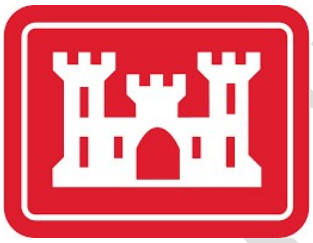
WATER CONTROL MANUAL

ROUGH RIVER RESERVOIR

Green River Basin



U.S. ARMY CORPS OF ENGINEERS
LOUISVILLE DISTRICT, GREAT LAKES AND OHIO RIVER DIVISION
Louisville, Kentucky

PREPARED BY
U.S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
JANUARY 2024

WATER CONTROL MANUAL

ROUGH RIVER RESERVOIR
Green River Basin
Kentucky

U.S. ARMY CORPS OF ENGINEERS
LOUISVILLE DISTRICT
LOUISVILLE, KENTUCKY

February 1967
REVISED JANUARY 2024

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Record of Changes

(1) 27 October 1969, ORLED-H: *Report on Feasibility of Increasing Minimum Pool Levels, Barren, Nolin and Rough River Reservoirs*; January 1970 – minimum Rough River pool raised from 465.0 to 470.0

(2) December 2002 – minimum Rough River pool raised from 470.0 to elevation 475.0

(3) December 2012 – minimum Rough River pool lowered from 475.0 to elevation 470.0

(4) April 2023 – spring fill begins on April 1. Summer pool elevation of 490 feet NGVD29 will be targeted

Notice to Users of This Manual

Regulations specify that this 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. Changes to individual pages must carry the date of revision, which is the Division's approval date.

WATER CONTROL MANUAL
ROUGH RIVER RESERVOIR

U.S. Army Corps of Engineers
Louisville District
February 2022

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Unit Conversions

1 acre	43,560 square feet
1 acre-foot	43,560 cubic feet
1 square mile (sq. mi.)	640 acres
1 meter	3.28083 feet
MSL	Mean Sea Level
NAVD88	North American Vertical Datum of 1988; NAVD88 = MSL – 0.43 feet
NGVD29	National Geodetic Vertical Datum of 1929; NGVD29 = MSL

Definitions and Common Terminology

Acre-foot: A unit of volume equal to the volume of a sheet of water one acre in area and one foot in depth; 43,560 cubic feet.

AHPS: (NWS) Advanced Hydrologic Prediction Service

cfs: Cubic feet per second

CWMS: Corps Water Management System

HEC: USACE Hydrologic Engineering Center

HEC-HMS: HEC Hydrologic Modeling System

HEC-RAS: HEC River Analysis System

HEC-ResSim: HEC Reservoir System Simulation model

KDFWR: Kentucky Department of Fish and Wildlife Resources

KDP: Kentucky Department of Parks

KDOW: Kentucky Division of Water

MSL: Mean Sea Level

NAVD88: North American Vertical Datum of 1988, equal to MSL – 0.43 feet

NGVD29: National Geodetic Vertical Datum of 1929; equal to MSL

NWS: National Weather Service

OHRFC: (NWS) Ohio River Forecast Center

QPF: Quantitative precipitation forecast

Recurrence interval: Also called return period – estimated average time between events in years, e.g. a 5-year flood will be exceeded on average once every 5 years

RRR: Rough River Reservoir

Telemark: Automated river stage data collection and transmission system

USACE: United States Army Corps of Engineers (Corps)

USACE-LRD (LRD): United States Army Corps of Engineers, Great Lakes and Ohio River Division

USACE-LRL (LRL): United States Army Corps of Engineers, Louisville District

USEPA: United States Environmental Protection Agency

USGS: United States Geological Survey

Pertinent Data

Authority for Project. Flood Control Act approved 28 June 1938.

Location. The project is located on Rough River in west central Kentucky, approximately 60 air miles southwest of Louisville, Kentucky. The dam site is 89.3 miles above the mouth of Rough River, which flows into the Green River at Livermore. Green River Lock 2 at Calhoun is 8.1 miles downstream of Livermore. The reservoir impounds areas in Breckinridge, Grayson, and Hardin counties.

Area protected. The reservoir operates as a unit of the general reservoir plan for the Ohio River Basin to effect reduction in flood stages at all points downstream from the reservoir. The area receiving the most positive protection consists of 36,000 acres in the Rough River valley, including the reach of the Rough River between the dam and the upstream limit of backwater from Green River.

Drainage Areas

Dam site	454 sq. mi.
Mouth of Rough River	1,081 sq. mi.
Lock 2, Green River	7,564 sq. mi.
Mouth of Green River	9,229 sq. mi.

Dam

Type:	Rolled earth fill
Maximum height, feet	130
Total Length, feet	1,590
Top elevation (feet MSL)[1]	556 + 3-foot parapet wall
Crown width, feet	40
Side slopes, upstream –	
2H:1V (elevation 556-**495**)	
3H:1V (elevation **495** to 471)	
4H:1V (elevation 471 to base)	
Side slopes, downstream –	
2H:1V (elevation 556-539)	
2.5H:1V (elevation 539 to 531)	
3H:1V (elevation 531 to base)	

[1] All elevations are in feet MSL unless otherwise stated

Spillway

Type:	Cut through left embankment
Crest elevation (feet MSL)	524.0
Base width of cut, feet	65
Side slopes	Rock 1 horizontal to 4 vertical Earth 2 horizontal to 1 vertical
Approach channel	Length 860 feet Slope 0.5 percent adverse
Exit channel	Length 820 feet Slope 0.5 percent positive

Outlet Works

Type:	Concrete, semi-elliptical conduit
Size, feet	12 x 12
Control gates, number	3 service, 1 emergency
Control gates, size, feet	4.75 x 9.5
Inlet invert elevation (feet MSL)	430
Discharge capacity, cfs	
At minimum pool elevation (470.0)	3,240
At top of conservation pool level (490.0)	4,240
At top of flood control pool (524.0)	5,580
Bypasses, number	2
Bypass diameter (inches)	24
Bypass inlet invert elevation (feet MSL)	449.8

Reservoir

	Elevation (feet MSL)	Surface Area (acres)	Storage Capacity (acre feet)	Equivalent Runoff (inches)
Minimum pool	470	1,700	29,800	1.23
Seasonal pool	490	4,500	95,940	3.96
Flood pool	524	10,260	334,380	13.81
Allocated to flood control	470-524	--	304,580	12.58
Available for seasonal flow regulation	470-490	--	66,140	2.71
Minimum available for seasonal flood control	490-524	--	238,440	9.85

Note: One inch of runoff over the 454-square mile drainage area at the dam is equivalent to 24,213 acre-feet of inflow to the reservoir.

Spillway Design Flood (1958 criteria)

All-season design flood

Total precipitation in 48 hours, inches	27.6
Total volume of runoff, inches	25.3[2]
Peak reservoir inflow, cfs	358,000
Total volume of hydrograph, acre-feet	607,000

All-season design flood routing results

Elevation of pool at start of flood	503
Release up to spillway crest elevation, cfs	100
Maximum spillway discharge, cfs	27,940[3]
Maximum water surface elevation	549.1
Adopted freeboard, feet	4.9

[2] Includes 0.2-inch recession of June 1935 flood
[3] Conduit discharge – 5,940 cfs; spillway discharge – 22,000 cfs

1.0 **INTRODUCTION**

1.01 Authorization for Manual

This manual is prepared according to instructions and criteria contained in Engineer Regulation 1110-2-240, *Water Control Management*, dated 30 May 2016, Engineer Manual 1110-2-3600, *Management of Water Control Systems*, dated 30 November 1987, Engineer Regulation 1110-2-8156, *Preparation of Water Control Manuals*, dated 30 September 2018, and Engineer Regulation 1110-2-8160, *Policies for Referencing of Project Elevation Grades to Nationwide Vertical Datums,* dated 1 March 2009.

1.02 Purpose and Scope

The purpose of this manual is to describe the general plan for the regulation of Rough River Reservoir in the Green River Basin. The manual will serve two purposes: first, documentation of the plan of regulation for Rough River Reservoir, and second, as a reference source for higher authority and for new personnel who will become concerned with, or responsible for, regulation of the reservoir during the life of the project. The manual also contains background information necessary for understanding project operational objectives and constraints, and application of water management schedules.

1.03 Related Manuals and Reports

The following manuals and reports concerning Rough River Dam have been previously completed:

- *Report on Definite Project for Rough River Reservoir, Kentucky* – July 1941
- Design Memorandum 1: *General Design Memorandum* – July 1953
- Design Memorandum 2: *Outlet Works* – September 1953
- Supplement to Design Memorandum 2, *Outlet Works* – October 1955
- Design Memorandum 3: *Dam and Spillway* – September 1956
- Supplement 1 to Design Memorandum 3, *Dam and Spillway* – October 1955
- Supplement 2 to Design Memorandum 3, *Dam and Spillway* – March 1957
- Design Memorandum 4: *Report on Necessity for Relocation, Kentucky Highways 65, 108, and 110* – October 1957
- Design Memorandum 5: *Real Estate – Partial Reservoir Area (Segments A, B, C and D)* – April 1957
- Design Memorandum 6: *Pool Preparation* – December 1957
- Design Memorandum 7: *Real Estate, Segments E through W* – January 1958
- Design Memorandum 8: *Preliminary Master Plan* – March 1958
- Design Memorandum 9: *Real Estate, Highway Relocation* – March 1958
- Design Memorandum 10: *Residences, Shop and Miscellaneous Items* – July 1958
- Design Memorandum 11 *Low Flow Regulation* – July 1958
- Design Memorandum 12: *Report on Necessity for Relocation of Electric Power and Telephone Lines* – August 1958
- Design Memorandum 13: *Report on Necessity for Relocation of County Roads* – October 1958
- Design Memorandum 14: *Channel Improvement of Rough River and Channel Improvement of Barnett Creek* – September 1959
- Design Memorandum 15: *Real Estate Required for Channel Cleaning* – 8 January 1960

- *Green River Basin Reservoir Regulation Plan* – February 1967
- *Green River Basin Reservoir Regulation Plan*, Appendix A, *Rough River Reservoir* – February 1967
- *Report on the Feasibility of Increasing Minimum Pool Levels – Barren, Nolin, and Rough River Reservoirs* – October 1969
- *Environmental Assessment, Rough River Lake Dam Rehabilitation, Falls of Rough, Kentucky* – March 2019 (USACE-LRL)

1.04 Project Owner

The project dam site, operations areas, and pool area below fee taking line are owned by the United States Government.

1.05 Operating Agency

Operation of Rough River Reservoir is the responsibility of the U.S. Army Corps of Engineers (USACE). The project is one of four multipurpose reservoirs in the Green River Basin under the jurisdiction of the Louisville District (LRL), Great Lakes and Ohio River Division (USACE-LRD). The dam is staffed daily; project staff consists of one project manager, four rangers, four maintenance workers, seasonal employees and two office administrators. The project telephone number is 270-257-2061.

1.06 Regulating Agency

The Water Management Team, Hydrology and Hydraulics Branch, Engineering Division is responsible for regulating Rough River Reservoir in a manner to provide the best overall benefit associated with the authorized purposes. Daily forecasts of pool elevations, reservoir releases, and control station information are the responsibility of the Water Management Team. Any water control regulation deviating from the approved water control plan as presented in this manual is coordinated with the Water Management Division, Great Lakes and Ohio River Division (LRD).

1.07 Vertical Datum

The Design Memorandums and design documentation for Rough River Dam reference Mean Sea Level (MSL), which has been interpreted to be consistent with the National Geodetic Vertical Datum of 1929 (NGVD29). Unless otherwise noted, the NGVD29/MSL datum is used throughout this manual. At the Rough River Dam location, conversion from NGVD29/MSL to NAVD88 elevation is made by subtraction of 0.43 feet from NGVD29/MSL elevation, e.g. 100 feet NGVD29/MSL = 100 feet – 0.43 = 99.57 feet NAVD88.

2.0 **DESCRIPTION OF PROJECT**

2.01 Location

Rough River Reservoir is located in west central Kentucky approximately 60 miles southwest of Louisville. The dam is located on Rough River 89.3 miles above its confluence with the Green River and 97.5 miles above Lock 2 on the Green River. The dam lies in Breckinridge and Grayson Counties, and the reservoir pool extends into both counties and approximately 45 miles upstream of the dam into Hardin County at flood pool elevation 524.0. The location of the project relative to other LRL dams and reservoirs is shown in **Plate 2-1 Location and Vicinity Map**. A map of the Rough River drainage basin is provided in **Plate 2-2 Map of Drainage Basin**.

2.02 Purpose

Rough River Reservoir is operated as a component of the system of reservoirs in the Green River Basin and part of the comprehensive plan for the Ohio River Basin (Flood Control Act approved 28 June 1938). The reservoir system effects significant reductions in flood stages downstream along the Rough and Green Rivers, and some reductions along the Lower Ohio and Mississippi Rivers as well. Authorized purposes of the project are Flood Risk Mitigation, Water Supply, Water Quality, Recreation, and Fish and Wildlife Enhancement. Some incidental benefit to downstream low flow augmentation and navigation is associated with the annual depletion of storage from summer pool to winter pool.

2.03 Physical Components

a. Dam. The Rough River dam consists of a rolled earth fill with a 3-foot thick layer of dumped stone protection on the upstream face and downstream toe. The top elevation of the embankment is 556, and maximum height above the natural streambed is 130 feet. A three-foot tall parapet wall sits on top of the embankment, extending the height of the dam to elevation 559. Total length of the dam is 1,590 feet. The embankment has a 40-foot top width to accommodate a roadway (Kentucky State Highway 79). Upstream dam slopes vary from 1V (vertical) on 2H (horizontal) near the top to 1V on 4H near the base. Downstream slopes vary from 1V on 2H near the top to 1V on 3H at the base. Embankment materials consist primarily of lean clay, sandy lean clay, and sandy fat clay.

b. Spillway. The general plan of the Rough River dam and spillway is shown in **Plate 2-3 General Plan and Sections**. The spillway is an open cut through the left embankment with a base width of 65 feet, with an approach channel length of 860 feet and an exit channel length of 820 feet. The sides of the spillway are excavated in earth and rock with slopes of 1V on 2H in earth overburden and 4V on 1H in rock. The spillway crest elevation is 524.0, with an adverse approach channel slope upstream of the crest of 0.50 percent, and a positive exit channel slope downstream of the crest of 0.50 percent. Upstream of the constructed spillway is a naturally vegetated swale. The spillway discharges through a wooded ravine into the Rough River approximately 2,000 feet downstream of the toe of the dam. The spillway rating curve is provided in on Plate 8-2.

c. Outlet works. The outlet works consist of a 400-foot long approach channel, intake structure, three service gates, emergency gate, transition, and 548-foot long semi-elliptical conduit discharging to a stilling basin. The stilling basin dissipates high velocities from the conduit exit and prevents damage to the downstream toe of the dam. The basin, which was modified in 2007, is level with the conduit outlet invert and extends 128 feet downstream. The service gates are placed in an intake structure located along the base of the right abutment at the upstream end of the conduit. To avoid frequent use of the main service gates to pass low flows, a low-flow bypass system is provided in the intake structure consisting of two 24-inch diameter reduced to 20-inch diameter circular steel pipes placed in each of the two outlet works piers. A profile through the outlet works is shown in **Plate 2-4 Outlet Works**. Rating curves for the outlet works and low-flow bypass are provided in Chapter 7.

2.04 Related Control Facilities

There are no related control facilities at Rough River Dam.

2.05 Real Estate Acquisition

Detailed information on Real Estate Acquisition is provided in Design Memorandum 5 for Segments A through D, and for Segments E through W in Design Memorandum 7. Within the Rough River Reservoir, the fee line and flowage easement were established using metes and bounds descriptions (i.e. straight lines) in the acquisition deeds. The elevation guide for fee acquisition was set at elevation 514.0 and the elevation guide for acquiring flowage easements was set at 534.0, ten feet above spillway crest. During the original acquisition in the mid-1950s, LRL hired a contractor to mark angle points along the 514.0 and 534.0 contours around the lake perimeter. The contractor surveyed and marked the intended flowage easements line. Because the flowage easements line was marked with temporary wooden stakes, however, and the lines were located and plotted with imprecisions, easement closure also included imprecisions. Furthermore, the 534.0 flowage easement elevation was described using tangent lines (straight-line approximations) instead of actual contour elevations of the land. The legal descriptions were prepared based on this information and then recorded as part of the acquisition deed. These recorded tangent lines descriptions of flowage easements are difficult to accurately locate in the field. One consequence of using the tangent lines for the legal descriptions was that flowage easements were not acquired up to elevation 534 throughout the entire project as intended, and, in many areas, flowage easements were acquired above the 534 elevation. Furthermore, fee simple was not always acquired up to 514.0 as was originally authorized. In total, approximately 6,330 acres were acquired in fee in the Rough River Reservoir and an additional 3,717 acres in easements. The approximate project boundary is displayed in **Plate 2-5 Project Boundary**.

In the 2011 flood event, the pool rose to an elevation of 527.35 and 32 habitable structures (mobile homes) were completely inundated and were required to be removed and replaced with recreational vehicle-style campers. Subsequent surveys found that approximately 416 habitable structures were identified to be located within the acquired flowage easements, many of which were also flooded during the 2011 flood event.

2.06 Public Facilities

There are 21 public access sites in the Rough River Reservoir, eight of which are managed by USACE-LRL. Rough River Dam State Resort park is managed by the Kentucky Department of Parks (KDP). USACE-LRL managed public facilities are mapped in **Plate 2-6 Public Use Sites**.

(1) Rough River Dam State Resort Park. 48-foot boat ramp, 596 car parking spaces, 130 spaces for boating and fishing, 5 picnic sites, 2 group shelters, a 45,000-square foot swimming pool, bathroom facilities, shower facility, lodge with 40 rooms, 17 cabins, marina with 269 slips, 2 basketball courts, 3 tennis courts, 1 disc golf field, 1 public beach, and 1 courtesy dock.

(2) Laurel Branch. 24-foot boat ramp, 40 car spaces, 84 space for boating and fishing, 7 picnic sites, 1 group shelter, 1 restroom, 1 shower house with restrooms, 1 public beach, 1 cleaning station, 1 fishing pier, 1 courtesy dock, 1 dump station, and 62 campsites.

(3) Cave Creek. 24-foot boat ramp, 40 car spaces, 74 spaces for boating and fishing, 2 picnic sites, 1 group shelter, 1 restroom, 1 shower house with restrooms, 1 public beach, 1 fishing pier, 1 courtesy dock, 1 dump station, 1 multipurpose mountain bike trail, and 65 campsites.

(4) Axtel. 24-foot boat ramp, 89 car spaces, 109 spaces for boating and fishing, campground only beach, 1 courtesy dock, 2 restrooms, 3 shower houses, 157 campsites; 1 dump station, 1 fish cleaning station.

(5) Nicks Marina. 1 Marina with 360 slips, fuel, marina store, 1 group shelter, 1 restroom, 108 car spaces, 21 spaces for boating and fishing, and 3 picnic sites.

(6) North Fork. 24-foot boat ramp, 146 car spaces, 115 spaces for boating and fishing, 81 campsites, 2 group shelters, 15 picnic sites, 1 basketball court, 1 public beach, 5 restrooms, 2 shower houses, 1 fishing pier, 1 courtesy dock, and 1 dump station

(7) Everleigh. 24-foot boat ramp, 40 spaces for boating and fishing, no picnic tables or campsites; no facilities

(8) Below Rough River Dam. Picnic tables, group shelter, mobility impaired fishing area, restroom, and gravel boat access point.

(9) Panther Creek. 24-foot boat ramp, 2 spaces for boating and fishing, no picnic tables or campsites; no facilities.

(10) Peter Cave. 24-foot boat ramp, 60 spaces space for boating and fishing, marina, fuel, store, 25 campsites, and shower house

(11) Cannons Point. 24-foot boat ramp, 3 spaces for boating and fishing, no picnic tables or campsites; no facilities.

(12) Adkins Camp. 24-foot boat ramp, 3 spaces for boating and fishing, no picnic tables or campsites; no facilities.

(13) Browns Hideaway. 24-foot boat ramp, 6 spaces for boating and fishing, no picnic tables or campsites; no facilities.

(14) Fernwood. 24-foot boat ramp, 3 spaces for boating and fishing, no picnic tables or campsites; no facilities.

(15) Fox Cliff. 24-foot boat ramp, 6 spaces for boating and fishing, no picnic tables or campsites; no facilities.

(16) Hidden Valley. 24-foot boat ramp, 2 space for boating and fishing, no picnic tables or campsites; no facilities.

(17) Cascade Acres. 24-foot boat ramp, 2 spaces for boating and fishing, no picnic tables or campsites; no facilities.

(18) Holiday Rough. 24-foot boat ramp, 6 spaces for boating and fishing, no picnic tables or campsites; no facilities.

(19) Pine Ridge. 24-foot boat ramp, 2 spaces for boating and fishing, no picnic tables or campsites; no facilities.

(20) Mills. 24-foot boat ramp, 3 spaces for boating and fishing, no picnic tables or campsites; no facilities.

(21) Indian Valley. 24-foot boat ramp, 10 spaces for boating and fishing, no picnic tables or campsites; no facilities.

3.0 HISTORY OF PROJECT

3.01 Authorization for Project

The Rough River Reservoir project is a unit in the general comprehensive flood control plan for the Ohio River Basin authorized by the Flood Control Act approved 28 June 1938, Public Law 75-761, 75th Congress, which states in part as follows:

> Section 4 – That the following works of improvement for benefit of navigation and control of distinctive flood waters and other purposes are hereby adopted and authorized to be prosecuted under the direction of the Secretary of War and supervision of the Chief of Engineers in accordance with the plans in the respective reports hereinafter designated: Provided, that penstocks or other similar facilities adapted to possible future use in the development of hydroelectric power shall be installed in any dam herein authorized when approved by the Secretary of War upon recommendation of the Chief of Engineers and of the Federal Power Commission.

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"OHIO RIVER BASIN"

> "The general comprehensive plan for flood control and other purposes in the Ohio River Basin, as set forth in Flood Control Committee Document Numbered 1, 75th Congress, 1st Session, with such modifications thereof as in the discretion of the Secretary of War and the Chief of Engineers may be advisable, is approved and for the initiation and partial accomplishment of said plan there is hereby authorized $75,000,000 for reservoirs and $50,300,000 for local flood-protection works; the reservoirs and local protection projects to be selected and approved by the Chief of Engineers.

The improvement listed in the above-cited documents included three flood control reservoirs in the Green River Basin, one on Nolin River, one on Rough River and the other at Mining City. The Water Supply Act of 1958 (Title III, Public Law 85-500), as modified by Federal Water Pollution Control Act Amendments of 1961 (Public Law 87-88), prescribes the conditions under which States and local interests may request the Federal Government to include provisions for storage for future water supplies for domestic, municipal, industrial, and other purposes in already authorized projects.

3.02 Planning and Design

a. House Document No. 81 (308 Report)

This survey report was made under the provisions of House Document No. 308, 69th Congress, 1st Session known as the "308 Report" on Green, Barren, and Rough Rivers. An investigation was made of the possibilities for utilization of the water resources of the basin for purposes of navigation, irrigation, hydropower, and control of floods. The report was submitted by the USACE-LRL District Engineer on 26 March 1931. In connection with flood control investigations, the region was examined carefully for reservoir sites,

and seven were selected as offering the greatest amount of flood control storage, one of which was located on Rough River 89.3 miles above the Green River confluence. Investigations indicated that hydropower development at the Rough River site was not economically feasible, and the report also concluded that construction of a flood control reservoir was not justified at the time.

b. House Document No. 306

This report, known as the "308 Report" on the Ohio River, was made during the first session of the 74th Congress. Three plans involving the use of reservoirs for flood control were given consideration. The Rough River Reservoir was included in each of these plans.

c. House Flood Control Committee Document No. 1, 75th Congress, 1st Session

This document entitled, "Comprehensive Flood Control Plan for Ohio and Lower Mississippi Rivers," contained recommendations for a comprehensive flood control plan. This plan was developed as a result of review of the plans considered in the "308 Report" from the aspect of additional information gained during the great flood of 1937 on the Ohio River. The recommendations included the construction of a system of reservoirs in the Ohio River Basin supplemented by local flood protection works, together with reservoirs on other tributaries of the Mississippi River. The comprehensive plan presented in this document formed the basic plan for the authorization contained in the Flood Control Acts approved in 1937 and 1938. The recommended plan provided for the construction of 45 reservoirs in the Ohio River Basin, one of which was the Rough River Reservoir on the Rough River in the Green River Basin. The Ohio River portion of this document was based on concise reports prepared following the January 1937 flood in the Ohio River Basin.

d. House Report No. 2353

This report, published in the third session of the 75th Congress, 13 May 1938, accompanied and supported the Flood Control Act approved 28 June 1938, and was based on the Brief Concise Reports that had been expanded and revised after their initial preparation for the Committee of Flood Control Document No. 1. Report No. 2353 lists the units of a comprehensive flood control plan for the Ohio River considered in light of the 1937 flood, among which was Rough River Reservoir.

e. House Document No. 535

Construction of the Rough River Reservoir was authorized by the Flood Control Act approved June 28, 1938. Modification of this authorization in general accord with House Document No. 535, 78th Congress, 2nd Session, to include work on Rough River below the reservoir and channel rectification of Barnett Creek, was included in the Flood Control Act of 1944.

f. Definite Project Report

This report, dated July 1941, contains results of extensive field investigations and office studies. The project plan provided for construction of an earth and rock dam with outlet works through the right abutment, and a saddle-type spillway consisting of a trapezoidal channel with 1V:4H side slopes. The project included replacement of two major highway bridges, relocation of five miles of highway, and clearing of all buildings, trees, fences, logs, brush, and other materials below elevation 465. Also included was the proposed acquisition in fee of all land in the reservoir below elevation 523. Modifications to the project were made in Design Memoranda beginning in July 1953. Studies of hydroelectric power potential of Rough River Reservoir made in connection with the Definite Project Report showed that power installation would not be feasible.

g. Adopted General Project Plan

The adopted general project plan for Rough River Reservoir differed somewhat from the Definite Project Report. Due to additional investigations, studies, or design criteria changes, Design Memorandum No. 1 dictated major changes, as follows:

- Minimum pool raised 5 feet to elevation 465.0;
- Flood pool raised one foot to elevation 524.0;
- Spillway crest width reduced from 200 feet to 65 feet, and
- Conduit size reduced to 12-foot semi-elliptical.

h. Supplement No. 1 to Design Memorandum

In this Supplement, the matter of low flow regulation was considered. At the time, detailed studies had not been made, but it appeared reasonable to utilize up to four inches of the flood pool on a seasonal basis for storage of water to be released as needed to augment Green River flows. The corresponding seasonal pool elevation was 495.0 feet – 30 feet above minimum pool level. The elevation in the pool, which would be reached once in five years on average with the reservoir regulated for flood control purposes only, was established as the basis for the fee taking line. This elevation was determined to be 514 feet. Elevation 538 was proposed for the easement taking line but was subsequently lowered to Elevation 534 at the dam by the Chief of Engineers.

i. Supplementary Studies, 1958 Criteria

Routing of the spillway design flood for 1958 criteria (higher maximum probable rainfall and with low-flow regulation) produced a peak pool elevation of 549.1 feet. The dam was constructed to elevation 554 feet instead of 551 feet as originally designed. A site plan of the dam and spillway is shown in **Plate 2-3 General Plan and Sections**, and details of the conduit are shown in **Plate 2-4 Outlet Works**.

3.03 Construction

Construction of the operating tower and outlet works began in November 1955 and was completed January 1958. Construction of the dam and spillway began in May 1957 and was completed in December 1958. Relocations were completed by October 1960, and construction of boat launching ramps in the pool area was completed in December 1960. On October 1, 1959, the gates were set at a total opening of 5/100, and the pool filled to elevation 450 by October 31. The Kentucky Department of Fish and Wildlife Resources (KDFWR) stocked the pool with fish at this time. Subsequently, the gates were manipulated to maintain elevation 450 regardless of inflows or downstream conditions. On June 28, 1960, the gates were set at 1/10 opening to bring the pool to elevation 460. However, a storm occurred, and the gates were operated for flood control. The pool peaked at elevation 466.7 on July 5 and was lowered to elevation 460 by July 9 for resumption of construction work. The reservoir was placed in complete flood control operation on December 8, 1960, and the minimum pool elevation of 465 was attained on December 12, 1960.

3.04 Related Projects

Rough River Reservoir is operated in conjunction with Green River Reservoir, Nolin River Reservoir, and Barren River Reservoir to reduce flooding along Green River, and to some extent, the lower Ohio and Mississippi Rivers. All four projects maintain a minimum release of 50 cubic feet per second (cfs), which provides low flow augmentation in the Green River basin during dry periods. The Green River basin reservoirs are mapped in **Plate 3-1 Neighboring Projects**.

3.05 Dam Safety History/Issues

Rough River was initially classified as a Dam Safety Action Classification (DSAC) Class II (urgent-unsafe or potentially unsafe) ranking by the Senior Oversight Group subsequent to an evaluation through the Screening Portfolio Risk Assessment (SPRA) program conducted in 2005. The dam was evaluated during a Periodic Assessment (PA) by a Potential Failure Mode Analysis (PFMA) in 2008, which maintained the DSAC II Classification after considering available project data, observed geologic conditions from site, instrumentation, and subsurface investigations, and the performance history of the structure. In 2012, a Dam Safety Modification Report (DSMR) was completed and recommended permanent modifications to the dam foundation due to potential internal erosion failure modes, per USACE Public Protection Guidelines (ER 1110-2-1156). The report concluded that there is direct evidence that adverse conditions exist at the project, making the dam subject to unacceptable performance and possible uncontrolled releases from reservoir storage. The key risk contributor is erosion into or at the karstic rock foundation of both abutments.

3.06 Principal Regulation Problems

Rough River is one of the most downstream tributaries in the Green River Basin and can experience significant backwater during periods of high flow on the Green River or during significant flooding on the Ohio River. The backwater effects are frequently observed at Hartford, Kentucky, which is approximately 29 miles upstream of the confluence of Rough River and Green River. Although the gage at Hartford is not an official control point, consideration can be given to the stage at this location when determining how flood storage releases are made from Rough River Reservoir. Additionally, the release of flood storage from Rough River Reservoir is often delayed (sometimes as much as two weeks) during Green River flooding because of the

amount of time needed for the Green River basin flooding to recede. The relatively low channel capacity along the Rough River results in a slow recession of the reservoir pool as flood storage is being released (i.e. the reservoir pool will usually not fall faster than one foot per day at the maximum allowable release rate). The combination of these two effects can result in double-peak pool elevations and occasional triple-peak pool elevations during wet months.

3.07 Modifications to Regulations

The operating plan in place during impoundment called for a winter pool elevation of 465 and a summer pool elevation of 495.0. In 1967, the Corps began receiving requests from the State of Kentucky and other stakeholders to raise the winter pool to increase recreational opportunities. The District developed a report in October 1969 citing "minimal" impact to flood control capabilities. In January 1970, the winter pool elevation was raised from 465.0 to 470.0.

From 2002 through 2012, the target winter pool elevation was raised from 470.0 to 475.0 to support water supply for the City of Hardinsburg, Kentucky. The City ultimately decided to use an alternative water source and the target winter pool elevation was returned to 470.0 in 2013.

From April 2023 to present, the initiation of the spring fill will be delayed by two weeks, beginning on April 1 instead of March 15. In addition, a summer pool elevation that is five feet lower (490 feet NGVD29) that the currently approved elevation of 495 feet, NGVD29 will be targeted for summer pool. This change in operation has been implemented to help reduce the risk of this DSAC 2 dam. The return to summer pool elevation of 495 feet NGVD29 and spring fill initiation on March 15 is expected to occur once modifications to the dam to lower risk are completed.

4.0 WATERSHED CHARACTERISTICS

4.01 General Characteristics

The Rough River Basin lies entirely within Kentucky, with the headwaters originating in west central Hardin County. The Rough River meanders 141 miles in a west-by-southwesterly direction, draining portions of six counties, to its confluence with the Green River at mile 71.3. The watershed is roughly rectangular in shape, about 63 miles in length with an average width of 17 miles wide. The drainage area at the Rough River Dam is 454 square miles, and total drainage area of the Rough River Basin at the Green River confluence is 1,081 square miles. A map of the drainage basin is shown in **Plate 2-2 Map of Drainage Basin**.

4.02 Topography

The Rough River valley lies in a relatively flat plain with an average slope of about 1.5 feet per mile. The channel below the dam has an average slope of 0.8 feet per mile, increasing over the next 38 miles to 1.9 feet per mile. The upper 13 miles of the Rough River above the reservoir rise sharply with an average slope of 5.5 feet per mile. The elevation of the stream bed ranges from approximately 350 MSL at the confluence with Green River to approximately 568 MSL near the source. In the vicinity of the dam, the stream channel is about 30 to 40 feet wide at the bottom, about 100 feet wide at the top, and the banks are about 14 feet high. Materials in the channel banks and bottom are generally silt and gravel with occasional rock and rock outcrops in the bottom.

4.03 Geology and Soils

Rough River Reservoir is located within the eastern-most portion of the Western Kentucky Coal Field physiographic region near its boundary with the Mississippian Plateaus region of south-central Kentucky. The Mississippian Plateaus region is subdivided into the western Mammoth Cave Plateau and the eastern Pennyroyal Plateau, which are separated by the Dripping Springs Escarpment. The Green River marks the approximate southern boundary between the Western Kentucky Coal Field region and the Mammoth Cave Plateau. The Mississippian Plateaus region of Kentucky is one of the most well-developed karst landscapes in the world. The development of the Mammoth Cave System has occurred within limestone of Mississippian age, divided stratigraphically (in ascending order) into the St. Louis, St. Genevieve, and Girkin formations. Overlying the Girkin is the Big Clifty Sandstone, also of Mississippian age, which acts as the protective cap rock for the Mammoth Cave Plateau. Geologic formations that are common to the Mammoth Cave Plateau are also present at the Nolin and Rough River Dam sites. Geologic formations exposed in the project area range from the Girkin Limestone of the Lower Chester Series upward into the Caseyville Formation of the Lower and Middle Pennsylvanian Series.

All rock in contact with the dam are part of the Chester series, and the stratigraphy from top to bottom is as follows:

- Hardinsburg Sandstone
- Golconda Formation (contains Haney Limestone, Big Clifty Sandstone Member, and Beech Creek Limestone)

- Elwren Shale, equivalent to Elwren Sandstone of Marlott
- Reelsville Limestone
- Sample Sandstone
- Beaver Bend Limestone

Upper portions of embankment at elevation 551 rest on Hardinsburg Sandstone. The upstream portion of the conduit is founded on Beech Creek Limestone (part of the Golconda Formation). The downstream portion of the conduit is founded on Elwren Shale.

4.04 Sediment

While erosion is prevalent in the headwater areas of the basin, periodic field inspections have not shown effects of silting in the reservoir to be a serious problem. Based on comparative figures and available data developed during the project's design, total annual deposition in the reservoir was estimated to be approximately 0.5 acre-foot per square mile of drainage area. A sediment survey conducted in 1969, ten years after impoundment, calculated an average annual sediment accumulation of 335 acre-feet (0.74 acre-feet per square mile of drainage area), and concluded that sedimentation did not impose a severe condition with respect to either the utility or operation of Rough River Reservoir for the foreseeable future.

4.05 Climate

The National Oceanic and Atmospheric Administration (NOAA) is the principal agency for collection and dissemination of climatological data in the Green River Basin. The Green River Basin has a temperate climate with relatively cold winters and hot, humid summers. The NOAA weather station at Leitchfield, Kentucky (Network ID GHCND: USC00154703) is considered representative of the Rough River Basin. The monthly temperature and precipitation data presented below are taken from the summary of monthly means from 1981-2010 (https://www.ncdc.noaa.gov/, accessed 15 June 2020).

a. Temperature. Temperatures are generally moderate with few days greater than 100 degrees Fahrenheit or less than zero degrees Fahrenheit. The maximum recorded temperature to date is 108 degrees Fahrenheit and the minimum recorded temperature is -27 degrees Fahrenheit. Mean annual temperature is about 57 degrees Fahrenheit, with monthly means varying from 37 degrees Fahrenheit in January to 76 degrees Fahrenheit in July. Approximate mean monthly temperatures for the Rough River watershed are as follows:

January	32.1	July	74.3
February	36.0	August	73.2
March	44.3	September	66.3
April	54.3	October	55.1
May	62.7	November	45.0
June	70.8	December	34.6

The average growing season, from the last killing frost in spring until the first killing frost in fall, extends from late-April to mid-October with a median length of approximately 177 days.

b. Precipitation. Precipitation in the project area is fairly evenly distributed throughout the year, with smaller amounts occurring in late summer and fall. Average annual rainfall at the Rough River Reservoir station is approximately 49 inches.

There are seven precipitation observation stations in close proximity to the Rough River watershed shown in **Plate 2-2 Map of Drainage Basin**. The average annual rainfall of the four stations considered to be the most representative of the watershed, shown in **Table 4-1**, is 49.32 inches.

Table 4-1 Average Monthly and Annual Precipitation
for Stations Representative of the Rough River Reservoir Area

	Leitchfield (inches)	Beaver Dam (inches)	Glendale (inches)	Rough River Lake (inches)	Average (inches)
Station ID	*USC00154703*	*USC00150490*	*USC00153252*	*USC00156988*	
POR	*1895-2019*	*1903-2010*	*1951-2012*	*1940-2019*	
Jan	3.31	3.46	3.71	3.35	3.46
Feb	4.03	4.24	4.17	3.75	4.05
Mar	4.30	4.34	4.65	3.99	4.32
Apr	4.15	4.50	4.29	4.42	4.34
May	5.68	5.42	5.63	6.31	5.76
Jun	3.73	3.74	3.90	3.92	3.82
Jul	4.58	4.31	4.71	4.14	4.44
Aug	3.53	3.32	3.27	3.31	3.36
Sep	3.28	3.57	3.39	3.40	3.41
Oct	3.73	3.76	3.64	3.77	3.73
Nov	3.87	4.19	4.29	4.13	4.12
Dec	4.42	4.69	4.71	4.28	4.53
Annual	48.61	49.54	50.36	48.77	49.32

Source: NOAA National Center for Environmental Information (ncdc.noaa.gov)

From 2002-2019, annual snowfall at the dam has averaged about 12 inches. Periods of extended snow and ice cover are unusual, and in general, snowmelt runoff does not significantly contribute to flooding.

c. Evaporation and Transpiration. Evaporation and transpiration are influenced by temperature, precipitation, ground cover, and other factors, and directly affect water yields that can be obtained from reservoirs and streams. Pan evaporation gages are commonly used to record evaporation. Pan evaporation has been shown to be greater than that from a large body of water, and a coefficient of about 0.7 is usually applied to pan evaporation data to estimate reservoir surface evaporation. Direct evaporation from water surfaces and transpiration by plants are major determinants of water loss, which, together with infiltration, account for the difference between precipitation and streamflow. **Table 4-2** presents mean monthly growing season evaporation based on observed land pan evaporation data at Nolin River Dam. Because Nolin Dam and Rough River Dam are in adjacent watersheds, the data are considered to be representative of the Rough River Basin as well.

Table 4-2 Mean Land Pan Evaporation Nolin River Reservoir
Edmonson County, KY

Month	Inches
Apr	5.58
May	6.63
Jun	7.15
Jul	8.92
Aug	6.63
Sep	4.73
Oct	3.71

Source: NOAA Technical Report NWS 34 December 1982

4.06 Storms and Floods

The Rough River basin lies in a region affected by frequent temperature changes, high humidity, and intense precipitation caused by passage of storms originating in southwestern United States and in the Gulf of Mexico and moving northeastwardly toward the north Atlantic Coast. Of the various types of meteorological disturbances which produce precipitation in the watershed, the cyclonic storm (mid-latitude cyclones) is the most frequent cause of excessive runoff. Storms of this type generally occur during the period from late winter to early spring when conditions are conducive to high runoff and have produced major floods in the Rough River basin. Convective storms which produce rainfalls of high intensity generally occur during summer months and seldom cause significant flooding, since they are localized, and transpiration and infiltration losses are high. Topography of the basin is such that orographic rainfall does not occur. The valleys of Rough River and its tributaries are subject to frequent flooding, usually once every year, and sometimes as frequent as six or seven times in wet years. Generally, major floods occur from winter to late spring. High pool events are generally associated with small to moderate successive rainfall events and the inability to release excess storage due to downstream flood control requirements, not necessarily a single, large magnitude storm. Some of the largest floods have occurred in 1937, 1950, 1989, 1997, and 2011. Average daily Rough River Reservoir inflows from 1929 through 1957 are shown in **Plate 4-1 Natural Inflow Hydrographs at Dam Site**.

a. January-February 1937. The Flood of 1937 is one of the largest floods on record in the Ohio River basin. The flood exceeded all previous recorded flood crests on the Ohio River at Louisville by 10 to 11 feet. Many of the Civil Works projects within the USACE-LRL boundaries were authorized or designed based on 1937 flood elevations. At Lock and Dam #2 at Calhoun, the peak average daily discharge reached 204,000 cfs. A hypothetical routing for the Rough River Reservoir used a starting winter pool elevation of 465 (target winter pool at the time the routing was developed) and indicated a peak pool elevation of 528.7 would have been reached with a maximum outflow of 4,000 cfs (based on the regulation schedule when the hypothetical routing was developed, 1966). The hypothetical pool elevation and flow hydrographs are shown in Plate 4-2A of **Plate 4-2 Flood Routings**.

b. January-March 1950. While the Flood of 1950 was a large flood in the Green River Basin, no documentation was found indicating that flooding occurred in any area outside of the Green River basin. At Lock and Dam #2 at Calhoun, the peak average daily discharge reached 86,100 cfs, whereas inflow to Rough River Reservoir peaked at about 12,400 cfs in mid-January. Hypothetical routings developed in 1966 indicated that a Rough River Reservoir pool elevation of 526.0 would have been reached with a maximum outflow of 5,800 cfs. The hypothetical pool elevation and flow hydrographs for the event are shown in Plate 4-2B of **Plate 4-2 Flood Routings**.

c. February 1989. Following a relatively wet late fall and early winter, the Rough River Reservoir pool was approximately 15 feet above seasonal guide curve elevation of 470.0 at the beginning of February 1989. More than 12 inches of rainfall occurred during the next 16 days, causing the reservoir to rise to elevation 518 by February 16th. An additional 7.6 inches of rain during the remainder of February through the end of March caused the pool to crest at elevation 521.6 on February 23rd and remain above elevation 510 through March 31st. Maximum rate of inflow from February through March of 1989 was 54,400 cfs, and maximum release over the same period was 4,294 cfs. Precipitation hyetographs, reservoir pool elevation, inflow, and outflow for the February 1989 flood are shown in Plate 4-2C of **Plate 4-2 Flood Routings**.

d. March 1997. Following more than 10 inches of rain – 7.4 inches of which occurred on March 2nd – the Rough River Reservoir pool rose by more than 37 feet (from elevation 470.6 to 507.8) in four days from February 28th through March 3rd. An additional 4 inches of rain raised the pool to elevation 517.9 on March 22nd, after which the reservoir gradually fell to its normal summer guide curve elevation (495.0) by the middle of July. Maximum reservoir inflow was 48,400 cfs on March 1st, and maximum release was 3,164 cfs on March 31st. Precipitation hyetographs, reservoir pool elevation, inflow, and outflow for the March 1997 flood are shown in Plate 4-2D of **Plate 4-2 Flood Routings**.

e. April-May 2011. The project was near summer pool **(**495.0) on April 11th, 2011. On April 12, 3.5 inches of rainfall was recorded at the project, which caused the reservoir to rise approximately 9 feet and resulted in wet antecedent moisture conditions. From April 20th through May 4th, rainfall was recorded at the project almost daily, and the total precipitation for this period was nearly 16.0 inches. This led to a peak 6-hour inflow of nearly 37,000 cfs on April 27th and a peak pool elevation of 527.35 on May 4th. During the 3-week period from April 12th to May 4th, a total of 19.9 inches of rainfall and approximately 306,000 acre-feet of runoff was

recorded at the project. At Lock and Dam #2 at Calhoun, the peak average daily discharge reached 76,000 cfs. Pool elevation and flow hydrographs for the event are shown on Plate 4-2E of **Plate 4-2 Flood Routings**.

4.07 Runoff Characteristics

Maximum runoff in the Rough River basin occurs from late winter to late spring and the minimum runoff occurs from summer through the fall. As shown in the previous section, the largest historical floods have occurred from late winter to late spring. Freezing or saturated ground in winter through late spring results in low infiltration rates and a high proportion of rainfall appearing as runoff. During the summer and early fall months, infiltration rates are higher, and a comparatively low percentage of precipitation appears as immediate runoff. Average daily inflow is greater than 5 cfs approximately 84% of the time. Inflow recession generally lasts from three to five days for small to moderate events and five to nine days for large runoff events. Monthly and annual inflow volumes are shown in **Table 4-3**. The Rough River Reservoir inflow duration curve is presented in **Plate 4-3 Inflow Annual Duration Curve**.

Table 4-3 Monthly and Annual Inflow Volume

Rough River Reservoir Inflow Volume (acre-feet)													
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
1983	33,540	38,994	26,499	138,660	179,580	19,666	4,850	1,110	102	8,144	34,427	63,401	**548,971**
1984	20,602	33,024	90,223	86,772	164,232	7,305	38,342	4,388	5,822	4,407	69,686	121,721	**646,526**
1985	52,997	77,889	42,199	30,053	30,612	21,549	2,945	5,410	1,271	11,495	70,502	23,376	**370,299**
1986	7,537	118,043	45,534	6,251	32,966	20,820	3,334	1,201	4,463	2,645	41,564	60,663	**345,021**
1987	11,098	60,995	45,498	63,545	11,011	3,480	4,374	956	1,250	1,394	2,862	70,286	**276,749**
1988	83,472	94,062	30,613	34,088	6,133	244	8,274	2,720	4,582	1,322	79,643	60,927	**406,081**
1989	82,839	294,422	107,195	60,158	30,692	51,135	38,068	7,549	2,877	13,694	21,908	13,831	**724,367**
1990	73,739	163,993	34,685	30,297	52,598	9,006	4,756	2,752	957	11,866	8,760	194,060	**587,470**
1991	79,888	107,764	59,330	27,172	19,560	9,453	8,381	1,149	3,826	2,943	6,366	64,407	**390,240**
1992	26,517	28,823	100,742	25,793	16,620	12,138	30,699	10,423	2,609	817	14,000	12,996	**282,176**
1993	55,437	66,560	78,884	26,112	28,500	28,456	3,880	1,235	2,538	13,560	33,549	29,343	**368,051**
1994	104,564	64,295	94,647	55,144	24,388	2,974	3,443	2,163	1,685	2,891	6,381	37,252	**399,829**
1995	43,552	60,962	35,167	28,874	191,738	17,287	8,036	7,353	850	11,115	12,309	14,687	**431,929**
1996	77,603	34,725	136,574	67,335	62,463	43,970	17,960	2,875	10,183	7,721	26,657	97,551	**585,617**
1997	62,025	74,950	284,485	29,394	40,982	112,076	6,301	1,877	847	1,996	2,268	16,611	**633,811**
1998	37,692	32,667	55,993	95,751	39,013	59,046	7,904	1,288	961	2,755	2,135	10,328	**345,531**
1999	105,216	39,419	51,188	37,342	32,892	4,823	1,608	213	218	1,947	1,760	10,740	**287,367**
2000	48,292	82,690	46,890	38,278	12,548	5,323	9,362	13,428	3,031	999	5,213	56,089	**322,143**
2001	16,911	83,454	36,655	26,116	9,248	5,336	13,689	4,279	2,313	30,701	79,366	90,026	**398,093**
2002	52,964	24,503	124,145	91,908	72,926	7,937	4,474	3,754	35,975	32,652	35,247	108,066	**594,551**
2003	44,440	140,022	30,721	73,155	120,737	35,878	8,407	18,689	41,963	4,086	47,039	50,269	**615,406**
2004	70,118	51,034	43,625	74,953	170,215	32,136	8,373	4,517	660	2,368	34,533	75,293	**567,824**
2005	93,190	45,795	73,231	37,201	31,152	4,181	6,050	24,515	4,693	910	2,533	6,512	**329,963**
2006	84,098	39,182	54,734	20,597	75,601	16,275	25,057	4,022	63,952	50,571	61,252	39,550	**534,891**
2007	87,615	41,743	36,694	40,451	17,394	4,436	10,787	3,543	4,524	57,566	19,113	162,014	**485,880**
2008	68,088	129,757	158,288	133,158	52,728	7,393	8,625	1,601	687	1,969	3,047	57,084	**622,424**
2009	50,338	49,254	35,662	69,056	69,576	49,683	31,949	12,154	12,238	84,620	21,521	51,299	**537,348**
2010	58,904	51,745	34,143	41,257	133,440	7,682	4,328	1,931	1,007	752	7,272	11,326	**353,788**
2011	18,473	73,105	93,825	275,987	120,875	37,745	23,475	3,329	10,540	2,205	80,295	102,424	**842,279**
2012	72,644	31,288	60,735	12,147	20,240	4,218	2,898	6,396	6,268	4,798	2,993	26,358	**250,983**
2013	78,287	24,400	88,217	48,607	57,157	16,026	33,360	5,871	9,352	14,818	11,157	59,103	**446,353**
2014	38,439	80,213	46,810	102,115	39,824	6,403	3,178	7,487	1,029	5,106	1,873	13,068	**345,545**
2015	7,816	25,228	162,155	140,177	17,191	17,557	58,110	11,306	6,539	14,272	55,440	125,917	**641,708**
2016	22,515	83,916	83,108	45,685	84,399	12,739	54,737	41,932	12,868	2,421	2,806	72,513	**519,641**
2017	94,934	31,720	55,165	43,171	69,778	41,378	33,883	4,377	17,116	83,286	15,768	26,448	**517,024**
2018	31,945	198,210	85,339	65,124	14,461	59,738	6,936	8,990	15,150	12,320	84,313	88,891	**671,417**
2019	78,775	194,118	52,677	86,927	44,397	102,243	13,504	4,796	1,582	11,756	58,738	101,762	**751,276**
Average	**56,138**	**77,648**	**73,575**	**62,400**	**59,402**	**24,263**	**14,982**	**6,529**	**8,014**	**14,024**	**28,765**	**60,167**	**485,907**

4.08 Water Quality

Water quality in Rough River Reservoir and its associated watershed is monitored by the Corps of Engineers, Kentucky Division of Water (KDOW), and water supply utilities. Locations periodically sampled by the LRL Water Quality team are shown in **Plate 4-4 Water Quality Sampling Locations**.

According to the KDOW's 2016 Section 303(d) list, Rough River is impaired from river mile (RM) 55.1 to 64.35 (Adams Fork to Caney Creek), for exceeding approved concentrations of iron, fecal coliform, and Escherichia coli, impacting warm water aquatic habitat, secondary contact recreation (i.e., boating, wading, fishing), and primary contact recreation (swimming), respectively. Within the reservoir itself, mercury in fish tissue has exceeded safe concentrations, affecting recreational fishing. From RM 125.2 (approximate reservoir backwater at summer pool (490.0)) to 149.45 (Vertrees Creek), the river is impaired due to fecal coliform, which impacts primary contact recreation.

Watershed geology, morphology, and land use are primary factors in determining the quality of water within a watershed. **Table 4-4** shows the proportion of land use types in the drainage area above Rough River Dam. Agricultural uses (hay/pasture and cultivated crops) make up 45.1% of the watershed. Watersheds with heavy agricultural use commonly experience eutrophication, or the overloading of nutrients into water bodies due to the runoff of fertilizers and animal waste. Nearly all stations sampled by the LRL Water Quality Team from 2012-2020 had median values of total nitrogen and total phosphorus higher than USEPA recommended criteria for nutrients in rivers/streams and lakes/reservoirs (published by USEPA 2000). This indicates Rough River Reservoir accumulates high loads of nutrients which can have a significant effect on the aquatic ecosystem and contribute to the production of Harmful Algal Blooms (HABs).

Although the state has rarely issued HAB advisories at Rough River Reservoir, LRL Water Quality Team data shows several instances of high cyanobacteria cell counts which indicate the reservoir has had a high potential to form HABs, and HAB development may be frequently undetected. These conclusions are also supported by high Trophic State Index values (typically eutrophic or hypereutrophic) calculated from data at sampling stations in the reservoir.

Table 4-4 Proportion of land use types in the watershed area above Rough River Dam (2019 National Land Cover Database, MRLC)

Land Use	Percent of Watershed
Open Water	0.12
Developed, Open Space	5.34
Developed, Low Intensity	0.73
Developed, Medium Intensity	0.30
Developed, High Intensity	0.07
Barren Land	0.05
Deciduous Forest	36.92
Evergreen Forest	1.49
Mixed Forest	8.55
Shrub/Scrub	0.74
Herbaceous	0.58
Hay/Pasture	30.88
Cultivated Crops	14.22
Woody Wetlands	0.00
Emergent Herbaceous Wetlands	0.00

4.09 Channel and Floodway Characteristics

Rough River Dam is located 89.3 stream miles upstream of the Green River confluence. The valleys of Rough River and tributaries are subject to frequent floods and overflowing of the banks at any time of the year. Flood damages are for the most part agricultural. Little damage is experienced in towns along the streams because they are situated well above the floodplain and only suffer the inconvenience of being temporarily isolated by inundated highways and bridges. Due to the flatness of the valley floor, flooding of the Green River causes considerable backwater in the lower reaches of Rough River. The average duration of floods at Dundee, which is above the influence of backwater, is about six days.

Rough River profiles shown in **Plate 4-5 Stream Profiles** display thalweg, left and right bank elevations, and 1913 and 1937 peak flood elevations from the Green River confluence to the headwaters approximately 140 stream miles upstream. Approximate travel times from Rough River Dam to various points along Rough River are shown in **Plate 4-6 Travel Times**.

4.10 Upstream Structures

There are no flow regulation structures upstream of Rough River Reservoir.

4.11 Downstream Structures

The Falls of Rough low head dam is approximately 7 miles downstream of Rough River Dam. Should this dam fail or be removed, it will significantly alter the downstream channel. Lock and Dams Numbers 1 and 2 on the Green River are downstream of the confluence of Rough River and Green River. These structures are currently owned and operated by USACE-LRL. Their operation is entirely independent of the operation of Rough River Reservoir.

4.12 Economic Data

a. Population. Based on 2010 census data and estimated population growth through 2017, total population of Breckinridge, Grayson, and Hardin Counties in which the Rough River Reservoir is located is approximately 154,000, 70 percent of whom reside in Hardin County. Current (2020) population of Leitchfield, Kentucky is nearly 7,000. Current Louisville metropolitan area population is nearly 1.3 million, and Owensboro population is slightly more than 60,000. Total population within a 50-mile radius of the project in 2019 was slightly over 1.6 million (http://www.statsamerica.org/radius/big.aspx), with the largest portion located in the Louisville/Jefferson County area. Area employment in the first quarter of 2020 totaled nearly 750,000 distributed predominantly in the manufacturing (14.1%), health care/social services (12.7%), retail trade (10%), lodging and food services (8.1%), transportation and warehousing (8.1%) sectors. Professional, financial, construction, and public administration make up the remaining employment categories.

b. Agriculture. Agriculture sales in Hardin County upstream of the dam consists primarily of grain crops (70 percent) and cattle and poultry (30 percent). In 2017, the total market value of crop and livestock sales in Hardin County was approximately $59.2 million. Downstream of the dam, total crop and livestock market sales in Grayson County was $59.6 million in 2017, and $135.8 million in 2017 in Ohio County.

c. Industry. A diverse array of manufacturing industries are located in Hardin County. These include truck frames, automobile and truck brakes, safety glass, pigments, sealants, roller bearings, machine parts, packaging, and chemicals.

d. Flood Damages. Through 2019, the accumulated value of flood damages prevented along Rough River and the lower Green River was approximately $293 million. Damages along the Green River are prevented due to the combined operation of Green River, Barren River, Nolin River, and Rough River Dams. Annual estimates for flood damages prevented are prepared by economists in the LRL Planning Branch. The Water Management Team provides the economists with estimates of river stages assuming the dam does not exist, and the difference between these estimates and actual observed river stages are used to estimate the flood damages prevented. Information used to develop estimates of flood damages prevented can be obtained from USACE-LRL Planning Branch.

e. Recreational Benefits. The Rough River Reservoir provides opportunities at facilities listed in Chapter 2.06 for a variety of recreational activities including picnicking, camping, swimming, hiking, fishing, and boating. Annual direct and indirect visitation benefits in 2019 realized within 30 miles of the lake totaled approximately $112 million.

5.0 DATA COLLECTION AND COMMUNICATION NETWORKS

5.01 Hydrometeorological Stations

a. Facilities. Key stations for the operation and monitoring of Rough River Reservoir are shown on **Plate 5-1 Key Stations for Operation and Monitoring**. Stream and rainfall stations in the project operating area are adequate for effective forecasting and water control management activities. Utilization of key stations data is covered in Chapter 6, "Hydrologic Forecasts."

b. Reporting. The Water Management Team of the Geotechnical and Water Resources Branch, Engineering Division, has a server dedicated to the collection and dissemination of water resource data. Gaging information is obtained in coordination with the USGS and other Corps Offices through data feeds. Forecasted flow and radar precipitation information used in conjunction with the operation of Rough River Reservoir is received through the LRD Office in Cincinnati, Ohio and relayed to the District via the Water Control Data System. Data for the lake (pool elevation, gate settings, tailwater elevation, and temperature, rainfall, etc.) are received from the project office each morning via the Daily Lake Bulletin process and published on the USACE-LRL Water Management website (https://www.lrl.usace.army.mil/Missions/Civil-Works/Water-Information/).

(1) Precipitation Gages. The Corps operates a recording and reporting station at the dam site. Radar estimates of observed and forecasted rainfall are available through the National Weather Service (NWS) Ohio River Forecast Center (OHRFC) web page (https://www.weather.gov/ohrfc/#) and the Kentucky Mesonet web page (http://www.kymesonet.org/). The USGS web page for Kentucky (https://waterdata.usgs.gov/ky/nwis/current/?type=precip&group_key=basin_cd) also shows all recording precipitation gages that can be used to evaluate precipitation depths in near-real time.

(2) Stream Gages. Outflow measured by the USGS is based on the recording tailwater gage and published as "Rough River Near Falls of Rough at Dam, KY." Data from the gage Rough River Near Dundee, KY are used as the basis for the maximum allowable release. Additional control stations are Green River at Lock 4 (Woodbury) and Green River at Lock 2 (Calhoun). Each of these gages are equipped with a telemark and are readily accessible via the Kentucky USGS streamflow web page (https://waterdata.usgs.gov/ky/nwis/current?type=flow&group_key=basin_cd&search_site_no_station_nm=). The Ohio River at Evansville is also considered in the scheduling of reservoir releases but does not typically control release decisions. Locations of stream gaging and control stations directly related to regulation of the project are presented in **Table 5-1**, and their locations are shown on **Plate 5-1 Key Stations for Operation and Monitoring**.

Table 5-1 Rough River Reservoir Stream Gages

Location	Station ID	Station Name	Latitude	Longitude
Reservoir Pool	USGS 03318005	ROUGH RIVER LAKE NEAR FALLS OF ROUGH, KY	37° 37 ' 12" N	86° 29' 58" W
Tailwater	USGS 03318010	ROUGH RIVER NEAR FALLS OF ROUGH AT DAM, KY	37° 37' 19" N	86° 30' 15" W
Horse Branch	USGS 03318800	CANEY CREEK NEAR HORSE BRANCH, KY	37° 27' 50" N	86° 39' 20" W
Dundee	USGS 03319000	ROUGH RIVER NEAR DUNDEE, KY	37° 32' 51" N	86° 43' 18" W
Hartford	USGS 03319600	ROUGH RIVER AT HARTFORD, KY	37° 27' 11" N	86° 54' 39" W
Lock and Dam 4	USGS 03315500	GREEN RIVER AT LOCK 4 AT WOODBURY, KY	37° 10' 56" N	86° 37' 48" W
Livermore	USGS 03319885	GREEN RIVER AT LIVERMORE, KY	37° 29' 08" N	87° 08' 11" W
Lock and Dam 2	USGS 03320000	GREEN RIVER AT LOCK 2 AT CALHOUN, KY	37° 32' 02" N	87° 15' 50" W
Evansville	USGS 03322000	OHIO RIVER AT EVANSVILLE, IN	37° 58' 20" N	87° 34' 35" W

The following stream gages have been discontinued:

- USGS 03318500 Rough River at Falls of Rough, KY
- USGS 03317500 North Fork Rough River near Westview, KY
- USGS 03318200 Rock Lick Creek near Glen Dean, KY

c. Maintenance. The Louisville District has elected to defer the operation and maintenance of all stream gaging equipment to the USGS. The Corps and the USGS enter into a Cooperative Stream Gaging Program agreement each Fiscal Year, with the Corps contributing funding for the operation and maintenance of gages needed for its water control missions. When issues with gaging equipment are observed, the appropriate USGS office is contacted and USGS personnel take the necessary steps to resolve the issue.

5.02 Water Quality Stations

a. Facilities. Eight water quality stations are typically sampled throughout the Rough River Reservoir pool, tailwater, and along tributary inflows. Station locations are shown on **Plate 4-4 Water Quality Sampling Locations** and are described in **Table 5-2**. The USGS gage in the tailwater (USGS 03318010) also measures water temperature for use in monitoring downstream temperature conditions.

b. Reporting. Water quality data collected at Rough River Reservoir is used to meet such objectives as:

(1) Ensuring that water quality affected by Corps activities are suitable for designated purposes, comply with applicable laws and regulations, and meet the authorized purposes and objectives of the project.

(2) Establishing and maintaining a water quality monitoring and data evaluation program that ensures achievement of water quality management objectives, evaluation of project performance and allows an understanding of water quality trends and factors and processes affecting water quality.

(3) Identifying existing and potential water quality problems in the watershed, develop and implement effective operational strategies per applicable Corps authority, and initiate management actions that offset or mitigate those problems.

(4) Ensuring that operation of the project results in the lowest potential negative impact to the aquatic environment by integrating water quality considerations into all water control management decisions.

(5) Support or perform rapid response in emergency scenarios, such as harmful algal blooms (HABs).

Water quality studies vary year-to-year based on available funding/resources and specific water quality needs. Vertical profiles of Rough River Reservoir are collected each year during the stratification period (i.e., when the reservoir is thermally stratified, typically late spring to late fall or early winter). Temperature and dissolved oxygen are measured at intervals from the surface to the bottom at the water quality station nearest the control tower (RRR20001). Temperature and dissolved oxygen are also measured in the tailwater at the same time as the reservoir profile. These measurements are to be recorded by the project staff at an interval

specified by the LRL Water Quality Team during the stratification season and submitted to the LRL Water Quality Team.

Ambient monitoring has typically been conducted on an annual basis with at least one collection event at Rough River Reservoir typically during the summer. Typical water quality parameters collected include:

(1) In-situ measurements: temperature, dissolved oxygen, pH, specific conductance, turbidity, oxidation-reduction potential, chlorophyll, phycocyanin, and secchi disk depth.

(2) Physical-chemical samples: total alkalinity, total solids, suspended solids, dissolved solids, total hardness, organic carbon (total and dissolved), total chloride, total sulfate, total Kjeldahl nitrogen, nitrate+nitrite nitrogen, ammonia nitrogen, total phosphorus, orthophosphate, silica (total and dissolved), atrazine, and total and dissolved metals (aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, strontium, and zinc).

(3) Biological samples: chlorophyll (a, b, and c), pheophytin, and phytoplankton and zooplankton communities.

c. Maintenance. The LRL Water Quality Team is responsible for operation and maintenance of all water quality sampling equipment. Project staff at Rough River Reservoir operate and maintain a temperature and dissolved oxygen meter for recording vertical profiles. When issues with water quality sampling equipment occur, the Water Quality Team is contacted, and the technical personnel take the necessary steps to resolve the issue.

Table 5-2 Water Quality Sampling Locations

Location	Station ID	Location Description	Latitude	Longitude
Pool	RRR20001	Rough River within the pool upstream of the dam at the Control Tower log boom	37.618597°	-86.498750°
Pool	RRR20003	Rough River within the pool near Cave Creek confluence 2.25 air miles SE of the dam	37.594167°	-86.475000°
Pool	RRR20004	Rough River within the pool 0.4 mile upstream of Walter Creek confluence 5.0 air miles SE of the dam	37.580556°	-86.422500°
Pool	RRR20005	Rough River within the pool at KY Highway 259 bridge 1.5 air miles SE of Madrid, KY	37.591667°	-86.329444°
Pool	RRR21002	North Fork Rough River within the pool 3.3 air miles NE of the dam 0.5 mile downstream of KY Highway 259 bridge	37.628889°	-86.441667°
Tailwater	RRR10000	Rough River downstream of the dam at the Tailwater Gage	37.621389°	-86.501944°
Inflow	RRR10006	Rough River at Highway 84 bridge 2.9 air miles S of Hudson, KY	37.612083°	-86.258889°
Inflow	RRR11003	North Fork Rough River at Highway 690 Bridge 1.1 air miles SE of Westview, KY	37.692250°	-86.391469°

5.03 Sediment Stations

The original Rough River Reservoir area-capacity curve was developed based on USGS contour mapping during design studies. Sediment range cross-sections were developed, and a sediment survey was completed in 1969, ten years after impoundment. The results of the survey are included in a report prepared in June 1970, which indicated that the total sediment accumulation below elevation 524.0 over the 10-year period was 3,270 acre-feet. The survey also calculated an average annual sediment accumulation of 335 acre-feet and concluded that sedimentation did not impose a severe condition with respect to either the utility or operation of Rough River Reservoir for the foreseeable future.

a. Facilities. Sediment ranges are included in **Plate 5-2 Sediment Ranges**. Coordinates for the sediment ranges are included in the June 1970 sedimentation report.

b. Reporting. Future sedimentation surveys will be reported to the Water Management Team and coordinated with other offices as appropriate.

c. Maintenance. Any future sediment studies will likely be performed as a bathymetric survey to occur at summer pool.

5.04 Recording Hydrologic Data

Data recorded at Rough River Reservoir on the Daily Lake Bulletin are retained permanently on the Daily Lake Bulletins that reside within the Hydrology and Hydraulics Design Section. These data are also stored digitally in the mastdb.dss file and USACE-LRL's Corps Water Management System (CWMS) database.

5.05 Communication Network

The CWMS database resides within the Water Management Stack, which consists of a server, a dedicated switch, a storage device, and an Uninterruptable Power Supply (UPS). The server is dedicated to the collection and dissemination of water resource data. Gage information is obtained in coordination with the USGS and other Corps Offices through data feeds. Forecasted flow and radar precipitation information developed by the NWS is provided to USACE-LRD in Cincinnati, Ohio, and relayed to LRL via the Local Data Manager (LDM). System users communicate with the stack either internally across the Corps Network or by using a Virtual Private Network (VPN). Reservoir forecast information shared with LRD and the NWS are sent via the LDM. In the case of a server failure, the Continuity of Operations Plan (COOP) is to switch over to the server located in the Huntington District. This server contains an instance that has been configured identically to the LRL server with a replicated database that is updated on a regular basis. During a COOP event, the system processes will have to be started on the COOP server and the CWMS models will need to be modified to extract data from that server. **Figure 5-1** illustrates the communication network.

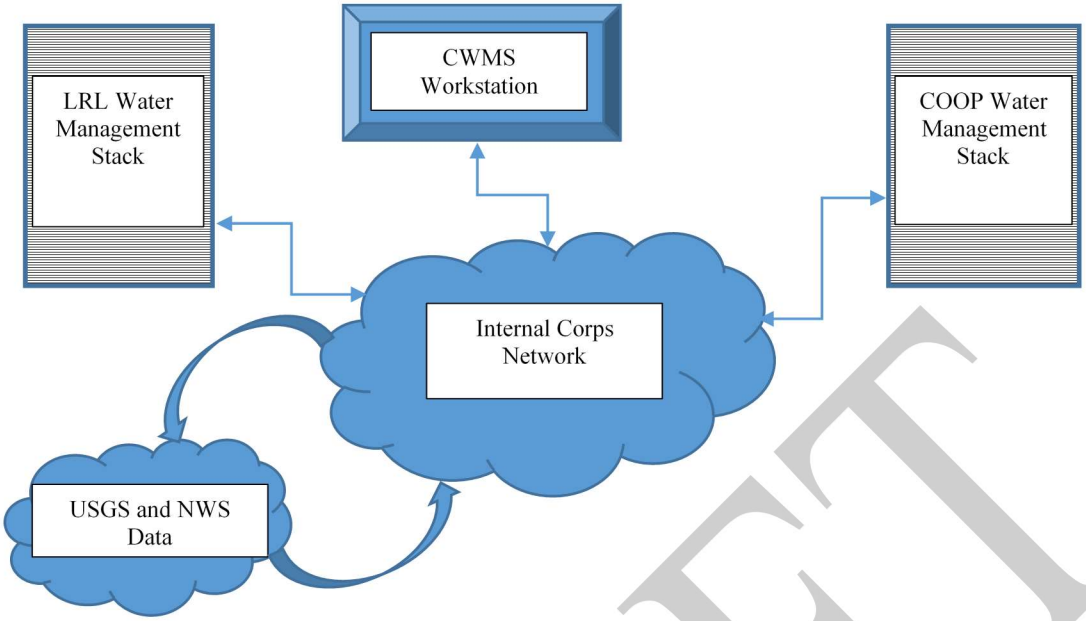


Figure 5-1 Conceptual CWMS communication network

5.06 Communication with Project

a. Between Regulating Office and Project Office. Normally, operations at Rough River Reservoir are dictated directly from the Water Management Team to operations personnel at the project. The bulk of operating instructions is transmitted via landlines, email, and/or cell phone. Water Management Team members and the project operations personnel have each other's cell phone numbers and can communicate via voice or text. Chapter 9 "Water Control Management" further identifies regulation instructions and lines of communication. "Instructions to Dam Operator," which dictates operating procedures if Water Management Team personnel cannot be reached, is presented as Exhibit B. It should be noted that the redundancy of being able to use personal cell phones to communicate between the Water Management Team and operations personnel significantly reduces the likelihood of being unable to communicate with one another. An organization chart is provided in **Plate 5-3 Organization Chart**.

b. Between Regulating/Project Office and Others. The Rough River Project office may provide information upon request to various stakeholders, including but not limited to marina owners and the Rough River Dam State Resort Park. Stakeholders are typically referred to publicly available water control information such as pool elevation, outflow, and 3-day forecast information for their planning purposes.

5.07 Project Reporting Instructions

The project office has been instructed to submit data required for the Daily Lake Bulletin by computer to the Water Management Team each morning. Confirmations of changes in gate settings are routinely posted on the Daily Lake Bulletin on the day following the operation or, during special operations, are reported by telephone. Complaints received at the project office are referred to the proper District Office element to respond, and complaints regarding project

operation are subsequently referred to the Water Management Team. Operating machinery failure or scheduled/unscheduled maintenance is reported to LRL Operations Division and the Water Management Team.

5.08 Warnings

To ensure that no one is endangered by an increase in reservoir release, project operating personnel visually inspect the tailwater area and sound a siren three times in 3-second blasts before operating project gates.

The normal maximum release of 3,000 cfs occurs annually, which discourages encroachment in downstream areas. Gates are opened and closed gradually (no more than two tenths per hour open or closed) so that fluctuations in downstream stages will not exceed those that would have been experienced under natural streamflow conditions.

If spillway releases are forecasted, the Water Management Team informs the LRL Emergency Operations Center (EOC), which disseminates forecasted pool elevations and release schedules to local Emergency Managers. This communication chain is shown in the Emergency Action Plan for Rough River Reservoir.

6.0 HYDROLOGIC FORECASTS

6.01 General

a. Role of USACE. The Water Management Team has the direct responsibility for providing daily three-day forecasts of reservoir pool elevations and releases to both the Water Management Division at LRD and the NWS OHRFC Monday through Friday, excluding holidays. Five-day forecasts at Green River Lock 2 at Calhoun, Kentucky are submitted to the LRD Water Management Division on a daily basis during the week, and upon special request on weekends and/or holidays to support lower Ohio River flood forecasting. Both the OHRFC and the Water Management Division utilize data provided by the Water Management Team in developing forecasts for downstream river levels.

b. Role of Other Agencies. The NWS has broad responsibility for acquiring hydrologic data used in the preparation of hydrologic forecasts and warnings. Weather Service Forecast Offices (WSFOs) and Weather Service Offices (WSOs) are responsible for issuing forecasts prepared by the River Forecast Centers. The NWS is responsible for issuing precipitation forecasts for both short-term and long-term application. The Quantitative Precipitation Forecast (QPF) issued by the NWS for the ensuing 24 and 48 hours, in conjunction with river stage forecasts issued by the NWS are valuable in the reservoir operational decision-making process.

6.02 Flood Condition Forecasts

a. Requirements. The early determination of a flood condition is essential to the effective utilization of flood control storage at the Rough River project. Reservoir operations and forecasts for control station stages are based on a combination of River Forecast Centers' projections and those determined by the Water Management Team. The operation of Rough River Reservoir considers stages along Rough River at Dundee, along the Green River at Woodbury and Calhoun, and on the Ohio River at Evansville. The Water Management Team's forecasts are generally available by 0900 CST each business day. The Water Management Team provides daily 3-day pool elevation and anticipated release forecasts expected at 0600 CST on each of the following three days.

b. Methods. Precipitation gage and radar estimates are evaluated each morning to determine the extent of observed and predicted rainfall coverage in the Green River Basin. A CWMS Model has been developed for the Green River Basin and uses observed and predicted precipitation to forecast 3-day pool elevations and outflows. The CWMS model contains a Hydrologic Modeling System (HEC-HMS) model that transforms observed and forecasted rainfall into runoff into the reservoir and downstream. Additionally, reservoir inflow and uncontrolled flow estimates made by the OHRFC are evaluated in the CWMS model. The HMS model has been calibrated for continuous simulation by accounting for changing soil moisture conditions. After reservoir inflow and downstream flows have been estimated, inflow is routed through the reservoir using the HEC-ResSim (Reservoir System Simulation) model and the schedule of regulation to determine impacts at downstream control points. Releases are iteratively adjusted and re-routed to best meet the objectives shown in the schedule of regulation

when considering current and forecasted weather and downstream conditions. Prior to CWMS implementation, routing of rainfall excess into Rough River Reservoir was accomplished using unit hydrographs derived from various historical floods, some examples of which are shown in **Plate 6-1 Inflow Unit Hydrographs**.

6.03 Conservation Purpose Forecasts

a. Requirements. Short-term forecasts of air temperature and precipitation are utilized by the Water Management Team for scheduling reservoir releases for purposes other than flood control. Water control management decisions concerning lake stabilization during annual fish spawn, utilization of storage for low flow augmentation, and operation during specially requested events are based on anticipated conditions. The CWMS software is used for conservation as well as flood control operation.

b. Methods. Forecasts of air temperatures and precipitation by the NWS are received by the Water Management Team daily. Additional weather forecast information is available through various web pages. NWS data are input into the CWMS model to simulate and evaluate different forecast and reservoir release scenarios. These results illustrate impacts on authorized project purposes, providing real-time water control management decision support.

6.04 Long-Range Forecasts

a. Requirements. Long-term forecasts are needed primarily for planning maintenance or repair work to be performed at the project. Long-term forecasts are also considered when determining summer pool filling and drawdown procedures.

b. Methods. Generally, long-term forecasts needed in the operation of Rough River Reservoir are based on observed data as well as long-range temperature and precipitation data provided by the Climate Prediction Center of the NWS. Runoff characteristics are discussed in **Section 4.07**.

6.05 Drought Forecasts

a. Requirements. Drought forecasts are needed primarily for planning the use of available storage to meet short-term water supply needs.

b. Methods. Generally, drought forecasts used in the operation of Rough River Reservoir are based on observed data as well as long-term temperature and precipitation data provided by the Climate Prediction Center of the NWS. Coordination with local, state, and other federal agencies also occurs as shown in the Green River Basin Drought Management Plan.

6.06 Water Quality Forecasting

a. Requirements. Water quality forecasts are needed for determining future conditions at the project as a result of operational, meteorological, and environmental factors. Impacts to water quality must be considered when making water control management decisions.

b. Methods. Vertical profiles in the reservoir near the control tower and temperature and dissolved oxygen measurements taken in the tailwater are utilized to determine downstream water quality management. While Rough River Dam does not have selective withdrawal capability (i.e., the control tower inlets are all below the thermocline during stratification), a minimum release of 50 cfs has been established at the project as sufficient to meet downstream water quality needs.

7.0 WATER CONTROL PLAN

7.01 General Objectives

The authorized project purposes for Rough River Reservoir are flood risk management, water supply, water quality, recreation, and fish and wildlife enhancement. Some incidental benefit to downstream low flow augmentation and navigation is associated with the annual depletion of storage from summer pool to winter pool.

The pool elevation guide curve, also known as the "Schedule of Regulation" for Rough River Reservoir is presented as **Plate 7-1 Schedule of Regulation**. Adherence to the guide curve assures that ample flood risk management storage is available year-round, and that conservation storage is available within the impoundment to meet the project's other authorized purposes. While it is desirable for the pool elevation to match the guide curve, the curve should not be considered a rigid rule that limits the operational flexibility of the project.

Rough River Reservoir is operated in coordination with three other reservoirs within the Green River basin: Nolin River, Green River, and Barren River Reservoirs. Coordination of these reservoirs' releases mitigates damage from flooding along the middle and lower Green River basin. Minor flood reduction is also subsequently achieved on the Lower Ohio and Mississippi Rivers.

7.02 Constraints

a. Discharge Constraints. Original design studies determined the channel capacity along Rough River to be approximately 3,000 cfs. During the first few years of operation, this capacity was re-evaluated, but ultimately retained and established as the normal maximum release in the Schedule of Regulation. The maximum discharge capacity of the bypass (BP) system with the reservoir at summer pool (elevation 490.0) is approximately 200 cfs, and the capacity of the conduit with the reservoir pool at spillway crest (elevation 524.0) is approximately 5,600 cfs.

The primary control point for determining the release of excess storage from Rough River Reservoir is the USGS gage on Rough River near Dundee, Kentucky (USGS 03319000). The maximum target stage at the Dundee gage varies depending on the time of year. During the crop season, the maximum target stage has been established at 15 feet to allow tillable land immediately adjacent to the river to be utilized, and at 22 feet during the non-crop season. In addition to conditions at Dundee, the USGS gages Green River at Lock 4 at Woodbury, Kentucky (USGS 0331500) and Green River at Lock 2 at Calhoun, Kentucky (USGS 0332000) are also considered to reduce flooding impacts along the middle and lower Green River. The farthest downstream control point is the Ohio River, where releases from Rough River Reservoir should not increase the crest when the Ohio River is above flood stage. The USGS gage Ohio River at Evansville (USGS 03322000) is the Ohio River control point. Although the USGS Rough River gage at Hartford (USGS 03319600) is not an official control point, consideration can be given to the stage at this location when determining how flood storage releases are made from Rough River Reservoir. This gage provides an indication of backwater impacts from the

Green River during high flow periods, and care should be taken not to exacerbate these impacts if possible.

The rating table for Rough River Dam's main conduit gates is shown in **Table 7-1**, and the rating curve is shown in **Plate 7-2 Outlet Works Rating Curves**. Main gate openings represent vertical opening distance for one gate. Therefore, a gate opening of 0.1 represents 1/10 or 10 percent of the maximum (vertical) opening height of 9.5 feet of one main gate, or 0.95 feet. An opening of 0.5 on one gate would be 5/10 or 50 percent of the vertical opening height, or 4.75 feet. Because Rough River Dam has three main gates, the maximum gate opening for the project would be noted as 3.0, or 30/10 (3 gates open 100 percent).

Incremental gate openings are shown in **Table 7-1** under the heading "Multiple Gate Settings." The sequence shown should be followed except when a gate becomes inoperable. During periods of inoperable gates, the Water Management Team will specify an interim sequence to be followed until all three gates become operable.

The main gates are to be operated in such a manner as to prevent abnormal fluctuations in tailwater stage. Rapid changes in stages and irregular flow characteristics are undesirable and may result in erosion and caving bank conditions along Rough River below the dam. To avoid these adverse effects, changes in outflow should be gradual to produce a rise or fall that mimics naturally occurring conditions as much as possible. The main gates shall not be opened or closed at a rate greater than 2/10 (20 percent) total opening per hour. Main gate changes are generally accomplished by increasing or decreasing gate openings 2/10 at a time but have occasionally been accomplished by increasing or decreasing gate openings 1/10 (10 percent) every 30 minutes.

Releases of less than 1/10 on the main gates (approximately 230 cfs) should be made utilizing the bypass gates, the rating table for which is provided in **Table 7-2** and the rating curve on **Plate 7-3 Bypass Rating Curve**. Two 24-inch diameter openings connect to 20-inch diameter bypass pipes to be used for low-flow releases. Bypass gate openings are also expressed in terms of tenths of total opening. Therefore, an opening of 2/10 would be 20 percent open, with 2.0 equating to both bypass gates fully open.

b. Storage Constraints. Flood control storage capacity between winter pool, elevation 470.0, and spillway crest, elevation 524.0, is 304,600 acre-feet, equivalent to 12.58 inches of runoff from the drainage area upstream of the reservoir. Elevation-area-capacity information for the project is provided in **Table 7-3**, the corresponding curves for which are shown in **Plate 7-4 Area Capacity Curve**.

c. Drawdown Constraints. Should the need ever arise, the project can be emptied from summer pool (elevation 490.0) to the invert of the conduit (elevation 430) in about 25 days. This assumes discharge at bankfull capacity of 3,000 cfs until the conduit can no longer pass this amount and no inflow. With the same inflow and starting pool level assumptions, the project can be emptied in 21 days discharging at maximum conduit capacity.

Table 7-1 Outlet Rating Table

ROUGH RIVER RESERVOIR
OUTLET RATING TABLES
RATING TABLE FOR CONDUIT GATES

Total Gate Openings (Tenths)	Multiple Gate Setting Incremental Gate Openings (Tenths of Vertical Distance) Gate 1	Gate 2	Gate 3	Reservoir Pool Elevation (Feet m.s.l.) 465*	470	475	480	485	490**	495	500	505	510	515	520	524***
				Discharge in c.f.s.												
1	0	1	0	165	180	190	205	215	220	230	240	250	235	265	270	275
2	0	2	0	330	360	385	410	430	445	460	480	493	510	525	535	545
3	1	2	0	495	540	575	615	645	665	690	720	745	765	790	805	820
4	1	2	1	660	720	765	820	860	885	920	960	995	1,020	1,055	1,075	1,095
5	1	3	1	825	900	955	1,025	1,070	1,105	1,150	1,200	1,245	1,280	1,320	1,340	1,370
6	2	3	1	990	1,080	1,150	1,230	1,285	1,330	1,380	1,440	1,490	1,535	1,580	1,605	1,640
7	2	3	2	1,155	1,260	1,345	1,435	1,500	1,555	1,610	1,680	1,735	1,790	1,840	1,870	1,910
8	2	4	2	1,320	1,440	1,535	1,635	1,715	1,775	1,840	1,915	1,980	2,045	2,100	2,140	2,385
9	3	4	2	1,485	1,620	1,725	1,840	1,925	1,995	2,070	2,155	2,230	2,305	2,365	2,405	2,460
10	3	4	3	1,650	1,800	1,915	2,045	2,135	2,215	2,300	2,395	2,480	2,565	2,630	2,670	2,735
11	3	5	3	1,815	1,980	2,110	2,250	2,350	2,440	2,530	2,635	2,730	2,820	2,895	2,935	3,010
12	4	5	3	1,980	2,160	2,300	2,450	2,565	2,660	2,760	2,870	2,975	3,075	3,155	3,205	
13	4	5	4	2,145	2,340	2,490	2,650	2,780	2,880	2,990	3,105	3,220				
14	4	6	4	2,310	2,520	2,680	2,855	2,995	3,100	3,220						
15	5	6	4	2,475	2,700	2,875	3,060	3,210								
16	5	6	5	2,640	2,880	3,070										
17	5	7	5	2,805	3,060											
18	6	7	5	2,970	3,240											
19	6	7	6	3,135												

These rating tables are preliminary and subject to adjustment on the basis of measured outflows.

* Minimum Pool Elevation
** Seasonal Pool Elevation
*** Flood Pool Elevation

Table 7-2 Bypass Rating Table

	Bypass Opening (in tenth)	RATING TABLE FOR SINGLE BYPASS Reservoir Pool Elevation (Feet m.s.l.)												
		465*	470	475	480	485	490**	495	500	505	510	515	520	524***
		Discharge in c.f.s.												
	1	2	2	3	3	3	3	3	3	3	3	4	4	4
	2	12	13	14	14	15	16	16	17	17	17	17	18	18
	3	26	28	29	30	31	32	33	34	34	35	35	36	36
These rating tables are preliminary	4	40	42	44	46	47	48	50	52	52	53	54	55	56
and subject to adjustment on the	5	54	56	59	61	63	65	67	70	70	72	74	75	76
basis of measured outflows.	6	68	71	74	77	79	82	84	88	88	91	93	95	96
	7	71	76	80	83	87	90	93	99	99	102	105	108	110
* Minimum Pool Elevation	8	73	78	82	86	90	94	98	104	104	108	111	114	116
** Seasonal Pool Elevation	9	74	79	83	88	92	96	100	107	107	110	114	117	120
*** Flood Pool Elevation	Fully open	74	80	85	90	94	98	102	109	109	113	116	120	123

Table 7-3 Area and Capacity Table

AREA AND CAPACITY
ROUGH RIVER RESERVOIR
ROUGH RIVER MILE 89.3 -- DRAINAGE AREA 454 SQUARE MILES

Elevation	Area	Storage Capacity		Elevation	Area	Storage Capacity		Elevation	Area	Storage Capacity		Elevation	Area	Storage Capacity	
FT NGVD29	ACRES	AC-FT	INCHES	FT NGVD29	ACRES	AC-FT	INCHES	FT NGVD29	ACRES	AC-FT	INCHES	FT NGVD29	ACRES	AC-FT	INCHES
455	860	7,500	0.31	484	3,770	71,170	2.94	513	7,900	234,960	9.70	534	12,900	449,760	18.58
456	940	8,360	0.35	485	3,880	75,060	3.10	514	8,090	242,850	10.03	535	13,200	462,960	19.12
457	1,010	9,380	0.39	486	4,000	78,940	3.26	515	8,300	251,050	10.37	536	13,510	476,170	19.67
458	1,090	10,390	0.43	487	4,120	84,060	3.47	516	8,500	259,440	10.71	537	13,840	490,020	20.24
459	1,120	11,560	0.48	488	4,250	87,190	3.60	517	8,700	268,140	11.07	538	14,180	503,860	20.81
460	1,260	12,740	0.53	489	4,370	91,560	3.78	518	8,910	276,850	11.43	539	14,520	518,380	21.41
461	1,340	14,080	0.58	490	4,500	95,940	3.96	519	9,140	286,000	11.81	540	14,850	532,890	22.01
462	1,430	15,430	0.64	491	4,620	100,560	4.15	520	9,380	295,140	12.19	541	15,180	548,070	22.64
463	1,520	16,950	0.70	492	4,740	105,180	4.34	521	9,590	304,730	12.59	542	15,510	563,250	23.26
464	1,610	18,470	0.76	493	4,860	110,040	4.54	522	9,800	314,320	12.98	543	15,860	579,100	23.92
465	1,700	20,170	0.83	494	4,980	114,900	4.75	523	10,030	324,350	13.40	544	16,200	594,960	24.57
466	1,790	21,870	0.90	495	5,100	120,010	4.96	524	10,260	334,380	13.81	545	16,550	611,510	25.26
467	1,880	23,760	0.98	496	5,230	125,110	5.17	525	10,500	349,380	14.43	546	16,900	628,060	25.94
468	1,980	25,640	1.06	497	5,360	130,480	5.39	526	10,740	355,380	14.68	547	17,260	645,320	26.65
469	2,080	27,720	1.14	498	5,500	135,840	5.61	527	11,000	366,380	15.13	548	17,610	662,570	27.36
470	2,180	29,800	1.23	499	5,620	141,460	5.84	528	11,250	377,370	15.59	549	17,980	680,560	28.11
471	2,280	32,090	1.33	500	5,750	147,090	6.07	529	11,520	388,890	16.06	550	18,360	698,540	28.85
472	2,390	34,370	1.42	501	5,880	152,980	6.32	530	11,790	400,410	16.54	551	18,730	717,270	29.62
473	2,500	36,960	1.53	502	6,020	158,960	6.57	531	12,060	412,470	17.04	552	19,100	736,000	30.40
474	2,620	39,380	1.63	503	6,170	165,030	6.82	532	12,330	424,530	17.53	553	19,490	755,490	31.20
475	2,720	41,140	1.70	504	6,320	171,200	7.07	533	12,610	437,140	18.05	554	19,880	774,980	32.01
476	2,830	44,830	1.85	505	6,470	177,680	7.34								
477	2,940	47,800	1.97	506	6,630	184,150	7.61								
478	3,060	50,720	2.09	507	6,800	190,950	7.89	NOTES							
479	3,170	53,860	2.22	508	6,970	197,750	8.17	1) Minimum Pool Elevation 470							
480	3,290	57,070	2.36	509	7,140	204,900	8.46	2) Seasonal Pool Elevation 490							
481	3,400	60,480	2.50	510	7,320	212,040	8.76	3) Flood Pool Elevation 524							
482	3,520	63,880	2.64	511	7,510	216,550	8.94	4) Top of Dam Elevation 556							
483	3,640	68,700	2.84	512	7,700	227,060	9.38	5) 1-inch of runoff from the 454 square miles drainage area = 24,213 acre-feet							

7.03 Overall Plan for Water Control

Rough River Reservoir is regulated singularly and in combination with Nolin River, Green River, and Barren River Reservoirs to meet downstream flood mitigation and water quality objectives. The four projects control 2,779 square miles – approximately 30 percent – of the Green River Basin's 9,229 square mile drainage area. Before Rough River Reservoir releases can be made, the impact of operations of the other three reservoirs and uncontrolled flow throughout the Green River Basin must be considered to avoid increasing downstream peak flows and flood crests.

7.04 Standing Instructions to Project Operator

Most operations at Rough River Reservoir are determined by Project staff and reviewed by the Water Management Team. This standard operating procedure is to be followed during normal duty hours. Project staff submits anticipated Main Gate or Bypass release changes to the District Office via the Daily Lake Bulletin. These changes are reviewed and checked for compliance with operating controls by the Water Management Team before they are initiated in the field. The staff has been instructed that if the reservoir is at a high rate of release and the immediate area is subjected to a heavy runoff event, they are to initiate reduction of the release rate and contact the Water Management Team for additional instructions. There are occasions that arise for which the Project staff have been instructed to operate the Project without oversight from the District Office. The most frequent example is a request for emergency reduction of release for downstream recovery operation by the State and local Police or water rescue personnel. In any case, the Project staff have been instructed to report the change to the Water Management Team as soon as possible. If the operation occurs during non-duty hours, Project staff have a list of Water Management Team personnel and their personal phone numbers. **Exhibit B – Instructions to Dam Operator**, has been provided to the project in case of extreme emergency when Water Management personnel cannot be reached or in case of communication outage.

When current or anticipated flood conditions are considered to be severe, arrangements may be made to maintain 24-hour staffing of the Water Management Team. This staffing level is accomplished during all spillway flow events and when spillway flow is anticipated to begin during non-duty hours.

7.05 Flood Control

a. General. When runoff results in impoundment above the guide curve, the reservoir is considered to be in flood control operation status.

During periods of impoundment above the guide curve, Rough's releases are determined by the controlling stages, time of the year, and the maximum release guidance listed in **Plate 7-1 Schedule of Regulation**. Schedules A and B dictate that all controlling stage criteria must be met before releasing excess storage up to the maximum release rate dictated by the USGS gage on Rough River near Dundee. Schedule C requires that, if any one of the controlling stage criteria exists and the pool elevation is between 470.0 and 514.0, releases from Rough River Reservoir are limited to 100 cfs. Schedule D requires that, if any one controlling stage criteria exists and the pool elevation is between 514.0 and 524.0, releases from Rough River Reservoir may be based upon precipitation forecasts to potentially avoid an uncontrolled spillway event so

long as the maximum release table is not exceeded. However, if an uncontrolled spillway event is not expected based on forecasts, regulation should not increase flood crests on the Green River or Ohio River. Once Schedule A or B criteria are met, excess storage should be released in accordance with the maximum release guidance.

When the reservoir reaches full pool elevation 524.0, control stations are no longer considered, and inflow is released up to the capacity of the conduit. If the pool crests above 524.0, the conduit remains fully opened until the pool recedes back to 524.0. Once this occurs, the main gate setting is adjusted to maintain the pool at spillway crest until downstream conditions permit the return to Schedule B.

Operating experience and studies of many years of flow records show the practicality of occasionally deviating from the guide curve during the fill period 01 April thru 01 May. Normal procedure is to release excess water stored in early spring until the pool elevation intersects the ascending limb of the guide curve, then follow the uniform filling prescribed by the curve. This occasionally results in a delay of filling the pool, and in years that experience low runoff the summer pool elevation of 490.0 feet may never be attained. Historical flow records and overall hydrologic conditions show the practicality of discontinuing release of excess flood storage at elevation 490.0 during the last 10 days of the prescribed filling period, effectively retaining approximately 1.3 inches of runoff from the drainage area above the reservoir. This variation in regulation in each instance must be tempered by judgment and consideration of current and forecasted weather conditions.

b. Constraints. During all periods of reservoir pool drawdown, the 24-hour rate of fall of the pool should not exceed 2.0 feet. This drawdown rate is determined by the LRL Dam Safety Section. If the need arises that the pool must be lowered more rapidly than two feet in 24 hours, this action must be coordinated through the Dam Safety Program Manager.

The maximum allowable release from Rough River Reservoir is contingent on downstream uncontrolled runoff (303 square miles), time of year, and considers two periods: crop season and non-crop season. The non-crop season generally occurs from mid- to late-November through early- to mid-April, and crop season occurs during the remainder of the year. During crop season, tillable land immediately adjacent to the river is farmed requiring lower river levels to prevent adverse impacts. This subsequently results in the need for lower releases from Rough River Reservoir during the crop season than during the non-crop season. As such, the normal maximum release from Rough River Reservoir should not cause the stage at the Dundee gage (USGS 03319000) to rise above 15 feet during crop season and 22 feet during non-crop season, while not exceeding 3,000 cfs. The exact timing of the change from non-crop season to crop-season or vice-versa does vary each season depending on weather conditions throughout the year. The Water Management Team coordinates annually with a point of contact (POC) representing farmers throughout the Rough River corridor to determine the appropriate time to implement crop or non-crop season release rates.

Elevation-area-capacity data for Rough River Reservoir are shown in **Table 7-3** and the corresponding chart is shown in **Plate 7-4 Area Capacity Curve**.

7.06 Recreation

From December 1st through April 1st, Rough River Reservoir targets a winter pool elevation of 470.0 to maximize the capacity to impound runoff. From April 1st through May 1st, the target pool elevation in the reservoir increases from 470.0 to 490.0. Targeting a pool elevation of 490.0 supports numerous recreational opportunities on and around Rough River Reservoir. If impoundment of flood storage occurs after April 13th, the reservoir is returned to elevation 490.0 as quickly as possible, while staying within the constraints of the controlling points and the maximum release criteria. From September 15th through October 14th the reservoir undergoes an initial drawdown period, and from October 15th through December 1st, the reservoir is lowered to winter pool elevation of 470.0. The river immediately below the dam is not heavily recreated, and consequently downstream recreation does not typically factor into decision making for the release of storage.

7.07 Water Quality

a. Minimum Discharge Constraints. The minimum discharge requirement for water quality is normally 50 cfs.

During periods of low inflow, when difficulty in filling to pool elevation 490.0 is encountered, downstream flows can be investigated to determine the feasibility of passing a flow less than the 50 cfs minimum rate for normal regulation. The reduced rate will depend upon flow conditions at the time but in no case will the outflow be lowered to the detriment of downstream users or water quality. Any consideration of reducing flow to less than 50 cfs should be coordinated with the KDOW and the KDFWR. These coordination efforts should follow the process outlined in the Green River Basin Drought Management Plan.

b. Temperature. The desired tailwater temperature guide curve shown on **Plate 7-5 Tailwater Guide Curve and Temperature Data** and **Plate 7-5a Tailwater Temperature Guide Curve (Tabular Data)** was developed by the KDFWR in the early 1970s. The Rough River Reservoir control tower does not have selective withdrawal capability, therefore the guide curve is currently used only for reference. Although the low-flow bypass intake elevations are higher than the main gates by about 20 feet, all water released from Rough River Dam during periods of thermal stratification comes from the hypolimnion. This results in cold water being released in the early spring as water temperatures begin to stratify. This continuous release of cold water throughout the spring and summer months depletes the available cold water in the reservoir and results in continually warming tailwater temperatures through early fall. Additional water quality information is discussed in **Section 4.08**.

7.08 Fish and Wildlife

The minimum release helps support downstream aquatic wildlife. Rough River Reservoir does not have the ability to vary the temperatures of releases due to the lack of selective withdrawal.

The transition from Rough River Reservoir's winter pool to summer pool may coincide with fish spawning in late March early April. During this period, delays in returning to the rising limb of the guide curve, i.e. holding the pool relatively stationary, may be acceptable if it is determined

by fish and wildlife partners that it is advantageous to fish spawning. Such delays should meet criteria listed in **Section 7.01 General Objectives**.

7.09 Water Supply

The City of Leitchfield has contracted for 120 acre-feet of storage in Rough River Reservoir between elevations 464.9 and 465. The City of Hardinsburg entered into a water supply contract in 1978 but terminated the contract in 2017. The Grayson County Water District has contracted for 260 acre-feet of storage between elevations 465 and 470. Given that the water supply storage is below winter pool, no operational accommodation is needed to meet contracted water supply.

7.10 Hydroelectric Power

House Document No. 81–308 Report [1931] found that Rough River Dam would not economically justify a power installation. Studies of hydroelectric power possibilities at Rough River Dam were made in connection with the Definite Project Report (1941) and showed that a power installation would not be feasible. Since 1983, there have been four applications to study the feasibility of adding hydropower at Rough River Dam. None of these have concluded that hydropower installation would be justifiable, and barring unforeseen major power market changes, it is not anticipated that future applications will conclude otherwise.

7.11 Navigation

Navigation is not an authorized project purpose of Rough River Reservoir. Release of excess storage, especially during the fall drawdown, will augment flows on the lower Green and Ohio Rivers and thereby provide some ancillary navigation benefits.

7.12 Drought Contingency Plans

Management of Rough River Reservoir during periods of drought is outlined in the Drought Management Plan for the Green River Basin, which was last updated in March of 1989. The plan primarily focuses on increased coordination between the Corps and their customers during drought periods, including but not limited to KDOW and the USGS.

7.13 Flood Emergency Action Plans

Flood Emergency Action Plans are maintained by LRL's Dam Safety Section. Hard copies exist in the Dam Safety Section and an electronic copy exists on an LRL network drive in the \\COE-LRLDFE01LOU\ORG\ED\Public\DS\Emergency Action Plans\ROUGH RIVER directory.

7.14 Other

The Falls of Rough low head dam is approximately 7 miles downstream of Rough River Dam. If this low head dam fails or is removed in the future, the river reach immediately downstream of Rough River Dam will be significantly altered. It is not anticipated that failure or removal of this low-head dam will necessitate any change to reservoir operations.

7.15 Deviation from Normal Regulation

a. Emergency Deviations. Some emergencies that may be expected include drowning and other accidents (both upstream and downstream of the dam) and failure of operational facilities. Necessary action under these emergency conditions is taken immediately

unless such action would create equal or worse conditions. The District Office, Water Management Team, should be informed as soon as time allows. The Water Management Team will then inform the LRD office and adhere to the current LRD deviation policy.

b. Unplanned Deviations. Though not considered emergencies, there are unplanned instances that create the need for temporary deviations from the normal regulation of the reservoir. Construction accounts for the majority of such incidents and includes utility stream crossings, bridge work, and major construction contracts. Changes in releases greater than those listed in **Section 7.02** are considered to be unplanned deviations. Each request for deviation is analyzed based on consideration of upstream watershed conditions, potential flood threat, current and forecasted condition of the lake with respect to the guide curve, and possible alternative measures. Unplanned deviations shall be coordinated with the LRD office and adhere to the current LRD deviation policy.

c. Planned Deviations. Planned deviations generally consist of long-term operational variances for construction or maintenance purposes. These variations are usually required for significant periods, i.e. longer than those defined in **Section 7.01**. Each condition is analyzed based on flood potential, lake and watershed conditions, possible alternative measures, benefits to be expected, and probable impacts to operational objectives. Planned deviations should be coordinated with the LRD office and adhere to the current LRD deviation policy.

7.16 Rate of Release Change

Changes in release rates should be determined to prevent abnormal fluctuations in stages downstream of the reservoir. Rapid changes in stages and irregular flow characteristics are highly undesirable and may result in erosion and caving bank conditions below the dam. To avoid these adverse effects, changes in outflows should be sufficiently gradual to produce a rise or fall in the downstream channel as near to naturally occurring changes as practicable. The Water Management Team will provide guidance on opening and closing rates, but in general conduit gates should not be opened or closed at a rate greater than 2/10 per hour as described in **Section 7.02 Constraints**.

8.0 EFFECT OF WATER CONTROL PLAN

8.01 General

The primary function of Rough River Reservoir is flood control. The reservoir operates as a component of the system of reservoirs in the Green River Basin and part of the comprehensive plan for the Ohio River Basin. The reservoir system reduces flood stages downstream along the Rough and Green Rivers and contributes to flood stage reductions along the Lower Ohio and Mississippi Rivers as well. The most significant reductions in flood stages are achieved on the Rough and Green Rivers. Other functions of the reservoir are water supply, water quality, recreation, and low-flow augmentation.

8.02 Flood Risk Management

a. Spillway Design Flood (SDF). The spillway design flood was based on the all-season 48-hour probable maximum precipitation for the 454-square mile drainage area above Rough River Dam, obtained from the U.S. Weather Bureau Hydrometeorological Report No. 33, dated April 1956, entitled *Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1,000 Square Miles and Durations of 6, 12, 24 and 48 Hours*. This storm was routed through the reservoir using the following criteria established by the District in 1958:

- Infiltration = 0.05 inches/hour
- Initial loss = 0.5 inches
- Starting reservoir elevation = 503 based on 1935 historical flood storage utilization

Peak inflow of the SDF is 358,000 cfs. Inflow, outflow, and pool elevation hydrographs for the SDF are shown on **Plate 8-1a Spillway Design Flood (1958 Criteria)**. The inflow hydrograph was routed through the reservoir with gates regulated to pass 100 cfs until hour 42 of the storm, after which gates would be raised to the fully opened position in three hours, followed by uncontrolled releases through the conduit and spillway thereafter. Calculated peak outflow is 27,940 cfs at maximum pool elevation of 549.1. Pertinent data for the Spillway Design Flood are as follows:

Spillway Design Flood

Total precipitation in 48 hours, inches	27.60
Total volume of runoff, inches	25.3*
Peak flow into full reservoir, cfs	358,000
Total volume of hydrograph, acre-feet	607,000
Elevation of pool at start of flood, feet, msl	503
Initial release (0-42 hours), cfs	100
Maximum total release, cfs	27,940**
Maximum reservoir elevation, feet, msl	549.1
Available freeboard, feet	4.9

*Includes 0.2-inch recession of June 1935 flood

**Conduit Discharge	5,940 cfs

The spillway rating curve is shown on **Plate 8-2 Spillway Rating Curve** and the tailwater rating curve is shown on **Plate 8-3 Tailwater Rating Curve**. Rating curves for key downstream locations are shown on **Plate 8-4 Stage Discharge Curves**.

b. Inflow Design Flood. As part of the 2012 Dam Safety Modification Study, the Inflow Design Flood was updated in 2019 using a calibrated HEC-HMS model and 72-hour Probable Maximum Precipitation rainfall estimates from the National Weather Service Hydrometeorological Report Numbers 51 and 52. A full explanation of this IDF update is given in the document "Rough River Watershed Hydrologic Model Development_ATRd Final_11272020.pdf" located on the LRL network drive. The hydrograph is shown on **Plate 8-1b Inflow Design Flood (2019)** and the pertinent data for the Inflow Design Flood is as follows:

Inflow Design Flood

Total precipitation in 72 hours, inches	27.83
Total volume of runoff, inches	26.58*
Peak flow into full reservoir, cfs	344,700
Total volume of hydrograph, acre-feet	619,700
Elevation of pool at start of flood, feet, msl	524
Initial release, cfs	5,530
Maximum total release, cfs	40,100**
Maximum reservoir elevation, feet, msl	556.69
Available freeboard, feet	2.23***

* Baseflow volume is 1.5 inches
** Approximately 6,600 cfs through conduit and 33,500 cfs through spillway
*** 2019 Parapet wall survey indicates low spot in parapet wall is elevation 558.92 NGVD29

c. Reservoir Design Flood. *The Basin of Design for Definite Project Report*, July 1941, indicated the flood of January 1937 was the greatest flood of record in the Rough River basin for a period exceeding 100 years. It also states that since the frequency of the 1937 flood indicates full utilization of the reservoir only once during the economic life of the project, it did not appear justifiable to provide control of a flood of greater magnitude. Accordingly, the flood of January 1937 was adopted as the Reservoir Design Flood. The flood routing assumed an outflow of 3,000 cfs any time the pool was above conservation pool (set at 460 during these studies). This routing procedure led to a storage utilization of 299,200 acre-feet which represented a storage equivalent of 12.5 inches of runoff from the drainage area and corresponded to a pool elevation of 522.9. This subsequently led to an adopted spillway elevation of 523.0. In Design Memorandum No. 1, July 1953, a Standard Project Flood was developed in compliance with Engineer Bulletin No. 52-8 dated March 1952. The result of this study led to a required reservoir capacity of 12.68 inches of runoff from the drainage area, which was very close to the 12.5 inches determined using the flood of January 1937. The spillway crest elevation was subsequently raised to elevation 524.0 to provide the required runoff capacity. Further refinement of the operational criteria resulted in a peak pool elevation of 528.7 after routing the flood of January 1937.

d. Other Floods. Effects of theoretical regulation on Rough River Reservoir elevations for 1930 through 1957 are shown in **Plate 8-5 Theoretical Regulation Pool Hydrographs**. Observed pool elevation data from July 1959 through the present and observed releases from January 1983 through the present can be viewed in the USACE-LRL Water Management Database in the mastdb.dss file. The maximum historical pool elevation through May 2020 is 527.35, which occurred on May 4, 2011. The highest annual historical pool elevations attained and maximum reservoir release during associated flood events are shown in **Table 8-1** below.

Table 8-1 Maximum Rough River Reservoir Flood Elevations
Period of Record: July 1959 through May 2020

Date	Pool elevation attained	Maximum flood release
DD-MMM-YYYY	FT-NGVD29	CFS
04-May-2011	527.35	6,400*
24-Feb-1989	521.61	2,160
22-May-1983	521.23	2,810
28-Sep-1979	520.90	1,850
22-Mar-1997	517.94	2,650

*5,500 cfs through conduit and 900 cfs through spillway

8.03 Recreation

The reservoir has a seasonal recreation pool of 4,500 acres. The Rough River Dam State Resort Park, managed by the KDP, borders the reservoir and offers water access for boating, fishing, and a marina for boat storage and boat rental. The reservoir and state park are convenient to Louisville, Elizabethtown, and Evansville. Visitation to the project averages about 1.8 million people per year with estimated total direct and indirect economic benefits in 2019 of $112 million.

8.04 Water Quality

Overall, water quality within Rough River Reservoir is generally good and meets the authorized purposes of the project. One of the largest threats to the water quality integrity of the reservoir is algal blooms, likely driven by high loads of nutrients entering the reservoir as runoff and accumulating within the sediment bed of the reservoir. Inflows to the lake are typical of rural/agricultural area runoff with high nutrient loading, which is reflected in water quality monitoring data (as discussed in **Section 4.08 Water Quality**).

In general, the minimum specified release has adequately met downstream water quality needs. Less than one percent of the measurements taken in the tailwater by the LRL Water Quality Team or USGS gage have resulted in exceedances of state criteria for temperature and dissolved oxygen. However, because of the lack of selective withdrawal capability the tailwater frequently doesn't meet the tailwater temperature guide curve. This can have a negative effect on the aquatic ecosystem downstream. Results from a biological study conducted by the LRL Water Quality Team in 2016 found the macroinvertebrate community was "very poor" following KDOW methodology; however, it's important to note KDOW's Macroinvertebrate Bioassessment Index was not calibrated for sites with drainage areas greater than 200 mi^2

(RRR10000 drainage area is 455 mi^2), so caution must be placed on any interpretation of these findings.

Historical tailwater temperature data were collected from the LRL Water Quality team as well as from the United States Geological Survey (USGS) gage (#3318010) located in the Rough River Reservoir tailwater. The USACE data were collected approximately monthly during the summer months with some variation from year to year beginning in 1970 until 2018. Regarding the USGS data, only approved data which has been reviewed by USGS staff for consistency was considered. The USGS data are comprised of average daily data beginning in 1990 and ending in 2016 with periods of inactivity from 1993-1999, 2001-2003, and 2014-2016. Because the USGS data were reported daily, the dataset is much more comprehensive and allows for a better comparison of annual temperature trends. In general, when both datasets are compared, they display very similar long-term trends, with variation in individual measurements between the two datasets. These differences in individual data points are likely due to differences in the timing and location of sample collection. In order to capture the annual variability of temperature across the period of record, temperatures were averaged for each day of the year using a moving average technique and daily variation in temperature was accounted for using two times the standard deviation for each day's temperature. The product of this procedure is shown in **Figure 8-1** below as solid purple lines and individual temperature measurements are also shown. This figure is primarily based on the USGS daily temperature data. Note that the x-axis is shown as days of the year, with 1 representing 1 January and 365 representing 31 December.

In an effort to compare water temperatures of Rough River Dam tailwater to a natural system, reference streams were selected from the region and their range of temperatures was compared with temperatures of Rough River Dam releases observed in the tailwater. Reference streams were selected from all available USGS gaging stations in Kentucky that have available temperature data. Of 47 potential sites, three streams were selected as temperature references. The selected streams have comparable drainage areas to Rough River, are largely unregulated by controlled releases from upstream storage reservoirs, have adequate periods of record, and are located in the vicinity of Rough River. In general, they may be considered to approximate unimpacted natural conditions regarding temperature variability.

In order to capture the annual variability of temperature across the period of record, the same moving average technique applied to the tailwater data above was performed on the three reference stream sites. **Figure 8-2** displays the variation in reference streams compared with the variation in observed temperatures from the Rough River Dam tailwater. Again, there is some overlap during some parts of the year and divergence in others. Note that the reference streams exhibit nearly symmetrical annual patterns centered around 19 July (day 200), whereas the observed data from tailwater is notably asymmetrical, with temperatures increasing up until around 4 October (day 277). Rough River Reservoir does not have selective withdrawal capability. Although the low-flow bypass intake elevations are higher than the main gates, all water released from Rough River Dam when the lake is stratified comes from the hypolimnion. This results in cold water being released in the early spring as water temperature stratification begins. This continuous release of cold water through the summer months depletes the available cold water in the reservoir, resulting in continually warming tailwater temperatures through early fall. Continuous releases from the hypolimnion are likely one of the factors driving the

discrepancy between the tailwater and reference stream temperature. Additionally, the Falls of Rough Dam is located approximately 7 miles downstream of the Rough River Dam. This low-head dam is approximately 13 feet tall and impounds water upstream to the toe of Rough River Dam. During periods of low flow and warm temperatures, this low-head dam may also contribute to elevated Rough River Dam tailwater temperatures.

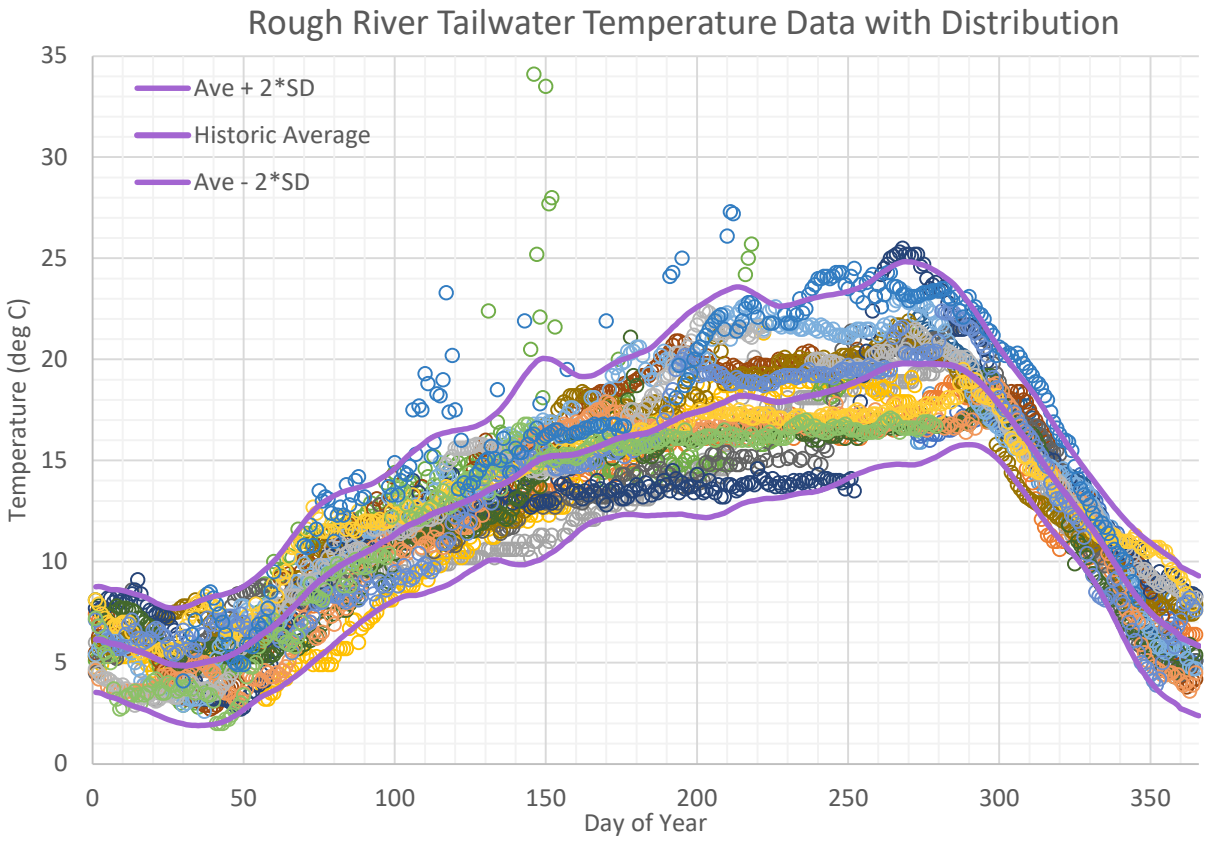


Figure 8-1 Rough River Tailwater Temperature Distribution
(modified from March 2019 *Environmental Assessment, Rough River Lake Dam Rehabilitation*)

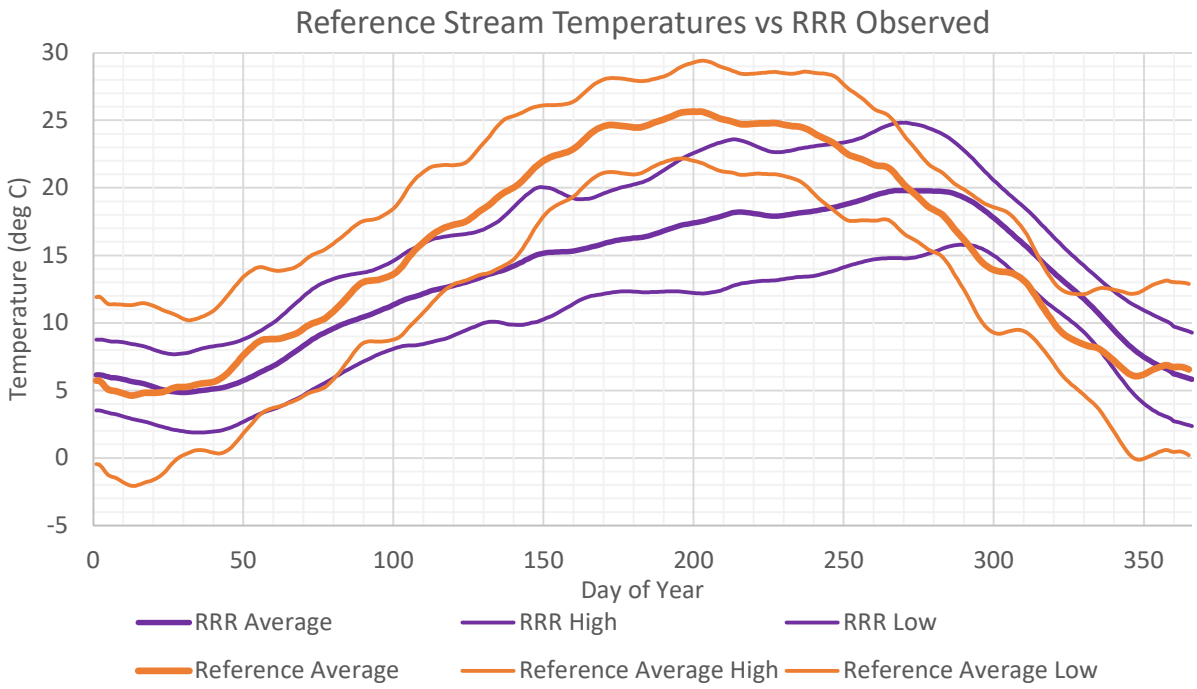


Figure 8-2 Reference and Observed Stream Temperatures
(modified from March 2019 *Environmental Assessment, Rough River Lake Dam Rehabilitation*)

8.05 Fish and Wildlife

In general, the diversity of habitat in the Rough River Reservoir project area provides for a relatively large variety of wildlife species. Fishes most sought by lake anglers include bass, catfish, hybrid striped bass, crappie, and panfish. The lake suffers from lack of suitable cover for some fish species, a condition fairly typical of multipurpose lakes. However, according to the KDFWR overall the largemouth bass population assessment at Rough River Reservoir has averaged a "Good" rating since 1996 and has rated in the "Excellent" range since 2012.

Habitat diversity around the lake provides for a relatively diverse composition of wildlife species. Several thousands of acres of project lands and water of Rough River Lake are licensed to the KDFWR for wildlife management. The KDP operates Rough River Lake State Park, which acts to preserve a large portion of forested lands. The diverse habitat allows for a large number of reptiles, amphibians, bird species, and various mammal species. Dove, quail, mallard, rabbit, fox, gray squirrels, and whitetail deer are the most commonly hunted species.

8.06 Water Conservation/Water Supply

The City of Leitchfield has contracted for 120 acre-feet of storage in Rough River Reservoir between elevations 464.9 and 465. The Grayson County Water District has contracted for 260 acre-feet of storage between elevations 465 and 470. Given that the water supply storage is below winter pool, no operational accommodation is needed in the Water Control Plan to meet contracted water demand.

8.07 Hydroelectric Power
See **Section 7.10 Hydroelectric Power**.

8.08 Navigation
See **Section 7.11 Navigation**.

8.09 Drought Contingency Plans
See **Section 7.12 Drought Contingency Plans**.

8.10 Flood Emergency Action Plans
See **Section 7.13 Flood Emergency Action Plans**.

8.11 Frequencies
The most recent frequency analysis for the project was performed in conjunction with the most recent risk assessment.

a. Peak Inflow Probability. The inflow frequency curve for Rough River Reservoir is shown on **Plate 8-6 Peak Inflow Probability**. This curve reflects the inflow frequency based on computed inflow values recorded at the dam site from January 1982 to May 2020.

b. Pool Elevation Duration and Frequency. The pool elevation-duration curve for the project under current operating conditions is shown on **Plate 8-7 Pool Elevation Annual Duration Curve**. The pool elevation-frequency curve for the project under current operating conditions is shown on **(29) Plate 8-8 Pool Elevation** Frequency Curve

c. .

d. Key Control Points. Key stations for the operation of Rough River Reservoir include the USGS gage on Rough River near Dundee, Kentucky (USGS 03319000), the USGS Green River gage at Lock 4 at Woodbury, Kentucky (USGS 0331500), and the USGS Green River gage at Lock 2 at Calhoun, Kentucky (USGS 0332000). The Dundee rating curve is shown on Plate 8-4B and the rating curves for Woodbury and Calhoun are shown on Plates 8-4D and 8-4E of **Plate 8-4 Stage Discharge Curves**, respectively. **Table 8-2** summarizes pertinent data for these key stations.

Table 8-2 Key Stations Pertinent Data

A. Rough River near Dundee, KY

Purpose of Control	Release control point		
Uncontrolled Drainage Area	303 square miles		
Total Drainage Area	757 square miles		
	Stage	Discharge	Sources
Minimum of Record	3.7	14 cfs	USGS Rating; USGS Daily Statistics
Average Annual	10.7	1,170 cfs	USGS Rating; USGS Annual Statistics
Zero Damage	N/A	N/A	
Flood Stage	25	7,000 cfs	NWS AHPS; USGS Rating
Maximum of Record	31.8	>32,200 cfs	USGS Peak Streamflow; USGS Rating

B. Green River at Lock 4 at Woodbury

Purpose of Control	Release Control Point		
Uncontrolled Drainage Area	3,079 square miles		
Total Drainage Area	5,404 square miles		
Time of Travel to:			
Lock 2 Calhoun	72 hours		
Evansville	132 hours		
	Stage	Discharge	Sources
Minimum of Record	<1.70	356 cfs	USGS Rating; USGS Daily Statistics
Average Annual	10.6	9,600 cfs	USGS Rating; USGS Annual Statistics
Zero Damage	N/A	N/A	
Flood Stage	26	40,600 cfs	NWS AHPS; USGS Rating
Maximum of Record	43.1	205,000	USGS Peak Streamflow

C. Green River at Lock 2 at Calhoun

Purpose of Control	Release Control Point		
Uncontrolled Drainage Area	4,787 square miles		
Total Drainage Area	7,566 square miles		
Time of Travel to:			
Evansville	60 hours		
	Stage	Discharge	Sources
Minimum of Record	<9.5	162 cfs	USGS Rating; USGS Daily Statistics
Average Annual	13.2	11,840 cfs	USGS Rating; USGS Annual Statistics
Zero Damage	N/A	N/A	
Flood Stage	23	46,800 cfs	NWS AHPS; USGS Rating
Maximum of Record	37.5	208,000 cfs	USGS Peak Streamflow

NOTE: Stage and discharge estimates are based on available USGS and NWS flow statistics accessed in August 2020, in combination with the key stations rating curves provided in this document.

8.12 Other Studies.

a. Examples of Regulation. The original regulation procedure was developed in 1953 in support of Design Memorandum No. 1 *General Design Memorandum*. Additional studies and consideration discussed in the Green River Basin Water Control Manual led to an updated regulation procedure shown in the original 1967 Water Control Manual. The release procedures determined for the manual were updated in 1995 to include consideration of the stage at the Rough River near Dundee, KY (USGS 03319000) and this procedure has been followed through to the present. This regulation procedure has been incorporated into a CWMS model, which is used to provide daily pool elevation and outflow forecasts.

b. Channel and Floodway Improvement. The dam is located on Rough River, 89.3 miles above its confluence with the Green River and 97.5 miles above Lock 2 on the Green River. The valleys of Rough River and tributaries are subject to frequent floods and overflowing of the banks at any time of the year. Flood damages are for the most part agricultural. Little damage is experienced in towns along the streams because they are situated well above the floodplain and only suffer the inconvenience of being temporarily isolated by inundated highways and bridges. Due to the flatness of the valley floor, flooding of the Green River causes considerable backwater in the lower reaches of Rough River. The average duration of floods at Dundee, which is above the influence of backwater, is about six days. Downstream channel conveyance capacity has not been reduced since the project was impounded, and no channel or floodway improvements have been undertaken by USACE-LRL.

c. Miscellaneous Studies. A report explaining the yearly results of water quality monitoring is prepared annually by the LRL Water Quality Team. Additionally, hydrologic and hydraulic studies have been summarized throughout various design memorandums. A Dam Safety Modification Report was prepared in 2012 and has resulted in the design of a cutoff wall and a new outlet works. These designs are expected to be completed in 2021 and will be awaiting construction when funding becomes available.

9.0 WATER CONTROL MANAGEMENT

9.01 Responsibilities and Organization

a. Corps of Engineers (USACE). The Louisville District (LRL) Office Water Management Team has the direct, day-to-day regulatory responsibility for the flood control, water supply, recreation, low flow supplementation, and fish and wildlife enhancement objectives of the Rough River Reservoir project. As discussed in previous sections of this manual, instructions for operation are issued by the Water Management Team to the Rough River Reservoir project office for actual implementation in the field. The operation and maintenance of the dam and outlet works is the responsibility of the LRL Operations Division. Instructions to the dam operator for emergency situations or for periods when the Water Management Team personnel are unavailable are included as **Exhibit B – Instructions to Dam Operator**. The Water Management Team is responsible for coordinating forecasted reservoir releases with LRD as well as the OHRFC of the NWS. These coordinated releases are used by both agencies in developing forecasts of both flood and low flows at stations downstream. Regulation for periods of low flow when additional releases are required or, in case of a spill, when dilution flows are needed, is coordinated between the KDOW and the Water Management Team. Coordination with the KDFWR for regulatory purposes concerning fish and wildlife are the responsibility of the Water Management Team.

b. Other Federal Agencies. Not Applicable

c. State, County, and Local Agencies. Not Applicable

d. Private Organizations. Not Applicable

9.02 Interagency Coordination

a. Local Press and USACE Bulletins. Special operations at Rough River Reservoir are generally preceded by a press release indicating the change in operation and the effects to be expected. The Water Management Team routes all pertinent information through the LRL Public Affairs Office, which will distribute the press release to the communities and counties surrounding Rough River Reservoir through various media including local newspapers, radio, television, and internet.

b. National Weather Service. As discussed in Chapters 5 and 6, the NWS plays a major role in the collection of data needed to operate Rough River Reservoir and in the issuance of flood forecasts for stations in the Green River Basin. Though USACE-LRL does not forecast flows for the general public, it does relay the stages forecasted by the NWS, OHRFC, to interested parties.

c. U.S. Geological Survey. As part of the cooperative stream gaging program, maintenance of stage-discharge relationships and record-keeping at key stations in the Green River Basin have been delegated to the USGS.

d. Power Marketing Agency. Not Applicable.

e. Other Federal, State, and Local Agencies. The wide variety of purposes served by Rough River Reservoir make it essential to coordinate with a number of state and federal agencies. During periods of abnormal weather or unusual stream flow conditions at or near Rough River Reservoir, the Water Management Team may coordinate reservoir operations with various entities including KDOW, KDFWR, and others.

9.03 Interagency Agreements

Not Applicable

9.04 Commissions, River Authorities, Compacts, and Committees

Not Applicable

9.05 Non-Federal Hydropower

Not Applicable

9.06 Reports

Reports associated with Rough River Reservoir consist of the Daily Lake Bulletin, LRD Form 85, and Annual Report. Data populated in the ORD Form 85 includes the observed pool level, outflow, and 24-hr recorded precipitation at 0600, and the forecasted pool level and outflow for the subsequent three-day period. The Annual Report provides a summary of the LRL Water Management program at the conclusion of each water year and discusses deviations or unusual operations of each project that fall within that project's operational latitude.

EXHIBIT A

FORMAL AGREEMENTS

FC-4/8-4

CONTRACT NO. DA-15029-CIVENG-66-150

File Copy ED-P 1505-25 FC-1

CONTRACT BETWEEN THE UNITED STATES OF AMERICA
AND
CITY OF LEITCHFIELD, KENTUCKY
FOR
WATER STORAGE SPACE IN ROUGH RIVER RESERVOIR, KENTUCKY

THIS CONTRACT, entered into this 18th day of April 1966, by the UNITED STATES OF AMERICA (hereinafter called the "Government"), represented by the Contracting Officer executing this contract, and the CITY OF LEITCHFIELD, KENTUCKY, a municipal corporation existing under the laws of the Commonwealth of Kentucky, with its principal office in Leitchfield, Grayson County, Kentucky (hereinafter called the "City"),

WITNESSETH THAT:

WHEREAS the Government, in pursuance of the Flood Control Act approved 28 June 1938 has constructed and is now operating Rough River Dam and Reservoir on Rough River, Kentucky (hereinafter called the "Project"); and

WHEREAS, under provisions of the Water Supply Act of 1958 (Title III of Public Law 85-500, as amended by Section 10 of Public Law 87-88), the Government is authorized to make contracts with States and Local interests for water supply storage for municipal and industrial purposes, provided that costs allocated to water supply shall be repaid within the life of the Project; and

WHEREAS, subject to the limitations prescribed thereby, Public Law 88-140 makes permanent the rights of States and Local Interests to utilize municipal and industrial storage in Corps of Engineers reservoirs for which they have contributed or will hereafter contribute, or have contracted or will hereafter contract to pay the Government over a specific period of years money, exclusive of interest, equivalent to the cost of providing space for such storage; and

WHEREAS, the City desires to utilize sufficient storage space in the Project to provide 1.5 M.G.D. (million gallons per day) for municipal and industrial water supply; and

WHEREAS, reallocation of storage to provide space desired by the City would not adversely affect the purposes for which the Project was authorized and constructed, within the meaning of Section 301(d) of the Water Supply Act of 1958; and utilization of the storage as proposed by the City represents a higher type of use than that to which such storage has previously been allocated; and

WHEREAS, the Division of Flood Control and Water Resource Development, Kentucky Department of Natural Resources has concurred in the application of the City for allocation of water supply storage space in the Project; and

WHEREAS, the City agrees to fulfill the local interest requirements of the Water supply Act of 1958, as amended:

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

ARTICLE 1. a. The Government has designed and constructed the Project for Flood Control and allied purposes. Upon execution of this contract, 120 acre-feet of the reservoir storage capacity available within the Project between elevation 464.9 m.s.l. (mean sea level) and elevation 465.0 m.s.l. measured at the dam, is allocated to the City for water supply use. Subject to the provisions hereinafter set forth, the City shall have the right at any time to withdraw the water in the said storage space, to the extent that such storage will yield, provided the elevation of said water is above elevation 464.9 m.s.l. Regardless of the elevation of the water, the Government reserves the right at all times to maintain a minimum downstream release of water 10 cubic feet per second through the gates or spillway of the dam. The foregoing provisions of this Article will not affect or change the right of the Government to draw down the water of the reservoir to elevation 465.0 m.s.l. at any time and in any manner it so desires, and the Government shall have the right to lower the water below elevation 464.9 m.s.l. should that become necessary in order to preserve the safety of the Project.

b. Whenever the elevation of the water is below elevation 495.0 m.s.l., withdrawal of water by the City during the period 1 April through 31 October from the aforesaid 120 acre-feet of storage shall not exceed an average of 1.5 million gallons per day (M.G.D.) as determined by the Contracting Officer from the records of withdrawal. Such adjustments shall be made in water supply withdrawal, as approved or directed by the Contracting Officer, as may be necessary at any time to effect compliance with the allowable maximum average rates of 1.5 M.G.D.

c. The City will not make withdrawals which would lower the water level below elevation 464.9 feet above mean sea level, unless expressly approved in writing by the Contracting Officer.

d. The Government shall not be responsible for diversion by others, nor will it become a party to any controversies between users of the aforesaid storage space, except as such controversies may affect storage space reserved by the Government.

e. The design and location of any future City installations or facilities that the City may construct at the Project for the purposes of diversions or withdrawals shall be subject to the approval of the

Contracting Officer, and the cost of such installations or facilities, or any modifications thereof, shall be borne by the City.

f. The Government reserves the right to take such measures as may be necessary in the operation of the Project to preserve life and/or property.

g. The City recognizes that this contract provides storage space only, as stated above, and that any water that may be impounded therein will be raw water. The Government makes no representation with respect to quality or availability of water and assumes no responsibility therefor, or for treatment of the water.

ARTICLE 2. METERING. For the purpose of maintaining an accurate record of water resources at the Project, the City agrees to install suitable meters or metering devices satisfactory to the Contracting Officer, without cost to the Government prior to use of the water storage space. The City shall furnish the Government regular monthly records of the quantity of water withdrawn, and shall furnish interim records at more frequent intervals when specifically requested by the Contracting Officer. See attached contract mod.

ARTICLE 3. FEDERAL AND STATE LAWS. The City shall use such storage space in a manner consistent with Federal and State Laws.

ARTICLE 4. REGULATION OF THE USE OF WATER. The regulation of the use of water withdrawn from the aforesaid storage space shall be the responsibility of the City and will not be considered a part of this contract.

ARTICLE 5. CONSIDERATION AND PAYMENT.

a. In consideration of the payments to be made by the City to the Government, it is agreed that the Government will make storage space in the Project available to the City as provided in Article 1. In consideration of the Government's providing the aforesaid storage space to the City, the City agrees to pay to the Government, based upon cost estimates and computations as set forth in Exhibit "A" attached hereto and made a part of this contract, the following amounts:

(1) $3,648 for the cost of providing the aforesaid space for water supply. This amount is 0.038 percent of the estimated total first cost of the Project joint-use facilities, representing that portion of such cost allocated to the water supply provisions.

(2) $418 for the cost of operating and maintaining the Project water supply storage space for a period of 50 years from the effective date of this contract. This amount is the agreed present worth of 50 equal annual payments representing that portion of the estimated annual costs of Project operation and maintenance allocated to water supply storage space.

1. AMENDMENT/MODIFICATION NO.	2. EFFECTIVE DATE	3. REQUISITION/PURCHASE REQUEST NO.	4. PROJECT NO. (If applicable)
P00001			PD

5. ISSUED BY	CODE	6. ADMINISTERED BY (If other than block 5)	CODE
U. S. Army Engineer District, Louisville Co of Engineers, 600 Federal Place P. O. Box 59, Louisville, Ky. 40201	W22N9K		

7. CONTRACTOR NAME AND ADDRESS (Street, city, county, state, and ZIP Code)	CODE	FACILITY CODE	8.
Mayor City of Leitchfield Leitchfield, Kentucky 42754			☐ AMENDMENT OF SOLICITATION NO. _____ DATED _____ (See block 9) ☒ MODIFICATION OF CONTRACT/ORDER NO. DA-15029-CIVENG-66-50 DATED 66 Apr 18 (See block 11)

9. THIS BLOCK APPLIES ONLY TO AMENDMENTS OF SOLICITATIONS

☐ The above numbered solicitation is amended as set forth in block 12. The hour and date specified for receipt of Offers ☐ is extended, ☐ is not extended.

Offerors must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation, or as amended, by one of the following methods: (a) By signing and returning _____ copies of this amendment; (b) By acknowledging receipt of this amendment on each copy of the offer submitted; or (c) By separate letter or telegram which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKOWLEDGMENT TO BE RECEIVED AT THE ISSUING OFFICE PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If, by virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter, provided such telegram or letter makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.

10. ACCOUNTING AND APPROPRIATION DATA (If required)

N/A

11. THIS BLOCK APPLIES ONLY TO MODIFICATIONS OF CONTRACTS/ORDERS

(a) ☐ This Change Order is issued pursuant to _____

The Changes set forth in block 12 are made to the above numbered contract/order.

(b) ☐ The above numbered contract/order is modified to reflect the administrative changes (such as changes in paying office, appropriation data, etc.) set forth in block 12.

☐ This Supplemental Agreement is entered into pursuant to authority of 43 USC 390b

It modifies the above numbered contract as set forth in block 12.

12. DESCRIPTION OF AMENDMENT/MODIFICATION

Subject contract for Water Storage Space in Rough River Reservoir, Kentucky, is hereby modified as follows:

1. The last sentence, Article 2, Metering, is hereby deleted in its entirety and the following is substituted therefor: "The City agrees to furnish to the Contracting Officer in January of each year monthly records of withdrawals for the preceding 12-month period, and shall furnish monthly withdrawal records at more frequent intervals upon specific request of the Contracting Officer."

2. Effective this date, administration of the above referenced contract is transferred to Thomas P. Nack, Colonel, Corps of Engineers, District Engineer, as Successor Contracting Officer.

3. All other terms and conditions remain the same.

This modification is necessary to delete a contract requirement that is no longer required.

Except as provided herein, all terms and conditions of the document referenced in block 8, as heretofore changed, remain unchanged and in full force and effect.

13. ☐ CONTRACTOR/OFFEROR IS NOT REQUIRED TO SIGN THIS DOCUMENT ☒ CONTRACTOR/OFFEROR IS REQUIRED TO SIGN THIS DOCUMENT AND RETURN 3 COPIES TO ISSUING OFFICE

14. NAME OF CONTRACTOR/OFFEROR	17. UNITED STATES OF AMERICA
CITY OF LEITCHFIELD	
BY _____ (Signature of person authorized to sign)	BY _____ (Signature of Contracting Officer)

15. NAME AND TITLE OF SIGNER (Type or print)	16. DATE SIGNED	18. NAME OF CONTRACTING OFFICER (Type or print)	19. DATE SIGNED
		THOMAS P. NACK, COL, CE District Engineer	

(3) $56 for the cost of major capital replacement required in the Project for the water supply storage space for a period of 50 years from the effective date of this contract. This amount is the agreed present worth of 50 annual equal payments representing that portion of the estimated major capital replacement cost allocated to water supply storage space.

b. The aforesaid payments shall be made by the City in lump sum prior to withdrawal of water by the City.

ARTICLE 6. PERIOD OF CONTRACT. This contract shall become effective as of the date of approval by the Secretary of the Army, or his duly authorized representative, and shall continue in full force and effect under the conditions set forth herein, not to exceed the life of the Project.

ARTICLE 7. PERMANENT RIGHTS. The City shall have a permanent right under the provisions of P. L. 88-140 to the use of water storage space in the Project as provided herein, subject to the following conditions:

a. That the City must have discharged its responsibilities for payment of the costs allocated to water supply as provided in Article 5 above.

b. That the City agrees to pay its proportionate share of any further costs allocated to water supply which may, subsequent to 50 years from the effective date of this contract, be required for such reconstruction, rehabilitiation or replacement of Project facilities and for such annual operation and maintenance as determined necessary to continue satisfactory operation of the Project. Such costs will be established by the Contracting Officer. Repayment arrangements will be made by supplemental agreement to this contract.

c. Upon expiration of 50 years from the effective date of this contract, the Contracting Officer shall redetermine the storage space for municipal and industrial water supply, taking into account such equitable reallocation of reservoir capacities among the purposes served by the Project as may be necessary due to sedimentation. Such findings, and the storage space allocated to municipal and industrial water supply, shall be defined and described in an exhibit which will be made a part of the supplemental agreement to this contract. Following the same principal, such reallocations of reservoir storage capacity may be further adjusted from time to time as a result of sedimentation resurveys to reflect actual rates of sedimentaion, and the contract further modified on the basis of revisions in storage space allocated to municipal and industrial water supply.

d. The permanent rights of the City under this contract shall continue as long as the Government continues to operate the Project. In the event the Government ceases to operate the Project, such rights may be continued subject to the execution of a separate contract, or additional supplemental agreement to this contract, providing for:

(1) Continued operation by the City of such part of the facility as is necessary for the utilization of the storage space allocated to the City;

(2) Terms which will protect the public interest; and

(3) Effective absolvement of the Government by the City from all liability in connection with such continued operation.

ARTICLE 8. DEFAULT. In the event the City refuses or fails to comply with any or all of the terms of this contract, including the foregoing provisions with respect to payments, the Government reserves the right to terminate the contract.

ARTICLE 9. OPERATION AND MAINTENANCE. The Government shall operate and maintain the Project owned by the Government. The City will have the right to make withdrawals for its purpose as needed, in accordance with Article 1. The City shall be responsible for operation of all features and appurtenances which may be provided and owned by the City.

ARTICLE 10. RIGHTS OF WAY. The grant of an easement for right-of-way over, across, in, and upon Government-owned lands under the control of the Secretary of the Army, required for transmission of the water from the point of withdrawal, shall be by separate instrument in a form satisfactory to the Secretary of the Army, without additional cost to the City, under the authority and in accordance with the provisions of 10 U.S.C. 2669.

ARTICLE 11. RELEASE OF CLAIMS. The City shall hold and save the Government, including its officers, agents and employees, harmless from liability of any nature or kind for or on account of any claim for damages which may be filed or asserted as a result of withdrawal of water from the Project by the City, or as a result of the construction, operation or maintenance of the features or appurtenances owned and operated by the City.

ARTICLE 12. TRANSFER OR ASSIGNMENT. The City shall not transfer or assign this contract, nor any rights acquired thereunder, nor suballot said water storage space or any part thereof, nor grant any interest, privilege, or license whatsoever in connection with this contract, without approval of the Secretary of the Army or his authorized representative; provided that unless contrary to the public interest, this restriction shall not be construed to apply to any water which may be obtained from the water supply storage by the City and furnished to any third party or parties.

ARTICLE 13. OFFICIALS NOT TO BENEFIT. No member of Congress or resident commissioner, shall be admitted to any share or part of this contract, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this contract if made with a corporation for its general benefit.

ARTICLE 14. COVENANT AGAINST CONTINGENT FEES. The City warrants that no person or selling agency has been employed or retained to solicit or secure this contract upon an agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees or bona fide established commercial or selling agencies maintained by the City for the purpose of securing business. For breach or violation of this warranty, the Government shall have the right to annul this contract without liability or, in its discretion, to add to the contract price or consideration or otherwise recover the full amount of such commission, percentage, brokerage, or contingent fee.

ARTICLE 15. DISPUTES (Nov. 1961). a. Except as otherwise provided in this contract, any dispute concerning a question of fact arising under this contract which is not disposed of by agreement shall be decided by the Contracting Officer who shall reduce his decision to writing and mail or otherwise furnish a copy thereof to the City. The decision of the Contracting Officer shall be final and conclusive unless, within 30 days from the date of receipt of such copy, the City mails or otherwise furnishes to the Contracting Officer a written appeal addressed to the head of the agency involved. The decision of the head of the agency or his duly authorized representative for the determination of such appeals shall be final and conclusive. This provision shall not be pleaded in any suit involving a question of fact arising under this contract as limiting judicial review of any such decision to cases where fraud by such official or his representative or board is alleged: Provided, however, that any such decision shall be final and conclusive unless the same is fraudulent or capricious or arbitrary or so grossly erroneous as necessarily to imply bad faith or is not supported by substantial evidence. In connection with any appeal proceeding under this clause, the City shall be afforded an opportunity to be heard and to offer evidence in support of its appeal. Pending final decision of a dispute hereunder, the City shall proceed diligently with the performance of the contract and in accordance with the Contracting Officer's decision.

b. This Disputes clause does not preclude consideration of questions of law in connection with decisions provided for in paragraph a. above. Nothing in this contract, however, shall be construed as making final the decision of any administrative official, representative, or board on a question of law.

ARTICLE 16. GRATUITIES (Mar. 1952). a. The Government may, by written notice to the City, terminate the right of the City to proceed under this contract if it is found, after notice and hearing, by the Secretary or his duly authorized representative, that gratuities (in the form of entertainment, gifts, or otherwise) were offered or given by the City or any agent or representative of the City, to any officer or employee of the Government with a view toward securing a contract or securing favorable treatment with respect to the awarding or amending, or the making of any determinations with respect to the performing of such contract; provided, that the existence of the facts upon which the Secretary or his duly authorized representative makes such findings shall be in issue and may be reviewed in any competent court.

b. In the event this contract is terminated as provided in paragraph a. hereof, the Government shall be entitled (i) to pursue the same remedies against the City as it could pursue in the event of a breach of the contract by the City, and (ii) as a penalty in addition to any other damages to which it may be entitled by law, to exemplary damages in an amount (as determined by the Secretary or his duly authorized representative) which shall be not less than three nor more than ten times the costs incurred by the City in providing any such gratuities to any such officer or employee.

c. The rights and remedies of the Government provided in this clause shall not be exclusive and are in addition to any other rights and remedies provided by law or under this contract.

ARTICLE 17. APPROVAL OF CONTRACT. This contract shall be subject to the written approval of the Secretary of the Army or his duly authorized representative and shall not be binding until so approved.

CONTRACT NO. DA-15029-CIVENG-66-150

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

THE UNITED STATES OF AMERICA

By /s/ W. Roper 31 May 1966
W. ROPER
Colonel, Corps of Engineers
District Engineer
Contracting Officer

APPROVED:

/s/ Stanley R. Resor
Stanley R. Resor
Secretary of the Army

DATE: 3 Aug 1966

CITY OF LEITCHFIELD, KENTUCKY

By /s/ James D. Deville Jr.
Mayor

ATTEST:

/s/ Ed Embry
City Clerk

(SEAL)

(SEAL)

CONTRACT NO. DA-15029-CIVENG-66-150

EXHIBIT "A"

I - RESERVOIR STORAGE

Feature	Elevation In Feet m.s.l.	Storage Acre-feet	Percent
Flood Control	465.0 - 524.0	314,210	99.962
Water supply (Leitchfield, Ky.)	464.9 - 465.0	120	0.038
Total active	464.9 - 524.0	314,330	100.000
Permanent Pool	464.9	20,050	
Total storage		334,380	

II - PROJECT COST

Total project first construction cost	$9,719,000
Less first costs, specific recreation facilities	590,000
Project first cost, joint-use facilities	9,129,000
Plus interest during construction, joint-use facilities (4-year construction period X 1/2 X .02584)	471,800
Project investment cost, joint-use facilities	9,600,800

III - PROJECT COST ALLOCATED TO THE CITY OF LEITCHFIELD, KENTUCKY

0.038 percent of net project investment cost, joint-use-facilities	$ 3,648

EXHIBIT "A" (Contd.)

IV - ANNUAL PROJECT OPERATION AND MAINTENANCE AND MAJOR REPLACEMENT CHARGES 1/

Ordinary operation and maintenance cost	$40,000
Equivalent annual charges for major replacement	6,000

V - CHARGES TO THE CITY OF LEITCHFIELD, KY.

	Annual Charges	Present Worth
Interest and amortization of cost of water supply features	$131 2/	$ 3,648
City's proportionate share (0.038%) of: Annual operation and maintenance charges estimated as (0.038% x $40,000)	15	418 3/
Major replacement estimated annually as (0.038% x $6,000)	2	56 3/
Estimated total annual charges	$148	

1/ Excludes operation and maintenance cost for land management and public use.

2/ Capital recovery factor for 50 equal payments at 2.584 percent interest rate (1955) = 0.035852 (Change 4, Appendix II, EM 1165-2-105) 0.035852 x $3,648 = $131 annually.

3/ Present worth value of annuity 1 per period:

$$P = \frac{1-(1+i)^{-n}}{i}$$

$$P = \frac{1-(1+.02584)^{-50}}{.02584}$$

$$P = 27.892$$

P = Present worth factor
n = 50 years
i = 2.584 percent interest

Operation and Maintenance: 27.892 x $15 = $418

Major Replacement: 27.892 x $2 = $ 56

2 - 2

SUPPLEMENTAL AGREEMENT
TO THE CONTRACT BETWEEN
THE UNITED STATES OF AMERICA
AND
THE CITY OF LEITCHFIELD, KENTUCKY
FOR
WATER STORAGE IN ROUGH RIVER RESERVOIR, KENTUCKY

THIS SUPPLEMENTAL AGREEMENT to Contract No. DA-15029-CIVENG-66-150 (hereinafter the "Contract") is entered into this 24th day of February, 2017, by and between the United States Department of the Army (hereinafter the "Government"), represented by the U.S. Army Engineer, Louisville (hereinafter the "District Engineer"), and the City of Leitchfield, Kentucky (hereinafter the "User"), represented by its Mayor and the Chairman of the Leitchfield Utility Commission.

WITNESSETH THAT:

WHEREAS, the Rough River Reservoir, Kentucky, flood risk management project (hereinafter the "Project") was authorized by the Flood Control Act of 1938, Public Law 761, 75th Congress, as part of the general comprehensive plan for the Ohio and Lower Mississippi Rivers described in the Committee on Flood Control Document No. 1, House of Representatives, 75th Congress, and was placed in operation in 1959;

WHEREAS, on April 18, 1966, the Government and the User entered into the Contract for the utilization by the User of 120 acre-feet of reservoir storage capacity available within the Project between elevation 464.9 and elevation 465.0 mean sea level for water supply use, which Contract became effective on August 3, 1966 upon signature of the Secretary of the Army;

WHEREAS, the User has exercised, and is currently exercising, the right to withdraw water under and pursuant to the terms and conditions set forth in the Contract;

WHEREAS, prior to the withdrawal of water by the User, the User paid the following amounts in accordance with Article 5 of the Contract: (i) the required investment costs allocated to the water supply storage space to be provided to the User; (ii) the User's required share of joint-use operation and maintenance costs for a period of fifty years from the effective date of the Contract; and (iii) the User's required share of major capital replacement costs for a period of fifty years from the effective date of the Contract;

WHEREAS, Article 7 of the Contract provided that the User shall have permanent rights to the storage space subject to the User's payment of the costs required by Article 5 of the Contract, and subject to the User's agreement to provide its proportionate share of costs allocated to water

supply after a period of fifty years from the effective date of the Contract for reconstruction, rehabilitation or replacement of Project facilities and for annual operation and maintenance of the Project, the payment arrangements to be established in a Supplemental Agreement; and

WHEREAS, the Government and the User recognize that the period of fifty years from the effective date of the contract will expire on August, 3, 2016, and desire to enter into such Supplemental Agreement for the User's payment of its proportionate share of costs allocated to water supply for reconstruction, rehabilitation or replacement of Project facilities and for annual operation and maintenance of the Project after August 3, 2016, in accordance with Article 7 of the Contract.

NOW, THEREFORE, the Government and the User agree as follows:

1. ARTICLE 5, CONSIDERATION AND PAYMENT, is hereby amended by adding the following Paragraphs c., d. and e. at the end thereof:

(c) Effective August 4, 2016, (hereinafter the "Effective Date"), the User shall be required to pay to the Government 0.038 percent of the cost of joint-use repair, rehabilitation, reconstruction and replacement costs of Project features which arise after the Effective Date. Payment of these costs shall be made either incrementally during construction or in lump sum (including interest during construction) upon completion of construction, at the option of the User. Prior to the commencement of construction or within 90 days following the commencement of construction the User shall notify the Government of its preference. All payments by the User shall be due and payable within 60 days of the receipt of a billing statement from the Finance and Accounting Officer, United States Army Engineer District, Louisville (hereinafter the "Due Date").

(d) Effective August 4, 2016, the User shall be required to pay to the Government 0.038 percent of the joint-use annual operation and maintenance expenses of the Project after the Effective Date. Payments of these expenses are due and payable in advance and shall be based on the experienced joint-use annual operation and maintenance expenses of the Project in the Government fiscal year most recently ended, or an estimate thereof when actual expense information is not available; except that the first payment under this paragraph, for Government fiscal year 2017, shall also include the pro-rated amount owed by the User to the Government for the time period between August 4, 2016 and September 30, 2016, based on the experienced joint-use annual operation and maintenance expenses in Government fiscal year 2016, or an estimate thereof if actual expense information is not available. All payments by the User shall be due and payable within 60 days of the receipt of a billing statement from the Finance and Accounting Officer, United States Army Engineer District, Louisville (hereinafter the "Due Date").

(e) Any payment not paid by the Due Date, owed by the User, shall be charged interest at the Current Value of Funds Rate, as determined by the Secretary of the Treasury that is applicable on the date that the payment became delinquent, with such penalty interest as may be required by Federal law or regulation.

2. ARTICLE 7, PERMANENT RIGHTS, is hereby amended by deleting the first two sentences of

Paragraph c., and, at the beginning of the third sentence of that paragraph, by substituting the word "Reallocations" for the phrase "Following the same principle, such reallocations".

3. The Contract is hereby amended by adding after ARTICLE 17 a new Article as follows:

"ARTICLE 18. DEFINITIONS .

a. The term "annual operation and maintenance expenses" shall mean the annual expenses of the Project generally funded under the Operation and Maintenance appropriations account. These expenses include the day-to-day costs to operate and maintain the Project as well as costs funded by the Operations and Maintenance appropriations account that are not capitalized.

b. The term "joint-use" shall mean that the monetary amounts referenced pertain to two or more Project purposes.

c. The term "repair, rehabilitation, reconstruction and replacement costs" shall mean costs of the Project generally funded under the Operation and Maintenance appropriations account, or the Construction appropriations account. Such expenditures are for funding infrequent and costly work and are intended to ensure continued satisfactory operation of the Project.

4. All other terms and conditions of the Contract remain unchanged.

IN WITNESS WHEREOF, the parties have executed this Supplemental Agreement, which shall become effective upon the date it is signed by the Government.

CITY OF LEITCHFIELD, KENTUCKY

BY: William H Thomason
William H. Thomason, Mayor

ATTEST: Lori Wessley
~~Kimberly Sowders~~, City Clerk
Lori Wessley

DATE: February 2, 2017

LEITCHFIELD UTILITY COMMISSION

BY: Robert Crawford
Robert Crawford, Chairman

BY: William H Thomason
William H. Thomason, Mayor
City of Leitchfield, Kentucky

DATE: February 2, 2017

DEPARTMENT OF THE ARMY

BY: _____ DATE: 24 Feb 17

Christopher G. Beck
Colonel, U.S. Army
District Engineer

CERTIFICATION

I David B. Vickery, Attorney for the City of Leitchfield, Kentucky, have reviewed the foregoing Supplemental Agreement, executed on behalf of the City by William H. Thomason, Mayor, and by Robert Crawford, Chairman of the Leitchfield Utility Commission, and as Attorney for the City of Leitchfield, Kentucky, certify that the City of Leitchfield, Kentucky is legally and financially capable of entering into the contractual obligations contained in the foregoing Supplemental Agreement and that, upon acceptance by the United States Department of the Army, it will be legally enforceable.

Given under my hand, this 2nd day of February, 2016.

David B. Vickery, Attorney for the City
of Leitchfield, Kentucky

DISCLOSURE OF LOBBYING

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

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

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

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

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

William H. Thomason, Mayor
City of Leitchfield, Kentucky

Date: 2nd February, 2016

DISCLOSURE OF LOBBYING

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

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

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

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

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

Robert Crawford, Chairman
Leitchfield Utility Commission

Date: February 2, 2016

WATER STORAGE AGREEMENT
BETWEEN THE UNITED STATES DEPARTMENT OF THE ARMY
AND
THE GRAYSON COUNTY WATER DISTRICT
FOR
REALLOCATED WATER STORAGE SPACE IN
ROUGH RIVER LAKE, KENTUCKY

THIS AGREEMENT is made and entered into this 20th day of November, 2017, by and between the United States Department of the Army, represented by the District Engineer executing this agreement (hereinafter called the "Government") and the Grayson County Water District (hereinafter called the "User"), represented by its Board of Commissioners.

WITNESSETH THAT:

WHEREAS, the Rough River Reservoir, Kentucky, flood risk management project (hereinafter the "Project") was authorized by the Flood Control Act of 1938, Public Law 761, 75th Congress, as part of the general comprehensive plan for the Ohio and Lower Mississippi Rivers described in the Committee on Flood Control Document No. 1, House of Representatives, 75th Congress, and was placed in operation in 1959;

WHEREAS, Section 322 of the Water Resources Development Act of 1990, Public Law 101-640 (33 U.S.C. 2324) (hereinafter called "Section 322") authorizes the Secretary of the Army to provide water supply storage to low-income communities at reduced pricing;

WHEREAS, the User desires to enter into an agreement with the Government for the use of storage for municipal and industrial water supply added to the Project by reallocation, and for payment of the cost thereof in accordance with the provisions of the Water Supply Act of 1958, as amended (43 U.S.C. 390b-f) and Section 322;

EXECUTED IN QUADRUPLICATE ORIGINAL

WHEREAS, on or around October 1, 2002, the User, with permission from the Government, began withdrawing municipal and industrial water from the Project, and this agreement is intended to make the Government whole with regard to the User's past use of storage; and

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

NOW, THEREFORE, the Government and the User agree as follows:

ARTICLE 1 - Water Storage Space.

a. Project Construction.

The Government, subject to the directions of Federal law and any limitations imposed thereby, has modified the Project so as to include therein space for the storage of water by the User.

b. Rights of User.

(1). The User shall have the right to utilize an undivided 0.0868 percent (estimated to contain 260 acre-feet after adjustment for sediment deposits) of the usable conservation storage space in the Project between elevations 470.0 feet and 465.0 feet National Geodetic Vertical Datum (NGVD), which is estimated to contain 1,800 acre-feet after adjustment for sediment deposits. The User's storage space (260 acre-feet) is to be used to impound water for present demand or need for municipal and industrial water supply.

(2). The User shall have the right to withdraw water from the lake, or to request releases to be made by the Government through the outlet works of the Project, subject to the provisions of Article lc and to the extent the aforesaid storage space will provide; and shall have the right to construct all such works, plants, pipelines, and appurtenances as may be necessary and convenient for the purpose of diversion or withdrawals, subject to the approval of the District Engineer as to design and location. The grant of an easement for right-of-way, across, in and upon land

of the Government at the Project shall be by a separate instrument in a form satisfactory to the Secretary of the Army, under the authority of and in accordance with the provisions of 10 U.S.C. 2668 and such other authorities as may be necessary. Subject to the conditions of such easement, the User shall have the right to use so much of the Project land as may reasonably be required in the exercise of the rights and privileges granted under this agreement.

c. Rights Reserved.

The Government reserves the right to control and use all storage in the Project in accordance with authorized Project purposes. The Government further reserves the right to take such measures as may be necessary in the operation of the Project to preserve life and/or property, including the right not to make downstream releases during such periods of time as are deemed necessary, in its sole discretion, to inspect, maintain, or repair the Project.

d. Quality or Availability of Water.

The User recognizes that this agreement provides storage space for raw water only. The Government makes no representations with respect to the quality or availability of water and assumes no responsibility therefor, or for the treatment of the water.

e. Sedimentation Surveys.

(1). Sedimentation surveys will be made by the District Engineer during the term of this agreement at intervals not to exceed fifteen (15) years unless the District Engineer determines that such surveys are unnecessary. When, in the opinion of the District Engineer, the findings of such survey indicate any Project purpose will be affected by unanticipated sedimentation distribution, there shall be an equitable redistribution of the sediment reserve storage space among the purposes served by the Project including municipal and industrial water supply. The total available remaining storage space in the Project will then be divided among the various Project features in the same ratio as was initially utilized. Adjusted pool elevations will be rounded to the nearest one-half foot. Such findings and the storage space

allocated to municipal and industrial water supply shall be defined and described as an exhibit, which will be made a part of this agreement, and the water control manual will be modified accordingly.

(2). The Government assumes no responsibility for deviations from estimated rates of sedimentation, or the distribution thereof. Such deviations may cause unequal distribution of sediment reserve storage greater than estimated, and/or encroachment on the total storage at the Project.

ARTICLE 2 - Regulation of and Right to Use of Water.

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

ARTICLE 3 - Operation and Maintenance.

The Government shall operate and maintain the Project and the User shall pay to the Government a share of the costs of such operation and maintenance as provided in Article 5c. The User shall be responsible for operation and maintenance of all installations and facilities which it may construct for the diversion or withdrawal of water, and shall bear all costs of construction, operation and maintenance of such installations and facilities.

ARTICLE 4 - Measurement of Withdrawals and Releases.

The User agrees to furnish and install, without cost to the Government, suitable meters or measuring devices satisfactory to the District Engineer for the measurement of water which is withdrawn from the Project by any means other than through the Project outlet works. The User shall furnish to the Government monthly statements

of all such withdrawals. Prior to the construction of any facilities for withdrawal of water from the Project, the User will obtain the District Engineer's approval of the design, location and installation of the facilities including the meters or measuring devices. Such devices shall be available for inspection by Government representatives at all reasonable times. Releases from the water supply storage space through the Project outlet works shall be made in accordance with written schedules furnished by the User and approved by the District Engineer and shall be subject to Article 1c. The measure of all such releases shall be by means of a rating curve of the outlet works, or by such other suitable means as may be agreed upon prior to use of the water supply storage space.

ARTICLE 5 - Payments.

In consideration of the right to utilize the aforesaid storage space in the Project for municipal and industrial water supply purposes, the User shall pay the following sums to the Government:

a. First Cost of Storage.

(1). The User shall repay to the Government, at the times as hereinafter specified, the amounts stated below which, as shown in Exhibit B-II attached to and made a part of this agreement, constitute the entire actual amount of the first cost of storage allocated to the water storage right acquired by the User under this agreement. The amount of the cost is based on the provisions of Section 322. The costs shown in Exhibit B are for 260 acre-feet of storage space.

(2). The cost allocated to the storage space indicated in Article 1b (1) is currently estimated at $34,934 on the basis of the costs presented in Exhibit B-II. These costs shall be repaid in one lump sum payment, as requested by the User, on the date of execution of this agreement.

b. Repair, Rehabilitation, and Replacement (RR&R) Costs.

The User will be required to pay 0.0868 percent of the cost of joint-use RR&R of Project features. Payment of these costs shall be made either incrementally during construction or in lump sum

(including interest during construction) upon completion of construction.

c. Annual Operation and Maintenance (O&M) Expense.

The User, on the date of execution of this agreement, shall pay a fee which represents 0.0868 percent of the annual experienced joint-use operation and maintenance expenses of the Project for a period beginning October 1, 2002 and ending at midnight on September 30, 2017. The User's monetary payment for Fiscal Year 2003 through Fiscal Year 2017 is calculated on Exhibit "C" attached to and made a part of this agreement.

Beginning in Fiscal Year 2018 the User will be required to pay 0.0868 percent of the annual experienced joint-use operations and maintenance expense of the Project. Payments for O&M expense are due and payable in advance within sixty one (61) calendar days of the start of the Government's new fiscal year. Payments shall be based on O&M expense for the Project in the Government fiscal year most recently ended. The amount of each annual payment will be the actual experienced O&M expense (allocated joint-use) for the preceding fiscal year or an estimate thereof when actual expense information is not available.

d. Delinquent Payments.

Any delinquent payment owed by the User shall be charged interest at the Current Value of Funds Rate as determined by the Secretary of the Treasury that is applicable on the date that the payment became delinquent, with such penalty charge and administrative fee as may be required by Federal law or regulation. This provision shall not be construed as giving the User a choice of either making payments when due or paying interest, nor shall it be construed as waiving any other rights of the Government, at law or in equity, which might result from any default by the User.

ARTICLE 6 - Duration of Agreement.

This agreement shall become effective when signed by the Secretary of the Army or his duly authorized representative and shall continue in full force and effect for the life of the Project.

ARTICLE 7 - Permanent Rights to Storage.

Upon completion of the payment by the User, as provided in Article 5a herein, the User shall have a permanent right, under the provisions of the Act of 16 October 1963 (Public Law 88-140, 43 U.S.C. 390e), to the use of the water supply storage space in the Project as provided in Article 1, subject to the following:

a. The User shall continue payment of annual operation and maintenance costs allocated to water supply.

b. The User shall bear the costs allocated to water supply of any necessary reconstruction, rehabilitation, or replacement of Project features which may be required to continue satisfactory operation of the Project. The District Engineer will establish such costs and repayment arrangements shall be in writing in accordance with the terms and conditions set forth in Article 5b for reconstruction, rehabilitation, and replacement costs, and be made a part of this agreement.

c. The District Engineer shall redetermine the storage space for municipal and industrial water supply in accordance with the provisions of Article 1e. Such redetermination of reservoir storage capacity may be further adjusted from time to time as the result of sedimentation resurveys to reflect actual rates of sedimentation and the exhibit revised to show the revised storage space allocated to municipal and industrial water supply.

d. The permanent rights of the User under this agreement shall be continued so long as the Government continues to operate the Project. In the event the Government no longer operates the Project, such rights may be continued subject to the execution of a separate agreement or additional supplemental agreement providing for:

(1). Continued operation by the User of such part of the facility as is necessary for utilization of the water supply storage space allocated to it;

(2). Terms which will protect the public interest; and,

(3). Effective absolvement of the Government by the User from all liability in connection with such continued operation.

ARTICLE 8 - Release of Claims.

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

ARTICLE 9 - Transfers and Assignments.

a. The User shall not transfer or assign this agreement nor any rights acquired thereunder, nor suballot said water supply storage space or any part thereof, nor grant any interest, privilege or license whatsoever in connection with this agreement, without the approval of the Secretary of the Army, or his duly authorized representative provided that, unless contrary to the public interest, this restriction shall not be construed to apply to any water that may be obtained from the water supply storage space by the User and furnished to any third party or parties, nor any method of allocation thereof.

b. Regarding approval of assignments, references to restriction of assignments shall not apply to any transfer or assignment to the United States Department of Agriculture, Rural Economic Community Development (RECD), formerly Farmers Home Administration, or its successor agency, or nominee, given in connection with the pledging of this water storage agreement as security for any loans or arising out of the foreclosure or liquidation of said loans. The User will notify the Corps in writing 15 days prior to applying for a RECD loan. A copy of the final loan instrument will be furnished to the Corps for their record.

ARTICLE 10 - Officials Not to Benefit.

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

ARTICLE 11 - Covenant Against Contingent Fees.

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

ARTICLE 12 - Environmental Quality.

During any construction, operation, and maintenance by User of any facilities, specific actions will be taken to control environmental pollution which could result from such activity and to comply with applicable Federal, State, and local laws and regulations concerning environmental pollution. Particular attention should be given to:

a. Reduction of air pollution by control of burning, minimization of dust, containment of chemical vapors, and control of engine exhaust gases, and of smoke from temporary heaters;

b. Reduction of water pollution by control of sanitary facilities, storage of fuels and other contaminants, and control of turbidity and siltation from erosion;

c. Minimization of noise levels;

d. On-site and off-site disposal of waste and spoil; and,

e. Prevention of landscape defacement and damage.

ARTICLE 13 - Federal and State Laws.

a. Compliance.

In acting under its rights and obligations hereunder, the User agrees to comply with all applicable Federal and State laws and regulations, including but not limited to: 40 U.S.C. 3141-3148 and 40 U.S.C. 3701-3708 (revising, codifying and enacting without substantive change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq.), the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c)), and the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 U.S.C. 4601-4655).

b. Civil Rights Act.

The User furnishes, as part of this agreement, an assurance (Exhibit "D") that it will comply with Title VI of the Civil Rights Act of 1964 (78 Stat. 241, 42 U.S.C. 2000d, et seq.) and Department of Defense Directive 5500.11 issued pursuant thereto and published in Part 195 of Title 32, Code of Federal Regulations.

c. Regulatory Program.

Any discharges of water or pollutants into a navigable stream or tributary thereof resulting from the User's facilities and operations undertaken under this agreement shall be performed only in accordance with applicable Federal, State, and local laws and regulations.

d. Lobbying Activities.

The User furnishes, as part of this agreement, a certification (Exhibit "E" and if applicable, Standard Form-LLL "Disclosure of Lobbying Activities") that it will comply with Title 31 U.S.C. Section 1352 of the limitation on use of appropriated funds to

influence certain Federal contracting and financial transactions (Public Law 101-121, October 23, 1989) and Federal Acquisition Regulation 52.203-12 issued pursuant thereto.

ARTICLE 14 - Definitions.

a. First cost of storage.

This is the cost assigned to the Users right to the storage space in the project. In this agreement, the first cost of storage is based upon the reduced pricing provisions of Section 322 and is summarized in Exhibit B-II.

b. Joint-use costs.

The costs of features used for any two or more Project purposes.

c. Annual operation and maintenance (O&M) expense.

Annual expenses funded under the O&M, General account. These expenses include the day-to-day costs to operate and maintain the Project as well as O&M costs which are not capitalized.

d. Repair, rehabilitation and replacement (RR&R) costs.

Costs funded in part under the Operation and Maintenance, General, or Construction, General accounts but not associated with first cost of storage. Such expenditures are for costly, infrequent work and are intended to ensure continued satisfactory operation of the Project. For the purposes of this agreement the term "reconstruction" used in Article 7 "Permanent Rights to Storage" shall be included in this definition of repair, rehabilitation and replacement; repayment of those costs shall be the same as described in Article 5b.

e. Fiscal Year.

Refers to the Government's fiscal year. This year begins on 1 October and ends on 30 September.

f. Life of the Project.

This is the physical life of the Project.

g. District Engineer.

Refers to the District Engineer, United States Army Engineer District, Louisville, or his/her successor or designee.

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

THE DEPARTMENT OF THE ARMY	GRAYSON COUNTY WATER DISTRICT
BY: Antoinette R. Gant	BY: John R. Tomes X
Antoinette R. Gant Colonel, U.S. Army District Commander	John Tomes, Chairman
DATE: 20 November, 2017	DATE: November 2, 2017 X

EXHIBIT A: CERTIFICATION

I Thomas H. Goff, General Counsel, Grayson County Water District, have reviewed the foregoing agreement executed by Kevin Shaw, Manager, Grayson County Water District, and as legal counsel of the Grayson County Water District certify that and find that the Grayson County Water District is legally and financially capable of entering into the contractual obligations contained in the foregoing agreement and that, upon acceptance by the Department of the Army, it will be legally enforceable.

Given under my hand, this 7th day of November, 2017. X

/s/ THG X

Thomas H. Goff, General Counsel
Grayson County Water District

EXHIBIT B: COST COMPUTATIONS
I - LAKE STORAGE
ROUGH RIVER LAKE, KENTUCKY
LAKE STORAGE FEATURES

Conserv. Storage Feature	Storage (ft. msl)	Existing Elevation (ac-ft)	Usable Storage (ac-ft)	Usable Storage 1/ (percent)	(percent)
Flood Control					
(Winter)	470-524	304,580	297,580	99.40	
(Summer)	495-524	(214,380)	(214,030)		--
Seasonal	470-495	(90,200)	(83,550)		--
Conservation Pool 2/	470	29,800	1,800	0.60	100.00
Water Supply 3/					
Leitchfield, KY		120	(120)		(0.04) (6.67)
GCWD (Pending)		260	(260)	(0.0868)	(14.44)
Total Storage	524	334,380	299,380	100.00	100.00

1/ Storage remaining after 100 years of sedimentation.
2/ The conservation pool, discussed in this report, includes all storage below elevation 470 feet msl. Included are sedimentation reserve, permanent recreation, water quality control, and water supply.
3/ Included in the Conservation Pool.

II - FIRST COST TO BE REPAID BY GCWD FOR REALLOCATED STORAGE SPACE

Total storage space from Article 5a(1) = 260 acre-feet

Cost allocated to water supply in accordance with Section 322 WRDA 90

Section 322 of WRDA 1990	CPI-U SEP 1990	CPI-U SEP 2001	2002 Price
$100 per acre-foot	132.70	178.30	$134 per acre-foot

Cost of 260 acre-feet of water supply storage under Section 322 = 260 acre-feet x $134 per acre-foot = $34,934

EXHIBIT B: (Continued)

III - TOTAL ANNUAL COST TO USER FOR REALLOCATED WATER SUPPLY STORAGE

Item	Type of Use	Computation	Cost
Operation and Maintenance 1/	Joint-use O&M estimated for FY16	0.0868% 2/ x $1,903,491	$1,652

1/ Payment due and payable on the date specified in Article 5a(2).
2/ Percent of User's share of the usable storage space in the project (column 5 of Exhibit B-I)

EXHIBIT C
ANNUAL OPERATION AND MAINTENANCE (O&M) EXPENSE
FISCAL YEAR 2003 - FISCAL YEAR 2017
ROUGH RIVER LAKE, KY

FY	Joint Use O&M Expense	% per contract	Agreed Payment Amount	Remarks
2003	$1,597,624.58	0.0868	$1,386.74	Based on actual FY02 Joint Use O&M Expense
2004	$1,674,405.47	0.0868	$1,453.38	Based on actual FY03 Joint Use O&M Expense
2005	$2,020,928.48	0.0868	$1,754.17	Based on actual FY04 Joint Use O&M Expense
2006	$1,577,791.58	0.0868	$1,369.52	Based on actual FY05 Joint Use O&M Expense
2007	$1,463,646.12	0.0868	$1,270.44	Based on actual FY06 Joint Use O&M Expense
2008	$1,718,539.79	0.0868	$1,491.69	Based on actual FY07 Joint Use O&M Expense
2009	$1,303,545.85	0.0868	$1,131.48	Based on actual FY08 Joint Use O&M Expense
2010	$1,561,403.63	0.0868	$1,355.30	Based on actual FY09 Joint Use O&M Expense
2011	$1,674,305.05	0.0868	$1,453.30	Based on actual FY10 Joint Use O&M Expense
2012	$1,502,019.18	0.0868	$1,303.75	Based on actual FY11 Joint Use O&M Expense
2013	$1,422,830.00	0.0868	$1,235.02	Based on actual FY12 Joint Use O&M Expense
2014	$2,451,850.51	0.0868	$2,128.21	Based on actual FY13 Joint Use O&M Expense
2015	$2,096,188.13	0.0868	$1,819.49	Based on actual FY14 Joint Use O&M Expense
2016	$2,044,566.98	0.0868	$1,774.68	Based on actual FY15 Joint Use O&M Expense
2017	$2,923,836.18	0.0868	$2,537.89	Based on actual FY16 Joint Use O&M Expense

	Joint Use O&M Expense	Agreed Payment Amount
Total	**$27,033,481.53**	**$23,465.06**

EXHIBIT D: ASSURANCE OF COMPLIANCE

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

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

If any personal property or real property, or interest therein, or structure thereon is provided or improved with the aid of Federal financial assistance extended to the applicant-recipient by the Department of the Army, or if such assistance is in the form of personal property or real property, or interest therein or structure thereon, then this assurance shall obligate the applicant-recipient or in the case of any transfer of such property, any transferee, for the period during which the property is used for a purpose for which the Federal financial assistance is extended or for another purpose involving the provision of similar services or benefits, or for the period during which it retains ownership or possession of the

property whichever is longer. In all other cases, this assurance shall obligate the applicant-recipient for the period during which the Federal financial assistance is extended to it by the Department of the Army. The Department of the Army representatives will be allowed to visit the recipient's facilities. They will inspect the facilities to ensure that there are no barriers to impede the handicap's accessibility in either programs or activities.

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

GRAYSON COUNTY WATER DISTRICT

BY: John R. Tomes X
John Tomes, Chairman

DATE: November 2, 2017 X

MAILING ADDRESS: Manager, Grayson County Water District
113 South Lee Avenue, Leitchfield, Kentucky 42754

EXHIBIT E: CERTIFICATION REGARDING LOBBYING

Rough River Lake, Kentucky
Grayson County Water District

1. The undersigned certifies, to the best of their knowledge and belief, that:

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

b. If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress or an employee of a Member of Congress in connection with the water supply agreement for the Grayson County Water District, Kentucky, the undersigned shall complete and submit Standard Form-LLL, "Disclosure of Lobbying Activities", in accordance with its instructions. This form is available at http://contacts.gsa.gov/webforms.nsf.

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

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

GRAYSON COUNTY WATER DISTRICT

BY: John R. Tomes DATE: November 2, 2017 X
John Tomes, Chairman

[JULY 19, 2017 CLEAN VERSION]

EXHIBIT B

INSTRUCTIONS TO DAM OPERATOR

ROUGH RIVER BASIN
KENTUCKY
RESERVOIR REGULATION PLAN

ROUGH RIVER RESERVOIR

INSTRUCTIONS TO DAM OPERATOR

TABLE OF CONTENTS

ROUGH RIVER RESERVOIR
KENTUCKY
RESERVOIR REGULATION PLAN

INSTRUCTIONS TO DAM OPERATOR

1. Collection, Recording and Transmission of Hydrologic Data.

These instructions are designed to standardize the procedures followed and records maintained in the Louisville District. The reservoir staff is responsible each day for collecting the following data as soon as possible each morning:

Pool Elevations
Tailwater
Main Gate and Bypass Data
Pool change information
Precipitation
Temperature
Anticipated 0600 gate settings
River stage information
Remarks

The above information will be entered into the Project's Daily Lake Bulletin (DLB) as defined below. Once entered and viewed (reviewed), it will be sent to the District Office. If any problems arise, Project personnel should contact another reservoir project within the Green River basin and have them submit the data to the District Office. If problems persist, the project should contact the District Office for further instructions. Compilation and submission of the DLB data must be given the highest level of attention. It is imperative that DLB data be accurate and timely to assure that mis-operations do not result.

2. Pool Elevations and Gate/Bypass Settings.

The previous day's Pool Elevations, Tailwater, Main and Bypass Gate settings including Bypass Levels are to be submitted for 1200, 1800, and 2400 hours. In addition, the current day's 0600 readings for the same dataset are to be submitted. The time of any gate changes made during the previous 24-hour period must be entered along with the same dataset.

3. Pool.

The "24 Hour Change" consists of 3 pieces of information. The first piece depicts the 24-hour trend and is shown as + or -, respectively, depending upon whether or not the pool has risen or fallen. If stationary, no symbol should be input. The second piece is the actual difference between the two readings, measured to 0.01 feet. The third piece is the trend between the 2400 (midnight) reading and the 0600 reading. This field should be shown as R, F or S depending upon whether the pool has risen, fallen or remained stationary.

4. Precipitation.

Precipitation (Precip) is measured at the dam's project office.

Precipitation should be measured to the nearest 0.01 inch and reflect the 24 hours total from the day before. The "Precipitation" field on the DLB consists of three categories: "Amount Precip Last 24 hrs", "Snow on Ground" and "Snow Water Content".

Amount Precip Last 24 hrs

Enter the total amount of precipitation received in the last 24 hours to the nearest 0.01 inch. The type of precipitation (rain, snow, sleet, ice, etc.) is irrelevant. If you had .5" of rain which then turned to ice, then snow, the correct value would be the 0.5" + the water equivalency (content) of the ice and snow.

Snow on Ground

Measured depth of snow on the ground. "Snow" includes all forms of frozen precipitation (ice, sleet, hail, etc.). Measure the depth in inches to the nearest 0.1. This value is not the amount of snow that fell over the past 24 hours, but rather a running total of the frozen precipitation that exists at the project on the ground. If there is no change from the previous day, continue to enter the observed measured value until it melts or changes.

Snow Water Content

Melt the above and record in inches to 0.01.
Note: If a trace of precipitation exists, enter "0" since a trace is less than 0.01, and make a note in the comment section; "Trace of precip". Do not enter "T" or "Trace", since the DLB only recognizes numbers. If you only have snow on the ground in shaded areas, you can make a general comment in the comment section; "Trace amounts of snow" for example. The water content can be shown as 0.

5. Temperature.

This field includes the "Present Weather" which should be selected from a drop-down menu. The "Current", "Maximum", "Minimum", and "Tailwater Degrees C" values should be entered into their appropriate fields. Note that only the Tailwater reading is in Celsius, all other temperatures are recorded as Fahrenheit.

6. Anticipated next 06:00 Outlet Settings.

This field is used to indicate any operations that the Project personnel feel is necessary to be made during the current day. The purpose of this field is to allow a member of the Water Management Team to review and verify the DLB to assure that the Project personnel's operation will meet the authorized project purposes. If the Water Management Team member disagrees with the anticipated operation, they will immediately notify the project and instruct them otherwise.

7. River Stations.

River stages observed at 0600 at Dundee are obtained from the USGS webpage and entered here.

8. Remarks.

This field is to be used by Project personnel to communicate directly with the Water Management Team member reviewing the DLB. It can be used for general comments or to pose a question.

Gate Operation

9. Bypasses.

Two 24-inch reduced to 20-inch circular low discharge bypasses are located in the control tower. The bypasses will be used for releasing low flows (~200 cfs) from the reservoir, whenever the release rate drops below 0.1 on the Main Gates. Discharge rating tables for a single bypass is presented in **Table 7-2** of the Water Control Manual (WCM). Bypass openings are expressed in tenths of vertical distance of the valve as shown by the indicator dial in the operating tower, and respective discharges are provided for selected reservoir pool levels. For intermediate openings of the bypass valve and elevations not shown, it will be necessary to compute the flow by interpolation.

10. Conduit Gates.

There are three hydraulically operated slide gates in the conduit for releasing major outflows from the reservoir. **Table 7-1** of the WCM, presents the discharge rating table for these gates for increments of five feet in reservoir pool elevations. Experience has shown that releasing through three gates simultaneously is far more desirable than through a single gate, inasmuch as there is a better distribution of flow, and vibration can be virtually eliminated. Settings for various total gate openings are given in **Table 7-1**. Settings are expressed as openings in tenths of total vertical distance as shown on indicator dials in the operating tower.

Gates are to be operated in such a manner that abnormal fluctuations in stages will not occur downstream from the reservoir. Rapid changes in stages and irregular flow characteristics are highly undesirable and may result in erosion and caving bank conditions along Rough River below the dam. To avoid these adverse effects, changes in outflows should be gradual to produce a rise in the downstream river channel as near to a natural characteristic as practicable. To accomplish this, conduit gates shall not be opened or closed at a rate greater than 2/10 total opening per hour.

Reservoir Regulation.

11. Routine.

Properly trained Project personnel are responsible for determining releases from the reservoir for maintenance of Minimum Pool (elevation 470.0) during the period 1 December – 14 March. A Rule Curve for seasonal regulation, 15 March – 30 November, is shown on **Plate 7-1 Schedule of Regulation** of the WCM. Project personnel will determine releases to maintain the reservoir pool level as dictated by the Rule Curve, consistent with flood control and minimum outflow requirement as prescribed in "Schedules of Regulation," Plate 7-1 of the WCM. Periodic instructions during routine regulatory periods may be issued by the Water Management Team, and operating personnel should request advice on procedure from the Team at any time such guidance is desired.

12. Flood Periods.

When the pool level exceeds elevation 470.0 during the 1 December – 14 March period, or is above the Rule Curve for seasonal regulation, as a result of excessive inflows or restrictions imposed on releases by controlling stages downstream, the reservoir will be regulated for Flood Control. Schedules A, B, C, and D in Plate 7-1 of the WCM, detail controlling stages, minimum releases, and allowable maximum release rates for various downstream river conditions, to be considered in effective flood control regulation. See **Section 7.05** of the WCM for more information.

Channel capacity in Rough River downstream from the reservoir corresponds to a flow of approximately 3,000 cfs. Therefore, the maximum allowable release from the dam has been set at this rate. However, releases must be modified by concurrent flows in downstream tributaries along Rough River (Rock Lick Creek and Caney Creek) so as not to create a situation of damage due to these releases. Allowable releases, based on existing stages at Dundee, are shown in Plate 7-1 of the WCM. Operating personnel will need to keep abreast of stages at this station when release rates are determined. Information on conditions in the lower Green and Ohio Rivers will be furnished to reservoir personnel by the Water Management Team as necessary.

The Dam Operator will determine releases to pass minor storage accumulations and increases in inflows, except when important flood conditions exist or are expected. For this manual, minor storage accumulations are defined as impoundments on the order of approximately 4 feet above Minimum Pool (470.0) during the 1 December – 14 March period, and approximately the same impoundment over the basic Rule Curve during the seasonal regulation period, 15 March – 30 November.

13. Low Flow.

No specific low flow objectives are included in the regulation procedure, except for a minimum release of 50 cfs at all times. In no case should the reservoir outflow be less than 50 cfs even if this release may

evacuate storage needed for filling or maintaining the pool level as prescribed by the Rule Curve.

14. Spillway Flood.

On the basis of recent studies, spillway crest (elevation 524.0) would be equaled or exceeded on an average once in 50 years. In the event of a flood of such magnitude, a constant release rate of 100 cfs will be maintained until elevation 514 is attained. Between elevation 514 and spillway crest (elevation 524.0), as prescribed in Schedule D, Plate 7-1 "Schedule of Regulation" of the WCM, the release should be continued at 100 cfs OR the conduit gates will be regulated to pass inflow only, provided a violation of maximum release table does not occur and if forecasts indicate the need to retain storage capacity in Rough River Reservoir. If Schedule D conditions exist, the Dam Operator shall release 100 cfs, until directed otherwise by the Water Management Team. When elevation 524.0 is attained, the conduit gates will be opened to pass inflow up to capacity of the conduit, as prescribed in Schedule E of Plate 7-1 of the WCM. After conduit gates are fully opened, excessive inflows will be uncontrolled through the conduit and spillway. Gates in fully opened position will be maintained until pool peaks and recedes to spillway crest (524.0). At this time gates will be adjusted to pass inflows only until downstream conditions permit return to Schedule B of Plate 7-1.

15. Public Notification of Releases.

In the interest of safety, Project personnel will take definite measures to warn downstream interests of important increases in outflows from the reservoir as far in advance as practicable. During emergency situations, this will be accomplished by telephone or personal visits by the reservoir staff to downstream strategic points. It is especially important that such warnings be issued when there is definite indication of a spillway flood which will require high releases through the conduit and uncontrolled flows through the spillway. These conditions definitely cannot be anticipated by downstream interests and could become disastrous. Discretion should be used, however, in issuing such notices. Project personnel is cautioned against unduly alarming downstream interests and notice of pending releases should be issued only when reasonably certain of important increases in outflows. Notification of downstream interests should occur in accordance with the Rough River Lake Emergency Action Plan.

16. Emergency Operations.

Personnel at the reservoir will be required to effect stop-gap regulation in the absence of information from the Water Management Team. Emergencies may arise as a result of flash flooding in the Rough River basin or a communications breakdown. In such instance, authorized Project personnel should follow regulation procedure detailed in Plate 7-1 of the WCM until contact can be re-established with the Water Management Team. Should critical condition develop or appear likely, it may be advisable to dispatch a member of the project staff to an area from where contact can be made with the Water Management Team. In an emergency of this nature, a

complete status report should be furnished, including information on current weather, rainfall, and stages at Dundee and Lock 2 on Green River, if possible. These data would be in addition to relevant data for the dam. Project personnel should make provision for obtaining these data, to the extent of dispatching observers to inspect these stations if necessary.

During duty hours, Water Management Team personnel can be contacted at their respective phone number or by calling the Water Management Public Line, 502-315-6487. During off-duty hours, Water Management Team personnel can be contacted (call or text) on their respective cell phone numbers.

Any time serous doubt exists for proper flood control regulation and contact cannot be made with the Water Management Team, release 100 cfs only and do not increase release before contact is made with the Water Management Team.

PLATES

(1) Plate 2-1 Location and Vicinity Map

CORPS OF ENGINEERS U.S. ARMY

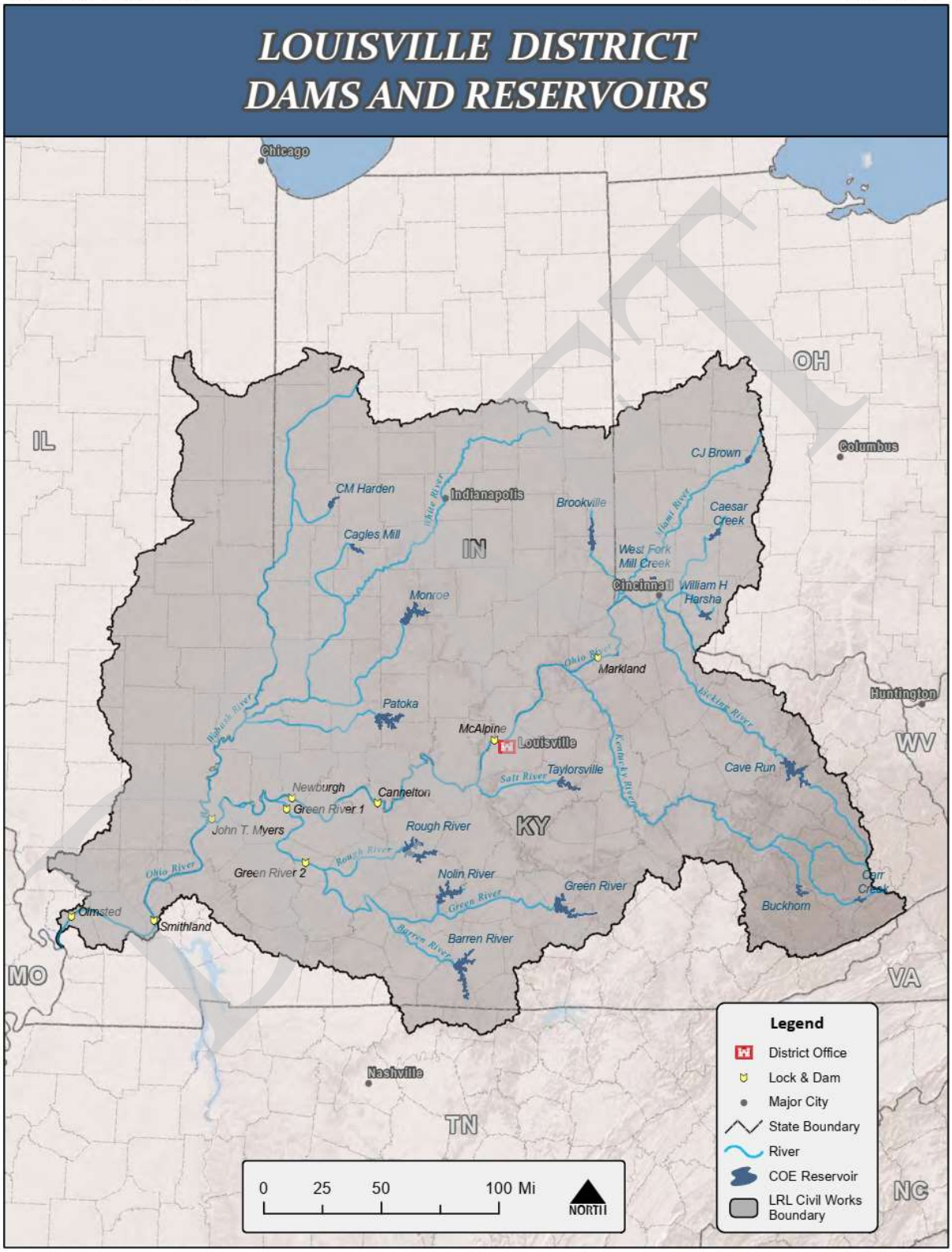


PLATE 2-1

(2) Plate 2-2 Map of Drainage Basin

CORPS OF ENGINEERS U.S. ARMY

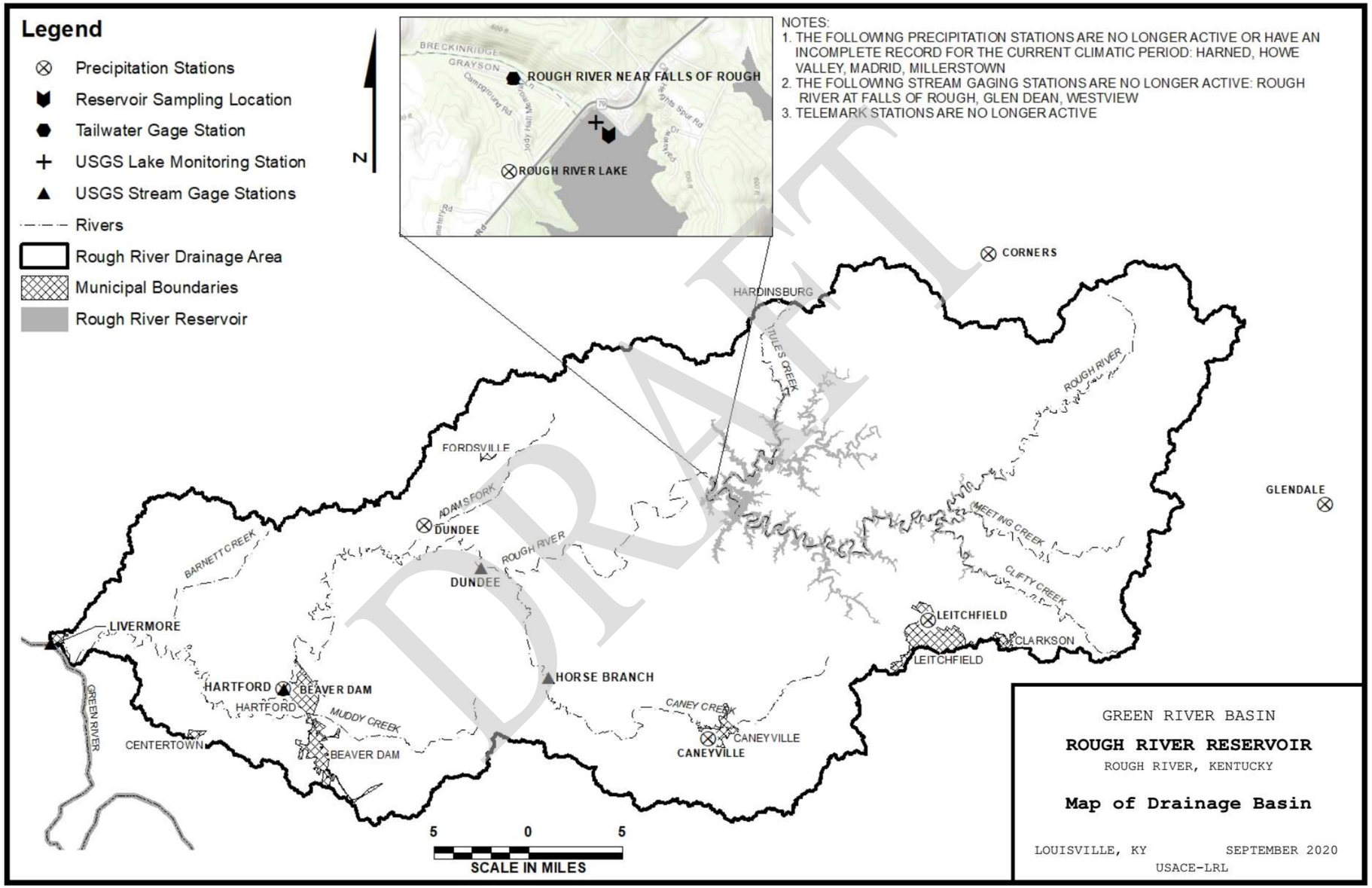
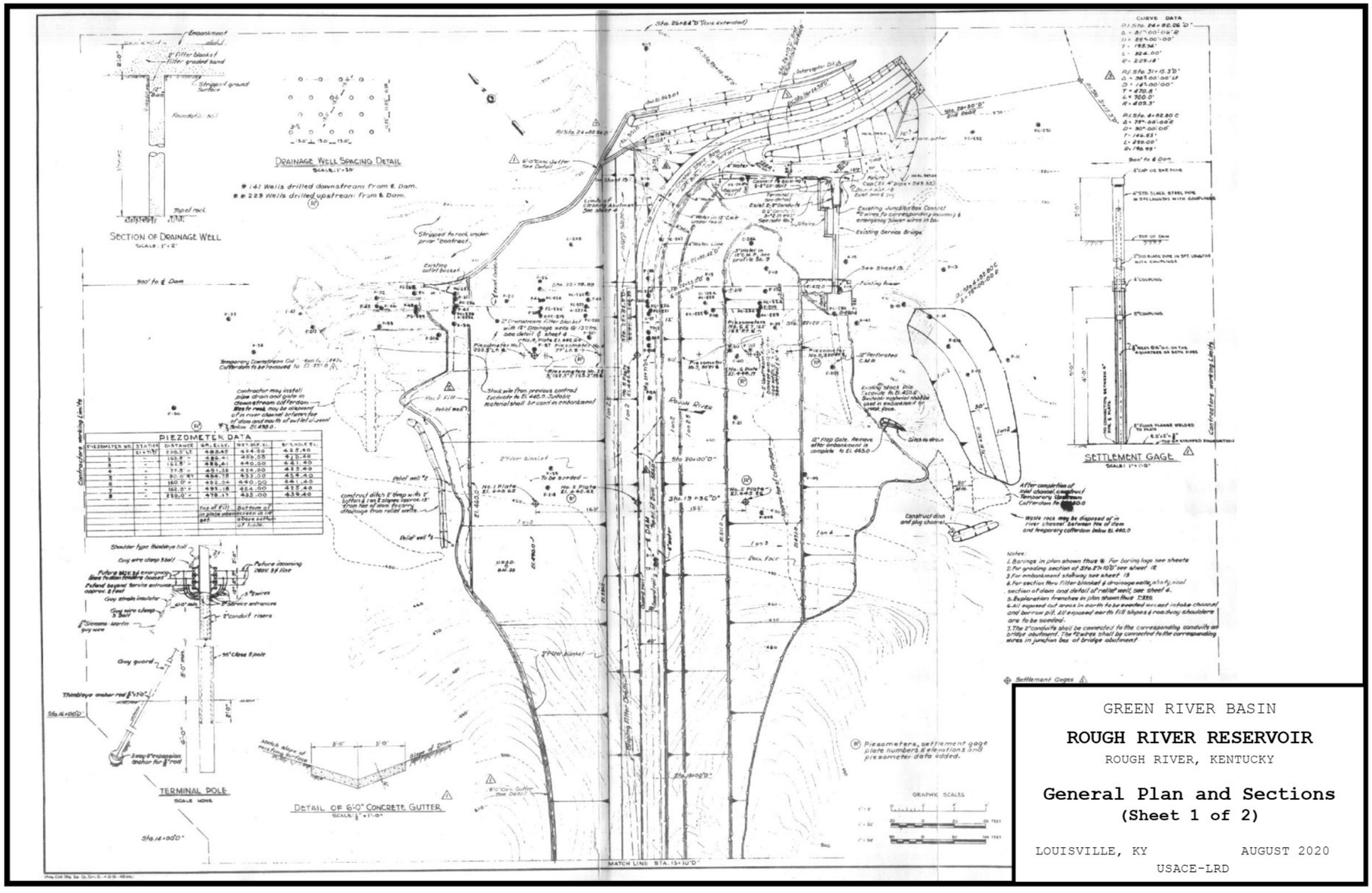


PLATE 2-2

(3) Plate 2-3 General Plan and Sections

CORPS OF ENGINEERS U.S. ARMY



GREEN RIVER BASIN

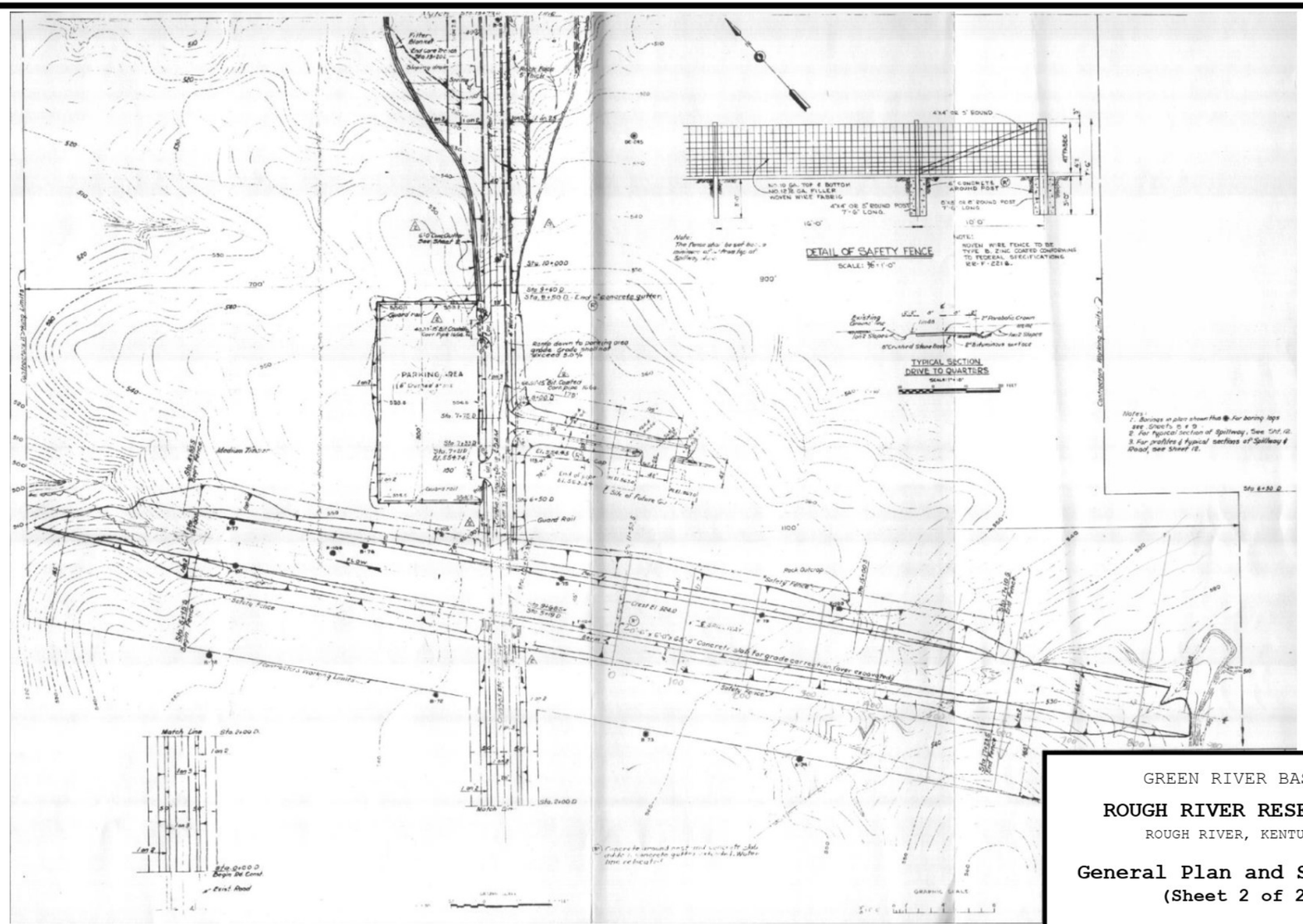
ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

General Plan and Sections
(Sheet 1 of 2)

LOUISVILLE, KY AUGUST 2020
USACE-LRD

PLATE 2-3A



GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

General Plan and Sections
(Sheet 2 of 2)

LOUISVILLE, KY AUGUST 2020
USACE-LRD

PLATE 2-3B

(4) Plate 2-4 Outlet Works

CORPS OF ENGINEERS U.S. ARMY

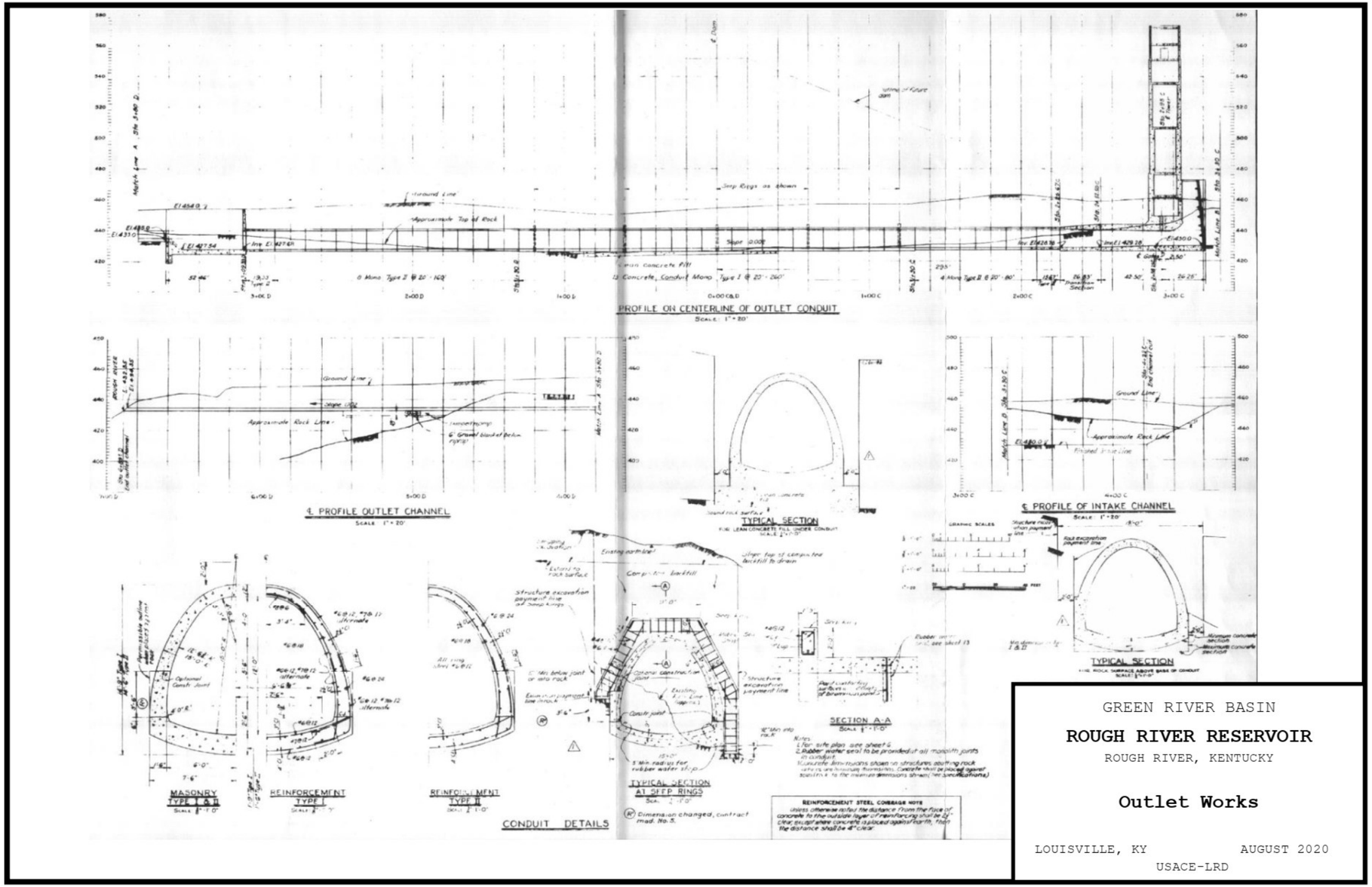
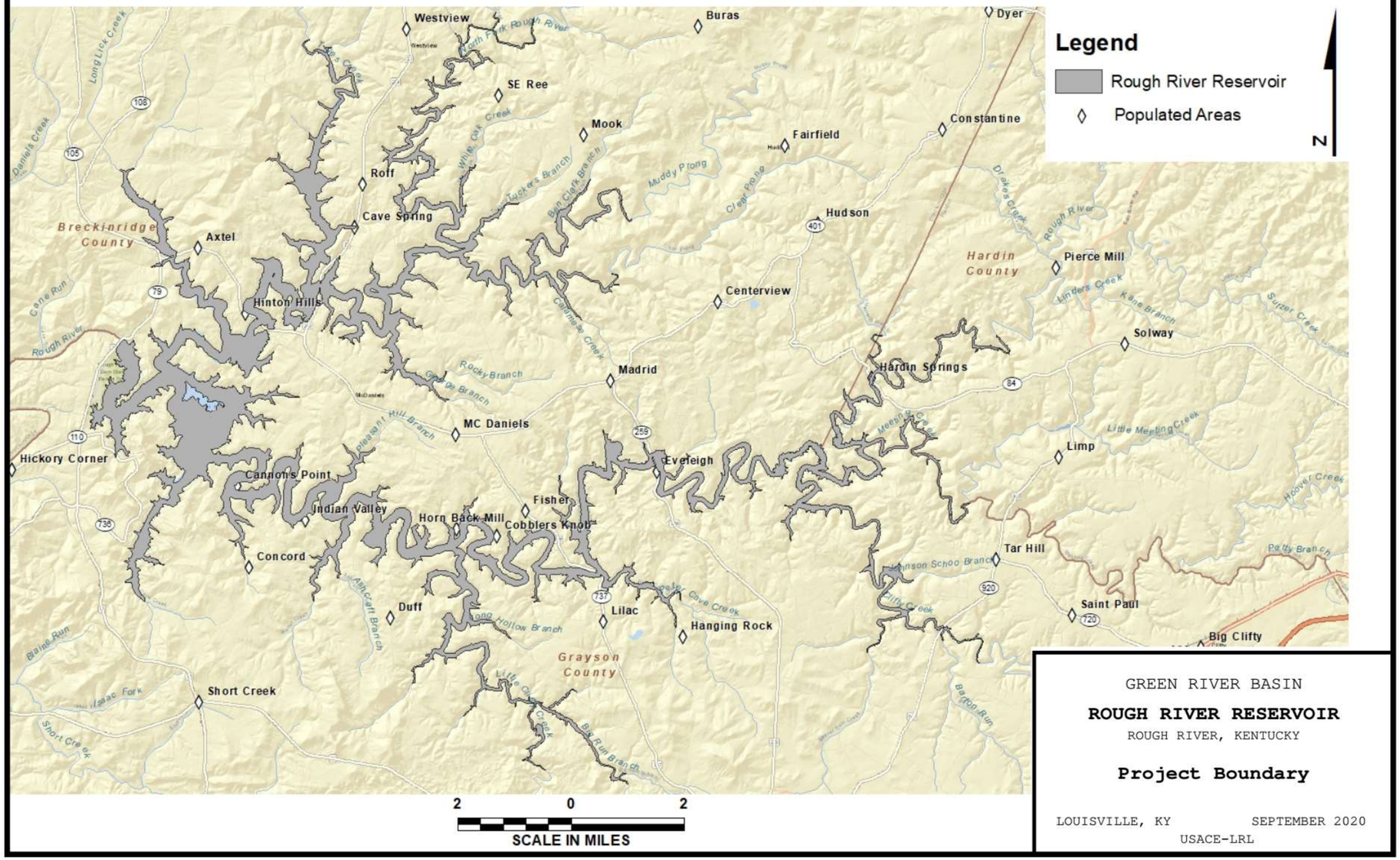


PLATE 2-4

(5) Plate 2-5 Project Boundary

CORPS OF ENGINEERS U.S. ARMY



GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

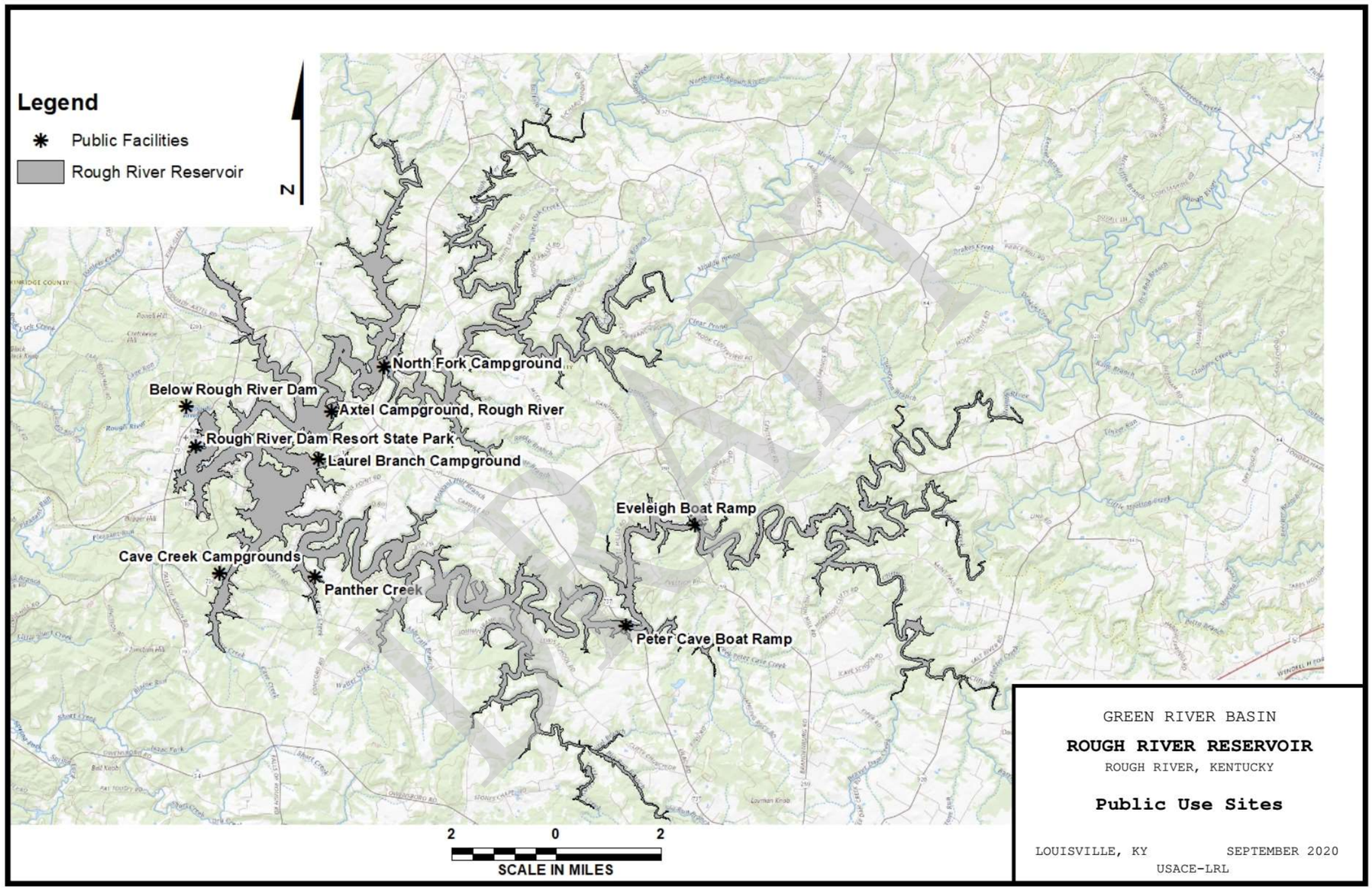
Project Boundary

LOUISVILLE, KY SEPTEMBER 2020
USACE-LRL

PLATE 2-5

(6) Plate 2-6 Public Use Sites

CORPS OF ENGINEERS U.S. ARMY



GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

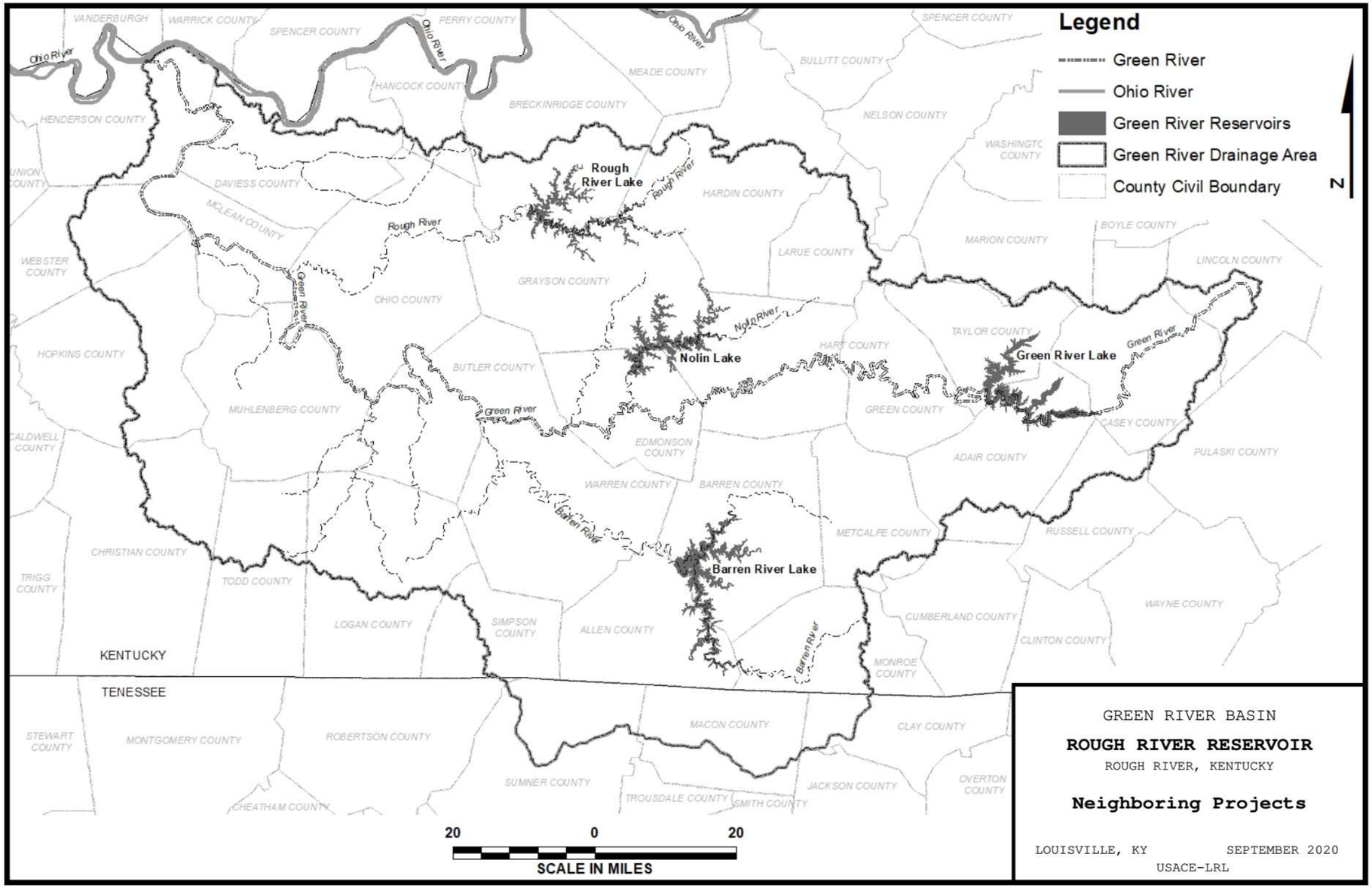
Public Use Sites

LOUISVILLE, KY SEPTEMBER 2020
USACE-LRL

PLATE 2-6

(7) Plate 3-1 Neighboring Projects

CORPS OF ENGINEERS U.S. ARMY



GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

Neighboring Projects

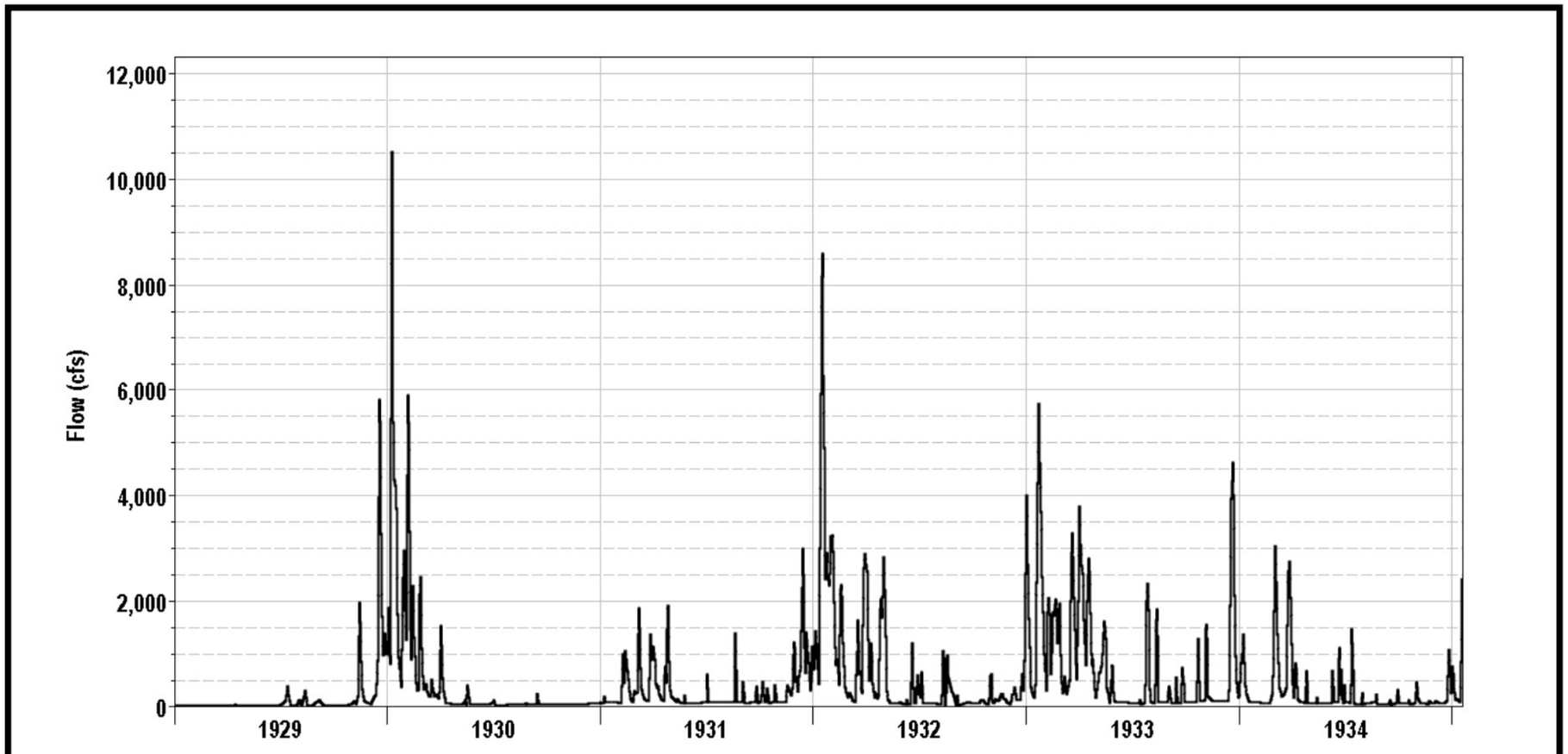
LOUISVILLE, KY SEPTEMBER 2020

USACE-LRL

PLATE 3-1

(8) Plate 4-1 Natural Inflow Hydrographs at Dam Site

CORPS OF ENGINEERS U.S. ARMY



NOTE:
1) Natural Inflow at Dam has been digitized from the continuous natural discharge hydrographs for the dam site presented on Plates 31 to 35 of the 1967 Reservoir Regulation Plan.
2) Natural Inflow at Dam is presented for the period of 1929-1957 prior to construction of the dam.

GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

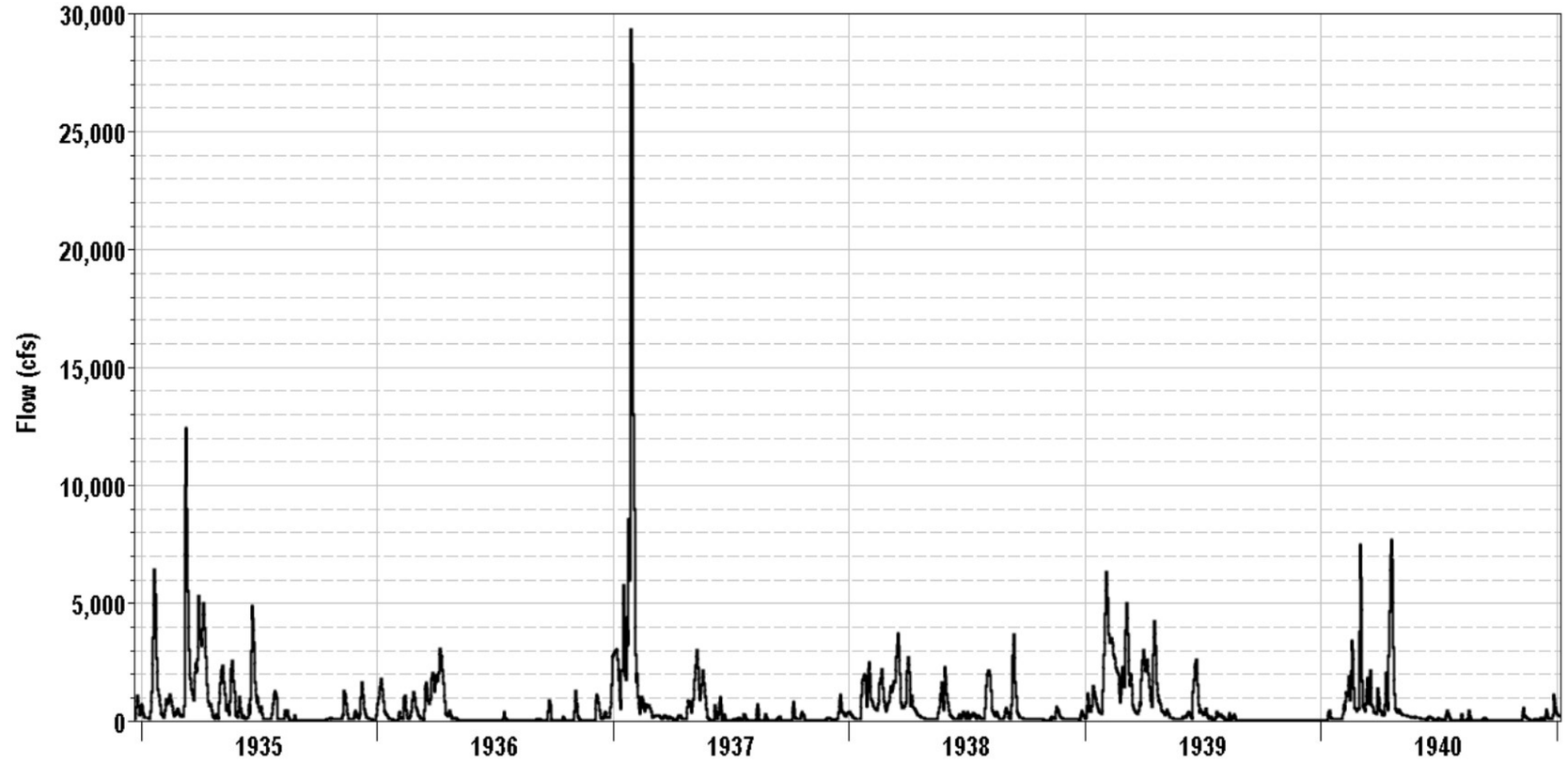
ROUGH RIVER, KENTUCKY

Natural Inflow Hydrographs At Dam Site 1929-1934

LOUISVILLE, KY AUGUST 2020

USACE-LRD

PLATE 4-1A



NOTE:
1) Natural Inflow at Dam has been digitized from the continuous natural discharge hydrographs for the dam site presented on Plates 31 to 35 of the 1967 Reservoir Regulation Plan.
2) Natural Inflow at Dam is presented for the period of 1929-1957 prior to construction of the dam.

GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

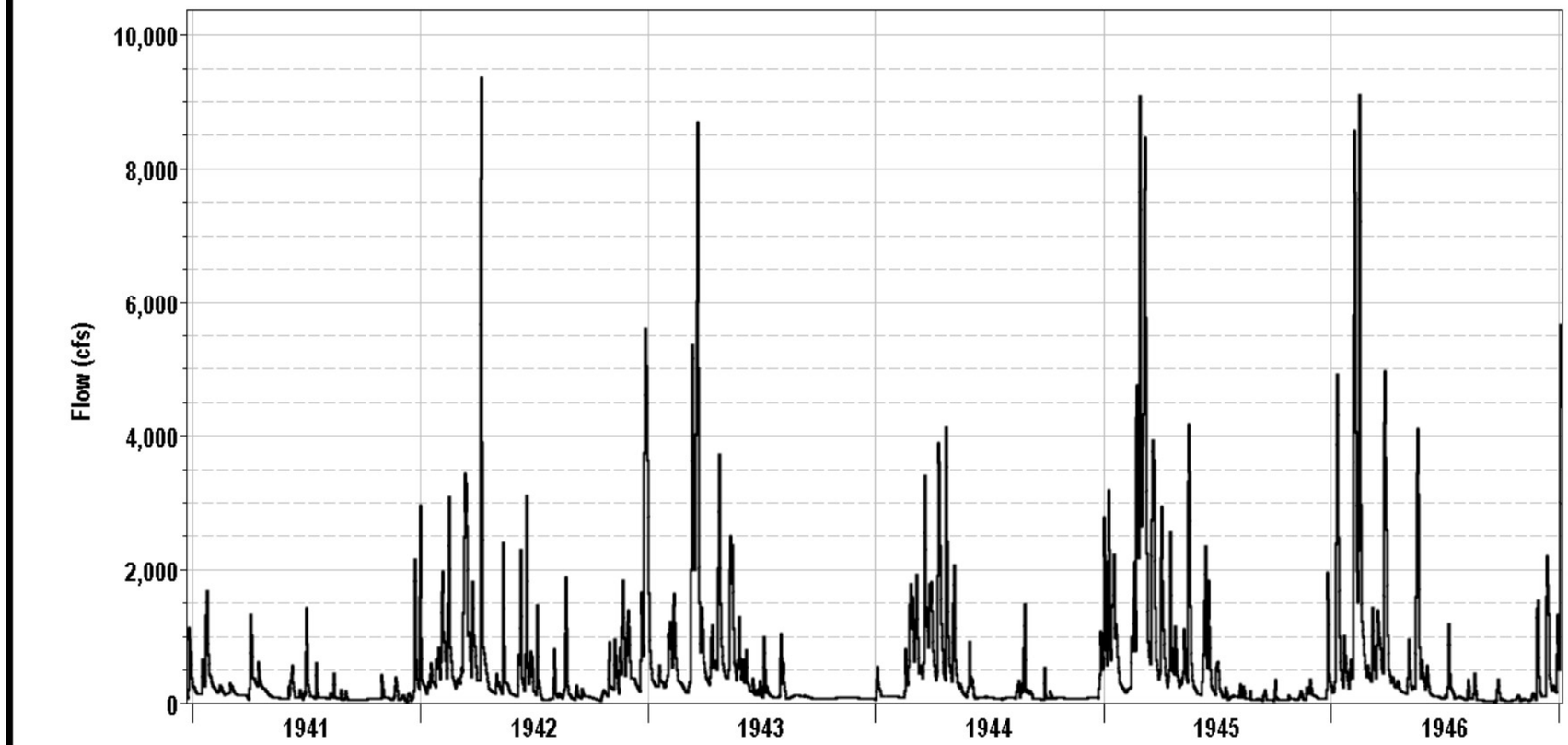
ROUGH RIVER, KENTUCKY

Natural Inflow Hydrographs At Dam Site 1935-1940

LOUISVILLE, KY AUGUST 2020

USACE-LRD

PLATE 4-1B



NOTE:
1) Natural Inflow at Dam has been digitized from the continuous natural discharge hydrographs for the dam site presented on Plates 31 to 35 of the 1967 Reservoir Regulation Plan.
2) Natural Inflow at Dam is presented for the period of 1929-1957 prior to construction of the dam.

GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

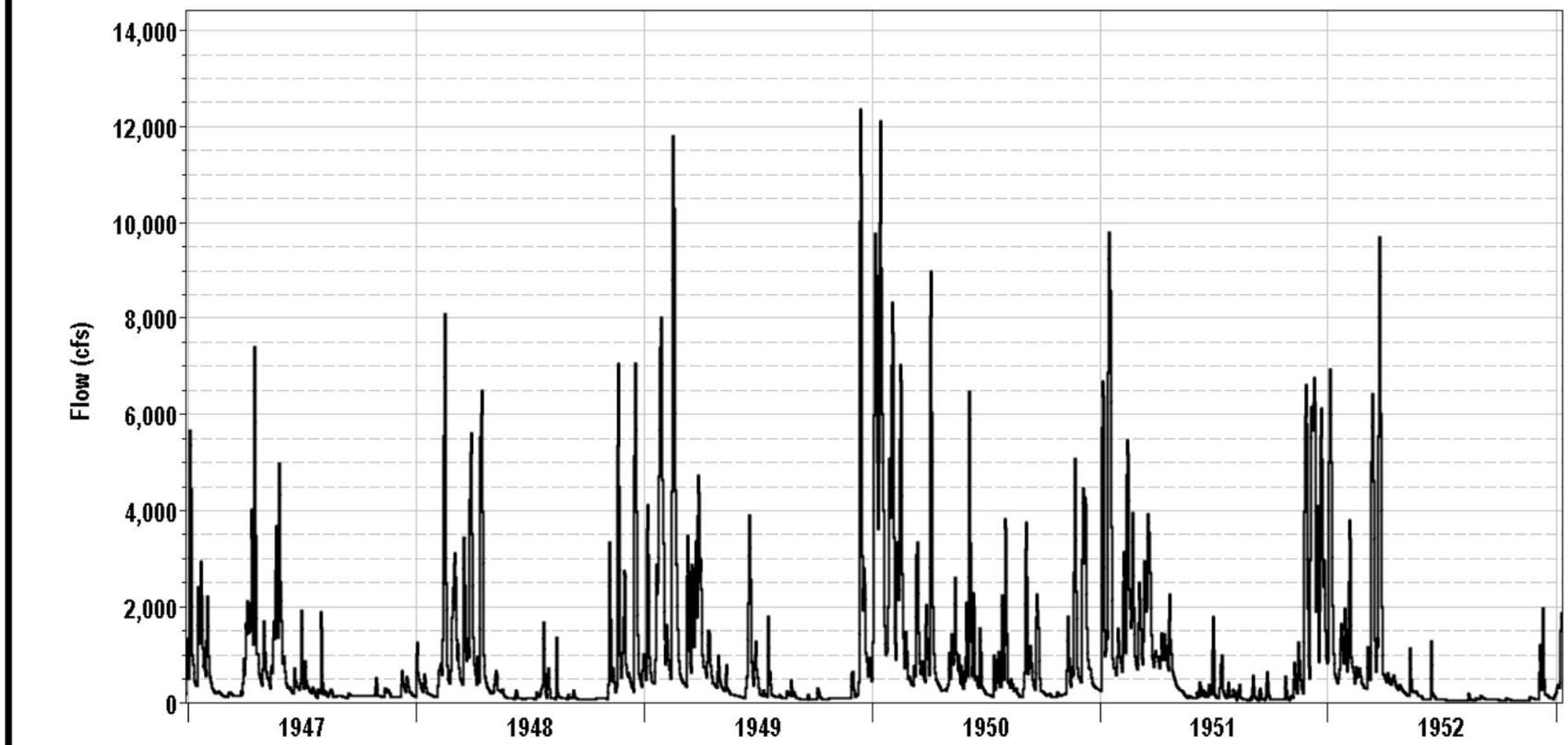
Natural Inflow Hydrographs At Dam Site

1941-1946

LOUISVILLE, KY AUGUST 2020

USACE-LRD

PLATE 4-1C



NOTE:
1) Natural Inflow at Dam has been digitized from the continuous natural discharge hydrographs for the dam site presented on Plates 31 to 35 of the 1967 Reservoir Regulation Plan.
2) Natural Inflow at Dam is presented for the period of 1929-1957 prior to construction of the dam.

GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

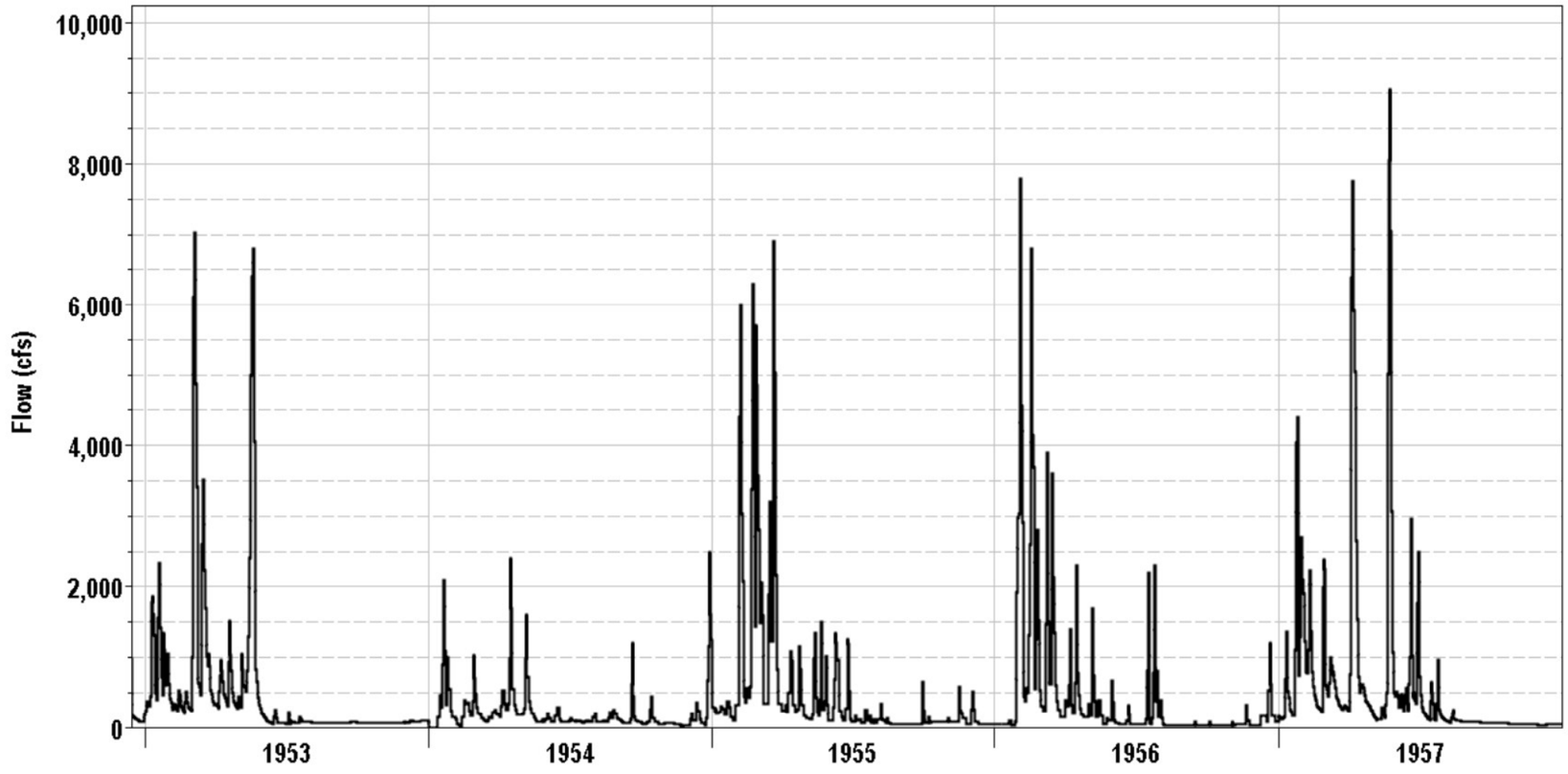
ROUGH RIVER, KENTUCKY

Natural Inflow Hydrographs At Dam Site 1947-1952

LOUISVILLE, KY AUGUST 2020

USACE-LRD

PLATE 4-1D



NOTE:
1) Natural Inflow at Dam has been digitized from the continuous natural discharge hydrographs for the dam site presented on Plates 31 to 35 of the 1967 Reservoir Regulation Plan.
2) Natural Inflow at Dam is presented for the period of 1929-1957 prior to construction of the dam.

GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

Natural Inflow Hydrographs At Dam Site 1953-1957

LOUISVILLE, KY AUGUST 2020

USACE-LRD

PLATE 4-1E

(9) Plate 4-2 Flood Routings

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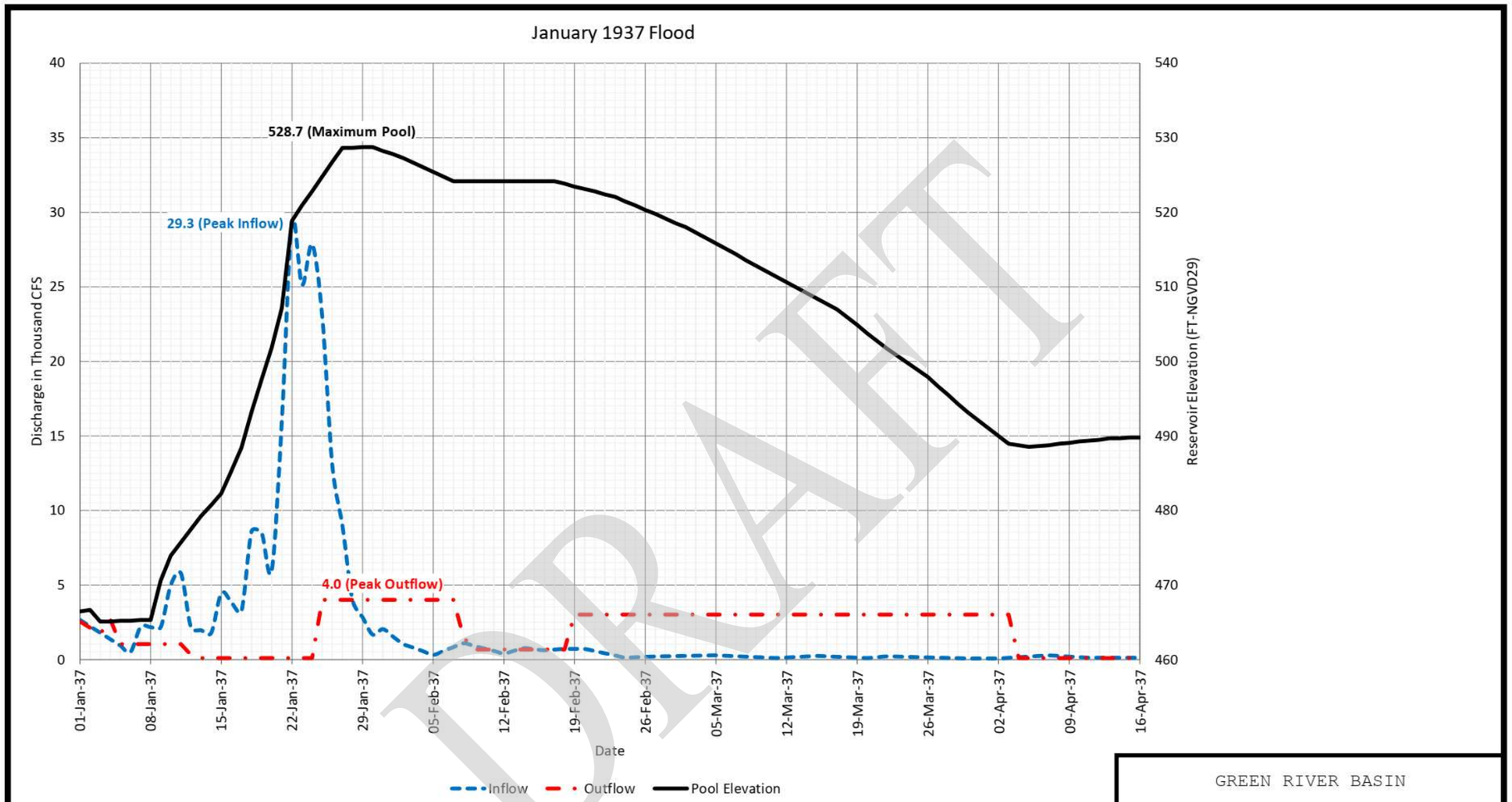


NOTE:
1) Inflow based on estimated natural discharge at the dam site from the 1967 Reservoir Regulation Plan.
2) Pool elevation and outflow based on theoretical routing of the reservoir response if the project was in operation from the 1967 Reservoir Regulation Plan.

GREEN RIVER BASIN

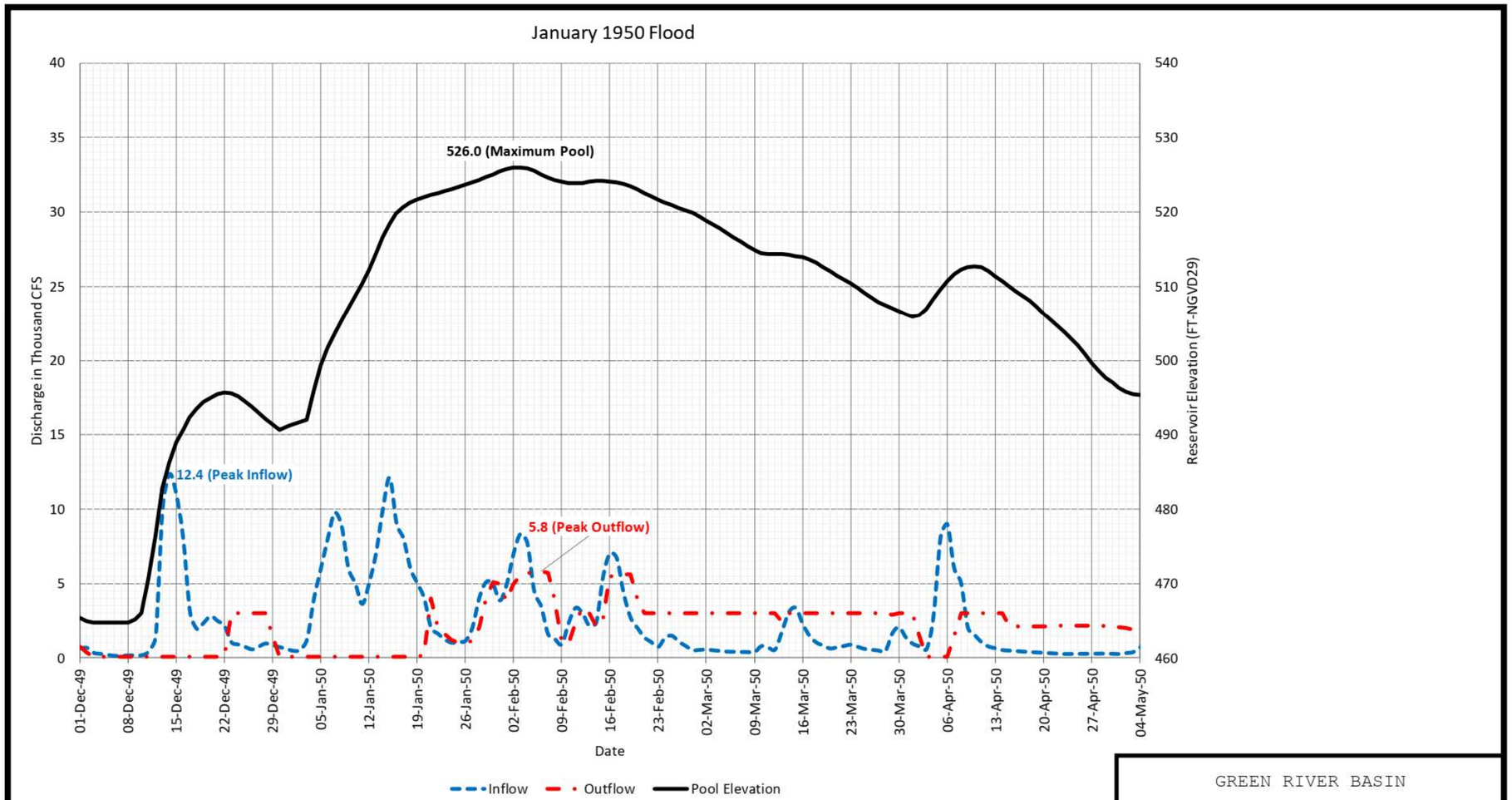
ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

January 1937 Flood

LOUISVILLE, KY AUGUST 2020
USACE-LRD

PLATE 4-2A



NOTE:
1) Inflow based on estimated natural discharge at the dam site from the 1967 Reservoir Regulation Plan.
2) Pool elevation and outflow based on theoretical routing of the reservoir response if the project was in operation. Pool elevation was digitized from the 1967 Reservoir Regulation Plan. Outflow was modeled by LRL using HEC-ResSim.

GREEN RIVER BASIN

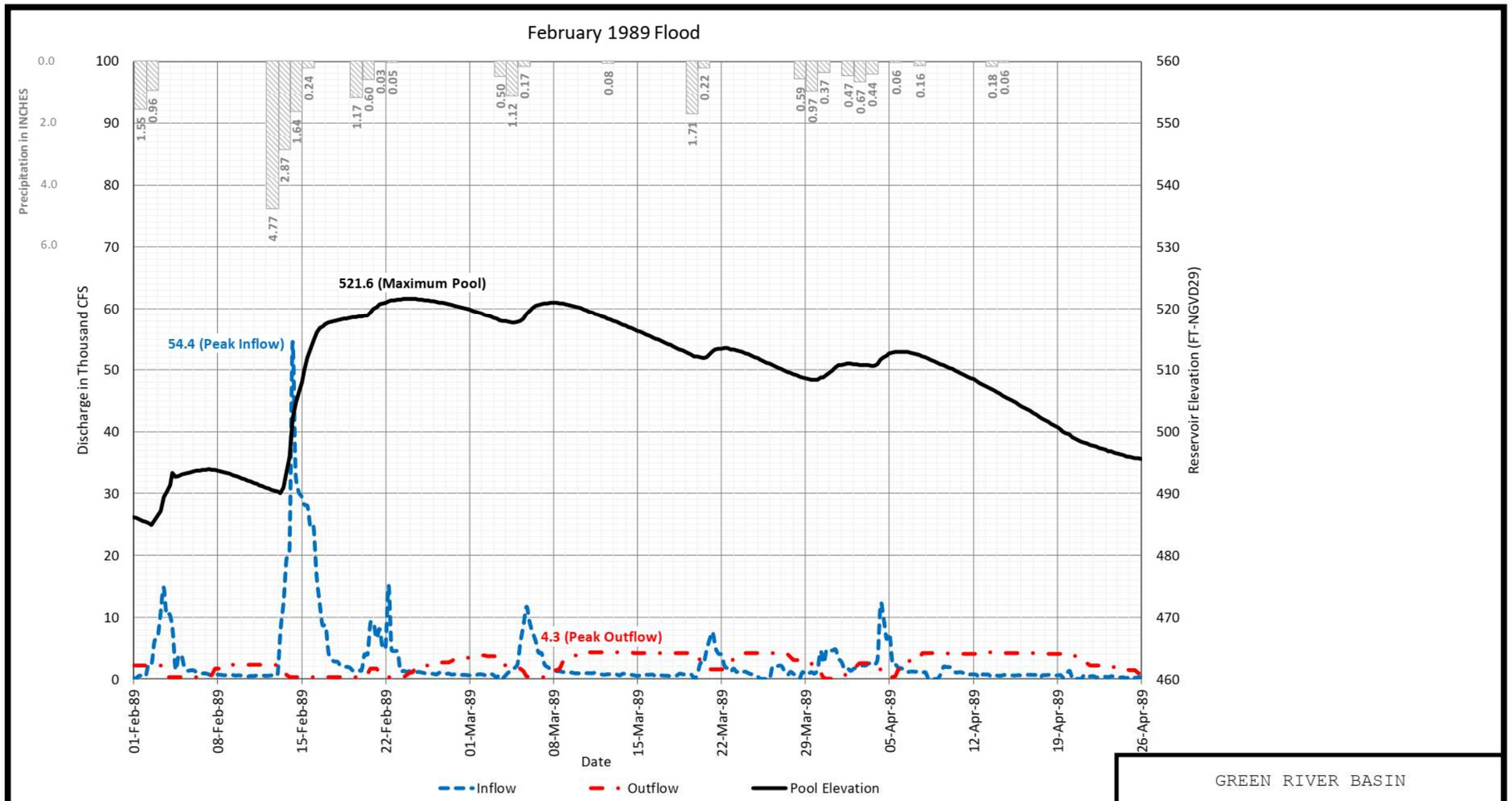
ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

January 1950 Flood

LOUISVILLE, KY AUGUST 2020
USACE-LRD

PLATE 4-2B



NOTE:
1) Inflow, outflow, and pool elevation based on 6-hour DSS data.
2) Precipitation based on daily 6AM data at the dam that has been shifted to display a 24-hour total for the previous day.

GREEN RIVER BASIN

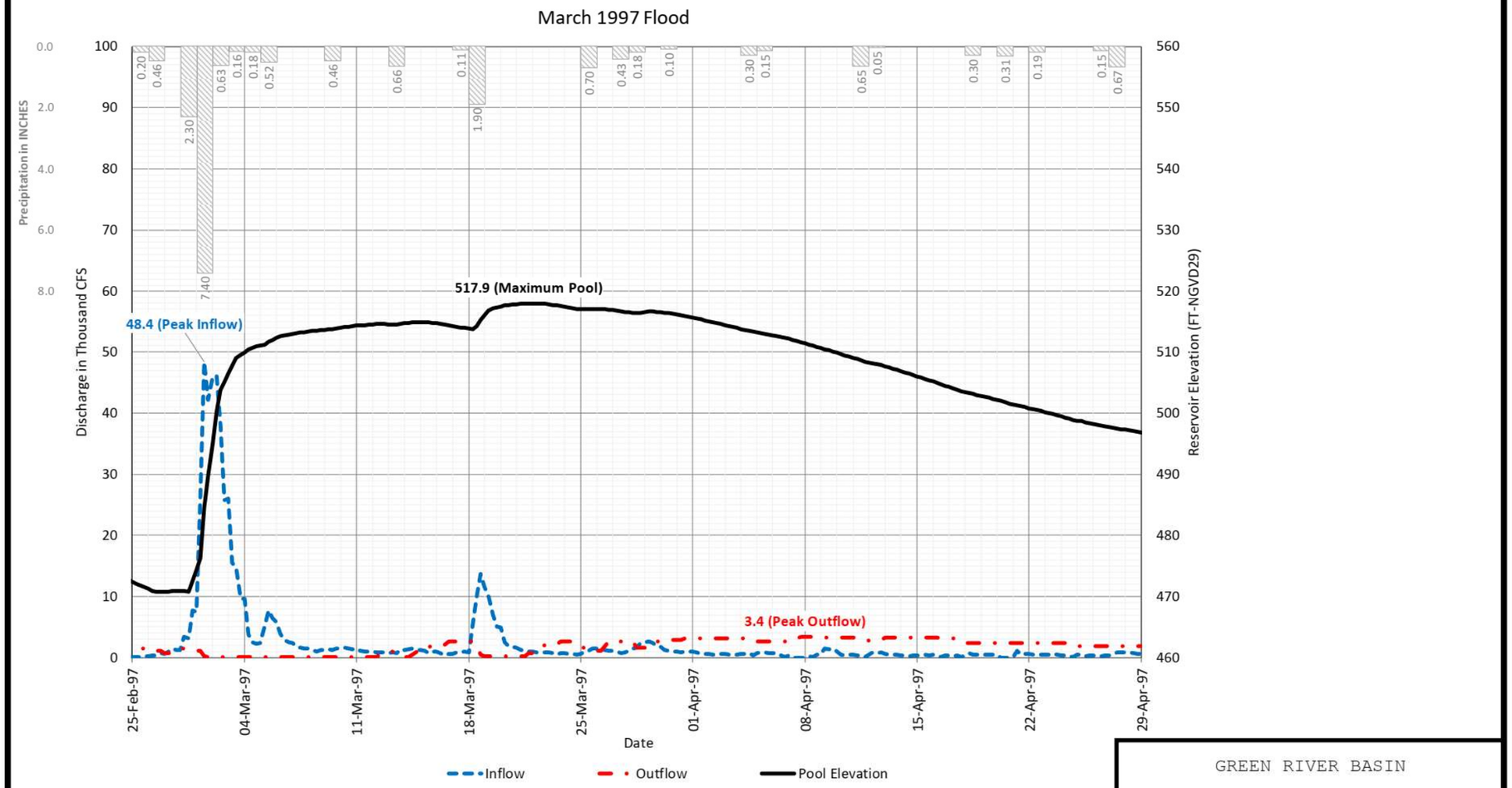
ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

February 1989 Flood

LOUISVILLE, KY AUGUST 2020
USACE-LRD

PLATE 4-2C



NOTE:
1) Inflow, outflow, and pool elevation based on 6-hour DSS data.
2) Precipitation based on daily 6AM data at the dam that has been shifted to display a 24-hour total for the previous day.

GREEN RIVER BASIN

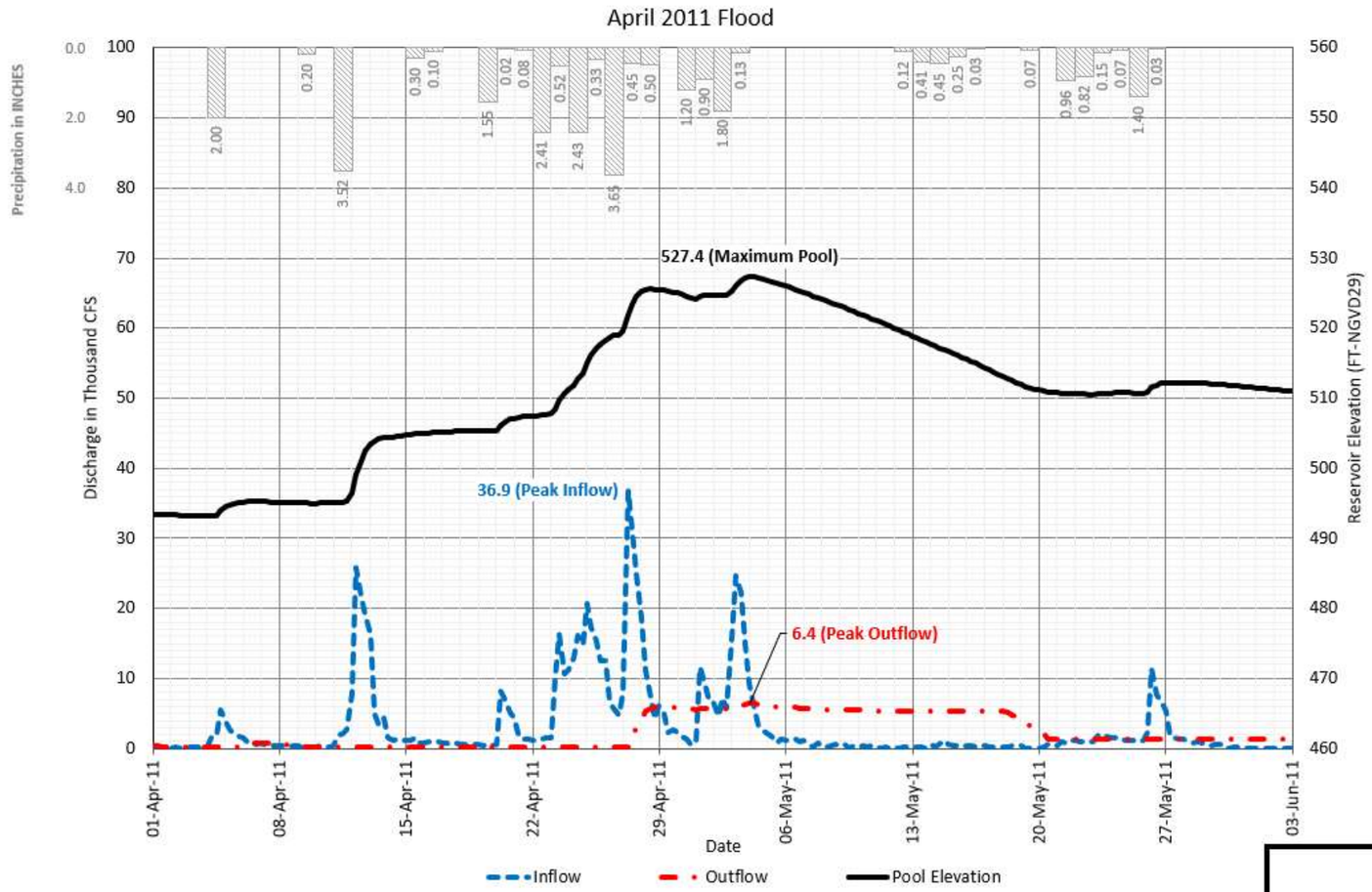
ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

March 1997 Flood

LOUISVILLE, KY AUGUST 2020
USACE-LRD

PLATE 4-2D



NOTES:
1) Inflow, outflow, and pool elevation based on 6-hr DSS data.
2) Precipitation based on daily 6AM data at the dam that has been shifted to display a 24-hour total for the previous day.

GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

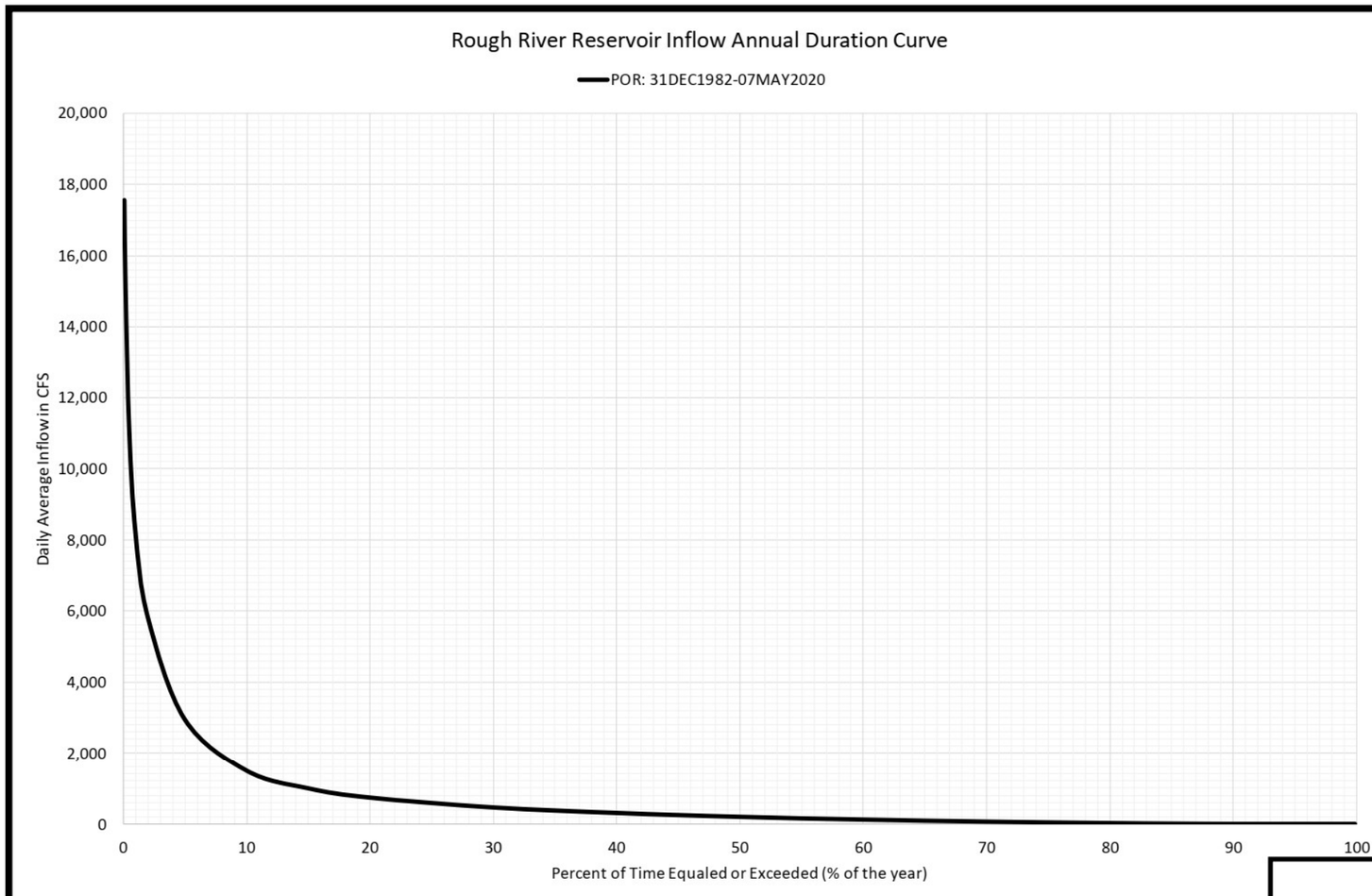
April 2011 Flood

LOUISVILLE, KY August 2020
USACE-LRL

PLATE 4-2E

(10) Plate 4-3 Inflow Annual Duration Curve

CORPS OF ENGINEERS U.S. ARMY



GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

Inflow

Annual Duration Curve

(Daily Average)

LOUISVILLE, KY AUGUST 2020

USACE-LRL

PLATE 4-3

(11) Plate 4-4 Water Quality Sampling Locations

CORPS OF ENGINEERS U.S. ARMY

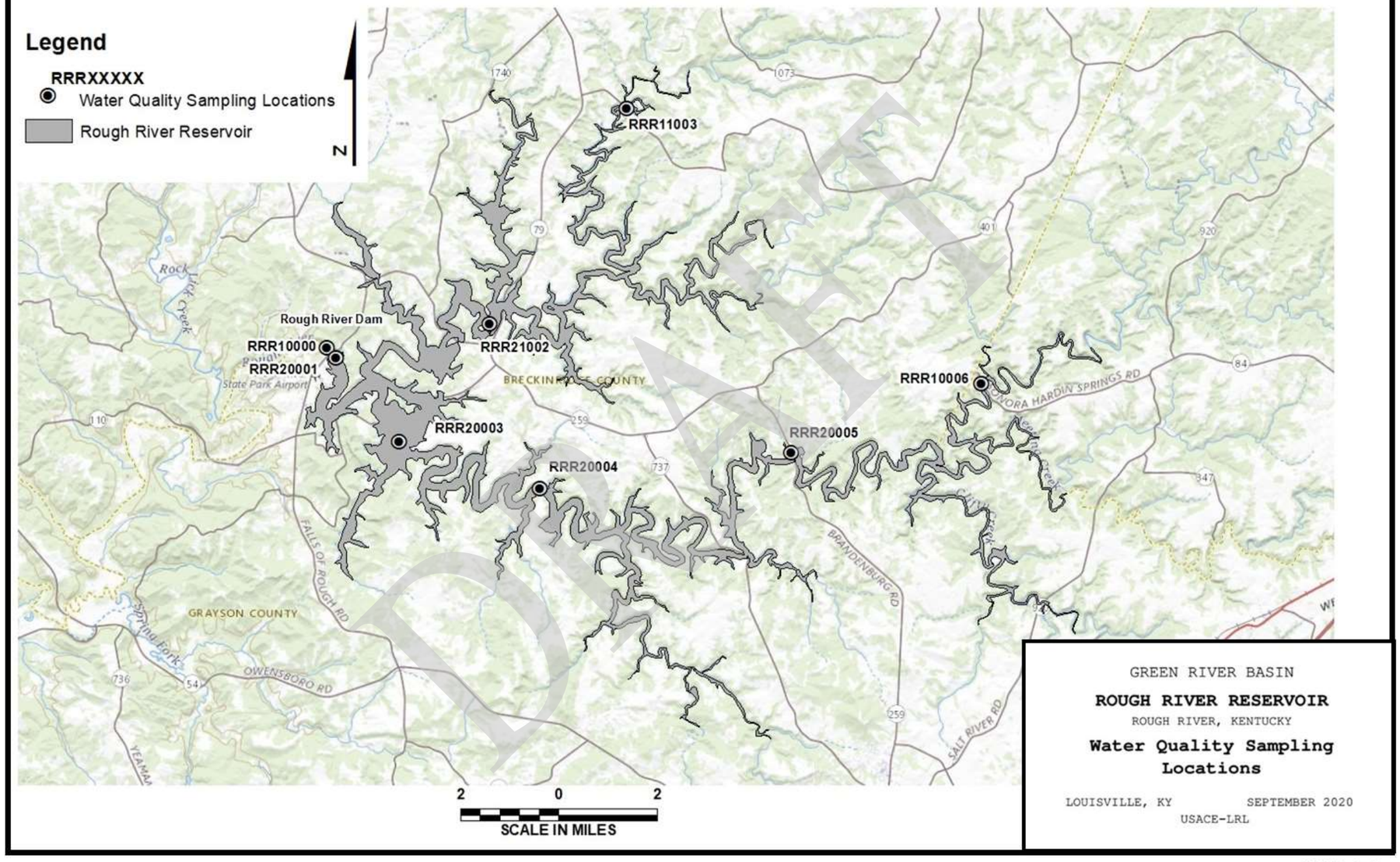


PLATE 4-4

(11) Plate 4-5 Stream Profiles

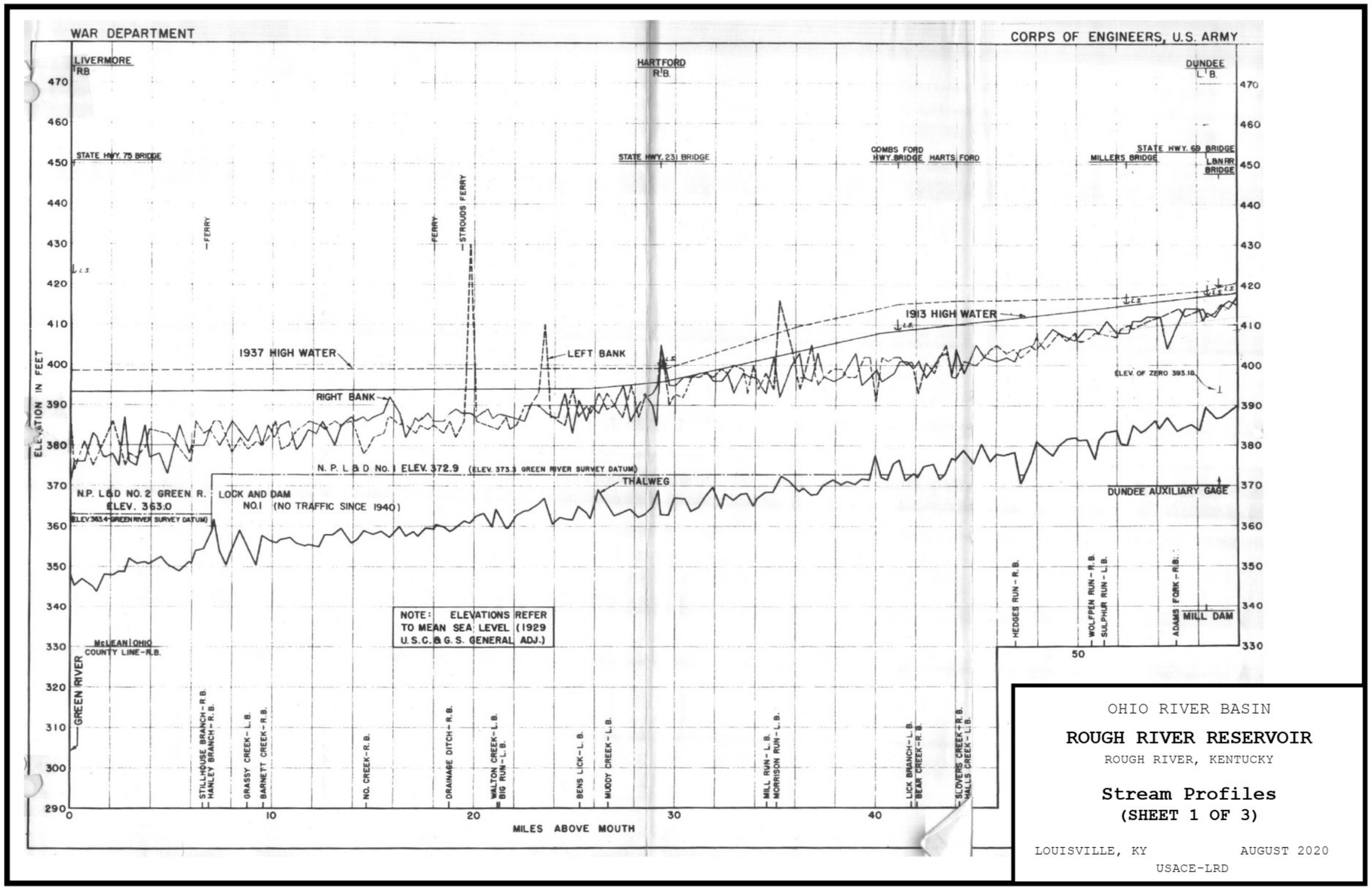


PLATE 4-5A

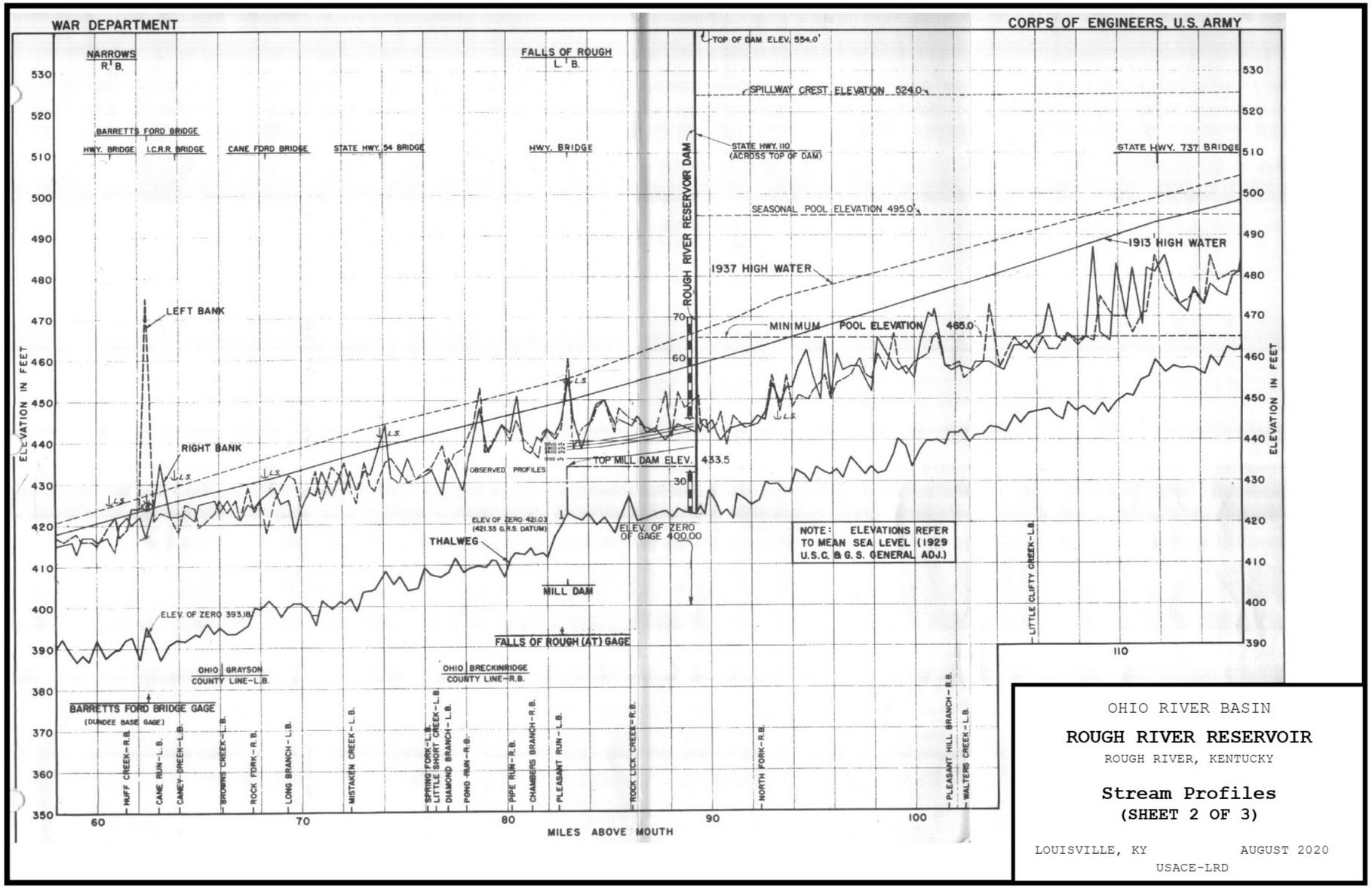
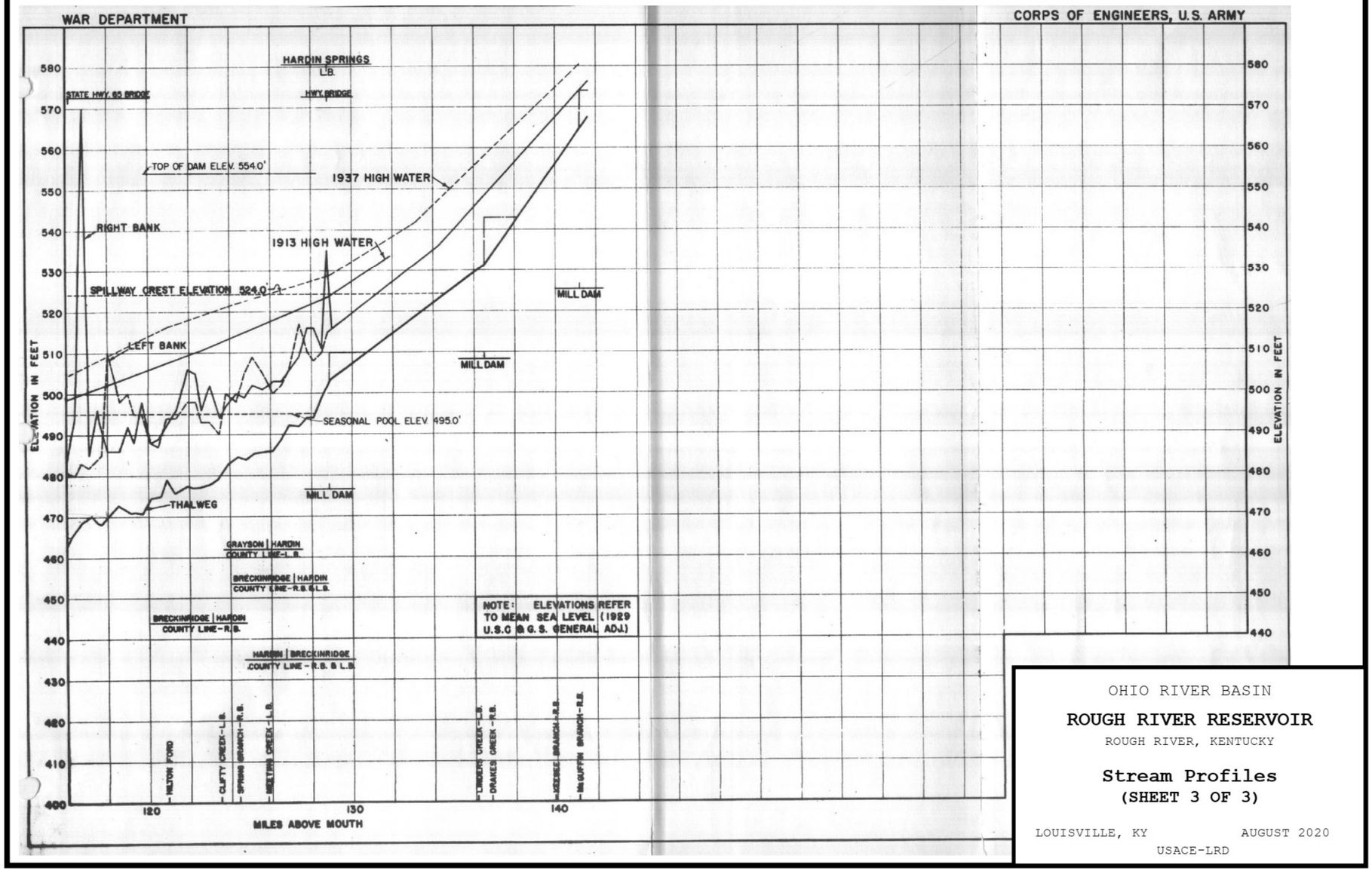

WAR DEPARTMENT
CORPS OF ENGINEERS, U.S. ARMY
NARROWS R.B.
FALLS OF ROUGH L.B.
TOP OF DAM ELEV. 554.0'
SPILLWAY CREST ELEVATION 524.0'
STATE HWY. 110 (ACROSS TOP OF DAM)
STATE HWY. 737 BRIDGE
BARRETTS FORD BRIDGE
HWY. BRIDGE
I.C.R.R. BRIDGE
CANE FORD BRIDGE
STATE HWY. 54 BRIDGE
HWY. BRIDGE
ROUGH RIVER RESERVOIR DAM
SEASONAL POOL ELEVATION 495.0'
1913 HIGH WATER
1937 HIGH WATER
MINIMUM POOL ELEVATION 465.0'
LEFT BANK
RIGHT BANK
TOP MILL DAM ELEV. 433.5
OBSERVED PROFILES
ELEV. OF ZERO 421.03 (421.33 G.R.S. DATUM)
THALWEG
ELEV. OF ZERO OF GAGE 400.00
MILL DAM
ELEV. OF ZERO 393.18
FALLS OF ROUGH (AT) GAGE
NOTE: ELEVATIONS REFER TO MEAN SEA LEVEL (1929 U.S.C. & G.S. GENERAL ADJ.)
OHIO | GRAYSON COUNTY LINE-L.B.
OHIO | BRECKINRIDGE COUNTY LINE-R.B.
BARRETTS FORD BRIDGE GAGE
(DUNDEE BASE GAGE)
HUFF CREEK-R.B.
CANE RUN-L.B.
CANEY CREEK-L.B.
BROWNS CREEK-L.B.
ROCK FORK-R.B.
LONG BRANCH-L.B.
MISTAKEN CREEK-L.B.
SPRING FORK-L.B.
LITTLE SHORT CREEK-L.B.
DIAMOND BRANCH-L.B.
POND RUN-R.B.
PIPE RUN-R.B.
CHAMBERS BRANCH-R.B.
PLEASANT RUN-L.B.
ROCK LICK CREEK-R.B.
NORTH FORK-R.B.
PLEASANT HILL BRANCH-R.B.
WALTERS CREEK-L.B.
LITTLE CLIFTY CREEK-L.B.
ELEVATION IN FEET
MILES ABOVE MOUTH
OHIO RIVER BASIN
ROUGH RIVER RESERVOIR
ROUGH RIVER, KENTUCKY
Stream Profiles
(SHEET 2 OF 3)
LOUISVILLE, KY AUGUST 2020
USACE-LRD

PLATE 4-5B



OHIO RIVER BASIN

ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

Stream Profiles
(SHEET 3 OF 3)

LOUISVILLE, KY AUGUST 2020
USACE-LRD

PLATE 4-5C

(12) Plate 4-6 Travel Times

CORPS OF ENGINEERS U.S. ARMY

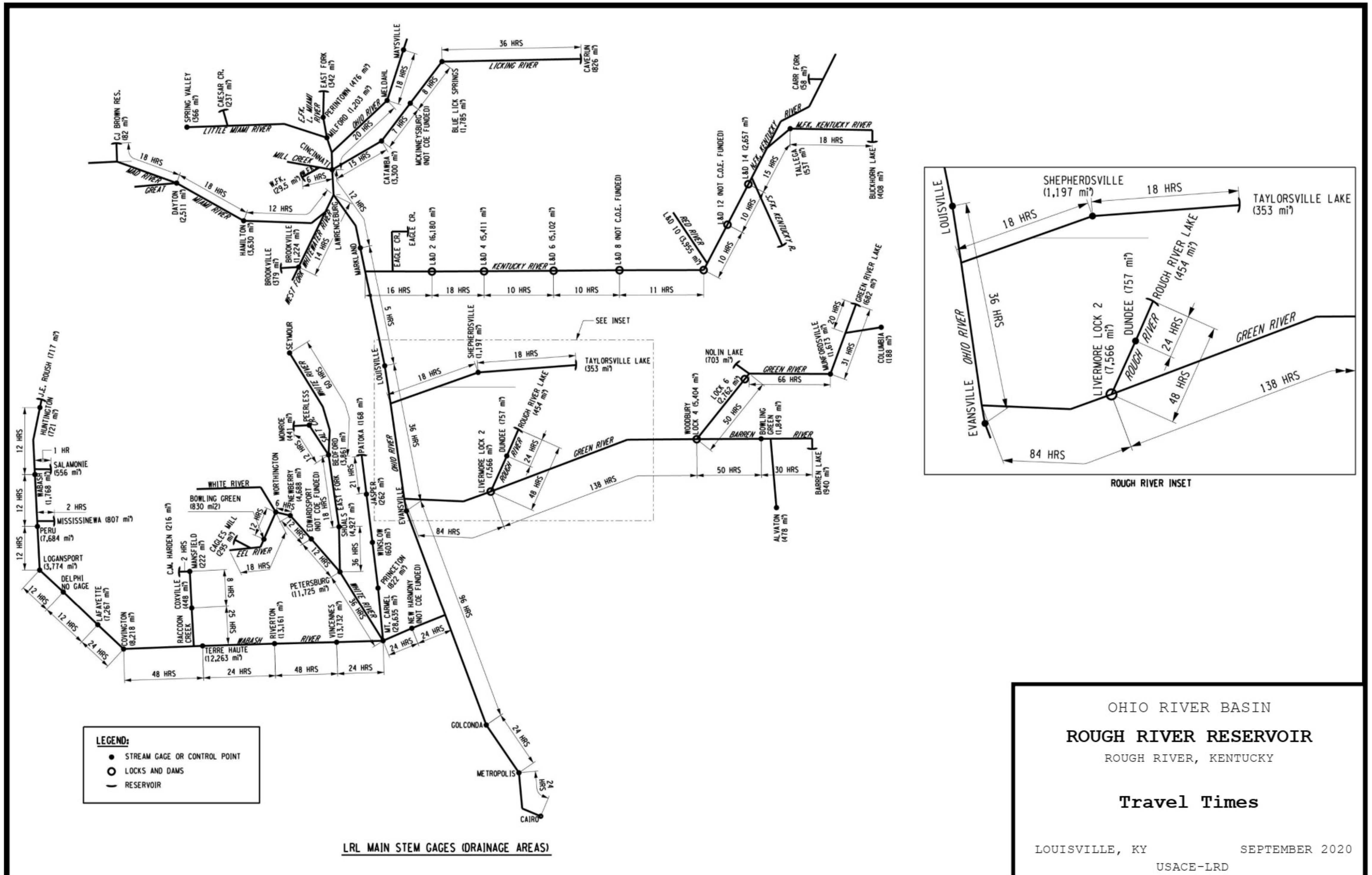


PLATE 4-6

(13) Plate 5-1 Key Stations for Operation and Monitoring

CORPS OF ENGINEERS U.S. ARMY

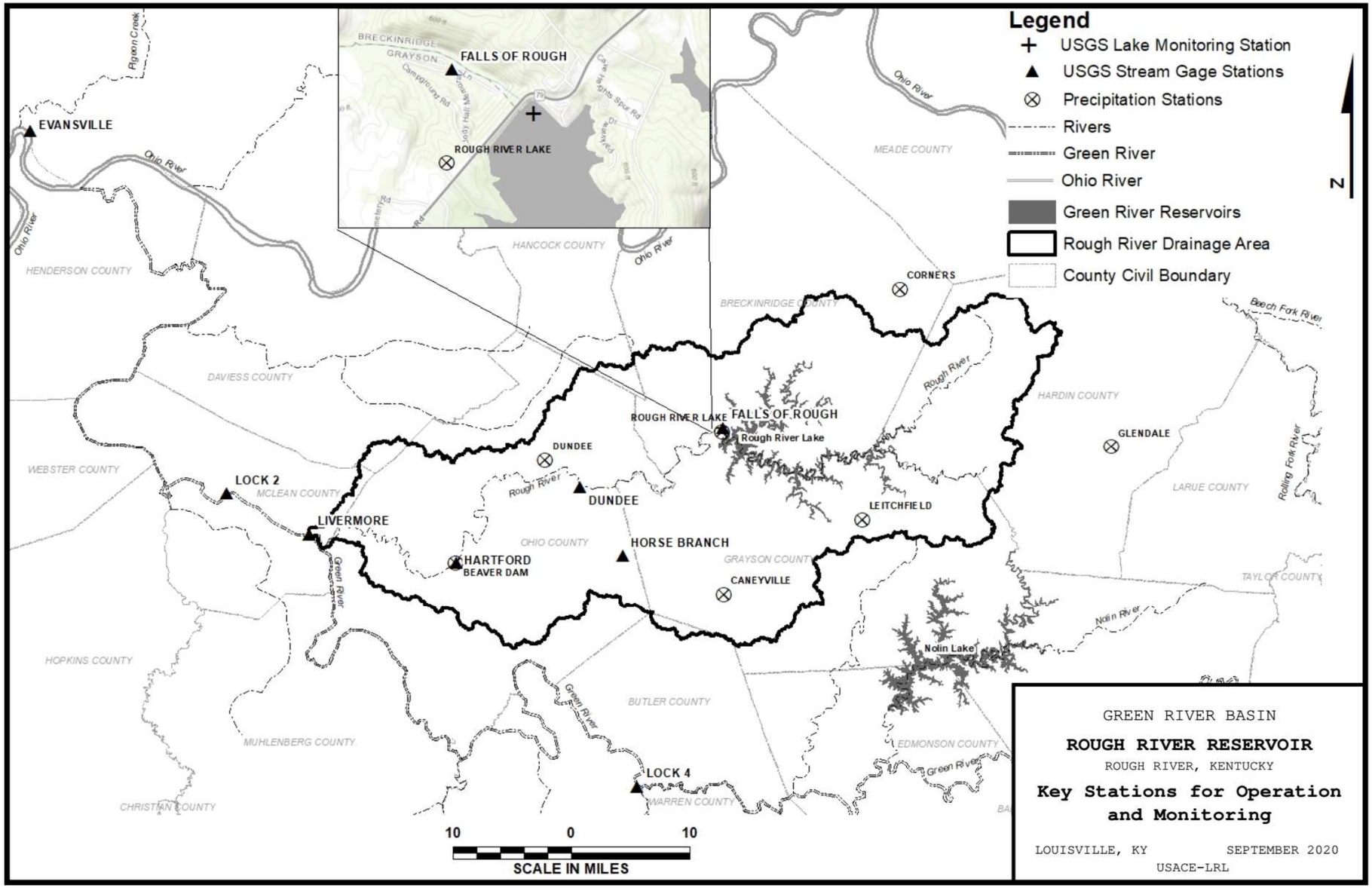
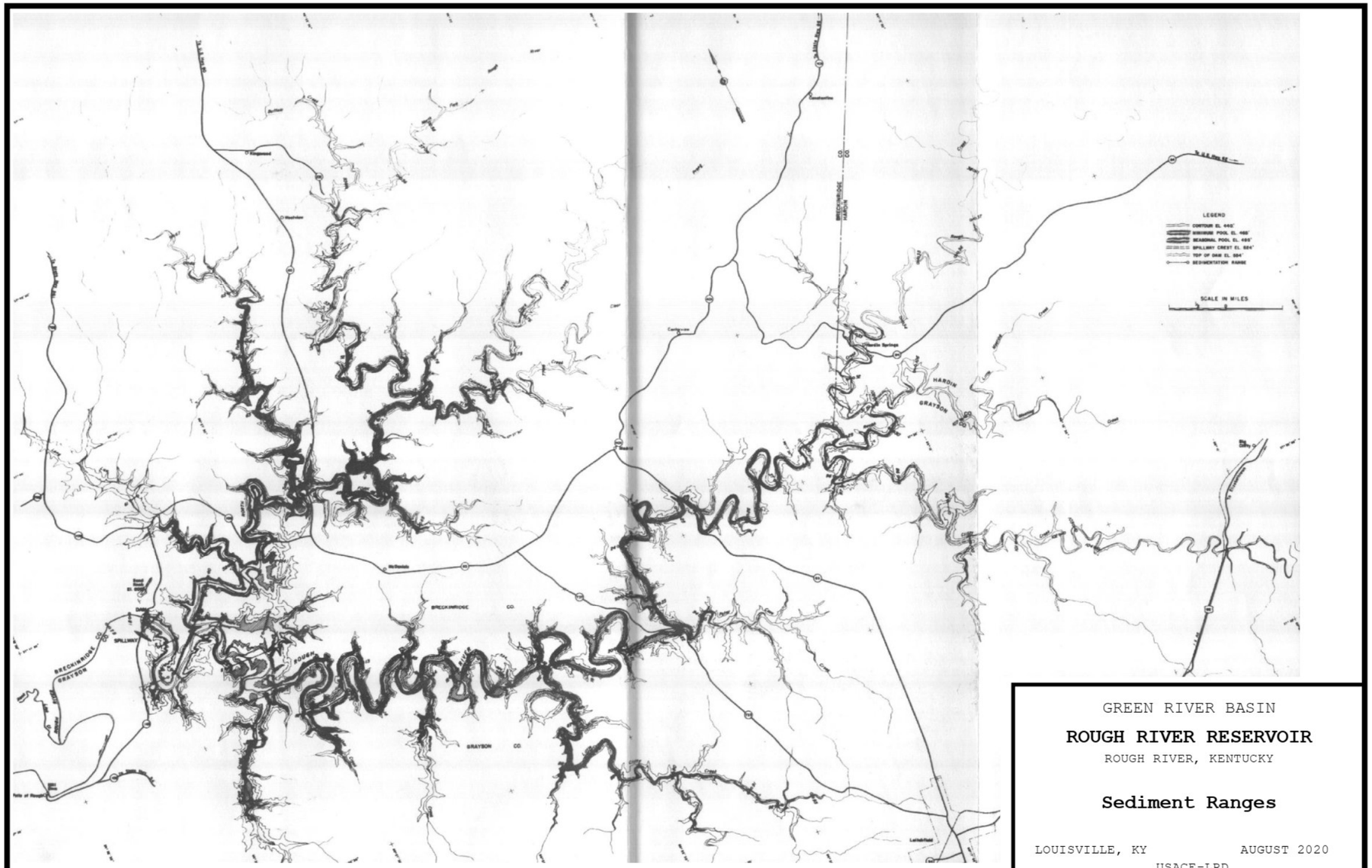


PLATE 5-1

(14) Plate 5-2 Sediment Ranges

CORPS OF ENGINEERS U.S. ARMY



GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

Sediment Ranges

LOUISVILLE, KY AUGUST 2020
USACE-LRD

PLATE 5-2

(15) Plate 5-3 Organization Chart

CORPS OF ENGINEERS U.S. ARMY

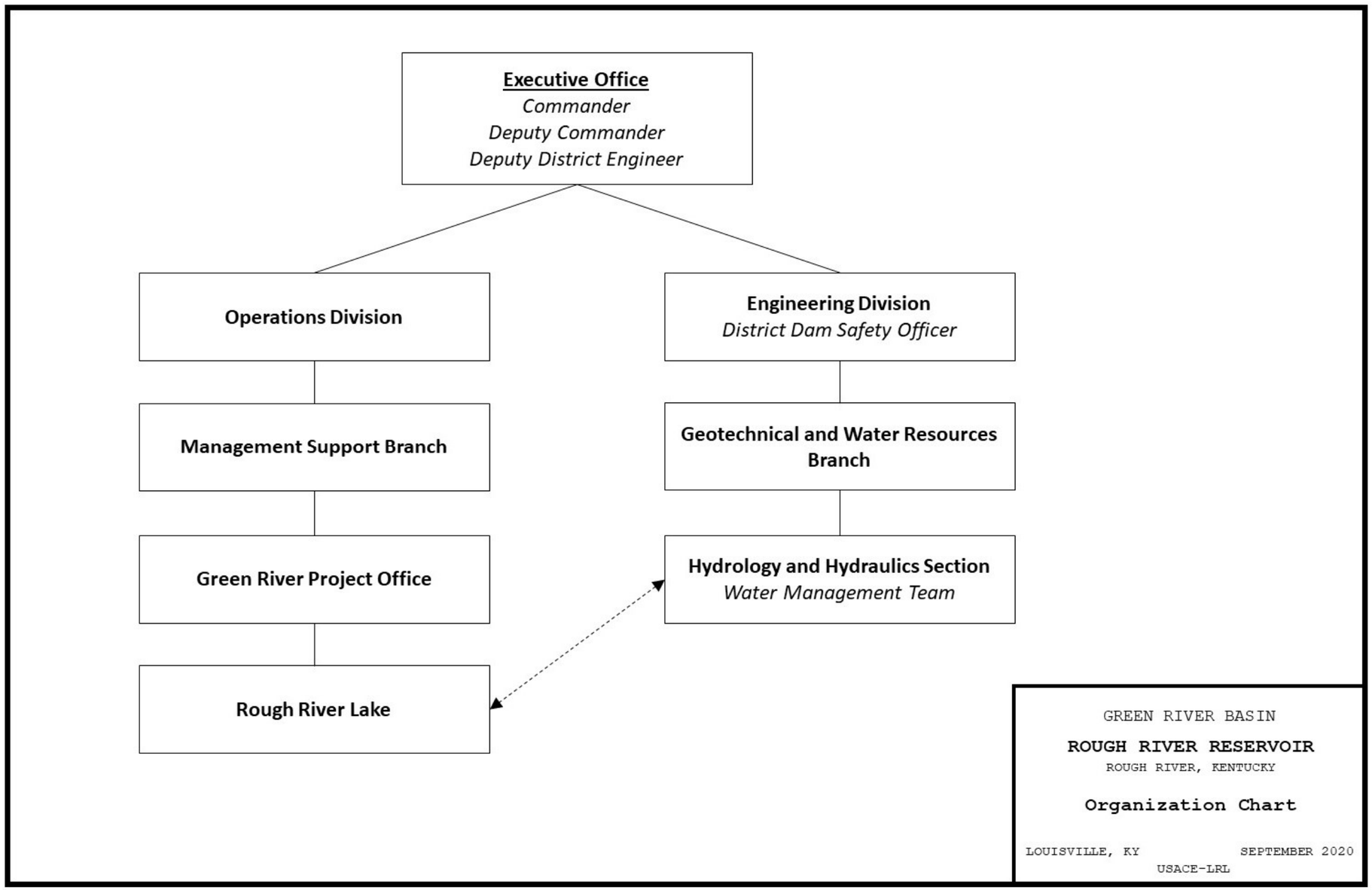
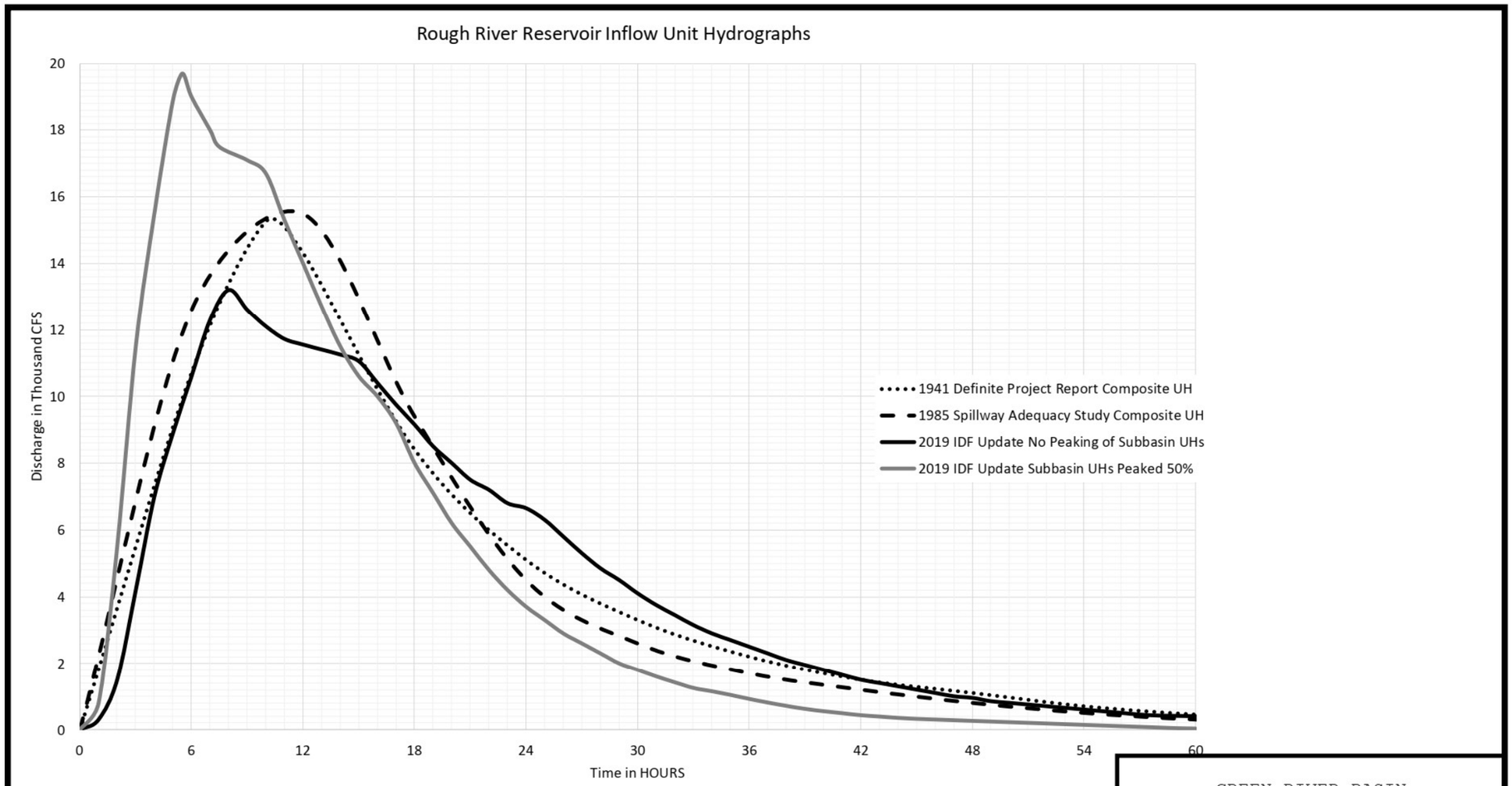


PLATE 5-3

(16) Plate 6-1 Inflow Unit Hydrographs

CORPS OF ENGINEERS U.S. ARMY



NOTE:
1) Data taken from the 2019 IDF Update document, Rough River Reservoir Watershed Hydrologic Model Development, U.S. Army Corps of Engineers, 23 January 2019.
2) 2019 IDF Update recommends 50% unit hydrograph (UH) peaking of Clark UH parameters as shown in the "2019 IDF Update Subbasin UHs Peaked 50%" dataset plotted.

GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

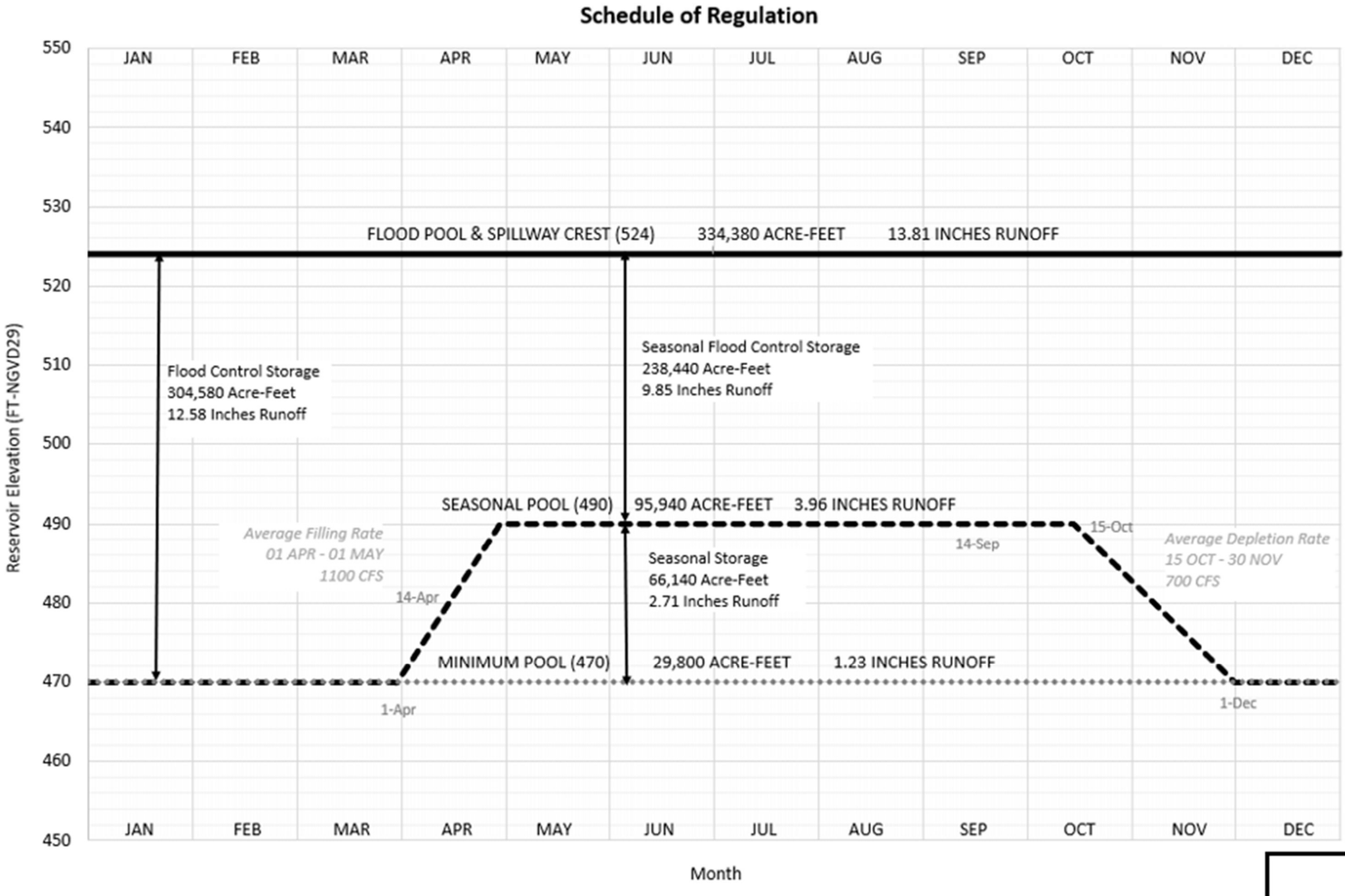
Inflow Unit Hydrographs

LOUISVILLE, KY AUGUST 2020
USACE-LRL

PLATE 6-1

(17) Plate 7-1 Schedule of Regulation

CORPS OF ENGINEERS U.S. ARMY



NOTE: Drainage Area is 454 square miles

GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

Schedule of Regulation

(Water Control Diagram)

LOUISVILLE, KY JANUARY 2024

USACE-LRL

PLATE 7-1A

REVISED

NOTES: *Replaced reference to Maximum Release table with Maximum Release rate; Minimum Releases taken from 2019 RRR IDF Update*

SCHEDULE OF REGULATION
ROUGH RIVER RESERVOIR
FLOOD CONTROL AND LOW FLOW REGULATION

	Controlling Stages (feet)					
Schedule	**Ohio River**	**Green River Lock 2**	**Green River Lock 4**	**Range in Pool Elevation**	**Time of Year**	**Regulation**
		UPPER GAGE	UPPER GAGE	FEET	DATES	
A	Do not add to crests that are above flood stage	Below 19 or Below 29F	Below 27 or Below 37F	Minimum pool (470)	01 DEC - 31 MAR	Release inflow necessary to maintain pool, provided Maximum Release rate is not exceeded.
B	---------- Same as Schedule A ----------			470 - Spillway Crest (524)	01 DEC - 31 MAR	Release up to Maximum Release during Normal Operation
					01 APR - 30 NOV	Maintain pool as near Guide Curve as possible while meeting minimum flow and flood control requirements.
	(Any one condition to exist for application of Schedule C)					
C	Do not add to crests that are above flood stage	At or above 19R or 2 days before 23	At or above 27R	470 - 514	01 DEC - 31 MAR 01 APR - 30 NOV	Release at a constant rate of 100 CFS. Release at a constant rate of 100 CFS when pool is at or above elevation prescribed by Guide Curve, when below elevation prescribed by Guide Curve release only the minimum requirement of 50 CFS.
D	---------- Same as Schedule C ----------			514 - 524	All year	When precipitation forecasts indicate need to retain storage especially for local Rough River control, pass inflow only, up to the Maximum Release rate. However, unless a regulation based on such a forecast can prevent significant damages in Rough River, regulate so as not to increase flooding on Green or Ohio Rivers, subject only to releasing at a minimum rate of 100 CFS.
E	---------- Control stations no longer considered ----------			At 524 and above	All year	Release inflow up to capacity of conduit. If pool exceeds elevation 524 keep conduit open until pool returns to elevation 524. Maintain pool at elevation 524 by passing inflow until downstream conditions permit return to Schedule B. (At such a time, the Reservoir Regulation Section will evaluate weather and river condition to determine feasibility of releasing on recession of downstream stages to regain storage capacity for possible storm recurrence.)

Maximum Release during Normal Operation
Release up to 3,000 CFS while limiting the stage at Dundee to 22' or less (non-crop season) and 15' or less (crop season).

Minimum Release during Normal Operation
50 CFS

Flood Setting
100 CFS

GREEN RIVER BASIN

ROUGH RIVER RESERVOIR
ROUGH RIVER, KENTUCKY

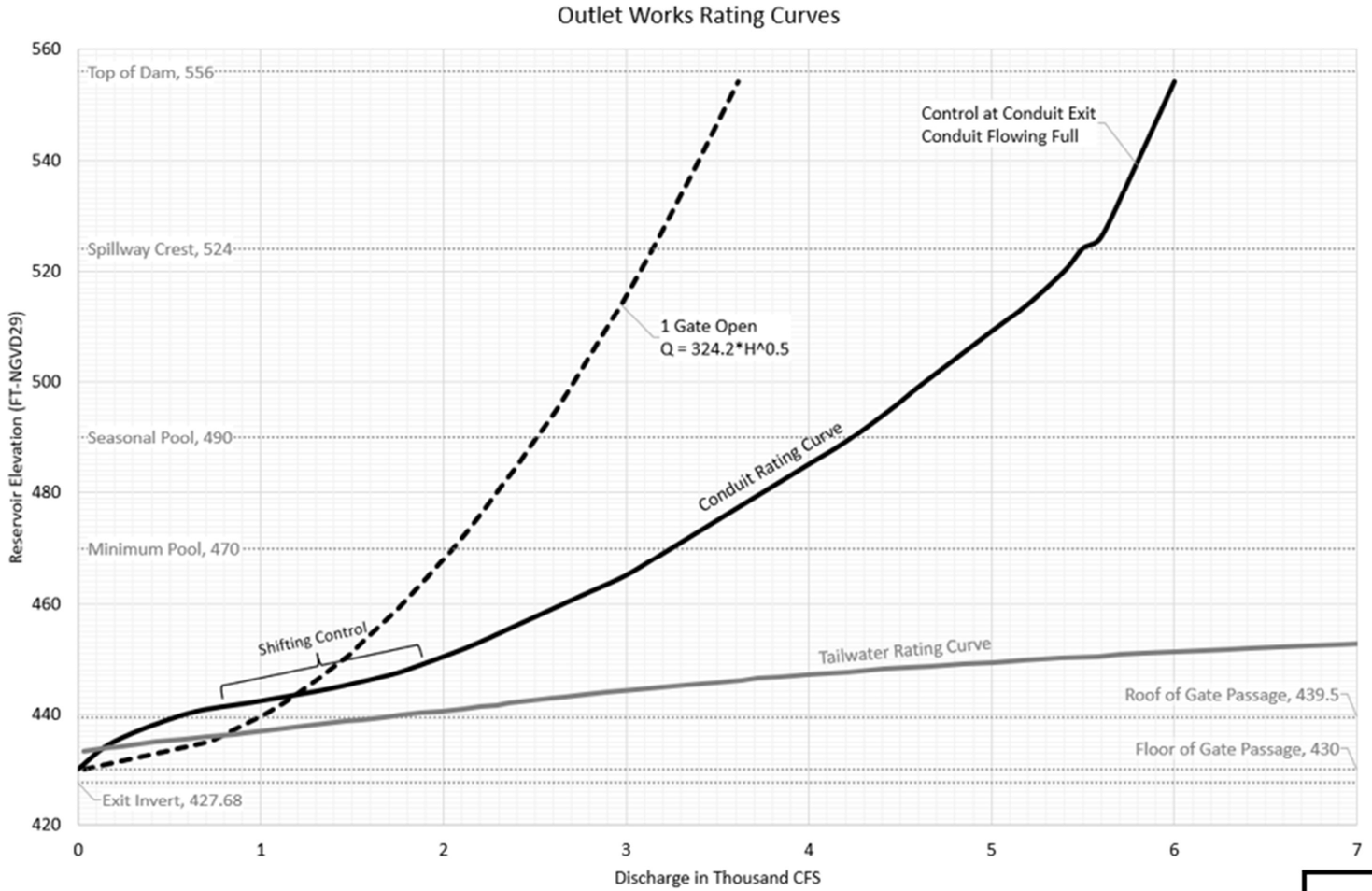
Schedule of Regulation
(Release Schedule)

LOUISVILLE, KY JANUARY 2024
USACE-LRL

PLATE 7-1B

(18) Plate 7-2 Outlet Works Rating Curves

CORPS OF ENGINEERS U.S. ARMY



NOTES:
1) Outlet works consist of one 12-ft by 12-ft semi-elliptical conduit, three 4.75-ft by 9.5-ft control gates with an inlet invert elevation of 430 FT-NGVD29, one emergency control gate, and two 24-inch diameter bypass valves.
2) Conduit rating curve obtained from CWMS DSS data.
3) Gate rating curve based on discharge equation presented in the 1967 Reservoir Regulation Plan.

GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

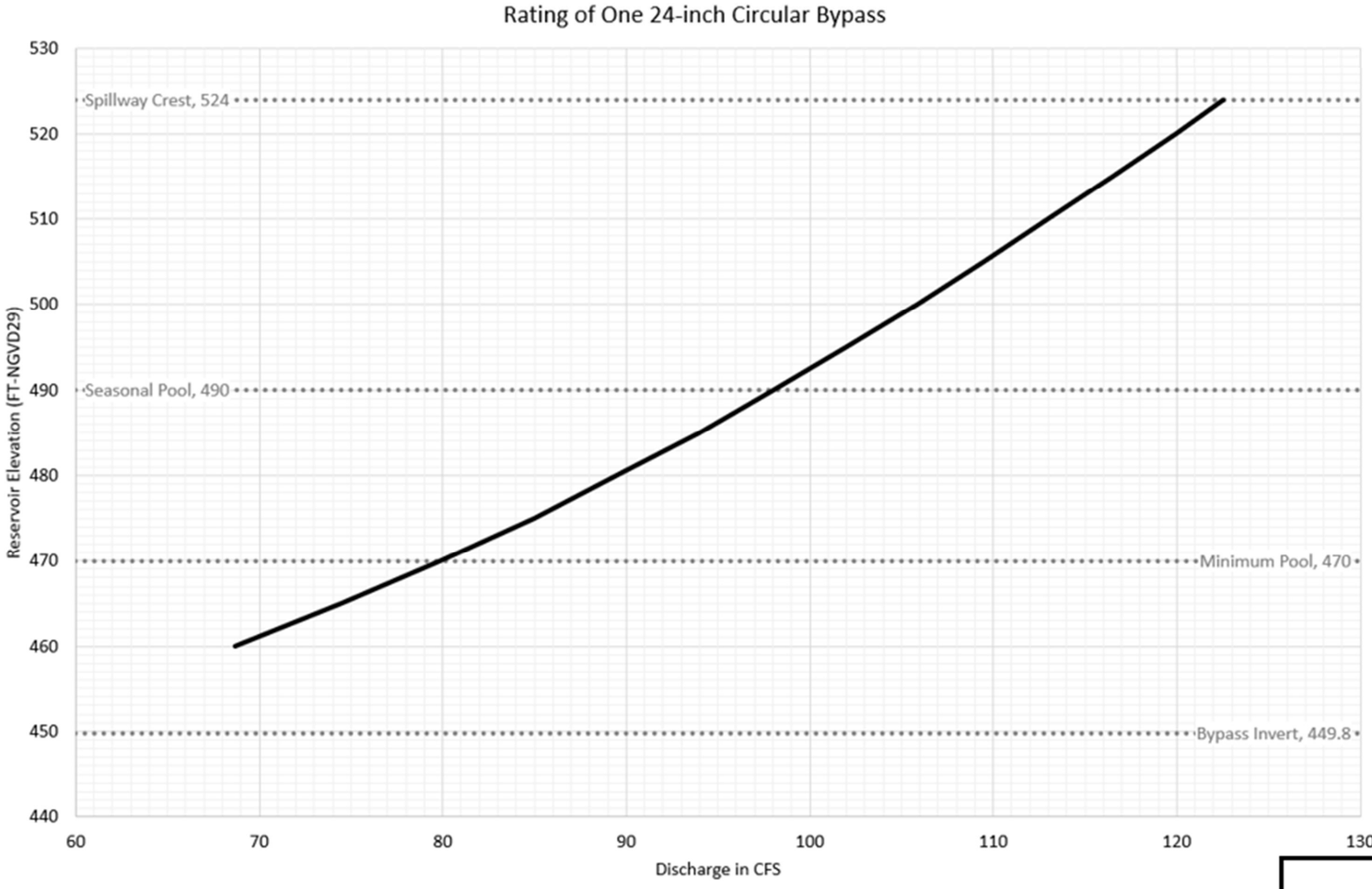
Outlet Works Rating Curves
(Flowing Full)

LOUISVILLE, KY JANUARY 2024
USACE-LRL

PLATE 7-2

(19) Plate 7-3 Bypass Rating Curve

CORPS OF ENGINEERS U.S. ARMY



NOTES:
1) Outlet works consist of one 12-ft by 12-ft semi-elliptical conduit, three 4.75-ft by 9.5-ft control gates with an inlet invert elevation of 430 FT-NGVD29, one emergency control gate, and two 24-inch diameter bypass valves.
2) Bypass rating curve taken from tables and plates presented in the 1967 Reservoir Regulation Plan.
3) Bypass rating curve is for one 24-inch circular bypass.

GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

Bypass Rating Curve

(Open Full)

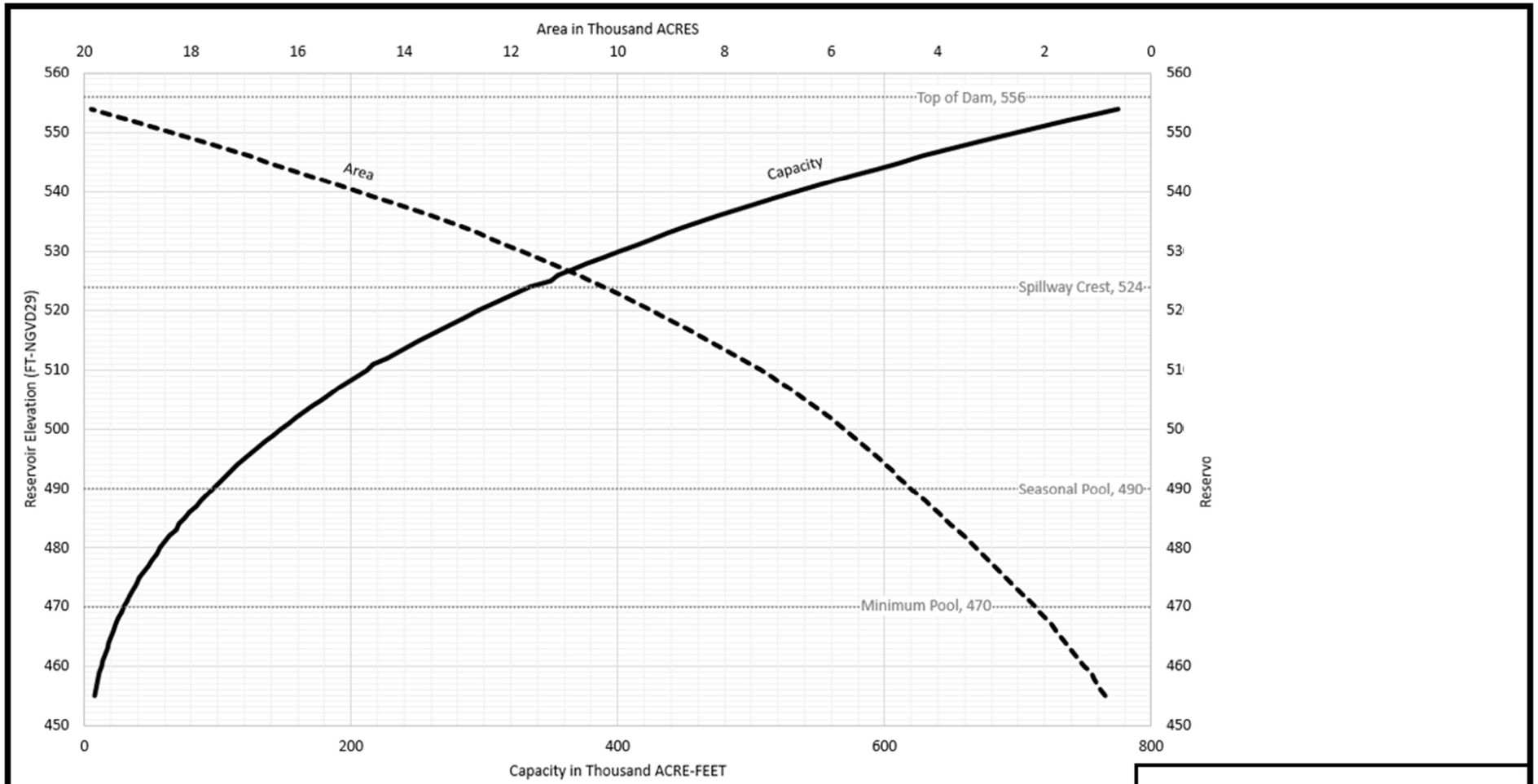
LOUISVILLE, KY JANUARY 2024

USACE-LRL

PLATE 7-3

(20) Plate 7-4 Area Capacity Curve

CORPS OF ENGINEERS U.S. ARMY



NOTE:
1) Drainage area above the dam is 454 square miles.
2) Dam site is 89.3 miles above the mouth of Rough River.
3) One-inch of runoff is equivalent to 24,213 acre-feet.

GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

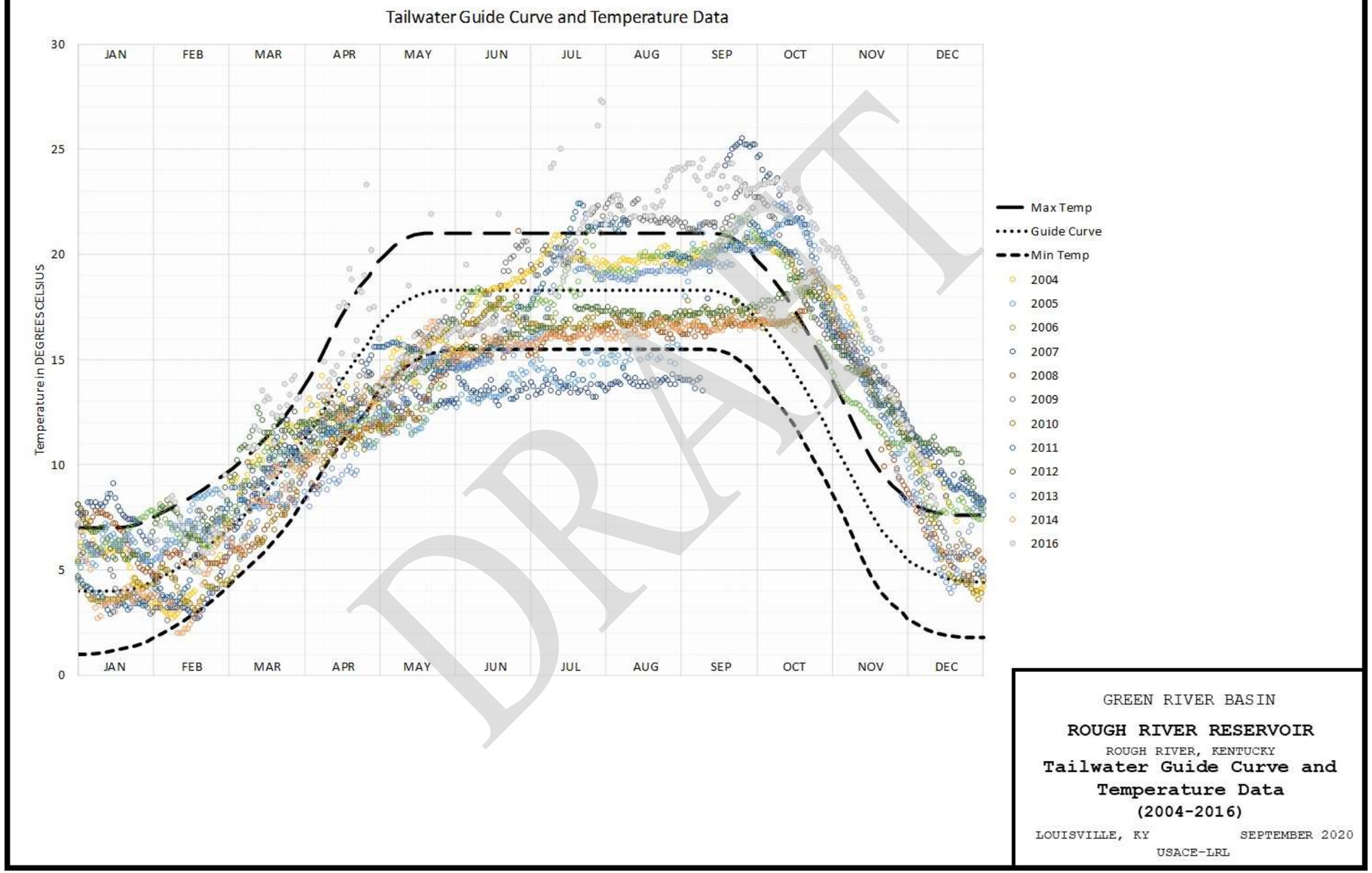
Area Capacity Curve

LOUISVILLE, KY JANUARY 2024
USACE-LRL

PLATE 7-4

(21) Plate 7-5 Tailwater Guide Curve and Temperature Data

CORPS OF ENGINEERS U.S. ARMY



GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

Tailwater Guide Curve and Temperature Data

(2004-2016)

LOUISVILLE, KY SEPTEMBER 2020

USACE-LRL

PLATE 7-5

(32) Plate 7-5a Tailwater Temperature Guide Curve (Tabular Data)

CORPS OF ENGINEERS U.S. ARMY

	Temperature (°C)				Temperature (°C)				Temperature (°C)				Temperature (°C)				Temperature (°C)				Temperature (°C)				Temperature (°C)			
Date	Guide	Max	Min	Date	Guide	Max	Min	Date	Guide	Max	Min	Date	Guide	Max	Min	Date	Guide	Max	Min	Date	Guide	Max	Min	Date	Guide	Max	Min	Date	Guide	Max	Min
1-Jan	4.00	6.50	1.50	3-Mar	6.98	9.48	4.48	3-May	16.38	18.88	13.88	3-Jul	18.00	20.50	15.50	2-Sep	18.00	20.50	15.50	13-Oct	14.68	17.18	12.18	23-Nov	6.70	9.20	4.20			
2-Jan	4.00	6.50	1.50	4-Mar	7.12	9.62	4.62	4-May	16.47	18.97	13.97	4-Jul	18.00	20.50	15.50	3-Sep	18.00	20.50	15.50	14-Oct	14.48	16.98	11.98	24-Nov	6.55	9.05	4.05			
3-Jan	4.00	6.50	1.50	5-Mar	7.25	9.75	4.75	5-May	16.56	19.06	14.06	5-Jul	18.00	20.50	15.50	4-Sep	18.00	20.50	15.50	15-Oct	14.29	16.79	11.79	25-Nov	6.40	8.90	3.90			
4-Jan	3.90	6.40	1.40	6-Mar	7.39	9.89	4.89	6-May	16.65	19.15	14.15	6-Jul	18.00	20.50	15.50	5-Sep	18.00	20.50	15.50	16-Oct	14.10	16.60	11.60	26-Nov	6.25	8.75	3.75			
5-Jan	3.90	6.40	1.40	7-Mar	7.53	10.03	5.03	7-May	16.74	19.24	14.24	7-Jul	18.00	20.50	15.50	6-Sep	18.00	20.50	15.50	17-Oct	13.90	16.40	11.40	27-Nov	6.10	8.60	3.60			
6-Jan	3.90	6.40	1.40	8-Mar	7.67	10.17	5.17	8-May	16.83	19.33	14.33	8-Jul	18.00	20.50	15.50	7-Sep	18.00	20.50	15.50	18-Oct	13.71	16.21	11.21	28-Nov	5.95	8.45	3.45			
7-Jan	3.90	6.40	1.40	9-Mar	7.81	10.31	5.31	9-May	16.92	19.42	14.42	9-Jul	18.00	20.50	15.50	8-Sep	18.00	20.50	15.50	19-Oct	13.52	16.02	11.02	29-Nov	5.80	8.30	3.30			
8-Jan	3.90	6.40	1.40	10-Mar	7.95	10.45	5.45	10-May	17.01	19.51	14.51	10-Jul	18.00	20.50	15.50	9-Sep	18.00	20.50	15.50	20-Oct	13.32	15.82	10.82	30-Nov	5.65	8.15	3.15			
9-Jan	3.90	6.40	1.40	11-Mar	8.09	10.59	5.59	11-May	17.10	19.60	14.60	11-Jul	18.00	20.50	15.50	10-Sep	18.00	20.50	15.50	21-Oct	13.13	15.63	10.63	1-Dec	5.50	8.00	3.00			
10-Jan	3.90	6.40	1.40	12-Mar	8.23	10.73	5.73	12-May	17.19	19.69	14.69	12-Jul	18.00	20.50	15.50	11-Sep	18.00	20.50	15.50	22-Oct	12.94	15.44	10.44	2-Dec	5.45	7.95	2.95			
11-Jan	3.90	6.40	1.40	13-Mar	8.36	10.86	5.86	13-May	17.28	19.78	14.78	13-Jul	18.00	20.50	15.50	12-Sep	18.00	20.50	15.50	23-Oct	12.74	15.24	10.24	3-Dec	5.40	7.90	2.90			
12-Jan	3.90	6.40	1.40	14-Mar	8.50	11.00	6.00	14-May	17.37	19.87	14.87	14-Jul	18.00	20.50	15.50	13-Sep	18.00	20.50	15.50	24-Oct	12.55	15.05	10.05	4-Dec	5.35	7.85	2.85			
13-Jan	4.00	6.50	1.50	15-Mar	8.64	11.14	6.14	15-May	17.46	19.96	14.96	15-Jul	18.00	20.50	15.50	14-Sep	18.00	20.50	15.50	25-Oct	12.35	14.85	9.85	5-Dec	5.30	7.80	2.80			
14-Jan	4.00	6.50	1.50	16-Mar	8.78	11.28	6.28	16-May	17.55	20.05	15.05	16-Jul	18.00	20.50	15.50	15-Sep	18.00	20.50	15.50	26-Oct	12.16	14.66	9.66	6-Dec	5.25	7.75	2.75			
15-Jan	4.00	6.50	1.50	17-Mar	8.92	11.42	6.42	17-May	17.64	20.14	15.14	17-Jul	18.00	20.50	15.50	16-Sep	18.00	20.50	15.50	27-Oct	11.97	14.47	9.47	7-Dec	5.20	7.70	2.70			
16-Jan	4.00	6.50	1.50	18-Mar	9.06	11.56	6.56	18-May	17.73	20.23	15.23	18-Jul	18.00	20.50	15.50	17-Sep	17.93	20.43	15.43	28-Oct	11.77	14.27	9.27	8-Dec	5.15	7.65	2.65			
17-Jan	4.00	6.50	1.50	19-Mar	9.20	11.70	6.70	19-May	17.82	20.32	15.32	19-Jul	18.00	20.50	15.50	18-Sep	17.87	20.37	15.37	29-Oct	11.58	14.08	9.08	9-Dec	5.10	7.60	2.60			
18-Jan	4.00	6.50	1.50	20-Mar	9.34	11.84	6.84	20-May	17.91	20.41	15.41	20-Jul	18.00	20.50	15.50	19-Sep	17.80	20.30	15.30	30-Oct	11.39	13.89	8.89	10-Dec	5.05	7.55	2.55			
19-Jan	4.00	6.50	1.50	21-Mar	9.47	11.97	6.97	21-May	18.00	20.50	15.50	21-Jul	18.00	20.50	15.50	20-Sep	17.73	20.23	15.23	31-Oct	11.19	13.69	8.69	11-Dec	5.00	7.50	2.50			
20-Jan	4.00	6.50	1.50	22-Mar	9.61	12.11	7.11	22-May	18.00	20.50	15.50	22-Jul	18.00	20.50	15.50	21-Sep	17.67	20.17	15.17	1-Nov	11.00	13.50	8.50	12-Dec	4.95	7.45	2.45			
21-Jan	4.00	6.50	1.50	23-Mar	9.75	12.25	7.25	23-May	18.00	20.50	15.50	23-Jul	18.00	20.50	15.50	22-Sep	17.60	20.10	15.10	2-Nov	10.80	13.30	8.30	13-Dec	4.90	7.40	2.40			
22-Jan	4.09	6.59	1.59	24-Mar	9.89	12.39	7.39	24-May	18.00	20.50	15.50	24-Jul	18.00	20.50	15.50	23-Sep	17.53	20.03	15.03	3-Nov	10.60	13.10	8.10	14-Dec	4.85	7.35	2.35			
23-Jan	4.14	6.64	1.64	25-Mar	10.03	12.53	7.53	25-May	18.00	20.50	15.50	25-Jul	18.00	20.50	15.50	24-Sep	17.47	19.97	14.97	4-Nov	10.40	12.90	7.90	15-Dec	4.80	7.30	2.30			
24-Jan	4.18	6.68	1.68	26-Mar	10.17	12.67	7.67	26-May	18.00	20.50	15.50	26-Jul	18.00	20.50	15.50	25-Sep	17.40	19.90	14.90	5-Nov	10.20	12.70	7.70	16-Dec	4.75	7.25	2.25			
25-Jan	4.23	6.73	1.73	27-Mar	10.31	12.81	7.81	27-May	18.00	20.50	15.50	27-Jul	18.00	20.50	15.50	26-Sep	17.33	19.83	14.83	6-Nov	10.00	12.50	7.50	17-Dec	4.70	7.20	2.20			
26-Jan	4.27	6.77	1.77	28-Mar	10.45	12.95	7.95	28-May	18.00	20.50	15.50	28-Jul	18.00	20.50	15.50	27-Sep	17.27	19.77	14.77	7-Nov	9.80	12.30	7.30	18-Dec	4.65	7.15	2.15			
27-Jan	4.32	6.82	1.82	29-Mar	10.58	13.08	8.08	29-May	18.00	20.50	15.50	29-Jul	18.00	20.50	15.50	28-Sep	17.20	19.70	14.70	8-Nov	9.60	12.10	7.10	19-Dec	4.60	7.10	2.10			
28-Jan	4.36	6.86	1.86	30-Mar	10.72	13.22	8.22	30-May	18.00	20.50	15.50	30-Jul	18.00	20.50	15.50	29-Sep	17.13	19.63	14.63	9-Nov	9.40	11.90	6.90	20-Dec	4.55	7.05	2.05			
29-Jan	4.41	6.91	1.91	31-Mar	10.86	13.36	8.36	31-May	18.00	20.50	15.50	31-Jul	18.00	20.50	15.50	30-Sep	17.07	19.57	14.57	10-Nov	9.20	11.70	6.70	21-Dec	4.60	7.10	2.10			
30-Jan	4.45	6.95	1.95	1-Apr	11.00	13.50	8.50	1-Jun	18.00	20.50	15.50	1-Aug	18.00	20.50	15.50	1-Oct	17.00	19.50	14.50	11-Nov	9.00	11.50	6.50	22-Dec	4.50	7.00	2.00			
31-Jan	4.50	7.00	2.00	2-Apr	11.17	13.67	8.67	2-Jun	18.00	20.50	15.50	2-Aug	18.00	20.50	15.50	2-Oct	16.81	19.31	14.31	12-Nov	8.80	11.30	6.30	23-Dec	4.50	7.00	2.00			
1-Feb	4.50	7.00	2.00	3-Apr	11.34	13.84	8.84	3-Jun	18.00	20.50	15.50	3-Aug	18.00	20.50	15.50	3-Oct	16.61	19.11	14.11	13-Nov	8.60	11.10	6.10	24-Dec	4.50	7.00	2.00			
2-Feb	4.58	7.08	2.08	4-Apr	11.51	14.01	9.01	4-Jun	18.00	20.50	15.50	4-Aug	18.00	20.50	15.50	4-Oct	16.42	18.92	13.92	14-Nov	8.40	10.90	5.90	25-Dec	4.50	7.00	2.00			
3-Feb	4.66	7.16	2.16	5-Apr	11.68	14.18	9.18	5-Jun	18.00	20.50	15.50	5-Aug	18.00	20.50	15.50	5-Oct	16.23	18.73	13.73	15-Nov	8.20	10.70	5.70	26-Dec	4.50	7.00	2.00			
4-Feb	4.74	7.24	2.24	6-Apr	11.85	14.35	9.35	6-Jun	18.00	20.50	15.50	6-Aug	18.00	20.50	15.50	6-Oct	16.03	18.53	13.53	16-Nov	8.00	10.50	5.50	27-Dec	4.50	7.00	2.00			
5-Feb	4.81	7.31	2.31	7-Apr	12.03	14.53	9.53	7-Jun	18.00	20.50	15.50	7-Aug	18.00	20.50	15.50	7-Oct	15.84	18.34	13.34	17-Nov	7.80	10.30	5.30	28-Dec	4.50	7.00	2.00			
6-Feb	4.89	7.39	2.39	8-Apr	12.20	14.70	9.70	8-Jun	18.00	20.50	15.50	8-Aug	18.00	20.50	15.50	8-Oct	15.65	18.15	13.15	18-Nov	7.60	10.10	5.10	29-Dec	4.50	7.00	2.00			
7-Feb	4.97	7.47	2.47	9-Apr	12.37	14.87	9.87	9-Jun	18.00	20.50	15.50	9-Aug	18.00	20.50	15.50	9-Oct	15.45	17.95	12.95	19-Nov	7.40	9.90	4.90	30-Dec	4.50	7.00	2.00			
8-Feb	5.05	7.55	2.55	10-Apr	12.54	15.04	10.04	10-Jun	18.00	20.50	15.50	10-Aug	18.00	20.50	15.50	10-Oct	15.26	17.76	12.76	20-Nov	7.20	9.70	4.70	31-Dec	4.50	7.00	2.00			
9-Feb	5.13	7.63	2.63	11-Apr	12.71	15.21	10.21	11-Jun	18.00	20.50	15.50	11-Aug	18.00	20.50	15.50	11-Oct	15.06	17.56	12.56	21-Nov	7.00	9.50	4.50							
10-Feb	5.21	7.71	2.71	12-Apr	12.88	15.38	10.38	12-Jun	18.00	20.50	15.50	12-Aug	18.00	20.50	15.50	12-Oct	14.87	17.37	12.37	22-Nov	6.85	9.35	4.35							
11-Feb	5.29	7.79	2.79	13-Apr	13.05	15.55	10.55	13-Jun	18.00	20.50	15.50	13-Aug	18.00	20.50	15.50															
12-Feb	5.36	7.86	2.86	14-Apr	13.22	15.72	10.72	14-Jun	18.00	20.50	15.50	14-Aug	18.00	20.50	15.50															
13-Feb	5.44	7.94	2.94	15-Apr	13.39	15.89	10.89	15-Jun	18.00	20.50	15.50	15-Aug	18.00	20.50	15.50															
14-Feb	5.52	8.02	3.02	16-Apr	13.56	16.06	11.06	16-Jun	18.00	20.50	15.50	16-Aug	18.00	20.50	15.50															
15-Feb	5.60	8.10	3.10	17-Apr	13.74	16.24	11.24	17-Jun	18.00	20.50	15.50	17-Aug	18.00	20.50	15.50															
16-Feb	5.68	8.18	3.18	18-Apr	13.91	16.41	11.41	18-Jun	18.00	20.50	15.50	18-Aug	18.00	20.50	15.50															
17-Feb	5.76	8.26	3.26	19-Apr	14.08	16.58	11.58	19-Jun	18.00	20.50	15.50	19-Aug	18.00	20.50	15.50															
18-Feb	5.84	8.34	3.34	20-Apr	14.25	16.75	11.75	20-Jun	18.00	20.50	15.50	20-Aug	18.00	20.50	15.50															
19-Feb	5.91	8.41	3.41	21-Apr	14.42	16.92	11.92	21-Jun	18.00	20.50	15.50	21-Aug	18.00	20.50	15.50															
20-Feb	5.99	8.49	3.49	22-Apr	14.59	17.09	12.09	22-Jun	18.00	20.50	15.50	22-Aug	18.00	20.50	15.50															
21-Feb	6.07	8.57	3.57	23-Apr	14.76	17.26	12.26	23-Jun	18.00	20.50	15.50	23-Aug	18.00	20.50	15.50															
22-Feb	6.15	8.65	3.65	24-Apr	14.93	17.43	12.43	24-Jun	18.00	20.50	15.50	24-Aug	18.00	20.50	15.50															
23-Feb	6.23	8.73	3.73	25-Apr	15.10	17.60	12.60	25-Jun	18.00	20.50	15.50	25-Aug	18.00	20.50	15.50															
24-Feb	6.31	8.81	3.81	26-Apr	15.27	17.77	12.77	26-Jun	18.00	20.50	15.50	26-Aug	18.00	20.50	15.50															
25-Feb	6.39	8.89	3.89	27-Apr	15.45	17.95	12.95	27-Jun	18.00	20.50	15.50	27-Aug	18.00	20.50	15.50															
26-Feb	6.46	8.96	3.96	28-Apr	15.62	18.12	13.12	28-Jun	18.00	20.50	15.50	28-Aug	18.00	20.50	15.50															
27-Feb	6.54	9.04	4.04	29-Apr	15.79	18.29	13.29	29-Jun	18.00	20.50	15.50	29-Aug	18.00	20.50	15.50															
28-Feb	6.62	9.12	4.12	30-Apr	15.96	18.46	13.46	30-Jun	18.00	20.50	15.50	30-Aug	18.00	20.50	15.50															
1-Mar	6.70	9.20	4.20	1-May	16.20	18.70	13.70	1-Jul	18.00	20.50	15.50	31-Aug	18.00	20.50	15.50															
2-Mar	6.84	9.34	4.34	2-May	16.29	18.79	13.79	2-Jul	18.00	20.50	15.50	1-Sep	18.00	20.50	15.50															

GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

Tailwater Temperature Guide Curve

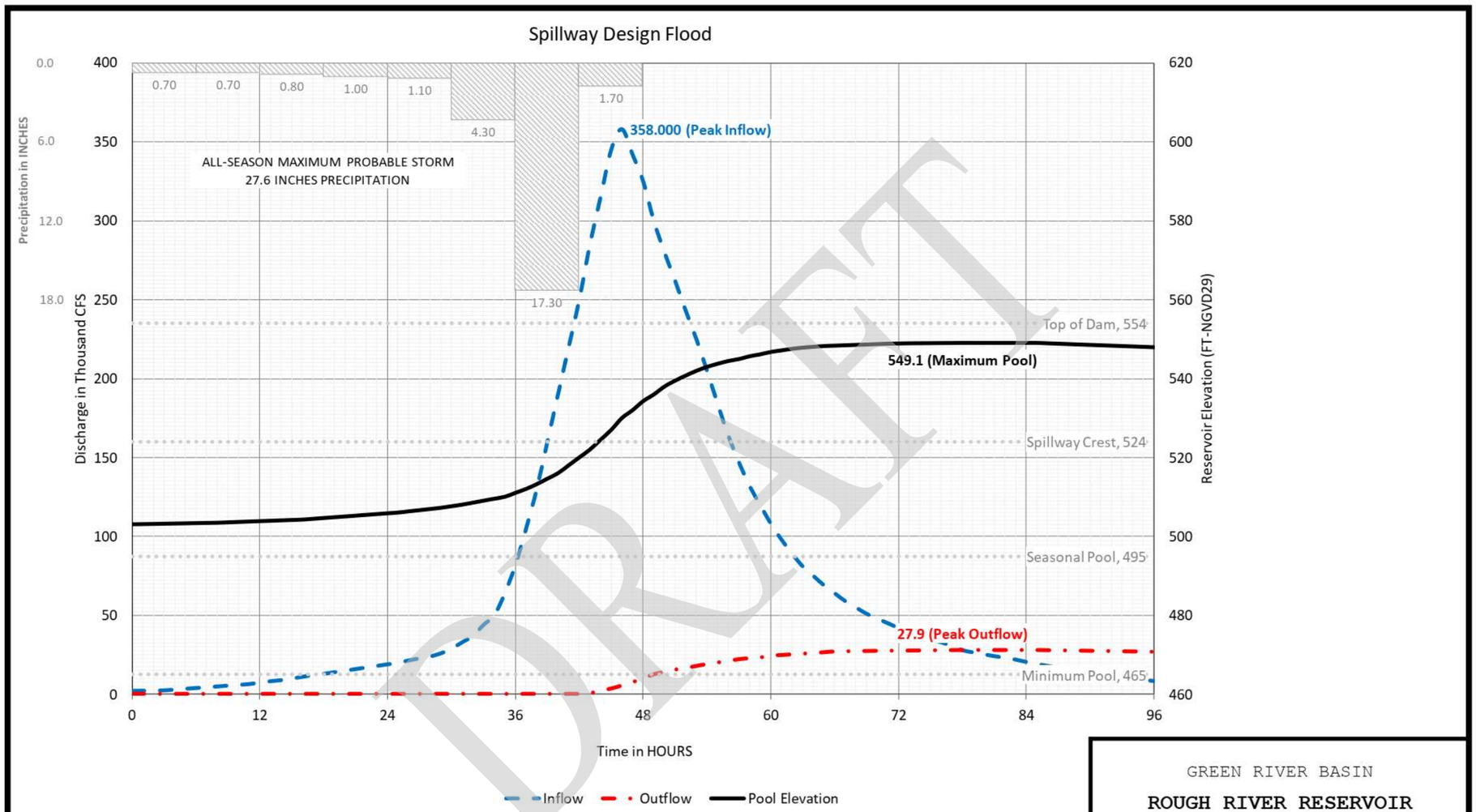
LOUISVILLE, KY SEPTEMBER 2020

USACE -LRL

PLATE 7-5a

(22) Plate 8-1a Spillway Design Flood (1958 Criteria)

CORPS OF ENGINEERS U.S. ARMY



SPILLWAY DESIGN FLOOD (1958 CRITERIA) NOTES:

1) Infiltration = 0.5" (initial loss) - 0.05" per hour(constant rate)
2) Reservoir assumed at envelope elevation 503 based on 1935 flood storage.
3) Gates are regulated to pass 100 CFS until end of 42nd hour. The gates are then gradually raised to fully open in 3 hours. After that time, the flood is routed uncontrolled through conduit and 65-foot spillway.

GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

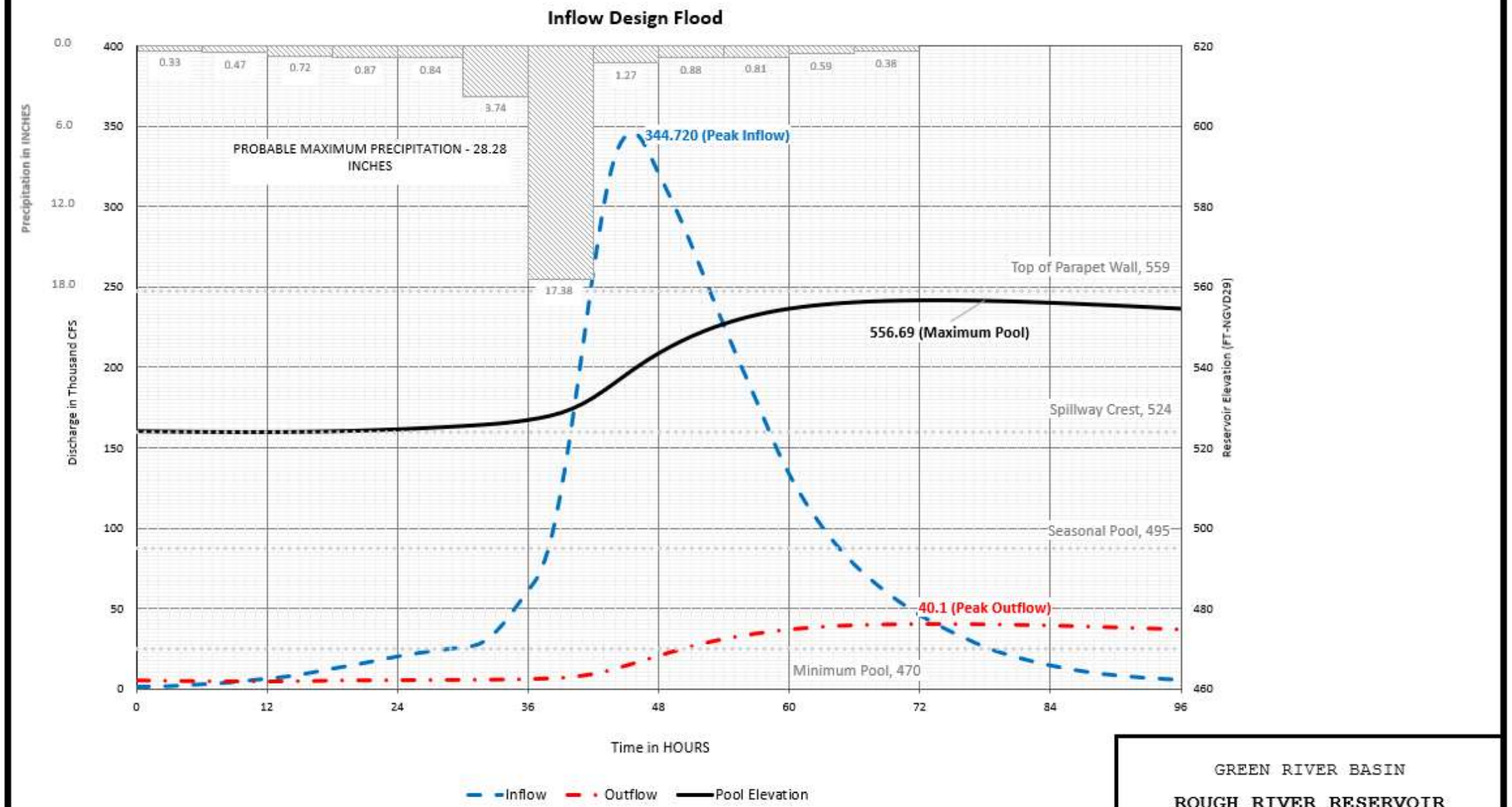
Spillway Design Flood
(1958 Criteria)

LOUISVILLE, KY SEPTEMBER 2020
USACE-LRL

PLATE 8-1

(31) Plate 8-1b Inflow Design Flood (2019)

CORPS OF ENGINEERS U.S. ARMY



INFLOW DESIGN FLOOD (2019) NOTES:
1) Infiltration losses vary by sub-basin.
2) Antecedent elevation is 524 NGVD (Spillway Crest).
3) For full details, see Rough River Watershed Hydrologic Model Development ATRd Final_11272020.pdf.

GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

Inflow Design Flood (2019)

LOUISVILLE, KY MARCH 2021

USACE-LRL

PLATE 8-1b

(23) Plate 8-2 Spillway Rating Curve

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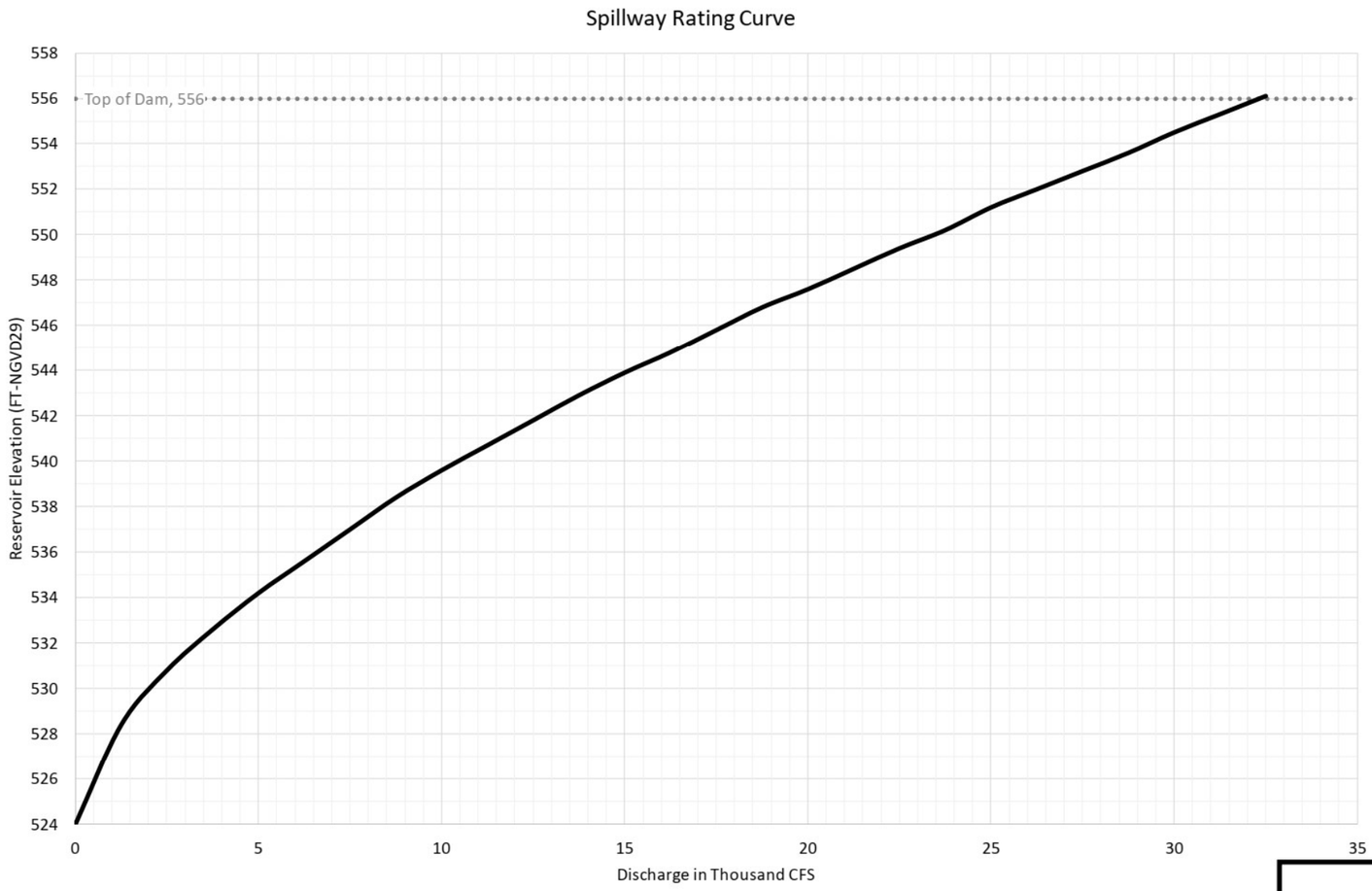


NOTE:
1) Spillway Crest Elevation is 524 FT NGVD29.
2) Spillway Base Width is 65 feet.

GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

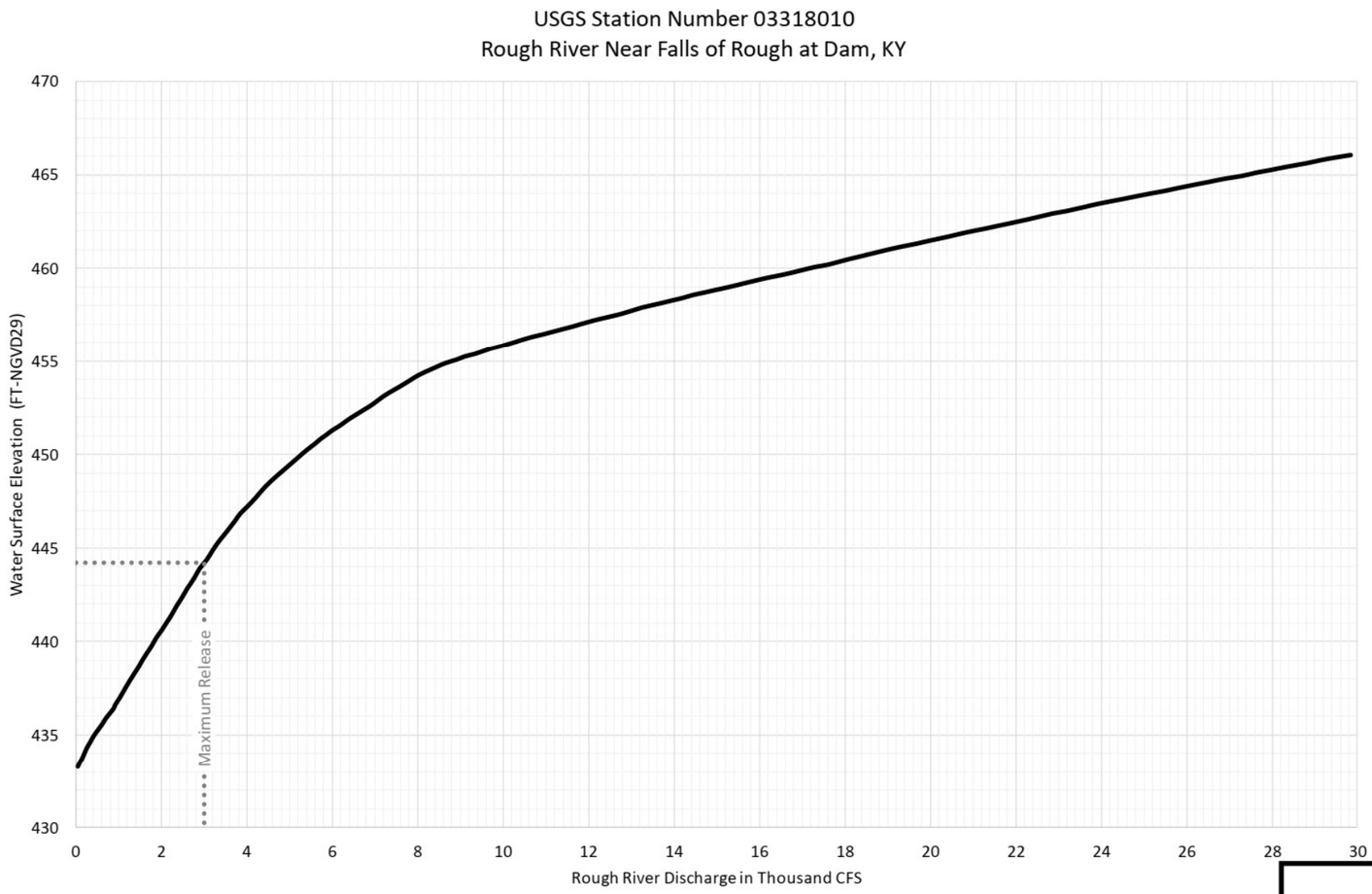
Spillway Rating Curve

LOUISVILLE, KY SEPTEMBER 2020
USACE-LRL

PLATE 8-2

(24) Plate 8-3 Tailwater Rating Curve

CORPS OF ENGINEERS U.S. ARMY



NOTE:
1) Tailwater gage is located approximately 1,300 feet downstream of the Rough River Dam.
2) Maximum Release of 3,000 CFS is a regulated maximum discharge for the low-level outlet works based on the Rough River Reservoir Schedule of Regulation.

GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

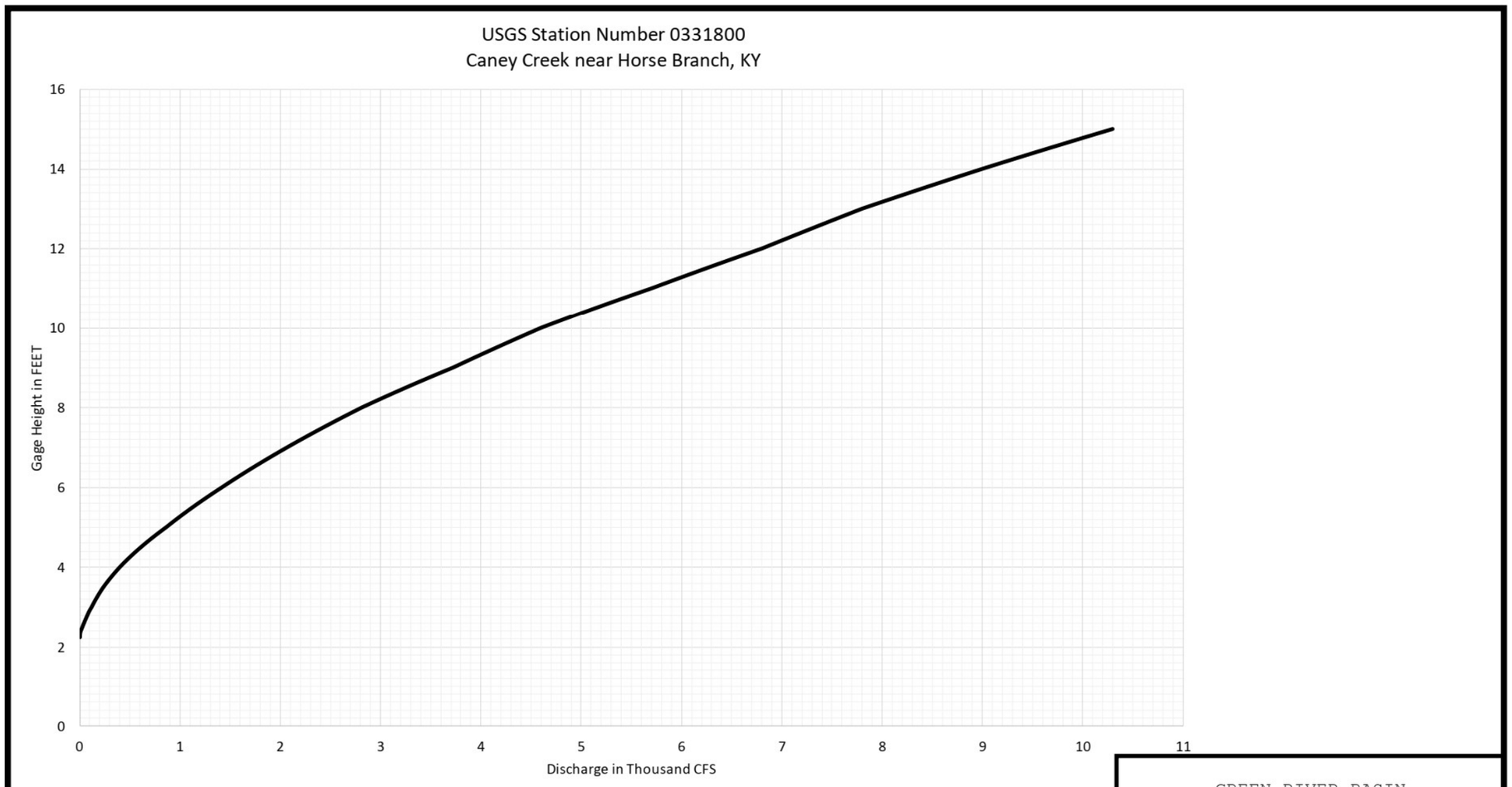
Tailwater Rating Curve

LOUISVILLE, KY SEPTEMBER 2020
USACE-LRL

PLATE 8-3

(25) Plate 8-4 Stage Discharge Curves

CORPS OF ENGINEERS U.S. ARMY



RATING PERTINENT DATA:
Gage Zero 415.94 feet NAVD88
USGS Rating Table No. 20.0
Dated 03-24-2020

GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

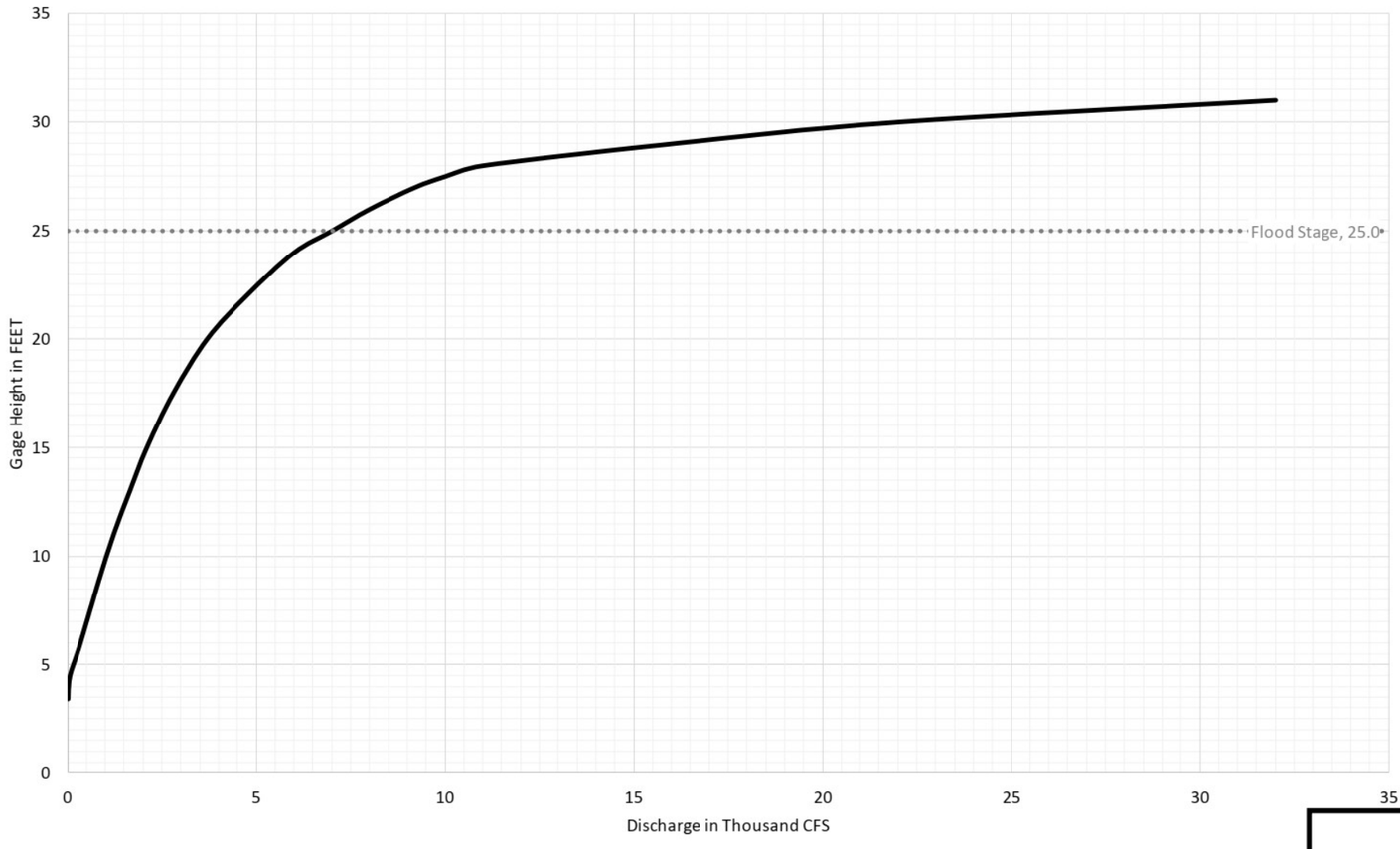
ROUGH RIVER, KENTUCKY

Stage Discharge Curve
Caney Creek
near Horse Branch, KY

LOUISVILLE, KY SEPTEMBER 2020
USACE-LRL

PLATE 8-4A

USGS Station Number 03319000
Rough River Near Dundee, KY



RATING PERTINENT DATA:
Gage Zero 393.18 feet NGVD29
USGS Rating Table No. 16.0
Dated 03-14-2002

GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

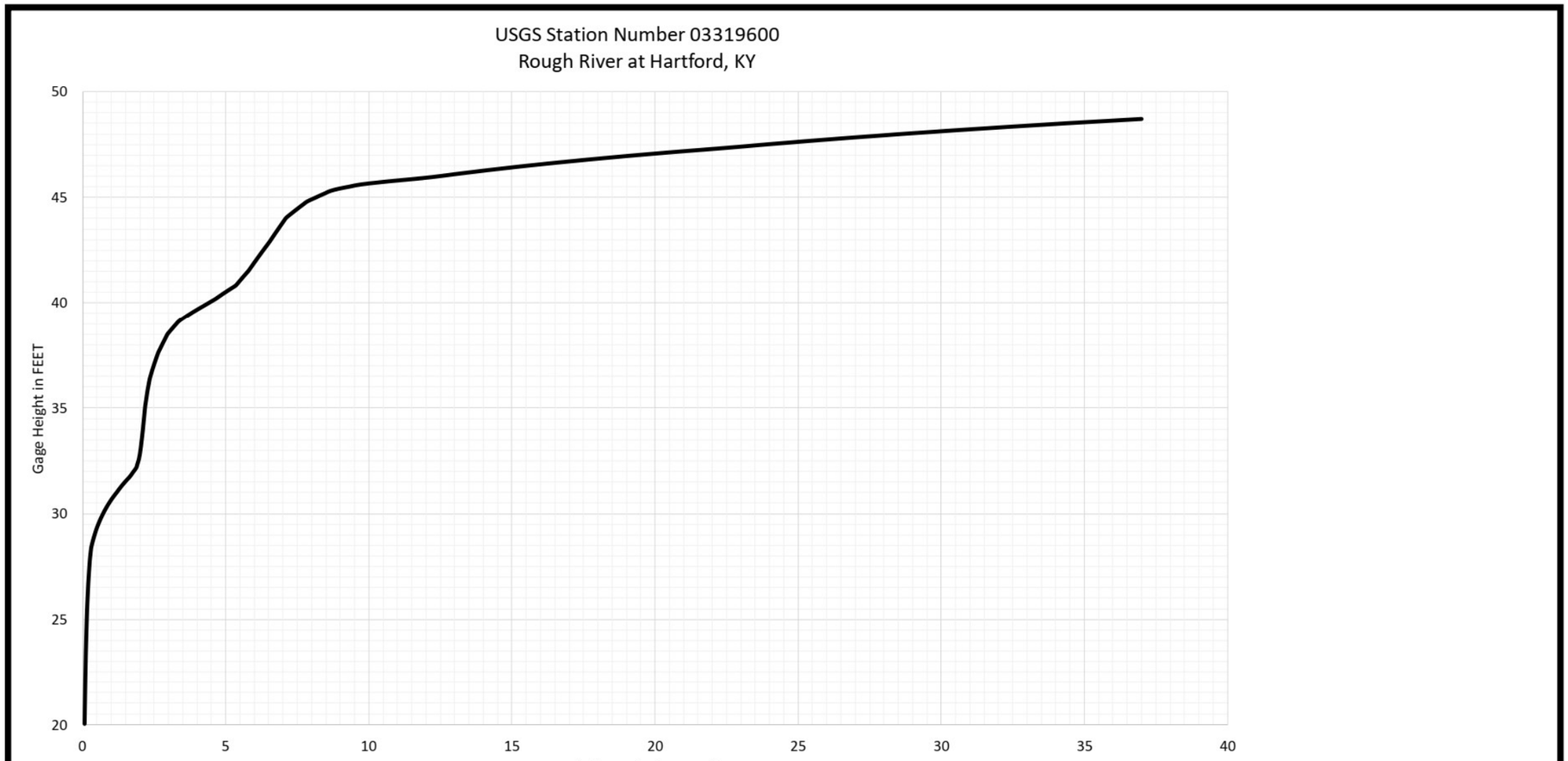
ROUGH RIVER, KENTUCKY

Stage Discharge Curve

Rough River
near Dundee, KY

LOUISVILLE, KY SEPTEMBER 2020
USACE-LRL

PLATE 8-4B



RATING PERTINENT DATA:
Gage Zero 406.41 feet NAVD88
USGS Rating Table No. 3.0
Dated 04-14-2020

CONTROL.--
The streambed is comprised of mud and silt and both banks are heavily wooded and have brush. The low water control is a rough constructed weir composed of rip rap overlaid with Gunite concrete with a weir elevation of around 28.0 ft. There is leakage through the weir, and an 18" pipe embedded into the weir to maintain minimum flow (elevation unknown) so a gage height of zero flow has not been determined. The left and right banks both rise steeply. The right bank rops off around 43.00 ft and flattens out considerably, allowing for much overflow when the Green River is above flood stage, the left bank rises considerably higher and will not overflow. The weir is the control for all stages except for those above around 38.0 ft, at which point channel control exists.

GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

Stage Discharge Curve

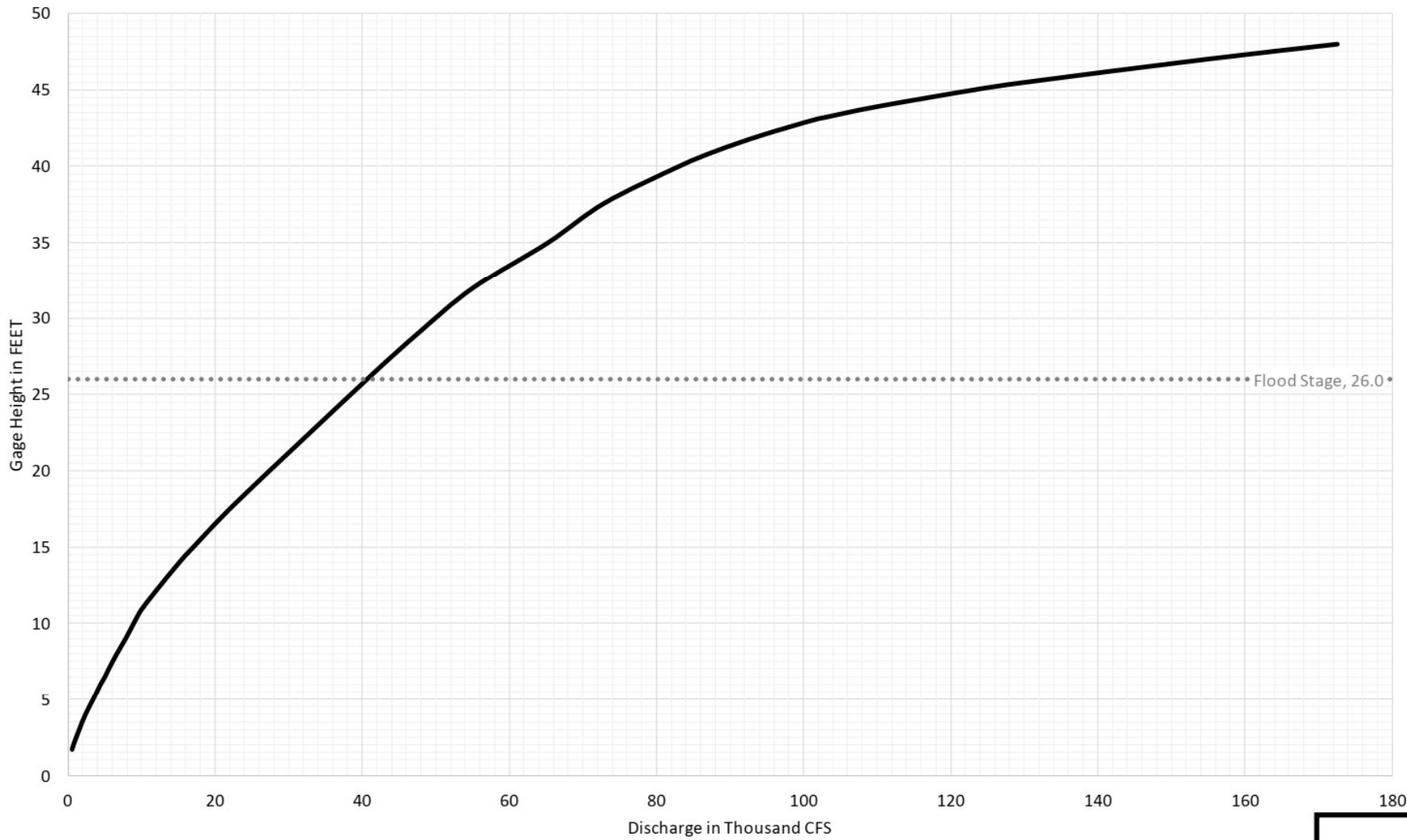
Rough River
at Hartford, KY

LOUISVILLE, KY SEPTEMBER 2020
USACE-LRL

PLATE 8-4C

CORPS OF ENGINEERS U.S. ARMY

USGS Station Number 03315500
Green River at Lock 4 at Woodbury, KY



RATING PERTINENT DATA:
Gage Zero 379.60 feet NGVD29
USGS Rating Table No. 13.0
Dated 10-01-1984

GREEN RIVER BASIN

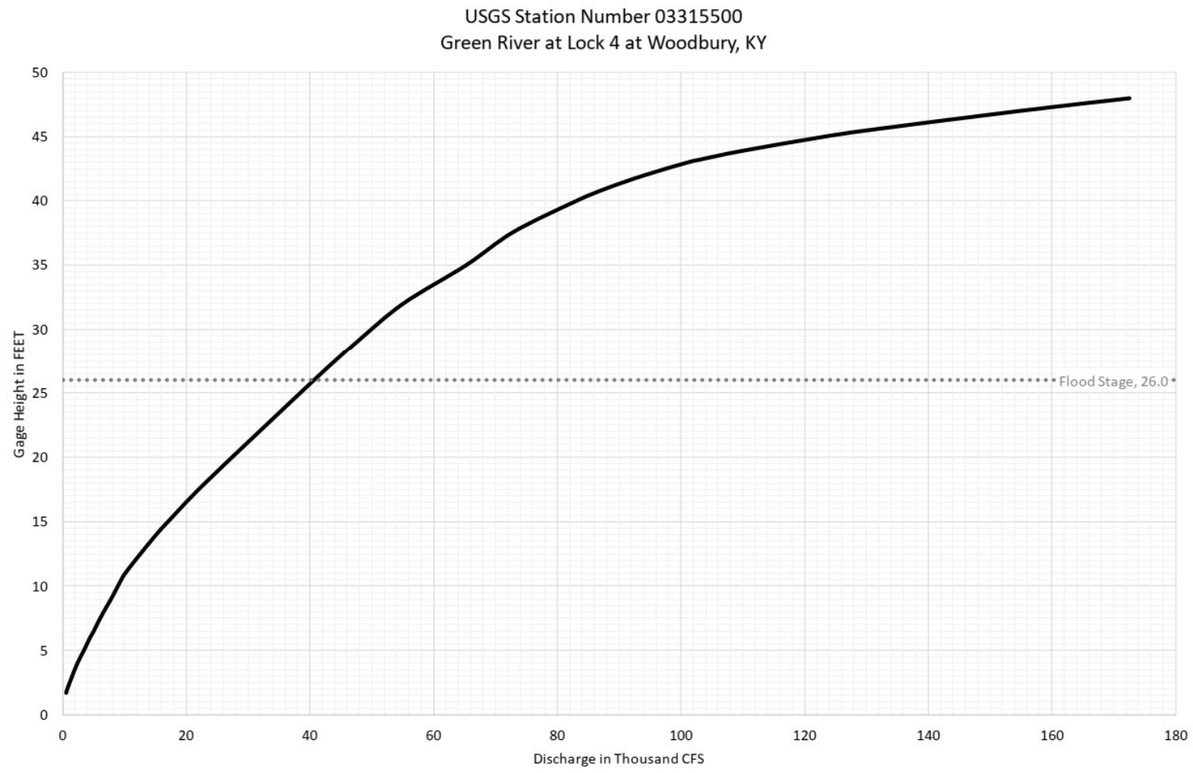
ROUGH RIVER RESERVOIR

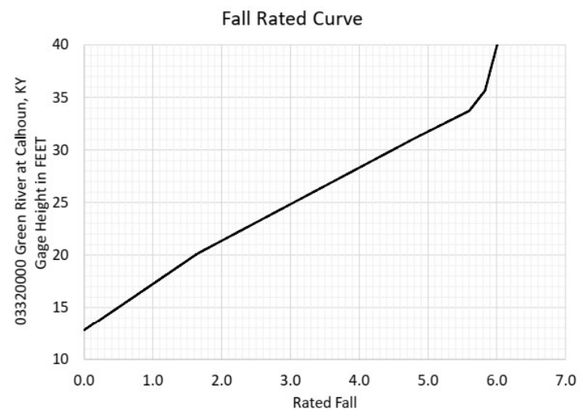
ROUGH RIVER, KENTUCKY

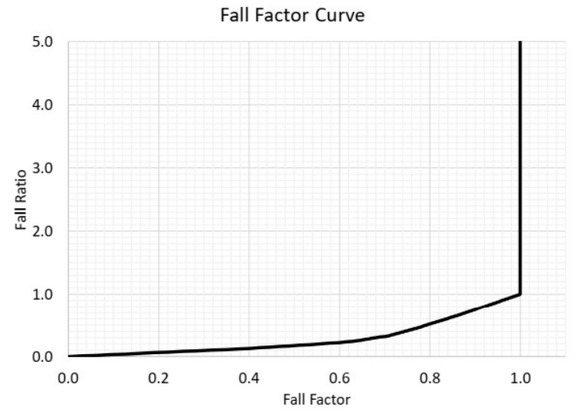
Stage Discharge Curve
Green River
at Lock 4 Woodbury, KY

LOUISVILLE, KY SEPTEMBER 2020
USACE-LRL

PLATE 8-4D







RATING PERTINENT DATA:

Gage Zero 353.95 feet NGVD29
USGS Rating Table No. 17.0
Dated 10-01-1990

GREEN RIVER AT LOCK 2 CALHOUN INSTRUCTIONS:

When the gage height at 03320000 is below 13.50 ft, the Stage/Discharge Rating 17.0 is used directly.
When the gage height at 03320000 is above 13.50 ft, the Slope Rated Discharge Calculation is used:
1) Add 6.36 ft to the Auxiliary gage height at 03319885 Green River at Livermore, KY to adjust datum.
2) Subtract the datum corrected gage height from 03319885 from the gage height of the base gage, 03320000 Green River at Calhoun, KY, giving you Fall Measured.
3) Obtain Rated Fall with the Fall Rated Curve using the gage height from 03320000 Green River at Calhoun, KY.
4) Compute Fall Ratio: Fall Measured value/Rated Fall value
5) Obtain Fall Factor with the Fall Factor Curve using the computed Fall Ratio.
6) Multiply the Fall Factor by the discharge from Stage/Discharge Rating 17.0, resulting in Slope Rated Discharge.

GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

Stage Discharge Curve

Green River

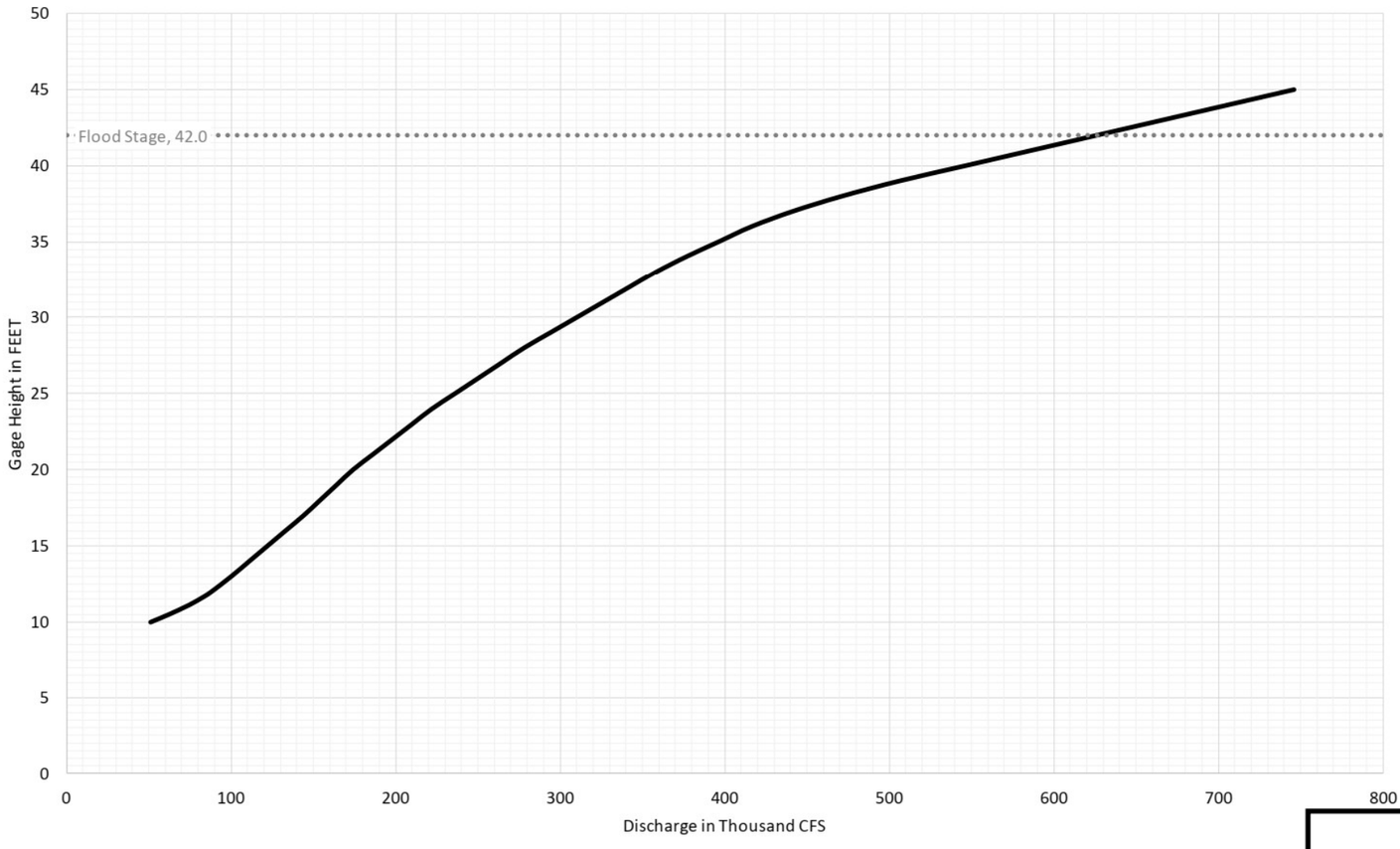
at Lock 2 Calhoun, KY

LOUISVILLE, KY SEPTEMBER 2020

USACE-LRL

PLATE 8-4E

USGS Station Number 03322000
Ohio River at Evansville, Indiana



RATING PERTINENT DATA:
Gage Zero 379.60 feet NGVD29
USGS Rating Table No. 13.0
Dated 10-01-1984

GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

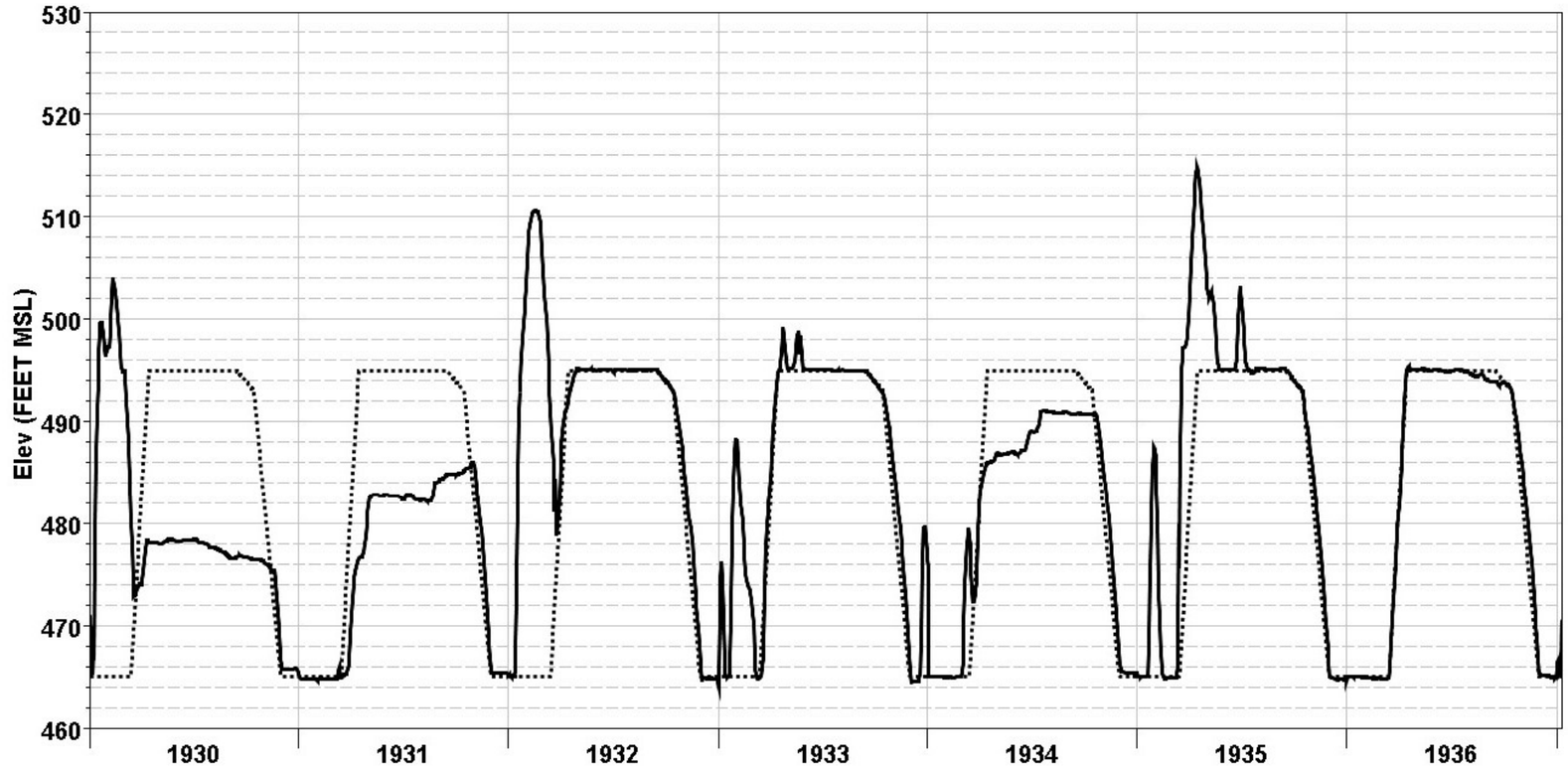
Stage Discharge Curve
Ohio River
at Evansville, IN

LOUISVILLE, KY SEPTEMBER 2020
USACE-LRL

PLATE 8-4F

(26) Plate 8-5 Theoretical Regulation Pool Hydrographs

CORPS OF ENGINEERS U.S. ARMY



GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

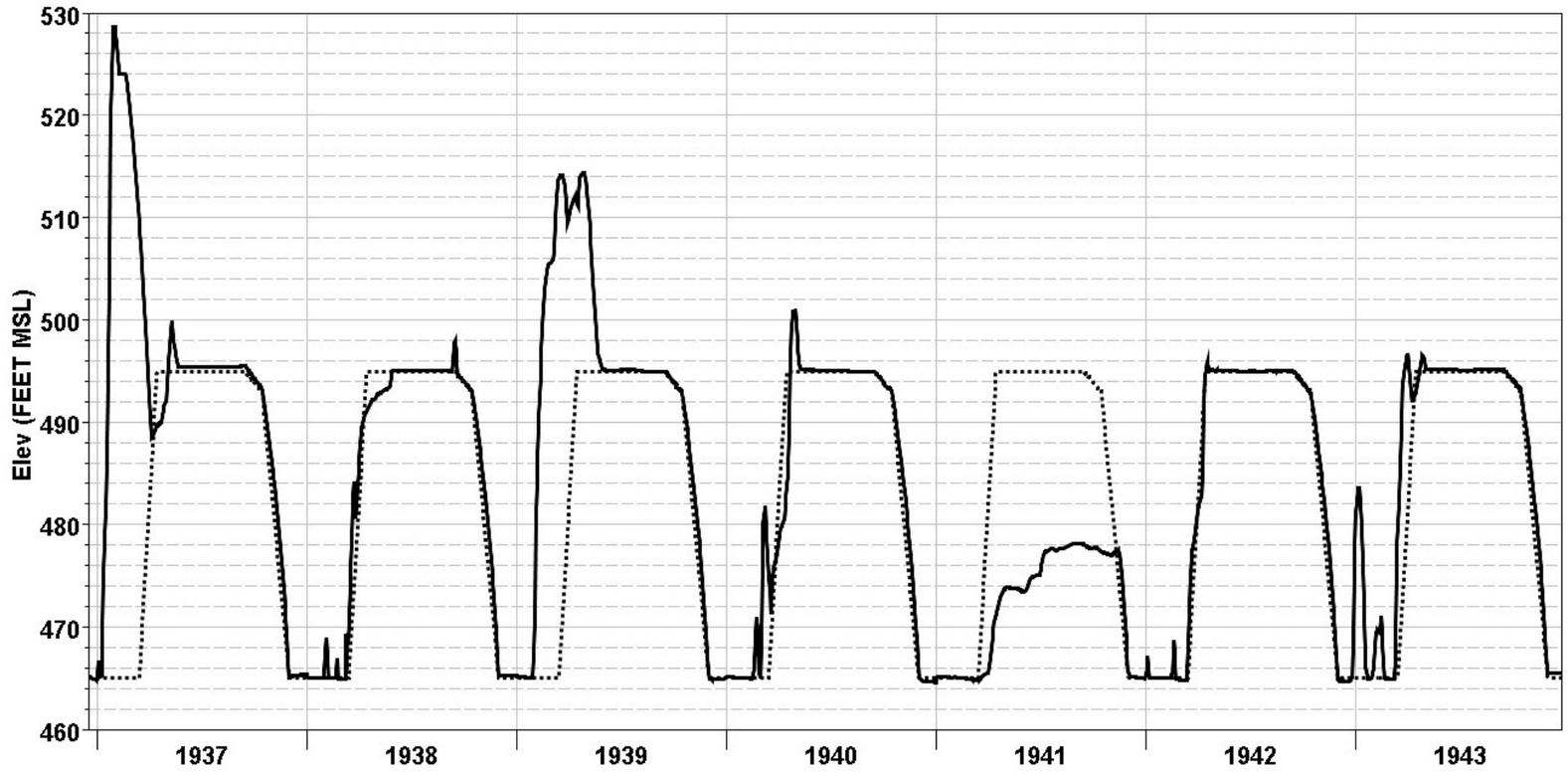
ROUGH RIVER, KENTUCKY

Theoretical Regulation Pool Hydrographs 1930-1936

LOUISVILLE, KY SEPTEMBER 2020

USACE-LRL

PLATE 8-5A



GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

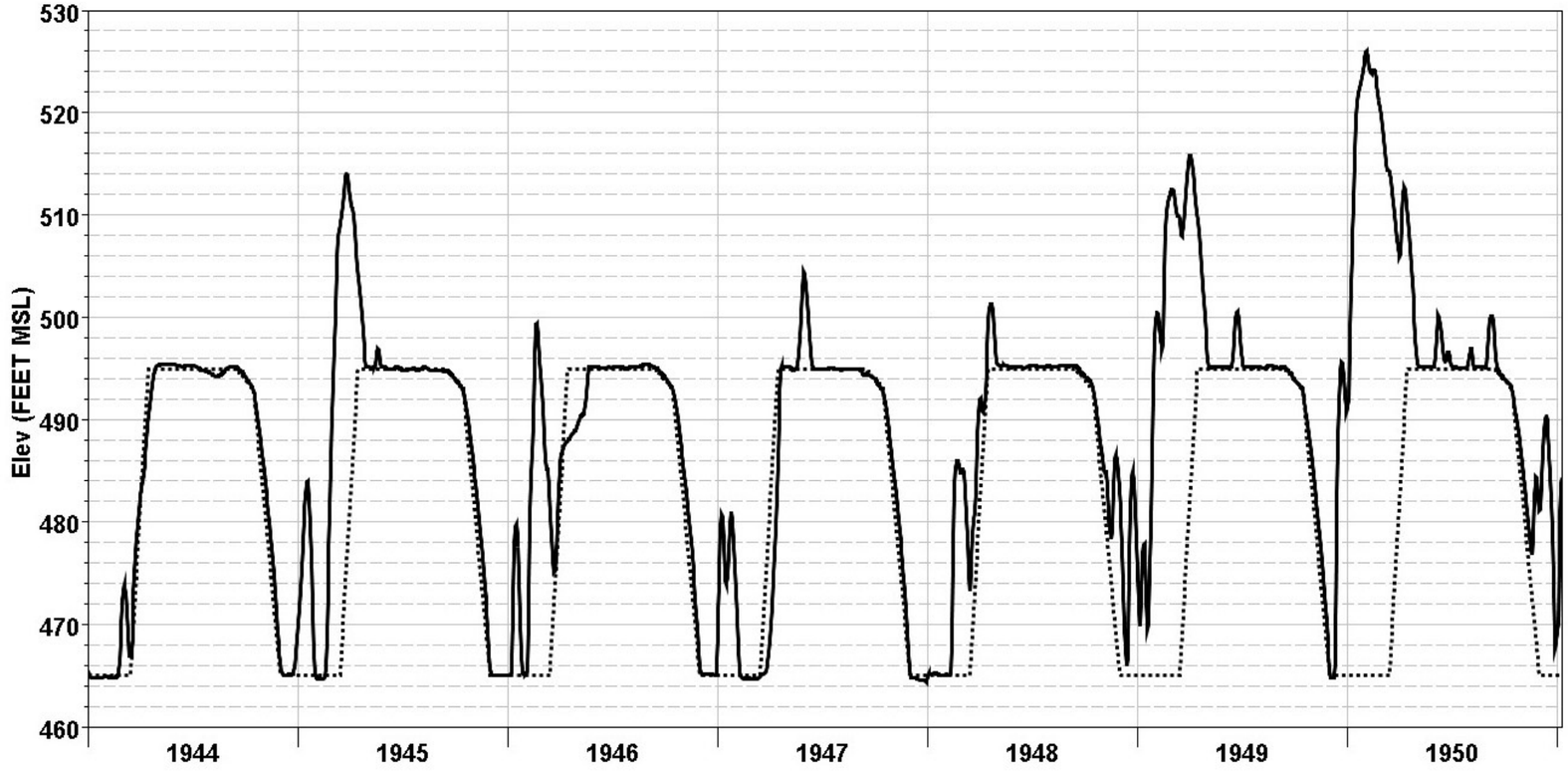
ROUGH RIVER, KENTUCKY

Theoretical Regulation Pool Hydrographs 1937-1943

LOUISVILLE, KY SEPTEMBER 2020

USACE-LRL

PLATE 8-5B



GREEN RIVER BASIN

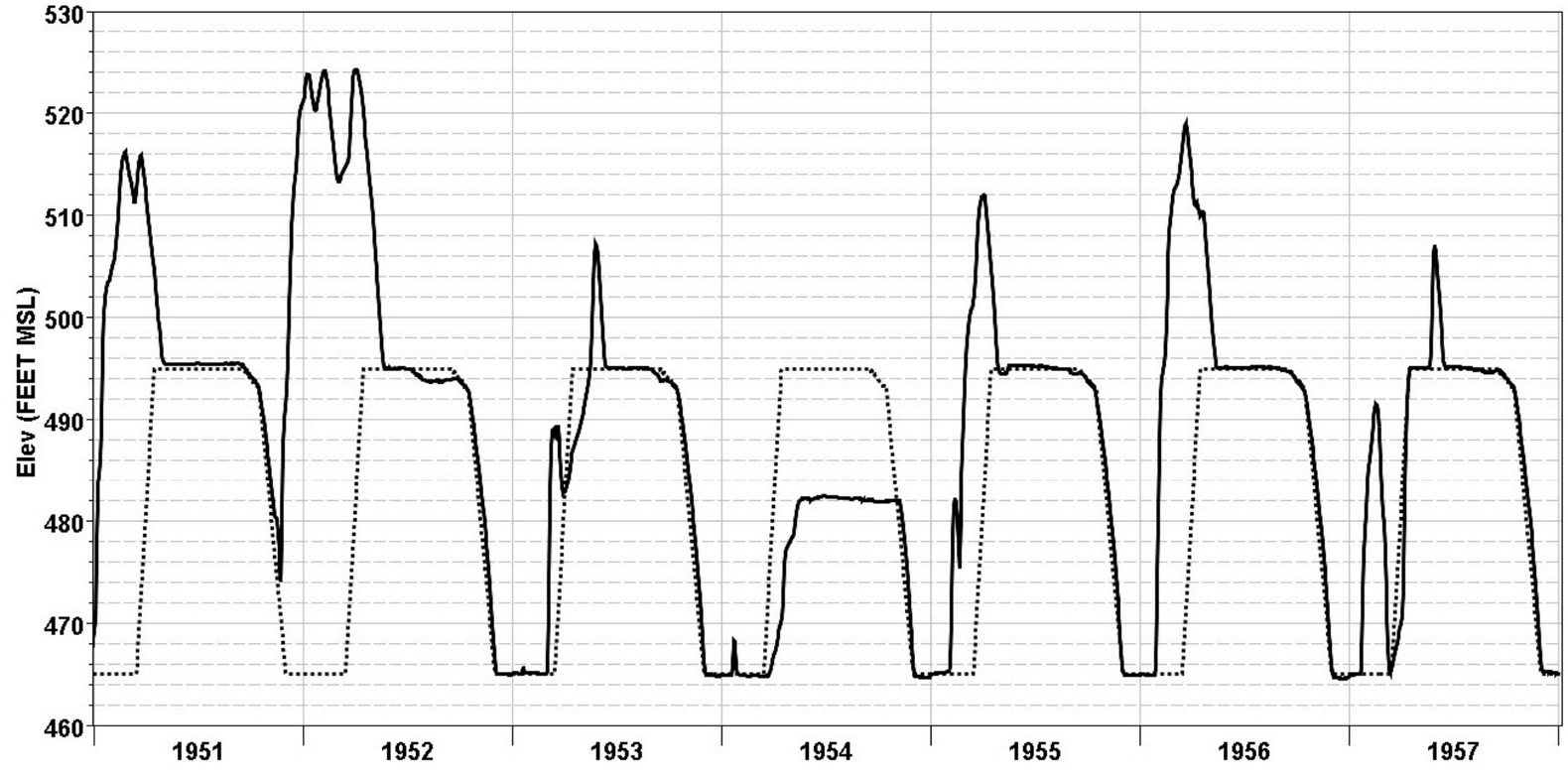
ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

Theoretical Regulation
Pool Hydrographs
1944-1950

LOUISVILLE, KY SEPTEMBER 2020
USACE-LRL

PLATE 8-5C



GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

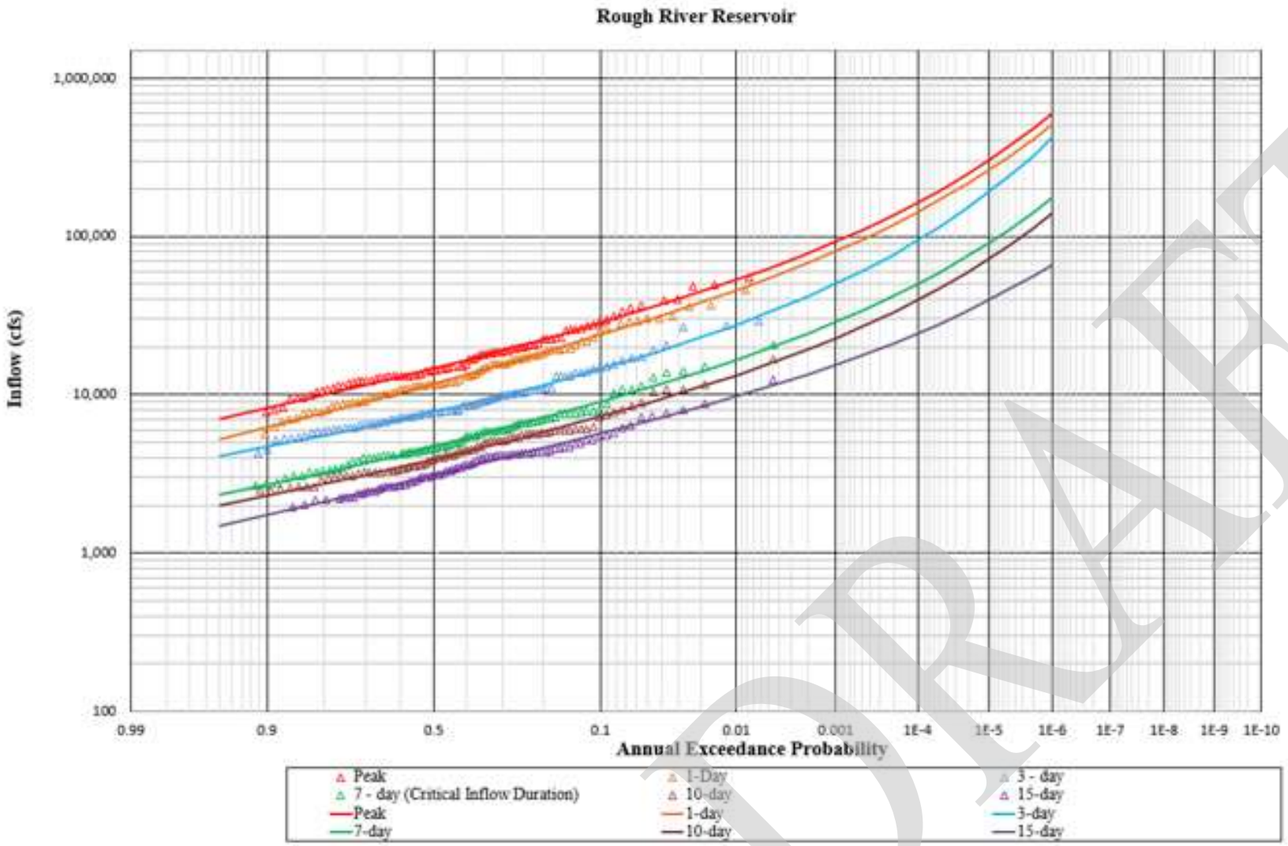
Theoretical Regulation
Pool Hydrographs
1951-1957

LOUISVILLE, KY SEPTEMBER 2020
USACE-LRL

PLATE 8-5D

(27) Plate 8-6 Peak Inflow Probability

CORPS OF ENGINEERS U.S. ARMY



GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

Peak Inflow Probability

LOUISVILLE, KY MARCH 2021

USACE-LRL

PLATE 8-6

(28) Plate 8-7 Pool Elevation Annual Duration Curve

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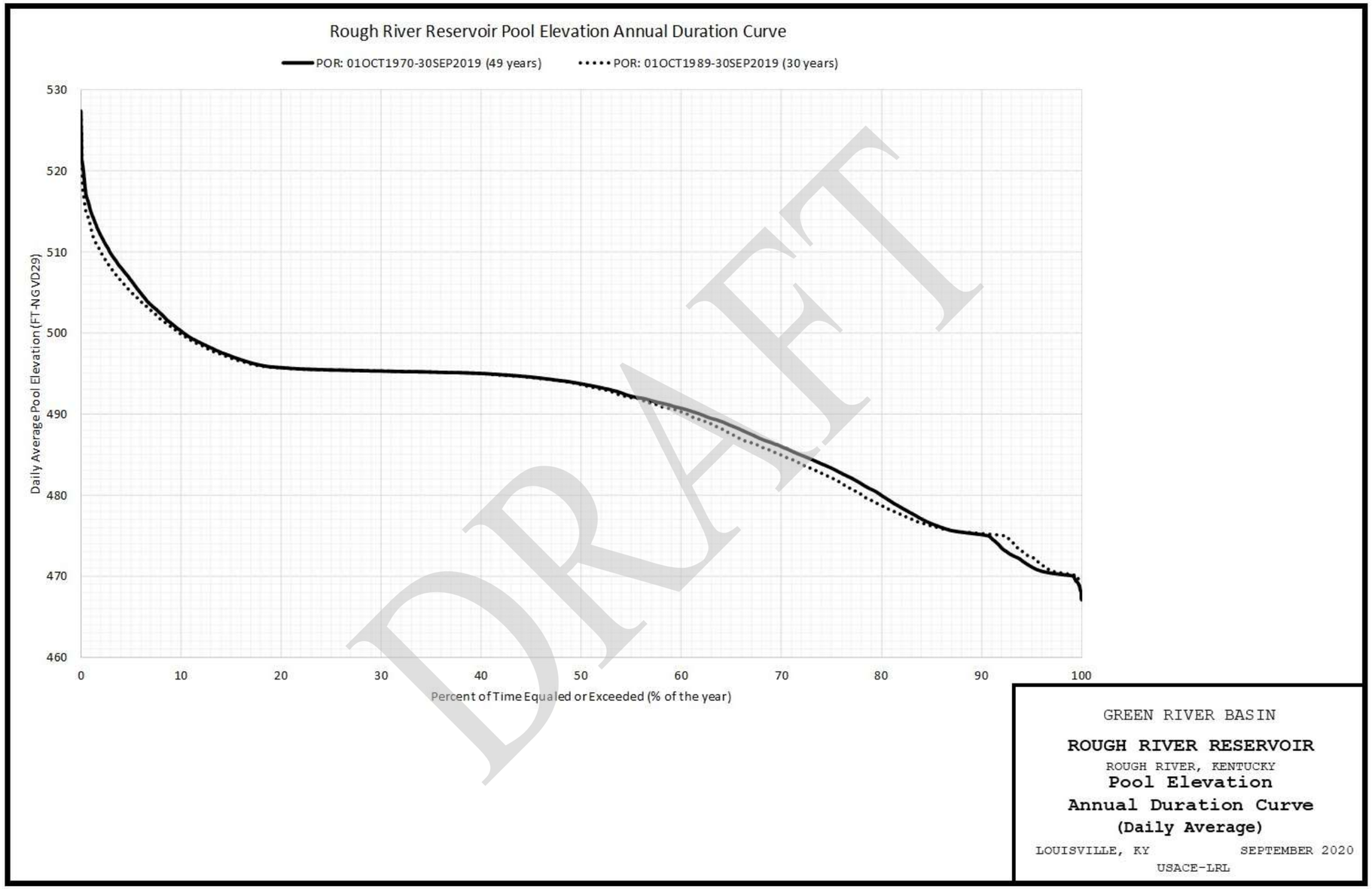


GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

Pool Elevation

Annual Duration Curve

(Daily Average)

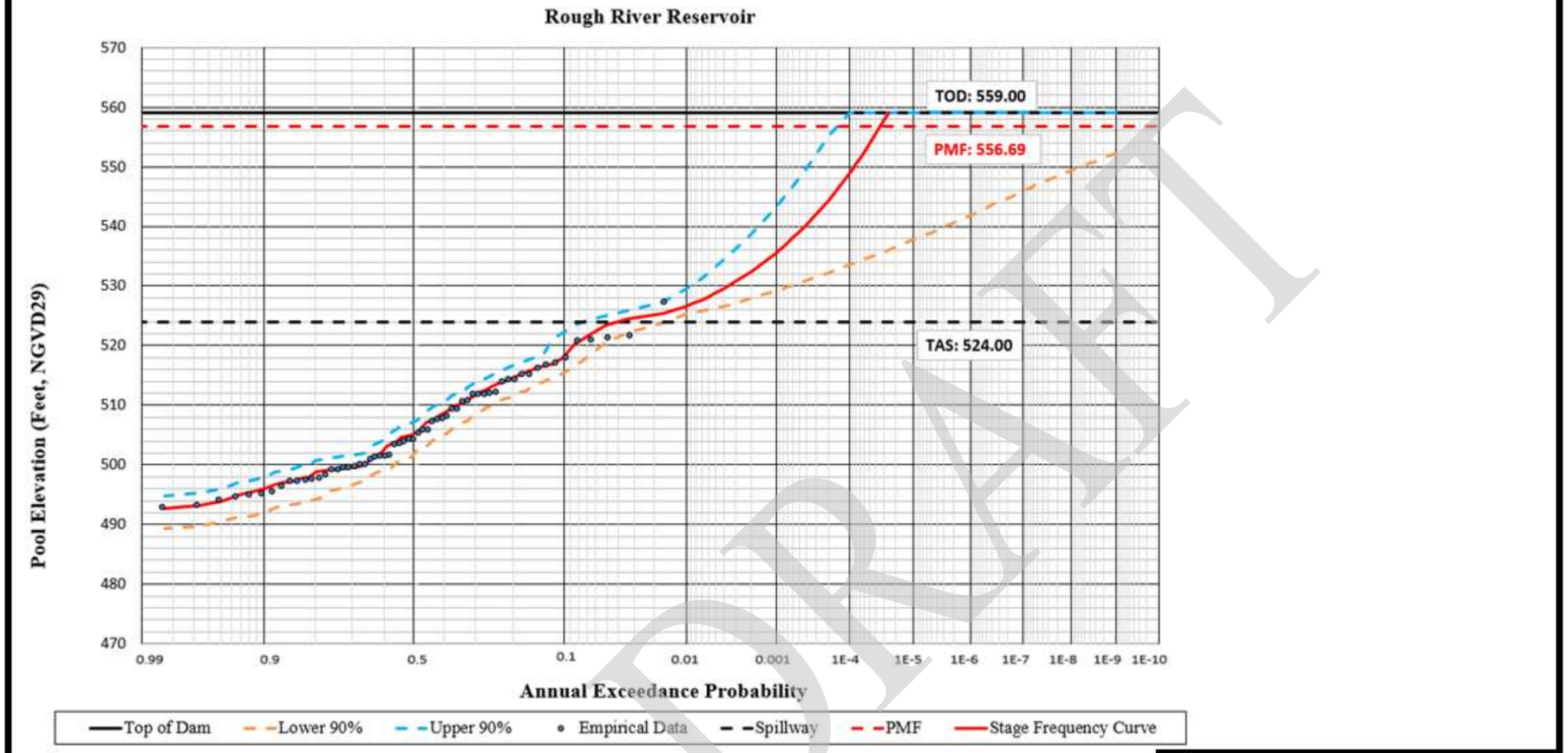
LOUISVILLE, KY SEPTEMBER 2020

USACE-LRL

PLATE 8-7

(29) Plate 8-8 Pool Elevation Frequency Curve

CORPS OF ENGINEERS U.S. ARMY



NOTES:
1) Results based on RMC-RFA modeling.
2) Top of dam elevation is 556 + a 3-foot parapet wall to elevation 559.
3) Probable maximum flood (PMF) elevation shown is based on 2019 IDF update.

GREEN RIVER BASIN

ROUGH RIVER RESERVOIR

ROUGH RIVER, KENTUCKY

Pool Elevation Frequency Curve

LOUISVILLE, KY MARCH 2021

USACE-LRL

PLATE 8-8