
Minimum	6,212	12.13	39,700	-	500	-

1/ First date of occurrence. Same values recorded on additional days in some years.

TABLE 8 - SUMMARY OF RUNOFF AND DISCHARGE DATA

Representative stream gaging stations in Snake and Columbia River Basins

Station	Drainage Area Sq. Mi.	Period Years	Recorded Annual Runoffs: Mean 1,000 A.F.	Mean Inches	Maximum 1,000 A.F.	Maximum Year	Minimum 1,000 A.F.	Minimum Year	1928-1957 Mean 2/ 1,000 A.F.	Historical Maximum Flood Peak c.f.s.	Date	Recorded Minimum Flow c.f.s.
Upstream Stations showing distribution of origin of flows												
Snake River at Weiser, Idaho	69,200	1911-1962	12,835	3.48	19,750	1952	7,880	1931	12,370	125,000	Jun 1894	5,100
Salmon River at Whitebird, Idaho	13,550	1911-1962 3/	7,862	10.88	11,550	1956	4,200	1931	7,784	120,000	Jun 1894	1,580
Grande Ronde River at Troy, Oregon	3,275	1945-1962	2,375	13.60	3,213	1948	1,647	1955	-	30,000	15 Dec 1946	434
Clearwater River at Spalding, Idaho	9,570	1927-1962	11,036	21.62	17,600	1928	6,212	1944	10,800	177,000	29 May 1948	500
Station representative of Lower Granite reach												
Snake River near Clarkston, Washington	103,200	1910-1962 4/	36,080	6.49	49,800	1921	20,600	1931	34,800	409,000	5 Jun 1894	6,660 6/
Stations on Columbia River showing distribution of flows as related to Lower Granite pool												
Columbia River at Trinidad, Washington	89,700	1914-1961 5/	87,310	18.25	113,000	1928	56,650	1944	85,860	740,000	7 Jun 1894	4,120
Columbia River near The Dalles, Oregon	237,000	1879-1962	141,200	10.38	227,000	1894	85,500	1926	130,350	1,240,000	6 Jun 1894	35,000

2/ Shown for period of recent years in order to afford comparisons of runoffs for various locations including effects of irrigation.

3/ Intermittent records in early years.

4/ Combination of records 1910-1915 at Burbank near Pasco, 1916-1922, and 1929-1933 at Riparia, 1923-1928 from W. B. stages at Lewiston and 1934-1962 at present site near Clarkston.

5/ Combination of records 1914-1916 at Wenatchee, 1917-1930 at Vernita near Priest Rapids and 1931-1961 at gage at Trinidad.

6/ Minimum discharge (6,660 cfs on 2 Sep 1958) caused by construction closure at Brownlee Dam. Natural minimum about 10,600 cfs in August, September 1931.

DISCHARGE RATING - ICE AND TRASH SLUICEWAY

DISCHARGE FOR ONE GATE

HEAD ON GATE FEET	DISCHARGE CFS	HEAD ON GATE FEET	DISCHARGE CFS
0	0	5.0	740
0.2	10	5.2	780
0.4	20	5.4	820
0.6	30	5.6	870
0.8	45	5.8	920
1.0	65	6.0	970
1.2	85	6.2	1020
1.4	110	6.4	1070
1.6	130	6.6	1120
1.8	160	6.8	1175
2.0	190	7.0	1230
2.2	220	7.2	1280
2.4	250	7.4	1335
2.6	280	7.6	1390
2.8	310	7.8	1445
3.0	345	8.0	1500
3.2	380	8.2	1560
3.4	420	8.4	1620
3.6	455	8.6	1680
3.8	490	8.8	1735
4.0	530	9.0	1790
4.2	570	9.2	1850
4.4	610	9.4	1910
4.6	650	9.6	1975
4.8	695	9.8	2040
		10.0	2100

TABLE 9

ICE HARBOR DAM

SNAKE RIVER, WASHINGTON

GATED SPILLWAY RATING TABLE

FLOW UNDER ONE GATE IN 1000 CFS

NOMINAL GATE OPENING IN FEET	0.0	.25	.50	.75	1.0	.25	.50	.75	2.0	.25	.50	.75	3.0	.25	.50	.75	4.0	.25	.50	.75	5.0	.25	.50	.75
POWERHOUSE INDICATOR	0000	0029	0057	0085	0112	0140	0168	0195	0222	0250	0278	0305	0332	0360	0387	0415	0442	0470	0498	0525	0553	0581	0608	0636
POOL ELEVATION MSL 441.0		0.44	0.88	1.32	1.76	2.20	2.64	3.08	3.52	3.95	4.38	4.82	5.26	5.69	6.13	6.56	6.99	7.42	7.85	8.28	8.71	9.13	9.55	9.97
.5		0.44	0.88	1.32	1.76	2.19	2.63	3.07	3.50	3.94	4.37	4.80	5.24	5.66	6.10	6.52	6.95	7.38	7.82	8.24	8.67	9.08	9.51	9.92
440.0		0.44	0.87	1.31	1.75	2.18	2.62	3.05	3.48	3.92	4.35	4.78	5.21	5.64	6.07	6.49	6.92	7.34	7.78	8.20	8.62	9.04	9.46	9.87
.5		0.43	0.87	1.30	1.74	2.17	2.60	3.04	3.46	3.90	4.32	4.75	5.18	5.60	6.04	6.45	6.88	7.30	7.73	8.15	8.58	9.00	9.42	9.82
439.0		0.43	0.86	1.30	1.73	2.16	2.59	3.02	3.45	3.88	4.30	4.73	5.15	5.57	6.00	6.42	6.85	7.26	7.69	8.11	8.53	8.95	9.37	9.77
.5		0.43	0.86	1.29	1.72	2.15	2.57	3.01	3.43	3.85	4.28	4.70	5.13	5.55	5.97	6.39	6.82	7.22	7.65	8.07	8.49	8.90	9.32	9.72
438.0		0.42	0.85	1.29	1.71	2.14	2.56	3.00	3.41	3.84	4.26	4.68	5.10	5.52	5.94	6.35	6.78	7.18	7.61	8.03	8.44	8.85	9.26	9.67
.5		0.42	0.85	1.28	1.70	2.13	2.55	2.98	3.40	3.82	4.24	4.65	5.07	5.49	5.91	6.32	6.75	7.15	7.57	7.98	8.40	8.80	9.21	9.61
437.0		0.42	0.85	1.27	1.70	2.12	2.54	2.96	3.37	3.80	4.22	4.63	5.05	5.46	5.88	6.29	6.70	7.11	7.53	7.94	8.35	8.75	9.16	9.55
.5		0.42	0.84	1.26	1.69	2.10	2.53	2.95	3.35	3.78	4.19	4.60	5.02	5.43	5.85	6.25	6.66	7.07	7.48	7.89	8.30	8.70	9.10	9.50
436.0		0.41	0.84	1.25	1.68	2.09	2.52	2.93	3.34	3.75	4.17	4.58	5.00	5.40	5.82	6.27	6.63	7.03	7.44	7.85	8.25	8.65	9.05	9.44

NOMINAL GATE OPENING IN FEET	6.0	.25	.50	.75	7.0	.5	8.0	.5	9.0	.5	10.0	.5	11.0	.5	
POWERHOUSE INDICATOR	0662	0690	0716	0741	0767	0818	0870	0922	0973	1025	1077	1103	1180	1230	
POOL ELEVATION MSL 441.0	10.4	10.8	11.2	11.7	12.1	12.9	13.8	14.6	15.4	16.3	17.1	17.9	18.8	19.6	441.0
.5	10.3	10.8	11.2	11.6	12.0	12.9	13.7	14.5	15.4	16.2	17.0	17.8	18.7	19.5	.5
440.0	10.3	10.7	11.1	11.5	12.0	12.8	13.6	14.5	15.3	16.1	16.9	17.7	18.6	19.4	440.0
.5	10.2	10.7	11.1	11.5	11.9	12.7	13.5	14.4	15.2	16.0	16.8	17.7	18.5	19.3	.5
439.0	10.2	10.6	11.0	11.4	11.8	12.6	13.5	14.3	15.1	15.9	16.7	17.6	18.4	19.2	439.0
.5	10.1	10.5	11.0	11.4	11.8	12.6	13.4	14.2	15.1	15.8	16.6	17.5	18.3	19.1	.5
438.0	10.1	10.5	10.9	11.3	11.7	12.5	13.3	14.1	15.0	15.8	16.5	17.4	18.2	19.0	438.0
.5	10.0	10.4	10.8	11.2	11.6	12.4	13.3	14.1	14.9	15.7	16.4	17.3	18.1	18.8	.5
437.0	10.0	10.4	10.8	11.2	11.6	12.4	13.2	14.0	14.8	15.6	16.4	17.2	17.9	18.7	437.0
.5	9.9	10.3	10.7	11.1	11.5	12.3	13.1	13.9	14.7	15.5	16.3	17.1	17.8	18.6	.5
436.0	9.8	10.2	10.6	11.0	11.4	12.2	13.0	13.8	14.6	15.4	16.2	17.0	17.7	18.5	436.0

NOMINAL GATE OPENING IN FEET	12.0	.5	13.0	.5	14.0	.5	15.0	.5	16.0	.5	17.0	.5	18.0	.5	19.0	.5	20.0	.5	21.0	.5
POWERHOUSE INDICATOR	1280	1330	1380	1431	1481	1532	1582	1632	1683	1731	1779	1827	1875	1923	1971	2018	2066	2114	2162	2210
POOL ELEVATION MSL 441.0	20.4	21.2	22.1	22.9	23.7	24.5	25.3	26.1	26.9	27.7	28.6	29.4	30.2	31.0	31.8	32.6	33.4	34.1	34.9	35.7
.5	20.3	21.1	21.9	22.7	23.6	24.4	25.2	26.0	26.8	27.6	28.4	29.2	30.0	30.8	31.6	32.4	33.2	33.9	34.7	35.5
440.0	20.2	21.0	21.8	22.6	23.4	24.2	25.0	25.8	26.6	27.4	28.2	29.0	29.8	30.6	31.4	32.2	33.0	33.7	34.5	35.3
.5	20.1	20.9	21.7	22.5	23.3	24.1	24.9	25.7	26.5	27.3	28.1	28.8	29.6	30.4	31.2	32.0	3.28	33.5	34.3	35.1
439.0	20.0	20.8	21.6	22.4	23.2	24.0	24.8	25.6	26.3	27.1	27.9	28.7	29.5	30.2	31.0	31.8	32.6	33.3	34.1	34.9
.5	19.8	20.6	21.4	22.2	23.0	23.8	24.6	25.4	26.2	27.0	27.7	28.5	29.3	30.0	30.8	31.6	32.4	33.1	33.9	34.7
438.0	19.7	20.5	21.3	22.1	22.9	23.7	24.5	25.3	26.0	26.8	27.6	28.3	29.1	29.9	30.6	31.4	32.2	32.9	33.7	34.5
.5	19.6	20.4	21.2	22.0	22.7	23.5	24.3	25.1	25.9	26.6	27.4	28.2	28.9	29.7	30.4	31.2	32.0	32.7	33.5	34.2
437.0	19.5	20.3	21.1	21.8	22.6	23.4	24.2	24.9	25.7	26.5	27.2	28.0	28.7	29.5	30.2	31.0	31.8	32.5	33.2	34.0
.5	19.4	20.2	20.9	21.7	22.5	23.3	24.0	24.8	25.5	26.3	27.0	27.8	28.5	29.3	30.0	30.8	31.6	32.3	33.0	33.8
436.0	19.3	20.0	20.8	21.6	22.4	23.1	23.9	24.6	25.4	26.1	26.9	27.6	28.4	29.1	29.8	30.6	31.4	32.1	32.8	33.6

NOMINAL GATE OPENING IN FEET	22.0	.5	23.0	.5	24.0	.5	25.0	.5	26.0	.5	27.0	.5	28.0	.5	29.0	.5	30.0	Free Flow Under Gate	
POWERHOUSE INDICATOR	2258	2306	2354	2402	2450	2498	2546	2594	2642	2686	2730	2774	2818	2862	2905	2949	2992		
POOL ELEVATION MSL 441.0	36.5	37.4	38.2	39.0	39.8	40.6	41.4	42.3	43.1	44.0	44.9	45.8	46.6	47.5	48.4	49.3	50.3	71.0	441.0
.5	36.3	37.1	37.9	38.7	39.5	40.4	41.2	42.0	42.9	43.8	44.6	45.5	46.3	47.2	48.1	49.0	49.9		.5
440.0	36.1	36.9	37.7	38.5	39.3	40.1	40.9	41.7	42.6	43.5	44.3	45.2	46.0	46.9	47.8	48.6	49.6	68.5	440.0
.5	35.9	36.7	37.5	38.2	39.0	39.8	40.6	41.5	42.3	43.2	44.0	44.9	45.7	46.6	47.4	48.3	49.2		.5
439.0	35.7	36.5	37.2	38.0	38.8	39.6	40.4	41.2	42.0	42.9	43.7	44.5	45.4	46.2	47.1	48.0	48.8	66.0	439.0
.5	35.5	36.2	37.0	37.7	38.5	39.3	40.1	40.9	41.7	42.6	43.4	44.2	45.0	45.9	46.8	47.6	48.5		.5
438.0	35.2	36.0	36.7	37.5	38.3	39.0	39.8	40.6	41.4	42.3	43.1	43.9	44.7	45.6	46.4	47.3	48.1	63.7	438.0
.5	35.0	35.7	36.5	37.2	38.0	38.8	39.6	40.3	41.1	42.0	42.8	43.6	44.4	45.2	46.1	46.9	47.8		.5
437.0	34.7	35.5	36.3	37.0	37.7	38.5	39.3	40.1	40.8	41.7	42.5	43.3	44.0	44.9	45.7	46.6	47.4	61.5	437.0
.5	34.5	35.2	36.0	36.7	37.5	38.3	39.0	39.8	40.5	41.4	42.2	42.9	43.7	44.5	45.4	46.2	47.1		.5
436.0	34.3	35.0	35.7	36.5	37.2	38.0	38.7	39.5	40.2	41.1	41.9	42.6	43.3	44.1	45.0	45.8	46.7	59.5	436.0

NOTES:

1. Nominal gate opening is the vertical distance between the gate seat, elevation 389.07 and the bottom of the gate.
2. Spillway crest elevation is 391.0.
3. Spillway has 10 tainter gates, each 50.0 feet wide - 52.9 feet high.

Revised Feb. 1966

ICE HARBOR DAM

SPILLWAY OPERATION LIMITS

Approx. Snake River Q in CFS (McNary Pool EL. 340.0)	Recommended Max. Q in CFS for Single Spillway Bay	Remarks	Tailwater EL. (M.S.L.)
	9,000		6.0
	9,500		8.0
	10,500		340.0
38,000	11,000		2.0
63,000	12,000		4.0
90,000	12,500		6.0
117,000	14,500		8.0
132,000	16,500	←→ See Note 3	9.0
147,000	38,000		350.0
180,000	41,000		2.0
216,000	45,000		4.0
257,000	49,000		6.0
300,000	53,000		8.0
330,000	56,500		360.0
380,000	60,500	Gate full open @ 436.5 pool	2.0
450,000	65,000		4.0
525,000	68,500	Gate full open @ 440.0 pool	6.0

NOTES:

1. These discharges should not be used in normal operation but only for short periods when it is necessary to make large changes in spillway discharges for short tests or in the emergency of power rejections.

2. These operation criteria need not apply for normal flushing of accumulated debris from the upstream side of the gate providing the gate is returned to the previous setting when the debris is passed.

3. Recommended maximum Q for tailwater elevations 436.0 to 449.0 is based on model tests for safe baffle pressures. For tailwater elevations 450.0 and above it is based on model studies to maintain the jump at the P.T. of the bucket.

ICE HARBOR RESERVOIR REGULATION MANUAL

RESERVOIR CAPACITY IN ACRE - FEET

Res. Inflow	20,000 cfs or less		50,000 cfs		100,000 cfs	
Pool Elev.	Volume	Diff.	Volume	Diff.	Volume	Diff.
436.0	373,160		373,500		375,140	
.1	373,975	815	374,310	810	375,940	800
.2	374,790		375,120	810	376,740	
.3	375,605		375,935	815	377,540	
.4	376,420	815	376,750		378,340	
.5	377,240	820	377,565		379,140	
.6	378,060		378,380		379,940	
.7	378,880		379,195		380,740	
.8	379,700		380,010		381,540	
.9	380,520		380,825		382,340	
437.0	381,340		381,640		383,140	
.1	382,160		382,455		383,940	
.2	382,980		383,270		384,740	800
.3	383,800		384,085		385,545	805
.4	384,620	820	384,900	815	386,350	
.5	385,445	825	385,720	820	387,155	
.6	386,270		386,540		387,960	
.7	387,095		387,360		388,765	
.8	387,920		388,180		389,570	
.9	388,745		389,000		390,375	
438.0	389,570		389,820		391,180	
.1	390,395		390,640		391,985	
.2	391,220	825	391,460		392,790	
.3	392,050	830	392,280		393,595	
.4	392,880		393,100		394,400	805
.5	393,710		393,920		395,210	810
.6	394,540		394,740	820	396,020	
.7	395,370		395,565	825	396,830	
.8	396,200		396,390		397,640	
.9	397,030		397,215		398,450	
439.0	397,860		398,040		399,260	
.1	398,690		398,865		400,070	
.2	399,520	830	399,690		400,880	
.3	400,355	835	400,515		401,690	
.4	401,190		401,340		402,500	
.5	402,025		402,165		403,310	
.6	402,860		402,990		404,120	810
.7	403,695		403,815		404,935	815
.8	404,530		404,640	825	405,750	
.9	405,365		405,470	830	406,565	
440.0	406,200		406,300		407,380	
.1	407,035		407,130		408,195	
.2	407,870	835	407,960		409,010	
.3	408,710	840	408,790		409,825	
.4	409,550		409,620		410,640	
.5	410,390		410,450		411,455	
.6	411,230		411,280		412,270	
.7	412,070		412,110		413,085	
.8	412,910		412,940		413,900	815
.9	413,750		413,770		414,720	820
441.0	414,590	840	414,600	830	415,540	820

Note: Use Chart 6 if inflow exceeds 100,000 cfs.

TABLE 12

TABLE 13
ICE HARBOR DAM
MEAN UNIT PERFORMANCE

POWER OUTPUT (MW)	GROSS HEAD IN FEET 80	81	82	83	84	85	86	87	88	89
	DISCHARGE IN CFS									
38	7019	6962	6906	6851	6797	6745	6693	6644	6595	6547
39	7142	7083	7026	6969	6915	6861	6808	6757	6707	6658
40	7266	7205	7146	7088	7032	6976	6922	6870	6819	6768
41	7389	7326	7266	7207	7149	7092	7037	6983	6930	6879
42	7512	7448	7386	7325	7266	7208	7151	7096	7042	6989
43	7635	7570	7506	7444	7383	7323	7265	7209	7154	7100
44	7758	7691	7626	7562	7500	7439	7380	7322	7266	7210
45	7881	7813	7746	7681	7617	7555	7494	7435	7378	7321
46	8004	7934	7866	7799	7734	7671	7609	7548	7489	7431
47	8127	8056	7986	7918	7851	7786	7723	7661	7601	7542
48	8250	8177	8106	8036	7968	7902	7838	7775	7713	7653
49	8373	8299	8226	8155	8085	8018	7952	7888	7825	7763
50	8496	8420	8346	8274	8203	8134	8066	8001	7937	7874
51	8633	8546	8466	8392	8320	8249	8181	8114	8048	7984
52	8771	8681	8596	8512	8437	8365	8295	8227	8160	8095
53	8921	8823	8729	8644	8560	8481	8410	8340	8272	8205
54	9074	8971	8874	8778	8691	8608	8527	8453	8384	8316
55	9231	9125	9021	8923	8829	8737	8654	8574	8496	8426
56	9396	9281	9174	9071	8971	8877	8785	8700	8619	8541
57	9563	9445	9331	9221	9119	9019	8925	8833	8744	8664
58	9734	9612	9494	9380	9269	9166	9067	8971	8880	8791
59	9904	9781	9660	9541	9427	9317	9212	9114	9017	8926
60	10075	9949	9826	9706	9588	9474	9365	9258	9159	9063
61	10246	10118	9993	9870	9750	9634	9521	9411	9305	9204
62	10416	10286	10159	10035	9913	9795	9679	9566	9456	9350
63	10587	10455	10326	10199	10075	9955	9838	9723	9610	9500
64	10758	10623	10492	10363	10238	10116	9996	9880	9765	9653
65	10928	10792	10659	10528	10400	10276	10155	10036	9920	9807
66	11101	10960	10825	10692	10563	10437	10313	10193	10075	9960
67	11275	11132	10992	10857	10725	10597	10472	10350	10231	10113
68	11450	11304	11162	11022	10888	10758	10631	10507	10386	10267
69	11624	11476	11332	11190	11051	10918	10789	10664	10541	10420
70	11798	11648	11502	11358	11217	11080	10948	10820	10696	10574
71	11972	11820	11672	11526	11383	11244	11109	10977	10851	10727
72	12147	11992	11842	11694	11549	11408	11271	11137	11006	10880
73	12321	12164	12012	11862	11715	11573	11433	11297	11165	11034
74	12495	12336	12182	12030	11881	11737	11595	11458	11323	11191
75	12670	12509	12352	12198	12047	11901	11757	11618	11482	11348
76	12844	12681	12522	12366	12213	12065	11919	11778	11640	11505
77	13018	12853	12692	12534	12379	12229	12082	11938	11799	11661
78	13192	13025	12862	12702	12545	12393	12244	12099	11957	11818
79	13367	13197	13032	12870	12711	12557	12406	12259	12115	11975
80	13541	13369	13202	13038	12877	12721	12568	12419	12274	12131
81	13715	13541	13372	13205	13043	12885	12730	12580	12432	12288
82	13890	13713	13542	13373	13209	13049	12892	12740	12591	12445
83	14064	13886	13712	13541	13375	13213	13055	12900	12749	12601
84	14238	14058	13882	13709	13541	13377	13217	13060	12908	12758
85	14412	14230	14052	13877	13707	13541	13379	13221	13066	12915
86	14587	14402	14222	14045	13873	13705	13541	13381	13225	13071
87	14761	14574	14392	14213	14039	13869	13703	13541	13383	13228
88	14935	14746	14562	14381	14205	14033	13865	13702	13542	13385
89	15110	14918	14732	14549	14371	14197	14028	13862	13700	13541
90	15284	15090	14902	14717	14537	14361	14190	14022	13858	13698
91	15458	15262	15072	14885	14703	14525	14352	14182	14017	13855
92	15637	15435	15242	15053	14869	14690	14514	14343	14175	14011
93	15817	15610	15412	15221	15035	14854	14676	14503	14334	14168
94	15998	15789	15584	15389	15201	15018	14838	14663	14492	14325
95	16178	15967	15760	15559	15367	15182	15001	14824	14651	14482
96	16359	16145	15936	15733	15534	15346	15163	14984	14809	14638
97	16539	16323	16112	15907	15706	15510	15325	15144	14968	14795
98	16719	16501	16288	16080	15878	15680	15487	15304	15126	14952
99	16900	16679	16464	16254	16049	15850	15654	15465	15284	15108
100	17080	16857	16640	16428	16221	16019	15822	15629	15443	15265
101	17260	17035	16816	16602	16393	16189	15990	15795	15605	15422
102	17441	17214	16992	16776	16565	16359	16158	15961	15769	15581
103	17621	17392	17168	16949	16736	16529	16326	16127	15933	15743
104	17802	17570	17344	17123	16908	16698	16493	16293	16097	15905
105	17982	17748	17520	17297	17080	16868	16661	16459	16261	16067
106	18169	17926	17696	17471	17251	17038	16829	16624	16425	16229
107	18356	18108	17872	17645	17423	17207	16997	16790	16589	16391
108	18548	18294	18049	17818	17595	17377	17164	16956	16752	16553
109	18754	18479	18233	17992	17766	17547	17332	17122	16916	16716

POWER OUTPUT (MW)	GROSS HEAD IN FEET 90	91	92	93	94	95	96	97	98	99
	DISCHARGE IN CFS									
38	6500									
39	6609	6563	6517							
40	6719	6671	6624	6578	6532					
41	6828	6779	6731	6684	6637	6592	6548	6505		
42	6937	6887	6838	6789	6742	6696	6651	6607	6563	6520
43	7047	6995	6945	6895	6847	6799	6753	6708	6664	6620
44	7156	7103	7052	7001	6951	6903	6856	6809	6764	6719
45	7265	7212	7159	7107	7056	7007	6958	6911	6864	6819
46	7375	7320	7266	7213	7161	7110	7061	7012	6965	6918
47	7484	7428	7373	7319	7265	7214	7163	7114	7065	7017
48	7593	7536	7480	7424	7370	7317	7266	7215	7166	7117
49	7703	7644	7587	7530	7475	7421	7368	7317	7266	7216
50	7812	7752	7694	7636	7580	7525	7471	7418	7366	7316
51	7922	7860	7801	7742	7684	7628	7573	7520	7467	7415
52	8031	7969	7907	7848	7789	7732	7676	7621	7567	7514
53	8140	8077	8014	7953	7894	7835	7778	7722	7668	7614
54	8250	8185	8121	8059	7998	7939	7881	7824	7768	7713
55	8359	8293	8228	8165	8103	8043	7983	7925	7868	7813
56	8468	8401	8335	8271	8208	8146	8086	8027	7969	7912
57	8587	8510	8442	8377	8313	8250	8188	8128	8069	8011
58	8709	8631	8555	8483	8417	8353	8291	8230	8170	8111
59	8838	8751	8674	8598	8524	8457	8393	8331	8270	8210
60	8971	8883	8797	8716	8641	8567	8496	8433	8370	8310
61	9108	9016	8928	8842	8758	8683	8610	8538	8471	8409
62	9247	9153	9061	8972	8886	8803	8724	8651	8579	8509
63	9395	9293	9197	9105	9015	8929	8846	8765	8691	8620
64	9544	9439	9338	9239	9148	9058	8971	8889	8808	8730
65	9696	9588	9483	9381	9282	9189	9100	9013	8930	8850
66	9847	9738	9631	9525	9424	9326	9230	9142	9055	8971
67	9999	9888	9779	9672	9567	9466	9368	9272	9182	9096
68	10151	10038	9927	9818	9712	9608	9507	9409	9314	9222
69	10302	10188	10076	9965	9857	9752	9649	9548	9450	9355
70	10454	10338	10224	10112	10002	9896	9791	9689	9588	9490
71	10606	10488	10372	10259	10148	10040	9934	9829	9727	9628
72	10757	10638	10521	10406	10293	10183	10076	9970	9866	9765
73	10909	10788	10669	10552	10438	10327	10218	10111	10006	9903
74	11062	10938	10818	10699	10583	10471	10360	10251	10145	10041
75	11217	11090	10966	10846	10728	10614	10502	10392	10284	10179
76	11372	11243	11117	10993	10874	10758	10645	10533	10423	10317
77	11527	11396	11268	11142	11019	10902	10787	10674	10563	10455
78	11682	11549	11420	11292	11168	11046	10929	10814	10702	10593
79	11837	11703	11571	11442	11316	11193	11073	10955	10841	10730
80	11992	11856	11723	11592	11464	11340	11218	11098	10980	10868
81	12147	12009	11875	11742	11613	11487	11363	11241	11122	11006
82	12302	12162	12026	11892	11761	11633	11508	11385	11265	11147
83	12457	12316	12178	12042	11909	11780	11653	11529	11407	11288
84	12612	12469	12329	12192	12058	11927	11799	11673	11549	11429
85	12767	12622	12481	12342	12206	12074	11944	11816	11691	11570
86	12921	12775	12632	12492	12355	12220	12089	11960	11834	11710
87	13076	12929	12784	12642	12503	12367	12234	12104	11976	11851
88	13231	13082	12935	12792	12651	12514	12379	12248	12118	11992
89	13386	13235	13087	12942	12800	12661	12525	12391	12261	12133
90	13541	13388	13239	13092	12948	12807	12670	12535	12403	12274
91	13696	13542	13390	13242	13096	12954	12815	12679	12545	12415
92	13851	13695	13542	13392	13245	13101	12960	12822	12687	12555
93	14006	13848	13693	13542	13393	13248	13106	12966	12830	12696
94	14161	14001	13845	13692	13542	13395	13251	13110	12972	12837
95	14316	14155	13996	13842	13690	13541	13396	13254	13114	12978
96	14471	14308	14148	13992	13838	13688	13541	13397	13256	13119
97	14626	14461	14300	14141	13987	13835	13686	13541	13399	13260
98	14781	14614	14451	14291	14135	13982	13832	13685	13541	13400
99	14936	14767	14603	14441	14283	14128	13977	13828	13683	13541
100	15091	14921	14754	14591	14432	14275	14122	13972	13825	13682
101	15246	15074	14906	14741	14580	14422	14267	14116	13968	13823
102	15401	15227	15057	14891	14728	14569	14412	14260	14110	13964
103	15558	15380	15209	15041	14877	14716	14558	14403	14252	14104
104	15718	15535	15361	15191	15025	14862	14703	14547	14395	14245
105	15878	15693	15513	15341	15174	15009	14848	14691	14537	14386
106	16038	15852	15669	15491	15322	15156	14993	14835	14679	14527
107	16199	16010	15826	15646	15470	15303	15138	14978	14821	14668
108	16359	16169	15983	15801	15623	15449	15284	15122	14964	14809
109	16519	16327	16139	15956	15776	15599	15429	15266	15106	14949

POWER OUTPUT (MW)	GROSS HEAD IN FEET 100	101	102	103	104	105	POWER OUTPUT (MW)
	DISCHAGE IN CFS						
38							38
39							39
40							40
41							41
42							42
43	6577	6535					43
44	6675	6633	6591	6549	6509		44
45	6774	6730	6687	6645	6603	6563	45
46	6872	6827	6784	6740	6698	6657	46
47	6970	6925	6880	6836	6792	6750	47
48	7069	7022	6977	6931	6887	6844	48
49	7167	7120	7073	7027	6982	6938	49
50	7266	7217	7170	7123	7076	7032	50
51	7364	7315	7266	7218	7171	7125	51
52	7463	7412	7363	7314	7266	7219	52
53	7561	7510	7459	7409	7360	7313	53
54	7659	7607	7555	7505	7455	7406	54
55	7758	7704	7652	7600	7550	7500	55
56	7856	7802	7748	7696	7644	7594	56
57	7955	7899	7845	7791	7739	7688	57
58	8053	7997	7941	7887	7834	7781	58
59	8152	8094	8038	7983	7928	7875	59
60	8250	8192	8134	8078	8023	7969	60
61	8348	8289	8231	8174	8118	8063	61
62	8447	8386	8327	8269	8212	8156	62
63	8550	8484	8424	8365	8307	8250	63
64	8659	8590	8523	8460	8402	8344	64
65	8770	8699	8630	8562	8496	8438	65
66	8891	8813	8737	8668	8601	8535	66
67	9011	8932	8854	8777	8706	8639	67
68	9136	9053	8972	8894	8817	8743	68
69	9262	9176	9093	9011	8933	8857	69
70	9396	9303	9216	9132	9050	8971	70
71	9530	9435	9344	9254	9171	9089	71
72	9667	9569	9474	9383	9293	9208	72
73	9803	9704	9607	9512	9421	9332	73
74	9939	9839	9741	9644	9550	9459	74
75	10076	9974	9875	9777	9681	9588	75
76	10212	10109	10008	9909	9812	9718	76
77	10349	10245	10142	10042	9944	9848	77
78	10485	10380	10276	10174	10075	9978	78
79	10622	10515	10410	10307	10206	10108	79
80	10758	10650	10544	10439	10337	10238	80
81	10895	10785	10678	10572	10469	10368	81
82	11032	10920	10811	10705	10600	10498	82
83	11171	11057	10945	10837	10731	10628	83
84	11311	11195	11081	10970	10862	10758	84
85	11450	11333	11217	11104	10993	10888	85
86	11590	11471	11354	11240	11127	11018	86
87	11729	11609	11491	11375	11261	11151	87
88	11868	11747	11627	11510	11396	11284	88
89	12008	11885	11764	11646	11530	11416	89
90	12147	12023	11901	11781	11664	11549	90
91	12287	12161	12038	11917	11798	11682	91
92	12426	12299	12174	12052	11932	11815	92
93	12566	12437	12311	12187	12066	11948	93
94	12705	12575	12448	12323	12200	12080	94
95	12844	12713	12584	12458	12334	12213	95
96	12984	12851	12721	12593	12468	12346	96
97	13123	12989	12858	12729	12602	12477	97
98	13263	13127	12994	12864	12736	12612	98
99	13402	13265	13131	13000	12871	12744	99
100	13541	13403	13268	13135	13005	12877	100
101	13681	13541	13404	13270	13139	13010	101
102	13820	13679	13541	13406	13273	13143	102
103	13960	13817	13678	13541	13407	13276	103
104	14099	13955	13815	13676	13541	13408	104
105	14238	14093	13951	13812	13675	13541	105
106	14378	14231	14088	13947	13809	13674	106
107	14517	14369	14225	14083	13943	13807	107
108	14657	14507	14361	14218	14077	13940	108
109	14796	14646	14498	14353	14211	14072	109

NOTE: Gross head is Forebay elevation minus Tailwater elevation in Feet.
SOURCE: Ice Harbor Turbine Ratings by the Currentmeter Method, NPOCE, March 1967.

Charts

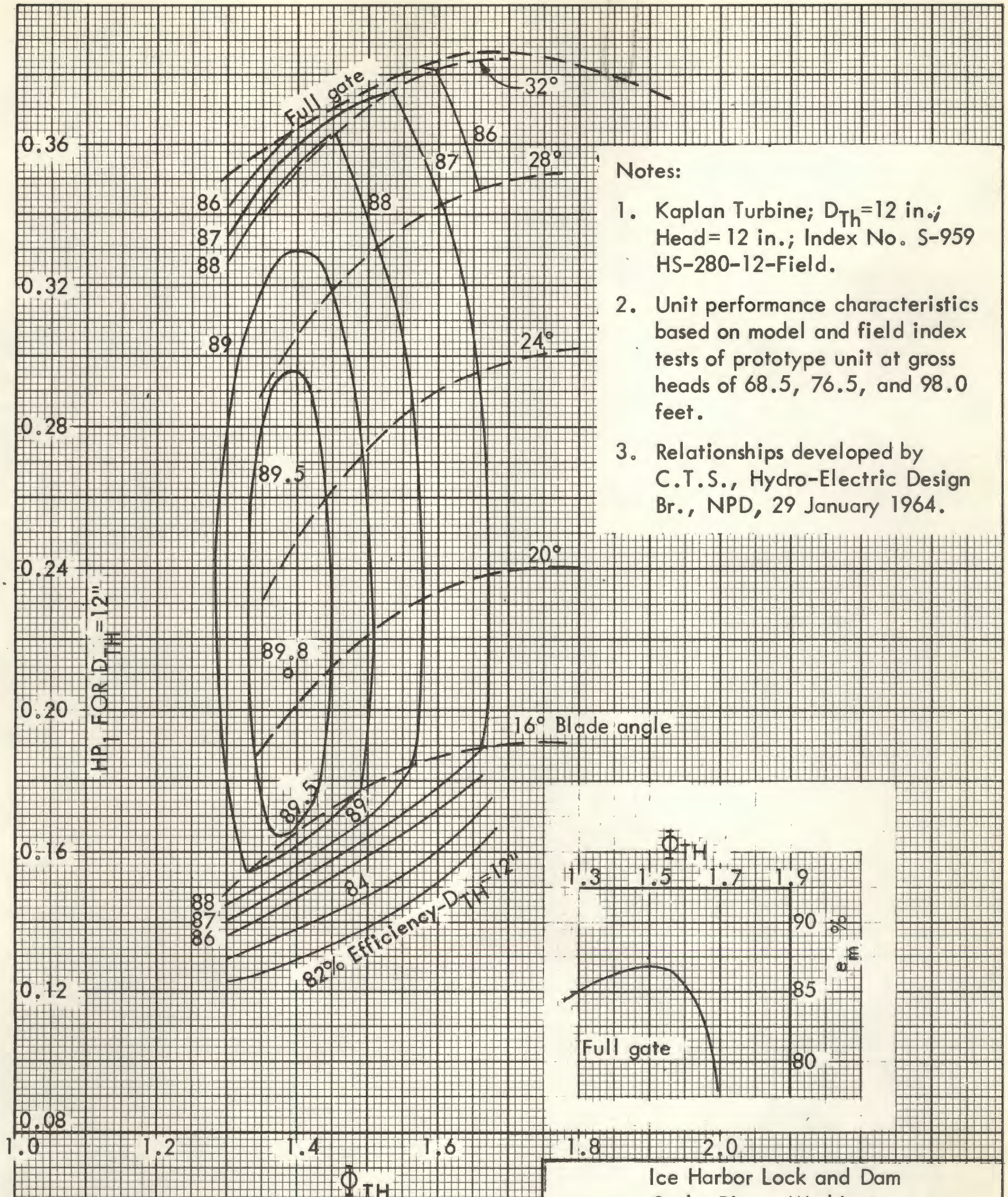
No.	
1 *	~~Annual Flood Peak Frequencies, Snake River near Clarkston~~
2	Turbine Unit Performance Characteristics
3	Power Unit Discharge Rating
4 *	~~Power Discharge Relationship, Single Power Unit~~
5	Expected Plant Capacity
6	Reservoir Area and Storage Capacity
7 *	~~Functional Organization Chart~~
8 *	~~Organization for Reservoir Regulation, Walla Walla District~~
9	Spillway Rating Curves, Single Bay
10	Water Surface Profiles below Ice Harbor Dam
11	Tailwater Rating Curves
12	Regulation of Large Historical Snake River Floods
13 *	~~Typical Winter Daily Power Operation~~

* DELETED BY REVISION

DELETED

CHART 1

ANNUAL FLOOD PEAK FREQUENCIES- SNAKE RIVER NEAR CLARKSTON, WASHINGTON



Notes:

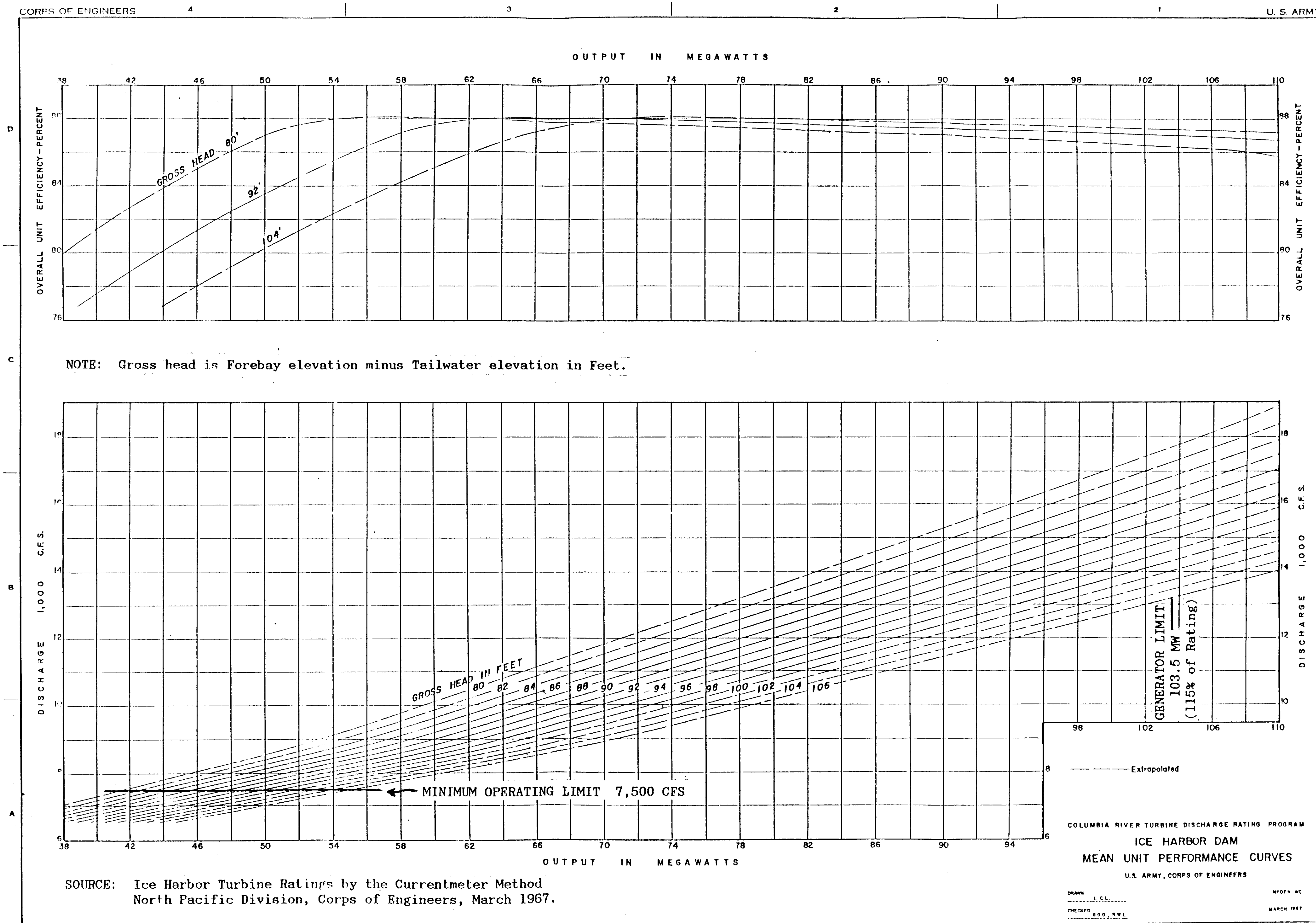
1. Kaplan Turbine; D_{Th}=12 in.; Head= 12 in.; Index No. S-959 HS-280-12-Field.
2. Unit performance characteristics based on model and field index tests of prototype unit at gross heads of 68.5, 76.5, and 98.0 feet.
3. Relationships developed by C.T.S., Hydro-Electric Design Br., NPD, 29 January 1964.

Ice Harbor Lock and Dam
Snake River, Washington
Reservoir Regulation Manual

TURBINE UNIT
PERFORMANCE CHARACTERISTICS

U.S. Army Engineer District, Walla Walla
Water Control Section

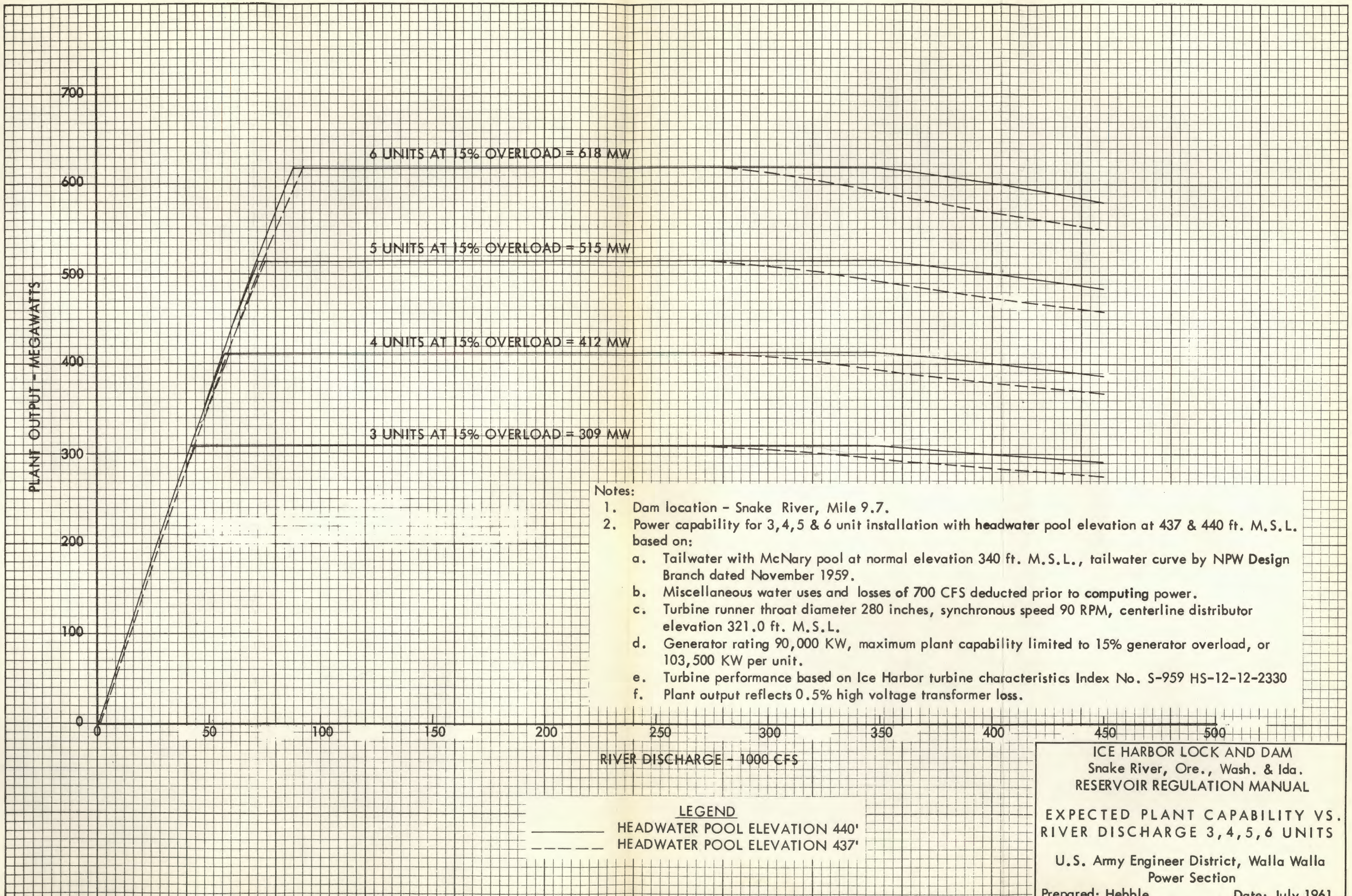
February 1964



CORPS OF ENGINEERS
U. S. ARMY
OUTPUT IN MEGAWATTS
OVERALL UNIT EFFICIENCY-PERCENT
GROSS HEAD 80'
92'
104'
NOTE: Gross head is Forebay elevation minus Tailwater elevation in Feet.
DISCHARGE 1,000 C.F.S.
GROSS HEAD IN FEET
80 82 84 86 88 90 92 94 96 98 100 102 104 106
GENERATOR LIMIT
103.5 MW
(115% of Rating)
MINIMUM OPERATING LIMIT 7,500 CFS
Extrapolated
COLUMBIA RIVER TURBINE DISCHARGE RATING PROGRAM
ICE HARBOR DAM
MEAN UNIT PERFORMANCE CURVES
U.S. ARMY, CORPS OF ENGINEERS
SOURCE: Ice Harbor Turbine Ratings by the Currentmeter Method
North Pacific Division, Corps of Engineers, March 1967.

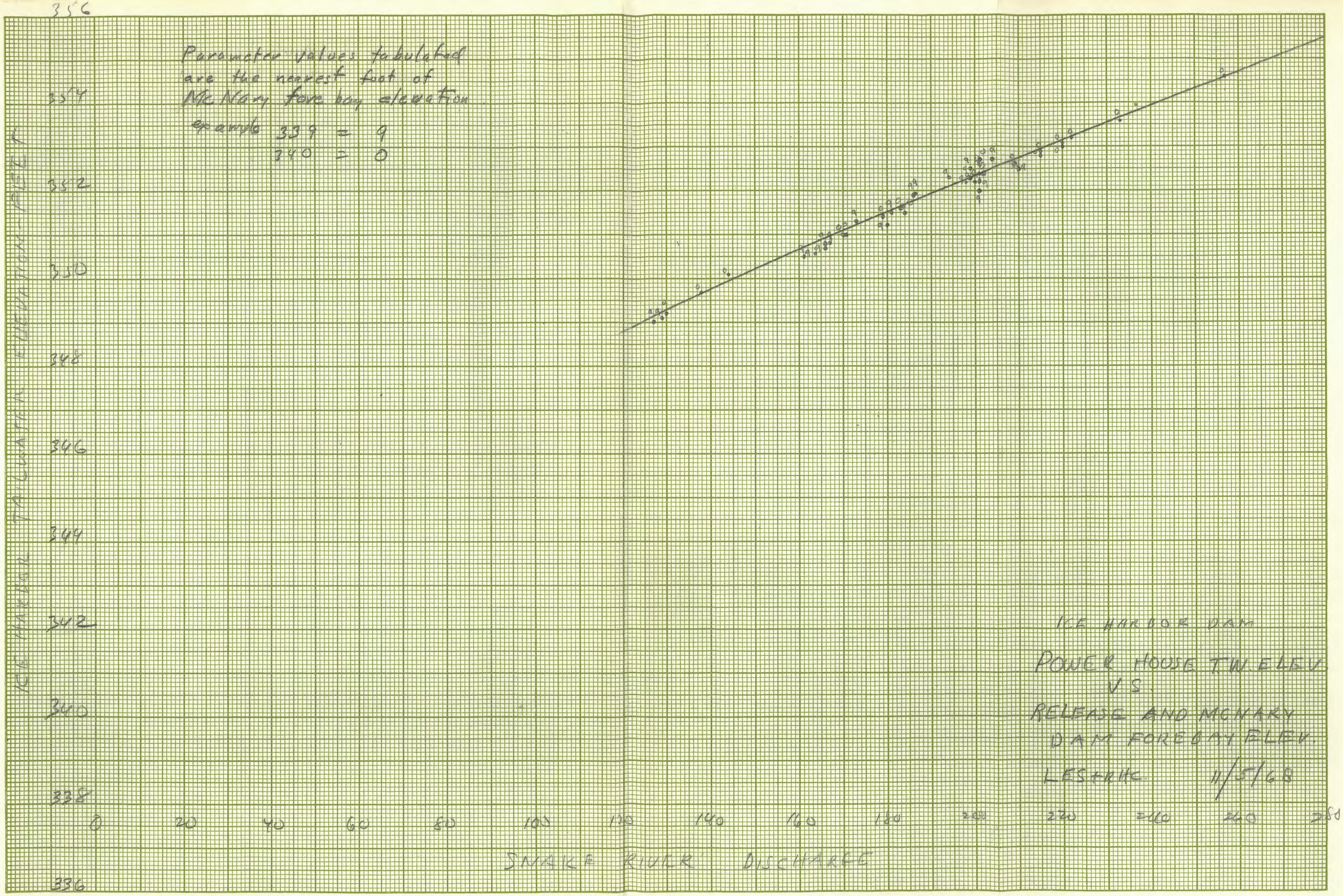
DELETED

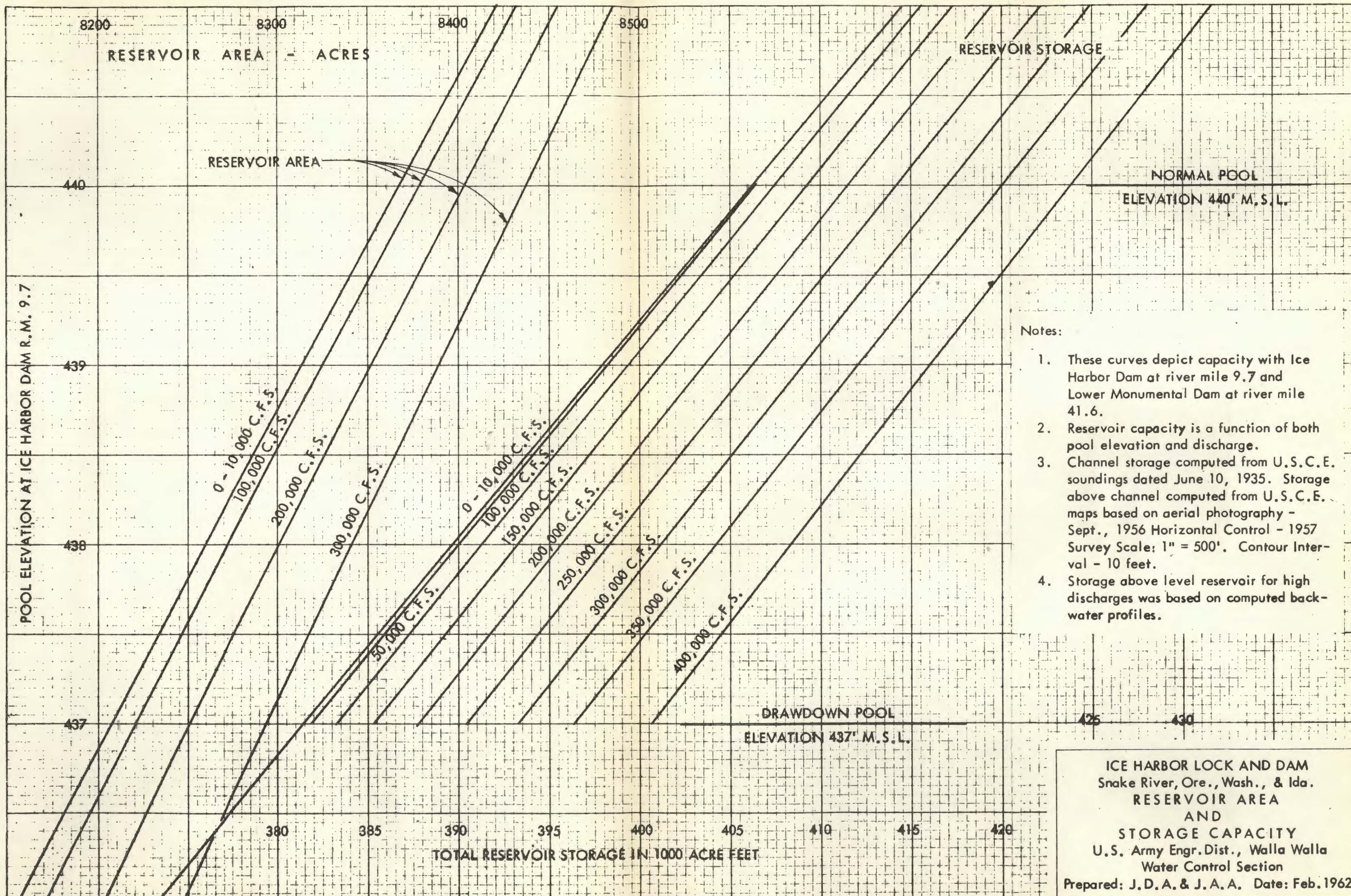
CHART 4
POWER - DISCHARGE RELATIONSHIP, SINGLE POWER UNIT



PLANT OUTPUT - MEGAWATTS
0
100
200
300
400
500
600
700
RIVER DISCHARGE - 1000 CFS
0
50
100
150
200
250
300
350
400
450
500
6 UNITS AT 15% OVERLOAD = 618 MW
5 UNITS AT 15% OVERLOAD = 515 MW
4 UNITS AT 15% OVERLOAD = 412 MW
3 UNITS AT 15% OVERLOAD = 309 MW
Notes:
1. Dam location - Snake River, Mile 9.7.
2. Power capability for 3,4,5 & 6 unit installation with headwater pool elevation at 437 & 440 ft. M.S.L. based on:
a. Tailwater with McNary pool at normal elevation 340 ft. M.S.L., tailwater curve by NPW Design Branch dated November 1959.
b. Miscellaneous water uses and losses of 700 CFS deducted prior to computing power.
c. Turbine runner throat diameter 280 inches, synchronous speed 90 RPM, centerline distributor elevation 321.0 ft. M.S.L.
d. Generator rating 90,000 KW, maximum plant capability limited to 15% generator overload, or 103,500 KW per unit.
e. Turbine performance based on Ice Harbor turbine characteristics Index No. S-959 HS-12-12-2330
f. Plant output reflects 0.5% high voltage transformer loss.
LEGEND
HEADWATER POOL ELEVATION 440'
HEADWATER POOL ELEVATION 437'
ICE HARBOR LOCK AND DAM
Snake River, Ore., Wash. & Ida.
RESERVOIR REGULATION MANUAL
EXPECTED PLANT CAPABILITY VS. RIVER DISCHARGE 3,4,5,6 UNITS
U.S. Army Engineer District, Walla Walla
Power Section
Prepared: Hebble
Date: July 1961

CHART 5


Parameter values tabulated
are the nearest foot of
McNary fore bay elevation
example 339 = 9
340 = 0
ICE HARBOR TAILWATER ELEVATION - FEET
356
354
352
350
348
346
344
342
340
338
336
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
SNAKE RIVER DISCHARGE
ICE HARBOR DAM
POWER HOUSE T.W. ELEV.
VS.
RELEASE AND MCNARY
DAM FOREBAY ELEV.
LESt RHC 11/5/68
K+E 10 X 10 TO THE ½ INCH 358-11L
KEUFFEL & ESSER CO. MADE IN U.S.A.



Notes:

1. These curves depict capacity with Ice Harbor Dam at river mile 9.7 and Lower Monumental Dam at river mile 41.6.
2. Reservoir capacity is a function of both pool elevation and discharge.
3. Channel storage computed from U.S.C.E. soundings dated June 10, 1935. Storage above channel computed from U.S.C.E. maps based on aerial photography - Sept., 1956 Horizontal Control - 1957 Survey Scale: 1" = 500'. Contour Interval - 10 feet.
4. Storage above level reservoir for high discharges was based on computed backwater profiles.

ICE HARBOR LOCK AND DAM
Snake River, Ore., Wash., & Ida.
RESERVOIR AREA
AND
STORAGE CAPACITY
U.S. Army Engr. Dist., Walla Walla
Water Control Section
Prepared: J.D.A. & J.A.A. Date: Feb. 1962

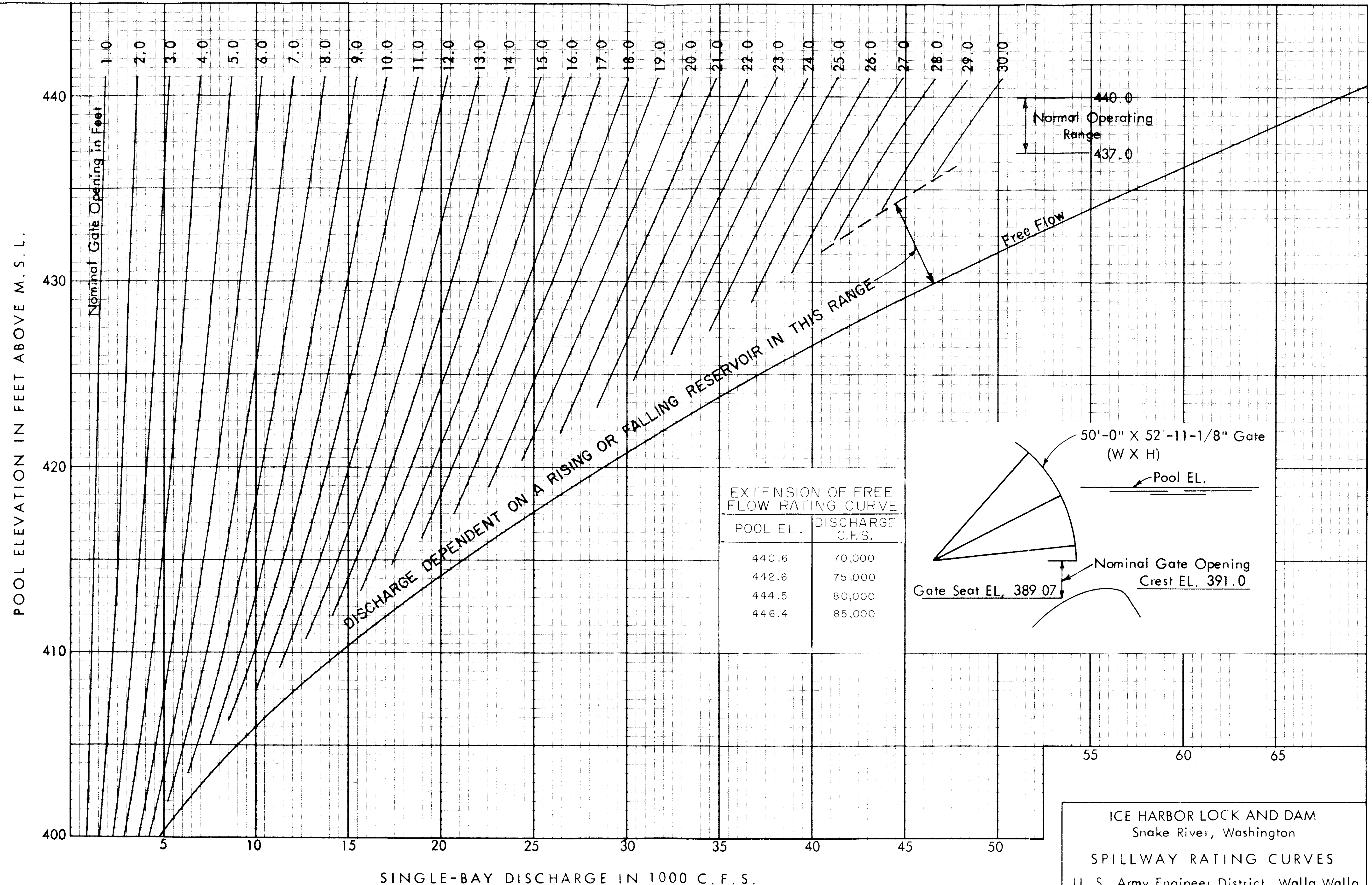
CHART 6

DELETED

CHART 7
FUNCTIONAL ORGANIZATION CHART

DELETED

CHART 8
ORGANIZATION FOR RESERVOIR REGULATION, WALLA WALLA DISTRICT



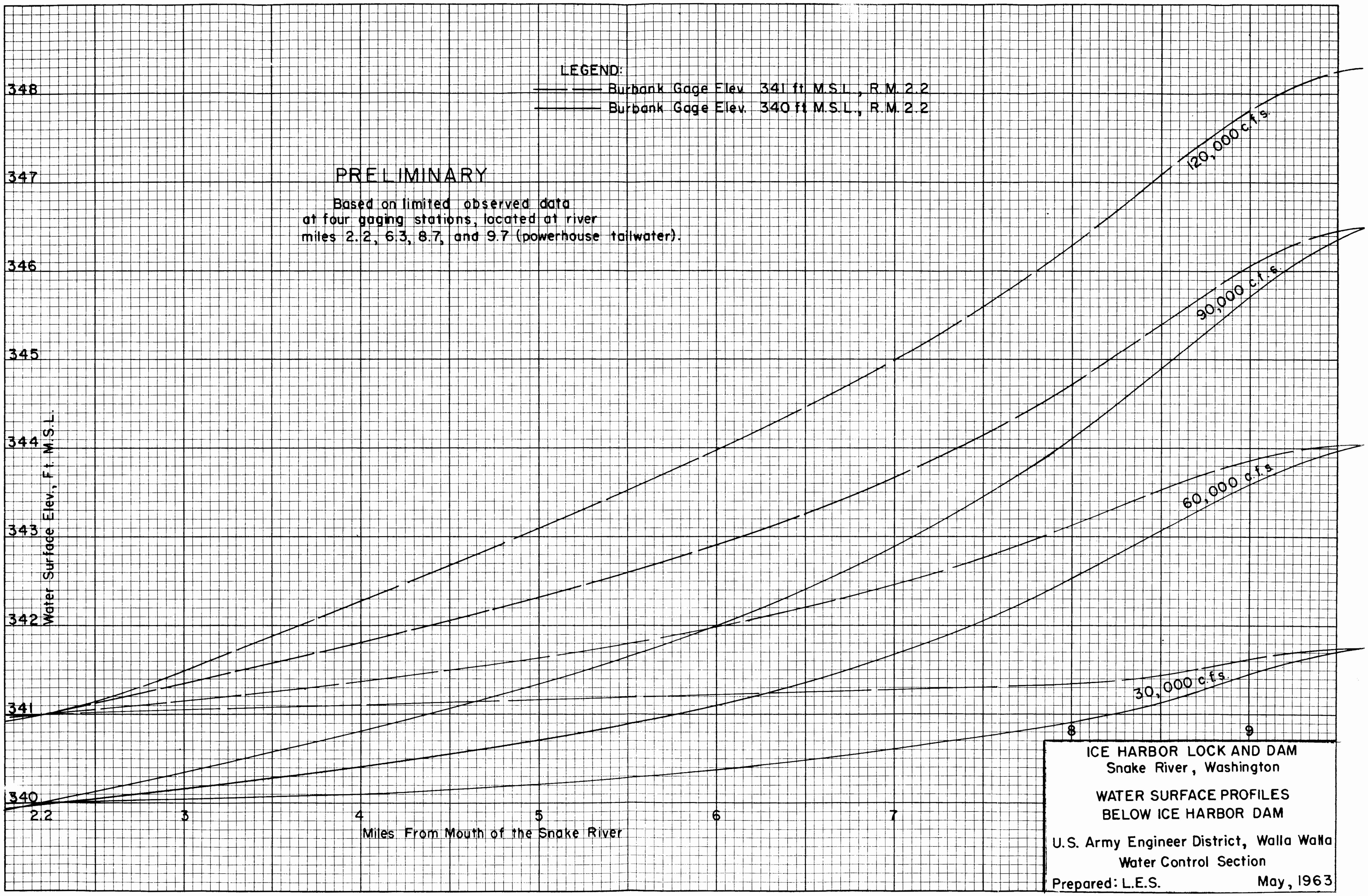
EXTENSION OF FREE FLOW RATING CURVE

POOL EL.	DISCHARGE C.F.S.
440.6	70,000
442.6	75,000
444.5	80,000
446.4	85,000

ICE HARBOR LOCK AND DAM
Snake River, Washington

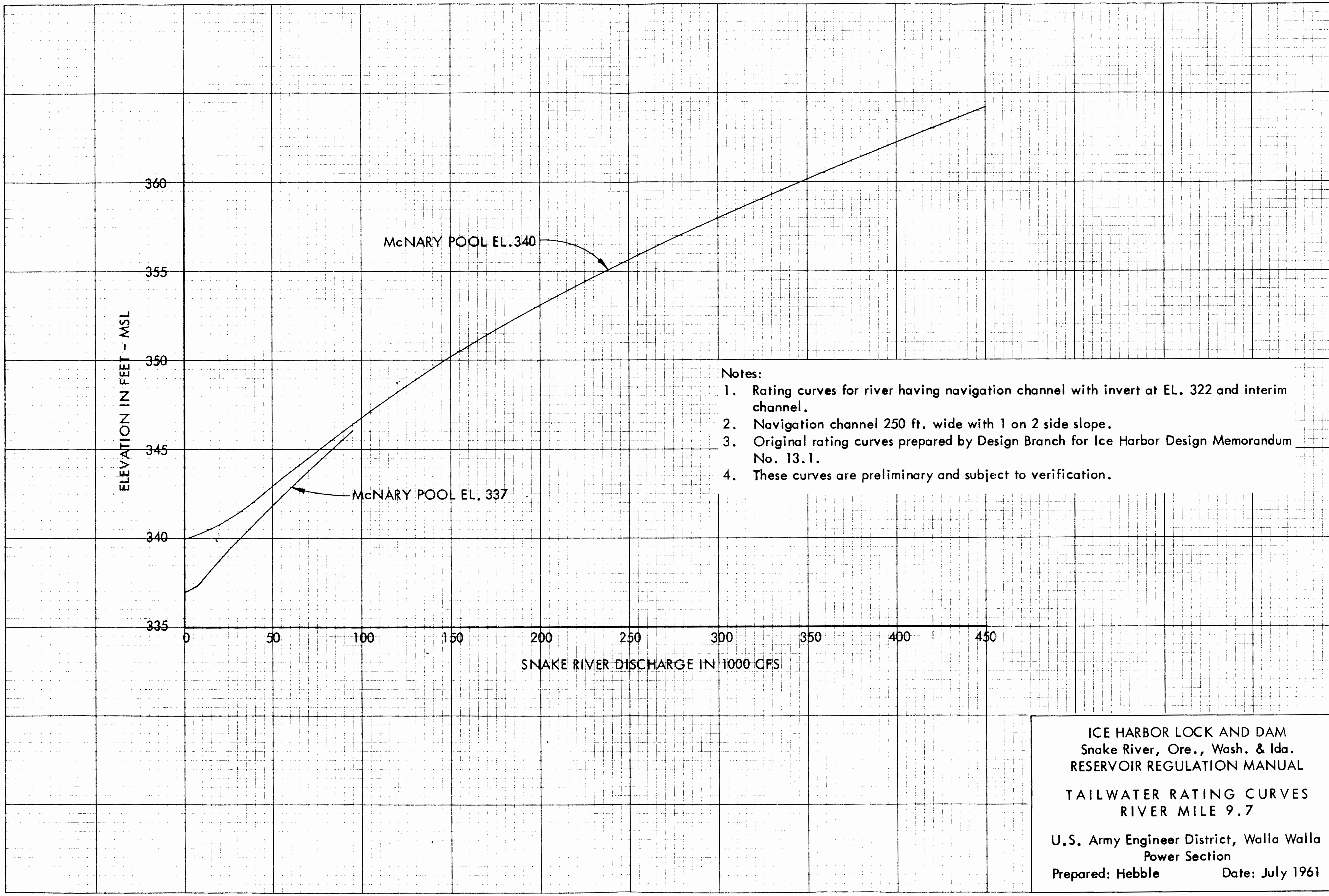
SPILLWAY RATING CURVES

U. S. Army Engineer District, Walla Walla
Hydraulic Design Section
Prepared: J. D. M. Date: 16 Jan. 64



LEGEND:
Burbank Gage Elev. 341 ft M.S.L., R.M. 2.2
Burbank Gage Elev. 340 ft M.S.L., R.M. 2.2
PRELIMINARY
Based on limited observed data at four gaging stations, located at river miles 2.2, 6.3, 8.7, and 9.7 (powerhouse tailwater).
120,000 c.f.s.
90,000 c.f.s.
60,000 c.f.s.
30,000 c.f.s.
348
347
346
345
344
343
342
341
340
Water Surface Elev., Ft. M.S.L.
2.2
3
4
5
6
7
8
9
Miles From Mouth of the Snake River
ICE HARBOR LOCK AND DAM
Snake River, Washington
WATER SURFACE PROFILES
BELOW ICE HARBOR DAM
U.S. Army Engineer District, Walla Walla
Water Control Section
Prepared: L.E.S.
May, 1963

CHART 10



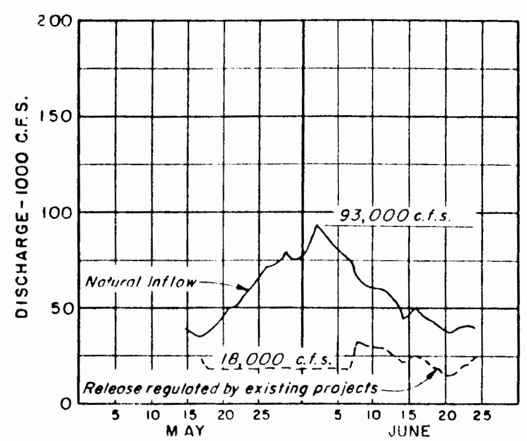
Notes:

1. Rating curves for river having navigation channel with invert at EL. 322 and interim channel.
2. Navigation channel 250 ft. wide with 1 on 2 side slope.
3. Original rating curves prepared by Design Branch for Ice Harbor Design Memorandum No. 13.1.
4. These curves are preliminary and subject to verification.

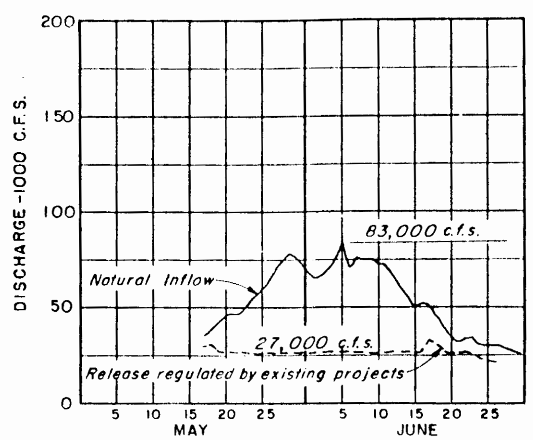
ICE HARBOR LOCK AND DAM
Snake River, Ore., Wash. & Ida.
RESERVOIR REGULATION MANUAL

TAILWATER RATING CURVES
RIVER MILE 9.7

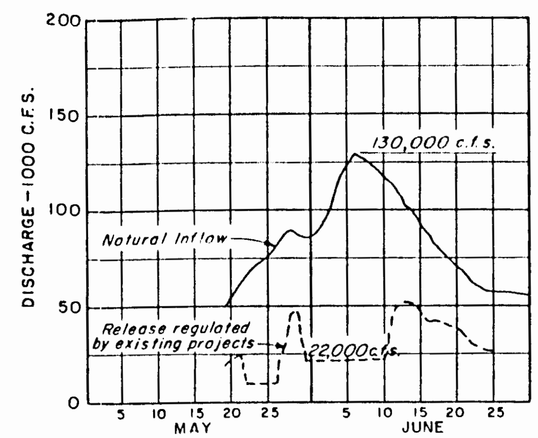
U.S. Army Engineer District, Walla Walla
Power Section
Prepared: Hebble Date: July 1961



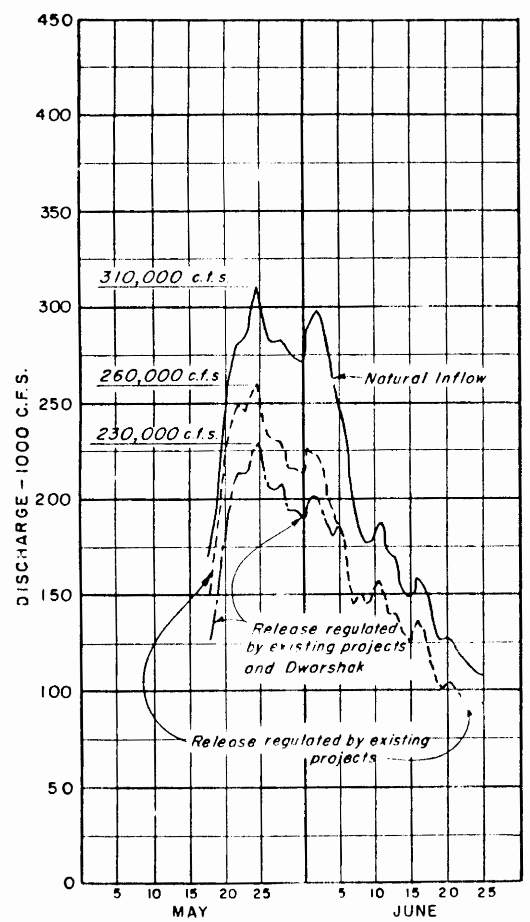
SNAKE RIVER AT BROWNLEE-1956



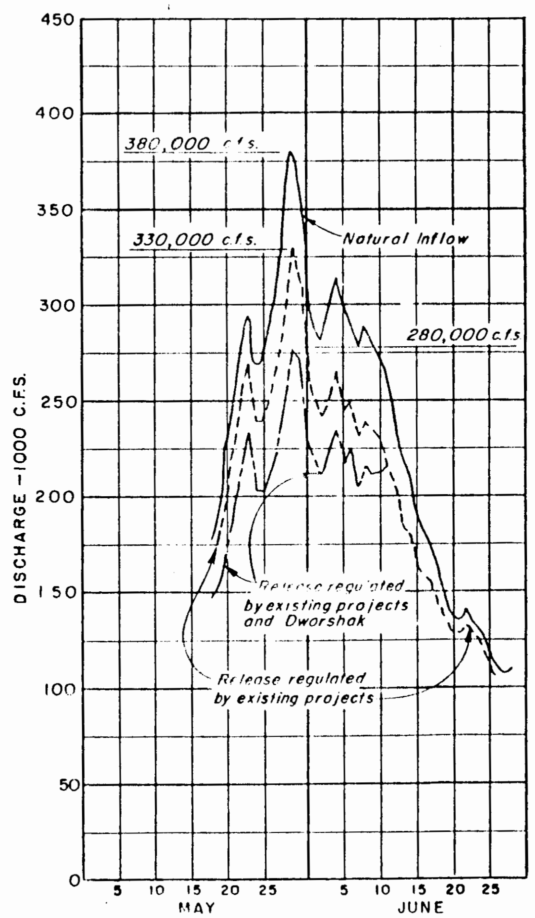
SNAKE RIVER AT BROWNLEE-1948



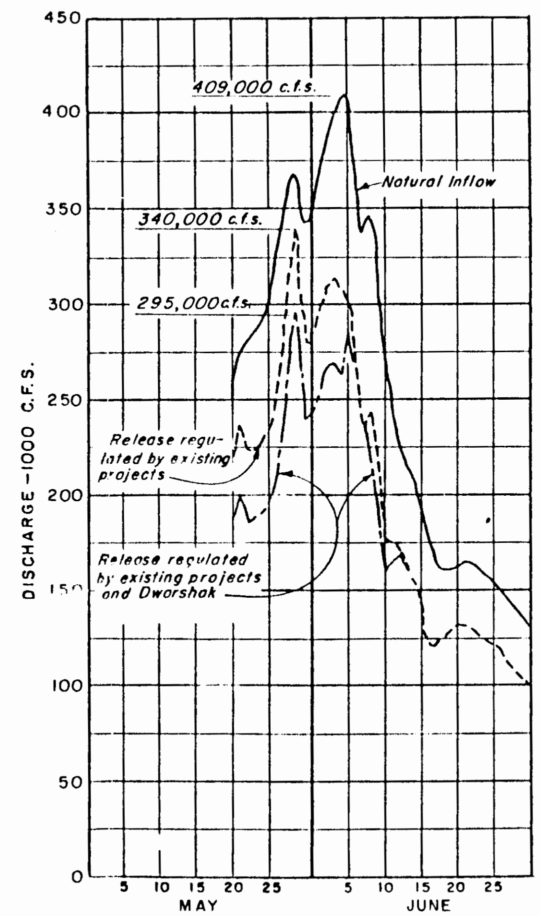
SNAKE RIVER AT BROWNLEE-1894



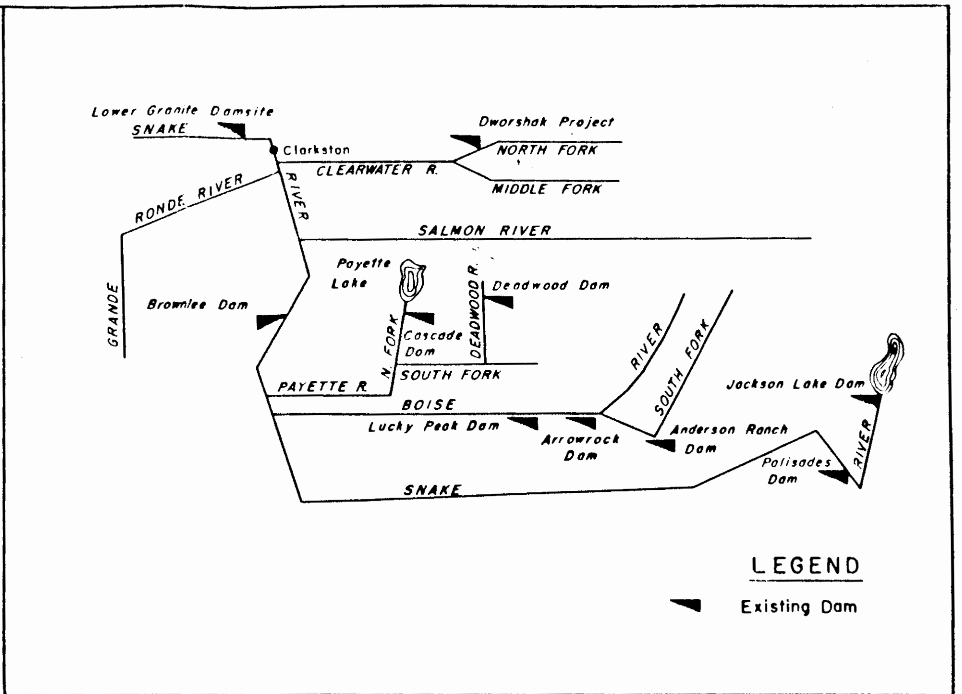
SNAKE RIVER AT CLARKSTON-1956



SNAKE RIVER AT CLARKSTON-1948



SNAKE RIVER AT CLARKSTON-1894



SCHEMATIC DIAGRAM OF MAJOR PROJECTS WITH FLOOD CONTROL STORAGE

MAJOR PROJECTS AND FLOOD CONTROL STORAGE

EXISTING PROJECTS		GROSS USABLE ACRE-FEET
UPPER SNAKE RIVER		
JACKSON LAKE AND PALISADES		1,400,000
BOISE RIVER		
ANDERSON RANCH		418,000
ARROWROCK		286,000
LUCKY PEAK		279,000
PAYETTE RIVER		
CASCADE		653,000
DEADWOOD		160,000
MIDDLE SNAKE RIVER		
BROWNLEE		980,000
	TOTAL	4,176,000
NORTH FORK CLEARWATER		
DWORSHAK		2,000,000
TOTAL EXISTING AND DWORSHAK		6,176,000

NOTES:

1. REGULATION BY EXISTING PROJECTS IS BASED ON REGULATION PROCEDURES USED IN "JUNE 1958 REVIEW REPORT OF HOUSE DOCUMENT 531."
2. DWORSHAK REGULATION PROCEDURES ARE OUTLINED IN APPENDIX A OF THE 15 SEPTEMBER 1961 "BRUCES EDDY DAM AND RESERVOIR GENERAL DESIGN MEMORANDUM."

REVISION	DATE	DESCRIPTION	BY

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

ICE HARBOR LOCK & DAM
SNAKE RIVER, OREGON, WASHINGTON AND IDAHO

REGULATION OF LARGE SNAKE RIVER FLOODS

DESIGNED T. Arnold
DRAWN R.L.B
CHECKED R. Conway
PREPARED
CHIEF, PROJECT PLANNING BRANCH
RECOMMENDED
CHIEF, ENGINEERING DIVISION
APPROVED DATE 22 Nov 1962
DISTRICT ENGINEER
SCALE AS SHOWN
INV. NO. ENG
FILE NO. GD-03-3/19

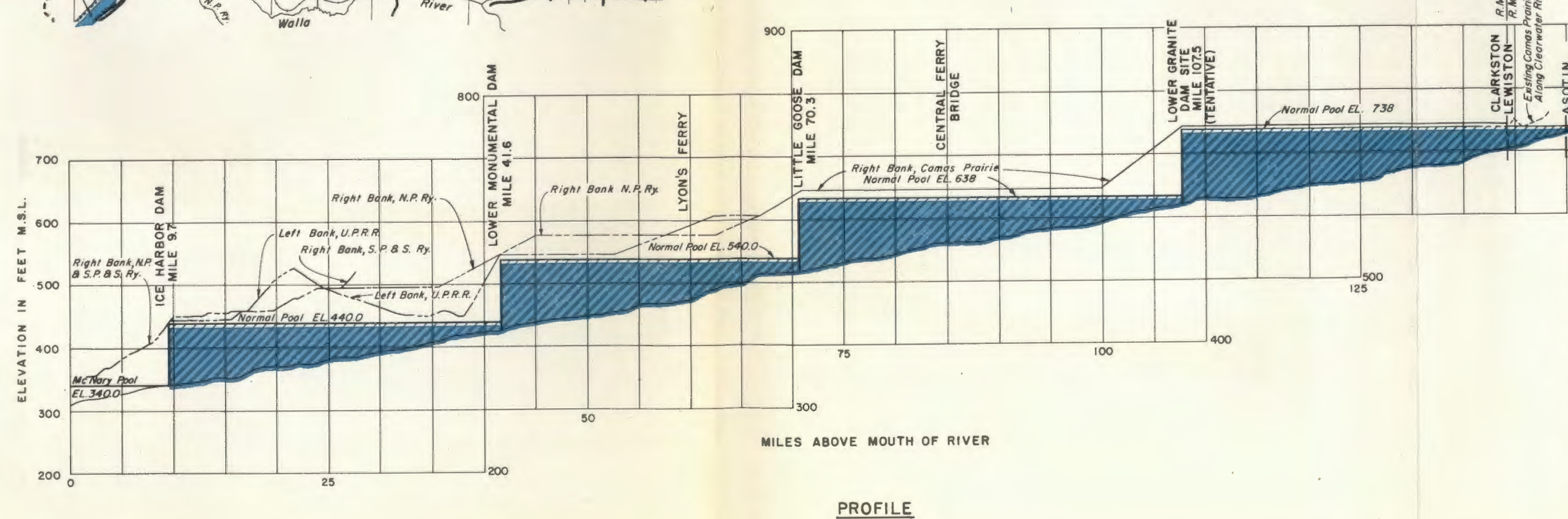
DELETED

CHART 13

TYPICAL WINTER POWER OPERATION

Plates

** ADDED BY REVISION



U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

SNAKE RIVER, OREGON, WASHINGTON AND IDAHO

PLAN AND PROFILE

LOWER SNAKE RIVER DEVELOPMENT

DESIGNED: E. Jones
DRAWN: D. Phillips
CHECKED: N. Hagges
SUPERVISED:
SUBMITTED: Glenn H. Von Gunten, CHIEF, PROJECT PLANNING BRANCH
RECOMMENDED: E. C. Frangon, CHIEF, ENGINEERING DIVISION
APPROVED: COLONEL, C. E. DISTRICT ENGINEER
DATE: 22 Nov 1963
SCALE AS SHOWN
INV. NO. ENG.
FILE NO. GD-05-3/1

PLATE 1

Ice Harbor
LAND USE · MASTER PLAN

PROJECT BOUNDARY

ROADS

RAILROADS

NORMAL POOL 440 m.s.l.

20 * RIVER MILE

Project Operations

PROJECT STRUCTURES

PUBLIC PORT TERMINAL

INDUSTRIAL USE and ACCESS

Operations · Recreation

INTENSIVE USE

INTENSIVE USE · FUTURE

LOW DENSITY USE

Operations · Fish and Wildlife

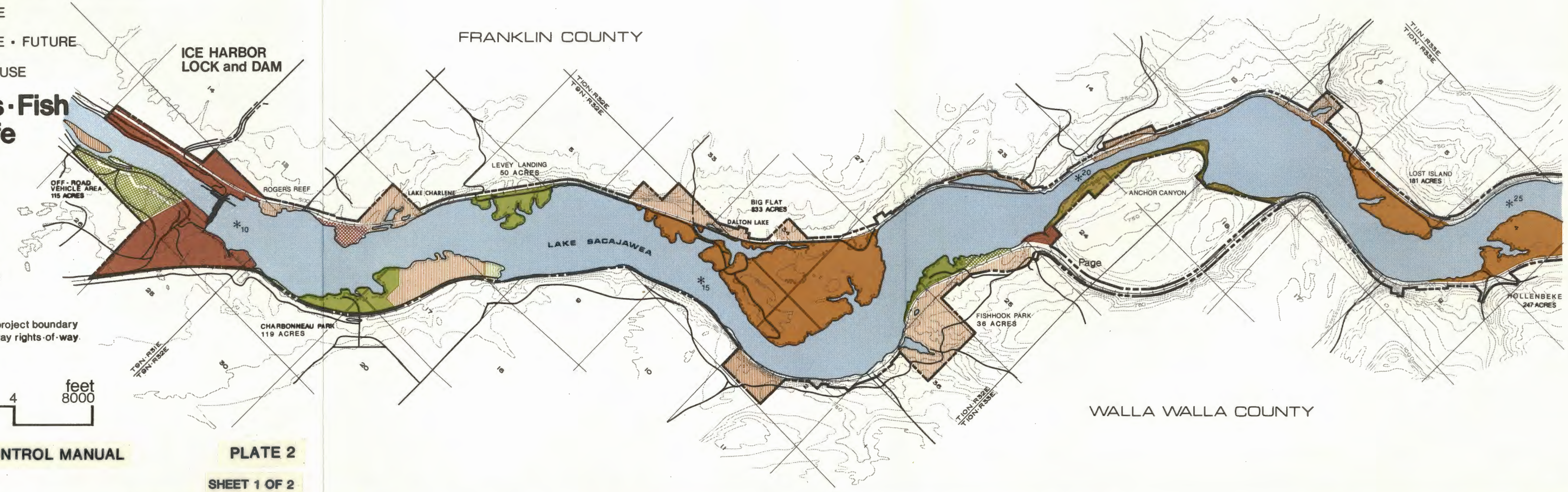
INTENSIVE MANAGEMENT

MODERATE MANAGEMENT

Other

OPERATIONS · NATURAL AREA

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



0 1 2 4 feet 8000

5 WATER CONTROL MANUAL

PLATE 2

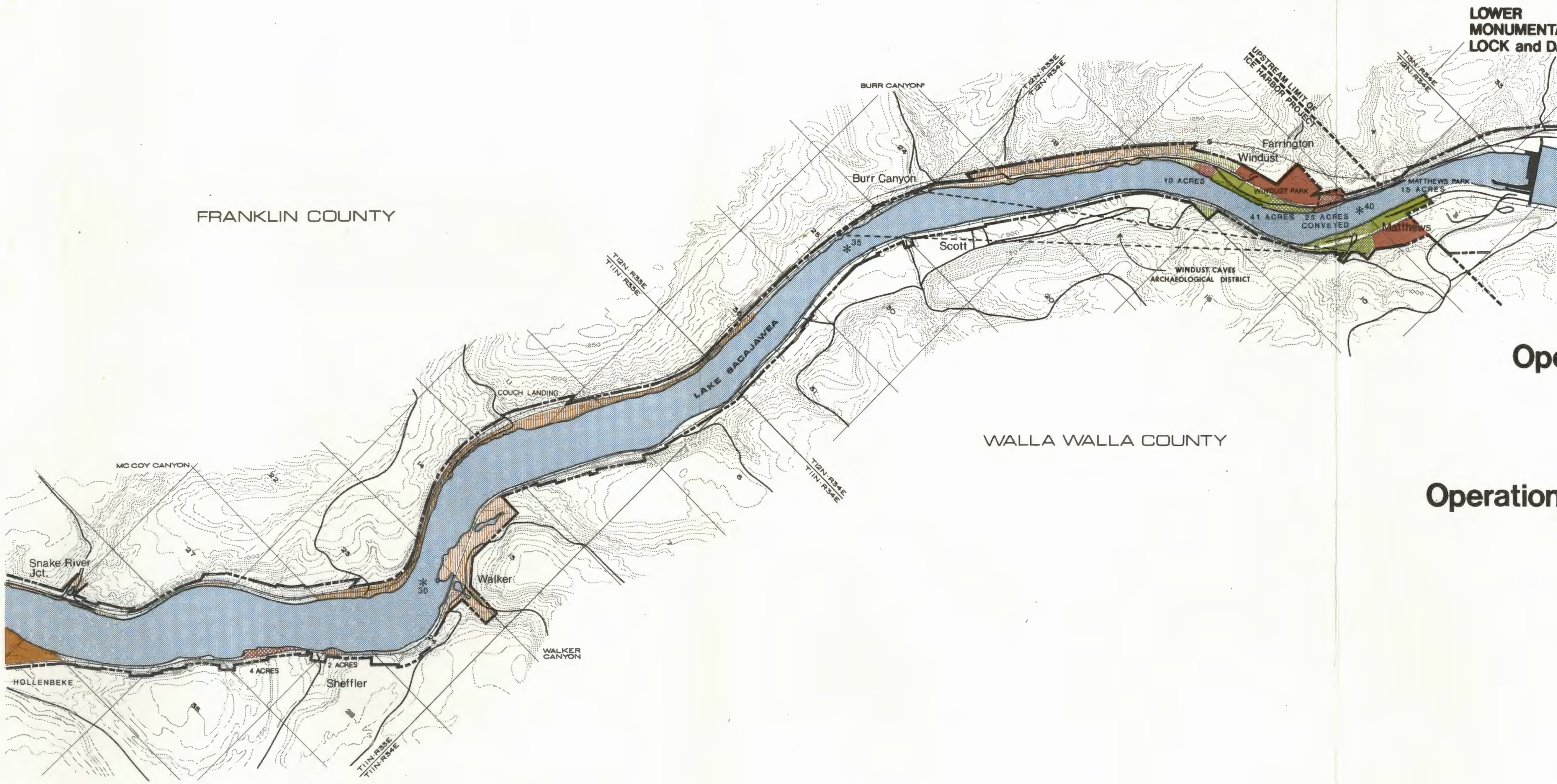
SHEET 1 OF 2

1981

LOWER SNAKE RIVER PROJECT

U.S. ARMY ENGINEER DISTRICT
Walla Walla, Washington

Ice Harbor
LAND USE · MASTER PLAN



PROJECT BOUNDARY

ROADS

RAILROADS

NORMAL POOL 440 m.s.l.

RIVER MILE * 20

Project Operations

PROJECT STRUCTURES

PUBLIC PORT TERMINAL

INDUSTRIAL USE and ACCESS

Operations · Recreation

INTENSIVE USE

INTENSIVE USE · FUTURE

LOW DENSITY USE

Operations · Fish and Wildlife

INTENSIVE MANAGEMENT

MODERATE MANAGEMENT

Other

OPERATIONS · NATURAL AREA

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

0 1 2 4 8000 feet

WATER CONTROL MANUAL

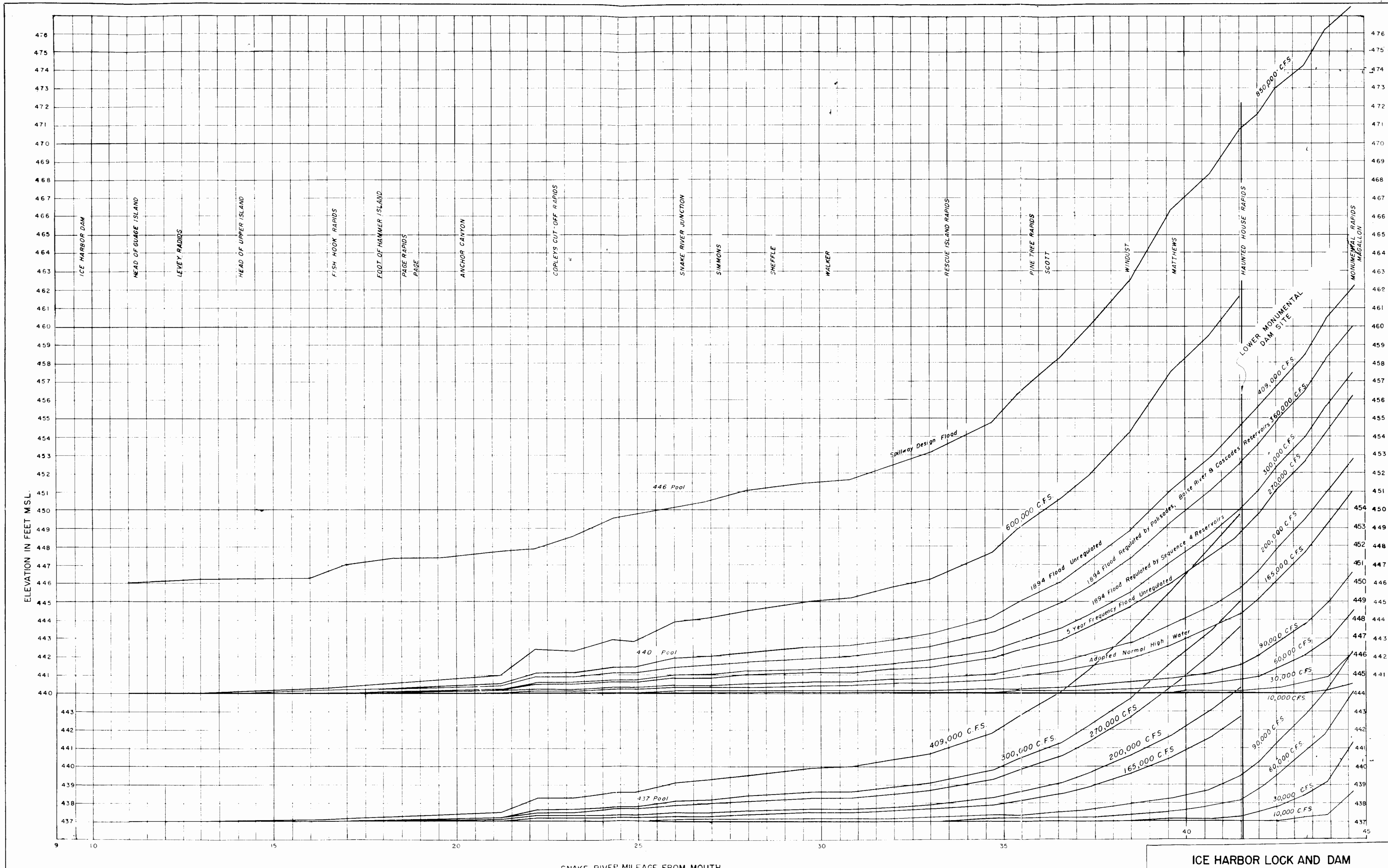
PLATE 2 5

SHEET 2 OF 2

1981

U.S. ARMY ENGINEER DISTRICT
Walla Walla, Washington

LOWER SNAKE RIVER PROJECT



ICE HARBOR LOCK AND DAM

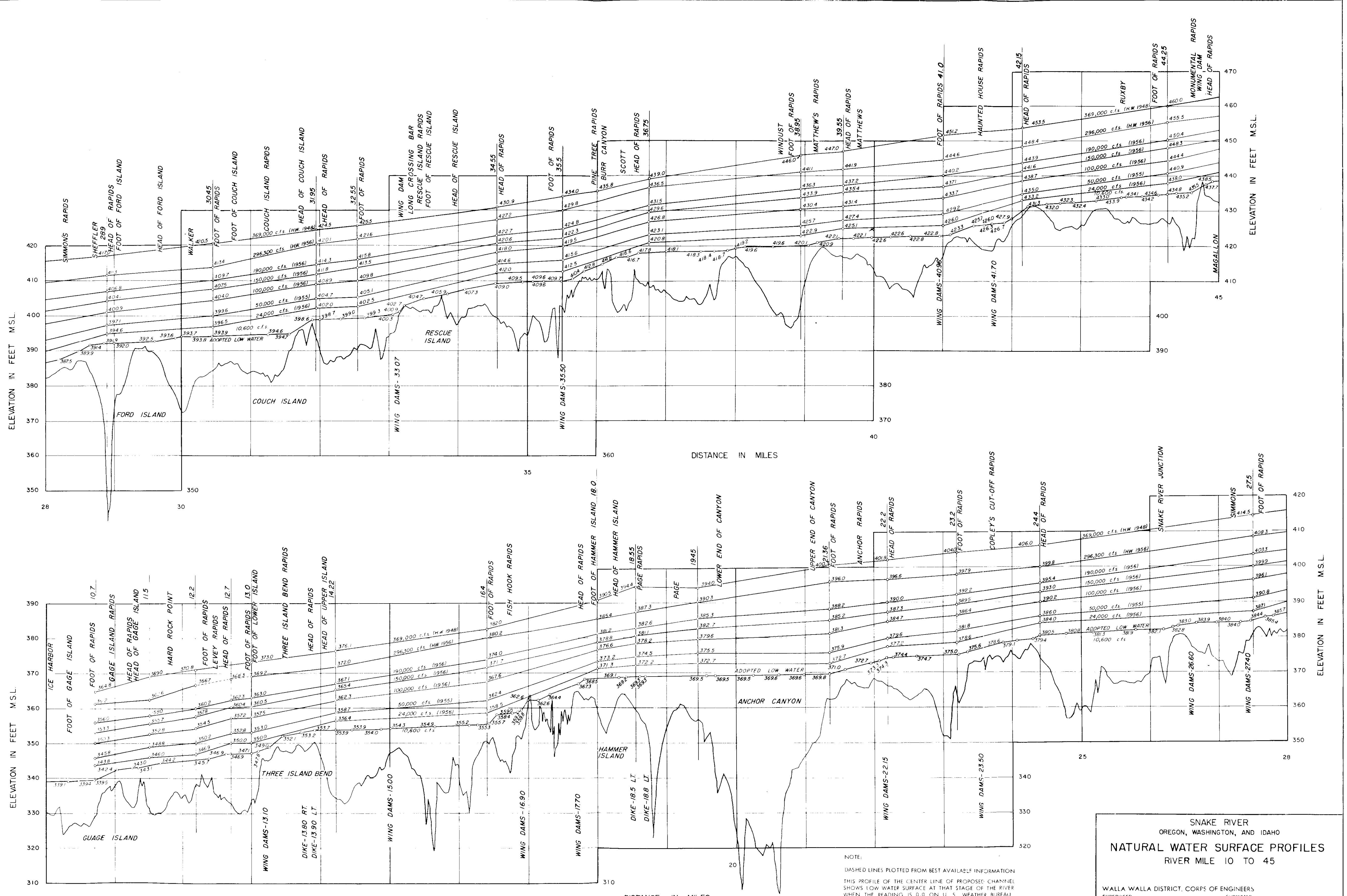
SNAKE RIVER, WASHINGTON

BACKWATER PROFILES

U.S. ARMY ENGINEER DISTRICT, WALLA WALLA

WATER CONTROL SECTION

PREPARED H.L.E. & S.D.P. DATE OCT. 8, 1957



NOTE:

DASHED LINES PLOTTED FROM BEST AVAILABLE INFORMATION

THIS PROFILE OF THE CENTER LINE OF PROPOSED CHANNEL SHOWS LOW WATER SURFACE AT THAT STAGE OF THE RIVER WHEN THE READING IS 0.0 ON U. S. WEATHER BUREAU GAGE AT RIPARIA. (512.05 M.S.L.)

ELEVATIONS ARE REFERRED TO MEAN SEA LEVEL (U.S.C. & G.S. DATUM OF 1929) DISTANCE IN MILES FROM MOUTH OF RIVER IS MEASURED ON CENTER LINE OF PROPOSED CHANNEL.

SNAKE RIVER

OREGON, WASHINGTON, AND IDAHO

NATURAL WATER SURFACE PROFILES

RIVER MILE 10 TO 45

WALLA WALLA DISTRICT, CORPS OF ENGINEERS

SUPERVISED — CHIEF, WATER CONTROL SECTION

SUBMITTED — CHIEF, PLANNING AND REPORTS BRANCH

RECOMMENDED — CHIEF, ENGINEERING DIVISION

APPROVED — COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER

PREPARED A. Hartung

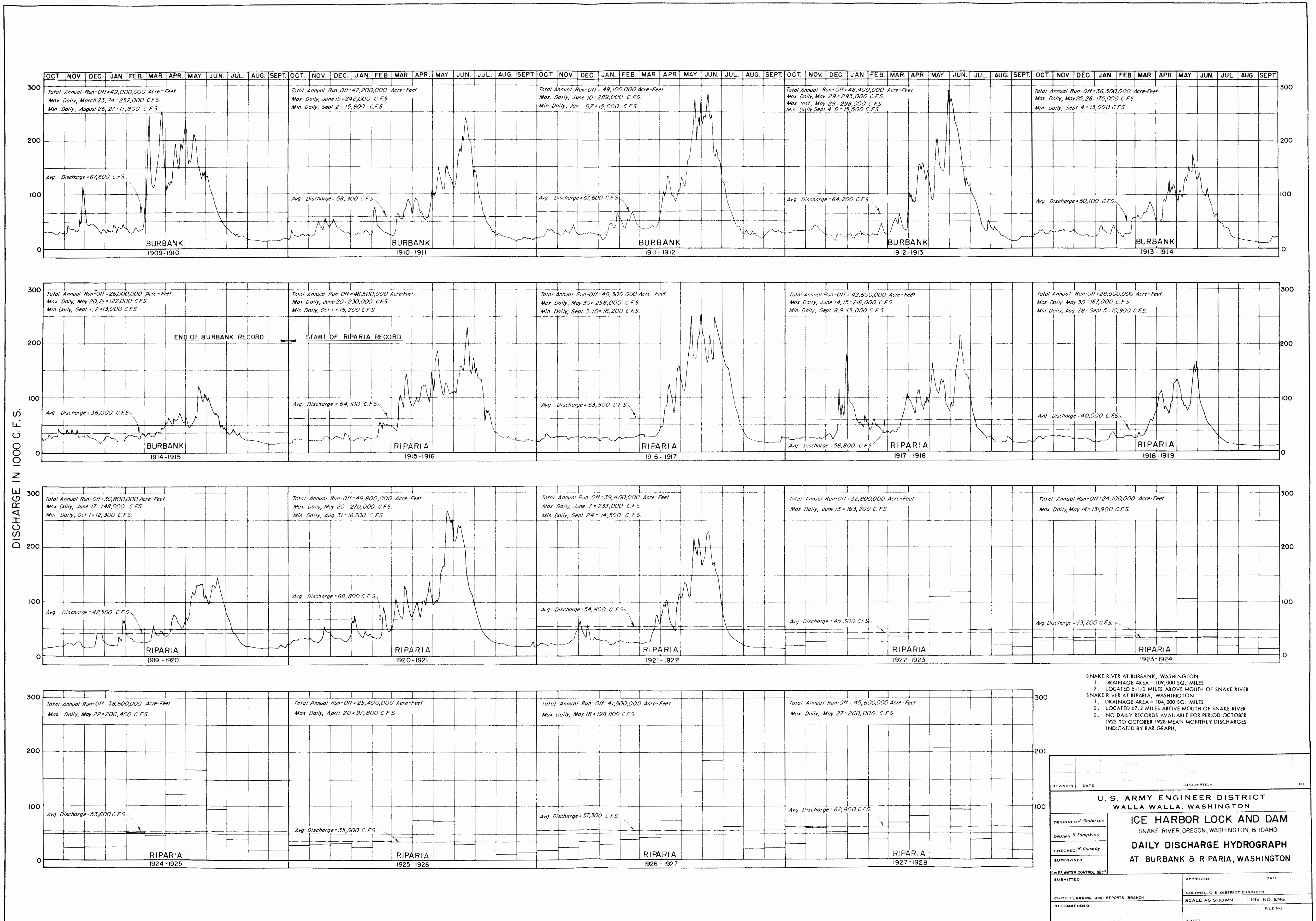
DRAWN R. Gilman

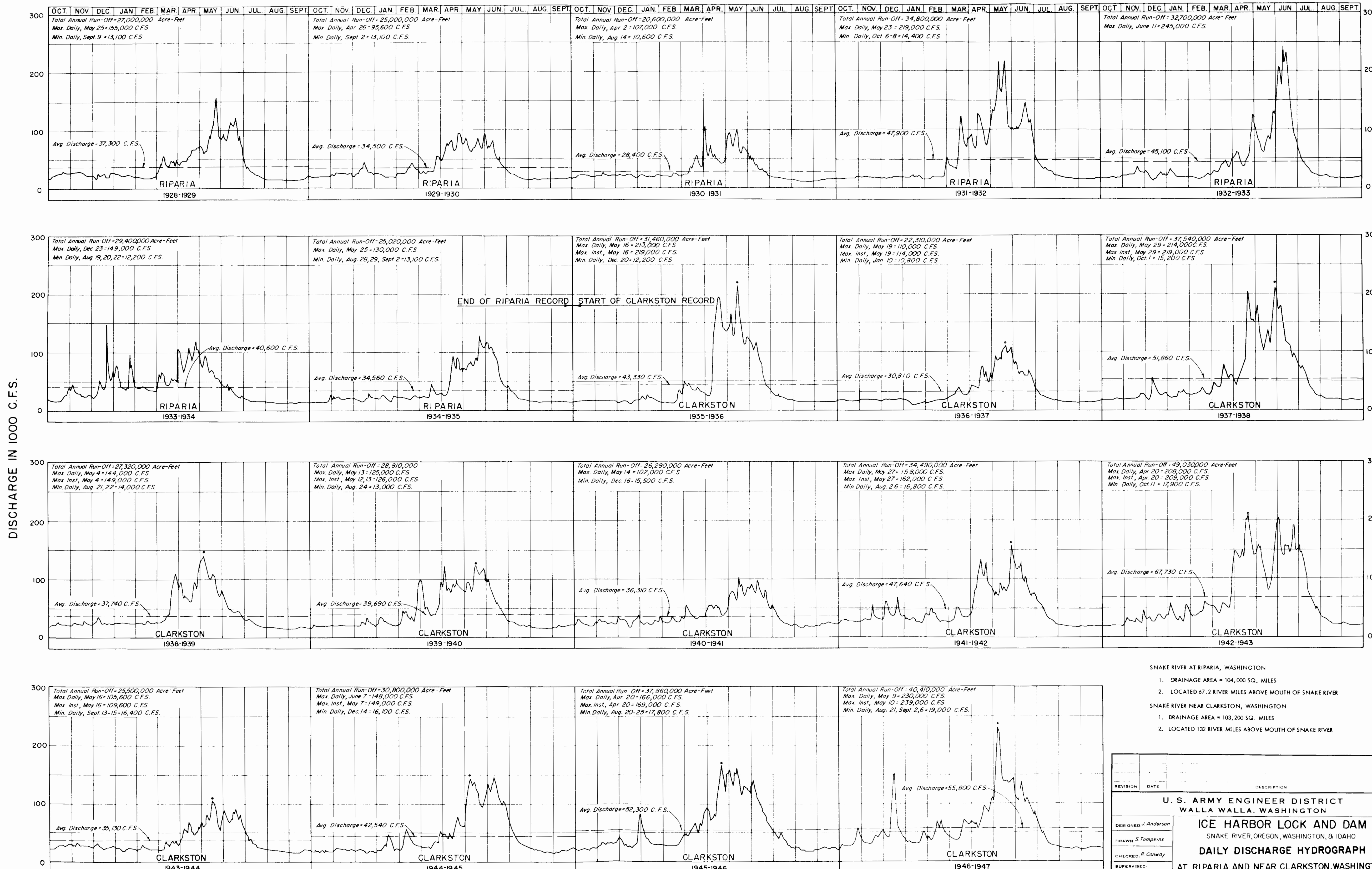
CHECKED R.H. Conway

TRANSMITTED WITH REPORT

DATED

SN-10-18/1


DISCHARGE IN 1000 C.F.S.
OCT. NOV. DEC. JAN. FEB. MAR. APR. MAY JUN. JUL. AUG. SEPT.
1909-1910 BURBANK
Total Annual Run-Off = 49,000,000 Acre-Feet
Max Daily, March 23, 24 = 252,000 C.F.S.
Min Daily, August 26, 27 = 11,800 C.F.S.
Avg. Discharge = 67,600 C.F.S.
1910-1911 BURBANK
Total Annual Run-Off = 42,200,000 Acre-Feet
Max Daily, June 15 = 242,000 C.F.S.
Min Daily, Sept. 2 = 15,600 C.F.S.
Avg. Discharge = 58,300 C.F.S.
1911-1912 BURBANK
Total Annual Run-Off = 49,100,000 Acre-Feet
Max Daily, June 10 = 289,000 C.F.S.
Min Daily, Jan. 6,7 = 15,000 C.F.S.
Avg. Discharge = 67,600 C.F.S.
1912-1913 BURBANK
Total Annual Run-Off = 46,400,000 Acre-Feet
Max Daily, May 29 = 293,000 C.F.S.
Max Inst., May 29 = 298,000 C.F.S.
Min Daily, Sept. 4-6 = 15,500 C.F.S.
Avg. Discharge = 64,200 C.F.S.
1913-1914 BURBANK
Total Annual Run-Off = 36,300,000 Acre-Feet
Max Daily, May 25, 26 = 175,000 C.F.S.
Min Daily, Sept 4 = 13,000 C.F.S.
Avg. Discharge = 50,100 C.F.S.
1914-1915 BURBANK
Total Annual Run-Off = 26,000,000 Acre-Feet
Max Daily, May 20, 21 = 122,000 C.F.S.
Min. Daily, Sept 1, 2 = 13,000 C.F.S.
Avg. Discharge = 36,000 C.F.S.
END OF BURBANK RECORD
START OF RIPARIA RECORD
1915-1916 RIPARIA
Total Annual Run-Off = 46,500,000 Acre-Feet
Max Daily, June 20 = 230,000 C.F.S.
Min Daily, Oct 1 = 15,200 C.F.S.
Avg. Discharge = 64,100 C.F.S.
1916-1917 RIPARIA
Total Annual Run-Off = 46,300,000 Acre-Feet
Max Daily, May 30 = 256,000 C.F.S.
Min Daily, Sept. 3-10 = 16,200 C.F.S.
Avg. Discharge = 63,800 C.F.S.
1917-1918 RIPARIA
Total Annual Run-Off = 42,600,000 Acre-Feet
Max Daily, June 14, 15 = 216,000 C.F.S.
Min. Daily, Sept 8, 9 = 15,000 C.F.S.
Avg. Discharge = 58,800 C.F.S.
1918-1919 RIPARIA
Total Annual Run-Off = 28,900,000 Acre-Feet
Max Daily, May 30 = 167,000 C.F.S.
Min Daily, Aug. 28 - Sept 5 = 10,900 C.F.S.
Avg. Discharge = 40,000 C.F.S.
1919-1920 RIPARIA
Total Annual Run-Off = 30,800,000 Acre-Feet
Max Daily, June 17 = 148,000 C.F.S.
Min Daily, Oct 1 = 12,300 C.F.S.
Avg. Discharge = 42,500 C.F.S.
1920-1921 RIPARIA
Total Annual Run-Off = 49,800,000 Acre-Feet
Max Daily, May 20 = 270,000 C.F.S.
Min Daily, Aug 31 = 16,700 C.F.S.
Avg. Discharge = 68,800 C.F.S.
1921-1922 RIPARIA
Total Annual Run-Off = 39,400,000 Acre-Feet
Max Daily, June 7 = 233,000 C.F.S.
Min Daily, Sept 24 = 14,500 C.F.S.
Avg. Discharge = 54,400 C.F.S.
1922-1923 RIPARIA
Total Annual Run-Off = 32,800,000 Acre-Feet
Max Daily, June 13 = 163,200 C.F.S.
Avg. Discharge = 45,300 C.F.S.
1923-1924 RIPARIA
Total Annual Run-Off = 24,100,000 Acre-Feet
Max Daily, May 14 = 131,900 C.F.S.
Avg. Discharge = 33,200 C.F.S.
1924-1925 RIPARIA
Total Annual Run-Off = 38,800,000 Acre-Feet
Max Daily, May 22 = 206,400 C.F.S.
Avg. Discharge = 53,600 C.F.S.
1925-1926 RIPARIA
Total Annual Run-Off = 25,400,000 Acre-Feet
Max Daily, April 20 = 97,800 C.F.S.
Avg. Discharge = 35,000 C.F.S.
1926-1927 RIPARIA
Total Annual Run-Off = 41,500,000 Acre-Feet
Max Daily, May 18 = 198,800 C.F.S.
Avg. Discharge = 57,300 C.F.S.
1927-1928 RIPARIA
Total Annual Run-Off = 45,600,000 Acre-Feet
Max Daily, May 27 = 260,000 C.F.S.
Avg. Discharge = 62,800 C.F.S.
SNAKE RIVER AT BURBANK, WASHINGTON
1. DRAINAGE AREA = 109,000 SQ. MILES
2. LOCATED 5-1/2 MILES ABOVE MOUTH OF SNAKE RIVER
SNAKE RIVER AT RIPARIA, WASHINGTON
1. DRAINAGE AREA = 104,000 SQ. MILES
2. LOCATED 67.2 MILES ABOVE MOUTH OF SNAKE RIVER
3. NO DAILY RECORDS AVAILABLE FOR PERIOD OCTOBER 1922 TO OCTOBER 1928 MEAN MONTHLY DISCHARGES INDICATED BY BAR GRAPH.
REVISION DATE DESCRIPTION BY
U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON
ICE HARBOR LOCK AND DAM
SNAKE RIVER, OREGON, WASHINGTON, & IDAHO
DAILY DISCHARGE HYDROGRAPH
AT BURBANK & RIPARIA, WASHINGTON
DESIGNED
DRAWN
CHECKED
SUPERVISED
CHIEF, WATER CONTROL SECT.
SUBMITTED
CHIEF, PLANNING AND REPORTS BRANCH
RECOMMENDED
CHIEF, ENGINEERING DIVISION
APPROVED DATE
COLONEL, C.E. DISTRICT ENGINEER
SCALE AS SHOWN
INV. NO. ENG.
FILE NO.
SHEET



SNAKE RIVER AT RIPARIA, WASHINGTON

1. DRAINAGE AREA = 104,000 SQ. MILES
2. LOCATED 67.2 RIVER MILES ABOVE MOUTH OF SNAKE RIVER

SNAKE RIVER NEAR CLARKSTON, WASHINGTON

1. DRAINAGE AREA = 103,200 SQ. MILES
2. LOCATED 132 RIVER MILES ABOVE MOUTH OF SNAKE RIVER

REVISION	DATE	DESCRIPTION	BY

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

DESIGNED: J. Anderson
DRAWN: S. Tompkins
CHECKED: R. Conway
SUPERVISED:
CHIEF, WATER CONTROL SECT.

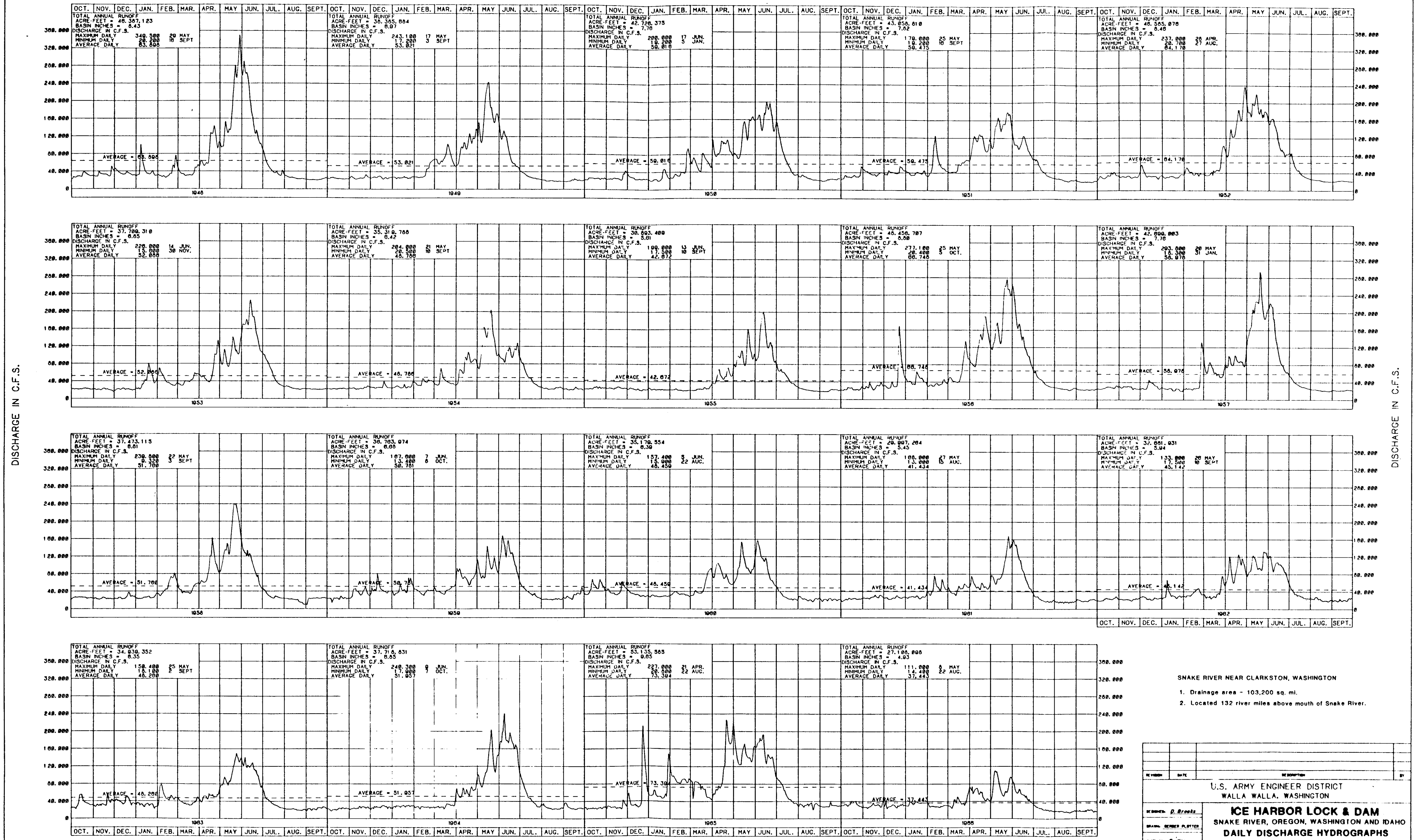
ICE HARBOR LOCK AND DAM

SNAKE RIVER, OREGON, WASHINGTON, & IDAHO

DAILY DISCHARGE HYDROGRAPH

AT RIPARIA AND NEAR CLARKSTON, WASHINGTON

SUBMITTED:
CHIEF, PLANNING AND REPORTS BRANCH
RECOMMENDED:
CHIEF, ENGINEERING DIVISION
APPROVED | DATE
COLONEL, C. E. DISTRICT ENGINEER
SCALE AS SHOWN | INV. NO. ENG.
FILE NO.
SHEET



SNAKE RIVER NEAR CLARKSTON, WASHINGTON

1. Drainage area - 103,200 sq. mi.
2. Located 132 river miles above mouth of Snake River.

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

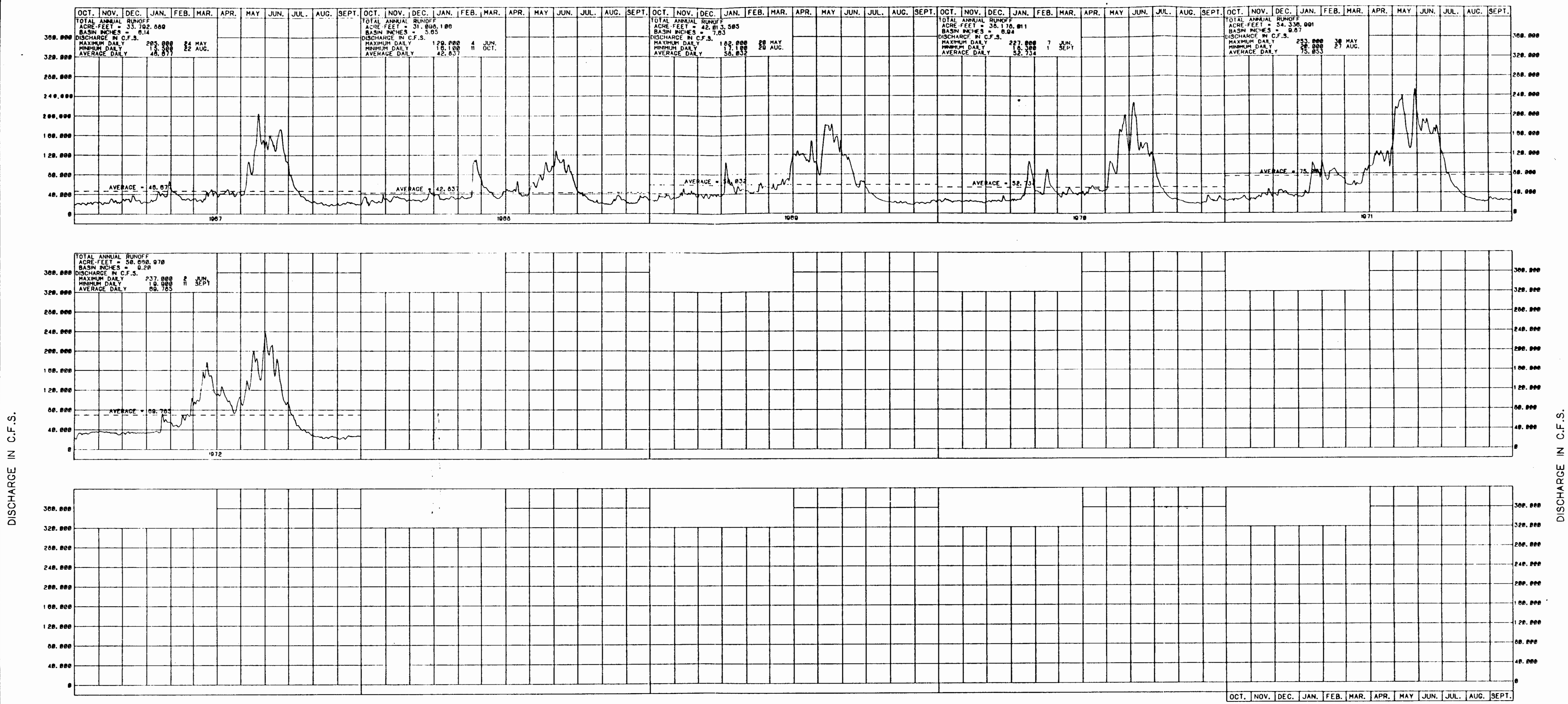
DESIGNED: D. Brooks
DRAWN: GERBER PLOTTER
CHECKED: E. Kim
PREPARED:

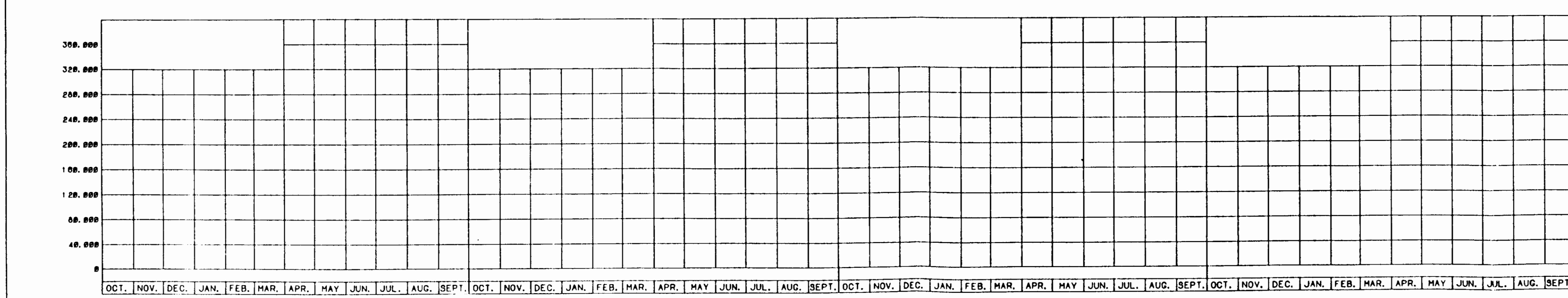
ICE HARBOR LOCK & DAM
SNAKE RIVER, OREGON, WASHINGTON AND IDAHO
DAILY DISCHARGE HYDROGRAPHS
SNAKE RIVER NEAR CLARKSTON, WASH.
1948 - 1966

SUPERVISED: [signature]
CHIEF, HYDROLOGY BRANCH
SUBMITTED: [signature]
CHIEF, PLANNING DIVISION

APPROVED: DATE

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





SNAKE RIVER NEAR CLARKSTON, WASHINGTON

1. Drainage area - 103,200 sq. mi.
2. Located 132 river miles above mouth of Snake River.
3. December 1972 gage discontinued.

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

ICE HARBOR LOCK & DAM
SNAKE RIVER, OREGON, WASHINGTON AND IDAHO
DAILY DISCHARGE HYDROGRAPHS
SNAKE RIVER NEAR CLARKSTON, WASH.
1967 - 1972

DESIGNED: D. Brooks
CHECKED: E. Kim
SCALE AS SHOWN

WATER CONTROL MANUAL

LOWER GRANITE RESERVOIR

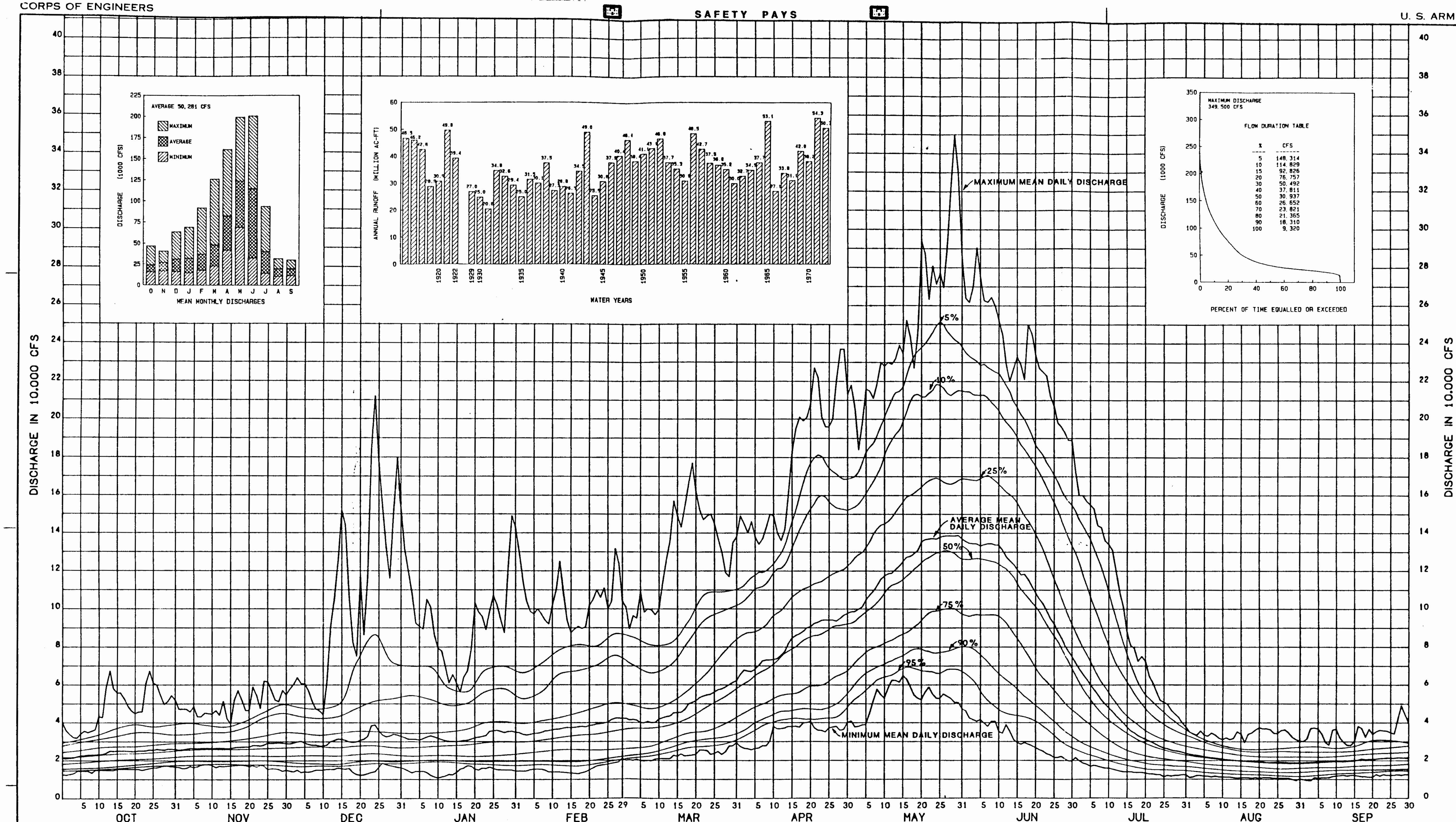
1. Drainage area = 103,500 sq. mi.
2. Located 107.5 miles above mouth of Snake River

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

DESIGNED: Q. Brooks
DRAWN: GERBER PLOTTER
CHECKED: E. Kim
PREPARED: CHIEF HYDROLOGY BR
SUPERVISED: (acting) CHIEF, PLANNING DIVISION
SUBMITTED:
CHIEF:

ICE HARBOR LOCK & DAM
SNAKE RIVER, OREGON, WASHINGTON, & IDAHO
DAILY DISCHARGE HYDROGRAPHS
LOWER GRANITE RESERVOIR
COMPUTED REGULATED INFLOWS
1976-1986

APPROVED: DATE
SCALE AS SHOWN | INV. NO. ENG.
FILE NO.
SHEET



NOTES:

1. RECORDS USED:
   a. WATER YEARS 1916-1922 AND 1929-1935, OBSERVED DISCHARGES AT RIPARIA, WASHINGTON. DRAINAGE AREA IS 104,000 SQUARE MILES.
   b. WATER YEARS 1936-1972, OBSERVED DISCHARGES AT CLARKSTON, WASHINGTON. DRAINAGE AREA IS 103,200 SQUARE MILES.
   c. DISCHARGE RECORDS USED ARE FROM DATA PUBLISHED BY U.S.G.S.
2. DISCHARGE RECORDS AT CLARKSTON AND RIPARIA HAVE BEEN CONSIDERED COMPARABLE AND HAVE BEEN USED WITHOUT CORRECTIONS FOR INCIDENTAL INFLOW BETWEEN THESE STATIONS.
3. DISCHARGES USED ARE THOSE OBSERVED AT THE TIME AND REFLECT VARYING EFFECTS OF PROGRESSIVE IRRIGATION AND RESERVOIR STORAGE DEVELOPMENTS.
4. CURVES OF PERCENT CHANCE OF OCCURRENCE REPRESENT THE AVERAGE DAILY DISCHARGE 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 OF TIME.

MAXIMUM ANNUAL MEAN DAILY DISCHARGES

WATER YEAR	DATE	CFS		WATER YEAR	DATE	CFS
1916	JUN 20	230,000		1942	MAY 27	158,000
1917	MAY 30	256,000		1943	APR 20	208,000
1918	JUN 14	216,000		1944	MAY 16	105,600
1919	MAY 30	167,000		1945	JUN 7	148,000
1920	JUN 17	148,000		1946	APR 20	166,000
1921	MAY 20	270,000		1947	MAY 9	23,000
1922	JUN 7	233,000		1948	MAY 29	349,500
1929	MAY 25	155,000		1949	MAY 17	243,100
1930	APR 26	95,600		1950	JUN 17	200,000
1931	APR 2	107,000		1951	MAY 25	179,000
1932	MAY 23	219,000		1952	APR 28	237,000
1933	JUN 11	245,000		1953	JUN 14	226,000
1934	DEC 23	149,000		1954	MAY 21	204,000
1935	MAY 25	130,000		1955	JUN 13	199,000
1937	MAY 19	110,000		1956	MAY 25	277,100
1938	MAY 29	214,000		1957	MAY 20	293,800
1939	MAY 4	144,000		1958	MAY 22	239,800
1940	MAY 13	125,000		1959	JUN 7	167,600
1941	MAY 14	102,000		1960	JUN 5	157,400

MAXIMUM ANNUAL MEAN DAILY DISCHARGES

WATER YEAR	DATE	CFS		WATER YEAR	DATE	CFS
1961	MAY 27	168,000				
1963	MAY 25	150,400				
1964	JUN 9	240,300				
1965	APR 21	227,000				
1966	MAY 8	111,000				
1967	MAY 24	205,000				
1968	JUN 4	129,000				
1969	MAY 20	182,000				
1970	JUN 7	227,000				
1971	MAY 30	253,000				
1972	JUN 2	237,000				

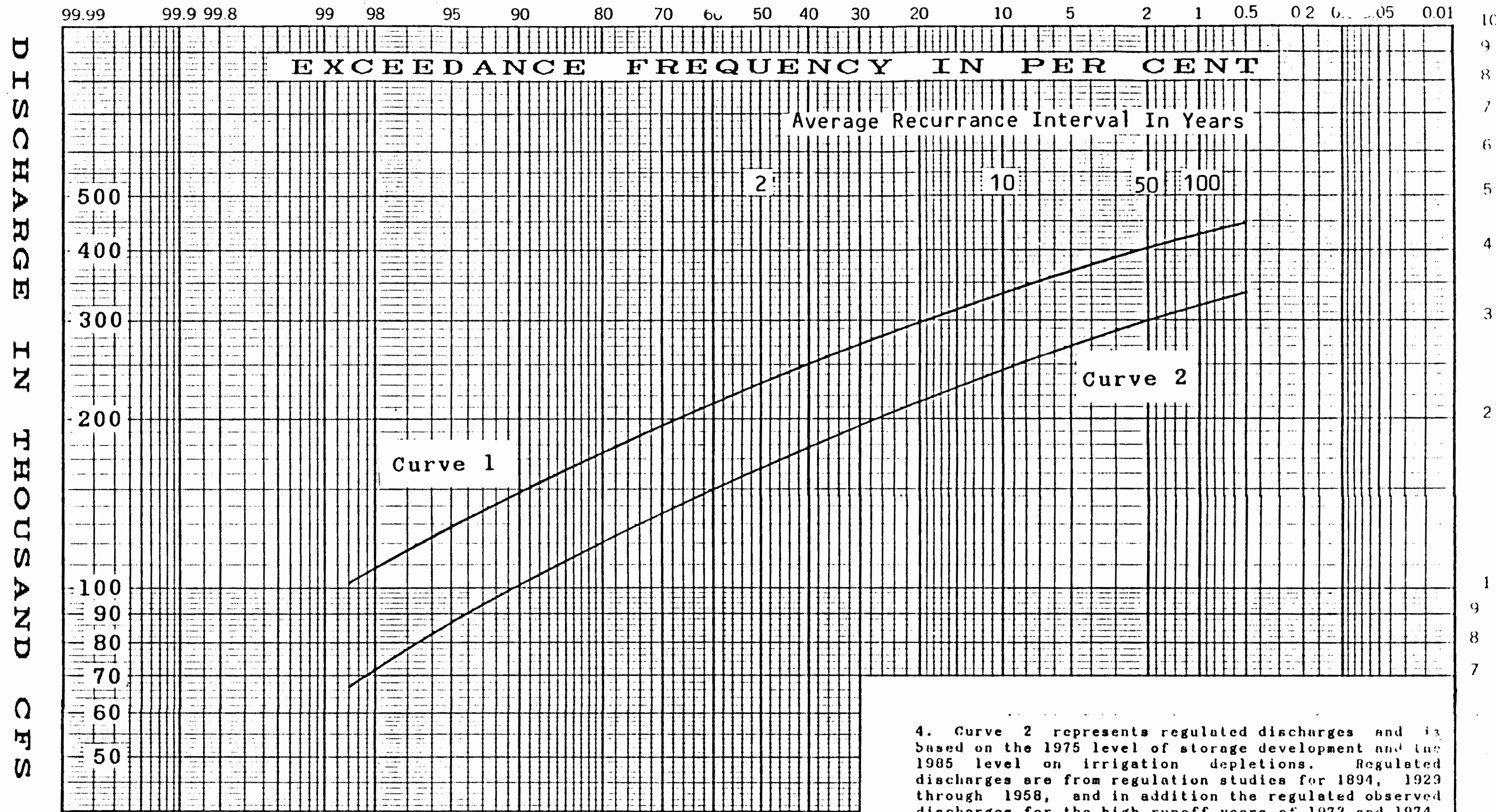
REVISION	DATE	DESCRIPTION	CHKD	APPR

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

ICE HARBOR LOCK & DAM
SNAKE RIVER, OREGON, WASHINGTON, & IDAHO

SUMMARY HYDROGRAPHS
SNAKE RIVER NEAR CLARKSTON, WASH

D. Brooks — DESIGNED BY
Gerber Plotter — DRAWN BY
E Kim — CHECKED BY
SUPERVISED: [signature] CHIEF HYDROLOGY BR
SUBMITTED: (Acting) [signature] CHIEF PLANNING DIVISION
RECOMMENDED
CHIEF
APPROVED DATE
SCALE AS SHOWN INV. NO.
SHEET NO FILE 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.

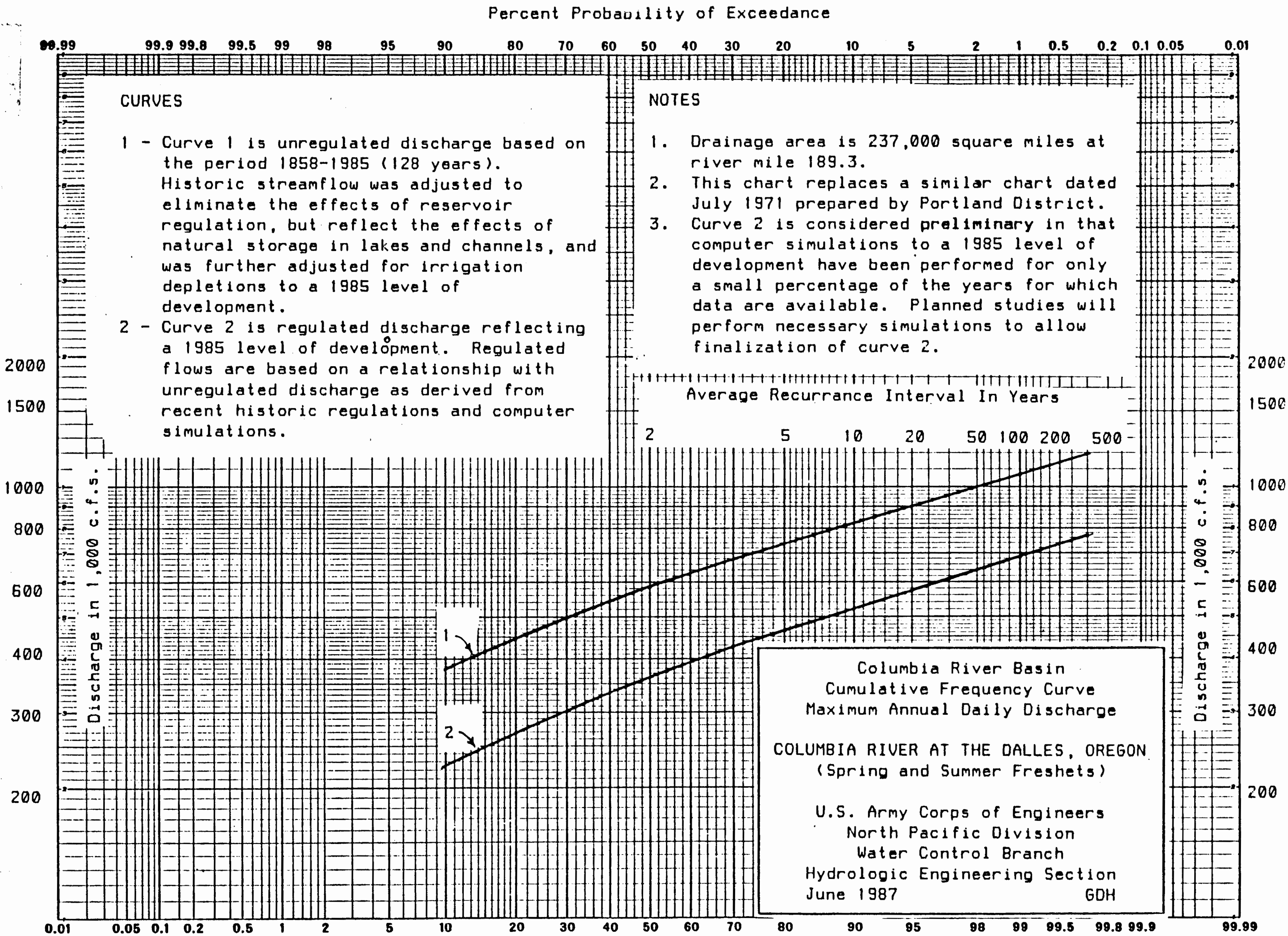
2. This is a preliminary graph subject to revision.

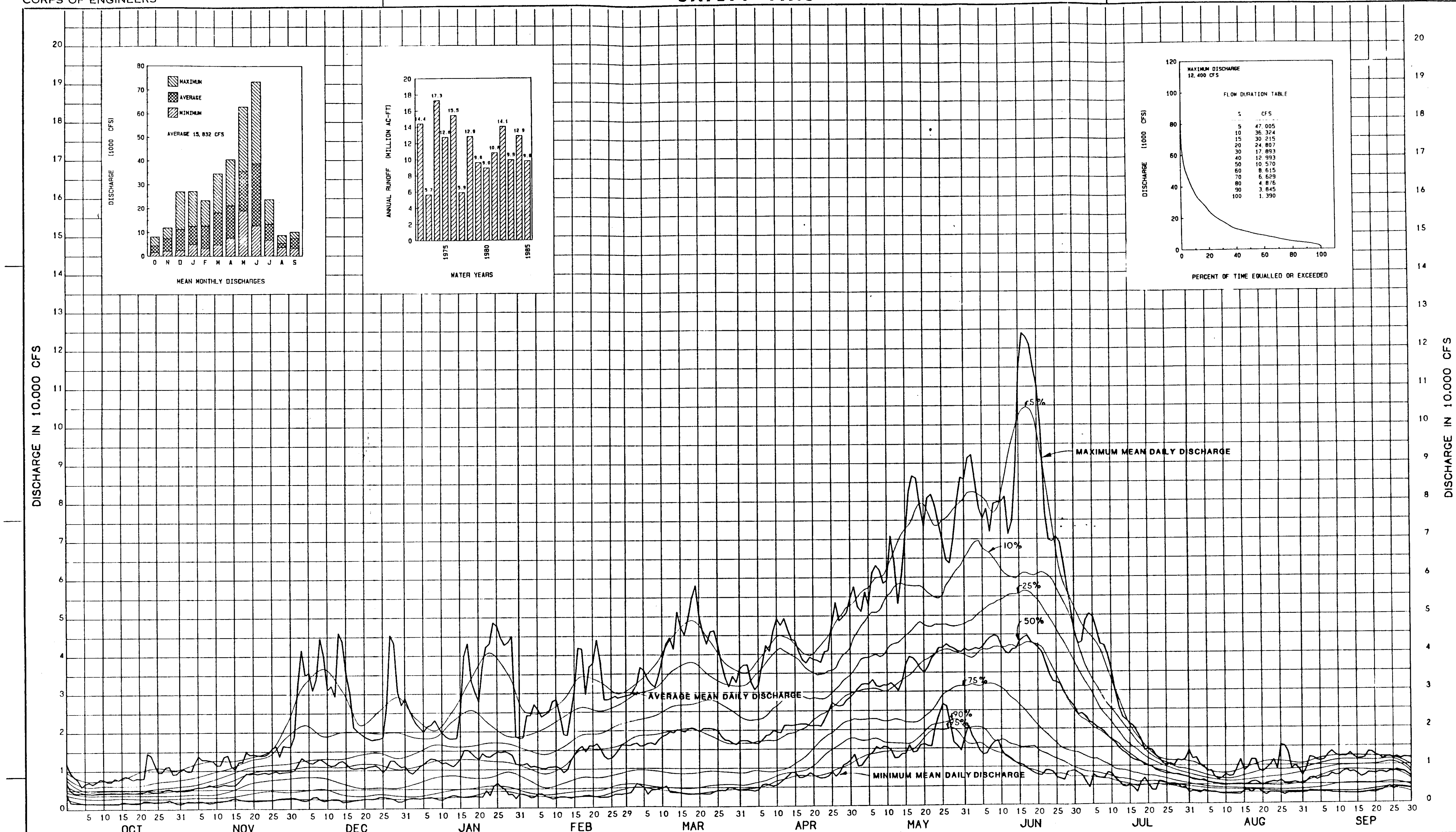
3. Curve 1 represents natural discharges and is based on the 1894-1975 station record adjusted for irrigation depletions and storage and extended by correlation with the 1858-1975 Columbia River at The Dalles station record. It includes an expected probability adjustment. The station and adopted skew 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.

ICE HARBOR LOCK AND DAM
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


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
Discharge in 1,000 c.f.s.
2000 1500 1000 800 600 400 300 200
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



NOTES:

1. RECORDS USED:
   WATER YEARS 1972-1985, OBSERVED DISCHARGES FOR THE CLEARWATER RIVER AT SPALDING, IDAHO.
   DISCHARGE RECORDS USED ARE FROM DATA PUBLISHED BY U.S.G.S.
2. DRAINAGE AREA IS 9,570 SUUARE MILES.
3. 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 OF TIME.

MAXIMUM ANNUAL MEAN DAILY DISCHARGES

WATER YEAR	DATE	CFS		WATER YEAR	DATE	CFS
1972	JUN 2	92,200				
1973	MAY 18	34,200				
1974	JUN 16	124,000				
1975	JUN 3	74,200				
1976	MAY 11	70,800				
1977	MAY 3	28,500				
1978	JUN 7	54,000				
1979	MAY 24	60,700				
1980	MAY 26	48,200				
1981	JUN 20	64,000				
1982	JUN 17	62,500				
1983	MAY 28	54,800				
1984	MAY 31	75,700				
1985	JUN 8	55,100				

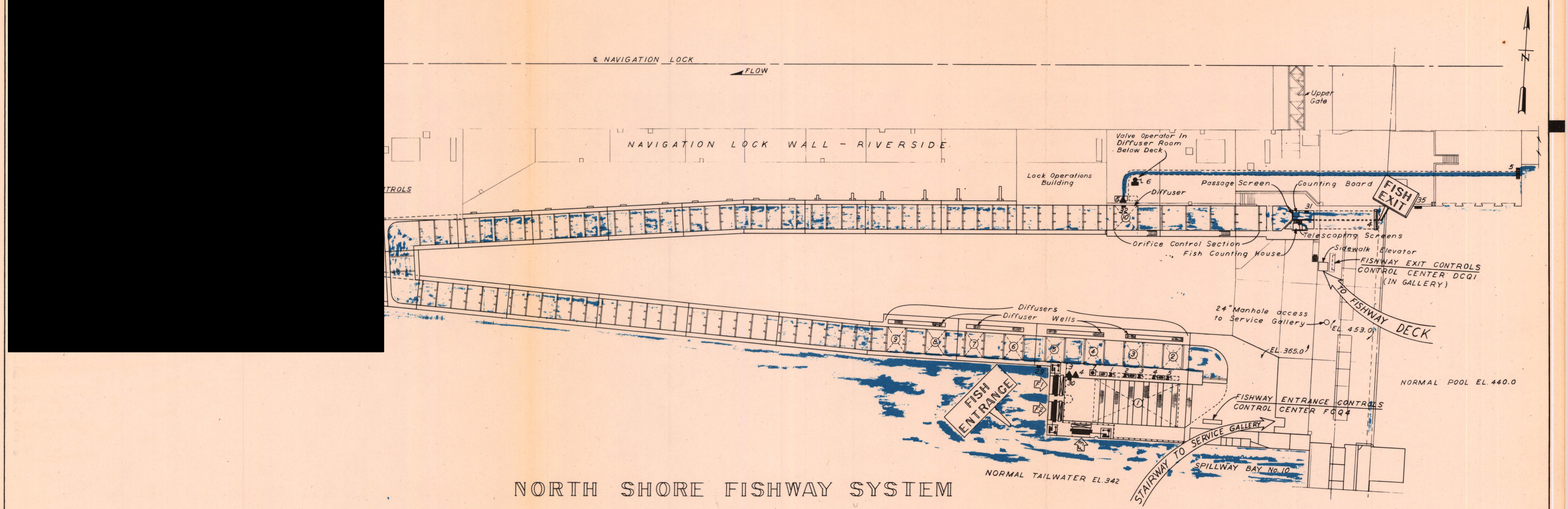
REVISION	DATE	DESCRIPTION	BY

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

DESIGNED: D. Brooks
DRAWN: Barbar Pfeffer
CHECKED: E. Kim
SUPERVISED: K. Kuhl, CHIEF, HYDROLOGY BRANCH
SUBMITTED: (acting) Brian J. Beechie, CHIEF, PLANNING DIVISION

ICE HARBOR LOCK & DAM
SNAKE RIVER, ORE., WASH. AND IDAHO
SUMMARY HYDROGRAPHS
CLEARWATER RIVER AT SPALDING, IDAHO
REGULATED DISCHARGE

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

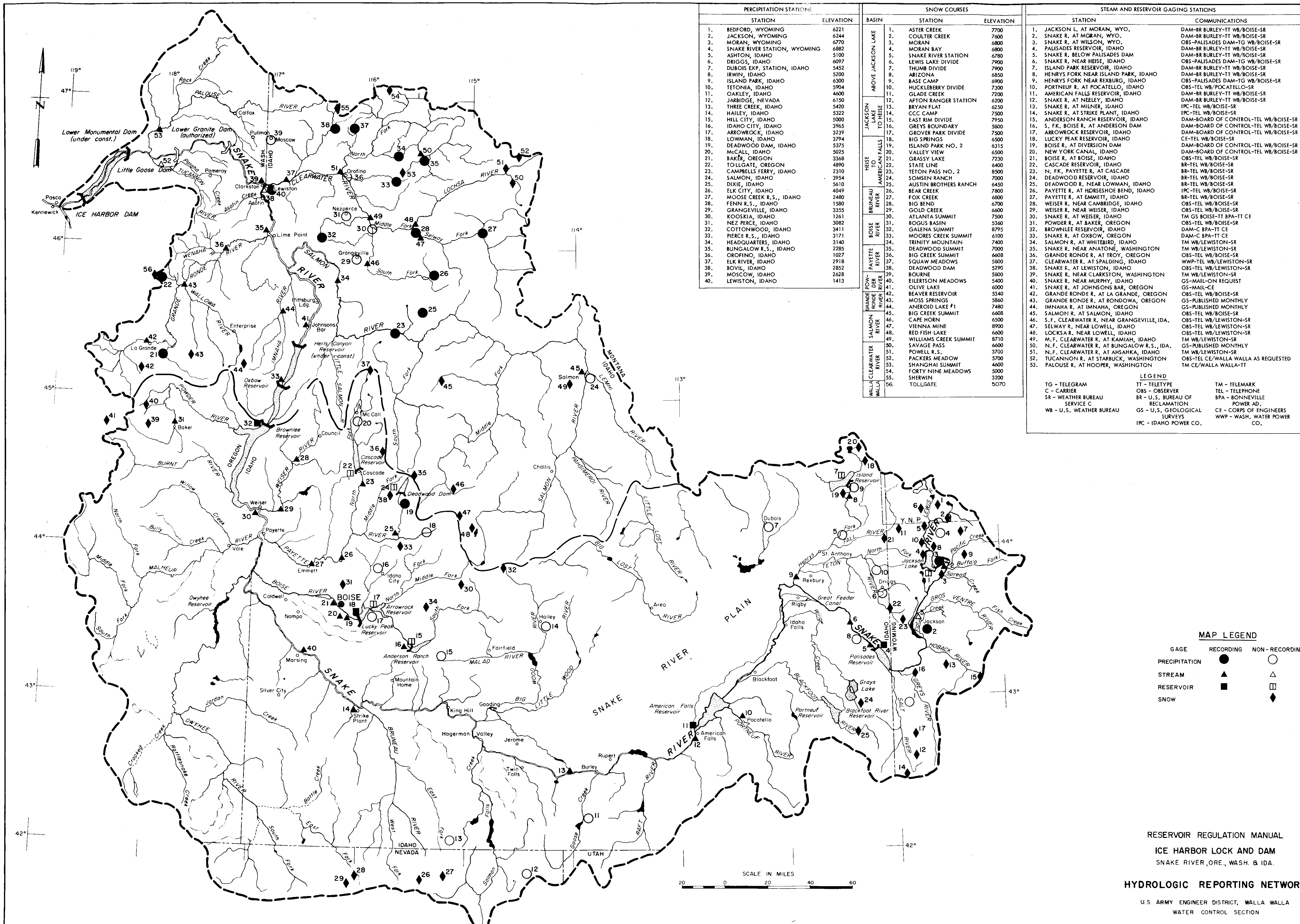


NORTH SHORE FISHWAY SYSTEM

SCALE IN FEET
20 0 20 40 60

EQUIPMENT LEGEND

Pump Intake	Float Wells
Fish Entrance	Diffuser (Sluice) Gates & Operators 1 thru 6
Staff Gages	
Bulkhead Slot	Hoist Machinery
Unwatering Pump	Telescoping Weir EW1, EW2, EW3
Fishway Pump	Trash Rack or Bulkhead Slot
Mud Valve	Diffusers



PERCIPITATION STATIONS		
	STATION	ELEVATION
1.	BEDFORD, WYOMING	6221
2.	JACKSON, WYOMING	6244
3.	MORAN, WYOMING	6770
4.	SNAKE RIVER STATION, WYOMING	6882
5.	ASHTON, IDAHO	5100
6.	DRIGGS, IDAHO	6097
7.	DUBOIS EXP. STATION, IDAHO	5452
8.	IRWIN, IDAHO	5200
9.	ISLAND PARK, IDAHO	6300
10.	TETONIA, IDAHO	5904
11.	OAKLEY, IDAHO	4600
12.	JARBIDGE, NEVADA	6150
13.	THREE CREEK, IDAHO	5420
14.	HAILEY, IDAHO	5322
15.	HILL CITY, IDAHO	5000
16.	IDAHO CITY, IDAHO	3965
17.	ARROWROCK, IDAHO	3239
18.	LOWMAN, IDAHO	3794
19.	DEADWOOD DAM, IDAHO	5375
20.	McCALL, IDAHO	5025
21.	BAKER, OREGON	3368
22.	TOLLGATE, OREGON	4890
23.	CAMPBELLS FERRY, IDAHO	2310
24.	SALMON, IDAHO	3954
25.	DIXIE, IDAHO	5610
26.	ELK CITY, IDAHO	4049
27.	MOOSE CREEK R.S., IDAHO	2480
28.	FENN R.S., IDAHO	1580
29.	GRANGEVILLE, IDAHO	3355
30.	KOOSKIA, IDAHO	1261
31.	NEZ PERCE, IDAHO	3082
32.	COTTONWOOD, IDAHO	3411
33.	PIERCE R.S., IDAHO	3171
34.	HEADQUARTERS, IDAHO	3140
35.	BUNGALOW R.S., IDAHO	2285
36.	OROFINO, IDAHO	1027
37.	ELK RIVER, IDAHO	2918
38.	BOVIL, IDAHO	2852
39.	MOSCOW, IDAHO	2628
40.	LEWISTON, IDAHO	1413

SNOW COURSES			
BASIN		STATION	ELEVATION
ABOVE JACKSON LAKE	1.	ASTER CREEK	7700
	2.	COULTER CREEK	7600
	3.	MORAN	6800
	4.	MORAN BAY	6800
	5.	SNAKE RIVER STATION	6780
	6.	LEWIS LAKE DIVIDE	7900
	7.	THUMB DIVIDE	7900
	8.	ARIZONA	6850
	9.	BASE CAMP	6900
	10.	HUCKLEBERRY DIVIDE	7300
	11.	GLADE CREEK	7200
JACKSON LAKE TO HEISE	12.	AFTON RANGER STATION	6200
	13.	BRYAN FLAT	6250
	14.	CCC CAMP	7500
	15.	EAST RIM DIVIDE	7950
	16.	GREYS BOUNDARY	5800
	17.	GROVER PARK DIVIDE	7500
HEISE TO AMERICAN FALLS	18.	BIG SPRINGS	6500
	19.	ISLAND PARK NO. 2	6315
	20.	VALLEY VIEW	6500
	21.	GRASSY LAKE	7230
	22.	STATE LINE	6400
	23.	TETON PASS NO. 2	8500
	24.	SOMSEN RANCH	7000
	25.	AUSTIN BROTHERS RANCH	6450
BRUNEAU RIVER	26.	BEAR CREEK	7800
	27.	FOX CREEK	6800
	28.	BIG BEND	6700
	29.	GOLD CREEK	6600
BOISE RIVER	30.	ATLANTA SUMMIT	7500
	31.	BOGUS BASIN	5360
	32.	GALENA SUMMIT	8795
	33.	MOORES CREEK SUMMIT	6100
	34.	TRINITY MOUNTAIN	7400
PAYETTE RIVER	35.	DEADWOOD SUMMIT	7000
	36.	BIG CREEK SUMMIT	6608
	37.	SQUAW MEADOWS	5800
	38.	DEADWOOD DAM	5290
POWDER RIVER	39.	BOURNE	5800
	40.	EILERTSON MEADOWS	5400
	41.	OLIVE LAKE	6000
GRANDE RONDE RIVER	42.	BEAVER RESERVOIR	5340
	43.	MOSS SPRINGS	5860
	44.	ANEROID LAKE #1	7480
SALMON RIVER	45.	BIG CREEK SUMMIT	6608
	46.	CAPE HORN	6500
	47.	VIENNA MINE	8900
	48.	RED FISH LAKE	6600
	49.	WILLIAMS CREEK SUMMIT	8710
CLEARWATER RIVER	50.	SAVAGE PASS	6600
	51.	POWELL R.S.	3700
	52.	PACKERS MEADOW	5700
	53.	SHANGHAI SUMMIT	4600
	54.	FORTY NINE MEADOWS	5000
	55.	SHERWIN	3200
WALLA WALLA	56.	TOLLGATE	5070

STEAM AND RESERVOIR GAGING STATIONS		
	STATION	COMMUNICATIONS
1.	JACKSON L. AT MORAN, WYO.	DAM-BR BURLEY-TT WB/BOISE-SR
2.	SNAKE R. AT MORAN, WYO.	DAM-BR BURLEY-TT WB/BOISE-SR
3.	SNAKE R. AT WILSON, WYO.	OBS-PALISADES DAM-TG WB/BOISE-SR
4.	PALISADES RESERVOIR, IDAHO	DAM-BR BURLEY-TT WB/BOISE-SR
5.	SNAKE R. BELOW PALISADES DAM	DAM-BR BURLEY-TT WB/BOISE-SR
6.	SNAKE R. NEAR HEISE, IDAHO	OBS-PALISADES DAM-TG WB/BOISE-SR
7.	ISLAND PARK RESERVOIR, IDAHO	DAM-BR BURLEY-TT WB/BOISE-SR
8.	HENRYS FORK NEAR ISLAND PARK, IDAHO	DAM-BR BURLEY-TT WB/BOISE-SR
9.	HENRYS FORK NEAR REXBURG, IDAHO	OBS-PALISADES DAM-TG WB/BOISE-SR
10.	PORTNEUF R. AT POCATELLO, IDAHO	OBS-TEL WB/POCATELLO-SR
11.	AMERICAN FALLS RESERVOIR, IDAHO	DAM-BR BURLEY-TT WB/BOISE-SR
12.	SNAKE R. AT NEELEY, IDAHO	DAM-BR BURLEY-TT WB/BOISE-SR
13.	SNAKE R. AT MILNER, IDAHO	IPC-TEL WB/BOISE-SR
14.	SNAKE R. AT STRIKE PLANT, IDAHO	IPC-TEL WB/BOISE-SR
15.	ANDERSON RANCH RESERVOIR, IDAHO	DAM-BOARD OF CONTROL-TEL WB/BOISE-SR
16.	S. FK. BOISE R. AT ANDERSON DAM	DAM-BOARD OF CONTROL-TEL WB/BOISE-SR
17.	ARROWROCK RESERVOIR, IDAHO	DAM-BOARD OF CONTROL-TEL WB/BOISE-SR
18.	LUCKY PEAK RESERVOIR, IDAHO	CE-TEL WB/BOISE-SR
19.	BOISE R. AT DIVERSION DAM	DAM-BOARD OF CONTROL-TEL WB/BOISE-SR
20.	NEW YORK CANAL, IDAHO	DAM-BOARD OF CONTROL-TEL WB/BOISE-SR
21.	BOISE R. AT BOISE, IDAHO	OBS-TEL WB/BOISE-SR
22.	CASCADE RESERVOIR, IDAHO	BR-TEL WB/BOISE-SR
23.	N. FK. PAYETTE R. AT CASCADE	BR-TEL WB/BOISE-SR
24.	DEADWOOD RESERVOIR, IDAHO	BR-TEL WB/BOISE-SR
25.	DEADWOOD R. NEAR LOWMAN, IDAHO	BR-TEL WB/BOISE-SR
26.	PAYETTE R. AT HORSESHOE BEND, IDAHO	IPC-TEL WB/BOISE-SR
27.	PAYETTE R. AT EMMETT, IDAHO	BR-TEL WB/BOISE-SR
28.	WEISER R. NEAR CAMBRIDGE, IDAHO	OBS-TEL WB/BOISE-SR
29.	WEISER R. NEAR WEISER, IDAHO	OBS-TEL WB/BOISE-SR
30.	SNAKE R. AT WEISER, IDAHO	TM GS BOISE-TT BPA-TT CE
31.	POWDER R. AT BAKER, OREGON	OBS-TEL WB/BOISE-SR
32.	BROWNLEE RESERVOIR, IDAHO	DAM-C BPA-TT CE
33.	SNAKE R. AT OXBOW, OREGON	DAM-C BPA-TT CE
34.	SALMON R. AT WHITEBIRD, IDAHO	TM WB/LEWISTON-SR
35.	SNAKE R. NEAR ANATONE, WASHINGTON	TM WB/LEWISTON-SR
36.	GRANDE RONDE R. AT TROY, OREGON	OBS-TEL WB/BOISE-SR
37.	CLEARWATER R. AT SPALDING, IDAHO	WWP-TEL WB/LEWISTON-SR
38.	SNAKE R. AT LEWISTON, IDAHO	OBS-TEL WB/LEWISTON-SR
39.	SNAKE R. NEAR CLARKSTON, WASHINGTON	TM WB/LEWISTON-SR
40.	SNAKE R. NEAR MURPHY, IDAHO	GS-MAIL-ON REQUEST
41.	SNAKE R. AT JOHNSONS BAR, OREGON	GS-MAIL-CE
42.	GRANDE RONDE R. AT LA GRANDE, OREGON	OBS-TEL WB/BOISE-SR
43.	GRANDE RONDE R. AT RONDOWA, OREGON	GS-PUBLISHED MONTHLY
44.	IMNAHA R. AT IMNAHA, OREGON	GS-PUBLISHED MONTHLY
45.	SALMON R. AT SALMON, IDAHO	OBS-TEL WB/BOISE-SR
46.	S.F. CLEARWATER R. NEAR GRANGEVILLE, IDA.	OBS-TEL WB/LEWISTON-SR
47.	SELWAY R. NEAR LOWELL, IDAHO	OBS-TEL WB/LEWISTON-SR
48.	LOCKSA R. NEAR LOWELL, IDAHO	OBS-TEL WB/LEWISTON-SR
49.	M.F. CLEARWATER R. AT KAMIAH, IDAHO	TM WB/LEWISTON-SR
50.	N.F. CLEARWATER R. AT BUNGALOW R.S., IDA.	GS-PUBLISHED MONTHLY
51.	N.F. CLEARWATER R. AT AHSAHKA, IDAHO	TM WB/LEWISTON-SR
52.	TUCANNON R. AT STARBUCK, WASHINGTON	OBS-TEL CE/WALLA WALLA AS REQUESTED
53.	PALOUSE R. AT HOOPER, WASHINGTON	TM CE/WALLA WALLA-TT

LEGEND

TG - TELEGRAM	TT - TELETYPE	TM - TELEMARK
C - CARRIER	OBS - OBSERVER	TEL - TELEPHONE
SR - WEATHER BUREAU SERVICE C	BR - U.S. BUREAU OF RECLAMATION	BPA - BONNEVILLE POWER AD.
WB - U.S. WEATHER BUREAU	GS - U.S. GEOLOGICAL SURVEYS	CE - CORPS OF ENGINEERS
	IPC - IDAHO POWER CO.	WWP - WASH. WATER POWER CO.

RESERVOIR REGULATION MANUAL

ICE HARBOR LOCK AND DAM

SNAKE RIVER, ORE., WASH. & IDA.

HYDROLOGIC REPORTING NETWORK

U.S. ARMY ENGINEER DISTRICT, WALLA WALLA

WATER CONTROL SECTION

Prepared J.W. Cayanus

Date: May 1963

Exhibits

** ADDED BY REVISION

ICE HARBOR LOCK AND DAM
DESIGN MEMORANDUMS

No.		Cover Date
	Preliminary Design Report, Powerhouse	December 1959
1	General Plan and Detailed Cost Estimate	31 October 1952
	Supplement 1 to D.M. 1	5 August 1955
2	First-Step Cofferdam and Access Facilities	23 January 1956
3	Powerhouse and Fish Pumping Plant (2 Volumes)	1 February 1956
4	Part 1 - South Shore Permanent Fish Facilities	Not Submitted
	Part 2 - North Shore Fish Facilities	15 July 1959
4.1	Deleted	
4.2	South Shore Visitor Facilities	30 August 1976
5	South Shore Nonoverflow and Spillway Dam	7 June 1957
6	Concrete Aggregate Investigation	20 July 1956
7	Relocation of SP&S Railway	19 September 1956
8	Part 1 - Real Estate, Construction Area	17 August 1955
	Supplement 1 to Part 1	1 August 1956
	Part 2 - Real Estate, Flowage Area	5 November 1957
	Supplement 1 to Part 2	1 June 1961
9	Downstream Gaging Station	June 1960
10	Resident Engineer Office Building	26 June 1956
11	Water Supply	25 July 1956
12	Second-Step Cofferdam	10 June 1958

ICE HARBOR LOCK AND DAM
DESIGN MEMORANDUMS
(CONTINUED)

No.		Cover Date
13	Navigation Facilities and North Nonoverflow Dam	24 November 1958
	Letter Supplement 1, Letter for Equipment Comparison	
13.1	Navigation Approach Channels	22 January 1960
14	Right Abutment Embankment	24 November 1958
15	Landscaping and Grounds Development	27 February 1963
16	Embankment Protection, SP&S	28 February 1958
17.1	UPRR Relocation - Part I	8 October 1958
17.2	UPRR Relocation - Part II	10 March 1959
	Supplement 1 - Relocation Realignment	22 September 1969
18	Embankment Protection, NP Railway	9 July 1959
19	Staffing of Ice Harbor Project	12 April 1957
20	Permanent Warehouse	22 April 1958
21	Remote Operation of Spillway Gates	18 November 1958
22B	Public Use and Access Facilities	22 May 1961
	Supplement 1	19 March 1962
	Supplement 2, Part A	25 June 1963
	Supplement 2, Part B	9 July 1963
23	Foundation Grouting and Drainage	22 October 1957
24	Reservoir Clearing	31 July 1959
25B	The Master Plan with Appendix 1	3 September 1963

ICE HARBOR LOCK AND DAM
DESIGN MEMORANDUMS
(CONTINUED)

No.		Cover Date
25.1	Charbonneau Park	28 January 1969
	Letter Supplement 1, Modification of Water Supply System	19 January 1978
	Letter Supplement 2, Breakwater and Shoreline Protection	12 October 1978
26	Debris Disposal Facilities	19 May 1961
27	Navigation Lock; Upstream Floating Guide Wall	30 November 1960
28	Cost Allocation Studies	21 June 1961
29	Remote Control of Snake River Projects	7 September 1962
	Supplement 1 - Microwave Communications	23 October 1962
	Supplement 2 - Communications System	22 January 1965
30	Navigation Lock Fire Protection System	23 May 1962
31	Preliminary Design Report, Powerplant Units 4-6	March 1968

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 lockage 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 one 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. When the river flow at Lower Granite exceeds 330,000 cubic feet per second the normal minimum 15-foot depth may be decreased to as little as eight 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 be passed in one lockage. 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 m.s.l. 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 Lockmaster. 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 as provided in paragraph (h) of this sections.

(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 one 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 lockage. 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 Lockmaster 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 hollowing 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 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: (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 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 downstream 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, Corps of Engineers, U.S. Army, 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 earth fill section of the dam near the upstream end of the powerhouse.

(3) At the 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° 30' true for a distance of 495 yards, thence 175° 15' true for 707 yards, thence 179° 00' true for 441 yards, thence 235° 00' true for 585 yards, thence 268° 00' 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 83° 00' 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° 00'true for a distance of 340 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$\pm$. 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

PRIMARY CONTACT: WALLA WALLA DISTRICT – Operations Division
(Rick Werner, 509-527-7101, or Andrea Valentine, 509-527-7102)

Who will in turn notify:

1. Chief, Project Operations, Walla Walla District.
2. Public Affairs Office, Walla Walla District.
3. Chief, Project Operations, Northwest Division.
4. Columbia River Towboat Association.

Appendixes

APPENDIXES

	Subject
A	Memorandum of Agreement between the Corps of Engineers and Bonneville Power Administration for Operation of Ice Harbor Project
B	Ice Harbor Navigation Lock Regulations
C	Public Notice

APPENDIX A

Memorandum of Agreement between the Corps of Engineers and Bonneville Power Administration for Operation of Ice Harbor Project

TO BE PROVIDED BY N.P.D.

-H2C- APPENDIX B

-H3C- PART 207--NAVIGATION REGULATIONS

-S2C- ICE HARBOR DAM NAVIGATION LOCK AND APPROACH CHANNELS

-S2C- SNAKE RIVER, WASH.

P Pursuant to the provisions of Section 7 of the River and Harbor Act of August 8, 1917 (40 Stat. 266; 33 U.S.C. 1), Section 207.716 is hereby prescribed governing the use, administration, and navigation of the Ice Harbor Dam Navigation Lock and Approach Channels, Snake River, Washington, effective 30 days after publication in the FEDERAL REGISTER, as follows:

P 207.716 Ice Harbor Dam Navigation Lock and Approach Channels, Snake River, Wash.; Use, Administration, and Navigation. (a) General. The lock and its approach channels, and all its appurtenances, shall be under the jurisdiction of the District Engineer, Corps of Engineers, United States Army, in charge of the locality. His representative at Ice Harbor Dam shall be the Project Engineer, who shall customarily give orders and instructions to the lock master and assistant lock masters in charge of the lock. Hereinafter, the term "lock master" shall be used to designate the lock official 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 such steps as may be immediately necessary without waiting for instructions from the Project Engineer.

P (b) Immediate 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. He shall see that all laws, rules, and regulations for the use of the lock and lock area are duly complied with, to which end he is authorized to give all necessary orders and directions, both to employees of the Government and to any and every person within the limits of the lock or lock area, whether navigating the lock or not. It shall be the duty of the Project Engineer to establish lines of succession for the men operating the lock on all shifts in order that in case of absence or accident to the designated lock master, one of his assistants will immediately assume the position of lock master.

P (c) Authority of lock master. No one shall cause any movement of any vessel, boat, or other floating thing in the lock or approaches except by or under the direction of the lock master or his assistants.

P (d) Signals: (1) Sound. All craft desiring lockage shall signal by two long and two short blasts of their whistle, delivered at a distance of one-half mile from the lock. When the lock is ready for entrance, notice will be given by one long blast. Permission to leave the lock will be given by one short blast. NOTE: Signal stations are provided at the upstream and downstream guide walls for use of small craft not equipped with signal equipment.

(2) Visual. Visual signals are located outside each lock gate and will be used in conjunction with the sound signals. When the green light is on, the lock is ready for entrance and vessels may enter under full control. When the red light is on, the lock cannot be made ready immediately and the vessel shall stand clear.

(3) Radio. The lock is equipped with two-way radio operating on frequencies of 2784 and 2182 kc. These frequencies are monitored by the lock master. Vessels equipped with two-way radio may communicate with the crew operating the lock but communications or signals so received will only augment and not replace the sound and visual signals.

(e) Permissible dimensions of boats. The lock chamber is 86 feet wide by 664.5 feet long in the clear. Single tows aggregating 650 feet or less in length will be permitted to lock through without disassembly. At normal pool elevation of 440 feet above m.s.l., the depth of water over the upstream gate sill will be 18 feet. The upstream sill elevation is 422 feet m.s.l. The depth of water over the downstream gate sill will depend upon the flow in the river but will usually exceed 19 feet when McNary Pool is at 340 feet m.s.l. The downstream gate sill elevation is 321 feet m.s.l. Gauges are located on the guide walls at each end of the lock and on the lock walls at each end. These gauges indicate water surface elevations in feet above m.s.l. Depth of water over the sills should be calculated before entrance into the lock. A craft must not attempt to enter the lock if its beam and length are greater than the above-indicated dimensions or if its draft exceeds the calculated depth over the sills with adequate allowances for safe clearances.

(f) Precedence at lock. Ordinarily the boat arriving before all others at the lock will be locked through first; however, depending upon whether the lock is full or empty, this precedence may be modified at the discretion of the lock master if boats are approaching from the opposite direction and are within reasonable distance of the lock at the time of the approach by the first boat. When several boats are to pass, precedence shall be given as follows:

First. Boats and craft owned by the United States and engaged upon river and harbor improvement work.

Second. Freight and tow boats.

Third. Rafts.

Fourth. Passenger boats.

Fifth. Small vessels and pleasure craft.

(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) Multiple lockage. The lock master shall decide whether one or more vessels may be locked through at the same time.

(i) Speed. 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.

(j) Lockage of small boats. (1) General. The lockage of pleasure boats, skiffs, fishing boats, and other small craft will be coordinated with the lockage of commercial craft, other than barges handling petroleum products or highly hazardous materials. If no commercial craft are scheduled to be locked through within a reasonable time not to exceed one hour after the arrival of the small craft at the lock, separate lockage will be made for such small craft.

(2) Signals. Signal stations which are connected to a bell located at the lock are located on the upstream and downstream guide walls to provide facilities for small boats to notify the lock master they desire lockage. The upstream station is located near the upstream end of the north guide wall. The downstream station is located on the north guidewall about 400 feet below the gate. Small boats desiring to use the lock will sound two long and two short rings of the bell for upstream lockage and two long and three short rings for downstream lockage. When the lock is ready for entrance, the lock master will notify the small boat by one long blast of the horn. Permission to leave the lock will be given by one short blast of the horn. The boat will wait at the signal station until the lock master signals to enter.

(k) Mooring in lock. All boats, rafts, and other craft when in the locks shall be moored by head and spring lines and such other lines as may be necessary to the fastenings provided for that purpose, and the lines shall not be released until the signal is given for the vessel to leave the lock. (Do not moor to stationary bits or ladders.)

(l) Mooring in approaches prohibited. The mooring or anchoring of boats or other craft in the approaches to the lock where such mooring will interfere with navigation through the lock is prohibited. Rafts to be passed through the lock shall be moored so as not to interfere with the navigation through lock or its approaches, and, if the raft is to be divided into sections for locking, the sections shall be brought into the lock as directed by the lock master. After passing through the lock, the sections shall be reassembled at such a distance from the entrance so as not to obstruct or interfere with navigation through the lock and approaches.

(m) Waiting for lockage. Boats and tows waiting downstream of the dam for lockage shall wait in the clear downstream of the navigation lock approach channel, or, contingent upon prior radio clearance of the lock master, may at their own risk lie inside the 250-foot approach channel alongside the north shore, provided that a 150-foot wide open channel is maintained between the boat or tow and the offshore guide wall. Vessels waiting upstream of the dam for lockage may lay to against the offshore floating guide wall provided they remain not less than 400 feet upstream of the upstream lock gate. In either event, a clear channel not less than 150 feet wide shall be kept open to accommodate passing traffic.

(n) Delay in lock. Boats or barges must not obstruct navigation by unnecessary delay in entering or leaving the lock.

(o) Damage to lock or other structures. The regulations contained in this section shall not affect the liability of the owners and operators of vessels for any damage by their operations to the lock or other structures. They 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 boats with metal nosings or projecting irons, or rough surfaces which may damage the gates or lock walls, will not be permitted to enter the lock unless provided with suitable buffers and fenders.

(p) Tows. Persons in charge of vessel towing a second vessel or barge by lines shall take the second vessel or barge alongside at a distance of at least 300 feet from the lock gate toward which the vessel is approaching and keep it alongside until at least 300 feet clear of the gate at the end from which it is departing.

(q) Crew to move craft. The masters in charge of tows and the persons in charge of rafts and other craft must provide a sufficient number of men to move barges, rafts, and other craft into and out of the lock easily and promptly.

(r) 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, but the lock master may call for assistance from the master of any boat using the lock, should such aid be necessary, and when rendering such assistance, the men so employed shall be strictly 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.

(s) Landing of freight. No one shall land freight or baggage on or over the walls of the lock so as in any way to delay or interfere with navigation or the operations of the lock. Freight and baggage consigned to Ice Harbor Project shall be landed only at such places as are designated by the lock master or his assistants.

(t) Refuse in locks. No material of any kind shall be thrown or discharged into the lock, and no material of any kind shall be deposited in the lock area.

(u) Statistics. On each passage through the lock, masters or pursers of vessels shall make to the lock master such written statement of passengers, freight, and registered tonnage and other information as are indicated on forms furnished such masters or pursers by the lock master.

(v) Persistent violation of regulations. If the owner or master of any boat persistently violates these regulations after due notice of the same, the boat or master may be refused lockage by the lock master at the time of violation or subsequent thereto if deemed necessary in the opinion of the lock master to protect Government property and works in the vicinity of the lock.

(w) Restricted areas. (1) All the waters described in subparagraphs (2) and (3) of this paragraph are restricted to all boats except those of the United States Coast Guard and Corps of Engineers.

(2) All of the waters downstream of the dam which are bounded on the east by the dam, on the north by the guide wall, on the south by the shore of the river, and on the west by a line approximately one-fourth mile downstream of the dam, the north end of which is indicated by the downstream end of the guide wall, and on the south by the downstream transmission line tower.

(3) All waters within a distance of about 2,400 feet above the dam lying south of the navigation channel leading to the lock. This restricted area is marked by a line of buoys extending 1,800 feet upstream from the end of the floating guide wall, and thence, across the river to the south shore.

JULIAN A. WILSON
Major General, U.S. Army
Acting The Adjutant General

(F. R. Doc. 62-4848; Filed, May 18, 1962; 8:45 a.m.)

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Published in Federal Register, Volume 27, Number 98, dated May 19, 1962.

APPENDIX C

U. S. ARMY ENGINEER DISTRICT, WALLA WALLA
CORPS OF ENGINEERS
Bldg. 602, City-County Airport
Walla Walla, Washington

EXAMPLE

NPWKO 2 May 1962

PUBLIC NOTICE

Fluctuations in Snake River at Ice Harbor Dam

Navigation interests and small boat operators are hereby notified of unusual fluctuations proposed for the Snake River near Ice Harbor Dam on dedication day, 9 May 1962.

Beginning sometime after 10 a.m., spillway gates will be closed and only a minimum flow of 15,000 cubic feet per second will pass the dam. The pool will then be raised rapidly to approach the normal elevation of 440 feet at approximately 3:30 p.m. Then the spillway gates will be opened gradually to allow the full flow of the river to pass the dam, causing a rapid rise of the river below the dam of about 6 or 7 feet in one-half hour and creating considerable turbulence and fast water for about two miles downstream from the dam. Total river rise immediately below the dam may be as much as 10 feet.

Boats should not be anchored or beached in the Snake River below Ice Harbor Dam during this period of unusual fluctuations.

Ice Harbor lock will be operated on the day of dedication at special times only between 8 a.m. and 8 p.m. Full-time operation of the lock will be announced at a later date.

Richard L Earnheart
RICHARD L. EARNHEART
Chief, Operations Division