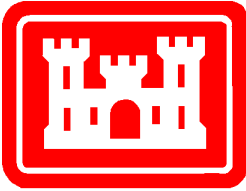


April 2020

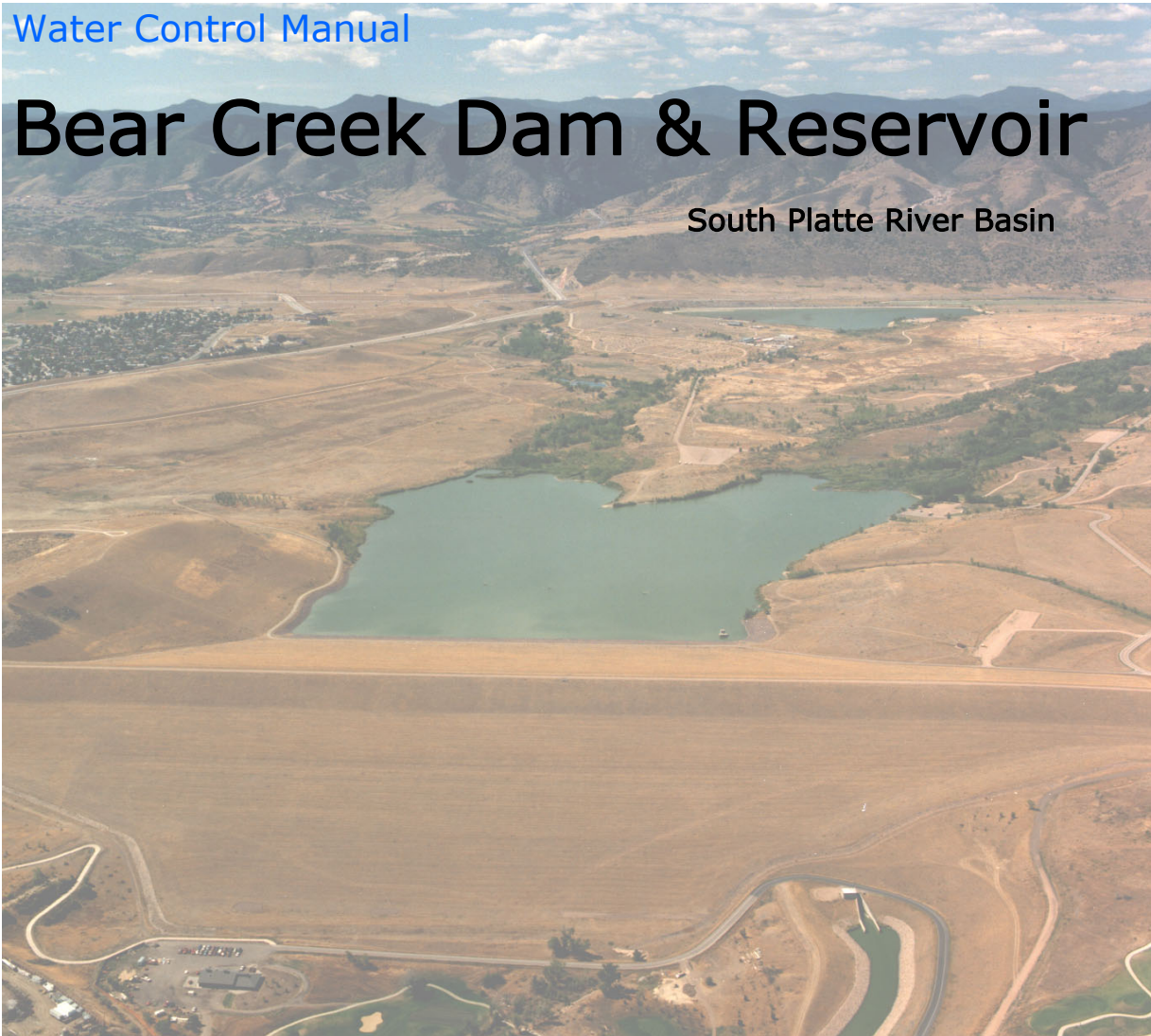


**US Army Corps
of Engineers®
Omaha District**

Water Control Manual

Bear Creek Dam & Reservoir

South Platte River Basin



REVISED APRIL 2020

WATER CONTROL MANUAL
BEAR CREEK DAM AND RESERVOIR
South Platte River Basin
Colorado

U.S. ARMY CORPS OF ENGINEERS
OMAHA DISTRICT
NORTHWESTERN DIVISION
OMAHA, NEBRASKA

April 2020

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DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, NORTHWESTERN DIVISION
1616 CAPITOL AVENUE, STE 365
OMAHA NE 68102

CENWD-PDR

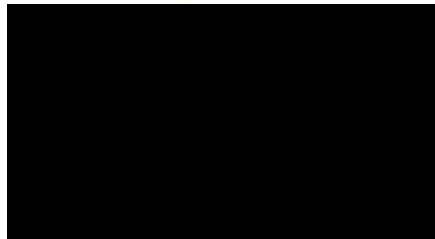
7 April 2020

MEMORANDUM FOR Commander, Omaha District (CENWO-ED-HA, Attn: Nelson)

SUBJECT: Request for Approval of Cherry Creek, Chatfield, and Bear Creek Water Control Manuals as Changed by the Implementation of the Chatfield Reservoir Joint-Use Flood Control-Conservation Zone

1. Reference memorandum dated 6 April 2020, CENWO-ED-HA, subject as above.
2. The subject water control manuals are approved.
3. As noted in your memo, the update of these manuals incorporates the extensive agency and public involvement in the approval of the Chatfield Reallocation FR/EIS.
4. We commend your staff for their professional and dedicated effort in updating these manuals. We realize that updating any water control manual is a considerable undertaking.
5. Please provide this office with final hardcopies of the manuals, electronic versions of the manuals to HQUSACE for Continuity of Operations (COOP) purposes, and redacted electronic versions for the national public-facing website.
6. If you have any questions concerning this reply, please contact me at [REDACTED]

FOR THE COMMANDER:



JOHN I. REMUS II, P.E.
Chief, Missouri River Basin Water
Management Division

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Bear Creek Dam and Reservoir



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NOTICE TO USERS OF THIS MANUAL

Regulations specify that this water control manual be published in a hard copy binder with 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.

RECORD OF MANUAL-HOLDERS

U.S. Army Corps of Engineers

Missouri River Basin Water Management Office	CENWD-PDR	Hard copy
Operations Division, Tri-Lakes Project Office	CENWO-OD-TL	Hard copy
Engineering Division, Dam Safety Section	CENWO-ED-GB	Hard copy
Engineering Division, Water Control Section (chief)	CENWO-ED-HA	Hard copy
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External Stakeholder

Colorado State Engineer's Office, Division Engineer		Electronic copy
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REGULATION ASSISTANCE PROCEDURES

In the event that unusual conditions arise during non-duty hours, communication can be achieved by contacting, in the order listed, one of the following personnel.

DIRECTORY OF REGULATION PERSONNEL BEAR CREEK DAM & RESERVOIR

Organization/Name	Office	FAX	Cell	Home/Personal	Email Address	Comments
<i>U.S. Army Corps of Engineers</i>						
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TABLE OF CONTENTS

<u>Paragraph</u>	<u>Title</u>	<u>Page</u>
SECTION 1. INTRODUCTION		
1-01.	Authorization.	1-1
1-02.	Purpose and Scope.	1-1
1-03.	Elevation Datum.	1-1
1-04.	Related Manuals and Reports.	1-1
1-05.	Project Owner.	1-3
1-06.	Operating Agency.	1-3
1-07.	Regulating Agencies.	1-3
SECTION 2. DESCRIPTION OF PROJECT		
2-01.	Location.	2-1
2-02.	Purpose.	2-1
2-03.	Physical Components.	2-1
	a. Embankment.	2-1
	b. Spillway.	2-1
	c. Outlet Works.	2-1
	d. Harriman Canal Outlet Structure.	2-3
2-04.	Related Control Facilities.	2-3
2-05.	Real Estate Acquisition.	2-4
2-06.	Public Facilities.	2-5
SECTION 3. HISTORY OF PROJECT		
3-01.	Authorization.	3-1
3-02.	Planning and Design.	3-1
3-03.	Construction.	3-1
3-04.	Related Projects.	3-2
3-05.	Modifications to Regulation.	3-3
3-06.	Principal Regulation Issues.	3-4
SECTION 4. WATERSHED CHARACTERISTICS		
4-01.	General Characteristics.	4-1
	a. Topography.	4-1
	b. Geology and Soils.	4-1
	c. Sediment.	4-2
4-02.	Climate.	4-2
	a. Temperature.	4-2
	b. Precipitation.	4-3
	c. Snow.	4-3
	d. Climate Variability.	4-5
	e. Wind.	4-5
	f. Evaporation.	4-6

Bear Creek Dam and Reservoir Water Control Manual
April 2020

<u>Paragraph</u>	<u>Title</u>	<u>Page</u>
4-03.	Storms and Floods.	4-7
	a. Flood of July 1896.	4-7
	b. Flood of July 1933.	4-7
	c. Flood of September 1938.	4-7
	d. Flood of April-May 1942.	4-7
	e. Flood of June 1965.	4-8
	f. Flood of May 1969.	4-9
	g. Flood of July 1983.	4-9
	h. Flood of April-July 1995.	4-9
	i. Flood of September 2013.	4-10
	j. Flood of May-June 2015.	4-11
4-04.	Runoff Characteristics.	4-11
4-05.	Water Quality.	4-12
4-06.	Channel and Floodway Characteristics.	4-13
4-07.	Upstream Structures.	4-14
4-08.	Downstream Structures.	4-14
4-09.	Economic Data.	4-15
	a. Population.	4-15
	b. Agriculture.	4-15
	c. Industry.	4-15
	d. Flood Damages.	4-16

SECTION 5. DATA COLLECTION AND COMMUNICATION NETWORKS

5-01.	Hydro-Meteorological Stations.	5-1
	a. Facilities.	5-1
	b. Reporting.	5-3
	c. Maintenance.	5-3
5-02.	Water Quality Stations.	5-4
5-03.	Sediment Stations.	5-4
5-04.	Recording Hydrologic Data.	5-4
5-05.	Communication Network.	5-4
	a. Telephone.	5-4
	b. Email.	5-5
	c. Hydrologic Data.	5-5
5-06.	Communication with Project.	5-5
5-07.	Regulating Office with Project Office and Others.	5-5
5-08.	Communication Between Project Office and Others.	5-6
5-09.	Project Reporting Instructions.	5-6
5-10.	Warnings.	5-6

SECTION 6. HYDROLOGIC FORECASTS

6-01.	General.	6-1
	a. Role of the Corps.	6-1
	b. Role of Other Agencies.	6-1

<u>Paragraph</u>	<u>Title</u>	<u>Page</u>
6-02.	Flood Condition Forecasts.	6-1
	a. Requirements.	6-1
	b. Methods.	6-3
6-03.	Conservation Purpose Forecasts.	6-6
6-04.	Long-Range Forecasts.	6-6
	a. National Weather Service.	6-6
	b. Natural Resources Conservation Service.	6-6
	c. U.S. Bureau of Reclamation.	6-6
	d. The Corps.	6-6
6-05.	Drought Forecasts.	6-6
 SECTION 7. WATER CONTROL PLAN		
7-01.	General Objectives.	7-1
7-02.	Constraints.	7-1
7-03.	Overall Plan for Water Control.	7-2
	a. Storage Allocations.	7-2
	b. State of Colorado Responsibilities.	7-3
	c. Corps' Responsibilities.	7-3
7-04.	Standing Instructions to Dam Tender.	7-5
7-05.	Flood Control.	7-5
	a. Operation of Bear Creek Reservoir as an Individual Project.	7-5
	b. System Operating Plan for Flood Storage Evacuation.	7-6
7-06.	Recreation.	7-12
7-07.	Water Quality.	7-12
7-08.	Fish and Wildlife.	7-12
	a. Constraints.	7-12
	b. Vegetation.	7-13
	c. Wildlife.	7-13
	d. Aquatic Life.	7-13
	e. Threatened and Endangered Species.	7-13
7-09.	Water Supply.	7-14
7-10.	Hydroelectric Power.	7-16
7-11.	Navigation.	7-16
7-12.	Drought Contingency Plan.	7-16
7-13.	Flood Emergency Action Plan.	7-16
7-14.	Deviation from Normal Regulation.	7-16
	a. Emergencies.	7-17
	b. Unplanned Minor Deviations.	7-17
	c. Planned Deviations.	7-17
7-15.	Rate of Release Change.	7-17

<u>Paragraph</u>	<u>Title</u>	<u>Page</u>
	SECTION 8. EFFECT OF WATER CONTROL PLAN	
8-01.	General.	8-1
8-02.	Flood Control.	8-1
	a. Standard Project Flood.	8-1
	b. Inflow Design Flood.	8-2
8-03.	Recreation.	8-4
8-04.	Water Quality.	8-4
8-05.	Fish and Wildlife.	8-5
8-06.	Water Supply.	8-5
8-07.	Hydroelectric Power.	8-5
8-08.	Navigation.	8-5
8-09.	Drought Contingency Plan.	8-5
8-10.	Flood Emergency Action Plan.	8-5
8-11.	Frequencies.	8-6
	a. Peak Inflow Frequency.	8-6
	b. Pool Elevation Duration and Probability.	8-6
	c. Key Control Points.	8-6
8-12.	Other Studies.	8-6
	a. Example of Emergency Regulation.	8-6
	b. Improvement of Regulation Techniques.	8-7
	c. Channel and Floodway Improvement.	8-8
	SECTION 9. WATER CONTROL MANAGEMENT	
9-01.	Responsibilities and Organization.	9-1
	a. Corps of Engineers.	9-1
	b. Other Federal Agencies.	9-2
	c. State of Colorado.	9-2
	d. City of Lakewood, CO.	9-2
9-02.	Interagency Coordination.	9-3
	a. Local Press and Corps Bulletins.	9-3
	b. National Weather Service.	9-3
	c. U.S. Geological Survey.	9-3
	d. Colorado Division of Water Resources.	9-3
	e. Natural Resources Conservation Service.	9-3
	f. Other Federal, State, or Local Agencies.	9-3
9-03.	Interagency Agreements.	9-3
9-04.	Commissions, River and Authorities, Compacts, and Committees.	9-3
9-05.	Non-Federal Hydropower.	9-3
9-06.	Reports.	9-3

<u>LIST OF TABLES</u>	<u>PAGE</u>
Table 1-1 CORPS OF ENGINEERS REPORTS - BEAR CREEK DAM AND RESERVOIR	1-2
Table 2-1 BEAR CREEK OFFSTREAM RESERVOIRS	2-3
Table 3-1 LIST OF PROJECT CONTRACTS	3-2
Table 3-2 PERTINENT EXISTING RESERVOIRS IN SOUTH PLATTE RIVER BASIN	3-3
Table 4-1 BEAR CREEK RESERVOIR STORAGE DEPLETION	4-2
Table 4-2 BEAR CREEK RESERVOIR AREA – RECORD OF TEMPERATURES (°F)	4-3
Table 4-3 BEAR CREEK RESERVOIR AREA – RECORD OF PRECIPITATION (in)	4-4
Table 4-4 BEAR CREEK RESERVOIR AREA – RECORD OF SNOWFALL (in)	4-4
Table 4-5 BEAR CREEK RESERVOIR AREA – RECORD OF SWE (in)	4-5
Table 4-6 ESTIMATED AVERAGE PAN EVAPORATION	4-6
Table 4-7 JUNE 1965 FLOOD – SOUTH PLATTE RIVER PEAK FLOWS	4-9
Table 4-8 SOUTH PLATTE RIVER BASIN INFILTRATION STUDIES	4-12
Table 4-9 BEAR CREEK DAM RELEASE TRAVEL TIMES	4-14
Table 4-10 POPULATION 1950 THROUGH 2010 CENSUS	4-15
Table 4-11 2013 EARNINGS BY WORKERS IN MAJOR INDUSTRIAL CLASSIFICATIONS	4-16
Table 4-12 POTENTIAL FLOOD DAMAGES UPPER SOUTH PLATTE RIVER BASIN	4-17
Table 4-13 FLOOD DAMAGES PREVENTED BY TRI-LAKES PROJECTS	4-18
Table 5-1 STREAM AND RESERVOIR GAGING STATIONS	5-1
Table 6-1 3-HOUR UNIT HYDROGRAPH ORDINATES (cfs)	6-5
Table 6-2 SOUTH PLATTE RIVER TRIBUTARY LAG AVERAGES	6-6
Table 7-1 RESERVOIR STORAGE ALLOCATION ZONES	7-2
Table 7-2 BEAR CREEK DAM RELEASE SCHEDULE	7-6
Table 7-3 FLOOD REGULATION STORAGE LEVELS	7-7
Table 7-4 DESIRED MAXIMUM FLOW TARGET AT SOUTH PLATTE RIVER AT DENVER STREAMGAGE	7-8
Table 7-5 PERCENTAGE OF STORAGE AND EVACUATION RATE REQUIRED TO CONTINUE A PARALLEL RESERVOIR BALANCE	7-9
Table 7-6 BEAR CREEK AVERAGE MONTHLY WATER DEPLETION	7-15
Table 7-7 BEAR CREEK BASIN DITCHES	7-16
Table 8-1 BEAR CREEK PROJECT DESIGN FLOOD SUMMARY	8-1
Table 8-2 SPILLWAY DESIGN FLOOD ROUTINGS	8-3
Table 9-1 BEAR CREEK PROJECT REPORT REQUIREMENTS	9-4

LIST OF PLATES

Plate 2-1a	South Platte River Basin Map	P2-1a
Plate 2-1b	Bear Creek Basin Map	P2-1b
Plate 2-2	Bear Creek Dam Plan and Sections	P2-2
Plate 2-3	Spillway Discharge Rating Curve	P2-3
Plate 2-4	Spillway Discharge Rating Table	P2-4
Plate 2-5	Outlet Works – Plan and Profile, Sheet 1	P2-5
Plate 2-6	Outlet Works – Plan and Profile, Sheet 2	P2-6
Plate 2-7	Outlet Works – Intake Structure	P2-7
Plate 2-8	Outlet Works – Gate Structure	P2-8
Plate 2-9	Outlet Works – Stilling Basin	P2-9
Plate 2-10a	Discharge Rating Curves - Outlet Works (Gate within a Gate)	P2-10a
Plate 2-10b	Discharge Rating Table – Outlet Works (Gate within a Gate)	P2-10b
Plate 2-11a	Discharge Rating Curves – Outlet Works (One Service Gate)	P2-11a
Plate 2-11b	Discharge Rating Table – Outlet Works (One Service Gate)	P2-11b
Plate 2-12a	Discharge Rating Curves – Outlet Works (Two Service Gates)	P2-12a
Plate 2-12b	Discharge Rating Table – Outlet Works (Two Service Gates)	P2-12b
Plate 2-13a	Discharge Rating Curves – Low-Level Butterfly Valve	P2-13a
Plate 2-13b	Discharge Rating Table – Low-Level Butterfly Valve	P2-13b
Plate 2-14a	Discharge Rating Curves – Mid-Level Butterfly Valve	P2-14a
Plate 2-14b	Discharge Rating Table – Mid-Level Butterfly Valve	P2-14b
Plate 2-15	Schematic Flow Diagram – Denver Water Dept Raw Water System	P2-15
Plate 2-16	Vicinity Canal Diversions	P2-16
Plate 2-17	Bear Creek Basin Ditch Map	P2-17
Plate 2-18	Bear Creek Project Boundary Map	P2-18
Plate 2-19	Bear Creek Reservoir Development	P2-19
Plate 2-20	Bear Creek Lake Park	P2-20
Plate 3-1	South Platte River System Diagram	P3-1
Plate 3-2	Chatfield Reallocation – Example System Flood Control Storage Evacuation	P3-2
Plate 4-1	Reservoir Surface Area Curve 2009 Survey	P4-1
Plate 4-2	Reservoir Storage Capacity Curve 2009 Survey	P4-2
Plate 4-3	Sediment Range Location	P4-3
Plate 4-4	Stream Profiles – Bear Creek and Turkey Creek	P4-4
Plate 4-5	Historic Hydrograph Bear Creek at Morrison, CO (1950-1959)	P4-5
Plate 4-6	Historic Hydrograph Bear Creek at Morrison, CO (1960-1969)	P4-6
Plate 4-7	Historic Hydrograph Bear Creek at Morrison, CO (1970-1979)	P4-7
Plate 4-8	Historic Hydrograph Bear Creek at Morrison, CO (1980-1989)	P4-8
Plate 4-9	Historic Hydrograph Bear Creek at Morrison, CO (1990-1999)	P4-9
Plate 4-10	Historic Hydrograph Bear Creek at Morrison, CO (2000-2016)	P4-10
Plate 4-11a	Inflow Frequency Curve – Bear Creek Dam (1978-2016)	P4-11a

LIST OF PLATES (CONTINUED)

Plate 4-11b Discharge Frequency Curve – Bear Creek Dam (1978-2016)	P4-11b
Plate 4-12 Historic Monthly Inflow Volume Graph	P4-12
Plate 4-13 Historic Monthly Inflow Volume Table	P4-13
Plate 4-14 Historic Annual Inflow Volume	P4-14
Plate 4-15 Low Flow Discharge Rating Curve – Bear Creek at Morrison, CO	P4-15
Plate 4-16 Low Flow Discharge Rating Curve – Bear Creek above Bear Creek Dam near Morrison, CO	P4-16
Plate 4-17 Low Flow Discharge Rating Curve – Bear Creek below Bear Creek Dam	P4-17
Plate 4-18 Low Flow Discharge Rating Curve – Bear Creek at Sheridan	P4-18
Plate 4-19 Low Flow Discharge Rating Curve – South Platte River at Denver	P4-19
Plate 4-20 Low Flow Discharge Rating Curve – South Platte River at Henderson	P4-20
Plate 4-21 Comparative Travel Times in Hours (Normal Flow)	P4-21
Plate 4-22 Comparative Travel Times in Hours (High Flow)	P4-22
Plate 4-23 Stage Damage Impacts Areas	P4-23
Plate 4-24a Stage Damage Curve - Impact Area 1	P4-24a
Plate 4-24b Impact Area 1 – Bear Creek Inundation Map, upstream of Wadsworth Blvd	P4-24b
Plate 4-24c Impact Area 1 – Bear Creek Inundation Map, downstream of Wadsworth Blvd	P4-24c
Plate 4-25a Stage Damage Curve - Impact Area 2	P4-25a
Plate 4-25b Impact Area 2 – South Platte R Inundation Map, upstream of Coal Mine Ave	P4-25b
Plate 4-25c Impact Area 2 – South Platte R Inundation Map, downstream of Coal Mine Ave	P4-25c
Plate 4-26a Stage Damage Curve - Impact Area 3	P4-26a
Plate 4-26b Impact Area 3 – South Platte R Inundation Map, upstream of Alameda Ave	P4-26b
Plate 4-26c Impact Area 3 – South Platte R Inundation Map, downstream of Alameda Ave	P4-26c
Plate 4-27a Stage Damage Curve - Impact Area 4	P4-27a
Plate 4-27b Impact Area 4 – Cherry Creek Inundation Map, upstream of Cherry Street	P4-27b
Plate 4-27c Impact Area 4 – Cherry Creek Inundation Map, downstream of Cherry Street	P4-27c
Plate 4-28a Stage Damage Curve - Impact Area 5	P4-28a
Plate 4-28b Impact Area 5 – South Platte R Inundation Map, Cherry Creek to Sand Creek	P4-28b
Plate 4-29a Stage Damage Curve -Impact Area 7	P4-29a
Plate 4-29b Impact Area 7 – South Platte R Inundation Map, upstream of 96 th Ave	P4-29b
Plate 4-29c Impact Area 7 – South Platte R Inundation Map, downstream of 96 th Ave	P4-29c
Plate 4-30a Stage Damage Curve - Impact Area 8	P4-30a
Plate 4-30b Impact Area 8 – Sand Creek Inundation Map, upstream of Alameda Pkwy	P4-30b
Plate 4-30c Impact Area 8 – Sand Creek Inundation Map, Alameda Pkwy to Peoria St	P4-30c
Plate 4-30d Impact Area 8 – Sand Creek Inundation Map, Peoria St to Quebec St	P4-30d
Plate 4-30e Impact Area 8 – Sand Creek Inundation Map, Quebec St to South Platte R	P4-30e
Plate 5-1 Tri-Lakes Snotel, River and Precipitation Stations	P5-1
Plate 5-2 Bear Creek Denver Alert & NOAA Precipitation Stations	P5-2
Plate 5-3 Data System Collection Diagram	P5-3

LIST OF PLATES (CONTINUED)

Plate 5-4	Monthly Summary Report	P5-4
Plate 5-5	Reservoir Regulation Coordination Chart	P5-5
Plate 5-6	Dam Tender's Reservoir Regulation Report	P5-6
Plate 6-1	3-Hour Unit Hydrograph Cherry Creek below Cherry Creek Dam	P6-1
Plate 6-2	3-Hour Unit Hydrograph Bear Creek at Sheridan	P6-2
Plate 6-3	3-Hour Unit Hydrograph Clear Creek at Derby	P6-3
Plate 6-4	3-Hour Unit Hydrograph South Platte River, Incremental above Denver	P6-4
Plate 6-5a	3-Hour Unit Hydrograph Upstream of the Tri-Lakes	P6-5a
Plate 6-5b	3-Hour Unit Hydrograph Upstream of the Tri-Lakes – Subbasins	P6-5b
Plate 7-1	Bear Creek Reservoir Storage Allocations	P7-1
Plate 7-2	Rule Curve for Flood Control Operation	P7-2
Plate 7-3	Parallel Reservoir Balance (without Chatfield Reallocation)	P7-3
Plate 7-4	System Flood Control Storage - Evacuation Example	P7-4
Plate 8-1	1-Hour Unit Hydrograph Bear Creek at Sheridan	P8-1
Plate 8-2	1-Hour Unit Hydrograph Bear Creek at Morrison	P8-2
Plate 8-3	Reservoir Operation for Selected Floods	P8-3
Plate 8-4a	Probable Maximum Flood Routing (original)	P8-4a
Plate 8-4b	Probable Maximum Flood Routing (updated)	P8-4b
Plate 8-5	Pool Probability Curve (1978-2016)	P8-5
Plate 8-6	Volume Duration Probability (1978-2016)	P8-6
Plate 8-7	Flow Frequency Curve – South Platte River at Denver (1978-2016)	P8-7
Plate 8-8	Flow Duration Curve – South Platte River at Denver (1978-2016)	P8-8
Plate 8-9	Actual System Regulation (1980)	P8-10
Plate 8-10	Actual System Regulation (1983)	P8-11
Plate 8-11	Actual System Regulation (1995)	P8-12
Plate 8-12	Actual System Regulation (2013)	P8-13
Plate 8-13	Actual System Regulation (2015)	P8-14
Plate 9-1	Omaha District Organization Chart	P9-1

LIST OF EXHIBITS

Exhibit I	Standing Instructions to the Dam Tender
Exhibit II	Letter, State Division of Game, Fish and Parks
	Agreement between the State of Colorado and the U.S. Army Corps of Engineers, Omaha, District
	Memorandum of Understanding between the United States of America and the State of Colorado on Regulation for Bear Creek Dam and Reservoir
Exhibit III	Area and Capacity Tables

BEAR CREEK DAM AND RESERVOIR PERTINENT DATA

GENERAL			
Location of Dam	8 stream miles upstream from Bear Creek’s confluence with South Platte River in Denver, CO		
County	Jefferson		
River and River Mile	Bear Creek, river mile 8		
Gross drainage area (sq mi)	236		
DAM			
Type	Rolled Earthfill		
Crest elevation (ft PD [Project Datum])	5689.5		
Height above streambed (ft)	Main Embankment	South Embankment	
Length (ft)	179.5	65	
Date of closure	5300	2100	
		July 1977	
SPILLWAY			
Type	Ungated Earth Channel		
Discharge capacity (cfs) at el. 5684.5 ft PD	153,500		
Crest width (ft)	800		
Crest elevation (ft PD)	5667.0		
OUTLET WORKS			
Gated Outlets	2 - 3x6 ft - Hydraulic slide		
	2 - 36 in K-Flo butterfly valve		
Conduit length (ft)	1690		
Discharge capacity (cfs) at el. 5667.0 ft PD	2169		
Ungated Drop Inlet	Elevation 5558.0 ft PD		
RESERVOIR STORAGE ALLOCATION ZONES		Elevation Limits (ft PD)	Capacity (af)
			2009 Survey
Surcharge	5635.5–5684.5	46,955	
Exclusive Flood Control	5558.0-5635.5	28,514	
Multipurpose	5528.0-5558.0	1,771	
Inactive	5510.0-5528.0	53	
RESERVOIR STORAGE ALLOCATION ZONES		Elevation (ft PD)	Gross Area (acres)
		2009 Survey	Gross Storage (af)
			2009 Survey
Top of Surcharge (Max Pool)	5684.5	1219	77,293
Top of Exclusive Flood Control	5635.5	711	30,338
Top of Multipurpose	5558.0	107	1,824
Top of Inactive	5528.0	16	53
Streambed Elevation	5510.0	0	0

ACRONYMS AND ABBREVIATIONS

Term	Definition
af	acre-feet
°C	Degrees Celsius
BCWA	Bear Creek Watershed Association
CAVI	Control and Visualization Interface (CWMS)
CC-ATI	Cold Content Antecedent Temperature Index
CCP	Corps Computation Processor
CDW	Colorado Division of Wildlife
CDWR	Colorado Division of Water Resources
CEQ	Council of Environmental Quality (Corps)
CFS/cfs	Cubic Feet Per Second
COA	City of Aurora
Corps	Corps of Engineers
CWCB	Colorado Water Conservation Board
CWMS	Corps Water Management System
DA	Data Acquisition (CWMS)
DB	Database (CWMS)
DCP	Data Collection Platform
DD	Data Dissemination (CWMS)
DM	Design Memorandum
DRCOG	Denver Regional Council Of Governments
DWB	Denver Water Board
EAP	Emergency Action Plan
EM	Engineer Manual
ENSO	El Niño/Southern Oscillation
EOC	Emergency Operations Center
EPA	Environmental Protection Agency
ER	Engineer Regulation (Corps)
ERDC-CRREL	Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory (Corps)
°F	Degrees Fahrenheit
FIA	Flood Impact Analysis (CWMS)
FR/EIS	Feasibility Report and Environmental Impact Statement
ft	Feet
FY	Fiscal Year
GOES	Geostationary Operational Environmental Satellite
H	Horizontal
HEC	Hydrologic Engineering Center (Corps)
HMR	Hydro-Meteorological Report
HMS	Hydrologic Modeling System (CWMS)
HQUSACE	Headquarters, United States Army Corps of Engineers
IDF	Inflow Design Flood
in	inch
MAX	Maximum
METAR	METeorological Aerodrome Report
MHFD	Mile High Flood District
MIN	Minimum
mph	Miles Per Hour

Term	Definition
MRBWM	Missouri River Basin Water Management
N/A	Not Applicable
NAVD88	North American Vertical Datum of 1988
NESDIS	National Environmental Satellite, Data, and Information Service
NGVD29	National Geodetic Vertical Datum of 1929
No.	Number
NOAA	National Oceanic and Atmospheric Administration
NOHRSC	National Operational Hydrologic Remote Sensing Center
NRCS	Natural Resources Conservation Service
NWD	Northwestern Division (Corps)
NWDR	Northwestern Division Regulation
NWS	National Weather Service
O&M	Operation and Maintenance
PC	Purchase Contract
PD	Project Datum
pg	Page
PMF	Probable Maximum Flood
PMSA	Primary Metropolitan Statistical Area
RAS	River Analysis System (CWMS)
RDF	Reservoir Design Flood
ResSim	Reservoir System Simulation (CWMS)
SNOTEL	Snow Telemetry
SPF	Standard Project Flood
SPRF	Standard Project Rainfall Flood
sq mi	square mile
SWE	Snow Water Equivalent
UDFCD	Urban Drainage and Flood Control District
USBR	U.S. Bureau of Reclamation
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
V	Vertical
WCP	Water Control Plan
WCWQS	Water Control and Water Quality Section
WFO	Weather Forecast Office
WRDA	Water Resources Development Act

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SECTION 1

INTRODUCTION

1-01. Authorization. This manual has been prepared in compliance with instructions contained in Engineer Regulation (ER) 1110-2-240, *Water Control Management*, May 30, 2016.

1-02. Purpose and Scope. The purpose of this manual is to outline the pertinent information and plan of operation for Bear Creek Dam and Reservoir as set forth in the authorizing legislation. This manual presents detailed information pertinent to the regulation of Bear Creek Dam and Reservoir, including regulation procedures and schedules. Other publications contain the instructions to reservoir operating personnel for the physical operation and maintenance of Bear Creek Dam and Reservoir. This report follows the guidance presented in Engineer Manual (EM) 1110-2-3600 *Management of Water Control Systems*, October 10, 2017 and ER 1110-2-8156 *Preparation of Water Control Manuals*, August 31, 1995.

1-03. Elevation Datum. In the original design and construction of Bear Creek Dam, elevations on design drawings and reservoir levels referenced the Sea Level Datum of 1929. This was based on measured water levels at 26 tide stations in the United States and Canada, commonly referred to as “feet above mean sea level”. In 1973, the Sea Level Datum of 1929 was renamed the “National Geodetic Vertical Datum of 1929” (NGVD29). The NGVD29 was subsequently replaced by the North American Vertical Datum of 1988 (NAVD88) as the current vertical reference datum used by the National Oceanic and Atmospheric Administration (NOAA). NAVD88 is based on a single point as the reference point from which all other elevations are measured. The NAVD88 is more accurate than the NGVD29 datum, and takes into account variations in the earth’s surface due to subsidence and rebounding, and distortions caused by gravity. As such, the conversion from NGVD29 to NAVD88 varies depending on location. As specified in ER 1110-2-8160, long-term efforts shall be programmed to transition from older datums to NAVD88.

In this water control manual, elevations for reservoir levels and project drawings are based on the Project Datum (PD), which for Bear Creek Dam and Reservoir is close to NGVD29 and approximately 3.0 feet (ft) lower than NAVD88. The PD has not been converted to NAVD88 in an effort to provide elevation data that is consistent with historical events and the original design drawings for the project.

1-04. Related Manuals and Reports. Table 1-1 lists related manuals and reports for Bear Creek Dam and Reservoir.

Table 1-1
CORPS OF ENGINEERS REPORTS - BEAR CREEK DAM AND RESERVOIR

No.	Title	Date Submitted	Date Approved
PB-1	Hydrology	Jun 70	Sep 70
	Justification of Recreation	Nov 70	None Required
PB-2	Preliminary Development and Site Selection	Nov 70	Mar 71
	Request for Waiver of Cost-Sharing Agreement	Dec 70	
PB-3	Structural-Nonstructural Considerations (Special Report to Secretary of the Army requested in letter dated June 25, 1968) (Revised)	Jun 71	Sep 71
—	Final Environmental Statement	Nov 71	Feb 72 (Filed with CEQ)
PB-4	Land Requirements Plan - Public Use (Revised)	Oct 72	Nov 72
PB-5	Real Estate	Feb 71	Jul 71
—	Special Report (OCE Request in PB-3)	May 72	Aug 72
PB-6	General Design Memorandum	Nov 72	May 73
PB-7	Embankment and Spillway (Revised)	Aug 74	Feb 75
PB-8	Relocation and Alteration of Roads Colorado State Highways No. 8 and No. 70	Oct 73	Aug 74
PB-9	Outlet Works	Nov 73	Jan 74
PB-10	Master Plan (Revised)	Feb 80	Mar 90
PB-10	Appendix B, Natural Resource Management Plan	May 77	Jun 78
PB-10	Appendix F, Interpretive Prospectus	Apr 75	May 75
PB-11	Relocation – Utilities Supplement No. 1	Mar 74 May 75	Apr 74 Jun 75
PB-12	Jefferson County Road System	May 74	Aug 74
PB-13	Water Rights, Water Supply Canals and Ditches (Revised) Supplement No. 1, Attorney's Report	Aug 74 Dec 74	Jan 75 May 75
—	Instrumentation and Inspection Program	Dec 75	—
PB-14	Vegetation Management Plan	Mar 77	Apr 77
PB-15	Proposed Sedimentation Investigation Supplement to the Final Environmental Statement	Jun 77 Dec 77	Jul 77 Jan 78 (Filed with CEQ)
PB-16	Access and Service Roads	Sep 79	Oct 79
—	Embankment Criteria and Performance Report	Jun 80	Aug 81
PB-17	Faulty Low Flow Intake Gate	Jan 81 Resubmitted Mar 81	Ret Feb 81
PB-18	Spillway Erosion Control	Jul 83	Aug 83
PB-19	Ticen House Relocation and Rehabilitation	Jul 85	Aug 85
—	Final Environmental Assessment, Fox Hollow at Lakewood Golf Course	Aug 91	
—	Finding of No Significant Impact, Fox Hollow at Lakewood Golf Course	Aug 91	

1-05. Project Owner. The project owner is the U.S. Army Corps of Engineers (referred to hereafter as the “Corps”), Omaha District.

1-06. Operating Agency. The operating agency is the Corps’ Omaha District, Operations Division, Tri-Lakes Project Office. The gates are operated manually by the Dam Tender. The Dam Tender, who is located at the Chatfield Project full-time, is also responsible for following regulation orders for Cherry Creek Dam and Chatfield Dam. The current personnel assigned to make gate changes at Bear Creek Dam are listed in the “Notice to Users of this Manual” Section of this manual in the Directory of Regulation Personnel – Tri-Lakes Project Office (pg iv-v).

1-07. Regulating Agencies. The Corps’ Omaha District is the regulating agency for the Bear Creek Project. During periods of flood control operation, Bear Creek Reservoir will become part of a parallel reservoir system with Chatfield and Cherry Creek Reservoirs. During these periods, regulation of the three reservoirs, also known as the Tri-Lakes Projects, will be coordinated as presented in Section 7 of this manual. During non-flood periods, below elevation 5559.0 ft PD, the State of Colorado, represented by the Colorado State Engineer of the Colorado Division of Water Resources (CDWR), tracks water rights on Bear Creek and the South Platte River and makes requests for releases to the Omaha District’s Water Control and Water Quality Section (WCWQS). These orders are then sent to the Tri-Lakes Project Office as described in Section 7 of this manual.

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SECTION 2

DESCRIPTION OF PROJECT

2-01. Location. Bear Creek Dam and Reservoir is located in Jefferson County, CO on Bear Creek about 8 miles upstream from its confluence with the South Platte River in Denver, CO. Bear Creek is a left bank tributary of the South Platte River that runs through Lakewood, CO and empties into the South Platte River near Sheridan, CO, a suburb of Denver, located in the southwestern portion of the Denver metropolitan area. The dam is located 2½ miles east of Morrison, CO (see Plates 2-1a and 2-1b). The basin drains a total of 262 square miles (sq mi). Plate 2-2 shows a project map.

2-02. Purpose. Bear Creek Dam was constructed by the Corps for the primary purpose of mitigating flood risk to the downstream metropolitan Denver area from floods originating above the dam. Additional authorized purposes include water supply, recreation, and fish and wildlife enhancement. The percentages of benefits assigned to the authorized purposes during the original design were 92.2% for flood control and 7.8% for recreation and fish and wildlife enhancement.

2-03. Physical Components.

a. Embankment. Bear Creek Dam has two separate rolled earth-filled embankments. The main embankment is 179.5 ft above the streambed, at a crest elevation of 5689.5 ft PD, and has a crest length of 5300 ft. The crest width of 30 ft is gravel, surfaced to accommodate a service road. A supplemental earth-filled dike, which is located south of the main embankment and is approximately 65 ft high, has a crest elevation of 5689.5 ft PD and a crest length of 2,100 ft (see *Bear Creek Reservoir O&M Manual*, Appendix B, Plates 3-7).

a. Freeboard. The elevation of the top of Bear Creek Dam was established by applying 5 ft of freeboard above the maximum pool elevation (5684.5 ft PD) reached during routing of the Probable Maximum Flood (PMF) through the reservoir with an 800-ft wide spillway. The re-evaluated Inflow Design Flood (IDF) has increased since the original design and subsequent construction of Bear Creek Dam resulting in 0.9 ft of available freeboard. See Section 8-02.b. for details.

b. Spillway. An ungated earth channel spillway is located north of the main embankment. The spillway is 800-ft wide, 3400-ft long, and has a crest elevation of 5667.0 ft PD. Its side slopes are 1 vertical (V) to 3 horizontal (H). The spillway channel bottom has a 200-ft long flat crest. Upstream of the crest, the channel has a bed slope of +0.001 ft/ft; downstream of the crest, the slope is -0.004 ft/ft. The discharge capacity of the spillway is 153,500 cubic feet per second (cfs) at the maximum pool level of 5685.8 ft PD. Plates 2-3 and 2-4 show the rating curve and table for the spillway, respectively. (Also see *Bear Creek Reservoir O&M Manual*, Appendix B, Plates 11-14).

c. Outlet Works. The outlet works consists of a two-way drop intake structure located at the upstream end of the outlet works conduit. The weir crest of the drop inlet

is at elevation 5558.0 ft PD. The intake structure is followed by a single circular conduit 7.0 ft in diameter and 576.5 ft long under the upstream portion of the embankment. A dome-type gated control structure buried under the embankment has two 3x6-ft hydraulically operated slide service gates in each gate passage from which the water is admitted into one of two oblong conduits that terminate at the exit portal. The downstream oblong conduit is 7.0 ft wide, 10.5 ft high, 1,037 ft long and sloped so that water will flow under open channel conditions versus pressure flow. The other conduit serves as an access gallery to the gate structure. At one stage in its design, it was also planned to use this conduit for installation of an irrigation penstock to the Warrior Canal. However, it was ultimately decided to route the Warrior Canal water into the upstream Harriman Ditch around the dam rather than through it. The outlet works includes a conventional hydraulic jump-type stilling basin with chute blocks and one row of baffles. A discharge channel returns the outlet works discharge water back into the Bear Creek channel. Approximately 650 ft downstream of the stilling basin, a 9.5-ft high drop structure diverts water into the Pioneer Union Ditch. Plates 2-5 through 2-9 show the plan and profiles of the outlet structures, intake structure, gates, and stilling basin, respectively.

Normal and flood control releases are controlled and regulated by the two 3x6-ft service gates. The outlet works has a discharge capacity of 2,390 cfs at elevation 5667.0 ft PD, the emergency spillway crest elevation. A gate-within-a-gate system exists on each of the two service gates for fine regulation of low flow releases (less than 70 cfs). Two 3x6-ft emergency gates are located 6 ft upstream of the two 3x6-ft service gates. Two low-level 36-in diameter K-Flo butterfly valves are provided in the intake structure for release of water from the multipurpose zone. Their invert elevations are at 5528.0 ft PD (low-level valve) and 5538.0 ft PD (mid-level valve). The lower outlet extends into the reservoir for drawdown and low flow releases. The butterfly valves, which were installed in late 1999, replaced the originally installed knife gates. Due to severe corrosion of the seating surface on the valve body, the butterfly valves were replaced in 2015. Refer to Plates 2-10a and 2-10b for the low flow gate-within-a-gate rating curve and table, respectively. Refer to Plates 2-11a and 2-12a for rating curves and Plates 2-11b and 2-12b for rating tables of the two service gates. Plate 2-13a and 2-13b show the rating curve and table for the 3-ft diameter low-level butterfly valve, respectively. Plate 2-14a and 2-14b show the rating curve and table for the 3-ft diameter mid-level butterfly valve, respectively.

The drop intake structure was designed to have stop logs placed on the weir crests to allow servicing of portions of the outlet works. However, the stops logs were never manufactured. An emergency bulkhead is provided for the mid-level intake.

An adit building is located at the exit portal of the outlet works. This building provides the only direct entrance to the domed gate control structure. The service gates can be operated from this building as can the domed gate control structure. This building also houses remote gage readings of the reservoir and tailwater levels and a standby generator to provide emergency power to operate the outlet works service and emergency gates. See *Bear Creek Reservoir O&M Manual* for details.

d. Harriman Canal Outlet Structure. An outlet gated structure is located on the Harriman Canal in the south embankment. As part of the project, the Harriman Canal was relocated through the south embankment. The invert elevation of the canal as it enters the south embankment is 5548.0 ft PD, which is 12.5 ft above the top of the flood control zone and 19 ft below the spillway crest. A gated control structure located in the south embankment keeps floodwater stored in the reservoir from flowing into the Harriman Canal below the project. The gated control structure contains a 7-ft x 7-ft sluice gate. The conduit entering and leaving this structure is a 7-ft diameter reinforced concrete pipe. Regulation of this gate during flood storage periods is coordinated between the Corps and the Harriman Ditch Company.

2-04. Related Control Facilities. A number of reservoirs and/or ponds have been constructed in the Bear Creek basin by city and private interests for irrigation, water supply and recreation purposes. Most of these reservoirs are offstream of Bear Creek. They, and the numerous natural lakes in the basin, affect Bear Creek streamflow. However, because of the limited diversion capabilities to the offstream reservoirs and short peaking time of floods, they offer little reduction to the higher peak Bear Creek flows. Table 2-1 lists some of the reservoirs.

**Table 2-1
BEAR CREEK OFFSTREAM RESERVOIRS**

Reservoir	Stream	Capacity (af)
Evergreen	Bear Creek	670
Little Soda Lakes	Offstream	220
Big Soda Lakes	Offstream	1500
Marsten	Offstream	19,800

From Morrison to Sheridan, the primary diversions are the Harriman, Ward, Warrior and Pioneer Union Ditches. Other diversions are the Lewis & Strouse, Hodgson, Simonton, and McBroom Ditches. These ditches have been used to divert water supply around Bear Creek Dam during inspection and repair operations. The diversion for the Warrior Ditch was moved upstream of its original location during construction of the Bear Creek Project and combined with the Harriman Ditch. The Lewis & Strouse Ditch was moved upstream and is diverted at the Morrison intake and the Ward Ditch. The combined canal capacity of the diversion ditches is 150 cfs, however actual diversions on average are less than 50 cfs.

The Harriman Ditch Company owns the Harriman Canal. The Denver Water Board (DWB) is the major shareholder. These two hold at least 50% of the shares and operate the canal. The public service company no longer exists.

The Ward Canal is owned and operated by approximately 40 stockholders in the Ward Canal Company.

The Warrior Canal is owned and operated by stockholders owning shares in the Warrior Ditch Company. Thirty eight stockholders hold a total of 160 shares in the company. The DWB is the largest single stockholder, holding about 28% of the shares. The Warrior decrees are some of the oldest on Bear Creek.

The Pioneer Union Ditch is owned by a number of entities, all responsible for their own diversions, transfers, exchanges, and augmentation plans. The largest of these are the DWB, the City of Lakewood, and the Evergreen Metro District.

Historically, changes to the water right shareholders have occurred, thus changes can be expected in the future. The oldest water right decree on Bear Creek is on the McBroom Ditch, which was established November 1, 1859. Plates 2-15, 2-16, and 2-17 include information on diversion locations.

2-05. Real Estate Acquisition. Real Estate Design Memorandum No. PB-5, dated February 1971, established the guide-taking line for the reservoir at maximum water surface elevation 5685.2 ft PD, or 300 ft horizontally from the full pool (flood storage pool elevation of 5633.0 ft PD). Due to the high value of land in the project area, the acquisition policy was to block out the guide acquisition line (full pool elevation 5633.0 ft PD) plus 5 ft of freeboard allowance or 300 ft setback for full pool elevation 5633.0 ft PD, whichever is greater, by close tangents rather than acquiring large blocks of land using governmental subdivisions. Plate 2-18 shows the Bear Creek Project boundary and easements.

The Government also acquired lands necessary for the relocation of Colorado State Highway No. 8. The relocated highway generally delineates the project boundary on the north side of the project. Acquisition of any interest downstream of the project was the responsibility of local governmental entities.

The Federal Government currently owns 2,308.52 acres of land in fee simple title and 0.14 acres in easements. The City of Lakewood manages lands at this project for park and recreational purposes. The Corps manages the remainder for operational purposes.

Construction of Bear Creek Dam and Reservoir required relocation of state and county highways, numerous telephone, electrical, and gas lines, and irrigation and water supply facilities. Morrison Road, also known as State Highway No. 8, the most traveled road between Denver and Morrison, was relocated around the north side of the Bear Creek Project. Before project authorization, U.S. Highway No. 285 was a joint route with State Highway No. 8; State Highway No. 70 was a separate route. The Colorado Highway Department had planned to improve Highway No. 70 to four lanes and extend it through the Bear Creek Project. Arrangements were made with the Federal Government to reroute the extension to a more southerly alignment that would be outside the Bear Creek Project boundary. The Federal Government paid for the additional cost of the relocated southerly alignment. U.S. Highway No. 285 was then combined with State Highway No. 70 through this area.

The major relocation of diversion canals involved moving the river diversion for Warrior Ditch upstream and combining it with the Harriman Ditch to reroute it around Bear Creek Dam and Reservoir. Approximately 1 mile of new underground flowage way connects the Warrior Ditch below Bear Creek Dam to the Harriman Canal. Part of the Ward Canal was also relocated so as not to interfere with the emergency spillway and the new relocated State Highway No. 8.

The Corps' Omaha District Real Estate Division files contain additional information pertaining to real estate acquisition for the Bear Creek Project.

2-06. Public Facilities. The City of Lakewood entered into a cost-sharing agreement, ODOP-221-82-003, with the Corps for initial recreation development at the Bear Creek Project on August 16, 1982. The initial recreation facilities were completed in the fall of 1985. These initial facilities accommodated boating, fishing, picnicking, overnight camping, bicycling, jogging, hiking, horseback riding, and wildlife observation. An archery range and other additional facilities were later added to serve the growing visitor demand.

Historically, visitation was computed in days but was changed in 1990 to hours. Beginning in 2014, the method for calculating the visitation hours at the Bear Creek Project changed, which resulted in non-comparative reduced numbers. Since construction of the Bear Creek Project, visitation has grown drastically to nearly 600,000 recreation visits in FY16. The Corps has not released the official visitation hours since FY16. As the local sponsor, the City of Lakewood has agreed to bear all costs of operation, maintenance, and replacement of recreation, and fish and wildlife lands and facilities. Plate 2-19 shows the Bear Creek Master Plan for reservoir development, approved in March 1990. Plate 2-20 shows a map of Bear Creek Lake Park.

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SECTION 3

HISTORY OF PROJECT

3-01. Authorization. House Document No. 669, 80th Congress, 2nd Session, provided an evaluation of the flood and related water problems of the South Platte River basin based on levels of economic growth existing in 1945. The report included a plan for flood control on Bear Creek by means of a reservoir at the current Bear Creek Dam site. However, this plan was not recommended at that time because it was economically infeasible. Between that time and the mid-1960s, development of housing and businesses along Bear Creek below the dam site resulted in a favorable economic justification for the Bear Creek Project. The project was authorized for construction by the Flood Control Act of 1968, substantially in accordance with the recommendations of the Chief of Engineers in Senate Document No. 87, 90th Congress, at an estimated cost of \$32,314,000. The recommendations presented in the project document stated the project purposes as flood control, general recreation, and fish and wildlife recreation.

3-02. Planning and Design. Bear Creek Dam and Reservoir is the only Federal flood control project within the Bear Creek basin. Some local levees and bank stabilization have been built for flood control by local interests within Bear Creek basin. In the Denver area, the Corps has constructed Cherry Creek Dam and Reservoir on Cherry Creek and Chatfield Dam and Reservoir on the South Platte River for flood control purposes. Cherry Creek Dam was completed in September 1952 and Chatfield Dam was completed in August 1973.

Municipal and industrial water supply was considered in Bear Creek Reservoir during the planning stages of the project. The parties expressing an interest were the City of Denver, town of Morrison, Genesee Village and Adolph Coors Company. However, the DWB, acting as spokesman for these interests, by letter dated November 3, 1971, indicated that the water supply price was beyond the economic limit of the interested parties.

An ungated drop inlet type structure was installed at the top of the Bear Creek Reservoir multipurpose zone. One benefit to this design was that it would provide the simplest way to keep the reservoir at a constant level without the requirement of continuous gate operation (reference DM No. PB-6, Paragraph 3.11.1.1).

3-03. Construction. Construction began on October 29, 1973. The construction of the Bear Creek Project was performed under two major contracts; the Outlet Works contract and the Earthwork Stage II contract. The Outlet Works contract was awarded to Centric Corporation of Denver, CO, under Contract No. DACW45-74-C-0170 on June 3, 1974. This contract was complete on December 31, 1976. The Earthwork Stage II contract was awarded to Holloway Construction Company of Wixom, MI, under Contract No. DACW45-75-C-0129 on June 20, 1975. Dam closure was made on July 19, 1977, about one year ahead of the original scheduled time. The multipurpose zone was initially filled,

reaching elevation 5558 ft PD for the first time, on May 10, 1979. The earthwork contract was completed in July 1979. Table 3-1 lists project contracts.

Table 3-1
LIST OF PROJECT CONTRACTS

Contract Title - Contractor and Contract No.	Work Start	Work Complete
Large Diameter Borings, Al Amidon Drilling Co. Lakewood, CO DACW45-74-C-0055	Nov 7, 1973	Jan 6, 1974
Earthwork Stage I, Winslow Construction Co. Englewood, CO DACW45-74-C-0055	Oct 29, 1973	Jun 30, 1974
Outlet Works, Centric Corporation Denver, CO DACW45-74-C-0170	Jun 17, 1974	Jan 25, 1977
Relocation of Colorado State Highway 8 Colorado State Department of Highways Denver, CO DACW45-73-C-0071	Oct 1974	Spring 1976
Earthwork Stage II, Holloway Construction Co. Wixom, MI DACW45-75-C-0129	Jun 20, 1975	Jul 1979
Warrior Canal Relocation, Lillard & Hanes Construction Lakewood, CO DACW45-76-C-0119	Sep 29, 1976	Jul 6, 1977

3-04. Related Projects. Parallel reservoir operation of the three area flood control projects, Bear Creek Dam, Chatfield Dam, and Cherry Creek Dam, is required when two or more of the projects are in flood operation. See Section 7-05 for further explanation on the parallel reservoir operation of these reservoirs.

No reservoir projects exist that directly impact Bear Creek Reservoir. Little and Big Soda Lakes are among the reservoirs and/or ponds in the Bear Creek basin. However, these reservoirs and/or ponds offer little reduction to the higher peak Bear Creek flows. Many reservoir projects exist upstream from Chatfield in the South Platte River basin.

A number of reservoirs have been constructed in the South Platte River basin for water supply, irrigation, and flood control purposes. Table 3-2 lists the pertinent reservoir information, and Plate 3-1 shows a three-dimensional system diagram of the location of

these reservoirs in relation to Chatfield Dam, Cherry Creek Dam, and Bear Creek Dam. In addition, a large number of reservoirs and ponds of less capacity have been constructed for irrigation and other conservation purposes.

**Table 3-2
PERTINENT EXISTING RESERVOIRS IN SOUTH PLATTE RIVER BASIN**

Reservoir	Stream	Storage Capacity (af)	Year Dam Closed	Operating Agency
Antero	South Platte River	19,881	1907	DWB
Spinney Mountain	South Platte River	53,651	1981	COA
Eleven Mile Canyon	South Platte River	97,779	1932	DWB
Tarryall Dam	Tarryall Creek	1,990	1930	CDW
Cheesman Lake	South Platte River	79,064	1902	DWB
Strontia Springs	South Platte River	7,863	1982	DWB & COA
Rueter-Hess	Cherry Creek	75,686	2012	Parker
Chatfield	South Platte River	349,454	1973	Corps
Bear Creek	Bear Creek	46,995 ⁽³⁾	1977	Corps
Cherry Creek	Cherry Creek	175,460 ⁽³⁾	1948	Corps
Kelly Road	Westerly Creek	800	1953	COA
Westerly Creek	Westerly Creek	9,300	1990	UDFCD / MHFD
Gross	Boulder Creek	41,811	1954	DWB
Carter Lake	Dry Creek ⁽²⁾	112,230	1954	USBR
Horsetooth	Charles Hansen Canal ⁽¹⁾	151,750	1951	USBR
(1) Offstream of Cache la Poudre River (2) Offstream of Big Thompson Creek (3) Includes Surcharge Zone DWB-Denver Water Board Corps-Corps of Engineers USBR-Bureau of Reclamation COA-City of Aurora CDW-CO Division of Wildlife UDFCD (Urban Drainage and Flood Control District) MHFD (Mile High Flood District) Parker (Parker Water and Sanitation District)				

3-05. Modifications to Regulation. Meetings regarding water supply reallocation at Chatfield Reservoir began in 1994 as a result of the public involvement process initiated during an update to the water control manuals for the Tri-Lakes Projects. A reconnaissance study was initiated in 1996. The Colorado Water Conservation Board (CWCB) signed a Feasibility Cost Share Agreement with the Corps in 1999, and the Feasibility Report and Environmental Impact Statement (FR/EIS) was initiated shortly after. Several challenges related to Federal funding, policy changes, and contract negotiations led to an extended schedule. Following extensive agency and public involvement, the Chatfield Reallocation FR/EIS, was approved in May 2014 and

implemented in FY20 following completion of recreation and environmental mitigation projects. The study concluded that transferring 20,600 af of the Chatfield Reservoir exclusive flood control storage to a new Chatfield Reservoir joint-use flood control-conservation zone (5432.0 – 5444.0 ft PD) does not impact the primary flood risk management purpose of Chatfield Reservoir. During Tri-Lakes system flood control storage evacuation for Level I (small flood events), defined in Section 7-05, the reallocation of flood control storage at Chatfield Reservoir slightly increases Cherry Creek Dam and Bear Creek Dam releases, and it affects the timing and duration of these releases, though the primary flood risk management purpose for Cherry Creek and Bear Creek Reservoirs is not affected. Plate 3-2 shows an example of how the release magnitudes are affected. There is no change to system flood control storage evacuation releases during Level II (large flood events), also defined in Section 7-05. The target flow at the South Platte River at Denver streamgage of 5,000 cfs was also unchanged by this study.

The Cherry Creek Dam Water Control Plan Modification Study began in October 2015. The purpose of the study was to establish a timeline and mechanism to allow increased releases from Cherry Creek Dam during an extreme flooding event to reduce the potential for dam overtopping and failure as well as reducing the overall flood extent. The study analyzed theoretical extreme storms, rainfall-runoff associated with these storms, current and increased Cherry Creek Dam releases, flood extent boundaries, and economic and environmental impacts as a result of increased releases. The study considered six release alternatives and recommended an alternative that required the release of 7,000 cfs from Cherry Creek Dam if the reservoir reaches elevation 5590.0 ft PD. A modification to the Cherry Creek Dam Water Control Plan (WCP) impacts the Chatfield Dam WCP and Bear Creek Dam WCP because these projects are operated as a system to mitigate flood risk through Denver, CO. Evacuating floodwater from Cherry Creek Reservoir at an accelerated rate reduced the risk of overtopping during an extreme rain event and resulted in minimal incremental damage following single rain events that have limited rainfall downstream of the dam. Some risk of additional damage was determined possible if releasing during subsequent storm events, however, that risk is outweighed by the need to release floodwater and reduce the risk of overtopping and failure because there is uncertainty in forecasting thunderstorm intensity, duration, and location. The environmental analysis resulted in a finding of no significant impact. As a result of the study recommendation, the Cherry Creek Dam, Chatfield Dam, and Bear Creek Dam WCPs were modified and became effective in April 2017.

3-06. Principal Regulation Issues. The control point for Bear Creek Reservoir regulation is a 5,000-cfs maximum flow target, except during extreme events, at the South Platte River at Denver streamgage. It is important to note that the 5,000-cfs flow target also includes Chatfield and Cherry Creek Dam releases as well as incremental runoff downstream of each of the dams. The primary regulation issue with the Tri-Lakes Projects is that the channel capacity downstream of the City of Denver is less than it is within the city itself. The non-damaging channel capacity on Bear Creek downstream from the dam of approximately 1,000 cfs has been verified with recent modeling efforts. The non-damaging channel capacity on the South Platte River through the City of

Denver has been improved since the construction of the Tri-Lakes Projects with estimated capacities ranging from 10,000 cfs to 30,000 cfs. Flows in excess of the channel capacity quickly flood the natural flood plain. In the 13-mile reach of the South Platte River from Brighton, CO to the geographic limits of the Denver metropolitan area, the channel capacity ranges from 3,000 cfs to 8,000 cfs. In this reach of the South Platte River, flows in excess of channel capacity spread extensively over the flood plain. Short-duration, high intensity rains in certain downstream reaches can produce regulation problems for the Tri-Lakes Projects. These rains can produce very quick peaking, short-duration basin hydrographs. Therefore, with the 12- to 24-hour travel time between the reservoirs, the downstream target streamgage, and the 4- to 8-hour peaking time on many of the tributaries, it may not be possible for the WCWQS to assess conditions and make gate orders, and for the Dam Tender to physically make those gate changes prior to the occurrence of the peak downstream rainfall-runoff.

The Bear Creek Project is a very “conservative” project due to the unique site. It was cheaper to over-build the project (in terms of the design storms) than to excavate the large quantities of rock for the spillway. The major regulation issues are caused by low pool levels with the need to administer water rights to the nearest cfs and encroachment of the downstream channel.

State administration of water rights requires a strict accounting of evaporation losses in any reservoir facility. Unless “excess” water is available, pool levels will decline due to evaporation losses. The storage loss could impact recreation uses at the project. The project sponsor, City of Lakewood, has been pursuing several alternate sources of additional water, including the purchase of water from downstream users and installing non-tributary wells, to offset evaporation losses.

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SECTION 4

WATERSHED CHARACTERISTICS

4-01. General Characteristics. The Bear Creek basin drains a total of 262 sq mi, of which approximately 236 sq mi are located above the Bear Creek Dam location. Bear Creek basin shares its boundary with the Clear Creek basin to the north and west, the North Fork of the South Platte River basin to the south and west, and numerous small tributary basins near the mouth. The basin is leaf-shaped with an approximate length and a maximum width of 36 and 13 miles, respectively. Streamflow originates near Summit Lake on the Mount Evans plateau. As flow moves easterly, it picks up contributions from numerous small tributaries along its way through the Arapaho National Forest. At Morrison, the flow breaks out of the confinement of the canyon and spreads through the foothills region. About 2 miles downstream from Morrison, Bear Creek is joined by the 52 sq mi Turkey Creek drainage, the only major tributary in the Bear Creek basin. Below the foothills, the area is mostly grassland with some urban development. The mountain area is heavily forested and the ground is liberally covered with forest duff typical of heavily wooded areas. Plates 2-1a and 2-1b show a map of the Bear Creek basin.

a. Topography. The Bear Creek Project is located in the foothills of the Colorado Rocky Mountain Front Range. Mountainous terrain accounts for 90% of the basin. The remaining 10% of the basin is characterized by high plains and rolling foothills and is separated from the mountains by a prominent hogback that crosses the basin near the Morrison area. Elevation varies from 14,264 ft at the headwaters on Mount Evans to 5295 ft at the Bear Creek at Sheridan streamgage near the mouth.

b. Geology and Soils. The Bear Creek Project is on the east slope of the Colorado Rocky Mountain Front Range, just 2 miles east of the Dakota Hogback, which forms the first prominent ridge of the Rocky Mountains. The foothills of the Rocky Mountain Front Range, which are within the Great Plains physiographic province, were created through folding, faulting, and uplifting. Bear and Turkey Creeks flow from their catchment areas in the mountains through gaps in the Dakota Hogback across upturned edges of Mesozoic strata and join near the project site. The Bear Creek valley drops approximately 80 ft/mile in this reach. Regional structural features include steep eastward dipping formations and a large thrust fault dipping westward, both associated with the formation of the Rocky Mountain Front Range. Structure within the rock of the foundation shows a very steep dip in the western part of the foundation area gradually becoming gentler to the east. Some minor faulting is possible either parallel to the beds or across bedding.

Soil overlying rock is relatively thin, varying from none at bedrock outcrops to 40 ft on the top of Mount Carbon. Mount Carbon is capped with a horizontal layer of sandy gravel about 40 ft thick. This is an alluvial deposit from a past geologic stage before Bear Creek and associated drainages had eroded down to their present levels. Another stage of erosion may have cut Bear Creek down to a broad valley that stretched from the present right valley wall to near the left abutment. Remains of alluvium from this

older valley show up as 25 ft of sandy gravel. Above this is 12 ft of silty sand or clayey sand. Alluvial material composes the present valley fill in the form of 15 ft of gravelly sand with about 3 ft of sandy clay soil.

c. Sediment. The accumulation of sediment within Bear Creek Reservoir is tracked by the Omaha District's River and Reservoir Engineering Section. Table 4-1 lists the total storage depletion rate between survey years. The average sediment storage depletion rate between survey years 1980 and 2009 is 27.3 af/year. The expected loss of reservoir storage from sedimentation influences over the 100-year life of the Bear Creek Project is estimated at 2000 af, or an average annual sediment depletion rate of 20 af. This rate is based on: (1) a sediment yield rate of 150 tons/sq mi of contributing drainage area per year, (2) a reservoir trap efficiency of 95%, and (3) an average deposit density of 75 pounds per cubic feet. This density value assumes a higher percentage of wash load inflow as portions of the drainage basin develop suburban characteristics. The total storage depletion rate between survey years 1984 and 1987 is 2 af/year. Plates 4-1 and 4-2 show the 2009 survey surface area and storage capacity curves, respectively. Exhibit III includes surface area and storage capacity tables. Plate 4-3 shows the sediment range location. New surface area and volume capacity tables based on a 2016 survey are scheduled to be made effective in 2020.

Table 4-1
BEAR CREEK RESERVOIR STORAGE DEPLETION

Storage Zone	Elevation (ft PD)	Storage Zone Capacity (af)		Change in Capacity (af)	Capacity Depletion Rate* (af/year)
		1980	2009	1980-2009	
Multipurpose	5528.0-5558.0	1,892	1,771	-121	-4
Flood Control	5558.0-5635.5	28,762	28,514	-248	-9
Surcharge	5635.5-5684.5	47,375	46,955	-880	-15
* Measured storage depletion rates should be used with caution. Actual rates are highly event driven and respond to extreme hydrologic events.					

4-02. Climate. The diverse topography of the Bear Creek basin above Denver causes a remarkable variety of climates with great differences occurring within short distances. The climate of the plains is distinctly continental. Situated a long distance from any moisture source and separated from the Pacific source of moisture by a high mountain barrier, the plains area normally experiences light rainfall, low relative humidity, a large daily range in temperature, a large amount of clear sky sunshine, moderately high wind movement, and few protracted cold spells in the winter. However, invasion of cold air from the north, combined with available moisture in the air and the high altitude, can result in abrupt and severe weather. In the mountain area, a decrease in temperature and an increase in precipitation and wind movement occur with increasing altitude.

a. Temperature. Temperatures in the Denver area can vary widely from day to day because of the invasion of large air masses from the north or south. Rapid warm-

ups during the winter months are common because of the effects of Chinook winds. The diurnal range in temperatures is less on the mountain slopes than in the valleys. The hottest month of the year is July, when daily temperatures average 74 degrees Fahrenheit (°F) in Denver, CO and 60 °F in Grant, CO. The coldest month of the year is January, when daily temperatures average 31 °F in Denver, CO and 22 °F in Grant, CO. Due to the effects of the urban heat island, the length of the frost-free period in Denver is approximately 155 days, several weeks longer than it is outside of the Denver urbanized area. The average date of the latest last freeze of the winter season at Denver is May 5. The average date for the earliest first freeze of the winter season is October 7. The latest last freeze and earliest first freeze dates of record are June 8, 2007 and September 8, 1962, respectively. Table 4-2 lists the minimum and maximum monthly temperature ranges for selected National Weather Service (NWS) weather stations near Bear Creek Dam.

b. Precipitation. The average annual precipitation in Kassler, CO near the Bear Creek Project is 17.6 in, most of which occurs as rain during the months of April through August. Thunderstorms, hailstorms, windstorms, and tornadoes are most frequent between May 15 and September 1. Table 4-3 lists the average, minimum and maximum monthly precipitation at the Denver Airport, Grant, CO, Evergreen, CO and Kassler, CO.

c. Snow. The largest amount of snow falls in March and April in the Bear Creek basin. The mountains average anywhere from 50 to 100 in of snow per year while the plains average about 60 in of snow per year. Table 4-4 lists monthly snowfall averages and maximums for the same gages as listed above.

**Table 4-2
BEAR CREEK RESERVOIR AREA – RECORD OF TEMPERATURES (°F)**

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PERIOD OF RECORD - 1948-2013												
HIGH PLAINS (DENVER AIRPORT, ID 052220) ELEVATION 5290 FT												
Normals	30.5	33.5	39.6	47.9	57.3	67.3	73.7	71.7	62.8	51.5	39.1	31.6
Max Daily	74	76	84	90	96	104	104	102	97	89	81	75
Min Daily	-25	-25	-8	-2	22	30	43	41	17	3	-8	-25
PERIOD OF RECORD - 1963-2013												
MOUNTAIN (GRANT COLORADO, ID 053530) ELEVATION 8670 FT												
Normals	21.7	23.4	29.7	36.6	45.5	54.2	59.6	57.3	50.3	41.1	29.4	21.9
Max Daily	58	58	65	76	82	90	89	88	84	77	67	58
Min Daily	-23	-30	-22	-10	2	20	27	25	7	-5	-18	-27
PERIOD OF RECORD - 1961-2013												
FOOTHILLS (EVERGREEN COLORADO, ID 052790) ELEVATION 7000 FT												
Normals	27.3	28.7	34.3	41.2	49.4	58.4	64.3	62.5	54.7	44.6	34.6	27.8
Max Daily	74	71	78	82	92	97	96	96	92	85	77	69
Min Daily	-38	-28	-18	-9	12	27	26	29	8	-8	-15	-29
PERIOD OF RECORD - 1918-2013												
HIGH PLAINS (KASSLER COLORADO, ID 054452) ELEVATION 5500 FT												
Normals	31.9	34.3	40.3	48.4	57.3	67.1	73.4	71.7	63.7	52.8	40.6	33.1
Max Daily	76	77	83	88	97	105	105	101	99	90	82	78
Min Daily	-32	-29	-20	-11	17	20	37	40	18	-8	-14	-31
Source: NOAA Climate Summaries - Western Regional Climate Center												

Table 4-3
BEAR CREEK RESERVOIR AREA – RECORD OF PRECIPITATION (in)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
PERIOD OF RECORD - 1948-2013													
HIGH PLAINS (DENVER AIRPORT, ID 052220) ELEVATION 5290 FT													
Ave	0.50	0.57	1.21	1.76	2.40	1.67	2.03	1.70	1.13	1.01	0.80	0.58	15.37
Min	0.00	0.01	0.00	0.03	0.06	0.03	0.15	0.06	0.01	0.05	0.01	0.00	7.51
Max	1.33	1.66	4.81	5.35	7.31	4.69	6.99	5.85	4.67	4.17	2.67	2.84	23.84
PERIOD OF RECORD - 1963-2013													
MOUNTAIN (GRANT COLORADO, ID 053530) ELEVATION 8670 FT													
Ave	0.51	0.56	1.07	1.35	1.65	1.40	2.61	2.39	1.39	1.02	0.74	0.69	15.26
Min	0.04	0.00	0.03	0.21	0.02	0.00	0.41	0.83	0.06	0.00	0.06	0.07	10.95
Max	2.10	1.70	3.57	4.02	4.74	3.91	6.09	4.82	4.23	3.97	2.18	1.98	20.68
PERIOD OF RECORD - 1961-2013													
FOOTHILLS (EVERGREEN COLORADO, ID 052790) ELEVATION 7000 FT													
Ave	0.55	0.72	1.62	2.18	2.55	2.09	2.27	2.26	1.45	1.26	0.91	0.77	18.64
Min	0.02	0.04	0.06	0.00	0.25	0.23	0.31	0.38	0.00	0.02	0.04	0.00	10.01
Max	1.59	2.07	6.04	6.32	10.94	4.94	6.92	5.44	3.34	5.33	3.36	3.31	27.98
PERIOD OF RECORD - 1918-2013													
HIGH PLAINS (KASSLER COLORADO, ID 054452) ELEVATION 5500 FT													
Ave	0.58	0.76	1.61	2.30	2.63	1.67	1.69	1.69	1.36	1.46	1.08	0.75	17.57
Min	0.00	0.02	0.08	0.04	0.24	0.00	0.38	0.04	0.00	0.00	0.00	0.00	10.68
Max	1.87	2.85	7.52	9.14	9.64	5.77	5.05	4.86	5.15	6.49	4.46	3.03	28.11
Source: NOAA Climate Summaries - Western Regional Climate Center													

Table 4-4
BEAR CREEK RESERVOIR AREA – RECORD OF SNOWFALL (in)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
PERIOD OF RECORD - 1948-2013													
HIGH PLAINS (DENVER AIRPORT, ID 052220) ELEVATION 5290 FT													
Ave	7.3	7.2	11.9	8.1	1.6	0.0	0.0	0.0	1.4	4.1	8.5	7.8	58.0
Max	24.3	18.3	35.2	25.5	13.7	0.8	0.0	1.3	17.2	31.2	29.6	30.8	112.0
PERIOD OF RECORD - 1963-2013													
MOUNTAIN (GRANT COLORADO, ID 053530) ELEVATION 8670 FT													
Ave	9.6	10.4	17.7	15.2	6.2	0.8	0.0	0.0	2.1	7.9	11.5	12.8	96.5
Max	27.5	33.5	41.0	37.0	32.0	13.0	0.0	0.0	21.0	49.0	39.0	41.0	172.2
PERIOD OF RECORD - 1961-2013													
FOOTHILLS (EVERGREEN COLORADO, ID 052790) ELEVATION 7000 FT													
Ave	8.5	10.3	18.2	13.7	3.3	0.1	0.0	0.0	1.4	7.2	11.6	10.4	84.7
Max	24.9	34.8	59.4	44.5	17.0	5.0	0.0	0.0	12.5	57.0	44.0	50.8	134.4
PERIOD OF RECORD - 1918-2013													
HIGH PLAINS (KASSLER COLORADO, ID 054452) ELEVATION 5500 FT													
Ave	9.6	10.9	15.2	10.0	0.8	0.0	0.0	0.0	0.8	4.1	11.0	11.4	73.6
Max	32.0	45.7	48.3	45.0	17.0	0.0	0.0	0.0	18.0	63.0	54.5	44.0	139.0
Source: NOAA Climate Summaries - Western Regional Climate Center													

The Natural Resources Conservation Service (NRCS) publishes data at Echo Lake, the only snow telemetry (SNOTEL) site in the Bear Creek basin. The 1981-2010 average Snow Water Equivalent (SWE) peaks around May 1 at 9.3 in Table 4-5 shows the accumulated mountain snowpack on the first day of each month. Mountain snowpack typically begins to accumulate in October, peaks from late April to early May and melts in May and June.

**Table 4-5
BEAR CREEK RESERVOIR AREA – RECORD OF SWE (in)**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PERIOD OF RECORD – 1981-2010												
ECHO LAKE (936) ELEVATION 10600 FT												
Ave	3.1	3.8	4.8	7.4	9.3	1.6	0.0	0.0	0.0	0.1	1.2	2.1
Source: NRCS 30-Year Climatic and Hydrologic Average SWE on first of month												

d. Climate Variability. Much research has been conducted over the past several decades concerning the impacts of climate variability on different regions of the planet. One of the more frequently studied phenomena is the El Niño/Southern Oscillation (ENSO) cycle that is observed across the central and east-central equatorial Pacific. The impacts in the continental United States from the different cycles of ENSO (El Niño and La Niña) are typically more pronounced along the Pacific coast and the southern tier states. However, some impacts have been attributed to the subbasins of the Missouri River basin. It is also important to note that impacts from the ENSO cycle are generally between the months of November and March, or from late fall into early spring.

The precipitation impacts during an El Niño episode are more pronounced within the upper South Platte River basin and would typically result in precipitation amounts that exceeded the climatological averages. This area generally divides the anomalously warmer-than-normal temperatures observed in the northern tier states during an El Niño episode from the typically cooler-than-normal temperatures observed further south, thus no strong correlation for temperatures can be made during an El Niño episode. Therefore, an El Niño episode could be seen as bringing increased chances for above-normal snowfall with snowmelt occurring near the normal time.

As opposed to El Niño, there are no strong correlations between La Niña episodes and climate anomalies across the Colorado Rockies. Warm and dry conditions have been frequently observed across the Southern Rockies during La Niña episodes as a result of the migration northward of the jet stream and primary storm track. The geographic proximity of the upper South Platte River basin would increase the potential for an expansion northward of drought conditions under such a scenario.

e. Wind. Wind speeds are generally low to moderate. Monthly average wind speeds range from 9 to 11 miles per hour (mph), and the yearly average is 10 mph. However, occasional wind gusts exceeding 50 mph do occur. Prevailing winds are generally from the south or south-southwest. During the winter, winds blowing from the north and northwest are generally colder than those blowing from the south. Chinook

winds, which blow from the west and are warmed as they descend to the plains east of the Rocky Mountains, are also an important climatic factor. The arrival of a Chinook wind can cause temperatures in the Bear Creek Reservoir vicinity to suddenly increase by several degrees.

f. Evaporation. Evaporation from Bear Creek Reservoir is calculated using a physically-based evaporation model implemented in routine calculations in 2012. The model, which was developed by the Corps' Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory (ERDC-CRREL), estimates evaporation from the flood control reservoirs in the Omaha District. The model has two components: the first component calculates the evaporation from the water surface using a Bulk Flux Algorithm and the second component estimates the vertical temperature profile of the reservoir based on a one-dimensional heat budget of the reservoir. The model requires no new instrumentation to be installed in the field, uses available meteorological observations from the NWS, and is compliant with the Corps Water Management System (CWMS) framework. The model input includes: hourly air temperature, hourly wind speed, hourly relative humidity, hourly barometric pressure, hourly cloud cover extent and elevation, hourly reservoir depth, reservoir location, current water surface elevation, and the elevation-area relationship. The model has some limitations, which include the inability to accurately calculate evaporation when the reservoir is ice covered. When the reservoir is ice covered, the WCWQS personnel estimate the evaporation utilizing the estimated average pan evaporation found in Table 4-6. This data is determined from an analysis of past computed evaporation including an analysis of empirical means for estimating evaporation for this area. To convert the pan evaporation depth in Table 4-6 to flow in cfs, the depth is converted to feet (divided by 12) and then multiplied by a factor of 70% and by the Bear Creek Reservoir area (in acres) and divided by 1.9835 to convert af to cfs.

Table 4-6
ESTIMATED AVERAGE PAN EVAPORATION

Month	Monthly Loss (in)	daily loss (in)
January	1.2	0.04
February	1.1	0.04
March	1.9	0.06
April	3.6	0.12
May	6.2	0.20
June	8.4	0.28
July	9.3	0.30
August	9.3	0.30
September	7.5	0.25
October	4.9	0.16
November	2.4	0.08
December	1.3	0.04
TOTAL	57.1	

Historically, the evaporation from Bear Creek Reservoir was determined by observing the daily evaporation from the Class A evaporation pan located at the Chatfield Project.

4-03. Storms and Floods. The following sections describe some of the floods that have occurred in the Bear Creek basin for which data are available. These floods were selected for description because of the magnitude of the event or because they represent a runoff characteristic or flood potential that is considered to be applicable to the Bear Creek Project.

a. Flood of July 1896. A general rain followed by an intense storm centered over the Cub Creek basin near Evergreen, CO caused severe flooding on Cub Creek and Bear Creek near Morrison, CO. The peak flow at the Bear Creek at Morrison streamgage, located upstream from the mouth of Mount Vernon Creek, was 8,600 cfs. According to newspaper reports, this peak discharge was produced from a 50-sq mi area. Downtown Denver reported 1.23 in of precipitation during this storm, however because this storm was not centered over downtown the heaviest precipitation was not included in this report.

b. Flood of July 1933. This flood was caused by runoff from an intense thunderstorm centered over Idledale, which is about 3 miles west of Morrison. Heavy runoff occurred on Mount Vernon Creek and on small tributaries located just upstream from the mouth of Mount Vernon Creek. The peak discharge at the Bear Creek above Morrison streamgage was 8,000 cfs. This discharge does not include the flow from Mount Vernon Creek, which was substantial. At the mouth of Bear Creek, 10 miles downstream from Morrison, the peak discharge attenuated to 3,000 cfs. Downtown Denver reported only 0.44 in of precipitation during this storm, however because this storm was not centered over downtown the heaviest precipitation was not included in this report.

c. Flood of September 1938. The flood of September 1938 was caused by a severe storm centered near the top of Genesee Mountain on the divide between Mount Vernon Creek and Bear Creek. Although there were no weather stations in the area of the storm, bucket survey data indicated rainfall amounts varied from 3 to 8.5 in with the bulk of the rain occurring in a 2-hour period. Downtown Denver reported 2.12 in, however because this storm was not centered over downtown the heaviest precipitation was not included in this report of precipitation during this storm. Runoff from this storm resulted in flooding on Cold Spring Gulch and Mount Vernon Creek. On Cold Spring Gulch, in the area of highest precipitation, a peak discharge of 9,000 cfs was estimated from a 4.48 sq mi area. A small gulch draining 400 acres in Cold Spring Gulch had a peak discharge of 2,050 cfs. The flow from Cold Spring Gulch attenuated to 6,200 cfs on Bear Creek at the Morrison streamgage. The peak discharge on Mount Vernon Creek, which joins the Bear Creek flow below the Morrison streamgage, was 9,230 cfs. The peak discharge at the mouth of Bear Creek was 2,810 cfs.

d. Flood of April-May 1942. The flood of April – May 1942 in the Bear Creek basin was the result of snowmelt runoff augmented by above-normal precipitation. Rainfall amounts during April 18-19 were 3.57 in at Kassler, 2.44 in at Idaho Springs

and 1.57 in at downtown Denver. Peak discharges during this flood were not as high as the previously described floods, but the volume of runoff was excessive. The 30-day and 60-day runoff volumes past the Sheridan streamgage were 44,100 af and 69,250 af, respectively. The peak flow at this streamgage was 1,600 cfs on April 19.

e. Flood of June 1965. Torrential rains during the period of June 14-17 resulted in record floods in the South Platte River basin in eastern Colorado. These floods were major hydrologic events that exceeded many previous maxima by several fold. Chatfield and Bear Creek Dams were built as a result of this flood to mitigate flooding impacts in the City of Denver. Six people drowned and two more deaths were later attributed to the flood. The flood was the result of runoff from heavy intense rainfall that started in Greeley and Sterling, CO on June 14-15, continued on the evening of June 16 centered over the high plains of the Plum and Cherry Creek basins, and ended on June 17 with rainfall centered over the headwaters of Kiowa and Bijou Creek basins. Near Larkspur, CO, 14 in of rain fell on June 16 and 10 to 12 in were reported at several other locations generally along a line through Monument and Parker, CO in the Plum and Cherry Creek basins. Serious flooding on the South Platte River upstream from Denver began on the afternoon of June 14, when Plum Creek washed out Interstate 25 roadway bridges and flooded portions of the town of Castle Rock. Very little runoff was experienced on the South Platte River above Plum Creek. The peak flow at Waterton, CO of 1,370 cfs was considered coincident with the Plum Creek peak runoff. The runoff from Plum Creek, produced a major disaster not only along the tributary itself, but also through the rural area along the South Platte River. The peak flow on Plum Creek was estimated at 154,000 cfs. Significant attenuation occurred as the flood moved downstream. By the time the flood peak reached Littleton, CO, the peak flow was reduced to 110,000 cfs, then reduced to 40,300 cfs at the South Platte River at Denver streamgage, nearly two times the previous record of 22,000 cfs. Damage was severe, totaling \$500 million in the South Platte River basin, of which \$300 million occurred in the Denver area. Flooding also occurred on all Cherry Creek tributaries below Franktown, CO concurrently with the runoff on Plum Creek. The peak inflow to Cherry Creek Reservoir was estimated to be 58,000 cfs. About 13,780 af of Cherry Creek rainfall-runoff was stored in Cherry Creek Reservoir. Without Cherry Creek Dam, it was estimated that Cherry Creek flows would have added directly to the Plum Creek flows through Denver and would have resulted in several times the actual damage experienced. Flooding along Sand Creek caused considerable bridge damage through Denver. A peak flow of 13,400 cfs was estimated below the confluence of Toll Gate and Sand Creeks. A peak flow of 274,000 cfs on East Bijou Creek at Deer Trail, CO was estimated to have occurred on June 17, resulting in a flow on Bijou Creek near Wiggins, CO of 466,000 cfs on June 18. The resulting South Platte River flows attenuated rapidly as it traveled downstream. Flows at the Colorado/Nebraska state line approximated those of the 1935 flood and were reduced by channel storage to reach only about two-thirds the value of the 1935 flood at North Platte, NE. Table 4-7 summarizes information showing the magnitude of this flood.

**Table 4-7
JUNE 1965 FLOOD – SOUTH PLATTE RIVER PEAK FLOWS**

Stream	Location	Drainage Area (sq mi)	Peak Flow (cfs)
Plum Creek	Louviers, CO	302	154,000 - Jun 16
South Platte River	Waterton, CO	2,621	1,370 - Jun 18
	Littleton, CO	3,069	110,000 - Jun 16
	Denver, CO	3,804	40,300 - Jun 17
	Kersey, CO	9,598	23,500 - Jun 18
	Weldona, CO	13,245	18,800 - Jun 19
	Balzac, CO	16,852	123,000 - Jun 18
	Julesburg, CO	23,138	37,600 - Jun 20
Cherry Creek	Cherry Creek Res	385	58,000 (est)- Jun 16
Bijou Creek	Wiggins, CO	1,314	466,000 - Jun 18

f. Flood of May 1969. Runoff from an intense burst of rainfall occurring on the third day of a 4-day storm over the foothills caused severe flooding on Bear Creek near the mouth. The heaviest amounts were centered 25 miles southwest of Denver and extended in a band along the foothills northward to Estes Park. Rainfall amounts during this 4-day storm were 7.93 in at Kassler, 6.63 in at Idaho Springs, 4.71 in at Denver, 9.02 in at Evergreen, and 11.27 in at Morrison. Unofficial amounts reported within the Bear Creek basin ranged from 6.7 in to 11.8 in for the total storm. On May 7, the peak discharges on Bear Creek at the Morrison and Sheridan streamgages were 2,340 cfs and 8,150 cfs, respectively.

g. Flood of July 1983. Continuous thunderstorms on June 21 and 22 resulted in flooding along Bear Creek from Evergreen to Bear Creek Reservoir. Following overnight thunderstorms, a heavy thunderstorm struck the Rocky Mountain Front Range on the afternoon of July 22. The heaviest rainfall reported from that afternoon storm was 3 in over 45 minutes at Kittredge, upstream of Morrison, on Bear Creek. Evergreen also reported 2.61 in over a 30-minute period. The resulting peak flow at the Morrison streamgage was 4,140 cfs on July 22.

h. Flood of April-July 1995. Heavy mountain snowfall and cooler-than-average temperatures were experienced in the South Platte River basin from April through June. A near-record mountain snowpack was recorded above Chatfield and Bear Creek Dams, and also along the South Platte River tributaries that enter the South Platte River downstream of the Tri-Lakes Projects. The Bear Creek Reservoir peak daily inflow was 796 cfs on June 9. The maximum pool elevation of 5587.1 ft PD occurred on June 17. A maximum daily release of 600 cfs was made to evacuate the flood control storage. However, the worst flooding occurred along the St. Vrain and upper Clear Creek basins

downstream of Bear Creek Dam. During May and June, localized heavy thunderstorms resulted in some flooding along the lower portions of several tributaries and added to the high flows in the South Platte River. Coordinated operations of Chatfield and Bear Creek Dams were challenging due to rapid rises downstream of the dams along the tributaries and the South Platte River. The releases at Bear Creek Dam were decreased several times during the flood event to target 5,000 cfs at the South Platte River at Denver streamgauge.

i. Flood of September 2013. The flood of September 2013 was much more severe downstream of the Tri-Lakes Projects and the relatively small releases from the dams had little to no effect on the downstream flooding. Eight people lost their lives as a direct result of rainfall-runoff that occurred in uncontrolled drainage areas located downstream of the Tri-Lakes Projects. Most of the deaths occurred during the height of the flash floods on the evenings of September 11 and 12. Nearly 18,000 people were evacuated by the local emergency management agencies. The flooding damaged approximately 19,000 homes and commercial buildings and about 485 miles of roads including 50 bridges. Monsoonal flow conditions resulted in daily rainfall tracking along the Rocky Mountain Front Range. The topography of the region and the location of a surface front promoted some of the heaviest rainfall in the foothills west and north of Denver, CO and in Aurora, CO, a suburb east of Denver, CO. Radar-estimated rainfall amounts during the entire storm showed the maximum amount in the 15- to 20-in range from Estes Park, CO to Boulder, CO with widespread areas of over 10 in Aurora, CO had radar-estimated rainfall amounts in the 10- to 15-in range during the entire storm. The annual exceedance probabilities for the heaviest 48-hour rainfall period exceeded a 500-year event and in some areas even exceeded a 1000-year event. Flooding was widespread and occurred along the main stem South Platte River and tributaries from Denver, CO to Kearney, NE. The South Platte River at Denver, CO streamgauge had a peak discharge of only 3,930 cfs while at Henderson, CO it was 11,200 cfs. The South Platte River at Kersey, CO streamgauge did not report during the peak flow, no measurement was taken and no estimated flow was calculated. A flow measurement of 24,900 cfs was taken following the peak at the South Platte River at Weldona, CO streamgauge on September 17. The peak flow was not estimated, but was likely much higher than the measurement. A flow measurement of 38,900 cfs was taken at the South Platte River at Fort Morgan, CO streamgauge on September 15, with a peak flow estimate of 60,000 cfs also on September 15. By the time the flood arrived at the South Platte River at Julesburg, CO streamgauge, the peak flow had dropped to 21,820 cfs on September 18, indicating an appreciable attenuation. At the South Platte River at Roscoe, NE streamgauge the peak flow estimate was 19,100 cfs on September 21. By the time the floodwater arrived at the Platte River at Kearney, NE streamgauge the peak flow estimate was 12,500 cfs on September 28. Bear Creek Dam releases were reduced from about 250 cfs to zero (0) cfs from September 13-15 to lessen downstream flooding. The Bear Creek Reservoir peak daily inflow was 1,170 cfs on September 16 and the maximum daily release was 500 cfs on September 27. Bear Creek Reservoir reached its record maximum pool elevation on September 21 of 5607.8 ft PD, which occupied just over 40% of its flood control zone. The Cherry Creek and Chatfield Reservoir multipurpose zones, which were drawn down due to water rights before the event, were refilled with rainfall-runoff. No flood control operations were necessary at

Chatfield Dam. Only minor flood control operations were made at Cherry Creek Dam with an evacuation release of 100 cfs following the downstream flooding. In addition, the emergency spillway was operated at Kelly Road Dam, with an estimated peak outflow of 900 cfs.

j. Flood of May-June 2015. Heavy mountain snowfall and cooler-than-average temperatures were experienced in the South Platte River basin from April through June. A near-record snowpack was generated in many of the mountain areas including those in the drainage basins above Chatfield and Bear Creek Dams, and also downstream along the South Platte River tributaries that enter north (downstream) of Denver. The Bear Creek Reservoir record peak daily inflow was 1,183 cfs on May 10, surpassing the record set in 2013. The Bear Creek Reservoir maximum pool elevation of 5602.6 ft PD occurred on May 25. A maximum daily release of 500 cfs was made to evacuate the stored flood waters. During May and June, localized heavy thunderstorms resulted in some flooding along the lower portions of several tributaries and added to the high flows in the South Platte River. Coordinated operations of Chatfield, Bear Creek, and Cherry Creek Dams were challenging due to rapid rises in river flow downstream of the dams along the tributaries and the South Platte River. The releases at Chatfield Dam were decreased several times during the flood event to target 5,000 cfs at the South Platte River at Denver streamgauge and to provide relief to the water supply infrastructure downstream from Denver.

4-04. Runoff Characteristics. The information presented in the preceding paragraphs illustrates the flooding on Bear Creek and in the upper South Platte River basin. To further illustrate the potential for flooding on Bear Creek, other devastating floods have occurred within recent years in and along the east side of the Rocky Mountains. A characteristic of all these floods is the swiftness and force with which they occur. For example, 13 lives were lost during the June 16-17, 1965 flood. During this event, the South Platte River at Denver streamgauge recorded the highest discharge of 80 years of record. Runoff in the Denver area occurred from rainfall that was centered over the Plum Creek and Cherry Creek basins. In the July 31, 1976 flood on the Big Thompson River, 139 lives were lost. This storm was centered in the mountains just east and northeast of Estes Park, about 50 miles northwest of Denver. Rainfall of more than 12 in occurred at an elevation of 7500 ft. Most of the rain occurred within a 5-hour period from 1830 to 2330 hours local time within the 7000- to 10,000-ft elevation range. The first reported damage occurred around 1900 hours.

The infiltration loss rate of 1 in/hour used in developing the Bear Creek Dam Standard Project Flood (SPF) and PMF is the same as that used in the design flood derivation for Chatfield Reservoir. This loss rate is based on infiltrometer studies made by the U.S. Forest Service in the mountain areas of the South Platte River basin. Results of the infiltrometer studies indicated an average infiltration rate of about 2 in/hour for forested mountain areas in this region. For purposes of design conservation, this rate was reduced 50% to 1 in/hour for use in the design flood derivations for Bear Creek Dam. Plate 4-4 shows stream profiles of Bear Creek and Turkey Creek. Plates 4-5 through 4-10 show the historical hydrograph for the Bear Creek at Morrison streamgauge. Plates 4-11a and 4-11b show the inflow and discharge frequency curves for Bear Creek Dam,

respectively. The curves are derived from the daily annual maximums for the 1978-2016 water years. The inflow frequency curve was best fit with a weighted skew using Bulletin 17C analysis. The discharge frequency curve was best fit with a station skew due to release decision impacts, which made the regional skew less applicable.

About 60% of the annual runoff into Bear Creek Reservoir occurs during the April through June period. Plate 4-12 shows a graph of historical monthly inflows and Plate 4-13 presents the data in tabular form. See Plate 4-14 for a graph of the historical annual inflow volume for the period of record. Table 4-8 lists the results of several runoff studies.

Table 4-8
SOUTH PLATTE RIVER BASIN INFILTRATION STUDIES

Source	Study	Location	Loss Rate (in/hour)
Corps of Engineers	Storm	Cherry Creek	0.8
Corps of Engineers	Storm	S Platte - Right Bank	1.0
Corps of Engineers	Storm	S Platte - Left Bank	1.2
Corps of Engineers	1965 Storm	Cherry Creek	0.86
Exp Station	Infiltrometer	Cherry Creek – Minimum	0.70
Exp Station	Infiltrometer	Cherry Creek – Average	1.07
Forest Service	Infiltrometer	Mountains – Pine Forest	2.37
Forest Service	Infiltrometer	Mountains – Pines – Grass	1.94
Forest Service	Infiltrometer	Mountains – Grass	1.50

4-05. Water Quality. The State of Colorado's water quality standards designate the following beneficial uses to Bear Creek Reservoir: primary contact recreation (Class E), Class 1 cold-water aquatic life use, water supply, and agriculture. Bear Creek Reservoir is listed on the 2018 State of Colorado 303(d) list of impaired waters due to exceedances of the chlorophyll *a* and total phosphorus water quality standards. Due to these exceedances the State of Colorado has determined the reservoir does not meet its applicable use of supporting cold-water aquatic life. The total maximum daily load development for chlorophyll *a* and total phosphorus has been given a high priority by the Colorado Department of Public Health and Environment.

Located southwest of the Denver metropolitan area, the basin encompasses 236 sq mi from Mount Evans Wilderness area in the west to the town of Morrison, CO in the east. Bear Creek Reservoir is impacted by both point and nonpoint source pollution. The upper basin contains rural and urban areas with rugged topography and a significant slope in elevation from west to east.

The Bear Creek Watershed Association (BCWA) established the following reservoir water quality target strategies:

- Monitor and implement programs to determine the compliance with standards and trends of reservoirs (Bear Creek, Genesee, and Evergreen Lake);

- In Evergreen Lake, support the reservoir as a direct use water supply;
- In Bear Creek Reservoir, target the reduction of the annual total phosphorus loading to the reservoir from both point and nonpoint sources found in the basin; target a near-term 75% reduction of point source loads and 35 to 50% reduction of nonpoint source loads within 10 to 20 years;
- In Bear Creek Reservoir, maintain reservoir management strategies that support improving the reservoir fishery and enhanced recreational potential, along with habitat in Bear Creek Park;
- In Bear Creek Reservoir, support a two-story fishery of mixed warm- and cold-water species in the reservoir; and
- Stay informed and/or directly involved with any proposed changes to the Bear Creek Reservoir water storage or other reservoir and/or distribution supply proposals.

Bear Creek Control Regulation No. 74 sets phosphorus wasteload allocations (pounds per year) to meet the beneficial uses of the reservoir. No point source may exceed the 1.0 mg/L as a 30-day average effluent limit for phosphorous. The mean in-reservoir chlorophyll *a* standard is 10 µg/L and the in-reservoir phosphorus standard is 32 µg/l in the mixed layer (July through September seasonal means).

4-06. Channel and Floodway Characteristics. Plates 4-15 through 4-20 show open water rating curves for selected stations most frequently used in the regulation of Bear Creek Reservoir. Only the current rating curves are on file with the WCWQS for use in making regulation decisions. The stage-discharge relationships, as defined by these curves, may shift over time and are updated with stage-discharge measurements made by the United States Geological Service (USGS) and CDWR. These relationships, illustrated on Plates 4-15 through 4-20, should only be used for approximation. More accurate relationships for current stream conditions are available online through the USGS and CDWR. The larger shifts from these open water relationships will occur when ice forms on the streams or following heavy rainfall-runoff events. With ice conditions, stages for a particular discharge may be several feet higher than indicated by the open water curves. Following heavy rainfall-runoff events, stages for a particular discharge may be lower than indicated by the open water curves.

Table 4-9 and Plate 4-21 list the approximate release travel times below Bear Creek Dam for normal flows. Plate 4-22 lists travel times during high flows such as occurred in 1995. As noted in Plate 4-22, travel times for high flows can be 2 to 3 times faster than travel times for normal flow.

Table 4-9
BEAR CREEK DAM RELEASE TRAVEL TIMES

Locations	Travel Time
Bear Creek Dam to mouth of Bear Creek	3 hours
Bear Creek Dam to South Platte River at Denver Streamgage	7 hours
Bear Creek Dam to Henderson, CO	12 hours
Chatfield Dam to Kersey, CO	2-3 days
Chatfield Dam to Julesburg, CO	4-7 days
Chatfield Dam to Mouth of S Platte River at North Platte, NE	6-9 days
Chatfield Dam to Mouth of Platte River near Louisville, NE	13-18 days

The maximum non-damaging channel capacity on Bear Creek downstream from the dam is approximately 1,000 cfs. Sustained near-bankfull flows on Bear Creek below the dam may cause bank erosion problems. The improved South Platte River non-damaging channel capacity through Denver has an estimated range of 10,000 cfs to 30,000 cfs. As in other reaches in the Denver area, much of the flood plain is lower than the channel bank. Flows in excess of channel capacity quickly flood the natural flood plain. A large number of bridges are located in this reach; several have limited flow conveyance capacity. Many of these bridges were lost in the 1965 flood when the flow was obstructed by debris. Backwater flooding in the vicinity of the bridges was also evident as a result of debris accumulation.

4-07. Upstream Structures. No significant regulating structures exist upstream of Bear Creek Dam.

4-08. Downstream Structures. Large numbers of pedestrian crossings, road bridges, and other structures have been constructed along Bear Creek downstream of Bear Creek Dam. Eighteen pedestrian bridges cross the Bear Creek downstream of Bear Creek Dam that allow people to traverse Bear Creek and use bicycle/pedestrian paths.

Ten major road bridges cross Bear Creek downstream of the dam. All are within the Denver metropolitan area and support significantly large numbers of daily vehicular traffic. These bridges are at the following locations: South Kipling Parkway southbound, South Kipling Parkway northbound, South Estes Street, South Wadsworth Boulevard, South Sheridan Boulevard, Westbound Highway 285, Eastbound Highway 285, South Lowell Boulevard, Irving Street, and Federal Boulevard.

Six drop structures are located on Bear Creek downstream of the dam. An encased aerial sewer pipeline, owned and operated by the Platte Canyon Water and Sanitation District, crosses Bear Creek near the South Platte River confluence. With a release of 500 cfs, debris begins to back up along the aerial pipeline. Historically, Bear Creek Dam releases have been reduced to allow removal of the debris by the sanitation district.

4-09. Economic Data.

a. Population. Below Bear Creek Dam, Bear Creek flows through the City of Sheridan, CO. Flood damages and flood damage potentials did not reach significant proportions until World War II when Denver entered an era of extensive growth. From 1940 to 1950 the city's metropolitan population increased by 155,000 and new suburban and commercial developments spilled out into the flood plains of the South Platte River and its tributaries. Table 4-10 lists the population changes from 1950-2010 for counties in the Bear Creek basin as well as the county total, Denver Primary Metropolitan Statistical Area (PMSA), and the State of Colorado for comparison. Many of the county populations in this area have increased three-fold from what it was in 1950. The Jefferson County population has increased almost ten-fold since 1950.

**Table 4-10
POPULATION 1950 THROUGH 2010 CENSUS**

Geographical Area	Census 1950	Census 1960	Census 1970	Census 1980	Census 1990	Census 2000	Census 2010
Clear Creek County	3,289	2,793	4,819	7,308	7,619	9,322	9,088
Denver County	415,786	493,887	514,678	492,365	467,610	554,636	600,158
Jefferson County	55,687	127,520	233,031	371,753	438,430	527,056	534,543
County Total	474,762	624,200	752,528	871,426	913,659	1,091,014	1,143,789
PMSA*	567,339	859,945	1,106,384	1,428,839	1,622,980	2,179,240	2,543,482
State of Colorado	1,325,089	1,753,947	2,207,259	2,889,964	3,294,394	4,301,261	5,029,196
Notes: Source of Census Data: U.S. Department of Commerce, U.S. Bureau of the Census. * The current Denver-Aurora-Lakewood Primary Metropolitan Statistical Area (PMSA) includes Adams, Arapahoe, Bloomfield, Clear Creek, Denver, Douglas, Elbert, Gilpin, Park and Jefferson counties. The Denver PMSA has expanded since 1950.							

b. Agriculture. According to the Colorado Department of Agriculture, as of 2012 agriculture in the State of Colorado annually contributes \$41 billion to the state's economy and employs nearly 173,000 people. Agriculture is very minor in the upper South Platte River basin above Bear Creek Dam due to the mountainous and arid nature of the countryside. The primary crops are hay and wheat; cattle are also maintained. Downstream of the City of Denver, there is an extensive irrigation network. Many areas rely on irrigation during the hot and dry summers. A variety of crops are grown including hay, wheat, barley, corn, vegetables, and sugar beets. Cattle, hogs, and sheep are maintained on many of the farms.

c. Industry. Table 4-11 lists the 2013 earnings for Colorado workers in major industrial classifications. According to the City and County of Denver, government website communications, utilities, and transportation are the chief industries. There is also an economic base in skiing, tourism, electronics, computers, and aviation. The Denver Federal Center is the most densely packed Federal area outside of Washington, DC. The center contains 26 Federal agencies.

Table 4-11
2013 EARNINGS BY WORKERS IN MAJOR INDUSTRIAL CLASSIFICATIONS
(IN THOUSANDS OF DOLLARS)

Earning Description	County Description									County Total % of State
	Adams County	Arapahoe County	Denver County	Douglas County	Jefferson County	Park County	Teller County	County Total	State of Colorado	
Accommodation and food services	318,712	613,144	1,391,747	252,108	523,733	6,712	48,193	318,712	6,445,904	4.9%
Administrative and waste management services	491,178	1,451,958	1,625,222	319,495	602,823	6,386	6,965	4,504,027	7,118,706	63.3%
Arts, entertainment, and recreation	40,193	379,992	624,511	89,993	90,550	816	29,779	1,255,834	2,371,135	53.0%
Construction	1,309,351	1,787,873	1,534,883	479,322	892,186	20,445	16,865	6,040,925	11,428,681	52.9%
Educational services	75,769	265,808	811,348	119,942	166,222	902	4,362	1,444,353	2,096,854	68.9%
Finance and insurance	222,599	3,221,484	4,075,780	775,745	694,398	3,133	10,923	9,004,062	12,115,913	74.3%
Forestry, fishing, and related activities	19,615	7,102	2,314	5,585	4,450	n/a	537	39,603	327,330	12.1%
Government and government enterprises	2,743,488	2,467,904	5,302,669	692,885	2,571,856	37,683	63,529	13,880,014	30,258,975	45.9%
Health care and social assistance	1,071,428	2,657,034	2,882,005	633,642	1,771,247	2,683	19,764	9,037,803	16,161,719	55.9%
Information	257,996	3,636,379	2,274,178	729,270	341,669	1,989	4,659	7,246,140	10,136,161	71.5%
Management of companies and enterprises	107,623	1,146,404	1,726,718	540,978	307,124	-	3,956	3,832,803	4,882,804	78.5%
Manufacturing	951,416	636,556	1,493,505	163,422	1,914,587	3,413	n/a	5,162,899	11,219,126	46.0%
Mining	73,807	821,830	4,228,672	147,877	118,904	n/a	n/a	5,391,090	7,939,962	67.9%
Other services, except public administration	558,832	950,036	1,247,540	306,958	589,976	15,343	21,178	3,689,863	6,811,006	54.2%
Professional, scientific, and technical services	575,778	3,862,891	5,919,239	1,380,279	2,213,307	13,680	32,547	13,997,721	22,714,903	61.6%
Real estate and rental and leasing	158,785	463,425	848,256	98,268	185,503	1,537	3,421	1,759,195	2,932,155	60.0%
Retail trade	790,983	1,600,194	1,247,820	576,040	1,027,178	9,406	27,818	5,279,439	10,207,543	51.7%
Transportation and warehousing	871,246	324,205	2,581,334	57,843	260,044	n/a	2,855	4,097,527	5,781,097	70.9%
Utilities	74,836	31,409	404,992	22,532	147,729	n/a	3,147	684,645	1,222,647	56.0%
Wholesale trade	1,254,689	1,589,371	2,461,913	463,362	816,842	5,586	3,517	6,595,280	9,241,101	71.4%

Data Source: Bureau of Economic Analysis www.bea.gov

d. Flood Damages. Plates 4-23 through 4-30e present curves for estimating the approximate magnitude of flood damages by impact area on the South Platte River and major tributaries downstream of Chatfield, Cherry Creek, and Bear Creek Dams and upstream of Henderson, CO with select flood inundation mapping in the same impact areas. Table 4-12 lists estimated flood damages, in 2014 dollars, for the same impact areas at flow rates of 2,000 cfs up to 20,000 cfs. Table 4-13 lists the flood damages prevented by each of the Tri-Lakes Projects since 1965. Construction of Cherry Creek was completed in 1951, however no damages prevented were noted until 1965.

Table 4-12
POTENTIAL FLOOD DAMAGES UPPER SOUTH PLATTE RIVER BASIN
 Adjusted to 2014 (\$1,000)

Impact Area		2,000 cfs	4,000 cfs	6,000 cfs	8,000 cfs	10,000 cfs	15,000 cfs	20,000 cfs
1	Bear Creek	347	974	4750	—	—	—	—
2	S. Platte to Bear Creek conf.	0	0	0	0	59	—	—
3	S. Platte to Cherry Creek conf.	0	0	3272	6810	18,997	68,102	—
4	Cherry Creek	0	1981	64,588	158,826	278,064	693,978	—
5	S. Platte to Sand Creek Conf.	0	4	14	17	19	22	32,705
6	S. Platte from Sand to Clear Creek	No damages estimated up to 30,000 cfs						
7	Clear Creek to Henderson, CO	—	58	102	138	184	371	619
8	Sand Creek	145	231	372	567	762	—	—
Damages represent the total estimated damage for the impact area and are displayed in \$1,000s.								

Table 4-13
FLOOD DAMAGES PREVENTED BY TRI-LAKES PROJECTS

Year	Unadjusted (\$1,000)				Adjusted to 2014 \$ (\$1,000)			
	Bear Creek	Chatfield	Cherry Creek	Tri-Lakes Total	Bear Creek	Chatfield	Cherry Creek	Tri-Lakes Total
1965*			130,000	130,000			1,148,872	1,148,872
1966			0	0			0	0
1967			0	0			0	0
1968			0	0			0	0
1969			0	0			0	0
1970			0	0			0	0
1971			0	0			0	0
1972			0	0			0	0
1973			27,000	27,000			131,467	131,467
1974			0	0			0	0
1975			0	0			0	0
1976		0	0	0		0	0	0
1977		0	0	0		0	0	0
1978		0	0	0		0	0	0
1979	0	0	0	0	0	0	0	0
1980	240	800	0	1,040	685	2,284	0	2,969
1981	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0
1983	210	1,080	6,256	7,546	488	2,510	14,541	17,539
1984	0	0	0	0	0	0	0	0
1985	0	65	11	76	0	148	25	173
1986	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0
1992	958	2,820	82	3,860	1,858	5,470	160	7,488
1993	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0
1995	729	788	93	1,610	1,295	1,398	165	2,858
1996	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0
2001	0	0	1,342	1,342	0	0	2,063	2,063
2002	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0
2013	84	0	5,160	5,244	88	0	5,410	5,498
2014	0	0	0	0	0	0	0	0
2015	1,199	96	2,876	4,171	1,199	96	2,876	4,171
TOTAL	3,420	5,649	172,820	181,889	5,613	11,906	1,305,579	1,323,098
* Cherry Creek was completed in 1951. No damages were prevented until the flood of 1965, thus the table begins with year 1965.								

SECTION 5

DATA COLLECTION AND COMMUNICATION NETWORKS

5-01. Hydro-Meteorological Stations. Multiple agencies maintain an extensive system of reservoir, stream, and precipitation gages within the State of Colorado that are continually being updated and improved. These agencies include the: USGS, NWS, United States Bureau of Reclamation (USBR), NRCS, CDWR, Corps and Mile High Flood District (MHFD) previously known as Urban Drainage and Flood Control District (UDFCD). Section 4-06 identifies the most relevant streamgage rating curves, which are also shown on Plates 4-15 through 4-20.

a. Facilities.

(1) Streamgages. The USGS, USBR, and CDWR publish discharge records at 313 streamgage locations in the South Platte River basin in Colorado. Some of the streamgage maintenance costs, for which their data is published by the USGS and CDWR, are funded by local agencies such as the DWB, the City of Aurora, and other private interests. Many of these streamgages are not extensively used for the regulation of Bear Creek Reservoir because they are located outside of the Bear Creek Reservoir drainage basin and the Denver, CO metropolitan area. About 24 of these streamgages are considered when regulating Bear Creek Reservoir. Field operations at the sites are primarily performed by the USGS, Corps, and State of Colorado. Other streamgages are operated by various agencies and private interests. The number of streamgages varies from year to year. See Plate 5-1 for a listing and location of the principal streamgages. Table 5-1 lists the streamgaging stations most useful to the regulation of Bear Creek Reservoir.

(2) Precipitation Gages. The NWS publishes precipitation records for 33 stations in the South Platte River basin. The MHFD publishes precipitation records for 149 stations in the South Platte River basin. Plate 5-2 shows the location of the NWS and MHFD precipitation gages located in the Bear Creek Reservoir drainage basin that are of specific interest to the regulation of Bear Creek Reservoir. The primary source of rainfall information is the NWS.

Table 5-1
STREAM AND RESERVOIR GAGING STATIONS
(Useful to Bear Creek Reservoir Regulation)

Stream	Station	Drainage Area (sq mi)	Operating Agency
South Platte River	South Platte	2,579	State
South Platte River	Waterton	2,621	State
Plum Creek	Louviers	316	USGS
South Platte River	Chatfield Reservoir	3,018	Corps
South Platte River	Below Chatfield Dam	3,018	State
South Platte River	Below Union Ave.	3,098	USGS
Bear Creek	Morrison	164	State

Bear Creek Dam and Reservoir Water Control Manual

April 2020

Stream	Station	Drainage Area (sq mi)	Operating Agency
Bear Creek	Bear Creek Reservoir	236	Corps
Bear Creek	Below Bear Creek Dam	236	State
Bear Creek	Sheridan	260	State
South Platte River	Englewood	3,391	USGS
Cherry Creek	Franktown	169	USGS
Cherry Creek	Cherry Creek Reservoir	386	Corps
Cherry Creek	Denver	410	USGS
South Platte River	Denver	3,804	State
South Platte River	Commerce	3,895	USGS
Clear Creek	Golden	399	State
Clear Creek	Derby	575	State
South Platte River	Henderson	4,713	State

(3) SNOTEL and Snow Courses. The NRCS and State of Colorado, in cooperation with other agencies, maintain a network of SWE measurement sites in the mountainous areas of the South Platte River basin. This network includes both automated SNOTEL and snow course sites. SNOTEL observations are automatically transmitted daily via satellite. Snow course observations are made manually, monthly or semi-monthly, starting on February 1 and continuing through May 1 and may be used if the SNOTEL data is incomplete. Plate 5-1 shows the SNOTEL and snow course stations for the South Platte River basin.

(4) Reservoir Data. The Bear Creek Reservoir pool elevation is measured with a pressure sensor located inside the dome structure and connected to a Data Collection Platform (DCP). Since the mid-1980s, a DCP has been used at the dam to automatically collect and transmit the pool elevation and precipitation data via satellite telemetry. A staff gage is attached to the intake structure and is used to verify the pool elevation. The Bear Creek Dam tailwater elevation is measured with a pressure sensor located at the streamgage downstream of the dam. The current Bear Creek Reservoir elevation can also be obtained via telephone by calling the DCP at 303-986-7304.

(5) Denver Weather Station. The Bear Creek Project evaporation model, as described in Section 4-02.f, relies on data from the METeorological Aerodrome Report (METAR) from the Denver Weather Station. The data used by the evaporation model from the weather station are:

- Cloud Cover (high, medium and low)
- Cloud Elevation (high, medium and low)
- Relative Humidity
- Air Pressure
- Wind Speed
- Air Temperature

(6) Other Basic Hydro-Meteorological Data. River, rain, and snow stations are the principal sources of reservoir regulation hydro-meteorological information. Other items of use are also available from other “value-added” type weather information services. These include radar, satellite, and weather chart information.

(7) Gridded Data. The NWS provides real-time observed and forecast gridded precipitation, SWE, and air temperature for use in real-time modeling. The gridded data is geographically distributed over the South Platte River basin with respect to time and can be used for more accurate model simulations and reservoir forecasting.

b. Reporting. The automated DCPs located throughout the basin transmit river stage, reservoir elevation, and precipitation data via a Geostationary Operational Environmental Satellite (GOES) to the Omaha District’s downlink and to the downlink at the NOAA National Environmental Satellite, Data, and Information Service (NESDIS). The WCWQS computer server located in Omaha, NE receives this data and stores it in a water control database, which provides accurate up-to-date information as needed during critical periods of regulation. Plate 5-3 illustrates the data system collection. The data system allows for monitoring of the pool elevations at Chatfield, Cherry Creek, and Bear Creek Reservoirs, and the river stage, precipitation, and evaporation parameters such as wind speed and air temperature throughout the basin. The current pool elevations at Chatfield, Cherry Creek, and Bear Creek Reservoirs can also be retrieved via a telephone directly connected to the DCPs. The current Bear Creek Reservoir pool elevation can be retrieved via telephone by calling 303-986-7304. If communication between the WCWQS and the Tri-Lakes Project Office is lost, the Emergency Operation procedures, as listed in Exhibit I, *Standing Instructions to the Dam Tender*, will be followed. Exhibit I includes a detailed listing of routine and flood observations to be made by the Dam Tender, the frequency of observations, and the manner in which they will be reported.

The automated DCPs are programmed to transmit 15-minute readings once every hour. The 15-minute data is automatically converted to hourly and daily data via the Corps Computation Processor (CCP) within CWMS. This data is used to determine the daily change in storage. Hourly and daily inflows are then automatically computed by CCP on the basis of storage changes and releases. The WCWQS uses this data to prepare a Monthly Reservoir Report for Bear Creek Reservoir, which contains the official daily elevation, inflow, and outflow; Plate 5-4 provides an example of the report. The daily inflow calculation includes modeled evaporation. See Section 4-02.f. for further information on the evaporation model.

When significant precipitation occurs, the data stored in CWMS, such as real-time river conditions, pool elevations, estimated rainfall, and SWE data, is used by the WCWQS for water management model simulations and decision making.

c. Maintenance. The USGS, NWS, USBR, NRCS, MHFD, State of Colorado, and Corps contribute personnel, equipment and/or funds to support the data collection and communications system.

The gaging stations at Chatfield, Cherry Creek, and Bear Creek Reservoirs are maintained by the WCWQS with support from the USGS. A cooperative streamgaging program is maintained by the State of Colorado, USGS, and the Corps. Open water rating curves are prepared by the State of Colorado and the USGS and are furnished to the Corps. Plates 4-15 through 4-20 show rating curves of the South Platte River and Bear Creek. These curves should only be used as an approximation. The stage-discharge relationship, as defined by the rating curves, are shifted as the river channel changes. The ratings are kept current via field measurements by the State of Colorado and the USGS. The current ratings are on file with the WCWQS for use in making regulation decisions.

5-02. Water Quality Stations. The BCWA is responsible for water quality monitoring in the basin. The BCWA and its membership have three separate monitoring efforts underway: (1) routine stream and reservoir sample program as defined in the BCWA's control regulation with sample sites on Bear Creek above the reservoir, below the reservoir, on Turkey Creek inflow, and at a vertical reservoir station located at the center of the reservoir, (2) special reservoir sampling by the City of Lakewood to maintain the in-reservoir aeration system and detail reservoir dynamics in the growing season, and (3) special Bear Creek stream monitoring to assess temperature, ammonia, and aquatic life stressor chemistry. The primary growing season assessment was extended to year-round in October 2004. Persons interested in water quality conditions at Bear Creek Reservoir can visit the website maintained by the BCWA at <http://www.bearcreekwatershed.org/>. The BCWA maintains a monitoring plan that meets rigorous quality assurance protocols and shares data with the Corps as requested.

5-03. Sediment Stations. No sediment sampling is done by the Corps at this project. As shown on Plate 4-3, 12 sediment ranges are located on Bear Creek Reservoir. The range lines are resurveyed periodically to update the reservoir surface area and volume capacity. The results are compared to original projections of sediment depletion that determine the remaining life of the project. Surveys for Bear Creek Reservoir were completed in 1984, 1987, 1997, and 2009. New reservoir surface area and volume capacity tables based on a 2016 survey are scheduled to be made effective in 2020.

5-04. Recording Hydrologic Data. CWMS is the Omaha District's primary data management system. CWMS was developed by the Corps' Hydrologic Engineering Center (HEC) and uses an Oracle database to store river, reservoir, and weather data.

5-05. Communication Network. The Corps maintains contact, anywhere from weekly to daily, with the Colorado State Engineer's Office for water rights releases from Bear Creek Dam. Periodic contact, mostly during flooding situations, is also maintained with the State of Colorado, NWS, USGS, USBR, and local agencies such as cities, counties, and state parks. The WCWQS has the following communication facilities:

a. Telephone. The primary means of direct contact with personnel at the Tri-Lakes Project Office located at Chatfield Dam is a commercial telephone or cellular phone. A phone list of relevant personnel is presented on page vi of this manual.

b. Email. Routine contact between the Omaha District and Tri-Lakes Project Office is made via email.

c. Hydrologic Data. Telephone and email contact with the Tri-Lakes Project Office and other local agencies can provide on-site information that give a general assessment of the basin and hydrologic conditions. There is no remote gate control operation at Bear Creek Dam, and no emergency warning systems have been installed. However, the Corps and local emergency management officials meet regularly to discuss the Corps' Emergency Action Plan (EAP) and the local emergency management evacuation plans.

5-06. Communication with Project. The Colorado State Engineer's Office maintains a staff of hydraulic engineers to administer the waters of the state. Regulation of Bear Creek Reservoir requires coordination between the state and the Corps to ensure that, insofar as practical, Bear Creek Reservoir regulation is compatible with state water administration. Project operating data, streamflow measurements, precipitation, and evaporation information are exchanged and coordinated among all parties.

Attachment 2 of Exhibit I, *Standing Instructions to the Dam Tender*, shows a directory of regulation personnel in the Omaha District, Tri-Lakes Project Office and Colorado State Engineer's Office.

5-07. Regulating Office with Project Office and Others. ER 1110-2-1400, *Reservoir/Water Control Management*, dated May 30, 2016, assigns the Corps' reservoir regulation responsibilities in the Missouri River basin to the Northwestern Division (NWD) Commander. ER 1110-2-1400 also permits delegation of certain reservoir regulation responsibilities to the District Engineer, in whose area of responsibility the project is located. The responsibilities for assembly and interpretation of data affecting current reservoir regulation and for carrying out routine regulation of Bear Creek Reservoir according to plans agreed to in advance have been delegated to the Omaha District Engineer. The NWD Commander, through the Missouri River Basin Water Management (MRBWM) office, monitors and reviews the regulation activities performed by the Omaha District. The responsibility for the regulation and all associated activities within the District Office is assigned to the WCWQS. Plate 5-5 illustrates the normal coordination for the Omaha District with regard to regulation of the Bear Creek Project.

All gate changes made at Bear Creek Dam are recorded by the Tri-Lakes Project Office in a *Dam Tender's Reservoir Regulation Report* (see Plate 5-6). The issuance of regulation orders is the function of the WCWQS; however, requests for regulation of project releases may also originate from the Colorado State Engineer's Office as a result of water rights administration primarily in the multipurpose zone. All requests will be referred to the WCWQS for approval and issuance of regulation orders when in the flood control zone. Requests for regulation of releases originating with the State Engineer's Office are made by telephone or email for concurrence and issuance of the formal regulation orders. Verbal or email issued regulation orders will be confirmed via a signed memorandum as soon as possible during the next work day. In the event the State

Engineer's Office cannot make contact with the WCWQS, requests can be made directly to the Dam Tender, who will confirm the order with the WCWQS as soon as practical.

It is not anticipated that any emergency regulation other than that provided in Section 7-05 will be required. However, under the provisions of Condition C of Exhibit I, *Standing Instructions to the Dam Tender*, communication failure during a flood event may occur and isolate the Dam Tender, thus making that individual the sole operating organization for the project. The *Standing Instructions to the Dam Tender* provide detailed instructions for regulation of project releases and storage under such emergency conditions. In the event of communication failure the Dam Tender may communicate via cellular telephone or by vehicular travel between offices.

Daily project operating data and miscellaneous hydrologic information are exchanged between the Colorado State Engineer's Office, the Colorado Division of Wildlife, and the Corps. The Tri-Lakes Project Office and WCWQS shall be kept apprised by the State Engineer's Office regarding the needs for regulation of releases and water storage in the multipurpose zone.

5-08. Communication Between Project Office and Others. The Colorado State Engineer's Office normally maintains a staff of hydraulic engineers to administer the waters of the state. Regulation of Bear Creek Reservoir during non-flood periods, below elevation 5559.0 ft PD, requires coordination between the State of Colorado and the Corps to ensure that, as soon as practical, Bear Creek regulation is compatible with state water administration. Project operating data, streamflow measurements, and precipitation and evaporation information are exchanged and coordinated among all parties. In the event of communication failure, the Dam Tender may communicate via cellular telephone or by vehicular travel between offices.

5-09. Project Reporting Instructions. The Tri-Lakes Project Office will notify the WCWQS, as soon as practical, regarding confirmation of gate settings, including gate openings, releases, time, and date. Whenever possible, while coordinating gate changes, the Tri-Lakes Project Office will transmit any information they have gathered relative to any concerns, complaints, or any other pertinent information to the WCWQS. During flood regulation, the Tri-Lakes Project Office and WCWQS coordinate all information related to the regulation decision. All gate changes made at Chatfield Dam are logged on the *Dam Tenders Reservoir Regulation Report*. An example report can be found on Plate 5-6. The form is available to the WCWQS on the Tri-Lakes Project Office shared drive.

5-10. Warnings. Warnings of impending releases will be issued as soon as possible before the release by the Tri-Lakes Project Office from a list of contacts maintained by this office. The Tri-Lakes Project Office will notify the WCWQS of any problems with the impending release. If prolonged or intensive releases are scheduled, the WCWQS may issue a press release if necessary. In addition, the WCWQS provides project release forecasts to the NWS during flood events to be incorporated into downstream river forecasts.

SECTION 6

HYDROLOGIC FORECASTS

6-01. General. Regulation of Bear Creek Reservoir requires the scheduling of releases and storage largely on the basis of observed and anticipated hydrologic events in the Bear Creek basin. Flood control releases are predicated on the use of project flood control storage capacity to prevent, insofar as possible, river flows exceeding those that will cause damage at downstream locations. Runoff forecasts will be used largely for the purpose of evacuation of storage from Bear Creek Reservoir. Forecasts of reservoir inflow from rainfall-only events are extremely challenging due to the very rapid time of concentration and the cloudburst characteristics of storms in the vicinity. Forecasts of reservoir inflow volume from mountain snowmelt are more reliable; however timing can be challenging due to temperature and precipitation impacts. While forecast procedures will be used to the maximum extent practical, actual scheduling of releases will generally be based on conditions observed at the time, due to the unpredictability coupled with the very short travel time to major downstream damage centers.

a. Role of the Corps. Using as much of the available hydro-meteorological information as possible, the WCWQS generates an event-driven inflow forecast for Bear Creek Reservoir. This process includes obtaining and coordinating any pertinent information such as snowpack and runoff forecasts from various agencies for the purpose of making inflow and pool level forecasts. The WCWQS will also prepare an event-driven downstream forecast using information from the NWS, MHFD, DWB, as well as any other information useful for the compilation of streamflow forecasts for Bear Creek and the South Platte River.

b. Role of Other Agencies. The preparation and distribution of forecasts to the general public relating to precipitation, temperature, river stages, and other meteorological elements are official functions of the NWS. The NWS prepares and transmits numerous forecasts of weather and river conditions throughout each day.

6-02. Flood Condition Forecasts.

a. Requirements. Close liaison is maintained between the WCWQS and the NWS. NWS satellite, radar, and forecast data are stored in the WCWQS CWMS database. WCWQS personnel continually monitor the NWS forecasts to obtain warnings of impending storms. Past experience has indicated that the Bear Creek basin is subject to highly intense localized storms. Historically, the remoteness of the upper South Platte River basin and the associated delay in receipt of hydrologic data made it extremely challenging to develop an adequate procedure for real-time forecasting of flood inflows. However, now that spatial radar precipitation estimates are more readily available and a spatial rainfall-runoff model for the upper South Platte River basin exists, the ability to produce skillful inflow forecasts has increased. The upper South Platte River CWMS modeling suite was developed in FY13 and can be used to generate inflow and reservoir operation forecasts. When necessary, downstream inundation mapping can be produced. The WCWQS uses the following meteorological

items as short-range and long-range forecasts of impending flood situations for advance alerting and/or staffing of personnel to operate the project as the severity of forecasts may indicate:

(1) Quantitative Precipitation Estimates and Precipitation Point Values. Each morning the NWS MBRFC generates and disseminates a gridded estimate of Missouri River basin precipitation for the previous day. The gridded precipitation is generated based on precipitation gage-biased radar data. The MBRFC also provides daily precipitation totals for all precipitation gages in the Missouri River basin.

(2) Quantitative Precipitation Forecasts. Each morning the MBRFC generates and disseminates Missouri River basin gridded forecasts of precipitation amounts in 6-hour time steps for the next five days (120 hours).

(3) Temperature Estimate. Each morning the MBRFC generates and disseminates hourly Missouri River basin gridded estimates of temperatures for the previous day. Estimates are generated based on point value data across the basin. The Corps' ERDC-CRREL reformats the grids to make them compatible with HEC-HMS (Hydrologic Modeling System) snowmelt modeling.

(4) Temperature Forecast. Each morning the MBRFC generates and disseminates hourly Missouri River basin gridded forecasts of temperature for the next 15 days (360 hours). Similar to the gridded temperature estimates, the Corps' ERDC-CRREL reformats the grids to make them compatible with HEC-HMS snowmelt modeling.

(5) Snow Water Equivalent (SWE). The NWS National Operational Hydrologic Remote Sensing Center (NOHRSC) generates and disseminates modeled daily SWE grids for the contiguous U.S. The Corps' ERDC-CRREL, in cooperation with HEC, reformats the grids and packages them with the required initial state grids, such as Cold Content Antecedent Temperature Index (CC-ATI) for the Missouri River basin to make them compatible with HEC-HMS snowmelt modeling.

(6) Seven-Day Point Forecast. The NWS generates an extended forecast summary each day for cities across the Missouri River basin.

(7) Regional Weather Summary. The NWS Boulder, CO Weather Forecast Office (WFO) issues an abbreviated language situation report and forecast changes for the next 24 hours on an event-driven basis.

(8) Area Forecast Discussion. The NWS Boulder, CO WFO issues an abbreviated plain language forecast of meteorological features.

(9) Weather Outlooks. The NWS Climate Prediction Center issues 6- to 10-day, 8- to 14-day, 30-day and seasonal 90-day outlook maps, which extend from 1 to 13 months into the future. The maps provide the expected deviation from normal conditions for precipitation and temperature across the United States. The 6- to 10-day and 8- to 14-day outlooks are issued daily while the monthly and seasonal outlooks are issued at the end of each month.

(10) Other Forecast Procedures. A meteorologist and hydraulic engineers with basic meteorological background are employed by the Omaha District, Hydrologic Engineering Branch to further analyze available information and prepare specialized forecasts not available from the NWS. The meteorological staff also interprets the aforementioned official NWS forecasts to alert District personnel of impending flood conditions. During flood events the meteorological staff assist WCWQS personnel by monitoring flood crest movement and hydro-meteorological conditions.

b. Methods. The following paragraphs describe the current methods and procedures to develop real-time hydrologic forecasts.

(1) Computer Applications. Models are used to forecast inflows and facilitate reservoir regulation decision making. There are two HEC-HMS models, and both use the gridded data described in Section 6-02.a. One of the HEC-HMS models is a snowmelt and rainfall model that includes the South Platte River basin above Waterton, CO. The other HEC-HMS model is a rainfall-driven model that includes the South Platte River basin from Waterton, CO downstream to Henderson, CO. This model includes Plum Creek, Cherry Creek, Bear Creek, Sand Creek, Clear Creek, and a portion of the South Platte River through Denver, CO. The HEC-HMS models are linked to the HEC-ResSim (Reservoir System Simulation) model, which is used to determine the Tri-Lakes system evacuation rates. HEC-RAS (River Analysis System) and HEC-FIA (Flood Impact Analysis) models are used to determine inundated areas and consequences, respectively, downstream of the Chatfield, Cherry Creek, and Bear Creek Dams. The HEC-RAS and HEC-FIA models were used to develop stage-damage relationships in 2015 (see Section 4-09.d.).

The CWMS database contains reservoir and river data, such as elevations, inflows, releases, and streamflow. CWMS also has the capability to provide decision support information needed to accomplish the water management mission. CWMS is a client-server system that uses an Oracle Solaris platform on the server side and Microsoft Windows on the client side for the Control and Visualization Interface (CAVI). Hardware and software configuration are customized for each District, but contain the same basic structure of major system components. The major components of CWMS are:

- **Data Acquisition (DA)**, which is the component that receives and processes incoming real-time hydro-meteorological data, transforms and validates data, and prepares data for insertion into the database.
- **Database (DB)**, which consists of the components that provide insertion, storage, and retrieval of CWMS data in the Oracle relational database.
- **Data Dissemination (DD)**, which is the component that retrieves data from the Oracle database, and delivers data, text, and graphic products to other system users, primarily via the internet.
- **Control and Visualization Interface (CAVI)**, which is the component that enables users to perform data validation, data visualization, and modeling analysis.

The HMS, ResSim, RAS, and FIA models are linked together through the CAVI. The CAVI allows the user to simulate a variety of scenarios with different precipitation

events, runoff conditions, and reservoir operations. The HMS model is used to determine runoff upstream and downstream of the dam; ResSim performs the reservoir regulation simulation; RAS determines downstream stage levels and is used to create flood inundation mapping; and FIA performs flood impact analysis and determines consequences.

(2) Unit Hydrographs. Hydrographs of 1 in of uniformly distributed runoff for a rainfall duration of 3 hours were developed for several key locations in the Bear Creek Dam vicinity. Table 6-1 lists the unit hydrograph ordinates. The unit hydrographs were compared and adjusted to conform to runoff characteristics indicated by actual streamflow records. See the Chatfield Design Memo PC-2 dated August 1966 for a description of the derivation of the graphs. Flood peaks from many existing detailed records are from partial area storms and are of questionable reliability in expanding to unit hydrograph magnitude.

Plate 6-1 shows the unit hydrograph for the Cherry Creek basin at Cherry Creek Dam. Plate 6-2 also shows the Bear Creek tributary unit hydrograph routed to the South Platte River at Denver streamgage near the mouth of Cherry Creek. Plate 6-3 shows the routed Clear Creek unit hydrograph to the South Platte River at Henderson streamgage. Plate 6-5a shows unit hydrographs of the South Platte River basin above the Tri-Lakes Projects; Plate 6-5b shows the subbasin delineation. As the flood progresses and gage heights become available, the hourly discharge values can be translated to the Denver or Henderson streamgage locations by the lag-average procedure summarized in Table 6-2.

**Table 6-1
3-HOUR UNIT HYDROGRAPH ORDINATES (cfs)**

Hour	Bear Cr at Bear Cr Dam	Bear Cr at Sheridan	Bear Cr Routed to Denver	Cherry Cr at Cherry Cr Dam	Incremental Area above Denver	Clear Cr at Derby	Clear Cr Routed to Henderson
0	0	0	0	0	0	0	0
1	1,400	600	0	1,000	3,300	900	0
2	6,667	3,700	500	5,333	9,700	4,000	400
3	16,433	8,600	2,800	14,167	14,400	10,500	2,900
4	27,700	14,300	6,300	26,500	14,130	20,000	7,600
5	31,633	18,600	10,100	37,933	10,070	29,500	13,200
6	27,867	21,800	12,800	42,633	7,230	34,500	18,000
7	18,467	23,300	14,700	40,633	5,830	34,900	21,600
8	10,900	22,300	16,000	33,933	5,070	32,600	24,400
9	5,567	18,400	16,400	27,267	4,570	30,800	27,300
10	2,300	13,100	15,900	20,533	4,170	29,300	29,000
11	667	7,900	14,500	13,833	3,770	27,800	29,300
12	0	4,100	12,600	7,667	3,430	25,500	28,100
13		1,800	10,200	3,233	3,100	21,900	25,700
14		600	7,500	867	2,770	16,400	22,700
15		100	5,000	167	2,470	11,200	19,600
16		0	3,000	0	2,170	7,100	16,400
17			1,400		1,900	4,100	13,200
18			500		1,630	2,100	10,100
19			0		1,400	800	7,200
20					1,170	200	4,800
21					900	0	3,000
22					600		1,700
23					0		1,000
24							500
25							200
26							0

Table 6-2
SOUTH PLATTE RIVER TRIBUTARY LAG AVERAGES

	No. of Hourly Discharges Averaged	Lag in Hours	
		To Denver	To Henderson
Chatfield Dam releases	3	6	
Bear Creek at Bear Creek Dam	9	5	
Bear Creek at Sheridan	9	3	
Cherry Creek Dam Releases	3	6	
South Platte River at Denver	3		6
Clear Creek at Derby	9		3

6-03. Conservation Purpose Forecasts. No special conservation purpose forecasts are prepared for Bear Creek Reservoir.

6-04. Long-Range Forecasts. Forecasts of water supply and extended period runoff for the Missouri River basin in Colorado are issued by several agencies on a monthly basis.

a. **National Weather Service.** Starting in January each year and for the succeeding months through May, the NWS issues *Water Supply Outlook for the Western United States*. This publication presents runoff forecasts at pertinent points based on an analysis of precipitation, SWE, and runoff. The volume forecasts are issued in three categories: most probable, reasonable maximum, and reasonable minimum. The forecast points pertinent to Bear Creek Reservoir regulation are South Platte River at South Platte (below Cheesman), Plum Creek near Sedalia, Bear Creek at Morrison, Cherry Creek near Franktown, and Clear Creek at Golden.

b. **Natural Resources Conservation Service.** The NRCS publishes a report following each of the principal snow survey dates from January 1 through June 1. The report, titled *Colorado Water Supply Outlook Report*, contain snow survey data and select streamflow volume forecasts including the upper South Platte River basin.

c. **U.S. Bureau of Reclamation.** Water Supply Monthly Operation forecasts for the Colorado and Big Thompson River basins are published by USBR on the first of each month throughout the year. No forecast is created for the upper South Platte River basin by the USBR as there are no USBR projects in this area.

d. **The Corps.** The majority of the annual inflow into Bear Creek Reservoir results from mountain snowmelt. The WCWQS developed a snowmelt volume forecast method for the May-July runoff on Bear Creek at Morrison, CO. The method was based on a 27-year period of record from 1949 through 1975, but is no longer used for regulation of the Bear Creek Project. The CWMS model described in Section 6-02.b.(1) can be used for long-range inflow volume forecasts.

6-05. Drought Forecasts. No special drought forecasts are prepared for Bear Creek Reservoir by the Corps.

SECTION 7

WATER CONTROL PLAN

7-01. General Objectives. ER 1110-2-1400 assigns the Corps' reservoir regulation responsibilities in the Missouri River basin to the NWD Commander. ER 1110-2-1400 permits delegation of certain reservoir regulation responsibilities to the District Engineer in whose area the project is located. The responsibilities for assembly and interpretation of data affecting current reservoir regulation and for carrying out routine regulation of Bear Creek Reservoir, according to plans agreed on in advance, have been delegated to the Omaha District Engineer. The NWD Commander, through the MRBWM office, monitors and reviews the regulation activities performed by the Omaha District.

Exhibit II, *Memorandum of Understanding between the United States of America and the State of Colorado on Regulation for Bear Creek Dam and Reservoir*, describes the Bear Creek Reservoir regulation responsibilities for different pool elevations and reservoir zones.

Bear Creek Reservoir is regulated for flood control primarily to mitigate flood risk to the metropolitan area of Denver from floods originating on Bear Creek upstream of the dam and will also be regulated to provide for general recreation and fish and wildlife purposes. Project regulation for these purposes is described in the following sections.

7-02. Constraints. The control point for Bear Creek Reservoir regulation is a 5,000-cfs maximum flow target at the South Platte River at Denver streamgauge when Cherry Creek Reservoir has not reached elevation 5590.0 ft PD. It is important to note that the 5,000-cfs flow target includes Cherry Creek Dam and Chatfield Dam releases as well as incremental runoff downstream of each of the dams. Flood control operation is described in detail in Section 7-05.

Channel capacity varies widely downstream of the dam. Maximum channel capacity on Bear Creek downstream from the dam is approximately 1,000 cfs. The South Platte River through the City of Denver was improved with flood walls to contain incremental runoff. The improvements were not made to increase releases from the Tri-Lakes Projects. The estimated non-damaging capacities range from 10,000 to 30,000 cfs in Denver. In the rural areas downstream of Denver, the natural channel flows wide and shallow and the existing non-damaging channel capacity is less than 5,000 cfs in some high-yield agricultural areas. Protection afforded these areas downstream of the Denver metropolitan area will not be as great as that through Denver. The maximum flow target at the South Platte River at Denver streamgauge continues to be 5,000 cfs when Cherry Creek Reservoir has not reached 5590.0 ft PD. To reduce the potential risk of dam failure as a result of an extreme flood, the Cherry Creek Dam release will be increased to 7,000 cfs when the reservoir exceeds elevation 5590.0 ft PD, as described in Section 7-05.

Downstream channel concerns, gate vibration, manpower needed to make gate changes, and required flow travel time to lessen the impact to downstream areas are items that may constrain operations.

After completion of the Bear Creek Project, extensive commercial and residential development has occurred in the Bear Creek flood plain downstream of the dam. Non-damaging channel capacities have been restricted by encroachment and major damage will occur in the event of spillway use. If spillway flow occurs, public safety in these areas could also become a concern.

Simultaneous Cherry Creek, Bear Creek, and Chatfield Dams' flood control releases require close coordination. Issues may arise in maintaining appropriate storage balances considering storm recurrence and reservoir and basin conditions within each project.

7-03. Overall Plan for Water Control.

a. Storage Allocations. Table 7-1 summarizes the allocation of storage space in Bear Creek Reservoir. Plate 7-1 schematically shows reservoir storage zones and elevations.

Table 7-1
RESERVOIR STORAGE ALLOCATION ZONES

Reservoir Zone	Elev. Limits (ft PD)	Capacity (af)*
Surcharge Storage	5635.5-5684.5	46,955
Exclusive Flood Control Storage	5558.0-5635.5	28,514
Multipurpose Storage	5528.0-5558.0	1,771
Inactive Storage	5510.0-5528.0	53
* 2009 Sediment Survey PD=Project Datum		

The normal regulation of Bear Creek Reservoir involves responsibilities of the State of Colorado and of the Corps. The State Engineer's Office tracks water rights on Bear Creek and the South Platte River and makes requests for releases to the WCVQS. Exhibit II, *Memorandum of Understanding between the United States of America and the State of Colorado on Regulation for Bear Creek Dam and Reservoir*, describes the operation of Bear Creek Reservoir for different pool elevations and reservoir zones. Per Section 4.b. of this memorandum, regulation of the waters in the first foot of the exclusive flood control zone, from elevation 5558.0 to 5559.0 ft PD, is determined by the State Engineer.

Since the top of the multipurpose zone, elevation 5558.0 ft PD, is also the crest of the ungated weir, no specific regulation of the water levels is anticipated when the pool elevation is in the 1-foot zone from 5558.0 to 5559.0 ft PD. Regulation for conservation will normally be automatic in that incoming water will flow via gravity over the weir crest. However, when the pool elevation is below the elevation of the weir, low-level releases may need to be made for water rights administration. Two low-level gated outlets are provided to permit releases of water from the multipurpose zone for reservoir drawdown, if the need arises. Fine regulation of low flow releases will be completed by a gate-within-a-gate (1-sq ft opening) on each of the two service gates in the gate structure.

b. State of Colorado Responsibilities. The State of Colorado will be represented by the Colorado State Engineer's Office of the CDWR. As requested by the State Engineer's Office, during non-flood periods below elevation 5559.0 ft PD, releases will be made to supply irrigation and/or water supply diversions and normal river flows insofar as water is available. To satisfy these rights, the State of Colorado has specified that, insofar as practical, the reservoir should be regulated so that reservoir inflow equals outflow, except during periods of flood operations.

c. Corps' Responsibilities. The operation of Bear Creek Reservoir involves two units of the Corps as described in Sections 7-03.c.(1) and 7-03.c.(2) of this manual. Additional responsibilities of the Corps are outlined below.

(1) Water Control and Water Quality Section, Engineering Division. WCWQS is responsible for matters pertaining to the regulation of Bear Creek Reservoir. The WCWQS prepares the official forecasts for the Corps. Throughout the year, the WCWQS monitors reservoir release requests made from the multipurpose zone by the State Engineer's Office. When the pool level is in, or forecasted by the WCWQS to enter the exclusive flood control zone, the WCWQS is responsible for scheduling reservoir releases to attain optimum flood control benefits and control of project storage to ensure regulation in conformance with the authorized functions of the project. The WCWQS is responsible for procurement of necessary snowpack, precipitation, streamflow, and reservoir elevation data, while also making advanced estimates of streamflow from snow cover and/or rainfall reports for regulation purposes, and to alert field operating personnel of potential flood occurrences. The WCWQS prepares the official daily elevation, inflow, and release for Bear Creek Reservoir. Issuance of reservoir regulation orders is also performed by the WCWQS.

(2) Tri-Lakes Project Office, Operations Division. The Operations Division plans and directs the maintenance and physical operation of the project. This Division establishes the standards of maintenance and provides proper staffing of operating personnel at the Tri-Lakes Project Office to accomplish these objectives. The Tri-Lakes Project Office staff performs all gate changes at Bear Creek Dam. This office has agreed to initiate email or telephone correspondence for reservoir releases in excess of 500 cfs with the MHFD, a local agency that coordinates releases with local county emergency managers.

(3) Flood Period Organization. The normal organization of the Omaha District is somewhat modified during a flood period to cover the additional duties made necessary by

the flood emergency. These duties are to: (1) regulate the flood control reservoirs for maximum risk mitigation, (2) collect and disseminate flood information, (3) protect the Corps' property and works, (4) obtain engineering data, and (5) in extreme emergency, assist in relief and rescue work. These activities take precedence over normal work and are performed by those employees of the District who have been trained for specific emergency duties. In case of localized flooding in a reservoir-controlled basin, such as Chatfield Reservoir, Bear Creek Reservoir, or Cherry Creek Reservoir, only those units of the Omaha District organization concerned with the normal operation of the reservoir are placed in an emergency status. A directory of regulation personnel is shown in Exhibit I, *Standing Instructions to the Dam Tender*.

(4) Regulation Orders. When it is the responsibility of the State of Colorado as indicated above, the State Engineer's Officer will contact the WCWQS for a regulation change due to downstream water rights. The State Engineer's Office determines the necessary release with approval from the WCWQS. The WCWQS then contacts the Tri-Lakes Project Office with the regulation change. In the event the State Engineer's Office cannot make contact with the WCWQS, requests can be made directly to the Dam Tender, who will confirm the order with the WCWQS as soon as practical. The two Corps offices discuss the regulation change, and as long as there are no constraints, the change is performed. All regulation orders will normally be issued verbally and then confirmed in writing, and electronically shared with the Tri-Lakes Project Office by the WCWQS as official signed orders as soon as possible. Tri-Lakes Project Office personnel will record the gate setting for each gate change in the pool report spreadsheet, which can be accessed by the WCWQS to complete the written order. A copy of all orders issued by the WCWQS will be furnished to the State Engineer's Office and the Tri-Lakes Project Office. Under normal circumstances, this copy will contain a brief statement outlining the background and reasons for issuance of the order. In the case of a dam safety issue or major flood control release, the signed reservoir regulation order should contain sufficient details to describe the reasoning of the reservoir regulation decision. In the case of a deviation from the Bear Creek Dam WCP, the reservoir regulation order should note that a signed deviation approval from the MRBWM office has been acquired.

(5) Coordination with Other Agencies. Daily project operating data and miscellaneous hydrologic information will be exchanged among the Tri-Lakes Project Office, the State Engineer's Office and the WCWQS. Project release forecasts are provided to the NWS during flood events to be incorporated into downstream river forecasts. Cooperation is also maintained with the USGS and CDWR relative to the collection and reporting of precipitation amounts and stream stages and flows. The NRCS provides snow survey data and select inflow volume forecasts, and the NWS provides precipitation and streamgauge forecasts.

(6) Communication. Telephone and email facilities are presently available for communication between the Tri-Lakes Project Office, State Engineer's Office, and WCWQS. In event of loss of these means of communication, the Dam Tender may communicate via vehicular travel between the respective offices noted above and/or via cellular phone.

7-04. Standing Instructions to Dam Tender. Exhibit I contains detailed instructions for regulation of project releases under emergency conditions. Communication failure may result and isolate the Dam Tender, thus making that person the sole operating organization for the project. The instructions, which otherwise follow the WCP, differ only when the pool level exceeds elevation 5635.5 ft PD to alleviate confusion during extreme flooding and communication failure. Regulation orders issued verbally will be confirmed as soon as possible in writing as official signed orders.

7-05. Flood Control. Bear Creek Reservoir will be regulated for flood control to mitigate flood risk to the City of Denver from floods originating on Bear Creek upstream of the project location. Operation of the Bear Creek Project will require both individual and system reservoir regulation.

a. Operation of Bear Creek Reservoir as an Individual Project. In general, the developed method of flood control regulation of Bear Creek Reservoir may be classified as Method C, defined in EM 1110-2-3600. This represents a combination of the concept of reducing downstream damaging stages as much as possible during each flood with the currently available storage space, with consideration for controlling floods of project design magnitude. Evacuation of flood control storage from Bear Creek Reservoir as an individual project will only occur when no flood storage is occupied in Cherry Creek or Chatfield Reservoirs.

During flood inflow periods and/or rising pool levels, Chatfield, Cherry Creek, and Bear Creek Reservoirs will be regulated to ensure safe control of each flood event. Releases from the dams will be based on observed inflows and pool levels and downstream flows. During flood inflow periods and/or while the pool level is in the flood control zone, releases will generally be kept as large as possible to meet the 5,000-cfs target at the South Platte River at Denver streamgauge. This target includes releases from Chatfield, Cherry Creek, and Bear Creek Dams and incremental runoff below the dams. Releases from the three dams from the forecasted flood onset to the complete evacuation of flood storage will be at the discretion of the WCWQS. However, at the onset of a flood or during heavy rainfall or knowledge of heavy runoff downstream, consideration will be given to reducing reservoir releases to as low as zero to lessen downstream flooding. The standard project rainfall flood design routing assumed no release for 2 days. The 60-day inflow volume design routing, which has a 300-year recurrence interval, assumed releases as given by the reservoir release schedule summarized in Table 7-2. However, due to short peaking times, this may not be possible in all instances. Following cessation of downstream flooding and stabilization of streamflows, releases will be made in accordance with the release schedule outlined in Table 7-2 and Plate 7-2.

Table 7-2
BEAR CREEK DAM RELEASE SCHEDULE

Reservoir Elevation (ft PD)		Release Rate (cfs)
From	To	
5558.0	5611.5	Inflow up to 500
5611.5	5625.0	1,000
5625.0	5635.5	1,500
5635.5	5667.0	2,000

Deviations from the release schedule will be made if conditions at the time are such that improved reservoir regulation will result. For example, (1) releases according to the schedule should not exceed downstream channel capacity unless the safety of the dam is in question, and (2) temporary delays of a few days duration in evacuation of flood storage will be considered so the water can be used by downstream users.

As a general rule, evacuation of flood storage should be made as soon as practical after the flood event. For control of possible subsequent flood events, flood control storage evacuation releases should be made at the highest rate that downstream conditions permit, as per Table 7-2. In years of exceptional drought, where conservation measures in the South Platte River basin are being actively implemented, it may be in the best interest of the Government, when practical, to release stored floodwaters at a rate beneficial to irrigation interests if such release rates will not unduly interfere with the primary flood control function of the project.

In the spillway design routing, no water was released through the gated outlet works. However, in the event of actual surcharge and spillway operation, release of water through the gated outlet must be considered. The release schedule specifies a release of 2,000 cfs in the portion of the surcharge zone between the top of the flood control zone (elevation 5635.5 ft PD) and the spillway crest (elevation 5667.0 ft PD). The gated outlets should also be used to provide a gradual transition of project releases from gated surcharge operation (pool level just below spillway crest) to spillway surcharge operation (pool level above spillway crest).

b. System Operating Plan for Flood Storage Evacuation. The following sections describe the system regulation plan for flood storage evacuation in the Tri-Lakes Projects when more than one project has storage in the flood control zone. This system procedure is also presented in the Water Control Manuals for Chatfield Dam and Reservoir and Cherry Creek Dam and Reservoir.

System regulation of Cherry Creek, Chatfield, and Bear Creek Reservoirs will be necessary only after flood flows have entered the reservoirs and during flood storage evacuation. Releases will be made from the projects, to the extent reasonably feasible, when water has accumulated in the flood control storage zones such that an equal protective balance of vacant flood control storage is maintained during flood control

storage evacuation. This balance is based on establishing an equal risk in each project of filling the remaining flood control storage space from a similar subsequent flood. The storage remaining should provide equal protection at each project. Flood storage evacuation will continue at Bear Creek Reservoir until the flood control storage has essentially been evacuated.

Two storage levels are established in the flood control zone in each project. Generally, the upper Level II of storage space approximates the volume of the rainfall SPF, described in Section 8-02.a. of this manual. In Chatfield, Level II volume amounts to 160,000 af, the volume of the rainfall SPF, and the Level I is 25,400 af. Since the flood control zones in both Cherry Creek and Bear Creek Reservoirs were designed mainly for protection from the sudden occurrence of a rainfall SPF and not from the longer duration mountain snowmelt flood, 95% of these flood control zones were assigned to Level II. The remaining 5% of flood control storage space in Cherry Creek and Bear Creek Reservoirs is allotted a lower evacuation rate at the downstream control point, the South Platte River at Denver streamgage. This space was assigned to Level I to provide for a transition from flood releases to multipurpose releases and to lessen unnecessary high releases for small encroachments of the flood control zones. The lower evacuation rate of Level I storage will not significantly affect the project flood control function. Table 7-3 presents a tabulation of storage in the three projects assigned to each level. Plate 7-3 shows the parallel reservoir balance for the three projects in percent of storage space filled for the two levels. Table 7-4 states the desired evacuation flow to be targeted at the control point, the South Platte River at Denver streamgage, depending on storage level, percent of storage space filled within the level, and time of year.

**Table 7-3
FLOOD REGULATION STORAGE LEVELS**

Location	Level I			Level II		
	Elevation (ft PD)	Storage (af)	Incr. Storage (af)	Elevation (ft PD)	Storage (af)	Incr. Storage (af)
Cherry Creek	5550.0	12,600		5554.4	16,500	
	to 5554.4	16,500	3,900*	5598.0	91,900	75,400
Chatfield***	5444.0	47,700		5455.3	73,100	
	to 5455.3	73,100	25,400**	5500.0	233,100	160,000
Bear Creek	5558.0	1,800		5569.2	3,300	
	to 5569.2	3,300	1,500*	5635.5	30,300	27,000
* 5% of total flood control zone ** Total Flood Control Storage (233,100 af) minus 47,700 af = 185,400 af; 185,400 af minus Standard Project Rainfall Flood (160,000 af) = 25,400 af *** The 1973 Chatfield Preliminary Reservoir Regulation Manual indicates the base of the flood control zone at an elevation 5430.0 ft PD. The base of the flood control zone was changed to 5432.0 ft PD in March 1979. The base of the exclusive flood control zone was changed to 5444.0 ft PD in response to the reallocation of flood control storage to joint-use flood control-conservation. Note: Based on area/capacity surveys from 2007 for Cherry Creek, 2010 for Chatfield, and 2009 for Bear Creek.						

Table 7-4
DESIRED MAXIMUM FLOW TARGET
AT SOUTH PLATTE RIVER AT DENVER STREAMGAGE

April – July: Any Reservoir at Level II – 5,000 cfs All Reservoirs at Level I, with one or more, more than 50% filled – 5,000 cfs All Reservoirs at Level I, and all less than 50% filled – 4,000 cfs August - March: Any Reservoir at Level II – 5,000 cfs All Reservoirs at Level I, with one or more, more than 50% filled – 4,000 cfs All Reservoirs at Level I, and all less than 50% filled – 3,000 cfs
Note: If Cherry Creek Reservoir reaches elevation 5590.0 ft PD or above, the Cherry Creek Dam release is dependent on the criteria in the Cherry Creek Water Control Manual. 50% filled refers to 50% of the storage level (e.g., Level I) occupied.

Equal balance must first be achieved by releasing more water from the project with the most occupied flood storage. When two or more of the reservoirs have the same percentage of storage in the same level, equal balance has been achieved.

Four balance combinations were developed dependent upon which reservoirs have occupied flood storage. Table 7-5 displays these combinations and the storage evacuation rates, which are the percentages of the total system release required from each project. Combination B assumes Chatfield and Bear Creek are balanced and Cherry Creek is either storing less water than the other two or no water in its flood control zone. Combination C assumes Chatfield and Cherry Creek are balanced and Bear Creek is either storing less water than the other two or no water in its flood control zone. Combination D assumes Bear Creek and Cherry Creek are balanced and Chatfield is either storing less water than the other two or no water in its flood control zone. The next step after releasing according to combinations B, C, and D may be to release according to combination A. Combination A assumes all three reservoirs have water stored in their flood control zones and the percent of flood storage occupied is balanced.

The following two examples are provided to describe how equal balance may occur:

1. All reservoirs are balanced if each has 50% of their Level II flood control storage occupied at the following total storages: Chatfield 153,000 af, Cherry Creek 54,000 af, and Bear Creek 16,800 af.
2. Chatfield and Cherry Creek are balanced, with Level I - Combination C, if 1,000 af of total flood control storage occupied is split between these projects as follows: Chatfield 870 af (87%) and Cherry Creek 130 af (13%) and if Bear Creek has no water stored in its flood control zone.

When two or more of the reservoirs have the same remaining balance of storage, the storage should be kept in balance or the percent of storage filled should be kept the same

until all water is evacuated to the extent reasonably feasible. The percentages in Table 7-5 also indicate the storage evacuation rate required out of each reservoir to enable continued parallel reservoir balance for all combinations of the three projects that may contain storage.

Table 7-5
PERCENTAGE OF STORAGE AND EVACUATION RATE REQUIRED TO CONTINUE
A PARALLEL RESERVOIR BALANCE (Values are in percent)

LEVEL II (see Table 7-3 for Elevations)			
Balance Combination	Chatfield	Bear Creek	Cherry Creek
A	61	10	29
B	86	14	0
C	68	0	32
D	0	26	74
LEVEL I (see Table 7-3 for Elevations)			
Balance Combination	Chatfield	Bear Creek	Cherry Creek
A	82	5	13
B	94	6	0
C	87	0	13
D	0	28	72
Based on storage capacity surveys from 2007 for Cherry Creek, 2010 for Chatfield, and 2009 for Bear Creek.			

The system evacuation releases are calculated two ways depending on the Cherry Creek Reservoir elevation.

(1) Cherry Creek Reservoir has not reached elevation 5590.0 ft PD. Releases are calculated based on Table 7-5.

The following example illustrates how to maintain an equal parallel reservoir balance during storage evacuation using Table 7-5. This example assumes that: (1) all three reservoirs are in an equal balanced condition as indicated by balance combination A of Level II of Table 7-5, (2) a maximum flow of 5,000 cfs is targeted at the South Platte River at Denver streamgauge, and (3) there are no downstream channel constraints below the three projects. Tabulated flows are average daily flows in cfs.

Bear Creek Dam and Reservoir Water Control Manual

April 2020

After the total system release on line 3 is determined, the estimated inflow into the three projects is totaled on line 4. The difference between line 3 (release needed from the three projects) and the total on line 4 (inflow) represents the total storage evacuation from the three projects on line 5. Table 7-5 is used to determine what percent of this storage is required out of each reservoir to enable a continued parallel reservoir balance on line 6. The addition of the estimated inflow and distributed storage evacuation represents the required release for each project on line 7. The total release from the three projects represents the required total release needed to target the desired flow at the South Platte River at Denver streamgage, including an allowance for incremental flow. Note that a release of 1 cfs over a 24-hour period is equivalent to 2 af of storage.

1. Desired flow at South Platte River at Denver streamgage (cfs)				5,000
2. Incremental flow between three projects and the Denver streamgage (cfs)				500
3. Total release needed from three projects				4,500
	Chatfield	Bear Creek	Cherry Creek	Total
4. Estimated inflow (cfs)	1,100	0	100	1,200
5. Total storage evacuation rate (cfs)*				3,300
6. Distributed storage evacuation rate (cfs)**	3,300*61% = 2,000	3,300*10% = 300	3,300*29% = 1,000	
7. Required release (cfs)	1,100+2,000 = 3,100	0+300 = 300	100+1,000 = 1,100	4,500

* The difference between total release and total estimated inflow

** Percentage from Table 7-5

(2) Cherry Creek Reservoir reached elevation 5590.0 ft PD. To reduce the potential risk of dam failure as a result of an extreme flood, the Cherry Creek Dam release will be increased to 7,000 cfs once Cherry Creek Reservoir reaches elevation 5590.0 ft PD until the flood control storage is evacuated. Upstream and downstream basin conditions will be monitored, and releases may be adjusted to mitigate the overall flood risk.

The following example illustrates how to maintain an equal parallel reservoir balance at Chatfield and Bear Creek Reservoirs during storage evacuation using Table 7-5 while increasing releases from Cherry Creek Dam. A Cherry Creek Accounting Reservoir was included to determine releases from Chatfield and Bear Creek Dams, but is **NOT** the actual release made from Cherry Creek Dam. This example assumes (1) the Cherry Creek Accounting, Chatfield and Bear Creek Reservoirs are in an equal balanced condition as indicated by balance combination A of Level II of Table 7-5, (2) a maximum flow of 5,000 cfs is targeted from Cherry Creek Accounting, Chatfield and Bear Creek Reservoirs at the South Platte River at Denver streamgage, and (3) Cherry Creek release is made based on the criteria listed in the Cherry Creek Water Control Manual. Values tabulated are average daily flows in cfs.

After the total release on line 3 is determined, the estimated inflow into the three projects is totaled on line 4; this excludes the estimated inflow for the Cherry Creek Accounting Reservoir. The difference between line 3 (release needed from the three projects) and the total on line 4 (inflow) represents the total storage evacuation from the three projects on line 5. Table 7-5 is then utilized to determine what percent of this storage is required out of each reservoir to enable a continued parallel reservoir balance on line 6. The Cherry Creek Accounting Reservoir is used to compute the required release from Chatfield and Bear Creek Dams. The addition of the estimated inflow and distributed storage evacuation represents the calculated release for Chatfield and Bear Creek Dams on line 7. The total release from the Cherry Creek Accounting, Chatfield and Bear Creek Reservoirs represents the required total release needed to target the desired flow at the South Platte River at Denver streamgage, including an allowance for incremental flow. The actual release from Cherry Creek Dam is determined based on the criteria listed in the Cherry Creek Water Control Manual. The Cherry Creek Dam release is set to 7,000 cfs because the reservoir rose to elevation 5590.0 ft PD, line 8. In this example, the combined release from the projects plus incremental flow is 10,900 cfs (3,100 + 300 + 7,000 + 500 cfs). Note that a release of 1 cfs over a 24-hour period is equivalent to 2 af of storage.

1. Desired flow at South Platte River at Denver streamgage (cfs)					5,000
2. Incremental flow between three projects and Denver streamgage (cfs)					500
3. Total release needed from three projects (cfs)					4,500
	Chatfield	Bear Creek	Cherry Creek Accounting	Cherry Creek	Total
4. Estimated inflow (cfs)	1,100	0	100	100	1,200
5. Total storage evacuation rate (cfs) *					3,300
6. Distributed storage evacuation rate (cfs) **	3,300*61% = 2,000	3,300*10% = 300	3,300*29% = 1,000	n/a	
7. Calculated release (cfs)	1,100+2,000 = 3,100	0+300 = 300	100+1,000 = 1,100 #	n/a	4,500
8. Required or actual release (cfs)	= 3,100	= 300	n/a	7,000 †	10,400

* The difference between total release and total estimated inflow

** Percentage from Table 7-5

Calculated to determine releases from Chatfield and Bear Creek Dams, but is **NOT** the actual release made from Cherry Creek Dam

† Actual Cherry Creek Dam release made based on the criteria list in the Cherry Creek Water Control Manual

Another example was prepared to demonstrate the time required to evacuate Level II system flood storage as illustrated on Plate 7-4. The example assumed that the flood storage in all three projects, Chatfield, Cherry Creek and Bear Creek, was full. Incremental inflow downstream of the three projects and above the South Platte River at Denver streamgage was estimated to be approximately 500 cfs.

7-06. Recreation. The demand for water-based recreation near the large metropolitan City of Denver is substantial. The Bear Creek Project satisfies part of the demand. The multipurpose zone, which extends from elevation 5528.0 to 5558.0 ft PD, is operated for multiple purposes, which include recreation and fish and wildlife. The lands at the Tri-Lakes Projects are not used for hunting due to the urban character of the area. Bear Creek Reservoir is large enough for boating and provides an excellent fishery. To initially fill the multipurpose zone, local interests agreed to allow storing of water, recognizing the eventual depletion effects of the multipurpose zone. Exhibit II, *Agreement between the State of Colorado and the U.S. Army Corps of Engineers, Omaha, District*, describes the State of Colorado's obligation to replenish evaporation losses within the Bear Creek Reservoir multipurpose zone. Also included in Exhibit II is a letter from the State Division of Game, Fish, and Parks indicating the State of Colorado's obligation to initially fill the reservoir to the top of the multipurpose zone, elevation of 5558.0 ft PD, and to replenish evaporation losses. The lands at the three Tri-Lakes Projects are not used for hunting due to the urban character of the area.

The Corps will continue to maintain a closely coordinated planning effort with the State of Colorado, Department of Natural Resources, and Colorado State Parks. The Corps constructed recreational areas upstream from the dam that the City of Lakewood leases, operates, and maintains for recreation use. Visitation to the Bear Creek Project has grown dramatically since construction. See Plate 2-20 for a map of Bear Creek Lake Park.

7-07. Water Quality. The BCWA maintains an ongoing program that involves water quality monitoring. Refer to Section 4-05 for a description of water quality characteristics and effects on operation of the lake. Section 8-04 includes a brief overview of how regulation of the reservoir could impact water quality.

7-08. Fish and Wildlife. Fish and wildlife is an authorized project purpose at the Bear Creek Project. The following describes the fish and wildlife considerations.

a. Constraints. Bear Creek Reservoir is a cold-water fishery because it is located near the Hogback Ridge of the Rocky Mountains and is fed by two mountain streams. The outlet works have only a single level for releases. Thus, it is not possible to mix water from multiple levels to manage for a particular species of fish. Normal operations and normal springtime floodwater inflows have little effect on the fishery from a water temperature standpoint. Flood inflows could, however, have a negative impact, at least temporarily, on the lake fishery and even on the creeks at the upstream limits of the lake if the inflows were high in suspended solids, thus making the water turbid. High turbidity has the effect of reducing light levels in the lower depths of the lake and of interfering with oxygen transfer (breathing) in the aquatic life forms in the lake. As temporary storage increases water residence time, suspended solids will tend to settle out. Settling of particulates may result in the surface waters becoming less turbid, but degradation of organic matter associated with settling particles may deplete oxygen in deeper waters while burial of bottom dwelling organisms may increase sediment oxygen demand.

b. Vegetation. Vegetation of the project area consists of grasslands that are part of the short grass plains and scattered wetlands characterized by such species as buffalo grass, blue grama, and a number of herbaceous species. Riparian vegetation along the stream courses consist of a plains cottonwood and boxelder overstory, chokecherry, hawthorn, smaller willows, cottonwoods, and boxelder understory. In the tributary drainage areas, shrubs consisting of chokecherry, skunkbush sumac, rose, and snowberry are common. There are also cattails, taller grasses, and many shrubs and forbs not otherwise found on the surrounding uplands. Some previously undisturbed areas still contain native shrublands dominated by mountain mahogany and rabbitbrush, with an understory of needlegrasses, yucca, prickly pear cactus, and assorted forbs.

Much of the original project area consisted of overgrazed agricultural land at the time of dam construction. Since project construction the area has been planted with warm and cool season grasses and herbaceous species to match intended uses.

c. Wildlife. The Bear Creek Project offers many varied habitats for wildlife. The extensive grasslands contain such species as meadowlark, horned lark, and ground-nesting sparrows, as well as prairie dogs, deer mice and pocket gophers. Other significant habitat types include the riparian areas along Bear Creek and Turkey Creek, both upstream and downstream from the dam. These riparian areas naturally contain a wider variety of species, especially birds. Travel lanes and other cover for deer, coyotes, fox, and several species of raptors may also be found here. The creeks contain beaver, several heron species and some ducks and geese. The riparian and upland shrub habitats are the most productive in terms of wildlife and esthetics.

Bear Creek Reservoir is not a primary waterfowl habitat area. It is not on a major migration flyway and it lacks the vegetation and cover necessary for it to be an important stopover point during spring or fall migration. Some local nesting of a few common waterfowl species likely occurs at the project. Larger numbers of Canada Geese use the reservoir as a roosting area in the fall and winter. Normal flood control operations would not be expected to have any significant impacts on such waterfowl nesting.

d. Aquatic Life. Bear Creek is a perennial stream that supports a minimal trout fishery and also contains suckers and minnows as dominant species. In recent years, there have been significant stockings of trout and warm-water species of fish in Bear Creek Reservoir. The reservoir is likely to remain a put-and-take fishery.

e. Threatened and Endangered Species. The U.S. Fish and Wildlife Service (USFWS) has responsibility for oversight of the Endangered Species Act and maintains a list of threatened and endangered species of plants and animals. For Jefferson County, CO and the Bear Creek Project vicinity, the bald eagle (*Haliaeetus leucocephalus*) and the American peregrine falcon (*Falco peregrines anatum*) were delisted due to recovery. The Mexican spotted owl (*Strix occidentalis lucida*), the piping plover (*Charadrius melodus*), the greenback cutthroat trout (*Oncorhynchus clarki stomias*), the Colorado butterfly plant (*Gaura neomexicana* var. *coloradensis*), Pawnee montane skipper (*Hesperia leonardus montana*), Ute ladies'-tresses (*Spiranthes diluvialis*), Canada lynx

(*Lynx Canadensis*), and Preble's meadow jumping mouse (*Zapus hudsonius preblei*) are listed as threatened. The least tern (*Sterna antillarum*) is listed as endangered.

The USFWS maintains that temporary storage of floodwaters in upstream reservoirs may have impacts on species that depend on the downstream Platte River for part of their life requisites. The Federal agencies that are responsible for manipulations of the Platte River system upstream are said to have some responsibilities for protection of those downstream species. The problem is complex; the two major elements to it are:

(1) Detention of upstream floodwaters in upstream reservoirs reduces the peak and the overall volume of the effects the flood would otherwise have on downstream areas. The Platte River in Nebraska, for instance, is no longer impacted by heavy and prolonged spring flooding that once periodically scoured the channel and kept trees from gaining a foothold. Where the channel was once wide, shallow, and relatively treeless, it is now narrower, deeper, and heavily tree-covered in many areas. Each upstream reservoir adds to the situation in a cumulative manner.

(2) The main species of concern on the central Platte River in Nebraska are the whooping crane, least tern, pallid sturgeon, and piping plover. All of these species have been designated as Federally threatened or endangered. Upstream impoundments and increased depletions from the Platte River have adversely influenced habitat for these downstream species because they have changed the timing and volume of flows. These adverse impacts have accumulated over the past 40 years or more, and continue to influence the flood plain environment.

7-09. Water Supply. The semiarid climate east of the Rocky Mountains, with its low annual precipitation and the rapid growth in population, has made water a guarded element of life in Colorado. The continued growth of the need for water for domestic, irrigation, and industrial uses will tend to ensure the further development of water supplies for use in the South Platte River basin. The strategic location of the Tri-Lakes Projects near the City of Denver and their capacity make them an important factor for inclusion in any water program. Irrigation and water rights play an important part in use and regulation of flows of streams within the State of Colorado. The State of Colorado has requested regulation of the Cherry Creek, Bear Creek, and Chatfield Projects to protect the water rights interests.

Bear Creek provides a valuable source of water supply for the South Platte River basin. It is estimated that 11% of the average annual runoff at the South Platte River at Denver streamgage is from Bear Creek. Bear Creek's contribution would be more except that much of its water is used within the basin. As is typical of the South Platte River basin, water resources of the Bear Creek basin are overappropriated. Stream runoff appropriations are administered by the State Engineer's Office under a priority system of water rights. Under this system, appropriations with senior water rights have prior claim to streamflows, and junior water rights are satisfied only when streamflow is sufficient to first fulfill priority rights. The aggregate of existing water rights on the water resources of the Bear Creek basin exceeds the normal range of runoff experience.

Since construction of Bear Creek Dam, the Omaha District entered into temporary 1-year storage contracts for municipal and industrial water supply under Section 6 of the Flood Control Act of 1944 (Public Law 34, 78th Congress), pending development of a long-term contract under the Water Supply Act of 1958 as amended (43 U.S.C. 390 b-f). The first contract, dated September 17, 1987, was for 25 af with the Indian Hills Water District. An ongoing or permanent contract does not exist.

Most of the water rights diversions from Bear Creek were originally intended for agricultural purposes and the decrees were for irrigation or agricultural uses. With urbanization in the basin, there has been a gradual change from agricultural to other uses, such as domestic, industrial, and irrigation of golf course areas and lawns. Table 7-6 lists the average monthly streamflow loss or gain and the maximum monthly loss between the Bear Creek at Morrison and Sheridan streamgages for 1928-1974.

**Table 7-6
BEAR CREEK AVERAGE MONTHLY WATER DEPLETION**

Month	Gain or Loss (cfs)	Maximum Loss (cfs)	Year
January	+ 6.5	- 4	1945
February	+ 5.2	- 20	1936
March	+ 0.6	- 16	1936
April	+ 2.3	- 25	1938
May	+ 12.1	- 133	1936
June	- 38.0	- 130	1936
July	- 47.4	- 127	1949
August	- 37.4	- 104	1930
September	- 29.7	- 115	1938
October	- 7.9	- 84	1939
November	0	- 13	1960
December	+ 5.0	- 6	1949

Five major ditches operate on Bear Creek between Morrison and Sheridan. Most of this water is diverted to storage facilities for municipal or agricultural use. Table 7-7 lists these ditches and the approximate appropriation for each. See Section 2-04 for more information on these canals.

Table 7-7
BEAR CREEK BASIN DITCHES

Ditch	Water Right Appropriation*	Location
Harriman	25 cfs	Downstream edge of Morrison
Ward	5 to 10 cfs	Bear Creek Reservoir Tail Race
Hodson	2 cfs	South side of Kipling Street
Pioneer Union	2.5 cfs	Bear Creek Reservoir Tail Race
McBroom	1 to 16 cfs	1/8 mile upstream of Sheridan gage
*Estimated values based on normal conditions; heavily dependent on actual conditions.		

7-10. Hydroelectric Power. None at this project.

7-11. Navigation. None at this project.

7-12. Drought Contingency Plan. A drought contingency fact sheet was finalized in July 1987 and states that the State of Colorado, Department of Natural Resources has agreed to fill and maintain the multipurpose zone with water. Low flow releases will be made to meet downstream water rights. Refer to Section 7-03.b. for details on responsibilities.

7-13. Flood Emergency Action Plan. Normal flood regulation of Bear Creek Reservoir is accomplished by specific regulation orders to the Tri-Lakes Project Office from the WCWQS. However, it is conceivable that communication may be disrupted between these offices at times when project events may require changes in existing regulation instructions so that the project may more properly perform its authorized function. A procedure has been developed to determine project operations under emergency conditions so that the Tri-Lakes Project Office staff have appropriate information and instructions for modifying their existing regulation orders. Condition C of Exhibit I, *Standing Instructions to the Dam Tender*, includes this procedure. The procedure is defined to begin with communication failure between the Tri-Lakes Project Office and the WCWQS personnel at a time when the reservoir is rising rapidly, high inflows are indicated, excessive rainfall has occurred, flooding below the dam is occurring or appears imminent, or when a combination of any of these is occurring. During such emergency periods, regulation of project releases will be made by the Tri-Lakes Project Office in accordance with the release schedule given in Exhibit I. Continuous effort will be made to re-establish communications. The dam will be attended at all times during an emergency.

The Omaha District's Geotechnical Engineering Branch annually updates the EAP for Bear Creek Dam and Reservoir.

7-14. Deviation from Normal Regulation. Deviations from the release schedule will be made if conditions at the time are such that improved reservoir regulation will result. For example: (1) release more than 7,000 cfs from Cherry Creek Dam when pool elevation 5590 ft PD has been reached or (2) releases that exceed the 5,000 cfs flow target at the

South Platte River at Denver streamgage. Deviations require prior approval from the MRBWM office, except as noted in Section 7-14.a. Written confirmation of the deviation, including a description of the cause of the emergency, will be furnished as soon as practical to the MRBWM office as described in NWDR 1110-2-6, *Deviation Requests for Approved Water Control Manuals*. Requests to deviate from normal regulation of the project fall into one of the categories described below.

a. Emergencies. Deviations from the release schedule will be made if emergency conditions exist upstream or downstream of the dam. Examples of these types of emergencies include dam safety emergencies, downstream chemical spills, drownings, and facility failures. During an emergency activity, the WCWQS will inform the MRBWM office of such activities as soon as possible.

b. Unplanned Minor Deviations. Temporary delays of a few days duration in evacuation of flood storage will be considered to mitigate damages and/or for special circumstances downstream. A typical example of activities that would create the potential for unplanned minor deviations would be modifications of bridge and utility crossings. In evaluating requests for these types of deviations, the WCWQS will consider upstream basin conditions, potential flood threats, the amount of water in storage at Bear Creek Reservoir, and whether any alternative measures could be taken that would not require a deviation.

c. Planned Deviations. Deviations from the release schedule will be made if determined necessary. All conditions such as data on flood potential, reservoir and basin conditions, possible alternative measures, benefits to be expected, and probable effects on other authorized and useful purposes will be analyzed. Planned deviations will be coordinated with all appropriate entities, including local and state offices.

7-15. Rate of Release Change. Normally, increases in releases should not exceed approximately 300 cfs/day. Releases should preferably be reduced at a similar rate and should consider downstream impacts. However, if a higher rate of change is necessary to accommodate operational circumstances, releases may be increased or reduced at an accelerated rate. The release may even be reduced to zero flow in a single gate change if required. Examples of downstream impacts include environmental, water quality, and bank failure. There should be communication with stakeholders if these rates of change will be exceeded.

When the reservoir is above elevation 5638.5 ft PD, consideration should be given to limiting the drop in reservoir pool elevation to less than 2 ft/day, if possible, due to the steep embankment along the dam face. Below the 5638.5 ft PD elevation, the pool elevation drop rate is not as critical due to the flatter slopes on the embankment. This drawdown guidance should only be used if practical and reasonable to do so.

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SECTION 8

EFFECT OF WATER CONTROL PLAN

8-01. General. Bear Creek Reservoir is regulated for flood control to mitigate risk to the metropolitan area of Denver from floods originating on Bear Creek upstream of the project location.

8-02. Flood Control. For the design of Bear Creek Dam and Reservoir, the rainfall SPF was used for the reservoir design flood, and the rainfall IDF, which in this case is equivalent to the PMF, was used for the emergency spillway design flood. The 300-year and 1,000-year high volume, low peak spring flood events were also developed for the design of the reservoir. The following paragraphs describe each of the design floods and include an example that demonstrates the evacuation of flood storage in the Tri-Lakes Projects. Table 8-1 summarizes the different design floods' durations, volume of runoff, and peak flows.

**Table 8-1
BEAR CREEK PROJECT DESIGN FLOOD SUMMARY**

Bear Creek Design Floods	Duration (Days)	Volume (af)	Peak Flow (cfs)
SPF	0.5	24,290	77,000
300-Year Spring Flood	60	101,740	2,800
1000-Year Spring Flood	60	132,360	4,100
IDF/PMF (original)	4	84,950	225,000
IDF/PMF (updated)	3	93,300	383,000

a. Standard Project Flood. The flood storage space in Bear Creek Reservoir was based on controlling the Standard Project Rainfall Flood (SPRF). The standard project rainfall over the Bear Creek basin was based on the 96-hour probable maximum rainfall study. The 24-hour 200-sq mi probable maximum precipitation (PMP) value of 18.4 in was reduced by 50% to obtain the standard project rainfall 24-hour, 200-sq mi index of 9.2 in. After adjusting the depth of this index storm to 236 sq mi by using the depth-area curves presented in EM 1110-2-1411, *Standard Project Flood Determination*, March 1, 1965, it was centered over the 141-sq mi area lying east of the Rocky Mountain Front Range. The residual storm values over the 95-sq mi area lying west of the Rocky Mountain Front Range were reduced by 10% to compensate for the mountain barrier effect in this region. The maximum 6-hour period of rainfall was distributed in accordance with the hourly distribution shown in EM 1110-2-1411. During the 96-hour period, rainfall in the 141-sq mi area east of the Rocky Mountain Front Range is 15.04 in and runoff is 2.28 in. In the 95-sq mi area west of the Rocky Mountain Front Range, rainfall is 13.37 in and runoff is 1.40 in. These runoff values were applied to the sub-area unit hydrographs shown on Plates 8-1 and 8-2. The resulting hydrographs

were routed and combined to obtain the SPRF hydrograph also known as the reservoir design flood in this case. Plate 8-3 shows this SPRF hydrograph.

Control of high volume, low peak floods that frequently occur in the spring were also studied with the allocated flood control space resulting from the SPRF routing. These floods are generally caused by mountain snowmelt combined with the rainfall-runoff. These studies indicate that, while using the release schedule given in Section 7-05, a 300-year volume event can be controlled within the allocated flood zone. Bear Creek Reservoir has the capability to control larger floods without using the spillway because of the surcharge storage space located between the top of the flood control zone and the spillway crest. An estimated 1,000-year volume spring flood event was routed through the reservoir using the release schedule. This routing resulted in a peak pool about 16.5 ft below the spillway crest. The observed 1942 spring flood was used to define the flow pattern of these two spring inflow hydrographs. Plate 8-3 also shows these inflow hydrographs and reservoir operations.

b. Inflow Design Flood.

(1) Inflow Hydrograph. The original rainfall PMF was selected as the event for which design of the emergency spillway for Bear Creek Dam and Reservoir is based. The derivation of the inflow hydrograph for this flood is presented in the Hydrology Design Memorandum No. PB-1. The PMF hydrograph has a peak inflow of 225,000 cfs and a total flood volume of 84,950 af.

(2) Spillway Design Flood Routings. The 96-hour probable maximum rainfall over the Bear Creek basin was determined from a depth-area relationship developed from the pattern "A" storm published in Hydro-Meteorological Report (HMR) No. 44 and discussed in the Chatfield Dam and Reservoir Hydrology Design Memorandum. The most critical orientation of this storm occurred when the center was placed over the 141-sq mi area lying east of the Rocky Mountain Front Range. The resulting PMP depths in the basin were 28.3 in east of the Rocky Mountain Front Range, and 22.8 in west of the Rocky Mountain Front Range, with an average basin depth of 26.1 in. A 10% reduction factor was applied to the 22.8 in average runoff value determined for the 91-sq mi area west of the Rocky Mountain Front Range to reflect the mountain barrier effect in this region. The hourly distribution for the maximum 6-hour rainfall period was taken from the curves presented in EM 1110-2-1411. During the 96-hour period, rainfall in the 141-sq mi area east of the Rocky Mountain Front Range is 28.30 in and runoff is 8.80 in. In the 95-sq mi area west of the Rocky Mountain Front Range rainfall is 20.50 in and runoff is 3.73 in. Plate 8-2 shows the runoff values that were applied to the sub-area unit hydrographs. The resulting hydrographs were routed and combined to obtain the PMF inflow hydrograph. The routing of this flood, on top of a full flood control zone using 800-ft wide spillway with a crest elevation of 5667.0 ft PD, established the maximum design pool at elevation 5684.5 ft PD. Freeboard of 5 ft was added to establish the top of dam elevation of 5689.5 ft PD.

The PMF was later routed through Bear Creek Reservoir based on the updated design flood criteria found in ER 1110-8-2, *Inflow Design Floods for Dams and Reservoirs*, dated March 1991. The regulation required using an antecedent flood equal to one half

of the PMF 5 days before the full PMF occurred. To obtain the 5-day antecedent flood elevation, one half of the PMF developed for Bear Creek Reservoir for the original spillway design flood analysis was routed into the reservoir with no outflow starting at the top of the multipurpose zone at elevation 5558.0 ft PD. The pool elevation of 5651.3 ft PD obtained after 24 hours was then used as the starting pool elevation for the 5-day drawdown. Flows through the outlet works were included for the 5-day drawdown. The pool elevation of 5625.9 ft PD after the 5-day drawdown was then used for the starting pool elevation for routing the PMF through the reservoir with the outlet works assumed inoperable. The elevation-capacity relationship developed from the 1987 range survey was used along with the developed rating curve for the spillway. Based on the new PMF analysis using updated criteria, a maximum pool elevation of 5684.1 ft PD was achieved with a maximum outflow of 129,700 cfs through the spillway. All of the routings were made using the 800-ft wide earthen cut emergency spillway, and assumed no outflow through the outlet works. Table 8-2 and Plate 8-4a summarize the routing results.

**Table 8-2
SPILLWAY DESIGN FLOOD ROUTINGS**

Lake Condition at Beginning of Flood Inflow	Lake Elevation at Beginning of Flood Inflow (ft PD)	Maximum Pool Elevation Reached in Routing (ft PD)
Half-full flood control zone	5611.5	5682.2
Full flood control zone	5635.5	5684.5
Pool level at spillway crest	5667.0	5687.1
Pool level 5 days after one-half PMF was routed through reservoir	5625.9	5684.1

In 1997, a restudy of the PMP was completed using the HMR No. 55a. A new PMP was derived using HMR No. 55a and the 96-hour PMP was scaled to the new standard 72-hour PMP. In 2015, the PMF was updated by applying the scaled 72-hour PMP (refer to the hydrology study, *Bear Creek Dam Inflow Design Flood Update*, dated September 2015). The resulting peak discharge increased from 225,000 cfs to 383,000 cfs and the runoff volume from 84,950 af to 93,300 af. Based on the results of the study, the increased flows did not overtop the dam; however, the dam no longer has adequate freeboard. Assuming a starting pool of 5635.5 ft PD (top of the flood control zone) at the start of the PMF, the pool elevation is within 3 ft of the maximum pool for a duration of 2 hours. Due to this duration, the required minimum freeboard is 3 ft according to ER 1110-8-2, *Inflow Design Floods for Dams and Reservoirs*, dated March 1991. It was recommended that a new maximum pool elevation of 5689.3 ft PD be adopted, which provides 0.9 ft of freeboard. To meet the minimum freeboard requirement of 3 ft, the dam would need to be raised by 2.1 ft. Refer to Plate 8-4b for the new PMF reservoir routings.

8-03. Recreation. Boat ramps, roads, and picnic areas are inundated and unusable when the pool level rises to an elevation of 5562.0 ft, which is 4 ft into the flood control zone. Inundation of recreation facilities that result from operation of the Bear Creek Project for downstream flood control would lower the carrying capacity of the project and cause a decline in visitation. The number of annual visits to the Bear Creek Project decreased by approximately 20,000, or about 10% of annual project visitation, when high reservoir levels inundated recreation facilities in FY95. Based on public safety considerations, recreation areas of the project in particular, or possibly even the entire project could be closed to public use.

8-04. Water Quality. Water quality upstream from Bear Creek Reservoir can be adversely impacted by nutrients and organic matter that enter Bear Creek during snowmelt and large rainfall events. Periods with little or no flow may occur, and the creek may dry up entirely under drought conditions.

During snowmelt or large rainfall events, nutrients and organic matter are transported from the basin into the reservoir. The influent concentrations of phosphorus and nitrogen can lead to nuisance algal growth and subsequent algal decomposition within the reservoir. Algal decomposition, decomposition of influent organic matter, and decomposition processes occurring in the sediment all exert an “in-reservoir” oxygen demand. When this demand surpasses the processes that replenish dissolved oxygen (wind mixing, algal production, influent dissolved oxygen, destratification or aeration systems) it depletes concentrations to hypoxic or even anoxic levels that can lead to fish kill events.

In the winter under snow and ice cover, there is little natural mixing and limited light for photosynthesis. The reservoir may become inversely stratified with the water near the bottom reaching a temperature of near 4 degrees Celsius (°C) and the surface water being slightly colder. Though occurring at a slower rate in cold temperatures, decomposition reactions can still exceed the dissolved oxygen supply. During this time, inflow to the reservoir is minimal; however, it could provide pockets of refugia in the upper reaches of the reservoir with dissolved oxygen conditions suitable for fish. Releases through the low-level gate during the late winter months could potentially send hypoxic, nutrient-laden water downstream while “pulling” some of the oxygenated influent water toward the dam. The hypoxic water would then be quickly oxygenated as it passes over the release structure.

With spring comes substantial mixing and light for photosynthetic oxygen production, but inflow conditions are variable. Thermal stratification of the reservoir occurs in the summer and may be transient depending on weather conditions. While the reservoir is stratified, decomposition occurs in the calm, colder, bottom layer known as the hypolimnion. Decomposition of accumulated organic matter depletes the hypolimnion of dissolved oxygen and creates an expanding hypoxic zone in the reservoir below the mixed, oxygenated upper layer. The actual volume of the hypolimnion will vary with pool elevation and weather conditions. In late summer during thermal stratification, the low-level gate could be opened to send hypoxic nutrient-laden water downstream. However, a dynamic water quality model should first be used to assess how much flow could be passed downstream without disrupting the thermal structure of the reservoir, and to

assess the ability of the outlet structure to oxygenate released water at warmer temperatures.

8-05. Fish and Wildlife. Section 7-08 of this manual describes the vegetation, wildlife, and threatened and endangered species impacted by the Bear Creek Project in detail. According to the Bear Creek Master Plan, dated September 2012, except for the occasional transient species, no Federally listed endangered, threatened, or candidate species under USFWS jurisdiction is known to exist in the Bear Creek Project area.

Since 1979 when the reservoir was first filled, flood water was stored in the flood control zone for more than 1 month and over 2 ft full in 1980, 1983, 1995, 2013, and 2015. The shoreline vegetation is sufficiently tolerant of short periods of inundation so that the shallower, short-duration flood events do not cause permanent damage. Longer duration events, however, may result in adverse impacts to shoreline vegetation. In such cases, barren mudflats may occur and a period of succession would ensue that could take several years before the vegetation returned to pre-flooding conditions. It is expected that future use of the flood control zone will negatively impact the vegetation.

It is possible that conditions may be favorable in the upstream reaches of the project to support the Ute ladies' tresses orchid. If the species is present, normal flood control operations do not seem to pose a threat to this orchid because inundation, even for extended periods, probably would not harm the long-term survivability of this species.

Since the Ute ladies' tresses orchid is a riparian species that blooms in late July or August, temporary, infrequent, and minor inundation in late spring and early summer would not be expected to have any significant impacts on the local populations.

There is no suitable habitat for the Eskimo curlew or the Pawnee montane skipper at the Bear Creek Project.

8-06. Water Supply. Water supply, stored water, and downstream water rights administration may impact the operation of the project. If a release for downstream water rights is requested and the pool elevation is not above the outlet weir, low-level releases are required. Releases must be made via the low-level valves to "charge" the conduit to allow these low-level releases. See Section 7-09 for additional water supply information. All water rights activities are administered by the State of Colorado.

8-07. Hydroelectric Power. None at this project.

8-08. Navigation. None at this project.

8-09. Drought Contingency Plan. A drought contingency fact sheet was finalized in July 1987. Reference Section 7-12 for details. A drought contingency plan for Bear Creek Dam and Reservoir will be coordinated with stakeholders as time allows.

8-10. Flood Emergency Action Plan. See Section 7-13 as well as Exhibit I, *Standing Instructions to the Dam Tender*.

The Omaha District's Geotechnical Engineering Branch annually updates the EAP for Cherry Creek Dam and Reservoir.

8-11. Frequencies.

a. Peak Inflow Frequency. Plates 4-11a and 4-11b show the inflow and discharge frequency curves for Bear Creek Dam, respectively. The curves are derived from the daily annual maximum values and include the 1978-2016 water years.

b. Pool Elevation Duration and Probability. Plate 8-5 shows the Bear Creek Reservoir pool probability curve for the period of 1977 to 2014. Plate 8-6 shows the volume duration probability curves for the same period. An update to these curves will be completed periodically and will be incorporated in this manual at that time.

c. Key Control Points. The key control point for the system and individual regulation of Bear Creek Reservoir is the South Platte River at Denver streamgauge. Reference Section 7-05 for further details. Plate 4-19 illustrates the stage-discharge relationship for this location. Plates 8-7 and 8-8 show the flow frequency and flow duration curves, respectively. The data analyzed included 1978-2016 representing the current flood control condition.

8-12. Other Studies.

a. Example of Emergency Regulation. Examples of system regulation for select years are described in the following paragraphs.

(1) Flood of 1980. Beginning on May 1, high runoff from rainfall and snowmelt in the entire South Platte River basin resulted in a rise in elevation at Chatfield Reservoir. High runoff from the Rocky Mountains, below Chatfield Dam, also occurred during the time of high runoff into the reservoir. Flooding occurred on tributaries below the dam and along the South Platte River from Kersey to Julesburg, CO. As shown on Plate 8-9, the storage and release of water from Bear Creek Dam was coordinated with the storage and release of water from Chatfield Dam to reduce downstream flooding. The Bear Creek Reservoir peak daily inflow of 900 cfs was observed on May 1 and the maximum release of 800 cfs was made to evacuate the flood control storage. The Bear Creek Reservoir maximum pool elevation of 5576.3 ft PD occurred on May 19.

(2) Flood of 1983. Late spring snows in the lower elevations combined with frequent rain showers in the foothills caused the sustained encroachment in the Bear Creek Reservoir flood control zone during May, June, and July. As shown on Plate 8-10, the storage and release of water from Bear Creek Dam was coordinated with the storage and release of water from Chatfield and Cherry Creek Dams to reduce downstream flooding. The Bear Creek Reservoir peak daily inflow of 625 cfs was observed on May 23. The maximum daily release of 605 cfs was made to evacuate the flood control storage. The Bear Creek Reservoir maximum pool elevation was 5581.0 ft PD on June 23.

(3) Flood of 1995. Heavy snowfall and cooler-than-normal temperatures were experienced in the South Platte River basin from April through June. A near record

snowpack was generated in much of the mountain basins including the South Platte River above Chatfield and Bear Creek Dams, but also downstream along the South Platte River tributaries. The worst flooding occurred along the St. Vrain Creek and upper Clear Creek basins downstream of Chatfield Dam. May and June were also a time of localized heavy thunderstorms that caused some flooding along the lower portions of several tributaries and added to the high flows in the South Platte River. As shown on Plate 8-11, the storage and release of water from Bear Creek Dam was coordinated with the storage and release of water from Chatfield and Cherry Creek Dams to reduce downstream flooding. The Bear Creek Reservoir peak daily inflow of 795 cfs was observed on June 9 and the maximum daily release of 612 cfs was made to evacuate the flood control storage. The Bear Creek Reservoir maximum pool elevation was 5587.1 ft PD on June 19.

(4) Flood of 2013. In September 2013, the heaviest area of rainfall-runoff was experienced along the main stem South Platte River and tributaries from Denver, CO to Kearney, NE downstream of Cherry Creek, Chatfield, and Bear Creek Reservoirs. The inflow was stored until the high South Platte River flows began to recede. The Bear Creek Reservoir record peak daily inflow of 1,170 cfs was observed on September 16. The maximum daily release of 500 cfs was made to evacuate the flood storage. Bear Creek Reservoir reached its record maximum pool elevation of 5607.8 ft PD on September 21. Plate 8-12 shows more detailed operations.

(5) Flood of 2015. Above-average snowfall and cooler-than-normal temperatures were experienced in the South Platte River basin in May and June. The above-normal mountain snowmelt runoff was compounded by heavy thunderstorms experienced from April through June. The rainfall in May in the upper South Platte River basin was 3 to 8 in above normal, which in some areas was over 600% of normal. The worst flooding occurred along the tributaries and main stem South Platte River downstream of Chatfield Dam and the City of Denver. As shown on Plate 8-13, the storage and release of water from Bear Creek Dam was coordinated with the storage and release of water from Chatfield and Cherry Creek Dams to reduce downstream flooding. The Bear Creek Reservoir record peak daily inflow of 1,183 cfs was observed on May 10. The maximum daily release of 500 cfs was made to evacuate the flood control storage. Bear Creek Reservoir reached its maximum pool elevation of 5602.6 ft PD on May 25.

b. Improvement of Regulation Techniques. Studies will continue to be produced and updated to improve the regulation techniques.

Following the development of the upper South Platte River CWMS modeling suite in FY13, new curves for estimating the approximate magnitude of flood damages by impact area were developed and finalized in July 2015. Plates 4-23 through 4-30e show the curves and inundation maps. In addition, the CWMS modeling suite was used in the FY16 Cherry Creek Dam Water Control Plan Modification Study that resulted in modified Cherry Creek Dam, Chatfield Dam, and Bear Creek Dam WCPs. The ongoing Cherry Creek Dam Safety Modification Study, which addresses the overtopping concern related to the PMF routing, was initiated in FY13 and is scheduled to be complete in

2020. The study developed and evaluated potential alternatives to reduce risks associated with Cherry Creek Dam. The no action alternative was the final decision.

c. Channel and Floodway Improvement. Between the Corps, MHFD, and the various other local entities, many studies have been completed that relate to flood plain improvements and channel capacity through the Denver metropolitan area. Recently the City and County of Denver (along with the MHFD, CWCB, and others) partnered with USACE to conduct an FR/EIS to investigate opportunities to restore degraded habitats and reduce flood risks along the South Platte River and several tributaries within City and County of Denver. The Final Chief's Report was approved in July 2019 and the record of decision was signed in October 2019 recommending a plan that will restore about 450 acres of habitat and increase channel capacity along the South Platte River, as well as reducing flood threats on Weir Gulch and Harvard Gulch tributaries through channel improvements and nonstructural means. The approved plan is expected to be implemented over the next 10-15 years.

Maintenance of downstream channel conveyance has been a challenge. The open conveyance areas downstream of reservoirs are often seen as locations for development and/or vegetated open space. These activities are at risk of inundation and may be impacted by large reservoir releases and local runoff.

SECTION 9

WATER CONTROL MANAGEMENT

9-01. Responsibilities and Organization.

a. **Corps of Engineers.** ER 1110-2-1400 assigns the Corps' reservoir regulation responsibilities in the Missouri River basin to the NWD Commander. ER 1110-2-1400 also permits delegation of certain reservoir regulation responsibilities to the District Engineer in whose area the project is located. The responsibilities for assembly and interpretation of data affecting current reservoir regulation and for carrying out routine regulation of Bear Creek Reservoir, according to plans agreed on in advance, have been delegated to the Omaha District Engineer. The NWD Commander, through the MRBWM office, monitors and reviews the regulation activities performed by the Omaha District. Plate 9-1 shows an organization chart for the Omaha District.

Plate 5-5 illustrates the normal coordination of the Omaha District with regards to Bear Creek Reservoir regulation. The operation of Bear Creek Dam and Reservoir normally involves two units of the Omaha District organization:

(1) Water Control and Water Quality Section, Engineering Division. The WCWQS acting for the District Engineer, is responsible for matters pertaining to the regulation of the reservoir. Throughout the year, the WCWQS maintains control of reservoir releases to attain optimum flood control benefits and control of project storage to ensure regulation in conformance with the authorized functions of the project. The WCWQS is responsible for procurement of necessary snowpack, precipitation, streamflow, and reservoir elevation data. The WCWQS also makes advance estimates of streamflows from snow cover and/or rainfall reports for forecasting and regulation purposes and to alert field operating personnel of potential flood threats.

(2) Tri-Lakes Project Office, Operations Division. The Operations Division plans and directs the maintenance and physical operation of the project. It establishes the standards of maintenance and provides proper staffing of operating personnel at the Tri-Lakes Project Office to accomplish these objectives. The Tri-Lakes Project Office's staff performs in the field those functions of operation, maintenance and regulation requested by the Operations Division and the WCWQS. Exhibit I, *Standing Instructions to the Dam Tender*, details the Dam Tender's duties for regulation, which generally are to:

- (i) collect and report project hydrologic data;
- (ii) receive and report streamflow and precipitation data;
- (iii) alert WCWQS personnel of actual or impending flood conditions affecting the project;
- (iv) maintain liaison with State Water Engineers;

(v) determine releases to be made from the project in the event of communication failure during a flood emergency;

(vi) prepare records and reports of regulation activities; and

(vii) operate outlet gates as required by regulation orders.

(3) Flood Period Organization. The normal organization of the Omaha District is somewhat modified during a flood period to take care of the additional duties made necessary by the flood emergency. Refer to Section 7-03.c.(3) for additional information.

b. Other Federal Agencies. None at this project.

c. State of Colorado. The State of Colorado will be represented by the Colorado State Engineer's Office of the CDWR. The State Engineer's Office is responsible for administration of all state water laws and accounting for ownership of all water stored below elevation 5559.0 ft PD, one foot into the flood control zone, allowing flexibility in targeting authorized pool levels. The State Engineer's Office is also responsible for satisfying all downstream water requirements below the Bear Creek Project. Under normal conditions, the State Engineer's Office tracks water rights on Bear Creek and the South Platte River and makes requests for releases to the WCWQS. The State Engineer's responsibilities in regard to Bear Creek Reservoir are presented in Paragraph 4.b of Exhibit II, *Memorandum of Understanding between the United States of America and the State of Colorado on Regulation for Bear Creek Dam and Reservoir*. However, as determined by the Corps' Omaha District dam safety officer, should any dam safety issues arise, the Corps will assume all regulation decisions.

At the discretion and under the supervision of the State Engineer, personnel of the irrigation and/or water supply districts may perform the physical operation of the outlet gate valves to supply water directly from the reservoir to their respective water supply ditches. These valves are separate from the main gates in the outlet works. The State Engineer's Office will monitor and control the amount of water taken by each ditch. The State Engineer's Office will be responsible for maintaining up-to-date, stage-discharge tables. The State Engineer's Office will furnish the Tri-Lakes Project Office with the daily canal discharge each day. Further responsibilities of the State Engineer's Office are presented in Exhibit II.

d. City of Lakewood, CO. The City of Lakewood, as the project sponsor, is responsible for acquiring the water for conservation uses including fish and wildlife. The project sponsor is also responsible for developing the recreation facilities at the project in accordance with the Master Plan developed by the Corps. The City of Lakewood leases the entire project for park and recreation purposes under Department of Army Lease No. DACW45-1-82-6019. The City of Lakewood has developed the municipal Bear Creek Lake Park, mainly with cost-shared facilities upstream from the dam, and the municipal Fox Hollow Golf Course downstream from the dam. The leased area was developed under Cost Share Agreement No. ODOP-221-82-003.

9-02. Interagency Coordination.

a. Local Press and Corps Bulletins. Press releases are made on an “as-needed” basis. Corps reservoir bulletins or reports are prepared daily and are available via the MRBWM website.

b. National Weather Service. Local weather forecasting information is provided by the Boulder, CO NWS WFO.

c. U.S. Geological Survey. An existing cooperative streamgaging program between the Corps and the USGS is used to maintain DCPs and streamflow measurements.

d. Colorado Division of Water Resources. An existing cooperative streamgaging agreement between the Corps and the State of Colorado is used to maintain DCPs and streamflow measurements.

e. Natural Resources Conservation Service. The NRCS is the agency responsible for compiling all snow course and SNOTEL information for the basin. This includes select streamflow volume forecasts for the basin.

f. Other Federal, State, or Local Agencies. The MHFD, CWCB, and Denver Regional Council Of Governments (DRCOG) are agencies with great interest in Bear Creek Project operations.

9-03. Interagency Agreements. Exhibit II, *Agreement between the State of Colorado and the U.S. Army Corps of Engineers, Omaha, District*, describes the State of Colorado’s obligation to replenish evaporation losses within the Bear Creek Reservoir multipurpose zone. Exhibit II, *Memorandum of Understanding between the United States of America and the State of Colorado on Regulation for Bear Creek Dam and Reservoir*, describes the Bear Creek Reservoir regulation responsibilities.

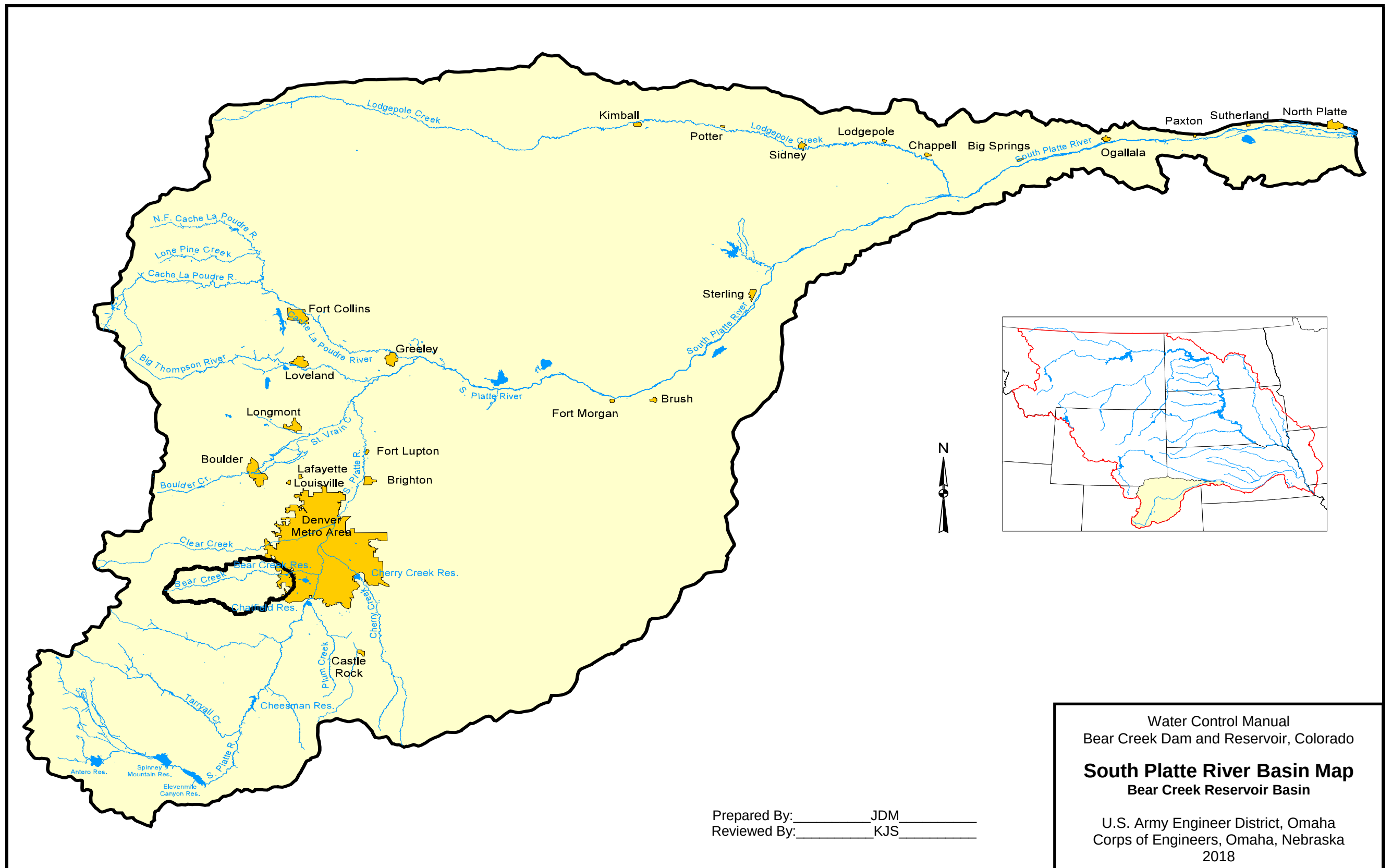
9-04. Commissions, River and Authorities, Compacts, and Committees. All water rights activities are administered by the State of Colorado.

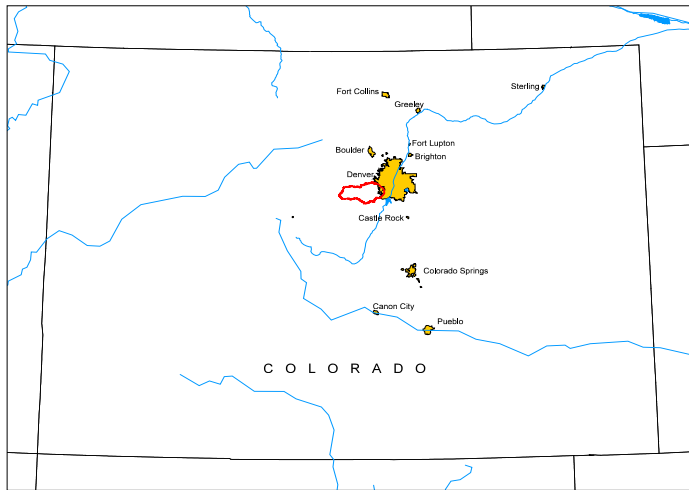
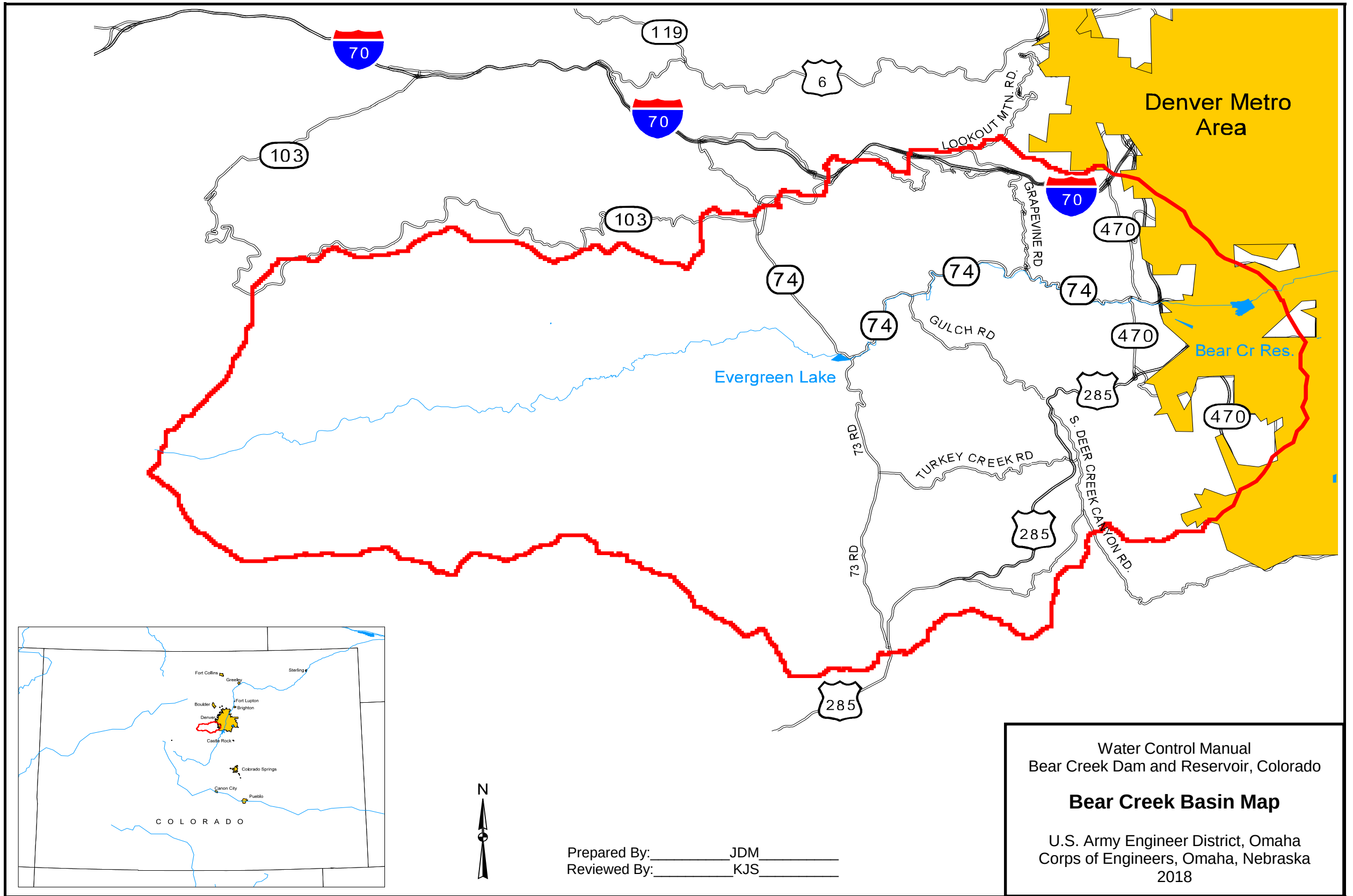
9-05. Non-Federal Hydropower. None at this project.

9-06. Reports. Required reports are shown in Table 9-1, along with the report’s governing regulation and required schedule.

Table 9-1
BEAR CREEK PROJECT REPORT REQUIREMENTS

Report Title	Regulation or Guidance	Schedule
Reservoir Regulation Orders	EM 1110-2-3600	Every release change
Reservoir Bulletin Omaha District WCWQS	EM 1110-2-3600	Daily
Monthly Reservoir Operation Reports	EM 1110-2-3600 ER 1110-2-240	Monthly
Annual Report Omaha District WCWQS	EM 1110-2-3600	Annual
Flood Damages Prevented Omaha District WCWQS	EM 1110-2-3600	Annual
Flood Emergency Reporting	EM 500-1-1	Per flood requirements



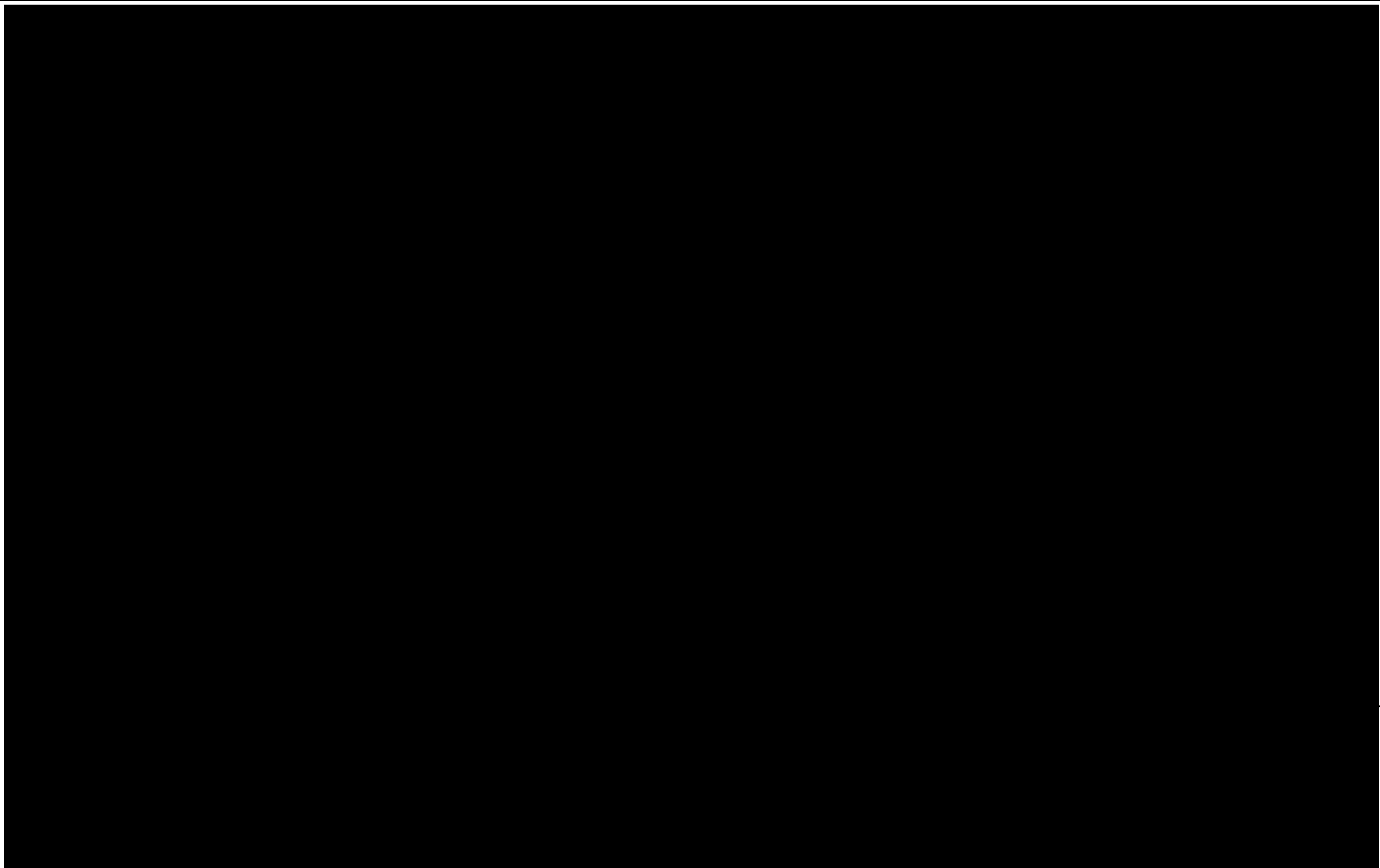


Water Control Manual
 Bear Creek Dam and Reservoir, Colorado

Bear Creek Basin Map

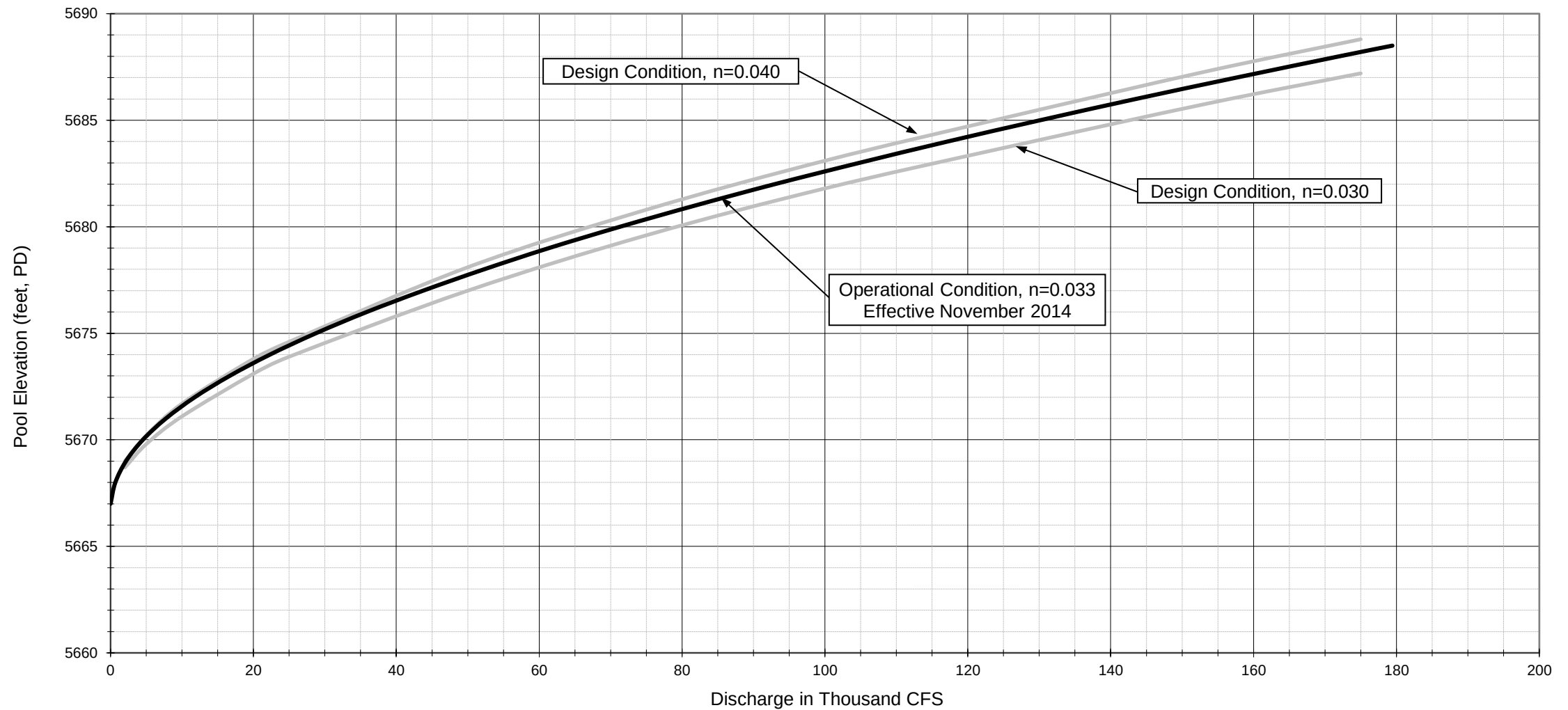
U.S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 2018

Prepared By: _____ JDM _____
 Reviewed By: _____ KJS _____



Spillway Discharge Rating Curve

Effective November 2014



Operational Condition:

1. Uncontrolled earth channel
2. Channel width = 800 ft
3. Manning's $n = 0.033$

Note:

The reservoir elevation is based on the Project Datum (PD), which for Bear Creek Reservoir is close to NGVD29 and 3.0 feet lower than NAVD88.

Prepared By: _____ KKA _____
Reviewed By: _____ KJS _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Spillway Discharge Rating Curve

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska

Bear Creek Dam
Spillway Rating Table -- Operational Condition
n = 0.033
Effective November 2014

Pool Elev. feet, PD	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
	Discharge in cfs									
5667	0	60	100	140	190	250	320	390	480	570
5668	670	790	910	1030	1170	1320	1470	1630	1790	1970
5669	2160	2350	2560	2780	3000	3220	3460	3720	3980	4240
5670	4520	4800	5090	5390	5700	6020	6340	6680	7030	7390
5671	7740	8110	8490	8860	9260	9660	10070	10510	10910	11350
5672	11790	12230	12720	13170	13650	14160	14630	15130	15620	16150
5673	16670	17210	17770	18310	18820	19400	19980	20560	21140	21720
5674	22310	22940	23570	24160	24810	25440	26090	26730	27380	28050
5675	28730	29440	30150	30820	31500	32210	32950	33670	34370	35120
5676	35860	36640	37430	38170	38950	39770	40540	41310	42130	42940
5677	43750	44610	45470	46280	47130	47970	48810	49690	50550	51380
5678	52260	53180	54090	54950	55880	56780	57710	58590	59550	60490
5679	61370	62410	63370	64320	65290	66310	67320	68250	69270	70290
5680	71310	72340	73360	74390	75490	76480	77560	78630	79710	80790
5681	81860	82940	84020	85090	86180	87330	88490	89640	90780	91830
5682	92980	94130	95280	96430	97690	98790	99990	101200	102410	103620
5683	104820	106020	107230	108440	109640	110920	112190	113460	114730	115890
5684	117150	118430	119830	121100	122370	123570	124870	126180	127490	128940
5685	130130	131440	132750	134060	135510	136770	138140	139520	140910	142180
5686	143540	144930	146310	147700	149080	150510	151950	153290	154700	156140
5687	157580	158930	160320	161770	163210	164630	166150	167590	169110	170580
5688	172000	173340	174860	176430	178000	179430				

Operational Condition:
1. Uncontrolled earth channel
2. Channel width = 800 ft
3. Manning's n = 0.033

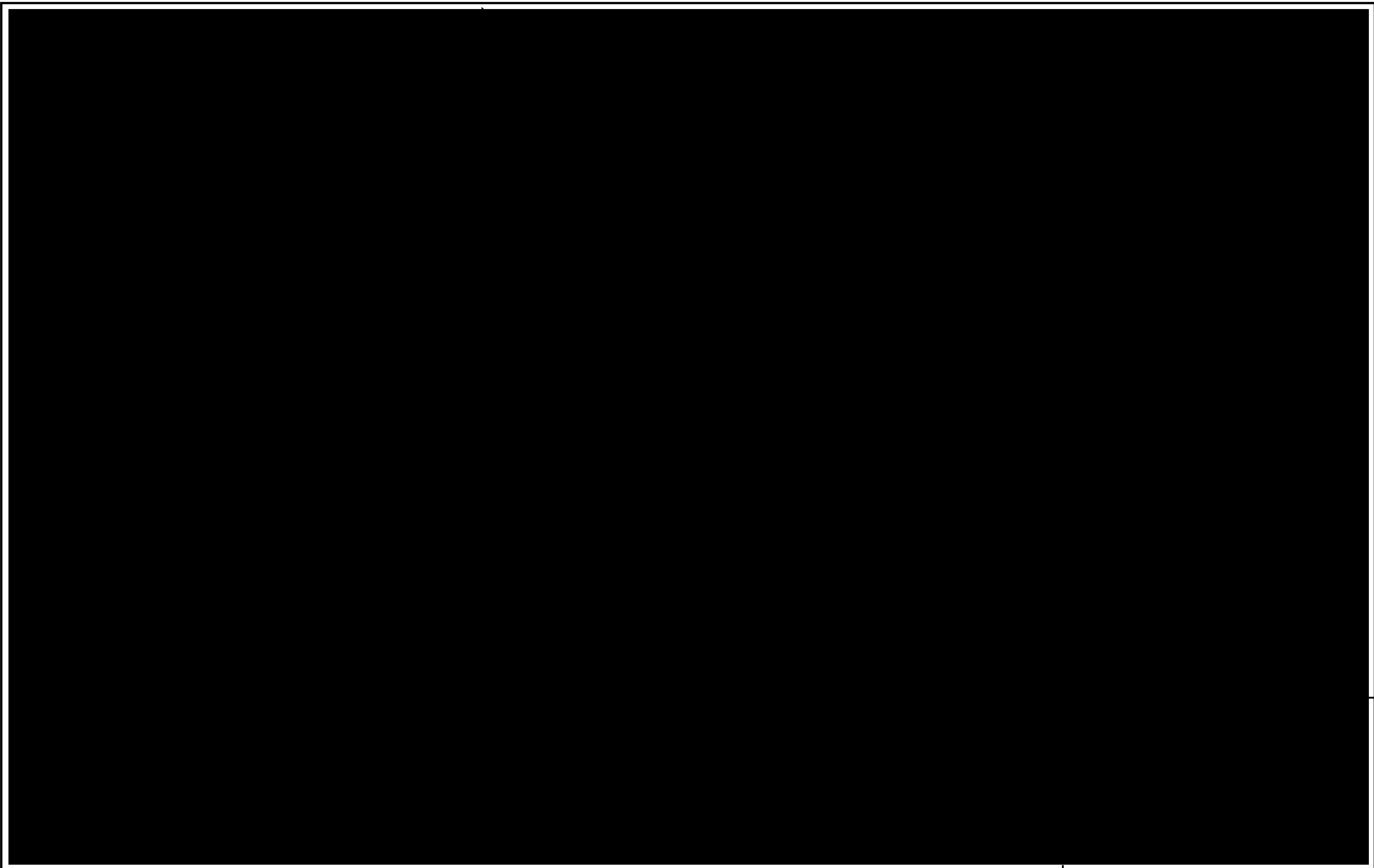
Note:
The reservoir elevation is based on the Project Datum (PD), which for Bear Creek Reservoir is close to NGVD29 and 3.0 feet lower than NAVD88.

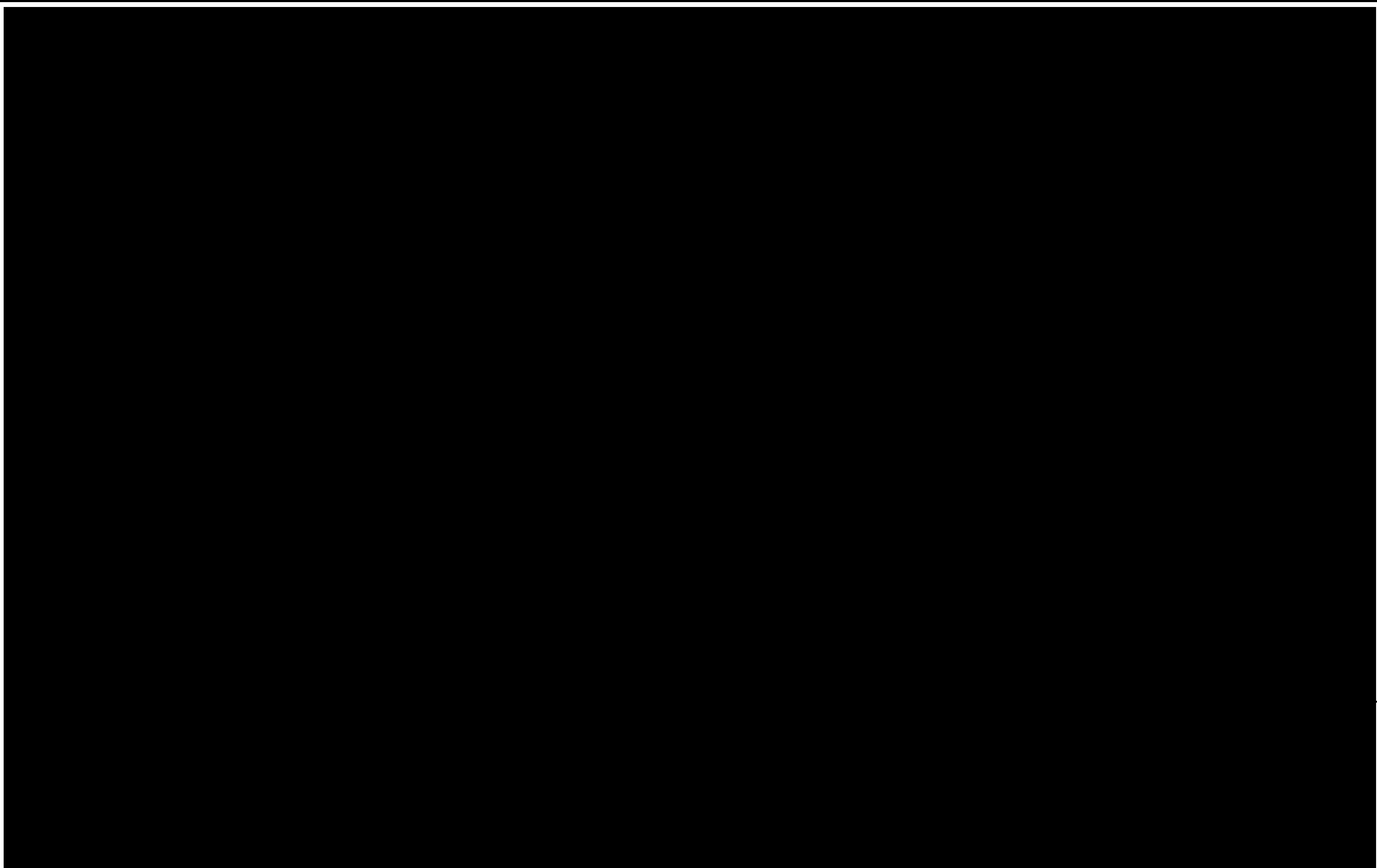
Prepared By: _____ KKA
Reviewed By: _____ KJS

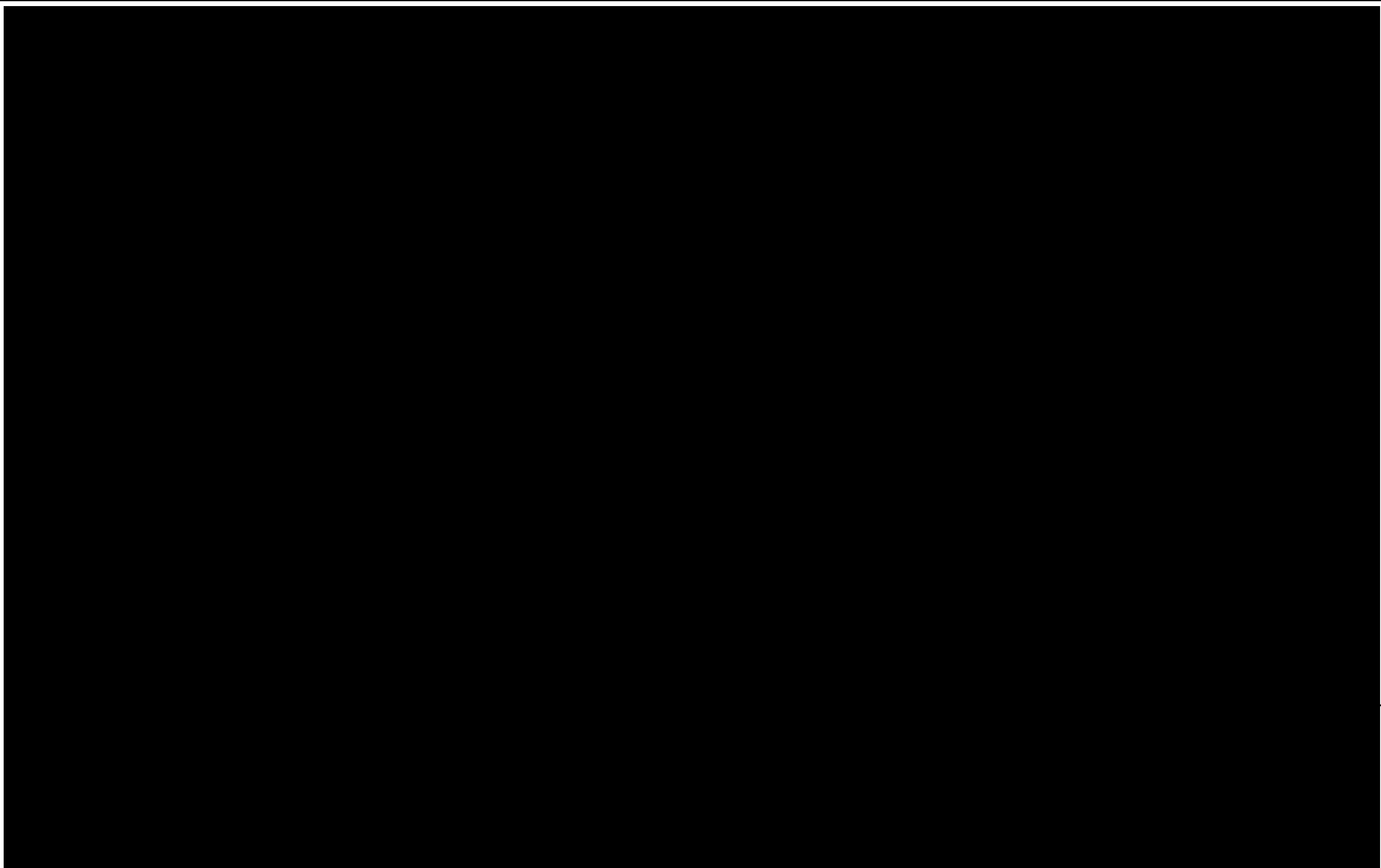
Water Control Manual
Bear Creek Dam and Reservoir, Colorado

**Spillway Discharge
Rating Table**

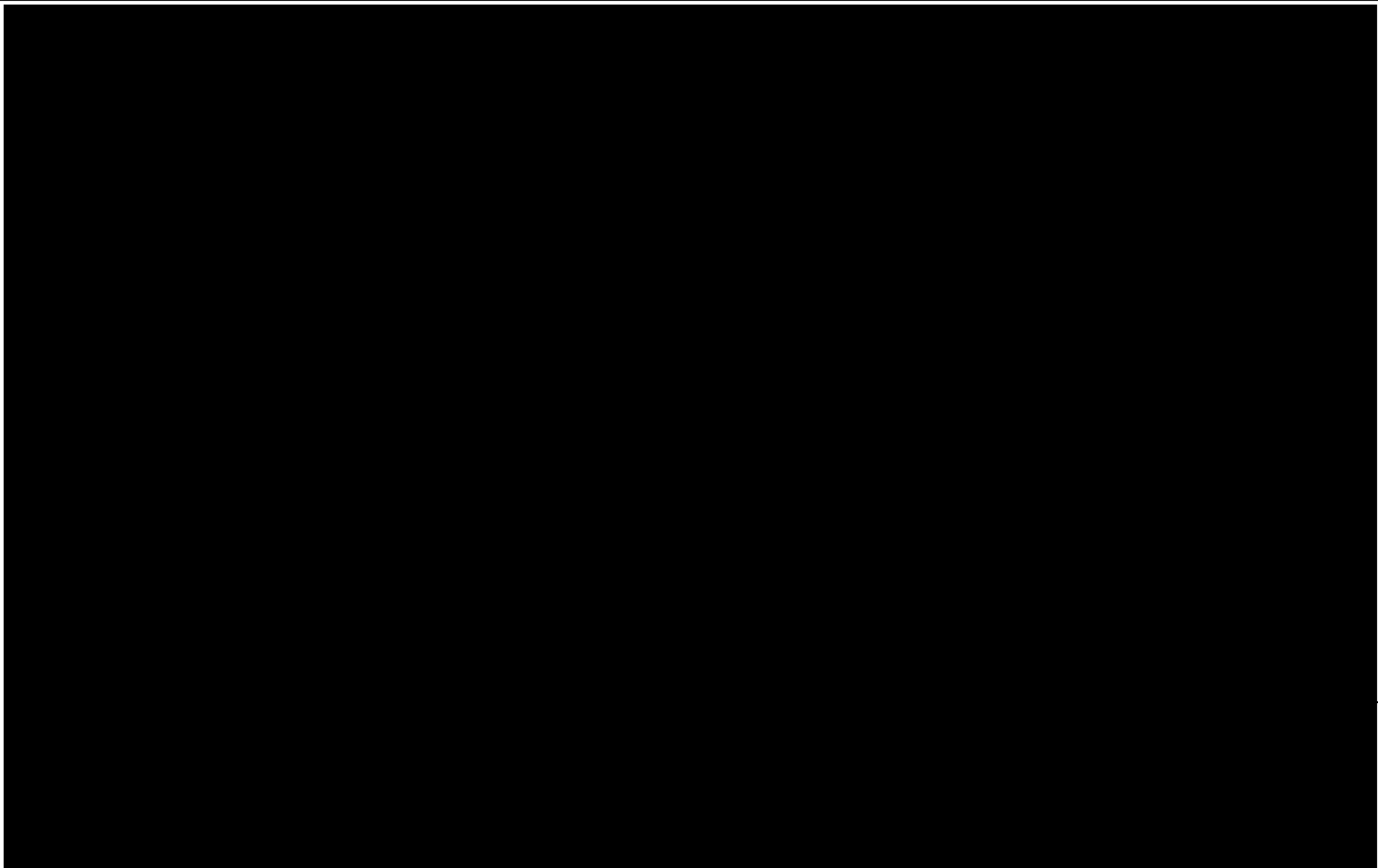
U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018



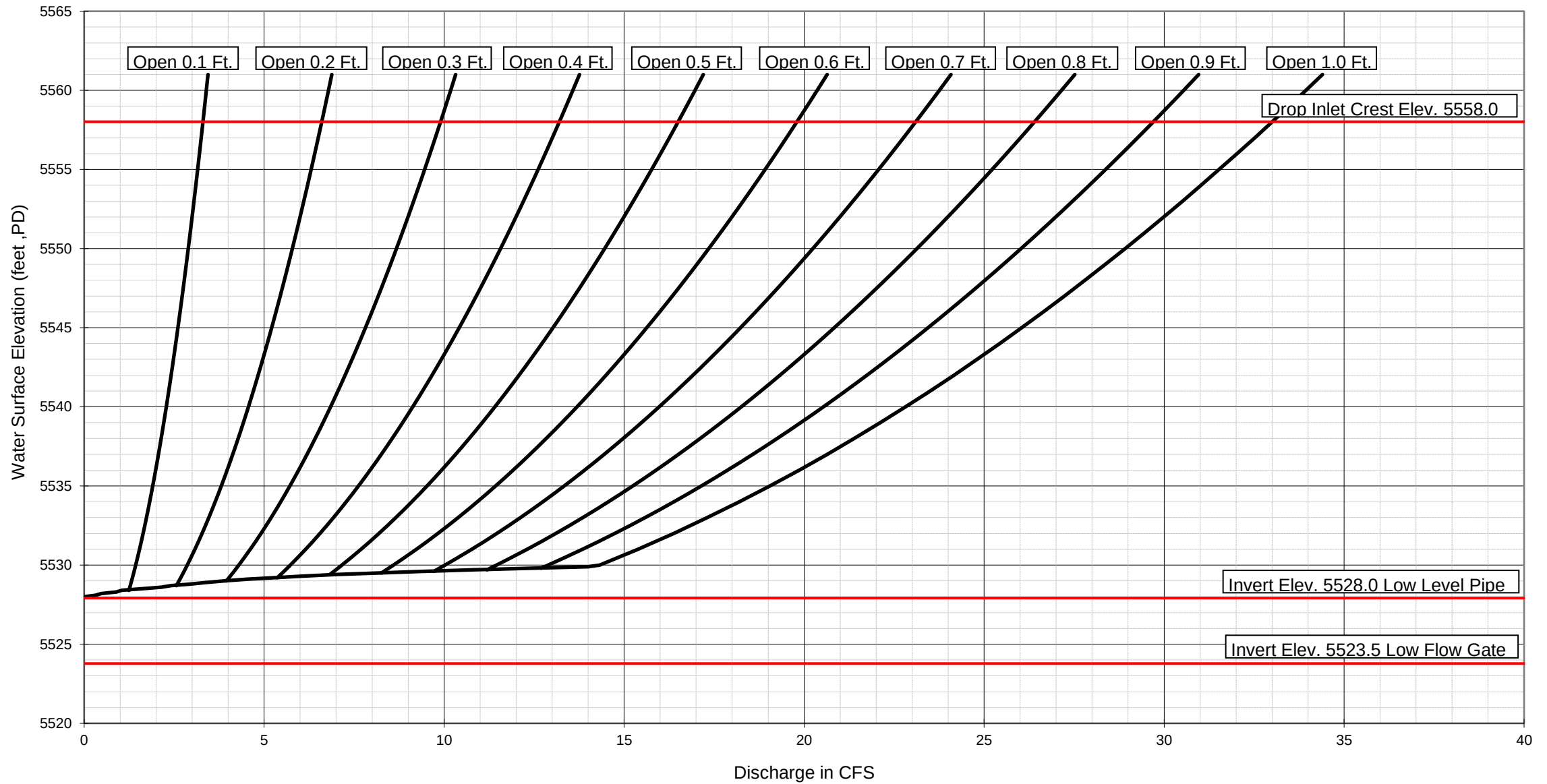








Outlet Works Discharge Rating Curves (Gate within a Gate)



Notes:

1. Low Flow Gate invert elevation 5523.5 ft PD.
2. A 1.0' X 1.0' gate within a gate is located on each service gate.
3. The reservoir elevation is based on the Project Datum (PD), which for Bear Creek Reservoir is close to NGVD29 and 3.0 feet lower than NAVD88.

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Discharge Rating Curves **Gate within a Gate**

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Prepared By: _____ KJS _____
Reviewed By: _____ AJF _____

**Discharge Rating Table
Gate within a Gate**

Elevation feet, PD	Gate Opening in Feet									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
	Discharge in cfs									
5528	0	0	0	0	0	0	0	0	0	0
5529	1	3	4	4	4	4	4	4	4	4
5530	2	3	4	5	7	8	9	11	12	14
5531	2	3	5	6	7	9	10	11	13	15
5532	2	3	5	6	8	9	11	12	14	16
5533	2	4	5	7	8	10	12	13	15	17
5534	2	4	5	7	9	11	12	14	16	18
5535	2	4	6	7	9	11	13	15	16	18
5536	2	4	6	8	10	12	14	15	17	19
5537	2	4	6	8	10	12	14	16	18	20
5538	2	4	6	8	10	13	15	17	19	21
5539	2	5	7	9	11	13	15	17	19	22
5540	3	5	7	9	11	13	16	18	20	22
5541	3	5	7	9	12	14	16	18	21	23
5542	3	5	7	10	12	14	17	19	21	24
5543	3	5	7	10	12	14	17	19	22	24
5544	3	5	8	10	13	15	18	20	22	25
5545	3	5	8	10	13	15	18	20	23	26
5546	3	5	8	11	13	16	18	21	24	26
5547	3	5	8	11	14	16	19	21	24	27
5548	3	6	8	11	14	17	19	22	25	27
5549	3	6	8	11	14	17	20	22	25	28
5550	3	6	9	12	14	17	20	23	26	29
5551	3	6	9	12	15	18	20	23	26	29
5552	3	6	9	12	15	18	21	24	27	30
5553	3	6	9	12	15	18	21	24	27	30
5554	3	6	9	12	15	18	21	25	28	31
5555	3	6	9	13	16	19	22	25	28	31
5556	3	6	9	13	16	19	22	25	28	32
5557	3	6	9	13	16	19	23	26	29	32
5558	3	6	10	13	17	20	23	26	29	33
5559	3	7	10	13	17	20	23	27	30	33
5560	4	7	10	14	17	20	24	27	30	34

Notes:

1. Low Flow Gate invert elevation 5523.5 ft PD.
2. A 1.0' X 1.0' gate within a gate is located on each service gate.
3. The reservoir elevation is based on the Project Datum (PD), which for Bear Creek Reservoir is close to NGVD29 and 3.0 feet lower than NAVD88.

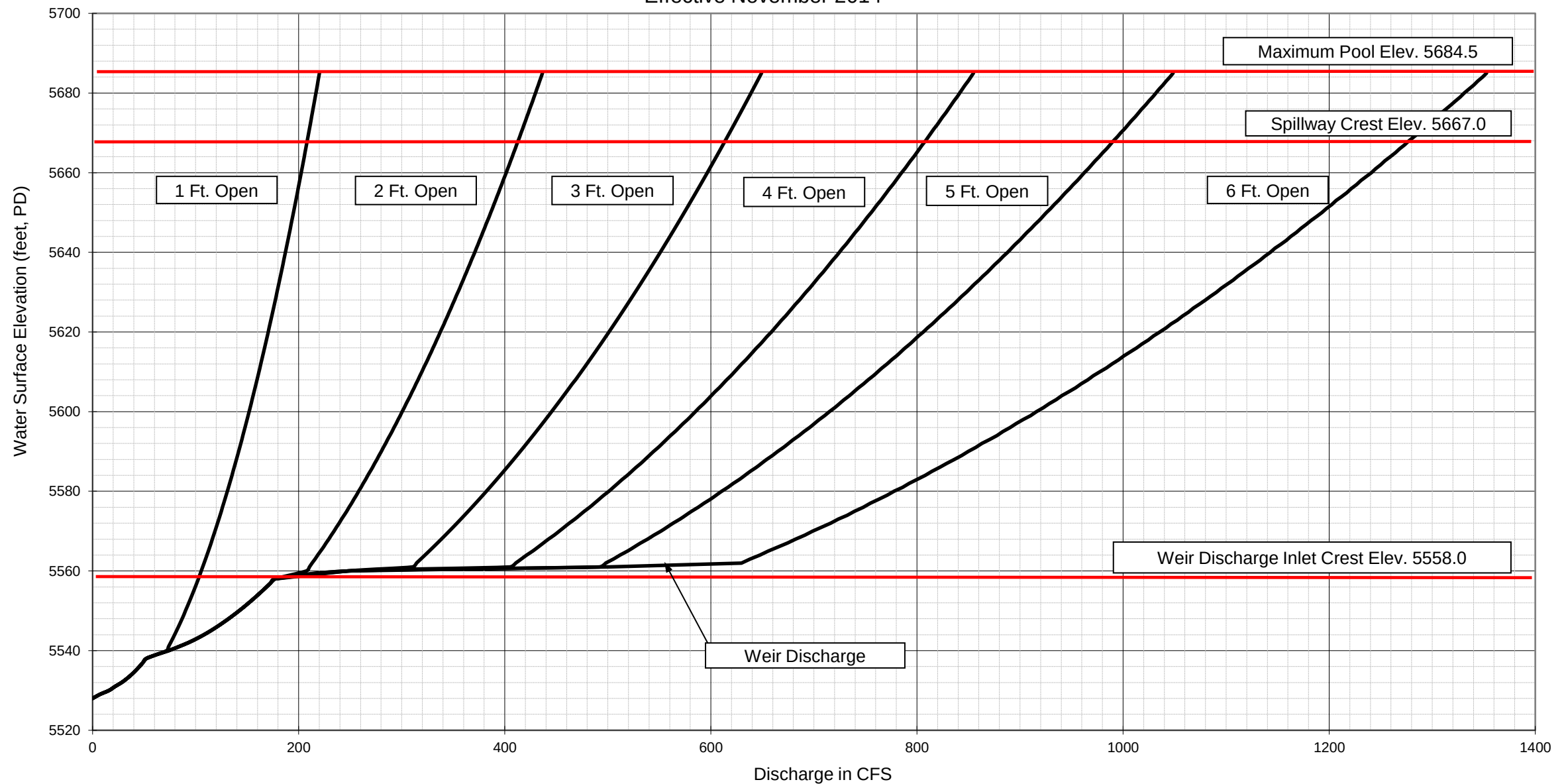
Prepared By: _____ KJS
Reviewed By: _____ AJF

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

**Discharge Rating Table
Gate within a Gate**

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Outlet Works Discharge Rating Curves
(One Service Gate with both Low Flow Valves Open 45° up to pool 5558 ft)
Effective November 2014



Notes:

1. The service gates are 3.0' x 6.0'.
2. Total Loss Coefficient = 0.7784.
3. Upstream conduit 7.0' diameter.
4. Downstream conduit 7.0' x 10.5' oblong.
5. Includes both low flow gates open 45° from elevation 5528-5558 ft PD.
6. The reservoir elevation is based on the Project Datum (PD), which for Bear Creek Reservoir is close to NGVD29 and 3.0 feet lower than NAVD88.

Prepared By: _____ KKA _____
Reviewed By: _____ KJS _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Discharge Rating Curves
One Service Gate with both Low Flow

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Discharge Rating Table
One Service Gate with both Low Flow Valves Open 45° up to elevation 5558 ft
 Effective November 2014

Elevation feet, PD	Gate Opening in Feet					
	1.0	2.0	3.0	4.0	5.0	6.0
	Discharge in cfs					
5530	16	16	16	16	16	16
5535	42	42	42	42	42	42
5540	72	74	74	74	74	74
5545	81	115	115	115	115	115
5550	90	142	142	142	142	142
5555	98	165	165	165	165	165
5556	100	169	169	169	169	169
5557	101	173	173	173	173	173
5558	103	177	177	177	177	177
5559*	77*	77*	77*	77*	77*	77*
	* Flow drops due to closure of low flow valves					
5560	105	207	248	248	248	248
5561	107	210	310	405	491	502
5562	108	213	314	411	498	630
5563	110	216	319	416	505	638
5564	111	218	323	421	512	648
5565	112	221	327	427	519	656
5566	114	224	331	432	525	665
5567	115	227	335	437	532	674
5568	116	229	338	442	539	682
5569	117	232	342	448	545	691
5570	119	234	346	453	552	699
5575	125	247	365	477	581	739
5580	131	258	382	501	610	778
5585	136	269	399	523	638	815
5590	142	280	415	544	665	850
5595	147	291	430	565	690	883
5600	152	300	445	585	715	916
5605	157	310	460	604	739	947
5610	161	320	474	623	762	978
5615	166	329	488	641	784	1007
5620	170	337	501	659	806	1036
5625	175	346	514	676	827	1063
5630	179	355	527	692	848	1091
5635	183	363	539	709	868	1117
5640	187	371	551	725	888	1143
5645	191	379	563	740	907	1168
5650	195	386	574	756	926	1193
5655	199	394	585	770	944	1217
5660	202	401	597	785	962	1241
5665	206	409	607	800	980	1264
5670	210	416	618	814	998	1287
5675	213	423	629	828	1015	1309
5680	217	430	639	841	1032	1331
5685	220	437	649	855	1049	1353

Notes:

1. The service gates are 3.0' x 6.0'.
2. Total Loss Coefficient = 0.7784.
3. Upstream conduit 7.0' diameter.
4. Downstream conduit 7.0' x 10.5' oblong.
5. Includes both low flow gates open 45° from elevation 5528-5558 ft PD.
6. The reservoir elevation is based on the Project Datum (PD), which for Bear Creek Reservoir is close to NGVD29 and 3.0 feet lower than NAVD88.

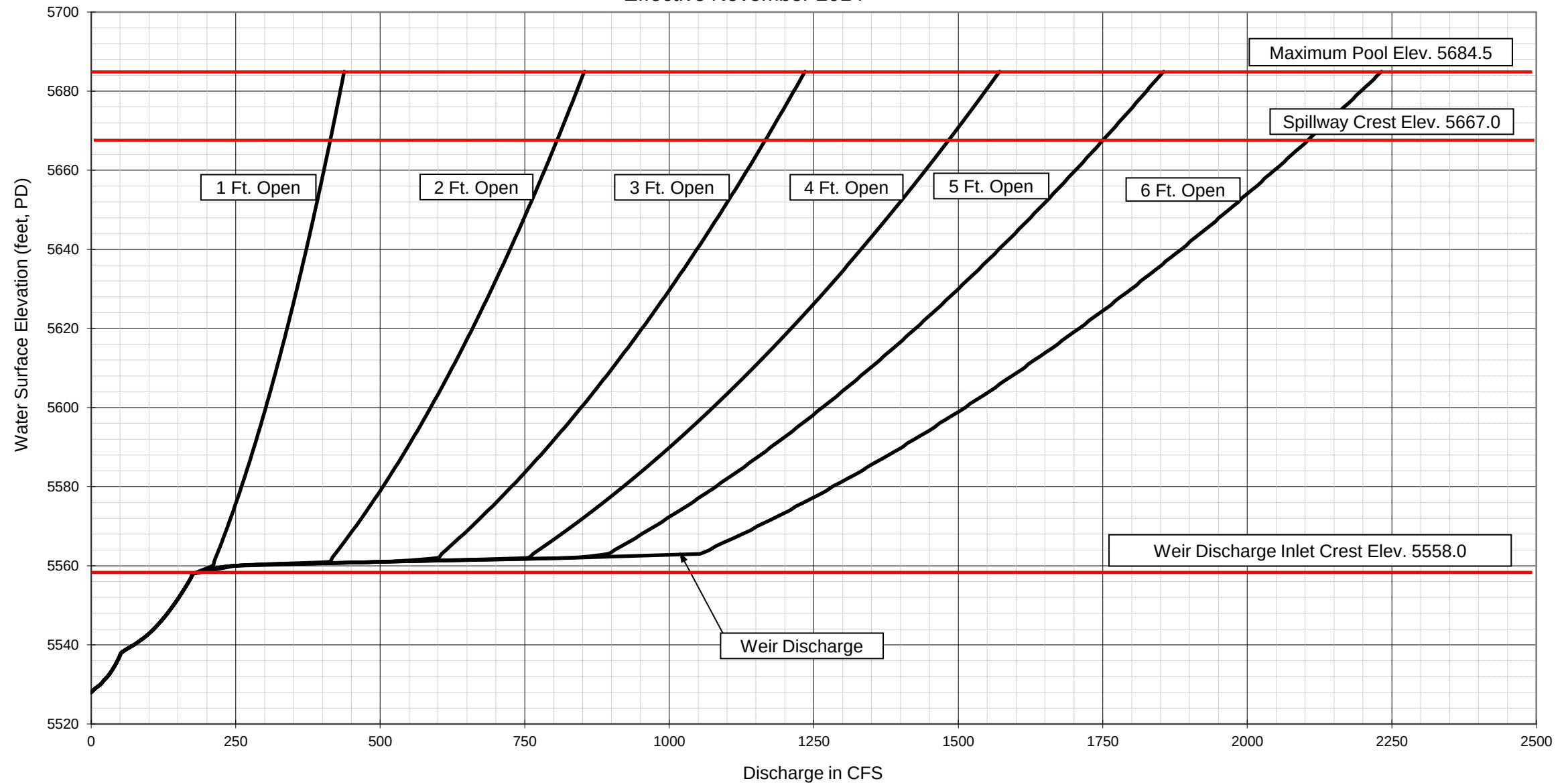
Prepared By: _____ KKA
 Reviewed By: _____ KJS

Water Control Manual
 Bear Creek Dam and Reservoir, Colorado

Discharge Rating Table
One Service Gate with both Low Flow

U.S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 2018

Outlet Works Discharge Rating Curves
(Two Service Gates Symmetrically Open with both Low Flow Valves Open 45° up to pool 5558 ft)
Effective November 2014



Notes:

1. Two 3.0' x 6.0' gates symmetrically open.
2. Total Loss Coefficient = 1.6268.
3. Upstream Conduit 7.0' diameter.
4. Downstream conduit 7.0' x 10.5' oblong.
5. Includes both low flow gates open 45° from elevation 5528-5558 ft PD.
6. The reservoir elevation is based on the Project Datum (PD), which for Bear Creek Reservoir is close to NGVD29 and 3.0 feet lower than NAVD88.

Prepared By: _____ KKA _____
Reviewed By: _____ KJS _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Discharge Rating Curves
Two Service Gates with both Low Flow

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Discharge Rating Table
Two Service Gates Symmetrically Open with both Low Flow Valves Open 45° up to elevation 5558 ft
Effective November 2014

Elevation feet, PD	Gate Opening in Feet					
	1.0	2.0	3.0	4.0	5.0	6.0
	Discharge in cfs					
5530	16	16	16	16	16	16
5535	42	42	42	42	42	42
5540	74	74	74	74	74	74
5545	115	115	115	115	115	115
5550	142	142	142	142	142	142
5555	165	165	165	165	165	165
5556	169	169	169	169	169	169
5557	173	173	173	173	173	173
5558	177	177	177	177	177	177
5559*	77*	77*	77*	77*	77*	77*
	* Flow drops due to closure of low flow valves					
5560	210	248	248	248	248	248
5561	213	411	502	502	502	502
5562	215	417	598	754	824	824
5563	218	422	606	764	893	1054
5564	221	427	614	774	905	1069
5565	223	432	621	784	918	1081
5566	226	438	629	794	930	1096
5567	228	443	636	804	942	1111
5568	231	448	644	813	952	1126
5569	234	453	652	823	964	1141
5570	236	458	659	832	975	1152
5575	248	482	694	877	1029	1219
5580	260	505	727	920	1081	1282
5585	271	526	759	961	1130	1343
5590	282	547	790	1001	1175	1403
5595	292	568	819	1039	1221	1459
5600	302	587	847	1075	1265	1512
5605	312	606	875	1111	1307	1564
5610	321	624	902	1145	1348	1614
5615	330	642	928	1178	1387	1662
5620	339	660	953	1211	1426	1709
5625	347	676	977	1242	1464	1755
5630	356	693	1002	1273	1500	1800
5635	364	709	1025	1303	1536	1843
5640	372	725	1048	1332	1570	1886
5645	380	740	1070	1360	1604	1927
5650	388	755	1092	1389	1638	1968
5655	395	770	1114	1416	1670	2008
5660	403	785	1135	1443	1703	2047
5665	410	799	1155	1470	1734	2085
5670	417	813	1176	1496	1765	2123
5675	424	826	1196	1521	1796	2160
5680	431	840	1215	1547	1826	2196
5685	438	853	1235	1572	1855	2232

Notes:

1. Two 3.0' x 6.0' gates symmetrically open.
2. Total Loss Coefficient = 1.6268.
3. Upstream Conduit 7.0' diameter.
4. Downstream conduit 7.0' x 10.5' oblong.
5. Includes both low flow gates open 45° from elevation 5528-5558 ft PD.
6. The reservoir elevation is based on the Project Datum (PD), which for Bear Creek Reservoir is close to NGVD29 and 3.0 feet lower than NAVD88.

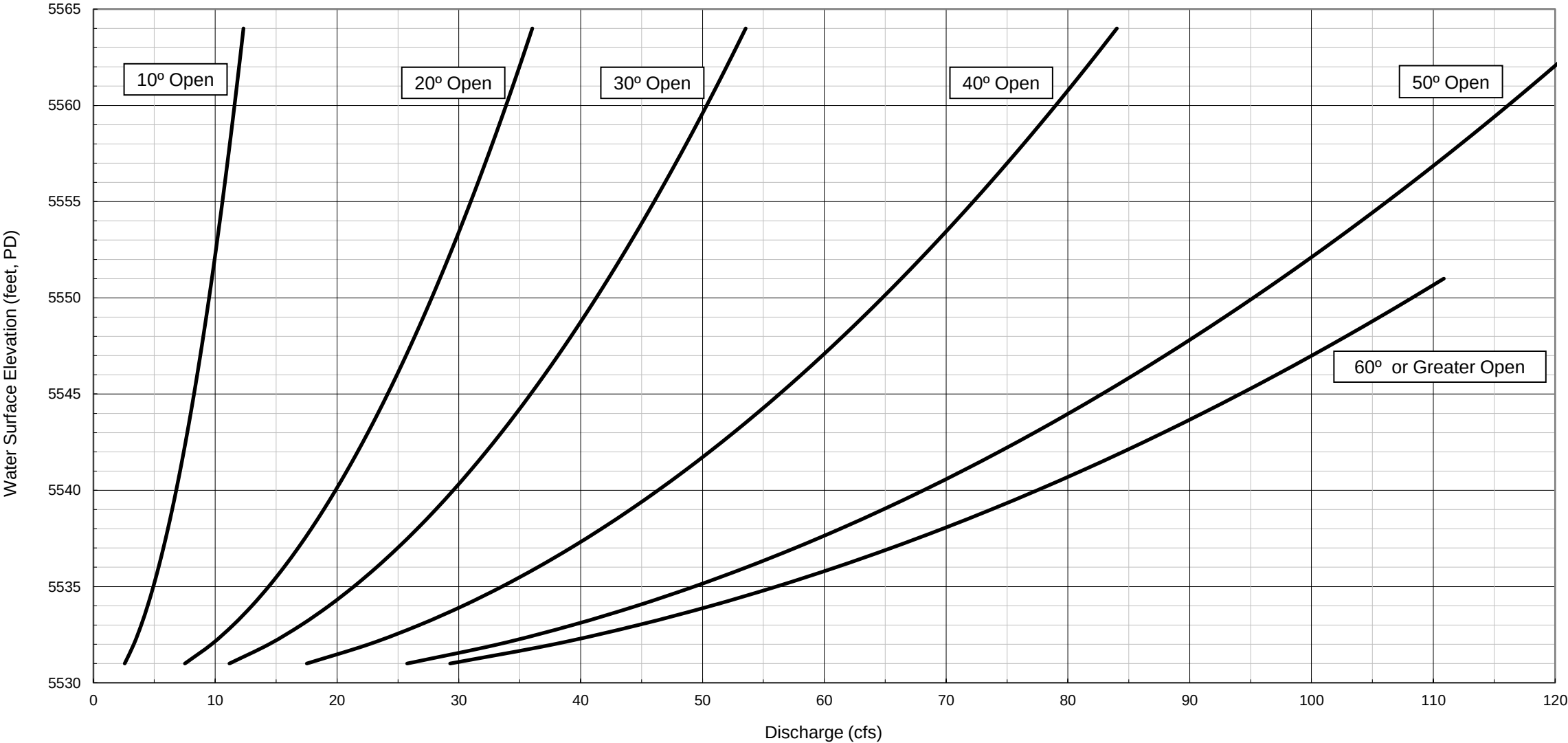
Prepared By: _____ KKA _____
Reviewed By: _____ KJS _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Discharge Rating Table
Two Service Gates with both Low Flow

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Low-Level Butterfly Valve Rating Curves



- Notes:
- 1. Low-Level invert elevation is 5528 ft PD.
 - 2. The reservoir elevation is based on the Project Datum (PD), which for Bear Creek Reservoir is close to NGVD29 and 3.0 feet lower than NAVD88.

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Discharge Rating Curves
Low-Level Butterfly Valve

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Prepared By: _____ KJS _____
Reviewed By: _____ AJF _____

**Discharge Rating Table
Low-Level Butterfly Valve
Invert Elevation is 5528 ft**

Elevation feet, PD	Degrees Open					
	10	20	30	40	50	60
	Discharge in cfs					
5528	0.0	0.0	0.0	0.0	0.0	0.0
5529	0.0	0.0	0.0	0.0	0.0	0.0
5530	0.0	0.0	0.0	0.0	0.0	0.0
5531	2.6	7.5	11.2	17.5	25.8	29.3
5532	3.3	9.7	14.4	22.6	33.2	37.8
5533	3.9	11.5	17.1	26.8	39.3	44.7
5534	4.4	13.0	19.3	30.3	44.6	50.7
5535	4.9	14.4	21.4	33.5	49.3	56.1
5536	5.3	15.6	23.2	36.5	53.6	61.0
5537	5.7	16.8	25.0	39.2	57.6	65.5
5538	6.1	17.9	26.6	41.7	61.3	69.7
5539	6.5	18.9	28.1	44.1	64.8	73.7
5540	6.8	19.9	29.5	46.4	68.1	77.5
5541	7.1	20.8	30.9	48.5	71.3	81.1
5542	7.4	21.7	32.2	50.6	74.3	84.5
5543	7.7	22.5	33.5	52.6	77.3	87.8
5544	8.0	23.4	34.7	54.5	80.1	91.0
5545	8.3	24.1	35.9	56.3	82.8	94.1
5546	8.5	24.9	37.0	58.1	85.4	97.1
5547	8.8	25.7	38.1	59.8	88.0	100.0
5548	9.0	26.4	39.2	61.5	90.4	102.8
5549	9.3	27.1	40.3	63.2	92.9	105.6
5550	9.5	27.8	41.3	64.8	95.2	108.3
5551	9.7	28.4	42.3	66.3	97.5	110.9
5552	9.9	29.1	43.2	67.9	99.7	
5553	10.2	29.7	44.2	69.3	101.9	
5554	10.4	30.4	45.1	70.8	104.1	
5555	10.6	31.0	46.0	72.2	106.2	
5556	10.8	31.6	46.9	73.6	108.3	
5557	11.0	32.2	47.8	75.0	110.3	
5558	11.2	32.7	48.7	76.4	112.3	
5559	11.4	33.3	49.5	77.7	114.2	
5560	11.6	33.9	50.3	79.0	116.1	
5561	11.8	34.4	51.2	80.3	118.0	
5562	12.0	35.0	52.0	81.5	119.9	
5563	12.1	35.5	52.8	82.8	121.7	
5564	12.3	36.0	53.5	84.0	123.5	

Notes:

1. Low-Level invert elevation is 5528 ft PD.
2. The reservoir elevation is based on the Project Datum (PD), which for Bear Creek Reservoir is close to NGVD29 and 3.0 feet lower than NAVD88.

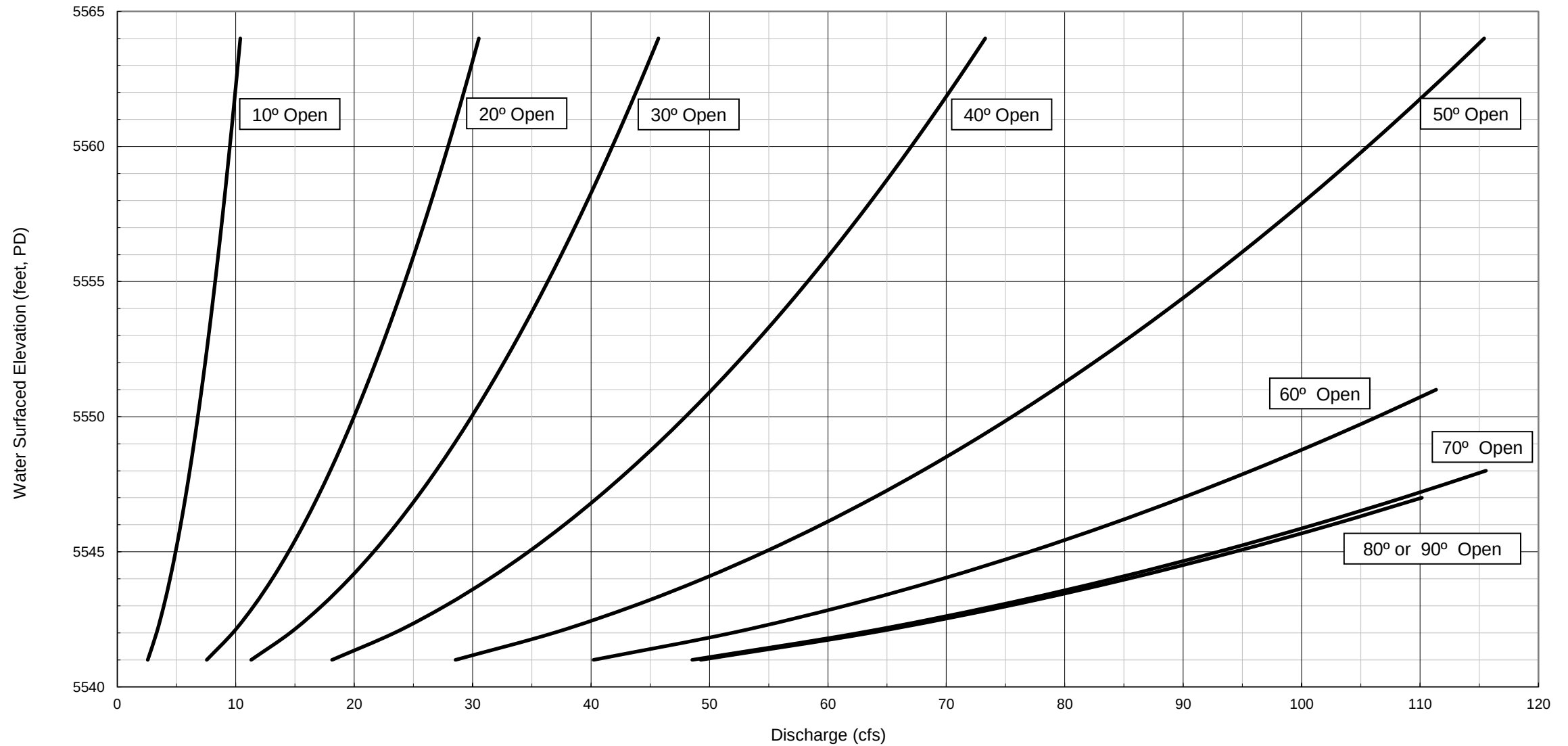
Prepared By: _____ KJS _____
Reviewed By: _____ AJF _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

**Discharge Rating Table
Low-Level Butterfly Valve**

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Discharge Rating Curves Mid-Level Butterfly Valve



Notes:

1. Mid-Level invert elevation is 5538 ft PD.
2. The reservoir elevation is based on the Project Datum (PD), which for Bear Creek Reservoir is close to NGVD29 and 3.0 feet lower than NAVD88.

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Discharge Rating Curves Mid-Level Butterfly Valve

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Prepared By: _____ KJS _____
Reviewed By: _____ AJF _____

**Discharge Rating Table
Mid-Level Butterfly Valve
Invert Elevation is 5538 ft**

Elevation feet, PD	Degrees Open							
	10	20	30	40	50	60	70	80 or 90
	Discharge in cfs							
5538	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5539	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5540	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5541	2.6	7.6	11.3	18.1	28.6	40.2	48.5	49.3
5542	3.3	9.8	14.6	23.4	36.9	51.9	62.7	63.6
5543	3.9	11.5	17.3	27.7	43.6	61.4	74.2	75.3
5544	4.5	13.1	19.6	31.4	49.5	69.7	84.1	85.3
5545	4.9	14.5	21.6	34.7	54.7	77.0	93.0	94.3
5546	5.4	15.7	23.5	37.7	59.4	83.7	101.1	102.6
5547	5.7	16.9	25.3	40.5	63.9	89.9	108.6	110.2
5548	6.1	18.0	26.9	43.2	68.0	95.7	115.6	
5549	6.5	19.0	28.5	45.6	71.9	101.2		
5550	6.8	20.0	29.9	48.0	75.6	106.4		
5551	7.1	20.9	31.3	50.2	79.1	111.4		
5552	7.4	21.8	32.6	52.3	82.4			
5553	7.7	22.7	33.9	54.4	85.7			
5554	8.0	23.5	35.2	56.4	88.8			
5555	8.3	24.3	36.3	58.3	91.8			
5556	8.5	25.1	37.5	60.1	94.7			
5557	8.8	25.8	38.6	61.9	97.5			
5558	9.0	26.5	39.7	63.7	100.3			
5559	9.3	27.2	40.8	65.4	103.0			
5560	9.5	27.9	41.8	67.0	105.6			
5561	9.7	28.6	42.8	68.7	108.1			
5562	10.0	29.3	43.8	70.2	110.6			
5563	10.2	29.9	44.8	71.8	113.0			
5564	10.4	30.5	45.7	73.3	115.4			

Notes:

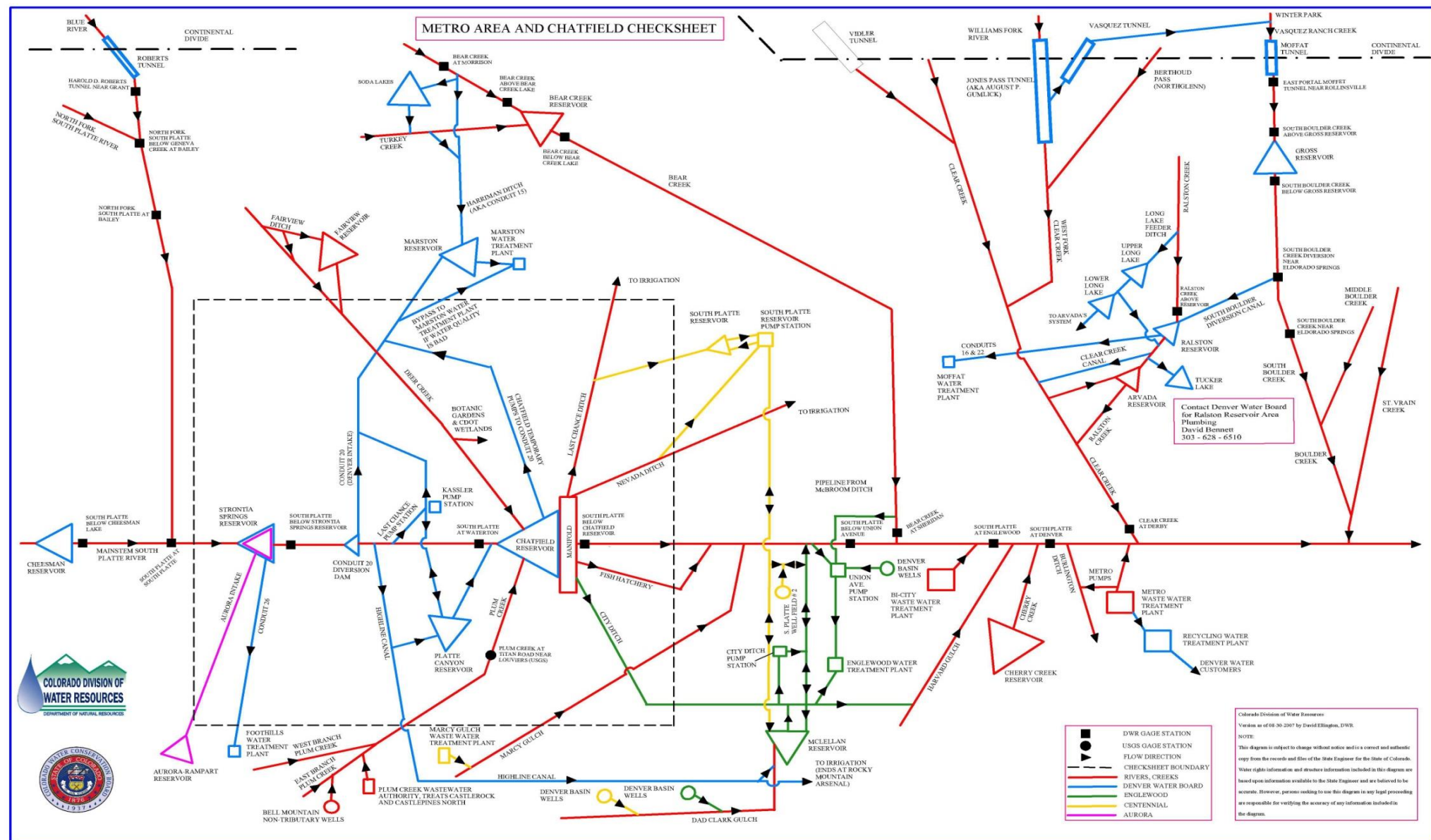
1. Mid-Level invert elevation is 5538 ft PD.
2. The reservoir elevation is based on the Project Datum (PD), which for Bear Creek Reservoir is close to NGVD29 and 3.0 feet lower than NAVD88.

Prepared By: _____ KJS
Reviewed By: _____ AJF

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

**Discharge Rating Table
Mid-Level Butterfly Valve**

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018



Visit the following website for a file with better resolution:
<http://water.state.co.us/DivisionsOffices/Div1SPlatteRiverBasin/Pages/Div1SPlatteRB.aspx>

Water Control Manual
 Bear Creek Dam and Reservoir, Colorado

Schematic Flow Diagram
 Denver Water Department
 Raw Water System

U.S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 2018

Prepared By: _____ KJS _____
 Reviewed By: _____ AJF _____

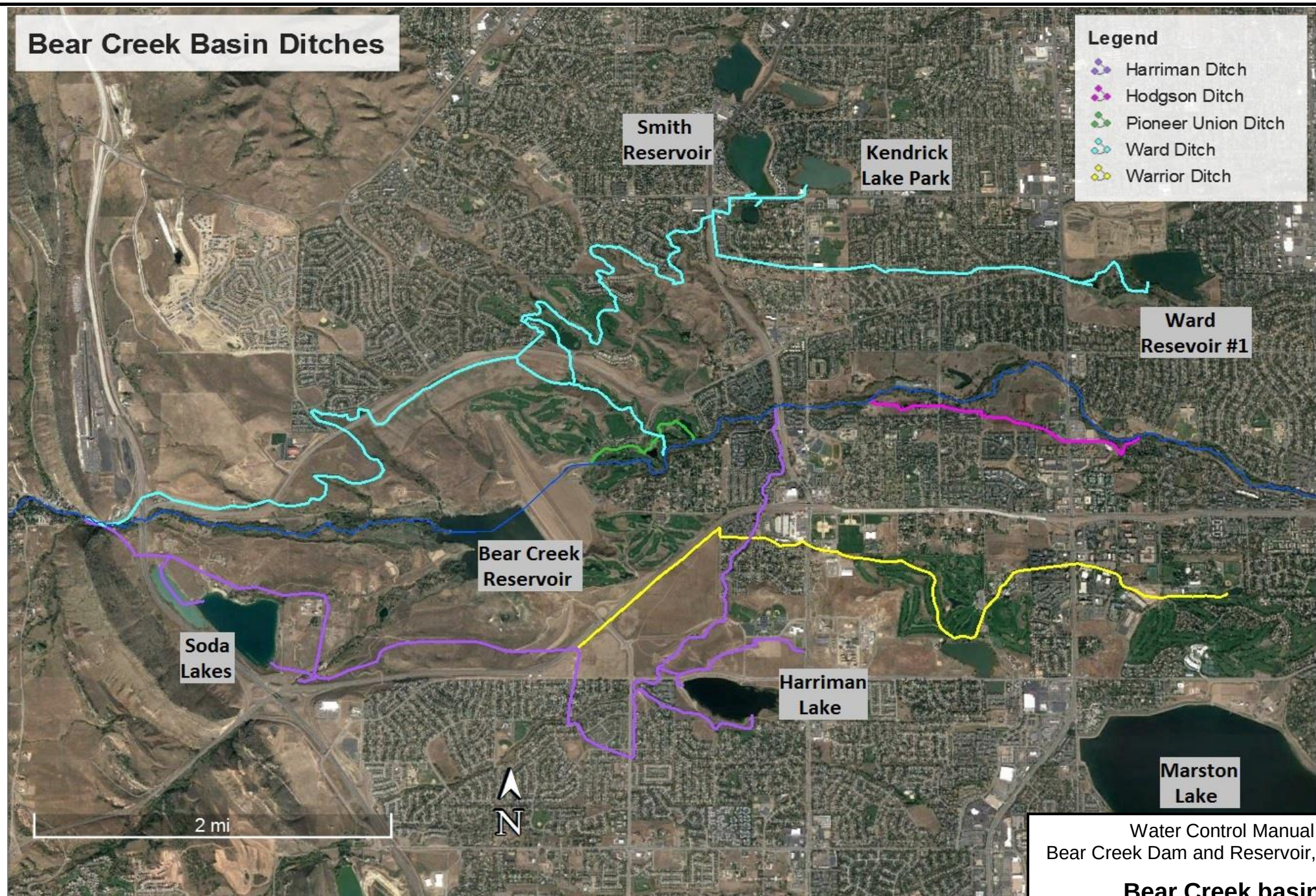
[illegible]

Prepared By: _____ KJS _____
Reviewed By: _____ AJF _____

Vicinity Canal Diversions

Plate 2-16

Bear Creek Basin Ditches

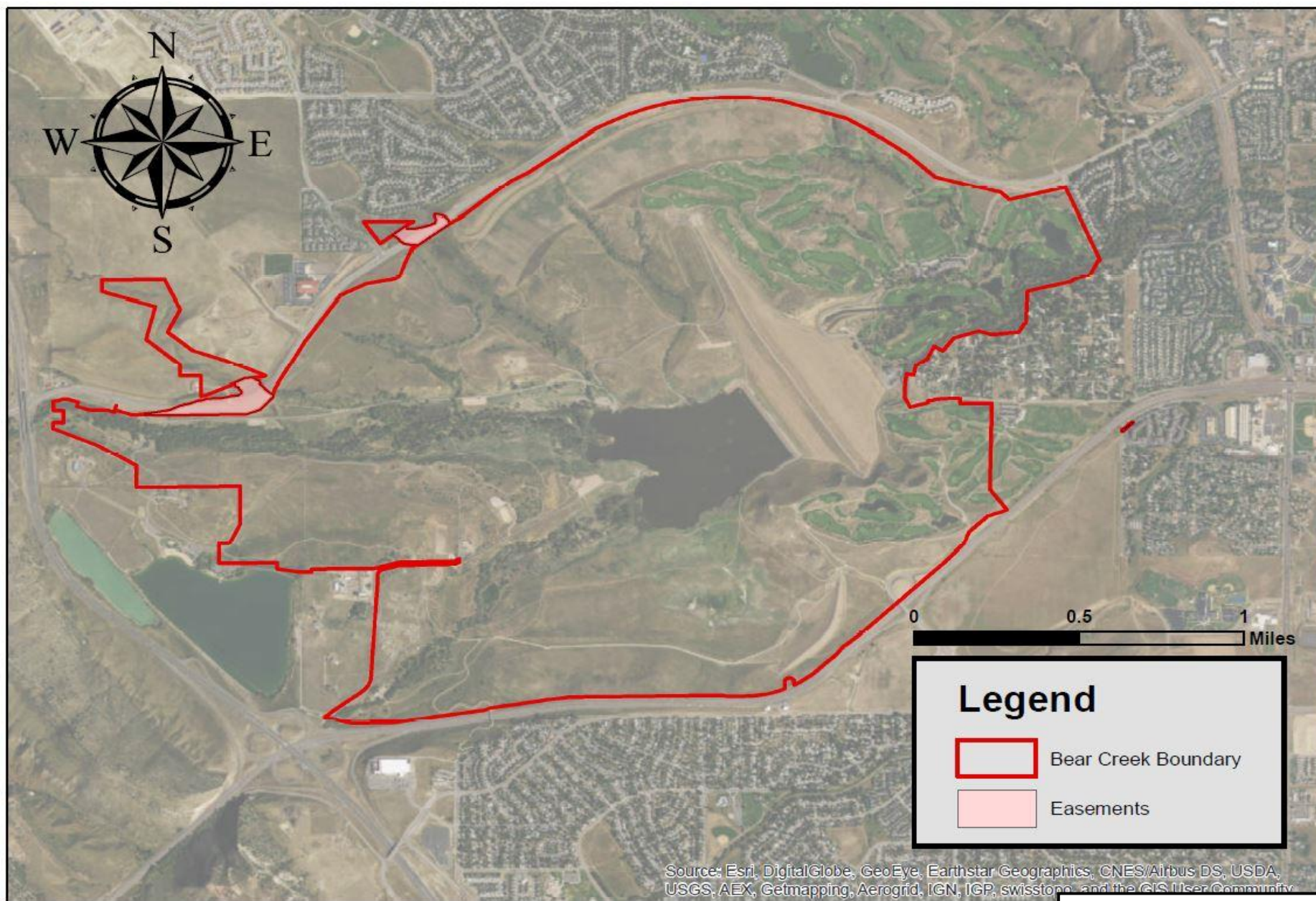


Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Bear Creek basin Ditch Map

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Prepared By: _____ TBuckley _____
Reviewed By: _____ KJS _____

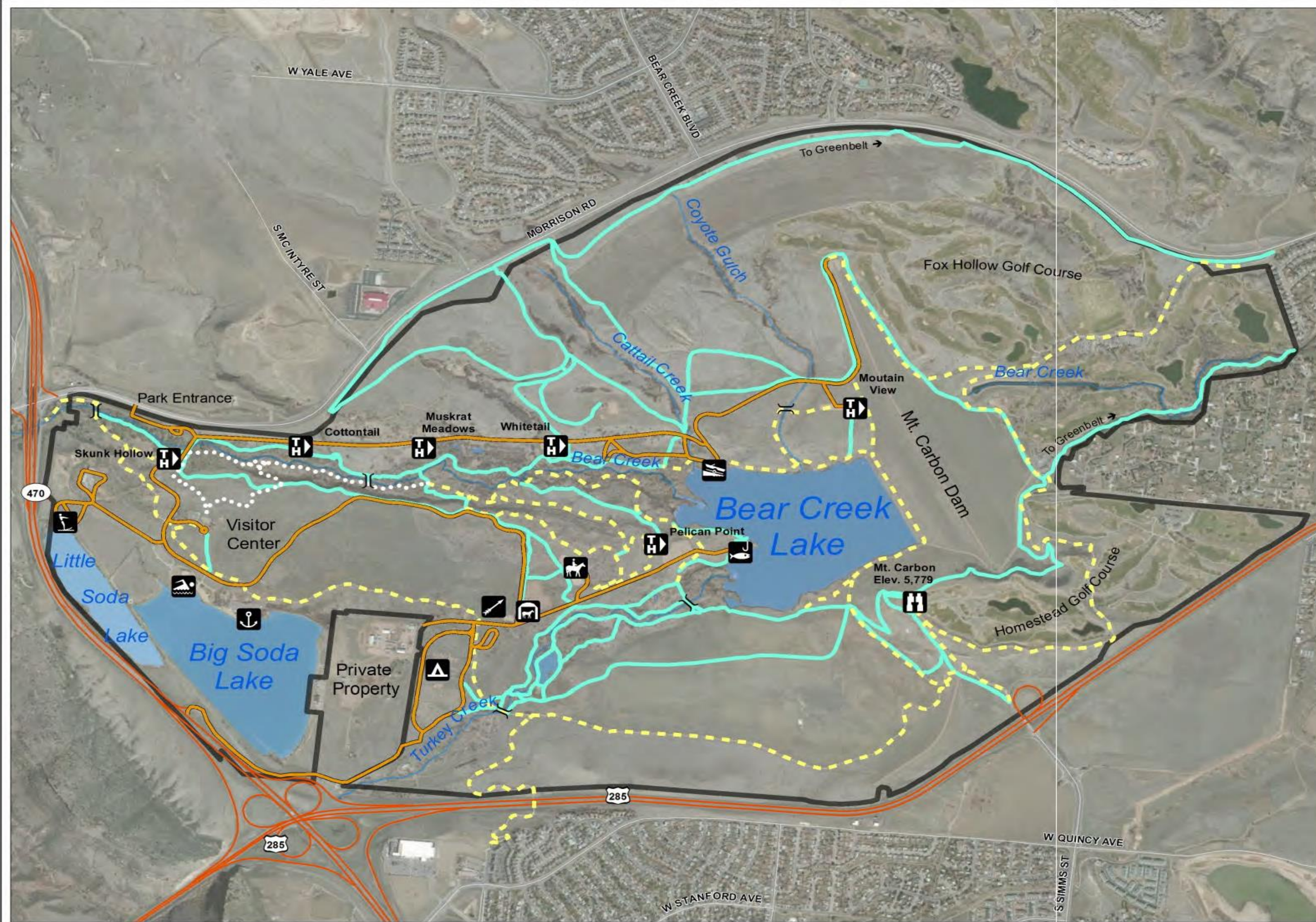


Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Bear Creek Project Boundary Map

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Prepared By: _____ SDS _____
Reviewed By: _____ KJS _____



Master Plan

Bear Creek Project / Bear Creek Lake

Park Amenities

- Archery Range
- Boat Ramp
- Equestrian Arena
- Campground
- Marina
- Overlook
- Fishing
- Stables
- Swim Beach
- Trailhead
- Water Skiing
- Trail: Hike
- Trail: Hike and Bike
- Trail: Horse, Hike, and Bike
- Park Roads
- Park Boundary

0 0.125 0.25 0.5 Miles
1 Inch = 0.25 Mile

U.S. Army Corps of Engineers / Omaha District - Omaha, Nebraska
Operations - Natural Resources Section
David Miller & Assoc., Inc. (C. McGarry) 18 Sept 12
E:\OMA\Bear Creek\Bear Creek GIS\Figure_6.mxd



Source: Bear Creek Master Plan

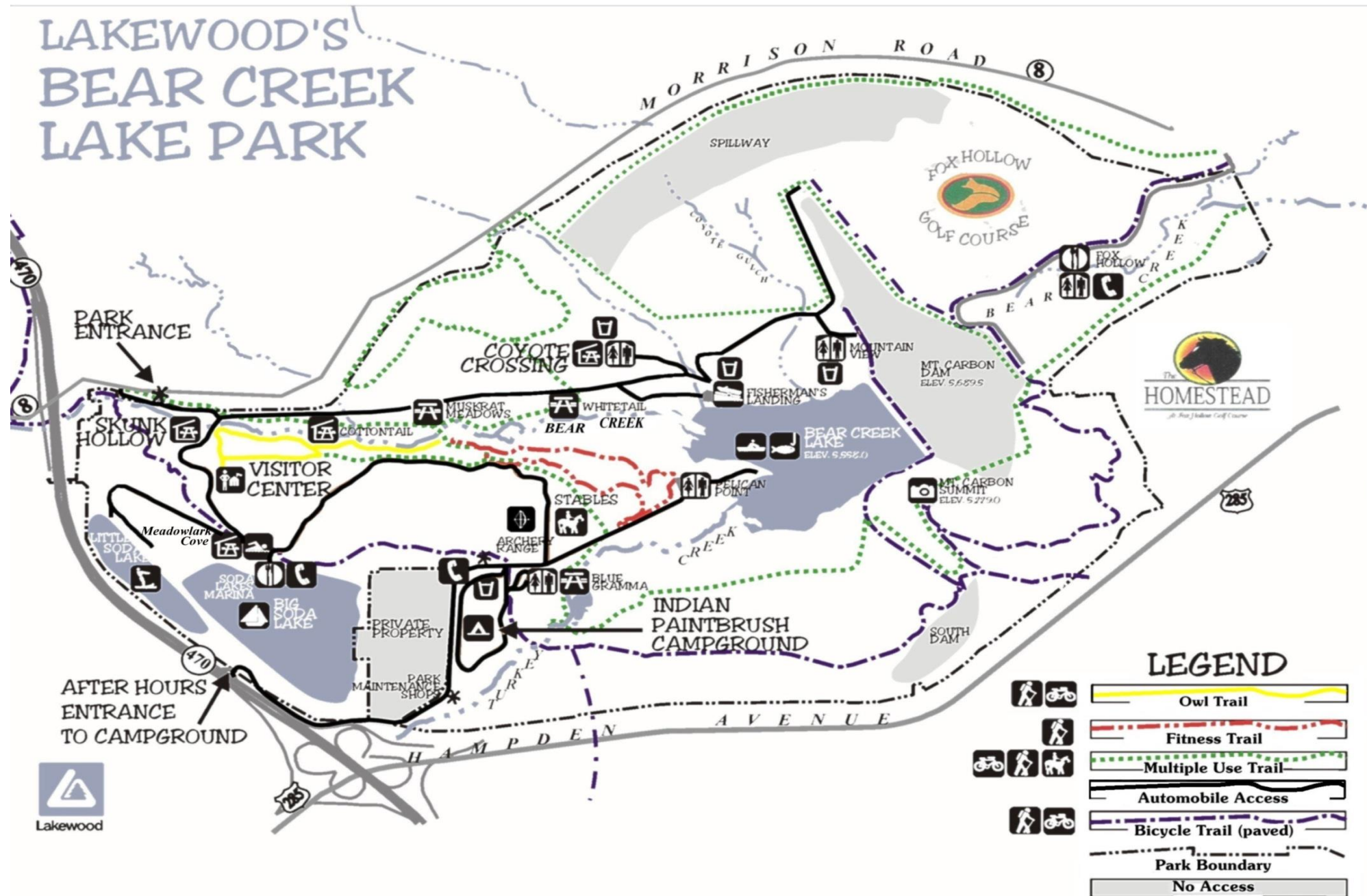
Prepared By: _____ KJS _____
Reviewed By: _____ AJF _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Bear Creek Reservoir Development

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

LAKEWOOD'S BEAR CREEK LAKE PARK



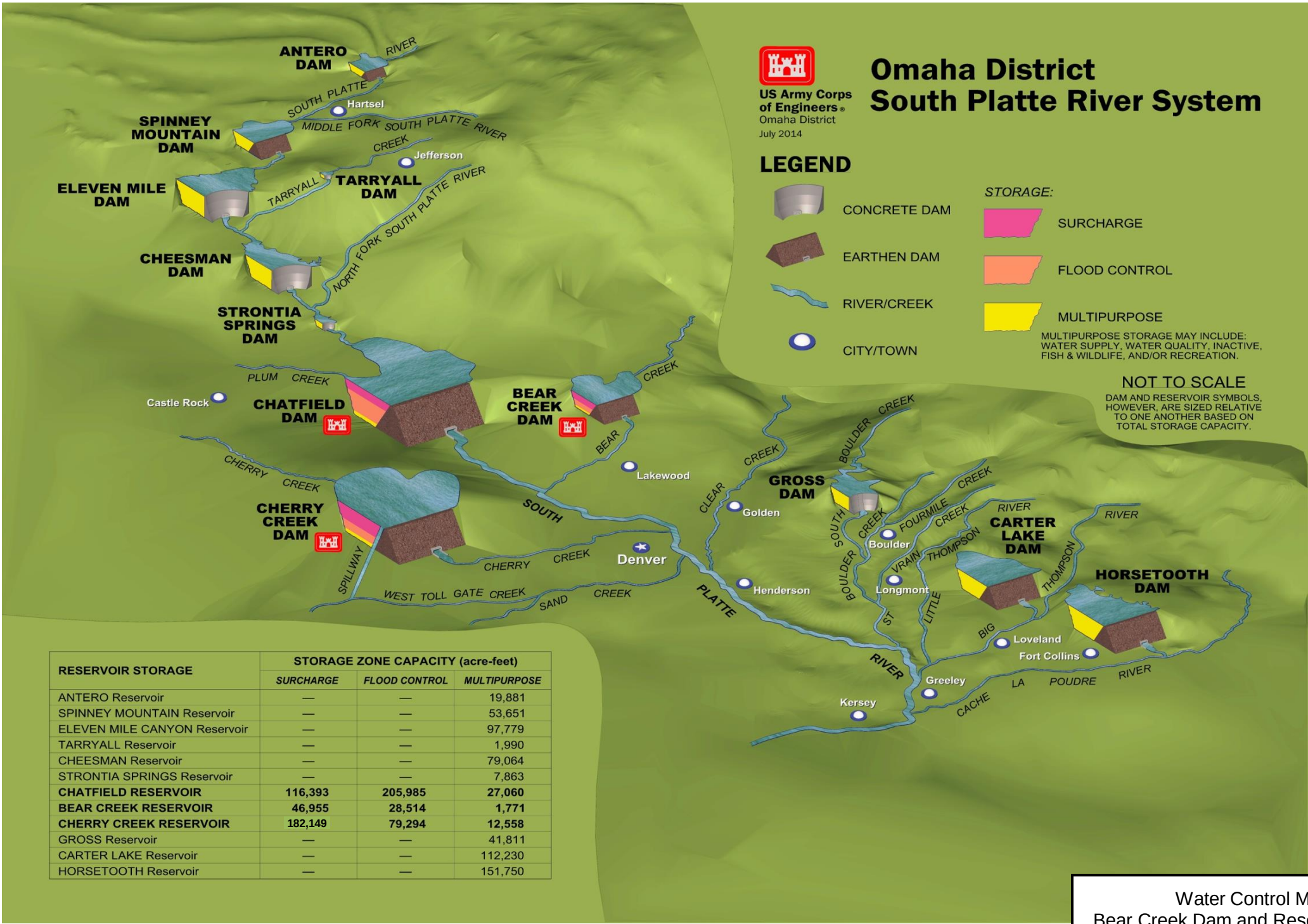
Source: <http://www.lakewood.org/bclp/>

Prepared By: _____ KJS
Reviewed By: _____ AJF

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Bear Creek Lake Park

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018



Water Control Manual
Bear Creek Dam and Reservoir, Colorado

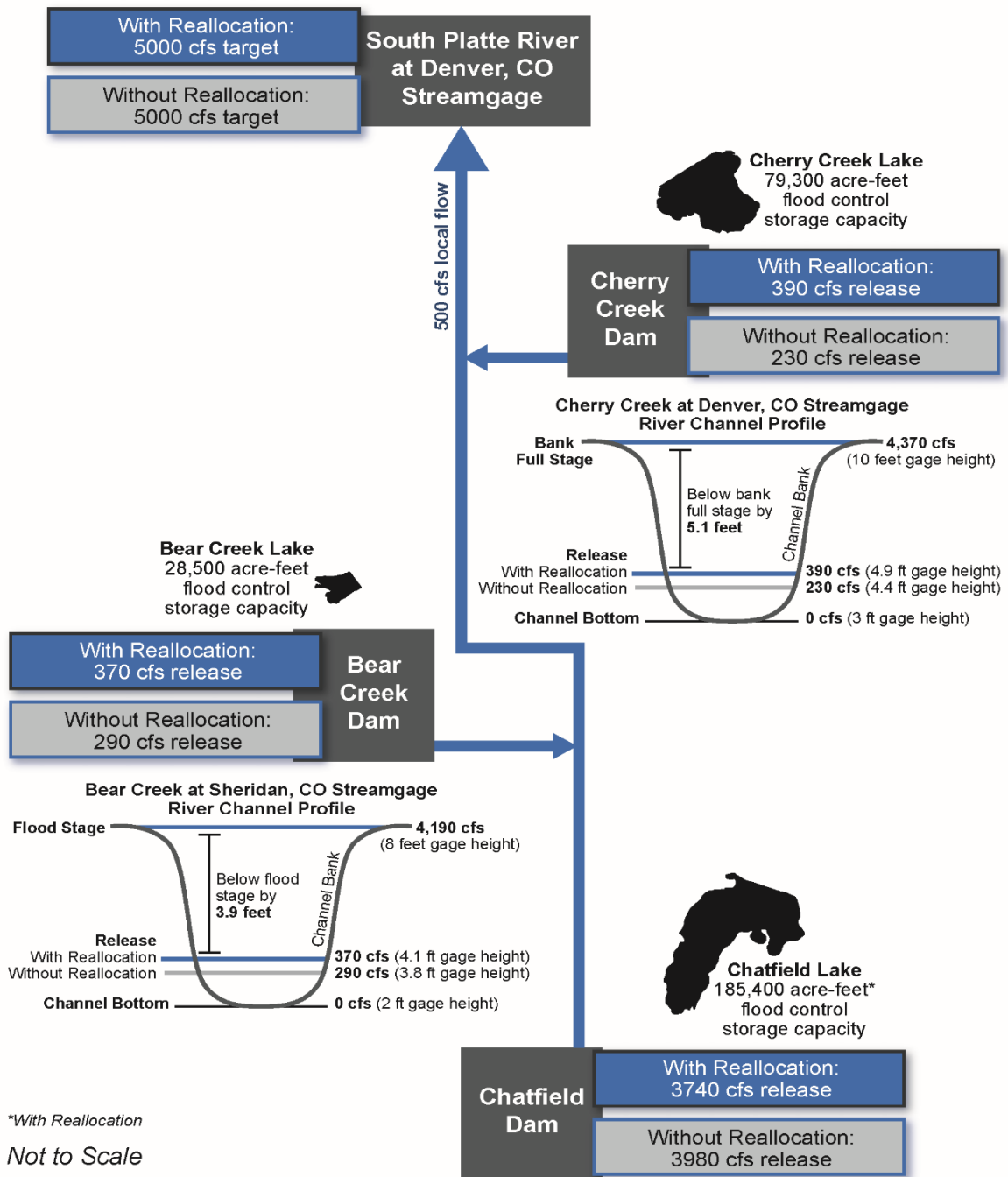
**South Platte River System
Diagram**

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Prepared By: _____ BCA _____
Reviewed By: _____ KJS _____

Chatfield Reservoir Flood Control Storage Reallocation

Example of Tri-Lakes system flood control storage evacuation for Level I (small flood events)

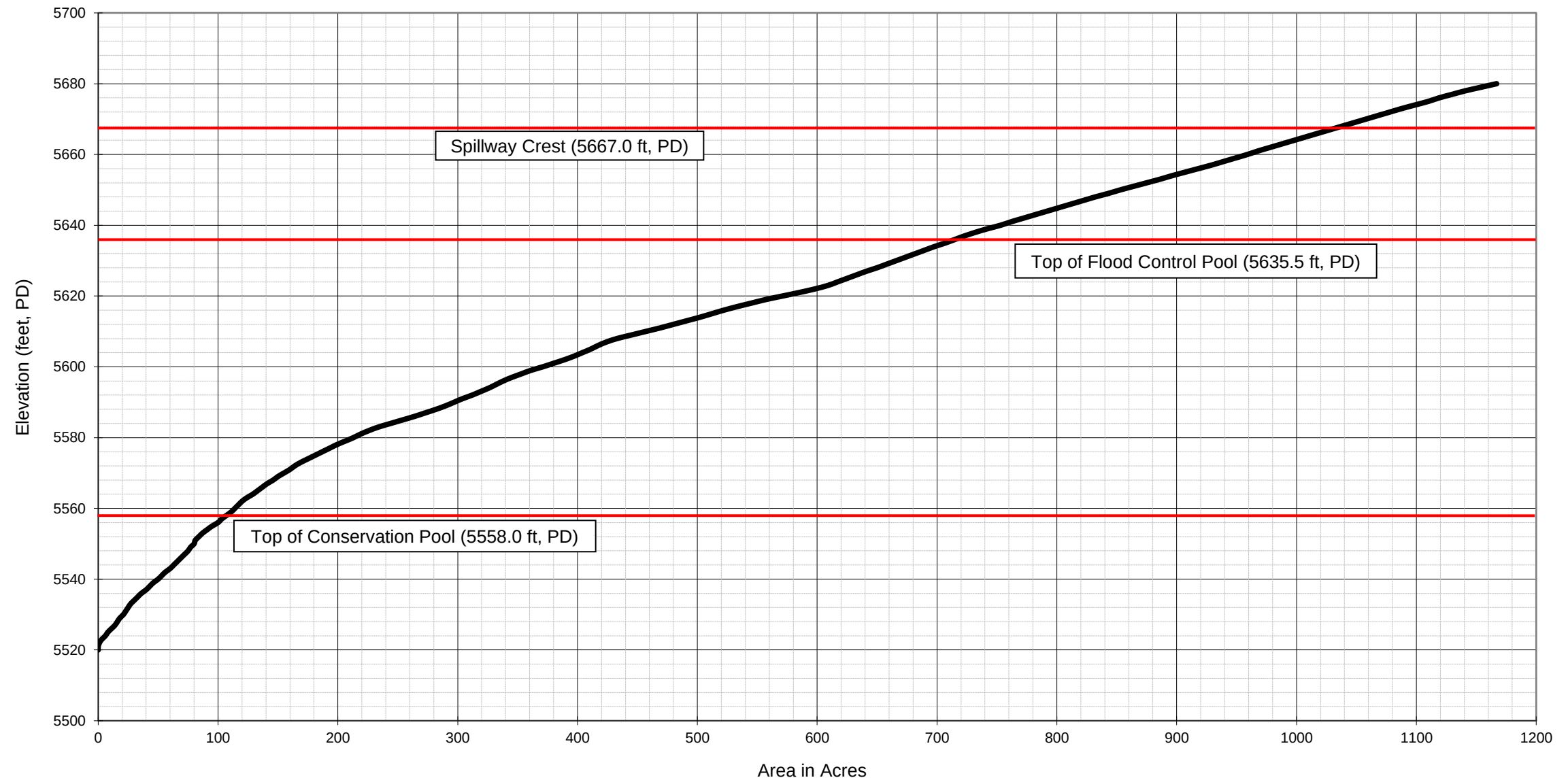


Water Control Manual
Bear Creek Dam and Reservoir, Colorado
Example System Flood Control Storage Evacuation

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Prepared By: _____ KJS _____
Reviewed By: _____ MJN _____

Bear Creek Reservoir Surface Area



Effective: 12 March 2010

Note:

The reservoir elevation is based on the Project Datum (PD), which for Bear Creek Reservoir is close to NGVD29 and 3.0 ft lower than NAVD88.

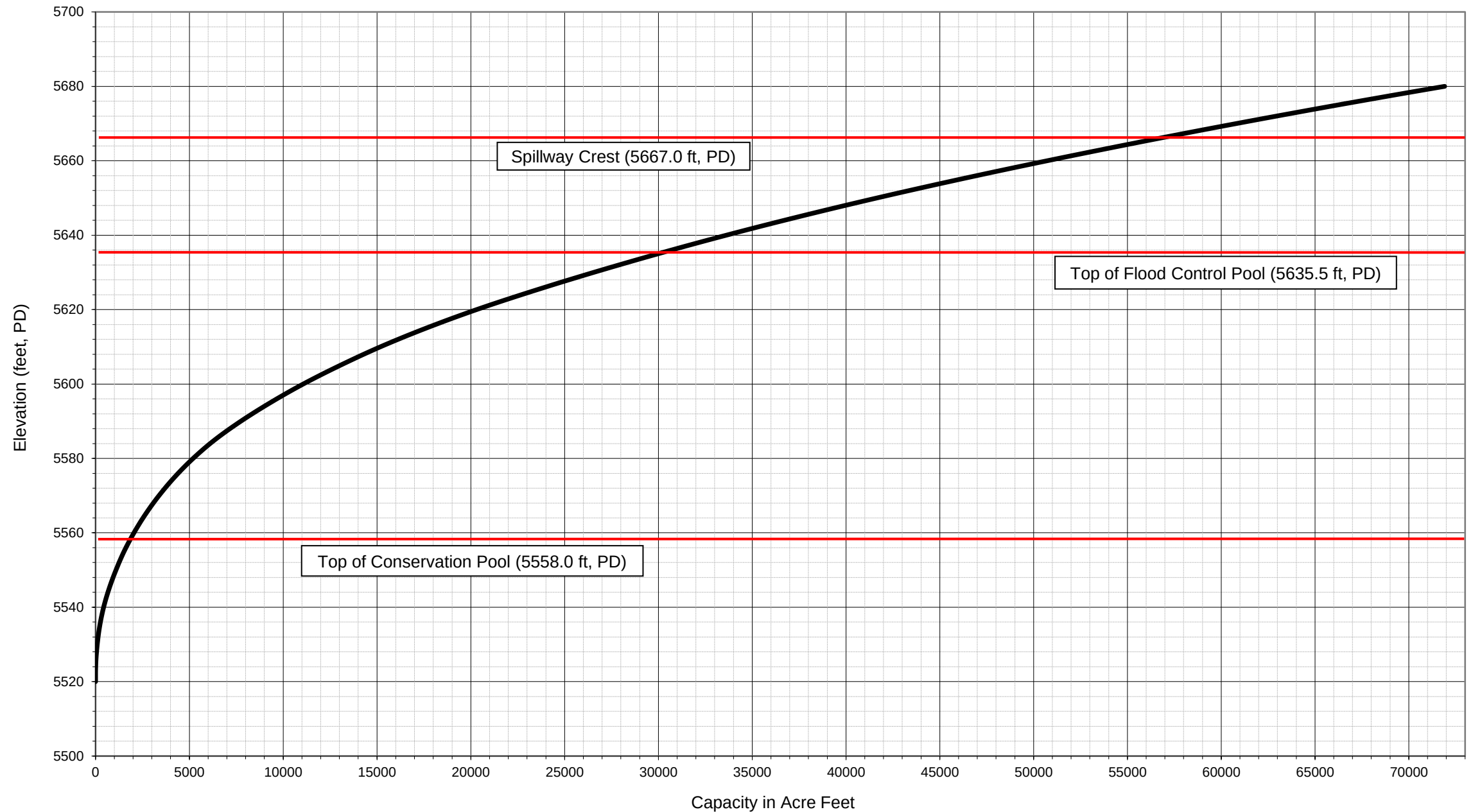
Prepared By: _____ KJS _____
 Reviewed By: _____ AJF _____

Water Control Manual
 Bear Creek Dam and Reservoir, Colorado

Reservoir Surface Area Curve 2009 Survey

U.S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 2018

Bear Creek Reservoir Storage Capacity



Effective 12 March 2010

Note:

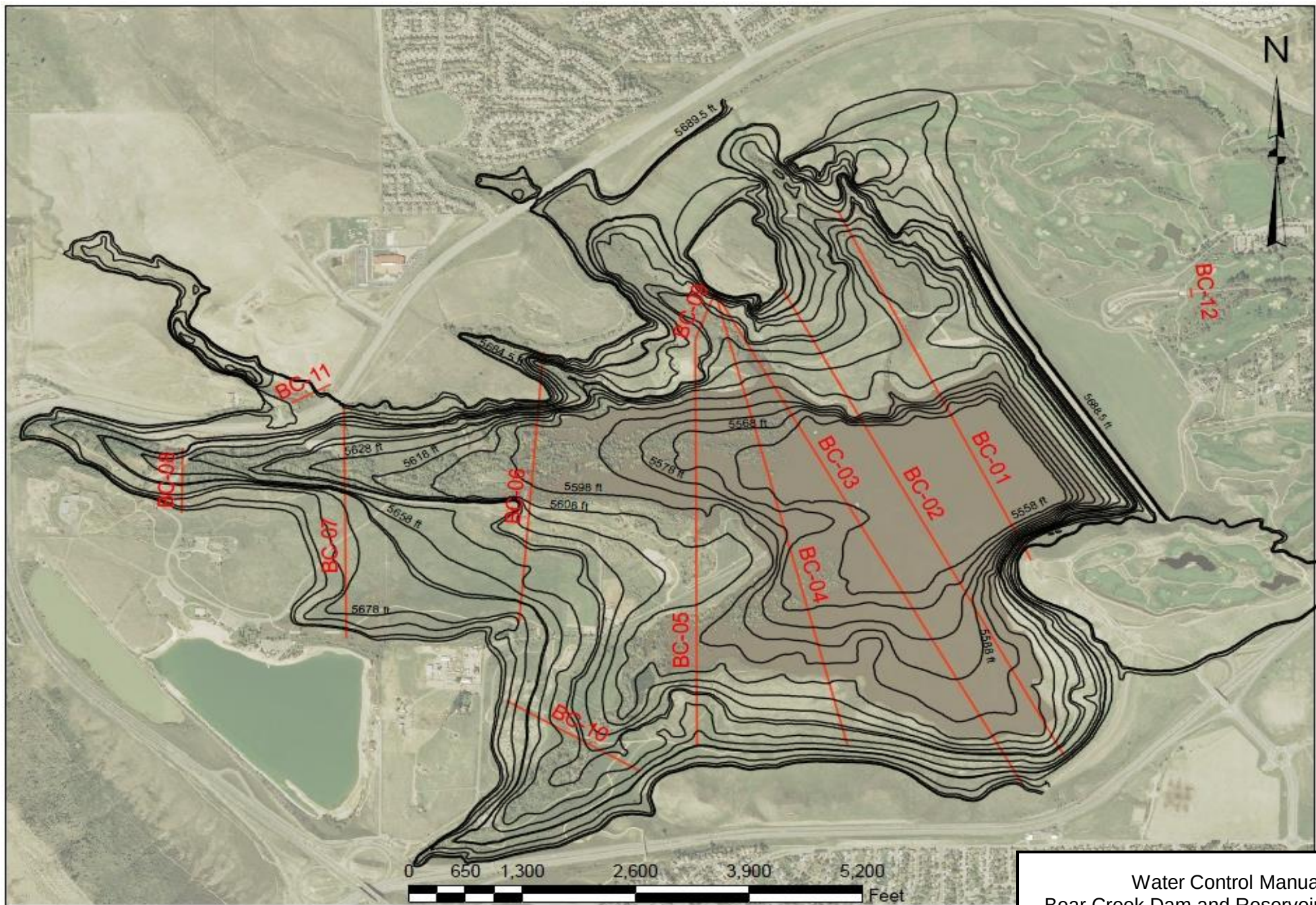
The reservoir elevation is based on the Project Datum (PD), which for Bear Creek Reservoir is close to NGVD29 and 3.0 ft lower than NAVD88.

Prepared By: _____ KJS _____
 Reviewed By: _____ AJF _____

Water Control Manual
 Bear Creek Dam and Reservoir, Colorado

Reservoir Storage Capacity Curve 2009 Survey

U.S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 2018



Note:

The reservoir elevation is based on the Project Datum (PD), which for Bear Creek Reservoir is close to NGVD29 and 3.0 ft lower than NAVD88.

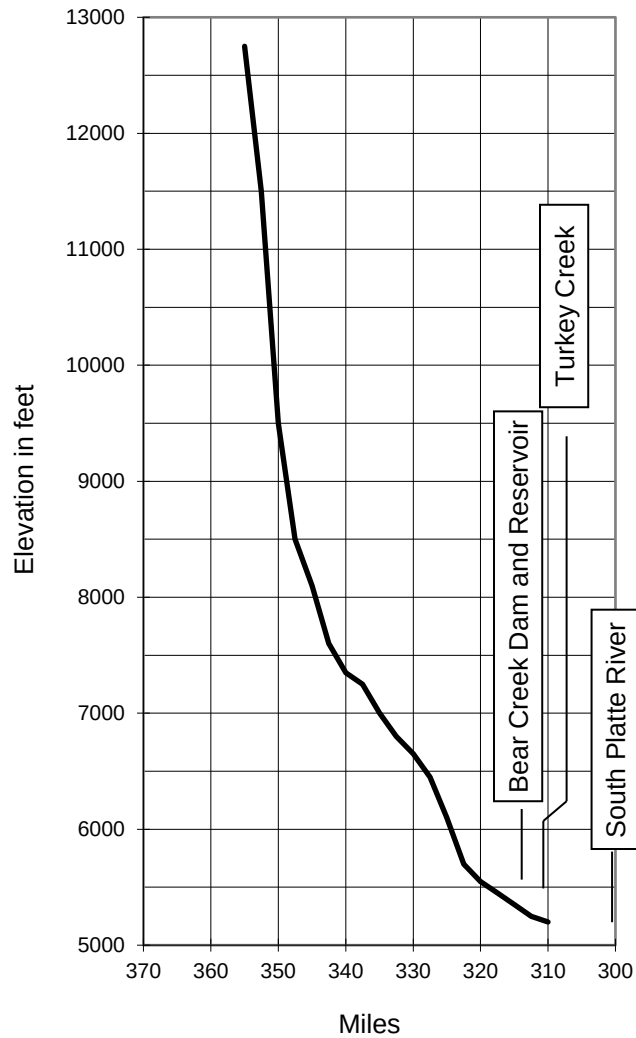
Prepared By: _____ JDM
Reviewed By: _____ KJS

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

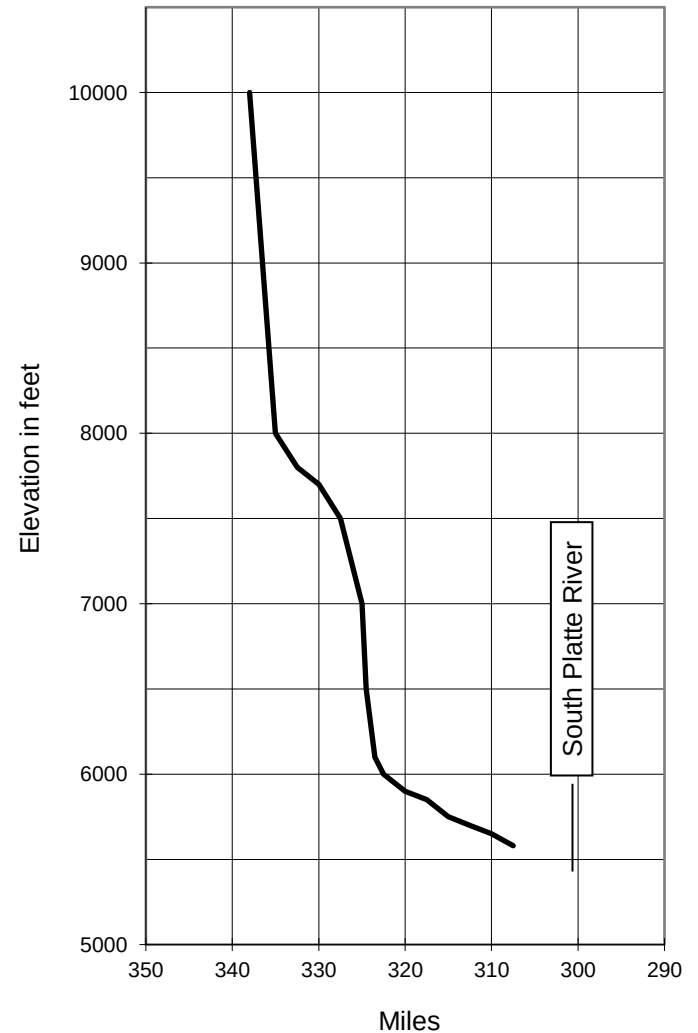
Sediment Range Location

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Bear Creek



Turkey Creek



Water Control Manual
Bear Creek Dam and Reservoir, Colorado

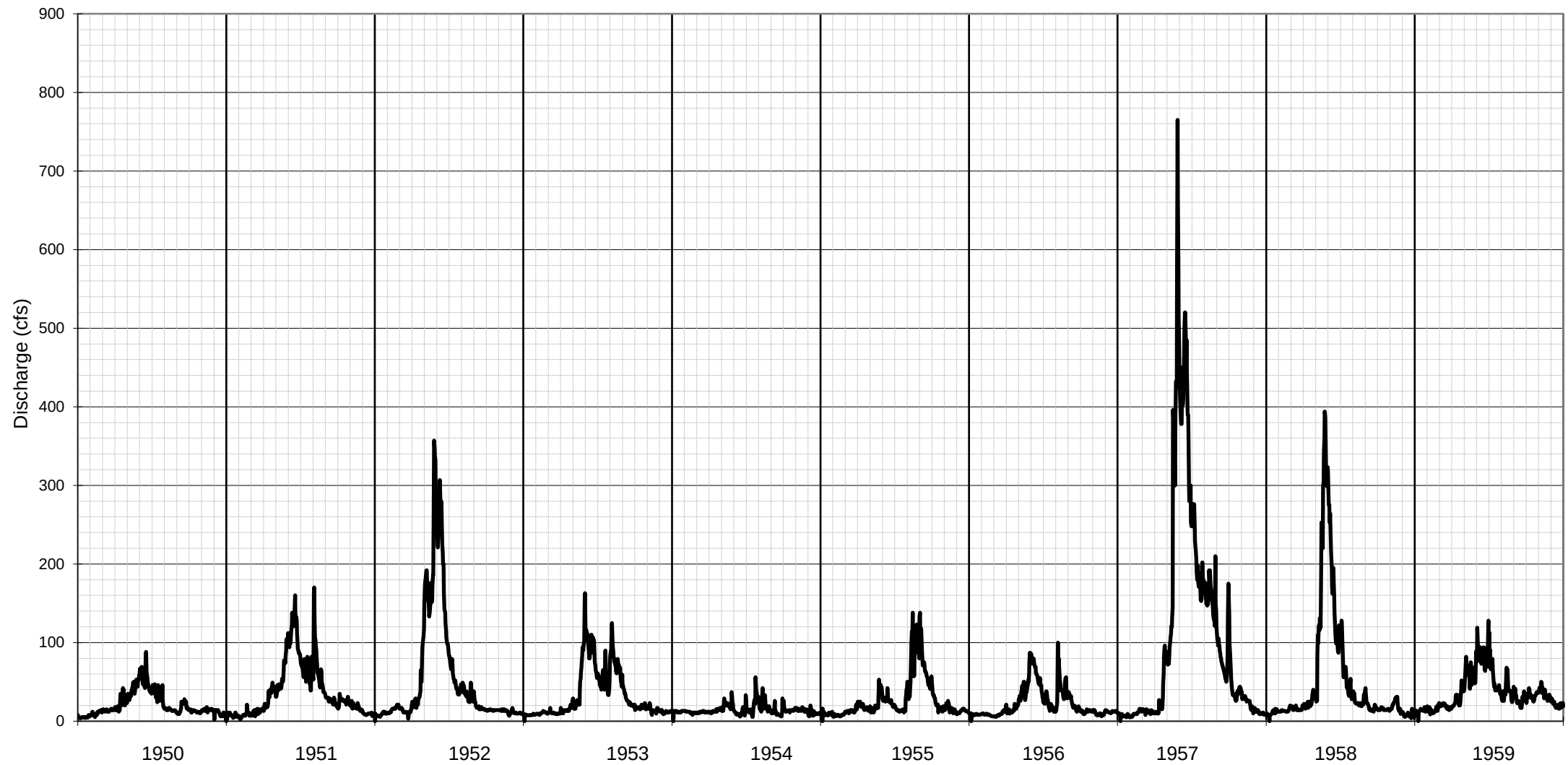
Stream Profiles

Bear Creek and Turkey Creek

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Prepared By: _____ KJS _____
Reviewed By: _____ AJF _____

Historical Hydrograph
Bear Creek at Morrison, Colorado (1950s)



Note:

Average daily flows - obtained from the Colorado Department of Water Resources. Record goes back to October 1919, but is not shown here.

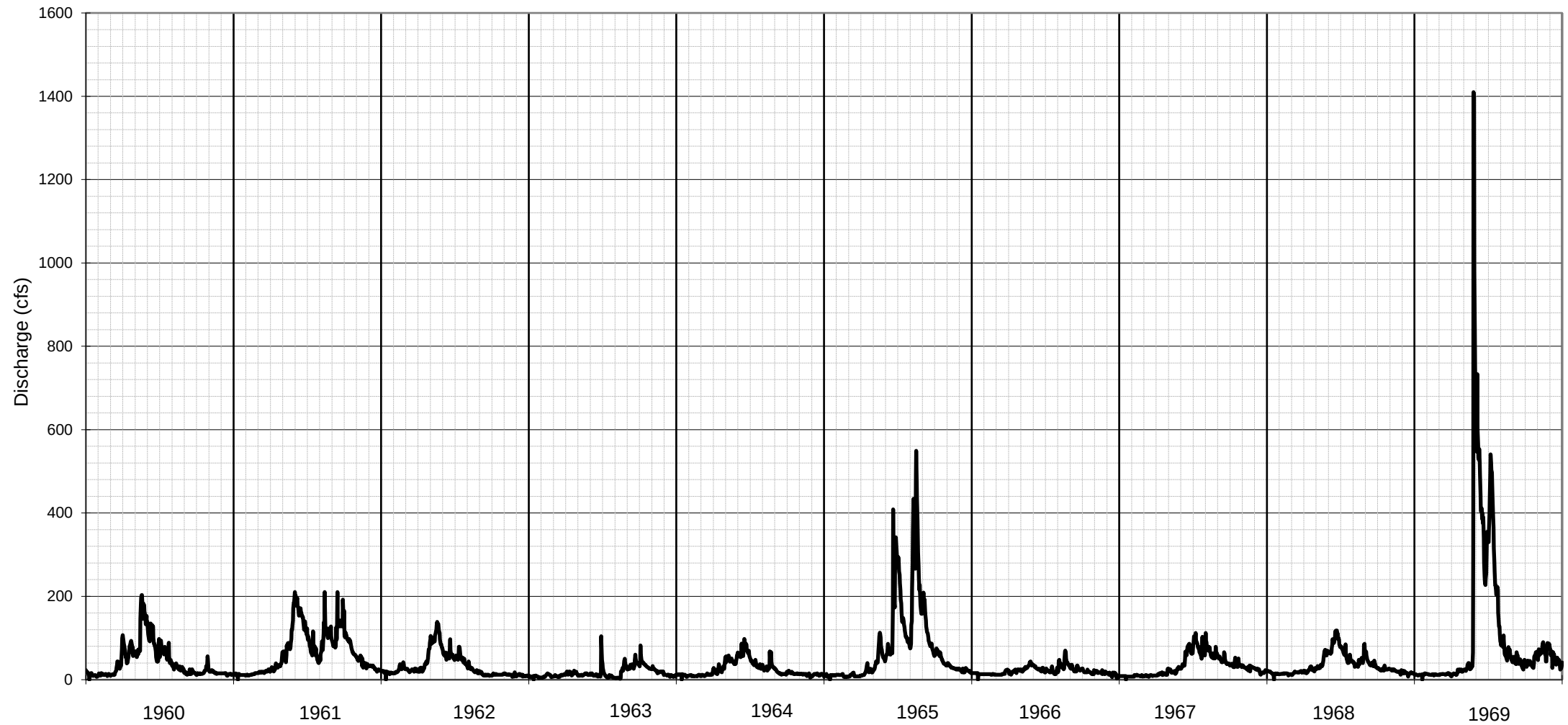
Prepared By: _____ JDM
Reviewed By: _____ KJS

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Historic Hydrograph (1950-59)
Bear Creek at Morrison, Colorado

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Historical Hydrograph Bear Creek at Morrison, Colorado (1960s)



Note:
Average daily flows - obtained from the Colorado Department of Water Resources. Record goes back to October 1919, but is not shown here.

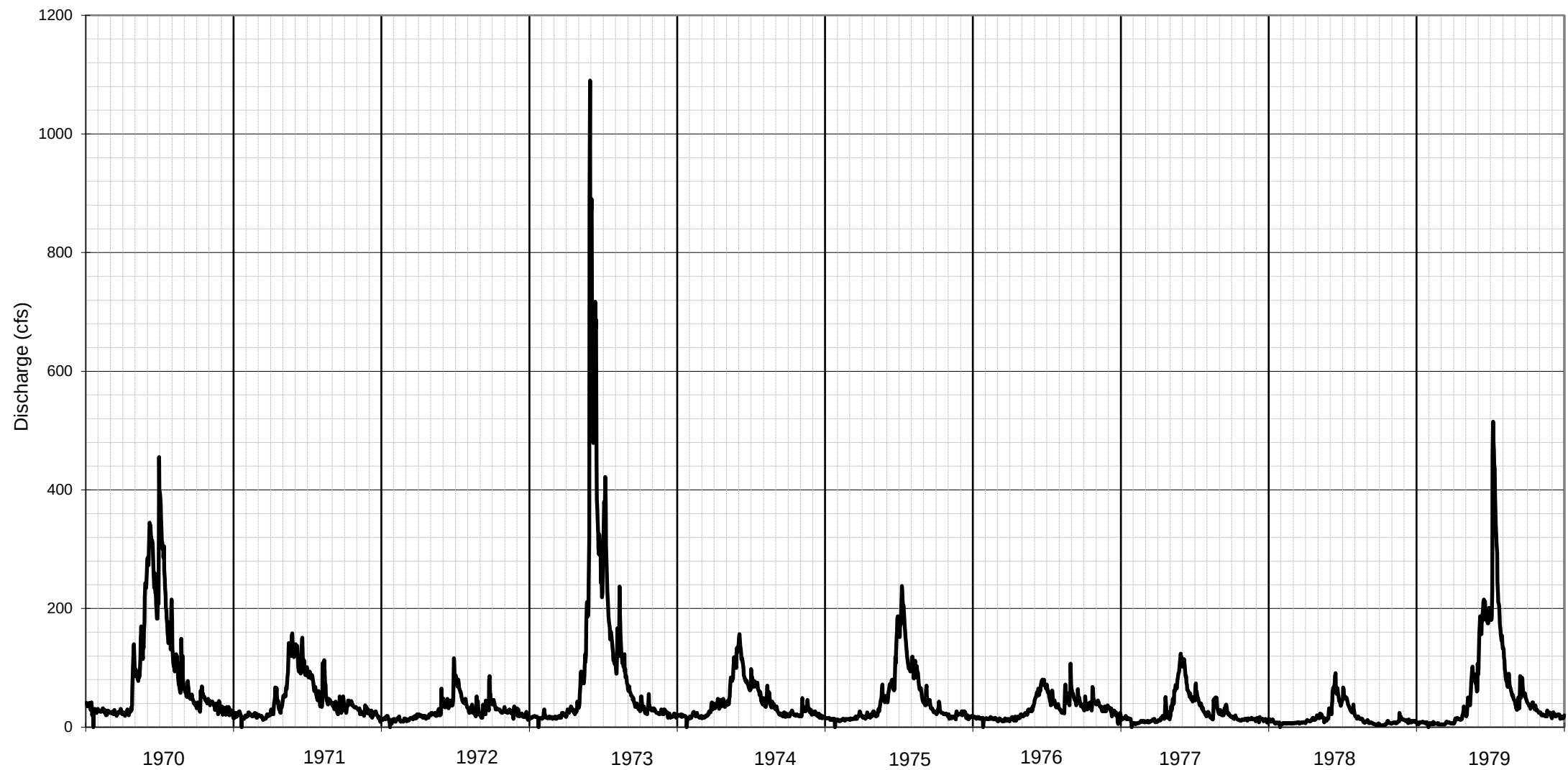
Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Historic Hydrograph (1960-69) **Bear Creek at Morrison, Colorado**

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Prepared By: _____ JDM _____
Reviewed By: _____ KJS _____

Historical Hydrograph
Bear Creek at Morrison, Colorado (1970s)



Note:
Average daily flows - obtained from the Colorado Department of Water
Resources. Record goes back to October 1919, but is not shown here.

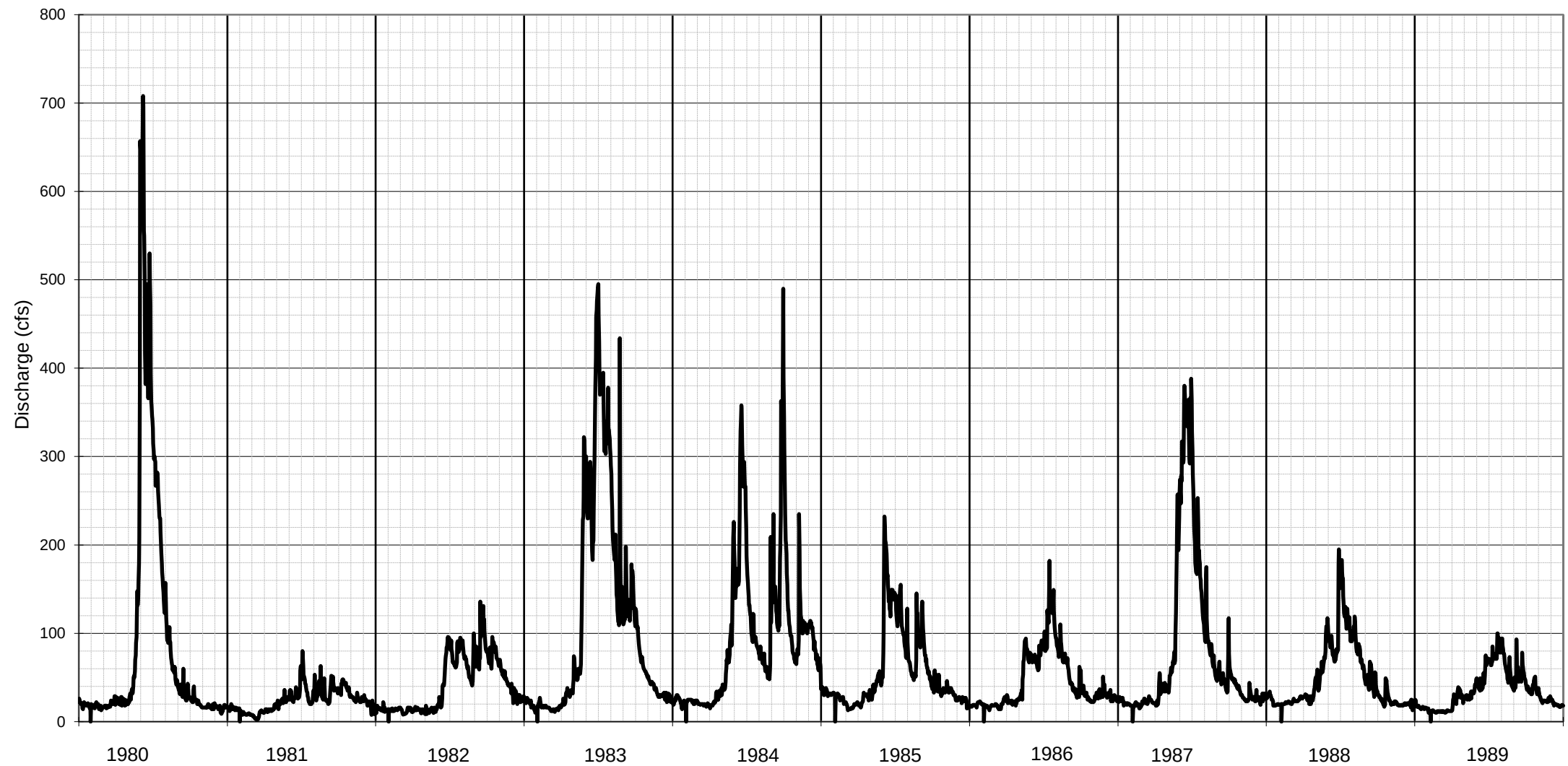
Prepared By: _____ JDM
Reviewed By: _____ KJS

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Historic Hydrograph (1970-79)
Bear Creek at Morrison, Colorado

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Historical Hydrograph Bear Creek at Morrison, Colorado (1980s)



Note:
Average daily flows - obtained from the Colorado Department of Water Resources. Record goes back to October 1919, but is not shown here.

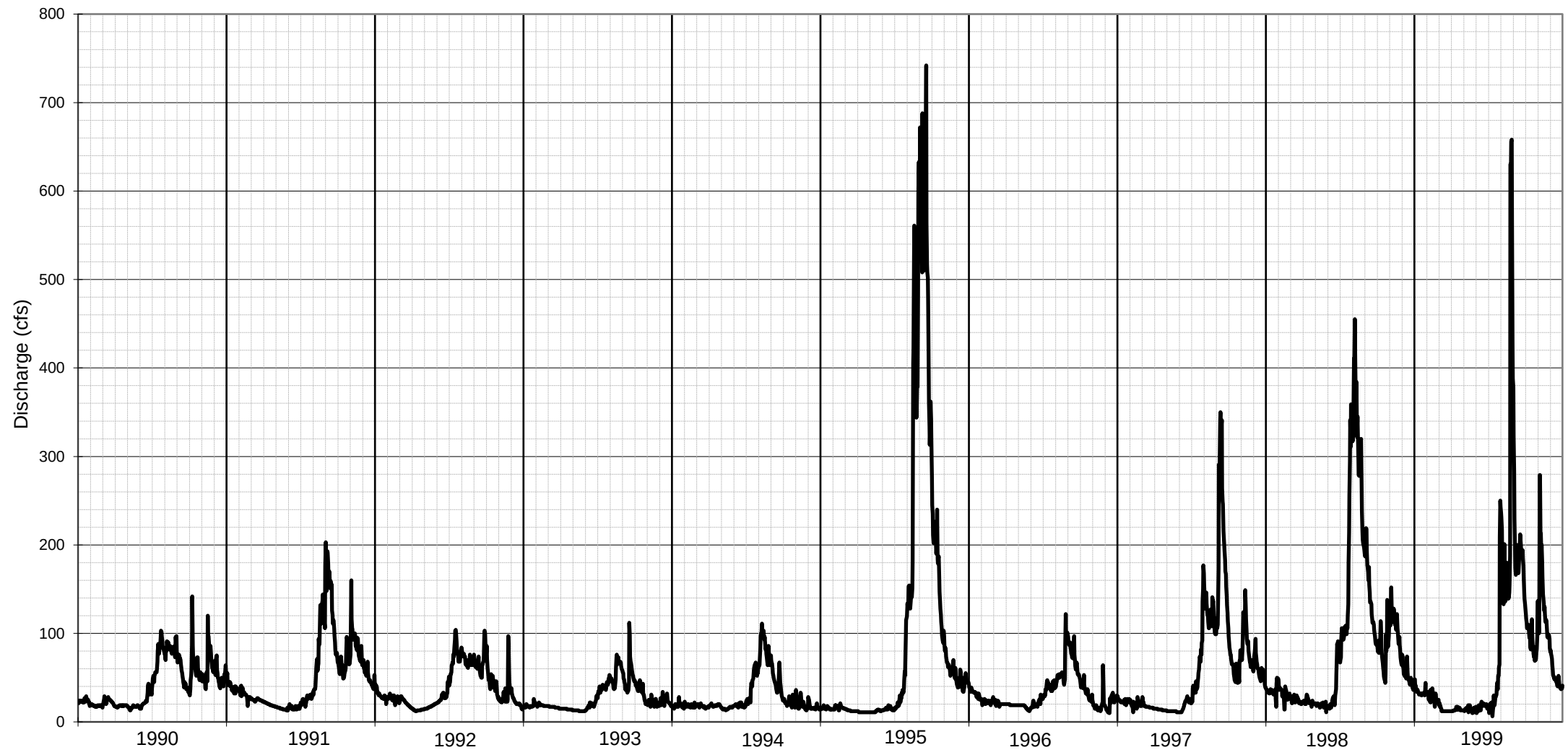
Prepared By: _____ JDM _____
Reviewed By: _____ KJS _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Historic Hydrograph (1980-89)
Bear Creek at Morrison, Colorado

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Historical Hydrograph Bear Creek at Morrison, Colorado (1990s)



Note:
Average daily flows - obtained from the Colorado Department of Water Resources. Record goes back to October 1919, but is not shown here.

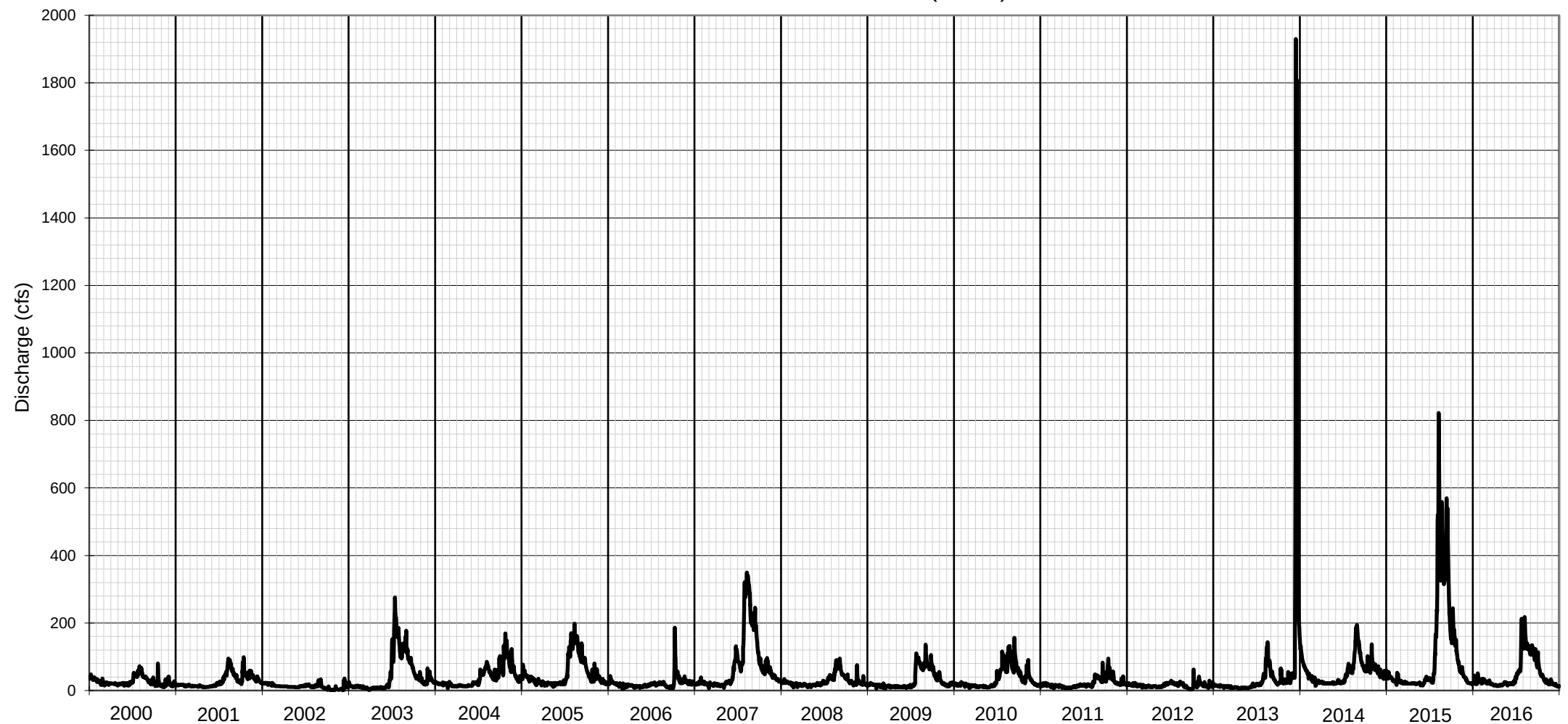
Prepared By: _____ JDM
Reviewed By: _____ KJS

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Historic Hydrograph (1990-99)
Bear Creek at Morrison, Colorado

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Historical Hydrograph Bear Creek at Morrison, Colorado (2000s)



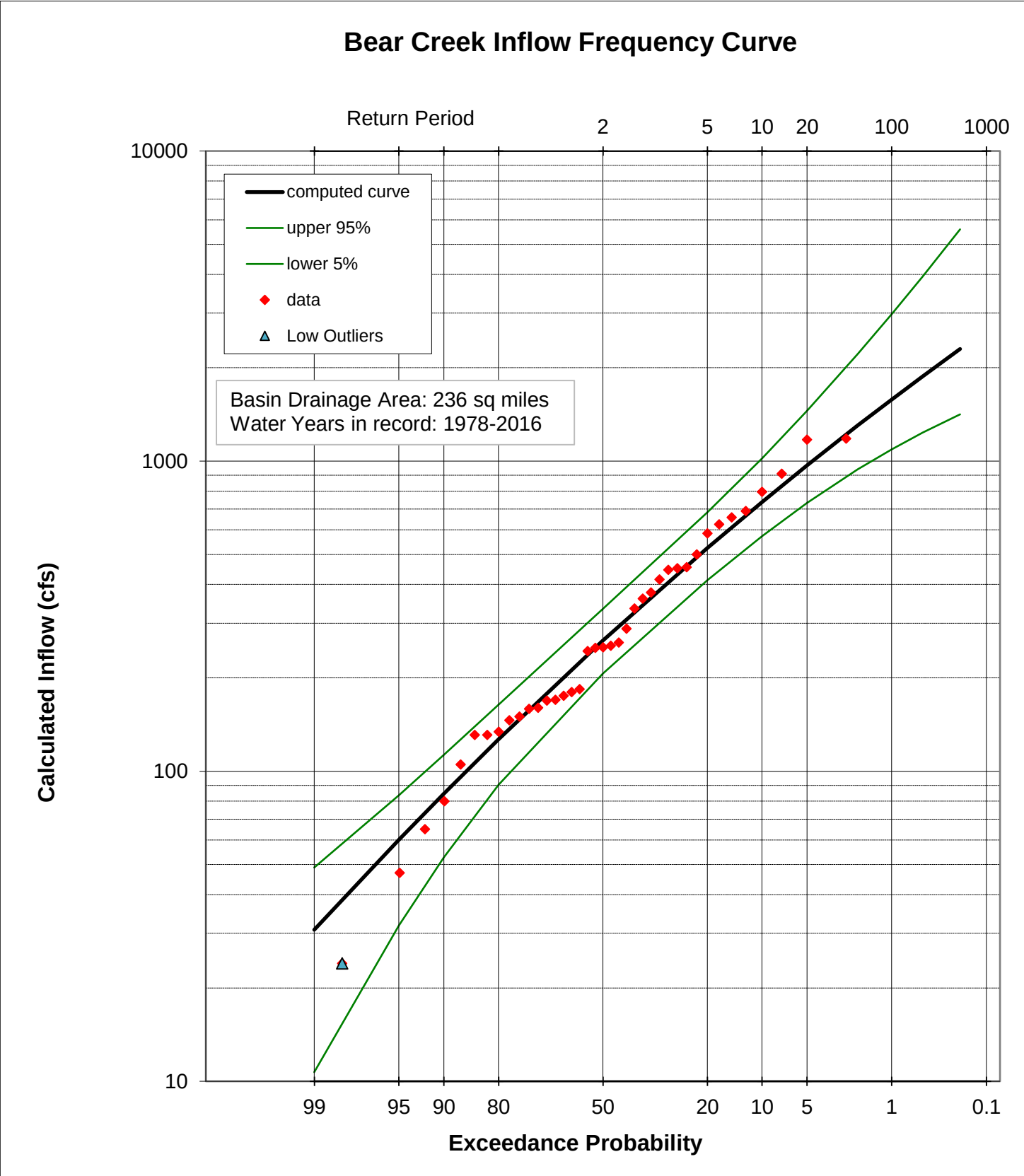
Note:
Average daily flows - obtained from the Colorado Department of Water Resources. Record goes back to October 1919, but is not shown here.

Prepared By: _____ JDM _____
Reviewed By: _____ KJS _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Historic Hydrograph (2000-16) **Bear Creek at Morrison, Colorado**

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018



Log Transform: Flow (cfs)		Number of Events	
Mean	2.407	Historic Events	0
Standard Dev	0.368	High Outliers	0
Station Skew	-0.254	Low Outliers & Zero Flows	1
Regional Skew	-0.2	Missing Events	0
Weighted Skew	-0.233	Systematic Events	39
Adopted Skew	-0.233	Historic Period	39

NOTE: Derived from the daily annual maximum and is calculated based on the daily change in storage, reservoir release, and evaporation loss. Used Bulletin 17C analysis. The weighted skew fit the dataset the best and therefore was applied.

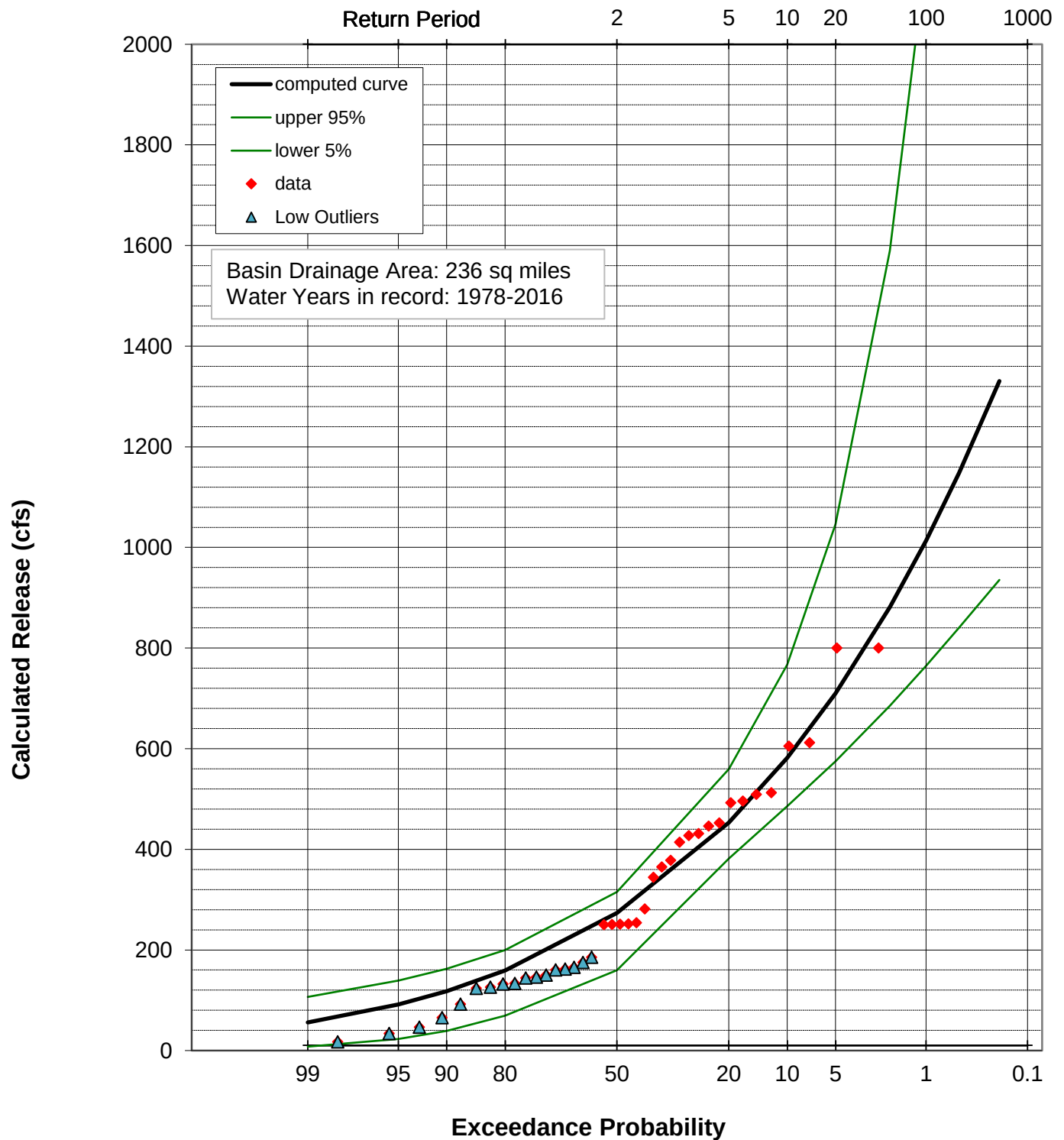
Prepared By: _____ KJS
Reviewed By: _____ JPD

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Inflow Frequency Curve
Bear Creek Dam

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Bear Creek Discharge Frequency Curve



Log Transform: Flow (cfs)		Number of Events	
Mean	2.426	Historic Events	0
Standard Dev	0.271	High Outliers	0
Station Skew	-0.248	Low Outliers & Zero Flows	17
Regional Skew		Missing Events	0
Weighted Skew		Systematic Events	39
Adopted Skew	-0.248	Historic Period	39

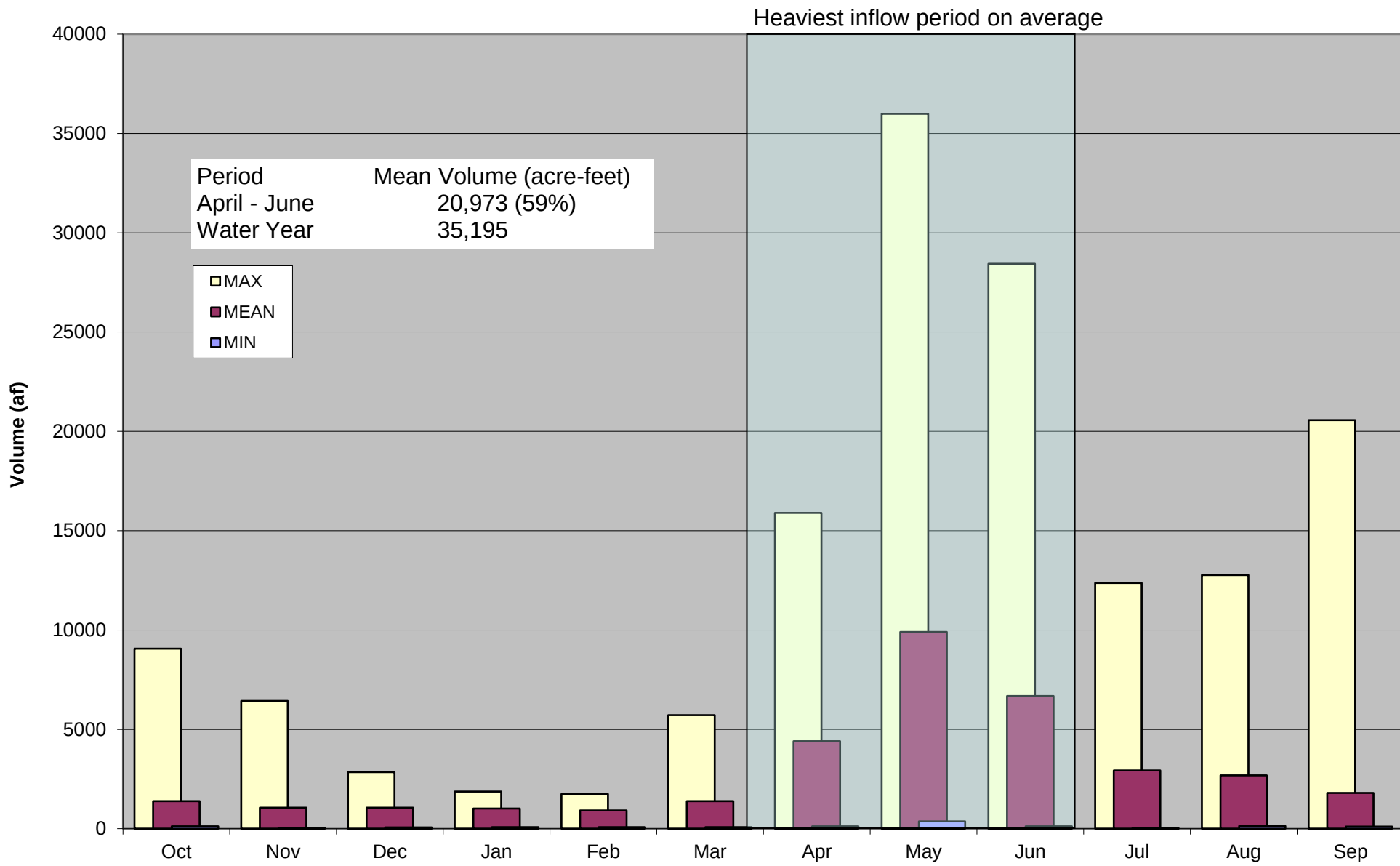
NOTE: Derived from the daily annual maximum and is calculated based on the daily change in storage, reservoir release, and evaporation loss. Used Bulletin 17C analysis. Station skew was applied because the discharge is impacted by release decisions making the regional skew less applicable.

Prepared By: _____ KJS
Reviewed By: _____ JPD

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Discharge Frequency Curve Bear Creek Dam

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018



Source of data: Corps Bear Creek Inflow Calculation (1978-2016).
 Calculated based on the daily change in storage, reservoir release, and evaporation loss.

Prepared By: _____ JDM _____
 Reviewed By: _____ KJS _____

Water Control Manual
 Bear Creek Dam and Reservoir, Colorado
Historic Monthly Inflow Volume
 U.S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 2018

Water Year	Flow per Month (Acre-Feet)												WY Total
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1978	187	635	594	560	480	409	114	1218	567	315	345	107	5531
1979	122	30	109	142	143	337	3571	12890	18609	4124	1183	249	41509
1980	551	1303	1223	999	808	2074	7860	34845	12947	2430	1545	1283	67868
1981	781	460	299	119	209	168	237	978	891	910	475	418	5945
1982	524	230	548	923	1081	945	662	2457	2558	2355	4996	4036	21315
1983	1869	114	132	380	160	2537	13535	26249	24905	11613	6912	3526	91932
1984	1604	1951	1956	1775	1498	2648	10312	20058	7074	4327	12769	6298	72270
1985	9057	6433	2849	1862	1148	2641	3860	12439	5680	3250	3781	1153	54153
1986	1976	1599	1686	1289	1269	1245	5150	3982	7153	2978	999	808	30134
1987	1017	2093	1827	1845	1540	3677	11390	21407	11053	3560	2477	1361	63247
1988	819	826	1646	1465	1750	3077	7874	10639	4153	831	2524	1364	36968
1989	870	749	650	900	1252	1136	219	411	927	1229	264	320	8927
1990	275	100	732	818	654	1818	4654	4798	2494	2423	2923	2015	23704
1991	1310	1778	1166	843	732	967	322	5072	8103	3122	5334	2326	31075
1992	1577	1847	1548	1111	1035	2280	6103	3809	2798	1662	1758	329	25857
1993	513	955	1423	1195	934	1026	1775	3955	2847	1195	831	535	17184
1994	367	921	942	756	513	748	3011	6494	2214	338	446	273	17023
1995	323	362	615	269	132	82	1686	22221	28445	12375	4591	1624	72725
1996	1116	1419	609	1108	976	929	1234	3082	5219	866	286	169	17013
1997	676	590	863	826	799	998	2961	8896	13324	3060	6474	3875	43342
1998	2374	2871	2105	1781	1424	3627	15896	24580	9547	5097	7298	2617	79217
1999	1990	1334	1379	1332	1089	380	2919	18585	13375	5220	9390	2827	59820
2000	1947	1637	1653	1503	1304	1006	2321	3248	534	734	585	549	17021
2001	577	238	511	587	616	611	1984	4992	1241	2118	1690	789	15954
2002	792	989	941	899	432	405	402	365	113	27	131	181	5677
2003	328	101	59	80	77	446	8587	6662	3776	842	1065	1099	23122
2004	639	123	293	775	843	776	2496	4118	1789	5337	3716	1565	22470
2005	3710	1728	2031	1634	1482	750	7426	11667	5848	1487	1741	508	40012
2006	1319	472	818	938	718	359	512	635	404	1530	645	506	8856
2007	980	361	1537	1393	1466	5710	9212	20095	9255	2547	2535	962	56053
2008	1053	476	729	1165	1220	1020	1929	4507	2864	758	881	678	17280
2009	824	301	382	818	662	319	3276	6304	7512	2923	980	720	25021
2010	1109	1286	1282	1097	907	2077	8513	9353	5550	1568	1975	501	35218
2011	702	16	242	643	361	476	638	1473	1692	2587	901	715	10446
2012	520	503	1040	1121	1389	1083	509	450	180	538	541	379	8253
2013	615	248	275	375	541	689	842	6216	1599	1596	1245	20571	34812
2014	5857	2042	1829	1497	1425	1102	2758	7820	6635	3958	4139	2084	41146
2015	2190	1416	961	1247	1167	1837	5286	35997	20112	10059	3206	568	84046
2016	934	782	1399	1264	1630	1568	9476	13072	6411	2546	974	406	40462
Water Year	Flow per Month (Acre-Feet)												WY Total
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
MEAN	1384	1059	1048	1009	920	1384	4398	9898	6677	2934	2681	1802	35195
MAX	9057	6433	2849	1862	1750	5710	15896	35997	28445	12375	12769	20571	91932
MIN	122	16	59	80	77	82	114	365	113	27	131	107	5531

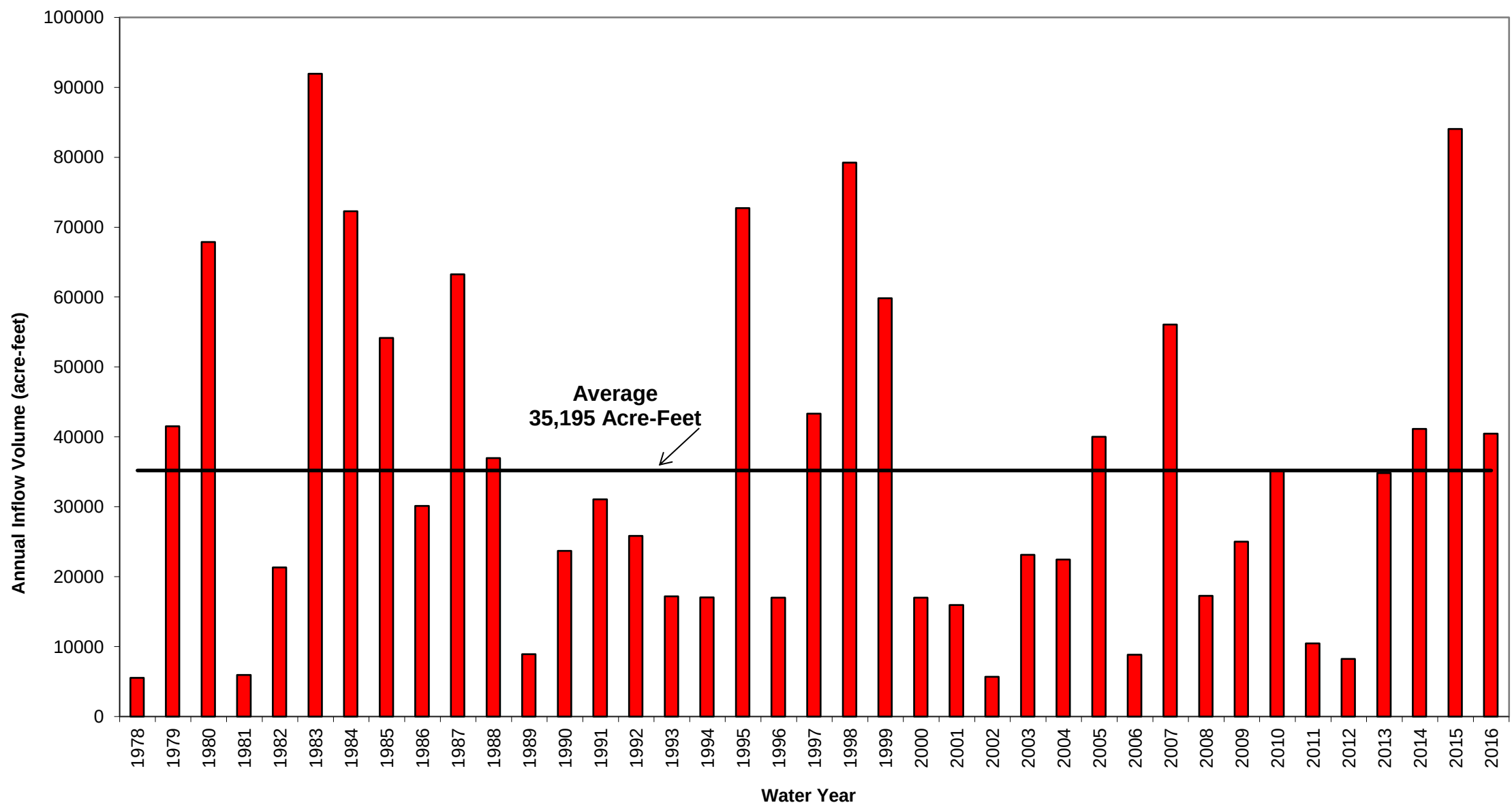
Source of data: Corps Bear Creek Inflow Calculation (1978-2016).
Calculated based on the daily change in storage, reservoir release, and
evaporation loss.

Prepared By: _____ JDM _____
Reviewed By: _____ KJS _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Historic Monthly Inflow Volume

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018



Source of data: Corps Bear Creek Inflow Calculation (1978-2016).
 Calculated based on the daily change in storage, reservoir release, and evaporation loss.

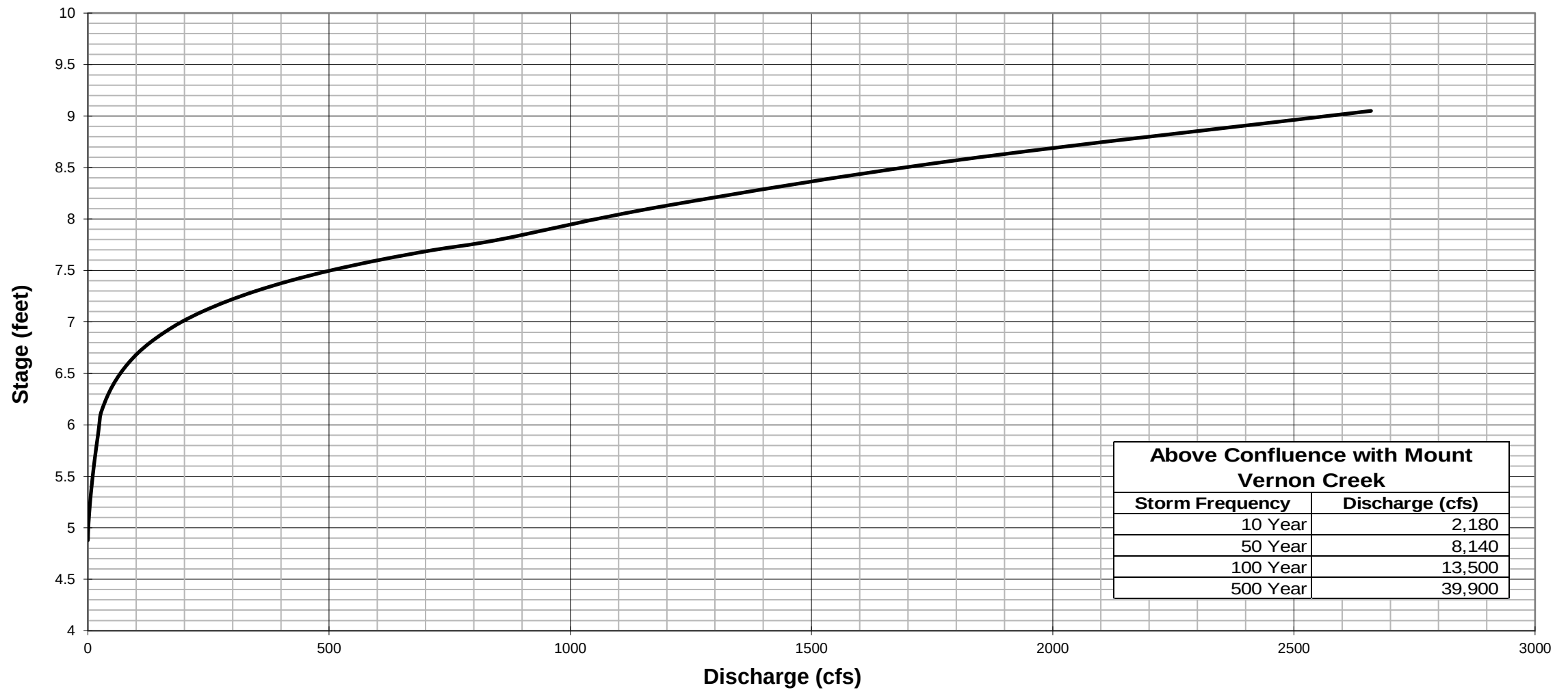
Water Control Manual
 Bear Creek Dam and Reservoir, Colorado

Historic Annual Inflow Volume

U.S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 2018

Prepared By: _____ JDM _____
 Reviewed By: _____ KJS _____

Low Flow Discharge Rating Curve Bear Creek at Morrison, CO



Note:

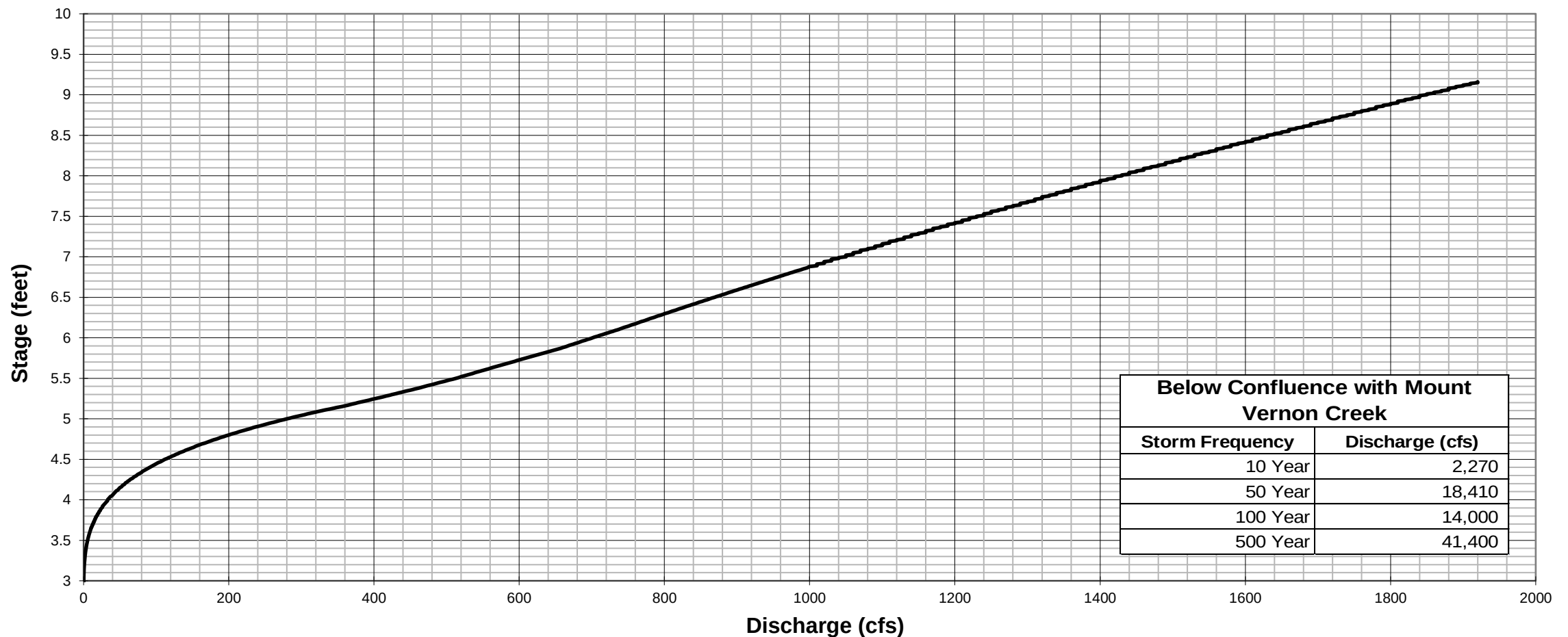
1. Rating table #23 from Colorado Division of Water Resources.
2. Rating curves change on a frequent basis due to regular field measurements. Therefore, these values should only be used as an approximation.
3. Datum of gage is 5,780.43 feet (NGVD29).
4. Flood Insurance Study, Jefferson County, Colorado February 05, 2014. Bear Creek above confluence with Mount Vernon Creek is the nearest FIS site, and is therefore used to be representative of Bear Creek at Morrison, CO.

Prepared By: _____ JDM _____
Reviewed By: _____ KJS _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado
**Low Flow Discharge Rating Curve and
Flood Flow Discharge Table
Bear Creek at Morrison, CO
Rating #23**

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Low Flow Discharge Rating Curve **Bear Creek above Bear Creek Dam near Morrison, CO**



Note:

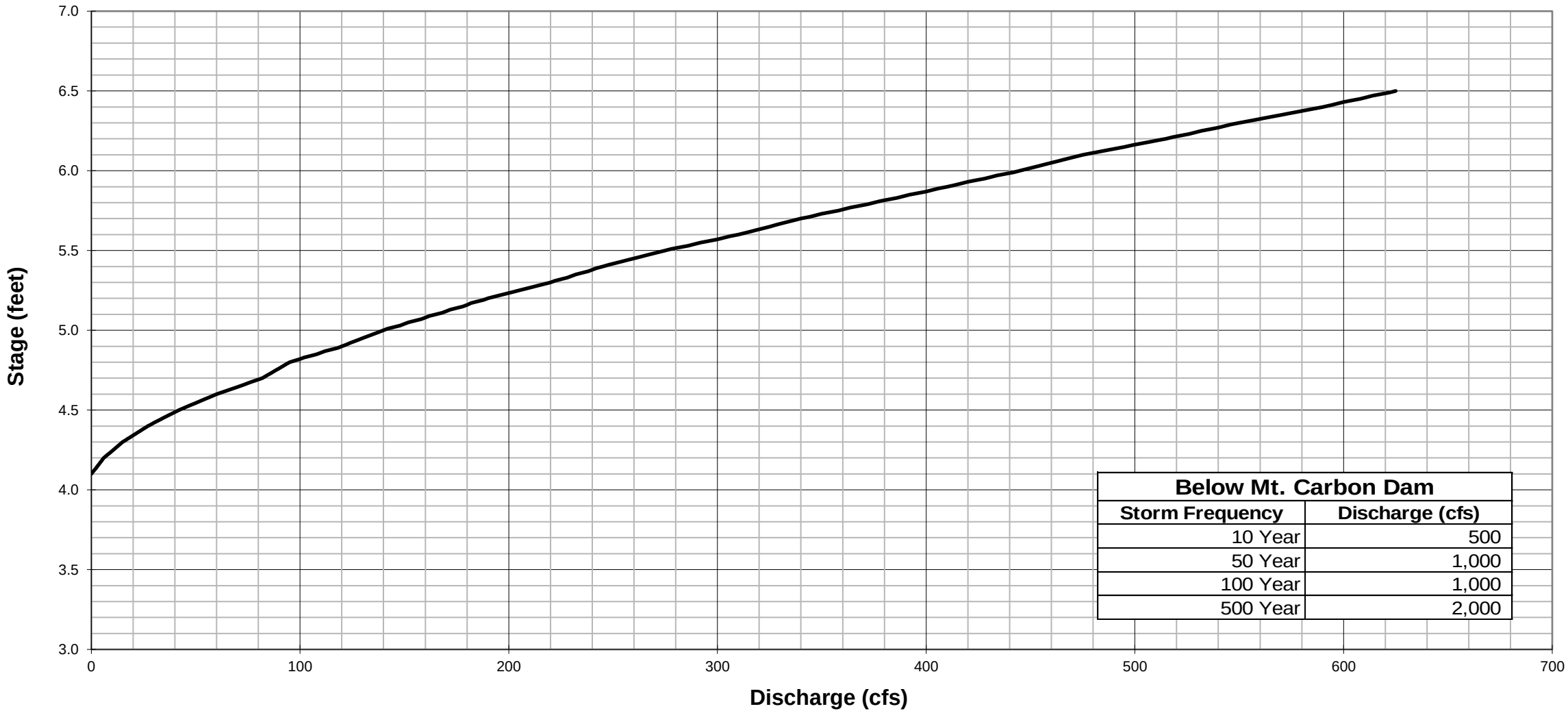
1. Rating table #10 from the USGS.
2. Rating curves change on a frequent basis due to regular field measurements. Therefore, these values should only be used as an approximation. Please check the USGS website for the most up-to-date rating for this station.
3. Datum of gage is 5,645 feet (NGVD29).
4. Flood Insurance Study, Jefferson County, Colorado February 05, 2014. Bear Creek below confluence with Mount Vernon Creek is the nearest FIS site, and is therefore used to be representative of Bear Creek above Bear Creek Lake near Morrison, CO.

Prepared By: _____ JDM _____
 Reviewed By: _____ KJS _____

Water Control Manual
 Bear Creek Dam and Reservoir, Colorado
**Low Flow Discharge Rating Curve and
 Flood Flow Discharge Table**
 Bear Creek above Bear Creek Dam near Morrison, CO
Rating #10

 U. S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 2018

Low Flow Discharge Rating Curve
Bear Creek below Bear Creek Dam, CO



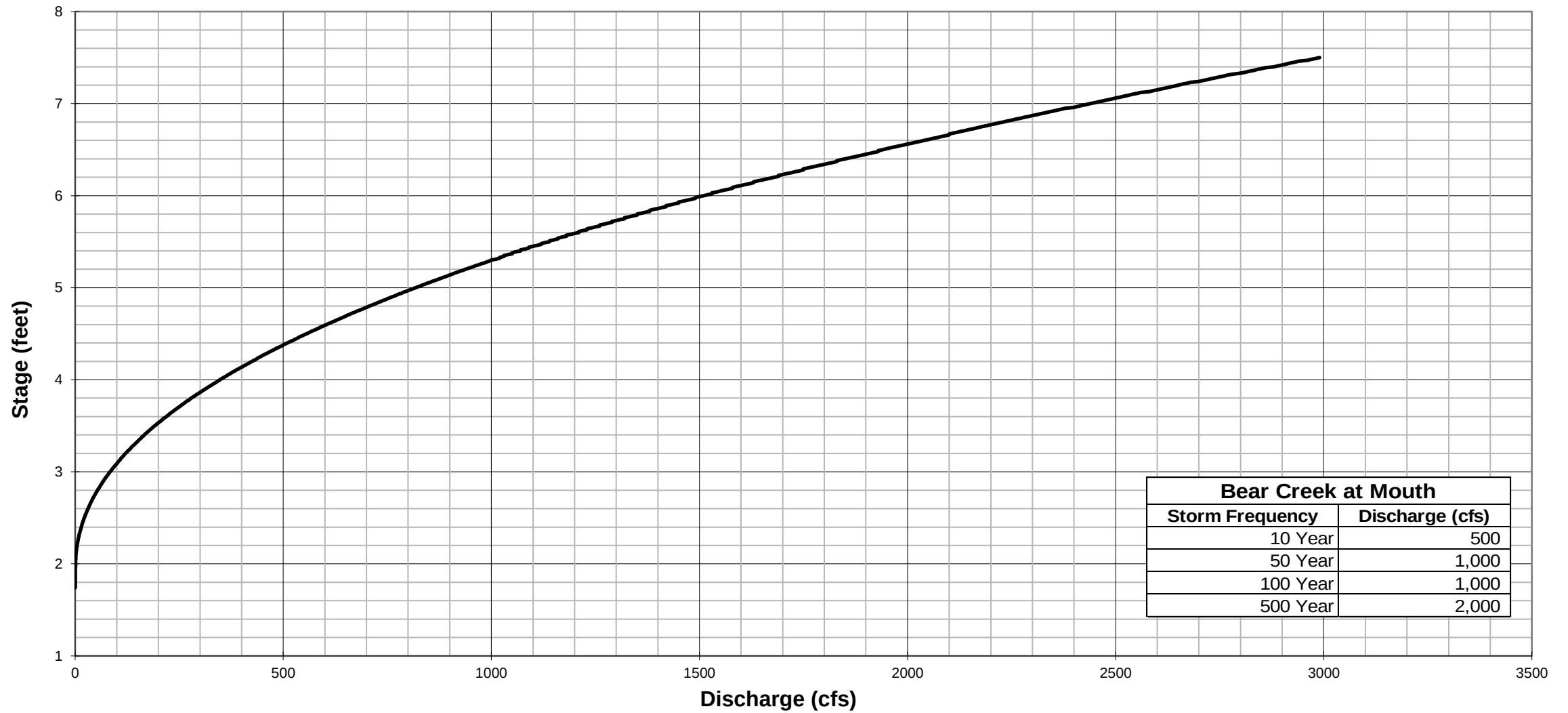
Note:
1. Rating table #01 from Colorado Division of Water Resources.
2. Rating curves change on a frequent basis due to regular field measurements. Therefore, these values should only be used as an approximation.
3. Flood Insurance Study, Jefferson County, Colorado February 05, 2014. Bear Creek below Mt. Carbon Dam is the nearest FIS site, and is therefore used to be representative of Bear Creek below Bear Creek Dam.

Prepared By: _____ JDM _____
Reviewed By: _____ KJS _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado
**Low Flow Discharge Rating Curve and
Flood Flow Discharge Table**
Bear Creek below Bear Creek Dam
Rating #01

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Low Flow Discharge Rating Curve Bear Creek at Sheridan, CO



Note:

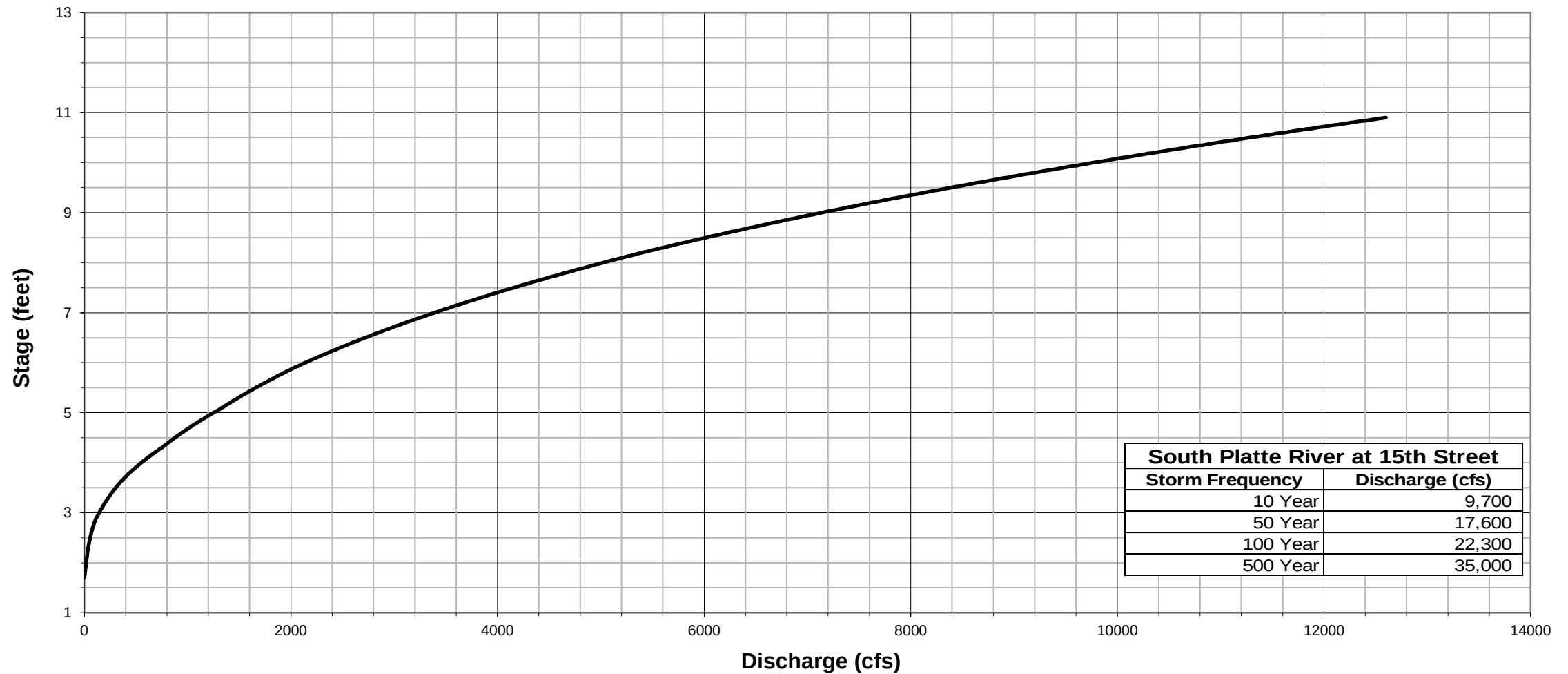
1. Rating table #33 from Colorado Division of Water Resources.
2. Rating curves change on a frequent basis due to regular field measurements. Therefore, these values should only be used as an approximation.
3. Datum of gage is 5,295 feet (NGVD29).
4. Flood Insurance Study, Arapahoe County, Colorado December 17, 2010. Bear Creek at Mouth is the nearest FIS site, and is therefore used to be representative of Bear Creek at Sheridan, CO.

Prepared By: _____ JDM _____
Reviewed By: _____ KJS _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado
**Low Flow Discharge Rating Curve and
Flood Flow Discharge Table**
Bear Creek at Sheridan, CO
Rating #33

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Low Flow Discharge Rating Curve South Platte River at Denver, CO



Note:

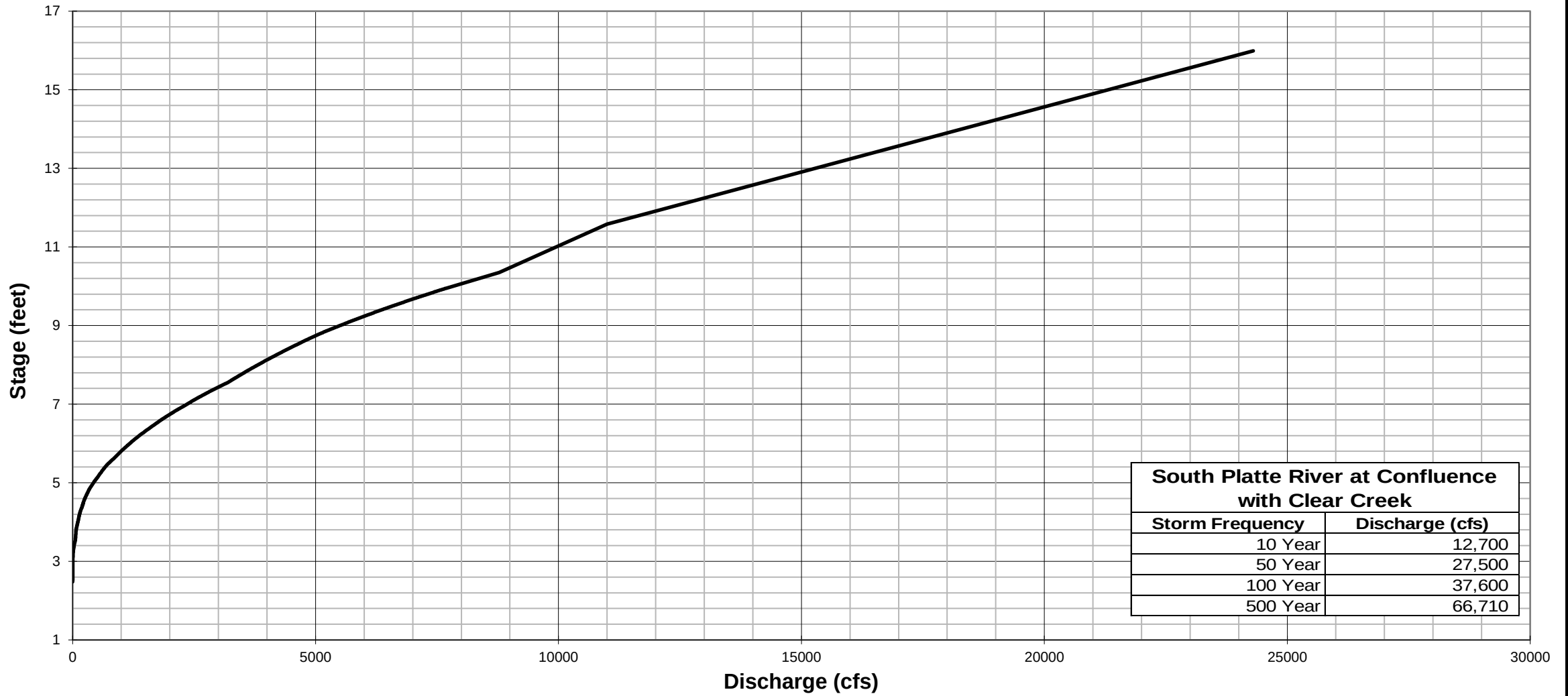
1. Rating table #34 from Colorado Division of Water Resources.
2. Rating curves change on a frequent basis due to regular field measurements. Therefore, these values should only be used as an approximation. Please check the USGS website for the most up-to-date rating for this station.
3. Datum of gage is 5,157.64 feet (NGVD29).
4. Flood Insurance Study, Denver County, Colorado November 20, 2013. South Platte River (Main Channel Only) at 15th Street is the nearest FIS site, and is therefore used to be representative of South Platte River at Denver, CO.

Prepared By: _____ JDM _____
Reviewed By: _____ KJS _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado
**Low Flow Discharge Rating Curve and
Flood Flow Discharge Table
South Platte River at Denver, CO
Rating #34**

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Low Flow Discharge Rating Curve South Platte River at Henderson, CO



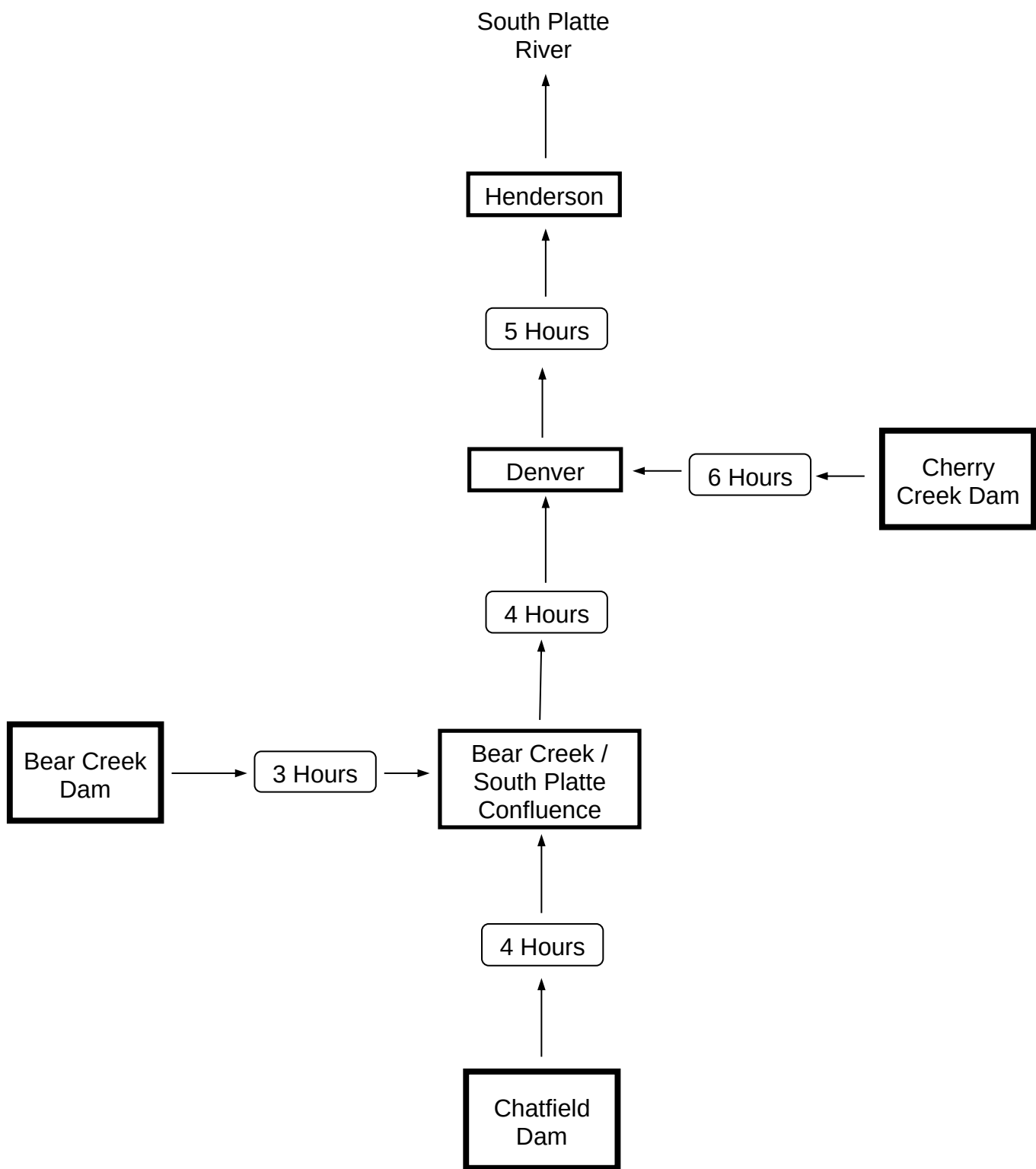
Note:

1. Rating table #34 from Colorado Division of Water Resources.
2. Rating curves change on a frequent basis due to regular field measurements. Therefore, these values should only be used as an approximation. Please check the USGS website for the most up-to-date rating for this station.
3. Datum of gage is 5,001.25 feet (NGVD29).
4. Flood Insurance Study, Denver County, Colorado November 20, 2013. South Platte River at Confluence with Clear Creek is the nearest FIS site, and is therefore used to be representative of South Platte River at Henderson, CO.

Prepared By: _____ JDM _____
Reviewed By: _____ KJS _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado
**Low Level Discharge Rating Curve and
Flood Flow Discharge Table
South Platte River at Henderson, CO
Rating #34**

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018



Water Control Manual
Bear Creek Dam and Reservoir, Colorado
Comparative Travel Times (hrs)
Normal Flow

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Prepared By: _____ KJS _____
Reviewed By: _____ AJF _____

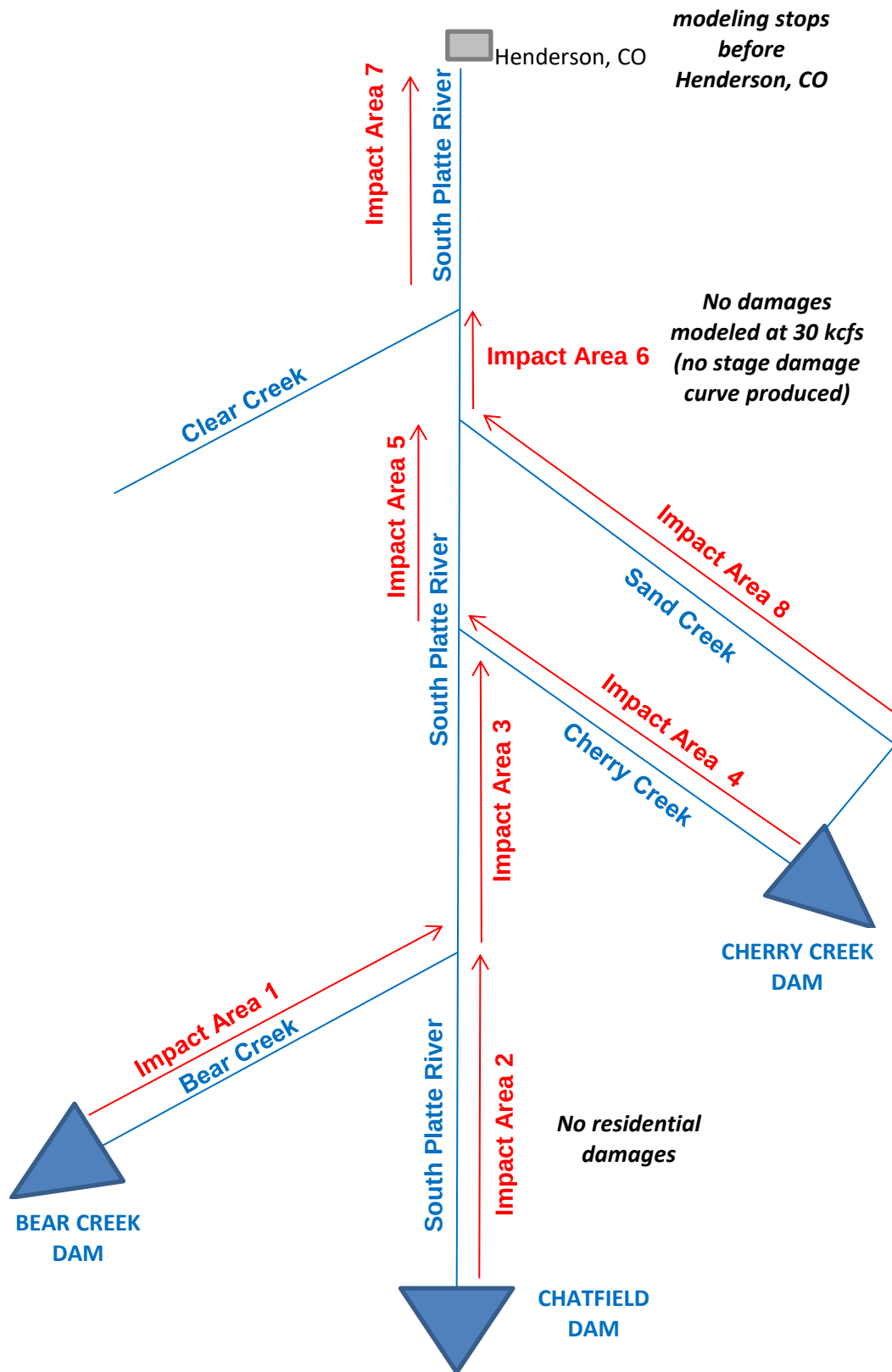
Travel times in hours between locations for high flows (June 1995). For normal flows, times will be 2 to 3 times faster.	South Platte River											Cherry Creek Reservoir	Bear Creek			Clear Creek	
	Antero	Spinney	Eleven Mile	Cheesman (Deckers)	South Platte	Strontia	Chatfield Reservoir	Denver	Henderson	Ft. Lupton	Kersey		Morrison	Bear Creek Reservoir	Sheridan	Golden	Derby
Antero		4	6	30	38	39	40	44	47	50	76						
Spinney			2	26	34	35	36	40	43	46	72						
Eleven Mile				24	32	33	34	38	41	44	70						
Cheesman (Deckers)					8	9	10	14	17	20	54						
South Platte						1	2	6	9	12	38						
Strontia							1	5	8	11	37						
Chatfield Reservoir								4	8	10	36						
Denver									4	6	29						
Henderson										3	34						
Ft. Lupton											26						
Kersey																	
Cherry Creek Reservoir								6	9	12	38						
Morrison								7	10	13	39			2	5		
Bear Creek Reservoir								5	8	11	37				3		
Sheridan								2	5	8	34						
Golden									4	7	33						2
Derby									2	5	31						

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Comparative Travel Times (hrs)
High Flow

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Prepared By: _____ KJS
Reviewed By: _____ AJF



Note: Eight impact areas were analyzed as defined in the graphic. Seven of them showed damages with the selected modeled depth grids. Thus, seven stage damage curves were developed downstream of the Tri-Lakes Dams.

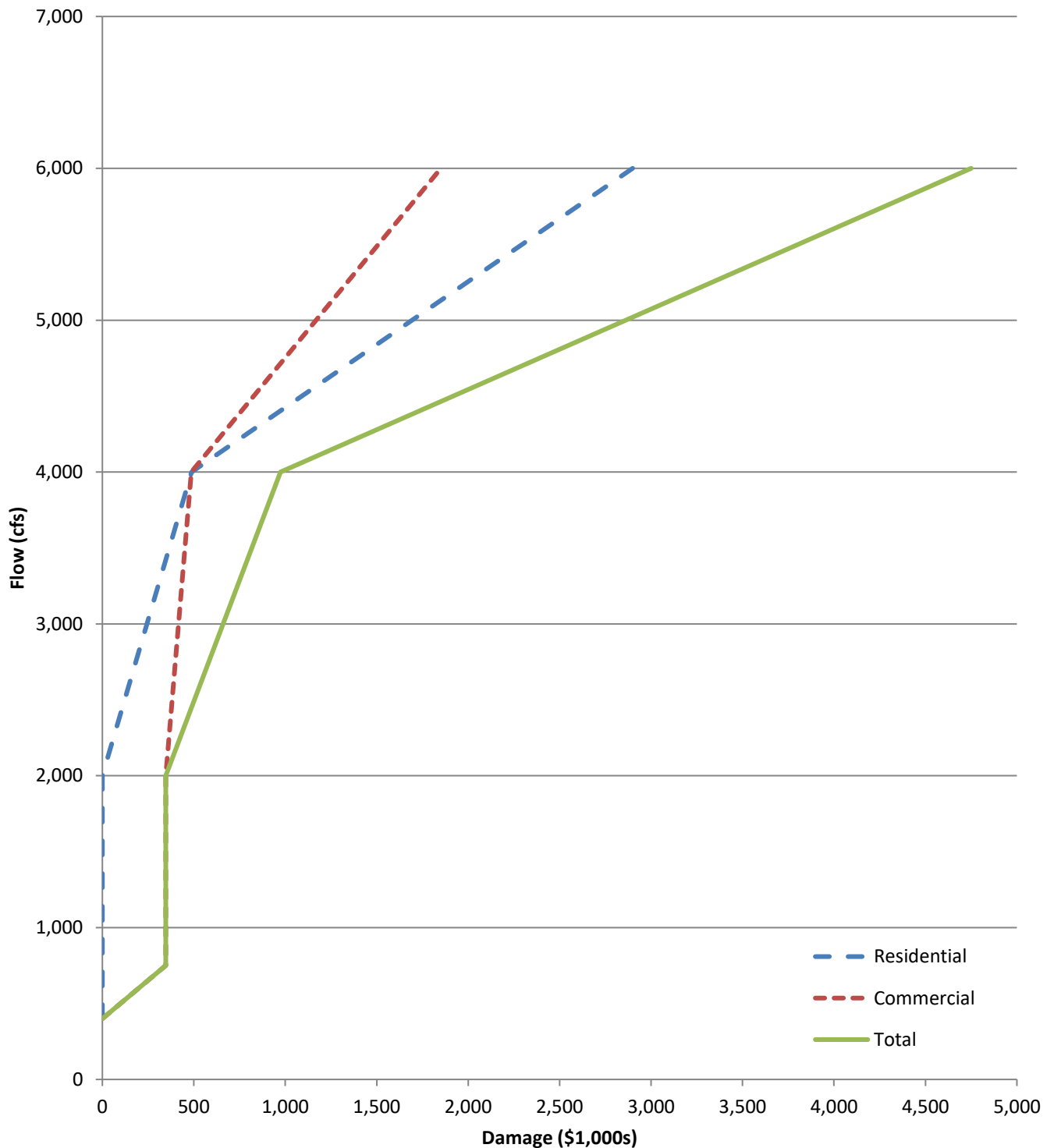
Prepared By: _____ LJH_ & JB _____
Reviewed By: _____ KJS _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Stage Damage Impact Areas

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Impact Area 1: Bear Creek



Prepared By: _____ LJH_ & _JB _____
 Reviewed By: _____ KJS _____

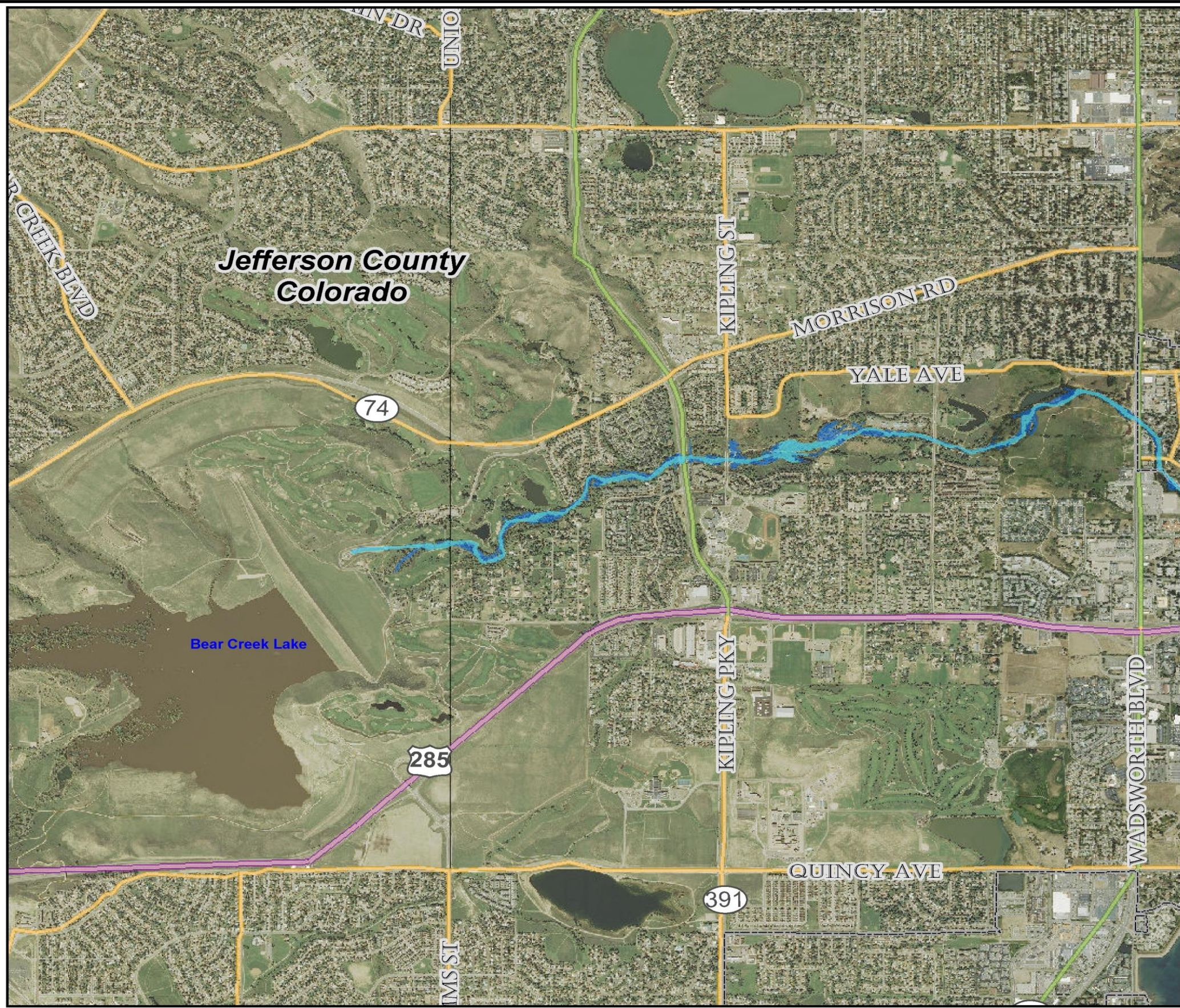
Notes:

- 1) The curves were finalized in August 2015 using HEC-FIA version 3.0 beta.
- 2) Curves focus solely on damages to structures and contents; agriculture and life loss estimates were not a primary motivator for these curves.
- 3) Input data sources: HEC-RAS modeled stream alignments, depth grids, and terrain grids as well as structure data obtained from assessors data in Denver, Arapahoe, Jefferson and Adams Counties.

Water Control Manual
 Bear Creek Dam and Reservoir, Colorado

Stage Damages Curves Impact Area 1 - Adjusted to 2014 \$

U.S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 2018



MAP REACH: IMPACT AREA 1

BEAR CREEK - BEAR CREEK DAM TO SOUTH PLATTE RIVER

Inundation at:

400 cfs
 2,000 cfs

0 0.125 0.25 0.5 0.75

Miles

US Army Corps of Engineers
Omaha District

Imagery Source:
U. S. Department of Agriculture, Farm Service Agency

Compiled On: Wednesday, September 23, 2015

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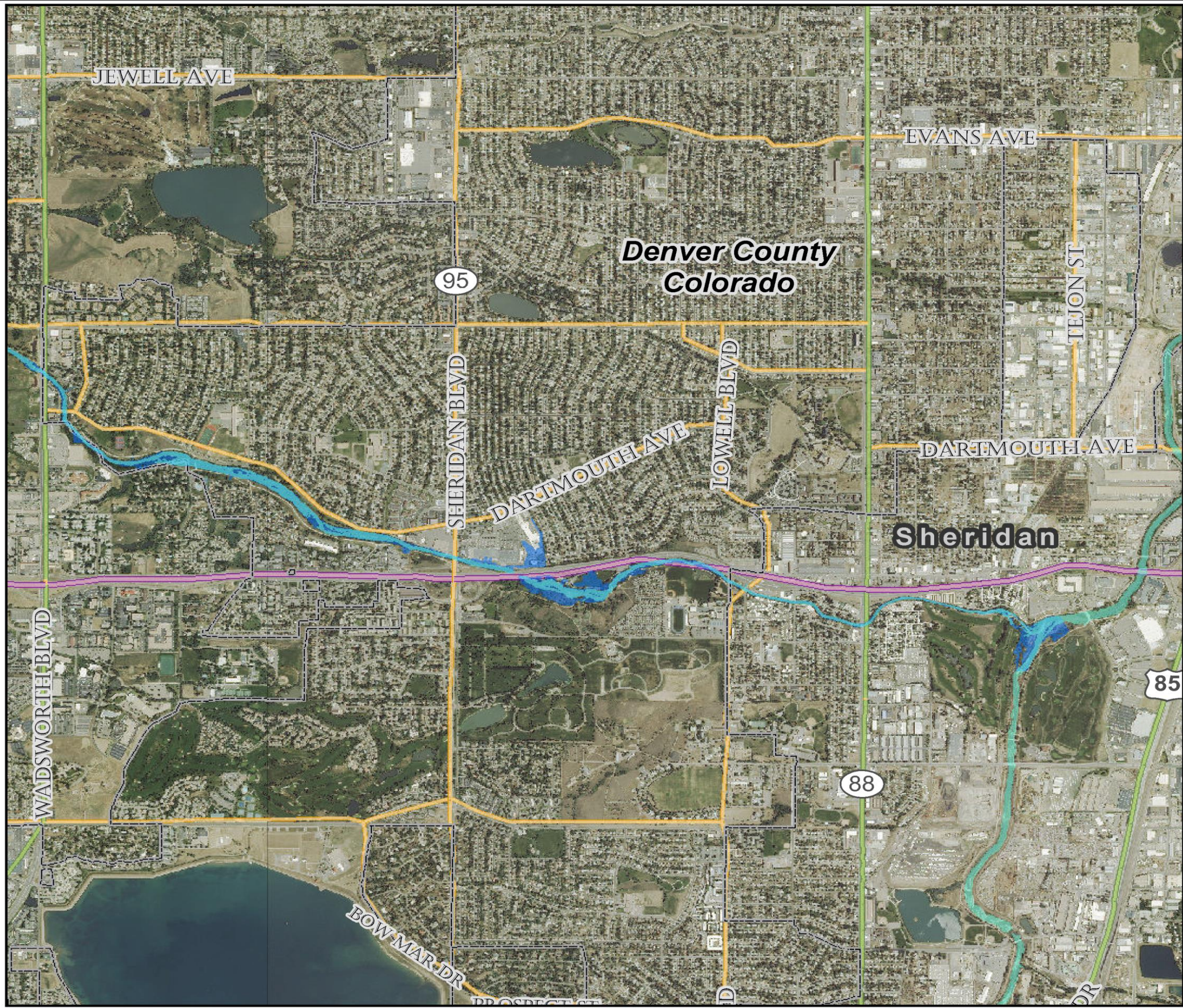
Prepared By: _____ LJH MAS _____

Reviewed By: _____ KJS _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

**Impact Area 1 - Bear Creek
upstream of Wadsworth Blvd.**

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018



MAP REACH: **IMPACT AREA 1**

BEAR CREEK - BEAR CREEK DAM TO SOUTH PLATTE RIVER

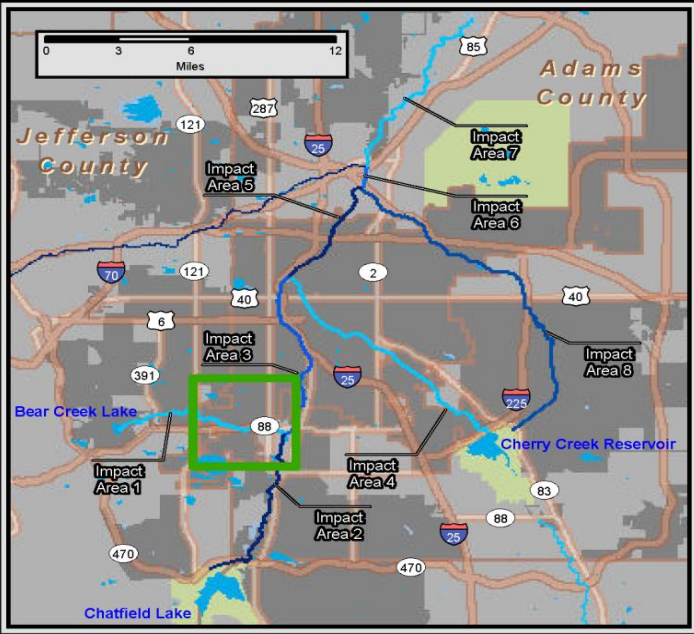
Inundation at:

400 cfs

2,000 cfs



**US Army Corps
of Engineers®**
Omaha District



Imagery Source:
U. S. Department of Agriculture,
Farm Service Agency

Compiled On: Thursday, September 24, 2015

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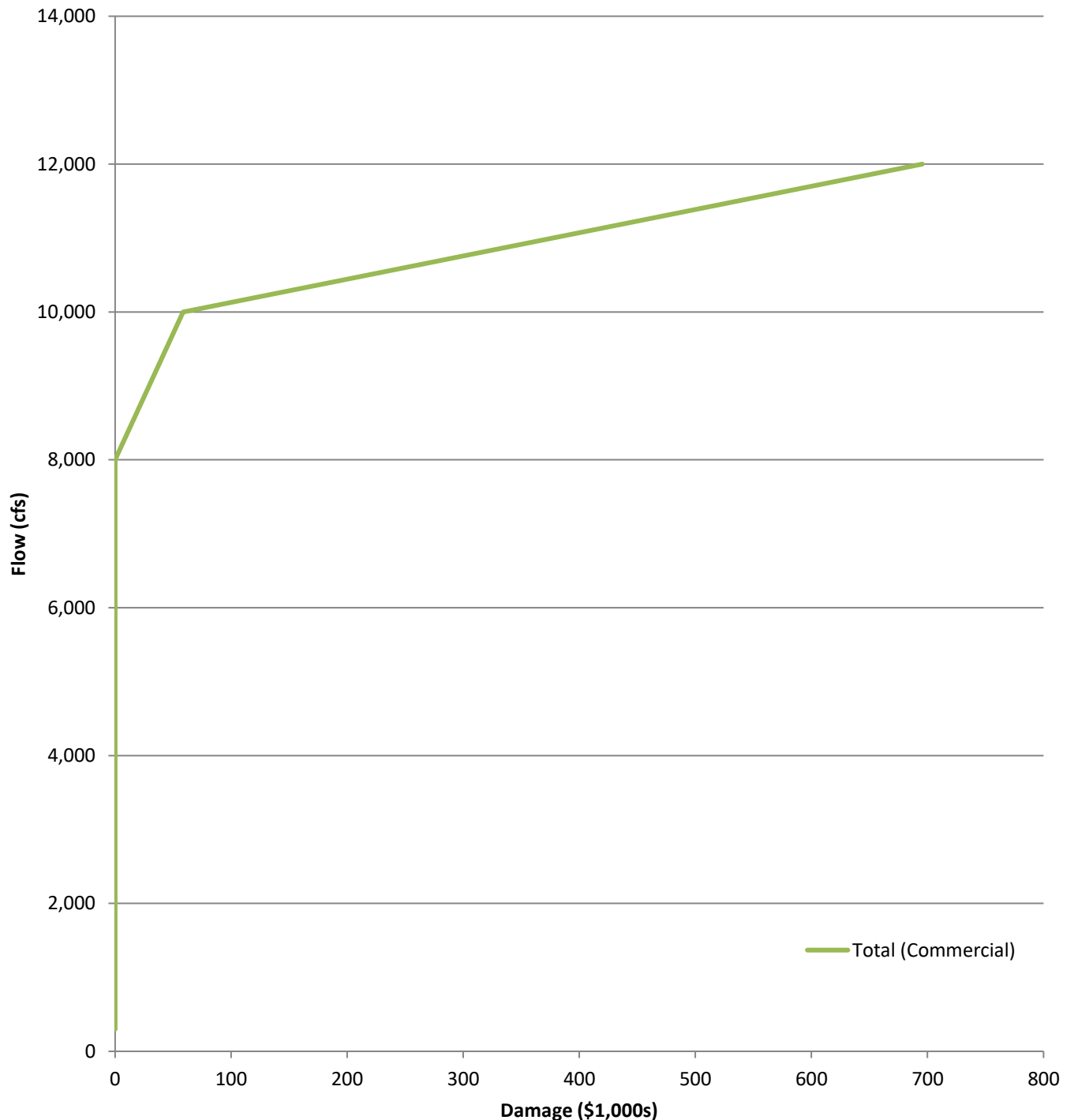
Prepared By: LJH MAS
Reviewed By: KJS

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

**Impact Area 1 - Bear Creek
downstream of Wadsworth Blvd.**

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Impact Area 2: South Platte, Chatfield to Bear Creek



Prepared By: _____ LJH_ & _JB _____
Reviewed By: _____ KJS _____

Notes:

- 1) The curves were finalized in August 2015 using HEC-FIA version 3.0 beta.
- 2) Curves focus solely on damages to structures and contents; agriculture and life loss estimates were not a primary motivator for these curves.
- 3) Input data sources: HEC-RAS modeled stream alignments, depth grids, and terrain grids as well as structure data obtained from assessors data in Denver, Arapahoe, Jefferson and Adams Counties.

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Stage Damages Curves Impact Area 2 - Adjusted to 2014 \$

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

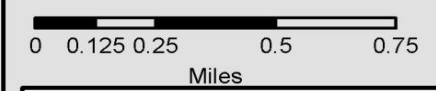


MAP REACH: **IMPACT AREA 2**

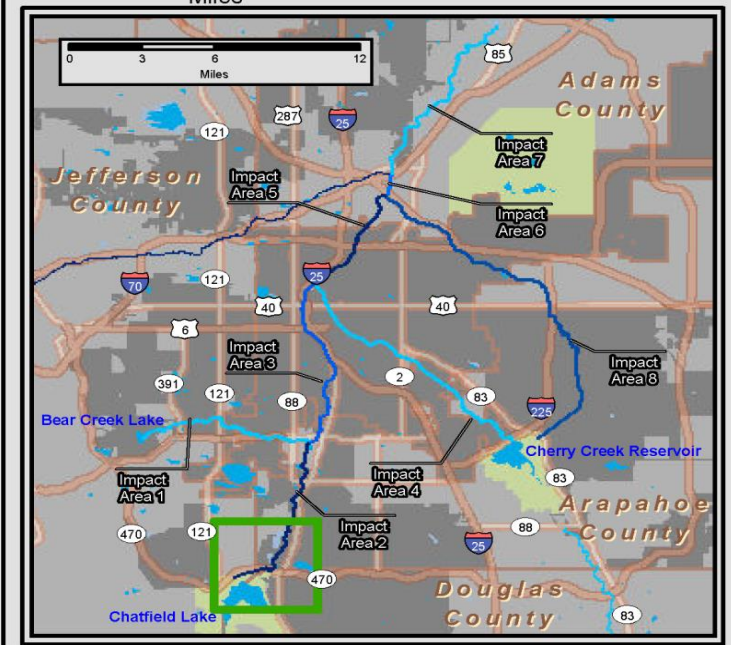
S. PLATTE RIVER - CHATFIELD DAM TO BEAR CREEK CONFLUENCE

Inundation at:

- 5,000 cfs
- 10,000 cfs



US Army Corps of Engineers
Omaha District



Imagery Source: U. S. Department of Agriculture, Farm Service Agency
Compiled On: Wednesday, September 23, 2015

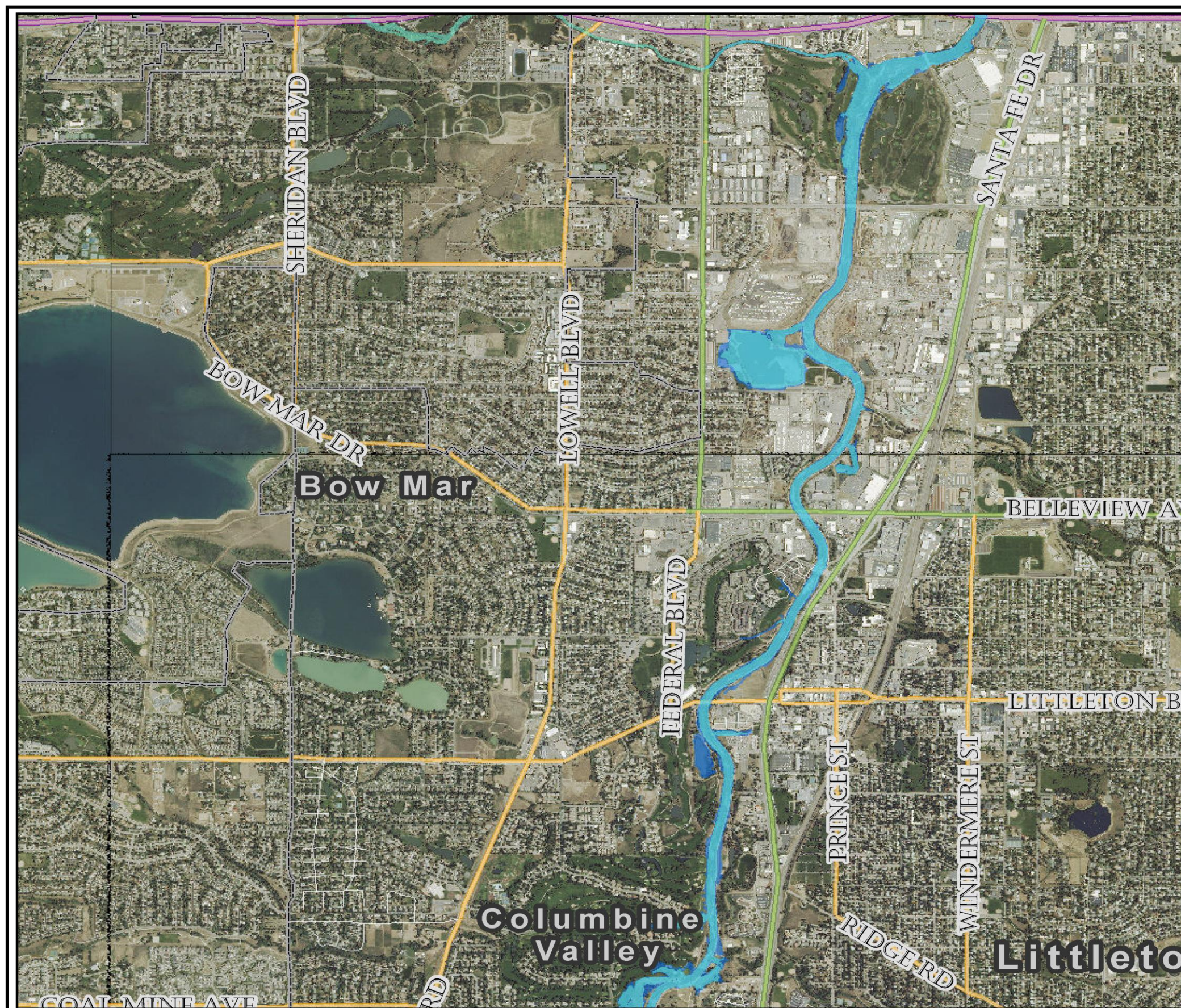
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Prepared By: _____ LJH_MAS _____
Reviewed By: _____ KJS _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

**Impact Area 2 - South Platte
upstream of Coal Mine Ave.**

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018



MAP REACH: **IMPACT AREA 2**

S. PLATTE RIVER - CHATFIELD DAM TO BEAR CREEK CONFLUENCE

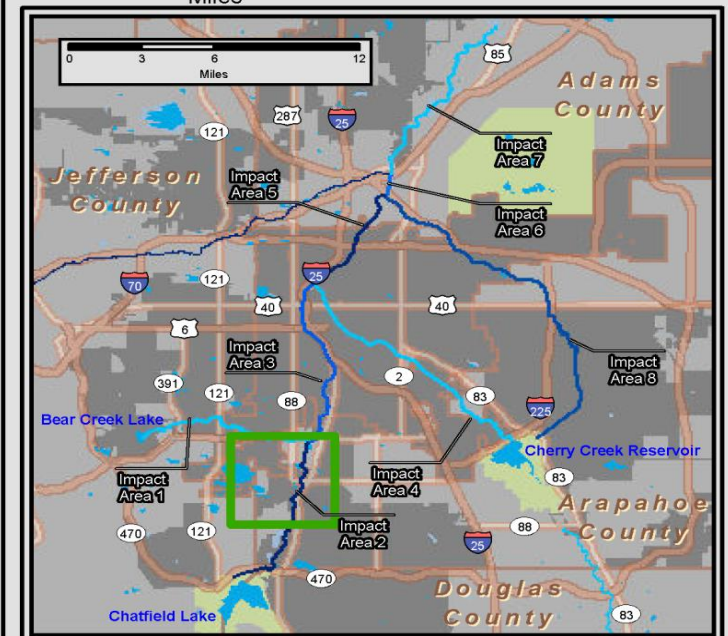
Inundation at:

5,000 cfs

10,000 cfs



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Omaha District



Imagery Source:
U. S. Department of Agriculture,
Farm Service Agency

Compiled On: Thursday, September 24, 2015

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Prepared By: _____ LJH MAS _____

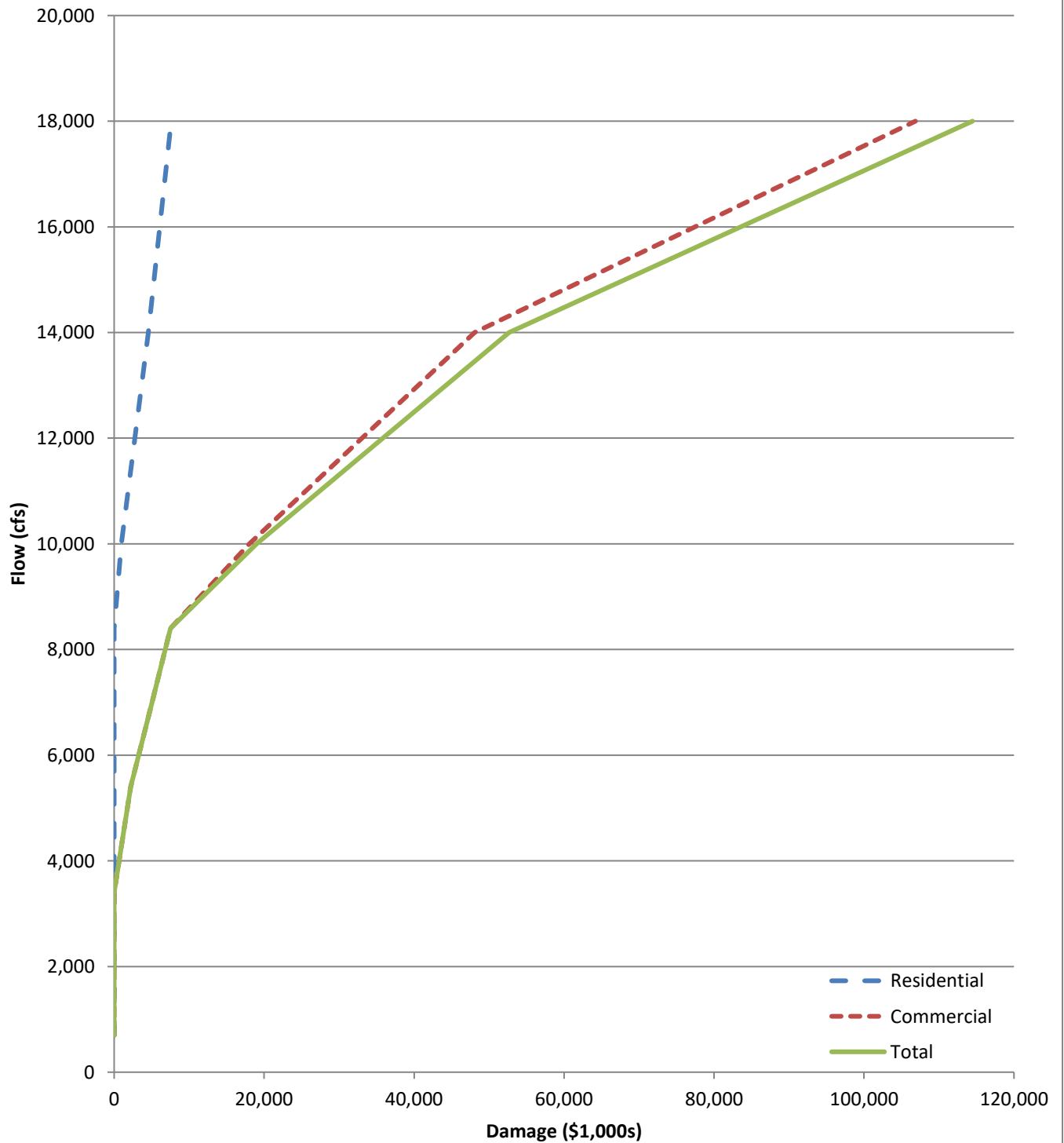
Reviewed By: _____ KJS _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

**Impact Area 2 - South Platte
downstream of Coal Mine Ave.**

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Impact Area 3: South Platte, Bear Ck to Cherry Ck



Prepared By: _____ LJH_&_JB _____
 Reviewed By: _____ KJS _____

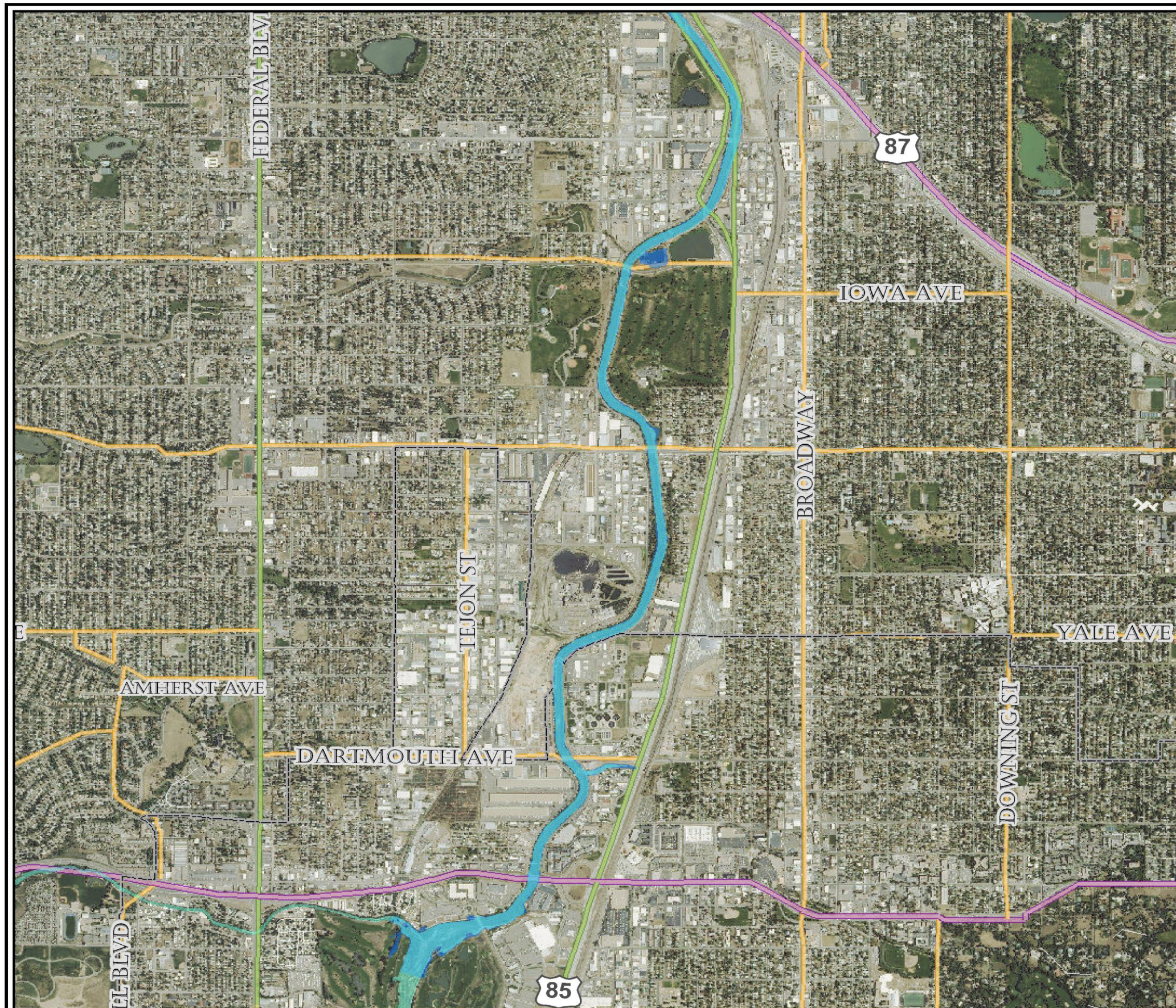
Notes:

- 1) The curves were finalized in August 2015 using HEC-FIA version 3.0 beta.
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- 3) Input data sources: HEC-RAS modeled stream alignments, depth grids, and terrain grids as well as structure data obtained from assessors data in Denver, Arapahoe, Jefferson and Adams Counties.

Water Control Manual
 Bear Creek Dam and Reservoir, Colorado

Stage Damages Curves Impact Area 3 - Adjusted to 2014 \$

U.S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 2018



MAP REACH: IMPACT AREA 3

SOUTH PLATTE RIVER - BEAR CREEK TO CHERRY CREEK CONFLUENCE

Inundation at:

5,400 cfs

10,000 cfs

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Omaha District

0 0.125 0.25 0.5 0.75
Miles

Imagery Source:
U. S. Department of Agriculture,
Farm Service Agency

Compiled On: Thursday, September 24, 2015

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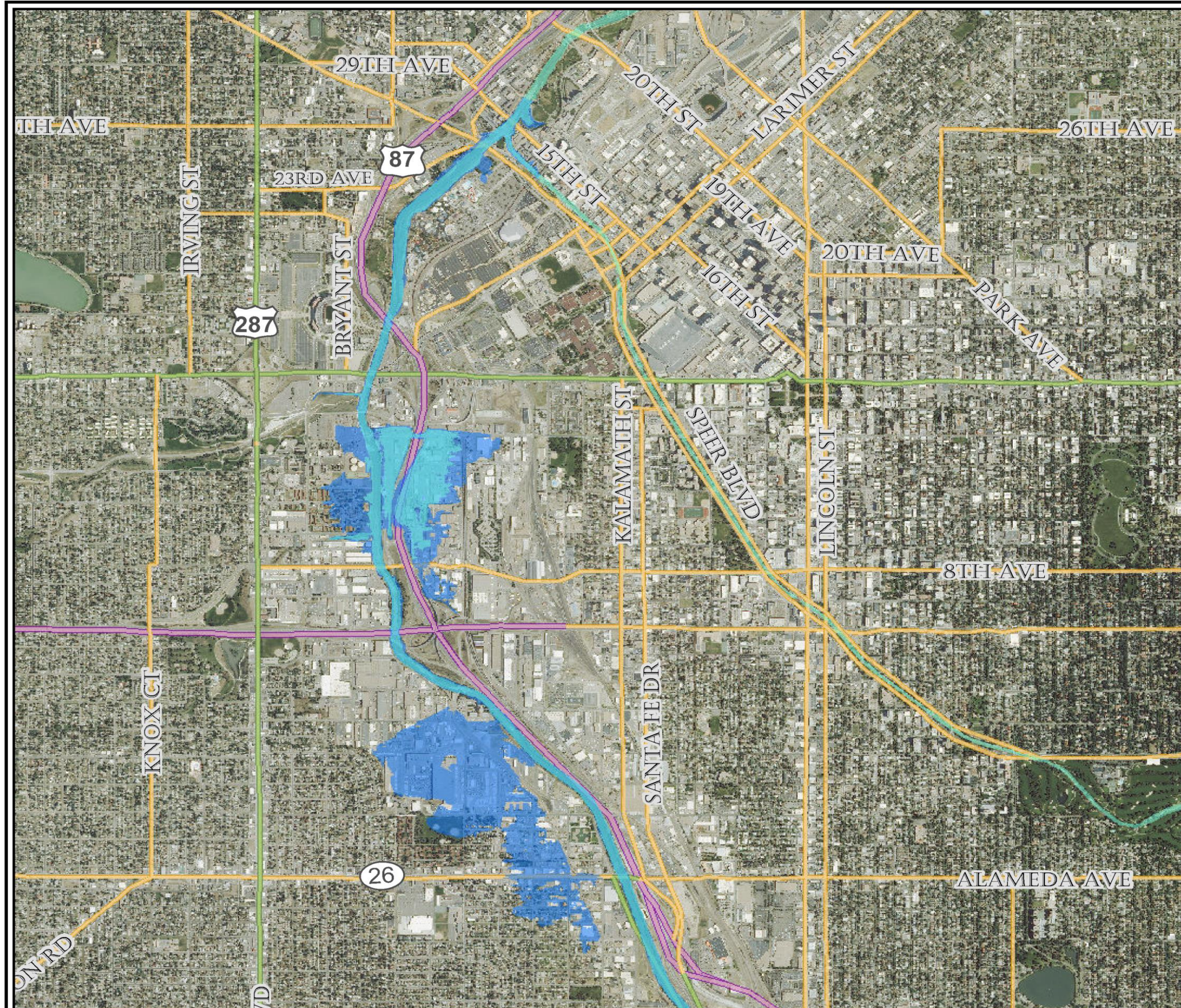
Prepared By: _____ LJH_MAS _____

Reviewed By: _____ KJS _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

**Impact Area 3 - South Platte
upstream of Almeda Ave.**

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018



MAP REACH: IMPACT AREA 3

SOUTH PLATTE RIVER - BEAR CREEK TO CHERRY CREEK CONFLUENCE

Inundation at:

5,400 cfs

10,000 cfs

**US Army Corps
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Omaha District

Miles

Imagery Source:
U. S. Department of Agriculture,
Farm Service Agency

Compiled On: Thursday, September 24, 2015

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Prepared By: _____ LJH_MAS _____

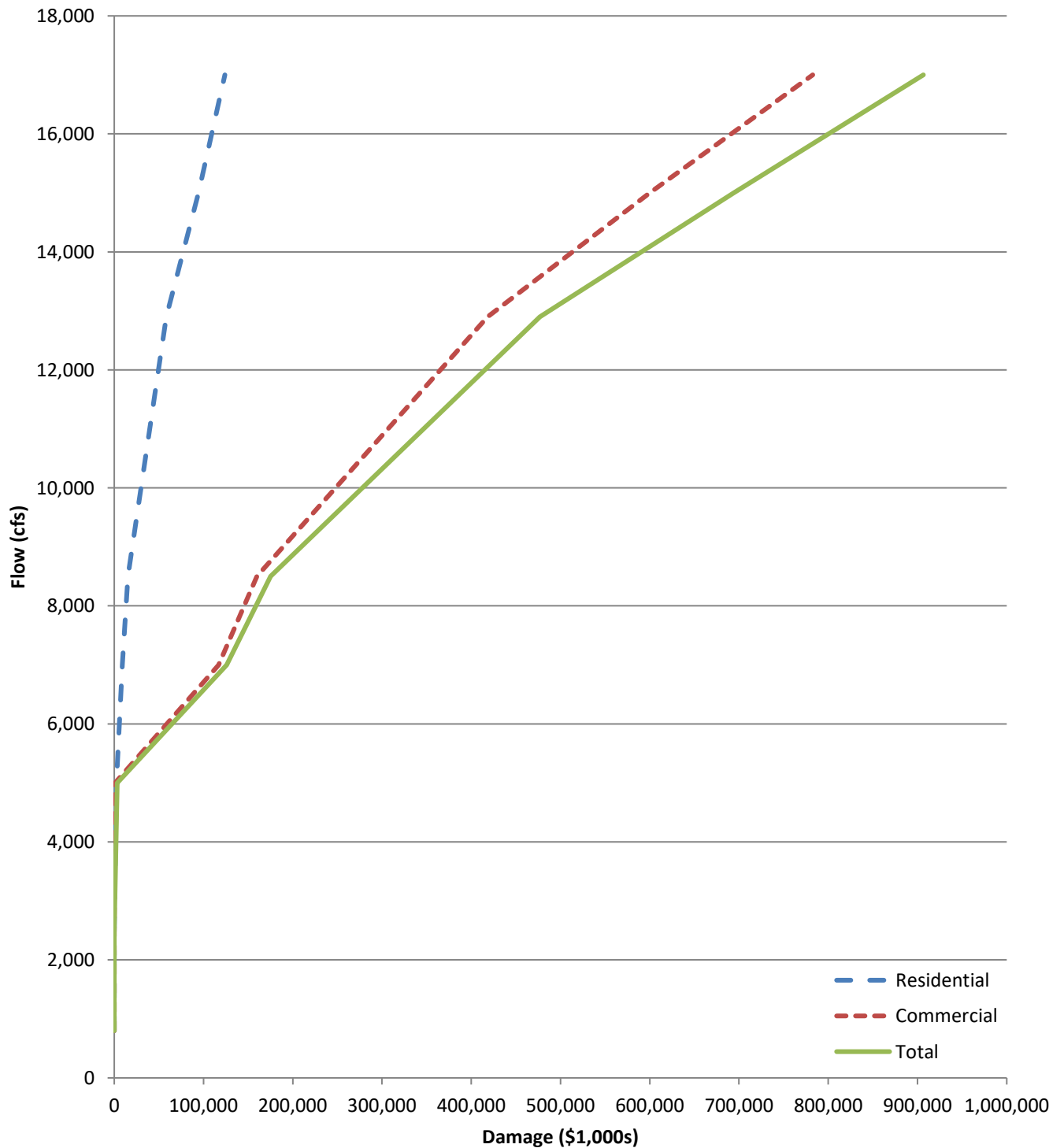
Reviewed By: _____ KJS _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

**Impact Area 3 - South Platte
downstream of Almeda Ave.**

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Impact Area 4: Cherry Creek



Prepared By: _____ LJH_ &_ JB _____
 Reviewed By: _____ KJS _____

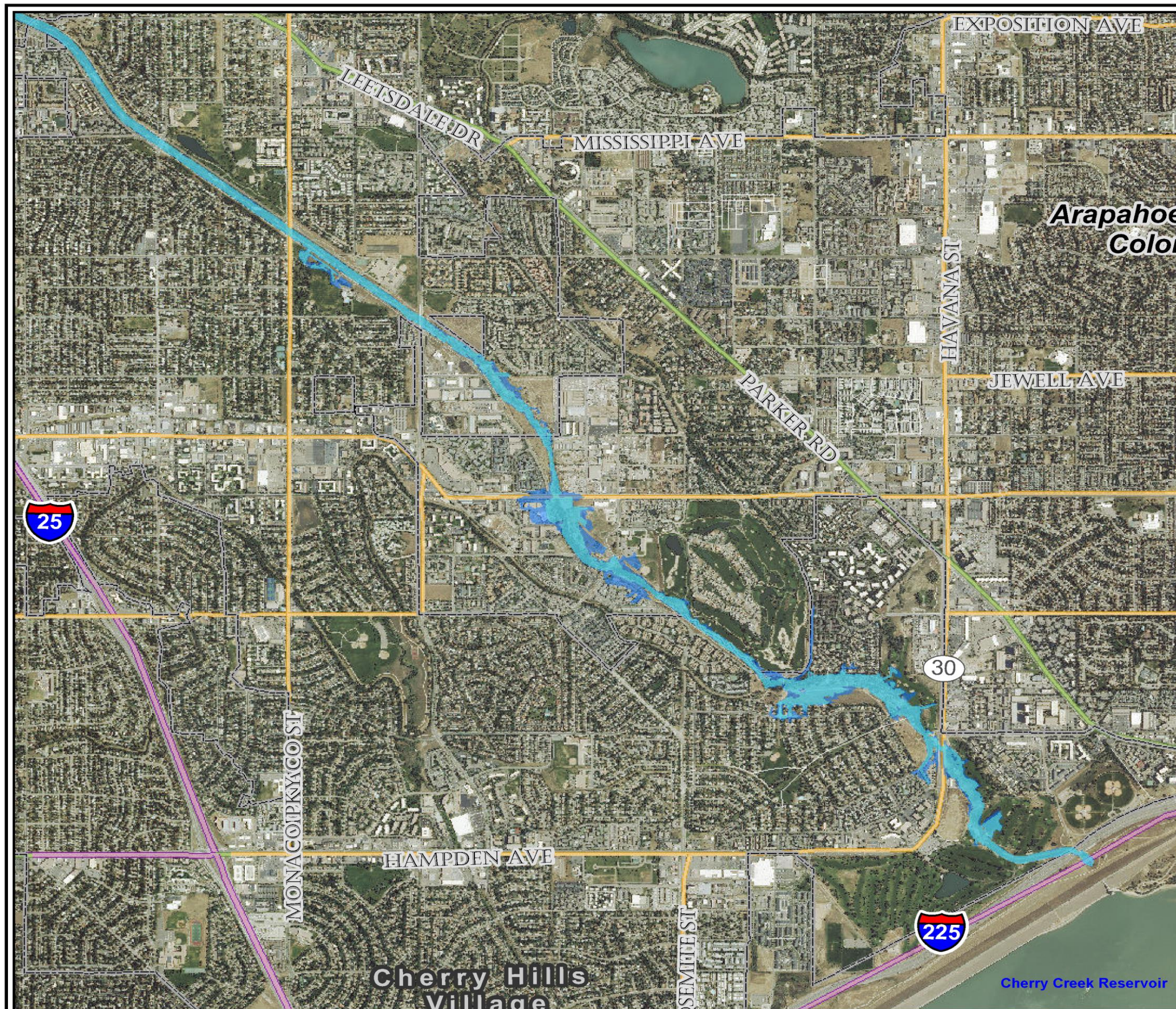
Notes:

- 1) The curves were finalized in August 2015 using HEC-FIA version 3.0 beta.
- 2) Curves focus solely on damages to structures and contents; agriculture and life loss estimates were not a primary motivator for these curves.
- 3) Input data sources: HEC-RAS modeled stream alignments, depth grids, and terrain grids as well as structure data obtained from assessors data in Denver, Arapahoe, Jefferson and Adams Counties.

Water Control Manual
 Bear Creek Dam and Reservoir, Colorado

Stage Damages Curves Impact Area 4 - Adjusted to 2014 \$

U.S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 2018



MAP REACH: **IMPACT AREA 4**

CHERRY CREEK - CHERRY CREEK DAM TO SOUTH PLATTE RIVER

Inundation at:

5,000 cfs

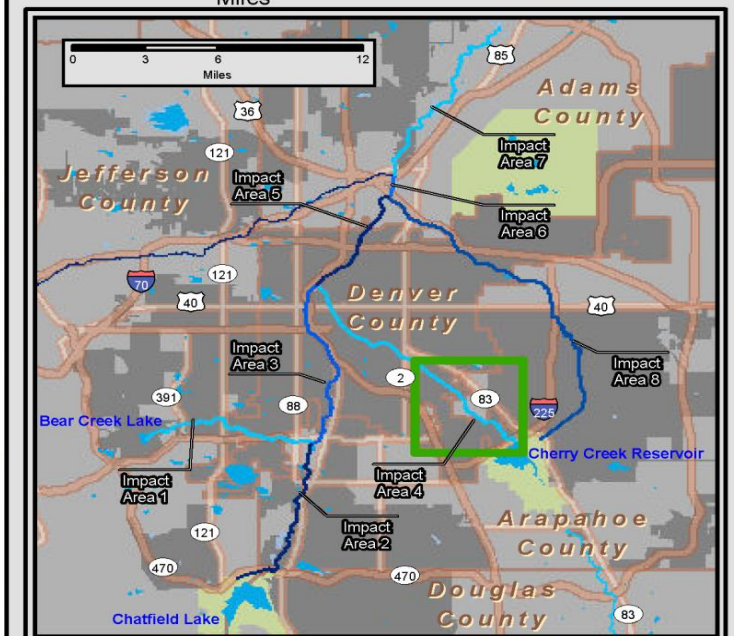
7,000 CFS

0 0.125 0.25 0.5 0.75

Miles



**US Army Corps
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Omaha District



Imagery Source:
U. S. Department of Agriculture,
Farm Service Agency

Compiled On: Thursday, September 24, 2015

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Prepared By: LJH_MAS

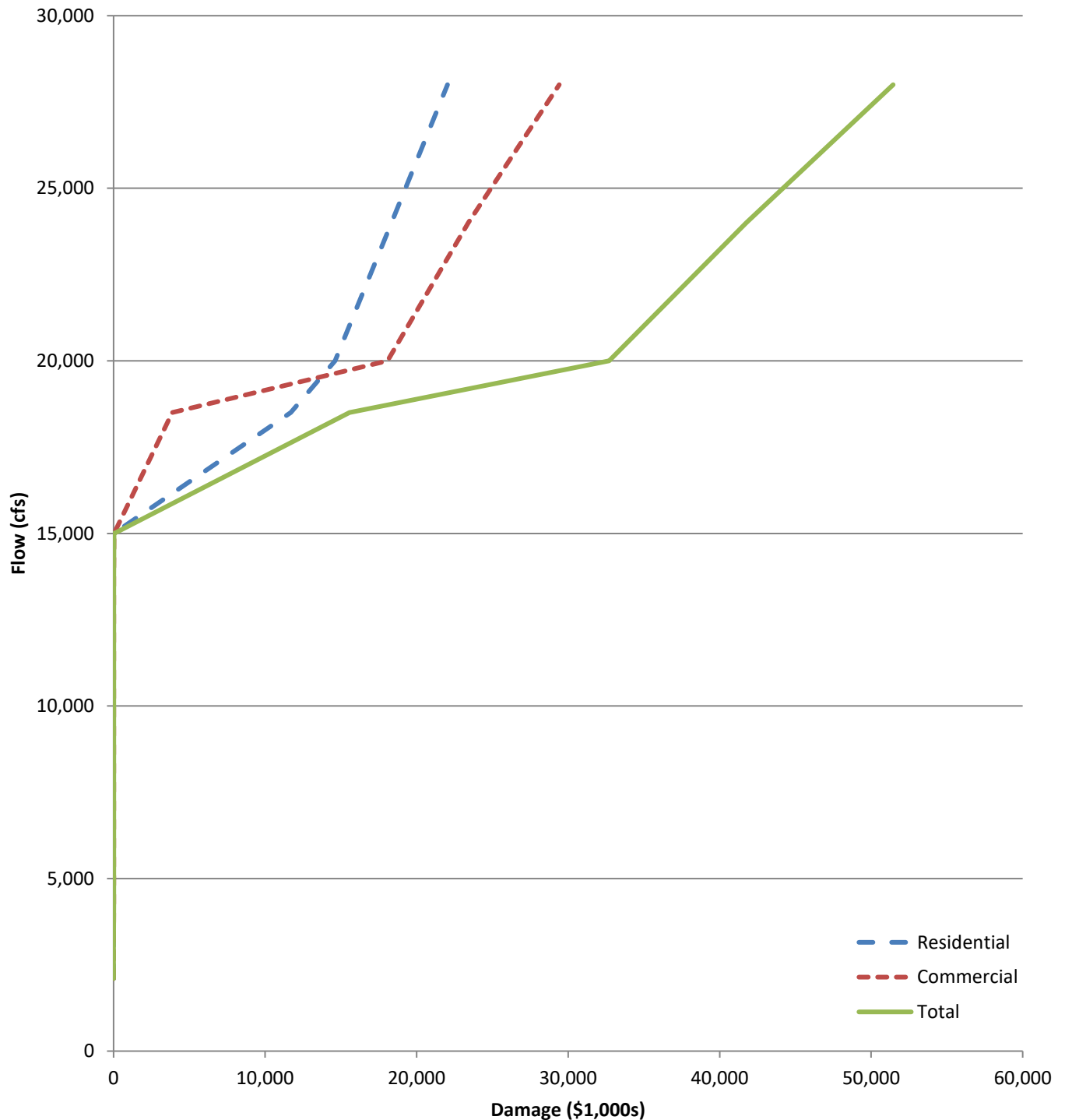
Reviewed By: KJS

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Impact Area 4 - Cherry Creek upstream of Cherry Street

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Impact Area 5: South Platte, Cherry Ck to Sand Ck



Prepared By: _____ LJH & JB
 Reviewed By: _____ KJS

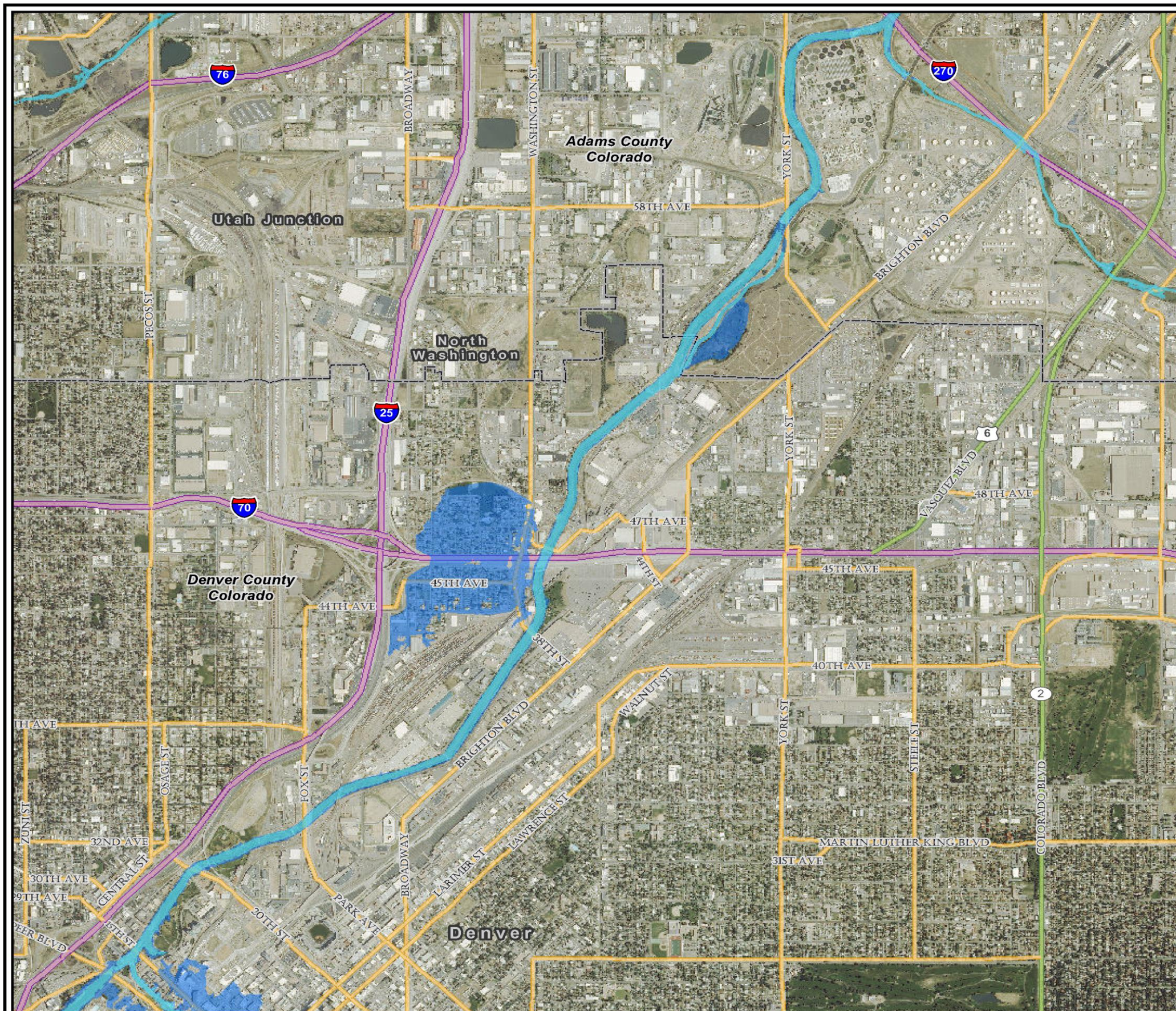
Notes:

- 1) The curves were finalized in August 2015 using HEC-FIA version 3.0 beta.
- 2) Curves focus solely on damages to structures and contents; agriculture and life loss estimates were not a primary motivator for these curves.
- 3) Input data sources: HEC-RAS modeled stream alignments, depth grids, and terrain grids as well as structure data obtained from assessors data in Denver, Arapahoe, Jefferson and Adams Counties.

Water Control Manual
 Bear Creek Dam and Reservoir, Colorado

Stage Damages Curves Impact Area 5 - Adjusted to 2014 \$

U.S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 2018



MAP REACH: **IMPACT AREA 5**
SOUTH PLATTE RIVER - CHEERY CREEK TO SAND CREEK

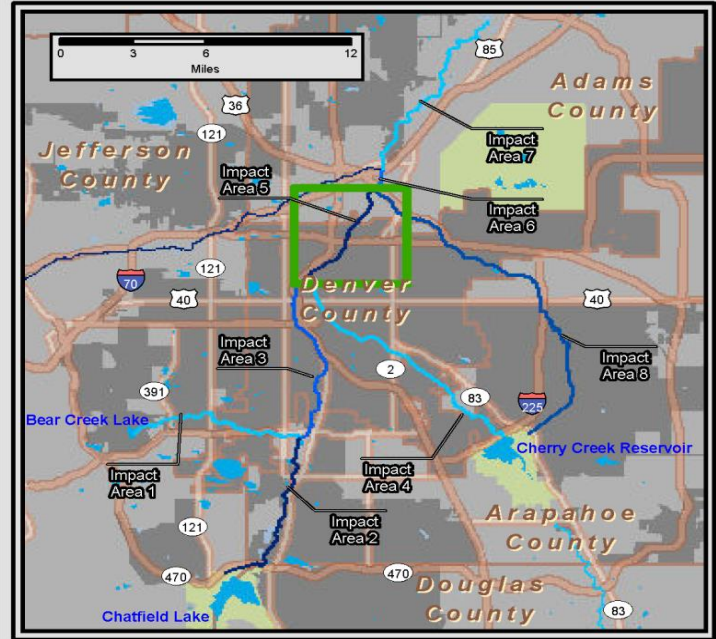
Inundation at:

5,700 cfs

18,500 cfs

0 0.25 0.5 Miles


US Army Corps of Engineers
Omaha District



Imagery Source: U. S. Department of Agriculture, Farm Service Agency
Compiled On: Thursday, September 24, 2015

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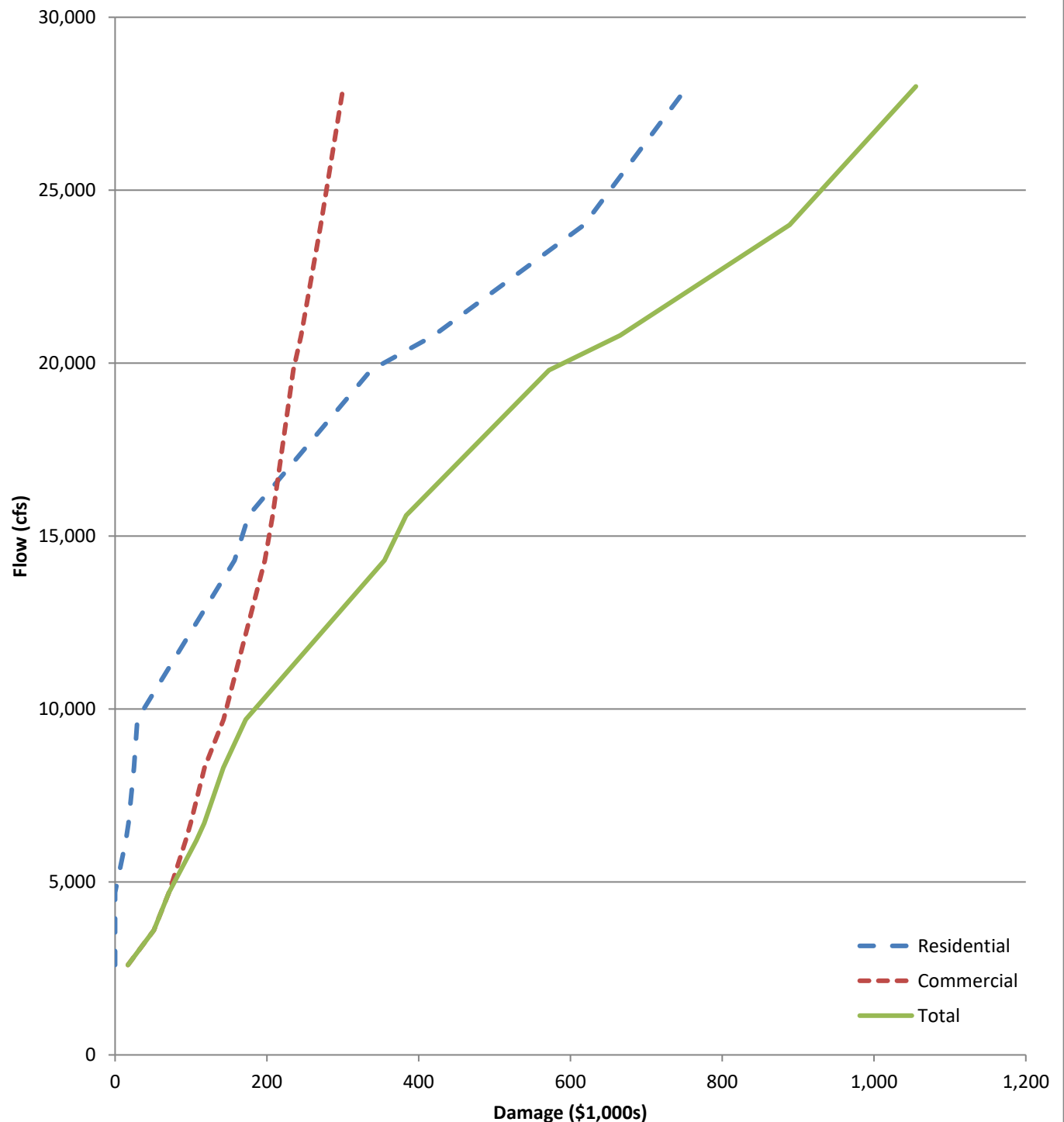
Prepared By: _____ LJH MAS _____
Reviewed By: _____ KJS _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Impact Area 5 - South Platte
Cherry Creek to Sand Creek

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Impact Area 7: S. Platte, Clear Ck to Henderson



Prepared By: _____ LJH_&_JB _____
 Reviewed By: _____ KJS _____

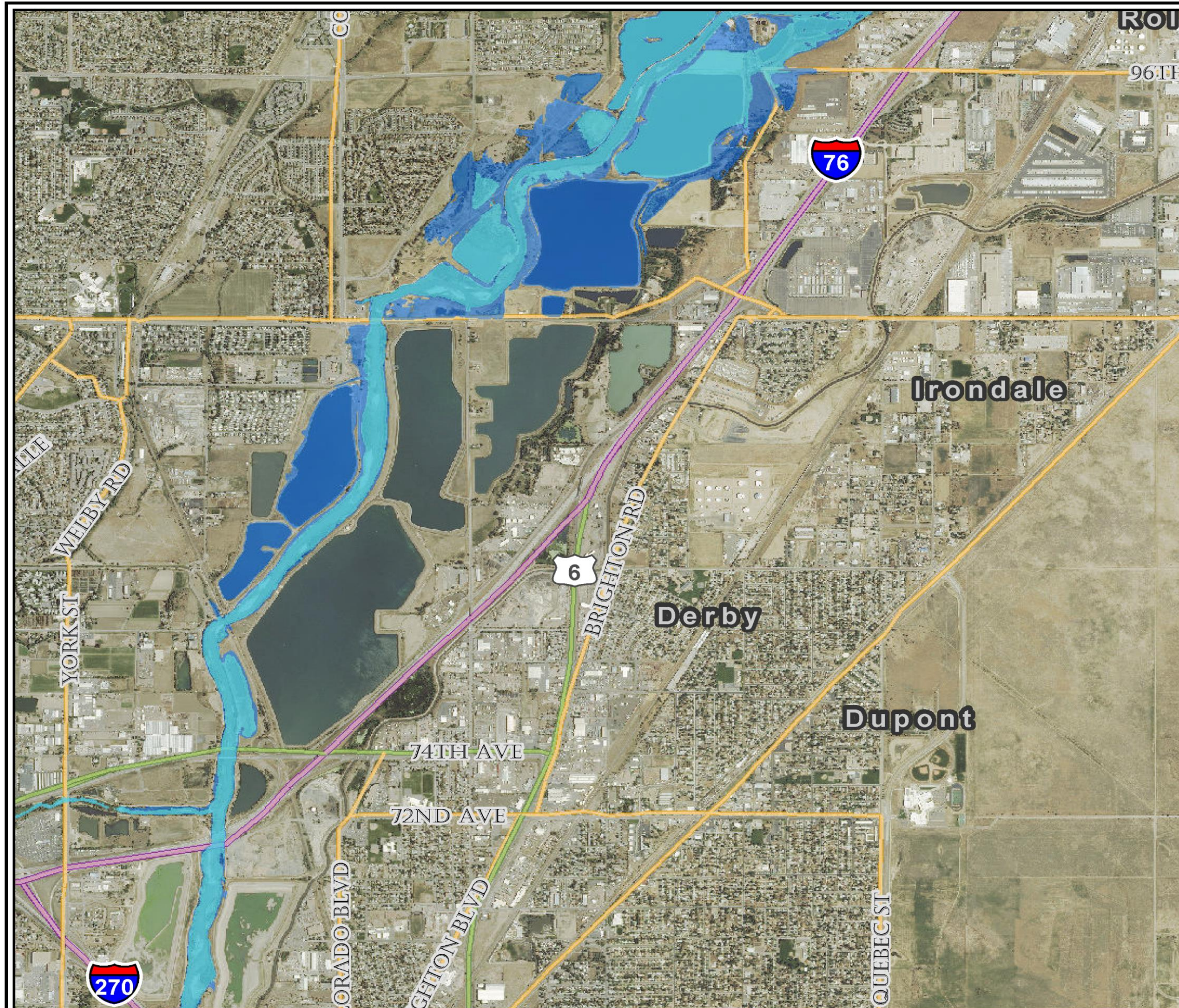
Notes:

- 1) The curves were finalized in August 2015 using HEC-FIA version 3.0 beta.
- 2) Curves focus solely on damages to structures and contents; agriculture and life loss estimates were not a primary motivator for these curves.
- 3) Input data sources: HEC-RAS modeled stream alignments, depth grids, and terrain grids as well as structure data obtained from assessors data in Denver, Arapahoe, Jefferson and Adams Counties.

Water Control Manual
 Bear Creek Dam and Reservoir, Colorado

Stage Damages Curves Impact Area 7 - Adjusted to 2014 \$

U.S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 2018



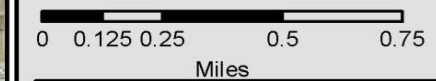
MAP REACH: **IMPACT AREA 7**

SOUTH PLATTE RIVER - DOWNSTREAM FROM CLEAR CREEK

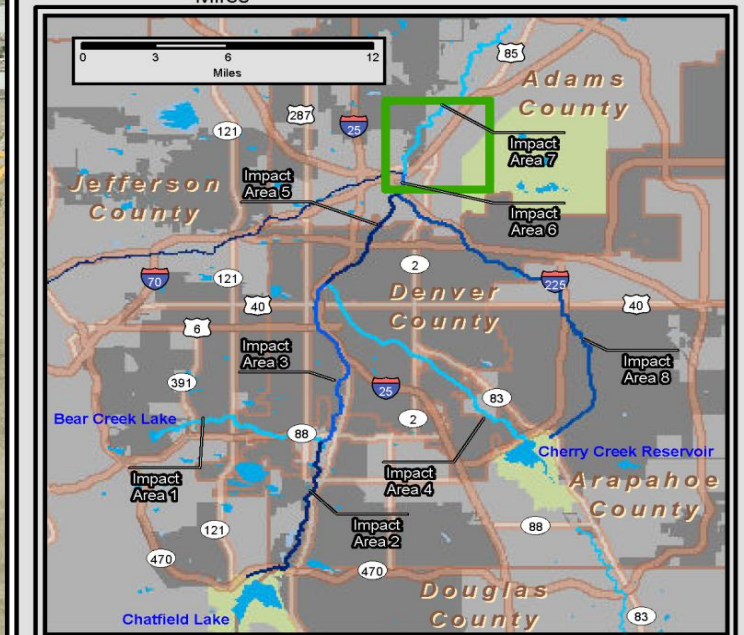
Inundation at:

6,700 cfs

19,800 cfs



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Omaha District



Imagery Source:
U. S. Department of Agriculture,
Farm Service Agency

Compiled On: Friday, September 25, 2015

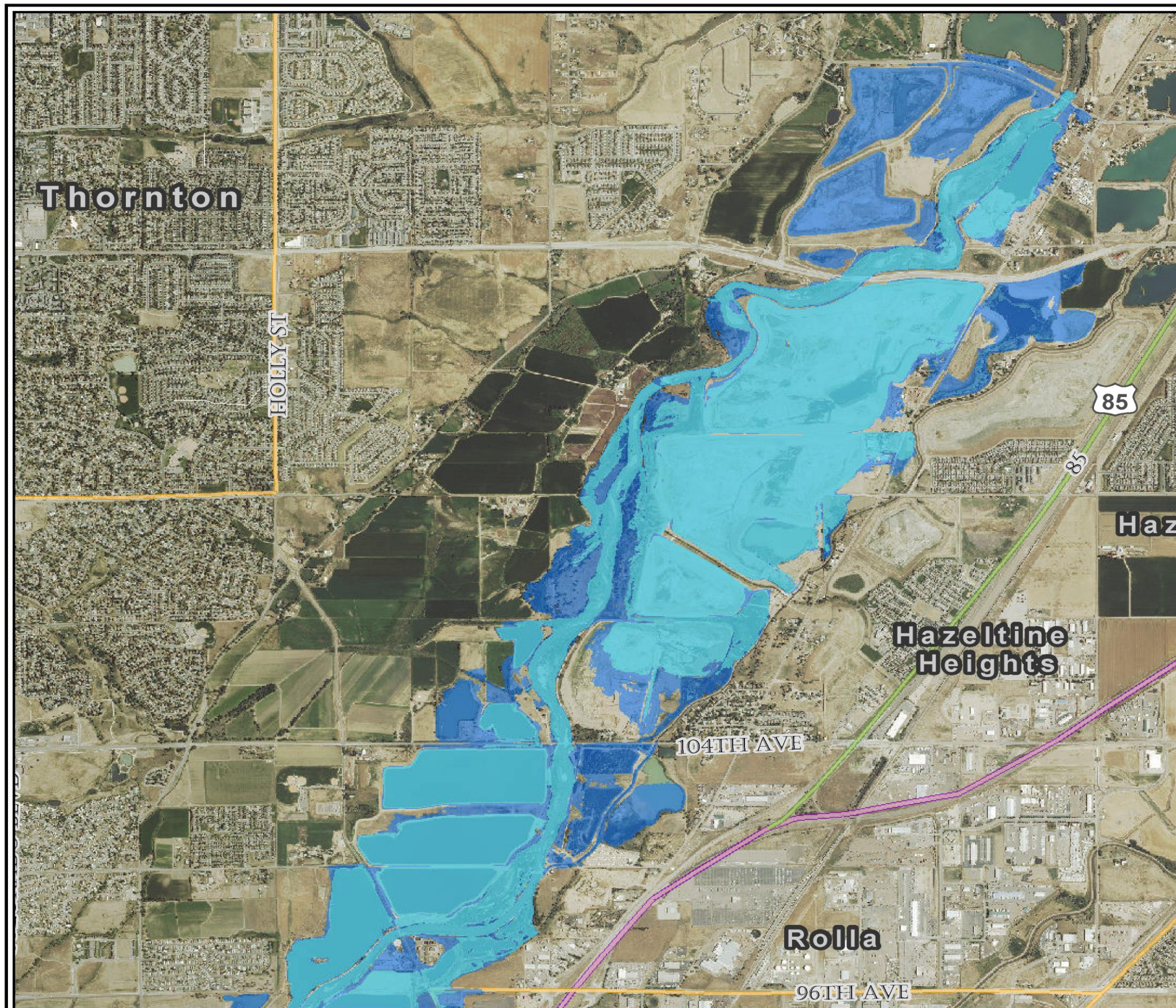
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Prepared By: LJH MAS
Reviewed By: KJS

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Impact Area 7 - South Platte upstream of 96th Ave.

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018



MAP REACH: **IMPACT AREA 7**

SOUTH PLATTE RIVER - DOWNSTREAM FROM CLEAR CREEK

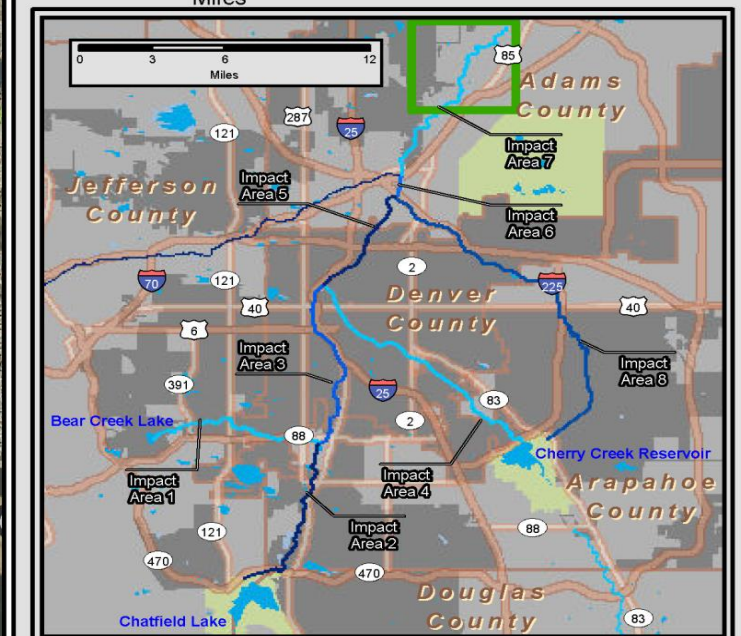
Inundation at:

6,700 cfs

19,800 cfs



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Imagery Source:
U. S. Department of Agriculture,
Farm Service Agency

Compiled On: Friday, September 25, 2015

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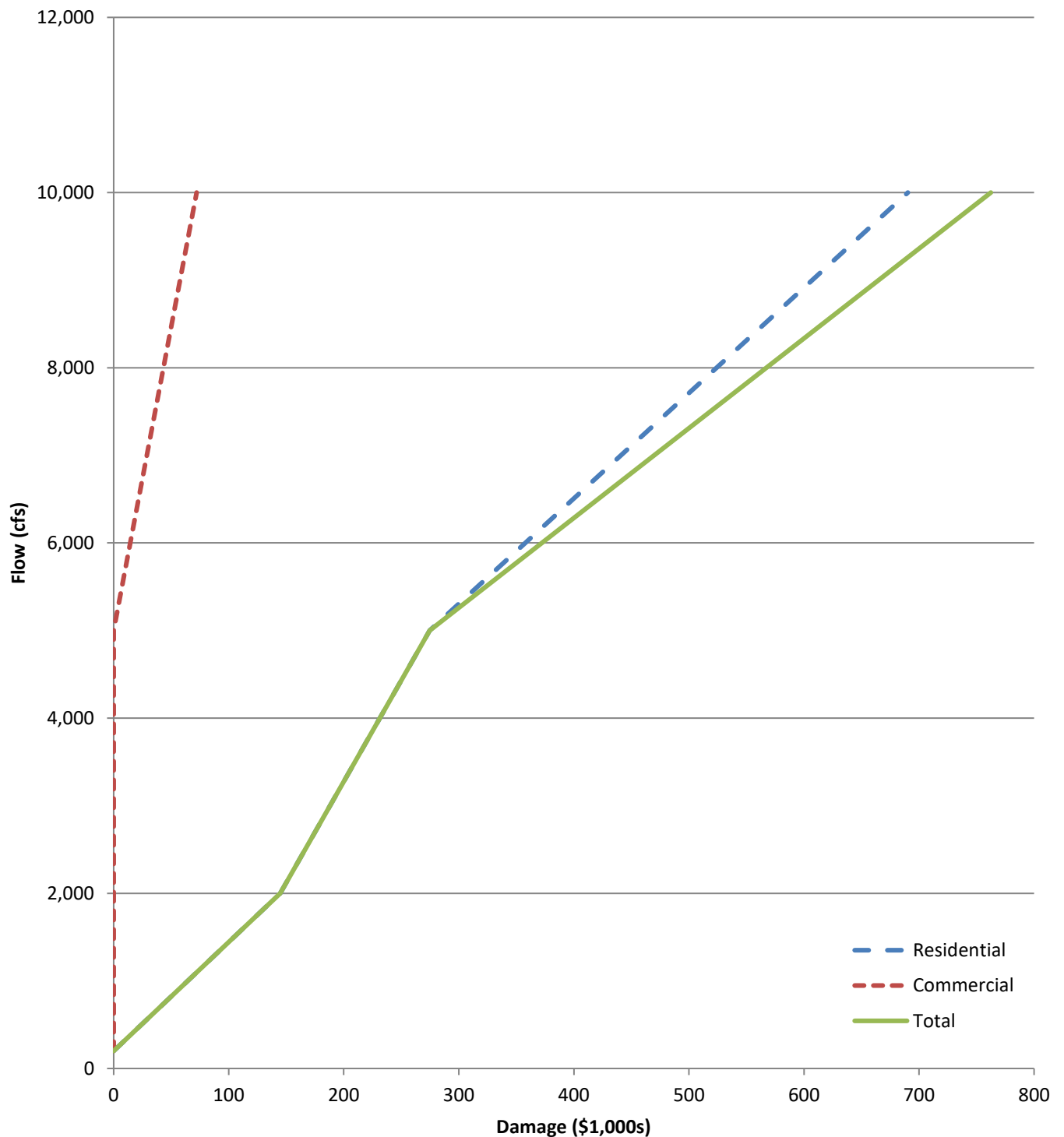
Prepared By: LJH_MAS
Reviewed By: KJS

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Impact Area 7 - South Platte downstream of 96th Ave.

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Impact Area 8: Sand Creek



Prepared By: _____ L J H _ & _ J B _____
 Reviewed By: _____ K J S _____

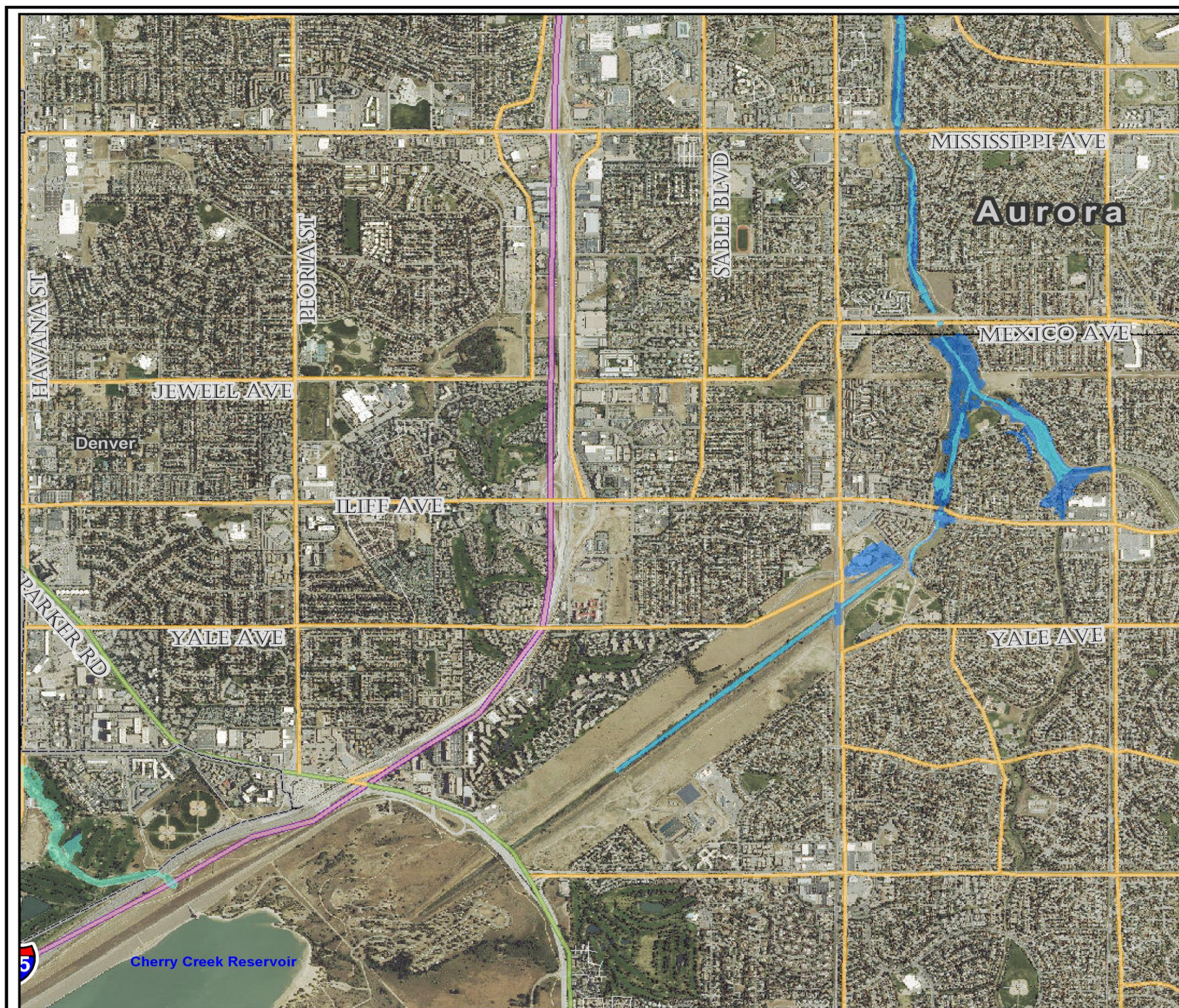
Notes:

- 1) The curves were finalized in August 2015 using HEC-FIA version 3.0 beta.
- 2) Curves focus solely on damages to structures and contents; agriculture and life loss estimates were not a primary motivator for these curves.
- 3) Input data sources: HEC-RAS modeled stream alignments, depth grids, and terrain grids as well as structure data obtained from assessors data in Denver, Arapahoe, Jefferson and Adams Counties.

Water Control Manual
 Bear Creek Dam and Reservoir, Colorado

Stage Damages Curves Impact Area 8 - Adjusted to 2014 \$

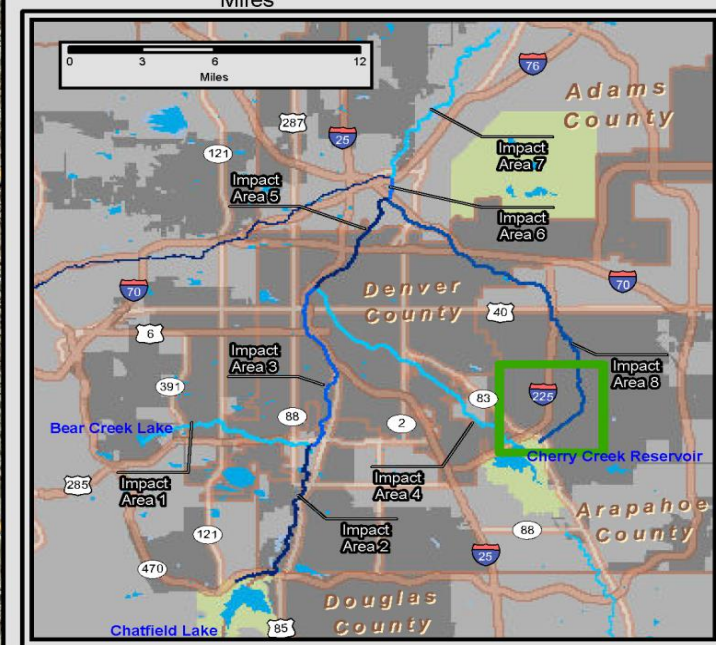
U.S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 2018



MAP REACH: **IMPACT AREA 8**
SAND CREEK - CHERRY CREEK DAM TO SOUTH PLATTE RIVER

Inundation at:

- 200 cfs
- 2,000 cfs



Imagery Source: U. S. Department of Agriculture, Farm Service Agency
Compiled On: Thursday, September 24, 2015

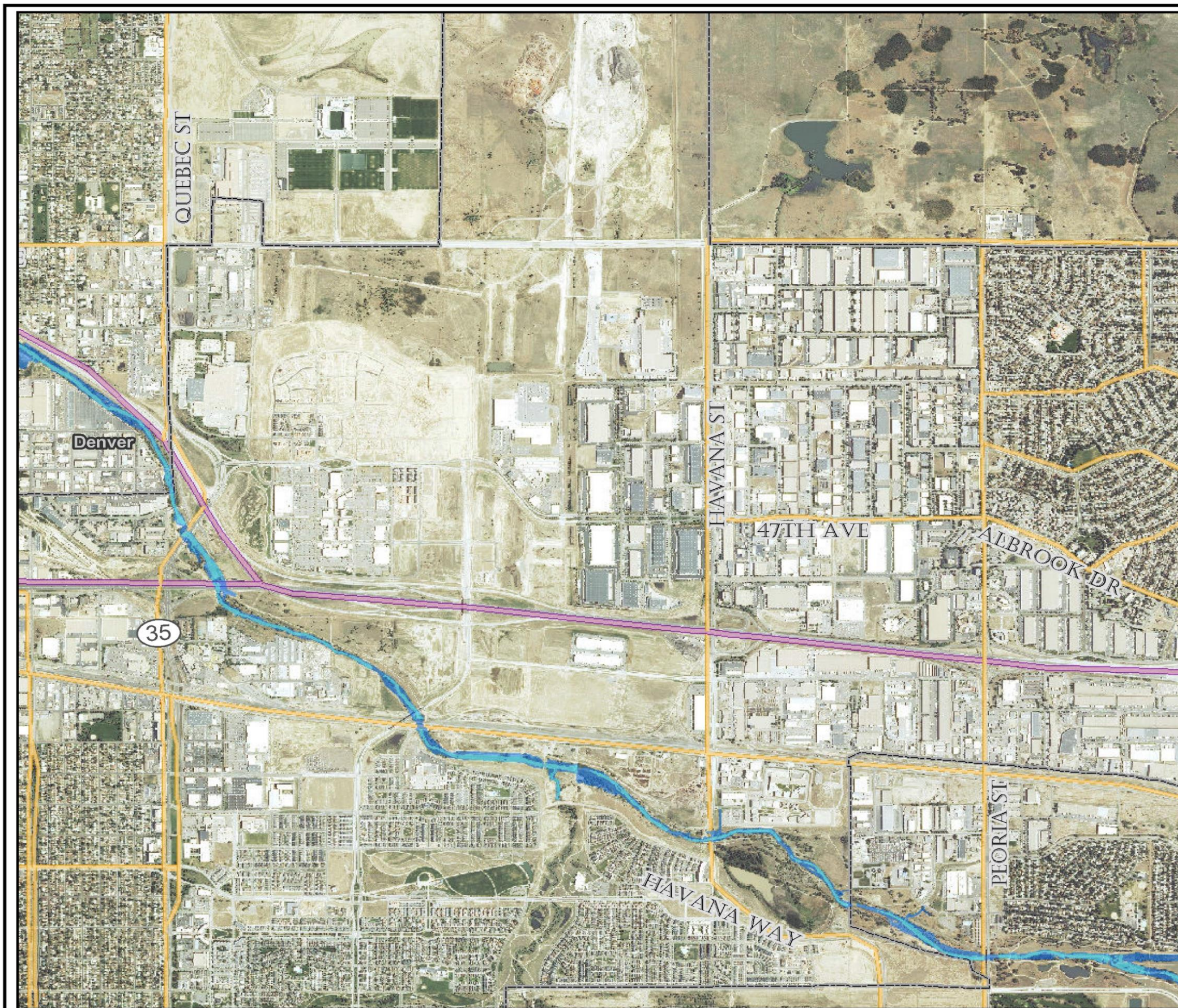
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Prepared By: LJH_MAS
Reviewed By: KJS

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

**Impact Area 8 - Sand Creek
upstream of Alameda Pkwy.**

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018



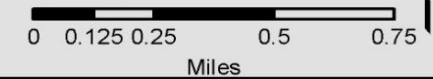
MAP REACH: **IMPACT AREA 8**

SAND CREEK - CHERRY CREEK DAM TO SOUTH PLATTE RIVER

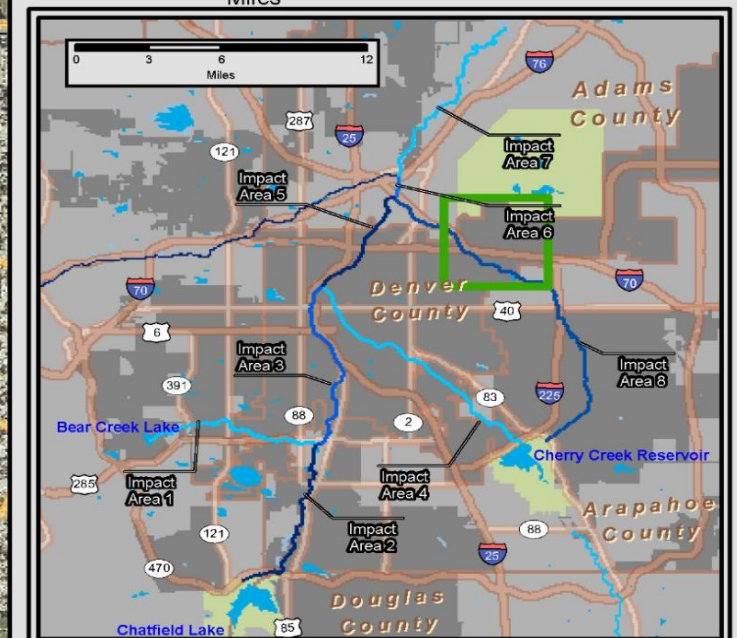
Inundation at:

200 cfs

2,000 cfs



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Imagery Source:
U. S. Department of Agriculture,
Farm Service Agency

Compiled On: Tuesday, November 28, 2017

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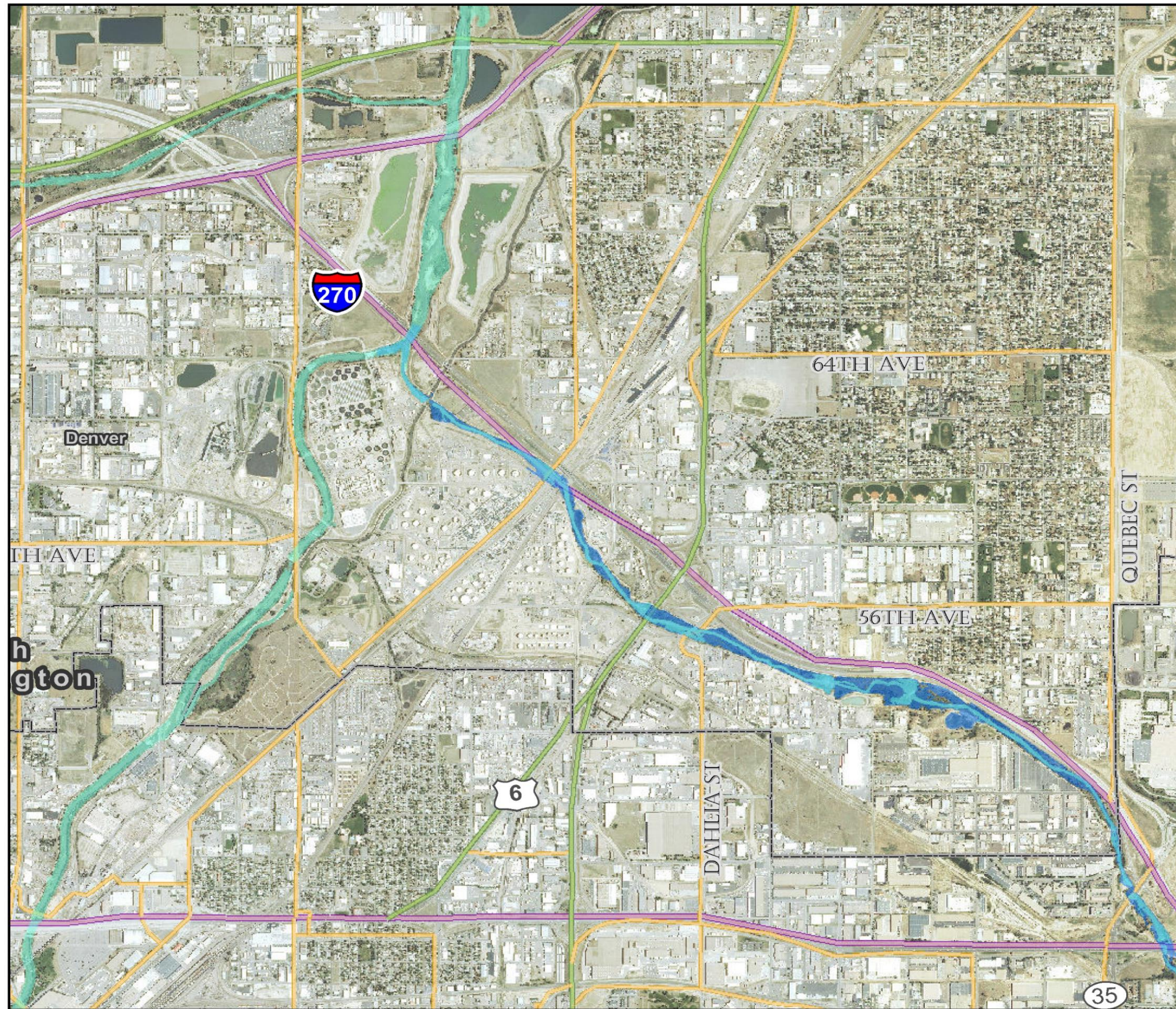
Prepared By: LJH MAS

Reviewed By: KJS

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Impact Area 8 - Sand Creek **Peoria St. to Quebec St.**

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018



MAP REACH: **IMPACT AREA 8**

SAND CREEK - CHERRY CREEK DAM TO SOUTH PLATTE RIVER

Inundation at:

200 cfs

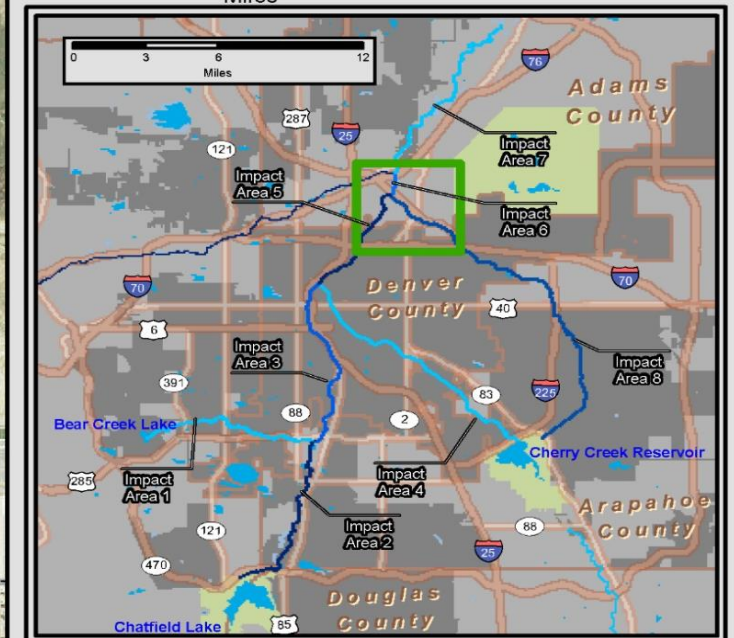
2,000 cfs

0 0.125 0.25 0.5 0.75

Miles



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Imagery Source:
U. S. Department of Agriculture,
Farm Service Agency

Compiled On: Tuesday, November 28, 2017

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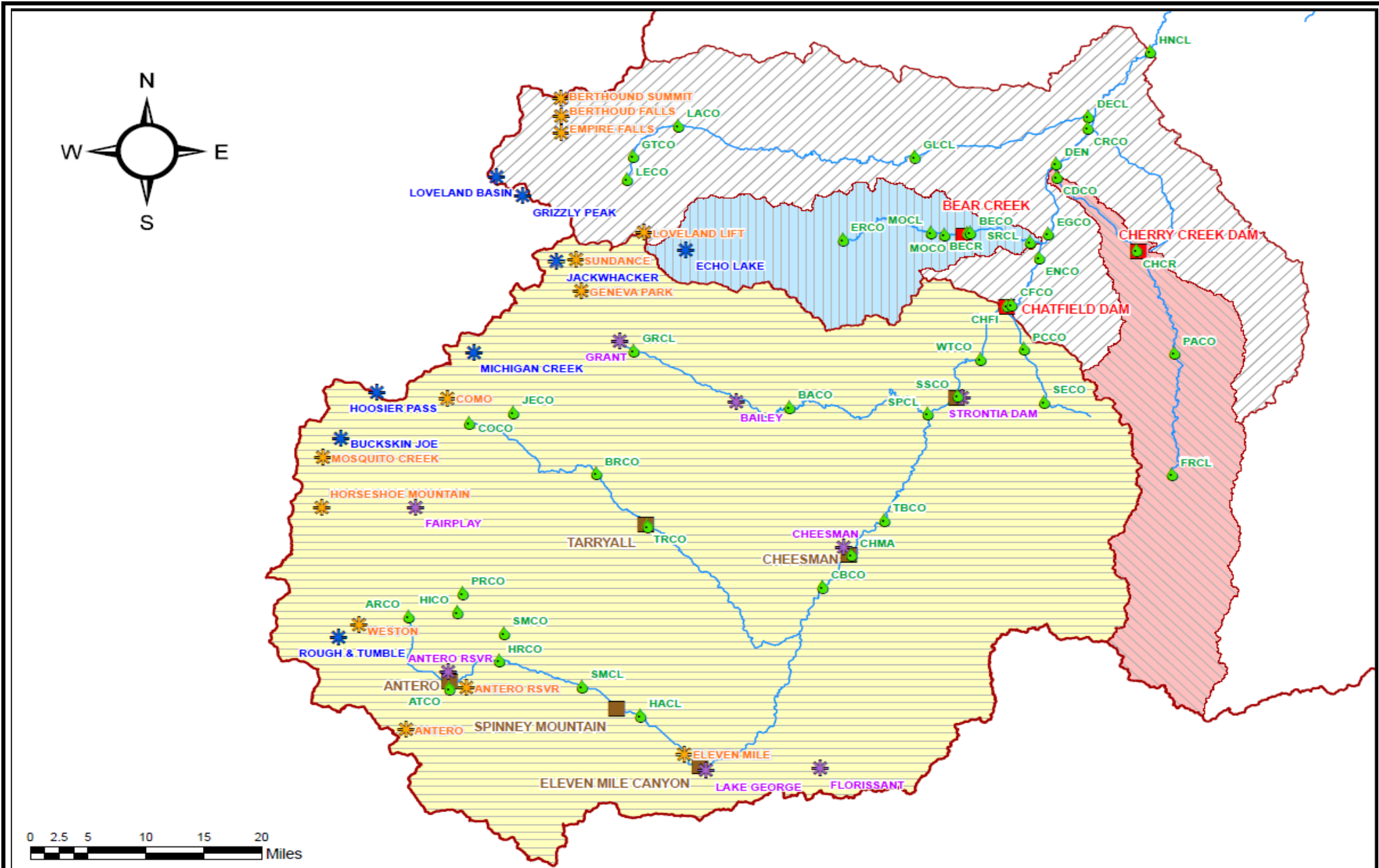
Prepared By: LJH_MAS

Reviewed By: KJS

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Impact Area 8 - Sand Creek **Quebec St. to South Platte R.**

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018



Label	Gage Name	Owner*
ARCO	South Fork South Platte above Antero Reservoir	COA
ATCO	South Fork South Platte below Antero Reservoir	CDWR
BACO	North Fork South Platte at Bailey, CO	CDWR
BECO	Bear Creek Dam Outflow	CDWR
BECR	Bear Creek Reservoir	COE
BRCO	Tarryall Creek at Borden Ditch	COA
CBCO	South Platte River above Cheesman Lake	USGS
CDCO	Cherry Creek at Denver	USGS
CFCO	South Platte River below Chatfield Reservoir	CDWR
CHCR	Cherry Creek Reservoir	COE
CHFI	Chatfield Reservoir	COE
CHMA	Cheesman Reservoir	CDWR
COCO	Tarryall Creek at Como, CO	USGS
CRCO	South Platte River at Commerce, CO	USGS
DECL	Clear Creek at Derby, CO	CDWR
DEN	South Platte River at Denver, CO	CDWR
EGCO	South Platte River at Englewood, CO	USGS
ENCO	South Platte River below Union Ave., CO	USGS
ERCO	Bear Creek above Evergreen, CO	USGS
FRCL	Cherry Creek near Franktown, CO	USGS
GLCL	Clear Creek at Golden, CO	USGS
GRCL	North Fork South Platte at Grant, CO	CDWR
GTCO	Clear Creek near Georgetown, CO	USGS
HACL	South Platte River above Elevenmile Reservoir	CDWR
HICO	Four Mile Creek at High Creek	COA
HNCL	South Platte River at Henderson, CO	CDWR
HRCO	Four Mile Creek at Hartsel, CO	COA
JECO	Michigan Creek at Jefferson, CO	COA
LACO	Clear Creek near Lawson, CO	USGS
LECO	Leavenworth Creek at Georgetown, CO	USGS
MOCL	Bear Creek at Morrison, CO	CDWR
MOCO	Bear Creek above Bear Creek Reservoir	USGS
PACO	Cherry Creek near Parker, CO	USGS
PCCO	Plum Creek at Louviers, CO	USGS
PRCO	Middle Fork South Platte at Prince, CO	COA
SECO	Plum Creek at Sedalia, CO	USGS
SMCL	South Platte River above Spinney Reservoir	COA
SMCO	Middle Fork South Platte at Santa Maria, CO	COA
SPCL	South Platte River at South Platte, CO	CDWR
SRCL	Bear Creek at Sheridan, CO	CDWR
SSCO	South Platte River below Strontia Springs Reservoir	CDWR
TBCO	South Platte at Trumbull, CO	USGS
TRCO	Tarryall Creek below Tarryall Reservoir	CDWR
WTCO	South Platte River at Waterton, CO	CDWR

*CDWR = Colorado Department of Water Resources
*COA = City of Aurora (Station Cooperator)
*COE = Corps of Engineers
*USGS = U.S. Geological Survey

Upper South Platte Watershed and River Gages

 Flow and Reservoir Gages

 Stream Centerline

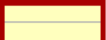
 NCDC

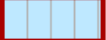
 NRCS Snow Course

 NRCS SNOTEL

 USACE Dams

 Local Water Supply Reservoirs

 Chatfield Watershed

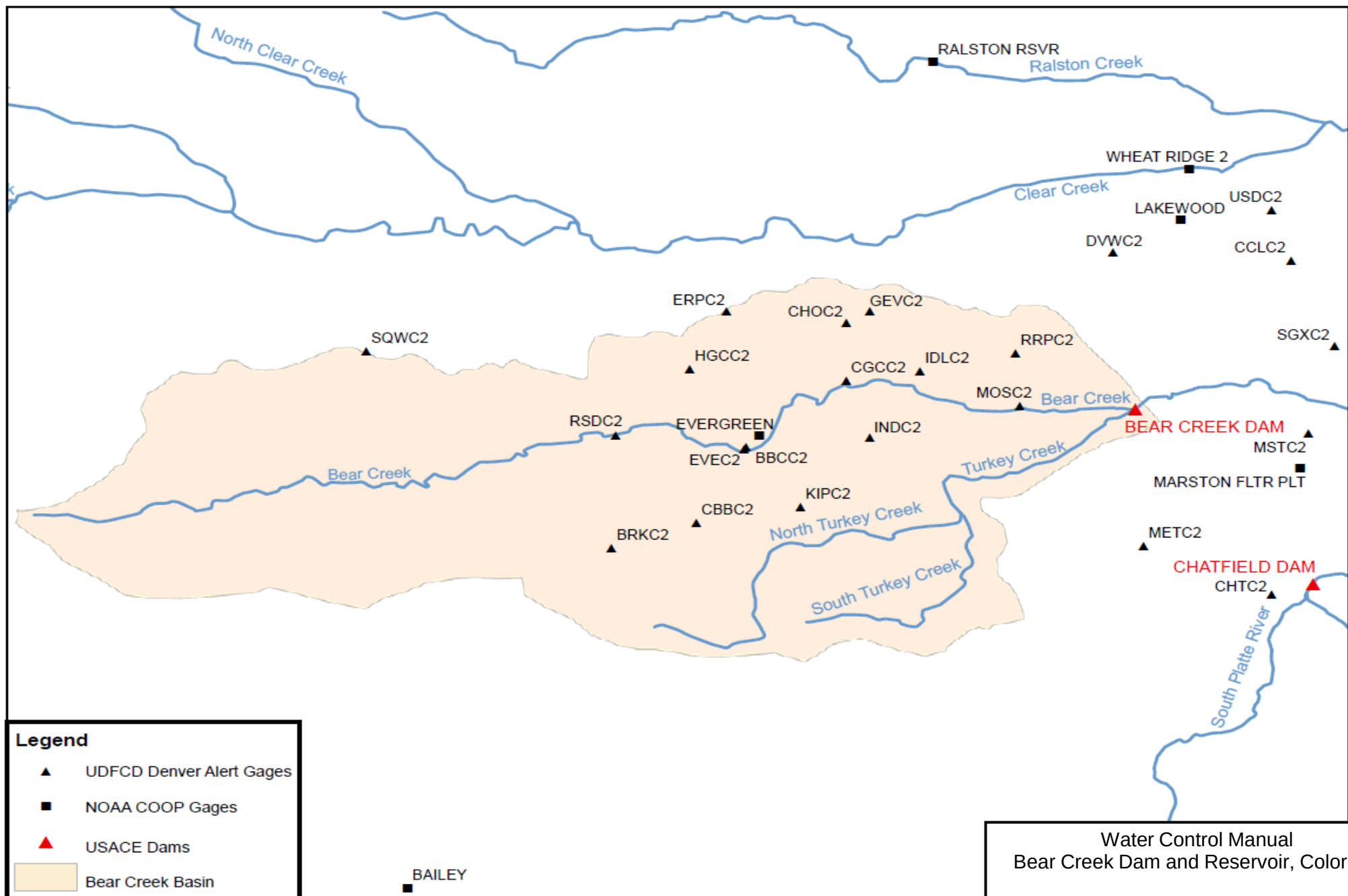
 Bear Creek Watershed

 Cherry Creek Watershed

 Upper South Platte Watershed

Prepared By: _____ KEH _____
Reviewed By: _____ KJS _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado
**Tri-Lakes Snotel, River and
Precipitation Stations**
U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018



Sources:

<http://alert5.udfcd.org/LDAD/gmapV3.html>

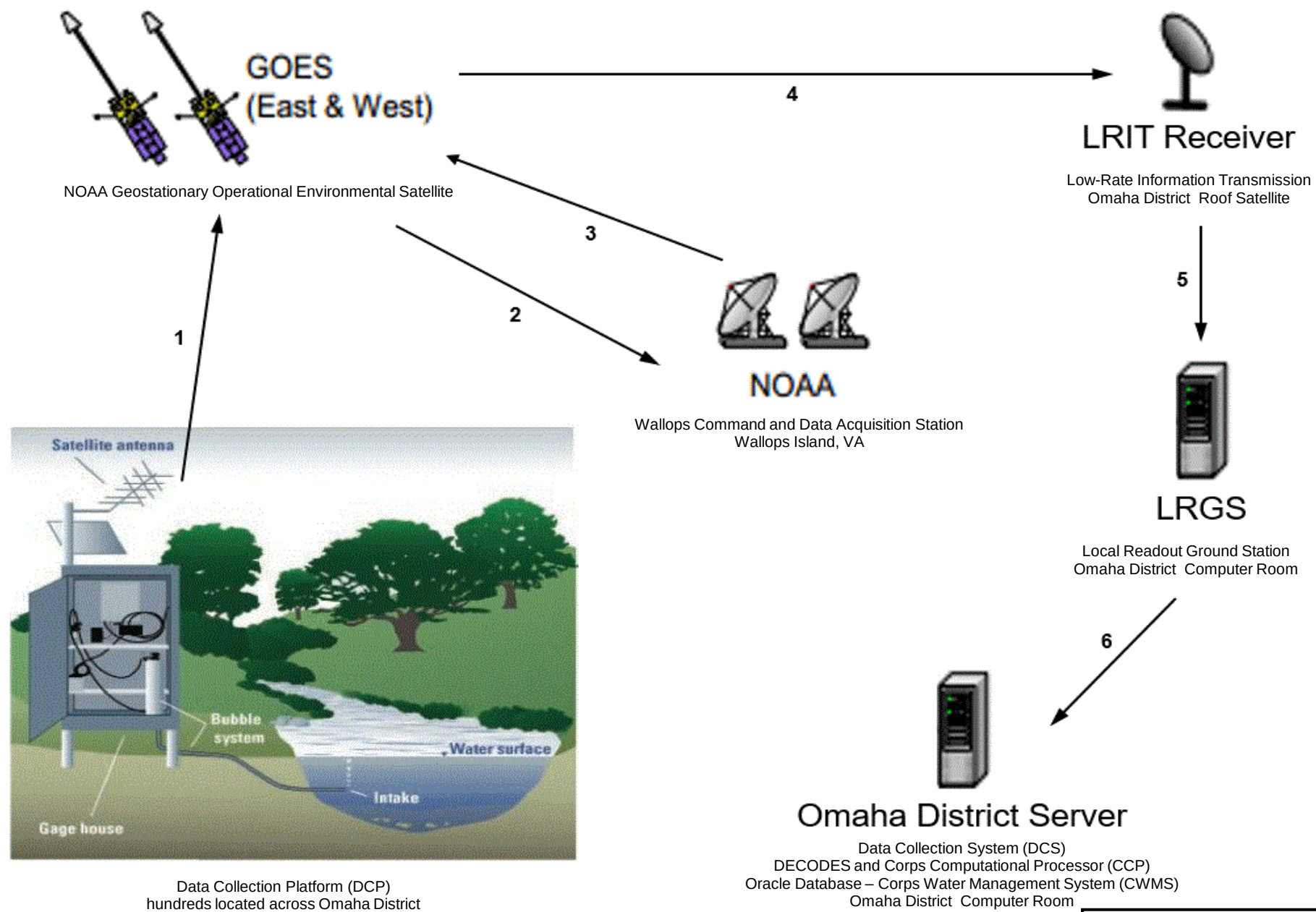
<http://scacis.rcc-acis.org/>

Prepared By: _____ KEH _____
 Reviewed By: _____ KJS _____

Water Control Manual
 Bear Creek Dam and Reservoir, Colorado

Bear Creek Denver Alert & NOAA Precipitation Stations

U.S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 2018



Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Data System Collection Diagram

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Prepared By: _____ KJS _____
Reviewed By: _____ JAB _____

**Monthly Reservoir Operation
Provisional Record**

Bear Creek Dam

Northwestern Division

U.S. Army Corps of Engineers

Omaha District

Date	Midnight Elevation (ft msl)	Estimated Evaporation (cfs)	Mean Daily Outflow (cfs)	Est. Mean Daily Inflow (cfs)
1-May-14	5558.80	0.7	62	61
2-May-14	5558.77	0.4	59	58
3-May-14	5558.74	0.4	56	54
4-May-14	5558.71	0.6	53	52
5-May-14	5558.73	0.6	52	55
6-May-14	5558.71	0.5	54	53
7-May-14	5558.73	0.5	51	53
8-May-14	5558.79	0.6	63	67
9-May-14	5558.68	0.6	59	54
10-May-14	5558.60 -	0.5	44 -	40 -
11-May-14	5559.13	1.0 +	66	96
12-May-14	5558.97	0.9	98	90
13-May-14	5558.79	0.8	78	68
14-May-14	5558.80	0.6	69	70
15-May-14	5559.01	0.5	85	97
16-May-14	5559.17	0.4	105	115
17-May-14	5559.21	0.3	122	125
18-May-14	5559.29	0.4	131	136
19-May-14	5559.35	0.6	142	146
20-May-14	5559.42	0.2	150	154
21-May-14	5559.50	0.2	158	162
22-May-14	5559.57	0.2 -	175	179
23-May-14	5559.62	0.3	187	190
24-May-14	5559.95 +	0.3	199	218
25-May-14	5559.93	0.5	252 +	251 +
26-May-14	5559.79	0.4	236	228
27-May-14	5559.74	0.5	217	215
28-May-14	5559.74	0.8	216	217
29-May-14	5559.76	0.7	219	221
30-May-14	5559.84	0.5	225	230

Total (dsf)	16	3913	3983
Total (ac-ft)	27	7762	7900
Mean	5379.87	0	126

End of Month Storage (ac-ft)	2028	Max Storage (ac-ft)	2040
Change in Storage (ac-ft)	115	Min Storage (ac-ft)	1889

Remarks: 1. Total Reported Monthly Precip (inches) 3.91
 2. Estimated Dam Seepage (cfs/day): 0.0

+ Maximum; - Minimum Pool Elevations are affected by wind MRD 0168

Prepared by _____ Date _____

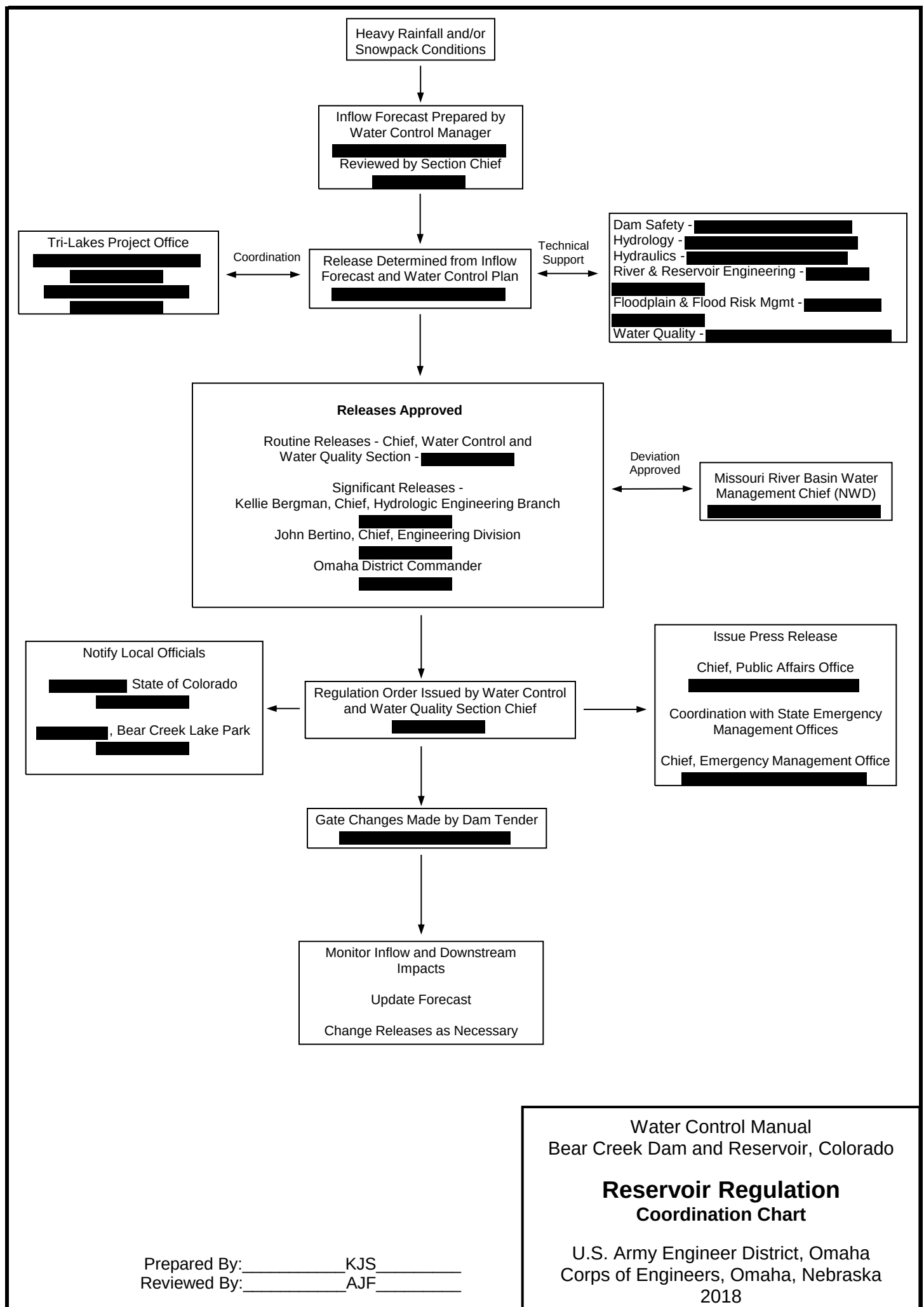
Reviewed by _____ Date _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Monthly Summary Report

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Prepared By: _____ KJS _____
 Reviewed By: _____ AJF _____



Corps of Engineers – Omaha District
 Bear Creek Dam and Lake
 Dam Tender's Reservoir Regulation Report
 Authorized Pool Elevation 5558
 Authorized Storage 1927
 Format Revised July 2012

Week Ending Day/Month/Year
 SOURCE - (1) Colorado State Engineer (2) Corps District Engineer
 MEANS - (1) Telephone (2) Person to Person
 PERSONNEL - Note Issuant and Person
 VERIFICATION OF VERBAL ORDERS ISSUED AND REGULATION BY COLORADO STATE ENGINEER
 My Signature formally confirms the below logged verbal orders for this weekly period.

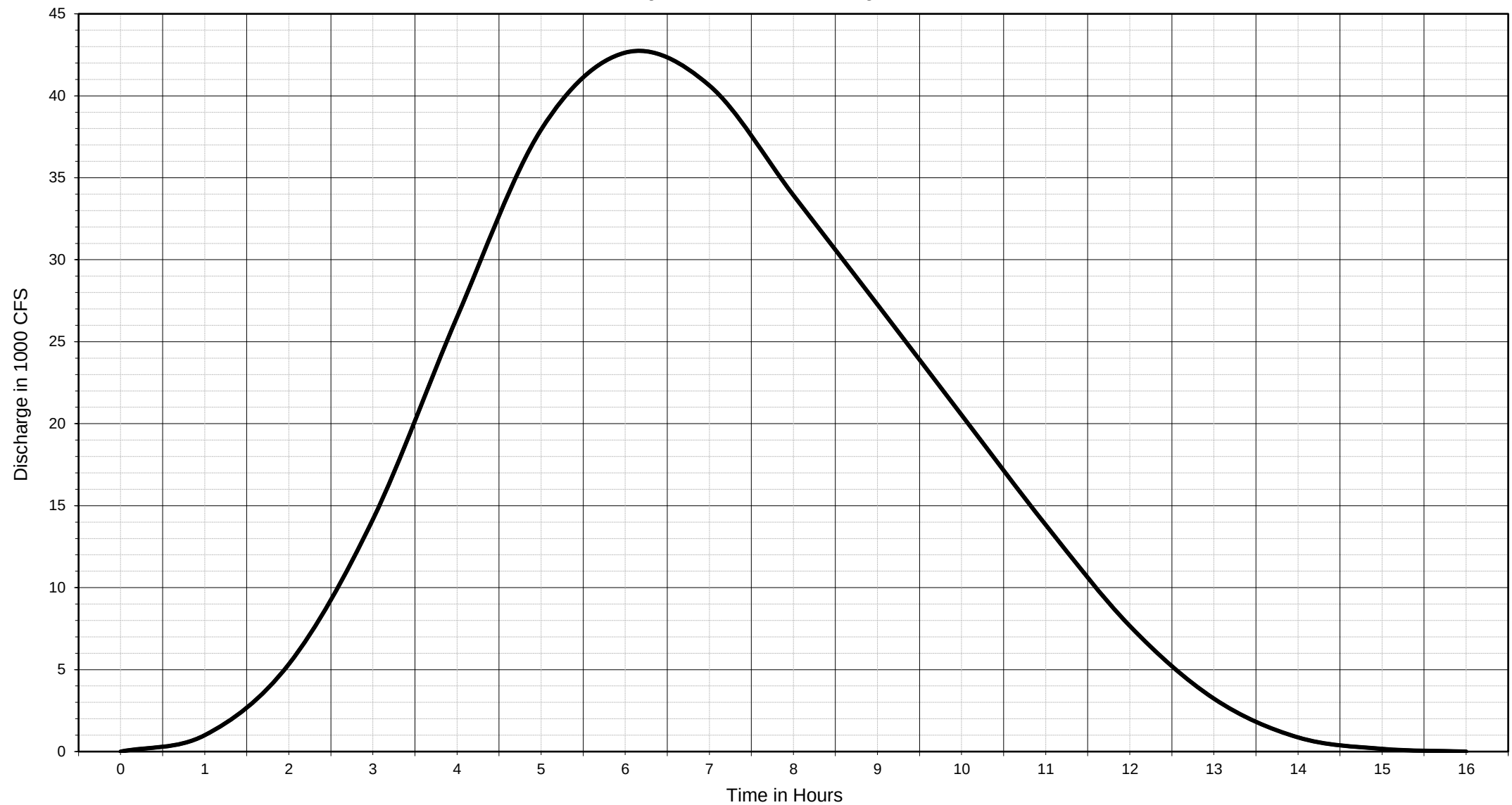
DATE							
Determined By - Flow Rate	0	0	0	0	0	0	0
Time of Flow	00:00 - 24:00	00:00 - 24:00	00:00 - 24:00	00:00 - 24:00	00:00 - 24:00	00:00 - 24:00	00:00 - 24:00
Hours/24 x Flow Rate	24 / 24 x 0	24 / 24 x 0	24 / 24 x 0	24 / 24 x 0	24 / 24 x 0	24 / 24 x 0	24 / 24 x 0
Flow Volume DSF	0	0	0	0	0	0	0
Determined By - Flow Rate							
Time of Flow	0:00 - 00:00	0:00 - 00:00	0:00 - 00:00	0:00 - 00:00	0:00 - 00:00	0:00 - 00:00	0:00 - 00:00
Hours/24 x Flow Rate	0 / 24 x 0	0 / 24 x 0	0 / 24 x 0	0 / 24 x 0	0 / 24 x 0	0 / 24 x 0	0 / 24 x 0
Flow Volume DSF	0	0	0	0	0	0	0
Determined By - Flow Rate							
Time of Flow	00:00 - 00:00	00:00 - 00:00	0:00 - 00:00	00:00 - 00:00	00:00 - 00:00	00:00 - 00:00	00:00 - 00:00
Hours/24 x Flow Rate	0 / 24 x 0	0 / 24 x 0	0 / 24 x 0	0 / 24 x 0	0 / 24 x 0	0 / 24 x 0	0 / 24 x 0
Flow Volume DSF	0	0	0	0	0	0	0
Determined By - Flow Rate							
Time of Flow	00:00 - 00:00	00:00 - 00:00	00:00 - 00:00	00:00 - 00:00	00:00 - 00:00	00:00 - 00:00	00:00 - 24:00
Hours/24 x Flow Rate	0 / 24 x 0	0 / 24 x 0	0 / 24 x 0	0 / 24 x 0	0 / 24 x 0	0 / 24 x 0	24 / 24 x 0
Flow Volume DSF	0	0	0	0	0	0	0
24 Hour Release Volume DSF	0	0	0	0	0	0	0

DATE	TIME	SOURCE	MEANS	PERSONNEL	ORDER - INCLUDE GATE SETTING

Water Control Manual
 Bear Creek Dam and Reservoir, Colorado
**Dam Tender's Reservoir
 Regulation Report**
 U.S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 2018

Prepared By: KJS
 Reviewed By: AJF

**3 - Hour Unit Hydrograph
Cherry Creek below Cherry Creek Dam**



Drainage Area = 386 Sq. Mi.

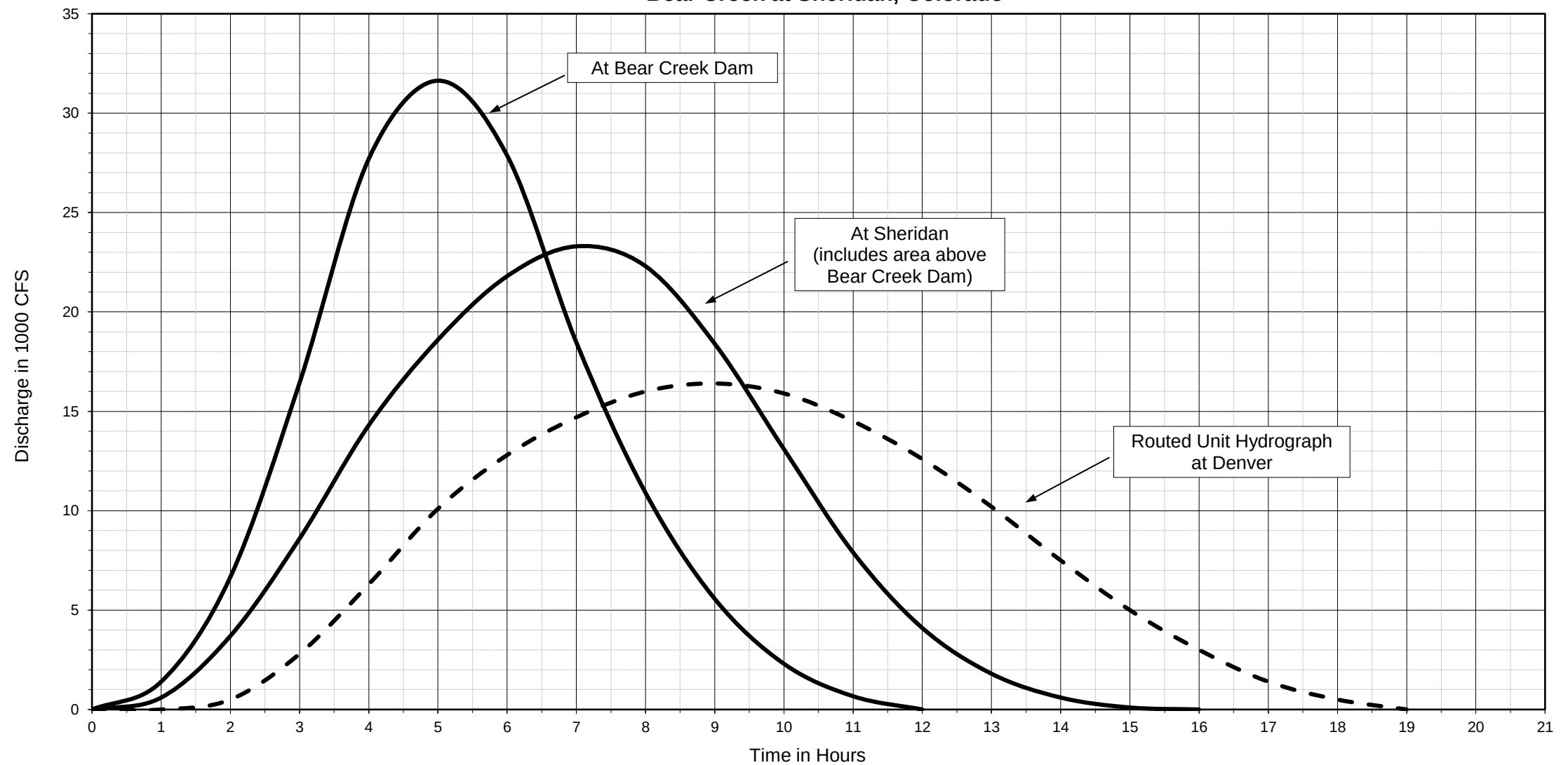
Prepared By: _____ KJS _____
Reviewed By: _____ AJF _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

**3-Hour Unit Hydrograph
Cherry Creek below Cherry Creek Dam**

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

3 - Hour Unit Hydrograph Bear Creek at Sheridan, Colorado



Drainage Area = 260 Sq. Mi.

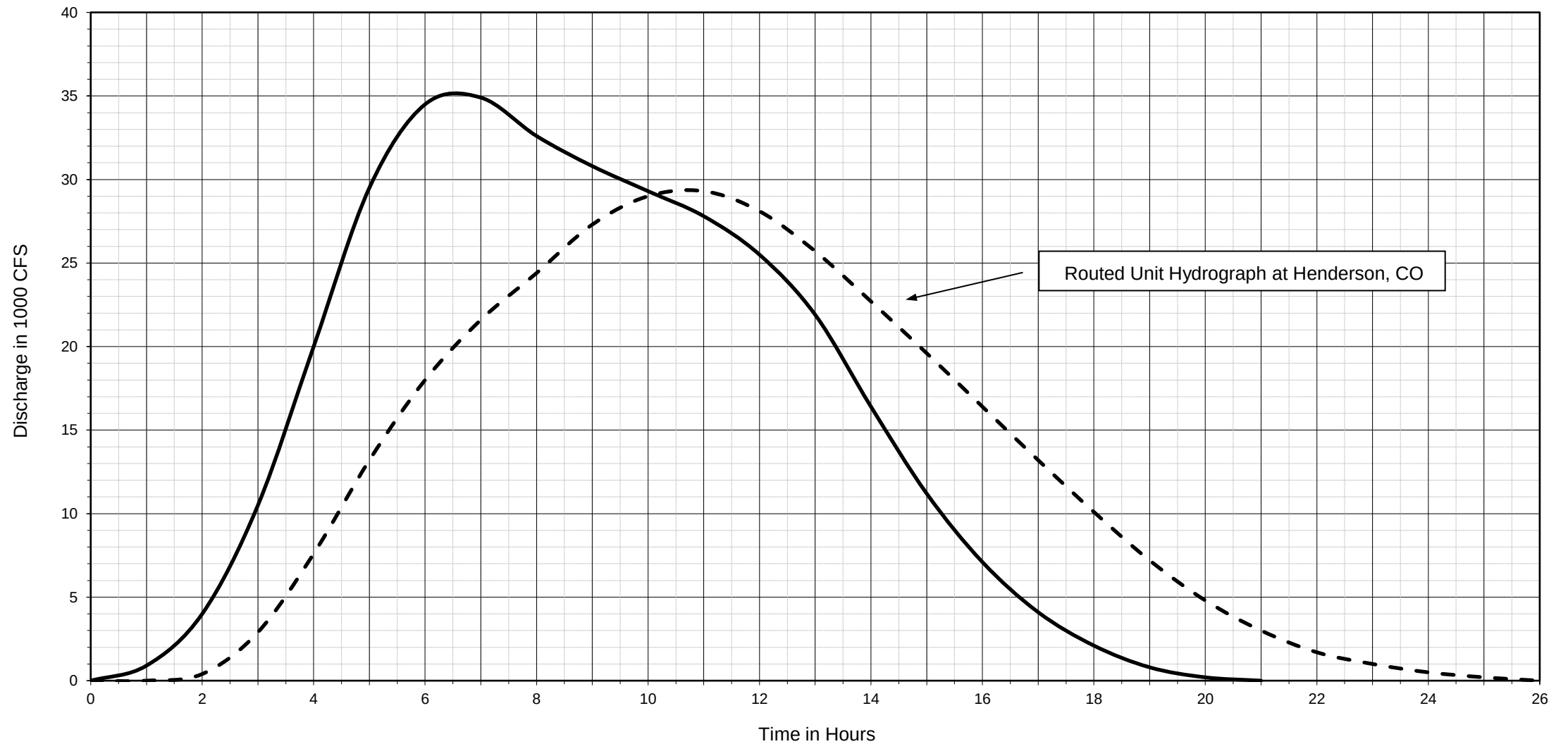
Water Control Manual
Bear Creek Dam and Reservoir, Colorado

3-Hour Unit Hydrograph Bear Creek at Sheridan, CO

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Prepared By: _____ KJS _____
Reviewed By: _____ AJF _____

3 - Hour Unit Hydrograph Clear Creek at Derby, Colorado



Drainage Area = 575 Sq. Mi.

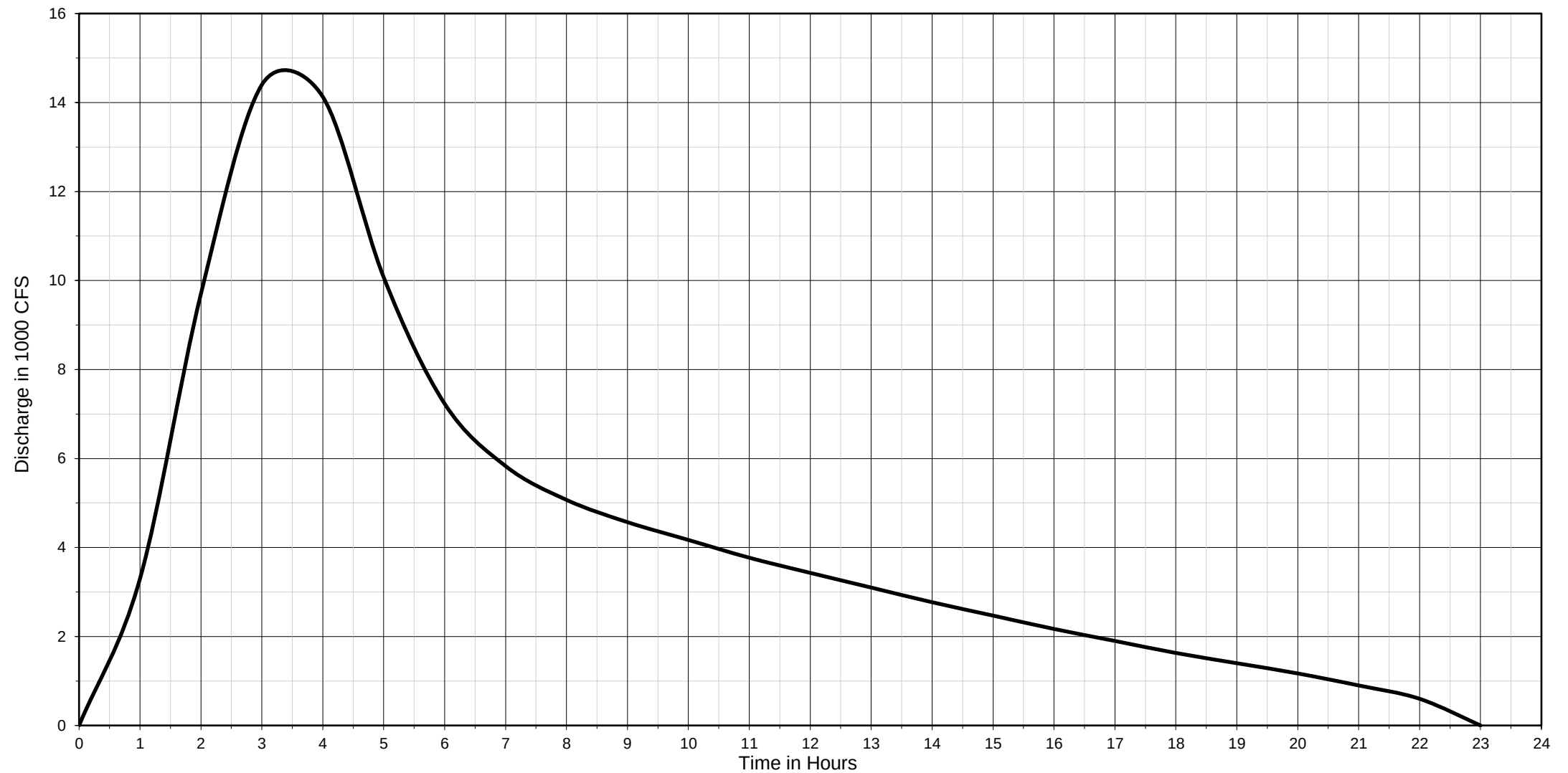
Water Control Manual
Bear Creek Dam and Reservoir, Colorado

3-Hour Unit Hydrograph Clear Creek at Derby, CO

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Prepared By: _____ KJS _____
Reviewed By: _____ AJF _____

3 - Hour Unit Hydrograph
South Platte River Incremental Area above Denver, Colorado



Drainage Area = 165 Sq. Mi.

Prepared By: _____ KJS _____
Reviewed By: _____ AJF _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

3-Hour Unit Hydrograph
South Platte River, Incremental above Denver, CO

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

3-Hour Unit Graphs (CFS) South Platte Basin

Hrs.	1	2	3A	3B	4	5	6	7A	7B	8	9	10	11	12	13	14	15	16	17
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1330	1000	833	500	333	1167	633	1100	1333	4083	1133	500	267	433	300	633	1400	3300	1000
2	9667	5833	6667	3933	2967	6333	4633	6767	7633	12250	5233	1633	833	1300	900	1867	6667	9700	5333
3	20833	14500	13433	7333	5400	15500	10333	16966	1876	19183	14166	6733	1667	4267	3400	7467	16433	14400	14167
4	25833	21000	16566	8833	6467	25566	12966	25400	2926	18200	26766	16833	4800	10700	8000	18000	27700	14130	26500
5	21166	20433	12933	6450	4600	27566	10800	27133	3046	11200	34833	28800	10233	20633	12900	29000	31633	10070	37933
6	11916	14100	7166	3450	2400	23200	6000	22500	2390	4533	34333	33700	17900	26666	14800	32400	27867	7230	42633
7	6350	7833	3500	1516	1000	15133	3100	16966	1473	1433	26366	30933	21866	27133	13200	27766	18467	5830	40633
8	2800	4217	1300	467	233	10083	1366	12333	8900	267	18333	23933	22133	22166	10100	20166	10900	5070	33933
9	883	2117	300	67	0	6583	467	8600	5567	0	13066	18533	18860	17666	7366	14433	5567	4570	27267
10	117	883	0	0		4250	100	5667	3733		9800	14200	15766	13733	5300	10166	2300	4170	20533
11	0	233				2600	0	3500	2600		7533	10800	12900	10333	3800	7100	667	3770	13833
12		0				1517		2000	1667		5666	8200	10300	7500	2733	5000	0	3430	7667
13						750		1100	933		4000	6166	8067	5233	1866	3633		3100	3233
14						283		500	400		2700	4466	6167	4300	1100	2766		2770	867
15						67		167	100		1733	3100	4667	2933	500	2033		2470	167
16						0		0	0		1067	1933	3500	1967	133	1333		2170	0
17											567	1000	2633	1200	0	700		1900	
18											233	367	1900	616		267		1630	
19											67	67	1300	217		67		1400	
20											0	0	800	50		0		1170	
21													433	0				900	
22													167					600	
23													33					0	
													0						
Total acre-ft	8530	7790	5390	2880	2080	11840	4370	12800	12750	6130	17280	17760	13970	14670	7250	15470	12590	8800	20530

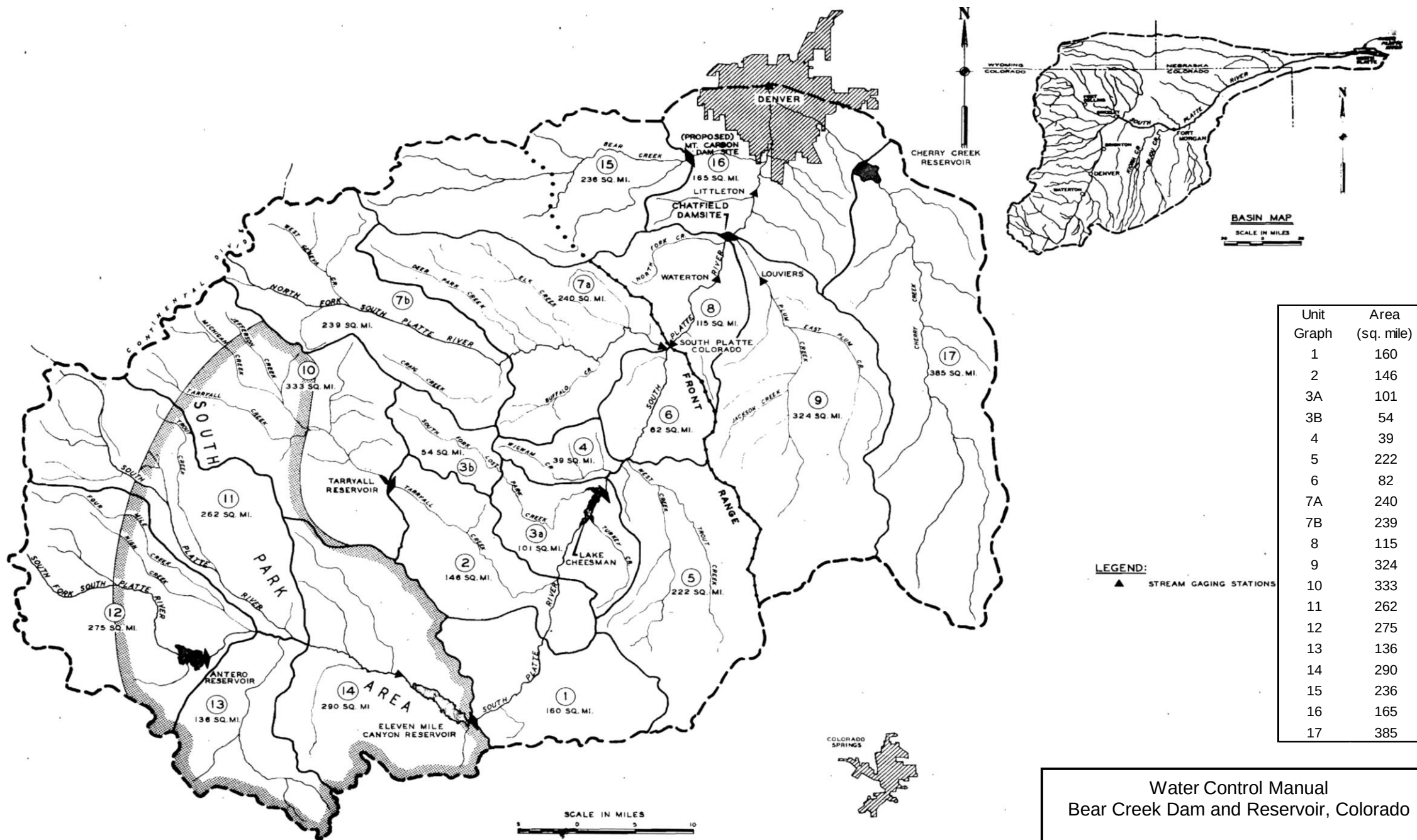
NOTE: Sub-basin delineations and drainage area by unit graph number are available on Plate 6-5b.

Prepared By: _____ JWS _____
Reviewed By: _____ KJS _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

3-Hour Unit Hydrograph Upstream of Tri-Lake Dams

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

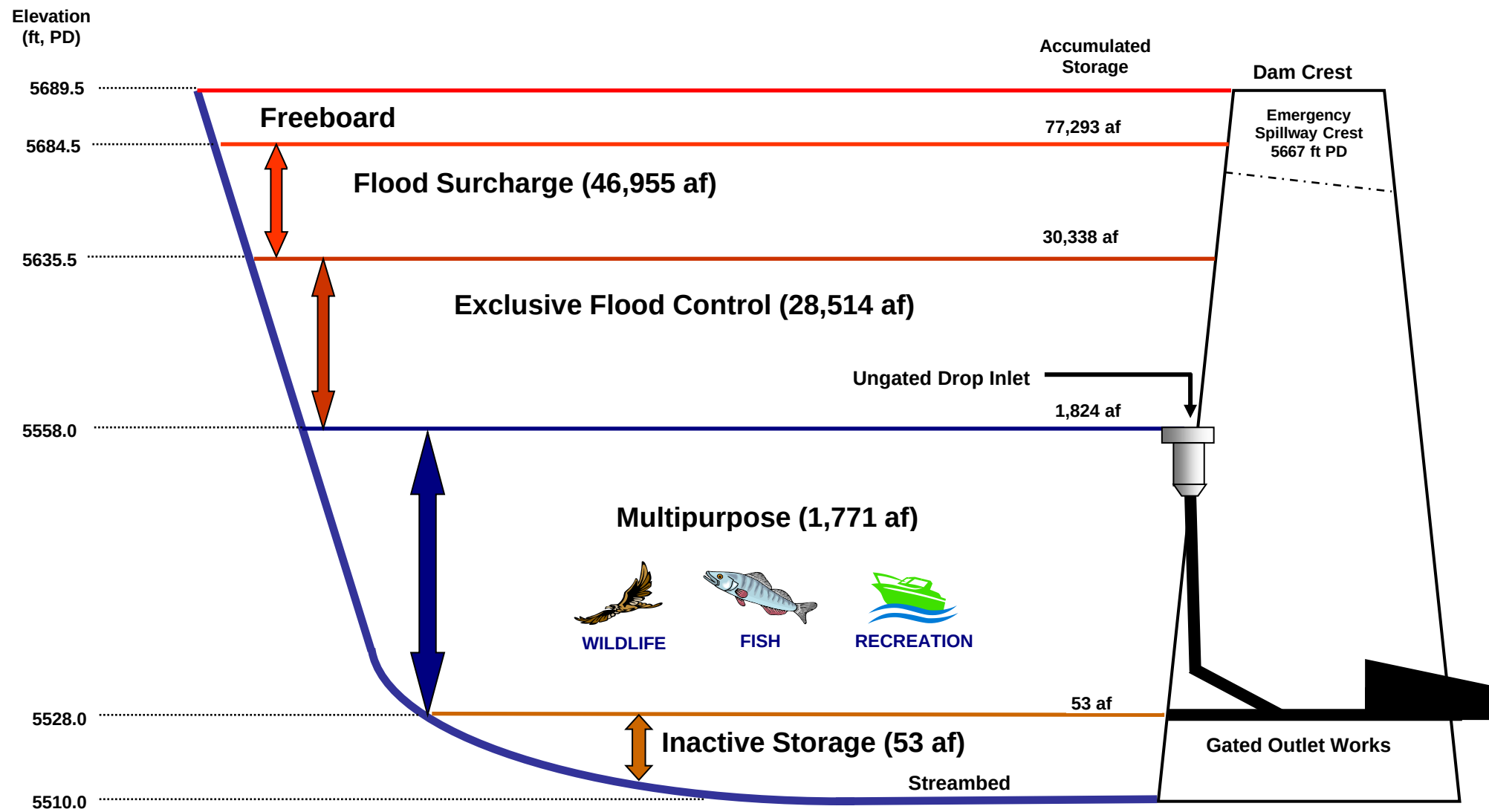


Prepared By: _____ KJS _____
 Reviewed By: _____ AJF _____

Water Control Manual
 Bear Creek Dam and Reservoir, Colorado

3-Hour Unit Hydrograph Subbasin Delineation

U.S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 2018



2009 Survey. Effective 12 March 2010.

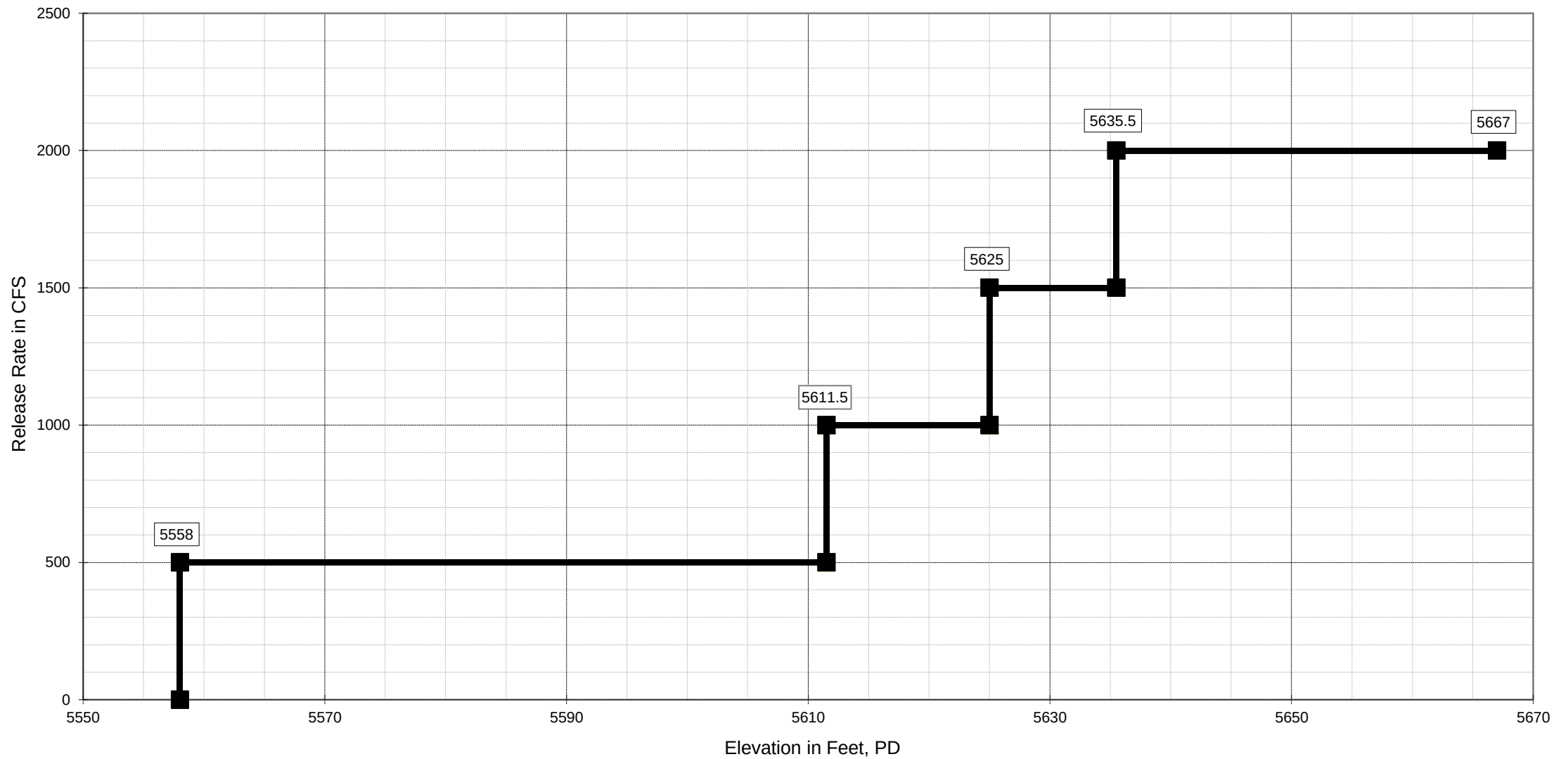
Prepared By: _____ KJS _____
Reviewed By: _____ AJF _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Bear Creek Reservoir Storage Allocations

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Bear Creek Dam and Reservoir Rule Curve for Flood Control Operation



Note:
Releases to be made following cessation of downstream flooding and stabilization of stream flows.

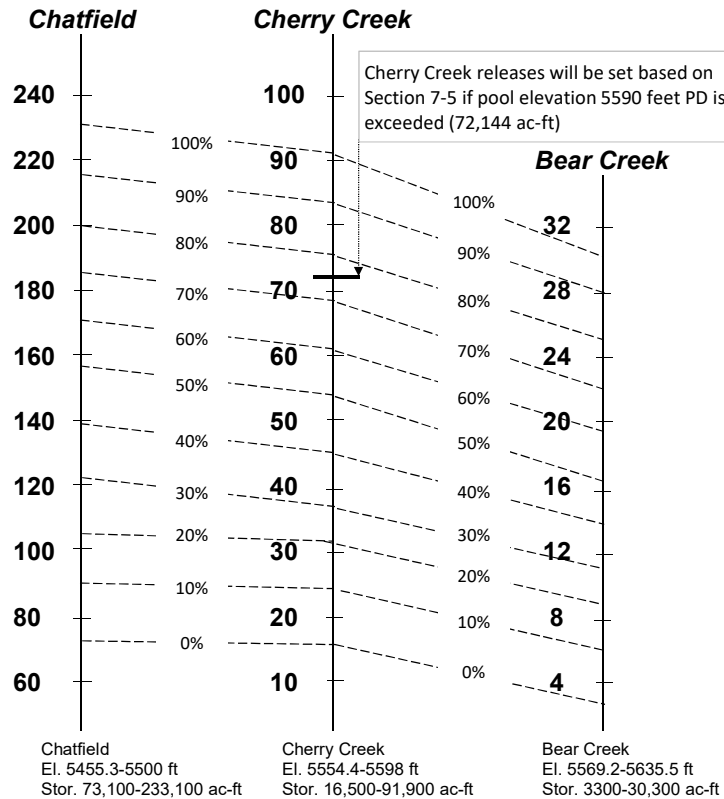
Prepared By: _____ KJS _____
Reviewed By: _____ AJF _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Rule Curve for Flood Control Operation

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

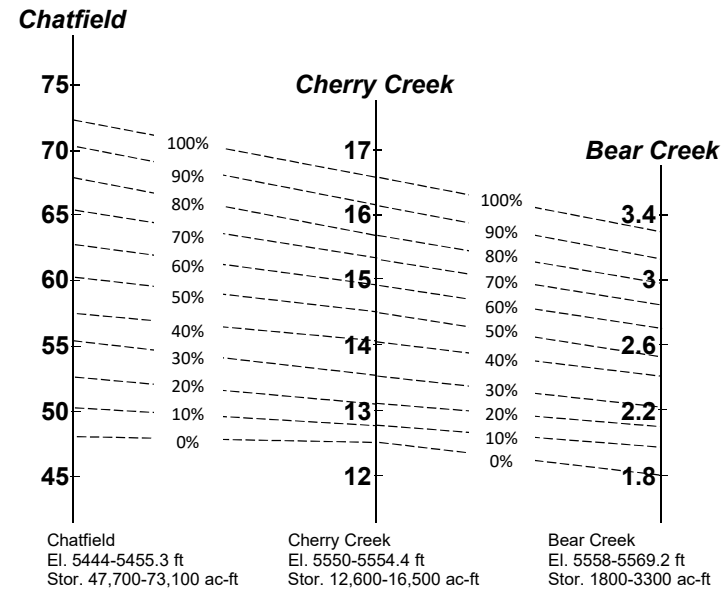
LEVEL II



NOTES:

- 1) For Chatfield Level II storage approximates the volume of the rainfall Standard Project Flood (160,000 ac-ft). The remaining flood control storage space is assigned to Level I.
- 2) For Cherry Creek and Bear Creek Level I is 5 percent of the total flood storage with the remaining flood control storage

LEVEL I

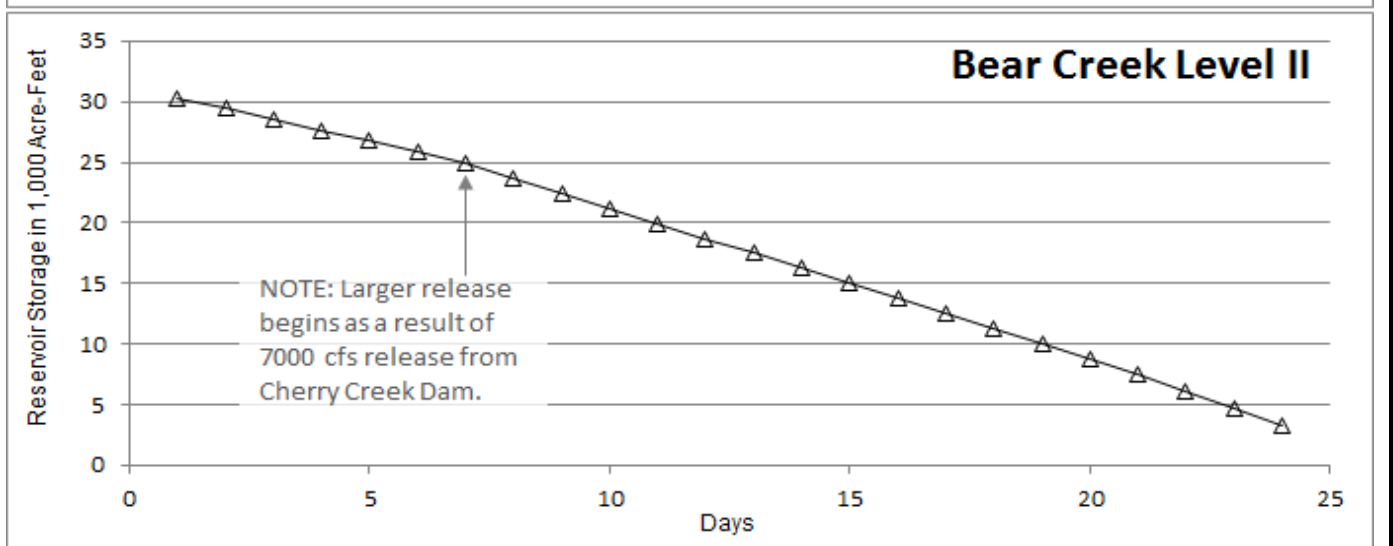
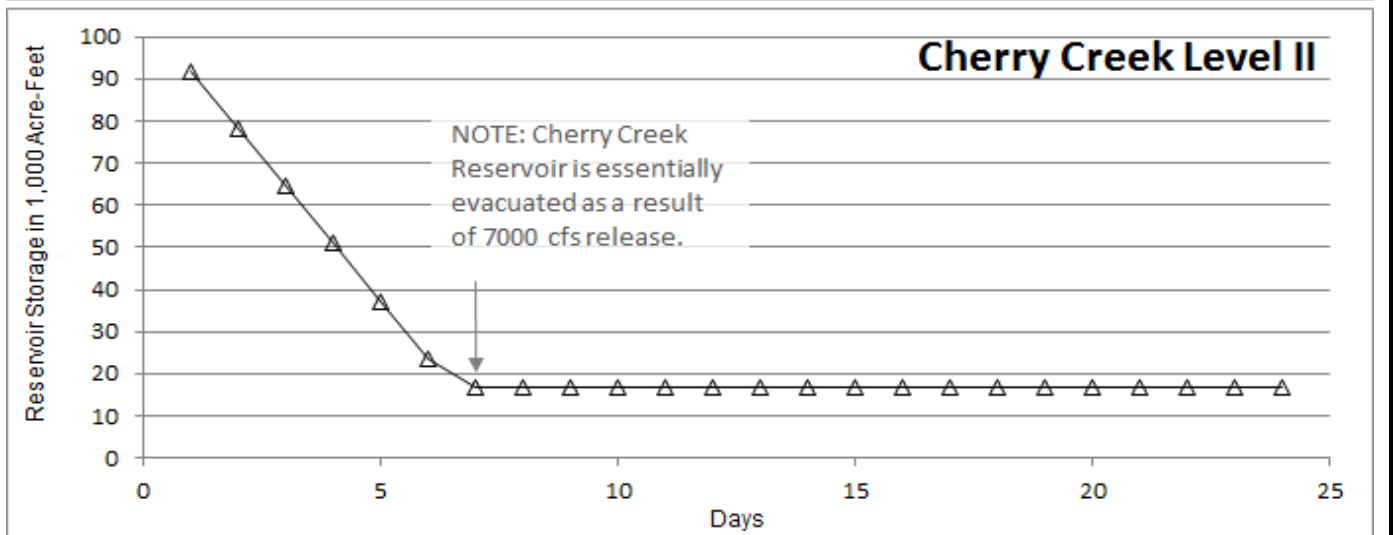
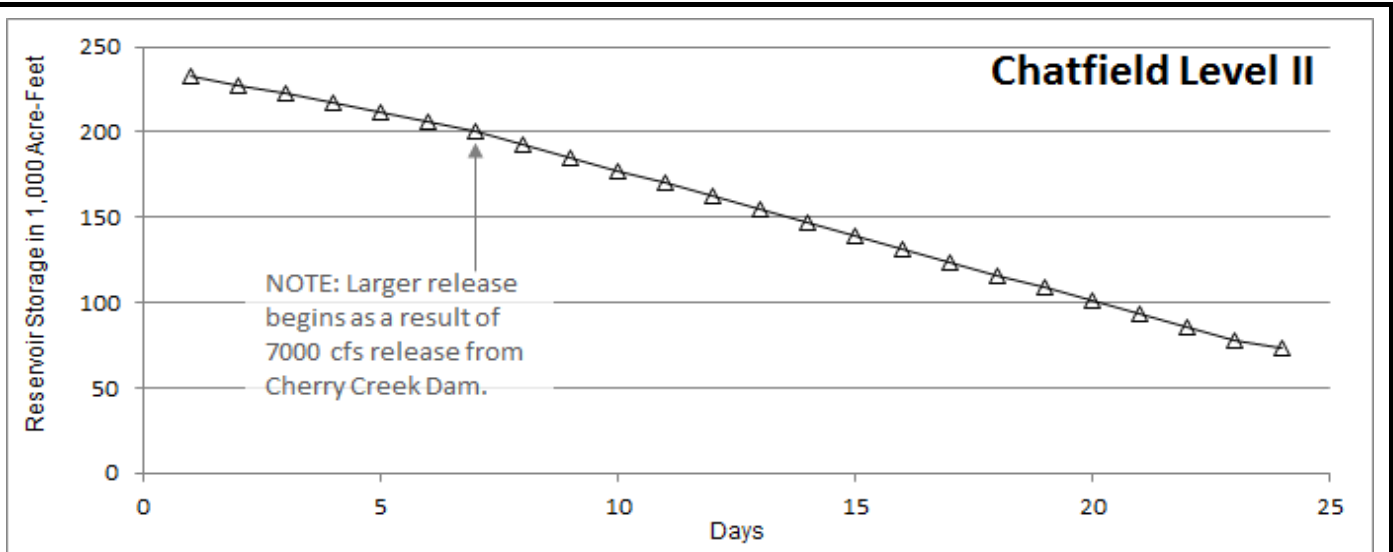


Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Parallel Reservoir Balance

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2020

Prepared By: _____ KJS
Reviewed By: _____ MJN



Notes:

1. System reservoir inflow assumed to be 400 cfs.
2. Uncontrolled drainage assumed to be 100 cfs.
3. Chatfield, Bear Creek and Cherry Creek Accounting are regulated for 5,000 cfs at the South Platte River at Denver streamgage.
4. Actual Cherry Creek release is 7000 cfs when the reservoir reaches elevation 5590 ft.

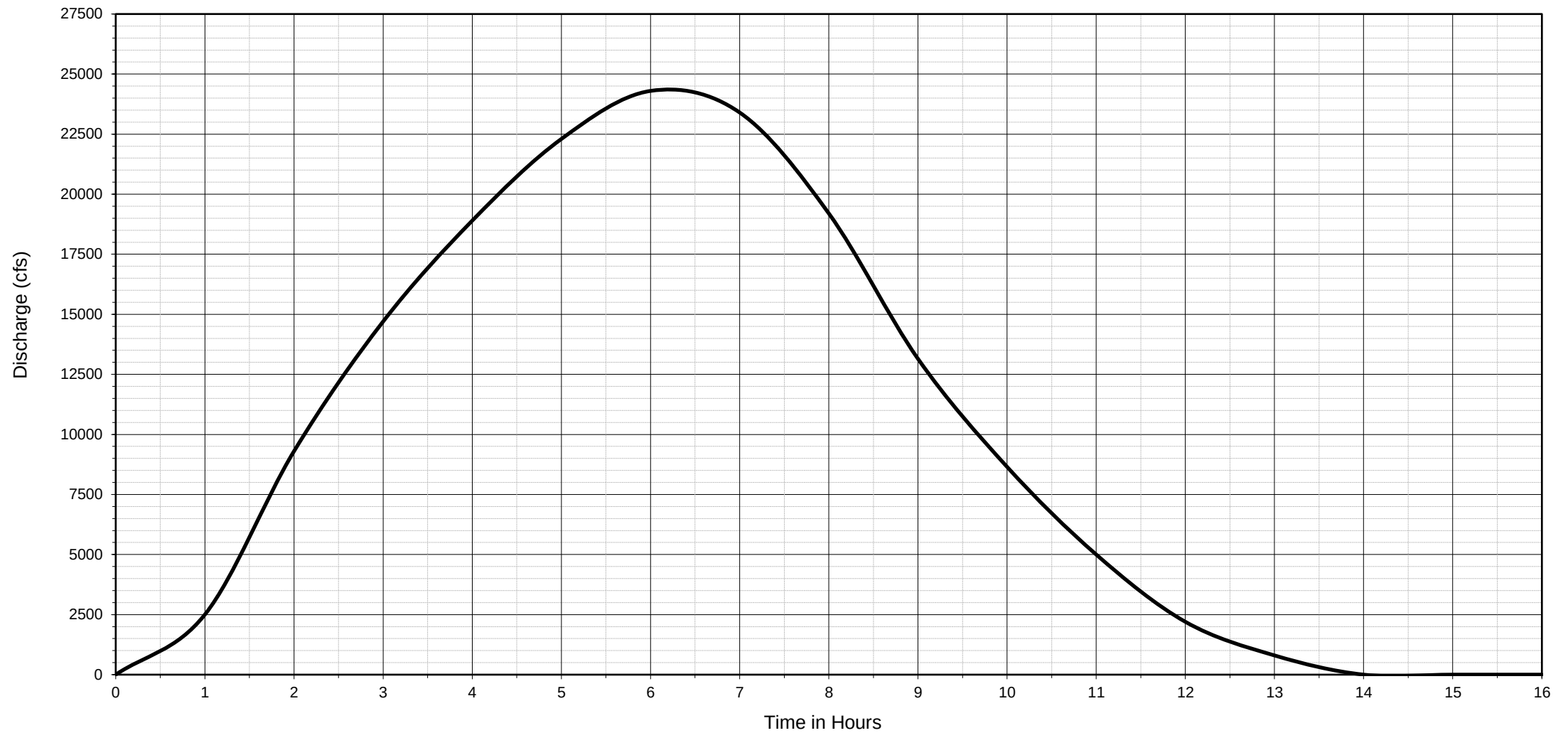
Prepared By: _____ KJS
 Reviewed By: _____ AJF

Water Control Manual
 Bear Creek Dam and Reservoir, Colorado

System Flood Control Storage Evacuation Example (Level II)

U.S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 2018

1-Hour Unit Hydrograph
Bear Creek at Sheridan, Colorado



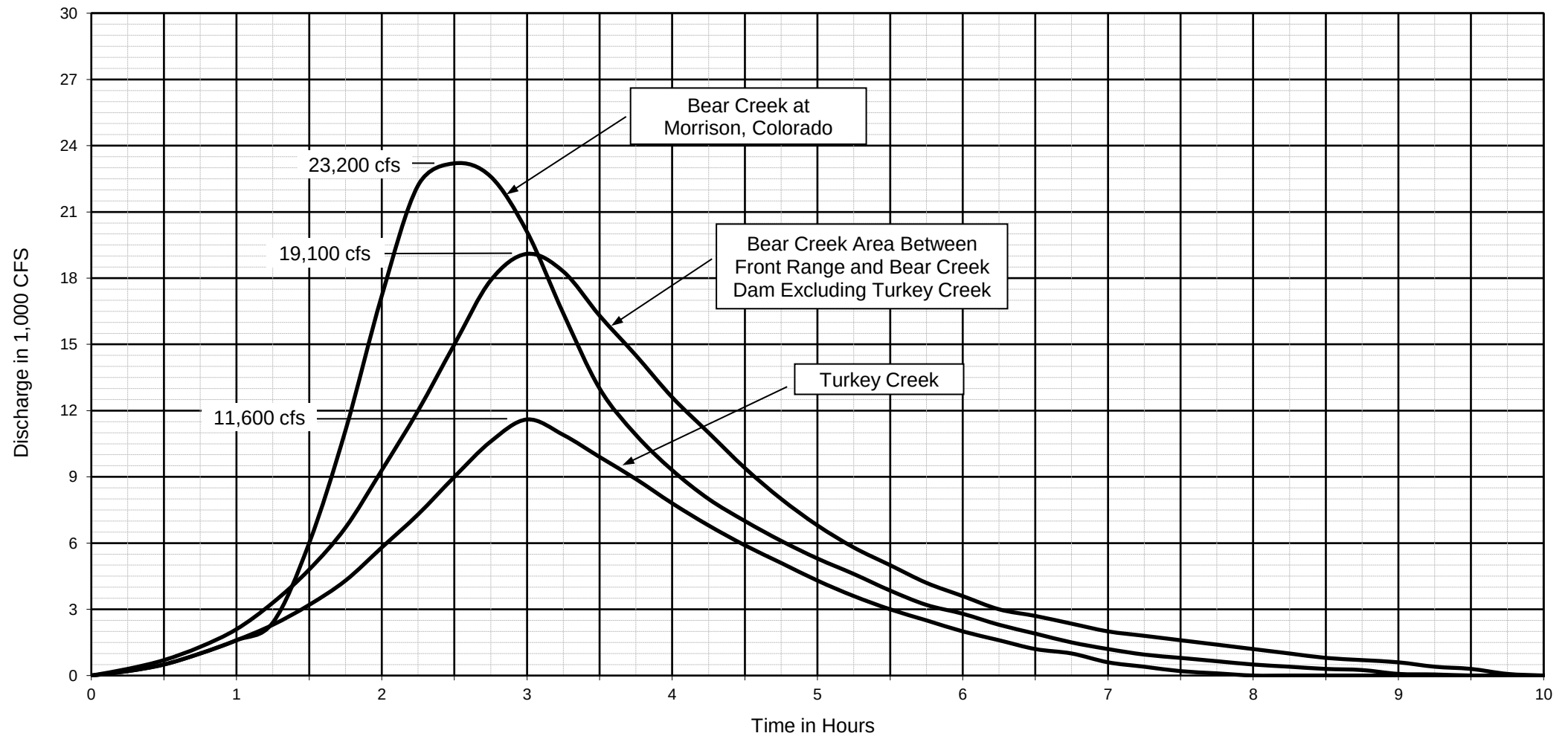
Water Control Manual
Bear Creek Dam and Reservoir, Colorado

1-Hour Unit Hydrograph
Bear Creek at Sheridan, Colorado

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Prepared By: _____ KJS _____
Reviewed By: _____ AJF _____

1-Hour Unit Hydrographs upstream of Bear Creek Dam

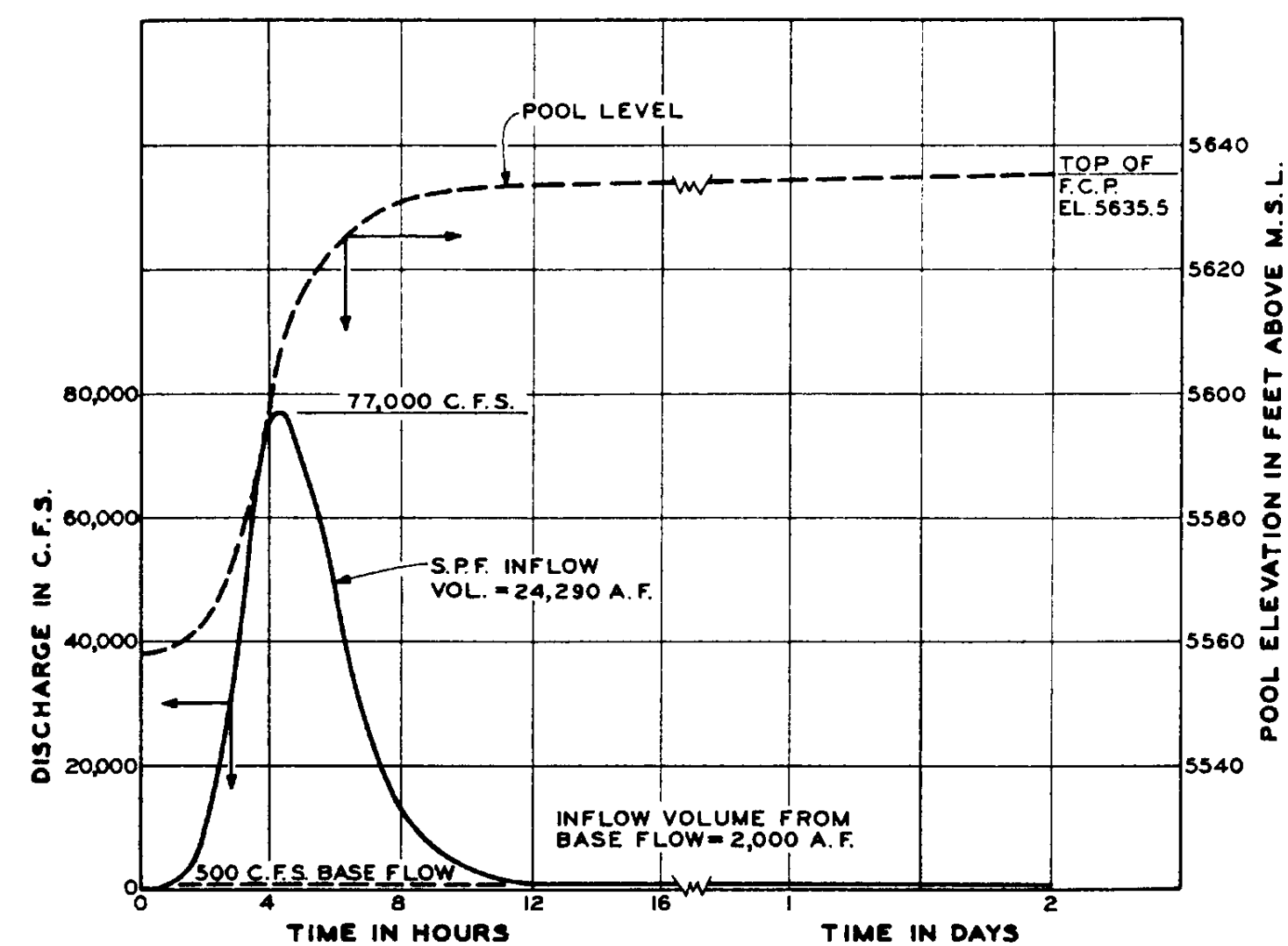


Water Control Manual
Bear Creek Dam and Reservoir, Colorado

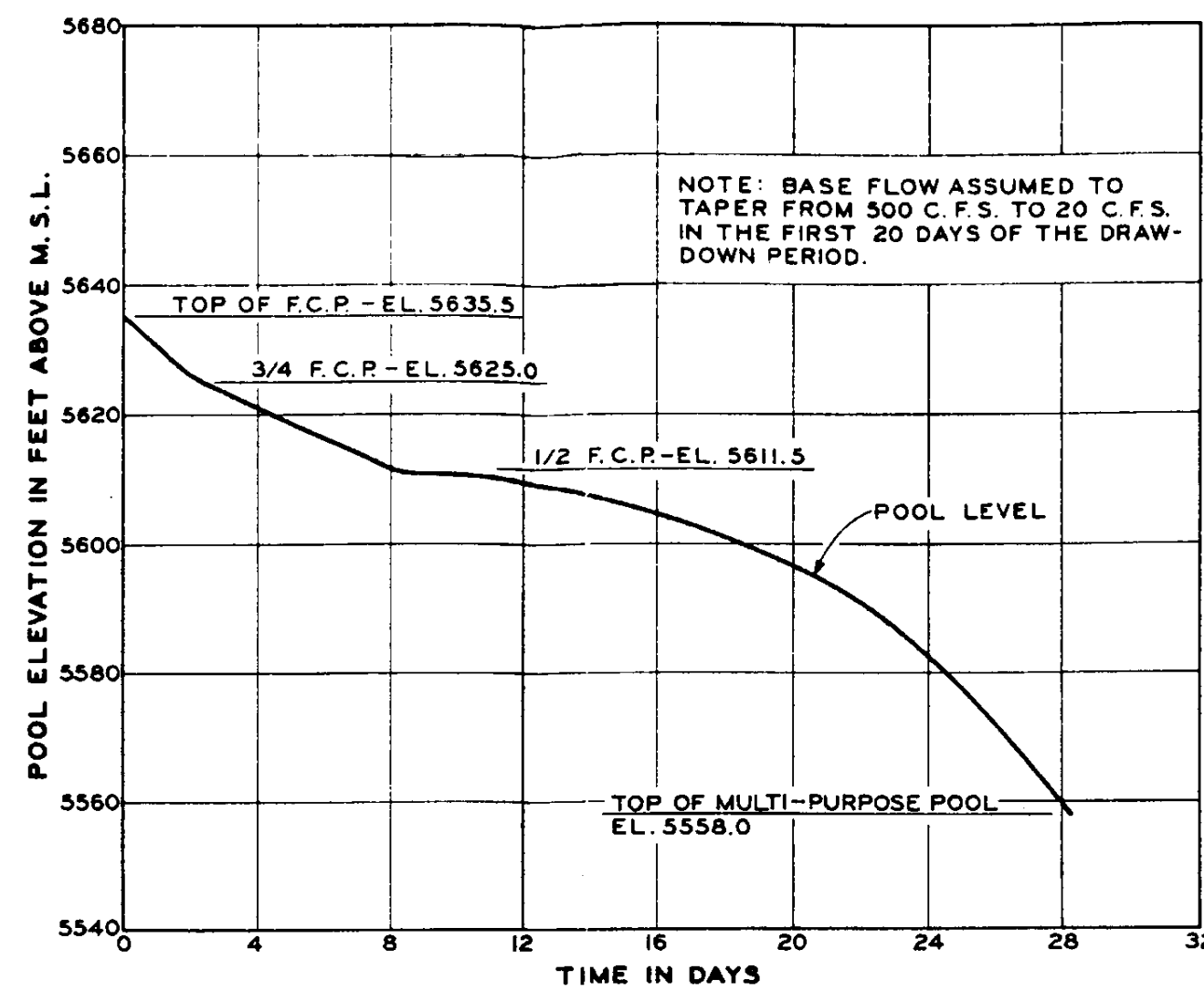
1-Hour Unit Hydrographs upstream of Bear Creek Dam

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

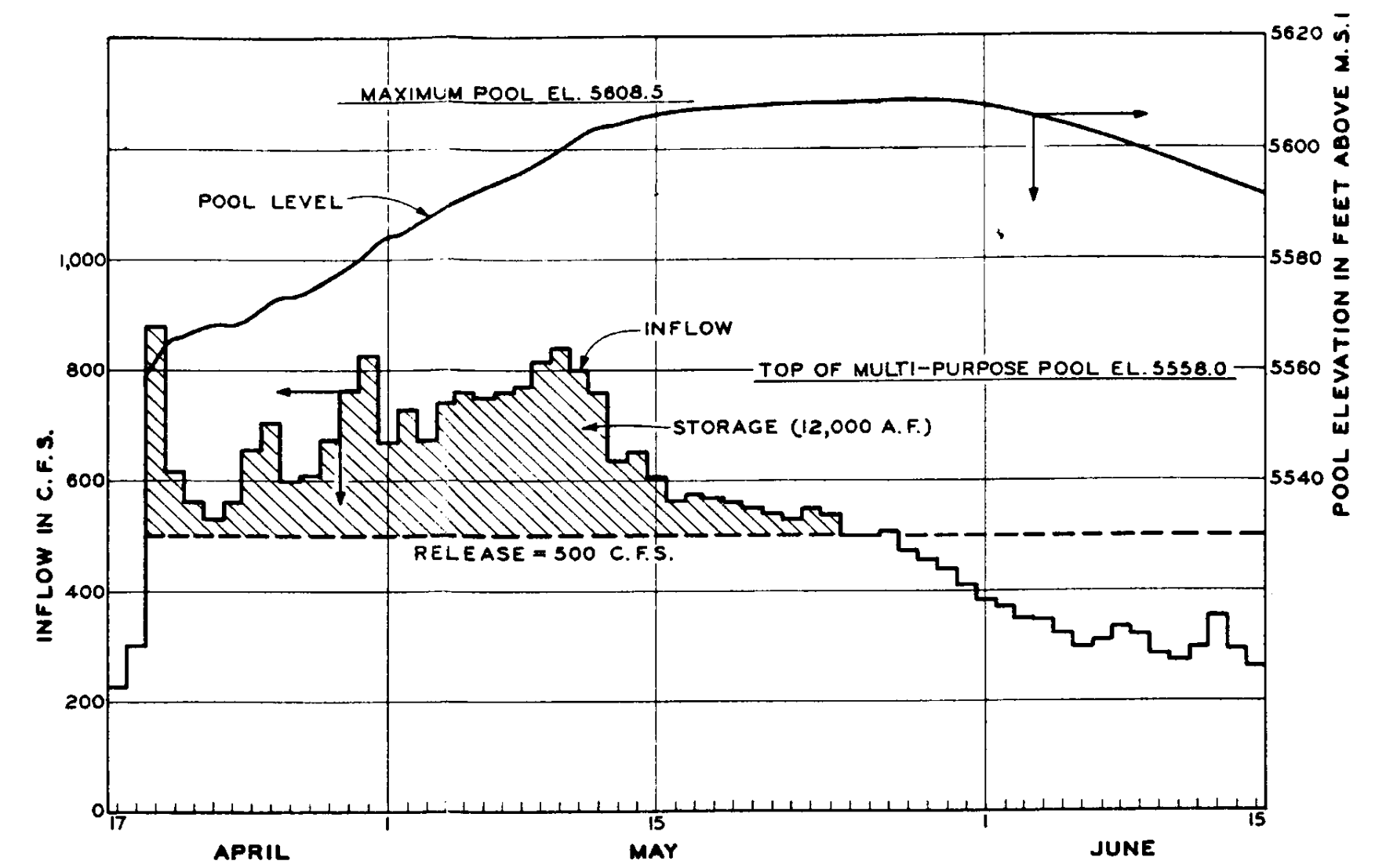
Prepared By: _____ KJS _____
Reviewed By: _____ AJF _____



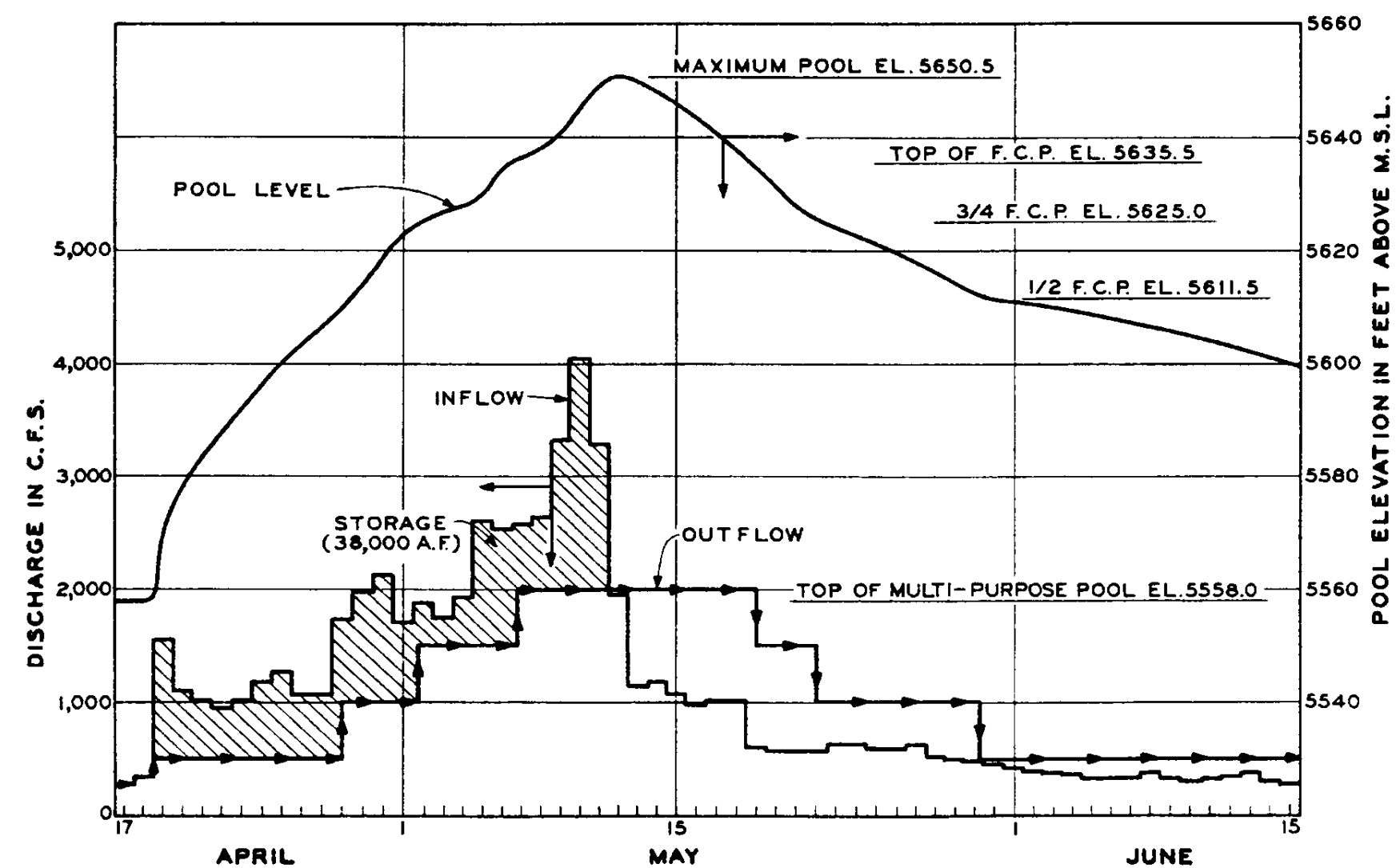
RESERVOIR DESIGN FLOOD
or **STANDARD PROJECT FLOOD**



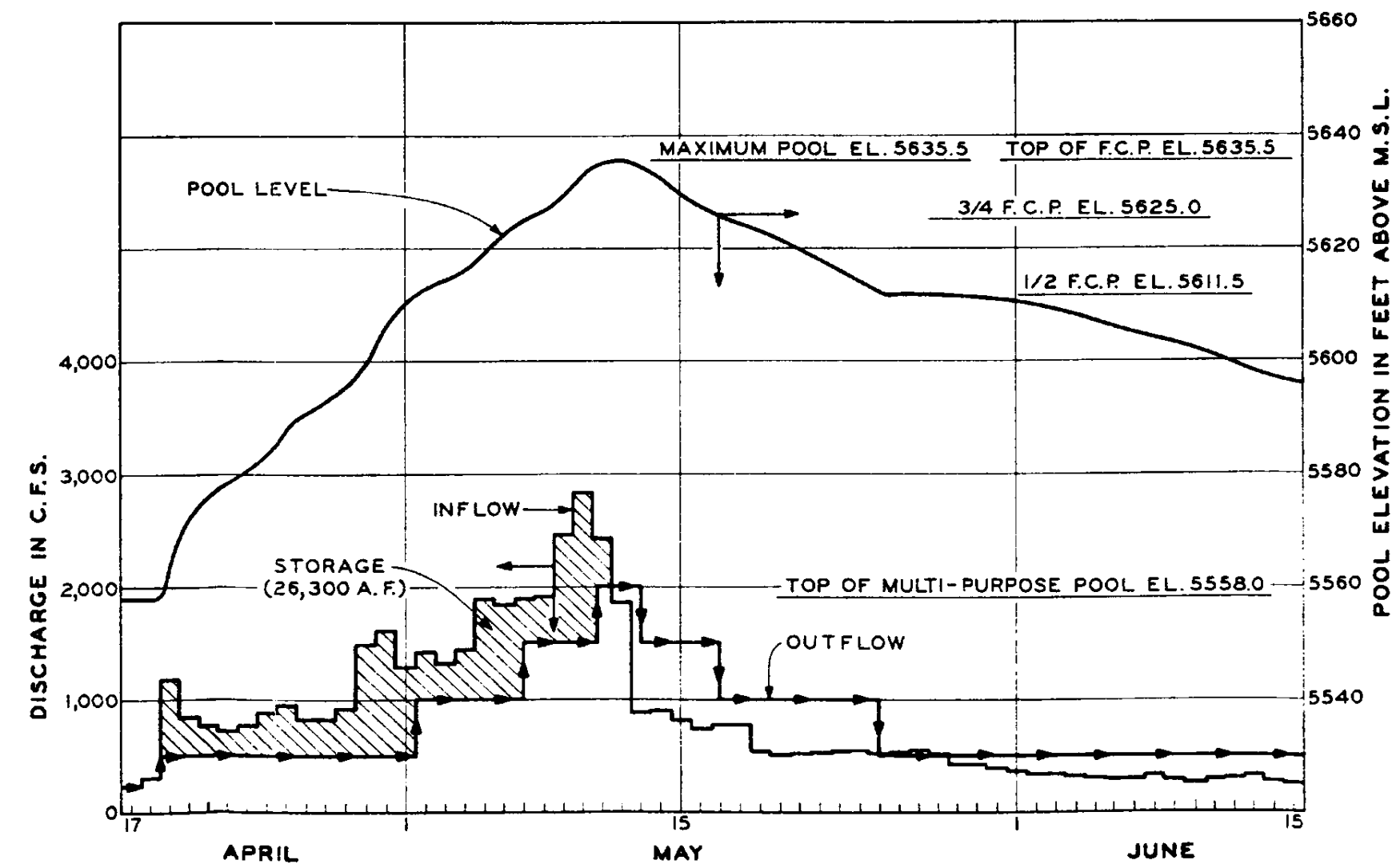
FLOOD CONTROL POOL EVACUATION



1942 SPRING FLOOD



1,000-YEAR SPRING FLOOD



300-YEAR SPRING FLOOD

NOTE:
1,000-year and 300-year spring flood inflow hydrographs were developed from the volume probability curves shown on Plate 3-3 by using the 1942 spring flood hydrograph to define the flow pattern.

Source: 1972 Bear Creek Design Memo No. PB-6
Plate 3-2

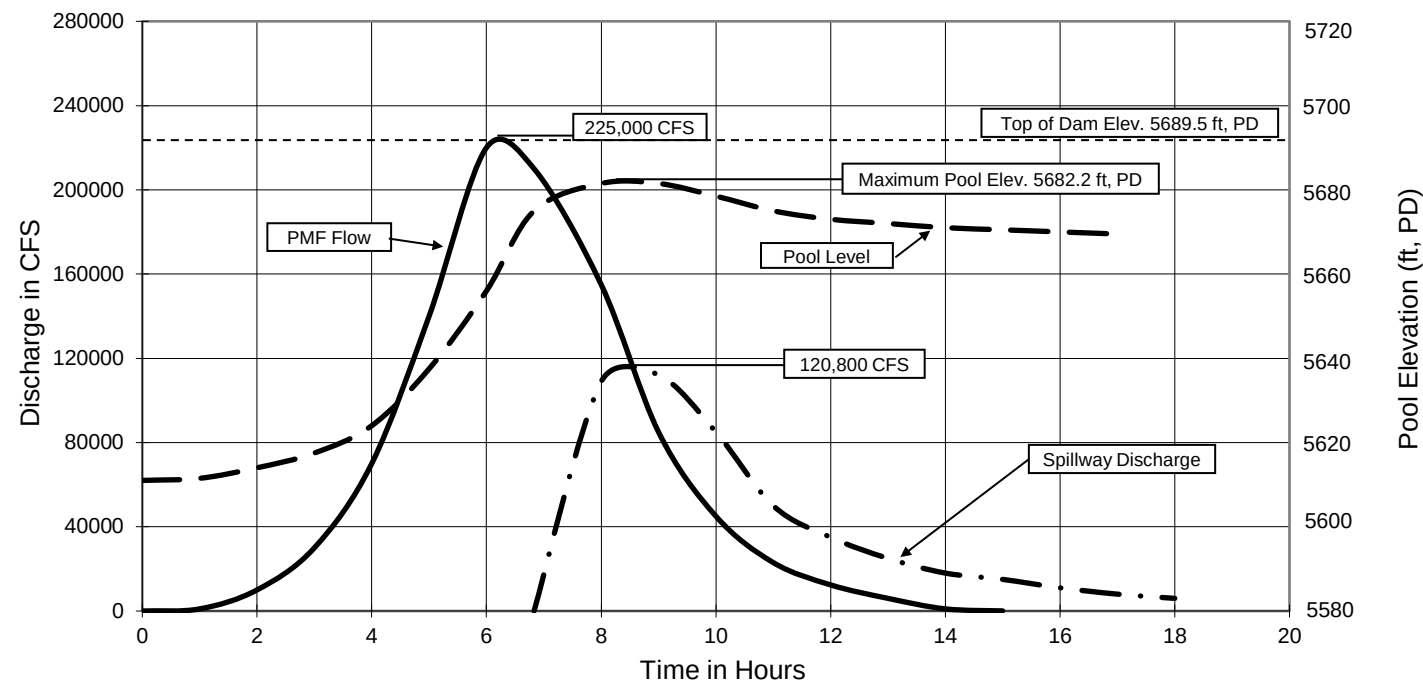
Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Reservoir Operation for Selected Floods

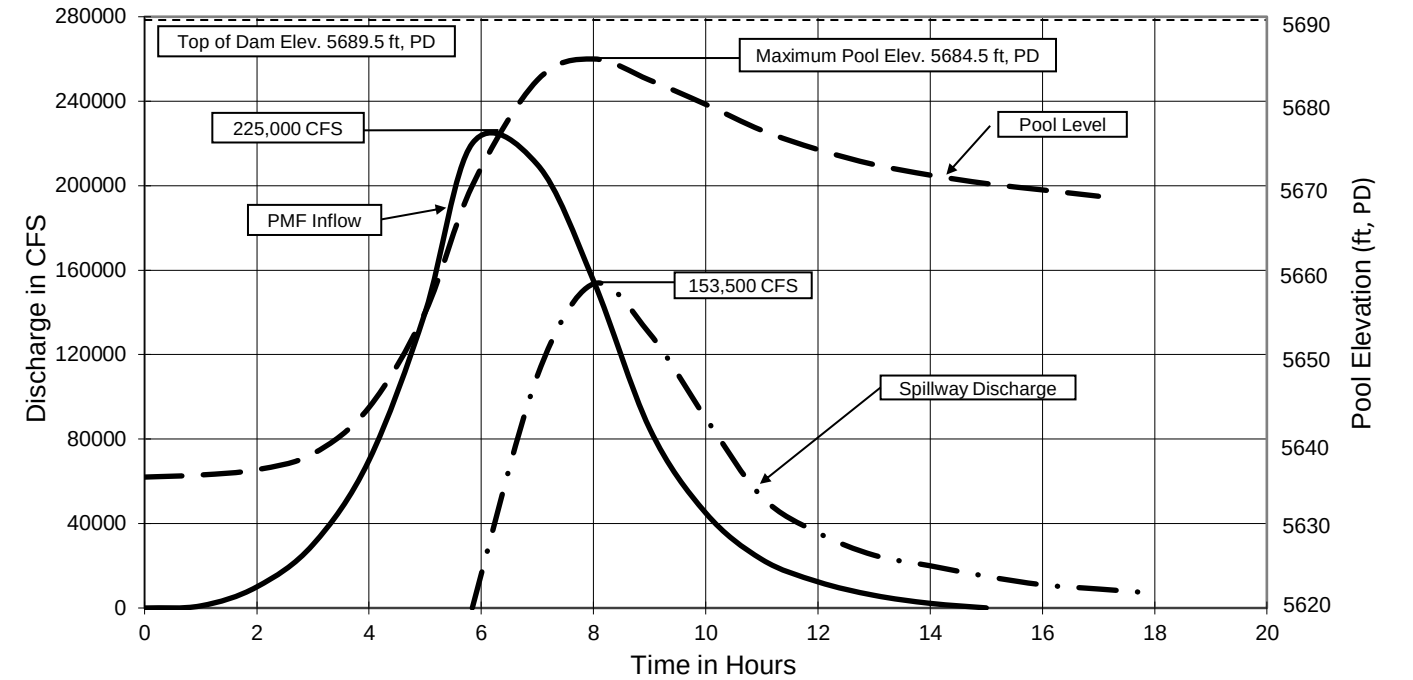
U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Prepared By: _____ KJS _____
Reviewed By: _____ AJF _____

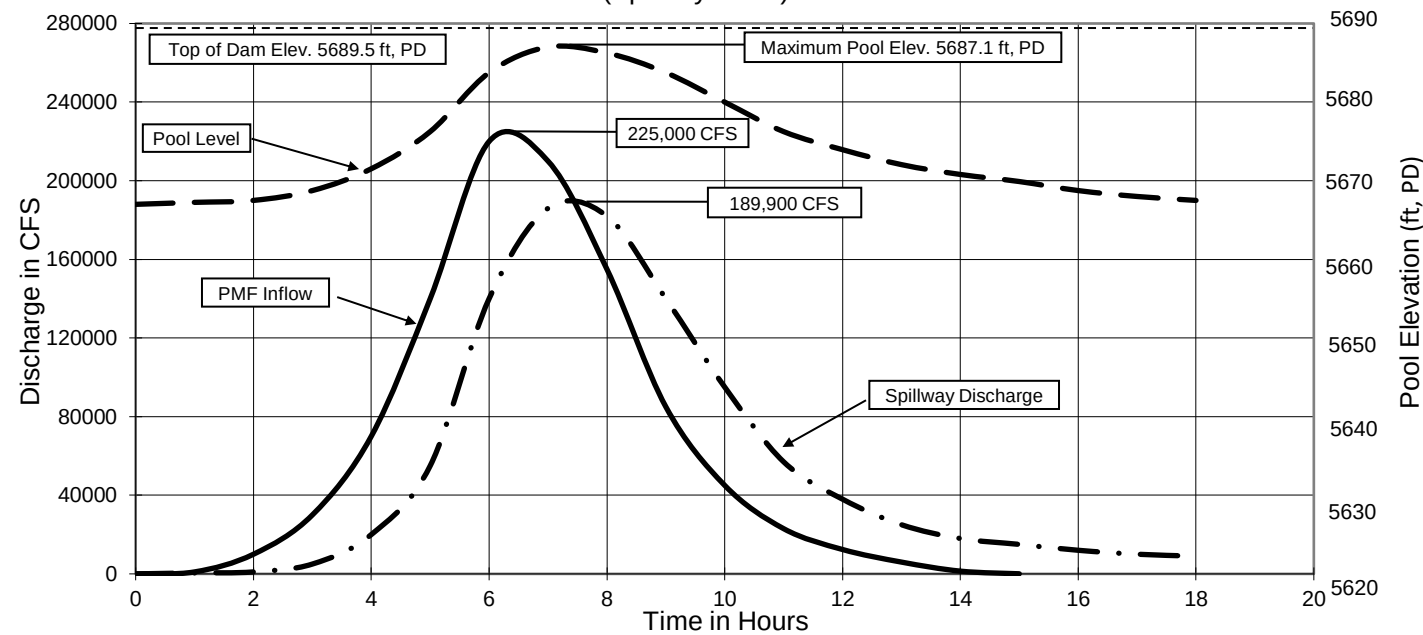
Beginning Pool Elevation - 5611.5 ft, PD
(Half - Full Flood Control Pool)



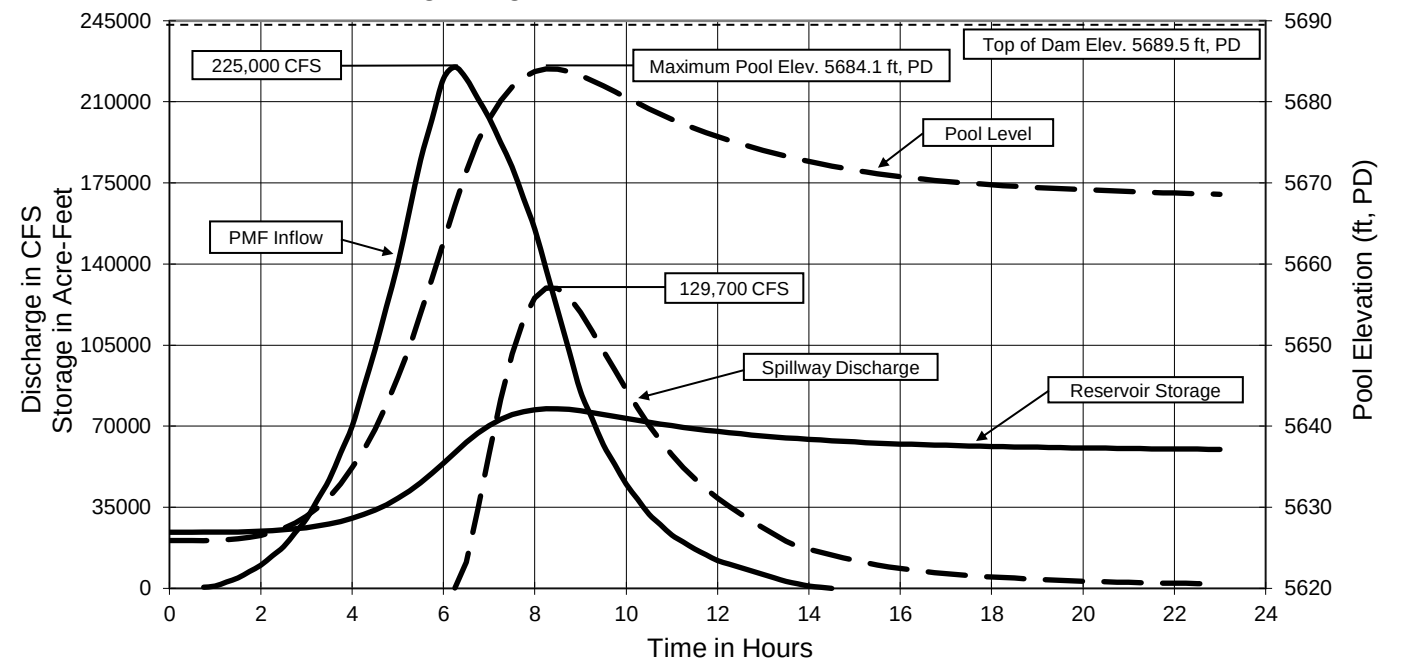
Beginning Pool Elevation - 5635.5 ft, PD
(Full Flood Control Pool)



Beginning Pool Elevation - 5667.0 ft, PD
(Spillway Crest)



Beginning Pool Elevation - 5625.9 ft, PD



Note:
All reservoir routings were made with an 800-foot wide emergency spillway with crest elevation of 5667.0 feet and no releases through the outlet works.

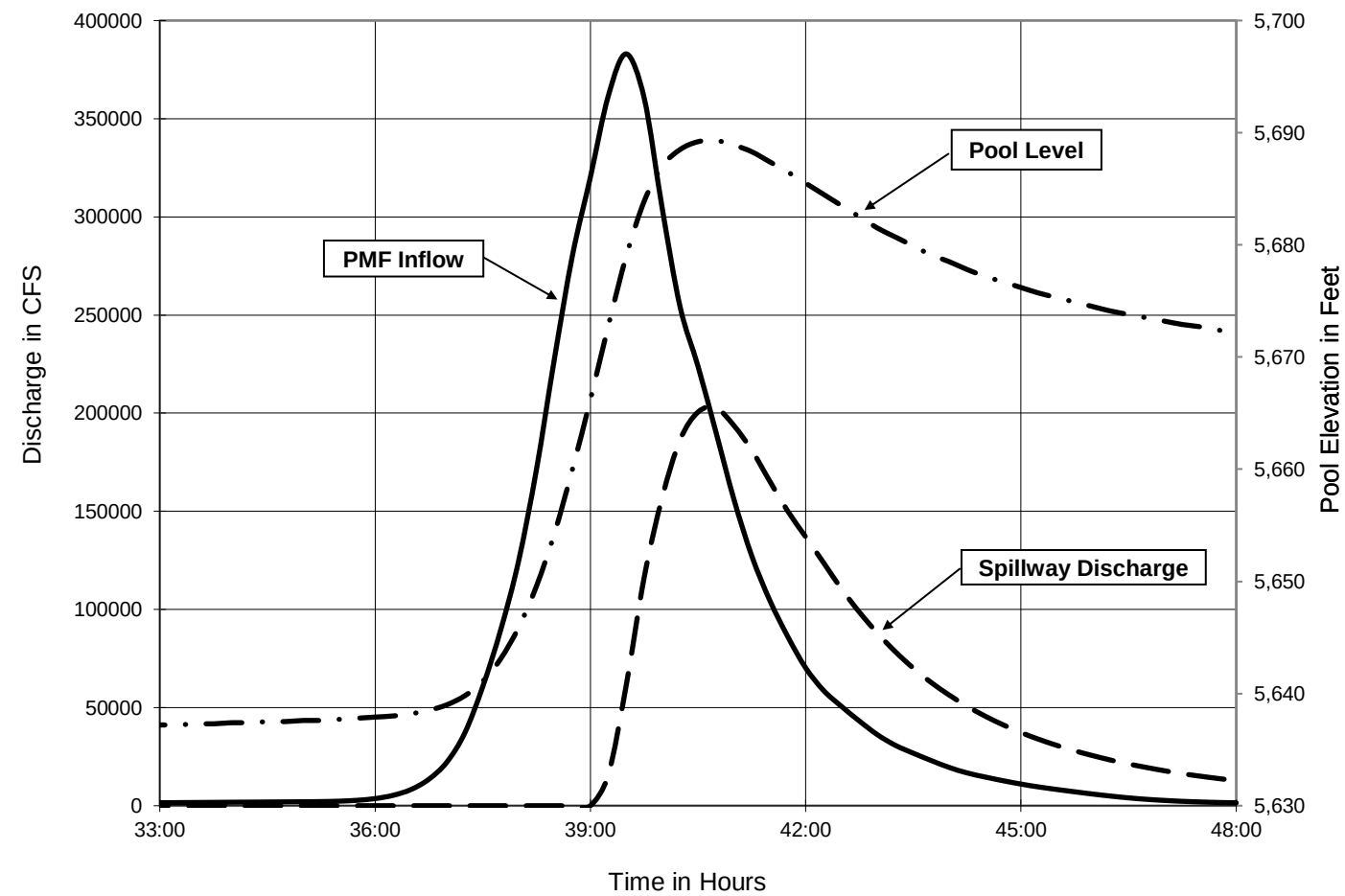
Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Probable Maximum Flood Routings Original Design Condition

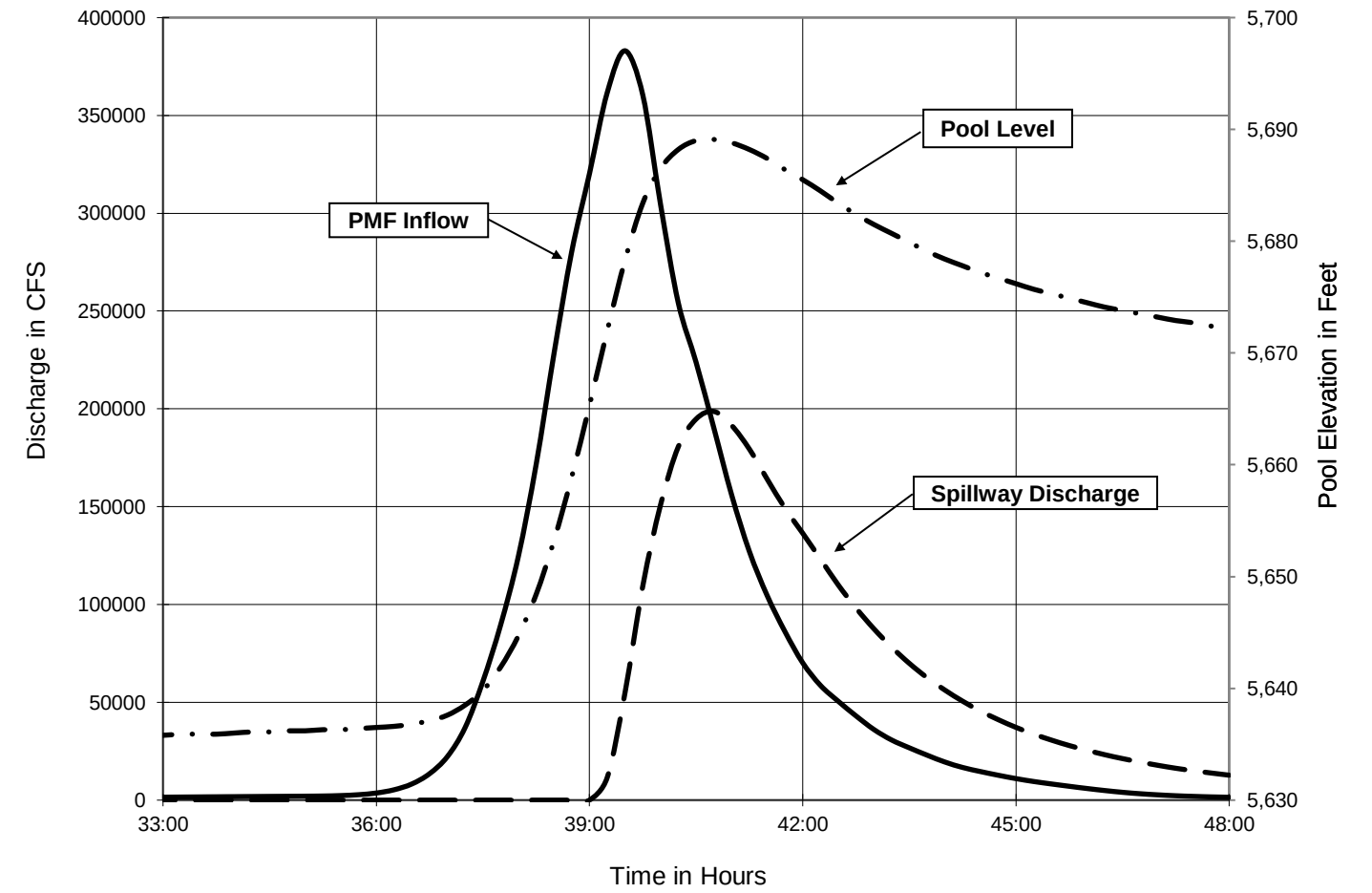
U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Prepared By: _____ KJS _____
Reviewed By: _____ AJF _____

Beginning Pool Elevation - 5635.5 Feet
(Full Flood Control Pool)



Beginning Pool Elevation - 5634.1 Feet
(50% PMF followed by 5-day drawdown)



Routing Scenario	PMF Routing starting pool (ft)	Max Pool (ft)	Freeboard (ft)	Freeboard Deficit (ft)	Peak Inflow (cfs)	Peak Outflow (cfs)	Inflow Volume (AF)
Starting Pool - top of Flood Control Pool							
0% peaked UH	5636.5	5688.2	2.0	1.0	302,000	180,000	93,300
50% peaked UH*	5635.5	5689.3	0.9	2.1	383,000	203,000	93,300
Starting Pool - 1/2 PMF then 5-day drawdown							
0% peaked UH	5634.1	5688.1	2.1	0.9	302,000	180,000	93,300
50% peaked UH*	5634.1	5689.1	1.1	1.9	383,000	200,000	93,300

* Displayed in the above figures

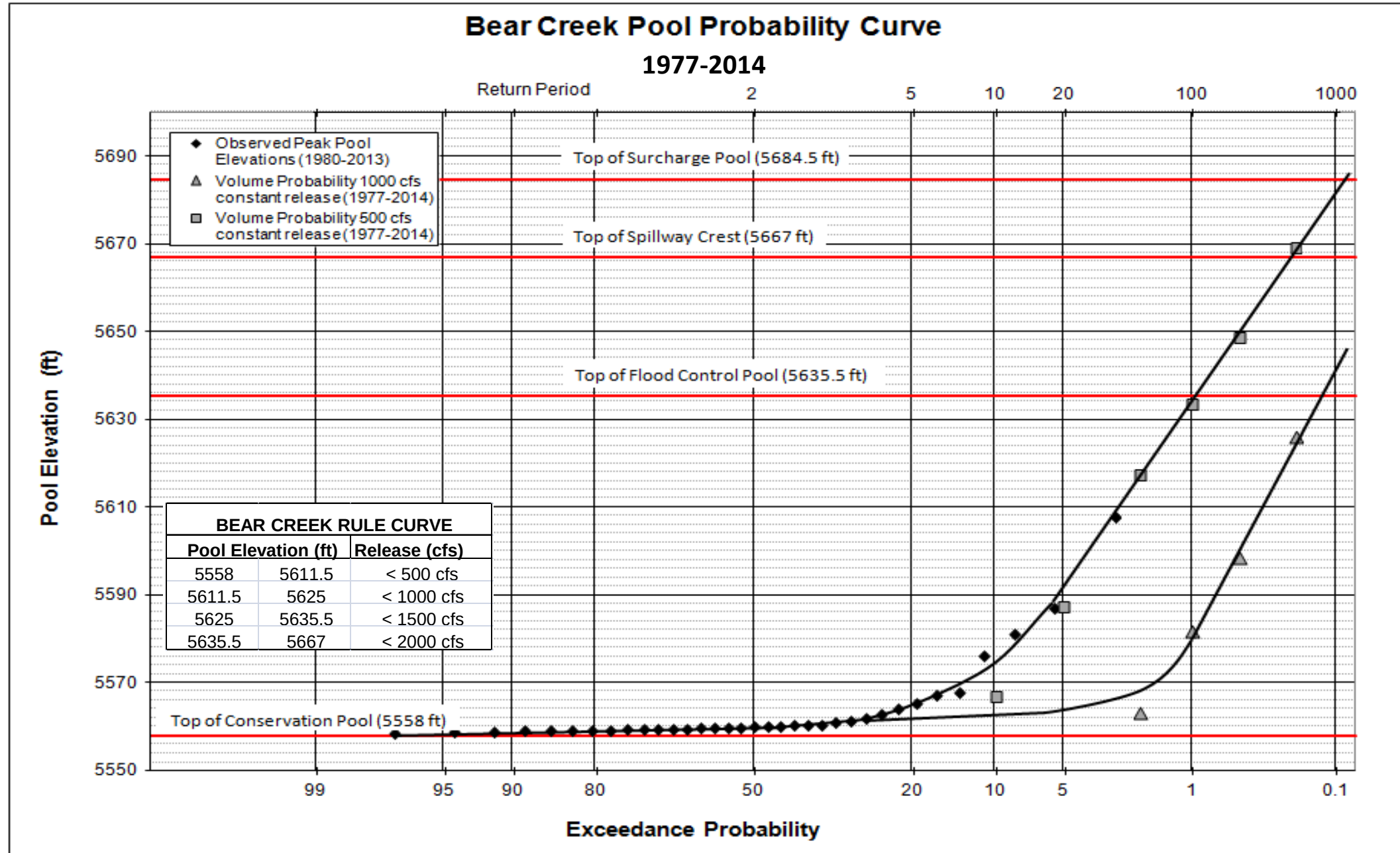
Notes:

- 1) All reservoir routings were made with 800-foot wide emergency spillway with crest elevation of 5667.0 feet.
- 2) It is not recommended that the probable maximum flood be required to begin at the spillway crest since the spillway is perched well above the top of the flood control pool. It is recommended that the more appropriate initial reservoir condition for the Bear Creek PMF is either the top of flood control pool elevation or the 50% PMF Antecedent Flood followed by a 5-day drawdown.
- 3) The PMF shown in the plots was created using the 15-minute unit hydrographs for each subbasin peaked 50%.
- 4) Source: Bear Creek Dam Inflow Design Flood Update, dated September 2015.

Prepared By: _____ JPD _____
Reviewed By: _____ KJS _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado
Probable Maximum Flood Routings
Updated Condition

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018



NOTES:

- 1) The volume probability is based on the daily calculated Bear Creek inflow (July 1977 - July 2014). It is calculated based on the daily change in storage, reservoir release, and evaporation loss.
- 2) The observed peak pool elevations begin in 1980 as this was the reservoirs initial fill date.
- 3) The volume probability at the upstream gage, Bear Creek at Morrison, CO (Oct 1919 - Sept 2013), was also calculated for comparison. It was not shown as the two were very similar.
- 4) An update to the curve is expected by May 2018.

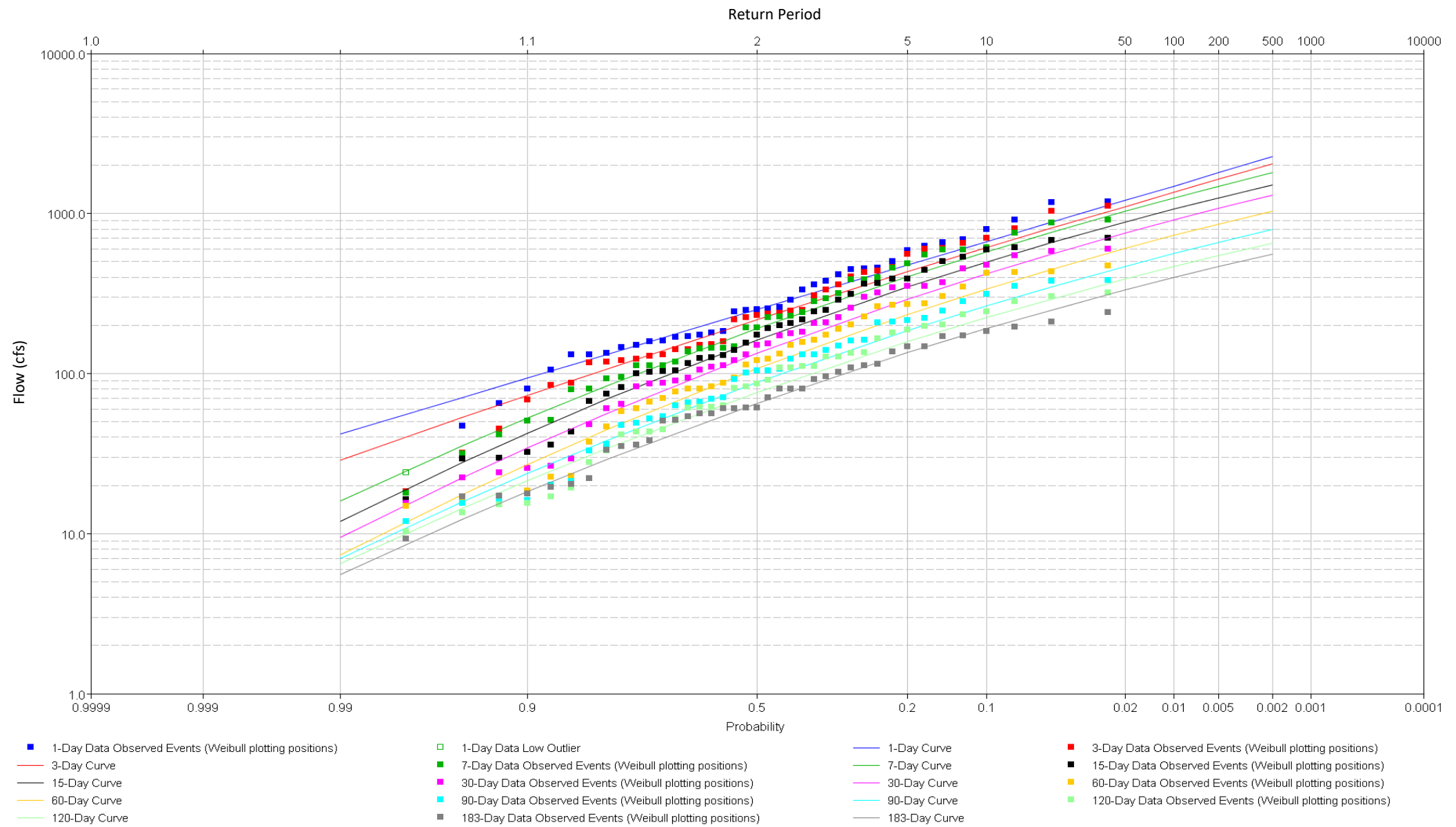
Prepared By: _____ KJS
Reviewed By: _____ DJC

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

**Pool Probability Curve (1977-2014)
Bear Creek Reservoir**

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Volume Duration Probability



Notes:

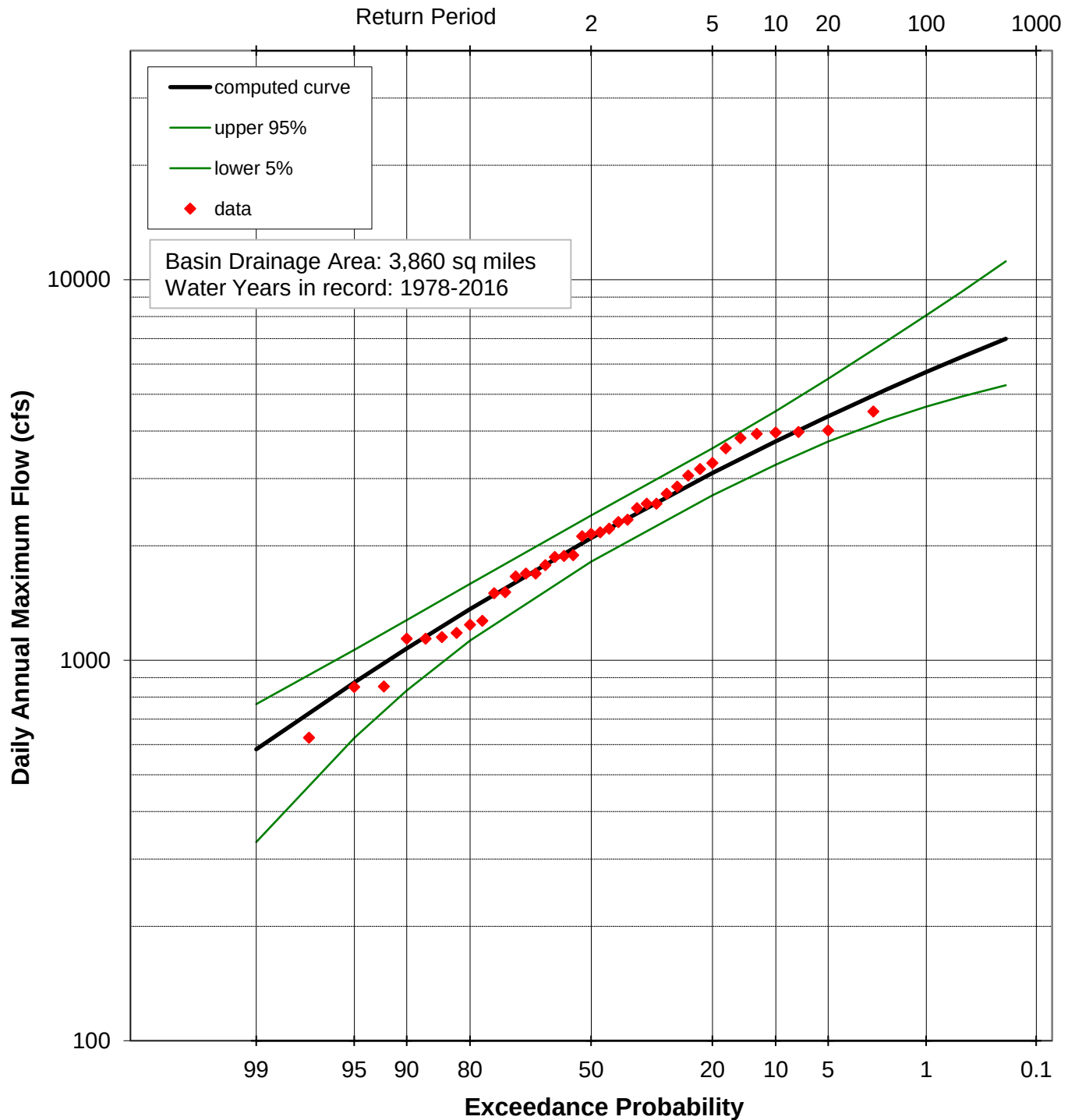
- 1) Annual maximum values for the durations of 1 through 183 days are shown. Assumes zero reservoir release.
- 2) Computed using the Bear Creek daily calculated inflow (July 1977 - July 2014), which is calculated based on the daily change in storage, reservoir release, and evaporation loss.
- 3) Final flow frequency relationships were computed from the smoothing statistics in accordance with EM 1110-2-1415.
- 4) An update to the curves are expected by May 2018.

Prepared By: _____ KJS _____
 Reviewed By: _____ DJC _____

Water Control Manual
 Bear Creek Dam and Reservoir, Colorado
Volume Duration Probability (1977-2014)
Bear Creek Reservoir

U.S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 2018

South Platte River at Denver Flow Frequency Curve



Log Transform: Flow (cfs)		Number of Events	
Mean	3.31	Historic Events	0
Standard Dev	0.213	High Outliers	0
Station Skew	-0.368	Low Outliers & Zero Flows	0
Regional Skew	-0.2	Zero Events	0
Weighted Skew	-0.31	Systematic Events	39
Adopted Skew	-0.31	Historic Period	39

NOTE: Derived from the daily annual maximum flow data at the South Platte River at Denver, CO streamgage after Cherry Creek, Chatfield and Bear Creek Dams where built in 1978 to represent the current flood control condition. Used Bulletin 17C analysis. The weighted skew fit the dataset the best and therefore was applied.

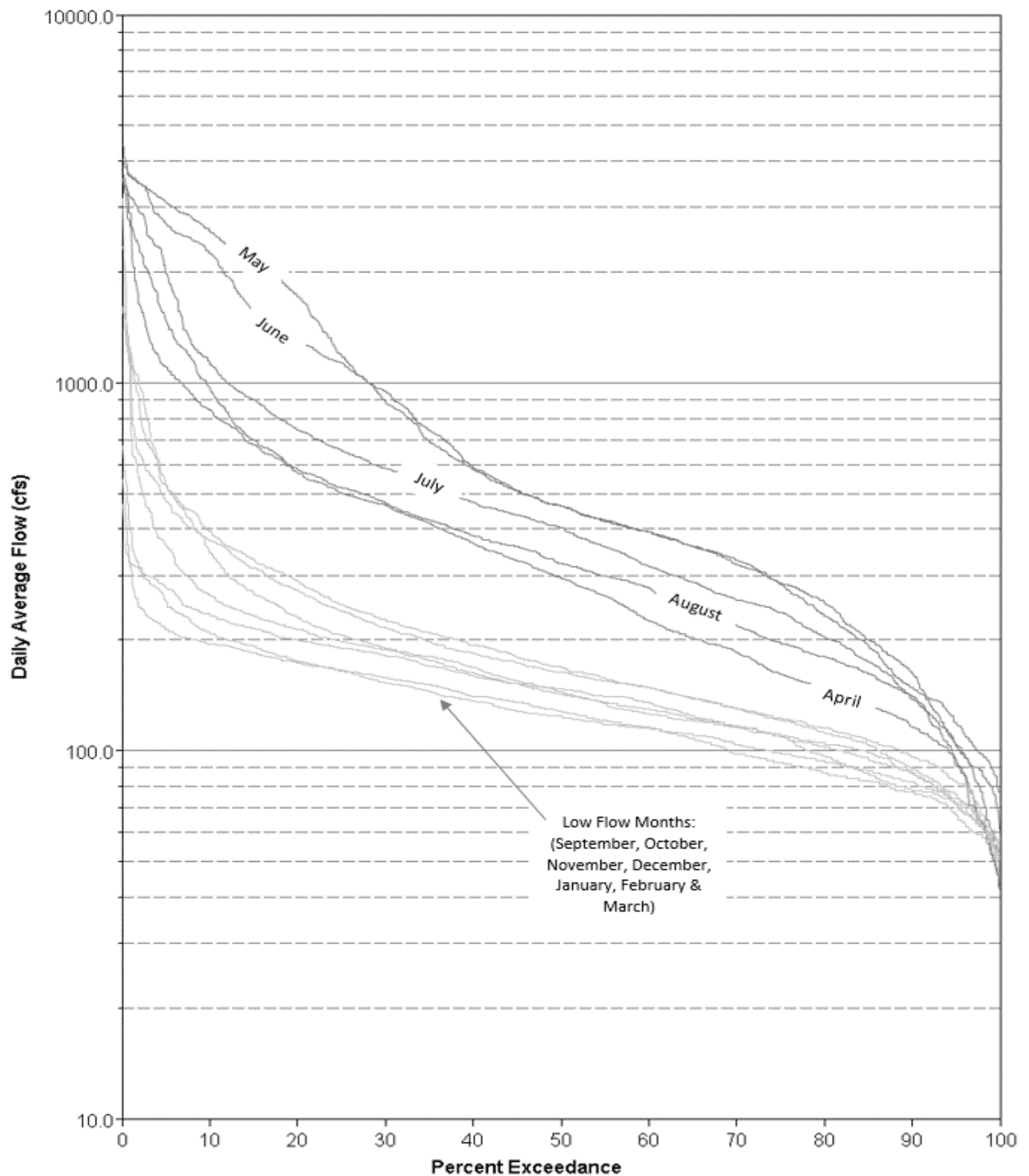
Prepared By: _____ KJS
Reviewed By: _____ JPD

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Flow Frequency Curve South Platte River at Denver, CO

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

South Platte River at Denver - Flow Duration Curve



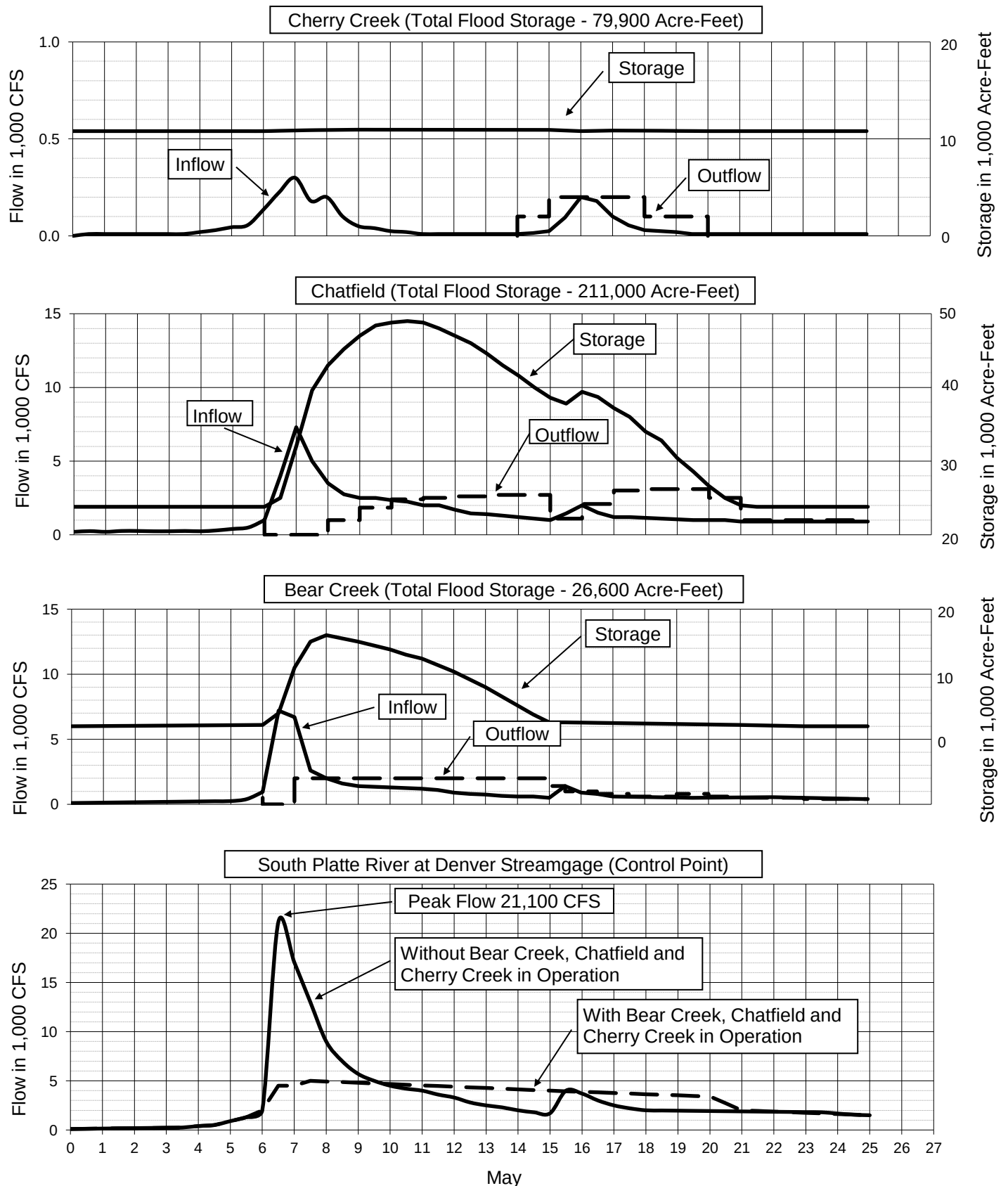
NOTE: Derived from the daily flow data at the South Platte River at Denver, CO streamgauge after Cherry Creek, Chatfield and Bear Creek Dams were built (1978-2016). Cherry Creek, Chatfield, and Bear Creek Dams were completed in 1950, 1975, and 1977, respectively. The data record represents the current flood control condition.

Prepared By: _____ KJS _____
 Reviewed By: _____ JPD _____

Water Control Manual
 Bear Creek Dam and Reservoir, Colorado

Flow Duration Curve South Platte River at Denver, CO

U.S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 2018

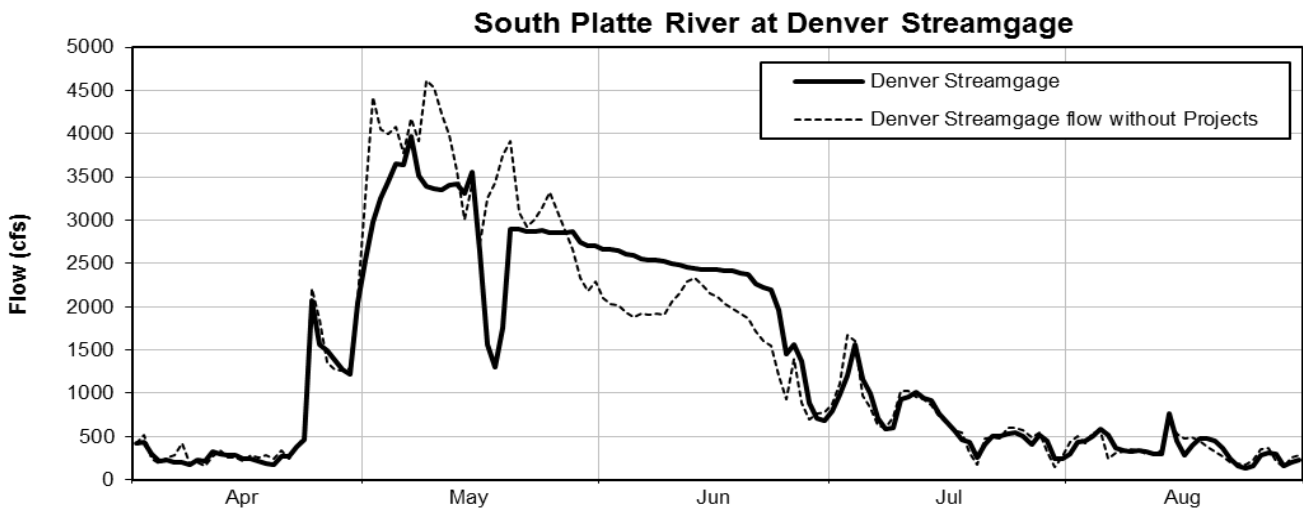
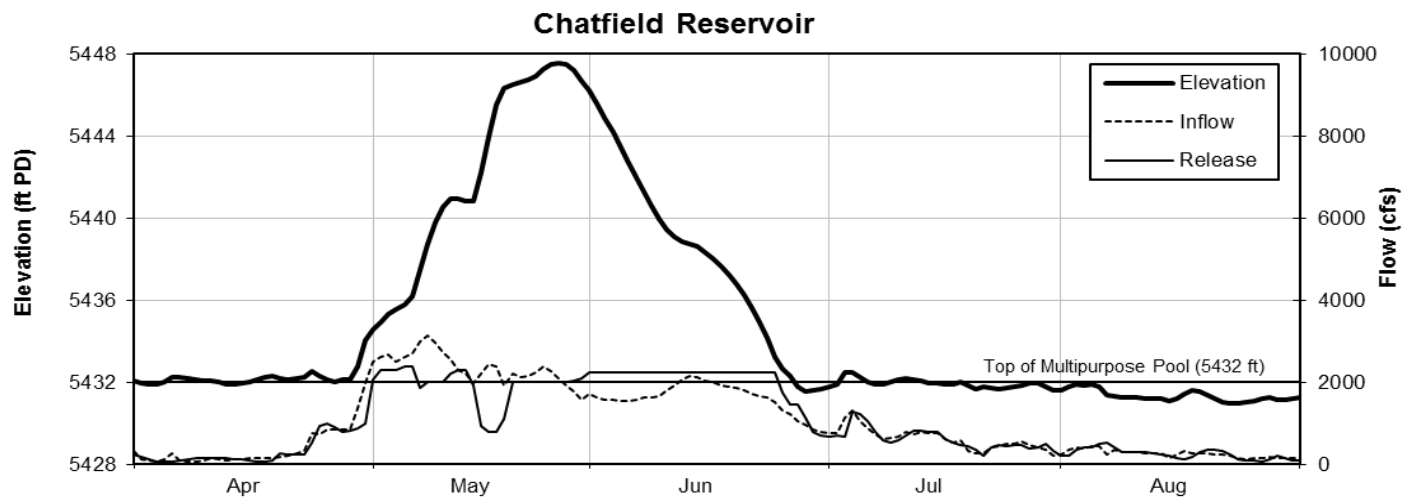
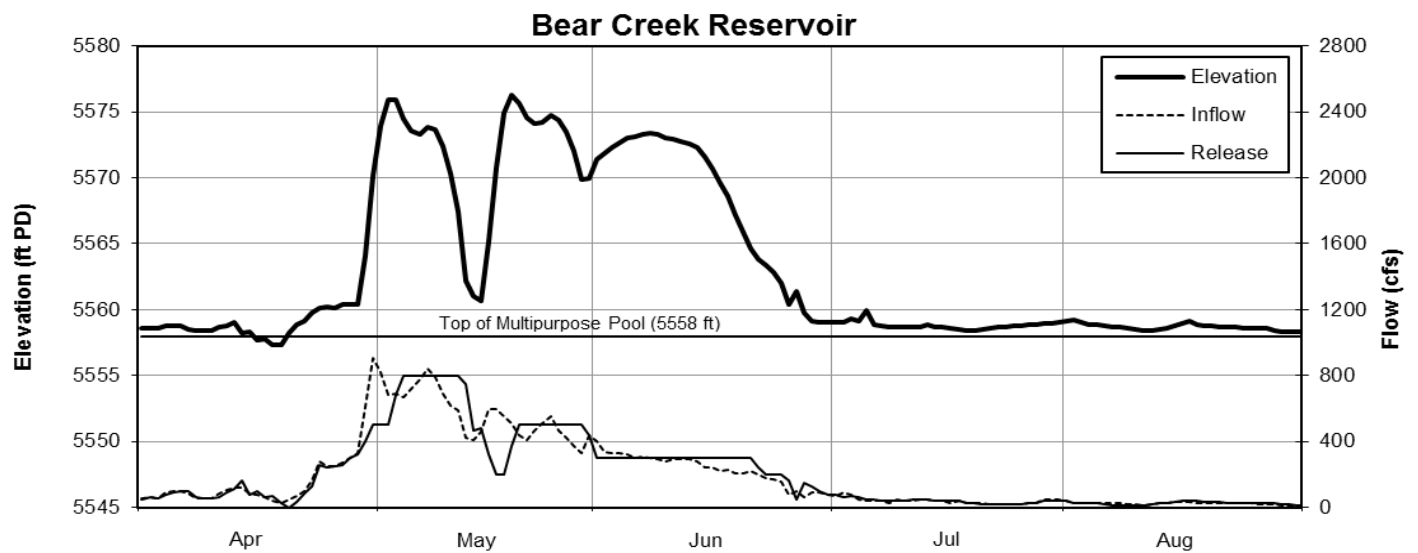


Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Example System Regulation 1969 Flood Flows

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018

Prepared By: _____ KJS _____
Reviewed By: _____ AJF _____



Notes:

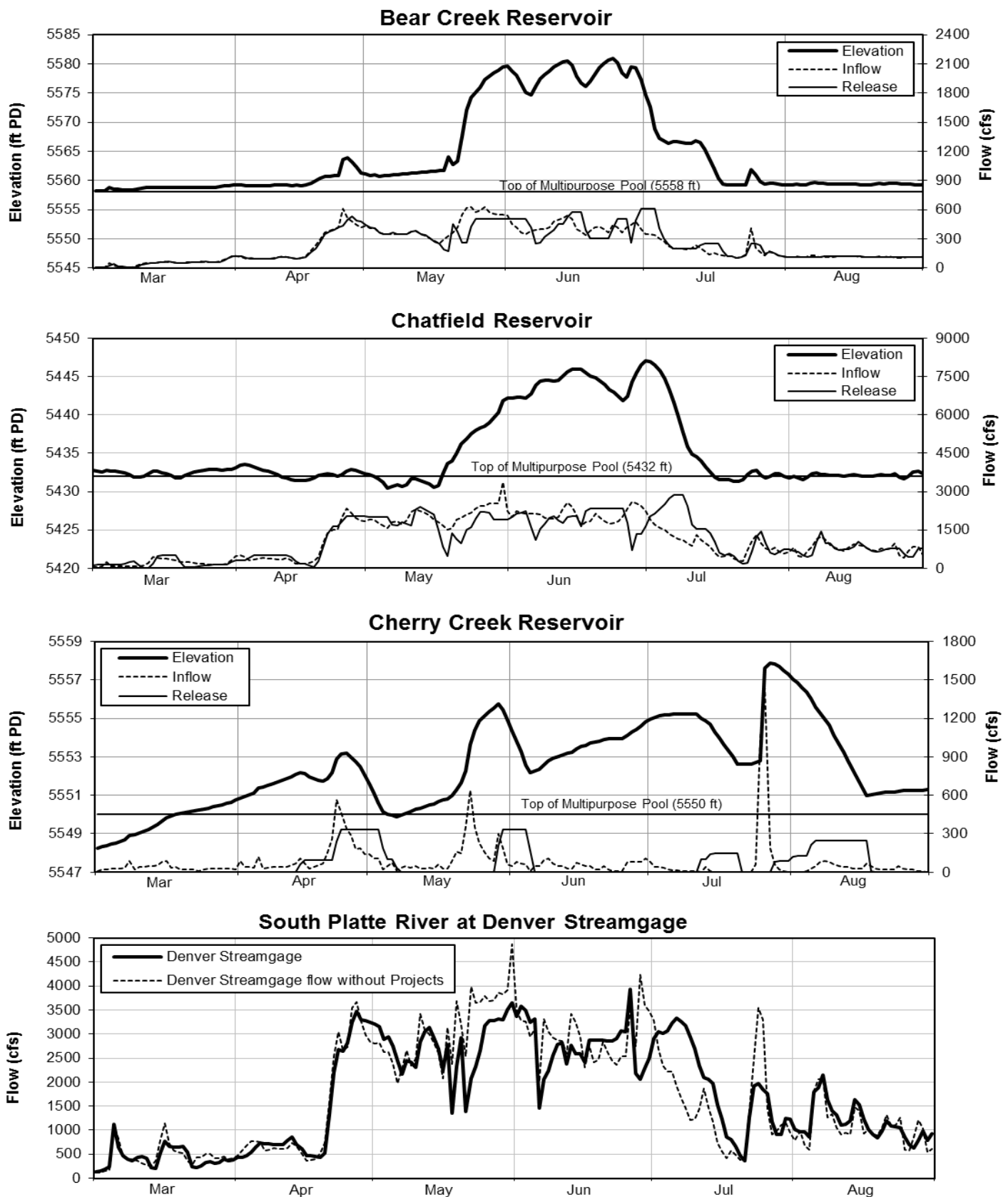
- 1) The reservoir elevation is based on the Project Datum (PD), which for Bear Creek Reservoir is close to NGVD29 and 3.0 ft lower than NAVD88.
- 2) Cherry Creek Reservoir inflow during 1980 was minor compared to Bear Creek and Chatfield Reservoirs, thus is not shown.

Prepared By: _____ JDM
 Reviewed By: _____ KJS

Water Control Manual
 Bear Creek Dam and Reservoir, Colorado

Actual System Regulation 1980 Flood Flows

U.S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 2018



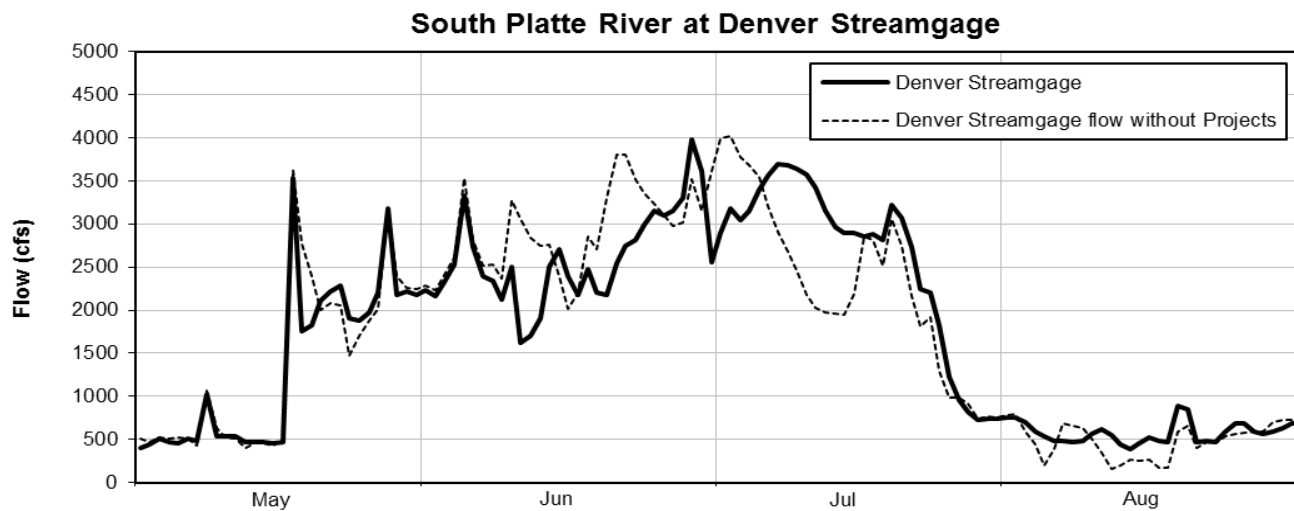
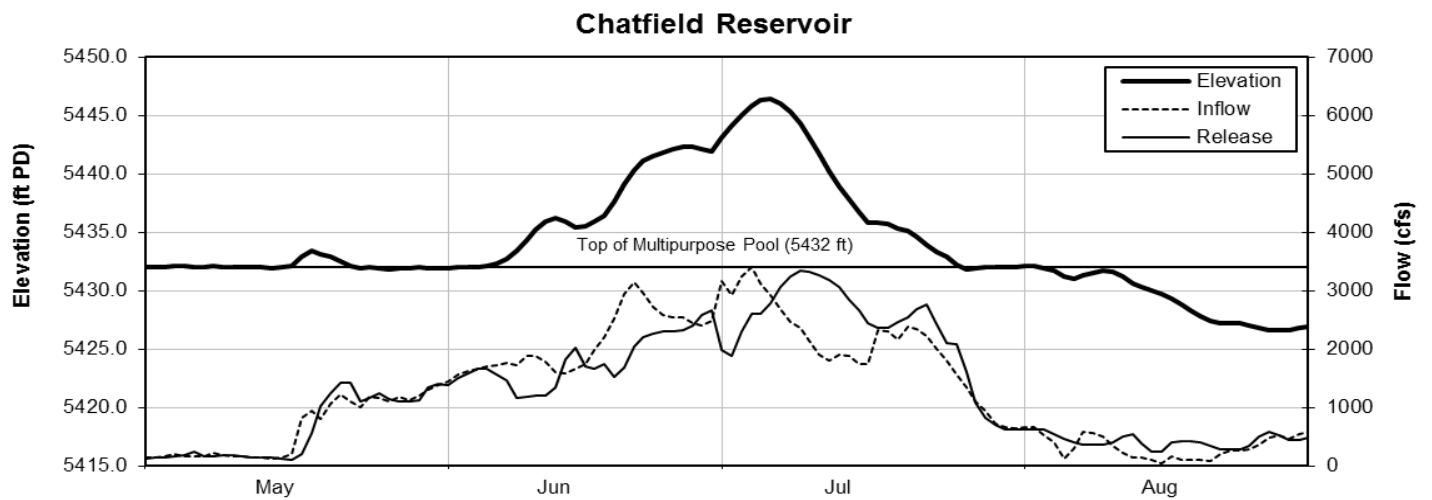
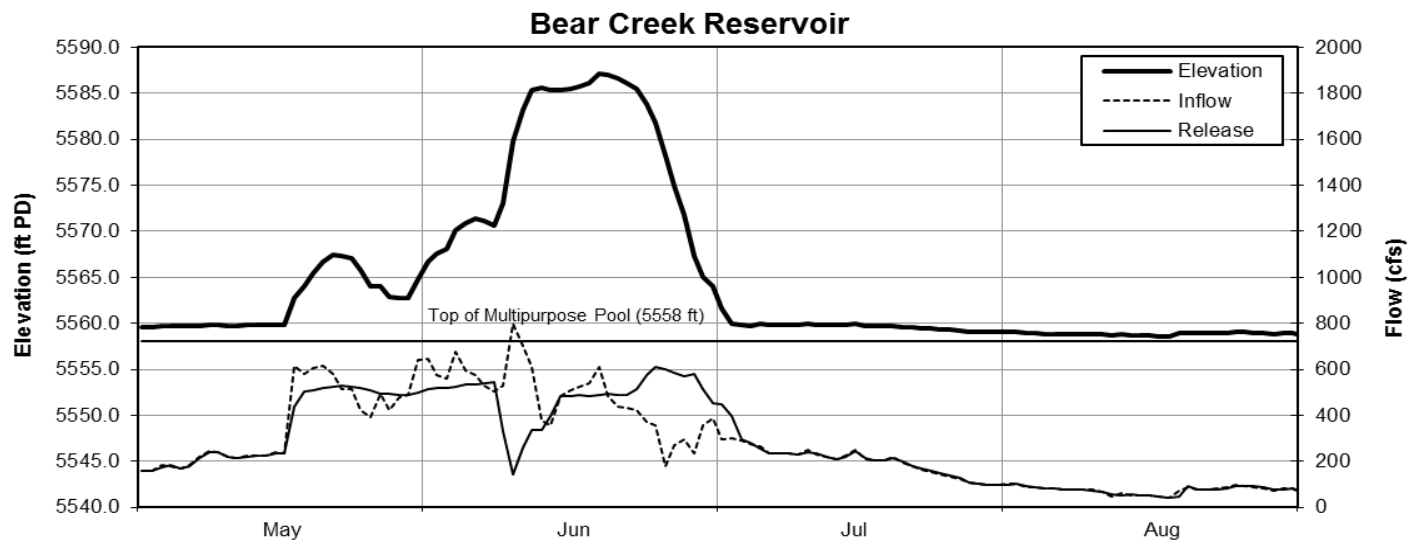
Note:
The reservoir elevation is based on the Project Datum (PD), which for Bear Creek Reservoir is close to NGVD29 and 3.0 ft lower than NAVD88.

Prepared By: _____ JDM
Reviewed By: _____ KJS

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Actual System Regulation 1983 Flood Flows

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018



Notes:

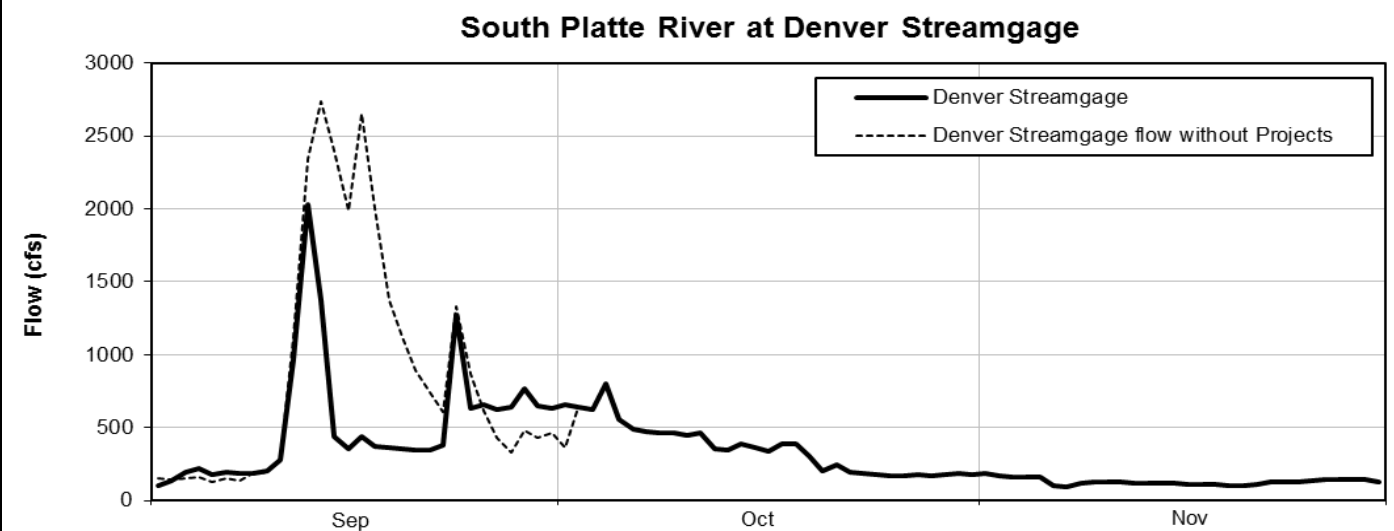
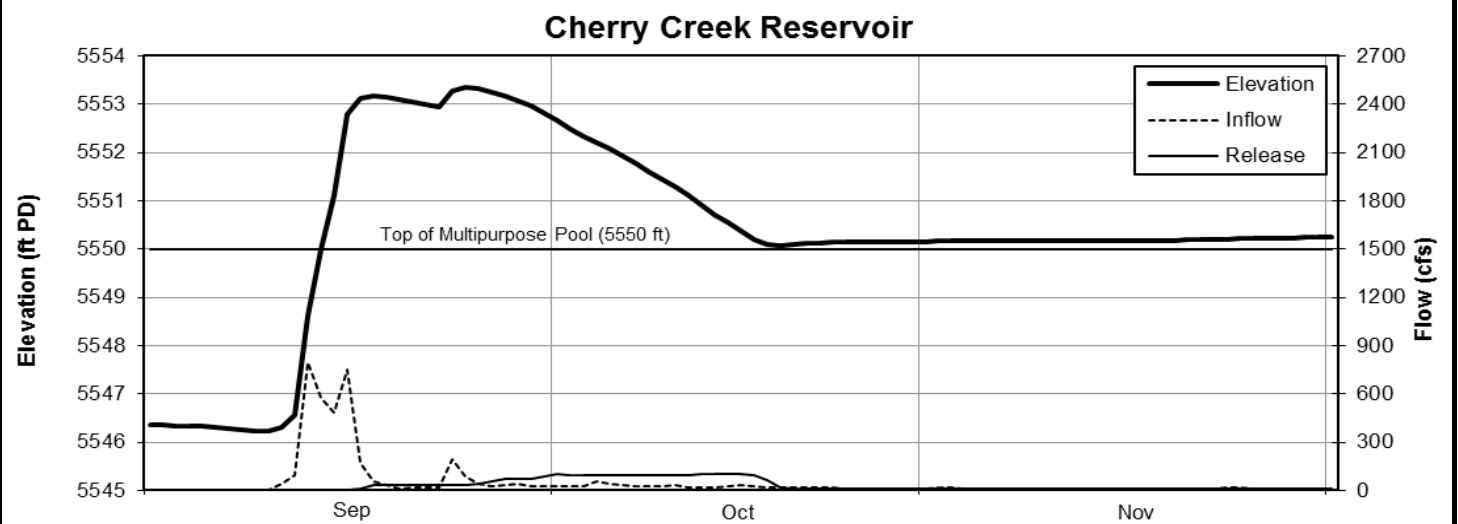
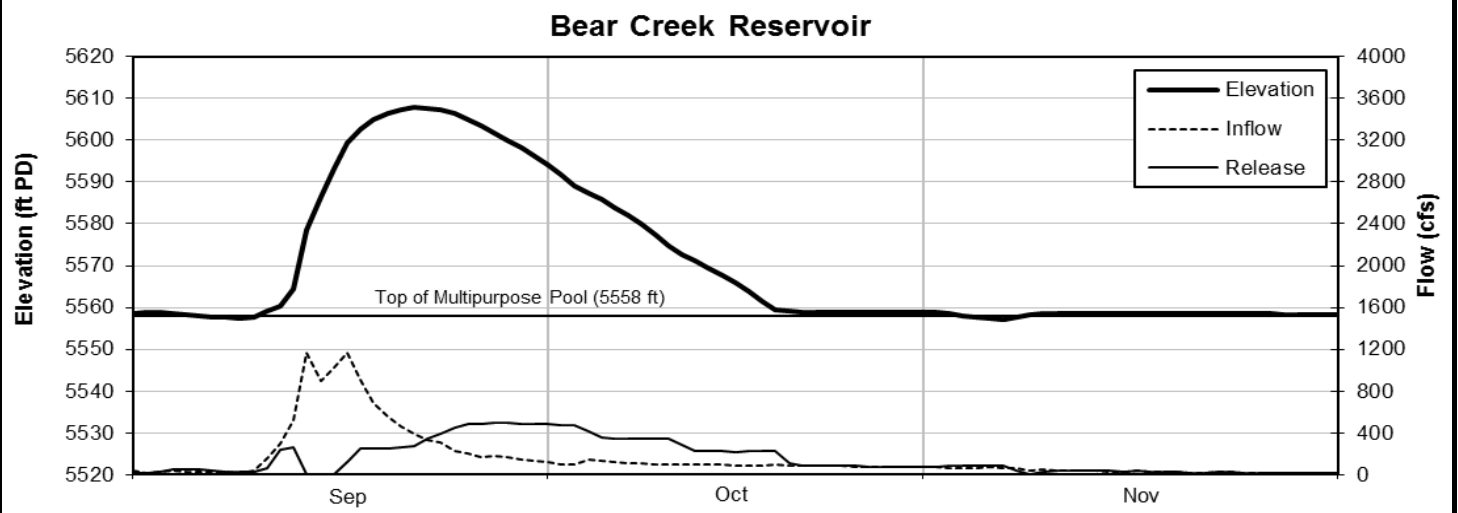
- 1) The reservoir elevation is based on the Project Datum (PD), which for Bear Creek Reservoir is close to NGVD29 and 3.0 ft lower than NAVD88.
- 2) Cherry Creek Reservoir inflow during 1995 was minor compared to Bear Creek and Chatfield Reservoirs, thus is not shown.

Prepared By: _____ JDM _____
 Reviewed By: _____ KJS _____

Water Control Manual
 Bear Creek Dam and Reservoir, Colorado

Actual System Regulation 1995 Flood Flows

U.S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 2018



Notes:

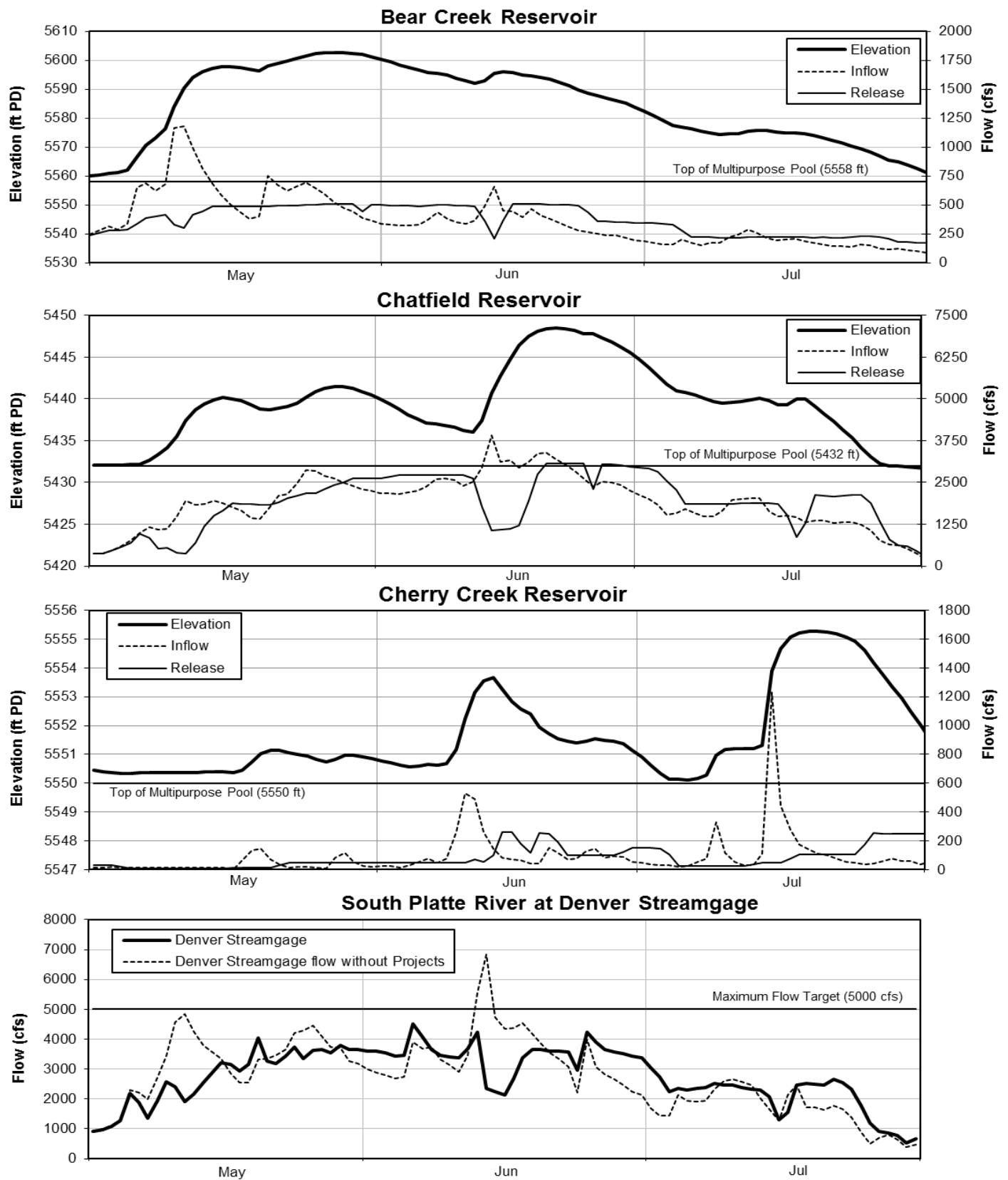
- 1) The reservoir elevation is based on the Project Datum (PD), which for Cherry Creek Reservoir is 1.3 feet higher than NGVD29 and 1.8 feet lower than NAVD88.
- 2) Chatfield Reservoir inflow during 2013 was minor compared to Bear Creek and Cherry Creek Reservoirs, thus is not shown.

Prepared By: _____ JDM _____
 Reviewed By: _____ KJS _____

Water Control Manual
 Bear Creek Dam and Reservoir, Colorado

Actual System Regulation 2013 Flood Flows

U.S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 2018



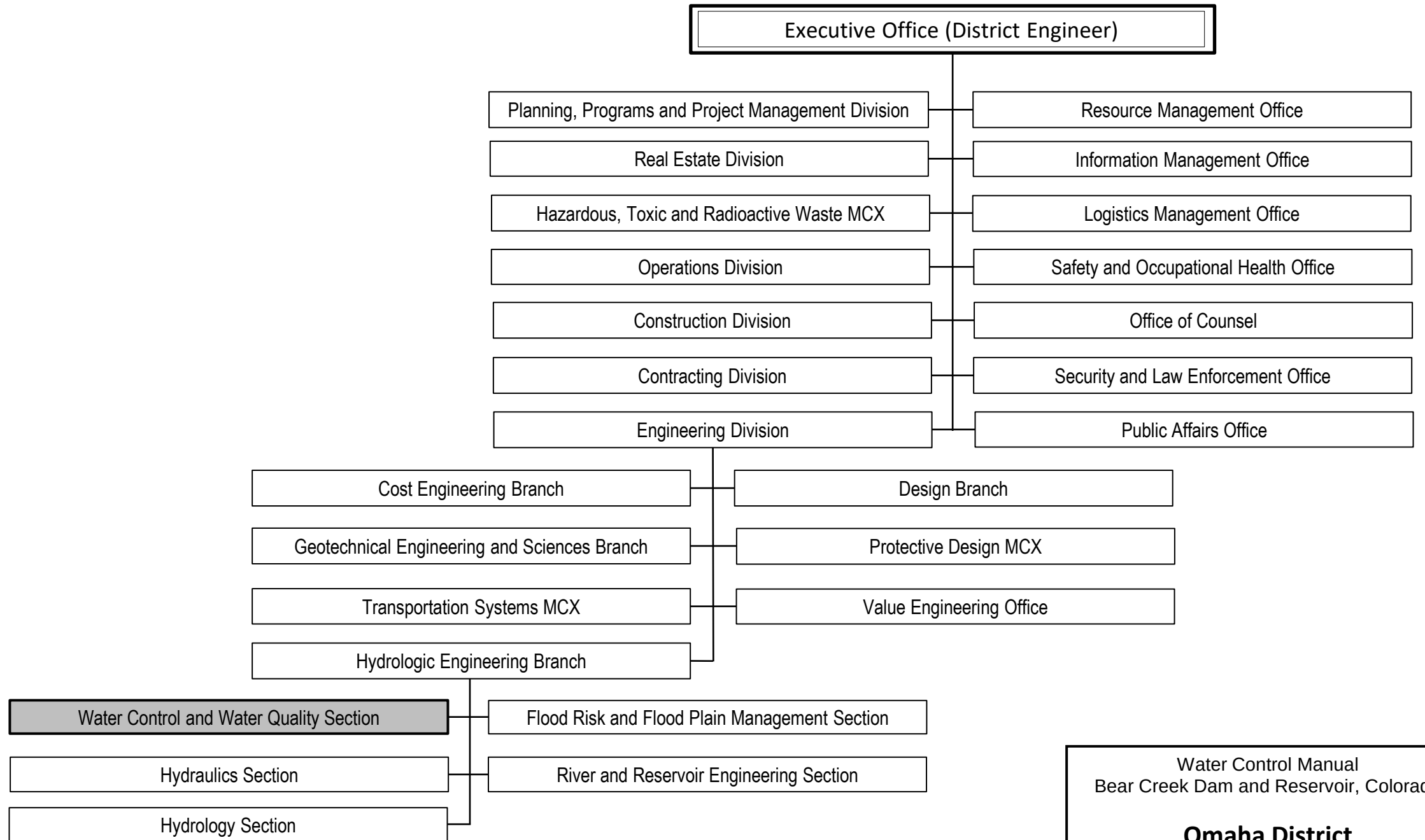
Note:
The reservoir elevation is based on the Project Datum (PD), which for Bear Creek Reservoir is close to NGVD29 and 3.0 ft lower than NAVD88.

Prepared By: _____ JDM _____
Reviewed By: _____ KJS _____

Water Control Manual
Bear Creek Dam and Reservoir, Colorado

Actual System Regulation 2015 Flood Flows

U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2018



Prepared By: _____ KJS _____
 Reviewed By: _____ MJN _____

Water Control Manual
 Bear Creek Dam and Reservoir, Colorado

**Omaha District
 Organization Chart**

U.S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 2018

EXHIBIT I

**STANDING INSTRUCTIONS TO DAM TENDER
FOR
RESERVOIR REGULATION
BEAR CREEK DAM AND RESERVOIR**

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Condition A - General

A-1. Purpose of Instructions. It is the purpose of these instructions to set forth the responsibilities of the Dam Tender and procedures to be followed for regulation of Bear Creek Reservoir. The Dam Tender will be familiar with these instructions and post them in a readily accessible place for reference and emergency use. The Dam Tender is responsible for notifying substitutes of the provisions and use of these instructions for reservoir regulation.

A-2. Purpose of Project. The project's primary purpose is to protect the City of Denver from floods originating on Bear Creek. Development and use of the inactive or multipurpose pool will provide incidental benefits for all forms of water related recreation activity. Storage allocations are listed in Table 1.

Table 1
Bear Creek Reservoir Storage Allocations

Zone	Pool Elevations (ft PD*)	Storage Allocations (Acre-Feet)**
Surcharge	5635.5 to 5684.5	46,955
Exclusive Flood Control	5558.0 to 5635.5	28,514
Multipurpose	5528.0 to 5558.0	1,771
Inactive	5510.0 to 5528.0	53

* PD = Project Datum

** 2009 Sediment Survey

A-3. Types of Regulation Responsibilities. The present status of the project entails both multipurpose and flood control regulation. The State of Colorado through its State Engineer, or designated representative, is responsible for the multipurpose regulation and accordingly will specify releases from and the storage of inflows when the pool is in the multipurpose zone. However, as determined by the Corps' Omaha District dam safety officer, should any dam safety issues arise, the Corps will assume all regulation decisions.

A-4. Flood Control Responsibilities. The Corps of Engineers has prime responsibility for determining releases from the exclusive flood control zone and is solely responsible for specifying releases from the surcharge zone. Such regulation will be construed as flood control regulation. In order to satisfy the water rights of irrigators taking water from the South Platte River, the State Engineer of Colorado may request the release of inflows to Bear Creek Reservoir while the pool is in the exclusive flood control zone. If such releases will not contribute to damages at or below Bear Creek Dam, the Corps of Engineers, upon receiving such requests, will order releases of inflow unless Cherry Creek Reservoir is above elevation 5590 ft PD.

A-5. Hydrologic Reporting Network. To facilitate the rapid collection and receipt of hydrologic data pertinent to the regulation of the Chatfield, Cherry Creek, and Bear Creek Dams and Reservoirs, a hydrologic reporting network has been established and expanded by several local, state and federal agencies. The network includes an extensive system of reservoir, stream and precipitation gages within the State of Colorado. Table 2 provides a list of pertinent stream and reservoir gages useful during the regulation of Chatfield, Cherry Creek, and Bear Creek Reservoirs. Real-time stage and flow data for these streamgages can be found on the CDWR website.

Table 2
Stream and Reservoir Gaging Stations

Stream	Station
South Platte River	South Platte
South Platte River	Waterton
Plum Creek	Louviers
South Platte River	Chatfield Lake
South Platte River	Below Chatfield Dam
South Platte River	Below Union Ave.
Bear Creek	Morrison
Bear Creek	Bear Creek Lake
Bear Creek	Below Bear Creek Dam
Bear Creek	Sheridan
South Platte River	Englewood
Cherry Creek	Franktown
Cherry Creek	Parker
Cherry Creek	Cherry Creek Lake
Cherry Creek	Denver
South Platte River	Denver
South Platte River	Commerce
Clear Creek	Golden
Clear Creek	Derby
South Platte River	Henderson

<https://www.dwr.state.co.us/SurfaceWater/default.aspx>

A-6. Routine Duties, Observation, and Reports. Attachment 1 shows an example routine regulation report required of the Dam Tender.

A-7. Special Reports. The following observations of conditions will be relayed immediately by the Dam Tender to one of the Omaha District Water Control and Water Quality Section (WCWQS) personnel listed in Attachment 2. Phone calls will be made in the order listed to the office phone numbers and cell phone numbers until notification is made.

(1) Knowledge exists of any flooding, flood damages, requests for regulation of releases, or heavy runoff occurring or appearing to be imminent upstream or downstream from the dam.

(2) Rainfall at any point in the South Platte River basin above Henderson, Colorado exceeds two inches in a six-hour period.

(3) Pool level rises 1.0 foot or more in a six-hour period. (A rise in pool, which in the opinion of the Dam Tender, reaches this limit only as a result of wind effects, need not be reported).

A-8. Notification Schedule. If the pool rises above elevation 5559.0 feet PD and is expected to continue to rise in the exclusive flood control zone, the Dam Tender will notify the WCWQS personnel listed in Attachment 2. If the rise in pool occurs between 7:00 am and 3:30 pm notification will be the same day. If the rise in pool occurs between 3:30 pm and 7:00 am, weekends and holidays included, notification will be made by 9:00 am the following day. All times assumed to be mountain time.

Condition B - Normal Regulation

B-1. Definition of Normal Regulation. For the purpose of these instructions, normal regulation is defined to occur at all times when:

(1) Rapid communication (telephone) between the Dam Tender and the WCWQS is possible.

(2) Rapid communication between the Dam Tender and regulatory offices referenced above is impaired; however, hydrologic and meteorologic conditions are such that flooding, flood damages or rapid increase in the Bear Creek pool elevation (defined in Condition C "Emergency Regulation") is not occurring or is not anticipated in the near future.

B-2. Regulation Instructions. Regulation orders will normally be issued to the Dam Tender by the WCWQS. However, during non-flood periods, when the pool level is below elevation 5559.0 ft PD the State Engineer's Office will determine the necessary release due to water rights and will contact the WCWQS for approval and regulation order issuance. The State Engineer's Office may issue instructions on releases for water rights directly to the Dam Tender if contact cannot be made with the WCWQS. All verbal orders issued to the Dam Tender will be confirmed in writing as soon as practical. The orders will specify total reservoir release and time of release change. All regulation orders will be filed in a convenient, accessible place in the Dam Tender's office. The Dam Tender will inform the substitutes as to the location of the regulation orders and their content.

B-3. Regulation Records. The Dam Tender shall keep a routine report of reservoir regulation (see Attachment 1 for a report example). The Dam Tender shall make the reports available to the WCWQS for use in development of the reservoir regulation orders. In the routine reservoir regulation report, the Dam Tender shall note all reservoir regulation orders received from the WCWQS. The notes shall include whom the reservoir regulation order was given by, the time and discharge. The Dam Tender shall keep, as part of the permanent files, copies of all reservoir regulation orders received. The Dam Tender shall keep records complete enough to reconstruct the events and activities at the project during flood periods.

The Dam Tender shall also keep a flood report during normal regulation. All conversations, especially with personnel outside the Corps, relative to flooding, flood damages, requests for regulation of releases, etc., should be documented. All observations of flooding and flood damages should also be documented. An example flood report under this condition can be found in Attachment 1 of this document.

B-4. Safety - Public Information. In order to provide ample warning before endangering recreational facilities in the Bear Creek Project area, the Dam Tender will immediately notify the City of Lakewood and the Colorado State Parks and/or Fish and Wildlife representative at the site, as listed in Appendix 2, whenever the pool level is

expected to exceed 5562.0 ft PD or a rapid rise in pool level of 1.0 foot in a six-hour period is occurring or is expected to occur in the next six hours. Bear Creek Project releases, made under the conditions contained herein, are not likely to endanger any of the inhabitants of the basin; however, the Colorado State Engineer and the Division Engineer, as listed in Appendix 2, will be notified by the Dam Tender of probable prolonged releases which might cause damage through the City of Denver. The Division Engineer and State Engineer should be notified in all cases when outlet releases in excess of 500 cfs are to be made from Bear Creek Dam.

B-5. Dam Tender Email Notification – Routine and Flood Regulation. In order to keep stakeholders, local agencies, local emergency management officials, and downstream contractors aware of changing downstream conditions due to reservoir operations, reservoir release change email notification lists are used and maintained by the Dam Tender. The email notification identifies the date, time, and release. For the Chatfield Reservoir Project there are two email lists.

(1) For all reservoir release changes, an email will be sent by the Dam Tender to the WCWQS, the State of Colorado, local agencies, contractors located within the South Platte River below Chatfield Dam, and designated stakeholders.

(2) For all reservoir release changes in excess of 500 cfs, an email will be sent by the Dam Tender to the group noted in B-5.(1) as well as the US Geological Survey, the National Weather Service, Urban Drainage and Flood Control District (UDFCD), and local emergency management officials.

Condition C - Emergency Regulation

C-1. Purpose of Emergency Instructions. Regulation of Bear Creek Reservoir will be normally accomplished by specific regulation orders to the Dam Tender from the WCWQS. However, it is conceivable that interruptions in communication may occur at times when regulation action, other than required in the latest available regulation order, may be necessary particularly in order for the project to fulfill its primary objective of flood control.

C-2. Reason for Emergency Instructions. Emergency instructions have been developed to provide the Dam Tender with instructions for the regulation of releases from the project during periods of communication failure. These instructions have been formulated to provide as high a degree of flood protection as practical for the City of Denver, within the safe capability of the project, and involve action by the Dam Tender based on meteorologic and hydrologic conditions of which the Dam Tender has knowledge.

C-3. Definition of Emergency. For the purpose of these instructions, an emergency is defined to begin with a failure in communications between the Dam Tender and the WCWQS personnel at a time when a report from the Dam Tender is required by Paragraph A-7.

C-4. Emergency Conditions. Emergency conditions will continue until such time personnel in the WCWQS have been contacted and the appropriate instructions are received by the Dam Tender. During the progress of the emergency as defined above, the Cherry Creek Dam Tender shall proceed and regulate the Cherry Creek Reservoir in accordance with the conditions and instructions which follow. The Dam Tender shall continue to record data and provide for safety and public information insofar as possible as directed in Condition B of these instructions.

C-5. Re-Establishment of Communications. Telephone and email are presently available for communication between the Dam Tender and the WCWQS personnel. During an emergency every effort should be made to re-establish communications between the Tri-Lakes Project Office and the WCWQS by any means available. If Tri-Lakes Project Office personnel are available, a vehicle should be dispatched to convey messages to contact the WCWQS personnel shown on Attachment 2 from a point where communications are not impaired. However, the Dam Tender shall ensure that the dam is attended at all times during the emergency.

C-6. Emergency Regulation. In the event of an emergency as defined in Paragraph C-3, the Dam Tender shall regulate releases as indicated by the following schedule. The Bear Creek Reservoir inflow may be estimated by determining the flow at the Bear Creek at Morrison streamgage. Turkey Creek will also contribute to the Bear Creek Reservoir inflow, but is ungaged. The goal is to store rainfall or snowmelt runoff to mitigate the downstream flood risk. Once downstream flooding has subsided, the stored flood water is evacuated as quickly as practical to return the reservoir to the base

of the flood control pool. This prepares the reservoir to store the next runoff event. **Once the reservoir level is stationary or begins to fall, the Dam Tender shall maintain the maximum gate opening attained while above elevation 5559.0 feet PD unless conditions change. At no time should water be released at a rate greater than the peak inflow experienced during the flood event.**

a. For a rising pool.

(1) When rainfall in the upper South Platte River basin **exceeds two inches** in six hours* or there is flooding or heavy runoff downstream.

Pool Elevation (feet PD)	Release Schedule
Above El. 5635.5	Release 2000 cfs
5630.0 to 5635.5	Release the larger of the following:
	1. That specified in the latest regulation order
	2. 1500 cfs
5625.0 to 5630.0	Release the larger of the following:
	1. That specified in the latest regulation order
	2. 1000 cfs
5611.5 to 5625.0	Release the larger of the following:
	1. That specified in the latest regulation order
	2. 500 cfs
5558.0 to 5611.5	If current release is greater than 50 cfs, reduce release to 50 cfs or according to the State Engineer's request for releases to satisfy streamflow water rights. If current release is less than 50 cfs, maintain current release or according to the State Engineer's request for releases to satisfy streamflow water rights.
Below El. 5558.0	Release specified in the latest regulation order, but not more than 50 cfs. Contact the State Engineer for superseding instructions to satisfy streamflow water rights.
* This condition can be estimated by referring to the storm total at the following website https://radar.weather.gov/radar.php?rid=ftg&product=N0R&overlay=11101111&loop=no	

(2) When rainfall in the upper South Platte River basin **is less than two inches** in six hours* or there is no flooding or heavy runoff downstream.

Pool Elevation (feet PD)	Release Schedule
Above El. 5635.5	Release 2000 cfs
5625.0 to 5635.5	Release the larger of the following:
	1. That specified in the latest regulation order
	2. 1500 cfs
5611.5 to 5625.0	Release the larger of the following:
	1. That specified in the latest regulation order
	2. 1000 cfs
Below El. 5611.5	Release that specified in the latest regulation order. Contact the State Engineer for superseding instructions to satisfy stream flow water rights.
* This condition can be estimated by referring to the storm total at the following website https://radar.weather.gov/radar.php?rid=ftg&product=N0R&overlay=11101111&loop=no	

b. For a Stationary or Falling Pool.

(1) When rainfall in the basin **exceeds two inches** in six hours* or there is flooding or heavy runoff downstream follow table located in Condition C-6.a.(1).

(2) When rainfall in the basin **is less than two inches** in six hours* or there is no flooding or heavy runoff downstream.

Pool Elevation (feet PD)	Release Schedule
Above El. 5611.5	Maintain maximum gate opening attained under Condition C-6 a.(1), a.(2), or b.(1).
5558.0 to 5611.5	Release the lesser of the following:
	1. Maximum gate opening attained under a Condition C-6 a.(1), a.(2), or b.(1).
	2. Between 500 to 1000 cfs to maintain the pool at elevation 5611.5**
Below El. 5558.0	Release that specified in the latest regulation order. Contact the State Engineer for superseding instructions to satisfy stream flow water rights.
* This condition can be estimated by referring to the storm total at the following website https://radar.weather.gov/radar.php?rid=ftg&product=N0R&overlay=11101111&loop=no	
** This allows some flexibility in operation to keep the reservoir below elevation 5611.5 ft PD (approximately 50% flood control pool).	

C-7. Special Reports of Emergency Operations. It is essential that the Dam Tender keep a flood report under emergency regulation. The flood report shall be complete enough to reconstruct the events and regulation activities at the project during the flood period. An explanation of the attempts to re-establish communications with the WCWQS personnel should be documented. All conversations, especially with

personnel outside the Corps, relative to flooding, flood damages, requests for regulation of releases, etc., should be documented. All observations of flooding and flood damages should also be documented. For all reservoir release changes made without the guidance of the WCWQS personnel, the release schedule outlined in Condition C-6 shall be followed. Also, the current flood event peak inflow and reason for the reservoir release change shall be determined and listed in the report prior to the physical reservoir release change. An example emergency report under this condition can be found in Attachment 1 of this document.

C-8. Dam Tender Email Notification – Routine and Flood Regulation. Reference Condition B-5 for details on email notification during routine and flood regulation. No change to the email notification is required during a communication interruption with the WCWQS personnel.

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ATTACHMENT 1

Routine Dam Tender's Reservoir Regulation Report Example - Condition A

Corps of Engineers – Omaha District				Week Ending Day/Month/Year			
Bear Creek Dam and Lake				SOURCE - (1) Colorado State Engineer (2) Corps District Engineer			
Dam Tender's Reservoir Regulation Report				MEANS - (1) Telephone (2) Person to Person			
Authorized Pool Elevation 5558				PERSONNEL - Note Issuant and Person			
Authorized Storage 1927				VERIFICATION OF VERBAL ORDERS ISSUED AND REGULATION BY COLORADO STATE ENGINEER			
Format Revised July 2012				My Signature formally confirms the below logged verbal orders for this weekly period.			

DATE							
Determined By - Flow Rate	0	0	0	0	0	0	0
Time of Flow	00:00 - 24:00	00:00 - 24:00	00:00 - 24:00	00:00 - 24:00	00:00 - 24:00	00:00 - 24:00	00:00 - 24:00
Hours/24 x Flow Rate	24 / 24 x 0	24 / 24 x 0	24 / 24 x 0	24 / 24 x 0	24 / 24 x 0	24 / 24 x 0	24 / 24 x 0
Flow Volume DSF	0	0	0	0	0	0	0
Determined By - Flow Rate							
Time of Flow	0:00 - 00:00	0:00 - 00:00	0:00 - 00:00	0:00 - 00:00	0:00 - 00:00	0:00 - 00:00	0:00 - 00:00
Hours/24 x Flow Rate	0 / 24 x 0	0 / 24 x 0	0 / 24 x 0	0 / 24 x 0	0 / 24 x 0	0 / 24 x 0	0 / 24 x 0
Flow Volume DSF	0	0	0	0	0	0	0
Determined By - Flow Rate							
Time of Flow	00:00 - 00:00	00:00 - 00:00	0:00 - 00:00	00:00 - 00:00	00:00 - 00:00	00:00 - 00:00	00:00 - 00:00
Hours/24 x Flow Rate	0 / 24 x 0	0 / 24 x 0	0 / 24 x 0	0 / 24 x 0	0 / 24 x 0	0 / 24 x 0	0 / 24 x 0
Flow Volume DSF	0	0	0	0	0	0	0
Determined By - Flow Rate							
Time of Flow	00:00 - 00:00	00:00 - 00:00	00:00 - 00:00	00:00 - 00:00	00:00 - 00:00	00:00 - 00:00	00:00 - 24:00
Hours/24 x Flow Rate	0 / 24 x 0	0 / 24 x 0	0 / 24 x 0	0 / 24 x 0	0 / 24 x 0	0 / 24 x 0	24 / 24 x 0
Flow Volume DSF	0	0	0	0	0	0	0
24 Hour Release Volume DSF	0	0	0	0	0	0	0

DATE	TIME	SOURCE	MEANS	PERSONNEL	ORDER - INCLUDE GATE SETTING

Flood Report - Condition B
Normal Regulation - NO Communication Interruption

Date	Time	Observations AND/OR Conversations with Local Agencies or Public		
		Flooding Location	Flooding Damage	Other Comments

Flood Report - Condition C

Emergency Regulation - Communication Interruption

PAGE 1

Date	Time	Explain Attempts to Re-Establish Communication	

Date	Time	Observations AND/OR Conversations with Local Agencies or Public	
		Flooding Location	Flooding Damage

(Continued on next page)

Flood Report - Condition C

Emergency Regulation - Communication Interruption

PAGE 2

Date	Time	Current Pool Elevation (rising, stationary, falling)	Rainfall exceeds or is less than 2"	Downstream Runoff (heavy or light)	Release Schedule to be Followed (C-6 a1, a2, b1, b2)
Date	Time	Current Flood Event Peak Inflow*	Reason for Release Change		Reservoir Release Change

* Release shall not exceed current flood event peak inflow. The Bear Creek Reservoir peak inflow may be estimated by determining the flow at the Bear Creek at Morrison streamgage. Turkey Creek will also contribute to the Bear Creek Reservoir inflow, but is ungaged.

ATTACHMENT 2

Regulation Assistance Procedures

In the event that unusual conditions arise during non-duty hours, communication can be achieved by contacting, in the order listed, one of the following personnel:

DIRECTORY OF REGULATION PERSONNEL CHATFIELD, CHERRY CREEK, AND BEAR CREEK RESERVOIRS

Personnel (Call in order listed)	Office Phone	Cell Phone
CORPS OF ENGINEERS - OMAHA DISTRICT		
Water Control and Water Quality Section (WCWQS)		
[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]
Tri-Lakes Project Office		
[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]
STATE OF COLORADO		
Division of Water Resources		
[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]

DIRECTORY OF PERSONNEL
 DENVER METROPOLITAN - STATE AND LOCAL AGENCIES

Personnel	Office Phone	Cell Phone
U.S. Geological Survey – Denver		
[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]
National Weather Service		
[REDACTED]	[REDACTED]	[REDACTED]
[REDACTED]	[REDACTED]	[REDACTED]
State of Colorado – Division of Homeland Security		
[REDACTED]	[REDACTED]	[REDACTED]
Colorado State Patrol		
[REDACTED]	[REDACTED]	[REDACTED]
Colorado Division of Wildlife		
[REDACTED]	[REDACTED]	[REDACTED]
City and County of Denver – Emergency Management		
[REDACTED]	[REDACTED]	[REDACTED]
City of Littleton – Emergency Management		
[REDACTED]	[REDACTED]	[REDACTED]
City of Sheridan – Public Works		
[REDACTED]	[REDACTED]	[REDACTED]
Commerce City Police Department – Emergency Management		
[REDACTED]	[REDACTED]	[REDACTED]
City of Aurora – Emergency Management		
[REDACTED]	[REDACTED]	[REDACTED]
City of Glendale – Public Works		
[REDACTED]	[REDACTED]	[REDACTED]

DIRECTORY OF PERSONNEL
 DENVER METROPOLITAN - STATE AND LOCAL AGENCIES

Personnel	Office Phone	Cell Phone
Arapahoe County – Emergency Management		
Jefferson County – Emergency Management		
Adams County – Emergency Management		
Urban Drainage and Flood Control District		
Chatfield State Park		
Cherry Creek State Park		
Bear Creek Lake Park		
Last Chance and Nevada Ditch		
City Ditch		
Denver Water		

For Colorado EM updates: <https://www.colorado.gov/pacific/dhsem/local-emergency-managers>

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EXHIBIT II

**LETTER, STATE DIVISION OF GAME, FISH AND PARKS
STATE'S OBLIGATION TO FURNISH WATER FOR BEAR
CREEK RECREATION POOL**

**AGREEMENT BETWEEN THE STATE OF COLORADO AND
THE U.S. ARMY CORPS OF ENGINEERS, OMAHA, DISTRICT**

**MEMORANDUM OF UNDERSTANDING ON REGULATION
FOR BEAR CREEK DAM AND RESERVOIR**

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STATE OF COLORADO John A. Love, Governor
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GAME, FISH AND PARKS

Harry R. Woodward, Director

6060 Broadway Denver, Colorado 80216 • 825-1192



DEPARTMENT OF NATURAL
RESOURCES

I. W. Ten Eyck,
Executive Director

GAME, FISH AND PARKS
COMMISSION

LeRoy Robson, Chairman
Harry Combs, Vice Chairman
Dean Suttie, Secretary
Wilton W. Cogswell, Jr.,
R. Wilbert Cool, Member
Charles A. Gebauer, Member
Orest Gerbacz, Member
Lonnie Pippin, Member
William W. Robinson, Member
Ford Strong, Member

October 1, 1970

Mr. Charles L. Hipp, Chief,
Engineering Division
U. S. Army Corps of Engineers
7410 U. S. Post Office and Court House
Omaha, Nebraska 68102

Dear Mr. Hipp:

The Colorado Game, Fish and Parks Commission has reviewed the Bear Creek Dam and Reservoir Project, South Platte River, Colorado. The Commission has concurred in statements relating to the fish, wildlife and recreational resources in accordance with the Federal Water Project Recreation Act. These statements are enumerated under local cooperation and quoted from the authorizing document (Senate Document 97, 90th Congress, 2nd Session). The Commission agrees with the following recommendations as enumerated in the aforementioned document.

1. Administer land and water areas for recreation and fish and wildlife enhancement.
2. Pay, contribute in kind, or repay (which may be through user fees) with interest, one-half of the separable cost allocated to recreation and fish and wildlife enhancement, presently estimated at \$1,911,000; and
3. Bear all costs of operation, maintenance, and replacement of recreation and fish and wildlife lands and facilities including water replacement, presently estimated at \$195,000 on an average annual basis;
4. Provide the water required for initial filling and replenishment of evaporation losses of the recreation pool by purchase or other means consistent with Federal and State laws, to assure effective operation of the project for recreation with provision that the cost thereof for initial filling is eligible for credit against the non-Federal obligation for assuming one-half the separable costs for recreation and fish and wildlife enhancement.

EXHIBIT 1-1

Mr. Charles L. Hipp
October 1, 1970
page 2.

Participation in the cost-sharing responsibilities and the administration of the area must necessarily be subject to future appropriation from the General Fund by the Colorado General Assembly.

The Commission does not want to participate in cost-sharing through the Land and Water Conservation Fund program. The Commission will participate pursuant to the provisions of P. L. 89-72, as previously stated and as the project is now authorized.

Should you need additional information or expression of interest, please notify me.

Sincerely,



Harry R. Woodward
Director

PTB:lp

cc: T. W. Ten Eyck
Felix L. Sparks
E. P. Cook

AGREEMENT
BETWEEN
THE UNITED STATES OF AMERICA
AND
THE STATE OF COLORADO

THIS AGREEMENT entered into this 16th day of August, 1982, by and between the UNITED STATES OF AMERICA (hereinafter called the "Government"), represented by the Contracting Officer executing this agreement, and the State of Colorado, acting by and through the Division of Parks and Outdoor Recreation and the Water Conservation Board, Department of Natural Resources (hereinafter called the "State");

WHEREAS, the Government has entered into a contract with the State for recreation and fish and wildlife development at Bear Creek Lake, Contract No. DACW45-73-C-0033 (hereinafter called the "Contract"), which Contract was approved by the Acting Secretary of the Army on 26 January, 1973; and

WHEREAS, no development has yet taken place pursuant to said Contract and the City of Lakewood, Colorado, now wishes to undertake such development; and

WHEREAS, the State by letter of 1 October 1970 advised the Government that the State intended to provide the water required for replenishment of evaporation losses of the recreation pool at the Bear Creek Lake project; and

WHEREAS, it is the desire of the parties hereto, in light of the above cited circumstances, to discharge each party of its obligations under the Contract in order to avoid any and all future claims that might arise out of said Contract; and

WHEREAS, the Government agrees to discharge the State from its obligations under the Contract in consideration of the State discharging the Government from its obligations under the Contract and providing water to replenish evaporation losses of the recreation pool at Bear Creek Lake project.

NOW THEREFORE, the parties agree as follow:

1. That Contract No. DACW45-73-C-0033 for recreation and fish and wildlife development at the Bear Creek Lake Project, Colorado is hereby terminated.

2. The State shall provide the water required for replenishment of evaporation losses of the recreation pool at the Bear Creek Lake Project by purchase or other means consistent with Federal and State laws, to assure effective operation of the project for recreation; provided, however, that the State's obligations in this regard shall be subject to future appropriations by the Colorado General Assembly and to the execution of a contract between the Government and the City of Lakewood, Colorado, for recreation development at Bear Creek Lake, Colorado.

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

THE UNITED STATES OF AMERICA

By

GRANT L. FREDRICKS
LTC, Corps of Engineers
Deputy District Engineer
Contracting Officer

Date 30 June 1982

APPROVED:

By

Assistant Secretary of the Army (Civil Works)

Date 16 AUG 1982

THE STATE OF COLORADO
RICHARD D. LAMM, GOVERNOR

By

D. Monte Pascoe
Executive Director
Colorado Department of
Natural Resources

Date June 28, 1982

By

George T. O'Malley
Director
Division of Parks &
Outdoor Recreation

Date June 25, 1982

By

J. William McDonald
Director
Water Conservation Board

Date June 25, 1982

APPROVED:

J. D. MacFarlane
Attorney General

By

Assistant Solicitor General
General Legal Services

Date June 28, 1982

James A. Stroup, Controller

By

Date 6.28.82

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**MEMORANDUM OF UNDERSTANDING
BETWEEN
UNITED STATES OF AMERICA AND THE STATE OF COLORADO
ON
REGULATION FOR BEAR CREEK DAM AND RESERVOIR**

(Revised March 1988)

This Memorandum of Understanding regarding the regulation for the Bear Creek Dam and Reservoir, Lakewood, Colorado is hereby mutually agreed to by and between the United States of America (herein after referred to as the "Government") represented by the District Engineer, United States Army Engineer District, Omaha, and the State of Colorado (herein after referred to as the "State") represented by the State Engineer for the following purposes: to effect a clear understanding of the procedure for the regulation of the flow in Bear Creek as it relates to Bear Creek Dam and Reservoir; to insure that such regulation is compatible with the States administration of water rights; and, to insure that the Bear Creek Dam and Reservoir is regulated for flood control as authorized.

This Memorandum of Understanding supersedes the Memorandum of Understanding previously agreed to by and between the parties and dated May 11, 1977. The Government and the State agree that this Memorandum of Understanding may be modified again at any time by mutual consent.

Nothing in this Memorandum of Understanding is intended or implied to relieve the State of its responsibility for the administration of the waters of the State. Also, nothing is intended or implied to relieve the Government of its responsibility for regulating the Bear Creek Dam and Reservoir to achieve its flood control purposes.

1. Project Authorization. Construction of the Bear Creek Dam and Reservoir was authorized by the U.S. Congress in the Flood Control Act of 1968 for the purposes of flood control, general recreation, and fish and wildlife enhancement. The project was planned and designed by and constructed under the supervision of the United States Army Corps of Engineers.

2. Storage Zones and Design Elevations. Bear Creek Reservoir currently contains an estimated 1,930 acre-feet of storage space below the overflow weir of the outlet works intake structure. The crest elevation of the weir is 5558.0 feet m.s.l. The storage capacity of the reservoir zone below this elevation is intended for sediment reserve and recreation usage. Between elevations 5558.0 feet m.s.l. and 5635.5 feet m.s.l., there is currently estimated to be 28,757

acre-feet of storage space which is designated for flood control regulation. Between elevations 5635.5 feet m.s.l. and 5684.5 feet m.s.l. there is currently estimated to be 47,350 acre-feet of storage space which is designated as surcharge storage to permit safe passage of the probable maximum flood. A freeboard zone of five feet is provided between elevations 5684.5 feet m.s.l. and the crest of the dam embankment at elevation 5689.5 feet m.s.l. An ungated spillway is provided with a crest elevation at 5667.0 feet m.s.l.

3. Plan of Regulation. The Bear Creek Dam and Reservoir will be regulated for flood control and multi-purpose usage by the parties to the Memorandum of Understanding. The project outlet works were designed and constructed to automatically discharge non-flood streamflow over the weir of the intake structure, and have been operated this way since the project became operational in 1977. Pursuant to this Memorandum of Understanding, continuous gated releases for water rights and/or water supply may be made.

4. Release Responsibility.

a. District Engineer. The District Engineer, U.S. Army Engineer District, Omaha, operating by and through the Engineering Division, U.S. Army Engineer District, Omaha will determine releases for flood control when the pool level rises to one foot above the top of the conservation pool, to elevation 5559.0 feet m.s.l. The discharge will be based on downstream discharge conditions and the design concepts of the reservoir project. The District Engineer will issue flood-control release orders directly to the Tri-Lakes Project Manager. The State Engineer or his representative will be consulted to assure that flood control releases are sufficient to meet downstream water right requirements, and to advise him of contemplated releases. However, during actual or incipient flash-flood-emergency situations downstream of the dam in the Denver area, if time or communication facilities do not permit such consultations, the District Engineer reserves the right to reduce the reservoir release rate to as low as zero in the interest of flood control. The decision on whether an actual or incipient flood emergency exists, and the decision on releases during the flood emergency period, will be the responsibility of the District Engineer. Oral orders to the Tri-Lakes Project Manager will be confirmed in writing, and a copy of the written orders will be furnished to the State Engineer.

b. State Engineer. The State Engineer or his representative will determine the storage and releases necessary to satisfy downstream water right requirements when the pool level is below elevation 5559.0 feet m.s.l. Elevation 5559.0 feet m.s.l. is one foot into the flood storage zone, thus allowing flexibility in targeting authorized pool levels. Pursuant to applicable law and regulations, the Government may contract with the State or with local entities for the use of water storage by the State or by such local entities, provided such storage is located below elevation 5559.0 feet m.s.l. With respect to such contracts, the State Engineer will be responsible for the administration and accounting for the use of such contracted storage.

The State Engineer or his representative will issue release orders directly to the Tri-Lakes Project Manager. In an effort to minimize gate operations, no more than one gate change will be regularly scheduled each day. However, more frequent changes will be made if so required by the State Engineer. The order will normally be given early in the work day (before 0900 hours) in order to allow the Tri-Lakes Project Manager to efficiently schedule his workforce. The State Engineer will notify the Tri-Lakes Project Manager of the authorized daily pool level if the outflow is not being discharged automatically over the weir of the intake structure. Conflicts relating to instructions on reservoir releases will be resolved by the District Engineer and the State Engineer.

5. Other Water Accounting Responsibilities and Duties.

a. Inflow Computation. The State Engineer will compute daily inflow to the Bear Creek Reservoir as required for his administrative purposes. The District Engineer will compute daily inflow for his operational and record purposes. Daily inflows will be verified and documented monthly by the District Engineer for the official record. Inflows will be computed using the following formula:

$\text{Inflow} = \text{River Release} + \text{Evaporation} + \text{Change in Storage}$
Such computation of inflow shall be compared with available area gaging station information.

b. Evaporation. Evaporation will be determined from the evaporation pan located at Cherry Creek Dam. During winter or other periods when the pan is inoperable, the average pan evaporation depths used for Cherry Creek Reservoir will be utilized. These average values are: Jan 0.7", Feb 0.9", Mar 1.5", Apr 3.9", May 6.4", Jun 8.2", Jul 9.5", Aug 8.0", Sep 6.5", Oct 4.6", Nov 2.3", and Dec 1.0".

c. Reservoir Outflow. The amount of water released from Bear Creek Dam and Reservoir will be determined from the rating of the (1) stream gaging station located approximately 600 feet below the dam and/or (2) outlet gates. These ratings will be periodically verified by discharge measurements made by the State, the U.S. Geological Survey and the U.S. Army Corps of Engineers.

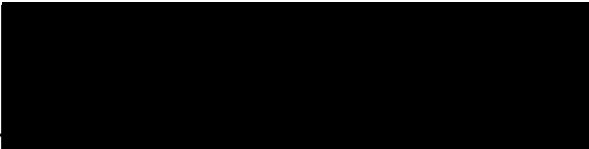
d. Exchange of Information. Inflow computed by representatives of the State Engineer or District Engineer will be freely exchanged as requested. Other project operational and hydrologic data will also be freely exchanged. This includes exchange of discharge measurements of the outlet release and at the Morrison and Sheridan stream gaging stations. A record of the water released to the Pioneer Union Ditch will be furnished to the District Engineer by the State Engineer as requested.

e. Project Log. The Tri-Lakes Project Manager will maintain a log on appropriate U.S. Army Corps of Engineer forms, of the daily authorized and actual pool elevations, reservoir release rates, computed inflow, and reservoir regulation orders furnished to him. A copy of the Manager's log will be furnished to the Omaha District, Engineering Division, normally on a weekly basis. The Manager's log

will note the release orders given by the State Engineer and may serve as a record of such orders. The State Engineer will certify the accuracy of the log and orders furnished by him, when requested by the District Engineer.

6. Project Safety. The District Engineer is solely responsible for the operation, maintenance and safety of the outlet works, spillway and dam.

7. The State agrees to hold and save the Government free and harmless from all claims for damages arising from reservoir regulations carried out in response to instructions from the State Engineer or his agents.



Jeris Danielson
State Engineer, Colorado

20 JUN 88
Date



Steven G. West
Colonel, U.S. Army
District Engineer

25 April 88
Date

EXHIBIT III

BEAR CREEK DAM AND RESERVOIR AREA AND STORAGE CAPACITY TABLES

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BEAR CREEK PROJECT - 2009 RESURVEY - Effective Date 12 March 2010**Area in Acres
(2009 Survey)**

ELEV	0	1	2	3	4	5	6	7	8	9
5520	0	0	1	3	6	8	11	14	16	18
5530	21	23	25	27	30	33	36	40	43	46
5540	50	53	56	60	63	66	69	72	75	77
5550	80	81	84	87	91	95	100	103	107	111
5560	114	117	120	124	129	133	137	141	146	150
5570	155	160	164	169	175	181	187	193	199	206
5580	213	219	226	234	244	254	264	273	282	290
5590	297	304	312	319	326	332	338	345	353	361
5600	371	380	389	397	404	411	417	424	433	445
5610	457	469	480	491	502	512	522	533	545	557
5620	571	585	598	609	617	625	633	641	650	658
5630	666	674	682	690	698	707	715	723	732	742
5640	753	762	772	782	792	802	812	822	832	843
5650	853	864	875	886	896	907	918	929	939	949
5660	959	968	978	988	998	1008	1018	1028	1038	1048
5670	1058	1068	1078	1088	1099	1110	1119	1130	1141	1154
5680	1167	1180	1193	1206	1219					

BEAR CREEK PROJECT - 2009 RESURVEY - Effective Date 12 March 2010**Capacity in Acre-Feet
(2009 Survey)**

ELEV	0	1	2	3	4	5	6	7	8	9
5520	0	0	0	2	7	14	24	37	53	70
5530	90	112	136	162	191	223	258	296	338	382
5540	430	482	537	595	657	721	789	859	933	1009
5550	1088	1169	1251	1337	1426	1519	1617	1719	1824	1933
5560	2046	2162	2281	2403	2530	2661	2796	2935	3079	3227
5570	3380	3538	3700	3867	4039	4218	4402	4592	4788	4990
5580	5200	5417	5639	5869	6108	6357	6617	6886	7164	7451
5590	7744	8045	8353	8669	8992	9322	9657	9999	10348	10705
5600	11071	11447	11832	12225	12626	13034	13448	13868	14296	14735
5610	15186	15649	16124	16609	17106	17613	18131	18658	19198	19749
5620	20313	20892	21484	22088	22702	23323	23952	24589	25235	25890
5630	26552	27222	27900	28586	29280	29983	30694	31413	32141	32878
5640	33626	34384	35151	35928	36716	37513	38320	39137	39964	40802
5650	41650	42509	43379	44260	45151	46053	46966	47890	48824	49769
5660	50723	51687	52660	53644	54637	55641	56654	57678	58711	59754
5670	60808	61871	62945	64028	65122	66227	67342	68466	69602	70749
5680	71910	73084	74271	75470	76681	77905				

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre-Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5521	0	0	0	0	0	0	0	0	0	0
0.1	0	0	0	0	0	0	0	0	0	0
0.2	0	0	0	0	0	0	0	0	0	0
0.3	0	0	0	0	0	0	0	0	0	0
0.4	0	0	0	0	0	0	0	0	0	0
0.5	0	0	0	0	0	0	0	0	0	0
0.6	0	0	0	0	0	0	0	0	0	0
0.7	0	0	0	0	0	0	0	0	0	0
0.8	0	0	0	0	0	0	0	0	0	0
0.9	0	0	0	0	0	0	0	0	0	0
5522	0	0	0	0	0	0	0	0	0	0
0.1	0	0	0	0	0	0	0	0	0	0
0.2	0	0	0	0	0	0	1	1	1	1
0.3	1	1	1	1	1	1	1	1	1	1
0.4	1	1	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1	1	1
0.6	1	1	1	1	1	1	1	1	1	1
0.7	1	1	1	1	1	1	2	2	2	2
0.8	2	2	2	2	2	2	2	2	2	2
0.9	2	2	2	2	2	2	2	2	2	2
5523	2	2	2	2	2	2	2	2	2	2
0.1	2	3	3	3	3	3	3	3	3	3
0.2	3	3	3	3	3	3	3	3	3	3
0.3	3	4	4	4	4	4	4	4	4	4
0.4	4	4	4	4	4	4	4	4	4	4
0.5	4	5	5	5	5	5	5	5	5	5
0.6	5	5	5	5	5	5	5	5	5	5
0.7	5	6	6	6	6	6	6	6	6	6
0.8	6	6	6	6	6	6	6	6	6	6
0.9	6	7	7	7	7	7	7	7	7	7
5524	7	7	7	7	7	7	7	7	8	8
0.1	8	8	8	8	8	8	8	8	8	8
0.2	8	8	9	9	9	9	9	9	9	9
0.3	9	9	9	9	9	9	10	10	10	10
0.4	10	10	10	10	10	10	10	10	10	10
0.5	10	11	11	11	11	11	11	11	11	11
0.6	11	11	11	11	11	12	12	12	12	12
0.7	12	12	12	12	12	12	12	12	12	13
0.8	13	13	13	13	13	13	13	13	13	13
0.9	13	13	13	14	14	14	14	14	14	14
5525	14	14	14	14	14	14	15	15	15	15
0.1	15	15	15	15	15	15	16	16	16	16
0.2	16	16	16	16	16	16	17	17	17	17
0.3	17	17	17	17	17	17	18	18	18	18
0.4	18	18	18	18	18	18	19	19	19	19
0.5	19	19	19	19	19	19	20	20	20	20
0.6	20	20	20	20	20	20	21	21	21	21
0.7	21	21	21	21	21	21	22	22	22	22
0.8	22	22	22	22	22	22	23	23	23	23
0.9	23	23	23	23	23	23	24	24	24	24

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5526	24	24	24	24	25	25	25	25	25	25
0.1	25	25	26	26	26	26	26	26	26	26
0.2	27	27	27	27	27	27	27	28	28	28
0.3	28	28	28	28	28	29	29	29	29	29
0.4	29	29	29	30	30	30	30	30	30	30
0.5	30	31	31	31	31	31	31	31	32	32
0.6	32	32	32	32	32	32	33	33	33	33
0.7	33	33	33	33	34	34	34	34	34	34
0.8	34	35	35	35	35	35	35	35	35	36
0.9	36	36	36	36	36	36	36	37	37	37
5527	37	37	37	37	38	38	38	38	38	38
0.1	39	39	39	39	39	39	40	40	40	40
0.2	40	40	41	41	41	41	41	41	41	42
0.3	42	42	42	42	42	43	43	43	43	43
0.4	43	44	44	44	44	44	44	45	45	45
0.5	45	45	45	45	46	46	46	46	46	46
0.6	47	47	47	47	47	47	48	48	48	48
0.7	48	48	49	49	49	49	49	49	49	50
0.8	50	50	50	50	50	51	51	51	51	51
0.9	51	52	52	52	52	52	52	53	53	53
5528	53	53	53	54	54	54	54	54	54	55
0.1	55	55	55	55	55	56	56	56	56	56
0.2	56	57	57	57	57	57	57	58	58	58
0.3	58	58	58	59	59	59	59	59	59	60
0.4	60	60	60	60	60	61	61	61	61	61
0.5	61	62	62	62	62	62	63	63	63	63
0.6	63	63	64	64	64	64	64	64	65	65
0.7	65	65	65	65	66	66	66	66	66	66
0.8	67	67	67	67	67	67	68	68	68	68
0.9	68	68	69	69	69	69	69	69	70	70
5529	70	70	70	71	71	71	71	71	72	72
0.1	72	72	72	73	73	73	73	73	74	74
0.2	74	74	74	75	75	75	75	75	76	76
0.3	76	76	76	77	77	77	77	77	78	78
0.4	78	78	78	79	79	79	79	79	80	80
0.5	80	80	80	81	81	81	81	81	82	82
0.6	82	82	82	83	83	83	83	83	84	84
0.7	84	84	84	85	85	85	85	85	86	86
0.8	86	86	86	87	87	87	87	87	88	88
0.9	88	88	88	89	89	89	89	89	90	90
5530	90	90	90	91	91	91	91	92	92	92
0.1	92	92	93	93	93	93	94	94	94	94
0.2	94	95	95	95	95	95	96	96	96	96
0.3	97	97	97	97	97	98	98	98	98	99
0.4	99	99	99	99	100	100	100	100	101	101
0.5	101	101	101	102	102	102	102	103	103	103
0.6	103	103	104	104	104	104	105	105	105	105
0.7	105	106	106	106	106	106	107	107	107	107
0.8	108	108	108	108	108	109	109	109	109	110
0.9	110	110	110	110	111	111	111	111	112	112

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre-Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5531	112	112	112	113	113	113	113	114	114	114
0.1	114	115	115	115	115	116	116	116	116	117
0.2	117	117	117	118	118	118	118	118	119	119
0.3	119	119	120	120	120	120	121	121	121	121
0.4	122	122	122	122	123	123	123	123	124	124
0.5	124	124	124	125	125	125	125	126	126	126
0.6	126	127	127	127	127	128	128	128	128	129
0.7	129	129	129	130	130	130	130	130	131	131
0.8	131	131	132	132	132	132	133	133	133	133
0.9	134	134	134	134	135	135	135	135	136	136
5532	136	136	137	137	137	137	138	138	138	138
0.1	139	139	139	139	140	140	140	140	141	141
0.2	141	141	142	142	142	142	143	143	143	144
0.3	144	144	144	145	145	145	145	146	146	146
0.4	146	147	147	147	147	148	148	148	148	149
0.5	149	149	150	150	150	150	151	151	151	151
0.6	152	152	152	152	153	153	153	153	154	154
0.7	154	154	155	155	155	155	156	156	156	157
0.8	157	157	157	158	158	158	158	159	159	159
0.9	159	160	160	160	160	161	161	161	161	162
5533	162	162	163	163	163	163	164	164	164	165
0.1	165	165	165	166	166	166	167	167	167	168
0.2	168	168	168	169	169	169	170	170	170	170
0.3	171	171	171	172	172	172	172	173	173	173
0.4	174	174	174	174	175	175	175	176	176	176
0.5	176	177	177	177	178	178	178	179	179	179
0.6	179	180	180	180	181	181	181	181	182	182
0.7	182	183	183	183	183	184	184	184	185	185
0.8	185	185	186	186	186	187	187	187	188	188
0.9	188	188	189	189	189	190	190	190	190	191
5534	191	191	192	192	192	193	193	193	194	194
0.1	194	195	195	195	195	196	196	196	197	197
0.2	197	198	198	198	199	199	199	200	200	200
0.3	201	201	201	202	202	202	203	203	203	203
0.4	204	204	204	205	205	205	206	206	206	207
0.5	207	207	208	208	208	209	209	209	210	210
0.6	210	211	211	211	211	212	212	212	213	213
0.7	213	214	214	214	215	215	215	216	216	216
0.8	217	217	217	218	218	218	219	219	219	219
0.9	220	220	220	221	221	221	222	222	222	223
5535	223	223	224	224	224	225	225	225	226	226
0.1	226	227	227	228	228	228	229	229	229	230
0.2	230	230	231	231	231	232	232	232	233	233
0.3	233	234	234	235	235	235	236	236	236	237
0.4	237	237	238	238	238	239	239	239	240	240
0.5	240	241	241	242	242	242	243	243	243	244
0.6	244	244	245	245	245	246	246	246	247	247
0.7	247	248	248	249	249	249	250	250	250	251
0.8	251	251	252	252	252	253	253	253	254	254
0.9	254	255	255	256	256	256	257	257	257	258

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5536	258	258	259	259	260	260	260	261	261	261
0.1	262	262	263	263	263	264	264	264	265	265
0.2	266	266	266	267	267	267	268	268	269	269
0.3	269	270	270	271	271	271	272	272	272	273
0.4	273	274	274	274	275	275	275	276	276	277
0.5	277	277	278	278	279	279	279	280	280	280
0.6	281	281	282	282	282	283	283	283	284	284
0.7	285	285	285	286	286	286	287	287	288	288
0.8	288	289	289	290	290	290	291	291	291	292
0.9	292	293	293	293	294	294	294	295	295	296
5537	296	296	297	297	298	298	299	299	299	300
0.1	300	301	301	301	302	302	303	303	304	304
0.2	304	305	305	306	306	306	307	307	308	308
0.3	309	309	309	310	310	311	311	312	312	312
0.4	313	313	314	314	314	315	315	316	316	317
0.5	317	317	318	318	319	319	320	320	320	321
0.6	321	322	322	322	323	323	324	324	325	325
0.7	325	326	326	327	327	327	328	328	329	329
0.8	330	330	330	331	331	332	332	333	333	333
0.9	334	334	335	335	335	336	336	337	337	338
5538	338	338	339	339	340	340	341	341	342	342
0.1	342	343	343	344	344	345	345	345	346	346
0.2	347	347	348	348	349	349	349	350	350	351
0.3	351	352	352	353	353	353	354	354	355	355
0.4	356	356	356	357	357	358	358	359	359	360
0.5	360	360	361	361	362	362	363	363	364	364
0.6	364	365	365	366	366	367	367	367	368	368
0.7	369	369	370	370	371	371	371	372	372	373
0.8	373	374	374	375	375	375	376	376	377	377
0.9	378	378	378	379	379	380	380	381	381	382
5539	382	382	383	383	384	384	385	385	386	386
0.1	387	387	388	388	389	389	390	390	391	391
0.2	392	392	393	393	394	394	394	395	395	396
0.3	396	397	397	398	398	399	399	400	400	401
0.4	401	402	402	403	403	404	404	405	405	406
0.5	406	406	407	407	408	408	409	409	410	410
0.6	411	411	412	412	413	413	414	414	415	415
0.7	416	416	417	417	418	418	418	419	419	420
0.8	420	421	421	422	422	423	423	424	424	425
0.9	425	426	426	427	427	428	428	429	429	430
5540	430	431	431	432	432	433	433	434	434	435
0.1	435	436	436	437	437	438	438	439	439	440
0.2	440	441	441	442	442	443	444	444	445	445
0.3	446	446	447	447	448	448	449	449	450	450
0.4	451	451	452	452	453	453	454	454	455	455
0.5	456	457	457	458	458	459	459	460	460	461
0.6	461	462	462	463	463	464	464	465	465	466
0.7	466	467	467	468	468	469	470	470	471	471
0.8	472	472	473	473	474	474	475	475	476	476
0.9	477	477	478	478	479	479	480	480	481	481

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5541	482	483	483	484	484	485	485	486	486	487
0.1	487	488	489	489	490	490	491	491	492	492
0.2	493	494	494	495	495	496	496	497	497	498
0.3	498	499	500	500	501	501	502	502	503	503
0.4	504	505	505	506	506	507	507	508	508	509
0.5	509	510	511	511	512	512	513	513	514	514
0.6	515	516	516	517	517	518	518	519	519	520
0.7	520	521	522	522	523	523	524	524	525	525
0.8	526	527	527	528	528	529	529	530	530	531
0.9	531	532	533	533	534	534	535	535	536	536
5542	537	538	538	539	539	540	540	541	542	542
0.1	543	543	544	545	545	546	546	547	547	548
0.2	549	549	550	550	551	551	552	553	553	554
0.3	554	555	556	556	557	557	558	558	559	560
0.4	560	561	561	562	563	563	564	564	565	565
0.5	566	567	567	568	568	569	569	570	571	571
0.6	572	572	573	574	574	575	575	576	576	577
0.7	578	578	579	579	580	580	581	582	582	583
0.8	583	584	585	585	586	586	587	587	588	589
0.9	589	590	590	591	592	592	593	593	594	594
5543	595	596	596	597	597	598	599	599	600	601
0.1	601	602	602	603	604	604	605	606	606	607
0.2	607	608	609	609	610	610	611	612	612	613
0.3	614	614	615	615	616	617	617	618	619	619
0.4	620	620	621	622	622	623	624	624	625	625
0.5	626	627	627	628	628	629	630	630	631	632
0.6	632	633	633	634	635	635	636	637	637	638
0.7	638	639	640	640	641	641	642	643	643	644
0.8	645	645	646	646	647	648	648	649	650	650
0.9	651	651	652	653	653	654	655	655	656	656
5544	657	658	658	659	660	660	661	661	662	663
0.1	663	664	665	665	666	667	667	668	669	669
0.2	670	670	671	672	672	673	674	674	675	676
0.3	676	677	677	678	679	679	680	681	681	682
0.4	683	683	684	685	685	686	686	687	688	688
0.5	689	690	690	691	692	692	693	693	694	695
0.6	695	696	697	697	698	699	699	700	701	701
0.7	702	702	703	704	704	705	706	706	707	708
0.8	708	709	709	710	711	711	712	713	713	714
0.9	715	715	716	717	717	718	718	719	720	720
5545	721	722	722	723	724	724	725	726	726	727
0.1	728	728	729	730	731	731	732	733	733	734
0.2	735	735	736	737	737	738	739	739	740	741
0.3	741	742	743	743	744	745	745	746	747	748
0.4	748	749	750	750	751	752	752	753	754	754
0.5	755	756	756	757	758	758	759	760	760	761
0.6	762	762	763	764	765	765	766	767	767	768
0.7	769	769	770	771	771	772	773	773	774	775
0.8	775	776	777	777	778	779	779	780	781	782
0.9	782	783	784	784	785	786	786	787	788	788

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5546	789	790	790	791	792	792	793	794	795	795
0.1	796	797	797	798	799	799	800	801	802	802
0.2	803	804	804	805	806	806	807	808	809	809
0.3	810	811	811	812	813	813	814	815	816	816
0.4	817	818	818	819	820	820	821	822	823	823
0.5	824	825	825	826	827	827	828	829	830	830
0.6	831	832	832	833	834	834	835	836	837	837
0.7	838	839	839	840	841	841	842	843	844	844
0.8	845	846	846	847	848	848	849	850	851	851
0.9	852	853	853	854	855	855	856	857	858	858
5547	859	860	860	861	862	863	863	864	865	866
0.1	866	867	868	869	869	870	871	872	872	873
0.2	874	875	875	876	877	877	878	879	880	880
0.3	881	882	883	883	884	885	886	886	887	888
0.4	889	889	890	891	892	892	893	894	895	895
0.5	896	897	897	898	899	900	900	901	902	903
0.6	903	904	905	906	906	907	908	909	909	910
0.7	911	912	912	913	914	914	915	916	917	917
0.8	918	919	920	920	921	922	923	923	924	925
0.9	926	926	927	928	929	929	930	931	932	932
5548	933	934	935	935	936	937	938	938	939	940
0.1	941	941	942	943	944	944	945	946	947	947
0.2	948	949	950	950	951	952	953	954	954	955
0.3	956	957	957	958	959	960	960	961	962	963
0.4	963	964	965	966	966	967	968	969	969	970
0.5	971	972	973	973	974	975	976	976	977	978
0.6	979	979	980	981	982	982	983	984	985	985
0.7	986	987	988	988	989	990	991	992	992	993
0.8	994	995	995	996	997	998	998	999	1000	1001
0.9	1001	1002	1003	1004	1004	1005	1006	1007	1007	1008
5549	1009	1010	1011	1011	1012	1013	1014	1015	1015	1016
0.1	1017	1018	1018	1019	1020	1021	1022	1022	1023	1024
0.2	1025	1026	1026	1027	1028	1029	1030	1030	1031	1032
0.3	1033	1033	1034	1035	1036	1037	1037	1038	1039	1040
0.4	1041	1041	1042	1043	1044	1045	1045	1046	1047	1048
0.5	1048	1049	1050	1051	1052	1052	1053	1054	1055	1056
0.6	1056	1057	1058	1059	1060	1060	1061	1062	1063	1064
0.7	1064	1065	1066	1067	1067	1068	1069	1070	1071	1071
0.8	1072	1073	1074	1075	1075	1076	1077	1078	1079	1079
0.9	1080	1081	1082	1082	1083	1084	1085	1086	1086	1087
5550	1088	1089	1090	1090	1091	1092	1093	1094	1094	1095
0.1	1096	1097	1098	1099	1099	1100	1101	1102	1103	1103
0.2	1104	1105	1106	1107	1107	1108	1109	1110	1111	1111
0.3	1112	1113	1114	1115	1116	1116	1117	1118	1119	1120
0.4	1120	1121	1122	1123	1124	1124	1125	1126	1127	1128
0.5	1128	1129	1130	1131	1132	1133	1133	1134	1135	1136
0.6	1137	1137	1138	1139	1140	1141	1141	1142	1143	1144
0.7	1145	1146	1146	1147	1148	1149	1150	1150	1151	1152
0.8	1153	1154	1154	1155	1156	1157	1158	1158	1159	1160
0.9	1161	1162	1163	1163	1164	1165	1166	1167	1167	1168

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5551	1169	1170	1171	1171	1172	1173	1174	1175	1176	1176
0.1	1177	1178	1179	1180	1180	1181	1182	1183	1184	1185
0.2	1185	1186	1187	1188	1189	1189	1190	1191	1192	1193
0.3	1194	1194	1195	1196	1197	1198	1199	1199	1200	1201
0.4	1202	1203	1203	1204	1205	1206	1207	1208	1208	1209
0.5	1210	1211	1212	1212	1213	1214	1215	1216	1217	1217
0.6	1218	1219	1220	1221	1221	1222	1223	1224	1225	1226
0.7	1226	1227	1228	1229	1230	1230	1231	1232	1233	1234
0.8	1235	1235	1236	1237	1238	1239	1240	1240	1241	1242
0.9	1243	1244	1244	1245	1246	1247	1248	1249	1249	1250
5552	1251	1252	1253	1254	1254	1255	1256	1257	1258	1259
0.1	1260	1260	1261	1262	1263	1264	1265	1266	1266	1267
0.2	1268	1269	1270	1271	1272	1272	1273	1274	1275	1276
0.3	1277	1278	1279	1279	1280	1281	1282	1283	1284	1285
0.4	1285	1286	1287	1288	1289	1290	1291	1291	1292	1293
0.5	1294	1295	1296	1297	1297	1298	1299	1300	1301	1302
0.6	1303	1303	1304	1305	1306	1307	1308	1309	1309	1310
0.7	1311	1312	1313	1314	1315	1315	1316	1317	1318	1319
0.8	1320	1321	1322	1322	1323	1324	1325	1326	1327	1328
0.9	1328	1329	1330	1331	1332	1333	1334	1334	1335	1336
5553	1337	1338	1339	1340	1341	1341	1342	1343	1344	1345
0.1	1346	1347	1348	1349	1349	1350	1351	1352	1353	1354
0.2	1355	1356	1357	1357	1358	1359	1360	1361	1362	1363
0.3	1364	1365	1365	1366	1367	1368	1369	1370	1371	1372
0.4	1373	1373	1374	1375	1376	1377	1378	1379	1380	1381
0.5	1381	1382	1383	1384	1385	1386	1387	1388	1389	1390
0.6	1390	1391	1392	1393	1394	1395	1396	1397	1398	1398
0.7	1399	1400	1401	1402	1403	1404	1405	1406	1406	1407
0.8	1408	1409	1410	1411	1412	1413	1414	1414	1415	1416
0.9	1417	1418	1419	1420	1421	1422	1422	1423	1424	1425
5554	1426	1427	1428	1429	1430	1431	1432	1433	1433	1434
0.1	1435	1436	1437	1438	1439	1440	1441	1442	1443	1444
0.2	1445	1446	1446	1447	1448	1449	1450	1451	1452	1453
0.3	1454	1455	1456	1457	1458	1459	1459	1460	1461	1462
0.4	1463	1464	1465	1466	1467	1468	1469	1470	1471	1472
0.5	1472	1473	1474	1475	1476	1477	1478	1479	1480	1481
0.6	1482	1483	1484	1485	1486	1486	1487	1488	1489	1490
0.7	1491	1492	1493	1494	1495	1496	1497	1498	1499	1499
0.8	1500	1501	1502	1503	1504	1505	1506	1507	1508	1509
0.9	1510	1511	1512	1512	1513	1514	1515	1516	1517	1518
5555	1519	1520	1521	1522	1523	1524	1525	1526	1527	1528
0.1	1529	1530	1531	1532	1533	1534	1535	1536	1537	1538
0.2	1539	1540	1541	1542	1543	1543	1544	1545	1546	1547
0.3	1548	1549	1550	1551	1552	1553	1554	1555	1556	1557
0.4	1558	1559	1560	1561	1562	1563	1564	1565	1566	1567
0.5	1568	1569	1570	1571	1572	1573	1574	1575	1576	1577
0.6	1578	1579	1580	1581	1582	1583	1584	1585	1586	1587
0.7	1588	1589	1590	1591	1592	1592	1593	1594	1595	1596
0.8	1597	1598	1599	1600	1601	1602	1603	1604	1605	1606
0.9	1607	1608	1609	1610	1611	1612	1613	1614	1615	1616

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5556	1617	1618	1619	1620	1621	1622	1623	1624	1625	1626
0.1	1627	1628	1629	1630	1631	1632	1633	1634	1635	1636
0.2	1637	1638	1639	1640	1641	1642	1644	1645	1646	1647
0.3	1648	1649	1650	1651	1652	1653	1654	1655	1656	1657
0.4	1658	1659	1660	1661	1662	1663	1664	1665	1666	1667
0.5	1668	1669	1670	1671	1672	1673	1674	1675	1676	1677
0.6	1678	1679	1680	1681	1682	1683	1684	1685	1686	1687
0.7	1688	1689	1690	1691	1692	1693	1695	1696	1697	1698
0.8	1699	1700	1701	1702	1703	1704	1705	1706	1707	1708
0.9	1709	1710	1711	1712	1713	1714	1715	1716	1717	1718
5557	1719	1720	1721	1722	1723	1724	1725	1726	1727	1728
0.1	1729	1731	1732	1733	1734	1735	1736	1737	1738	1739
0.2	1740	1741	1742	1743	1744	1745	1746	1747	1748	1749
0.3	1750	1752	1753	1754	1755	1756	1757	1758	1759	1760
0.4	1761	1762	1763	1764	1765	1766	1767	1768	1769	1770
0.5	1771	1773	1774	1775	1776	1777	1778	1779	1780	1781
0.6	1782	1783	1784	1785	1786	1787	1788	1789	1790	1791
0.7	1792	1794	1795	1796	1797	1798	1799	1800	1801	1802
0.8	1803	1804	1805	1806	1807	1808	1809	1810	1811	1812
0.9	1813	1815	1816	1817	1818	1819	1820	1821	1822	1823
5558	1824	1825	1826	1827	1828	1829	1831	1832	1833	1834
0.1	1835	1836	1837	1838	1839	1840	1841	1843	1844	1845
0.2	1846	1847	1848	1849	1850	1851	1852	1853	1855	1856
0.3	1857	1858	1859	1860	1861	1862	1863	1864	1865	1867
0.4	1868	1869	1870	1871	1872	1873	1874	1875	1876	1877
0.5	1878	1880	1881	1882	1883	1884	1885	1886	1887	1888
0.6	1889	1890	1892	1893	1894	1895	1896	1897	1898	1899
0.7	1900	1901	1902	1904	1905	1906	1907	1908	1909	1910
0.8	1911	1912	1913	1914	1916	1917	1918	1919	1920	1921
0.9	1922	1923	1924	1925	1926	1928	1929	1930	1931	1932
5559	1933	1934	1935	1936	1938	1939	1940	1941	1942	1943
0.1	1944	1945	1947	1948	1949	1950	1951	1952	1953	1954
0.2	1956	1957	1958	1959	1960	1961	1962	1964	1965	1966
0.3	1967	1968	1969	1970	1971	1973	1974	1975	1976	1977
0.4	1978	1979	1980	1982	1983	1984	1985	1986	1987	1988
0.5	1989	1991	1992	1993	1994	1995	1996	1997	1999	2000
0.6	2001	2002	2003	2004	2005	2006	2008	2009	2010	2011
0.7	2012	2013	2014	2015	2017	2018	2019	2020	2021	2022
0.8	2023	2025	2026	2027	2028	2029	2030	2031	2032	2034
0.9	2035	2036	2037	2038	2039	2040	2041	2043	2044	2045
5560	2046	2047	2048	2049	2051	2052	2053	2054	2055	2056
0.1	2058	2059	2060	2061	2062	2063	2065	2066	2067	2068
0.2	2069	2070	2072	2073	2074	2075	2076	2077	2078	2080
0.3	2081	2082	2083	2084	2085	2087	2088	2089	2090	2091
0.4	2092	2094	2095	2096	2097	2098	2099	2101	2102	2103
0.5	2104	2105	2106	2107	2109	2110	2111	2112	2113	2114
0.6	2116	2117	2118	2119	2120	2121	2123	2124	2125	2126
0.7	2127	2128	2130	2131	2132	2133	2134	2135	2136	2138
0.8	2139	2140	2141	2142	2143	2145	2146	2147	2148	2149
0.9	2150	2152	2153	2154	2155	2156	2157	2159	2160	2161

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV

5561	2162	2163	2164	2166	2167	2168	2169	2170	2172	2173
0.1	2174	2175	2176	2177	2179	2180	2181	2182	2183	2185
0.2	2186	2187	2188	2189	2191	2192	2193	2194	2195	2197
0.3	2198	2199	2200	2201	2202	2204	2205	2206	2207	2208
0.4	2210	2211	2212	2213	2214	2216	2217	2218	2219	2220
0.5	2221	2223	2224	2225	2226	2227	2229	2230	2231	2232
0.6	2233	2235	2236	2237	2238	2239	2241	2242	2243	2244
0.7	2245	2246	2248	2249	2250	2251	2252	2254	2255	2256
0.8	2257	2258	2260	2261	2262	2263	2264	2266	2267	2268
0.9	2269	2270	2271	2273	2274	2275	2276	2277	2279	2280
5562	2281	2282	2283	2285	2286	2287	2288	2290	2291	2292
0.1	2293	2294	2296	2297	2298	2299	2301	2302	2303	2304
0.2	2305	2307	2308	2309	2310	2311	2313	2314	2315	2316
0.3	2318	2319	2320	2321	2322	2324	2325	2326	2327	2329
0.4	2330	2331	2332	2333	2335	2336	2337	2338	2340	2341
0.5	2342	2343	2344	2346	2347	2348	2349	2351	2352	2353
0.6	2354	2355	2357	2358	2359	2360	2362	2363	2364	2365
0.7	2366	2368	2369	2370	2371	2372	2374	2375	2376	2377
0.8	2379	2380	2381	2382	2383	2385	2386	2387	2388	2390
0.9	2391	2392	2393	2394	2396	2397	2398	2399	2401	2402
5563	2403	2404	2406	2407	2408	2409	2411	2412	2413	2414
0.1	2416	2417	2418	2420	2421	2422	2423	2425	2426	2427
0.2	2428	2430	2431	2432	2433	2435	2436	2437	2439	2440
0.3	2441	2442	2444	2445	2446	2447	2449	2450	2451	2453
0.4	2454	2455	2456	2458	2459	2460	2461	2463	2464	2465
0.5	2466	2468	2469	2470	2472	2473	2474	2475	2477	2478
0.6	2479	2480	2482	2483	2484	2486	2487	2488	2489	2491
0.7	2492	2493	2494	2496	2497	2498	2500	2501	2502	2503
0.8	2505	2506	2507	2508	2510	2511	2512	2513	2515	2516
0.9	2517	2519	2520	2521	2522	2524	2525	2526	2527	2529
5564	2530	2531	2533	2534	2535	2537	2538	2539	2540	2542
0.1	2543	2544	2546	2547	2548	2550	2551	2552	2554	2555
0.2	2556	2558	2559	2560	2561	2563	2564	2565	2567	2568
0.3	2569	2571	2572	2573	2575	2576	2577	2578	2580	2581
0.4	2582	2584	2585	2586	2588	2589	2590	2592	2593	2594
0.5	2595	2597	2598	2599	2601	2602	2603	2605	2606	2607
0.6	2609	2610	2611	2613	2614	2615	2616	2618	2619	2620
0.7	2622	2623	2624	2626	2627	2628	2630	2631	2632	2633
0.8	2635	2636	2637	2639	2640	2641	2643	2644	2645	2647
0.9	2648	2649	2651	2652	2653	2654	2656	2657	2658	2660
5565	2661	2662	2664	2665	2666	2668	2669	2670	2672	2673
0.1	2674	2676	2677	2679	2680	2681	2683	2684	2685	2687
0.2	2688	2689	2691	2692	2693	2695	2696	2697	2699	2700
0.3	2701	2703	2704	2706	2707	2708	2710	2711	2712	2714
0.4	2715	2716	2718	2719	2720	2722	2723	2724	2726	2727
0.5	2728	2730	2731	2733	2734	2735	2737	2738	2739	2741
0.6	2742	2743	2745	2746	2747	2749	2750	2751	2753	2754
0.7	2755	2757	2758	2760	2761	2762	2764	2765	2766	2768
0.8	2769	2770	2772	2773	2774	2776	2777	2778	2780	2781
0.9	2782	2784	2785	2787	2788	2789	2791	2792	2793	2795

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5566	2796	2797	2799	2800	2802	2803	2804	2806	2807	2809
0.1	2810	2811	2813	2814	2815	2817	2818	2820	2821	2822
0.2	2824	2825	2827	2828	2829	2831	2832	2834	2835	2836
0.3	2838	2839	2840	2842	2843	2845	2846	2847	2849	2850
0.4	2852	2853	2854	2856	2857	2859	2860	2861	2863	2864
0.5	2865	2867	2868	2870	2871	2872	2874	2875	2877	2878
0.6	2879	2881	2882	2884	2885	2886	2888	2889	2891	2892
0.7	2893	2895	2896	2897	2899	2900	2902	2903	2904	2906
0.8	2907	2909	2910	2911	2913	2914	2916	2917	2918	2920
0.9	2921	2922	2924	2925	2927	2928	2929	2931	2932	2934
5567	2935	2936	2938	2939	2941	2942	2944	2945	2947	2948
0.1	2949	2951	2952	2954	2955	2957	2958	2959	2961	2962
0.2	2964	2965	2967	2968	2970	2971	2972	2974	2975	2977
0.3	2978	2980	2981	2983	2984	2985	2987	2988	2990	2991
0.4	2993	2994	2995	2997	2998	3000	3001	3003	3004	3006
0.5	3007	3008	3010	3011	3013	3014	3016	3017	3019	3020
0.6	3021	3023	3024	3026	3027	3029	3030	3031	3033	3034
0.7	3036	3037	3039	3040	3042	3043	3044	3046	3047	3049
0.8	3050	3052	3053	3055	3056	3057	3059	3060	3062	3063
0.9	3065	3066	3067	3069	3070	3072	3073	3075	3076	3078
5568	3079	3080	3082	3083	3085	3086	3088	3089	3091	3092
0.1	3094	3095	3097	3098	3100	3101	3103	3104	3106	3107
0.2	3109	3110	3112	3113	3115	3116	3117	3119	3120	3122
0.3	3123	3125	3126	3128	3129	3131	3132	3134	3135	3137
0.4	3138	3140	3141	3143	3144	3146	3147	3149	3150	3152
0.5	3153	3154	3156	3157	3159	3160	3162	3163	3165	3166
0.6	3168	3169	3171	3172	3174	3175	3177	3178	3180	3181
0.7	3183	3184	3186	3187	3189	3190	3191	3193	3194	3196
0.8	3197	3199	3200	3202	3203	3205	3206	3208	3209	3211
0.9	3212	3214	3215	3217	3218	3220	3221	3223	3224	3226
5569	3227	3229	3230	3232	3233	3235	3236	3238	3239	3241
0.1	3242	3244	3245	3247	3248	3250	3251	3253	3255	3256
0.2	3258	3259	3261	3262	3264	3265	3267	3268	3270	3271
0.3	3273	3274	3276	3277	3279	3281	3282	3284	3285	3287
0.4	3288	3290	3291	3293	3294	3296	3297	3299	3300	3302
0.5	3303	3305	3307	3308	3310	3311	3313	3314	3316	3317
0.6	3319	3320	3322	3323	3325	3326	3328	3330	3331	3333
0.7	3334	3336	3337	3339	3340	3342	3343	3345	3346	3348
0.8	3349	3351	3352	3354	3356	3357	3359	3360	3362	3363
0.9	3365	3366	3368	3369	3371	3372	3374	3375	3377	3378
5570	3380	3382	3383	3385	3386	3388	3389	3391	3393	3394
0.1	3396	3397	3399	3401	3402	3404	3405	3407	3408	3410
0.2	3412	3413	3415	3416	3418	3419	3421	3423	3424	3426
0.3	3427	3429	3431	3432	3434	3435	3437	3438	3440	3442
0.4	3443	3445	3446	3448	3450	3451	3453	3454	3456	3457
0.5	3459	3461	3462	3464	3465	3467	3468	3470	3472	3473
0.6	3475	3476	3478	3480	3481	3483	3484	3486	3487	3489
0.7	3491	3492	3494	3495	3497	3498	3500	3502	3503	3505
0.8	3506	3508	3510	3511	3513	3514	3516	3517	3519	3521
0.9	3522	3524	3525	3527	3529	3530	3532	3533	3535	3536

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5571	3538	3540	3541	3543	3544	3546	3548	3549	3551	3553
0.1	3554	3556	3557	3559	3561	3562	3564	3566	3567	3569
0.2	3570	3572	3574	3575	3577	3578	3580	3582	3583	3585
0.3	3587	3588	3590	3591	3593	3595	3596	3598	3600	3601
0.4	3603	3604	3606	3608	3609	3611	3613	3614	3616	3617
0.5	3619	3621	3622	3624	3625	3627	3629	3630	3632	3634
0.6	3635	3637	3638	3640	3642	3643	3645	3647	3648	3650
0.7	3651	3653	3655	3656	3658	3659	3661	3663	3664	3666
0.8	3668	3669	3671	3672	3674	3676	3677	3679	3681	3682
0.9	3684	3685	3687	3689	3690	3692	3694	3695	3697	3698
5572	3700	3702	3703	3705	3707	3708	3710	3712	3713	3715
0.1	3717	3718	3720	3722	3723	3725	3727	3728	3730	3732
0.2	3733	3735	3737	3738	3740	3742	3743	3745	3747	3748
0.3	3750	3752	3753	3755	3757	3758	3760	3762	3763	3765
0.4	3767	3768	3770	3772	3773	3775	3777	3778	3780	3782
0.5	3783	3785	3787	3789	3790	3792	3794	3795	3797	3799
0.6	3800	3802	3804	3805	3807	3809	3810	3812	3814	3815
0.7	3817	3819	3820	3822	3824	3825	3827	3829	3830	3832
0.8	3834	3835	3837	3839	3840	3842	3844	3845	3847	3849
0.9	3850	3852	3854	3855	3857	3859	3860	3862	3864	3865
5573	3867	3869	3870	3872	3874	3876	3877	3879	3881	3882
0.1	3884	3886	3888	3889	3891	3893	3895	3896	3898	3900
0.2	3901	3903	3905	3907	3908	3910	3912	3913	3915	3917
0.3	3919	3920	3922	3924	3925	3927	3929	3931	3932	3934
0.4	3936	3938	3939	3941	3943	3944	3946	3948	3950	3951
0.5	3953	3955	3956	3958	3960	3962	3963	3965	3967	3968
0.6	3970	3972	3974	3975	3977	3979	3981	3982	3984	3986
0.7	3987	3989	3991	3993	3994	3996	3998	3999	4001	4003
0.8	4005	4006	4008	4010	4011	4013	4015	4017	4018	4020
0.9	4022	4024	4025	4027	4029	4030	4032	4034	4036	4037
5574	4039	4041	4043	4044	4046	4048	4050	4052	4053	4055
0.1	4057	4059	4060	4062	4064	4066	4068	4069	4071	4073
0.2	4075	4077	4078	4080	4082	4084	4086	4087	4089	4091
0.3	4093	4094	4096	4098	4100	4102	4103	4105	4107	4109
0.4	4111	4112	4114	4116	4118	4120	4121	4123	4125	4127
0.5	4128	4130	4132	4134	4136	4137	4139	4141	4143	4145
0.6	4146	4148	4150	4152	4154	4155	4157	4159	4161	4163
0.7	4164	4166	4168	4170	4171	4173	4175	4177	4179	4180
0.8	4182	4184	4186	4188	4189	4191	4193	4195	4197	4198
0.9	4200	4202	4204	4205	4207	4209	4211	4213	4214	4216
5575	4218	4220	4222	4224	4225	4227	4229	4231	4233	4235
0.1	4236	4238	4240	4242	4244	4246	4247	4249	4251	4253
0.2	4255	4257	4258	4260	4262	4264	4266	4268	4270	4271
0.3	4273	4275	4277	4279	4281	4282	4284	4286	4288	4290
0.4	4292	4293	4295	4297	4299	4301	4303	4304	4306	4308
0.5	4310	4312	4314	4316	4317	4319	4321	4323	4325	4327
0.6	4328	4330	4332	4334	4336	4338	4339	4341	4343	4345
0.7	4347	4349	4350	4352	4354	4356	4358	4360	4362	4363
0.8	4365	4367	4369	4371	4373	4374	4376	4378	4380	4382
0.9	4384	4385	4387	4389	4391	4393	4395	4396	4398	4400

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5576	4402	4404	4406	4408	4410	4411	4413	4415	4417	4419
0.1	4421	4423	4425	4427	4429	4430	4432	4434	4436	4438
0.2	4440	4442	4444	4446	4448	4449	4451	4453	4455	4457
0.3	4459	4461	4463	4465	4467	4468	4470	4472	4474	4476
0.4	4478	4480	4482	4484	4486	4487	4489	4491	4493	4495
0.5	4497	4499	4501	4503	4505	4506	4508	4510	4512	4514
0.6	4516	4518	4520	4522	4524	4525	4527	4529	4531	4533
0.7	4535	4537	4539	4541	4543	4544	4546	4548	4550	4552
0.8	4554	4556	4558	4560	4562	4563	4565	4567	4569	4571
0.9	4573	4575	4577	4579	4581	4582	4584	4586	4588	4590
5577	4592	4594	4596	4598	4600	4602	4604	4606	4608	4610
0.1	4612	4614	4616	4617	4619	4621	4623	4625	4627	4629
0.2	4631	4633	4635	4637	4639	4641	4643	4645	4647	4649
0.3	4651	4653	4655	4657	4659	4661	4663	4665	4666	4668
0.4	4670	4672	4674	4676	4678	4680	4682	4684	4686	4688
0.5	4690	4692	4694	4696	4698	4700	4702	4704	4706	4708
0.6	4710	4712	4714	4715	4717	4719	4721	4723	4725	4727
0.7	4729	4731	4733	4735	4737	4739	4741	4743	4745	4747
0.8	4749	4751	4753	4755	4757	4759	4761	4763	4764	4766
0.9	4768	4770	4772	4774	4776	4778	4780	4782	4784	4786
5578	4788	4790	4792	4794	4796	4798	4800	4802	4804	4806
0.1	4808	4810	4812	4814	4816	4818	4820	4822	4824	4826
0.2	4828	4830	4832	4834	4836	4838	4841	4843	4845	4847
0.3	4849	4851	4853	4855	4857	4859	4861	4863	4865	4867
0.4	4869	4871	4873	4875	4877	4879	4881	4883	4885	4887
0.5	4889	4891	4893	4895	4897	4899	4901	4903	4905	4907
0.6	4909	4911	4913	4915	4917	4919	4921	4923	4925	4927
0.7	4929	4931	4933	4935	4937	4939	4942	4944	4946	4948
0.8	4950	4952	4954	4956	4958	4960	4962	4964	4966	4968
0.9	4970	4972	4974	4976	4978	4980	4982	4984	4986	4988
5579	4990	4992	4994	4996	4998	5000	5003	5005	5007	5009
0.1	5011	5013	5015	5017	5019	5021	5024	5026	5028	5030
0.2	5032	5034	5036	5038	5040	5042	5045	5047	5049	5051
0.3	5053	5055	5057	5059	5061	5063	5066	5068	5070	5072
0.4	5074	5076	5078	5080	5082	5084	5087	5089	5091	5093
0.5	5095	5097	5099	5101	5103	5105	5108	5110	5112	5114
0.6	5116	5118	5120	5122	5124	5126	5129	5131	5133	5135
0.7	5137	5139	5141	5143	5145	5147	5150	5152	5154	5156
0.8	5158	5160	5162	5164	5166	5168	5171	5173	5175	5177
0.9	5179	5181	5183	5185	5187	5189	5192	5194	5196	5198
5580	5200	5202	5204	5207	5209	5211	5213	5215	5217	5220
0.1	5222	5224	5226	5228	5230	5233	5235	5237	5239	5241
0.2	5243	5246	5248	5250	5252	5254	5256	5259	5261	5263
0.3	5265	5267	5269	5272	5274	5276	5278	5280	5282	5285
0.4	5287	5289	5291	5293	5295	5298	5300	5302	5304	5306
0.5	5308	5311	5313	5315	5317	5319	5322	5324	5326	5328
0.6	5330	5332	5335	5337	5339	5341	5343	5345	5348	5350
0.7	5352	5354	5356	5358	5361	5363	5365	5367	5369	5371
0.8	5374	5376	5378	5380	5382	5384	5387	5389	5391	5393
0.9	5395	5397	5400	5402	5404	5406	5408	5410	5413	5415

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5581	5417	5419	5421	5424	5426	5428	5430	5433	5435	5437
0.1	5439	5441	5444	5446	5448	5450	5453	5455	5457	5459
0.2	5461	5464	5466	5468	5470	5472	5475	5477	5479	5481
0.3	5484	5486	5488	5490	5492	5495	5497	5499	5501	5504
0.4	5506	5508	5510	5512	5515	5517	5519	5521	5524	5526
0.5	5528	5530	5532	5535	5537	5539	5541	5544	5546	5548
0.6	5550	5552	5555	5557	5559	5561	5564	5566	5568	5570
0.7	5572	5575	5577	5579	5581	5583	5586	5588	5590	5592
0.8	5595	5597	5599	5601	5603	5606	5608	5610	5612	5615
0.9	5617	5619	5621	5623	5626	5628	5630	5632	5635	5637
5582	5639	5641	5644	5646	5648	5650	5653	5655	5657	5660
0.1	5662	5664	5667	5669	5671	5673	5676	5678	5680	5683
0.2	5685	5687	5690	5692	5694	5696	5699	5701	5703	5706
0.3	5708	5710	5713	5715	5717	5719	5722	5724	5726	5729
0.4	5731	5733	5736	5738	5740	5742	5745	5747	5749	5752
0.5	5754	5756	5759	5761	5763	5765	5768	5770	5772	5775
0.6	5777	5779	5782	5784	5786	5788	5791	5793	5795	5798
0.7	5800	5802	5805	5807	5809	5811	5814	5816	5818	5821
0.8	5823	5825	5828	5830	5832	5834	5837	5839	5841	5844
0.9	5846	5848	5851	5853	5855	5857	5860	5862	5864	5867
5583	5869	5871	5874	5876	5879	5881	5883	5886	5888	5891
0.1	5893	5895	5898	5900	5902	5905	5907	5910	5912	5914
0.2	5917	5919	5922	5924	5926	5929	5931	5934	5936	5938
0.3	5941	5943	5945	5948	5950	5953	5955	5957	5960	5962
0.4	5965	5967	5969	5972	5974	5977	5979	5981	5984	5986
0.5	5988	5991	5993	5996	5998	6000	6003	6005	6008	6010
0.6	6012	6015	6017	6020	6022	6024	6027	6029	6032	6034
0.7	6036	6039	6041	6043	6046	6048	6051	6053	6055	6058
0.8	6060	6063	6065	6067	6070	6072	6075	6077	6079	6082
0.9	6084	6086	6089	6091	6094	6096	6098	6101	6103	6106
5584	6108	6110	6113	6115	6118	6120	6123	6125	6128	6130
0.1	6133	6135	6138	6140	6143	6145	6148	6150	6153	6155
0.2	6158	6160	6163	6165	6168	6170	6173	6175	6178	6180
0.3	6183	6185	6188	6190	6193	6195	6198	6200	6203	6205
0.4	6208	6210	6213	6215	6218	6220	6223	6225	6228	6230
0.5	6232	6235	6237	6240	6242	6245	6247	6250	6252	6255
0.6	6257	6260	6262	6265	6267	6270	6272	6275	6277	6280
0.7	6282	6285	6287	6290	6292	6295	6297	6300	6302	6305
0.8	6307	6310	6312	6315	6317	6320	6322	6325	6327	6330
0.9	6332	6335	6337	6340	6342	6345	6347	6350	6352	6355
5585	6357	6360	6362	6365	6367	6370	6373	6375	6378	6380
0.1	6383	6386	6388	6391	6393	6396	6399	6401	6404	6406
0.2	6409	6412	6414	6417	6419	6422	6425	6427	6430	6432
0.3	6435	6438	6440	6443	6445	6448	6451	6453	6456	6458
0.4	6461	6464	6466	6469	6471	6474	6477	6479	6482	6484
0.5	6487	6490	6492	6495	6497	6500	6503	6505	6508	6510
0.6	6513	6516	6518	6521	6523	6526	6529	6531	6534	6536
0.7	6539	6542	6544	6547	6549	6552	6555	6557	6560	6562
0.8	6565	6568	6570	6573	6575	6578	6581	6583	6586	6588
0.9	6591	6594	6596	6599	6601	6604	6607	6609	6612	6614

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5586	6617	6620	6622	6625	6628	6630	6633	6636	6639	6641
0.1	6644	6647	6649	6652	6655	6657	6660	6663	6665	6668
0.2	6671	6673	6676	6679	6682	6684	6687	6690	6692	6695
0.3	6698	6700	6703	6706	6708	6711	6714	6717	6719	6722
0.4	6725	6727	6730	6733	6735	6738	6741	6743	6746	6749
0.5	6751	6754	6757	6760	6762	6765	6768	6770	6773	6776
0.6	6778	6781	6784	6786	6789	6792	6795	6797	6800	6803
0.7	6805	6808	6811	6813	6816	6819	6821	6824	6827	6830
0.8	6832	6835	6838	6840	6843	6846	6848	6851	6854	6856
0.9	6859	6862	6864	6867	6870	6873	6875	6878	6881	6883
5587	6886	6889	6892	6894	6897	6900	6903	6905	6908	6911
0.1	6914	6917	6919	6922	6925	6928	6930	6933	6936	6939
0.2	6942	6944	6947	6950	6953	6955	6958	6961	6964	6967
0.3	6969	6972	6975	6978	6981	6983	6986	6989	6992	6994
0.4	6997	7000	7003	7006	7008	7011	7014	7017	7019	7022
0.5	7025	7028	7031	7033	7036	7039	7042	7044	7047	7050
0.6	7053	7056	7058	7061	7064	7067	7069	7072	7075	7078
0.7	7081	7083	7086	7089	7092	7094	7097	7100	7103	7106
0.8	7108	7111	7114	7117	7120	7122	7125	7128	7131	7133
0.9	7136	7139	7142	7145	7147	7150	7153	7156	7158	7161
5588	7164	7167	7170	7173	7175	7178	7181	7184	7187	7190
0.1	7193	7196	7198	7201	7204	7207	7210	7213	7216	7219
0.2	7221	7224	7227	7230	7233	7236	7239	7241	7244	7247
0.3	7250	7253	7256	7259	7262	7264	7267	7270	7273	7276
0.4	7279	7282	7285	7287	7290	7293	7296	7299	7302	7305
0.5	7307	7310	7313	7316	7319	7322	7325	7328	7330	7333
0.6	7336	7339	7342	7345	7348	7351	7353	7356	7359	7362
0.7	7365	7368	7371	7374	7376	7379	7382	7385	7388	7391
0.8	7394	7396	7399	7402	7405	7408	7411	7414	7417	7419
0.9	7422	7425	7428	7431	7434	7437	7440	7442	7445	7448
5589	7451	7454	7457	7460	7463	7466	7469	7472	7474	7477
0.1	7480	7483	7486	7489	7492	7495	7498	7501	7504	7507
0.2	7510	7513	7515	7518	7521	7524	7527	7530	7533	7536
0.3	7539	7542	7545	7548	7551	7554	7556	7559	7562	7565
0.4	7568	7571	7574	7577	7580	7583	7586	7589	7592	7595
0.5	7597	7600	7603	7606	7609	7612	7615	7618	7621	7624
0.6	7627	7630	7633	7636	7639	7641	7644	7647	7650	7653
0.7	7656	7659	7662	7665	7668	7671	7674	7677	7680	7682
0.8	7685	7688	7691	7694	7697	7700	7703	7706	7709	7712
0.9	7715	7718	7721	7723	7726	7729	7732	7735	7738	7741
5590	7744	7747	7750	7753	7756	7759	7762	7765	7768	7771
0.1	7774	7777	7780	7783	7786	7789	7792	7795	7798	7801
0.2	7804	7807	7810	7813	7816	7819	7822	7825	7828	7831
0.3	7834	7837	7840	7843	7846	7849	7852	7855	7858	7861
0.4	7864	7867	7870	7873	7876	7879	7882	7885	7888	7891
0.5	7894	7898	7901	7904	7907	7910	7913	7916	7919	7922
0.6	7925	7928	7931	7934	7937	7940	7943	7946	7949	7952
0.7	7955	7958	7961	7964	7967	7970	7973	7976	7979	7982
0.8	7985	7988	7991	7994	7997	8000	8003	8006	8009	8012
0.9	8015	8018	8021	8024	8027	8030	8033	8036	8039	8042

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5591	8045	8048	8051	8054	8057	8060	8063	8067	8070	8073
0.1	8076	8079	8082	8085	8088	8091	8094	8097	8100	8104
0.2	8107	8110	8113	8116	8119	8122	8125	8128	8131	8134
0.3	8137	8140	8144	8147	8150	8153	8156	8159	8162	8165
0.4	8168	8171	8174	8177	8181	8184	8187	8190	8193	8196
0.5	8199	8202	8205	8208	8211	8214	8217	8221	8224	8227
0.6	8230	8233	8236	8239	8242	8245	8248	8251	8254	8258
0.7	8261	8264	8267	8270	8273	8276	8279	8282	8285	8288
0.8	8291	8294	8298	8301	8304	8307	8310	8313	8316	8319
0.9	8322	8325	8328	8331	8335	8338	8341	8344	8347	8350
5592	8353	8356	8359	8362	8366	8369	8372	8375	8378	8381
0.1	8385	8388	8391	8394	8397	8400	8404	8407	8410	8413
0.2	8416	8419	8423	8426	8429	8432	8435	8438	8441	8445
0.3	8448	8451	8454	8457	8460	8464	8467	8470	8473	8476
0.4	8479	8483	8486	8489	8492	8495	8498	8502	8505	8508
0.5	8511	8514	8517	8520	8524	8527	8530	8533	8536	8539
0.6	8543	8546	8549	8552	8555	8558	8562	8565	8568	8571
0.7	8574	8577	8581	8584	8587	8590	8593	8596	8599	8603
0.8	8606	8609	8612	8615	8618	8622	8625	8628	8631	8634
0.9	8637	8641	8644	8647	8650	8653	8656	8660	8663	8666
5593	8669	8672	8675	8679	8682	8685	8688	8692	8695	8698
0.1	8701	8705	8708	8711	8714	8717	8721	8724	8727	8730
0.2	8734	8737	8740	8743	8747	8750	8753	8756	8759	8763
0.3	8766	8769	8772	8776	8779	8782	8785	8789	8792	8795
0.4	8798	8801	8805	8808	8811	8814	8818	8821	8824	8827
0.5	8830	8834	8837	8840	8843	8847	8850	8853	8856	8860
0.6	8863	8866	8869	8872	8876	8879	8882	8885	8889	8892
0.7	8895	8898	8902	8905	8908	8911	8914	8918	8921	8924
0.8	8927	8931	8934	8937	8940	8944	8947	8950	8953	8956
0.9	8960	8963	8966	8969	8973	8976	8979	8982	8986	8989
5594	8992	8995	8999	9002	9005	9008	9012	9015	9018	9022
0.1	9025	9028	9032	9035	9038	9041	9045	9048	9051	9055
0.2	9058	9061	9065	9068	9071	9074	9078	9081	9084	9088
0.3	9091	9094	9098	9101	9104	9107	9111	9114	9117	9121
0.4	9124	9127	9131	9134	9137	9140	9144	9147	9150	9154
0.5	9157	9160	9164	9167	9170	9173	9177	9180	9183	9187
0.6	9190	9193	9197	9200	9203	9206	9210	9213	9216	9220
0.7	9223	9226	9230	9233	9236	9239	9243	9246	9249	9253
0.8	9256	9259	9263	9266	9269	9272	9276	9279	9282	9286
0.9	9289	9292	9296	9299	9302	9305	9309	9312	9315	9319
5595	9322	9325	9329	9332	9335	9339	9342	9345	9349	9352
0.1	9355	9359	9362	9366	9369	9372	9376	9379	9382	9386
0.2	9389	9392	9396	9399	9402	9406	9409	9412	9416	9419
0.3	9422	9426	9429	9433	9436	9439	9443	9446	9449	9453
0.4	9456	9459	9463	9466	9469	9473	9476	9479	9483	9486
0.5	9489	9493	9496	9500	9503	9506	9510	9513	9516	9520
0.6	9523	9526	9530	9533	9536	9540	9543	9546	9550	9553
0.7	9556	9560	9563	9567	9570	9573	9577	9580	9583	9587
0.8	9590	9593	9597	9600	9603	9607	9610	9613	9617	9620
0.9	9623	9627	9630	9634	9637	9640	9644	9647	9650	9654

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5596	9657	9660	9664	9667	9671	9674	9678	9681	9684	9688
0.1	9691	9695	9698	9701	9705	9708	9712	9715	9719	9722
0.2	9725	9729	9732	9736	9739	9742	9746	9749	9753	9756
0.3	9760	9763	9766	9770	9773	9777	9780	9784	9787	9790
0.4	9794	9797	9801	9804	9807	9811	9814	9818	9821	9825
0.5	9828	9831	9835	9838	9842	9845	9849	9852	9855	9859
0.6	9862	9866	9869	9872	9876	9879	9883	9886	9890	9893
0.7	9896	9900	9903	9907	9910	9913	9917	9920	9924	9927
0.8	9931	9934	9937	9941	9944	9948	9951	9955	9958	9961
0.9	9965	9968	9972	9975	9978	9982	9985	9989	9992	9996
5597	9999	10002	10006	10009	10013	10016	10020	10023	10027	10030
0.1	10034	10037	10041	10044	10048	10051	10055	10058	10062	10065
0.2	10069	10072	10076	10079	10083	10086	10090	10093	10097	10100
0.3	10104	10107	10111	10114	10118	10121	10125	10128	10132	10135
0.4	10139	10142	10146	10149	10153	10156	10160	10163	10167	10170
0.5	10173	10177	10180	10184	10187	10191	10194	10198	10201	10205
0.6	10208	10212	10215	10219	10222	10226	10229	10233	10236	10240
0.7	10243	10247	10250	10254	10257	10261	10264	10268	10271	10275
0.8	10278	10282	10285	10289	10292	10296	10299	10303	10306	10310
0.9	10313	10317	10320	10324	10327	10331	10334	10338	10341	10345
5598	10348	10352	10355	10359	10362	10366	10369	10373	10377	10380
0.1	10384	10387	10391	10394	10398	10402	10405	10409	10412	10416
0.2	10419	10423	10427	10430	10434	10437	10441	10444	10448	10452
0.3	10455	10459	10462	10466	10469	10473	10477	10480	10484	10487
0.4	10491	10494	10498	10502	10505	10509	10512	10516	10519	10523
0.5	10526	10530	10534	10537	10541	10544	10548	10551	10555	10559
0.6	10562	10566	10569	10573	10576	10580	10584	10587	10591	10594
0.7	10598	10601	10605	10609	10612	10616	10619	10623	10626	10630
0.8	10634	10637	10641	10644	10648	10651	10655	10659	10662	10666
0.9	10669	10673	10676	10680	10684	10687	10691	10694	10698	10701
5599	10705	10709	10712	10716	10720	10723	10727	10731	10734	10738
0.1	10742	10745	10749	10753	10756	10760	10764	10767	10771	10775
0.2	10778	10782	10786	10789	10793	10796	10800	10804	10807	10811
0.3	10815	10818	10822	10826	10829	10833	10837	10840	10844	10848
0.4	10851	10855	10859	10862	10866	10870	10873	10877	10881	10884
0.5	10888	10892	10895	10899	10903	10906	10910	10914	10917	10921
0.6	10925	10928	10932	10936	10939	10943	10947	10950	10954	10958
0.7	10961	10965	10969	10972	10976	10979	10983	10987	10990	10994
0.8	10998	11001	11005	11009	11012	11016	11020	11023	11027	11031
0.9	11034	11038	11042	11045	11049	11053	11056	11060	11064	11067
5600	11071	11075	11079	11082	11086	11090	11094	11097	11101	11105
0.1	11109	11112	11116	11120	11124	11127	11131	11135	11139	11142
0.2	11146	11150	11154	11157	11161	11165	11169	11173	11176	11180
0.3	11184	11188	11191	11195	11199	11203	11206	11210	11214	11218
0.4	11221	11225	11229	11233	11236	11240	11244	11248	11251	11255
0.5	11259	11263	11267	11270	11274	11278	11282	11285	11289	11293
0.6	11297	11300	11304	11308	11312	11315	11319	11323	11327	11330
0.7	11334	11338	11342	11345	11349	11353	11357	11361	11364	11368
0.8	11372	11376	11379	11383	11387	11391	11394	11398	11402	11406
0.9	11409	11413	11417	11421	11424	11428	11432	11436	11439	11443

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5601	11447	11451	11455	11459	11462	11466	11470	11474	11478	11482
0.1	11485	11489	11493	11497	11501	11505	11509	11512	11516	11520
0.2	11524	11528	11532	11536	11539	11543	11547	11551	11555	11559
0.3	11562	11566	11570	11574	11578	11582	11586	11589	11593	11597
0.4	11601	11605	11609	11613	11616	11620	11624	11628	11632	11636
0.5	11639	11643	11647	11651	11655	11659	11663	11666	11670	11674
0.6	11678	11682	11686	11690	11693	11697	11701	11705	11709	11713
0.7	11716	11720	11724	11728	11732	11736	11740	11743	11747	11751
0.8	11755	11759	11763	11767	11770	11774	11778	11782	11786	11790
0.9	11793	11797	11801	11805	11809	11813	11817	11820	11824	11828
5602	11832	11836	11840	11844	11848	11852	11856	11860	11863	11867
0.1	11871	11875	11879	11883	11887	11891	11895	11899	11903	11907
0.2	11911	11915	11918	11922	11926	11930	11934	11938	11942	11946
0.3	11950	11954	11958	11962	11966	11970	11973	11977	11981	11985
0.4	11989	11993	11997	12001	12005	12009	12013	12017	12021	12025
0.5	12028	12032	12036	12040	12044	12048	12052	12056	12060	12064
0.6	12068	12072	12076	12080	12084	12087	12091	12095	12099	12103
0.7	12107	12111	12115	12119	12123	12127	12131	12135	12139	12142
0.8	12146	12150	12154	12158	12162	12166	12170	12174	12178	12182
0.9	12186	12190	12194	12197	12201	12205	12209	12213	12217	12221
5603	12225	12229	12233	12237	12241	12245	12249	12253	12257	12261
0.1	12265	12269	12273	12277	12281	12285	12289	12293	12297	12301
0.2	12305	12309	12313	12317	12321	12325	12329	12333	12337	12341
0.3	12345	12349	12353	12357	12361	12365	12369	12373	12377	12381
0.4	12385	12389	12393	12397	12401	12405	12409	12413	12417	12421
0.5	12425	12430	12434	12438	12442	12446	12450	12454	12458	12462
0.6	12466	12470	12474	12478	12482	12486	12490	12494	12498	12502
0.7	12506	12510	12514	12518	12522	12526	12530	12534	12538	12542
0.8	12546	12550	12554	12558	12562	12566	12570	12574	12578	12582
0.9	12586	12590	12594	12598	12602	12606	12610	12614	12618	12622
5604	12626	12630	12634	12638	12642	12646	12650	12655	12659	12663
0.1	12667	12671	12675	12679	12683	12687	12691	12695	12699	12704
0.2	12708	12712	12716	12720	12724	12728	12732	12736	12740	12744
0.3	12748	12752	12757	12761	12765	12769	12773	12777	12781	12785
0.4	12789	12793	12797	12801	12806	12810	12814	12818	12822	12826
0.5	12830	12834	12838	12842	12846	12850	12854	12859	12863	12867
0.6	12871	12875	12879	12883	12887	12891	12895	12899	12903	12908
0.7	12912	12916	12920	12924	12928	12932	12936	12940	12944	12948
0.8	12952	12956	12961	12965	12969	12973	12977	12981	12985	12989
0.9	12993	12997	13001	13005	13010	13014	13018	13022	13026	13030
5605	13034	13038	13042	13046	13051	13055	13059	13063	13067	13071
0.1	13075	13080	13084	13088	13092	13096	13100	13104	13109	13113
0.2	13117	13121	13125	13129	13133	13137	13142	13146	13150	13154
0.3	13158	13162	13166	13171	13175	13179	13183	13187	13191	13195
0.4	13200	13204	13208	13212	13216	13220	13224	13229	13233	13237
0.5	13241	13245	13249	13253	13258	13262	13266	13270	13274	13278
0.6	13282	13287	13291	13295	13299	13303	13307	13311	13316	13320
0.7	13324	13328	13332	13336	13340	13344	13349	13353	13357	13361
0.8	13365	13369	13373	13378	13382	13386	13390	13394	13398	13402
0.9	13407	13411	13415	13419	13423	13427	13431	13436	13440	13444

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5606	13448	13452	13456	13461	13465	13469	13473	13477	13482	13486
0.1	13490	13494	13498	13503	13507	13511	13515	13519	13524	13528
0.2	13532	13536	13540	13545	13549	13553	13557	13561	13566	13570
0.3	13574	13578	13582	13587	13591	13595	13599	13603	13608	13612
0.4	13616	13620	13624	13629	13633	13637	13641	13645	13650	13654
0.5	13658	13662	13666	13671	13675	13679	13683	13687	13692	13696
0.6	13700	13704	13708	13713	13717	13721	13725	13729	13734	13738
0.7	13742	13746	13750	13755	13759	13763	13767	13771	13776	13780
0.8	13784	13788	13792	13797	13801	13805	13809	13813	13818	13822
0.9	13826	13830	13834	13839	13843	13847	13851	13855	13860	13864
5607	13868	13872	13877	13881	13885	13889	13894	13898	13902	13907
0.1	13911	13915	13919	13924	13928	13932	13936	13941	13945	13949
0.2	13954	13958	13962	13966	13971	13975	13979	13984	13988	13992
0.3	13996	14001	14005	14009	14014	14018	14022	14026	14031	14035
0.4	14039	14043	14048	14052	14056	14061	14065	14069	14073	14078
0.5	14082	14086	14091	14095	14099	14103	14108	14112	14116	14121
0.6	14125	14129	14133	14138	14142	14146	14150	14155	14159	14163
0.7	14168	14172	14176	14180	14185	14189	14193	14198	14202	14206
0.8	14210	14215	14219	14223	14228	14232	14236	14240	14245	14249
0.9	14253	14257	14262	14266	14270	14275	14279	14283	14287	14292
5608	14296	14300	14305	14309	14314	14318	14322	14327	14331	14336
0.1	14340	14344	14349	14353	14357	14362	14366	14371	14375	14379
0.2	14384	14388	14393	14397	14401	14406	14410	14415	14419	14423
0.3	14428	14432	14436	14441	14445	14450	14454	14458	14463	14467
0.4	14472	14476	14480	14485	14489	14494	14498	14502	14507	14511
0.5	14515	14520	14524	14529	14533	14537	14542	14546	14551	14555
0.6	14559	14564	14568	14573	14577	14581	14586	14590	14595	14599
0.7	14603	14608	14612	14616	14621	14625	14630	14634	14638	14643
0.8	14647	14652	14656	14660	14665	14669	14674	14678	14682	14687
0.9	14691	14695	14700	14704	14709	14713	14717	14722	14726	14731
5609	14735	14740	14744	14749	14753	14758	14762	14767	14771	14776
0.1	14780	14785	14789	14794	14798	14803	14807	14812	14816	14821
0.2	14825	14830	14834	14839	14843	14848	14852	14857	14861	14866
0.3	14870	14875	14879	14884	14888	14893	14897	14902	14906	14911
0.4	14915	14920	14924	14929	14933	14938	14942	14947	14951	14956
0.5	14960	14965	14970	14974	14979	14983	14988	14992	14997	15001
0.6	15006	15010	15015	15019	15024	15028	15033	15037	15042	15046
0.7	15051	15055	15060	15064	15069	15073	15078	15082	15087	15091
0.8	15096	15100	15105	15109	15114	15118	15123	15127	15132	15136
0.9	15141	15145	15150	15154	15159	15163	15168	15172	15177	15181
5610	15186	15191	15195	15200	15205	15209	15214	15218	15223	15228
0.1	15232	15237	15242	15246	15251	15255	15260	15265	15269	15274
0.2	15279	15283	15288	15292	15297	15302	15306	15311	15316	15320
0.3	15325	15330	15334	15339	15343	15348	15353	15357	15362	15367
0.4	15371	15376	15380	15385	15390	15394	15399	15404	15408	15413
0.5	15417	15422	15427	15431	15436	15441	15445	15450	15455	15459
0.6	15464	15468	15473	15478	15482	15487	15492	15496	15501	15505
0.7	15510	15515	15519	15524	15529	15533	15538	15543	15547	15552
0.8	15556	15561	15566	15570	15575	15580	15584	15589	15593	15598
0.9	15603	15607	15612	15617	15621	15626	15630	15635	15640	15644

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5611	15649	15654	15659	15663	15668	15673	15678	15682	15687	15692
0.1	15696	15701	15706	15711	15715	15720	15725	15730	15734	15739
0.2	15744	15749	15753	15758	15763	15768	15772	15777	15782	15787
0.3	15791	15796	15801	15806	15810	15815	15820	15825	15829	15834
0.4	15839	15844	15848	15853	15858	15863	15867	15872	15877	15882
0.5	15886	15891	15896	15901	15905	15910	15915	15920	15924	15929
0.6	15934	15939	15943	15948	15953	15958	15962	15967	15972	15977
0.7	15981	15986	15991	15996	16000	16005	16010	16015	16019	16024
0.8	16029	16034	16038	16043	16048	16053	16057	16062	16067	16072
0.9	16076	16081	16086	16091	16095	16100	16105	16110	16114	16119
5612	16124	16129	16134	16139	16143	16148	16153	16158	16163	16168
0.1	16172	16177	16182	16187	16192	16197	16202	16206	16211	16216
0.2	16221	16226	16231	16236	16240	16245	16250	16255	16260	16265
0.3	16269	16274	16279	16284	16289	16294	16299	16303	16308	16313
0.4	16318	16323	16328	16333	16337	16342	16347	16352	16357	16362
0.5	16366	16371	16376	16381	16386	16391	16396	16400	16405	16410
0.6	16415	16420	16425	16430	16434	16439	16444	16449	16454	16459
0.7	16463	16468	16473	16478	16483	16488	16493	16497	16502	16507
0.8	16512	16517	16522	16527	16531	16536	16541	16546	16551	16556
0.9	16560	16565	16570	16575	16580	16585	16590	16594	16599	16604
5613	16609	16614	16619	16624	16629	16634	16639	16644	16649	16654
0.1	16659	16664	16669	16674	16679	16684	16689	16693	16698	16703
0.2	16708	16713	16718	16723	16728	16733	16738	16743	16748	16753
0.3	16758	16763	16768	16773	16778	16783	16788	16793	16798	16803
0.4	16808	16813	16818	16823	16828	16833	16838	16843	16848	16853
0.5	16857	16862	16867	16872	16877	16882	16887	16892	16897	16902
0.6	16907	16912	16917	16922	16927	16932	16937	16942	16947	16952
0.7	16957	16962	16967	16972	16977	16982	16987	16992	16997	17002
0.8	17007	17012	17017	17022	17026	17031	17036	17041	17046	17051
0.9	17056	17061	17066	17071	17076	17081	17086	17091	17096	17101
5614	17106	17111	17116	17121	17126	17131	17136	17141	17147	17152
0.1	17157	17162	17167	17172	17177	17182	17187	17192	17197	17202
0.2	17207	17212	17218	17223	17228	17233	17238	17243	17248	17253
0.3	17258	17263	17268	17273	17278	17283	17289	17294	17299	17304
0.4	17309	17314	17319	17324	17329	17334	17339	17344	17349	17354
0.5	17359	17365	17370	17375	17380	17385	17390	17395	17400	17405
0.6	17410	17415	17420	17425	17430	17436	17441	17446	17451	17456
0.7	17461	17466	17471	17476	17481	17486	17491	17496	17501	17507
0.8	17512	17517	17522	17527	17532	17537	17542	17547	17552	17557
0.9	17562	17567	17572	17578	17583	17588	17593	17598	17603	17608
5615	17613	17618	17623	17629	17634	17639	17644	17649	17654	17660
0.1	17665	17670	17675	17680	17686	17691	17696	17701	17706	17711
0.2	17717	17722	17727	17732	17737	17742	17748	17753	17758	17763
0.3	17768	17774	17779	17784	17789	17794	17799	17805	17810	17815
0.4	17820	17825	17831	17836	17841	17846	17851	17856	17862	17867
0.5	17872	17877	17882	17888	17893	17898	17903	17908	17913	17919
0.6	17924	17929	17934	17939	17945	17950	17955	17960	17965	17970
0.7	17976	17981	17986	17991	17996	18001	18007	18012	18017	18022
0.8	18027	18033	18038	18043	18048	18053	18058	18064	18069	18074
0.9	18079	18084	18090	18095	18100	18105	18110	18115	18121	18126

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5616	18131	18136	18142	18147	18152	18157	18163	18168	18173	18178
0.1	18184	18189	18194	18200	18205	18210	18215	18221	18226	18231
0.2	18236	18242	18247	18252	18257	18263	18268	18273	18279	18284
0.3	18289	18294	18300	18305	18310	18315	18321	18326	18331	18337
0.4	18342	18347	18352	18358	18363	18368	18373	18379	18384	18389
0.5	18394	18400	18405	18410	18416	18421	18426	18431	18437	18442
0.6	18447	18452	18458	18463	18468	18474	18479	18484	18489	18495
0.7	18500	18505	18510	18516	18521	18526	18532	18537	18542	18547
0.8	18553	18558	18563	18568	18574	18579	18584	18589	18595	18600
0.9	18605	18611	18616	18621	18626	18632	18637	18642	18647	18653
5617	18658	18663	18669	18674	18680	18685	18690	18696	18701	18707
0.1	18712	18717	18723	18728	18734	18739	18744	18750	18755	18761
0.2	18766	18771	18777	18782	18788	18793	18798	18804	18809	18815
0.3	18820	18825	18831	18836	18842	18847	18852	18858	18863	18869
0.4	18874	18879	18885	18890	18896	18901	18906	18912	18917	18923
0.5	18928	18933	18939	18944	18950	18955	18960	18966	18971	18977
0.6	18982	18987	18993	18998	19004	19009	19014	19020	19025	19031
0.7	19036	19041	19047	19052	19058	19063	19068	19074	19079	19085
0.8	19090	19095	19101	19106	19112	19117	19122	19128	19133	19139
0.9	19144	19149	19155	19160	19166	19171	19176	19182	19187	19193
5618	19198	19204	19209	19215	19220	19226	19231	19237	19242	19248
0.1	19253	19259	19264	19270	19275	19281	19286	19292	19297	19303
0.2	19308	19314	19319	19325	19330	19336	19341	19347	19352	19358
0.3	19363	19369	19374	19380	19385	19391	19396	19402	19407	19413
0.4	19418	19424	19429	19435	19440	19446	19451	19457	19462	19468
0.5	19473	19479	19485	19490	19496	19501	19507	19512	19518	19523
0.6	19529	19534	19540	19545	19551	19556	19562	19567	19573	19578
0.7	19584	19589	19595	19600	19606	19611	19617	19622	19628	19633
0.8	19639	19644	19650	19655	19661	19666	19672	19677	19683	19688
0.9	19694	19699	19705	19710	19716	19721	19727	19732	19738	19743
5619	19749	19755	19760	19766	19772	19777	19783	19788	19794	19800
0.1	19805	19811	19817	19822	19828	19834	19839	19845	19851	19856
0.2	19862	19867	19873	19879	19884	19890	19896	19901	19907	19913
0.3	19918	19924	19929	19935	19941	19946	19952	19958	19963	19969
0.4	19975	19980	19986	19992	19997	20003	20008	20014	20020	20025
0.5	20031	20037	20042	20048	20054	20059	20065	20070	20076	20082
0.6	20087	20093	20099	20104	20110	20116	20121	20127	20133	20138
0.7	20144	20149	20155	20161	20166	20172	20178	20183	20189	20195
0.8	20200	20206	20211	20217	20223	20228	20234	20240	20245	20251
0.9	20257	20262	20268	20274	20279	20285	20290	20296	20302	20307
5620	20313	20319	20325	20330	20336	20342	20348	20354	20359	20365
0.1	20371	20377	20382	20388	20394	20400	20406	20411	20417	20423
0.2	20429	20435	20440	20446	20452	20458	20464	20469	20475	20481
0.3	20487	20492	20498	20504	20510	20516	20521	20527	20533	20539
0.4	20545	20550	20556	20562	20568	20574	20579	20585	20591	20597
0.5	20602	20608	20614	20620	20626	20631	20637	20643	20649	20655
0.6	20660	20666	20672	20678	20684	20689	20695	20701	20707	20713
0.7	20718	20724	20730	20736	20741	20747	20753	20759	20765	20770
0.8	20776	20782	20788	20794	20799	20805	20811	20817	20823	20828
0.9	20834	20840	20846	20851	20857	20863	20869	20875	20880	20886

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5621	20892	20898	20904	20910	20916	20922	20928	20933	20939	20945
0.1	20951	20957	20963	20969	20975	20981	20987	20993	20999	21004
0.2	21010	21016	21022	21028	21034	21040	21046	21052	21058	21064
0.3	21070	21076	21081	21087	21093	21099	21105	21111	21117	21123
0.4	21129	21135	21141	21147	21152	21158	21164	21170	21176	21182
0.5	21188	21194	21200	21206	21212	21218	21224	21229	21235	21241
0.6	21247	21253	21259	21265	21271	21277	21283	21289	21295	21300
0.7	21306	21312	21318	21324	21330	21336	21342	21348	21354	21360
0.8	21366	21372	21377	21383	21389	21395	21401	21407	21413	21419
0.9	21425	21431	21437	21443	21448	21454	21460	21466	21472	21478
5622	21484	21490	21496	21502	21508	21514	21520	21526	21532	21538
0.1	21544	21550	21556	21563	21569	21575	21581	21587	21593	21599
0.2	21605	21611	21617	21623	21629	21635	21641	21647	21653	21659
0.3	21665	21671	21677	21683	21689	21695	21701	21707	21714	21720
0.4	21726	21732	21738	21744	21750	21756	21762	21768	21774	21780
0.5	21786	21792	21798	21804	21810	21816	21822	21828	21834	21840
0.6	21846	21852	21858	21865	21871	21877	21883	21889	21895	21901
0.7	21907	21913	21919	21925	21931	21937	21943	21949	21955	21961
0.8	21967	21973	21979	21985	21991	21997	22003	22009	22016	22022
0.9	22028	22034	22040	22046	22052	22058	22064	22070	22076	22082
5623	22088	22094	22100	22106	22113	22119	22125	22131	22137	22143
0.1	22149	22156	22162	22168	22174	22180	22186	22192	22199	22205
0.2	22211	22217	22223	22229	22235	22241	22248	22254	22260	22266
0.3	22272	22278	22284	22291	22297	22303	22309	22315	22321	22327
0.4	22334	22340	22346	22352	22358	22364	22370	22377	22383	22389
0.5	22395	22401	22407	22413	22420	22426	22432	22438	22444	22450
0.6	22456	22463	22469	22475	22481	22487	22493	22499	22506	22512
0.7	22518	22524	22530	22536	22542	22548	22555	22561	22567	22573
0.8	22579	22585	22591	22598	22604	22610	22616	22622	22628	22634
0.9	22641	22647	22653	22659	22665	22671	22677	22684	22690	22696
5624	22702	22708	22714	22721	22727	22733	22739	22745	22752	22758
0.1	22764	22770	22777	22783	22789	22795	22801	22808	22814	22820
0.2	22826	22832	22839	22845	22851	22857	22863	22870	22876	22882
0.3	22888	22895	22901	22907	22913	22919	22926	22932	22938	22944
0.4	22950	22957	22963	22969	22975	22981	22988	22994	23000	23006
0.5	23012	23019	23025	23031	23037	23044	23050	23056	23062	23068
0.6	23075	23081	23087	23093	23099	23106	23112	23118	23124	23130
0.7	23137	23143	23149	23155	23162	23168	23174	23180	23186	23193
0.8	23199	23205	23211	23217	23224	23230	23236	23242	23248	23255
0.9	23261	23267	23273	23280	23286	23292	23298	23304	23311	23317
5625	23323	23329	23336	23342	23348	23354	23361	23367	23373	23380
0.1	23386	23392	23398	23405	23411	23417	23424	23430	23436	23443
0.2	23449	23455	23461	23468	23474	23480	23487	23493	23499	23505
0.3	23512	23518	23524	23531	23537	23543	23549	23556	23562	23568
0.4	23575	23581	23587	23593	23600	23606	23612	23619	23625	23631
0.5	23637	23644	23650	23656	23663	23669	23675	23682	23688	23694
0.6	23700	23707	23713	23719	23726	23732	23738	23744	23751	23757
0.7	23763	23770	23776	23782	23788	23795	23801	23807	23814	23820
0.8	23826	23832	23839	23845	23851	23858	23864	23870	23877	23883
0.9	23889	23895	23902	23908	23914	23921	23927	23933	23939	23946

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5626	23952	23958	23965	23971	23977	23984	23990	23997	24003	24009
0.1	24016	24022	24028	24035	24041	24048	24054	24060	24067	24073
0.2	24079	24086	24092	24099	24105	24111	24118	24124	24130	24137
0.3	24143	24149	24156	24162	24169	24175	24181	24188	24194	24200
0.4	24207	24213	24220	24226	24232	24239	24245	24251	24258	24264
0.5	24270	24277	24283	24290	24296	24302	24309	24315	24321	24328
0.6	24334	24341	24347	24353	24360	24366	24372	24379	24385	24392
0.7	24398	24404	24411	24417	24423	24430	24436	24442	24449	24455
0.8	24462	24468	24474	24481	24487	24493	24500	24506	24513	24519
0.9	24525	24532	24538	24544	24551	24557	24564	24570	24576	24583
5627	24589	24595	24602	24608	24615	24621	24628	24634	24641	24647
0.1	24654	24660	24667	24673	24679	24686	24692	24699	24705	24712
0.2	24718	24725	24731	24738	24744	24750	24757	24763	24770	24776
0.3	24783	24789	24796	24802	24809	24815	24822	24828	24834	24841
0.4	24847	24854	24860	24867	24873	24880	24886	24893	24899	24906
0.5	24912	24918	24925	24931	24938	24944	24951	24957	24964	24970
0.6	24977	24983	24990	24996	25002	25009	25015	25022	25028	25035
0.7	25041	25048	25054	25061	25067	25073	25080	25086	25093	25099
0.8	25106	25112	25119	25125	25132	25138	25145	25151	25157	25164
0.9	25170	25177	25183	25190	25196	25203	25209	25216	25222	25229
5628	25235	25242	25248	25255	25261	25268	25274	25281	25287	25294
0.1	25300	25307	25314	25320	25327	25333	25340	25346	25353	25359
0.2	25366	25373	25379	25386	25392	25399	25405	25412	25418	25425
0.3	25431	25438	25445	25451	25458	25464	25471	25477	25484	25490
0.4	25497	25504	25510	25517	25523	25530	25536	25543	25549	25556
0.5	25562	25569	25576	25582	25589	25595	25602	25608	25615	25621
0.6	25628	25635	25641	25648	25654	25661	25667	25674	25680	25687
0.7	25693	25700	25707	25713	25720	25726	25733	25739	25746	25752
0.8	25759	25766	25772	25779	25785	25792	25798	25805	25811	25818
0.9	25824	25831	25838	25844	25851	25857	25864	25870	25877	25883
5629	25890	25897	25903	25910	25916	25923	25930	25936	25943	25950
0.1	25956	25963	25969	25976	25983	25989	25996	26003	26009	26016
0.2	26022	26029	26036	26042	26049	26055	26062	26069	26075	26082
0.3	26089	26095	26102	26108	26115	26122	26128	26135	26142	26148
0.4	26155	26161	26168	26175	26181	26188	26195	26201	26208	26214
0.5	26221	26228	26234	26241	26247	26254	26261	26267	26274	26281
0.6	26287	26294	26300	26307	26314	26320	26327	26334	26340	26347
0.7	26353	26360	26367	26373	26380	26386	26393	26400	26406	26413
0.8	26420	26426	26433	26439	26446	26453	26459	26466	26473	26479
0.9	26486	26492	26499	26506	26512	26519	26526	26532	26539	26545
5630	26552	26559	26565	26572	26579	26585	26592	26599	26606	26612
0.1	26619	26626	26632	26639	26646	26652	26659	26666	26673	26679
0.2	26686	26693	26699	26706	26713	26719	26726	26733	26740	26746
0.3	26753	26760	26766	26773	26780	26786	26793	26800	26807	26813
0.4	26820	26827	26833	26840	26847	26853	26860	26867	26874	26880
0.5	26887	26894	26900	26907	26914	26920	26927	26934	26941	26947
0.6	26954	26961	26967	26974	26981	26987	26994	27001	27008	27014
0.7	27021	27028	27034	27041	27048	27054	27061	27068	27075	27081
0.8	27088	27095	27101	27108	27115	27121	27128	27135	27142	27148
0.9	27155	27162	27168	27175	27182	27188	27195	27202	27209	27215

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5631	27222	27229	27236	27242	27249	27256	27263	27269	27276	27283
0.1	27290	27297	27303	27310	27317	27324	27330	27337	27344	27351
0.2	27358	27364	27371	27378	27385	27391	27398	27405	27412	27419
0.3	27425	27432	27439	27446	27453	27459	27466	27473	27480	27486
0.4	27493	27500	27507	27514	27520	27527	27534	27541	27547	27554
0.5	27561	27568	27575	27581	27588	27595	27602	27608	27615	27622
0.6	27629	27636	27642	27649	27656	27663	27669	27676	27683	27690
0.7	27697	27703	27710	27717	27724	27730	27737	27744	27751	27758
0.8	27764	27771	27778	27785	27792	27798	27805	27812	27819	27825
0.9	27832	27839	27846	27853	27859	27866	27873	27880	27886	27893
5632	27900	27907	27914	27921	27927	27934	27941	27948	27955	27962
0.1	27969	27975	27982	27989	27996	28003	28010	28017	28023	28030
0.2	28037	28044	28051	28058	28065	28071	28078	28085	28092	28099
0.3	28106	28113	28120	28126	28133	28140	28147	28154	28161	28168
0.4	28174	28181	28188	28195	28202	28209	28216	28222	28229	28236
0.5	28243	28250	28257	28264	28270	28277	28284	28291	28298	28305
0.6	28312	28318	28325	28332	28339	28346	28353	28360	28366	28373
0.7	28380	28387	28394	28401	28408	28414	28421	28428	28435	28442
0.8	28449	28456	28463	28469	28476	28483	28490	28497	28504	28511
0.9	28517	28524	28531	28538	28545	28552	28559	28565	28572	28579
5633	28586	28593	28600	28607	28614	28621	28628	28635	28642	28648
0.1	28655	28662	28669	28676	28683	28690	28697	28704	28711	28718
0.2	28725	28732	28739	28746	28753	28759	28766	28773	28780	28787
0.3	28794	28801	28808	28815	28822	28829	28836	28843	28850	28857
0.4	28864	28871	28877	28884	28891	28898	28905	28912	28919	28926
0.5	28933	28940	28947	28954	28961	28968	28975	28982	28989	28995
0.6	29002	29009	29016	29023	29030	29037	29044	29051	29058	29065
0.7	29072	29079	29086	29093	29100	29106	29113	29120	29127	29134
0.8	29141	29148	29155	29162	29169	29176	29183	29190	29197	29204
0.9	29211	29218	29224	29231	29238	29245	29252	29259	29266	29273
5634	29280	29287	29294	29301	29308	29315	29322	29329	29336	29343
0.1	29350	29357	29364	29371	29378	29385	29392	29400	29407	29414
0.2	29421	29428	29435	29442	29449	29456	29463	29470	29477	29484
0.3	29491	29498	29505	29512	29519	29526	29533	29540	29547	29554
0.4	29561	29568	29575	29582	29589	29596	29603	29610	29617	29624
0.5	29631	29639	29646	29653	29660	29667	29674	29681	29688	29695
0.6	29702	29709	29716	29723	29730	29737	29744	29751	29758	29765
0.7	29772	29779	29786	29793	29800	29807	29814	29821	29828	29835
0.8	29842	29849	29856	29863	29871	29878	29885	29892	29899	29906
0.9	29913	29920	29927	29934	29941	29948	29955	29962	29969	29976
5635	29983	29990	29997	30004	30011	30019	30026	30033	30040	30047
0.1	30054	30061	30068	30075	30083	30090	30097	30104	30111	30118
0.2	30125	30132	30139	30147	30154	30161	30168	30175	30182	30189
0.3	30196	30203	30211	30218	30225	30232	30239	30246	30253	30260
0.4	30267	30275	30282	30289	30296	30303	30310	30317	30324	30331
0.5	30338	30346	30353	30360	30367	30374	30381	30388	30395	30402
0.6	30410	30417	30424	30431	30438	30445	30452	30459	30466	30474
0.7	30481	30488	30495	30502	30509	30516	30523	30530	30538	30545
0.8	30552	30559	30566	30573	30580	30587	30594	30602	30609	30616
0.9	30623	30630	30637	30644	30651	30658	30666	30673	30680	30687

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5636	30694	30701	30708	30716	30723	30730	30737	30744	30752	30759
0.1	30766	30773	30780	30787	30795	30802	30809	30816	30823	30831
0.2	30838	30845	30852	30859	30867	30874	30881	30888	30895	30903
0.3	30910	30917	30924	30931	30938	30946	30953	30960	30967	30974
0.4	30982	30989	30996	31003	31010	31018	31025	31032	31039	31046
0.5	31053	31061	31068	31075	31082	31089	31097	31104	31111	31118
0.6	31125	31133	31140	31147	31154	31161	31169	31176	31183	31190
0.7	31197	31204	31212	31219	31226	31233	31240	31248	31255	31262
0.8	31269	31276	31284	31291	31298	31305	31312	31320	31327	31334
0.9	31341	31348	31355	31363	31370	31377	31384	31391	31399	31406
5637	31413	31420	31428	31435	31442	31449	31457	31464	31471	31479
0.1	31486	31493	31500	31508	31515	31522	31529	31537	31544	31551
0.2	31559	31566	31573	31580	31588	31595	31602	31610	31617	31624
0.3	31631	31639	31646	31653	31661	31668	31675	31682	31690	31697
0.4	31704	31711	31719	31726	31733	31741	31748	31755	31762	31770
0.5	31777	31784	31792	31799	31806	31813	31821	31828	31835	31843
0.6	31850	31857	31864	31872	31879	31886	31893	31901	31908	31915
0.7	31923	31930	31937	31944	31952	31959	31966	31974	31981	31988
0.8	31995	32003	32010	32017	32025	32032	32039	32046	32054	32061
0.9	32068	32075	32083	32090	32097	32105	32112	32119	32126	32134
5638	32141	32148	32156	32163	32170	32178	32185	32193	32200	32207
0.1	32215	32222	32229	32237	32244	32252	32259	32266	32274	32281
0.2	32288	32296	32303	32311	32318	32325	32333	32340	32347	32355
0.3	32362	32369	32377	32384	32392	32399	32406	32414	32421	32428
0.4	32436	32443	32451	32458	32465	32473	32480	32487	32495	32502
0.5	32509	32517	32524	32532	32539	32546	32554	32561	32568	32576
0.6	32583	32591	32598	32605	32613	32620	32627	32635	32642	32650
0.7	32657	32664	32672	32679	32686	32694	32701	32708	32716	32723
0.8	32731	32738	32745	32753	32760	32767	32775	32782	32790	32797
0.9	32804	32812	32819	32826	32834	32841	32849	32856	32863	32871
5639	32878	32885	32893	32900	32908	32915	32923	32930	32938	32945
0.1	32953	32960	32968	32975	32983	32990	32998	33005	33013	33020
0.2	33028	33035	33043	33050	33058	33065	33072	33080	33087	33095
0.3	33102	33110	33117	33125	33132	33140	33147	33155	33162	33170
0.4	33177	33185	33192	33200	33207	33215	33222	33230	33237	33245
0.5	33252	33259	33267	33274	33282	33289	33297	33304	33312	33319
0.6	33327	33334	33342	33349	33357	33364	33372	33379	33387	33394
0.7	33402	33409	33417	33424	33432	33439	33446	33454	33461	33469
0.8	33476	33484	33491	33499	33506	33514	33521	33529	33536	33544
0.9	33551	33559	33566	33574	33581	33589	33596	33604	33611	33619
5640	33626	33634	33641	33649	33656	33664	33671	33679	33687	33694
0.1	33702	33709	33717	33725	33732	33740	33747	33755	33762	33770
0.2	33778	33785	33793	33800	33808	33815	33823	33831	33838	33846
0.3	33853	33861	33869	33876	33884	33891	33899	33906	33914	33922
0.4	33929	33937	33944	33952	33960	33967	33975	33982	33990	33997
0.5	34005	34013	34020	34028	34035	34043	34050	34058	34066	34073
0.6	34081	34088	34096	34104	34111	34119	34126	34134	34141	34149
0.7	34157	34164	34172	34179	34187	34194	34202	34210	34217	34225
0.8	34232	34240	34248	34255	34263	34270	34278	34285	34293	34301
0.9	34308	34316	34323	34331	34339	34346	34354	34361	34369	34376

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5641	34384	34392	34399	34407	34415	34422	34430	34438	34445	34453
0.1	34461	34468	34476	34484	34491	34499	34507	34514	34522	34530
0.2	34537	34545	34553	34560	34568	34576	34583	34591	34599	34606
0.3	34614	34622	34629	34637	34645	34652	34660	34668	34675	34683
0.4	34691	34698	34706	34714	34721	34729	34737	34744	34752	34760
0.5	34767	34775	34783	34791	34798	34806	34814	34821	34829	34837
0.6	34844	34852	34860	34867	34875	34883	34890	34898	34906	34913
0.7	34921	34929	34936	34944	34952	34959	34967	34975	34982	34990
0.8	34998	35005	35013	35021	35028	35036	35044	35051	35059	35067
0.9	35074	35082	35090	35097	35105	35113	35120	35128	35136	35143
5642	35151	35159	35167	35174	35182	35190	35198	35205	35213	35221
0.1	35229	35236	35244	35252	35260	35268	35275	35283	35291	35299
0.2	35306	35314	35322	35330	35337	35345	35353	35361	35369	35376
0.3	35384	35392	35400	35407	35415	35423	35431	35438	35446	35454
0.4	35462	35470	35477	35485	35493	35501	35508	35516	35524	35532
0.5	35539	35547	35555	35563	35571	35578	35586	35594	35602	35609
0.6	35617	35625	35633	35641	35648	35656	35664	35672	35679	35687
0.7	35695	35703	35710	35718	35726	35734	35742	35749	35757	35765
0.8	35773	35780	35788	35796	35804	35811	35819	35827	35835	35843
0.9	35850	35858	35866	35874	35881	35889	35897	35905	35912	35920
5643	35928	35936	35944	35952	35960	35967	35975	35983	35991	35999
0.1	36007	36015	36023	36030	36038	36046	36054	36062	36070	36078
0.2	36086	36093	36101	36109	36117	36125	36133	36141	36149	36157
0.3	36164	36172	36180	36188	36196	36204	36212	36220	36227	36235
0.4	36243	36251	36259	36267	36275	36283	36290	36298	36306	36314
0.5	36322	36330	36338	36346	36354	36361	36369	36377	36385	36393
0.6	36401	36409	36417	36424	36432	36440	36448	36456	36464	36472
0.7	36480	36487	36495	36503	36511	36519	36527	36535	36543	36551
0.8	36558	36566	36574	36582	36590	36598	36606	36614	36621	36629
0.9	36637	36645	36653	36661	36669	36677	36684	36692	36700	36708
5644	36716	36724	36732	36740	36748	36756	36764	36772	36780	36788
0.1	36796	36804	36812	36820	36828	36836	36844	36851	36859	36867
0.2	36875	36883	36891	36899	36907	36915	36923	36931	36939	36947
0.3	36955	36963	36971	36979	36987	36995	37003	37011	37019	37027
0.4	37035	37043	37051	37059	37067	37075	37083	37091	37099	37107
0.5	37114	37122	37130	37138	37146	37154	37162	37170	37178	37186
0.6	37194	37202	37210	37218	37226	37234	37242	37250	37258	37266
0.7	37274	37282	37290	37298	37306	37314	37322	37330	37338	37346
0.8	37354	37362	37370	37378	37385	37393	37401	37409	37417	37425
0.9	37433	37441	37449	37457	37465	37473	37481	37489	37497	37505
5645	37513	37521	37529	37537	37545	37553	37561	37569	37578	37586
0.1	37594	37602	37610	37618	37626	37634	37642	37650	37658	37666
0.2	37674	37682	37691	37699	37707	37715	37723	37731	37739	37747
0.3	37755	37763	37771	37779	37787	37795	37804	37812	37820	37828
0.4	37836	37844	37852	37860	37868	37876	37884	37892	37900	37908
0.5	37916	37925	37933	37941	37949	37957	37965	37973	37981	37989
0.6	37997	38005	38013	38021	38029	38038	38046	38054	38062	38070
0.7	38078	38086	38094	38102	38110	38118	38126	38134	38142	38151
0.8	38159	38167	38175	38183	38191	38199	38207	38215	38223	38231
0.9	38239	38247	38255	38264	38272	38280	38288	38296	38304	38312

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5646	38320	38328	38336	38345	38353	38361	38369	38377	38385	38394
0.1	38402	38410	38418	38426	38434	38443	38451	38459	38467	38475
0.2	38483	38492	38500	38508	38516	38524	38532	38541	38549	38557
0.3	38565	38573	38581	38590	38598	38606	38614	38622	38630	38639
0.4	38647	38655	38663	38671	38679	38688	38696	38704	38712	38720
0.5	38728	38737	38745	38753	38761	38769	38778	38786	38794	38802
0.6	38810	38818	38827	38835	38843	38851	38859	38867	38876	38884
0.7	38892	38900	38908	38916	38925	38933	38941	38949	38957	38965
0.8	38974	38982	38990	38998	39006	39014	39023	39031	39039	39047
0.9	39055	39063	39072	39080	39088	39096	39104	39112	39121	39129
5647	39137	39145	39154	39162	39170	39178	39187	39195	39203	39211
0.1	39220	39228	39236	39245	39253	39261	39269	39278	39286	39294
0.2	39302	39311	39319	39327	39335	39344	39352	39360	39369	39377
0.3	39385	39393	39402	39410	39418	39426	39435	39443	39451	39460
0.4	39468	39476	39484	39493	39501	39509	39517	39526	39534	39542
0.5	39550	39559	39567	39575	39584	39592	39600	39608	39617	39625
0.6	39633	39641	39650	39658	39666	39675	39683	39691	39699	39708
0.7	39716	39724	39732	39741	39749	39757	39766	39774	39782	39790
0.8	39799	39807	39815	39823	39832	39840	39848	39856	39865	39873
0.9	39881	39890	39898	39906	39914	39923	39931	39939	39947	39956
5648	39964	39972	39981	39989	39998	40006	40014	40023	40031	40039
0.1	40048	40056	40065	40073	40081	40090	40098	40106	40115	40123
0.2	40132	40140	40148	40157	40165	40173	40182	40190	40199	40207
0.3	40215	40224	40232	40241	40249	40257	40266	40274	40282	40291
0.4	40299	40308	40316	40324	40333	40341	40349	40358	40366	40375
0.5	40383	40391	40400	40408	40417	40425	40433	40442	40450	40458
0.6	40467	40475	40484	40492	40500	40509	40517	40525	40534	40542
0.7	40551	40559	40567	40576	40584	40592	40601	40609	40618	40626
0.8	40634	40643	40651	40660	40668	40676	40685	40693	40701	40710
0.9	40718	40727	40735	40743	40752	40760	40768	40777	40785	40794
5649	40802	40810	40819	40827	40836	40844	40853	40861	40870	40878
0.1	40887	40895	40904	40912	40921	40929	40938	40946	40955	40963
0.2	40972	40980	40989	40997	41006	41014	41022	41031	41039	41048
0.3	41056	41065	41073	41082	41090	41099	41107	41116	41124	41133
0.4	41141	41150	41158	41167	41175	41184	41192	41201	41209	41218
0.5	41226	41234	41243	41251	41260	41268	41277	41285	41294	41302
0.6	41311	41319	41328	41336	41345	41353	41362	41370	41379	41387
0.7	41396	41404	41413	41421	41430	41438	41446	41455	41463	41472
0.8	41480	41489	41497	41506	41514	41523	41531	41540	41548	41557
0.9	41565	41574	41582	41591	41599	41608	41616	41625	41633	41642
5650	41650	41659	41667	41676	41684	41693	41702	41710	41719	41727
0.1	41736	41744	41753	41762	41770	41779	41787	41796	41805	41813
0.2	41822	41830	41839	41848	41856	41865	41873	41882	41891	41899
0.3	41908	41916	41925	41933	41942	41951	41959	41968	41976	41985
0.4	41994	42002	42011	42019	42028	42037	42045	42054	42062	42071
0.5	42079	42088	42097	42105	42114	42122	42131	42140	42148	42157
0.6	42165	42174	42183	42191	42200	42208	42217	42226	42234	42243
0.7	42251	42260	42268	42277	42286	42294	42303	42311	42320	42329
0.8	42337	42346	42354	42363	42372	42380	42389	42397	42406	42415
0.9	42423	42432	42440	42449	42457	42466	42475	42483	42492	42500

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5651	42509	42518	42526	42535	42544	42552	42561	42570	42579	42587
0.1	42596	42605	42613	42622	42631	42639	42648	42657	42666	42674
0.2	42683	42692	42700	42709	42718	42726	42735	42744	42753	42761
0.3	42770	42779	42787	42796	42805	42813	42822	42831	42840	42848
0.4	42857	42866	42874	42883	42892	42900	42909	42918	42927	42935
0.5	42944	42953	42961	42970	42979	42987	42996	43005	43014	43022
0.6	43031	43040	43048	43057	43066	43074	43083	43092	43101	43109
0.7	43118	43127	43135	43144	43153	43161	43170	43179	43188	43196
0.8	43205	43214	43222	43231	43240	43248	43257	43266	43275	43283
0.9	43292	43301	43309	43318	43327	43335	43344	43353	43362	43370
5652	43379	43388	43397	43405	43414	43423	43432	43441	43449	43458
0.1	43467	43476	43485	43494	43502	43511	43520	43529	43538	43546
0.2	43555	43564	43573	43582	43590	43599	43608	43617	43626	43634
0.3	43643	43652	43661	43670	43679	43687	43696	43705	43714	43723
0.4	43731	43740	43749	43758	43767	43775	43784	43793	43802	43811
0.5	43819	43828	43837	43846	43855	43864	43872	43881	43890	43899
0.6	43908	43916	43925	43934	43943	43952	43960	43969	43978	43987
0.7	43996	44005	44013	44022	44031	44040	44049	44057	44066	44075
0.8	44084	44093	44101	44110	44119	44128	44137	44145	44154	44163
0.9	44172	44181	44190	44198	44207	44216	44225	44234	44242	44251
5653	44260	44269	44278	44287	44296	44305	44313	44322	44331	44340
0.1	44349	44358	44367	44376	44385	44394	44403	44411	44420	44429
0.2	44438	44447	44456	44465	44474	44483	44492	44501	44509	44518
0.3	44527	44536	44545	44554	44563	44572	44581	44590	44599	44607
0.4	44616	44625	44634	44643	44652	44661	44670	44679	44688	44697
0.5	44705	44714	44723	44732	44741	44750	44759	44768	44777	44786
0.6	44795	44804	44812	44821	44830	44839	44848	44857	44866	44875
0.7	44884	44893	44902	44910	44919	44928	44937	44946	44955	44964
0.8	44973	44982	44991	45000	45008	45017	45026	45035	45044	45053
0.9	45062	45071	45080	45089	45098	45106	45115	45124	45133	45142
5654	45151	45160	45169	45178	45187	45196	45205	45214	45223	45232
0.1	45241	45250	45259	45268	45277	45286	45295	45304	45313	45322
0.2	45331	45340	45349	45358	45367	45376	45386	45395	45404	45413
0.3	45422	45431	45440	45449	45458	45467	45476	45485	45494	45503
0.4	45512	45521	45530	45539	45548	45557	45566	45575	45584	45593
0.5	45602	45611	45620	45629	45638	45647	45656	45665	45674	45683
0.6	45692	45701	45710	45719	45728	45737	45746	45755	45764	45773
0.7	45782	45791	45800	45809	45818	45827	45837	45846	45855	45864
0.8	45873	45882	45891	45900	45909	45918	45927	45936	45945	45954
0.9	45963	45972	45981	45990	45999	46008	46017	46026	46035	46044
5655	46053	46062	46071	46080	46090	46099	46108	46117	46126	46135
0.1	46144	46153	46163	46172	46181	46190	46199	46208	46217	46226
0.2	46236	46245	46254	46263	46272	46281	46290	46300	46309	46318
0.3	46327	46336	46345	46354	46363	46373	46382	46391	46400	46409
0.4	46418	46427	46436	46446	46455	46464	46473	46482	46491	46500
0.5	46509	46519	46528	46537	46546	46555	46564	46573	46583	46592
0.6	46601	46610	46619	46628	46637	46646	46656	46665	46674	46683
0.7	46692	46701	46710	46719	46729	46738	46747	46756	46765	46774
0.8	46783	46793	46802	46811	46820	46829	46838	46847	46856	46866
0.9	46875	46884	46893	46902	46911	46920	46929	46939	46948	46957

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5656	46966	46975	46984	46994	47003	47012	47021	47031	47040	47049
0.1	47058	47068	47077	47086	47095	47105	47114	47123	47132	47142
0.2	47151	47160	47169	47179	47188	47197	47206	47215	47225	47234
0.3	47243	47252	47262	47271	47280	47289	47299	47308	47317	47326
0.4	47336	47345	47354	47363	47373	47382	47391	47400	47410	47419
0.5	47428	47437	47446	47456	47465	47474	47483	47493	47502	47511
0.6	47520	47530	47539	47548	47557	47567	47576	47585	47594	47604
0.7	47613	47622	47631	47641	47650	47659	47668	47677	47687	47696
0.8	47705	47714	47724	47733	47742	47751	47761	47770	47779	47788
0.9	47798	47807	47816	47825	47835	47844	47853	47862	47872	47881
5657	47890	47899	47909	47918	47927	47937	47946	47955	47965	47974
0.1	47983	47993	48002	48011	48021	48030	48039	48049	48058	48067
0.2	48077	48086	48095	48105	48114	48123	48133	48142	48152	48161
0.3	48170	48180	48189	48198	48208	48217	48226	48236	48245	48254
0.4	48264	48273	48282	48292	48301	48310	48320	48329	48338	48348
0.5	48357	48366	48376	48385	48394	48404	48413	48422	48432	48441
0.6	48450	48460	48469	48478	48488	48497	48506	48516	48525	48534
0.7	48544	48553	48562	48572	48581	48590	48600	48609	48619	48628
0.8	48637	48647	48656	48665	48675	48684	48693	48703	48712	48721
0.9	48731	48740	48749	48759	48768	48777	48787	48796	48805	48815
5658	48824	48833	48843	48852	48862	48871	48881	48890	48900	48909
0.1	48918	48928	48937	48947	48956	48966	48975	48985	48994	49004
0.2	49013	49022	49032	49041	49051	49060	49070	49079	49089	49098
0.3	49107	49117	49126	49136	49145	49155	49164	49174	49183	49193
0.4	49202	49211	49221	49230	49240	49249	49259	49268	49278	49287
0.5	49296	49306	49315	49325	49334	49344	49353	49363	49372	49382
0.6	49391	49400	49410	49419	49429	49438	49448	49457	49467	49476
0.7	49485	49495	49504	49514	49523	49533	49542	49552	49561	49571
0.8	49580	49589	49599	49608	49618	49627	49637	49646	49656	49665
0.9	49674	49684	49693	49703	49712	49722	49731	49741	49750	49760
5659	49769	49779	49788	49798	49807	49817	49826	49836	49845	49855
0.1	49864	49874	49883	49893	49903	49912	49922	49931	49941	49950
0.2	49960	49969	49979	49988	49998	50007	50017	50027	50036	50046
0.3	50055	50065	50074	50084	50093	50103	50112	50122	50132	50141
0.4	50151	50160	50170	50179	50189	50198	50208	50217	50227	50236
0.5	50246	50256	50265	50275	50284	50294	50303	50313	50322	50332
0.6	50341	50351	50360	50370	50380	50389	50399	50408	50418	50427
0.7	50437	50446	50456	50465	50475	50484	50494	50504	50513	50523
0.8	50532	50542	50551	50561	50570	50580	50589	50599	50609	50618
0.9	50628	50637	50647	50656	50666	50675	50685	50694	50704	50713
5660	50723	50733	50742	50752	50762	50771	50781	50790	50800	50810
0.1	50819	50829	50839	50848	50858	50868	50877	50887	50897	50906
0.2	50916	50925	50935	50945	50954	50964	50974	50983	50993	51003
0.3	51012	51022	51031	51041	51051	51060	51070	51080	51089	51099
0.4	51109	51118	51128	51138	51147	51157	51166	51176	51186	51195
0.5	51205	51215	51224	51234	51244	51253	51263	51272	51282	51292
0.6	51301	51311	51321	51330	51340	51350	51359	51369	51379	51388
0.7	51398	51407	51417	51427	51436	51446	51456	51465	51475	51485
0.8	51494	51504	51513	51523	51533	51542	51552	51562	51571	51581
0.9	51591	51600	51610	51620	51629	51639	51648	51658	51668	51677

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5661	51687	51697	51706	51716	51726	51736	51745	51755	51765	51775
0.1	51784	51794	51804	51813	51823	51833	51843	51852	51862	51872
0.2	51882	51891	51901	51911	51921	51930	51940	51950	51959	51969
0.3	51979	51989	51998	52008	52018	52028	52037	52047	52057	52066
0.4	52076	52086	52096	52105	52115	52125	52135	52144	52154	52164
0.5	52173	52183	52193	52203	52212	52222	52232	52242	52251	52261
0.6	52271	52281	52290	52300	52310	52319	52329	52339	52349	52358
0.7	52368	52378	52388	52397	52407	52417	52426	52436	52446	52456
0.8	52465	52475	52485	52495	52504	52514	52524	52534	52543	52553
0.9	52563	52572	52582	52592	52602	52611	52621	52631	52641	52650
5662	52660	52670	52680	52690	52699	52709	52719	52729	52739	52749
0.1	52758	52768	52778	52788	52798	52808	52817	52827	52837	52847
0.2	52857	52867	52876	52886	52896	52906	52916	52926	52936	52945
0.3	52955	52965	52975	52985	52995	53004	53014	53024	53034	53044
0.4	53054	53063	53073	53083	53093	53103	53113	53122	53132	53142
0.5	53152	53162	53172	53182	53191	53201	53211	53221	53231	53241
0.6	53250	53260	53270	53280	53290	53300	53309	53319	53329	53339
0.7	53349	53359	53368	53378	53388	53398	53408	53418	53428	53437
0.8	53447	53457	53467	53477	53487	53496	53506	53516	53526	53536
0.9	53546	53555	53565	53575	53585	53595	53605	53614	53624	53634
5663	53644	53654	53664	53674	53684	53694	53704	53714	53723	53733
0.1	53743	53753	53763	53773	53783	53793	53803	53813	53823	53833
0.2	53843	53853	53862	53872	53882	53892	53902	53912	53922	53932
0.3	53942	53952	53962	53972	53982	53992	54001	54011	54021	54031
0.4	54041	54051	54061	54071	54081	54091	54101	54111	54121	54131
0.5	54140	54150	54160	54170	54180	54190	54200	54210	54220	54230
0.6	54240	54250	54260	54270	54280	54289	54299	54309	54319	54329
0.7	54339	54349	54359	54369	54379	54389	54399	54409	54419	54428
0.8	54438	54448	54458	54468	54478	54488	54498	54508	54518	54528
0.9	54538	54548	54558	54567	54577	54587	54597	54607	54617	54627
5664	54637	54647	54657	54667	54677	54687	54697	54707	54717	54727
0.1	54737	54747	54757	54768	54778	54788	54798	54808	54818	54828
0.2	54838	54848	54858	54868	54878	54888	54898	54908	54918	54928
0.3	54938	54948	54958	54968	54978	54988	54998	55008	55019	55029
0.4	55039	55049	55059	55069	55079	55089	55099	55109	55119	55129
0.5	55139	55149	55159	55169	55179	55189	55199	55209	55219	55229
0.6	55239	55249	55259	55270	55280	55290	55300	55310	55320	55330
0.7	55340	55350	55360	55370	55380	55390	55400	55410	55420	55430
0.8	55440	55450	55460	55470	55480	55490	55500	55510	55521	55531
0.9	55541	55551	55561	55571	55581	55591	55601	55611	55621	55631
5665	55641	55651	55661	55671	55682	55692	55702	55712	55722	55732
0.1	55742	55752	55763	55773	55783	55793	55803	55813	55823	55833
0.2	55844	55854	55864	55874	55884	55894	55904	55915	55925	55935
0.3	55945	55955	55965	55975	55985	55996	56006	56016	56026	56036
0.4	56046	56056	56066	56077	56087	56097	56107	56117	56127	56137
0.5	56147	56158	56168	56178	56188	56198	56208	56218	56229	56239
0.6	56249	56259	56269	56279	56289	56299	56310	56320	56330	56340
0.7	56350	56360	56370	56380	56391	56401	56411	56421	56431	56441
0.8	56451	56462	56472	56482	56492	56502	56512	56522	56532	56543
0.9	56553	56563	56573	56583	56593	56603	56613	56624	56634	56644

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5666	56654	56664	56674	56685	56695	56705	56715	56726	56736	56746
0.1	56756	56767	56777	56787	56797	56808	56818	56828	56838	56849
0.2	56859	56869	56879	56890	56900	56910	56920	56930	56941	56951
0.3	56961	56971	56982	56992	57002	57012	57023	57033	57043	57053
0.4	57064	57074	57084	57094	57105	57115	57125	57135	57146	57156
0.5	57166	57176	57186	57197	57207	57217	57227	57238	57248	57258
0.6	57268	57279	57289	57299	57309	57320	57330	57340	57350	57361
0.7	57371	57381	57391	57402	57412	57422	57432	57442	57453	57463
0.8	57473	57483	57494	57504	57514	57524	57535	57545	57555	57565
0.9	57576	57586	57596	57606	57617	57627	57637	57647	57658	57668
5667	57678	57688	57699	57709	57719	57730	57740	57750	57761	57771
0.1	57781	57792	57802	57812	57823	57833	57843	57854	57864	57874
0.2	57885	57895	57905	57916	57926	57936	57947	57957	57967	57978
0.3	57988	57998	58009	58019	58029	58040	58050	58060	58071	58081
0.4	58091	58102	58112	58122	58133	58143	58153	58164	58174	58184
0.5	58194	58205	58215	58225	58236	58246	58256	58267	58277	58287
0.6	58298	58308	58318	58329	58339	58349	58360	58370	58380	58391
0.7	58401	58411	58422	58432	58442	58453	58463	58473	58484	58494
0.8	58504	58515	58525	58535	58546	58556	58566	58577	58587	58597
0.9	58608	58618	58628	58639	58649	58659	58670	58680	58690	58701
5668	58711	58721	58732	58742	58753	58763	58774	58784	58794	58805
0.1	58815	58826	58836	58847	58857	58867	58878	58888	58899	58909
0.2	58920	58930	58940	58951	58961	58972	58982	58993	59003	59013
0.3	59024	59034	59045	59055	59066	59076	59086	59097	59107	59118
0.4	59128	59139	59149	59159	59170	59180	59191	59201	59212	59222
0.5	59232	59243	59253	59264	59274	59285	59295	59306	59316	59326
0.6	59337	59347	59358	59368	59379	59389	59399	59410	59420	59431
0.7	59441	59452	59462	59472	59483	59493	59504	59514	59525	59535
0.8	59545	59556	59566	59577	59587	59598	59608	59618	59629	59639
0.9	59650	59660	59671	59681	59691	59702	59712	59723	59733	59744
5669	59754	59765	59775	59786	59796	59807	59817	59828	59838	59849
0.1	59859	59870	59880	59891	59902	59912	59923	59933	59944	59954
0.2	59965	59975	59986	59996	60007	60017	60028	60039	60049	60060
0.3	60070	60081	60091	60102	60112	60123	60133	60144	60155	60165
0.4	60176	60186	60197	60207	60218	60228	60239	60249	60260	60270
0.5	60281	60292	60302	60313	60323	60334	60344	60355	60365	60376
0.6	60386	60397	60407	60418	60429	60439	60450	60460	60471	60481
0.7	60492	60502	60513	60523	60534	60544	60555	60566	60576	60587
0.8	60597	60608	60618	60629	60639	60650	60660	60671	60682	60692
0.9	60703	60713	60724	60734	60745	60755	60766	60776	60787	60797
5670	60808	60819	60829	60840	60851	60861	60872	60882	60893	60904
0.1	60914	60925	60936	60946	60957	60967	60978	60989	60999	61010
0.2	61021	61031	61042	61052	61063	61074	61084	61095	61106	61116
0.3	61127	61138	61148	61159	61169	61180	61191	61201	61212	61223
0.4	61233	61244	61254	61265	61276	61286	61297	61308	61318	61329
0.5	61339	61350	61361	61371	61382	61393	61403	61414	61425	61435
0.6	61446	61456	61467	61478	61488	61499	61510	61520	61531	61541
0.7	61552	61563	61573	61584	61595	61605	61616	61627	61637	61648
0.8	61658	61669	61680	61690	61701	61712	61722	61733	61743	61754
0.9	61765	61775	61786	61797	61807	61818	61828	61839	61850	61860

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5671	61871	61882	61892	61903	61914	61925	61935	61946	61957	61968
0.1	61978	61989	62000	62011	62021	62032	62043	62054	62064	62075
0.2	62086	62097	62107	62118	62129	62139	62150	62161	62172	62182
0.3	62193	62204	62215	62225	62236	62247	62258	62268	62279	62290
0.4	62301	62311	62322	62333	62344	62354	62365	62376	62387	62397
0.5	62408	62419	62429	62440	62451	62462	62472	62483	62494	62505
0.6	62515	62526	62537	62548	62558	62569	62580	62591	62601	62612
0.7	62623	62634	62644	62655	62666	62676	62687	62698	62709	62719
0.8	62730	62741	62752	62762	62773	62784	62795	62805	62816	62827
0.9	62838	62848	62859	62870	62881	62891	62902	62913	62924	62934
5672	62945	62956	62967	62977	62988	62999	63010	63021	63032	63042
0.1	63053	63064	63075	63086	63097	63107	63118	63129	63140	63151
0.2	63162	63172	63183	63194	63205	63216	63227	63237	63248	63259
0.3	63270	63281	63292	63302	63313	63324	63335	63346	63357	63367
0.4	63378	63389	63400	63411	63422	63432	63443	63454	63465	63476
0.5	63486	63497	63508	63519	63530	63541	63551	63562	63573	63584
0.6	63595	63606	63616	63627	63638	63649	63660	63671	63681	63692
0.7	63703	63714	63725	63736	63746	63757	63768	63779	63790	63801
0.8	63811	63822	63833	63844	63855	63866	63876	63887	63898	63909
0.9	63920	63931	63941	63952	63963	63974	63985	63996	64006	64017
5673	64028	64039	64050	64061	64072	64083	64094	64105	64116	64126
0.1	64137	64148	64159	64170	64181	64192	64203	64214	64225	64236
0.2	64247	64258	64269	64280	64291	64301	64312	64323	64334	64345
0.3	64356	64367	64378	64389	64400	64411	64422	64433	64444	64455
0.4	64466	64477	64487	64498	64509	64520	64531	64542	64553	64564
0.5	64575	64586	64597	64608	64619	64630	64641	64652	64663	64673
0.6	64684	64695	64706	64717	64728	64739	64750	64761	64772	64783
0.7	64794	64805	64816	64827	64838	64848	64859	64870	64881	64892
0.8	64903	64914	64925	64936	64947	64958	64969	64980	64991	65002
0.9	65013	65024	65034	65045	65056	65067	65078	65089	65100	65111
5674	65122	65133	65144	65155	65166	65177	65188	65199	65210	65221
0.1	65232	65244	65255	65266	65277	65288	65299	65310	65321	65332
0.2	65343	65354	65365	65376	65387	65398	65409	65420	65431	65442
0.3	65453	65465	65476	65487	65498	65509	65520	65531	65542	65553
0.4	65564	65575	65586	65597	65608	65619	65630	65641	65652	65663
0.5	65674	65686	65697	65708	65719	65730	65741	65752	65763	65774
0.6	65785	65796	65807	65818	65829	65840	65851	65862	65873	65884
0.7	65895	65907	65918	65929	65940	65951	65962	65973	65984	65995
0.8	66006	66017	66028	66039	66050	66061	66072	66083	66094	66105
0.9	66116	66128	66139	66150	66161	66172	66183	66194	66205	66216
5675	66227	66238	66249	66260	66272	66283	66294	66305	66316	66327
0.1	66338	66350	66361	66372	66383	66394	66405	66417	66428	66439
0.2	66450	66461	66472	66483	66495	66506	66517	66528	66539	66550
0.3	66561	66573	66584	66595	66606	66617	66628	66640	66651	66662
0.4	66673	66684	66695	66706	66718	66729	66740	66751	66762	66773
0.5	66784	66796	66807	66818	66829	66840	66851	66863	66874	66885
0.6	66896	66907	66918	66929	66941	66952	66963	66974	66985	66996
0.7	67007	67019	67030	67041	67052	67063	67074	67086	67097	67108
0.8	67119	67130	67141	67152	67164	67175	67186	67197	67208	67219
0.9	67230	67242	67253	67264	67275	67286	67297	67309	67320	67331

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5676	67342	67353	67364	67376	67387	67398	67409	67421	67432	67443
0.1	67454	67466	67477	67488	67499	67511	67522	67533	67544	67556
0.2	67567	67578	67589	67601	67612	67623	67634	67645	67657	67668
0.3	67679	67690	67702	67713	67724	67735	67747	67758	67769	67780
0.4	67792	67803	67814	67825	67837	67848	67859	67870	67882	67893
0.5	67904	67915	67926	67938	67949	67960	67971	67983	67994	68005
0.6	68016	68028	68039	68050	68061	68073	68084	68095	68106	68118
0.7	68129	68140	68151	68163	68174	68185	68196	68207	68219	68230
0.8	68241	68252	68264	68275	68286	68297	68309	68320	68331	68342
0.9	68354	68365	68376	68387	68399	68410	68421	68432	68444	68455
5677	68466	68477	68489	68500	68511	68523	68534	68546	68557	68568
0.1	68580	68591	68602	68614	68625	68636	68648	68659	68670	68682
0.2	68693	68705	68716	68727	68739	68750	68761	68773	68784	68795
0.3	68807	68818	68830	68841	68852	68864	68875	68886	68898	68909
0.4	68920	68932	68943	68954	68966	68977	68989	69000	69011	69023
0.5	69034	69045	69057	69068	69079	69091	69102	69114	69125	69136
0.6	69148	69159	69170	69182	69193	69204	69216	69227	69238	69250
0.7	69261	69273	69284	69295	69307	69318	69329	69341	69352	69363
0.8	69375	69386	69398	69409	69420	69432	69443	69454	69466	69477
0.9	69488	69500	69511	69522	69534	69545	69557	69568	69579	69591
5678	69602	69613	69625	69636	69648	69659	69671	69682	69694	69705
0.1	69717	69728	69740	69751	69763	69774	69786	69797	69808	69820
0.2	69831	69843	69854	69866	69877	69889	69900	69912	69923	69935
0.3	69946	69958	69969	69981	69992	70003	70015	70026	70038	70049
0.4	70061	70072	70084	70095	70107	70118	70130	70141	70153	70164
0.5	70175	70187	70198	70210	70221	70233	70244	70256	70267	70279
0.6	70290	70302	70313	70325	70336	70348	70359	70370	70382	70393
0.7	70405	70416	70428	70439	70451	70462	70474	70485	70497	70508
0.8	70520	70531	70543	70554	70565	70577	70588	70600	70611	70623
0.9	70634	70646	70657	70669	70680	70692	70703	70715	70726	70738
5679	70749	70761	70772	70784	70795	70807	70819	70830	70842	70853
0.1	70865	70877	70888	70900	70912	70923	70935	70946	70958	70970
0.2	70981	70993	71004	71016	71028	71039	71051	71062	71074	71086
0.3	71097	71109	71121	71132	71144	71155	71167	71179	71190	71202
0.4	71213	71225	71237	71248	71260	71271	71283	71295	71306	71318
0.5	71329	71341	71353	71364	71376	71388	71399	71411	71422	71434
0.6	71446	71457	71469	71480	71492	71504	71515	71527	71538	71550
0.7	71562	71573	71585	71597	71608	71620	71631	71643	71655	71666
0.8	71678	71689	71701	71713	71724	71736	71747	71759	71771	71782
0.9	71794	71806	71817	71829	71840	71852	71864	71875	71887	71898
5680	71910	71922	71933	71945	71957	71969	71980	71992	72004	72016
0.1	72027	72039	72051	72063	72074	72086	72098	72110	72121	72133
0.2	72145	72157	72168	72180	72192	72203	72215	72227	72239	72250
0.3	72262	72274	72286	72297	72309	72321	72333	72344	72356	72368
0.4	72380	72391	72403	72415	72427	72438	72450	72462	72474	72485
0.5	72497	72509	72520	72532	72544	72556	72567	72579	72591	72603
0.6	72614	72626	72638	72650	72661	72673	72685	72697	72708	72720
0.7	72732	72744	72755	72767	72779	72790	72802	72814	72826	72837
0.8	72849	72861	72873	72884	72896	72908	72920	72931	72943	72955
0.9	72967	72978	72990	73002	73014	73025	73037	73049	73061	73072

BEAR CREEK PROJECT CAPACITY TABLES - Effective Date 12 March 2009

Capacity in Acre Feet - 2009 resurvey

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
5681	73084	73096	73108	73120	73131	73143	73155	73167	73179	73191
0.1	73203	73215	73226	73238	73250	73262	73274	73286	73298	73310
0.2	73321	73333	73345	73357	73369	73381	73393	73404	73416	73428
0.3	73440	73452	73464	73476	73488	73499	73511	73523	73535	73547
0.4	73559	73571	73583	73594	73606	73618	73630	73642	73654	73666
0.5	73677	73689	73701	73713	73725	73737	73749	73761	73772	73784
0.6	73796	73808	73820	73832	73844	73856	73867	73879	73891	73903
0.7	73915	73927	73939	73951	73962	73974	73986	73998	74010	74022
0.8	74034	74045	74057	74069	74081	74093	74105	74117	74129	74140
0.9	74152	74164	74176	74188	74200	74212	74224	74235	74247	74259
5682	74271	74283	74295	74307	74319	74331	74343	74355	74367	74379
0.1	74391	74403	74415	74427	74439	74451	74463	74475	74487	74499
0.2	74511	74523	74535	74547	74559	74571	74583	74595	74607	74619
0.3	74631	74643	74655	74667	74679	74691	74703	74715	74727	74739
0.4	74751	74763	74775	74787	74799	74811	74823	74835	74847	74859
0.5	74870	74882	74894	74906	74918	74930	74942	74954	74966	74978
0.6	74990	75002	75014	75026	75038	75050	75062	75074	75086	75098
0.7	75110	75122	75134	75146	75158	75170	75182	75194	75206	75218
0.8	75230	75242	75254	75266	75278	75290	75302	75314	75326	75338
0.9	75350	75362	75374	75386	75398	75410	75422	75434	75446	75458
5683	75470	75482	75494	75506	75518	75531	75543	75555	75567	75579
0.1	75591	75603	75615	75627	75640	75652	75664	75676	75688	75700
0.2	75712	75724	75736	75749	75761	75773	75785	75797	75809	75821
0.3	75833	75845	75858	75870	75882	75894	75906	75918	75930	75942
0.4	75954	75967	75979	75991	76003	76015	76027	76039	76051	76063
0.5	76075	76088	76100	76112	76124	76136	76148	76160	76172	76184
0.6	76197	76209	76221	76233	76245	76257	76269	76281	76293	76306
0.7	76318	76330	76342	76354	76366	76378	76390	76402	76415	76427
0.8	76439	76451	76463	76475	76487	76499	76511	76524	76536	76548
0.9	76560	76572	76584	76596	76608	76620	76633	76645	76657	76669
5684	76681	76693	76705	76718	76730	76742	76754	76767	76779	76791
0.1	76803	76816	76828	76840	76852	76865	76877	76889	76901	76914
0.2	76926	76938	76950	76963	76975	76987	76999	77011	77024	77036
0.3	77048	77060	77073	77085	77097	77109	77122	77134	77146	77158
0.4	77171	77183	77195	77207	77220	77232	77244	77256	77269	77281
0.5	77293	77305	77317	77330	77342	77354	77366	77379	77391	77403
0.6	77415	77428	77440	77452	77464	77477	77489	77501	77513	77526
0.7	77538	77550	77562	77575	77587	77599	77611	77623	77636	77648
0.8	77660	77672	77685	77697	77709	77721	77734	77746	77758	77770
0.9	77783	77795	77807	77819	77832	77844	77856	77868	77881	77893
5685	77905	77917	77930	77942	77954	77967	77979	77992	78004	78016
0.1	78029	78041	78053	78066	78078	78090	78103	78115	78127	78140
0.2	78152	78165	78177	78189	78202	78214	78226	78239	78251	78263
0.3	78276	78288	78301	78313	78325	78338	78350	78362	78375	78387
0.4	78399	78412	78424	78436	78449	78461	78474	78486	78498	78511
0.5	78523	78535	78548	78560	78572	78585	78597	78610	78622	78634
0.6	78647	78659	78671	78684	78696	78708	78721	78733	78745	78758
0.7	78770	78783	78795	78807	78820	78832	78844	78857	78869	78881
0.8	78894	78906	78919	78931	78943	78956	78968	78980	78993	79005
0.9	79017	79030	79042	79054	79067	79079	79092	79104	79116	79129