Appendix B2. River Hydraulic Criteria for Intake Sizing (Final Draft)

1. Introduction and Purpose

The purpose of this technical memorandum (TM) is to determine the hydrologic basis for Delta Conveyance System Project (Project) intake screen sizing along the Bethany Reservoir Alignment tunnel. This TM summarizes the collection and data analysis conducted to determine the median high water and the stage-durations curves to establish the low water surface elevations (WSELs) to be used for intake planning and design.

1.1 Organization

This TM is organized as follows:

- Introduction and Purpose
- Methodology
- Analysis and Evaluation
- Conclusions and Recommendations
- References
- Attachment 1 – Annual Stage-Discharge Curves: IST, FPT, and SDC
- Attachment 2- Monthly Stage-Discharge Curves: IST, FPT, and SDC

1.2 Background

The Project intake hydrologic sizing criteria include establishing the stage-duration data for the Sacramento River WSEL at the intakes. The goal is to design the intake fish screens to function at full capacity 99 percent of the time. Median annual highest water levels are also of interest at each intake location, as they establish the highest water level that can be expected in what is often referred to as an "ordinary" year.

The intake site stage-duration information was determined by statistical analysis of decades of stage gage data at three locations on the Sacramento River and adjusting that data to the specific intake sites.

Stage data were collected for pertinent Sacramento River gages as follows:

- California Department of Water Resources (DWR) California Data Exchange Center (CDEC) Station on the Sacramento River at I Street Bridge (IST, number [No.] 11447500), obtained from 1984 to 2019 (DWR 2017a)
- U.S. Geological Society (USGS) Station on the Sacramento River at Freeport (FPT, No. 11447650), obtained from 1984 to 2019 (USGS 2019)
- USGS Station on the Sacramento River above the Delta Cross Channel (SDC, No. 11447890), obtained from 2007 to 2019 (the available data period for this station) (USGS 2019)

The periods used capture a wide variety of wet, average, and dry water years since both Shasta and Oroville dams were constructed. The stage data were downloaded from the CDEC (DWR 2017a) and USGS (2019) web sites.

1.3 Summary of Results

Two intake sites were identified for the Project in the Concept Engineering Report (CER) Appendix B6 – *Intake Site Identification and Evaluation*. The location of these intake sites, along with the DWR and USGS gaging stations, are shown by River Mile (RM) in Table 1 and on Figure 1. Table 1 also shows the low WSELs to be used to size the intakes, as well as the estimated median annual maximum WSEL to show the high water level at each intake in an "ordinary" year. Figure 1 shows the locations of the DWR and USGS stations and the intake options.

Table 1. Boundary Condition WSELs at Intake and Gaging Station Locations

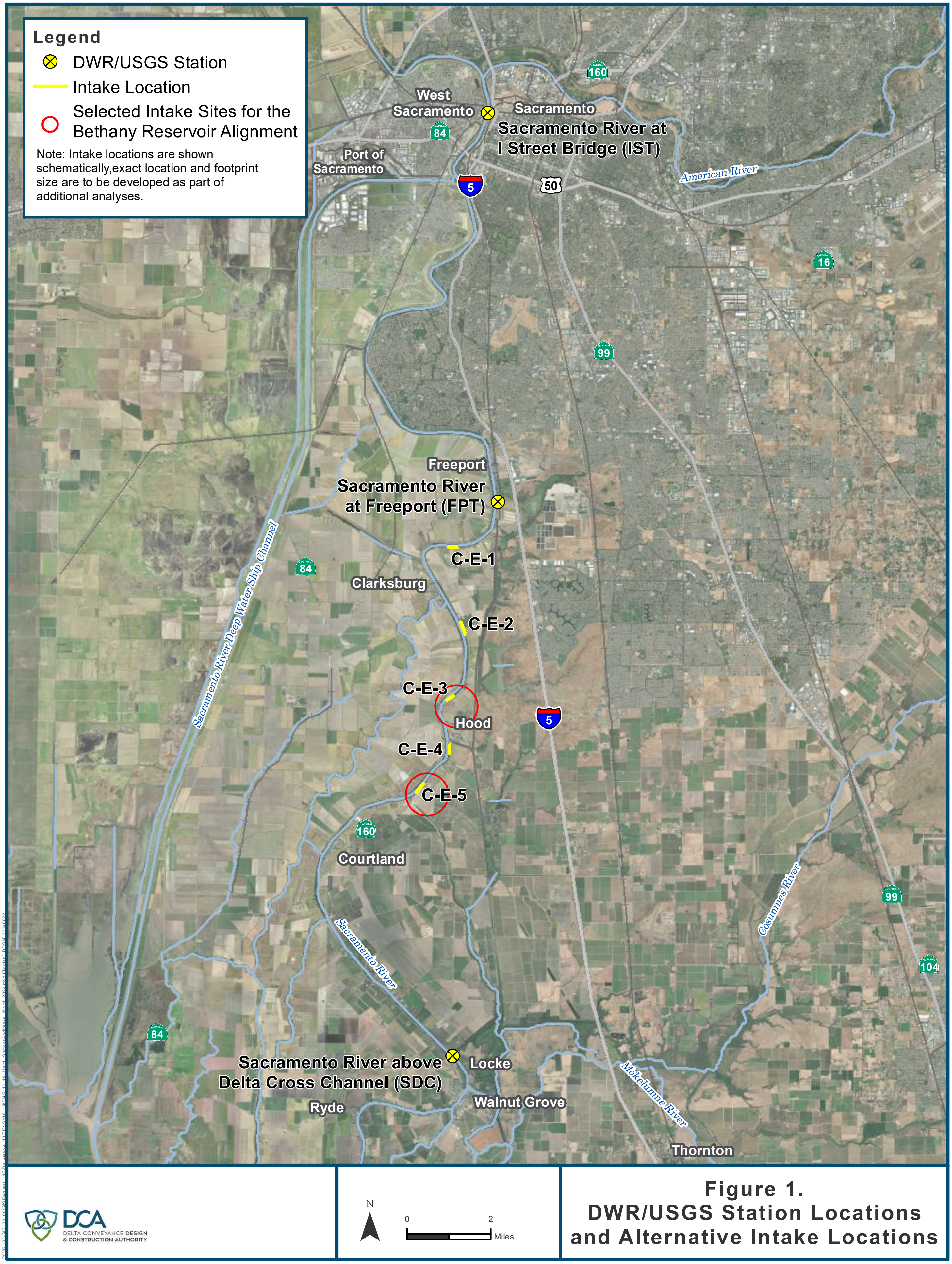
Intake	Description	RM	Estimated 99% Exceedance (ft, NAVD88)	Estimated Median Annual Maximum WSEL (ft, NAVD88)
not applicable	DWR Gaging Station at I Street Bridge (IST)	59.4	4.38	25.14
not applicable	USGS Gaging Station at Freeport (FPT)	46.3	4.02	19.16
C-E-3	Central and East Corridor Intake 3, north of Hood, eastern side	39.4	3.72	16.32
C-E-5	Central and East Corridor Intake 5, north of Snodgrass Slough, eastern side	36.8	3.61	15.24
not applicable	USGS Gaging Station at Delta Cross Channel (SDC)	27.5	3.21	11.41

Notes:
% = percent
ft = foot (feet)
NAVD88 = North American Vertical Datum of 1988

2. Methodology

The median annual maximum and lower boundary condition WSELs for the intake sites were determined using historical water level data obtained from the DWR (DWR 2017a, b, c, d) and USGS (USGS 2019a, b).

The median annual maximum WSEL was calculated by tabulating the maximum WSEL recorded each year and then determining the median value of that data set.



DCA DELTA CONVEYANCE DESIGN & CONSTRUCTION AUTHORITY

Figure 1.
DWR/USGS Station Locations and Alternative Intake Locations

Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
USGS, Jacobs.

For the lower boundary condition, the historical water level data were used to develop stage-duration curves for each gaging station location. The stage-duration curves show the percent exceedance for each water level within the data range. The lower boundary condition WSELs for each intake location were established by determining the 99 percent exceedance WSEL at each gaging station, and then interpolating the value by RM between the adjacent two stations. The 99 percent exceedance values mean that 99 percent of the time, the WSEL is greater than that value. The 99% exceedance values were selected since these values are consistent with the 99% exceedance levels defined by DWR (2010) and incorporated into the 2018 Conceptual Engineering Report (California WaterFix 2018) for the same intakes in the WaterFix Project. This value could be adjusted to a lower percent exceedance factor as more information id defined by operational modeling. The 99% exceedance value would be considered slightly conservative and is suitable to use for Project planning purposes.

Note that the upper boundary condition WSEL for each intake location is also important for the Project's long-term flood resiliency. The upper boundary condition is determined from modeling the 200-year flood with downstream tailwater conditions that reflect future estimates of sea-level rise (SLR). Those levels are under development by DWR and will be summarized in a subsequent TM.

2.1 Data Sources

WSEL data were collected from both CDEC and USGS information sources. Table 2 includes the Sacramento River sites used in the following data evaluation.

Table 2. Sacramento River DWR and USGS Stations Used in Data Evaluation

Station	Data Source	Date Range Used	RM
Sacramento River at I Street Bridge (IST)	DWR via CDEC (DWR 2017b)	January 1, 1984 to Present	59.4
Sacramento River at Freeport (FPT)	USGS via CDEC (DWR 2017c)	January 1, 1984 to Present	46.3
Sacramento River above Delta Cross Channel (SDC)	USGS (2019)	October 1, 2007 to Present	27.5

There are no intake locations on the Sacramento River between the I Street Bridge and Freeport gaging stations. As such, the I Street Bridge gaging station is not used directly for the WSEL analyses in this TM. However, it is an important data location on the river and was analyzed for completeness, as it helps demonstrate the consistency and validity of the data at the other two gaging stations.

Data from other gaging stations were considered for the analysis but were not used. Both the Sacramento River at Hood and the Sacramento River at Courtland stations have less than 4 years of data. These data are not representative of several types of water years and were not used.

In addition to the sites shown in Table 2, the data gathered from the following sources were used to verify the datum for the sites:

- VERTCON – North American Vertical Datum Conversion Tool (NGS 2017)
- Sacramento River at Georgiana Slough (DWR 2017d)

For the information presented in this analysis, the NAVD88 datum was used. All elevations provided in other datums were converted to the NAVD88 datum.

2.2 Assumptions

The following assumptions were used for this analysis:

- Vertical Datum: NAVD88
- In the reach of the Sacramento River being studied, WSELs at specific locations can be approximated by linear interpolation between statistical WSEL values (for example, 99 percent exceedance level) from adjacent DWR and USGS stations.

3. Analysis and Evaluation

3.1 Development of Lower Boundary Stage-Duration Curves

3.1.1 Datum Comparison

The vertical datum used for the Project, including all data in this TM, are NAVD88. This section provides a discussion of the datum verification for each station used for the analysis.

3.1.1.1 Sacramento River at I Street Bridge (IST) Station Datum

The IST station data are National Geodetic Vertical Datum 1929 (NGVD29). To convert the data into NAVD88, a conversion factor was applied from NGVD29 to NAVD88 elevations. The NGS VERTCON tool was used to determine the appropriate conversion value from NGVD29 to NAVD88 of +2.37 feet (NGVD29 elevation + 2.37 = NAVD88 elevation).

3.1.1.2 Sacramento River at Freeport (FPT) Station Datum

The FPT station data are NGVD29 with a 100-foot factor added on. To convert the data into NAVD88, 100 was subtracted from the FPT gage data. A conversion factor was then applied from NGVD29 to NAVD88 elevations. The NGS VERTCON tool was used to determine the appropriate conversion value from NGVD29 to NAVD88 of +2.477 feet (NGVD29 elevation + 2.477 = NAVD88 elevation).

3.1.1.3 Sacramento River above Delta Cross Channel (SDC) Station Datum

The SDC station data are NAVD88. No data conversion was conducted for this station. The datum was confirmed with the USGS. Additionally, data from the Georgiana Slough at Sacramento River (a nearby station) were reviewed to confirm the validity of the elevations at the SDC station.

3.1.2 Data Analysis

All the data downloaded were reviewed for significant outliers (that is, erroneous negative or extremely large positive values). These values were removed from the data set included in this analysis.

To facilitate the data analysis, every 10^{th} data point was selected to create the stage-duration curve with a condensed data set. A comparison was done between the full and the condensed data sets (every 10th value). The comparison showed a negligible difference between the full and the condensed data set curves; therefore, the condensed data sets were used to generate the stage-duration curves.

3.1.3 Stage-Duration Curves

For each DWR and USGS station, stage-duration curves were developed and used to find the 99 percent exceedance value. The stage-duration curves were established by plotting the percent exceedance for each water level within the data set. The curves shown in this section are based on the annual exceedance values. Attachment 1 includes larger versions of these figures. Attachment 2 includes monthly stage-duration curves for each gaging station for reference.

3.1.3.1 Sacramento River at I Street Bridge (IST) Station

Figure 2 shows the annual stage-duration curve for the IST station. The curve has elevation (stage) shown on the y axis in feet (NAVD88 data) and percent duration shown on the x axis. The 95 percent exceedance value is 5.02 feet, and the 99 percent exceedance value is 4.38 feet. This means that 99 percent of the time, the WSEL at IST is higher than 4.38 feet.

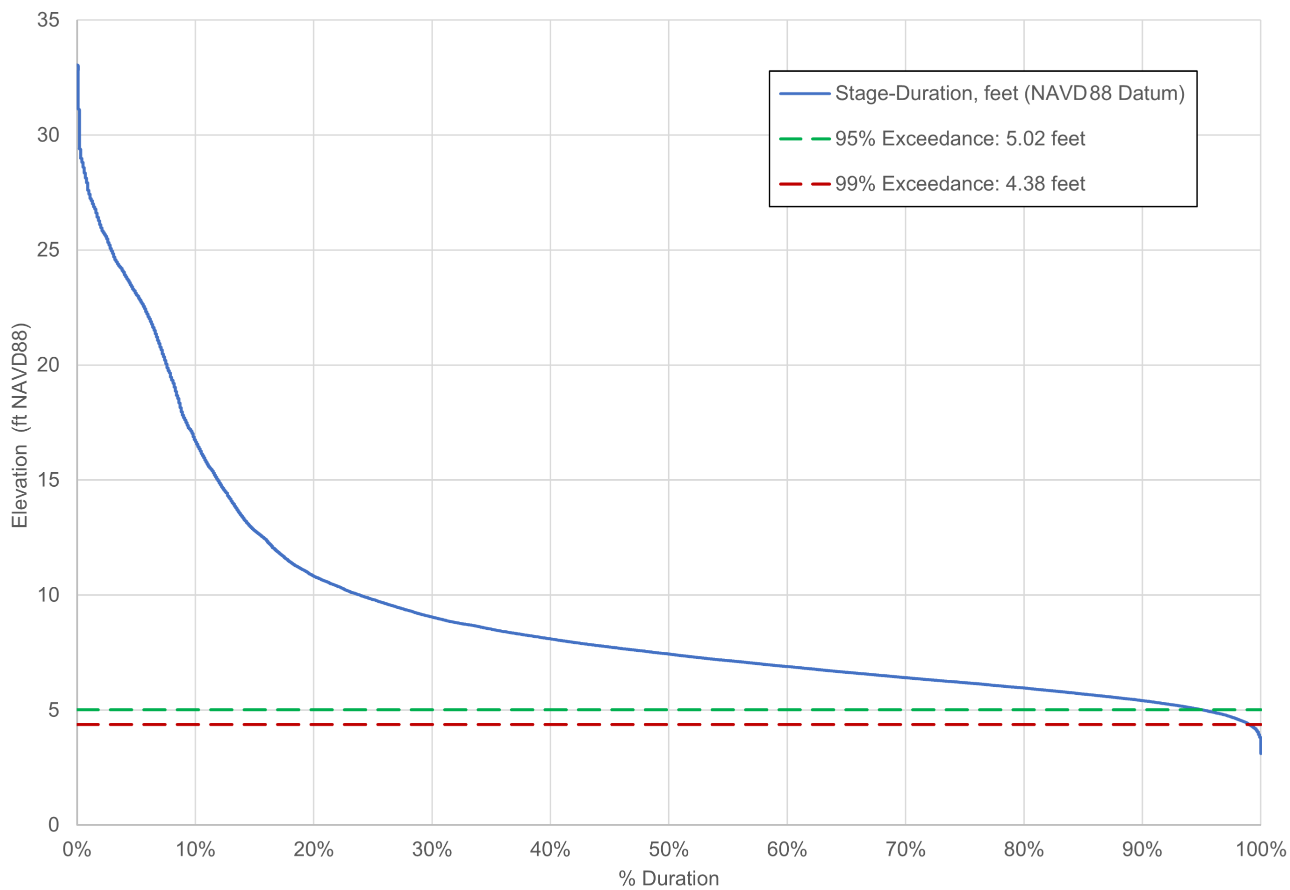


Figure 2. Annual Stage-Duration Curve for IST Station

3.1.3.2 Sacramento River at Freeport (FPT) Station

Figure 3 shows the annual stage-duration curve for the FPT station. The 95 percent exceedance value is 4.56 feet, and the 99 percent exceedance value is 4.02 feet. This means that 99 percent of the time, the WSEL at FPT is higher than 4.B02 feet.

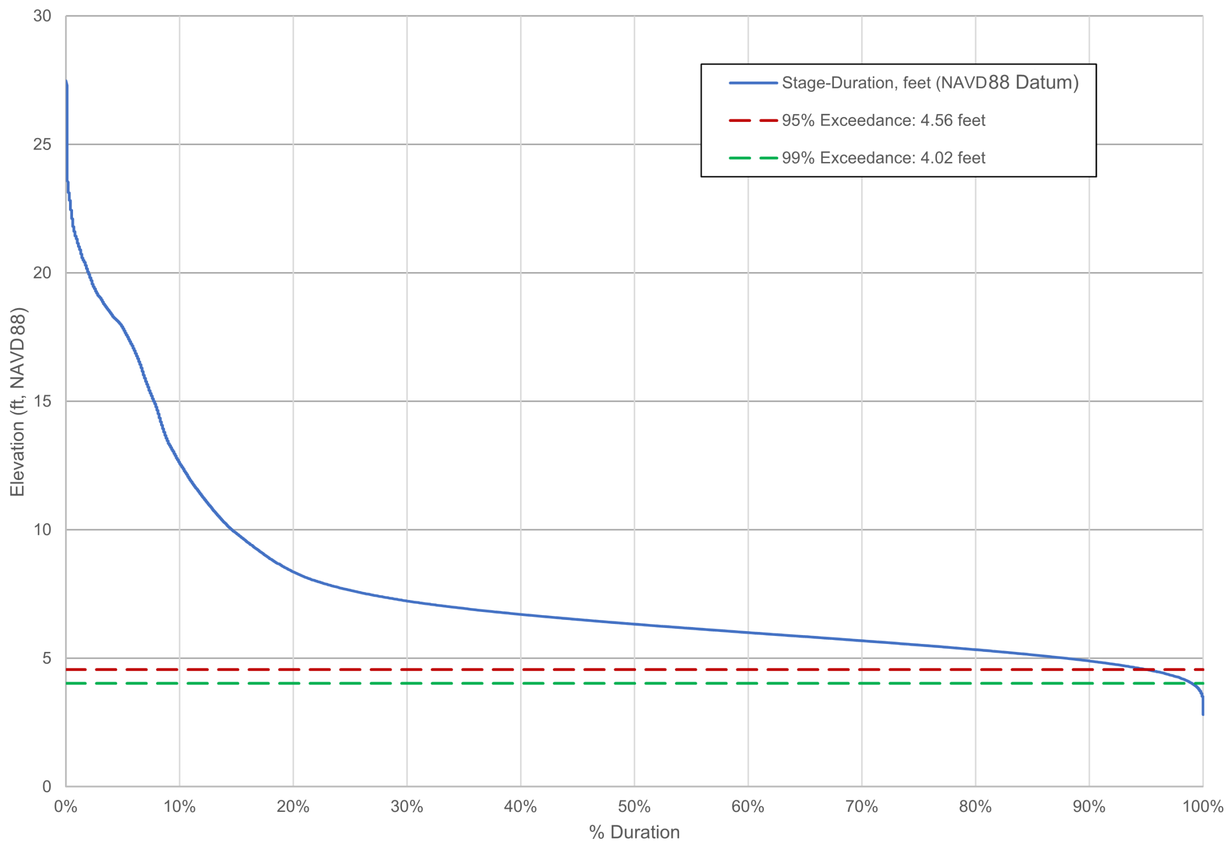


Figure 3. Annual Stage-Duration Curve for FPT Station

3.1.3.3 Sacramento River above Delta Cross Channel (SDC) Station

Figure 4 shows the annual stage-duration curve for the SDC station. The 95 percent exceedance value is 3.76 feet, and the 99 percent exceedance value is 3.21 feet. This means that 99 percent of the time, the WSEL at SDC is higher than 3.21 feet.

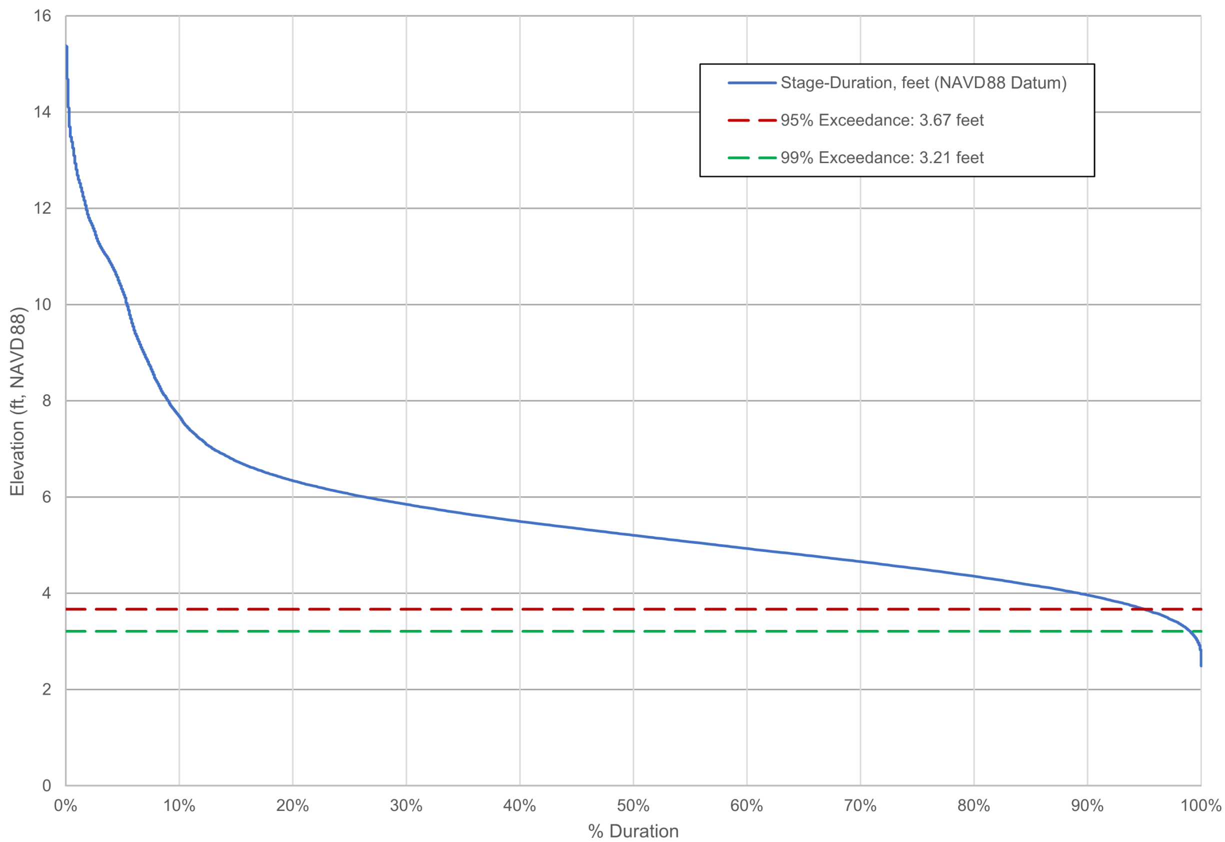


Figure 4. Annual Stage-Duration Curve for SDC Station

3.2 Median Annual Maximum Water Surface Elevation

Using the data collected for each station, the median annual maximum WSEL was calculated. This was done by tabulating the maximum WSEL recorded each year in the period of record, and then determining the median of that data set. Table 3 shows the values for each station.

Table 3. Estimated Median Annual Maximum WSEL at DWR and USGS Stations

Station	RM	Estimated Median Annual Maximum WSEL (feet, NAVD88)
Sacramento River at I Street Bridge (IST)	59.4	25.14
Sacramento River at Freeport (FPT)	46.3	19.16
Sacramento River above Delta Cross Channel (SDC)	27.5	11.41

3.3 Intake Location Water Surface Elevations

The 99 percent exceedance WSEL and median annual maximum WSEL were determined for each intake location. As shown on Figure 1, the intakes are all located between the FPT and SDC gaging stations. The 99 percent exceedance WSEL and median annual maximum WSEL for the intake locations were determined by linear interpolation using their RM and those of the adjacent gaging stations.

Figure 5 shows the 99 percent exceedance WSEL and the median annual maximum WSEL values at each DWR and USGS station, a linear trendline between the gaging station data points, and the interpolated values at each intake. This figure helps demonstrate the validity of the assumption that linear interpolation provides suitable values between stations, since all three stations essentially fall on a straight line for both low and high WSELs. Tables 4 and 5 show the interpolated values for the intake locations.

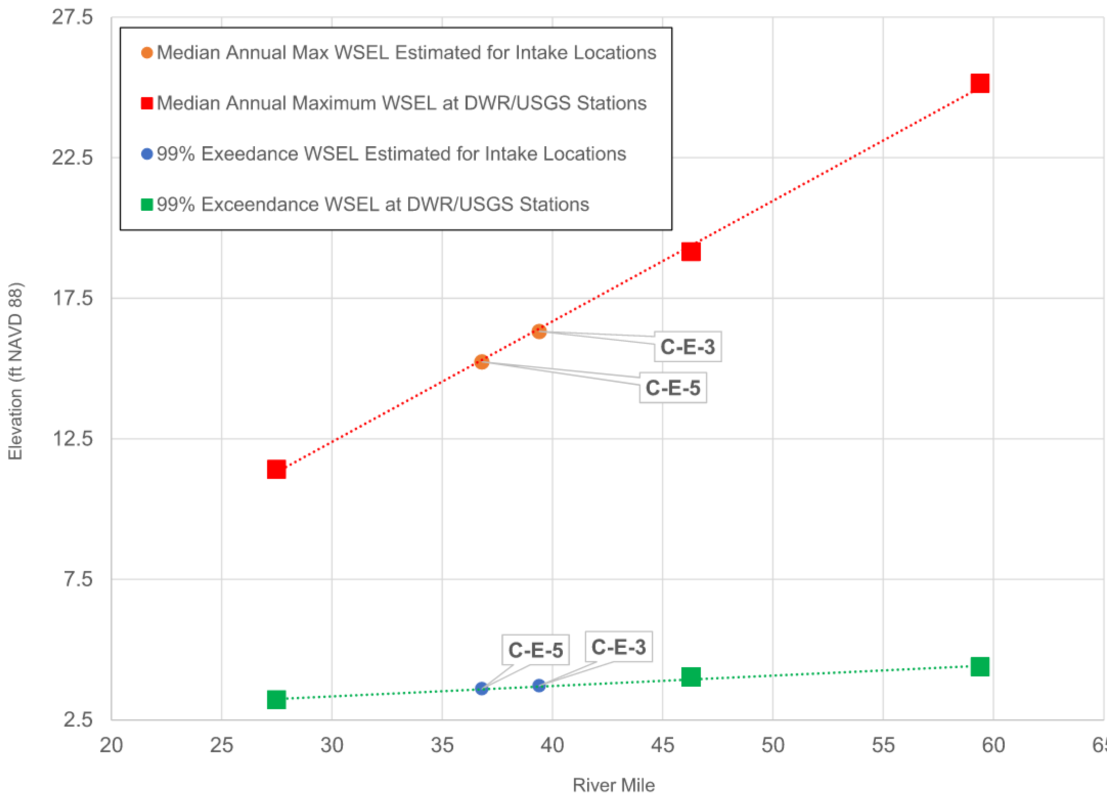


Figure 5. Median Annual Maximum WSEL and 99% Exceedance WSEL at DWR and USGS Stations and Intake Locations

3.3.1 Low WSEL Boundary

Table 4 shows the estimated 99 percent exceedance WSEL at each intake location.

Table 4. 99 Percent Exceedance WSELs at Intake Locations

Intake	Description	RM	Estimated 99% Exceedance WSEL (ft, NAVD88)
not applicable	DWR Gaging Station at I Street Bridge (IST)	59.4	4.38
not applicable	USGS Gaging Station at Freeport (FPT)	46.3	4.02
C-E-3	Central and East Corridor Intake 3, north of Hood, eastern side	39.4	3.72
C-E-5	Central and East Corridor Intake 5, north of Snodgrass Slough, eastern side	36.8	3.61
not applicable	USGS Gaging Station at Delta Cross Channel (SDC)	27.5	3.21

3.3.2 Median Annual Maximum Water Surface Elevation

Table 5 shows the median annual maximum WSEL at each intake location.

Table 5. Median Annual Maximum WSELs at Intake Locations

Intake	Description	RM	Estimated Median Annual Maximum WSEL (ft, NAVD88)
not applicable	DWR Gaging Station at I Street Bridge (IST)	59.4	25.14
not applicable	USGS Gaging Station at Freeport (FPT)	46.3	19.16
C-E-3	Central and East Corridor Intake 3, north of Hood, eastern side	39.4	16.32
C-E-5	Central and East Corridor Intake 5, north of Snodgrass Slough, eastern side	36.8	15.24
not applicable	USGS Gaging Station at Delta Cross Channel (SDC)	27.5	11.41

4. Conclusions and Recommendations

Per the data collected and analyzed using the methods discussed in this TM, it is recommended to use the values shown in Table 6 for sizing and analyses for the Project intakes.

Table 6. Design WSELs at Intake Locations

Intake	Description	RM	Estimated 99% Exceedance (ft, NAVD88)	Estimated Median Annual Maximum WSEL (ft, NAVD88)
C-E-3	Intake 3, north of Hood, eastern side	39.4	3.72	16.32
C-E-5	Intake 5, north of Snodgrass Slough, eastern side	36.8	3.61	15.24

5. References

California Department of Water Resources (DWR). 2010. *Technical Memorandum – Initial Intake Hydraulic Analyses, Delta Habitat Conservation and Conveyance Program (DHCCP).* Revision 0.

California Department of Water Resources (DWR). 2017a. *California Data Exchange Center*. Accessed August 28, 2019. http://cdec.water.ca.gov/index.html.

California Department of Water Resources (DWR). 2017b. "Sacramento River at I Street Bridge." *California Data Exchange Center.* Accessed November 2019. http://cdec.water.ca.gov/dynamicapp/staMeta?station_id=IST.

California Department of Water Resources (DWR). 2017c. "Sacramento River at Freeport. *California Data Exchange Center.* Accessed November 2019. http://cdec.water.ca.gov/dynamicapp/staMeta?station_id=FPT.

California Department of Water Resources (DWR). 2017d. "Georgiana Slough at Sacramento River." *California Data Exchange Center*. Accessed November 2019. https://cdec.water.ca.gov/dynamicapp/staMeta?station_id=GSS

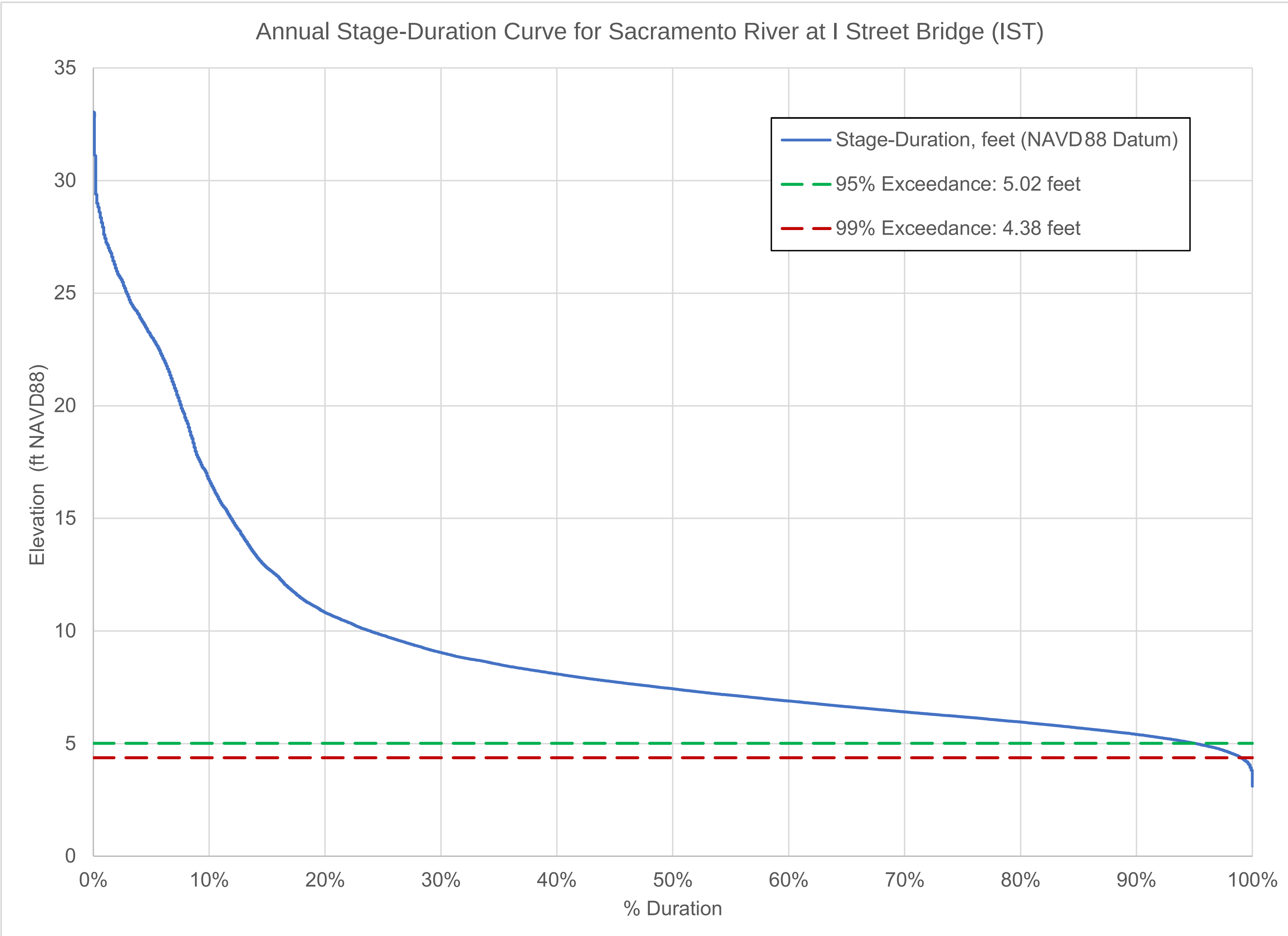
California WaterFix. 2018. *Conceptual Engineering Report California WaterFix Byron Tract Forebay Option (WaterFix BTO)*.

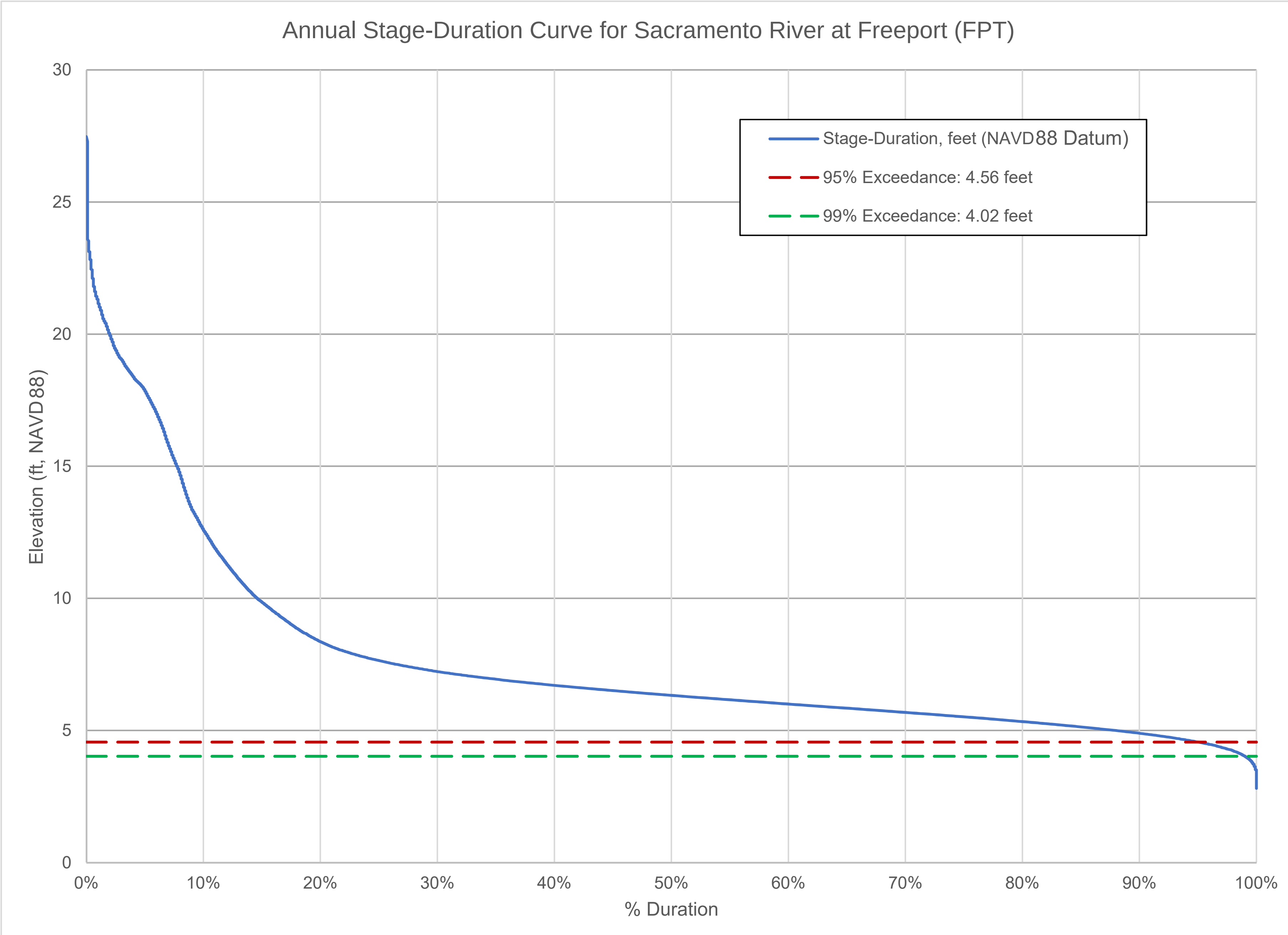
National Geodetic Survey (NGS). 2017. *VERTCON – North American Vertical Datum Conversion*. May 16. https://www.ngs.noaa.gov/TOOLS/Vertcon/vertcon.html.

U.S. Geological Survey (USGS). 2019a. *National Water Information System: Web Interface*. November 6. https://waterdata.usgs.gov/nwis/.

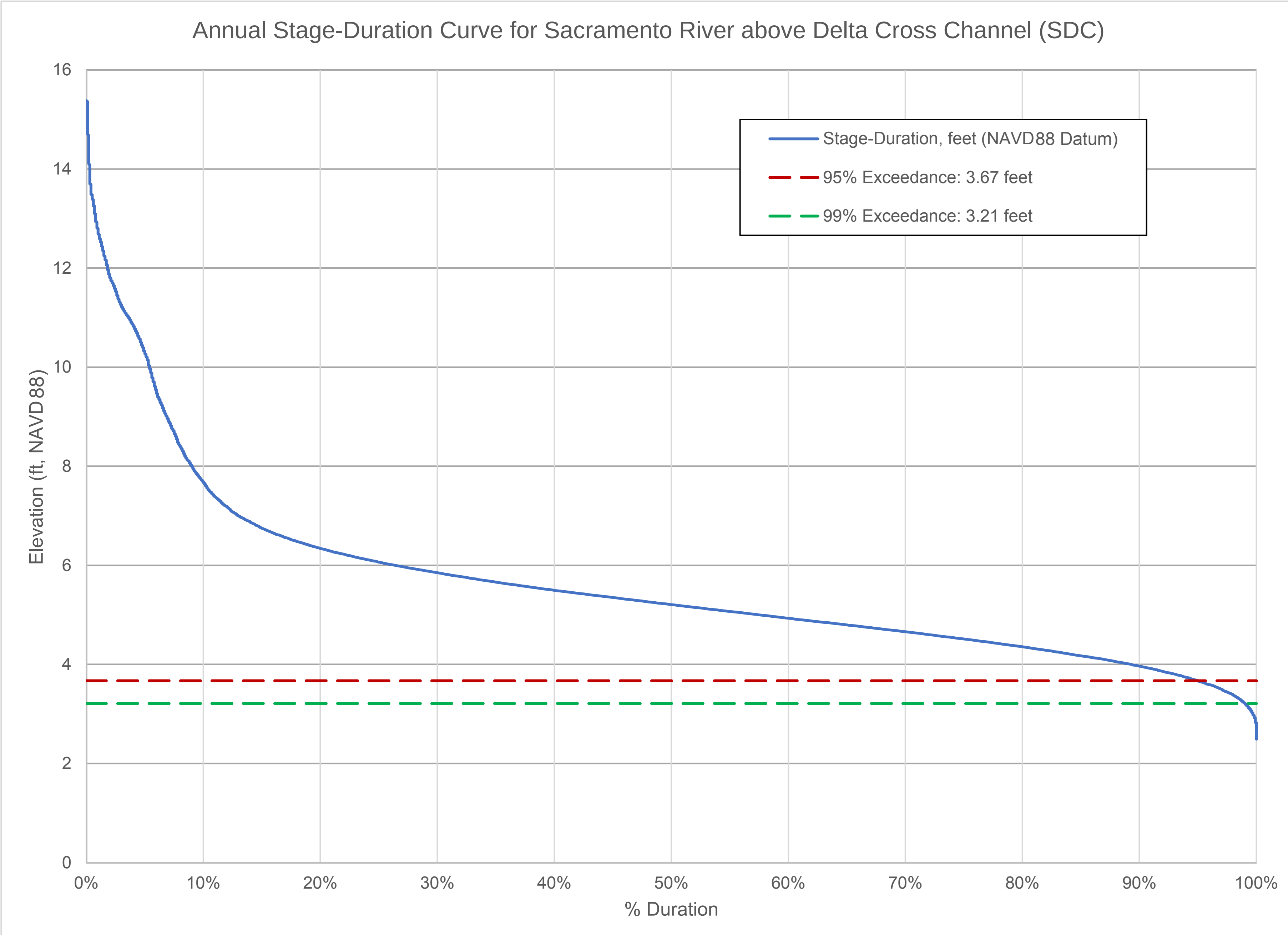
U.S. Geological Survey (USGS). 2019b. "USGS 11447890 Sacramento R AB Delta Cross Channel CA." *NWIS Site Information for USA: Site Inventory*. https://waterdata.usgs.gov/nwis/inventory/?site_no=11447890&agency_cd=USGS&amp

Attachment 1
Annual Stage-Discharge Curves: IST, FPT, and SDC

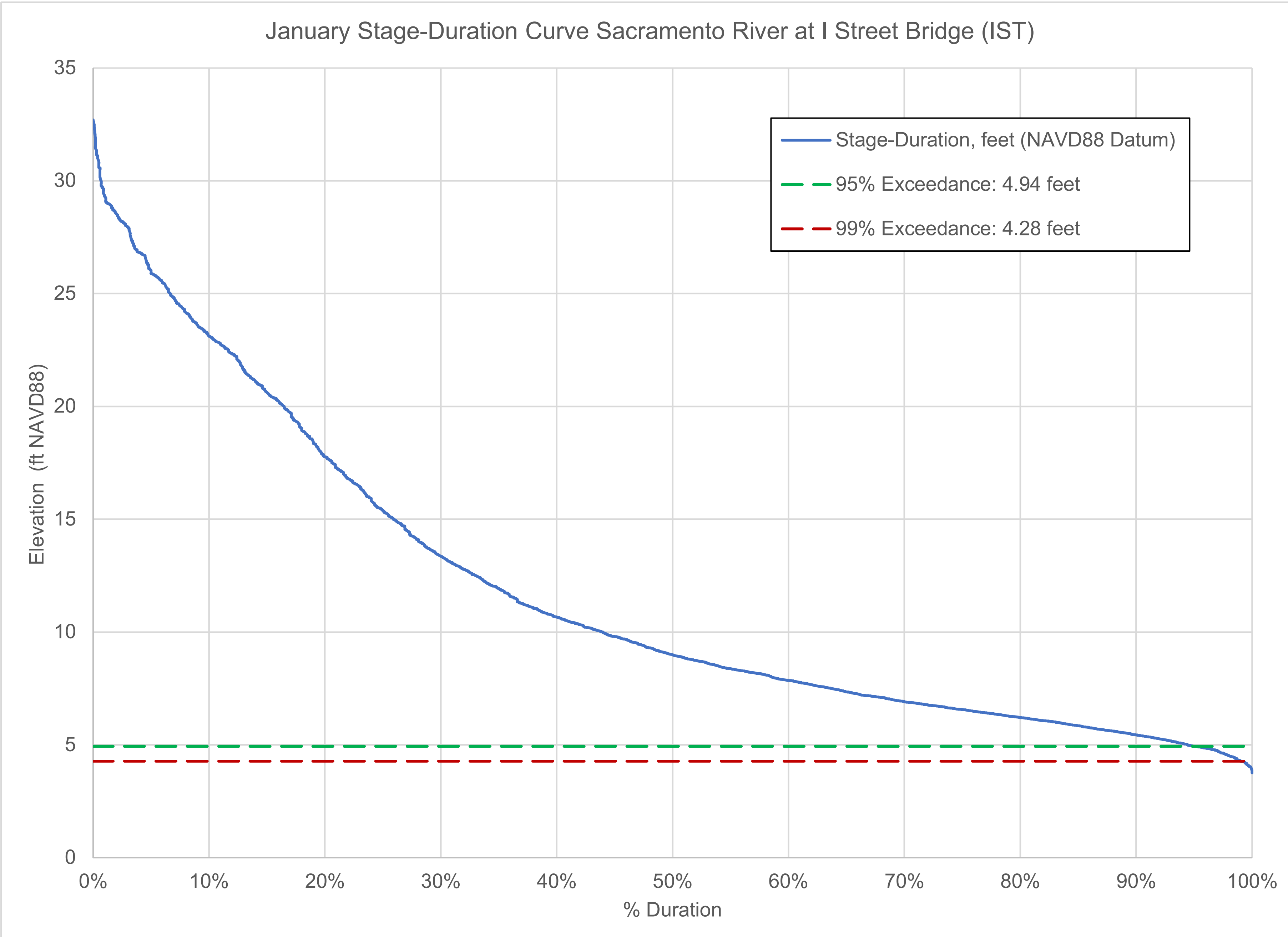

Annual Stage-Duration Curve for Sacramento River at I Street Bridge (IST)
Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 5.02 feet
99% Exceedance: 4.38 feet
Elevation (ft NAVD88)
35
30
25
20
15
10
5
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
% Duration



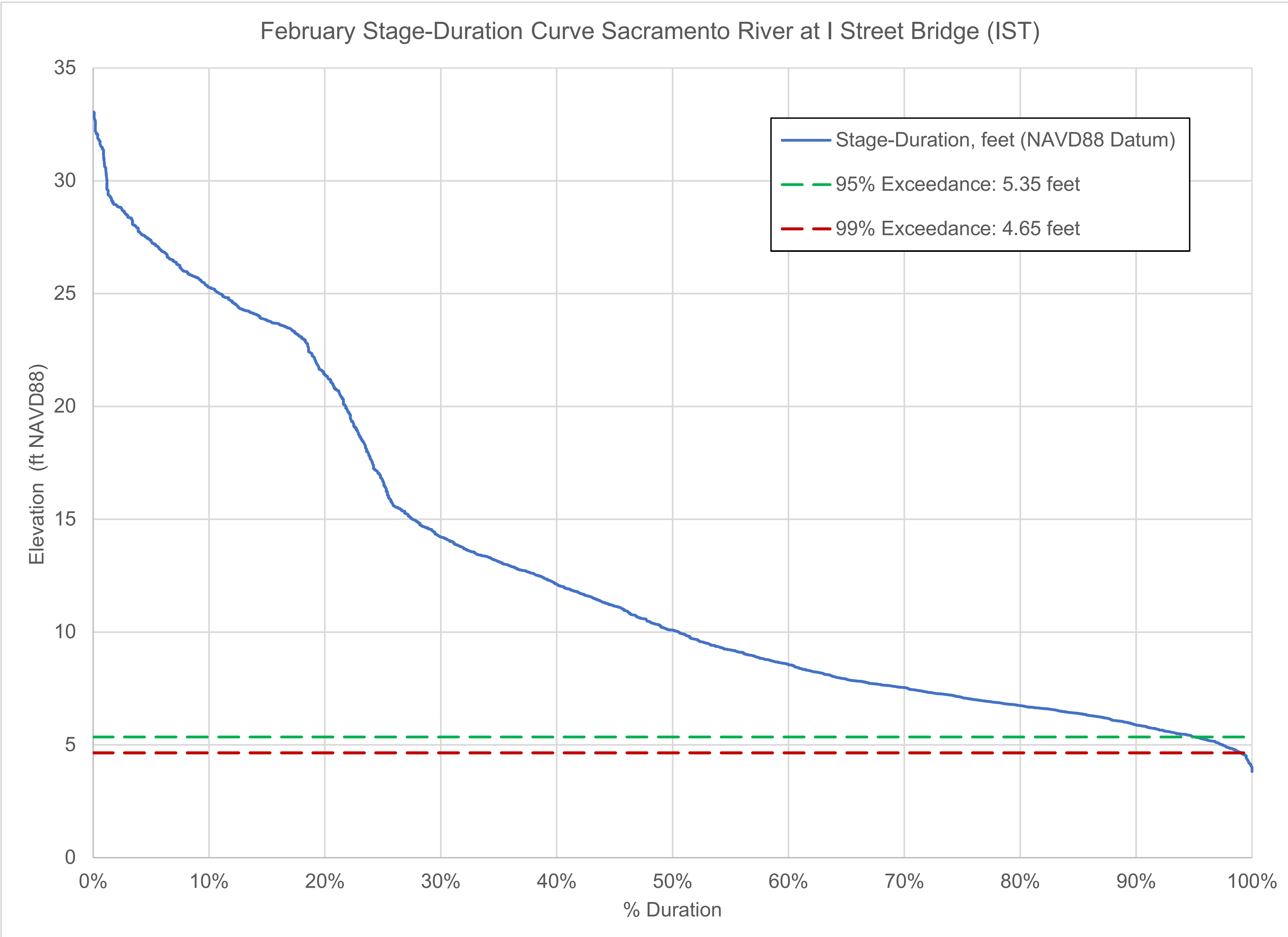
Annual Stage-Duration Curve for Sacramento River at Freeport (FPT)
Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 4.56 feet
99% Exceedance: 4.02 feet
Elevation (ft, NAVD88)
30
25
20
15
10
5
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
% Duration

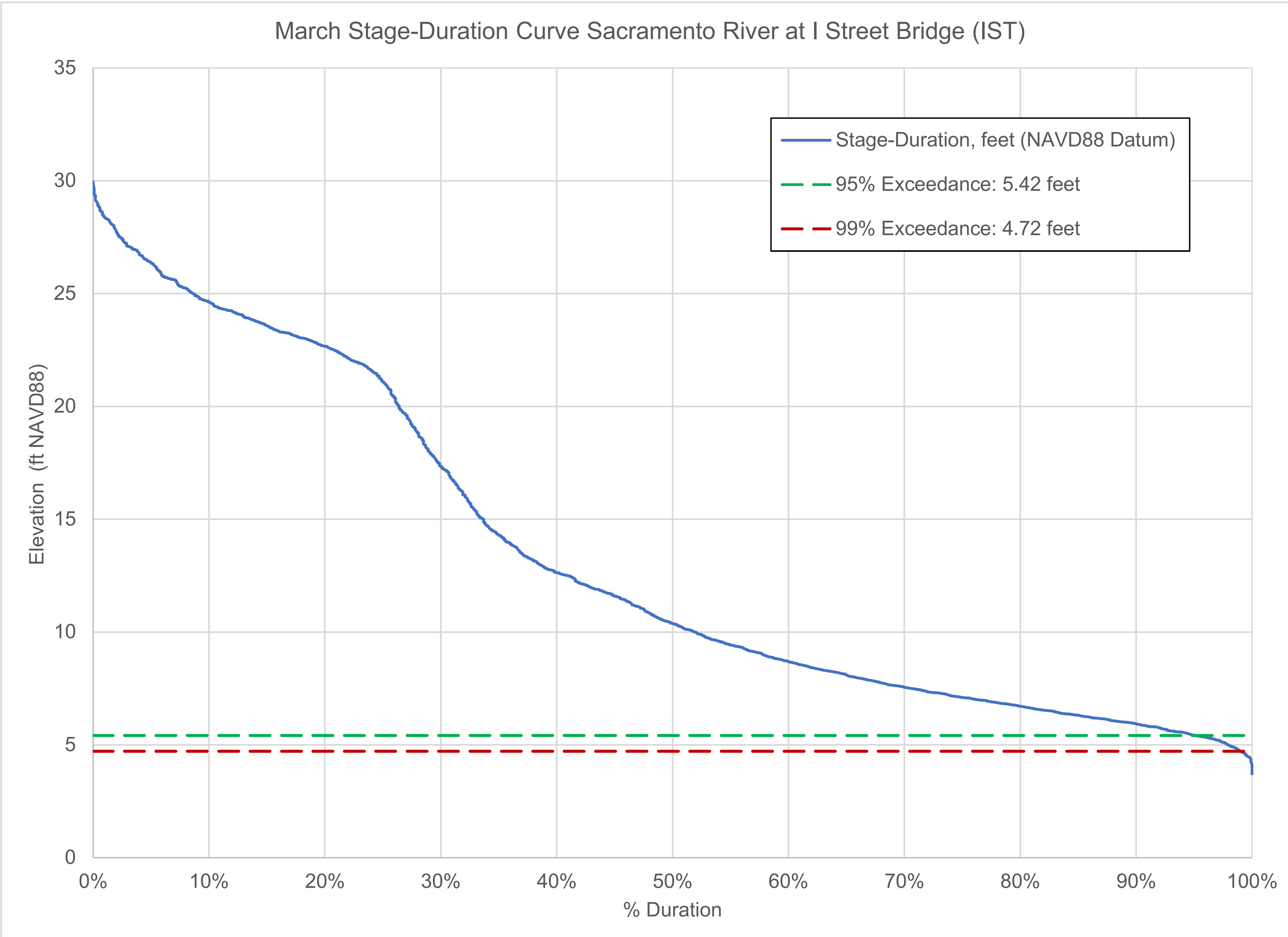

Annual Stage-Duration Curve for Sacramento River above Delta Cross Channel (SDC)
Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 3.67 feet
99% Exceedance: 3.21 feet
Elevation (ft, NAVD88)
16
14
12
10
8
6
4
2
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
% Duration

Attachment 2
Monthly Stage-Discharge Curves: IST, FPT, and SDC

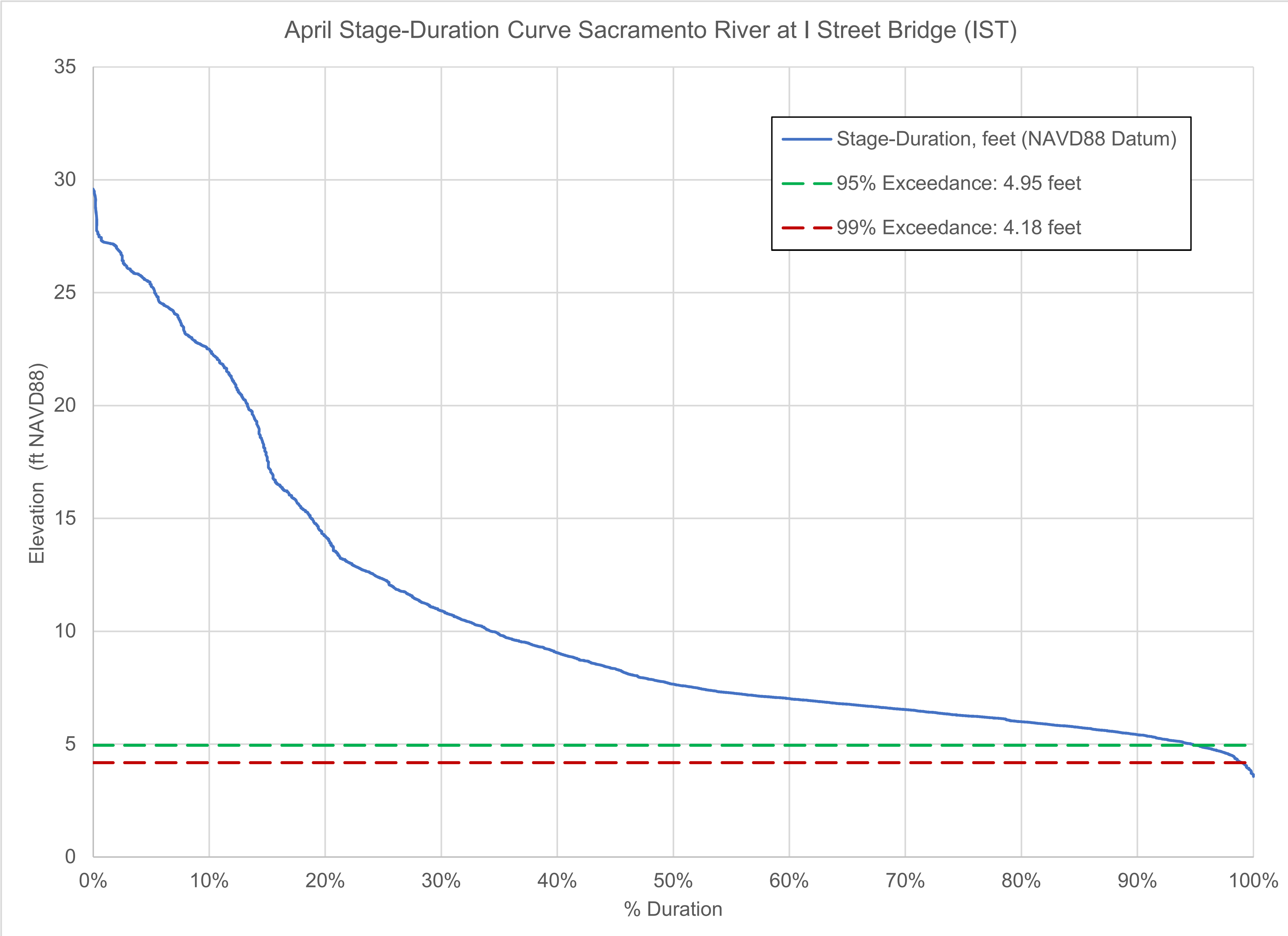


January Stage-Duration Curve Sacramento River at I Street Bridge (IST)
Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 4.94 feet
99% Exceedance: 4.28 feet
Elevation (ft NAVD88)
% Duration
0
5
10
15
20
25
30
35
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

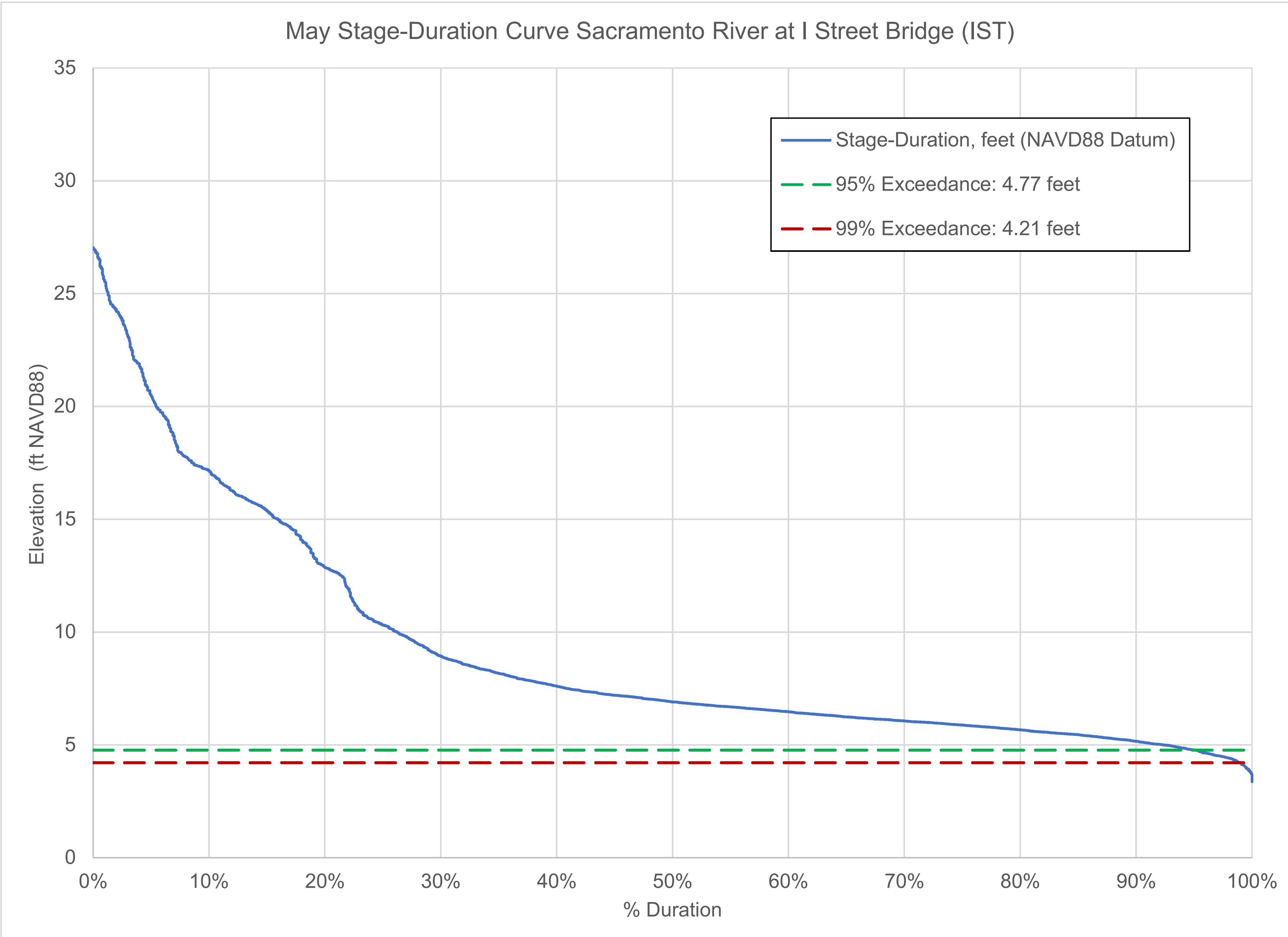

February Stage-Duration Curve Sacramento River at I Street Bridge (IST)
Elevation (ft NAVD88)
% Duration
0
5
10
15
20
25
30
35
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 5.35 feet
99% Exceedance: 4.65 feet

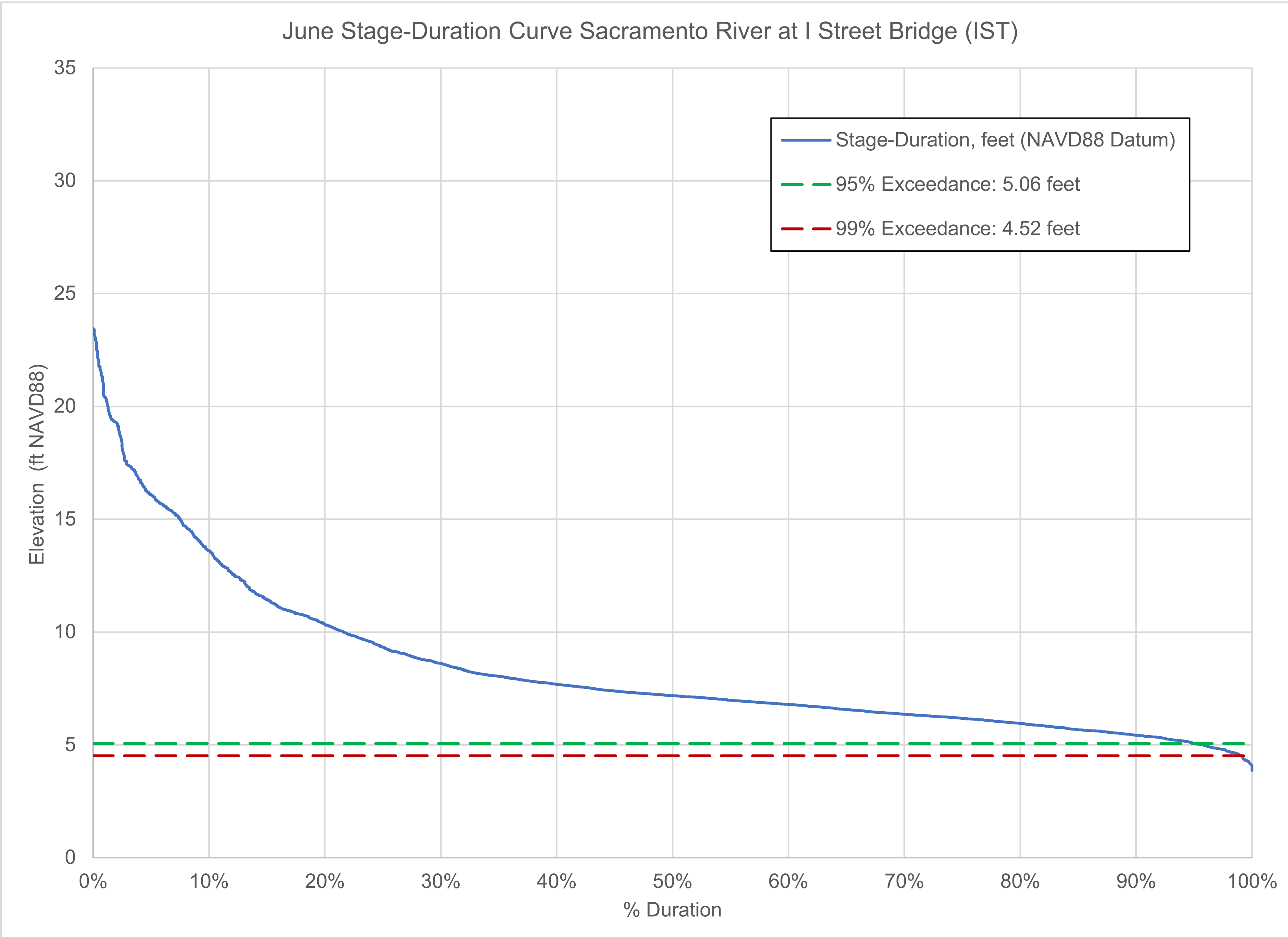


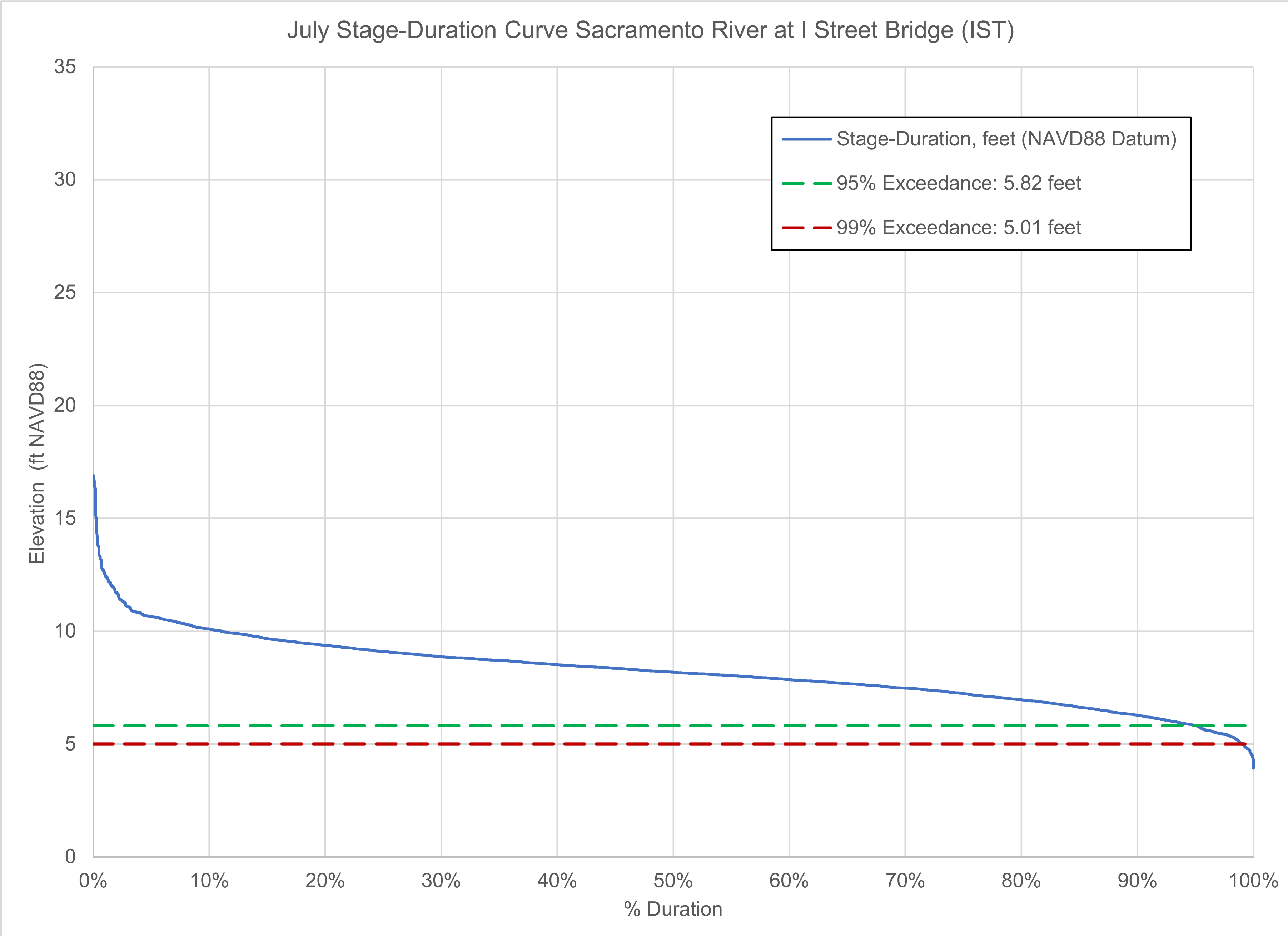
March Stage-Duration Curve Sacramento River at I Street Bridge (IST)
Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 5.42 feet
99% Exceedance: 4.72 feet
Elevation (ft NAVD88)
35
30
25
20
15
10
5
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
% Duration

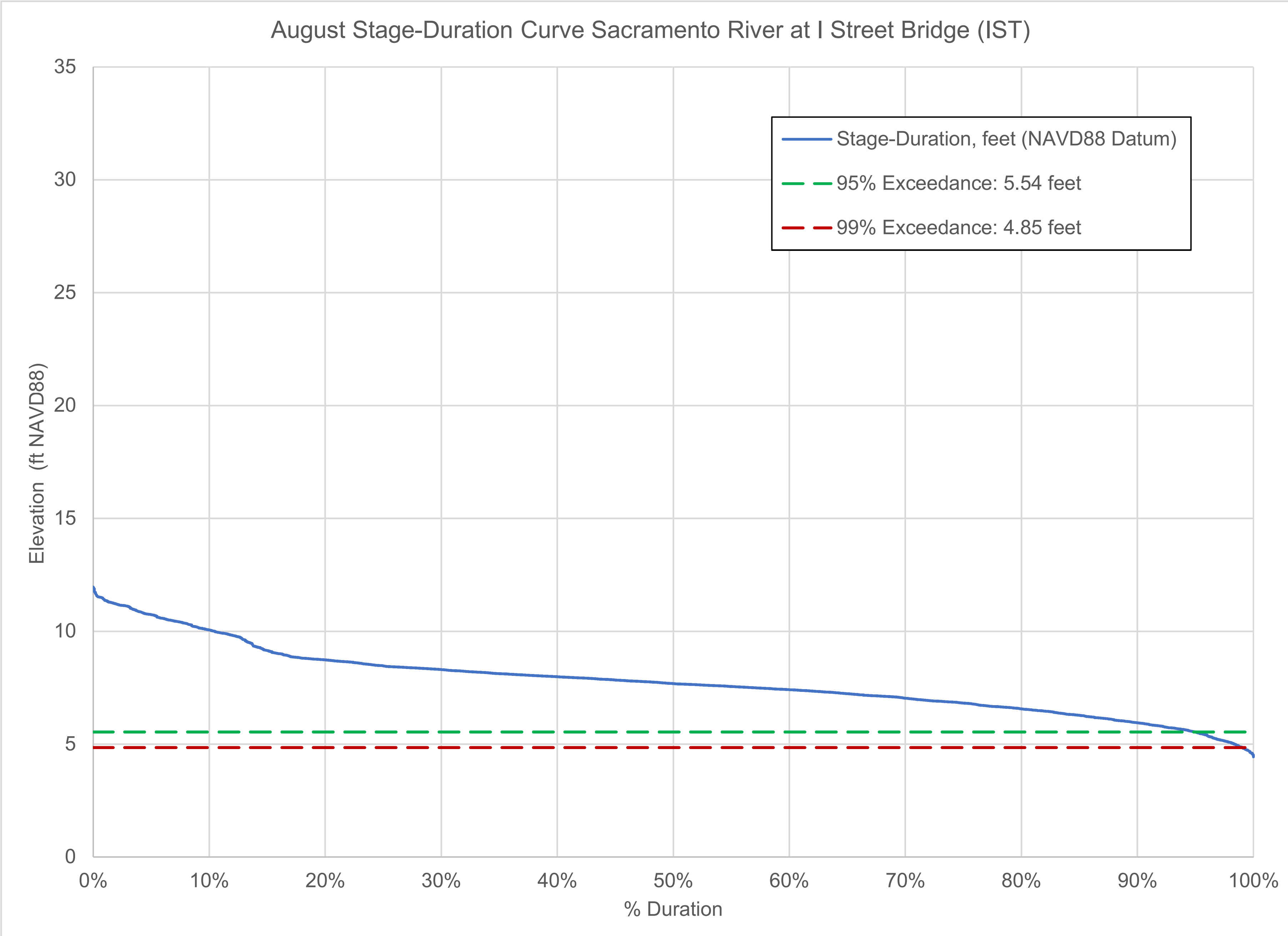


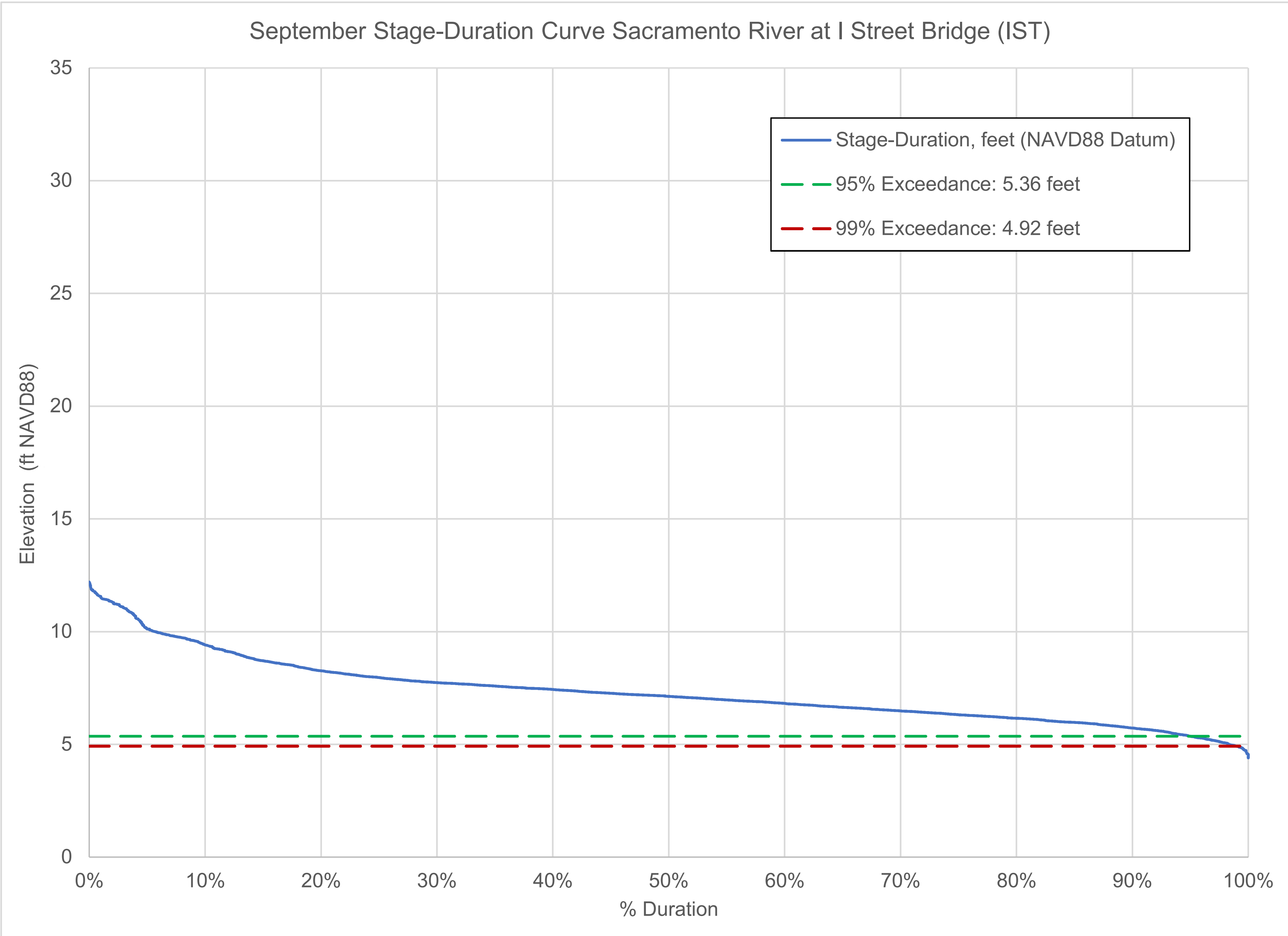
April Stage-Duration Curve Sacramento River at I Street Bridge (IST)
Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 4.95 feet
99% Exceedance: 4.18 feet
Elevation (ft NAVD88)
% Duration
0
5
10
15
20
25
30
35
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

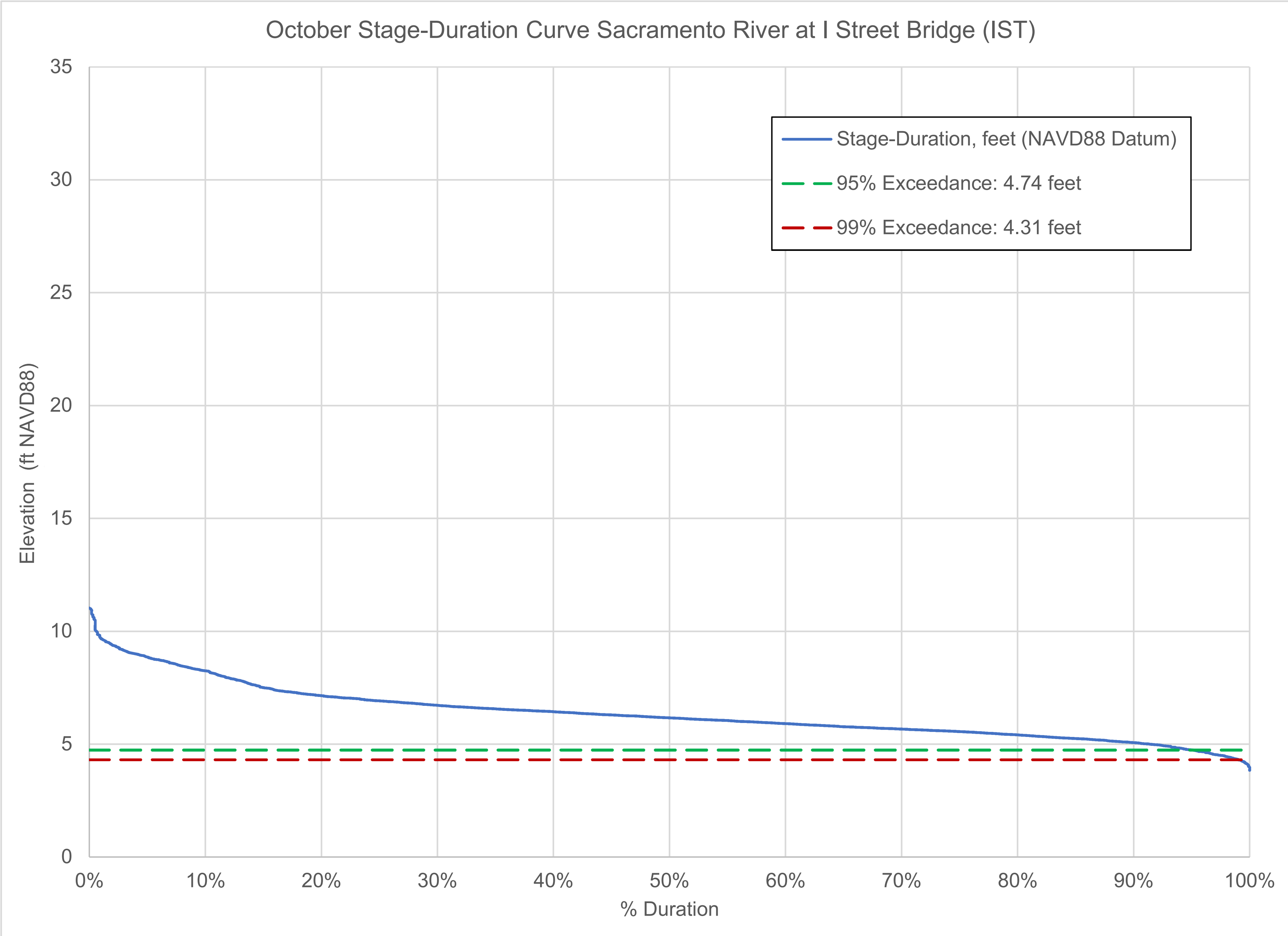

May Stage-Duration Curve Sacramento River at I Street Bridge (IST)
Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 4.77 feet
99% Exceedance: 4.21 feet
Elevation (ft NAVD88)
35
30
25
20
15
10
5
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
% Duration

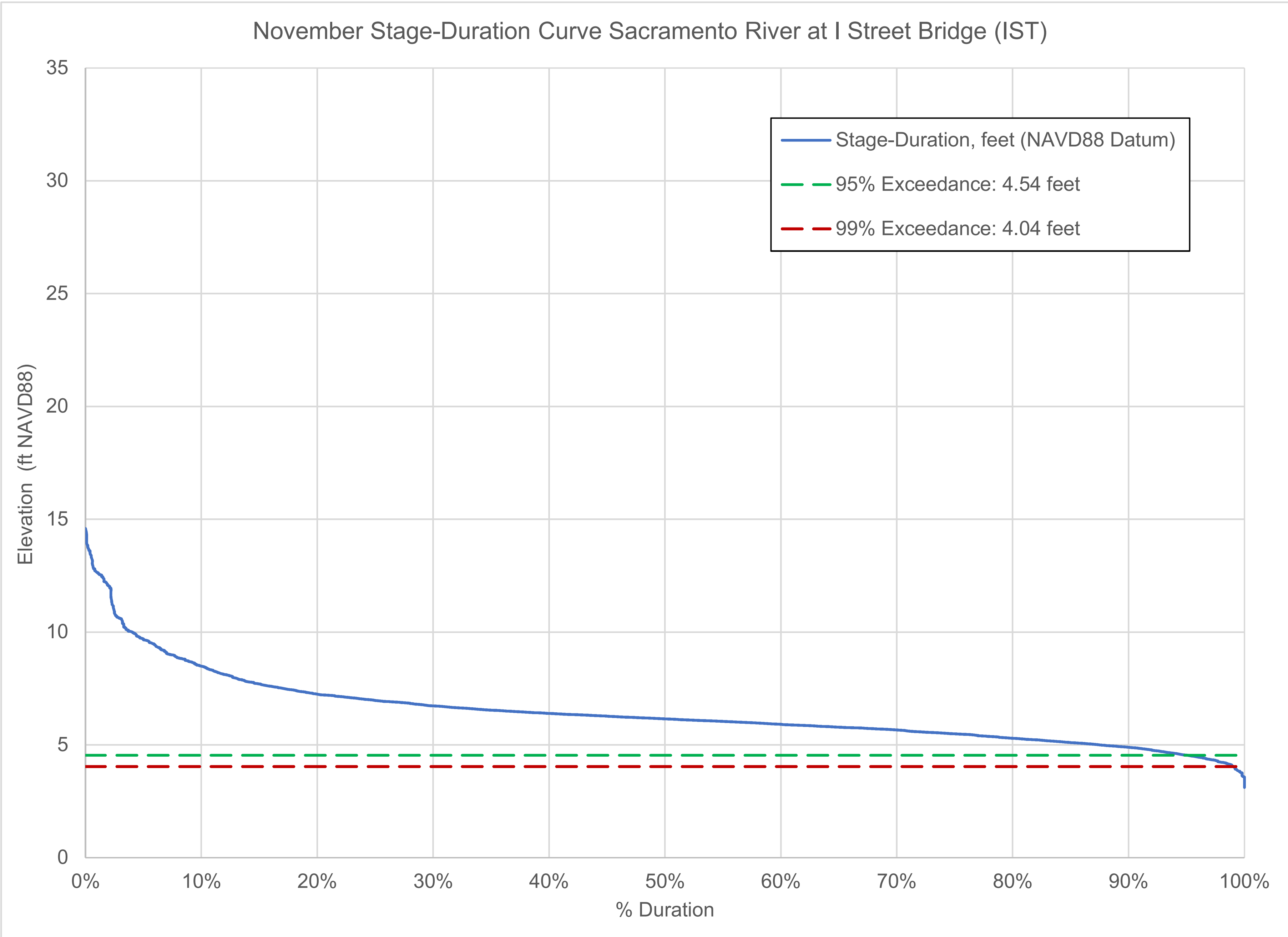

June Stage-Duration Curve Sacramento River at I Street Bridge (IST)
35
30
25
20
15
10
5
0
Elevation (ft NAVD88)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
% Duration
Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 5.06 feet
99% Exceedance: 4.52 feet

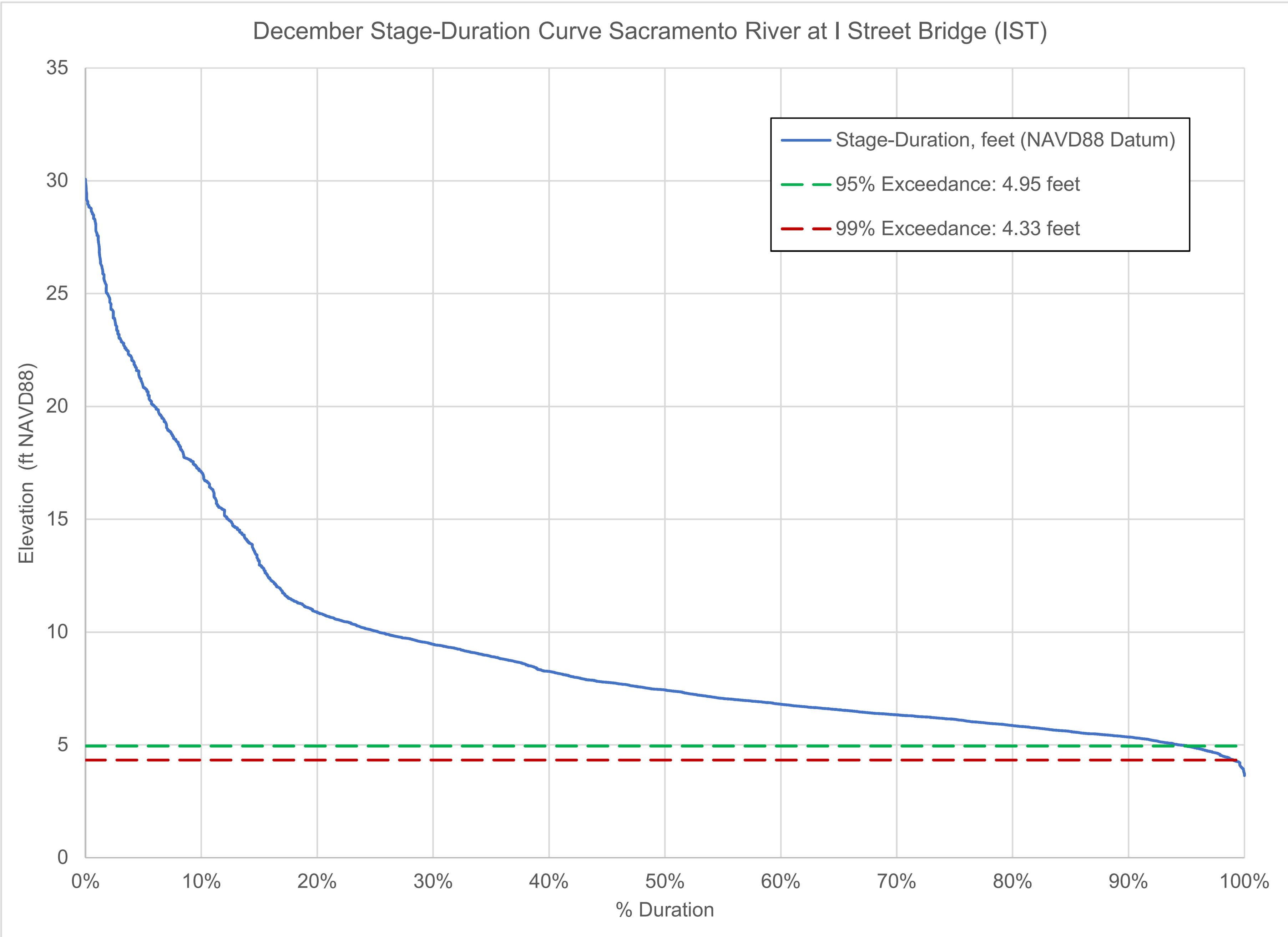

July Stage-Duration Curve Sacramento River at I Street Bridge (IST)
Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 5.82 feet
99% Exceedance: 5.01 feet
Elevation (ft NAVD88)
35
30
25
20
15
10
5
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
% Duration


August Stage-Duration Curve Sacramento River at I Street Bridge (IST)
Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 5.54 feet
99% Exceedance: 4.85 feet
Elevation (ft NAVD88)
35
30
25
20
15
10
5
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
% Duration

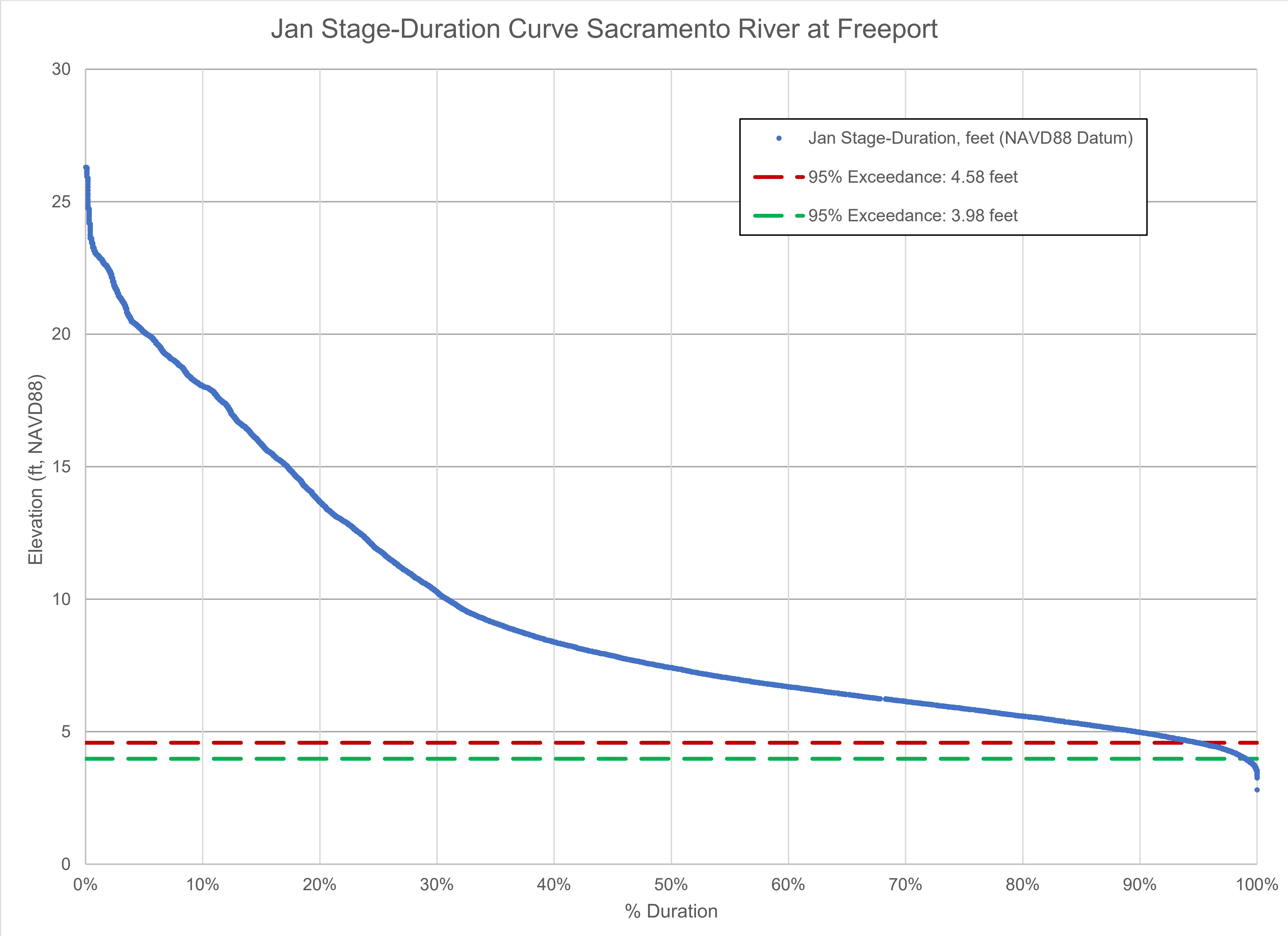

September Stage-Duration Curve Sacramento River at I Street Bridge (IST)
Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 5.36 feet
99% Exceedance: 4.92 feet
Elevation (ft NAVD88)
35
30
25
20
15
10
5
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
% Duration

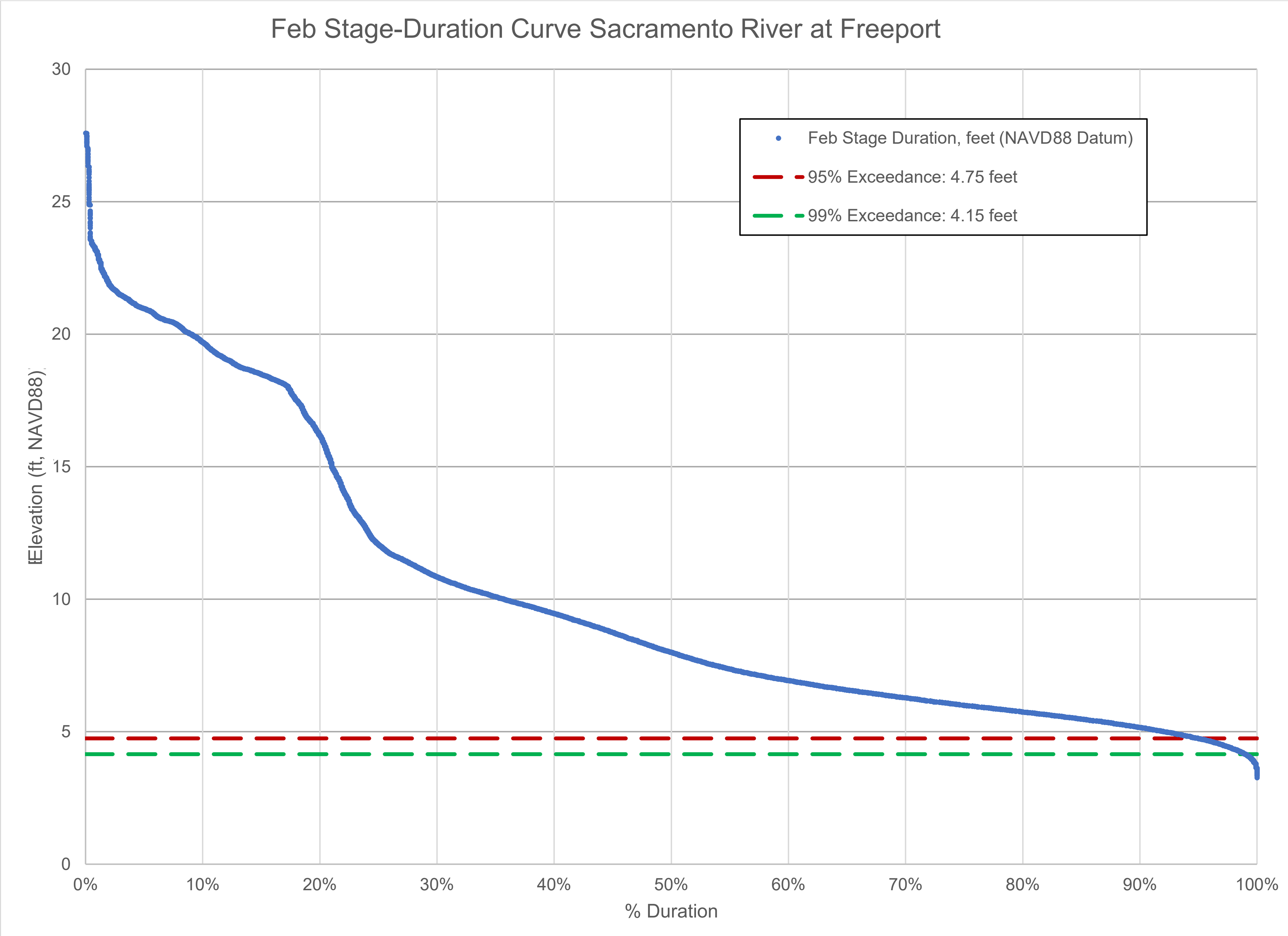

October Stage-Duration Curve Sacramento River at I Street Bridge (IST)
Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 4.74 feet
99% Exceedance: 4.31 feet
Elevation (ft NAVD88)
35
30
25
20
15
10
5
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
% Duration


November Stage-Duration Curve Sacramento River at I Street Bridge (IST)
Elevation (ft NAVD88)
% Duration
Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 4.54 feet
99% Exceedance: 4.04 feet
0
5
10
15
20
25
30
35
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

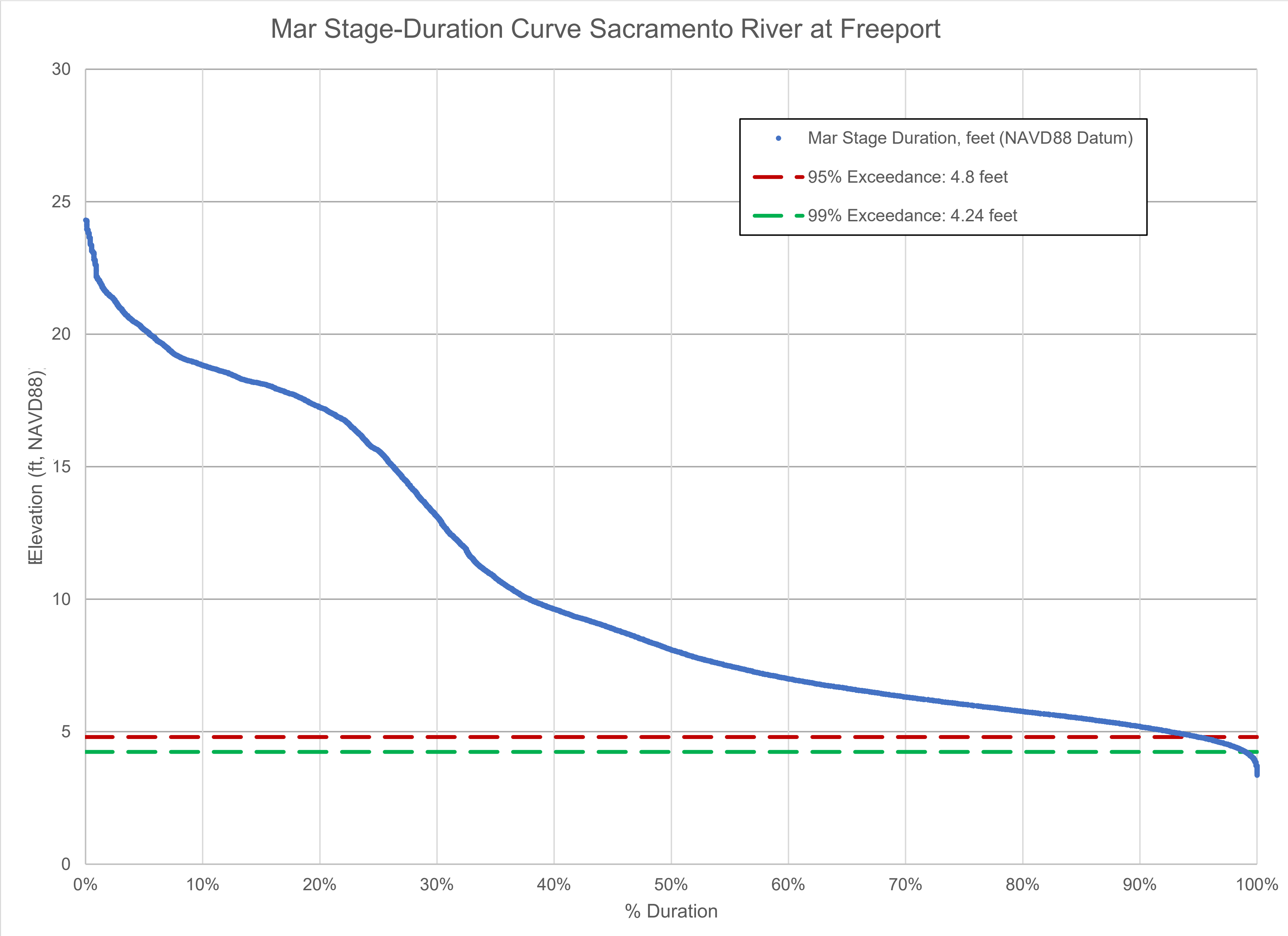


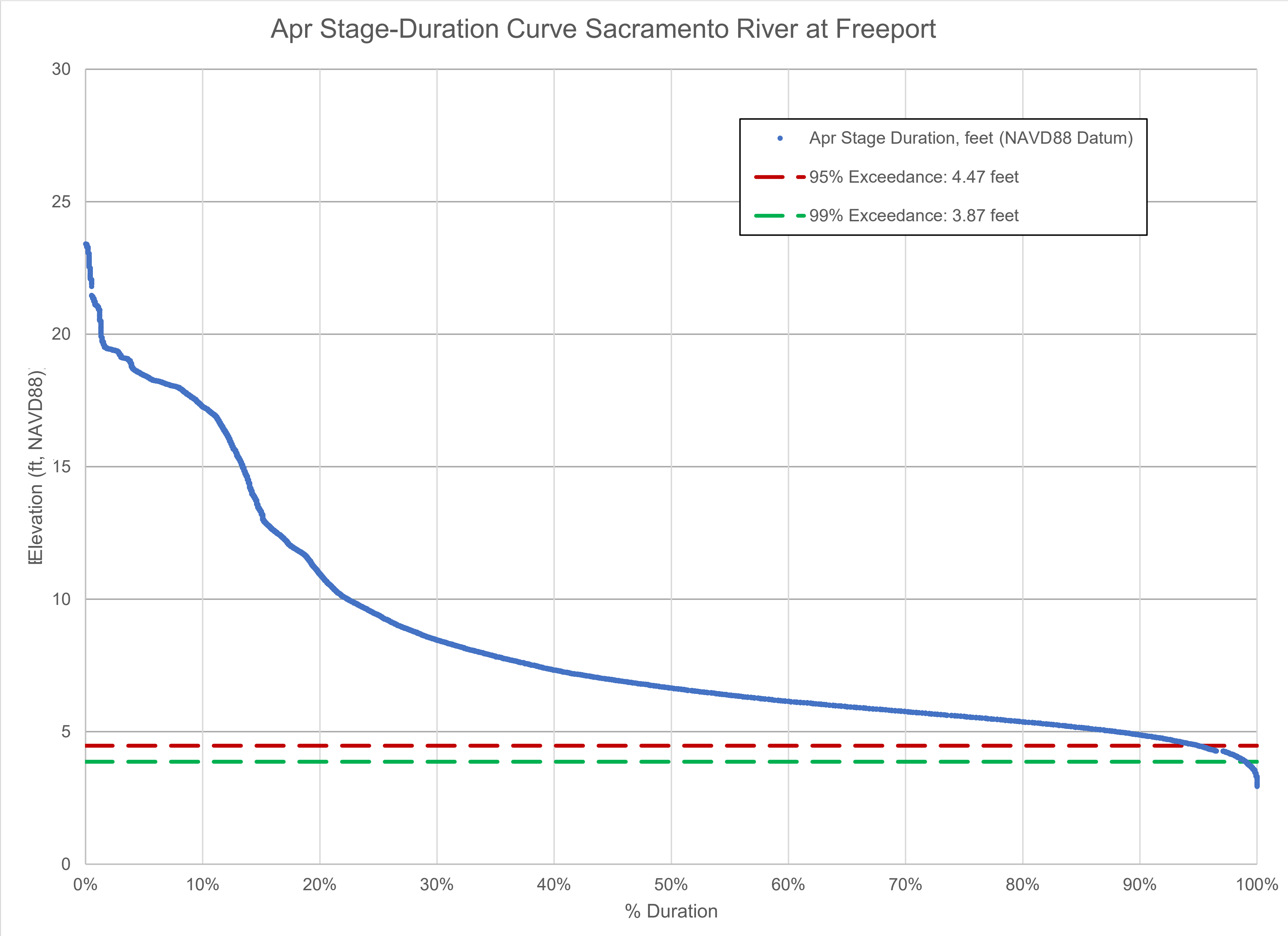
December Stage-Duration Curve Sacramento River at I Street Bridge (IST)
Elevation (ft NAVD88)
% Duration
35
30
25
20
15
10
5
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 4.95 feet
99% Exceedance: 4.33 feet


Jan Stage-Duration Curve Sacramento River at Freeport
Elevation (ft, NAVD88)
% Duration
0
5
10
15
20
25
30
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Jan Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 4.58 feet
95% Exceedance: 3.98 feet

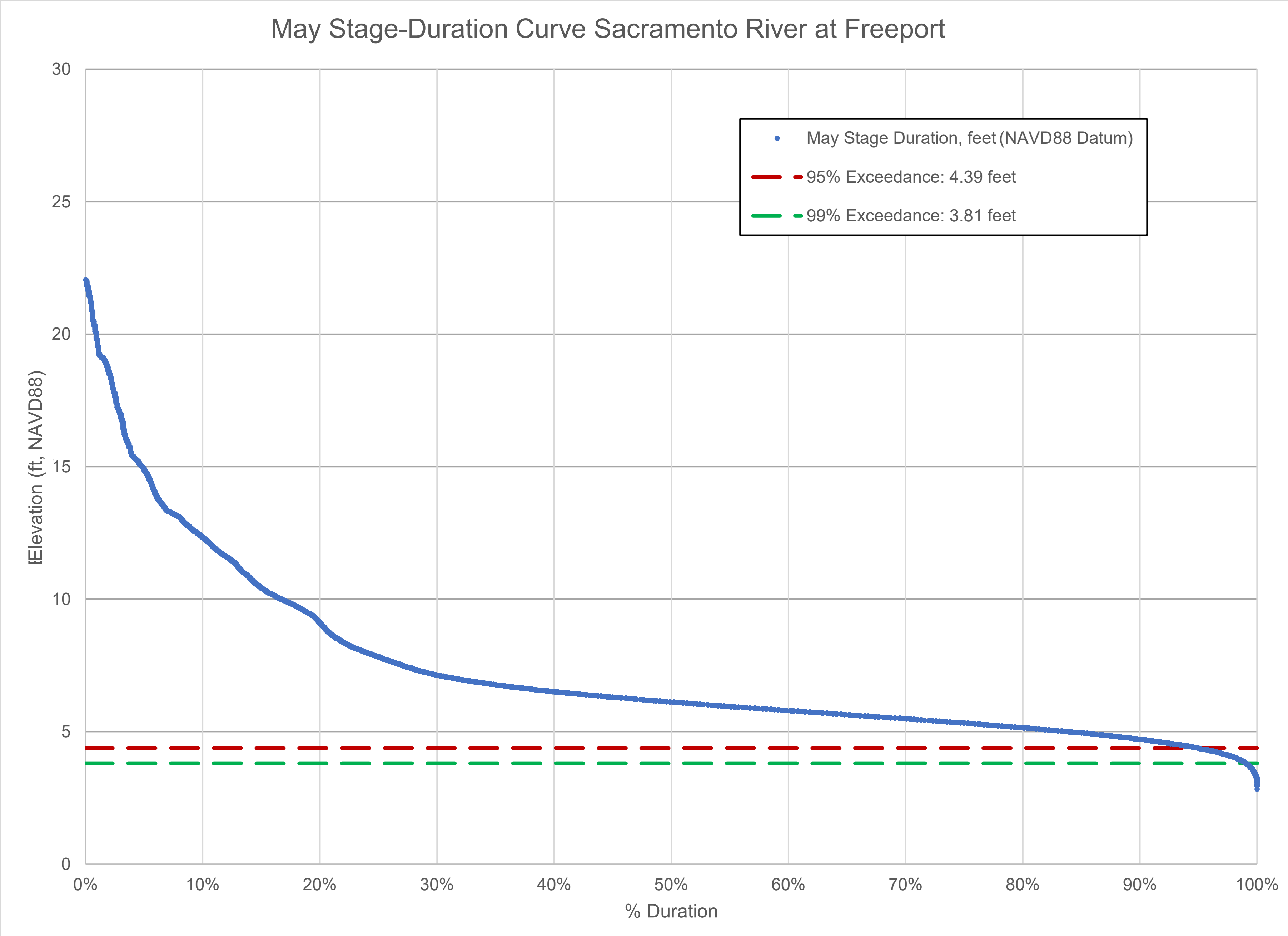


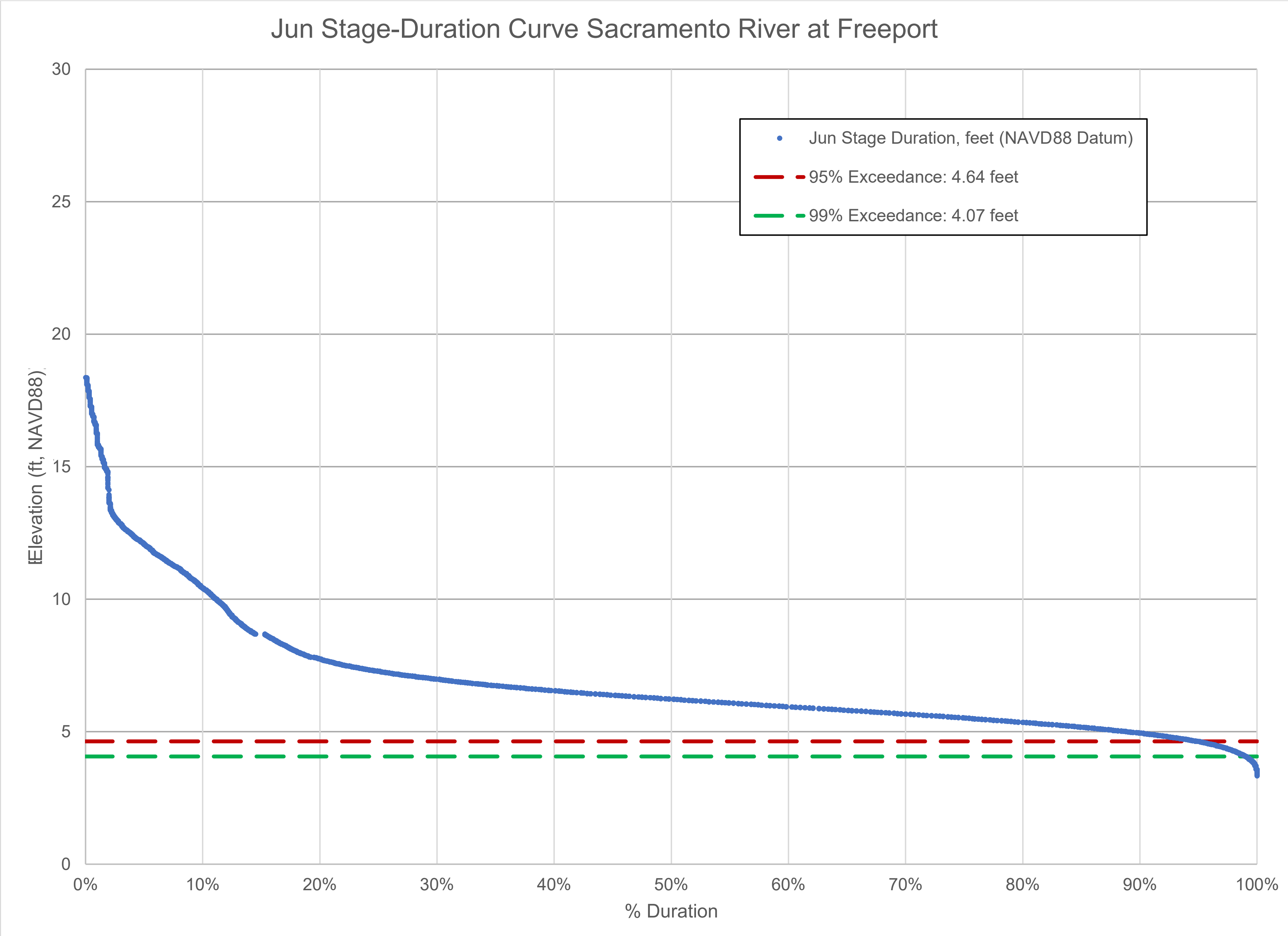
Feb Stage-Duration Curve Sacramento River at Freeport
30
25
20
15
10
5
0
Elevation (ft, NAVD88)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
% Duration
Feb Stage Duration, feet (NAVD88 Datum)
95% Exceedance: 4.75 feet
99% Exceedance: 4.15 feet


Mar Stage-Duration Curve Sacramento River at Freeport
Mar Stage Duration, feet (NAVD88 Datum)
95% Exceedance: 4.8 feet
99% Exceedance: 4.24 feet
Elevation (ft, NAVD88)
% Duration
0
5
10
15
20
25
30
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

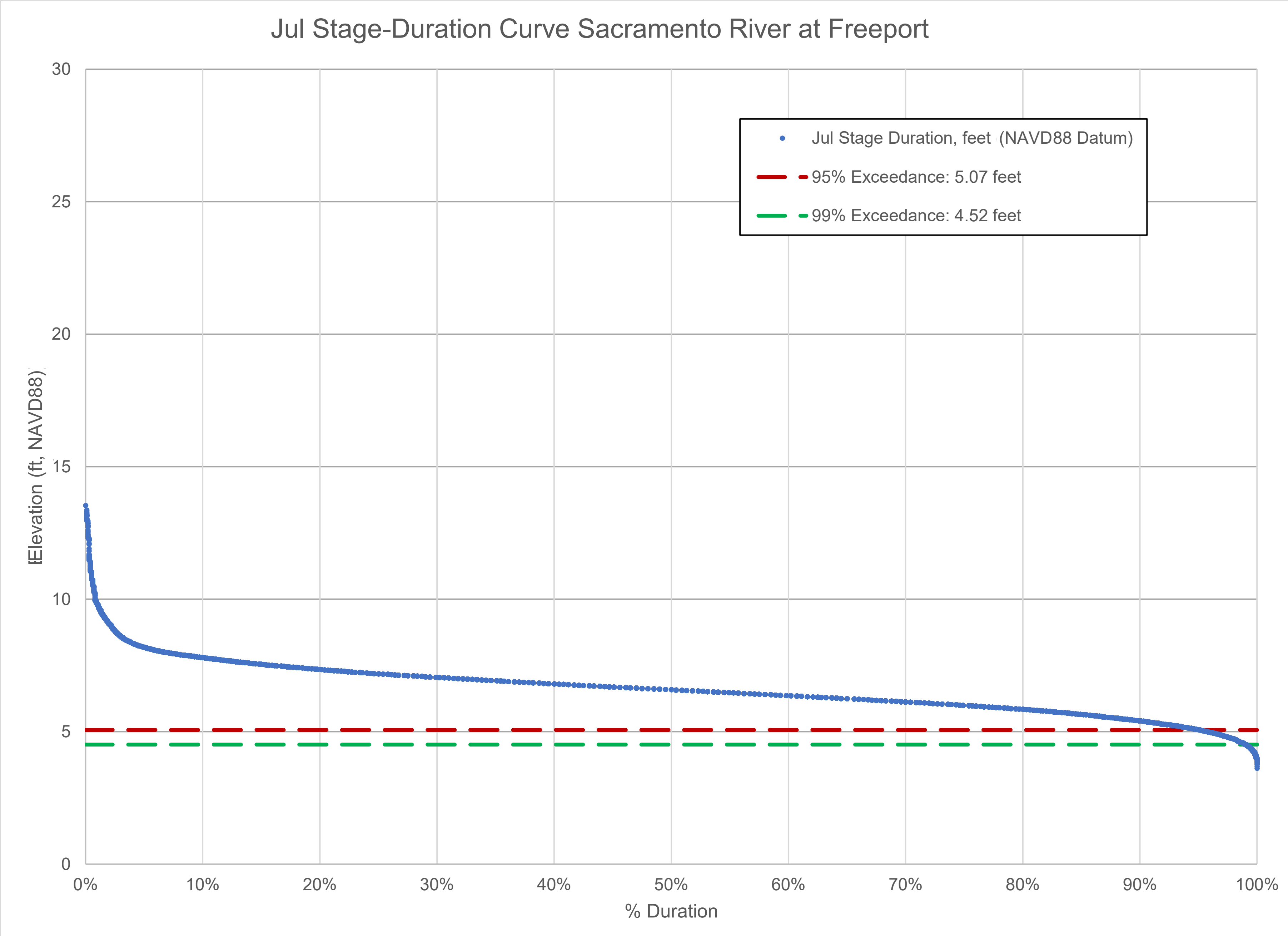


Apr Stage-Duration Curve Sacramento River at Freeport
Apr Stage Duration, feet (NAVD88 Datum)
95% Exceedance: 4.47 feet
99% Exceedance: 3.87 feet
Elevation (ft, NAVD88)
% Duration
0
5
10
15
20
25
30
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

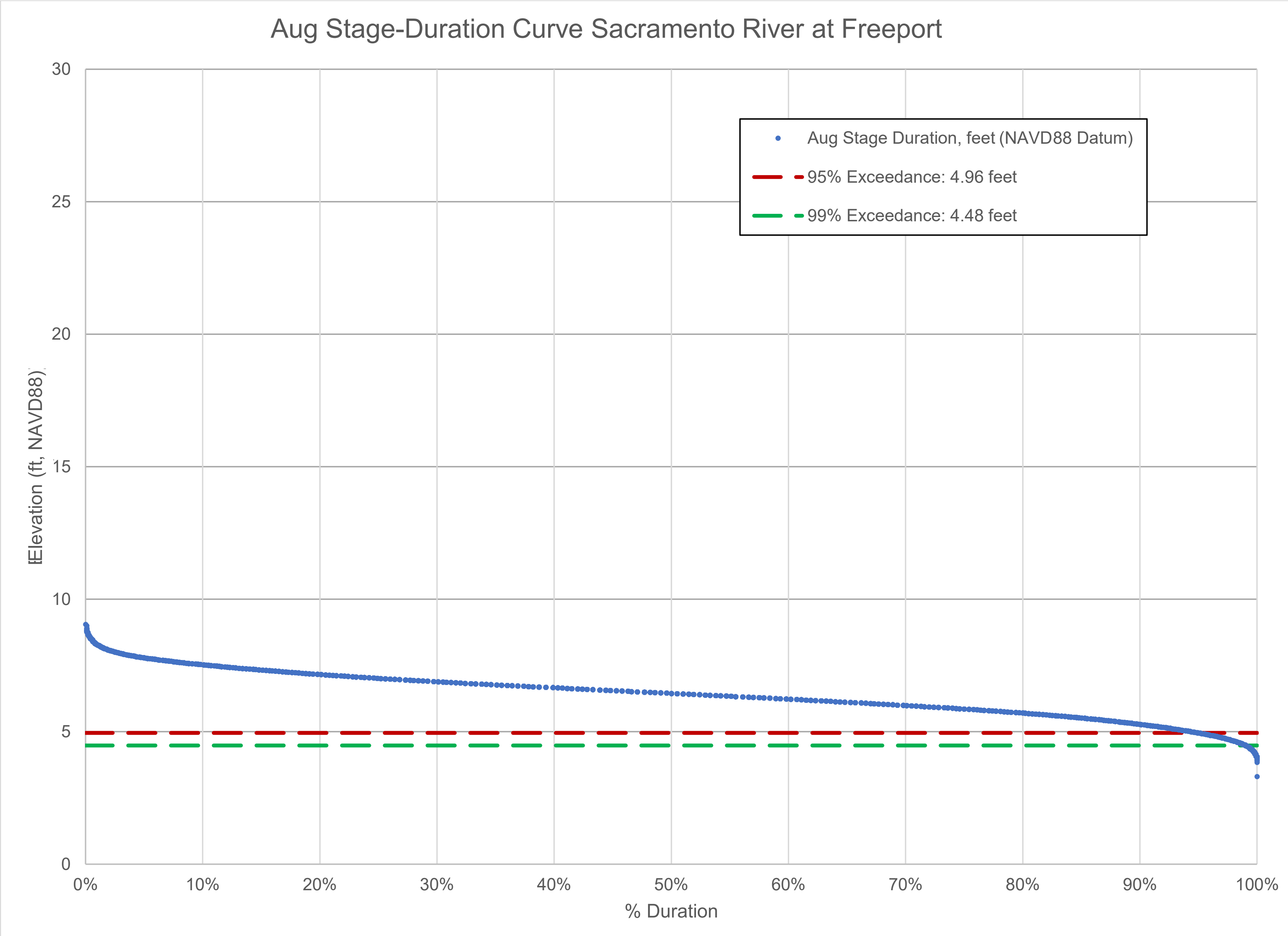

May Stage-Duration Curve Sacramento River at Freeport
May Stage Duration, feet (NAVD88 Datum)
95% Exceedance: 4.39 feet
99% Exceedance: 3.81 feet
Elevation (ft, NAVD88)
% Duration
0
5
10
15
20
25
30
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

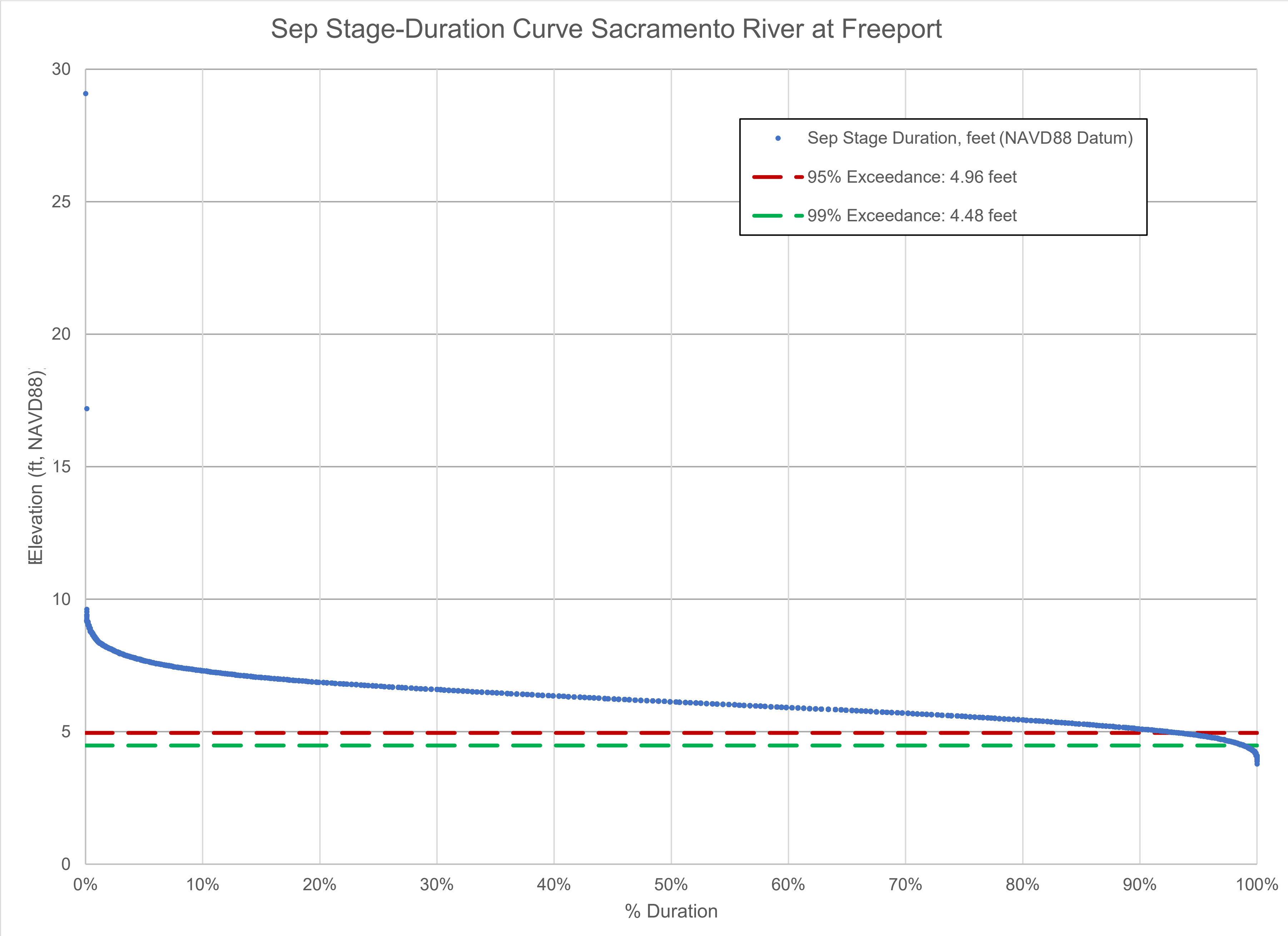


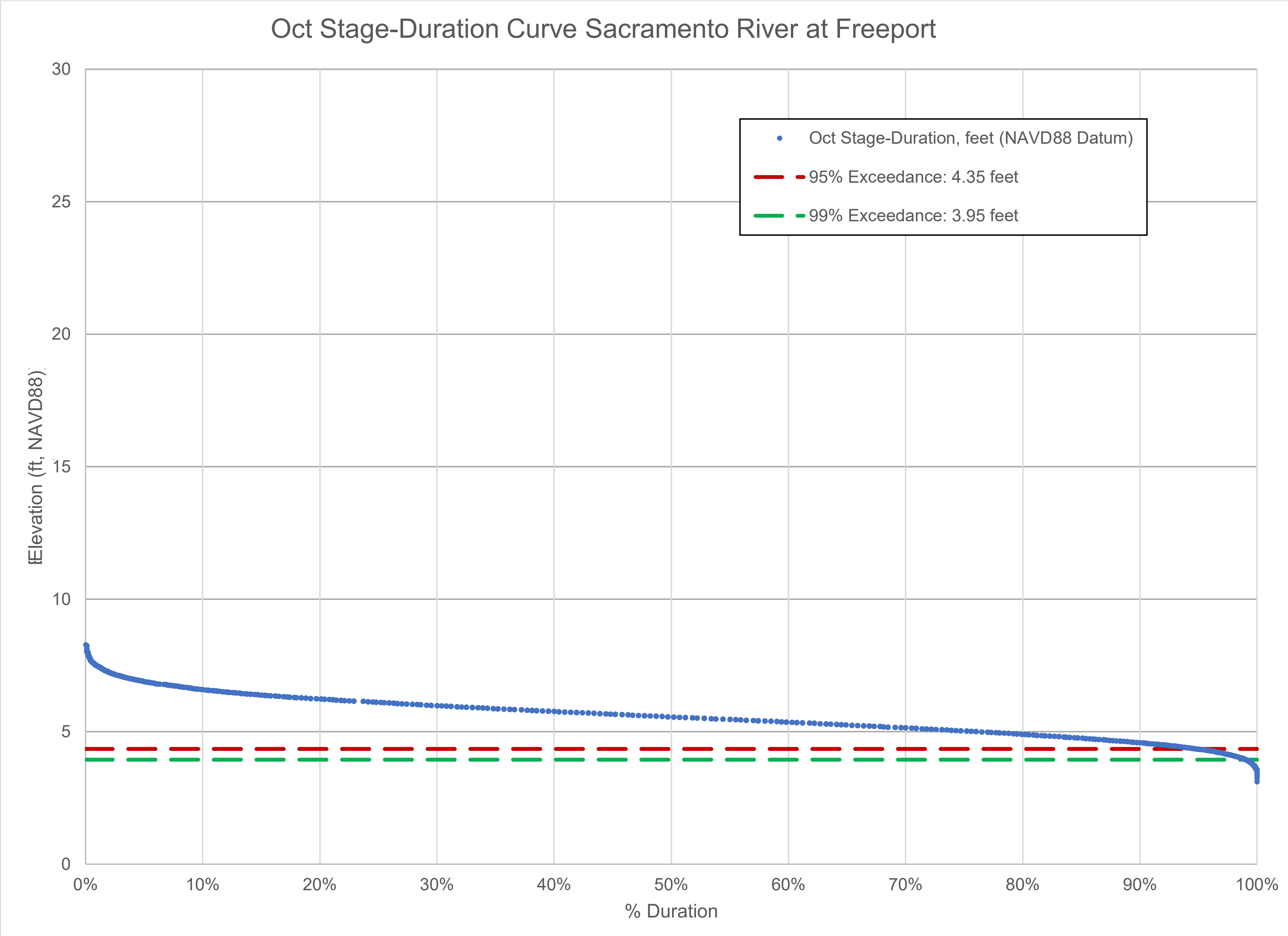
Jun Stage-Duration Curve Sacramento River at Freeport
Jun Stage Duration, feet (NAVD88 Datum)
95% Exceedance: 4.64 feet
99% Exceedance: 4.07 feet
Elevation (ft, NAVD88)
% Duration
0
5
10
15
20
25
30
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

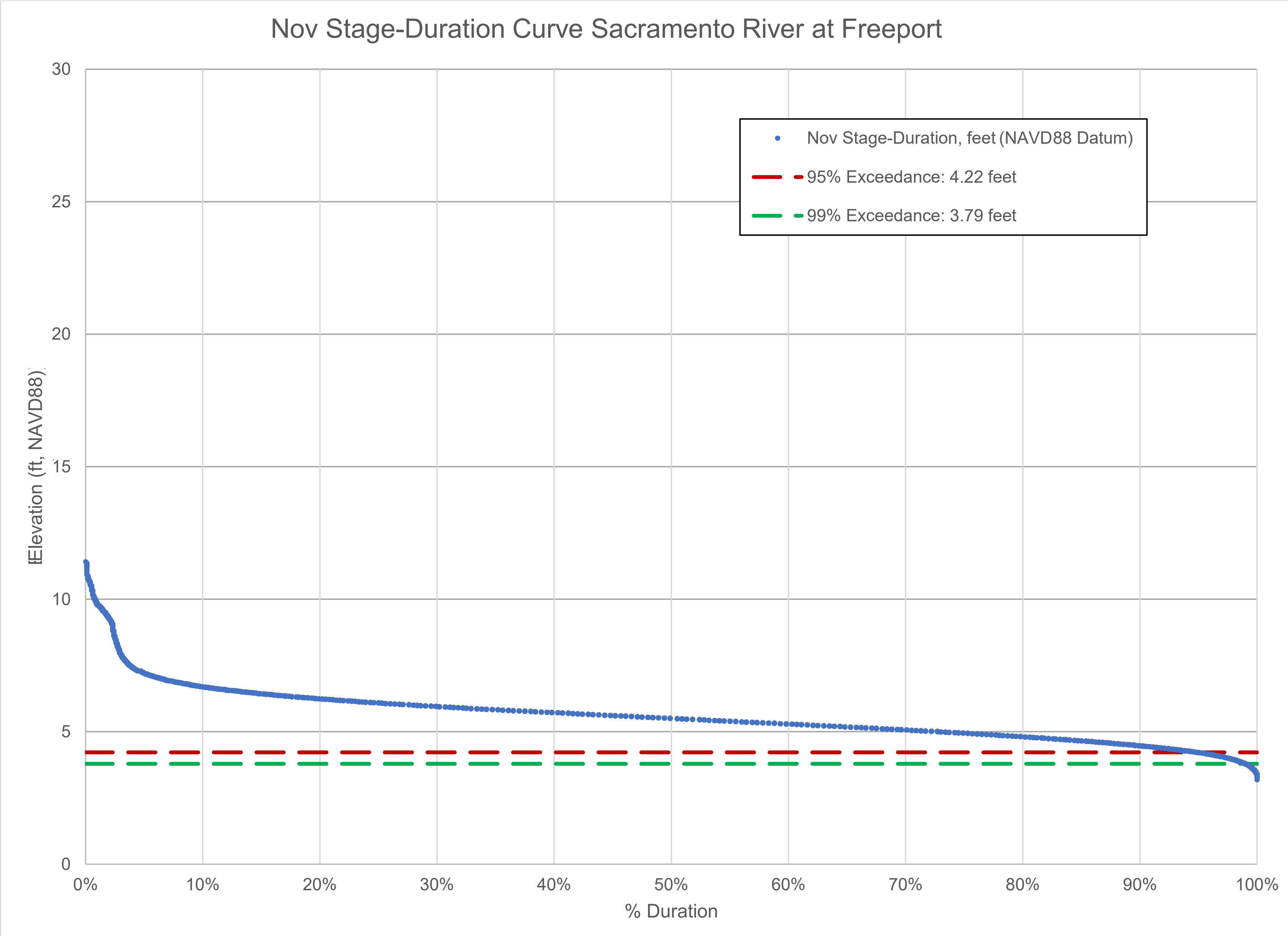


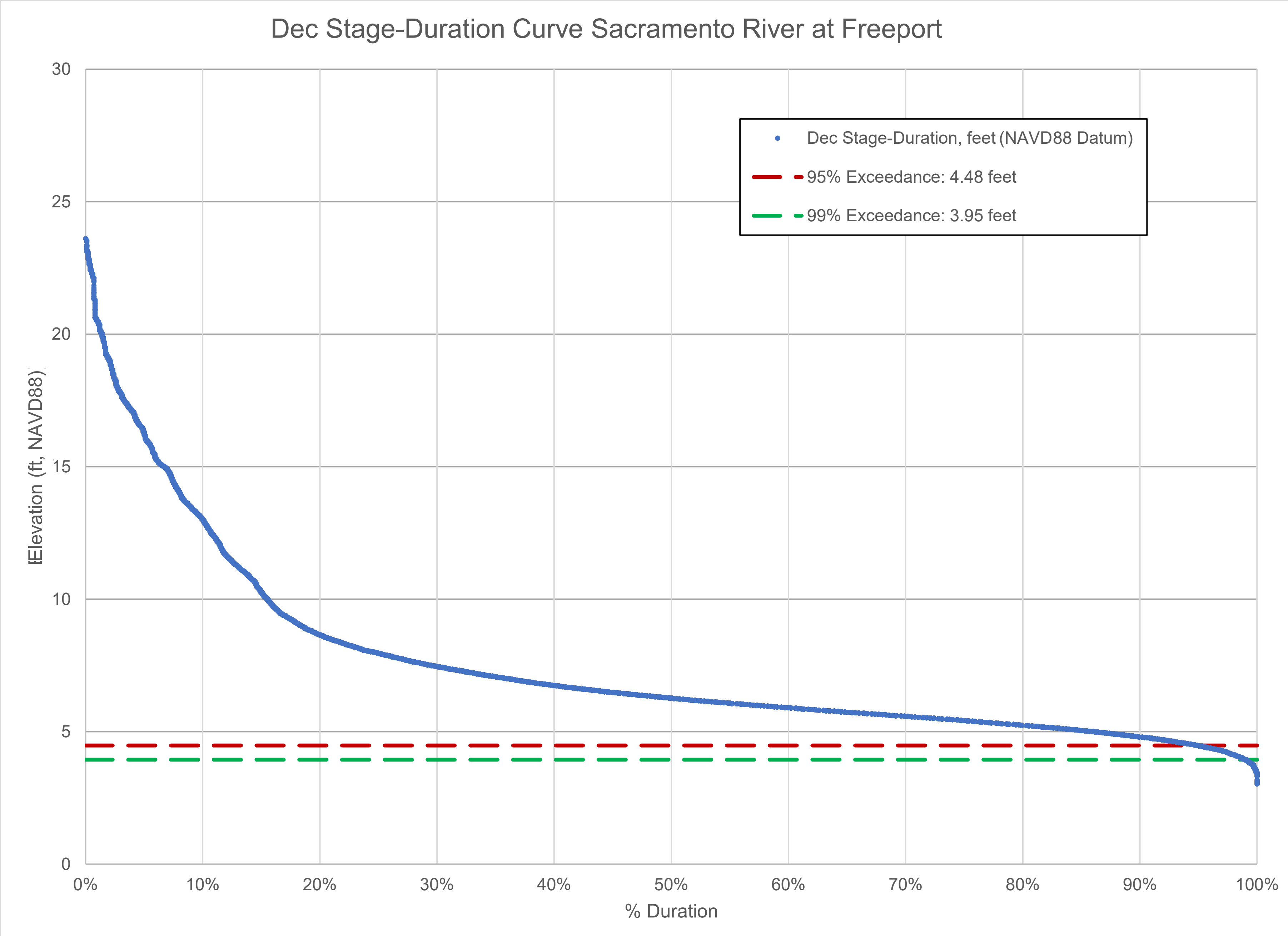
Jul Stage-Duration Curve Sacramento River at Freeport
Jul Stage Duration, feet (NAVD88 Datum)
95% Exceedance: 5.07 feet
99% Exceedance: 4.52 feet
Elevation (ft, NAVD88)
% Duration
0
5
10
15
20
25
30
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%


Aug Stage-Duration Curve Sacramento River at Freeport
Aug Stage Duration, feet (NAVD88 Datum)
95% Exceedance: 4.96 feet
99% Exceedance: 4.48 feet
Elevation (ft, NAVD88)
30
25
20
15
10
5
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
% Duration

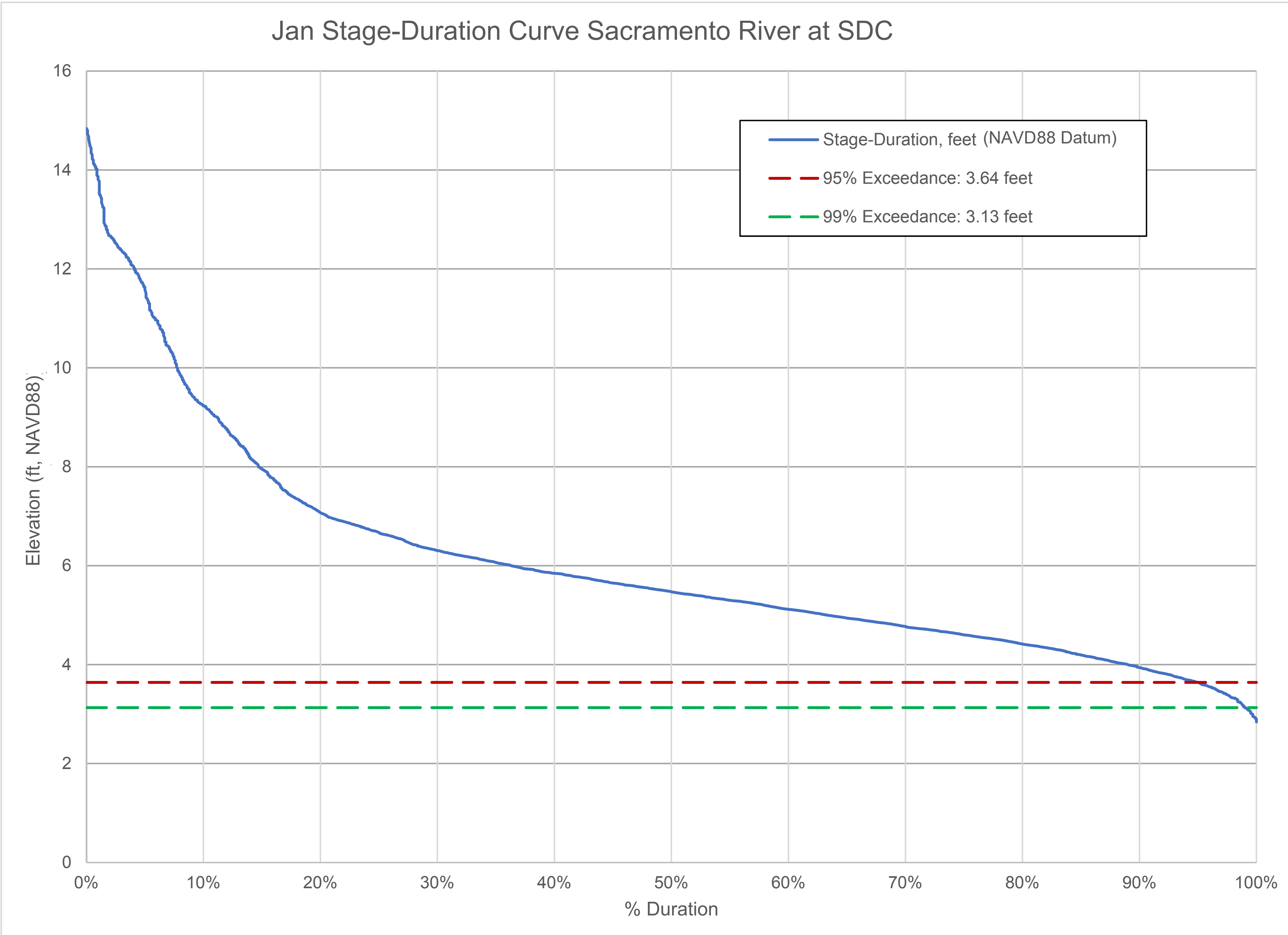

Sep Stage-Duration Curve Sacramento River at Freeport
Sep Stage Duration, feet (NAVD88 Datum)
95% Exceedance: 4.96 feet
99% Exceedance: 4.48 feet
Elevation (ft, NAVD88)
% Duration
0
5
10
15
20
25
30
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%


Oct Stage-Duration Curve Sacramento River at Freeport
Oct Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 4.35 feet
99% Exceedance: 3.95 feet
Elevation (ft, NAVD88)
% Duration
0
5
10
15
20
25
30
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

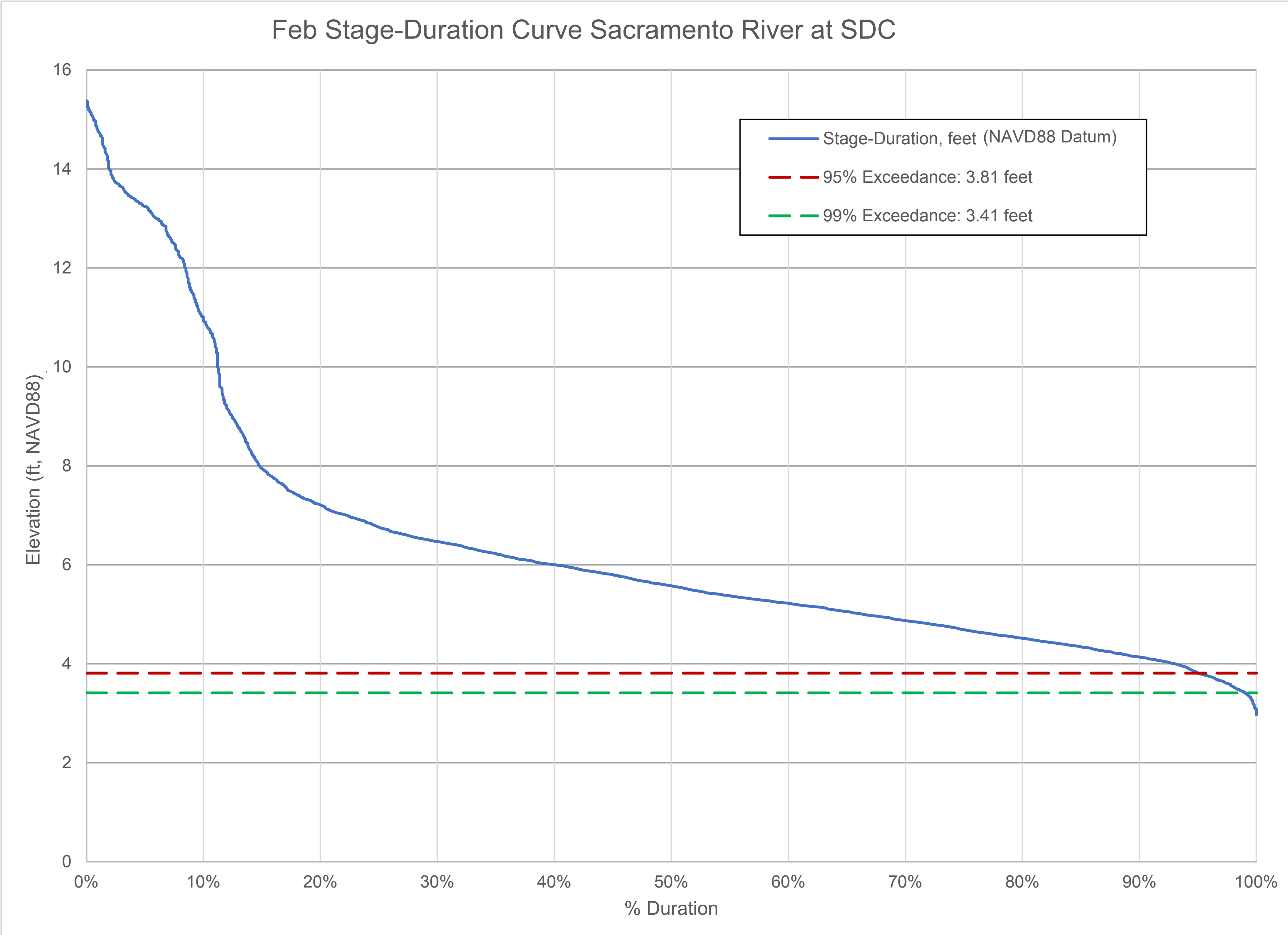

Nov Stage-Duration Curve Sacramento River at Freeport
30
25
20
15
10
5
0
Elevation (ft, NAVD88)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
% Duration
Nov Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 4.22 feet
99% Exceedance: 3.79 feet



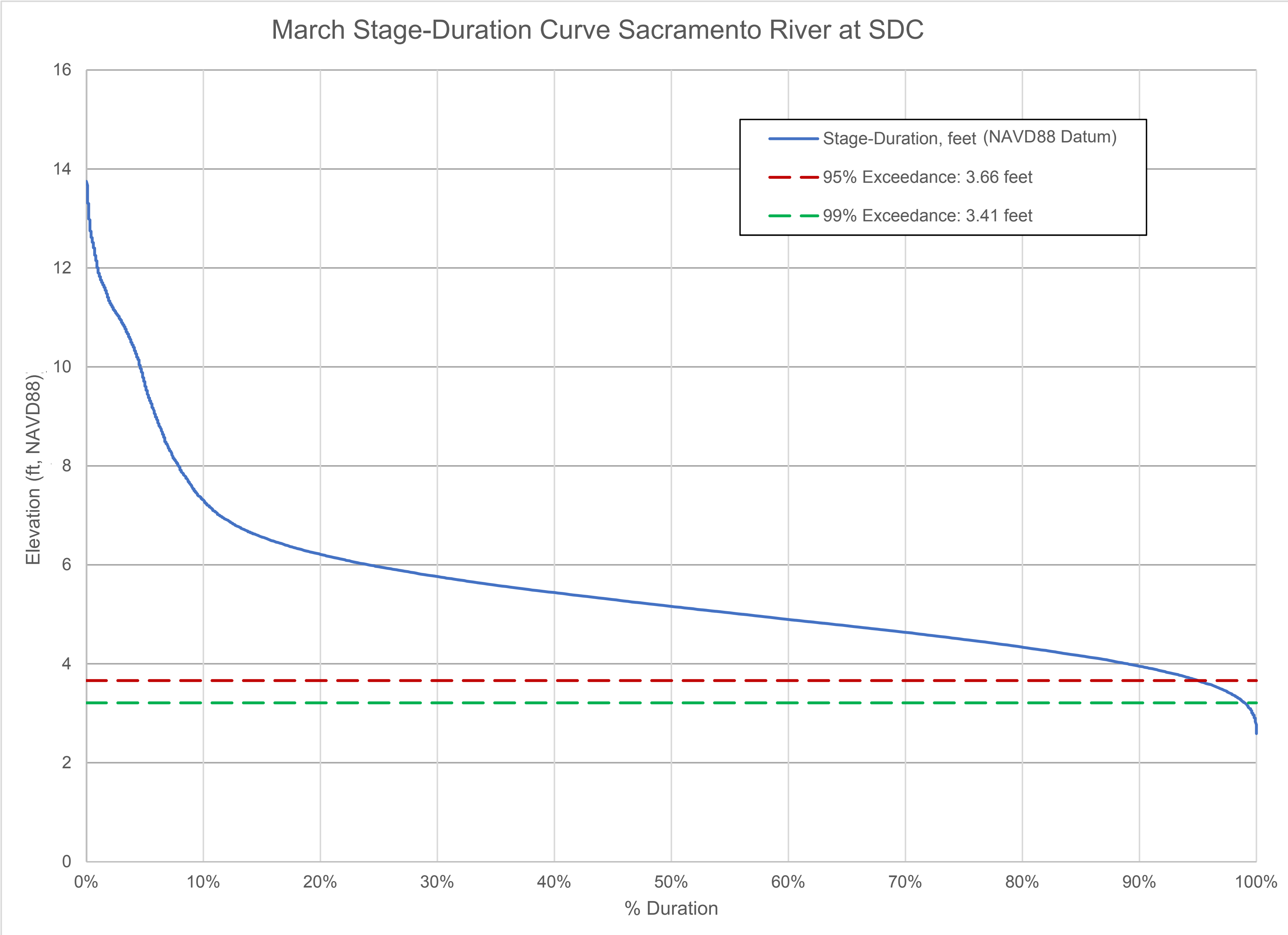
Dec Stage-Duration Curve Sacramento River at Freeport
Dec Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 4.48 feet
99% Exceedance: 3.95 feet
Elevation (ft, NAVD88)
% Duration
0
5
10
15
20
25
30
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

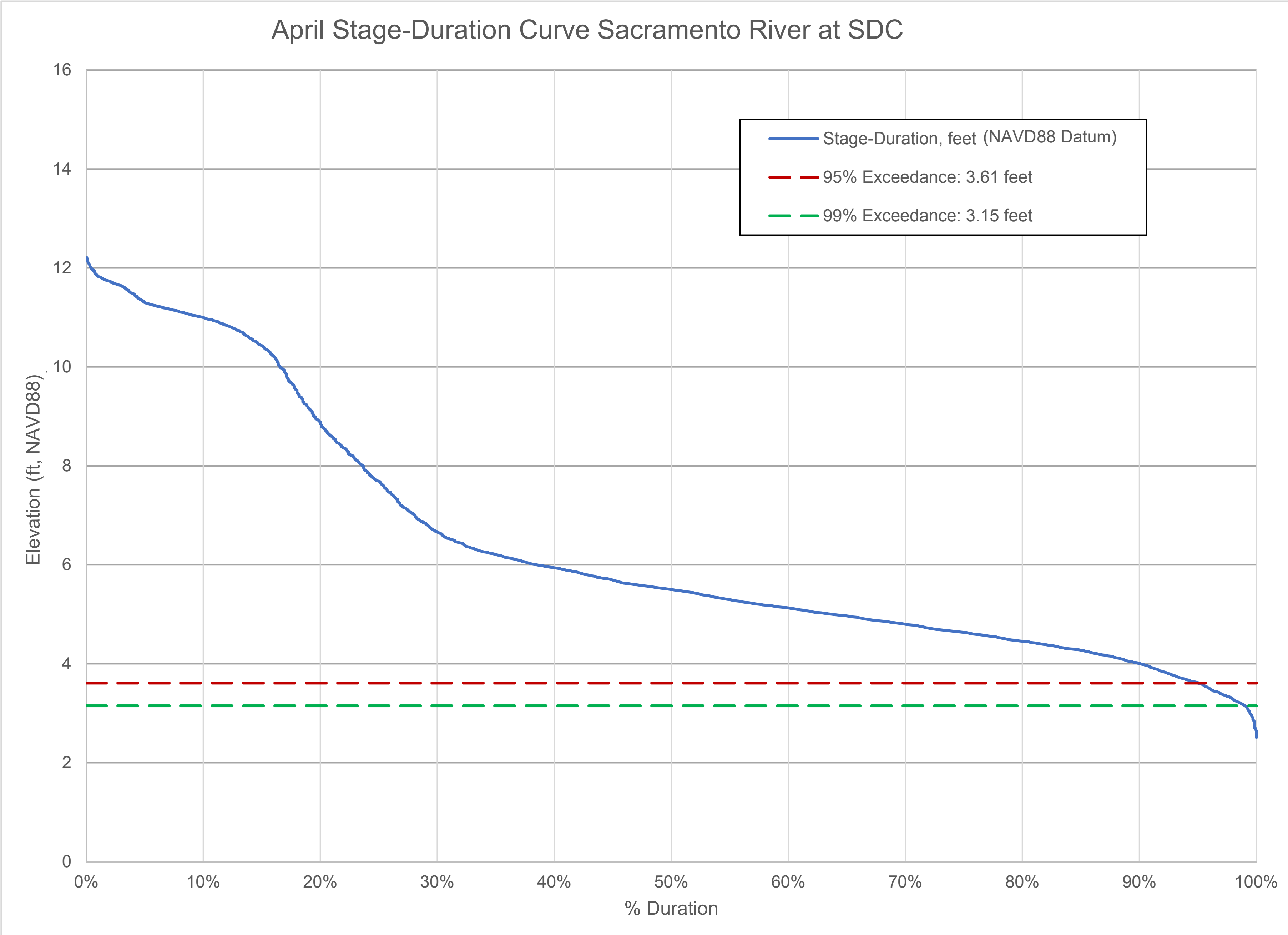


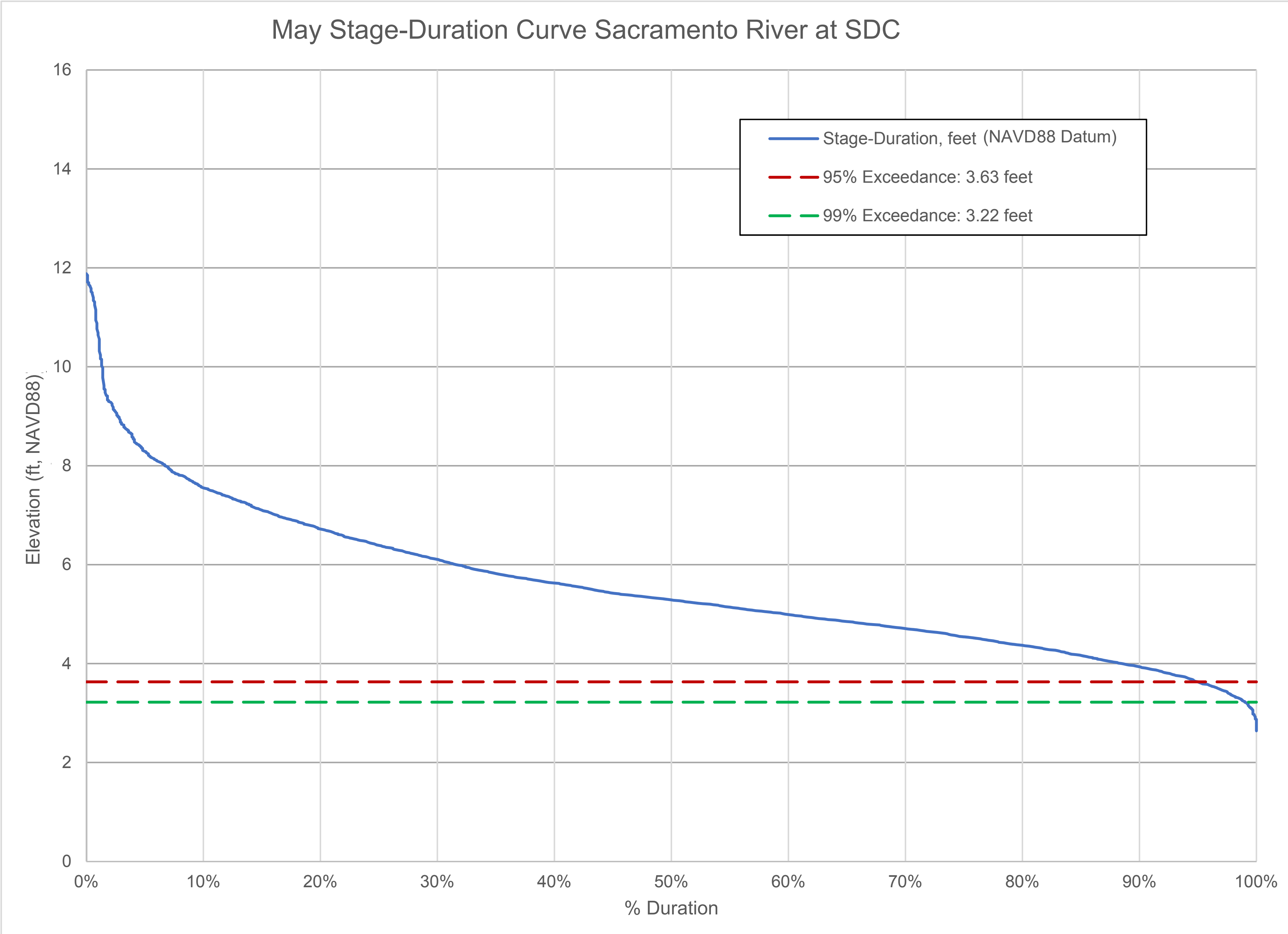
Jan Stage-Duration Curve Sacramento River at SDC
Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 3.64 feet
99% Exceedance: 3.13 feet
Elevation (ft, NAVD88)
16
14
12
10
8
6
4
2
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
% Duration

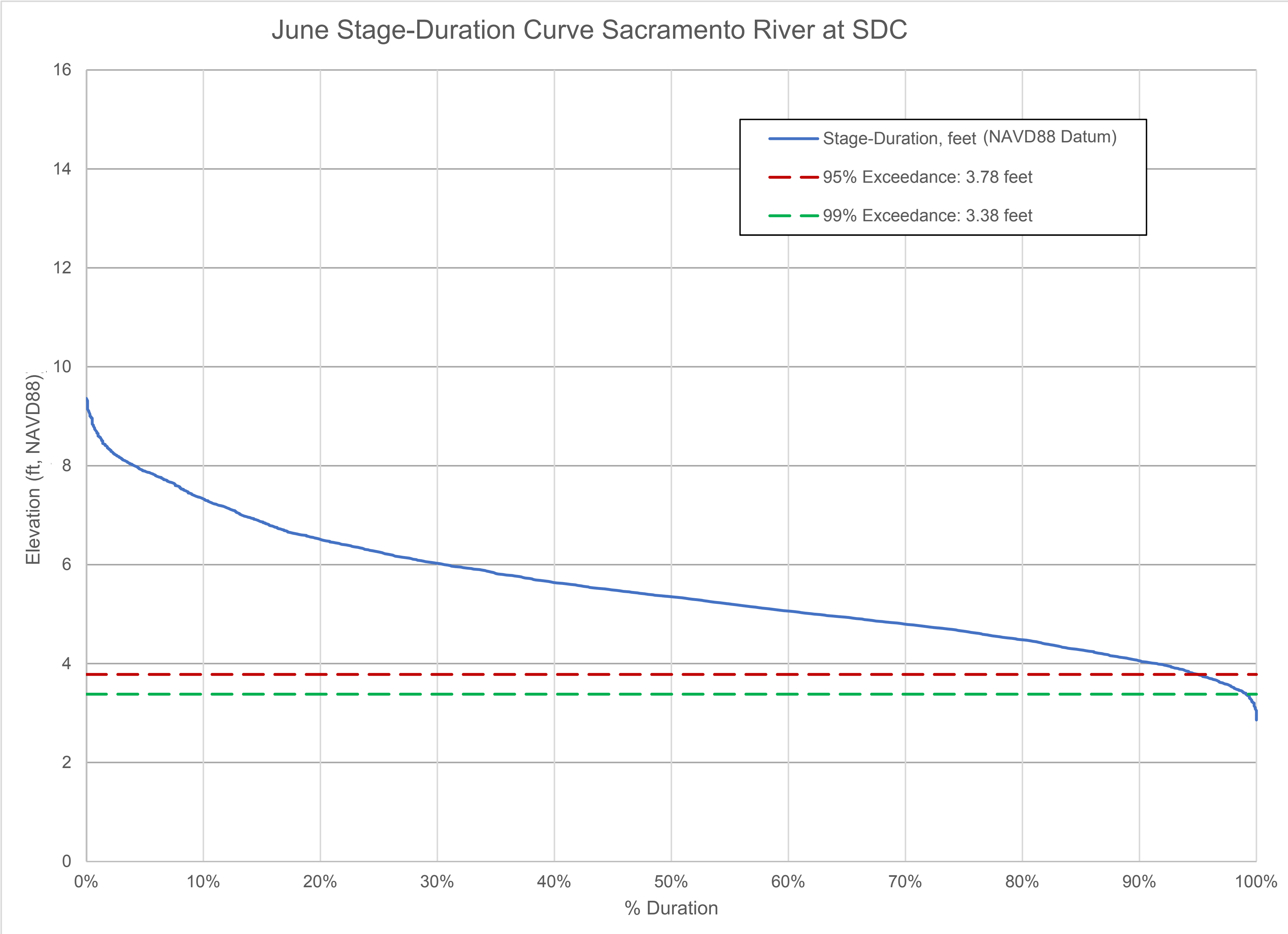


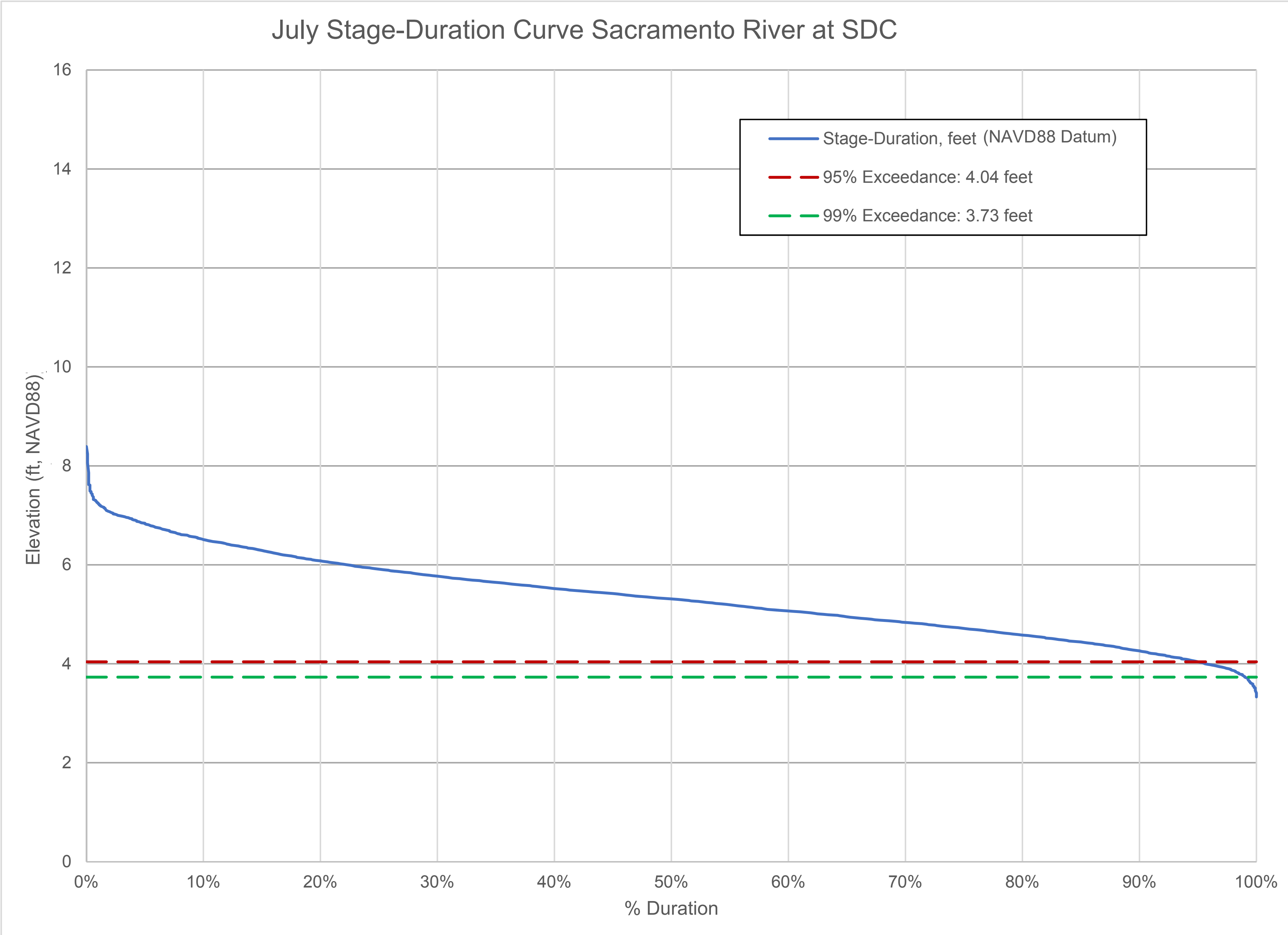
Feb Stage-Duration Curve Sacramento River at SDC
Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 3.81 feet
99% Exceedance: 3.41 feet
Elevation (ft, NAVD88)
0
2
4
6
8
10
12
14
16
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
% Duration

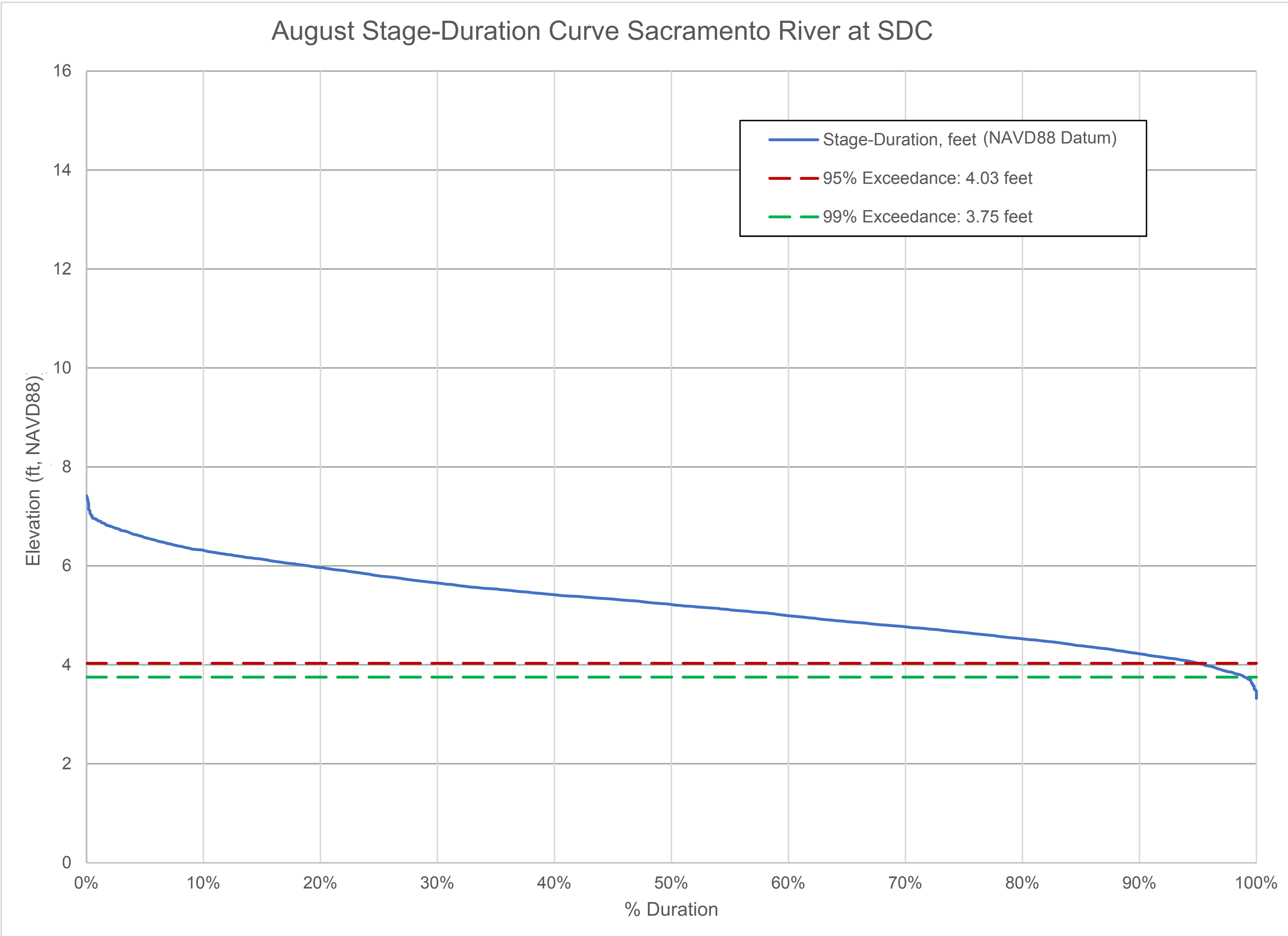

March Stage-Duration Curve Sacramento River at SDC
Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 3.66 feet
99% Exceedance: 3.41 feet
Elevation (ft, NAVD88)
16
14
12
10
8
6
4
2
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
% Duration


April Stage-Duration Curve Sacramento River at SDC
Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 3.61 feet
99% Exceedance: 3.15 feet
Elevation (ft, NAVD88)
% Duration
16
14
12
10
8
6
4
2
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

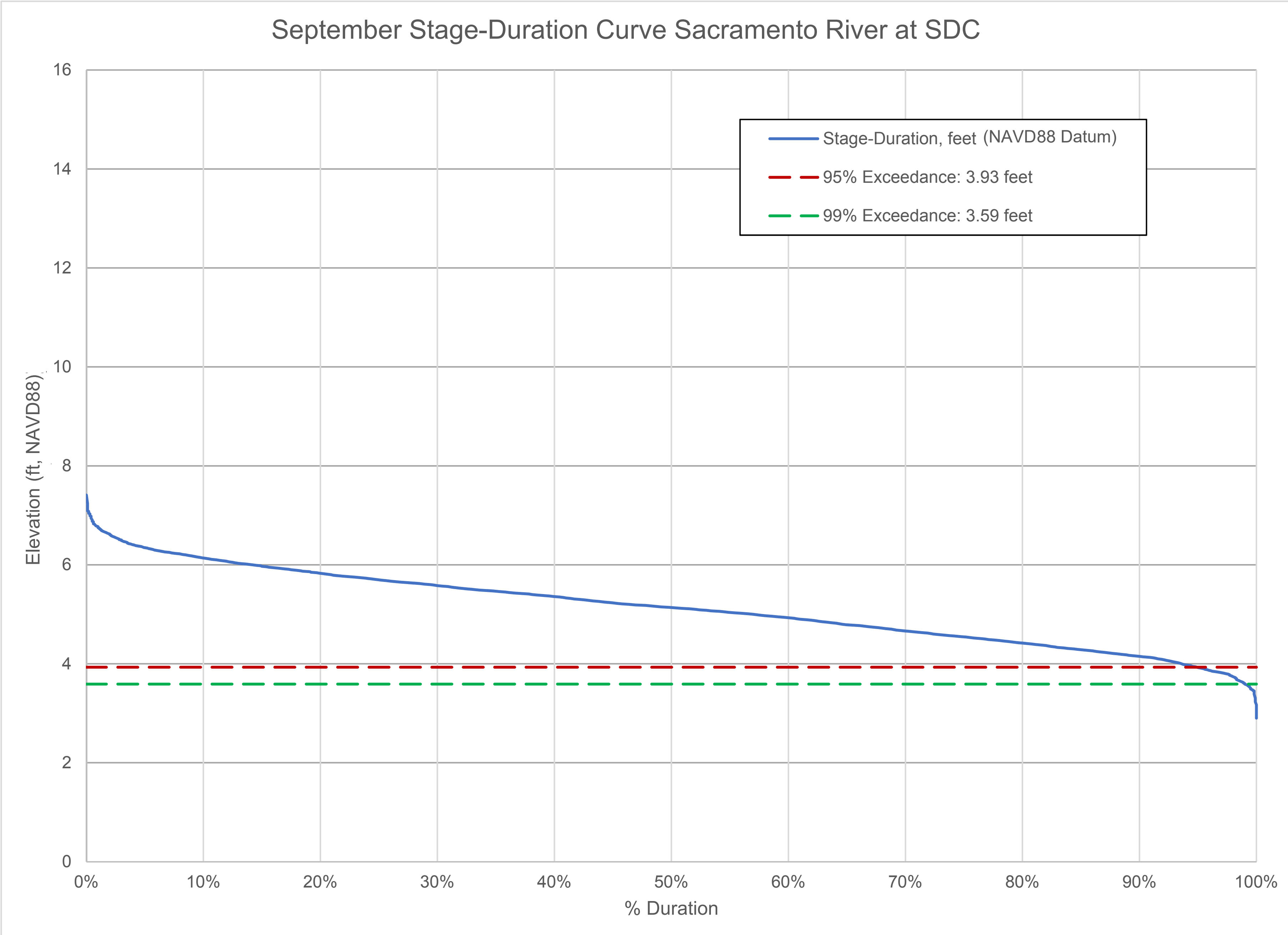

May Stage-Duration Curve Sacramento River at SDC
Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 3.63 feet
99% Exceedance: 3.22 feet
Elevation (ft, NAVD88)
% Duration
0
2
4
6
8
10
12
14
16
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

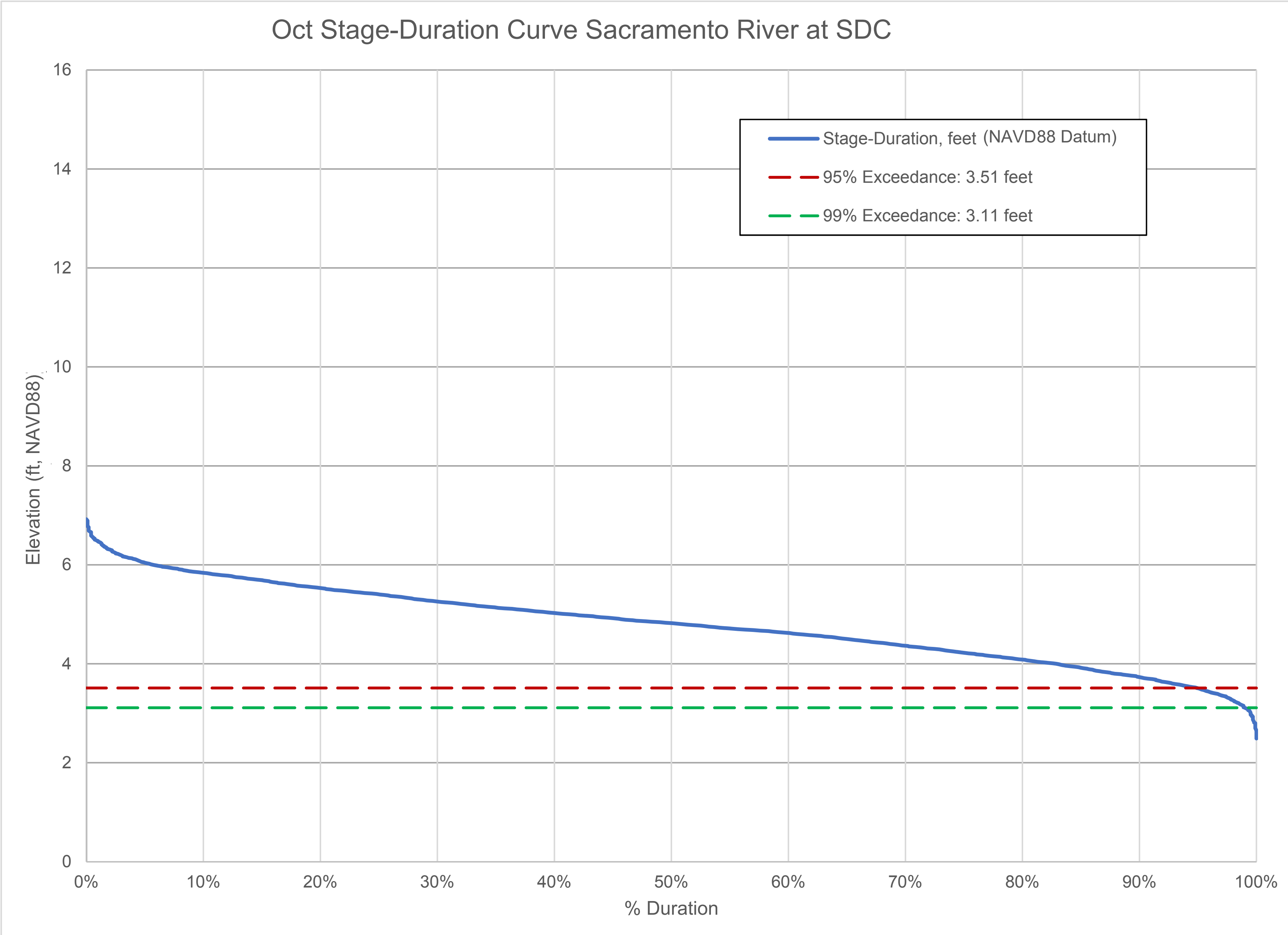

June Stage-Duration Curve Sacramento River at SDC
Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 3.78 feet
99% Exceedance: 3.38 feet
Elevation (ft, NAVD88)
16
14
12
10
8
6
4
2
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
% Duration

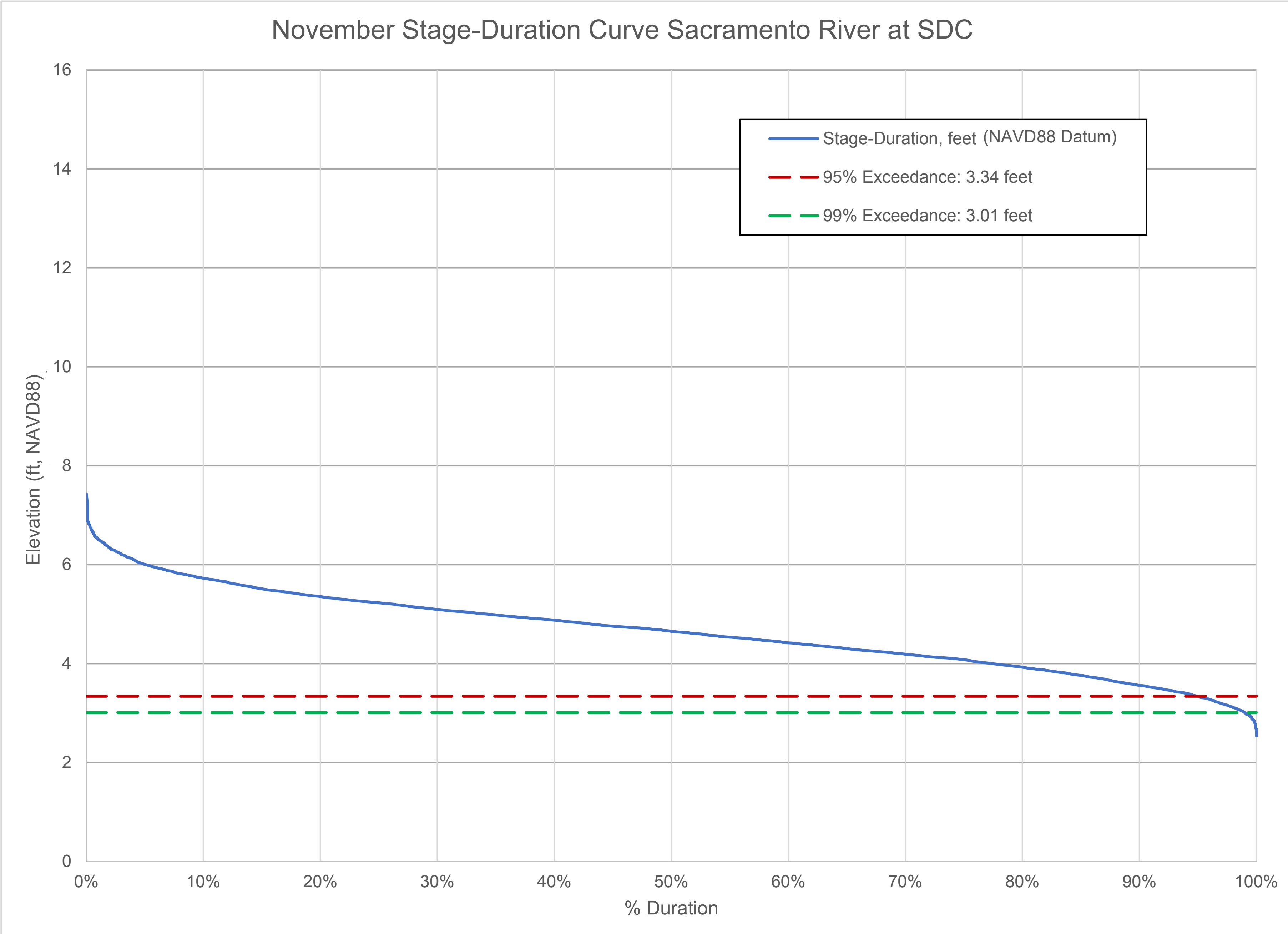

July Stage-Duration Curve Sacramento River at SDC
Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 4.04 feet
99% Exceedance: 3.73 feet
Elevation (ft, NAVD88)
% Duration
0
2
4
6
8
10
12
14
16
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

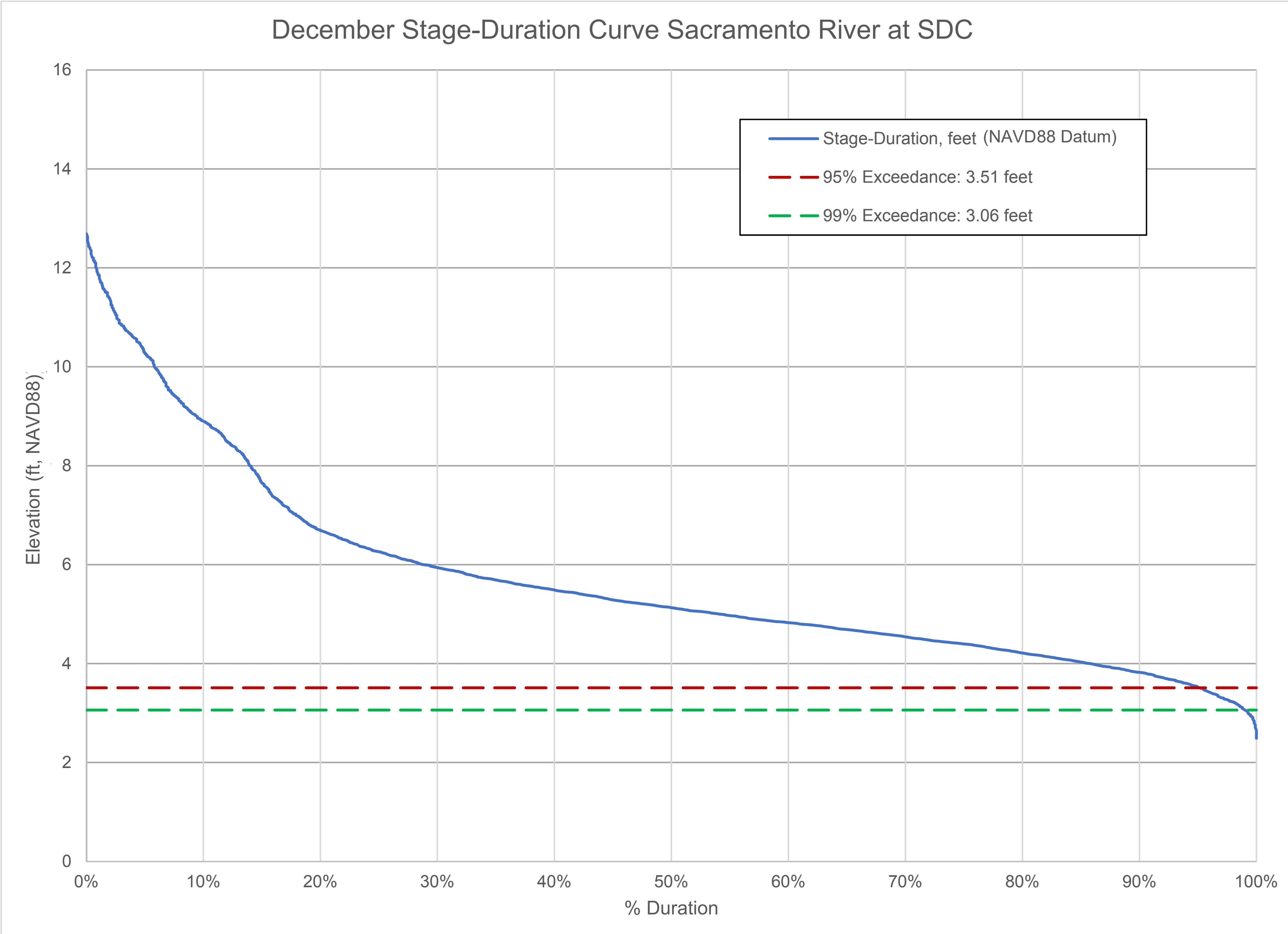


August Stage-Duration Curve Sacramento River at SDC
Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 4.03 feet
99% Exceedance: 3.75 feet
Elevation (ft, NAVD88)
16
14
12
10
8
6
4
2
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
% Duration


September Stage-Duration Curve Sacramento River at SDC
Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 3.93 feet
99% Exceedance: 3.59 feet
Elevation (ft, NAVD88)
16
14
12
10
8
6
4
2
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
% Duration


Oct Stage-Duration Curve Sacramento River at SDC
Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 3.51 feet
99% Exceedance: 3.11 feet
Elevation (ft, NAVD88)
16
14
12
10
8
6
4
2
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
% Duration


November Stage-Duration Curve Sacramento River at SDC
Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 3.34 feet
99% Exceedance: 3.01 feet
Elevation (ft, NAVD88)
% Duration
16
14
12
10
8
6
4
2
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%


December Stage-Duration Curve Sacramento River at SDC
Stage-Duration, feet (NAVD88 Datum)
95% Exceedance: 3.51 feet
99% Exceedance: 3.06 feet
Elevation (ft, NAVD88)
16
14
12
10
8
6
4
2
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
% Duration