

# **Pensacola Hydroelectric Project**

## **FERC Project No. 1494**

### **Exhibit B**

### **Project Operation and Resource Utilization**

#### **Final License Application**

**Note:** All information in this Exhibit B and its Appendices relating to water surface elevations is provided for information only, and not for approval by the Federal Energy Regulatory Commission (Commission) or any other agency. Section 7612(b)(2) of the National Defense Authorization Act of 2020, Pub. L. No. 116-92, 133 Stat. 1198 (2019), prohibits the Commission and other agencies—except with respect to the U.S. Army Corps of Engineers in carrying out its flood control responsibilities under section 7 of the Flood Control Act of 1944—from including in any license for the Pensacola Hydroelectric Project “any condition or other requirement relating to—(i) surface elevations of the conservation pool; or (ii) the flood pool (except to the extent it references flood control requirements prescribed by the Secretary).” Thus, the Commission should not make this Exhibit B or any of its appendices part of the new license for the Project.

**Prepared for**



**Prepared by**



**May 2023**

## TABLE OF CONTENTS

	Page
<b>1. Project Operation .....</b>	<b>1</b>
1.1    Neosho (Grand) River Basin Flow Management .....	2
1.2    Anticipated Operation of the Pensacola Project .....	2
1.2.1    Anticipated Reservoir Normal Operations .....	3
1.2.2    Anticipated Reservoir High Flow Operations .....	3
1.2.3    Anticipated Reservoir Low Flow Operations .....	4
<b>2. Generating Characteristics and Flow Data.....</b>	<b>5</b>
2.1    Average Annual Generation.....	5
2.2    Plant Factor.....	5
2.3    River Flow Characteristics .....	6
2.3.1    Pensacola Dam Mean Monthly Inflows.....	6
2.3.2    Inflow Duration Curves.....	7
2.3.3    Pensacola Dam Discharge Variation .....	7
2.4    Dependable Capacity .....	8
2.5    Area Capacity Curves .....	9
2.6    Plant Estimated Hydraulic Capacity .....	9
2.7    Tailwater Rating Curve .....	9
2.8    Plant Capability Versus Head .....	9
2.9    Operations Model Output Data .....	10
<b>3. Utilization of Public Power .....</b>	<b>10</b>
<b>4. Proposed Future Development.....</b>	<b>10</b>
<b>5. Works Cited .....</b>	<b>10</b>

## TABLES

Table 2.3.1-1: Pensacola Dam Mean Monthly Inflows .....	6
Table 2.3.3-1: Modeled Pensacola Dam Total Discharge Variation for Anticipated Operation .....	7
Table 2.3.3-2: Modeled Pensacola Dam Spillway Discharge Variation for Anticipated Operation.....	8
Table 2.3.3-3: Modeled Pensacola Dam Turbine Discharge Variation for Anticipated Operation.....	8

## APPENDICES

Appendix B-1    Pensacola Modeled Headwater Elevation Exceedance Curves for Anticipated Operation	
Appendix B-2    Pensacola Observed Inflow Duration Curves and Exceedance Table	
Appendix B-3    Pensacola Modeled Total, Spillway, and Turbine Discharge Flow Duration Curves and Exceedance Tables for Anticipated Operation	

- 
- Appendix B-4 Reservoir Area and Storage Capacity Curves
  - Appendix B-5 Tailwater Rating Curve
  - Appendix B-6 Modeled Pensacola Tailwater Elevation and Lake Hudson Headwater Elevation Exceedance Curves for Anticipated Operation
  - Appendix B-7 Powerplant Capability Curve
  - Appendix B-8 Current Operation Supplementary Document and Appendices
  - Appendix B-9 Modeled Current Operation Data
  - Appendix B-10 Modeled Anticipated Operation Data

## LIST OF ABBREVIATIONS

cfs	cubic feet per second
DO	Dissolved Oxygen
ECC	Energy Control Center
FERC	Federal Energy Regulatory Commission
FPA	Federal Power Act
FRM	Flood Routing Model
GRDA	Grand River Dam Authority
Grand Lake	Grand Lake O' the Cherokees
H&H	Hydrologic and Hydraulic
Licensee	Grand River Dam Authority
MW	Megawatts
MWh	Megawatt-hours
NAVD 88	North American Vertical Datum of 1988
NDAA 2020	National Defense Authorization Act for Fiscal Year 2020
NGVD 29	National Geodetic Vertical Datum of 1929
OM	Operations Model
PD	Pensacola Datum
Pensacola Project	Pensacola Hydroelectric Project
Project	Pensacola Hydroelectric Project
RWM	RiverWare Model
SPP	Southwest Power Pool
STID	Supporting Technical Information Document
USACE	U.S. Army Corps of Engineers
USGS	United States Geological Survey

## 1. Project Operation

The Pensacola Hydroelectric Project (Pensacola Project or Project) is owned and operated by the Grand River Dam Authority (GRDA or Licensee). As required by the Commission's regulations, this Exhibit B contains "a statement of project operation and resource utilization" 18 C.F.R. § 4.51(c). **GRDA emphasizes, however, that information contained in this Exhibit B regarding anticipated operations under the new license relating to water surface elevations at Grand Lake is being provided for informational purposes only, as section 7612 of the National Defense Authorization Act for Fiscal Year 2020 (NDAA 2020) expressly prohibits the Commission or any other agency from imposing license obligations relating to water surface elevations of the Project's conservation pool (i.e., surface elevations in Grand Lake up to elevation 745 PD).** NDAA 2020 section 612 provides, in relevant part:

A) IN GENERAL.—Except as may be required by the Secretary to carry out responsibilities under section 7 of the Flood Control Act of 1944 (33 U.S.C. 709), the Commission or any other Federal or State agency shall not include in any license for the project any condition or other requirement relating to—

- (i) surface elevations of the conservation pool; or
- (ii) the flood pool (except to the extent it references flood control requirements prescribed by the Secretary).

(B) EXCEPTION.—Notwithstanding subparagraph (A), the project shall remain subject to the Commission's rules and regulations for project safety and protection of human health.

Although Congress in NDAA 2020 granted GRDA independence in Project operations relative to surface elevations at Grand Lake, GRDA does not object to providing information on anticipated Project operations as provided in regulations governing the contents of this Exhibit B. For purposes of meeting the Exhibit B reporting requirements, GRDA hereby presents its anticipated parameters during the new license term, as follows:

1. GRDA will no longer utilize a rule curve with seasonal target elevations.
2. GRDA will maintain the reservoir between elevations 742 and 745 feet Pensacola Datum (PD)<sup>1</sup> for purposes of normal hydropower operations and until flood control operations are directed by the U.S. Army Corps of Engineers (USACE).
3. GRDA will continue to adhere to the USACE's direction on flood control operations in accordance with the Water Control Manual (USACE, 1992).
4. Hydraulic flow for hydropower operations is anticipated to take place as the first priority for discharge when the USACE is directing operation under its exclusive jurisdiction over Grand Lake for flood control purposes.

<sup>1</sup> Unless stated otherwise, all elevations are presented in Pensacola Datum (PD). To convert from PD to the National Geodetic Vertical Datum of 1929 (NGVD29), add 1.07 feet. To convert from NGVD29 to the North American Vertical Datum of 1988 (NAVD88), add 0.33 feet.

- 
5. Instead of managing the Project to target a specified seasonal elevation, GRDA's anticipated operations may fluctuate reservoir levels within the elevational range of 742 and 745 feet PD, for purposes of responding to grid demands, market conditions, and the public interest, such as environmental and recreational considerations.

## **1.1 Neosho (Grand) River Basin Flow Management**

The Pensacola Project is located on the Neosho (Grand) River in Craig, Delaware, Mayes, and Ottawa Counties, Oklahoma and consists of Pensacola Dam with a gated main spillway, middle gated spillway, east gated spillway, and powerhouse. Pensacola Dam impounds Grand Lake O' the Cherokees (Grand Lake). The Federal Energy Regulatory Commission (FERC) license number associated with the Pensacola Project is P-1494.

The Pensacola Project serves multiple purposes including hydropower generation, water supply, public recreation, flood control, and wildlife enhancement. For purposes of flood control of the overall upper Arkansas River Basin System, the Tulsa USACE office manages an expansive system of eleven large reservoirs. Grand Lake is within this system. Upstream of the Pensacola Project, USACE manages three federal reservoirs – Marion Reservoir, Council Grove, and John Redmond—with a combined storage capacity of approximately 465,000 acre-feet. Downstream of Grand Lake and GRDA's Lake Hudson (Markham Ferry), USACE manages Fort Gibson Reservoir (919,000 acre-feet) on the Grand River prior to its confluence with the Arkansas River. Within this large system, USACE must provide the safe passage of flows to municipalities and lands as far upstream as Emporia, Kansas, and downstream to Muskogee, Oklahoma—and further down the Arkansas River system, including Fort Smith, Russellville, Van Buren, and even Little Rock, Arkansas (GRDA, 2017).

Pensacola, Markham Ferry, and Fort Gibson Reservoirs are regulated as a subsystem of the upper Arkansas River Basin System, with similar percentages of the total flood control storage in each project utilized during periods of high flow. The system is also balanced by percentage of flood control storage utilized during evacuation (USACE, 1992). Under Section 7 of the Flood Control Act of 1944 (CFR, 1944), the USACE has the responsibility to prescribe releases from Pensacola Dam under active or anticipated flood operations (CFR, 1945).

As noted above, Congress in 2019 enacted the NDAA 2020.<sup>2</sup> Importantly, NDAA 2020 includes special legislation applicable only to operations of the Pensacola Project, and it significantly changes the scope of the ongoing relicensing for this Project. Specifically, as explained above, NDAA 2020 expressly forbids the Commission and other agencies from imposing license conditions relating to surface elevations of the conservation pool at Grand Lake.

## **1.2 Anticipated Operation of the Pensacola Project**

Power generation at the Pensacola Project is coordinated with GRDA's other hydroelectric generating resources at the Markham Ferry and Salina Pumped-Storage Projects; with the fossil fuel generating units at GRDA's Grand River Energy Center (formerly known as the Coal Fired Complex) and Redbud

---

<sup>2</sup> Pub. L. No. 116-92 (2019).

Power Plant; and renewable energy from wind turbines. Power generation at the Project and GRDA's other generating resources is controlled from GRDA's Energy Control Center (ECC), which is located at Kerr Dam. The ECC is continuously staffed. The ECC operators are responsible for operating GRDA's 16 hydroelectric units. The operating condition of all hydroelectric generators, headwater and tailwater levels, and other status information is continuously updated and available to operators from GRDA's supervisory control and data acquisition system. Since 2013, GRDA has participated in the regional power market that is managed by the Southwest Power Pool (SPP), a multistate regional transmission organization. SPP coordinates the generation from all member utilities to supply current electrical demands using the most economical mix of generating resources (GRDA, 2021b).

### **1.2.1 Anticipated Reservoir Normal Operations**

For the purposes of normal hydropower operations, GRDA anticipates maintaining the reservoir between elevations 742 and 745 feet PD, with reservoir elevations fluctuating within this elevational range for purposes of responding to grid demands, market conditions, and the public interest, such as environmental and recreational considerations. The basic operating goal of the Project is to use any water available within its operating range for electric generation as efficiently as possible.

### **1.2.2 Anticipated Reservoir High Flow Operations**

As demonstrated by extensive study during this relicensing process, GRDA's normal hydropower Project operations between the elevations of 742 and 745 feet PD do not materially affect water surface elevations, frequency, timing, amplitude, or duration of flooding in the Grand/Neosho watershed upstream of Pensacola Dam. These findings demonstrate the efforts completed under the Storm Adaptive Management Plan (SAMP) required under the current license are unnecessary to address any Project effect. Therefore, GRDA is not proposing to continue the SAMP under the new license. Instead, any questions or concerns related to flood control at Grand Lake should be raised with USACE—the agency designated by Congress for exclusive jurisdiction over flood control at Grand Lake.

Federal law establishes a Congressionally authorized regulatory structure at Grand Lake. Under Section 7 of the Flood Control Act of 1944 (CFR, 1944), for example, Congress conferred upon the USACE the exclusive responsibility to prescribe releases from Pensacola Dam under active or anticipated flood operations (CFR, 1945). The USACE is also responsible for directing spillway releases in accordance with the procedures for system balancing of flood storage outlined in the Arkansas River Basin Water Control Master Manual (USACE, 1992). This exclusive authority is reinforced by Section 7612(c) of the NDAA of Fiscal Year 2020 which states that "The Secretary [of the Army] shall have exclusive jurisdiction and responsibility for management of the flood pool for flood control operations at Grand Lake O' the Cherokees" (NDAA, 2020). Other federal laws, such as Public Law 76-597, 54 Stat. 303 (1940), and Public Law 79-573, 60 Stat. 743 (1946), confirm that Congress has long established that USACE has sole jurisdiction over flood control, while the Commission retains jurisdiction under the FPA within the conservation pool. Even the original license issued by the Federal Power Commission in 1939 recognizes this bifurcated authority.

The flood storage associated with Grand Lake consists of the storage volume available between the approximate reservoir elevation of 745 feet and the elevation of 755 feet PD (USACE, 1992). When reservoir elevations are either above elevation 745 feet PD or projected to rise above 745 feet PD,

the USACE directs the water releases from the dam under the terms of Section 7 of the Flood Control Act of 1944. When directed to make lake releases by USACE, GRDA first discharges as much water as possible through the Project's hydropower units. Once the Project has reached the powerhouse's maximum hydraulic capacity, USACE may direct GRDA to open one or more spillway gates if the reservoir is still rising, but typically not unless the reservoir elevation exceeds, or is projected to exceed 745 feet PD. USACE will then determine if additional gates need to be opened. The target discharge rate at any time is based on the current reservoir elevation, the current estimated inflow to Grand Lake, and the amount of projected flooding downstream in the Grand or Arkansas River basins (GRDA, 2017).

Operators in the ECC are contacted by USACE personnel when gate operations are required. When USACE directs GRDA to release water from Grand Lake, the staff at Pensacola Dam decides which specific gate or gates to open. The opening order of these gates is rotated so each gate is opened about the same number of times. However, a general exception to this rule is that GRDA avoids opening the outside gates on all three spillways, when possible, to help limit bank erosion in the discharge channels downstream of the spillways (GRDA, 2021b).

### **1.2.3 Anticipated Reservoir Low Flow Operations**

GRDA's anticipated operations are not based on a targeted seasonal rule curve. As a result, GRDA will not be implementing a Drought Adaptive Management Plan under its anticipated operations because it is no longer necessary to maintain targeted minimums. GRDA anticipates maintaining required dissolved oxygen (DO) concentrations downstream of the Pensacola Project and Markham Ferry Projects during drought conditions while still maintaining reservoir elevations at the Markham Ferry Project sufficient to operate the Salina Pumped Storage Project, as well as meeting water supply needs (FERC, 2017).

A graph with 10%, 25%, 50%, 75% and 90% exceedance curves for modeled headwater elevations during the anticipated operation of the Project is provided in **Appendix B-1**. The graph was developed using hourly headwater elevation outputs from the Operations Model (OM) developed as part of the Hydrologic and Hydraulic (H&H) study (Mead & Hunt, 2022). The hourly headwater elevations from the OM used for development of the graphs span a time period from April 1, 2004 through December 31, 2019.

Detailed descriptions of current reservoir operations (subsequent to the August 14, 2015 Commission Order that revised the rule curve) under normal, high, and low flow conditions and the current rule curve used under current operation are provided in **Appendix B-8**. Graphs with 10%, 25%, 50%, 75%, and 90% exceedance curves for Pensacola observed and modeled headwater elevations for current operation (current rule curve) are also provided in **Appendix B-8**.

## 2. Generating Characteristics and Flow Data

### 2.1 Average Annual Generation

The Pensacola Project has a generating capacity of 105.176 megawatts (MW). The OM was used to compute the annual average generation for anticipated operation. The modeled average annual generation for anticipated operation is 432,843 megawatt-hours (MWh), of which 230,012 MWh is on-peak generation and 202,831 MWh is off-peak generation. The modeled average annual generation values were computed using a time period of January 1, 2005 through December 31, 2019 so that only full calendar years were used.

Actual average annual generation under current operation and modeled average annual generation for current operation, along with the associated on-peak and off-peak generation values, are provided in **Appendix B-8**.

The input conditions used in the OM and/or Flood Routing Model (FRM) include inflows, evaporation and seepage rates, reservoir stage-storage-area tables, reservoir operating level tables, maximum regulated spill tables, induced surcharge tables, and hydrologic routing coefficient tables. The FRM attempts to replicate the flow routing decisions in the RiverWare Model (RWM) using Corps procedures including operating level balancing, flat top surcharge method, allowable rising/falling release change rates, and regulating discharges. The RWM illustrates, for example, how the USACE may increase the headwater elevation and reduce discharges at Pensacola Dam during a large flood event to limit flow at USGS Gage No. 07250500 in Van Buren, Arkansas to mitigate basin-wide flooding. The RWM, FRM, and OM are discussed in detail in the *Updated Study Report for Hydrologic and Hydraulic Modeling: Operations Model* (Mead & Hunt, 2022) as an appendix to Exhibit E.

The period of historic inflows used for the OM represents a typical distribution of normal, high, and low flow conditions. This was confirmed by comparing the distribution of daily inflow values from the RWM (1940-2019 period of record), the OM (2004-2019 period of record), and historical data for other 16-year sample periods (1940-1955, 1956-1971, 1972-1987, and 1988-2003 periods of record), all of which are highly correlated.

### 2.2 Plant Factor

The following equation is used to determine the average annual plant factor:

$$\text{Average Annual Plant Factor} = (\text{Average Annual Output}) \div (\text{Nameplate Capacity} \times 8,760 \text{ hours/year})$$

According to GRDA's generation records for the 10-year period spanning January 2012 through December 2021, the Pensacola Project had a gross average annual energy production (output) of 444,855 MWh per year and an annual plant factor of 0.482 based on its current FERC authorized capacity of 105.176 MW.

The same input conditions are used in the OM for both current operation under the existing license<sup>3</sup> and anticipated operation beginning with the new license term. The only changes between these two operating scenarios are operating rules, not input conditions, and includes the following:

- The operating level table associated with the current rule curve is updated to reflect the anticipated operational range.
- The modeled anticipated operating rules include an incentive table to determine when to generate power based on trailing standard deviations of power prices and the reservoir elevation within the anticipated operating range, whereas the modeled current operating rules use a simpler price ranking and excess volume (above rule curve) method to schedule power generation. This change is necessary based on the different type of operation (anticipated range of power pool elevations vs. current rule curve elevation).

To provide a proper comparison of the estimated change in project generation, the OM estimates an average annual generation under the current operation (current rule curve) of 413,830 MWh (see **Appendix B-8**) with a plant factor of 0.449 based on the FERC authorized capacity of 105.176 MW, and an average annual generation under the anticipated operation of 432,843 MWh with a plant factor of 0.470.

## 2.3 River Flow Characteristics

Inflow to the Pensacola Project comes from three rivers which are tributaries to Grand Lake: the Neosho River, Spring River, and Elk River. Flow data for each river is recorded by U.S. Geological Survey (USGS) surface water gaging station Nos. 07185000, 07188000, and 07189000 respectively. Drainage areas at the USGS stream gages are 5,926, 2,516, and 851 square miles respectively for a total gage drainage area of 9,293 square miles (USGS, 2022a), (USGS, 2022b), (USGS, 2022c). The drainage area at Pensacola Dam is 10,345 square miles (USGS, 2022d). Dividing the Pensacola Dam drainage area by the total gage drainage area results in a drainage area ratio of 1.113. Mean daily flow data was retrieved for the period of record from January 1, 1965 to December 31, 2022 for each river and the flows were combined to determine the total tributary flows. To compute the inflows to Pensacola Dam, the total tributary flows were scaled up to account for the larger drainage area of Pensacola Dam by multiplying the total tributary flows by the drainage area ratio of 1.113. Daily mean flows were obtained only for dates after January 1, 1965, to account for completion of the upstream John Redmond Reservoir in 1964.

### 2.3.1 Pensacola Dam Mean Monthly Inflows

Unscaled and scaled mean monthly inflows to Pensacola Dam are shown below in **Table 2.3.1-1**.

*Table 2.3.1-1: Pensacola Dam Mean Monthly Inflows*

Month	Mean Monthly Inflow Unscaled (cfs)	Mean Monthly Inflow Scaled (cfs)
January	5,013	5,580
February	6,021	6,703
March	9,957	11,084

<sup>3</sup> The current operation is further described in Appendix B-8.

Month	Mean Monthly Inflow Unscaled (cfs)	Mean Monthly Inflow Scaled (cfs)
April	10,823	12,048
May	14,096	15,691
June	12,085	13,453
July	6,754	7,519
August	3,343	3,721
September	4,136	4,604
October	4,921	5,478
November	6,342	7,060
December	5,560	6,189

Sources: USGS Gaging Station Nos. 07185000, 07188000, 07189000

### 2.3.2 Inflow Duration Curves

Flow duration data shows the percentage of time a given flow is equaled or exceeded. Flow duration curves for inflow to Pensacola Dam and the annual exceedance table are based on data collected for the period of record from January 1965 to December 2022 and are included in **Appendix B-2**. The flow duration curves and annual exceedance table use the scaled (adjusted) inflow values.

### 2.3.3 Pensacola Dam Discharge Variation

Flow duration curves and annual exceedance tables for total discharge from Pensacola Dam, turbine discharge, and spillway discharge for modeled anticipated operation are provided in **Appendix B-3**. These flow duration curves and annual exceedance tables were developed using hourly discharge values from the OM and span a time period of April 1, 2004 through December 31, 2019.

Total discharge, turbine discharge, and spillway discharge flow duration curves for observed current operation and modeled current operation are provided in **Appendix B-8**.

Pensacola Dam modeled discharge variations for anticipated operation for total discharge, spillway discharge, and turbine discharge are shown below in **Tables 2.3.3-1, 2.3.3-2, and 2.3.3-3** respectively. Discharge variations are based on the results of the OM for the time period from April 1, 2004 through December 31, 2019.

*Table 2.3.3-1: Modeled Pensacola Dam Total Discharge Variation for Anticipated Operation*

Flow Statistic	Flow Statistic Value (cfs) <sup>4</sup>	Date(s)
Annual mean	8,617	Apr 1, 2004 – Dec 31, 2019
Highest annual mean	19,569	2019
Lowest annual mean	1,436	2006
Highest hourly flow	220,288	Dec 29, 2015 23:00

<sup>4</sup> The values in Tables 2.3.3-1, 2.3.3-2, and 2.3.3-3 were revised to represent discharges from Pensacola Dam, not inflow to the dam.

Flow Statistic	Flow Statistic Value (cfs) <sup>4</sup>	Date(s)
Lowest hourly flow	0	N/A <sup>5</sup>
10-percent exceedance	16,083	--
50-percent exceedance	0	--
90-percent exceedance	0	--

Table 2.3.3-2: Modeled Pensacola Dam Spillway Discharge Variation for Anticipated Operation

Flow Statistic	Flow Statistic Value (cfs) <sup>4</sup>	Date(s)
Annual mean	2,733	Apr 1, 2004 – Dec 31, 2019
Highest annual mean	8,614	2019
Lowest annual mean	134	2006
Highest hourly flow	207,459	Dec 29, 2015 0:00
Lowest hourly flow	0	N/A <sup>5</sup>
10-percent exceedance	1,982	--
50-percent exceedance	0	--
90-percent exceedance	0	--

Table 2.3.3-3: Modeled Pensacola Dam Turbine Discharge Variation for Anticipated Operation

Flow Statistic	Flow Statistic Value (cfs) <sup>4</sup>	Date(s)
Annual mean	5,885	Apr 1, 2004 – Dec 31, 2019
Highest annual mean	10,956	2019
Lowest annual mean	1,302	2006
Highest hourly flow	14,915	May 22, 2019 23:00
Lowest hourly flow	0	N/A <sup>5</sup>
10-percent exceedance	14,323	--
50-percent exceedance	0	--
90-percent exceedance	0	--

## 2.4 Dependable Capacity

Dependable capacity refers to the power the Pensacola Project is guaranteed to produce during future hours of peak demand under adverse flow conditions. GRDA has defined the dependable capacity as equal to the Project's limited total nameplate capacity (turbine-limited to 17.446 MW for the six main units and generator-limited to 500 kW for the house unit) or 105.176 MW. The hydraulic capacity for the Pensacola Project's six turbine-generator units and the house unit is 15,090 cfs.

<sup>5</sup> Numerous hourly discharge values equal to zero were computed by the OM, so specific dates are not included.

## 2.5 Area Capacity Curves

**Appendix B-4** presents area capacity and storage capacity curves for the Pensacola Project obtained from the 2019 bathymetric survey of Grand Lake performed by USGS (Hunter, Trevisan, Villa, & Smith, 2020). The reservoir encompasses 41,581 acres with a gross storage capacity of 1,307,289 acre-feet at a reservoir elevation of 742 feet PD (the bottom of the anticipated operating range). At a reservoir elevation of 745 feet PD, the reservoir encompasses 45,056 acres with a gross storage capacity of 1,437,348 acre-feet. The useable storage capacity of the Pensacola Project within the range of 742 and 745 feet PD is therefore 130,059 acre-feet.

## 2.6 Plant Estimated Hydraulic Capacity

The maximum hydraulic capacity is 15,090 cfs at a net head of 125 feet. The minimum hydraulic capacity limited by cavitation on the main units is 2,005 cfs<sup>6</sup> at a net head of 95 feet (Mead & Hunt, 2022).

## 2.7 Tailwater Rating Curve

The Pensacola Project discharges into the Neosho River immediately downstream of the powerhouse. Under normal operating conditions, the tailrace elevation varies in direct response to the operation of the Pensacola Project. The tailwater rating curve for the Project is included as **Appendix B-5**. The tailwater elevations indicated by the curve are only valid for the tailrace channel below the Pensacola Powerhouse. Also, this curve should be applied only for conditions when the reservoir elevation of downstream Lake Hudson is near normal (elevation 619.0 feet NGVD). The Lake Hudson reservoir elevation can have a significant impact on tailwater elevations at Pensacola Project (GRDA, 2021b).

Graphs with 10%, 25%, 50%, 75% and 90% exceedance curves for Pensacola modeled tailwater elevations and Lake Hudson modeled headwater elevations for anticipated operation are provided in **Appendix B-6**. These graphs were developed using hourly water surface elevations computed by the OM for the time period of April 1, 2004 through December 31, 2019.

Graphs with 10%, 25%, 50%, 75% and 90% exceedance curves for Pensacola modeled tailwater elevations and Lake Hudson modeled headwater elevations for current operation are provided in **Appendix B-8**.

## 2.8 Plant Capability Versus Head

For normal hydropower operations at the Pensacola Project, the reservoir elevation is anticipated to fluctuate between 742 and 745 feet PD. The head available for power generation is dependent on tailwater elevations. The turbine-generator units are rated for a nominal head of 117.5 feet. Plant capability based on maximum generator output at various head elevations for the Pensacola Project were derived from inputs used for the Operations Model developed as part of the H&H study (Mead & Hunt, 2022). The plant capability curve for the Pensacola Project is presented as **Appendix B-7**.

---

<sup>6</sup> The house unit has a hydraulic capacity of 60 cfs at an as-built head of 115 feet. The minimum hydraulic capacity is not known.

## 2.9 Operations Model Output Data

Un-summarized data for modeled current operation and modeled anticipated operation for project inflow (total and net), Grand Lake (Pensacola) headwater elevation, Pensacola tailwater elevation, Lake Hudson headwater elevation, project discharge (turbine, spillway, and total), and project generation (on-peak, off-peak, and total) are included in this application as **Appendix B-9** and **Appendix B-10** respectively. Total and net project inflows use a daily time-step and all other values use hourly time-steps.

## 3. Utilization of Public Power

Power generated at the Pensacola Project is sold to three customer classes: municipalities, electric cooperatives, and industries. GRDA customers include 15 Oklahoma public power municipalities, resident industries in the MidAmerica Industrial Park, Western Farmers Electric Cooperative, and other customers across a four-state region (GRDA, n.d.).

## 4. Proposed Future Development

GRDA is not proposing any new development or any expansion of any land or water rights as a consequence of this application.

## 5. Works Cited

- CFR. (1944). *Regulations for use of storage waters*. 33 U.S. Code § 709.
- CFR. (1945). *Pensacola Dam and Reservoir, Grand (Neosho) River, Okla.* 33 CFR § 208.25.
- FERC. (2009). *Order Amending Licensse by Revising Annual Charges*.
- FERC. (2017). *Order Amending License and Dismissing Application for Temporary Variance*.
- GRDA. (2017). *Pensacola Hydroelectric Project, FERC No. 1494 Pre-Application Document*.
- GRDA. (2021a, December 29). Pensacola Hydroelectric Project (FERC Project No. 1494-438); Response to Comments on Intitial Study Report, Notice of Technical Meeting, and Request for Privileged Treatment of Cultural Resources Information.
- GRDA. (2021b). *Supporting Technical Information Document - Revision 3*.
- GRDA. (n.d.). *Electricity*. Retrieved October 24, 2022, from GRDA: <https://grda.com/electricity/>
- Hunter, S. L., Trevisan, A. R., Villa, J., & Smith, K. A. (2020). *Bathymetric Map, Surface Area, and Capacity of Grand Lake O' the Cherokees, Northeastern Oklahoma, 2019*. Denver: USGS.
- Mead & Hunt. (2022). *Hydrologic and Hydraulic Modeling: Operations Model*.
- NDAA. (2020). S. 1790 National Defense Authorization Act for Fiscal Year 2020. Public Law No. 116-92.
- USACE. (1992). *Arkansas River Basin Water Control Master Manual*. Tulsa and Little Rock Districts.

USACE. (1992). *Pensacola Reservoir Water Control Manual-Appendix E, Part I of III to the Water Control Manual for the Arkansas River System.*

USGS. (2022a, September). *USGS 07185000 Neosho River near Commerce, OK.* Retrieved from National Water Information System:  
[https://waterdata.usgs.gov/nwis/inventory?agency\\_code=USGS&site\\_no=07185000](https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=07185000)

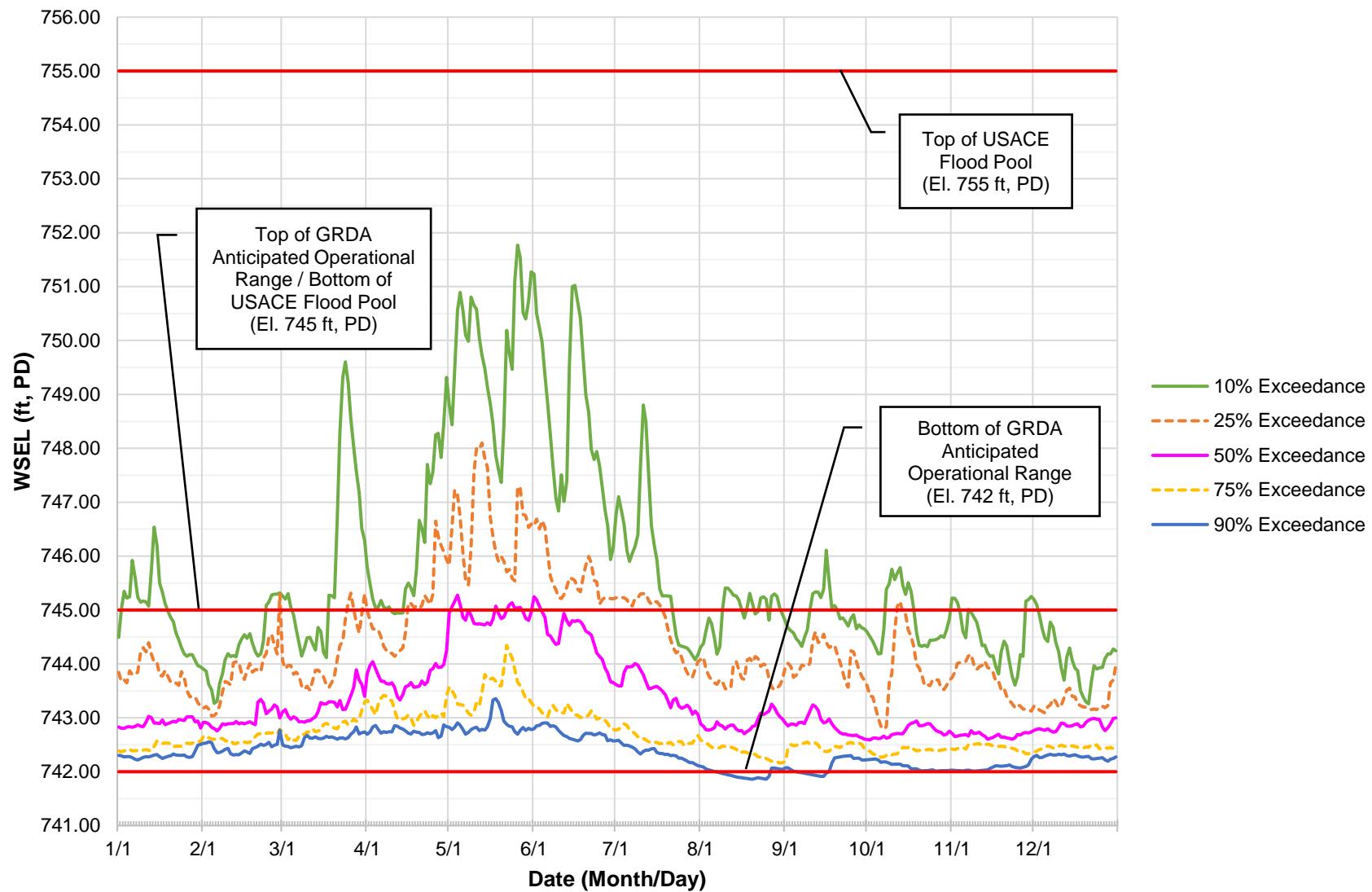
USGS. (2022b, September). *USGS 07188000 Spring River near Quapaw, OK.* Retrieved from National Water Information System:  
[https://waterdata.usgs.gov/nwis/inventory?agency\\_code=USGS&site\\_no=07188000](https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=07188000)

USGS. (2022c, September). *USGS 07189000 Elk River near Tiff City, MO.* Retrieved from National Water Information System:  
[https://waterdata.usgs.gov/nwis/inventory?agency\\_code=USGS&site\\_no=07189000](https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=07189000)

USGS. (2022d, September). *USGS 071890000 Lake O' the Cherokees at Langley, OK.* Retrieved from National Water Information System:  
[https://waterdata.usgs.gov/ok/nwis/inventory/?site\\_no=07190000&agency\\_cd=USGS](https://waterdata.usgs.gov/ok/nwis/inventory/?site_no=07190000&agency_cd=USGS)

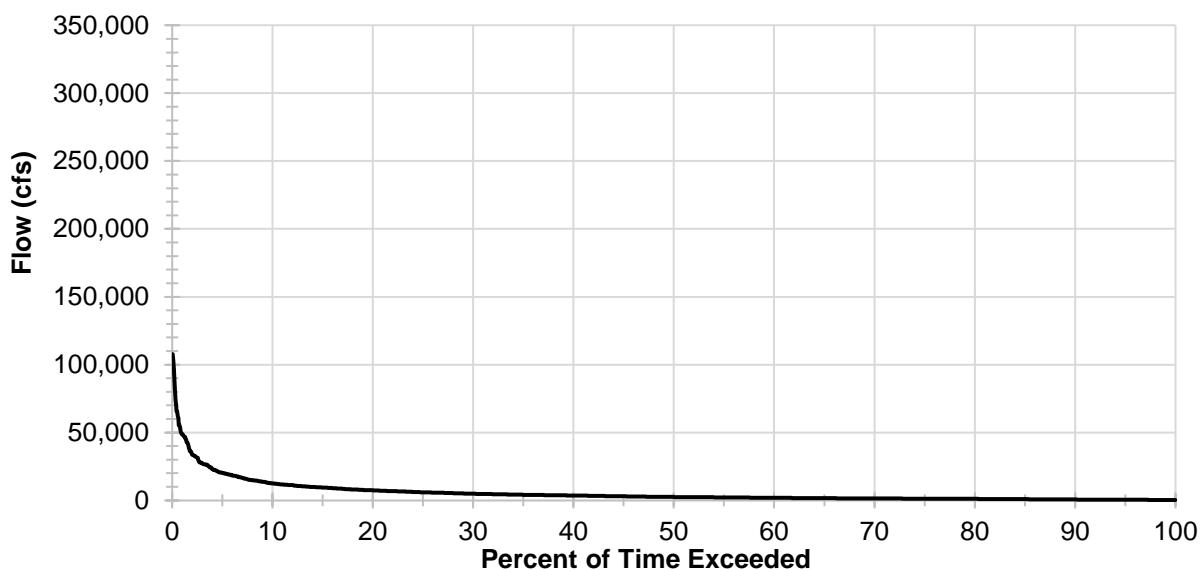
**APPENDIX B-1****Pensacola Modeled Headwater Elevation Exceedance Curves for  
Anticipated Operation**

## Pensacola Modeled Headwater Elevations Anticipated Operation

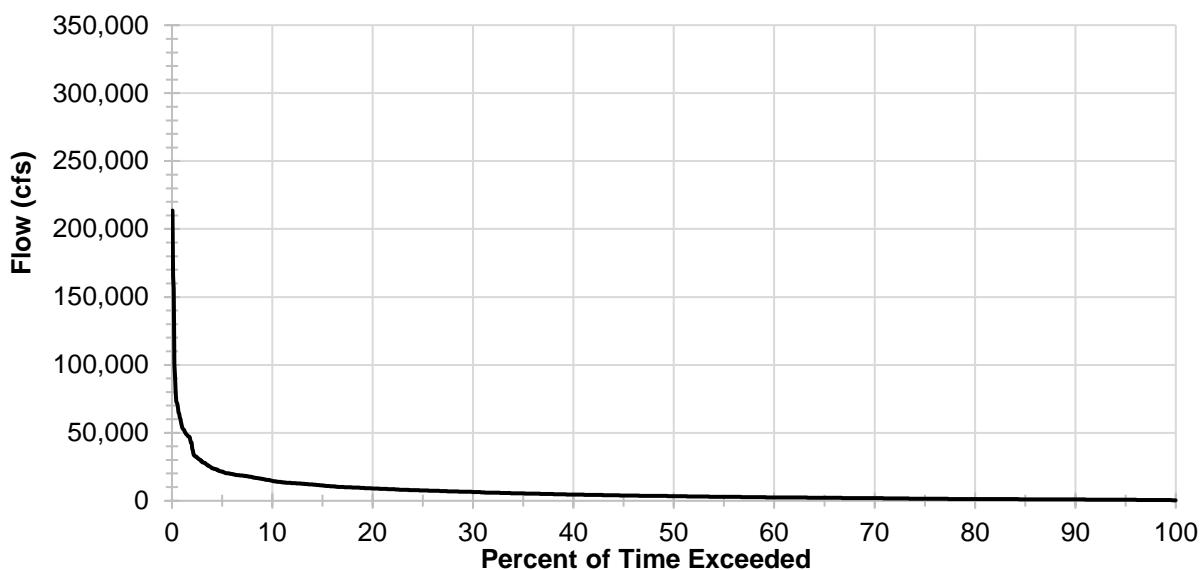


**APPENDIX B-2      Pensacola Observed Inflow Flow Duration Curves and Exceedance Table**

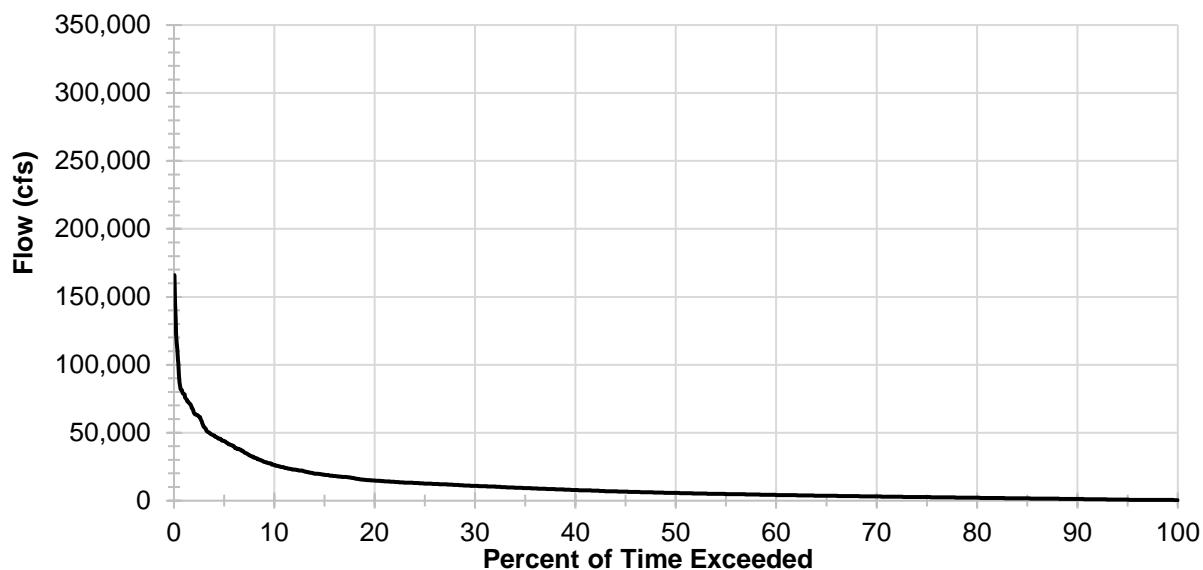
**January Flow Duration for Pensacola Dam  
Observed Inflow  
Period of Record Jan 1, 1965 - Dec 31, 2022**



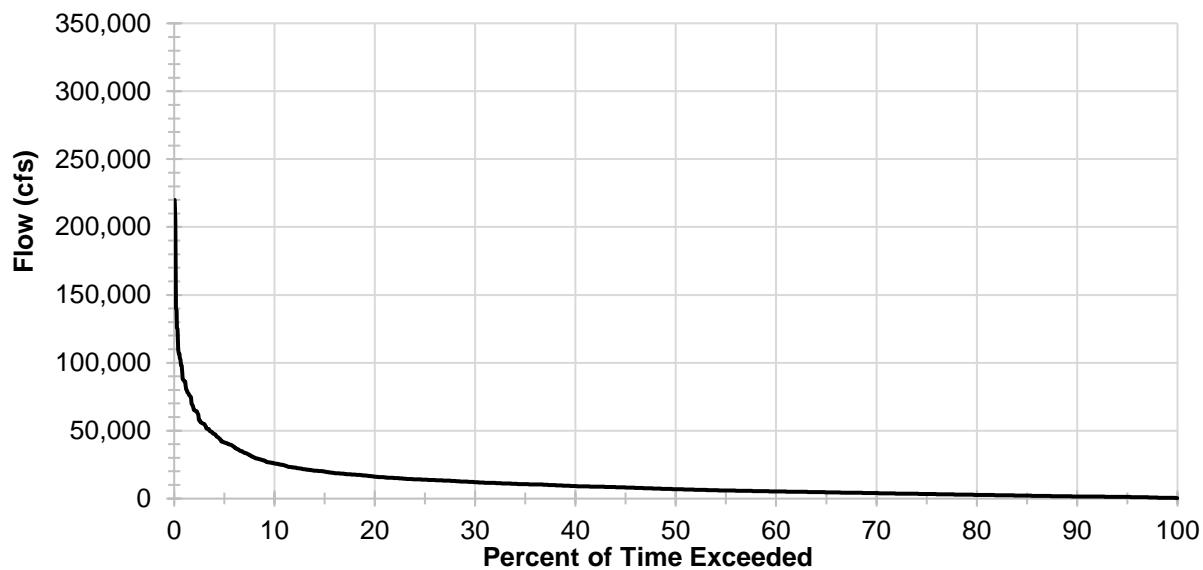
**February Flow Duration for Pensacola Dam  
Observed Inflow  
Period of Record Jan 1, 1965 - Dec 31, 2022**



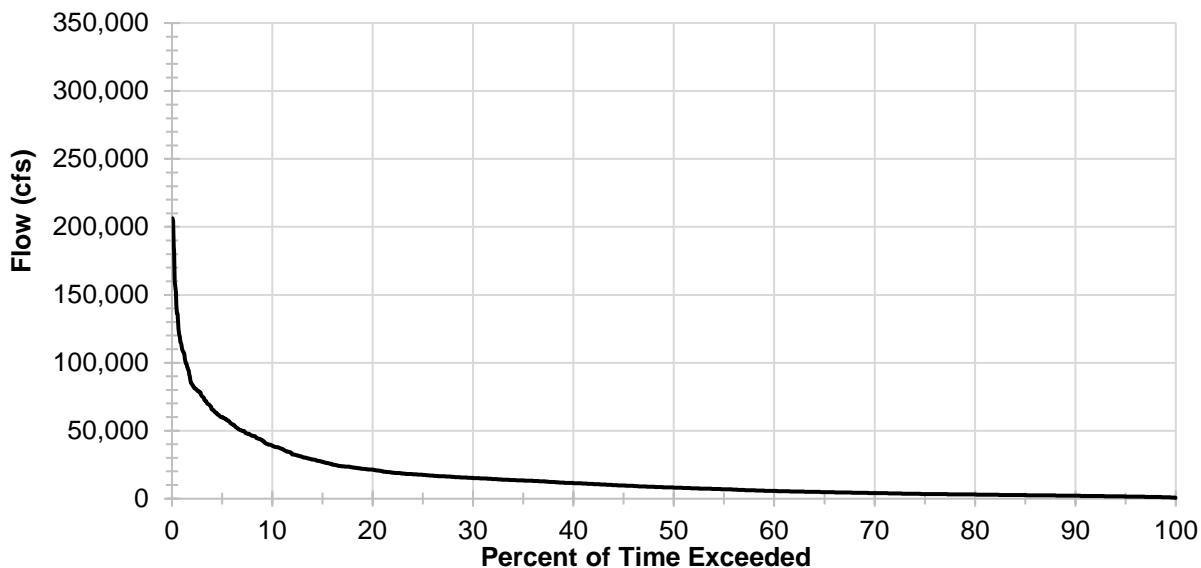
**March Flow Duration for Pensacola Dam  
Observed Inflow  
Period of Record Jan 1, 1965 - Dec 31, 2022**



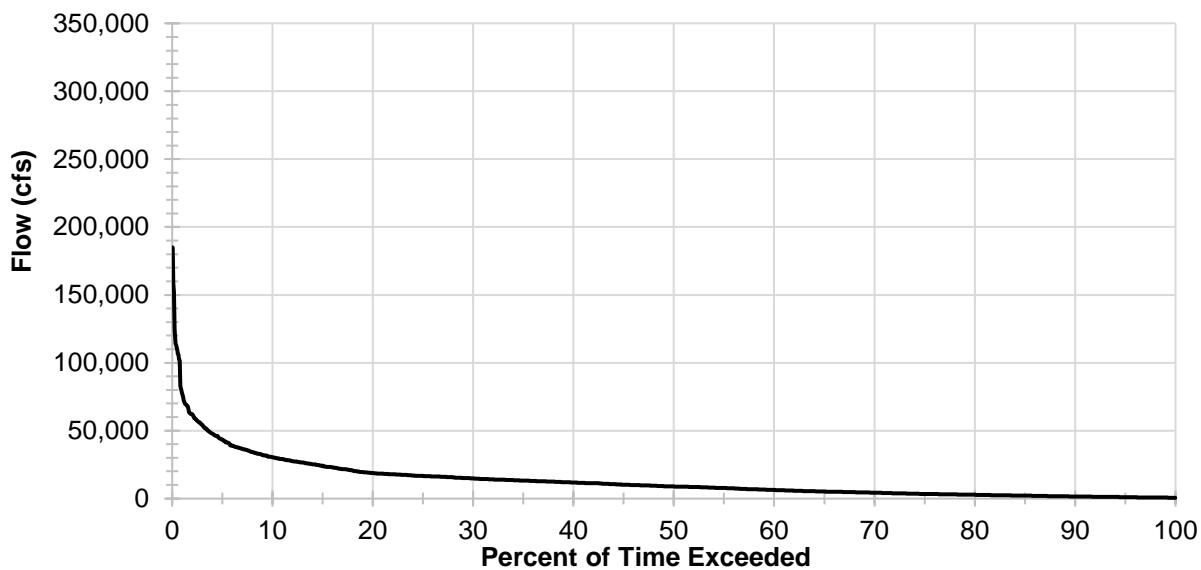
**April Flow Duration for Pensacola Dam  
Observed Inflow  
Period of Record Jan 1, 1965 - Dec 31, 2022**



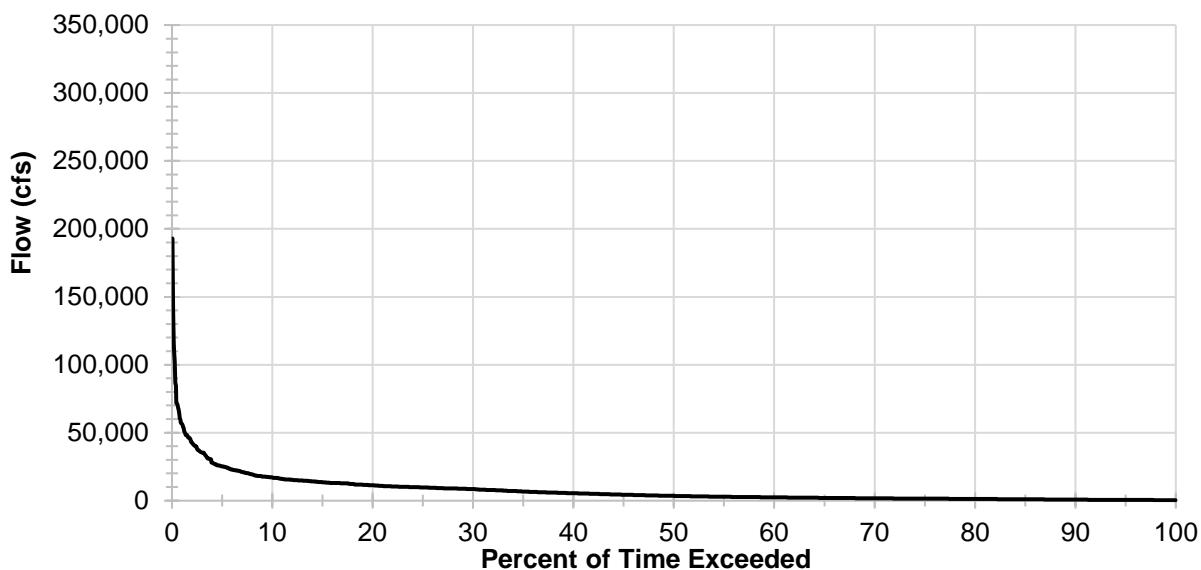
**May Flow Duration for Pensacola Dam  
Observed Inflow  
Period of Record Jan 1, 1965 - Dec 31, 2022**



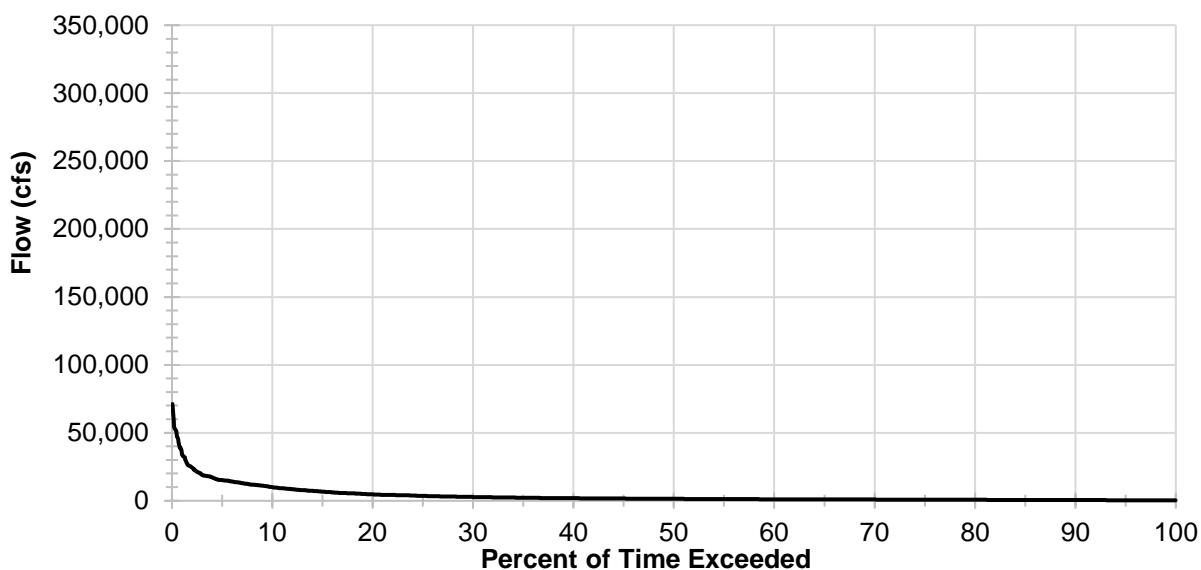
**June Flow Duration for Pensacola Dam  
Observed Inflow  
Period of Record Jan 1, 1965 - Dec 31, 2022**



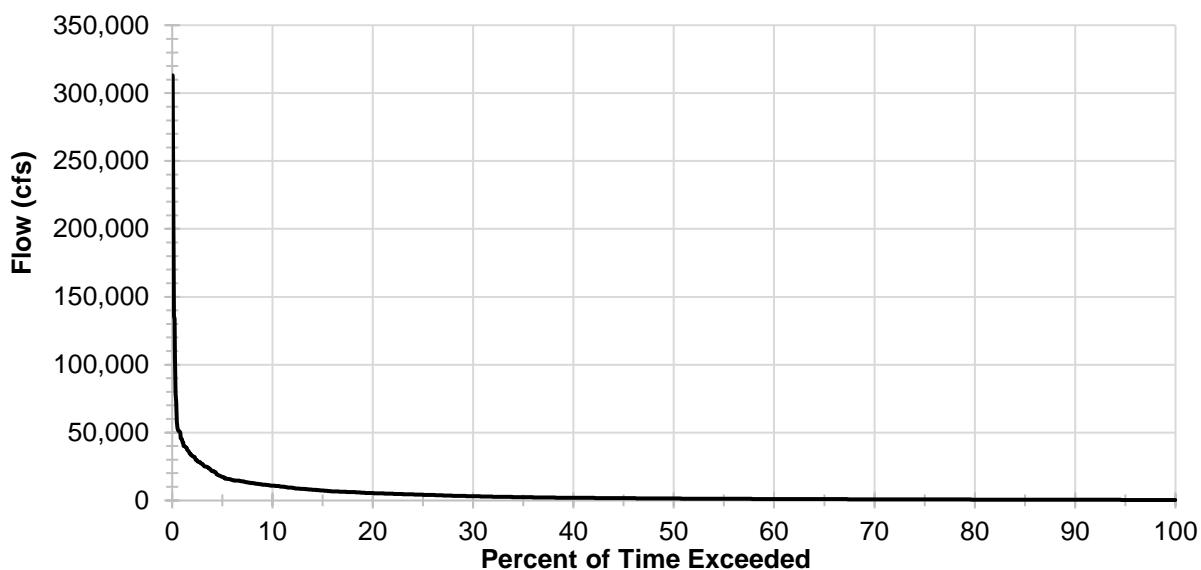
**July Flow Duration for Pensacola Dam  
Observed Inflow  
Period of Record Jan 1, 1965 - Dec 31, 2022**



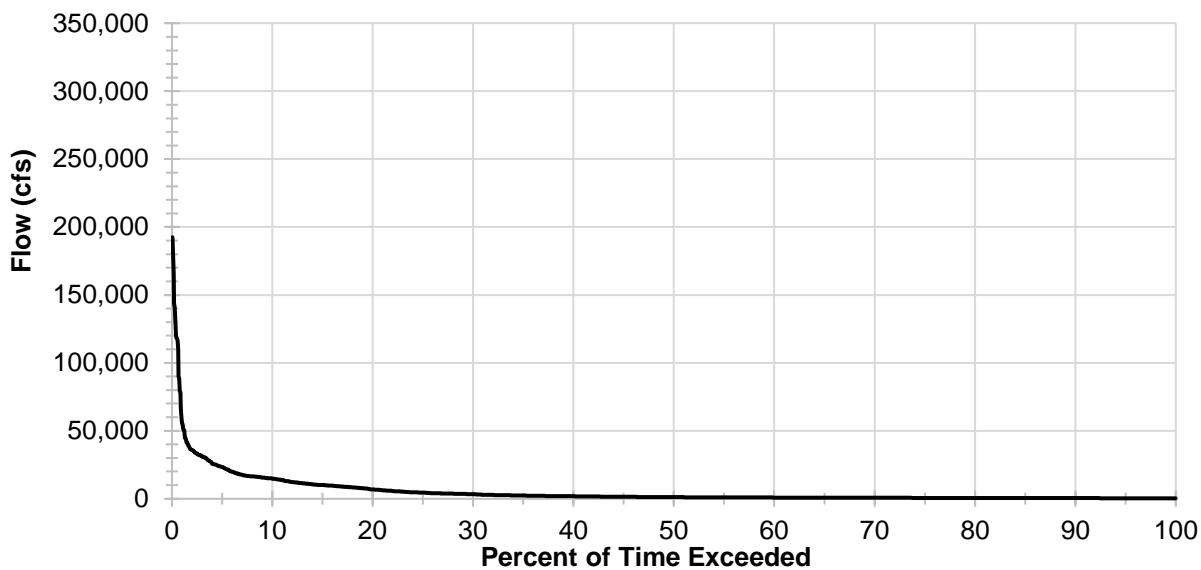
**August Flow Duration for Pensacola Dam  
Observed Inflow  
Period of Record Jan 1, 1965 - Dec 31, 2022**



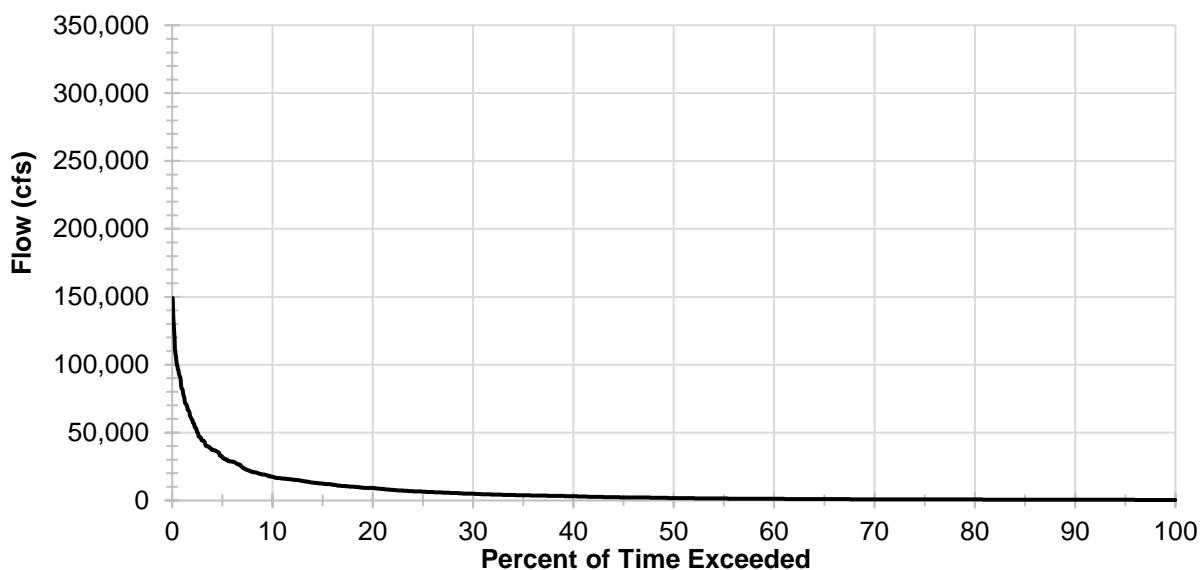
**September Flow Duration for Pensacola Dam**  
**Observed Inflow**  
**Period of Record Jan 1, 1965 - Dec 31, 2022**



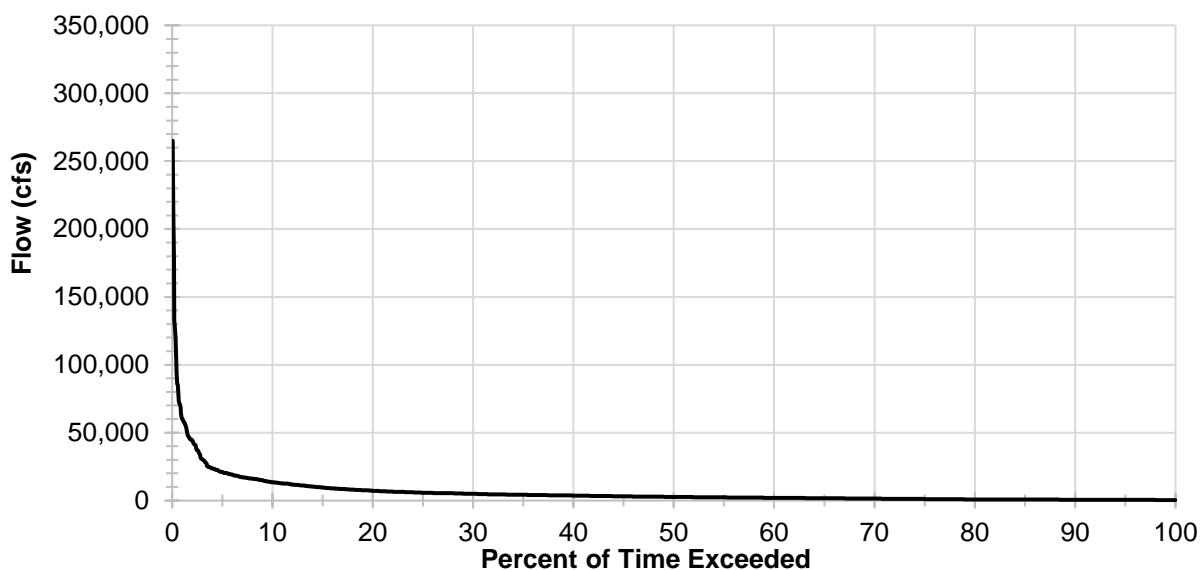
**October Flow Duration for Pensacola Dam**  
**Observed Inflow**  
**Period of Record Jan 1, 1965 - Dec 31, 2022**



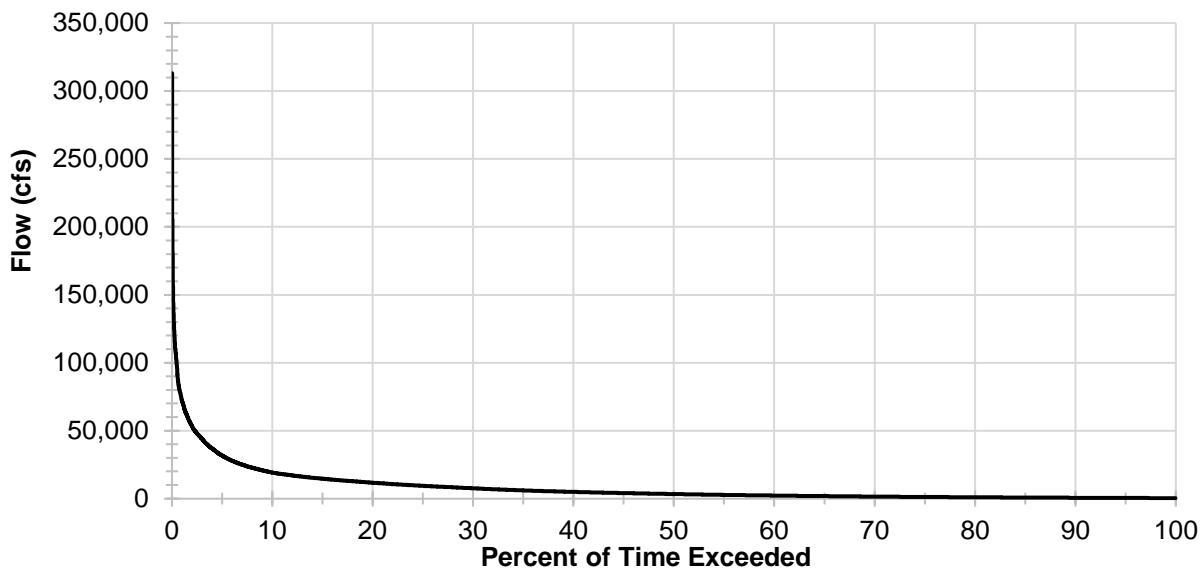
**November Flow Duration for Pensacola Dam  
Observed Inflow  
Period of Record Jan 1, 1965- Dec 31, 2022**



**December Flow Duration for Pensacola Dam  
Observed Inflow  
Period of Record Jan 1, 1965 - Dec 31, 2022**



**Annual Flow Duration for Pensacola Dam  
Observed Inflow  
Period of Record Jan 1, 1965 - Dec 31, 2022**

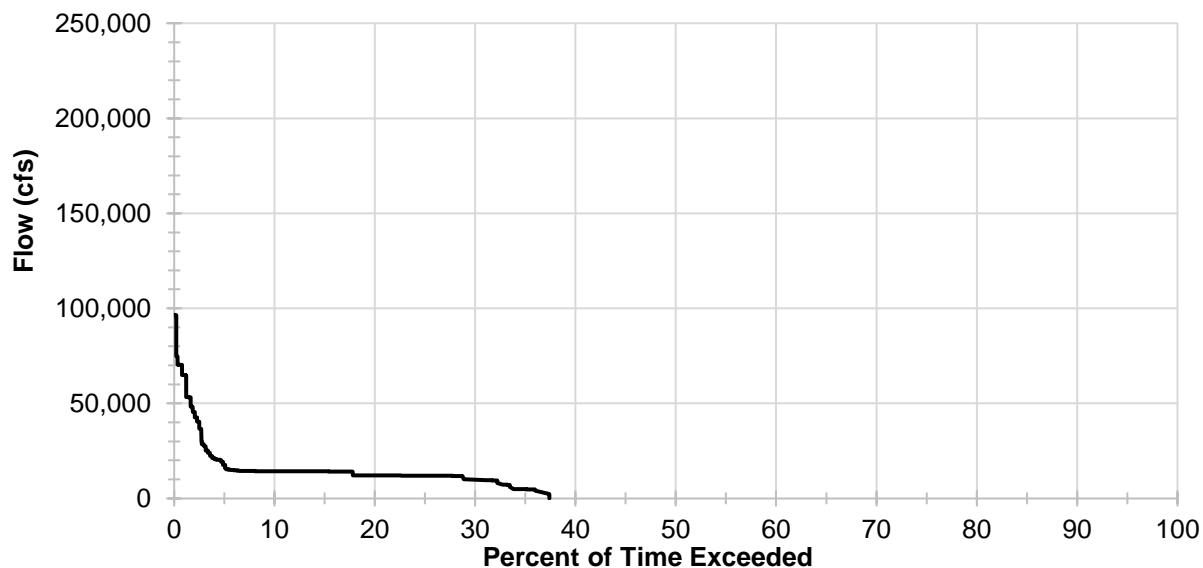


**Flow Duration for Pensacola Dam Observed Inflow (Period of Record Jan 1, 1965 - Dec 31, 2022)**

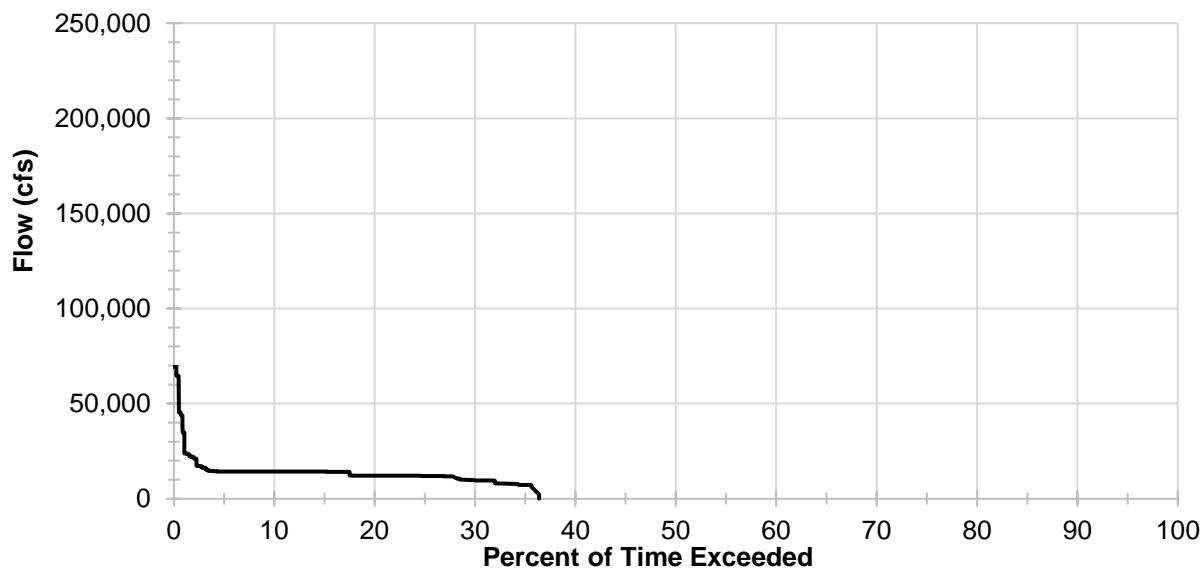
Percent of Time	January	February	March	April	May	June	July	August	September	October	November	December	Annual
95	454	646	612	1,100	1,527	1,006	479	331	360	312	402	436	444
90	610	883	1,100	1,517	2,065	1,474	653	422	443	408	471	579	586
85	874	1,058	1,591	2,084	2,490	2,084	960	519	528	468	537	653	735
80	1,095	1,196	2,056	2,686	2,983	2,728	1,172	625	598	520	612	797	954
75	1,235	1,469	2,540	3,307	3,390	3,360	1,387	729	682	578	698	1,084	1,176
70	1,394	1,822	2,998	3,912	4,080	4,231	1,650	842	788	657	780	1,348	1,446
65	1,612	2,147	3,536	4,576	4,742	5,114	1,992	931	889	730	933	1,669	1,806
60	1,856	2,419	4,122	5,218	5,559	6,262	2,360	1,041	1,007	836	1,109	1,953	2,221
55	2,180	2,829	4,824	5,899	6,884	7,708	2,802	1,170	1,163	948	1,326	2,268	2,701
50	2,489	3,369	5,562	6,846	8,097	8,821	3,429	1,335	1,333	1,107	1,687	2,655	3,317
45	2,974	3,834	6,509	8,093	9,562	10,186	4,296	1,547	1,609	1,377	2,216	3,060	4,029
40	3,558	4,478	7,692	9,106	11,410	11,778	5,377	1,815	1,901	1,790	2,997	3,636	4,891
35	4,123	5,316	9,217	10,486	13,314	13,167	6,624	2,176	2,362	2,280	3,804	4,169	5,996
30	4,897	6,415	10,810	12,043	15,140	14,819	8,412	2,713	3,057	3,301	4,856	4,856	7,570
25	5,952	7,570	12,568	13,882	17,466	16,569	9,685	3,492	4,154	4,448	6,374	5,744	9,377
20	7,414	9,025	14,750	16,075	21,329	18,757	11,257	4,648	5,321	6,776	9,103	7,171	11,655
15	9,484	11,254	19,036	19,826	27,132	24,140	13,523	6,660	7,328	10,046	12,301	9,628	14,632
10	12,501	14,739	26,316	25,804	39,140	30,251	17,092	10,026	10,854	14,871	17,399	13,381	19,123
5	20,349	21,407	43,960	41,222	60,013	43,437	25,231	15,165	17,223	23,503	31,844	21,028	31,693

**APPENDIX B-3 Modeled Total, Spillway, and Turbine Discharge Flow Duration Curves and Exceedance Tables for Anticipated Operation**

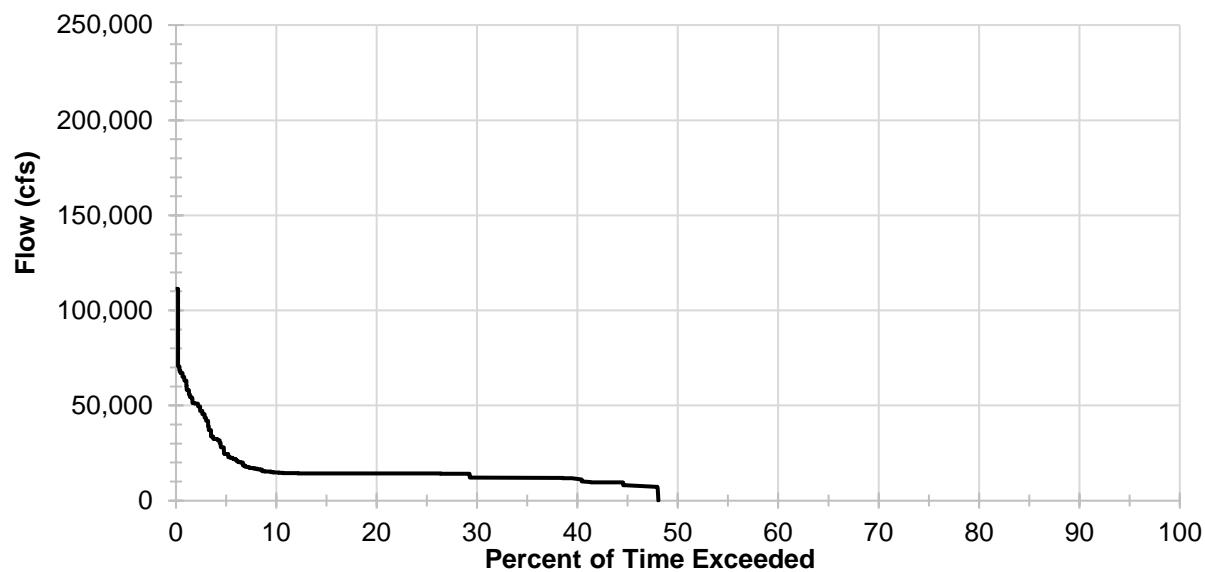
**January Flow Duration for Pensacola Dam  
Modeled Total Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



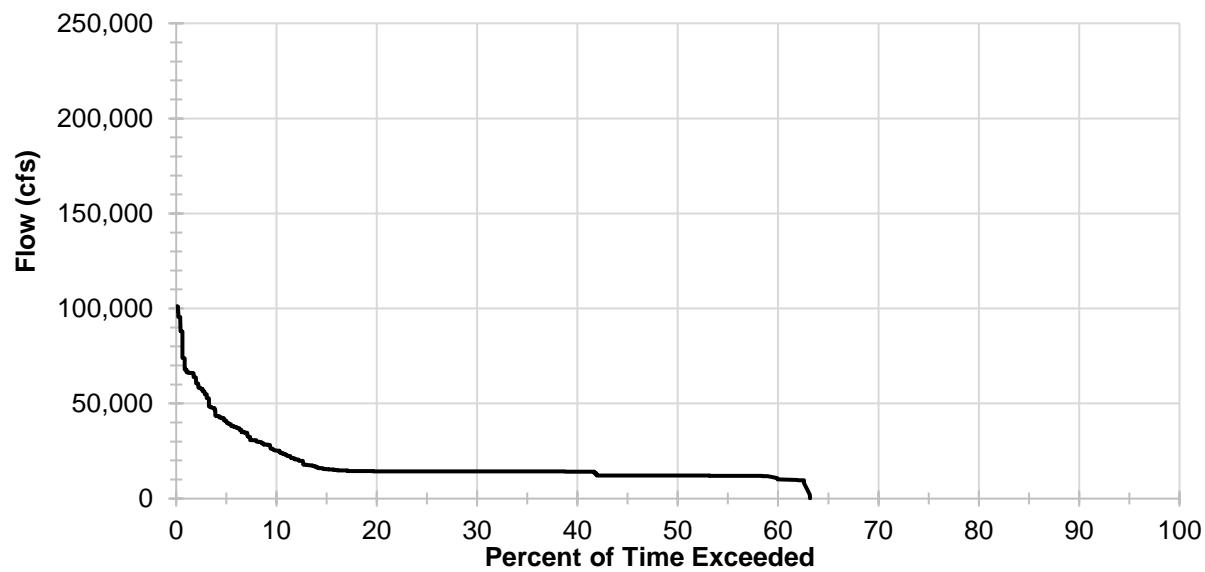
**February Flow Duration for Pensacola Dam  
Modeled Total Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



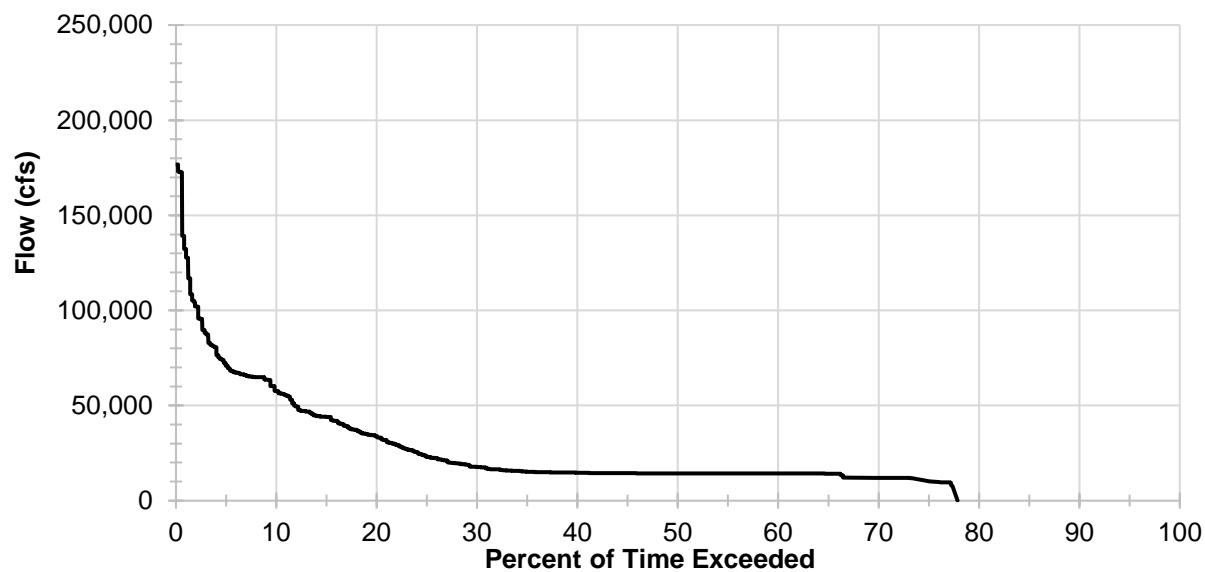
**March Flow Duration for Pensacola Dam  
Modeled Total Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



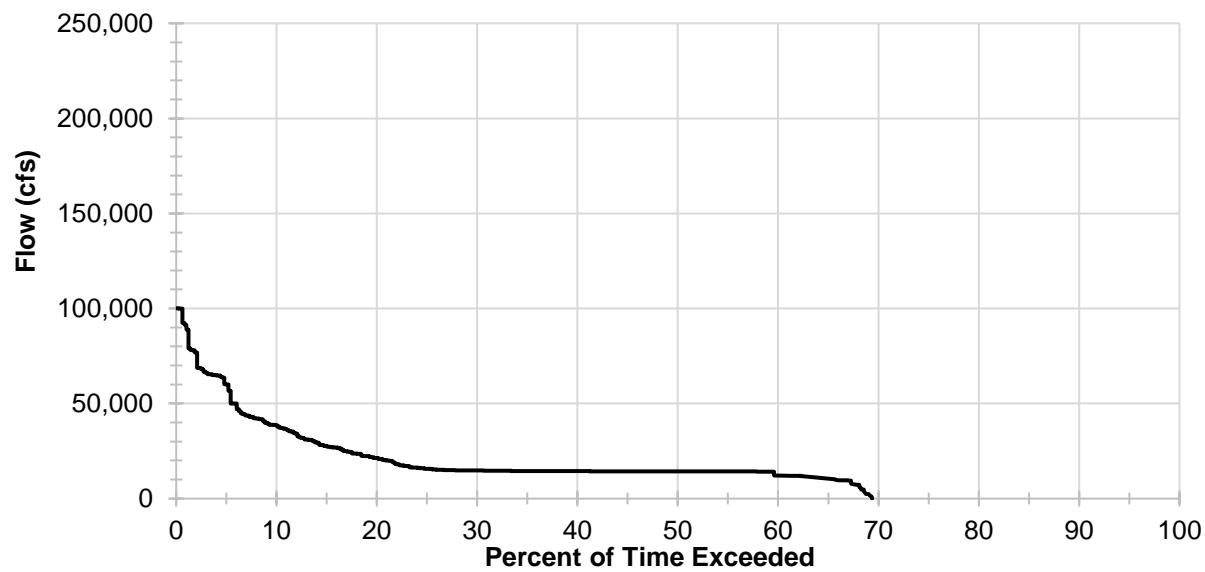
**April Flow Duration for Pensacola Dam  
Modeled Total Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



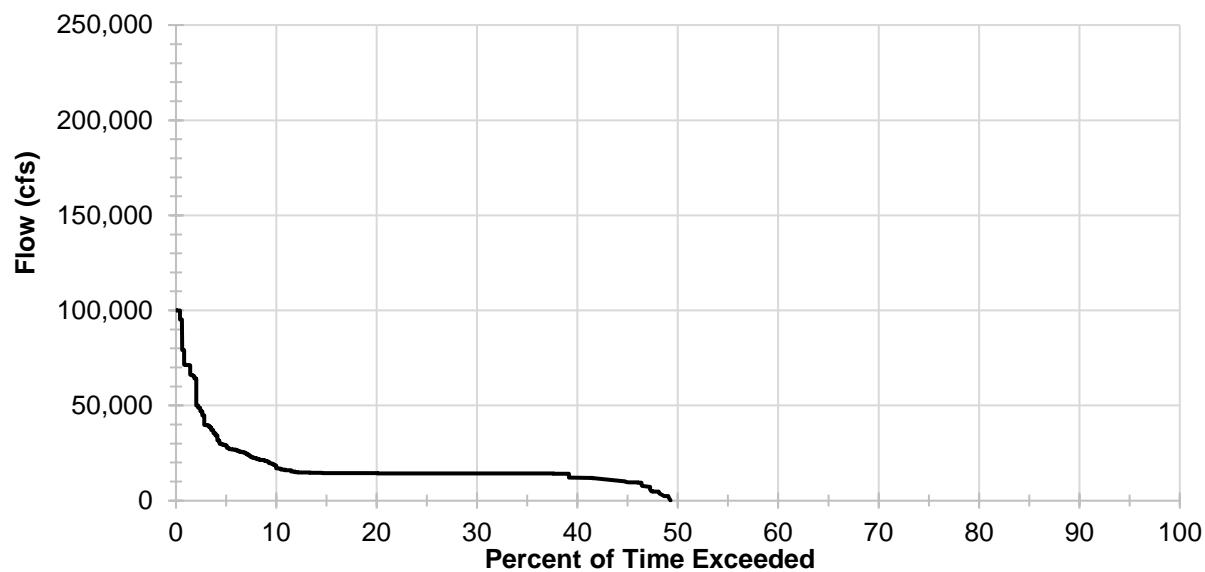
**May Flow Duration for Pensacola Dam  
Modeled Total Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



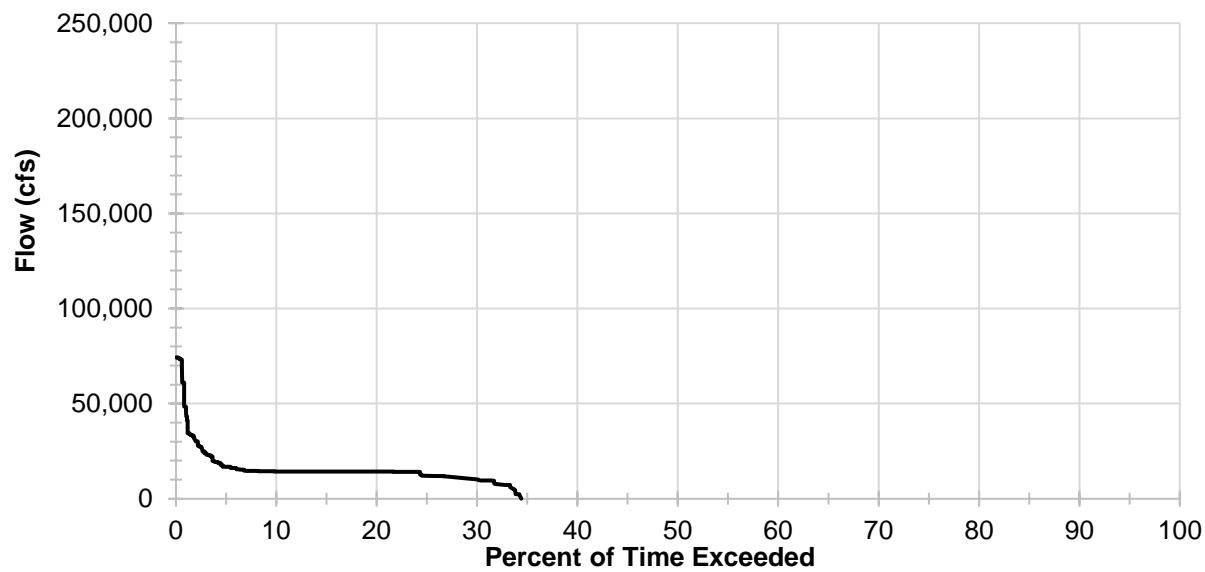
**June Flow Duration for Pensacola Dam  
Modeled Total Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



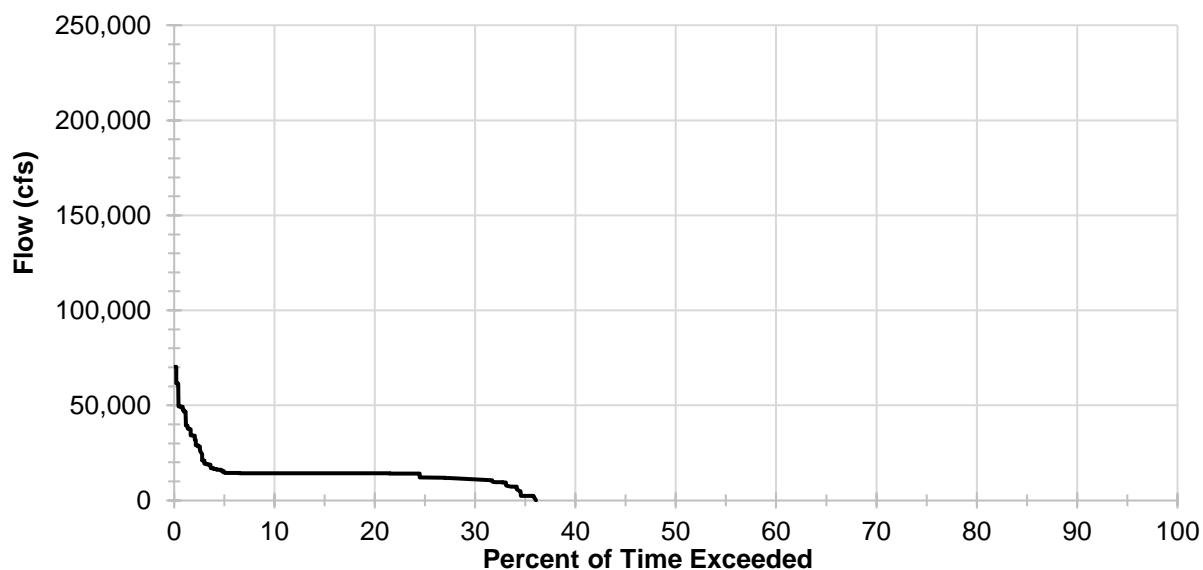
**July Flow Duration for Pensacola Dam  
Modeled Total Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



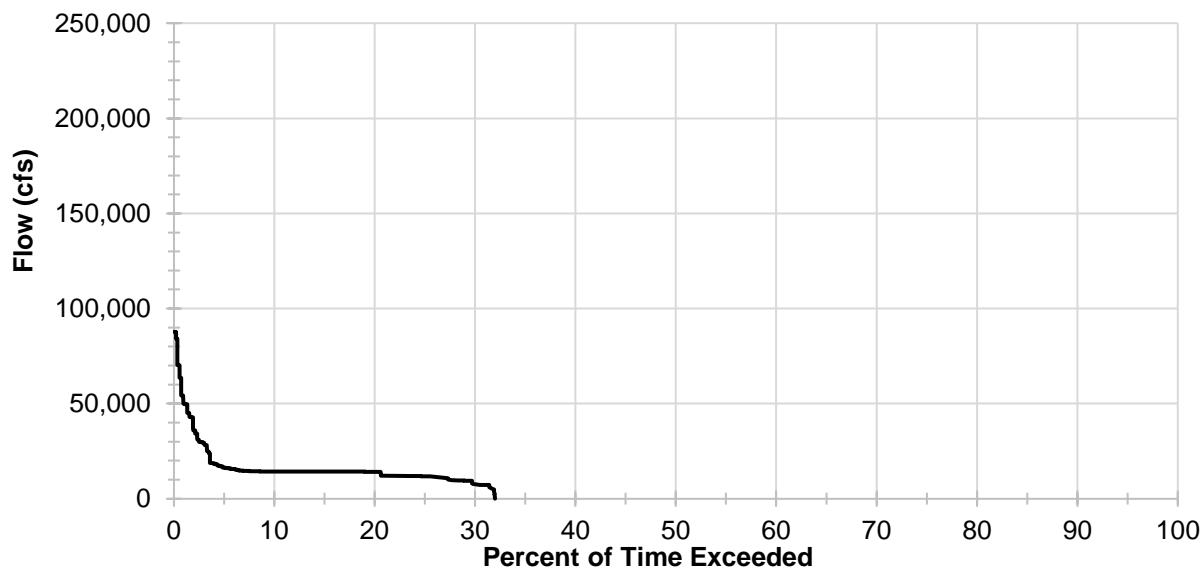
**August Flow Duration for Pensacola Dam  
Modeled Total Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



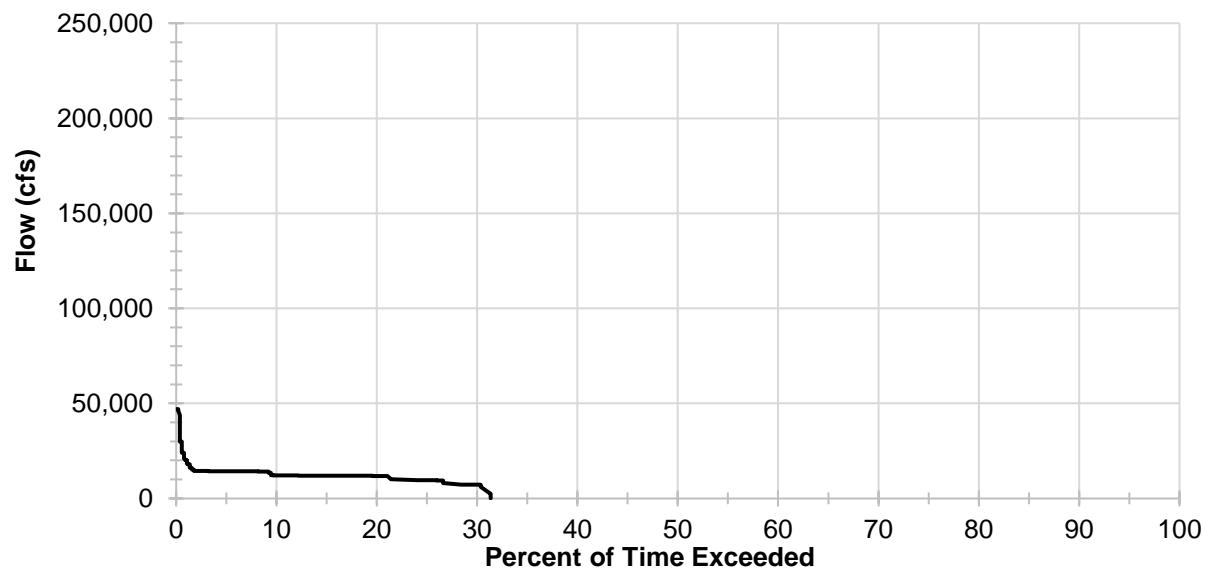
**September Flow Duration for Pensacola Dam  
Modeled Total Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



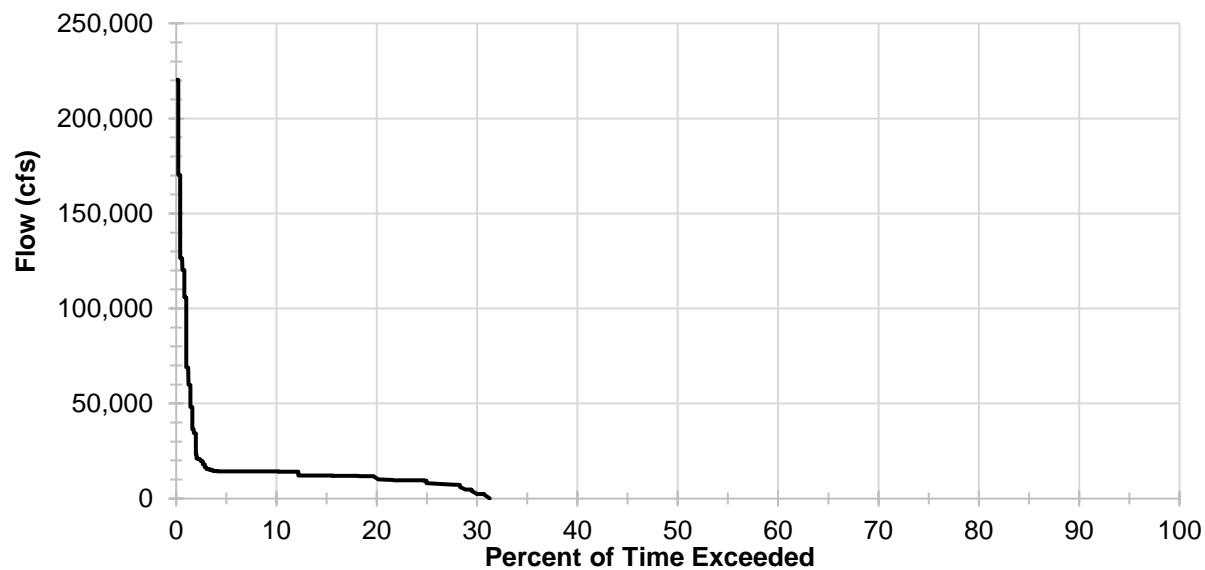
**October Flow Duration for Pensacola Dam  
Modeled Total Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



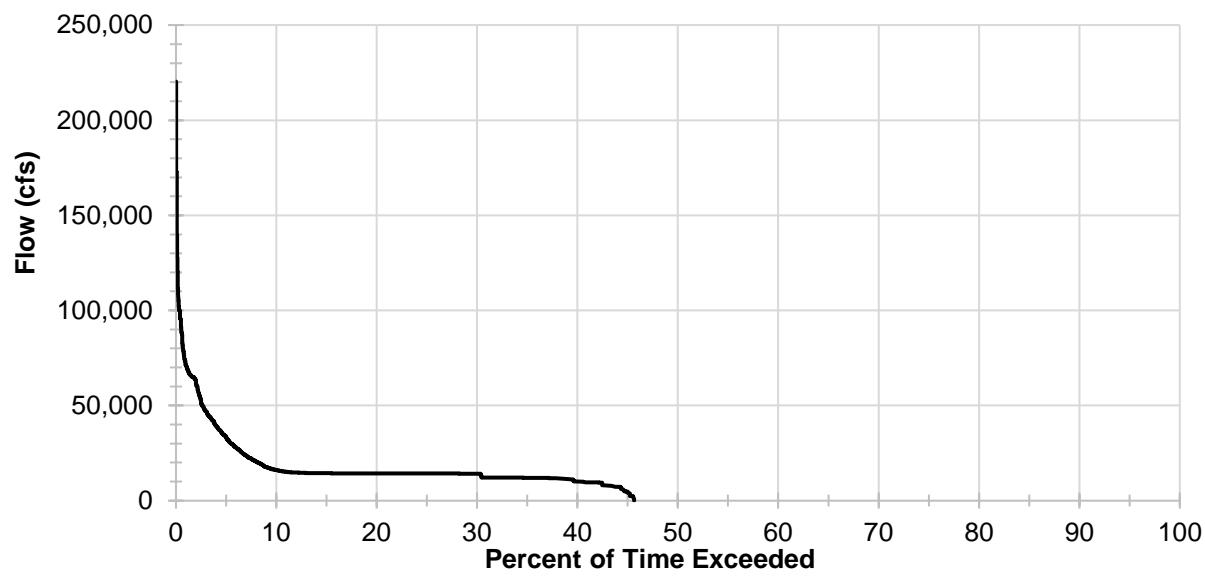
**November Flow Duration for Pensacola Dam  
Modeled Total Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



**December Flow Duration for Pensacola Dam  
Modeled Total Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



**Annual Flow Duration for Pensacola Dam  
Modeled Total Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**

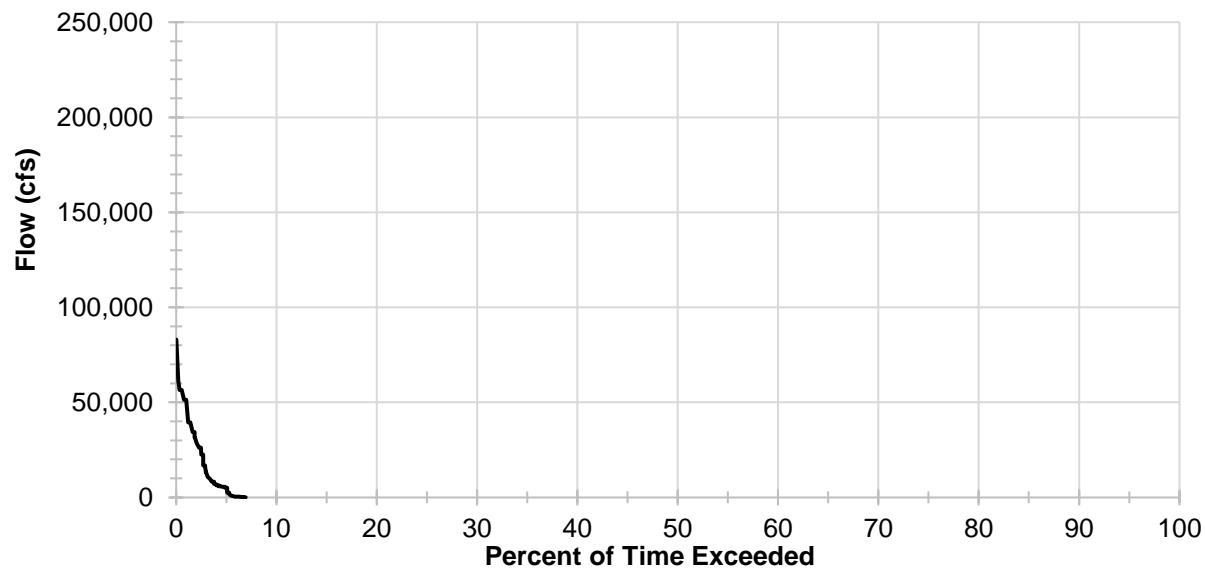


**Flow Duration for Pensacola Dam Modeled Total Discharge for Anticipated Operation (Period of Record Apr 1, 2004 - Dec 31, 2019)**

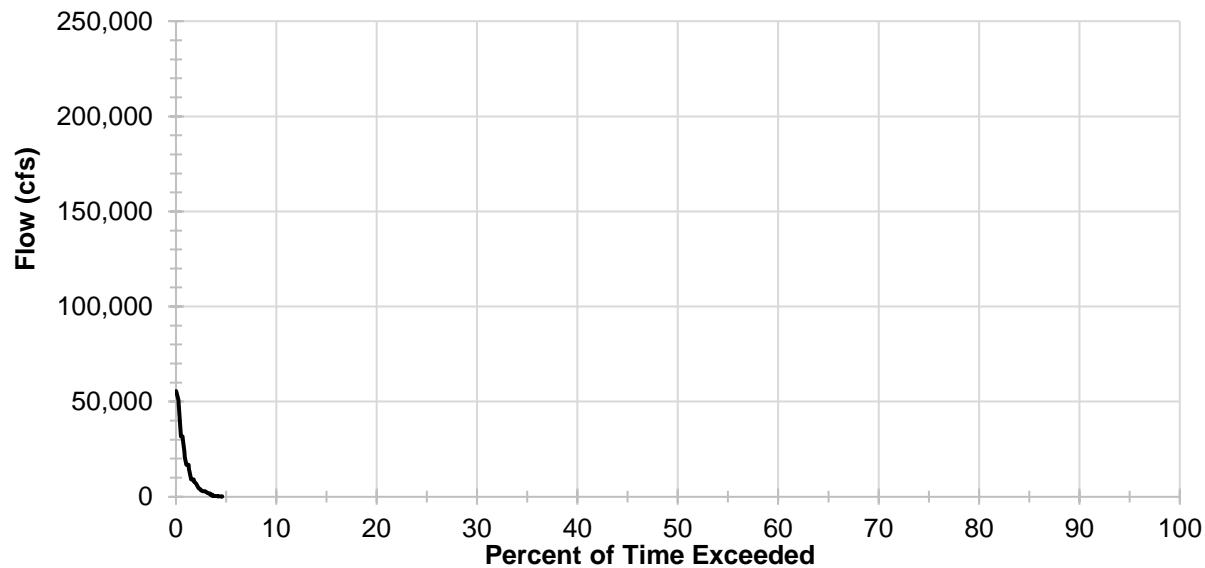
Percent of Time	January	February	March	April	May	June	July	August	September	October	November	December	Annual
95	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0	0
75	0	0	0	0	11,700	0	0	0	0	0	0	0	0
70	0	0	0	0	11,982	0	0	0	0	0	0	0	0
65	0	0	0	0	14,162	11,700	0	0	0	0	0	0	0
60	0	0	0	10,000	14,270	12,000	0	0	0	0	0	0	0
55	0	0	0	11,941	14,304	14,255	0	0	0	0	0	0	0
50	0	0	0	12,000	14,325	14,298	0	0	0	0	0	0	0
45	0	0	8,000	12,000	14,351	14,329	9,750	0	0	0	0	0	4,769
40	0	0	11,700	14,164	14,669	14,348	12,000	0	0	0	0	0	10,000
35	4,793	7,195	12,000	14,216	15,180	14,362	14,229	0	2,420	0	0	0	11,977
30	10,000	9,750	12,000	14,271	17,694	14,734	14,266	11,700	11,700	7,800	7,159	2,400	14,110
25	11,915	11,979	14,197	14,320	22,971	15,593	14,310	12,000	12,000	11,800	9,513	8,000	14,245
20	12,000	12,000	14,256	14,344	33,896	21,223	14,347	14,210	14,229	14,122	11,810	11,700	14,302
15	14,194	14,195	14,315	15,419	44,016	27,392	14,421	14,275	14,295	14,277	11,958	12,000	14,349
10	14,318	14,252	14,713	25,216	57,677	38,523	16,982	14,343	14,318	14,320	12,000	14,191	16,083
5	17,609	14,310	24,422	40,495	70,889	60,051	28,960	16,784	14,794	16,214	14,293	14,318	33,180

**Modeled Spillway Discharge Flow Duration Curves and Exceedance Table for Anticipated Operation**

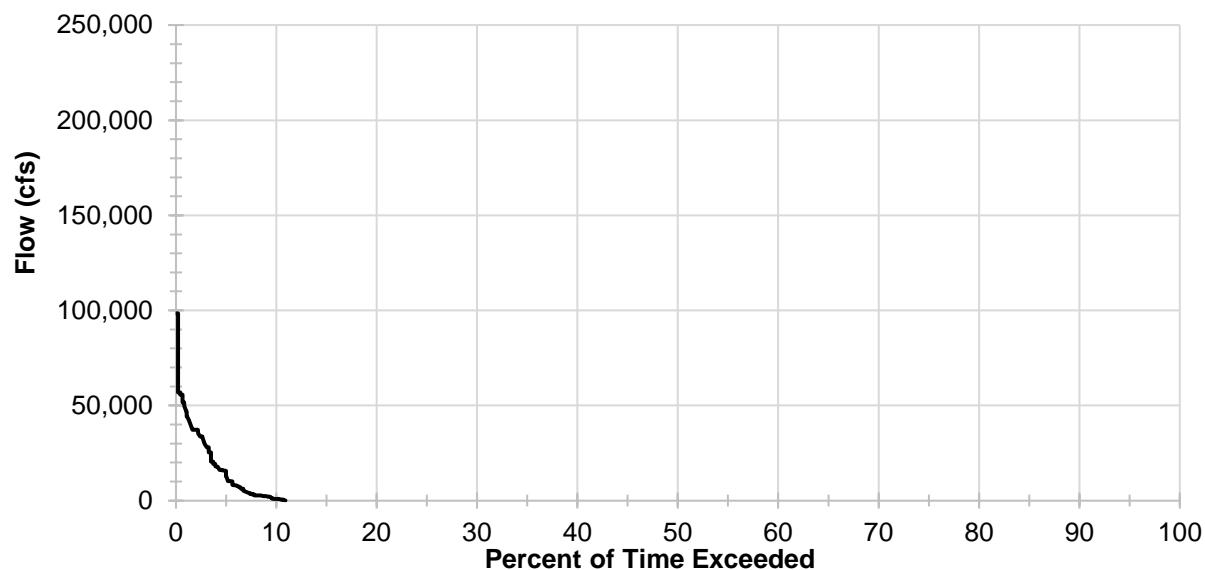
**January Flow Duration for Pensacola Dam  
Modeled Spillway Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



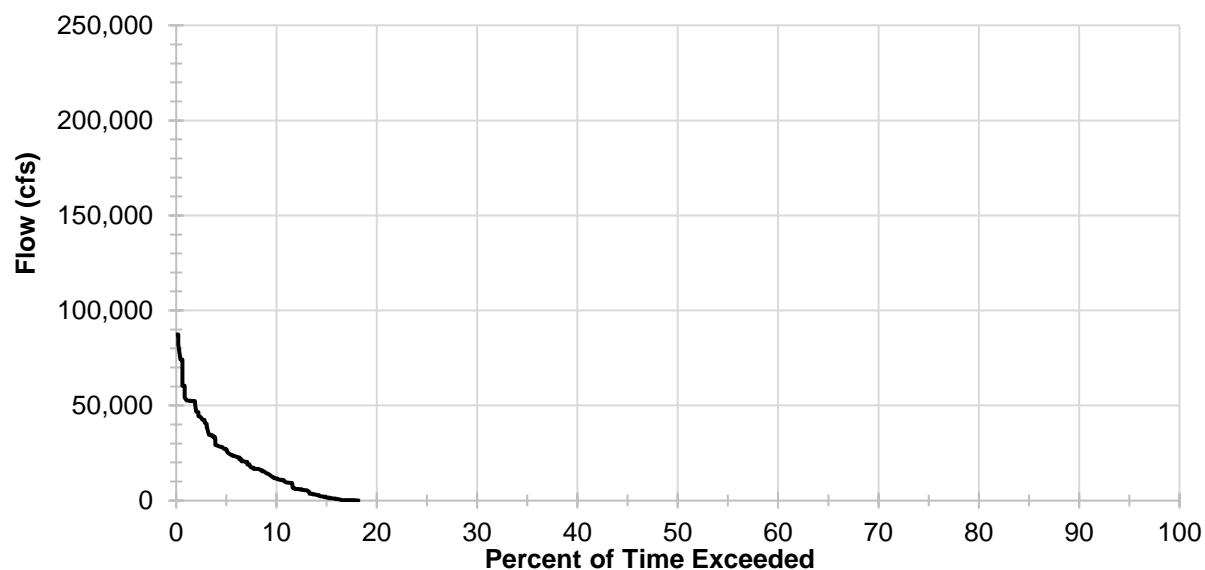
**February Flow Duration for Pensacola Dam  
Modeled Spillway Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



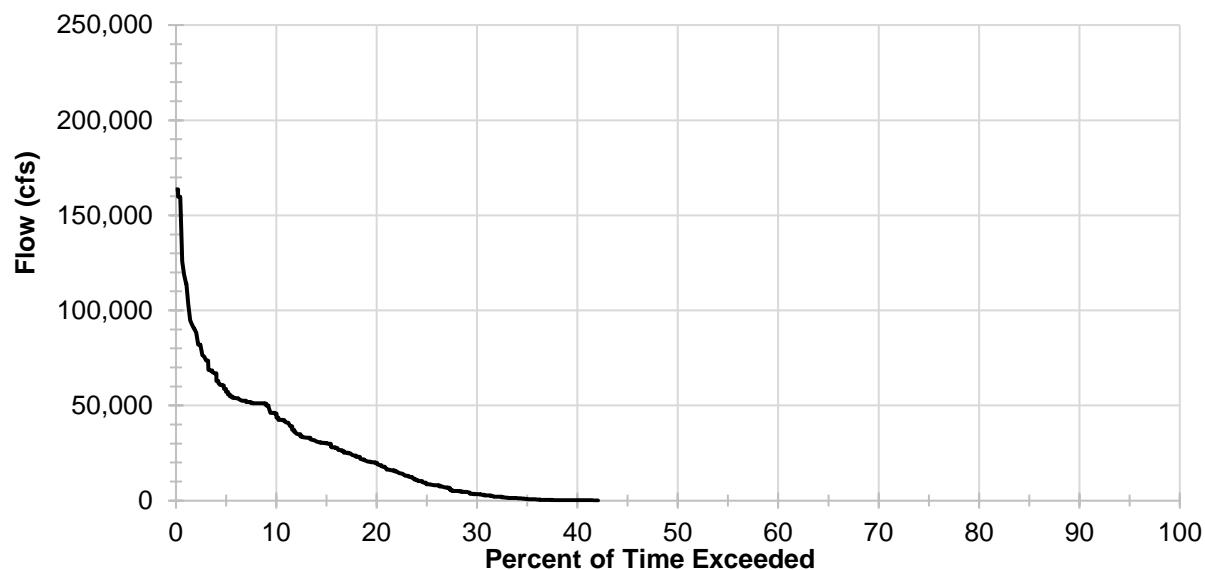
**March Flow Duration for Pensacola Dam  
Modeled Spillway Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



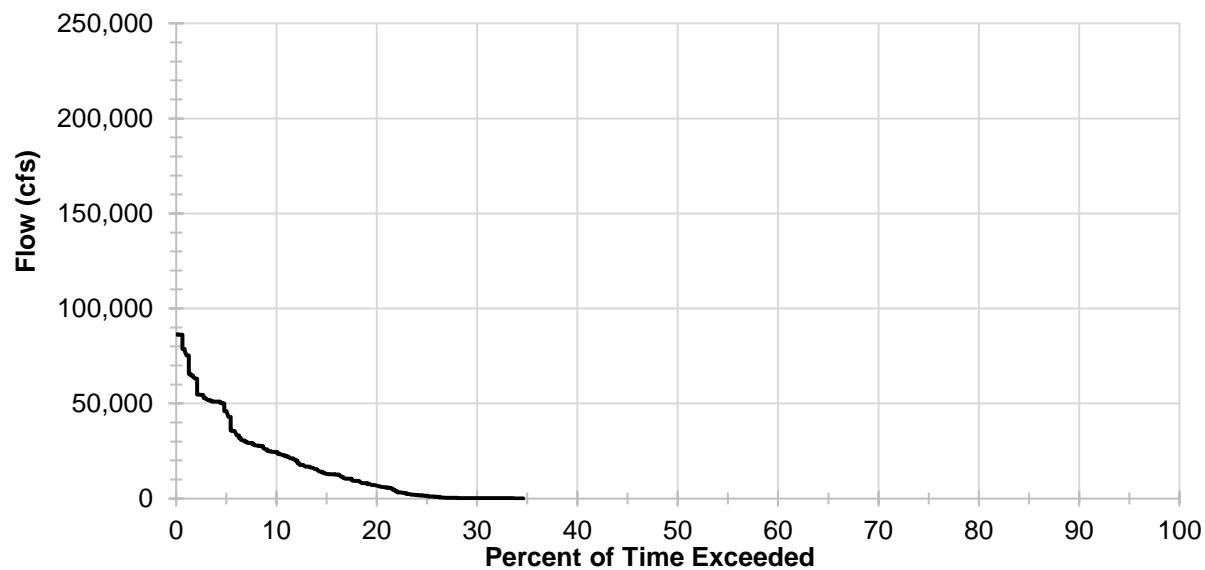
**April Flow Duration for Pensacola Dam  
Modeled Spillway Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



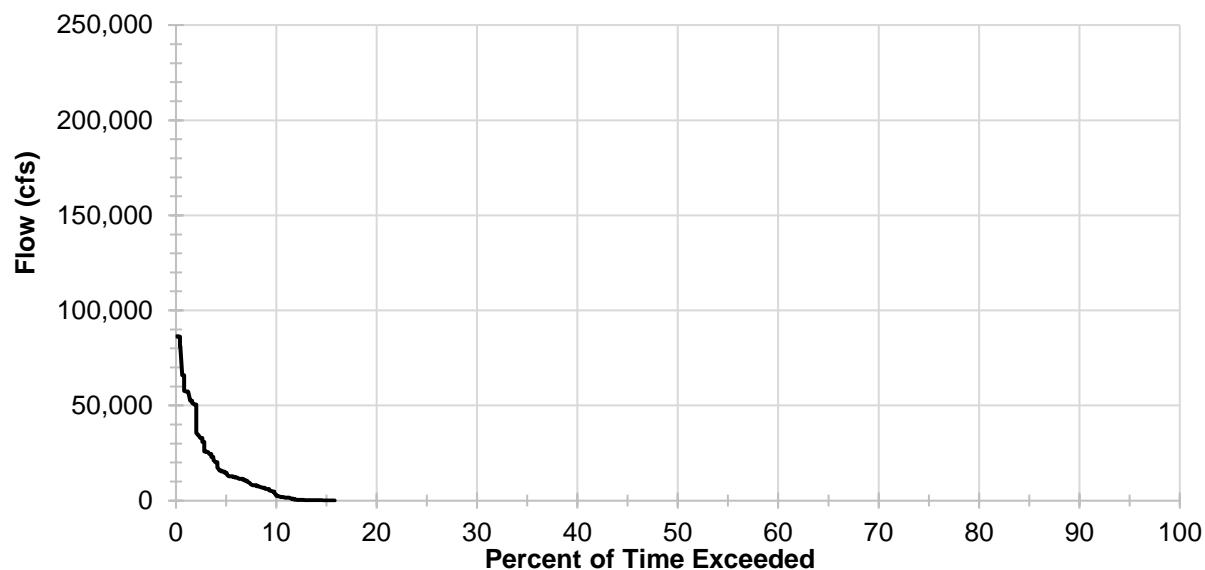
**May Flow Duration for Pensacola Dam  
Modeled Spillway Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



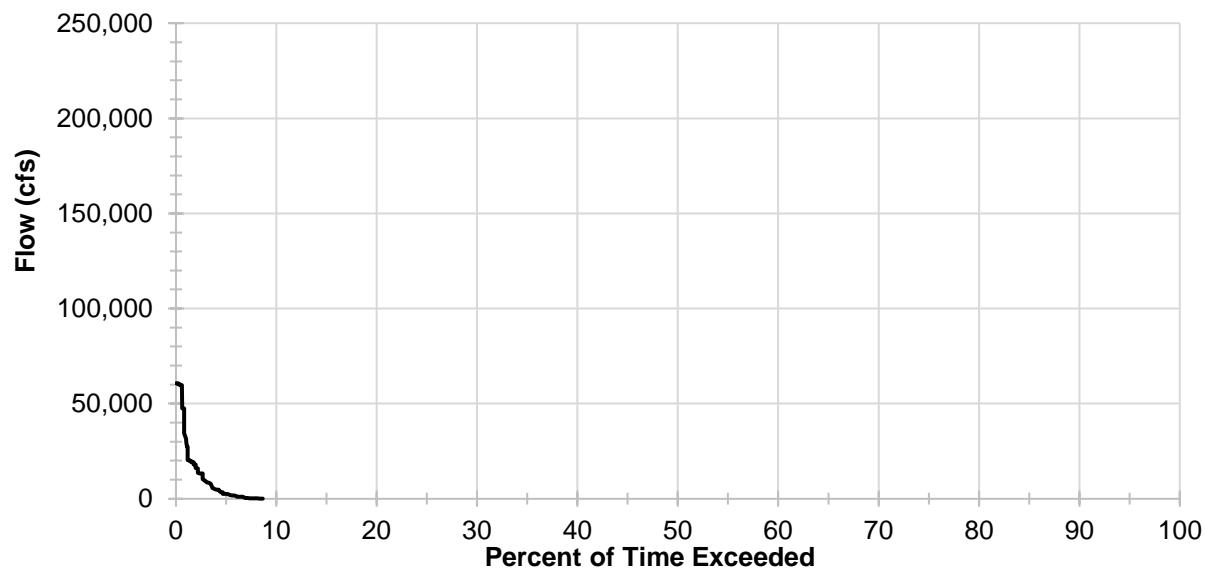
**June Flow Duration for Pensacola Dam  
Modeled Spillway Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



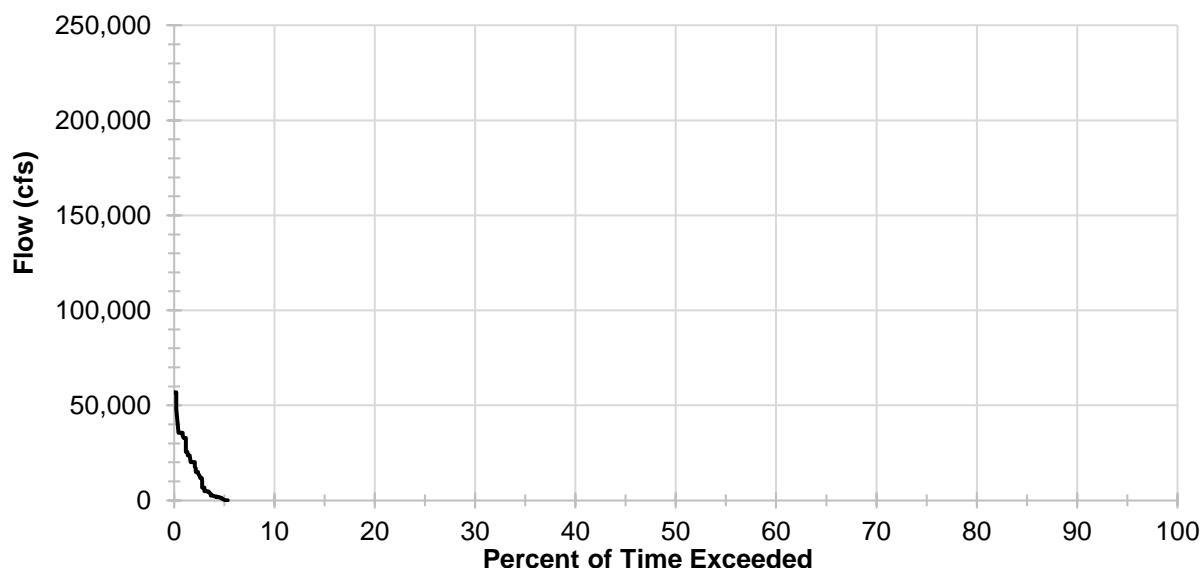
**July Flow Duration for Pensacola Dam  
Modeled Spillway Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



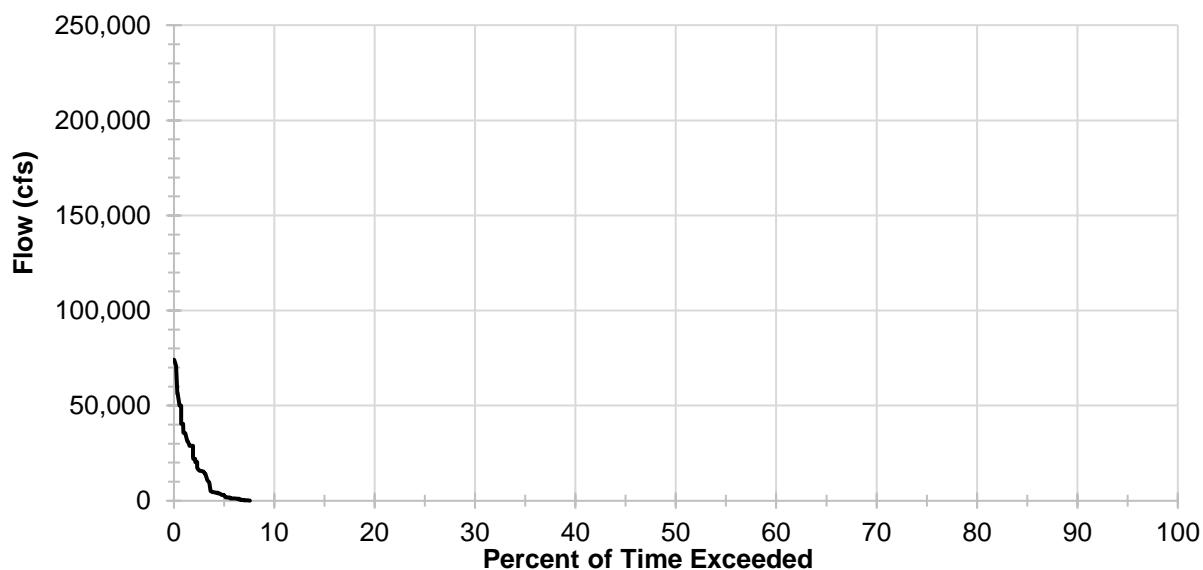
**August Flow Duration for Pensacola Dam  
Modeled Spillway Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



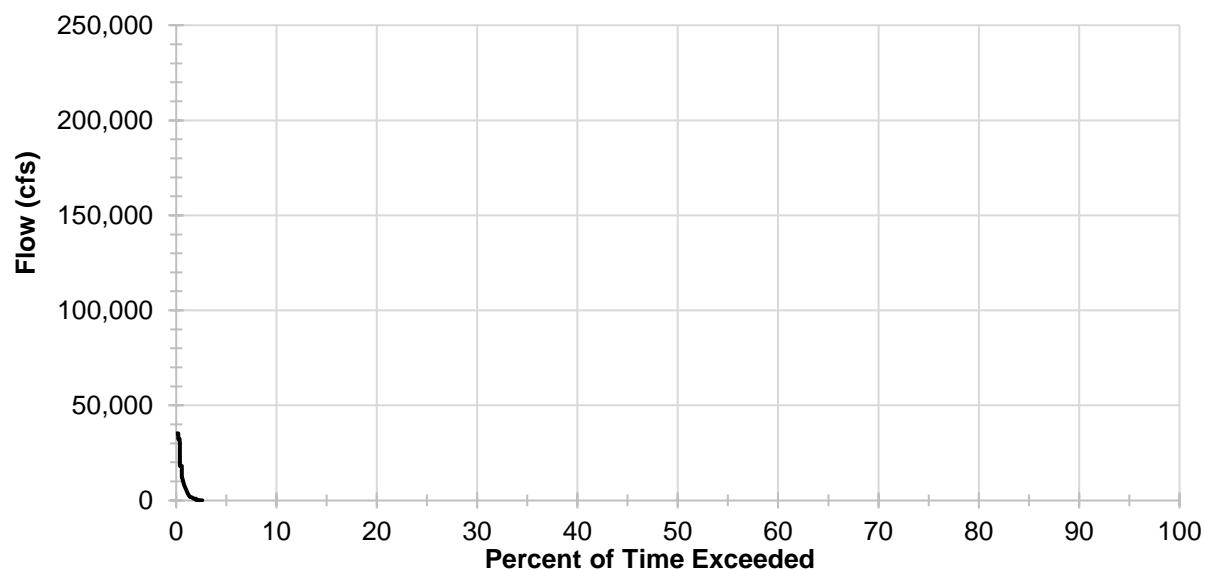
**September Flow Duration for Pensacola Dam  
Modeled Spillway Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



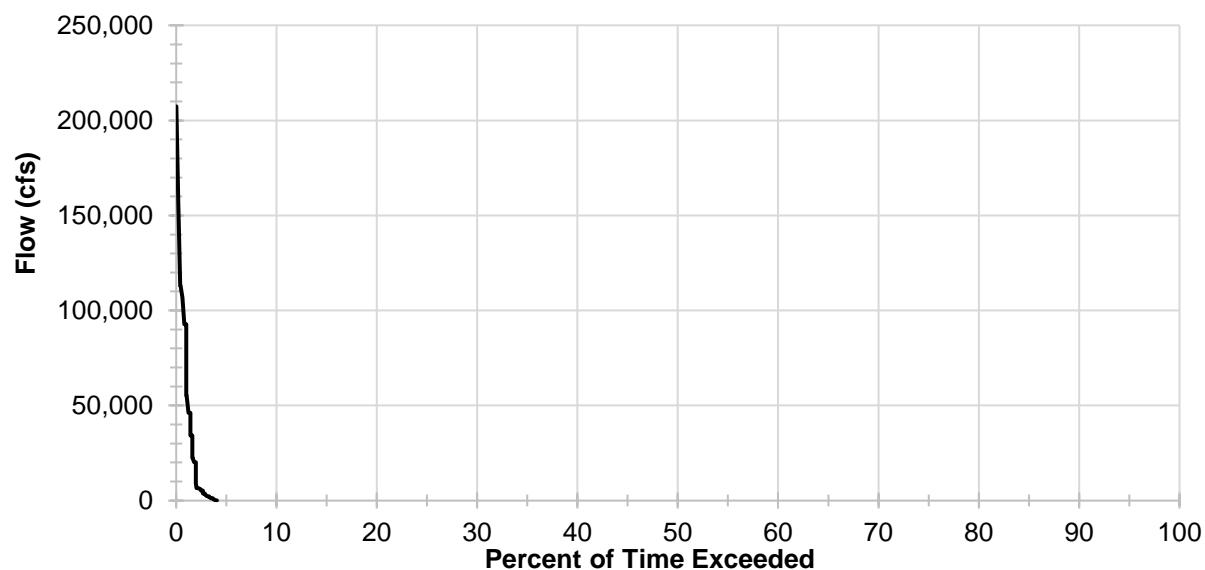
**October Flow Duration for Pensacola Dam  
Modeled Spillway Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



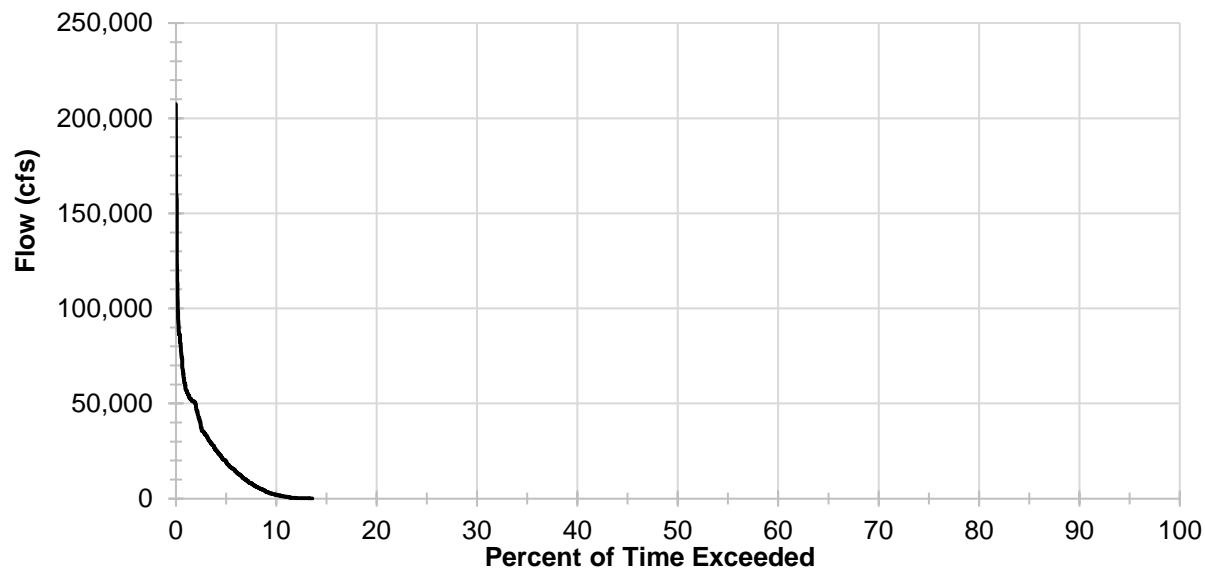
**November Flow Duration for Pensacola Dam  
Modeled Spillway Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



**December Flow Duration for Pensacola Dam  
Modeled Spillway Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



**Annual Flow Duration for Pensacola Dam  
Modeled Spillway Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**

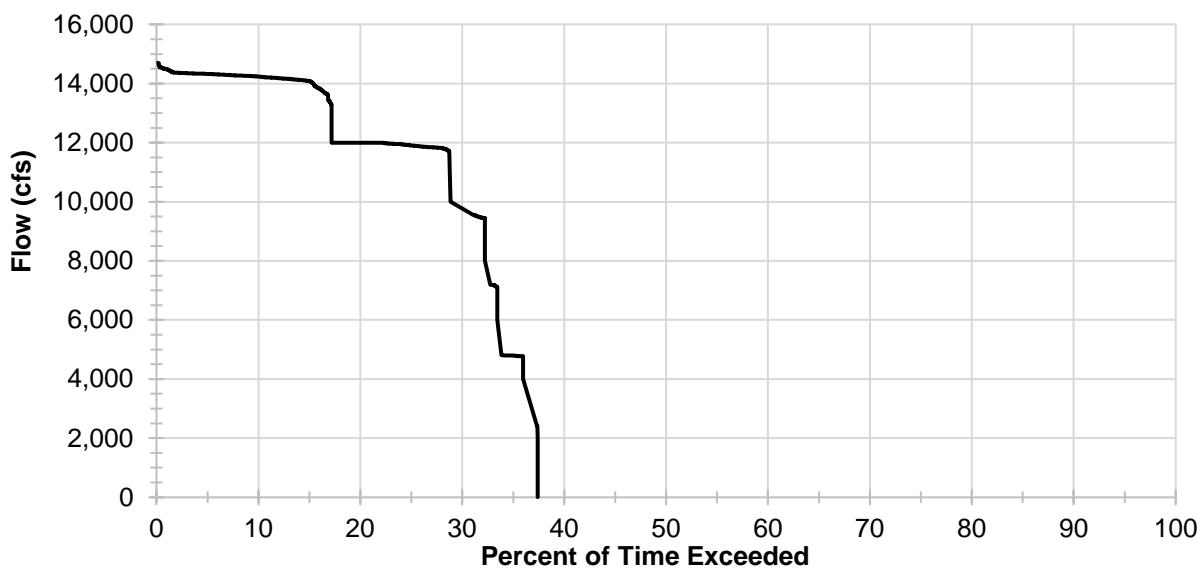


**Flow Duration for Pensacola Dam Modeled Spillway Discharge for Anticipated Operation (Period of Record Apr 1, 2004 - Dec 31, 2019)**

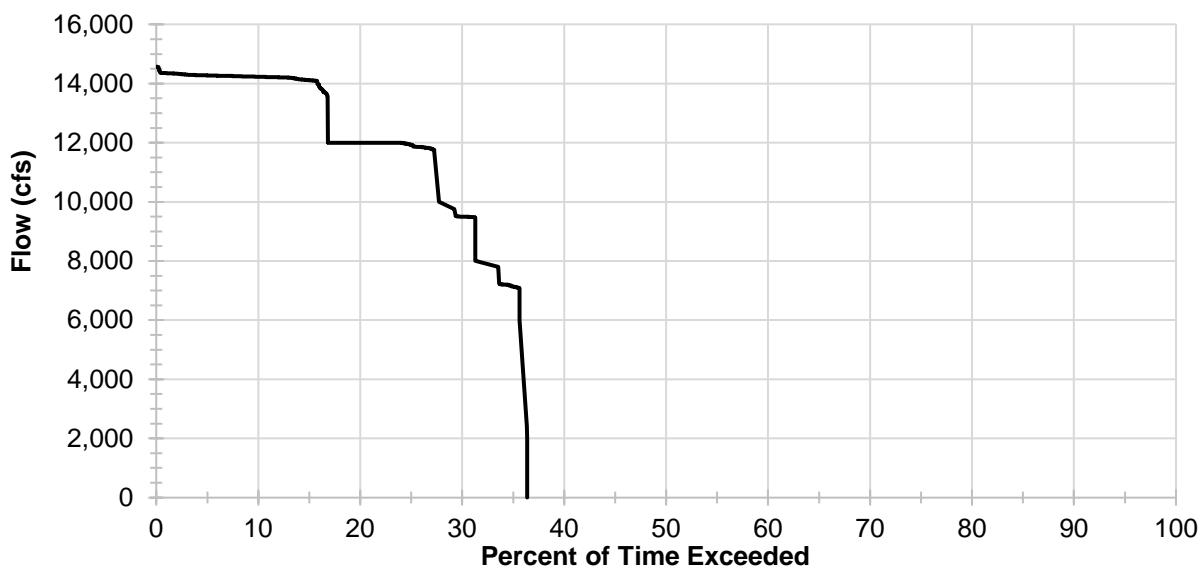
Percent of Time	January	February	March	April	May	June	July	August	September	October	November	December	Annual
95	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0	0
75	0	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	195	0	0	0	0	0	0	0	0
35	0	0	0	0	857	0	0	0	0	0	0	0	0
30	0	0	0	0	3,403	227	0	0	0	0	0	0	0
25	0	0	0	0	8,590	1,225	0	0	0	0	0	0	0
20	0	0	0	0	19,866	6,939	0	0	0	0	0	0	0
15	0	0	0	1,644	30,188	12,951	61	0	0	0	0	0	0
10	0	0	875	11,522	45,825	24,524	2,688	0	0	0	0	0	1,982
5	5,084	0	12,804	26,624	57,183	45,912	14,568	2,460	432	2,886	0	0	19,258

**Modeled Turbine Discharge Flow Duration Curves and Exceedance Table for Anticipated Operation**

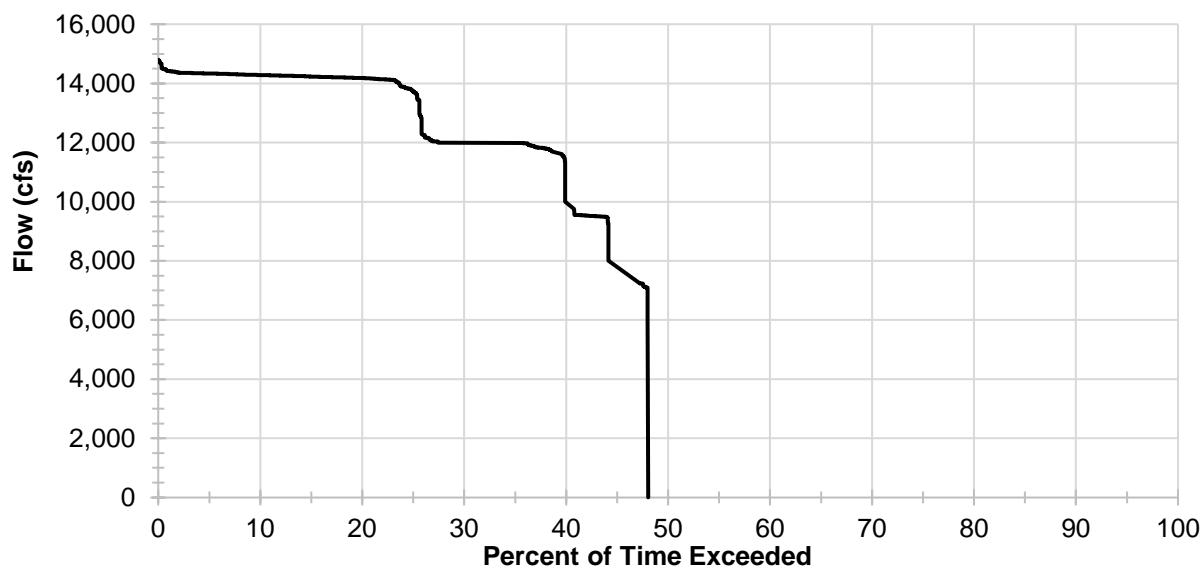
**January Flow Duration for Pensacola Dam  
Modeled Turbine Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



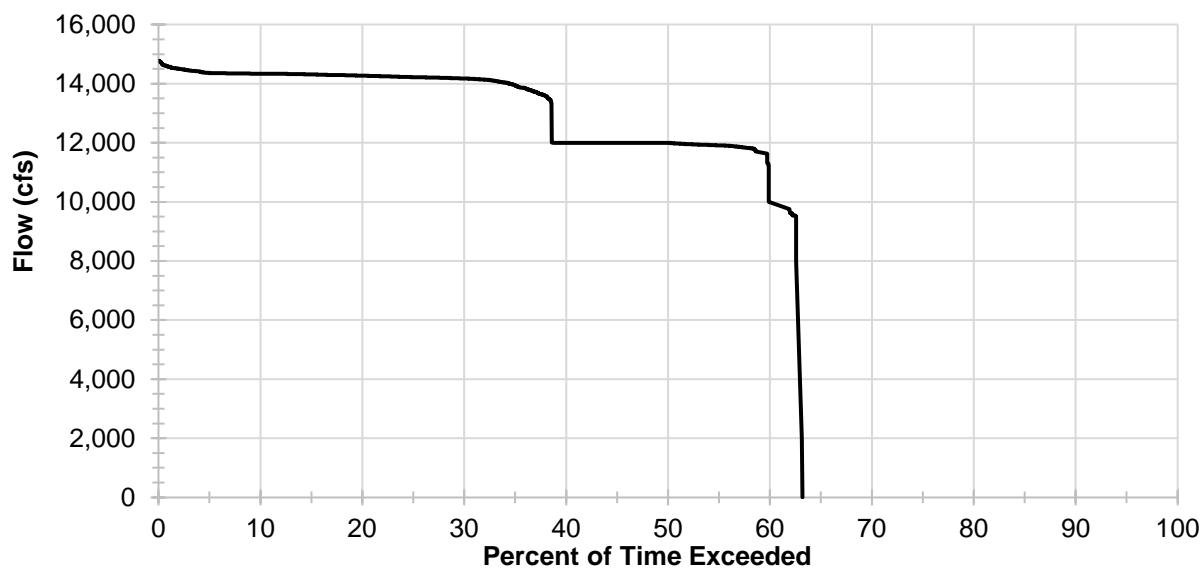
**February Flow Duration for Pensacola Dam  
Modeled Turbine Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



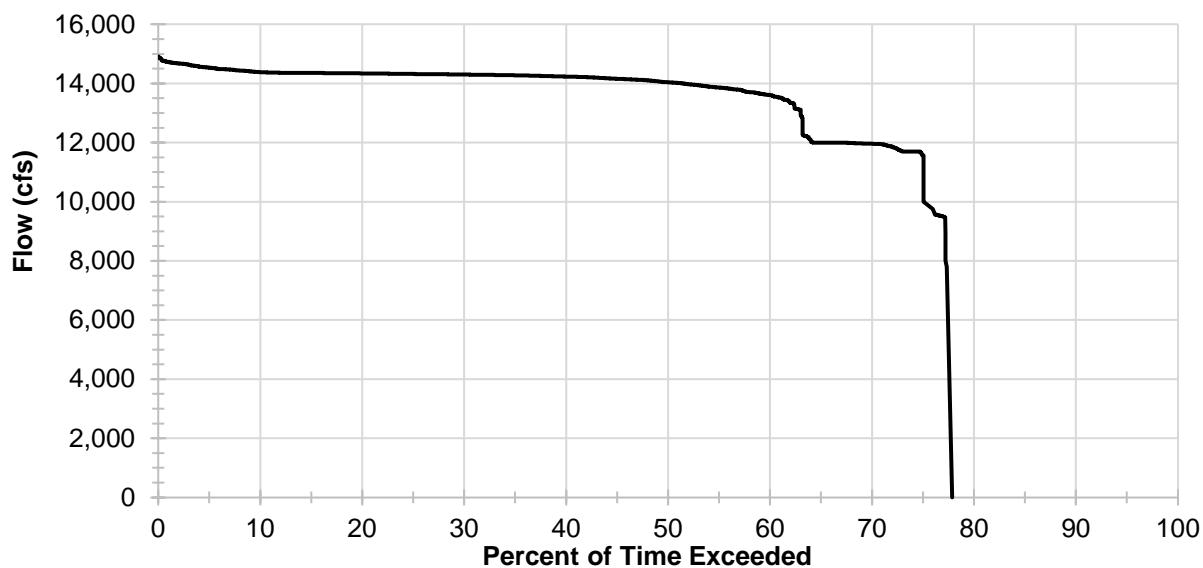
**March Flow Duration for Pensacola Dam  
Modeled Turbine Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



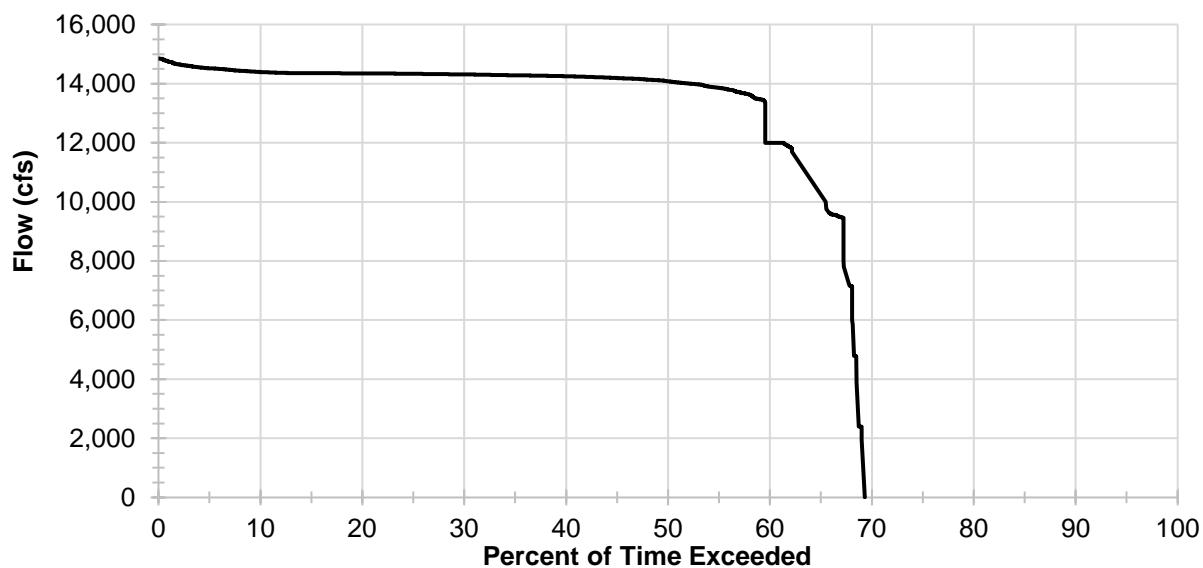
**April Flow Duration for Pensacola Dam  
Modeled Turbine Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



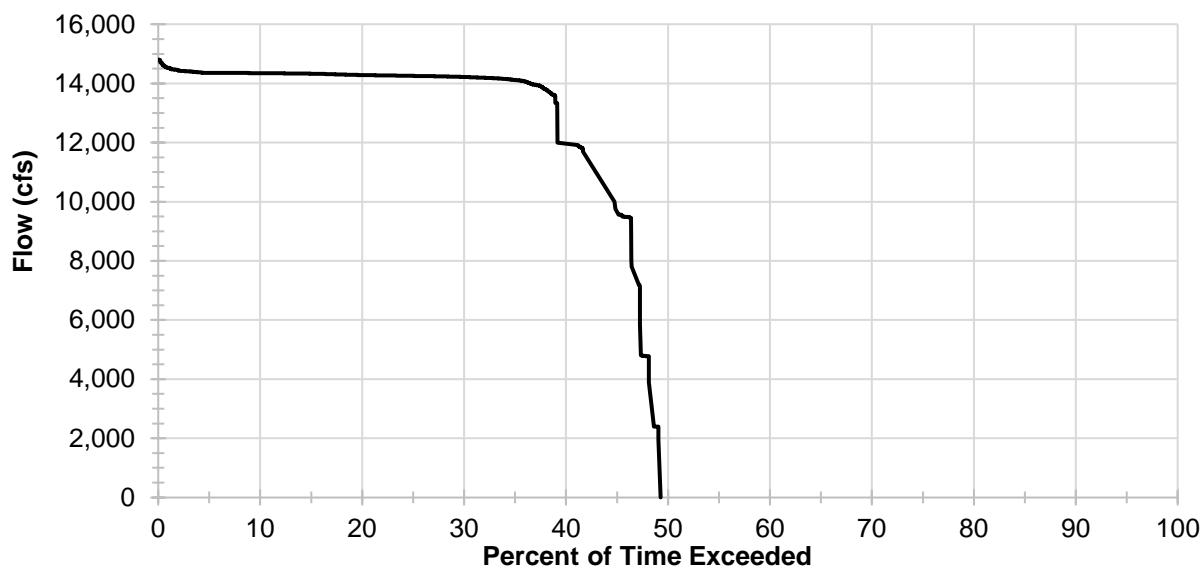
**May Flow Duration for Pensacola Dam  
Modeled Turbine Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



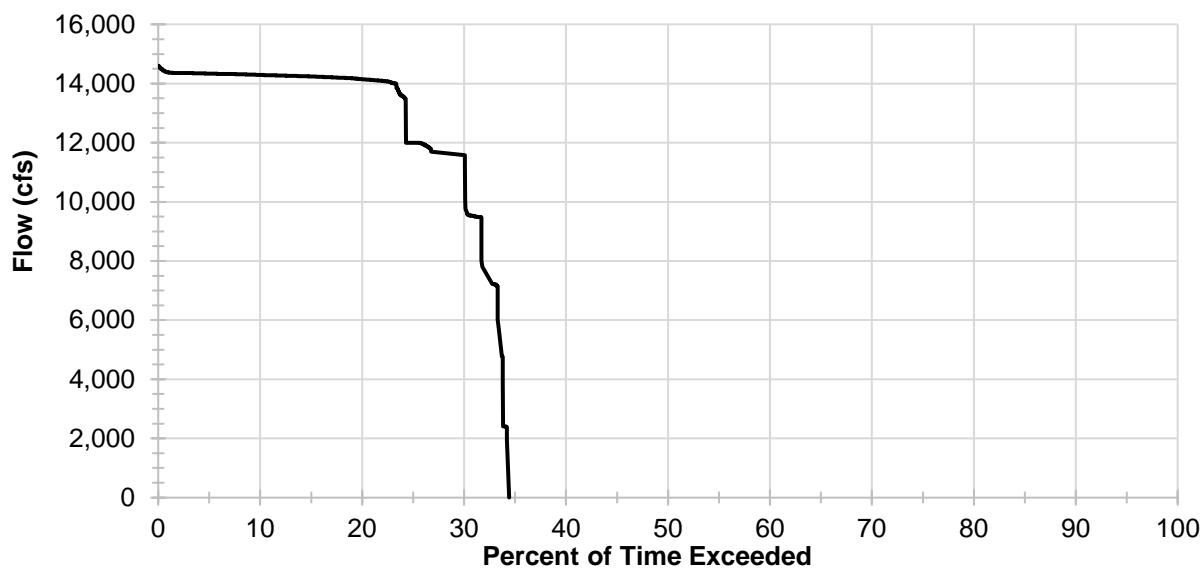
**June Flow Duration for Pensacola Dam  
Modeled Turbine Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



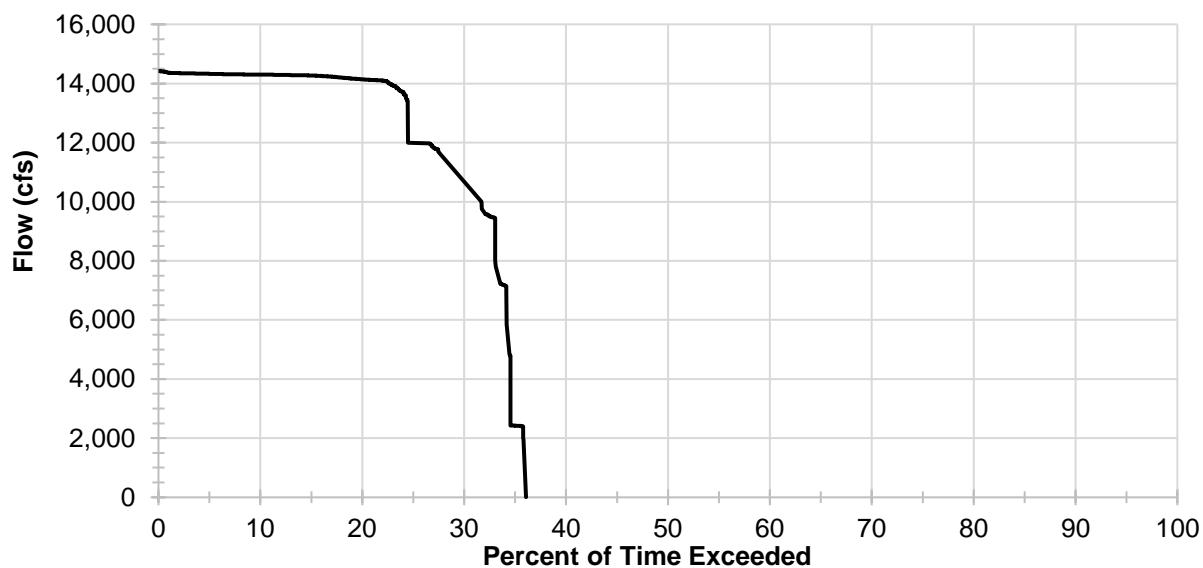
**July Flow Duration for Pensacola Dam  
Modeled Turbine Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



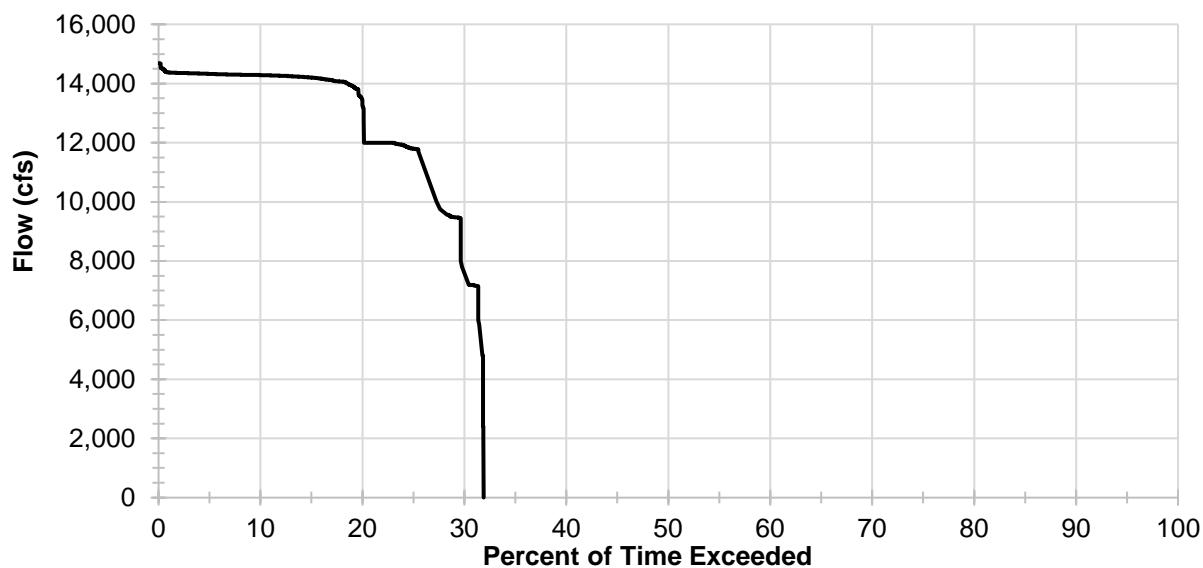
**August Flow Duration for Pensacola Dam  
Modeled Turbine Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



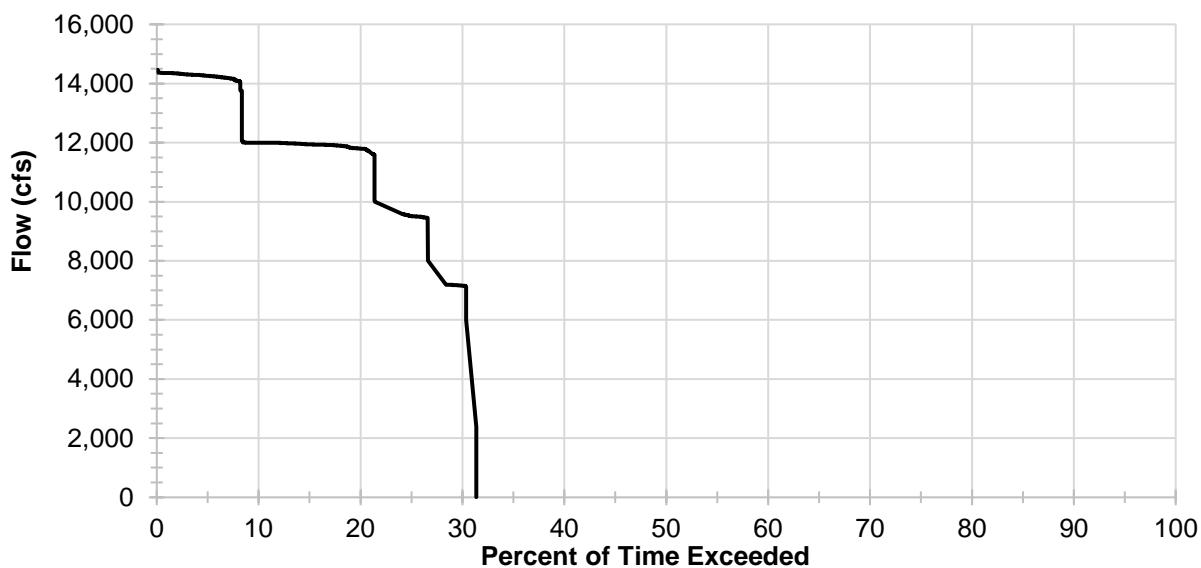
**September Flow Duration for Pensacola Dam  
Modeled Turbine Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



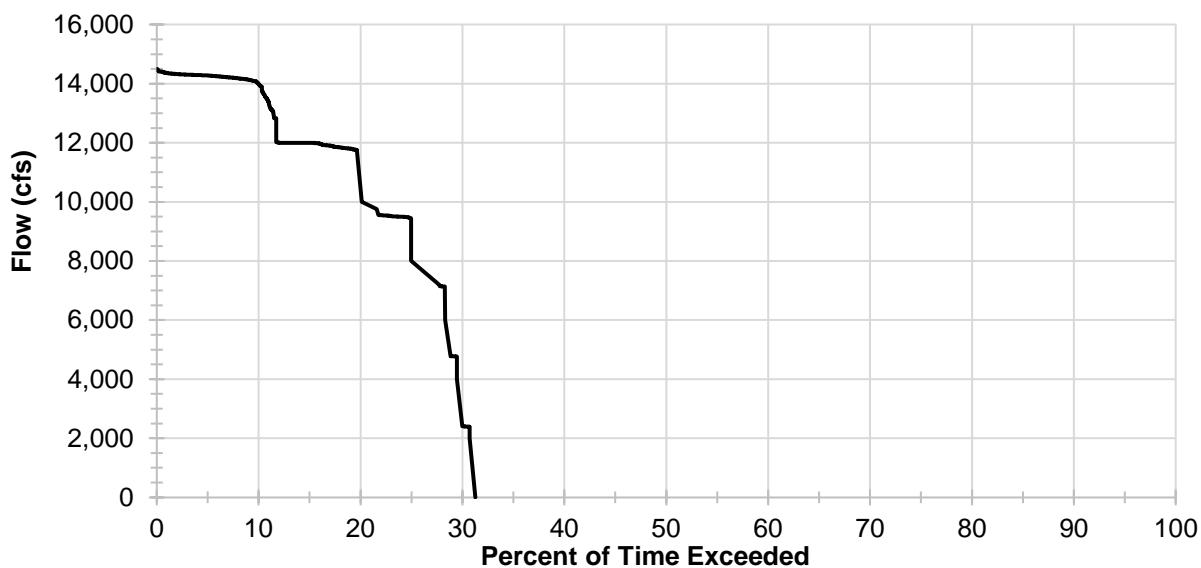
**October Flow Duration for Pensacola Dam  
Modeled Turbine Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



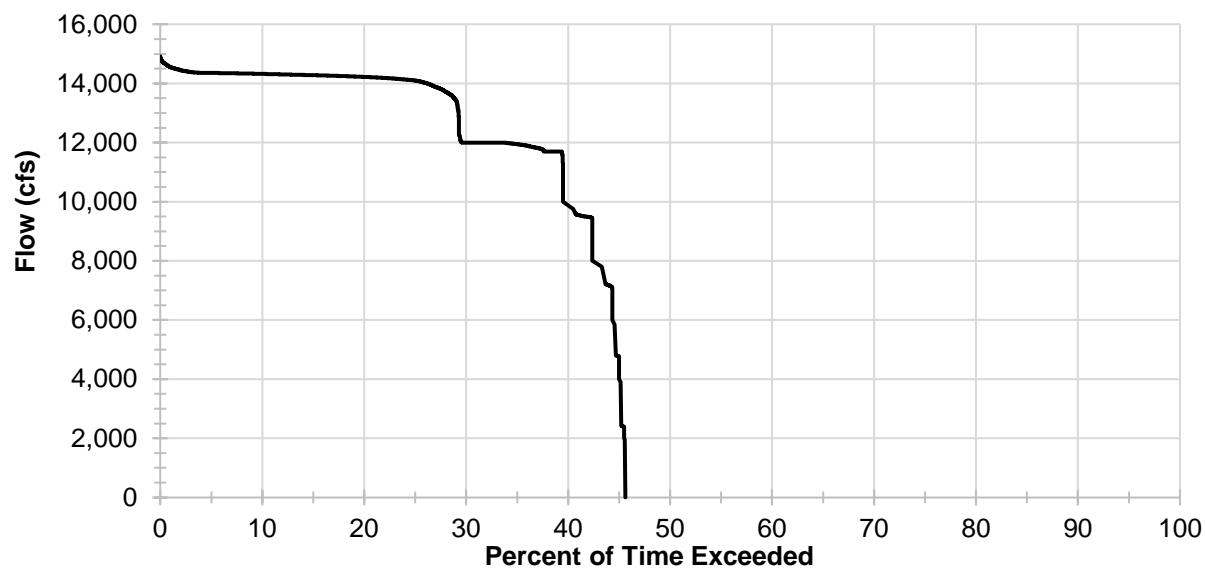
**November Flow Duration for Pensacola Dam  
Modeled Turbine Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



**December Flow Duration for Pensacola Dam  
Modeled Turbine Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



**Annual Flow Duration for Pensacola Dam  
Modeled Turbine Discharge for Anticipated Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**

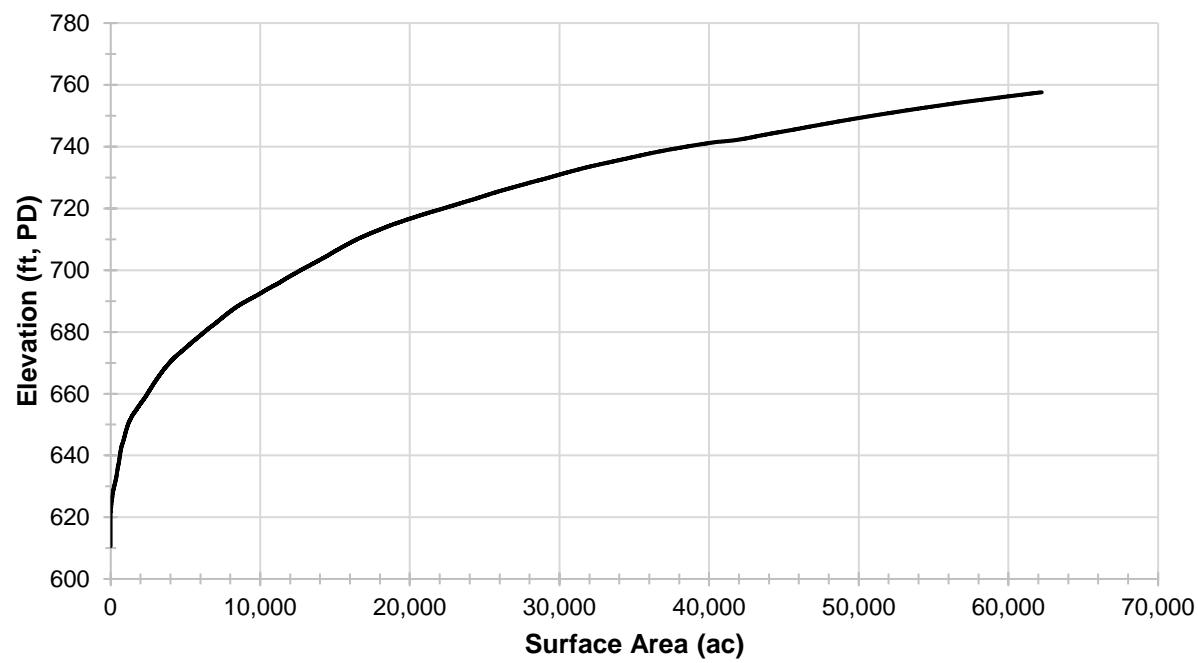


**Flow Duration for Pensacola Dam Modeled Turbine Discharge for Anticipated Operation (Period of Record Apr 1, 2004 - Dec 31, 2019)**

Percent of Time	January	February	March	April	May	June	July	August	September	October	November	December	Annual
95	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0	0
75	0	0	0	0	11,571	0	0	0	0	0	0	0	0
70	0	0	0	0	11,961	0	0	0	0	0	0	0	0
65	0	0	0	0	12,000	11,700	0	0	0	0	0	0	0
60	0	0	0	10,000	13,609	12,000	0	0	0	0	0	0	0
55	0	0	0	11,912	13,862	13,860	0	0	0	0	0	0	0
50	0	0	0	11,998	14,041	14,080	0	0	0	0	0	0	0
45	0	0	8,000	12,000	14,158	14,191	9,750	0	0	0	0	0	4,000
40	0	0	10,000	12,000	14,233	14,253	12,000	0	0	0	0	0	10,000
35	4,793	7,132	12,000	13,939	14,276	14,284	14,116	0	2,420	0	0	0	11,945
30	10,000	9,498	12,000	14,175	14,302	14,314	14,219	11,700	11,700	7,800	7,159	2,400	12,000
25	11,904	11,929	13,730	14,220	14,320	14,335	14,256	12,000	12,000	11,798	9,513	8,000	14,099
20	12,000	12,000	14,182	14,271	14,341	14,348	14,284	14,147	14,144	13,259	11,798	11,700	14,221
15	14,084	14,115	14,232	14,314	14,355	14,358	14,330	14,241	14,273	14,202	11,942	12,000	14,280
10	14,238	14,231	14,286	14,338	14,381	14,394	14,349	14,294	14,304	14,286	12,000	13,996	14,323
5	14,328	14,277	14,338	14,363	14,535	14,520	14,360	14,337	14,330	14,328	14,259	14,279	14,356

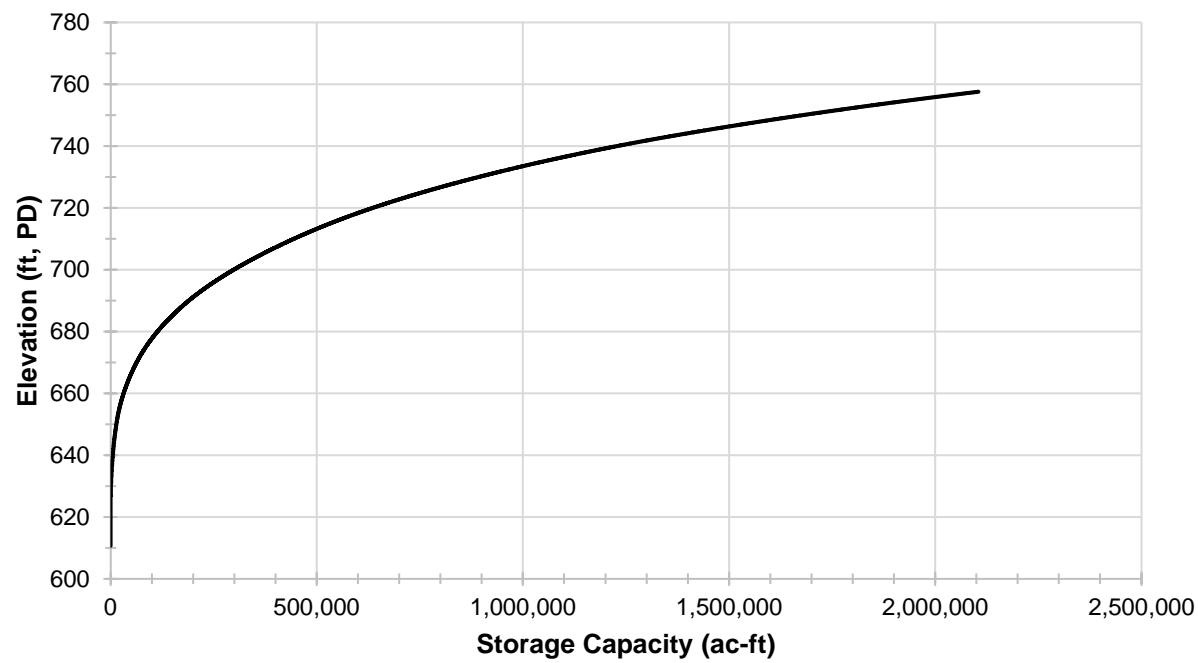
**APPENDIX B-4      Reservoir Area and Storage Capacity Curves**

### Pensacola Reservoir Area Curve



Area capacity curve obtained from the 2019 bathymetric survey of Grand Lake performed by USGS (Hunter, Trevisan, Villa, & Smith, 2020)

### Pensacola Reservoir Storage Capacity Curve

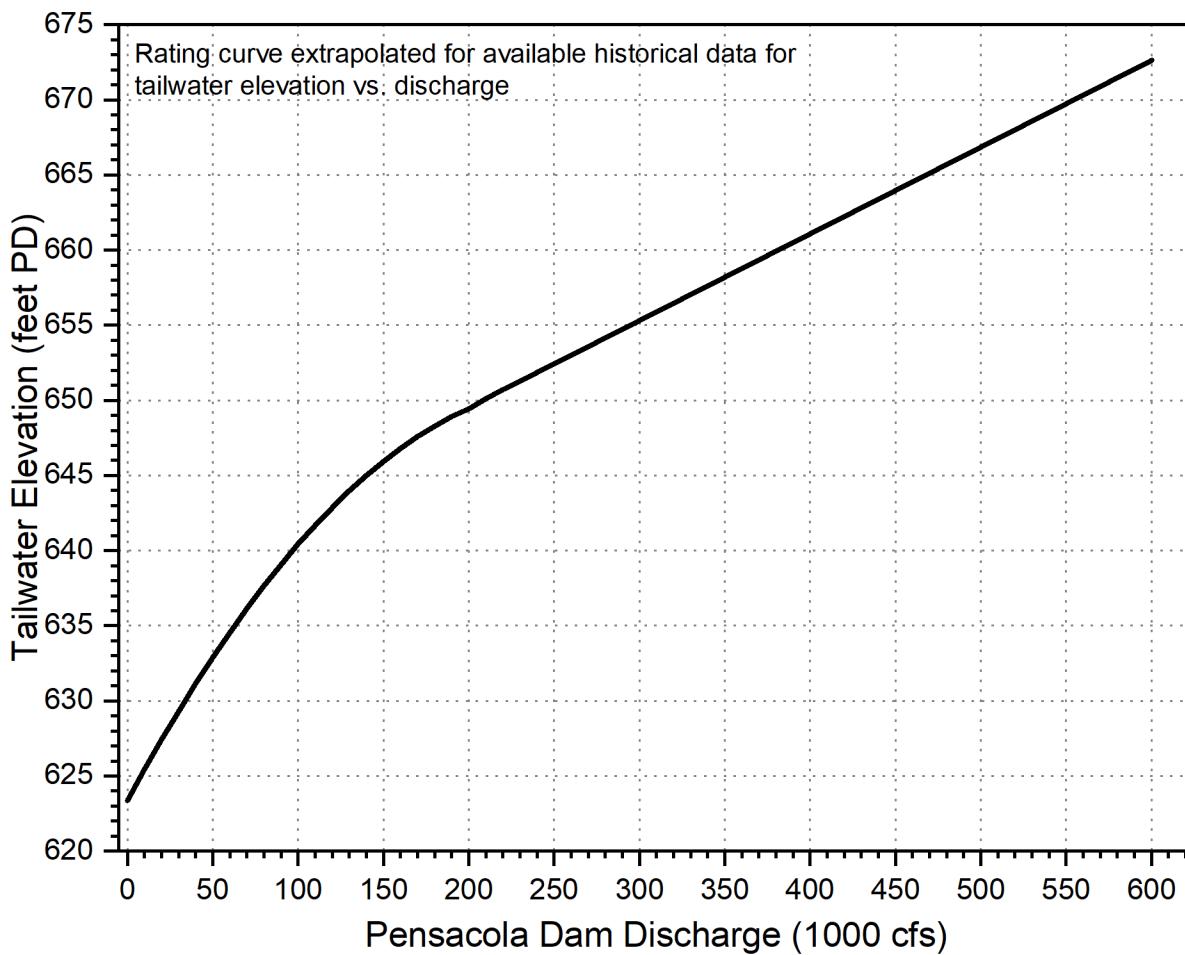


Storage capacity curve obtained from the 2019 bathymetric survey of Grand Lake performed by USGS (Hunter, Trevisan, Villa, & Smith, 2020)

**APPENDIX B-5**

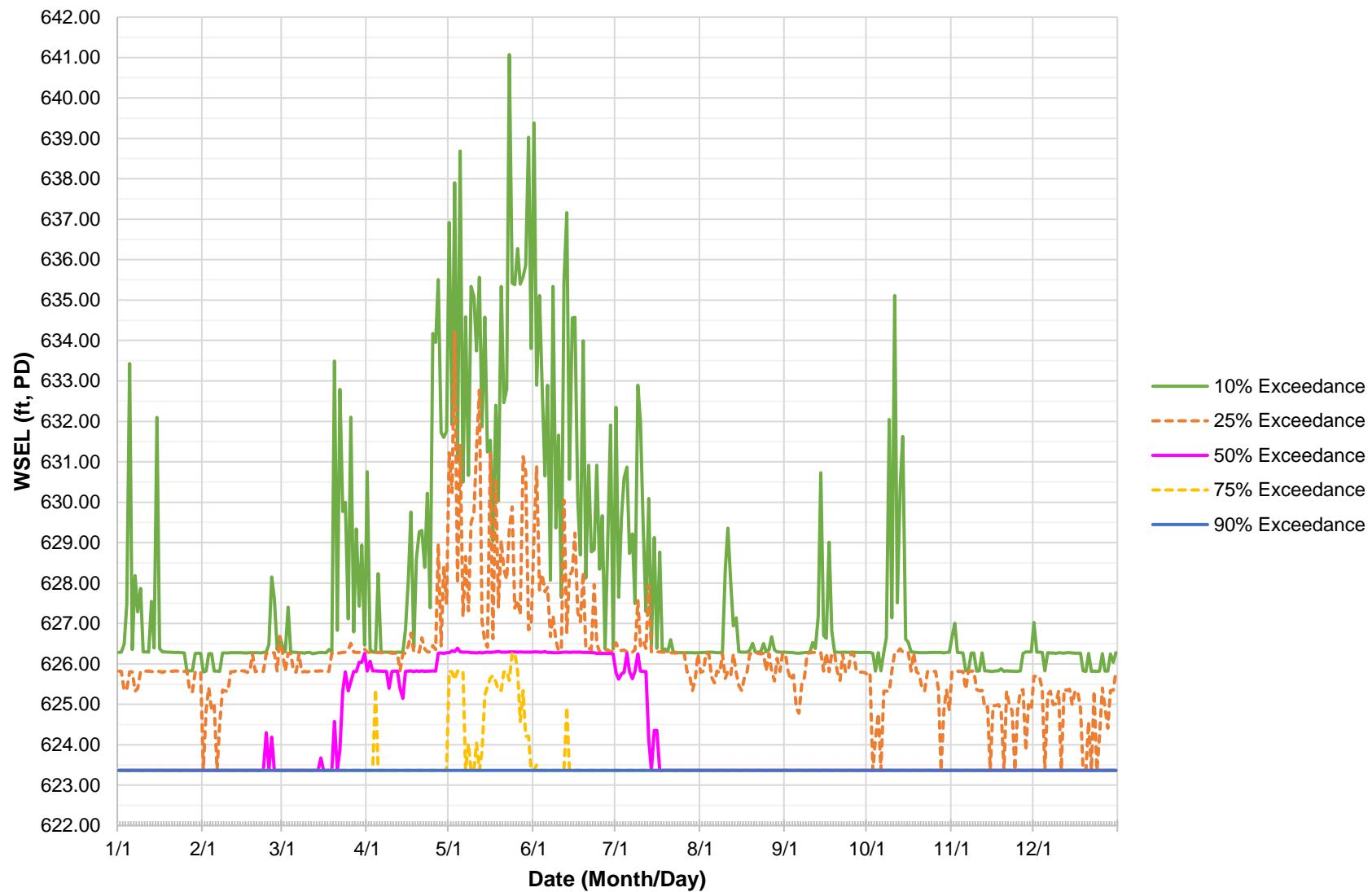
**Tailwater Rating Curve**

### Pensacola Project Tailwater Rating Curve

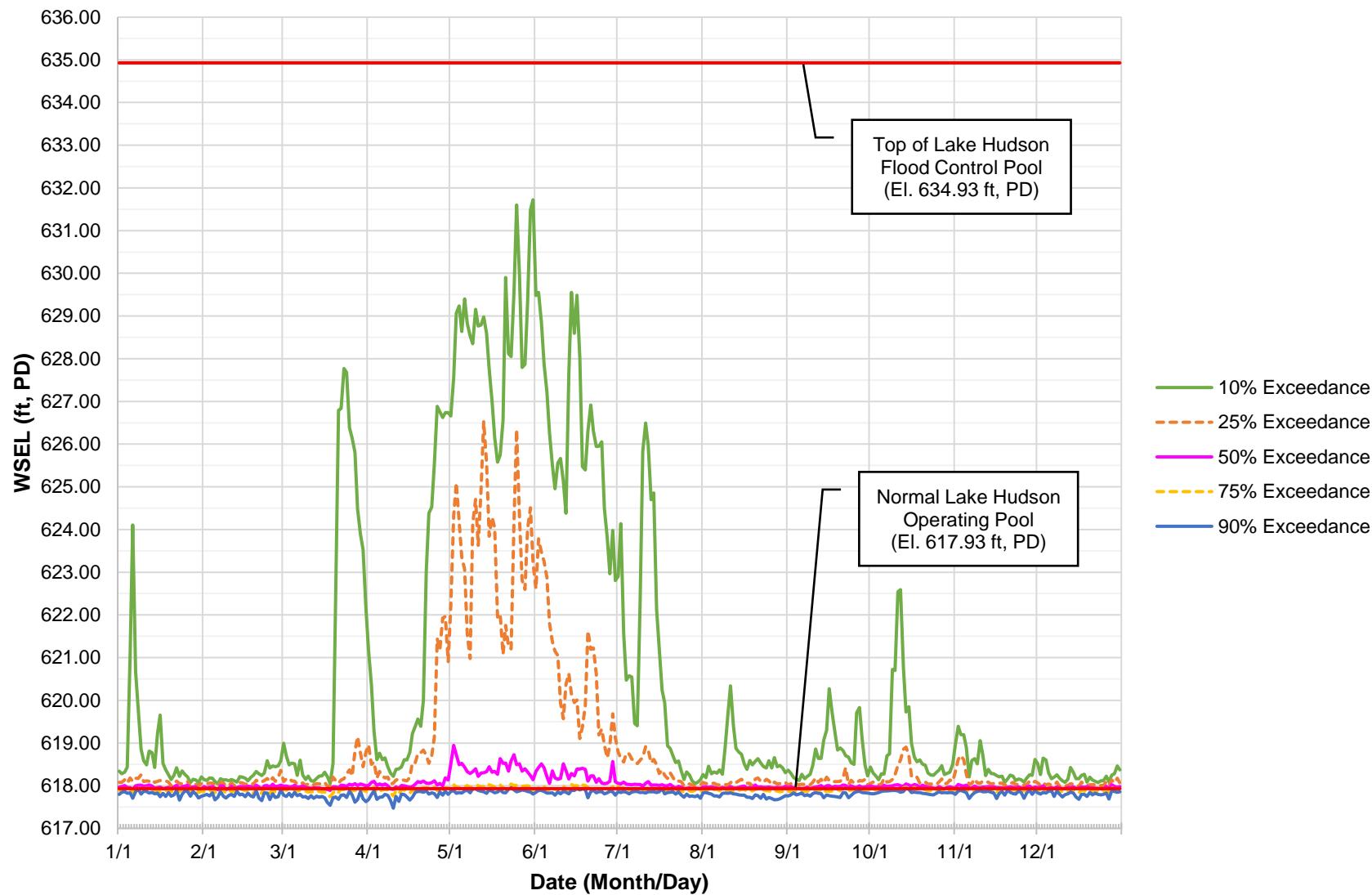


**APPENDIX B-6****Modeled Pensacola Tailwater Elevation and Lake Hudson Headwater  
Elevation Exceedance Curves for Anticipated Operation**

## Pensacola Modeled Tailwater Elevations Anticipated Operation

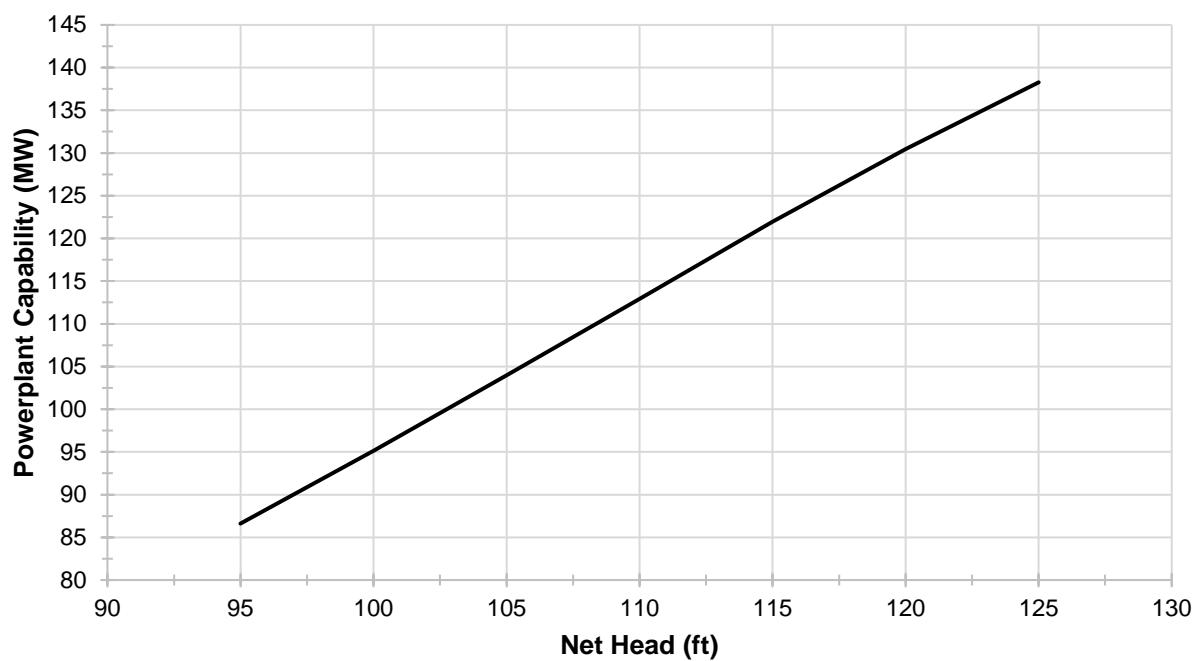


## Lake Hudson Modeled Headwater Elevations Anticipated Operation



**APPENDIX B-7      Powerplant Capability Curve**

### Powerplant Capability Curve



**APPENDIX B-8      Project Operation, Generation Characteristics, and Flow  
Data for the Current Operation**

## TABLE OF CONTENTS

	Page
<b>1. Project Operation .....</b>	<b>1</b>
1.1 Current Operation of the Pensacola Project .....	1
1.1.1 Current Reservoir Normal Operations .....	1
1.1.2 Current Reservoir High Flow Operations .....	2
1.1.3 Current Reservoir Low Flow Operations.....	3
<b>2. Generating Characteristics and Flow Data.....</b>	<b>3</b>
2.1 Average Annual Generation.....	3
2.2 Plant Factor .....	4
2.3 Pensacola Dam Discharge Variation for Current Operation .....	4
2.4 Pensacola Tailwater Elevations and Lake Hudson Headwater Elevations .....	7
<b>3. Works Cited .....</b>	<b>7</b>

## FIGURES

Figure 1.1.1-1: Pensacola Dam Rule Curve-Seasonal Target Elevations.....	2
--	---

## TABLES

Table 1.1.1-1: Target Elevations for the Pensacola Project .....	1
Table 2.3.1-1: Observed Pensacola Dam Total Discharge Variation for Current Operation.....	5
Table 2.3.1-2: Observed Pensacola Dam Spillway Discharge Variation for Current Operation.....	5
Table 2.3.1-3: Observed Pensacola Dam Turbine Discharge Variation for Current Operation.....	5
Table 2.3.1-4: Modeled Pensacola Dam Total Discharge Variation for Current Operation.....	6
Table 2.3.1-5: Modeled Pensacola Dam Spillway Discharge Variation for Current Operation .....	6
Table 2.3.1-6: Modeled Pensacola Dam Turbine Discharge Variation for Current Operation .....	6

## APPENDICES

Appendix B-8.1 Pensacola Observed and Modeled Headwater Elevation Exceedance Curves for Current Operation	
Appendix B-8.2 Pensacola Observed Total, Spillway, and Turbine Discharge Flow Duration Curves and Exceedance Tables for Current Operation	
Appendix B-8.3 Pensacola Modeled Total, Spillway, and Turbine Discharge Flow Duration Curves and Exceedance Tables for Current Operation	
Appendix B-8.4 Modeled Pensacola Tailwater Elevation and Lake Hudson Headwater Elevation Exceedance Curves for Current Operation	

## LIST OF ABBREVIATIONS

cfs	cubic feet per second
DO	Dissolved Oxygen
ECC	Energy Control Center
FERC	Federal Energy Regulatory Commission
FPA	Federal Power Act
GRDA	Grand River Dam Authority
Grand Lake	Grand Lake O' the Cherokees
H&H	Hydrologic and Hydraulic
MW	Megawatts
MWh	Megawatt-hours
NDAA 2020	National Defense Authorization Act for Fiscal Year 2020
NGVD 29	National Geodetic Vertical Datum of 1929
OM	Operations Model
PD	Pensacola Datum
Pensacola Project	Pensacola Hydroelectric Project
Project	Pensacola Hydroelectric Project
USACE	U.S. Army Corps of Engineers
USGS	United States Geological Survey

## 1. Project Operation

The National Defense Authorization Act for Fiscal Year 2020 (NDAA 2020) prohibits the Federal Energy Regulatory Commission (FERC) from imposing reservoir level requirements at Grand Lake O' the Cherokees. The information presented in this **Appendix B-8** regarding current operations of the Pensacola Hydroelectric Project (Pensacola Project or Project) is for informational purposes at the request of FERC staff. Nothing in this **Appendix B-8** is intended to impose any operational constraint on the Grand River Dam Authority (GRDA) during the current or new license term with respect to water surface elevation requirements.

### 1.1 Current Operation of the Pensacola Project

#### 1.1.1 Current Reservoir Normal Operations

Under the expiring license's current operation, the Pensacola Project is operated according to a rule curve that sets target reservoir surface elevations pursuant to Article 401. The current rule curve was first approved by FERC as part of a temporary variance issued on August 14, 2015 (FERC, 2015) and officially amended by the Commission's Order issued August 15, 2017.<sup>1</sup> Article 401 requires GRDA to operate the Pensacola Project to maintain, to the extent practicable, the following seasonal target reservoir elevations shown in **Table 1.1.1-1** and **Figure 1.1.1-1**, except as required by the Storm Adaptive Management Plan and Drought Adaptive Management Plan, and as necessary for the USACE to provide flood protection (FERC, 2017). During periods of low dissolved oxygen (DO), GRDA utilizes air induction ports within the turbines to draw in air that is mixed with the water as it passes through the turbines to help oxygenate the water within the tailrace (Grand River Dam Authority, 2021b).

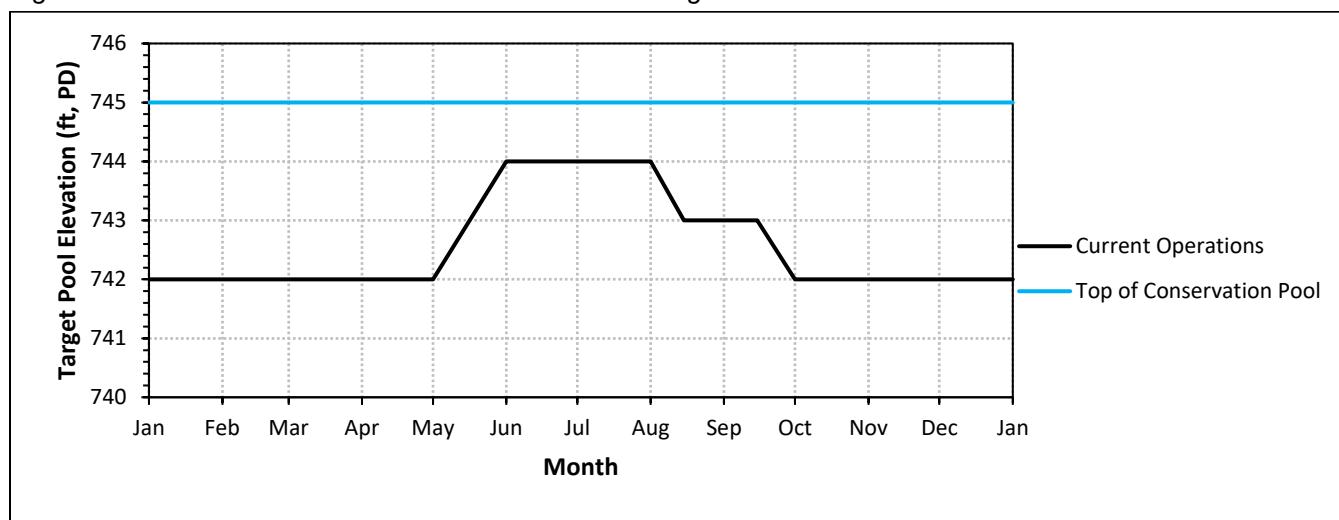
*Table 1.1.1-1: Target Elevations for the Pensacola Project*

Period	Reservoir Elevation (Feet PD <sup>2</sup> )
May 1 through May 31	Raise elevation from 742 to 744
June 1 through July 31	Maintain Elevation at 744
August 1 through August 15	Lower Elevation from 744 to 743
August 16 through September 15	Maintain Elevation at 743
September 16 through September 30	Lower Elevation from 743 to 742
October 1 to April 30	Maintain Elevation at 742

<sup>1</sup> 160 FERC ¶ 61,001

<sup>2</sup> Unless stated otherwise, all elevations are presented in Pensacola Datum (PD). To convert from PD to the National Geodetic Vertical Datum of 1929 (NGVD29), add 1.07 feet. To convert from NGVD29 to the North American Vertical Datum of 1988 (NAVD88), add 0.33 feet.

*Figure 1.1.1-1: Pensacola Dam Rule Curve-Seasonal Target Elevations*



### 1.1.2 Current Reservoir High Flow Operations

Federal law establishes a Congressionally authorized regulatory structure at Grand Lake. Under Section 7 of the Flood Control Act of 1944 (CFR, 1944), for example, Congress conferred upon the USACE the exclusive responsibility to prescribe releases from Pensacola Dam under active or anticipated flood operations (CFR, 1945). The USACE is also responsible for directing spillway releases in accordance with the procedures for system balancing of flood storage outlined in the Arkansas River Basin Water Control Master Manual (USACE, 1992). This exclusive authority is reinforced by Section 7612(c) of the NDAA of Fiscal Year 2020 which states that “The Secretary [of the Army] shall have exclusive jurisdiction and responsibility for management of the flood pool for flood control operations at Grand Lake O’ the Cherokees” (NDAA, 2020). Other federal laws, such as Public Law 76-597, 54 Stat. 303 (1940), and Public Law 79-573, 60 Stat. 743 (1946), confirm that Congress has long established that USACE has sole jurisdiction over flood control, while the Commission retains jurisdiction under the FPA within the conservation pool. Even the original license issued by the Federal Power Commission in 1939 recognizes this bifurcated authority.

The flood storage associated with Grand Lake generally consists of the storage volume available above reservoir elevation of 745 feet PD (USACE, 1992). When reservoir elevations are either above elevation 745 feet PD or projected to rise above 745 feet PD, the USACE directs the water releases from the dam under the terms of Section 7 of the Flood Control Act of 1944. When directed to make lake releases by USACE, GRDA first discharges as much water as possible through the Project’s hydropower units. Once the Project has reached the powerhouse’s maximum hydraulic capacity, USACE may direct GRDA to open one or more spillway gates if the reservoir is still rising, but typically not unless the reservoir elevation exceeds, or is projected to exceed 745 feet PD. USACE will then determine if additional gates need to be opened. The target discharge rate at any time is based on the current reservoir elevation, the current estimated inflow to Grand Lake, and the amount of projected flooding downstream in the Grand or Arkansas River basins (GRDA, 2017).

Operators in the ECC are contacted by USACE personnel when gate operations are required. When USACE directs GRDA to release water from Grand Lake, the staff at Pensacola Dam decides which

specific gate or gates to open. The opening order of these gates is rotated so each gate is opened about the same number of times. However, a general exception to this rule is that GRDA avoids opening the outside gates on all three spillways, when possible, to help limit bank erosion in the discharge channels downstream of the spillways (GRDA, 2021b).

### 1.1.3 Current Reservoir Low Flow Operations

In the event that the National Drought Mitigation Center's U.S. Drought Monitor has identified a severe to exceptional drought within the Grand/Neosho River basin, GRDA will continue to make releases at the Project to meet downstream obligations, regardless of the prevailing levels at Grand Lake O' the Cherokees (Grand Lake) and the minimum reservoir elevation of 742 feet PD. Such releases are limited to up to 0.06 feet of reservoir elevation per day—up to approximately 837 cubic feet per second per hour over a 24-hour period.

The daily release allowances under this Plan are designed to allow short-duration pulsed releases to simultaneously conserve water in Grand Lake while maintaining downstream DO requirements. These release allowances are expected to provide enough flow to maintain gate releases downstream at the Markham Ferry Project while maintaining an elevation of 619 feet mean sea level at Lake Hudson, which is necessary to meet general daily operations and North American Electric Reliability Corporation reliability standards associated with the Salina Pumped Storage Project.

In the unusual event that the allowances are insufficient to meet its objectives, GRDA may release additional flows from Grand Lake to meet downstream requirements during a severe to exceptional drought.

Graphs with 10%, 25%, 50%, 75%, 90% exceedance curves for Pensacola observed and modeled headwater elevations for current operation are provided in **Appendix B-8.1**. The observed headwater exceedance graph for current operation was developed using hourly stage data from USGS Gage 07190000 (USGS, 2022d) and spans a time period from August 14, 2015 through December 31, 2022. The modeled headwater exceedance graph for current operation was developed using hourly headwater elevations from the Operations Model (OM) and spans a time period from April 1, 2004 through December 31, 2019.

## 2. Generating Characteristics and Flow Data

### 2.1 Average Annual Generation

The observed annual average generation for current operation is 491,510 MWh, of which 249,309 MWh is on-peak generation and 242,201 MWh is off-peak generation. Observed annual average generation for current operation was computed using hourly generation data (recorded by GRDA and supplied to the USACE in monthly reports) with a time period of January 1, 2016 through December 31, 2022.

The modeled annual average generation for current operation is 413,830 MWh, of which 219,345 MWh is on-peak generation and 194,486 MWh is off-peak generation. Modeled annual average generation for current operation was computed using hourly generation values computed by the OM with a time period of January 1, 2005 through December 31, 2019.

## 2.2 Plant Factor

The following equation is used to determine the average annual plant factor:

$$\text{Average Annual Plant Factor} = (\text{Average Annual Output}) \div (\text{Nameplate Capacity} \times 8,760 \text{ hours/year})$$

The observed annual average generation for current operation of 491,510 MWh produces a plant factor of 0.533, and the OM estimates an average annual generation for current operation of 413,830 MWh with a plant factor of 0.449 based on the FERC authorized capacity of 105.176 MW.

## 2.3 Pensacola Dam Discharge Variation for Current Operation

Flow duration curves and annual exceedance tables for observed and modeled total discharge from Pensacola Dam, turbine discharge, and spillway discharge for current operation are provided in **Appendix B-8.2** and **Appendix B-8.3**. The observed flow duration curves and exceedance table for current operation were developed using hourly discharge values recorded by GRDA for the time period of August 14, 2015 through December 31, 2022. The modeled flow duration curves and exceedance table were developed using hourly discharge values from the OM and span a time period of April 1, 2004 through December 31, 2019.

The Pensacola Dam observed and modeled discharge variations for current operation for total discharge from Pensacola Dam, spillway discharge, and turbine discharge are shown below in **Tables 2.3.1-1, 2.3.1-2, 2.3.1-3, 2.3.1-4, 2.3.1-5, and 2.3.1-6**. Observed discharge variations for current operation are based on the hourly discharge values recorded by GRDA and use a time period of August 14, 2015 through December 31, 2022. Modeled discharge variations for current operation are based on the results of the OM for the time period of April 1, 2004 through December 31, 2019.

*Table 2.3.1-1: Observed Pensacola Dam Total Discharge Variation for Current Operation*

Flow Statistic	Flow Statistic Value (cfs)	Date(s)
Annual mean	9,892	Aug 14, 2015 – Dec 31, 2022
Highest annual mean	19,184	2019
Lowest annual mean	4,954	2018
Highest hourly flow	236,165	Dec 29, 2015 9:00
Lowest hourly flow	0	N/A <sup>2</sup>
10-percent exceedance	21,457	--
50-percent exceedance	5,308	--
90-percent exceedance	0	--

*Table 2.3.1-2: Observed Pensacola Dam Spillway Discharge Variation for Current Operation*

Flow Statistic	Flow Statistic Value (cfs)	Date(s)
Annual mean	3,710	Aug 14, 2015 – Dec 31, 2022
Highest annual mean	8,489	2019
Lowest annual mean	574	2018
Highest hourly flow	223,263	Dec 29, 2015 9:00
Lowest hourly flow	0	N/A <sup>2</sup>
10-percent exceedance	8,616	--
50-percent exceedance	0	--
90-percent exceedance	0	--

*Table 2.3.1-3: Observed Pensacola Dam Turbine Discharge Variation for Current Operation*

Flow Statistic	Flow Statistic Value (cfs)	Date(s)
Annual mean	6,182	Aug 14, 2015 – Dec 31, 2022
Highest annual mean	10,696	2019
Lowest annual mean	4,380	2018
Highest hourly flow	14,337	May 14, 2019 14:00
Lowest hourly flow	0	N/A <sup>2</sup>
10-percent exceedance	13,516	--
50-percent exceedance	5,288	--
90-percent exceedance	0	--

<sup>2</sup> Numerous hourly discharge values equal to zero were observed or computed by the OM, so specific dates are not included.

*Table 2.3.1-4: Modeled Pensacola Dam Total Discharge Variation for Current Operation*

Flow Statistic	Flow Statistic Value (cfs)	Date(s)
Annual mean	8,624	Apr 1, 2004 – Dec 31, 2019
Highest annual mean	19,582	2019
Lowest annual mean	1,508	2006
Highest hourly flow	215,762	Dec 29, 2015 23:00
Lowest hourly flow	0	N/A <sup>2</sup>
10-percent exceedance	19,583	--
50-percent exceedance	0	--
90-percent exceedance	0	--

*Table 2.3.1-5: Modeled Pensacola Dam Spillway Discharge Variation for Current Operation*

Flow Statistic	Flow Statistic Value (cfs)	Date(s)
Annual mean	3,004	Apr 1, 2004 – Dec 31, 2019
Highest annual mean	9,359	2019
Lowest annual mean	171	2006
Highest hourly flow	202,905	Dec 29, 2015 1:00
Lowest hourly flow	0	N/A <sup>2</sup>
10-percent exceedance	6,315	--
50-percent exceedance	0	--
90-percent exceedance	0	--

*Table 2.3.1-6: Modeled Pensacola Dam Turbine Discharge Variation for Current Operation*

Flow Statistic	Flow Statistic Value (cfs)	Date(s)
Annual mean	5,621	Apr 1, 2004 – Dec 31, 2019
Highest annual mean	10,223	2019
Lowest annual mean	1,337	2006
Highest hourly flow	15,018	April 12, 2008 23:00
Lowest hourly flow	0	N/A <sup>2</sup>
10-percent exceedance	14,197	--
50-percent exceedance	0	--
90-percent exceedance	0	--

<sup>2</sup> Numerous hourly discharge values equal to zero were observed or computed by the OM, so specific dates are not included.

## 2.4 Pensacola Tailwater Elevations and Lake Hudson Headwater Elevations

Graphs with 10%, 25%, 50%, 75%, and 90% exceedance curves for Pensacola modeled tailwater elevations and Lake Hudson modeled headwater elevations for current operation are provided in **Appendix B-8.4**. These graphs were developed using hourly water surface elevations computed by the OM for the time period of April 1, 2004 through December 31, 2019.

## 3. Works Cited

- CFR. (1944). *Regulations for use of storage waters*. 33 U.S. Code § 709.
- CFR. (1945). *Pensacola Dam and Reservoir, Grand (Neosho) River, Okla.* 33 CFR § 208.25.
- FERC. (2009). *Order Amending Licensse by Revising Annual Charges*.
- FERC. (2015). *Order Approving Request for Temporary Variance*. August 14, 2015.
- FERC. (2017). *Order Amending License and Dismissing Application for Temporary Variance*.
- FERC. (2017). *Order Amending License and Dismissing Application for Temporary Variance*. August 15, 2017.
- Grand River Dam Authority. (2021b). *Supporting Technical Information Document for the Pensacola Project No. 1494, Revision 3*. January, 2021.
- GRDA. (2017). *Pensacola Hydroelectric Project, FERC No. 1494 Pre-Application Document*.
- GRDA. (2021a, December 29). Pensacola Hydroelectric Project (FERC Project No. 1494-438); Response to Comments on Intitial Study Report, Notice of Technical Meeting, and Request for Privileged Treatment of Cultural Resources Information.
- GRDA. (2021b). *Supporting Technical Information Document - Revision 3*.
- GRDA. (n.d.). *Electricity*. Retrieved October 24, 2022, from GRDA: <https://grda.com/electricity/>
- Hunter, S. L., Trevisan, A. R., Villa, J., & Smith, K. A. (2020). *Bathymetric Map, Surface Area, and Capacity of Grand Lake O' the Cherokees, Northeastern Oklahoma, 2019*. Denver: USGS.
- Mead & Hunt. (2022). *Hydrologic and Hydraulic Modeling: Operations Model*.
- NDAA. (2020). S. 1790 National Defense Authorization Act for Fiscal Year 2020. Public Law No. 116-92.
- USACE. (1992). *Arkansas River Basin Water Control Master Manual*. Tulsa and Little Rock Districts.
- USACE. (1992). *Pensacola Reservoir Water Control Manual-Appendix E, Part I of III to the Water Control Manual for the Arkansas River System*.

USGS. (2022a, September). *USGS 07185000 Neosho River near Commerce, OK*. Retrieved from National Water Information System:  
[https://waterdata.usgs.gov/nwis/inventory?agency\\_code=USGS&site\\_no=07185000](https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=07185000)

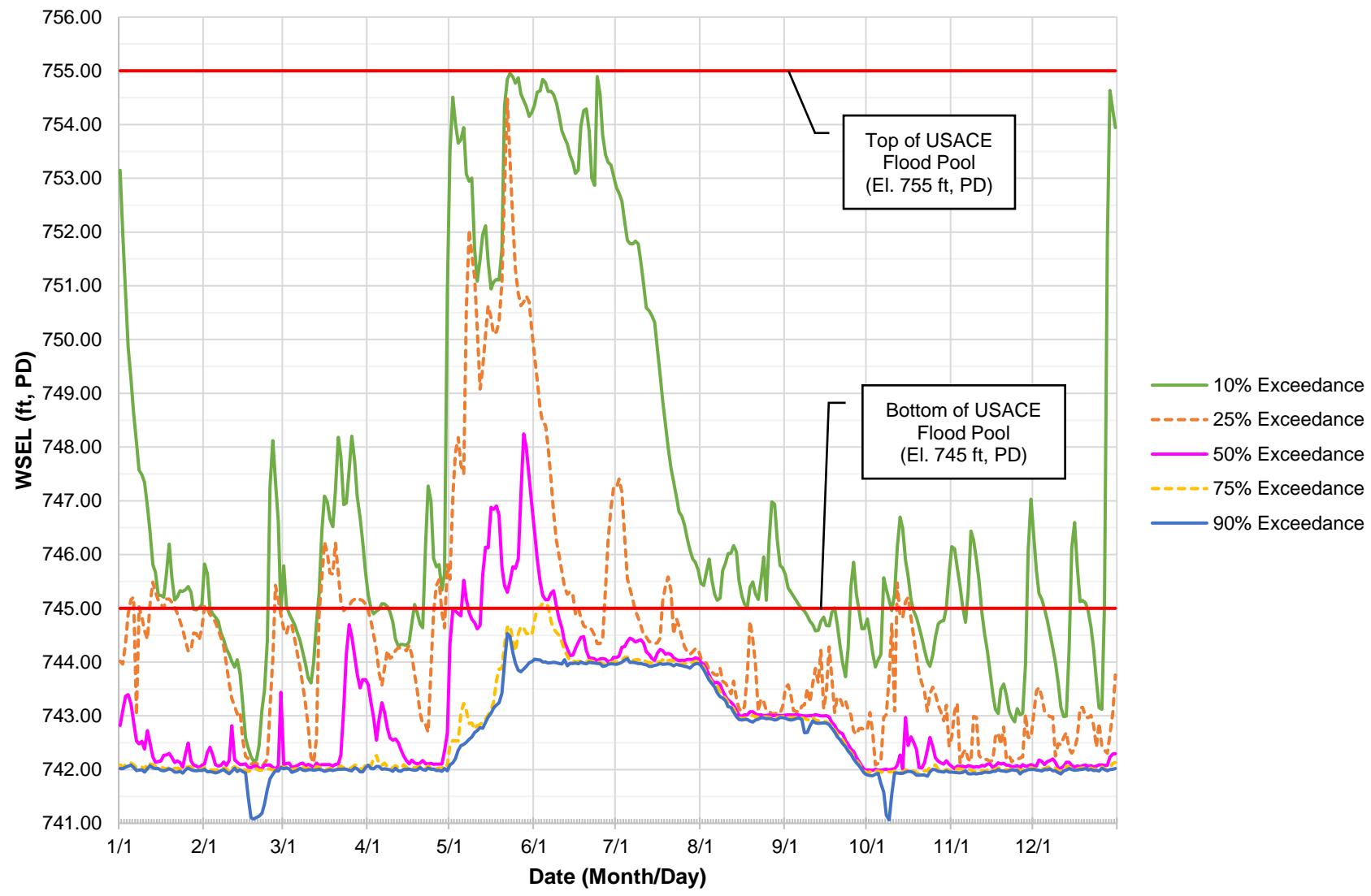
USGS. (2022b, September). *USGS 07188000 Spring River near Quapaw, OK*. Retrieved from National Water Information System:  
[https://waterdata.usgs.gov/nwis/inventory?agency\\_code=USGS&site\\_no=07188000](https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=07188000)

USGS. (2022c, September). *USGS 07189000 Elk River near Tiff City, MO*. Retrieved from National Water Information System:  
[https://waterdata.usgs.gov/nwis/inventory?agency\\_code=USGS&site\\_no=07189000](https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=07189000)

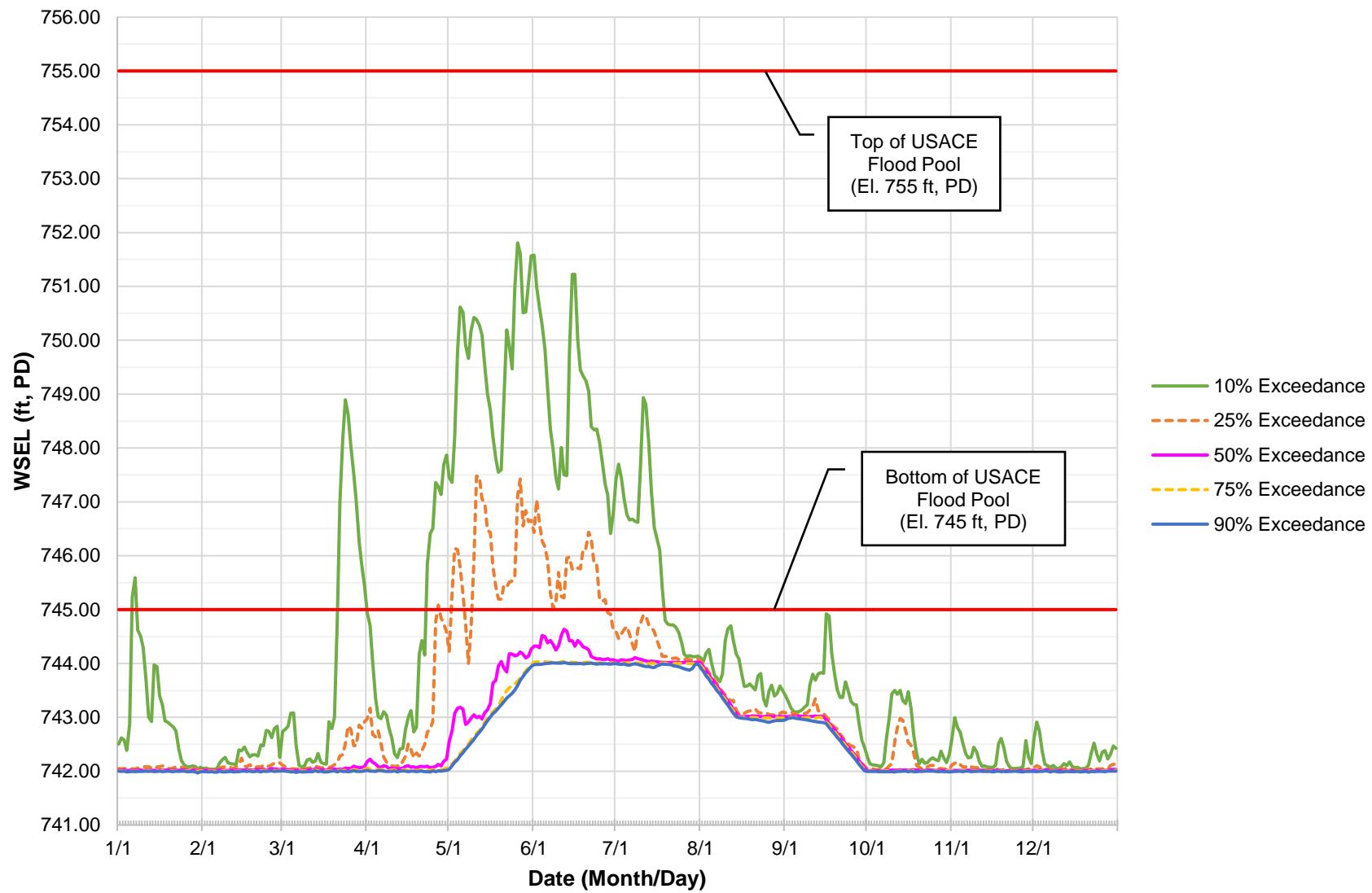
USGS. (2022d, September). *USGS 071890000 Lake O' the Cherokees at Langley, OK*. Retrieved from National Water Information System:  
[https://waterdata.usgs.gov/ok/nwis/inventory/?site\\_no=07190000&agency\\_cd=USGS](https://waterdata.usgs.gov/ok/nwis/inventory/?site_no=07190000&agency_cd=USGS)

**APPENDIX B-8.1      Pensacola Observed and Modeled Headwater Elevation Exceedance Curves for Current Operation**

## Pensacola Observed Headwater Elevations Current Operation

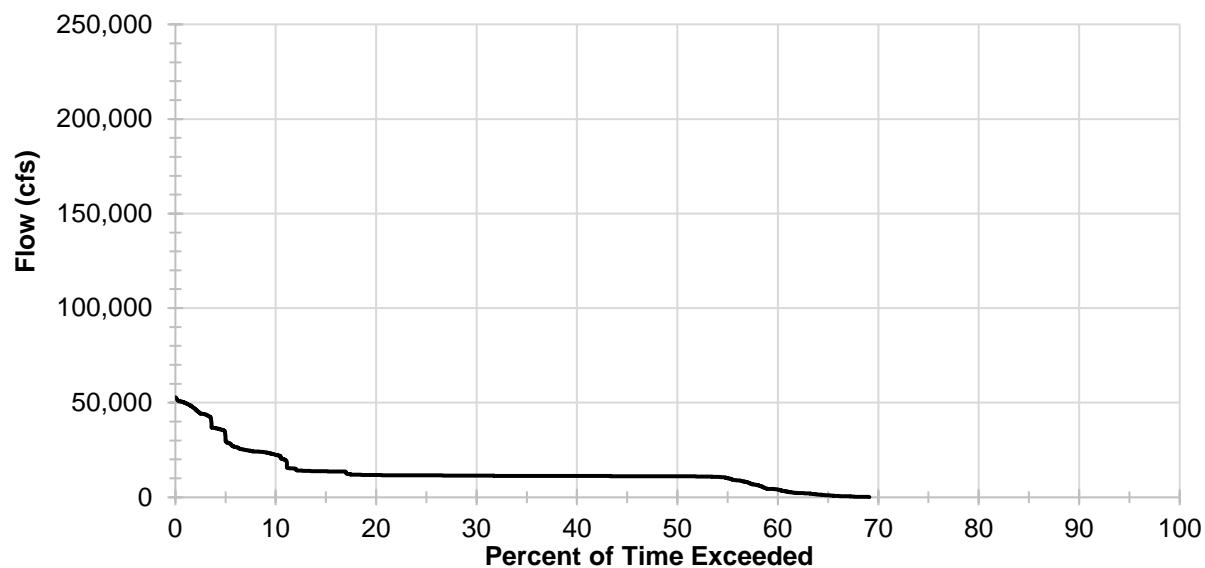


## Pensacola Modeled Headwater Elevations Current Operation

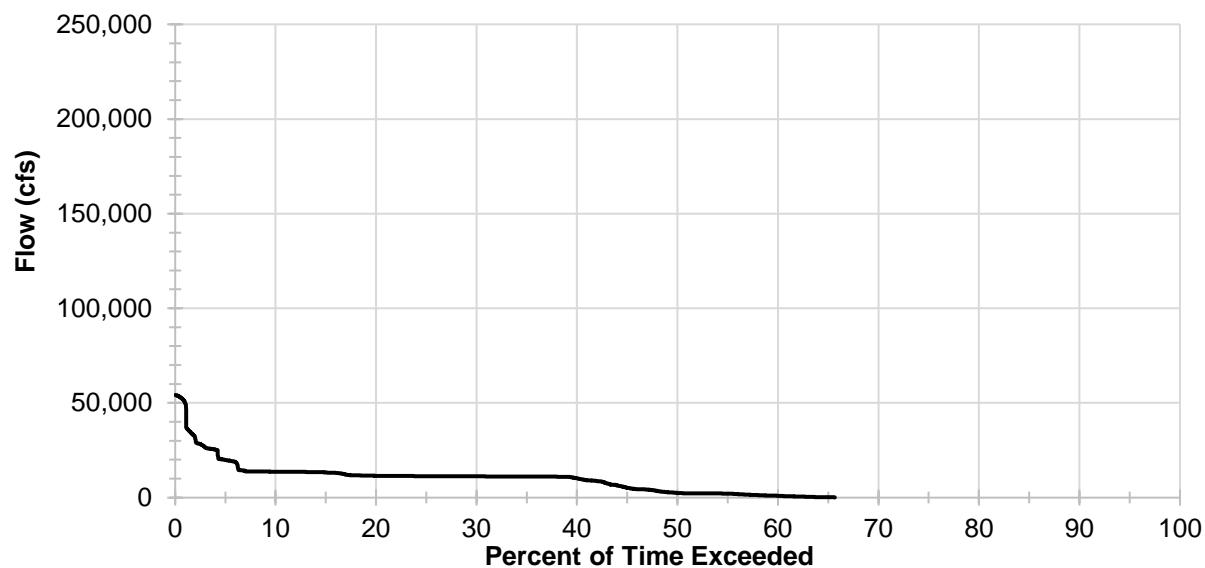


**APPENDIX B-8.2      Observed Total, Spillway, and Turbine Discharge Flow Duration Curves and Exceedance Tables for Current Operation**

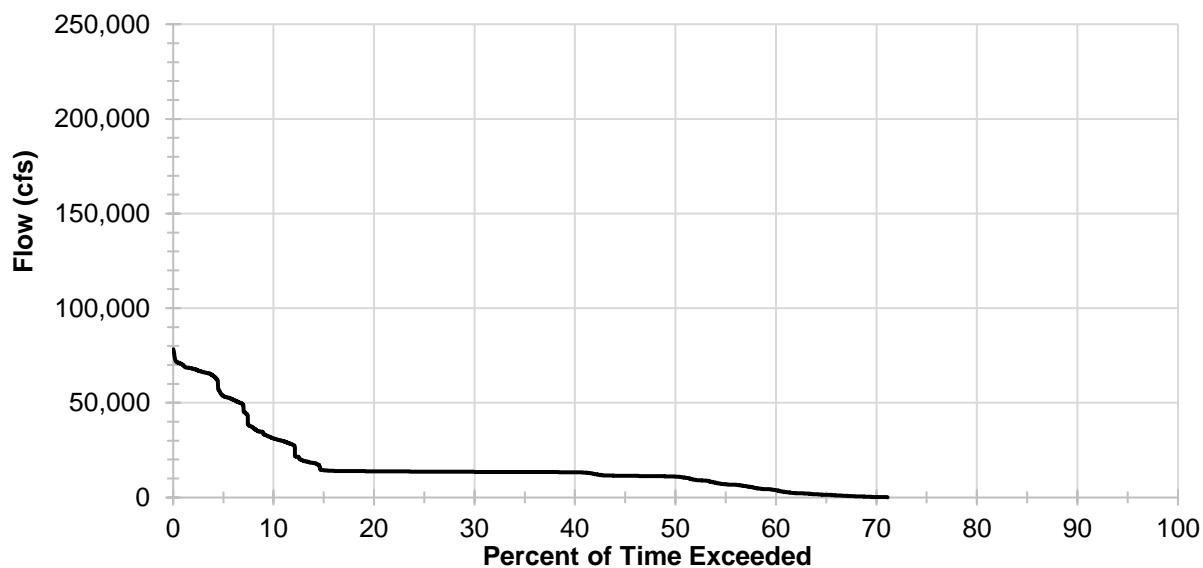
**January Flow Duration for Pensacola Dam**  
**Observed Total Discharge for Current Operation**  
**Period of Record Aug 14, 2015 - Dec 31, 2022**



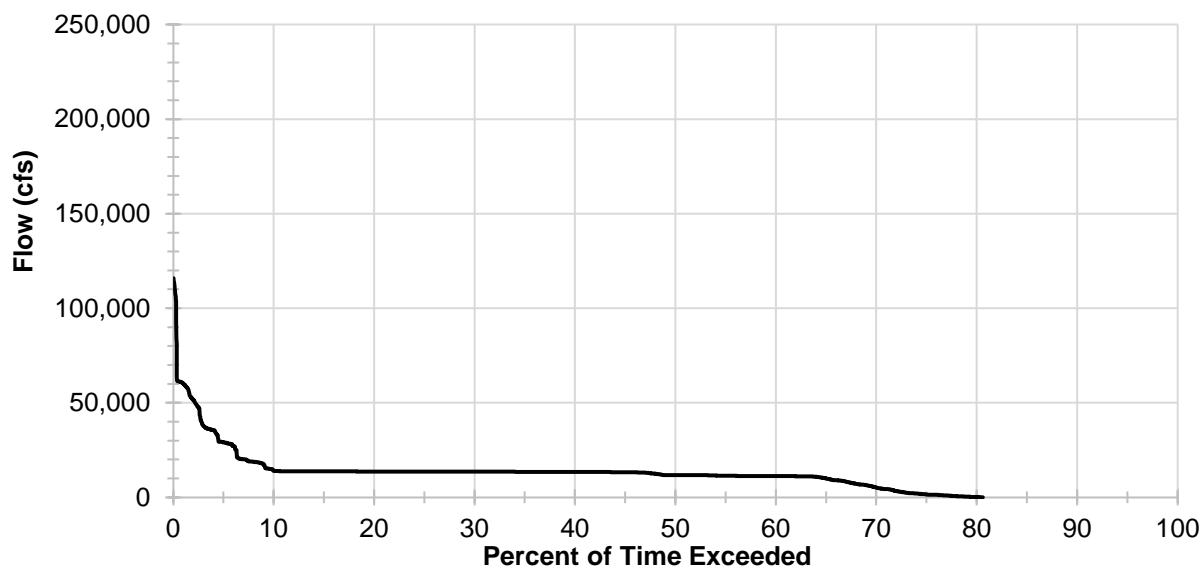
**February Flow Duration for Pensacola Dam**  
**Observed Total Discharge for Current Operation**  
**Period of Record Aug 14, 2015 - Dec 31, 2022**



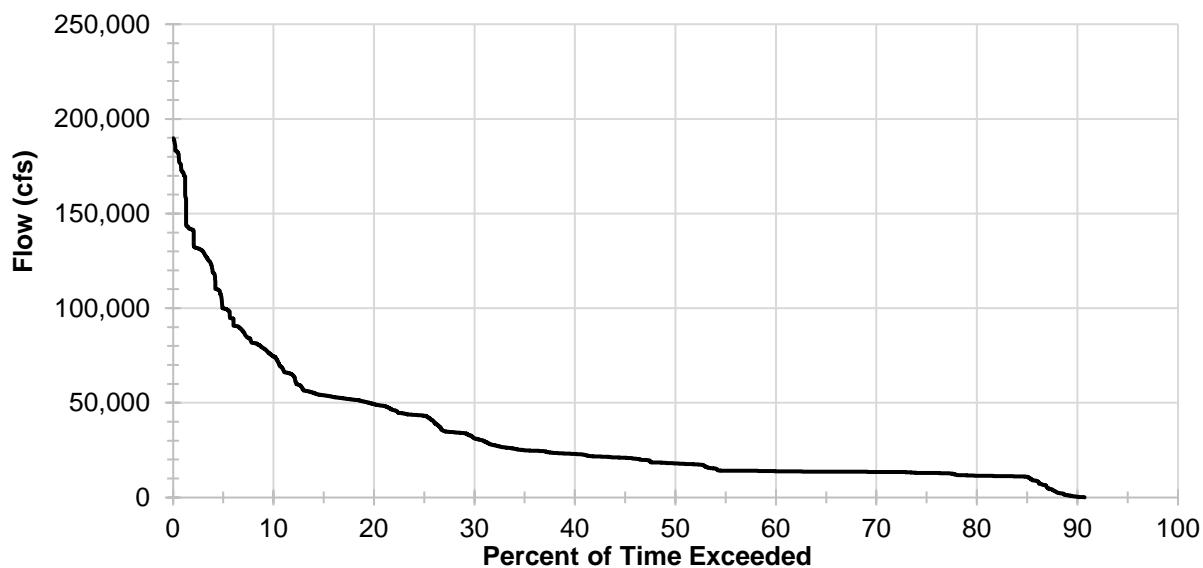
**March Flow Duration for Pensacola Dam**  
**Observed Total Discharge for Current Operation**  
**Period of Record Aug 14, 2015 - Dec 31, 2022**



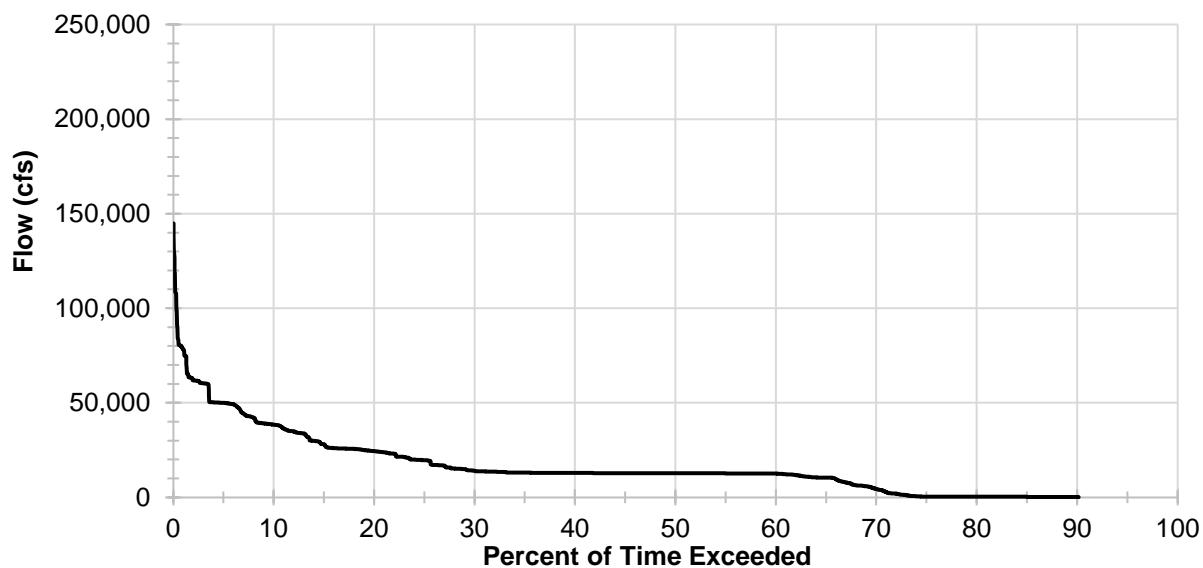
**April Flow Duration for Pensacola Dam**  
**Observed Total Discharge for Current Operation**  
**Period of Record Aug 14, 2015 - Dec 31, 2022**



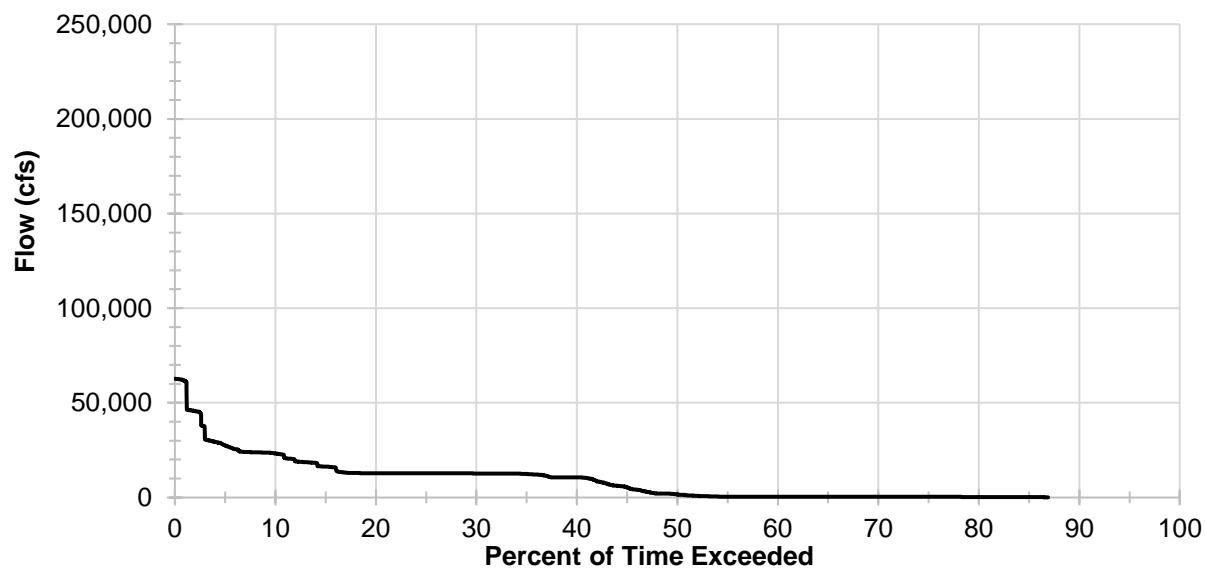
**May Flow Duration for Pensacola Dam**  
**Observed Total Discharge for Current Operation**  
**Period of Record Aug 14, 2015 - Dec 31, 2022**



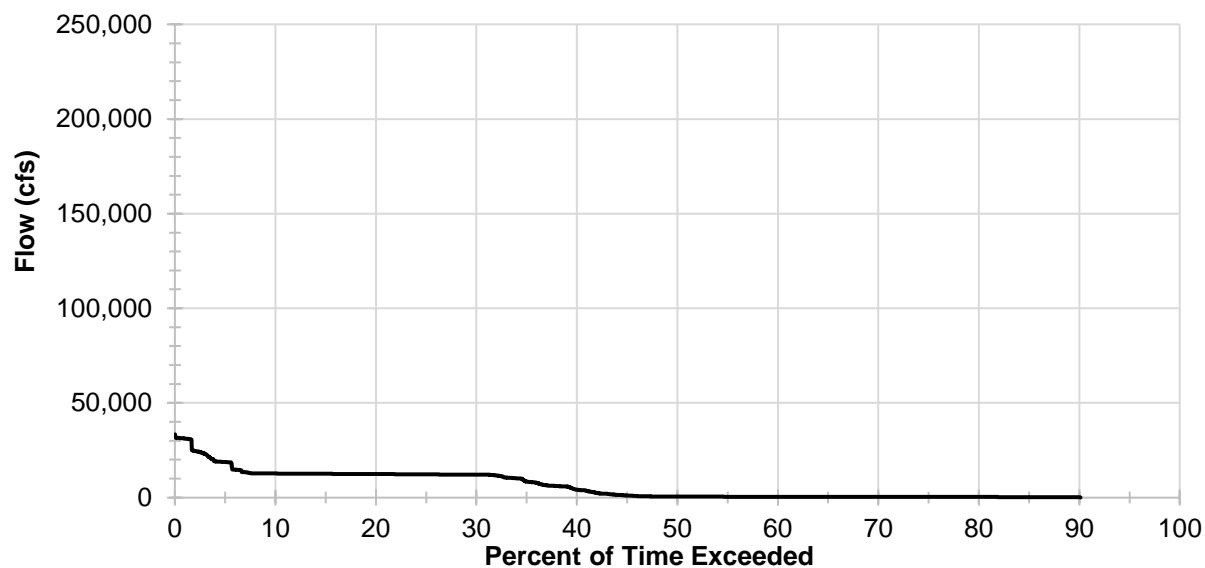
**June Flow Duration for Pensacola Dam**  
**Observed Total Discharge for Current Operation**  
**Period of Record Aug 14, 2015 - Dec 31, 2022**



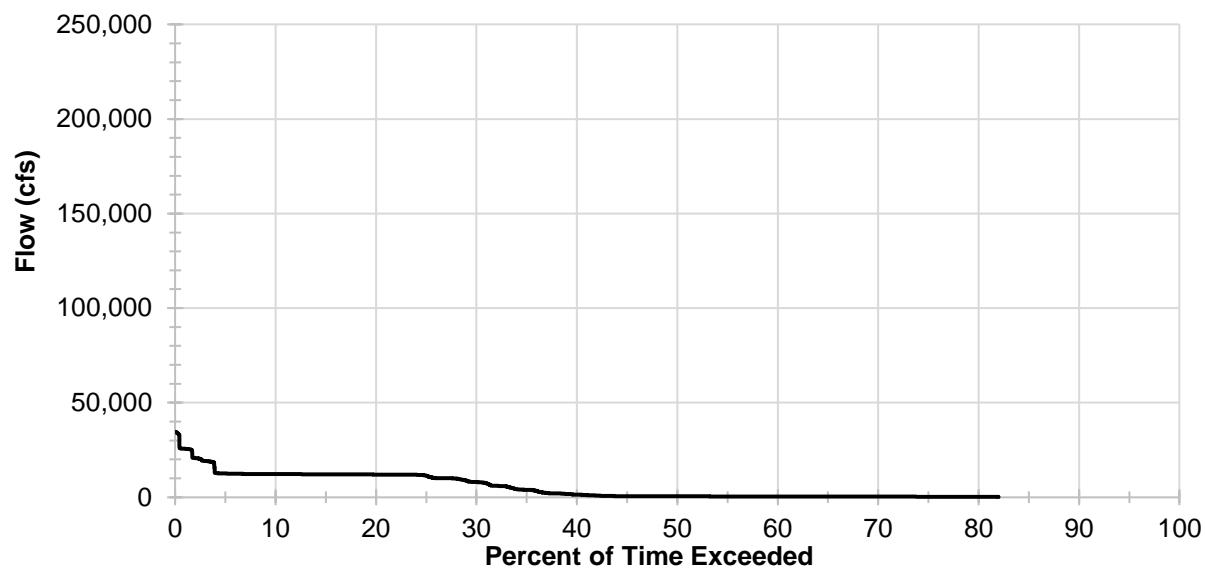
**July Flow Duration for Pensacola Dam**  
**Observed Total Discharge for Current Operation**  
**Period of Record Aug 14, 2015 - Dec 31, 2022**



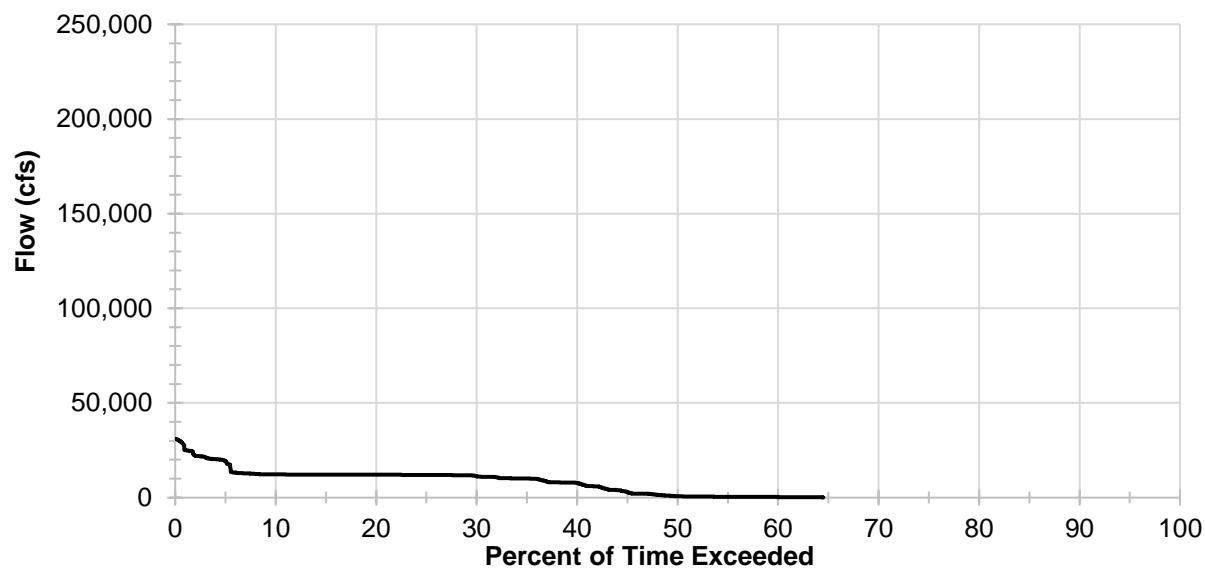
**August Flow Duration for Pensacola Dam**  
**Observed Total Discharge for Current Operation**  
**Period of Record Aug 14, 2015 - Dec 31, 2022**



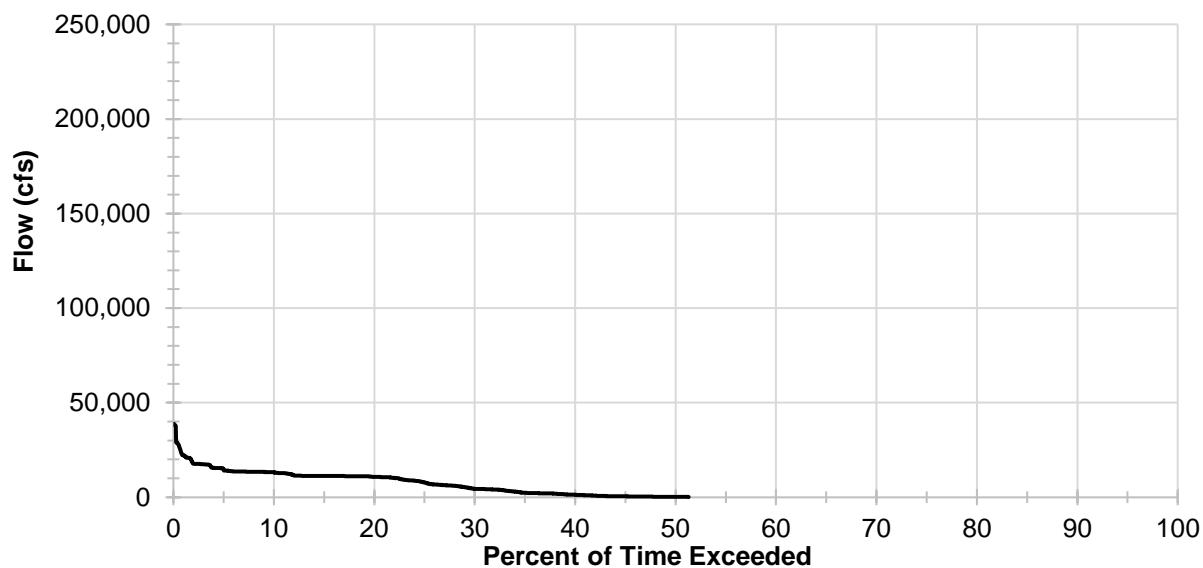
**September Flow Duration for Pensacola Dam**  
**Observed Total Discharge for Current Operation**  
**Period of Record Aug 14, 2015 - Dec 31, 2022**



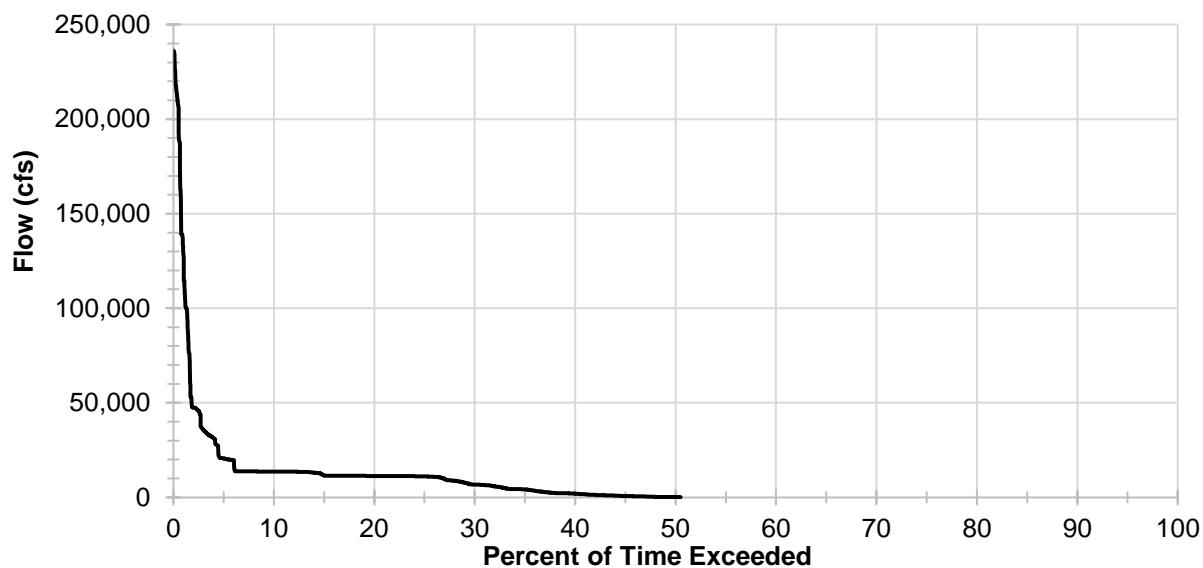
**October Flow Duration for Pensacola Dam**  
**Observed Total Discharge for Current Operation**  
**Period of Record Aug 14, 2015 - Dec 31, 2022**



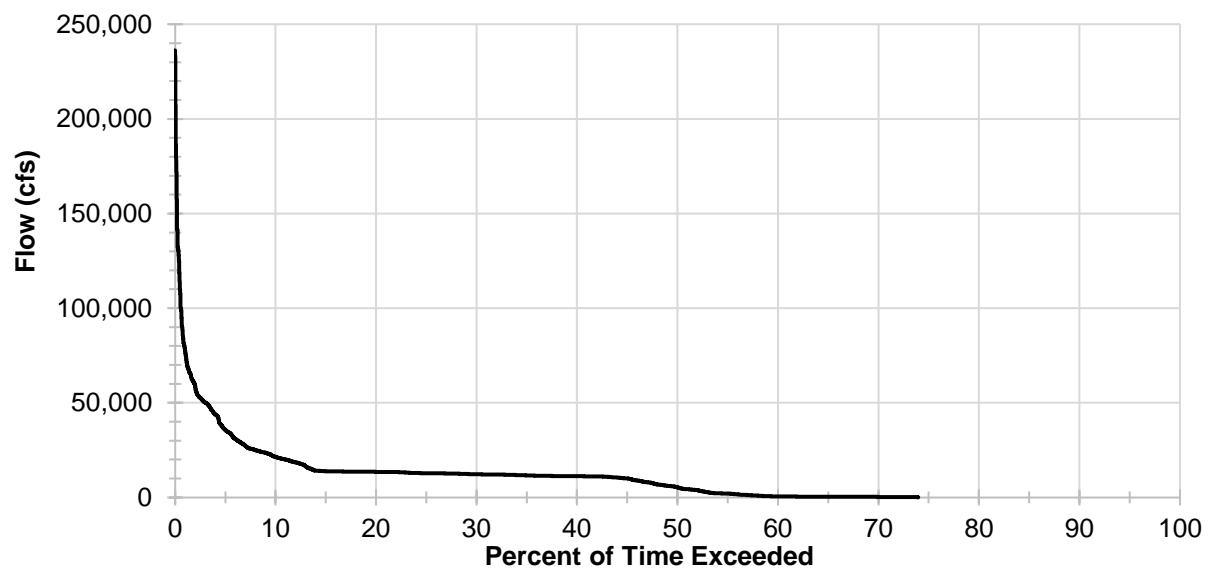
**November Flow Duration for Pensacola Dam**  
**Observed Total Discharge for Current Operation**  
**Period of Record Aug 14, 2015 - Dec 31, 2022**



**December Flow Duration for Pensacola Dam**  
**Observed Total Discharge for Current Operation**  
**Period of Record Aug 14, 2015 - Dec 31, 2022**



**Annual Flow Duration for Pensacola Dam  
Observed Total Discharge for Current Operation  
Period of Record Aug 14, 2015 - Dec 31, 2022**

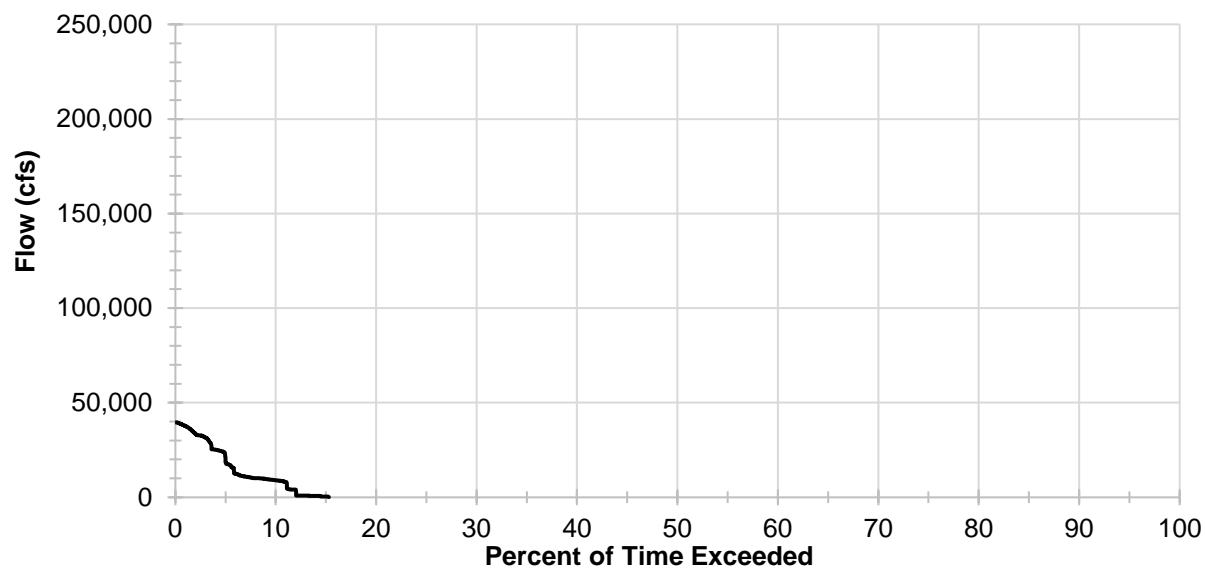


**Flow Duration for Pensacola Dam Observed Total Discharge for Current Operation (Period of Record Aug 14, 2015 - Dec 31, 2022)**

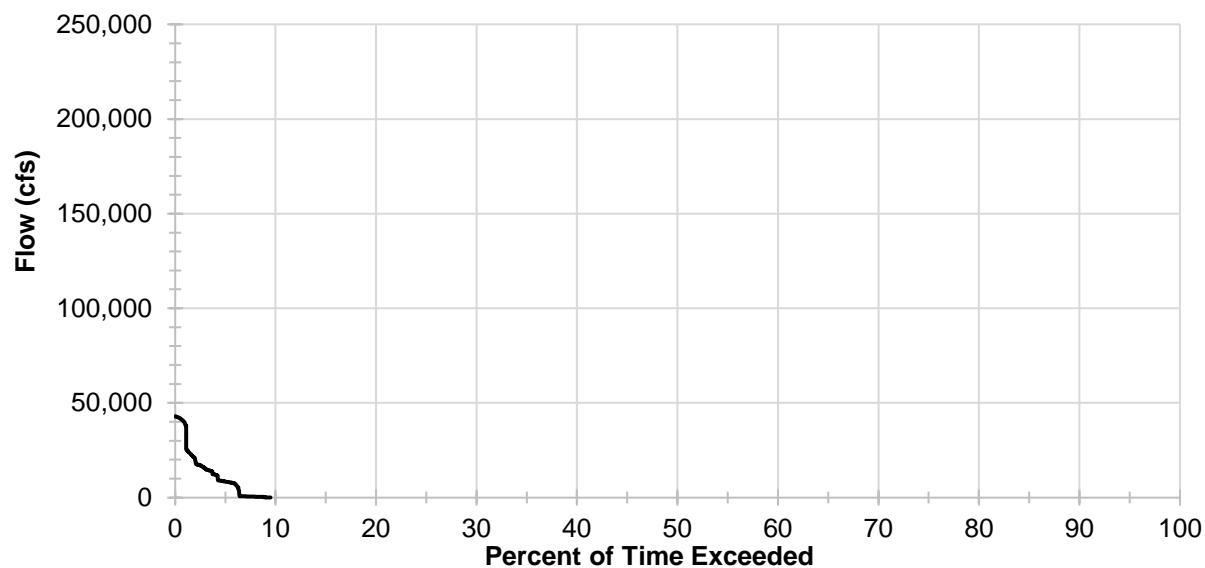
Percent of Time	January	February	March	April	May	June	July	August	September	October	November	December	Annual
95	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	322	107	0	107	0	0	0	0	0
85	0	0	0	0	10,895	317	213	216	0	0	0	0	0
80	0	0	0	109	11,464	321	214	321	109	0	0	0	0
75	0	0	0	1,536	12,941	429	320	323	217	0	0	0	0
70	0	0	217	5,239	13,463	4,407	321	324	323	0	0	0	219
65	1,006	109	1,324	9,943	13,616	10,436	321	324	324	0	0	0	325
60	4,076	878	3,851	11,247	13,814	12,519	427	326	325	221	0	0	512
55	10,067	2,072	6,939	11,341	14,117	12,670	429	431	327	327	0	0	1,971
50	11,054	2,402	11,000	11,701	17,936	12,727	1,535	433	433	756	109	109	5,308
45	11,131	5,125	11,411	13,281	20,923	12,761	5,223	1,085	540	2,961	433	670	10,029
40	11,214	10,172	13,264	13,421	22,941	12,903	10,556	4,146	1,403	7,680	1,302	1,904	11,205
35	11,280	11,091	13,403	13,498	24,896	13,029	12,381	8,409	3,934	10,035	2,304	4,183	11,645
30	11,344	11,180	13,507	13,540	31,189	14,134	12,661	12,095	8,016	11,232	4,438	6,696	12,215
25	11,545	11,307	13,623	13,598	43,144	19,625	12,748	12,202	11,390	11,940	7,783	11,053	12,773
20	11,693	11,474	13,788	13,648	49,298	24,424	12,800	12,398	11,991	12,039	10,777	11,288	13,507
15	13,697	13,270	14,303	13,704	53,958	27,970	16,262	12,529	12,108	12,089	11,237	11,593	13,817
10	22,349	13,649	31,200	14,022	74,495	38,423	23,206	12,679	12,228	12,193	13,166	13,598	21,457
5	32,465	19,834	53,608	29,093	99,913	49,966	27,502	18,766	12,567	19,173	14,167	20,578	35,669

**Observed Spillway Discharge Flow Duration Curves and Exceedance Table for Current Operation**

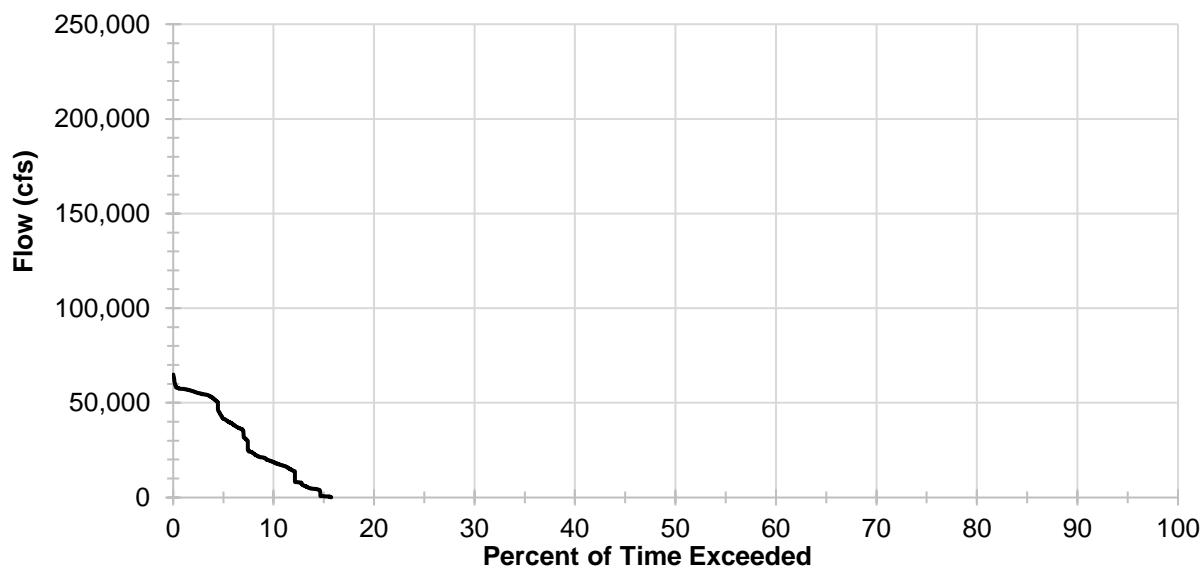
**January Flow Duration for Pensacola Dam  
Observed Spillway Discharge for Current Operation  
Period of Record Aug 14, 2015 - Dec 31, 2022**



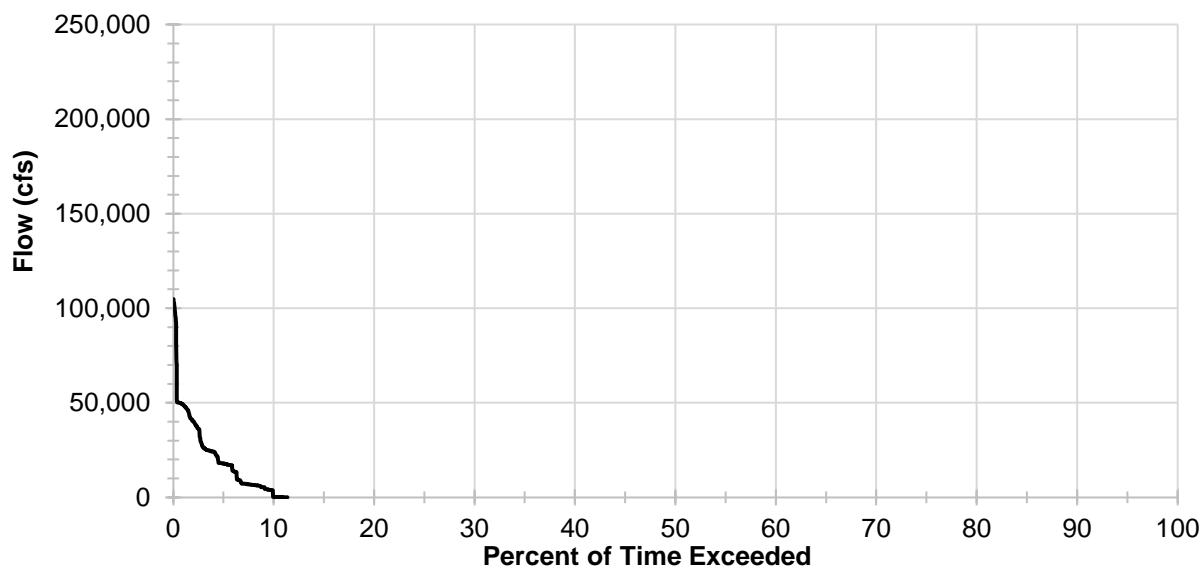
**February Flow Duration for Pensacola Dam  
Observed Spillway Discharge for Current Operation  
Period of Record Aug 14, 2015 - Dec 31, 2022**



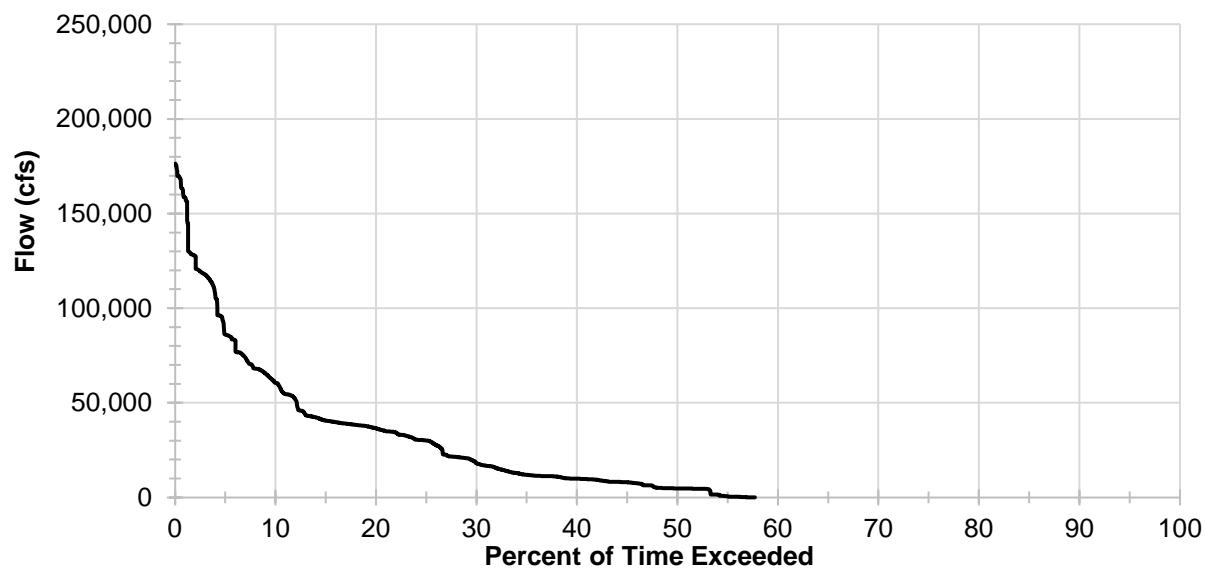
**March Flow Duration for Pensacola Dam  
Observed Spillway Discharge for Current Operation  
Period of Record Aug 14, 2015 - Dec 31, 2022**



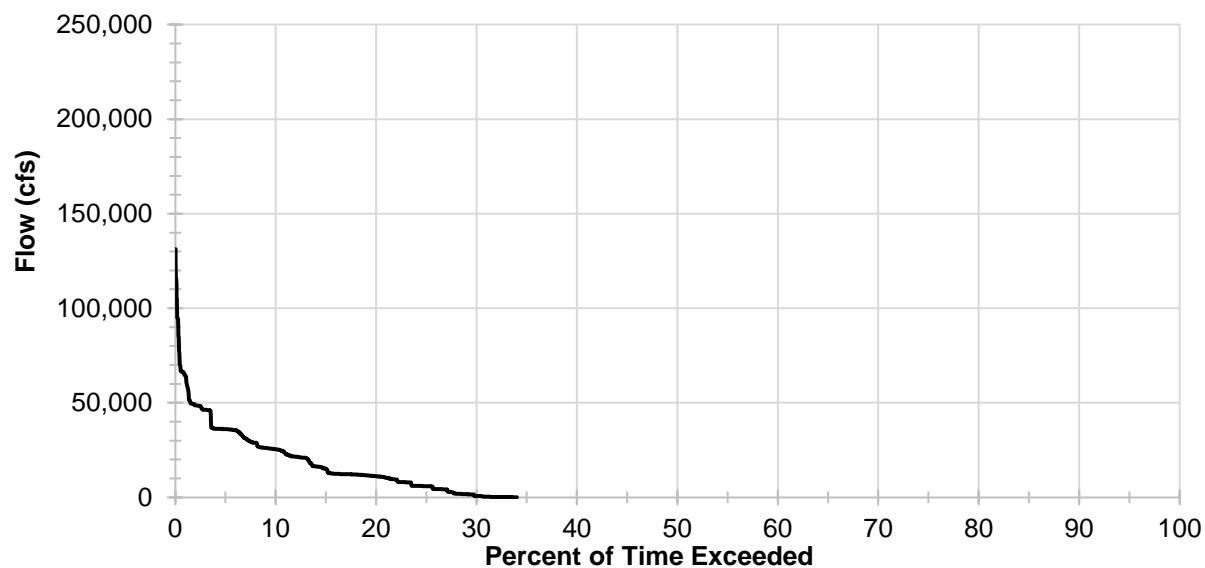
**April Flow Duration for Pensacola Dam  
Observed Spillway Discharge Current Operation  
Period of Record Aug 14, 2015 - Dec 31, 2022**



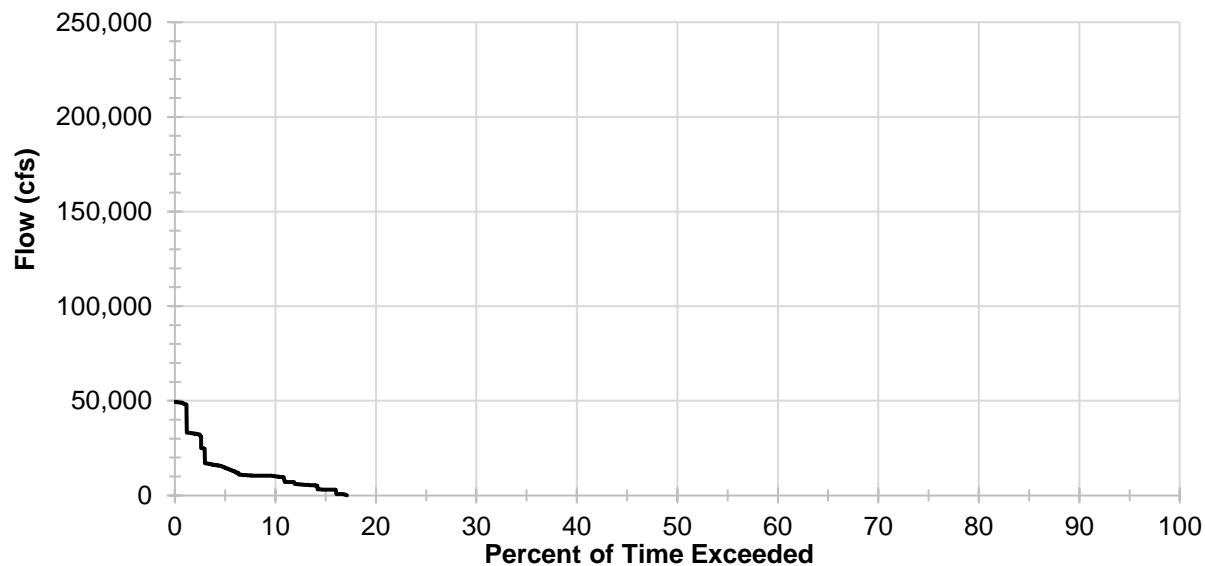
**May Flow Duration for Pensacola Dam**  
**Observed Spillway Discharge for Current Operation**  
**Period of Record Aug 14, 2015 - Dec 31, 2022**



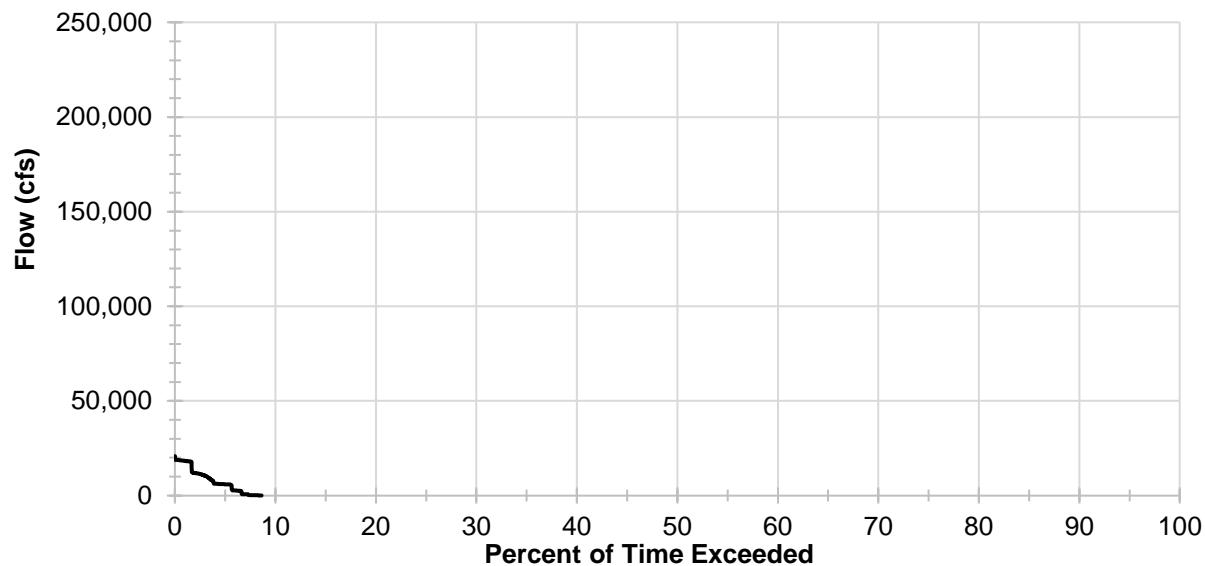
**June Flow Duration for Pensacola Dam**  
**Observed Spillway Discharge for Current Operation**  
**Period of Record Aug 14, 2015 - Dec 31, 2022**



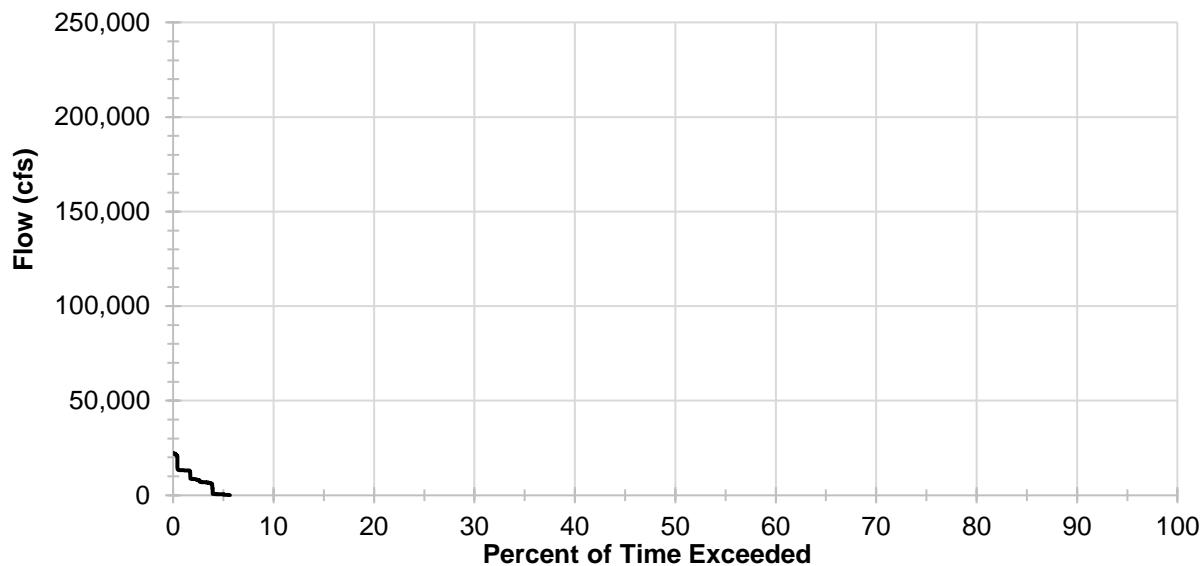
**July Flow Duration for Pensacola Dam**  
**Observed Spillway Discharge for Current Operation**  
**Period of Record Aug 14, 2015 - Dec 31, 2022**



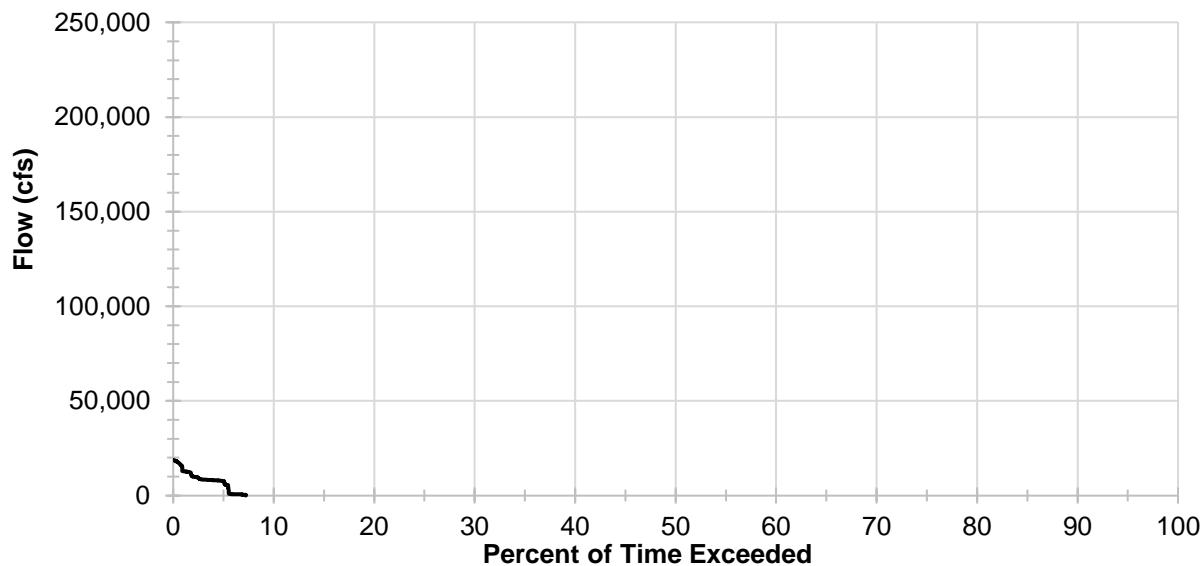
**August Flow Duration for Pensacola Dam**  
**Observed Spillway Discharge for Current Operation**  
**Period of Record Aug 14, 2015 - Dec 31, 2022**



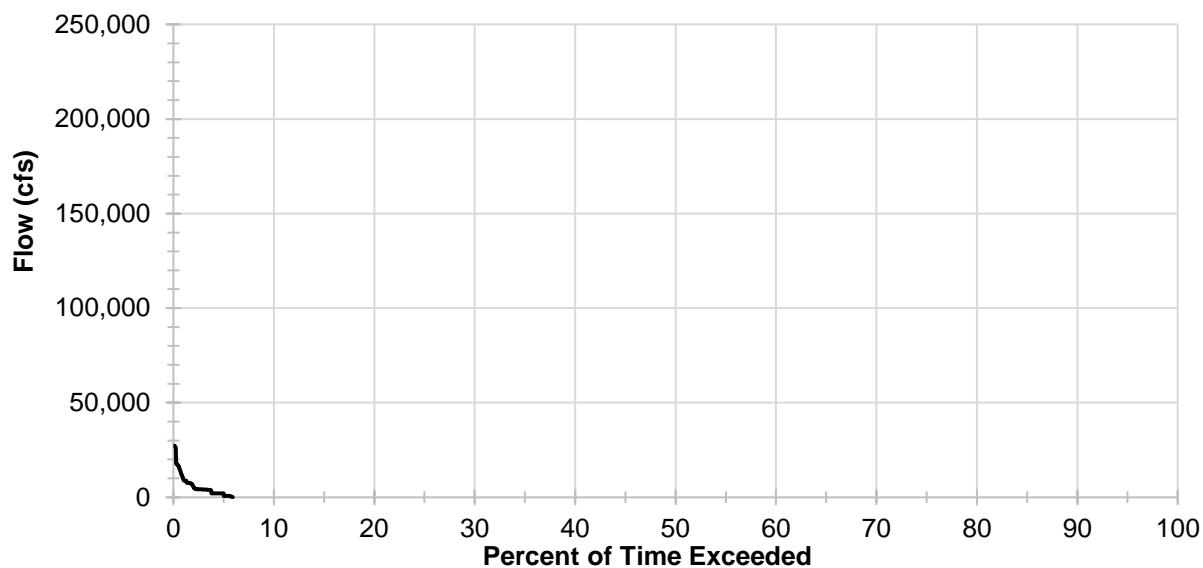
**September Flow Duration for Pensacola Dam  
Observed Spillway Discharge for Current Operation  
Period of Record Aug 14, 2015 - Dec 31, 2022**



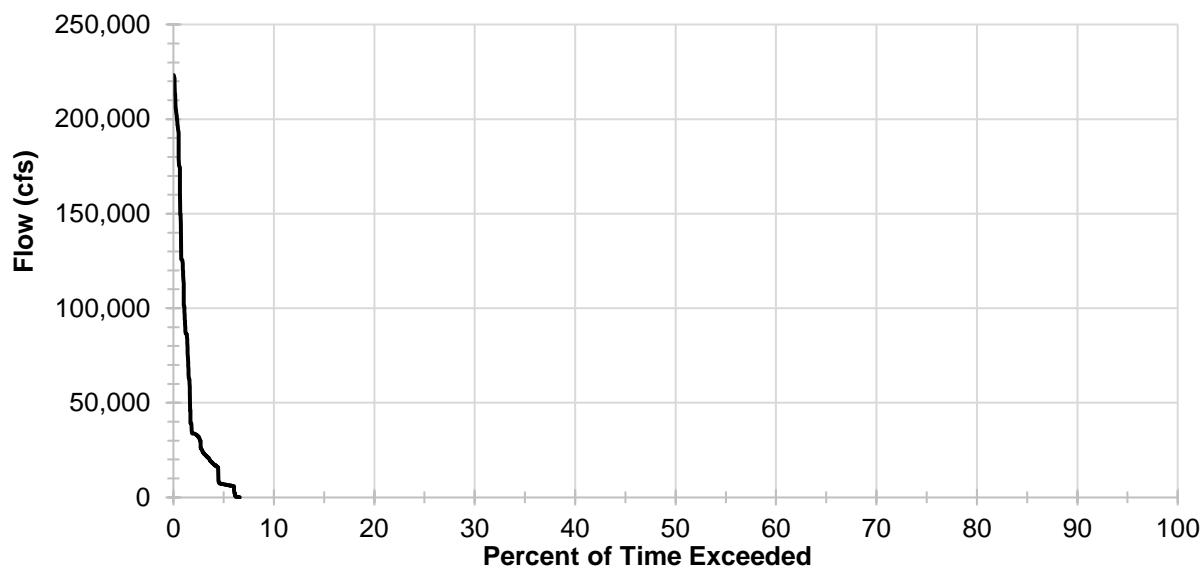
**October Flow Duration for Pensacola Dam  
Observed Spillway Discharge for Current Operation  
Period of Record Aug 14, 2015 - Dec 31, 2022**



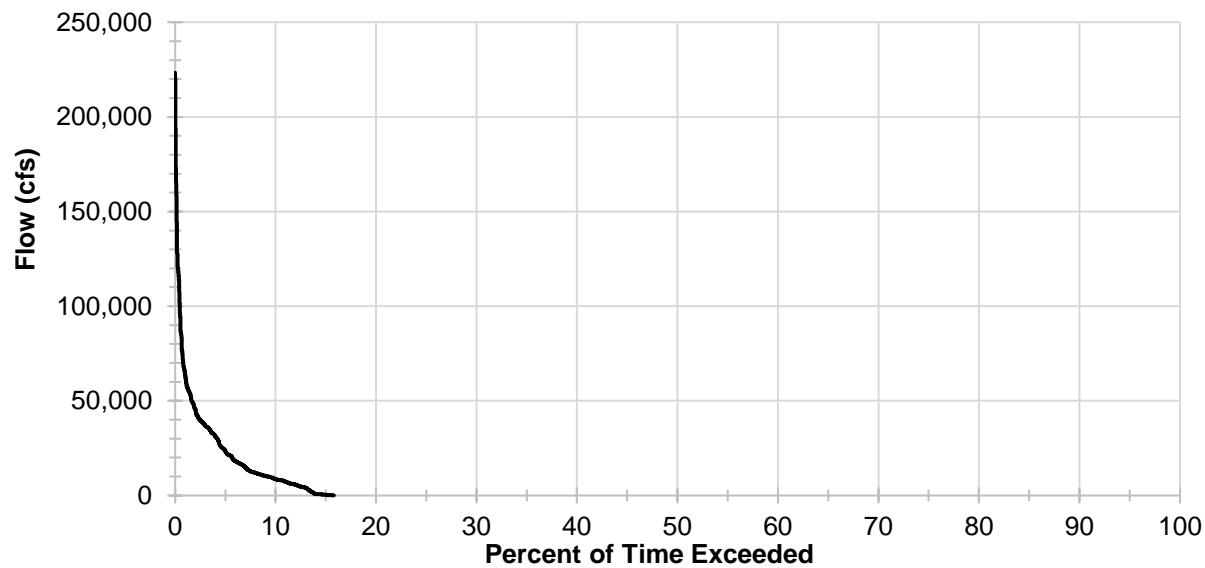
**November Flow Duration for Pensacola Dam  
Observed Spillway Discharge for Current Operation  
Period of Record Aug 14, 2015 - Dec 31, 2022**



**December Flow Duration for Pensacola Dam  
Observed Spillway Discharge for Current Operation  
Period of Record Aug 14, 2015 - Dec 31, 2022**



**Annual Flow Duration for Pensacola Dam  
Observed Spillway Discharge for Current Operation  
Period of Record Aug 14, 2015 - Dec 31, 2022**

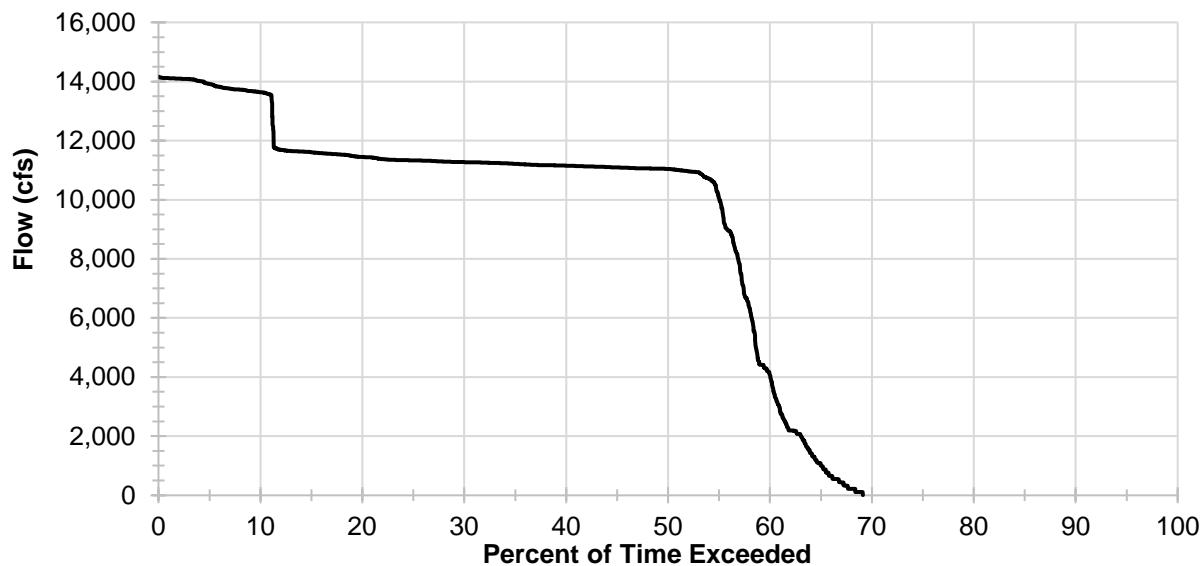


**Flow Duration for Pensacola Dam Observed Spillway Discharge for Current Operation (Period of Record Aug 14, 2015 - Dec 31, 2022)**

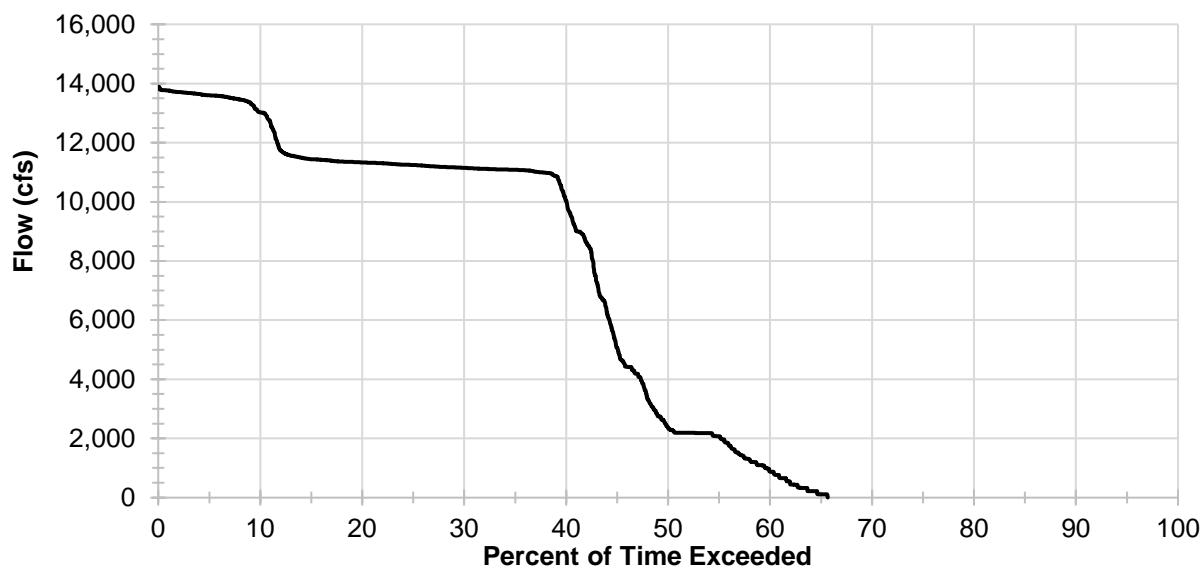
Percent of Time	January	February	March	April	May	June	July	August	September	October	November	December	Annual
95	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0	0
75	0	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0
55	0	0	0	0	560	0	0	0	0	0	0	0	0
50	0	0	0	0	4,730	0	0	0	0	0	0	0	0
45	0	0	0	0	7,984	0	0	0	0	0	0	0	0
40	0	0	0	0	9,906	0	0	0	0	0	0	0	0
35	0	0	0	0	11,940	0	0	0	0	0	0	0	0
30	0	0	0	0	18,130	634	0	0	0	0	0	0	0
25	0	0	0	0	30,108	5,896	0	0	0	0	0	0	0
20	0	0	0	0	36,480	11,160	0	0	0	0	0	0	0
15	320	0	600	0	40,600	15,120	2,993	0	0	0	0	0	313
10	8,959	0	18,640	181	60,550	25,428	10,105	0	0	0	0	0	8,616
5	21,109	8,471	41,670	17,881	86,047	36,084	14,652	5,940	499	7,537	1,305	6,896	23,381

**Observed Turbine Discharge Flow Duration Curves and Exceedance Table for Current Operation**

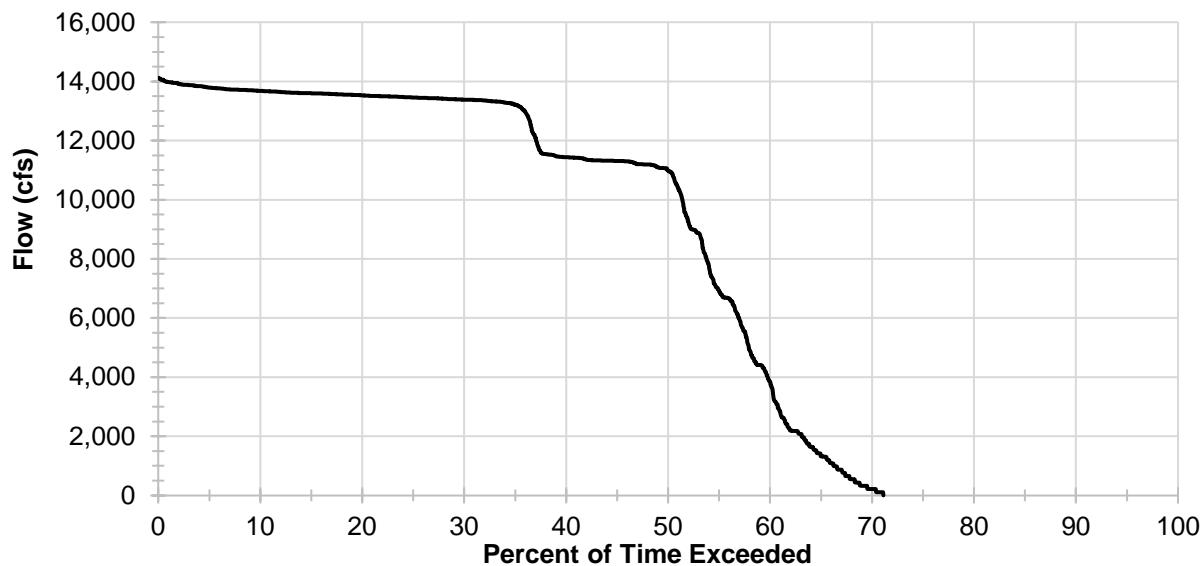
**January Flow Duration for Pensacola Dam  
Observed Turbine Discharge for Current Operation  
Period of Record Aug 14, 2015 - Dec 31, 2022**



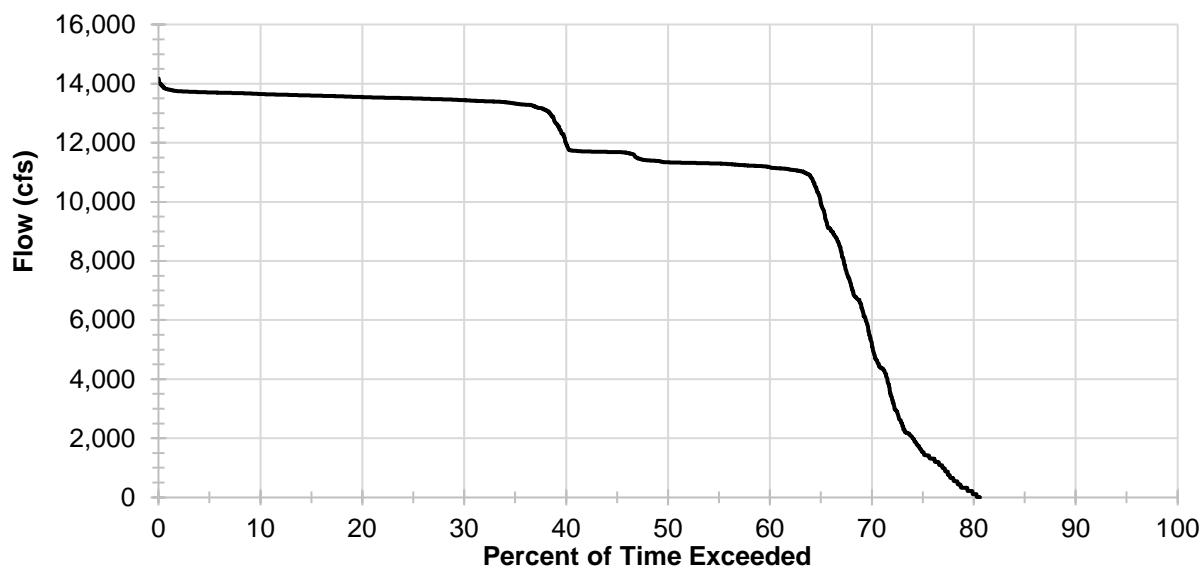
**February Flow Duration for Pensacola Dam  
Observed Turbine Discharge for Current Operation  
Period of Record Aug 14, 2015 - Dec 31, 2022**



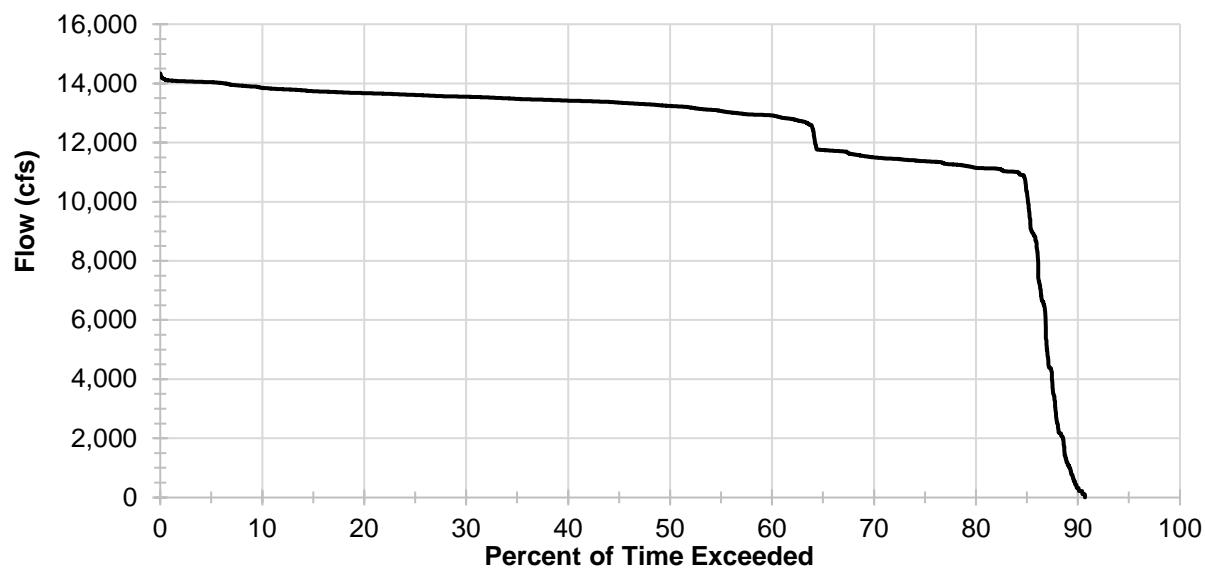
**March Flow Duration for Pensacola Dam  
Observed Turbine Discharge for Current Operation  
Period of Record Aug 14, 2015 - Dec 31, 2022**



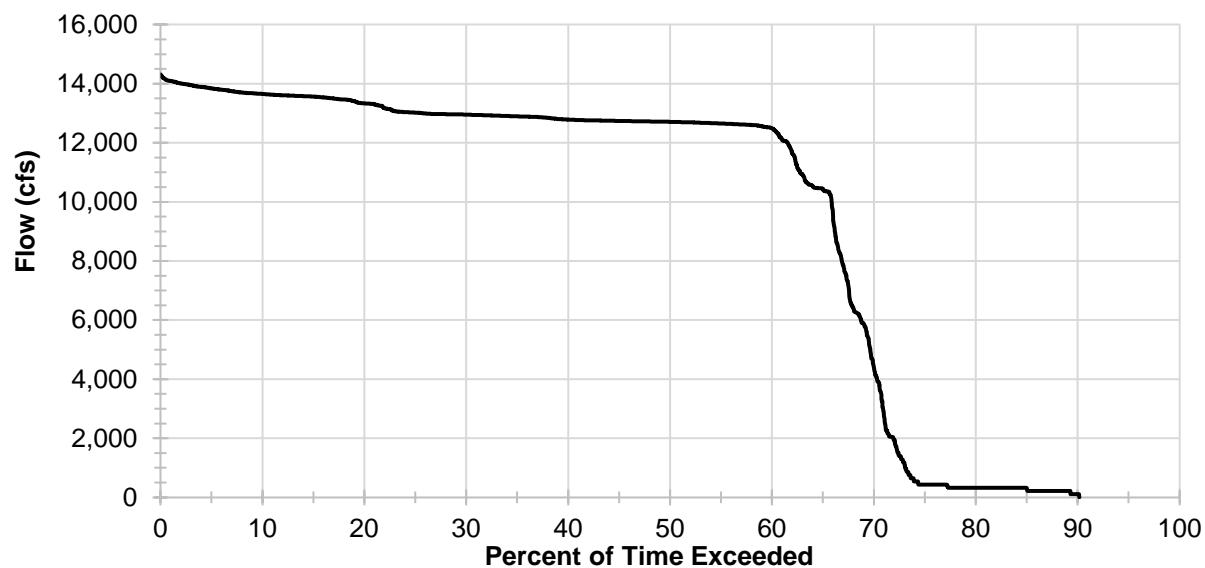
**April Flow Duration for Pensacola Dam  
Observed Turbine Discharge for Current Operation  
Period of Record Aug 14, 2015 - Dec 31, 2022**



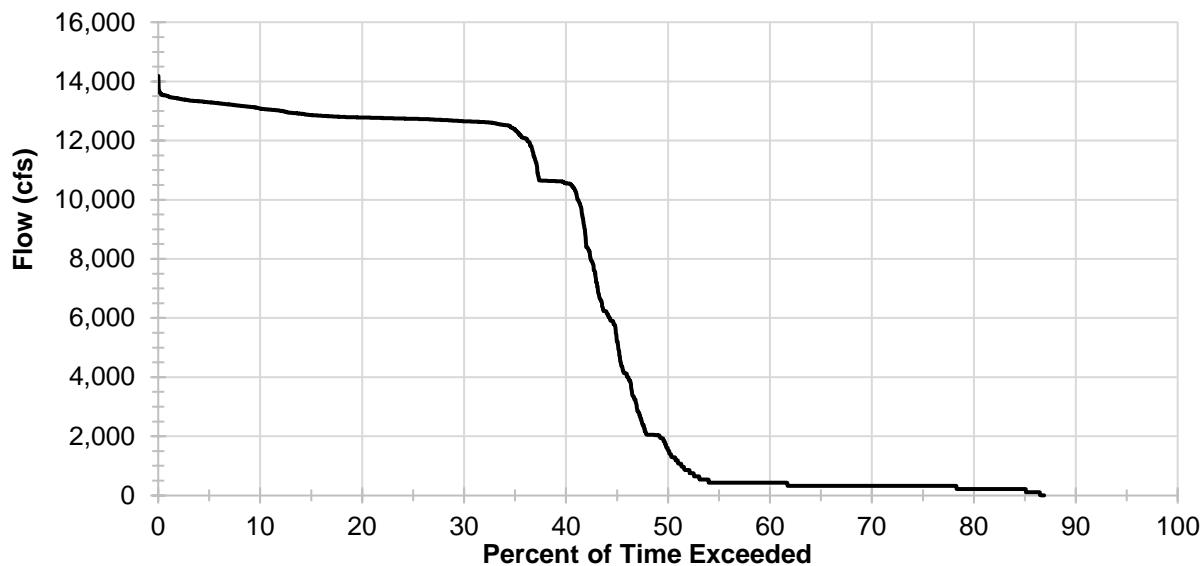
**May Flow Duration for Pensacola Dam  
Observed Turbine Discharge for Current Operation  
Period of Record Aug 14, 2015 - Dec 31, 2022**



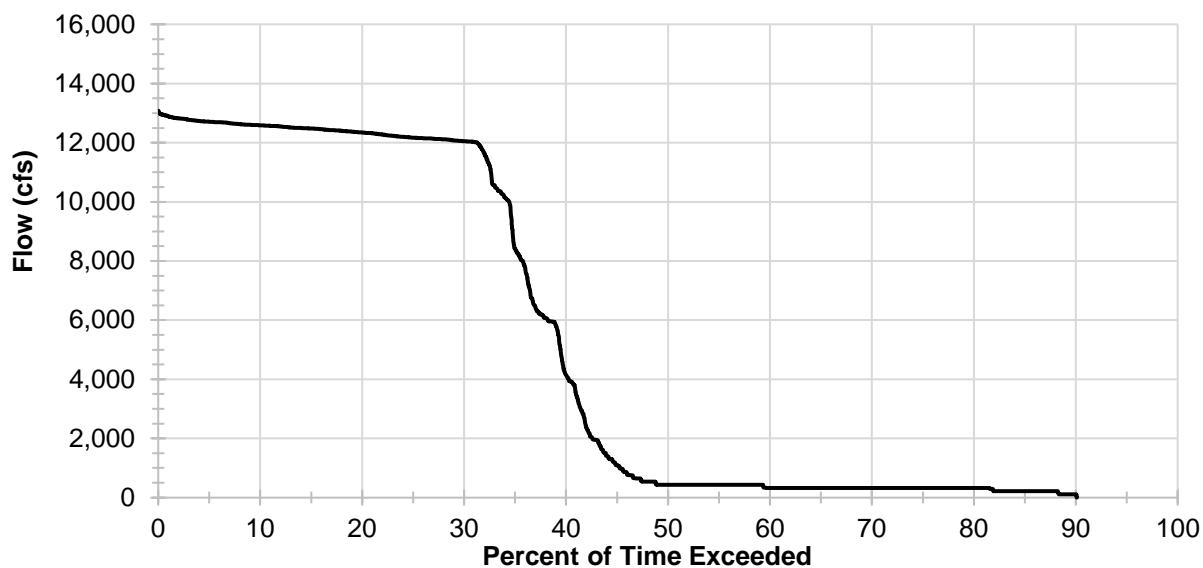
**June Flow Duration for Pensacola Dam  
Observed Turbine Discharge for Current Operation  
Period of Record Aug 14, 2015 - Dec 31, 2022**



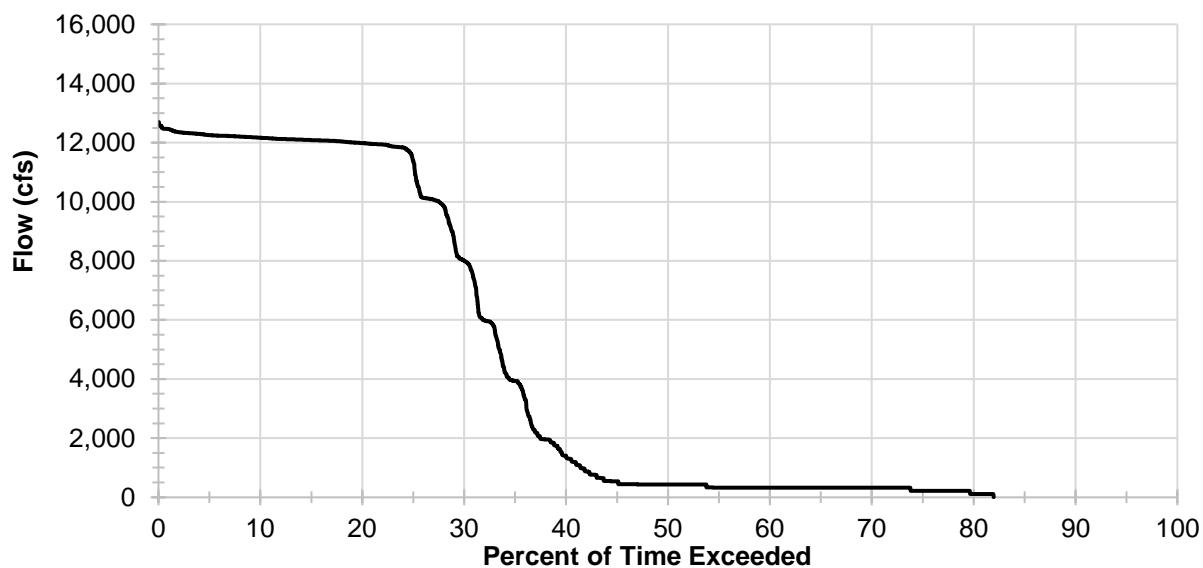
**July Flow Duration for Pensacola Dam  
Observed Turbine Discharge for Current Operation  
Period of Record Aug 14, 2015 - Dec 31, 2022**



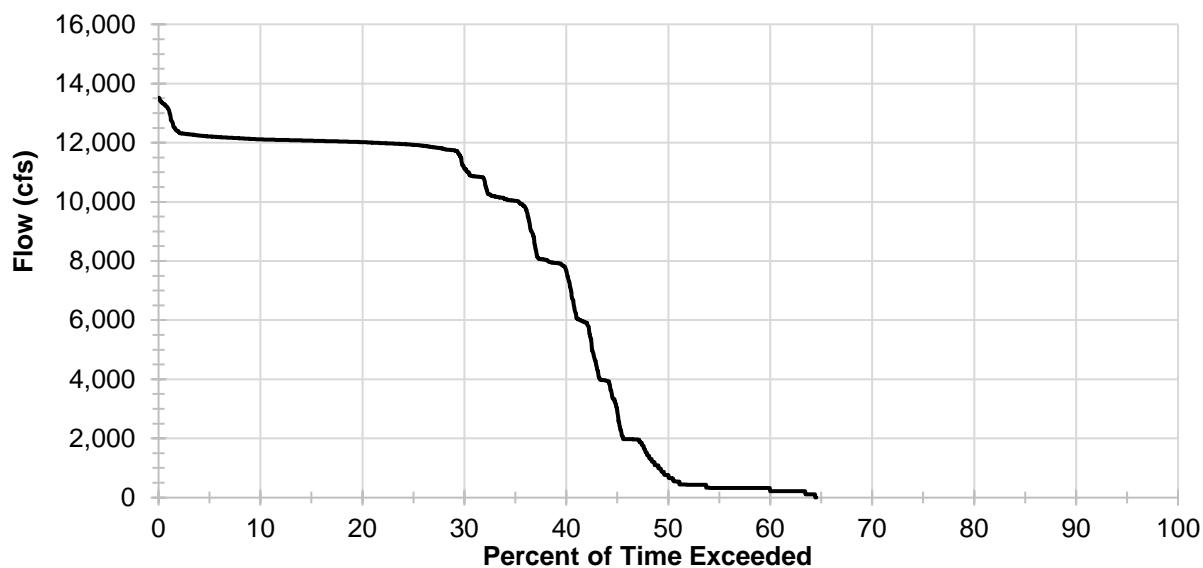
**August Flow Duration for Pensacola Dam  
Observed Turbine Discharge for Current Operation  
Period of Record Aug 14, 2015 - Dec 31, 2022**



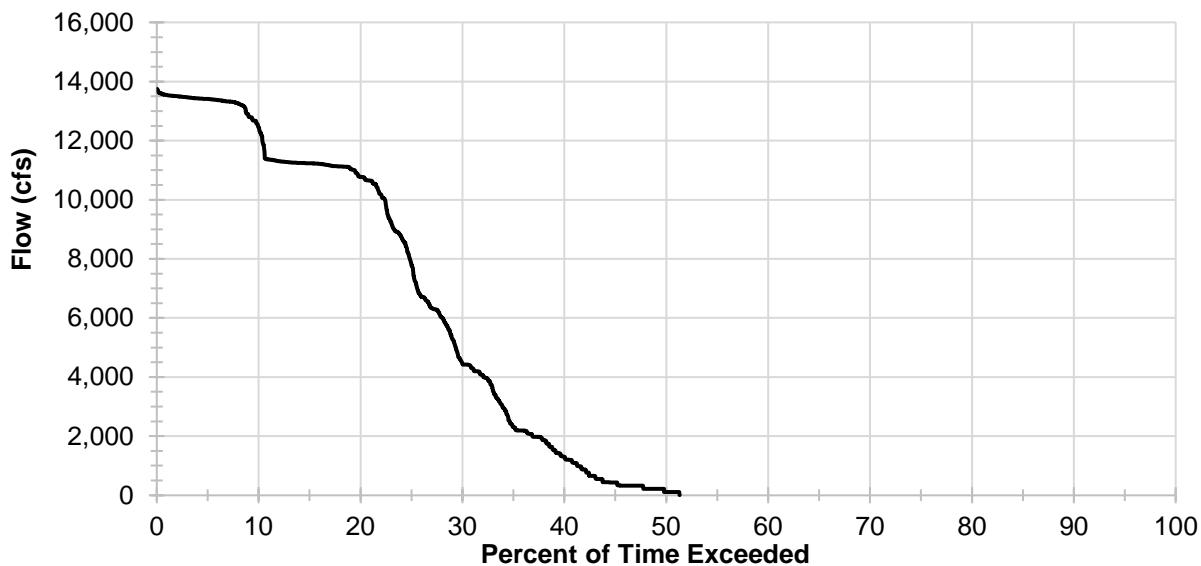
**September Flow Duration for Pensacola Dam  
Observed Turbine Discharge for Current Operation  
Period of Record Aug 14, 2015 - Dec 31, 2022**



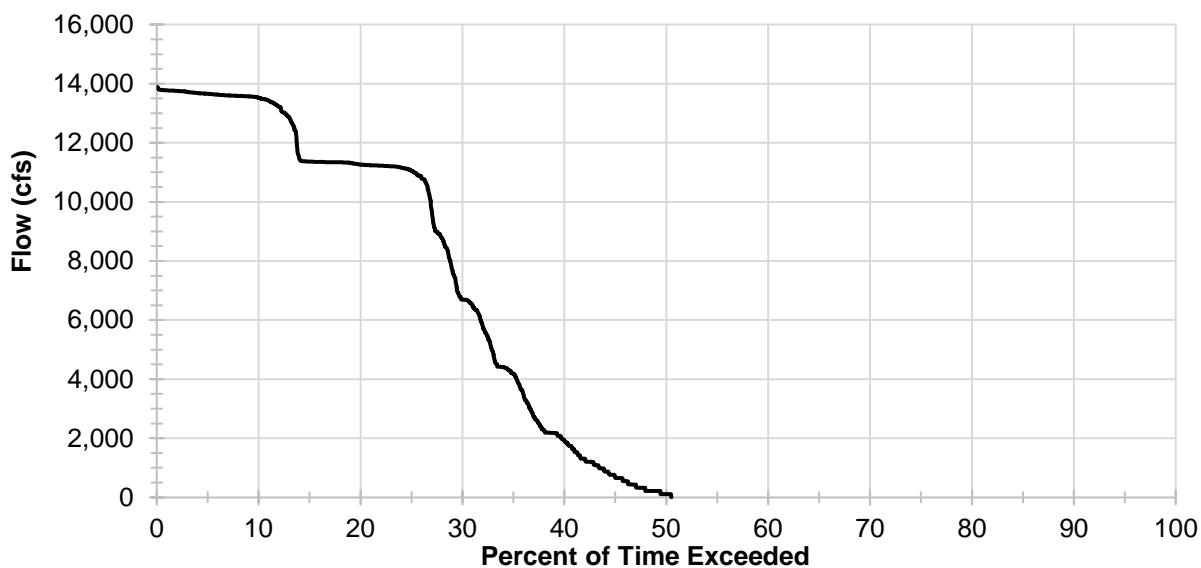
**October Flow Duration for Pensacola Dam  
Observed Turbine Discharge for Current Operation  
Period of Record Aug 14, 2015 - Dec 31, 2022**



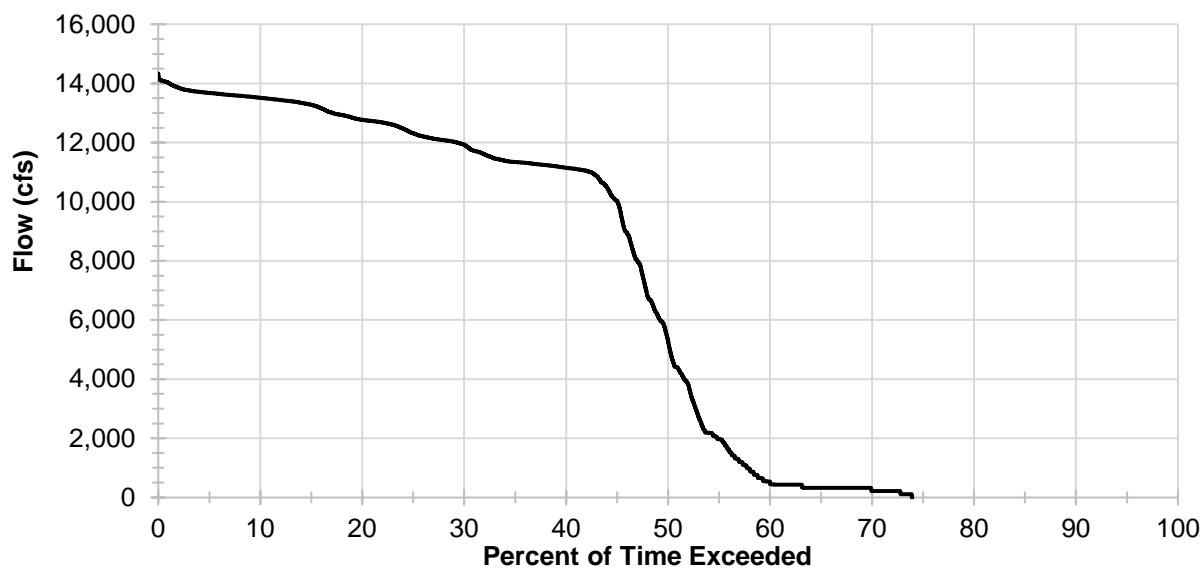
**November Flow Duration for Pensacola Dam  
Observed Turbine Discharge for Current Operation  
Period of Record Aug 14, 2015 - Dec 31, 2022**



**December Flow Duration for Pensacola Dam  
Observed Turbine Discharge for Current Operation  
Period of Record Aug 14, 2015 - Dec 31, 2022**



**Annual Flow Duration for Pensacola Dam  
Observed Turbine Discharge for Current Operation  
Period of Record Aug 14, 2015 - Dec 31, 2022**

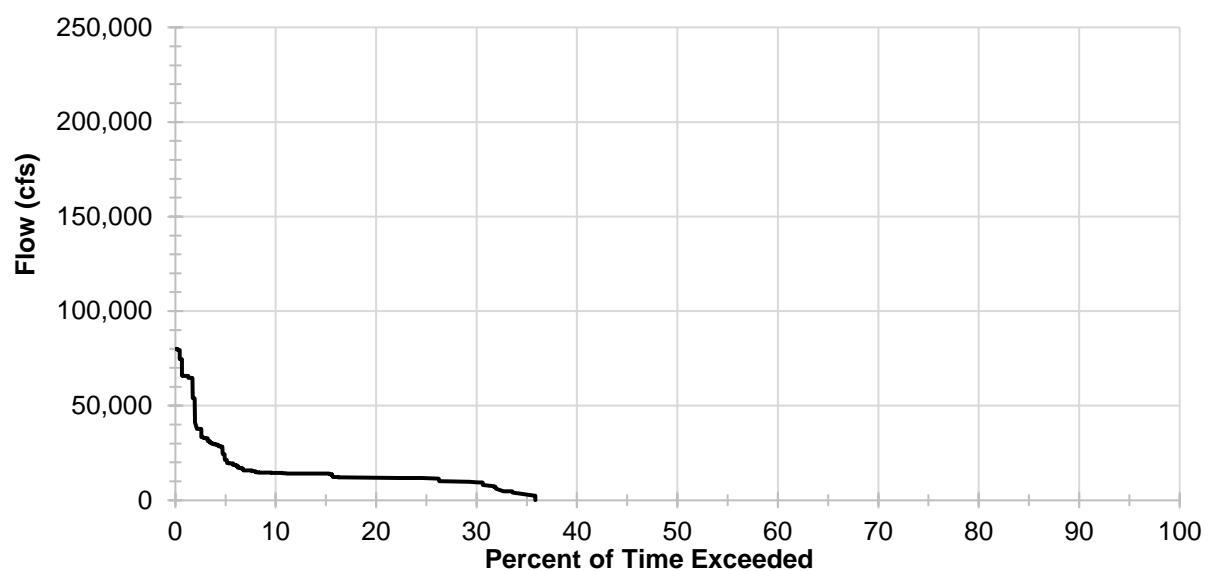


**Flow Duration for Pensacola Dam Observed Turbine Discharge for Current Operation (Period of Record Aug 14, 2015 - Dec 31, 2022)**

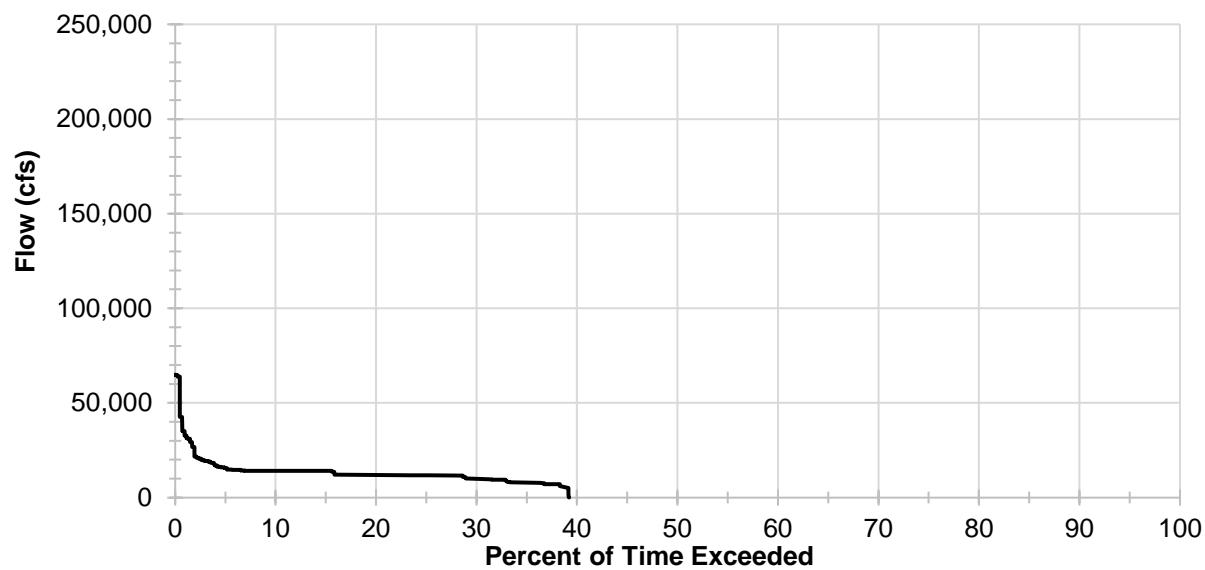
Percent of Time	January	February	March	April	May	June	July	August	September	October	November	December	Annual
95	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	322	107	0	107	0	0	0	0	0
85	0	0	0	0	10,340	317	213	216	0	0	0	0	0
80	0	0	0	109	11,146	321	214	321	109	0	0	0	0
75	0	0	0	1,536	11,371	429	320	323	217	0	0	0	0
70	0	0	217	5,239	11,500	4,407	321	324	323	0	0	0	219
65	1,006	109	1,324	9,943	11,748	10,436	321	324	324	0	0	0	325
60	4,076	878	3,851	11,172	12,919	12,487	427	326	325	221	0	0	511
55	10,067	2,071	6,939	11,296	13,073	12,652	429	431	327	327	0	0	1,971
50	11,043	2,354	10,986	11,340	13,239	12,709	1,535	433	433	756	109	109	5,288
45	11,093	5,073	11,313	11,686	13,350	12,741	5,223	1,085	540	2,961	433	670	10,021
40	11,154	10,045	11,440	11,975	13,419	12,785	10,556	4,146	1,403	7,680	1,302	1,904	11,146
35	11,215	11,083	13,214	13,327	13,479	12,895	12,381	8,409	3,934	10,035	2,304	4,183	11,343
30	11,273	11,152	13,386	13,442	13,551	12,954	12,655	12,053	8,016	11,113	4,438	6,696	11,930
25	11,333	11,246	13,458	13,502	13,611	13,020	12,737	12,171	11,390	11,929	7,783	11,053	12,315
20	11,447	11,336	13,530	13,547	13,674	13,334	12,782	12,346	11,986	12,020	10,777	11,262	12,770
15	11,605	11,442	13,601	13,600	13,739	13,564	12,861	12,482	12,088	12,069	11,234	11,363	13,279
10	13,640	13,027	13,681	13,650	13,851	13,653	13,084	12,589	12,167	12,112	12,445	13,524	13,516
5	13,920	13,604	13,792	13,705	14,043	13,841	13,294	12,709	12,254	12,213	13,411	13,656	13,680

**APPENDIX B-8.3 Modeled Total, Spillway, and Turbine Discharge Flow Duration Curves and Exceedance Tables for Current Operation**

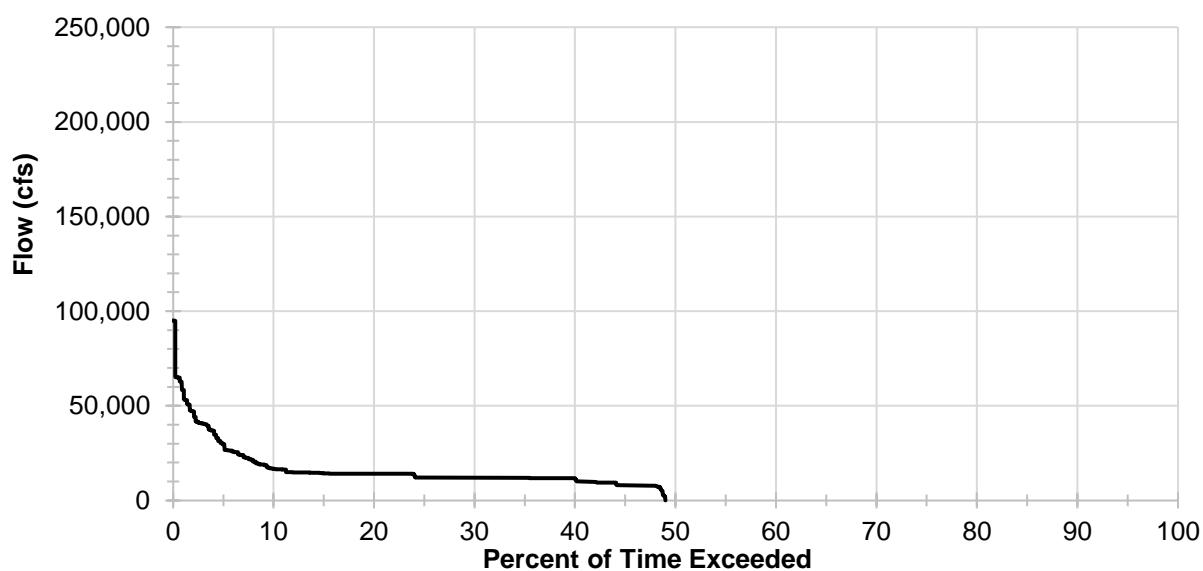
**January Flow Duration for Pensacola Dam  
Modeled Total Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



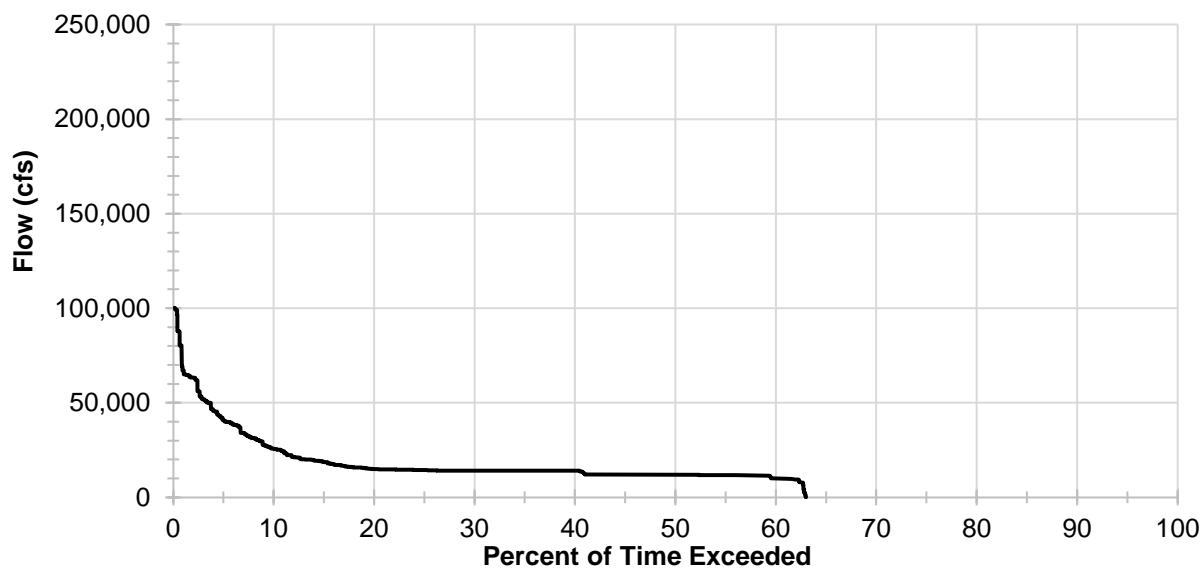
**February Flow Duration for Pensacola Dam  
Modeled Total Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



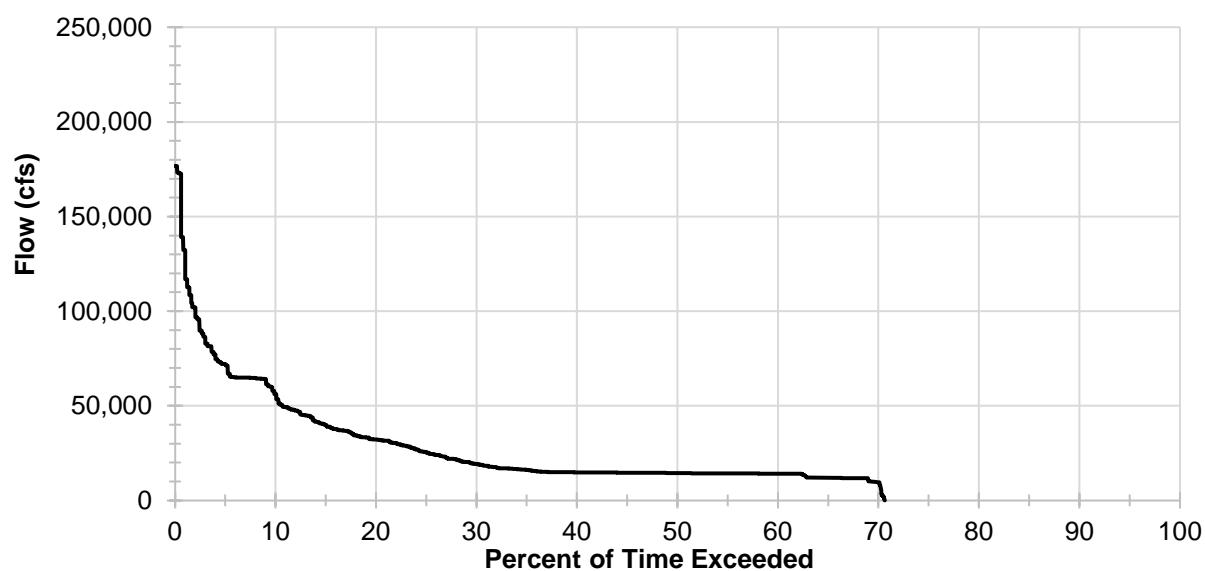
**March Flow Duration for Pensacola Dam  
Modeled Total Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



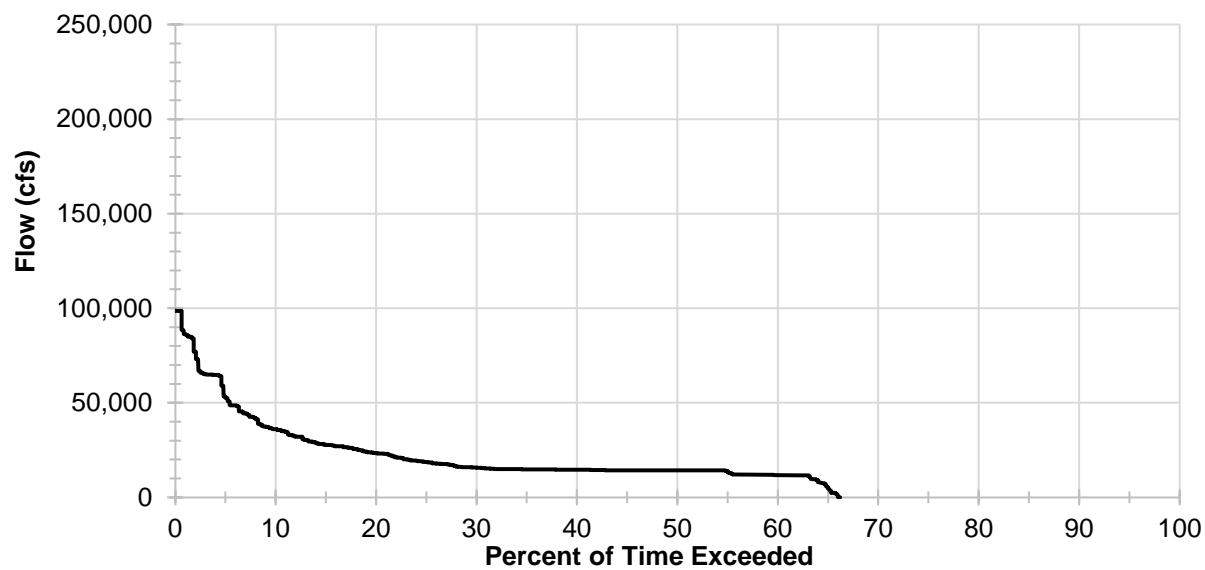
**April Flow Duration for Pensacola Dam  
Modeled Total Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



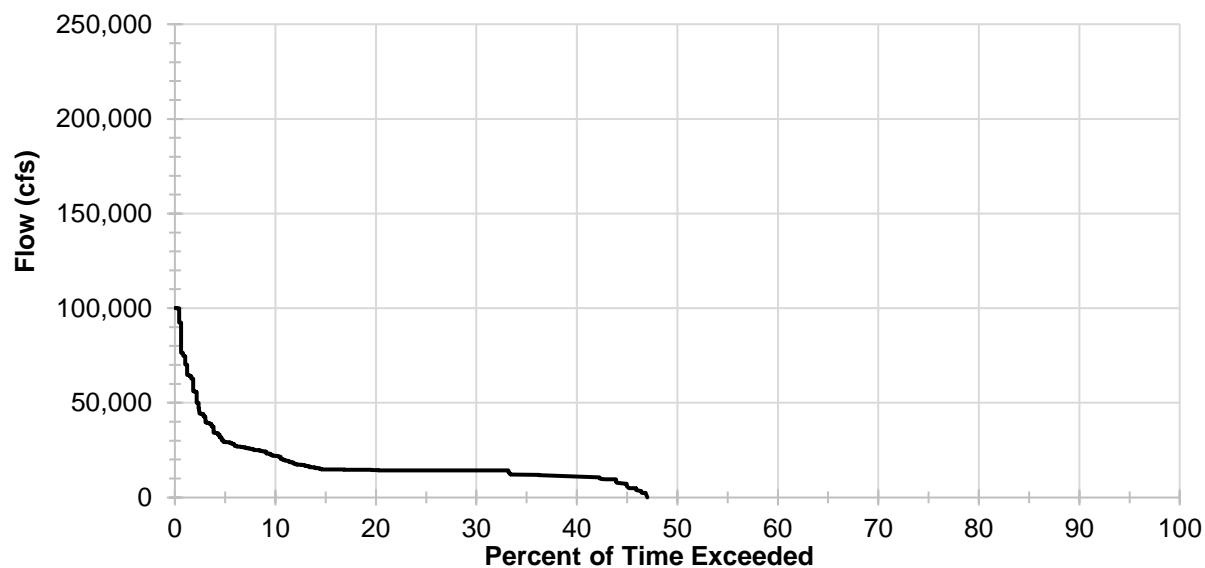
**May Flow Duration for Pensacola Dam  
Modeled Total Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



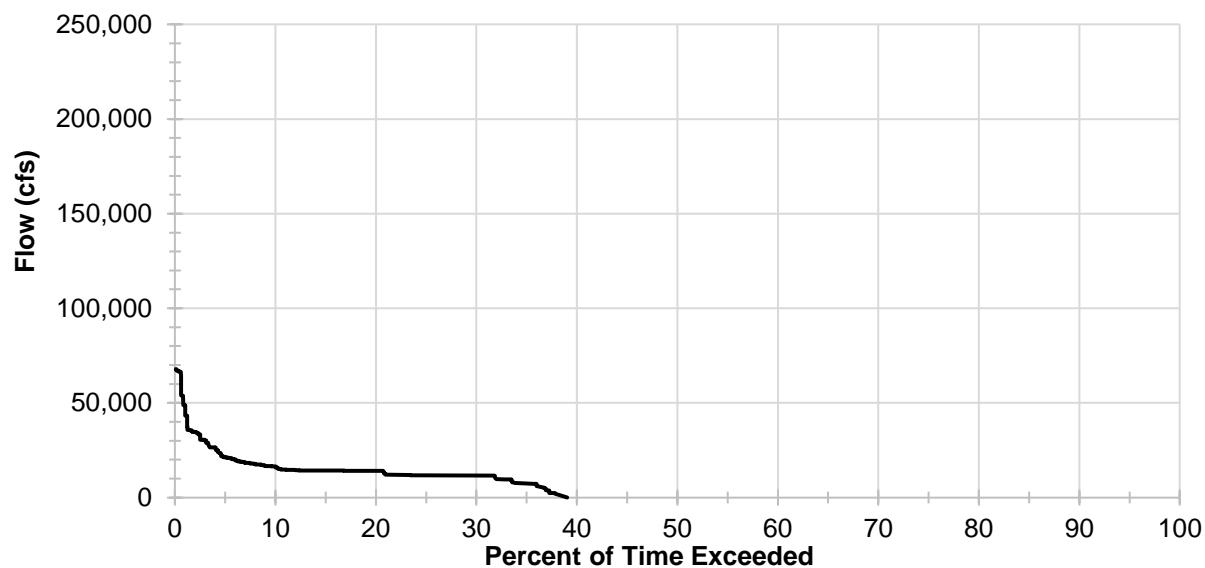
**June Flow Duration for Pensacola Dam  
Modeled Total Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



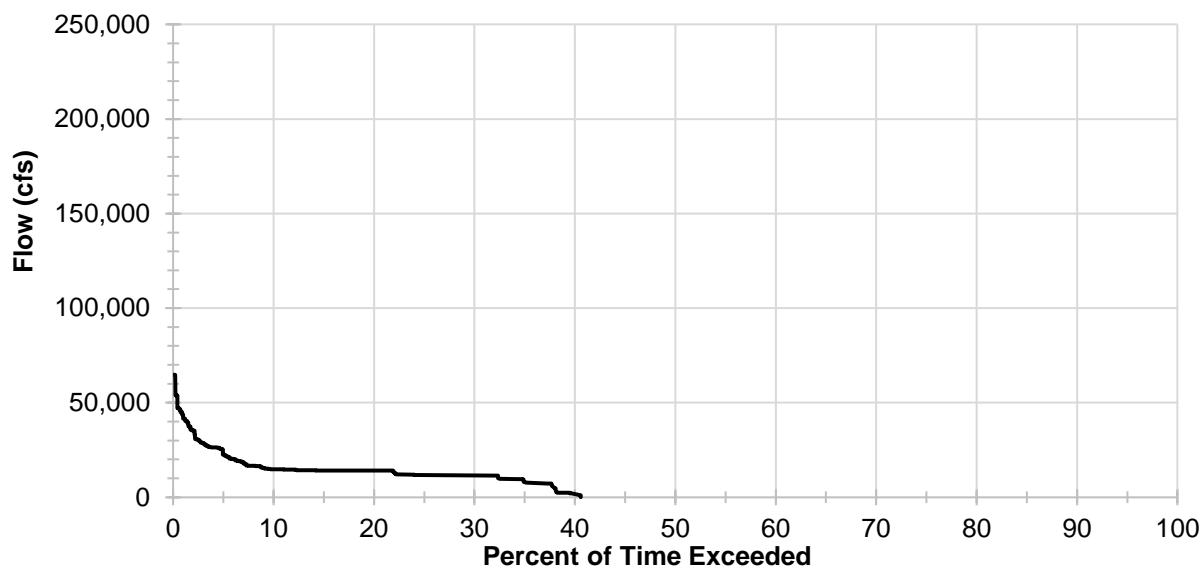
**July Flow Duration for Pensacola Dam  
Modeled Total Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



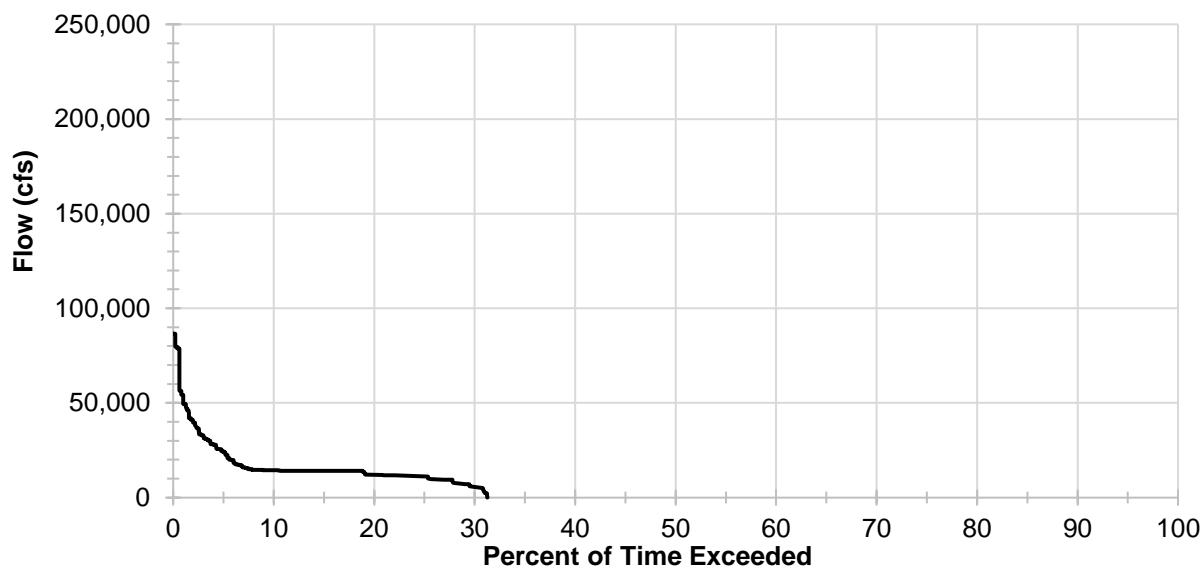
**August Flow Duration for Pensacola Dam  
Modeled Total Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



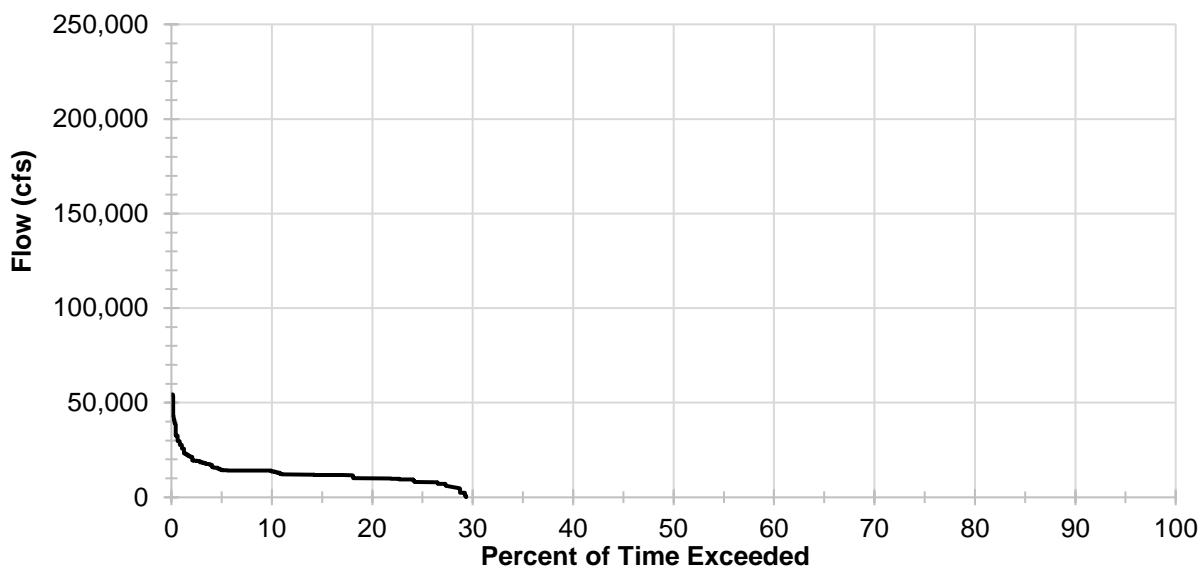
**September Flow Duration for Pensacola Dam  
Modeled Total Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



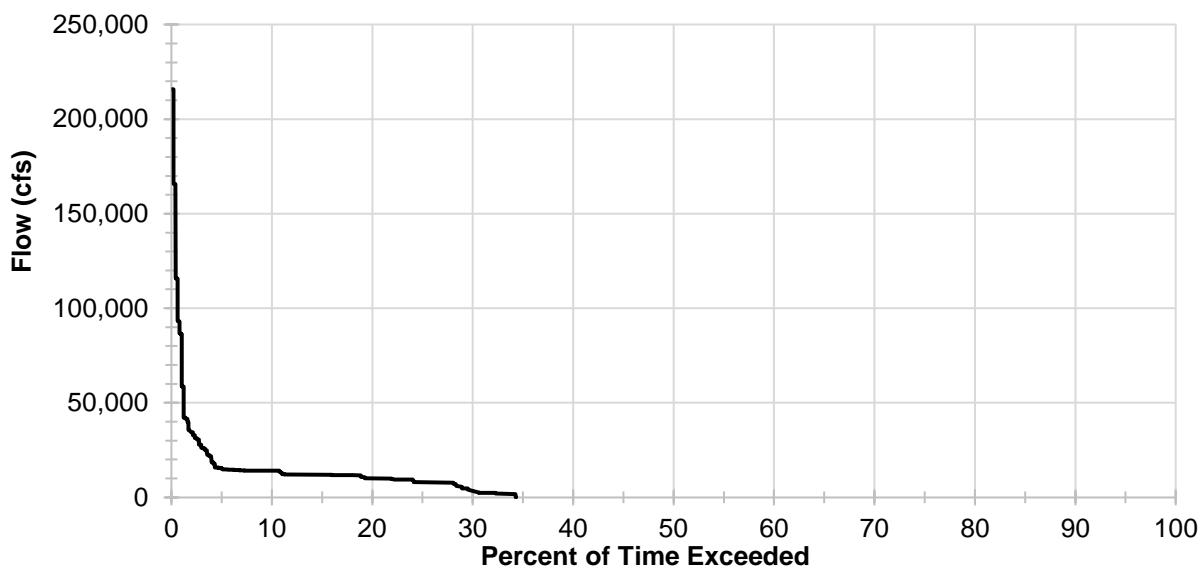
**October Flow Duration for Pensacola Dam  
Modeled Total Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



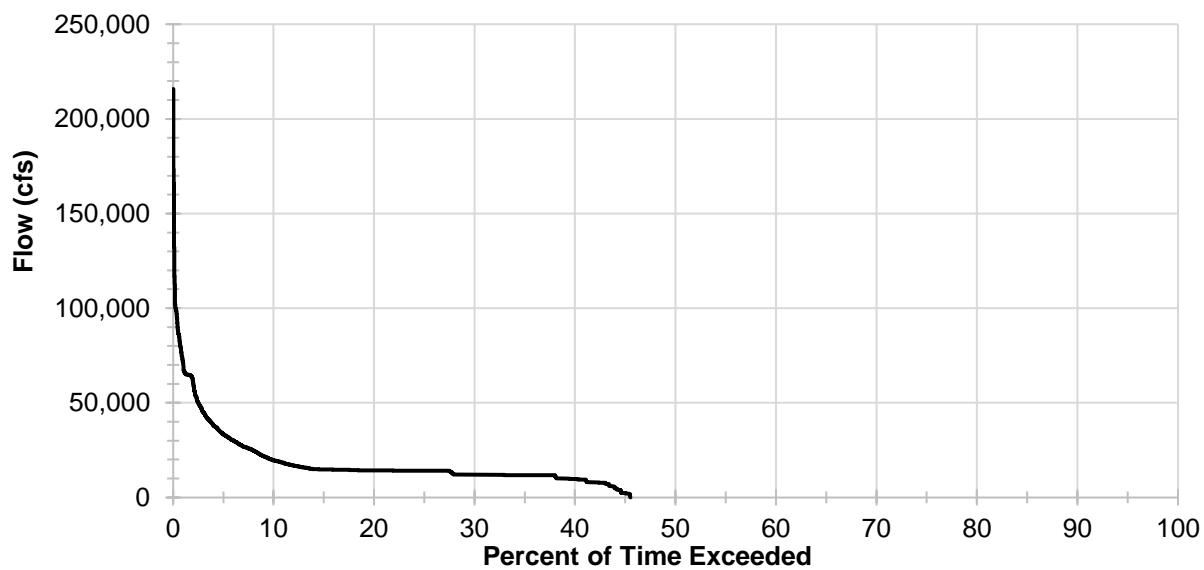
**November Flow Duration for Pensacola Dam  
Modeled Total Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



**December Flow Duration for Pensacola Dam  
Modeled Total Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



**Annual Flow Duration for Pensacola Dam  
Modeled Total Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**

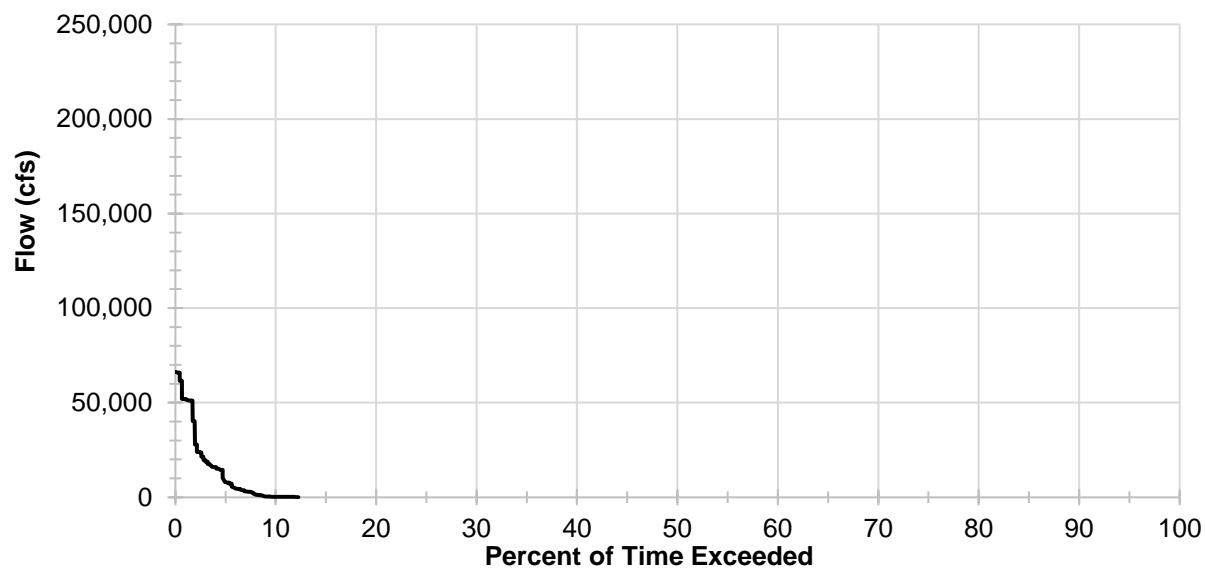


**Flow Duration for Pensacola Dam Modeled Total Discharge for Current Operation (Period of Record Apr 1, 2004 - Dec 31, 2019)**

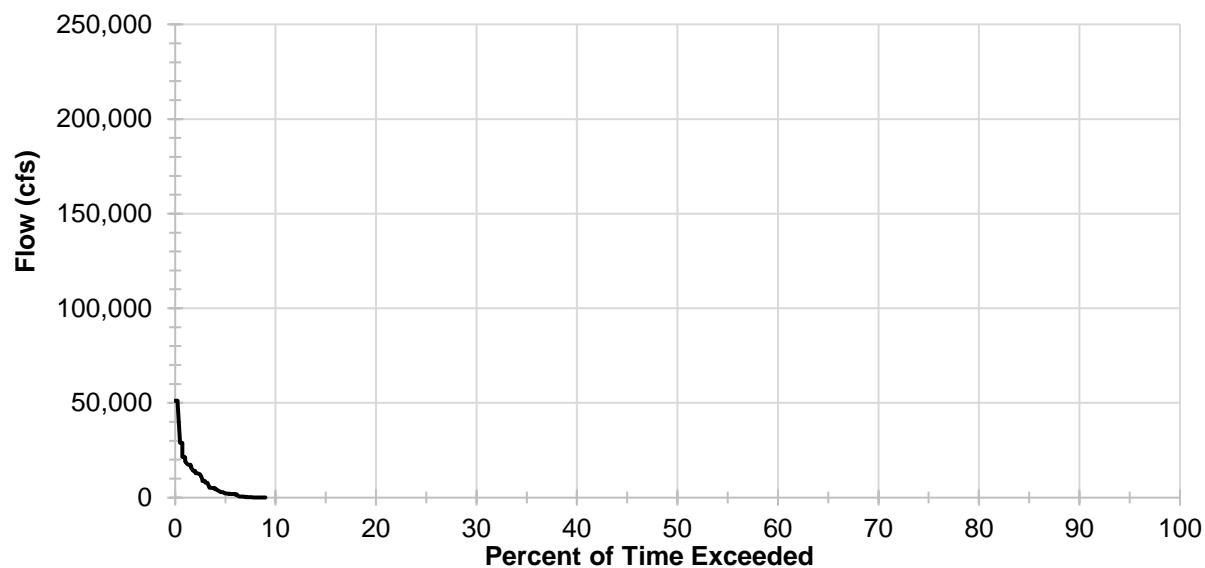
Percent of Time	January	February	March	April	May	June	July	August	September	October	November	December	Annual
95	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0	0
75	0	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	9,545	0	0	0	0	0	0	0	0
65	0	0	0	0	12,000	4,809	0	0	0	0	0	0	0
60	0	0	0	10,000	14,147	11,700	0	0	0	0	0	0	0
55	0	0	0	11,756	14,240	13,657	0	0	0	0	0	0	0
50	0	0	0	12,000	14,462	14,263	0	0	0	0	0	0	0
45	0	0	8,000	12,000	14,634	14,294	5,850	0	0	0	0	0	2,381
40	0	0	11,664	14,055	14,835	14,612	11,700	0	1,950	0	0	0	9,750
35	4,000	8,000	12,000	14,063	16,184	14,803	12,000	7,800	8,000	0	0	0	11,700
30	9,750	10,000	12,000	14,081	19,212	15,707	14,259	11,700	11,700	5,850	0	4,000	12,000
25	11,700	11,752	12,000	14,367	25,523	18,598	14,265	11,700	11,700	11,700	8,000	8,000	14,071
20	12,000	12,000	14,064	14,935	32,134	23,261	14,499	14,158	14,118	12,000	10,000	10,000	14,262
15	14,056	14,056	14,309	18,697	39,828	27,765	14,757	14,209	14,171	14,069	11,791	12,000	14,763
10	14,409	14,080	16,731	25,597	56,189	36,050	21,906	16,467	14,817	14,426	13,675	14,058	19,583
5	21,271	15,678	29,619	40,902	72,007	53,260	29,301	21,357	22,418	23,946	14,498	15,329	33,314

**Modeled Spillway Discharge Flow Duration Curves and Exceedance Table for Current Operation**

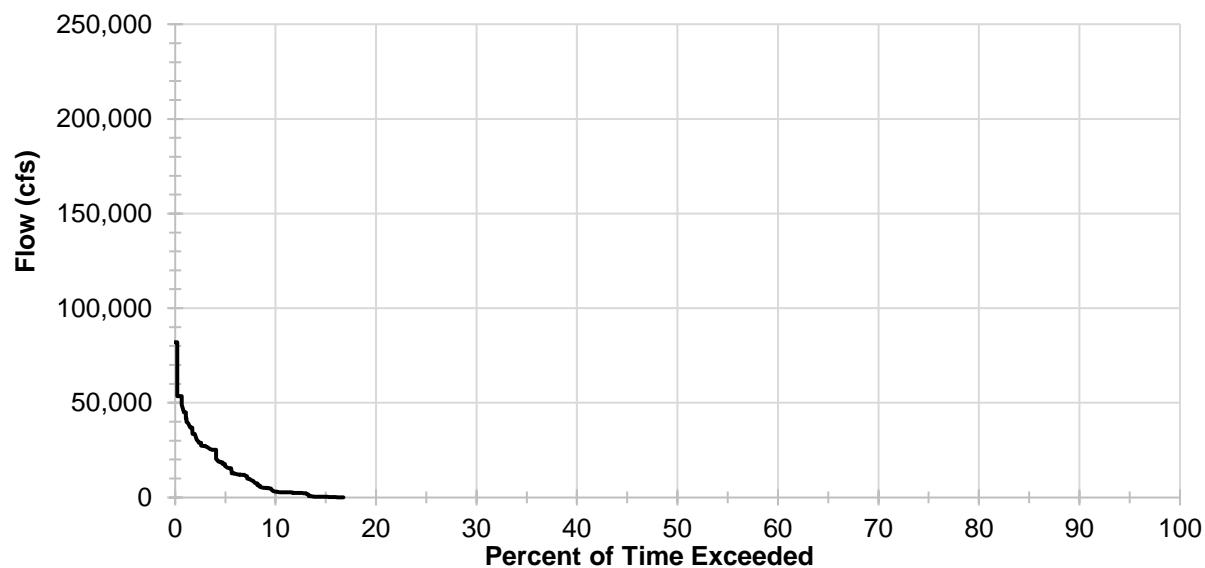
**January Flow Duration for Pensacola Dam  
Modeled Spillway Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



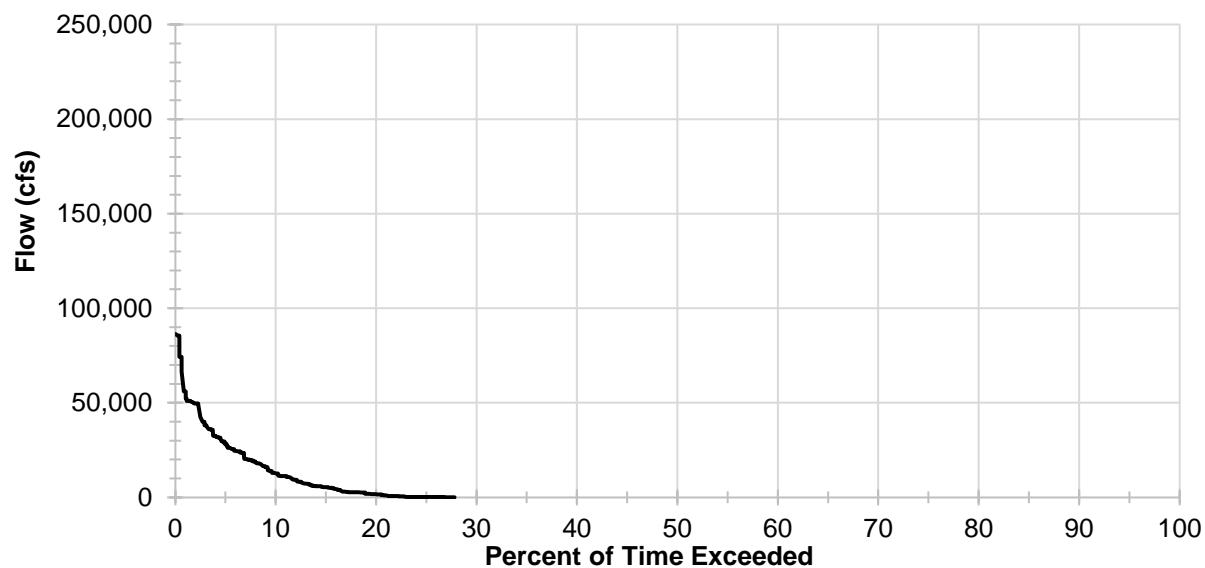
**February Flow Duration for Pensacola Dam  
Modeled Spillway Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



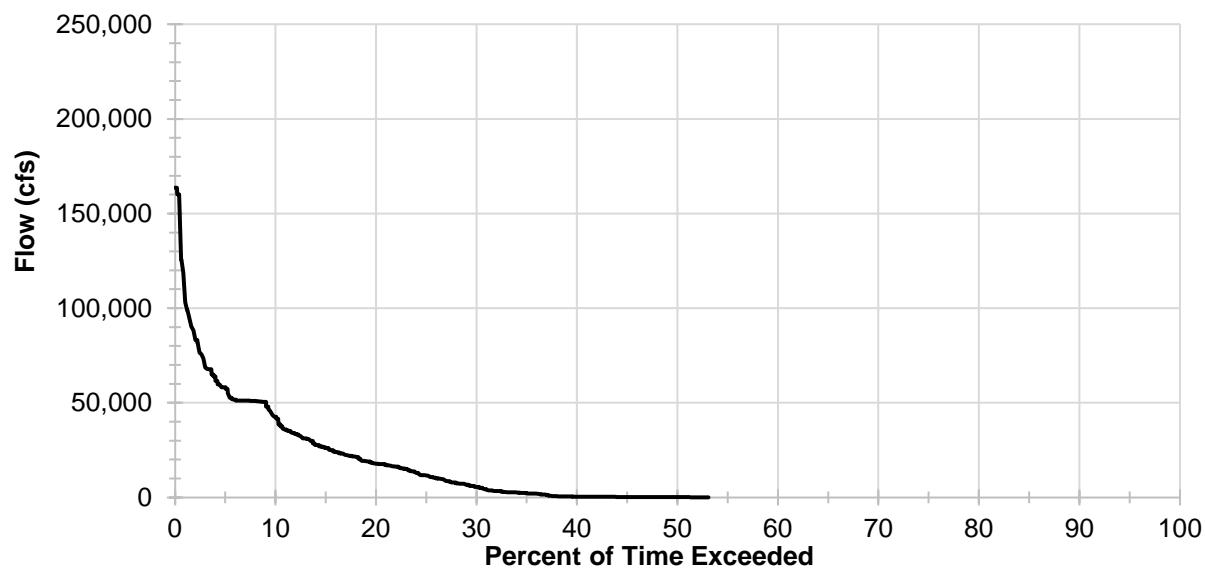
**March Flow Duration for Pensacola Dam  
Modeled Spillway Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



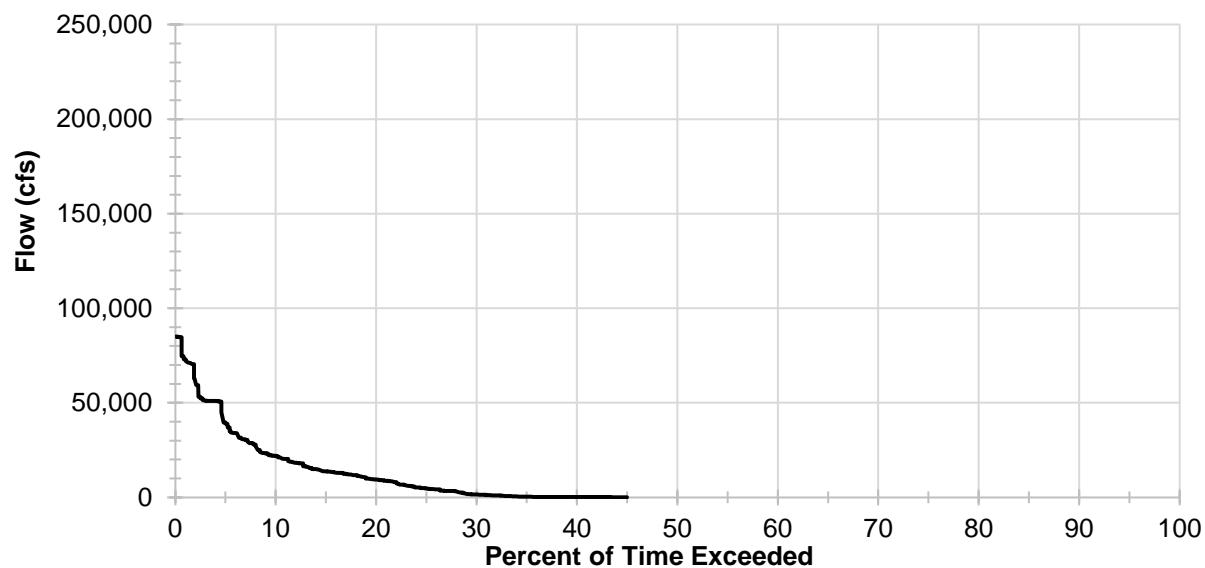
**April Flow Duration for Pensacola Dam  
Modeled Spillway Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



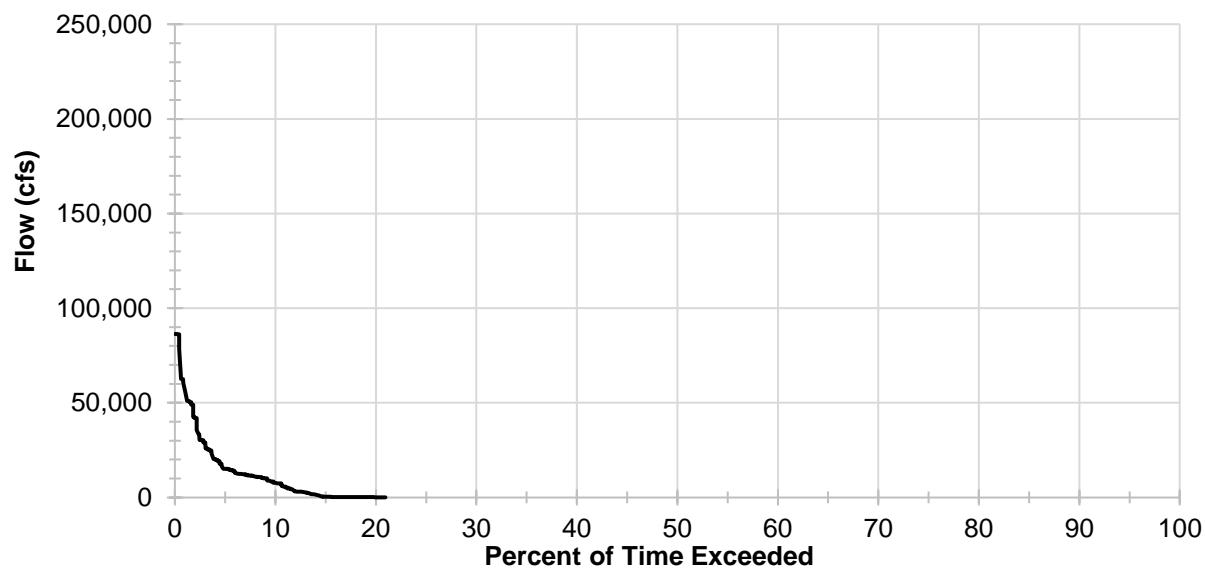
**May Flow Duration for Pensacola Dam  
Modeled Spillway Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



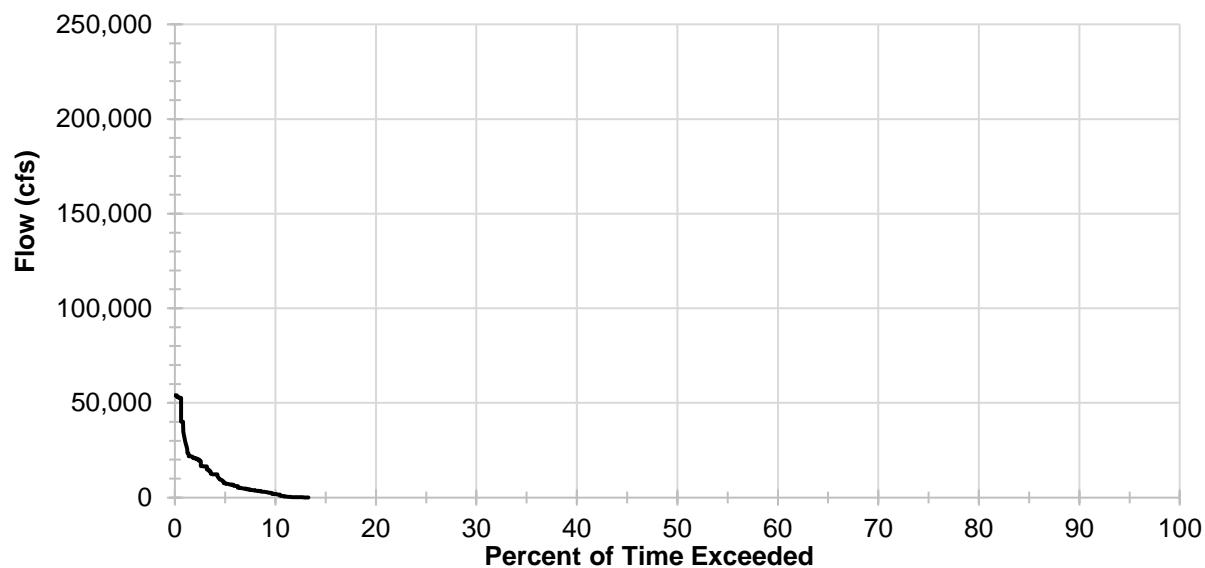
**June Flow Duration for Pensacola Dam  
Modeled Spillway Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



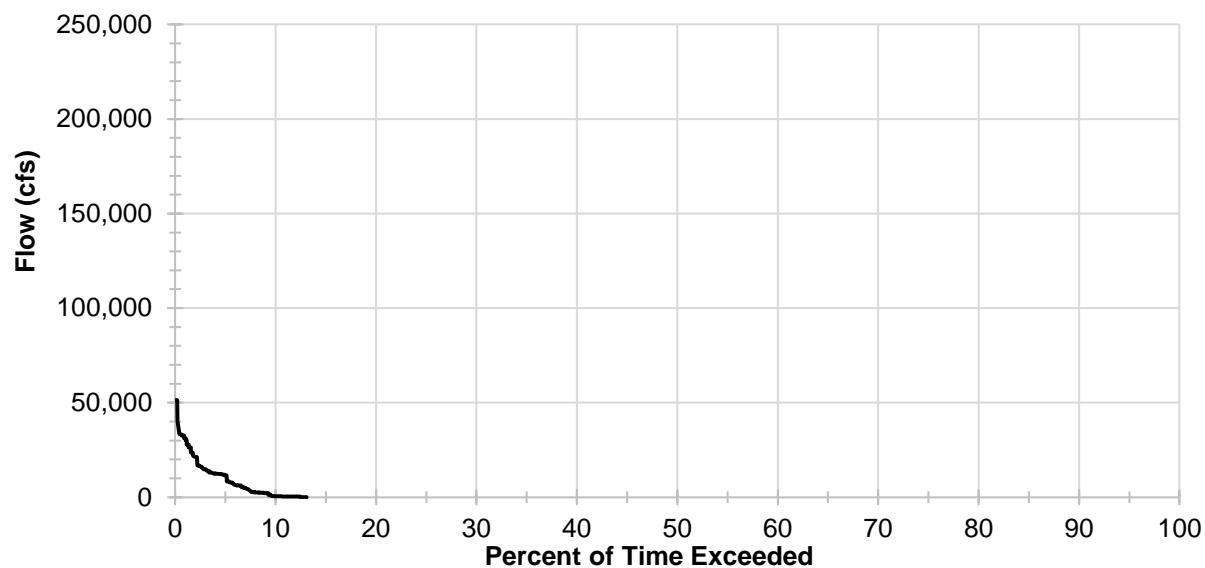
**July Flow Duration for Pensacola Dam  
Modeled Spillway Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



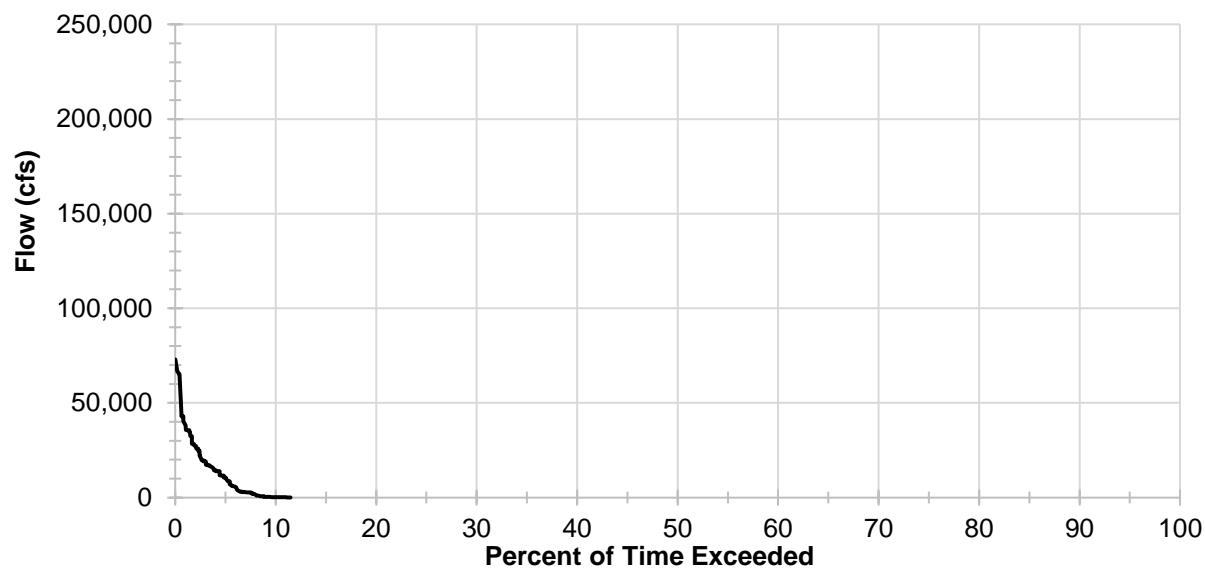
**August Flow Duration for Pensacola Dam  
Modeled Spillway Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



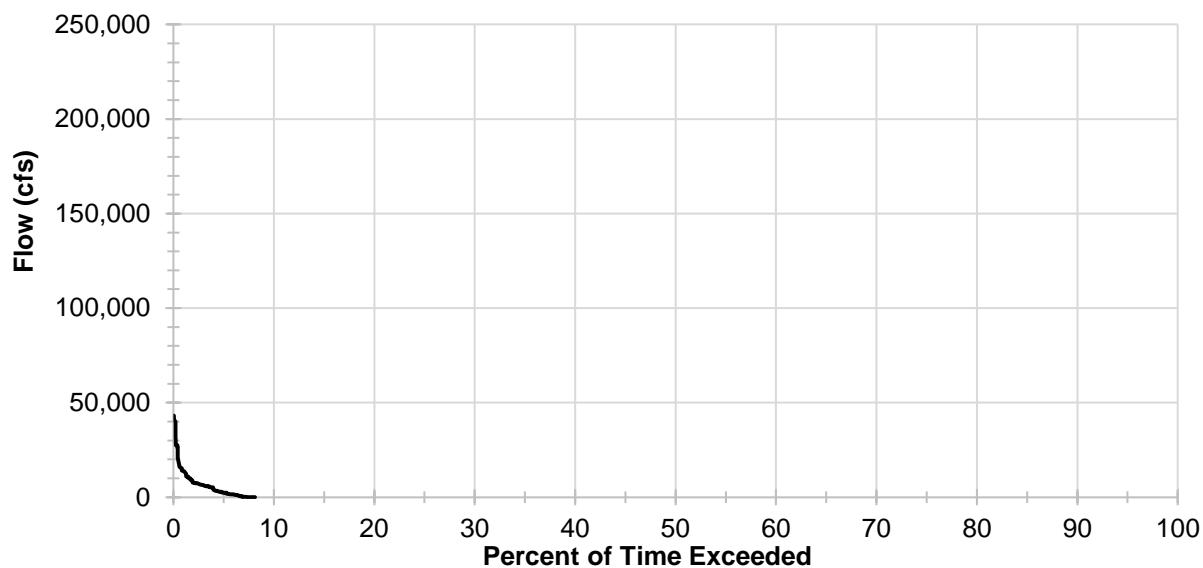
**September Flow Duration for Pensacola Dam  
Modeled Spillway Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



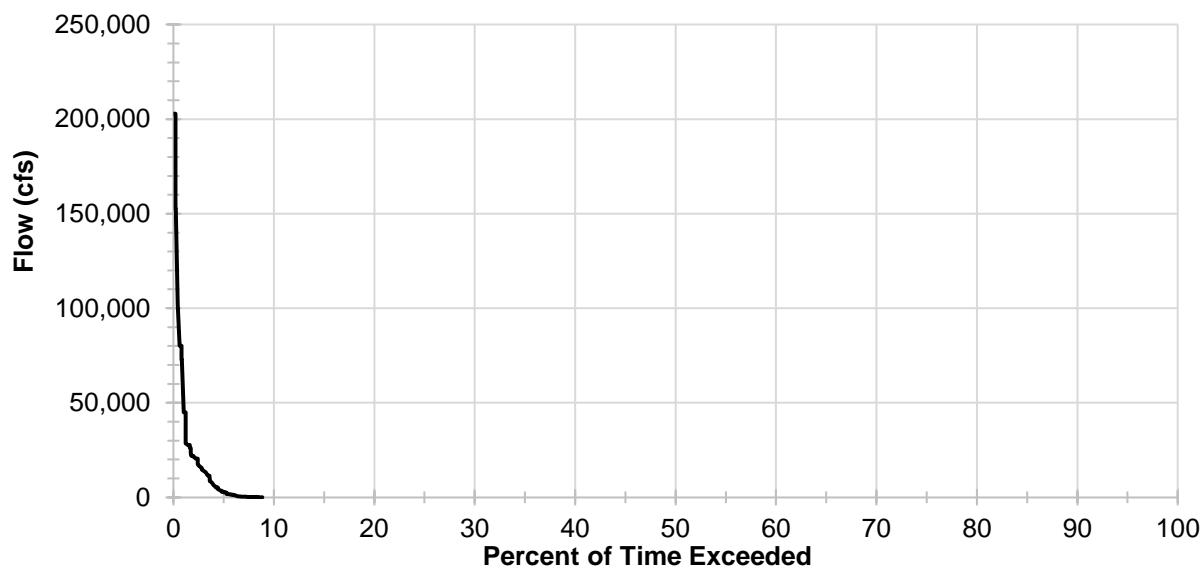
**October Flow Duration for Pensacola Dam  
Modeled Spillway Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



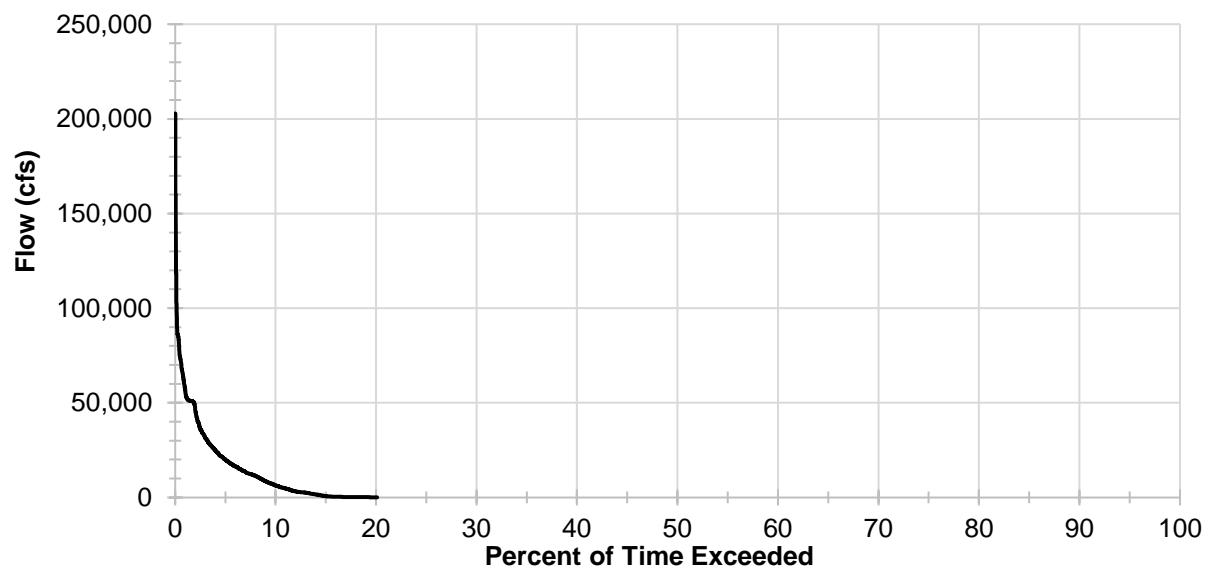
**November Flow Duration for Pensacola Dam  
Modeled Spillway Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



**December Flow Duration for Pensacola Dam  
Modeled Spillway Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



**Annual Flow Duration for Pensacola Dam  
Modeled Spillway Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**

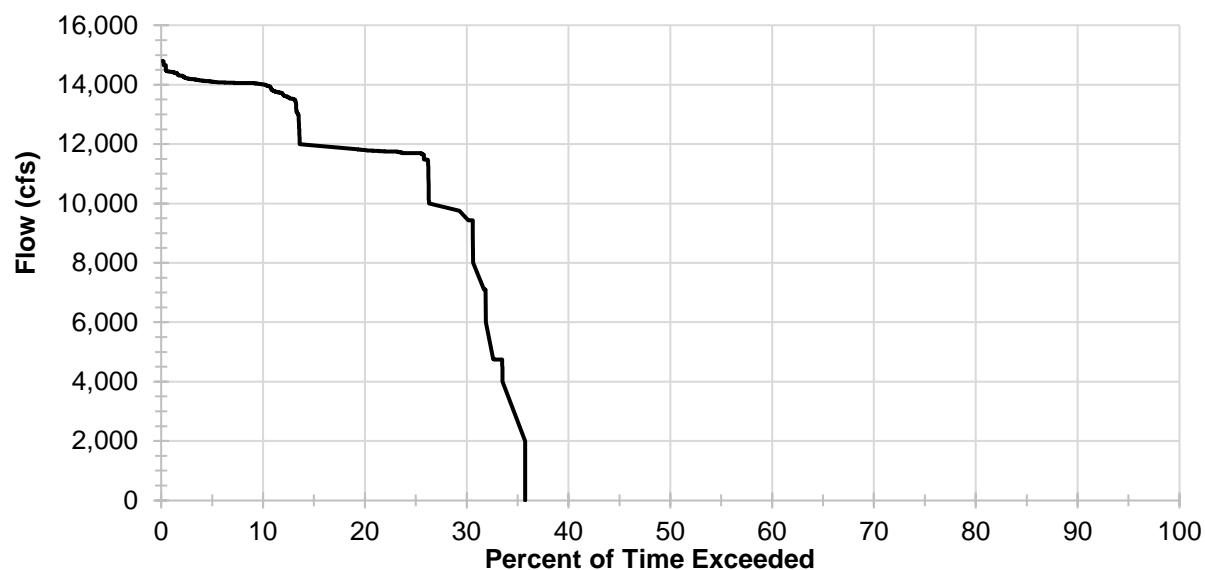


**Flow Duration for Pensacola Dam Modeled Spillway Discharge for Current Operation (Period of Record Apr 1, 2004 - Dec 31, 2019)**

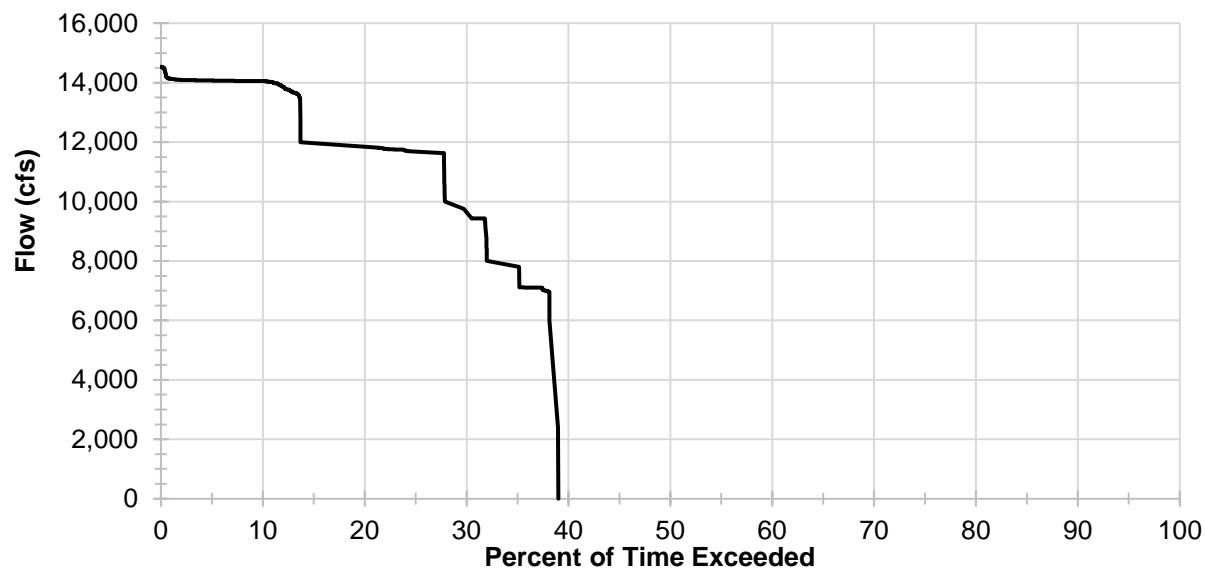
Percent of Time	January	February	March	April	May	June	July	August	September	October	November	December	Annual
95	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0	0
75	0	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	171	0	0	0	0	0	0	0	0
45	0	0	0	0	245	0	0	0	0	0	0	0	0
40	0	0	0	0	427	198	0	0	0	0	0	0	0
35	0	0	0	0	2,141	286	0	0	0	0	0	0	0
30	0	0	0	0	5,501	1,464	0	0	0	0	0	0	0
25	0	0	0	206	11,760	4,717	0	0	0	0	0	0	0
20	0	0	0	1,615	17,887	9,374	80	0	0	0	0	0	15
15	0	0	329	5,330	26,161	13,768	363	0	0	0	0	0	688
10	242	0	3,081	12,940	42,592	22,010	7,679	1,870	586	252	0	0	6,315
5	8,017	2,157	16,595	28,313	58,187	39,657	15,137	7,530	11,568	10,570	2,464	2,800	19,912

**Modeled Turbine Discharge Flow Duration Curves and Exceedance Table for Current Operation**

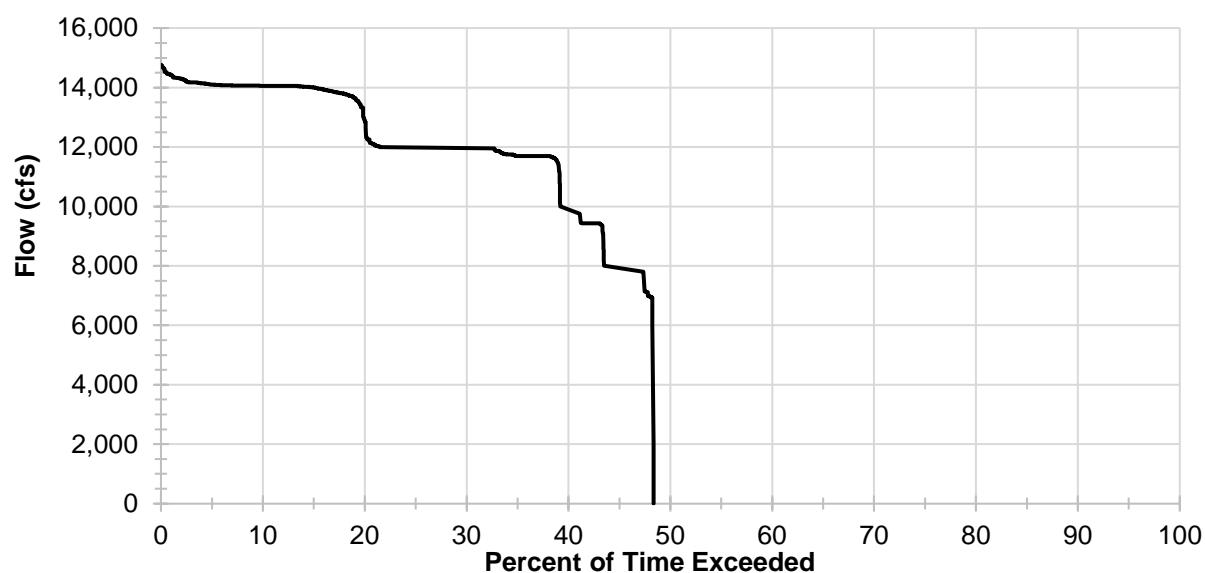
**January Flow Duration for Pensacola Dam  
Modeled Turbine Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



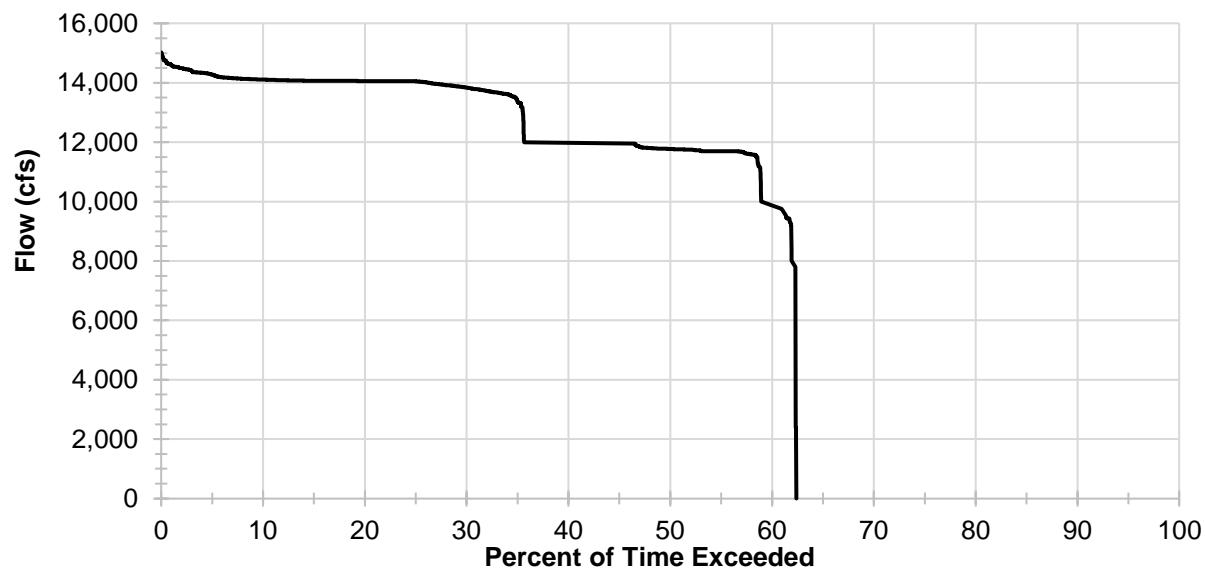
**February Flow Duration for Pensacola Dam  
Modeled Turbine Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



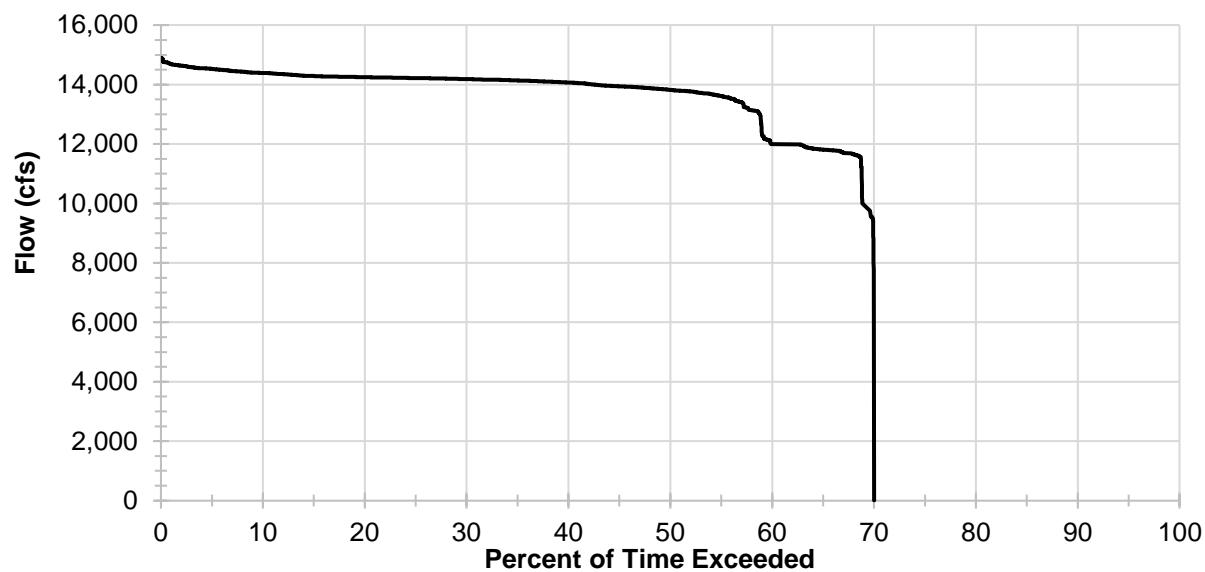
**March Flow Duration for Pensacola Dam  
Modeled Turbine Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



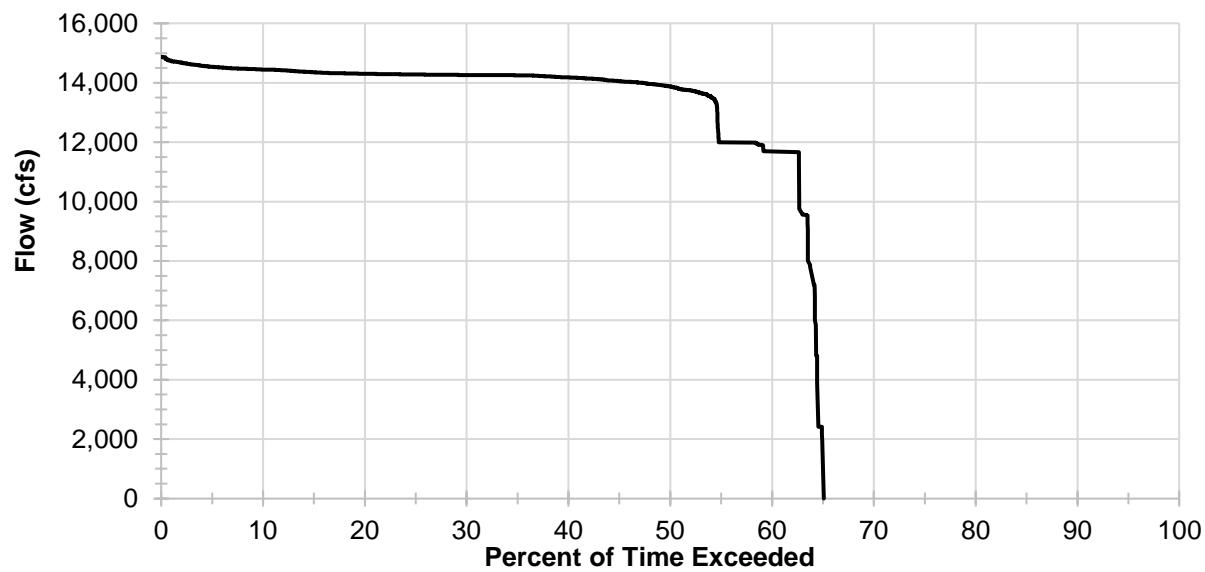
**April Flow Duration for Pensacola Dam  
Modeled Turbine Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



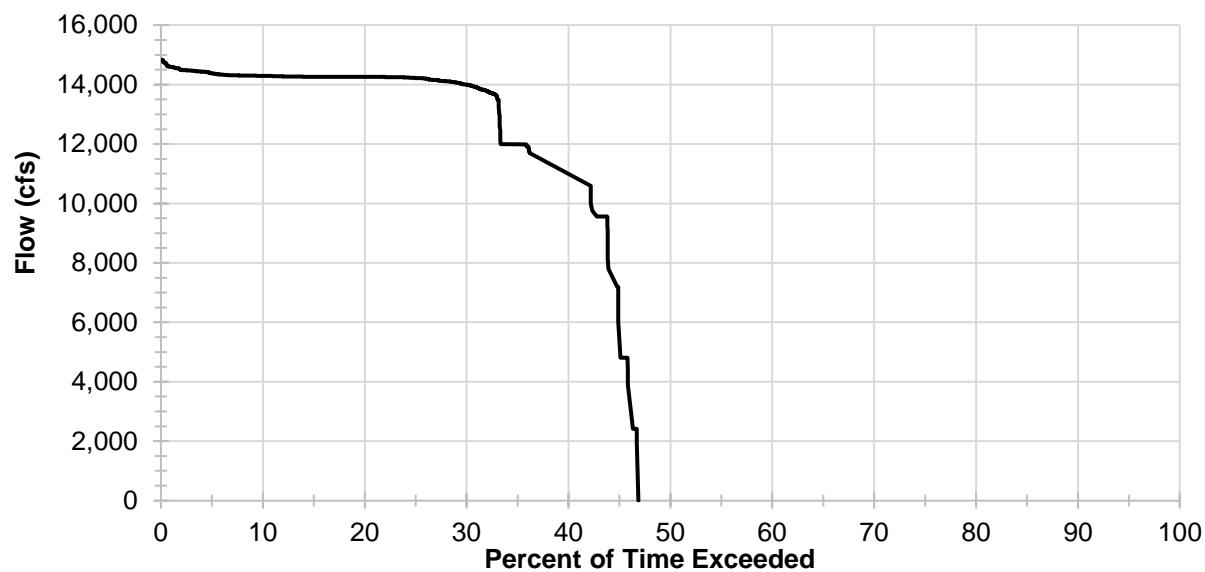
**May Flow Duration for Pensacola Dam  
Modeled Turbine Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



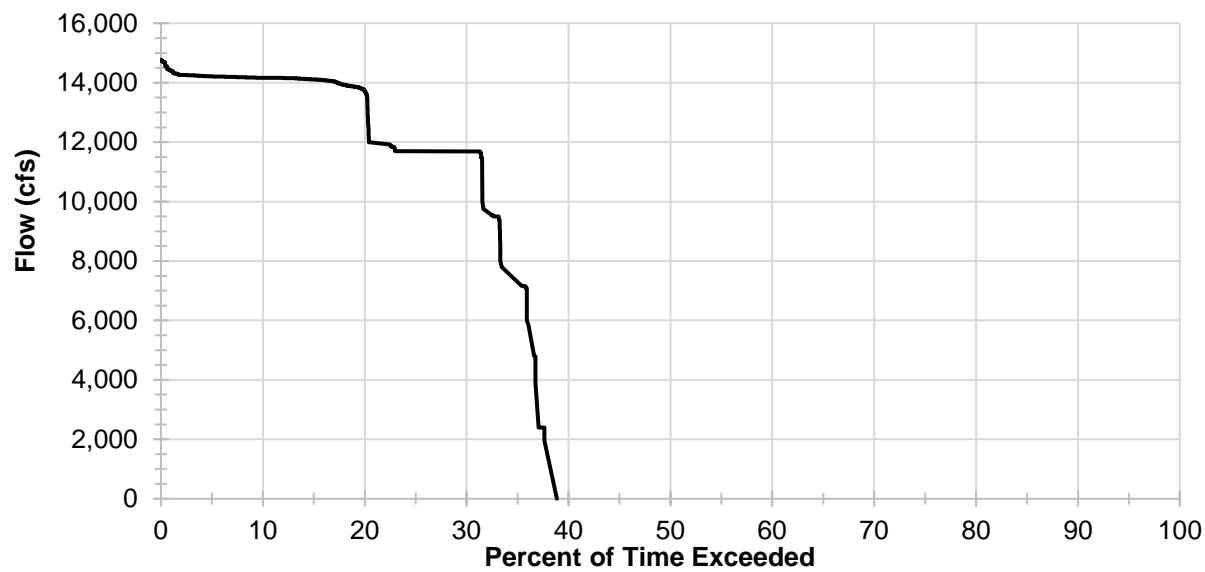
**June Flow Duration for Pensacola Dam  
Modeled Turbine Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



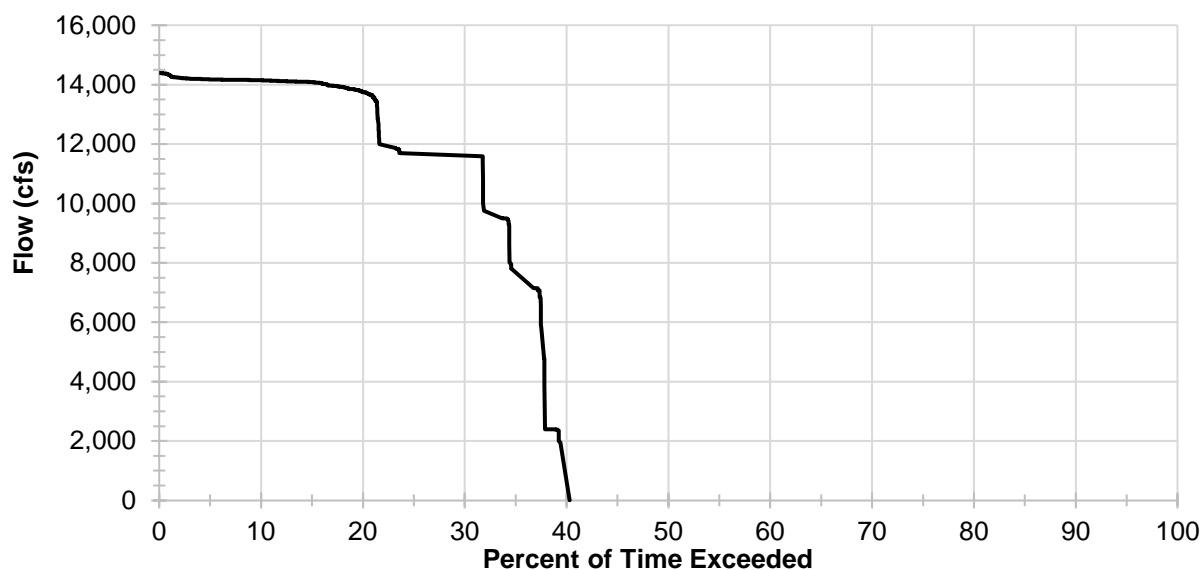
**July Flow Duration for Pensacola Dam  
Modeled Turbine Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



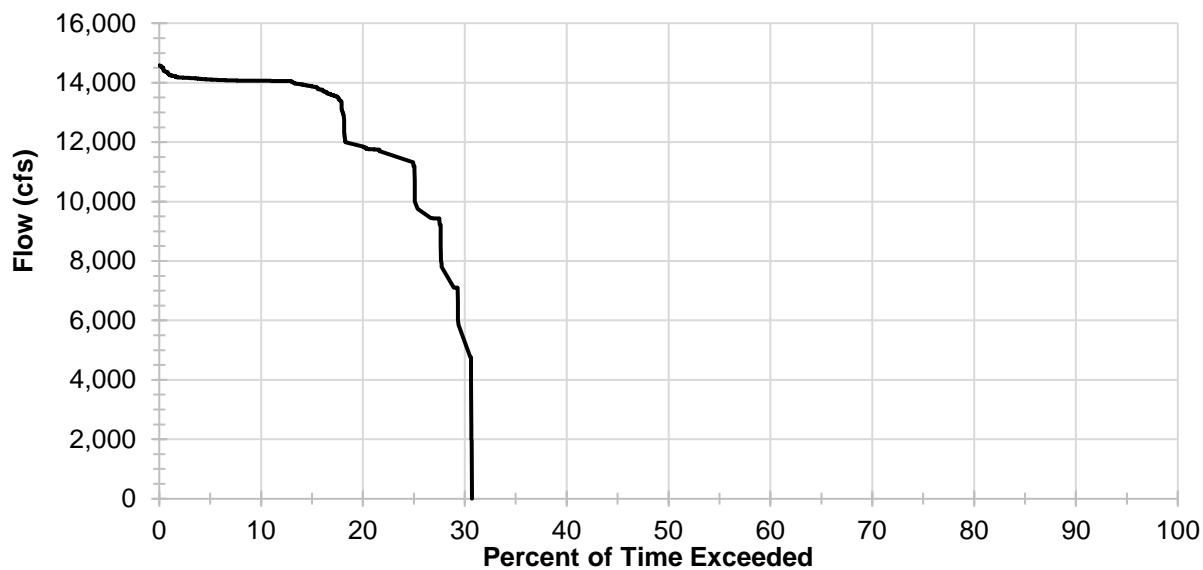
**August Flow Duration for Pensacola Dam  
Modeled Turbine Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



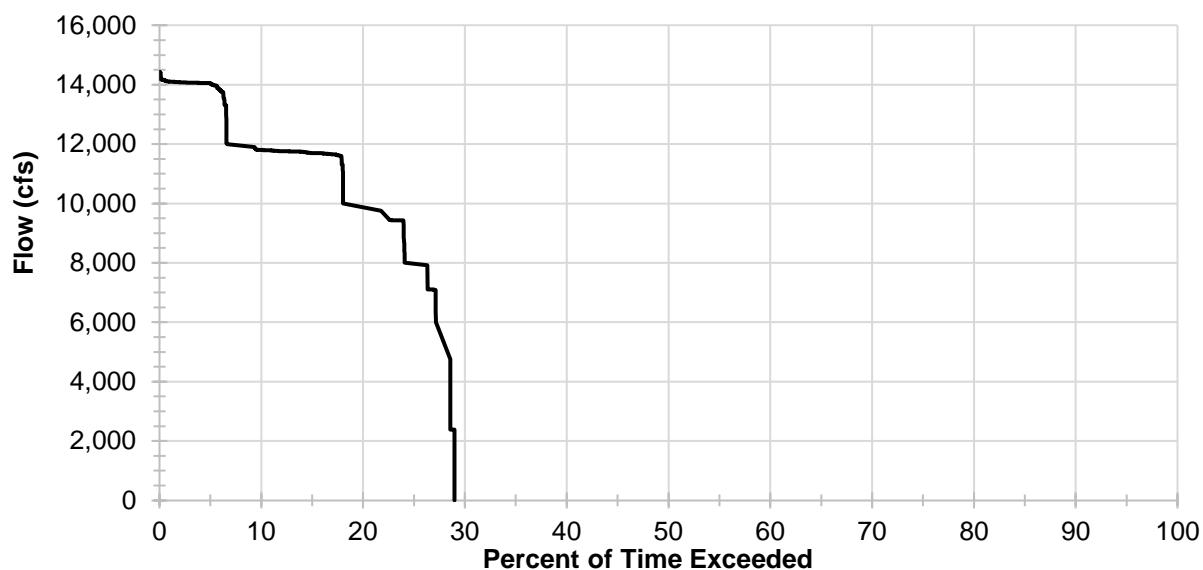
**September Flow Duration for Pensacola Dam  
Modeled Turbine Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



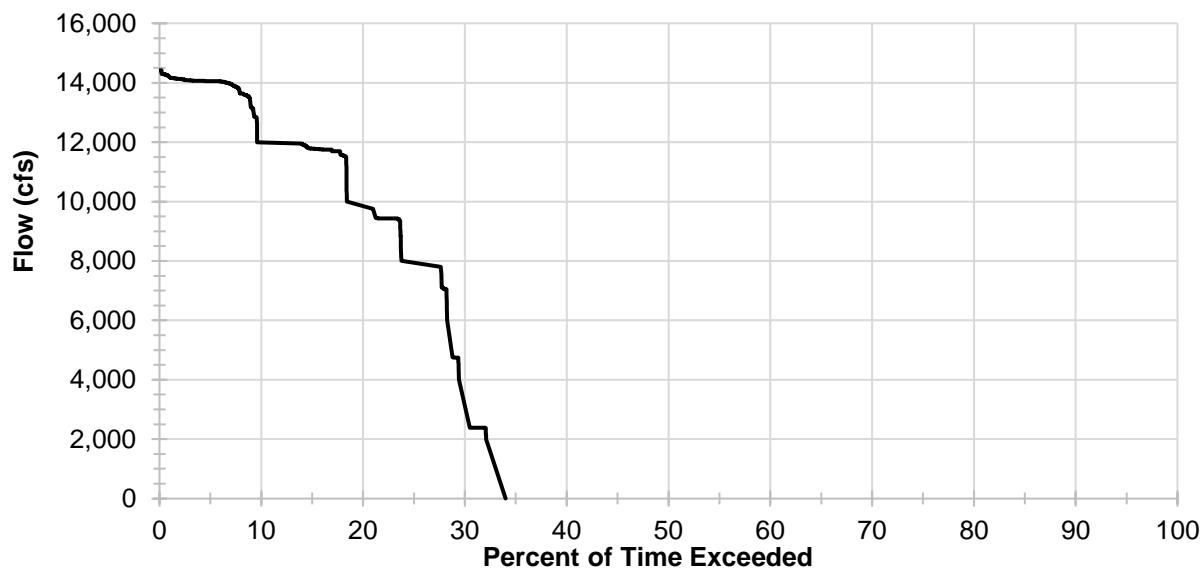
**October Flow Duration for Pensacola Dam  
Modeled Turbine Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



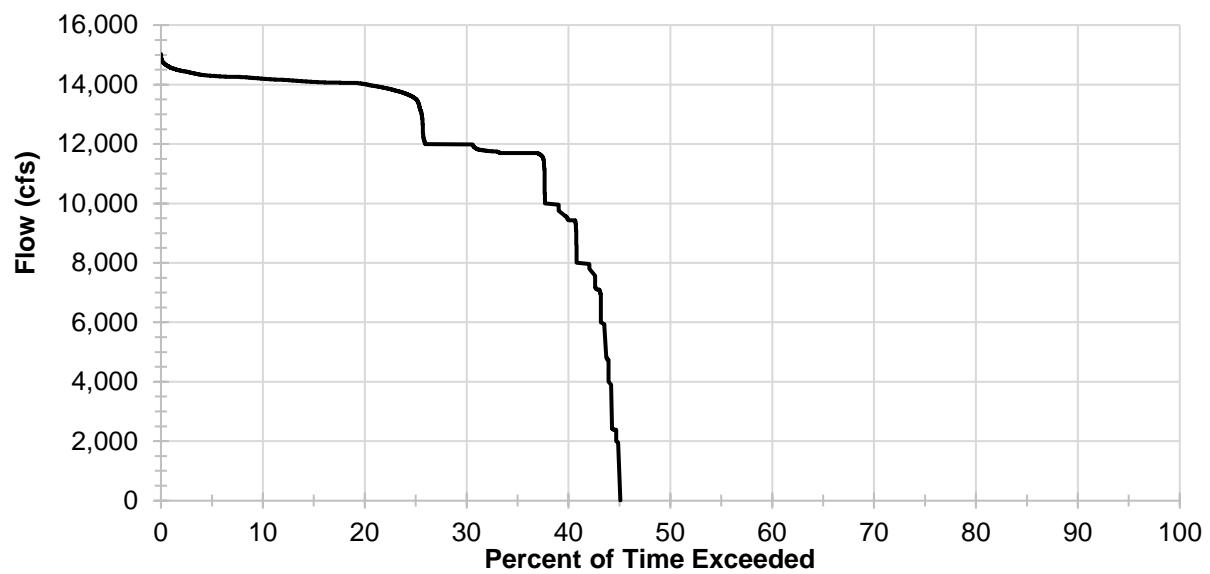
**November Flow Duration for Pensacola Dam  
Modeled Turbine Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



**December Flow Duration for Pensacola Dam  
Modeled Turbine Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**



**Annual Flow Duration for Pensacola Dam  
Modeled Turbine Discharge for Current Operation  
Period of Record Apr 1, 2004 - Dec 31, 2019**

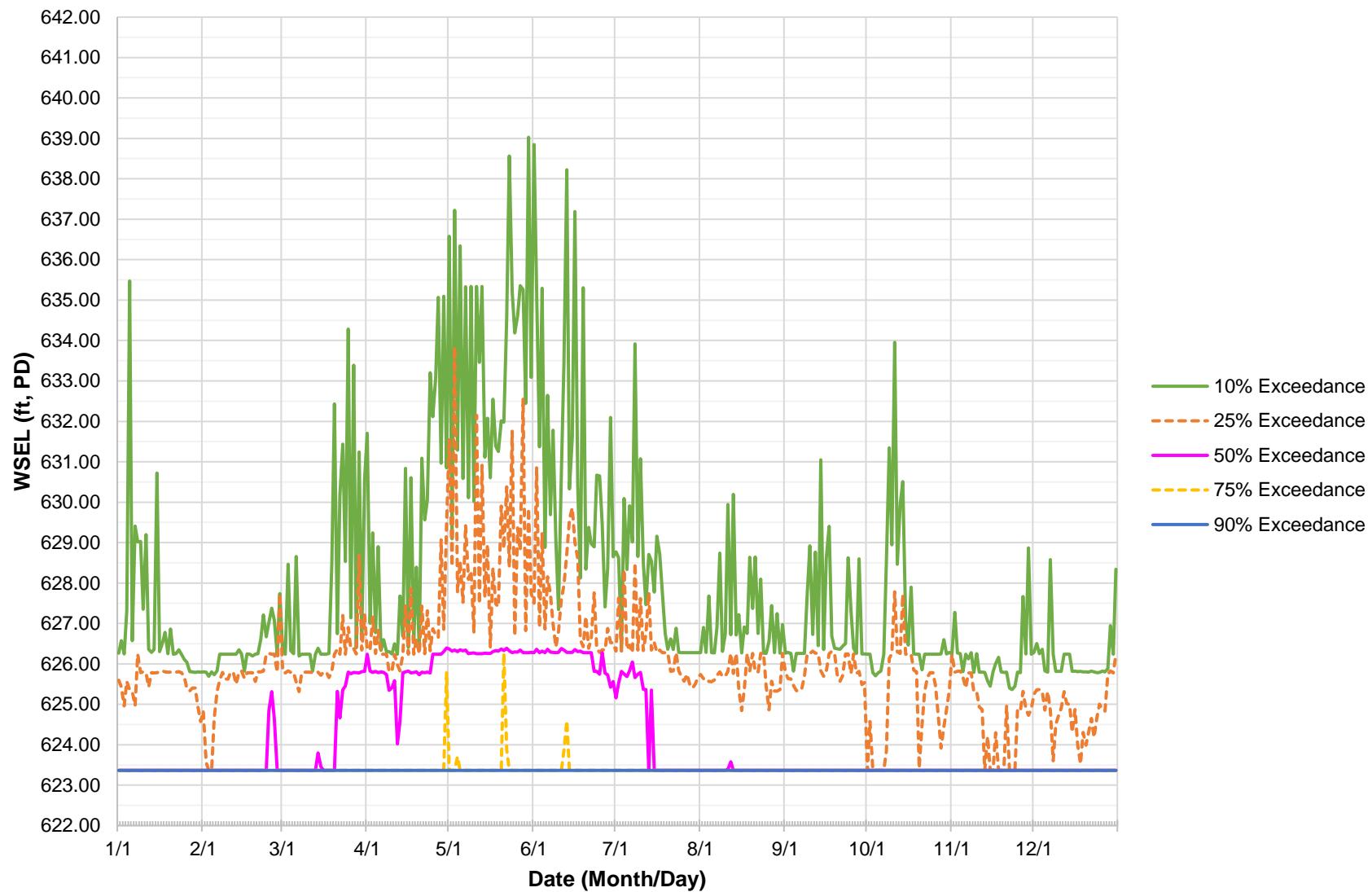


**Flow Duration for Pensacola Dam Modeled Turbine Discharge for Current Operation (Period of Record Apr 1, 2004 - Dec 31, 2019)**

Percent of Time	January	February	March	April	May	June	July	August	September	October	November	December	Annual
95	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0	0
75	0	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	7,800	0	0	0	0	0	0	0	0
65	0	0	0	0	11,810	1,950	0	0	0	0	0	0	0
60	0	0	0	10,000	12,000	11,700	0	0	0	0	0	0	0
55	0	0	0	11,700	13,615	12,000	0	0	0	0	0	0	0
50	0	0	0	11,772	13,821	13,878	0	0	0	0	0	0	0
45	0	0	8,000	12,000	13,944	14,056	5,850	0	0	0	0	0	1,950
40	0	0	10,000	12,000	14,070	14,182	11,700	0	1,950	0	0	0	9,440
35	4,000	8,000	11,700	13,382	14,140	14,255	12,000	7,800	7,800	0	0	0	11,700
30	9,750	9,750	12,000	13,837	14,184	14,264	14,002	11,700	11,700	5,850	0	4,000	12,000
25	11,700	11,700	12,000	14,051	14,220	14,280	14,222	11,700	11,700	11,191	8,000	8,000	13,518
20	11,799	12,000	12,883	14,061	14,249	14,305	14,259	13,715	13,755	11,846	10,000	10,000	14,016
15	12,000	12,000	14,003	14,071	14,289	14,355	14,264	14,110	14,087	13,879	11,700	11,782	14,090
10	14,011	14,055	14,061	14,111	14,390	14,447	14,291	14,166	14,151	14,066	11,801	12,000	14,197
5	14,102	14,074	14,099	14,278	14,529	14,539	14,378	14,213	14,179	14,108	14,047	14,059	14,295

**APPENDIX B-8.4 Modeled Pensacola Tailwater Elevation and Lake Hudson Headwater Elevation Exceedance Curves for Current Operation**

## Pensacola Modeled Tailwater Elevations Current Operation



## Lake Hudson Modeled Headwater Elevations Current Operation

