5.B DSM2 Modeling and Results

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5.B.1 Introduction

The overall analytical framework used for the CWF BA effects analysis is summarized in the Appendix 5A, *CalSim II Modeling and Results*. The current appendix summarizes the tools and methods used to characterize Delta hydrodynamics and water quality conditions for the NAA and PA considered under this BA.

Appendix 5A, *CalSim II Modeling and Results* includes a summary of the CalSim II modeling for the CWF BA, and Appendix 5C, *Upstream Water Temperature Methods and Results* includes a summary of the reservoir and upstream river water temperature modeling for the CWF BA.

5.B.2 Delta Hydrodynamics and Water Quality

Hydrodynamics and water quality modeling is essential to understand the impact of proposed modifications to the Delta and the operations of the CVP/SWP. Changes to the configuration of the Delta and project operations will influence the tidal hydrodynamics and water quality conditions in the Delta. The analysis and understanding of the hydrodynamics and water quality changes as a result of these complex changes are critical in understanding the impacts to habitat, species and water users that depend on the Delta.

The main components of the CWF BA that can significantly alter the hydrodynamics in the Delta are the north Delta diversion and Head of Old River gate, along with the sea level rise assumed inherent to the NAA and PA at Year 2030. Delta morphology was assumed to remain unchanged for the quantitative analysis of changes in the hydrodynamics and the water quality, even though some tidal habitat restoration is likely under both the NAA and PA.

This document describes in detail the methodology used for simulating Delta hydrodynamics and water quality for evaluating the changes under the PA relative to the NAA. It briefly describes the primary tool (DSM2) used in this process and specific improvements performed for application in the CWF BA. Additional detail is included in the Attachments to this appendix and appropriate references are provided herein.

5.B.2.1 Overview of Hydrodynamics and Water Quality Modeling Approach

The proposed north Delta diversion and the Head of Old River (HOR) gate in the PA will affect flow through the Delta along with the changes in sea level that are assumed in the analysis of the future NAA and PA scenarios. These changes have the potential to result in modified hydrodynamics and salinity transport in the Sacramento – San Joaquin Delta.

There are several tools available to simulate hydrodynamics and water quality in the Delta. Some tools simulate detailed processes with two or three dimensional representation, however they are computationally intensive and have long runtimes. Other tools approximate certain processes and have short runtimes, while only compromising slightly on the accuracy of the results. For a long-term planning level analysis such as the current BA it is ideal to understand the resulting changes than can occur over the span of several years and as such, the simulation period cover a range of hydrologic and tidal conditions. A tool which can simulate the changed hydrodynamics and water quality in the Delta accurately and that has short runtimes is desired. The Delta Simulation Model (DSM2), a one-dimensional hydrodynamics and water quality model serves this purpose.

DSM2 has a limited ability to simulate two-dimensional features such as open water bodies (reservoir, flooded islands, tidal marshes etc.) and three-dimensional transport processes such as gravitational circulation which is found to increase with sea level rise in the estuaries. Therefore, it is imperative that DSM2 be recalibrated or corroborated based on a dataset that accurately represents the conditions in the Delta with sea level rise. Since the proposed conditions are hypothetical, the best available approach to estimate the Delta hydrodynamics would be to simulate the Delta with higher dimensional models which can resolve the three-dimensional processes well. These models would generate the datasets needed to corroborate or recalibrate DSM2 under the future conditions so that it can simulate the hydrodynamics and salinity transport with reasonable accuracy.

Figure 5.B.2-1 shows a schematic of how the hydrodynamics and water quality modeling was formulated for the CWF BA. UnTRIM Bay-Delta Model (MacWilliams et al., 2009), a three-dimensional hydrodynamics and water quality model was used to simulate the sea level rise effects on hydrodynamics and salinity transport under the historical operations in the Delta. UnTrim modeling is described in Appendix B, Attachment 2, *UnTRIM San Francisco Bay-Delta Model Sea Level Rise Scenario Modeling Report*. The results from the UnTRIM model were used to corroborate DSM2 models so that DSM2 can simulate the effect of sea level rise consistent with a higher order model that can better resolve estuarine processes such as UnTRIM. The DSM2 – UnTRIM corroboration process and the results are presented in Appendix B, Attachment 3, *DSM2 SLR corroboration*.

The corroborated DSM2 was used to simulate hydrodynamics and water quality in the Delta by integrating sea level rise effects over a 82-year period (WY 1922 – 2003), using the hydrological inputs and exports determined by CalSim II under the projected operations for the NAA and the PA. It was also used to retrain ANNs (Section 5.A.4.2, *Artificial Neural Network*) that can emulate modified flow-salinity relationships in the Delta.

5.B.2.2 Delta Simulation Model (DSM2)

DSM2 is a one-dimensional hydrodynamics, water quality and particle tracking simulation model used to simulate hydrodynamics, water quality, and particle tracking in the Sacramento-San Joaquin Delta (Anderson and Mierzwa, 2002). DSM2 is appropriate for describing the existing conditions in the Delta, as well as performing simulations for the assessment of incremental environmental impacts caused by future facilities and operations. The DSM2 model has three separate components: HYDRO, QUAL, and PTM. HYDRO simulates one-dimensional hydrodynamics including flows, velocities, depth, and water surface elevations. HYDRO provides the flow input for QUAL and PTM. QUAL simulates one-dimensional fate and transport of conservative and non-conservative water quality constituents given a flow field simulated by HYDRO. PTM simulates pseudo 3-D transport of neutrally buoyant particles based on the flow field simulated by HYDRO.

DSM2 v8.0.6 (DWR, 2010) was used in modeling of the hydrodynamics and salinity transport in the Delta under the CWF BA NAA and PA scenarios. Version 8 of the DSM2 includes several enhancements compared to Version 6 such as improved data management, increased speed and robustness, ability to simulate gates with multiple structures and the ability to specify Operating Rules in the HYDRO module. The Operating Rules form a powerful tool which triggers changes in gate operations or source/sink flow boundaries while the model is running, based on the current value of a state variable (flow, stage or velocity), pre-specified timeseries or the simulation timestep.

DSM2 hydrodynamics and salinity (EC) were initially calibrated in 1997 (DWR, 1997). In 2000, a group of agencies, water users, and stakeholders recalibrated and validated DSM2 in an open process resulting in a model that could replicate the observed data more closely than the 1997 version (DSM2PWT, 2001). In 2009, CH2M HILL performed a calibration and validation of DSM2 by including the flooded Liberty Island in the DSM2 grid, which allowed for an improved simulation of tidal hydrodynamics and EC transport in DSM2 (CH2M HILL, 2009). Technical report documenting this calibration effort is included in Appendix B, Attachment 1, *DSM2 Recalibration for Bay-Delta Conservation Plan*. The model used for evaluating the CWF BA scenarios was based on this calibration version, i.e., DSM2 version 8.0.6 .

Since 2009 DWR has released DSM2 version 8.1.2, which includes major changes such as updated bathymetric reference to NAVD 88 and modified representation of dispersion in the QUAL. DWR also recalibrated DSM2 model given the magnitude of changes in the version 8.1.2, which found that the performance of the model in simulating observed hydrodynamics and salinity conditions was very close to the 2009 calibration (Liu and Sandhu, 2013). Given that the ANNs used to emulate flow-salinity relationship in the Delta (Section 5.B.2.3.4, *ANN Retraining*) were based on the DSM2 version 8.0.6, for the CWF BA DSM2 version 8.0.6 was used to simulate Delta hydrodynamics and salinity transport under the NAA and the PA.

Simulation of Dissolved Organic Carbon (DOC) transport in DSM2 was successfully validated in 2001 by DWR (Pandey, 2001). The temperature and Dissolved Oxygen calibration was initially performed in 2003 by DWR (Rajbhandari, 2003). Recent effort by RMA since 2009 allowed for improved calibration of temperature, DO and the nutrients transport in DSM2 (Guerin, 2010 and Guerin, 2011).

5.B.2.2.1 Delta Hydrodynamics (DSM2-HYDRO)

The HYDRO module is a one-dimensional, implicit, unsteady, open channel flow model that DWR developed from FOURPT, a four-point finite difference model originally developed by the USGS in Reston, Virginia. DWR adapted the model to the Delta by revising the input-output system, including open water elements, and incorporating water project facilities, such as gates, barriers, and the Clifton Court Forebay. HYDRO simulates water surface elevations, velocities and flows in the Delta channels (Nader-Tehrani, 1998). HYDRO provides the flow input necessary for QUAL and PTM modules.

The HYDRO module solves the continuity and momentum equations fully implicitly. These partial differential equations are solved using a finite difference scheme requiring four points of computation. The equations are integrated in time and space, which leads to a solution of stage and flow at the computational points. HYDRO enforces an "equal stage" boundary condition for all the channels connected to a junction. The model can handle both irregular cross-sections derived from the bathymetric surveys and trapezoidal cross-sections. Even though, the model formulation includes a baroclinic term, the density is held constant, generally, in the HYDRO simulations.

HYDRO allows the simulation of hydraulic gates in the channels. A gate may have a number of associated hydraulic structures such as radial gates, flash boards, boat ramps etc., each of which may be operated independently to control flow. Gates can be placed either at the upstream or downstream end of a channel. Once the location of a gate is defined, the boundary condition for the gated channel is modified from "equal stage" to "known flow," with the calculated flow. The gates can be opened or closed in one or both directions by specifying a coefficient of zero or one.

Reservoirs are used to represent open bodies of water that store flow. These "reservoirs" in the Delta are represented by cylindrical tanks in DSM2, with a known surface area and bottom elevation and are considered instantly well-mixed. The flow interaction between the open water area and one or more of the connecting channels is determined using the general orifice formula. The flow in and out of the reservoir is controlled using the flow coefficient in the orifice equation, which can be different in each direction. DSM2 does not allow the cross-sectional area of the inlet to vary with the water level.

DSM2 version 8.0.6 includes a feature called "operating rules" by which the gate operations or the flow boundaries can be modified dynamically when the model is running based on the current value of a state variable (flow, stage or velocity). The change can also be triggered based on a timeseries input to the model (e.g. daily averaged Martinez EC) or based on the current timestep of the simulation (e.g. a change can occur at the end of the day or end of the season). The operating rules include many functions which allow derivation of the quantities to be used as triggers, from the model data or outside timeseries data. Operating rules allow a change or an action to occur when the trigger value changes from false to true.

5.B.2.2.2 Delta Water Quality (DSM2-QUAL)

The QUAL module is a one-dimensional water quality transport model that DWR adapted from the Branched Lagrangian Transport Model originally developed by the USGS in Reston, Virginia. DWR added many enhancements to the QUAL module, such as open water areas and gates. A Lagrangian feature in the formulation eliminates the numerical dispersion that is inherent in other segmented formulations, although the tidal dispersion coefficients must still be specified. QUAL simulates fate and transport of conservative and non-conservative water quality constituents given a flow field simulated by HYDRO. It can calculate mass transport processes for salts, water temperature, nutrients, dissolved oxygen, and trihalomethane formation potential.

The main processes contributing to the fate and transport of the constituents include flow dependent advection and tidal dispersion in the longitudinal direction. Mass balance equations are solved for all quality constituents in each parcel of water using the tidal flows and volumes calculated by the HYDRO module. Additional information and the equations used are specified in the 19th annual progress report by DWR (Rajbhandari, 1998).

For the CWF BA application DSM2 QUAL was used to quantify Delta salinity conditions, water temperatures and sourcewater fingerprinting. A brief description is provided below for each of the constituents.

5.B.2.2.2.1 Delta Salinity

Salinity is the primary conservative constituent simulated using the DSM2 QUAL model. Electrical Conductivity (EC) is used as a surrogate for salinity in DSM2 given the availability of observed data across the Delta (DSM2PWT 2001). As noted above, DSM2 QUAL version 8.0.6 was calibrated for simulating salinity conditions in the Delta in 2009 (CH2M HILL, 2009). DSM2 QUAL was corroborated based on the higher order UnTRIM3D model to account for sea level rise effects on Delta salinity conditions as described in Section 5.B.2.3.3, *Incorporating Sea Level Rise Effects in DSM2 Planning Simulations*. As shown Appendix 5B Attachment 1 and 3, DSM2 performs well in simulating observed salinity conditions in the Delta, and in replicating expected salinity conditions under sea level rise as estimated by UnTRIM3D.

5.B.2.2.2.2 Delta Sourcewater Fingerprinting

The QUAL module was also used to simulate source water finger printing which allows determining the relative contributions of water sources to the volume at any specified location. It is also used to simulate constituent finger printing which determines the relative contributions of conservative constituent sources to the concentration at any specified location. For fingerprinting studies, six main sources are typically tracked: Sacramento River, San Joaquin River, Martinez, eastside streams (Mokelumne, Cosumnes and Calaveras combined), agricultural drains (all combined), and Yolo Bypass. For source water fingerprinting a tracer with constant concentration is assumed for each inflow source tracked, while keeping the concentrations at other inflows as zero. For constituent (e.g., EC) fingerprinting analysis, the concentrations of the desired constituent is specified at each tracked source, while keeping the concentrations at other inflows as zero (Anderson, 2003). Results provide, for each time step, the % distribution of either water or constituent concentration at any given location in the Delta from each of the six potential sources.

5.B.2.2.2.3 Delta Water Temperature

DSM2 QUAL was also used to simulate water temperatures in the Delta. For the CWF BA application, DSM2 QUAL version 8.1.2 was used to simulate water temperatures instead of version 8.0.6, even though hydrodynamics were modeled using version 8.0.6. Appendix 5A, Attachment 4, *DSM2 Temperature Modeling* provides a detailed description of the DSM2 temperature model and the application to the CWF BA NAA and PA.

5.B.2.2.3 DSM2 Input Requirements

DSM2 requires input assumptions relating to physical description of the system (e.g. Delta channel, marsh, and island configuration), description of flow control structures such as gates, initial estimates for stage, flow and EC throughout the Delta, and time-varying input for all boundary river flows and exports, tidal boundary conditions, gate operations, and constituent concentrations at each inflow. Figure 5.B.2-2 illustrates the hydrodynamic and water quality boundary conditions required in DSM2. For long-term planning simulations, output from the CalSim II model generally provides the necessary input for the river flows and exports.

. Assumptions relating to Delta configuration and gate operations are directly input into the hydrodynamic models. Adjusted astronomical tide (Ateljevich, 2001a) normalized for sea level rise (Ateljevich and Yu, 2007) is forced at Martinez boundary. Constituent concentrations are specified at the inflow boundaries, which are either estimated from historical information or CalSim II results. EC boundary condition at Vernalis location is derived from the CalSim II results. Martinez EC boundary condition is derived based on the simulated net Delta outflow from CalSim II and using a modified G-model (Atljevich, 2001b). For other northern boundary freshwater inflows, constant low EC values are assumed based on historical salnity data.

The major hydrodynamic boundary conditions are listed in Table 5.B.2-1 and the locations at which constituent concentrations are specified for the water quality model are listed in Table 5.B.2-2.

For DSM2 temperature simulations additional source flows are included to account for the effluent discharges from the wastewater treatment plants located in the Delta. Temperature modeling also requires meteorological inputs. The input requirements for the DSM2 temperature simulations are provided in the Appendix 5B Attachment 4, *DSM2 Temperature Modeling*.

5.B.2.3 Application of DSM2 to Evaluate CWF BA NAA and PA

Several long-term planning analyses have used DSM2 to evaluate Delta hydrodynamics and water quality. For CWF BA, DSM2 was run for an 82-year period from WY1922 to WY2003, on a 15-min timestep. The inputs needed for DSM2 – inflows, exports, and Delta Cross Channel (DCC) gate operations were provided by the 82-year CalSim II simulations. The tidal boundary condition at Martinez was provided by an adjusted astronomical tide (Ateljevich and Yu, 2007). Monthly Delta channel depletions (i.e., diversions, seepage and drainage) were estimated using DWR's Delta Island Consumptive Use (DICU) model (Mahadevan, 1995).

CalSim II provides monthly inflows and exports in the Delta. Traditionally, the Sacramento and San Joaquin River inflows are disaggregated to a daily time step for use in DSM2 either by applying rational histosplines, or by assuming that the monthly average flow as constant over the whole month. The splines allow a smooth transition between the months. The smoothing reduces sharp transitions at the start of the month, but still results in constant flows for most of the month. Other inflows, exports and diversions were assumed to be constant over the month. For CWF BA modifications to these traditional methods are discussed below.

Delta Cross Channel gate operation input in DSM2 is based on CalSim II output. For each month, DSM2 assumes the DCC gates are open for the "number of the days open" simulated in CalSim II, from the start of the month. See Section 5.A.5.1.5.2 *Delta Cross Channel Gate Operations* for a description of the modeling of the DCC operations in CalSim II.

The operation of the south Delta Temporary Barriers is determined dynamically in using the operating rules feature in DSM2. These operations depend on the season, San Joaquin River flow at Vernalis and tidal condition in the south Delta. Similarly, the Montezuma Slough Salinity Control Gate operations are determined using an operating rule that sets the operations based on the season, Martinez salinity and tidal condition in the Montezuma Slough.

For salinity, EC at Martinez is estimated using the G-model on a 15-min timestep, based on the Delta outflow simulated in CalSim II and the pure astronomical tide at Martinez (Ateljevich, 2001a). The monthly averaged EC for the San Joaquin River at Vernalis estimated in CalSim II for the 82-year period is used in DSM2. For other river flows, which have low salinity, constant values are assumed. For the Sacramento River and Yolo Bypass boundary inflows, a constant EC of 175 µmhos/cm was used. For the Eastside streams, a constant EC of 150 µmhos/cm was used. Monthly average timeseries of the EC values associated with Delta agricultural drainage and return flows was estimated for three regions in the Delta based on observed data identifying the seasonal trend. These values are repeated for each year of the simulation.

For CWF BA, several enhancements were incorporated in the planning analysis approach traditionally used for DSM2. Some of the changes were to address the assumptions for CWF BA while the others are improvements which make the DSM2 planning simulations more realistic.

The changes that are based on the CWF BA assumptions include modifications to DSM2 to capture the effect of sea level rise and north Delta diversion intakes. The DSM2 models incorporating these changes were used in developing new ANNs for CalSim II.

The other enhancement is with regard to the flow boundary conditions used in DSM2. As described above, the traditional approach does not represent the variability that would exist in the Delta inflows within a month. As described in Appendix 5.A, CalSimII was modified to account for daily flow variability in estimating flows for Yolo Bypass and Sacramento at Freeport for limited purposes. A new approach was developed to incorporate daily variability into the DSM2 boundary flows using a similar approach.

The following sections describe in detail various enhancements and changes made to the DSM2 hydrodynamics, salinity and nutrient modeling methods as part of the CWF BA analyses.

5.B.2.3.1 Changes to the DSM2 Grid

The DSM2 model grid from the 2009 recalibration (CH2M HILL, 2009) was further modified in the north Delta to locate the DSM2 nodes at the proposed north Delta diversion intake locations as agreed on January 29th 2010 BDCP Steering Committee meeting. Two new nodes and two new channels were added to the grid and several existing nodes were relocated and channel lengths were modified for the Sacramento River in the reach upstream of Delta Cross Channel. One of the new node added was located downstream of the Delta Cross Channel. Figure 5.B.2-3 shows the grid used in the NAA model for the CWF BA. The DSM2 grid for PA includes several other changes related to the north Delta diversion intakes and is shown in Figure 5.B.2-6.

5.B.2.3.2 Incorporation of Daily Hydrologic Inputs to DSM2

DSM2 is simulated on a 15-minute time step to address the changing tidal dynamics of the Delta system. However, the boundary flows are typically provided from monthly CalSim II results. In the previous planning-level evaluations, the DSM2 boundary flow inputs were applied on a daily time step but used constant flows equivalent to the monthly average CalSim II flows except at month transitions.

As shown in Figures 5.B.2-4 and 5.B.2-5, Sacramento River flow at Freeport exhibits significant daily variability around the monthly mean in the winter and spring period in most water year types. The winter-spring daily variability is deemed important to species of concern. In an effort to better represent the sub-monthly flow variability, particularly in early winter, a monthly-to-daily flow mapping technique is applied to the main boundary inflow inputs to DSM2 (Yolo Bypass, Sacramento River, Cosumnes River, Mokelumne River, Calaveras River and San Joaquin River) . The daily mapping approach used in CalSim II and DSM2 are consistent. The incorporation of daily mapping in CalSim II is described in the Section 5.A.4.3.2, *Incorporation of Sacramento River Daily Variability*. A detailed description of the implementation of the daily variability in DSM2 boundary conditions is provided in Appendix 5B Attachment 5, *Incorporation of Daily Variability in CWF BA Modeling*.

It is important to note that this daily mapping approach does not in any way represent the flows that would result from any operational responses on a daily time step. It is simply a technique to incorporate representative daily variability into the flows resulting from CalSim II's monthly operational decisions.

5.B.2.3.3 Incorporating Sea Level Rise Effects in DSM2 Planning Simulations

A sea level rise of 15 cm at the Golden Gate Bridge was assumed at year 2030 for the analysis in this BA. The hydrodynamics and salinity changes in the Delta due to sea level rise were determined from the UnTRIM 3D Bay-Delta model. DSM2 model results were corroborated for the assumed sea level using the UnTRIM results. Detailed descriptions of the UnTRIM modeling of the sea level rise scenarios and DSM2 corroboration are included in Appendix 5B, Attachments 2 and 3, respectively.

Based on the outcome of the sea level rise corroboration an updated DSM2 grid configuration and model setup was prepared for use in the CWF BA NAA and PA planning simulations to account for the projected 15cm sea level rise. Using the results from the UnTRIM models, two correlations were developed to compute the resulting stage and EC at Martinez location for the 15cm sea level rise scenario. Table 5.B.2-3 shows the Martinez stage and EC correlations for the 15cm sea level rise scenario. It also shows the lag in minutes between the baseline stage or EC and the resulting stage or EC under the scenario with sea level rise. The regressed baseline stage or EC timeseries needs to be shifted by the lag time noted in the Table 5.B.2-3.

As noted earlier, adjusted astronomical tide at Martinez is used as the downstream stage boundary in the DSM2 planning simulation representing current Delta configuration without any sea level rise. This stage timeseries is modified using the stage correlation equation identified in Table 5.B.2-3 for use in a planning simulation with 15cm sea level rise. The EC boundary condition in a DSM2 planning simulation is estimated using the G-model based on the monthly net Delta outflow simulated in CalSim II and the pure astronomical tide (Ateljevich, 2001b). Even though the rim flows and exports are patterned on a daily step in DSM2, the operational decisions, including exports, are still on a monthly timestep. This means that the net Delta outflow may or may not meet the standards on a daily timestep. Therefore, to estimate the EC boundary condition at Martinez, monthly net Delta outflow simulated in CalSim II is used. For a planning simulation with 15cm sea level rise, the EC timeseries from the G-model was adjusted using the EC correlation listed in Table 5.B.2-3 to account for the anticipated changes at Martinez.

5.B.2.3.4 ANN Retraining

ANNs are used for flow-salinity relationships in CalSim II. They are trained on DSM2 outputs and therefore, emulate DSM2 results. Such an ANN requires retraining whenever the flow – salinity relationship in the Delta changes. The CWF BA analysis, with its assumed 15cm sea level rise at Year 2030, is expected to have a different flow – salinity relationship in the Delta compared to the current conditions, and therefore requires a new ANN.

DWR Bay-Delta Modeling staff has retrained the ANN for the 15cm sea level rise scenario. ANN retraining process involved following steps:

- Corroboration of the DSM2 model using UnTRIM model to account for sea level rise effects, as described above
- Development of a range of example long-term CalSim II scenarios to provide a broad range of boundary conditions for the DSM2 models
- Using the grid configuration and the correlations from the corroboration process, several 16-year (WY 1976-1991) DSM2 planning runs are simulated based on the boundary conditions from the identified CalSim II scenarios to create a training dataset for each new ANN
- ANNs are trained using the Delta flows and DCC operations from CalSim II, along with the EC results from DSM2 and the Martinez tide
- The training dataset is divided into two parts. One is used for training the ANN and the other for validating
- Once the ANN is ready, a full circle analysis is performed to assess the performance of the ANN

A detailed description of the ANN training procedure and the full circle analysis is provided in DWR’s 2007 annual report (Seneviratne and Wu, 2007).

5.B.2.3.5 North Delta Diversion Operations

California WaterFix PA includes three new intakes on Sacramento River upstream of Sutter Slough, in the north Delta. The diversions at the intakes are governed by the bypass rules. The bypass rules are simulated in CalSim II using daily mapped Sacramento River flow, which provides the maximum potential diversion that can occur in the north Delta for each day. CalSim II uses the monthly average of this daily potential diversion as one of the constraints in determining the final monthly north Delta diversion. For use in DSM2, the monthly diversion output from CalSim II at the north Delta intakes is mapped onto the daily pattern of the potential diversion estimated in CalSim II.

In the DSM2 simulation of the PA, diversion at each intake is determined on a 15 min timestep, subject to a minimum sweeping velocity criteria so that the fish migrating past the fish screens do not impinge on them. For the CWF BA, it was assumed for modeling purposes that water could be diverted at an intake only if the sweeping velocity was at least 0.4 fps, based on the combination of the required approach velocity for Delta Smelt protection (0.2 fps) and the CDFW (2009) sweeping velocity criterion for streams and rivers (i.e., at least two times the allowable approach velocity). For the PA DSM2 simulation a minimum sweeping velocity of 0.4 fps was used in determining whether or not water can be diverted at an intake, as described below. The assumed intake operations are also subjected to ramping rates while shutting off or starting of the diversion at the intakespartly to minimize potential model instabilities from a sharp and sudden change. These criteria cannot be simulated in CalSim II. However, they are dynamically simulated using the operating rules feature in DSM2.

The north Delta diversion operating rule in the DSM2 allows diverting up to the amount specified by CalSim II each day while subjecting each intake to the sweeping velocity and the ramping criteria. The intakes are operated as long as the daily diversion volume specified by CalSim II is not met. Once the specified volume is diverted for the day, the diversions at the intakes are shut off until the next day.

The volume corresponding to the first 100cfs per intake (for three intakes 300 cfs) of the daily north Delta diversion specified by CalSim II is diverted equally at all the intakes included for the PA. The remaining volume for the day will be diverted such that operation of the upstream intakes is prioritized over the downstream intakes. Intake diversions are ramped over an hour to allow smooth transitions without numerical instabilites when the diversions at the intakes are turned on and off.

In the current modeling of the PA, the diversion flow at an intake for each time step is estimated assuming that the remaining diversion volume in a day will have to be diverted in one time step at the upstream-most intake first and immediate downstream one next and so on until the daily specified total is diverted. However, the estimated amount of diversion at each intake is only diverted when the cross-section’s average velocity measured just downstream of the DSM2 diversion node is greater than or equal to 0.4fps. If in any time step this criteria is violated then the diversion occurs in a future time step when the velocity is above 0.4fps or may occur at a different intake. The sweeping velocity criterion is measured at 1000ft downstream from the diversion node in DSM2 to minimize potential instabilities in the model. Even though DSM2 produces a cross-sectional averaged velocity due to its one-dimensional nature, it is not corrected for the velocity profile across the cross-section for this application..

This dynamic operation of the proposed north Delta diversion intakes modeled in DSM2 is only a simplified representation to account for the variability in the sub-daily flows in the channels downstream of the intakes, and to estimate potential effects on the sub-daily hydrodynamic conditions in the vicinity of the intakes, for the CWF planning effort. The assumed sub-daily operations criteria for the intakes in the DSM2 model are not meant to represent the standard operating procedures of the proposed intakes. The simplified assumptions used in here attempted to consider various factors such as sweeping velocity requirements, ramping rates, north to south intake priority etc., that are likely to be part of the regulatory criteria required by the fishery agencies. The actual values and criteria for these and any other factors to be considered in operating the proposed intakes are anticipated to be determined through operational testing prior to the full operation of the intakes in consultation with regulatory agencies, as alluded to in section 3.3.2.1 of the BA.

New channels, transfers and a reservoir are added to the DSM2 grid to simulate three (3) north Delta diversion intakes as shown in the Figure 5.B.2-6. Three channels, 602, 603, and 605, divert water off the Sacramento River and transfer to channel 607 and 608, from where the total diverted water is transferred to a new reservoir (IF_FOREBAY). Figure 5.B.2-7 shows an example timeseries of sweeping velocities and the diversions at each intake. The plot shows how the intakes are ramped up and down when the velocity falls below 0.4 ft/s.

5.B.2.4 Output Parameters

DSM2 HYDRO provides the following outputs on a 15-minute time step:

- Cross-section Average Flow Rate in the Channelsat nodes
- Stage
- Cross-section Average Velocity

The following variables can be derived from the above outputs:

- Net flows for a specified period, e.g., day
- Mean sea level, mean higher high water, mean lower low water and tidal range
- Water depth
- Tidal reversals
- Flow splits, etc.

DSM2 QUAL provides the following outputs on a 15-minute time step:

- Salinity (EC)
- Source water and constituent fingerprinting
- Water temperature

Following variables can be derived from the above QUAL outputs:

- Bromide, chloride, and total dissolved solids
- Selenium

In a planning analysis, the flow boundary conditions that drive DSM2 are obtained from the monthly CalSim II model. The agricultural diversions, return flows and corresponding salinities used in DSM2 are on a monthly time step. The implementation of Delta Cross Channel gate operations in DSM2 assumes that the gates are open from the beginning of a month, irrespective of the water quality needs in the south Delta.

The input assumptions stated above should be considered when DSM2 EC results are used to evaluate performance of a baseline or an alternative against the standards. Even though CalSim II releases sufficient flow to meet the standards on a monthly average basis, the resulting EC from DSM2 may be over the standard for part of a month and under the standard for part of the month, depending on the spring/neap tide and other factors (e.g. simplification of operations). It is recommended that the results are presented on a monthly basis. Frequency of compliance with a criterion should be computed based on monthly average results. Averaging on a sub-monthly (14-day or more) scale may be appropriate as long as the limitations with respect to the compliance of the baseline model are described in detail and the alternative results are presented as an incremental change from the baseline model. A detailed discussion is required in this case.

In general, it is appropriate to present DSM2 QUAL results including EC, DOC, volumetric fingerprinting and constituent fingerprinting on a monthly time step. When comparing results from two scenarios, computing differences based on these mean monthly statistics would be appropriate.

5.B.2.5 Linkages to Other Models

The Delta boundary flows and exports from CalSim II are used to drive the DSM2 Delta hydrodynamic and water quality models for estimating tidally-based flows, stage, velocity, and salt transport within the estuary. DSM2 water quality and volumetric fingerprinting results are used to assess changes in concentration of selenium in Delta waters. DSM2 results are also used in fisheries models (IOS, DPM) or aquatics species survival/habitat relationships developed based on peer reviewed scientific publications, and other secondary hydrodynamics analyses to assess the effects on listed fish species in the Delta.

5.B.2.6 Modeling Limitations

DSM2 is a one-dimensional model with inherent limitations in simulating hydrodynamic and transport processes in a complex estuarine environment such as the Sacramento – San Joaquin Delta. DSM2 assumes that velocity in a channel can be adequately represented by a single average velocity over the channel cross-section, meaning that variations both across the width of the channel and through the water column are negligible. DSM2 does not have the ability to model short-circuiting of flow through a reach, where a majority of the flow in a cross-section is confined to a small portion of the cross-section. DSM2 does not conserve momentum at the channel junctions and does not model the secondary currents in a channel. DSM2 also does not explicitly account for dispersion due to flow accelerating through channel bends. It cannot model the vertical salinity stratification in the channels.

It has inherent limitations in simulating the hydrodynamics related to the open water areas. Since a reservoir surface area is constant in DSM2, it impacts the stage in the reservoir and thereby impacting the flow exchange with the adjoining channel. Due to the inability to change the cross-sectional area of the reservoir inlets with changing water surface elevation, the final entrance and exit coefficients were fine tuned to match a median flow range. This causes errors in the flow exchange at breaches during the extreme spring and neap tides. Using an arbitrary bottom elevation value for the reservoirs representing the proposed marsh areas to get around the wetting-drying limitation of DSM2 may increase the dilution of salinity in the reservoirs.

For open water bodies DSM2 assumes uniform and instantaneous mixing over entire open water area. Thus it does not account for the any salinity gradients that may exist within the open water bodies. Significant uncertainty exists in flow and EC input data related to in-Delta agriculture, which leads to uncertainty in the simulated EC values. Caution needs to be exercised when using EC outputs on a sub-monthly scale.

5.B.3 Delta Particle Tracking Modeling

Particle tracking models (PTM) are excellent tools to visualize and summarize the impacts of modified hydrodynamics in the Delta. These tools can simulate the movement of passive particles or particles with behavior representing either larval or adult fish through the Delta. The PTM tools can provide important information relating hydrodynamic results to the analysis needs of biologists that are essential in assessing the impacts to the fisheries and habitat in the Delta.

5.B.3.1 DSM2-PTM

DSM2-PTM simulates pseudo 3-D transport of neutrally buoyant particles based on the flows simulated by HYDRO. The PTM module simulates the transport and fate of individual particles traveling throughout the Delta. The model uses geometry files, velocity, flow, and stage output from the HYDRO module to monitor the location of each individual particle using assumed vertical and lateral velocity profiles and specified random movement to simulate mixing. The location of a particle in a channel is determined as the distance from the downstream end of the channel segment (x), the distance from the centerline of the channel (y), and the distance above the channel bottom (z).PTM has multiple applications ranging from visualization of flow patterns to simulation of discrete organisms such as fish eggs and larvae.

The longitudinal distance traveled by a particle is determined from a combination of the lateral and vertical velocity profiles in each channel. The transverse velocity profile simulates the effects of channel shear that occurs along the sides of a channel. The result is varying velocities across the width of the channel. The average cross-sectional velocity is multiplied by a factor based on the particle’s transverse location in the channel. The model uses a fourth order polynomial to represent the velocity profile. The vertical velocity profile shows that particles located near the bottom of the channel move more slowly than particles located near the surface. The model uses the Von Karman logarithmic profile to create the velocity profile. Particles also move because of random mixing. The mixing rates (i.e., distances) are a function of the water depth and the velocity in the channel. High velocities and deeper water result in greater mixing.

At a junction the path of a particle is determined randomly based on the proportion of flow. The proportion of flow determines the probability of movement into each reach. A random number based on this determined probability then determines where the particle will go. A particle that moves into an open water area, such as a reservoir, no longer retains its position information. A DSM2 open water area is considered a fully mixed reactor. The path out of the open water area is a decision based on the volume in the open water area, the time step, and the flow out of the area. At the beginning of a time step, the volume of the open water area and the volume of water leaving at each opening of the open water area are determined. From that, the probability of the particle leaving the open water area is calculated. Particles entering exports or agricultural diversions are considered "lost" from the system. Their final destination is recorded. Once particles pass the Martinez boundary, they have no opportunity to return to the Delta. (Smith, 1998, Wilbur, 2001, Miller, 2002)

5.B.3.2 Application of DSM2-PTM to Evaluate CWF

DSM2 PTM was used in multiple applications for the CWF BA effects analysis. The key applications are outlined below. A detailed description of each application along with the modeling assumption are provided in the following sections.

- *Use of DSM2-PTM for evaluating larval delta smelt:* PTM simulations were performed to characterize the potential entrainment effects of larval delta smelt at the key export/diversion locations in the Delta under the NAA and the PA, during March through June months.

- *Use of DSM2-PTM for evaluating larval longfin smelt:* PTM simulations were performed to characterize the potential entrainment effects of larval longfin smelt at the key export/diversion locations in the Delta under the NAA and the PA, primarily during January through March months.

- *Use of DSM2-PTM for evaluating Delta residence times:* PTM simulations were performed to characterize the Delta residence times under the NAA and the PA, for a range of hydrologic conditions and operations in the Delta, during July through November months.

- *Use of DSM2-PTM for evaluating adult delta smelt:* PTM simulations were performed to characterize the potential for adult delta smelt to migrate upstream on the Sacramento River mainstem towards the proposed north Delta intakes under the PA, primarily during December through February months. Unlike the above PTM applications which use neutrally buoyant passive particles, this application includes particle behavior.

DSM2 PTM version 8.1.2 was used for the CWF BA PTM analyses even though the hydrodynamics are simulated using version 8.0.6, to take advantage of new PTM features such as the particle filtering to limit particles from leaving the Delta through in-Delta agricultural diversion and seepage sources.

5.B.3.3 DSM2-PTM for Evaluating Larval Delta Smelt

DSM2 PTM was used to assess the potential for entrainment of delta smelt larvae at various water exports and diversions locations in the Delta (i.e., the south Delta export facilities, the NDD, and the NBA Barker Slough Pumping Plant).

5.B.3.3.1 PTM Period Selection

PTM runs were simulated for March, April, May and June months in each year from 1922 to 2003, leading to a total of 328 release periods for this application.

5.B.3.3.2 PTM Simulations

Particles were released at the 39 locations shown in Figure 5.B.3-1. These locations are also listed in Table 5.B.3-1. PTM simulations, one for each release locations, were performed in a batch mode, for each of the 328 insertion periods. This brought the total PTM simulations performed for four release periods per year and 82 years, to 12,792 under this application. 4,000 neutrally buoyant passive particles were released over a 24.75 hour period, starting on the first day of the selected month for each PTM simulation. Particle entrainment at the Delta agricultural locations was turned off in these simulations.

Each PTM simulation was run for a 60 day period, from the date of release, and the fate of the released particles was tracked continuously over the 60 days. The particle flux was tracked at the key exit locations – south Delta exports (CVP Jones Pumping Plant, SWP Clifton Court Forebay), north Delta intakes, North Bay Aqueduct, past Martinez and particles remaining in the Delta channels, and at several internal tracking locations as shown in Figure 5.B.3-1. The timeseries output was post-processed to determine the % of particles ended up at the above locations at the end of 30 days after release and used in the larval delta smelt entrainment evaluation.

5.B.3.4 DSM2-PTM for Evaluating Larval Longfin Smelt

DSM2 PTM was used to assess the potential for entrainment of longfin smelt larvae at various water exports and diversions locations in the Delta (i.e., the south Delta export facilities, the NDD, and the NBA Barker Slough Pumping Plant).

5.B.3.4.1 PTM Period Selection

PTM runs were simulated for December, January, February and March months in each water year from 1922 to 2003, leading to a total of 328 release periods for this application.

5.B.3.4.2 PTM Simulations

Particles were released at the 39 locations shown in Figure 5.B.3-1. These locations are also listed in Table 5.B.3-1. PTM simulations, one for each release locations, were performed in a batch mode, for each of the 328 insertion periods. This brought the total PTM simulations performed for four release periods per year and 82 years, to 12,792 under this application. 4,000 neutrally buoyant passive particles were released over a 24.75 hour period, starting on the first day of the selected month for each PTM simulation. Particle entrainment at the Delta agricultural locations was turned off in these simulations.

Each PTM simulation was run for a 60 day period, from the date of release, and the fate of the released particles was tracked continuously over the 60 days. The particle flux was tracked at the key exit locations – south Delta exports, north Delta intakes, past Chipps Island, to Suisun Marsh and past Martinez and at several internal tracking locations as shown in Figure 5.B.3-1. Specifically, % of particles entrained at the SWP's Clifton Court Forebay, the CVP's Jones Pumping Plant, the proposed NDD, and the NBA Barker Slough Pumping Plant, and % of particles entered into the south Delta (defined as the sum of particles entering Big Break, Dutch Slough, False River, Fishermans Cut, Old River mouth, Middle River mouth, Columbia Cut, and Turner Cut) were reported. The timeseries output was post-processed to determine the % of particles at above locations, at the end of 45 days after release and used in the larval longfin smelt entrainment evaluation.

5.B.3.5 DSM2-PTM for Evaluating Delta Residence Times

DSM2 PTM was used to assess the water residence time in the Delta for use in the evaluation of the potential for the Microcystis blooms in the Delta.

5.B.3.5.1 PTM Period Selection

A subset of 25 years that are representative of the range of hydrologic conditions, and the range of Delta operations over the 82-year period (1922 – 2003) were identified for this application.

To this end, the mean July to November Delta exports, outflow, and inflow across all 82 years were computed for the NAA scenario. The 82 years were sorted into four CVP/SWP total Delta export bins (2500-5000 cfs, 5000 – 7500 cfs, 7500 – 10000 cfs, and 10000 – 12500 cfs) , and several years were selected within each bin after examining plots of inflow versus outflow, in order to represent the range of inflow versus outflow conditions. A total of 25 years were chosen, and DSM2-PTM simulations were run based on the DSM2-HYDRO simulations for these years. Figures 5.B.3-2 to 5.B.3-5 contain plots of the selected outflow and inflow combinations for different export ranges. Table 5.B.3-2 lists the selected years along with the July through November average Delta exports, outflow and inflow for the NAA scenario.

5.B.3.5.2 PTM Simulations

For each of the 25 years selected for this analysis, 90-day DSM2-PTM runs were simulated beginning on the first day in each month, for July to November. There were a total of 125 runs performed per each scenario. Particles were released at locations that were grouped based on Delta subregions shown in Figure 5.B.3-6. Four thousand particles were inserted per subregion, and were evenly divided between the release locations within each subregion. The simulated particle fates were used to estimate residence time under each of these 125 sets of conditions.

25 PTM simulations, one for each sub-region, were performed in a batch mode, for each insertion period. This brought the total PTM simulations performed for five release periods per year and 25 years, to 3125. For each simulation, particles were inserted at the DSM2 nodes identified in each sub-region as shown in Figure 5.B.3-7 and Table 5.B.3-3. Hourly timeseries of

number of particles remained in each sub-region was saved from each run over the 90-day simulation period. Residence time (in hours) was calculated as the time since the start of the simulation i weighted by the number of particles remaining in the subregion at time i:

$$Residence\ time\ (hours) = \frac{\sum_{i=1}^{90*24}(No.of\ particles\ in\ the\ subregion)_i * i}{\sum_{i=1}^{90*24}(No.of\ particles\ in\ the\ subregion)_i}$$

5.B.3.6 DSM2-PTM for Adult Delta Smelt

DSM2 PTM was used to assess the potential for upstream migration of the adult delta smelt towards the NDD intakes.

5.B.3.6.1 PTM Period Selections

Periods were selected based on a turbidity trigger. In modeling the USFWS RPA Component 1, Action 1, the turbidity trigger was based on the following (Appendix 5.A Attachment 6):

- If the monthly average unimpaired Sacramento River Index (four-river index: sum of Sacramento, Yuba, Feather, and American Rivers) exceeds 20,000 cfs, then it was assumed that an event, in which the 3-day average turbidity at Hood exceeded 12 NTU, had occurred within the month (see Figure 5.B.3-8).

The above criteria was used to identify the month (Dec, Jan, or Feb) in each of the 82 water years, when the particles would be released. For each of the months identified, daily averaged Freeport (RSAC155) flow output from the NAA DSM2 simulation was used to identify the day when the peak flow occurred in the month. The particles were released on the day when the peak flow occurred in the month. In the water years if the above turbidity criteria was not triggered during Dec – Feb months, then the particles were released on Feb 1st for that year irrespective of the flow. Selected periods are summarized in Table 5.B.3-4 and in Figure 5.B.3-9.

5.B.3.6.2 PTM Simulations

Particles were released at Chipps Island (DSM2 node 465), Decker Island (DSM2 node 353), Montezuma Slough (DSM2 node 420), and Cache Slough at Liberty Island (DSM2 node 323). 4000 particles were released uniformly over a tidal day (1485 minutes) and tracked for 30 days. Particles released were assumed to have vertical migration behavior such that they remain in the upper 10% of water level during flood tide, and remain in the lower 10% of water level during the ebb tide.

The entrainment at each of the major pumping facilities (North Delta Diversion, Clifton Court Forebay, Jones Pumping Plant, and NBA) at the end of 30-days was reported. Also, the particle flux across key transects in the Sacramento River (at Isleton and past Chipps Island) were reported at the end of the 30-day period. Particles remaining within each of the sub-regions shown in Figure 5.B.3-6 were also reported at the end of 30 days.

5.B.3.7 Limitations

PTM results are most often used to understand the potential movement of eggs and larval fish with flow changes. Similarly, the PTM is also used to study the changes in the residence time (residence time being a surrogate of the water quality conditions in the Delta) in the Delta associated with flow changes. PTM approximates movement of neutrally-buoyant particles or particles with assumed behavior based on the hydrodynamics. The PTM model requires input of channel velocity fields from HYDRO model, which leads to the translation of the limitations inherent to HYDRO to the PTM model. The partitioning of the particles at a junction in the PTM is simplistic and is based on the flow split into different branches at a junction. Information related to higher order hydraulics such as acceleration around the bend and secondary currents are not simulated in the PTM, despite its use of an approximate 3D velocity field. Use of the PTM results to analyze certain species and life stages with significant active behavior responses should be used with caution. While some uncertainty exists in the PTM results, the model is a reasonable tool to compare the movement and fate of particles between various scenarios, if results are interpreted within the context of these limitations.

5.B.4 DSM2 Modeling Assumptions

This section presents the assumptions used in developing the DSM2 simulations of the NAA and PA for use in the CWF BA evaluation. The assumptions were selected based on the recommendations from the agencies involved in the SCT. The DSM2 assumptions for the NAA and the PA are listed in Table 5.B.4-1.

5.B.4.1 DSM2 Assumptions for the NAA

5.B.4.1.1 River Flows

For the NAA DSM2 simulation, the river flows at the DSM2 boundaries are based on the monthly flow time series from CalSim II.

5.B.4.1.2 Tidal Boundary

For the NAA, the tidal boundary condition at Martinez is based on an adjusted astronomical tide normalized for sea level rise (Ateljevich and Yu, 2007) and is modified to account for the sea level rise using the correlations derived based on three-dimensional (UnTRIM) modeling of the Bay-Delta with sea level rise at Year 2030.

5.B.4.1.3 Water Quality

5.B.4.1.3.1 Martinez EC

For the NAA, the Martinez EC boundary condition in the DSM2 planning simulation is estimated using the G-model based on the net Delta outflow simulated in CalSim II and the pure astronomical tide (Ateljevich, 2001), as modified to account for the salinity changes related to the sea level rise using the correlations derived based on the three-dimensional (UnTRIM) modeling of the Bay-Delta with sea level rise at Year 2030.

5.B.4.1.3.2 Vernalis EC

For the NAA DSM2 simulation, the Vernalis EC boundary condition is based on the monthly San Joaquin EC time series estimated in CalSim II.

5.B.4.1.4 Morphological Changes

No additional morphological changes were assumed as part of the NAA simulation. The DSM2 model and grid developed as part of the 2009 recalibration effort (CH2M HILL, 2009) was used for the NAA modeling.

5.B.4.1.5 Facilities

5.B.4.1.5.1 Delta Cross Channel Gates

Delta Cross Channel gate operations are modeled in DSM2. The number of days in a month the DCC gates are open is based on the monthly time series from CalSim II.

5.B.4.1.5.2 South Delta Temporary Barriers

South Delta Temporary Barriers are included in the NAA simulation. The three agricultural temporary barriers located on Old River, Middle River and Grant Line Canal are included in the model. The temporary fish barrier located at the Head of Old River is also included in the model.

5.B.4.1.5.3 Clifton Court Forebay Gates

Clifton Court Forebay gates are operated based on the Priority 3 operation, where the gate operations are synchronized with the incoming tide to minimize the impacts to low water levels in nearby channels. The Priority 3 operation is described in the 2008 OCAP BA Appendix F Section 5.2 (USBR, 2008b).

5.B.4.1.6 Operations Criteria

5.B.4.1.6.1 South Delta Temporary Barriers

South Delta Temporary Barriers are operated based on San Joaquin flow conditions. Head of Old River Barrier is assumed to be only installed from September 16 to November 30 and is not installed in the spring months, based on the USFWS Delta Smelt BiOp Action 5. The agricultural barriers on Old and Middle Rivers are assumed to be installed starting from May 16 and the one on Grant Line Canal from June 1. All three agricultural barriers are allowed to operate until November 30. The tidal gates on Old and Middle River agricultural barriers are assumed to be tied open from May 16 to May 31.

5.B.4.1.6.2 Montezuma Salinity Control Gate

The radial gates in the Montezuma Slough Salinity Control Gate Structure are assumed to be tidally operating from October through February each year, to minimize propagation of high salinity conditions into the interior Delta.

5.B.4.2 DSM2 Assumptions for the PA

5.B.4.2.1 River Flows

Consistent with the NAA

5.B.4.2.2 Tidal Boundary

Consistent with the NAA

5.B.4.2.3 Water Quality

5.B.4.2.3.1 Martinez EC

Consistent with the NAA

5.B.4.2.3.2 Vernalis EC

Consistent with the NAA

5.B.4.2.4 Morphological Changes

Consistent with the NAA

5.B.4.2.5 Facilities

5.B.4.2.5.1 Delta Cross Channel

Consistent with the NAA.

5.B.4.2.5.2 South Delta Temporary Barriers and HOR Gate

The temporary agricultural barriers under the PA are consistent with the NAA. A permanent HOR gate is assumed under the PA in place of the temporary HOR barrier included under the NAA.

5.B.4.2.5.1 Clifton Court Forebay Gates

Consistent with the NAA

5.B.4.2.5.2 North Delta Diversion Intakes

North Delta diversion intakes 2, 3, and 5 are modeled in DSM2 for the PA, with 3,000 cfs diversion capacity at each intake. A detailed description of the modeling of the north Delta diversion intakes in DSM2 for the PA is included in the Section 5.B.2.3.5, *North Delta Diversion Operations*.

5.B.4.2.6 Operations Criteria

5.B.4.2.6.1 South Delta Temporary Barriers and HOR Gate

The operations of the agricultural barriers are consistent with the NAA. The HOR gate operations under the PA are assumed such that appropriate gate opening is simulated to allow the fraction of "the flow that would have entered the Old River if the barrier were fully open", as noted in Table 5.B. 4-2. For October, the HORB is closed for the last two weeks, during the San Joaquin River pulse flows.

5.B.4.2.6.2 Montezuma Salinity Control Gate

Consistent with the NAA.

5.B.4.2.6.3 North Delta Diversion Intakes

The diversion operation at the north Delta intakes are dynamically simulated in DSM2 such that the amount specified by CalSim II each day is diverted while subjecting each intake to the sweeping velocity and the ramping criteria. A maximum of 3,000 cfs is withdrawn at each intake while meeting a velocity requirement of 0.4 fps downstream of each intake. The intakes are operated as long as the daily diversion volume specified by CalSim II is not diverted. Once the specified volume is diverted for the day, the diversions at the intakes are shut off until next day. The volume corresponding to first 300 cfs of the daily north Delta diversion specified by CalSim II is diverted equally at all the three intakes. The remaining volume for the day will be diverted such that operation of the upstream intake is prioritized over the downstream one. Intake diversions are ramped over an hour to allow smooth transitions when they are turned on and off.

5.B.5 DSM2 Results

This section provides DSM2 model simulation results for the NAA and the PA evaluated for the CWF BA. For each parameter listed below figures and tables in various formats are included to provide the reader with tools for multiple ways of analysis. Different types of presentations are explained below:

- Long Term Average Summary and Water Year Type Based Statistics Summary Tables: These tables provide parameter values for each 10% increment of exceedance probability (rows) for each month (columns) as well as long-term and year-type averages, using the Sacramento Valley 40-30-30 Index for the locations in the Delta and 60-20-20 Index for the San Joaquin River developed by the SWRCB for projected climate at Year 2030 (under Q5 scenario) for each month.

- Probability of Exceedance Plots: Probability of exceedance plots are provided for each month over the period of record as well as monthly plots by water year type. Probability of exceedance plots provide the frequency of occurrence of values of a parameter that exceed a reference value. For this appendix, the calculation of exceedance probability is done by ranking the data. For example, for Sacramento River downstream of North Delta Intakes Flow exceedance plot, Sacramento River flow values for each month, for each simulated year are sorted in ascending order. The smallest value would have a probability of exceedance of 100% since all other values would be greater than that value; and the largest value would have a probability of exceedance of 0%. All the values are plotted with probability of exceedance on the x-axis and the value of the parameter on the y-axis. Following the same example, if for one scenario, Sacramento River downstream of North Delta Intakes Flow in October of 7,000 cfs corresponds to 80% probability; it implies that Sacramento River downstream of North Delta Intakes Flow in October is higher than 7,000 cfs in 80% of the years under the simulated conditions.

- Box and Whisker Plots: These plots show the monthly DSM2 results under the NAA and the PA for each month for each water year type. The plots display the distribution of data based on the following statistical summary.
  - 5th percentile that corresponds to 95% exceedance probability,
  - first quartile (25^{th} percentile that corresponds to 75% exceedance probability),
  - median (50% exceedance probability),
  - third quartile (75^{th} percentile that corresponds to 25% exceedance probability),
  - 95^{th} percentile that corresponds to 5% exceedance probability, and
  - mean

Monthly average flows, salinity, volumetric fingerprinting and water temperature results as listed below are presented in this appendix. For each of the parameter identified below a table comparing monthly results, a monthly exceedance plot, and box-whisker plot by water year type are included.

5.B.5-1 Sacramento River downstream of North Delta Intakes Flow

5.B.5-2 Sutter Slough Flow

5.B.5-3 Steamboat Slough Flow

5.B.5-4 Delta Cross Channel Flow

5.B.5-5 Georgiana Slough Flow

5.B.5-6 Sacramento River at Rio Vista Flow

5.B.5-7 San Joaquin River at Antioch Flow

5.B.5-8 Head of Old River Flow

5.B.5-9 Sacramento River downstream of Georgiana Slough Salinity

5.B.5-10 Cache Slough at Ryer Island Salinity

5.B.5-11 Sacramento River at Rio Vista Salinity

5.B.5-12 Sacramento River at Emmaton Salinity

5.B.5-13 San Joaquin River at Jersey Point Salinity

5.B.5-14 Sacramento River at Collinsville Salinity

5.B.5-15 Sacramento River at Port Chicago Salinity

5.B.5-16 San Joaquin River at Antioch Salinity

5.B.5-17 Chipps Island South Channel Salinity

5.B.5-18 Old River at Rock Slough Salinity

5.B.5-19 Jones Pumping Plant South Delta Exports Salinity

5.B.5-20 Banks Pumping Plant South Delta Exports Salinity

5.B.5-21 Sacramento River at Collinsville Sacramento River plus Yolo Bypass Volumetric Fingerprinting

5.B.5-22 Sacramento River at Collinsville San Joaquin River Volumetric Fingerprinting

5.B.5-23 Sacramento River at Collinsville Martinez Volumetric Fingerprinting

5.B.5-24 Delta Cross Channel Number of Days Gates Open

5.B.5-25 Chadborne Slough at Sunrise Duck Club Salinity

5.B.5-26 Suisun Slough near Volanti Intake Salinity

5.B.5-27 Montezuma Slough at Beldon's Landing Salinity

5.B.5-28 Montezuma Slough at National Steel Salinity

5.B.5-29 Montezuma Slough upstream of Salinity Control Gate Flow

5.B.5-30 Roaring Slough upstream of Roaring River Distribution System Flow

5.B.5-31 Morrow Island Distribution System M-line towards Goodyear Slough Flow

5.B.5-32 Morrow Island Distribution System M-line towards Suisun Bay Flow

5.B.5-33 Morrow Island Distribution System C-line Flow

5.B.5-34 Goodyear Slough upstream of Goodyear Outfall Flow

5.B.5-35 Barker Slough at North Bay Aqueduct Intake Flow

5.B.5-36 Rock Slough at Contra Costa Canal Intake Flow

5.B.5-37 San Joaquin River at Prisoners Point Salinity

5.B.5-38 Sacramento River at Freeport Flow

5.B.5-39 North Delta Intakes Diversion Flow

5.B.5-40 Sacramento River at Rio Vista Monthly Temperature

5.B.5-41 San Joaquin River at Prisoners Point Monthly Temperature

5.B.5-42 San Joaquin River at Brandt Bridge Monthly Temperature

5.B.5-43 Stockton Deep Water Ship Channel Monthly Temperature

5.B.6 References

Anderson, J. (2003). “Chapter 14: DSM2 Fingerprinting Methodology”. Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh. 24th Annual Progress Report to the State Water Resources Control Board. Sacramento, CA.

Anderson, J., and M. Mierzwa. (2002). “DSM2 tutorial—an introduction to the Delta Simulation Model II (DSM2) for simulation of hydrodynamics and water quality of the Sacramento–San Joaquin Delta”. Draft. February. Delta Modeling Section, Office of State Water Project Planning, California Department of Water Resources. Sacramento, CA.

Ateljevich, E. and Yu, M. (2007). “Chapter 4 – Extended 82-year Martinez Planning Tide”. Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh.28th Annual Progress Report to the State Water Resources Control Board. Sacramento, CA.

Ateljevich, E. (2001a). “Chapter 10: Planning tide at the Martinez boundary”. Methodology for flow and salinity estimates in the Sacramento-San Joaquin Delta and Suisun Marsh. 22nd Annual Progress Report to the State Water Resources Control Board. Sacramento, CA.

Ateljevich, E. (2001b). “Chapter 11: Improving salinity estimates at the Martinez boundary”. Methodology for flow and salinity estimates in the Sacramento-San Joaquin Delta and Suisun Marsh. 22nd Annual Progress Report to the State Water Resources Control Board. Sacramento, CA.

Brown, Linfield C., Thomas O. Barnwell, 1987. The Enhanced Stream Water Quality Models QUAL2E and QUAL2E_UNCAS: Documentation and User Manual, USEPA Environmental Prot3ction Laboratory, May, 1987.

CH2M HILL (2009). “DSM2 Recalibration”. prepared for California Department of Water Resources, October 2009.

California Department of Fish and Game. 2009. “Fish Screening Criteria”. Website last accessed in January 2011.URL: http://www.dfg.ca.gov/fish/Resources/Projects/Engin/Engin_ScreenCriteria.asp.

California Department of Water Resources. 2010. “DSM2 Version 8.0.6 Release (11/17/2010)”. Website last accessed in September 2015.URL: http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/models/dsm2/dsm2.cfm

DSM2PWT. 2001. Enhanced Calibration and Validation of DSM2 HYDRO and QUAL, Draft Final Report, Interagency Ecological Program for the Sacramento-San Joaquin Estuary. November, 2011.

Guerin, M., Modeling the Fate and Transport of Ammonia Using DSM2-QUAL: Calibration/Validation Report, Prepared for: Metropolitan Water District, 2010.

Guerin, M., Modeling the Fate and Transport of Nutrients Using DSM2: Calibration/Validation Report, Prepared for: Metropolitan Water District, November, 2011.

Kimmerer, W. J. 2008. Losses of Sacramento River Chinook Salmon and Delta Smelt to Entrainment in Water Diversions in the Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science 6(2).

Kimmerer, W. J. 2011. Modeling Delta Smelt Losses at the South Delta Export Facilities. San Francisco Estuary and Watershed Science 9(1).

Liu, L. and Sandhu, P. (2013). “Chapter 3: DSM2 Version 8.1 Calibration with NAVD 88 Datum”. Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh. 34th Annual Progress Report to the State Water Resources Control Board. Sacramento, CA.

Mahadevan, N. (1995). “Estimation of Delta island diversions and return flows”. California Department of Water Resources, Division of Planning. February. Sacramento, CA.

Miller, A. (2002). “Chapter 2: Particle Tracking Model Verification and Calibration.” Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh.22nd Annual Progress Report to the State Water Resources Control Board. Sacramento, CA.

Nader-Tehrani, P. (1998). “Chapter 2: DSM2-HYDRO”. Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh.19th Annual Progress Report to the State Water Resources Control Board. Sacramento, CA.

Pandey, G. (2001). “Chapter 3 – Simulation of Historical DOC and UVA Conditions in the Delta”. Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh.22nd Annual Progress Report to the State Water Resources Control Board. Sacramento, CA.

Nobriga, M. L., Z. Matica, and Z. P. Hymanson. 2004. Evaluating Entrainment Vulnerability to Agricultural Irrigation Diversions: A Comparison among Open-Water Fishes. American Fisheries Society Symposium 39:281-295.

Rajbhandari, H. (2003). “Chapter 3: Extending DSM2-QUAL Calibration of Dissolved Oxygen”. Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh.24th Annual Progress Report to the State Water Resources Control Board.

Seneviratne, S. and Wu, S. (2007). “Chapter 3 – Enhanced Development of Flow-Salinity Relationships in the Delta Using Artificial Neural Networks: Incorporating Tidal Influence”. Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh.28th Annual Progress Report to the State Water Resources Control Board. Sacramento, CA.

Smith, T. (1998). “Chapter 4: DSM2-PTM.” Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh.22nd Annual Progress Report to the State Water Resources Control Board. Sacramento, CA.

U. S. Bureau of Reclamation, 2008b. 2008 Central Valley Project and State Water Project Operations Criteria and Plan Biological Assessment, Appendix D DSM2 Model, May 2008.

Wilbur, R. and Munévar, A. (2001). “Chapter 7 – Integration of CalSim and Artificial Neural Networks Models for Sacramento-San Joaquin Delta Flow-Salinity Relationships”. Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh.22nd Annual Progress Report to the State Water Resources Control Board. Sacramento, CA.

Attachment 1: DSM2 Recalibration for Bay-Delta Conservation Plan

DWR’s DSM2 is the primary analytical tool used to evaluate the changes to Delta hydrodynamics and water quality associated with the proposed elements of the CWF PA. The ability to accurately simulate tidal flows and salt transport in the northern Delta and Cache Slough region is of particular importance for the CWF considering the proposed diversion intakes on the Sacramento River. In preparing the analytical tools for use in the BDCP modeling, DSM2 model was recalibrated using recent historical flow, stage and salinity data in the Delta (CH2M HILL 2009). The DSM2 grid was modified to include recent morphological changes such as the flooded Liberty Island, in addition to some updated bathymetric data in the north Delta region. The recalibration effort significantly improved DSM2’s simulation of the observed tidal stage, flows and salt transport in the Delta. Detailed description of the recalibration process and results are included in a technical report previously documented. This technical report is included as the Attachment 1 to the Appendix 5B (separate PDF file).

Attachment 2: UnTRIM San Francisco Bay-Delta Model Sea Level Rise Scenario Modeling Report

CWF BA NAA and PA scenarios include the effects of future projections of sea level rise on the hydrodynamics and salinity intrusion in the Sacramento-San Joaquin Delta. For the selected sea level rise scenarios, three-dimensional UnTRIM Bay-Delta model was simulated to evaluate the Delta hydrodynamic and salinity conditions under historical conditions. UnTRIM results were used in corroborating the hydrodynamics and salinity results from the one-dimensional DSM2 model (described in Appendix 5B Attachment 3, *DSM2 Corroboration*) for projected 15 cm sea level rise at year 2030. A technical report prepared for the BDCP Effects Analysis summarizes the UnTRIM results for various projections of sea level rise values. This technical report is included as the Attachment 2 to the Appendix 5B (separate PDF file).

Even though, CWF BA analyses used 15 cm sea level rise at Year 2030, several other values were simulated using UnTRIM to capture the range of uncertainty in the sea level rise projections and to understand the potential impact on the CVP/SWP operations. UnTRIM was simulated for sea level rise values including 15 cm, 30 cm, 45 cm, 60 cm, 140 cm and 140 cm with 5% tidal range amplification. UnTRIM results for the simulated sea level rise scenarios are included in the Appendix 5B Attachment 2.

Attachment 3: DSM2 Sea Level Rise Corroboration

In the analysis of the CWF BA NAA and PA scenarios, simulation of the effects related to the projected sea level rise are integral parts of the physical modeling to understand the overall effects. CWF PA evaluation requires long-term analysis of hydrodynamics and water quality in the Delta resulting from the proposed physical and operational changes. DSM2 is an appropriate model for this type of analysis. It has been successfully used in analyzing several projects in the Delta. However, DSM2 has a limited ability to simulate three-dimensional processes such as gravitational circulation which is known to increase with sea level rise in the estuaries. Therefore, it is imperative that DSM2 be recalibrated or corroborated based on a dataset that accurately represents the Delta conditions under sea level rise.

Since the proposed conditions are hypothetical, the Delta hydrodynamics conditions under the proposed conditions were estimated by simulating higher order model, which can resolve the three-dimensional processes well, over a short time period. The results from the higher order model provided the data sets needed to corroborate or recalibrate DSM2 under the future conditions so that the hydrodynamics and salinity transport in the Delta can be simulated with reasonable accuracy.

DSM2 was corroborated using results from the three-dimensional UnTRIM model for 15cm sea level rise scenarios. Detailed descriptions of the corroboration process and results are documented in a technical report included as the Attachment 3 to the Appendix 5B.

Attachment 4: DSM2 Temperature Modeling

Attachment 4 includes a summary of the Delta water temperature modeling performed for the CWF NAA and PA scenarios using DSM2 QUAL. The attachment includes an overview of the model setup, boundary conditions, meteorological boundary conditions development, and application to the CWF NAA and PA scenarios. The attachment also includes a brief summary of the calibration results for the DSM2 temperature modeling, and the bias in the simulated temperatures based on the calibration results.

Attachment 5: Incorporation of Daily Variability in the CalSim II and DSM2 Modeling

CalSim II is the primary model that integrates all the proposed CWF elements with existing system and regulatory framework. It provides operational decisions on a monthly timestep. The operation of some of the proposed CWF elements such as the north Delta intakes were found to be sensitive to the daily variability of flows. This section summarizes the approach used to incorporate daily variability in the Sacramento River flows into CalSim II and DSM2 modeling performed for the CWF BA.

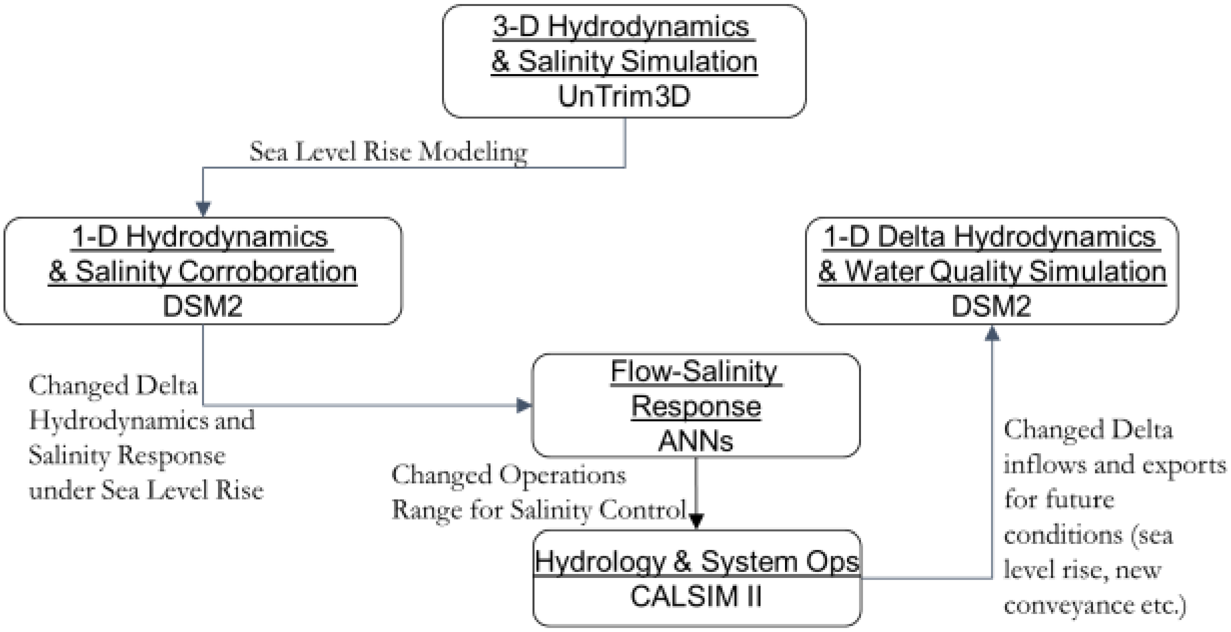


Figure 5.B.2-1: Hydrodynamics and Water Quality Modeling Approach used in the CWF BA

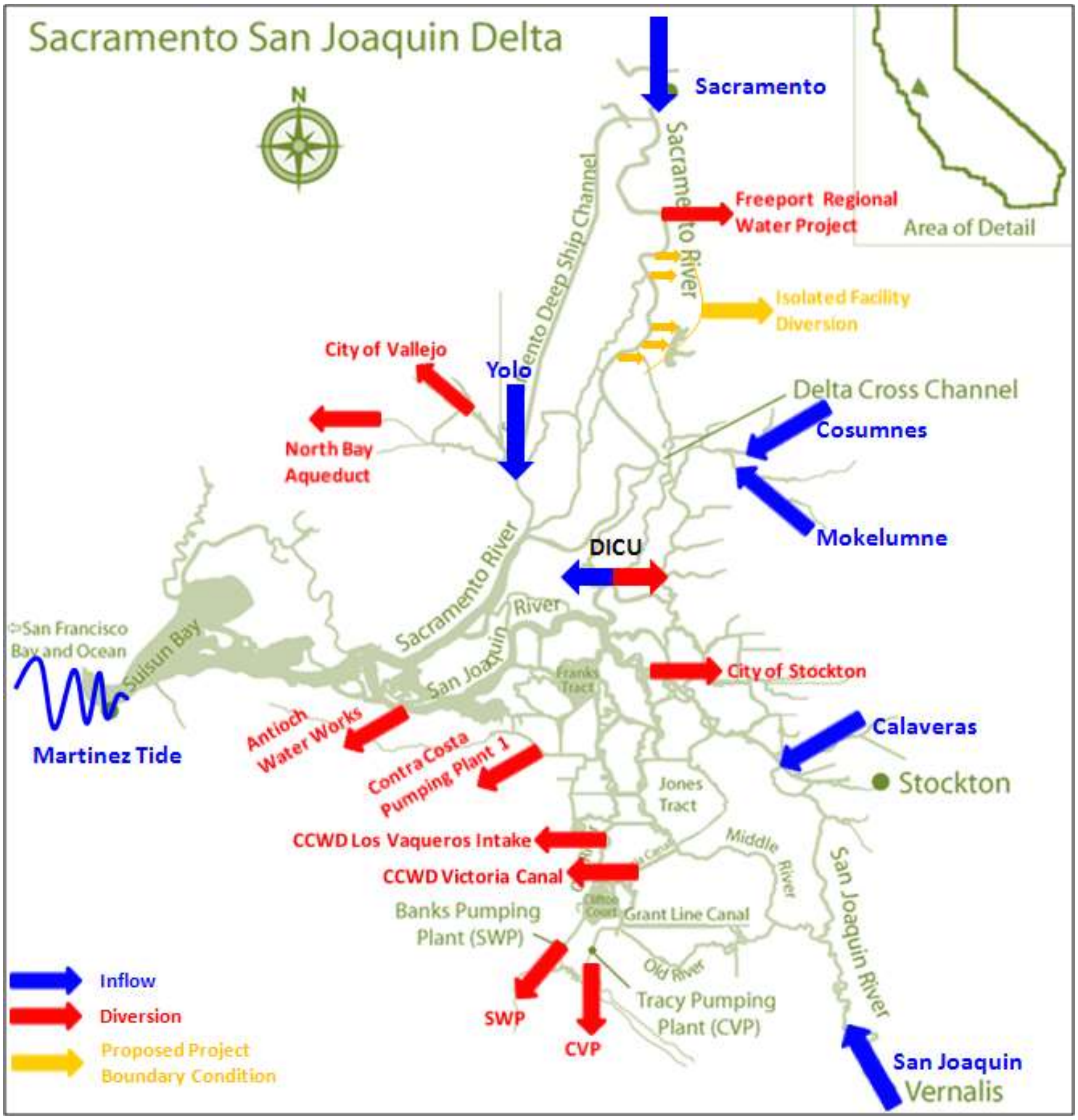


Figure 5.B.2-2: Hydrodynamic and Water Quality Boundary Conditions in DSM2

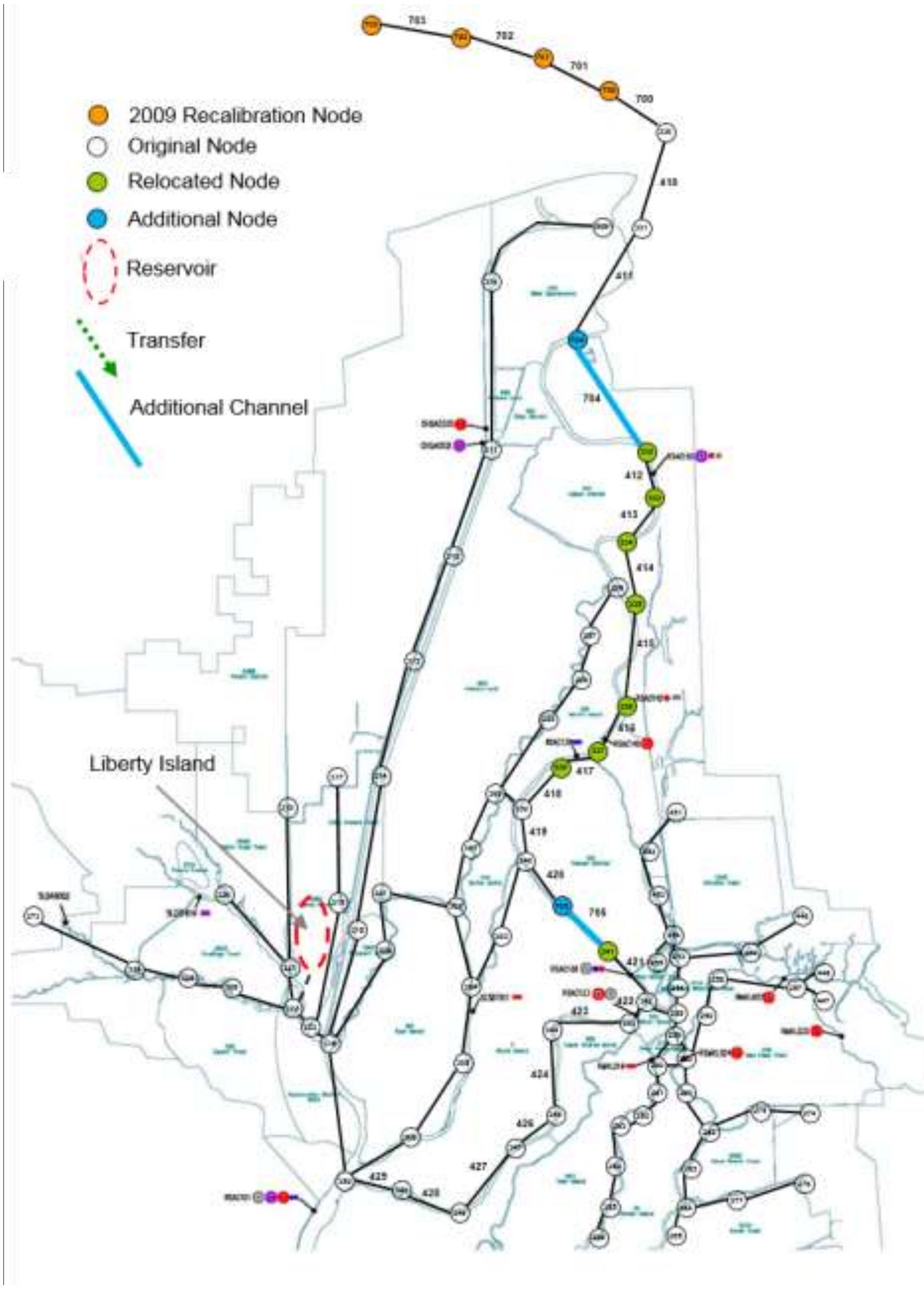


Figure 5.B.2-3: North Delta DSM2 grid used in the CWF BA Modeling

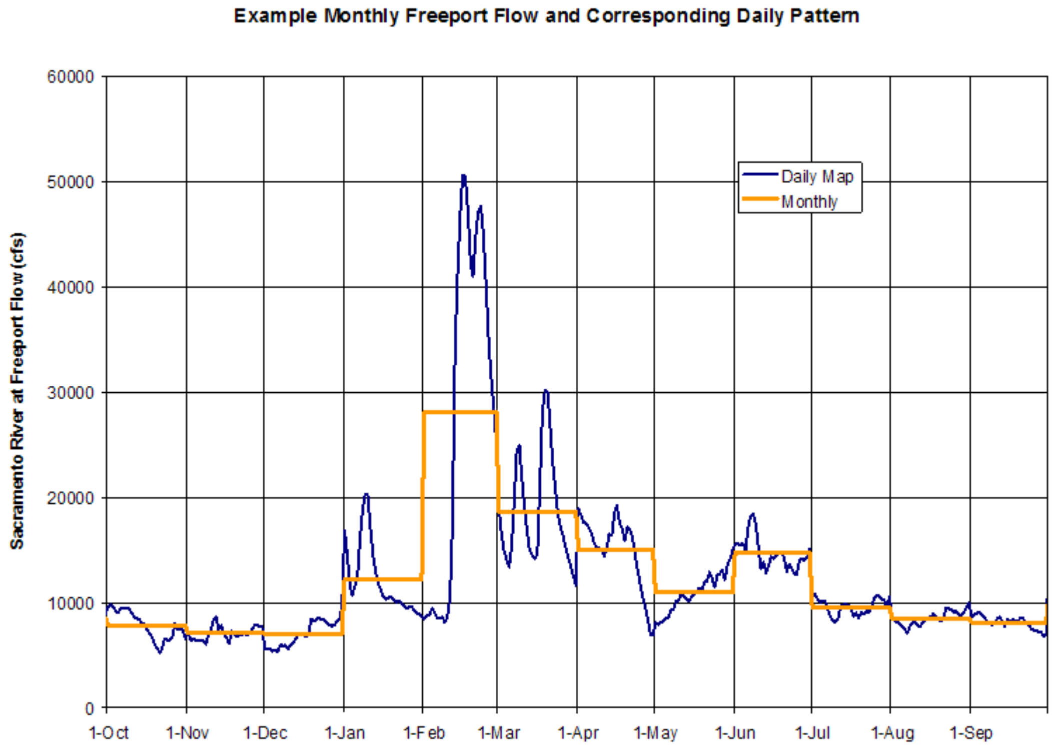


Figure 5.B.2-4: Example monthly-averaged and daily-averaged flow for Sacramento River at Freeport

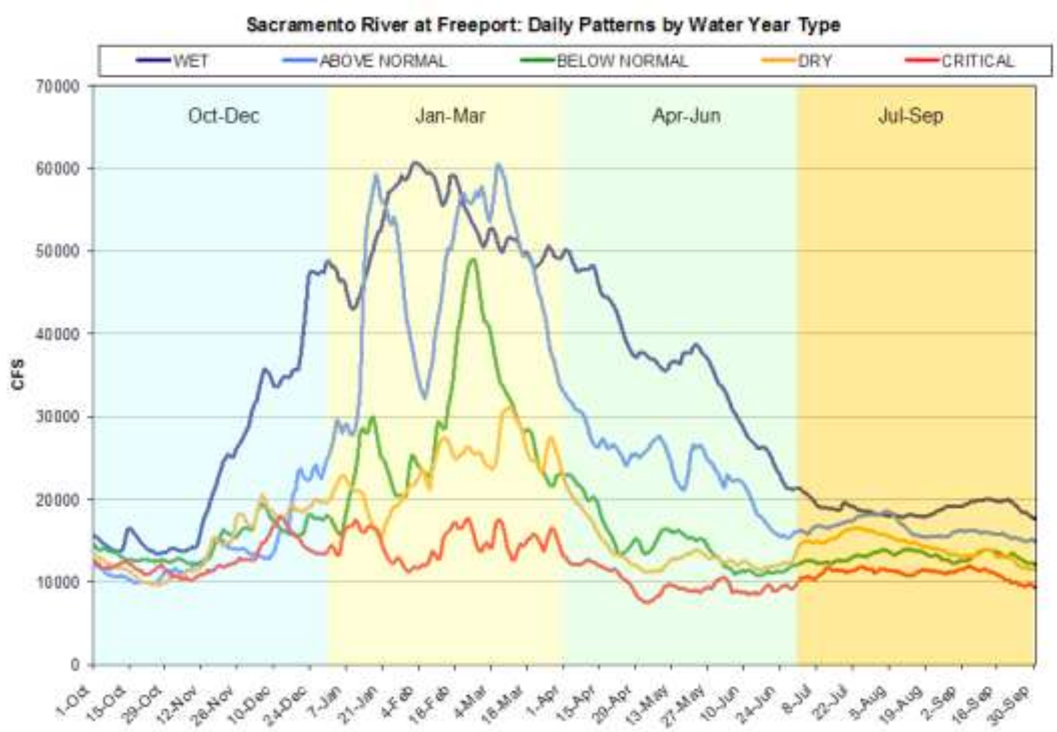


Figure 5.B.2-5: Mean daily flows by Water Year Type for Sacramento River at Freeport

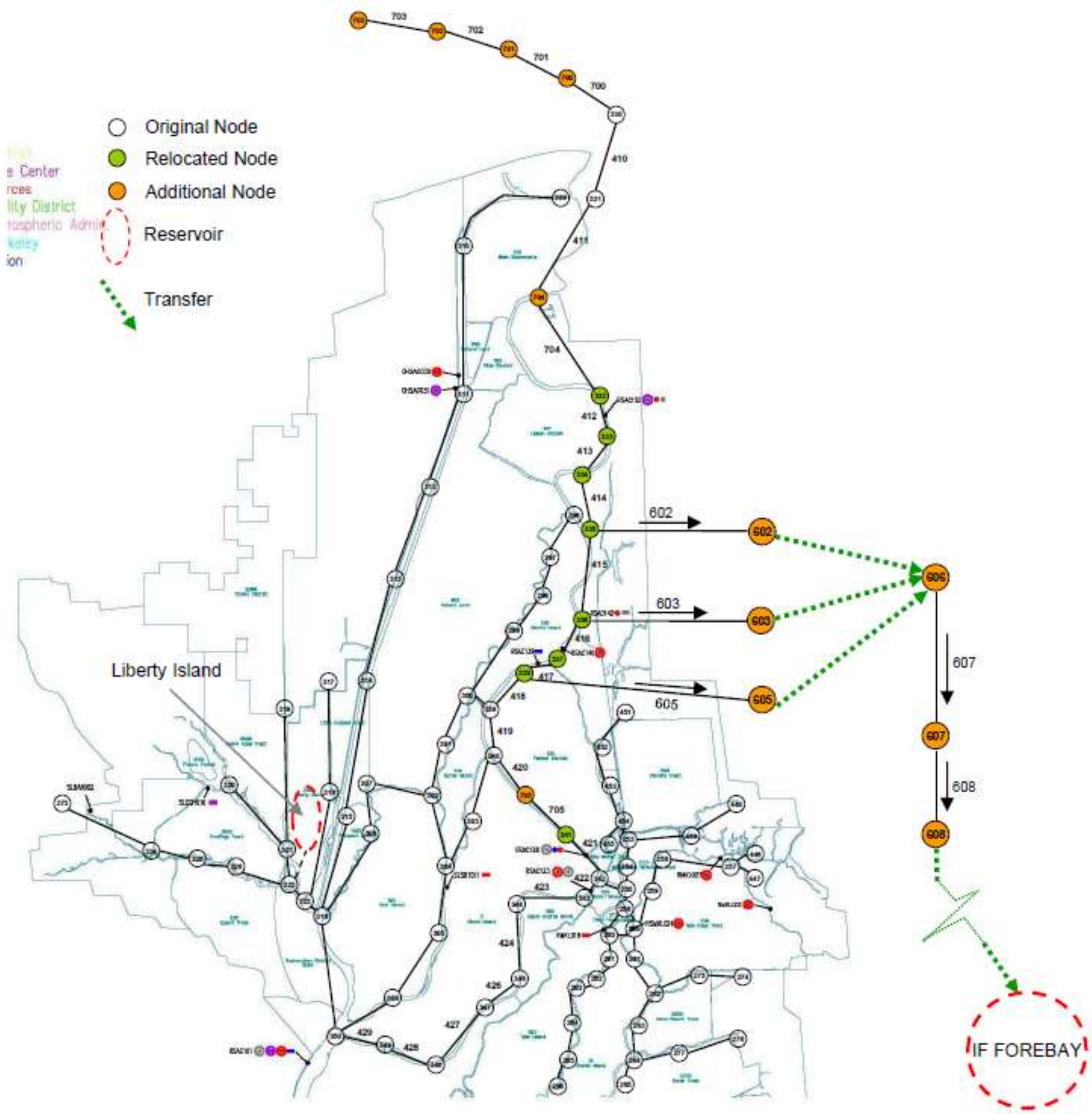


Figure 5.B.2-6: North Delta DSM2 Grid Modifications for Simulating North Delta Diversions

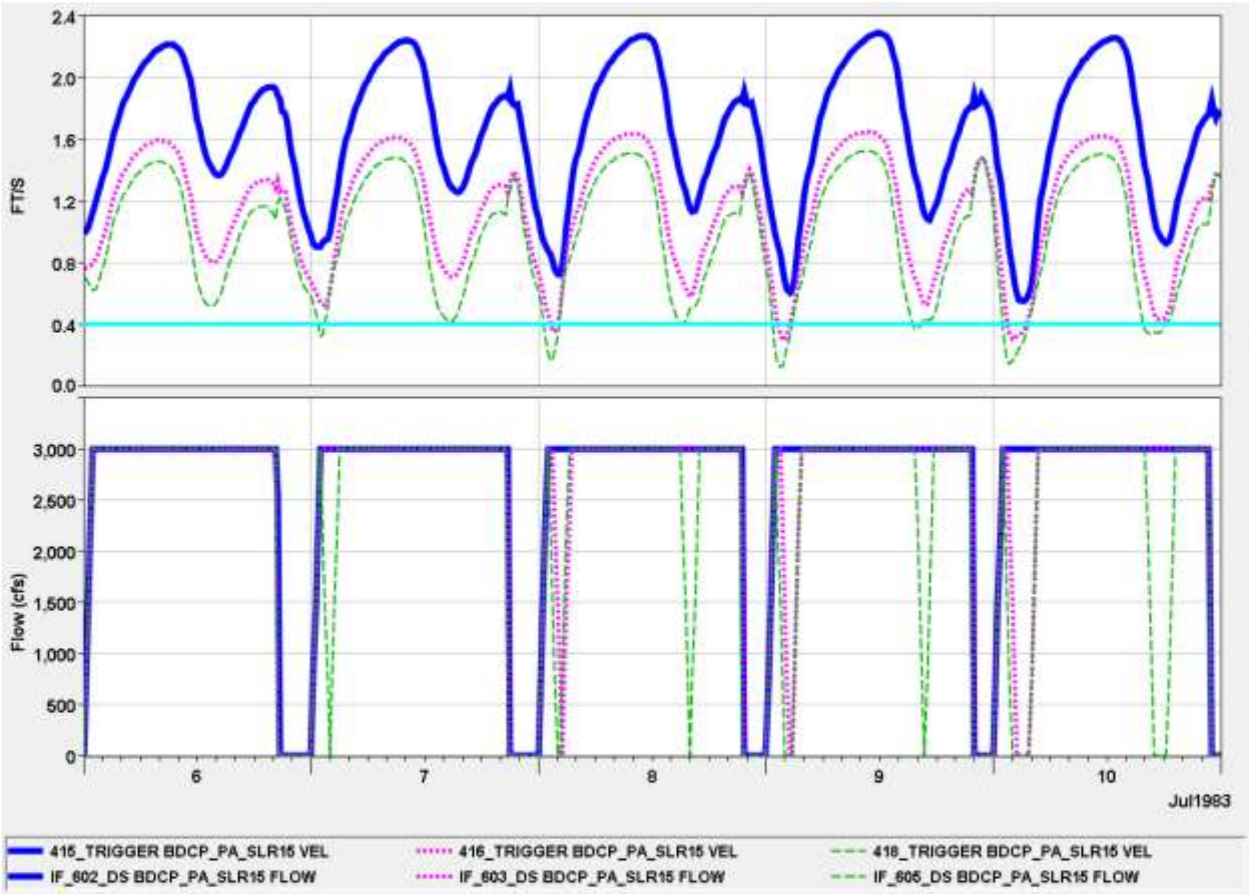


Figure 5.B.2-7: An Example of Sweeping Velocity and the Diversion at the Three Intakes Simulated in DSM2

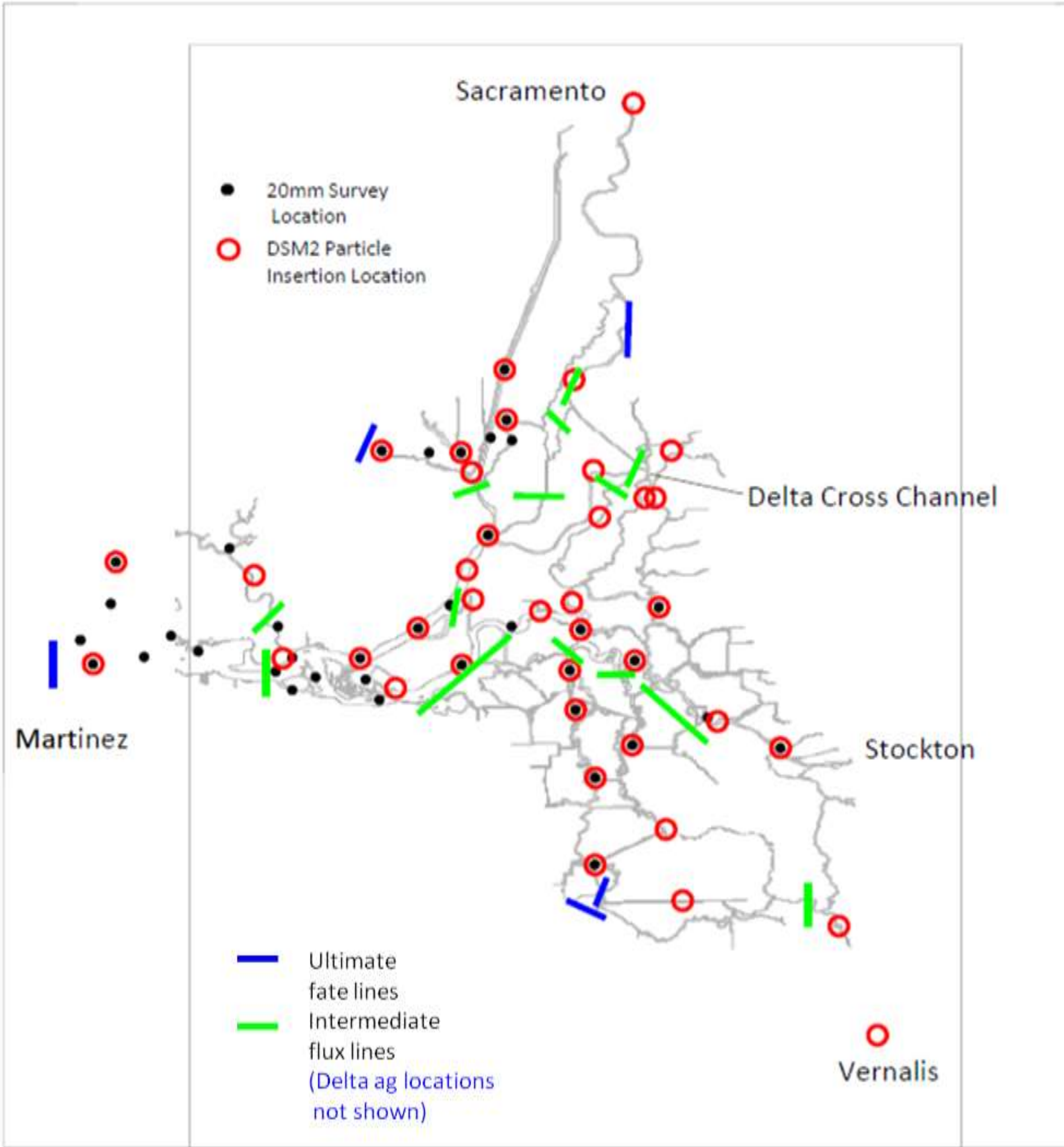


Figure 5.B.3-1: Particle release and tracking locations for larval delta smelt and longfin smelt evaluations

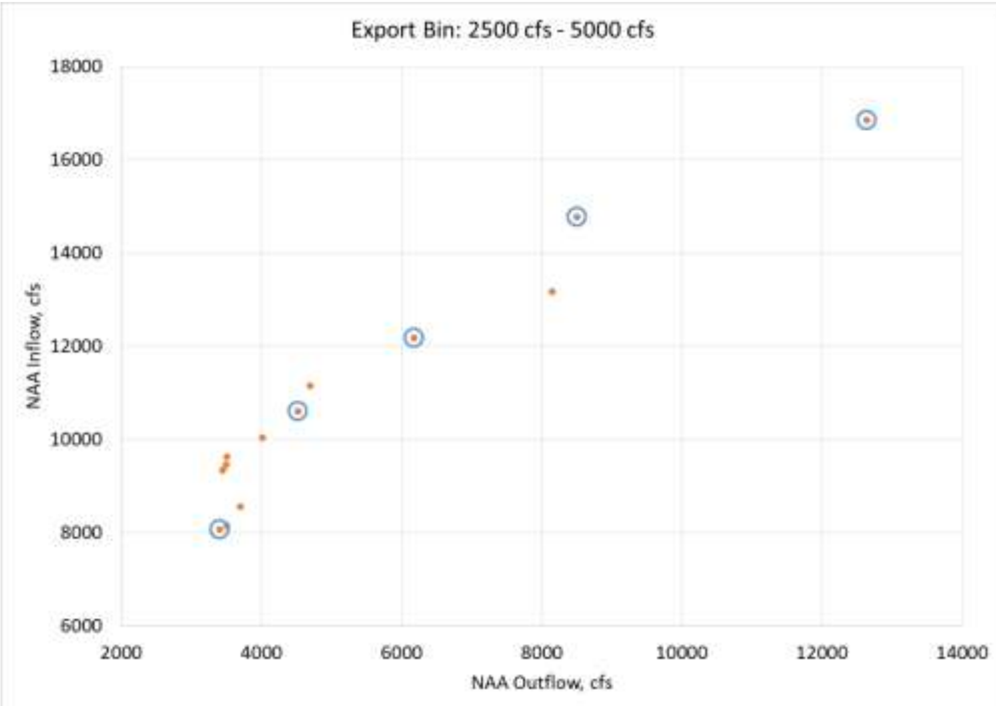


Figure 5.B.3-2: PTM period selection for evaluating residence times for exports between 2,500 and 5,000 cfs.

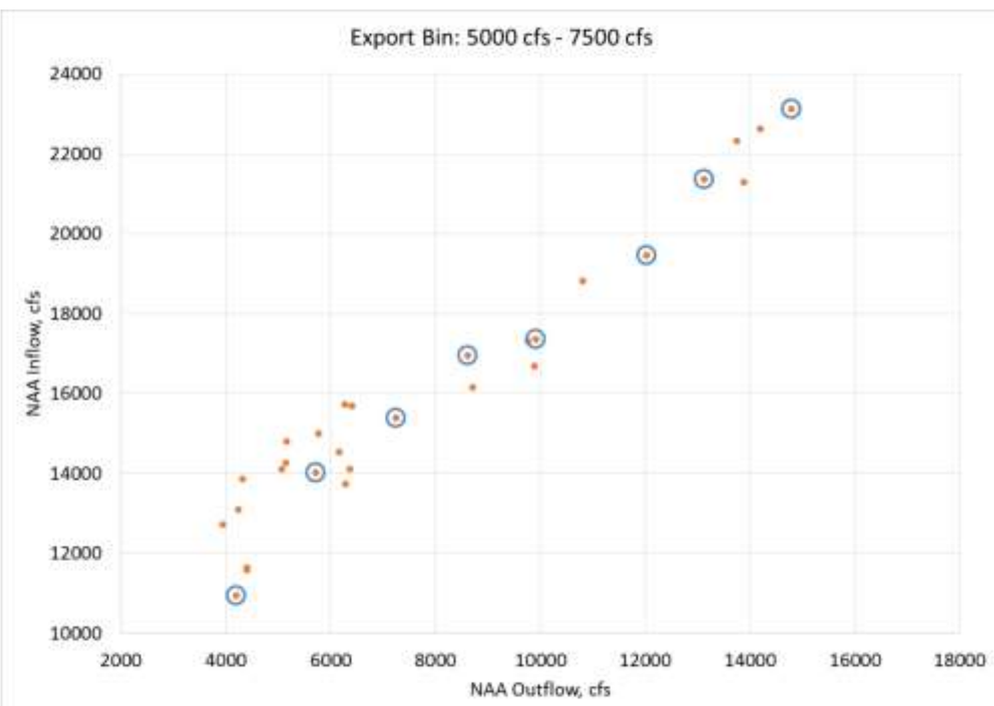


Figure 5.B.3-3: PTM period selection for evaluating residence times for exports between 5,000 and 7,500 cfs.

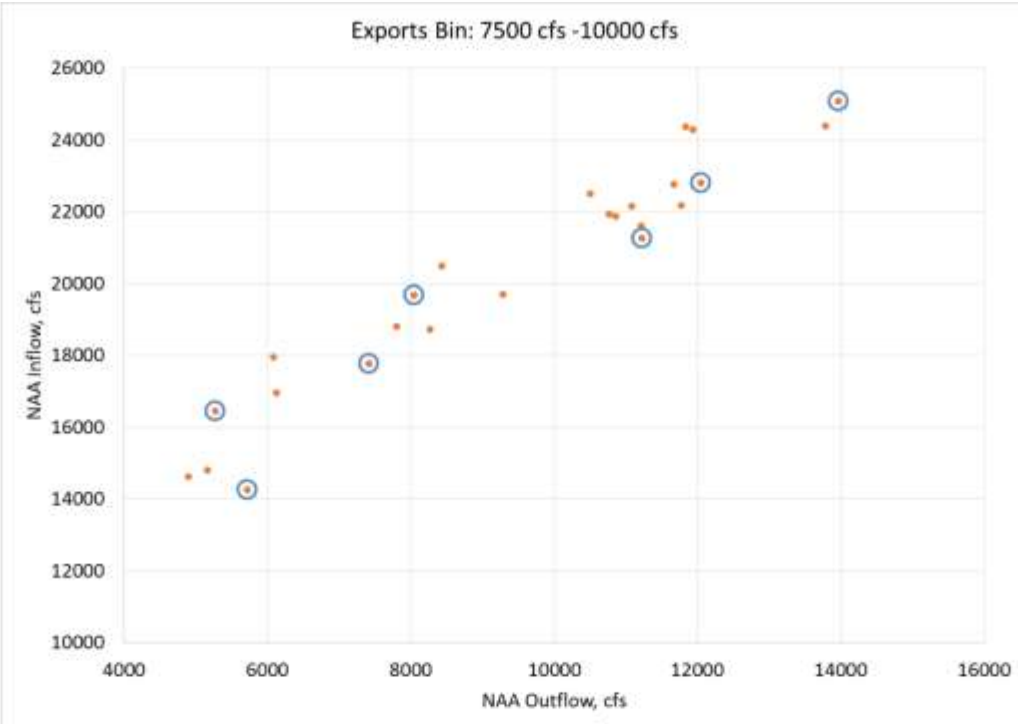


Figure 5.B.3-4: PTM period selection for evaluating residence times for exports between 7,500 and 10,000 cfs.

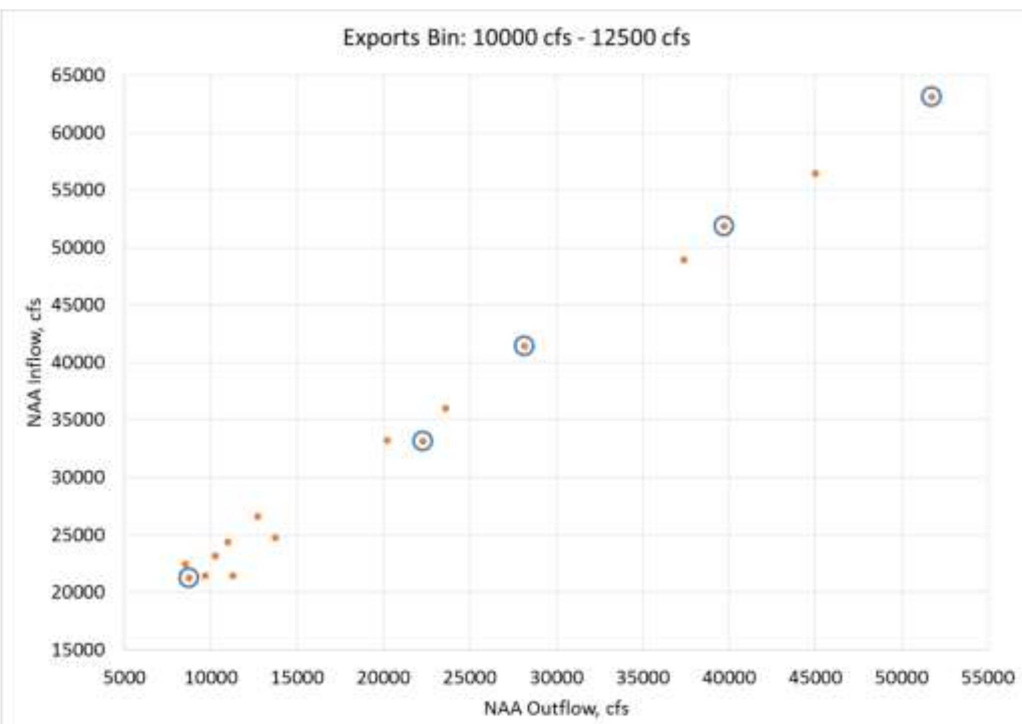


Figure 5.B.3-5: PTM period selection for evaluating residence times for exports between 7,500 and 12,500 cfs.

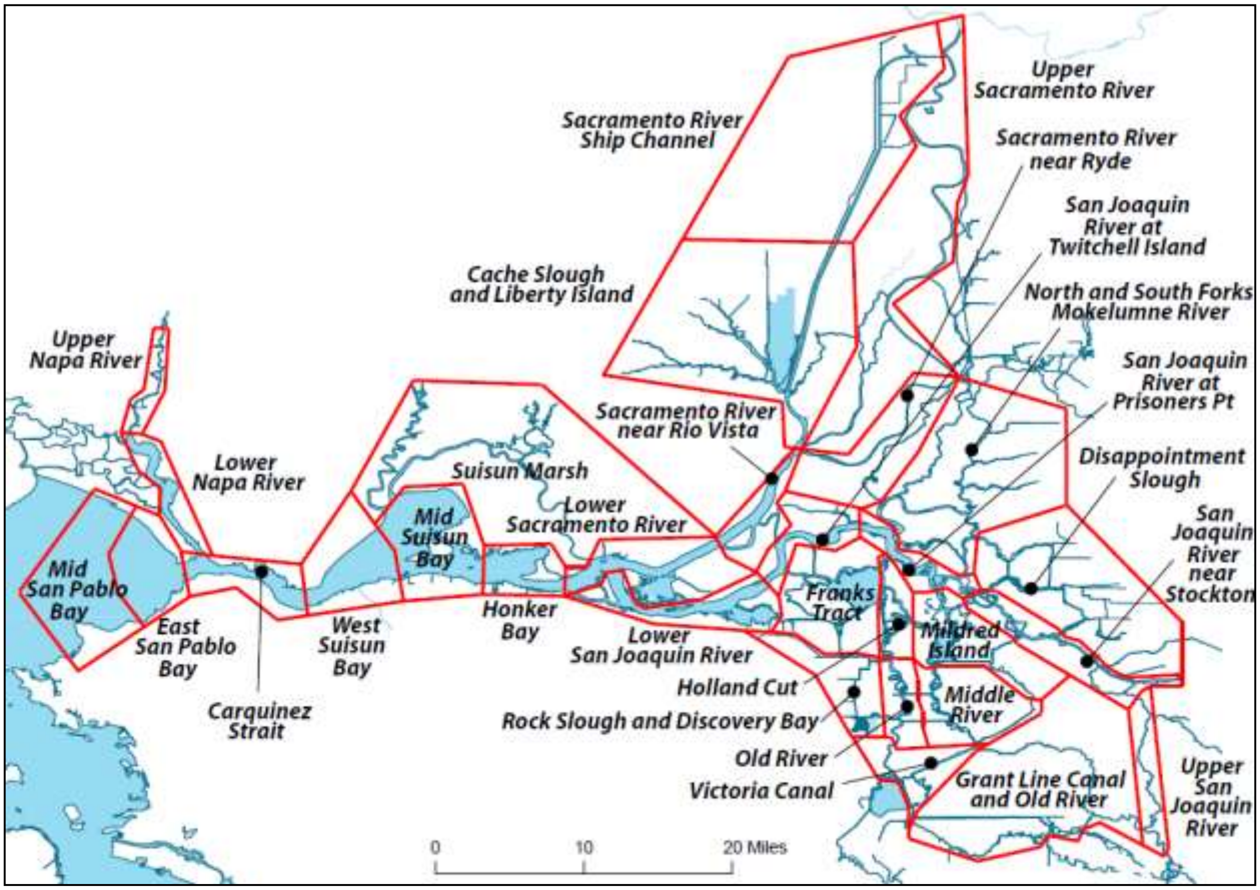


Figure 5.B.3-6. Subregions Used in the Analysis of Residence Time Based on DSM2-PTM.

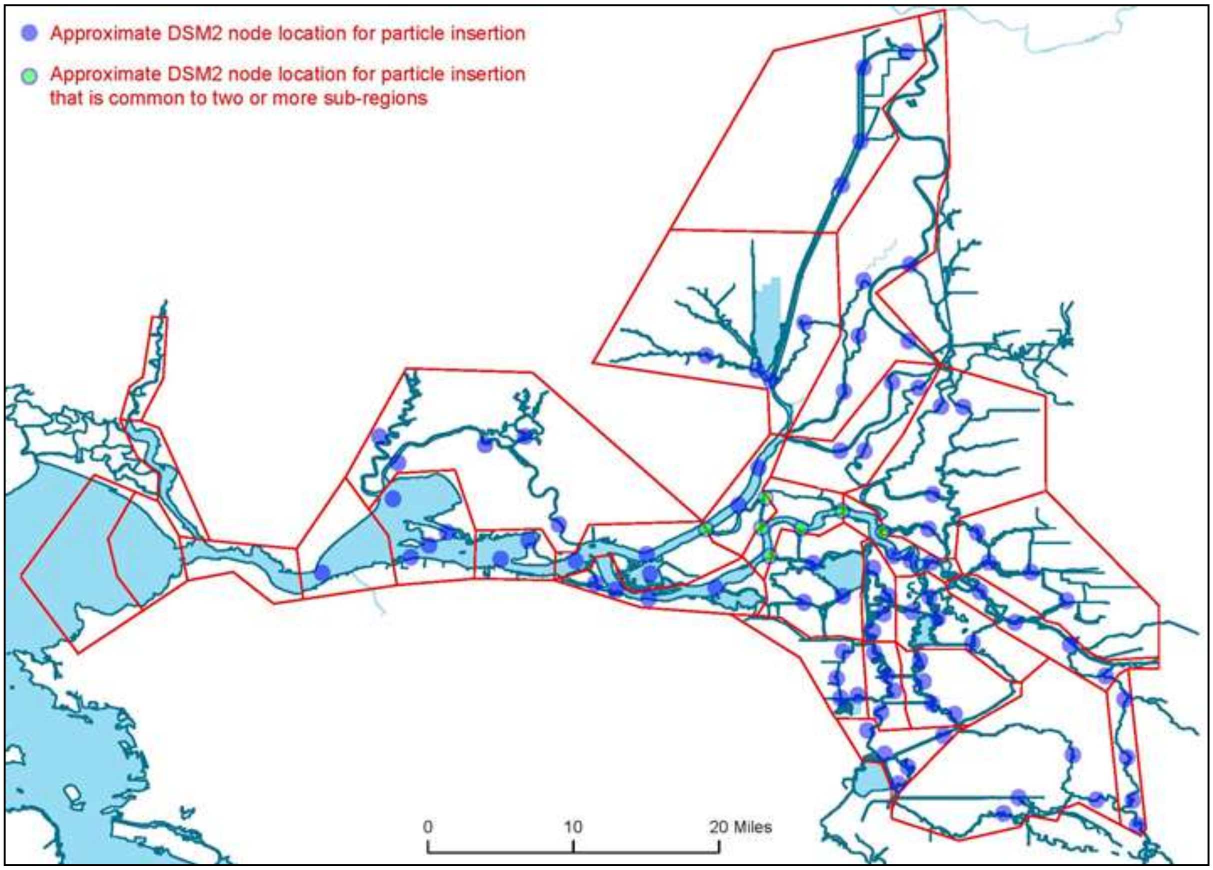


Figure 5.B.3-7. Particle Release Locations Within the Subregions Used in the Analysis of Residence Time Based on DSM2-PTM.

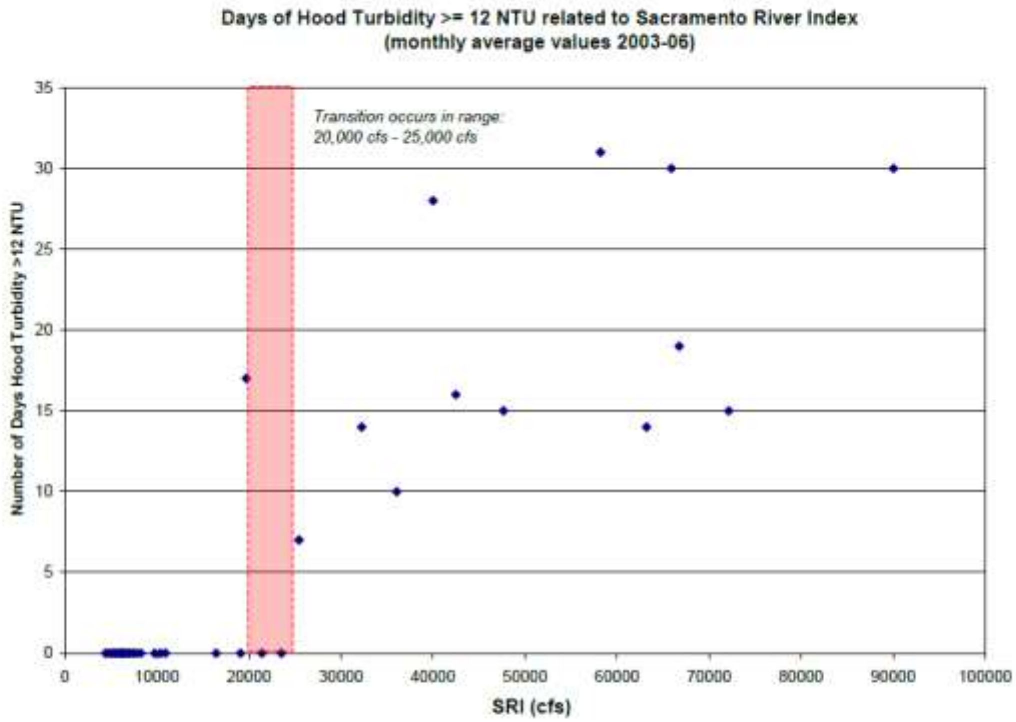


Figure 5.B.3-8: Relationship between turbidity at Hood and Sacramento River Index

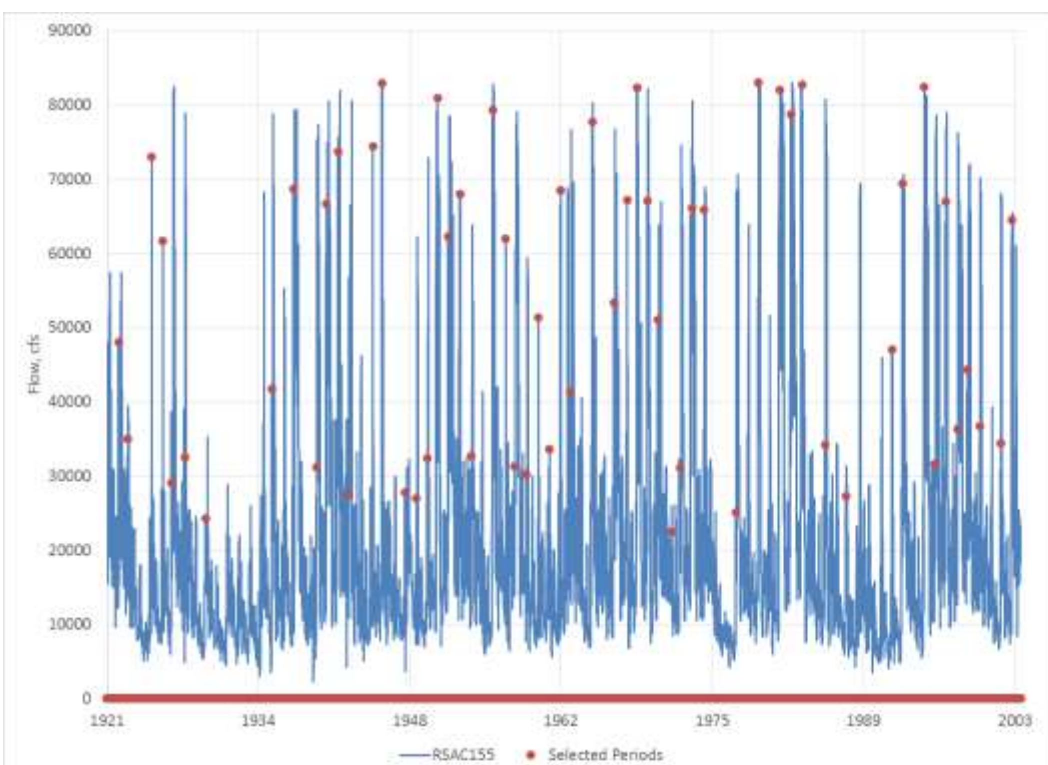


Figure 5.B.3-9: Selected particle release dates for the 82-year simulation period

Table 5.B.2-1. DSM2 HYDRO Boundary Conditions

Boundary Condition	Location/Control Structure	Typical Temporal Resolution
Tide	Martinez	15min
Delta Inflows	Sacramento River at Freeport	1day
CWF BA_ROA0ac_SLR45cm_18Mar2010	San Joaquin River at Vernalis	1day
	Eastside Streams (Mokelumne and Cosumnes Rivers)	1day
	Calaveras River	1day
	Yolo Bypass	1day
Delta Exports/Diversions	Banks Pumping Plant (SWP)	1day
	Jones Pumping Plant (CVP)	1day
	Contra Costa Water District Diversions at Rock Slough, Old River at Highway 4 and Victoria Canal	1day
	North Bay Aqueduct	1day
	City of Vallejo	1day
	Antioch Water Works	1day
	Freeport Regional Water Project	1day
	City of Stockton	1day
	Isolated Facility Diversion	1day
Delta Island Consumptive Use	Diversion	1mon
	Seepage	1mon
	Drainage	1mon
Gate Operations	Delta Cross Channel	Irregular Timeseries
	South Delta Temporary Barriers	dynamically operated on 15min
	Montezuma Salinity Control Gate	dynamically operated on 15min

Table 5.B.2-2. DSM2 QUAL Boundary Conditions Typically used in a Salinity Simulation

Boundary Condition	Location/Control Structure	Typical Temporal Resolution
Ocean Salinity	Martinez	15min
Delta Inflows	Sacramento River at Freeport	Constant
CWF BA_ROA0ac_SLR45cm_18Mar2010	San Joaquin River at Vernalis	1mon
	Eastside Streams (Mokelumne and Cosumnes Rivers)	Constant
	Calaveras River	Constant
	Yolo Bypass	Constant
Delta Island Consumptive Use	Drainage	1mon (repeated each year)
a For other water quality constituents, concentrations are required at the same locations		

Table 5.B.2-3. Correlations to Transform Baseline Martinez Stage and EC for use in DSM2 CWF BA Planning Runs with 15cm Sea Level Rise

	Martinez Stage (ft NGVD 29)		Martinez EC (µS/cm)	
Scenario	Correlation	Lag (min)	Correlation	Lag (min)
15cm SLR	Y = 1.0033*X + .47	-1	Y = 0.9954* X + 556.3	0
a Baseline Martinez stage or EC and Y = Scenario Martinez stage or EC				

Table 5.B.3-1: List of Particle Release Locations for Larval Delta and Longfin Smelt Evaluations

Location	DSM2 Node
San Joaquin River at Vernalis	1
San Joaquin River at Mossdale	7
San Joaquin River D/S of Rough and Ready Island	21
San Joaquin River at Buckley Cove	25
San Joaquin River near Medford Island	34
San Joaquin River at Potato Slough	39
San Joaquin River at Twitchell Island	41
Old River near Victoria Canal	75
Old River at Railroad Cut	86
Old River near Quimby Island	99
Middle River at Victoria Canal	113
Middle River u/s of Mildred Island	145
Grant Line Canal	174
Frank's Tract East	232

Location	DSM2 Node
Threemile Slough	240
Little Potato Slough	249
Mokelumne River d/s of Cosumnes confluence	258
South Fork Mokelumne	261
Mokelumne River d/s of Georgiana confluence	272
North Fork Mokelumne	281
Georgiana Slough	291
Miner Slough	307
Sacramento Deep Water Ship Channel	314
Cache Slough at Shag Slough	321
Cache Slough at Liberty Island	323
Lindsey slough at Barker Slough	324
Sacramento River at Sacramento	330
Sacramento River at Sutter Slough	339
Sacramento River at Ryde	344
Sacramento River near Cache Slough confluence	350
Sacramento River at Rio Vista	351
Sacramento River d/s of Decker Island	353
Sacramento River at Sherman Lake	354
Sacramento River at Port Chicago	359
Montezuma Slough at Head	418
Montezuma Slough at Suisun Slough	428
San Joaquin River d/s of Dutch Slough	461
Sacramento River at Pittsburg	465
San Joaquin River near Jersey Point	469

Table 5.B.3-2. July through November Average Delta Exports, Delta Outflow, and Delta Inflows under NAA for Years Selected for Residence Time PTM Simulations

Year	Exports	Outflow	Inflow
1922	10016	8713	21265
1928	6615	9906	17359
1929	3932	6174	12169
1930	5181	4200	10946
1934	4421	4522	10600
1940	7787	7413	17778
1941	7183	13128	21371
1944	6243	8609	16960
1961	6764	5714	14026
1962	8722	5274	16456
1964	6634	12019	19464
1966	9471	12046	22806
1968	7592	5717	14261
1974	11089	28138	41404
1976	4238	8502	14765
1980	9246	8043	19687
1981	10355	22293	33153
1983	10632	51743	63135
1984	10419	39704	51869
1986	2970	12633	16847
1990	3638	3400	8069
1997	6786	14785	23122
1998	8843	13970	25087
2000	7807	11226	21266
2001	6604	7247	15395

Table 5.B.3-3. DSM2-PTM Release Locations (Nodes) Within the Subregions Used in the Analysis of Residence Time Based on DSM2-PTM.

Subregion	DSM2 Particle Insertion Nodes
Upper Sacramento River	338, 341, 300, 303, 305
Sacramento River Ship channel	309, 310, 311, 312
Cache Slough and Liberty Island	307, 316, 322, 325
Sacramento River near Ryde	344, 288, 348, 293
North and South Forks Mokelumne River *	281, 261, 269, 251, 39
Sacramento River near Rio Vista *	351, 352, 240, 43, 353
Lower Sacramento River *	353, 354, 459, 465
Upper San Joaquin River	7, 9, 11, 13
Grant Line Canal and Old River	50, 106, 171, 60
Victoria Canal	188, 185, 72, 79, 75
Rock Slough and Discovery Bay	197, 198, 200, 202
Old River	81, 84, 86, 92
Middle River	115, 117, 120, 124
Mildred Island	142, 130, 207, 133
San Joaquin River near Stockton	16, 22, 25, 30
Disappointment Slough	241, 242, 243, 248
San Joaquin River at Prisoners Pt*	34, 35, 37, 39, 41
Holland Cut	94, 98, 100, 101
Franks Tract*	225, 216, 222, 42, 44
San Joaquin River at Twitchell Island*	41, 42, 43, 44, 240
Lower San Joaquin River	45, 46, 47, 463
Honker Bay	357, 328
Suisun Marsh	406, 418, 422, 375, 428
Mid Suisun Bay	238, 329, 358, 365
West Suisun Bay	360

Note:
*Subregions that share DSM2 particle insertion nodes with one or more sub-regions

Table 5.B.3-4. Selected particle release dates for the 82-year simulation period

Water Year	First Month with Turbidity Trigger	Date of particle release	NAA RSAC155 (cfs)
1922	Feb	2/16/1922	48019
1923	Dec	12/25/1922	35016
1924	NONE	2/1/1924	
1925	Feb	2/17/1925	72968
1926	Feb	2/21/1926	61669
1927	Dec	12/1/1926	29069
1928	Feb	2/17/1928	32496
1929	NONE	2/1/1929	
1930	Dec	12/29/1929	24325
1931	NONE	2/1/1931	
1932	NONE	2/1/1932	
1933	NONE	2/1/1933	
1934	NONE	2/1/1934	
1935	NONE	2/1/1935	
1936	Jan	1/3/1936	41767
1937	NONE	2/1/1937	
1938	Dec	12/10/1937	68715
1939	NONE	2/1/1939	
1940	Jan	1/31/1940	31182
1941	Dec	12/6/1940	66727
1942	Dec	12/29/1941	73722
1943	Dec	12/21/1942	27509
1944	NONE	2/1/1944	
1945	Feb	2/17/1945	74434
1946	Dec	12/23/1945	82931
1947	NONE	2/1/1947	
1948	Jan	1/18/1948	27782
1949	NONE	2/1/1949	27030
1950	Jan	1/18/1950	32404
1951	Dec	12/29/1950	80941
1952	Dec	12/6/1951	62325

Water Year	First Month with Turbidity Trigger	Date of particle release	NAA RSAC155 (cfs)
1953	Jan	1/3/1953	67969
1954	Jan	1/23/1954	32750
1955	NONE	2/1/1955	
1956	Dec	12/22/1955	79290
1957	Feb	2/28/1957	62023
1958	Dec	12/21/1957	31346
1959	Jan	1/16/1959	30164
1960	Feb	2/12/1960	51379
1961	Feb	2/15/1961	33663
1962	Feb	2/17/1962	68505
1963	Dec	12/21/1962	41328
1964	NONE	2/1/1964	
1965	Dec	12/24/1964	77682
1966	NONE	2/1/1966	
1967	Dec	12/9/1966	53365
1968	Feb	2/28/1968	67184
1969	Jan	1/18/1969	82362
1970	Dec	12/28/1969	67078
1971	Dec	12/6/1970	51009
1972	Feb	2/11/1972	22535
1973	Dec	12/22/1972	31138
1974	Dec	12/31/1973	66061
1975	Feb	2/16/1975	65882
1976	NONE	2/1/1976	
1977	NONE	2/1/1977	
1978	Dec	12/20/1977	25108
1979	NONE	2/1/1979	
1980	Jan	1/16/1980	82985
1981	NONE	2/1/1981	
1982	Dec	12/25/1981	82043
1983	Dec	12/24/1982	78689
1984	Dec	12/20/1983	82747

Water Year	First Month with Turbidity Trigger	Date of particle release	NAA RSAC155 (cfs)
1985	NONE	2/1/1985	
1986	Jan	1/20/1986	34238
1987	NONE	2/1/1987	
1988	Dec	12/13/1987	27316
1989	NONE	2/1/1989	
1990	NONE	2/1/1990	
1991	NONE	2/1/1991	
1992	Feb	2/17/1992	47040
1993	Jan	1/24/1993	69396
1994	NONE	2/1/1994	
1995	Jan	1/13/1995	82395
1996	Dec	12/18/1995	31567
1997	Dec	12/31/1996	67015
1998	Jan	1/15/1998	36299
1999	Dec	12/9/1998	44379
2000	Jan	1/27/2000	36745
2001	NONE	2/1/2001	
2002	Dec	12/25/2001	34382
2003	Dec	12/20/2002	64492

Table 5.B.4-1. DSM2 Assumptions

	No Action Alternative Assumption	Proposed Action Assumption
Period of simulation	82 years (1922-2003)[a,b]	Same
REGIONAL SUPPLIES		
Boundary flows	Monthly timeseries from CalSim II output (alternatives provide different flows and exports)[c]	Same
REGIONAL DEMANDS AND CONTRACTS		
Ag flows (DICU)	2005 Level, DWR Bulletin 160-98[d]	Same
TIDAL BOUNDARY		
Martinez stage	15-minute adjusted astronomical tide modified to account for the 15 cm sea level rise at Year 2030[a]	Same
WATER QUALITY		
Vernalis EC	Monthly time series from CalSim II output[e]	Same
Agricultural Return EC	Municipal Water Quality Investigation Program analysis	Same
Martinez EC	Monthly net Delta Outflow from CalSim output & G-model modified to account for the 15 cm sea level rise at Year 2030[f]	Same
FACILITIES		
Contra Costa Water District Delta Intakes	Rock Slough Pumping Plant, Old River at Highway 4 Intake and Alternate Improvement Project Intake on Victoria Canal	Same
South Delta Barriers	Temporary Barriers Program – agricultural barriers and Head of Old River Barrier	Temporary Agricultural Barriers Same as NAA; Permanent HOR gate
North Delta Diversion Intakes	None	Three 3,000 cfs capacity north Delta diversion intakes (total maximum diversion capacity of 9,000 cfs)

SPECIFIC PROJECTS		
Water Supply Intake Projects		
Freeport Regional Water Project	Monthly output from CalSim II	Same
Stockton Delta Water Supply Project	Monthly output from CalSim II	Same
Antioch Water Works	Monthly output from CalSim II	Same
Sanitary and Agricultural Discharge Projects		
Veale Tract Drainage Relocation	The Veale Tract Water Quality Improvement Project, funded by CALFED, relocates the agricultural drainage outlet was relocated from Rock Slough channel to the southern end of Veale Tract, on Indian Slough[g]	Same
OPERATIONS CRITERIA		
Delta Cross Channel	Monthly time series of number of days open from CalSim II output	Same
Clifton Court Forebay	Priority 3, gate operations synchronized with incoming tide to minimize impacts to low water levels in nearby channels	Same
South Delta barriers	Temporary Barriers Project operated based on San Joaquin River flow time series from CalSim II output; HORB is assumed only installed[h] Sep 16 – Nov 30; Agricultural barriers on Old and Middle Rivers are assumed to be installed starting from May 16 and on Grant Line Canal from June 1; All three barriers are allowed to be operated until November 30; May 16 to May 31; the tidal gates are assumed to be tied open for the barriers on Old and Middle Rivers[i].	Same for Temporary Agricultural Barriers; HOR gate Operations assumptions (% OPEN) Oct 50%, Nov 100%, Dec 100%, Jan 50%, Feb - Jun 15th 50%, Jun 16-30 100%, Jul - Sep 100% ; HOR gate will be open 100% whenever flows are greater than 10,000 cfs at Vernalis.; Oct-Nov: Before the D-1641 pulse = HOR gate open, During the D-1641 pulse = for 2 weeks HOR gate closed; After D-1641 pulse: HORB open 50% for 2 weeks
North Delta Diversion Intakes	None	Proposed north Delta diversion intakes are operated with priority from north to south. Maximum of 3,000 cfs is withdrawn at each intake while meeting velocity of 0.4 fps downstream. Daily diversion volume equivalent to CALSIM II output

Notes:

a A new adjusted astronomical tide for use in DSM2 planning studies has been developed by DWR's Bay Delta Office Modeling Support Branch Delta Modeling Section in cooperation with the Common Assumptions workgroup. This tide is based on a more extensive observed dataset and covers the entire 82-year period of record.

b The 16-year period of record is the simulation period for which DSM2 has been commonly used for impacts analysis in many previous projects, and includes varied water year types.

c Although monthly CalSim output was used as the DSM2-HYDRO input, the Sacramento and San Joaquin rivers were interpolated to daily values in order to smooth the transition from high to low and low to high flows. DSM2 then uses the daily flow values along with a 15-minute adjusted astronomical tide to simulate effect of the spring and neap tides.

d The Delta Island Consumptive Use (DICU) model is used to calculate diversions and return flows for all Delta islands based on the level of development assumed. The nominal 2005 Delta region hydrology land-use was determined by interpolation between the 1995 and projected 2020 land-use assumptions associated with Bulletin 160-98.

e CalSim II calculates monthly EC for the San Joaquin River, which was then converted to daily EC using the monthly EC and flow for the San Joaquin River. Fixed concentrations of 150, 175, and 125 µmhos/cm were assumed for the Sacramento River, Yolo Bypass, and eastside streams, respectively.

f Net Delta outflow based on the CalSim II flows was used with an updated G-model to calculate Martinez EC. Under changed climate conditions Martinez EC is modified to account for the sea level rise at Year 2030 (15 cm).

g Information was obtained based on the information from the draft final "Delta Region Drinking Water Quality Management Plan" dated June 2005 prepared under the CALFED Water Quality Program and a presentation by David Briggs at SWRCB public workshop for periodic review. The presentation "Compliance location at Contra Costa Canal at Pumping Plant #1 – Addressing Local Degradation" notes that the Veale Tract drainage relocation project will be operational in June 2005. The DICU drainage currently simulated at node 204 is moved to node 202 in DSM2.

h Based on the FWS Delta Smelt BiOp Action 5, Head of Old River Barrier (HORB) is assumed to be not installed in April or May; therefore HORB is only installed in the Fall as shown.

I Based on the FWS Delta Smelt BiOp Action 5 and the project description provided in the page 119.

Table 5.B.4-2 Head of Old River Operable Barrier Operations Criteria if San Joaquin River Flows at Vernalis are Equal To or Less Than 10,000 cfs

Month	Head of Old River Gate Operations/Modeling assumptions Open %[a]
Oct[b]	50% (except during the pulse)
Nov[b]	100% (except during the post-pulse period)
Dec	100%
Jan[c]	50%
Feb	50%
Mar	50%
April	50%
May	50%
Jun 1-15	50%
Jun 16-30	100%
Jul	100%
Aug	100%
Sep	100%

[a] % of time the HOR gate is open. Agricultural barriers are in and operated consistent with current practices. HOR gate will be open 100% whenever flows are greater than 10,000 cfs at Vernalis.

[b] Head of Old River Barrier operation is triggered based upon State Water Board D-1641 pulse trigger. For modeling assumptions only, two weeks before the D-1641 pulse, it is assumed that the Head of Old River Barrier will be open 50%.

During the D-1641 pulse (assumed to occur October 16-31 in the modeling), it is assumed the HOR gate will be closed.

For two weeks following the D-1641 pulse, it was assumed that the HOR gate will be open 50%. Exact timing of the action will be based on hydrologic conditions.

[c] The HOR gate becomes operational at 50% when salmon fry are migrating (based on real time monitoring). This generally occurs when flood flow releases are being made. For the purposes of modeling, it was assumed that salmon fry are migrating starting on January 1.

Table 5.B.5-1. Sacramento River downstream of North Delta Intakes, Monthly Flow

Statistic	Monthly Flow (cfs)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	15,264	9,031	-6,232	-41%	21,939	14,789	-7,151	-33%	47,659	41,440	-6,219	-13%	63,571	54,532	-9,040	-14%	69,664	60,643	-9,021	-13%	62,797	54,849	-7,948	-13%
20%	13,924	8,220	-5,704	-41%	18,798	12,335	-6,463	-34%	32,942	29,630	-3,312	-10%	53,862	45,425	-8,437	-16%	61,808	53,237	-8,572	-14%	50,029	41,403	-8,626	-17%
30%	13,389	7,946	-5,443	-41%	17,962	11,011	-6,952	-39%	20,838	20,063	-774	-4%	37,452	33,456	-3,996	-11%	48,985	43,634	-5,351	-11%	37,698	30,110	-7,588	-20%
40%	12,006	7,848	-4,157	-35%	16,696	10,176	-6,519	-39%	18,034	17,054	-979	-5%	24,862	20,742	-4,120	-17%	42,074	36,110	-5,963	-14%	30,099	22,460	-7,639	-25%
50%	11,005	7,789	-3,215	-29%	15,049	8,333	-6,716	-45%	15,709	14,234	-1,475	-9%	20,733	19,440	-1,293	-6%	32,257	24,807	-7,451	-23%	24,265	18,646	-5,620	-23%
60%	9,291	7,731	-1,560	-17%	13,041	7,798	-5,243	-40%	15,071	12,995	-2,076	-14%	18,094	16,326	-1,769	-10%	25,236	19,695	-5,542	-22%	21,035	16,434	-4,602	-22%
70%	8,316	7,683	-632	-8%	10,023	7,745	-2,279	-23%	13,526	12,686	-839	-6%	14,878	13,953	-925	-6%	19,487	16,809	-2,678	-14%	18,520	14,490	-4,031	-22%
80%	7,826	7,544	-282	-4%	8,537	7,657	-880	-10%	10,616	10,171	-445	-4%	13,472	12,620	-852	-6%	16,171	14,486	-1,685	-10%	15,115	12,987	-2,128	-14%
90%	6,347	6,285	-62	-1%	7,336	7,351	15	0%	9,306	9,012	-294	-3%	11,724	10,981	-742	-6%	13,989	12,932	-1,057	-8%	11,480	10,714	-766	-7%
Long Term																								
Full Simulation Period[b]	11,059	8,014	-3,046	-28%	15,422	11,197	-4,225	-27%	22,393	20,419	-1,975	-9%	30,274	26,575	-3,699	-12%	37,384	32,218	-5,166	-14%	31,391	26,261	-5,130	-16%
Water Year Types[c]																								
Wet (32%)	14,279	8,401	-5,878	-41%	20,276	14,007	-6,269	-31%	25,167	22,865	-2,302	-9%	31,735	28,094	-3,641	-11%	56,785	48,947	-7,838	-14%	48,095	40,255	-7,841	-16%
Above Normal (16%)	12,728	8,507	-4,221	-33%	17,901	10,436	-7,465	-42%	22,338	20,156	-2,181	-10%	28,716	25,318	-3,399	-12%	46,296	39,626	-6,670	-14%	41,195	34,485	-6,710	-16%
Below Normal (13%)	11,316	9,359	-1,958	-17%	12,090	8,745	-3,345	-28%	20,224	18,638	-1,586	-8%	28,488	24,964	-3,523	-12%	29,910	25,860	-4,050	-14%	18,973	15,469	-3,504	-18%
Dry (24%)	8,583	7,682	-901	-10%	14,271	11,839	-2,432	-17%	26,058	23,672	-2,386	-9%	33,686	28,998	-4,688	-14%	23,340	19,996	-3,343	-14%	21,415	17,381	-4,034	-19%
Critical (15%)	6,167	5,959	-208	-3%	7,192	7,113	-79	-1%	12,326	11,614	-712	-6%	24,750	22,084	-2,665	-11%	15,949	14,142	-1,807	-11%	12,591	11,728	-863	-7%

Statistic	Monthly Flow (cfs)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	46,702	43,606	-3,096	-7%	38,278	33,100	-5,178	-14%	20,117	13,880	-6,237	-31%	24,035	15,804	-8,231	-34%	17,199	10,643	-6,556	-38%	28,766	21,447	-7,319	-25%
20%	32,263	29,088	-3,175	-10%	25,716	24,519	-1,197	-5%	15,986	12,854	-3,132	-20%	23,530	14,277	-9,253	-39%	16,842	10,486	-6,356	-38%	28,044	20,913	-7,131	-25%
30%	23,260	21,909	-1,351	-6%	16,390	15,395	-996	-6%	13,757	12,349	-1,407	-10%	22,439	13,715	-8,725	-39%	16,281	10,324	-5,957	-37%	22,138	17,184	-4,954	-22%
40%	20,285	18,749	-1,537	-8%	13,472	12,260	-1,212	-9%	13,091	12,000	-1,091	-8%	20,407	13,112	-7,296	-36%	15,755	9,986	-5,769	-37%	21,295	13,987	-7,309	-34%
50%	15,961	15,351	-610	-4%	12,387	11,544	-843	-7%	12,855	11,485	-1,370	-11%	18,594	12,562	-6,032	-32%	14,870	9,504	-5,366	-36%	14,424	6,789	-7,634	-53%
60%	13,113	12,587	-526	-4%	11,415	10,934	-481	-4%	12,281	11,106	-1,175	-10%	17,779	11,918	-5,861	-33%	13,812	9,032	-4,781	-35%	11,826	6,665	-5,162	-44%
70%	11,569	11,306	-263	-2%	10,809	10,398	-411	-4%	11,828	10,643	-1,184	-10%	16,682	11,111	-5,571	-33%	11,473	8,605	-2,868	-25%	9,939	6,607	-3,332	-34%
80%	10,855	10,802	-53	0%	9,947	9,846	-100	-1%	10,885	10,196	-690	-6%	14,982	10,504	-4,478	-30%	9,670	8,343	-1,327	-14%	8,396	6,522	-1,874	-22%
90%	9,926	9,795	-131	-1%	8,874	8,677	-196	-2%	9,924	8,365	-1,559	-16%	11,593	8,998	-2,595	-22%	8,111	7,872	-240	-3%	6,932	6,398	-534	-8%
Long Term																								
Full Simulation Period[b]	22,169	20,937	-1,233	-6%	17,865	16,531	-1,333	-7%	14,670	12,383	-2,287	-16%	18,592	12,474	-6,118	-33%	13,679	9,395	-4,284	-31%	17,195	12,212	-4,983	-29%
Water Year Types[c]																								
Wet (32%)	35,456	32,835	-2,621	-7%	29,825	26,743	-3,082	-10%	20,247	15,361	-4,886	-24%	20,212	13,589	-6,623	-33%	16,017	9,292	-6,724	-42%	27,616	20,684	-6,932	-25%
Above Normal (16%)	24,362	23,222	-1,140	-5%	16,872	15,600	-1,272	-8%	13,470	11,449	-2,022	-15%	22,560	13,816	-8,744	-39%	16,836	9,944	-6,892	-41%	21,059	14,072	-6,987	-33%
Below Normal (13%)	14,100	13,626	-473	-3%	12,511	12,067	-443	-4%	12,695	11,880	-815	-6%	21,747	13,644	-8,103	-37%	15,593	9,008	-6,585	-42%	12,036	6,535	-5,501	-46%
Dry (24%)	15,004	14,451	-553	-4%	11,702	11,430	-272	-2%	12,534	11,432	-1,101	-9%	16,739	11,481	-5,257	-31%	10,620	9,806	-814	-8%	9,999	6,582	-3,418	-34%
Critical (15%)	10,344	10,191	-152	-1%	8,206	8,011	-194	-2%	9,259	8,989	-270	-3%	10,982	9,189	-1,794	-16%	8,541	8,694	153	2%	7,156	6,433	-723	-10%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-1-1. Monthly Flow Ranges For Sacramento River downstream of North Delta Intakes, All Years

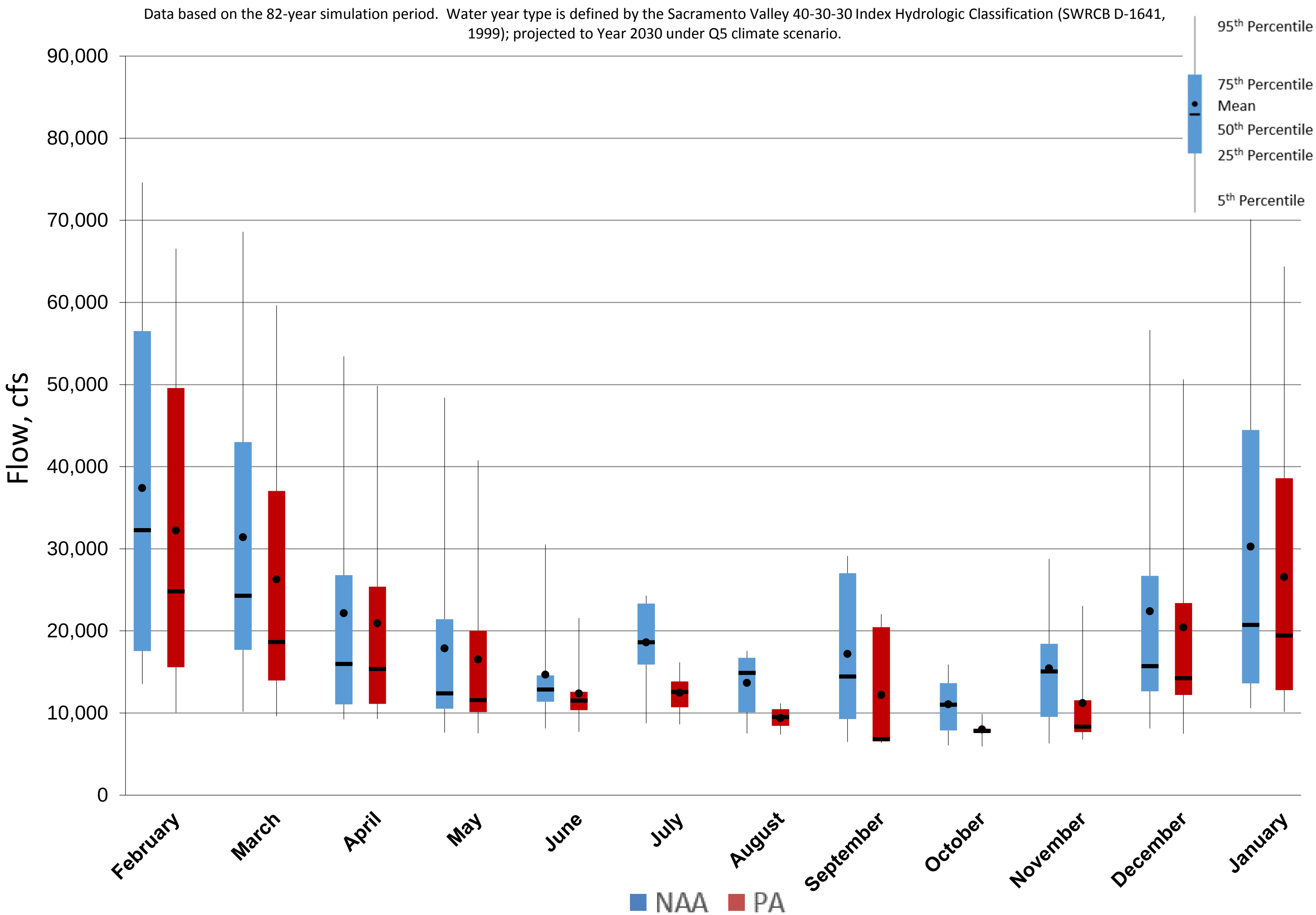


Figure 5.B.5-1-2. Monthly Flow Ranges For Sacramento River downstream of North Delta Intakes, Wet Years

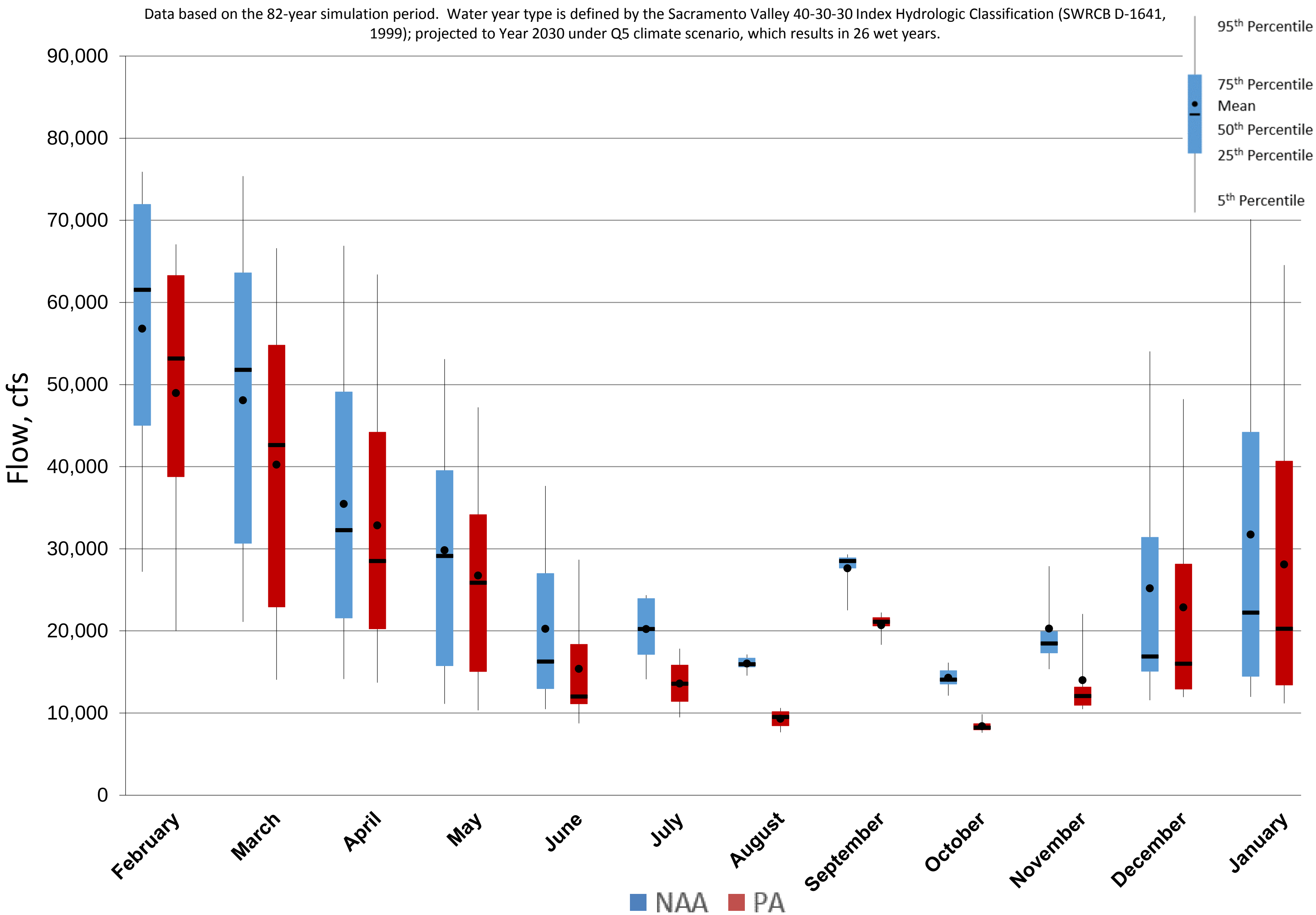


Figure 5.B.5-1-3. Monthly Flow Ranges For Sacramento River downstream of North Delta Intakes, Above Normal Years

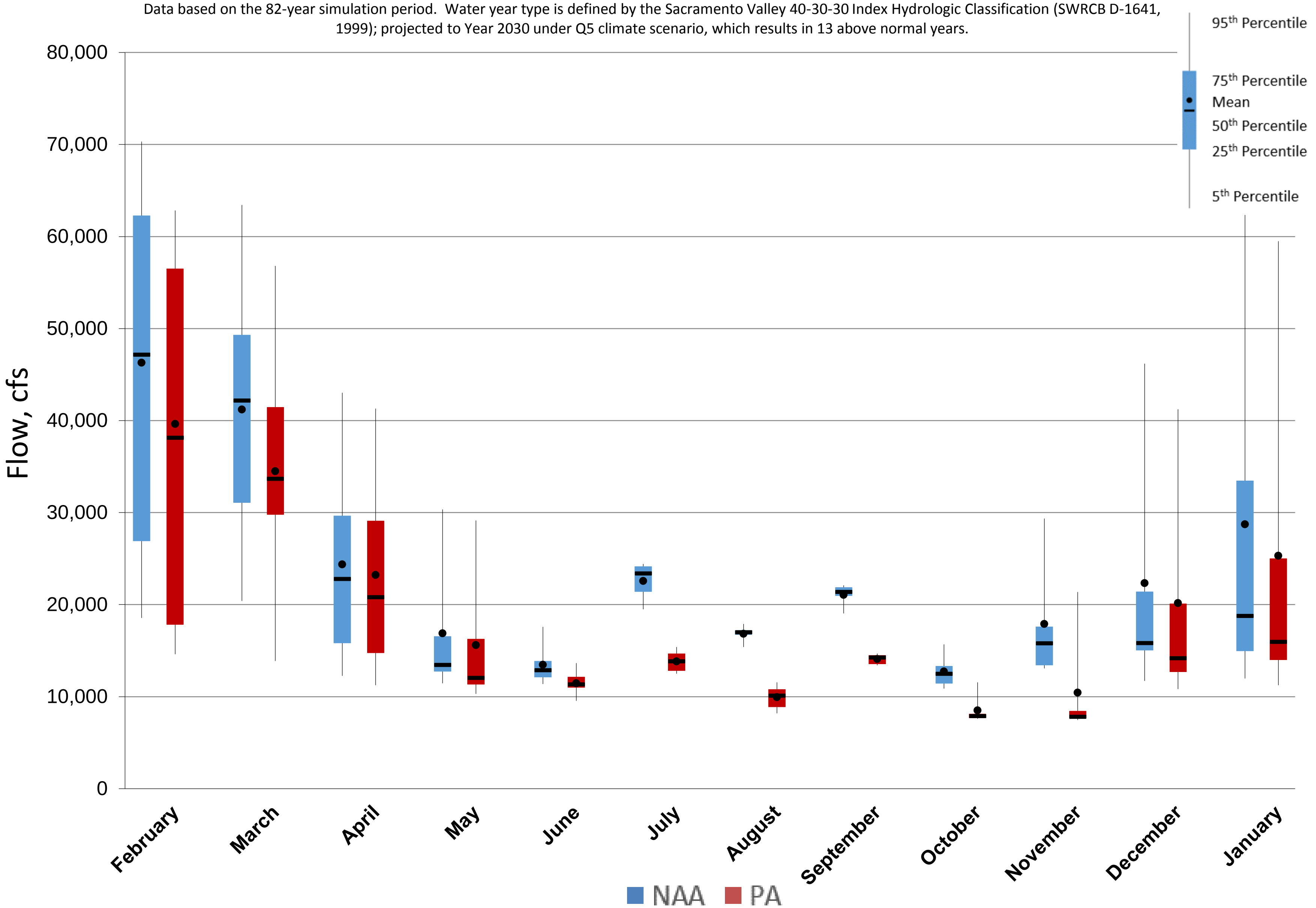


Figure 5.B.5-1-4. Monthly Flow Ranges For Sacramento River downstream of North Delta Intakes, Below Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 11 below normal years.

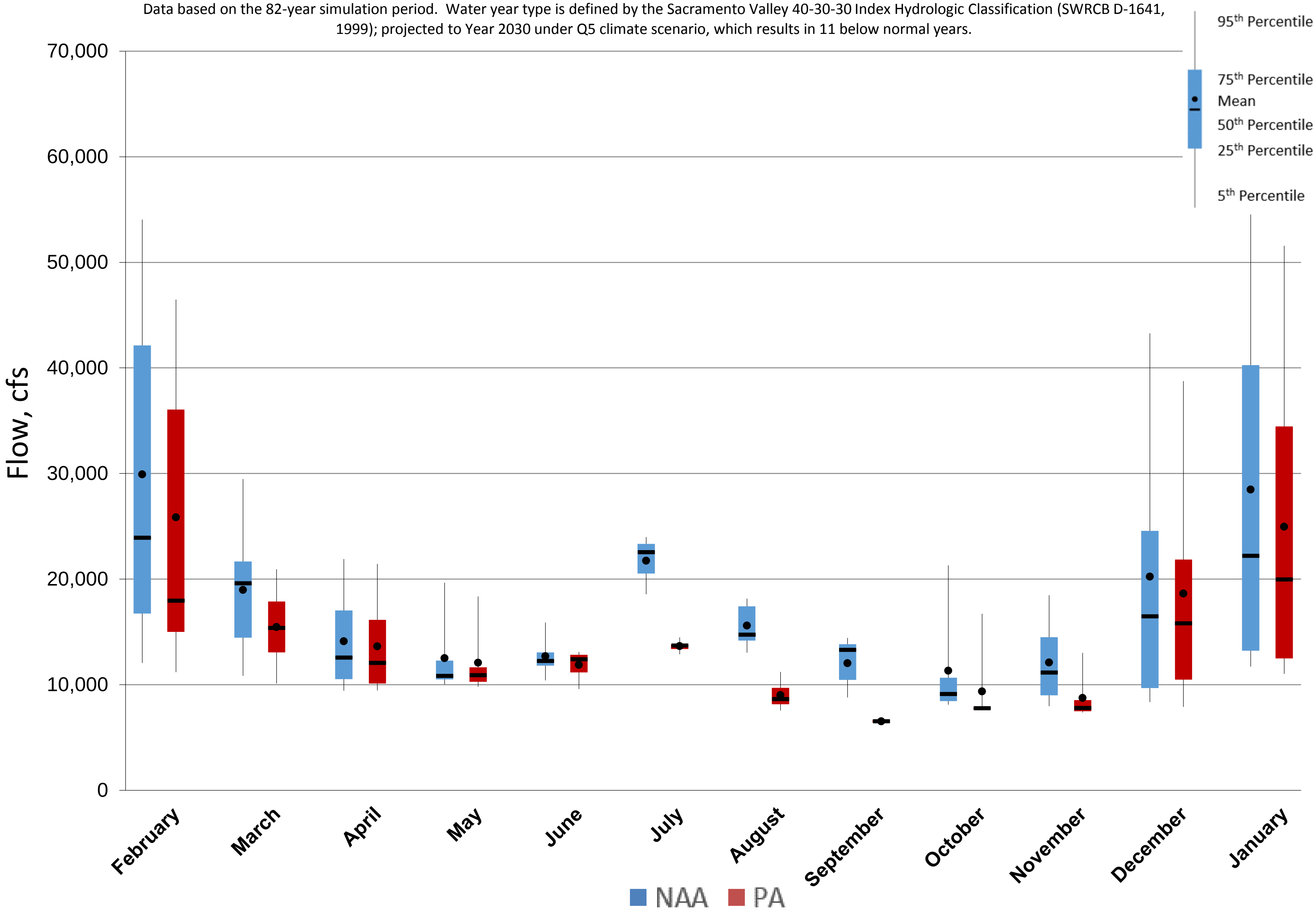
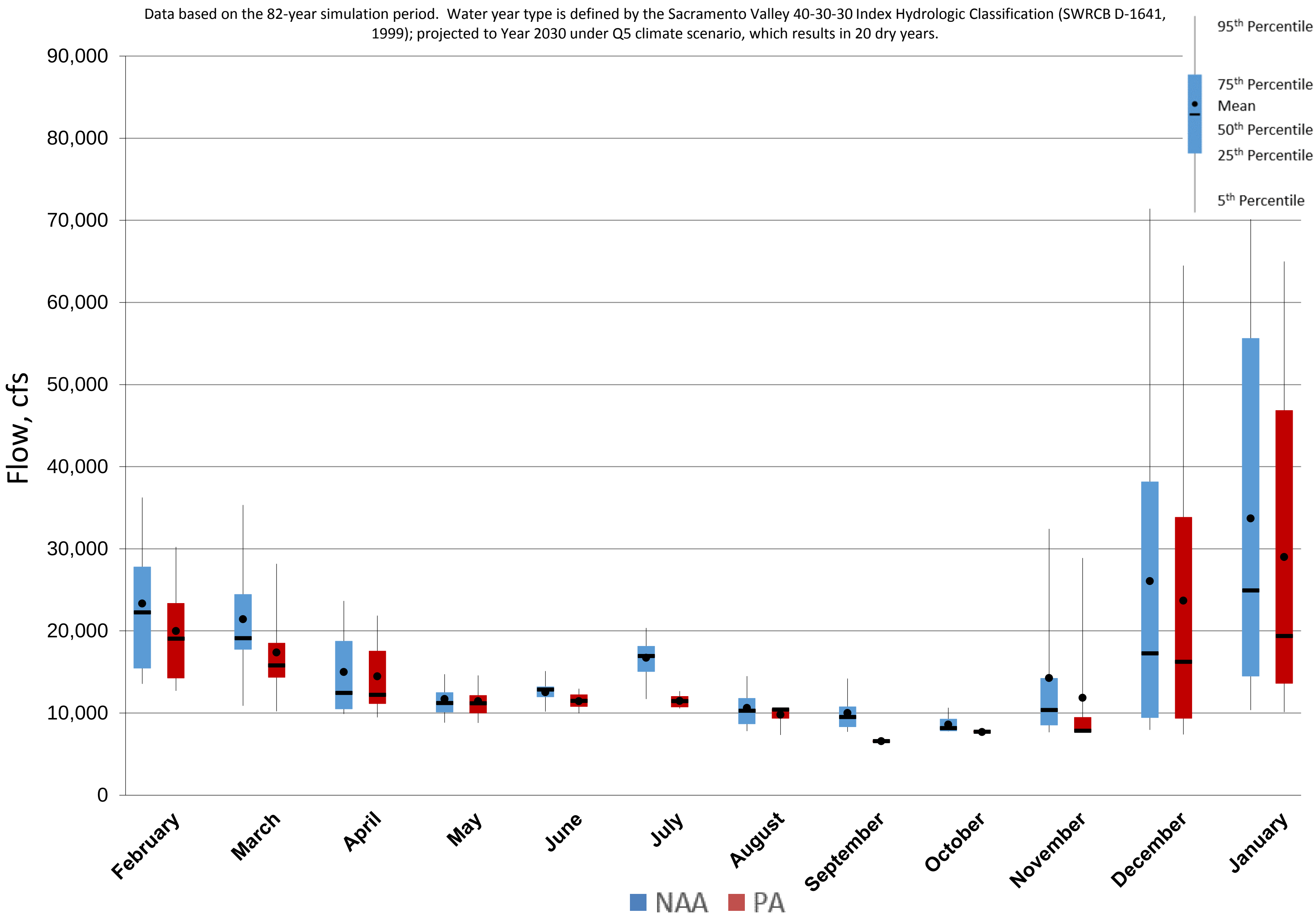


Figure 5.B.5-1-5. Monthly Flow Ranges For Sacramento River downstream of North Delta Intakes, Dry Years



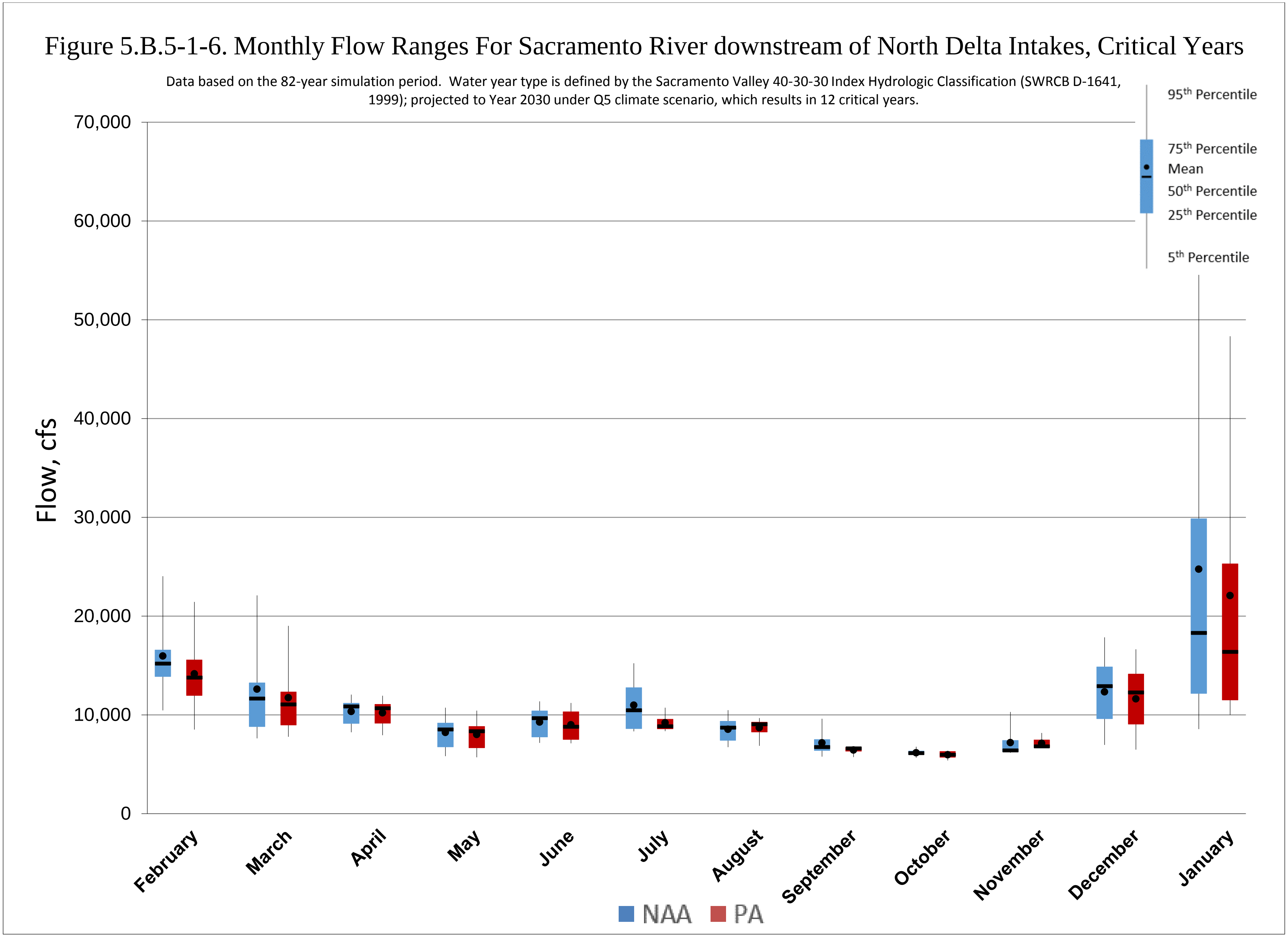
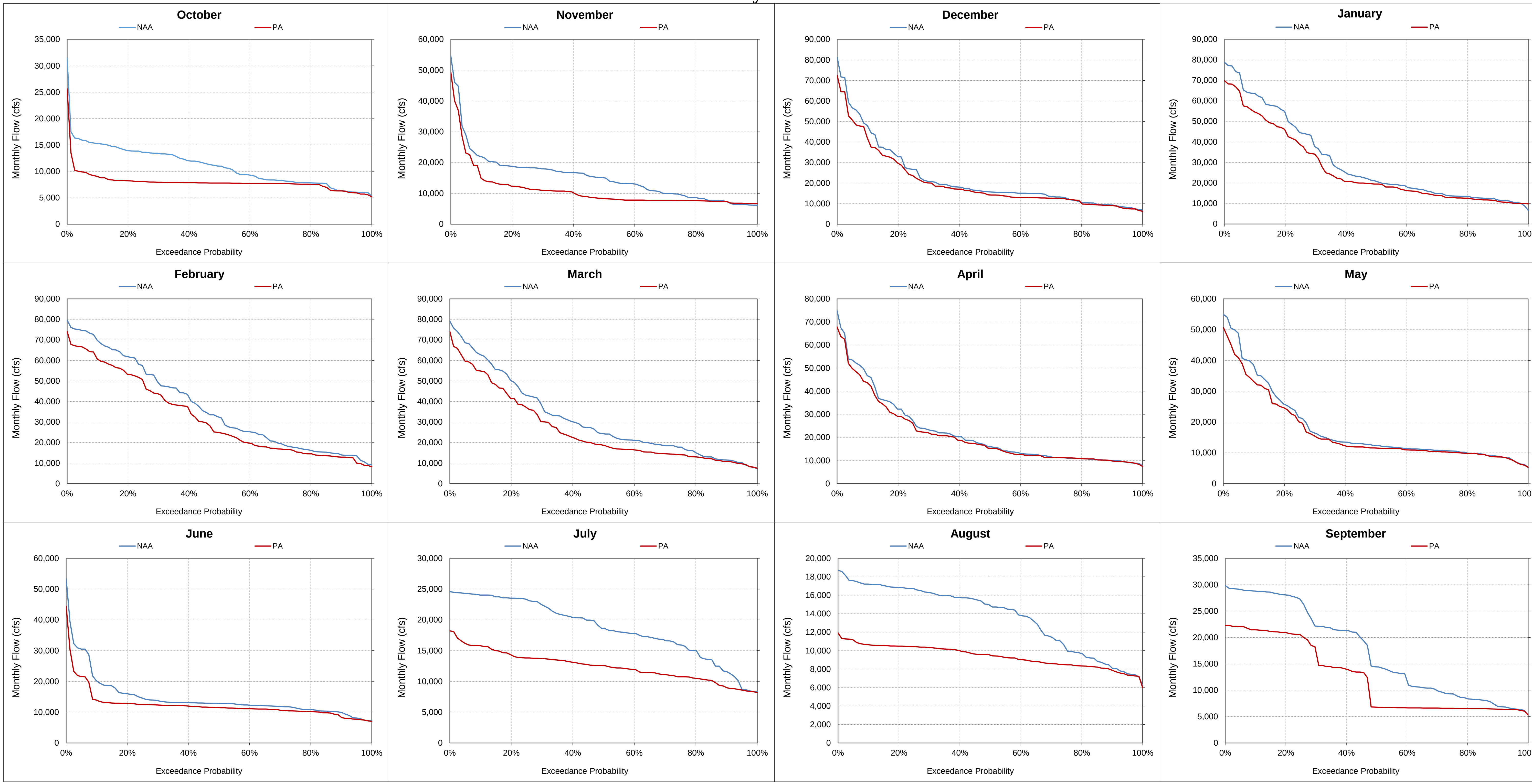


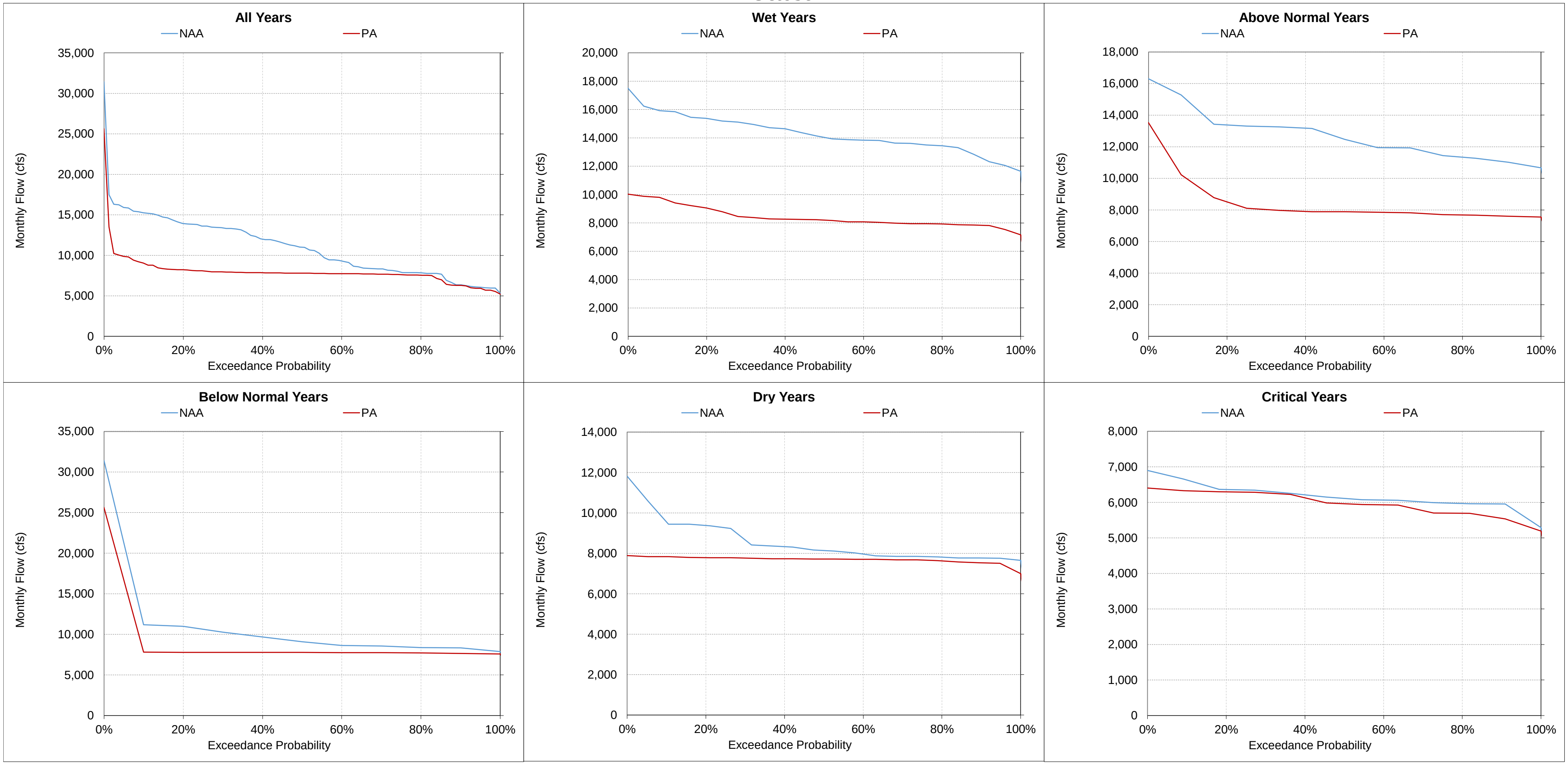
Figure 5.B.5-1-6. Monthly Flow Ranges For Sacramento River downstream of North Delta Intakes, Critical Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 12 critical years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
Flow, cfs
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-1-7. Sacramento River downstream of North Delta Intakes, Monthly Flow Probability of Exceedance



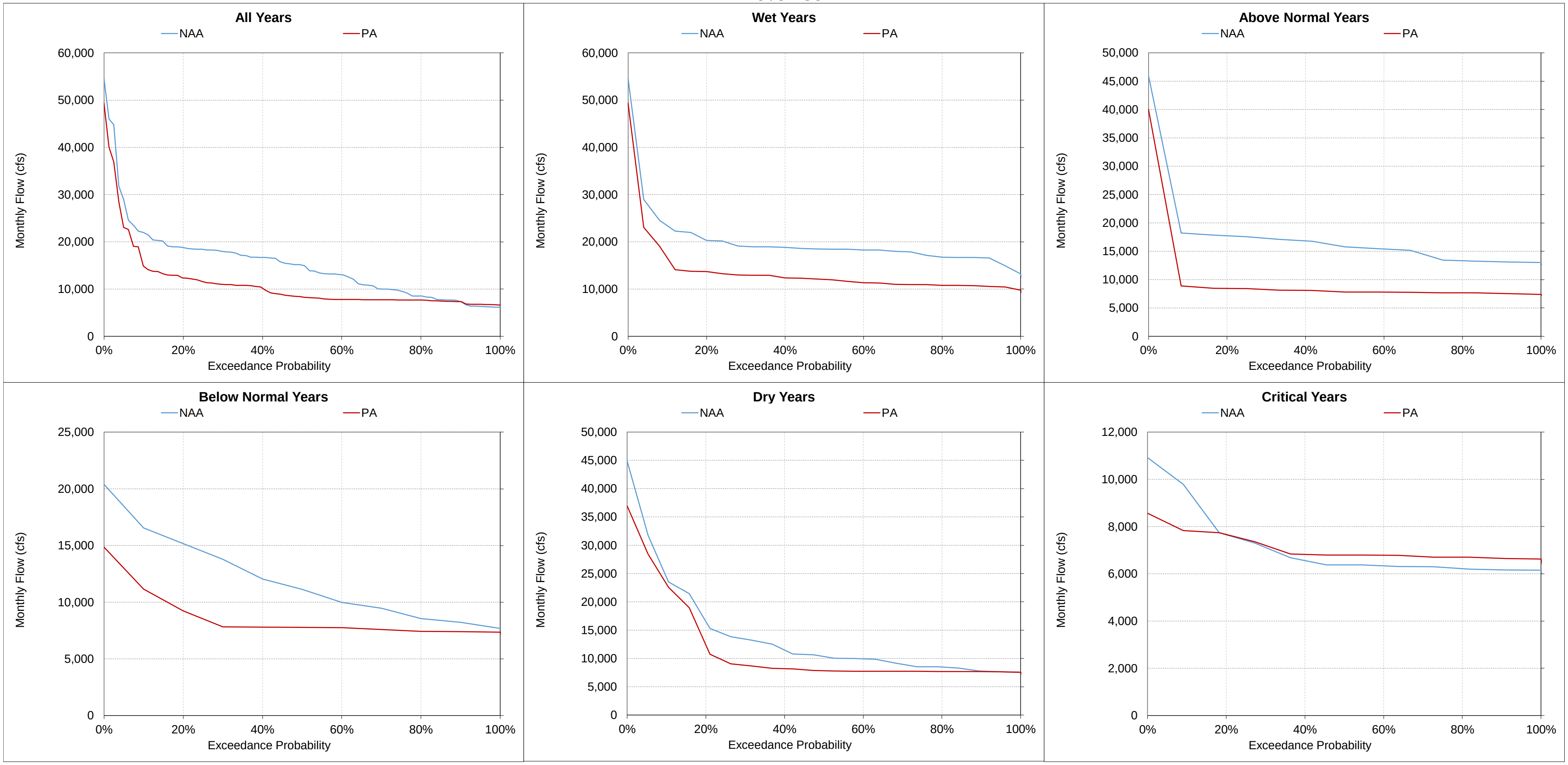
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-1-8. Sacramento River downstream of North Delta Intakes, Monthly Flow
October



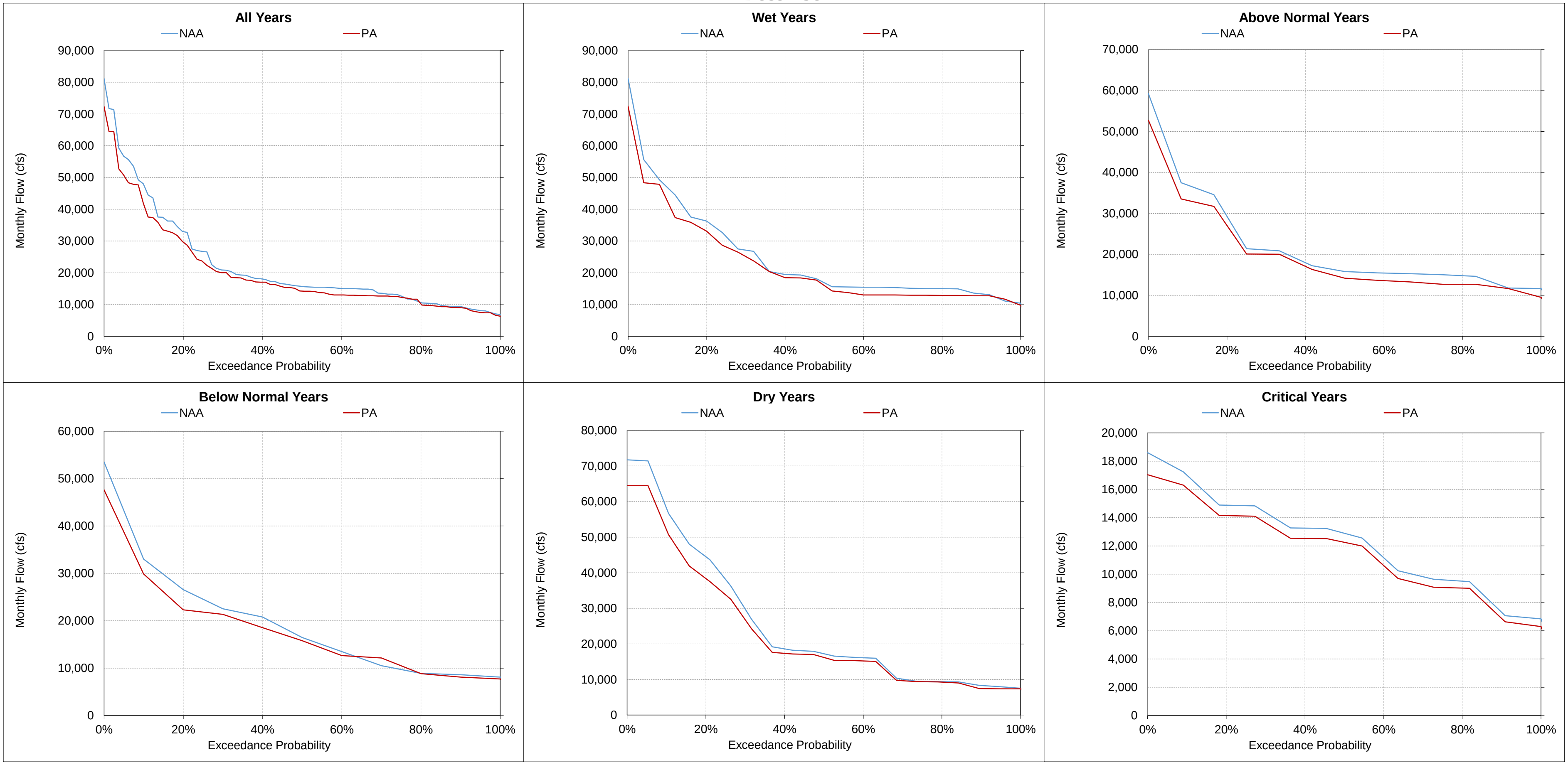
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-1-9. Sacramento River downstream of North Delta Intakes, Monthly Flow November



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-1-10. Sacramento River downstream of North Delta Intakes, Monthly Flow December



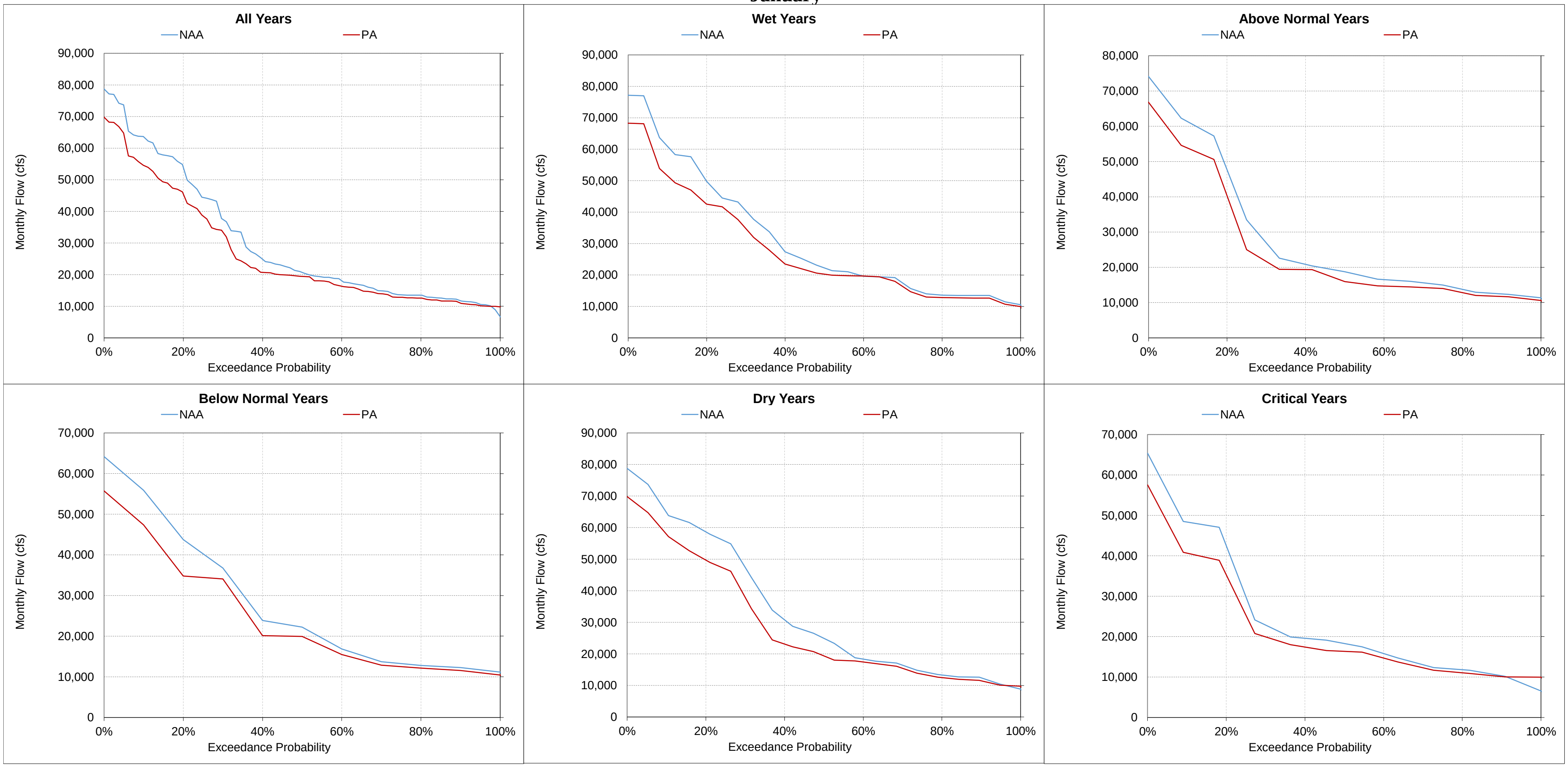
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

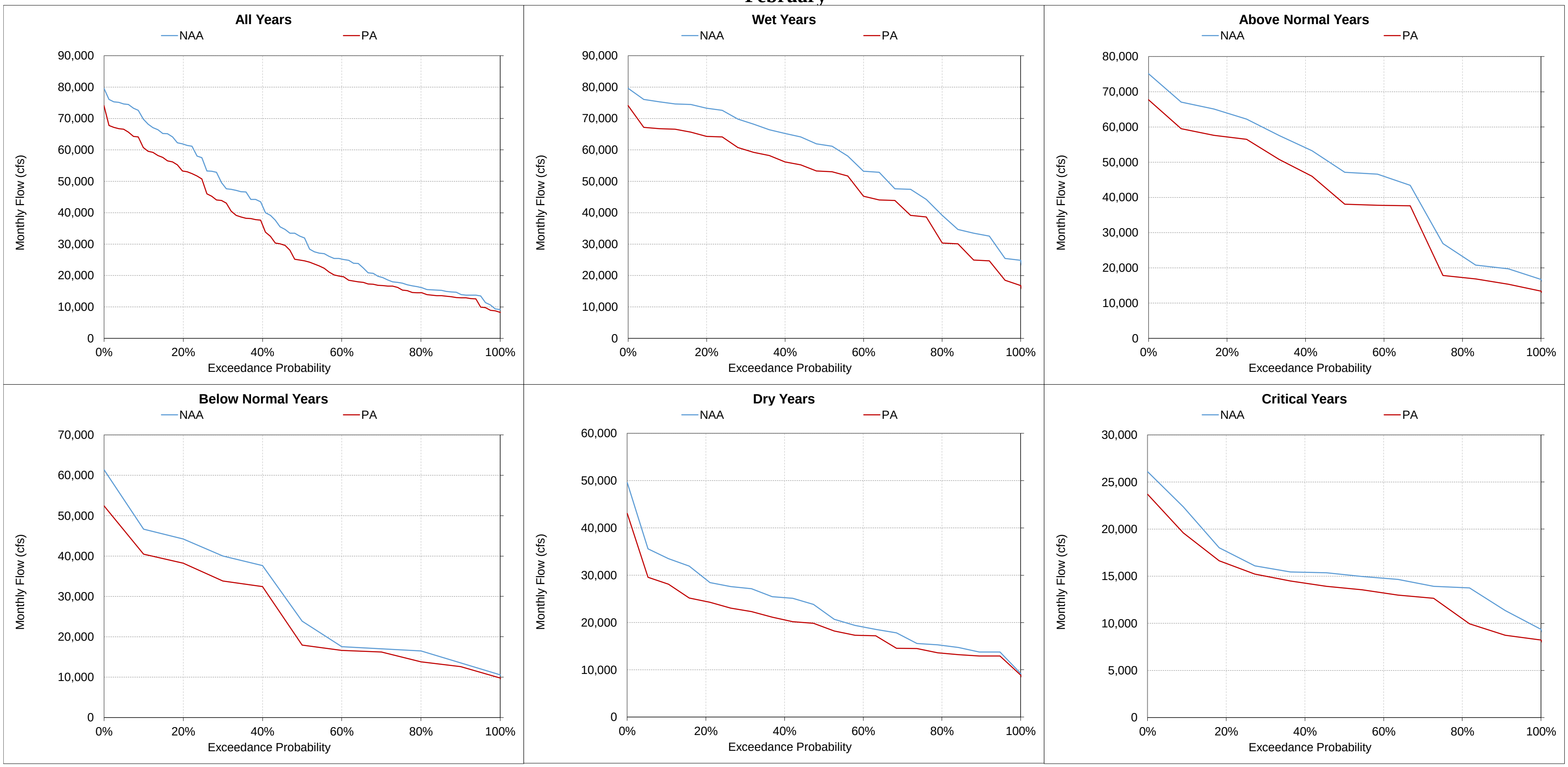
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-1-11. Sacramento River downstream of North Delta Intakes, Monthly Flow
January



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-1-12. Sacramento River downstream of North Delta Intakes, Monthly Flow February



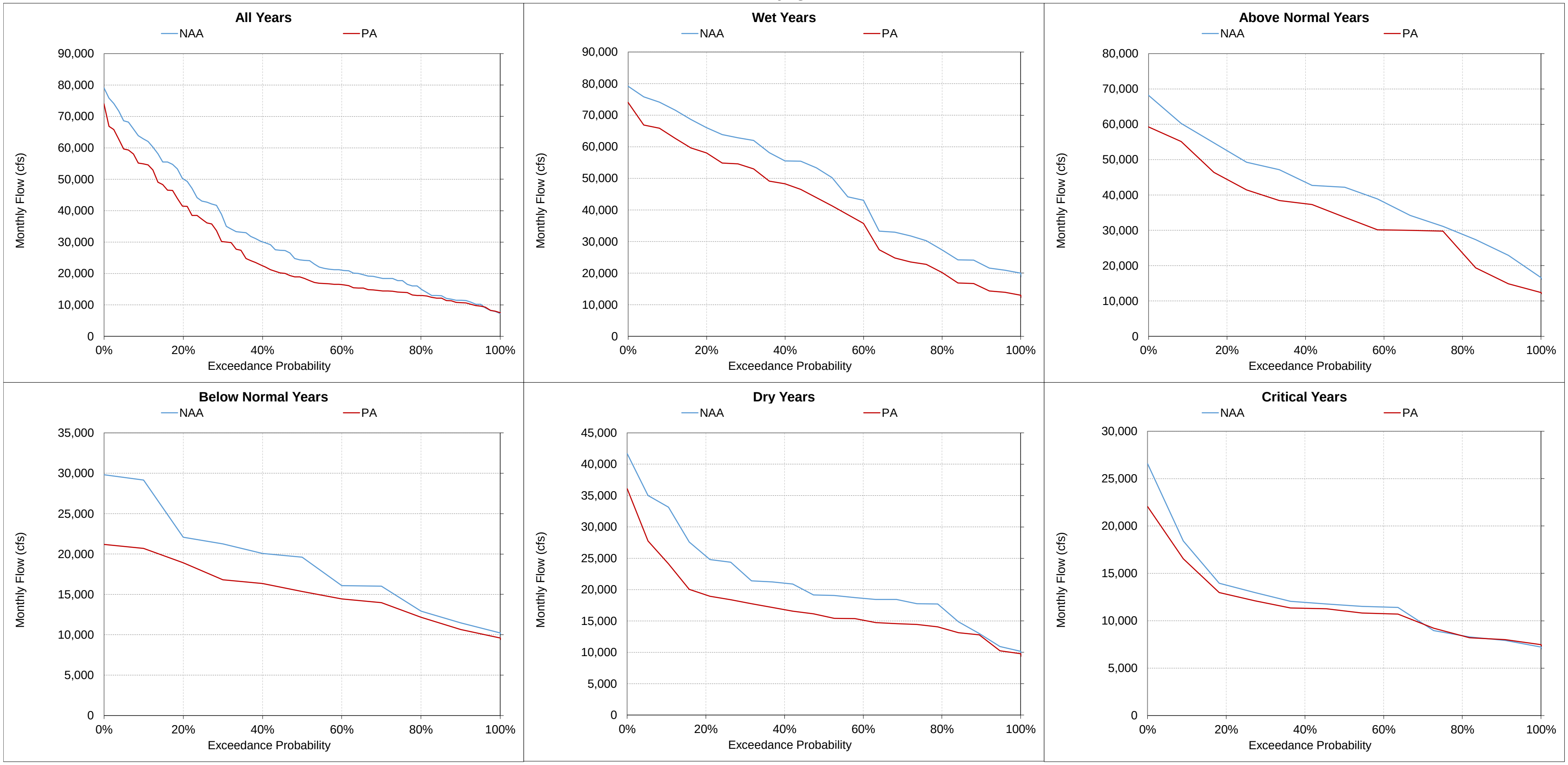
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

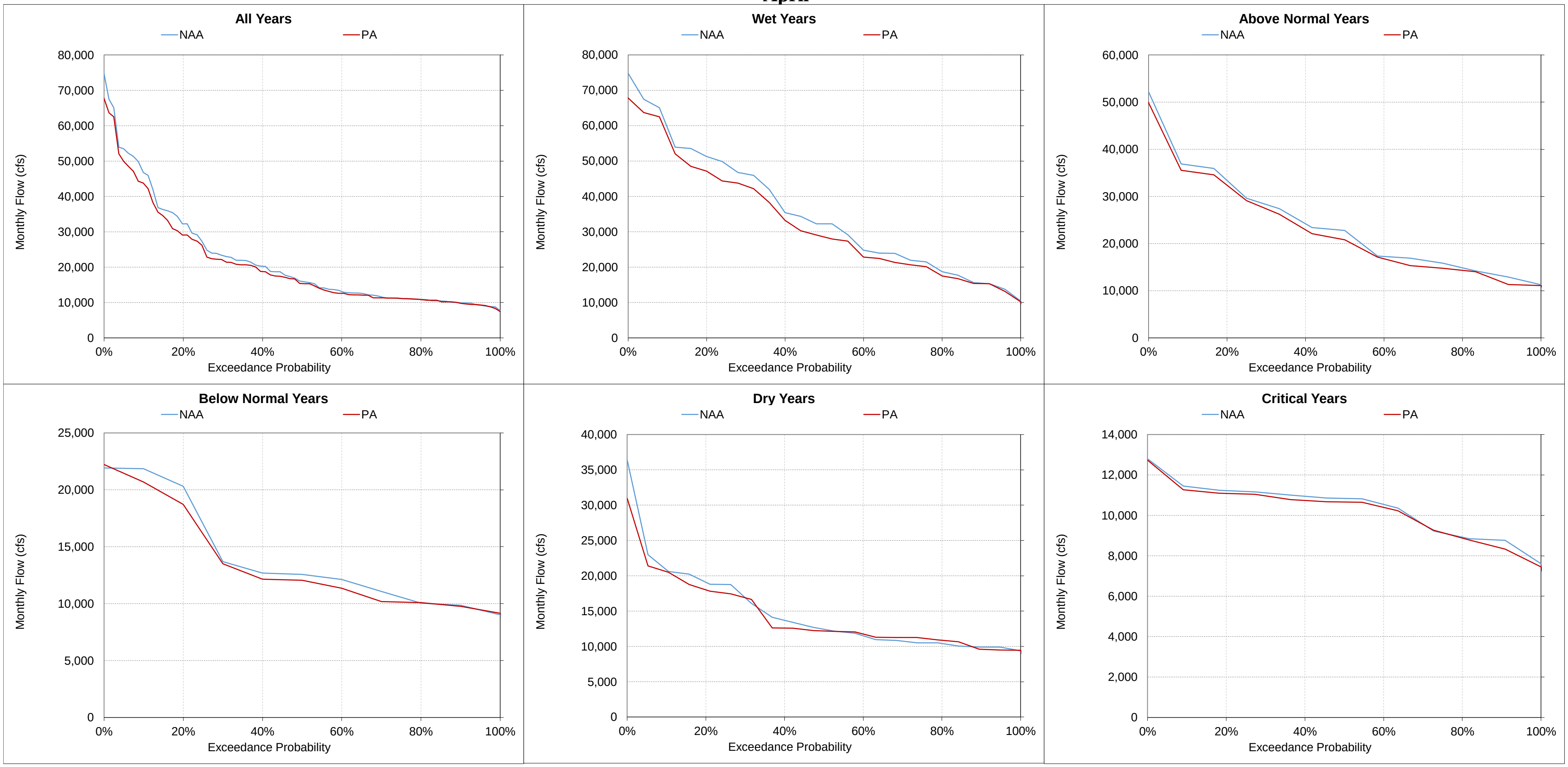
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-1-13. Sacramento River downstream of North Delta Intakes, Monthly Flow
March



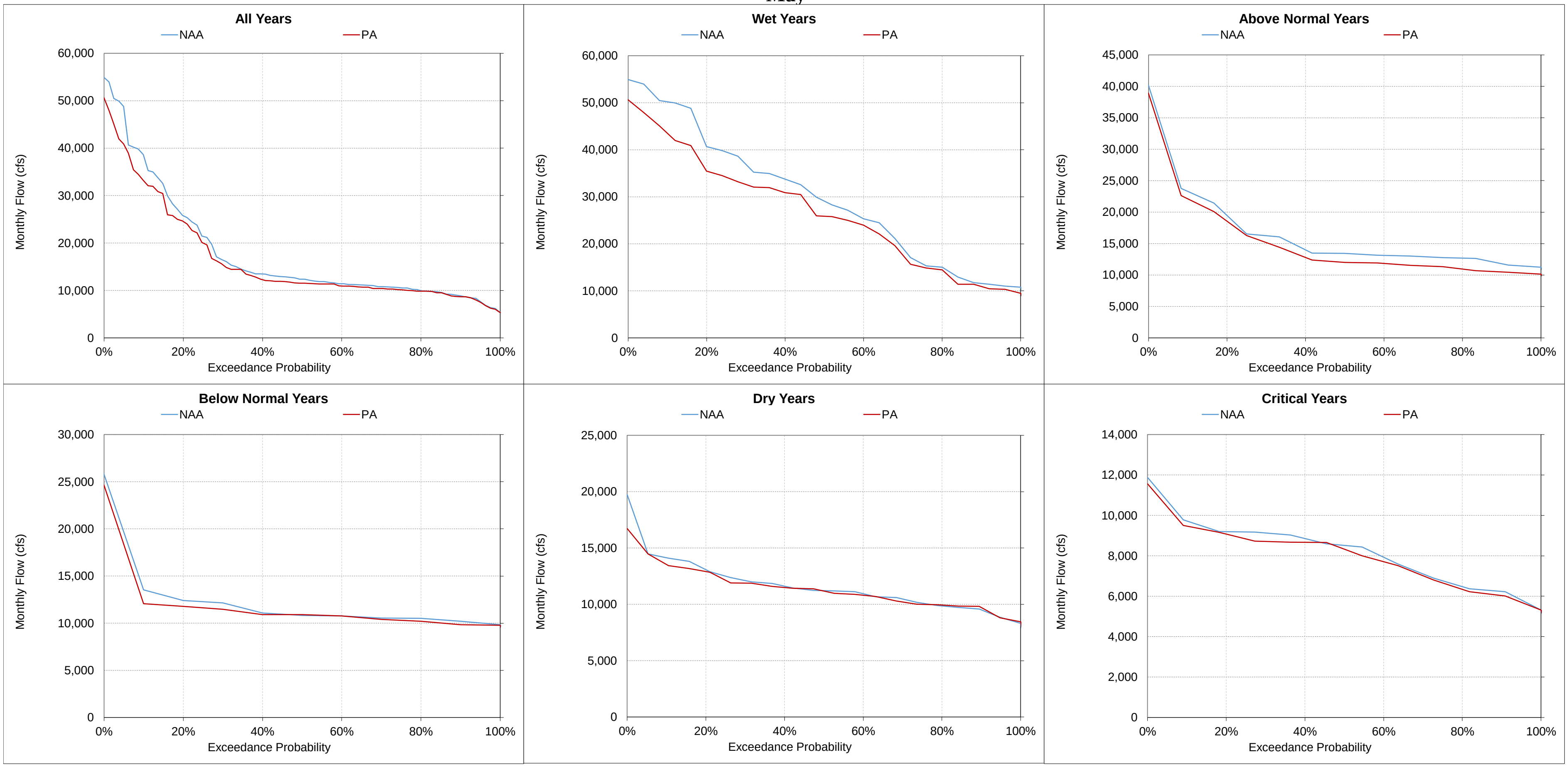
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-1-14. Sacramento River downstream of North Delta Intakes, Monthly Flow April



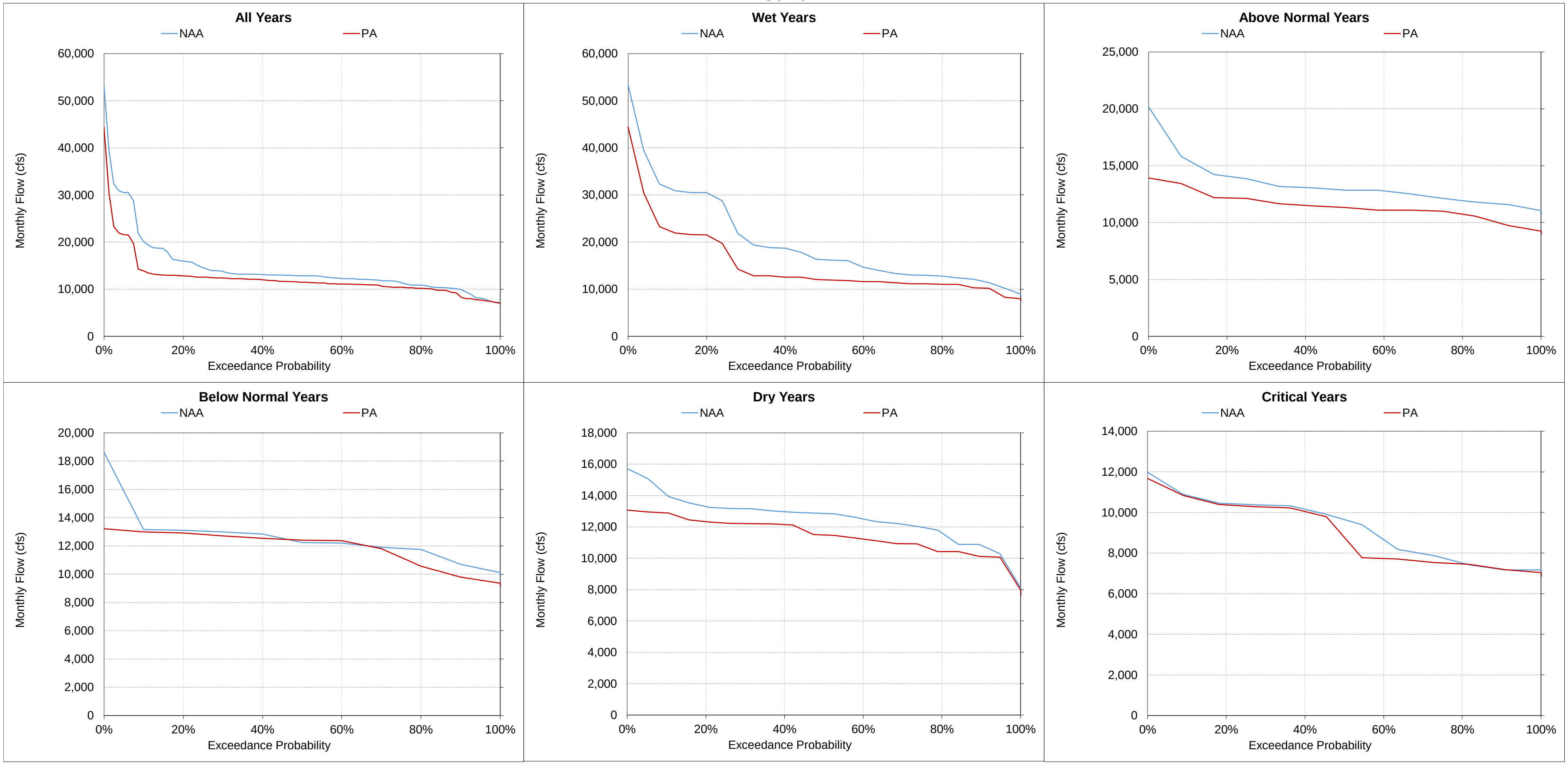
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-1-15. Sacramento River downstream of North Delta Intakes, Monthly Flow May



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-1-16. Sacramento River downstream of North Delta Intakes, Monthly Flow June



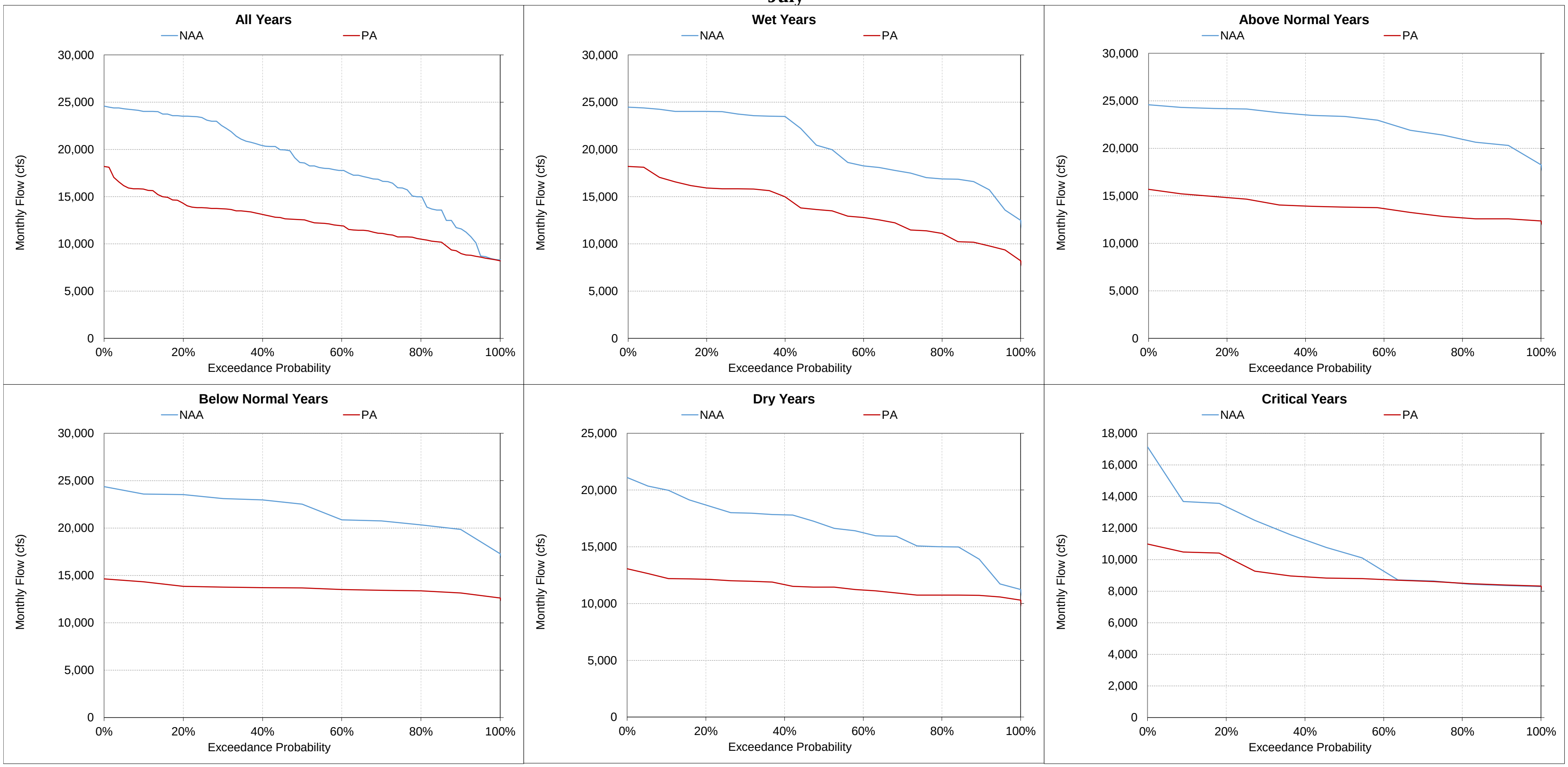
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

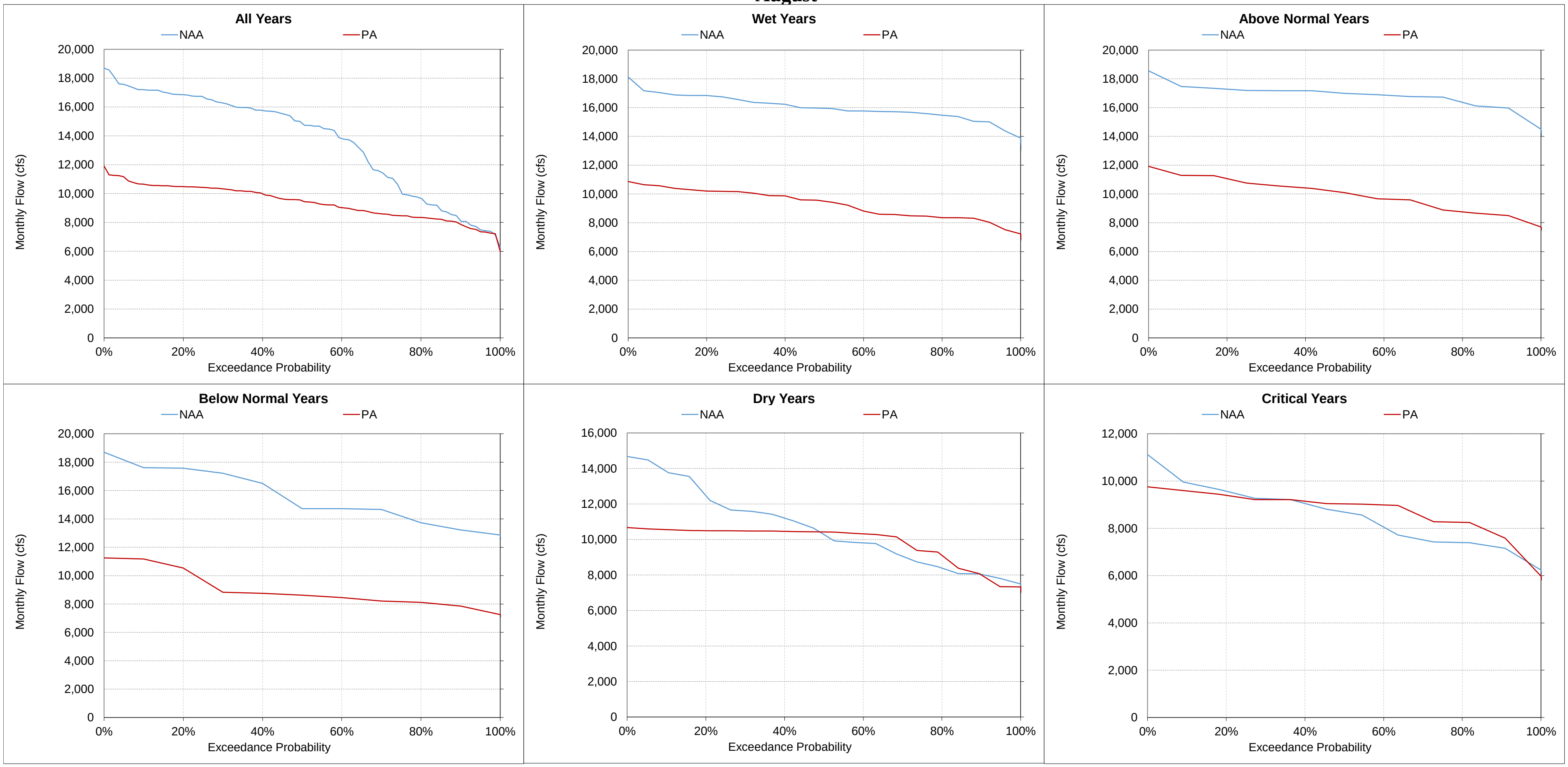
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-1-17. Sacramento River downstream of North Delta Intakes, Monthly Flow
July



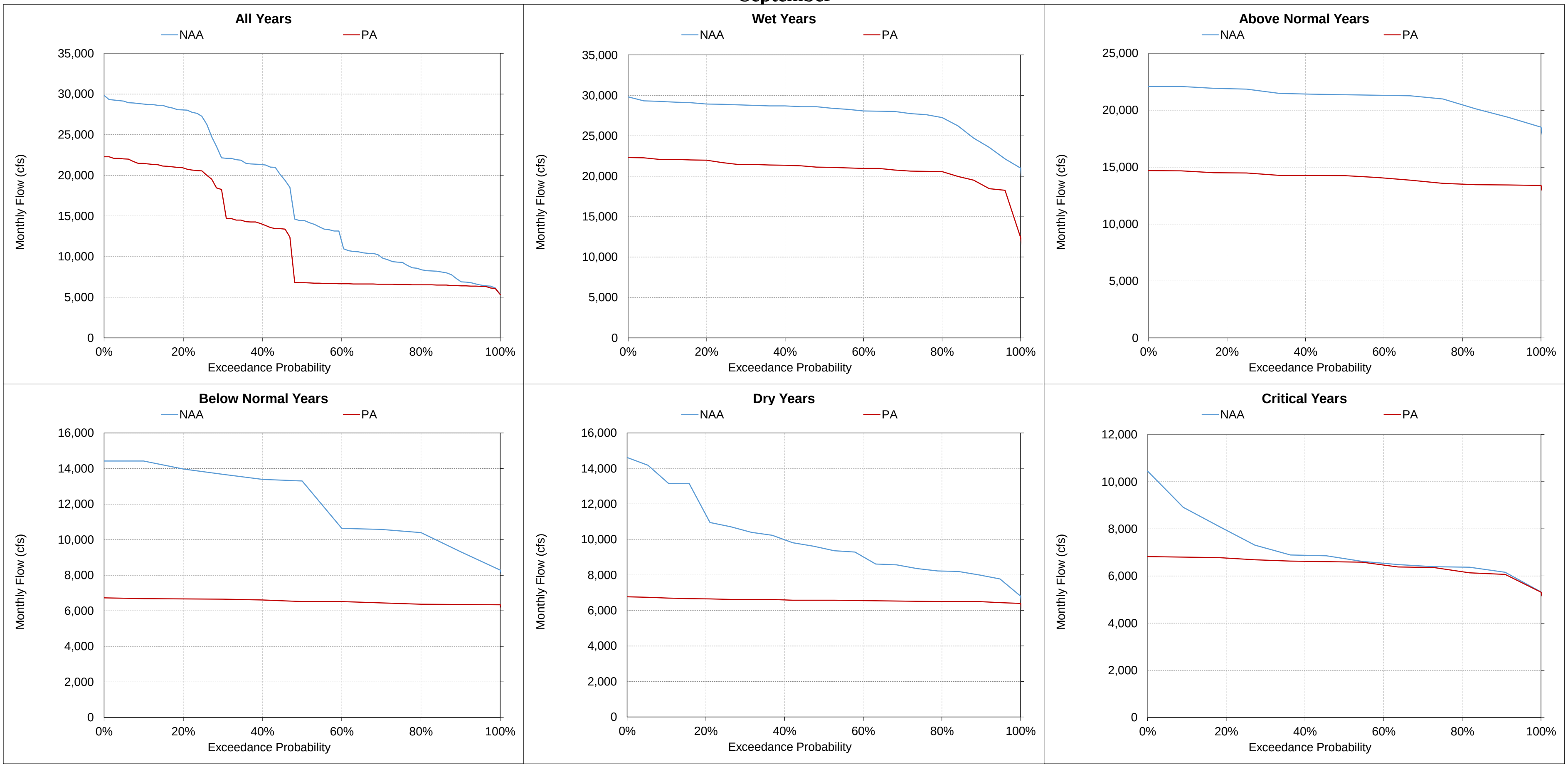
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-1-18. Sacramento River downstream of North Delta Intakes, Monthly Flow August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-1-19. Sacramento River downstream of North Delta Intakes, Monthly Flow
September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-2. Sutter Slough, Monthly Flow

Statistic	Monthly Flow (cfs)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	3,620	1,743	-1,877	-52%	5,666	3,718	-1,948	-34%	12,540	10,835	-1,705	-14%	16,946	14,402	-2,544	-15%	18,671	16,127	-2,544	-14%	16,715	14,601	-2,114	-13%
20%	3,102	1,610	-1,492	-48%	4,827	3,049	-1,778	-37%	8,571	7,693	-878	-10%	14,313	11,981	-2,332	-16%	16,439	14,157	-2,282	-14%	13,299	10,938	-2,362	-18%
30%	2,778	1,522	-1,256	-45%	4,617	2,568	-2,049	-44%	5,393	5,193	-200	-4%	9,819	8,713	-1,106	-11%	13,006	11,539	-1,468	-11%	9,866	7,866	-2,000	-20%
40%	2,445	1,450	-995	-41%	4,144	2,265	-1,880	-45%	4,583	4,351	-232	-5%	6,385	5,304	-1,080	-17%	11,113	9,466	-1,647	-15%	7,849	5,774	-2,075	-26%
50%	2,091	1,423	-668	-32%	3,543	1,855	-1,688	-48%	3,824	3,517	-307	-8%	5,284	5,002	-282	-5%	8,391	6,377	-2,014	-24%	6,283	4,807	-1,476	-23%
60%	1,693	1,410	-283	-17%	2,911	1,579	-1,332	-46%	3,640	3,038	-602	-17%	4,604	4,146	-458	-10%	6,497	5,010	-1,488	-23%	5,435	4,200	-1,236	-23%
70%	1,509	1,402	-108	-7%	2,174	1,551	-623	-29%	3,258	2,927	-332	-10%	3,748	3,492	-256	-7%	5,036	4,308	-728	-14%	4,771	3,699	-1,072	-22%
80%	1,417	1,392	-25	-2%	1,698	1,538	-160	-9%	2,440	2,406	-34	-1%	3,365	3,149	-216	-6%	4,171	3,641	-530	-13%	3,846	3,281	-565	-15%
90%	1,141	1,153	12	1%	1,478	1,454	-24	-2%	1,997	1,945	-52	-3%	2,890	2,683	-207	-7%	3,573	3,252	-321	-9%	2,863	2,634	-229	-8%
Long Term Full Simulation Period[b]	2,292	1,550	-743	-32%	3,764	2,600	-1,164	-31%	5,692	5,152	-540	-9%	7,900	6,885	-1,015	-13%	9,848	8,428	-1,420	-14%	8,236	6,845	-1,391	-17%
Water Year Types[c]																								
Wet (32%)	3,200	1,674	-1,525	-48%	5,207	3,425	-1,782	-34%	6,422	5,785	-637	-10%	8,304	7,308	-996	-12%	15,108	12,947	-2,161	-14%	12,771	10,635	-2,137	-17%
Above Normal (16%)	2,651	1,640	-1,011	-38%	4,453	2,409	-2,044	-46%	5,670	5,079	-591	-10%	7,481	6,548	-933	-12%	12,254	10,426	-1,828	-15%	10,875	9,066	-1,808	-17%
Below Normal (13%)	2,311	1,900	-410	-18%	2,729	1,864	-865	-32%	5,090	4,664	-426	-8%	7,399	6,435	-965	-13%	7,829	6,717	-1,112	-14%	4,877	3,934	-942	-19%
Dry (24%)	1,581	1,411	-170	-11%	3,389	2,755	-635	-19%	6,718	6,065	-654	-10%	8,831	7,541	-1,290	-15%	6,034	5,122	-912	-15%	5,528	4,444	-1,084	-20%
Critical (15%)	1,108	1,093	-15	-1%	1,465	1,435	-30	-2%	2,972	2,782	-189	-6%	6,385	5,651	-733	-11%	4,052	3,553	-499	-12%	3,142	2,898	-244	-8%

Statistic	Monthly Flow (cfs)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	12,350	11,552	-798	-6%	10,089	8,735	-1,354	-13%	4,717	3,013	-1,704	-36%	5,716	3,302	-2,413	-42%	3,645	1,977	-1,668	-46%	7,474	4,907	-2,567	-34%
20%	8,443	7,604	-839	-10%	6,699	6,382	-317	-5%	3,462	2,670	-792	-23%	5,550	2,889	-2,662	-48%	3,539	1,941	-1,598	-45%	7,288	4,718	-2,570	-35%
30%	6,041	5,683	-358	-6%	4,202	3,967	-235	-6%	2,855	2,535	-320	-11%	5,068	2,735	-2,333	-46%	3,372	1,904	-1,467	-44%	5,066	3,733	-1,333	-26%
40%	5,275	4,849	-426	-8%	3,437	3,099	-338	-10%	2,686	2,465	-221	-8%	4,494	2,590	-1,904	-42%	3,261	1,826	-1,435	-44%	4,757	2,861	-1,896	-40%
50%	4,113	3,952	-160	-4%	3,136	2,894	-242	-8%	2,636	2,323	-313	-12%	4,001	2,464	-1,537	-38%	3,023	1,730	-1,293	-43%	2,883	1,218	-1,666	-58%
60%	3,321	3,168	-153	-5%	2,858	2,741	-116	-4%	2,525	2,230	-295	-12%	3,823	2,278	-1,545	-40%	2,747	1,645	-1,102	-40%	2,227	1,179	-1,048	-47%
70%	2,890	2,815	-75	-3%	2,694	2,576	-119	-4%	2,393	2,147	-245	-10%	3,570	2,128	-1,442	-40%	2,142	1,565	-577	-27%	1,790	1,157	-633	-35%
80%	2,686	2,673	-13	0%	2,428	2,415	-13	-1%	2,145	2,037	-109	-5%	3,055	2,014	-1,042	-34%	1,760	1,493	-267	-15%	1,502	1,143	-358	-24%
90%	2,437	2,406	-32	-1%	2,140	2,088	-52	-2%	1,947	1,719	-228	-12%	2,207	1,667	-540	-24%	1,478	1,380	-97	-7%	1,234	1,124	-110	-9%
Long Term Full Simulation Period[b]	5,755	5,420	-336	-6%	4,597	4,241	-357	-8%	3,220	2,627	-593	-18%	4,118	2,484	-1,634	-40%	2,760	1,717	-1,043	-38%	3,942	2,550	-1,392	-35%
Water Year Types[c]																								
Wet (32%)	9,352	8,637	-715	-8%	7,835	7,006	-829	-11%	4,831	3,496	-1,336	-28%	4,593	2,803	-1,790	-39%	3,325	1,703	-1,622	-49%	7,093	4,698	-2,395	-34%
Above Normal (16%)	6,349	6,040	-308	-5%	4,343	4,004	-340	-8%	2,833	2,332	-501	-18%	5,220	2,785	-2,434	-47%	3,531	1,829	-1,702	-48%	4,689	2,882	-1,807	-39%
Below Normal (13%)	3,590	3,456	-134	-4%	3,144	3,028	-116	-4%	2,607	2,434	-173	-7%	4,950	2,733	-2,217	-45%	3,206	1,631	-1,575	-49%	2,311	1,143	-1,168	-51%
Dry (24%)	3,814	3,666	-148	-4%	2,929	2,860	-70	-2%	2,559	2,313	-245	-10%	3,529	2,201	-1,329	-38%	2,004	1,797	-207	-10%	1,850	1,154	-697	-38%
Critical (15%)	2,539	2,498	-42	-2%	1,970	1,921	-48	-2%	1,810	1,763	-48	-3%	2,112	1,706	-406	-19%	1,552	1,572	20	1%	1,283	1,151	-132	-10%

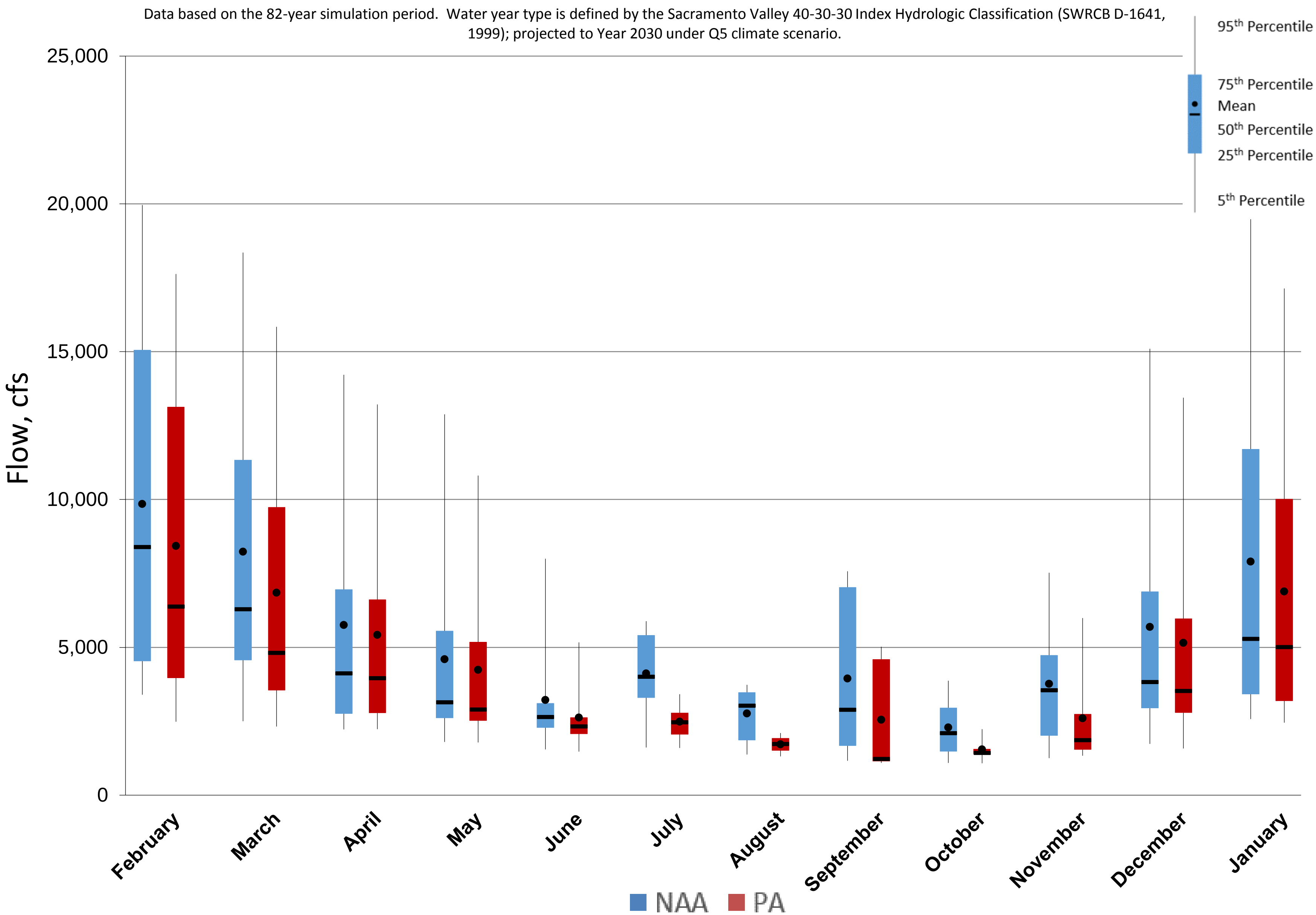
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-2-1. Monthly Flow Ranges For Sutter Slough, All Years



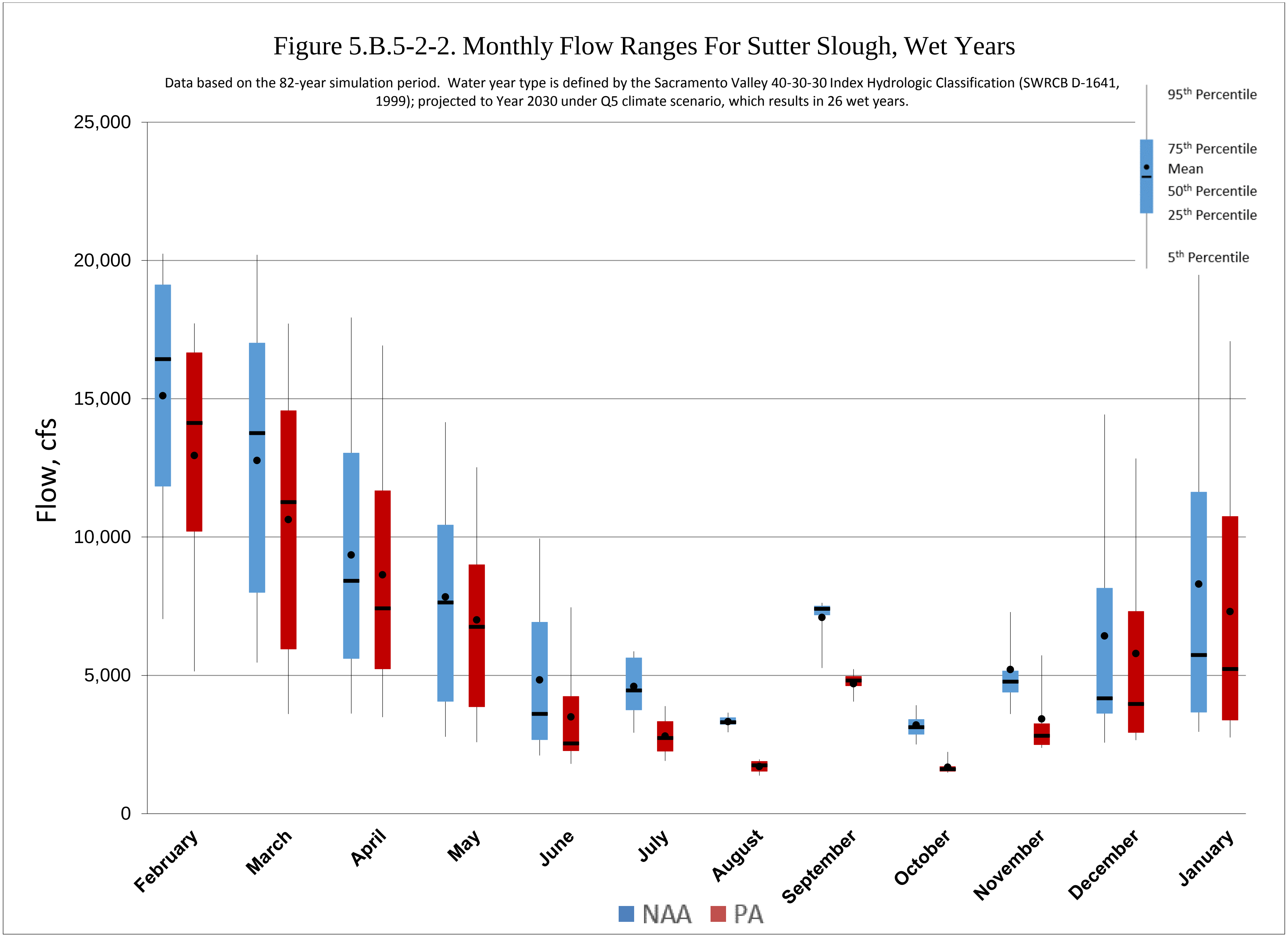
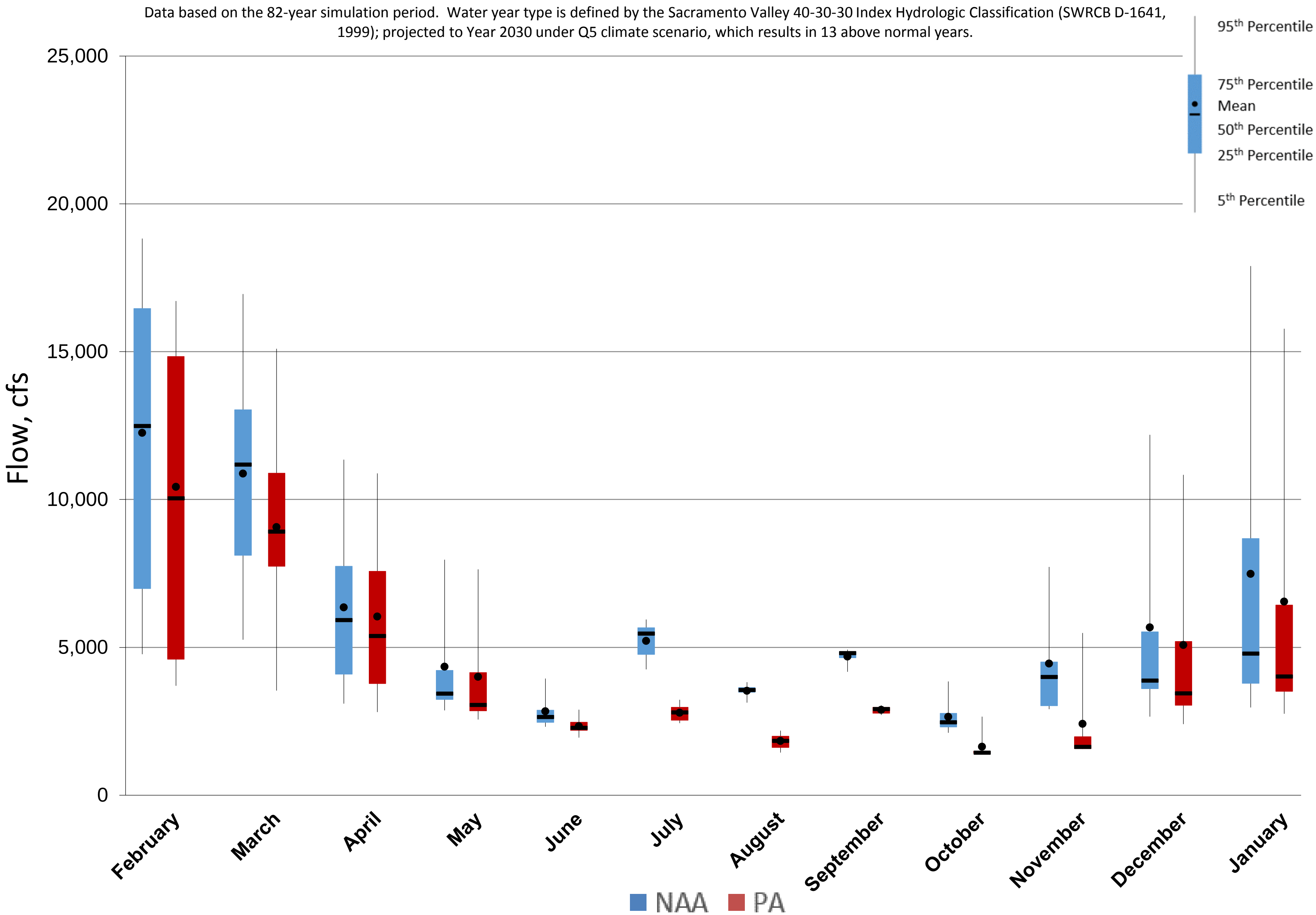


Figure 5.B.5-2-2. Monthly Flow Ranges For Sutter Slough, Wet Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 26 wet years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
Flow, cfs
25,000
20,000
15,000
10,000
5,000
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-2-3. Monthly Flow Ranges For Sutter Slough, Above Normal Years



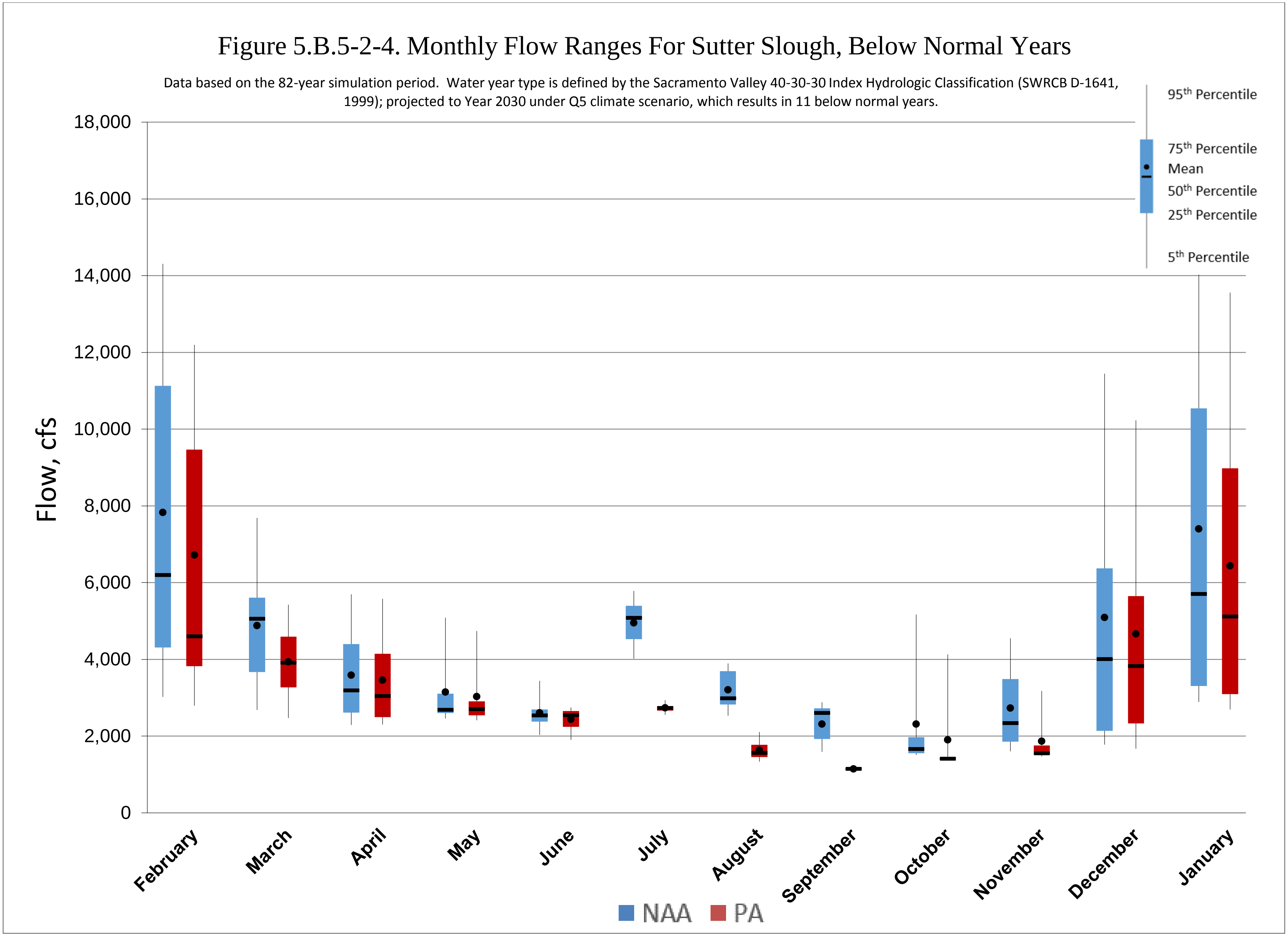
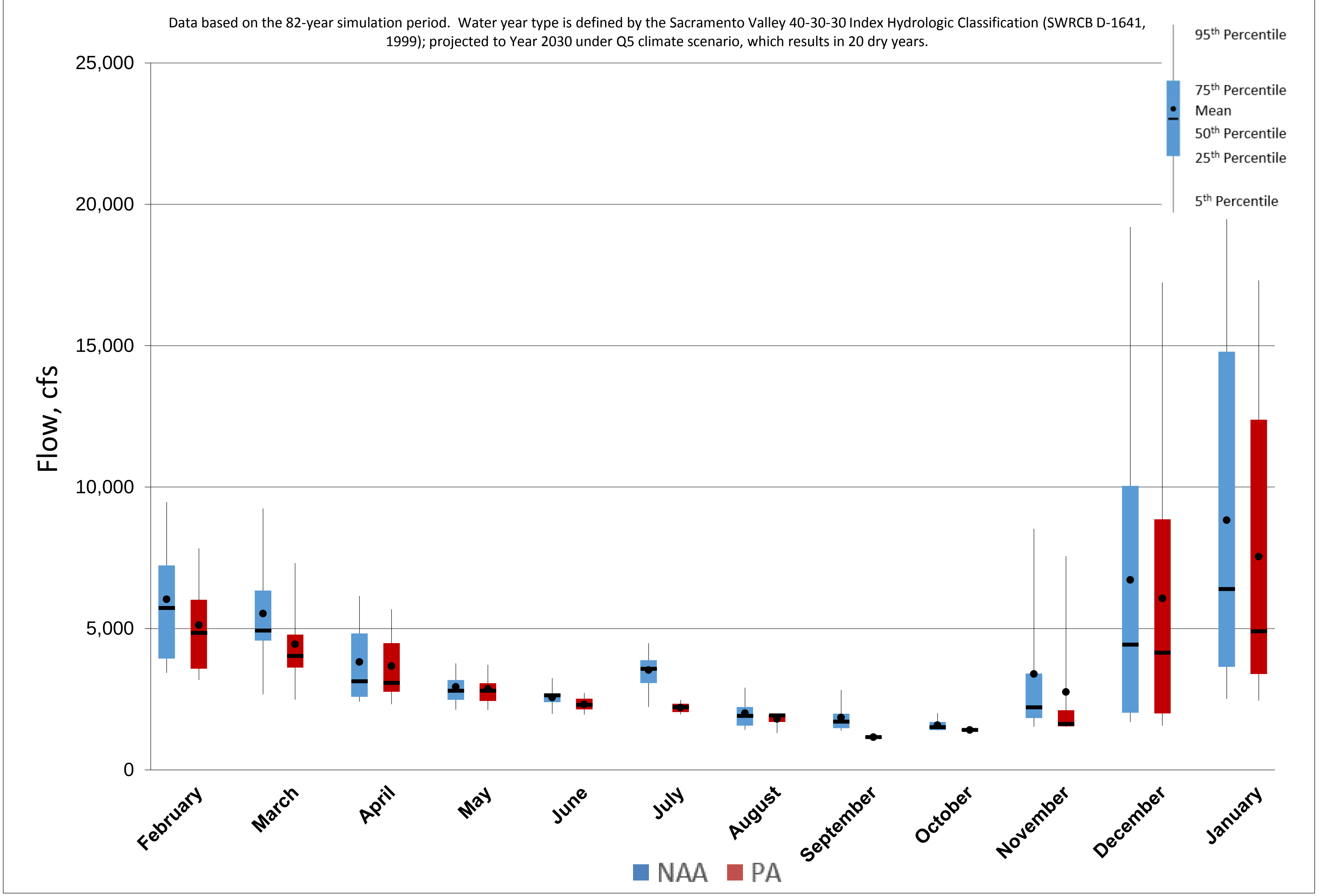


Figure 5.B.5-2-4. Monthly Flow Ranges For Sutter Slough, Below Normal Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 11 below normal years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
Flow, cfs
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-2-5. Monthly Flow Ranges For Sutter Slough, Dry Years



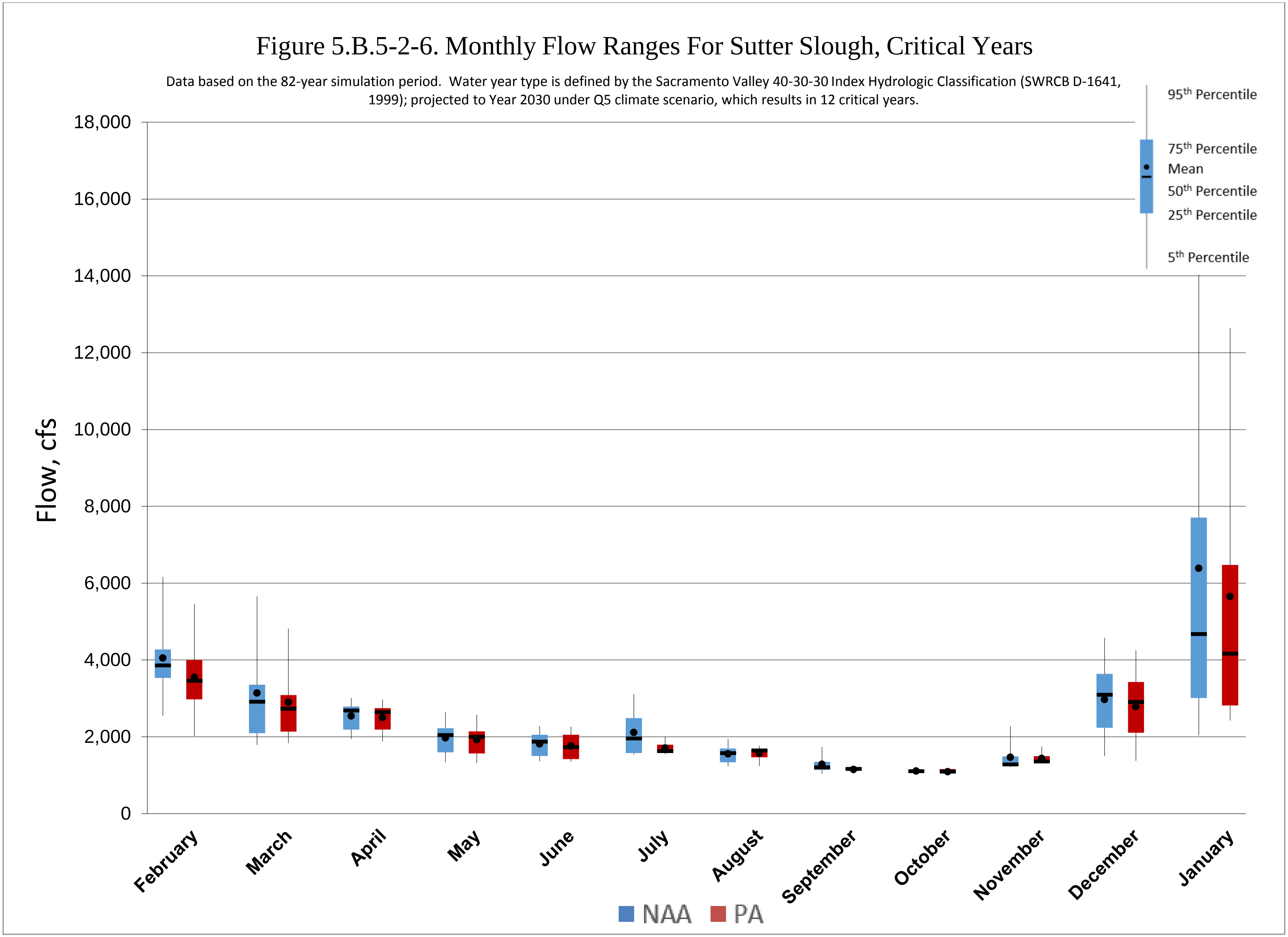
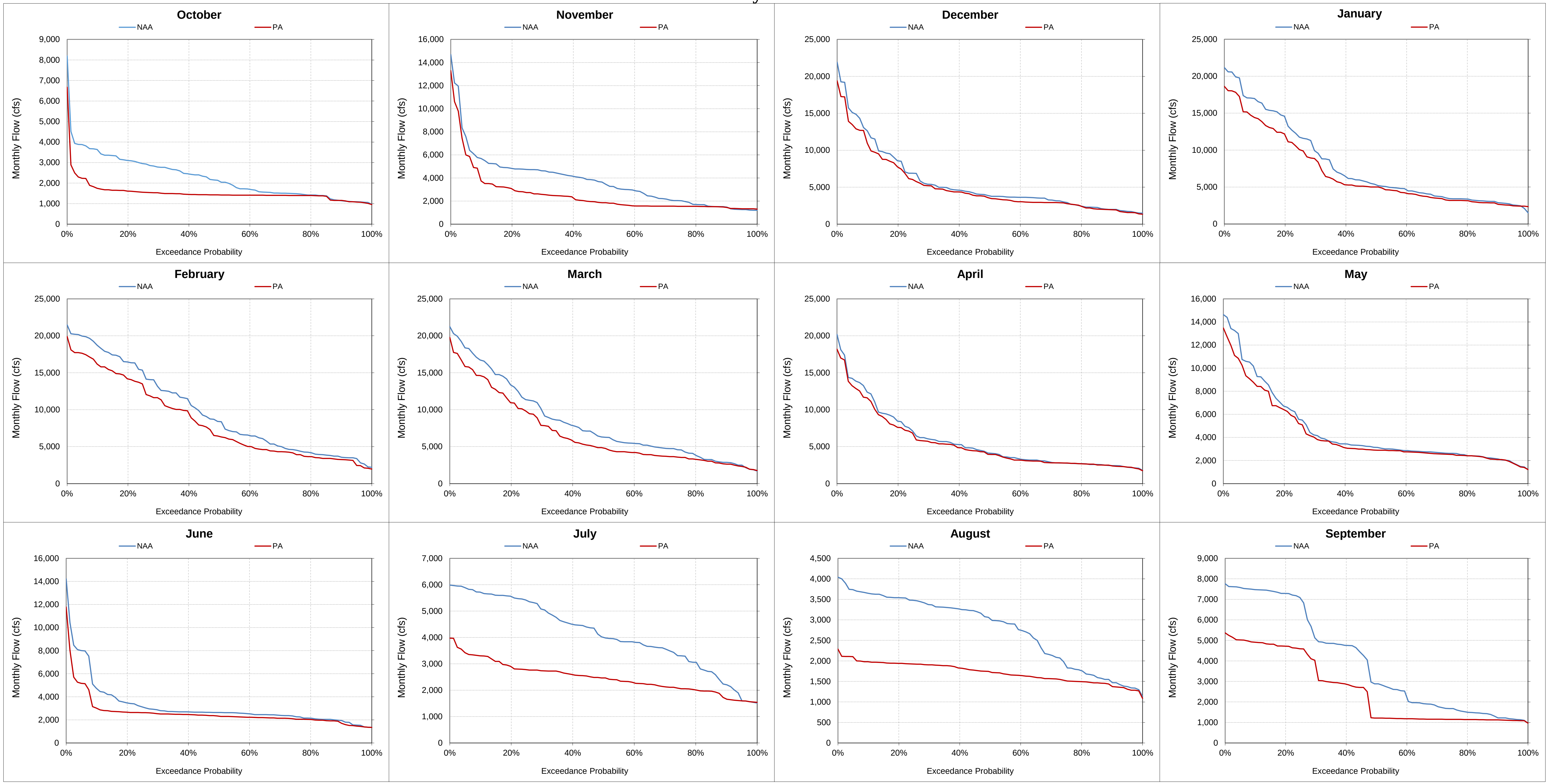


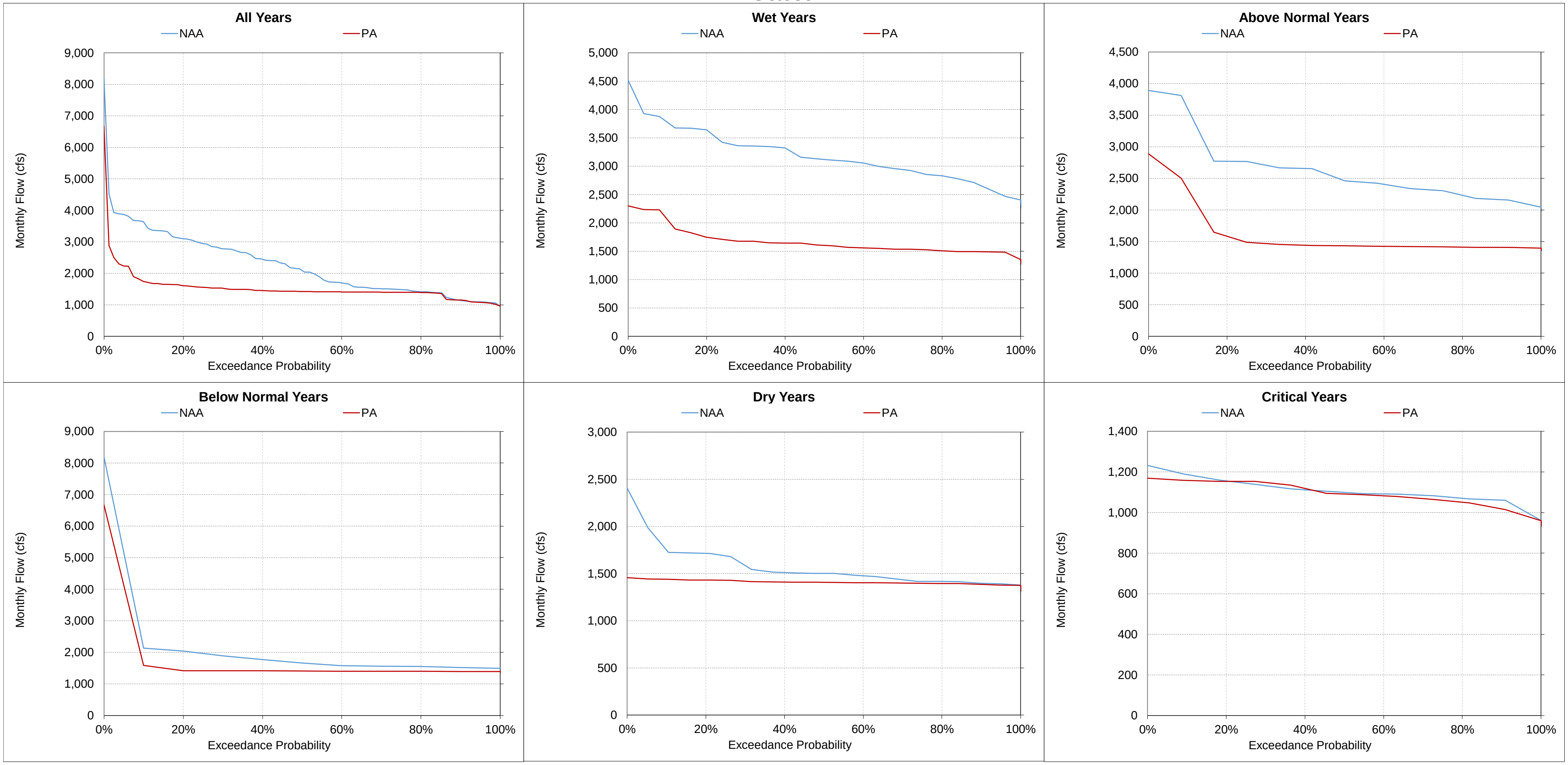
Figure 5.B.5-2-6. Monthly Flow Ranges For Sutter Slough, Critical Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 12 critical years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
Flow, cfs
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-2-7. Sutter Slough, Monthly Flow Probability of Exceedance



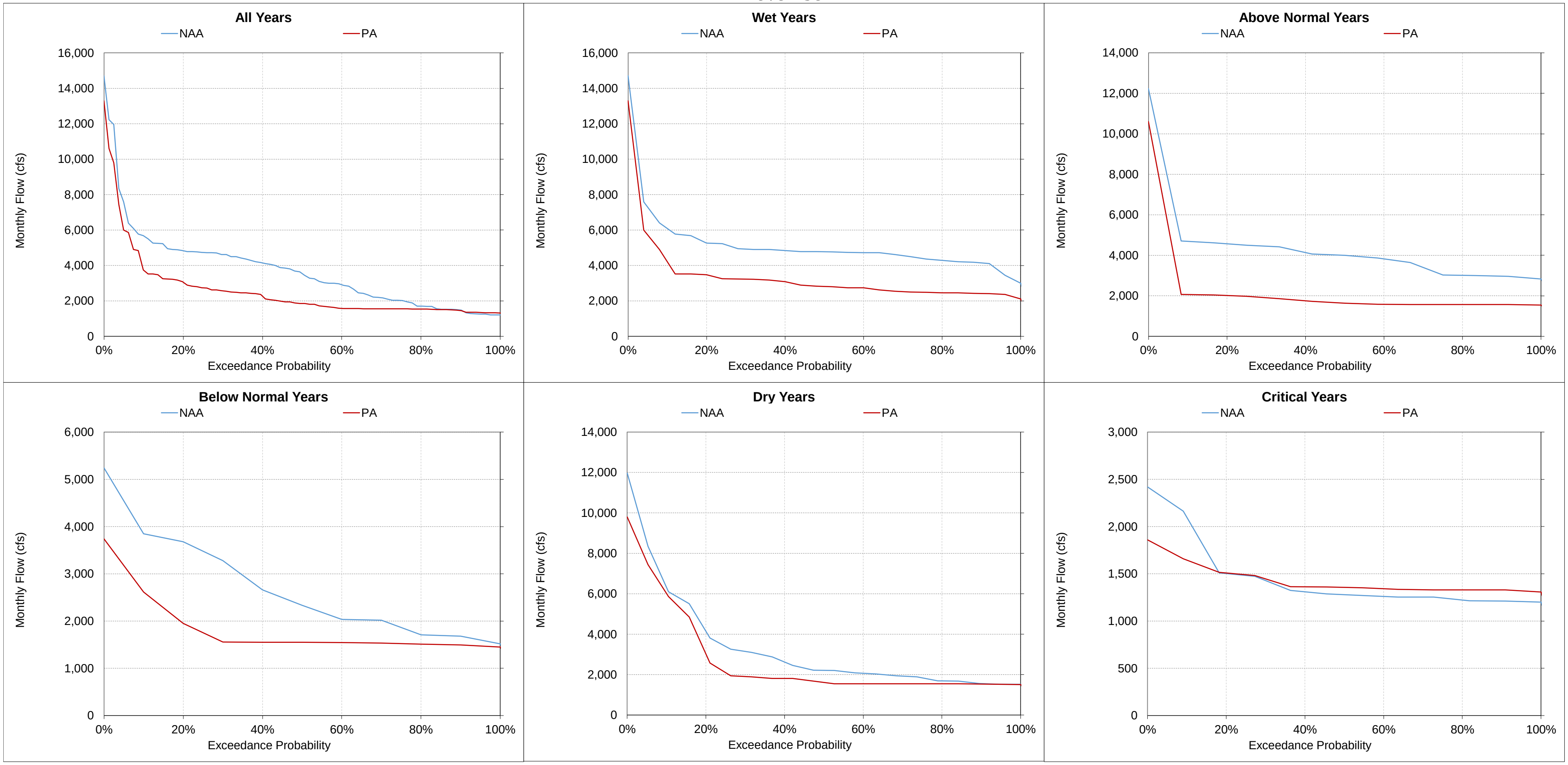
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-2-8. Sutter Slough, Monthly Flow
October



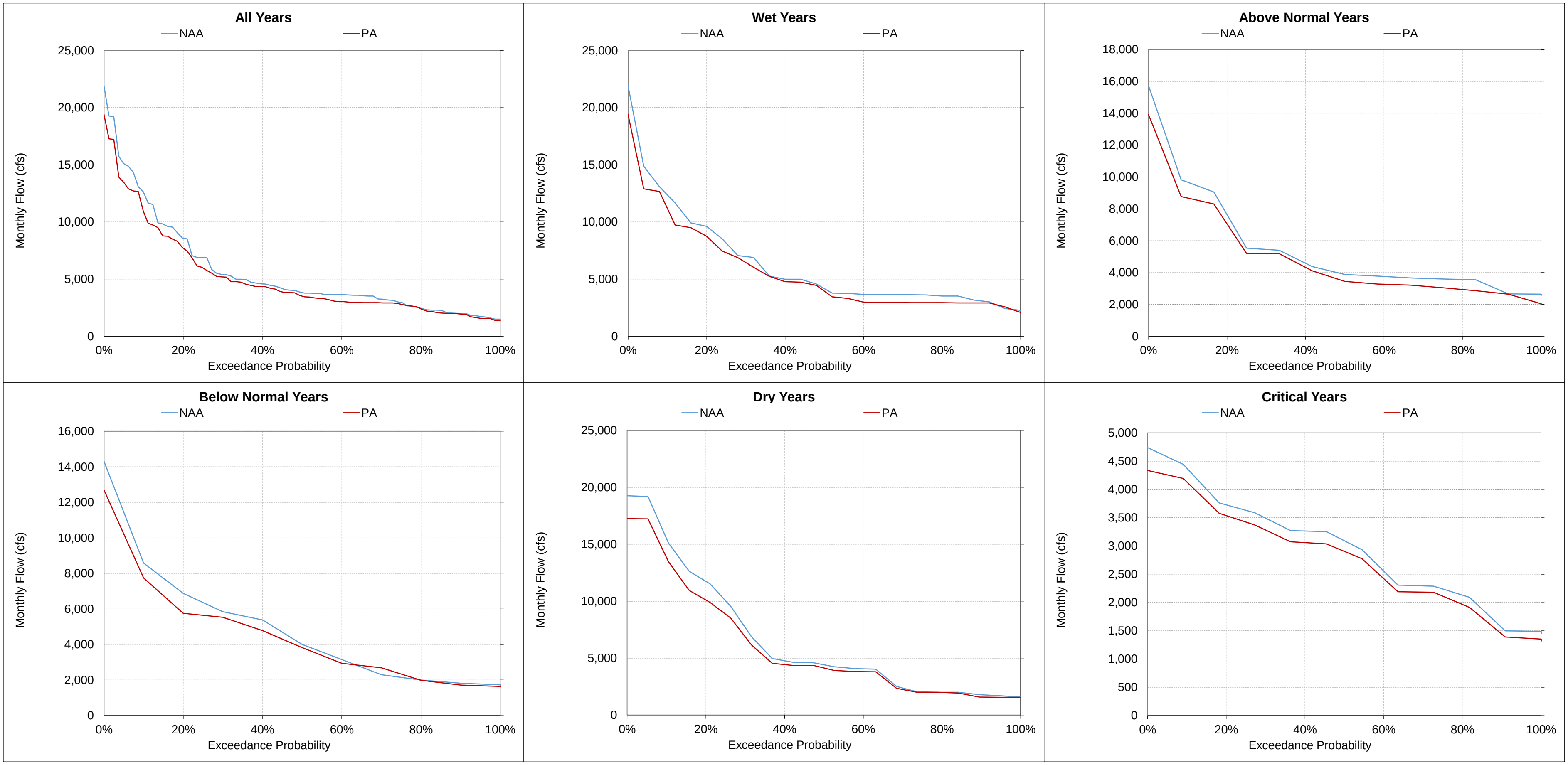
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-2-9. Sutter Slough, Monthly Flow
November



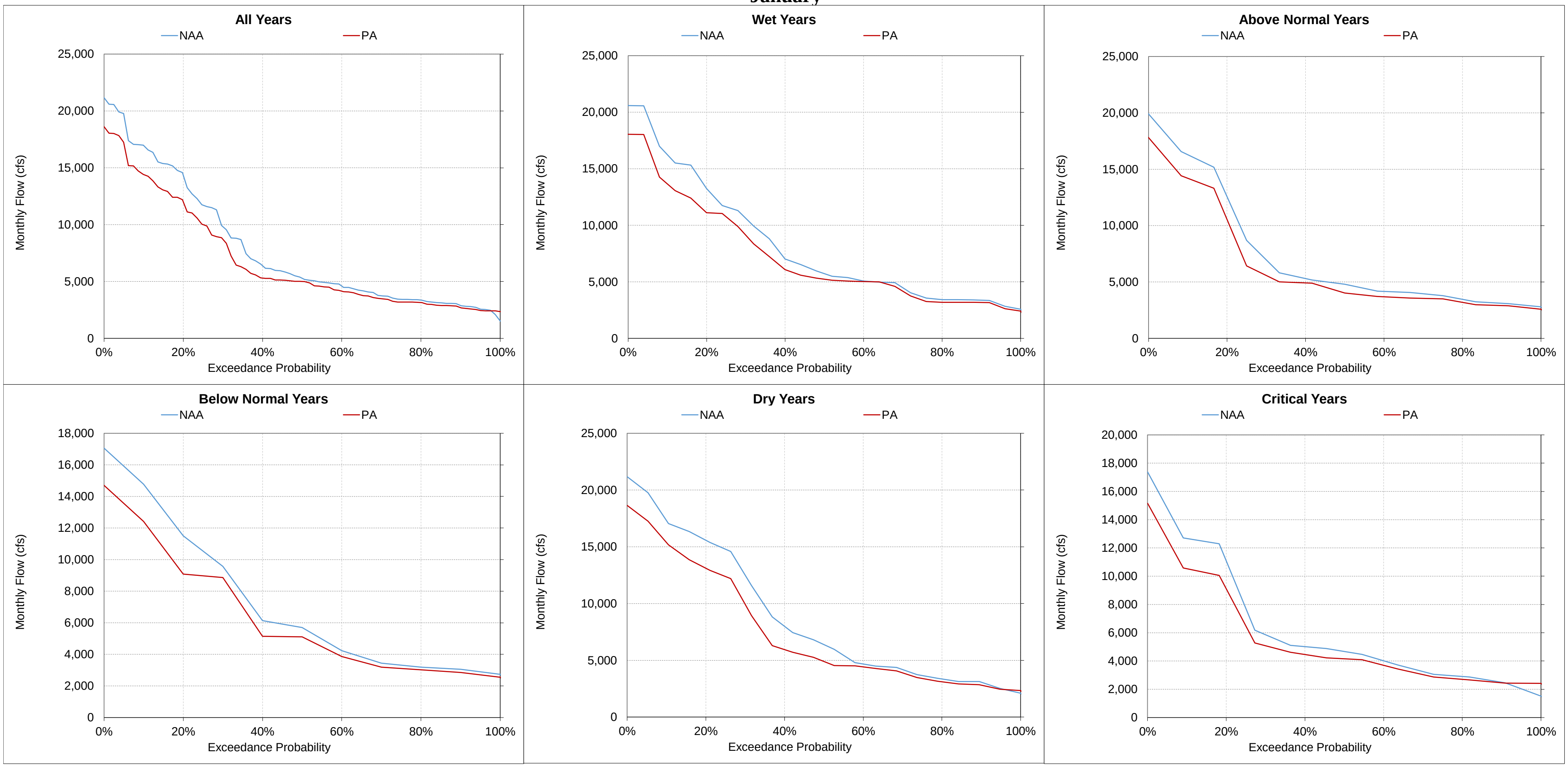
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-2-10. Sutter Slough, Monthly Flow
December



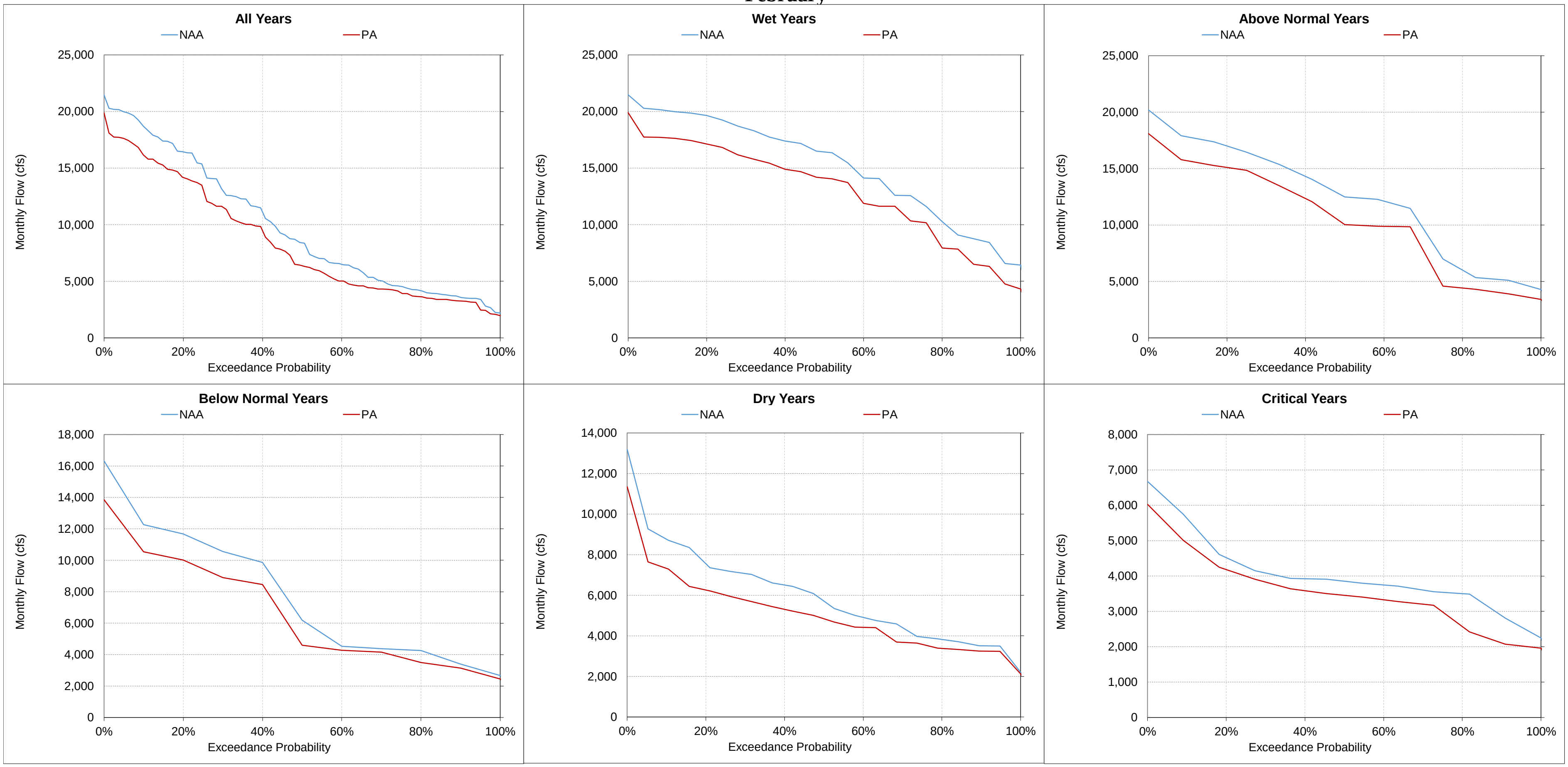
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-2-11. Sutter Slough, Monthly Flow
January



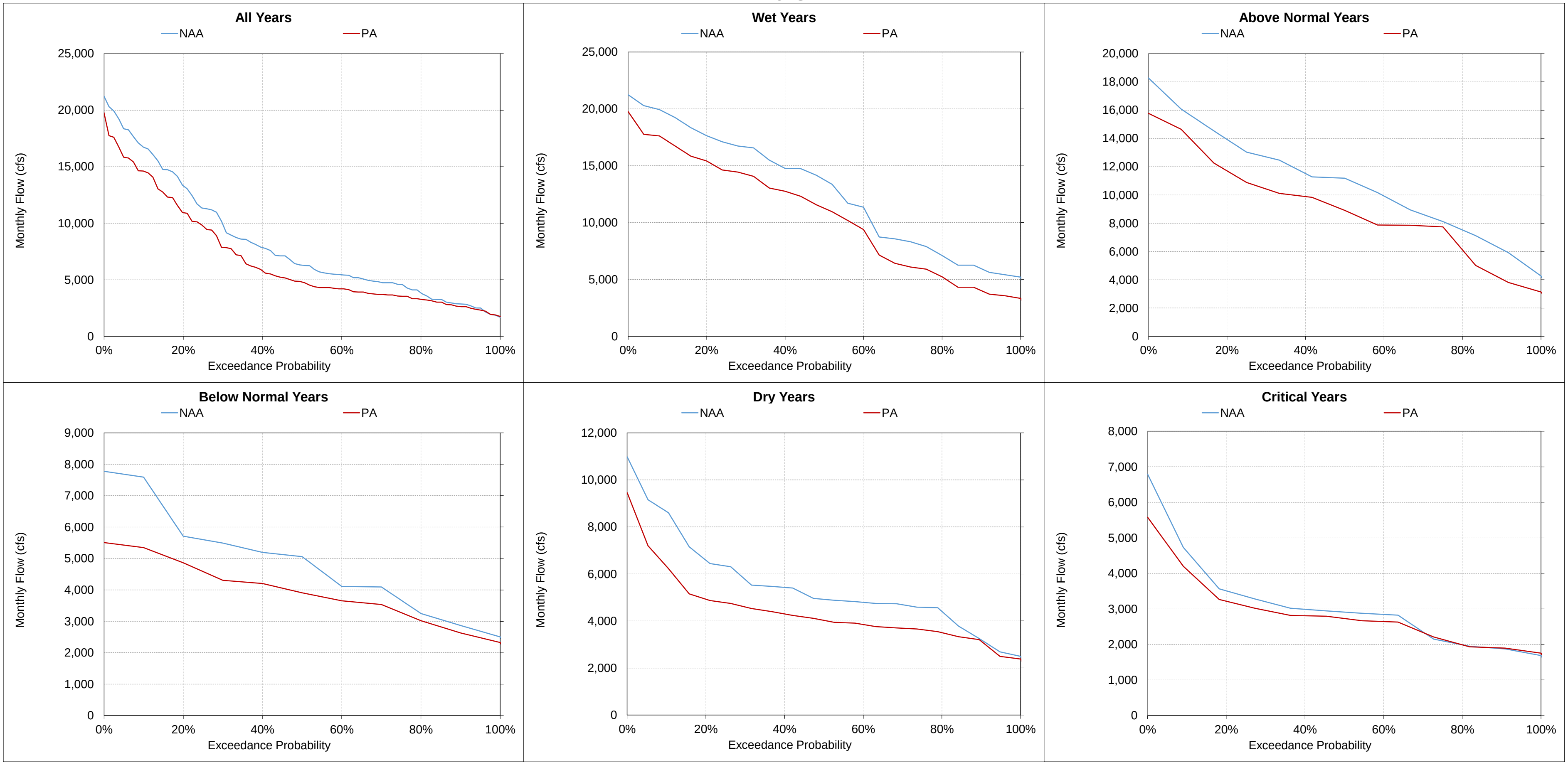
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-2-12. Sutter Slough, Monthly Flow
February



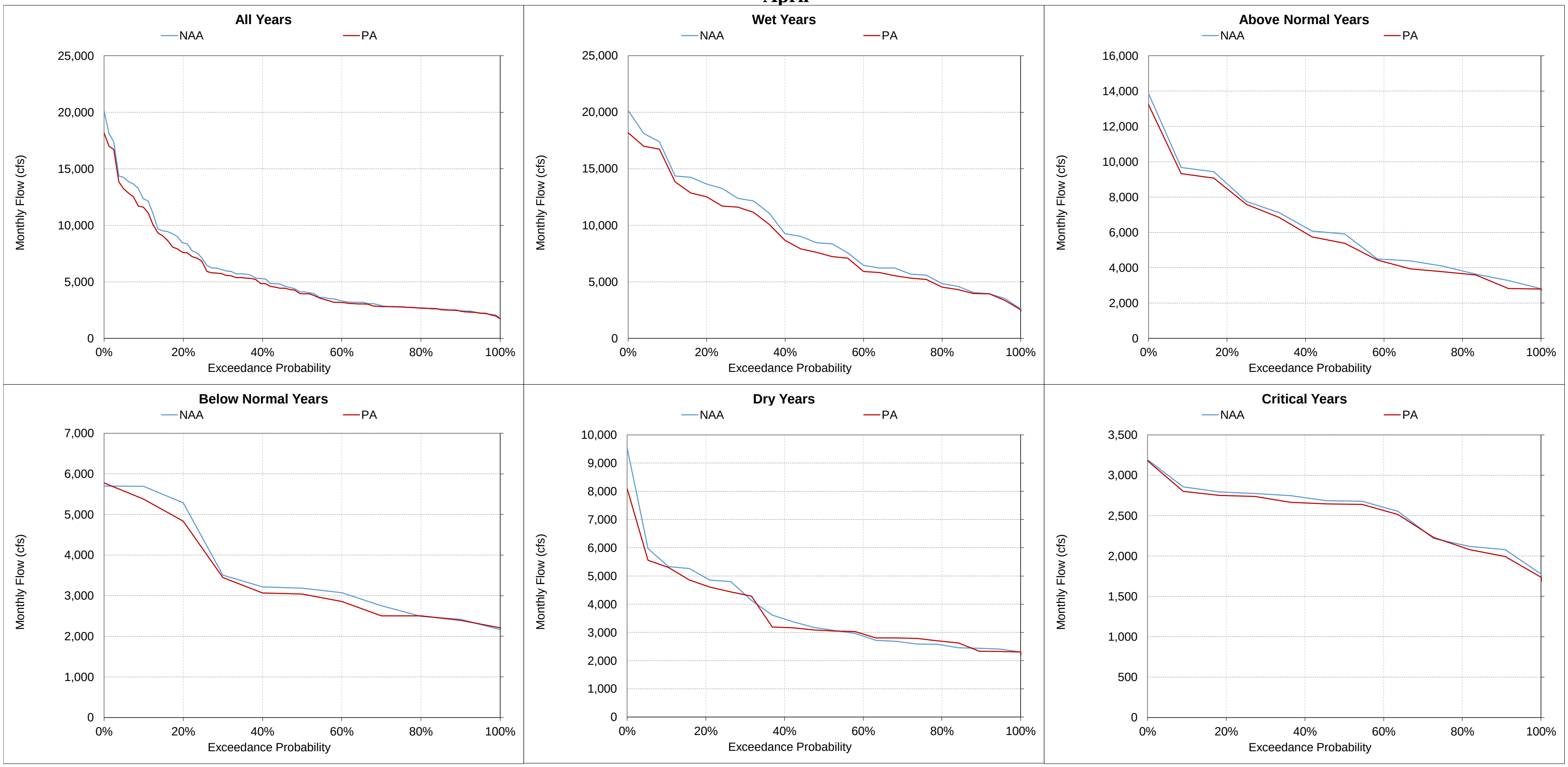
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-2-13. Sutter Slough, Monthly Flow
March



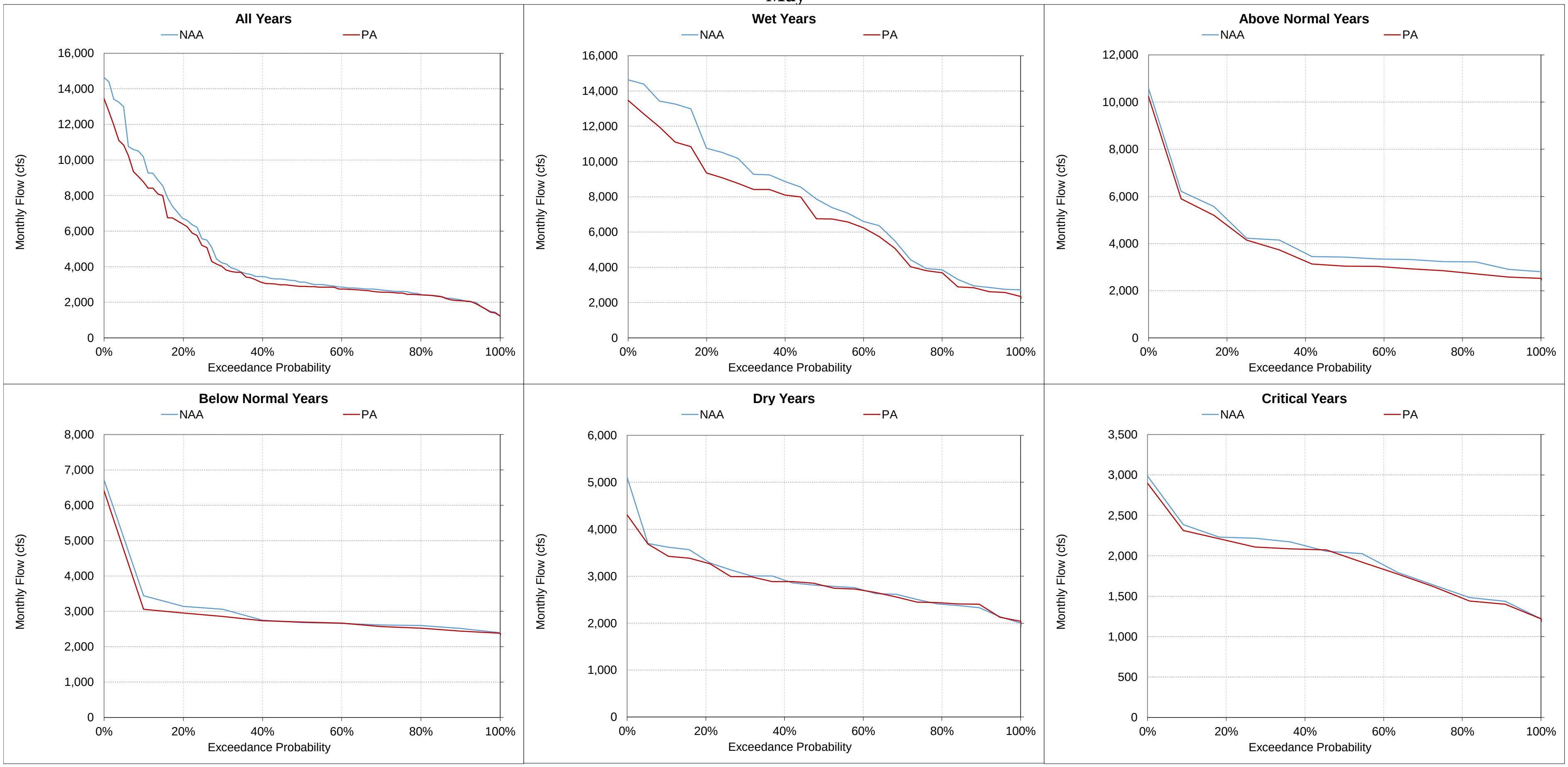
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-2-14. Sutter Slough, Monthly Flow
April



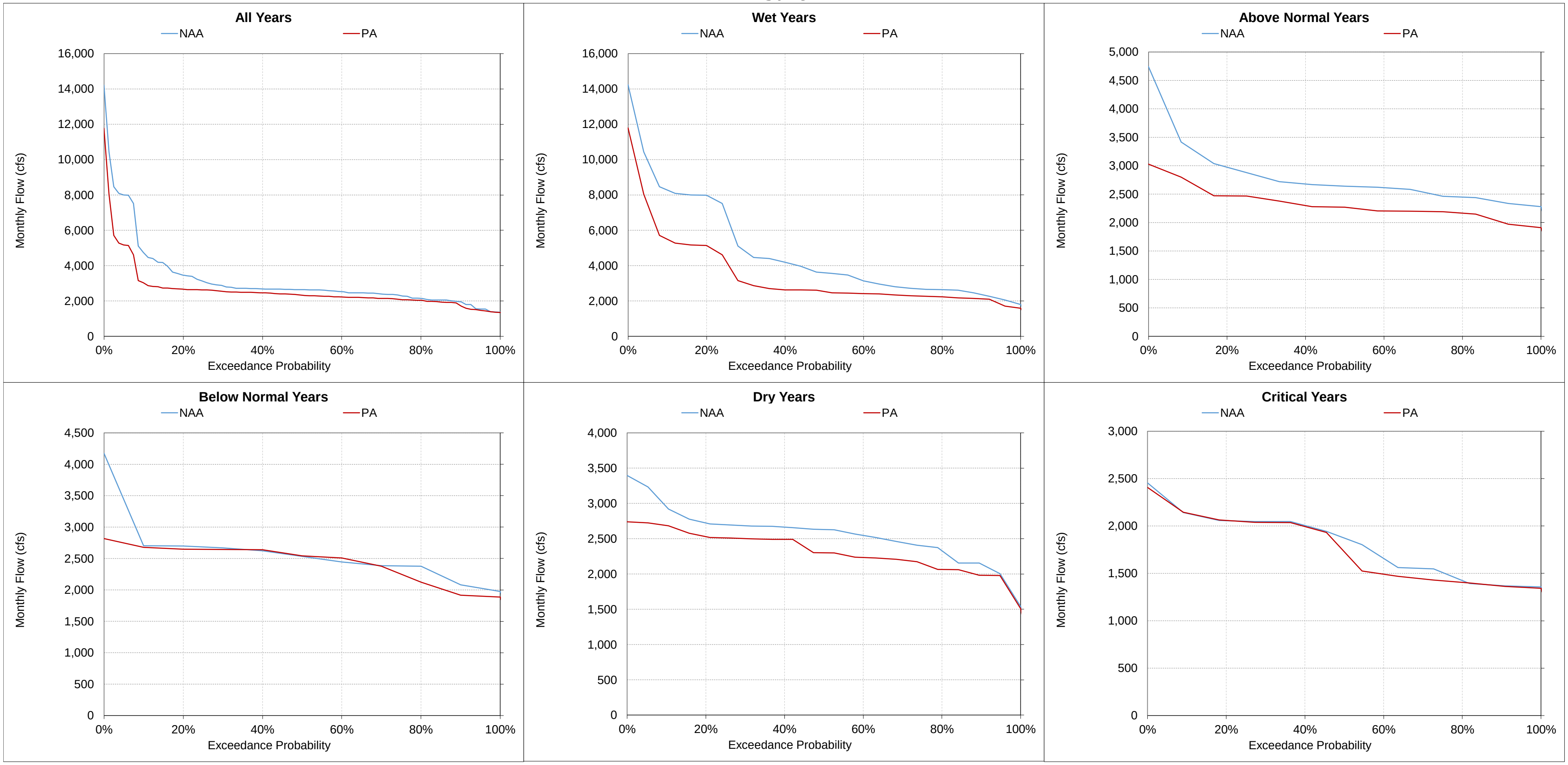
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-2-15. Sutter Slough, Monthly Flow
May



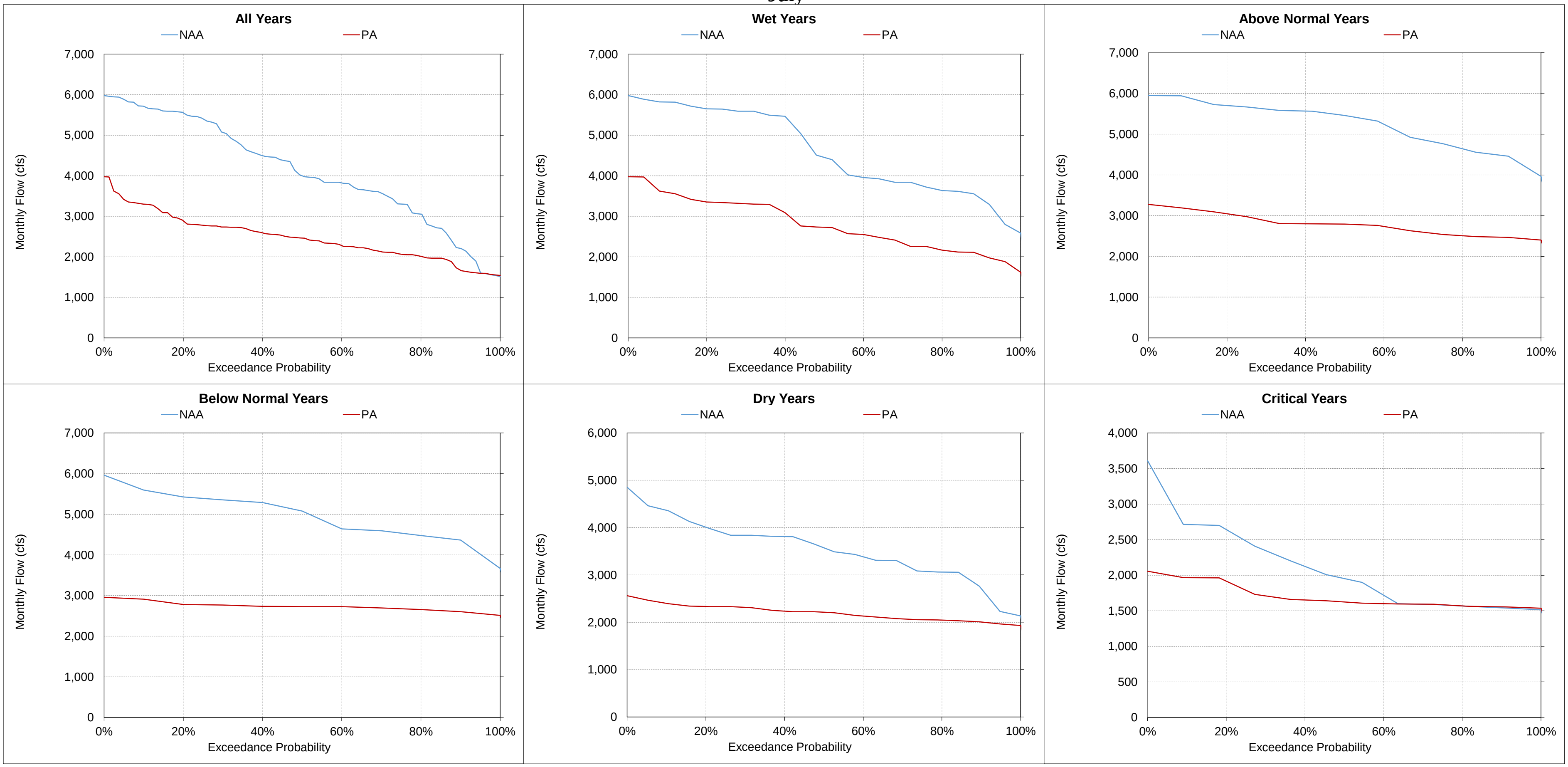
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-2-16. Sutter Slough, Monthly Flow
June



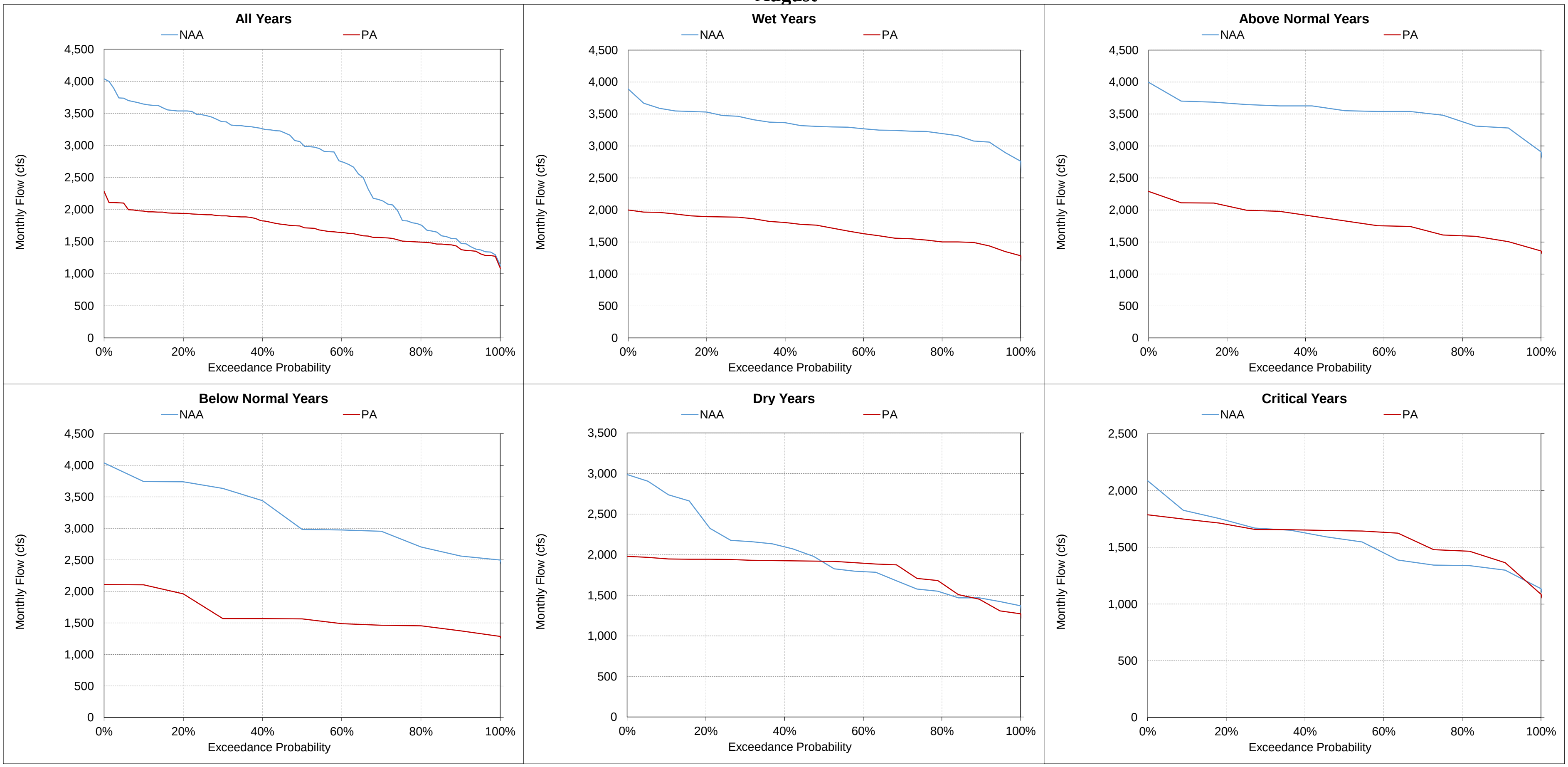
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-2-17. Sutter Slough, Monthly Flow
July



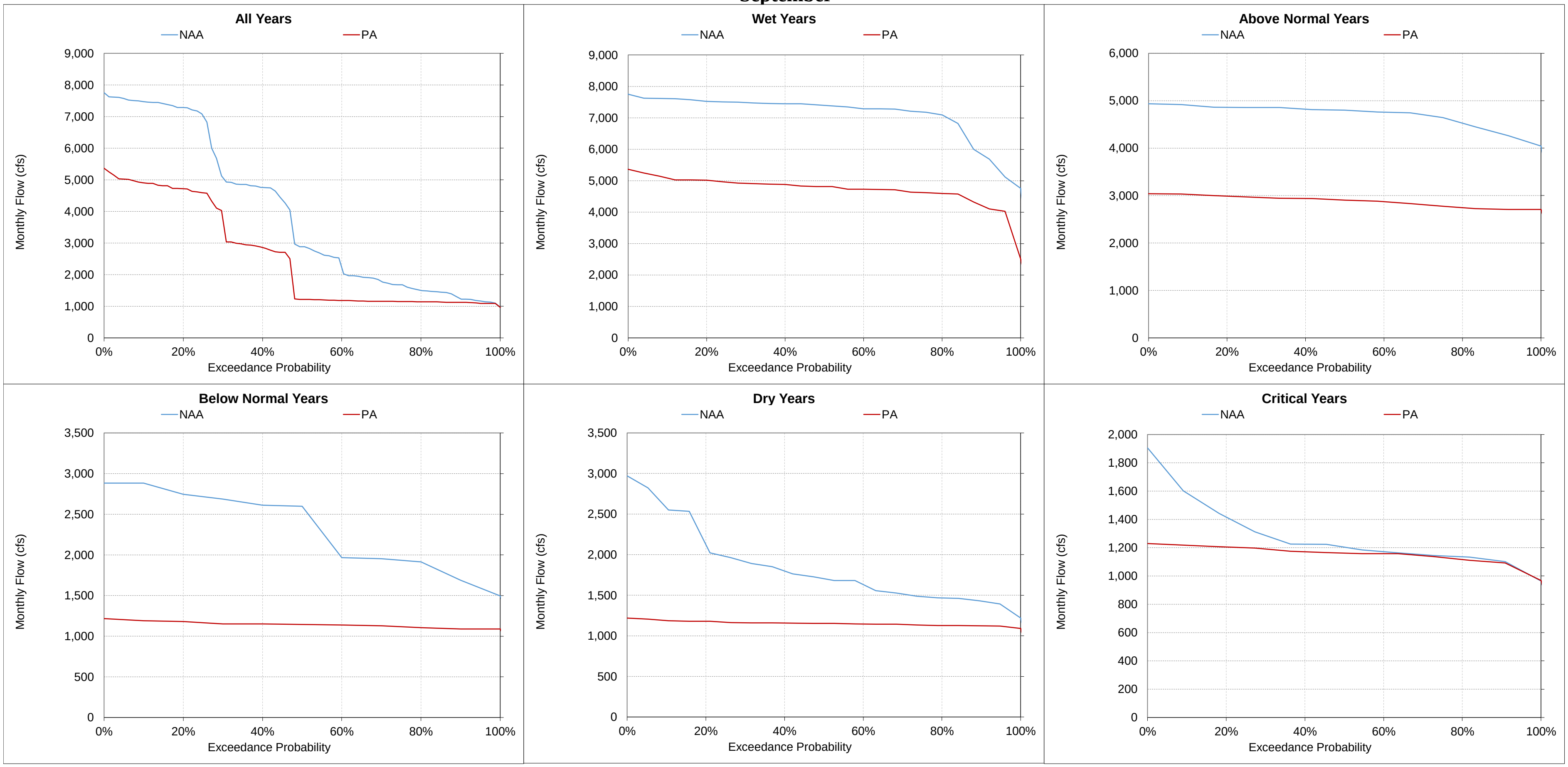
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-2-18. Sutter Slough, Monthly Flow
August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-2-19. Sutter Slough, Monthly Flow
September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-3. Steamboat Slough, Monthly Flow

Statistic	Monthly Flow (cfs)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	2,281	1,072	-1,209	-53%	3,984	2,571	-1,414	-35%	9,975	8,543	-1,433	-14%	13,596	11,478	-2,118	-16%	15,200	12,971	-2,229	-15%	13,477	11,476	-2,001	-15%
20%	1,946	994	-951	-49%	3,237	2,003	-1,234	-38%	6,387	5,715	-672	-11%	11,276	9,294	-1,982	-18%	13,161	11,112	-2,049	-16%	10,325	8,340	-1,985	-19%
30%	1,731	925	-805	-47%	3,080	1,656	-1,424	-46%	3,731	3,576	-155	-4%	7,549	6,615	-934	-12%	10,274	8,935	-1,339	-13%	7,415	5,809	-1,606	-22%
40%	1,499	870	-629	-42%	2,705	1,410	-1,296	-48%	3,098	2,950	-149	-5%	4,638	3,775	-863	-19%	8,569	7,202	-1,367	-16%	5,740	4,111	-1,630	-28%
50%	1,269	856	-413	-33%	2,222	1,148	-1,075	-48%	2,533	2,320	-213	-8%	3,750	3,473	-277	-7%	6,309	4,676	-1,633	-26%	4,510	3,307	-1,202	-27%
60%	1,015	845	-170	-17%	1,831	964	-866	-47%	2,318	1,944	-374	-16%	3,167	2,806	-361	-11%	4,704	3,501	-1,204	-26%	3,772	2,820	-951	-25%
70%	896	840	-55	-6%	1,346	936	-410	-30%	2,121	1,814	-306	-14%	2,504	2,319	-185	-7%	3,466	2,936	-531	-15%	3,287	2,406	-881	-27%
80%	845	826	-20	-2%	1,023	929	-95	-9%	1,520	1,514	-5	0%	2,187	2,034	-153	-7%	2,733	2,400	-333	-12%	2,498	2,108	-390	-16%
90%	657	664	6	1%	867	871	3	0%	1,222	1,182	-40	-3%	1,841	1,702	-139	-8%	2,308	2,097	-211	-9%	1,776	1,647	-128	-7%
Long Term Full Simulation Period[b]	1,423	949	-474	-33%	2,534	1,718	-816	-32%	4,126	3,698	-429	-10%	6,014	5,167	-846	-14%	7,627	6,438	-1,189	-16%	6,208	5,068	-1,140	-18%
Water Year Types[c]																								
Wet (32%)	2,015	1,031	-984	-49%	3,586	2,297	-1,289	-36%	4,688	4,188	-501	-11%	6,333	5,503	-830	-13%	12,117	10,258	-1,859	-15%	10,040	8,235	-1,805	-18%
Above Normal (16%)	1,635	999	-637	-39%	2,998	1,600	-1,397	-47%	4,035	3,580	-455	-11%	5,650	4,882	-768	-14%	9,662	8,110	-1,552	-16%	8,343	6,846	-1,497	-18%
Below Normal (13%)	1,506	1,237	-269	-18%	1,744	1,167	-577	-33%	3,646	3,300	-345	-9%	5,607	4,813	-794	-14%	5,891	4,968	-923	-16%	3,359	2,629	-730	-22%
Dry (24%)	942	843	-99	-11%	2,297	1,862	-435	-19%	5,038	4,498	-540	-11%	6,787	5,705	-1,083	-16%	4,355	3,627	-728	-17%	3,896	3,047	-849	-22%
Critical (15%)	636	631	-5	-1%	871	854	-16	-2%	1,930	1,795	-134	-7%	4,800	4,179	-621	-13%	2,740	2,382	-358	-13%	2,055	1,883	-172	-8%

Statistic	Monthly Flow (cfs)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	9,602	8,888	-715	-7%	7,530	6,486	-1,043	-14%	3,189	1,893	-1,296	-41%	3,878	2,004	-1,874	-48%	2,260	1,194	-1,066	-47%	5,390	3,235	-2,155	-40%
20%	6,254	5,522	-732	-12%	4,774	4,518	-256	-5%	2,153	1,619	-533	-25%	3,724	1,763	-1,962	-53%	2,165	1,168	-997	-46%	5,241	3,067	-2,174	-41%
30%	4,254	3,967	-288	-7%	2,857	2,593	-264	-9%	1,736	1,529	-206	-12%	3,313	1,670	-1,643	-50%	2,083	1,153	-929	-45%	3,334	2,312	-1,023	-31%
40%	3,617	3,295	-322	-9%	2,191	1,972	-219	-10%	1,643	1,482	-162	-10%	2,856	1,582	-1,275	-45%	1,994	1,100	-895	-45%	3,084	1,747	-1,337	-43%
50%	2,681	2,575	-106	-4%	2,011	1,832	-178	-9%	1,618	1,404	-214	-13%	2,492	1,493	-999	-40%	1,852	1,046	-806	-44%	1,758	712	-1,045	-59%
60%	2,149	2,043	-106	-5%	1,768	1,714	-53	-3%	1,541	1,346	-195	-13%	2,366	1,382	-984	-42%	1,689	983	-705	-42%	1,358	687	-671	-49%
70%	1,803	1,778	-25	-1%	1,668	1,591	-77	-5%	1,450	1,303	-147	-10%	2,221	1,308	-913	-41%	1,288	937	-351	-27%	1,077	679	-398	-37%
80%	1,664	1,658	-6	0%	1,492	1,493	1	0%	1,298	1,218	-80	-6%	1,867	1,216	-651	-35%	1,056	897	-158	-15%	895	669	-226	-25%
90%	1,513	1,505	-8	-1%	1,303	1,274	-29	-2%	1,171	1,030	-141	-12%	1,319	983	-336	-25%	877	825	-52	-6%	720	656	-64	-9%
Long Term Full Simulation Period[b]	4,133	3,860	-273	-7%	3,186	2,905	-281	-9%	2,087	1,646	-441	-21%	2,652	1,505	-1,147	-43%	1,687	1,033	-654	-39%	2,656	1,608	-1,048	-39%
Water Year Types[c]																								
Wet (32%)	7,081	6,484	-597	-8%	5,750	5,074	-675	-12%	3,335	2,316	-1,018	-31%	3,006	1,717	-1,289	-43%	2,044	1,029	-1,015	-50%	5,073	3,080	-1,993	-39%
Above Normal (16%)	4,545	4,300	-245	-5%	2,937	2,689	-248	-8%	1,757	1,413	-344	-20%	3,457	1,692	-1,765	-51%	2,179	1,106	-1,073	-49%	3,010	1,760	-1,250	-42%
Below Normal (13%)	2,347	2,255	-92	-4%	2,019	1,935	-84	-4%	1,593	1,463	-130	-8%	3,236	1,659	-1,577	-49%	1,972	982	-990	-50%	1,407	672	-735	-52%
Dry (24%)	2,548	2,430	-118	-5%	1,849	1,799	-50	-3%	1,558	1,388	-171	-11%	2,179	1,320	-859	-39%	1,209	1,078	-130	-11%	1,114	674	-440	-39%
Critical (15%)	1,577	1,552	-26	-2%	1,202	1,170	-32	-3%	1,077	1,044	-32	-3%	1,266	1,010	-256	-20%	919	933	14	2%	752	670	-82	-11%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

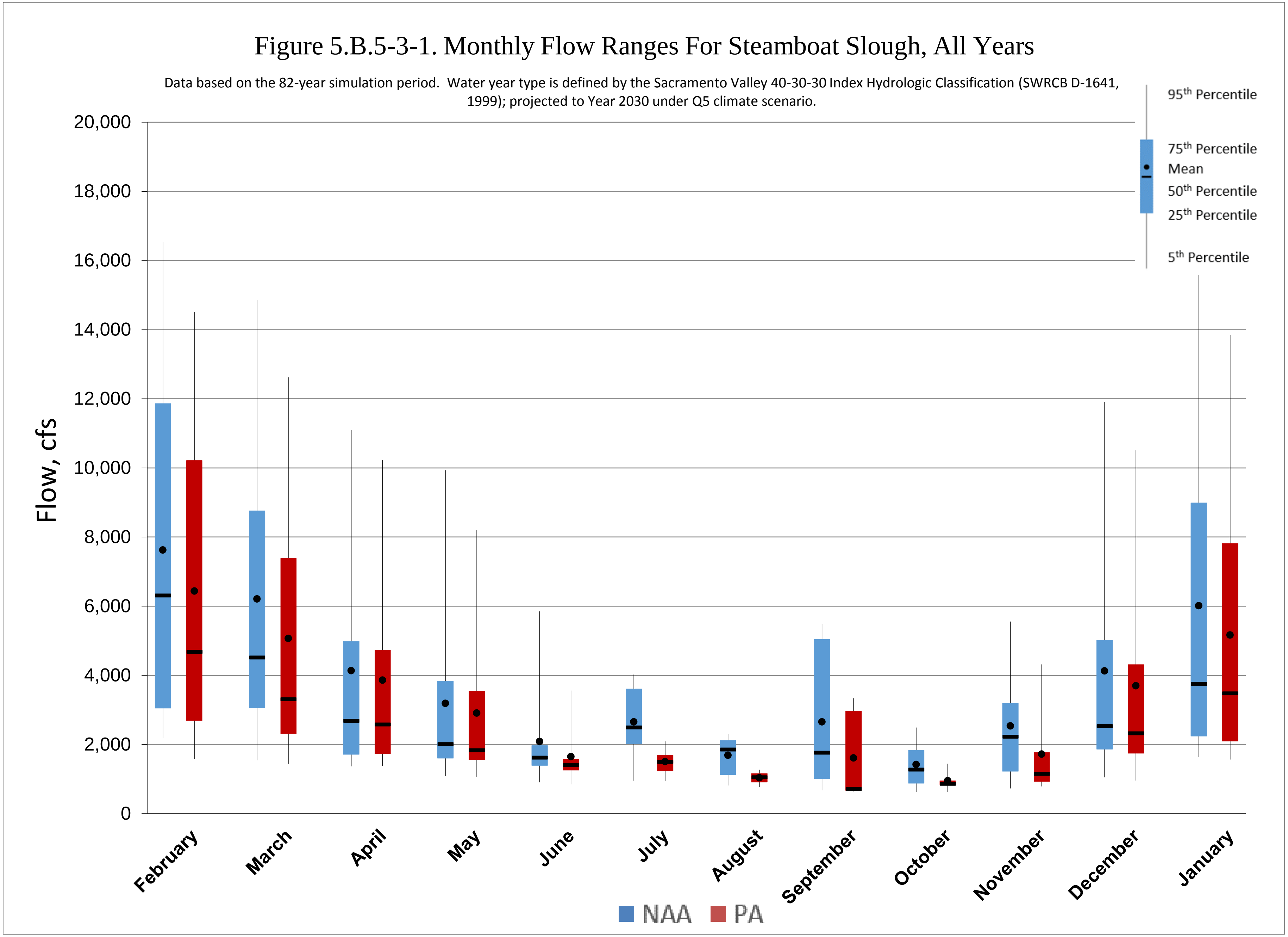


Figure 5.B.5-3-1. Monthly Flow Ranges For Steamboat Slough, All Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
Flow, cfs
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-3-2. Monthly Flow Ranges For Steamboat Slough, Wet Years

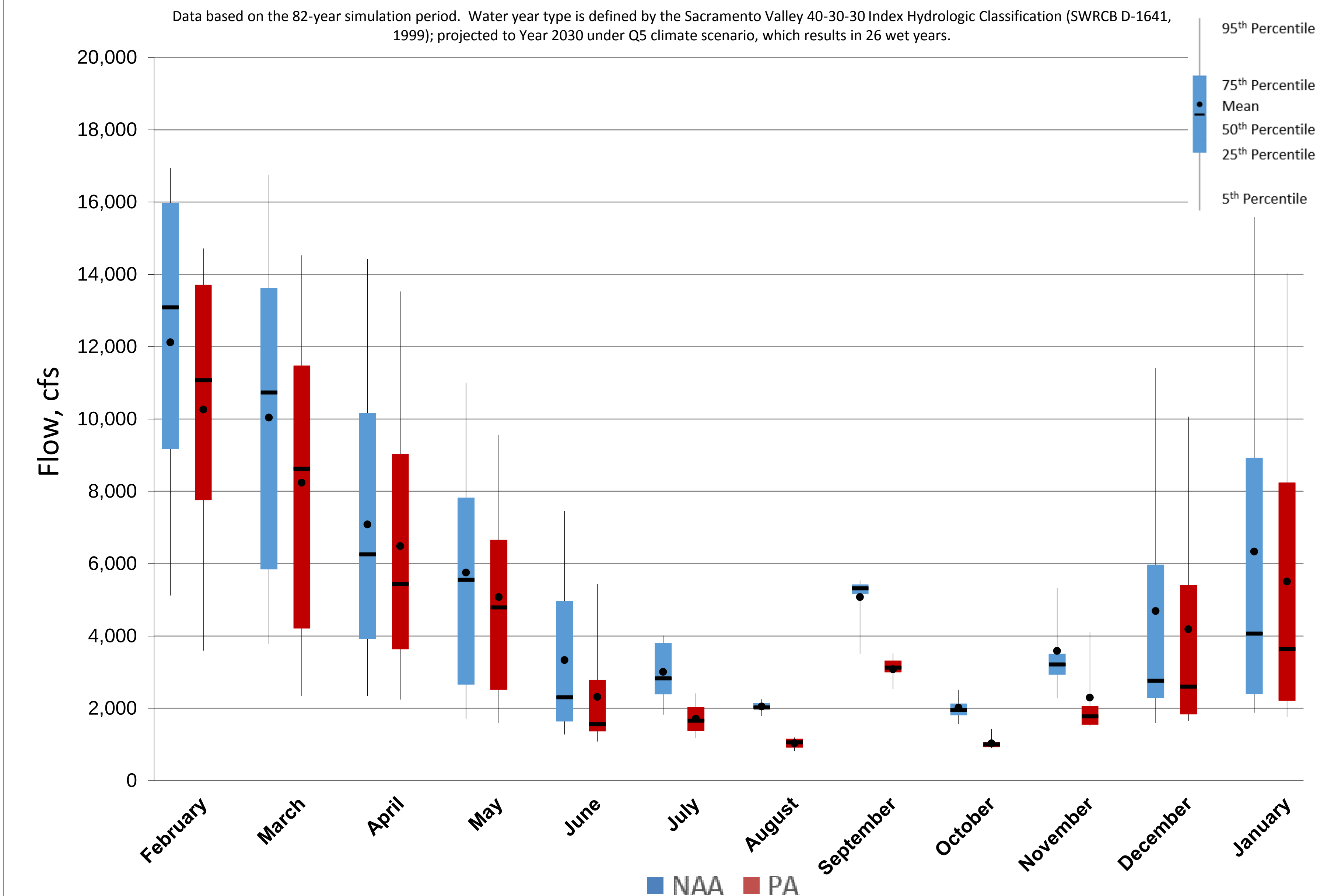
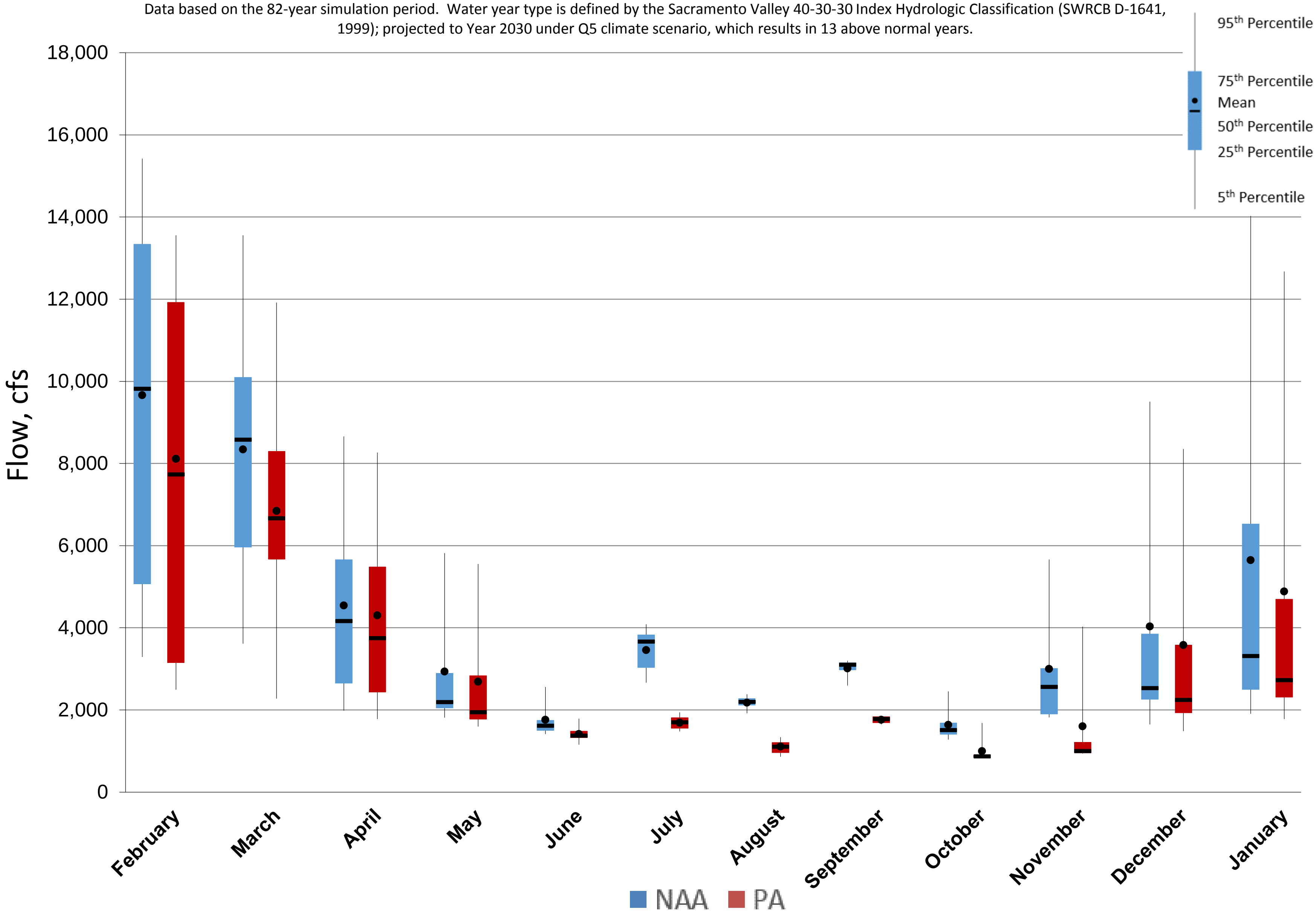


Figure 5.B.5-3-3. Monthly Flow Ranges For Steamboat Slough, Above Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 13 above normal years.



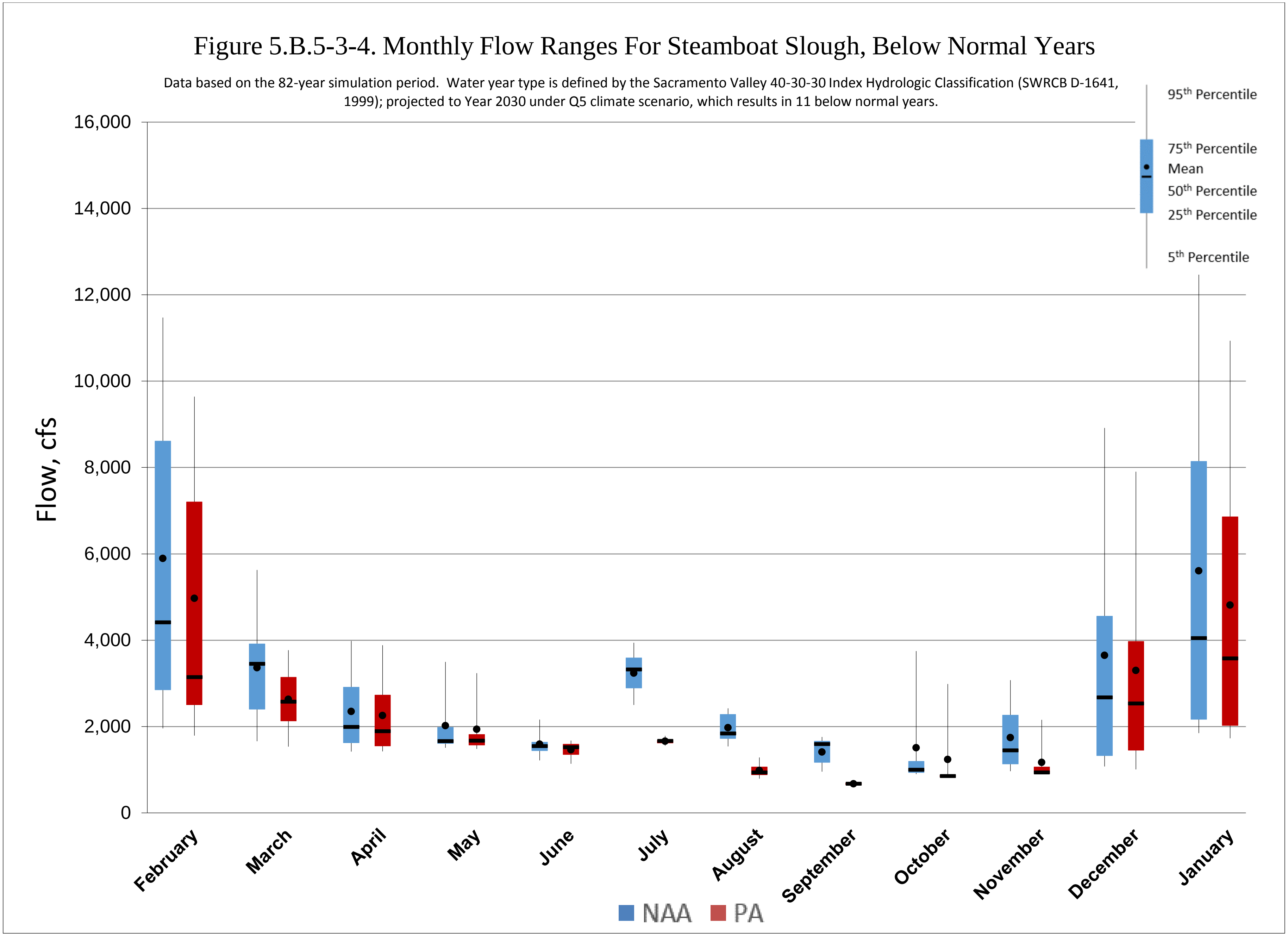


Figure 5.B.5-3-4. Monthly Flow Ranges For Steamboat Slough, Below Normal Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 11 below normal years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
Flow, cfs
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-3-5. Monthly Flow Ranges For Steamboat Slough, Dry Years

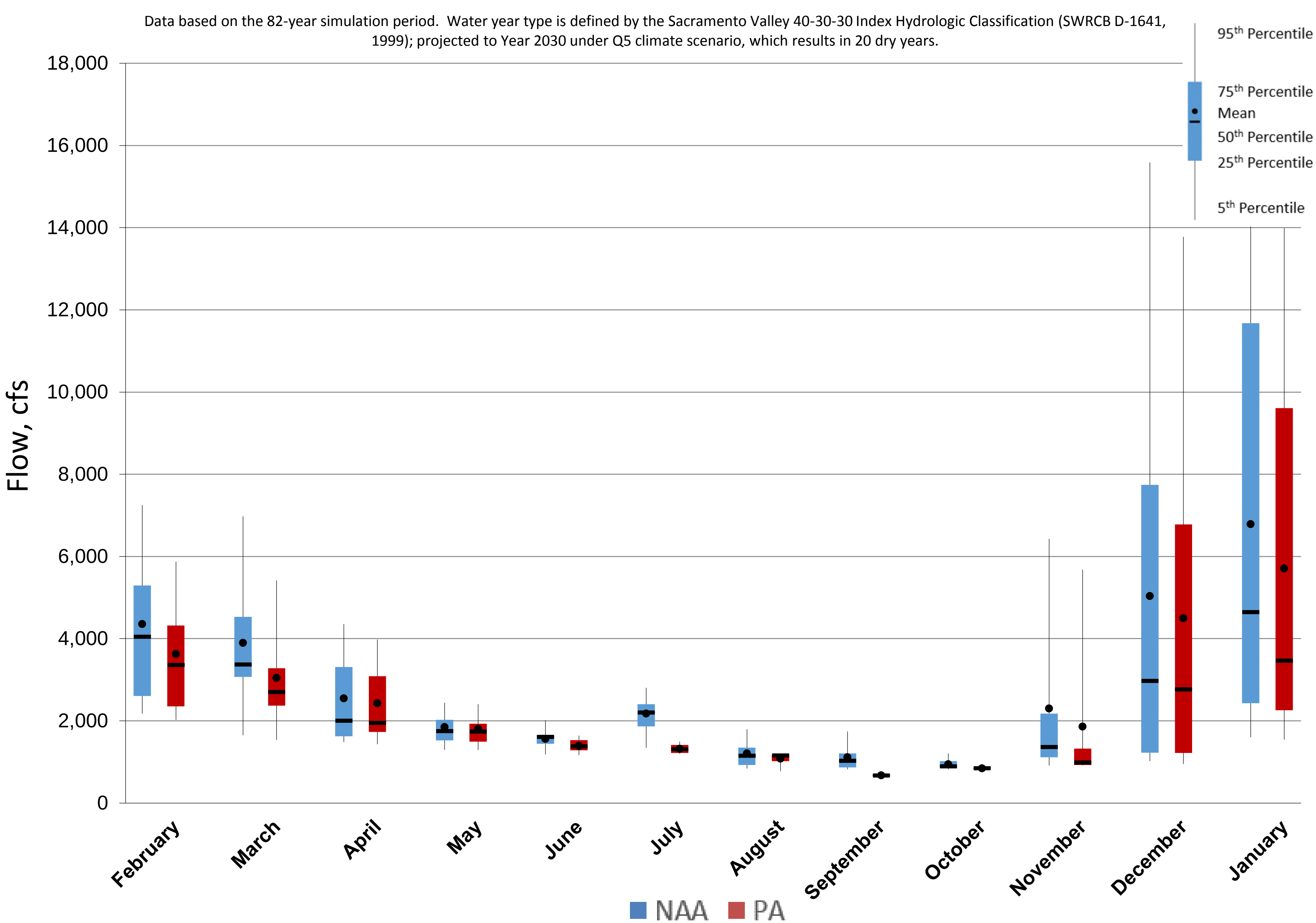


Figure 5.B.5-3-6. Monthly Flow Ranges For Steamboat Slough, Critical Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 12 critical years.

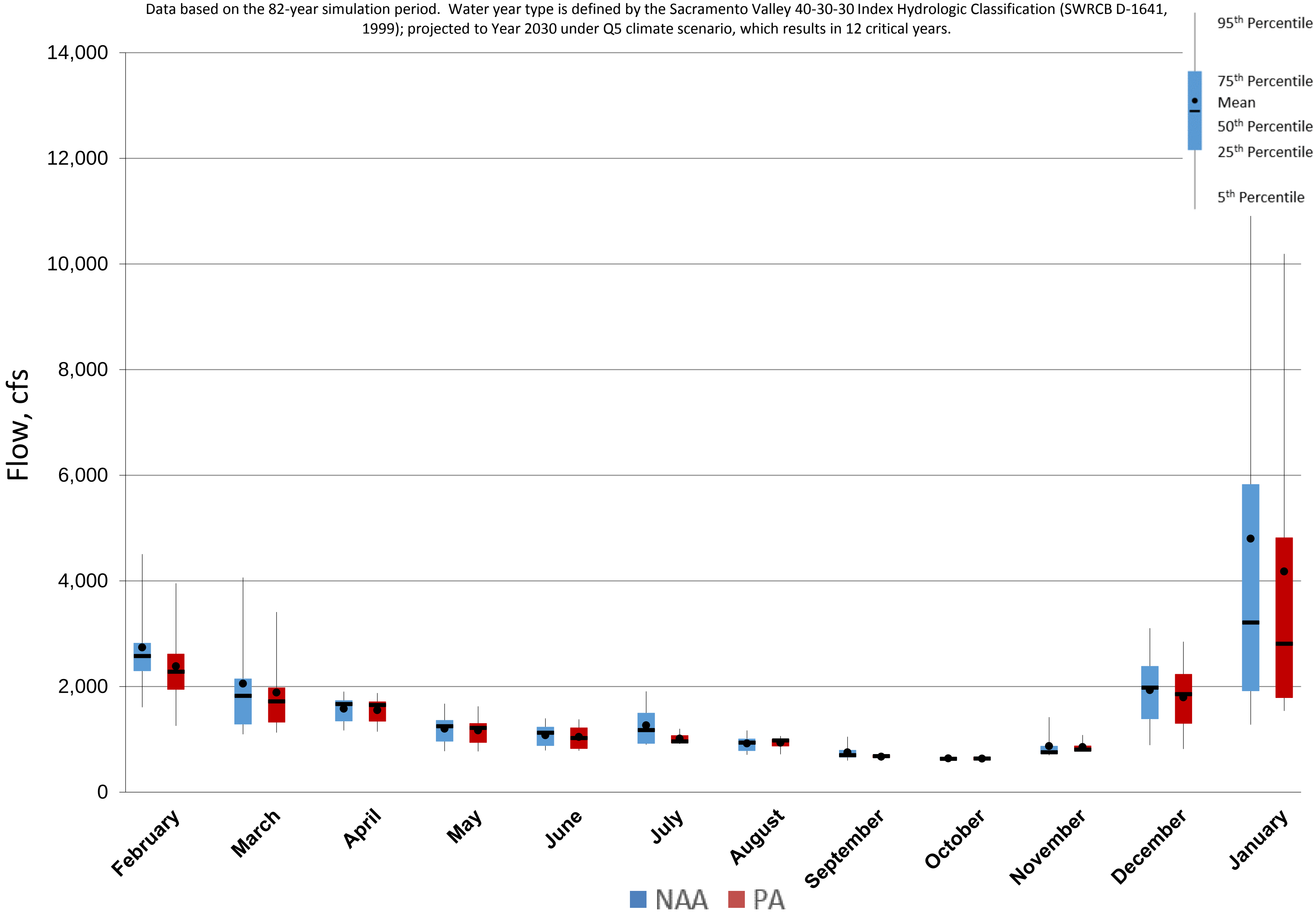
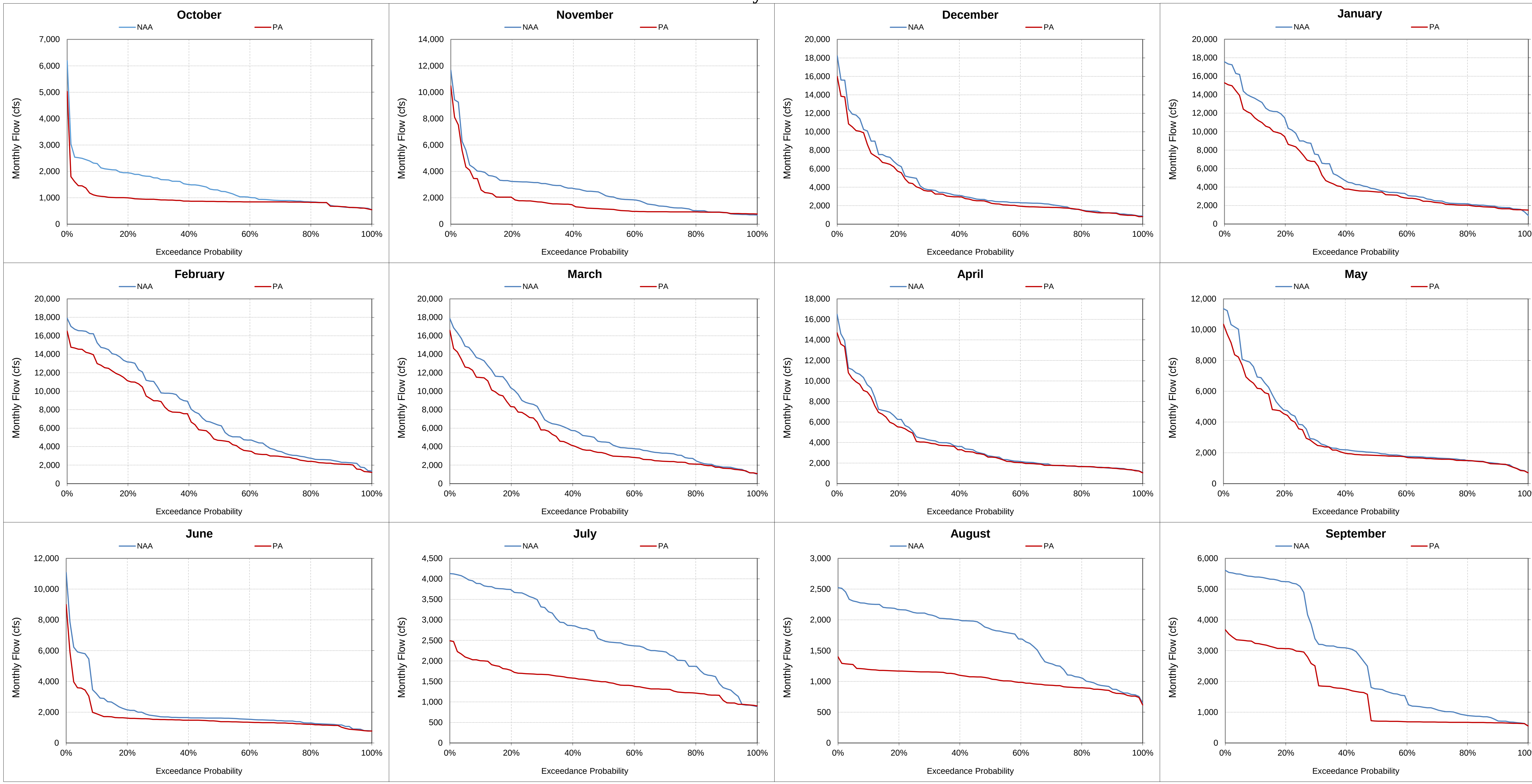
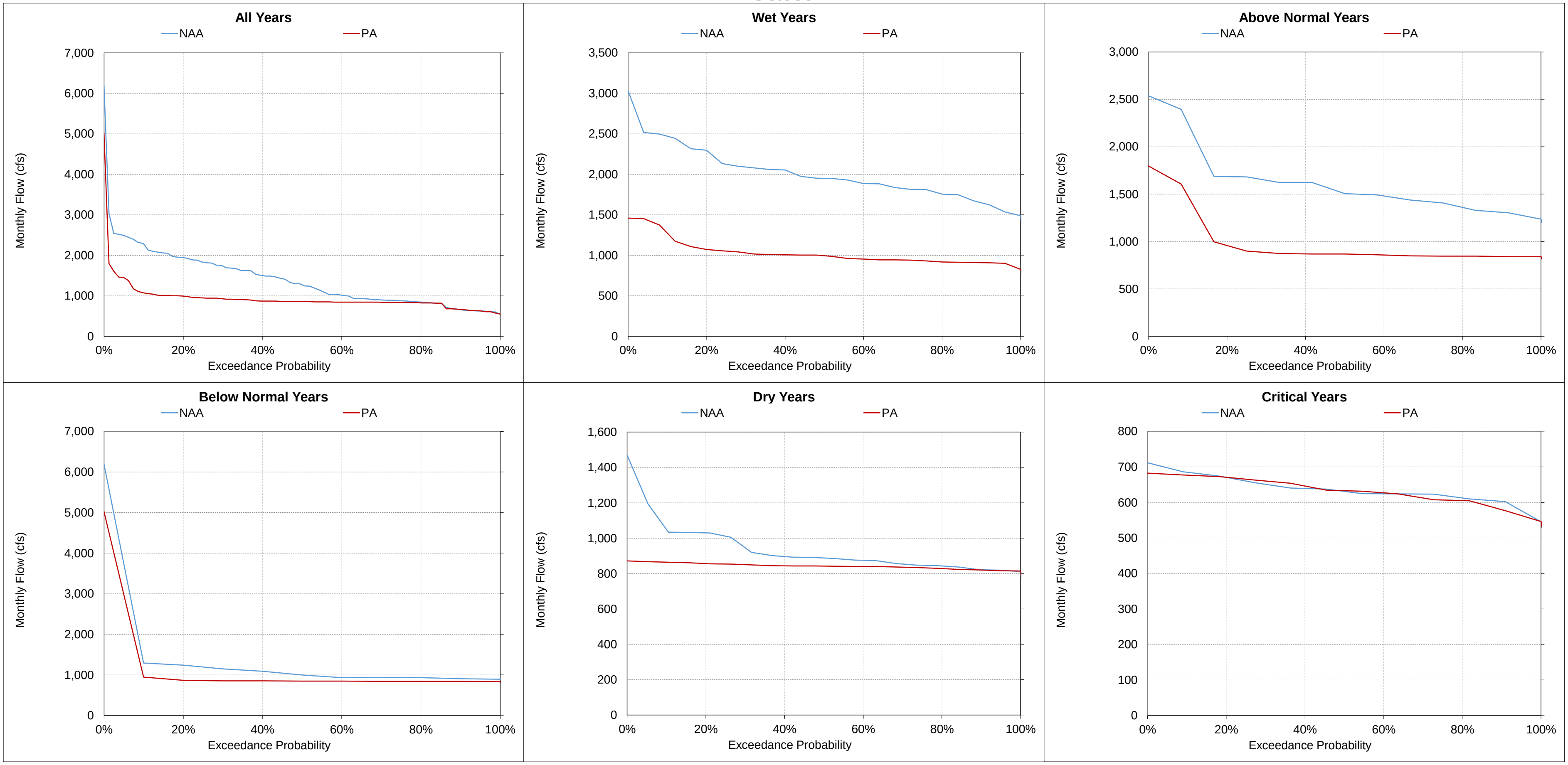


Figure 5.B.5-3-7. Steamboat Slough, Monthly Flow Probability of Exceedance



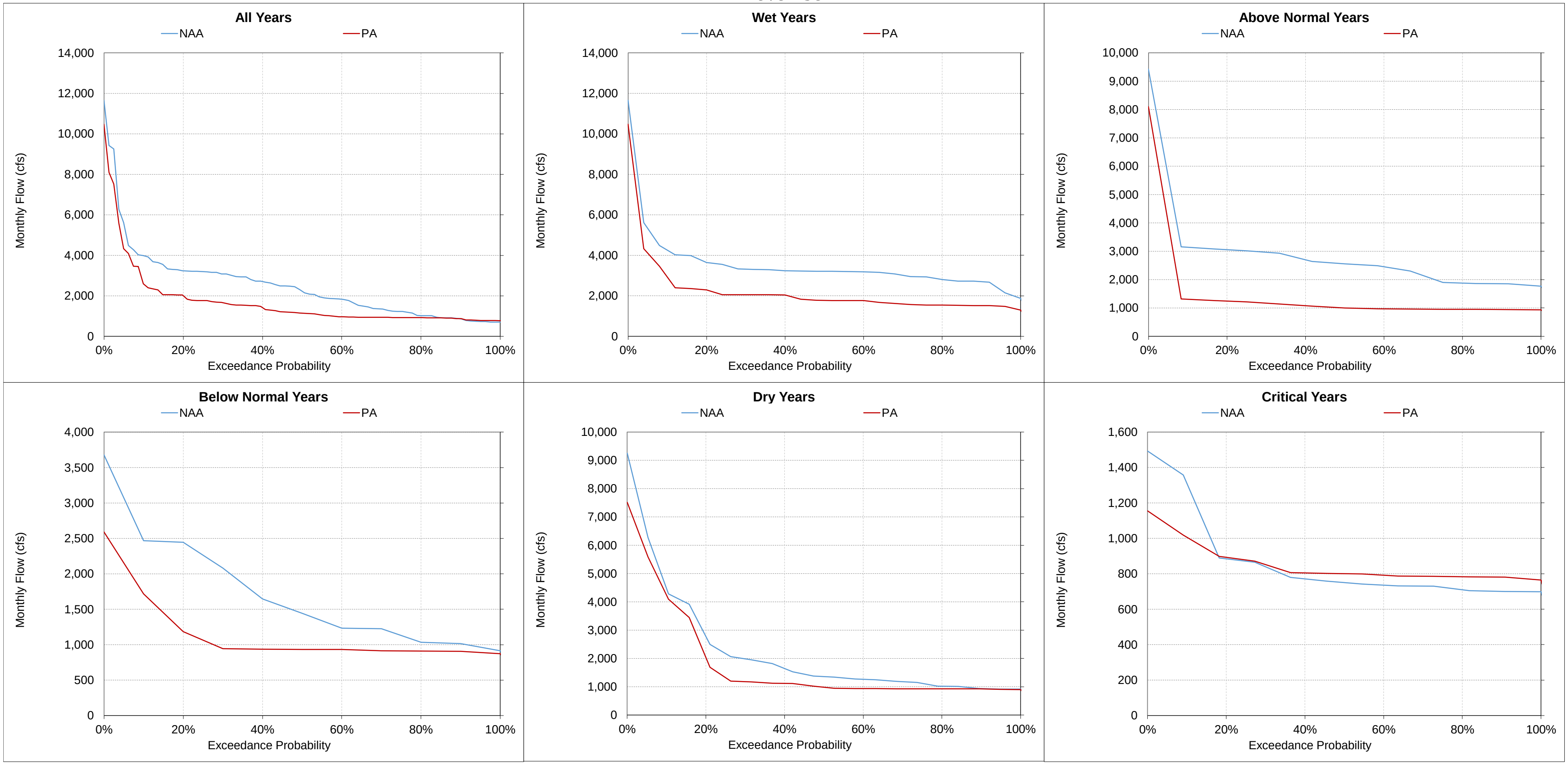
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-3-8. Steamboat Slough, Monthly Flow
October



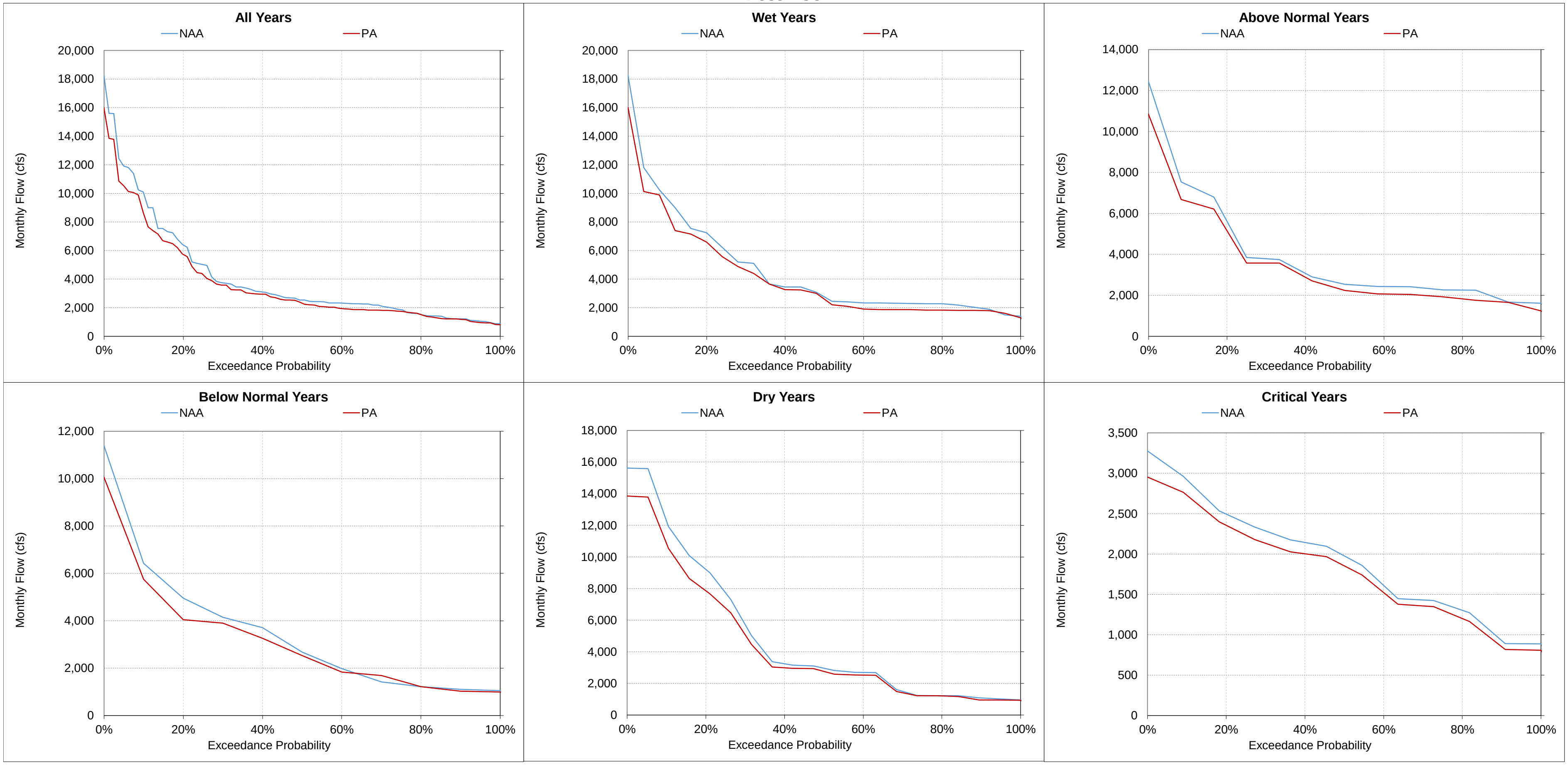
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-3-9. Steamboat Slough, Monthly Flow
November



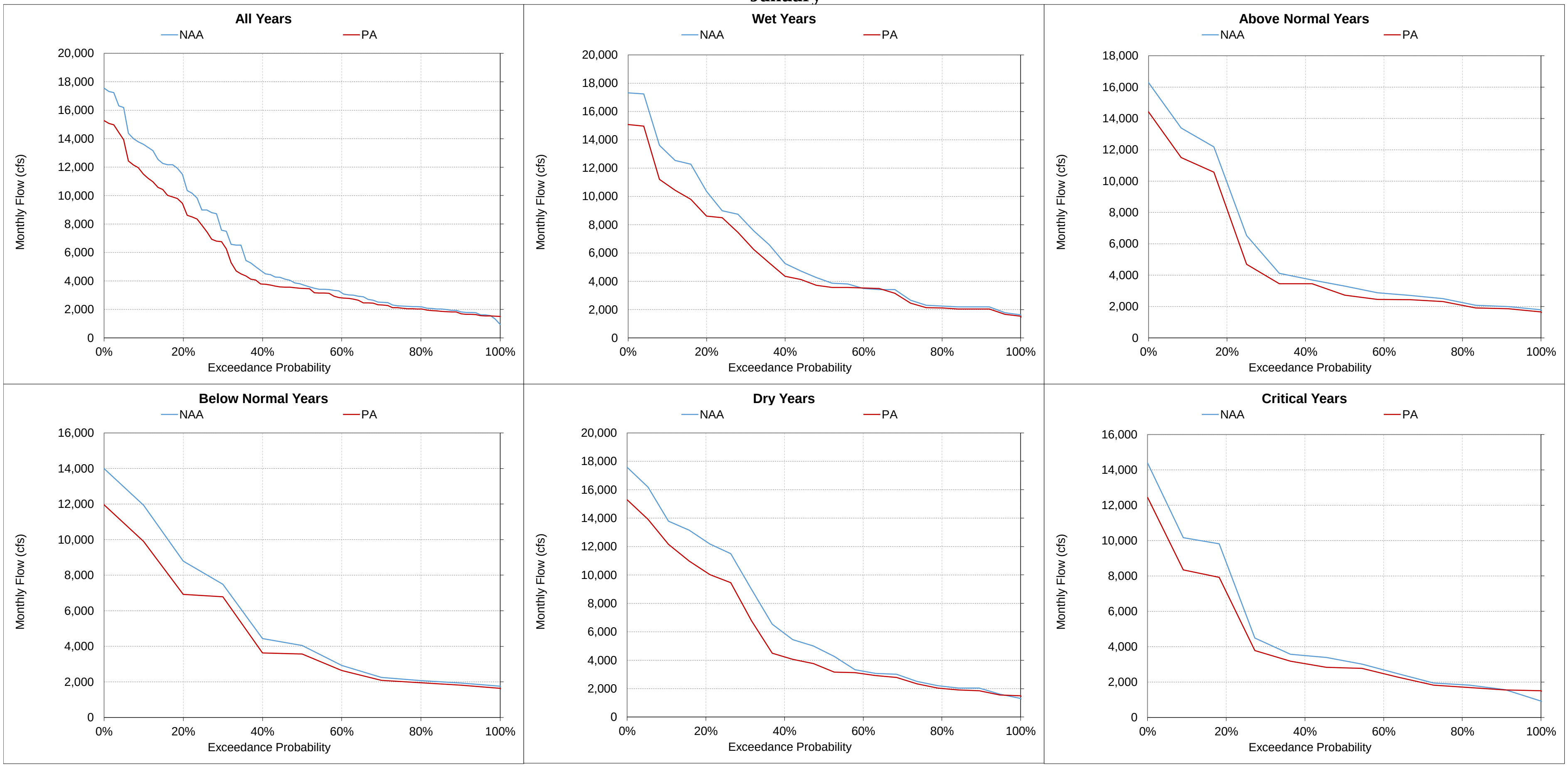
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-3-10. Steamboat Slough, Monthly Flow
December



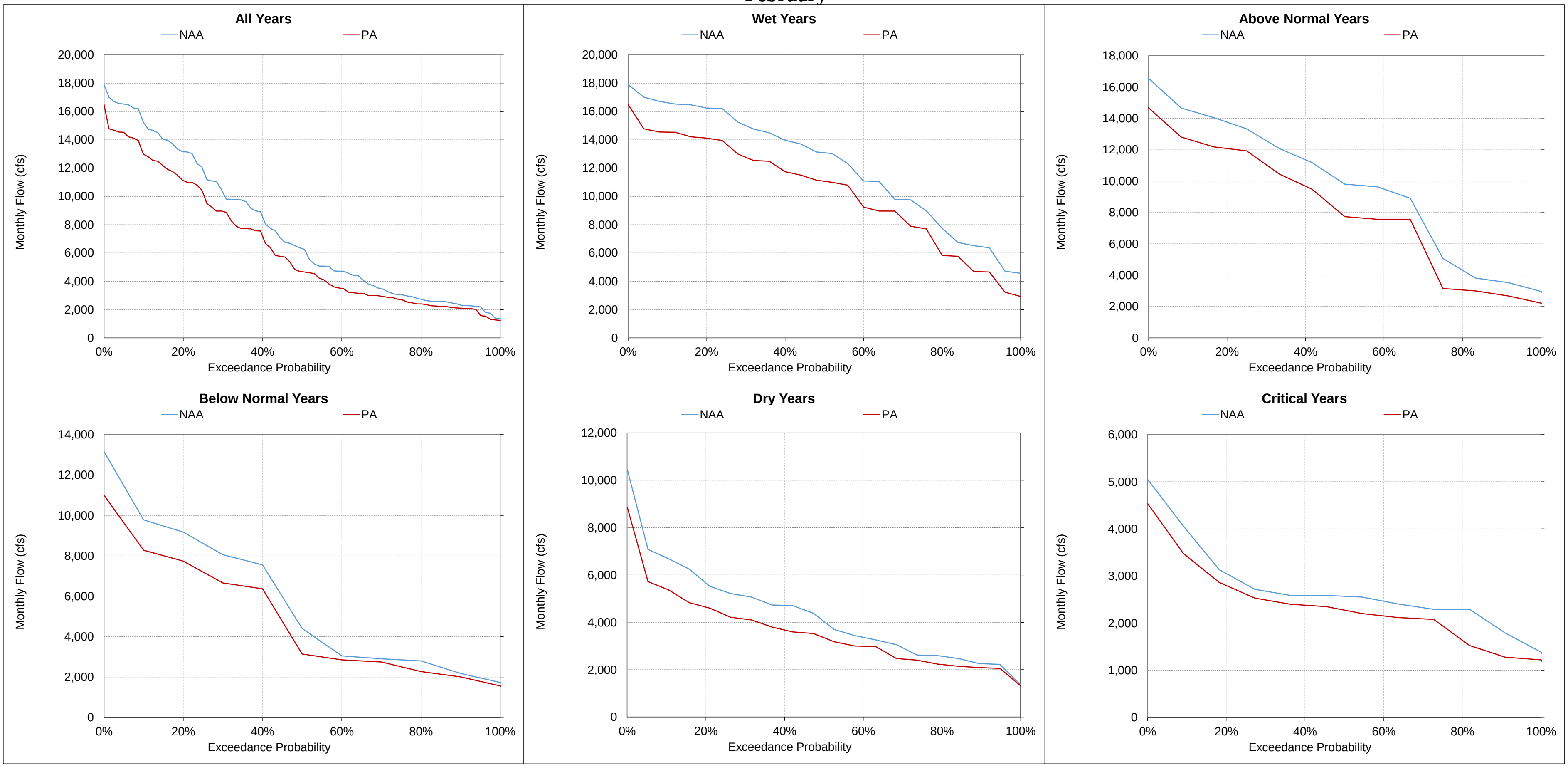
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-3-11. Steamboat Slough, Monthly Flow
January



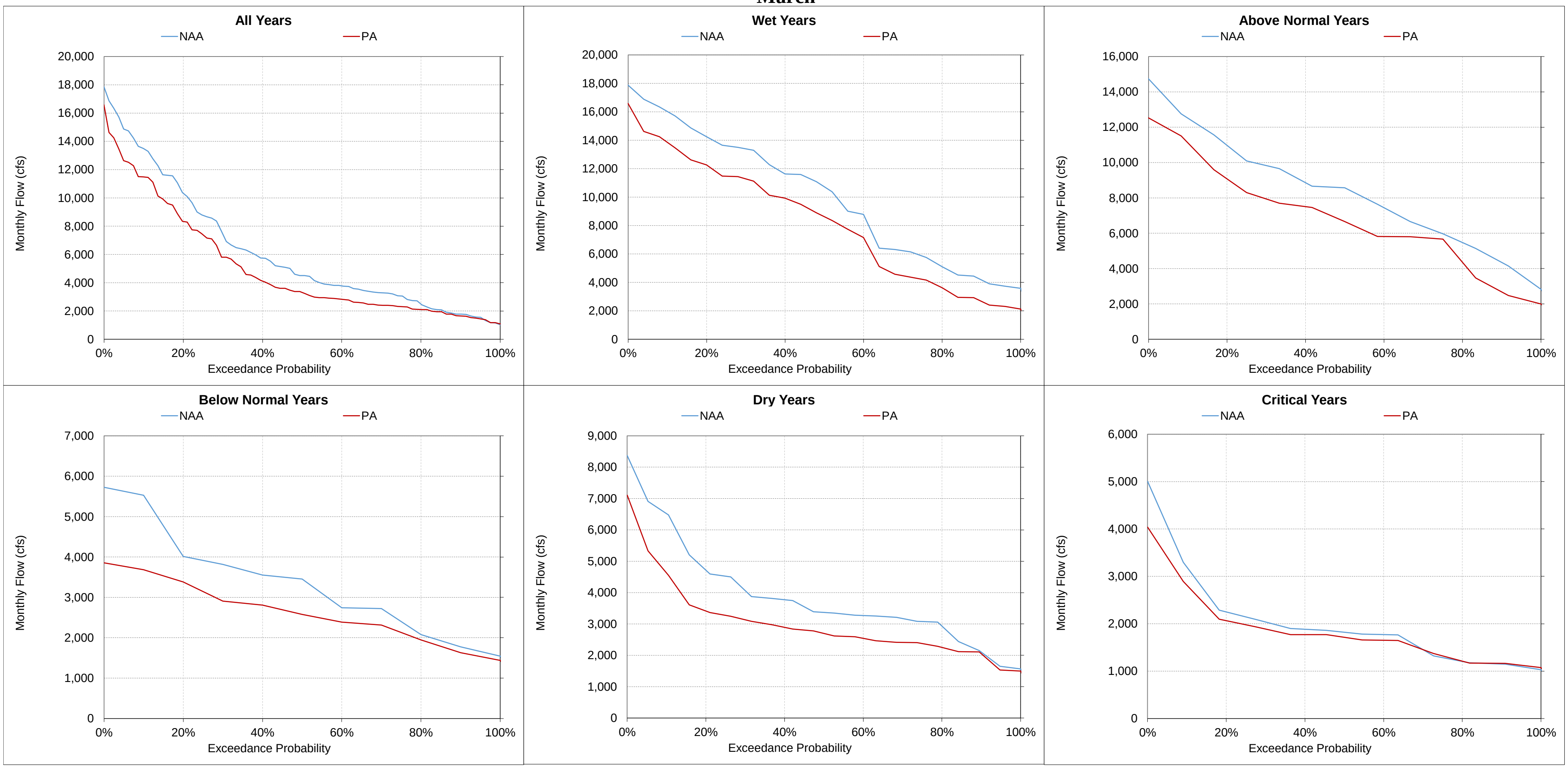
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-3-12. Steamboat Slough, Monthly Flow February



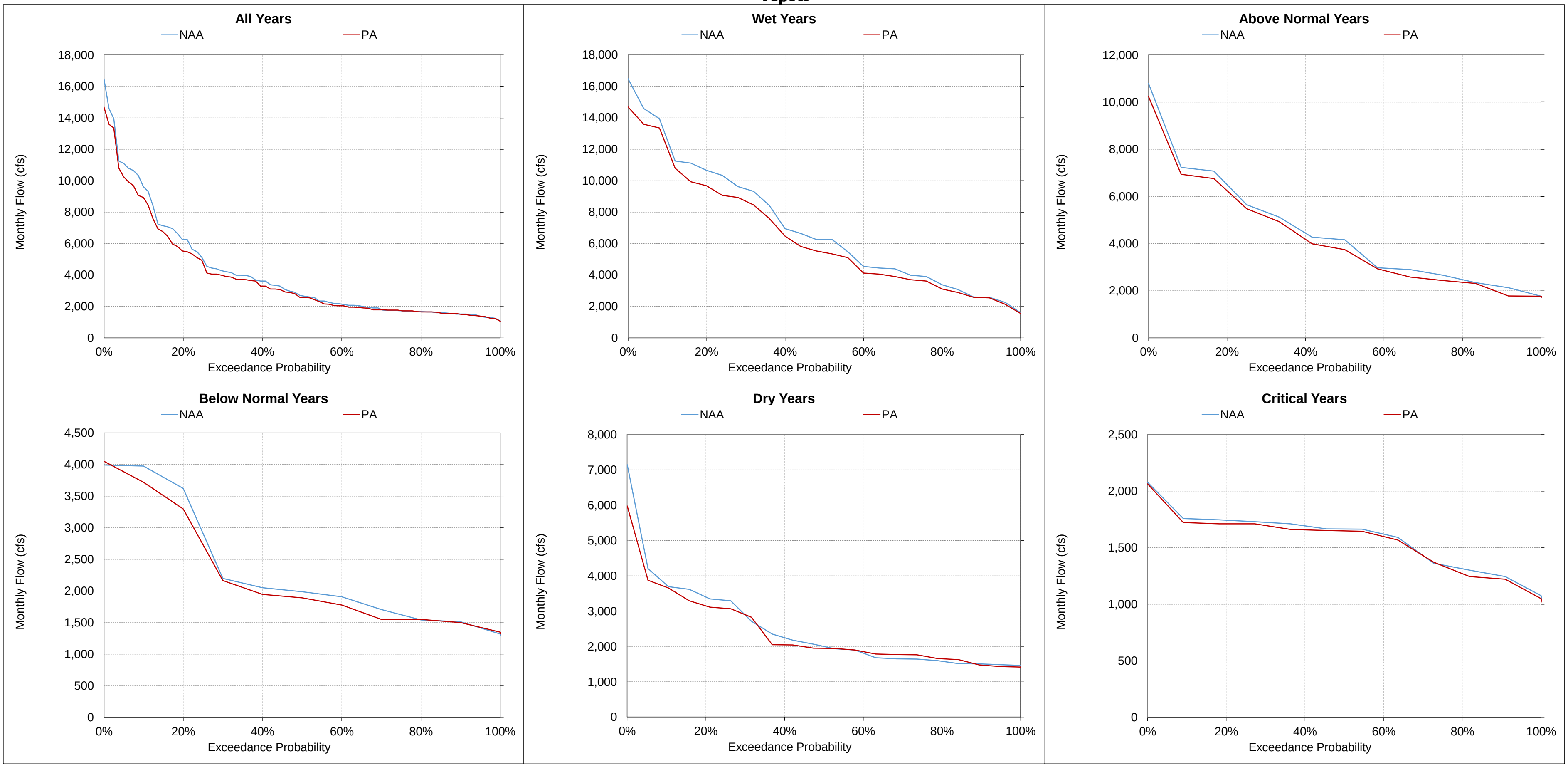
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-3-13. Steamboat Slough, Monthly Flow
March



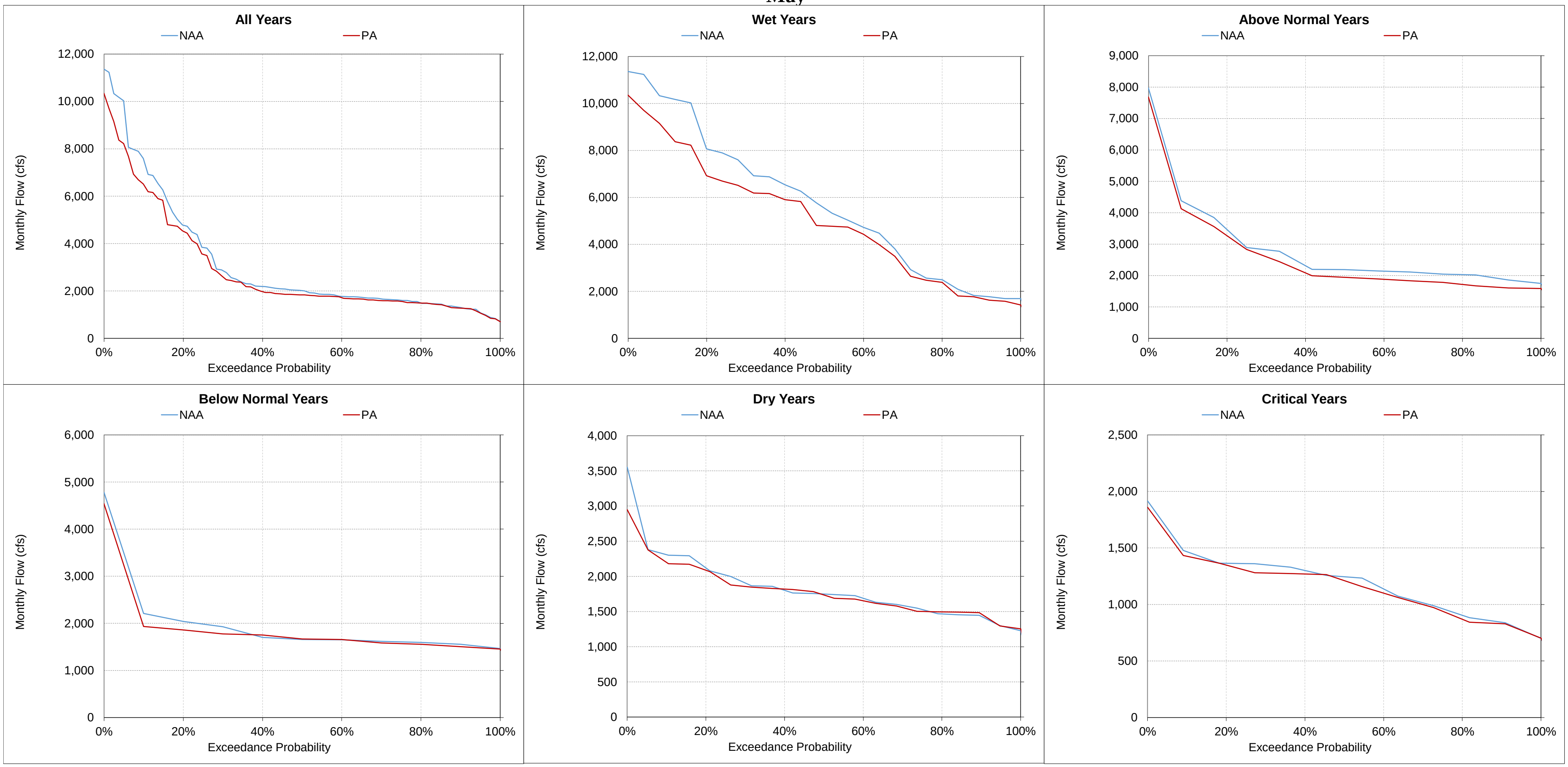
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-3-14. Steamboat Slough, Monthly Flow
April



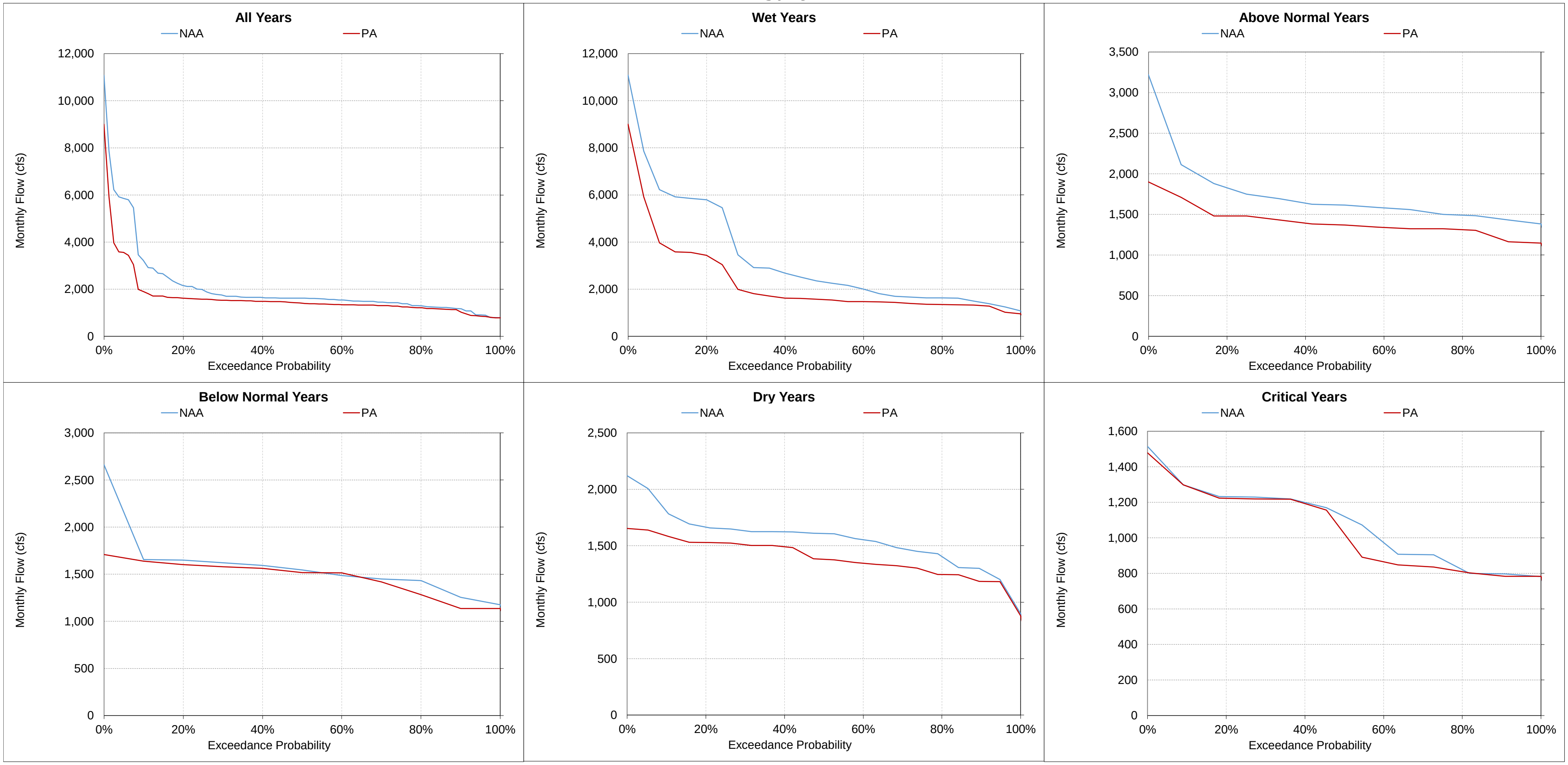
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-3-15. Steamboat Slough, Monthly Flow
May



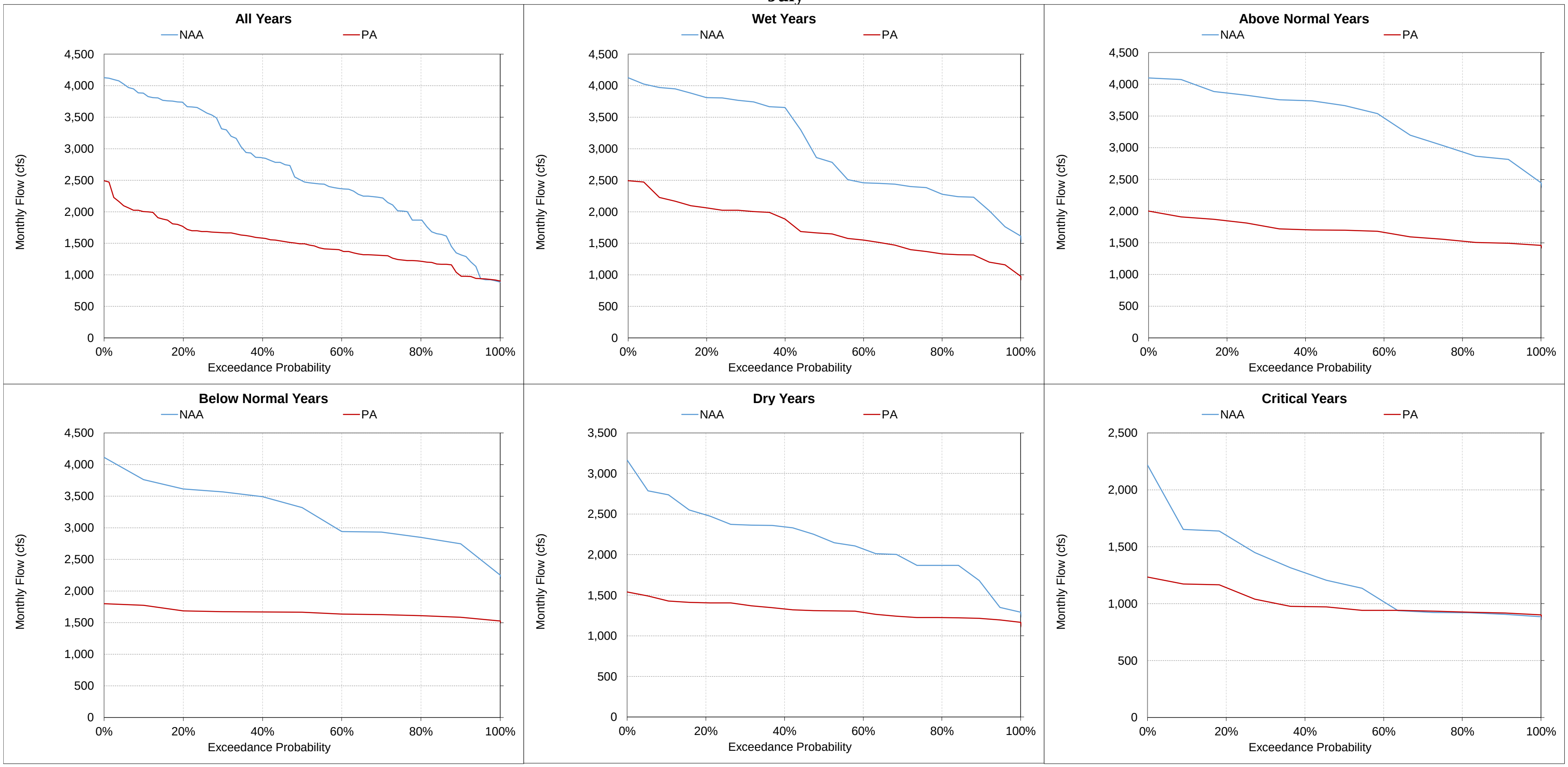
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-3-16. Steamboat Slough, Monthly Flow
June



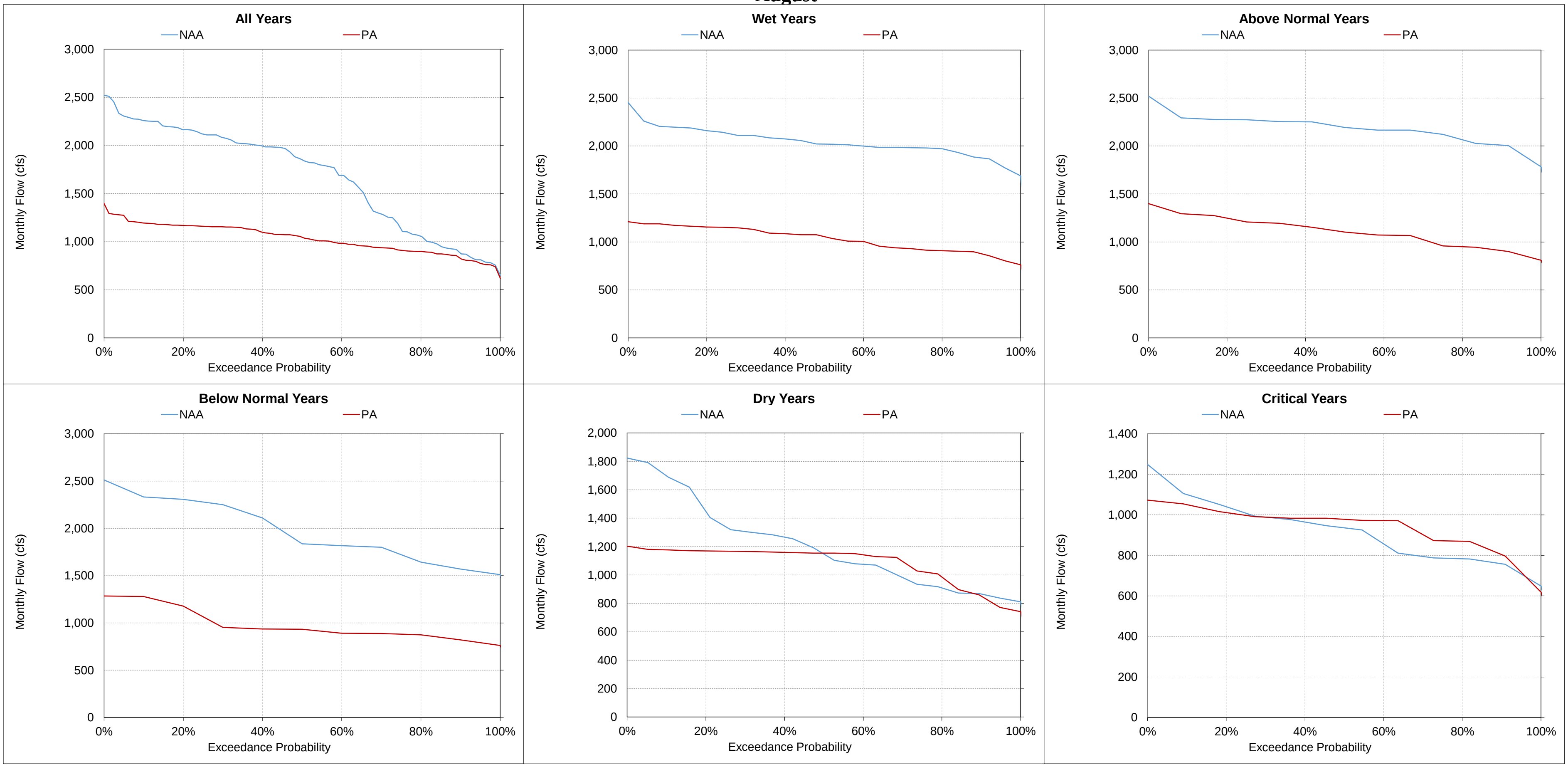
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-3-17. Steamboat Slough, Monthly Flow
July



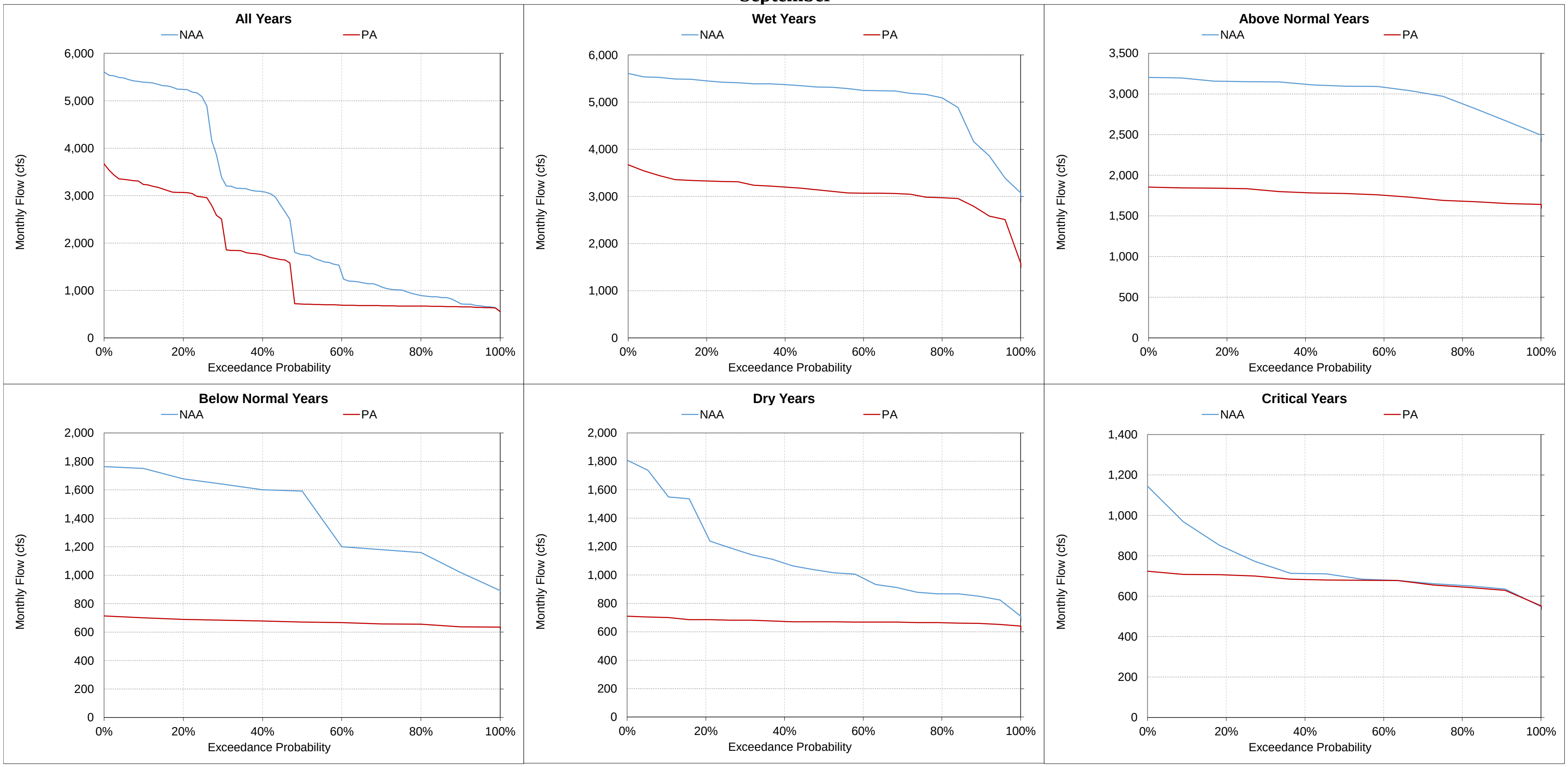
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-3-18. Steamboat Slough, Monthly Flow
August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-3-19. Steamboat Slough, Monthly Flow
September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-4. Delta Cross Channel, Monthly Flow

Statistic	Monthly Flow (cfs)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	3,203	2,226	-977	-30%	1,803	1,456	-348	-19%	1,427	1,491	64	4%	0	0	0	-	0	0	0	-	0	0	0	-
20%	2,941	2,184	-757	-26%	1,533	1,405	-129	-8%	1,177	1,193	17	1%	0	0	0	-	0	0	0	-	0	0	0	-
30%	2,667	2,158	-509	-19%	1,293	1,322	29	2%	1,009	987	-22	-2%	0	0	0	-	0	0	0	-	0	0	0	-
40%	2,450	2,131	-319	-13%	1,186	1,206	20	2%	901	834	-66	-7%	0	0	0	-	0	0	0	-	0	0	0	-
50%	2,293	2,082	-211	-9%	1,081	1,114	33	3%	447	441	-6	-1%	0	0	0	-	0	0	0	-	0	0	0	-
60%	2,142	1,990	-152	-7%	478	962	485	102%	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-
70%	1,867	1,700	-167	-9%	272	692	419	154%	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-
80%	1,691	1,598	-93	-5%	1	309	309	49797%	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-
90%	1,454	1,344	-110	-8%	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-
Long Term																								
Full Simulation Period[b]	2,279	1,877	-402	-18%	877	919	41	5%	581	573	-8	-1%	0	0	0	-	0	0	0	-	0	0	0	-
Water Year Types[c]																								
Wet (32%)	2,274	1,779	-494	-22%	367	662	295	80%	712	716	4	1%	0	0	0	-	0	0	0	-	0	0	0	-
Above Normal (16%)	2,715	2,034	-681	-25%	872	860	-12	-1%	599	563	-36	-6%	0	0	0	-	0	0	0	-	0	0	0	-
Below Normal (13%)	2,354	1,929	-425	-18%	1,403	1,181	-222	-16%	612	608	-4	-1%	0	0	0	-	0	0	0	-	0	0	0	-
Dry (24%)	2,302	2,045	-258	-11%	1,053	963	-90	-9%	375	367	-8	-2%	0	0	0	-	0	0	0	-	0	0	0	-
Critical (15%)	1,708	1,591	-117	-7%	1,215	1,224	9	1%	593	584	-9	-2%	0	0	0	-	0	0	0	-	0	0	0	-

Statistic	Monthly Flow (cfs)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	0	0	0	-	1	0	-1	-100%	3,320	2,977	-344	-10%	4,964	4,030	-933	-19%	4,490	3,050	-1,440	-32%	4,920	4,906	-15	0%
20%	0	0	0	-	1	0	-1	-100%	3,121	2,902	-219	-7%	4,676	3,795	-881	-19%	4,418	3,015	-1,402	-32%	3,978	4,332	353	9%
30%	0	0	0	-	0	0	0	-100%	3,013	2,833	-181	-6%	4,478	3,606	-872	-19%	4,301	2,950	-1,351	-31%	3,506	3,744	238	7%
40%	0	0	0	-	0	0	0	-100%	2,964	2,718	-246	-8%	4,292	3,518	-775	-18%	4,171	2,804	-1,367	-33%	2,971	3,480	509	17%
50%	0	0	0	-	0	0	0	-100%	2,871	2,623	-248	-9%	4,140	3,337	-803	-19%	3,969	2,684	-1,284	-32%	2,519	1,972	-548	-22%
60%	0	0	0	-	0	0	0	-100%	2,695	2,472	-223	-8%	3,900	3,198	-702	-18%	3,786	2,594	-1,192	-31%	2,245	1,907	-338	-15%
70%	0	0	0	-	0	0	0	-100%	2,575	2,369	-206	-8%	3,543	2,988	-555	-16%	3,306	2,472	-834	-25%	1,795	1,886	91	5%
80%	0	0	0	-	0	0	0	-100%	2,333	2,138	-195	-8%	3,130	2,889	-241	-8%	2,807	2,383	-424	-15%	169	1,877	1,708	1014%
90%	0	0	0	-	0	0	0	-	1,737	1,827	90	5%	2,758	2,403	-355	-13%	2,288	2,216	-73	-3%	161	1,825	1,664	1033%
Long Term																								
Full Simulation Period[b]	0	0	0	-	0	0	0	-100%	2,592	2,480	-112	-4%	3,950	3,283	-667	-17%	3,671	2,682	-990	-27%	2,474	2,939	466	19%
Water Year Types[c]																								
Wet (32%)	0	0	0	-	0	0	0	-100%	2,192	2,272	80	4%	3,858	3,396	-463	-12%	4,187	2,596	-1,591	-38%	728	4,335	3,607	495%
Above Normal (16%)	0	0	0	-	0	0	0	-100%	2,918	2,627	-291	-10%	4,134	3,642	-492	-12%	4,397	2,853	-1,544	-35%	5,026	3,697	-1,329	-26%
Below Normal (13%)	0	0	0	-	0	0	0	-100%	2,936	2,763	-173	-6%	4,422	3,646	-776	-18%	4,172	2,612	-1,560	-37%	3,380	1,881	-1,499	-44%
Dry (24%)	0	0	0	-	0	0	0	-100%	2,942	2,707	-235	-8%	4,261	3,155	-1,106	-26%	2,990	2,825	-165	-6%	2,849	1,889	-959	-34%
Critical (15%)	0	0	0	-	0	0	0	-100%	2,207	2,136	-72	-3%	3,000	2,533	-467	-16%	2,442	2,507	65	3%	2,033	1,814	-219	-11%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

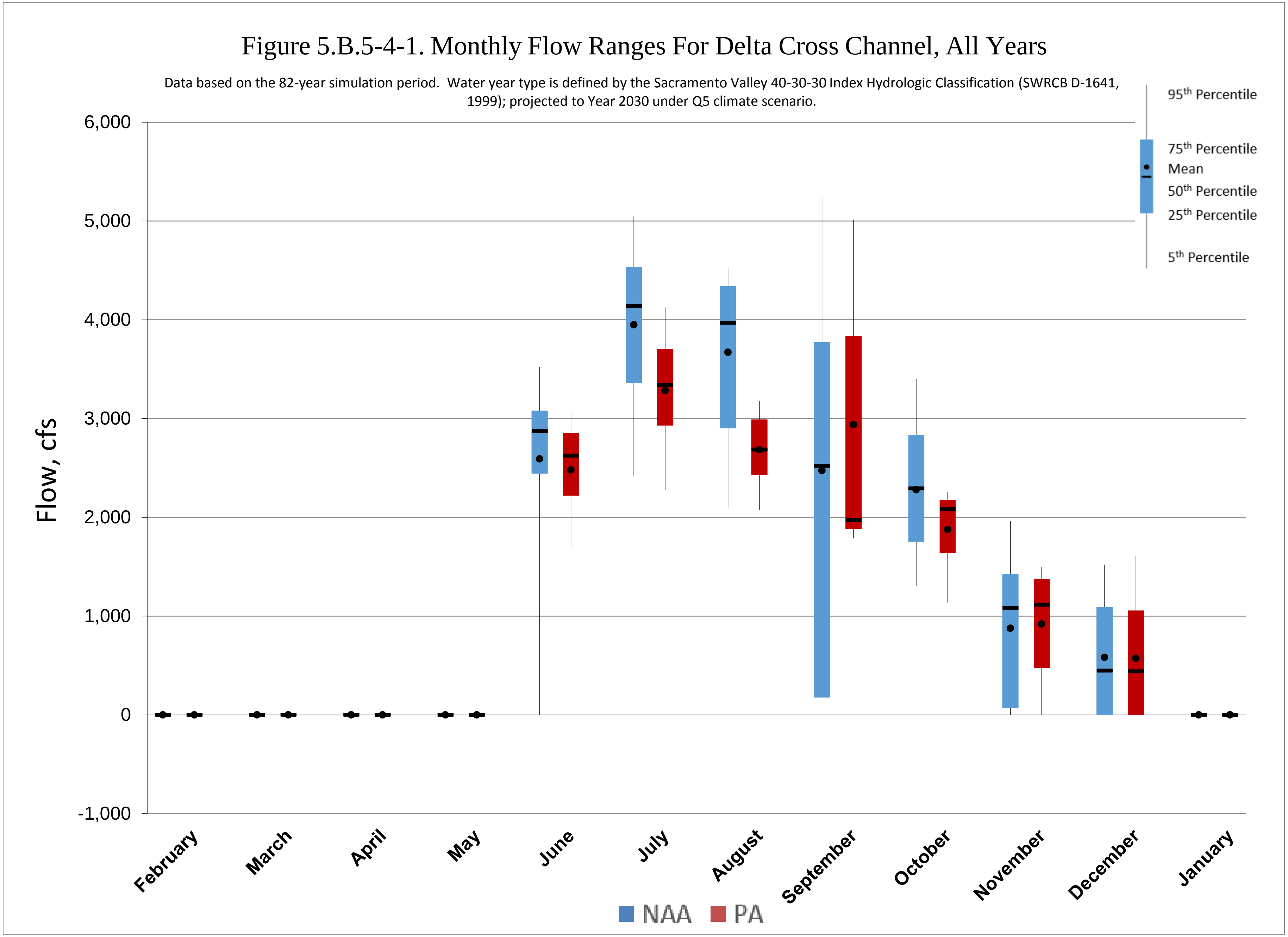
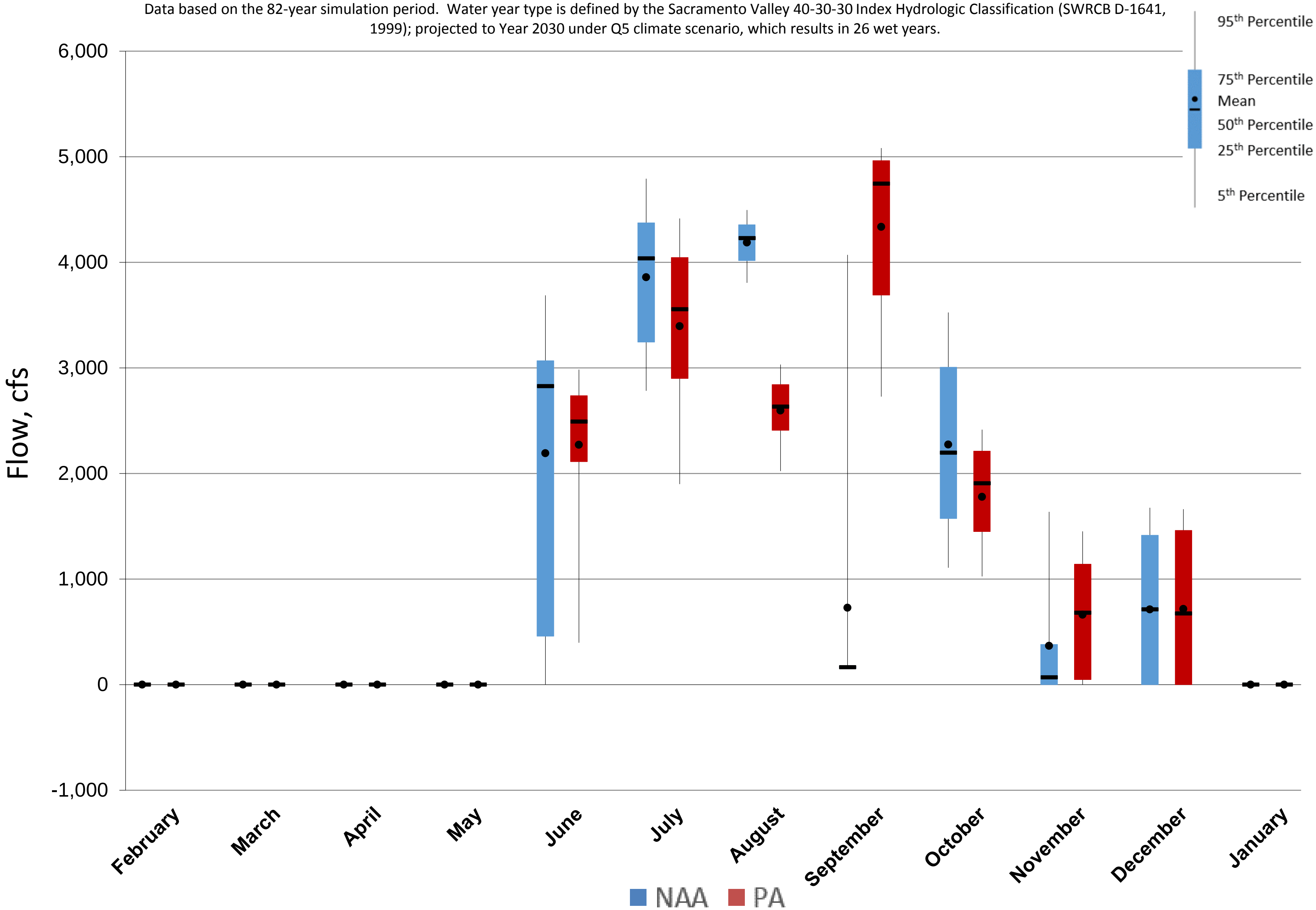


Figure 5.B.5-4-1. Monthly Flow Ranges For Delta Cross Channel, All Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario.
Flow, cfs
6,000
5,000
4,000
3,000
2,000
1,000
0
-1,000
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile

Figure 5.B.5-4-2. Monthly Flow Ranges For Delta Cross Channel, Wet Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 26 wet years.



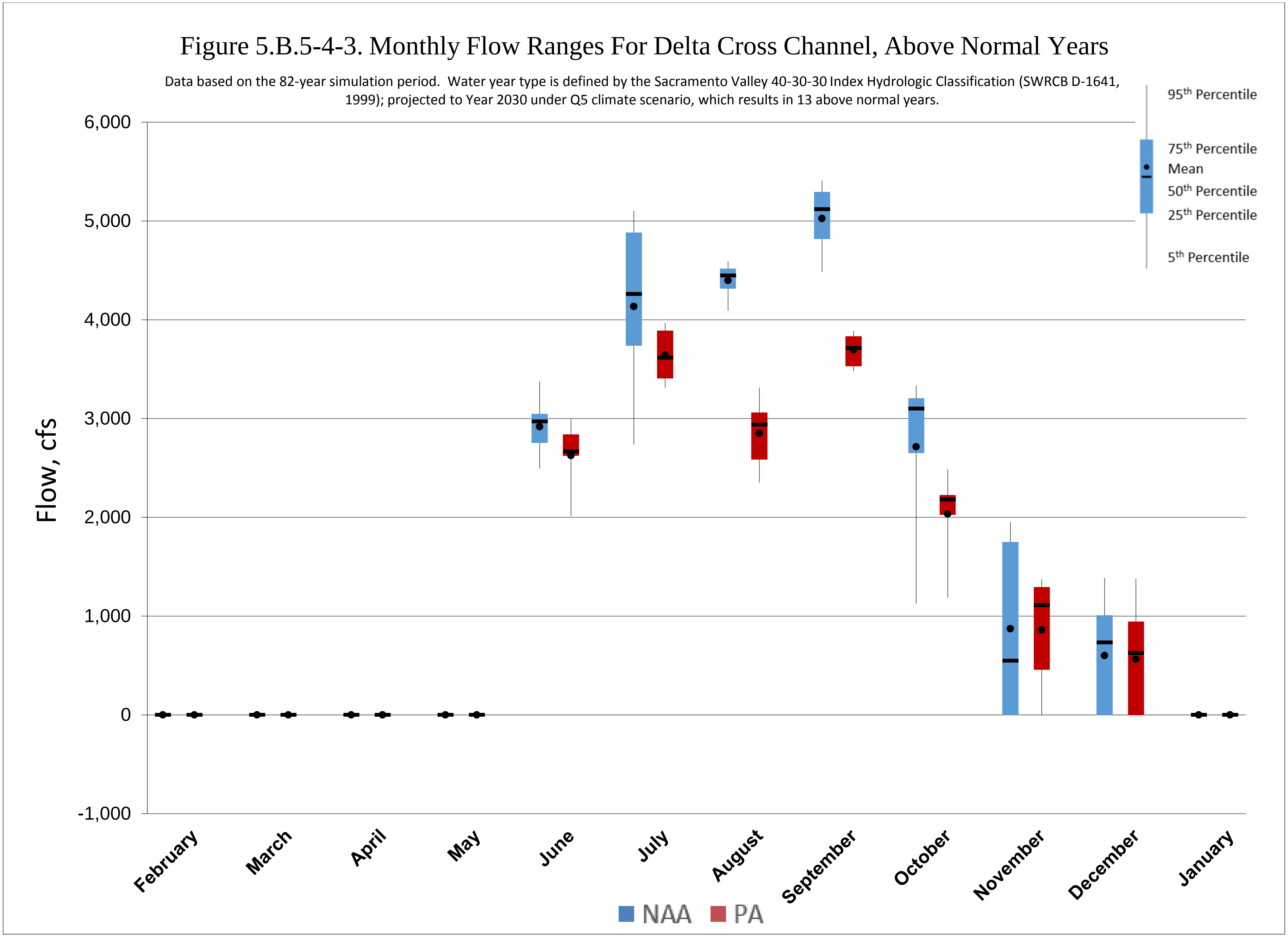
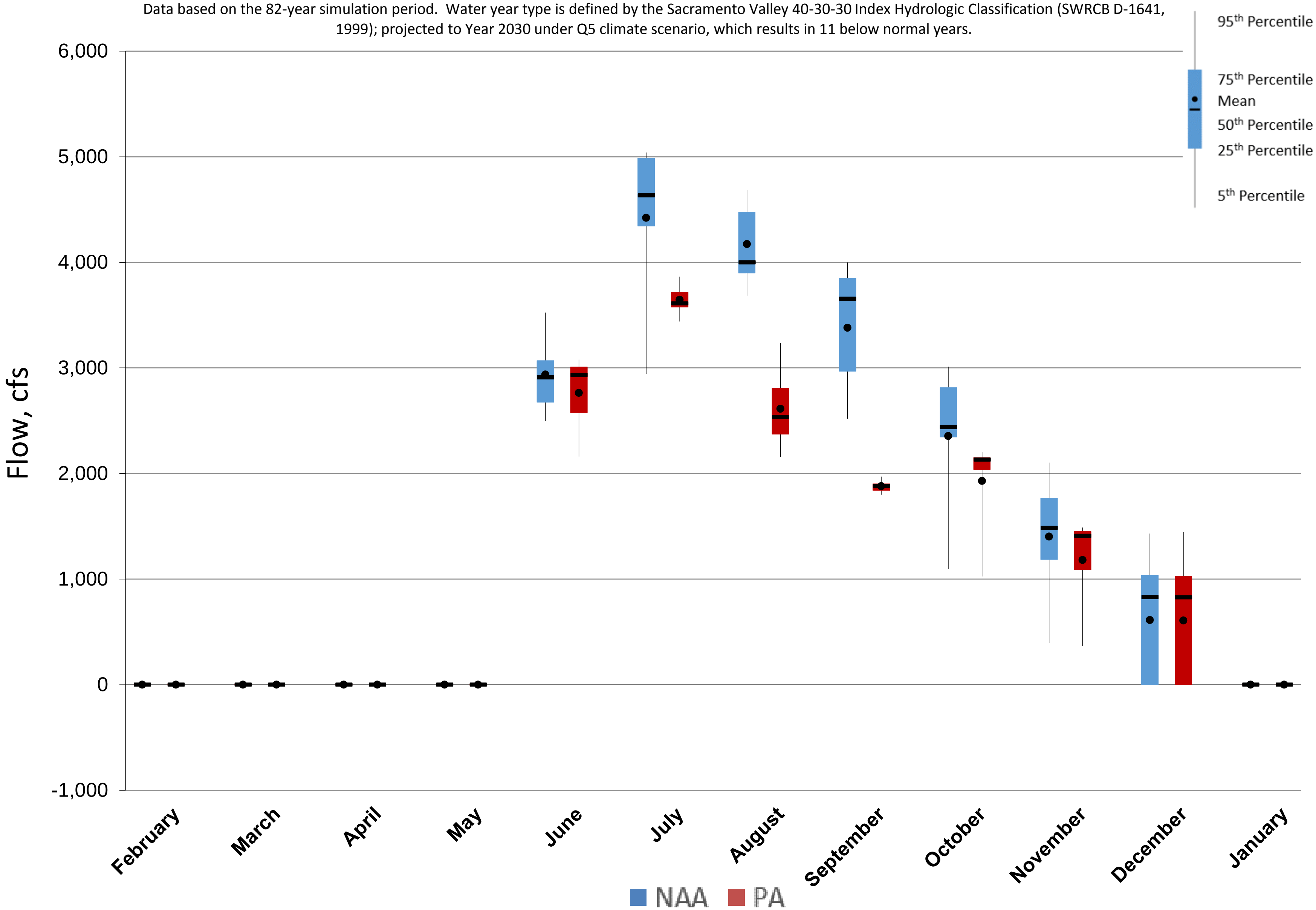


Figure 5.B.5-4-3. Monthly Flow Ranges For Delta Cross Channel, Above Normal Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 13 above normal years.
Flow, cfs
6,000
5,000
4,000
3,000
2,000
1,000
0
-1,000
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile

Figure 5.B.5-4-4. Monthly Flow Ranges For Delta Cross Channel, Below Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 11 below normal years.



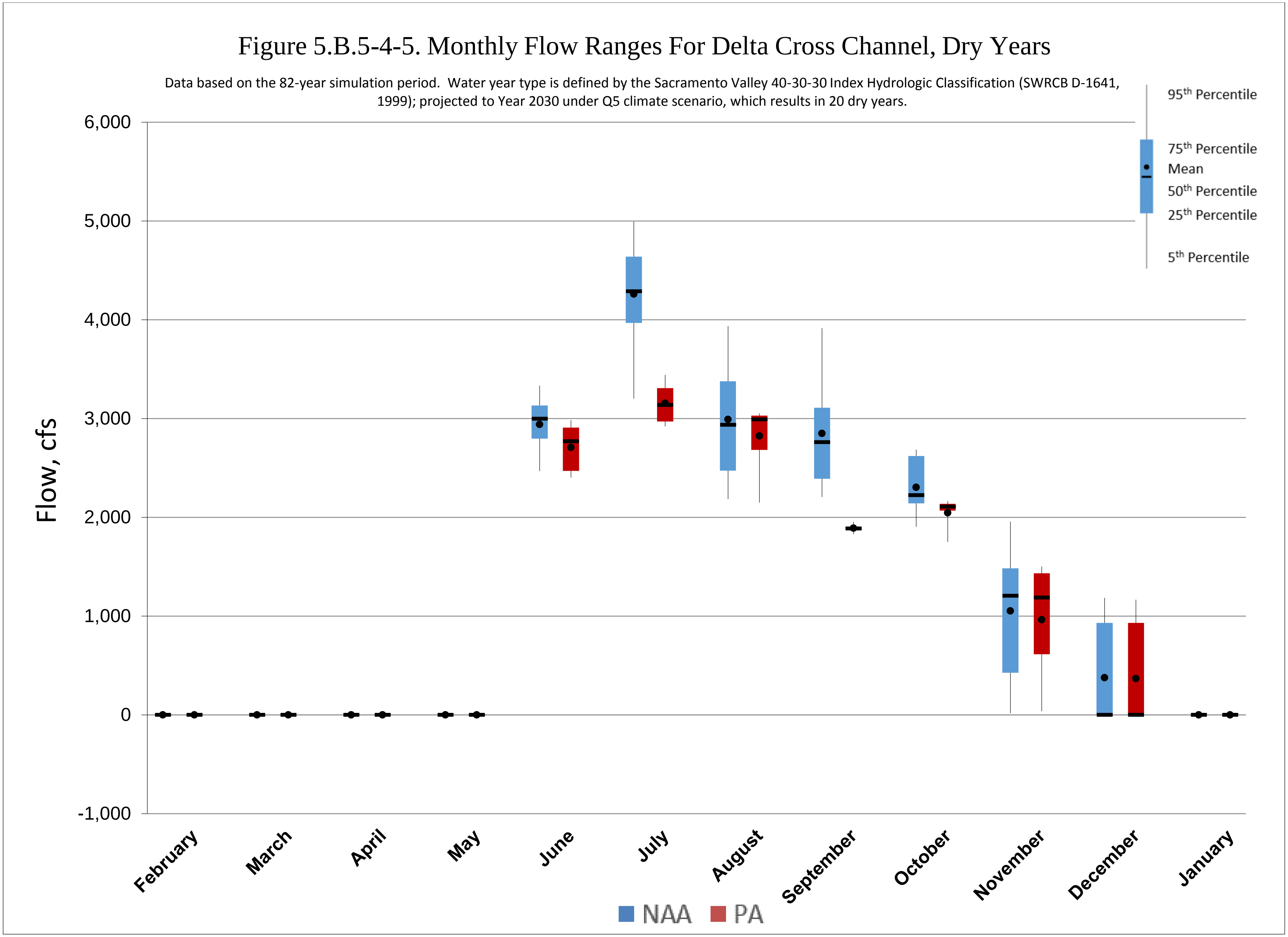


Figure 5.B.5-4-5. Monthly Flow Ranges For Delta Cross Channel, Dry Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 20 dry years.
Flow, cfs
6,000
5,000
4,000
3,000
2,000
1,000
0
-1,000
February
March
April
May
June
July
August
September
October
November
December
January
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
NAA
PA

Figure 5.B.5-4-6. Monthly Flow Ranges For Delta Cross Channel, Critical Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 12 critical years.

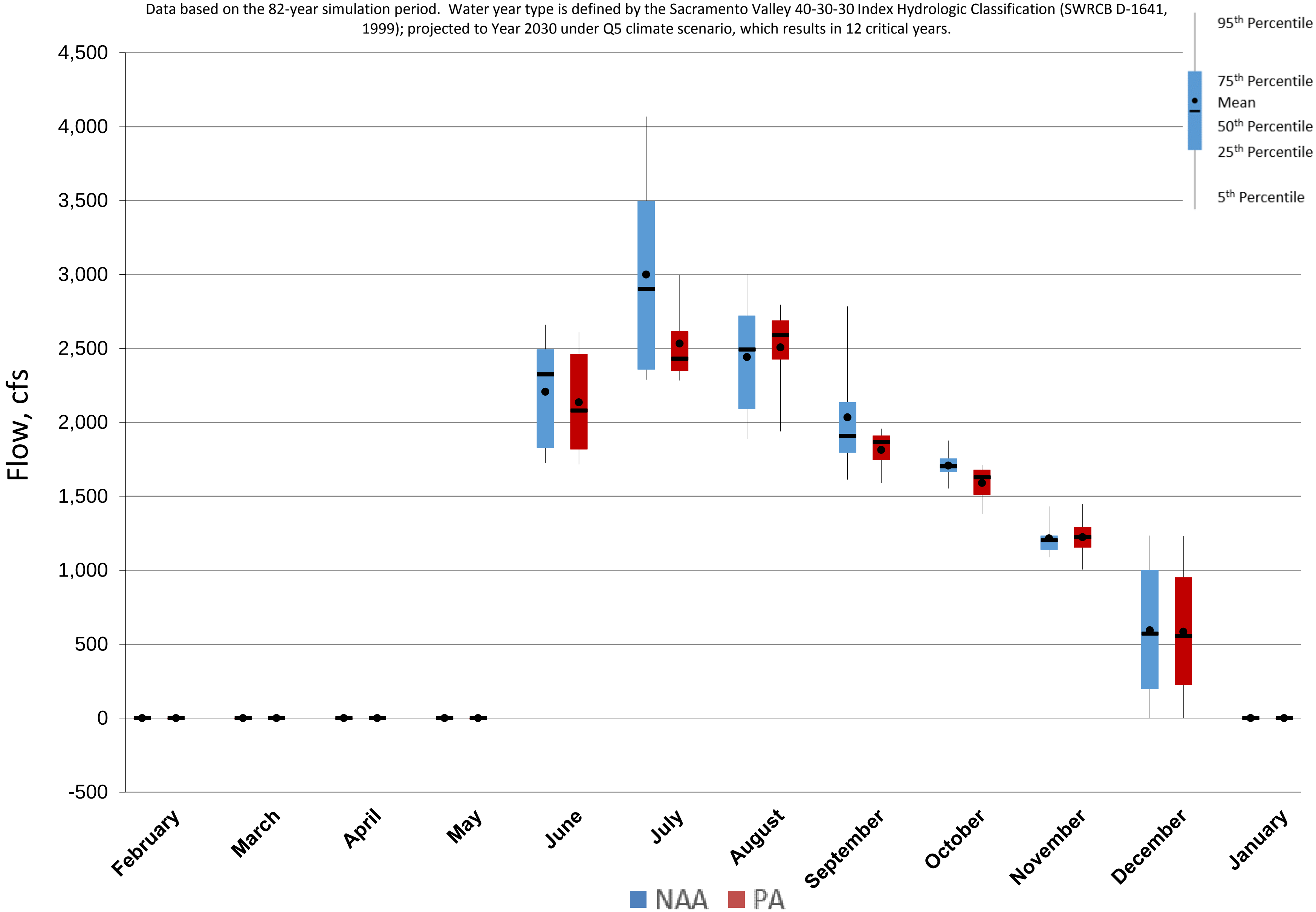
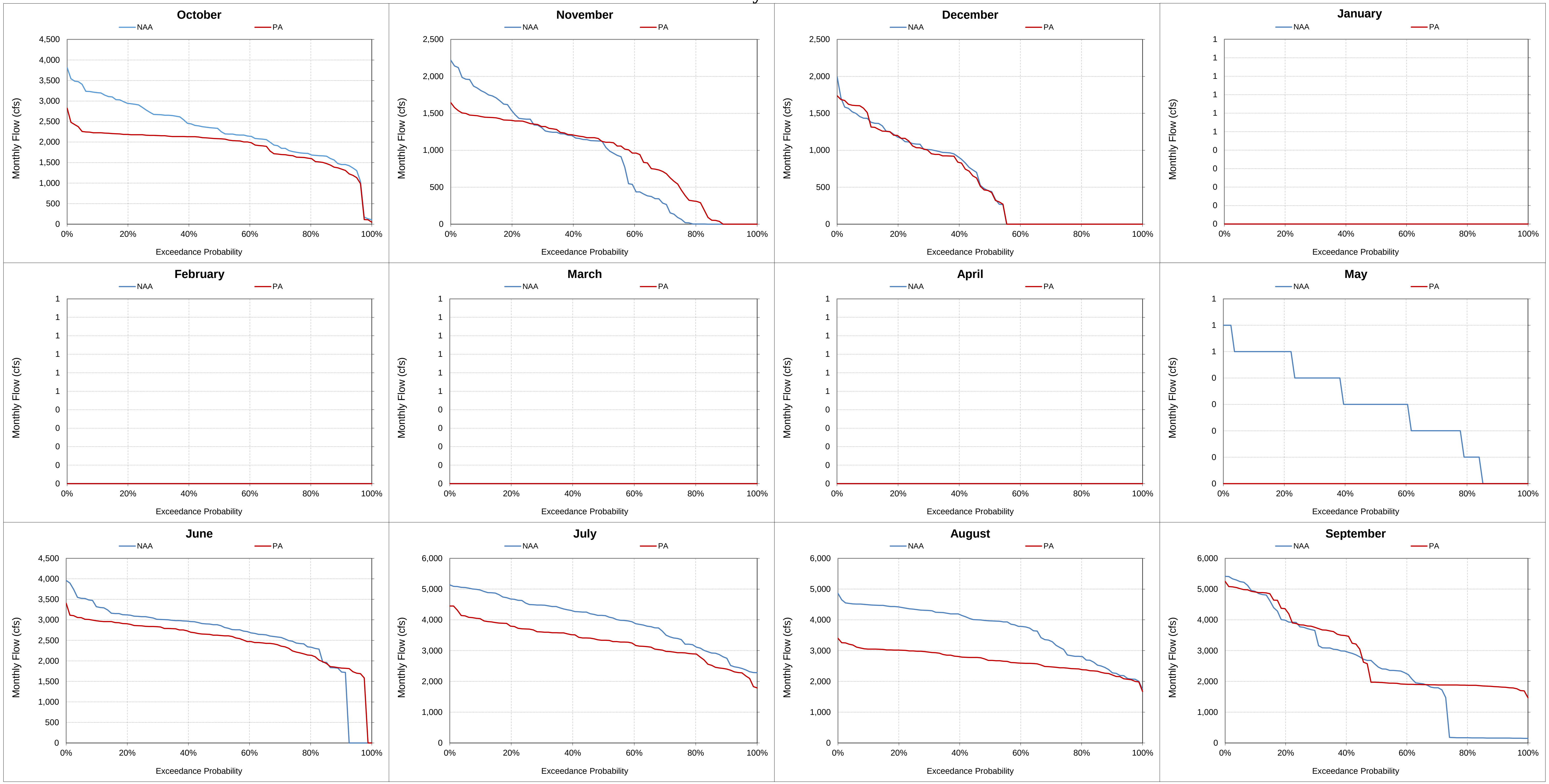
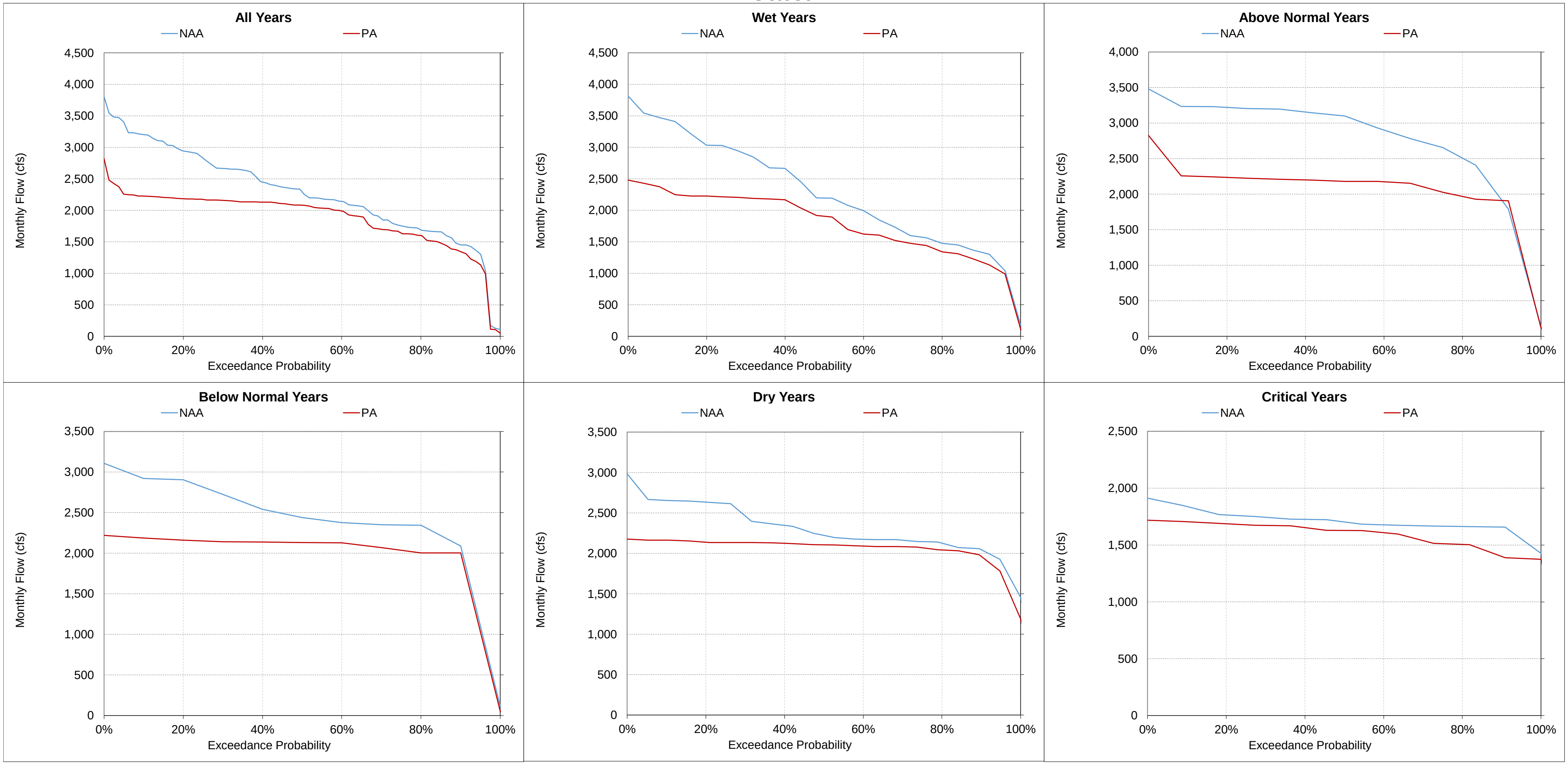


Figure 5.B.5-4-7. Delta Cross Channel, Monthly Flow Probability of Exceedance



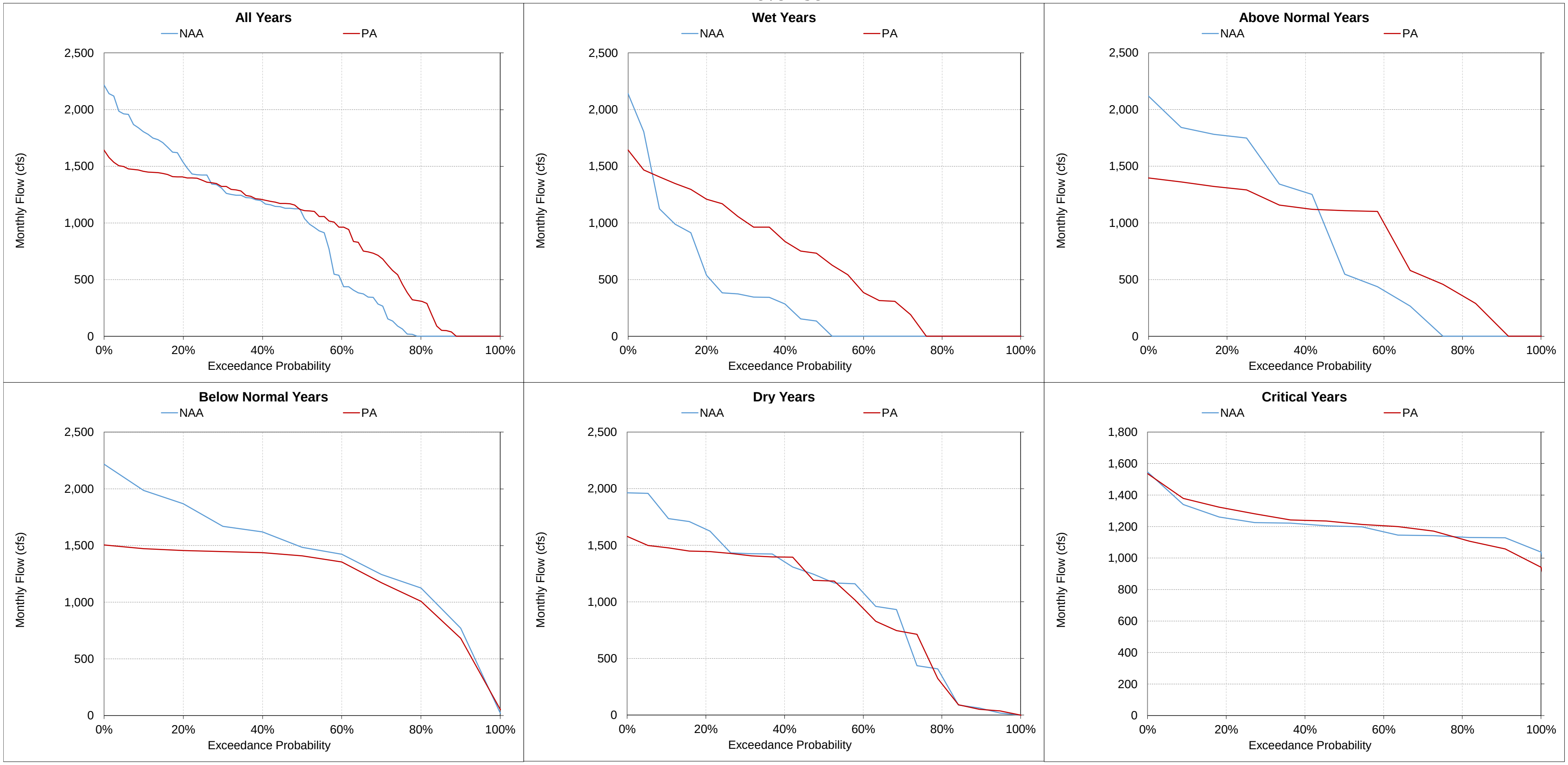
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-4-8. Delta Cross Channel, Monthly Flow October



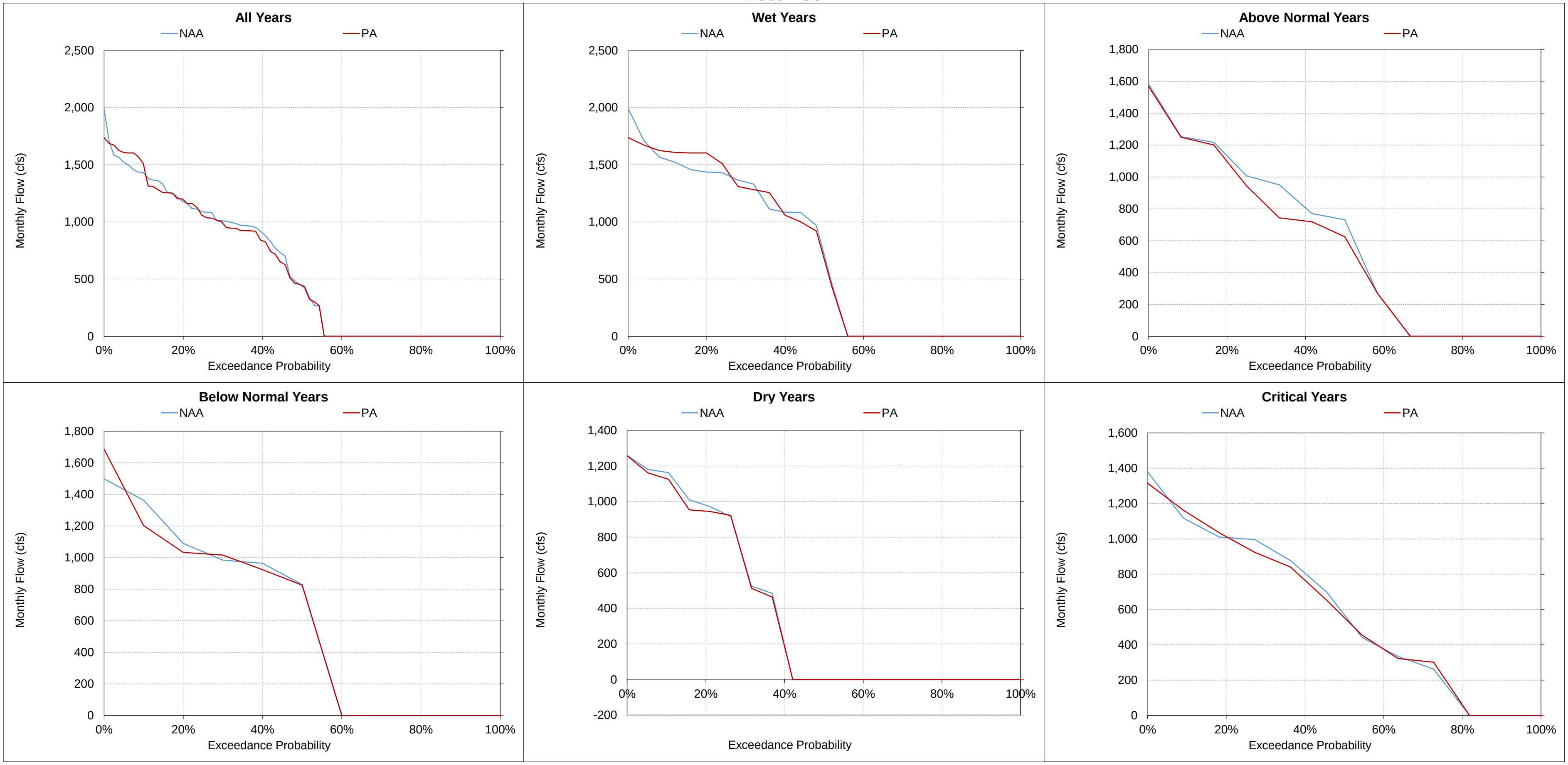
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-4-9. Delta Cross Channel, Monthly Flow
November



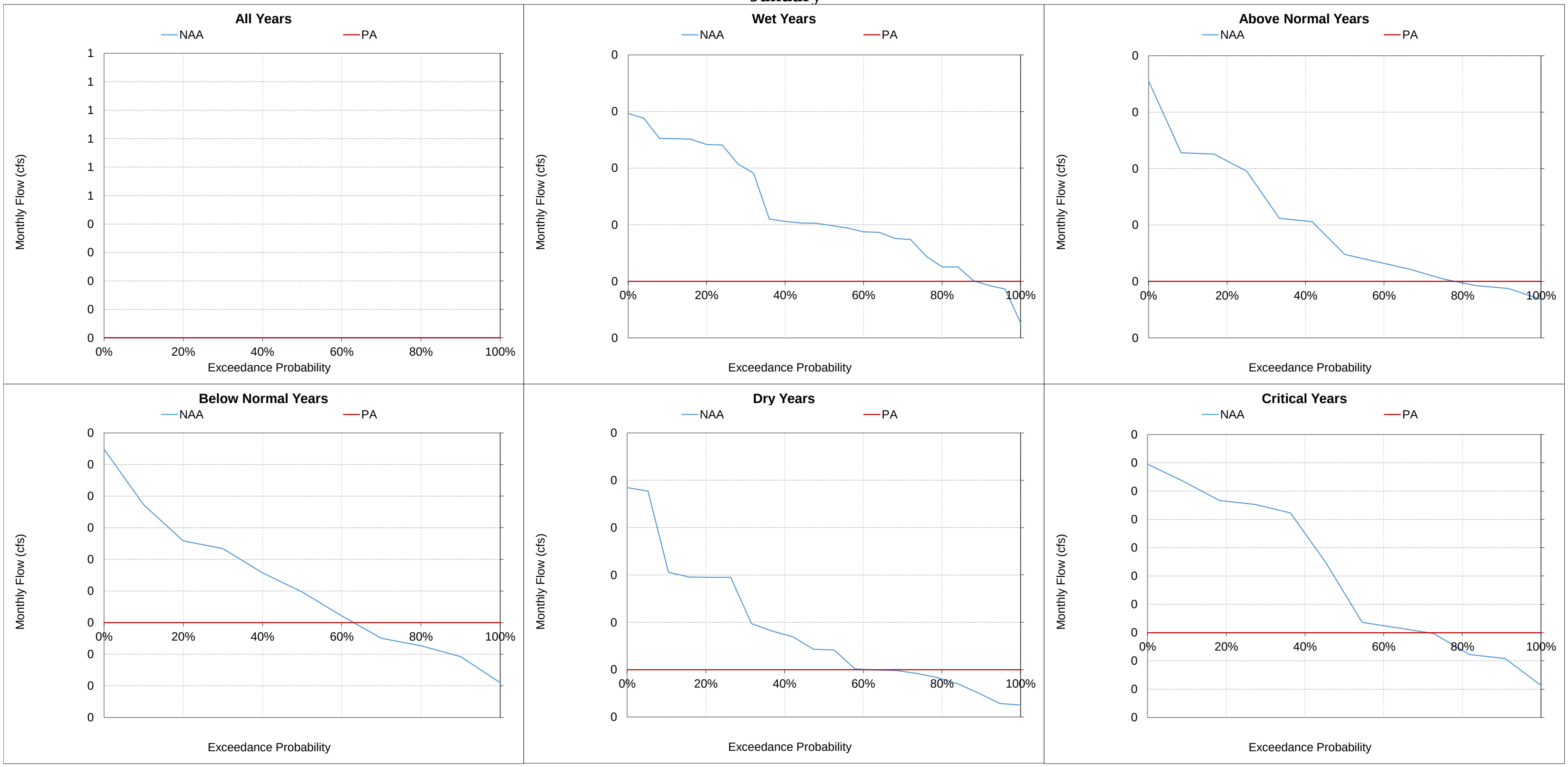
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-4-10. Delta Cross Channel, Monthly Flow
December



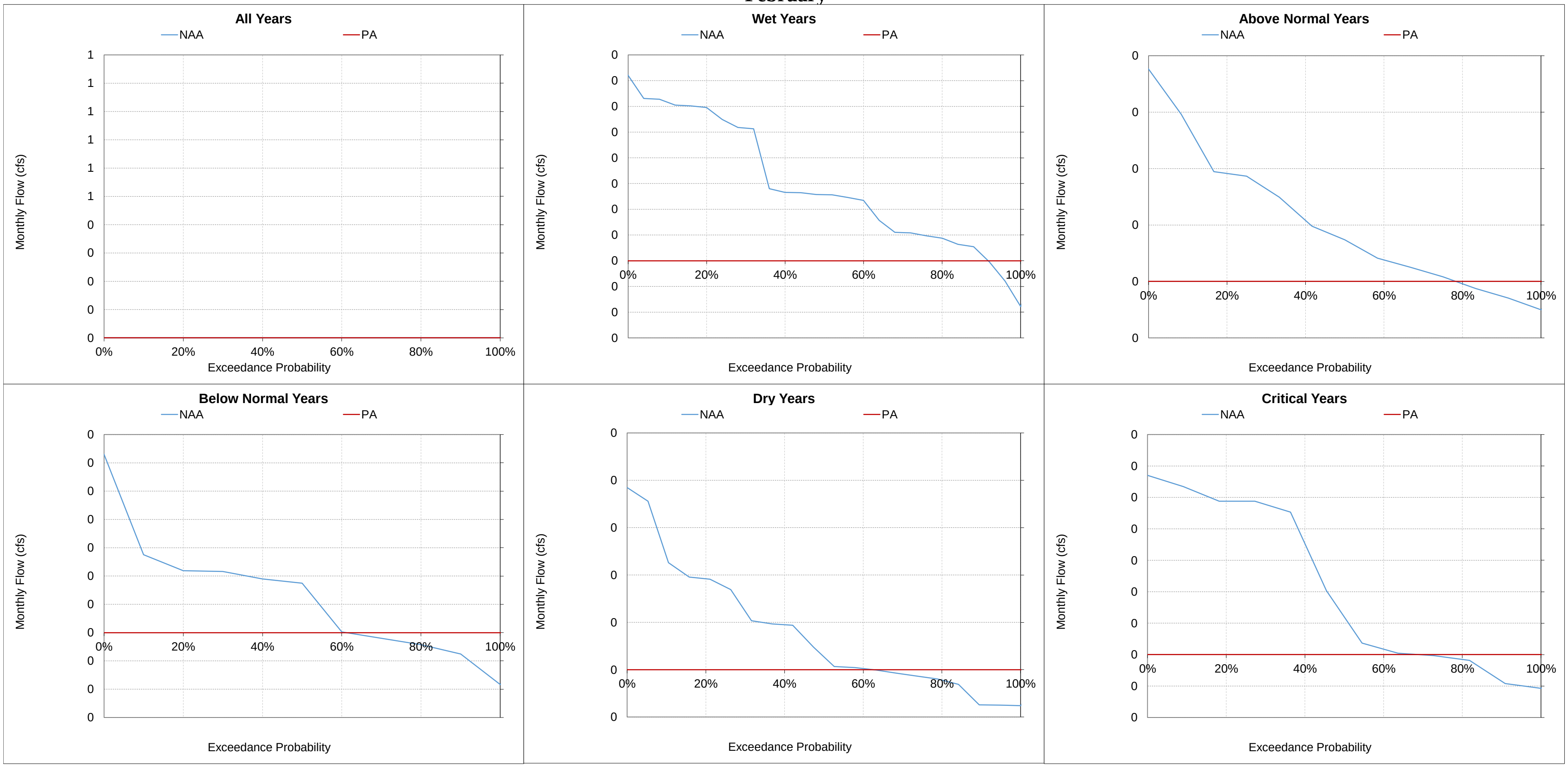
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-4-11. Delta Cross Channel, Monthly Flow
January



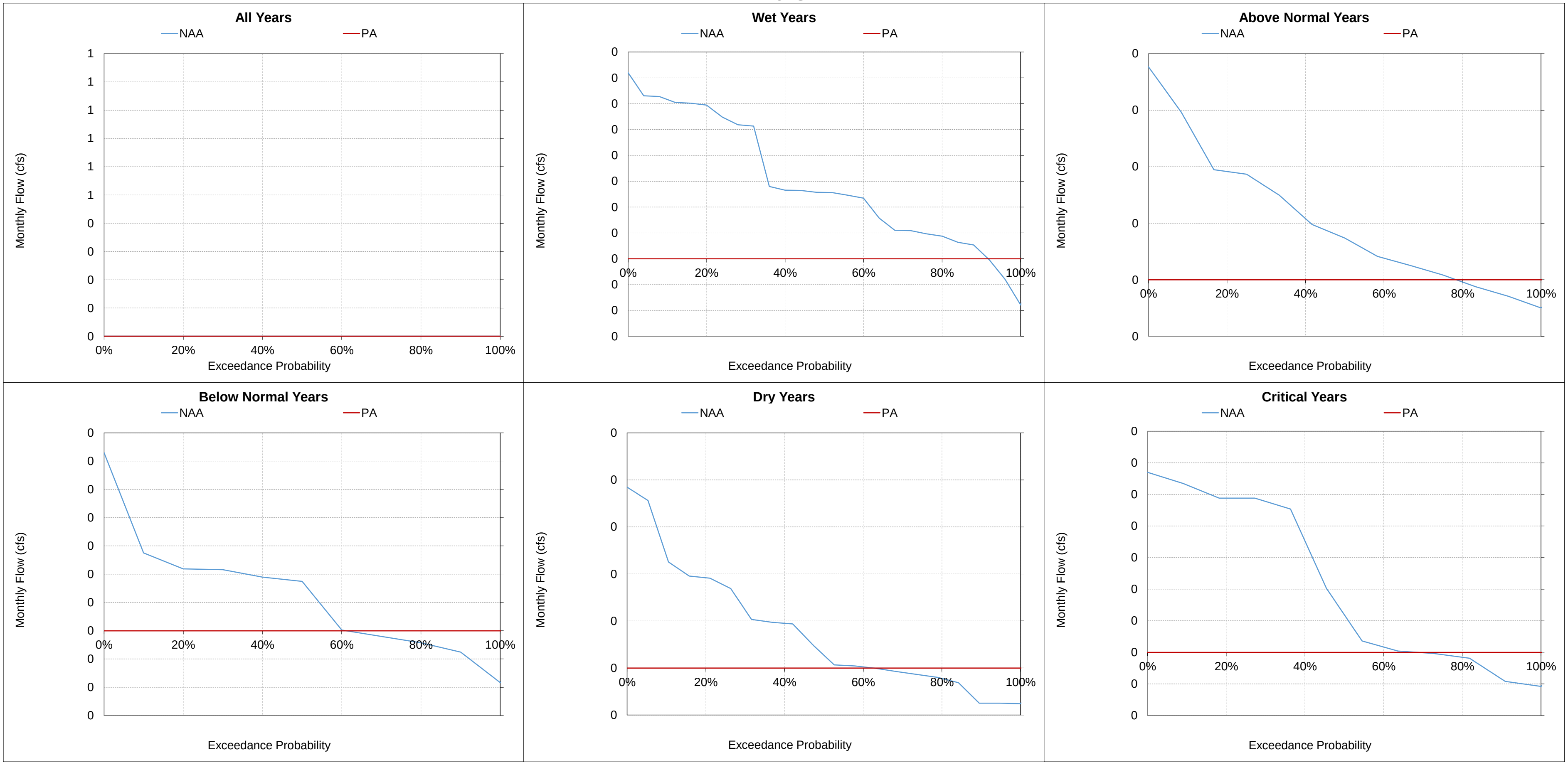
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-4-12. Delta Cross Channel, Monthly Flow
February



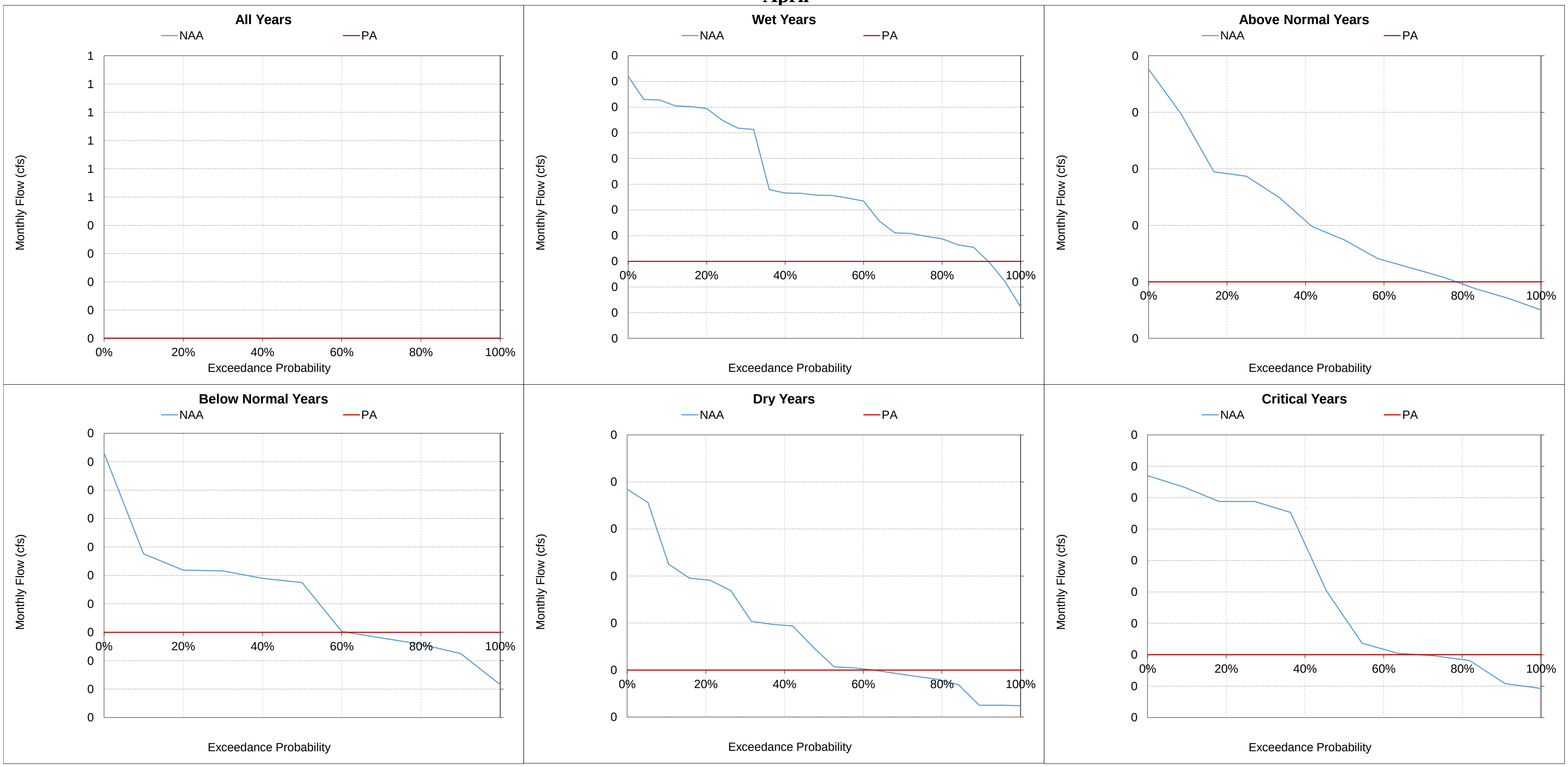
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-4-13. Delta Cross Channel, Monthly Flow
March



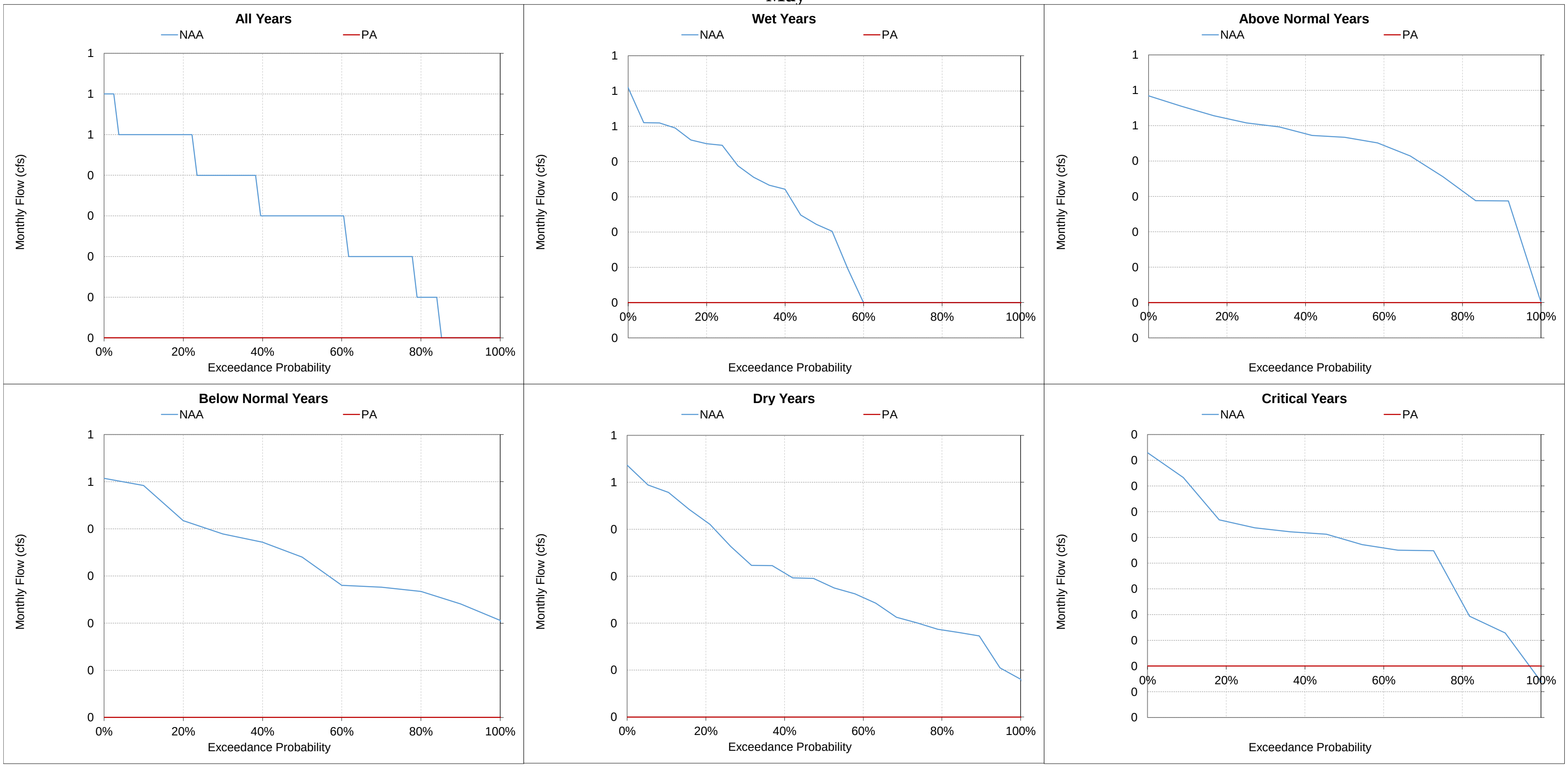
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-4-14. Delta Cross Channel, Monthly Flow April



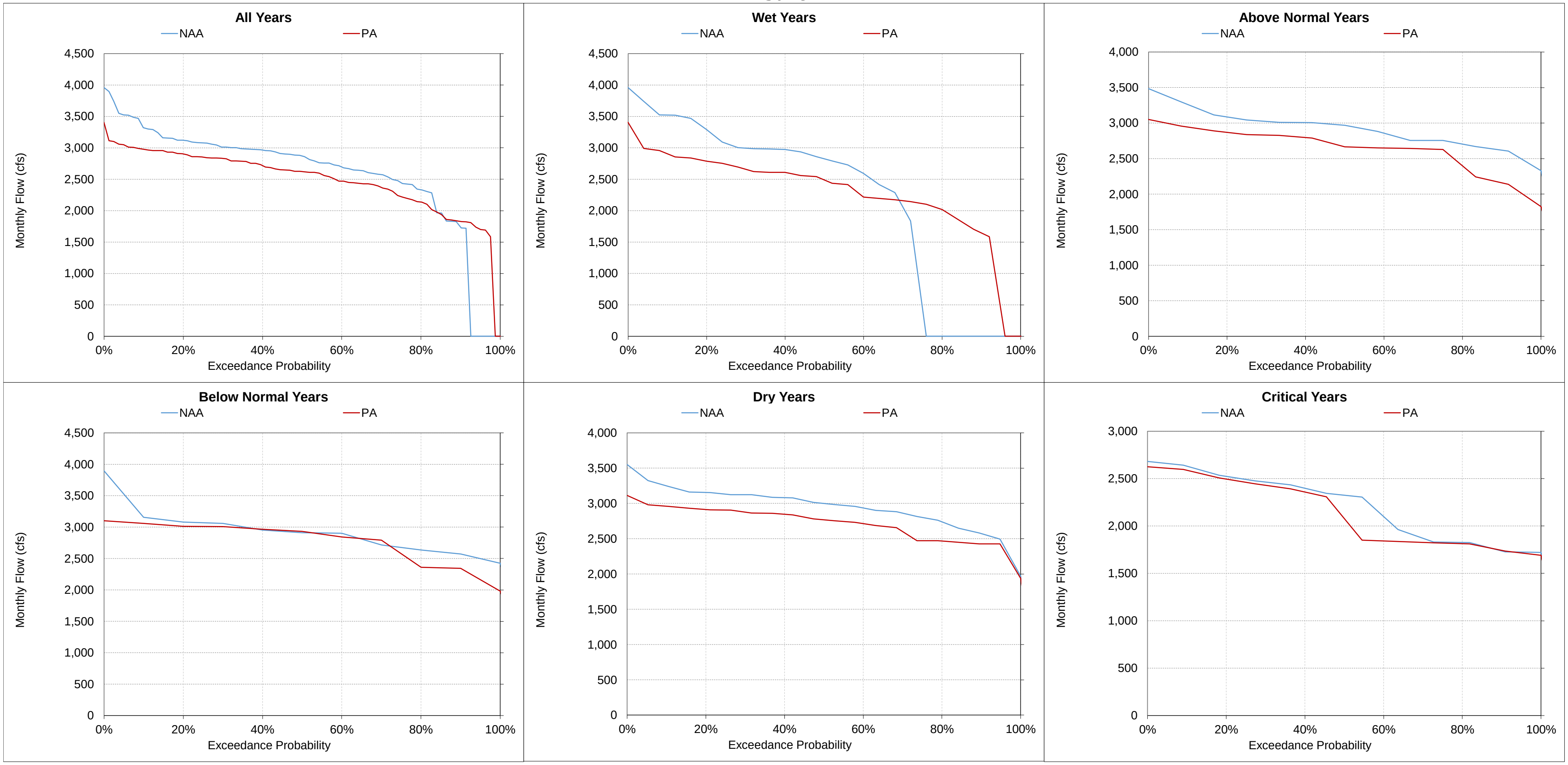
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-4-15. Delta Cross Channel, Monthly Flow
May



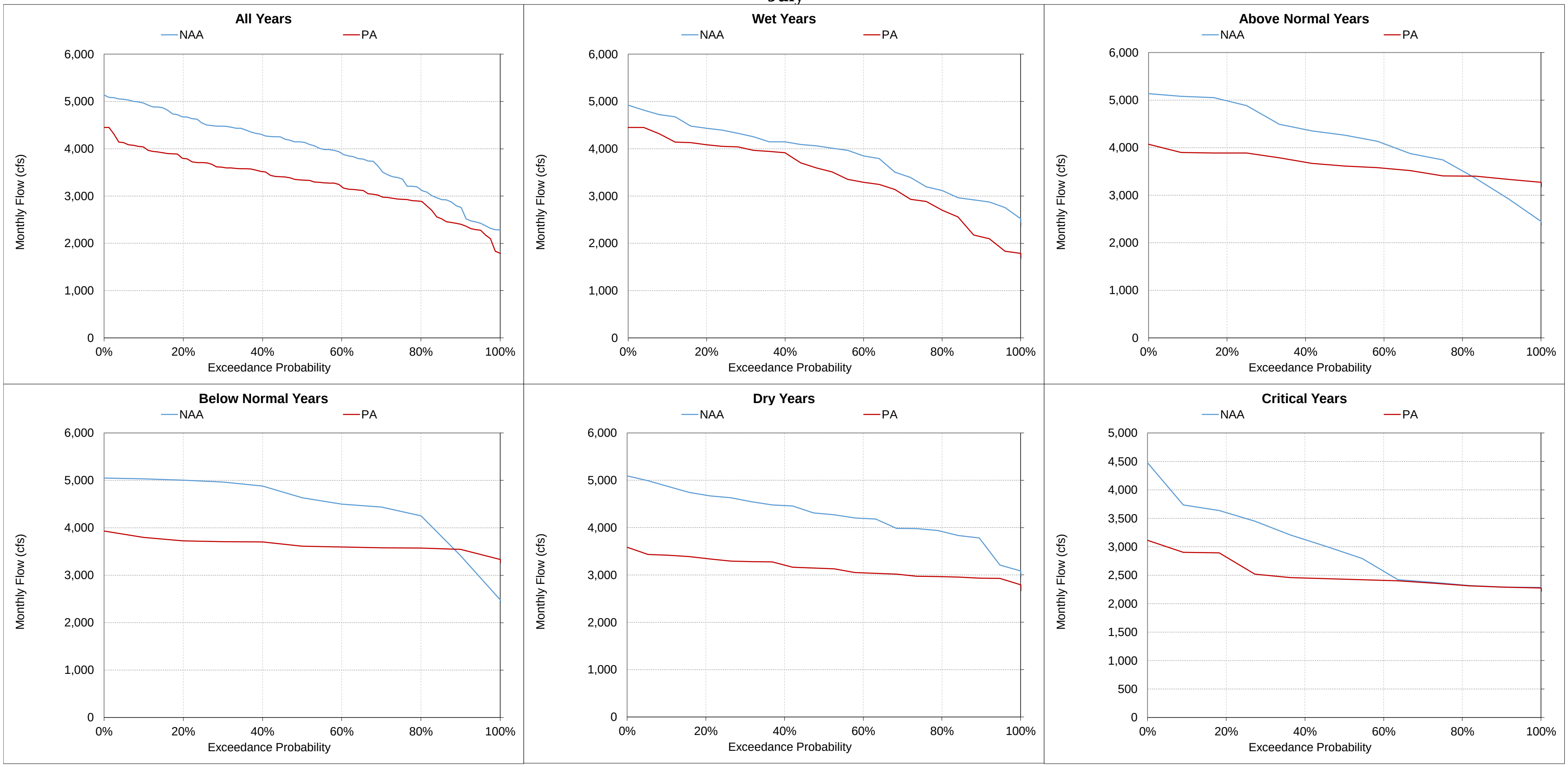
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-4-16. Delta Cross Channel, Monthly Flow
June



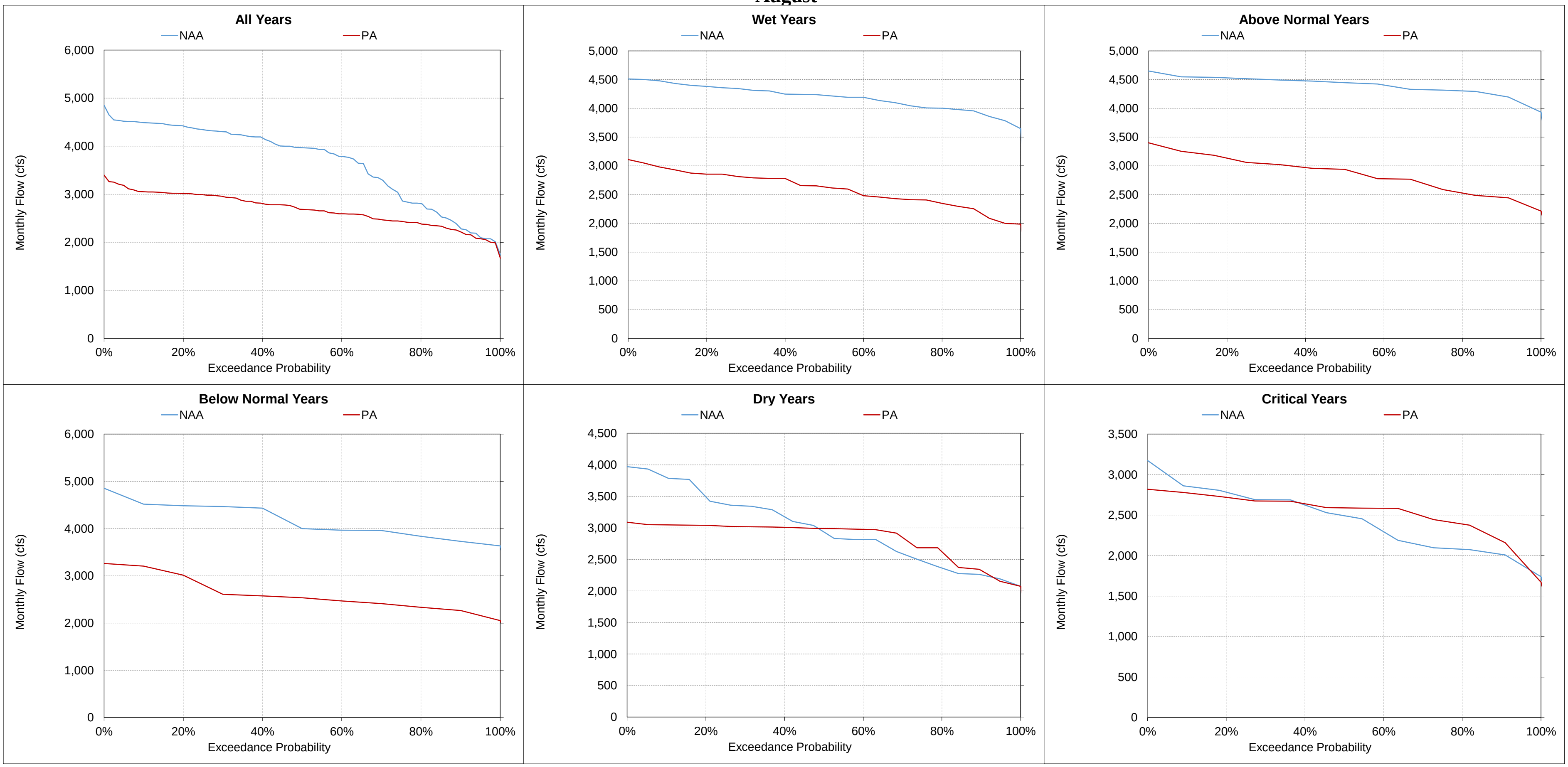
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-4-17. Delta Cross Channel, Monthly Flow
July



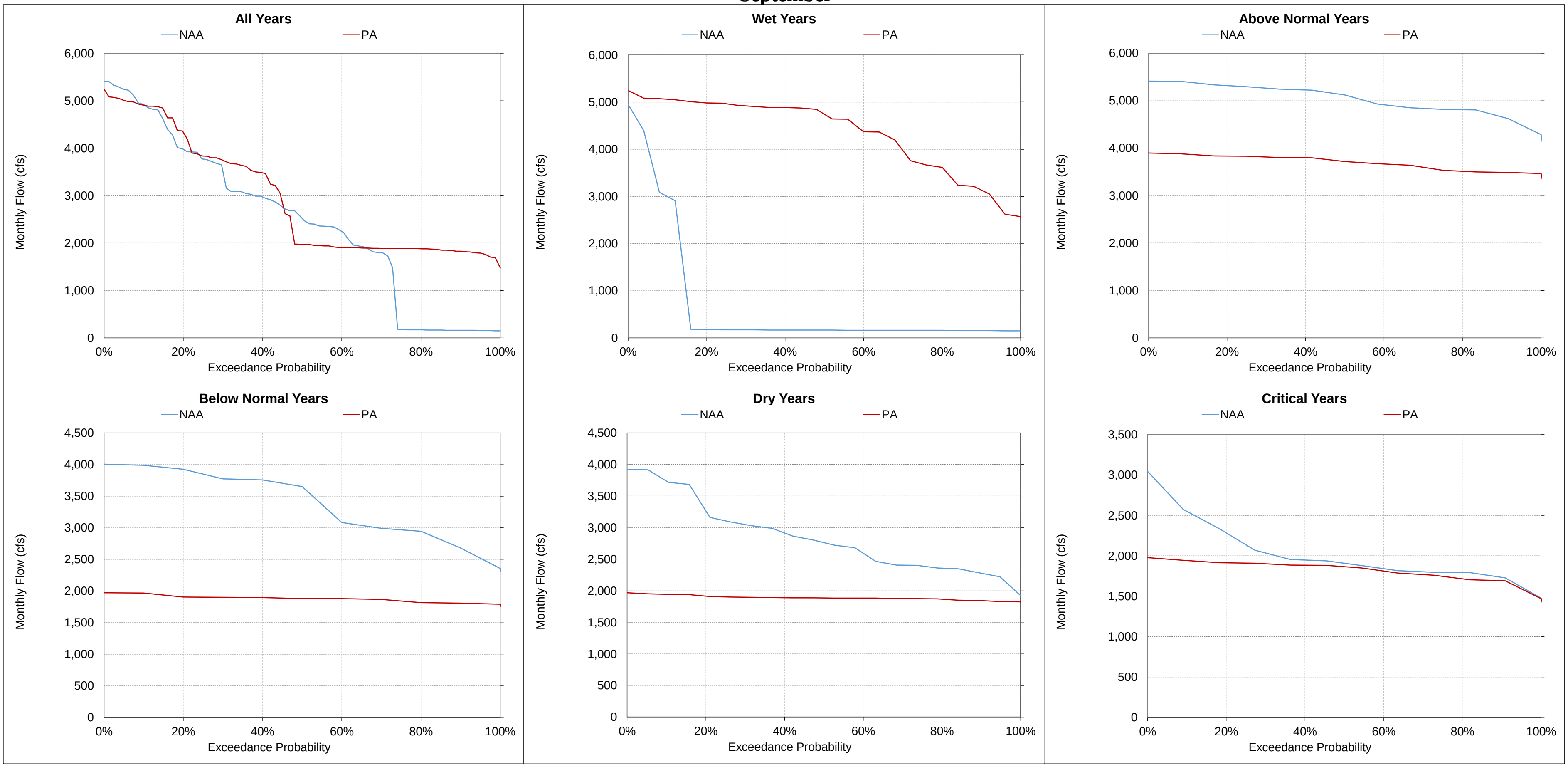
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-4-18. Delta Cross Channel, Monthly Flow
August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-4-19. Delta Cross Channel, Monthly Flow September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-5. Georgiana Slough, Monthly Flow

Statistic	Monthly Flow (cfs)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	2,863	1,811	-1,052	-37%	4,041	3,053	-988	-24%	7,461	6,664	-797	-11%	9,483	8,347	-1,136	-12%	10,427	9,210	-1,217	-12%	9,390	8,309	-1,081	-12%
20%	2,623	1,679	-944	-36%	3,587	2,688	-899	-25%	5,478	5,045	-432	-8%	8,229	7,037	-1,192	-14%	9,347	8,152	-1,195	-13%	7,667	6,504	-1,162	-15%
30%	2,490	1,623	-867	-35%	3,494	2,374	-1,121	-32%	3,914	3,804	-110	-3%	6,046	5,516	-530	-9%	7,607	6,820	-788	-10%	6,108	5,024	-1,085	-18%
40%	2,302	1,607	-694	-30%	3,188	2,200	-988	-31%	3,492	3,388	-103	-3%	4,349	3,827	-522	-12%	6,719	5,869	-851	-13%	5,025	4,001	-1,024	-20%
50%	2,110	1,596	-514	-24%	2,894	1,977	-917	-32%	3,153	2,983	-170	-5%	3,897	3,667	-229	-6%	5,359	4,286	-1,074	-20%	4,253	3,489	-764	-18%
60%	1,884	1,579	-305	-16%	2,563	1,819	-744	-29%	3,012	2,754	-259	-9%	3,512	3,301	-211	-6%	4,399	3,738	-661	-15%	3,826	3,236	-590	-15%
70%	1,767	1,563	-204	-12%	2,228	1,798	-430	-19%	2,845	2,685	-159	-6%	3,108	2,983	-125	-4%	3,636	3,331	-305	-8%	3,569	3,047	-522	-15%
80%	1,668	1,527	-141	-8%	1,952	1,754	-198	-10%	2,355	2,295	-60	-3%	2,943	2,805	-138	-5%	3,249	3,031	-218	-7%	3,159	2,822	-338	-11%
90%	1,391	1,350	-41	-3%	1,749	1,693	-55	-3%	2,099	2,070	-30	-1%	2,739	2,643	-96	-4%	3,035	2,863	-172	-6%	2,679	2,582	-97	-4%
Long Term Full Simulation Period[b]	2,160	1,640	-520	-24%	2,997	2,345	-652	-22%	4,007	3,748	-258	-6%	5,138	4,637	-501	-10%	6,058	5,366	-692	-11%	5,246	4,546	-700	-13%
Water Year Types[c]																								
Wet (32%)	2,668	1,707	-961	-36%	3,734	2,794	-940	-25%	4,376	4,070	-306	-7%	5,329	4,801	-527	-10%	8,629	7,555	-1,074	-12%	7,447	6,360	-1,087	-15%
Above Normal (16%)	2,407	1,721	-687	-29%	3,398	2,207	-1,190	-35%	4,044	3,765	-279	-7%	4,952	4,498	-454	-9%	7,236	6,348	-887	-12%	6,544	5,608	-936	-14%
Below Normal (13%)	2,185	1,820	-365	-17%	2,502	1,991	-510	-20%	3,693	3,502	-191	-5%	4,896	4,435	-461	-9%	5,042	4,514	-529	-10%	3,600	3,134	-466	-13%
Dry (24%)	1,802	1,607	-195	-11%	2,835	2,438	-398	-14%	4,511	4,193	-318	-7%	5,594	4,972	-622	-11%	4,206	3,773	-433	-10%	3,921	3,397	-523	-13%
Critical (15%)	1,370	1,298	-72	-5%	1,693	1,694	1	0%	2,613	2,517	-96	-4%	4,389	4,059	-330	-8%	3,227	2,994	-233	-7%	2,788	2,673	-115	-4%

Statistic	Monthly Flow (cfs)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	7,240	6,641	-599	-8%	5,994	5,348	-646	-11%	3,273	2,391	-882	-27%	3,729	2,590	-1,139	-31%	2,798	2,045	-753	-27%	4,853	3,162	-1,691	-35%
20%	5,266	4,817	-449	-9%	4,360	4,109	-251	-6%	2,675	2,313	-362	-14%	3,596	2,428	-1,168	-32%	2,766	2,019	-747	-27%	4,746	3,027	-1,719	-36%
30%	4,060	3,884	-176	-4%	3,210	3,055	-155	-5%	2,440	2,240	-200	-8%	3,353	2,369	-984	-29%	2,703	1,984	-719	-27%	3,323	2,677	-646	-19%
40%	3,627	3,465	-162	-4%	2,835	2,722	-113	-4%	2,387	2,194	-193	-8%	3,085	2,304	-780	-25%	2,660	1,928	-732	-28%	3,153	2,344	-809	-26%
50%	3,196	3,103	-94	-3%	2,737	2,601	-136	-5%	2,345	2,157	-188	-8%	2,923	2,228	-696	-24%	2,546	1,876	-670	-26%	2,489	1,501	-988	-40%
60%	2,820	2,756	-64	-2%	2,625	2,541	-84	-3%	2,276	2,118	-157	-7%	2,833	2,165	-668	-24%	2,431	1,805	-626	-26%	2,208	1,470	-738	-33%
70%	2,640	2,623	-17	-1%	2,576	2,446	-131	-5%	2,237	2,062	-175	-8%	2,715	2,082	-633	-23%	2,164	1,731	-433	-20%	1,998	1,459	-539	-27%
80%	2,581	2,521	-60	-2%	2,454	2,380	-73	-3%	2,081	1,965	-115	-6%	2,544	1,993	-550	-22%	1,904	1,684	-220	-12%	1,773	1,439	-334	-19%
90%	2,437	2,392	-45	-2%	2,299	2,236	-63	-3%	1,952	1,702	-250	-13%	2,167	1,780	-387	-18%	1,661	1,609	-52	-3%	1,533	1,408	-125	-8%
Long Term Full Simulation Period[b]	3,989	3,811	-178	-4%	3,420	3,208	-212	-6%	2,591	2,247	-343	-13%	2,969	2,213	-757	-25%	2,383	1,848	-534	-22%	2,961	2,104	-857	-29%
Water Year Types[c]																								
Wet (32%)	5,706	5,329	-376	-7%	4,940	4,475	-465	-9%	3,362	2,621	-741	-22%	3,176	2,316	-860	-27%	2,679	1,831	-848	-32%	4,606	3,077	-1,528	-33%
Above Normal (16%)	4,251	4,090	-161	-4%	3,283	3,076	-207	-6%	2,420	2,137	-283	-12%	3,450	2,377	-1,073	-31%	2,763	1,918	-845	-31%	3,130	2,368	-762	-24%
Below Normal (13%)	2,925	2,856	-69	-2%	2,750	2,671	-79	-3%	2,317	2,195	-122	-5%	3,320	2,364	-956	-29%	2,613	1,772	-840	-32%	2,228	1,439	-790	-35%
Dry (24%)	3,059	2,978	-81	-3%	2,663	2,606	-57	-2%	2,295	2,136	-159	-7%	2,741	2,123	-618	-23%	2,015	1,920	-96	-5%	1,972	1,454	-518	-26%
Critical (15%)	2,508	2,479	-29	-1%	2,150	2,102	-47	-2%	1,851	1,792	-59	-3%	2,060	1,822	-238	-12%	1,731	1,761	30	2%	1,537	1,405	-132	-9%

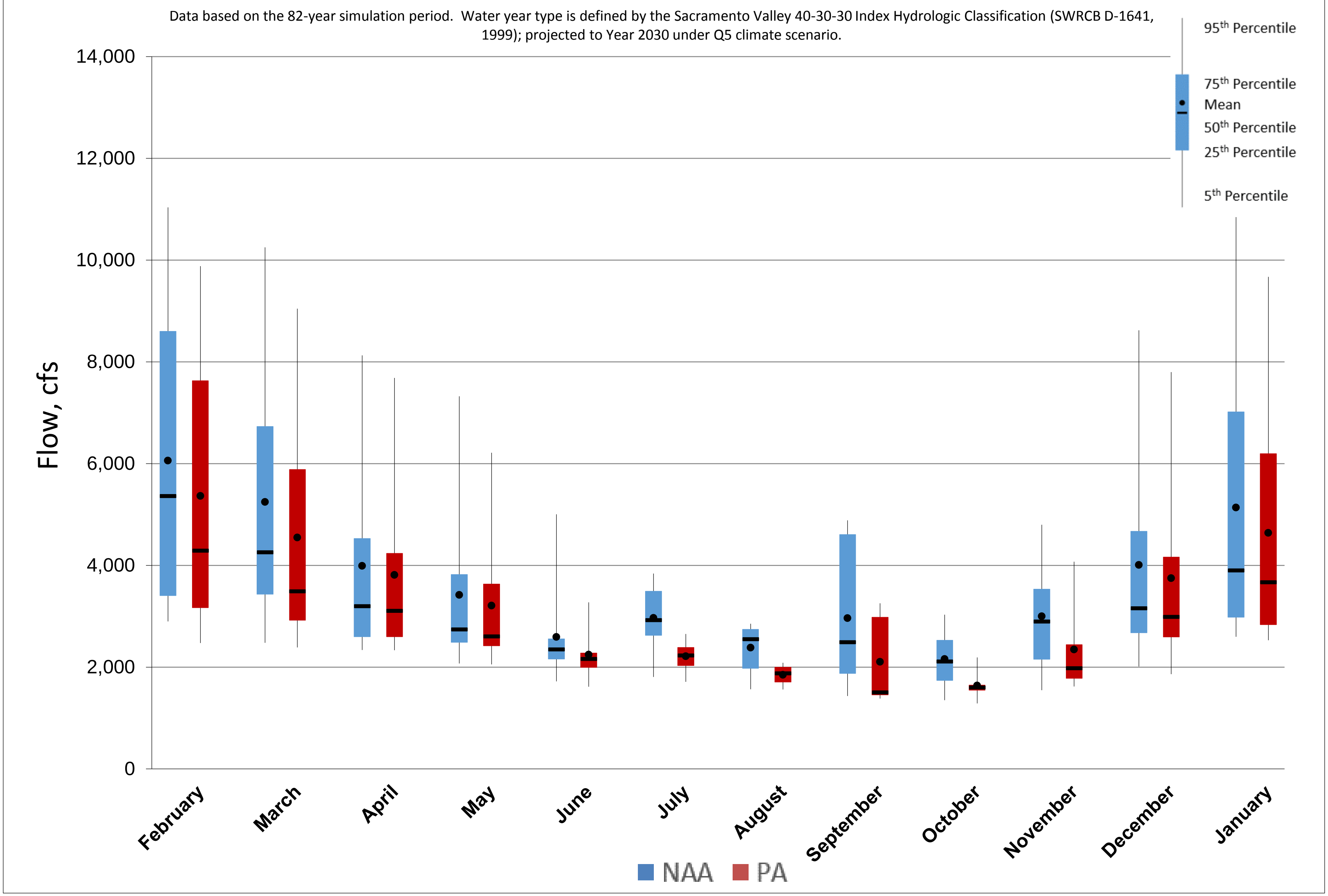
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-5-1. Monthly Flow Ranges For Georgiana Slough, All Years



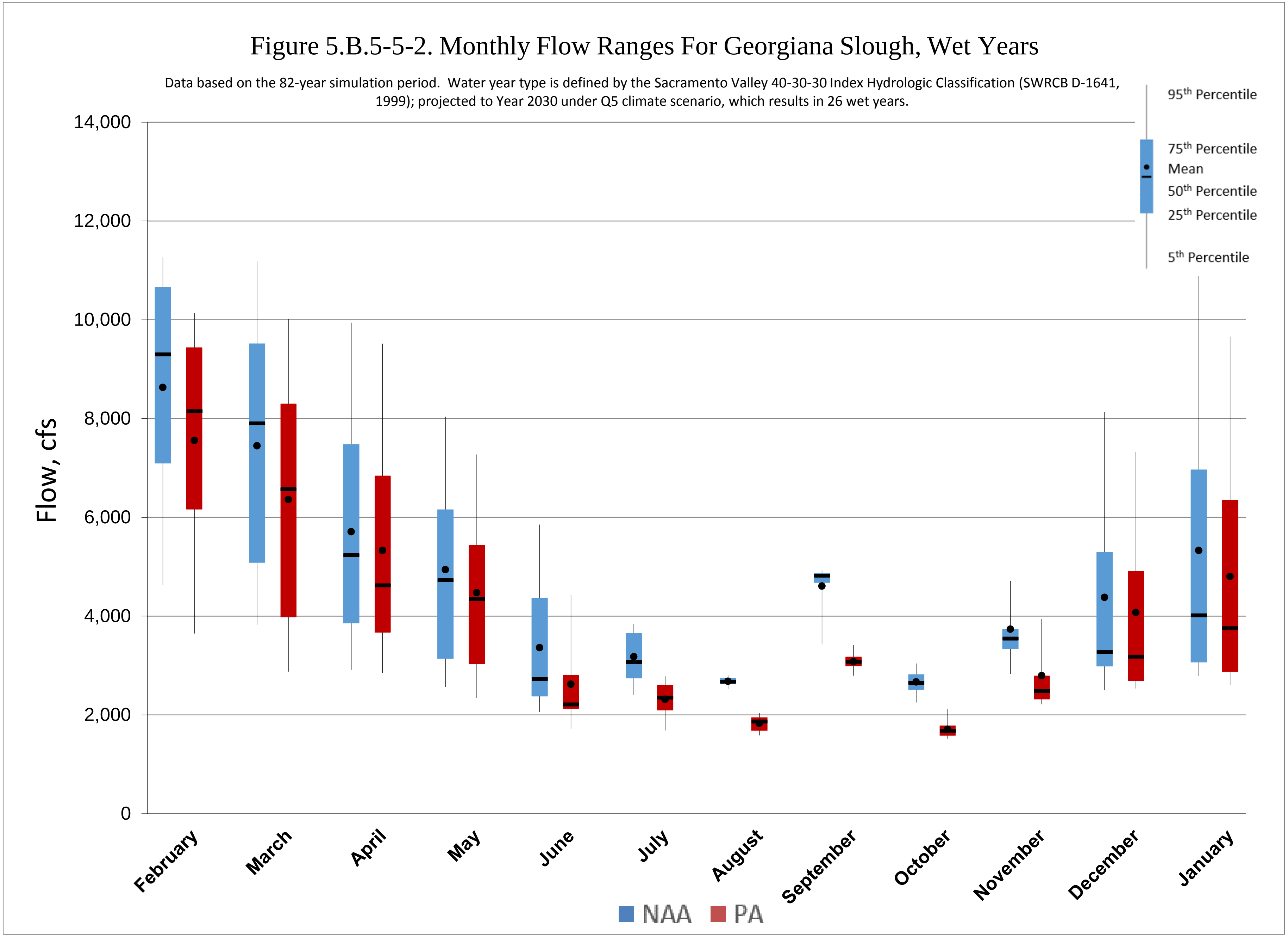


Figure 5.B.5-5-2. Monthly Flow Ranges For Georgiana Slough, Wet Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 26 wet years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
Flow, cfs
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-5-3. Monthly Flow Ranges For Georgiana Slough, Above Normal Years

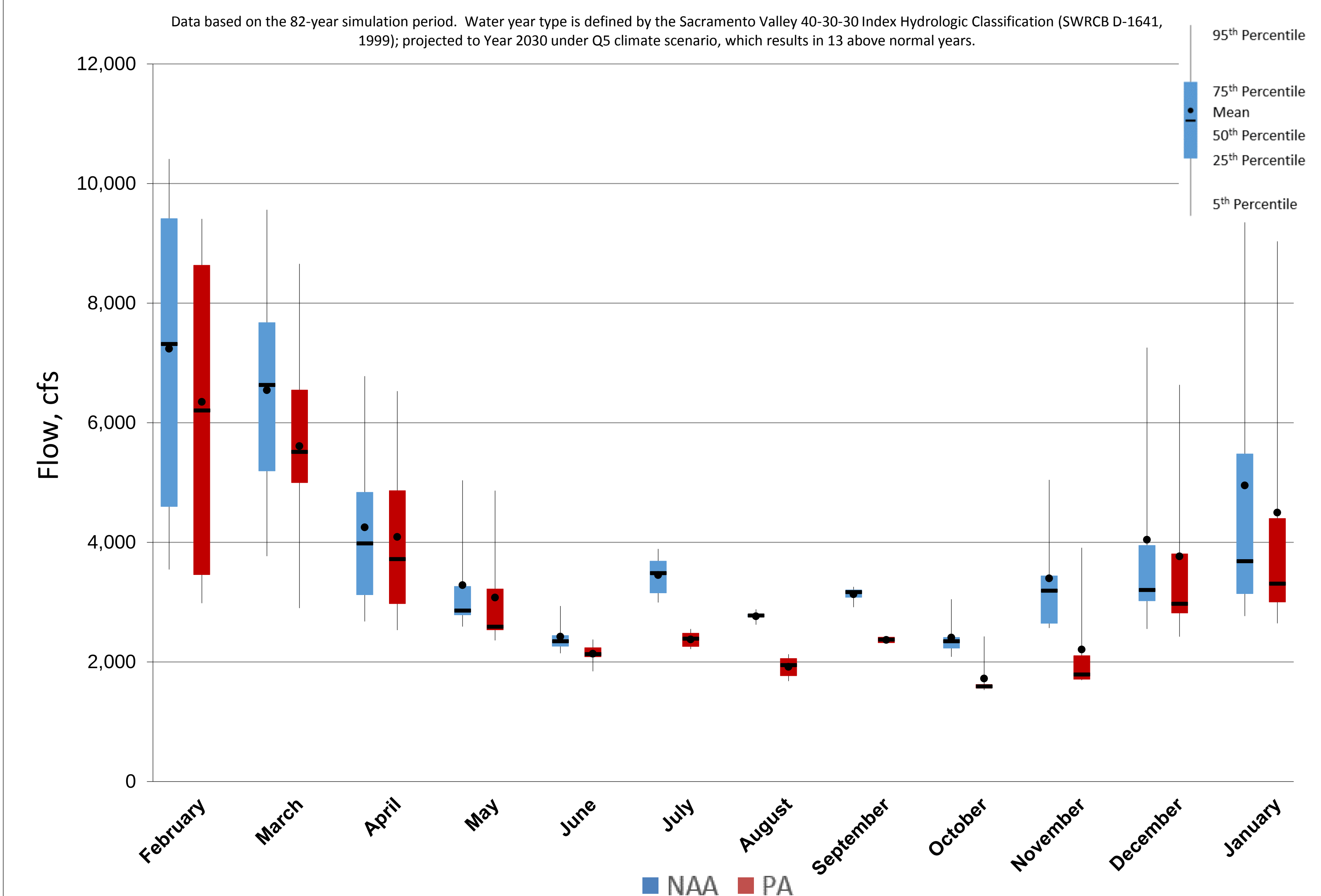
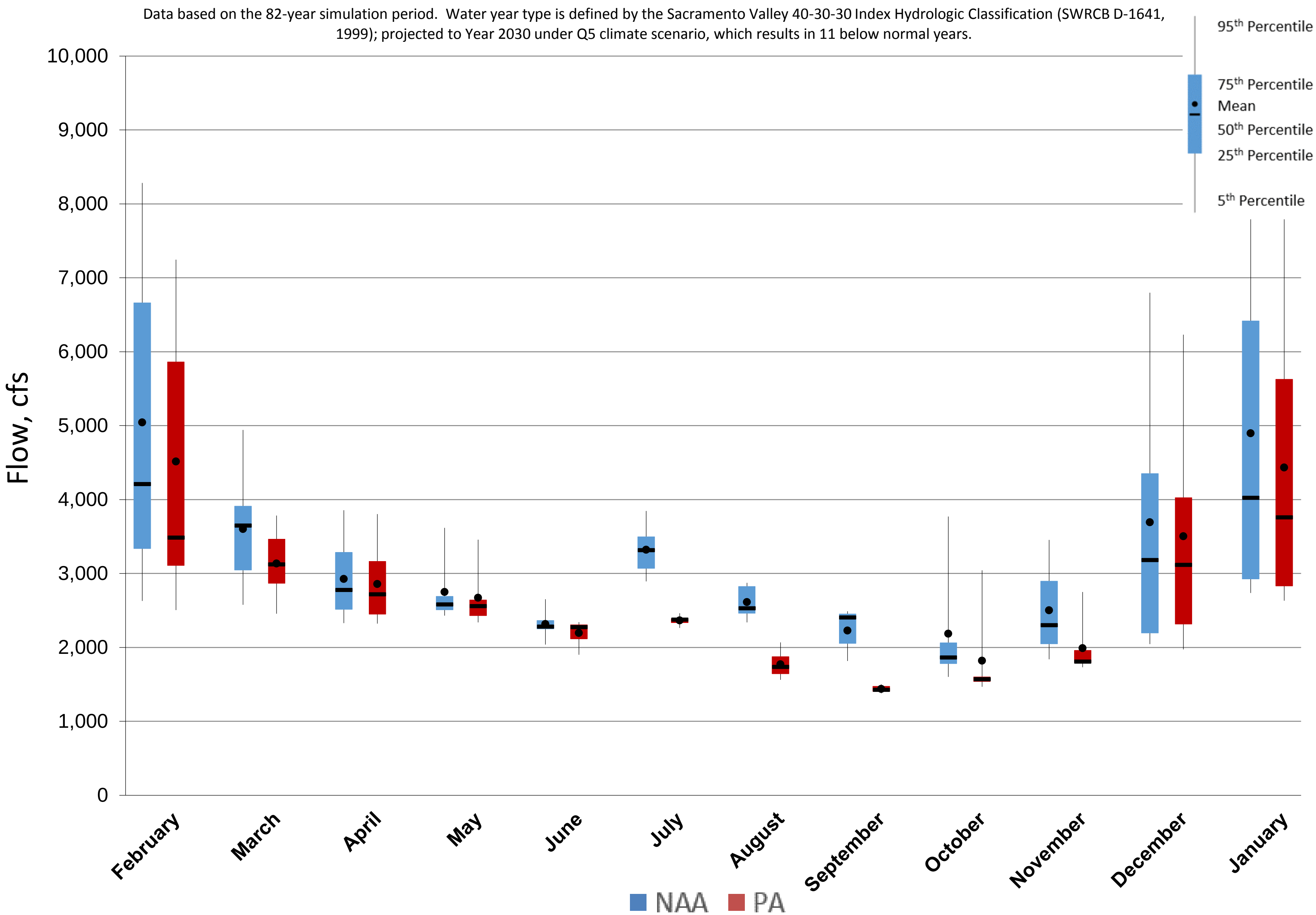


Figure 5.B.5-5-4. Monthly Flow Ranges For Georgiana Slough, Below Normal Years



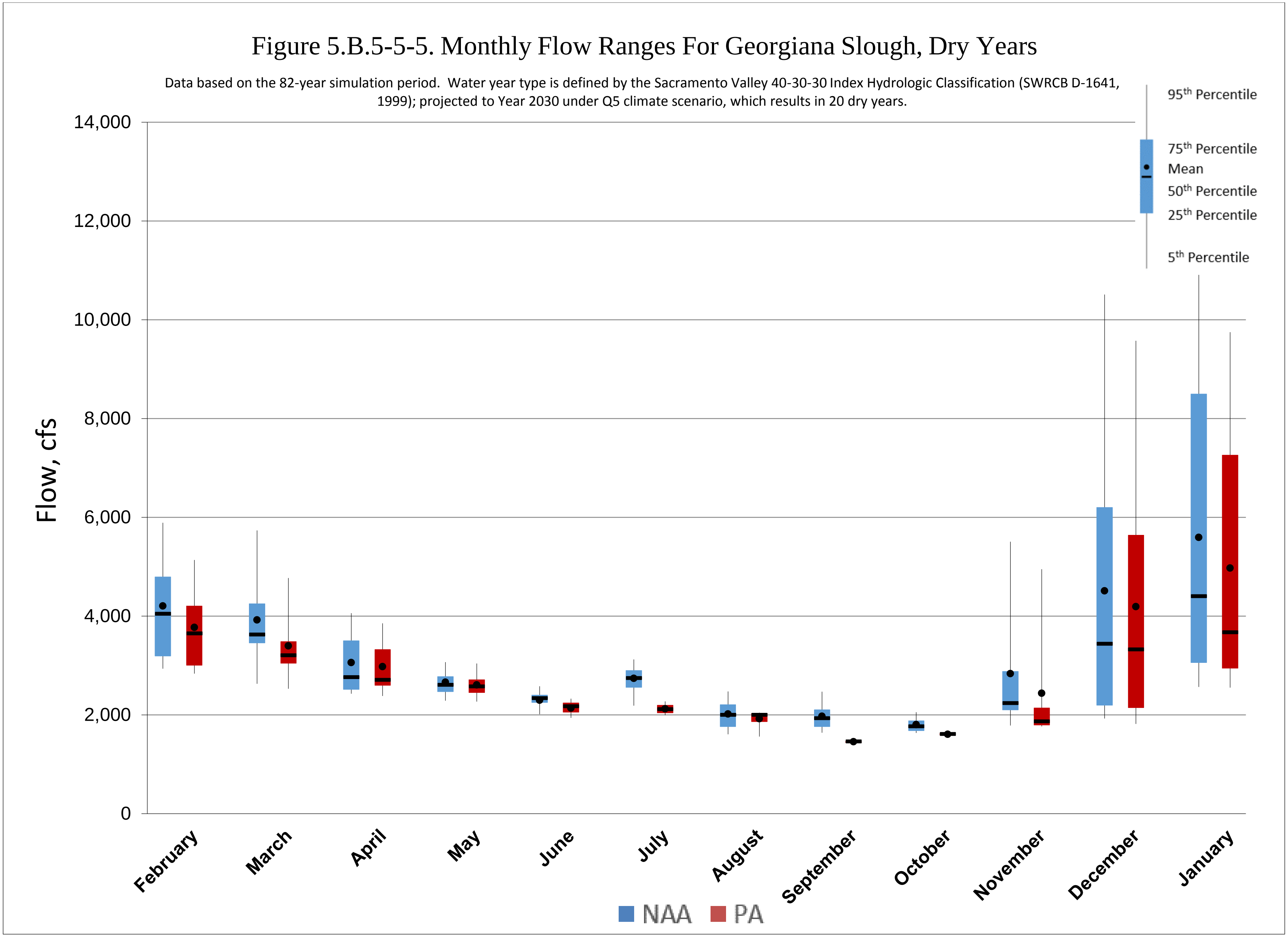


Figure 5.B.5-5-5. Monthly Flow Ranges For Georgiana Slough, Dry Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 20 dry years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
Flow, cfs
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-5-6. Monthly Flow Ranges For Georgiana Slough, Critical Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 12 critical years.

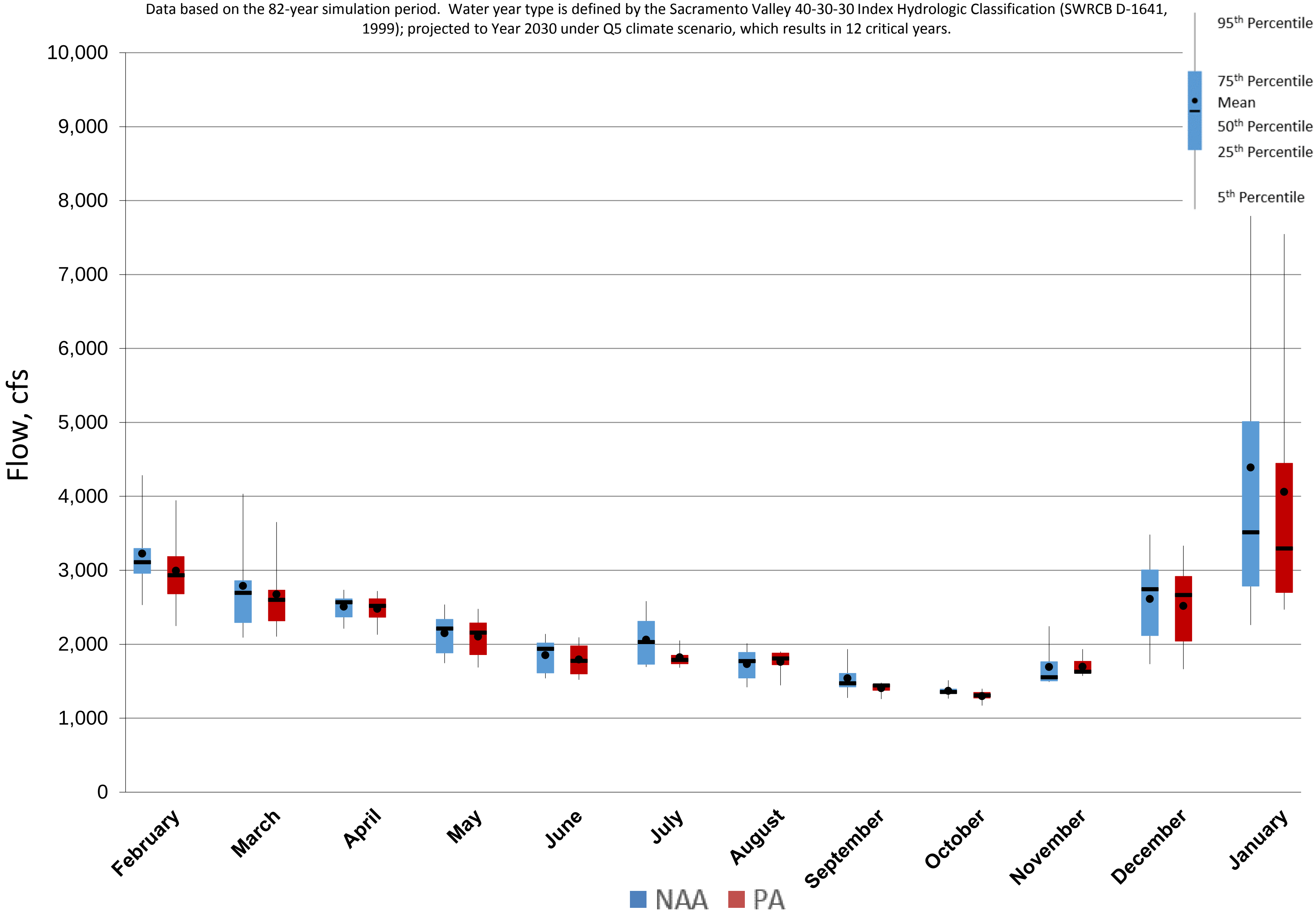
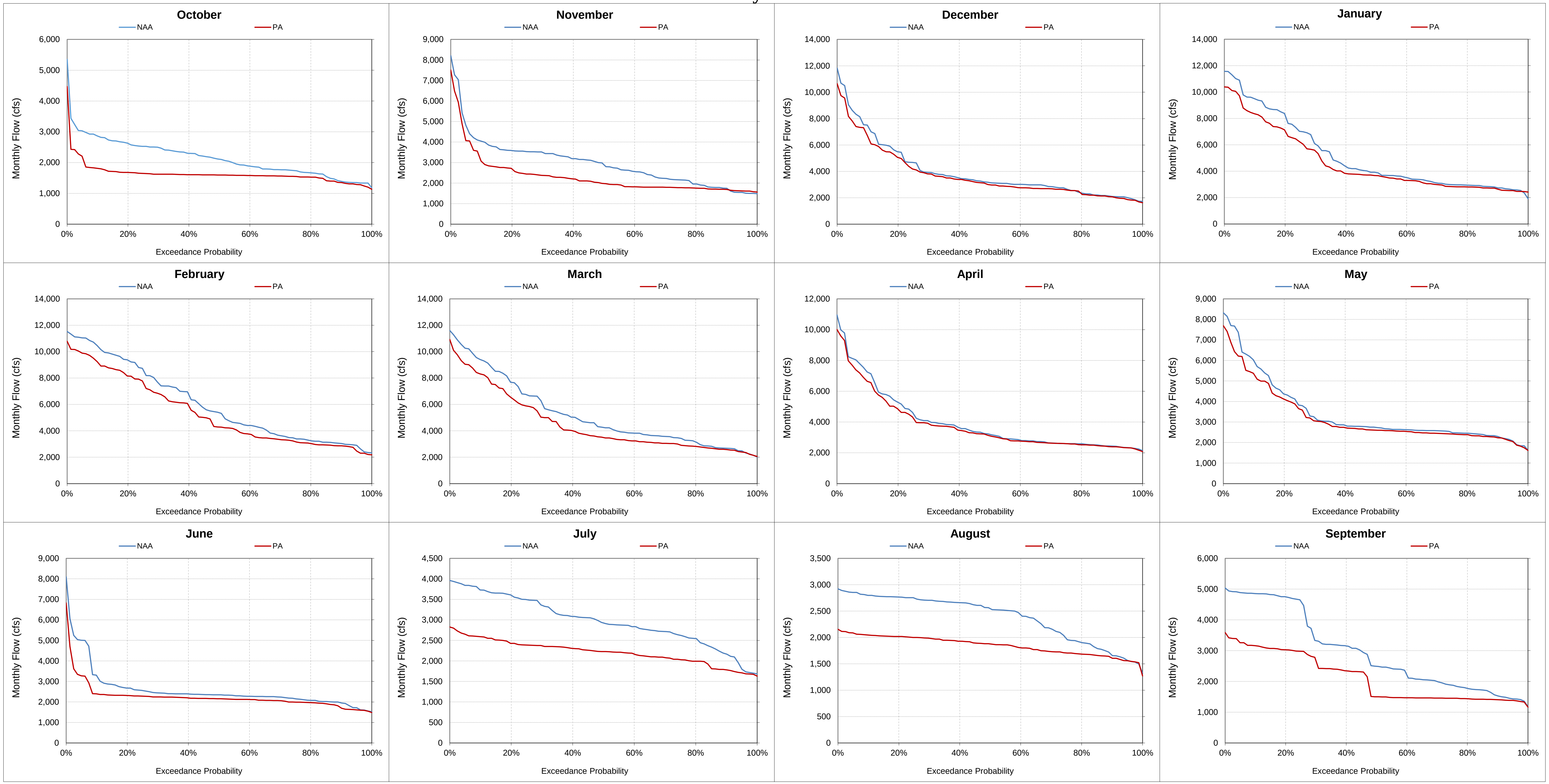
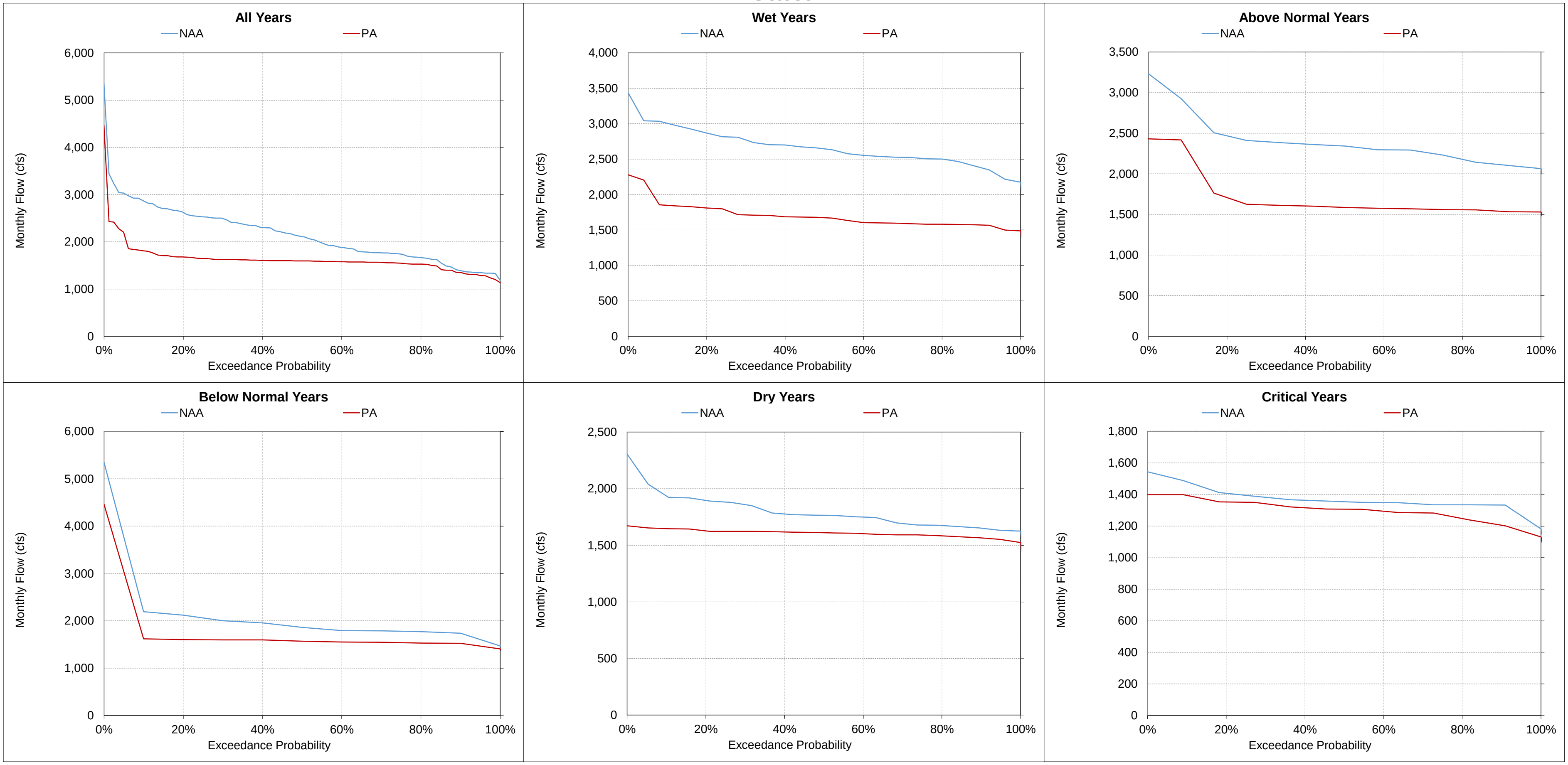


Figure 5.B.5-5-7. Georgiana Slough, Monthly Flow Probability of Exceedance



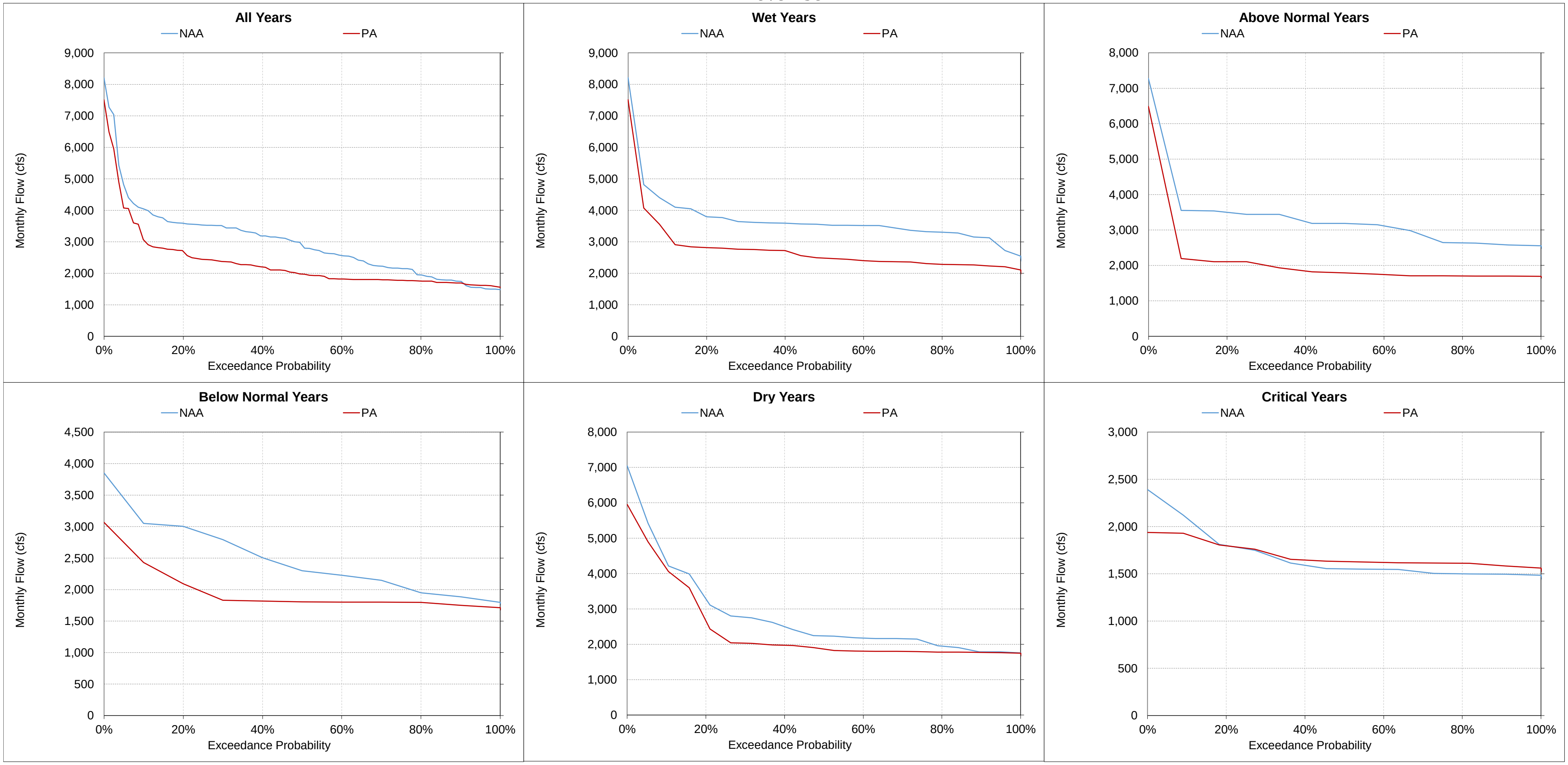
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-5-8. Georgiana Slough, Monthly Flow
October



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-5-9. Georgiana Slough, Monthly Flow November



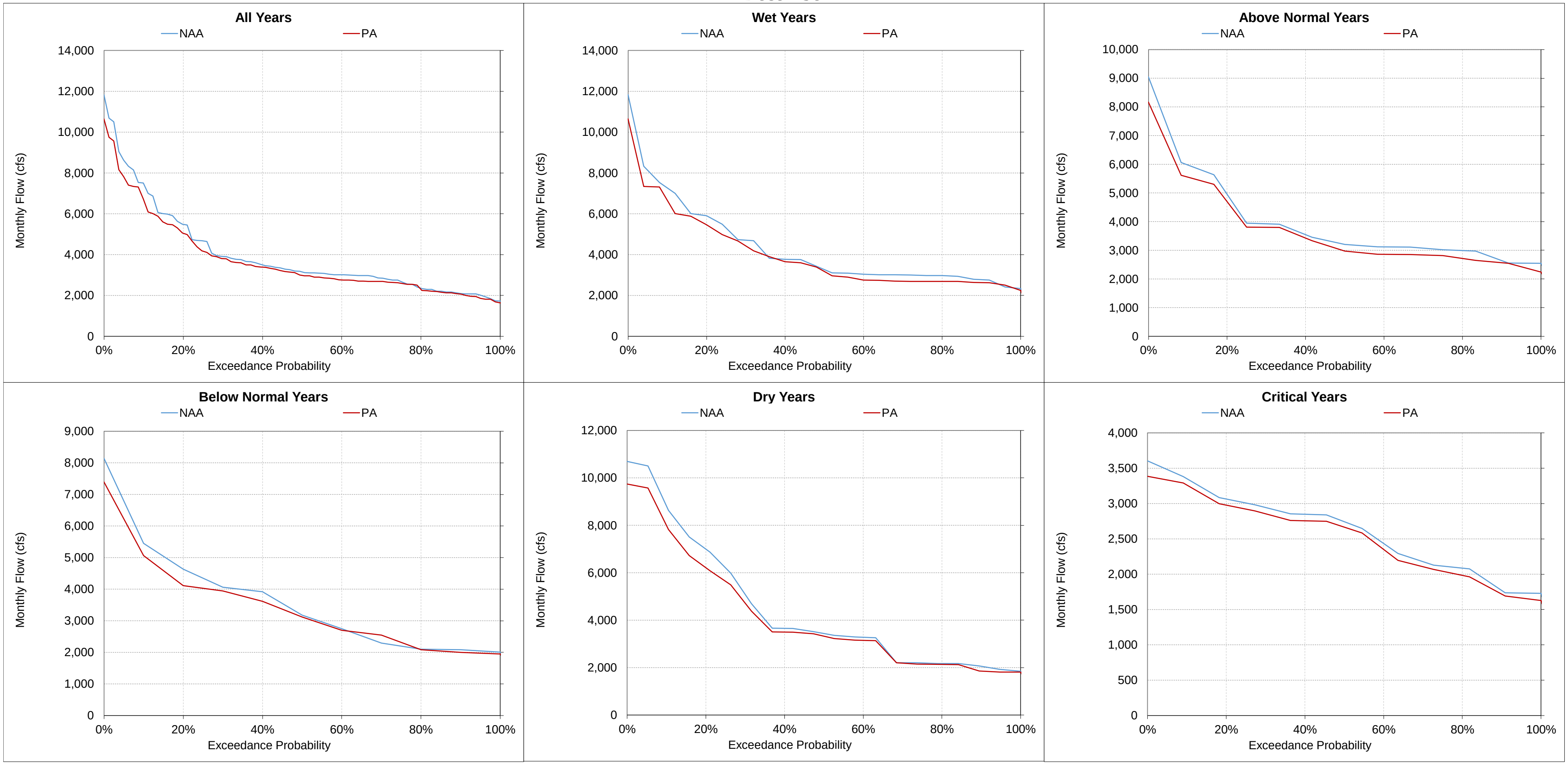
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

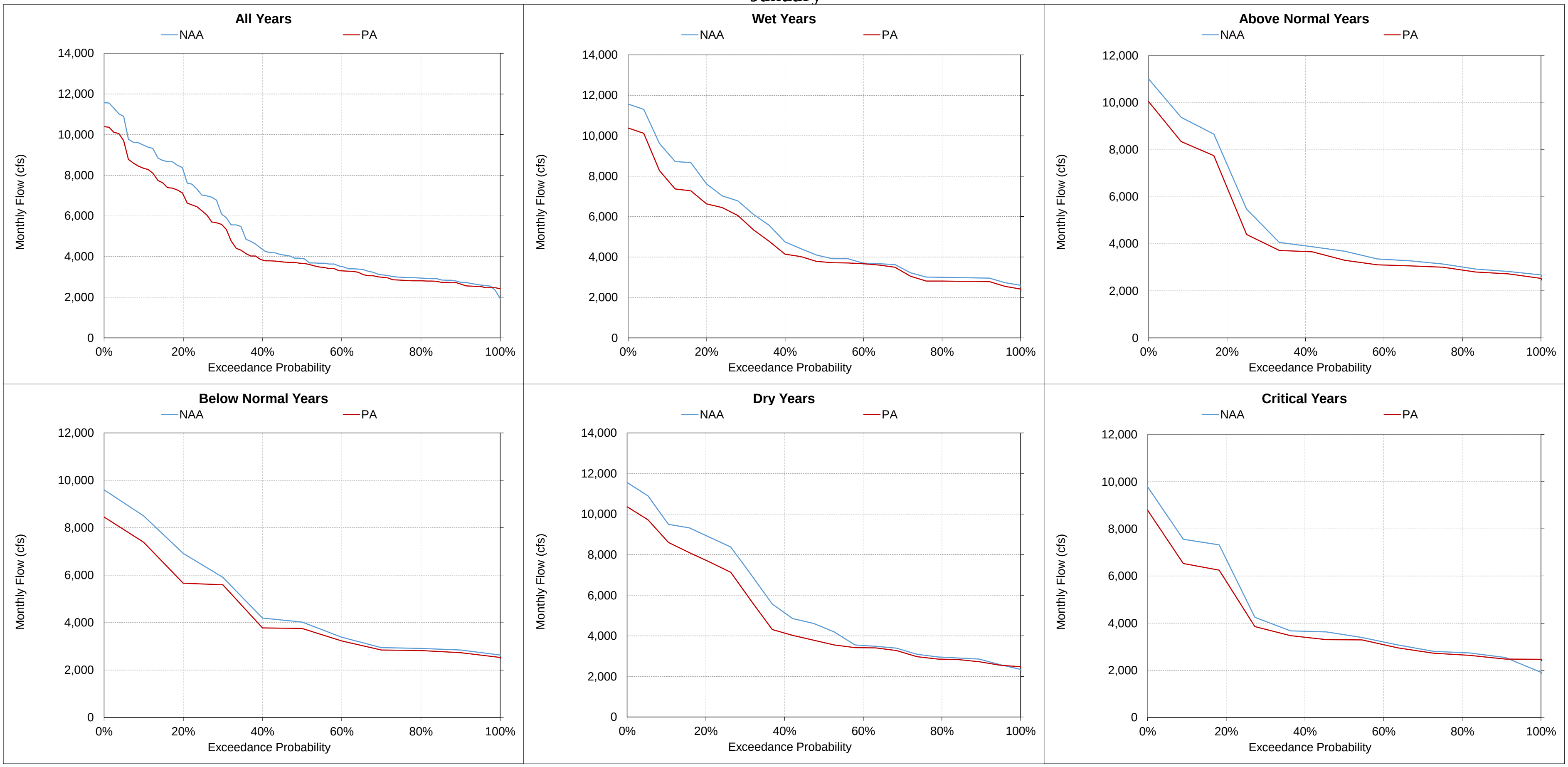
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-5-10. Georgiana Slough, Monthly Flow December



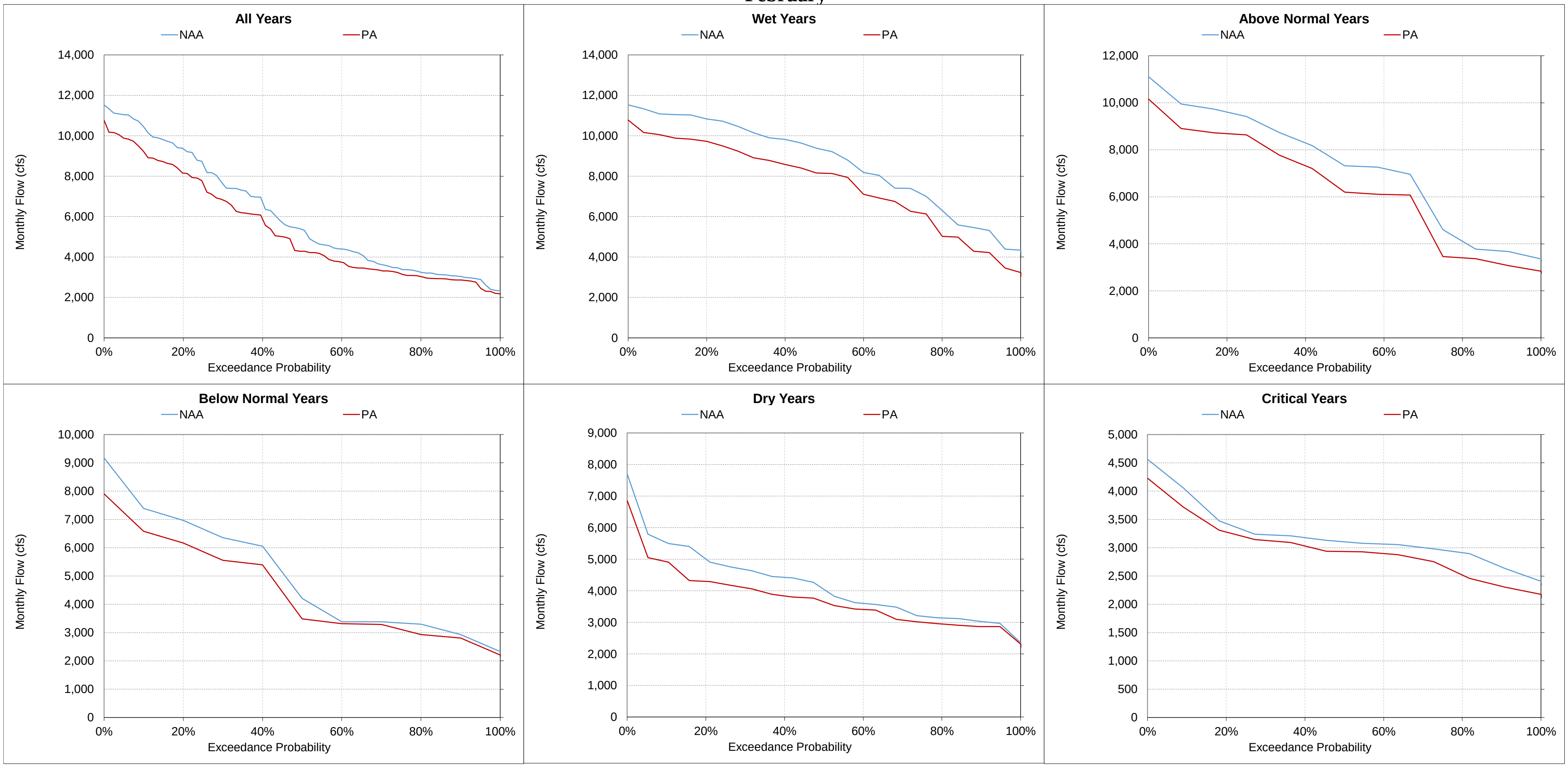
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-5-11. Georgiana Slough, Monthly Flow
January



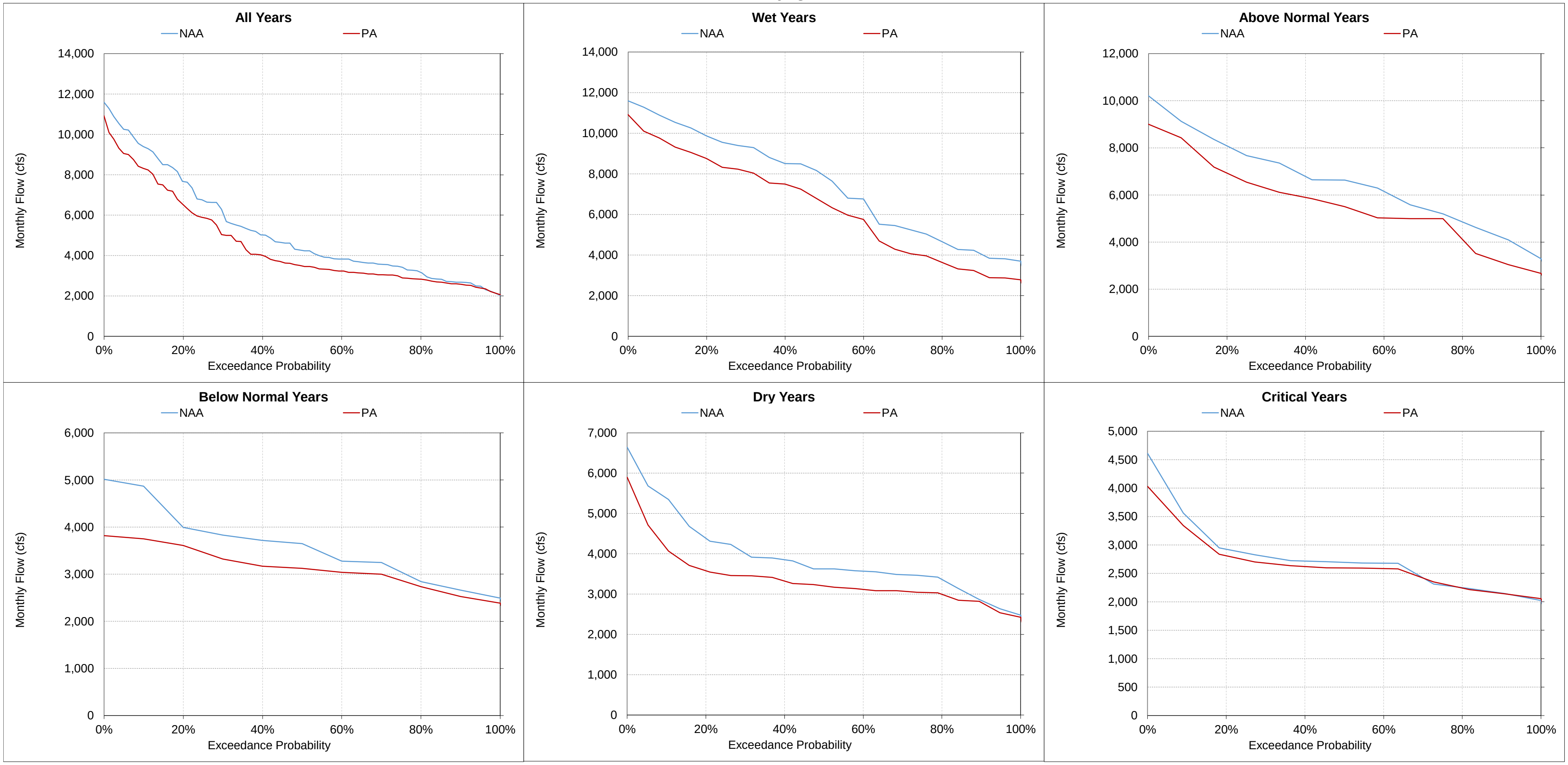
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-5-12. Georgiana Slough, Monthly Flow
February



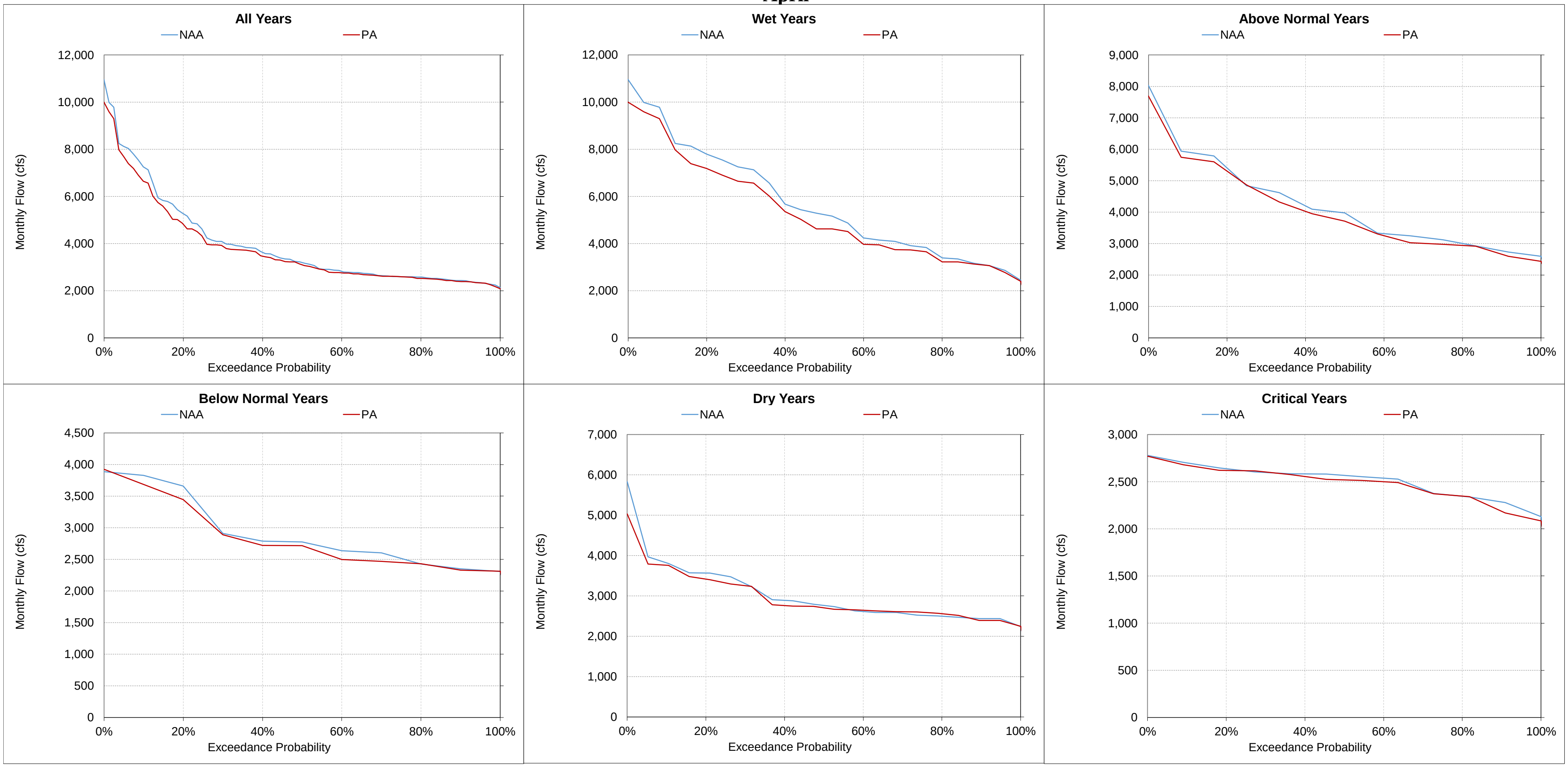
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-5-13. Georgiana Slough, Monthly Flow
March



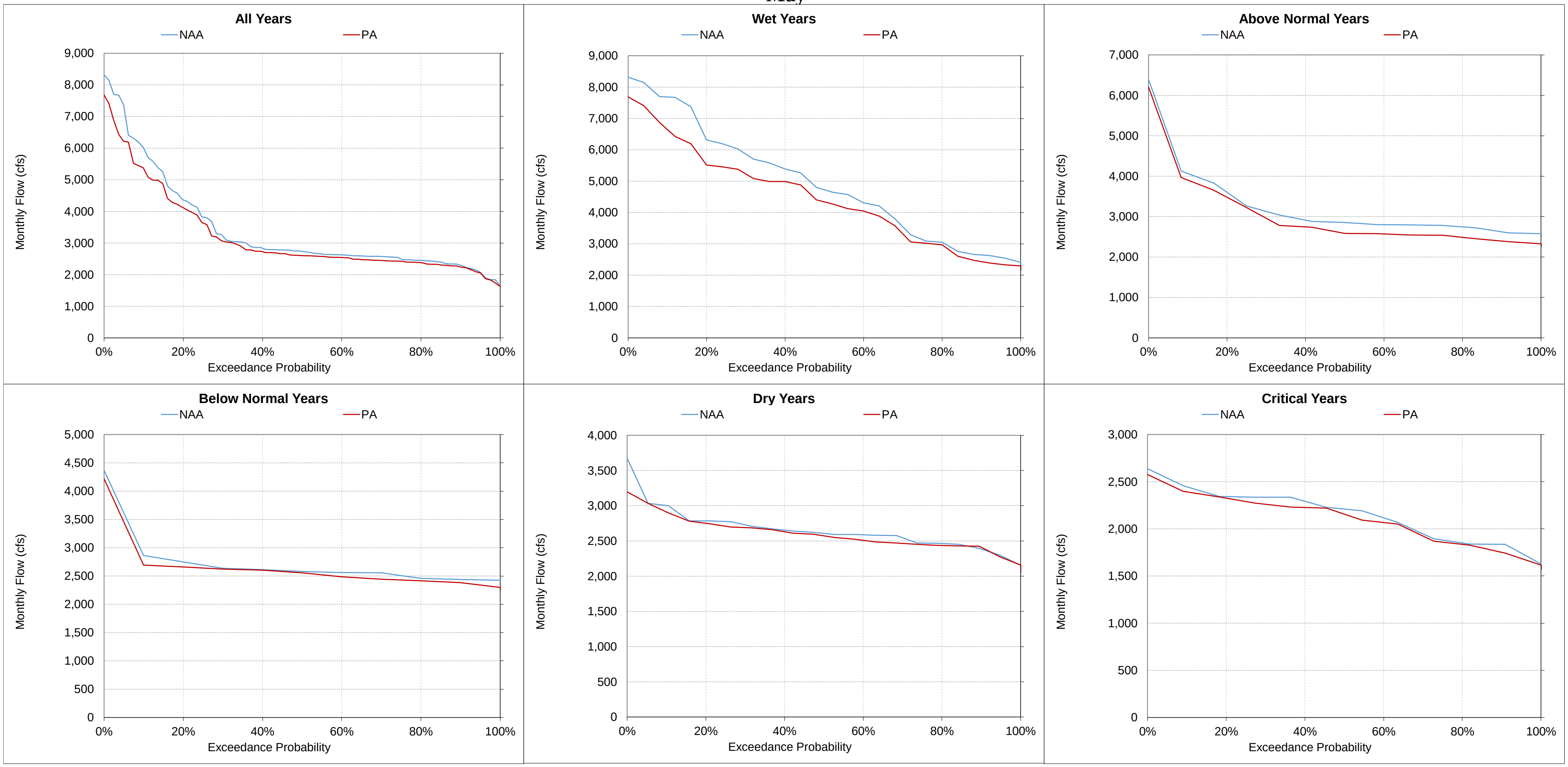
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-5-14. Georgiana Slough, Monthly Flow April



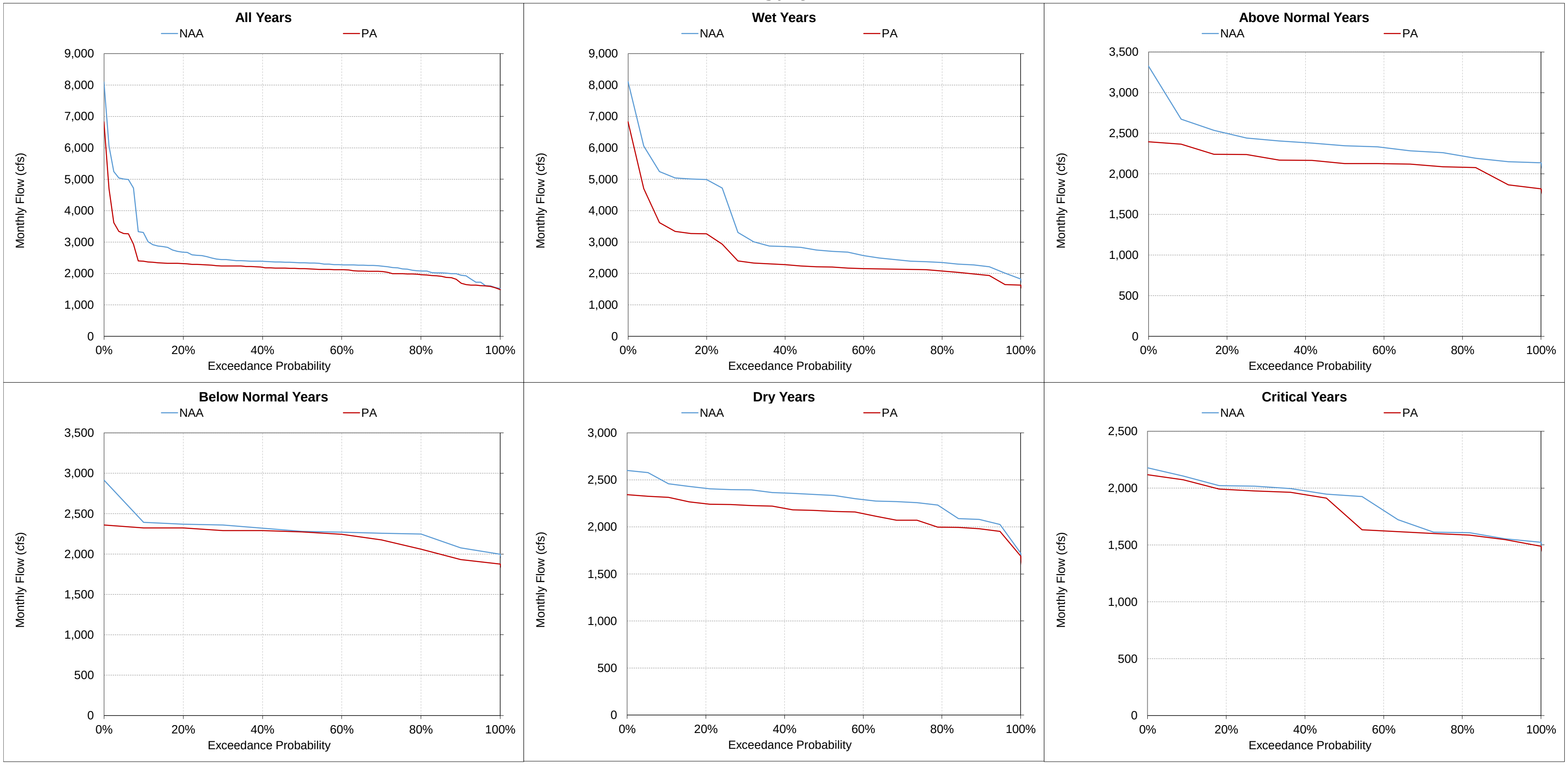
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-5-15. Georgiana Slough, Monthly Flow May



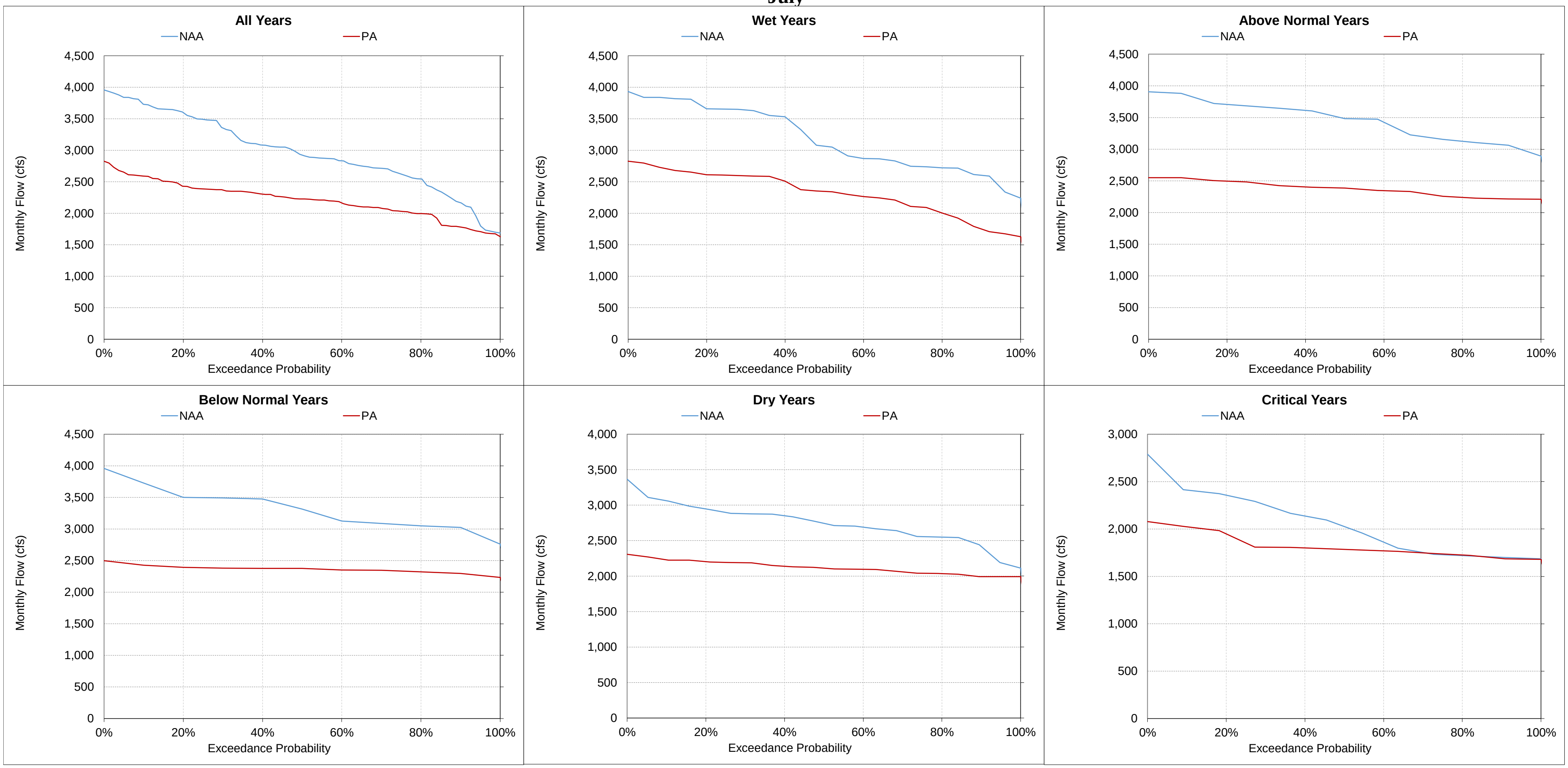
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-5-16. Georgiana Slough, Monthly Flow
June



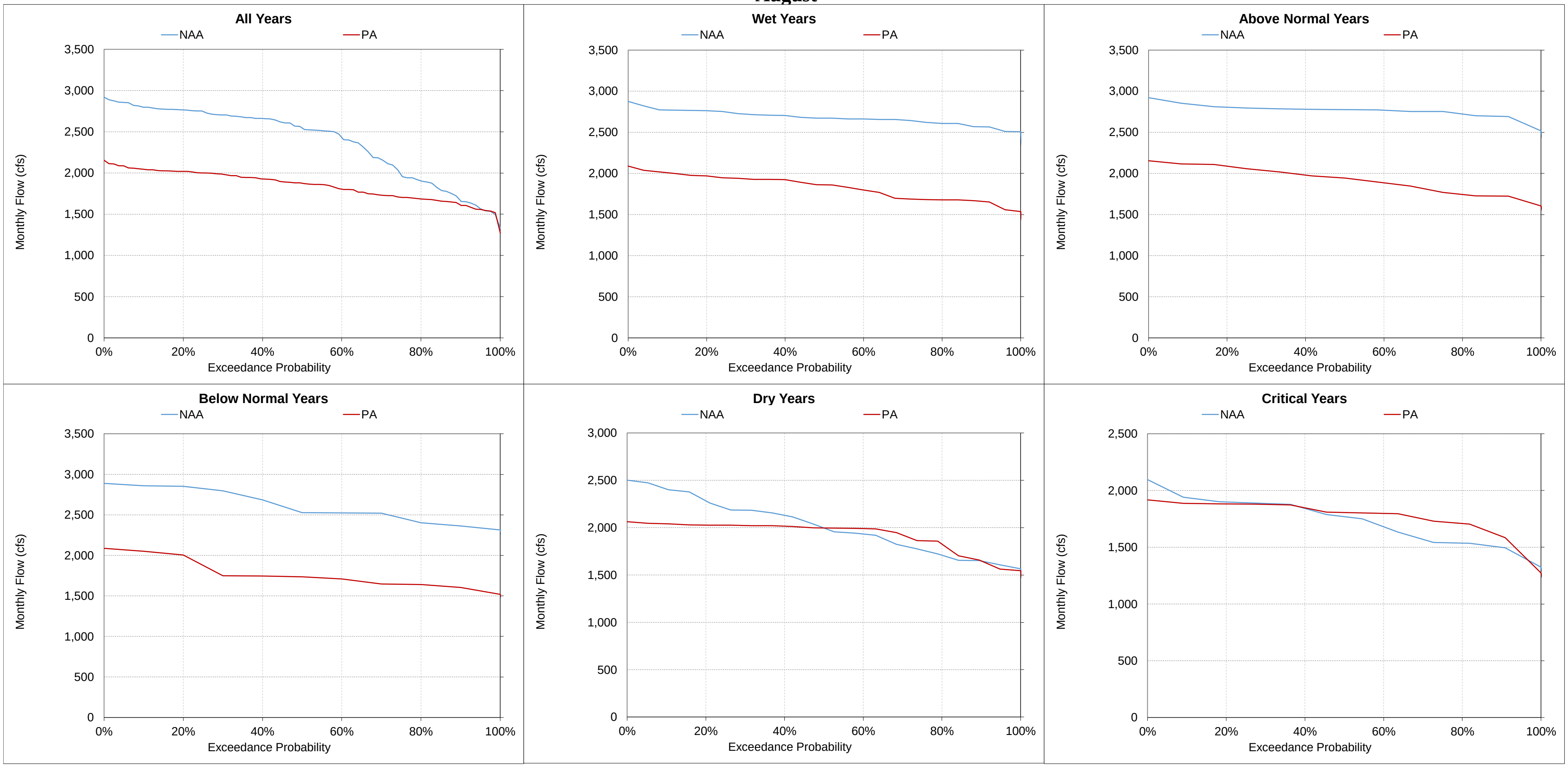
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-5-17. Georgiana Slough, Monthly Flow
July



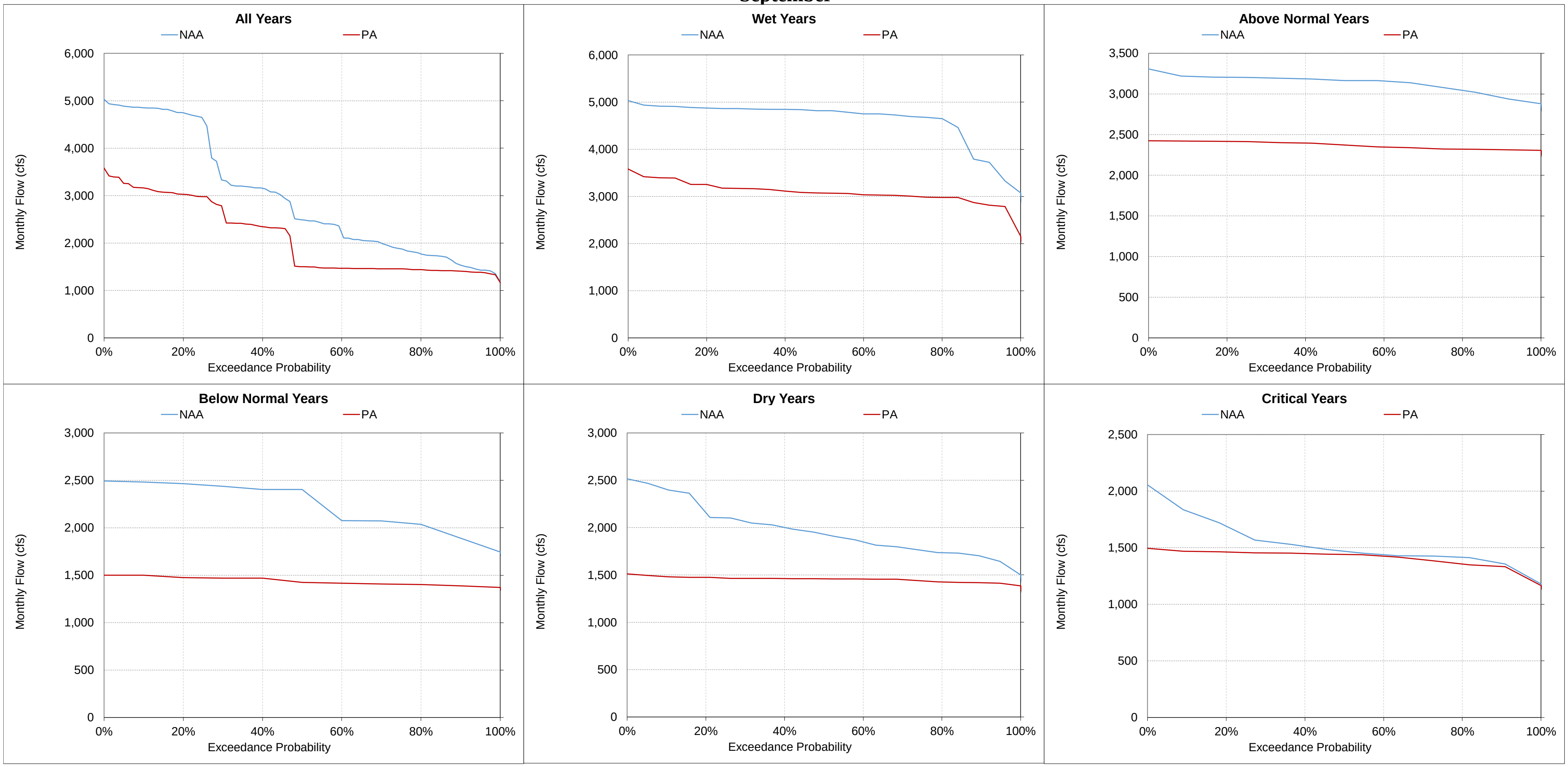
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-5-18. Georgiana Slough, Monthly Flow
August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-5-19. Georgiana Slough, Monthly Flow
September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-6. Sacramento River at Rio Vista, Monthly Flow

Statistic	Monthly Flow (cfs)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	10,483	5,171	-5,312	-51%	18,143	12,437	-5,706	-31%	58,427	54,243	-4,184	-7%	87,560	75,132	-12,428	-14%	115,544	108,076	-7,468	-6%	71,803	65,987	-5,817	-8%
20%	8,824	4,693	-4,131	-47%	14,964	9,316	-5,648	-38%	33,723	31,324	-2,399	-7%	59,378	51,998	-7,381	-12%	73,677	68,005	-5,672	-8%	56,286	48,284	-8,002	-14%
30%	7,812	4,347	-3,465	-44%	14,172	7,762	-6,410	-45%	18,869	18,501	-368	-2%	43,828	38,892	-4,936	-11%	56,048	49,453	-6,595	-12%	39,265	32,303	-6,961	-18%
40%	6,846	4,197	-2,649	-39%	12,413	6,742	-5,671	-46%	14,917	14,458	-460	-3%	26,793	24,024	-2,769	-10%	43,150	38,611	-4,539	-11%	30,053	23,928	-6,126	-20%
50%	5,719	4,116	-1,603	-28%	10,290	5,437	-4,853	-47%	12,030	11,179	-850	-7%	19,470	18,088	-1,382	-7%	32,300	26,522	-5,778	-18%	22,660	18,112	-4,548	-20%
60%	4,585	3,999	-586	-13%	8,435	4,685	-3,750	-44%	10,751	9,305	-1,447	-13%	15,556	14,422	-1,133	-7%	23,282	18,493	-4,789	-21%	18,111	13,886	-4,225	-23%
70%	4,114	3,889	-226	-5%	6,326	4,503	-1,823	-29%	10,274	8,558	-1,716	-17%	12,529	11,583	-946	-8%	16,358	14,568	-1,790	-11%	15,926	12,174	-3,752	-24%
80%	3,890	3,781	-109	-3%	4,757	4,327	-429	-9%	7,152	7,031	-122	-2%	10,566	9,699	-867	-8%	13,187	11,838	-1,349	-10%	12,115	10,012	-2,103	-17%
90%	3,038	3,194	156	5%	4,076	4,103	27	1%	5,845	5,578	-267	-5%	9,219	8,494	-725	-8%	11,383	10,097	-1,286	-11%	8,624	7,882	-742	-9%
Long Term Full Simulation Period[b]	6,523	4,527	-1,996	-31%	11,797	8,279	-3,518	-30%	22,393	20,774	-1,619	-7%	37,722	34,564	-3,158	-8%	47,887	43,814	-4,073	-9%	36,582	32,232	-4,350	-12%
Water Year Types[c]																								
Wet (32%)	9,222	4,912	-4,310	-47%	16,588	11,073	-5,515	-33%	26,018	24,219	-1,798	-7%	44,188	40,900	-3,288	-7%	86,112	80,141	-5,971	-7%	65,624	59,015	-6,608	-10%
Above Normal (16%)	7,432	4,611	-2,821	-38%	14,406	8,176	-6,231	-43%	19,826	18,198	-1,628	-8%	34,555	31,662	-2,893	-8%	56,961	51,873	-5,088	-9%	45,657	40,448	-5,209	-11%
Below Normal (13%)	6,952	6,122	-830	-12%	8,129	5,587	-2,542	-31%	19,936	18,383	-1,553	-8%	33,570	30,702	-2,868	-9%	29,951	26,767	-3,183	-11%	16,589	13,441	-3,148	-19%
Dry (24%)	4,321	4,009	-312	-7%	10,466	8,665	-1,801	-17%	28,418	26,399	-2,018	-7%	39,283	35,255	-4,028	-10%	22,657	19,755	-2,903	-13%	19,653	16,033	-3,619	-18%
Critical (15%)	2,967	3,002	35	1%	4,172	4,165	-7	0%	9,533	8,919	-614	-6%	28,351	26,368	-1,983	-7%	13,724	12,098	-1,625	-12%	10,369	9,526	-843	-8%

Statistic	Monthly Flow (cfs)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	53,068	49,514	-3,554	-7%	32,163	27,414	-4,748	-15%	13,530	8,054	-5,476	-40%	15,636	8,163	-7,473	-48%	9,548	5,072	-4,476	-47%	23,544	13,746	-9,797	-42%
20%	33,908	31,822	-2,086	-6%	21,128	20,039	-1,089	-5%	9,024	6,817	-2,207	-24%	14,960	7,124	-7,836	-52%	9,107	4,816	-4,291	-47%	22,742	12,757	-9,985	-44%
30%	20,991	19,293	-1,697	-8%	12,972	11,814	-1,158	-9%	7,188	6,388	-800	-11%	13,135	6,667	-6,468	-49%	8,721	4,649	-4,072	-47%	13,916	10,003	-3,913	-28%
40%	17,291	16,482	-808	-5%	10,097	9,150	-948	-9%	6,858	6,224	-634	-9%	11,330	6,445	-4,885	-43%	8,288	4,539	-3,749	-45%	12,746	7,588	-5,158	-40%
50%	12,594	11,960	-635	-5%	9,435	8,479	-956	-10%	6,695	5,823	-872	-13%	10,020	5,874	-4,146	-41%	7,638	4,375	-3,263	-43%	7,653	3,246	-4,406	-58%
60%	10,185	9,556	-629	-6%	8,310	7,957	-352	-4%	6,459	5,563	-896	-14%	9,515	5,436	-4,079	-43%	7,136	4,094	-3,042	-43%	5,906	3,107	-2,799	-47%
70%	8,639	8,476	-163	-2%	7,736	7,396	-340	-4%	6,080	5,396	-685	-11%	8,884	5,112	-3,772	-42%	5,385	3,908	-1,478	-27%	4,784	3,040	-1,744	-36%
80%	8,077	7,942	-134	-2%	7,051	6,864	-187	-3%	5,336	5,052	-284	-5%	7,428	4,743	-2,685	-36%	4,284	3,782	-502	-12%	3,917	3,007	-910	-23%
90%	7,298	7,168	-129	-2%	6,133	5,920	-213	-3%	4,773	4,171	-602	-13%	5,267	3,920	-1,347	-26%	3,513	3,422	-91	-3%	3,270	2,905	-366	-11%
Long Term Full Simulation Period[b]	21,586	20,376	-1,210	-6%	14,161	12,966	-1,195	-8%	8,714	6,878	-1,836	-21%	10,678	6,023	-4,655	-44%	7,033	4,282	-2,752	-39%	11,461	6,949	-4,512	-39%
Water Year Types[c]																								
Wet (32%)	38,583	36,150	-2,433	-6%	24,873	22,172	-2,701	-11%	14,007	9,782	-4,226	-30%	12,181	6,889	-5,292	-43%	8,583	4,241	-4,342	-51%	21,970	13,044	-8,926	-41%
Above Normal (16%)	23,092	21,944	-1,148	-5%	13,278	12,164	-1,114	-8%	7,295	5,851	-1,443	-20%	13,964	6,908	-7,055	-51%	9,113	4,672	-4,441	-49%	12,544	7,728	-4,816	-38%
Below Normal (13%)	11,319	10,800	-519	-5%	9,282	8,875	-407	-4%	6,575	6,041	-534	-8%	12,980	6,704	-6,277	-48%	8,246	4,114	-4,132	-50%	6,143	3,015	-3,128	-51%
Dry (24%)	12,531	11,923	-609	-5%	8,620	8,305	-315	-4%	6,505	5,780	-725	-11%	8,759	5,219	-3,540	-40%	4,982	4,432	-551	-11%	4,896	3,029	-1,867	-38%
Critical (15%)	7,630	7,366	-264	-3%	5,618	5,407	-211	-4%	4,422	4,294	-128	-3%	4,946	3,899	-1,046	-21%	3,729	3,850	122	3%	3,334	3,039	-294	-9%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-6-1. Monthly Flow Ranges For Sacramento River at Rio Vista, All Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario.

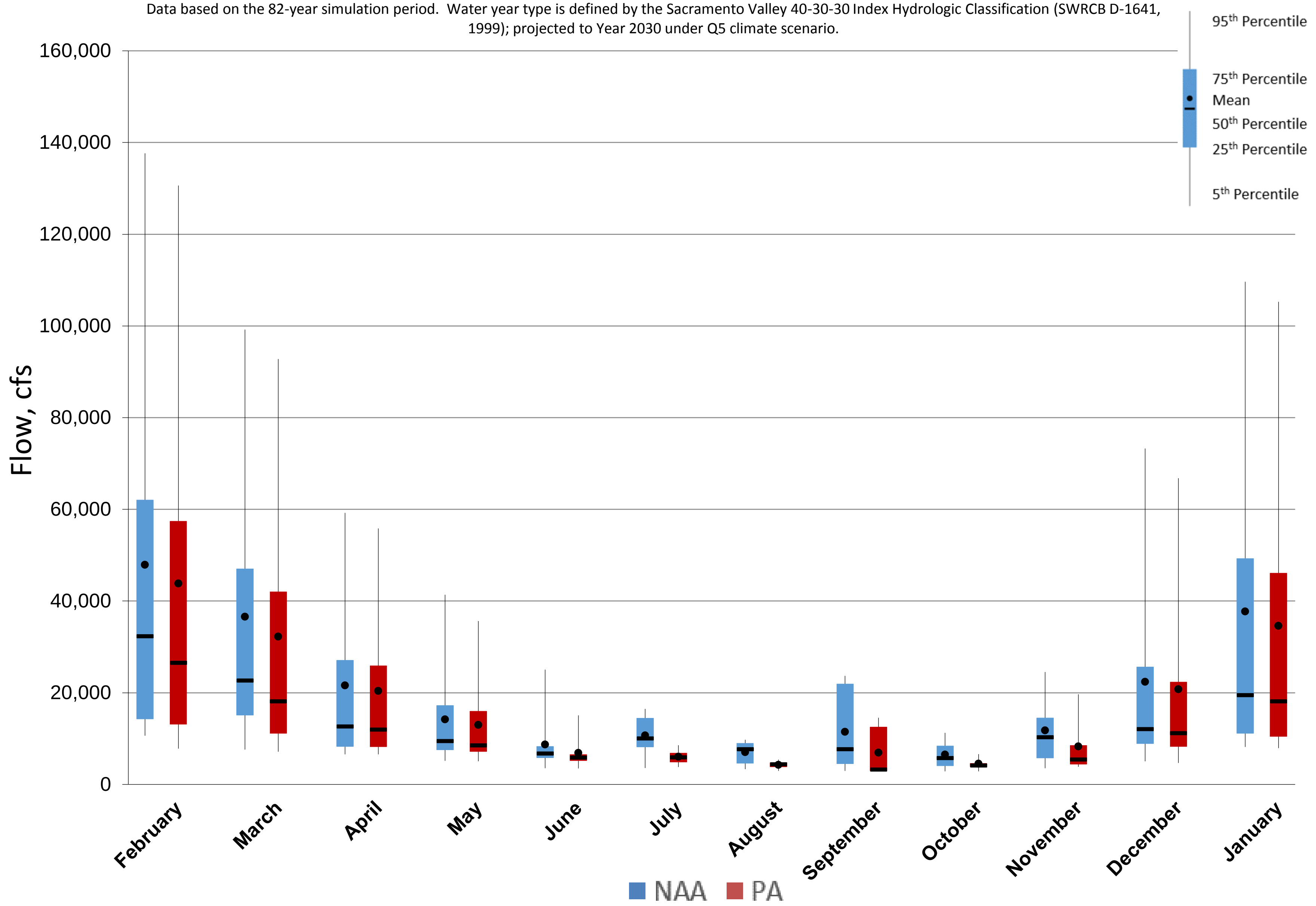


Figure 5.B.5-6-2. Monthly Flow Ranges For Sacramento River at Rio Vista, Wet Years

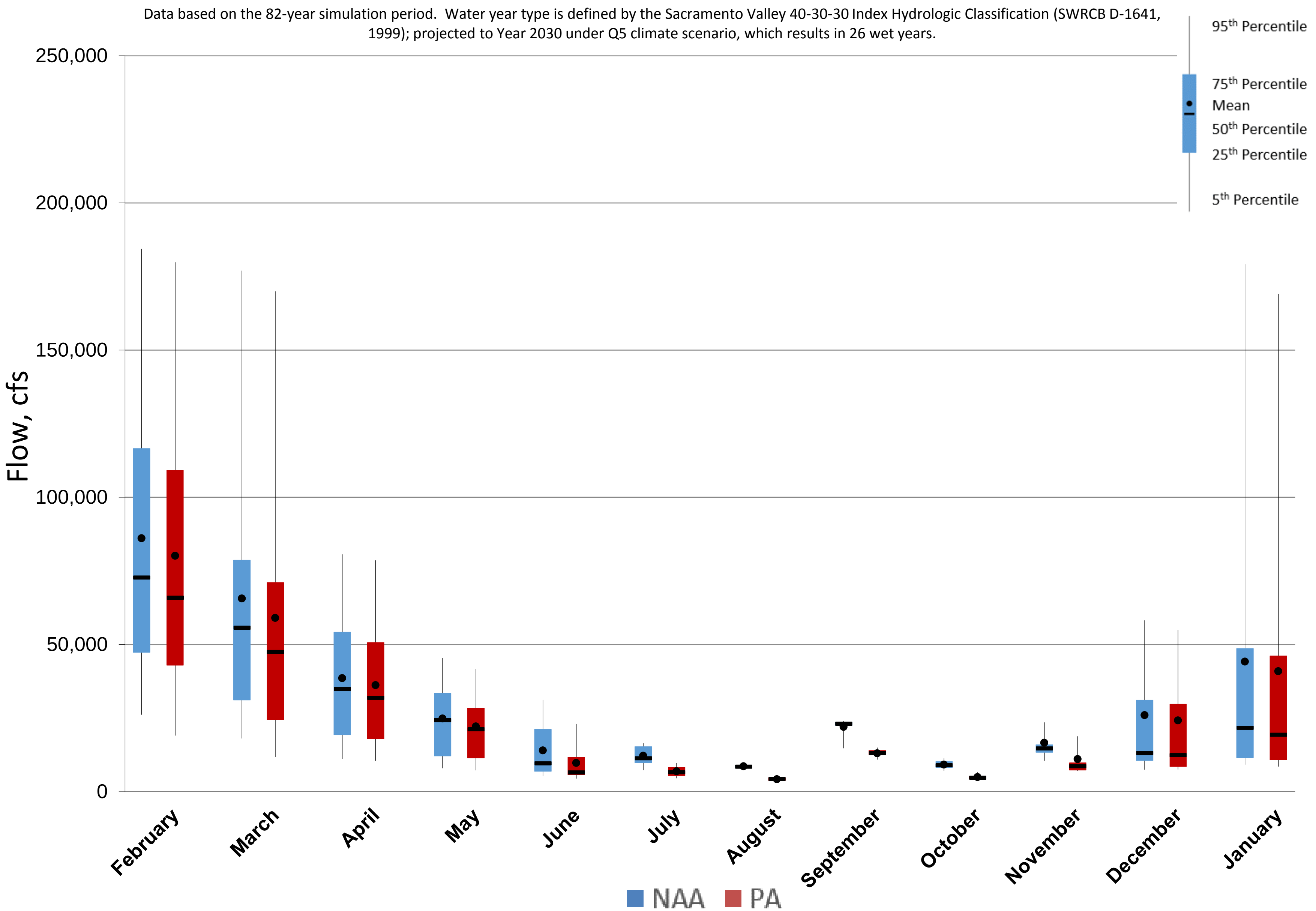


Figure 5.B.5-6-3. Monthly Flow Ranges For Sacramento River at Rio Vista, Above Normal Years

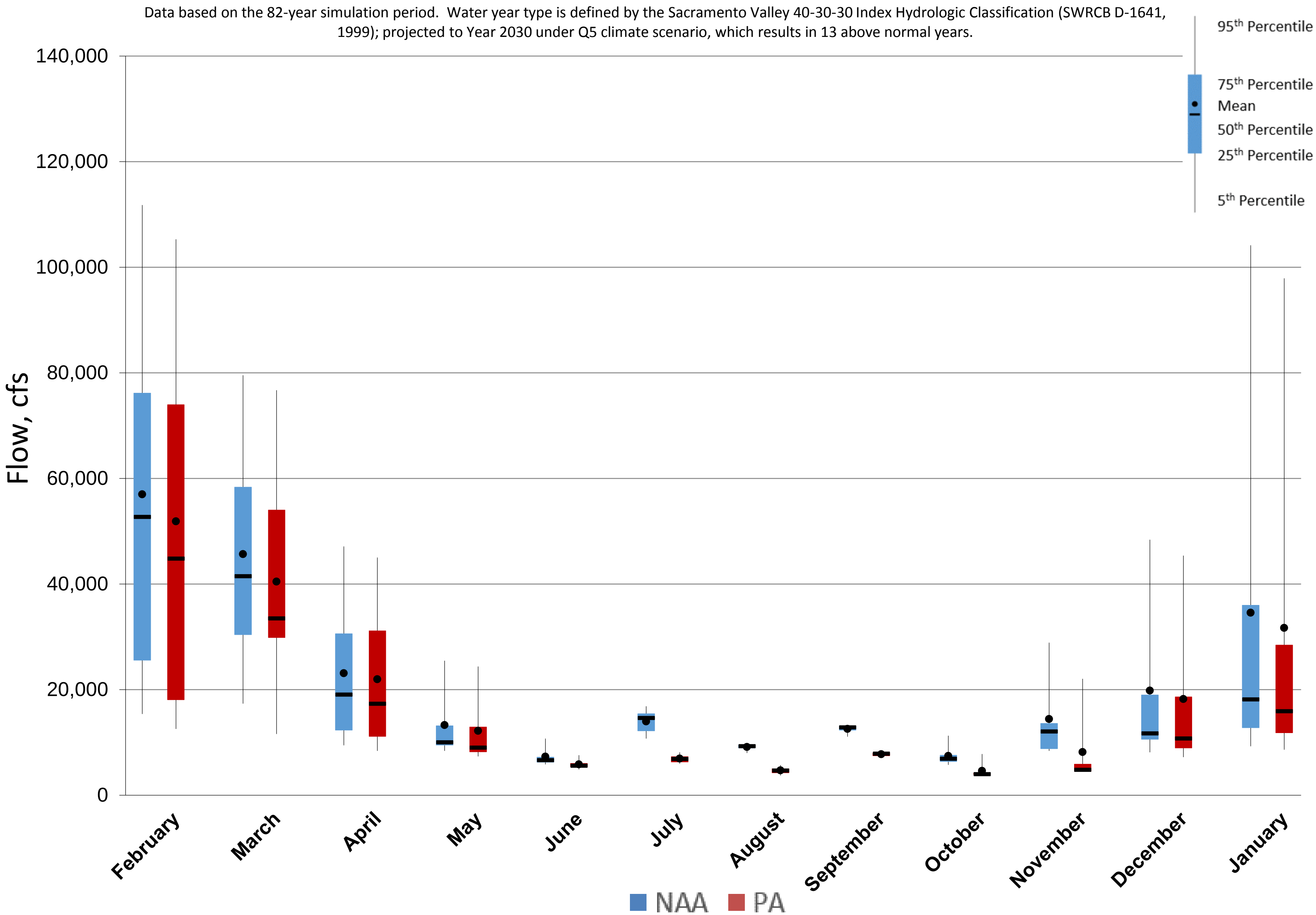
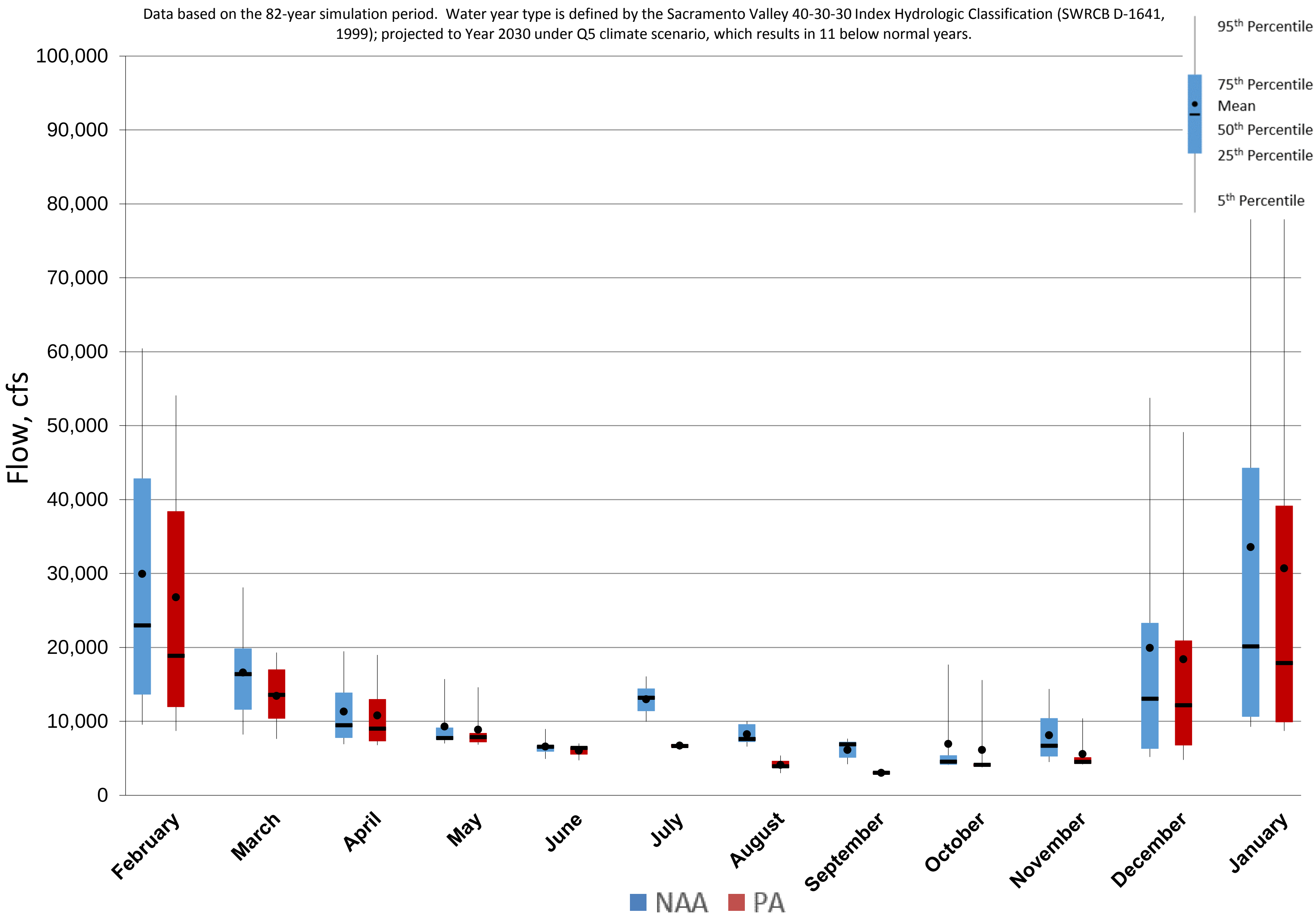


Figure 5.B.5-6-4. Monthly Flow Ranges For Sacramento River at Rio Vista, Below Normal Years



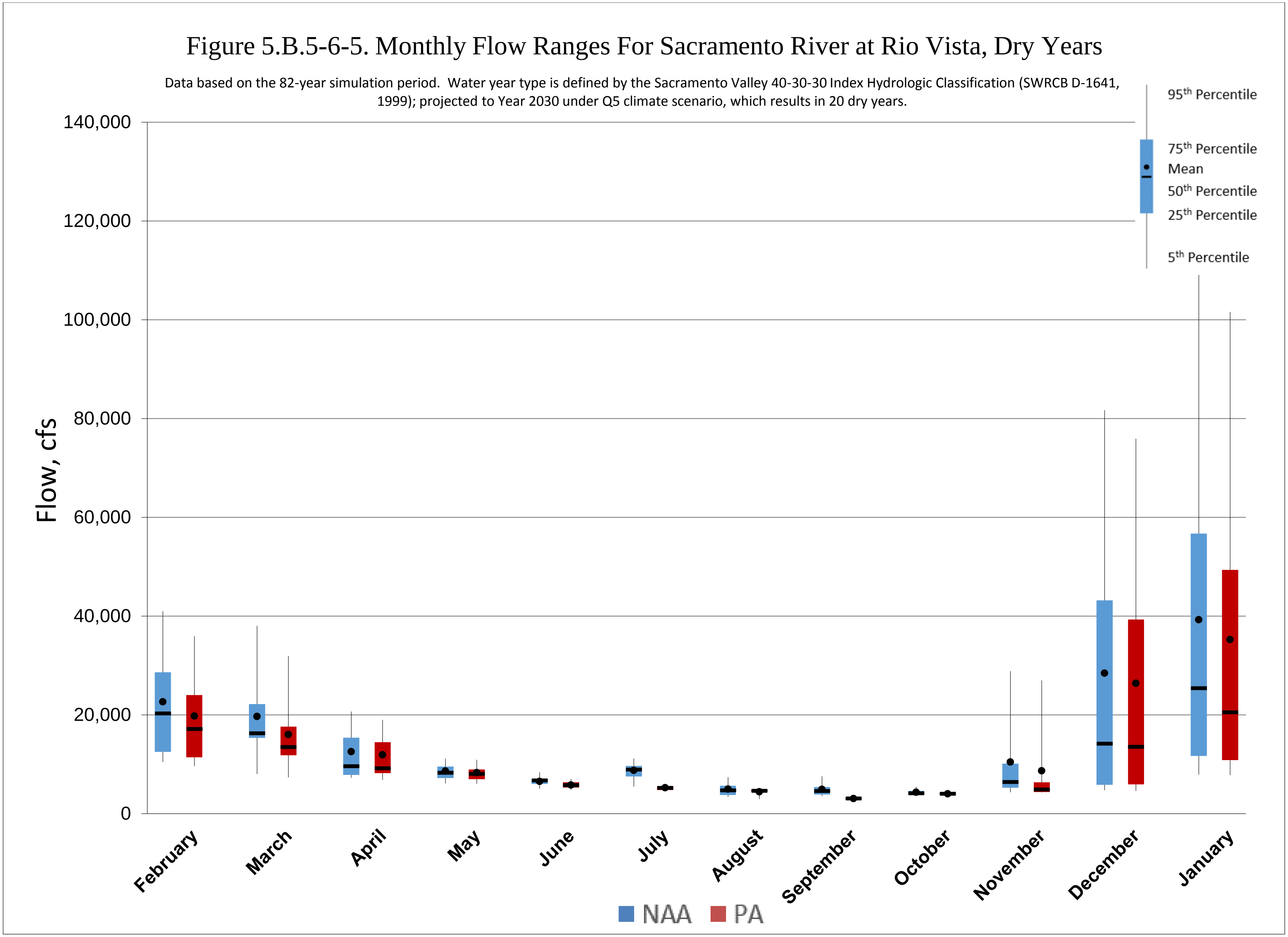


Figure 5.B.5-6-5. Monthly Flow Ranges For Sacramento River at Rio Vista, Dry Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 20 dry years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
Flow, cfs
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-6-6. Monthly Flow Ranges For Sacramento River at Rio Vista, Critical Years

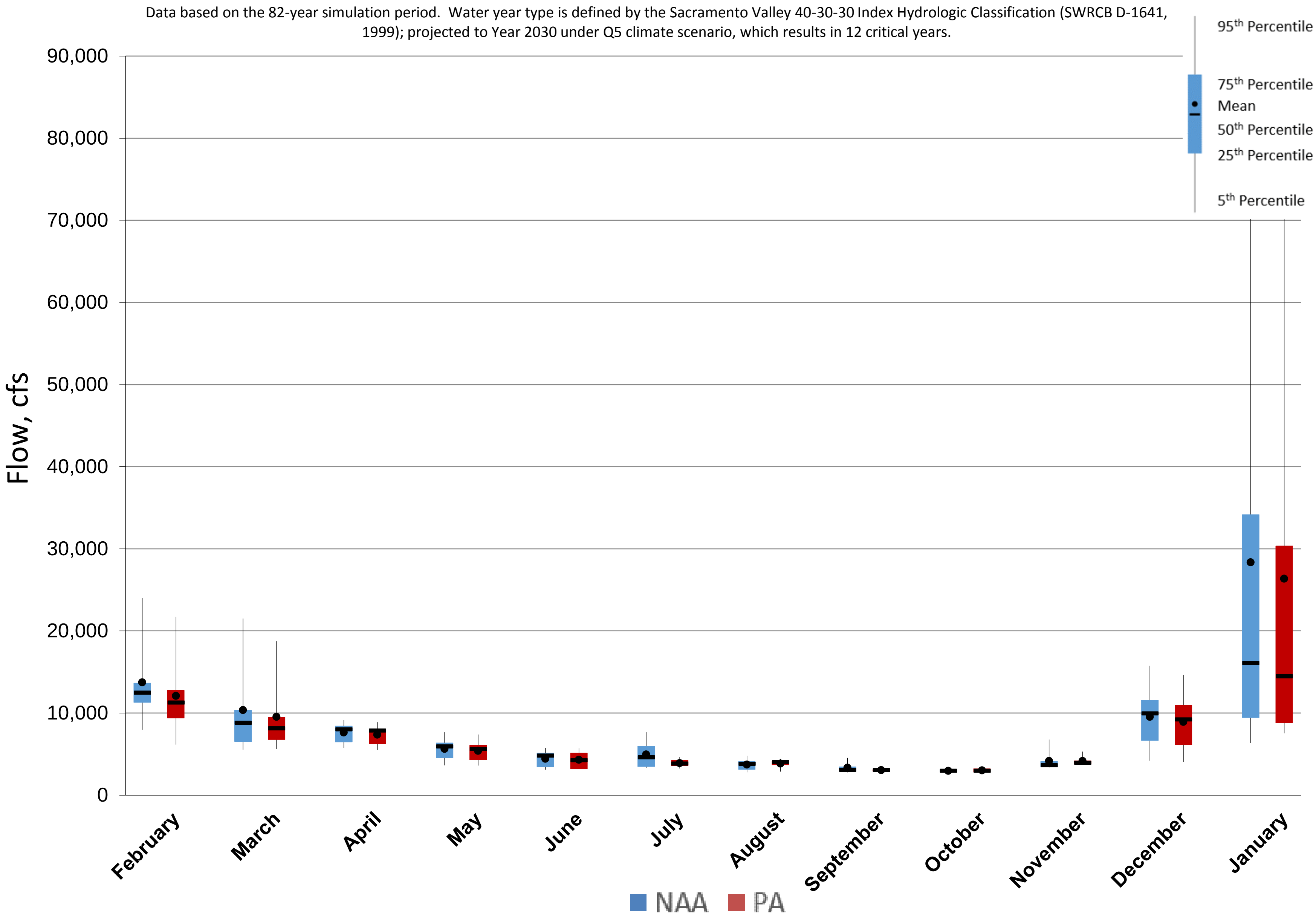
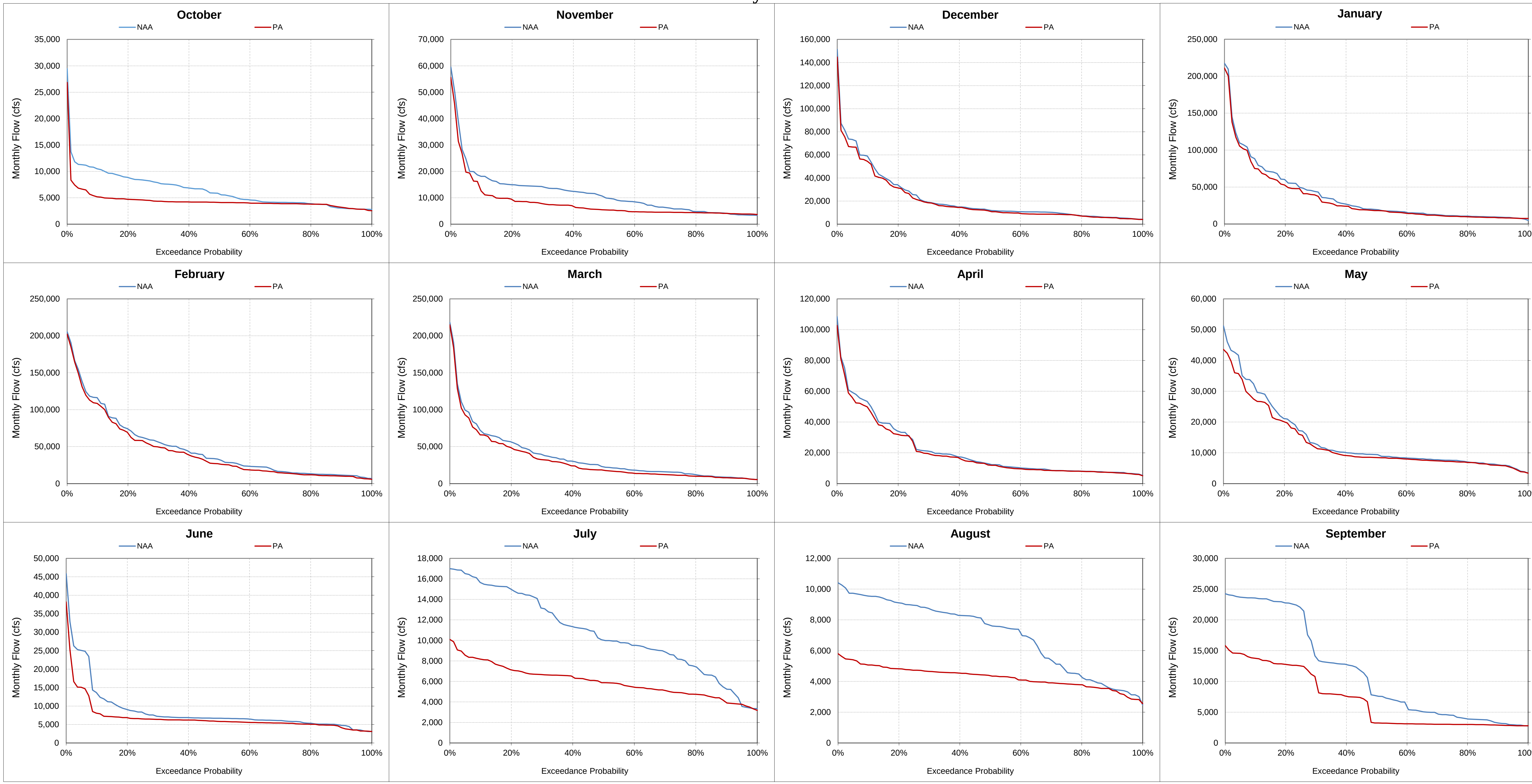
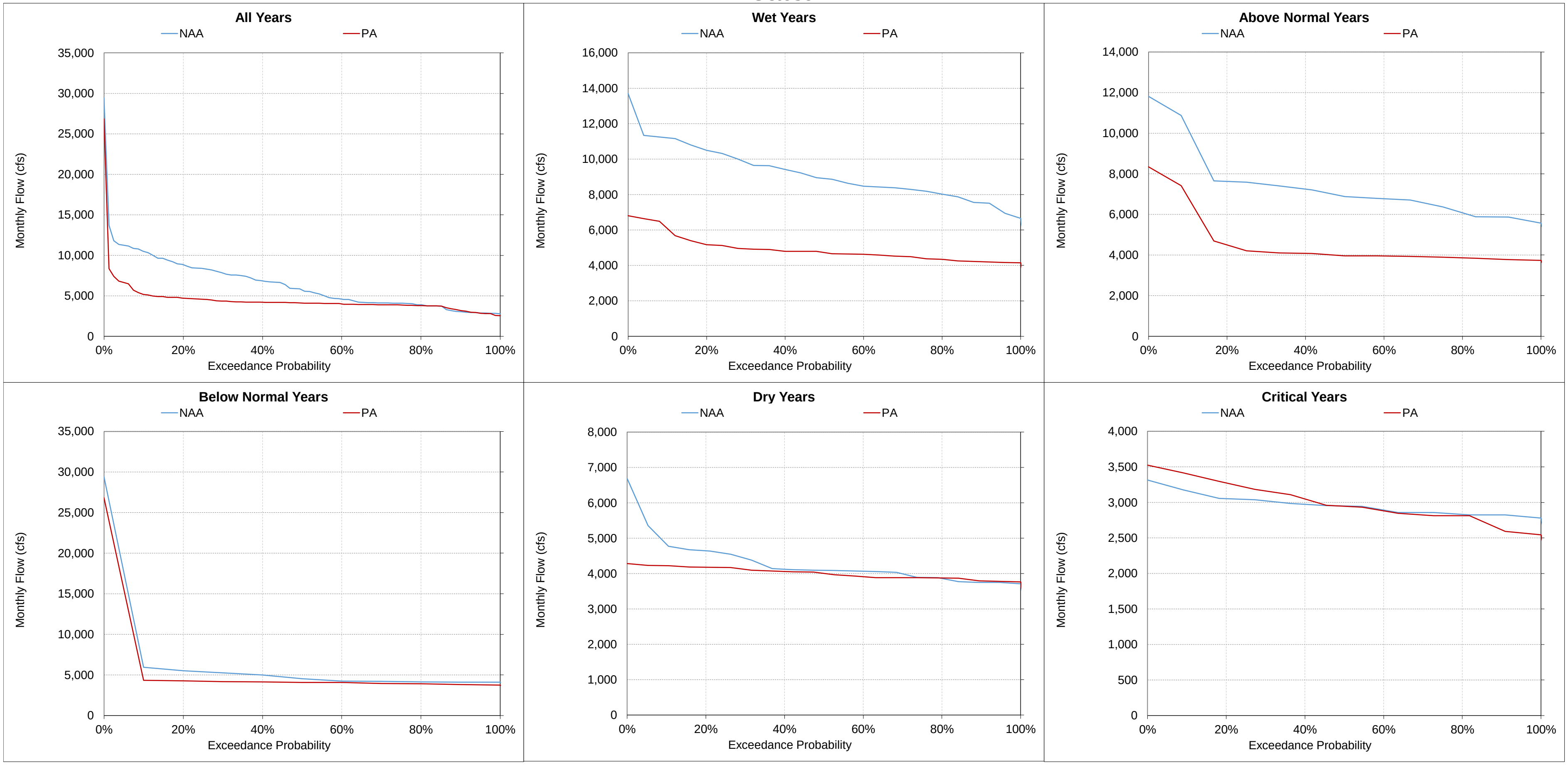


Figure 5.B.5-6-7. Sacramento River at Rio Vista, Monthly Flow Probability of Exceedance



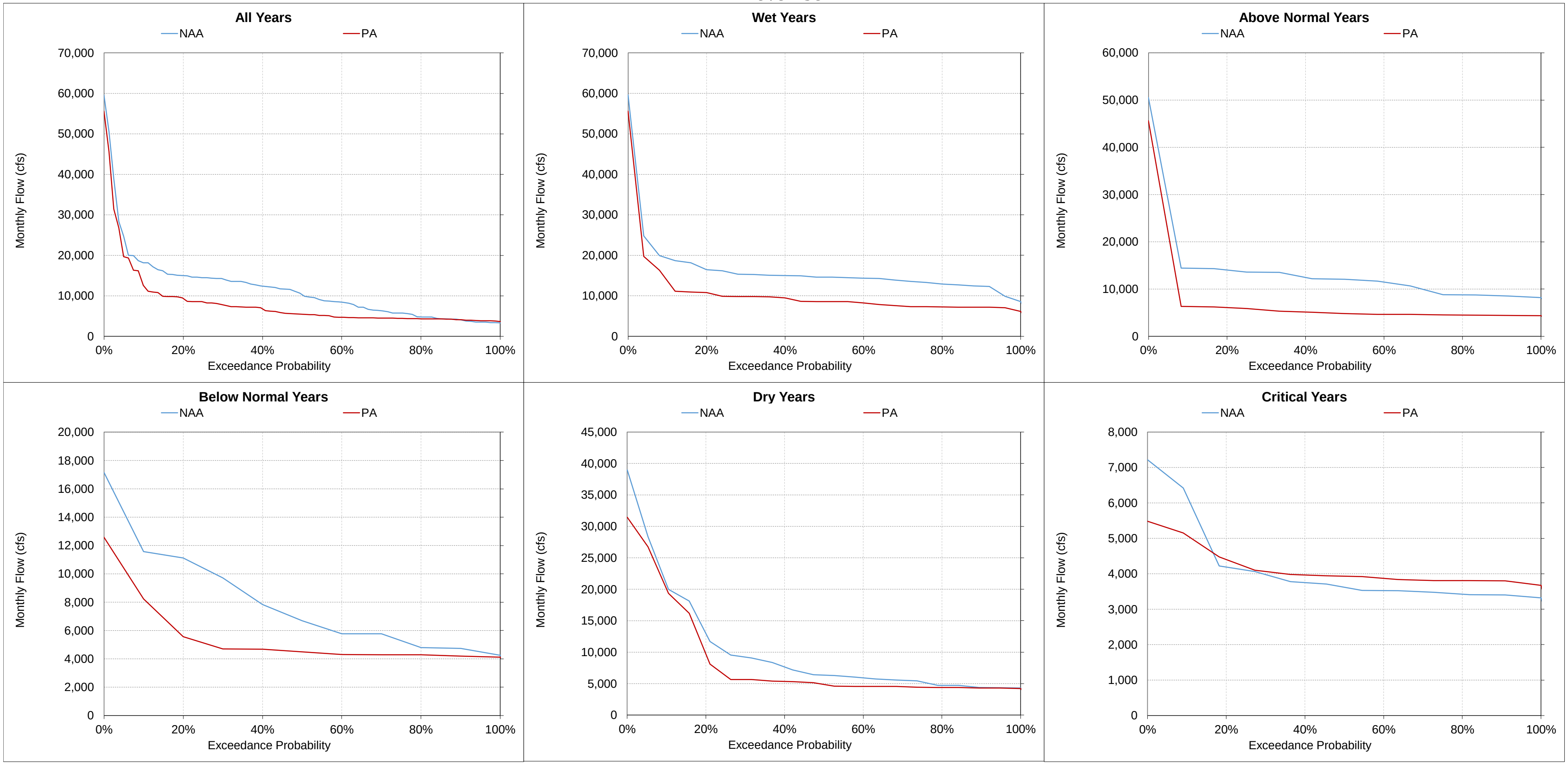
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-6-8. Sacramento River at Rio Vista, Monthly Flow
October



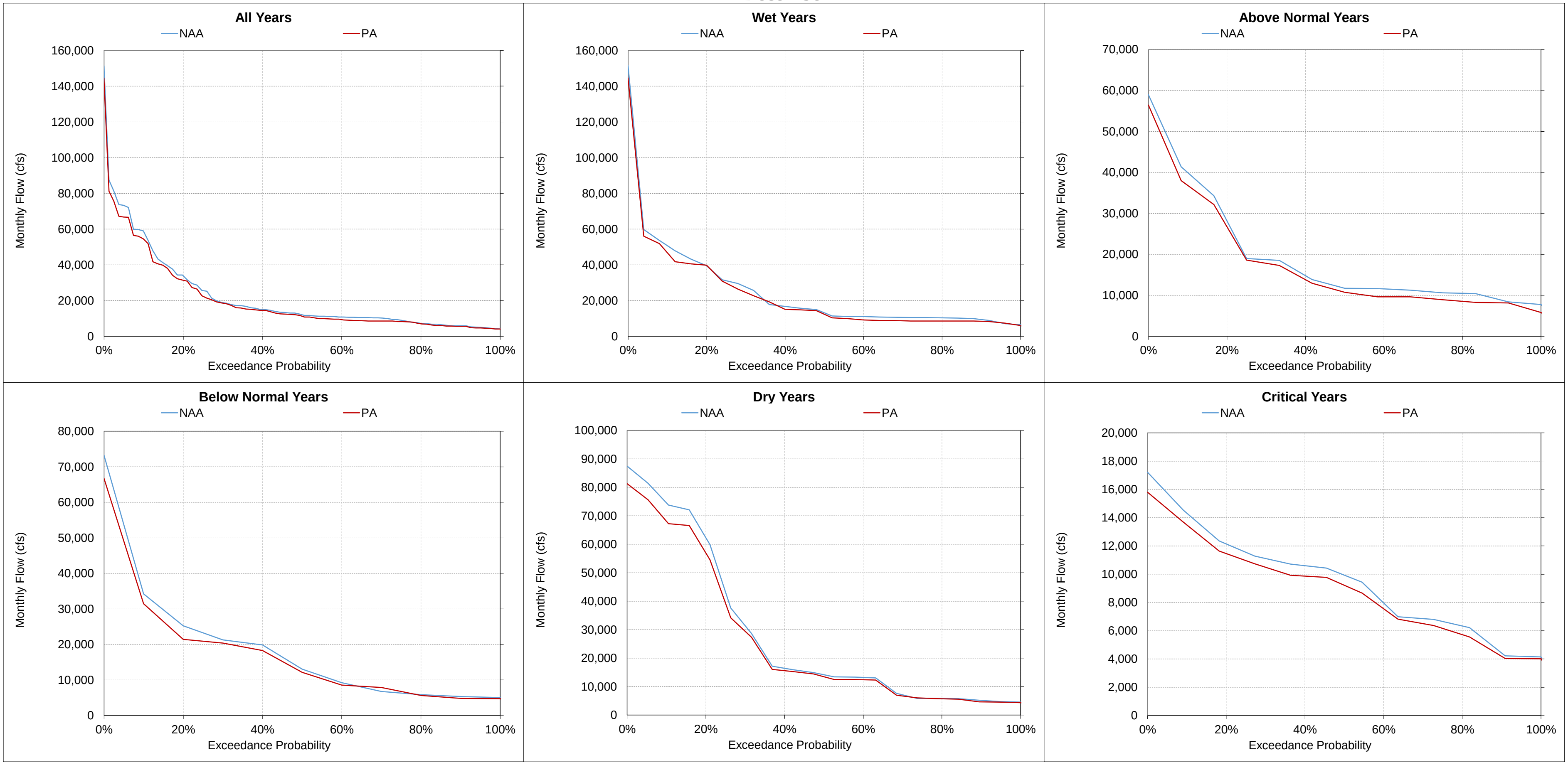
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-6-9. Sacramento River at Rio Vista, Monthly Flow
November



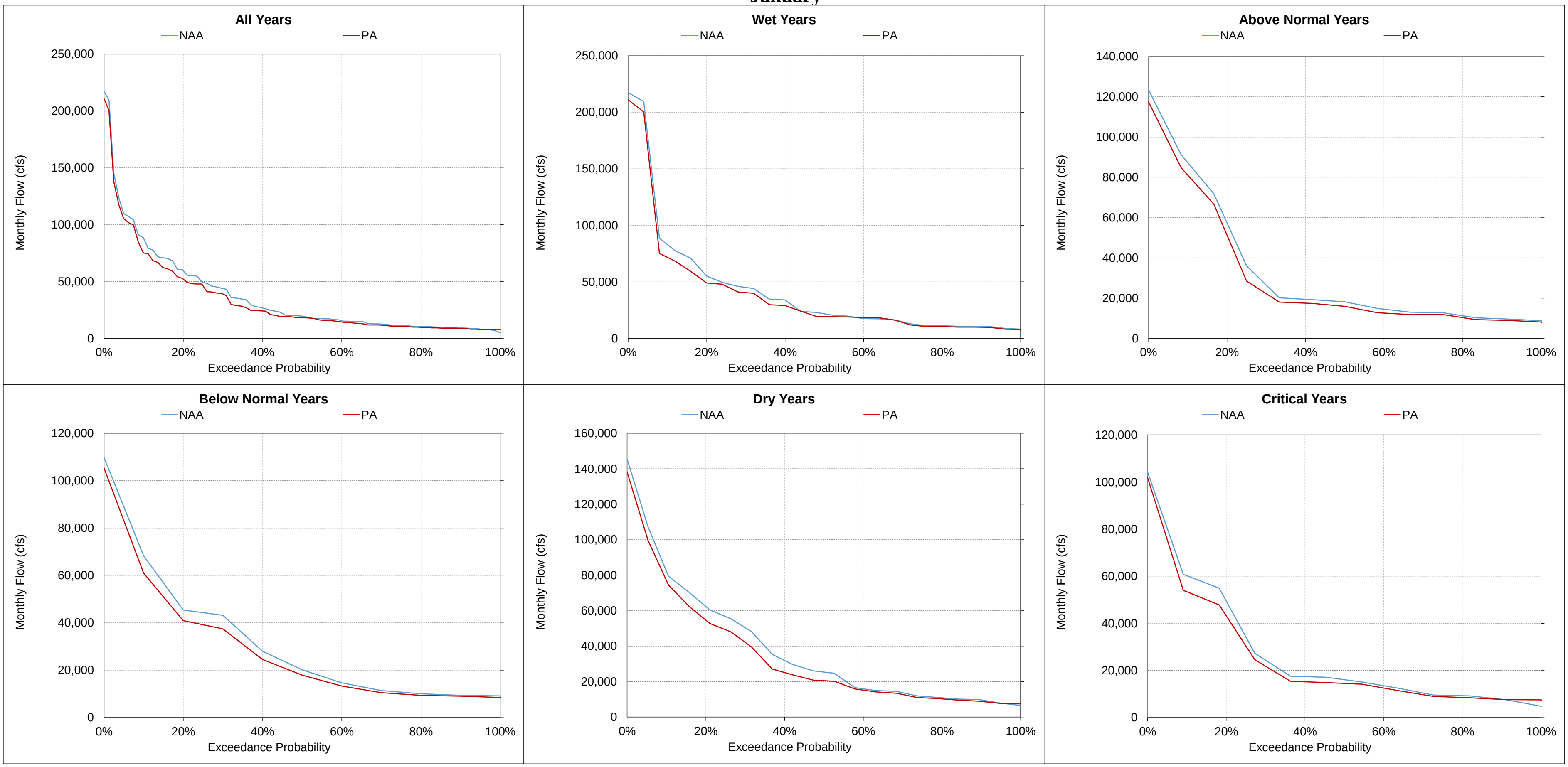
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-6-10. Sacramento River at Rio Vista, Monthly Flow
December



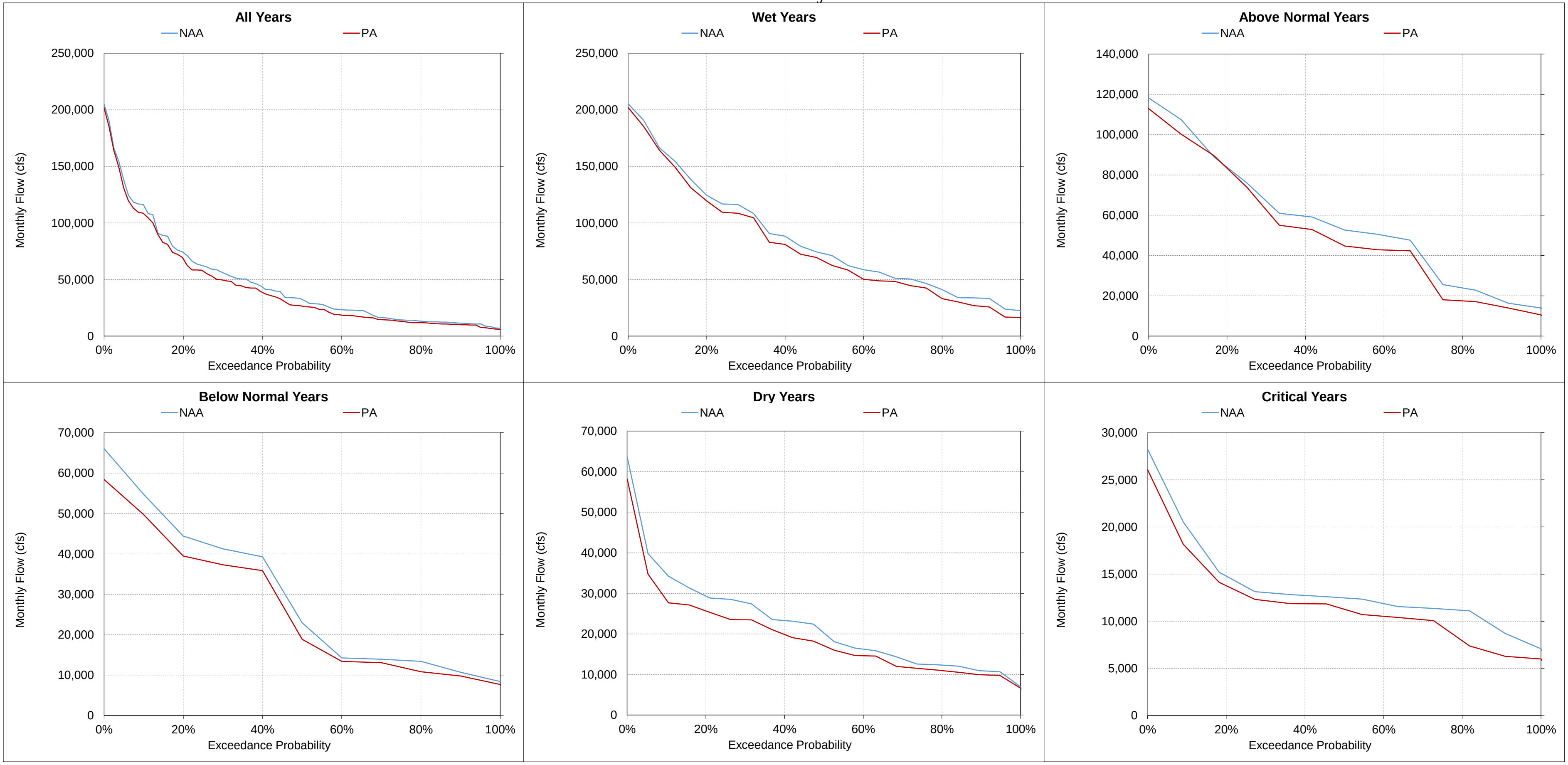
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-6-11. Sacramento River at Rio Vista, Monthly Flow January



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-6-12. Sacramento River at Rio Vista, Monthly Flow
February



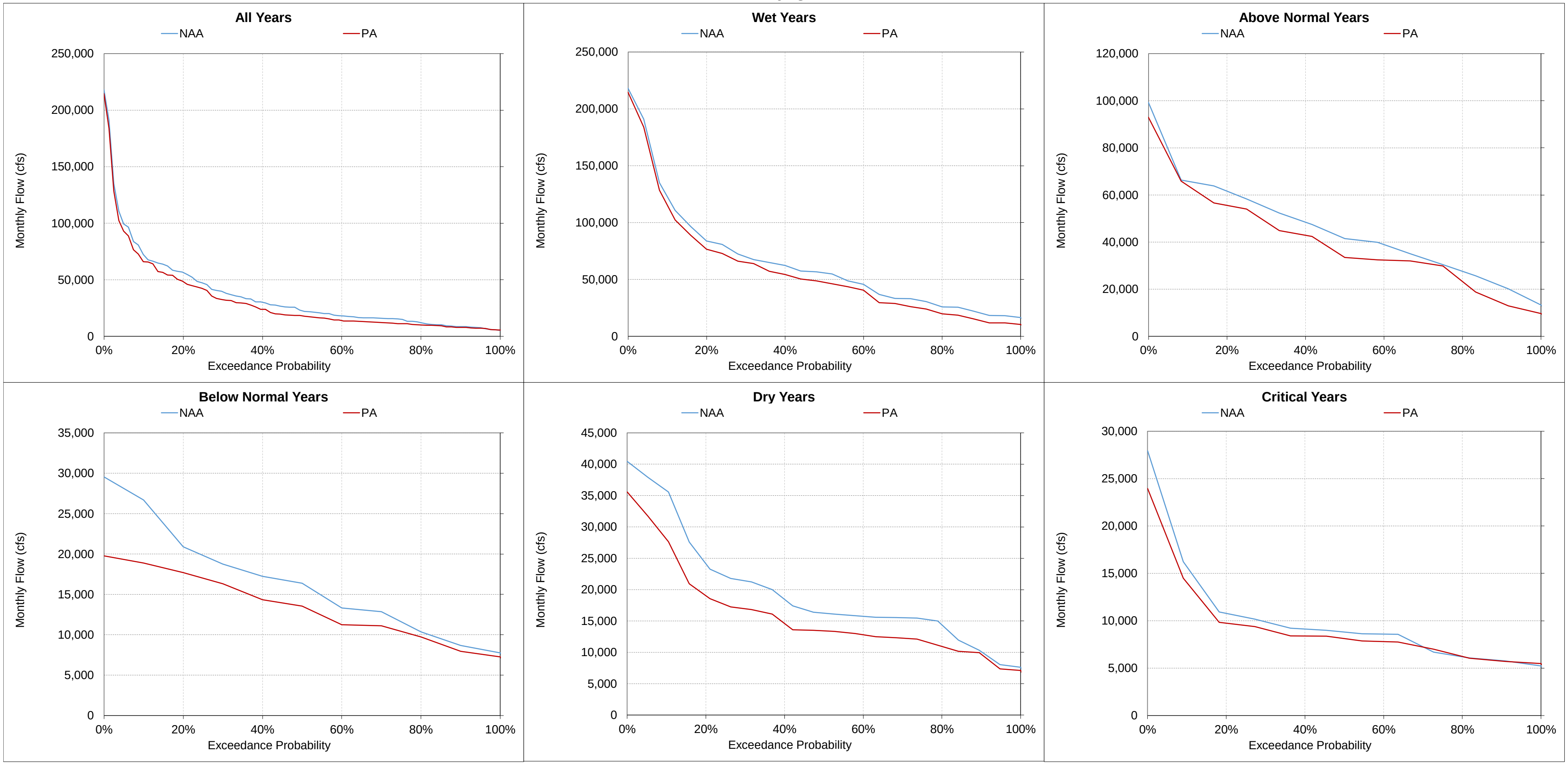
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

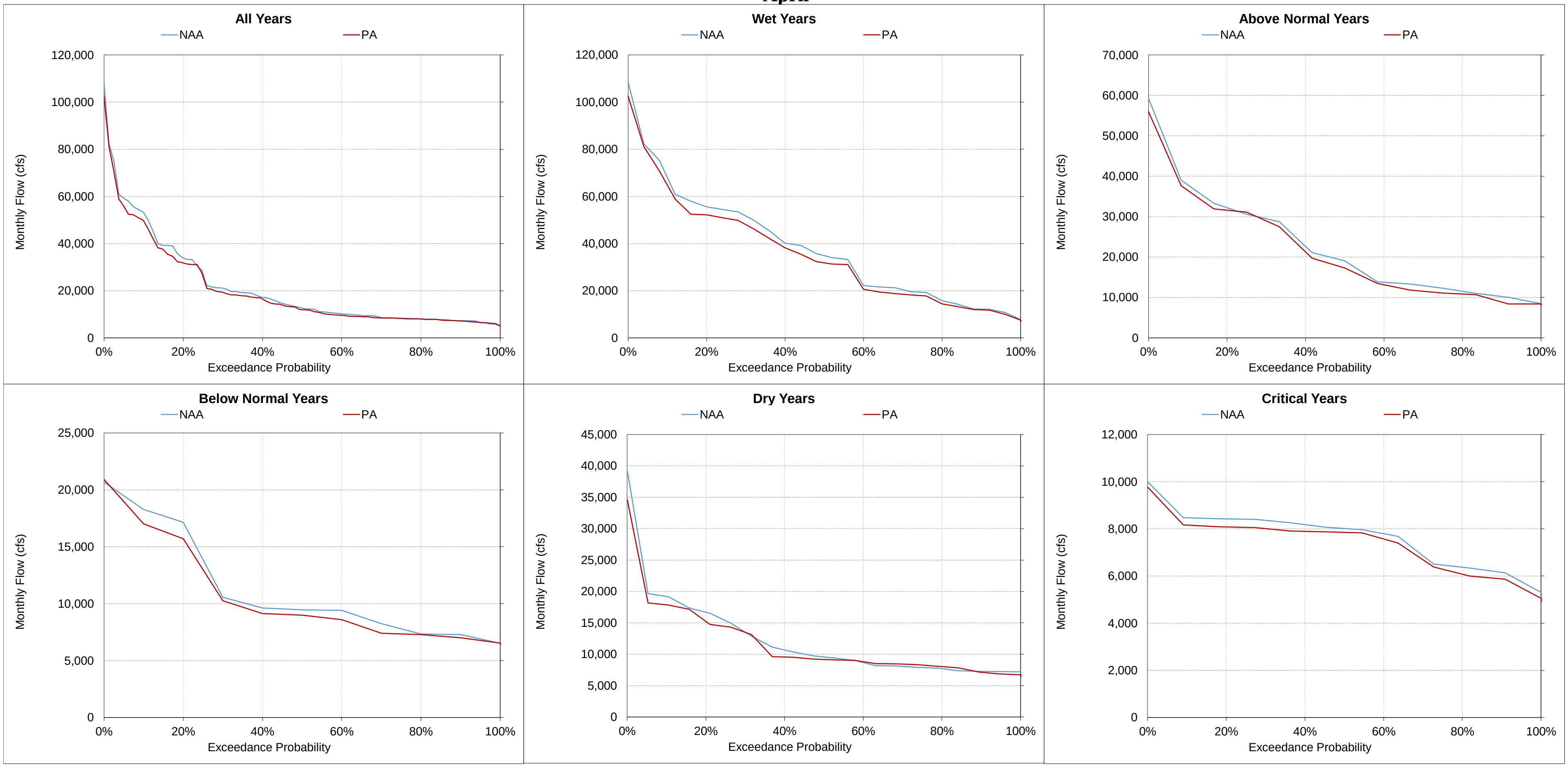
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-6-13. Sacramento River at Rio Vista, Monthly Flow March



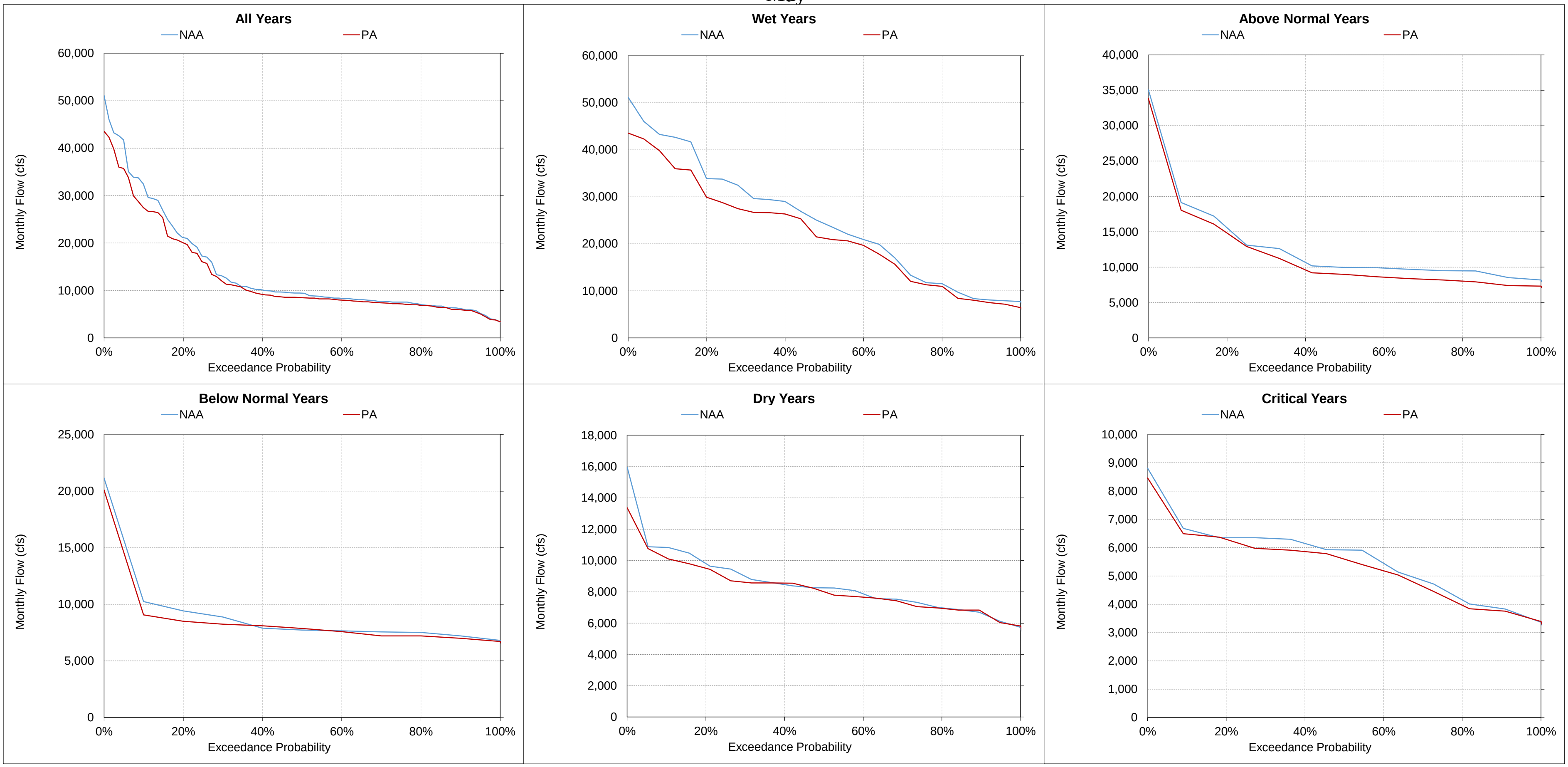
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-6-14. Sacramento River at Rio Vista, Monthly Flow
April



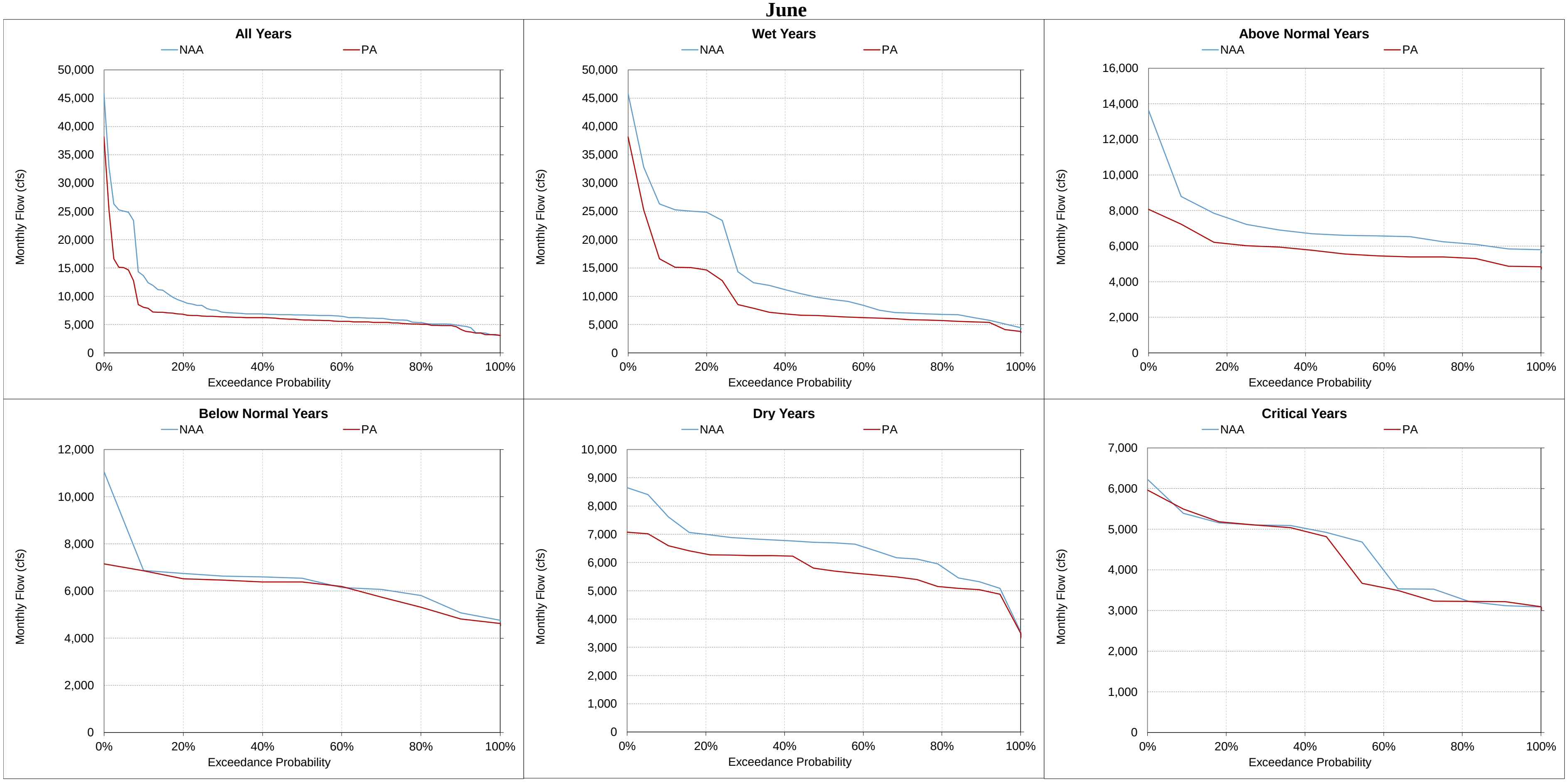
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-6-15. Sacramento River at Rio Vista, Monthly Flow
May



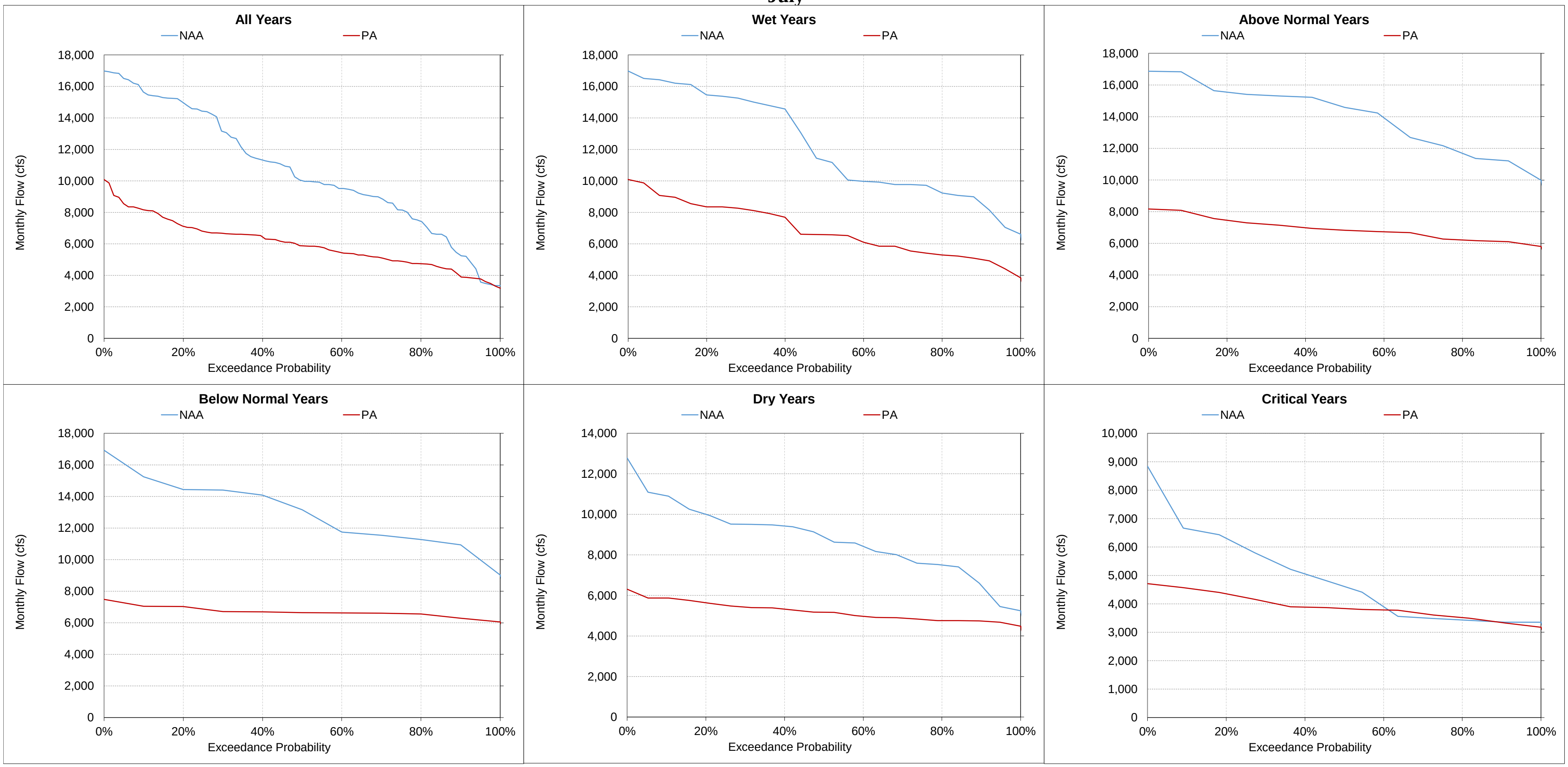
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-6-16. Sacramento River at Rio Vista, Monthly Flow
June



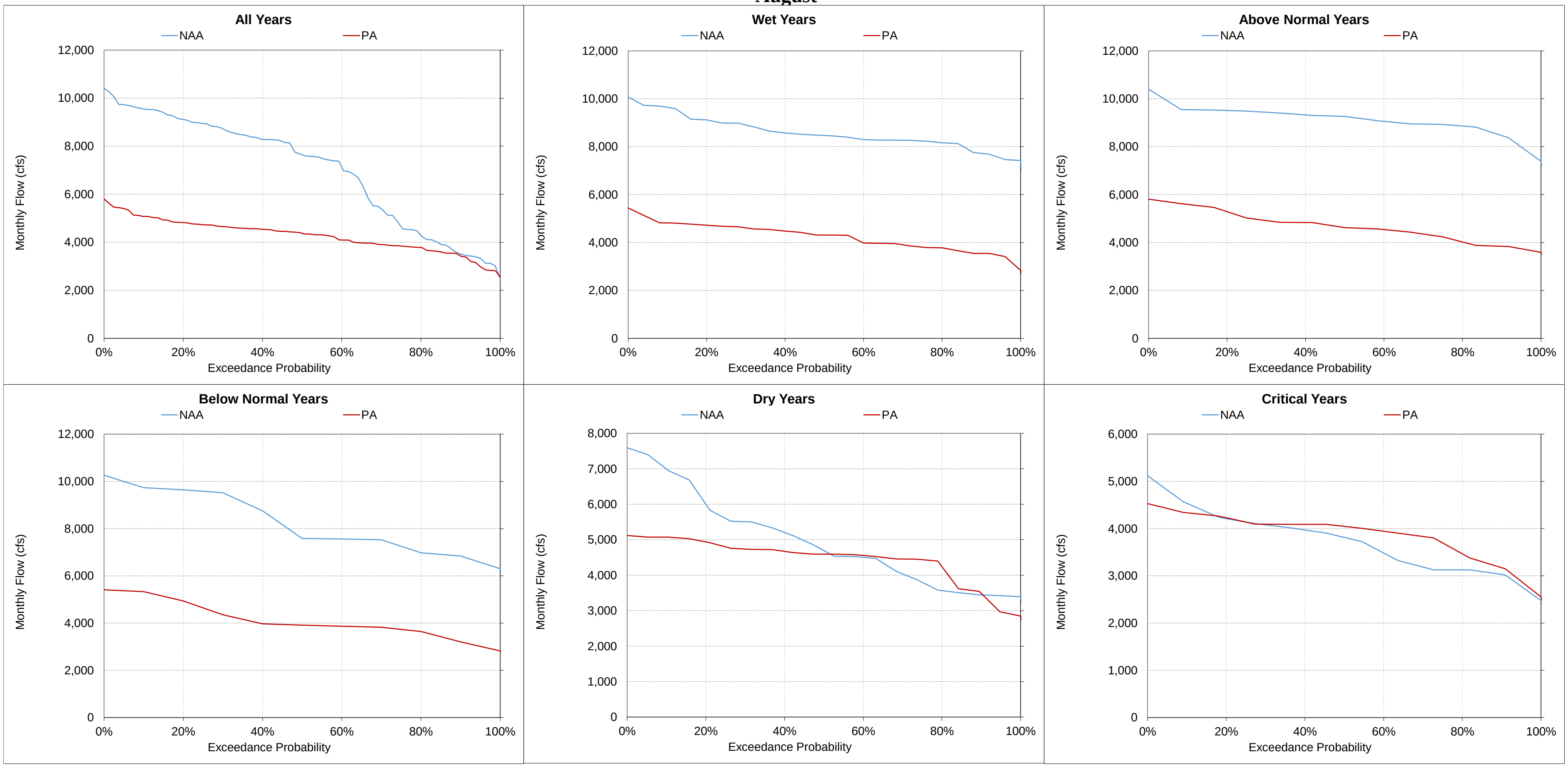
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-6-17. Sacramento River at Rio Vista, Monthly Flow
July



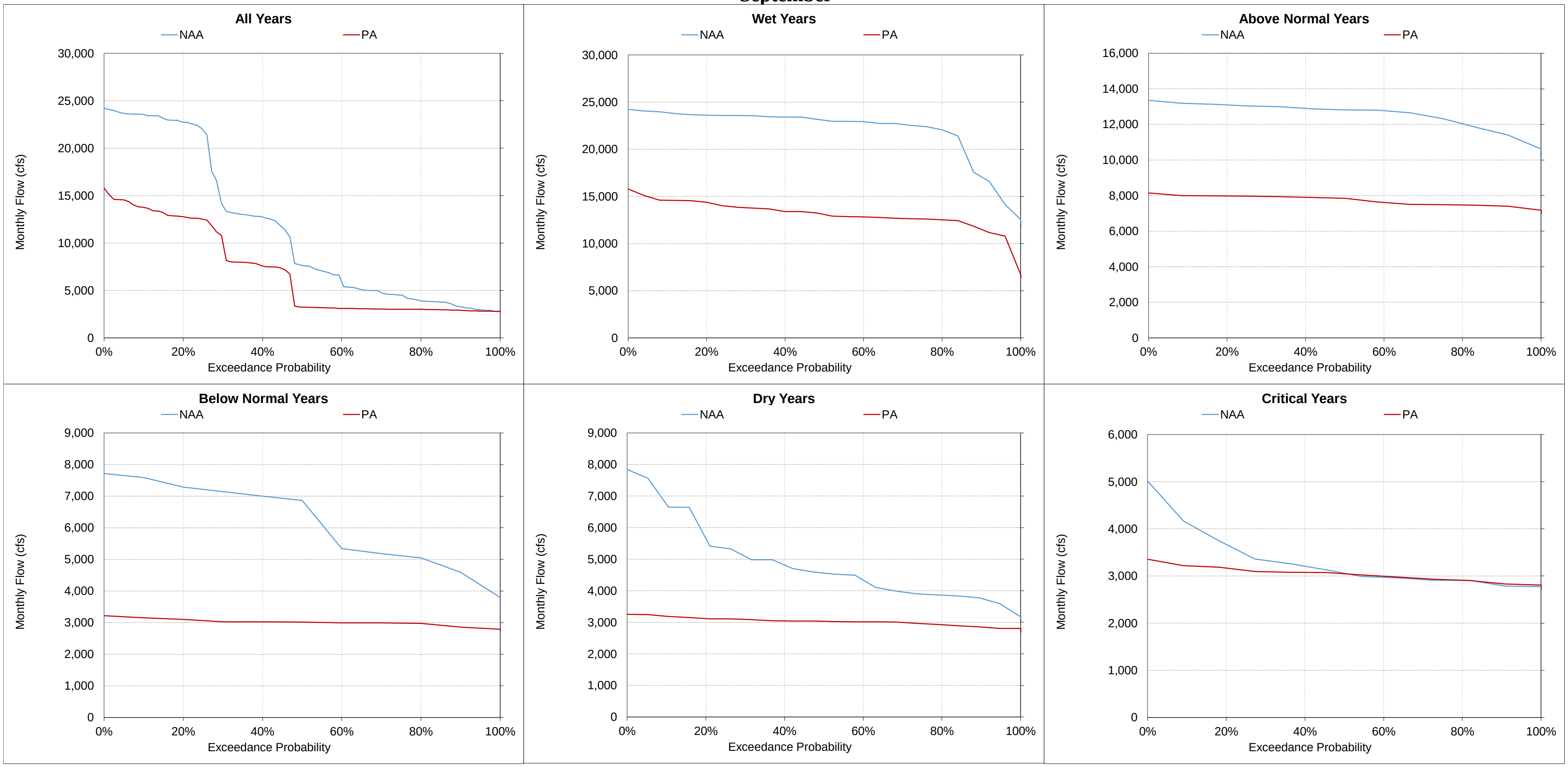
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-6-18. Sacramento River at Rio Vista, Monthly Flow
August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-6-19. Sacramento River at Rio Vista, Monthly Flow September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-7. San Joaquin River at Antioch, Monthly Flow

Statistic	Monthly Flow (cfs)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	1,470	4,271	2,801	191%	1,604	5,060	3,456	216%	11,893	12,775	881	7%	23,782	24,466	683	3%	27,582	30,935	3,353	12%	21,239	25,501	4,262	20%
20%	1,206	3,842	2,635	218%	734	4,505	3,771	514%	4,772	4,430	-342	-7%	15,741	16,682	941	6%	18,663	22,433	3,770	20%	14,480	18,535	4,055	28%
30%	770	3,302	2,532	329%	509	3,571	3,062	601%	944	1,017	72	8%	8,970	9,712	742	8%	14,088	14,986	899	6%	8,853	11,640	2,787	31%
40%	292	2,481	2,189	750%	14	2,957	2,943	20874%	393	301	-92	-23%	4,897	5,924	1,027	21%	10,519	12,301	1,783	17%	6,630	9,037	2,407	36%
50%	55	2,174	2,119	3878%	-110	1,618	1,728	-1573%	-126	-4	121	-97%	2,893	4,339	1,446	50%	6,737	7,169	432	6%	5,030	5,978	948	19%
60%	-69	2,023	2,093	-3014%	-337	348	685	-203%	-935	-613	322	-34%	1,966	3,690	1,724	88%	3,619	4,399	781	22%	3,156	3,488	332	11%
70%	-181	1,822	2,002	-1109%	-543	119	662	-122%	-1,708	-948	759	-44%	622	2,586	1,964	315%	3,141	3,246	105	3%	2,396	2,828	432	18%
80%	-262	1,591	1,853	-708%	-815	-103	711	-87%	-2,251	-1,544	707	-31%	106	1,350	1,244	1172%	2,250	2,397	146	7%	2,001	2,283	282	14%
90%	-561	1,202	1,763	-314%	-1,306	-434	873	-67%	-2,699	-1,794	905	-34%	-289	470	759	-263%	784	1,527	743	95%	1,490	1,519	29	2%
Long Term																								
Full Simulation Period[b]	333	2,549	2,216	665%	427	2,350	1,923	450%	2,500	2,864	364	15%	8,546	9,894	1,348	16%	11,922	13,208	1,286	11%	9,441	11,153	1,712	18%
Water Year Types[c]																								
Wet (32%)	1,273	3,956	2,683	211%	1,947	5,306	3,359	173%	3,645	4,396	751	21%	11,994	15,300	3,306	28%	23,343	26,550	3,206	14%	19,254	22,752	3,498	18%
Above Normal (16%)	371	2,453	2,082	560%	-90	3,193	3,283	-3630%	265	852	587	221%	6,006	6,784	778	13%	13,425	14,281	856	6%	10,397	13,735	3,338	32%
Below Normal (13%)	-424	2,373	2,798	-659%	-814	72	886	-109%	1,637	1,340	-298	-18%	7,209	7,608	400	6%	7,335	7,838	503	7%	2,866	3,604	739	26%
Dry (24%)	-168	1,867	2,034	-1213%	-147	794	942	-638%	4,414	4,661	247	6%	8,597	8,978	381	4%	4,326	4,606	280	6%	4,077	3,965	-112	-3%
Critical (15%)	-215	902	1,118	-519%	-208	-288	-80	38%	43	126	83	190%	4,969	5,175	205	4%	2,412	2,395	-16	-1%	2,110	2,125	15	1%

Statistic	Monthly Flow (cfs)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	19,157	21,094	1,937	10%	15,023	16,489	1,466	10%	5,676	8,019	2,343	41%	268	1,929	1,662	621%	138	358	220	159%	71	5,599	5,528	7742%
20%	11,426	12,383	957	8%	7,842	8,262	420	5%	2,362	4,649	2,287	97%	-204	1,416	1,620	-793%	-500	142	641	-128%	-343	5,032	5,375	-1565%
30%	8,660	9,171	512	6%	6,043	6,747	704	12%	1,577	2,294	717	45%	-724	868	1,592	-220%	-921	-86	835	-91%	-574	4,484	5,058	-882%
40%	6,682	7,243	561	8%	5,011	5,752	740	15%	1,351	1,638	287	21%	-1,185	676	1,862	-157%	-1,526	-204	1,322	-87%	-670	3,156	3,826	-571%
50%	5,455	5,787	332	6%	3,766	4,521	755	20%	1,100	1,462	362	33%	-1,620	246	1,865	-115%	-2,170	-347	1,823	-84%	-765	232	997	-130%
60%	3,938	3,932	-6	0%	2,637	2,539	-98	-4%	808	1,199	391	48%	-1,925	43	1,968	-102%	-2,488	-444	2,044	-82%	-882	52	934	-106%
70%	2,958	2,738	-220	-7%	1,904	1,943	39	2%	571	822	251	44%	-2,180	-154	2,027	-93%	-2,556	-548	2,008	-79%	-1,035	-116	919	-89%
80%	2,139	1,928	-212	-10%	1,214	1,427	213	18%	432	548	116	27%	-2,463	-485	1,978	-80%	-2,729	-794	1,934	-71%	-1,431	-238	1,192	-83%
90%	1,650	1,456	-194	-12%	800	777	-23	-3%	292	357	66	23%	-2,804	-755	2,049	-73%	-2,938	-1,058	1,880	-64%	-1,876	-361	1,515	-81%
Long Term																								
Full Simulation Period[b]	7,979	8,430	451	6%	5,844	6,412	568	10%	2,126	3,071	945	44%	-1,213	642	1,855	-153%	-1,700	-311	1,389	-82%	-727	2,097	2,824	-389%
Water Year Types[c]																								
Wet (32%)	15,376	16,475	1,099	7%	12,167	13,380	1,213	10%	4,824	6,898	2,073	43%	-76	1,831	1,908	-2495%	-2,366	-108	2,259	-95%	-262	5,327	5,588	-2136%
Above Normal (16%)	8,256	8,882	626	8%	5,526	6,089	563	10%	951	1,934	984	103%	-1,041	1,339	2,381	-229%	-2,699	-132	2,567	-95%	-151	3,122	3,274	-2162%
Below Normal (13%)	4,428	4,467	39	1%	3,125	3,350	225	7%	834	1,159	324	39%	-2,369	43	2,412	-102%	-2,412	-13	2,399	-99%	-1,747	-185	1,562	-89%
Dry (24%)	3,916	3,998	82	2%	2,312	2,592	279	12%	827	1,157	330	40%	-2,343	-463	1,880	-80%	-648	-715	-67	10%	-1,235	-124	1,111	-90%
Critical (15%)	1,677	1,528	-149	-9%	868	842	-26	-3%	904	955	51	6%	-920	-297	623	-68%	-274	-545	-271	99%	-577	-216	361	-63%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

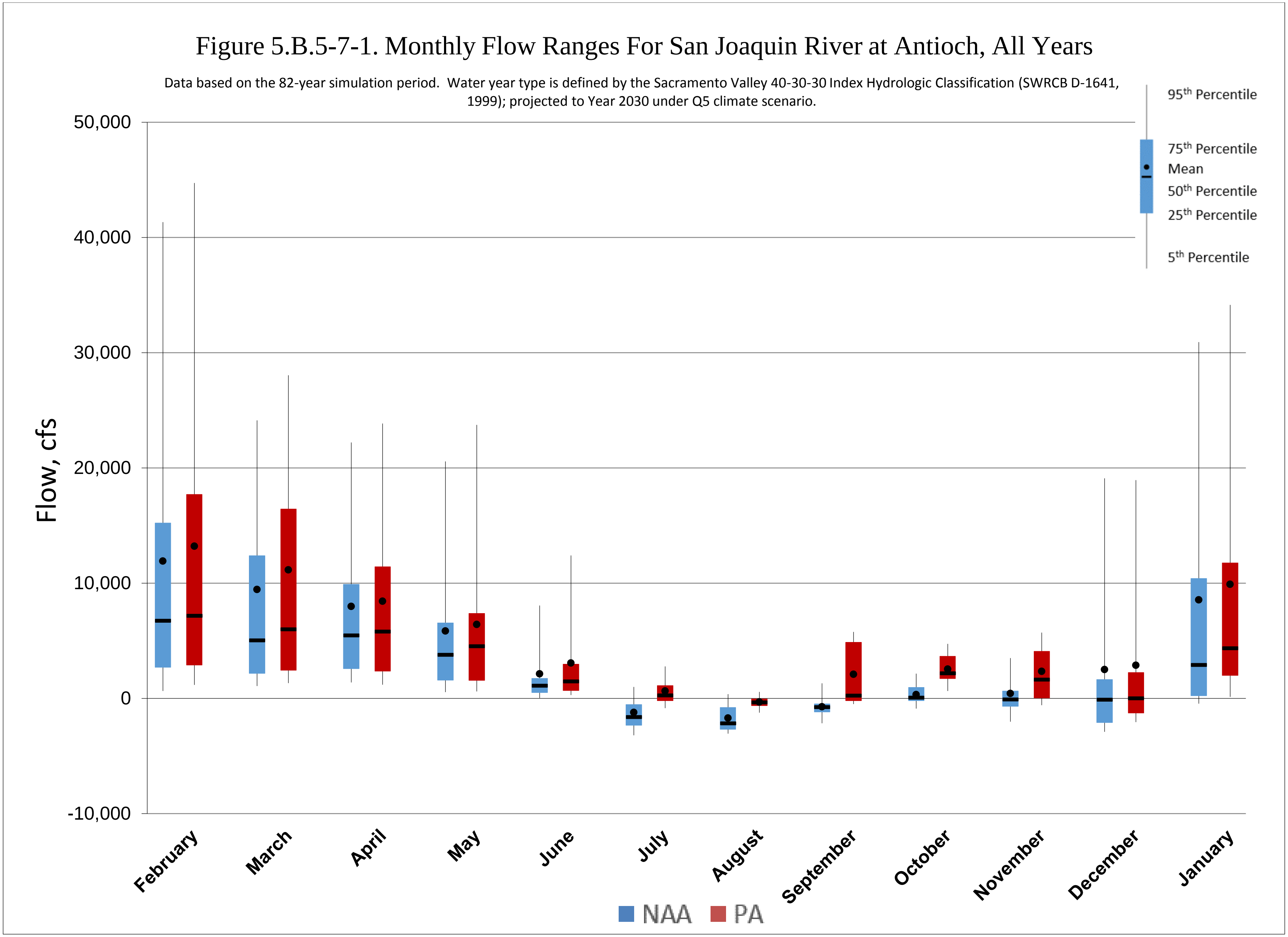


Figure 5.B.5-7-1. Monthly Flow Ranges For San Joaquin River at Antioch, All Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
Flow, cfs
50,000
40,000
30,000
20,000
10,000
0
-10,000
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

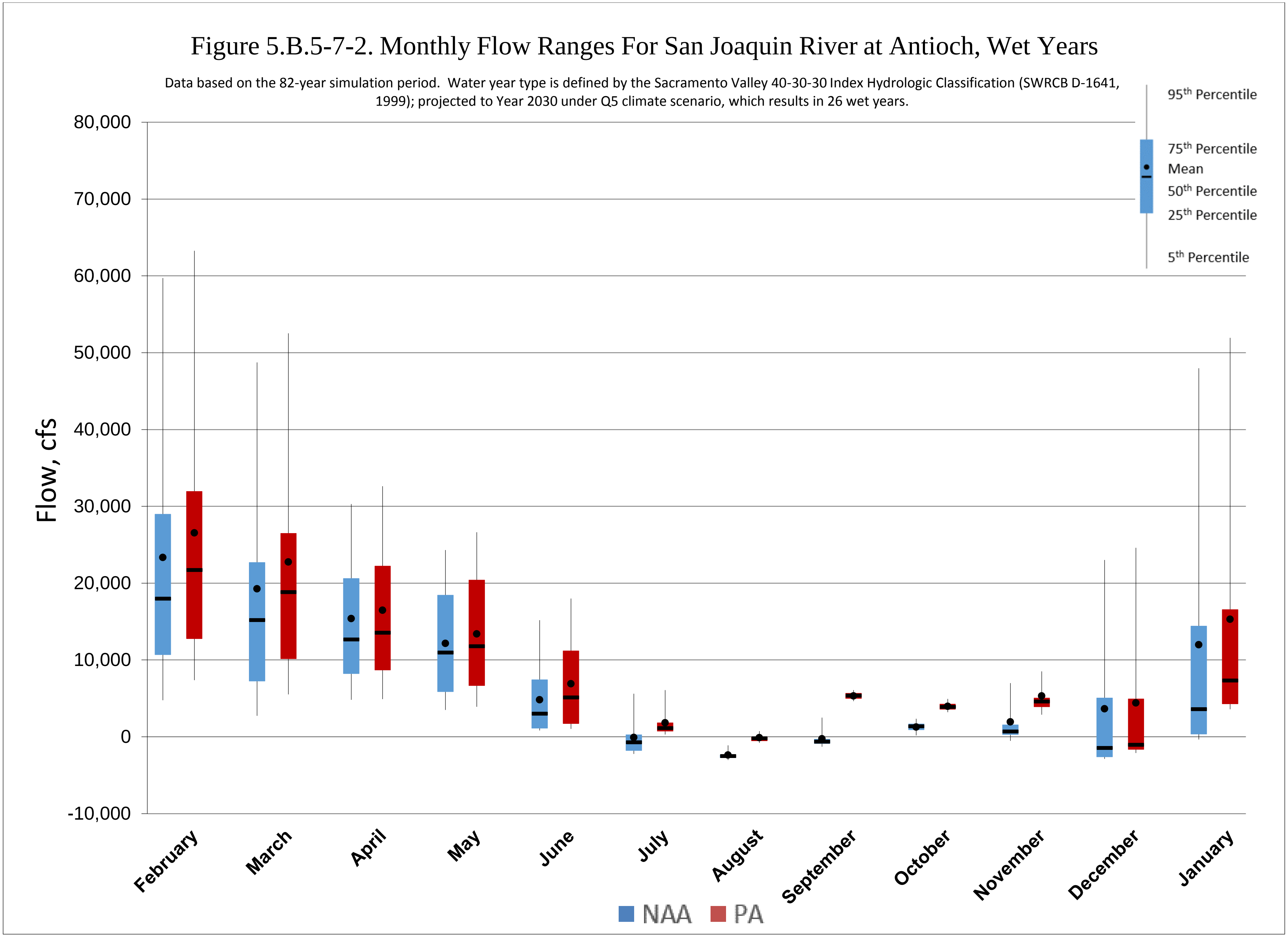


Figure 5.B.5-7-2. Monthly Flow Ranges For San Joaquin River at Antioch, Wet Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 26 wet years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
Flow, cfs
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
-10,000
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-7-3. Monthly Flow Ranges For San Joaquin River at Antioch, Above Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 13 above normal years.

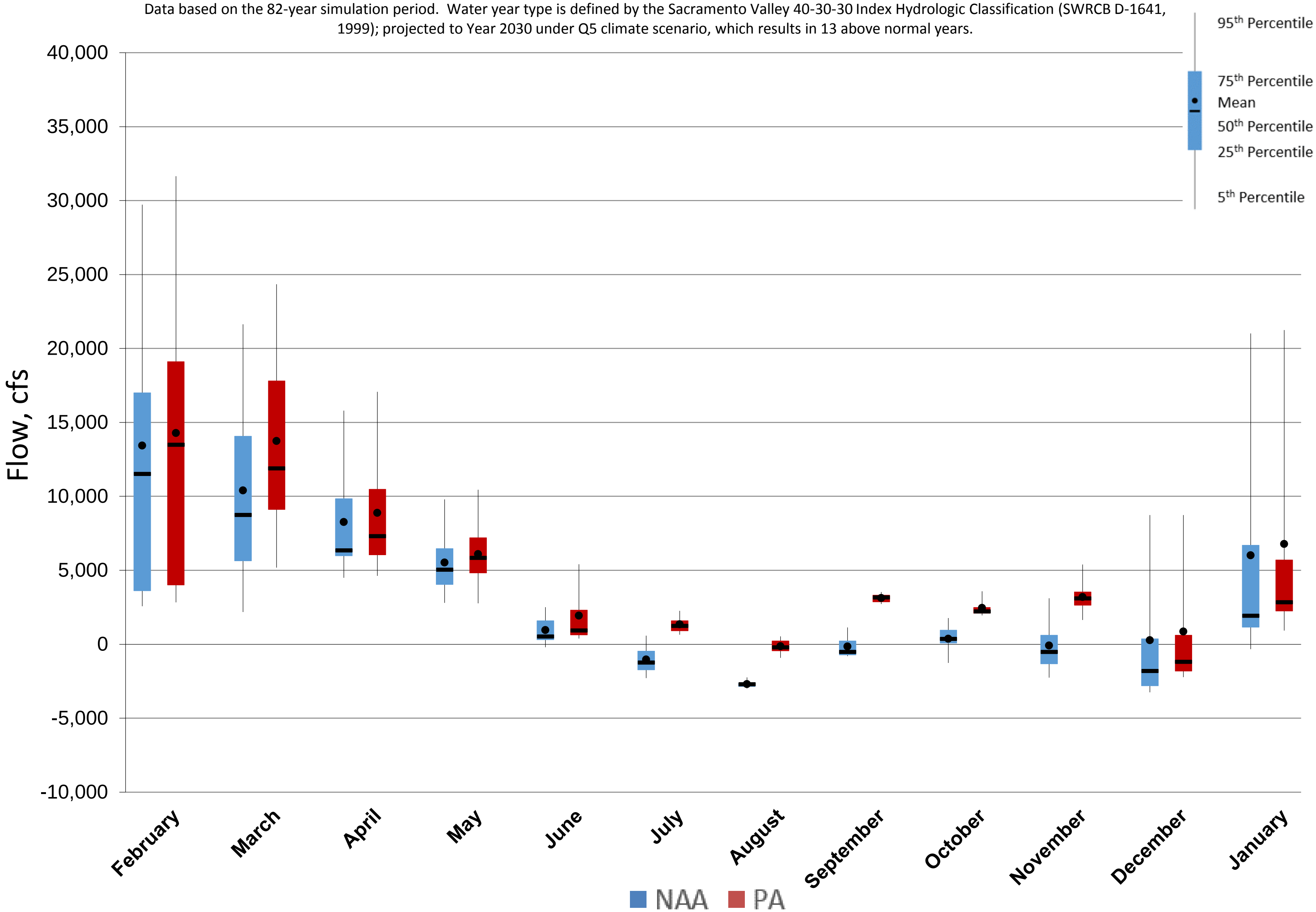


Figure 5.B.5-7-4. Monthly Flow Ranges For San Joaquin River at Antioch, Below Normal Years

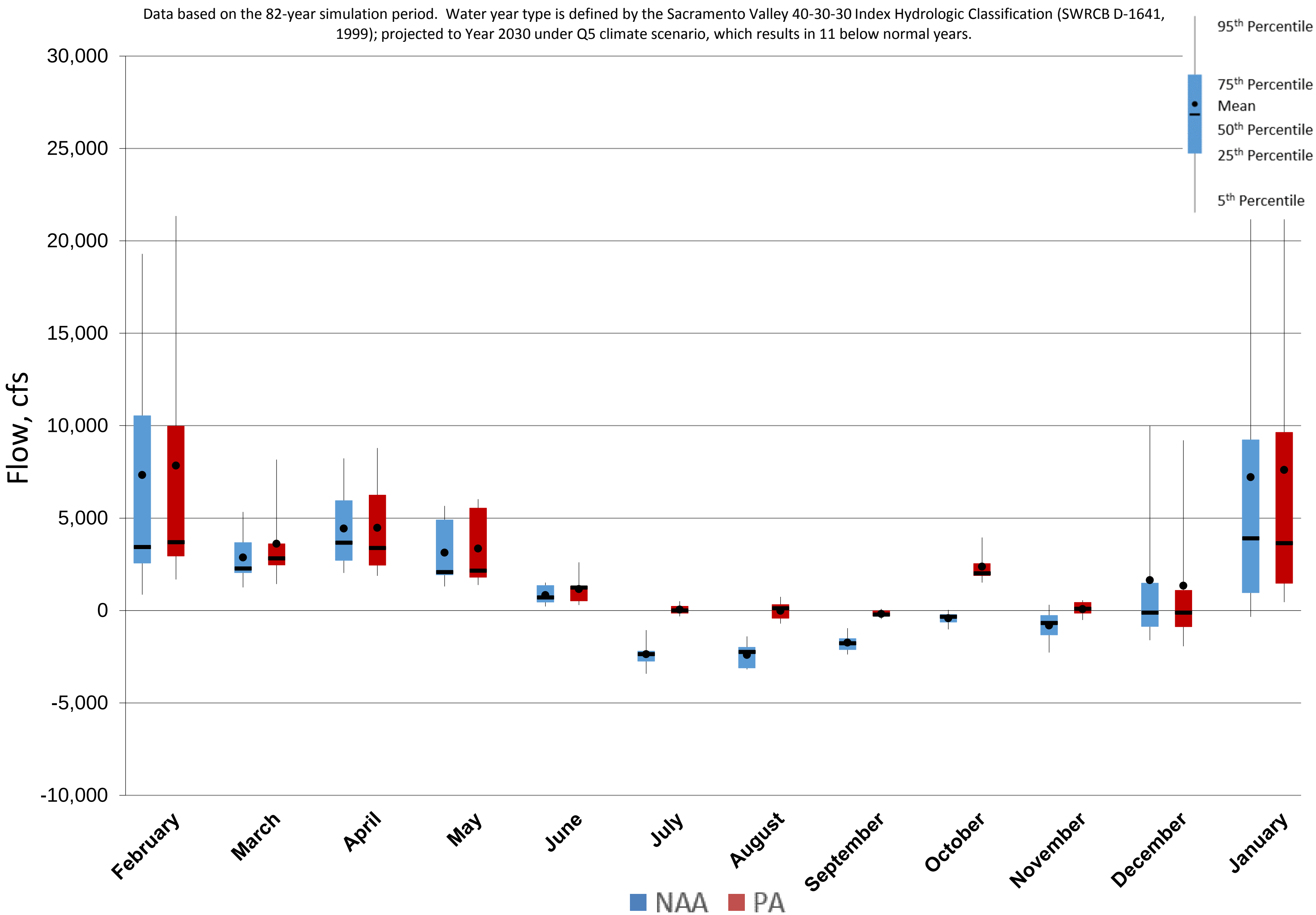
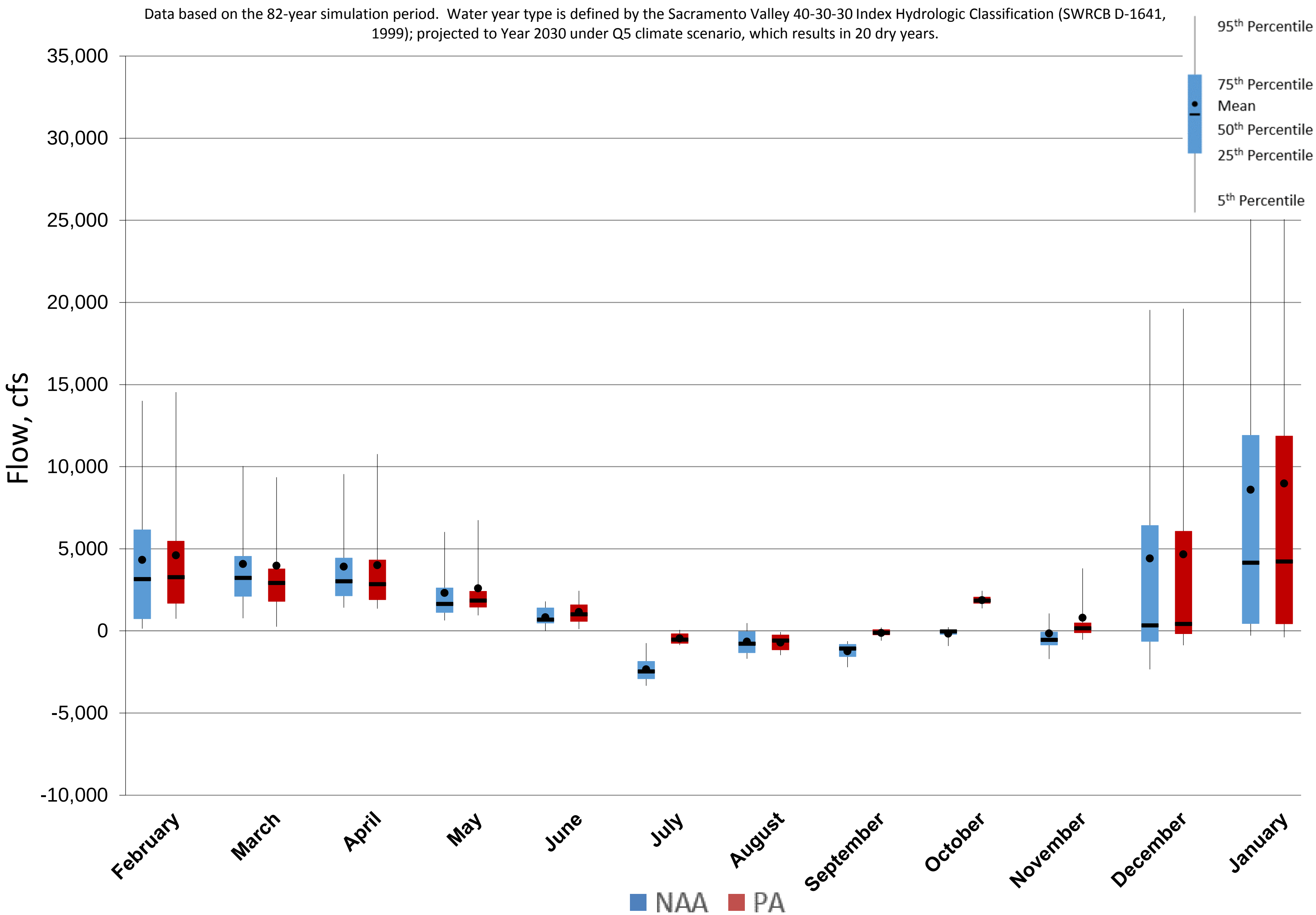


Figure 5.B.5-7-5. Monthly Flow Ranges For San Joaquin River at Antioch, Dry Years



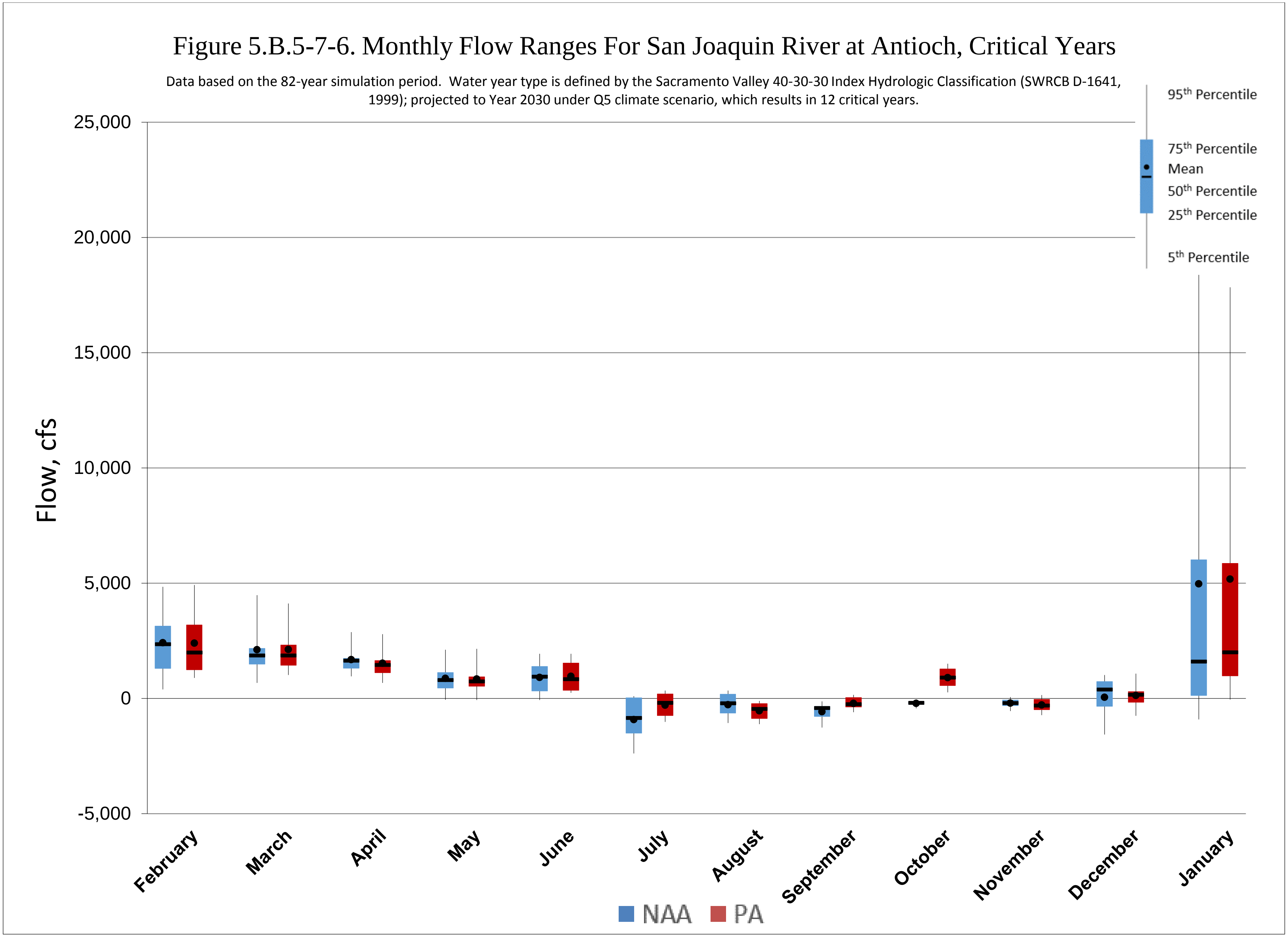
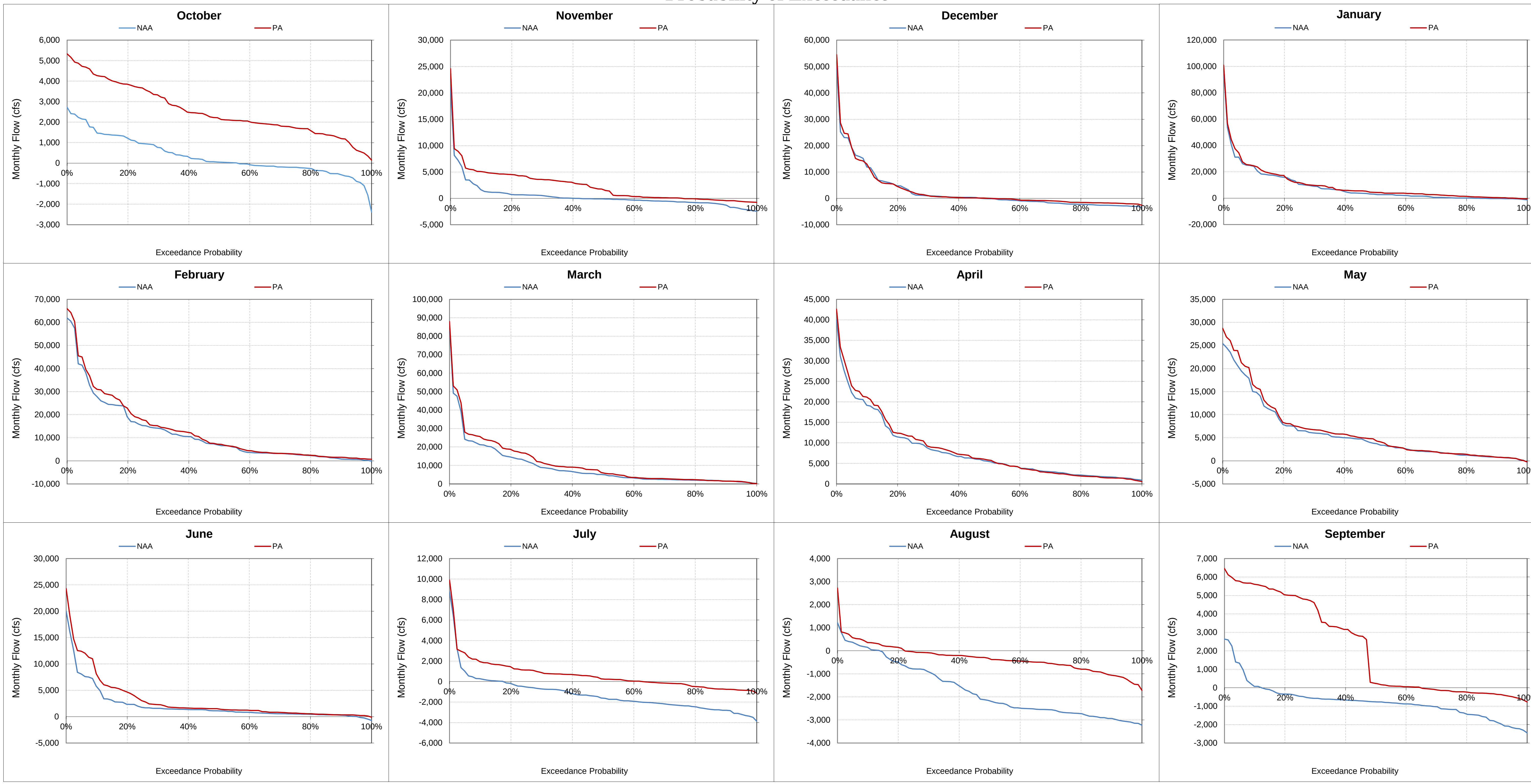


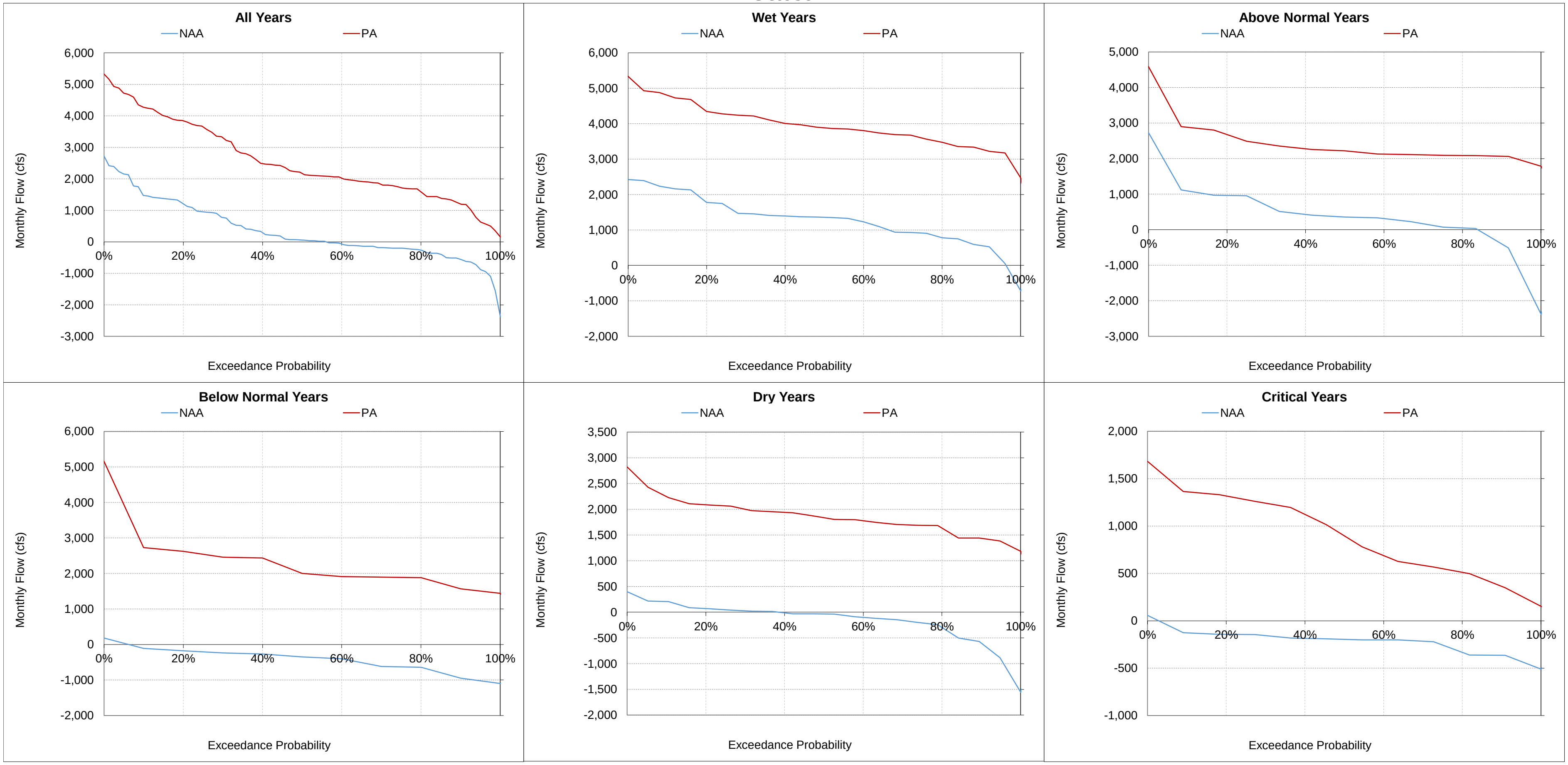
Figure 5.B.5-7-6. Monthly Flow Ranges For San Joaquin River at Antioch, Critical Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 12 critical years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
Flow, cfs
25,000
20,000
15,000
10,000
5,000
0
-5,000
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-7-7. San Joaquin River at Antioch, Monthly Flow Probability of Exceedance



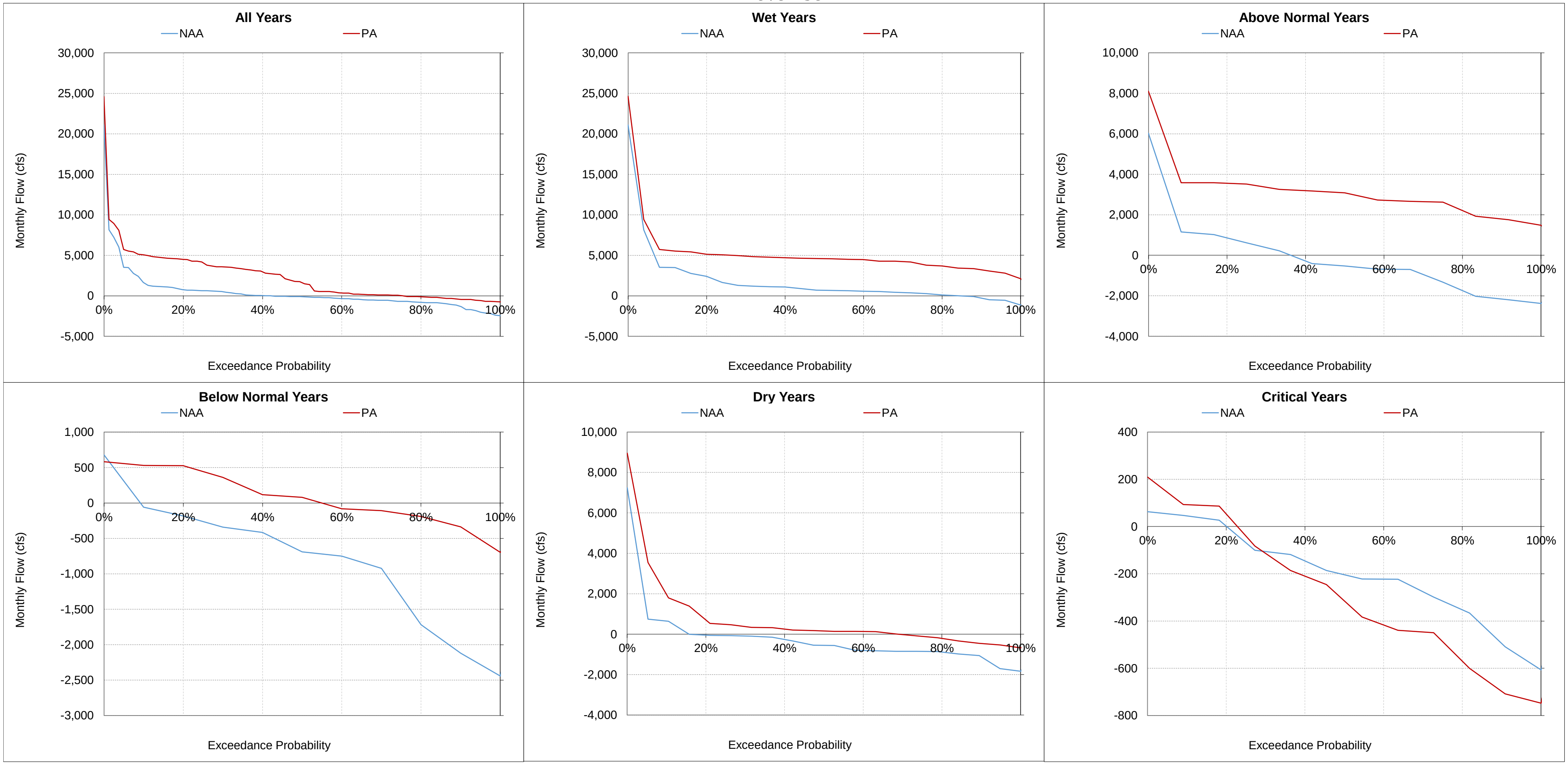
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-7-8. San Joaquin River at Antioch, Monthly Flow
October



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-7-9. San Joaquin River at Antioch, Monthly Flow November



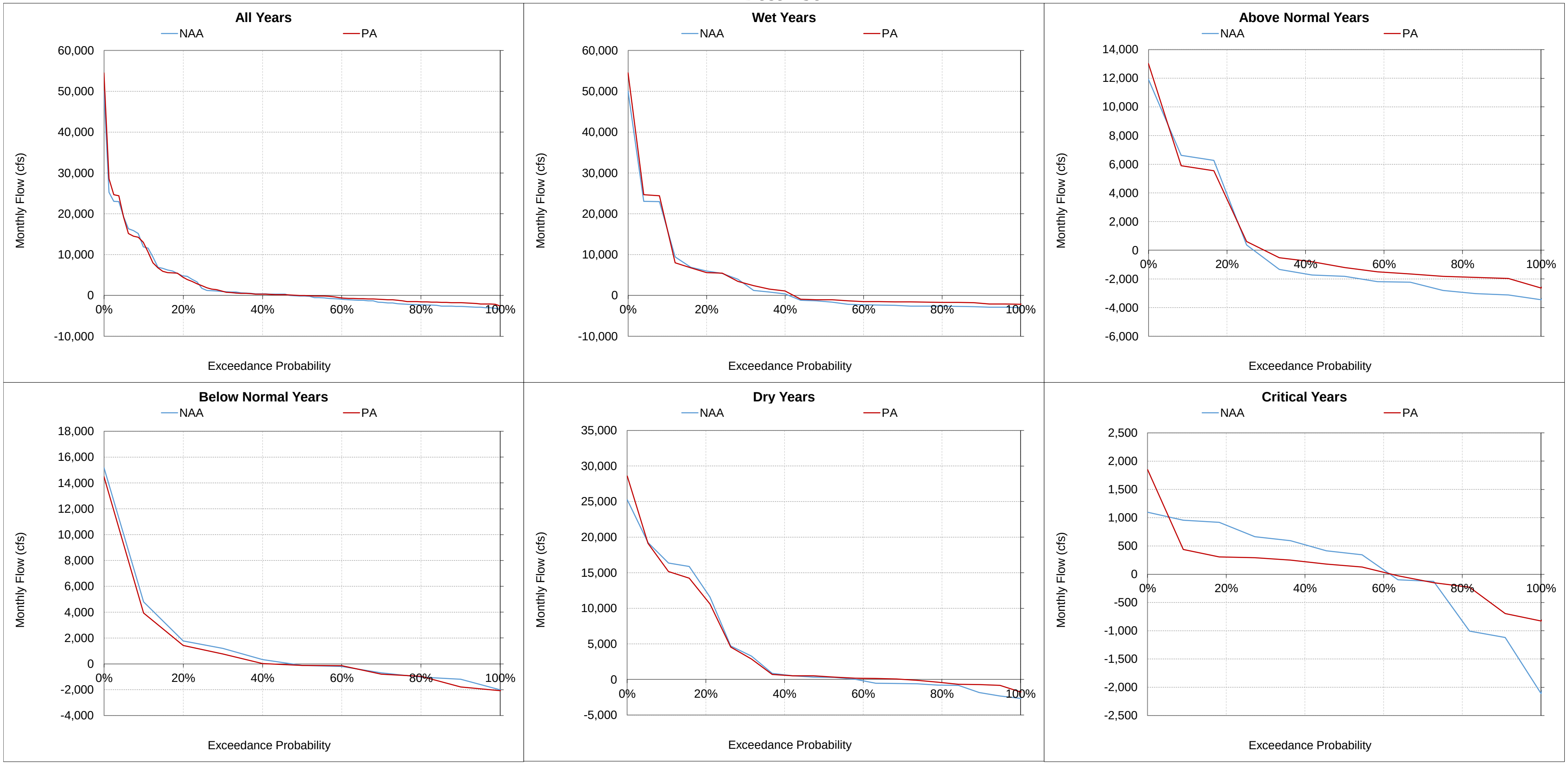
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

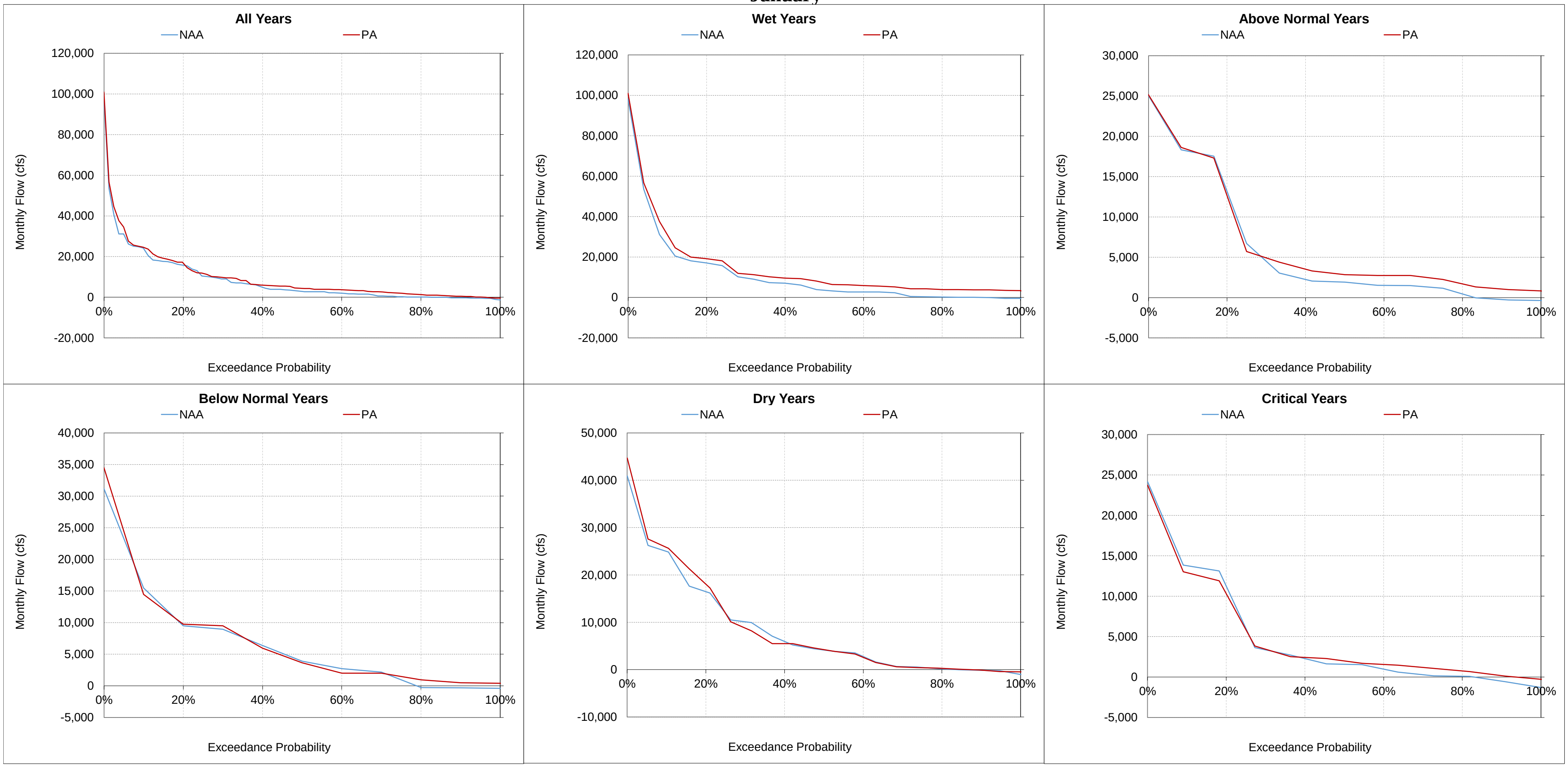
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-7-10. San Joaquin River at Antioch, Monthly Flow
December



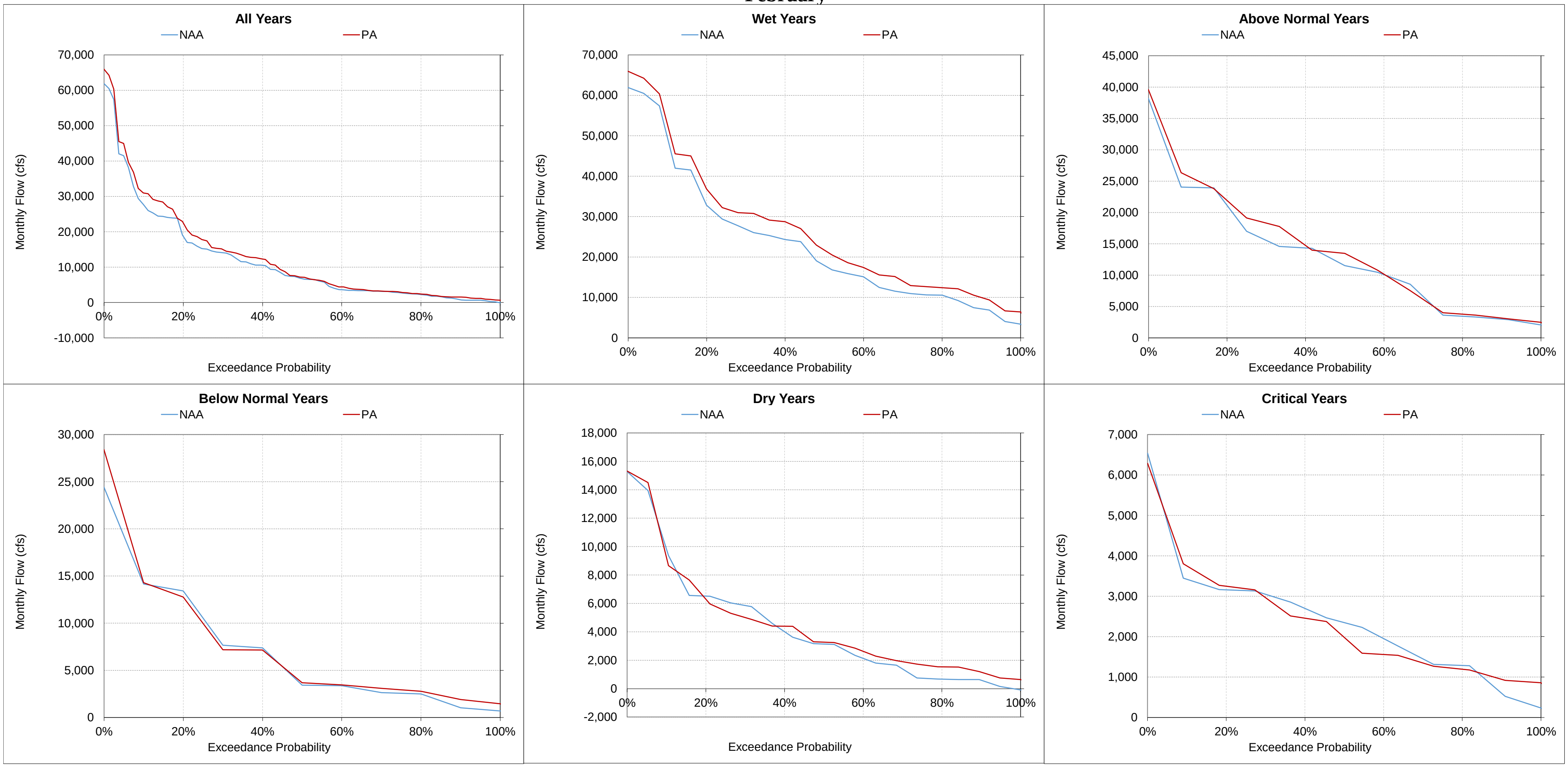
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-7-11. San Joaquin River at Antioch, Monthly Flow January



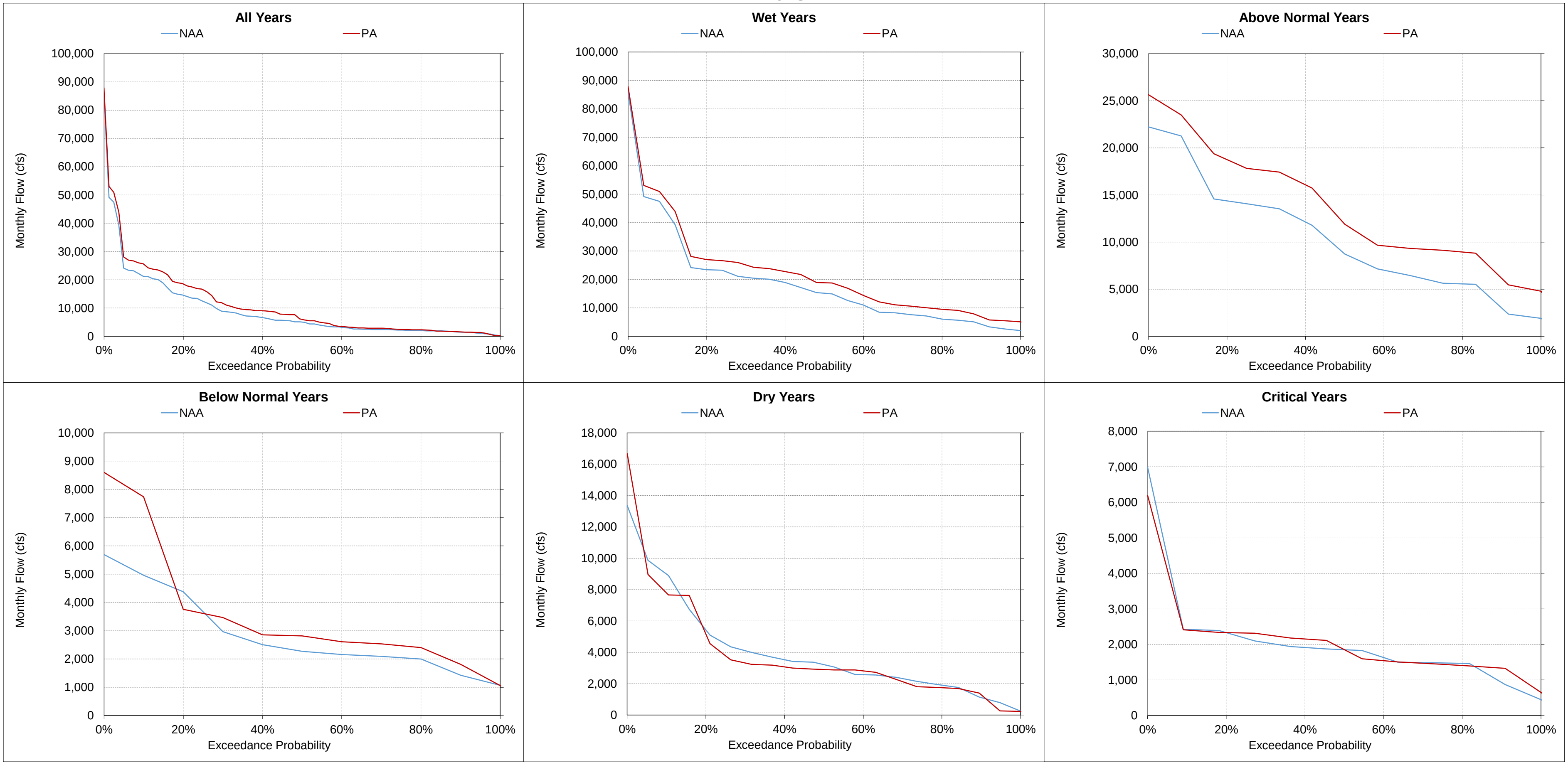
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-7-12. San Joaquin River at Antioch, Monthly Flow February



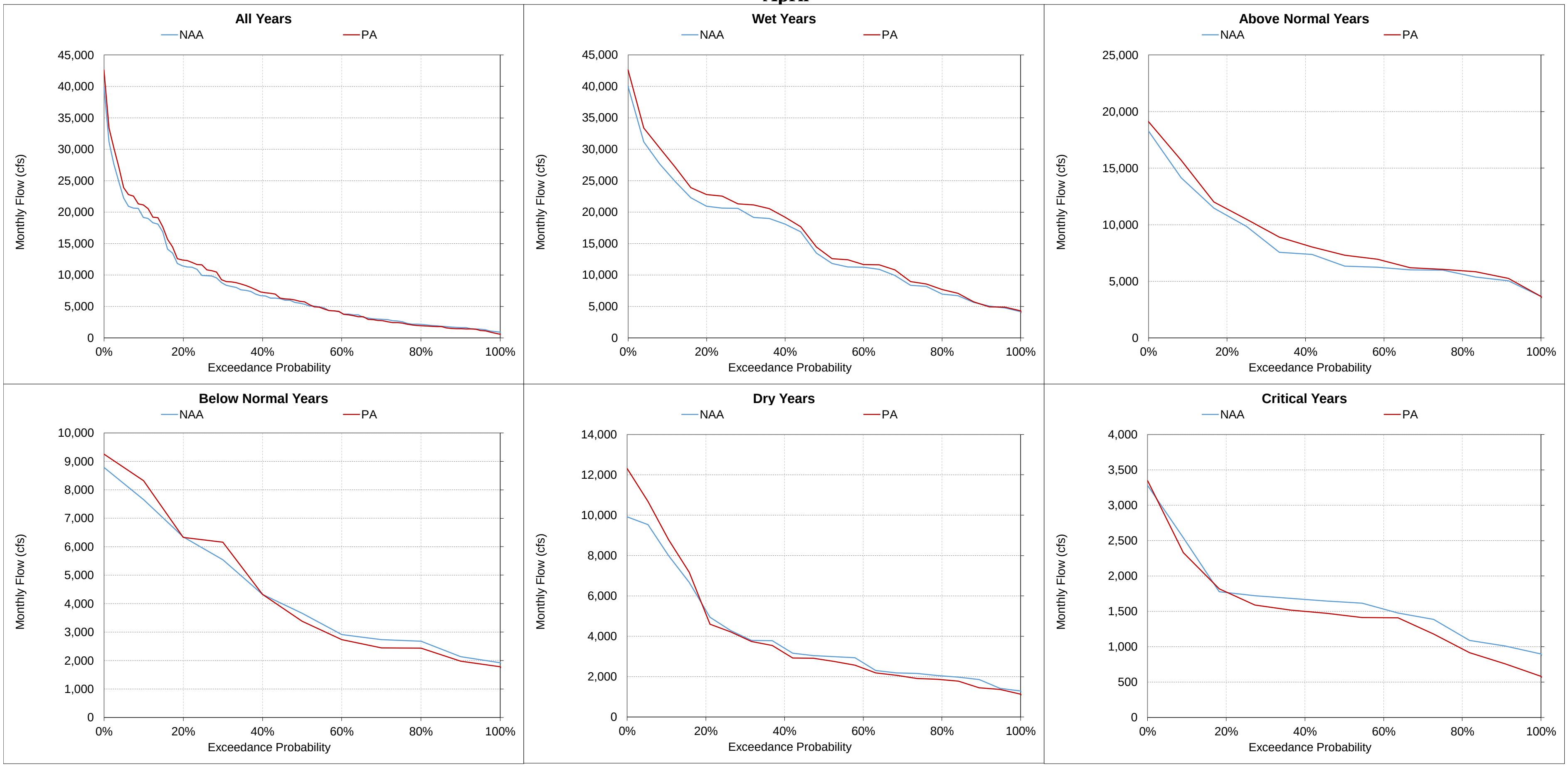
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-7-13. San Joaquin River at Antioch, Monthly Flow
March



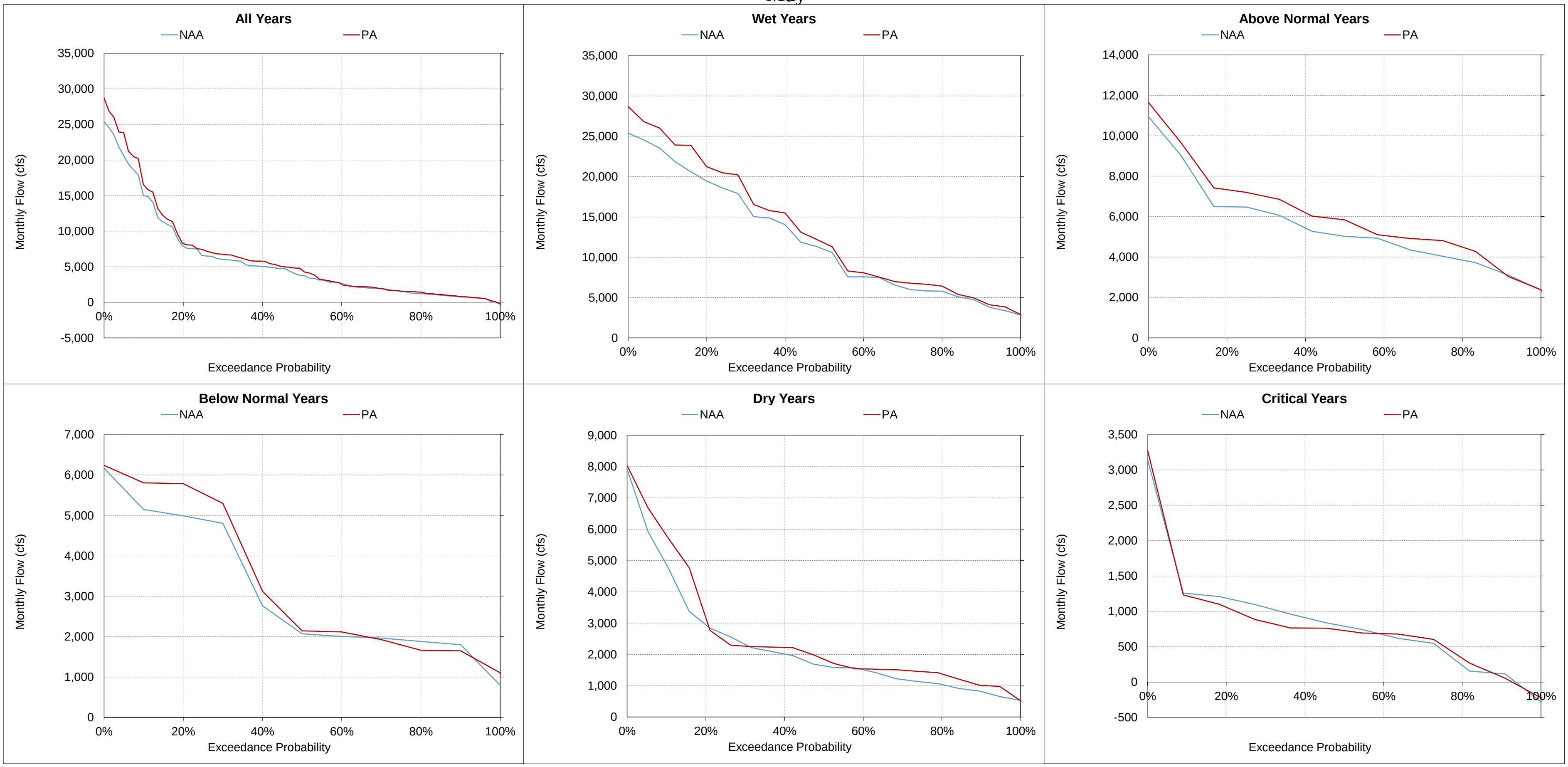
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-7-14. San Joaquin River at Antioch, Monthly Flow
April



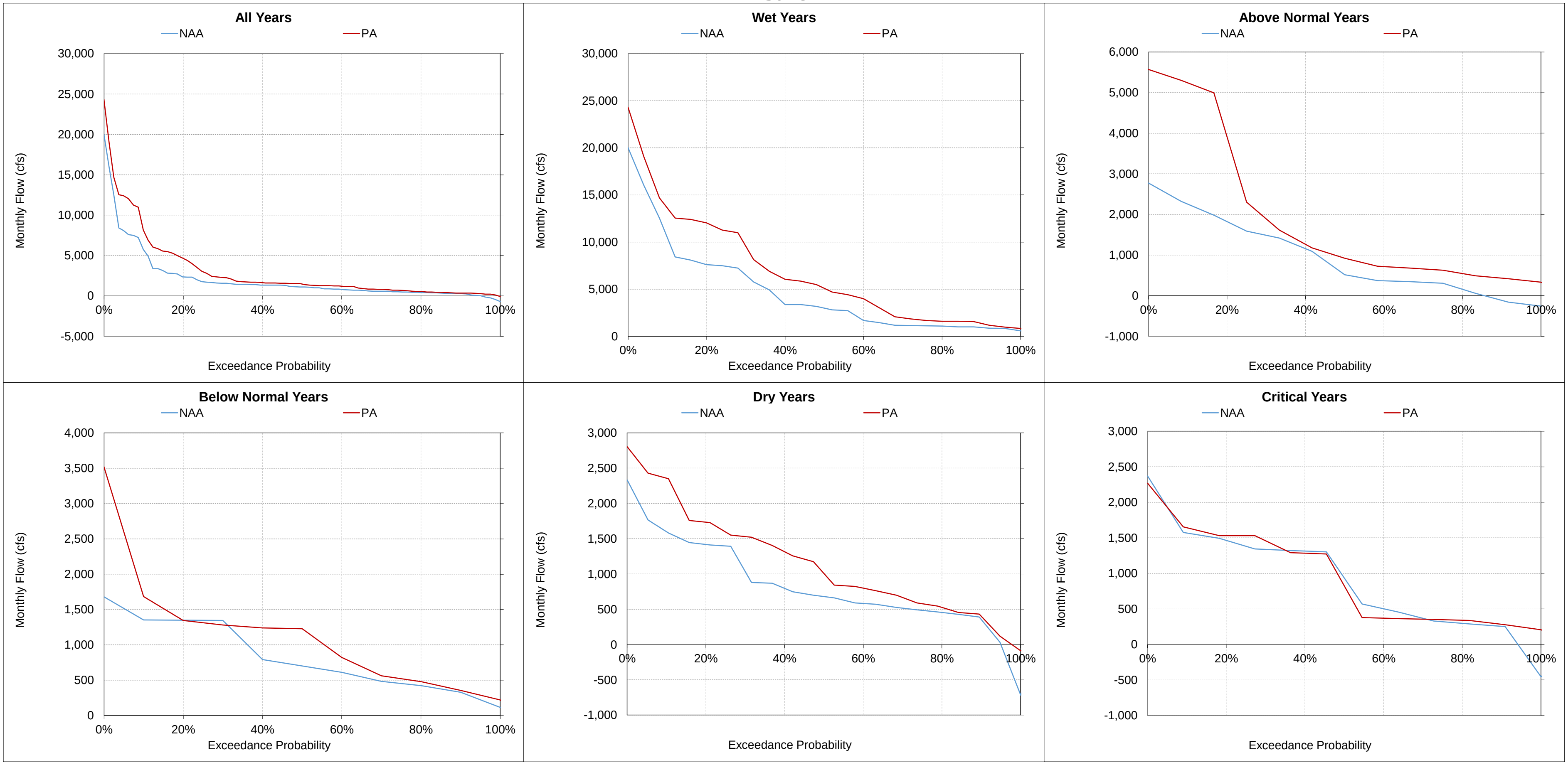
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-7-15. San Joaquin River at Antioch, Monthly Flow
May



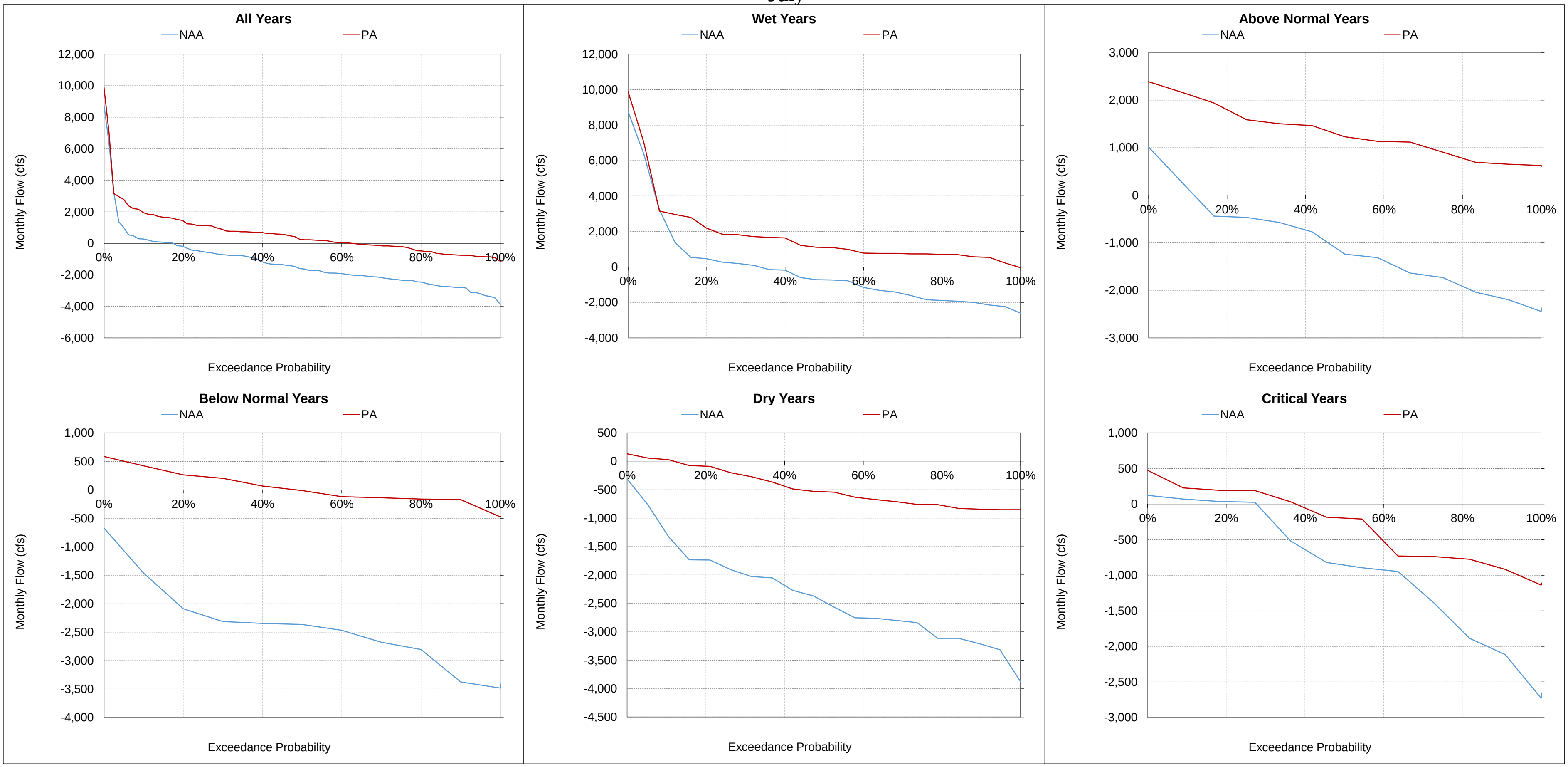
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-7-16. San Joaquin River at Antioch, Monthly Flow
June



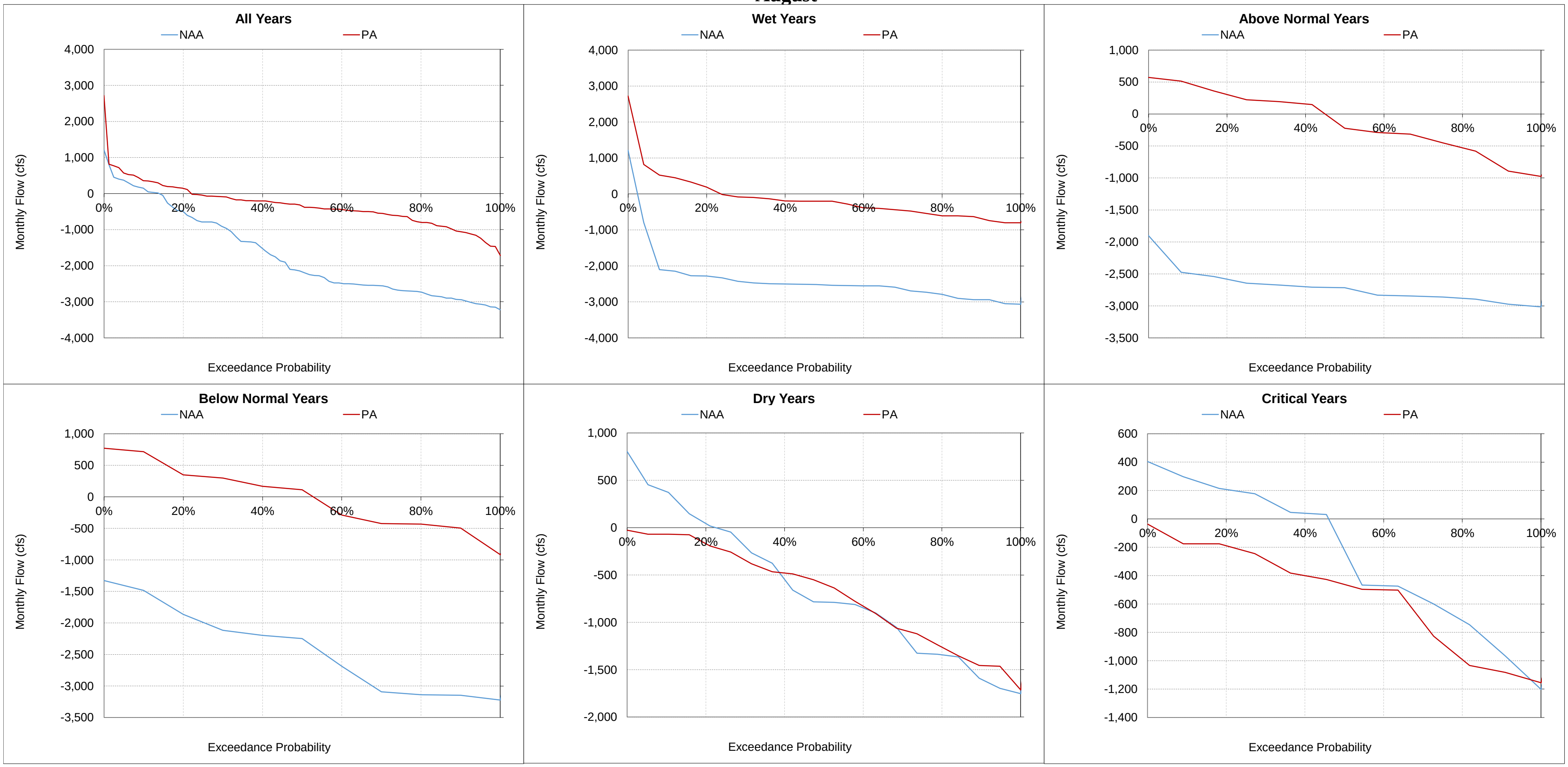
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-7-17. San Joaquin River at Antioch, Monthly Flow
July



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-7-18. San Joaquin River at Antioch, Monthly Flow August



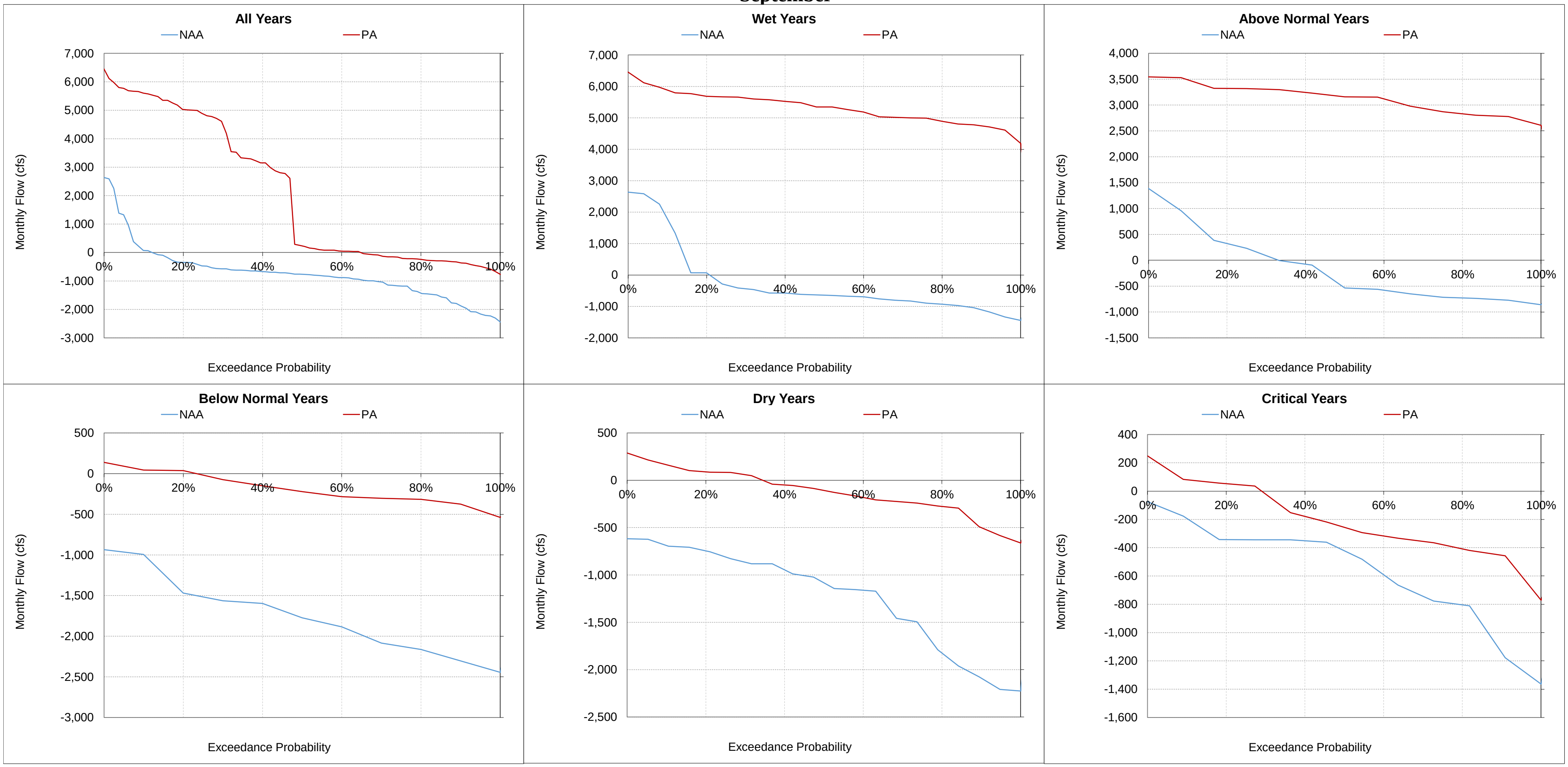
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-7-19. San Joaquin River at Antioch, Monthly Flow
September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-8. Head of Old River, Monthly Flow

Statistic	October NAA	October PA	October Diff.	October Perc. Diff.	November NAA	November PA	November Diff.	November Perc. Diff.	December NAA	December PA	December Diff.	December Perc. Diff.	January NAA	January PA	January Diff.	January Perc. Diff.	February NAA	February PA	February Diff.	February Perc. Diff.	March NAA	March PA	March Diff.	March Perc. Diff.
Probability of Exceedance[a]																								
10%	1,131	751	-380	-34%	959	1,110	151	16%	2,745	2,720	-26	-1%	6,113	5,279	-834	-14%	6,958	6,212	-746	-11%	7,790	7,183	-607	-8%
20%	1,018	634	-384	-38%	885	1,000	115	13%	1,806	1,787	-19	-1%	2,692	1,323	-1,369	-51%	5,274	4,510	-764	-14%	5,072	3,696	-1,376	-27%
30%	969	601	-368	-38%	832	971	140	17%	1,704	1,660	-43	-3%	2,115	963	-1,152	-54%	3,214	1,721	-1,493	-46%	4,237	2,441	-1,796	-42%
40%	907	567	-340	-37%	795	907	113	14%	1,589	1,562	-27	-2%	1,662	786	-876	-53%	2,399	1,079	-1,321	-55%	2,689	1,225	-1,464	-54%
50%	861	535	-326	-38%	760	844	84	11%	1,549	1,524	-24	-2%	1,555	720	-835	-54%	2,102	899	-1,203	-57%	2,003	907	-1,096	-55%
60%	814	496	-318	-39%	714	823	108	15%	1,485	1,480	-5	0%	1,471	695	-776	-53%	1,617	758	-859	-53%	1,782	826	-955	-54%
70%	748	470	-278	-37%	679	790	111	16%	1,400	1,396	-4	0%	1,396	668	-728	-52%	1,479	729	-750	-51%	1,552	694	-859	-55%
80%	677	441	-237	-35%	648	757	110	17%	1,343	1,314	-29	-2%	1,286	639	-647	-50%	1,410	698	-712	-51%	1,255	650	-605	-48%
90%	624	413	-211	-34%	579	715	136	23%	1,210	1,212	2	0%	1,193	624	-569	-48%	1,309	659	-649	-50%	1,146	607	-539	-47%
Long Term Full Simulation Period[b]	897	567	-330	-37%	914	1,027	113	12%	2,006	1,985	-22	-1%	2,662	1,832	-831	-31%	3,345	2,474	-871	-26%	3,451	2,551	-900	-26%
Water Year Types[c]																								
Wet (32%)	1,161	709	-452	-39%	1,348	1,426	78	6%	2,684	2,651	-33	-1%	3,884	3,039	-845	-22%	5,802	4,832	-970	-17%	6,329	5,372	-957	-15%
Above Normal (16%)	909	584	-325	-36%	818	875	58	7%	1,772	1,728	-43	-2%	1,920	903	-1,018	-53%	3,196	2,169	-1,027	-32%	3,403	2,250	-1,153	-34%
Below Normal (13%)	871	545	-326	-37%	739	885	146	20%	1,635	1,634	-1	0%	2,085	1,217	-868	-42%	2,605	1,776	-829	-32%	2,103	1,046	-1,057	-50%
Dry (24%)	738	484	-254	-34%	712	866	154	22%	1,938	1,921	-17	-1%	2,543	1,835	-708	-28%	1,812	1,045	-767	-42%	1,853	1,068	-785	-42%
Critical (15%)	605	402	-203	-34%	575	729	153	27%	1,248	1,246	-2	0%	1,546	779	-767	-50%	1,417	715	-702	-50%	1,166	614	-552	-47%

Statistic	April NAA	April PA	April Diff.	April Perc. Diff.	May NAA	May PA	May Diff.	May Perc. Diff.	June NAA	June PA	June Diff.	June Perc. Diff.	July NAA	July PA	July Diff.	July Perc. Diff.	August NAA	August PA	August Diff.	August Perc. Diff.	September NAA	September PA	September Diff.	September Perc. Diff.
Probability of Exceedance[a]																								
10%	7,588	7,287	-301	-4%	7,676	7,647	-29	0%	4,570	3,940	-629	-14%	2,969	2,908	-61	-2%	1,561	1,450	-111	-7%	1,350	1,529	179	13%
20%	4,124	2,438	-1,686	-41%	3,862	1,909	-1,953	-51%	2,171	1,472	-699	-32%	1,462	1,344	-117	-8%	1,419	1,271	-148	-10%	1,187	1,326	139	12%
30%	3,185	1,543	-1,641	-52%	2,768	1,323	-1,445	-52%	1,709	1,171	-539	-32%	1,165	1,055	-110	-9%	1,189	1,016	-173	-15%	1,129	1,268	139	12%
40%	2,786	1,335	-1,451	-52%	2,356	1,100	-1,256	-53%	1,487	1,045	-442	-30%	1,073	930	-143	-13%	1,044	866	-178	-17%	1,016	1,087	71	7%
50%	2,312	1,089	-1,223	-53%	2,088	973	-1,115	-53%	1,181	824	-358	-30%	966	801	-165	-17%	968	813	-155	-16%	954	1,006	52	5%
60%	1,915	908	-1,008	-53%	1,702	813	-889	-52%	965	725	-240	-25%	912	715	-197	-22%	921	760	-160	-17%	914	945	31	3%
70%	1,659	789	-870	-52%	1,567	756	-811	-52%	691	547	-145	-21%	786	622	-164	-21%	733	707	-27	-4%	824	888	65	8%
80%	1,297	673	-624	-48%	1,296	656	-640	-49%	585	452	-133	-23%	704	538	-166	-24%	610	624	14	2%	744	798	54	7%
90%	1,051	578	-473	-45%	1,044	578	-466	-45%	469	363	-106	-23%	516	467	-49	-10%	527	513	-14	-3%	626	728	102	16%
Long Term Full Simulation Period[b]	3,144	2,197	-947	-30%	3,014	2,139	-875	-29%	1,967	1,650	-317	-16%	1,440	1,321	-119	-8%	1,042	951	-91	-9%	1,026	1,122	96	9%
Water Year Types[c]																								
Wet (32%)	5,488	4,540	-948	-17%	5,301	4,437	-864	-16%	4,046	3,628	-418	-10%	2,706	2,623	-83	-3%	1,548	1,420	-128	-8%	1,399	1,524	125	9%
Above Normal (16%)	3,046	1,794	-1,252	-41%	2,866	1,670	-1,196	-42%	1,691	1,208	-483	-29%	1,179	1,019	-160	-14%	1,100	933	-168	-15%	1,048	1,110	62	6%
Below Normal (13%)	2,268	1,091	-1,177	-52%	1,991	957	-1,034	-52%	1,017	751	-267	-26%	978	811	-167	-17%	988	806	-183	-18%	953	1,037	84	9%
Dry (24%)	1,883	989	-894	-47%	1,846	1,032	-813	-44%	857	624	-233	-27%	794	645	-149	-19%	731	724	-7	-1%	824	904	81	10%
Critical (15%)	1,077	587	-489	-45%	1,105	595	-511	-46%	479	376	-104	-22%	481	425	-56	-12%	454	469	15	3%	600	706	105	18%

Monthly Flow (cfs)

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

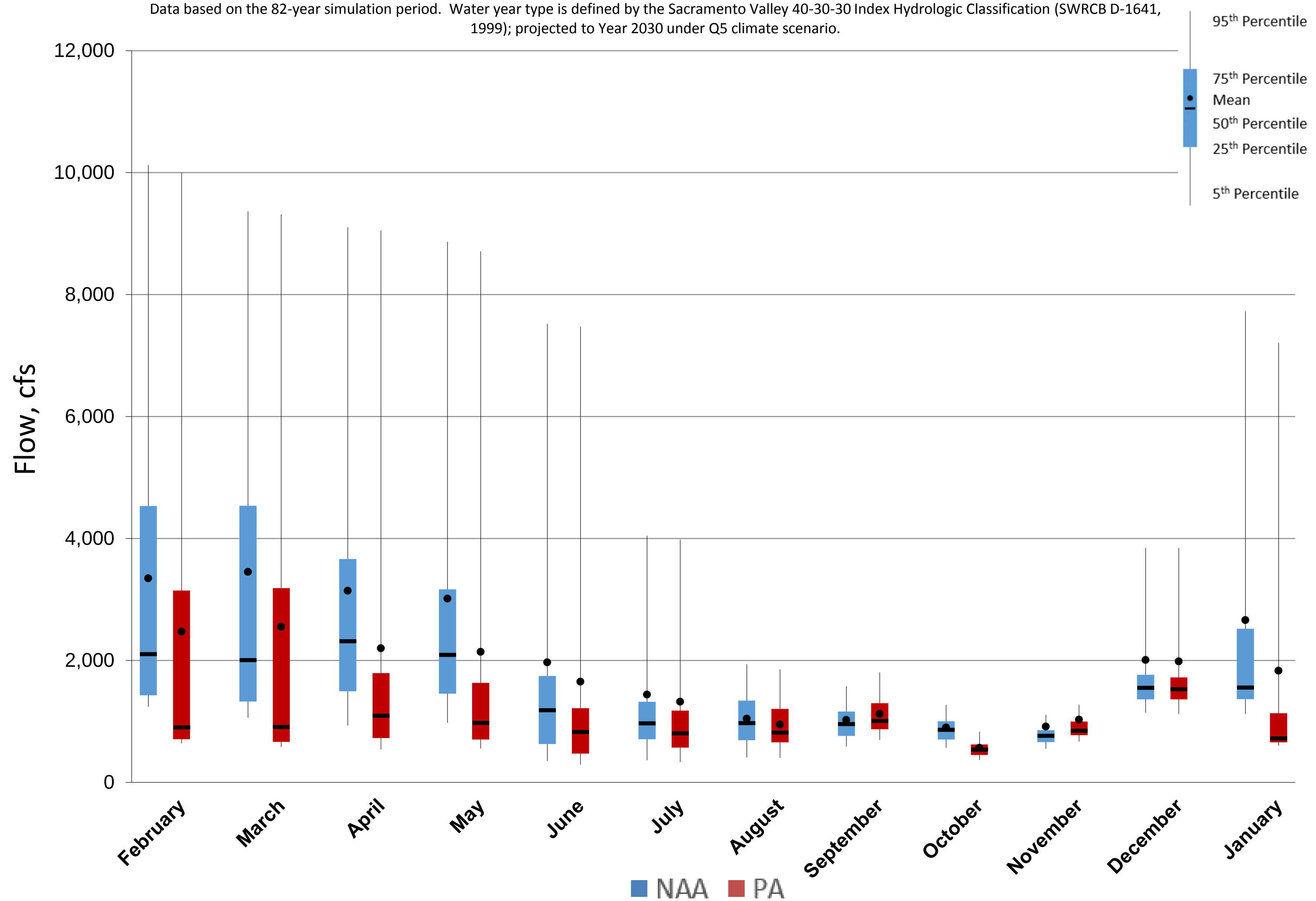
b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-8-1. Monthly Flow Ranges For Head of Old River, All Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario.



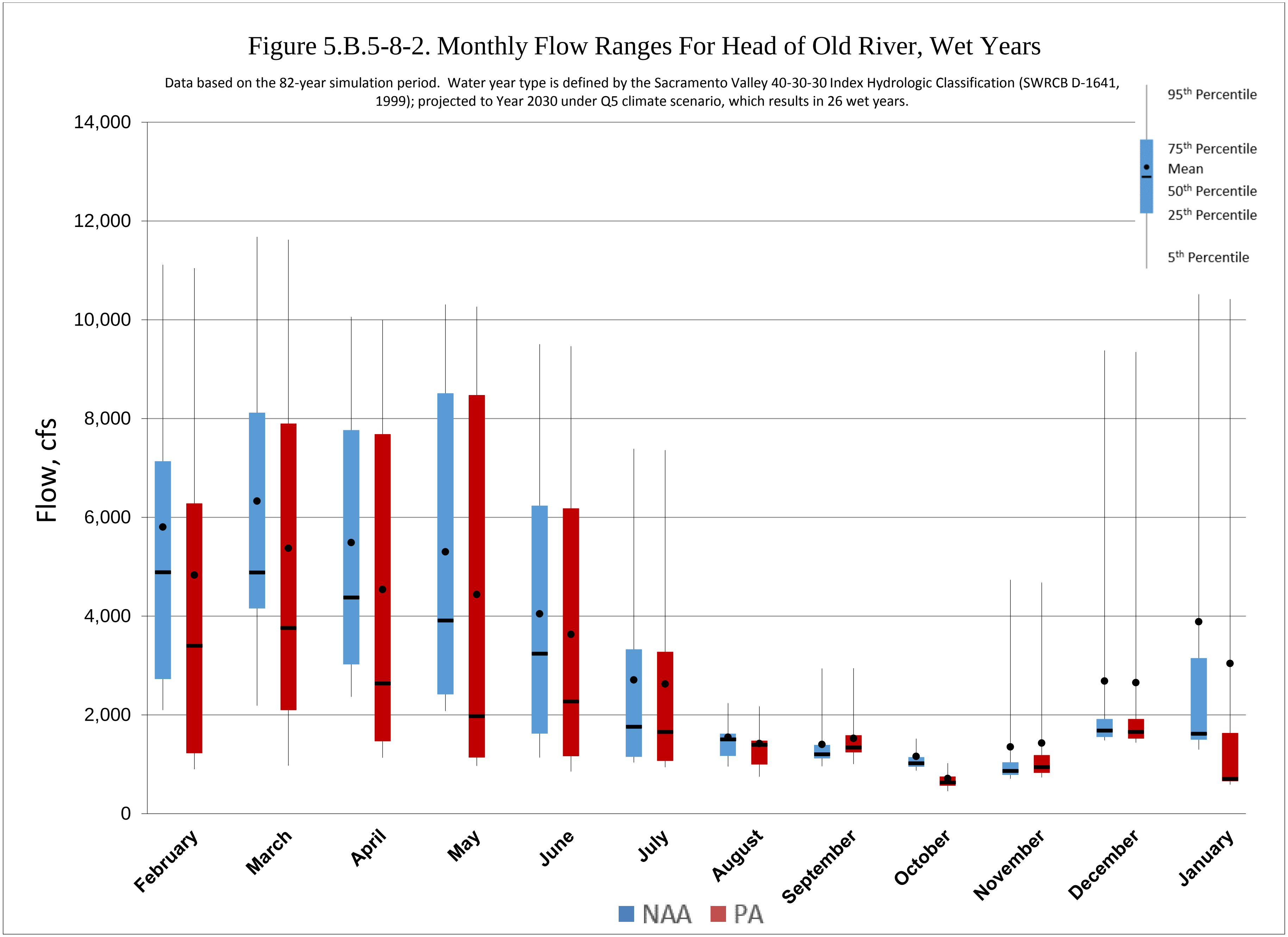


Figure 5.B.5-8-2. Monthly Flow Ranges For Head of Old River, Wet Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 26 wet years.
Flow, cfs
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
February
March
April
May
June
July
August
September
October
November
December
January
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
NAA
PA

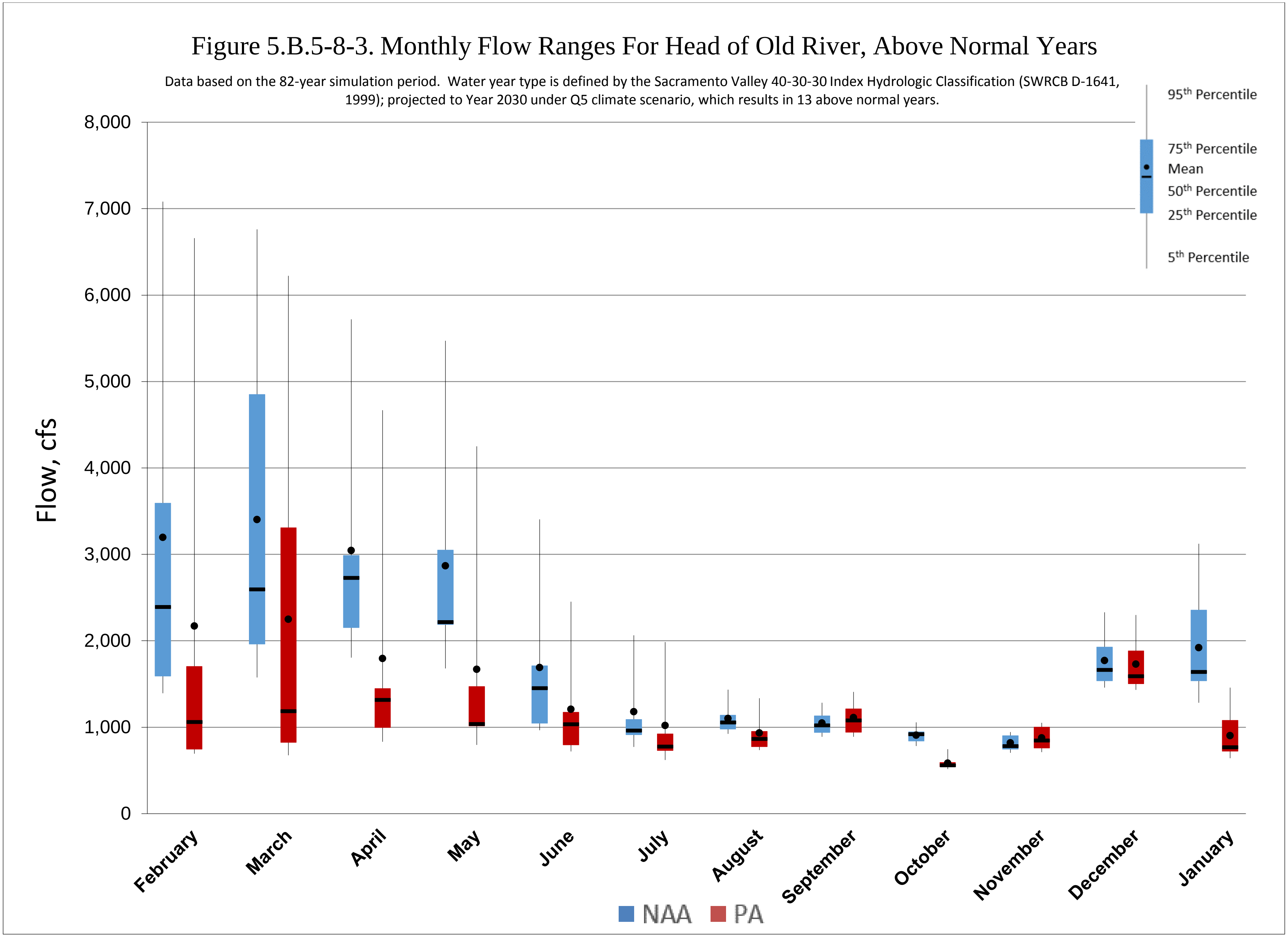
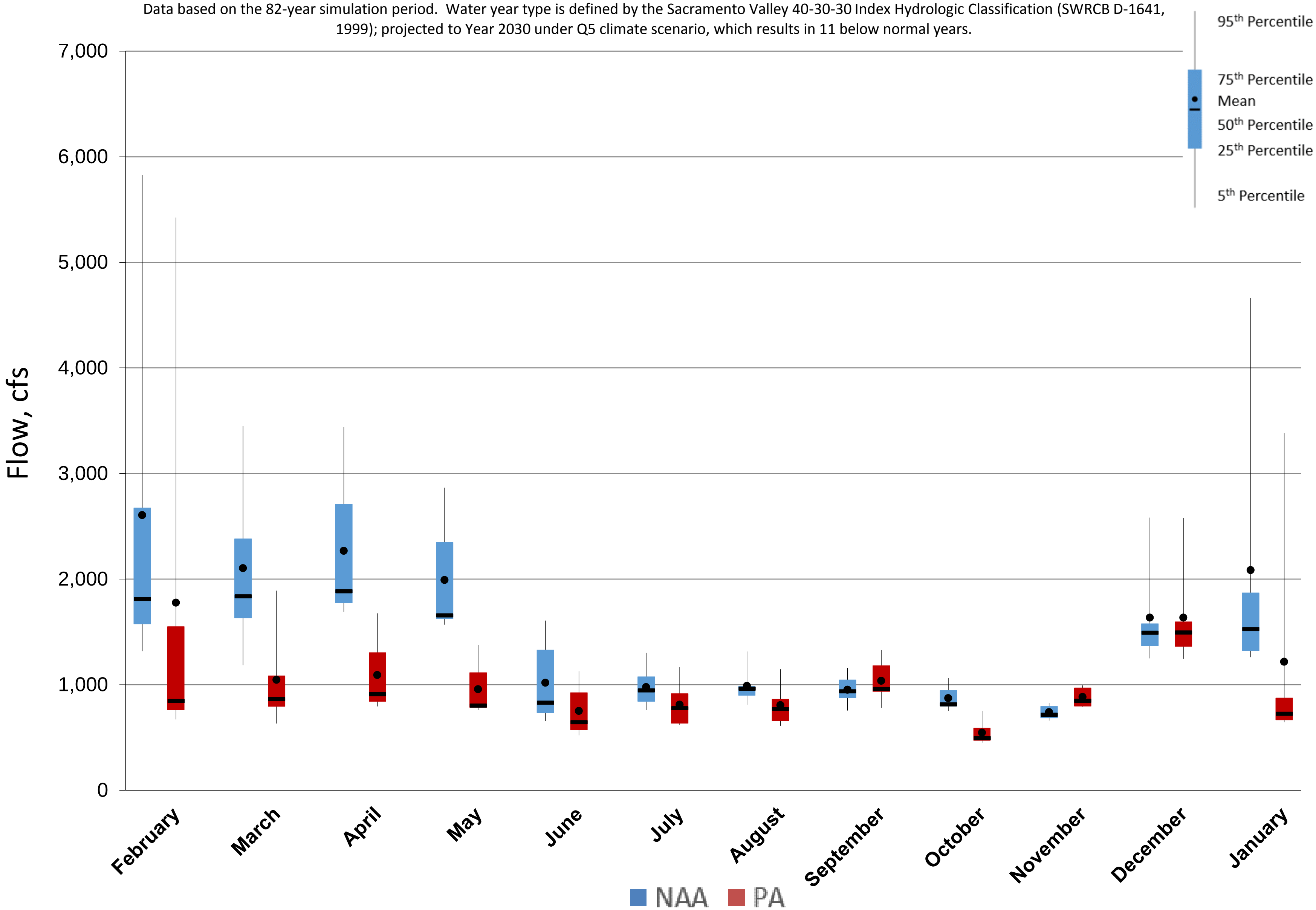


Figure 5.B.5-8-3. Monthly Flow Ranges For Head of Old River, Above Normal Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 13 above normal years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
Flow, cfs
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-8-4. Monthly Flow Ranges For Head of Old River, Below Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 11 below normal years.



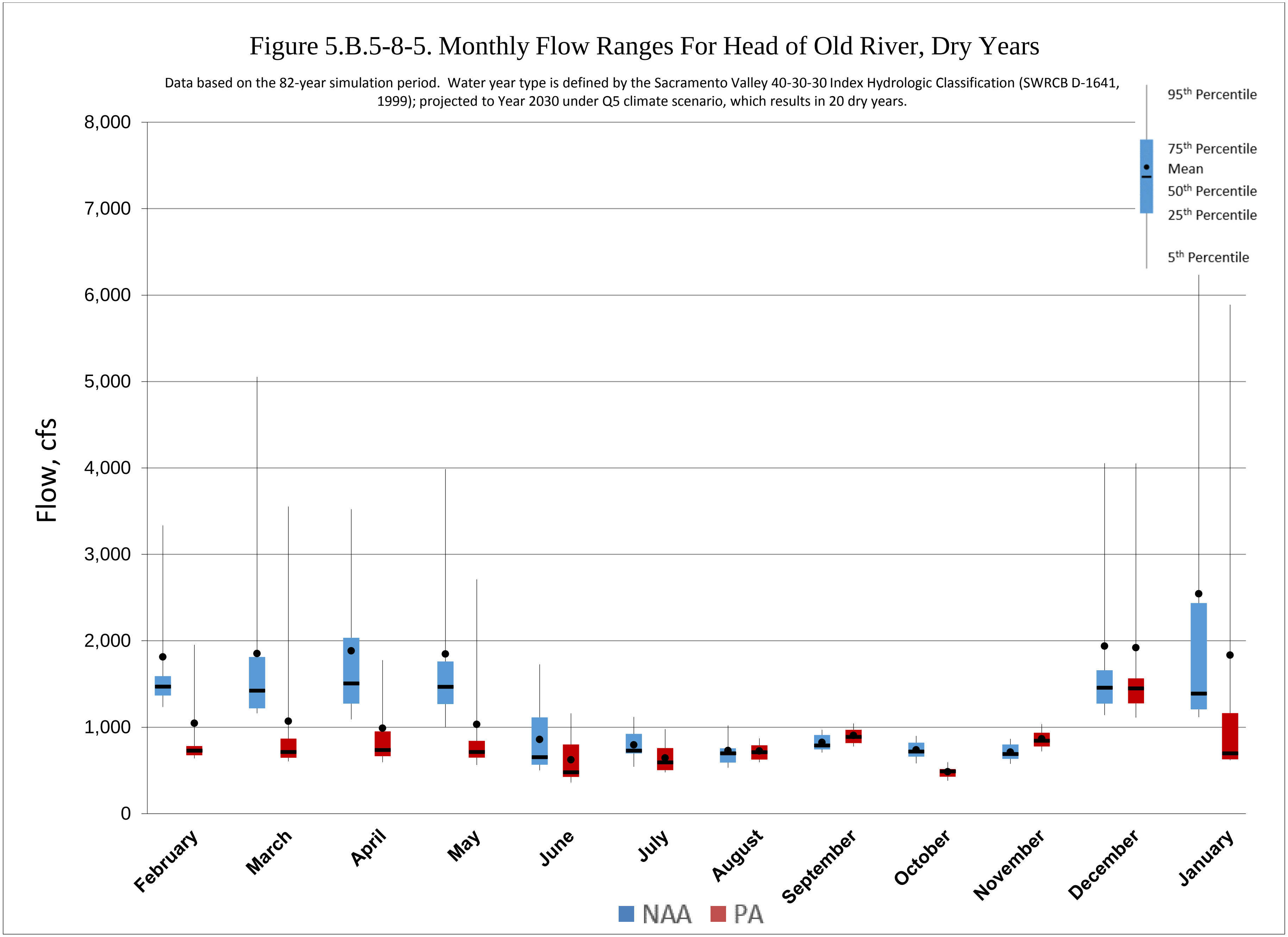


Figure 5.B.5-8-5. Monthly Flow Ranges For Head of Old River, Dry Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 20 dry years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
Flow, cfs
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-8-6. Monthly Flow Ranges For Head of Old River, Critical Years

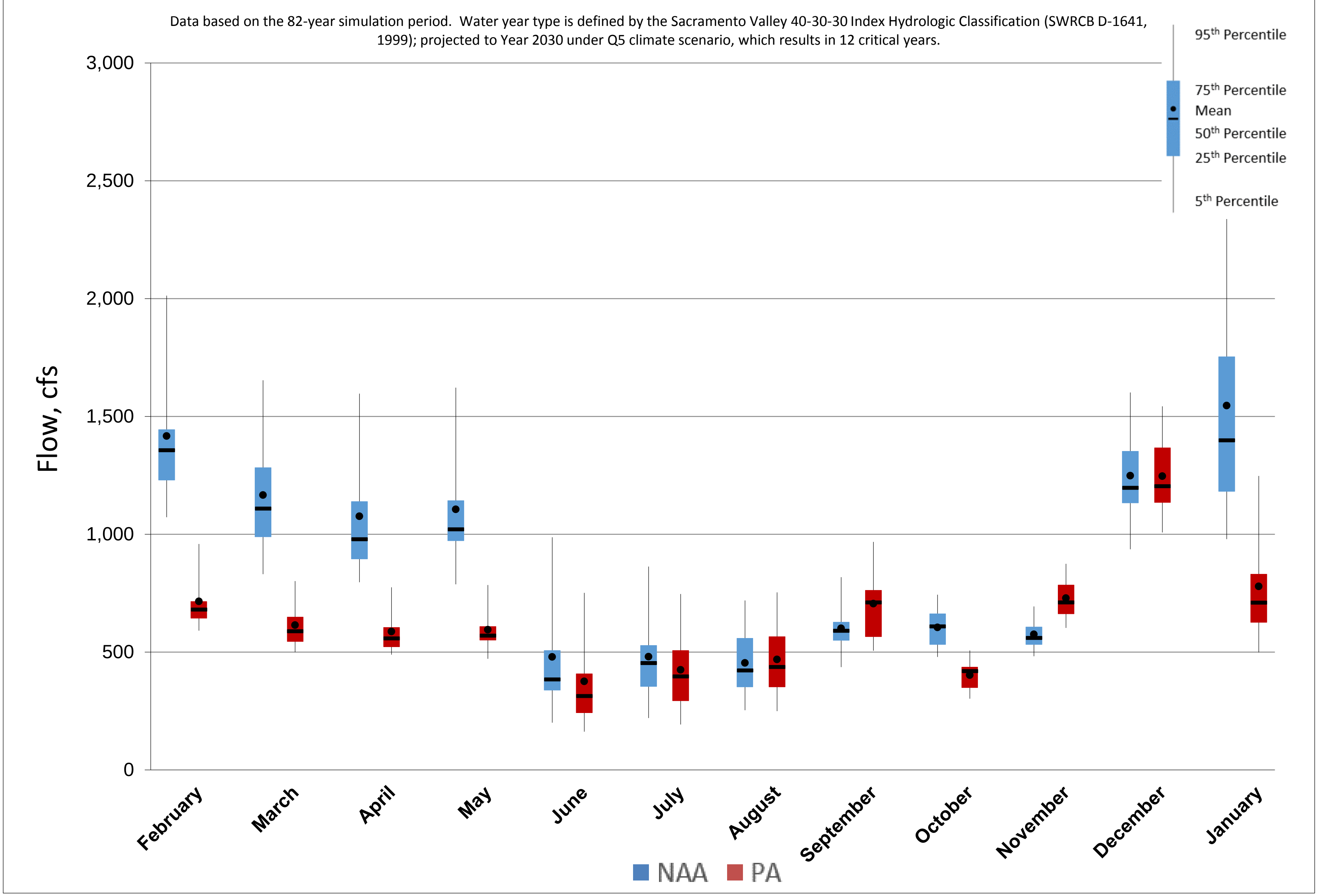
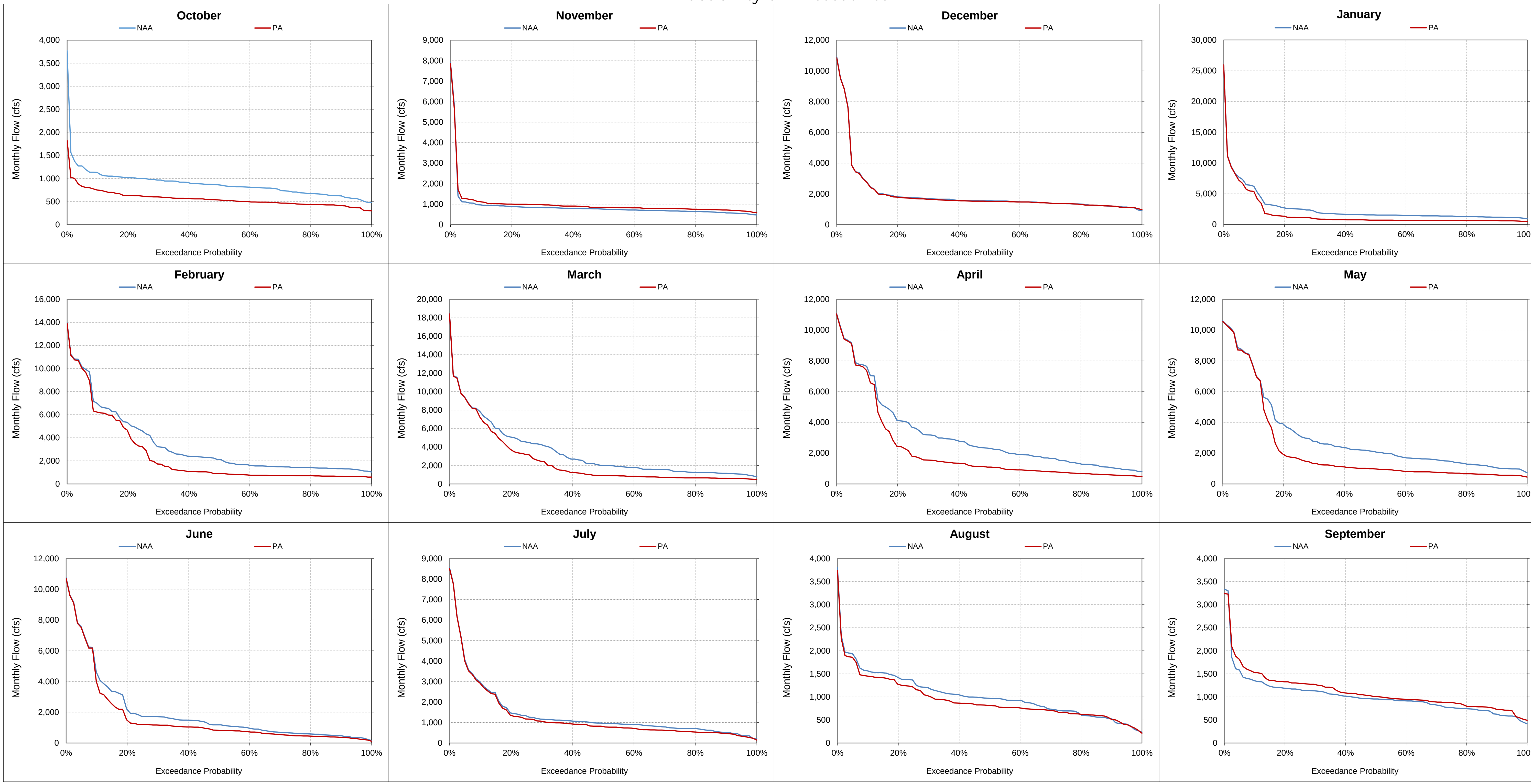
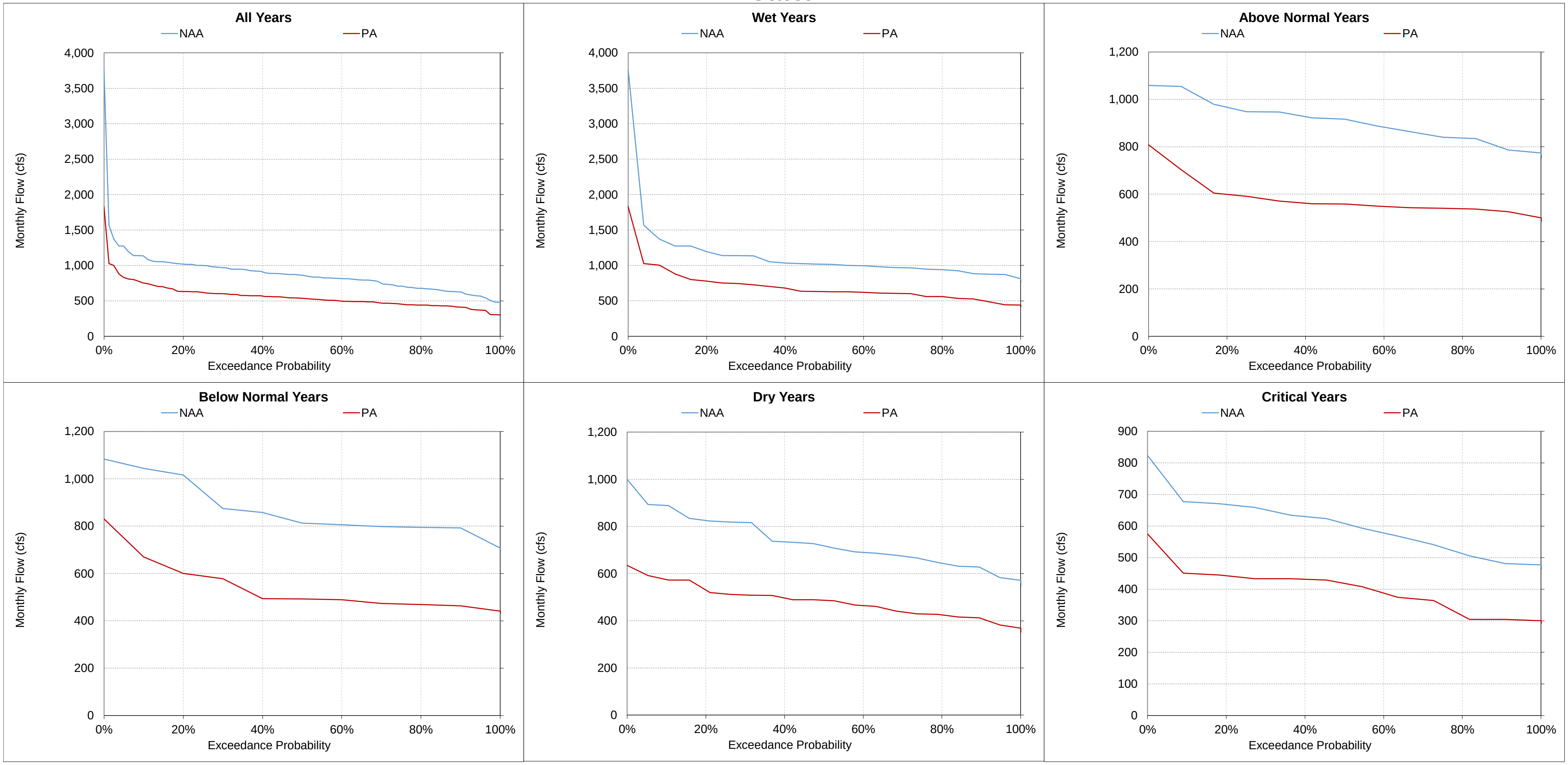


Figure 5.B.5-8-7. Head of Old River, Monthly Flow Probability of Exceedance



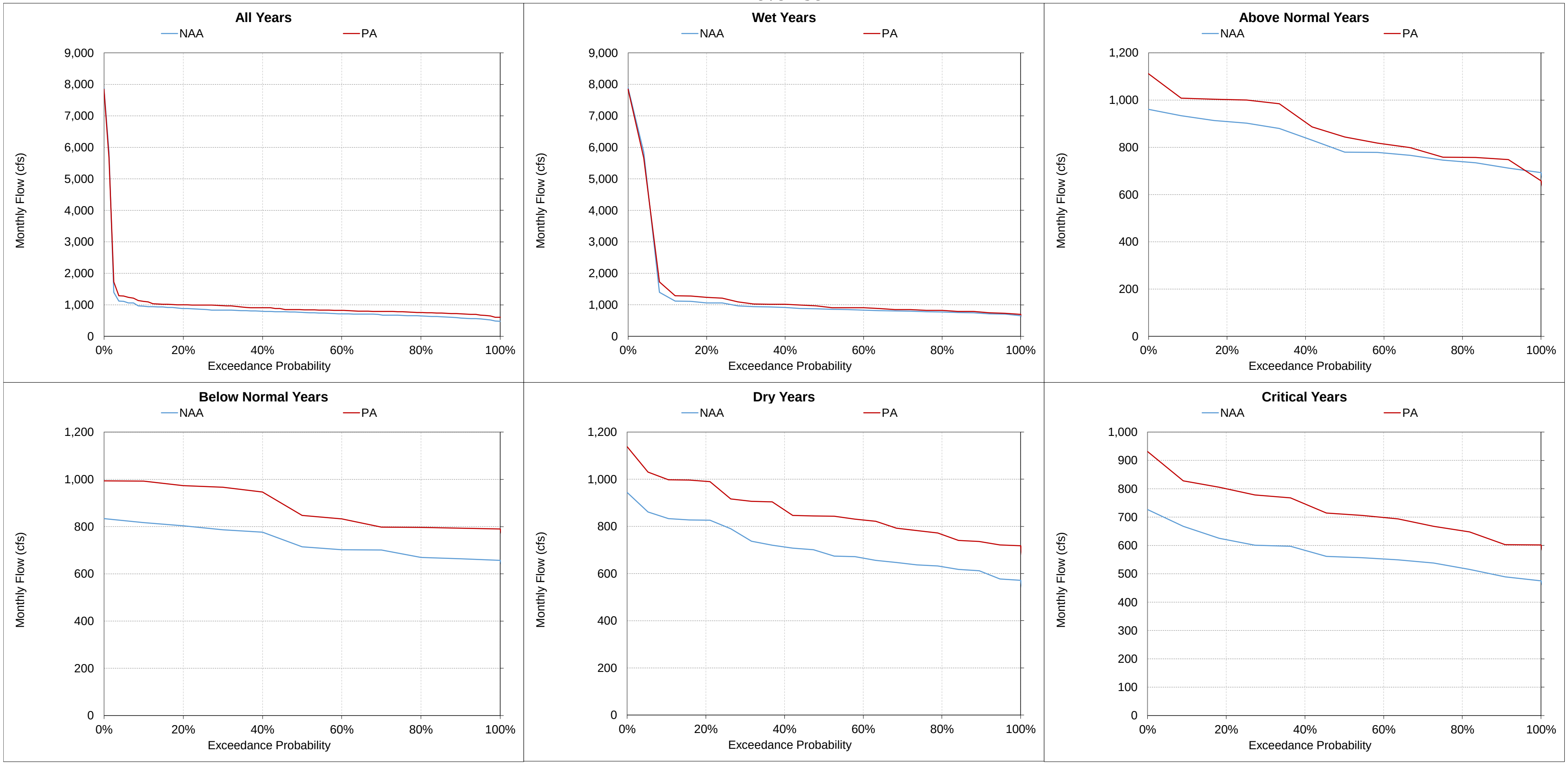
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-8-8. Head of Old River, Monthly Flow
October



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-8-9. Head of Old River, Monthly Flow November



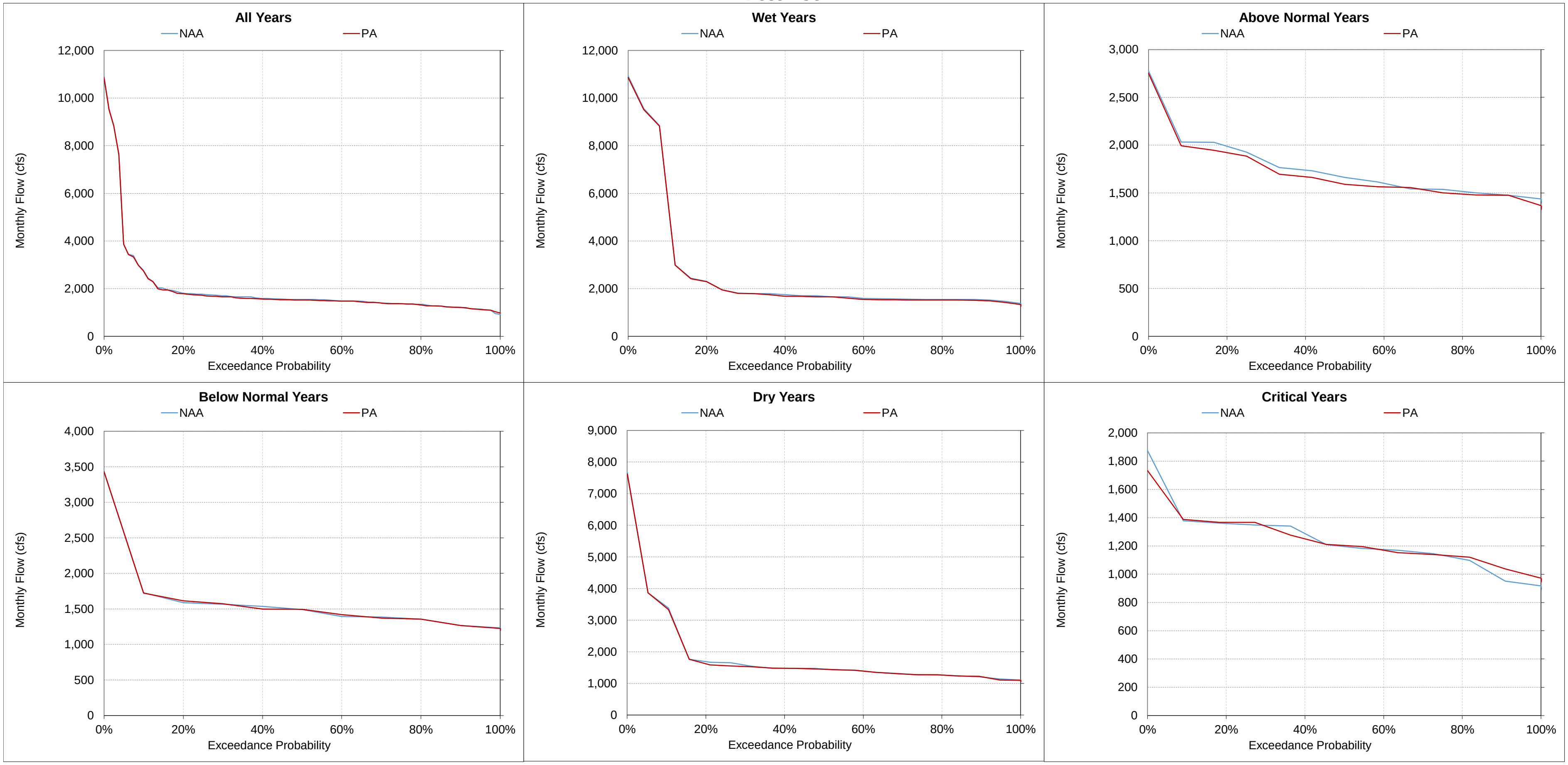
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

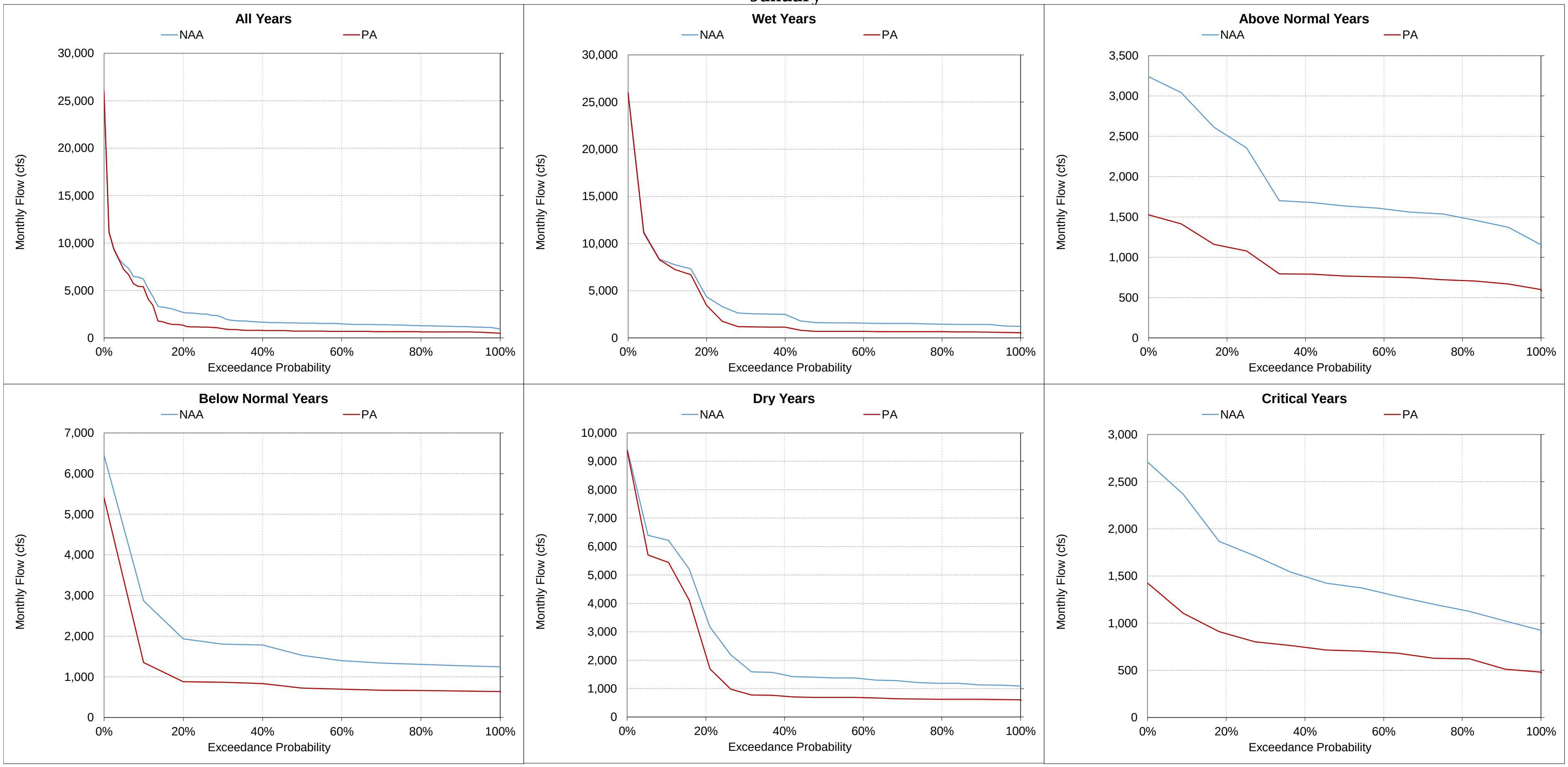
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-8-10. Head of Old River, Monthly Flow December



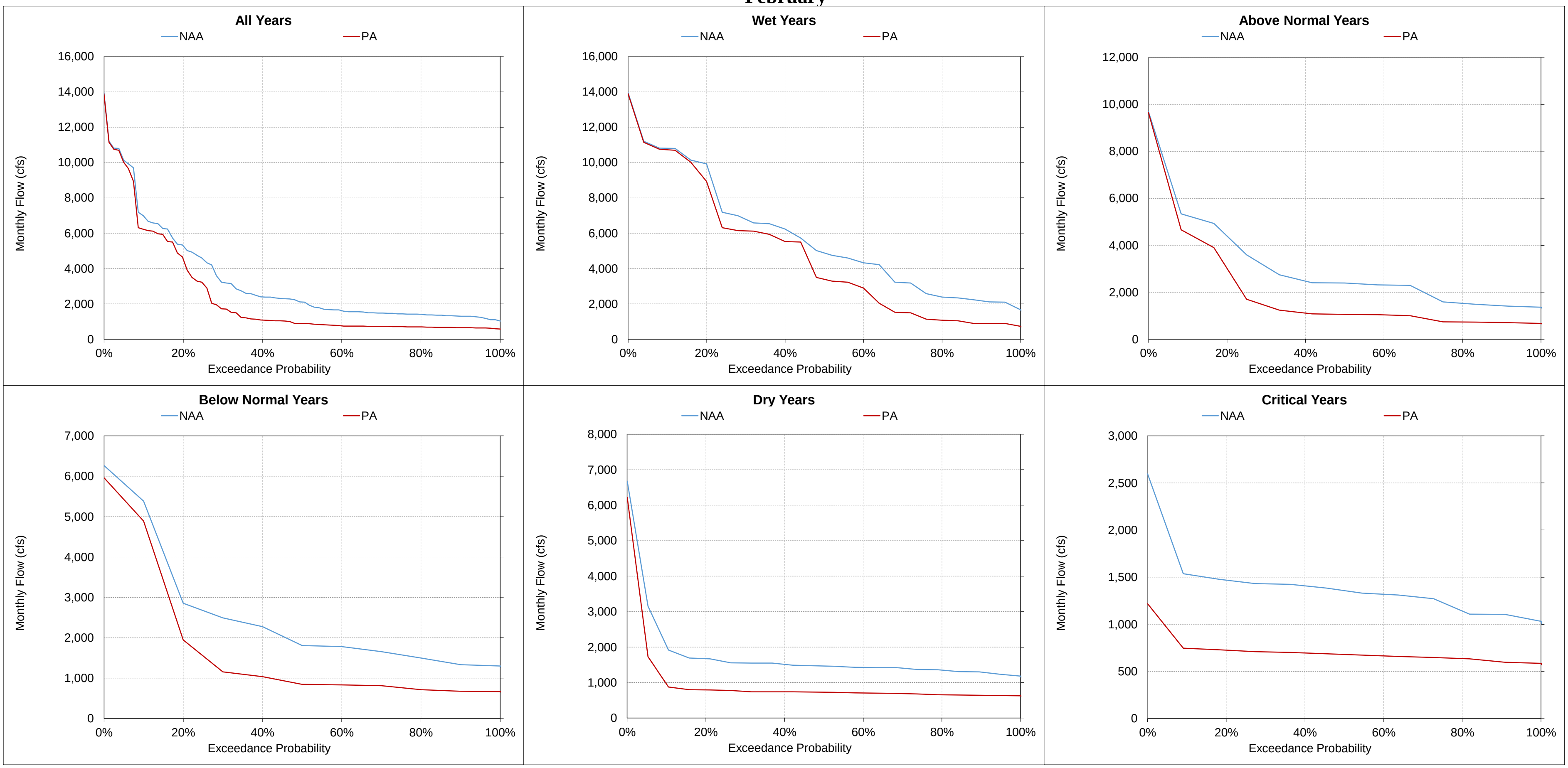
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-8-11. Head of Old River, Monthly Flow
January



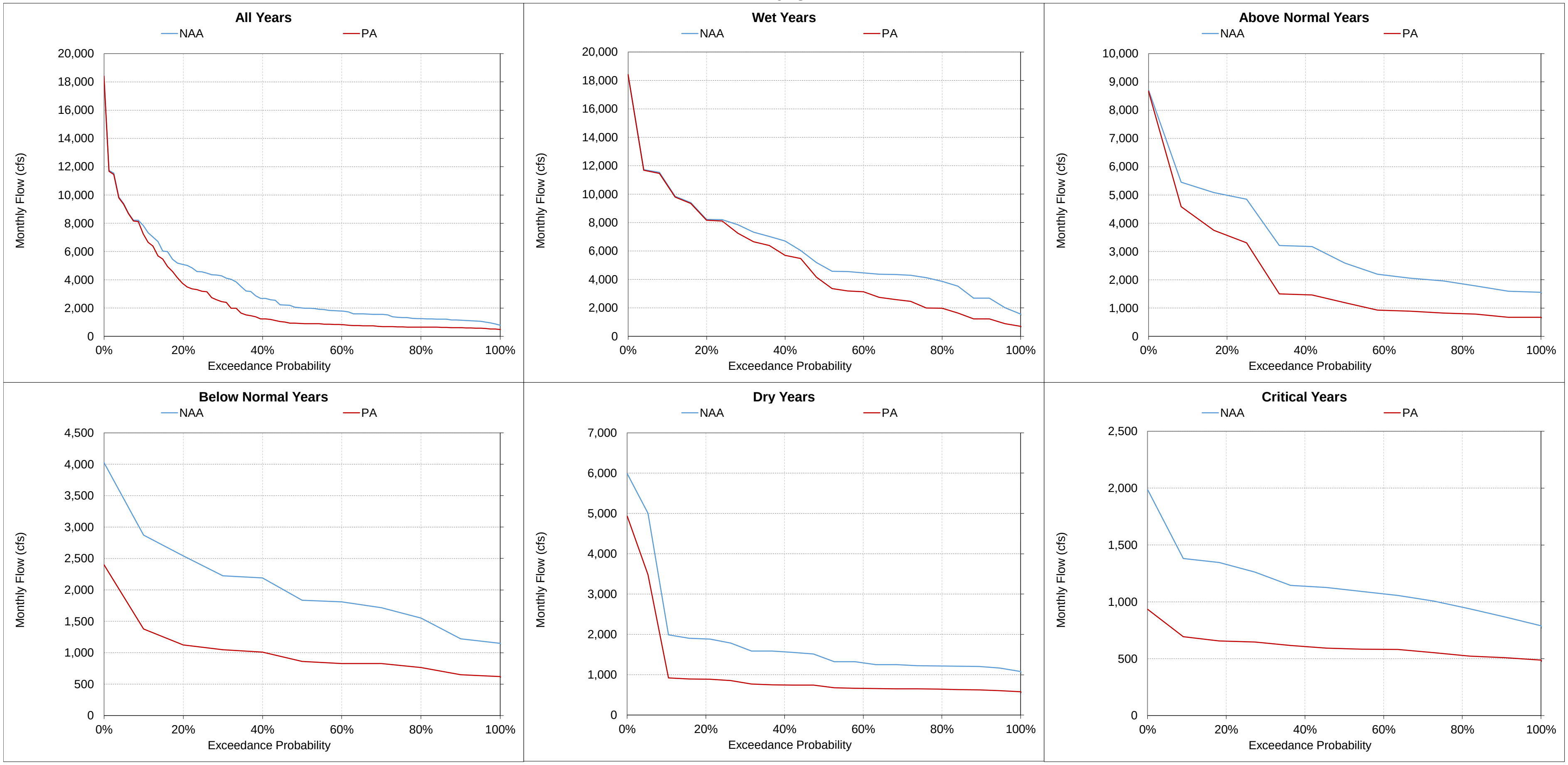
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-8-12. Head of Old River, Monthly Flow
February



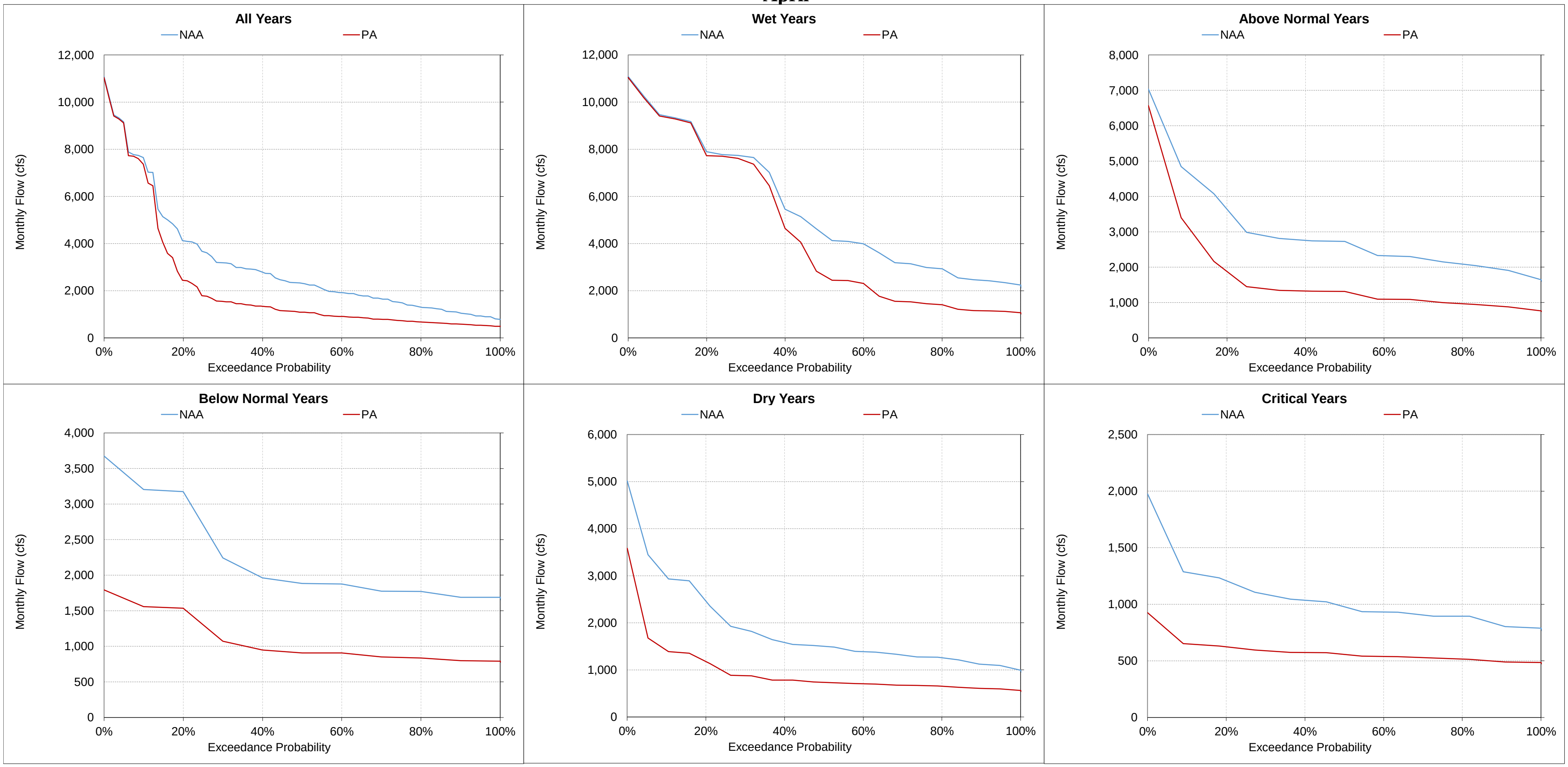
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-8-13. Head of Old River, Monthly Flow
March



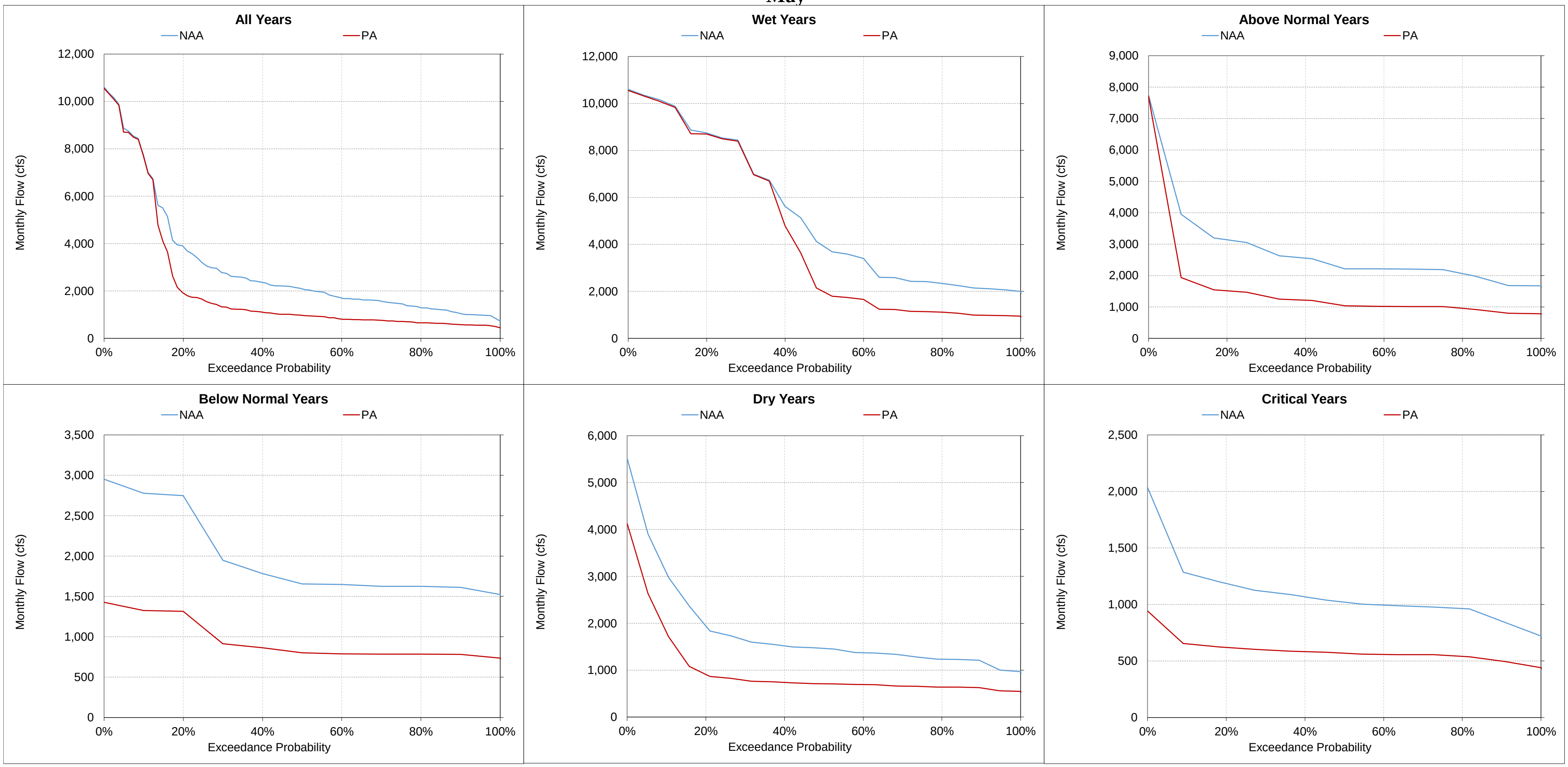
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-8-14. Head of Old River, Monthly Flow
April



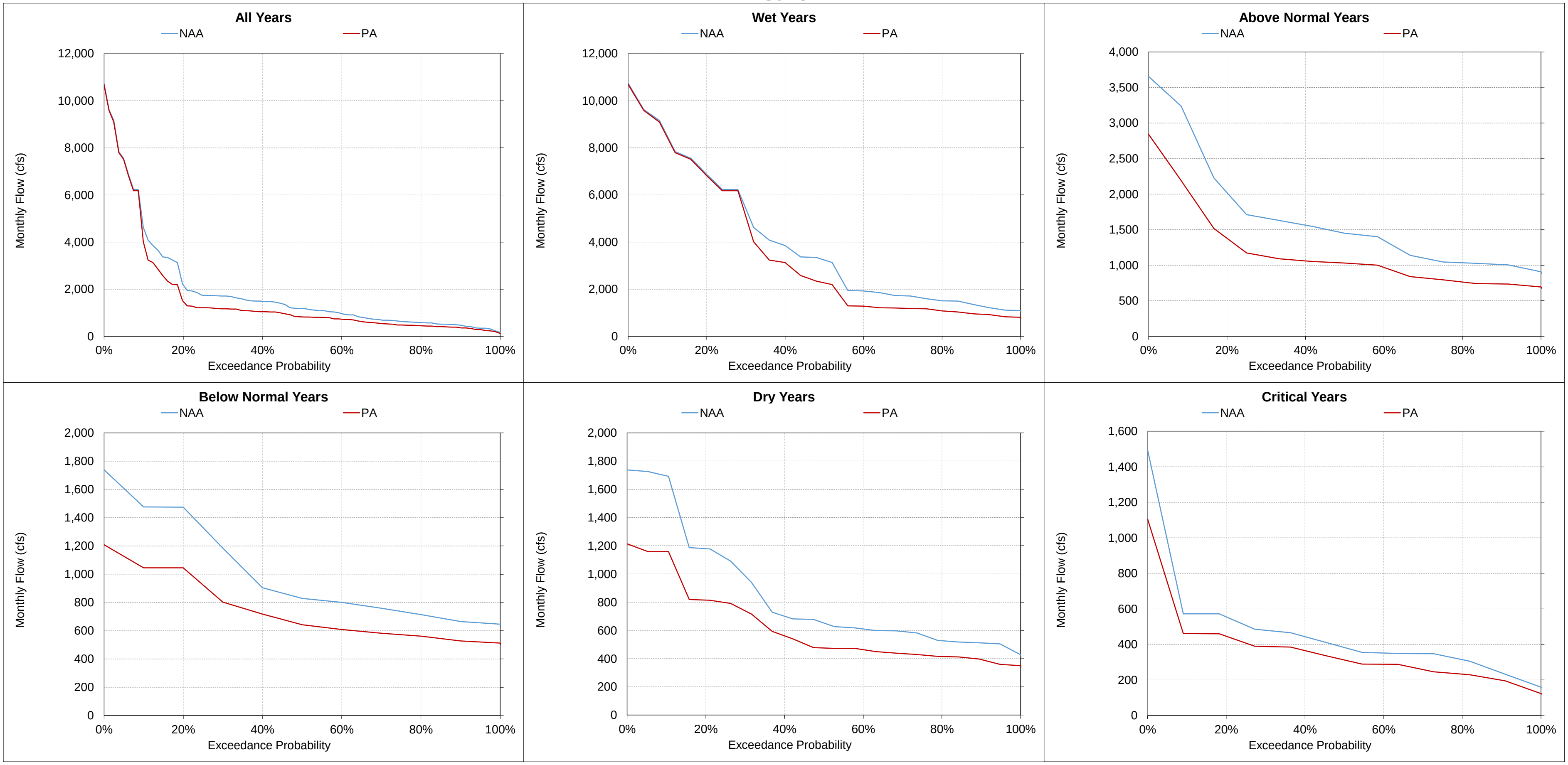
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-8-15. Head of Old River, Monthly Flow
May



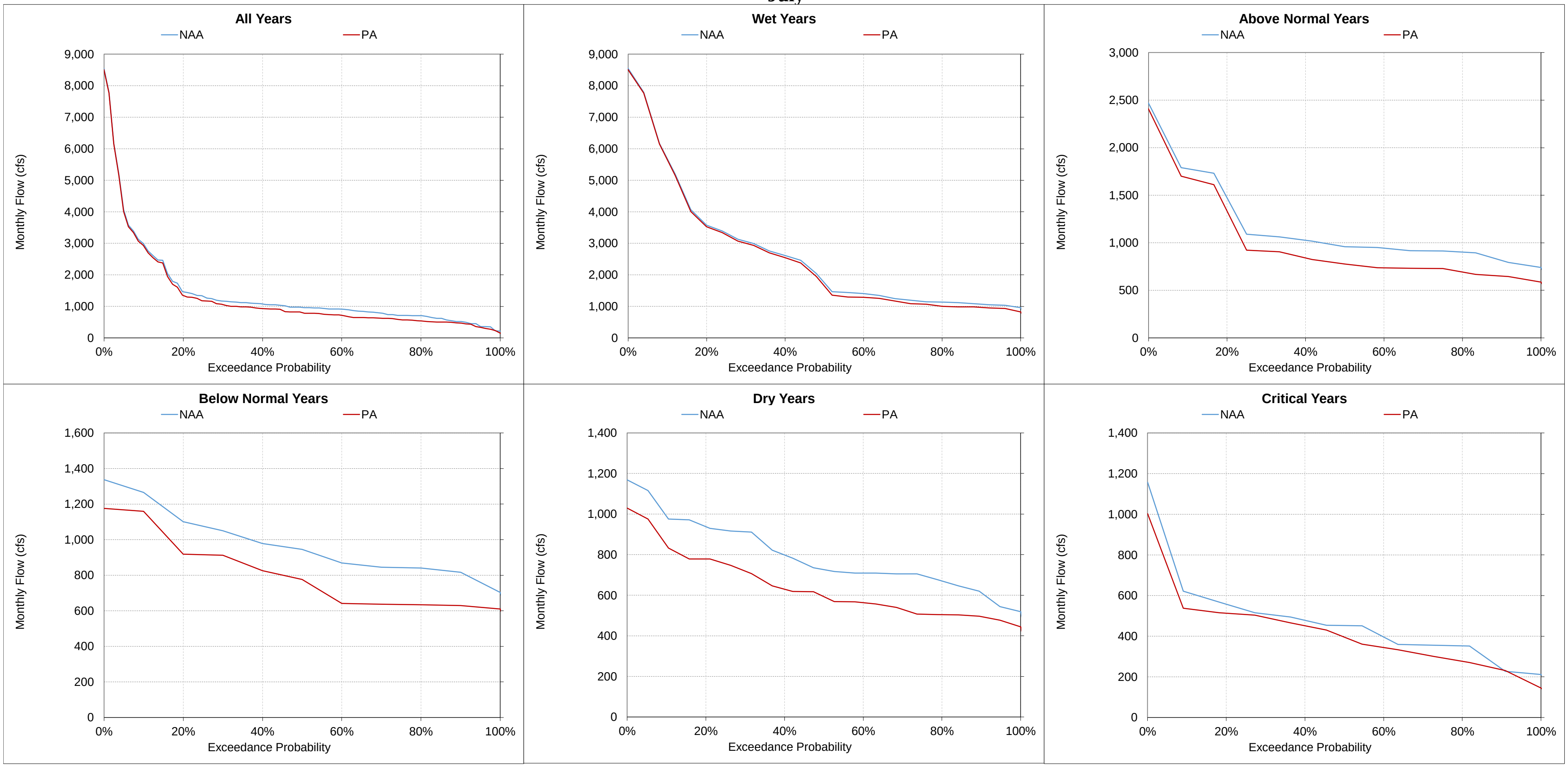
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-8-16. Head of Old River, Monthly Flow June



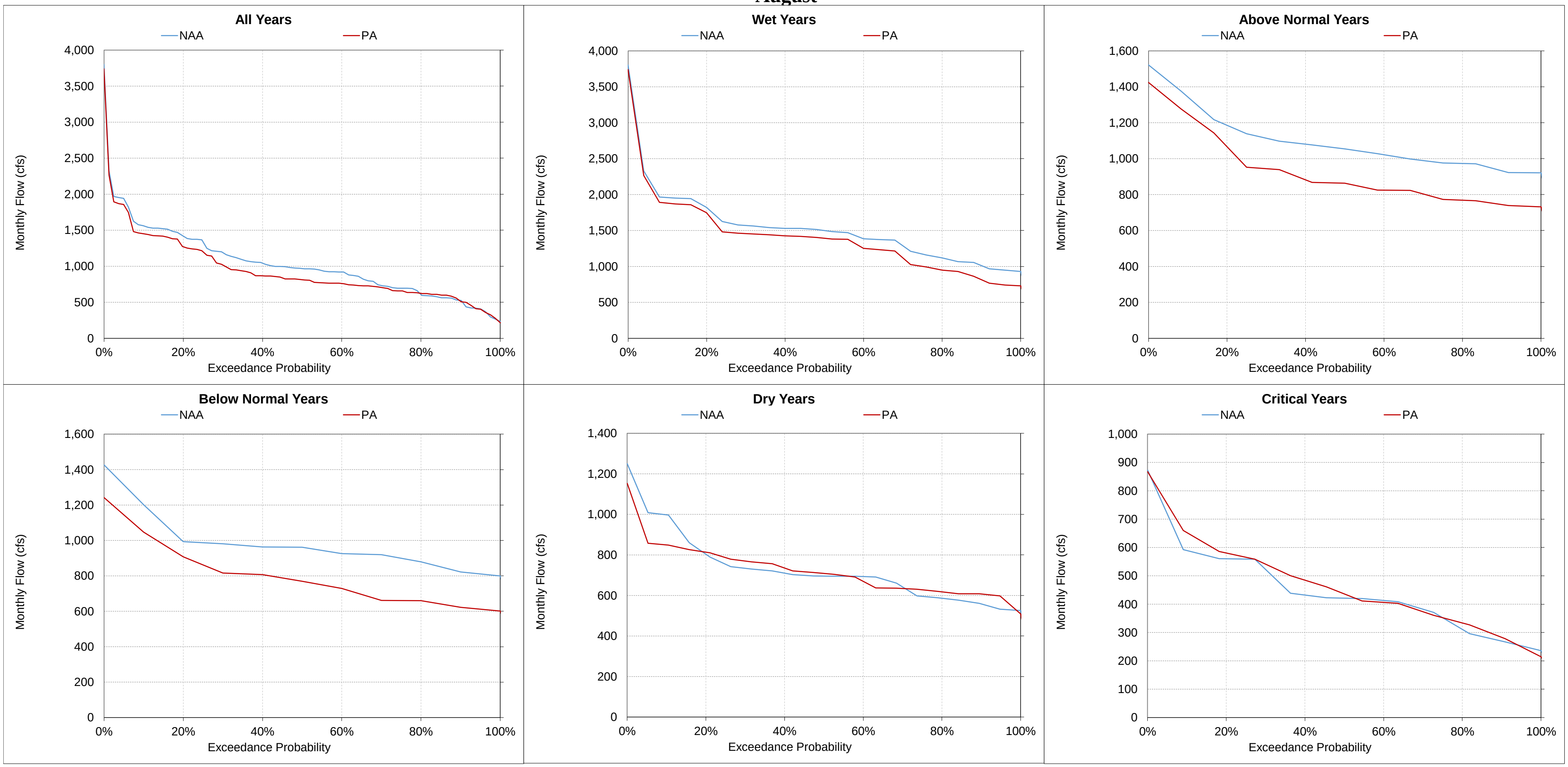
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-8-17. Head of Old River, Monthly Flow
July



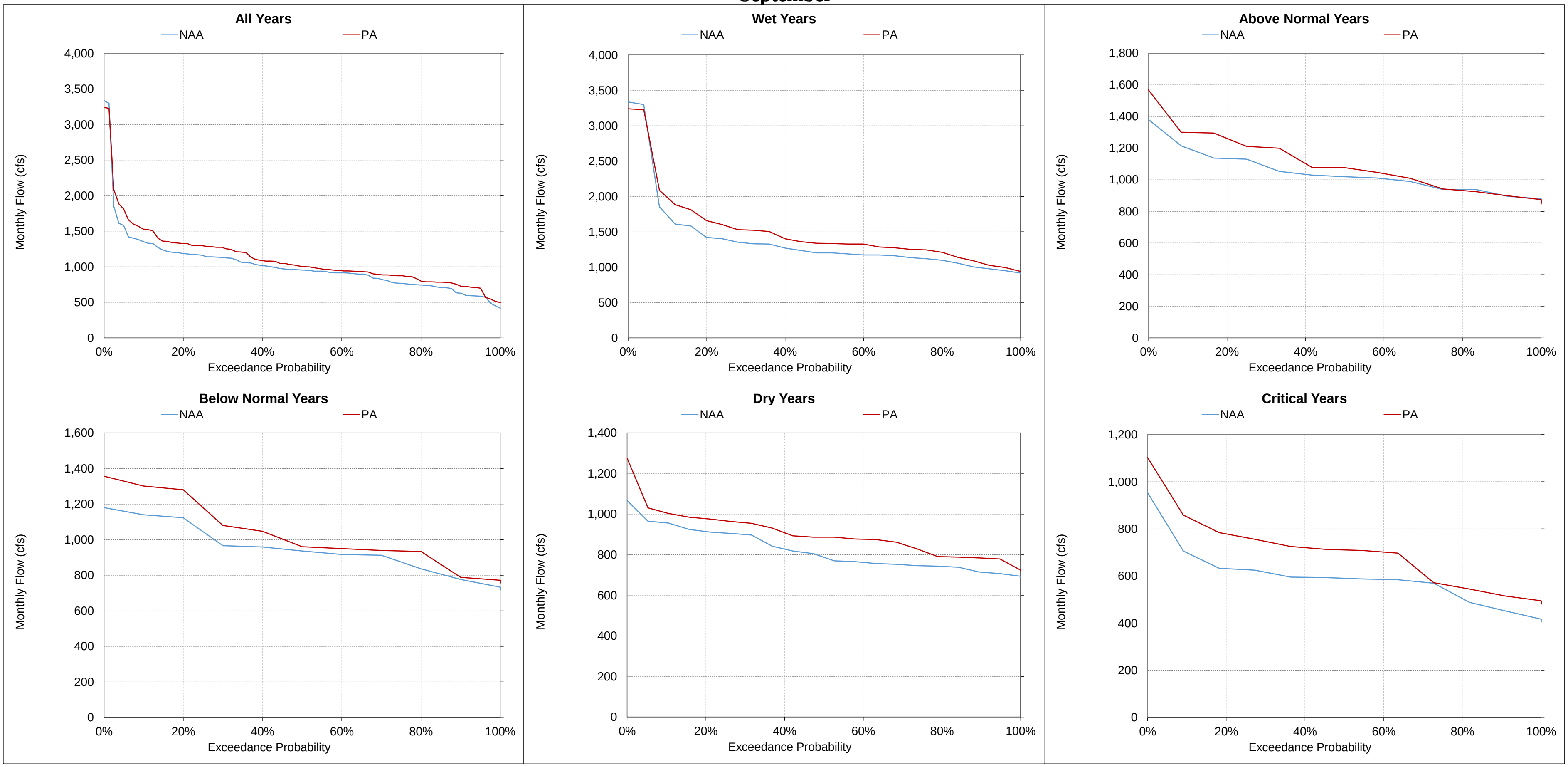
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-8-18. Head of Old River, Monthly Flow
August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-8-19. Head of Old River, Monthly Flow September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-9. Sacramento River downstream of Georgiana Slough Salinity, Monthly EC

Statistic	Monthly EC (UMHOS/CM)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	177	177	0	0%	177	177	0	0%	179	179	0	0%	181	182	0	0%	180	180	0	0%	177	177	0	0%
20%	176	176	0	0%	176	176	0	0%	178	178	0	0%	181	181	0	0%	179	179	0	0%	177	177	0	0%
30%	176	176	0	0%	176	176	0	0%	177	177	0	0%	180	179	0	0%	178	178	0	0%	177	177	0	0%
40%	176	176	0	0%	176	176	0	0%	177	177	0	0%	179	179	0	0%	177	178	0	0%	176	176	0	0%
50%	176	176	0	0%	176	176	0	0%	176	176	0	0%	179	179	0	0%	177	177	0	0%	176	176	0	0%
60%	176	176	0	0%	176	176	0	0%	176	176	0	0%	178	178	0	0%	177	177	0	0%	176	176	0	0%
70%	176	176	0	0%	176	176	0	0%	176	176	0	0%	178	178	0	0%	176	177	0	0%	176	176	0	0%
80%	176	176	0	0%	175	176	0	0%	176	176	0	0%	177	177	0	0%	176	176	0	0%	176	176	0	0%
90%	175	176	0	0%	175	176	0	0%	175	176	0	0%	177	177	0	0%	176	176	0	0%	176	176	0	0%
Long Term Full Simulation Period[b]	176	176	0	0%	176	176	0	0%	177	177	0	0%	179	179	0	0%	178	178	0	0%	176	176	0	0%
Water Year Types[c]																								
Wet (32%)	176	176	0	0%	176	176	0	0%	177	177	0	0%	178	178	0	0%	177	177	0	0%	176	176	0	0%
Above Normal (16%)	176	176	0	0%	176	176	0	0%	177	177	0	0%	179	180	0	0%	177	178	0	0%	176	176	0	0%
Below Normal (13%)	176	176	0	0%	176	176	0	0%	177	177	0	0%	180	180	0	0%	178	178	0	0%	176	176	0	0%
Dry (24%)	176	176	0	0%	176	176	0	0%	177	177	0	0%	178	178	0	0%	178	178	0	0%	176	177	0	0%
Critical (15%)	177	177	0	0%	176	176	0	0%	179	179	0	0%	180	180	0	0%	178	179	0	0%	177	177	0	0%

Statistic	Monthly EC (UMHOS/CM)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	177	177	0	0%	176	176	0	0%	176	176	0	0%	176	176	0	0%	176	176	0	0%	176	177	0	0%
20%	177	177	0	0%	176	176	0	0%	176	176	0	0%	176	176	0	0%	176	176	0	0%	176	176	0	0%
30%	176	176	0	0%	176	176	0	0%	176	176	0	0%	176	176	0	0%	176	176	0	0%	176	176	0	0%
40%	176	176	0	0%	176	176	0	0%	176	176	0	0%	176	176	0	0%	176	176	0	0%	176	176	1	0%
50%	176	176	0	0%	176	176	0	0%	176	176	0	0%	176	176	0	0%	176	176	0	0%	176	176	0	0%
60%	176	176	0	0%	176	176	0	0%	176	176	0	0%	176	176	0	0%	176	176	0	0%	175	176	0	0%
70%	176	176	0	0%	176	176	0	0%	176	176	0	0%	175	176	0	0%	176	176	0	0%	175	175	0	0%
80%	176	176	0	0%	175	175	0	0%	176	176	0	0%	175	176	0	0%	176	176	0	0%	175	175	0	0%
90%	175	175	0	0%	175	175	0	0%	176	176	0	0%	175	176	0	0%	176	176	0	0%	175	175	0	0%
Long Term Full Simulation Period[b]	176	176	0	0%	176	176	0	0%	176	176	0	0%	176	176	0	0%	176	176	0	0%	176	176	0	0%
Water Year Types[c]																								
Wet (32%)	176	176	0	0%	175	175	0	0%	176	176	0	0%	176	176	0	0%	176	176	0	0%	175	175	0	0%
Above Normal (16%)	176	176	0	0%	176	176	0	0%	176	176	0	0%	175	176	0	0%	176	176	0	0%	175	176	0	0%
Below Normal (13%)	176	176	0	0%	176	176	0	0%	176	176	0	0%	175	176	0	0%	176	176	0	0%	176	176	0	0%
Dry (24%)	176	176	0	0%	176	176	0	0%	176	176	0	0%	176	176	0	0%	176	176	0	0%	176	176	0	0%
Critical (15%)	177	177	0	0%	176	176	0	0%	176	176	0	0%	176	176	0	0%	176	176	0	0%	176	177	0	0%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

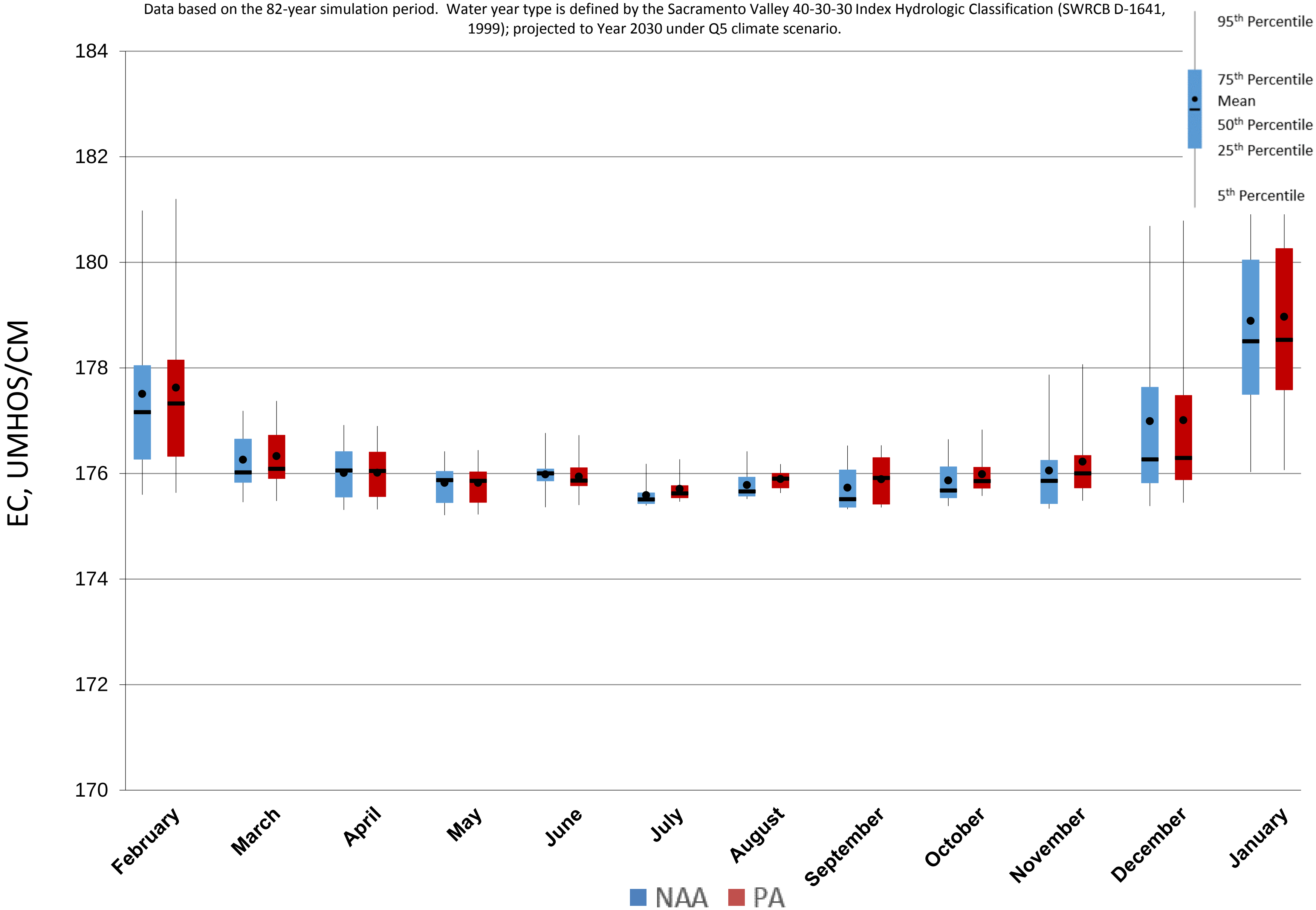
b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-9-1. Monthly EC Ranges For Sacramento River downstream of Georgiana Slough Salinity, All Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario.



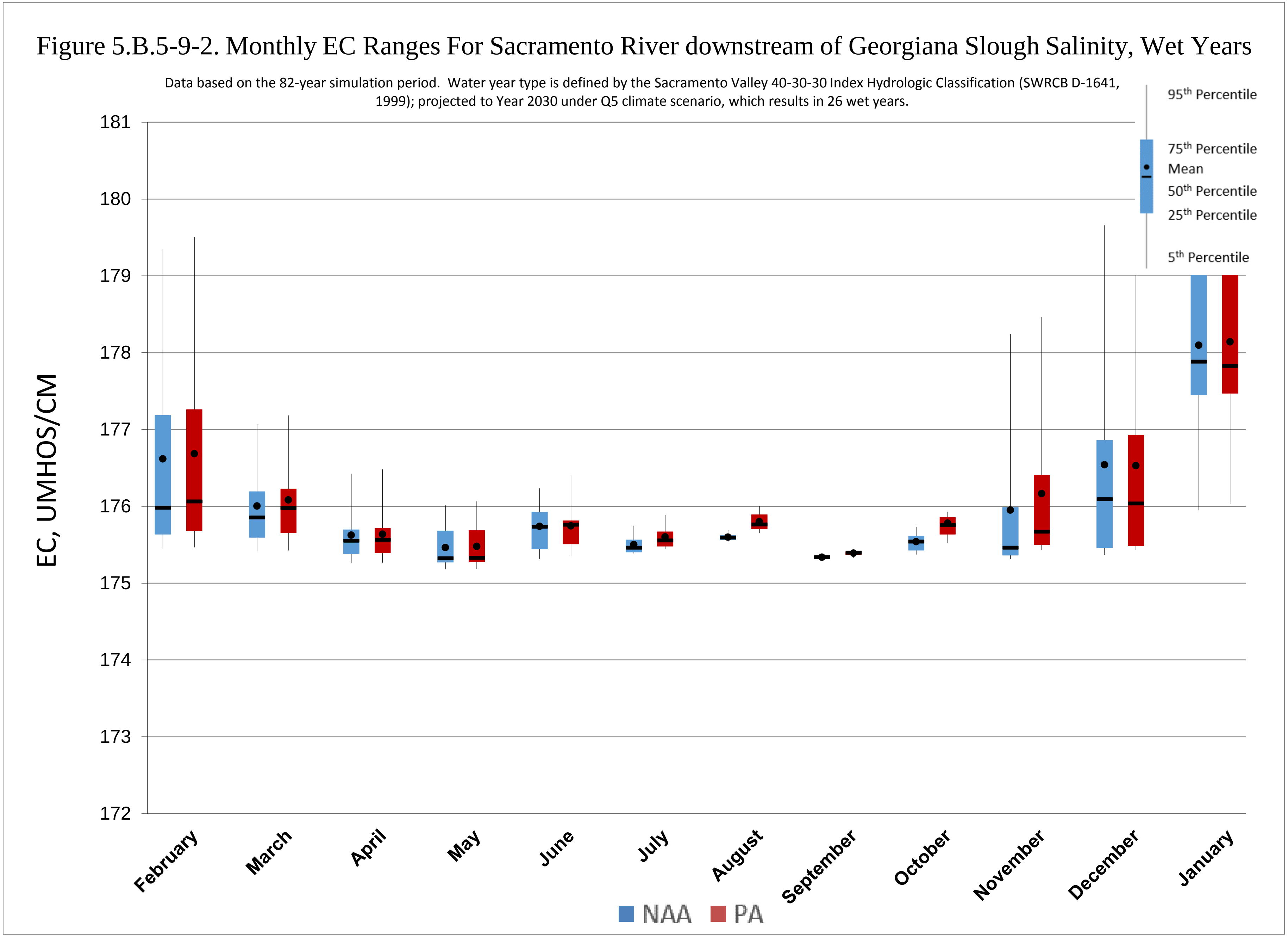
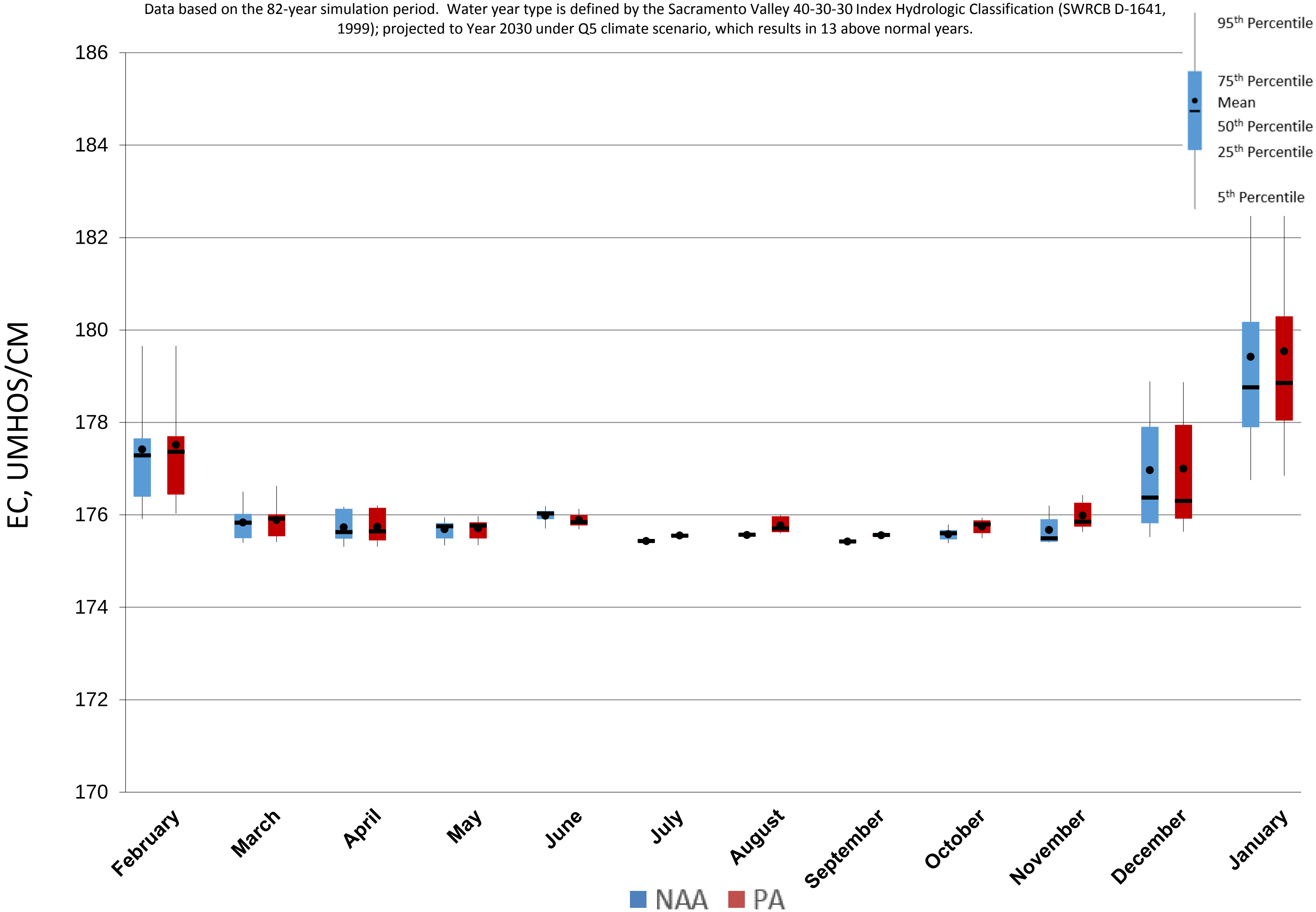


Figure 5.B.5-9-2. Monthly EC Ranges For Sacramento River downstream of Georgiana Slough Salinity, Wet Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 26 wet years.
EC, UMHOS/CM
181
180
179
178
177
176
175
174
173
172
February
March
April
May
June
July
August
September
October
November
December
January
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
NAA
PA

Figure 5.B.5-9-3. Monthly EC Ranges For Sacramento River downstream of Georgiana Slough Salinity, Above Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 13 above normal years.



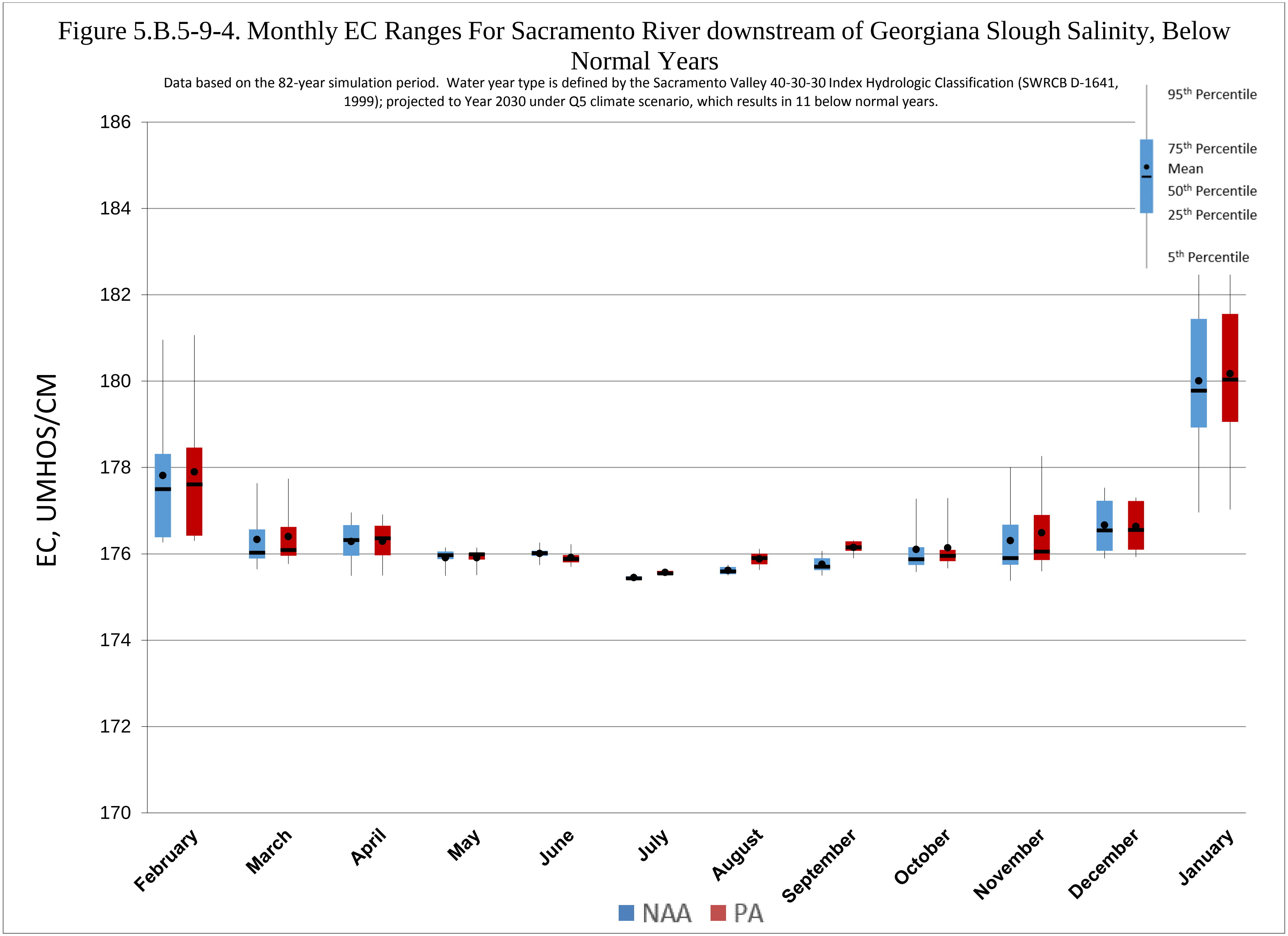


Figure 5.B.5-9-4. Monthly EC Ranges For Sacramento River downstream of Georgiana Slough Salinity, Below Normal Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 11 below normal years.
EC, UMHOS/CM
186
184
182
180
178
176
174
172
170
February
March
April
May
June
July
August
September
October
November
December
January
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
NAA
PA

Figure 5.B.5-9-5. Monthly EC Ranges For Sacramento River downstream of Georgiana Slough Salinity, Dry Years

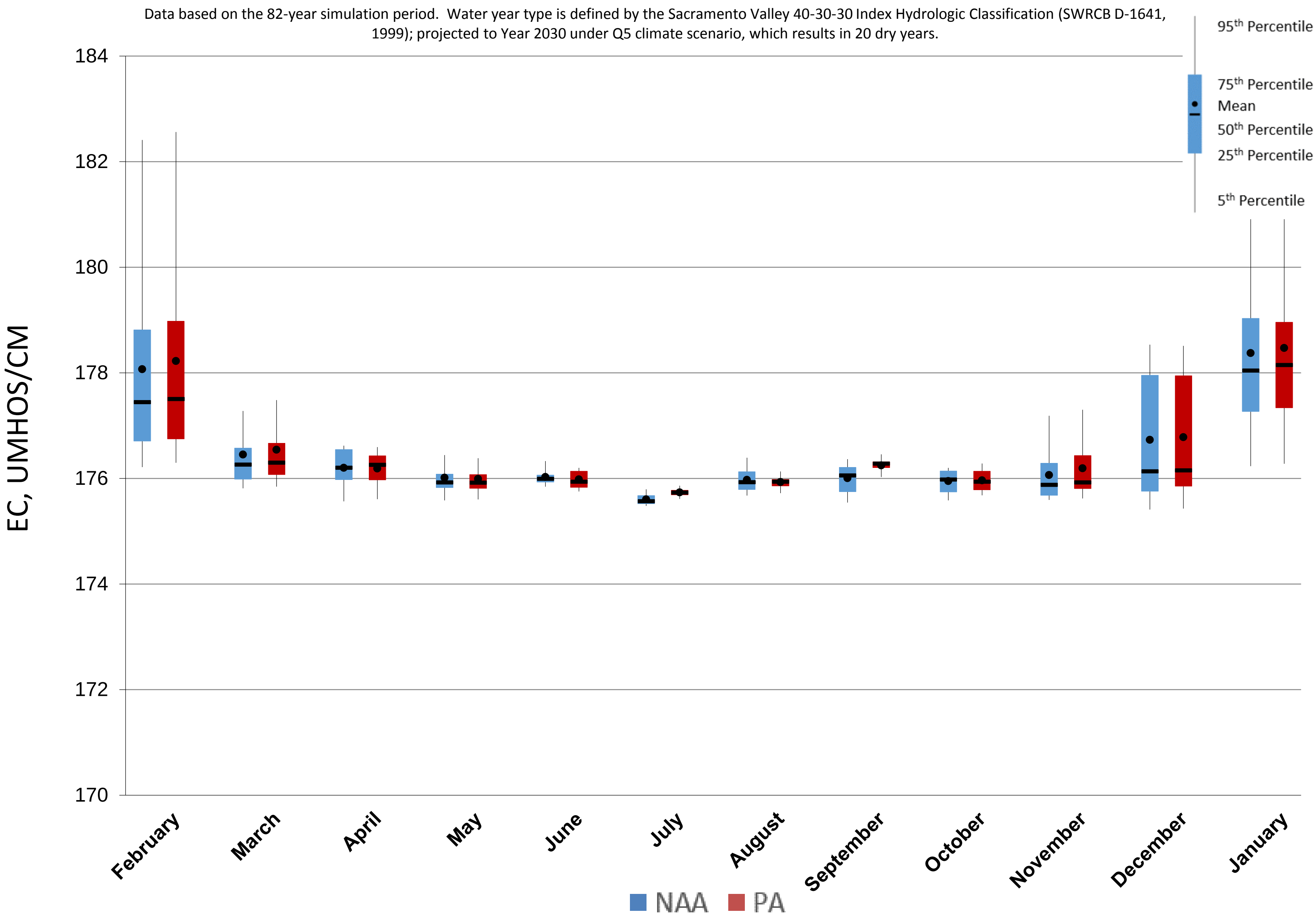


Figure 5.B.5-9-6. Monthly EC Ranges For Sacramento River downstream of Georgiana Slough Salinity, Critical Years

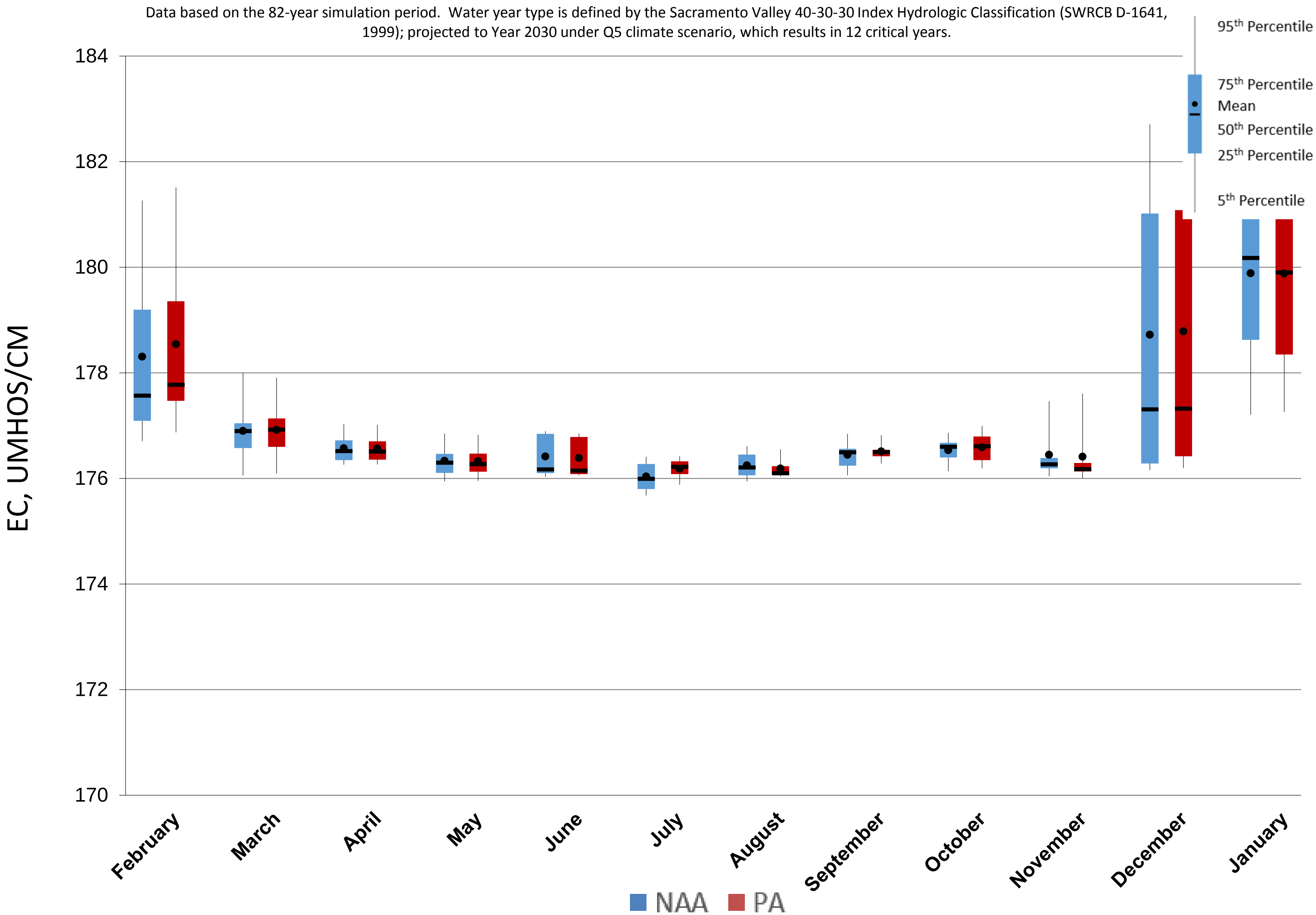
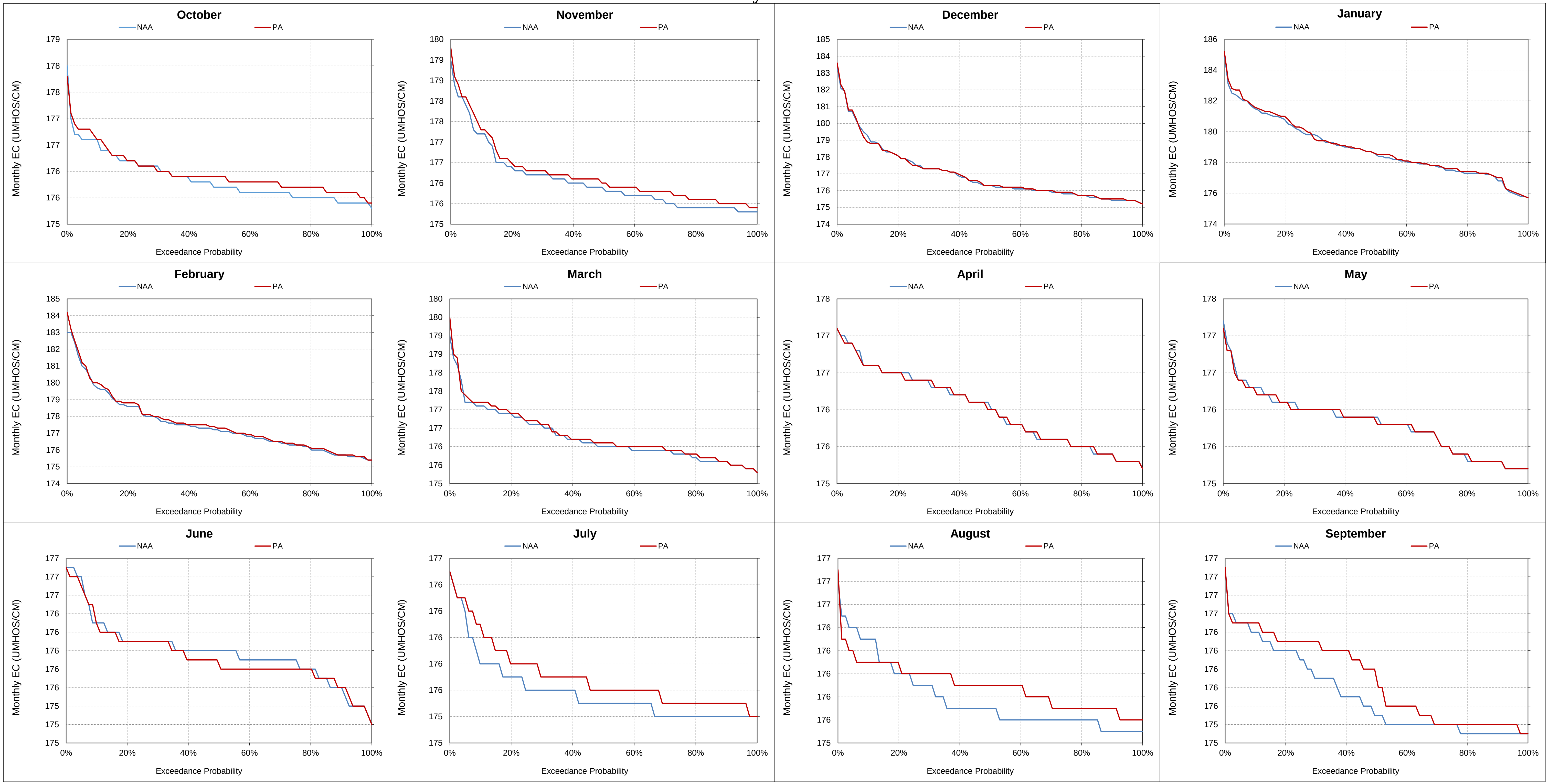
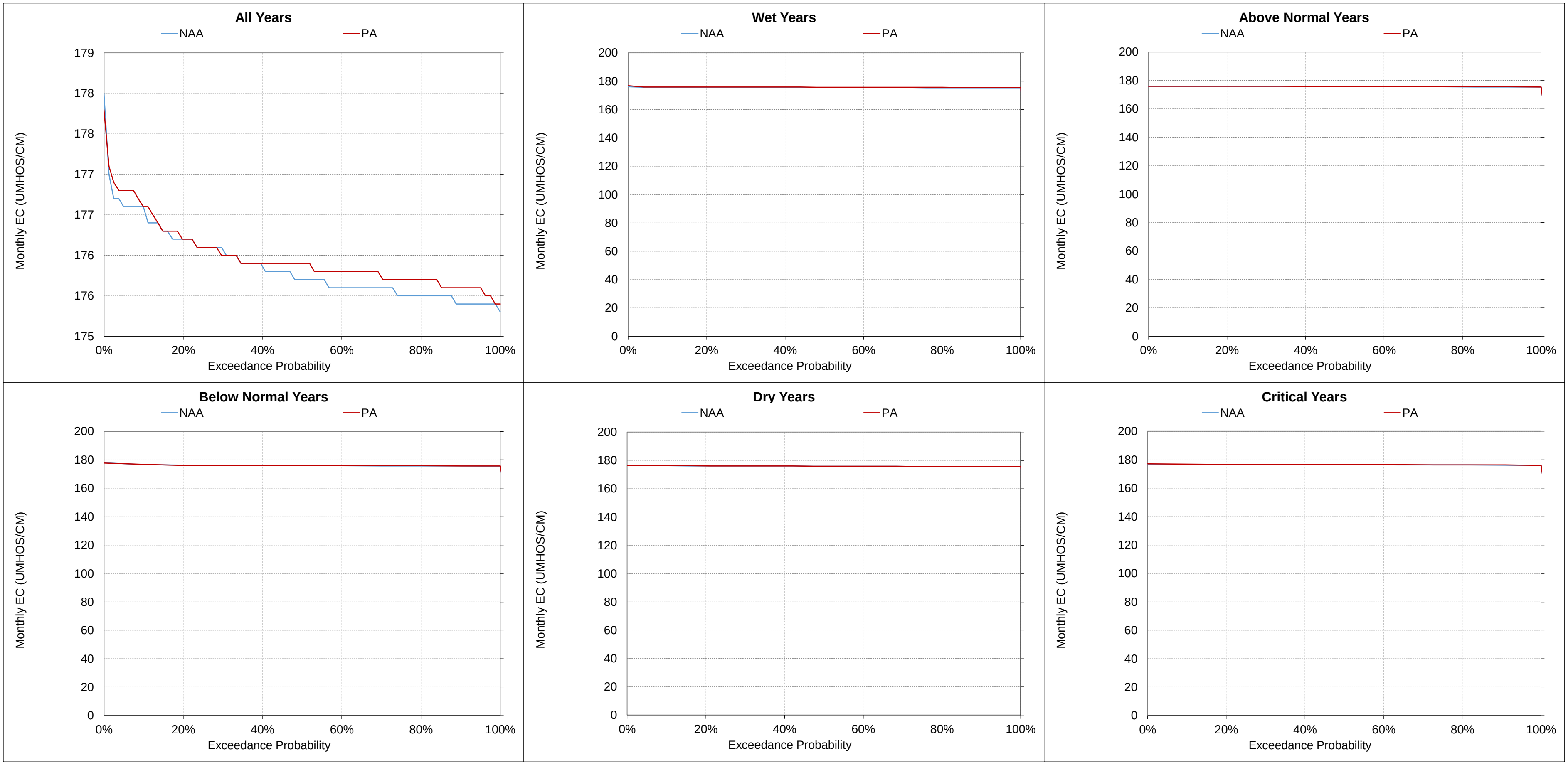


Figure 5.B.5-9-7. Sacramento River downstream of Georgiana Slough Salinity, Monthly EC Probability of Exceedance



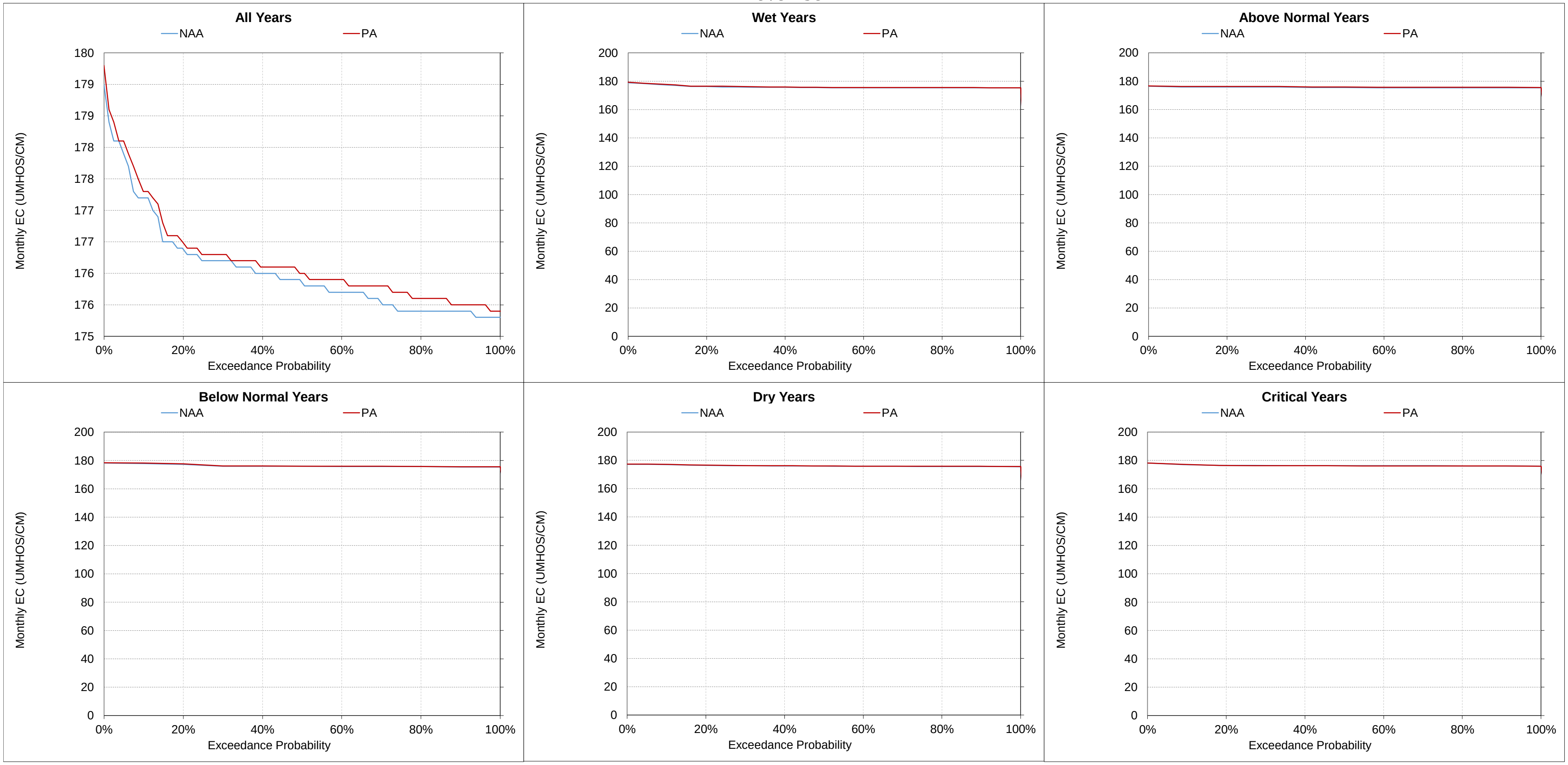
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-9-8. Sacramento River downstream of Georgiana Slough Salinity, Monthly EC
October



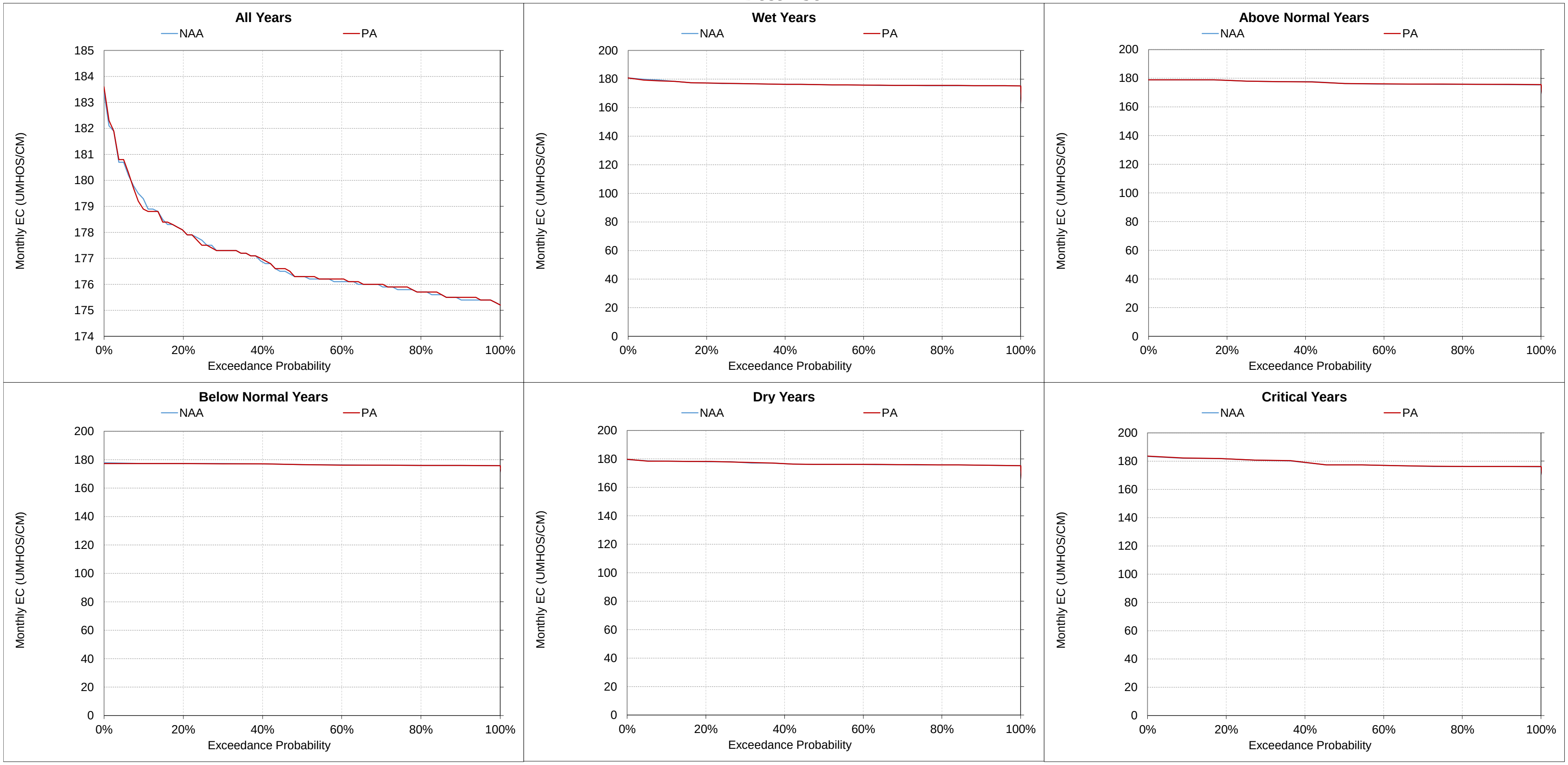
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-9-9. Sacramento River downstream of Georgiana Slough Salinity, Monthly EC November



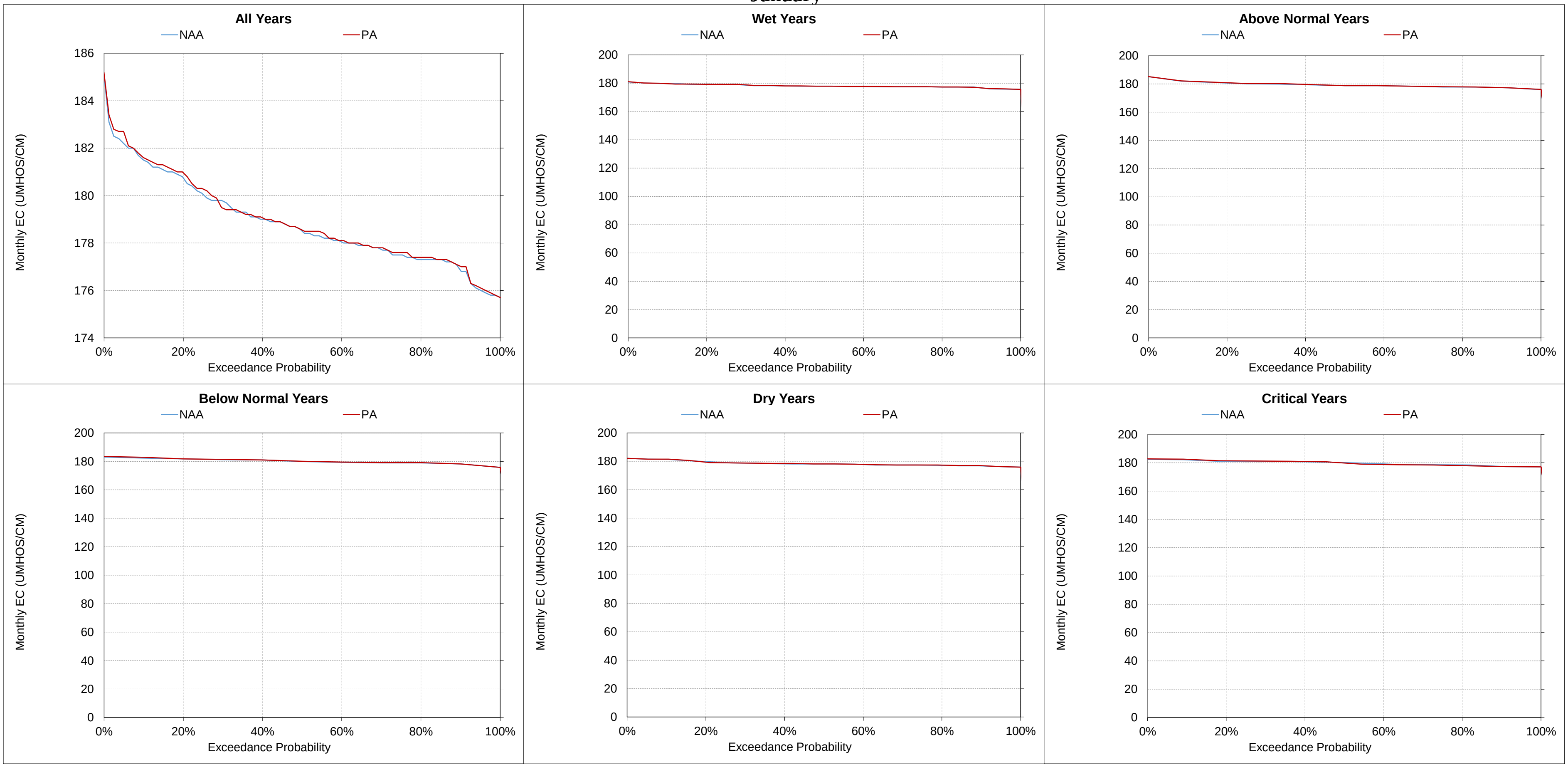
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-9-10. Sacramento River downstream of Georgiana Slough Salinity, Monthly EC
December



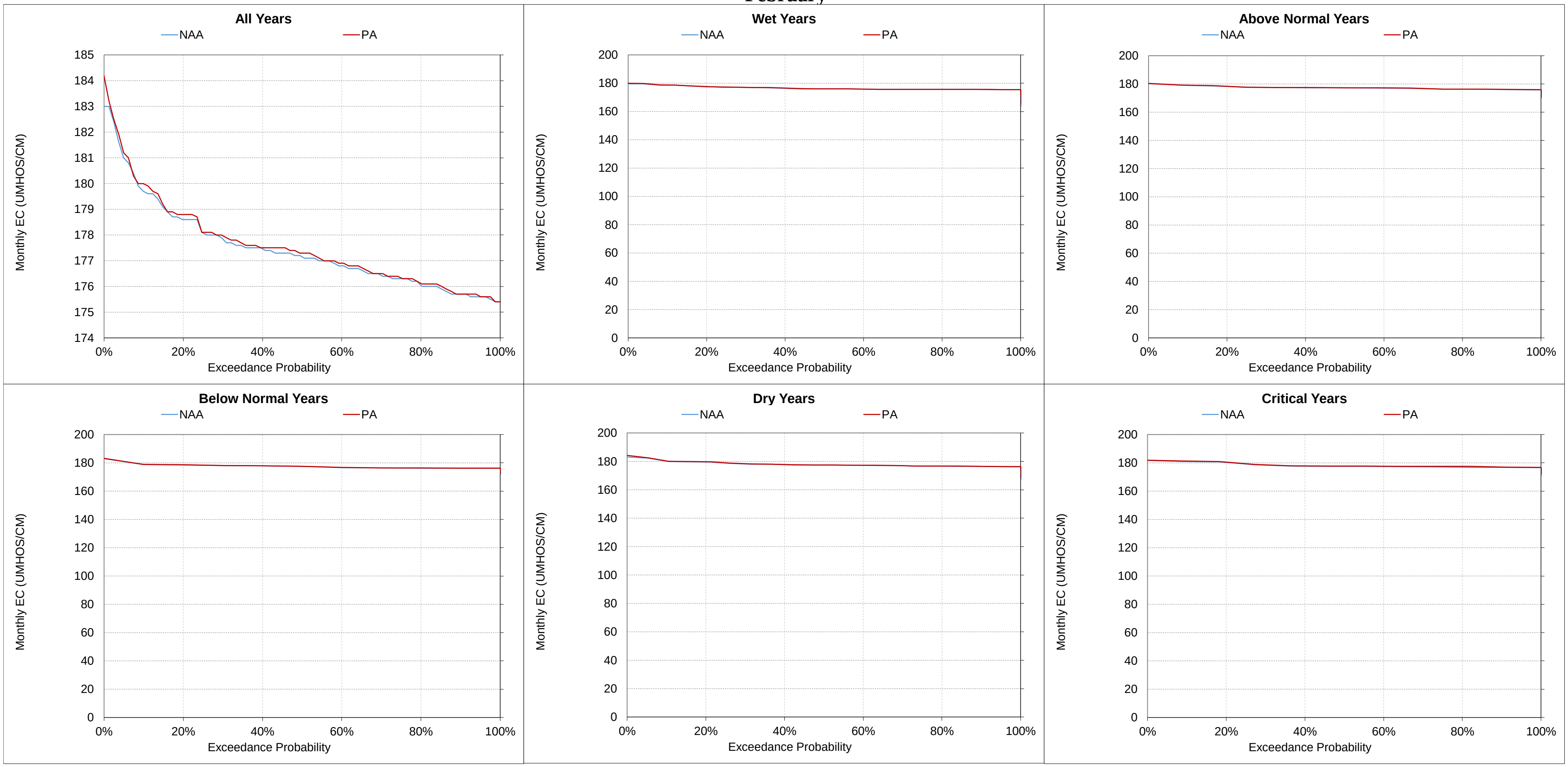
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-9-11. Sacramento River downstream of Georgiana Slough Salinity, Monthly EC
January



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-9-12. Sacramento River downstream of Georgiana Slough Salinity, Monthly EC February



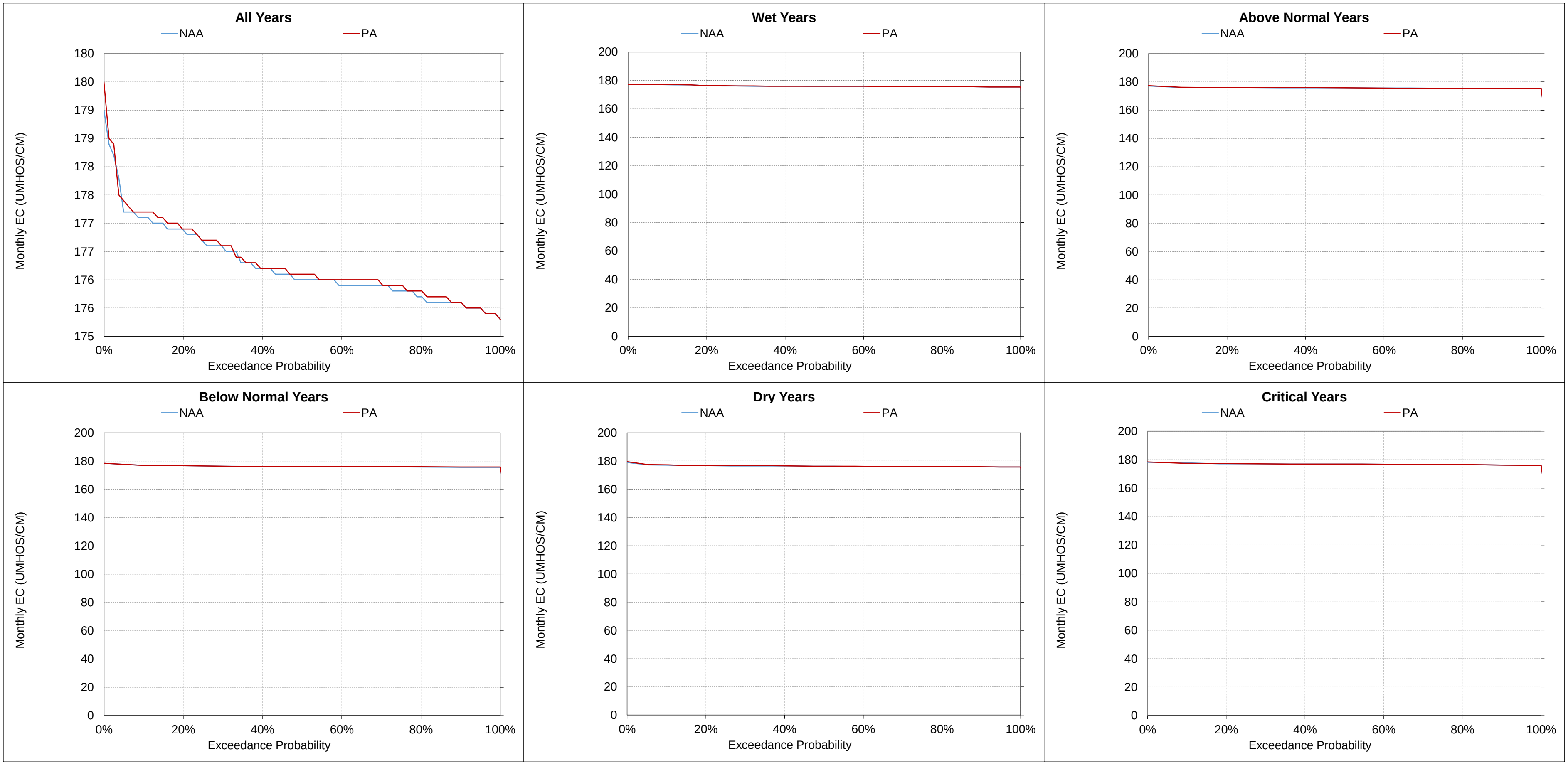
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

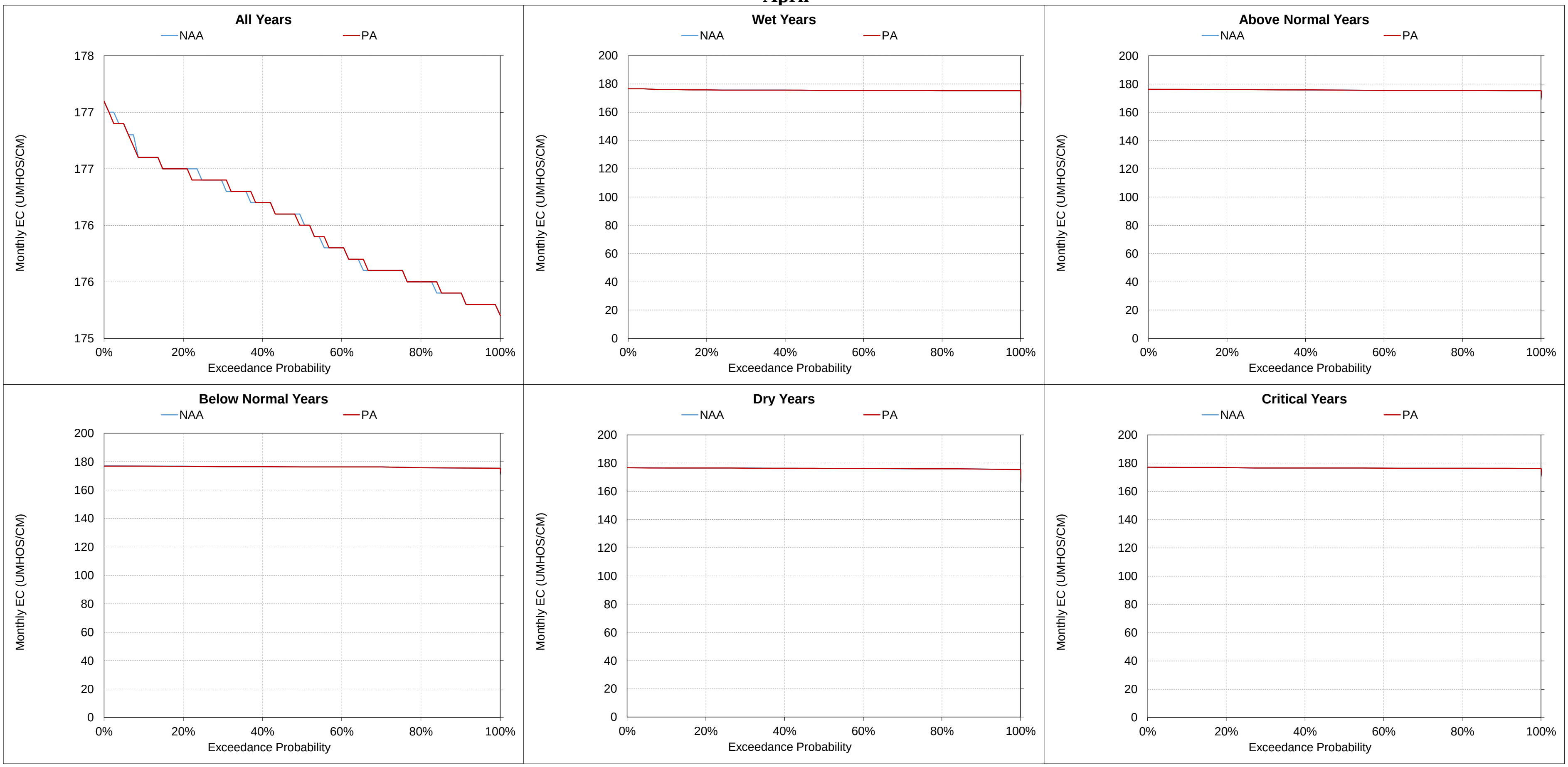
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-9-13. Sacramento River downstream of Georgiana Slough Salinity, Monthly EC
March



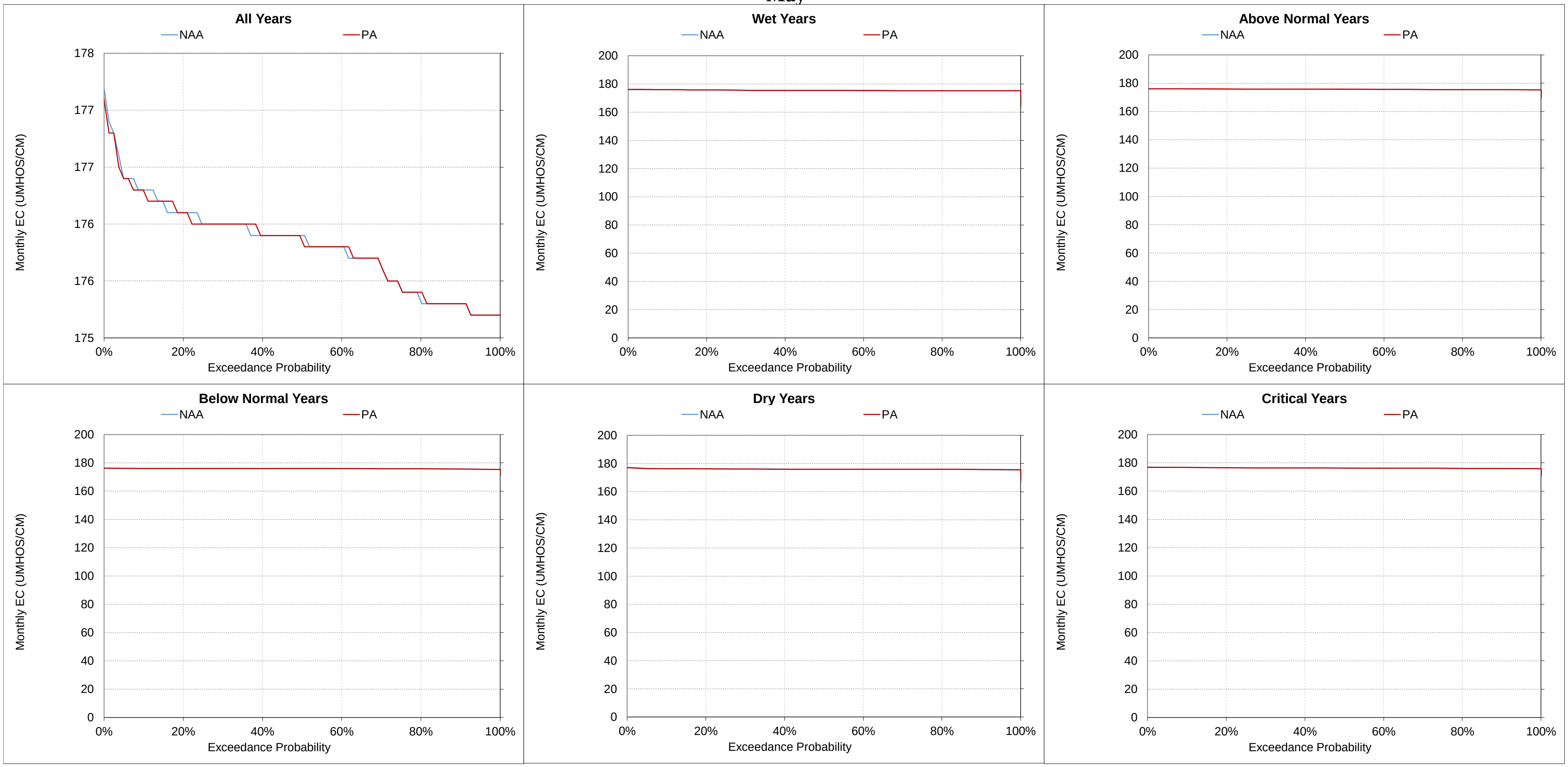
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-9-14. Sacramento River downstream of Georgiana Slough Salinity, Monthly EC April



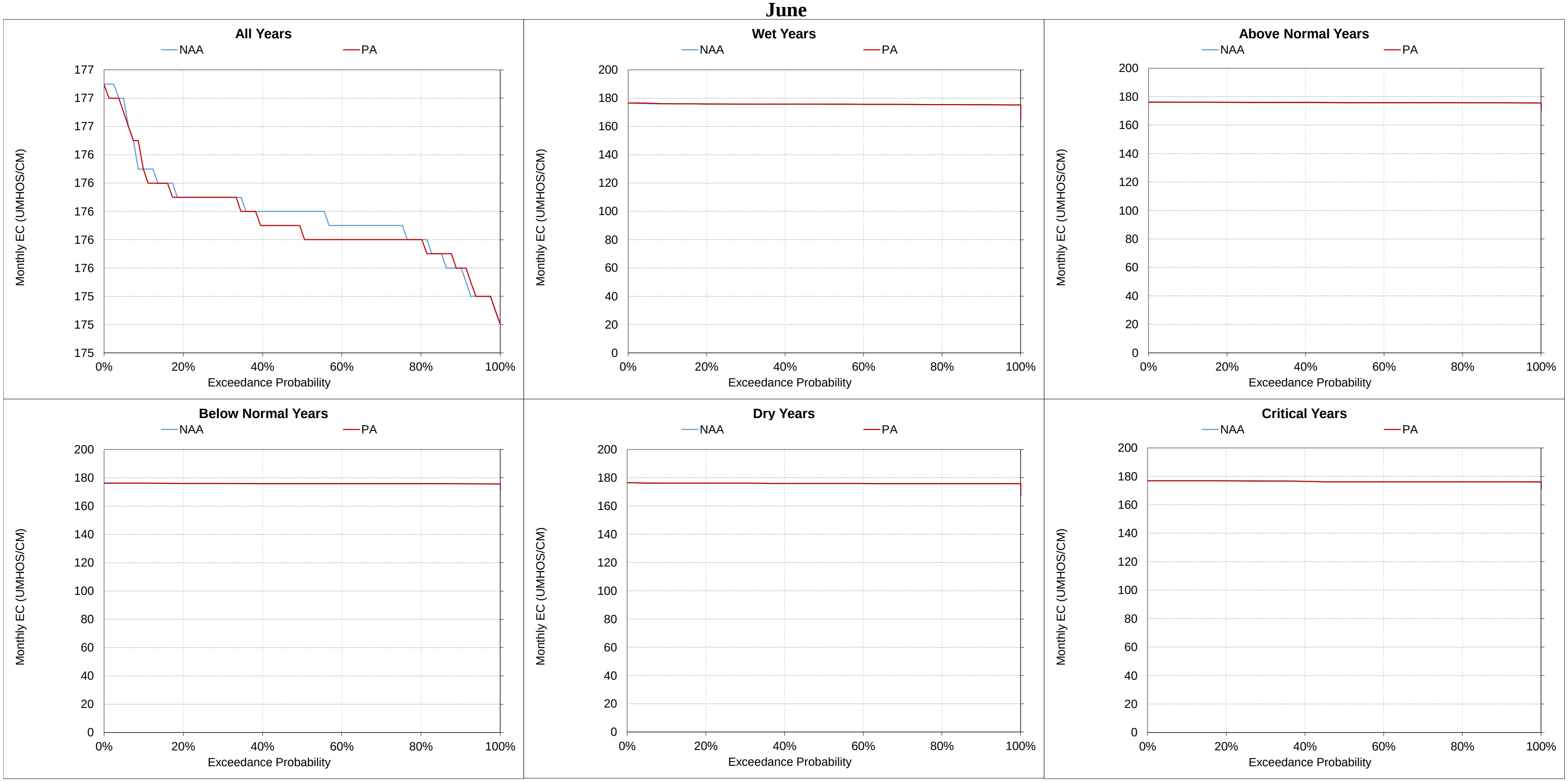
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-9-15. Sacramento River downstream of Georgiana Slough Salinity, Monthly EC
May



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-9-16. Sacramento River downstream of Georgiana Slough Salinity, Monthly EC
June



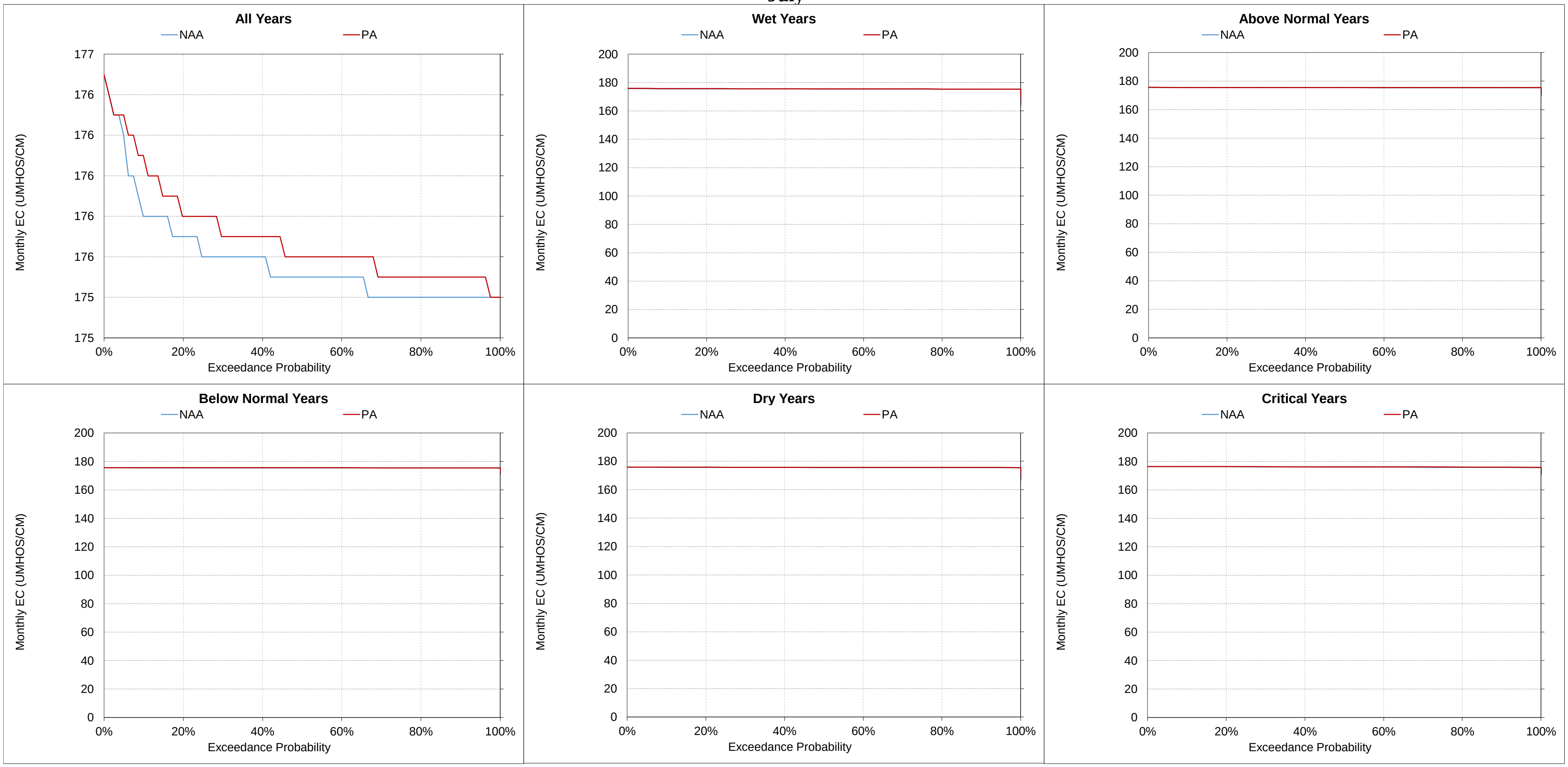
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

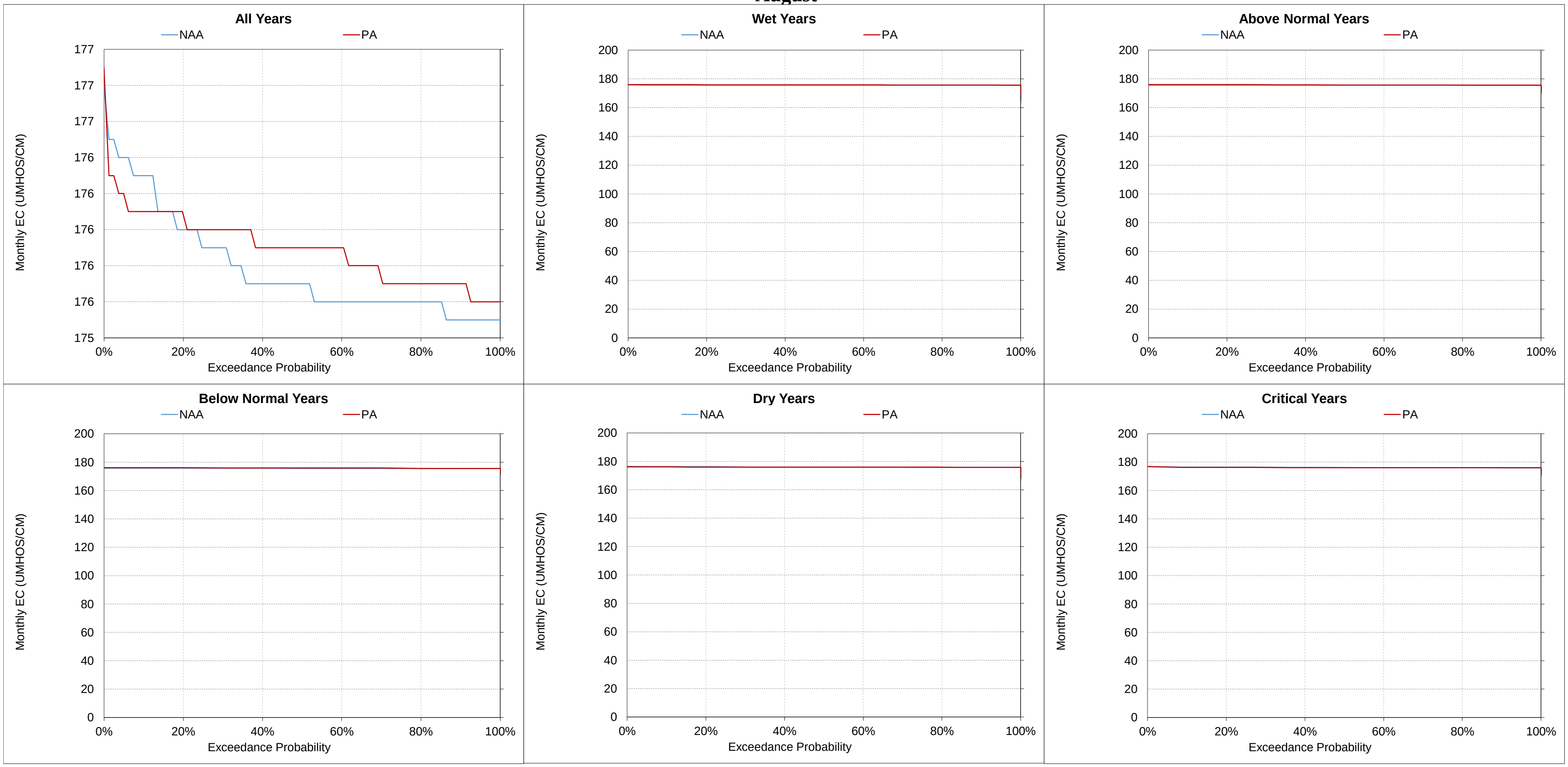
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-9-17. Sacramento River downstream of Georgiana Slough Salinity, Monthly EC
July



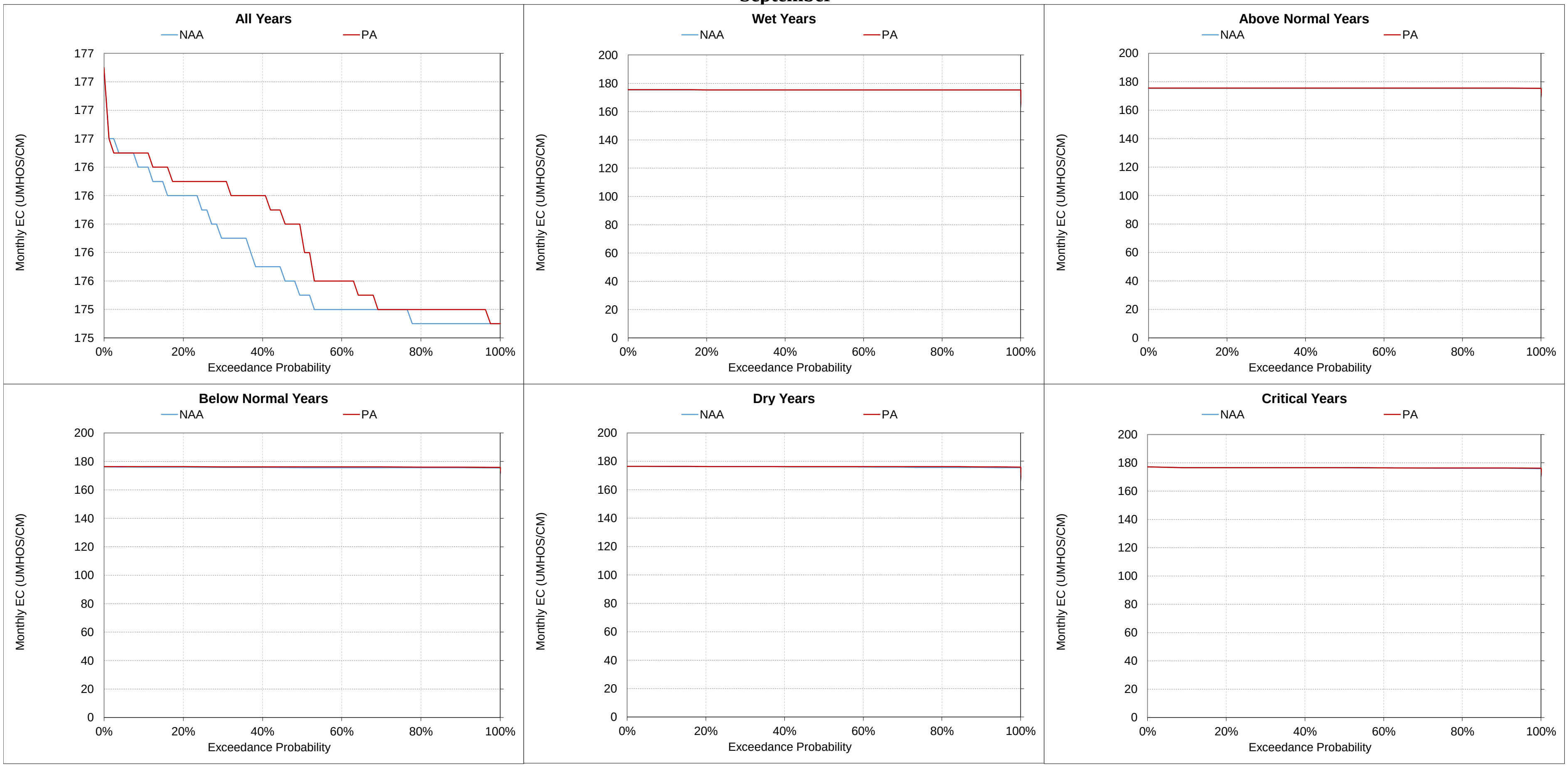
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-9-18. Sacramento River downstream of Georgiana Slough Salinity, Monthly EC August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-9-19. Sacramento River downstream of Georgiana Slough Salinity, Monthly EC
September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-10. Cache Slough at Ryer Island Salinity, Monthly EC

Statistic	Monthly EC (UMHOS/CM)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	201	201	0	0%	208	200	-8	-4%	196	195	0	0%	202	203	1	0%	201	203	2	1%	193	195	1	1%
20%	188	188	1	0%	189	190	2	1%	190	191	0	0%	197	197	0	0%	196	199	3	2%	192	193	1	1%
30%	185	188	2	1%	186	189	2	1%	188	188	0	0%	194	194	0	0%	193	194	1	0%	189	190	1	0%
40%	184	187	3	2%	185	186	2	1%	186	186	0	0%	193	193	1	0%	191	192	1	0%	187	188	1	1%
50%	182	186	4	2%	182	185	3	2%	184	185	1	0%	191	191	1	0%	189	189	1	0%	185	186	1	1%
60%	180	183	2	1%	181	184	3	2%	182	183	1	1%	190	190	0	0%	186	187	1	1%	184	185	1	0%
70%	180	182	2	1%	180	183	3	2%	181	182	1	1%	188	188	0	0%	185	186	1	1%	183	184	1	0%
80%	180	182	2	1%	179	182	2	1%	180	181	1	1%	186	187	1	0%	183	184	1	1%	182	182	1	0%
90%	179	181	2	1%	179	181	2	1%	180	180	1	0%	183	183	1	0%	182	182	0	0%	181	181	0	0%
Long Term Full Simulation Period[b]	186	187	1	1%	187	188	1	0%	187	188	1	0%	192	193	1	0%	190	191	1	0%	186	187	1	1%
Water Year Types[c]																								
Wet (32%)	180	182	2	1%	180	183	2	1%	183	183	1	0%	188	189	0	0%	184	185	1	0%	183	184	1	0%
Above Normal (16%)	180	182	2	1%	180	183	3	2%	183	184	1	1%	193	195	1	1%	190	191	1	0%	184	185	1	0%
Below Normal (13%)	187	189	2	1%	186	188	2	1%	186	186	0	0%	198	199	1	0%	191	192	1	0%	188	189	1	1%
Dry (24%)	186	187	2	1%	186	187	1	1%	188	188	0	0%	189	190	1	0%	195	196	1	1%	188	190	1	1%
Critical (15%)	204	202	-3	-1%	213	204	-9	-4%	201	203	2	1%	198	198	0	0%	196	197	1	1%	191	192	1	0%

Statistic	Monthly EC (UMHOS/CM)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	187	188	0	0%	184	185	0	0%	185	185	1	0%	186	188	2	1%	188	188	0	0%	189	195	6	3%
20%	186	187	0	0%	183	184	0	0%	184	184	0	0%	182	184	3	2%	185	186	2	1%	185	193	8	4%
30%	186	186	0	0%	183	183	0	0%	183	184	0	0%	181	184	3	2%	182	185	3	1%	182	191	9	5%
40%	185	185	1	0%	183	183	0	0%	183	183	0	0%	181	183	3	1%	181	185	4	2%	181	190	9	5%
50%	183	184	1	0%	182	182	0	0%	182	183	1	0%	180	183	2	1%	180	184	4	2%	180	187	8	4%
60%	183	183	1	0%	181	182	0	0%	182	182	1	0%	180	182	2	1%	180	184	4	2%	179	181	2	1%
70%	182	183	0	0%	181	181	0	0%	182	182	1	0%	180	182	2	1%	180	183	4	2%	179	180	2	1%
80%	180	181	0	0%	180	180	0	0%	180	182	1	1%	180	182	2	1%	179	183	3	2%	178	180	2	1%
90%	180	180	0	0%	179	179	1	0%	179	181	1	1%	179	181	2	1%	179	182	3	2%	178	180	2	1%
Long Term Full Simulation Period[b]	184	184	0	0%	182	182	0	0%	183	184	1	0%	181	184	2	1%	182	185	2	1%	182	187	5	3%
Water Year Types[c]																								
Wet (32%)	182	182	0	0%	180	181	0	0%	181	182	1	1%	180	182	2	1%	180	184	4	2%	178	180	2	1%
Above Normal (16%)	183	183	0	0%	181	182	0	0%	182	183	1	0%	180	182	2	1%	179	183	3	2%	179	181	2	1%
Below Normal (13%)	185	185	0	0%	182	182	0	0%	182	182	0	0%	180	182	2	1%	180	184	4	2%	181	190	9	5%
Dry (24%)	185	186	1	0%	183	183	0	0%	183	183	0	0%	181	184	3	2%	184	185	1	0%	184	192	9	5%
Critical (15%)	187	187	0	0%	185	185	0	0%	190	190	0	0%	188	191	2	1%	191	190	0	0%	192	195	3	2%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

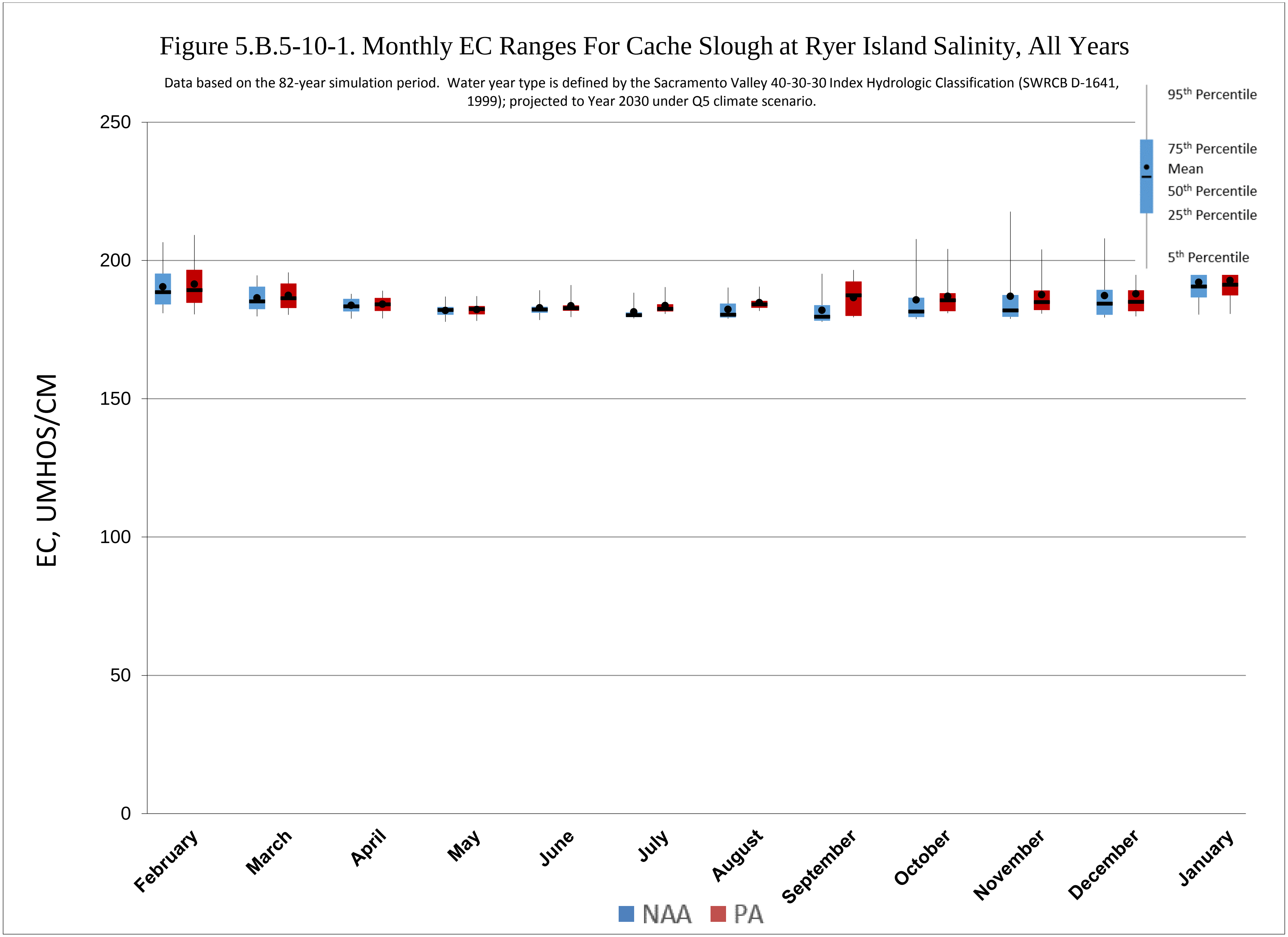


Figure 5.B.5-10-1. Monthly EC Ranges For Cache Slough at Ryer Island Salinity, All Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario.
EC, UMHOS/CM
250
200
150
100
50
0
February
March
April
May
June
July
August
September
October
November
December
January
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
NAA
PA

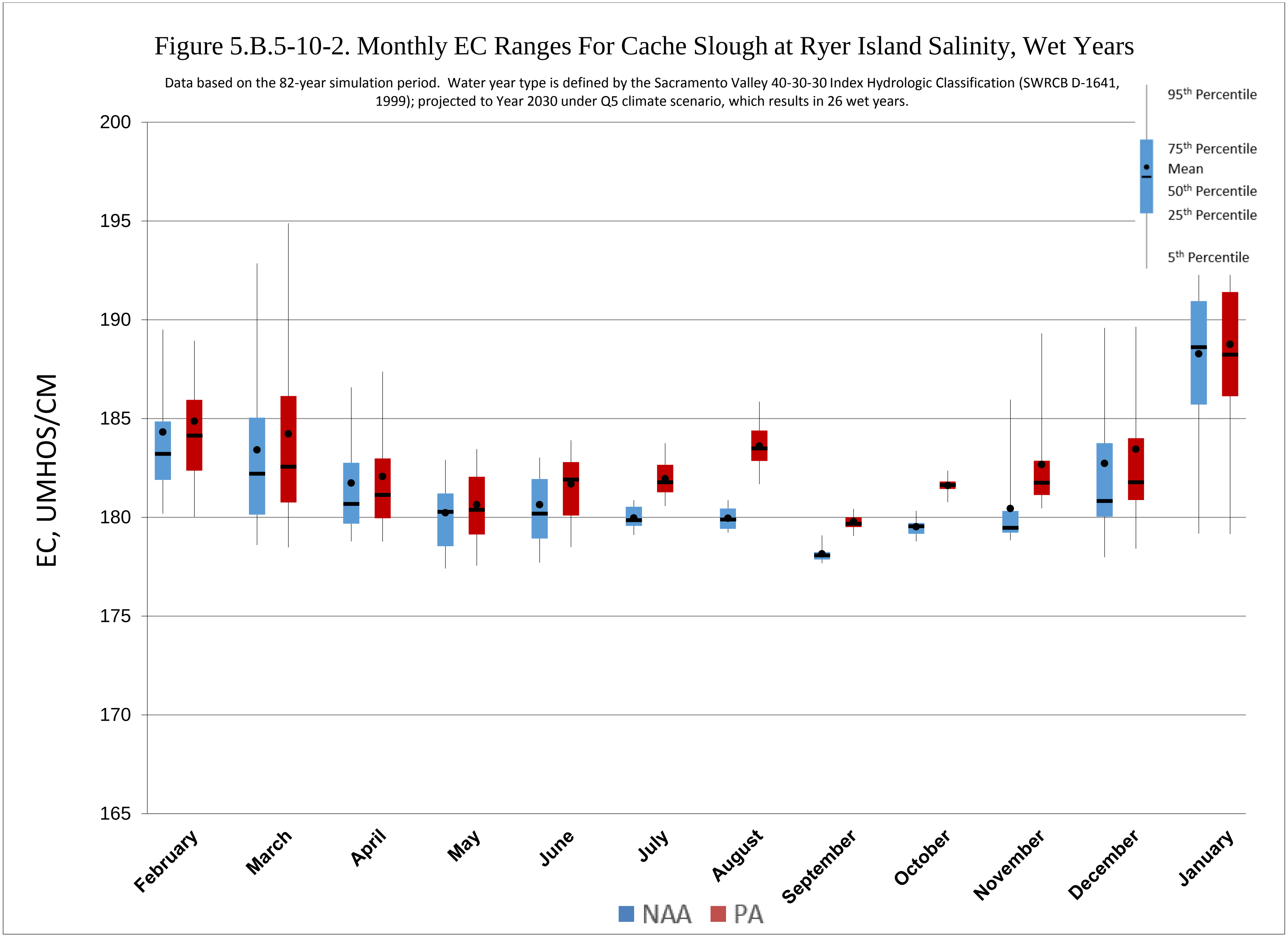


Figure 5.B.5-10-2. Monthly EC Ranges For Cache Slough at Ryer Island Salinity, Wet Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 26 wet years.
EC, UMHOS/CM
200
195
190
185
180
175
170
165
February
March
April
May
June
July
August
September
October
November
December
January
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
NAA
PA

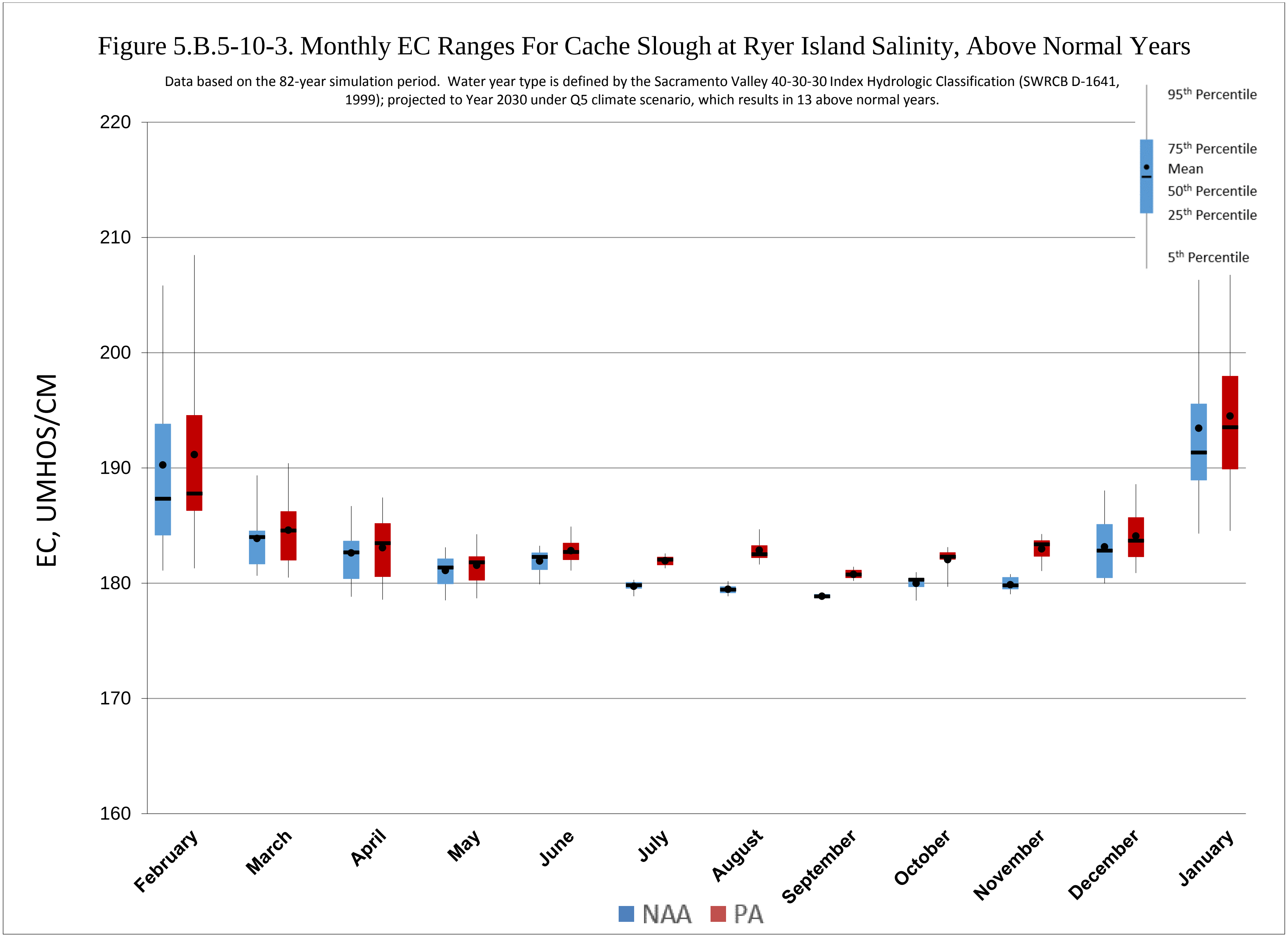


Figure 5.B.5-10-3. Monthly EC Ranges For Cache Slough at Ryer Island Salinity, Above Normal Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 13 above normal years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
EC, UMHOS/CM
220
210
200
190
180
170
160
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-10-4. Monthly EC Ranges For Cache Slough at Ryer Island Salinity, Below Normal Years

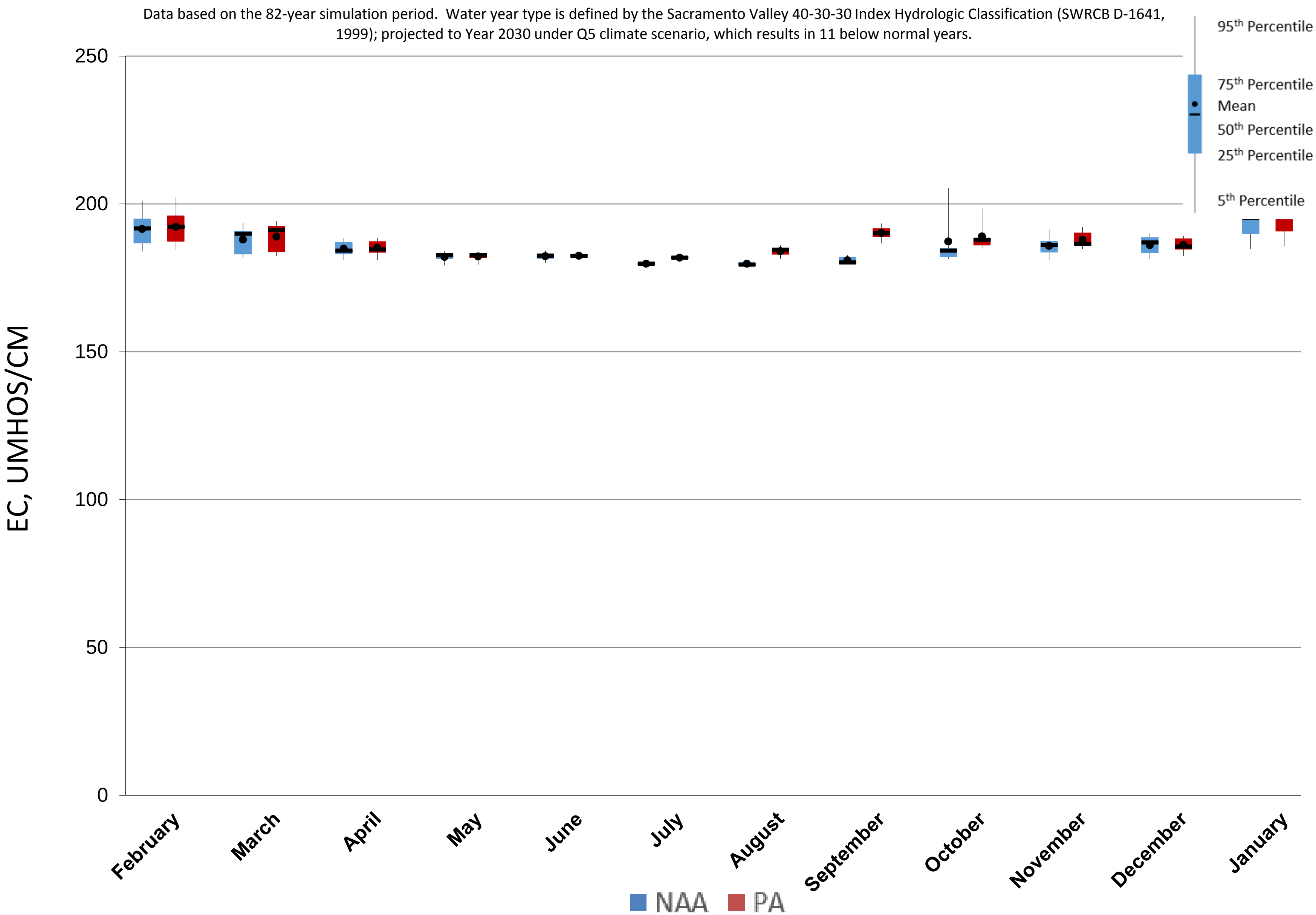


Figure 5.B.5-10-5. Monthly EC Ranges For Cache Slough at Ryer Island Salinity, Dry Years

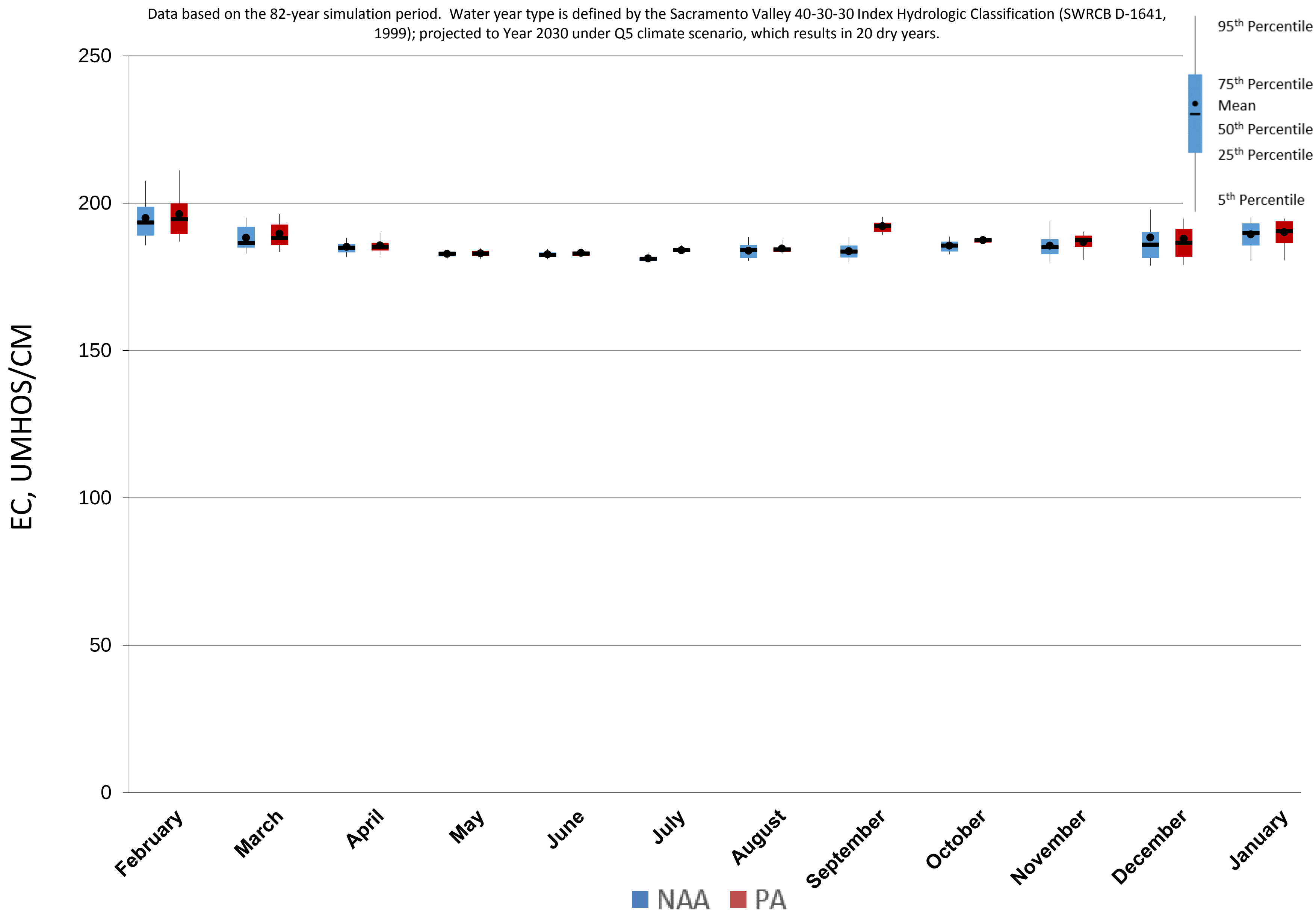


Figure 5.B.5-10-6. Monthly EC Ranges For Cache Slough at Ryer Island Salinity, Critical Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 12 critical years.

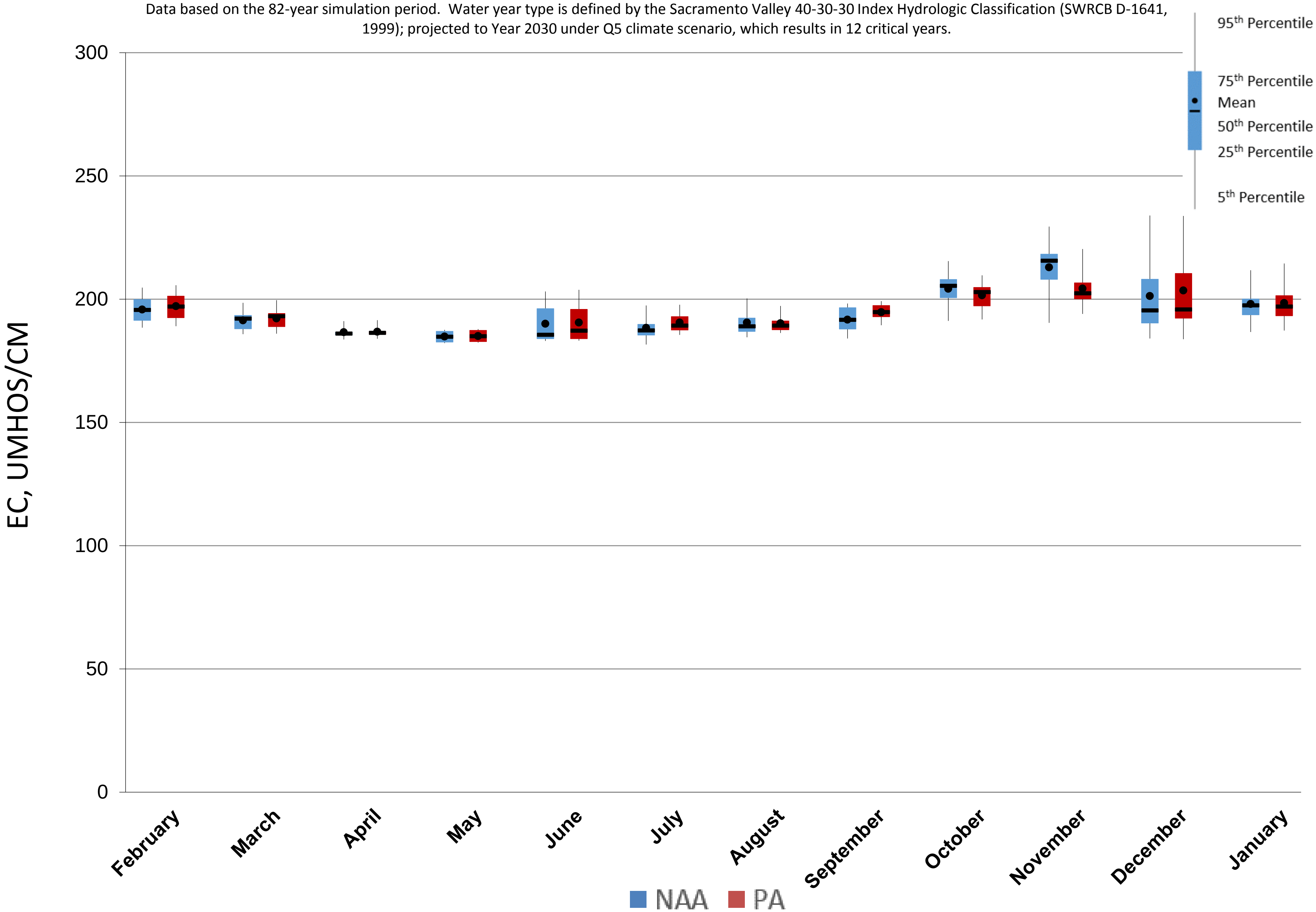
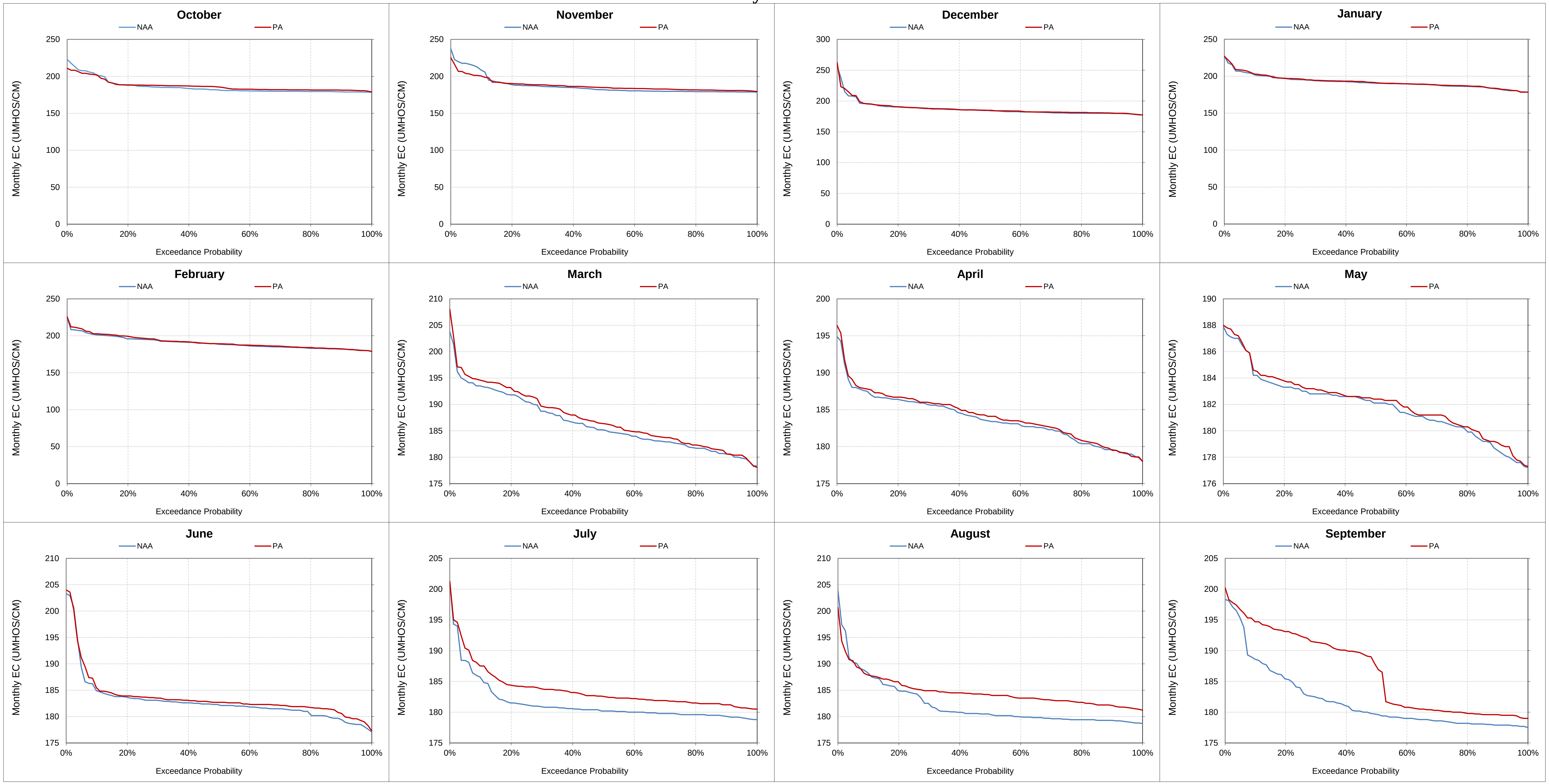
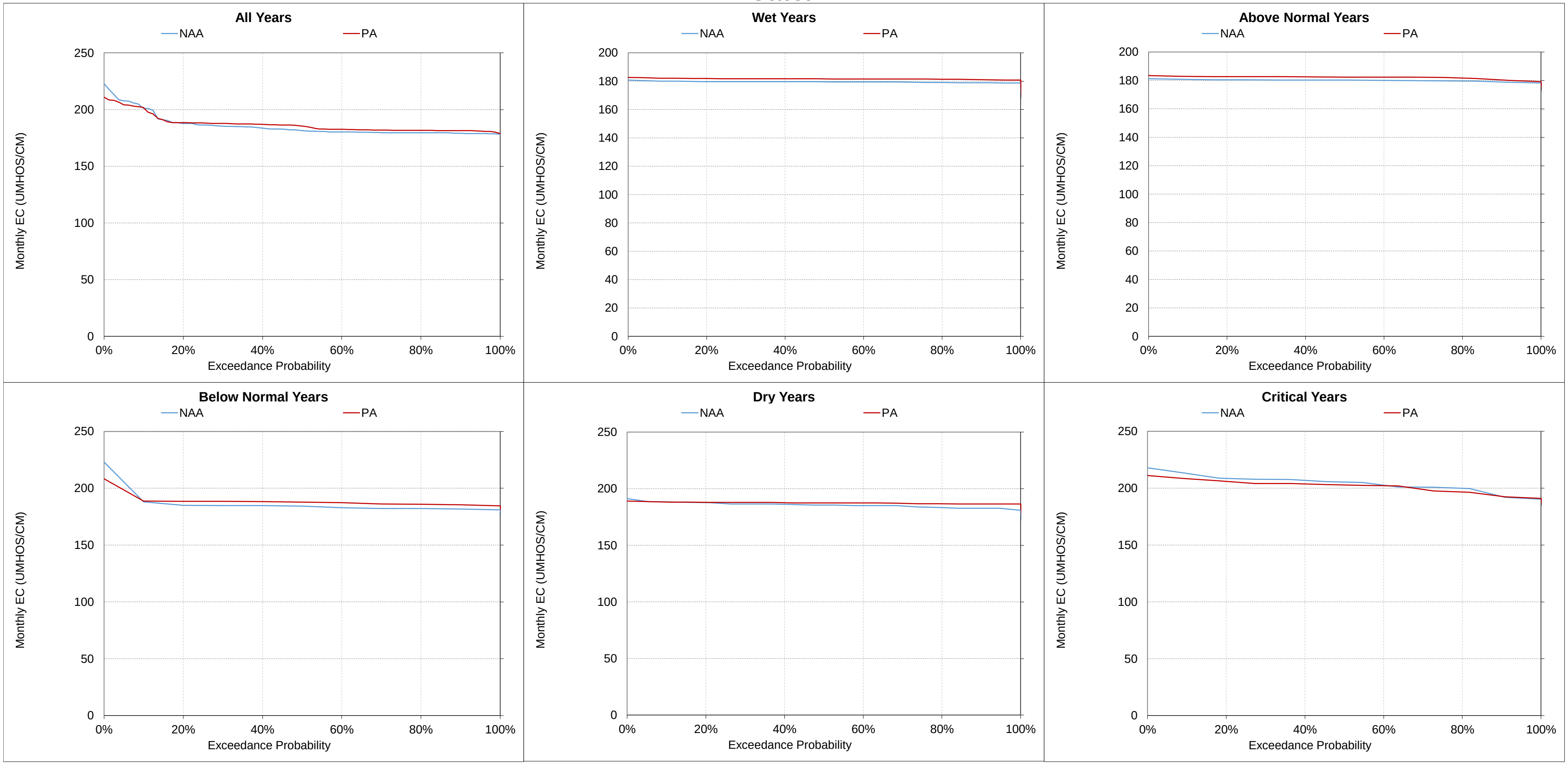


Figure 5.B.5-10-7. Cache Slough at Ryer Island Salinity, Monthly EC Probability of Exceedance



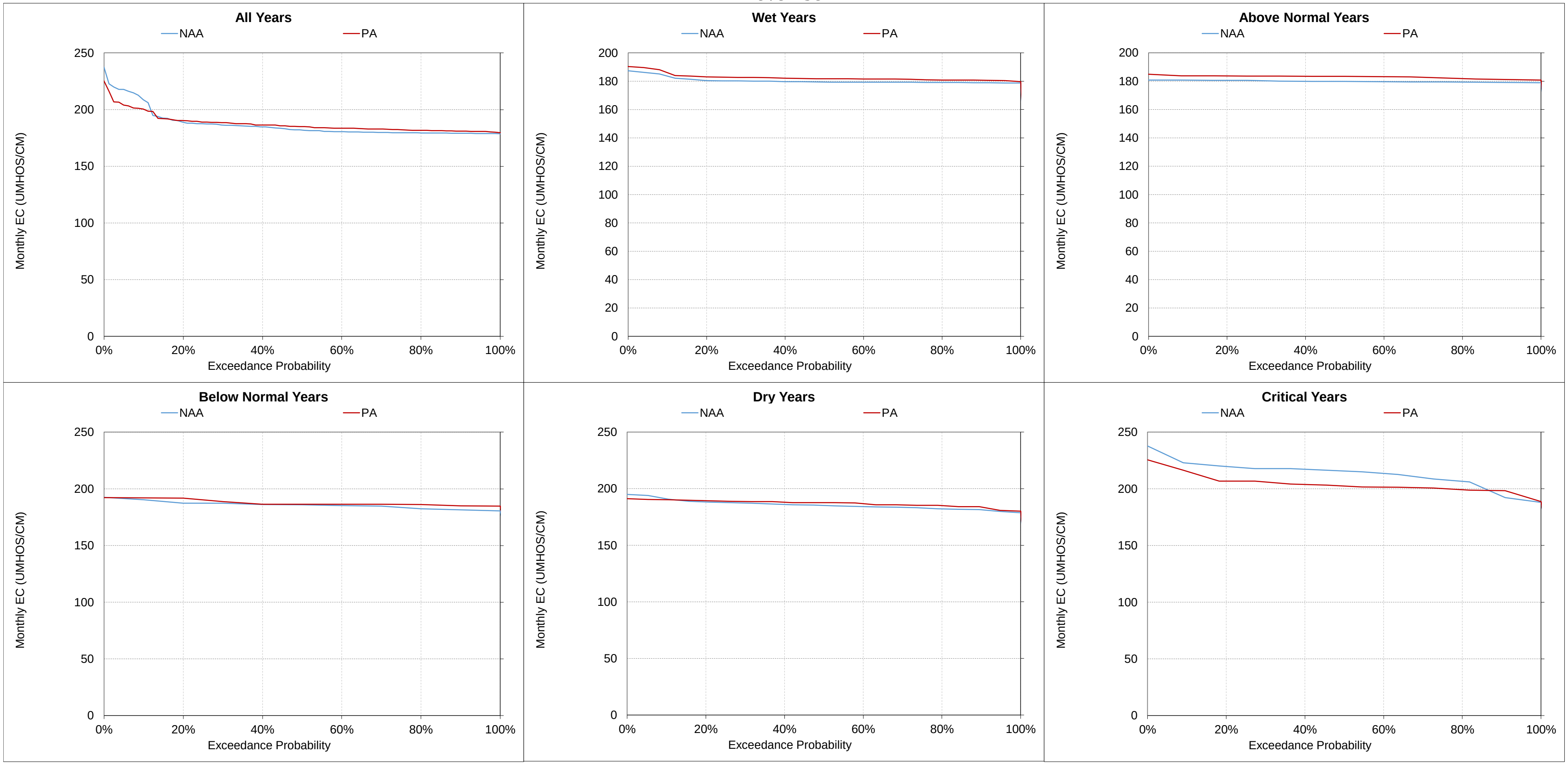
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-10-8. Cache Slough at Ryer Island Salinity, Monthly EC
October



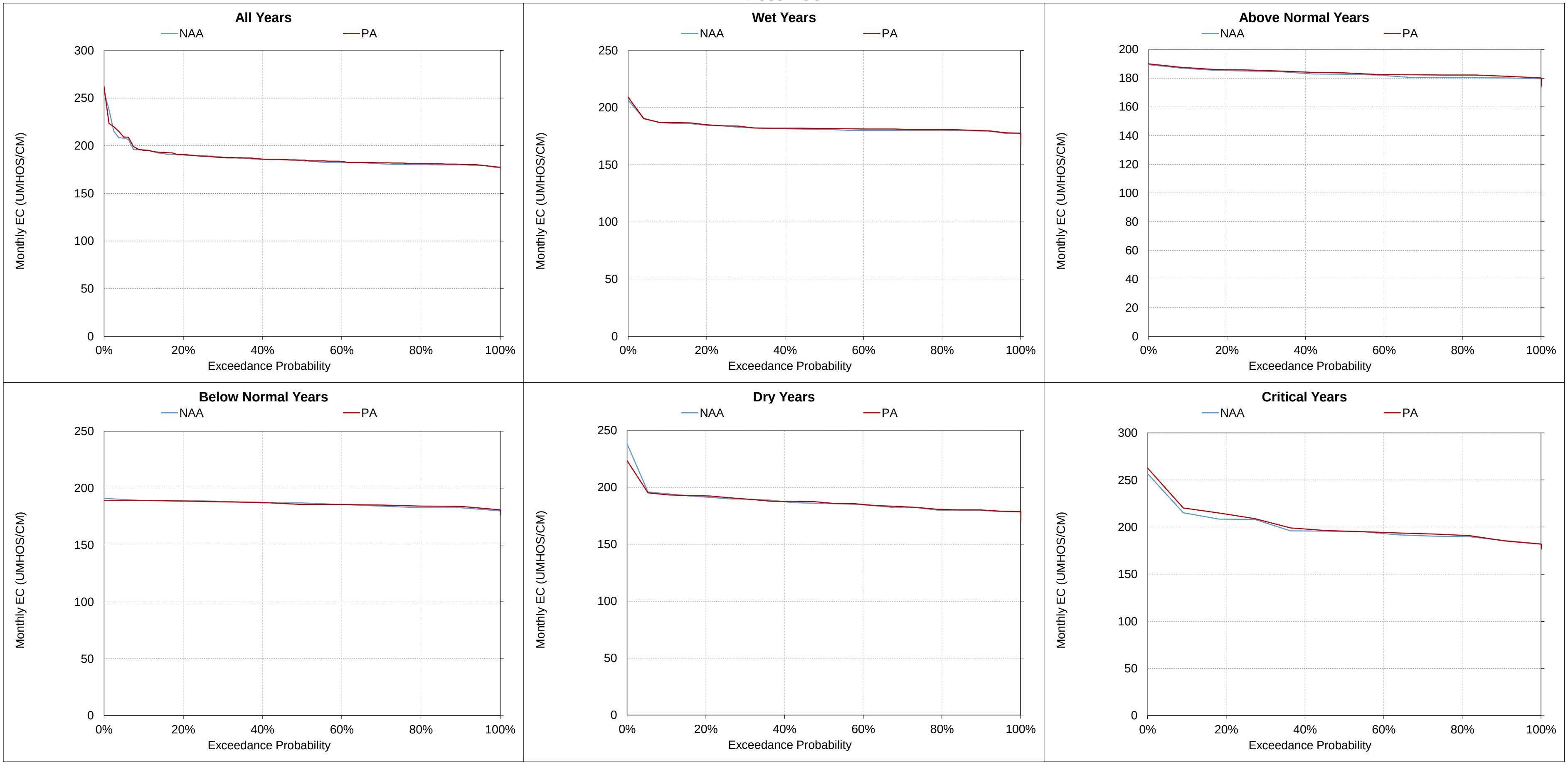
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-10-9. Cache Slough at Ryer Island Salinity, Monthly EC
November



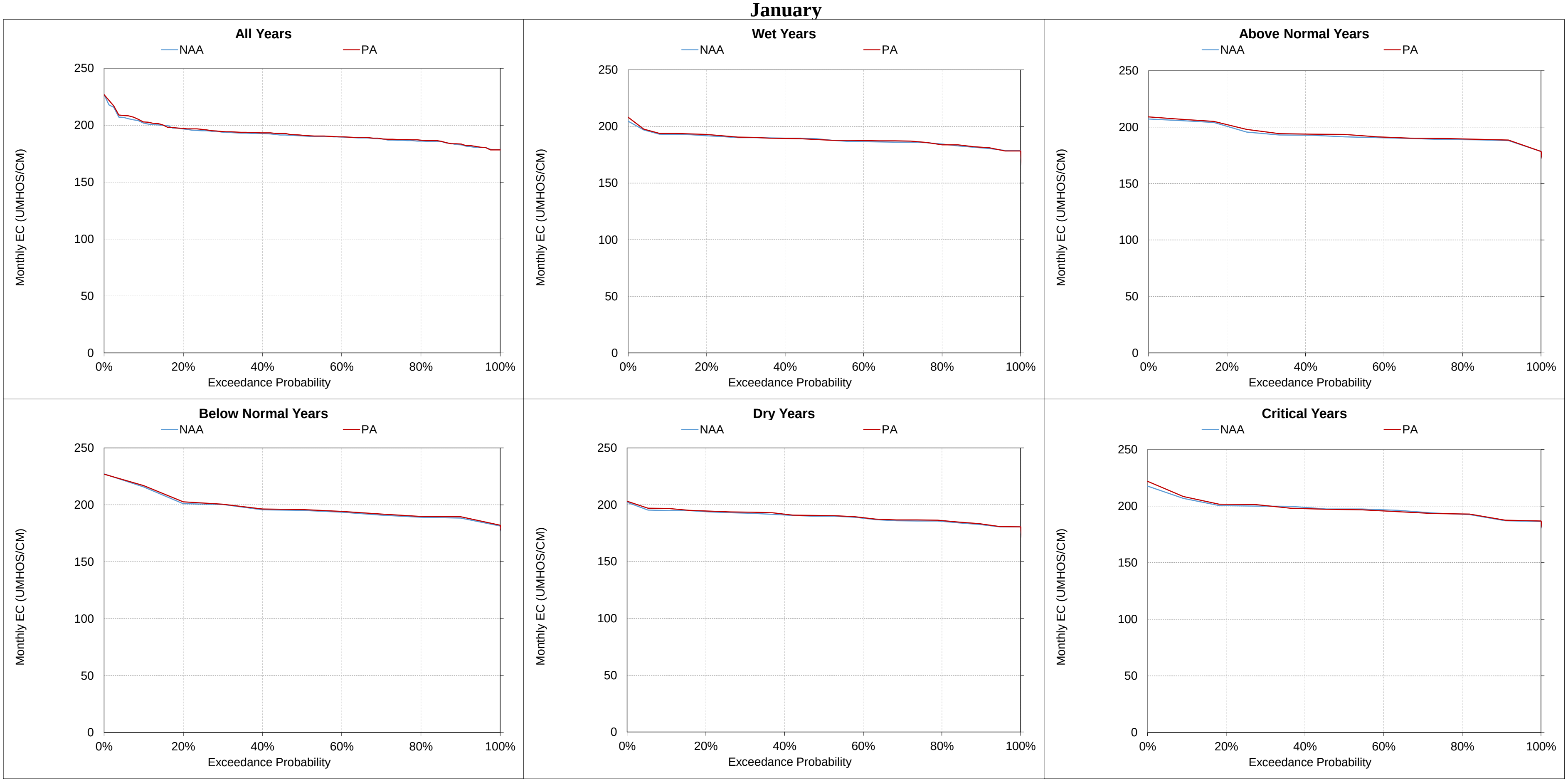
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-10-10. Cache Slough at Ryer Island Salinity, Monthly EC December



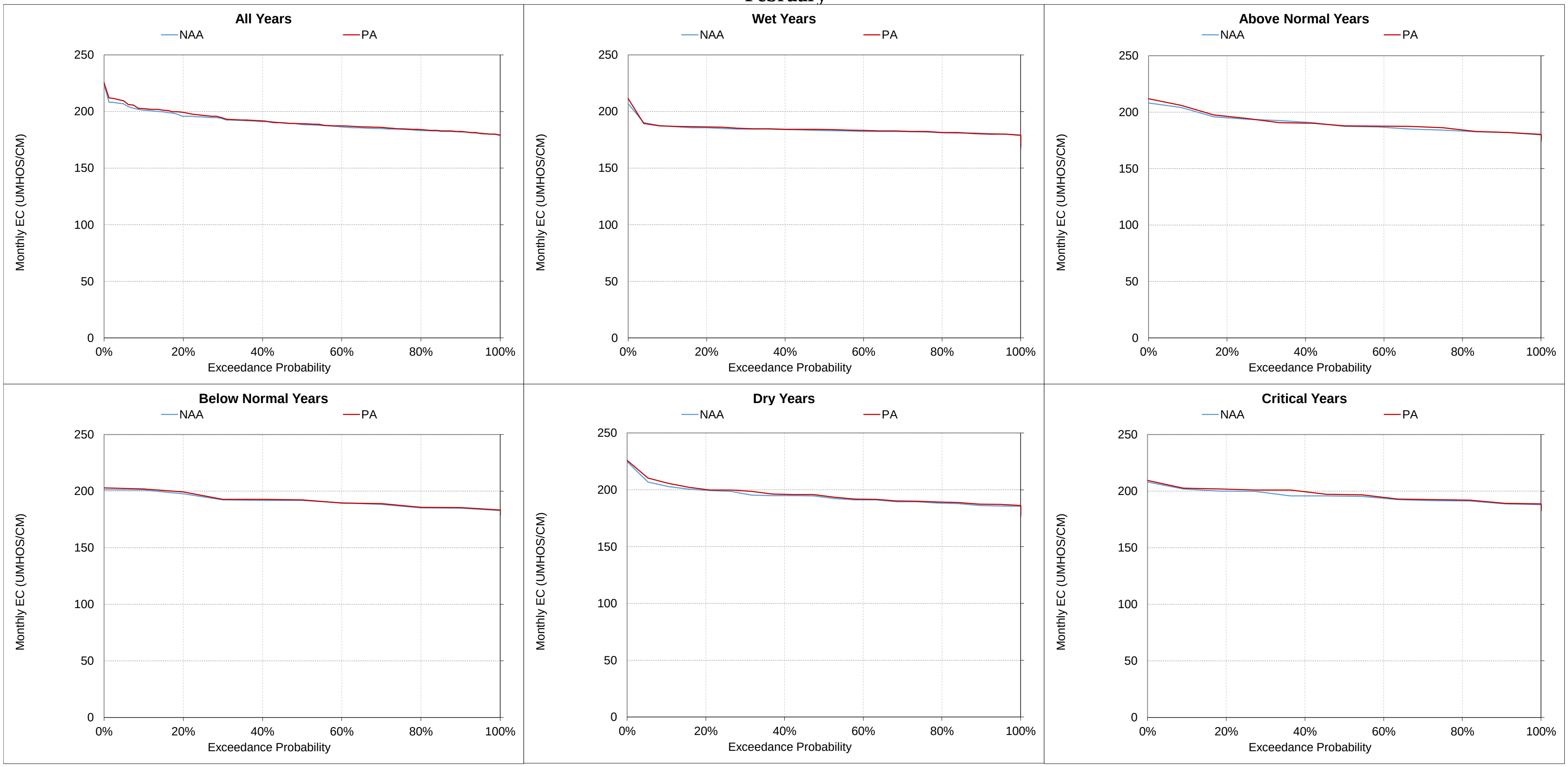
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-10-11. Cache Slough at Ryer Island Salinity, Monthly EC
January



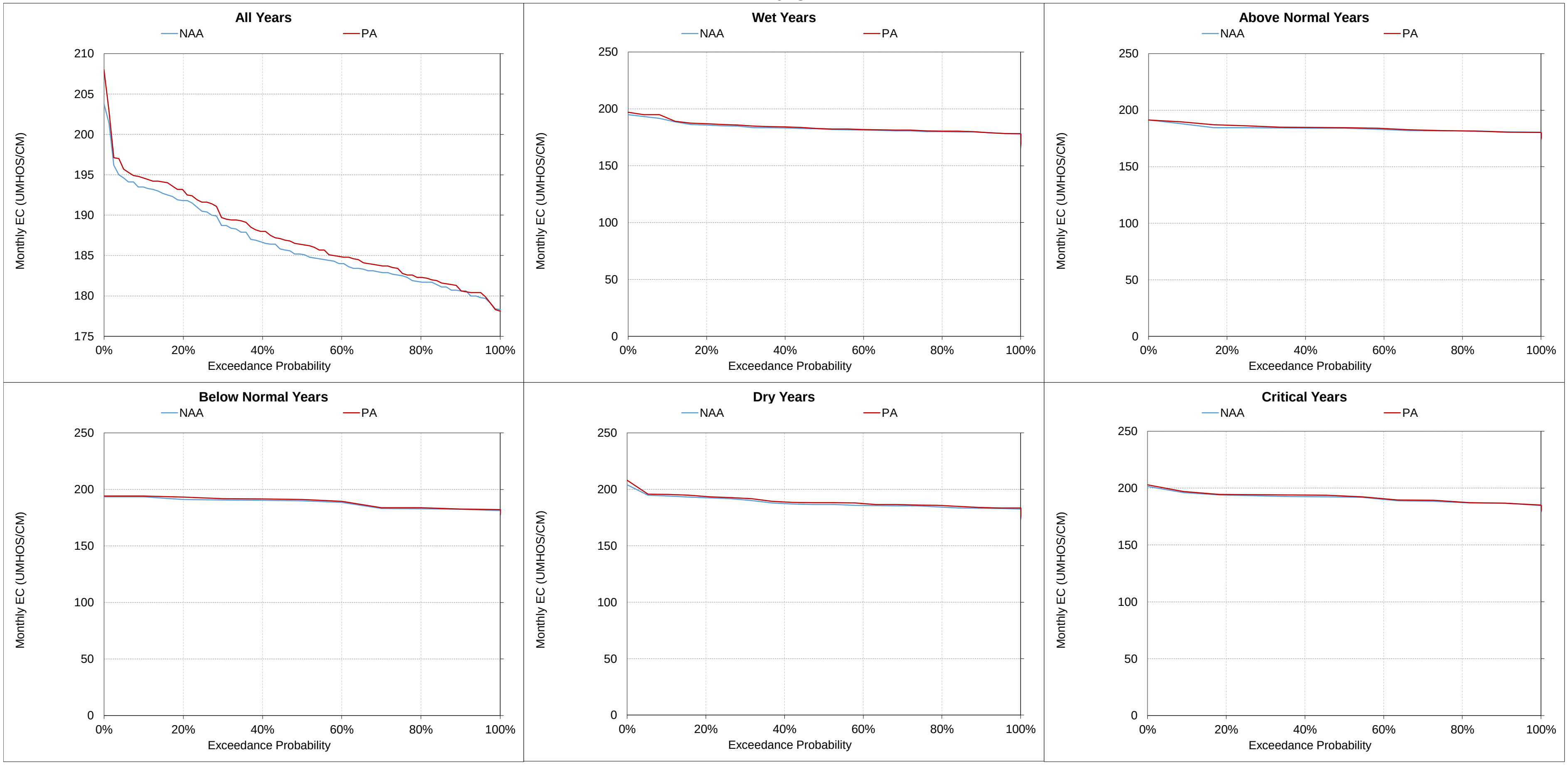
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-10-12. Cache Slough at Ryer Island Salinity, Monthly EC
February



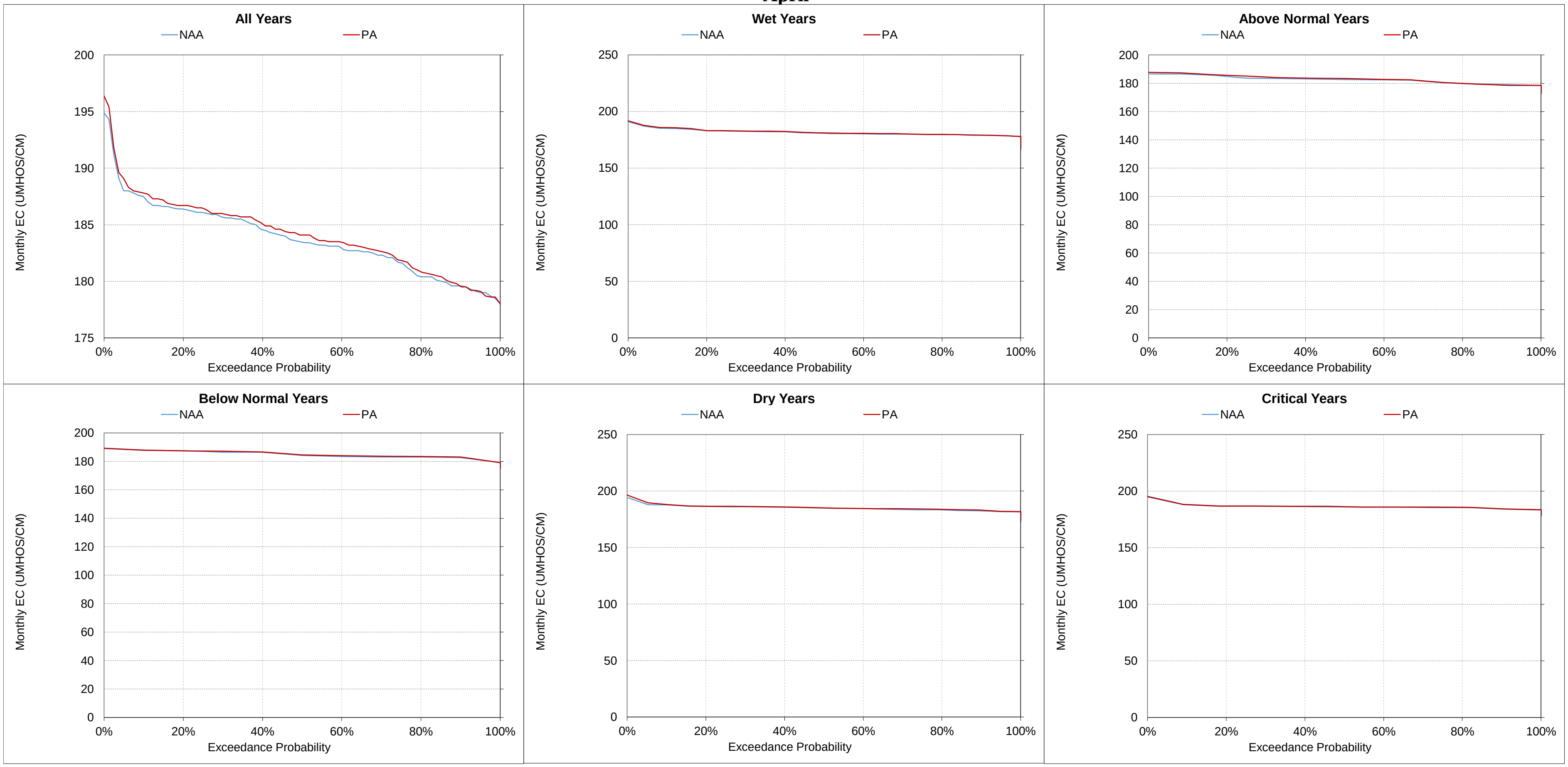
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-10-13. Cache Slough at Ryer Island Salinity, Monthly EC
March



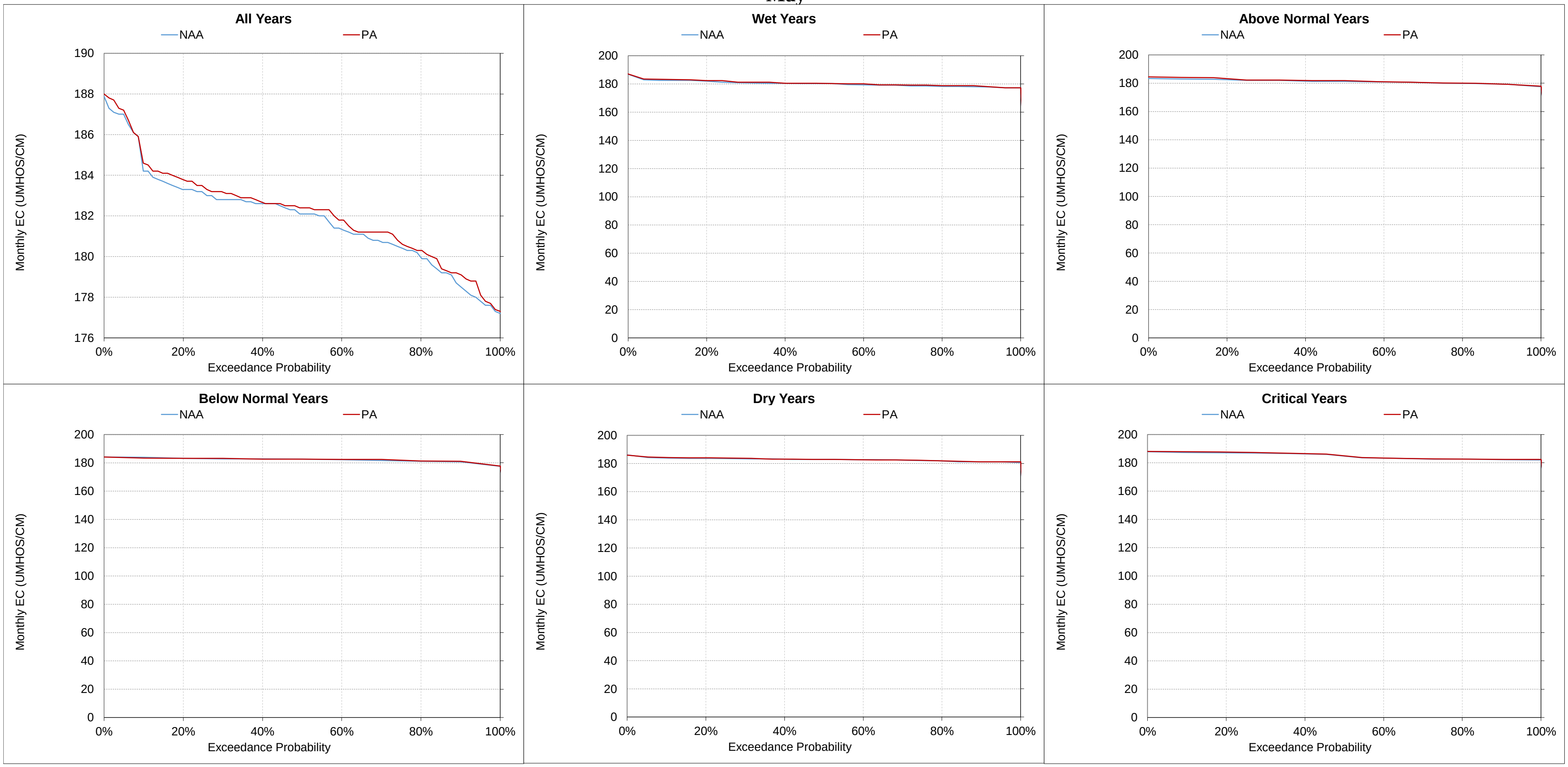
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-10-14. Cache Slough at Ryer Island Salinity, Monthly EC
April



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-10-15. Cache Slough at Ryer Island Salinity, Monthly EC May



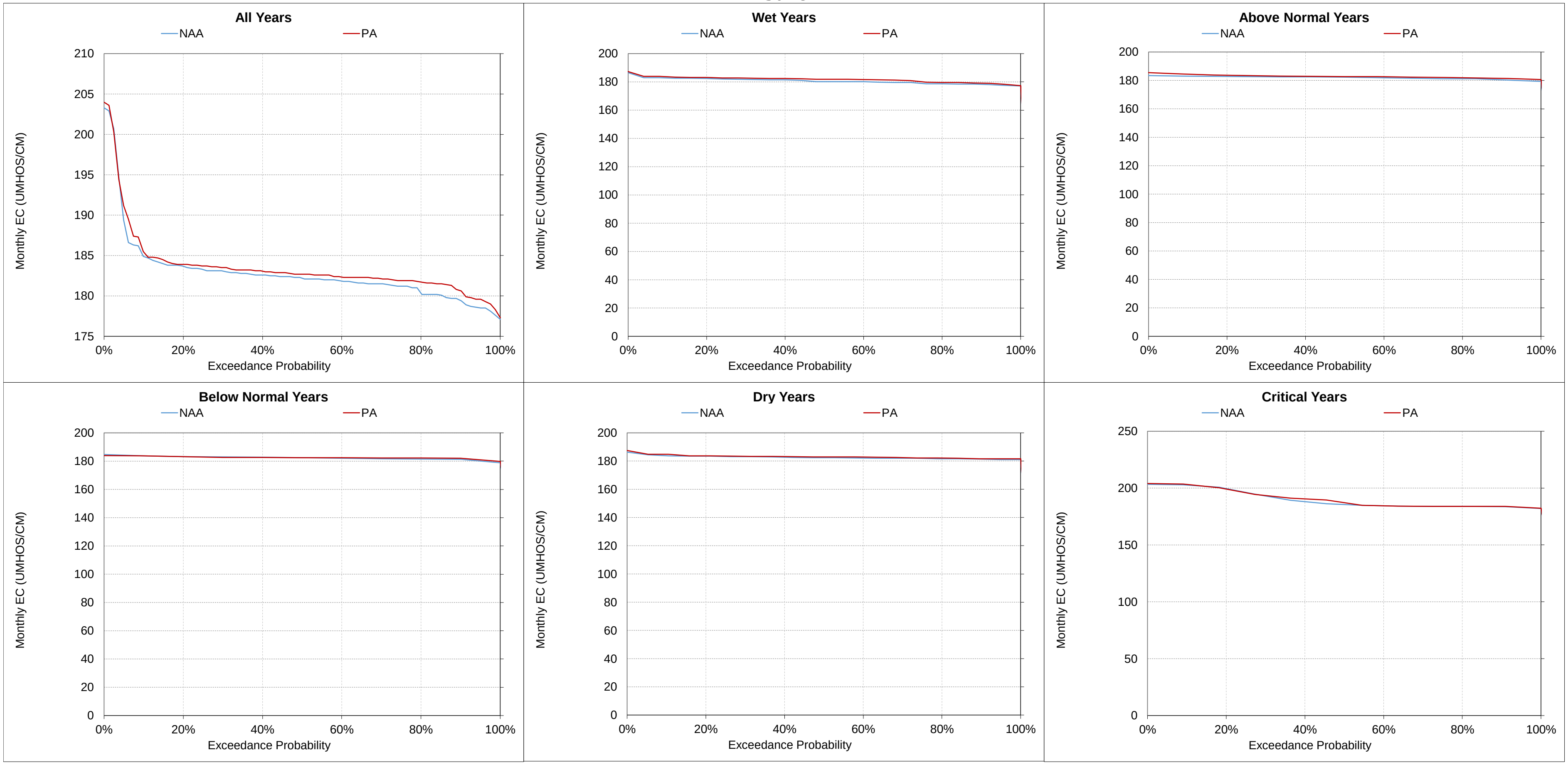
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

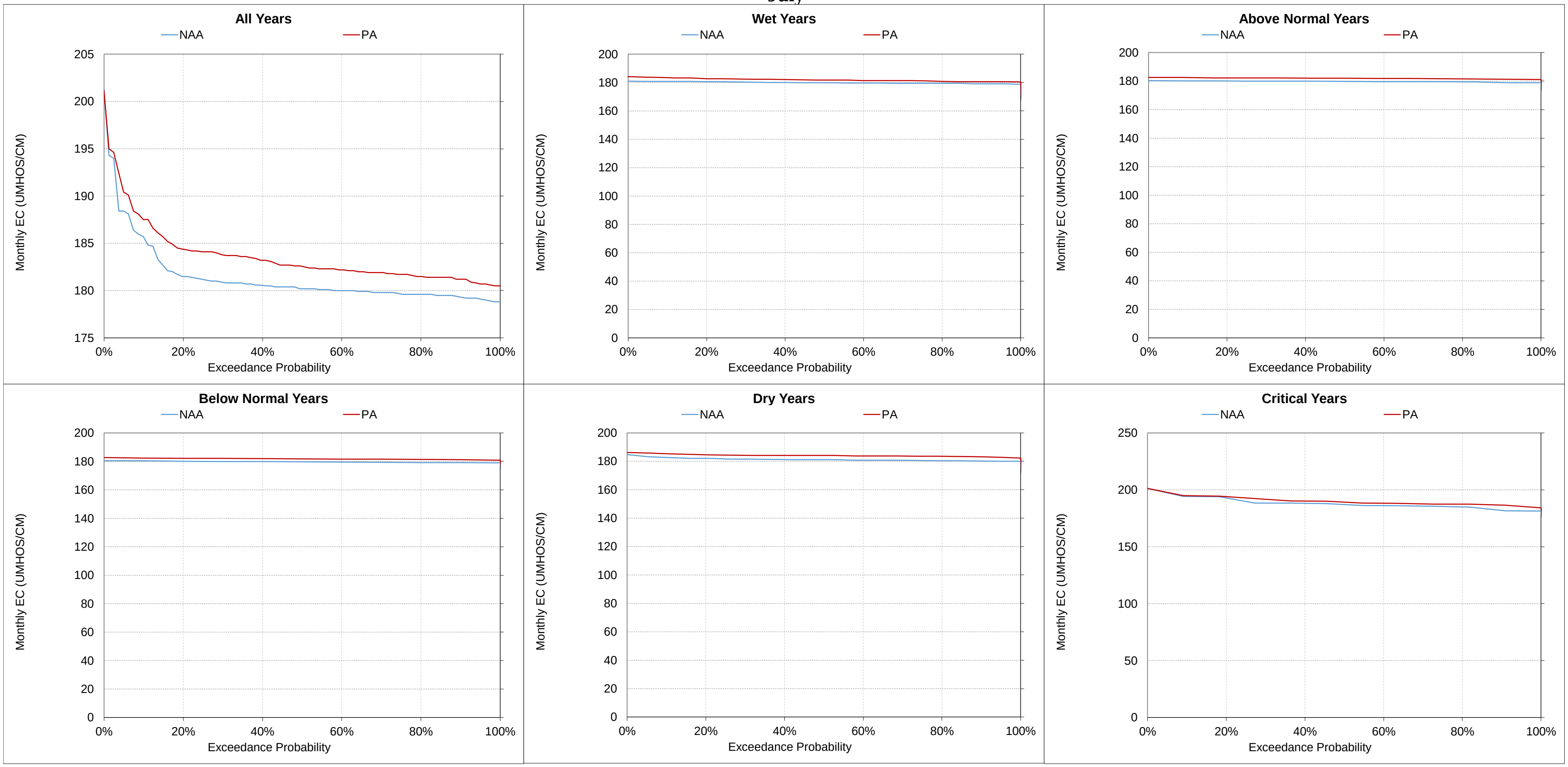
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-10-16. Cache Slough at Ryer Island Salinity, Monthly EC
June



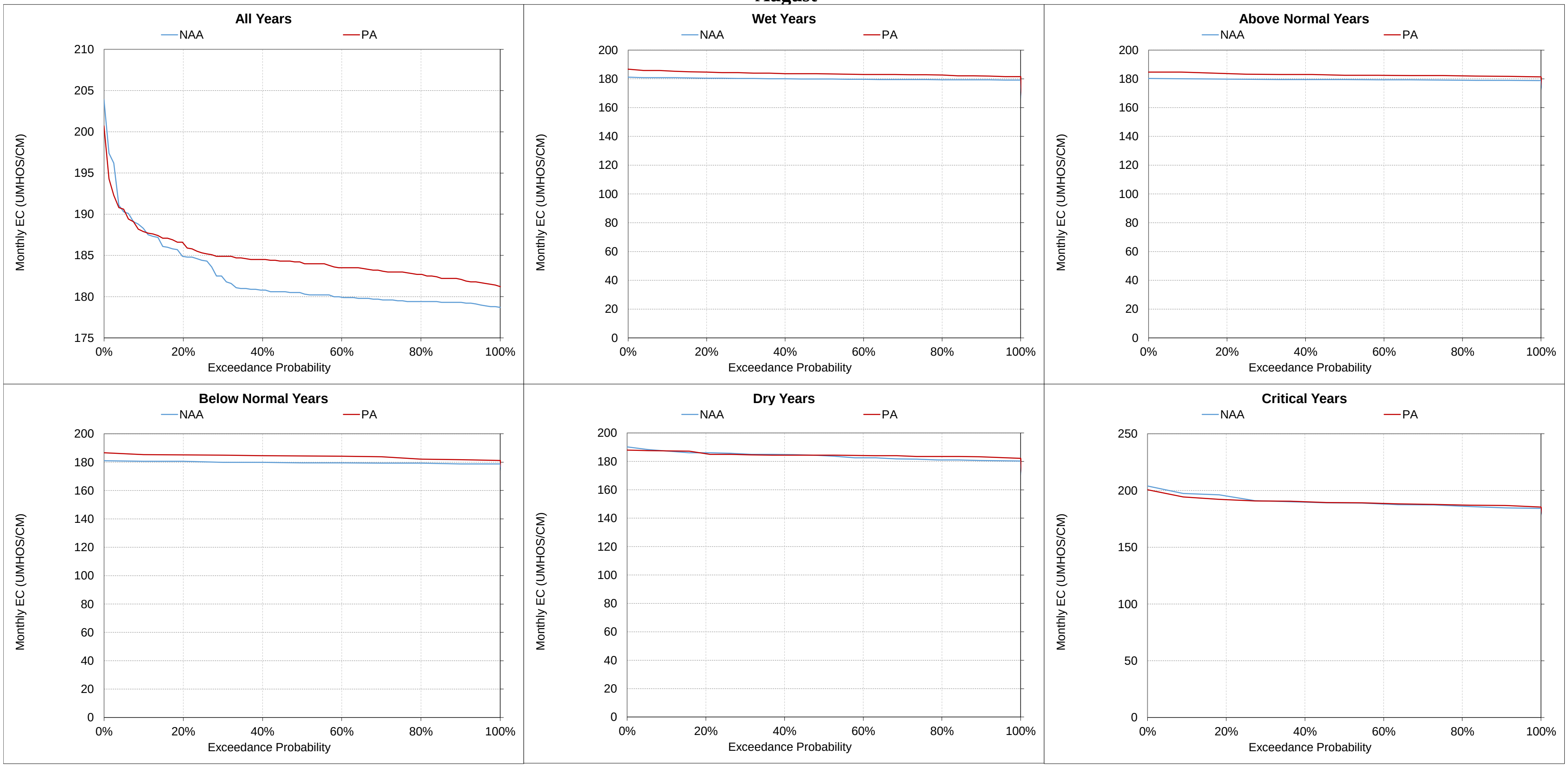
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-10-17. Cache Slough at Ryer Island Salinity, Monthly EC
July



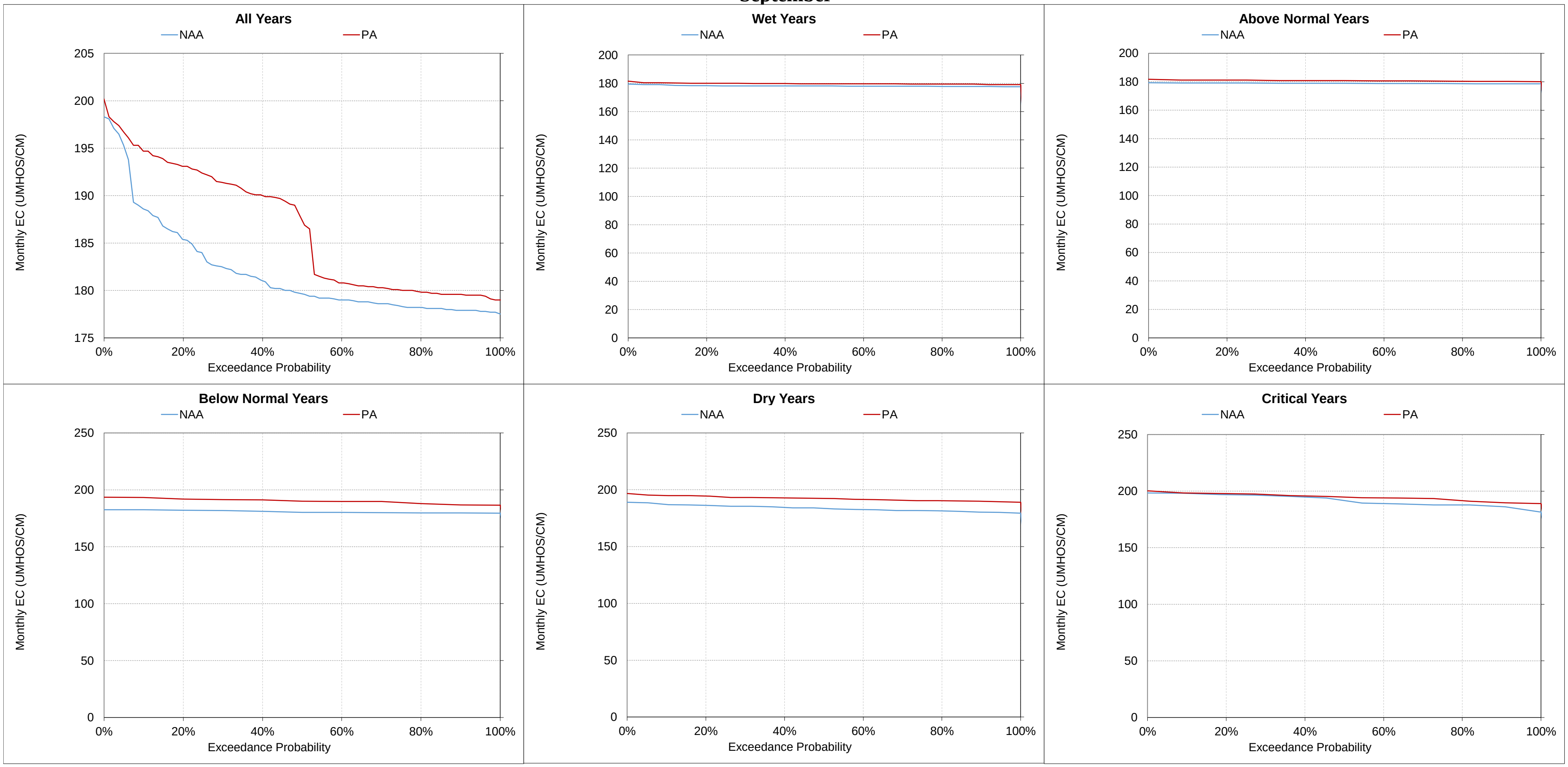
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-10-18. Cache Slough at Ryer Island Salinity, Monthly EC
August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-10-19. Cache Slough at Ryer Island Salinity, Monthly EC
September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-11. Sacramento River at Rio Vista Salinity, Monthly EC

Statistic	Monthly EC (UMHOS/CM)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	702	532	-170	-24%	699	561	-137	-20%	429	404	-26	-6%	258	254	-4	-1%	209	210	2	1%	196	198	2	1%
20%	483	409	-74	-15%	462	395	-67	-14%	366	351	-16	-4%	245	240	-5	-2%	201	202	1	0%	190	194	4	2%
30%	457	391	-66	-14%	415	357	-58	-14%	244	247	3	1%	226	220	-7	-3%	198	198	0	0%	188	191	3	2%
40%	427	376	-51	-12%	335	305	-30	-9%	230	227	-4	-2%	212	211	-1	-1%	193	195	2	1%	185	189	3	2%
50%	349	330	-19	-5%	221	214	-7	-3%	207	209	2	1%	204	203	0	0%	190	191	1	0%	184	187	3	2%
60%	201	203	2	1%	197	207	10	5%	201	202	1	1%	198	199	1	1%	185	187	1	1%	182	185	3	2%
70%	188	191	3	2%	188	196	7	4%	195	192	-4	-2%	190	192	2	1%	183	185	2	1%	181	182	1	1%
80%	186	189	4	2%	182	191	9	5%	186	187	1	1%	186	187	1	0%	182	183	1	0%	180	181	1	0%
90%	185	188	4	2%	181	189	8	4%	180	181	1	0%	181	182	1	0%	180	181	1	0%	179	180	1	0%
Long Term Full Simulation Period[b]	362	328	-34	-9%	339	306	-33	-10%	268	267	-2	-1%	216	213	-3	-1%	194	194	0	0%	186	188	2	1%
Water Year Types[c]																								
Wet (32%)	185	189	4	2%	183	191	8	4%	194	196	2	1%	203	198	-5	-3%	182	183	1	1%	181	183	2	1%
Above Normal (16%)	199	200	1	1%	198	205	8	4%	210	210	-1	0%	217	214	-4	-2%	188	189	1	1%	181	184	2	1%
Below Normal (13%)	428	376	-52	-12%	359	309	-49	-14%	287	272	-15	-5%	224	225	1	0%	197	196	-1	0%	187	190	3	1%
Dry (24%)	451	391	-60	-13%	385	338	-46	-12%	302	285	-17	-6%	215	215	0	0%	200	200	0	0%	188	190	2	1%
Critical (15%)	712	618	-94	-13%	739	609	-129	-17%	420	448	28	7%	237	233	-4	-2%	213	212	-1	0%	199	201	2	1%

Statistic	Monthly EC (UMHOS/CM)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	194	196	2	1%	201	202	1	1%	234	233	-1	-1%	307	326	19	6%	424	450	27	6%	533	610	78	15%
20%	191	193	2	1%	195	194	-1	-1%	209	210	1	1%	253	270	17	7%	357	355	-3	-1%	429	559	130	30%
30%	188	191	3	2%	191	192	0	0%	205	203	-2	-1%	238	249	11	5%	315	335	21	7%	389	535	145	37%
40%	186	189	3	2%	188	190	2	1%	201	201	0	0%	207	225	18	9%	273	313	40	15%	360	513	153	43%
50%	184	186	2	1%	186	189	3	2%	195	197	2	1%	199	211	12	6%	242	285	43	18%	302	449	146	48%
60%	183	184	2	1%	185	187	2	1%	191	194	3	1%	192	204	11	6%	231	267	35	15%	203	201	-2	-1%
70%	181	183	2	1%	182	183	1	1%	188	192	4	2%	190	198	8	4%	226	253	27	12%	194	195	2	1%
80%	179	180	1	0%	179	180	1	1%	184	189	6	3%	188	195	8	4%	220	247	27	12%	184	188	5	2%
90%	178	178	0	0%	178	178	0	0%	180	185	4	2%	185	193	8	4%	217	244	27	13%	182	185	2	1%
Long Term Full Simulation Period[b]	186	187	2	1%	191	193	1	1%	212	215	3	1%	229	243	14	6%	288	312	24	8%	316	381	65	21%
Water Year Types[c]																								
Wet (32%)	181	182	1	1%	180	181	1	0%	185	189	3	2%	187	195	8	4%	226	255	29	13%	185	188	4	2%
Above Normal (16%)	182	185	3	1%	184	186	2	1%	193	197	4	2%	191	203	12	6%	223	253	30	13%	203	202	-1	0%
Below Normal (13%)	188	190	2	1%	189	190	1	1%	200	199	-1	0%	201	215	14	7%	244	288	44	18%	342	475	133	39%
Dry (24%)	187	189	2	1%	191	191	1	0%	203	205	2	1%	246	264	17	7%	330	340	10	3%	406	554	148	36%
Critical (15%)	197	199	2	1%	227	229	2	1%	317	322	5	2%	361	383	22	6%	463	478	16	3%	549	616	67	12%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

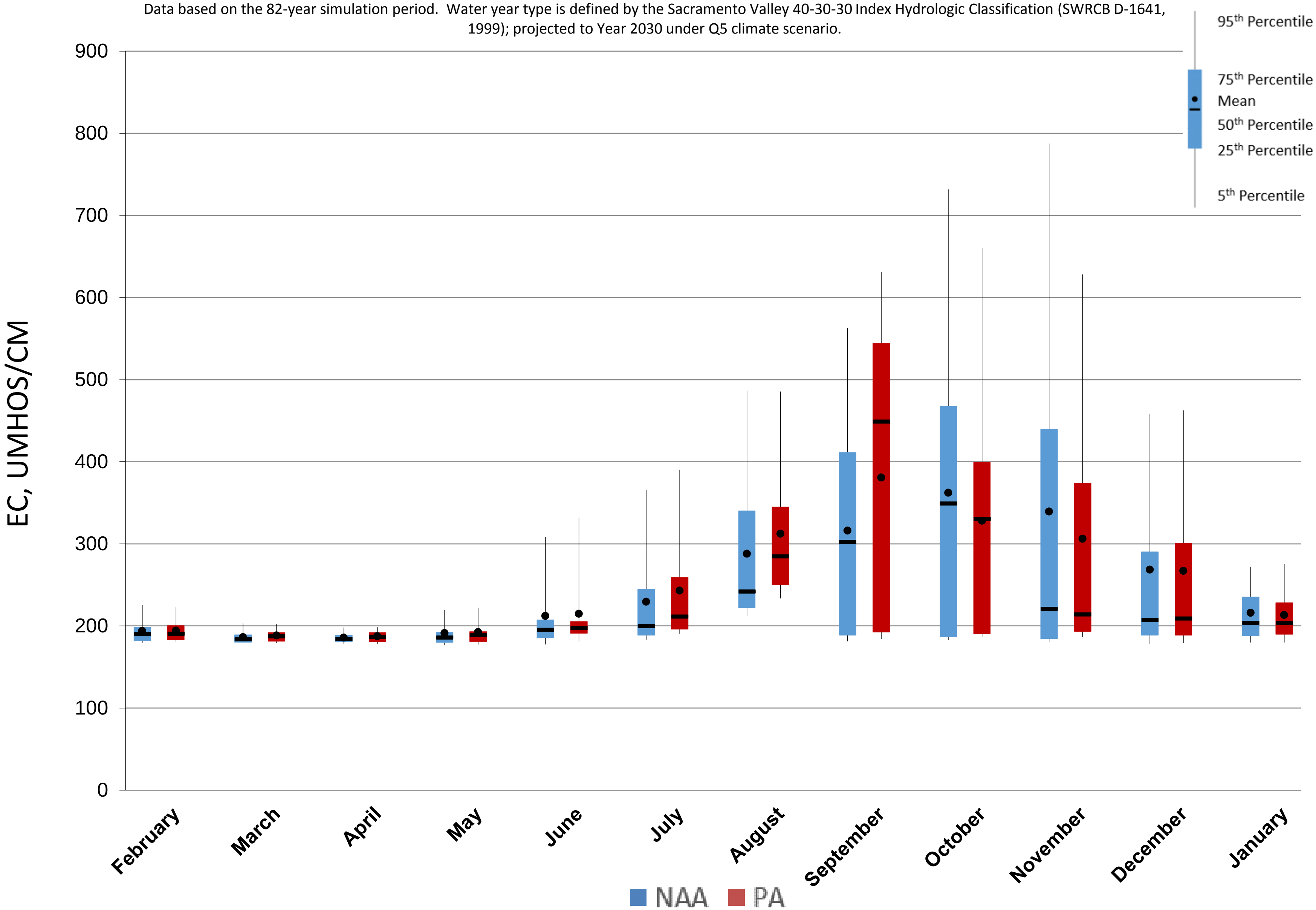
b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-11-1. Monthly EC Ranges For Sacramento River at Rio Vista Salinity, All Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario.



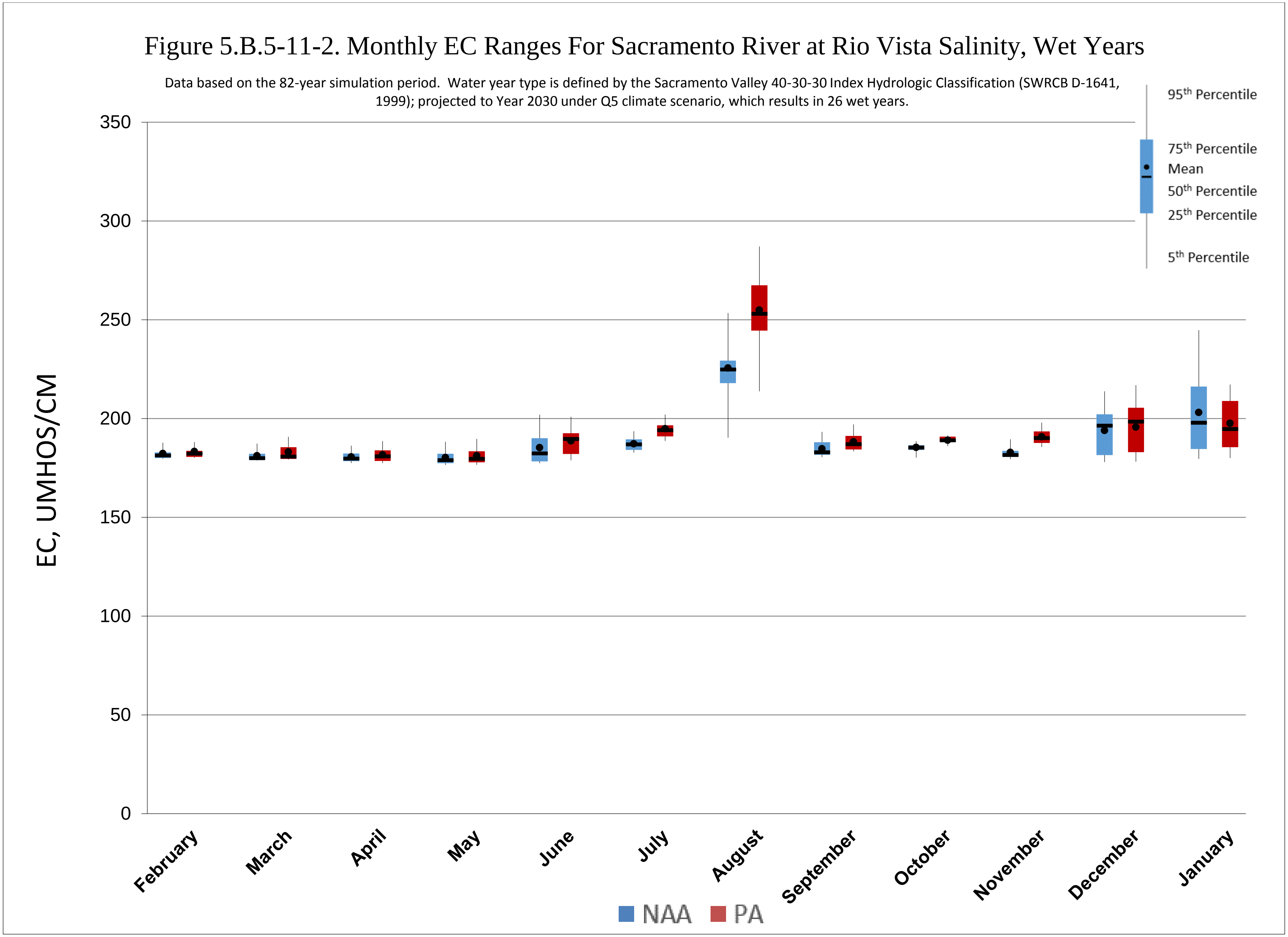


Figure 5.B.5-11-2. Monthly EC Ranges For Sacramento River at Rio Vista Salinity, Wet Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 26 wet years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
EC, UMHOS/CM
350
300
250
200
150
100
50
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-11-3. Monthly EC Ranges For Sacramento River at Rio Vista Salinity, Above Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 13 above normal years.

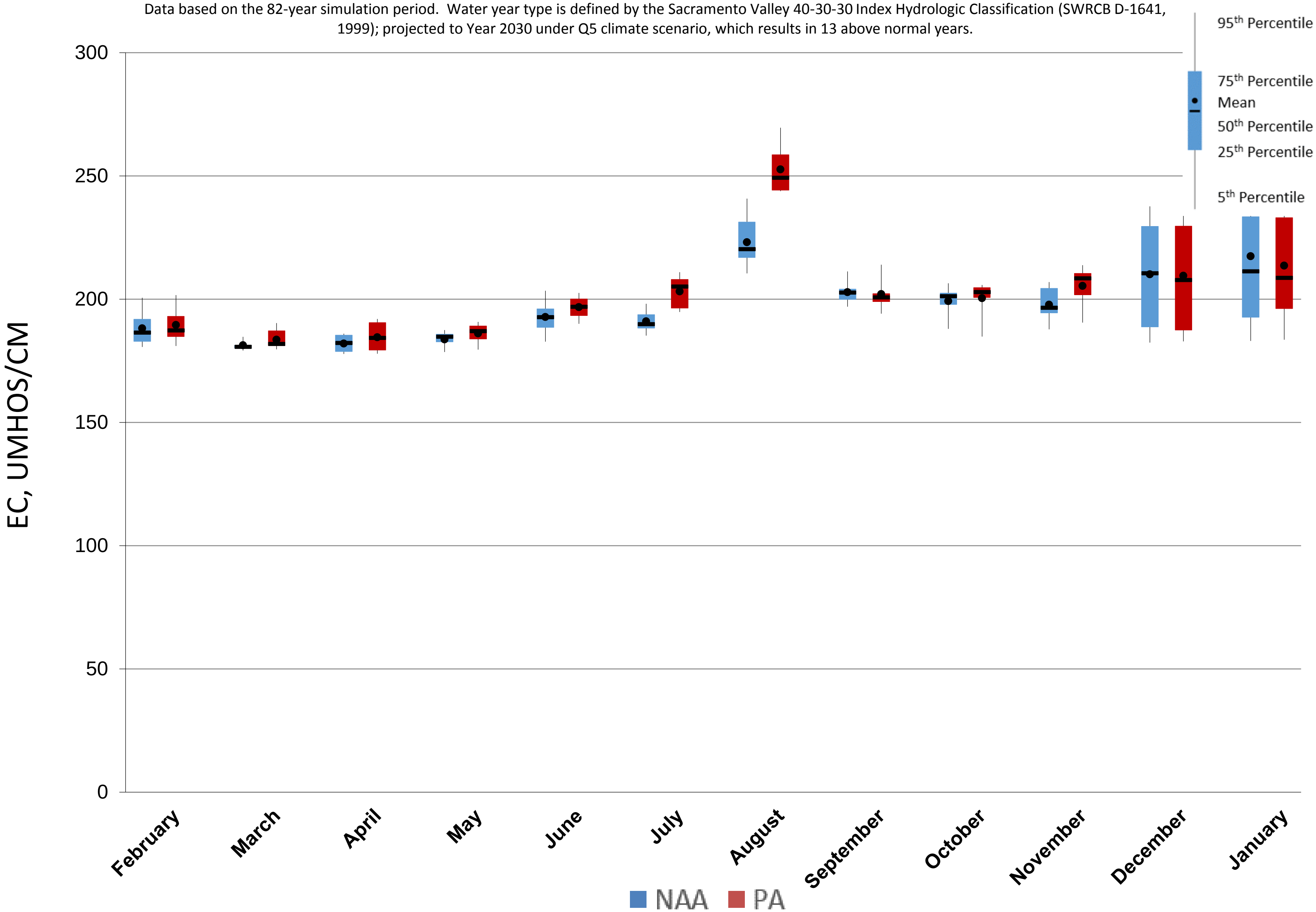
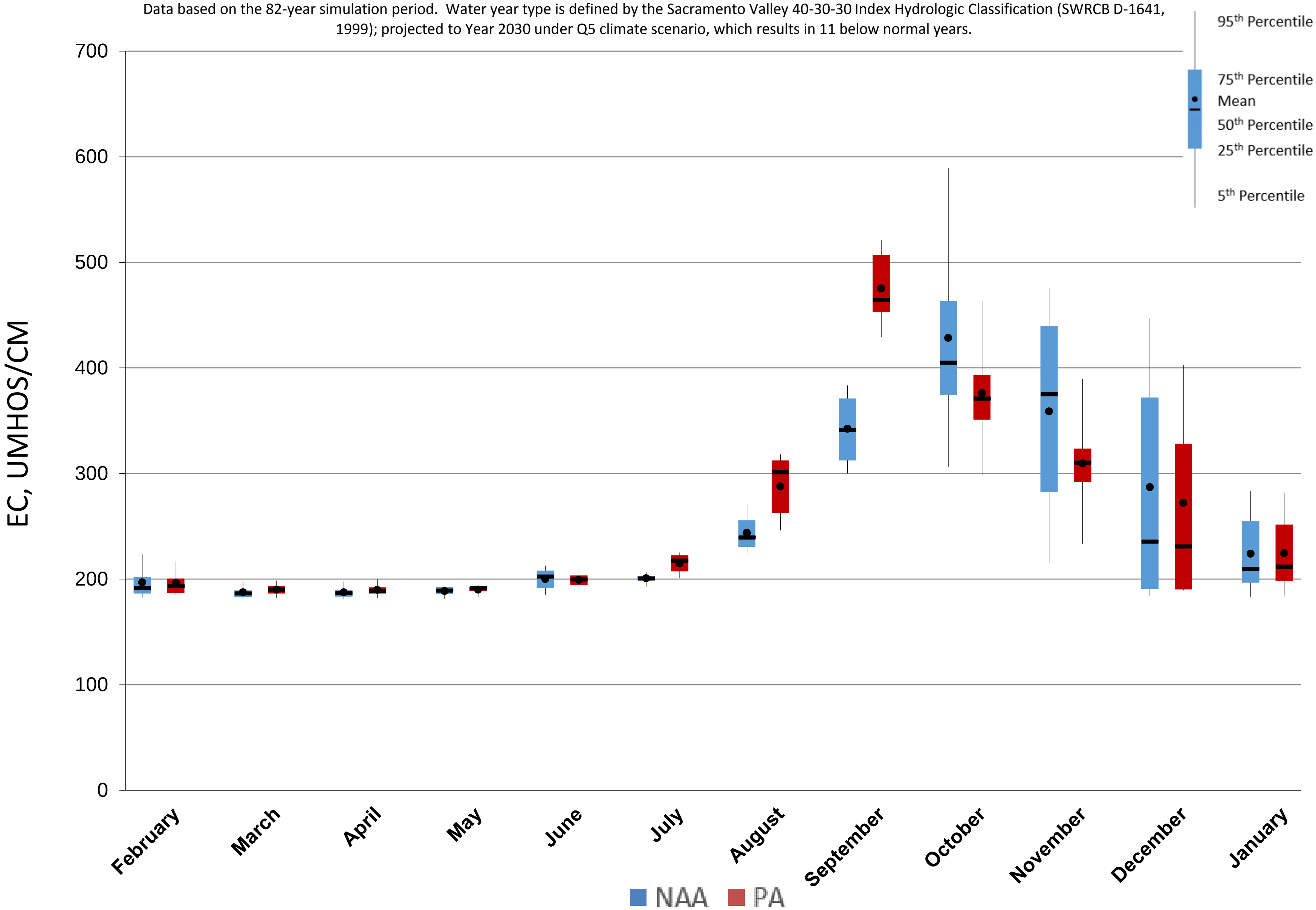


Figure 5.B.5-11-4. Monthly EC Ranges For Sacramento River at Rio Vista Salinity, Below Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 11 below normal years.



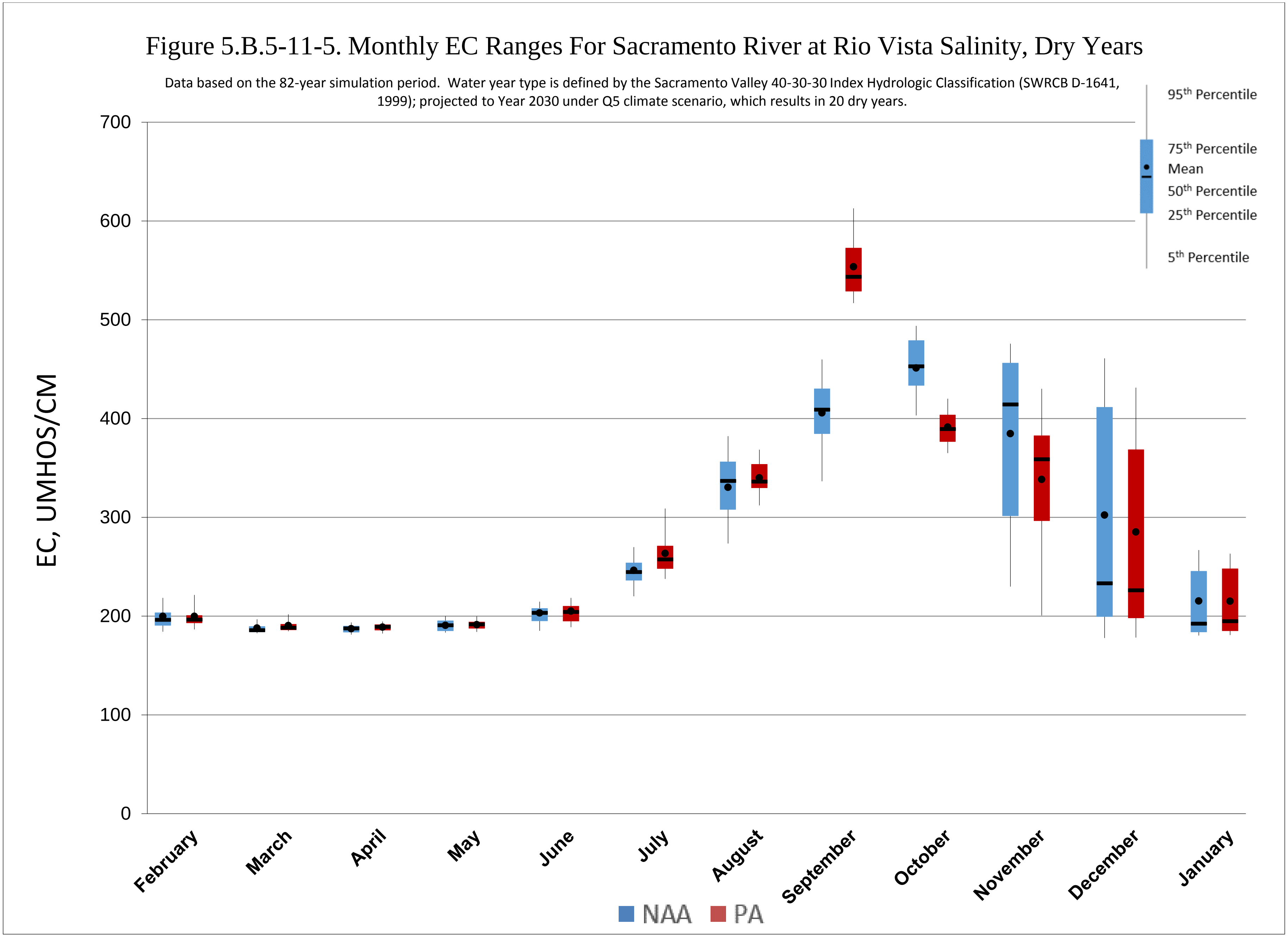


Figure 5.B.5-11-5. Monthly EC Ranges For Sacramento River at Rio Vista Salinity, Dry Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 20 dry years.
EC, UMHOS/CM
700
600
500
400
300
200
100
0
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-11-6. Monthly EC Ranges For Sacramento River at Rio Vista Salinity, Critical Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 12 critical years.

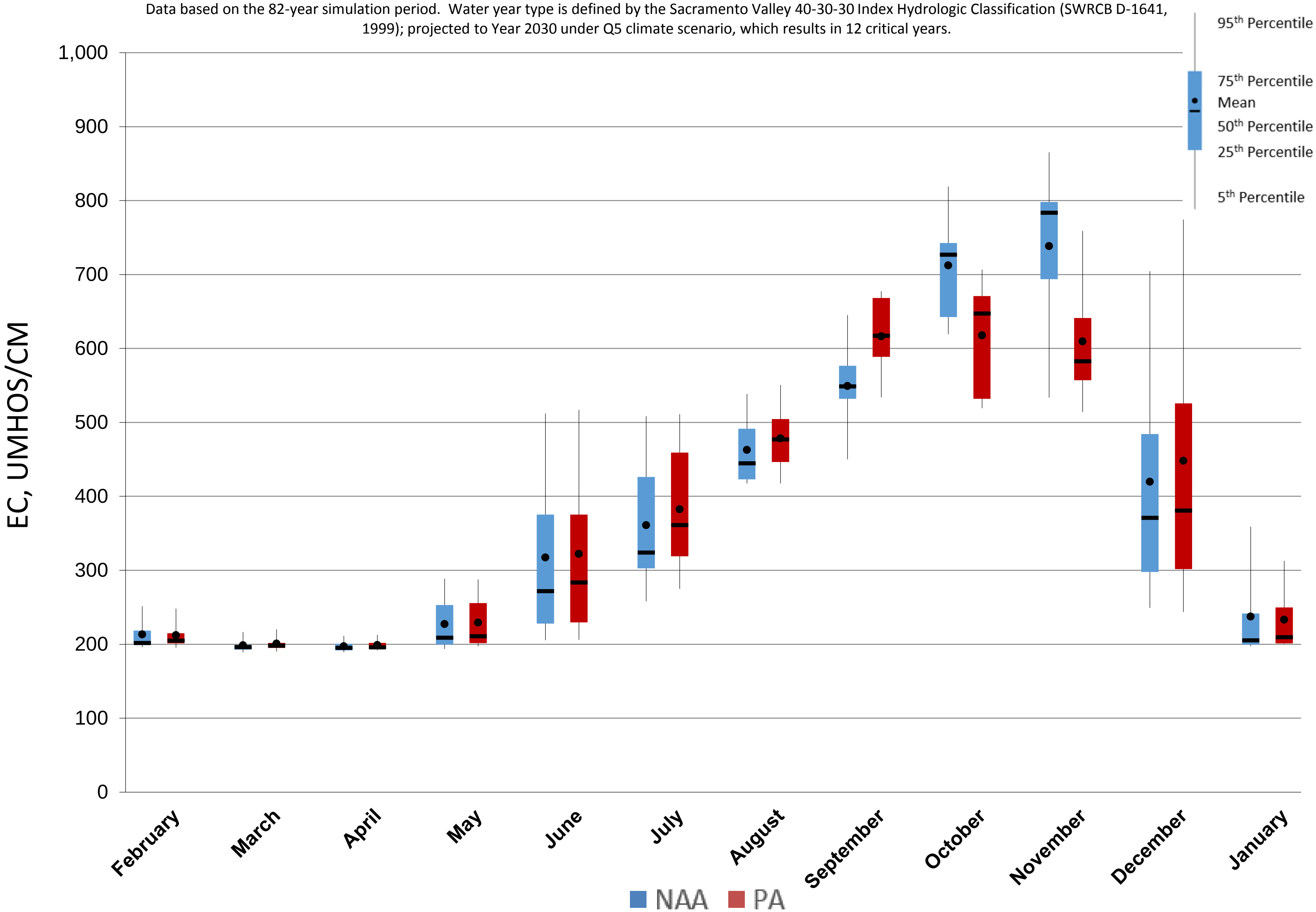
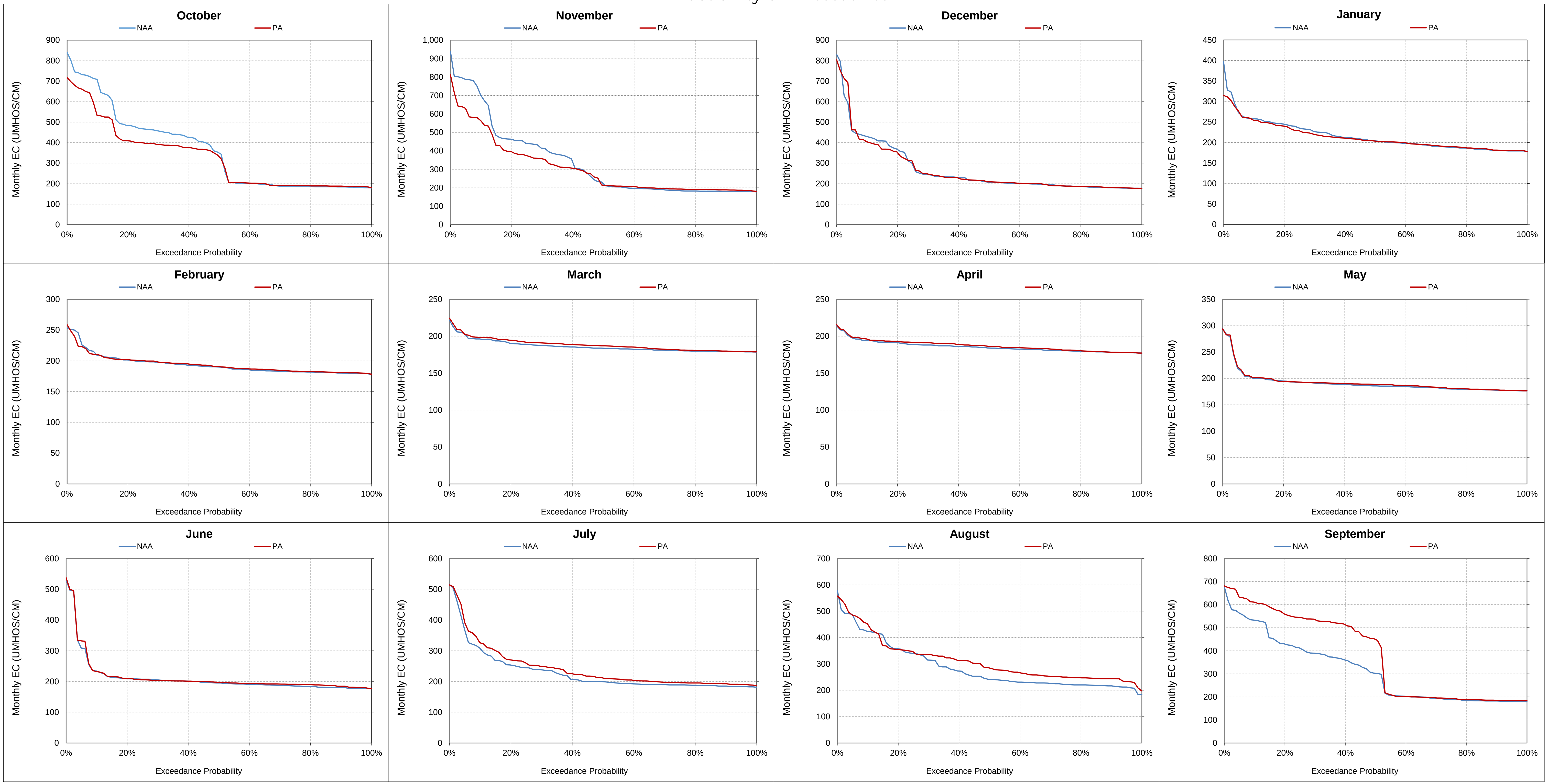
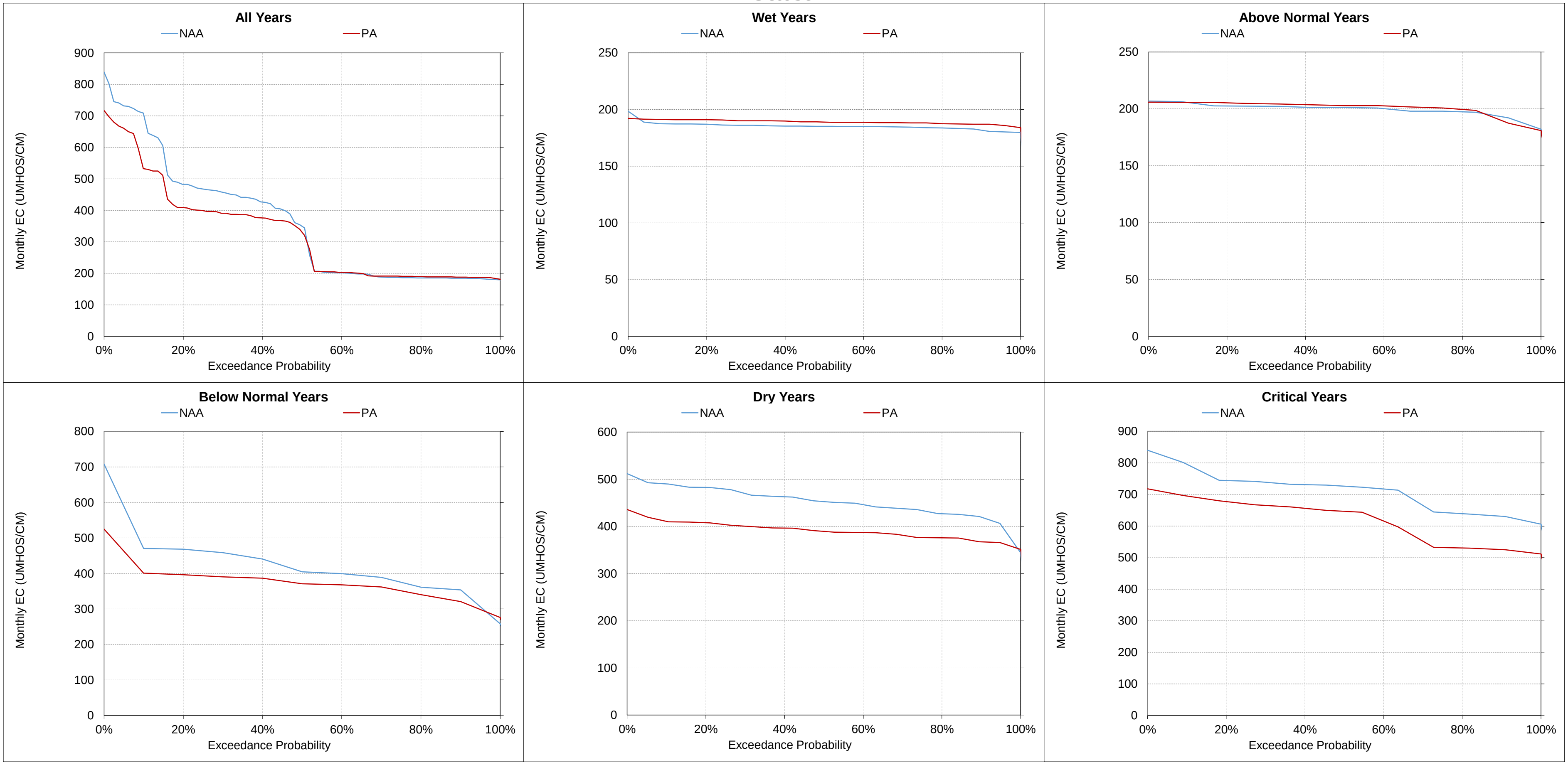


Figure 5.B.5-11-7. Sacramento River at Rio Vista Salinity, Monthly EC Probability of Exceedance



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-11-8. Sacramento River at Rio Vista Salinity, Monthly EC October



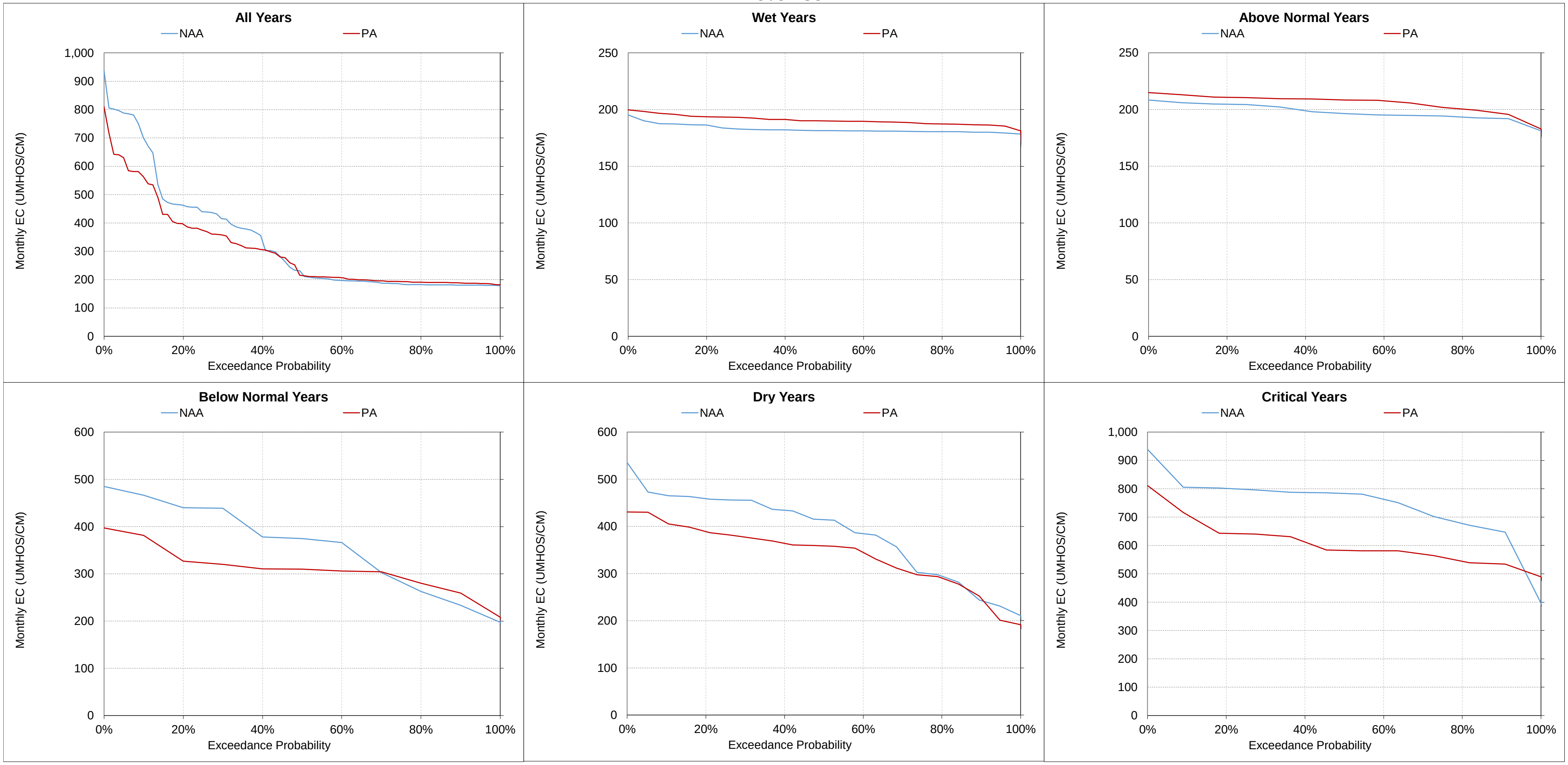
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

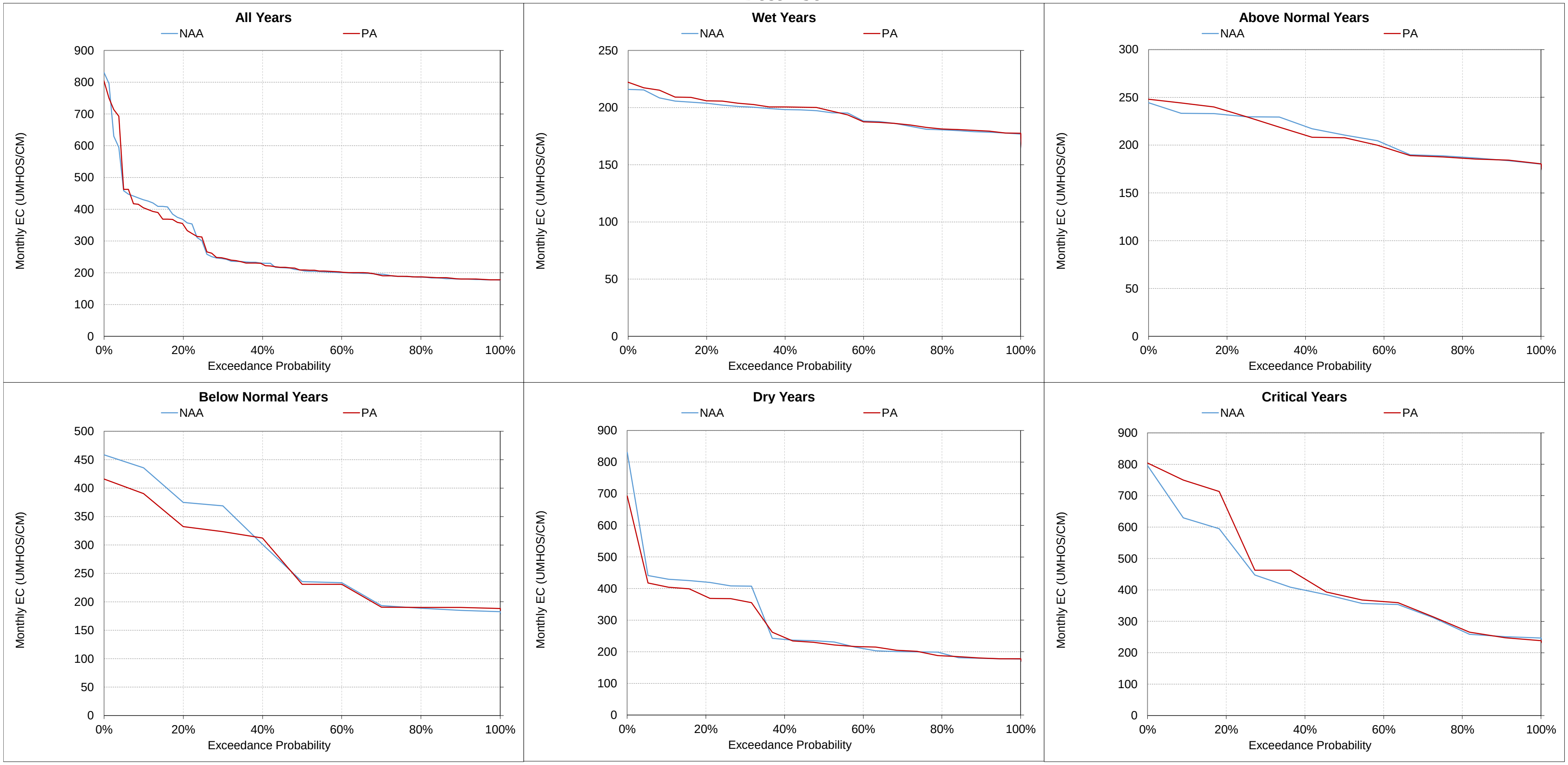
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-11-9. Sacramento River at Rio Vista Salinity, Monthly EC November



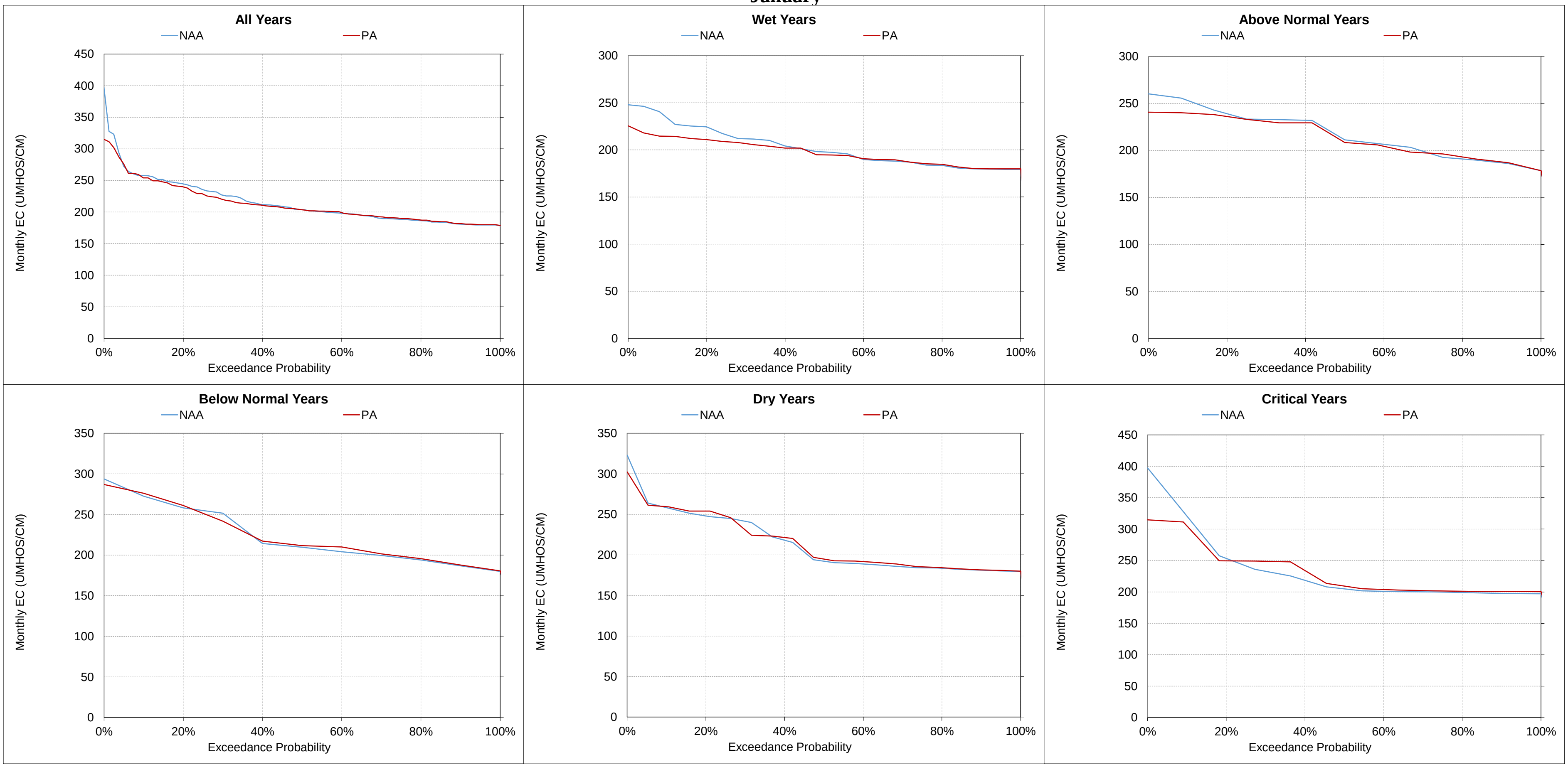
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-11-10. Sacramento River at Rio Vista Salinity, Monthly EC December



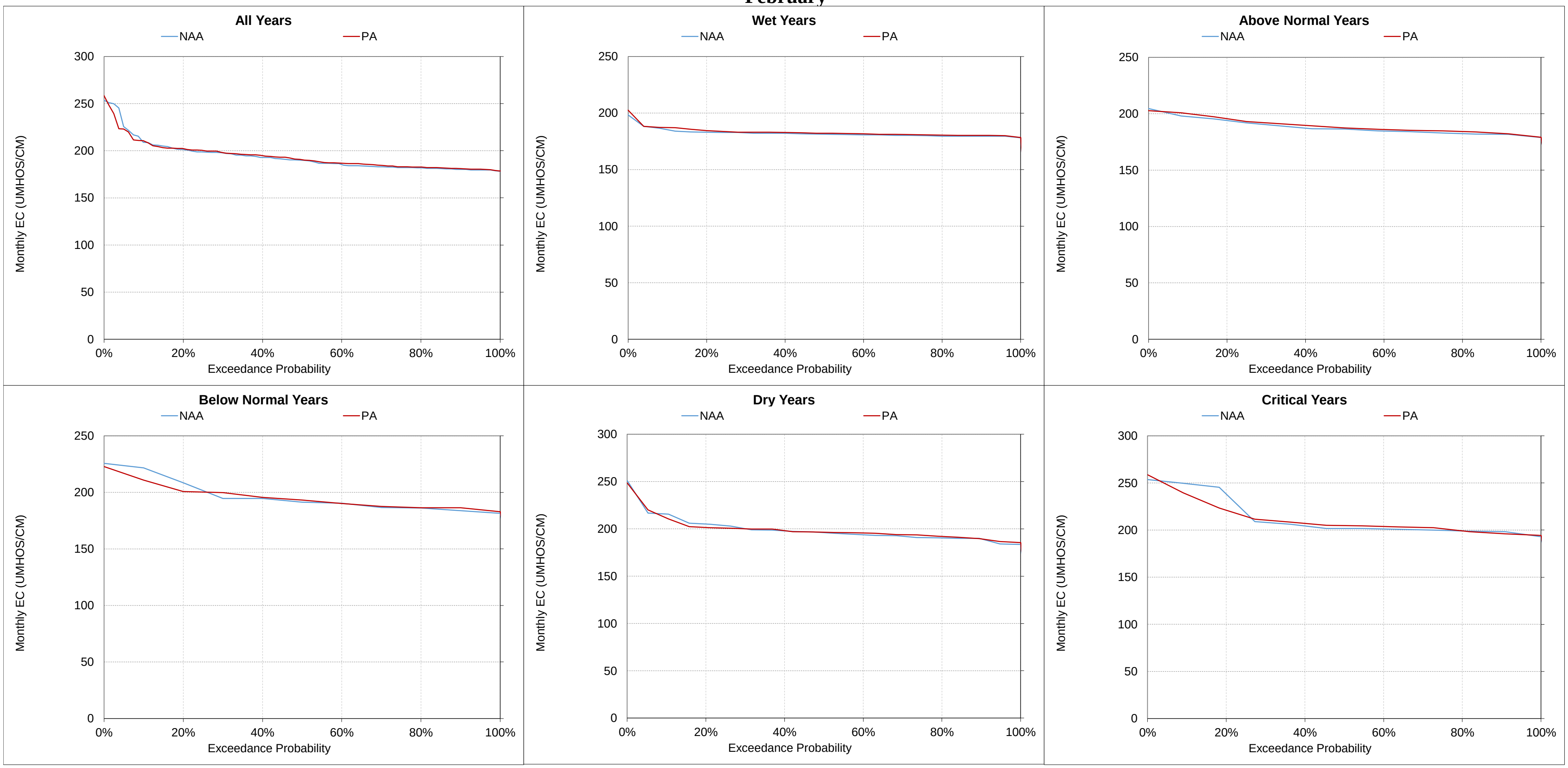
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-11-11. Sacramento River at Rio Vista Salinity, Monthly EC
January



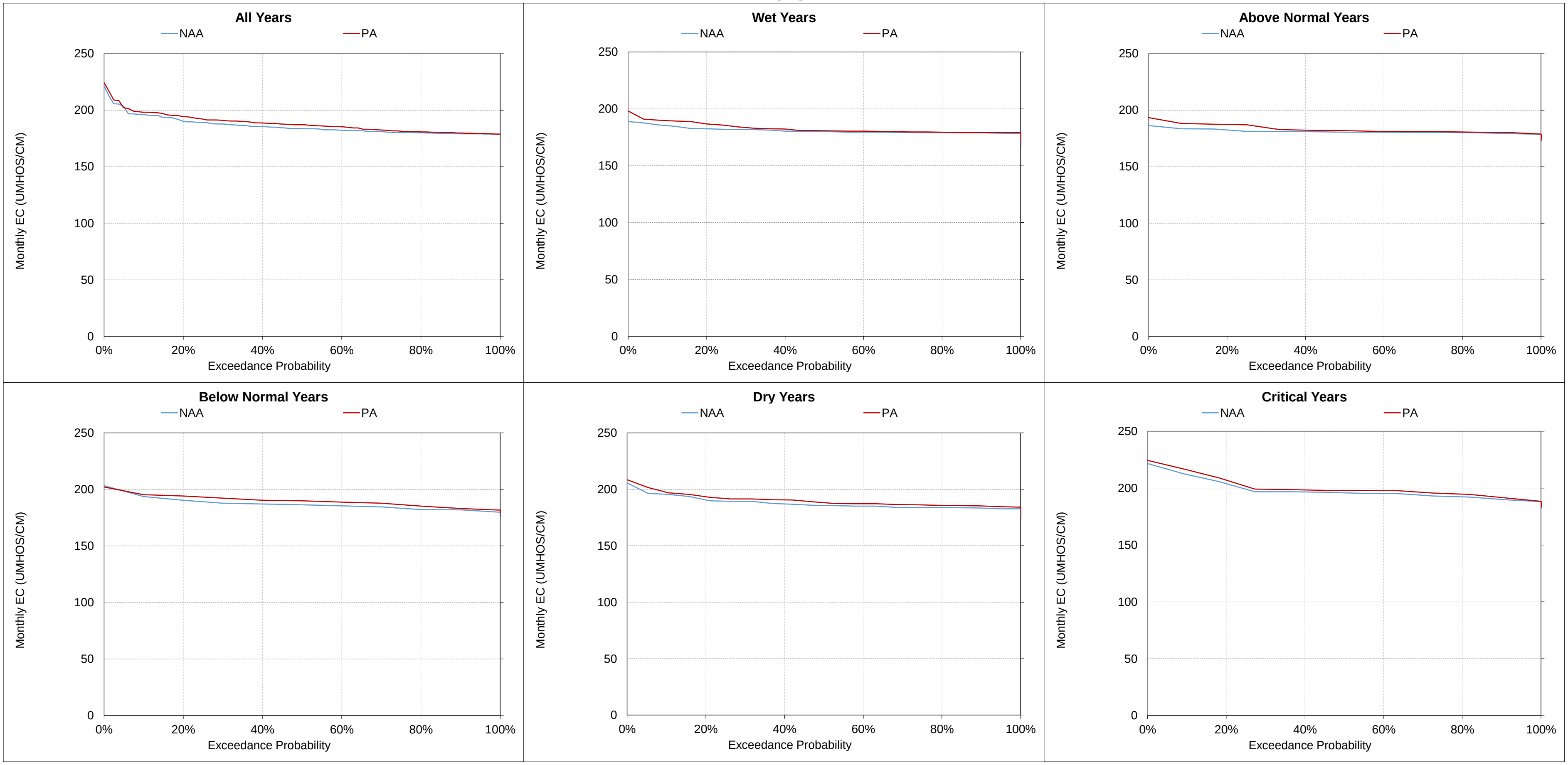
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-11-12. Sacramento River at Rio Vista Salinity, Monthly EC February



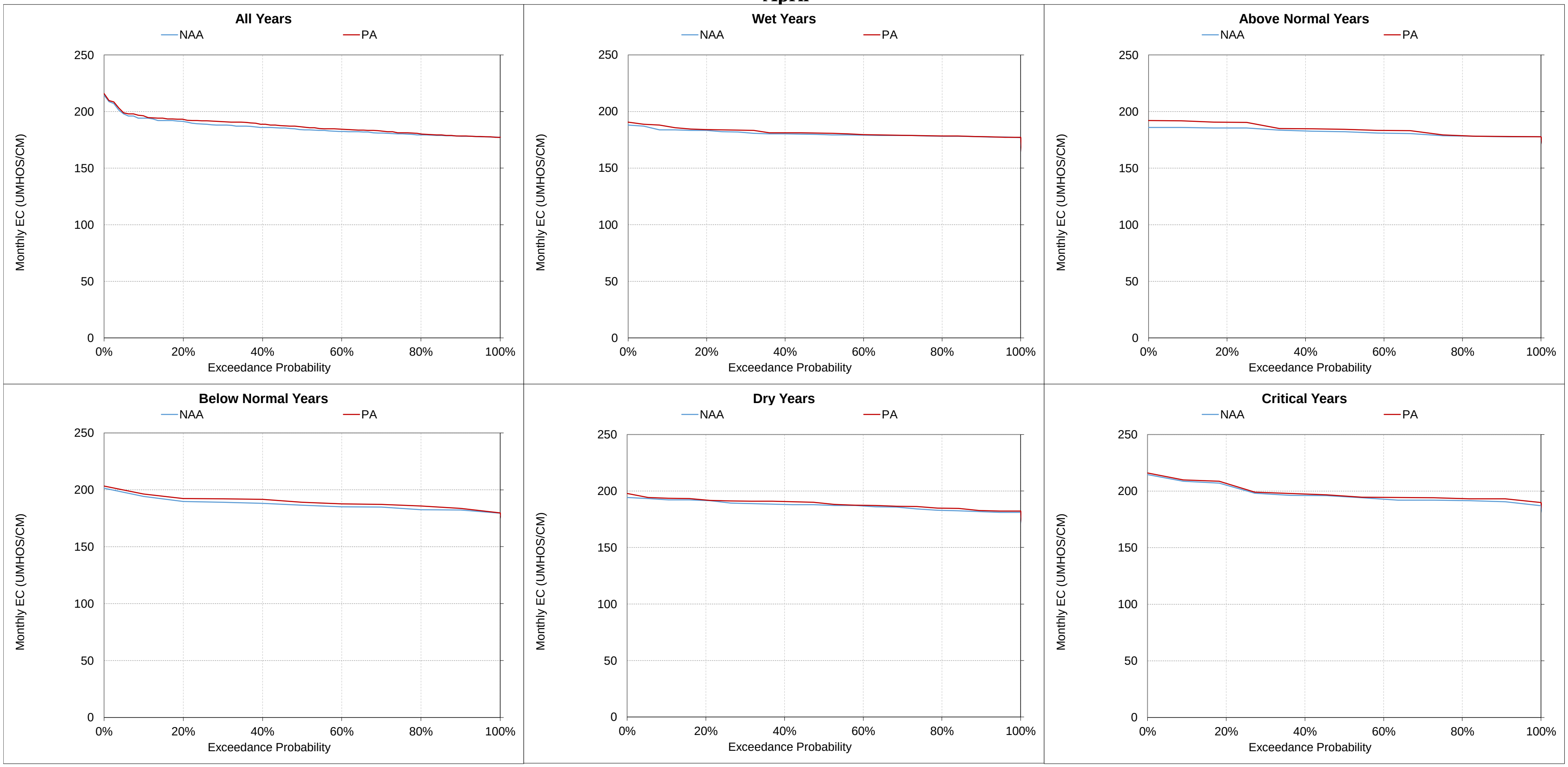
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-11-13. Sacramento River at Rio Vista Salinity, Monthly EC March



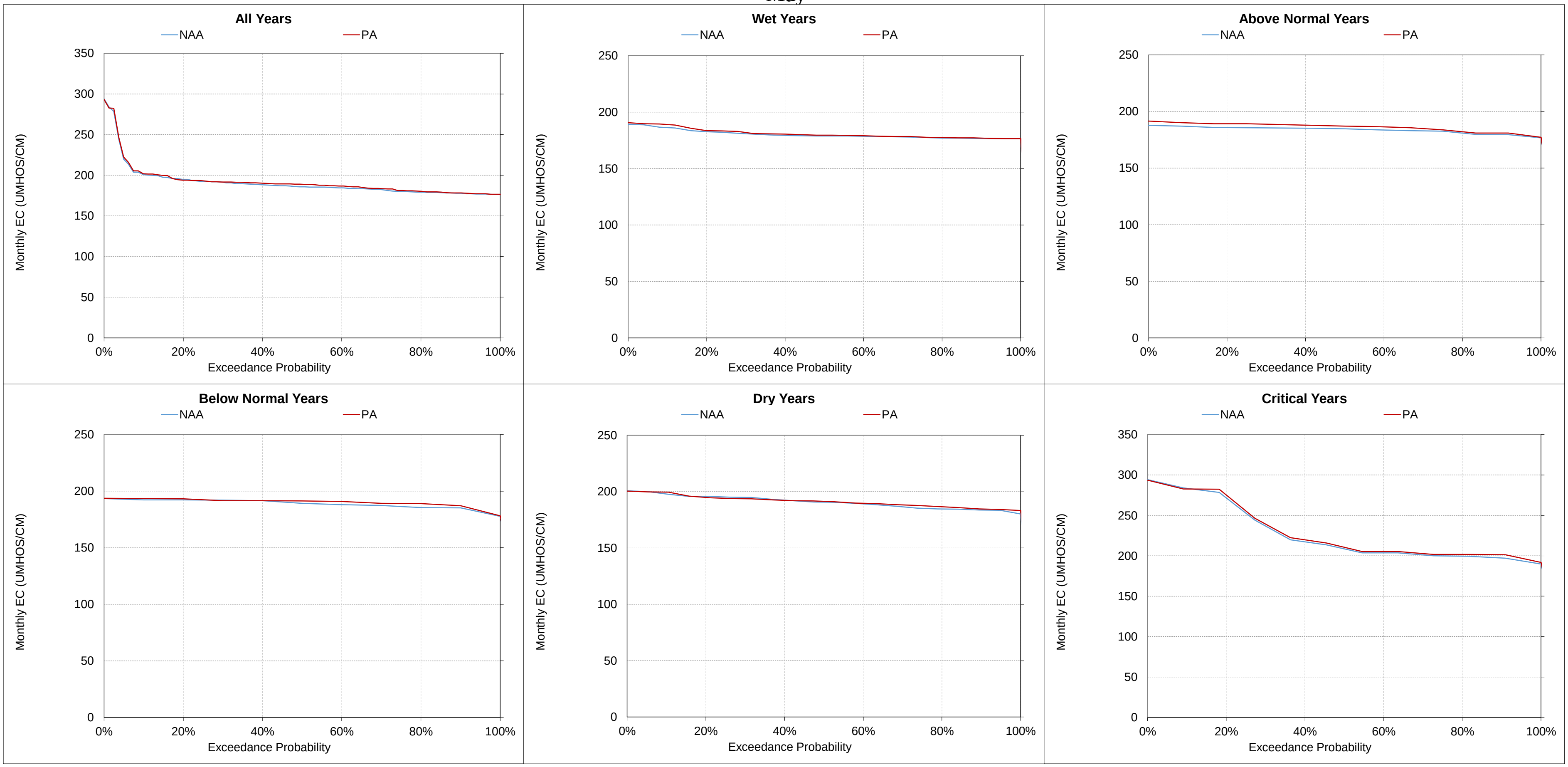
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-11-14. Sacramento River at Rio Vista Salinity, Monthly EC
April



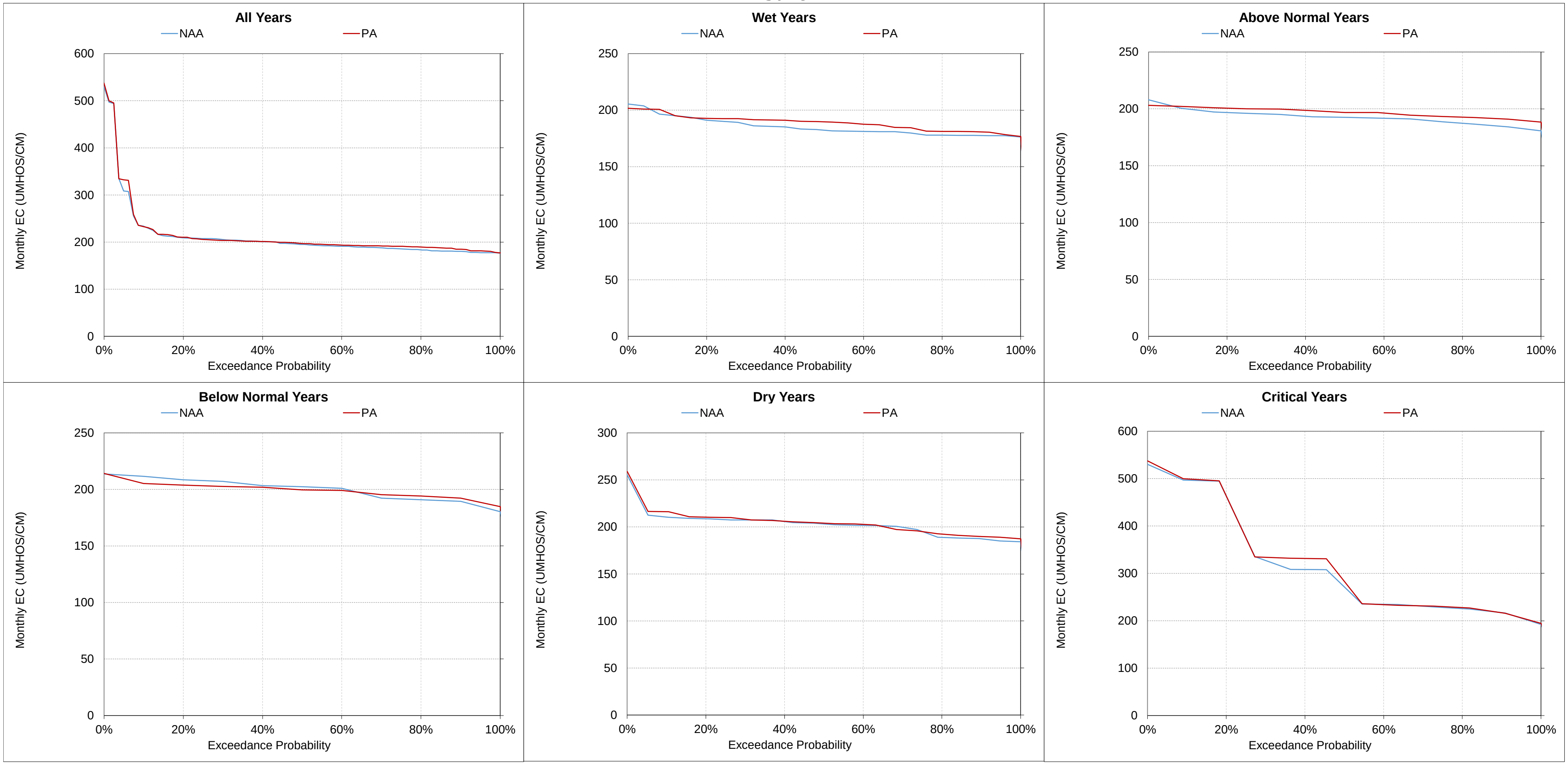
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-11-15. Sacramento River at Rio Vista Salinity, Monthly EC
May



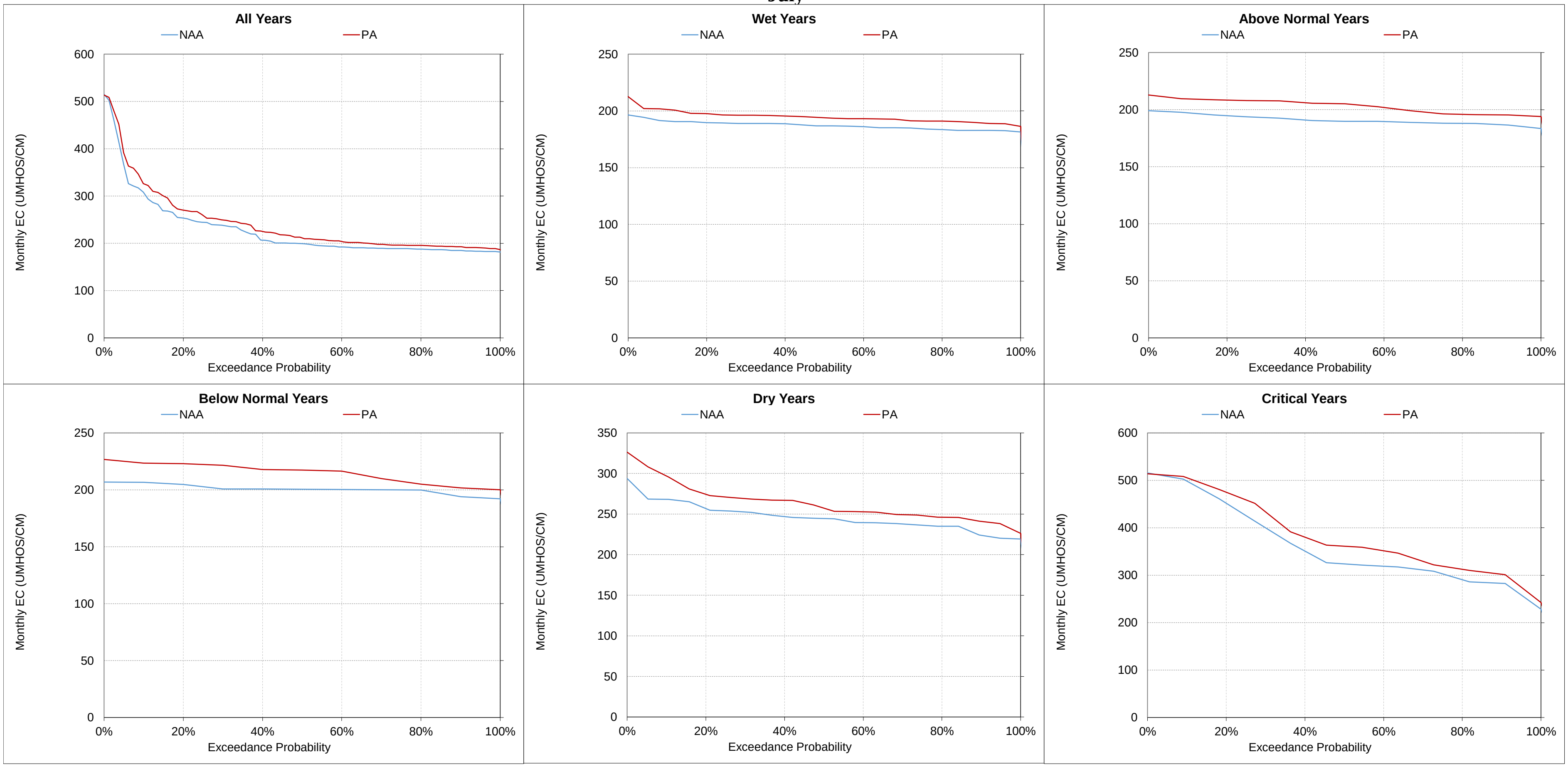
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-11-16. Sacramento River at Rio Vista Salinity, Monthly EC
June



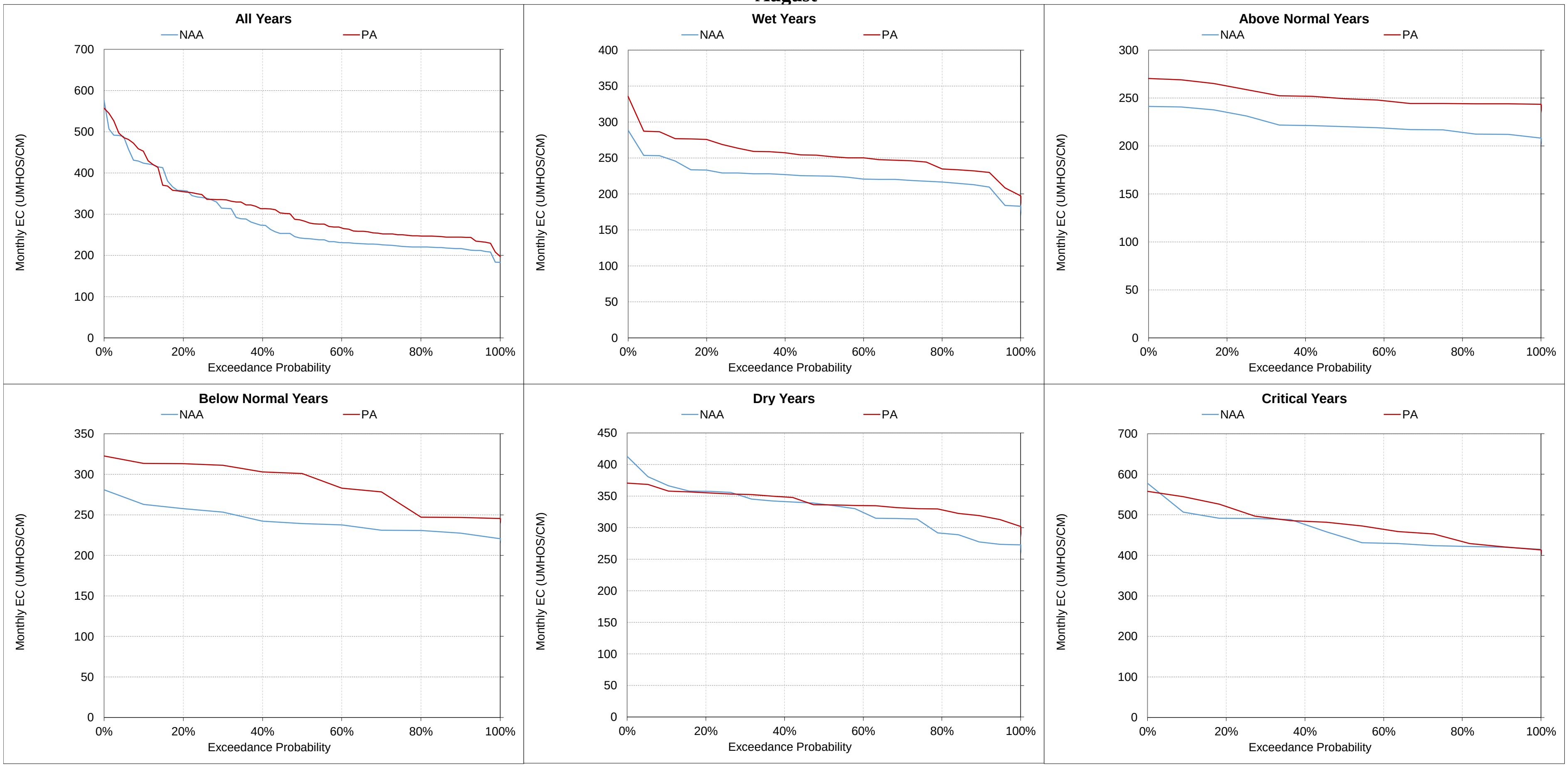
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-11-17. Sacramento River at Rio Vista Salinity, Monthly EC
July



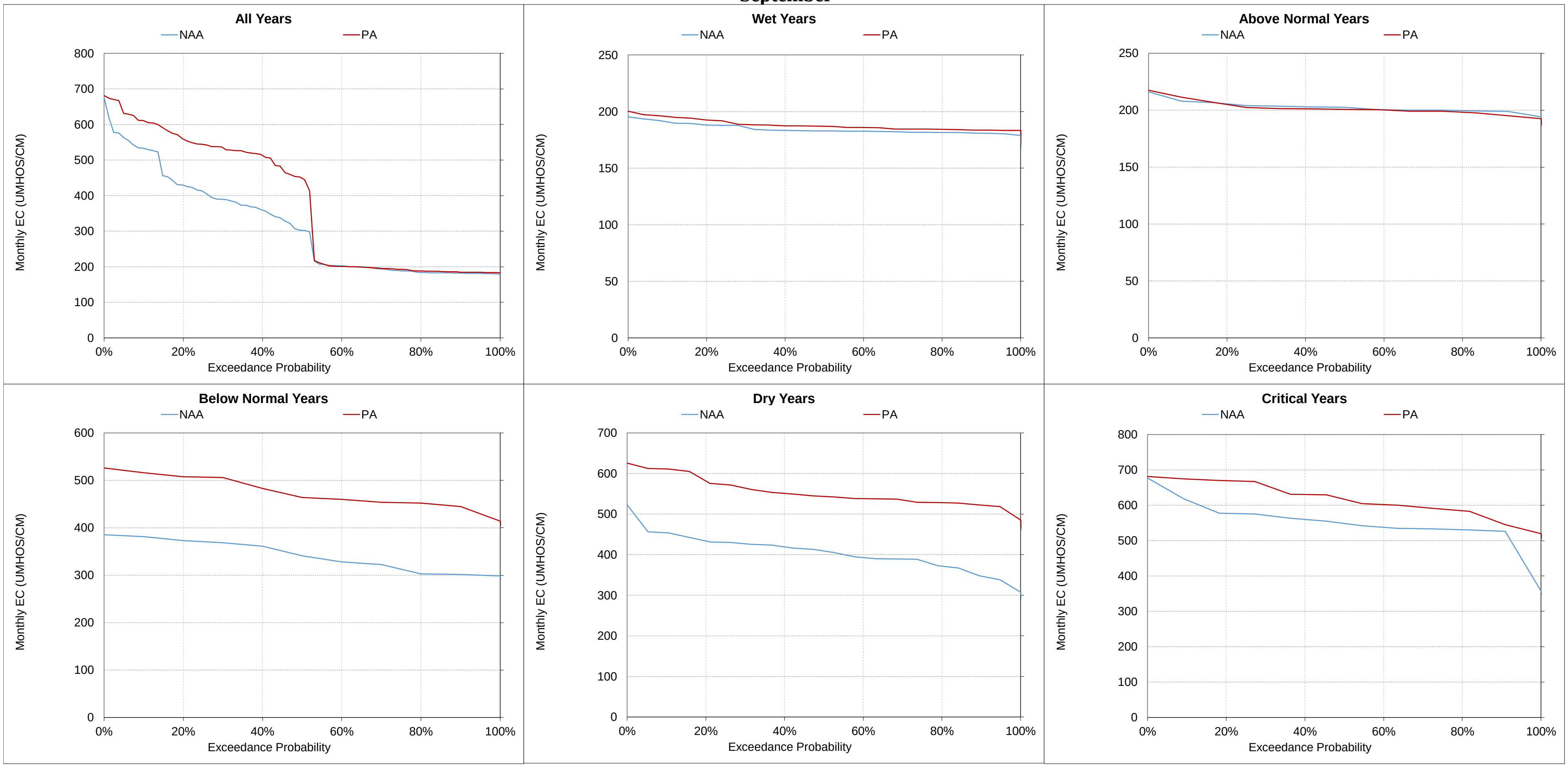
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-11-18. Sacramento River at Rio Vista Salinity, Monthly EC
August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-11-19. Sacramento River at Rio Vista Salinity, Monthly EC September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-12. Sacramento River at Emmaton Salinity, Monthly EC

Monthly EC (UMHOS/CM)

Statistic	October NAA	October PA	October Diff.	October Perc. Diff.	November NAA	November PA	November Diff.	November Perc. Diff.	December NAA	December PA	December Diff.	December Perc. Diff.	January NAA	January PA	January Diff.	January Perc. Diff.	February NAA	February PA	February Diff.	February Perc. Diff.	March NAA	March PA	March Diff.	March Perc. Diff.
Probability of Exceedance[a]																								
10%	4,366	3,611	-756	-17%	4,517	3,674	-843	-19%	2,743	2,532	-211	-8%	1,102	1,096	-6	-1%	428	383	-45	-11%	318	321	3	1%
20%	3,376	2,767	-610	-18%	3,152	2,579	-572	-18%	2,129	2,002	-127	-6%	945	835	-110	-12%	317	315	-2	-1%	247	254	7	3%
30%	3,195	2,661	-535	-17%	2,895	2,305	-591	-20%	929	1,033	104	11%	714	628	-87	-12%	252	254	2	1%	207	227	20	10%
40%	3,091	2,402	-689	-22%	2,136	1,888	-249	-12%	776	815	40	5%	465	408	-56	-12%	229	230	1	0%	200	217	17	8%
50%	2,233	2,179	-54	-2%	826	788	-38	-5%	601	640	39	6%	349	295	-54	-16%	204	213	9	4%	192	209	18	9%
60%	636	657	20	3%	569	600	31	5%	496	521	25	5%	245	257	12	5%	193	204	11	6%	188	199	12	6%
70%	320	323	3	1%	373	430	57	15%	329	334	4	1%	200	203	3	1%	186	191	5	3%	183	192	9	5%
80%	286	303	17	6%	270	307	38	14%	228	245	17	7%	191	194	3	2%	183	188	5	3%	183	188	6	3%
90%	274	286	12	4%	245	276	31	13%	186	188	2	1%	182	187	4	2%	182	184	3	1%	181	184	3	1%
Long Term Full Simulation Period[b]	1,999	1,723	-276	-14%	1,755	1,539	-216	-12%	1,043	1,058	14	1%	550	503	-47	-9%	286	274	-12	-4%	231	243	12	5%
Water Year Types[c]																								
Wet (32%)	285	298	13	4%	272	311	39	14%	393	412	19	5%	425	329	-96	-23%	186	190	3	2%	184	193	9	5%
Above Normal (16%)	612	604	-8	-1%	555	633	78	14%	580	612	32	5%	542	497	-44	-8%	212	209	-3	-2%	185	196	11	6%
Below Normal (13%)	2,782	2,353	-430	-15%	2,246	1,845	-401	-18%	1,338	1,277	-61	-5%	615	610	-5	-1%	313	284	-29	-9%	224	231	7	3%
Dry (24%)	3,177	2,623	-554	-17%	2,461	2,099	-363	-15%	1,329	1,269	-60	-5%	569	569	0	0%	319	298	-21	-7%	242	253	11	4%
Critical (15%)	4,536	3,949	-587	-13%	4,636	3,965	-671	-14%	2,209	2,386	177	8%	738	677	-61	-8%	502	479	-22	-4%	370	393	23	6%

Monthly EC (UMHOS/CM)

Statistic	April NAA	April PA	April Diff.	April Perc. Diff.	May NAA	May PA	May Diff.	May Perc. Diff.	June NAA	June PA	June Diff.	June Perc. Diff.	July NAA	July PA	July Diff.	July Perc. Diff.	August NAA	August PA	August Diff.	August Perc. Diff.	September NAA	September PA	September Diff.	September Perc. Diff.
Probability of Exceedance[a]																								
10%	416	407	-8	-2%	597	586	-11	-2%	990	975	-16	-2%	1,760	1,977	217	12%	2,651	2,942	291	11%	3,623	3,908	285	8%
20%	277	294	17	6%	475	451	-24	-5%	721	705	-17	-2%	1,146	1,471	325	28%	2,099	2,233	134	6%	2,912	3,672	760	26%
30%	240	262	22	9%	379	379	0	0%	675	638	-37	-5%	1,019	1,246	227	22%	1,865	2,062	197	11%	2,664	3,521	857	32%
40%	211	226	16	7%	259	265	6	2%	553	551	-2	0%	664	977	313	47%	1,364	1,912	548	40%	2,310	3,296	986	43%
50%	200	214	14	7%	227	236	9	4%	473	440	-33	-7%	511	805	294	57%	1,069	1,560	491	46%	1,752	2,970	1,218	69%
60%	192	204	13	7%	211	221	10	5%	382	371	-11	-3%	440	657	217	49%	971	1,435	464	48%	562	649	87	15%
70%	188	195	7	4%	196	202	6	3%	309	321	12	4%	397	574	177	44%	872	1,289	417	48%	450	515	65	15%
80%	184	192	7	4%	188	193	5	3%	243	264	21	8%	362	477	115	32%	784	1,241	458	58%	359	386	27	8%
90%	181	183	2	1%	180	181	1	1%	190	201	11	6%	302	424	121	40%	744	1,174	430	58%	320	337	17	5%
Long Term Full Simulation Period[b]	252	260	8	3%	353	354	1	0%	607	607	0	0%	834	1,028	194	23%	1,447	1,804	357	25%	1,682	2,112	430	26%
Water Year Types[c]																								
Wet (32%)	187	193	5	3%	194	197	3	2%	283	281	-1	0%	345	445	100	29%	880	1,280	400	45%	349	383	33	9%
Above Normal (16%)	192	206	14	7%	212	221	9	4%	400	410	10	3%	423	655	232	55%	830	1,286	456	55%	580	669	89	15%
Below Normal (13%)	251	261	10	4%	311	312	1	0%	561	529	-32	-6%	554	851	297	54%	1,067	1,615	548	51%	2,090	3,132	1,042	50%
Dry (24%)	254	263	9	3%	371	358	-13	-3%	605	601	-4	-1%	1,121	1,374	253	23%	1,896	2,129	234	12%	2,743	3,616	873	32%
Critical (15%)	455	457	2	0%	858	868	10	1%	1,581	1,605	25	2%	2,118	2,280	163	8%	2,944	3,131	187	6%	3,617	3,980	363	10%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-12-1. Monthly EC Ranges For Sacramento River at Emmaton Salinity, All Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario.

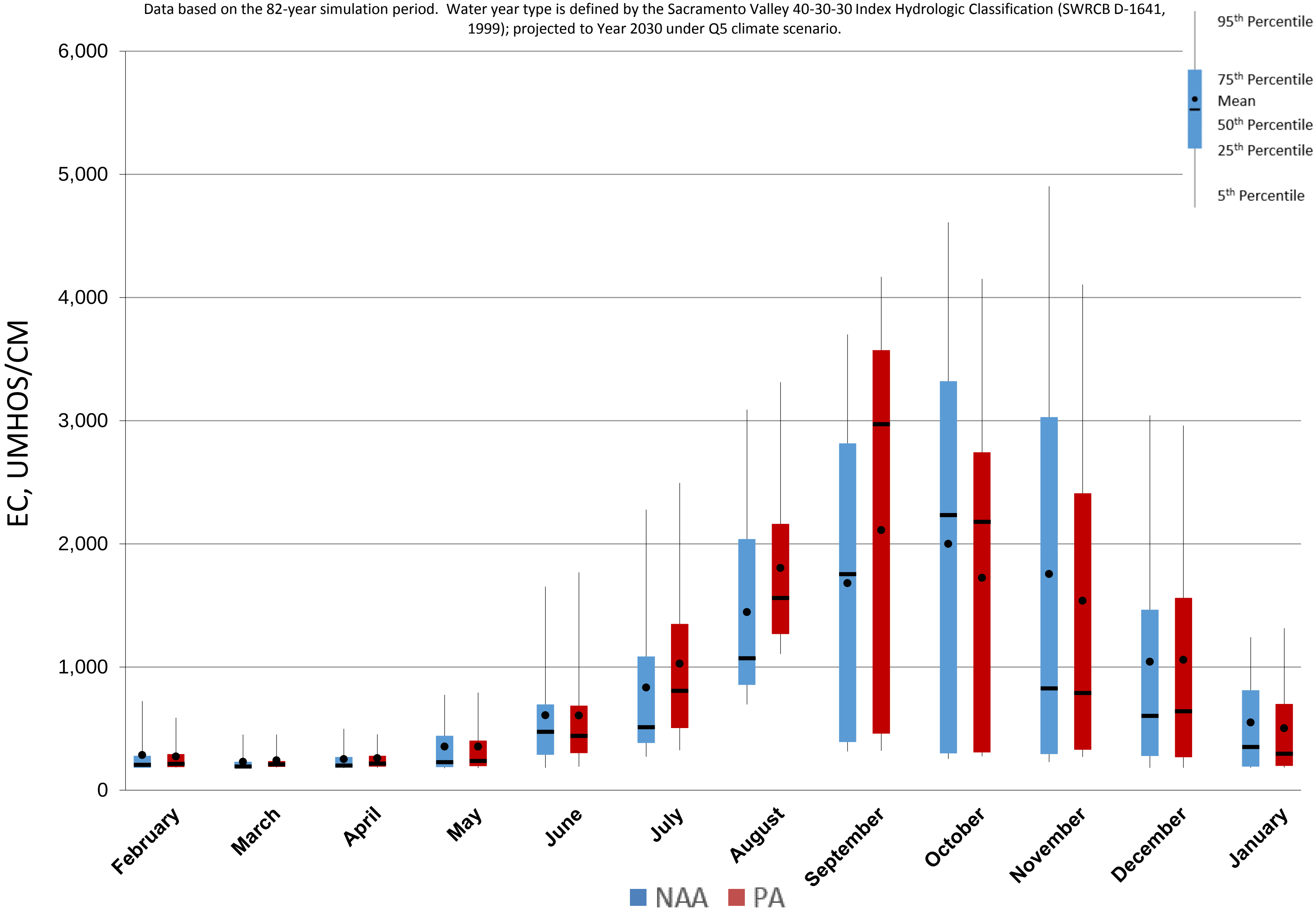


Figure 5.B.5-12-2. Monthly EC Ranges For Sacramento River at Emmaton Salinity, Wet Years

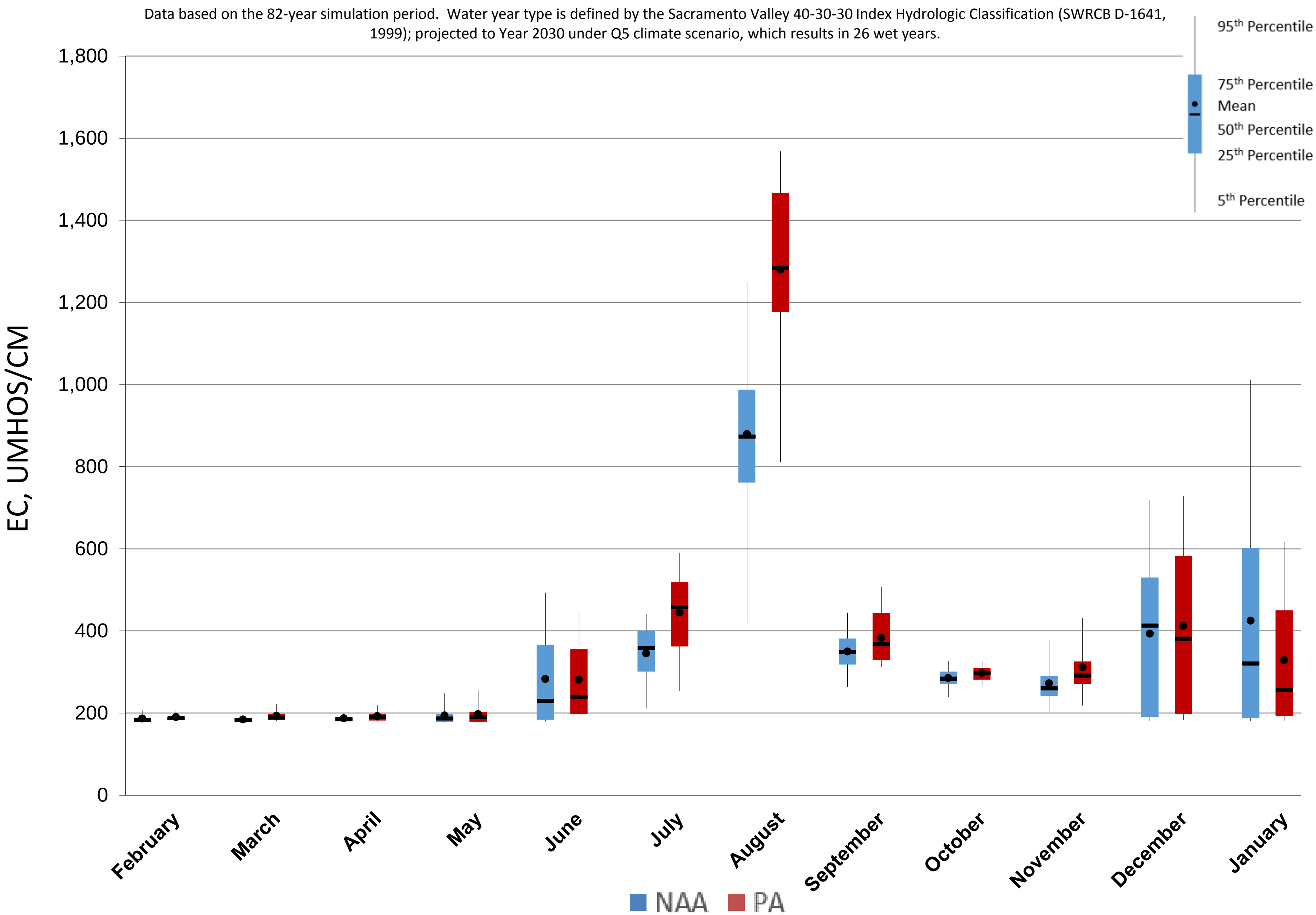
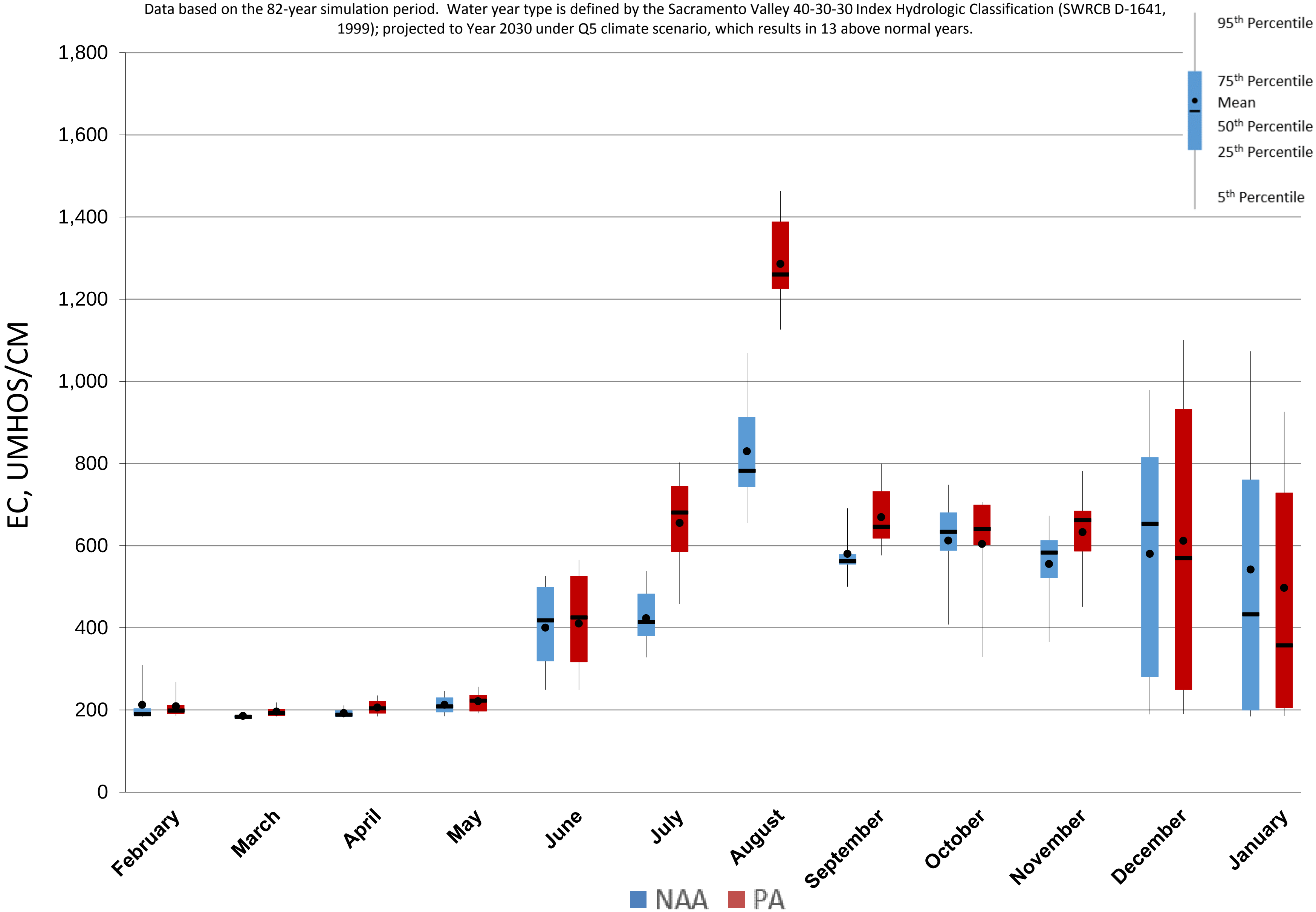


Figure 5.B.5-12-3. Monthly EC Ranges For Sacramento River at Emmaton Salinity, Above Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 13 above normal years.



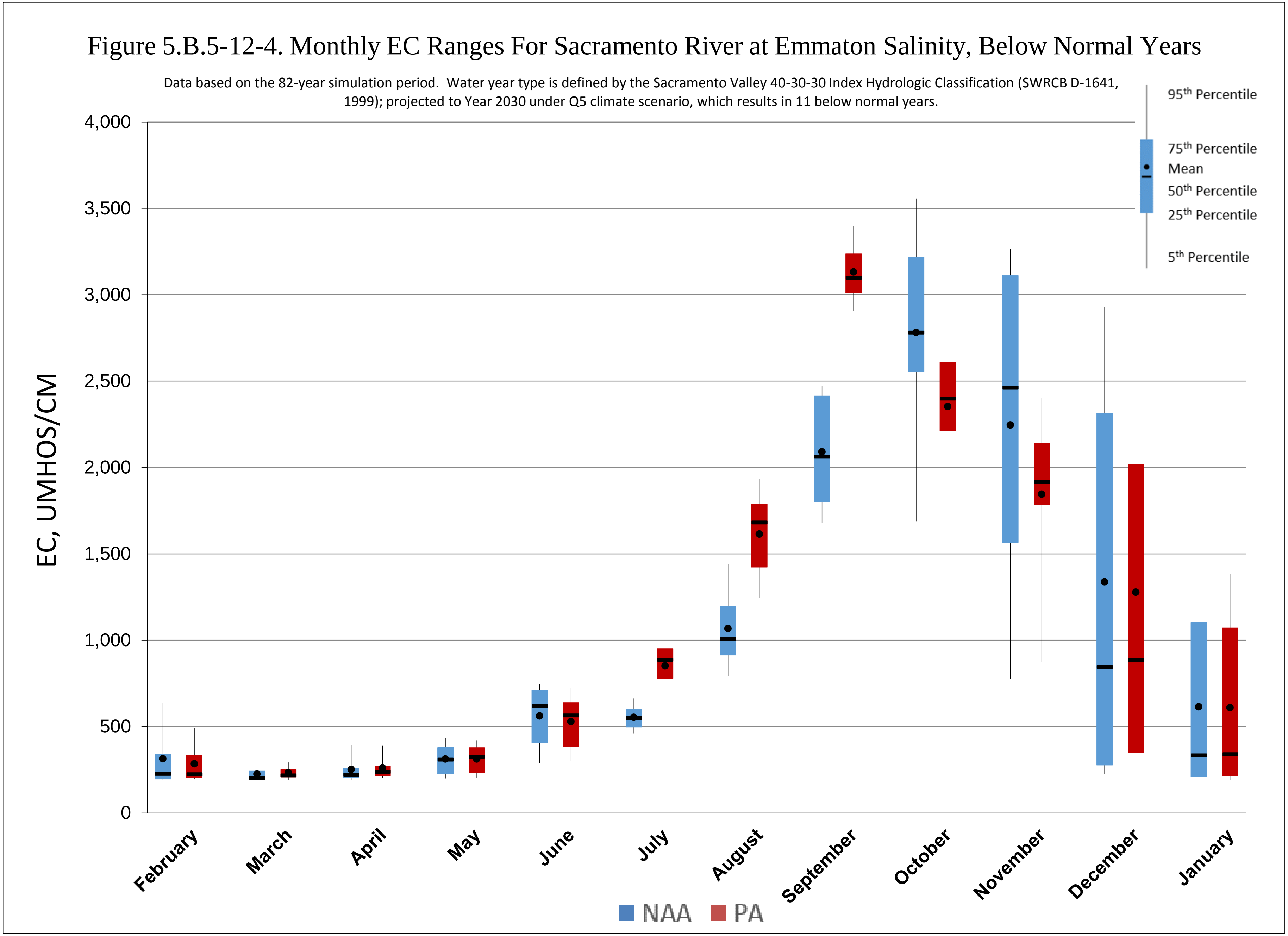


Figure 5.B.5-12-4. Monthly EC Ranges For Sacramento River at Emmaton Salinity, Below Normal Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 11 below normal years.
EC, UMHOS/CM
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
February
March
April
May
June
July
August
September
October
November
December
January
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
NAA
PA

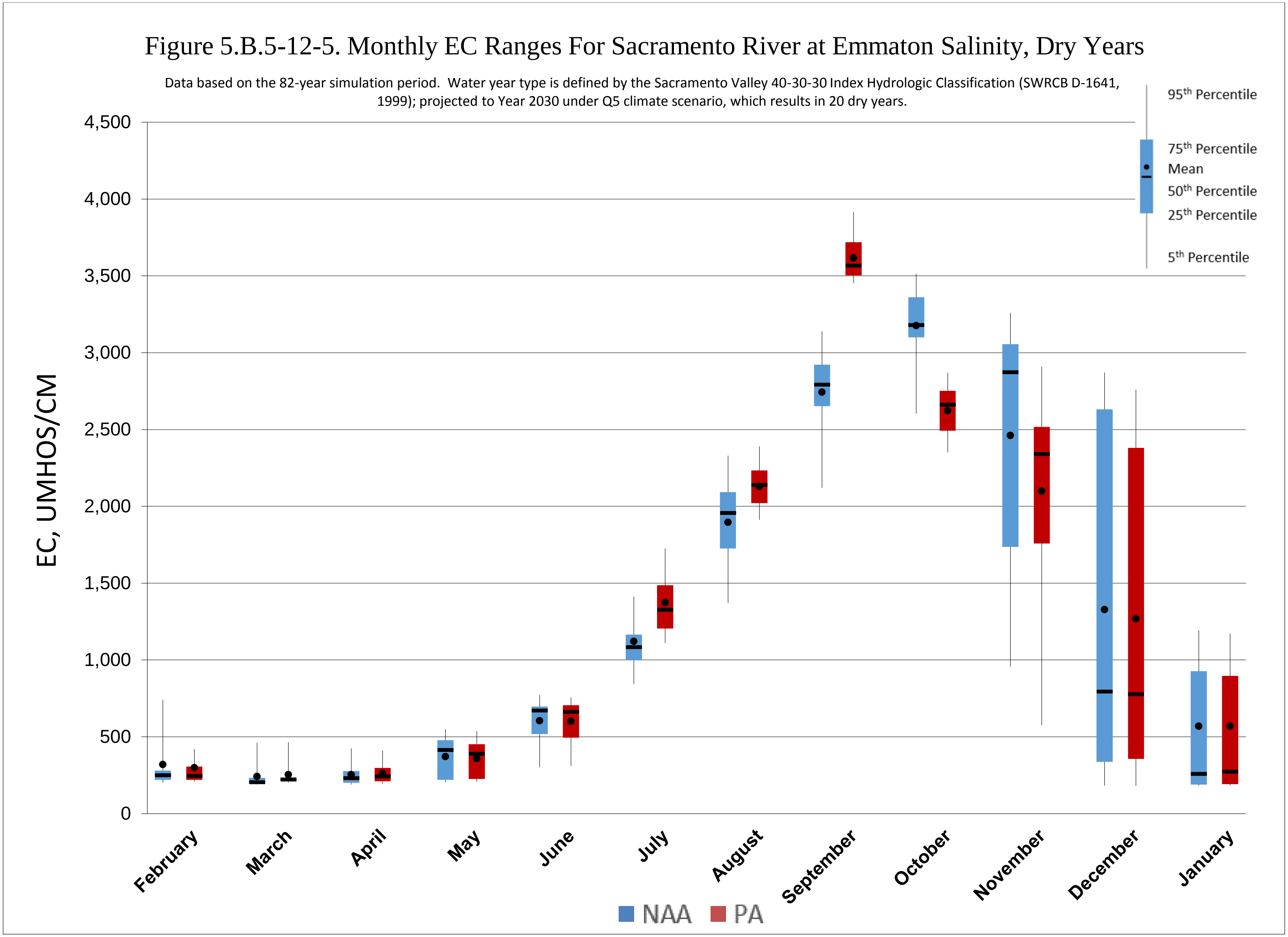


Figure 5.B.5-12-5. Monthly EC Ranges For Sacramento River at Emmaton Salinity, Dry Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 20 dry years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
EC, UMHOS/CM
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

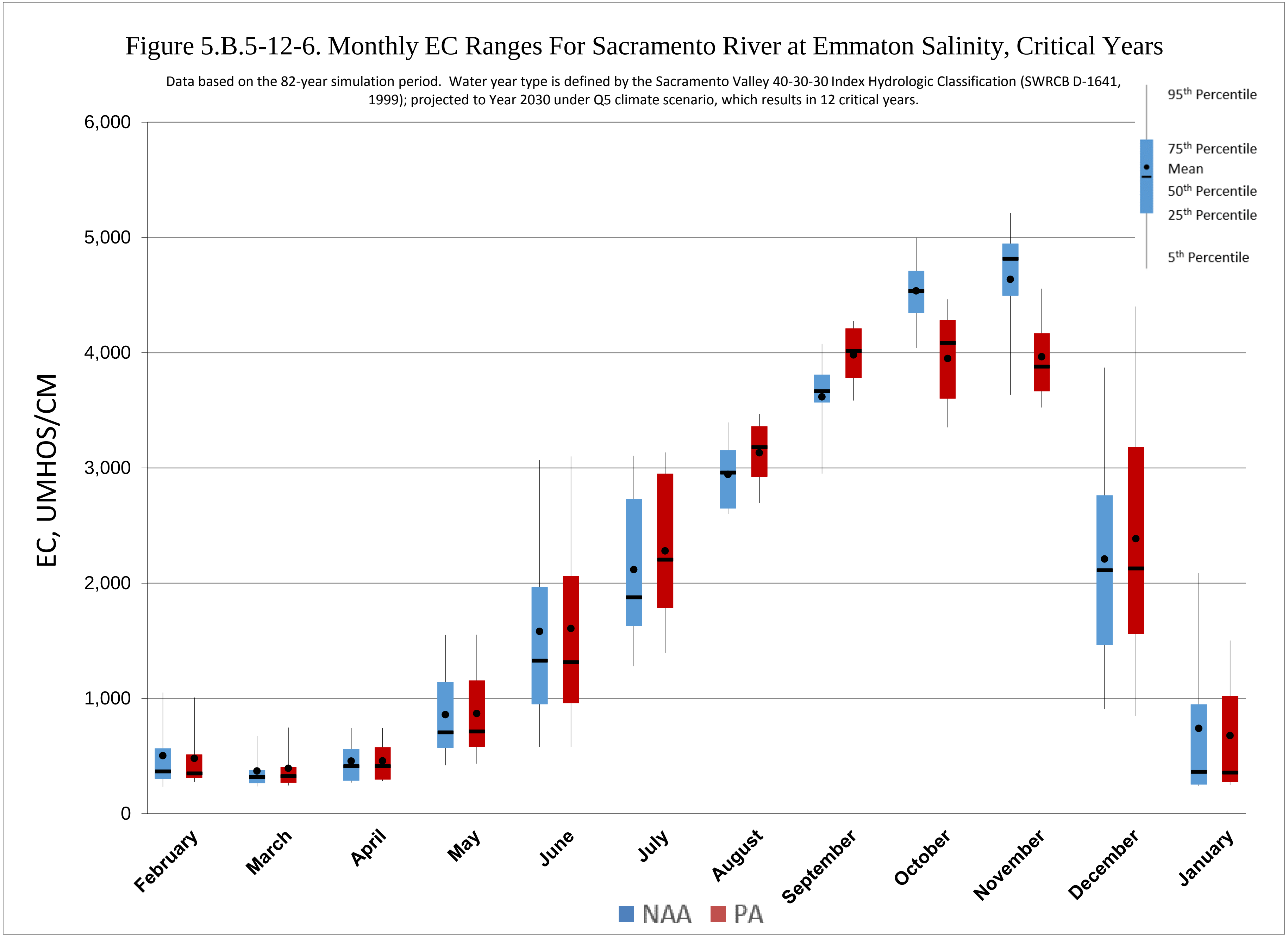
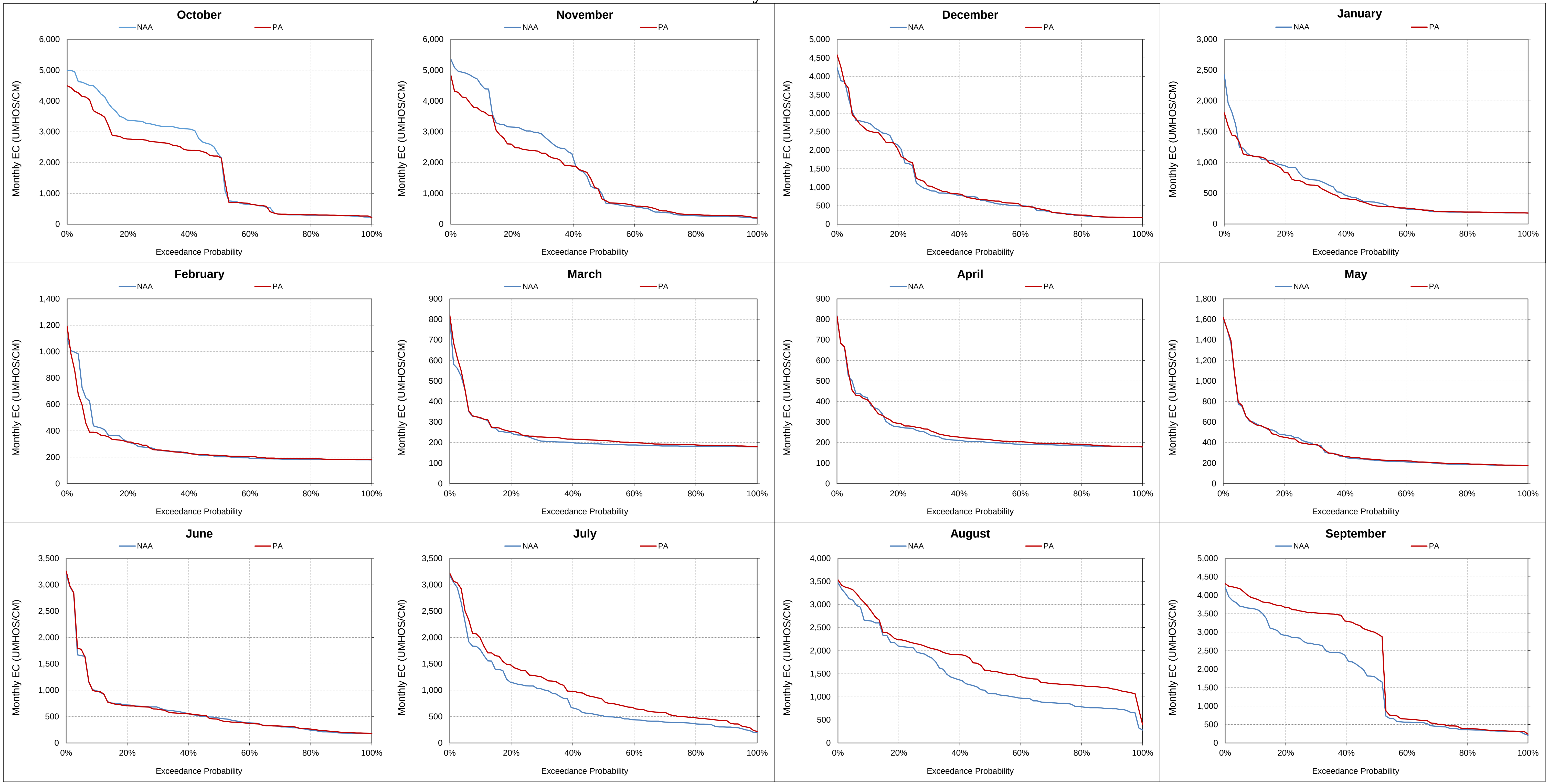


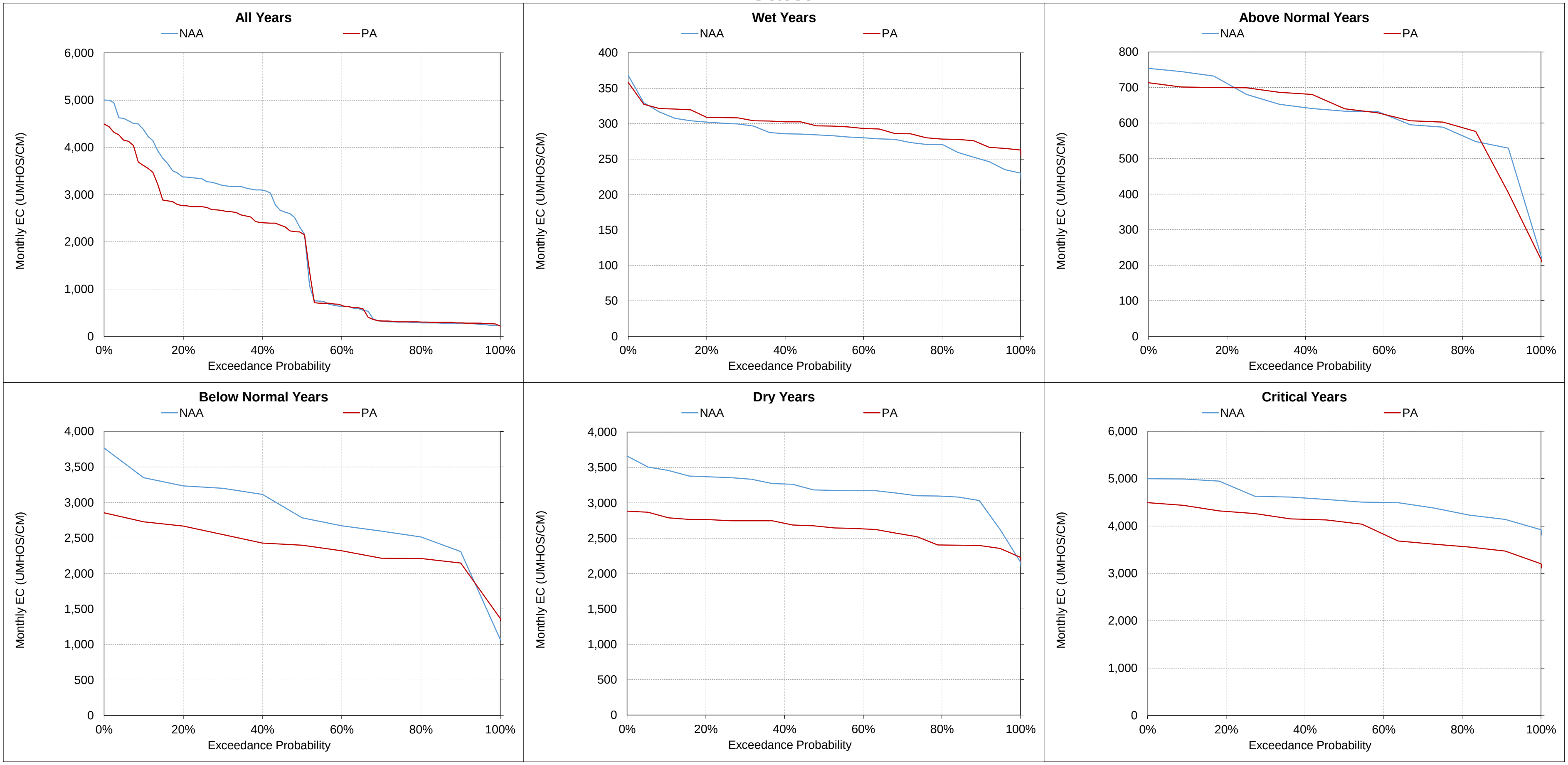
Figure 5.B.5-12-6. Monthly EC Ranges For Sacramento River at Emmaton Salinity, Critical Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 12 critical years.
EC, UMHOS/CM
6,000
5,000
4,000
3,000
2,000
1,000
0
February
March
April
May
June
July
August
September
October
November
December
January
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
NAA
PA

Figure 5.B.5-12-7. Sacramento River at Emmaton Salinity, Monthly EC Probability of Exceedance



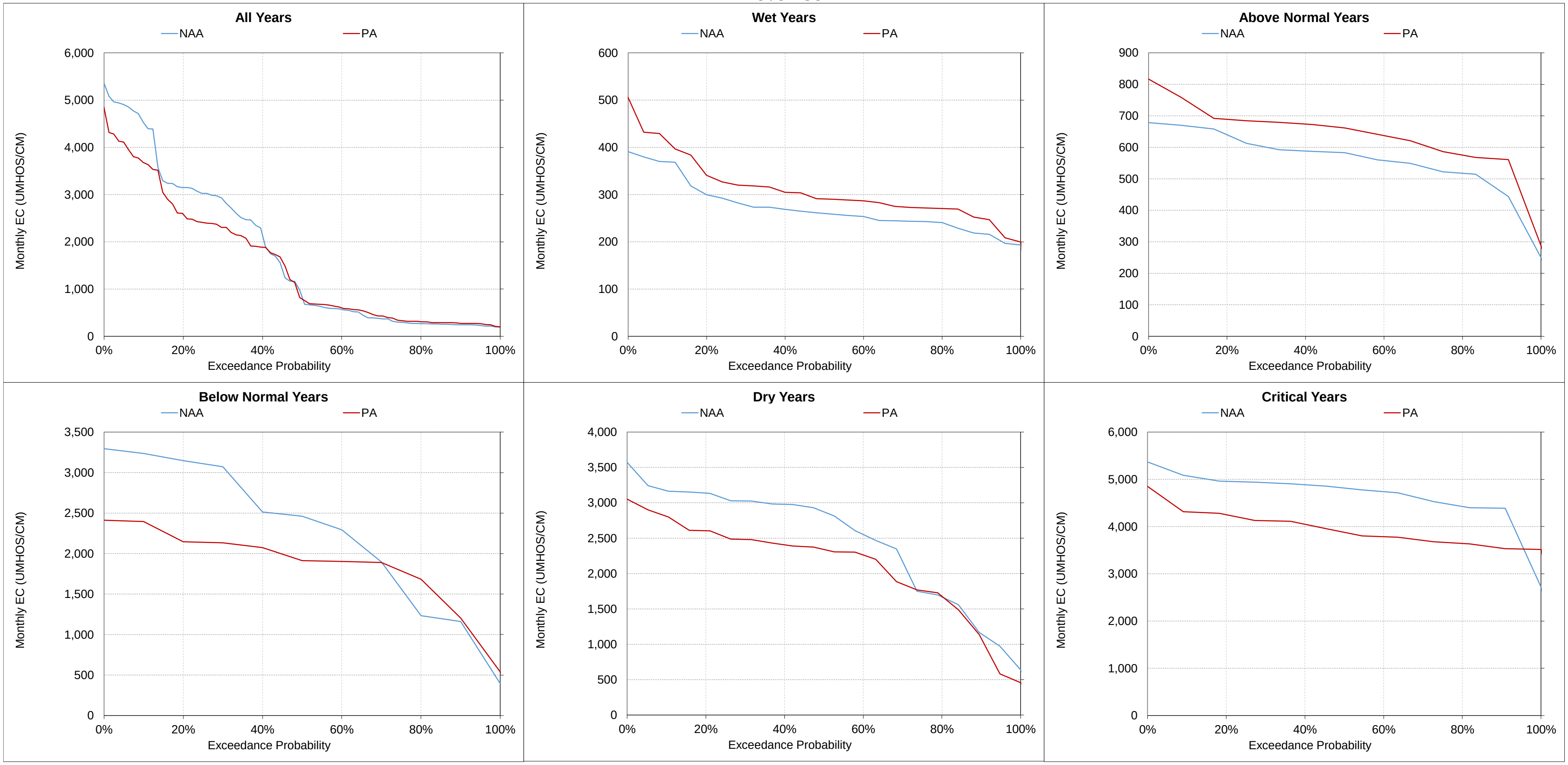
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-12-8. Sacramento River at Emmaton Salinity, Monthly EC
October



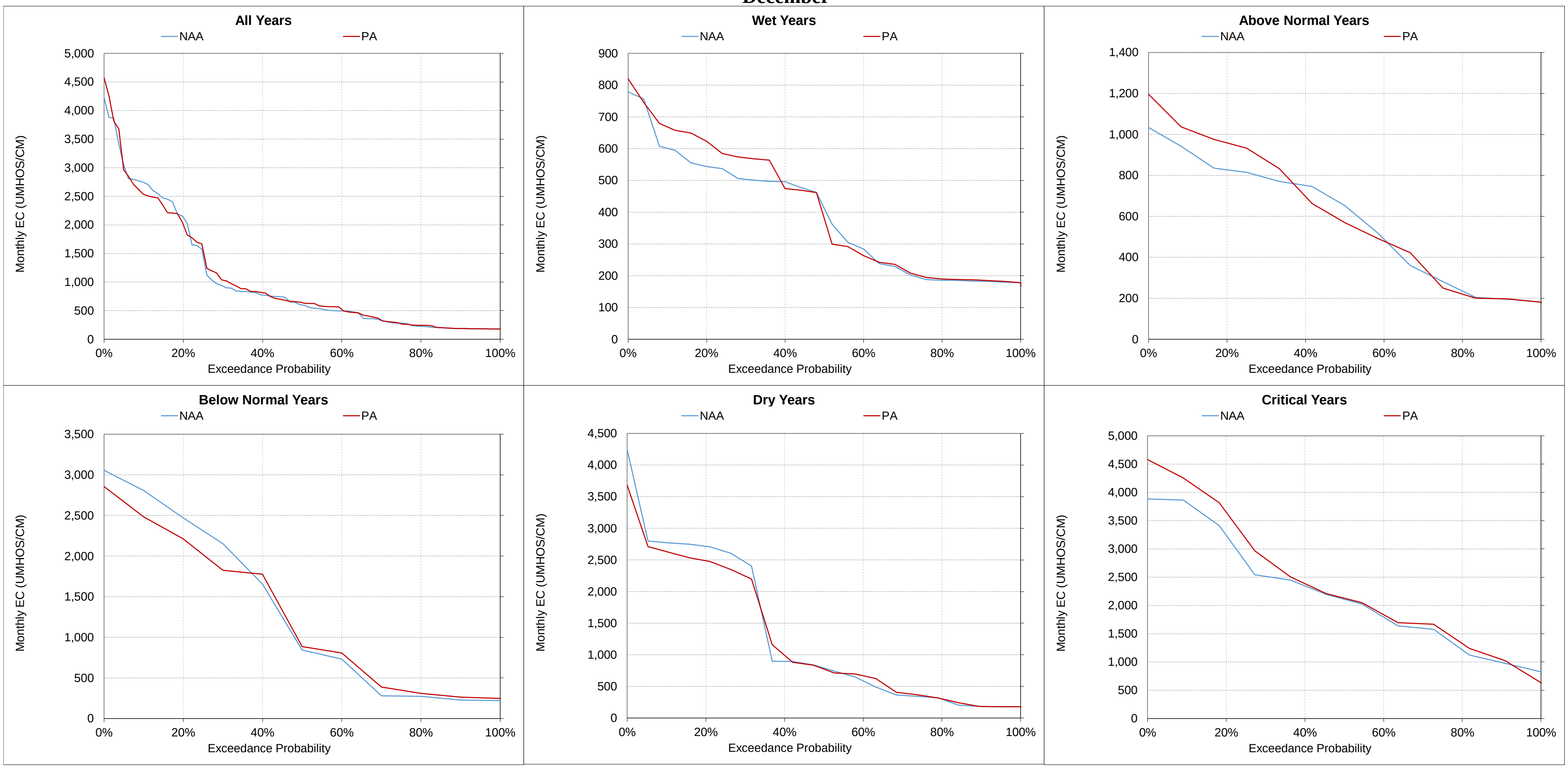
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

**Figure 5.B.5-12-9. Sacramento River at Emmaton Salinity, Monthly EC
November**



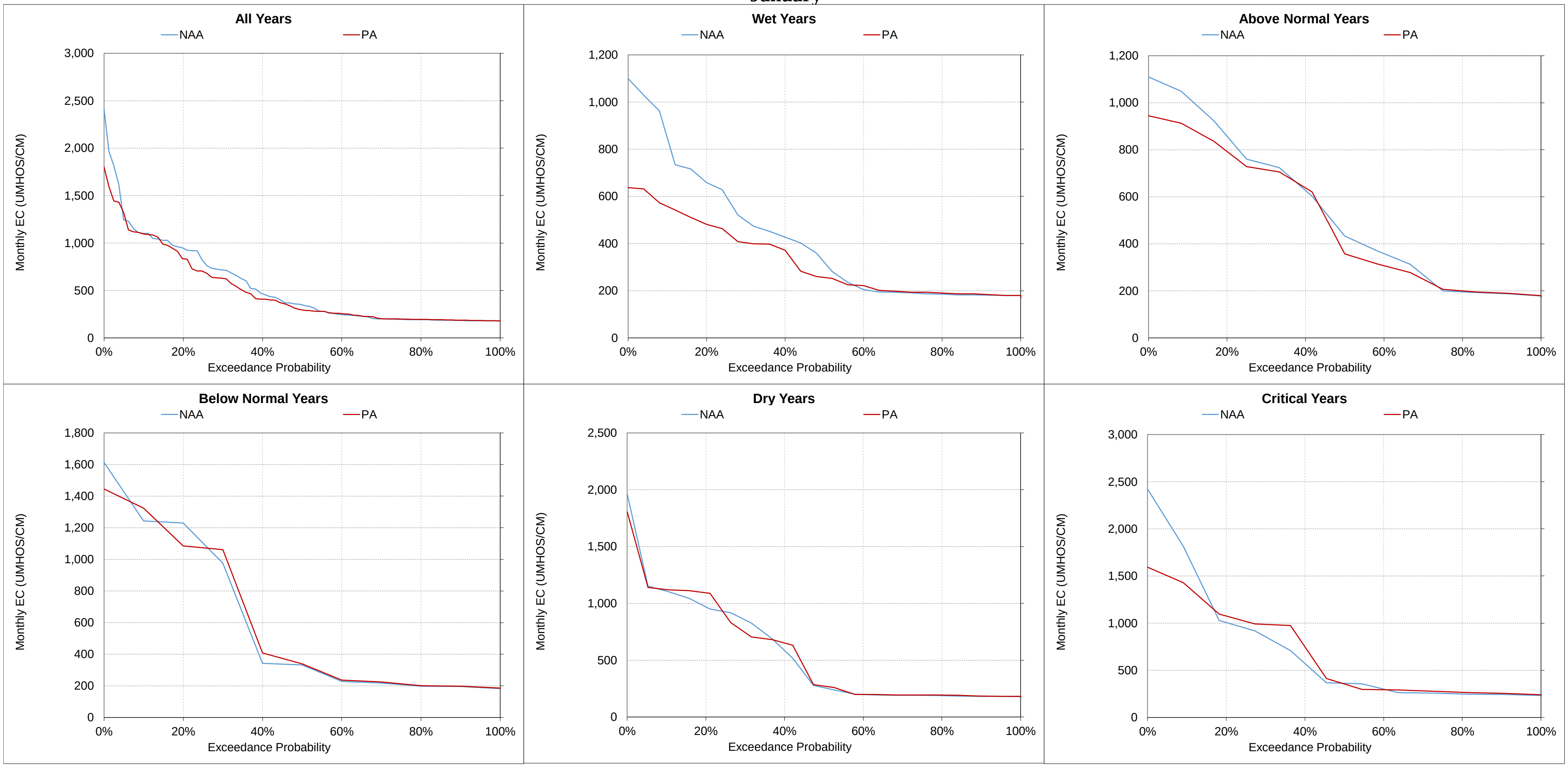
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-12-10. Sacramento River at Emmaton Salinity, Monthly EC December



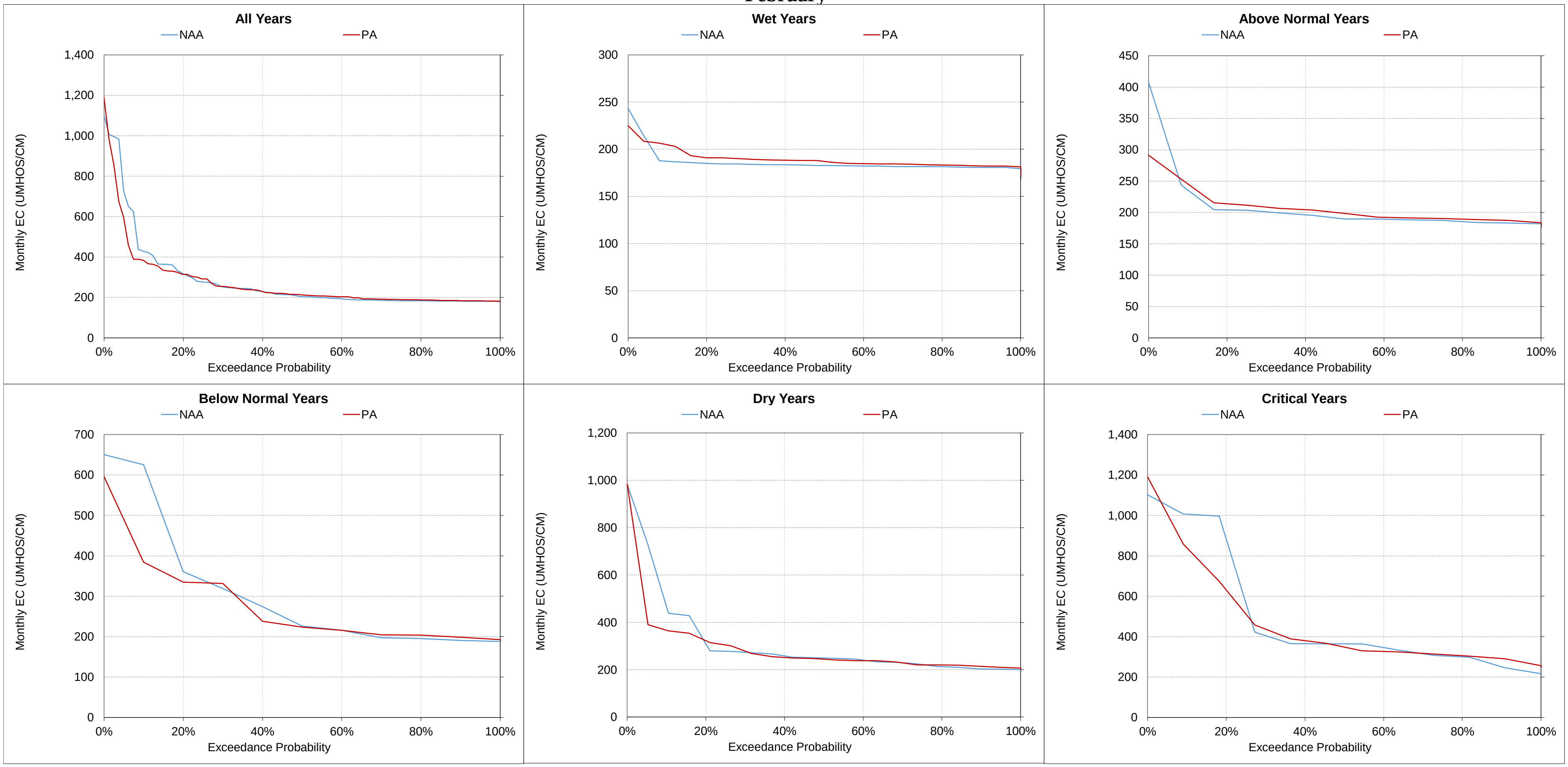
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-12-11. Sacramento River at Emmaton Salinity, Monthly EC
January



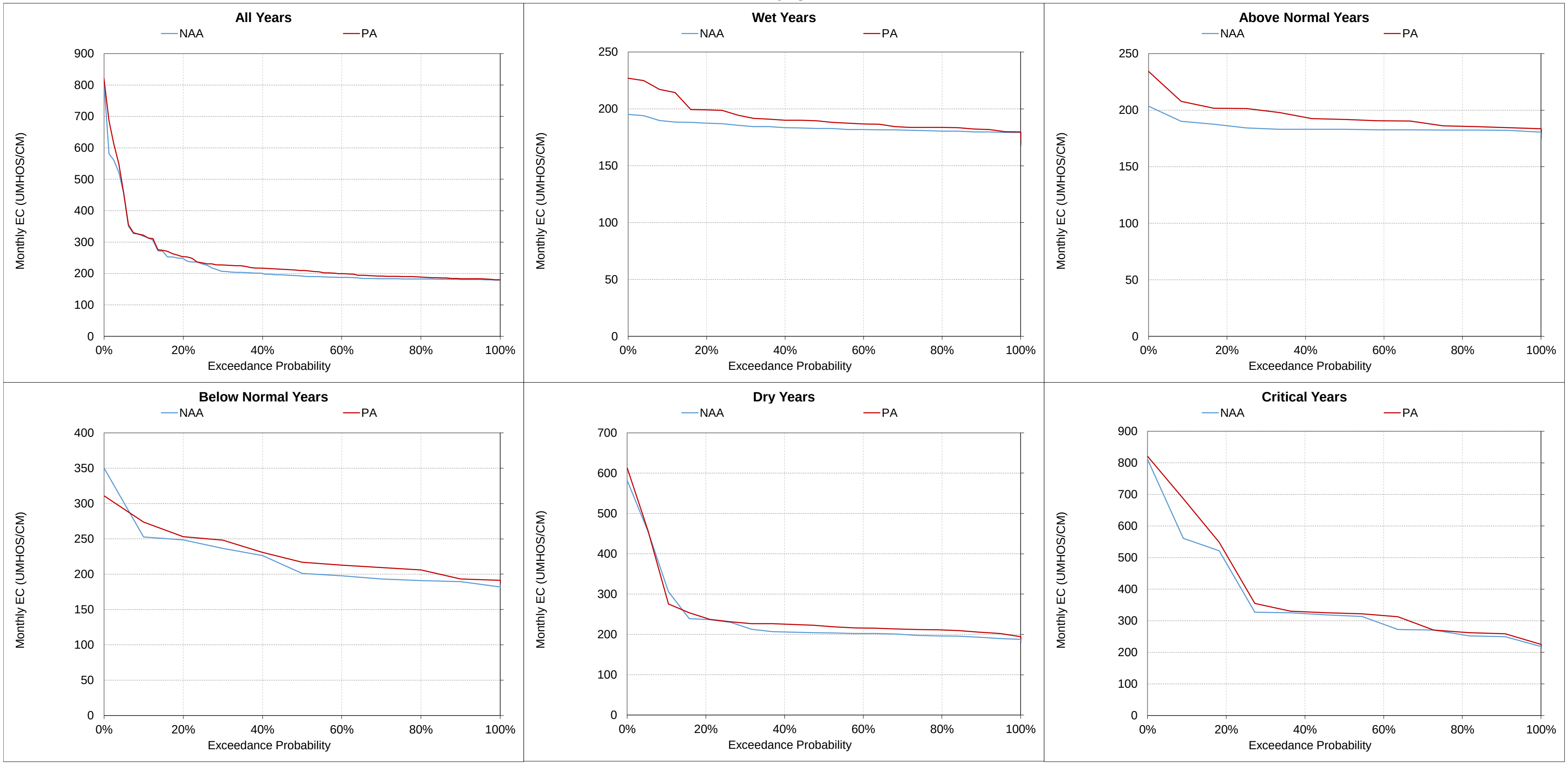
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-12-12. Sacramento River at Emmaton Salinity, Monthly EC February



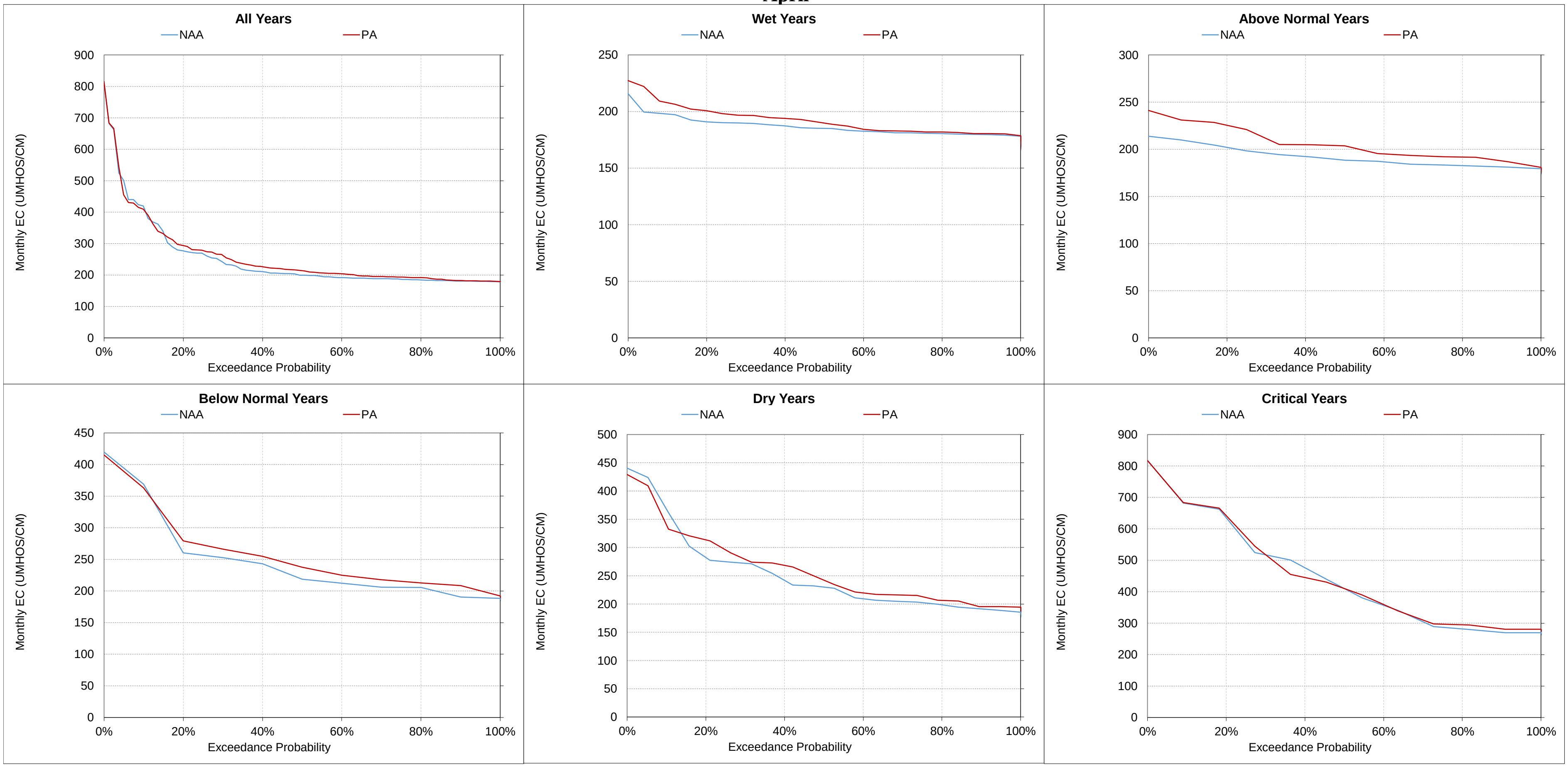
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-12-13. Sacramento River at Emmaton Salinity, Monthly EC
March



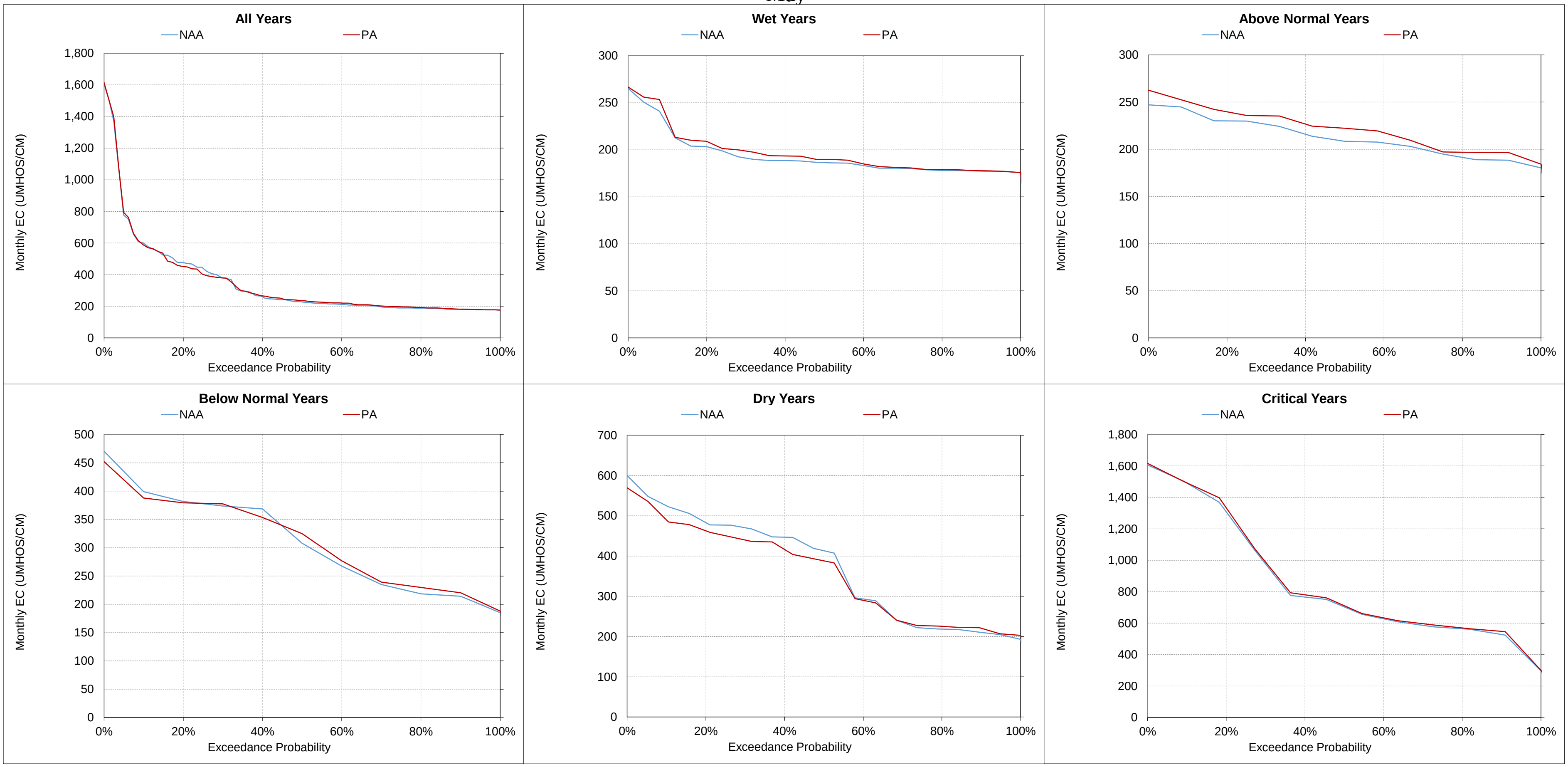
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-12-14. Sacramento River at Emmaton Salinity, Monthly EC
April



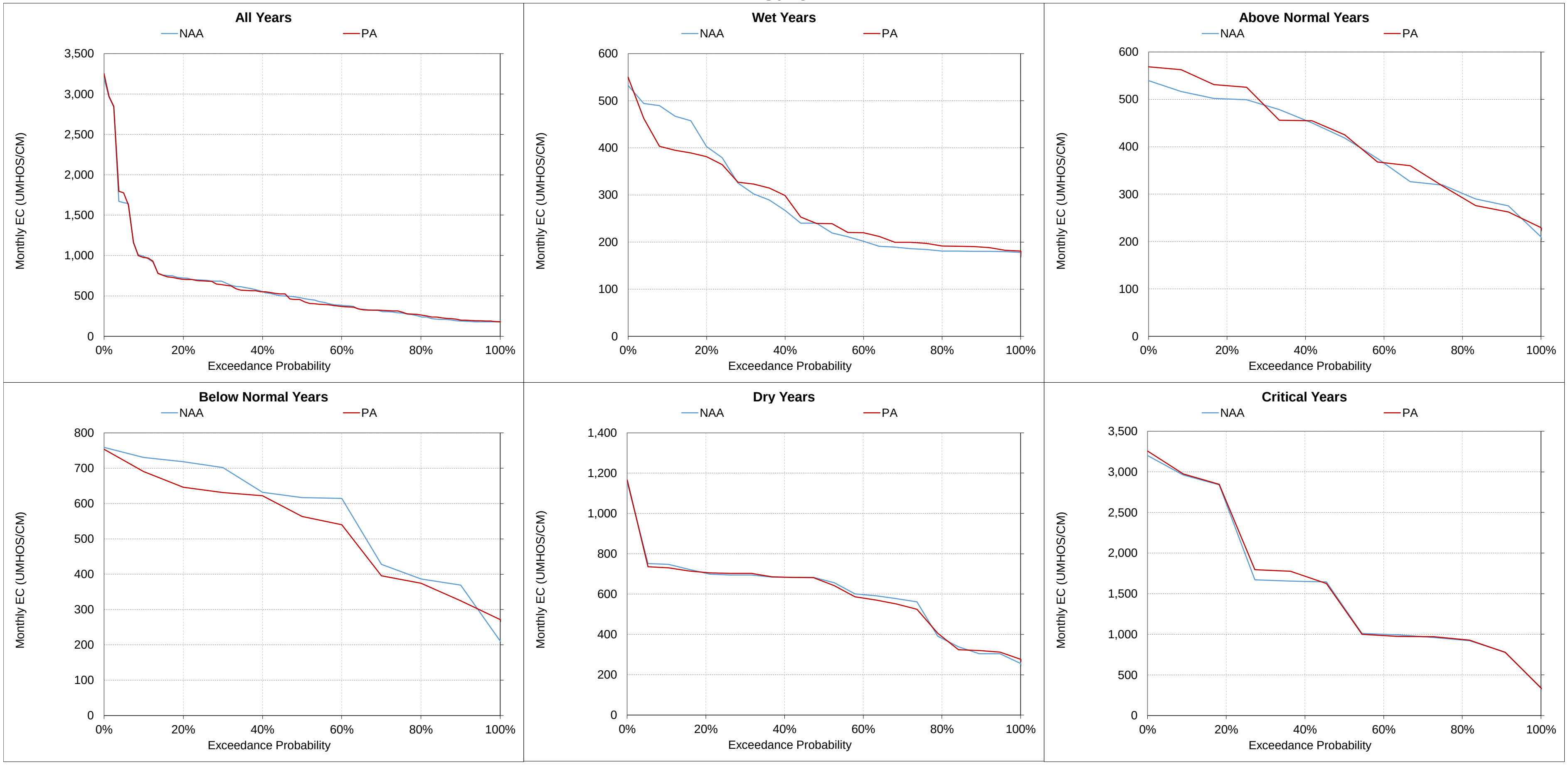
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-12-15. Sacramento River at Emmaton Salinity, Monthly EC
May



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-12-16. Sacramento River at Emmaton Salinity, Monthly EC June



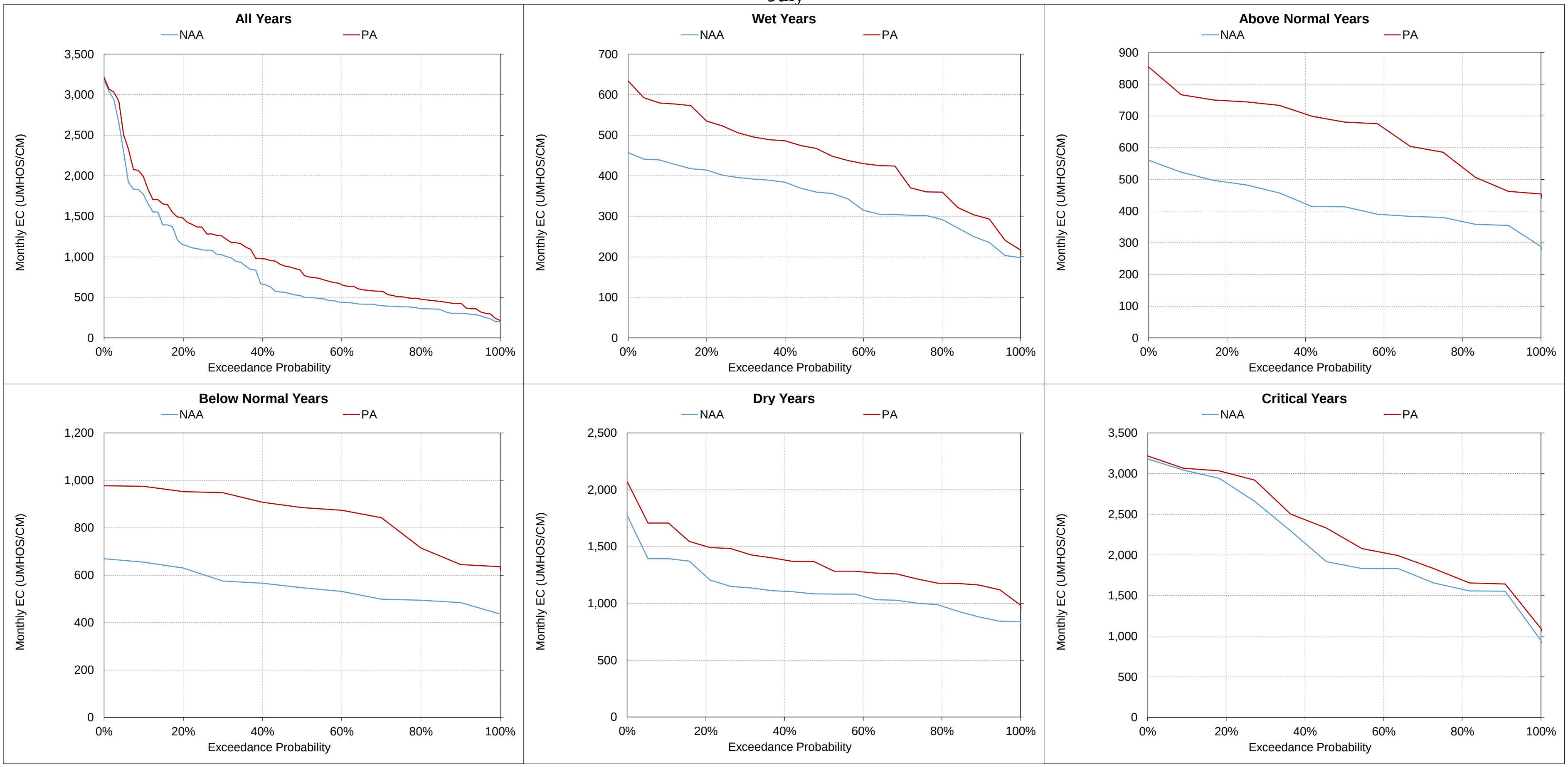
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-12-17. Sacramento River at Emmaton Salinity, Monthly EC July



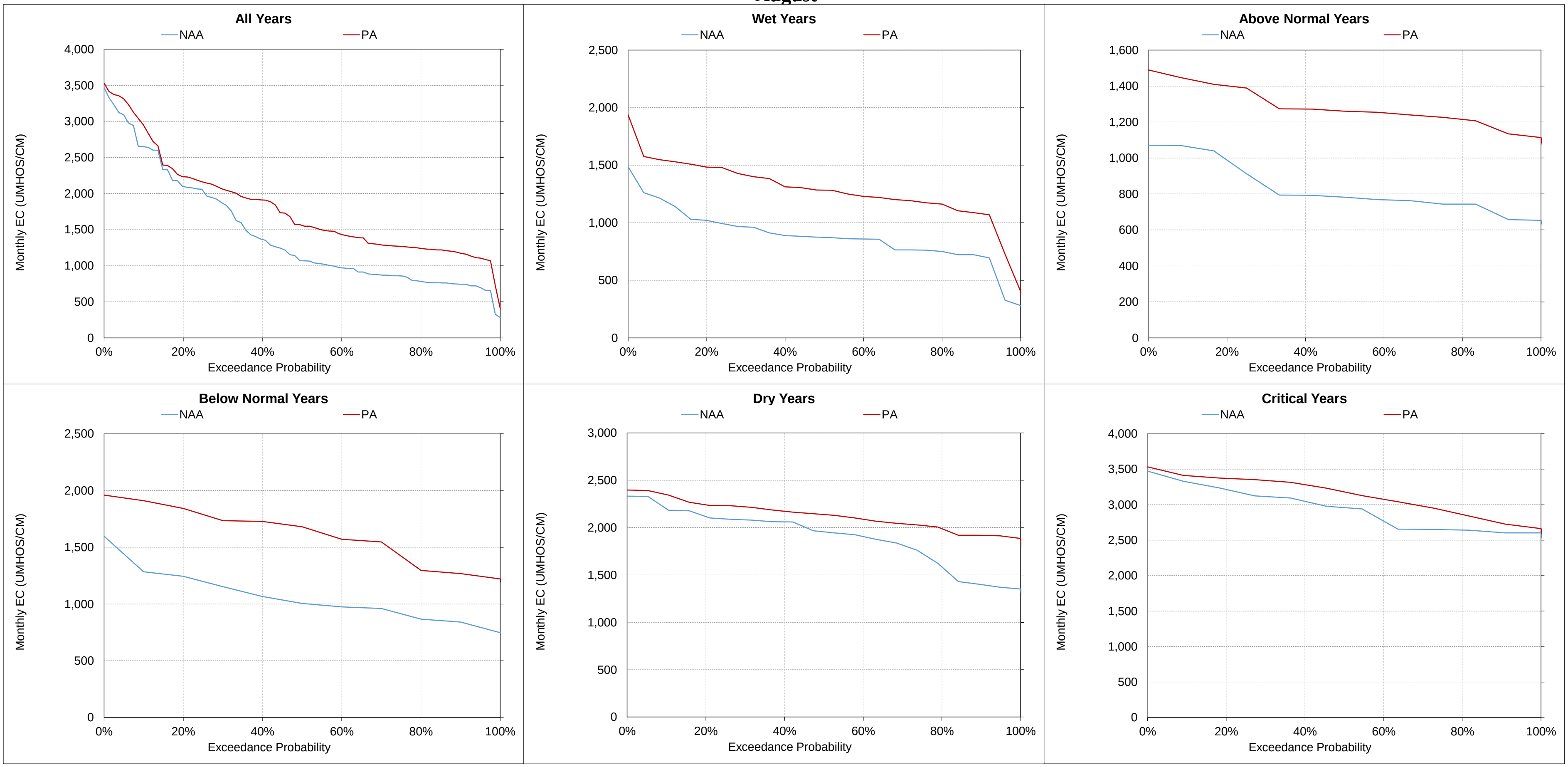
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

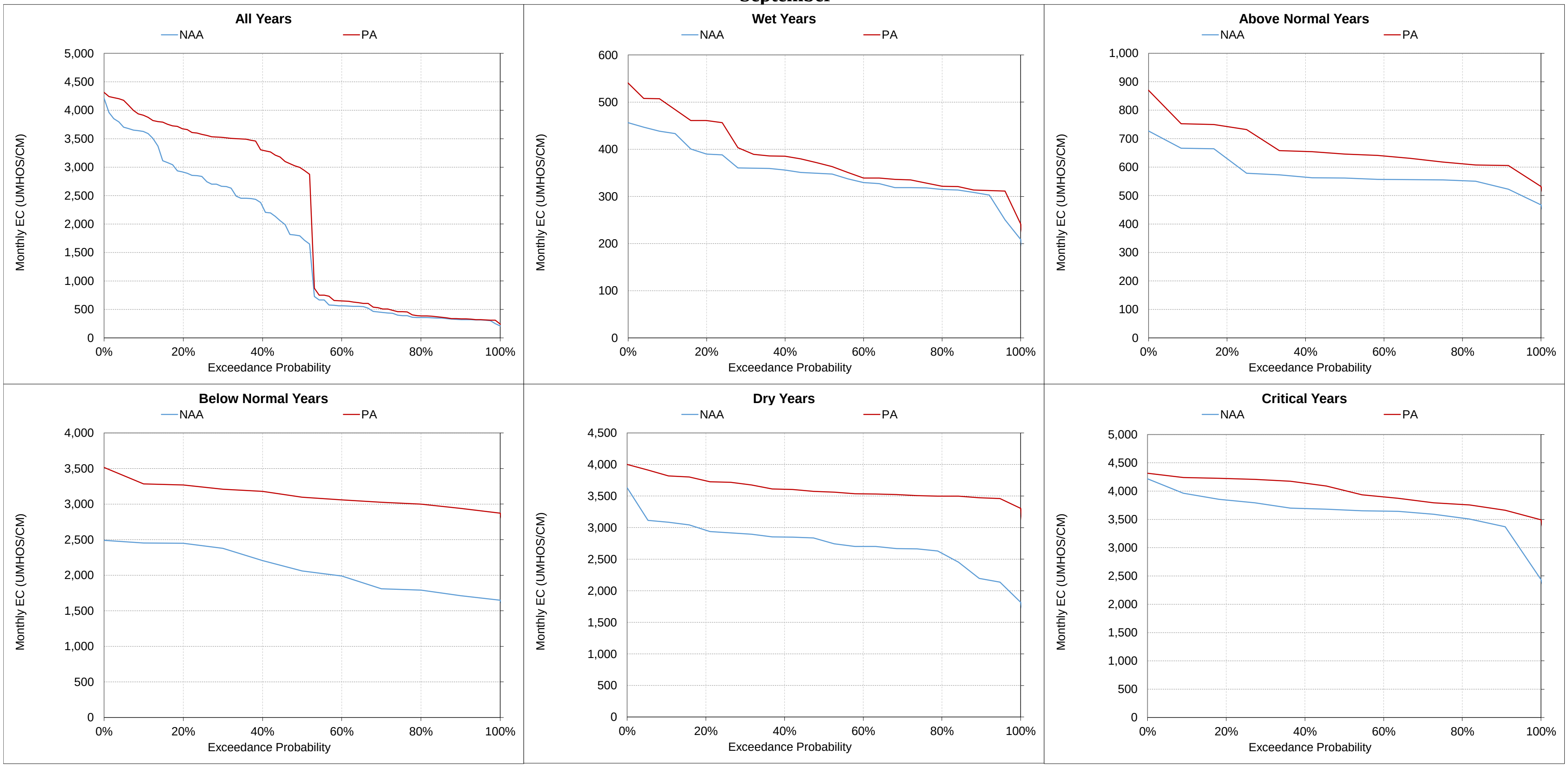
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-12-18. Sacramento River at Emmaton Salinity, Monthly EC
August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-12-19. Sacramento River at Emmaton Salinity, Monthly EC
September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-13. San Joaquin River at Jersey Point Salinity, Monthly EC

Statistic	Monthly EC (UMHOS/CM)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	2,866	2,014	-853	-30%	3,439	2,515	-924	-27%	2,555	2,314	-242	-9%	1,519	1,396	-123	-8%	625	491	-134	-22%	330	331	0	0%
20%	2,643	1,582	-1,061	-40%	2,995	1,850	-1,145	-38%	2,180	2,021	-159	-7%	1,278	1,069	-209	-16%	474	408	-66	-14%	284	309	25	9%
30%	2,465	1,476	-989	-40%	2,616	1,521	-1,095	-42%	1,680	1,480	-201	-12%	1,106	753	-353	-32%	343	331	-13	-4%	260	298	38	15%
40%	2,348	1,309	-1,038	-44%	2,194	1,236	-958	-44%	1,284	1,133	-151	-12%	870	597	-273	-31%	297	307	10	3%	242	278	36	15%
50%	2,137	1,134	-1,003	-47%	1,359	555	-804	-59%	888	830	-58	-7%	608	464	-144	-24%	286	297	11	4%	233	270	38	16%
60%	541	298	-242	-45%	674	341	-333	-49%	751	676	-75	-10%	405	350	-55	-14%	261	287	26	10%	225	264	40	18%
70%	325	239	-87	-27%	469	314	-155	-33%	609	533	-76	-13%	274	291	16	6%	240	277	37	16%	219	257	38	17%
80%	298	232	-66	-22%	331	275	-56	-17%	339	331	-8	-2%	234	263	29	12%	223	263	40	18%	211	249	37	18%
90%	279	225	-54	-19%	276	262	-13	-5%	230	230	0	0%	221	237	16	7%	214	249	35	16%	203	237	34	17%
Long Term																								
Full Simulation Period[b]	1,544	991	-553	-36%	1,665	1,106	-559	-34%	1,252	1,150	-103	-8%	763	644	-119	-16%	366	344	-21	-6%	255	287	31	12%
Water Year Types[c]																								
Wet (32%)	292	230	-62	-21%	337	276	-61	-18%	514	482	-32	-6%	589	400	-189	-32%	236	273	37	16%	221	266	46	21%
Above Normal (16%)	532	292	-240	-45%	787	341	-446	-57%	899	734	-165	-18%	810	623	-187	-23%	265	282	17	6%	219	280	61	28%
Below Normal (13%)	2,492	1,323	-1,170	-47%	2,240	1,258	-982	-44%	1,544	1,383	-160	-10%	863	788	-75	-9%	397	359	-38	-10%	251	274	23	9%
Dry (24%)	2,427	1,469	-958	-39%	2,564	1,523	-1,041	-41%	1,562	1,371	-191	-12%	781	743	-38	-5%	437	372	-65	-15%	275	287	12	4%
Critical (15%)	3,015	2,297	-718	-24%	3,471	2,899	-572	-16%	2,453	2,463	10	0%	968	900	-68	-7%	609	509	-101	-17%	341	350	9	3%

Statistic	Monthly EC (UMHOS/CM)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	326	325	-1	0%	426	419	-7	-2%	542	543	0	0%	1,781	1,266	-515	-29%	1,929	2,066	137	7%	2,670	2,624	-46	-2%
20%	258	296	38	15%	360	345	-15	-4%	481	473	-8	-2%	1,453	1,037	-417	-29%	1,702	1,783	81	5%	2,511	2,367	-144	-6%
30%	246	290	44	18%	302	308	5	2%	428	400	-28	-7%	1,179	856	-323	-27%	1,619	1,498	-120	-7%	2,358	2,219	-139	-6%
40%	234	282	48	21%	257	277	20	8%	374	362	-13	-3%	998	718	-281	-28%	1,519	1,179	-340	-22%	2,232	1,998	-234	-11%
50%	229	270	41	18%	246	265	18	7%	326	317	-9	-3%	860	609	-251	-29%	1,360	954	-406	-30%	1,948	1,729	-219	-11%
60%	224	257	33	15%	237	258	22	9%	296	282	-14	-5%	717	489	-228	-32%	1,255	889	-365	-29%	1,181	475	-706	-60%
70%	219	246	27	12%	231	245	14	6%	264	269	5	2%	582	430	-152	-26%	1,183	821	-361	-31%	1,094	429	-664	-61%
80%	215	236	20	9%	226	238	12	5%	230	254	24	10%	484	377	-107	-22%	1,086	767	-319	-29%	996	381	-615	-62%
90%	210	227	16	8%	196	197	0	0%	206	221	15	7%	375	303	-72	-19%	1,015	688	-327	-32%	909	330	-579	-64%
Long Term																								
Full Simulation Period[b]	250	277	26	11%	298	306	8	3%	409	406	-3	-1%	968	737	-232	-24%	1,413	1,215	-198	-14%	1,755	1,396	-359	-20%
Water Year Types[c]																								
Wet (32%)	220	243	23	11%	215	223	8	4%	243	252	9	4%	463	361	-102	-22%	1,160	785	-374	-32%	958	363	-595	-62%
Above Normal (16%)	223	280	57	25%	237	259	22	9%	311	314	3	1%	638	463	-175	-27%	1,129	800	-330	-29%	1,095	481	-614	-56%
Below Normal (13%)	246	272	26	10%	281	290	10	3%	380	364	-15	-4%	949	659	-290	-31%	1,379	970	-409	-30%	2,342	1,878	-464	-20%
Dry (24%)	248	270	22	9%	309	307	-2	-1%	409	388	-20	-5%	1,441	988	-454	-31%	1,572	1,566	-5	0%	2,446	2,319	-127	-5%
Critical (15%)	355	363	8	2%	541	547	6	1%	905	907	2	0%	1,649	1,499	-150	-9%	2,037	2,235	198	10%	2,507	2,647	140	6%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

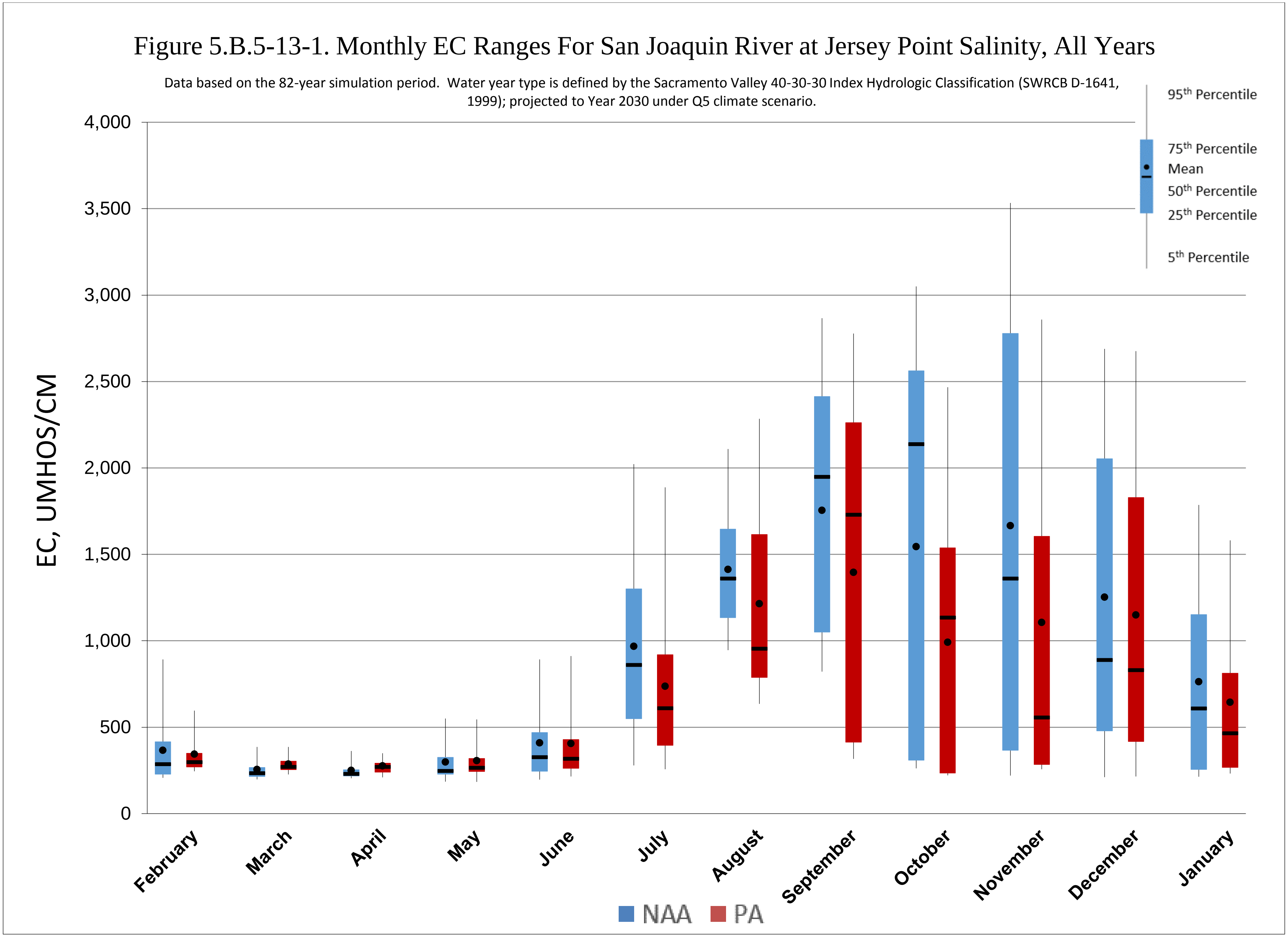


Figure 5.B.5-13-1. Monthly EC Ranges For San Joaquin River at Jersey Point Salinity, All Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario.
EC, UMHOS/CM
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-13-2. Monthly EC Ranges For San Joaquin River at Jersey Point Salinity, Wet Years

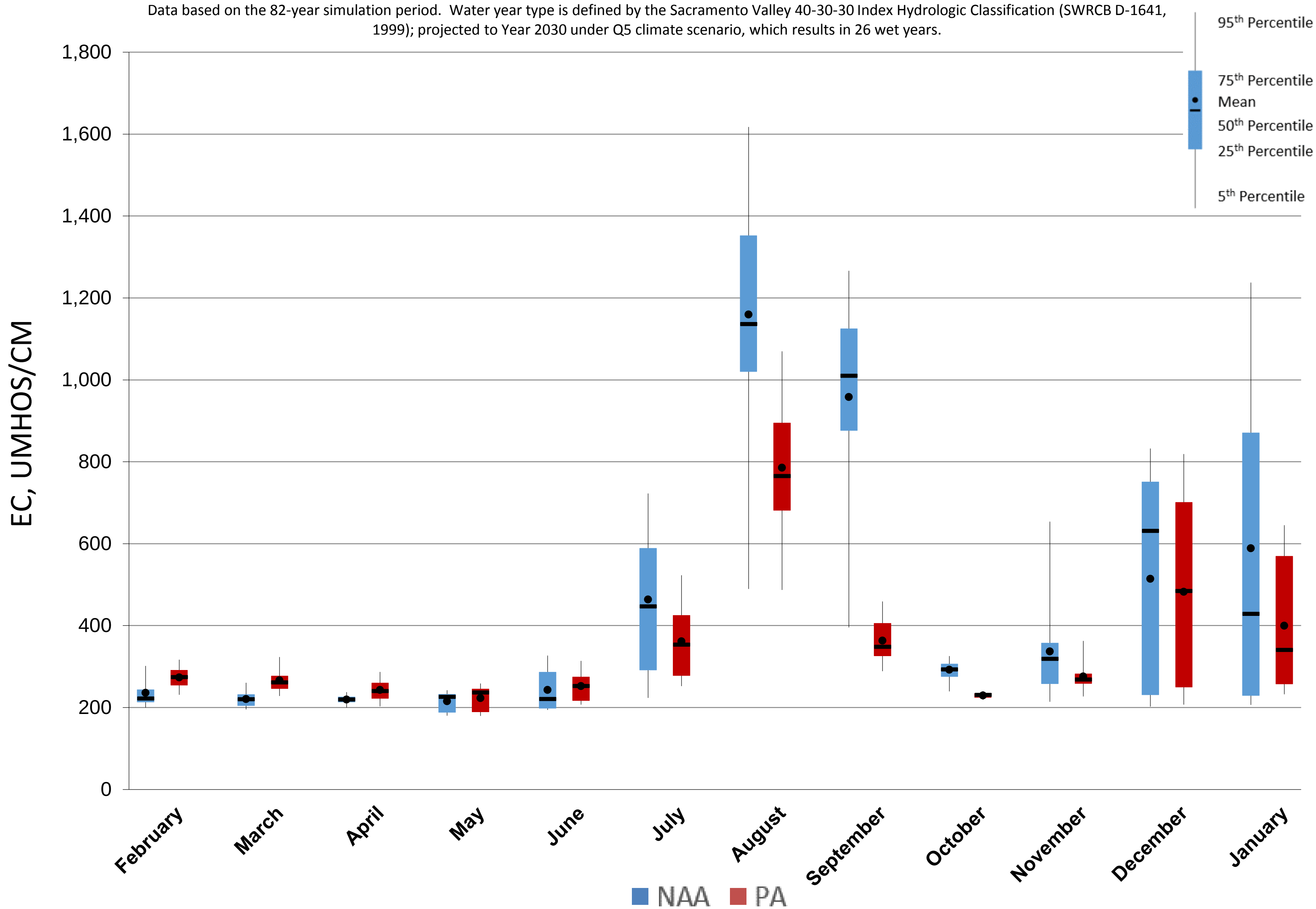
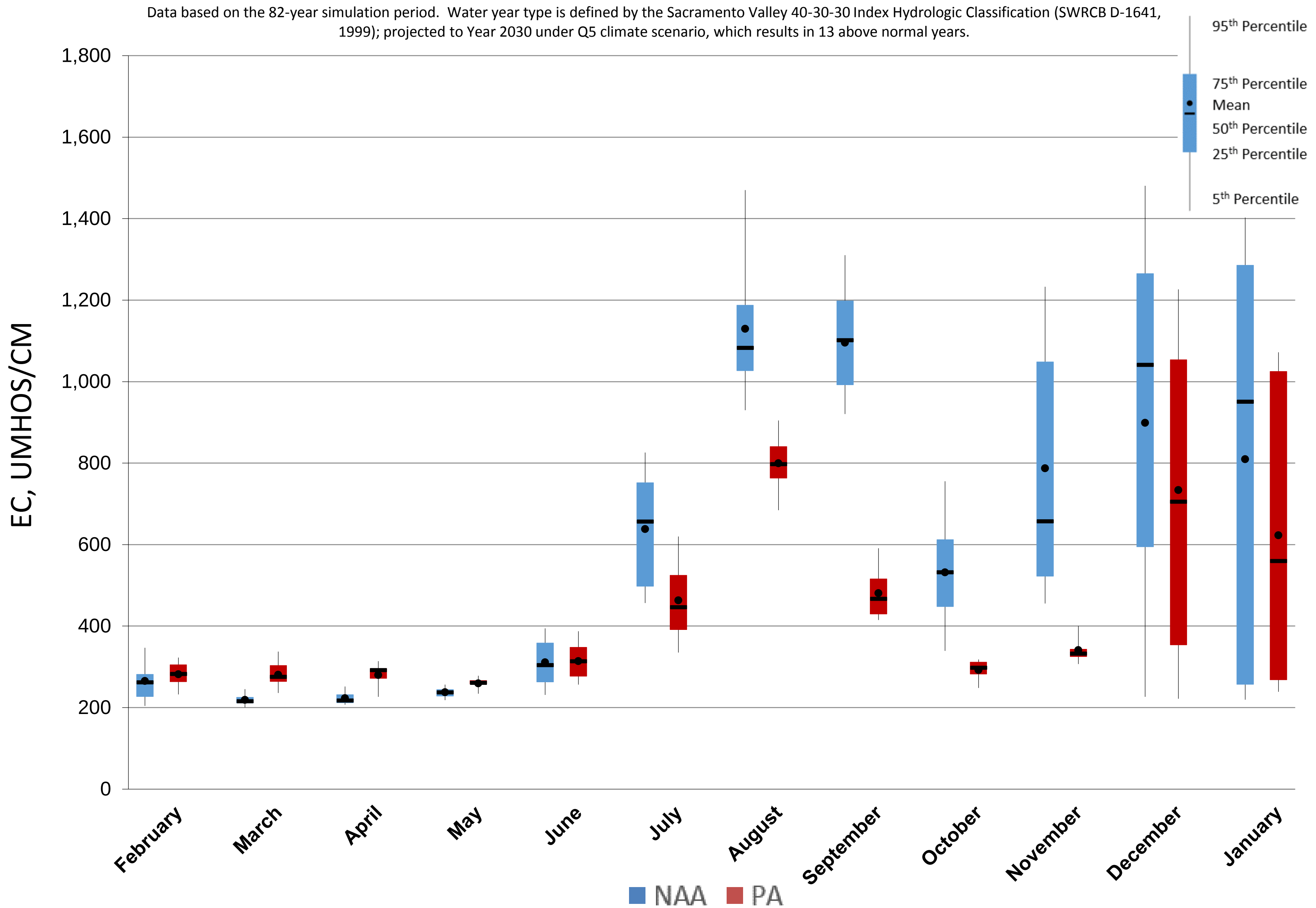


Figure 5.B.5-13-3. Monthly EC Ranges For San Joaquin River at Jersey Point Salinity, Above Normal Years



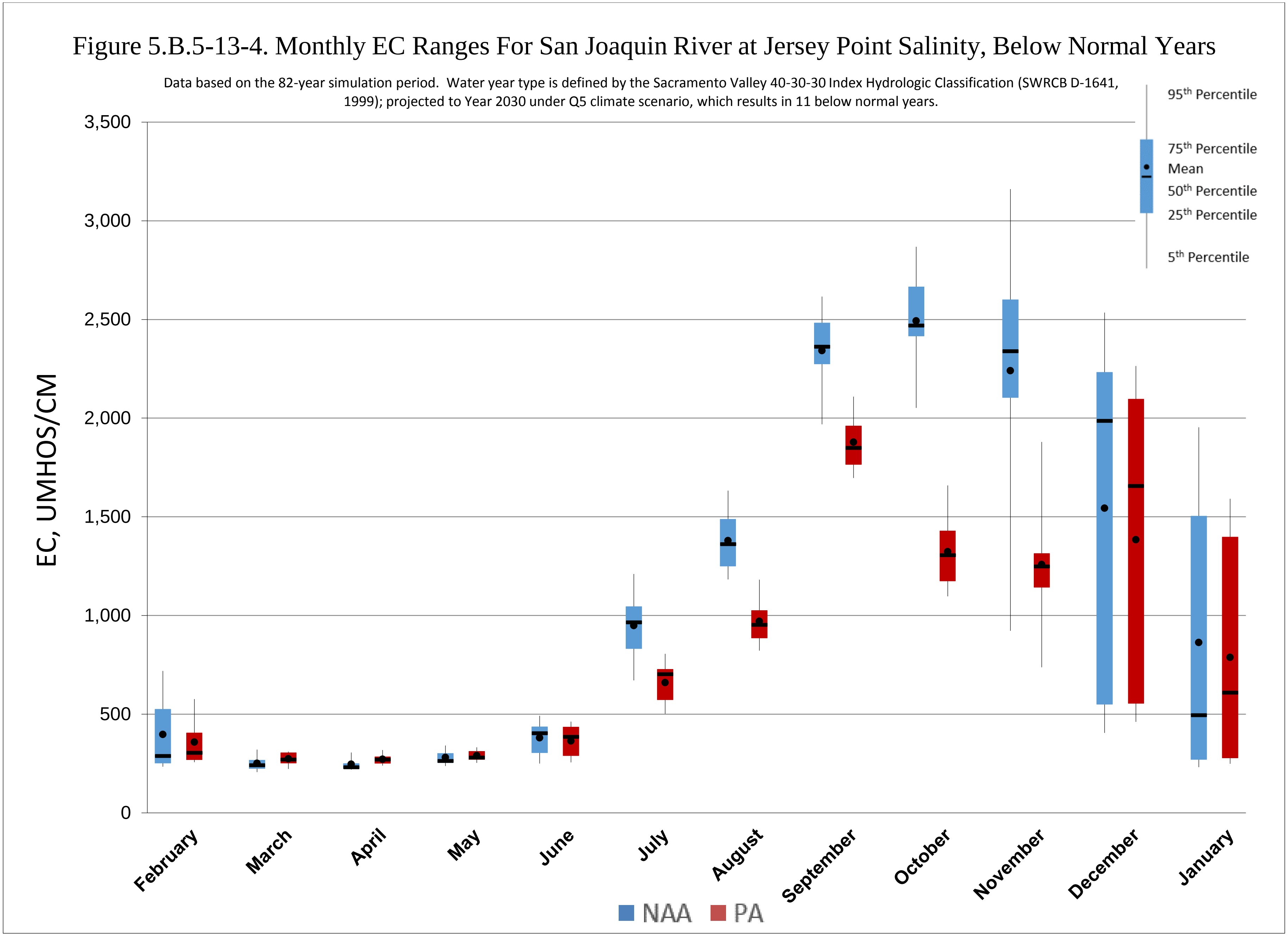


Figure 5.B.5-13-4. Monthly EC Ranges For San Joaquin River at Jersey Point Salinity, Below Normal Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 11 below normal years.
EC, UMHOS/CM
3,500
3,000
2,500
2,000
1,500
1,000
500
0
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-13-5. Monthly EC Ranges For San Joaquin River at Jersey Point Salinity, Dry Years

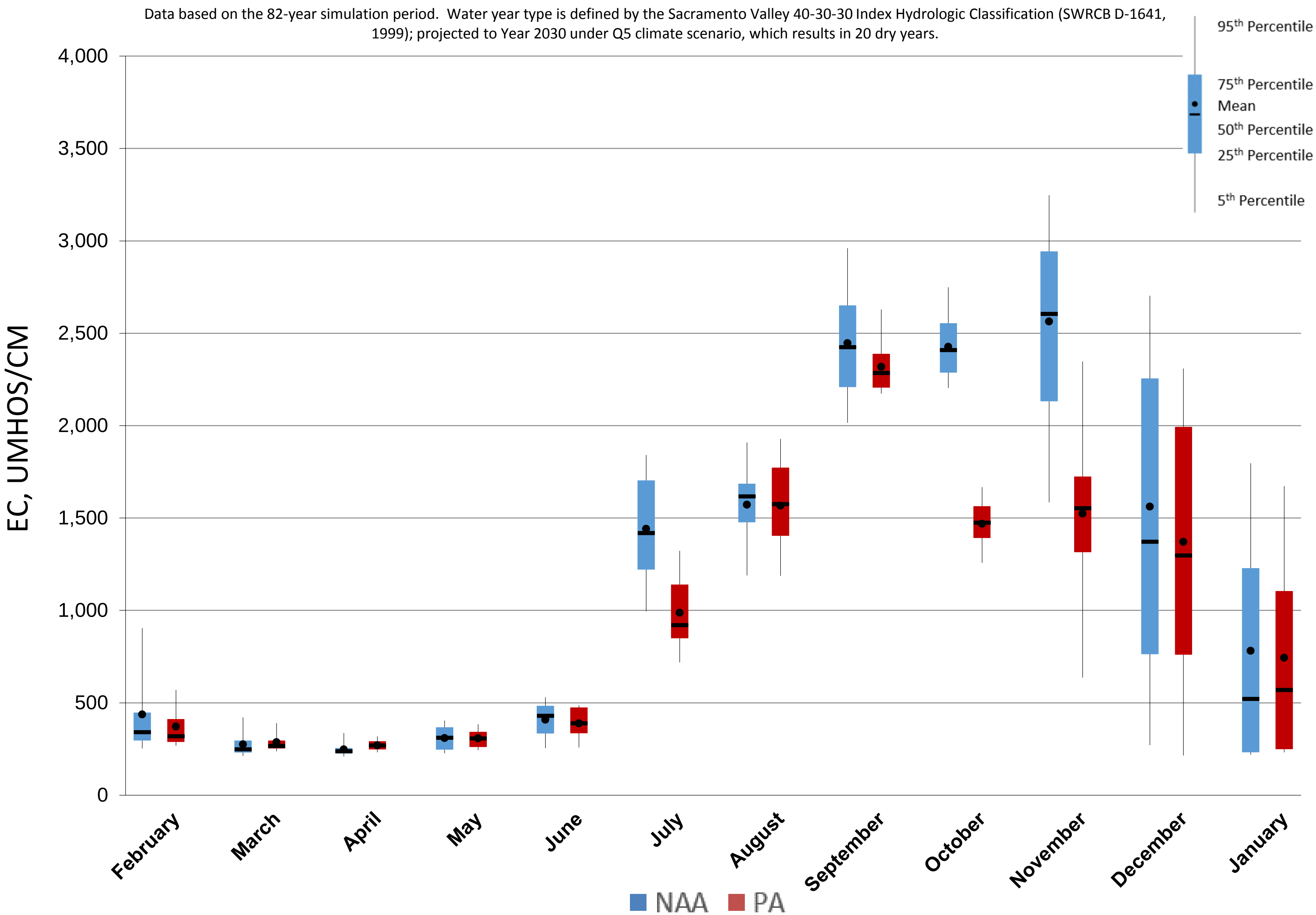


Figure 5.B.5-13-6. Monthly EC Ranges For San Joaquin River at Jersey Point Salinity, Critical Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 12 critical years.

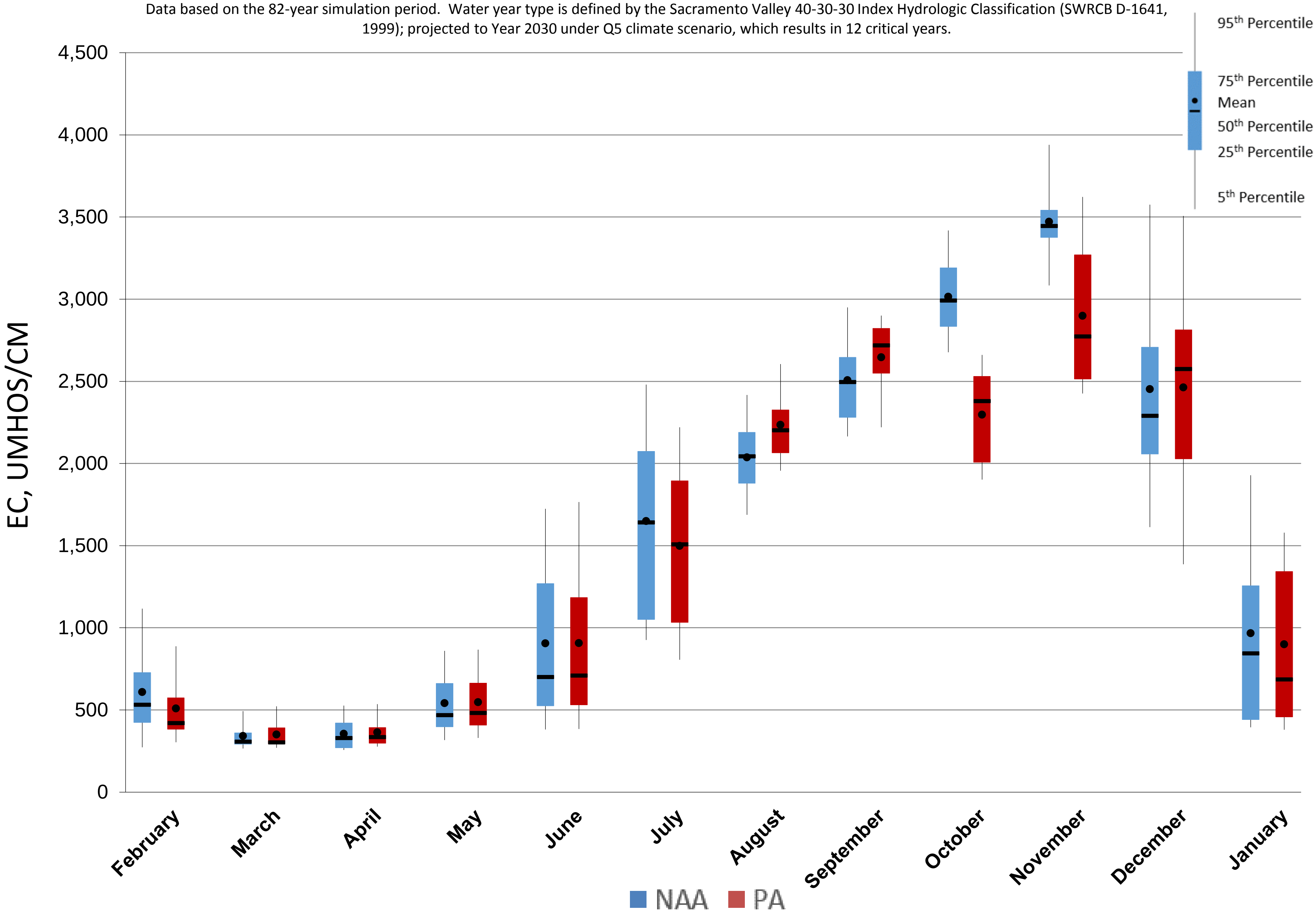
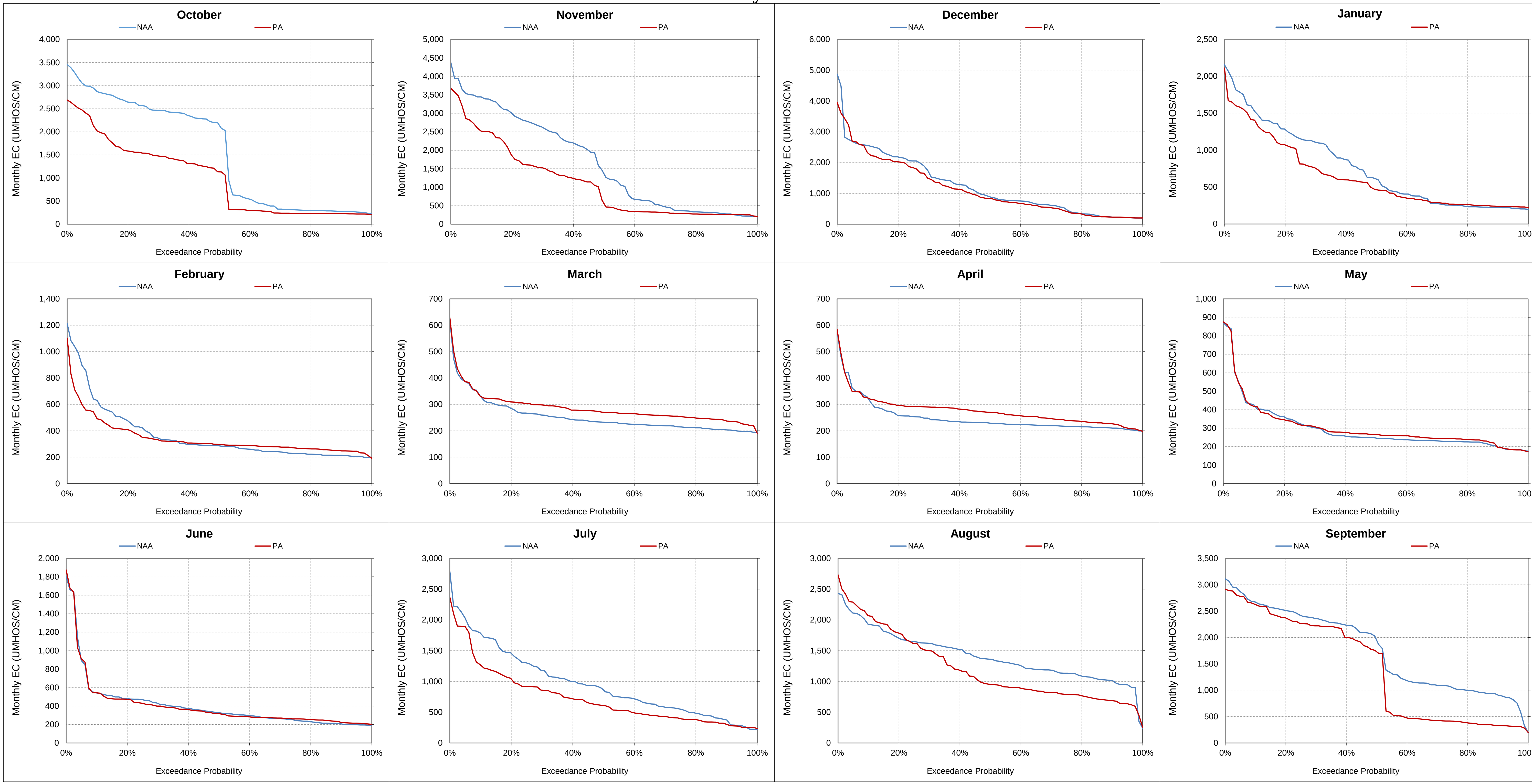
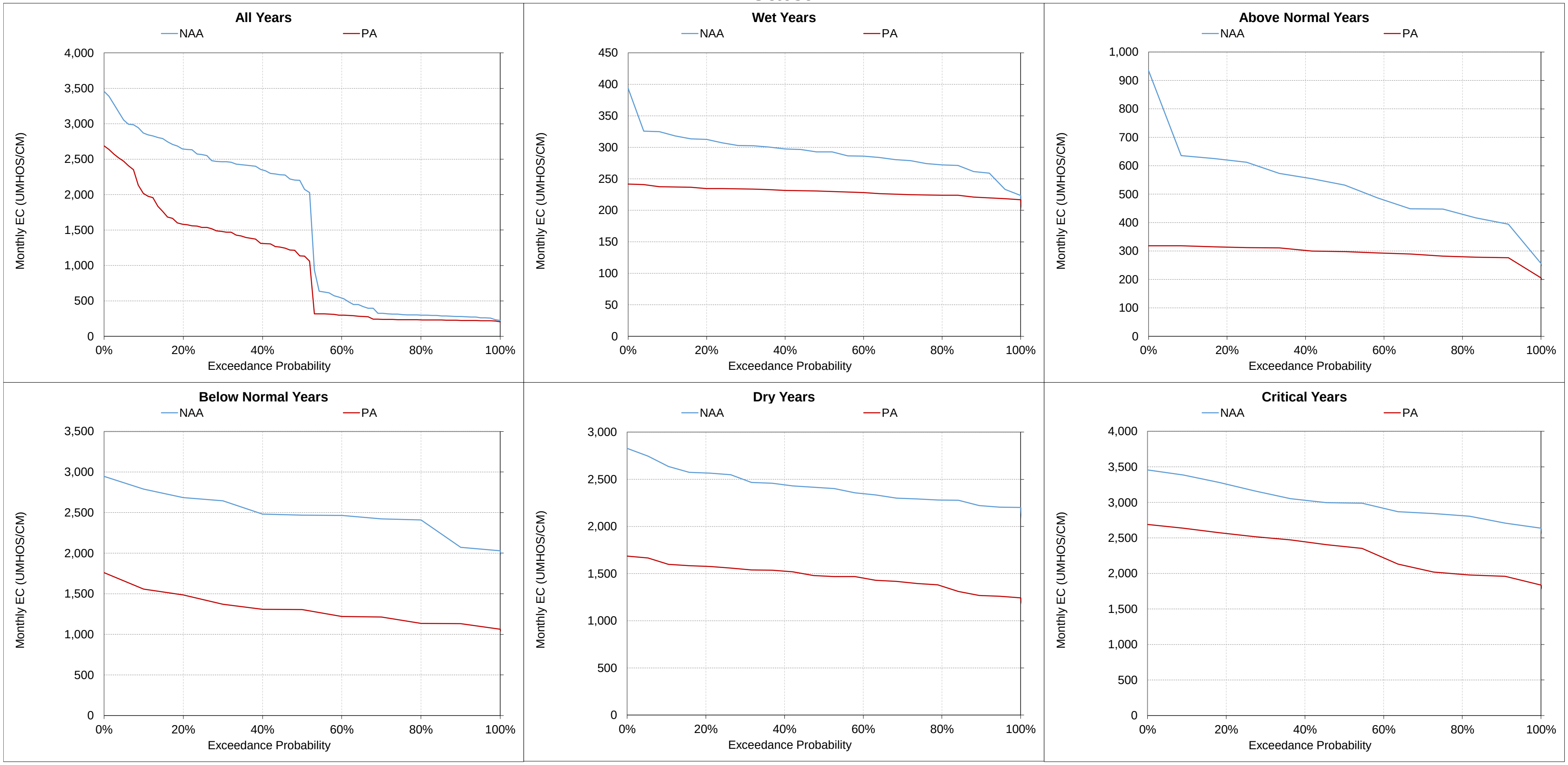


Figure 5.B.5-13-7. San Joaquin River at Jersey Point Salinity, Monthly EC Probability of Exceedance



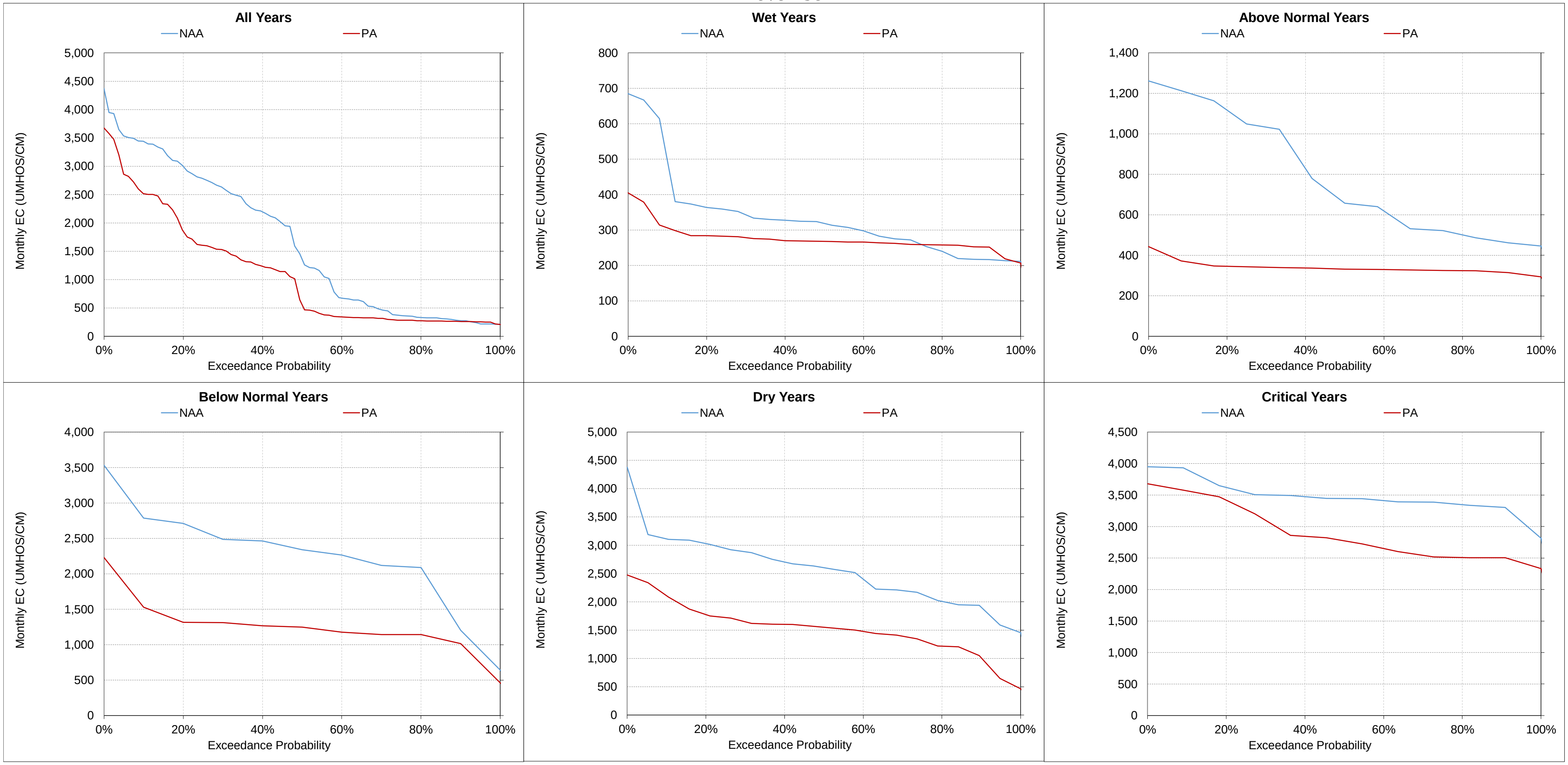
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-13-8. San Joaquin River at Jersey Point Salinity, Monthly EC
October



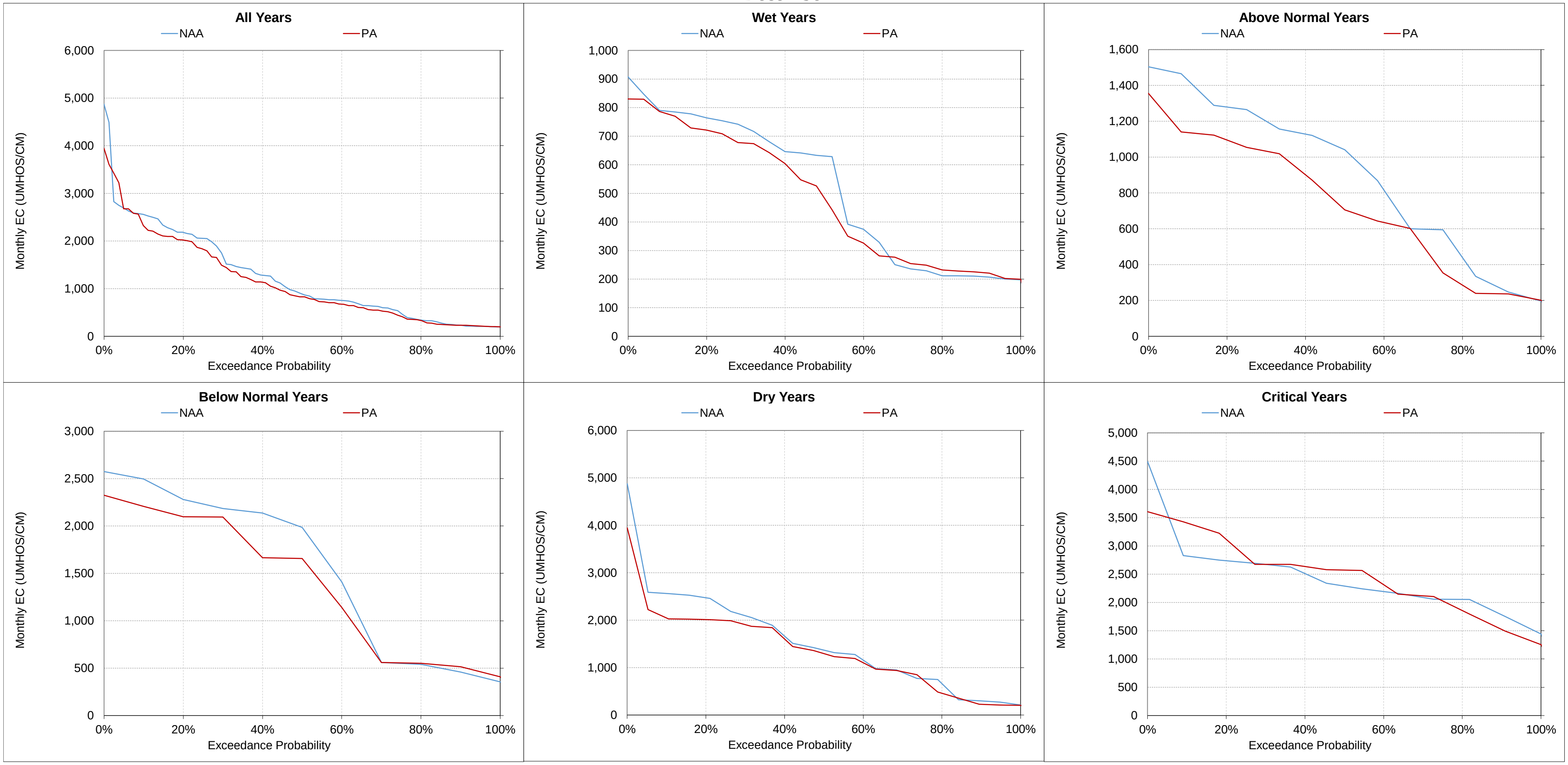
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-13-9. San Joaquin River at Jersey Point Salinity, Monthly EC November



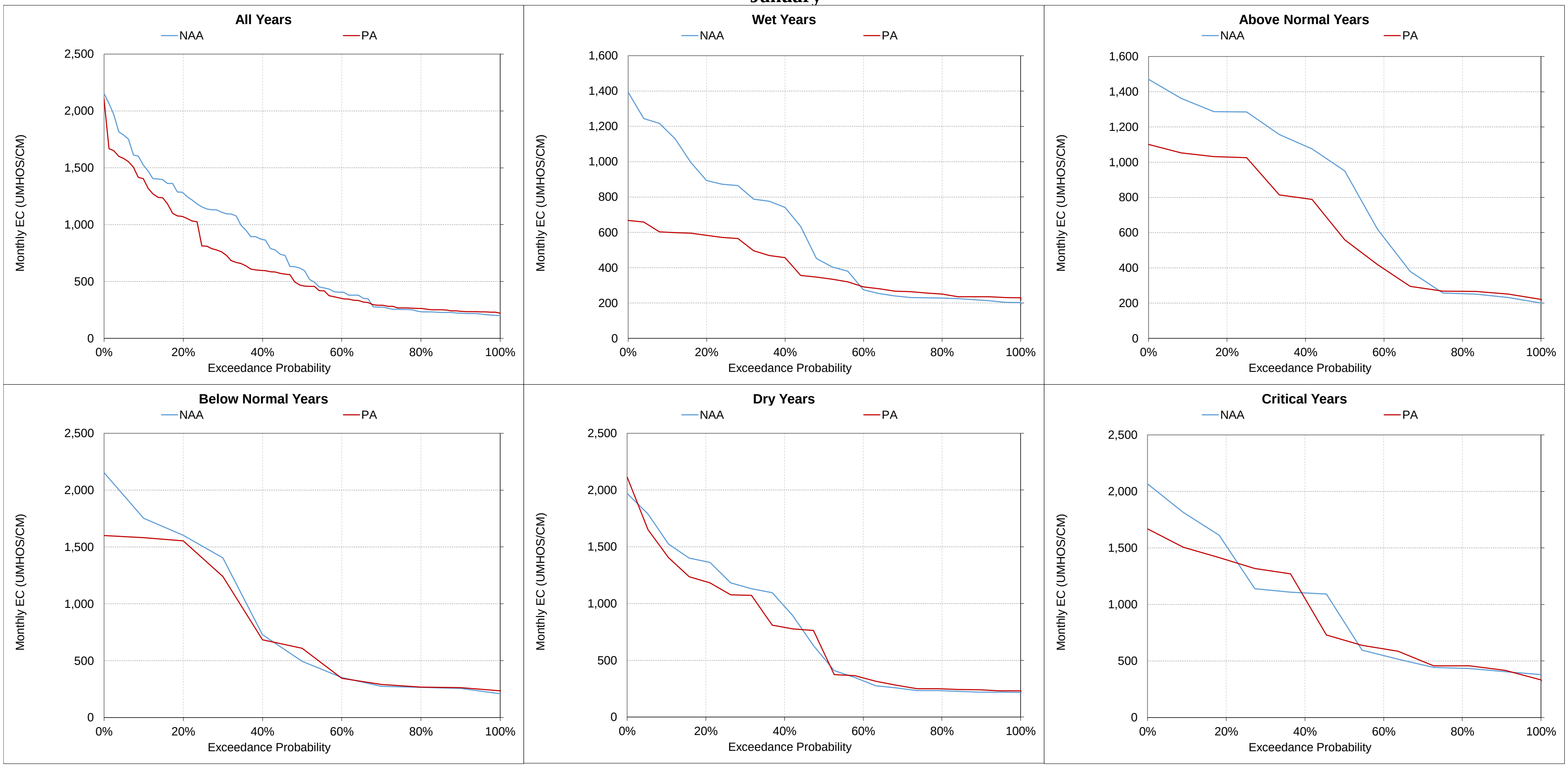
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-13-10. San Joaquin River at Jersey Point Salinity, Monthly EC
December



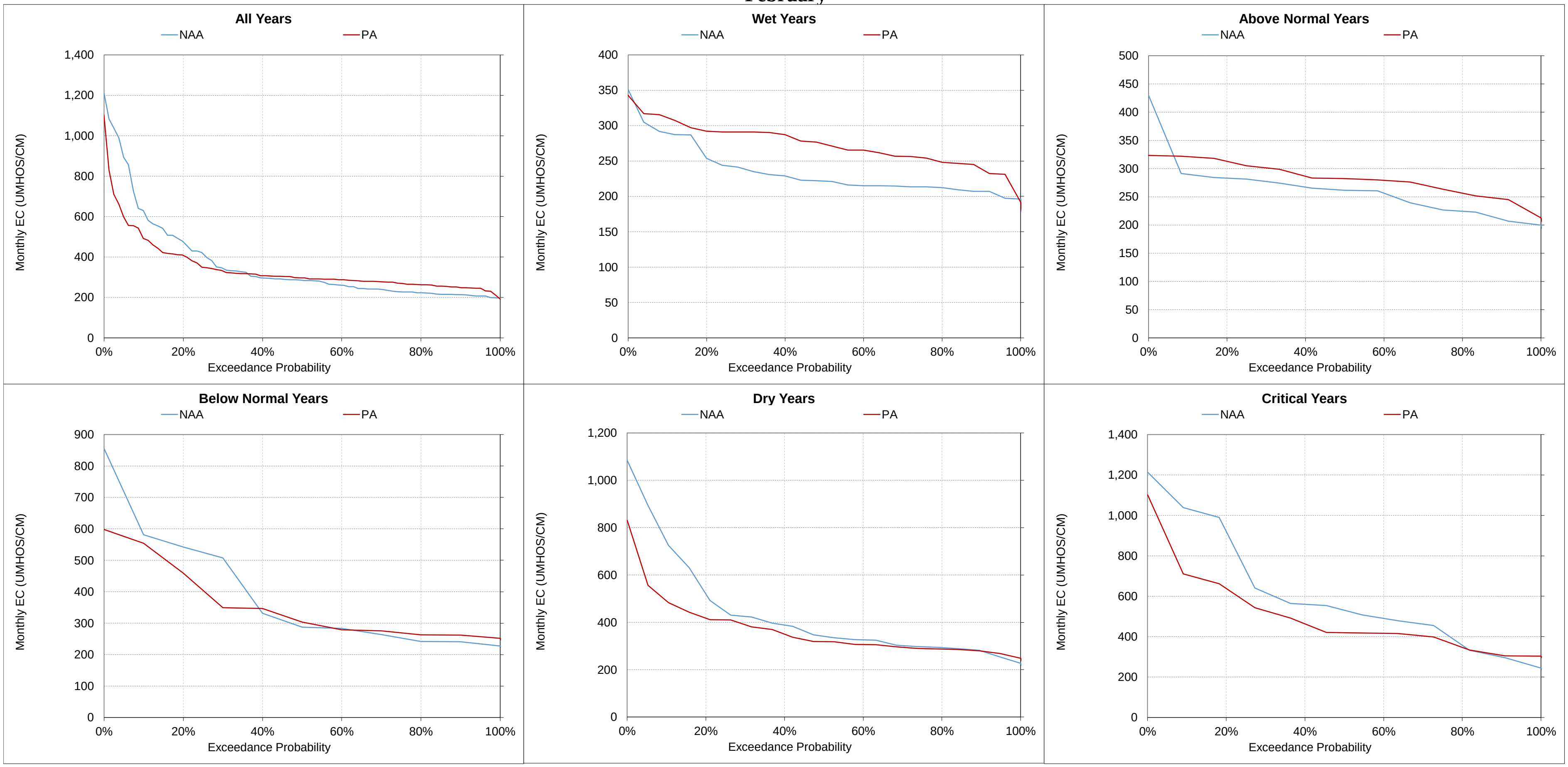
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-13-11. San Joaquin River at Jersey Point Salinity, Monthly EC January



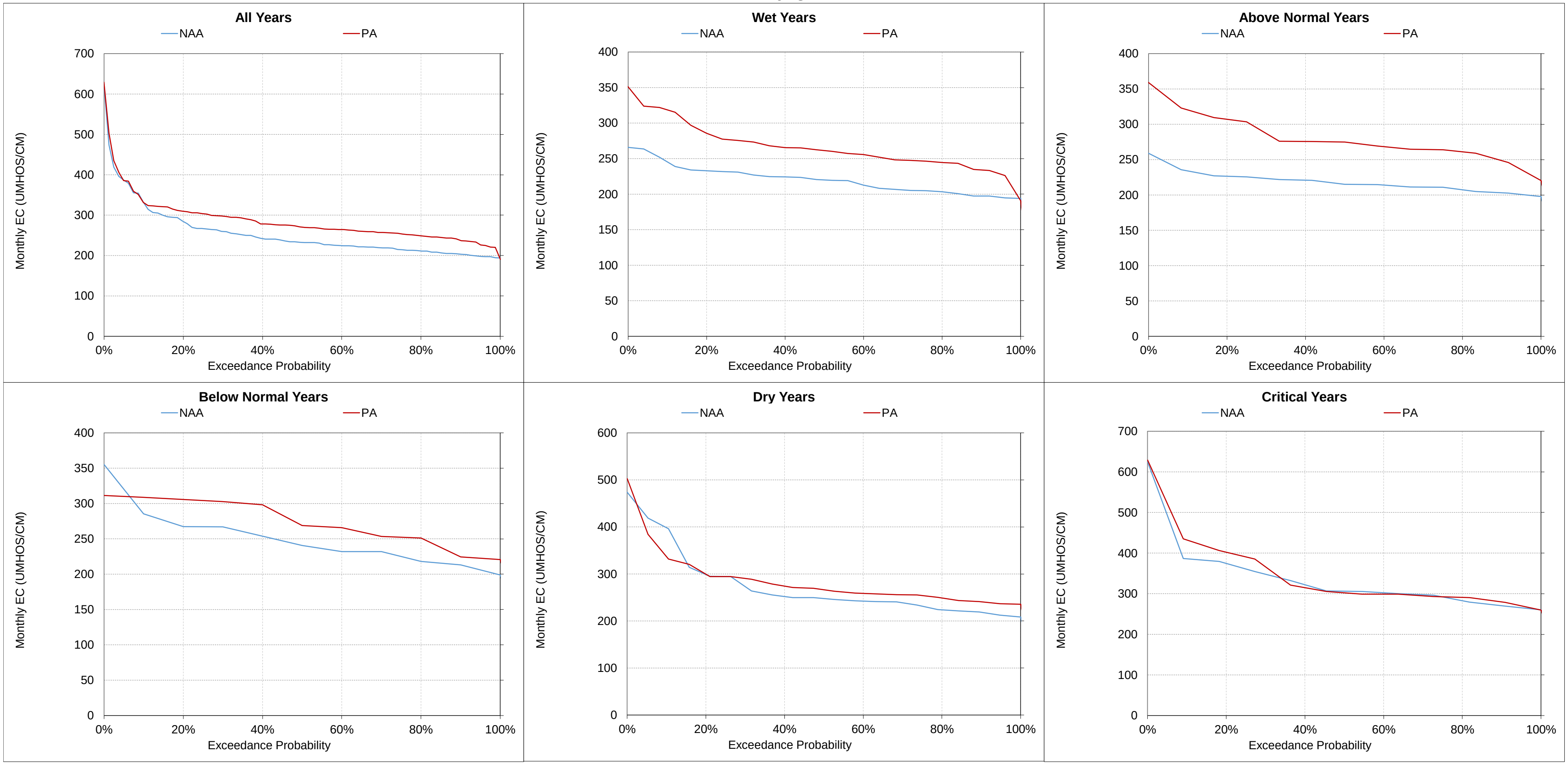
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-13-12. San Joaquin River at Jersey Point Salinity, Monthly EC
February



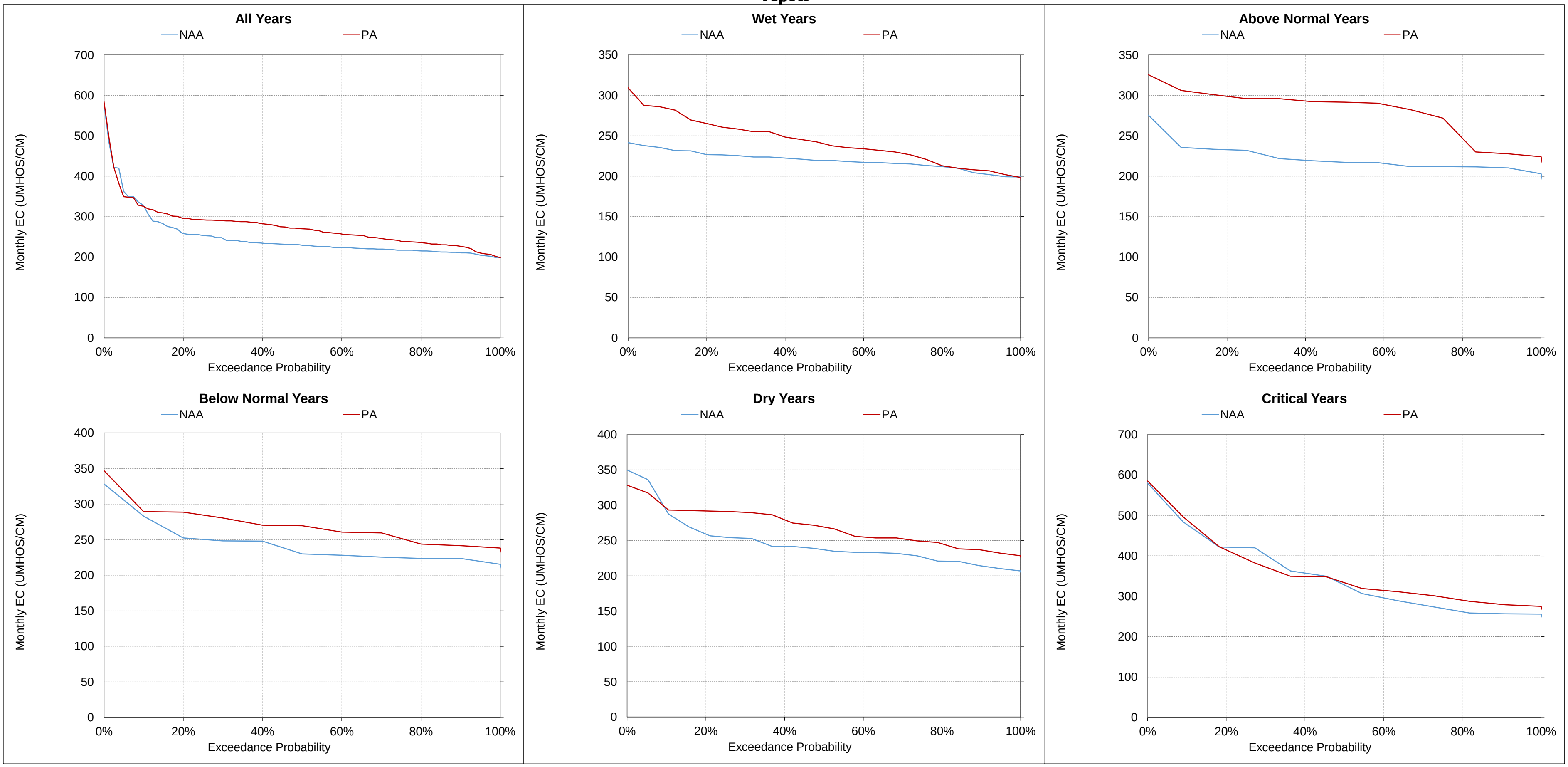
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-13-13. San Joaquin River at Jersey Point Salinity, Monthly EC March



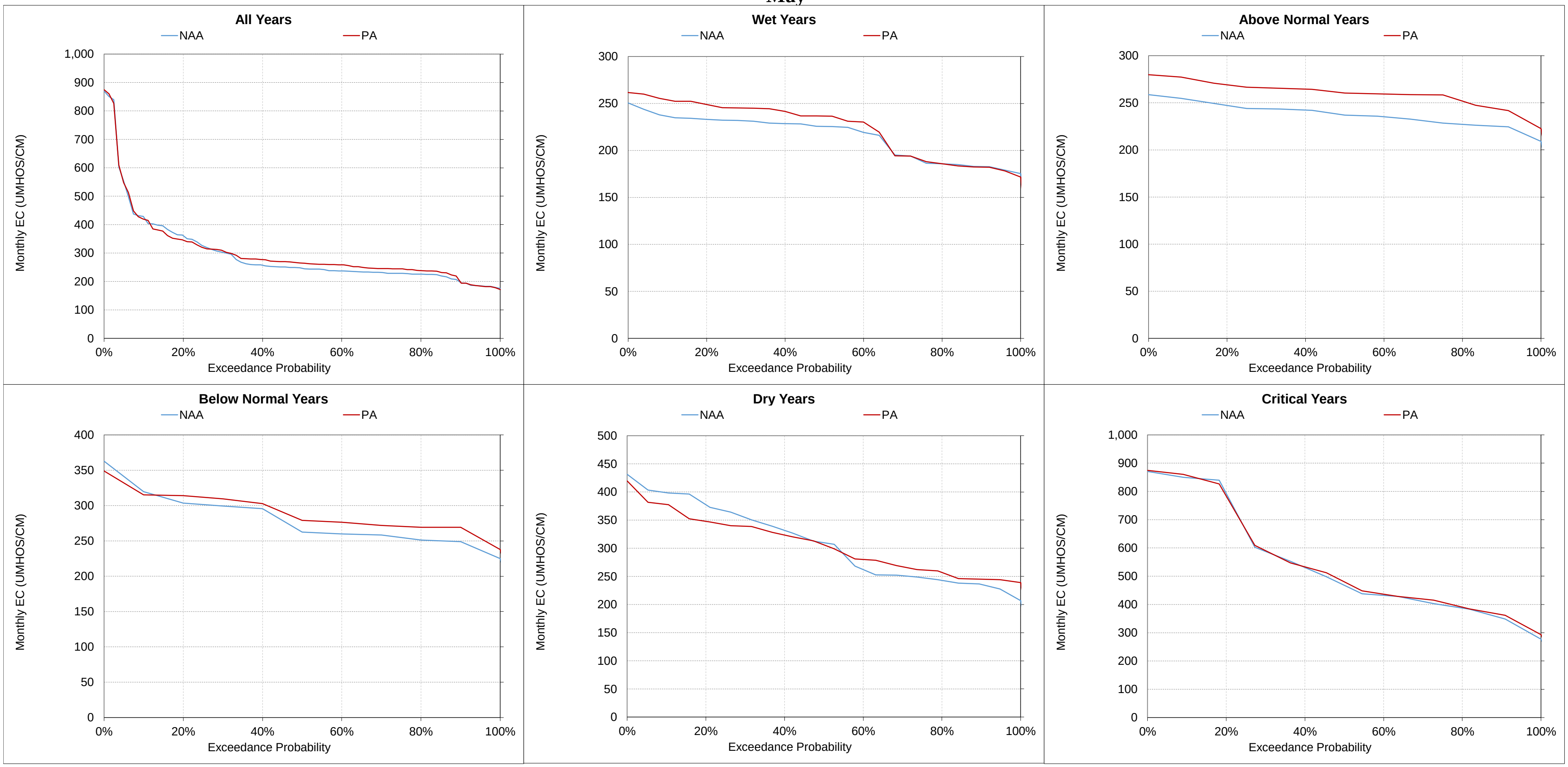
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-13-14. San Joaquin River at Jersey Point Salinity, Monthly EC April



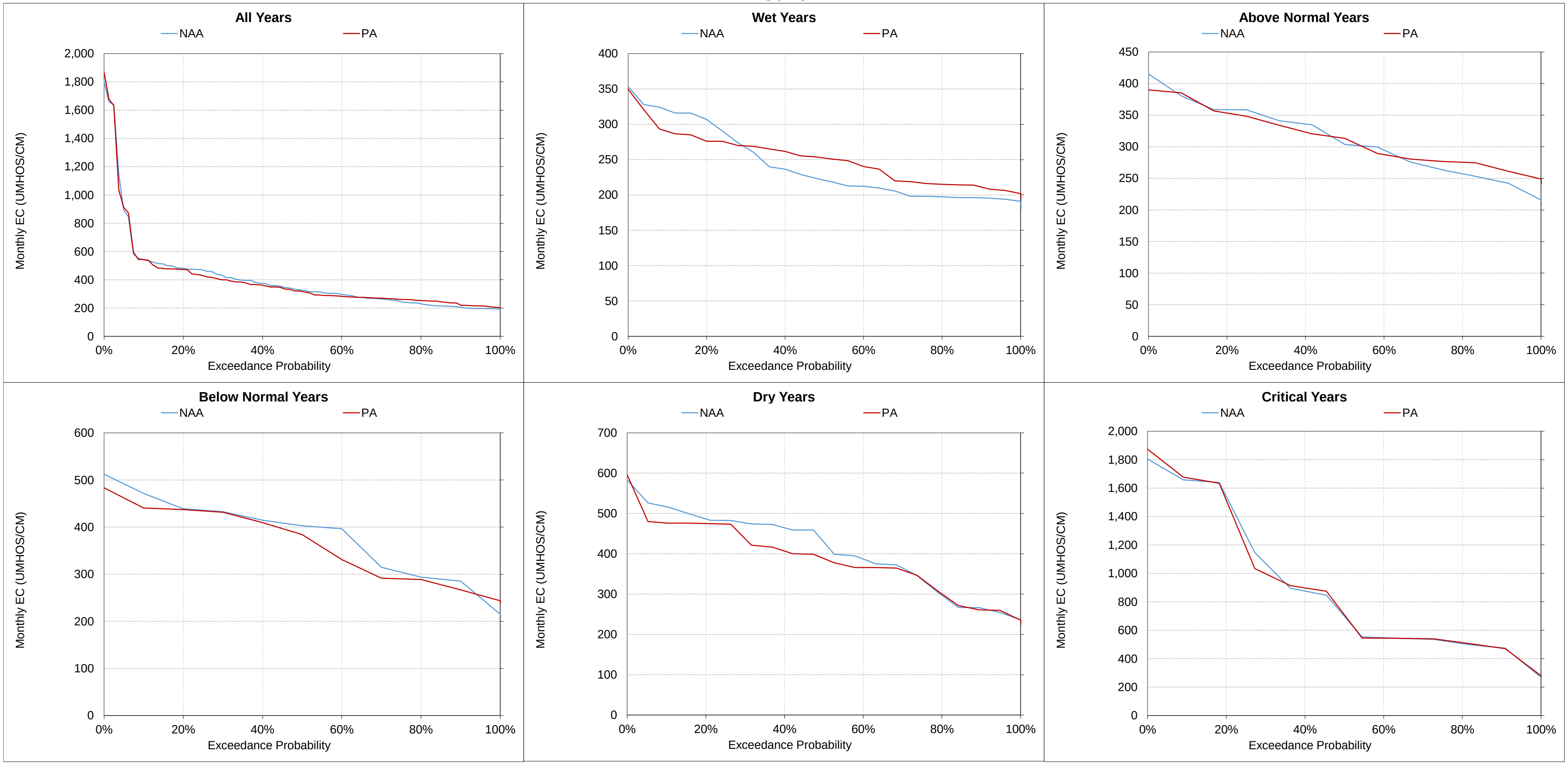
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

**Figure 5.B.5-13-15. San Joaquin River at Jersey Point Salinity, Monthly EC
May**



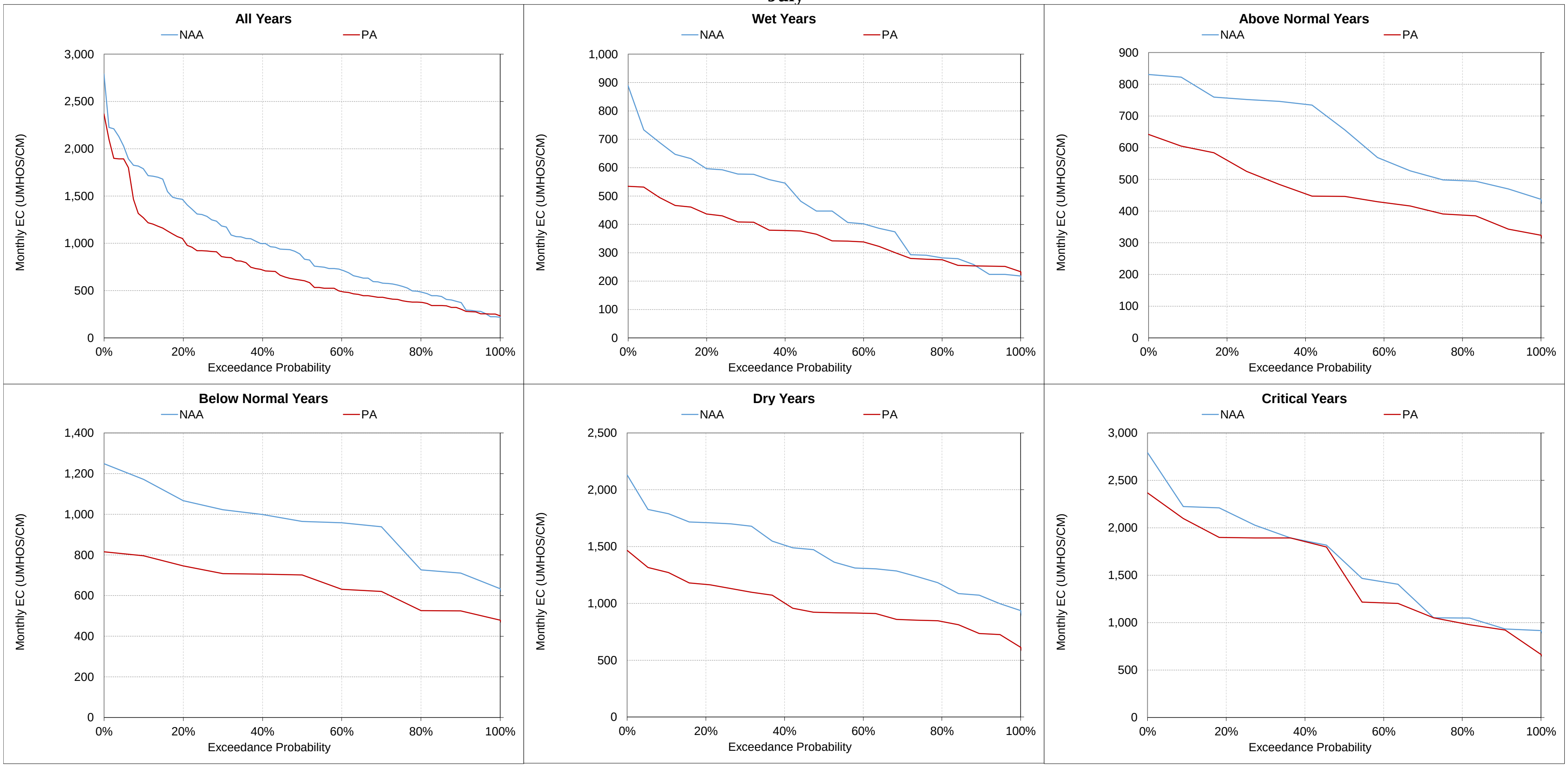
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-13-16. San Joaquin River at Jersey Point Salinity, Monthly EC June



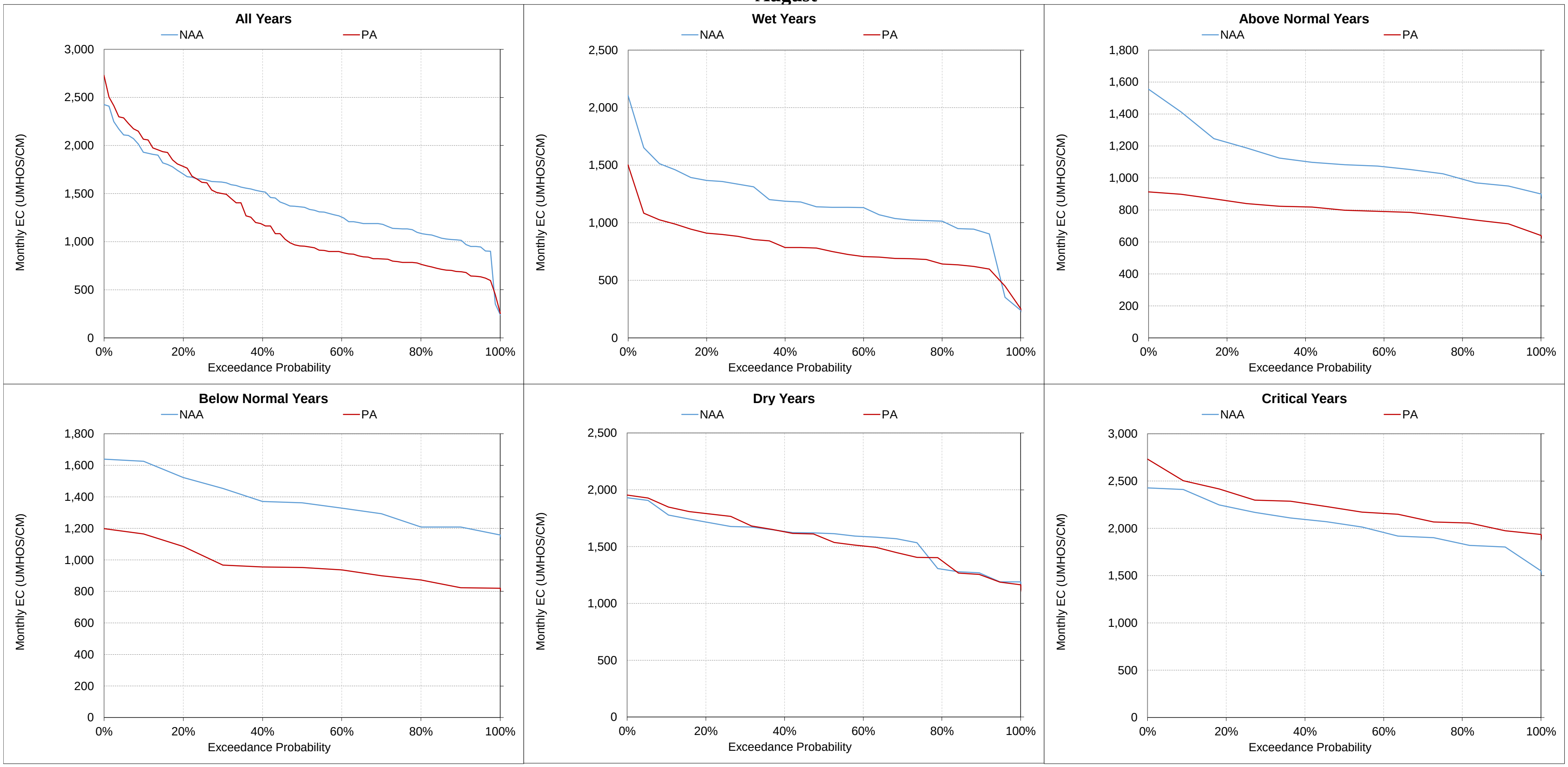
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-13-17. San Joaquin River at Jersey Point Salinity, Monthly EC
July



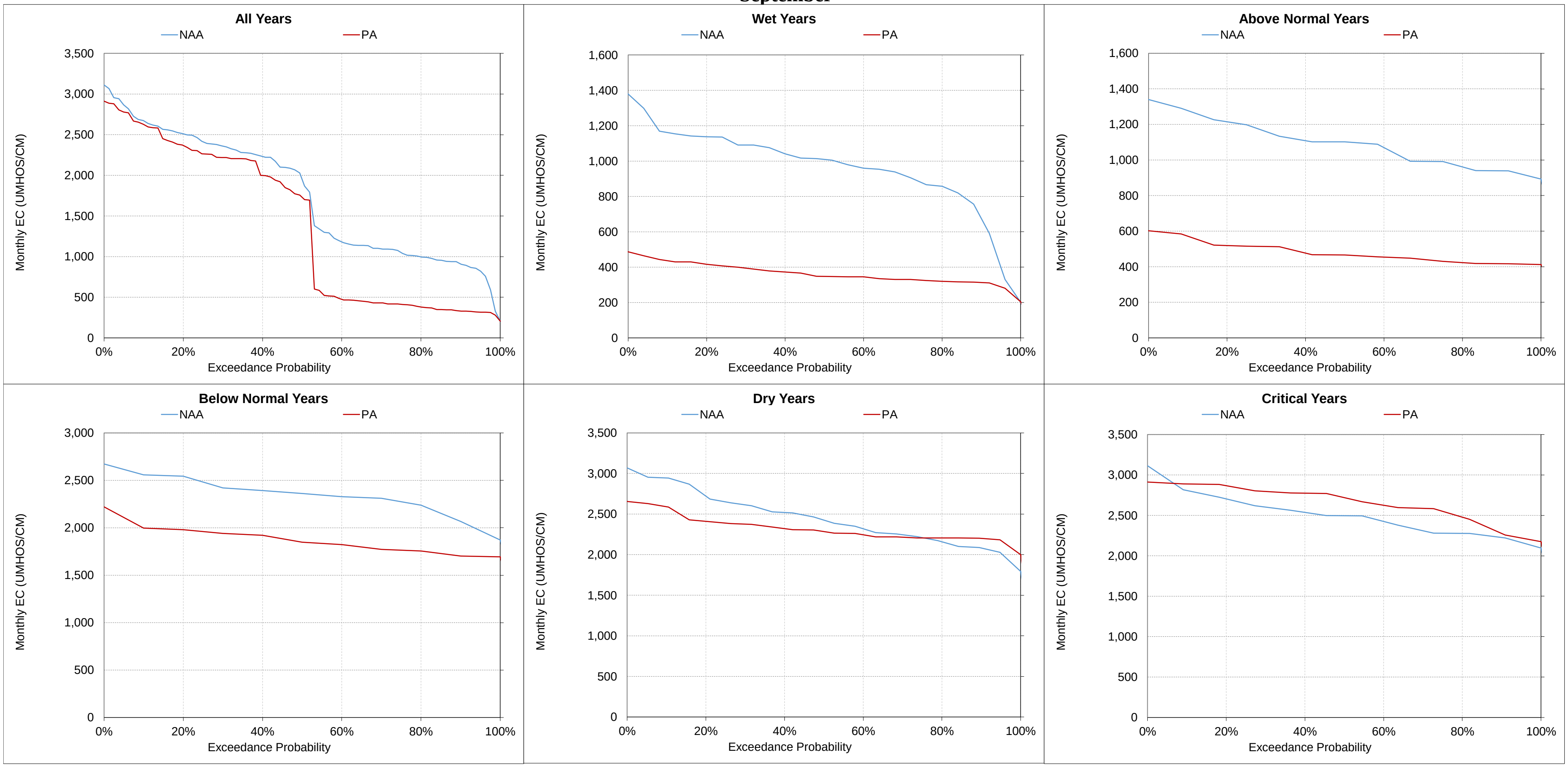
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-13-18. San Joaquin River at Jersey Point Salinity, Monthly EC
August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-13-19. San Joaquin River at Jersey Point Salinity, Monthly EC September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-14. Sacramento River at Collinsville Salinity, Monthly EC

Statistic	Monthly EC (UMHOS/CM)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	11,506	10,307	-1,199	-10%	12,262	10,861	-1,401	-11%	9,360	8,966	-394	-4%	5,300	5,300	0	0%	2,282	2,107	-176	-8%	1,544	1,458	-86	-6%
20%	10,221	8,979	-1,242	-12%	10,130	8,901	-1,229	-12%	7,487	7,641	154	2%	4,764	4,070	-694	-15%	1,375	1,418	42	3%	947	1,007	60	6%
30%	10,002	8,583	-1,419	-14%	9,737	8,167	-1,571	-16%	4,768	5,124	356	7%	3,647	3,013	-634	-17%	904	884	-21	-2%	508	597	89	17%
40%	9,866	8,174	-1,692	-17%	7,760	7,315	-445	-6%	4,001	3,998	-3	0%	2,258	1,960	-298	-13%	591	655	64	11%	403	486	83	21%
50%	8,460	7,540	-920	-11%	4,334	3,866	-468	-11%	3,266	3,451	184	6%	1,427	1,175	-252	-18%	378	381	3	1%	274	328	55	20%
60%	3,490	3,249	-241	-7%	3,338	3,197	-140	-4%	2,858	3,006	148	5%	691	817	126	18%	221	249	28	13%	214	255	40	19%
70%	1,520	1,445	-75	-5%	1,957	1,977	21	1%	1,409	1,408	-1	0%	247	273	26	11%	201	211	10	5%	198	217	19	10%
80%	1,377	1,350	-27	-2%	1,464	1,430	-33	-2%	788	1,074	286	36%	211	220	10	5%	191	205	14	7%	190	205	14	8%
90%	1,291	1,285	-6	0%	1,256	1,245	-11	-1%	241	276	35	15%	190	197	7	4%	188	196	8	4%	188	199	10	5%
Long Term																								
Full Simulation Period[b]	6,297	5,614	-683	-11%	5,897	5,355	-543	-9%	4,037	4,106	69	2%	2,297	2,062	-235	-10%	929	860	-69	-7%	615	659	43	7%
Water Year Types[c]																								
Wet (32%)	1,345	1,323	-22	-2%	1,387	1,401	14	1%	1,917	1,958	41	2%	1,784	1,185	-599	-34%	220	217	-3	-1%	211	230	19	9%
Above Normal (16%)	3,286	3,004	-281	-9%	3,269	3,186	-83	-3%	2,939	3,047	108	4%	2,398	2,177	-222	-9%	403	360	-43	-11%	235	251	17	7%
Below Normal (13%)	8,974	7,740	-1,234	-14%	7,989	6,928	-1,062	-13%	5,043	5,066	23	0%	2,529	2,514	-15	-1%	1,155	951	-204	-18%	675	675	0	0%
Dry (24%)	9,954	8,631	-1,323	-13%	8,535	7,509	-1,026	-12%	4,732	4,703	-29	-1%	2,277	2,313	36	2%	1,238	1,117	-122	-10%	725	805	80	11%
Critical (15%)	11,740	10,760	-981	-8%	12,204	11,237	-967	-8%	7,737	8,032	295	4%	3,121	3,006	-114	-4%	2,312	2,285	-28	-1%	1,665	1,770	105	6%

Statistic	Monthly EC (UMHOS/CM)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	2,151	2,171	20	1%	3,079	3,043	-35	-1%	4,482	4,448	-35	-1%	6,753	6,854	100	1%	8,485	9,117	632	7%	9,950	10,307	357	4%
20%	1,256	1,341	85	7%	2,643	2,460	-182	-7%	3,626	3,532	-94	-3%	5,492	5,922	430	8%	7,236	7,719	484	7%	8,934	9,809	875	10%
30%	889	991	102	11%	2,059	2,023	-36	-2%	3,356	3,302	-55	-2%	4,974	5,216	242	5%	6,701	7,099	399	6%	8,667	9,574	907	10%
40%	573	578	5	1%	1,120	1,115	-5	0%	2,898	2,819	-79	-3%	3,740	4,565	825	22%	5,784	6,711	927	16%	7,934	9,188	1,254	16%
50%	392	398	5	1%	754	733	-21	-3%	2,245	2,095	-150	-7%	3,068	3,931	863	28%	5,057	5,754	697	14%	6,983	8,606	1,623	23%
60%	263	295	31	12%	456	445	-11	-2%	1,945	1,772	-173	-9%	2,571	3,398	827	32%	4,658	5,432	775	17%	3,107	3,295	188	6%
70%	235	252	18	8%	331	329	-2	-1%	1,409	1,474	65	5%	2,309	3,041	733	32%	4,424	5,243	819	19%	2,127	2,314	188	9%
80%	198	216	18	9%	220	230	10	4%	919	893	-26	-3%	2,065	2,600	535	26%	3,995	5,087	1,092	27%	1,597	1,724	127	8%
90%	188	195	8	4%	188	189	1	1%	295	331	36	12%	1,662	1,797	135	8%	3,828	4,801	973	25%	1,342	1,492	150	11%
Long Term																								
Full Simulation Period[b]	807	828	21	3%	1,374	1,351	-24	-2%	2,558	2,502	-56	-2%	3,749	4,238	489	13%	5,599	6,345	746	13%	5,577	6,147	571	10%
Water Year Types[c]																								
Wet (32%)	246	256	11	4%	339	340	1	0%	1,036	986	-50	-5%	1,800	2,208	409	23%	4,236	4,972	736	17%	1,522	1,698	176	12%
Above Normal (16%)	295	312	17	6%	524	527	2	0%	1,903	1,863	-40	-2%	2,426	3,330	904	37%	4,125	5,170	1,045	25%	3,152	3,345	193	6%
Below Normal (13%)	899	928	29	3%	1,420	1,392	-27	-2%	2,800	2,662	-138	-5%	3,272	4,184	912	28%	4,947	5,997	1,050	21%	7,518	8,854	1,336	18%
Dry (24%)	909	962	52	6%	1,788	1,696	-91	-5%	3,019	2,942	-78	-3%	5,256	5,546	289	6%	6,760	7,356	596	9%	8,741	9,711	970	11%
Critical (15%)	2,326	2,314	-12	-1%	3,809	3,819	11	0%	5,574	5,597	23	0%	7,328	7,488	161	2%	8,814	9,227	413	5%	9,934	10,402	468	5%

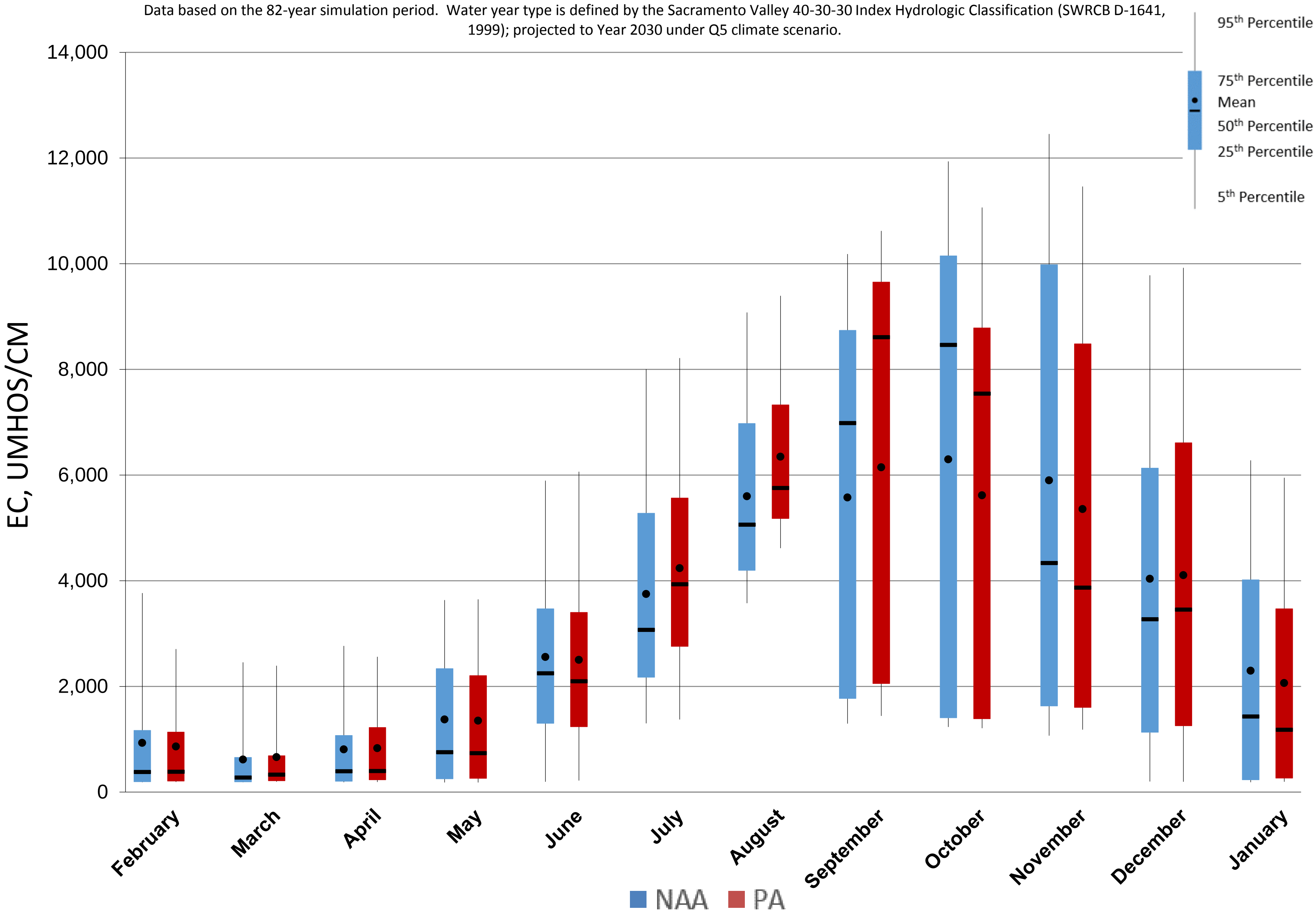
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-14-1. Monthly EC Ranges For Sacramento River at Collinsville Salinity, All Years



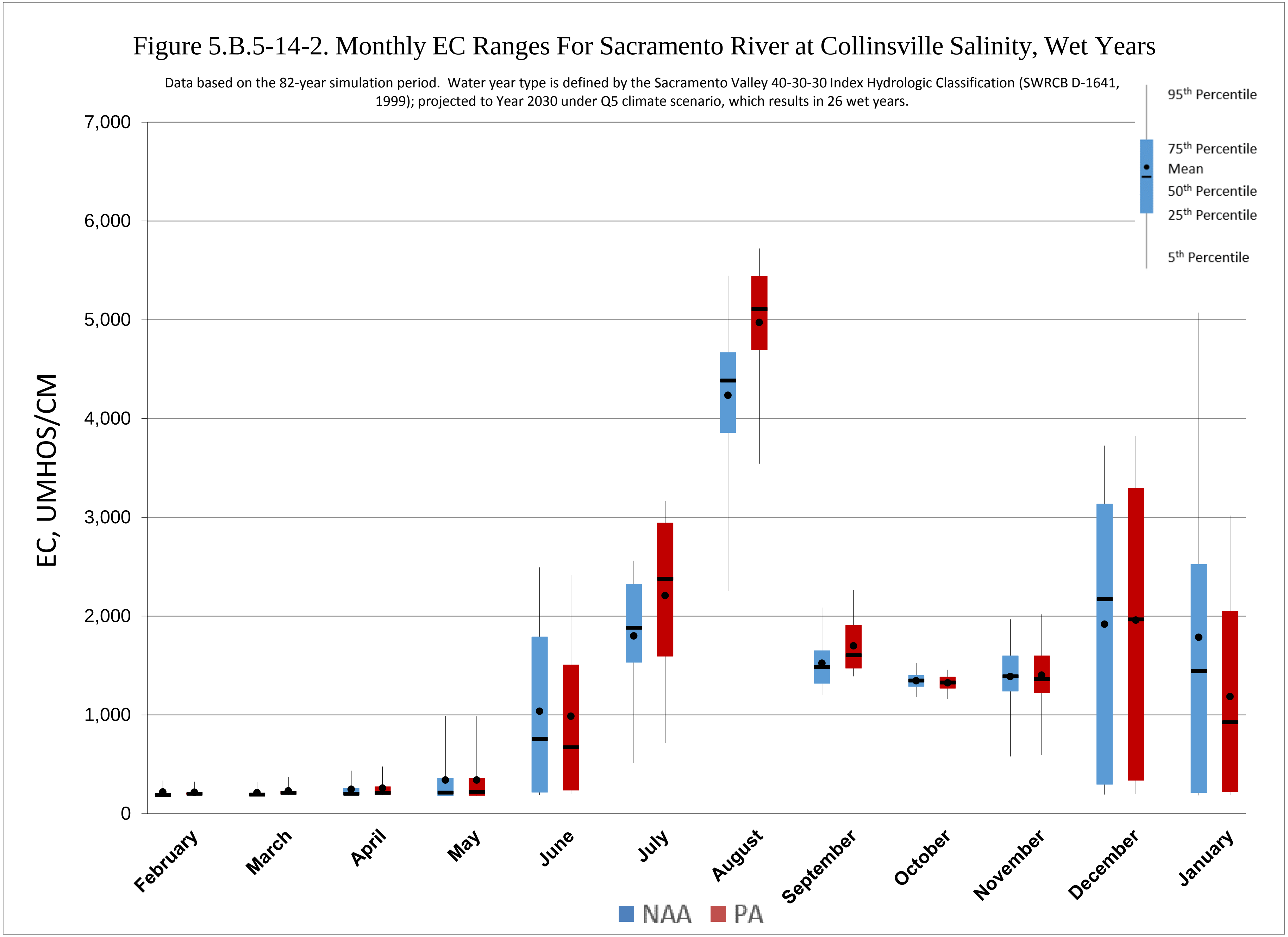


Figure 5.B.5-14-2. Monthly EC Ranges For Sacramento River at Collinsville Salinity, Wet Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 26 wet years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
EC, UMHOS/CM
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-14-3. Monthly EC Ranges For Sacramento River at Collinsville Salinity, Above Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 13 above normal years.

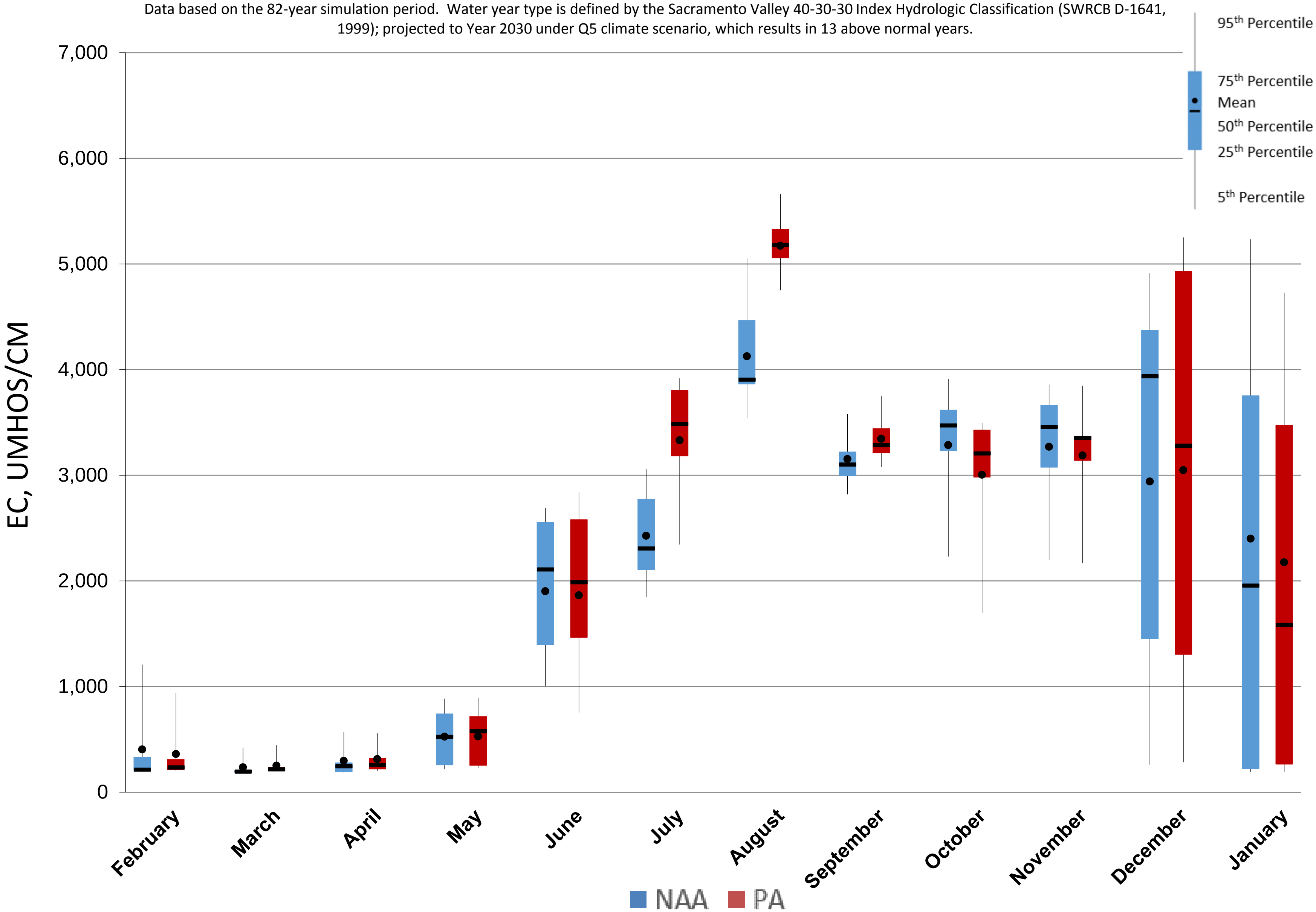
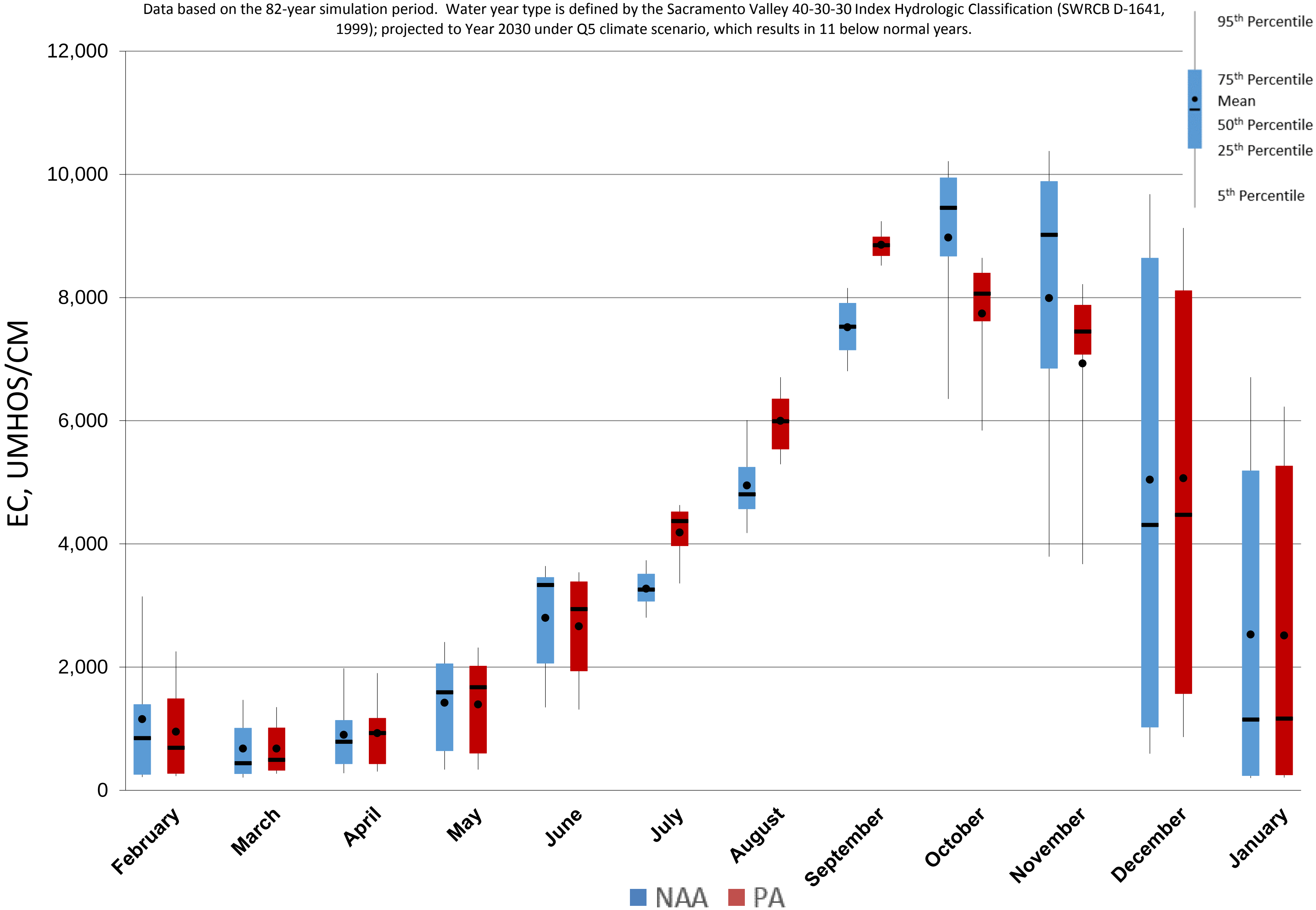


Figure 5.B.5-14-4. Monthly EC Ranges For Sacramento River at Collinsville Salinity, Below Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 11 below normal years.



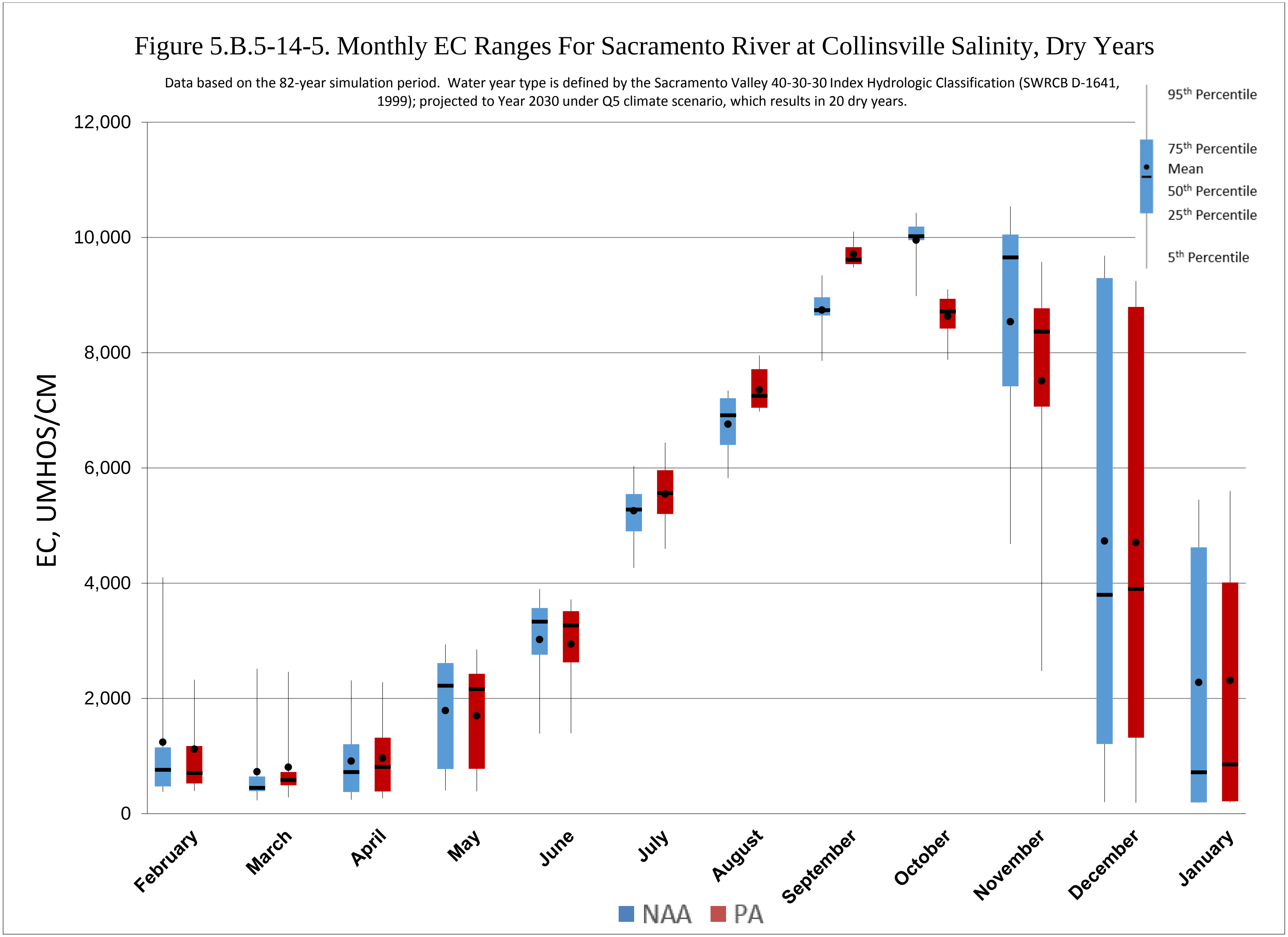


Figure 5.B.5-14-5. Monthly EC Ranges For Sacramento River at Collinsville Salinity, Dry Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 20 dry years.
EC, UMHOS/CM
12,000
10,000
8,000
6,000
4,000
2,000
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile

Figure 5.B.5-14-6. Monthly EC Ranges For Sacramento River at Collinsville Salinity, Critical Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 12 critical years.

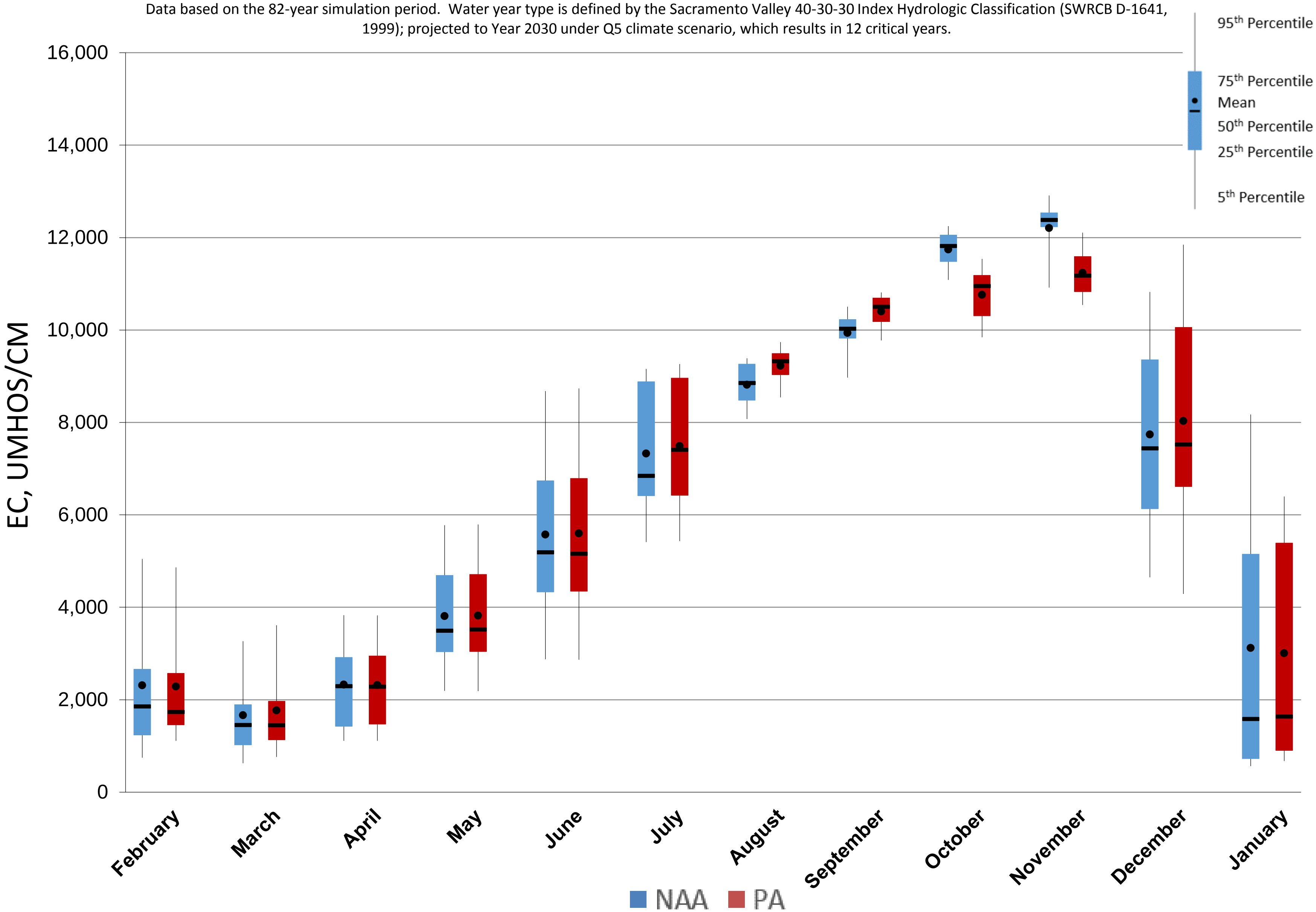
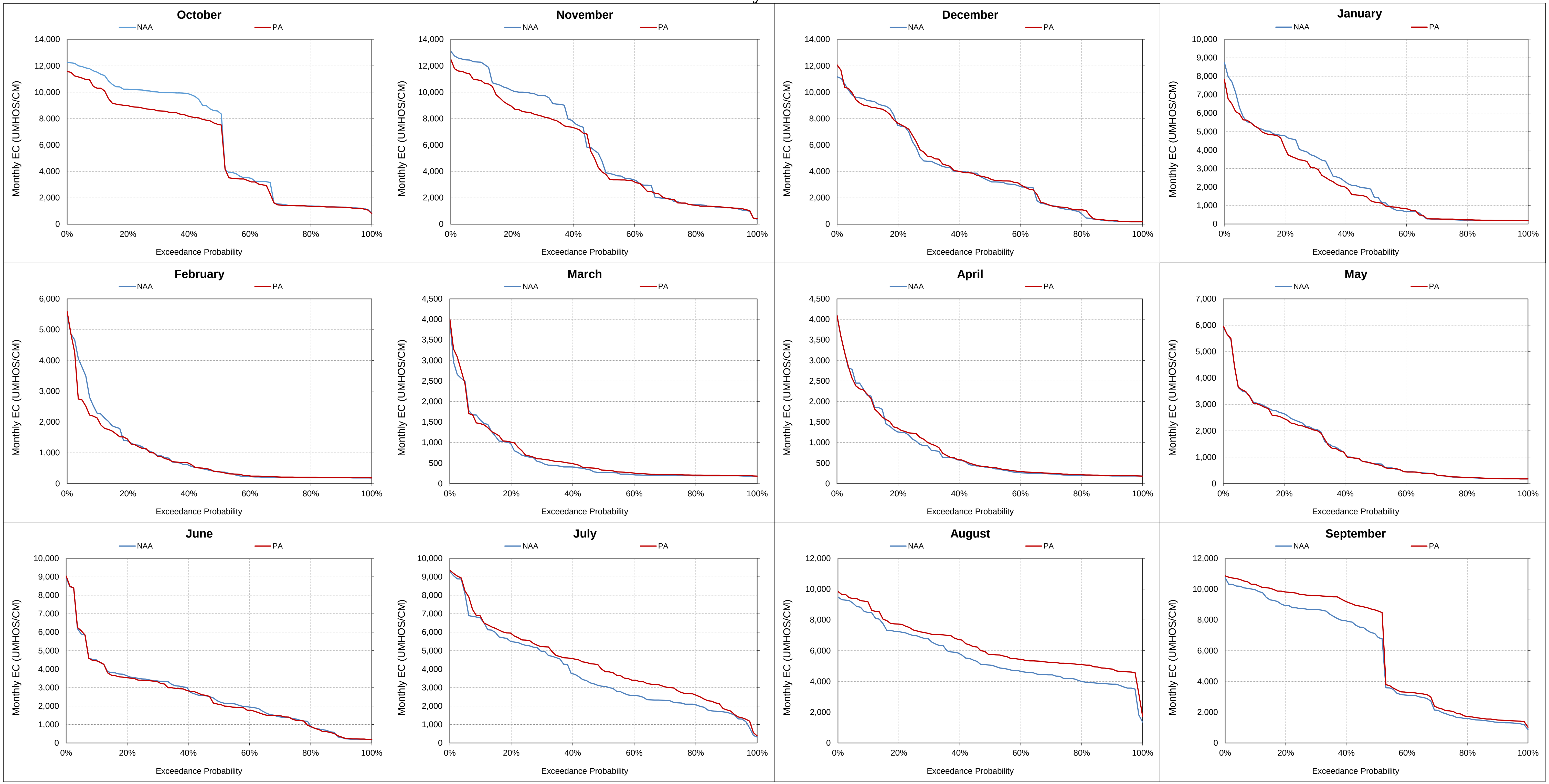
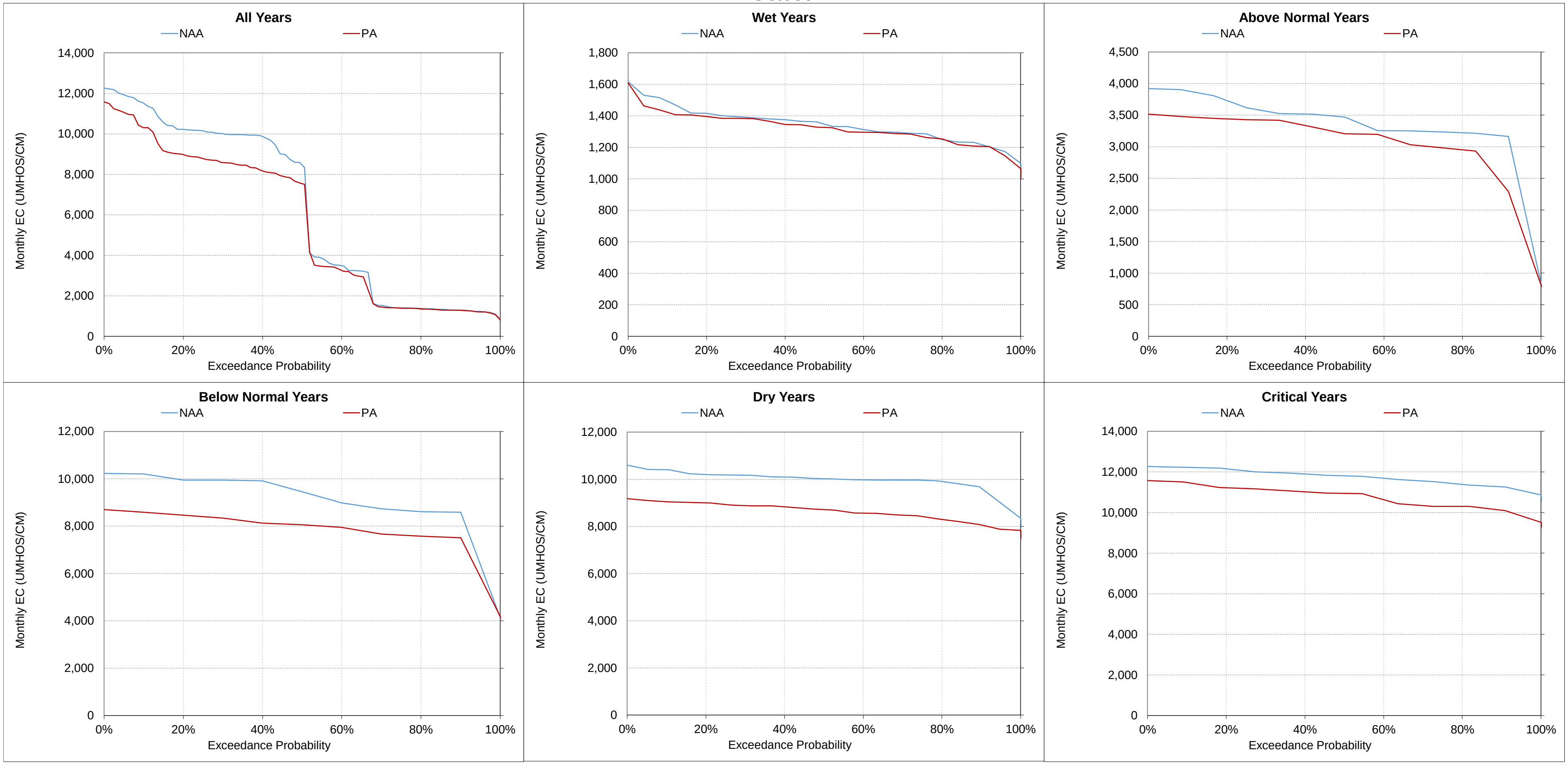


Figure 5.B.5-14-7. Sacramento River at Collinsville Salinity, Monthly EC Probability of Exceedance



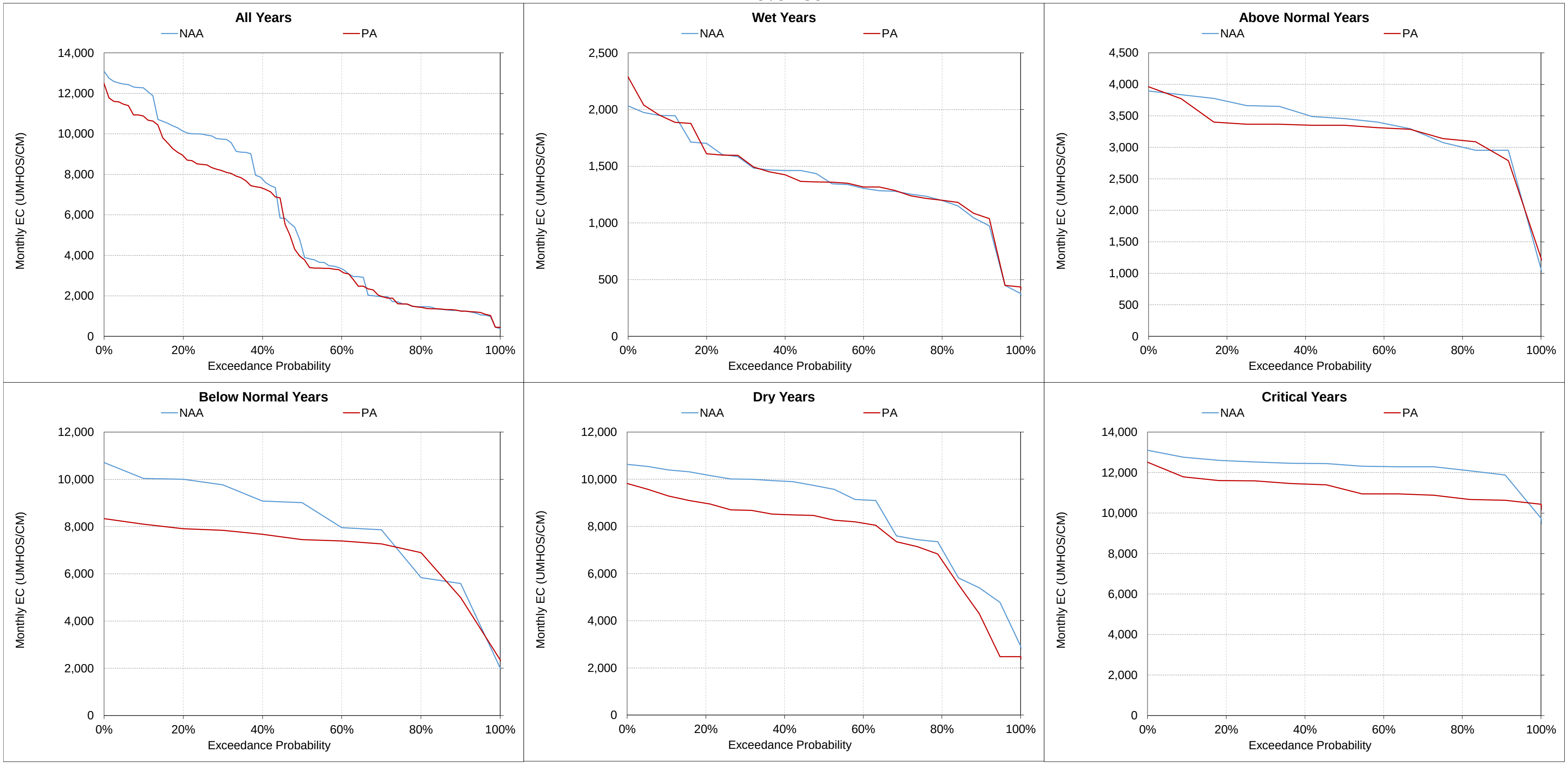
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-14-8. Sacramento River at Collinsville Salinity, Monthly EC October



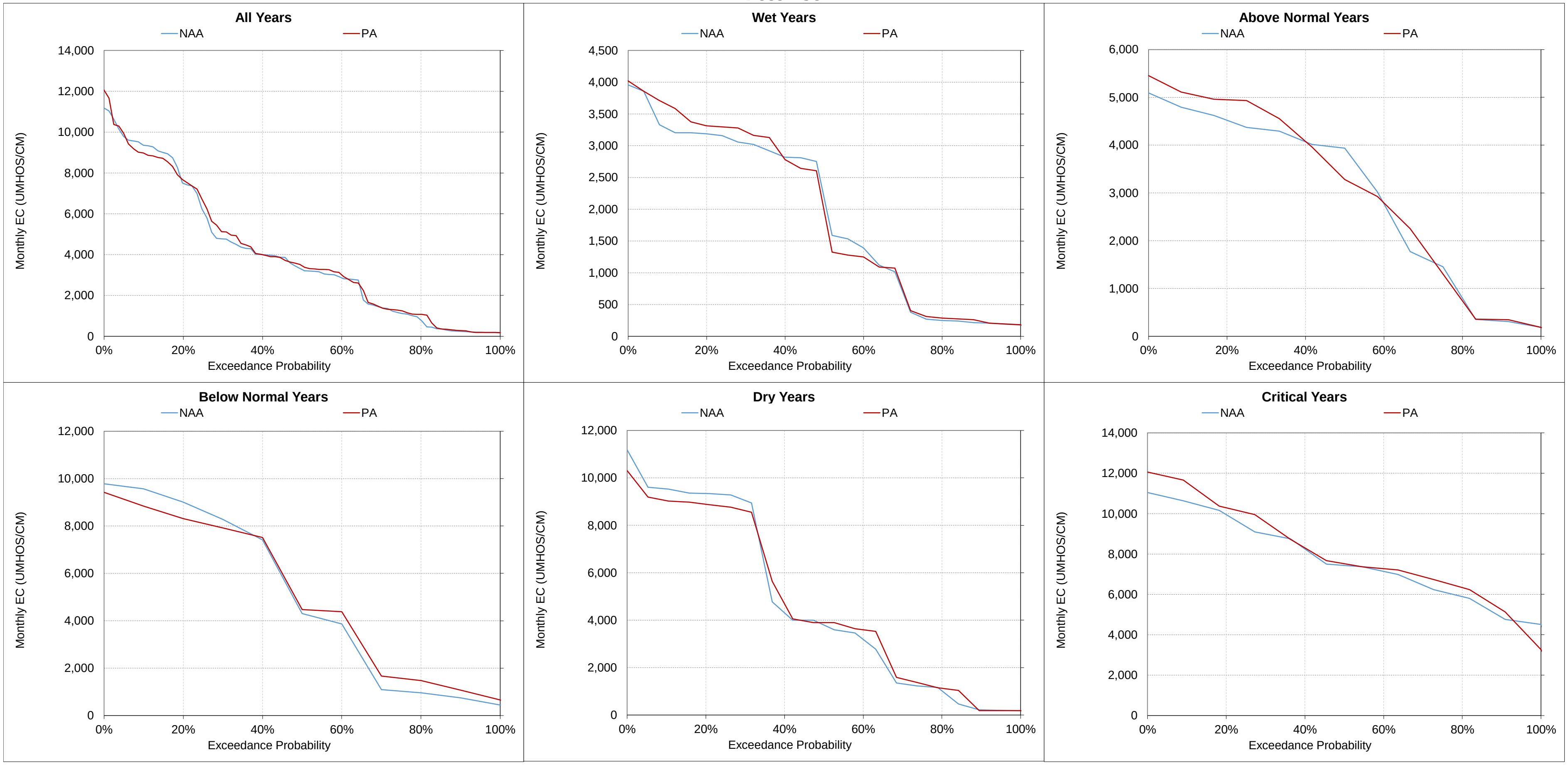
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-14-9. Sacramento River at Collinsville Salinity, Monthly EC
November



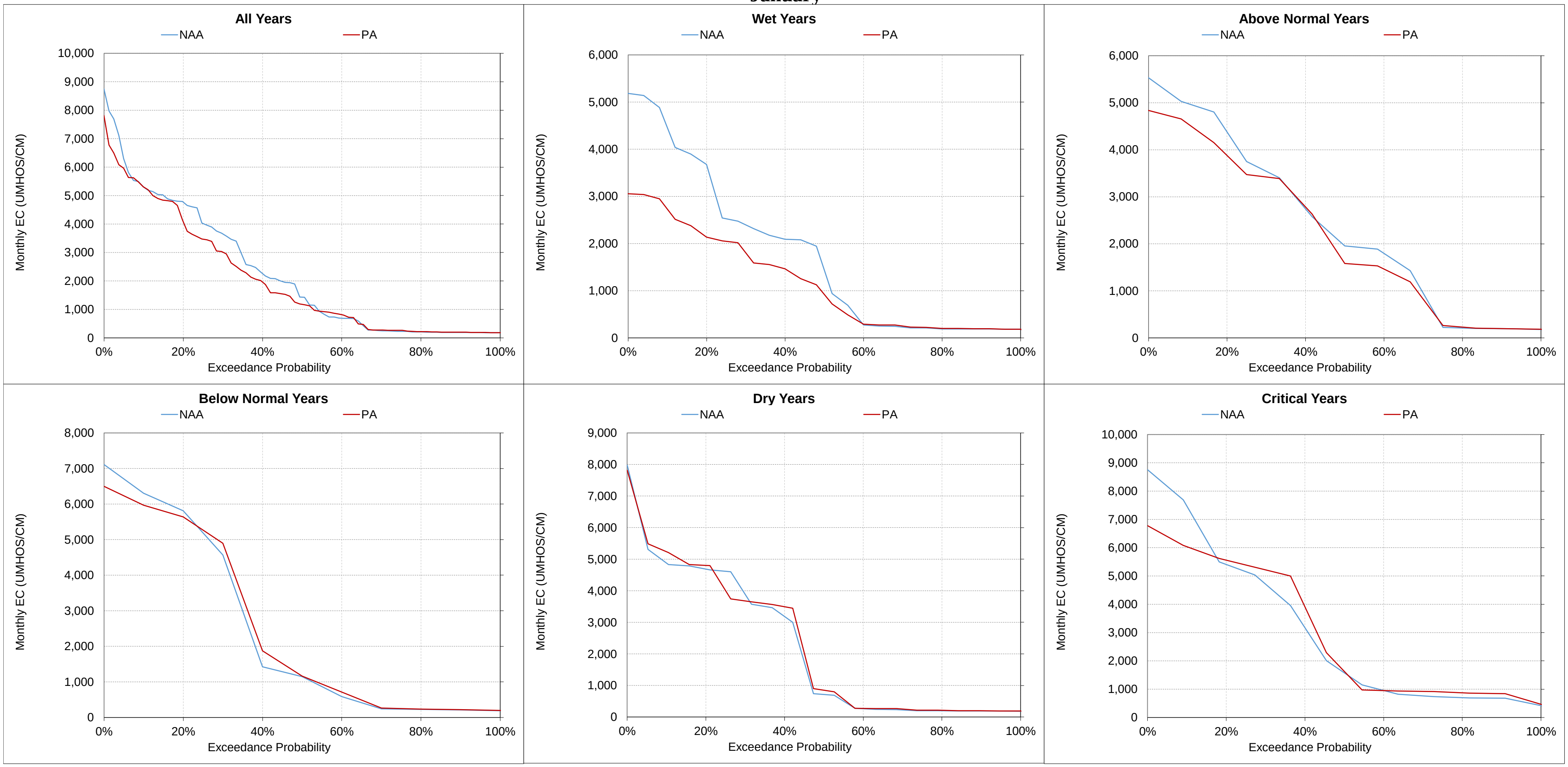
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-14-10. Sacramento River at Collinsville Salinity, Monthly EC
December



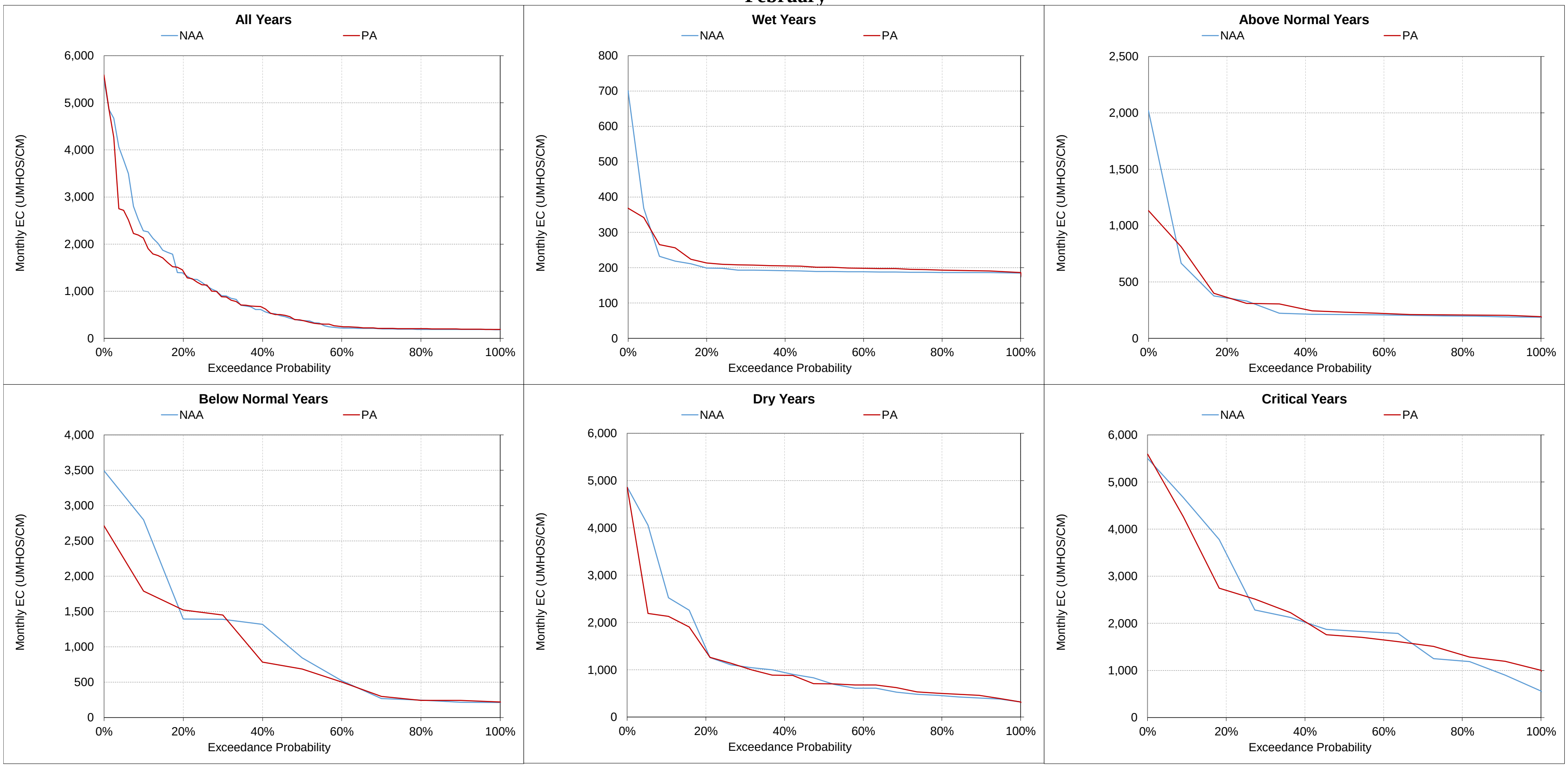
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-14-11. Sacramento River at Collinsville Salinity, Monthly EC January



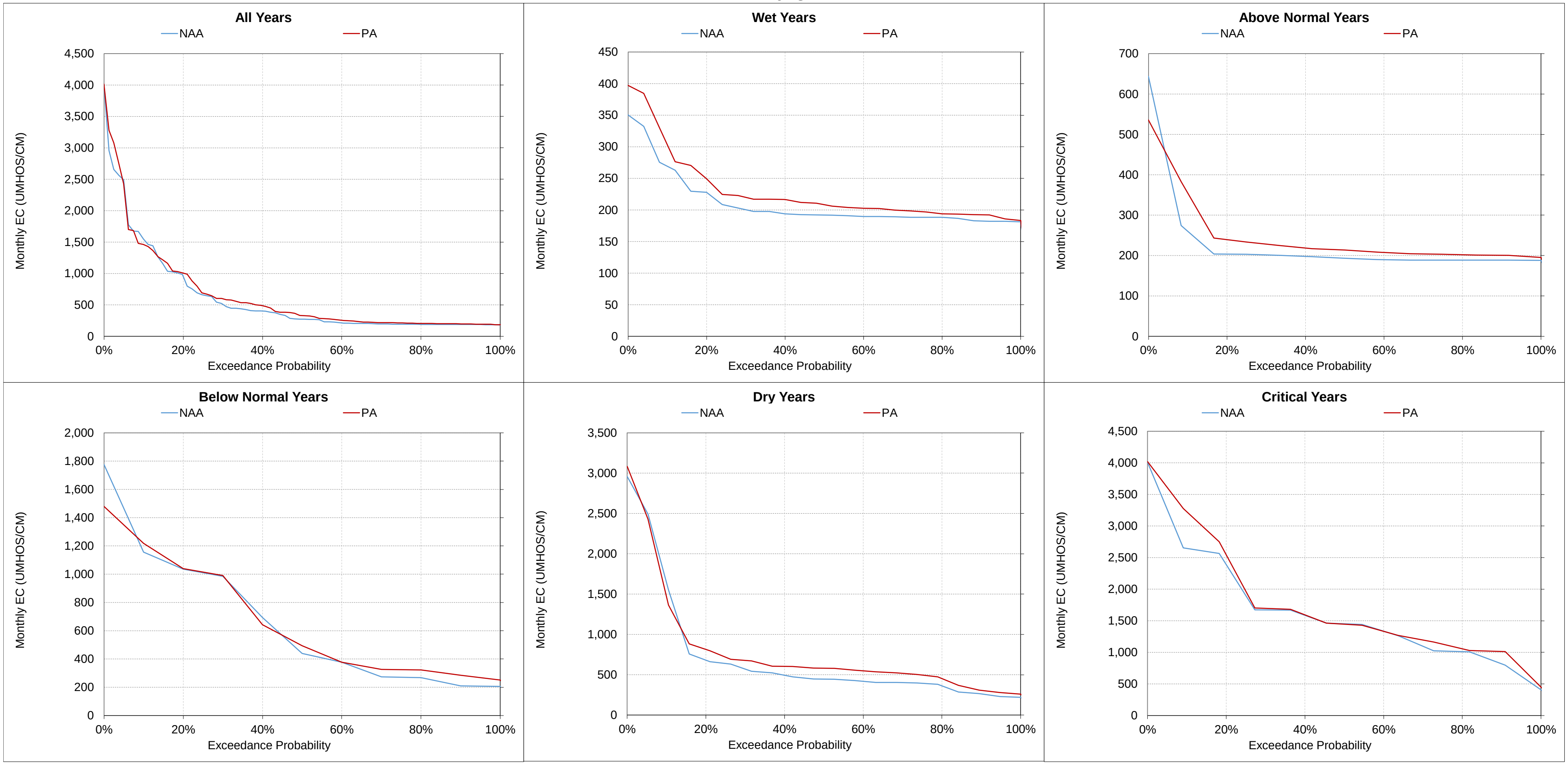
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-14-12. Sacramento River at Collinsville Salinity, Monthly EC February



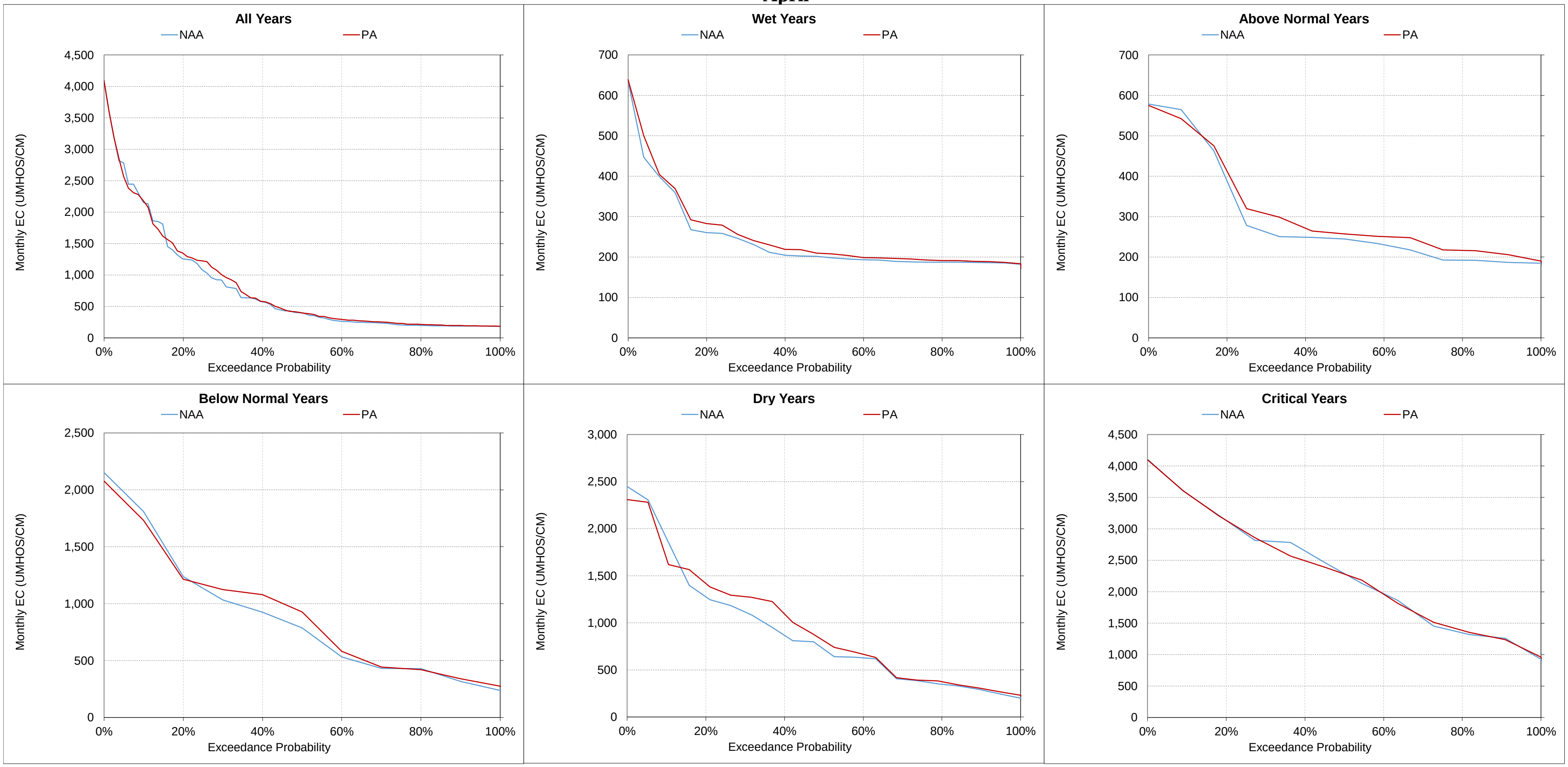
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-14-13. Sacramento River at Collinsville Salinity, Monthly EC March



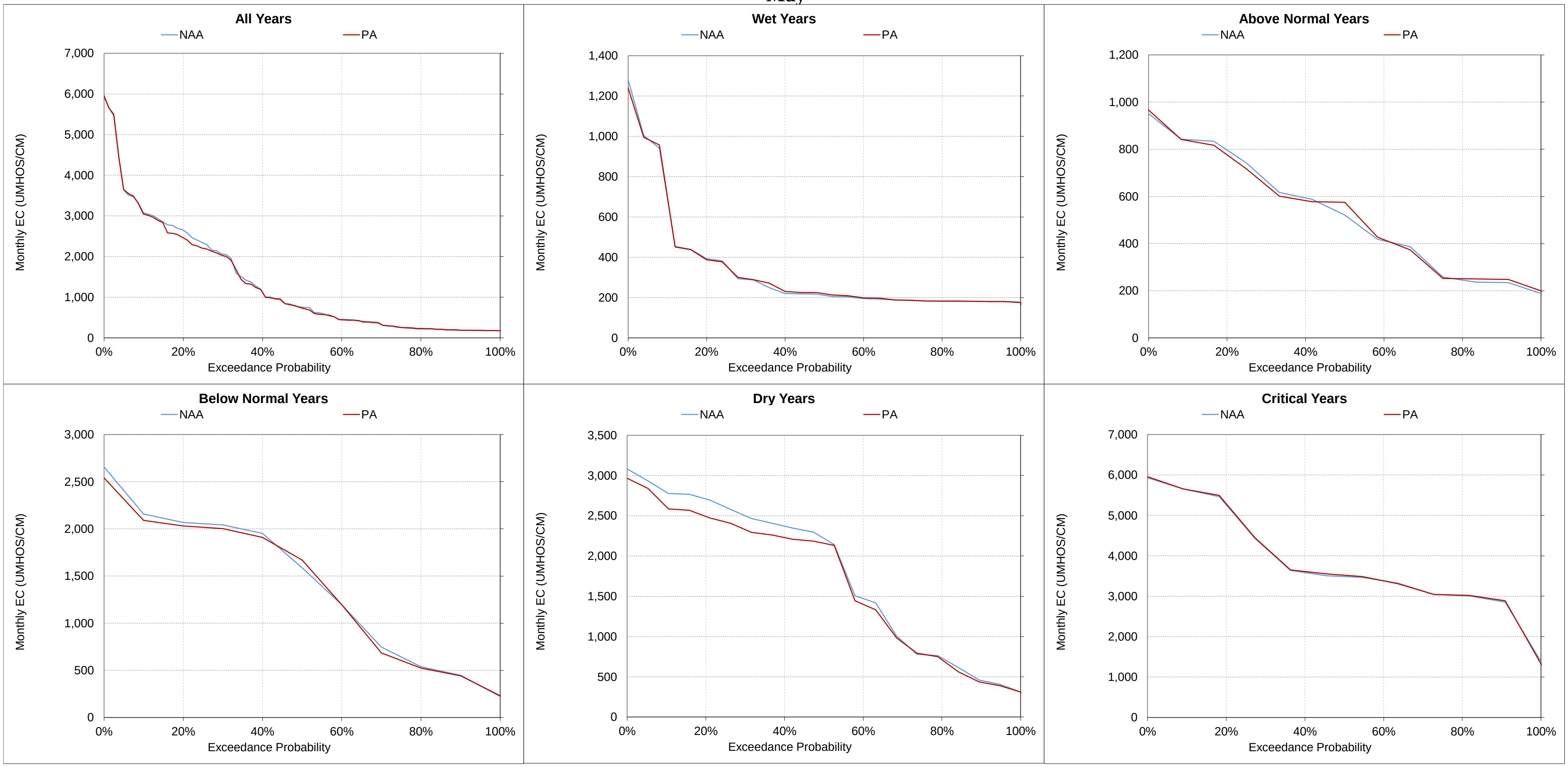
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-14-14. Sacramento River at Collinsville Salinity, Monthly EC April



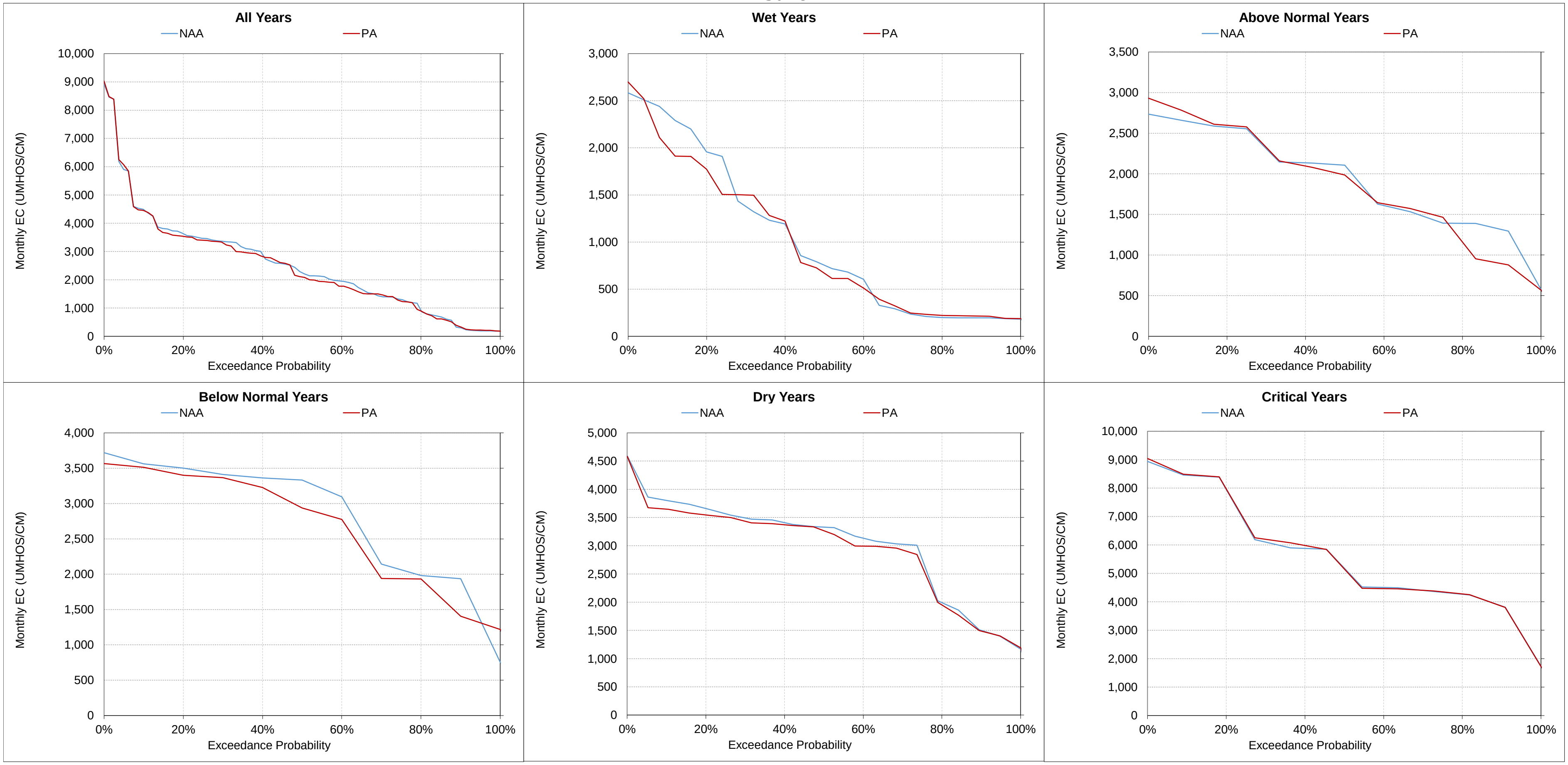
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-14-15. Sacramento River at Collinsville Salinity, Monthly EC
May



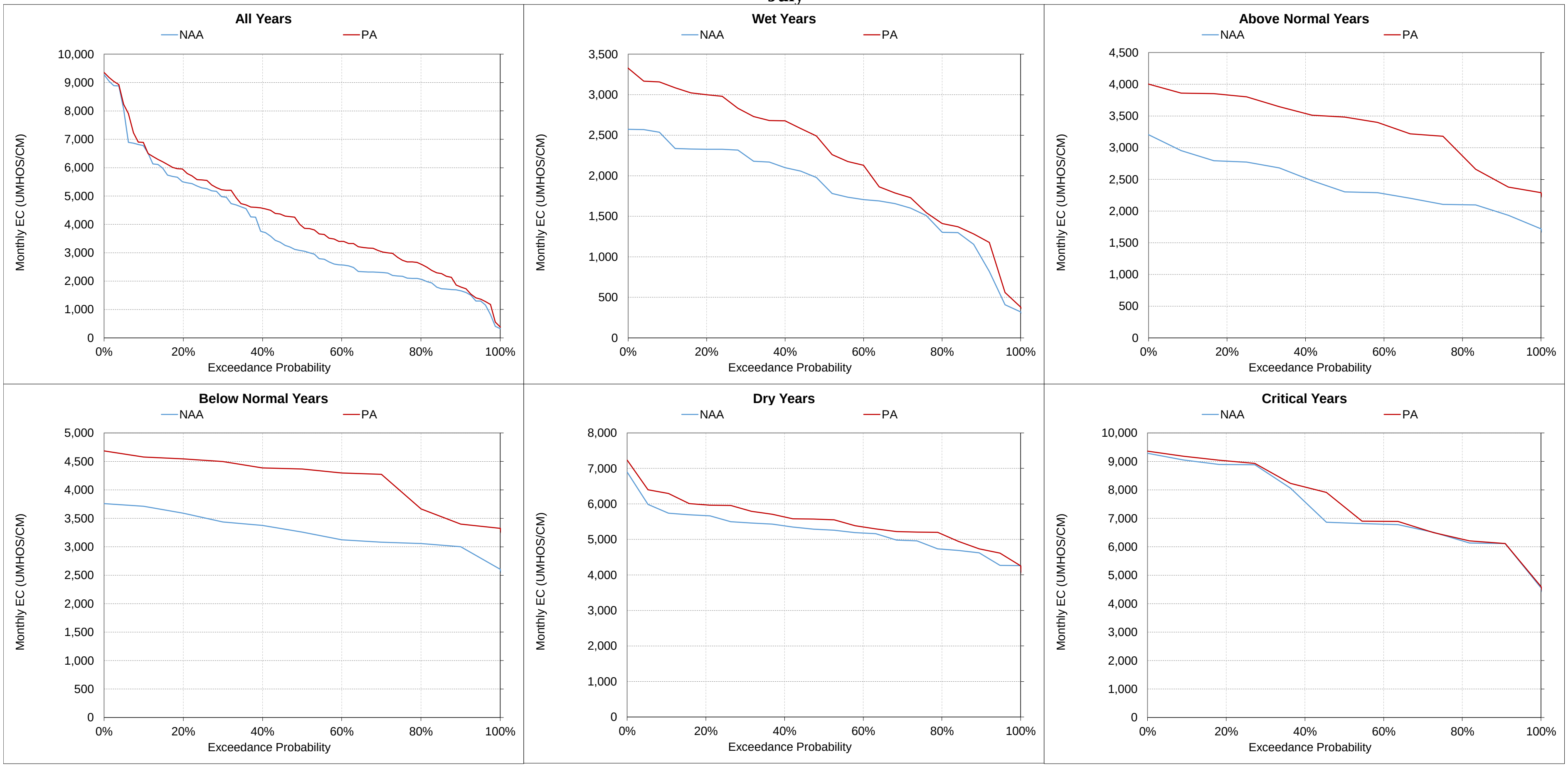
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-14-16. Sacramento River at Collinsville Salinity, Monthly EC
June



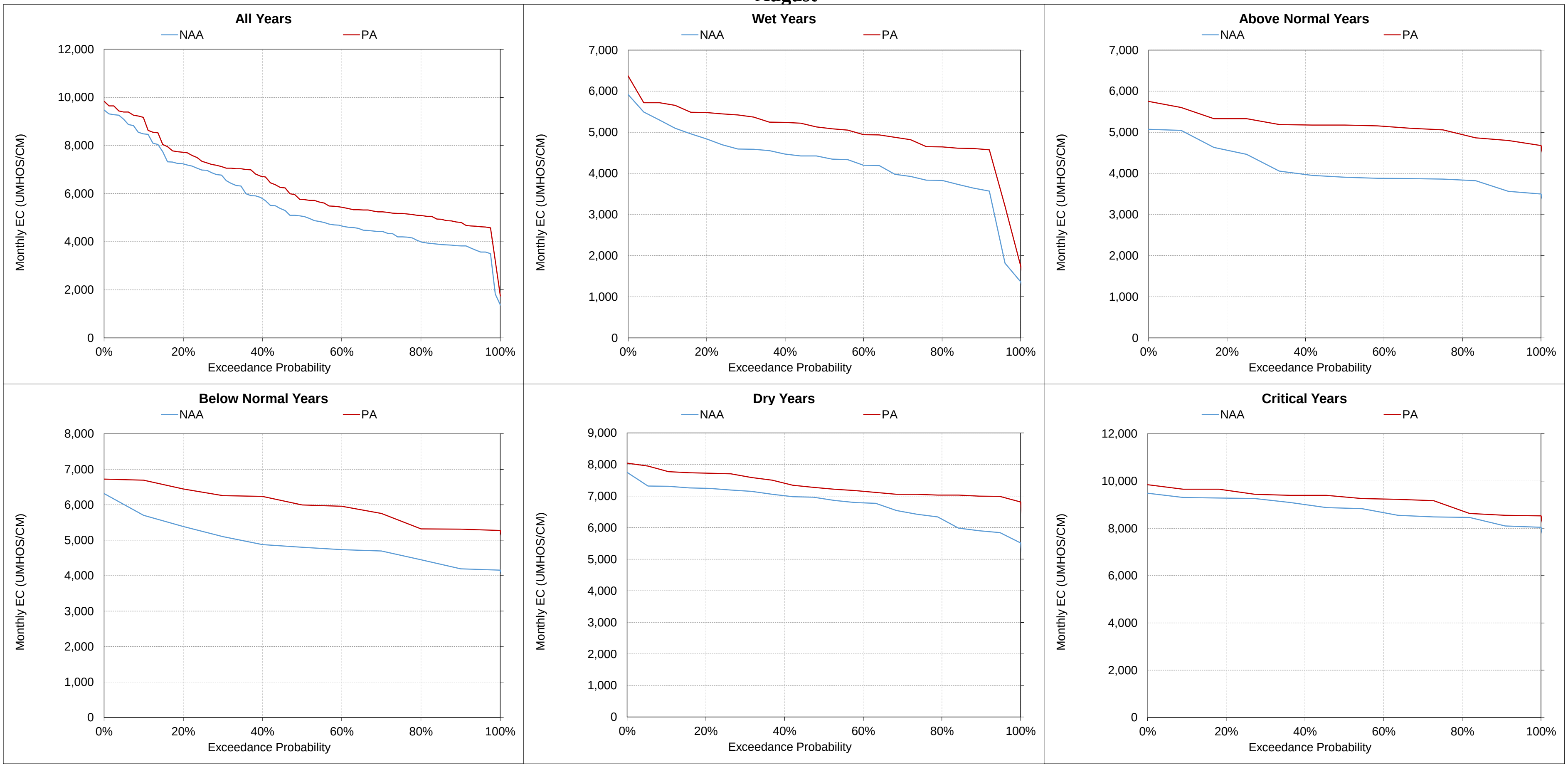
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-14-17. Sacramento River at Collinsville Salinity, Monthly EC
July



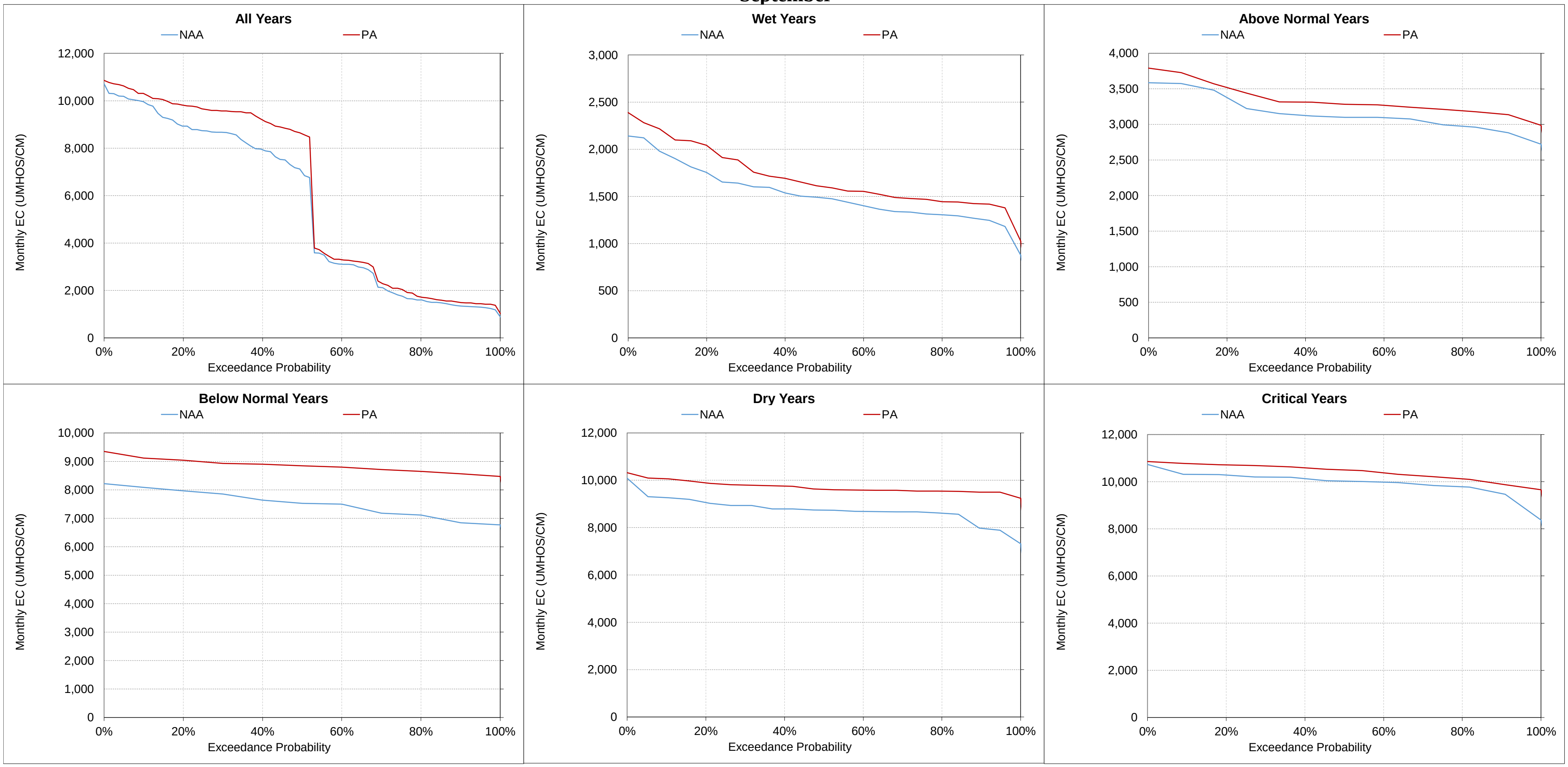
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-14-18. Sacramento River at Collinsville Salinity, Monthly EC
August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-14-19. Sacramento River at Collinsville Salinity, Monthly EC
September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-15. Sacramento River at Port Chicago Salinity, Monthly EC

Statistic	Monthly EC (UMHOS/CM)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	19,679	19,040	-639	-3%	20,093	19,086	-1,007	-5%	18,310	17,814	-496	-3%	14,356	14,788	432	3%	9,851	8,915	-936	-10%	8,385	8,260	-125	-1%
20%	18,761	17,938	-823	-4%	18,746	17,502	-1,243	-7%	16,752	16,783	31	0%	13,274	12,571	-703	-5%	7,120	6,628	-491	-7%	6,770	6,845	75	1%
30%	18,639	17,626	-1,013	-5%	18,299	16,876	-1,424	-8%	13,630	13,918	288	2%	11,905	10,136	-1,769	-15%	4,579	5,443	864	19%	3,789	4,521	732	19%
40%	18,404	17,219	-1,185	-6%	16,386	16,261	-125	-1%	12,798	12,640	-157	-1%	8,922	7,701	-1,221	-14%	3,317	3,714	397	12%	3,455	3,976	520	15%
50%	17,415	16,636	-779	-4%	12,115	11,836	-279	-2%	11,355	11,634	279	2%	6,755	6,334	-421	-6%	2,433	2,774	342	14%	2,129	2,649	519	24%
60%	11,715	11,470	-245	-2%	11,505	11,293	-212	-2%	10,529	10,492	-37	0%	3,846	4,030	184	5%	1,332	1,173	-159	-12%	1,365	1,403	38	3%
70%	7,739	7,750	11	0%	8,117	8,086	-31	0%	6,897	7,033	136	2%	1,553	1,807	254	16%	413	470	57	14%	612	658	47	8%
80%	7,564	7,543	-21	0%	7,738	7,747	9	0%	3,019	3,569	550	18%	541	614	73	13%	256	277	22	8%	297	300	4	1%
90%	7,405	7,390	-15	0%	7,388	7,330	-58	-1%	1,493	1,752	259	17%	267	291	24	9%	234	246	12	5%	236	253	17	7%
Long Term																								
Full Simulation Period[b]	13,911	13,396	-515	-4%	13,218	12,704	-514	-4%	10,515	10,591	76	1%	6,995	6,666	-329	-5%	3,724	3,668	-56	-2%	3,255	3,461	206	6%
Water Year Types[c]																								
Wet (32%)	7,491	7,467	-24	0%	7,230	7,262	32	0%	7,165	7,234	68	1%	5,885	4,705	-1,180	-20%	581	572	-9	-2%	826	861	34	4%
Above Normal (16%)	11,338	10,954	-384	-3%	11,004	10,858	-147	-1%	9,481	9,578	97	1%	7,428	7,148	-280	-4%	1,547	1,589	42	3%	1,169	1,195	26	2%
Below Normal (13%)	17,176	16,199	-976	-6%	16,396	15,407	-988	-6%	11,957	12,148	191	2%	7,181	7,330	149	2%	4,732	4,266	-467	-10%	4,644	4,759	116	2%
Dry (24%)	18,595	17,661	-934	-5%	16,601	15,517	-1,084	-7%	10,918	10,930	12	0%	6,650	6,880	230	3%	5,553	5,479	-74	-1%	4,162	4,719	557	13%
Critical (15%)	19,807	19,210	-597	-3%	20,040	19,329	-711	-4%	16,897	16,971	74	0%	9,336	9,425	89	1%	8,919	9,061	142	2%	7,993	8,266	273	3%

Statistic	Monthly EC (UMHOS/CM)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	9,661	9,658	-3	0%	11,126	11,176	50	0%	13,069	13,058	-11	0%	15,502	15,510	9	0%	17,605	17,801	196	1%	18,632	18,987	356	2%
20%	7,541	7,719	179	2%	10,369	10,039	-330	-3%	12,046	11,848	-198	-2%	14,537	14,665	127	1%	16,331	16,736	405	2%	17,897	18,488	592	3%
30%	5,721	6,542	821	14%	9,269	9,296	26	0%	11,513	11,257	-256	-2%	14,036	14,148	112	1%	15,956	16,424	468	3%	17,663	18,286	623	4%
40%	4,617	4,605	-12	0%	6,913	6,850	-63	-1%	10,871	10,597	-275	-3%	12,418	13,297	879	7%	15,060	15,626	566	4%	17,058	17,783	725	4%
50%	3,638	3,753	115	3%	5,833	5,652	-181	-3%	9,397	9,190	-207	-2%	11,646	12,296	649	6%	14,050	14,734	684	5%	16,376	17,531	1,155	7%
60%	2,356	2,450	94	4%	4,015	3,913	-102	-3%	8,926	8,530	-396	-4%	10,286	11,765	1,479	14%	13,661	14,214	553	4%	11,823	12,064	241	2%
70%	1,550	1,547	-3	0%	3,211	3,093	-118	-4%	7,594	7,628	34	0%	9,833	11,169	1,336	14%	13,243	14,075	832	6%	8,643	8,771	128	1%
80%	618	615	-3	-1%	1,741	1,710	-31	-2%	5,617	5,802	185	3%	9,298	10,100	802	9%	12,723	13,862	1,139	9%	7,956	8,171	215	3%
90%	291	293	2	1%	515	507	-8	-1%	2,759	3,017	258	9%	8,117	8,294	177	2%	12,418	13,597	1,179	9%	7,707	7,866	159	2%
Long Term																								
Full Simulation Period[b]	4,234	4,314	81	2%	5,950	5,889	-61	-1%	9,066	8,963	-103	-1%	11,676	12,274	598	5%	14,471	15,227	756	5%	13,671	14,075	404	3%
Water Year Types[c]																								
Wet (32%)	1,270	1,276	6	0%	2,046	2,036	-10	0%	5,106	5,053	-53	-1%	8,320	9,048	727	9%	12,714	13,504	790	6%	7,864	8,020	156	2%
Above Normal (16%)	2,131	2,088	-43	-2%	3,932	3,891	-41	-1%	8,404	8,252	-152	-2%	10,101	11,435	1,334	13%	12,842	14,109	1,267	10%	11,804	11,991	187	2%
Below Normal (13%)	5,580	5,704	124	2%	7,201	7,131	-70	-1%	10,363	10,153	-210	-2%	11,904	12,846	942	8%	14,126	15,161	1,034	7%	16,717	17,616	900	5%
Dry (24%)	5,465	5,742	277	5%	8,026	7,853	-173	-2%	10,889	10,741	-148	-1%	14,155	14,233	78	1%	16,017	16,511	494	3%	17,730	18,367	637	4%
Critical (15%)	9,646	9,658	12	0%	11,985	11,986	1	0%	14,138	14,153	15	0%	16,311	16,380	69	0%	17,784	18,092	308	2%	18,717	19,052	334	2%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-15-1. Monthly EC Ranges For Sacramento River at Port Chicago Salinity, All Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario.

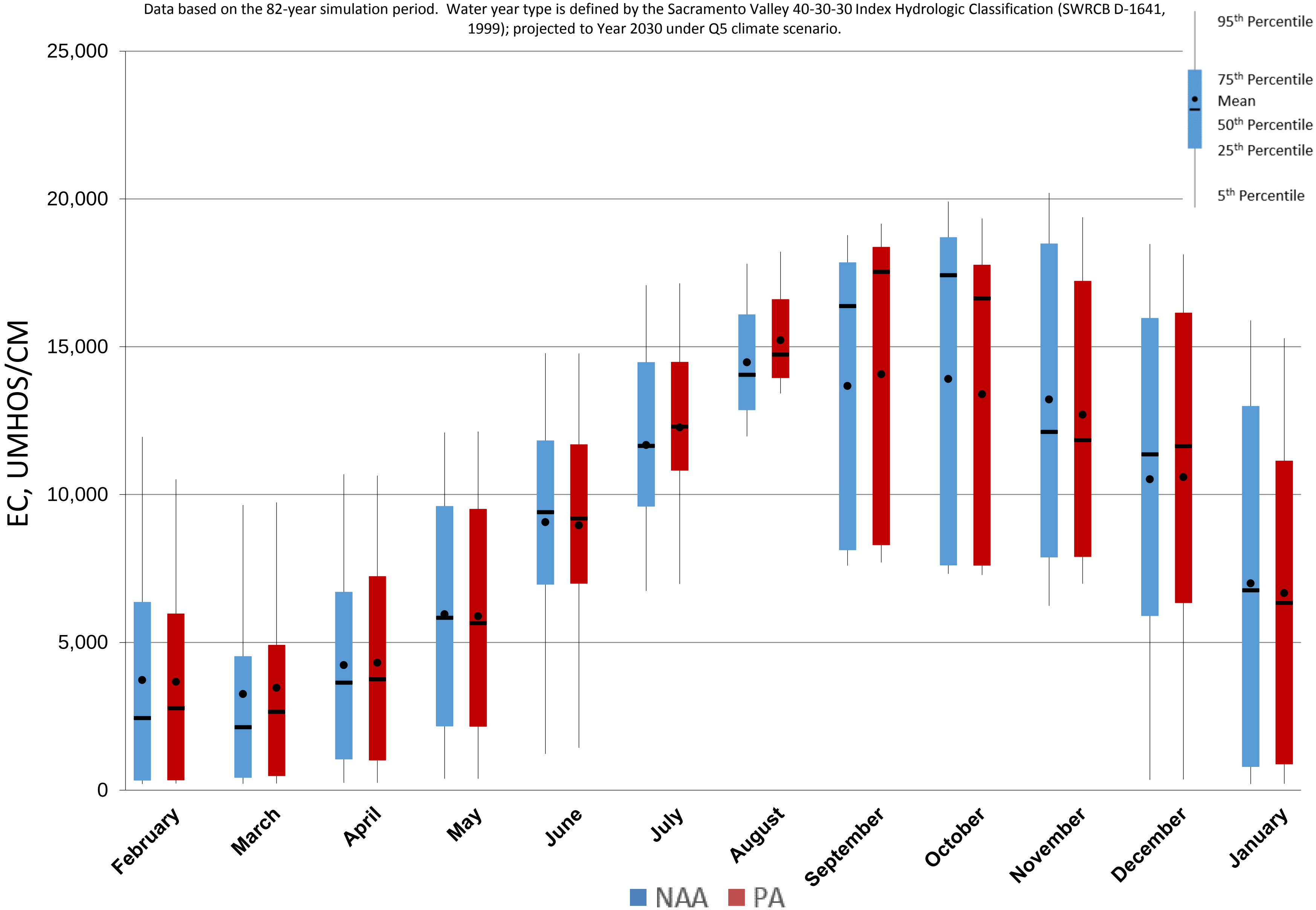


Figure 5.B.5-15-2. Monthly EC Ranges For Sacramento River at Port Chicago Salinity, Wet Years

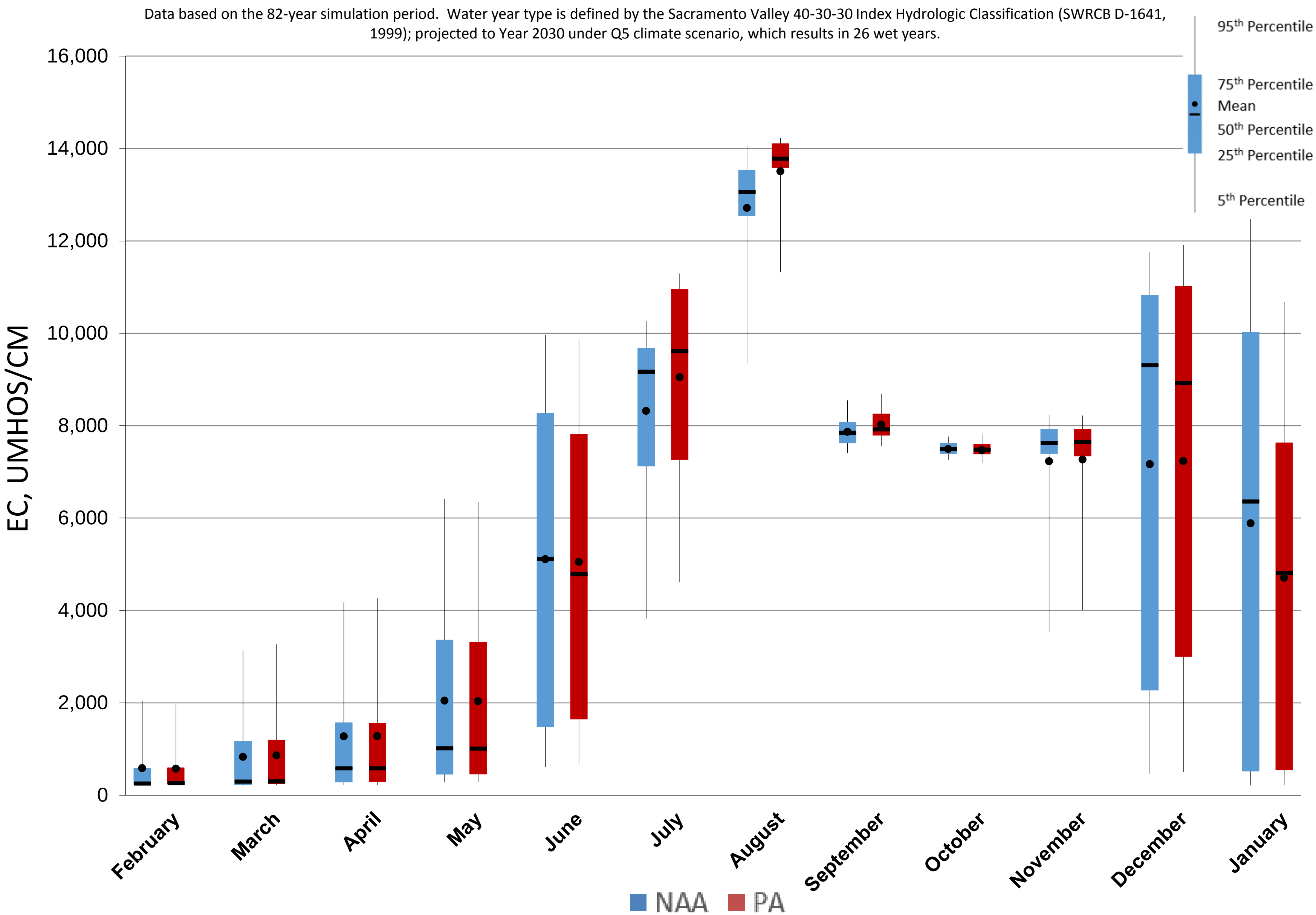
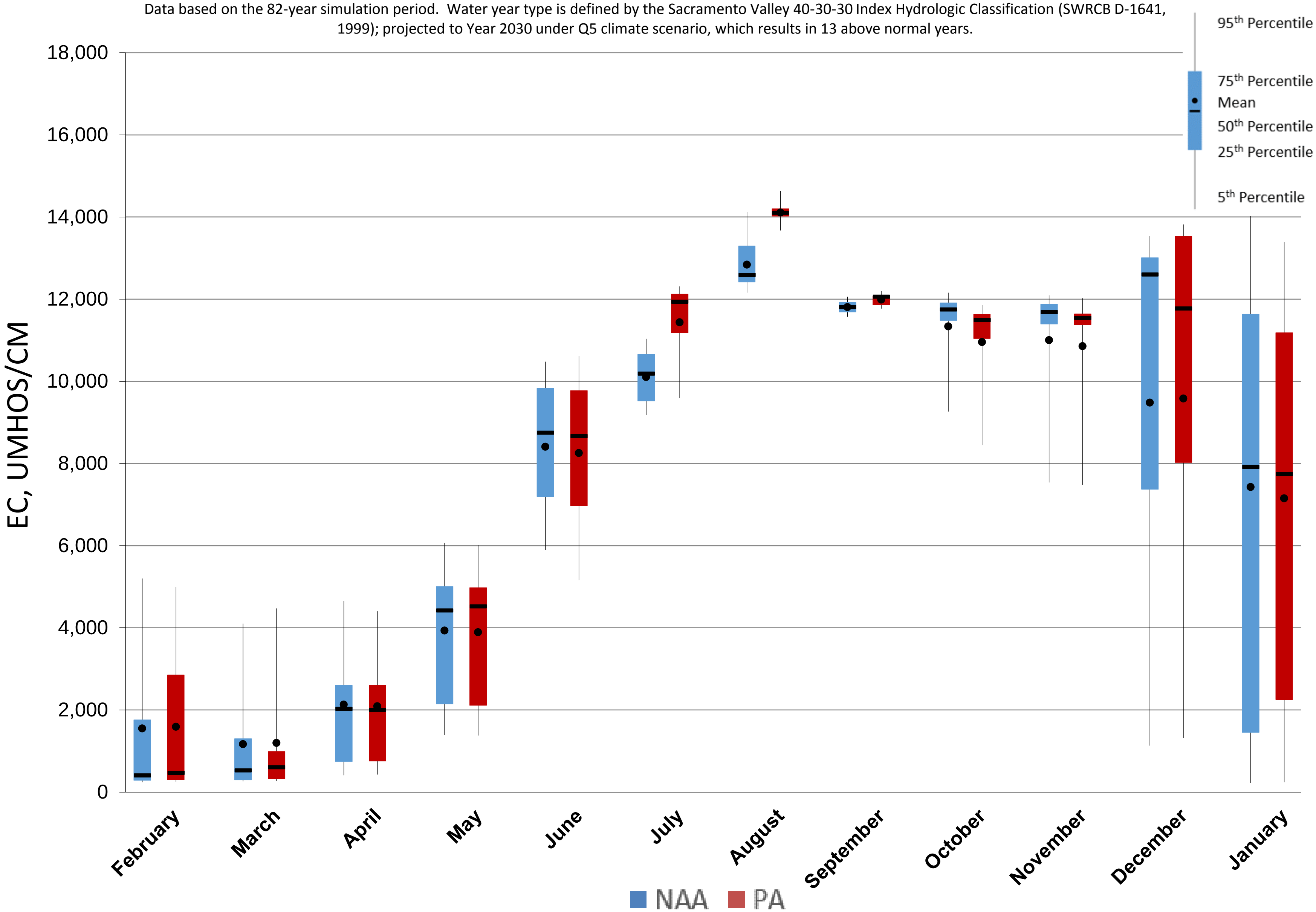


Figure 5.B.5-15-3. Monthly EC Ranges For Sacramento River at Port Chicago Salinity, Above Normal Years



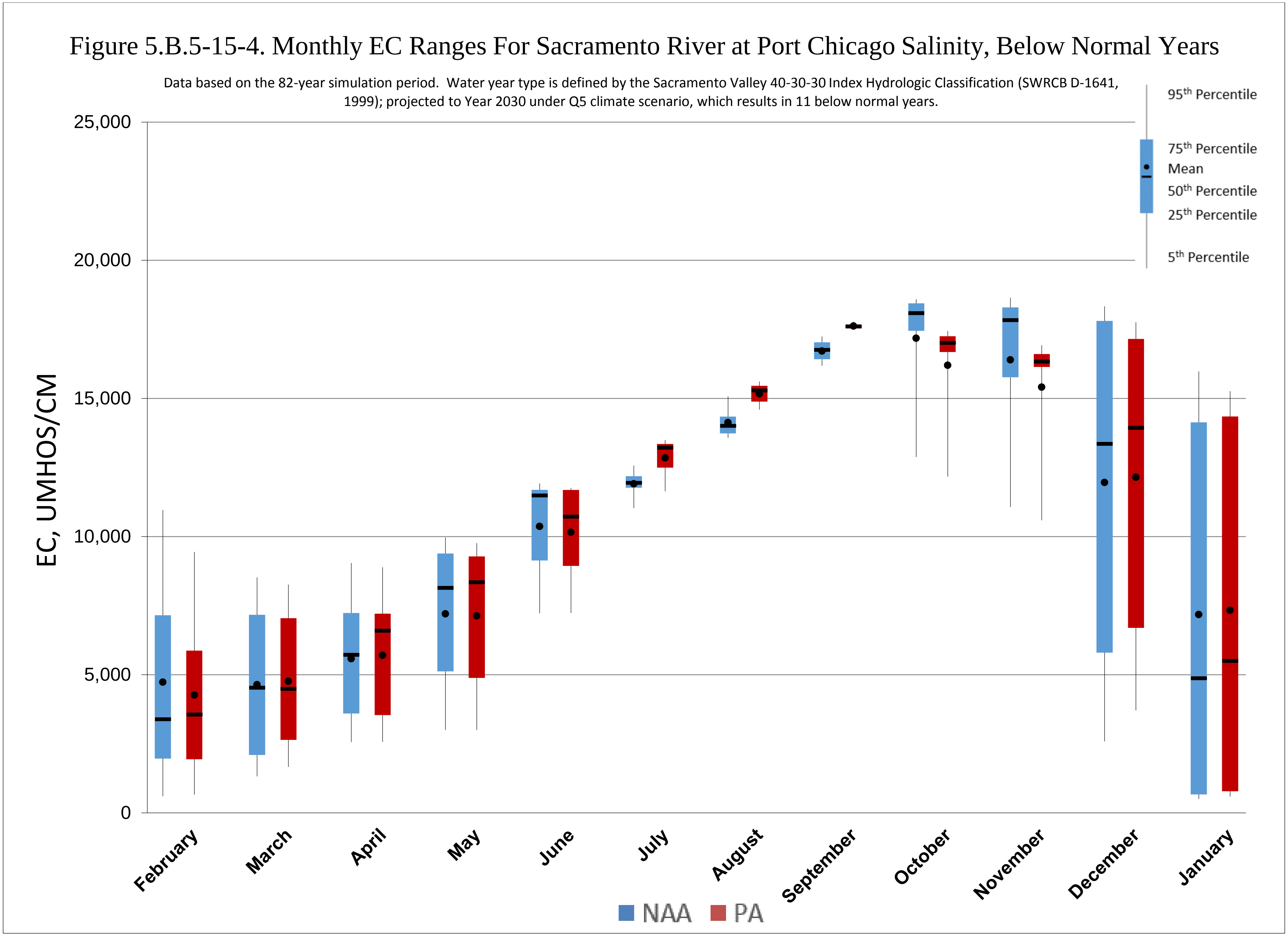


Figure 5.B.5-15-4. Monthly EC Ranges For Sacramento River at Port Chicago Salinity, Below Normal Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 11 below normal years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
EC, UMHOS/CM
25,000
20,000
15,000
10,000
5,000
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-15-5. Monthly EC Ranges For Sacramento River at Port Chicago Salinity, Dry Years

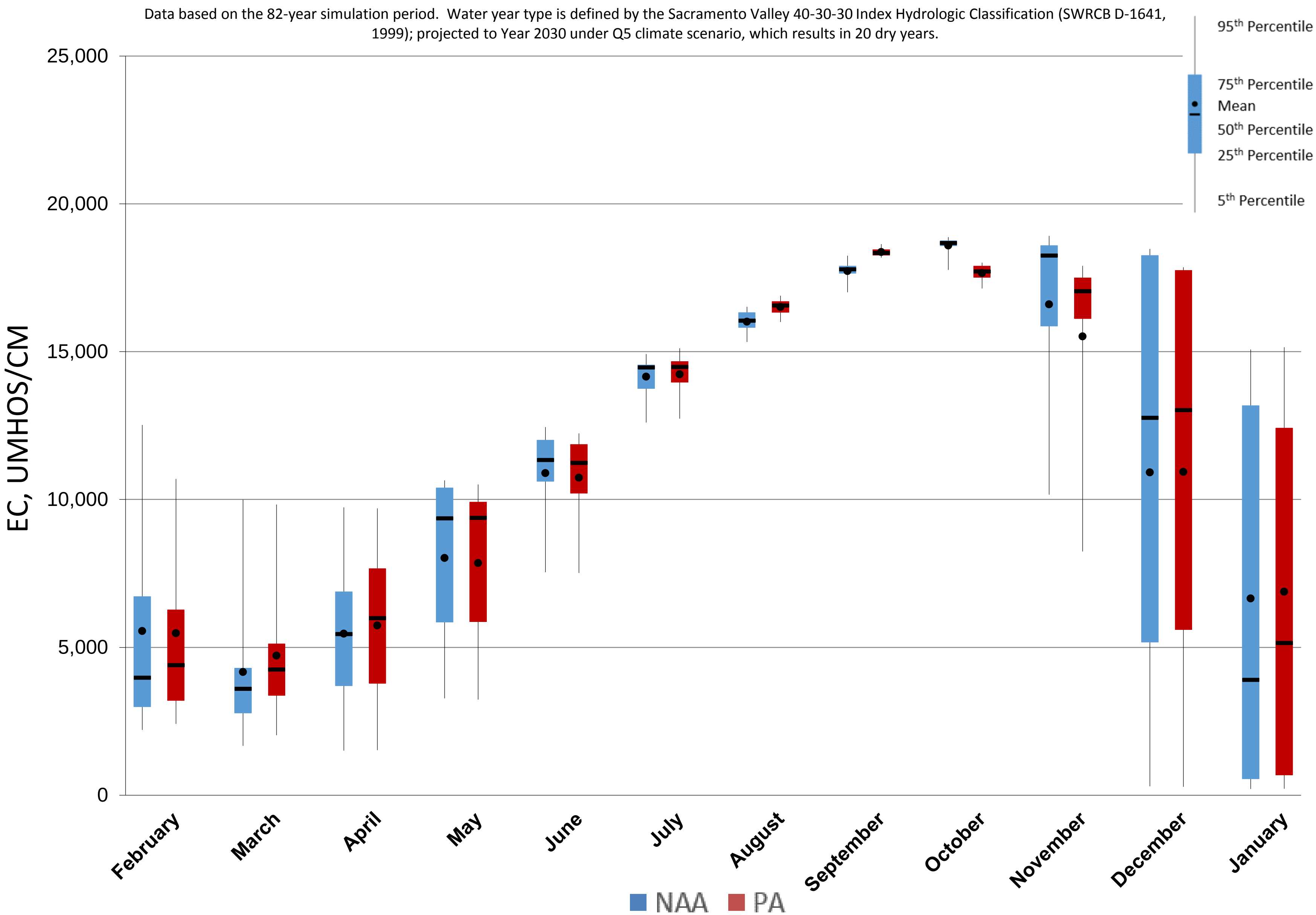


Figure 5.B.5-15-6. Monthly EC Ranges For Sacramento River at Port Chicago Salinity, Critical Years

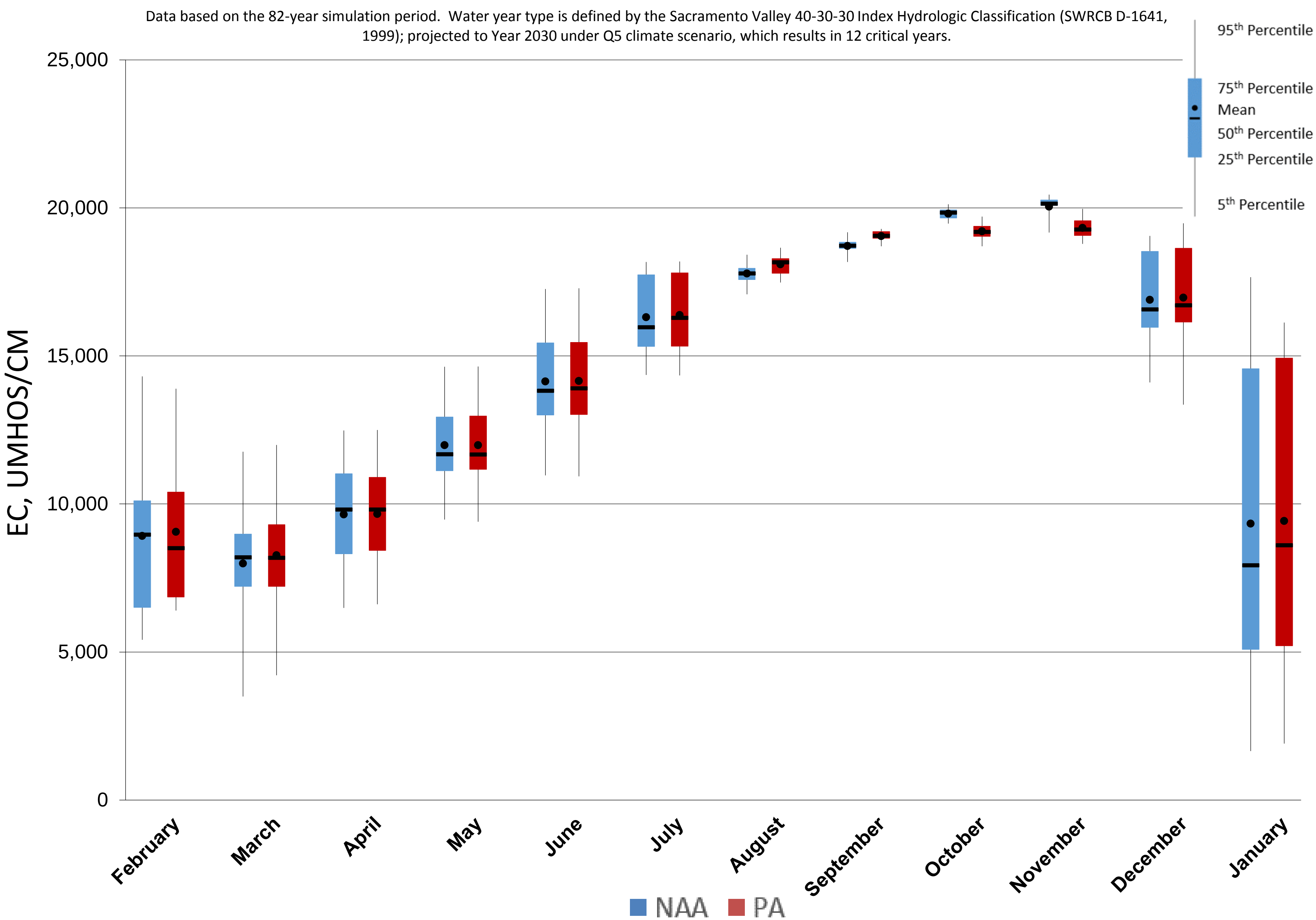
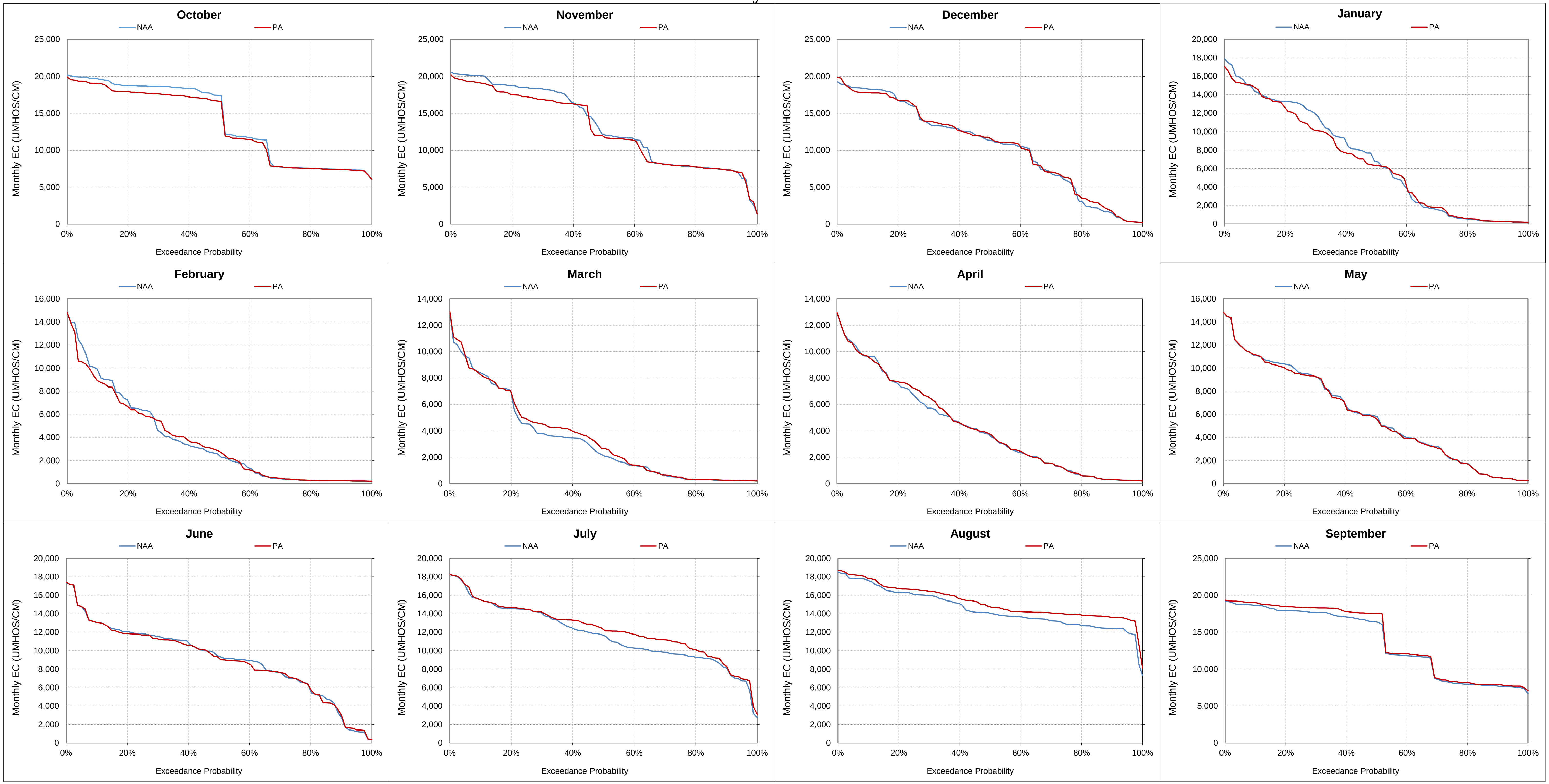
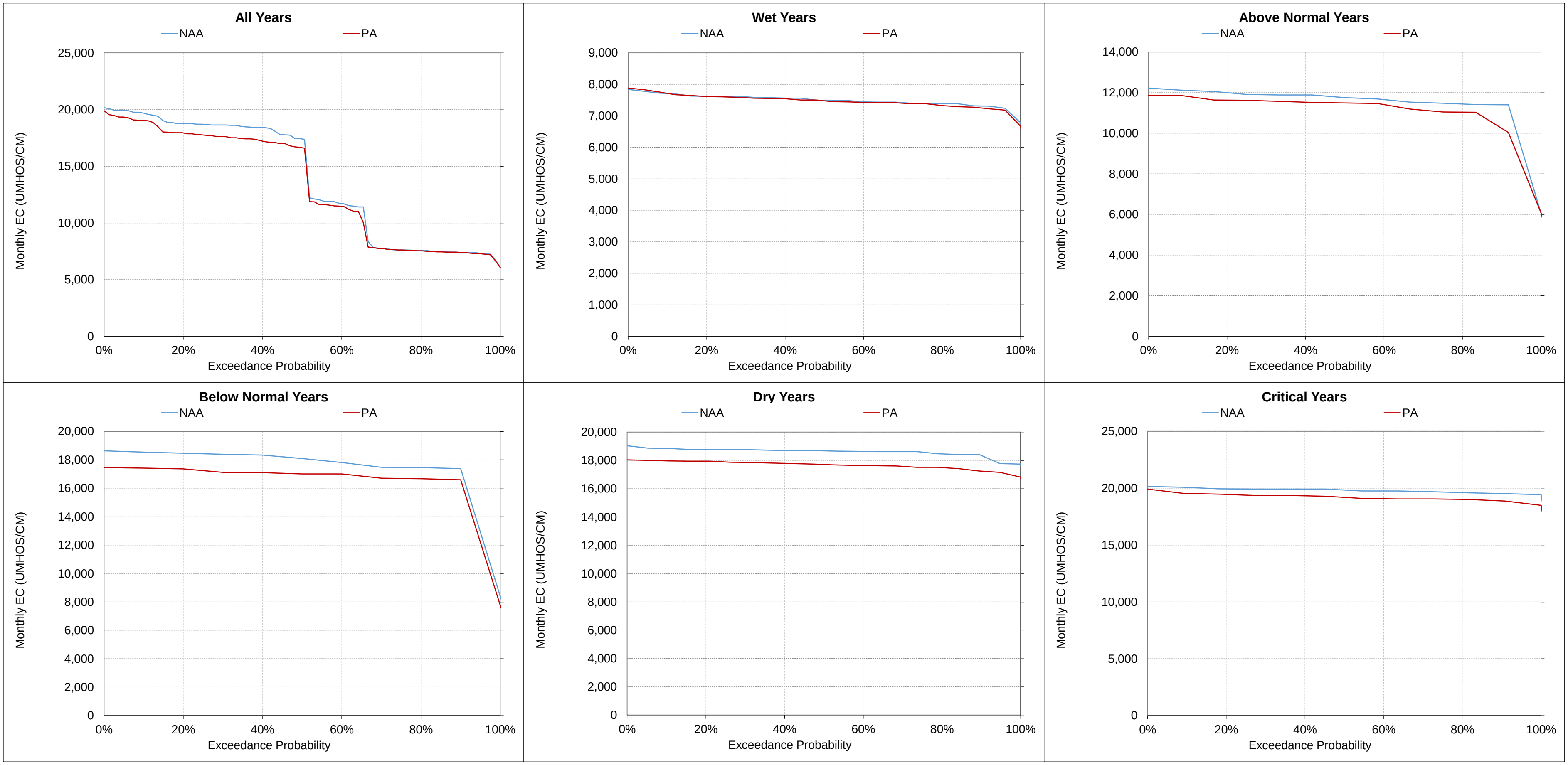


Figure 5.B.5-15-7. Sacramento River at Port Chicago Salinity, Monthly EC Probability of Exceedance



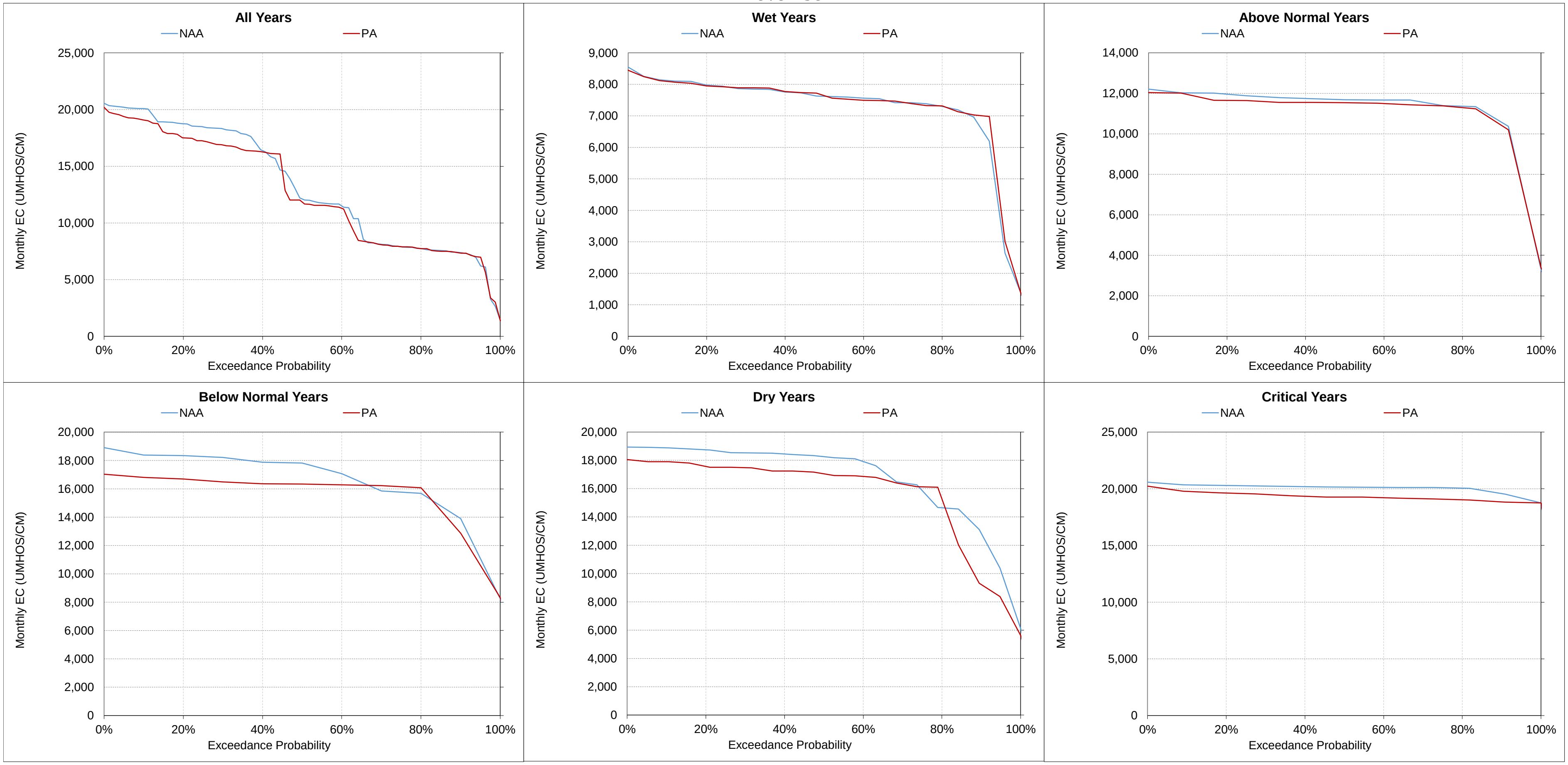
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-15-8. Sacramento River at Port Chicago Salinity, Monthly EC October



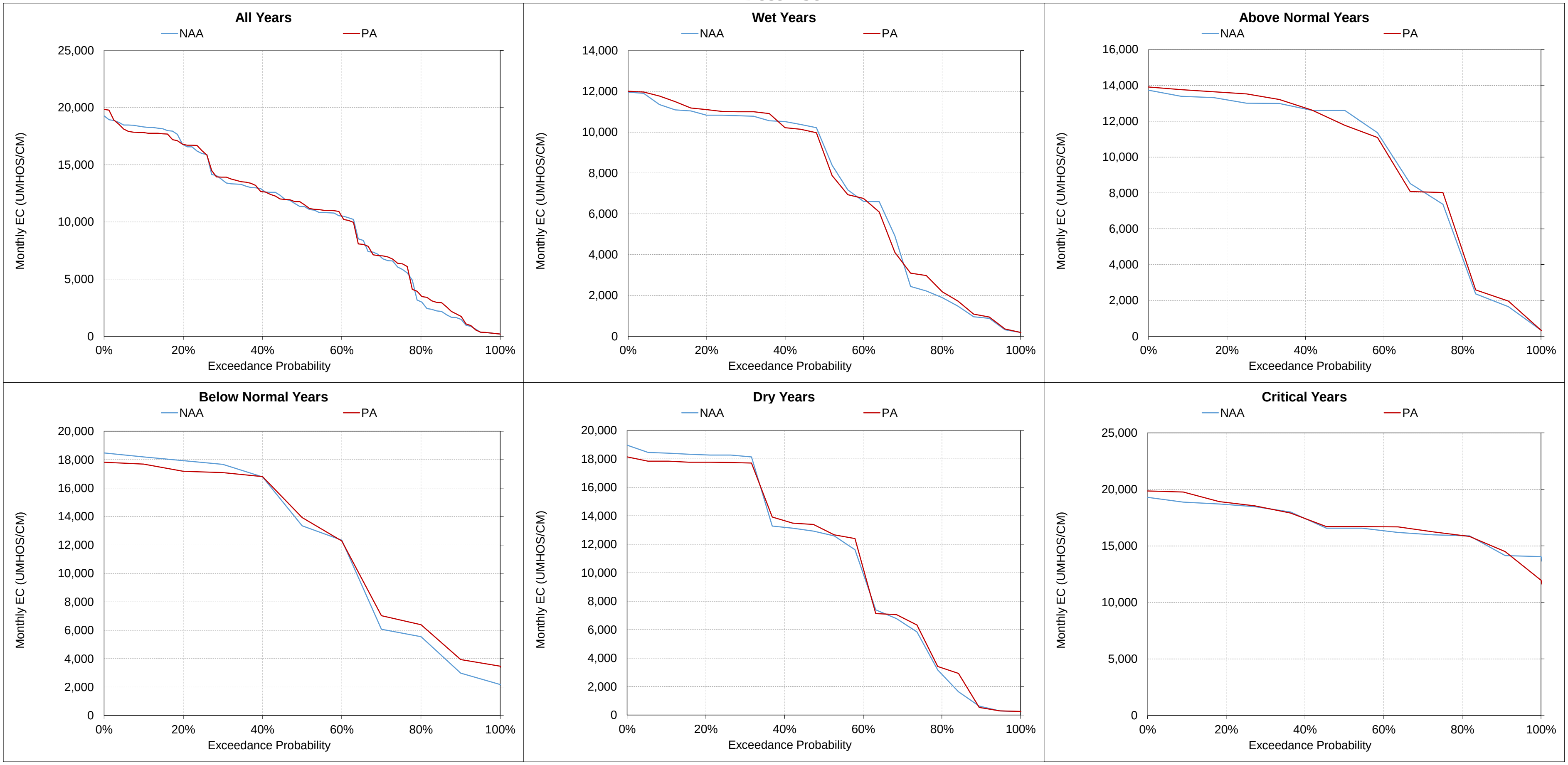
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-15-9. Sacramento River at Port Chicago Salinity, Monthly EC November



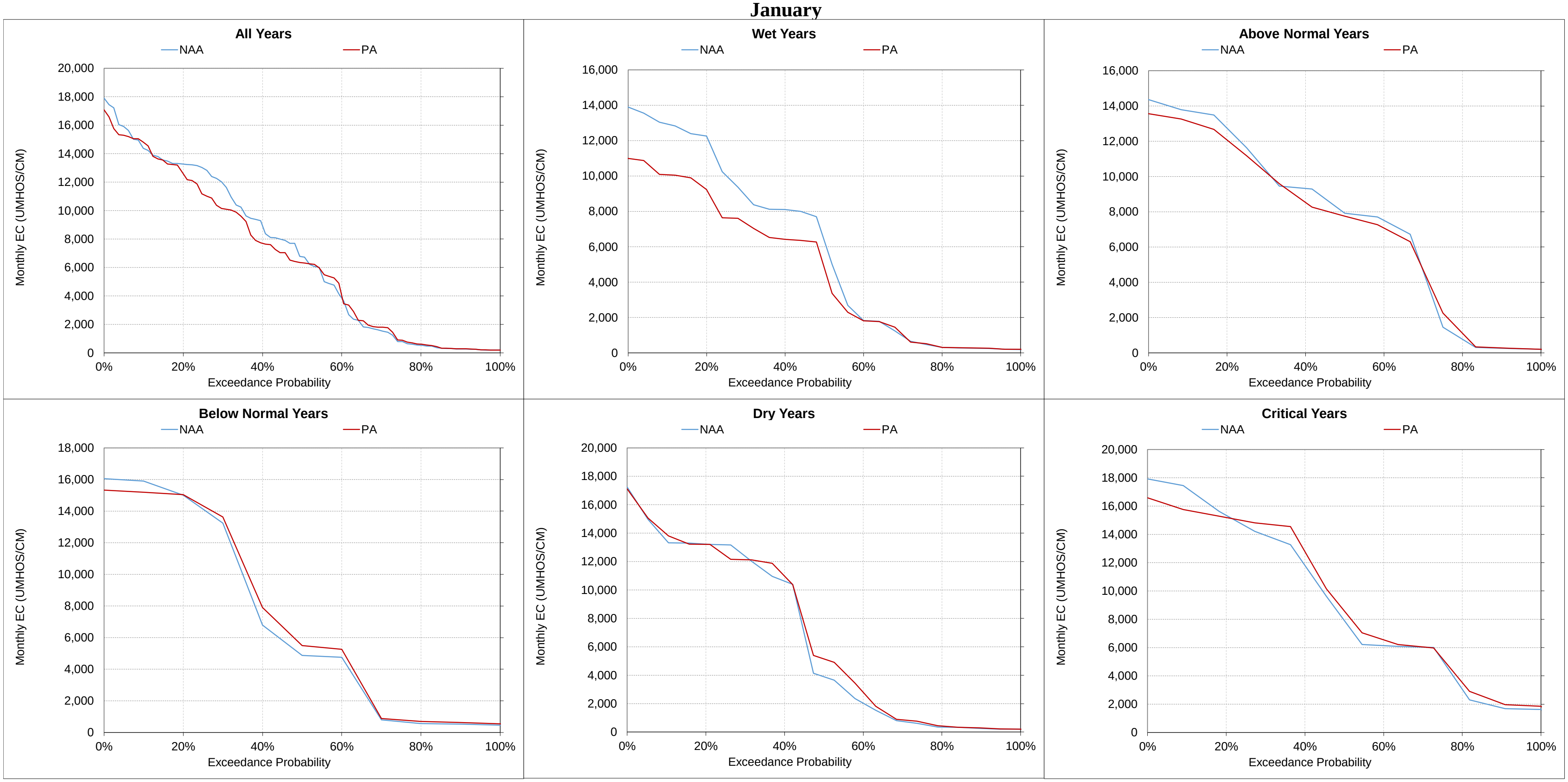
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-15-10. Sacramento River at Port Chicago Salinity, Monthly EC
December



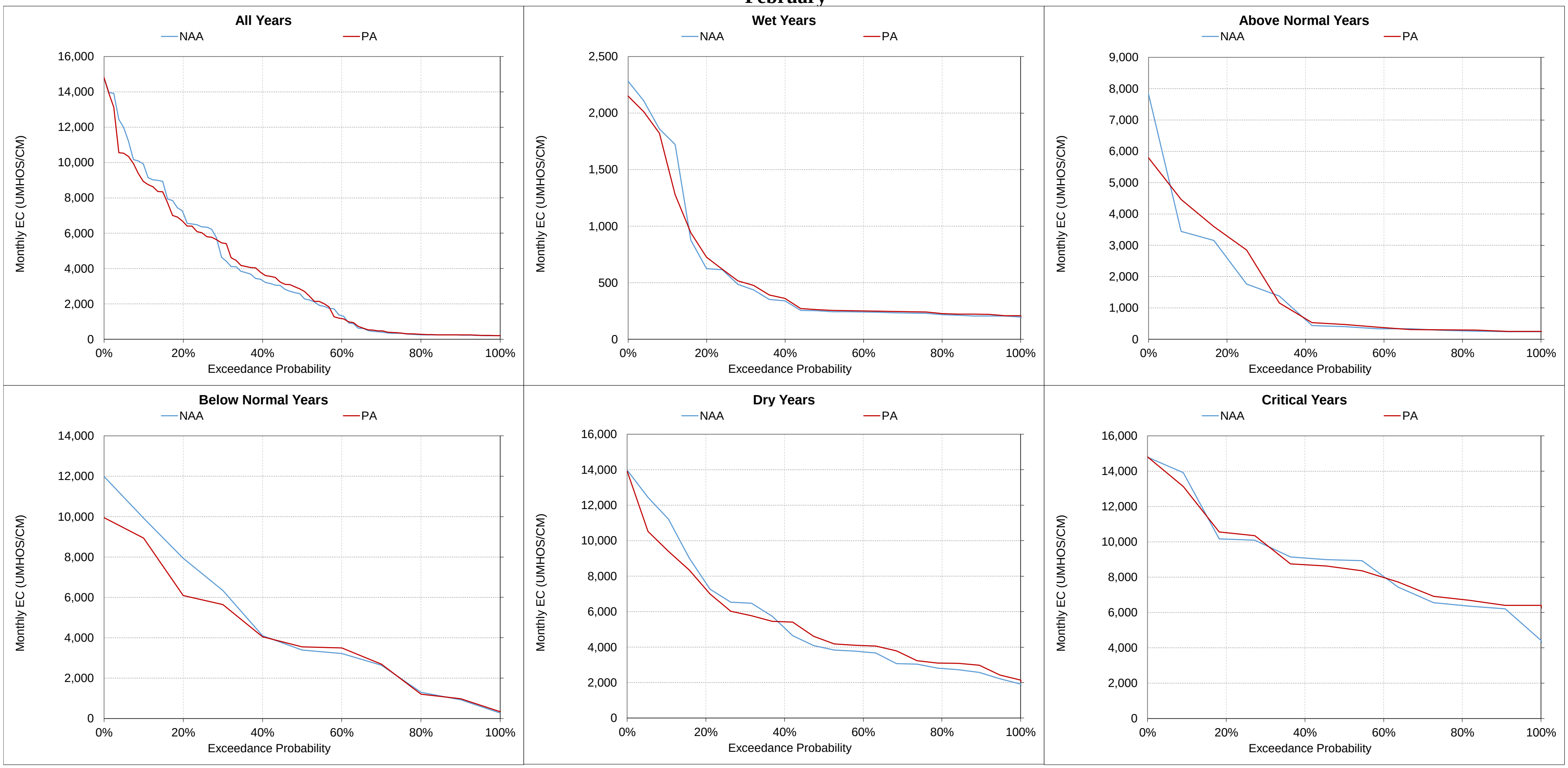
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-15-11. Sacramento River at Port Chicago Salinity, Monthly EC
January



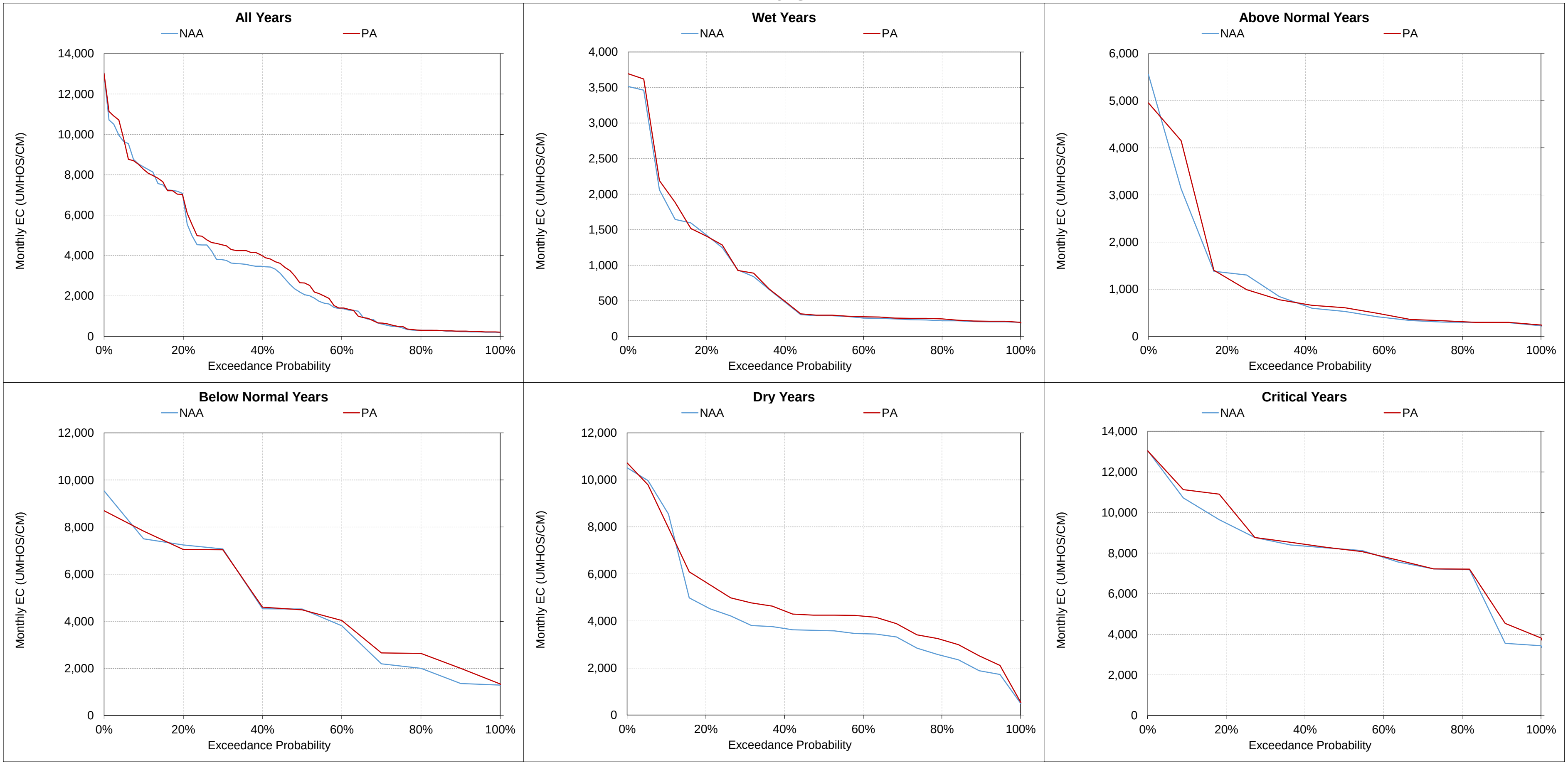
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-15-12. Sacramento River at Port Chicago Salinity, Monthly EC
February



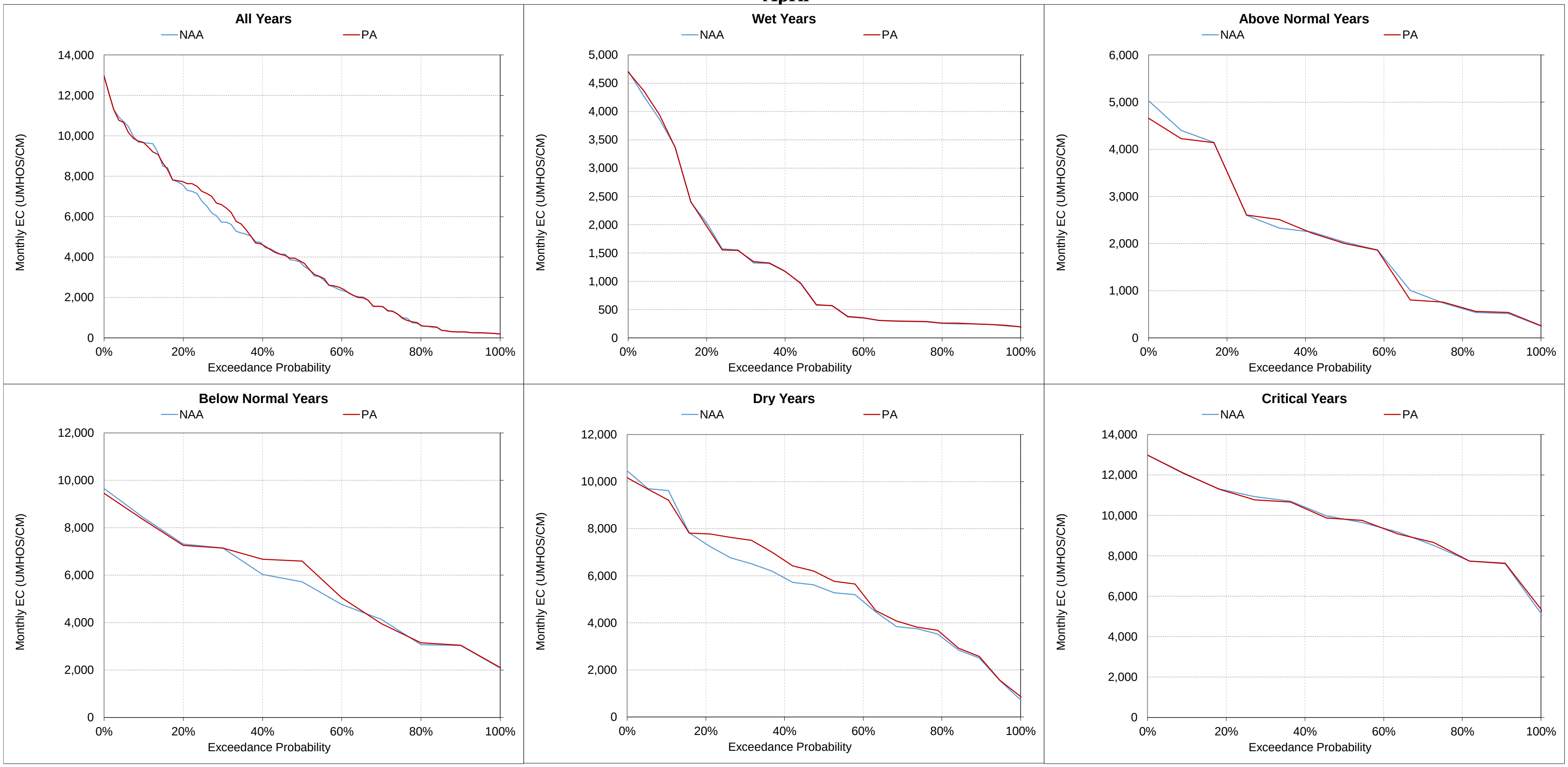
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-15-13. Sacramento River at Port Chicago Salinity, Monthly EC
March



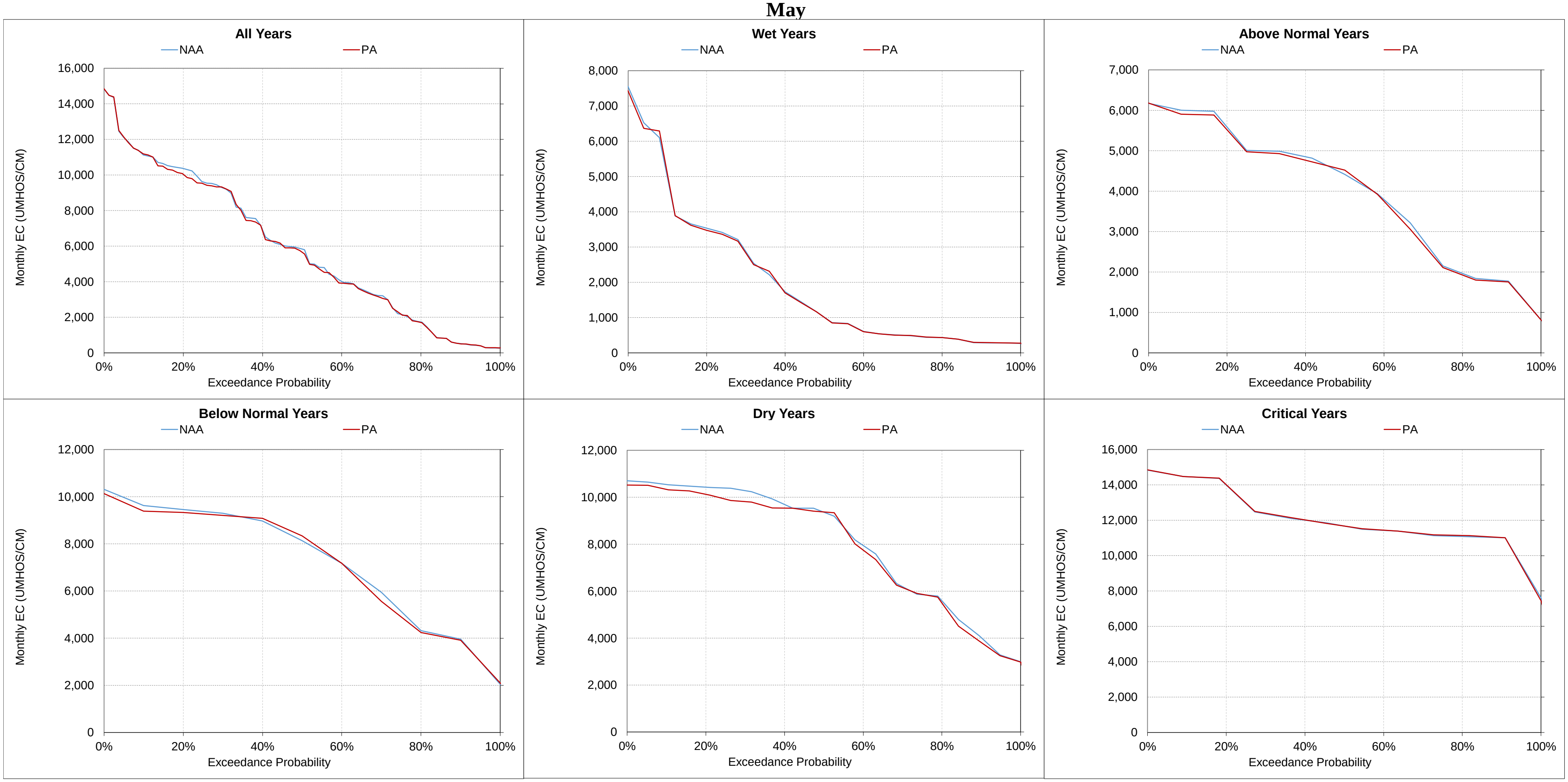
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-15-14. Sacramento River at Port Chicago Salinity, Monthly EC
April



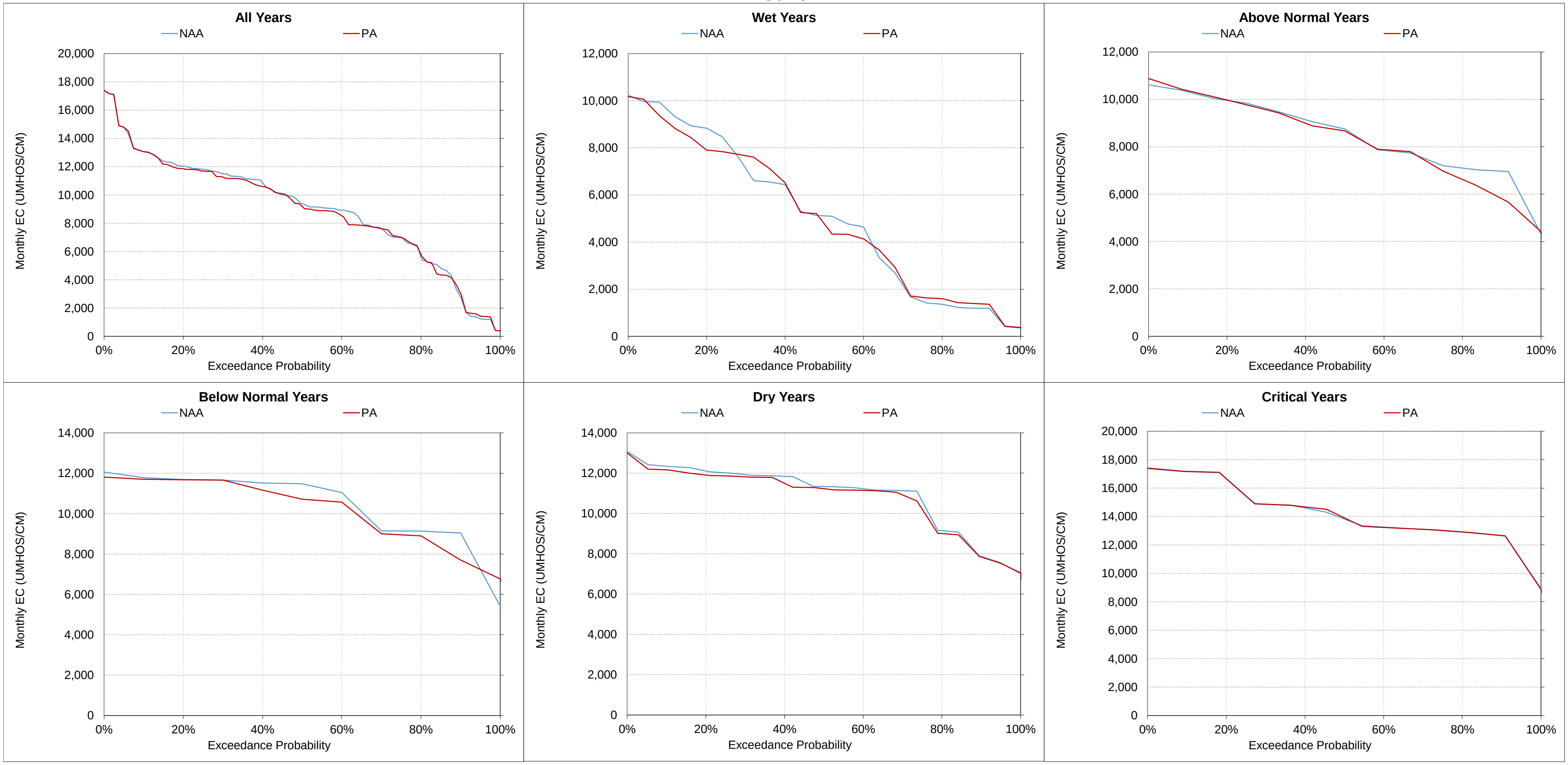
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-15-15. Sacramento River at Port Chicago Salinity, Monthly EC May



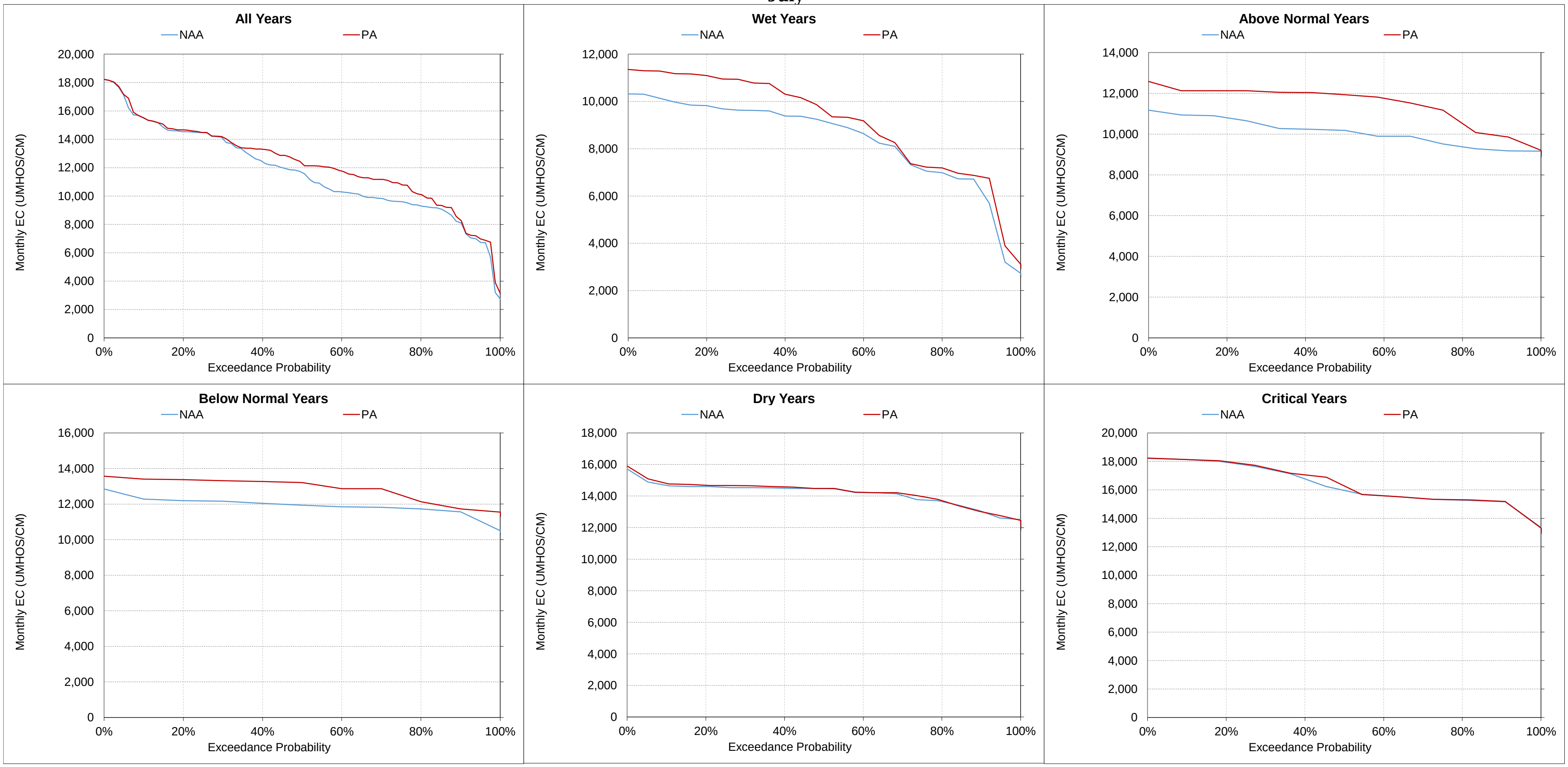
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-15-16. Sacramento River at Port Chicago Salinity, Monthly EC
June



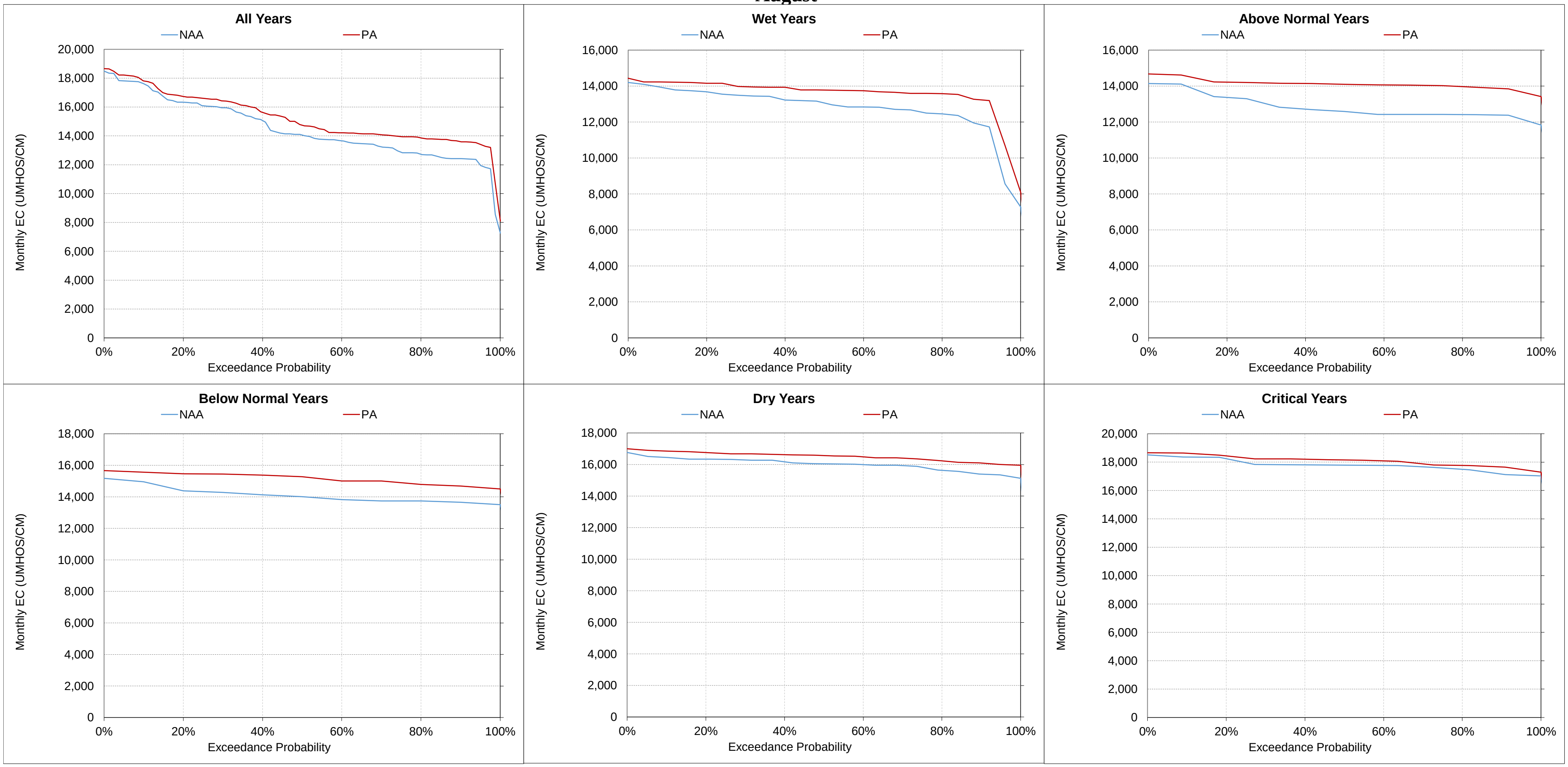
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-15-17. Sacramento River at Port Chicago Salinity, Monthly EC July



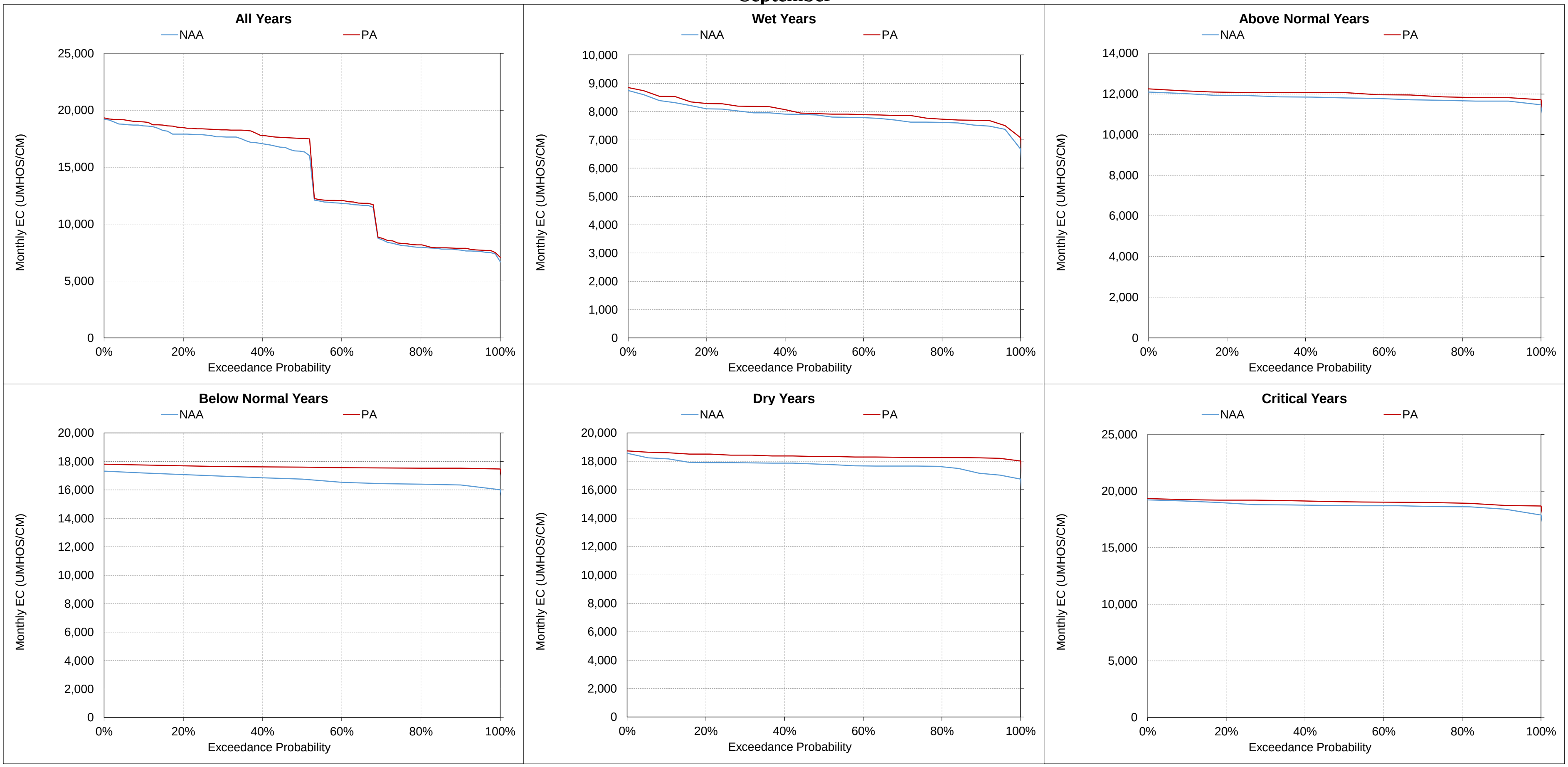
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-15-18. Sacramento River at Port Chicago Salinity, Monthly EC
August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-15-19. Sacramento River at Port Chicago Salinity, Monthly EC September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-16. San Joaquin River at Antioch Salinity, Monthly EC

Statistic	Monthly EC (UMHOS/CM)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	8,132	6,841	-1,290	-16%	9,000	7,569	-1,431	-16%	6,472	6,266	-206	-3%	3,691	3,622	-69	-2%	1,477	1,194	-284	-19%	829	738	-91	-11%
20%	7,296	5,696	-1,600	-22%	7,479	5,986	-1,493	-20%	5,844	5,607	-237	-4%	3,278	2,561	-717	-22%	1,041	894	-147	-14%	510	506	-4	-1%
30%	7,105	5,428	-1,678	-24%	6,857	5,210	-1,647	-24%	3,386	3,381	-5	0%	2,561	1,748	-813	-32%	669	552	-117	-17%	317	374	58	18%
40%	6,928	4,952	-1,976	-29%	5,904	4,528	-1,376	-23%	2,839	2,872	33	1%	1,593	1,241	-352	-22%	436	408	-28	-6%	288	337	50	17%
50%	6,003	4,458	-1,545	-26%	3,230	1,944	-1,287	-40%	2,064	2,225	162	8%	1,217	923	-294	-24%	315	332	17	6%	252	302	50	20%
60%	1,954	1,493	-462	-24%	2,156	1,515	-642	-30%	1,867	1,832	-34	-2%	596	553	-43	-7%	278	294	17	6%	236	279	43	18%
70%	837	636	-201	-24%	1,289	1,104	-185	-14%	992	1,134	142	14%	274	303	29	10%	239	278	39	16%	225	264	39	17%
80%	707	578	-129	-18%	841	643	-198	-24%	592	629	38	6%	240	258	18	8%	226	264	38	17%	218	254	36	16%
90%	641	537	-104	-16%	709	574	-135	-19%	254	248	-6	-2%	220	238	18	8%	213	248	35	17%	202	243	41	20%
Long Term																								
Full Simulation Period[b]	4,341	3,425	-916	-21%	4,211	3,444	-767	-18%	2,861	2,856	-5	0%	1,650	1,426	-224	-14%	663	592	-71	-11%	409	442	33	8%
Water Year Types[c]																								
Wet (32%)	696	566	-130	-19%	805	662	-143	-18%	1,204	1,202	-3	0%	1,255	775	-480	-38%	249	270	21	8%	223	263	39	18%
Above Normal (16%)	1,853	1,390	-462	-25%	2,064	1,514	-550	-27%	1,961	1,945	-16	-1%	1,726	1,469	-257	-15%	341	325	-16	-5%	229	273	44	19%
Below Normal (13%)	6,530	4,832	-1,699	-26%	5,757	4,431	-1,325	-23%	3,635	3,567	-68	-2%	1,874	1,802	-72	-4%	791	635	-155	-20%	400	401	1	0%
Dry (24%)	7,027	5,388	-1,639	-23%	6,307	5,004	-1,303	-21%	3,500	3,390	-110	-3%	1,674	1,666	-8	0%	846	707	-139	-16%	477	502	25	5%
Critical (15%)	8,452	7,262	-1,190	-14%	9,006	8,054	-952	-11%	5,651	5,883	233	4%	2,180	2,047	-133	-6%	1,488	1,348	-139	-9%	900	951	51	6%

Statistic	Monthly EC (UMHOS/CM)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	1,060	1,082	23	2%	1,675	1,601	-73	-4%	2,404	2,366	-38	-2%	4,509	4,332	-177	-4%	5,977	6,295	319	5%	7,021	7,441	420	6%
20%	597	650	54	9%	1,362	1,229	-133	-10%	1,999	1,849	-150	-7%	3,717	3,719	2	0%	4,886	5,427	541	11%	6,544	6,990	446	7%
30%	437	504	66	15%	992	977	-15	-1%	1,778	1,707	-70	-4%	3,429	3,296	-134	-4%	4,483	4,767	284	6%	6,263	6,766	503	8%
40%	314	341	27	9%	536	532	-4	-1%	1,495	1,453	-42	-3%	2,473	2,762	289	12%	4,015	4,420	405	10%	5,885	6,423	538	9%
50%	266	296	30	11%	374	373	-1	0%	1,168	1,042	-127	-11%	2,009	2,334	325	16%	3,490	3,681	191	5%	5,207	5,893	687	13%
60%	239	277	38	16%	291	299	8	3%	954	843	-111	-12%	1,604	1,882	279	17%	3,148	3,377	229	7%	2,310	1,844	-466	-20%
70%	223	260	37	17%	253	258	5	2%	707	691	-16	-2%	1,412	1,708	296	21%	2,963	3,216	253	9%	1,806	1,434	-372	-21%
80%	215	243	28	13%	224	236	13	6%	456	428	-28	-6%	1,307	1,402	95	7%	2,701	3,103	401	15%	1,453	1,086	-366	-25%
90%	210	227	17	8%	198	199	0	0%	217	251	34	16%	1,016	1,003	-13	-1%	2,506	2,815	309	12%	1,317	935	-382	-29%
Long Term																								
Full Simulation Period[b]	470	492	22	5%	760	748	-12	-2%	1,409	1,362	-47	-3%	2,490	2,585	95	4%	3,819	4,149	330	9%	4,159	4,238	79	2%
Water Year Types[c]																								
Wet (32%)	226	247	21	9%	249	254	4	2%	559	523	-36	-6%	1,103	1,200	97	9%	2,882	3,052	170	6%	1,360	1,044	-316	-23%
Above Normal (16%)	235	281	45	19%	311	324	13	4%	981	947	-34	-3%	1,558	1,835	277	18%	2,765	3,157	392	14%	2,333	1,887	-446	-19%
Below Normal (13%)	473	494	21	4%	713	702	-11	-2%	1,469	1,370	-99	-7%	2,159	2,489	330	15%	3,380	3,745	365	11%	5,565	6,130	565	10%
Dry (24%)	491	521	30	6%	931	873	-58	-6%	1,601	1,525	-76	-5%	3,606	3,510	-96	-3%	4,581	5,003	422	9%	6,418	6,913	494	8%
Critical (15%)	1,214	1,200	-14	-1%	2,115	2,115	1	0%	3,343	3,351	8	0%	4,946	4,941	-4	0%	6,125	6,548	423	7%	7,147	7,512	365	5%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-16-1. Monthly EC Ranges For San Joaquin River at Antioch Salinity, All Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario.

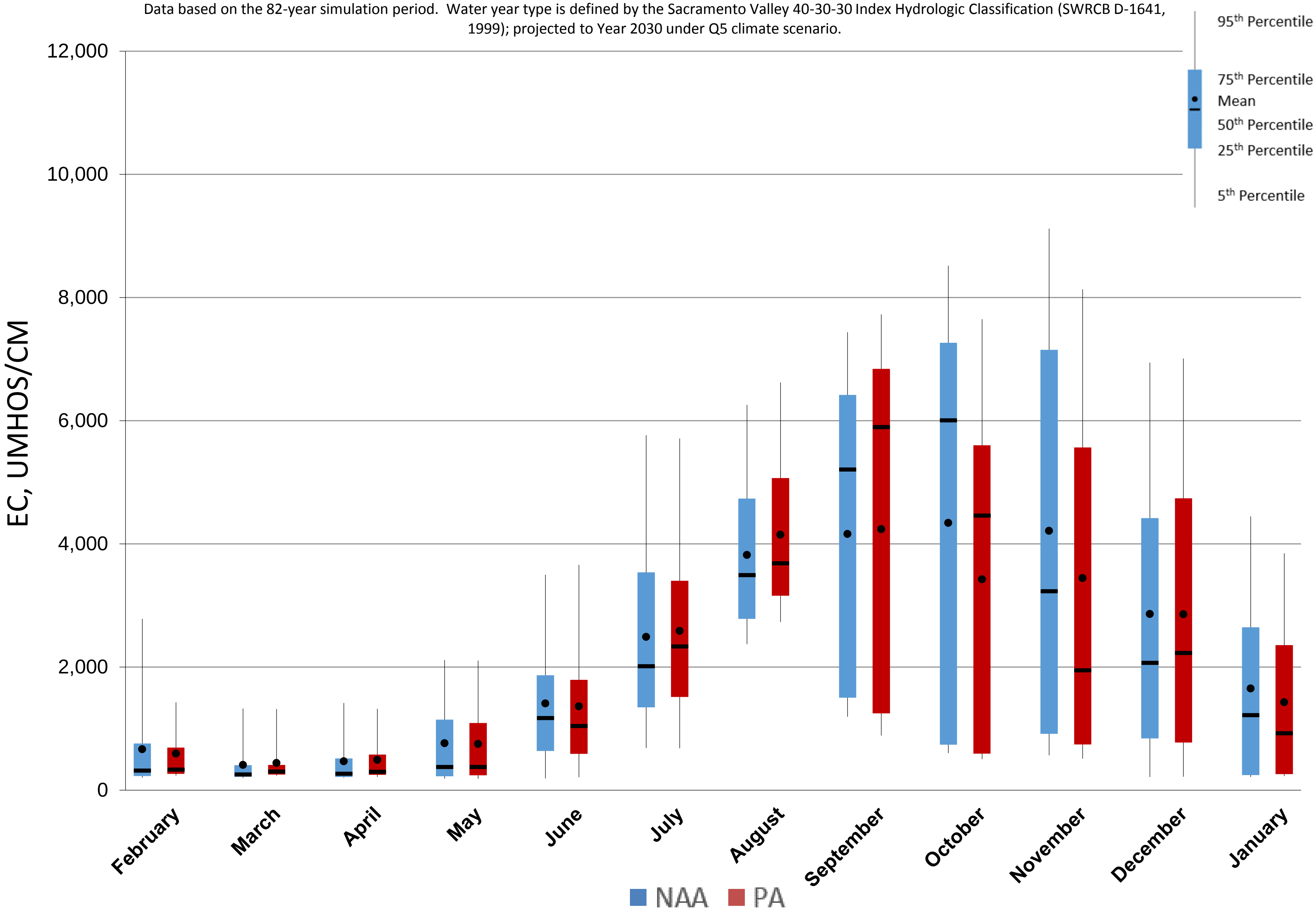


Figure 5.B.5-16-2. Monthly EC Ranges For San Joaquin River at Antioch Salinity, Wet Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 26 wet years.

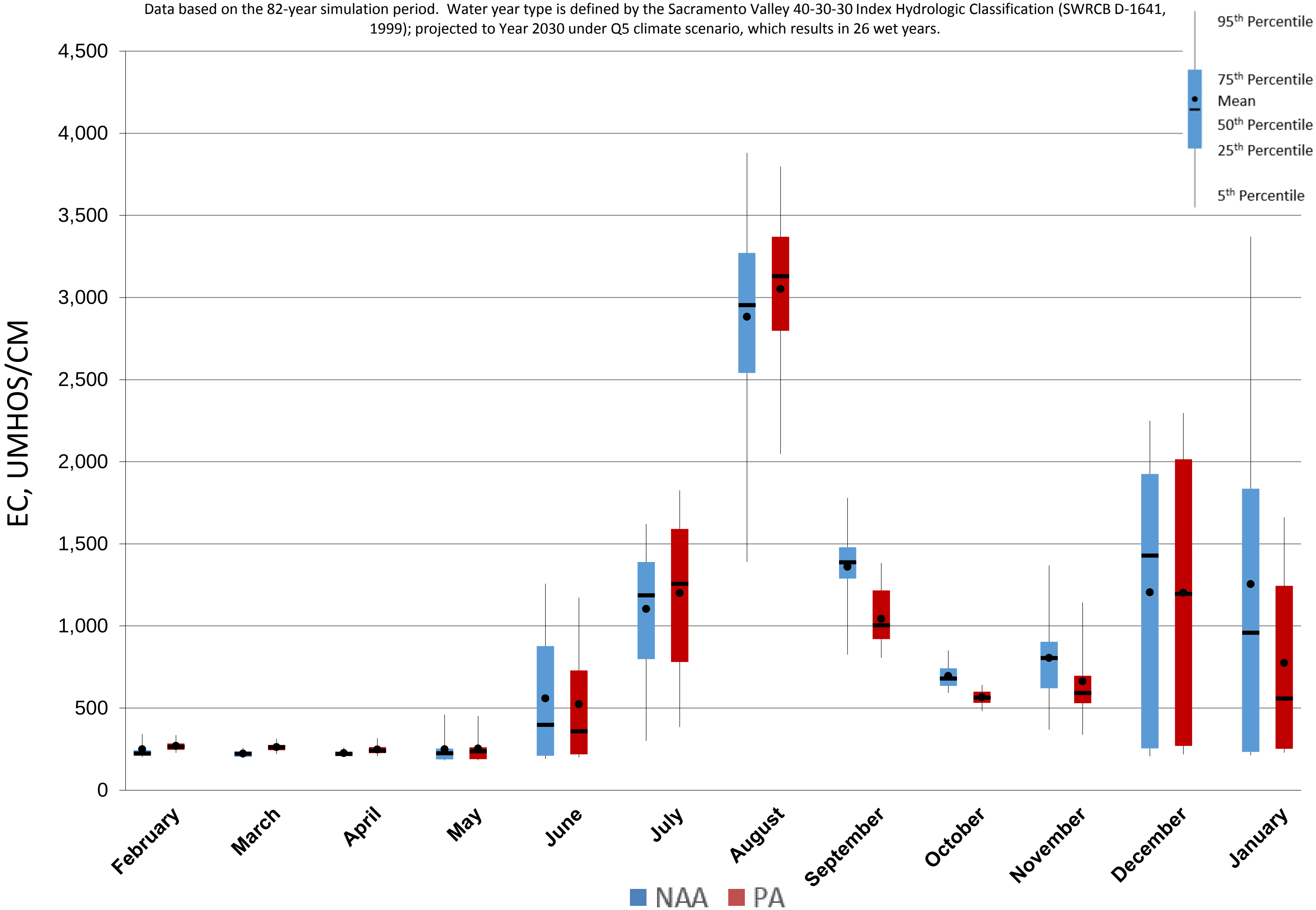


Figure 5.B.5-16-3. Monthly EC Ranges For San Joaquin River at Antioch Salinity, Above Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 13 above normal years.

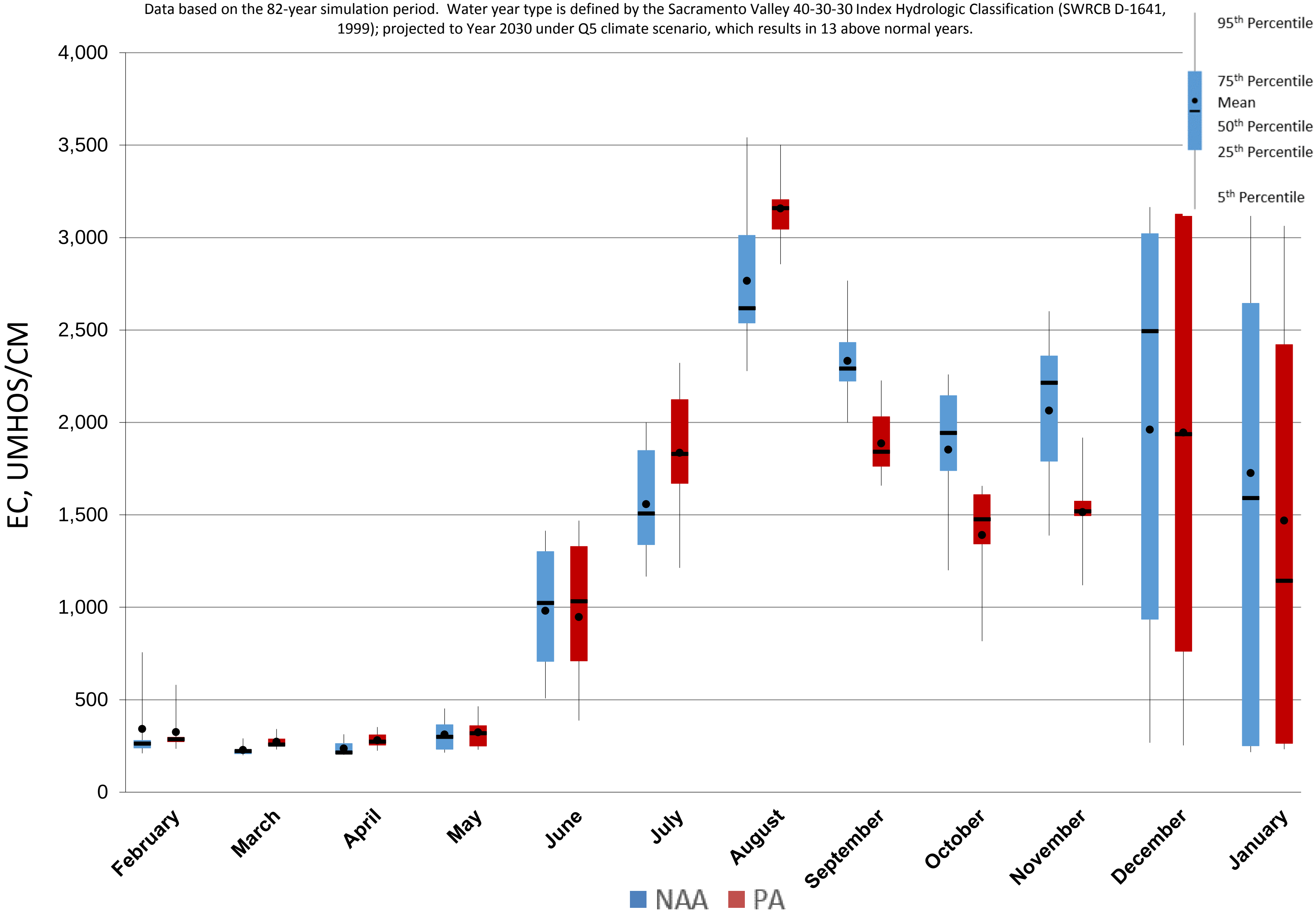
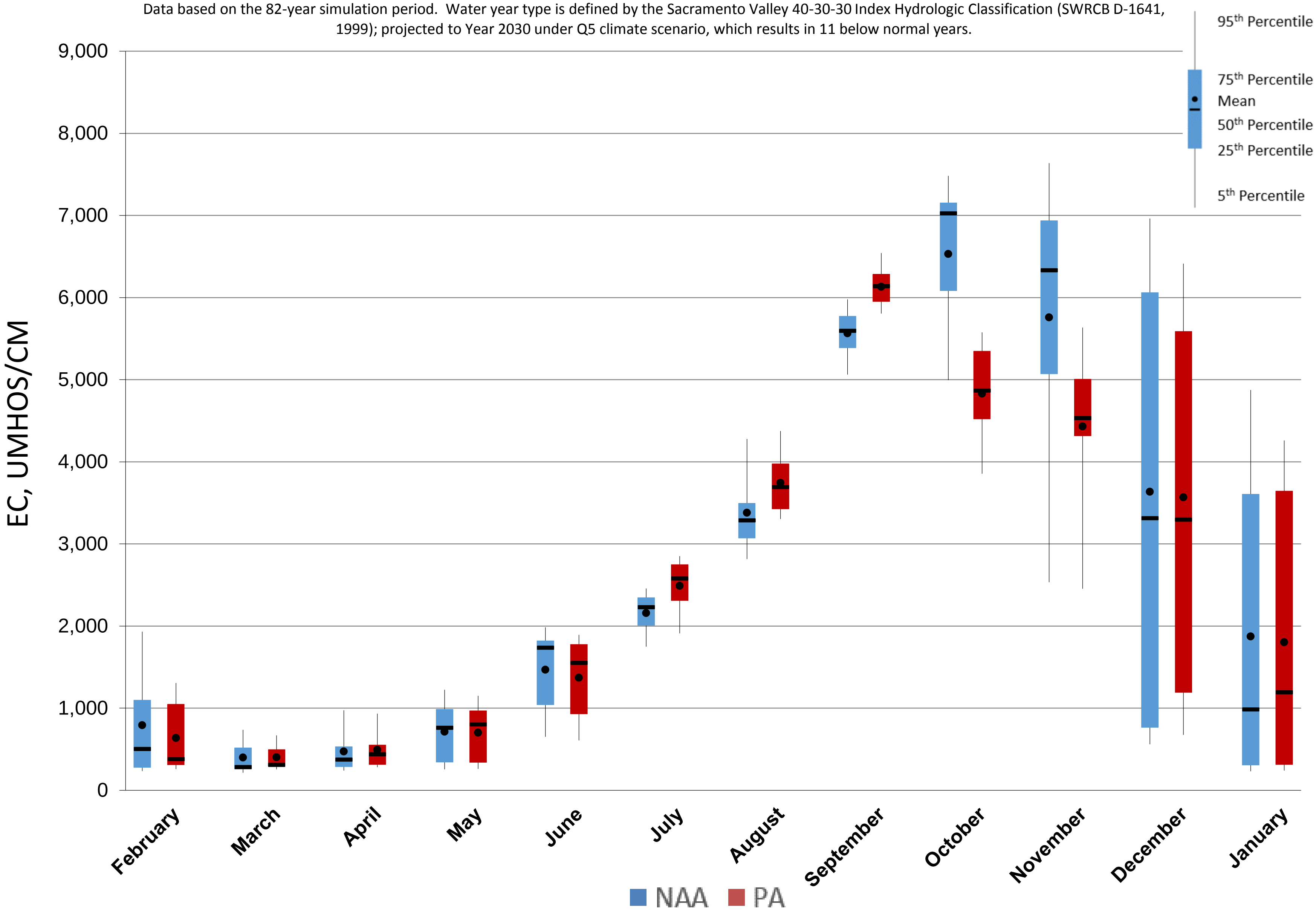


Figure 5.B.5-16-4. Monthly EC Ranges For San Joaquin River at Antioch Salinity, Below Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 11 below normal years.



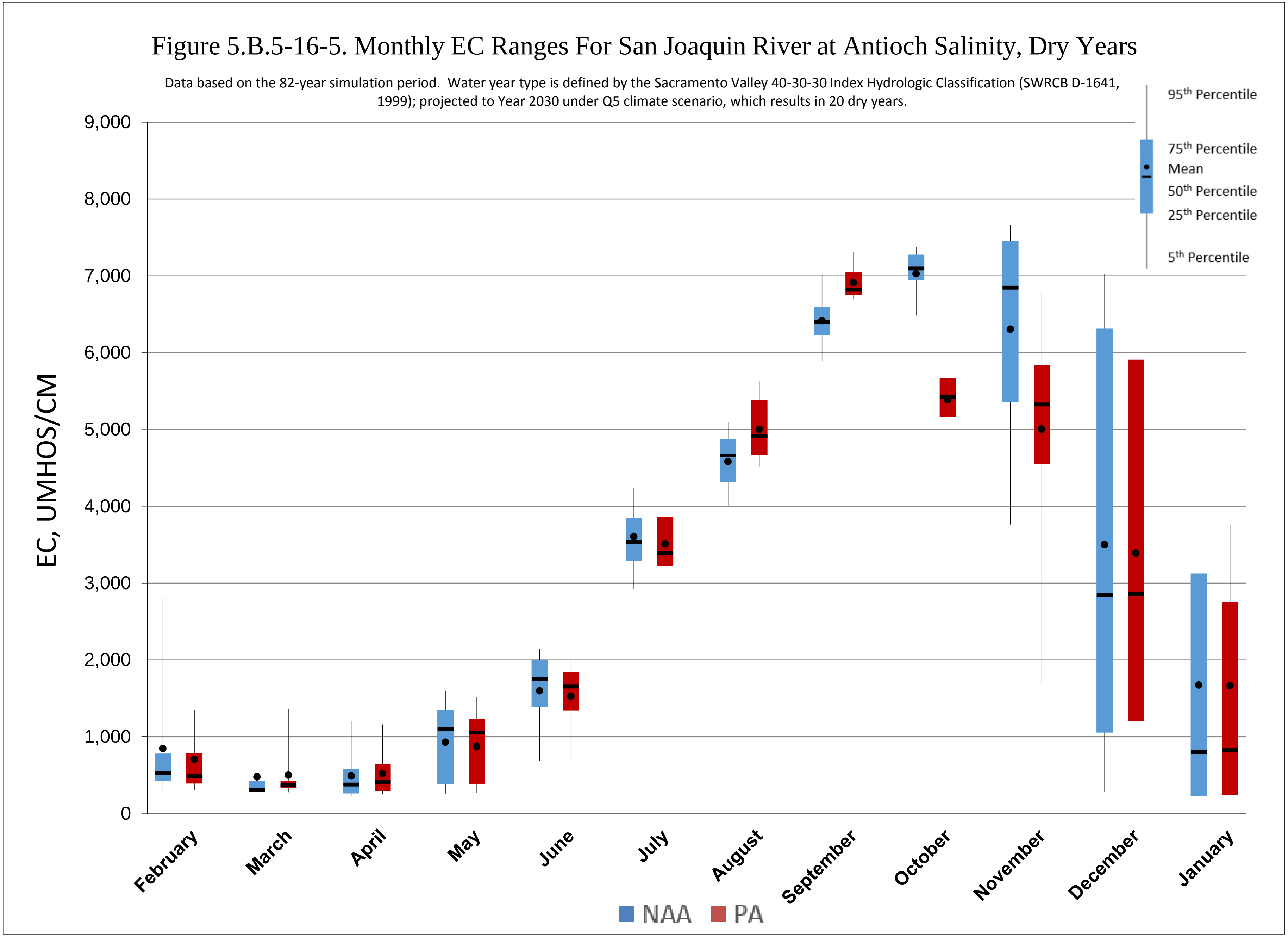


Figure 5.B.5-16-5. Monthly EC Ranges For San Joaquin River at Antioch Salinity, Dry Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 20 dry years.
EC, UMHOS/CM
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
February
March
April
May
June
July
August
September
October
November
December
January
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
NAA
PA

Figure 5.B.5-16-6. Monthly EC Ranges For San Joaquin River at Antioch Salinity, Critical Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 12 critical years.

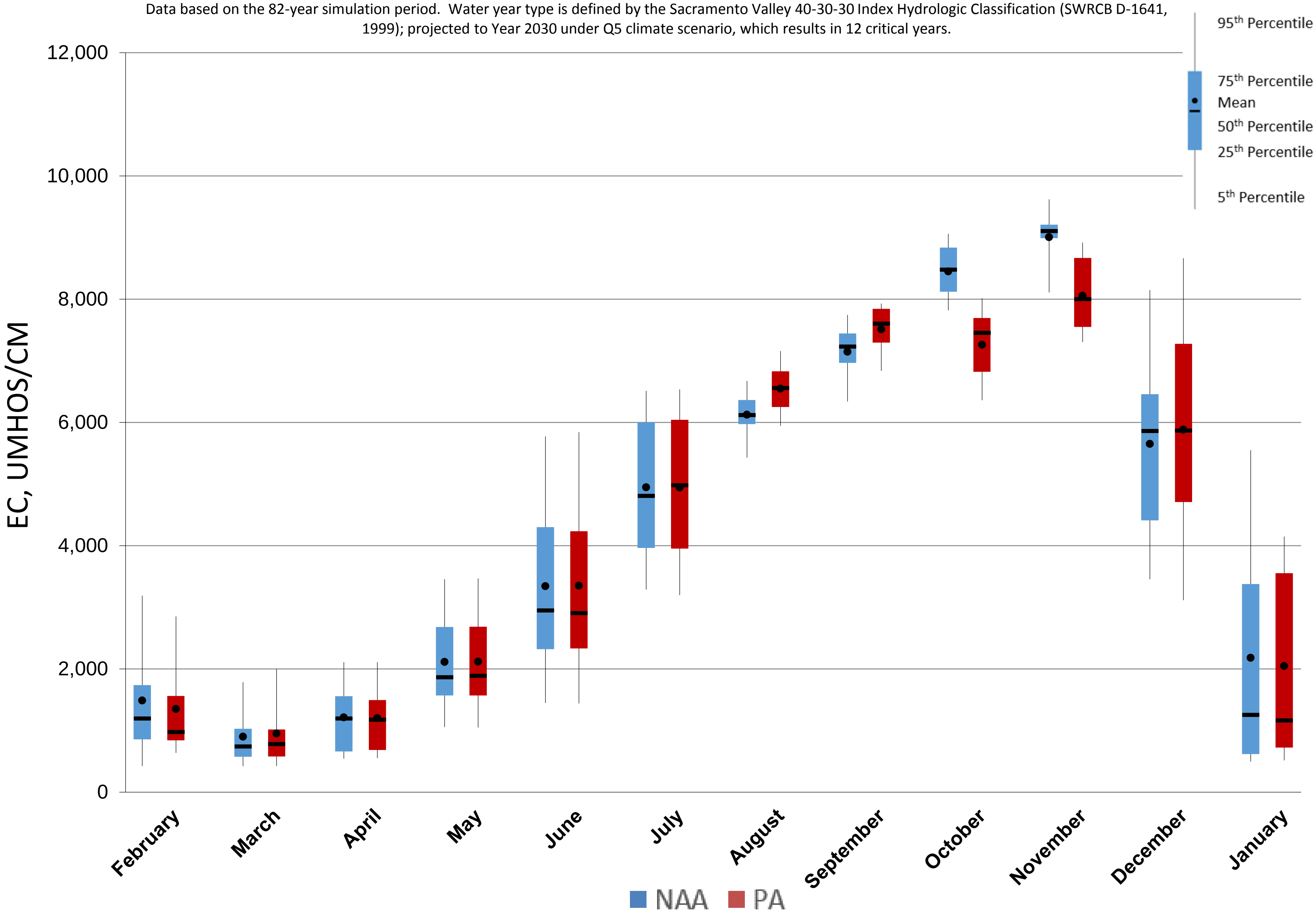
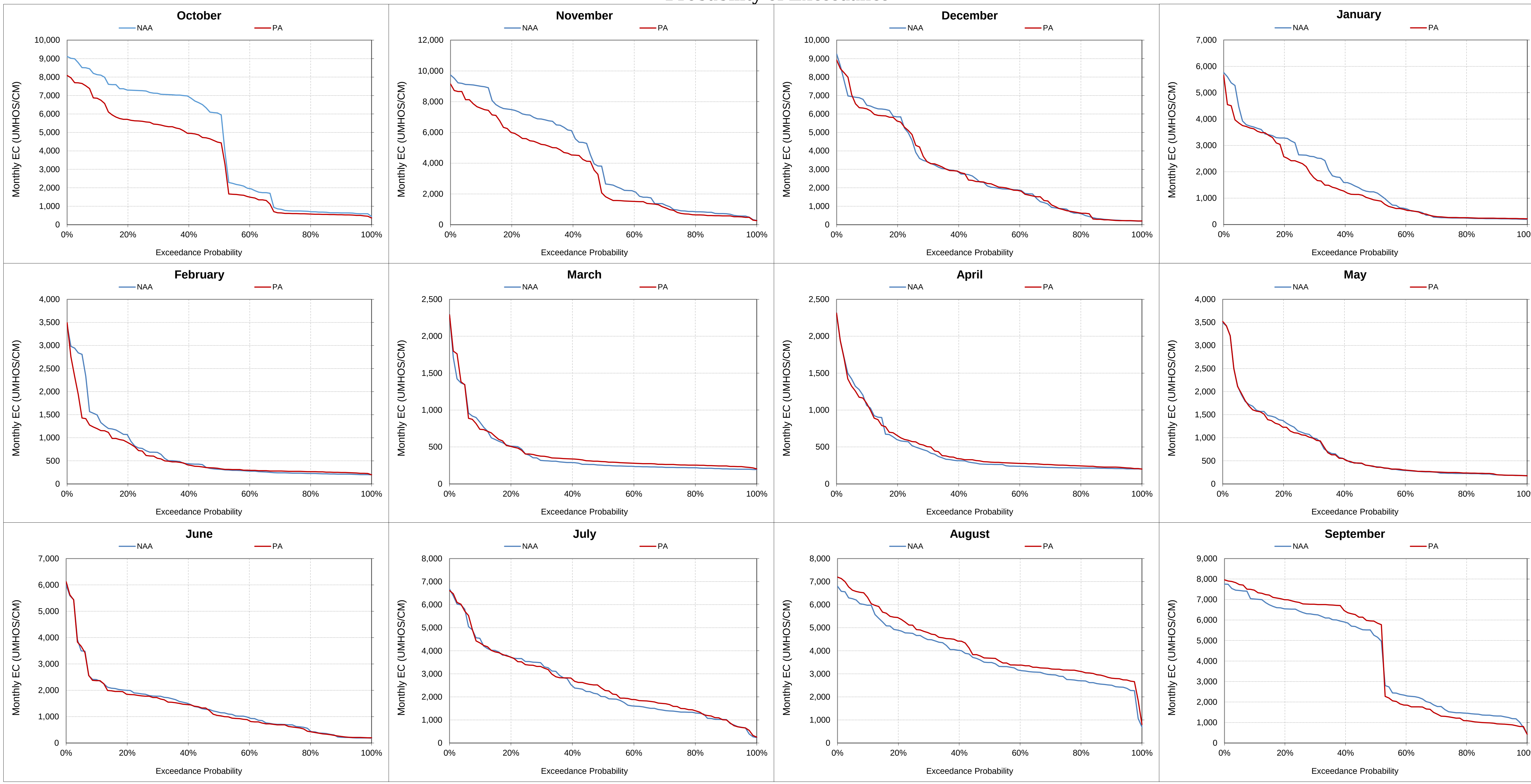
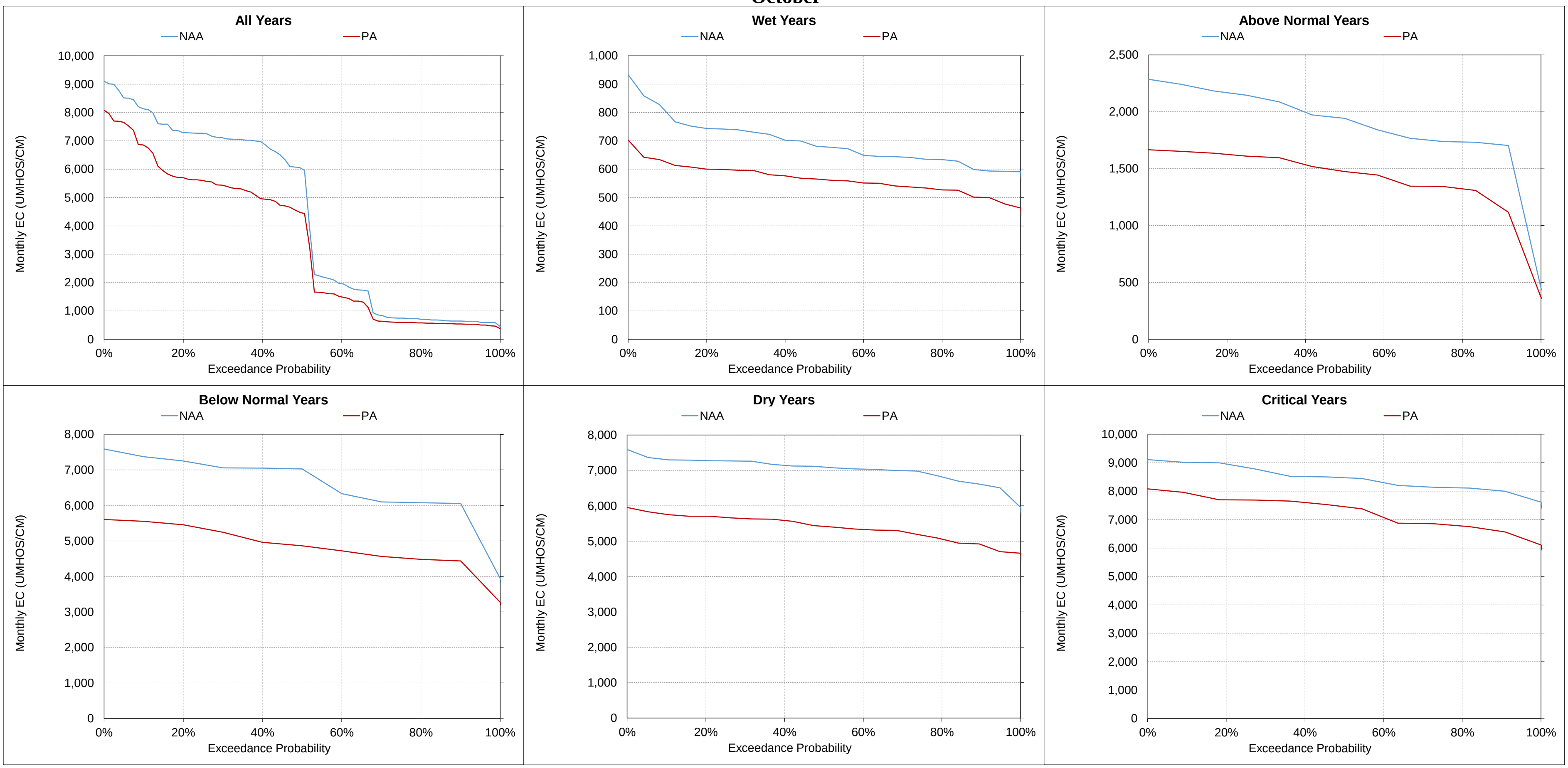


Figure 5.B.5-16-7. San Joaquin River at Antioch Salinity, Monthly EC Probability of Exceedance



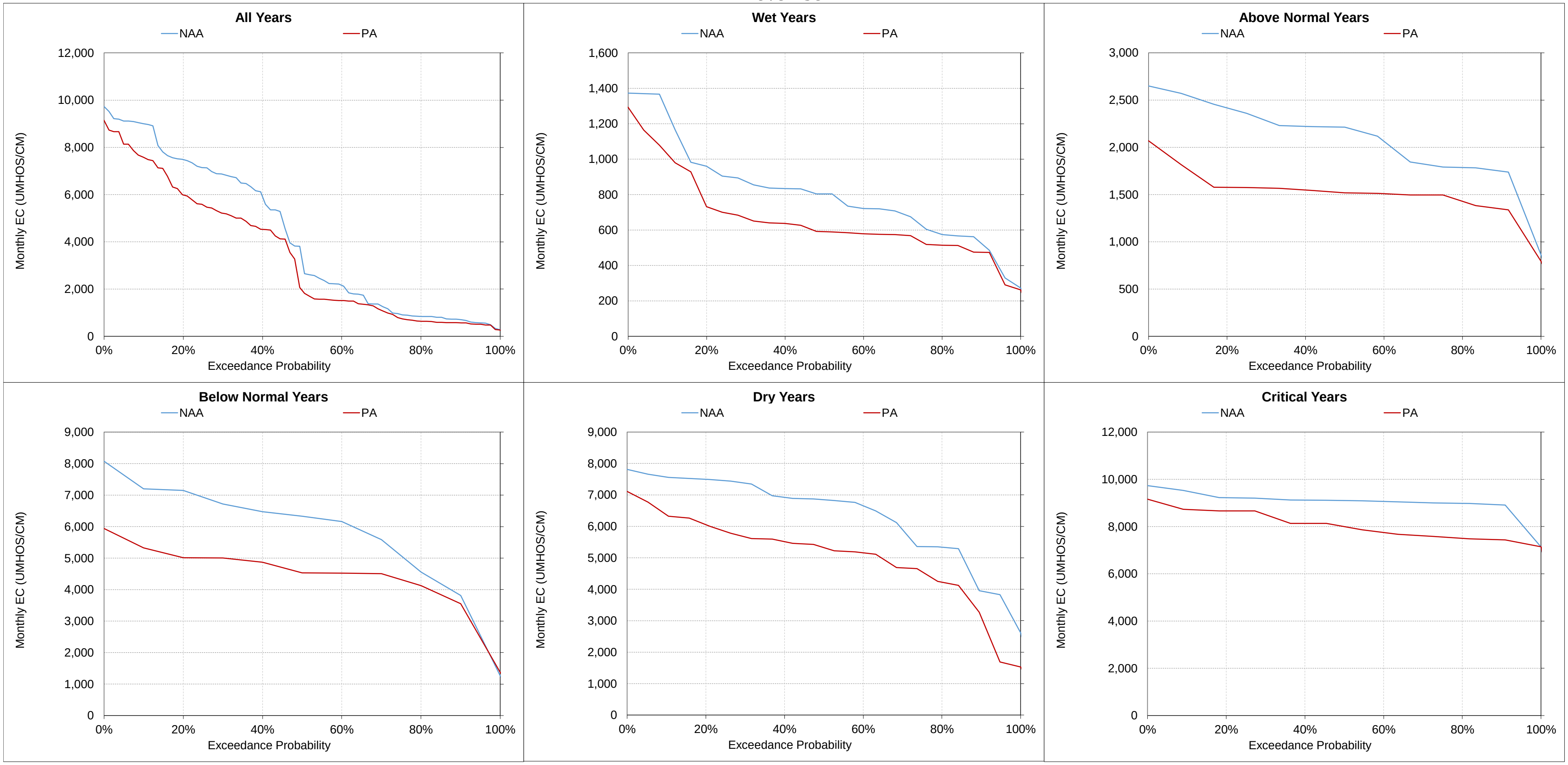
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-16-8. San Joaquin River at Antioch Salinity, Monthly EC
October



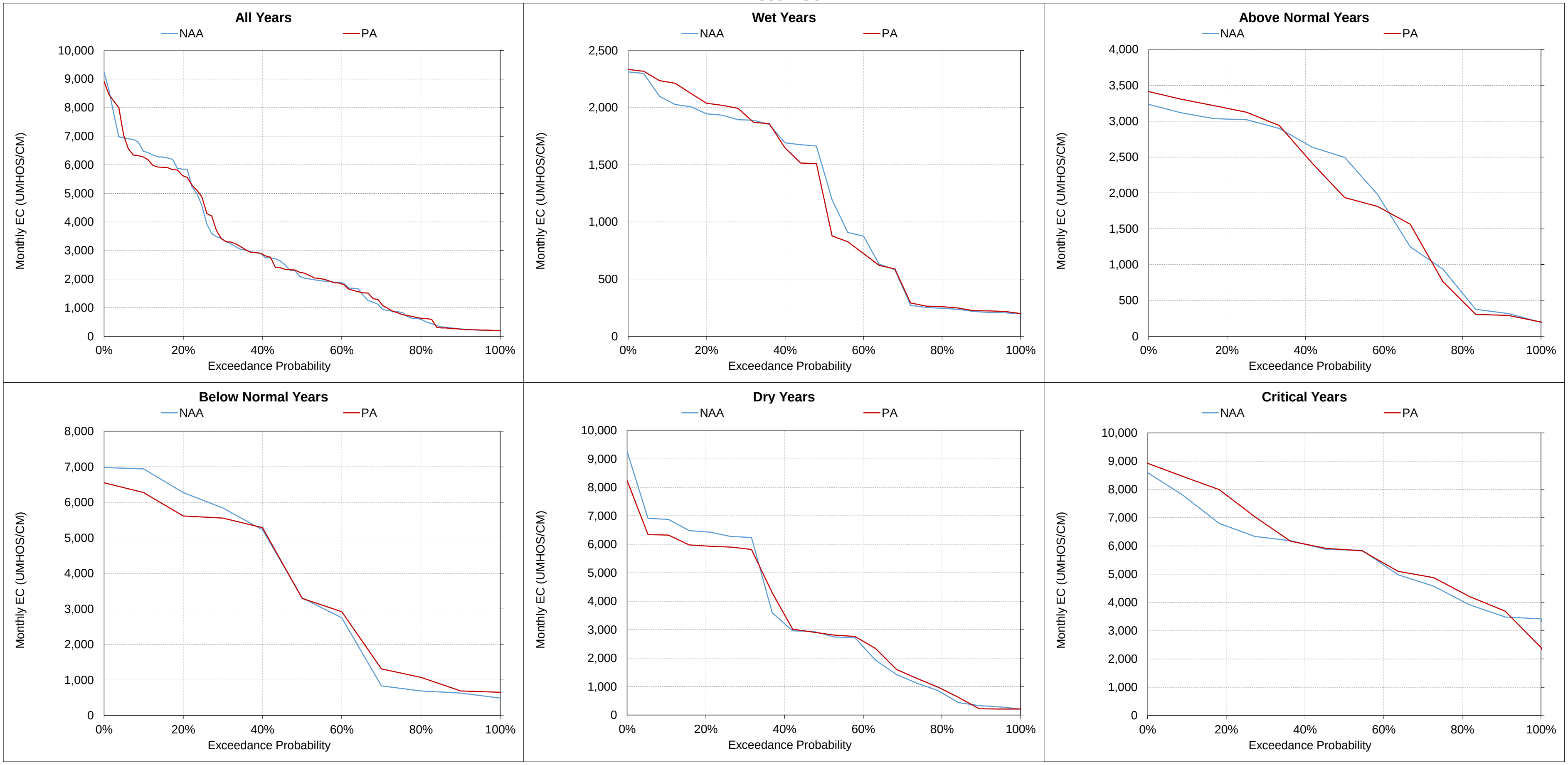
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-16-9. San Joaquin River at Antioch Salinity, Monthly EC November



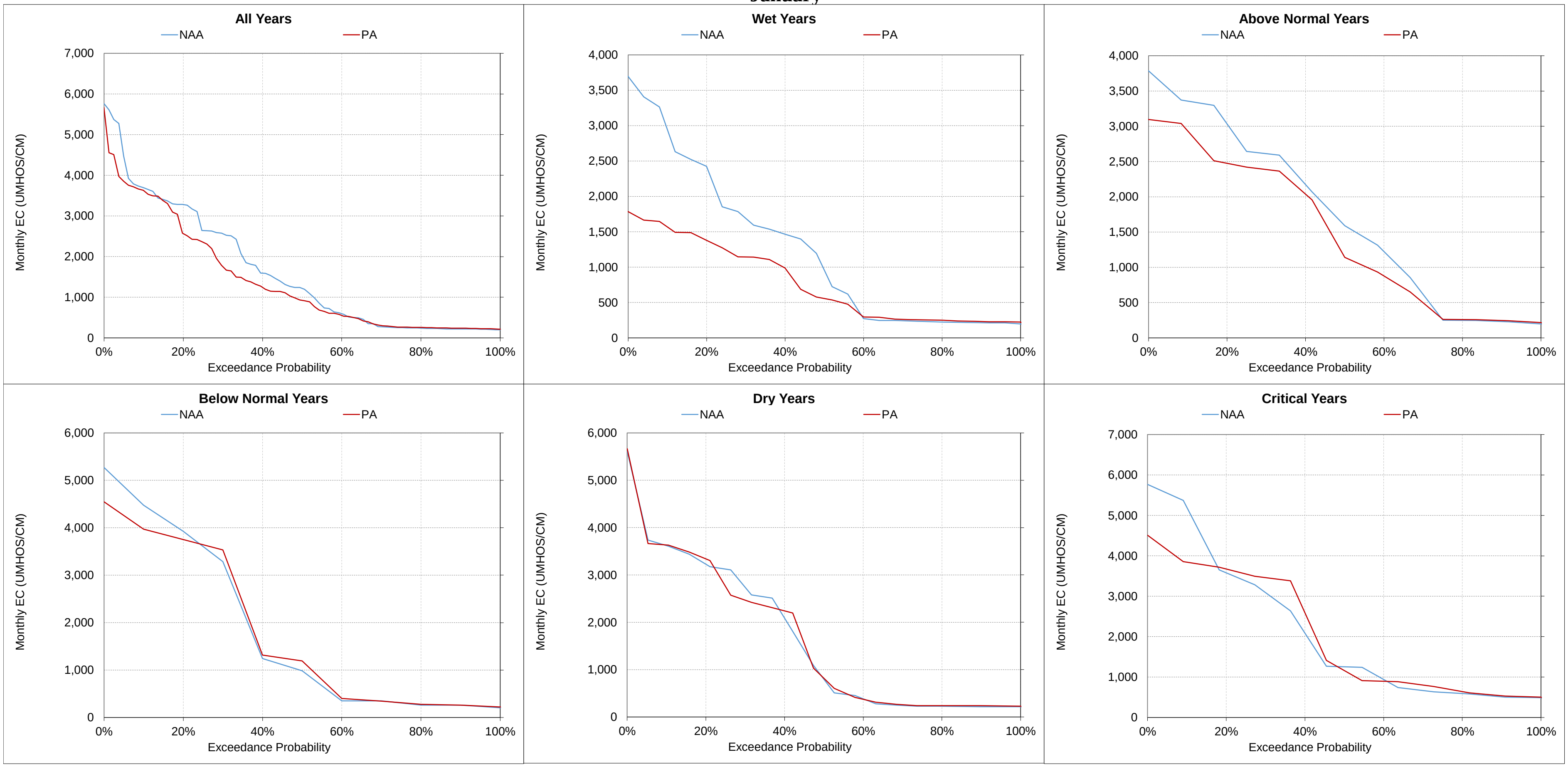
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-16-10. San Joaquin River at Antioch Salinity, Monthly EC
December



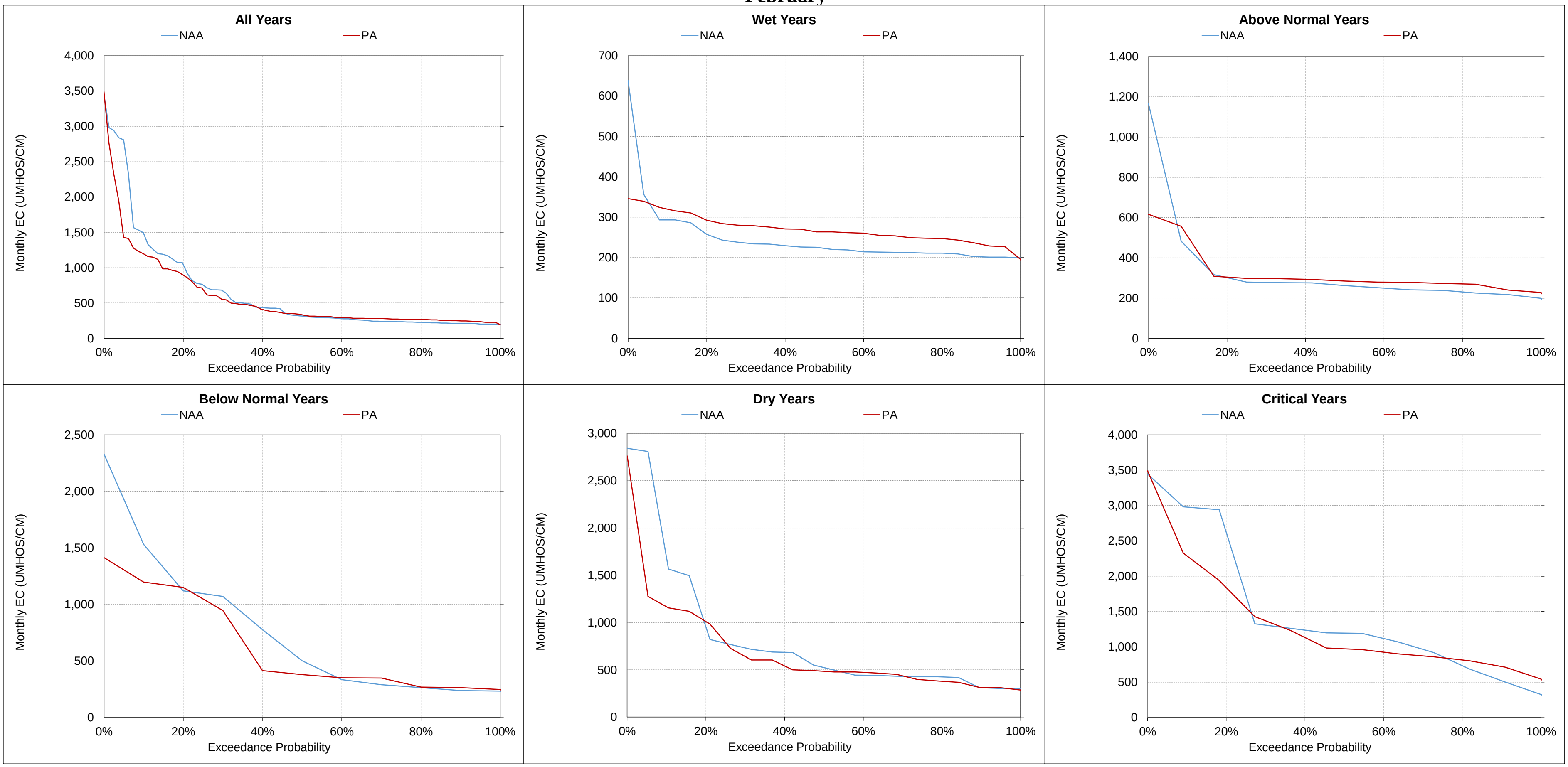
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-16-11. San Joaquin River at Antioch Salinity, Monthly EC
January



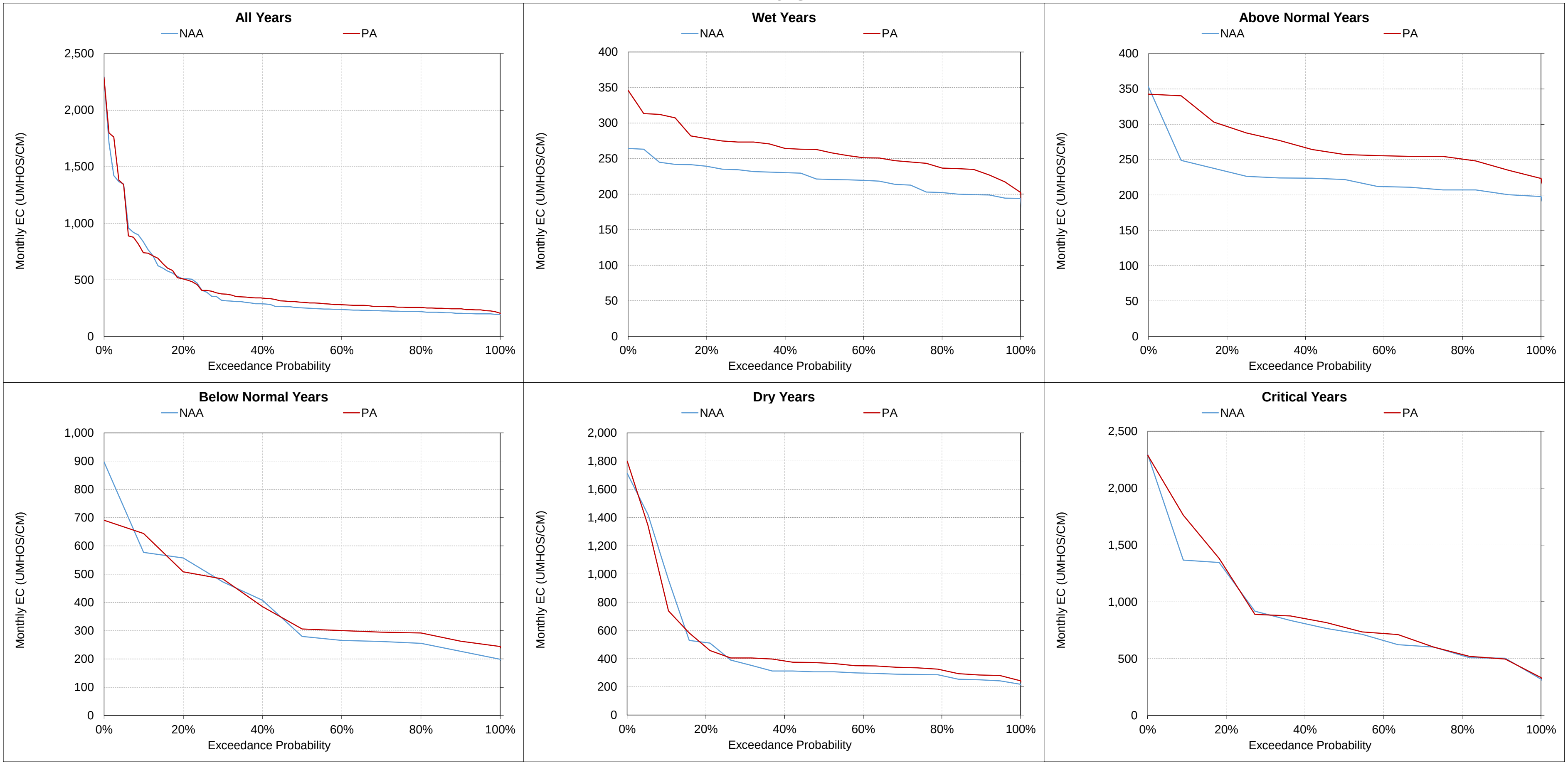
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-16-12. San Joaquin River at Antioch Salinity, Monthly EC
February



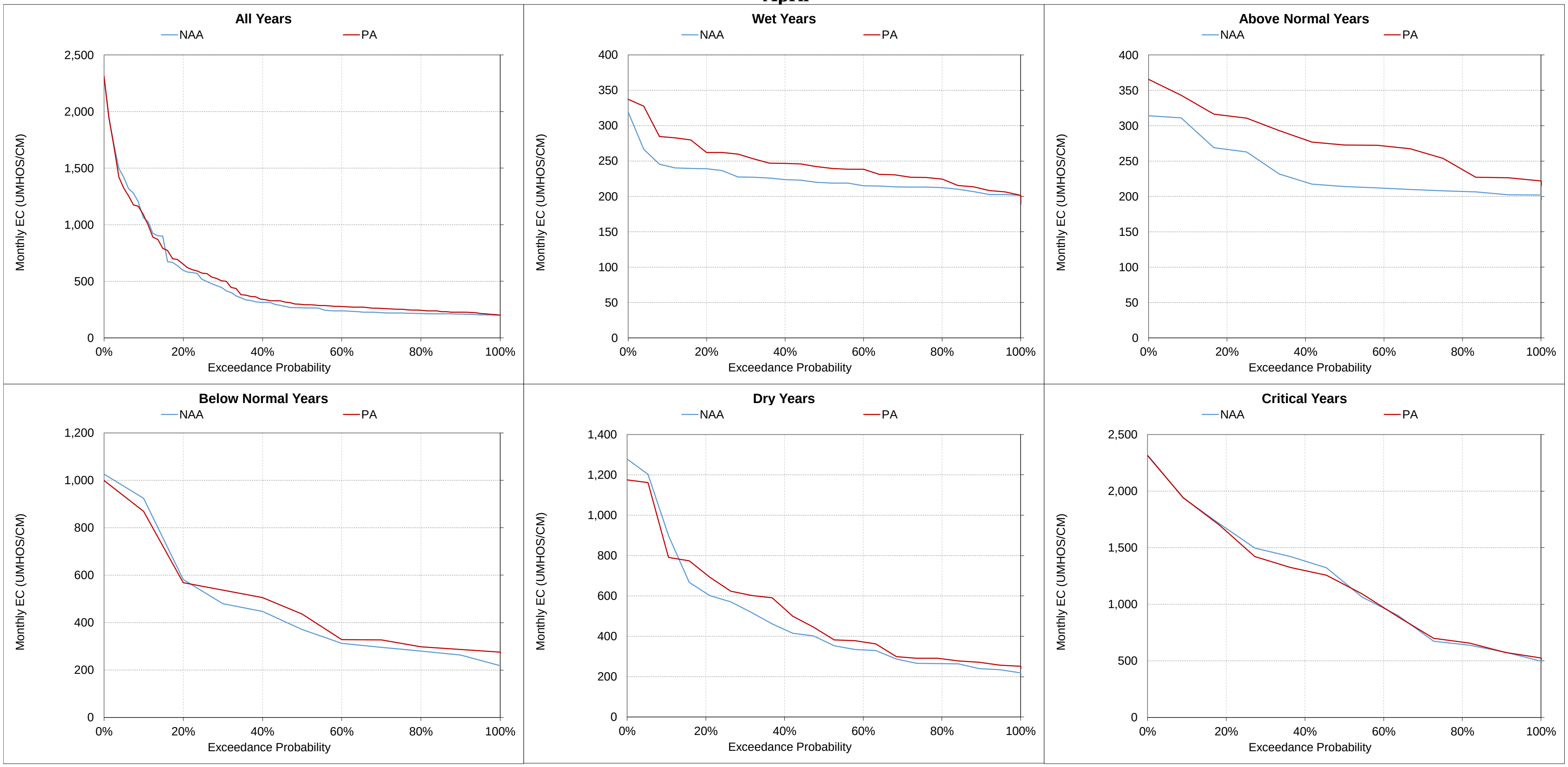
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-16-13. San Joaquin River at Antioch Salinity, Monthly EC
March



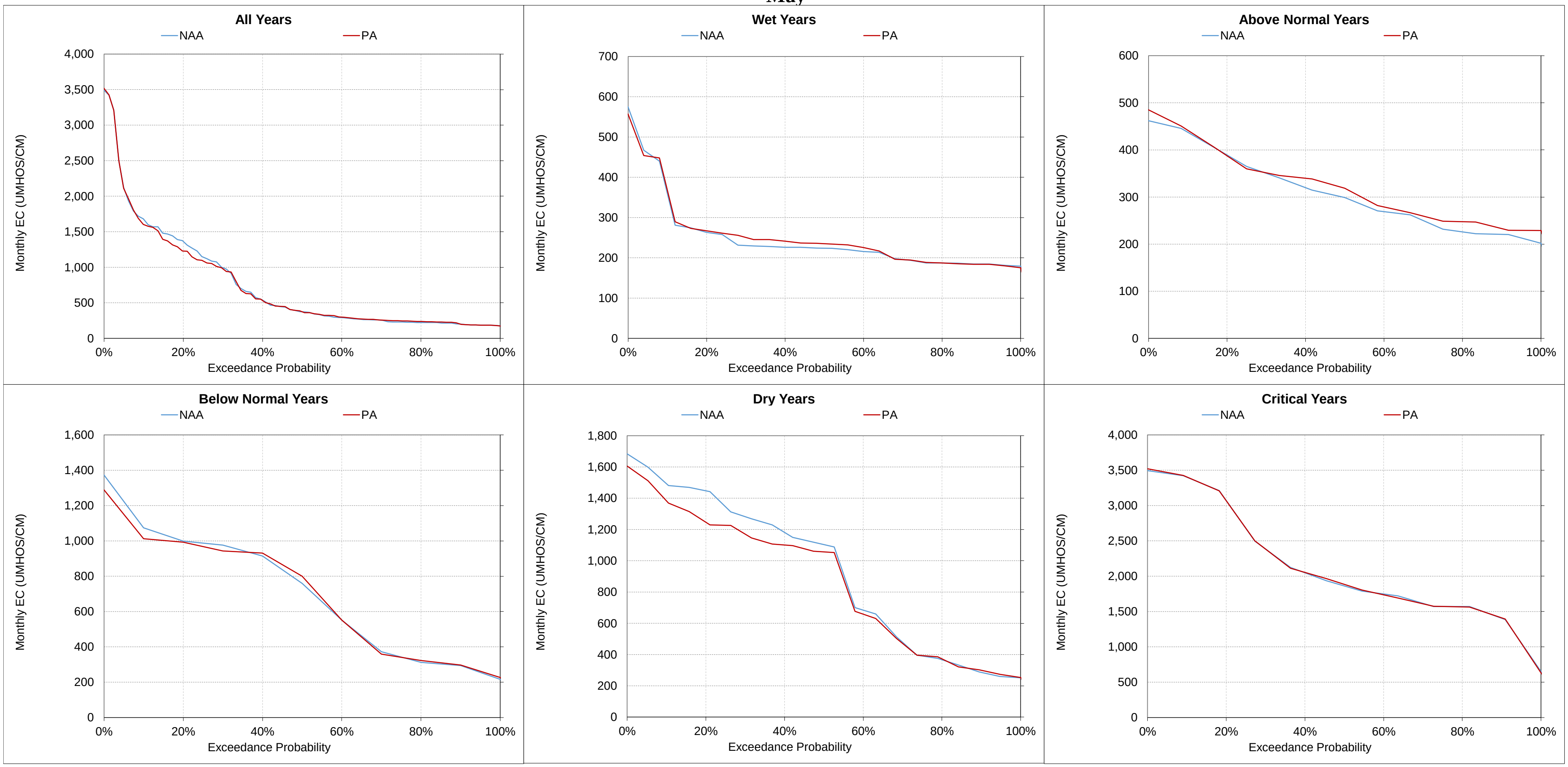
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-16-14. San Joaquin River at Antioch Salinity, Monthly EC April



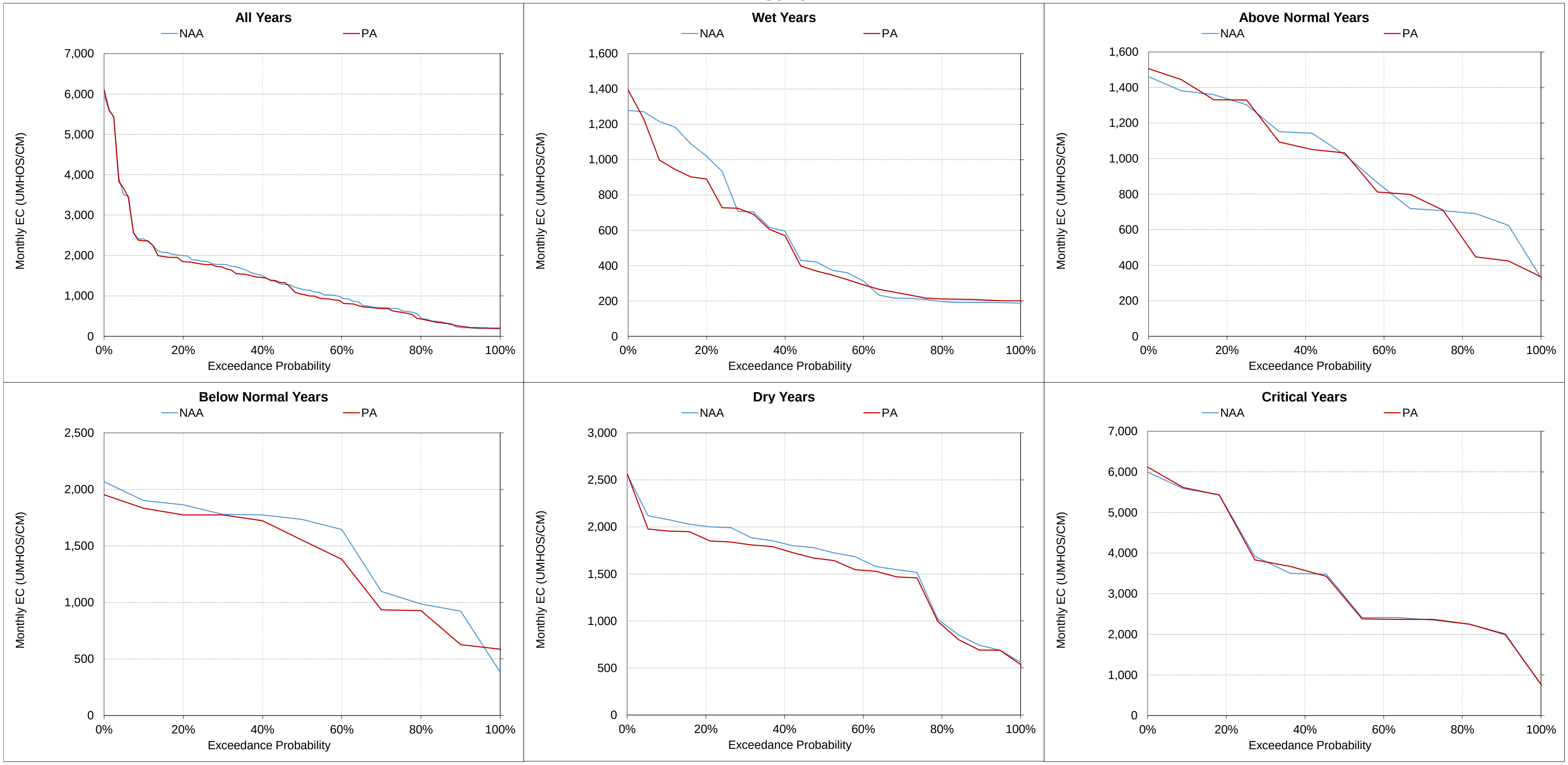
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-16-15. San Joaquin River at Antioch Salinity, Monthly EC May



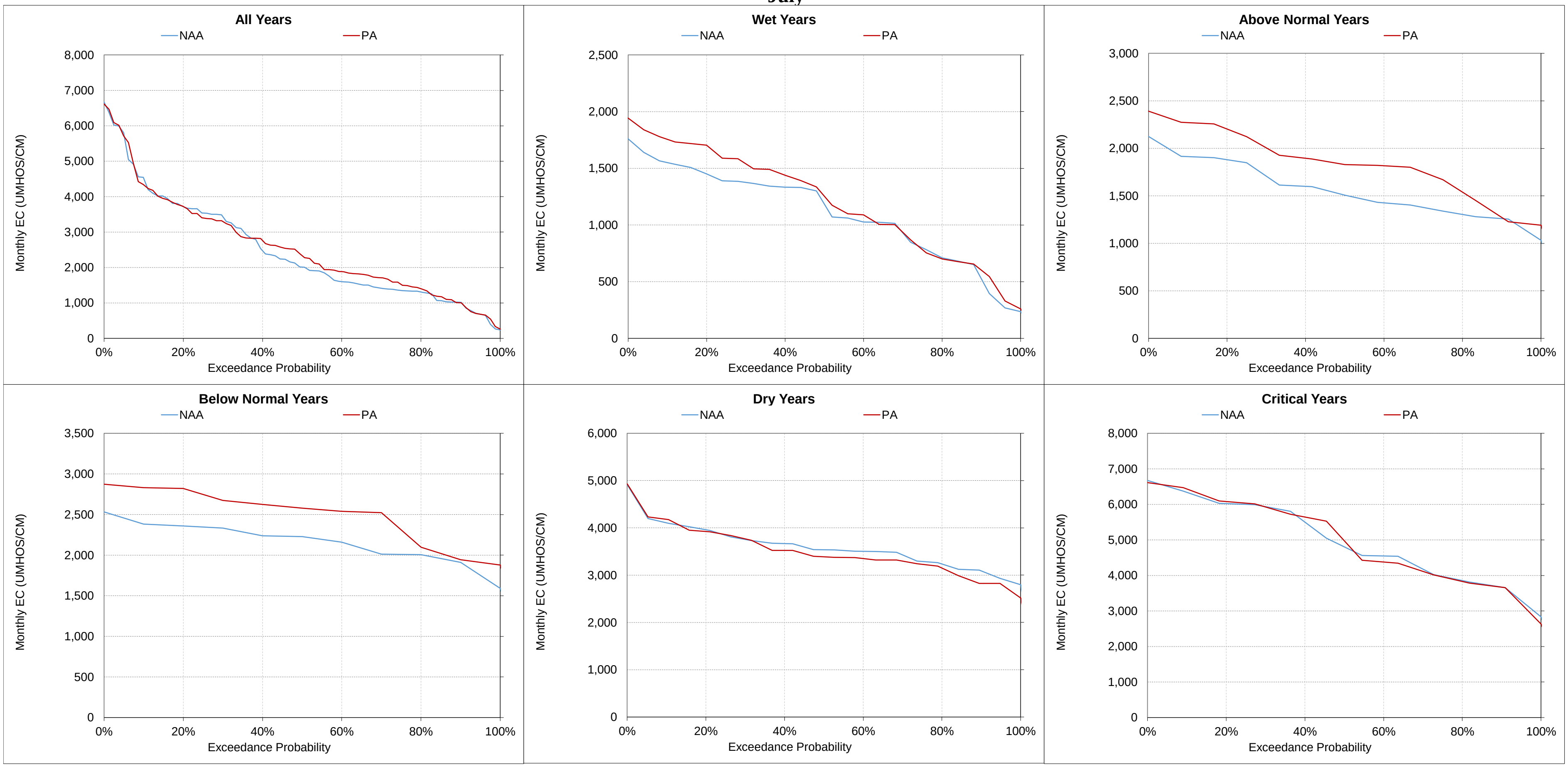
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-16-16. San Joaquin River at Antioch Salinity, Monthly EC
June



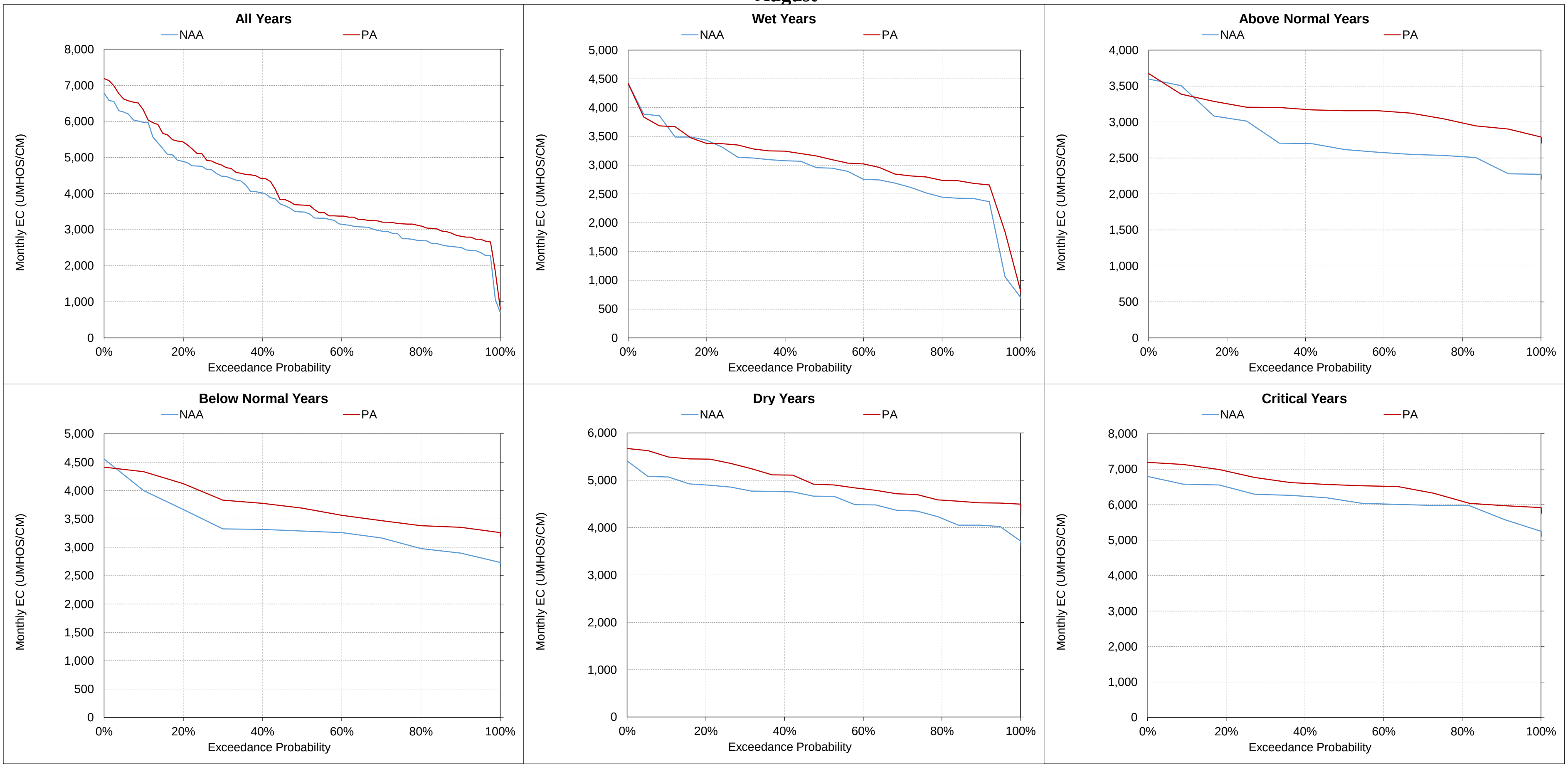
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-16-17. San Joaquin River at Antioch Salinity, Monthly EC
July



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-16-18. San Joaquin River at Antioch Salinity, Monthly EC August



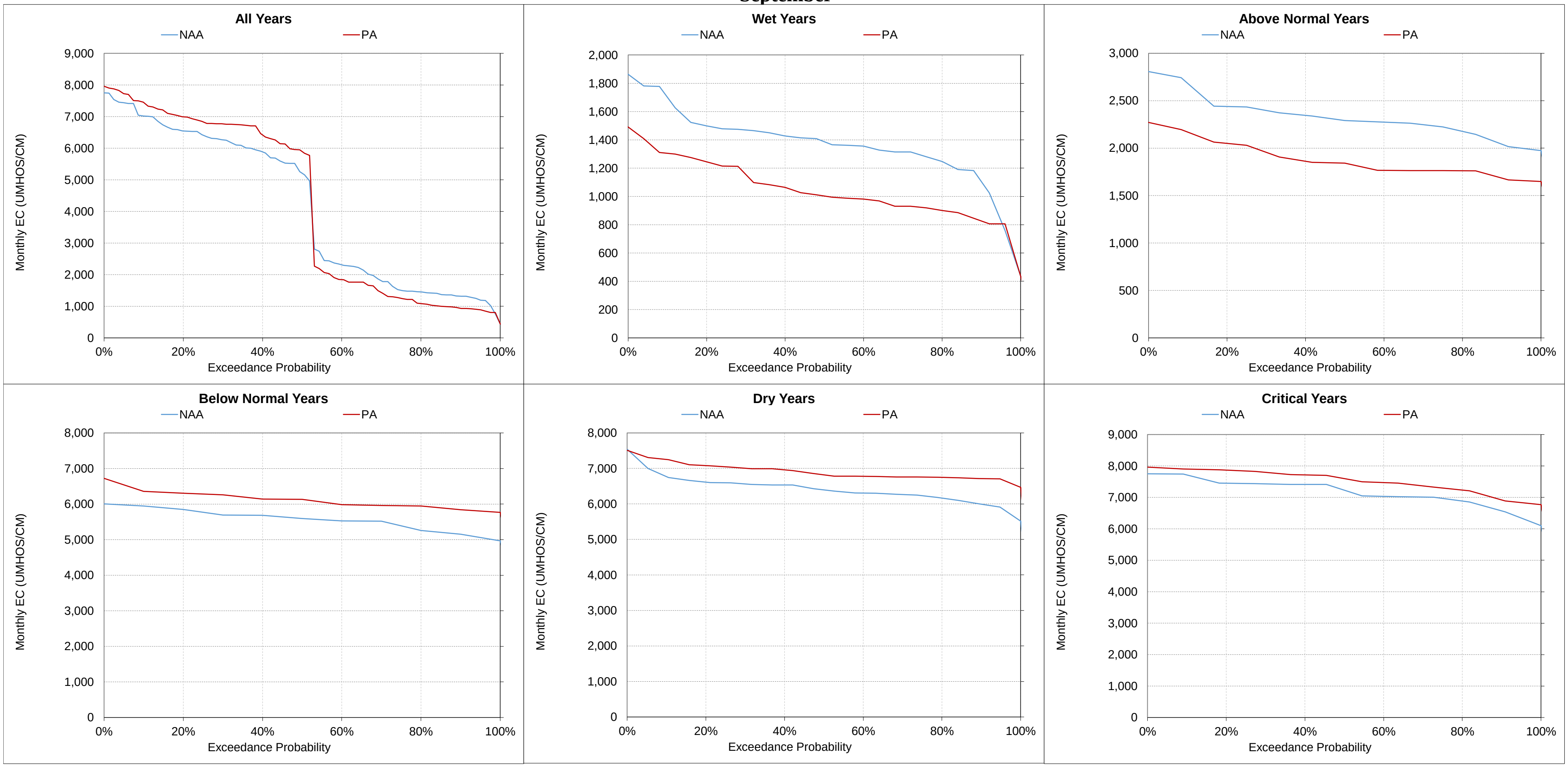
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-16-19. San Joaquin River at Antioch Salinity, Monthly EC September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-17. Chipps Island South Channel Salinity, Monthly EC

Statistic	Monthly EC (UMHOS/CM)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	14,758	13,855	-902	-6%	15,503	14,105	-1,399	-9%	12,757	12,312	-445	-3%	8,469	8,523	53	1%	4,320	4,026	-294	-7%	3,155	2,938	-218	-7%
20%	13,642	12,524	-1,118	-8%	13,695	12,292	-1,403	-10%	10,877	10,981	104	1%	7,587	6,720	-867	-11%	2,422	2,530	108	4%	1,963	2,094	131	7%
30%	13,491	12,153	-1,338	-10%	13,220	11,351	-1,869	-14%	7,757	8,048	291	4%	6,237	5,320	-918	-15%	1,911	1,714	-197	-10%	960	1,160	201	21%
40%	13,243	11,702	-1,541	-12%	11,039	10,516	-523	-5%	6,517	6,728	211	3%	4,028	3,482	-546	-14%	1,091	1,294	203	19%	770	981	211	27%
50%	11,848	11,025	-823	-7%	7,248	6,267	-981	-14%	5,350	5,659	309	6%	2,717	2,311	-407	-15%	743	716	-27	-4%	449	549	100	22%
60%	5,883	5,564	-320	-5%	5,785	5,511	-274	-5%	5,004	5,085	81	2%	1,363	1,583	220	16%	303	353	50	16%	266	309	43	16%
70%	2,843	2,768	-75	-3%	3,474	3,584	110	3%	2,571	2,743	173	7%	354	436	82	23%	217	236	19	9%	210	242	32	15%
80%	2,618	2,588	-30	-1%	2,981	2,897	-84	-3%	1,552	2,098	545	35%	223	258	36	16%	200	216	16	8%	200	216	16	8%
90%	2,531	2,504	-27	-1%	2,630	2,594	-37	-1%	399	515	116	29%	193	204	12	6%	192	207	15	8%	194	209	15	8%
Long Term Full Simulation Period[b]	8,812	8,162	-650	-7%	8,426	7,770	-656	-8%	6,064	6,149	85	1%	3,722	3,410	-313	-8%	1,620	1,509	-111	-7%	1,090	1,169	79	7%
Water Year Types[c]																								
Wet (32%)	2,599	2,566	-32	-1%	2,752	2,749	-3	0%	3,179	3,220	41	1%	2,982	2,106	-876	-29%	277	262	-15	-5%	265	288	23	9%
Above Normal (16%)	5,573	5,201	-372	-7%	5,670	5,452	-218	-4%	4,798	4,932	134	3%	3,974	3,674	-299	-8%	633	561	-72	-11%	323	343	20	6%
Below Normal (13%)	12,214	11,035	-1,179	-10%	11,171	9,905	-1,266	-11%	7,381	7,479	98	1%	4,015	4,033	19	0%	2,084	1,726	-358	-17%	1,321	1,325	4	0%
Dry (24%)	13,394	12,170	-1,224	-9%	11,834	10,569	-1,265	-11%	6,876	6,890	14	0%	3,602	3,667	65	2%	2,258	2,080	-177	-8%	1,340	1,511	171	13%
Critical (15%)	15,025	14,177	-849	-6%	15,511	14,540	-971	-6%	11,128	11,360	232	2%	4,988	4,947	-40	-1%	4,111	4,088	-24	-1%	3,080	3,262	182	6%

Statistic	Monthly EC (UMHOS/CM)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	4,047	3,971	-76	-2%	5,113	5,113	0	0%	6,949	6,902	-46	-1%	9,592	9,605	13	0%	11,729	12,277	549	5%	13,134	13,563	430	3%
20%	2,497	2,581	84	3%	4,566	4,343	-224	-5%	5,933	5,763	-170	-3%	8,356	8,676	320	4%	10,266	10,835	569	6%	12,226	13,036	810	7%
30%	1,602	1,865	263	16%	3,759	3,675	-85	-2%	5,459	5,330	-129	-2%	7,720	7,911	191	2%	9,751	10,230	479	5%	11,953	12,787	834	7%
40%	1,161	1,152	-9	-1%	2,190	2,206	16	1%	4,718	4,751	33	1%	6,303	7,035	732	12%	8,616	9,671	1,055	12%	11,223	12,368	1,144	10%
50%	803	817	13	2%	1,514	1,453	-61	-4%	3,708	3,605	-103	-3%	5,465	6,332	867	16%	7,762	8,592	830	11%	10,253	11,782	1,529	15%
60%	435	482	47	11%	868	833	-35	-4%	3,347	3,111	-236	-7%	4,508	5,603	1,095	24%	7,348	8,094	745	10%	5,702	5,873	171	3%
70%	315	329	14	4%	556	552	-4	-1%	2,554	2,576	22	1%	4,083	5,171	1,088	27%	6,965	7,920	955	14%	3,936	4,211	275	7%
80%	217	231	14	7%	310	315	5	2%	1,653	1,680	27	2%	3,877	4,503	625	16%	6,379	7,692	1,314	21%	3,135	3,367	232	7%
90%	193	202	10	5%	196	195	0	0%	491	573	82	17%	2,965	3,175	210	7%	6,150	7,368	1,218	20%	2,799	3,064	265	9%
Long Term Full Simulation Period[b]	1,440	1,477	37	3%	2,323	2,286	-37	-2%	4,078	3,994	-83	-2%	5,951	6,487	536	9%	8,343	9,165	822	10%	8,186	8,745	559	7%
Water Year Types[c]																								
Wet (32%)	344	356	12	3%	543	541	-2	0%	1,738	1,675	-64	-4%	3,263	3,793	530	16%	6,676	7,481	804	12%	3,069	3,312	243	8%
Above Normal (16%)	482	490	8	2%	977	971	-6	-1%	3,213	3,139	-74	-2%	4,382	5,513	1,132	26%	6,594	7,838	1,244	19%	5,696	5,927	232	4%
Below Normal (13%)	1,745	1,797	52	3%	2,595	2,553	-42	-2%	4,637	4,457	-180	-4%	5,665	6,649	984	17%	7,689	8,846	1,156	15%	10,760	11,990	1,230	11%
Dry (24%)	1,713	1,828	115	7%	3,154	3,030	-124	-4%	4,959	4,837	-122	-2%	8,028	8,194	166	2%	9,803	10,434	631	6%	12,030	12,907	877	7%
Critical (15%)	4,116	4,096	-21	-1%	6,001	6,004	3	0%	8,104	8,120	16	0%	10,275	10,386	111	1%	12,015	12,429	415	3%	13,203	13,657	454	3%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

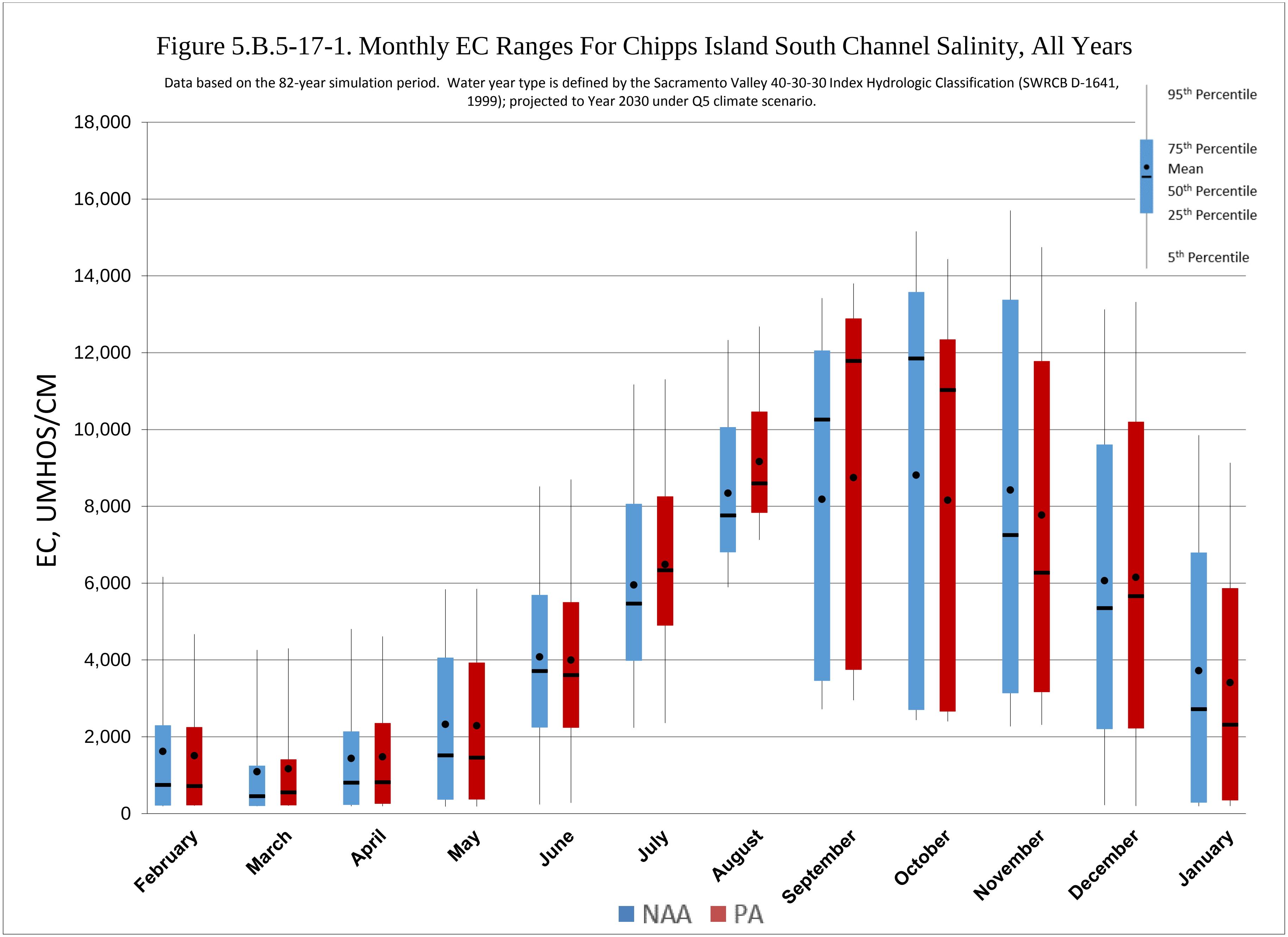


Figure 5.B.5-17-1. Monthly EC Ranges For Chipps Island South Channel Salinity, All Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario.
EC, UMHOS/CM
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
February
March
April
May
June
July
August
September
October
November
December
January
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
NAA
PA

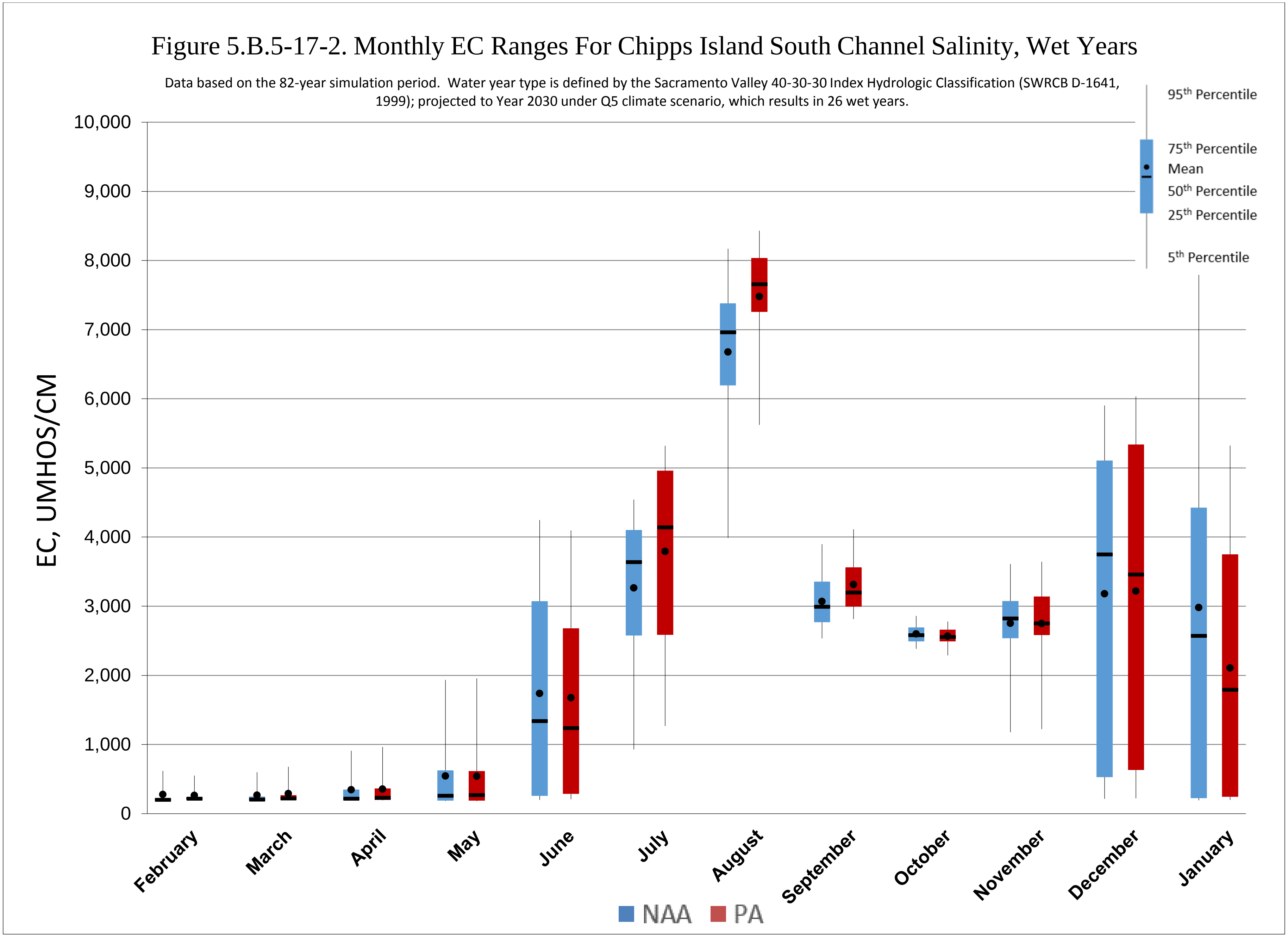


Figure 5.B.5-17-2. Monthly EC Ranges For Chipps Island South Channel Salinity, Wet Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 26 wet years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
EC, UMHOS/CM
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

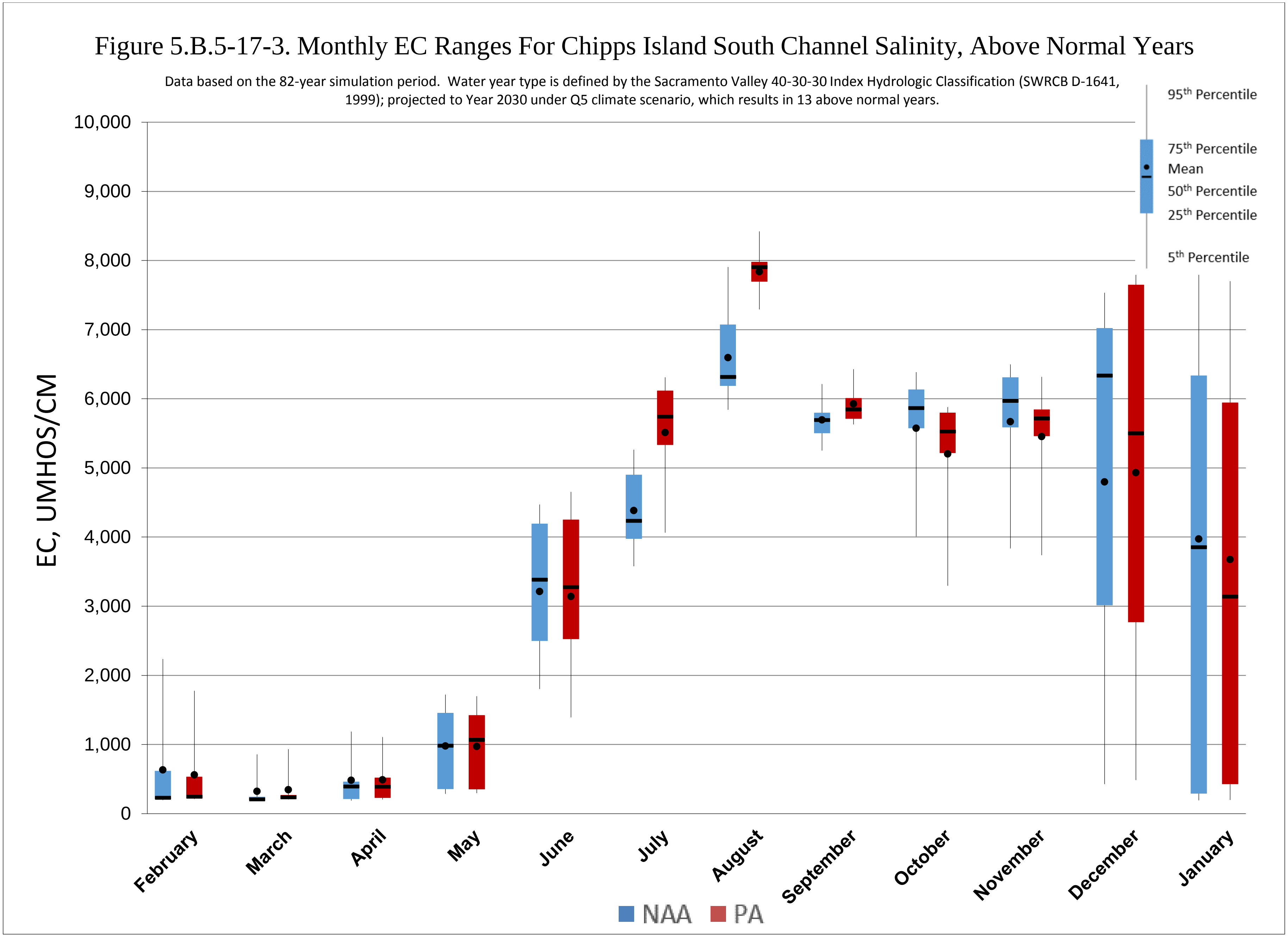


Figure 5.B.5-17-3. Monthly EC Ranges For Chipps Island South Channel Salinity, Above Normal Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 13 above normal years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
EC, UMHOS/CM
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

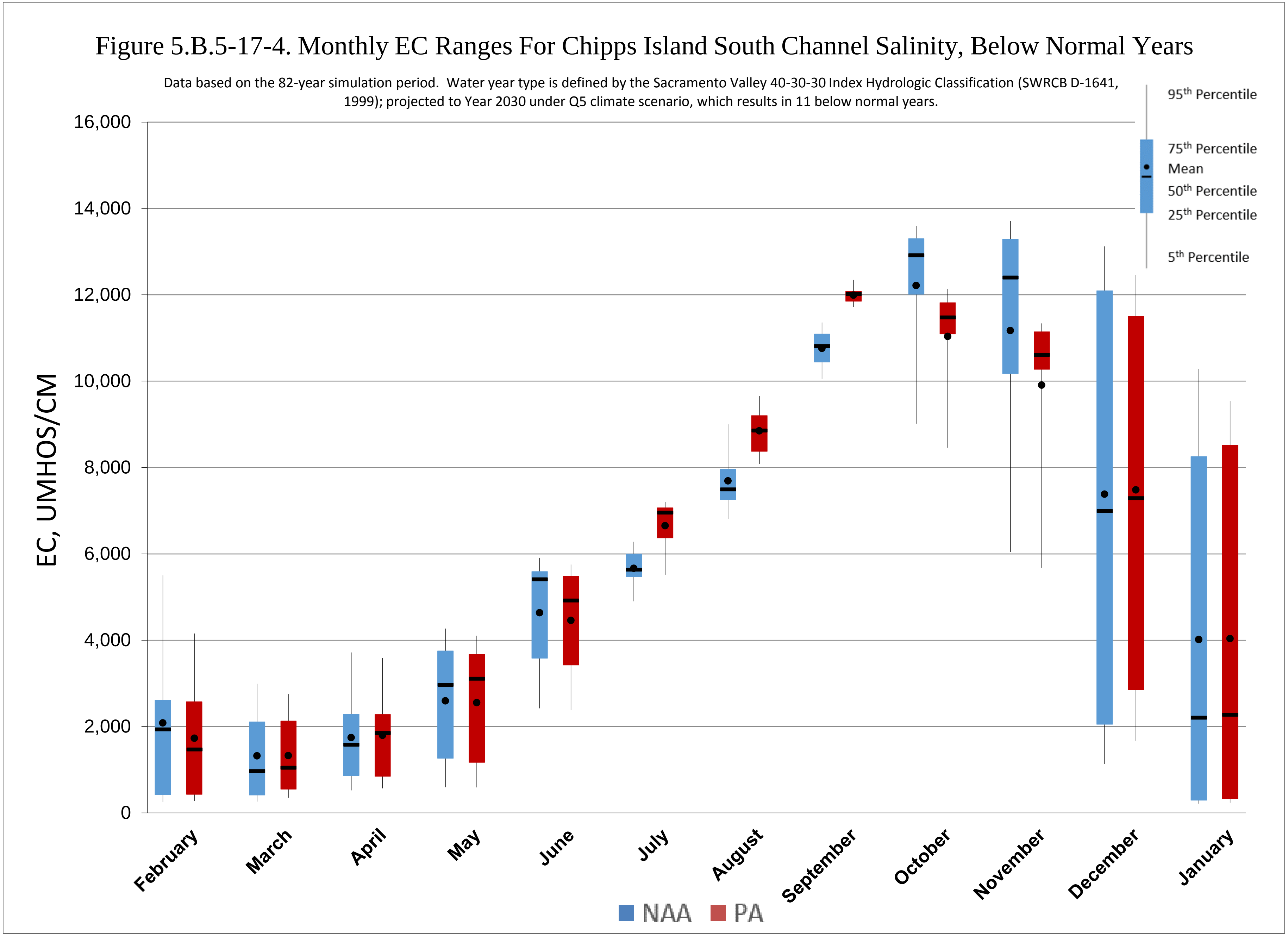


Figure 5.B.5-17-4. Monthly EC Ranges For Chipps Island South Channel Salinity, Below Normal Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 11 below normal years.
EC, UMHOS/CM
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
February
March
April
May
June
July
August
September
October
November
December
January
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
NAA
PA

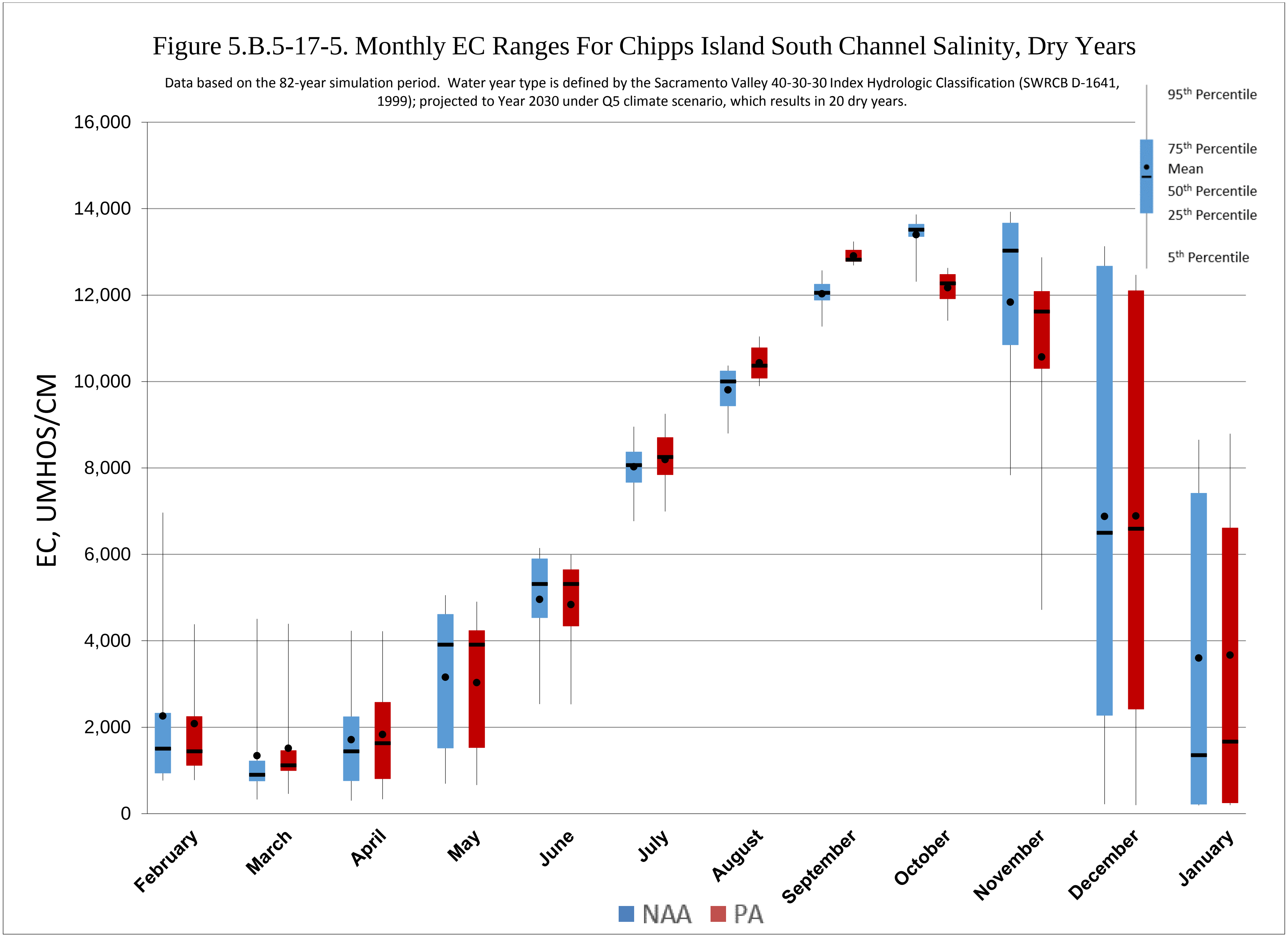


Figure 5.B.5-17-5. Monthly EC Ranges For Chipps Island South Channel Salinity, Dry Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 20 dry years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
EC, UMHOS/CM
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-17-6. Monthly EC Ranges For Chipps Island South Channel Salinity, Critical Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 12 critical years.

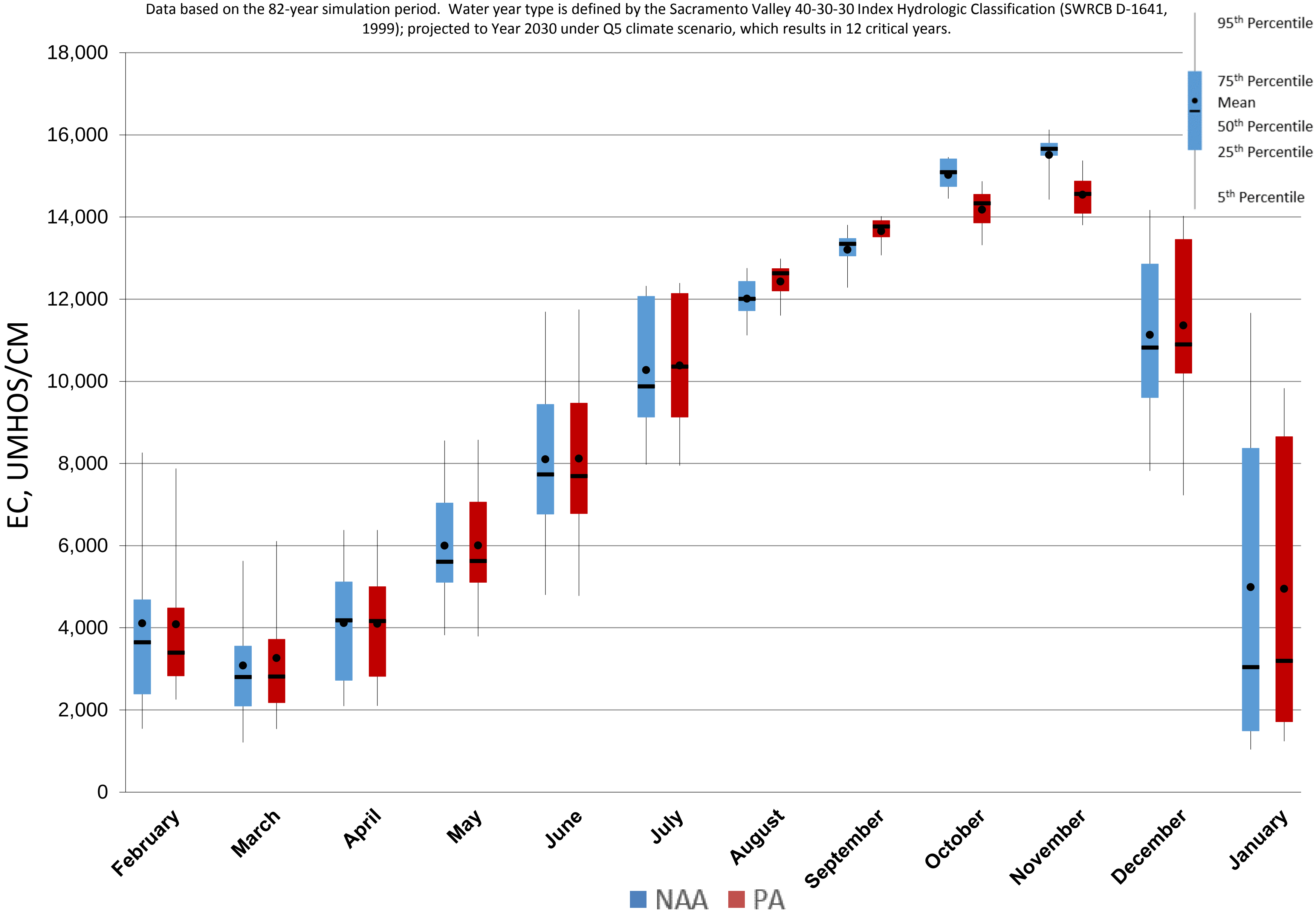
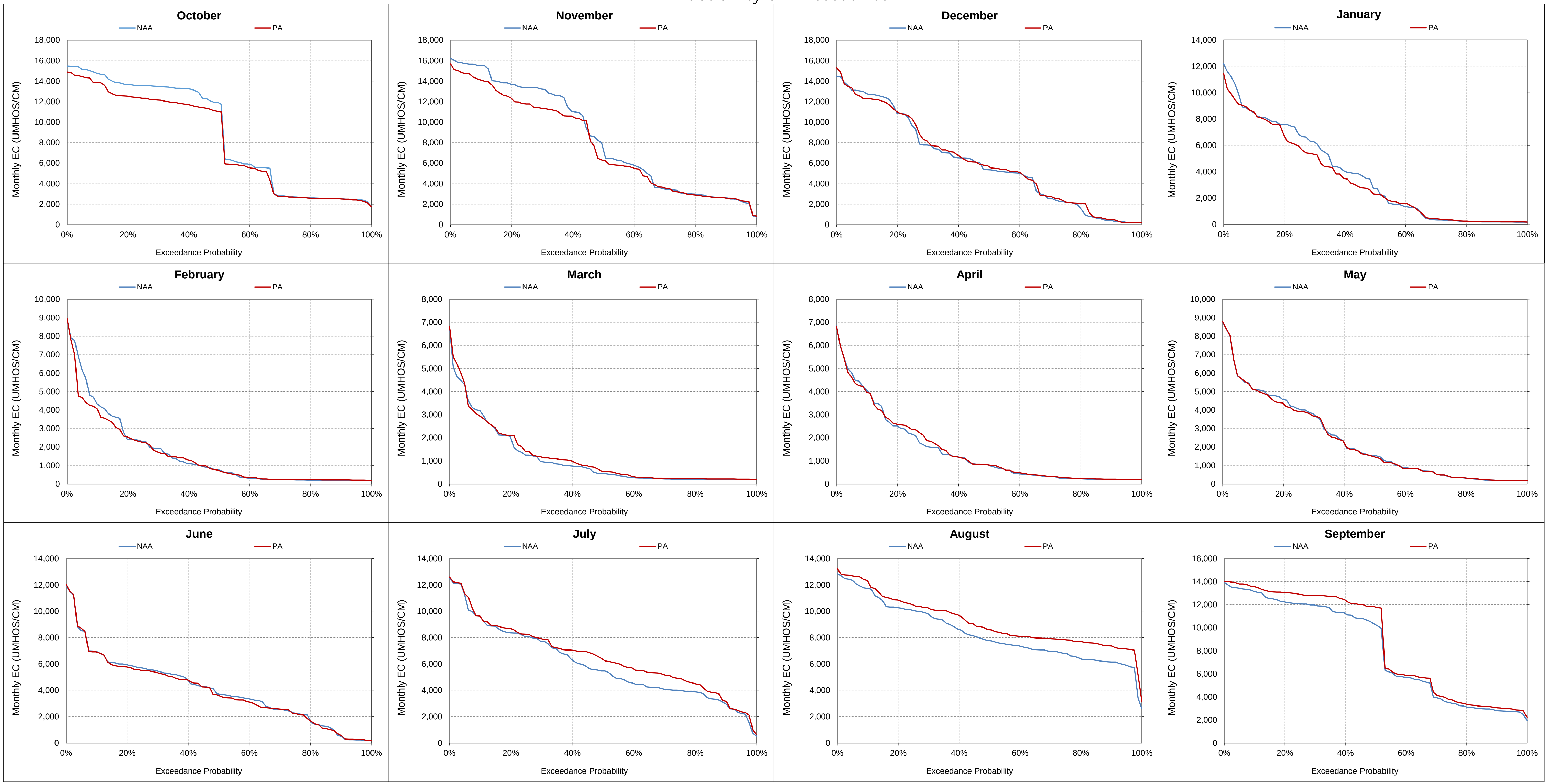
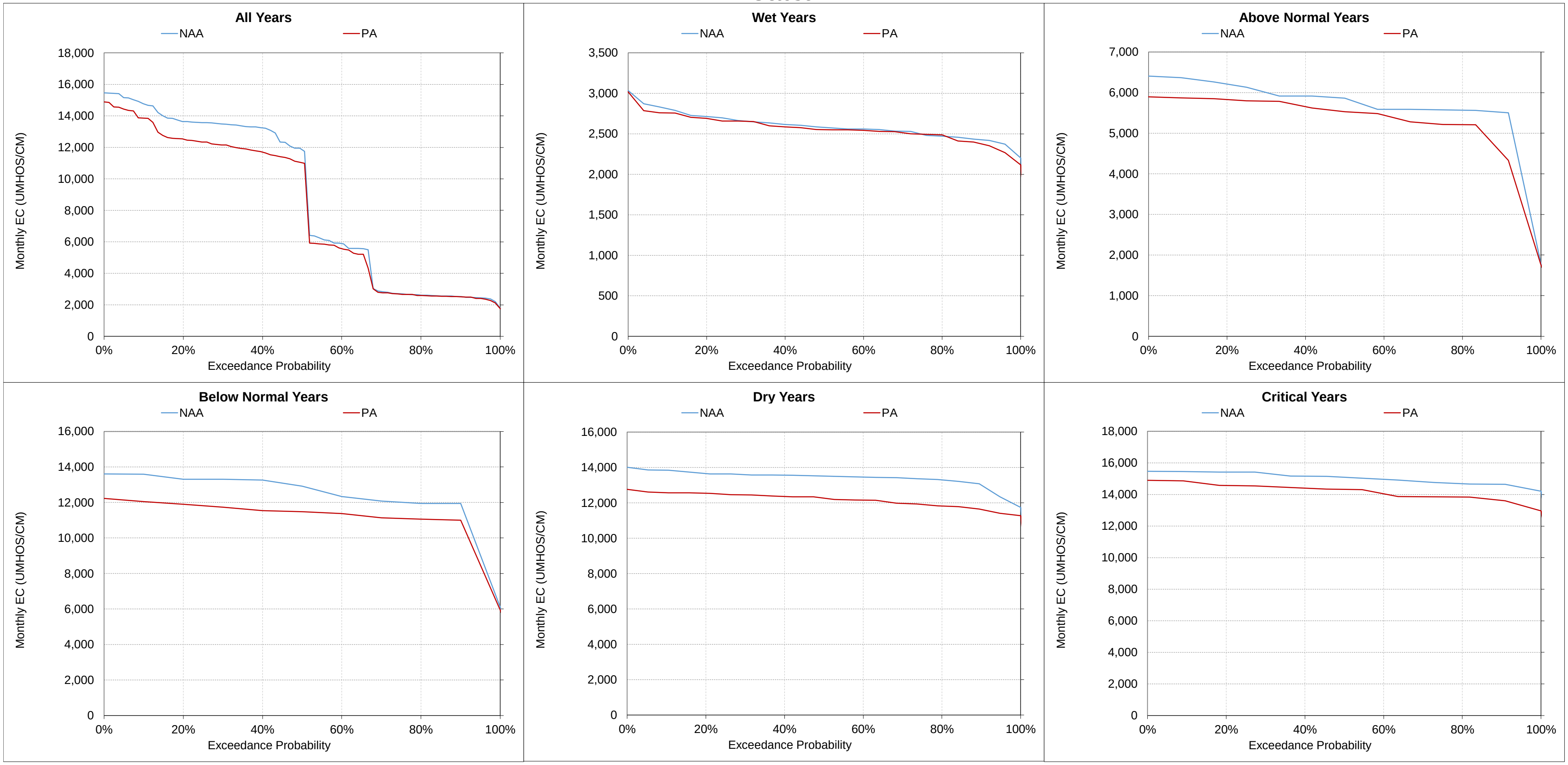


Figure 5.B.5-17-7. Chipps Island South Channel Salinity, Monthly EC Probability of Exceedance



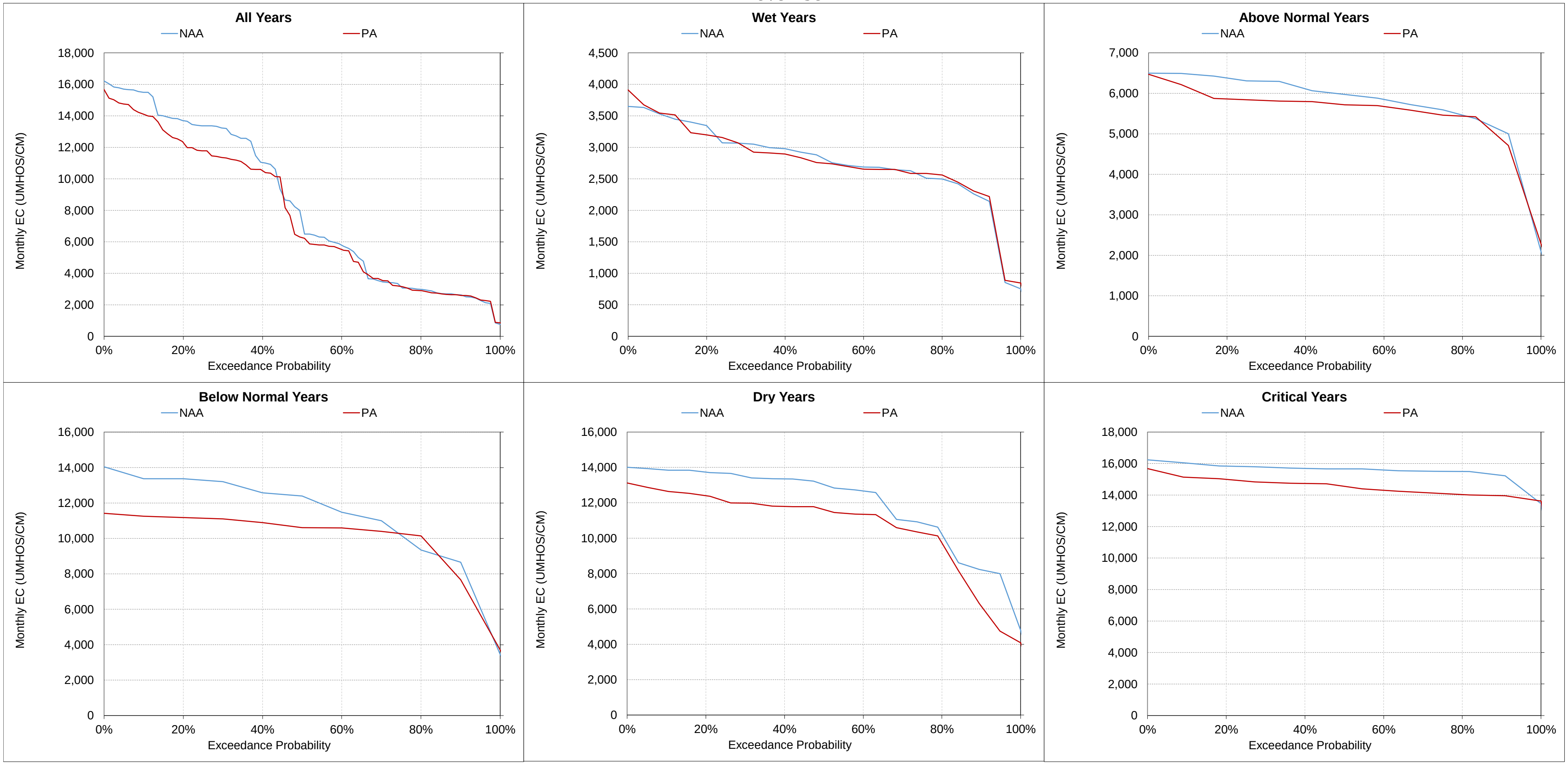
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-17-8. Chipps Island South Channel Salinity, Monthly EC October



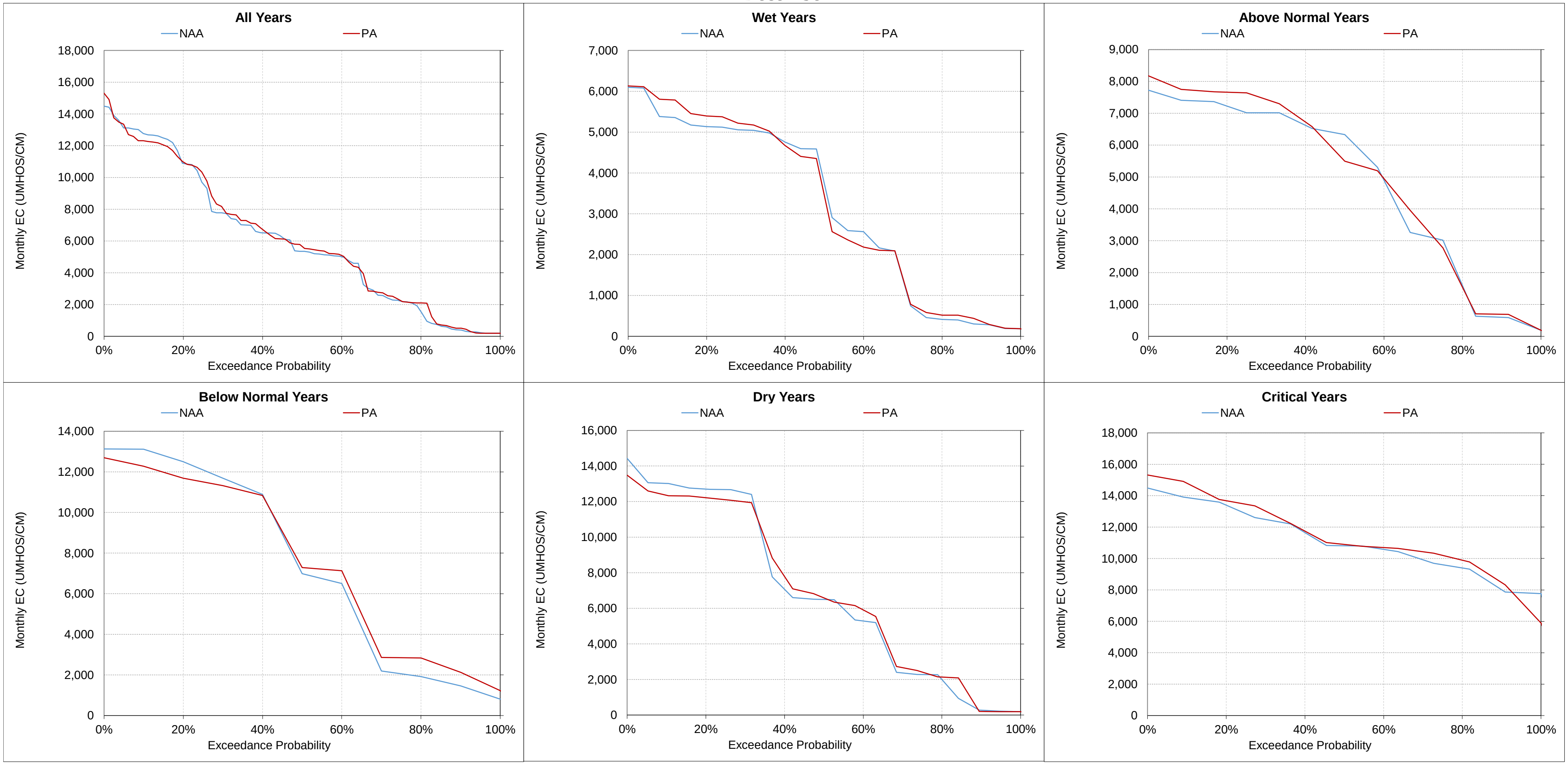
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-17-9. Chipps Island South Channel Salinity, Monthly EC November



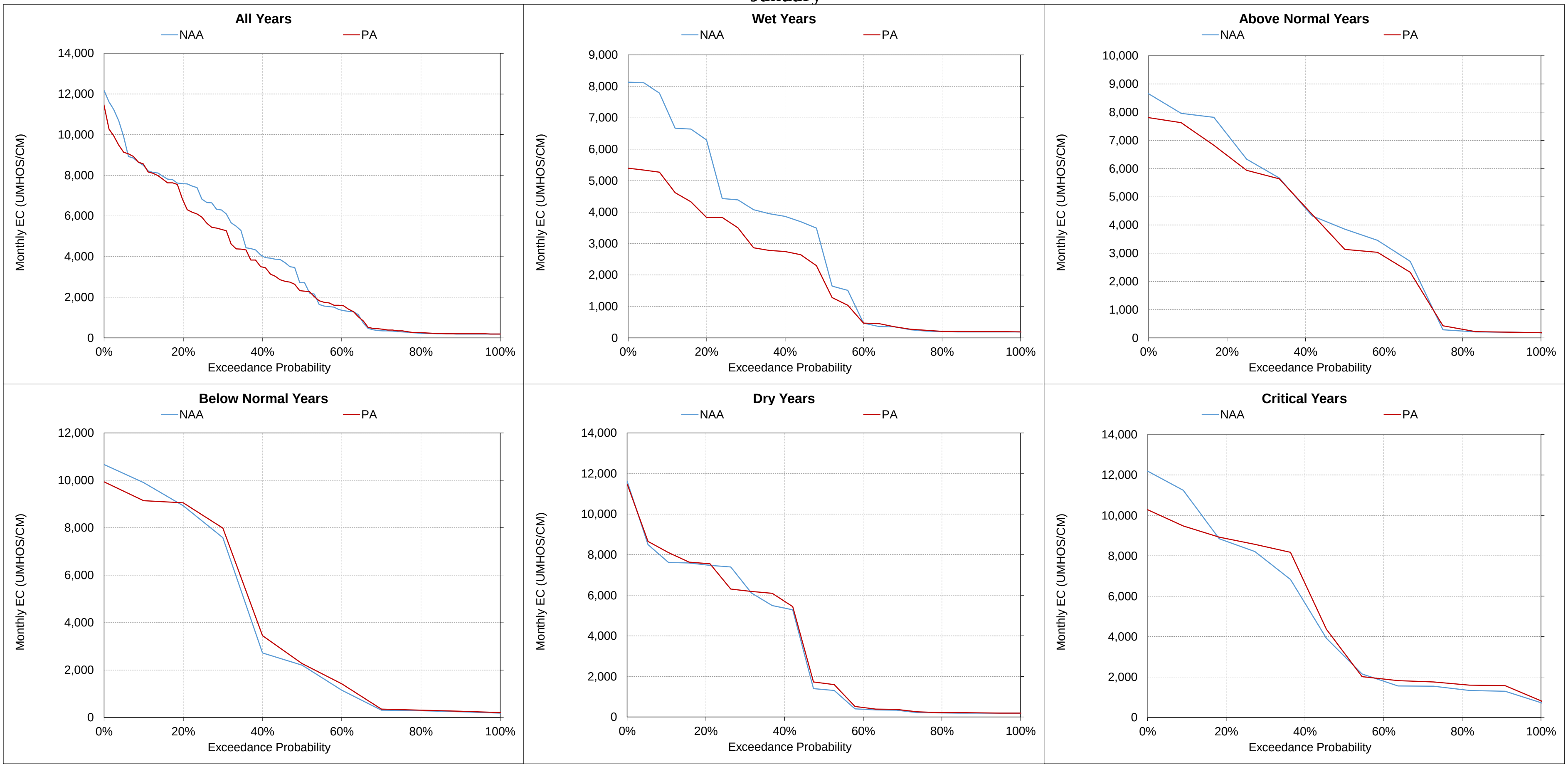
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-17-10. Chipps Island South Channel Salinity, Monthly EC
December



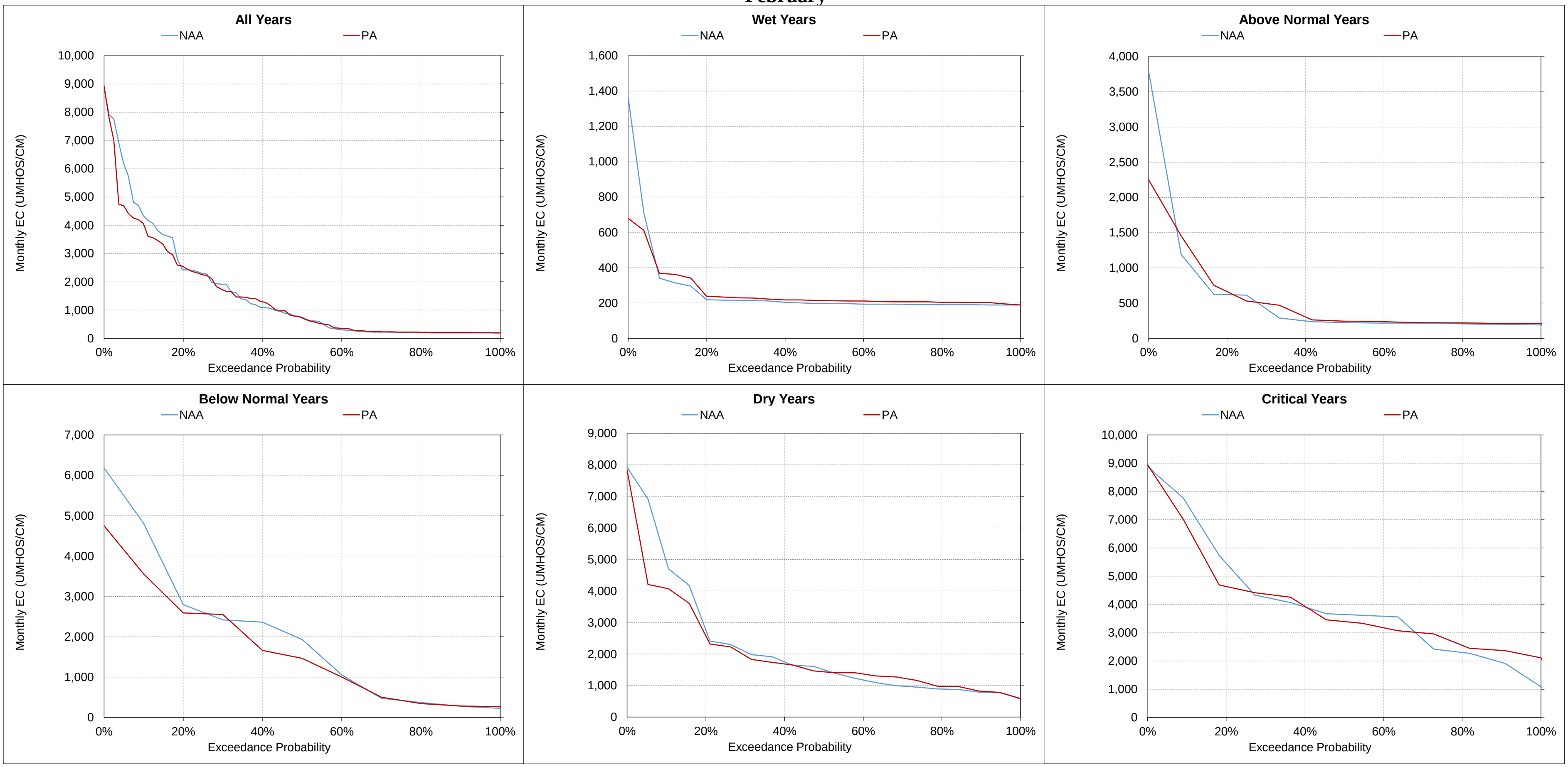
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-17-11. Chipps Island South Channel Salinity, Monthly EC
January



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-17-12. Chipps Island South Channel Salinity, Monthly EC February



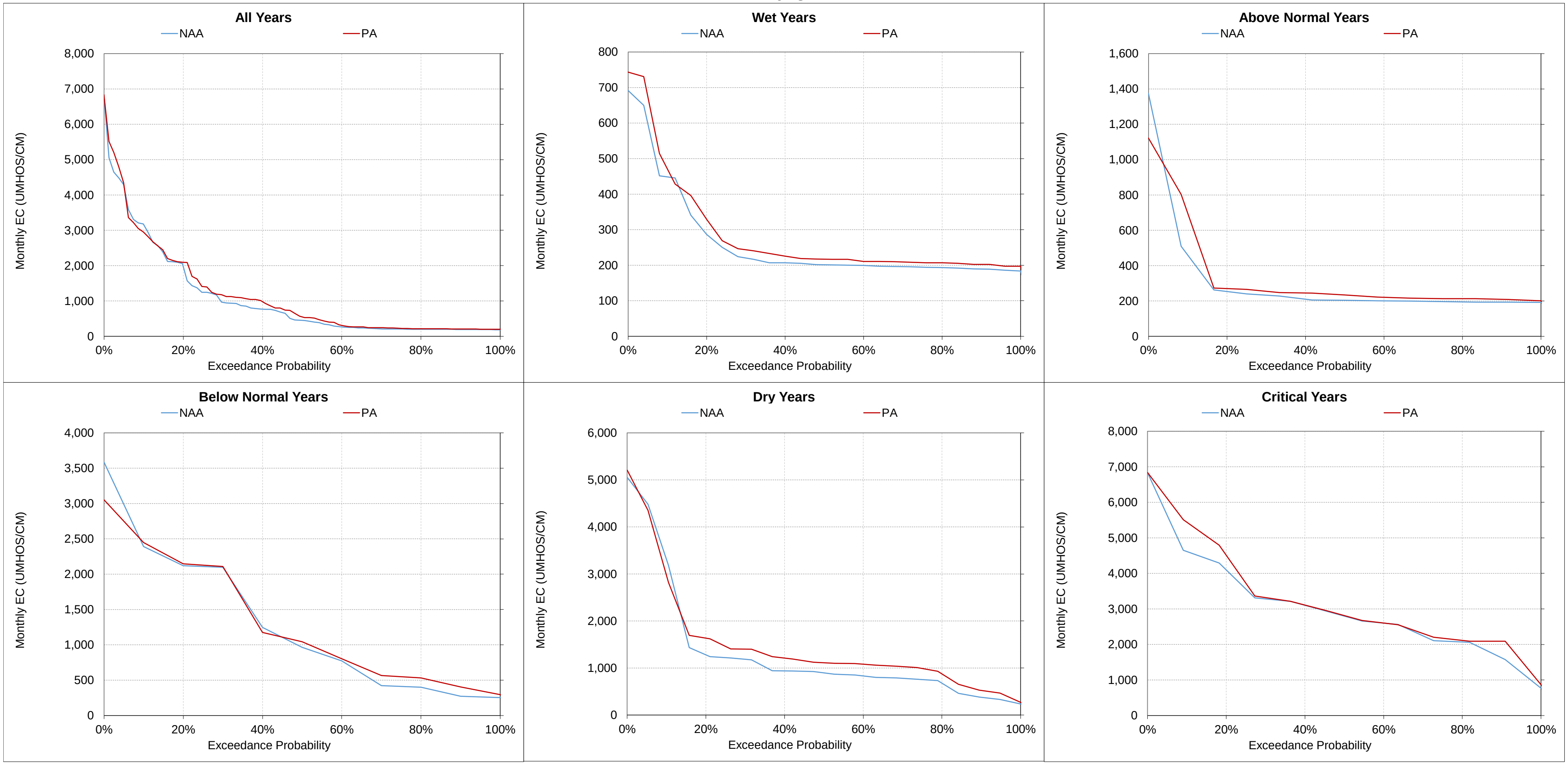
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-17-13. Chipps Island South Channel Salinity, Monthly EC March



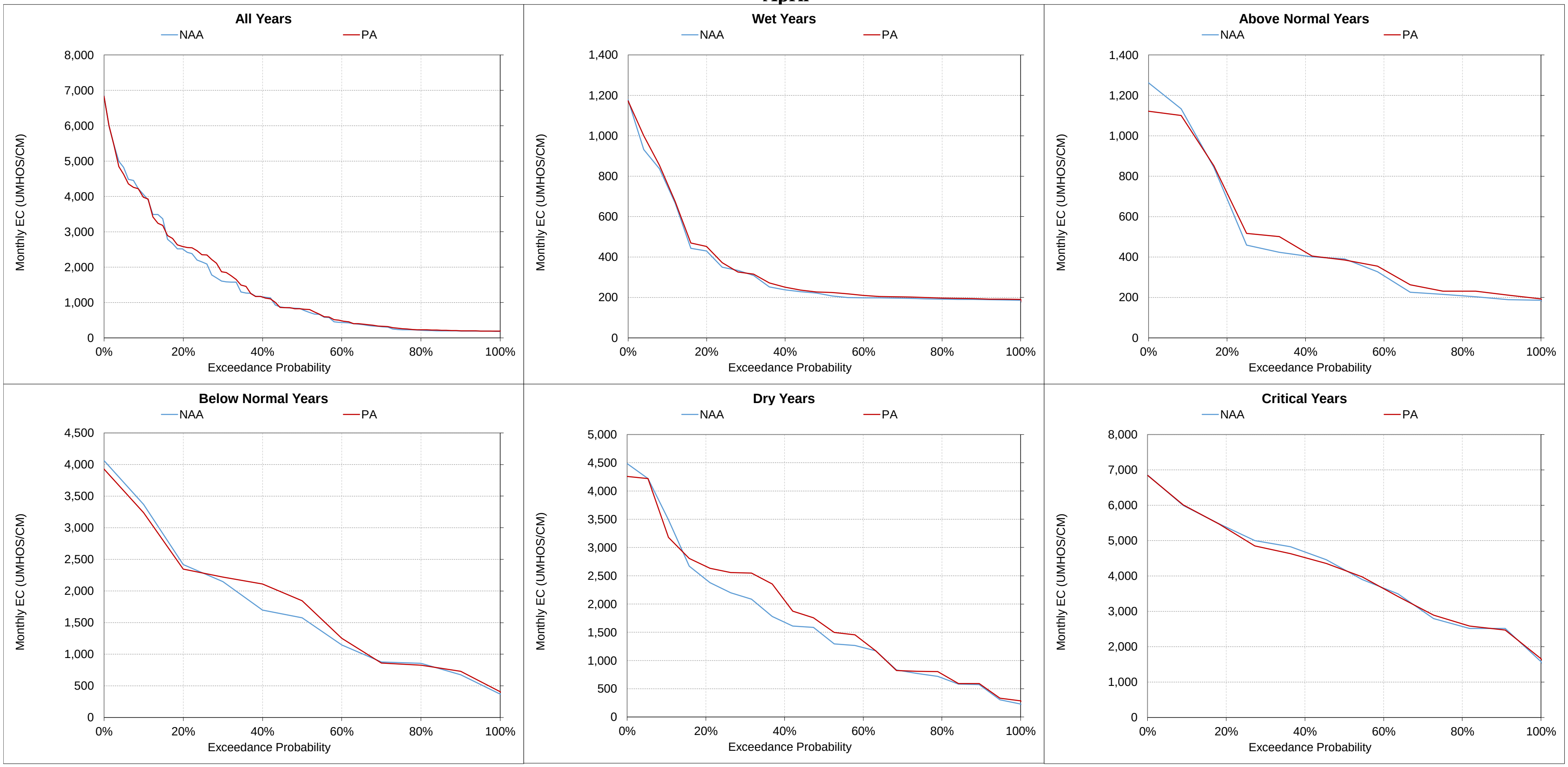
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

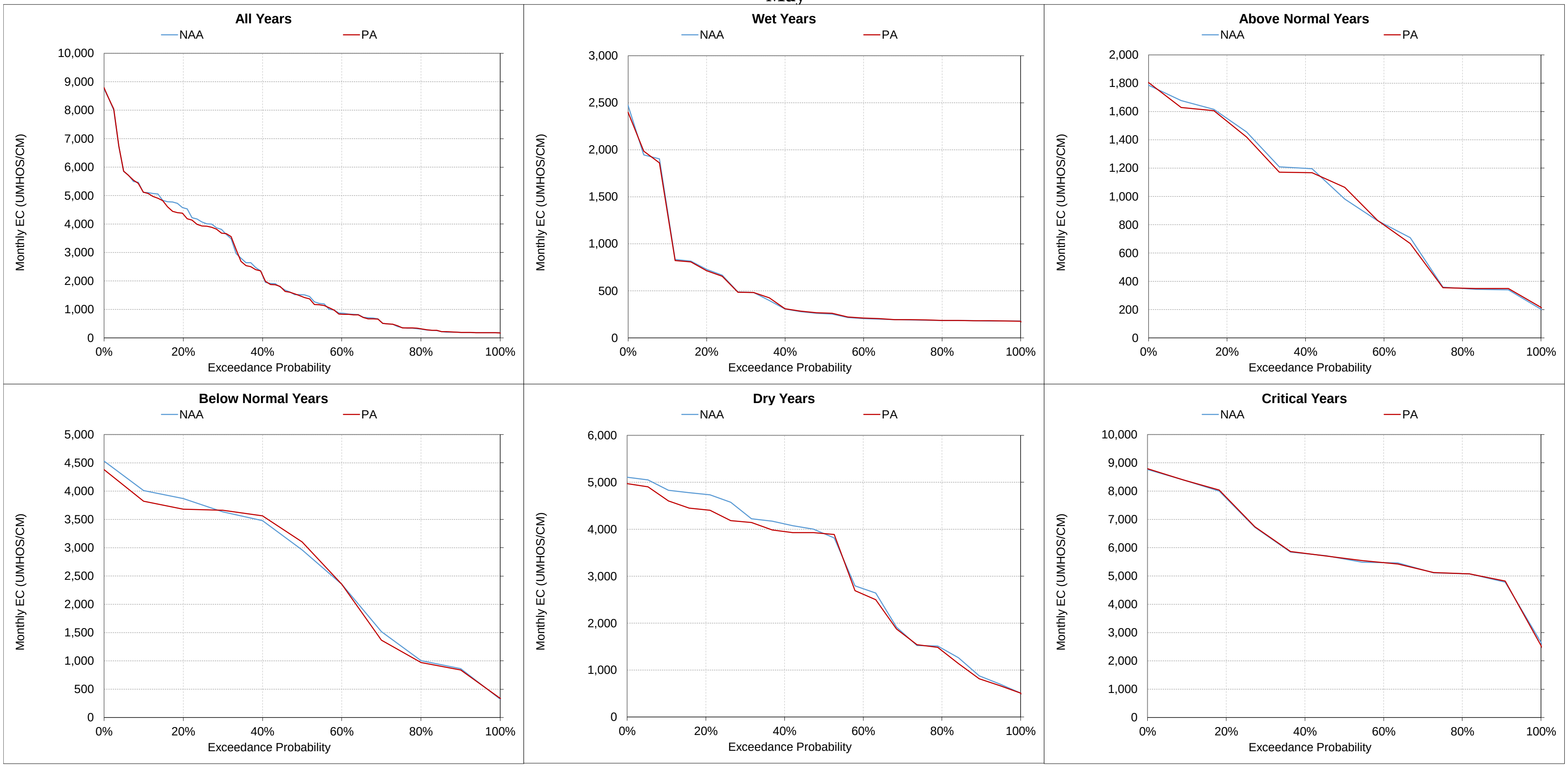
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-17-14. Chipps Island South Channel Salinity, Monthly EC
April



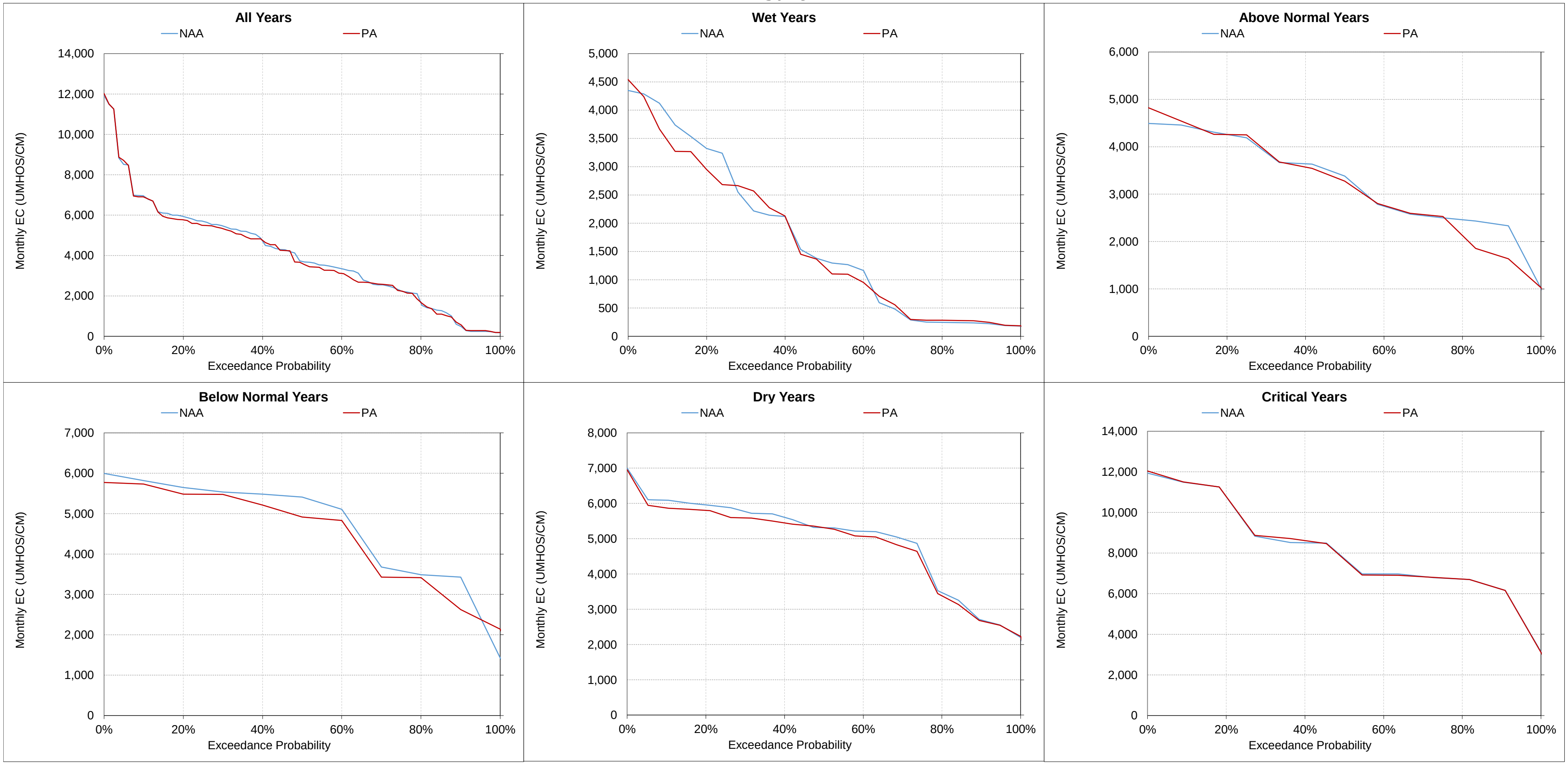
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-17-15. Chipps Island South Channel Salinity, Monthly EC
May



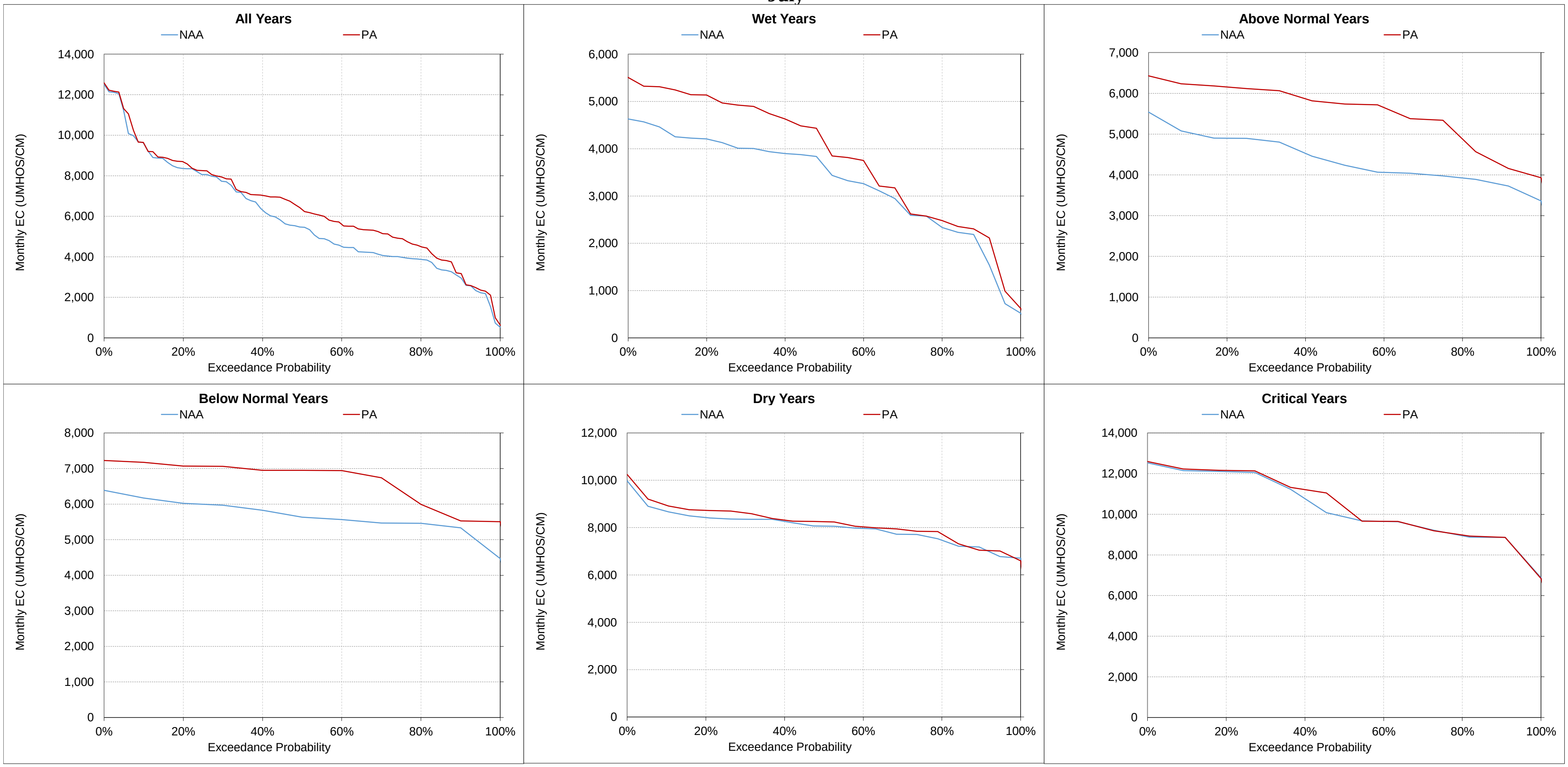
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-17-16. Chipps Island South Channel Salinity, Monthly EC
June



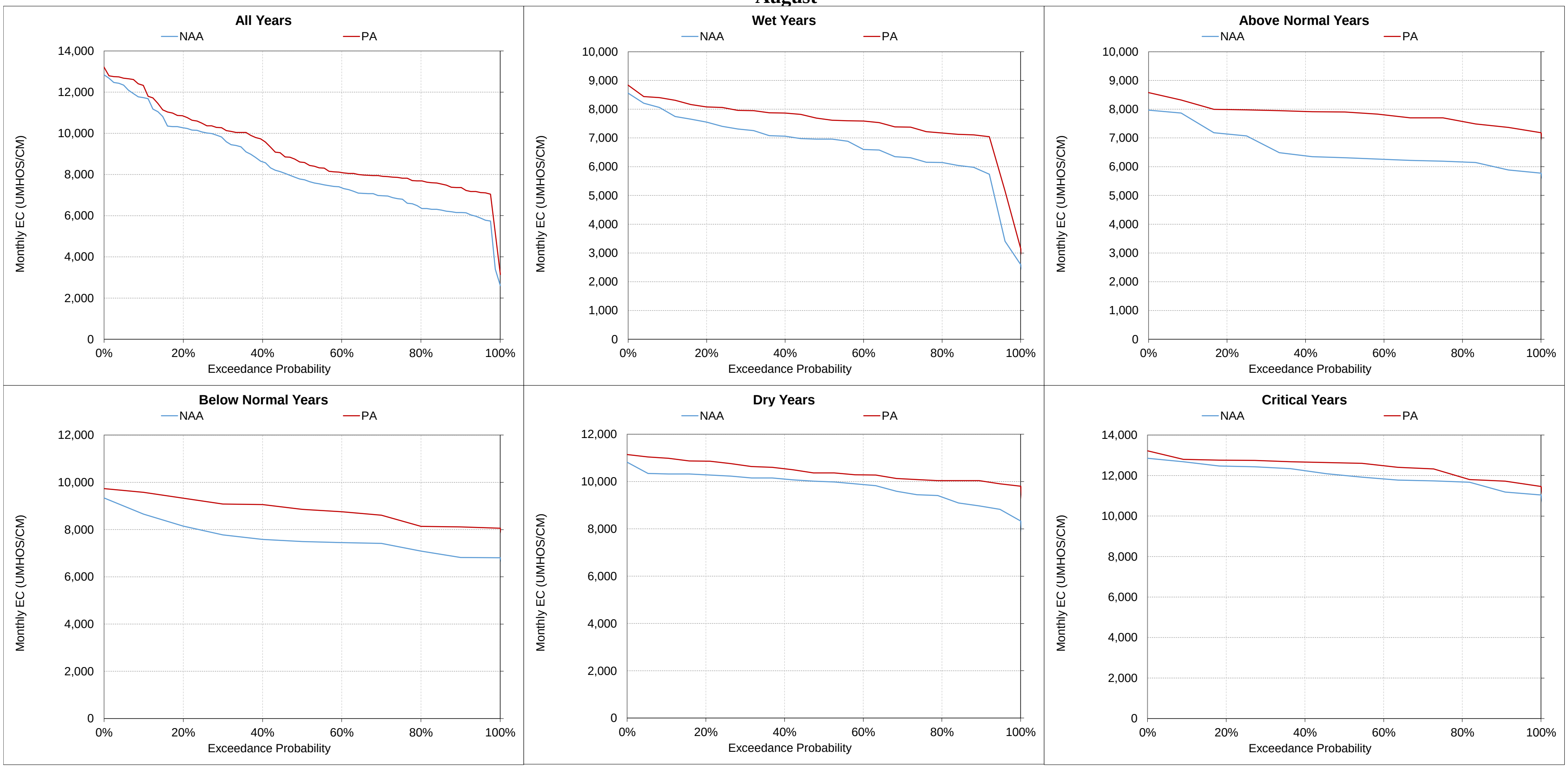
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-17-17. Chipps Island South Channel Salinity, Monthly EC
July



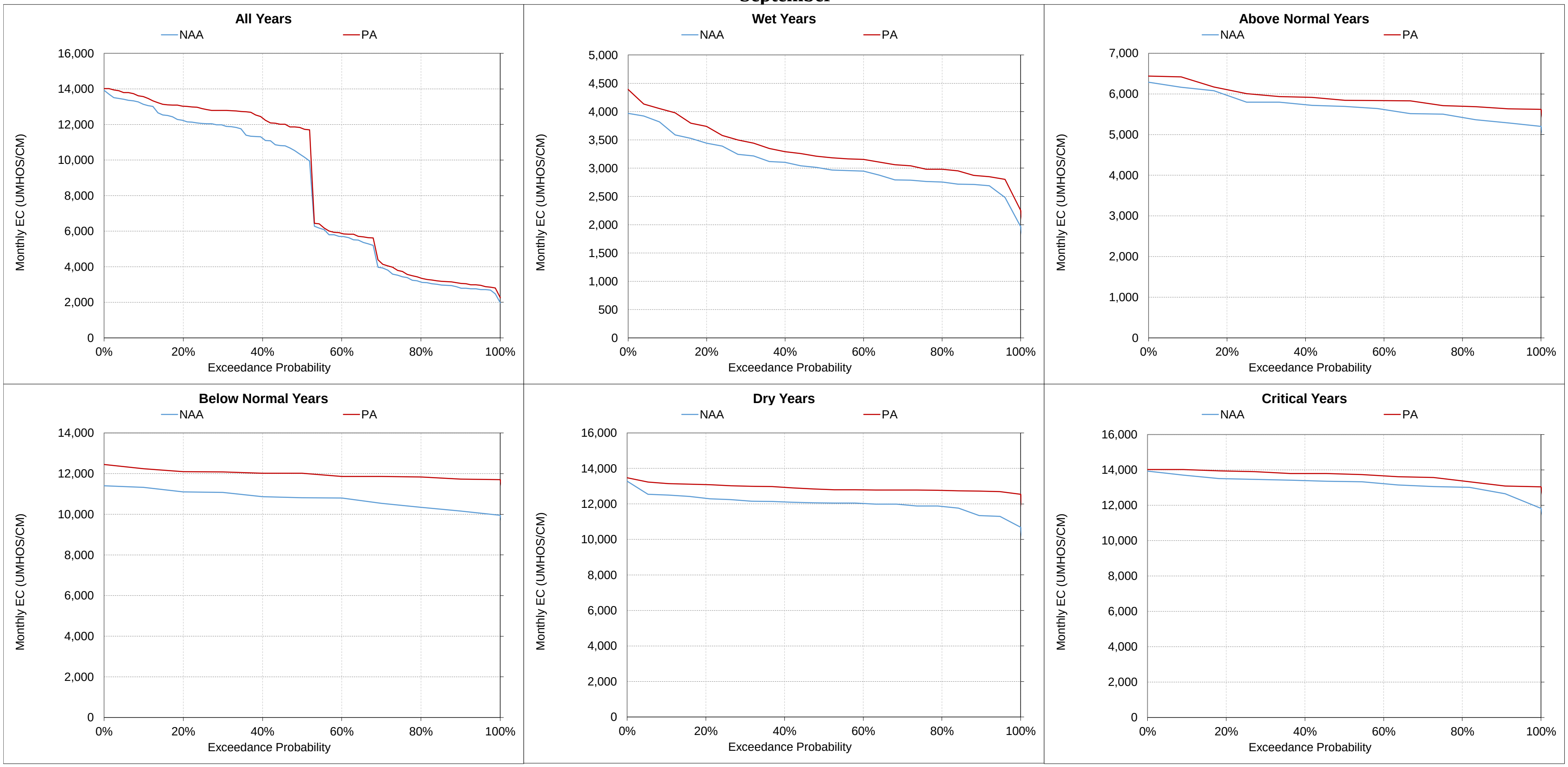
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-17-18. Chipps Island South Channel Salinity, Monthly EC
August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-17-19. Chipps Island South Channel Salinity, Monthly EC September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-18. Old River at Rock Slough Salinity, Monthly EC

Monthly EC (UMHOS/CM)

Statistic	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	1,089	931	-158	-15%	1,313	905	-408	-31%	1,175	1,043	-132	-11%	972	845	-127	-13%	556	574	18	3%	391	538	146	37%
20%	970	800	-170	-18%	1,087	627	-460	-42%	981	759	-221	-23%	808	714	-94	-12%	486	531	45	9%	346	492	146	42%
30%	917	767	-150	-16%	952	557	-394	-41%	872	679	-194	-22%	680	574	-106	-16%	420	486	66	16%	317	433	116	37%
40%	847	709	-138	-16%	804	467	-337	-42%	719	545	-175	-24%	588	518	-70	-12%	384	451	67	17%	305	415	110	36%
50%	804	617	-187	-23%	689	436	-254	-37%	459	377	-83	-18%	532	477	-54	-10%	360	412	52	15%	296	379	83	28%
60%	305	346	41	13%	321	418	97	30%	374	320	-54	-14%	453	429	-24	-5%	339	396	56	17%	280	347	67	24%
70%	286	316	30	11%	259	402	143	55%	302	301	-1	0%	347	396	49	14%	308	378	70	23%	259	330	71	27%
80%	279	283	4	1%	239	371	133	56%	284	288	3	1%	316	372	56	18%	287	356	69	24%	244	313	68	28%
90%	265	264	-1	0%	232	311	79	34%	249	271	22	9%	289	316	27	9%	263	323	60	23%	233	290	56	24%
Long Term Full Simulation Period[b]	640	568	-72	-11%	681	520	-160	-24%	644	552	-92	-14%	567	539	-27	-5%	391	440	49	12%	304	401	97	32%
Water Year Types[c]																								
Wet (32%)	276	316	40	15%	244	386	142	58%	270	286	16	6%	431	424	-7	-2%	312	443	132	42%	271	396	126	46%
Above Normal (16%)	291	267	-24	-8%	350	346	-5	-1%	420	333	-87	-21%	564	486	-78	-14%	350	417	67	19%	278	493	215	78%
Below Normal (13%)	953	675	-277	-29%	858	469	-388	-45%	764	571	-193	-25%	631	617	-14	-2%	401	432	31	8%	299	373	74	25%
Dry (24%)	904	773	-131	-15%	988	551	-436	-44%	817	641	-176	-22%	611	556	-56	-9%	432	426	-6	-1%	317	356	39	12%
Critical (15%)	1,079	1,003	-76	-7%	1,310	995	-315	-24%	1,298	1,197	-101	-8%	730	748	18	2%	533	490	-44	-8%	387	409	22	6%

Monthly EC (UMHOS/CM)

Statistic	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	386	492	106	27%	399	422	23	6%	319	370	51	16%	575	384	-191	-33%	732	606	-125	-17%	909	909	0	0%
20%	364	439	75	21%	376	397	21	5%	288	341	53	18%	445	349	-97	-22%	630	525	-106	-17%	831	802	-28	-3%
30%	346	412	66	19%	365	380	16	4%	277	318	42	15%	400	313	-87	-22%	582	469	-112	-19%	774	741	-33	-4%
40%	333	390	56	17%	357	364	7	2%	273	303	30	11%	350	300	-50	-14%	535	378	-157	-29%	717	601	-117	-16%
50%	322	369	47	15%	335	351	15	4%	265	293	28	10%	338	293	-46	-14%	472	326	-146	-31%	665	514	-151	-23%
60%	310	344	34	11%	321	342	21	7%	259	288	29	11%	307	286	-21	-7%	436	304	-132	-30%	610	351	-259	-42%
70%	301	324	24	8%	303	327	24	8%	251	283	32	13%	276	277	1	0%	414	286	-128	-31%	569	329	-240	-42%
80%	287	294	8	3%	283	301	18	6%	242	276	34	14%	257	271	14	5%	369	276	-93	-25%	535	323	-212	-40%
90%	254	240	-14	-5%	218	207	-12	-5%	231	262	31	13%	240	255	15	6%	338	263	-75	-22%	485	307	-178	-37%
Long Term Full Simulation Period[b]	323	377	54	17%	326	344	17	5%	278	313	35	13%	374	325	-49	-13%	511	404	-106	-21%	675	554	-121	-18%
Water Year Types[c]																								
Wet (32%)	291	329	39	13%	294	300	6	2%	246	299	53	21%	266	275	9	3%	387	289	-99	-25%	550	315	-235	-43%
Above Normal (16%)	335	482	146	44%	362	403	42	11%	258	302	44	17%	295	278	-18	-6%	389	281	-108	-28%	508	341	-167	-33%
Below Normal (13%)	344	378	35	10%	361	363	2	1%	274	294	21	8%	377	284	-93	-25%	497	333	-164	-33%	787	557	-231	-29%
Dry (24%)	325	361	36	11%	315	337	21	7%	270	293	23	9%	464	336	-129	-28%	631	488	-144	-23%	772	763	-10	-1%
Critical (15%)	355	390	35	10%	345	367	22	6%	388	408	20	5%	541	506	-35	-6%	721	716	-6	-1%	859	950	91	11%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

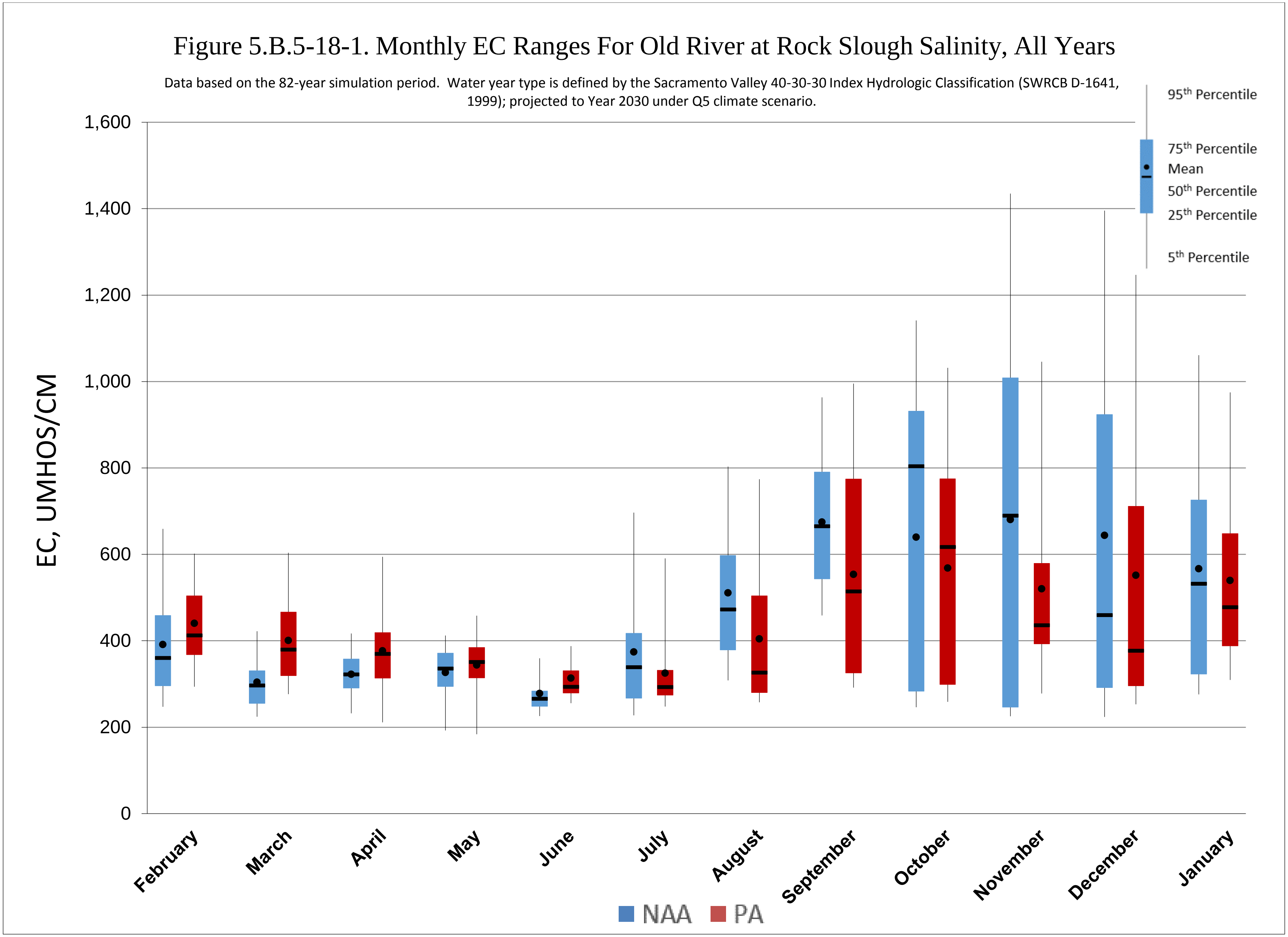


Figure 5.B.5-18-1. Monthly EC Ranges For Old River at Rock Slough Salinity, All Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
EC, UMHOS/CM
1,600
1,400
1,200
1,000
800
600
400
200
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-18-2. Monthly EC Ranges For Old River at Rock Slough Salinity, Wet Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 26 wet years.

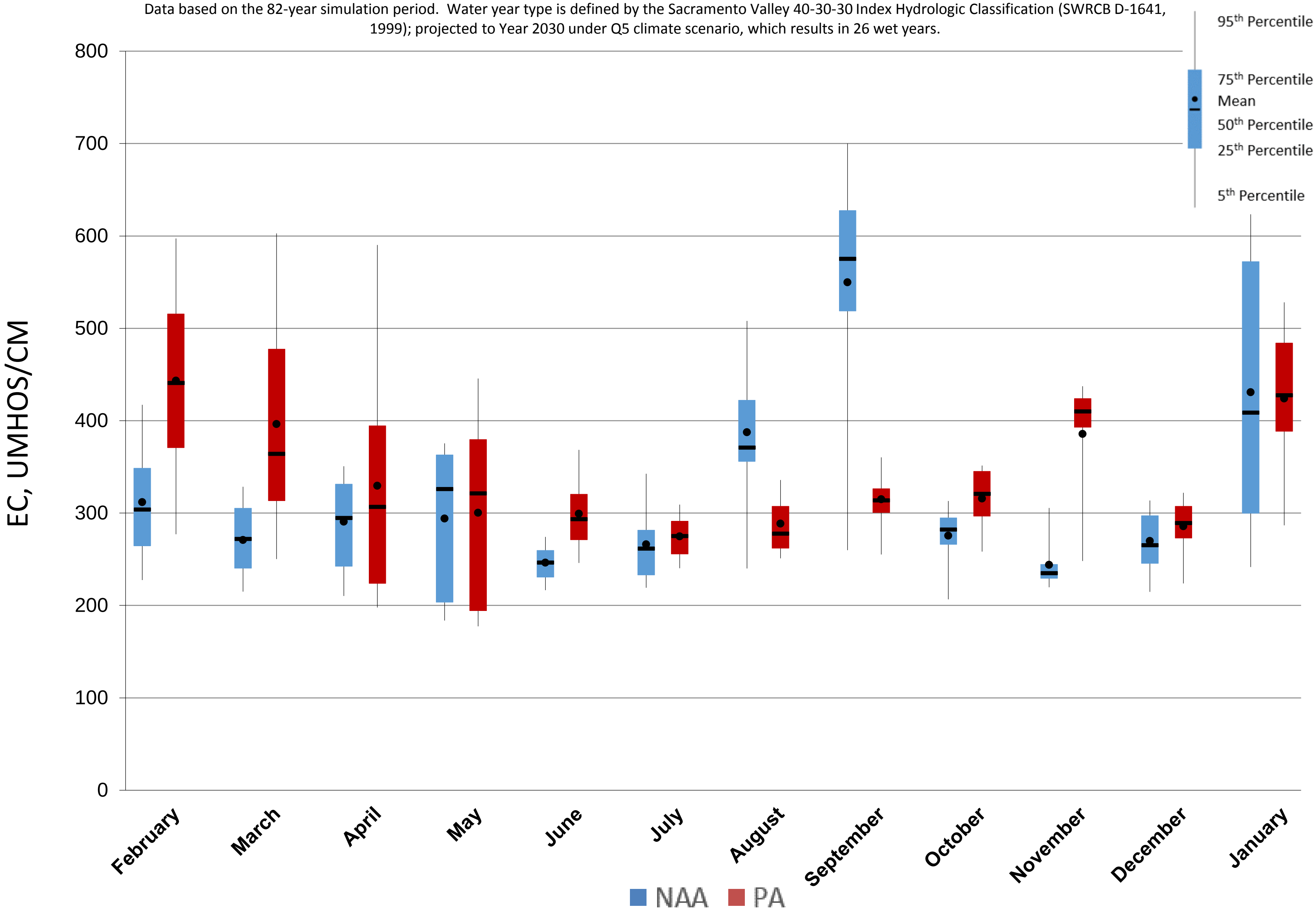


Figure 5.B.5-18-3. Monthly EC Ranges For Old River at Rock Slough Salinity, Above Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 13 above normal years.

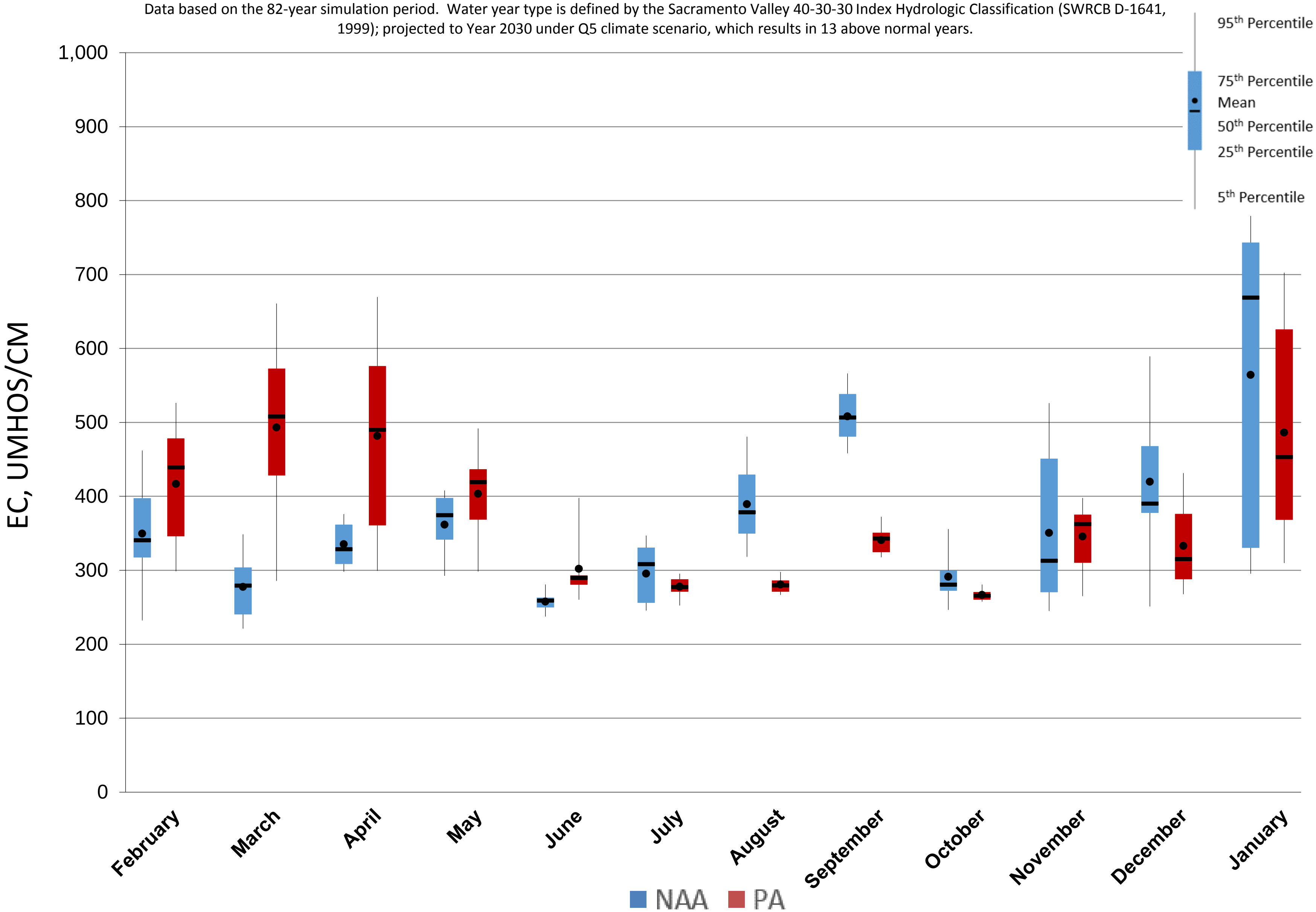
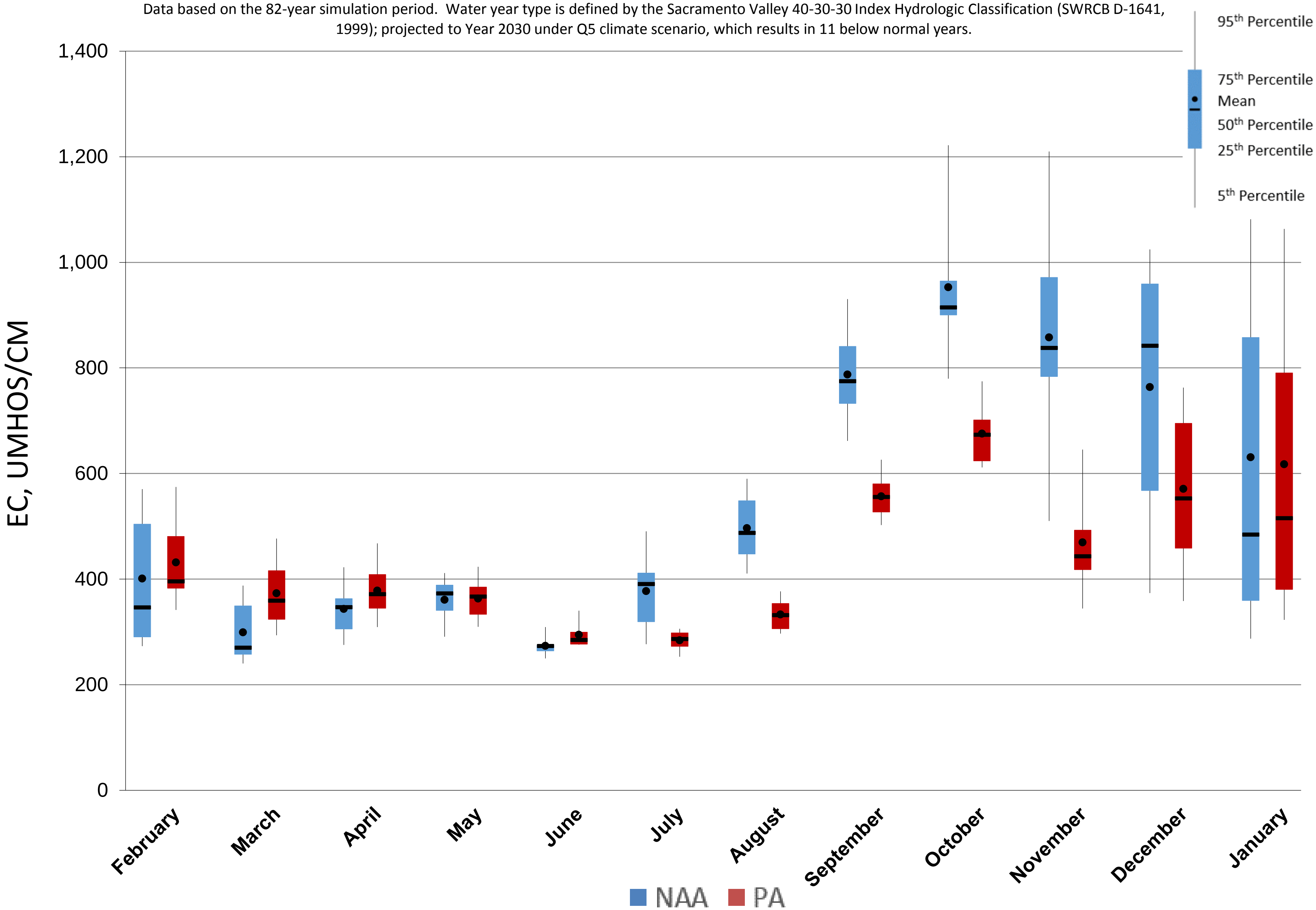


Figure 5.B.5-18-4. Monthly EC Ranges For Old River at Rock Slough Salinity, Below Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 11 below normal years.



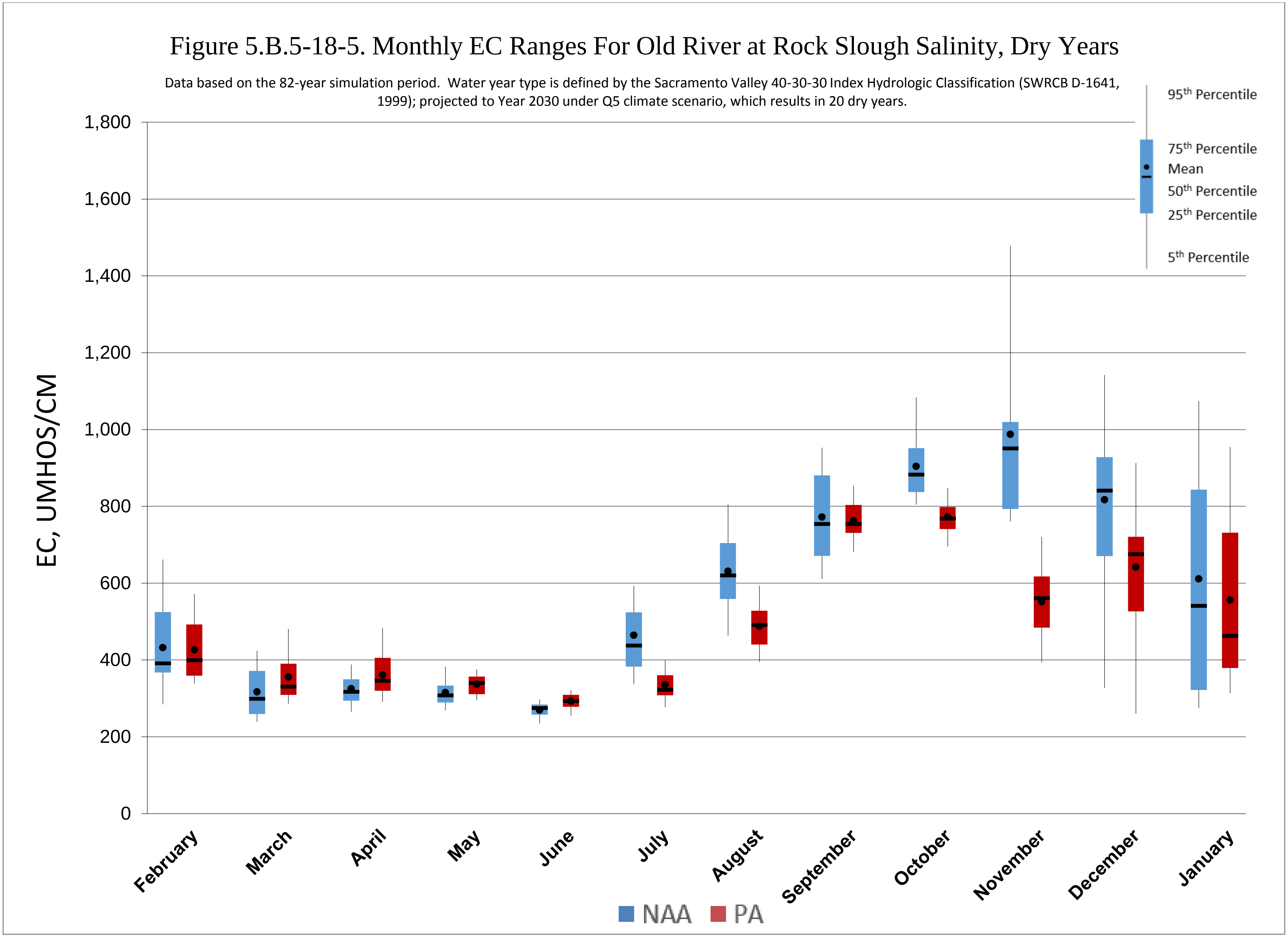


Figure 5.B.5-18-5. Monthly EC Ranges For Old River at Rock Slough Salinity, Dry Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 20 dry years.
EC, UMHOS/CM
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-18-6. Monthly EC Ranges For Old River at Rock Slough Salinity, Critical Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 12 critical years.

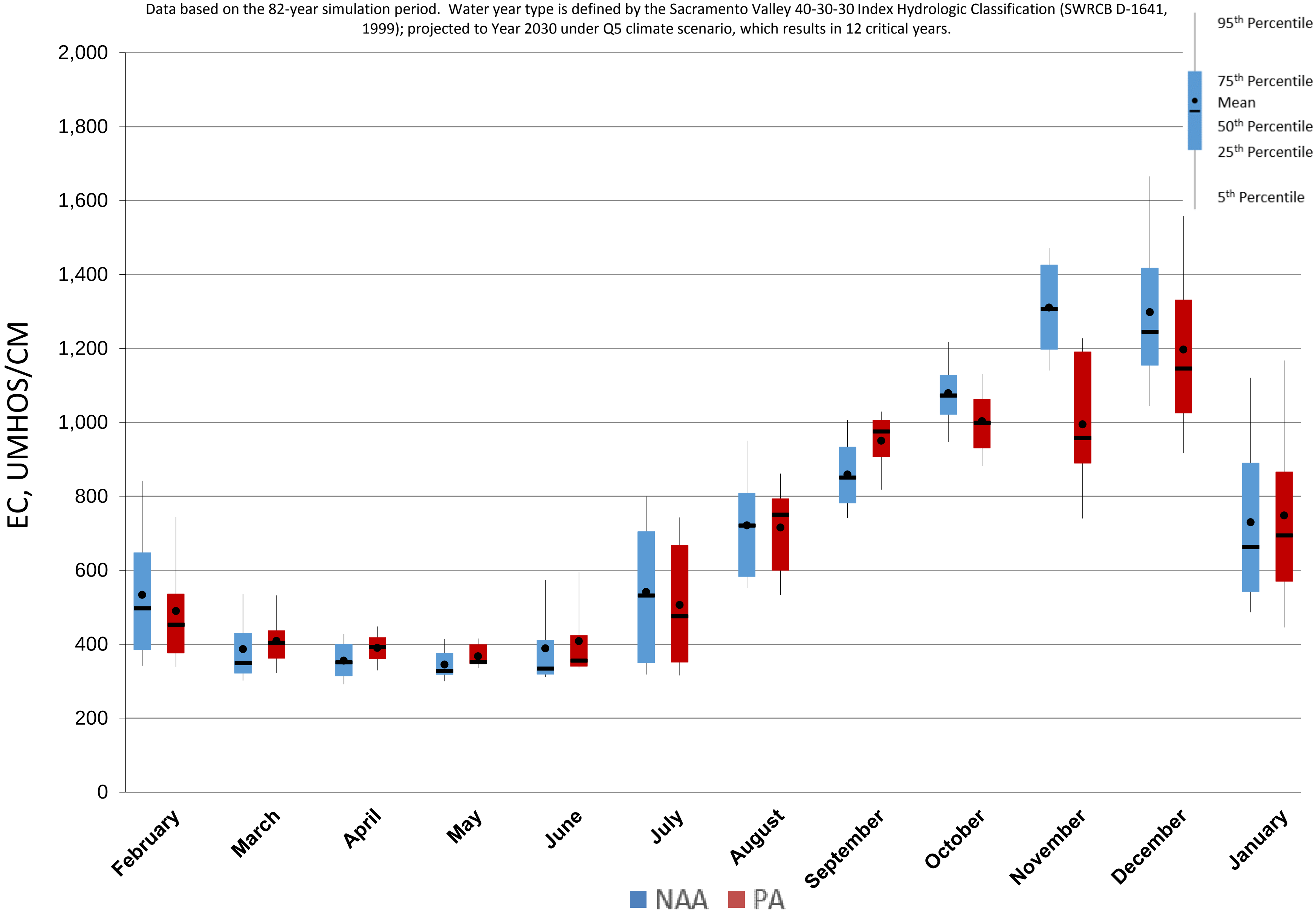
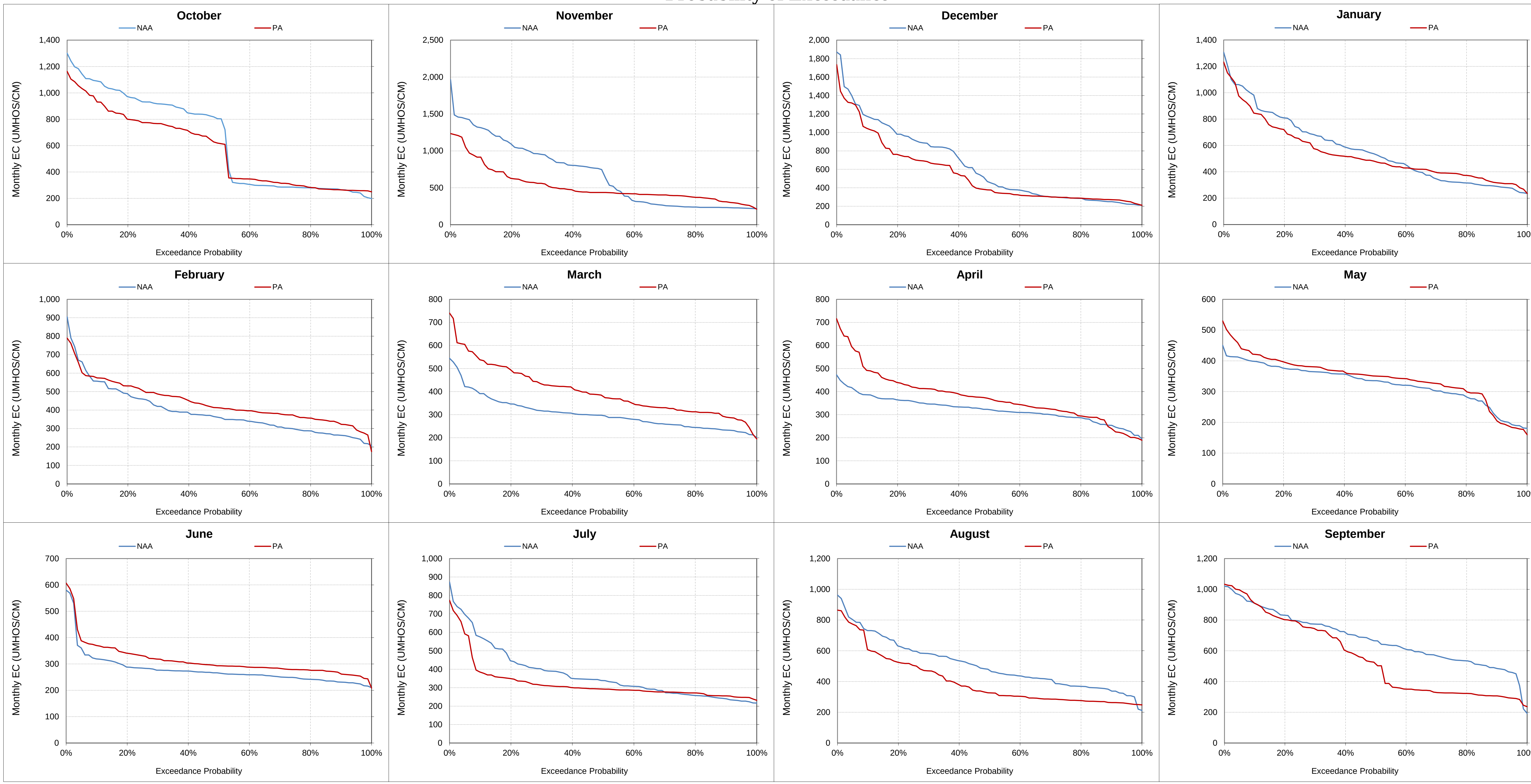
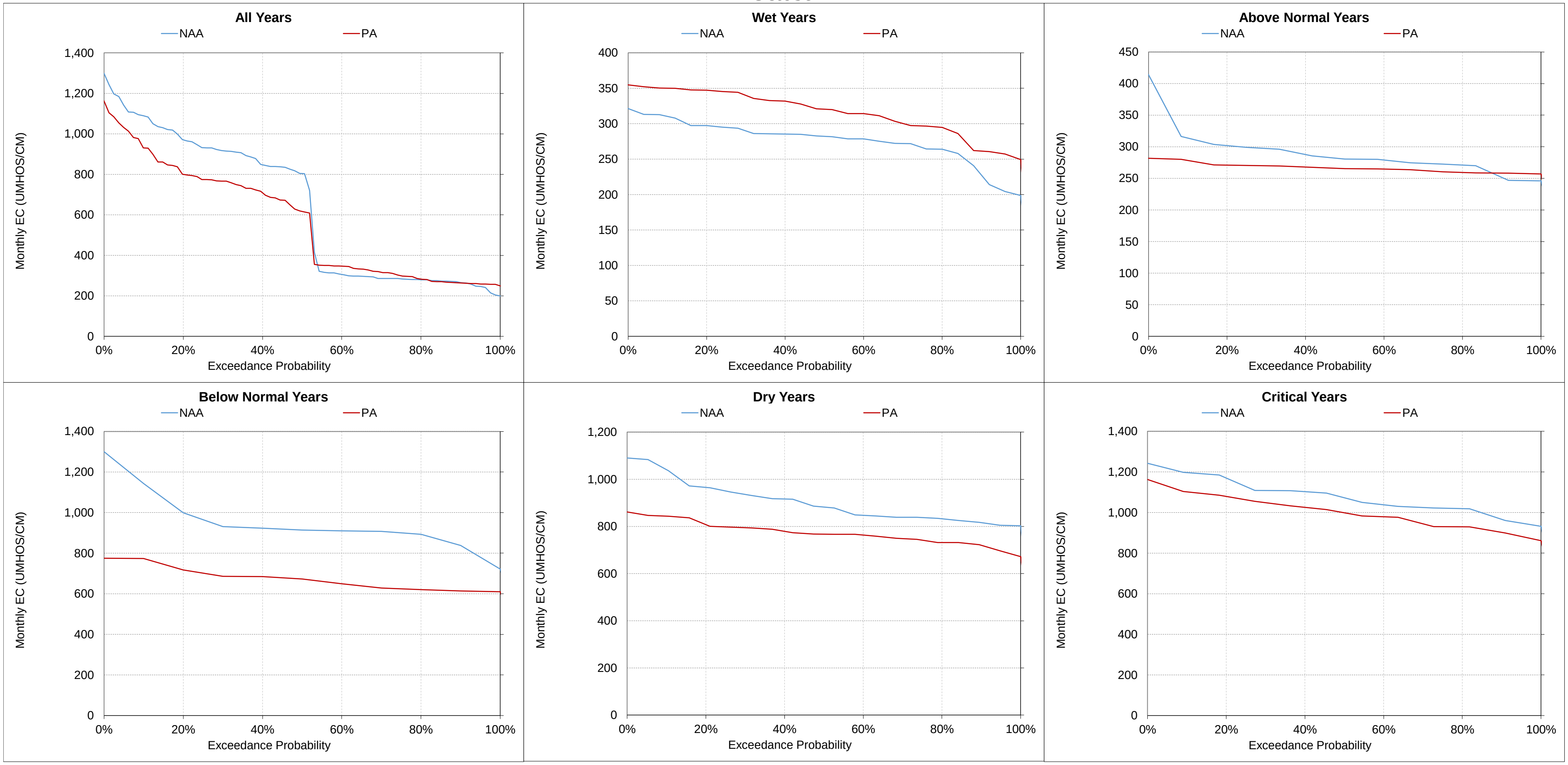


Figure 5.B.5-18-7. Old River at Rock Slough Salinity, Monthly EC Probability of Exceedance



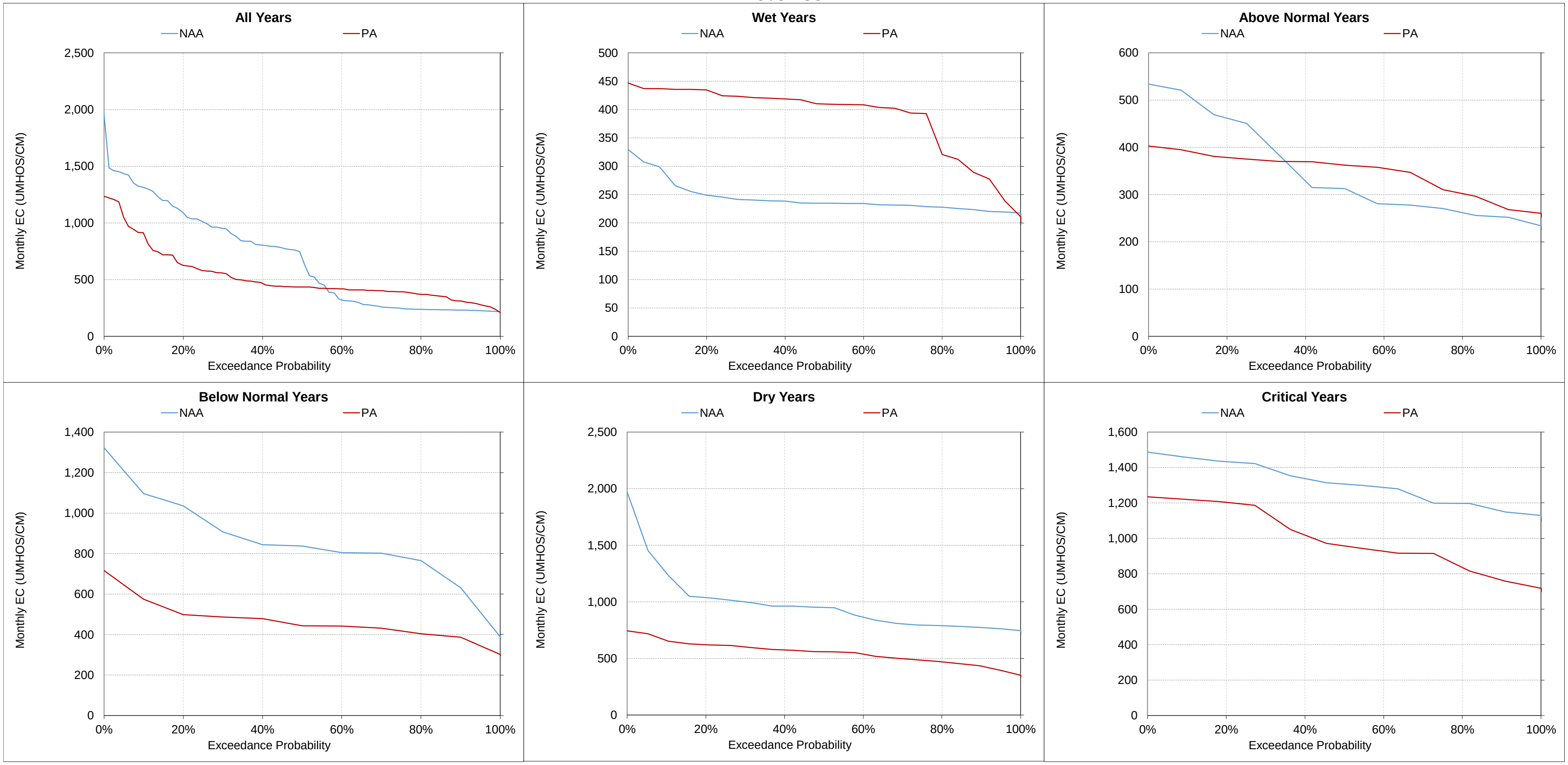
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-18-8. Old River at Rock Slough Salinity, Monthly EC
October



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-18-9. Old River at Rock Slough Salinity, Monthly EC November



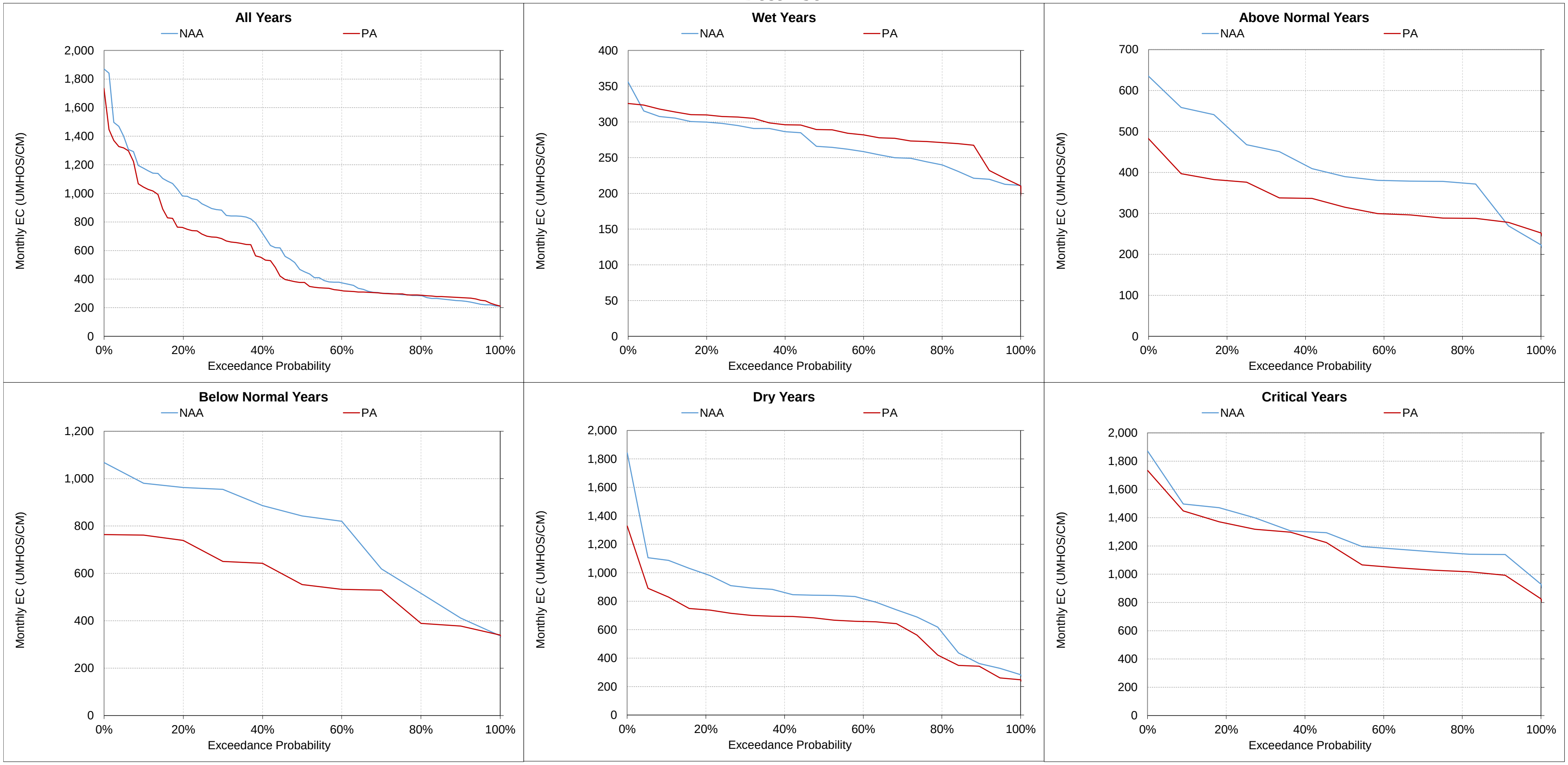
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

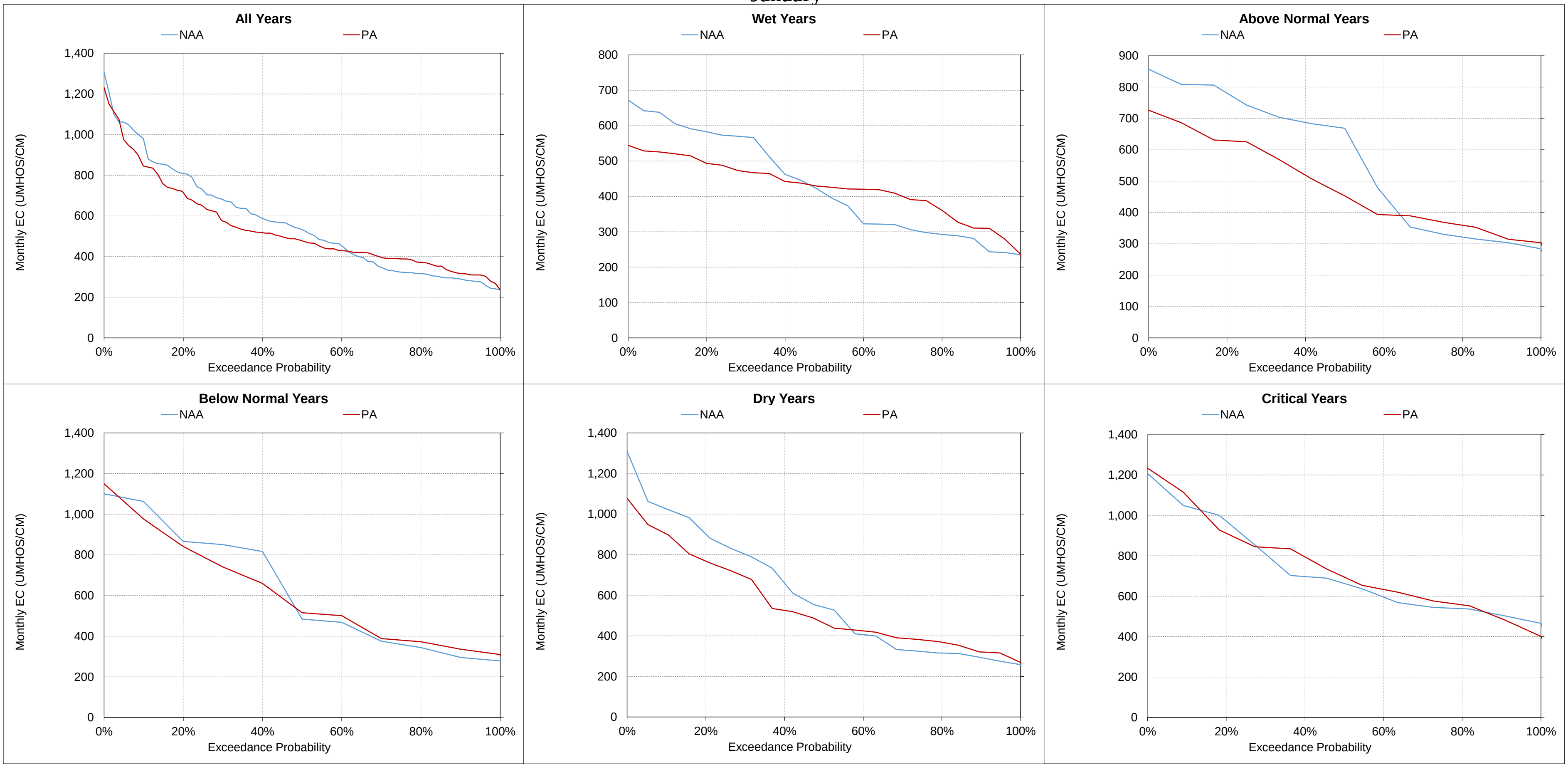
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-18-10. Old River at Rock Slough Salinity, Monthly EC
December



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-18-11. Old River at Rock Slough Salinity, Monthly EC January



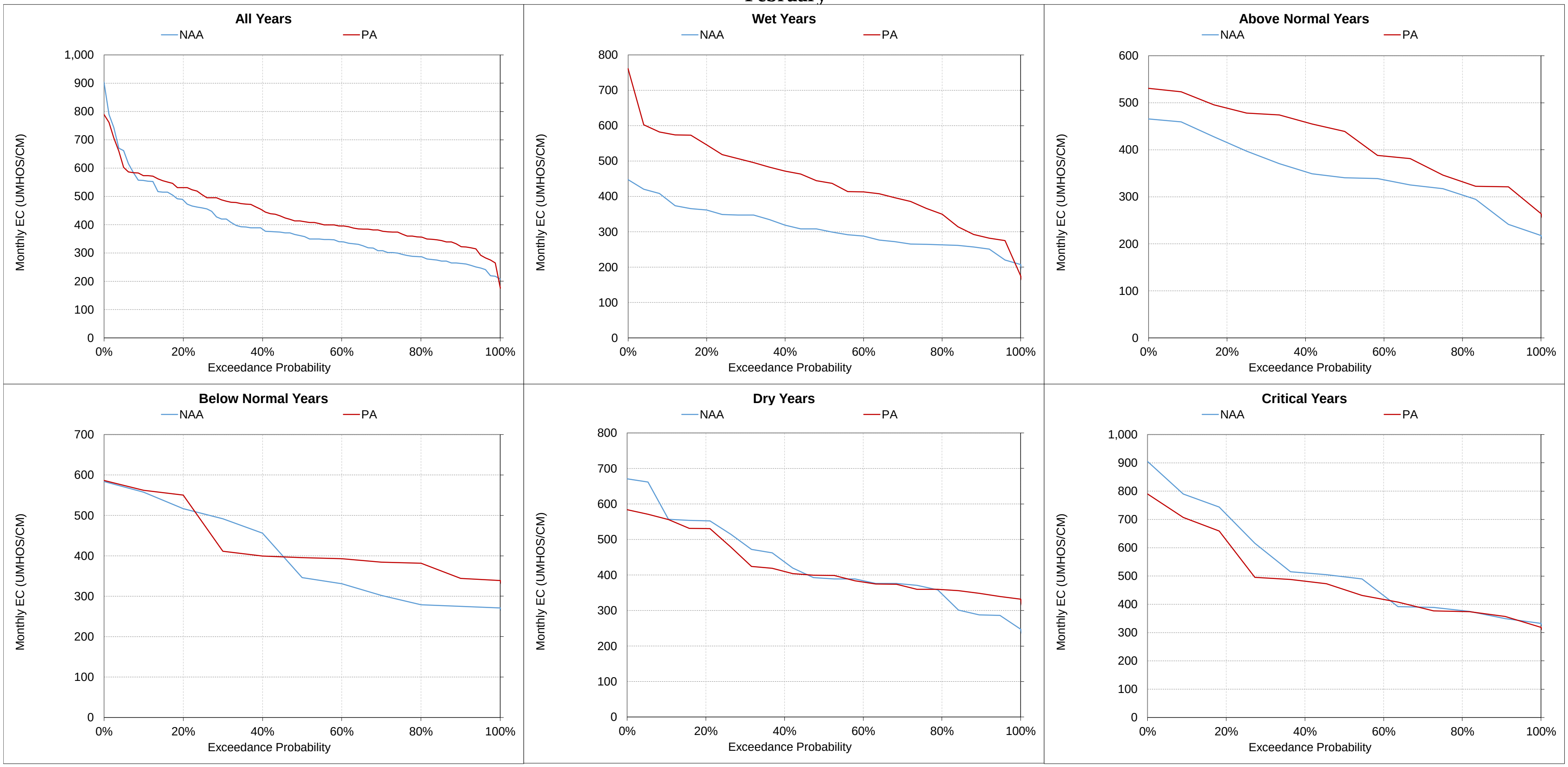
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

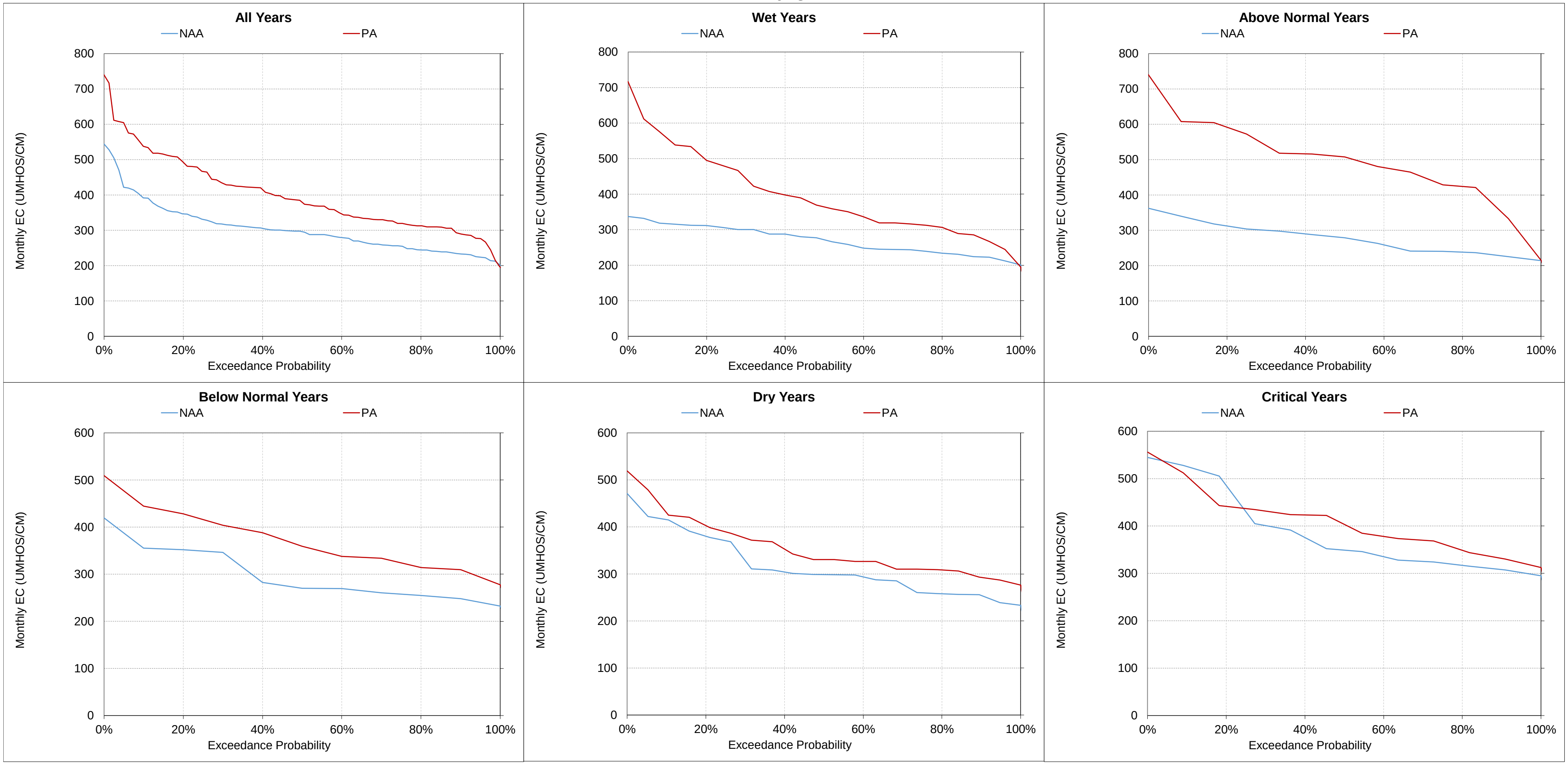
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-18-12. Old River at Rock Slough Salinity, Monthly EC
February



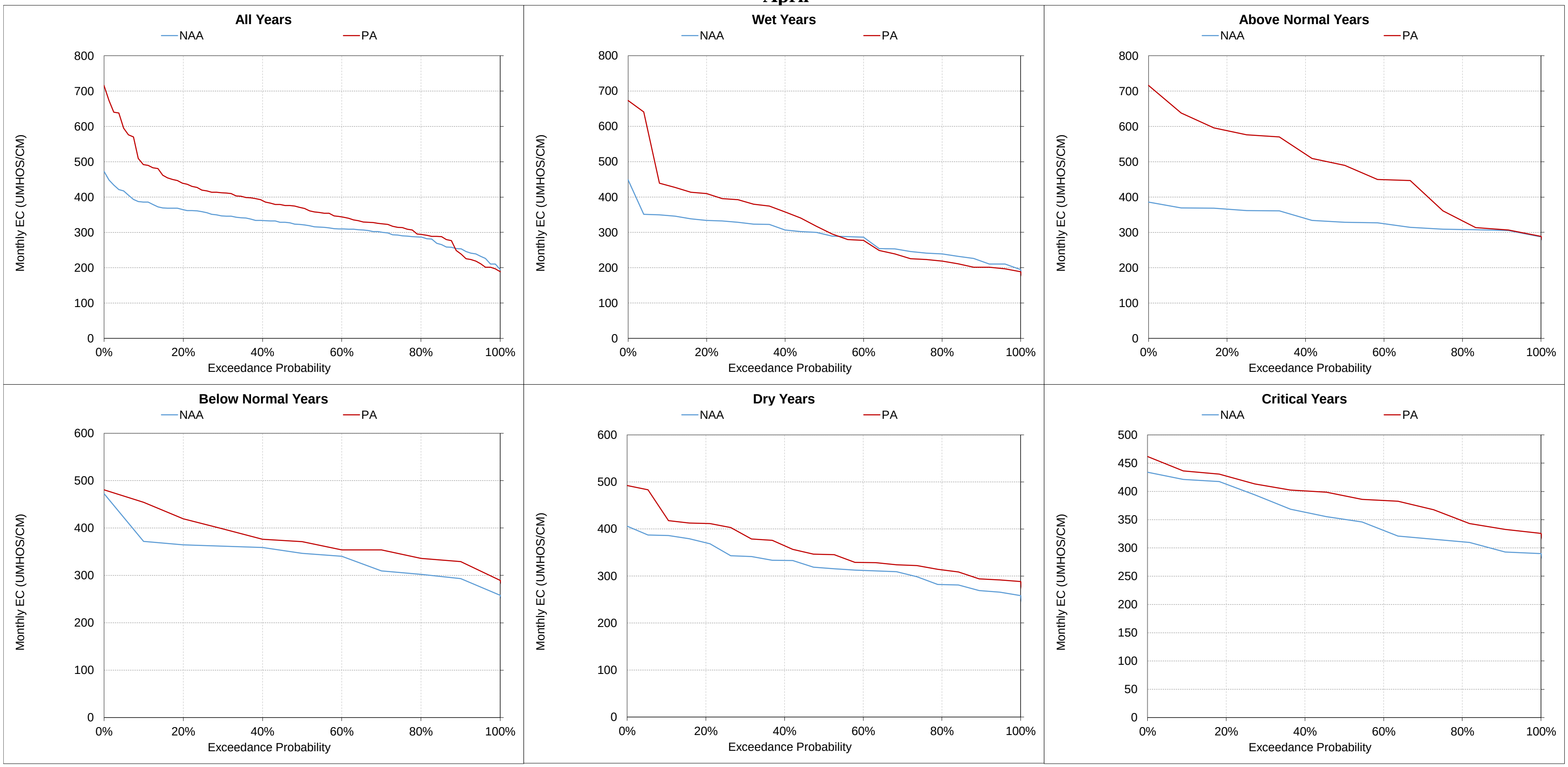
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-18-13. Old River at Rock Slough Salinity, Monthly EC
March



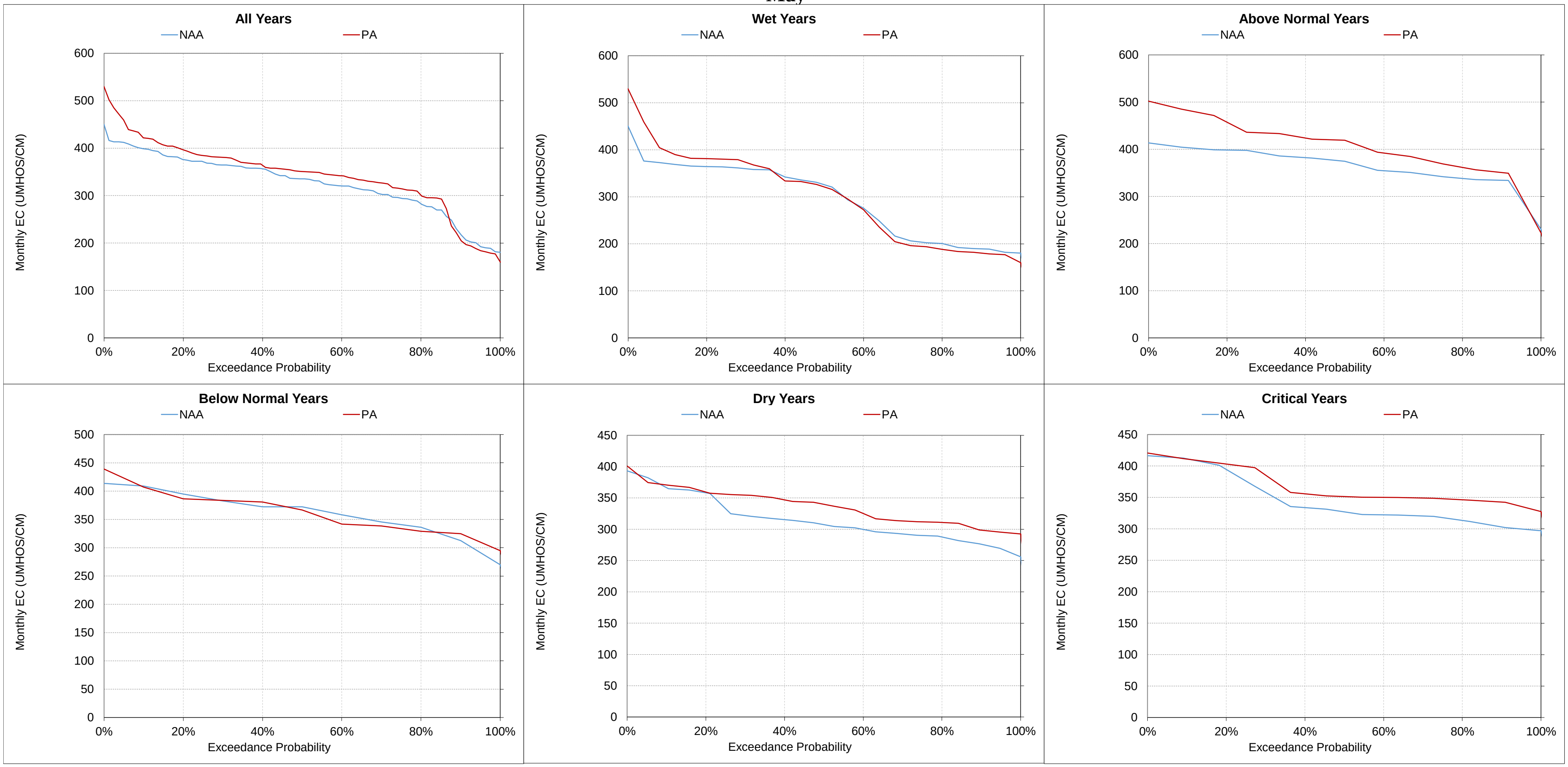
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-18-14. Old River at Rock Slough Salinity, Monthly EC
April



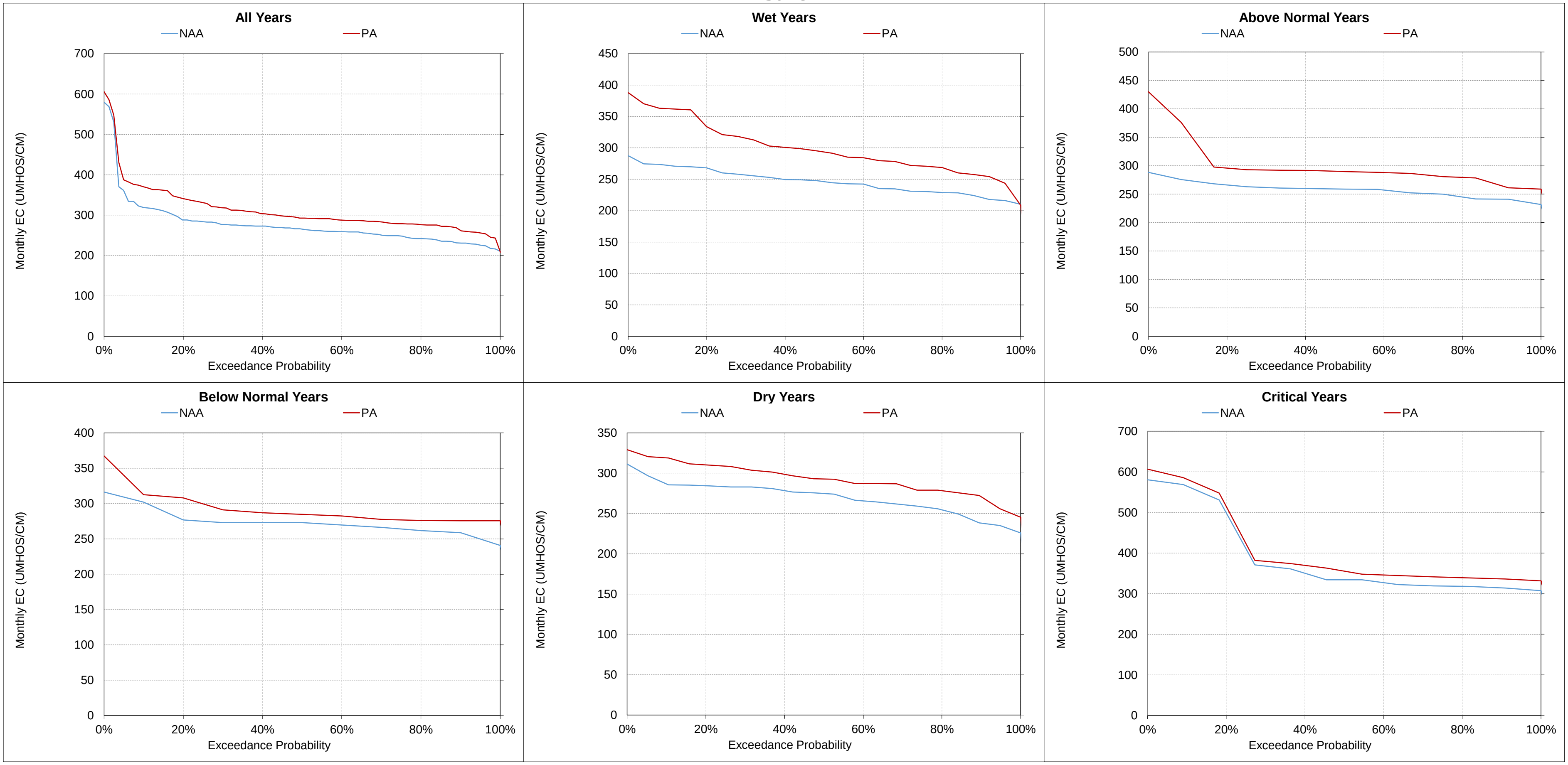
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-18-15. Old River at Rock Slough Salinity, Monthly EC
May



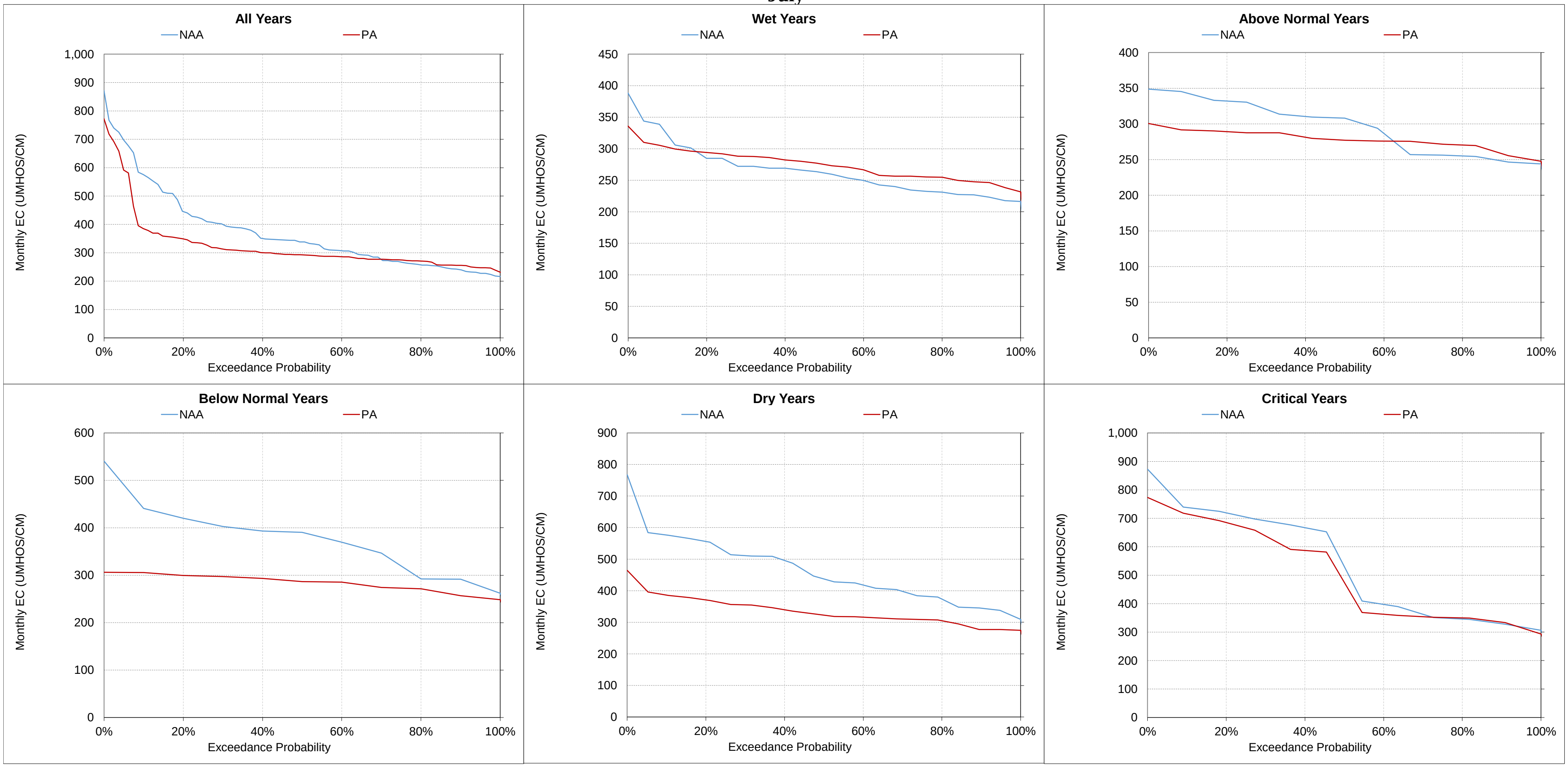
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-18-16. Old River at Rock Slough Salinity, Monthly EC
June



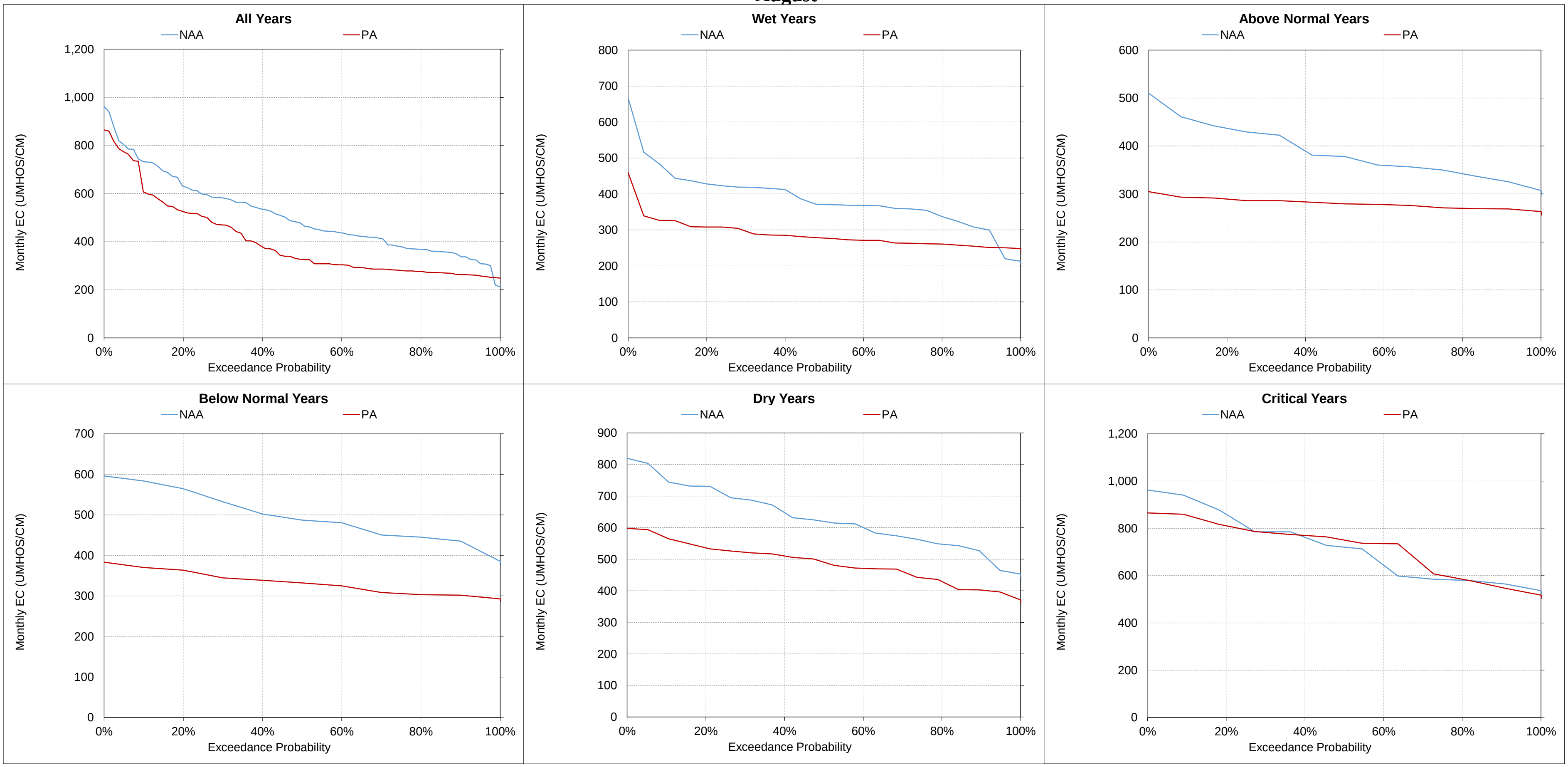
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-18-17. Old River at Rock Slough Salinity, Monthly EC
July



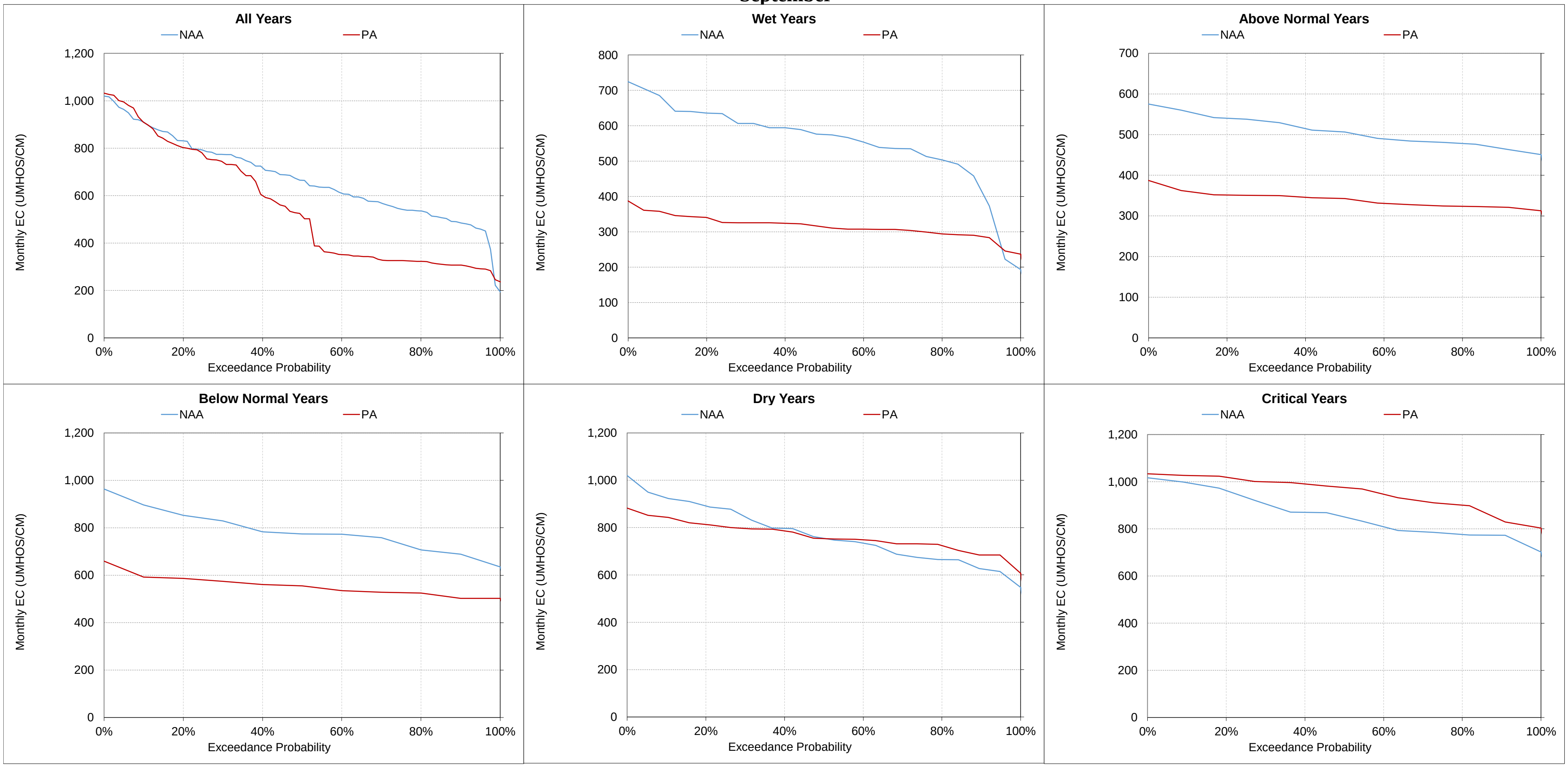
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-18-18. Old River at Rock Slough Salinity, Monthly EC
August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-18-19. Old River at Rock Slough Salinity, Monthly EC
September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-19. Jones Pumping Plant South Delta Exports Salinity, Monthly EC

Statistic	Monthly EC (UMHOS/CM)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	732	677	-55	-8%	882	694	-189	-21%	881	822	-59	-7%	841	849	7	1%	837	818	-18	-2%	856	829	-27	-3%
20%	695	629	-66	-9%	742	583	-159	-21%	824	695	-129	-16%	770	785	14	2%	729	771	42	6%	712	768	56	8%
30%	668	601	-67	-10%	694	546	-148	-21%	738	659	-79	-11%	733	753	20	3%	689	724	35	5%	643	717	74	12%
40%	635	564	-71	-11%	634	519	-115	-18%	713	599	-114	-16%	681	723	41	6%	659	682	24	4%	598	675	78	13%
50%	602	522	-80	-13%	574	499	-75	-13%	549	538	-11	-2%	651	679	28	4%	615	643	28	5%	550	639	90	16%
60%	405	478	73	18%	423	478	55	13%	504	505	1	0%	617	628	11	2%	548	619	72	13%	445	614	169	38%
70%	385	431	46	12%	374	447	73	20%	466	485	20	4%	585	600	15	3%	496	581	85	17%	375	535	161	43%
80%	372	409	37	10%	352	383	31	9%	440	475	35	8%	536	561	26	5%	424	485	61	14%	323	401	78	24%
90%	359	363	4	1%	343	366	23	7%	423	452	28	7%	456	478	21	5%	320	346	25	8%	291	321	30	10%
Long Term **Full Simulation Period**[b]	536	523	-12	-2%	563	507	-56	-10%	622	586	-36	-6%	649	666	17	3%	590	629	40	7%	538	609	72	13%
Water Year Types[c]																								
Wet (32%)	371	417	46	12%	348	411	63	18%	422	457	35	8%	535	645	110	21%	409	487	78	19%	341	450	109	32%
Above Normal (16%)	372	407	35	9%	403	419	17	4%	519	503	-16	-3%	655	596	-59	-9%	577	689	112	19%	464	698	233	50%
Below Normal (13%)	671	542	-130	-19%	652	516	-135	-21%	697	600	-97	-14%	702	696	-6	-1%	626	681	56	9%	564	630	66	12%
Dry (24%)	659	606	-53	-8%	725	551	-174	-24%	724	631	-92	-13%	668	638	-30	-4%	691	677	-14	-2%	657	663	6	1%
Critical (15%)	738	724	-14	-2%	855	729	-126	-15%	931	868	-63	-7%	808	807	-1	0%	793	745	-48	-6%	821	749	-72	-9%

Statistic	Monthly EC (UMHOS/CM)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	642	756	114	18%	565	712	147	26%	481	542	61	13%	469	514	45	10%	587	505	-82	-14%	653	646	-7	-1%
20%	605	682	78	13%	545	579	34	6%	438	494	57	13%	423	486	63	15%	538	468	-70	-13%	627	578	-48	-8%
30%	541	636	95	18%	505	539	35	7%	419	479	61	14%	404	460	56	14%	489	446	-44	-9%	581	552	-28	-5%
40%	477	606	129	27%	449	523	74	16%	401	456	56	14%	392	429	37	9%	458	437	-21	-4%	554	511	-42	-8%
50%	423	562	139	33%	405	491	85	21%	394	434	39	10%	380	411	31	8%	421	418	-3	-1%	536	482	-54	-10%
60%	375	507	132	35%	381	445	63	17%	385	400	15	4%	372	395	23	6%	393	392	-1	0%	512	464	-48	-9%
70%	348	437	89	26%	365	400	35	10%	373	389	16	4%	365	377	12	3%	374	369	-5	-1%	484	456	-28	-6%
80%	316	373	57	18%	338	378	41	12%	362	381	20	5%	348	363	15	4%	359	356	-3	-1%	463	417	-46	-10%
90%	237	340	102	43%	205	336	131	64%	333	354	21	6%	332	345	12	4%	345	344	-1	0%	451	393	-58	-13%
Long Term **Full Simulation Period**[b]	441	549	108	24%	413	495	81	20%	398	447	49	12%	395	428	33	8%	448	421	-26	-6%	535	501	-34	-6%
Water Year Types[c]																								
Wet (32%)	290	440	149	51%	292	449	157	54%	356	447	91	26%	362	425	64	18%	361	379	18	5%	469	417	-52	-11%
Above Normal (16%)	394	631	237	60%	379	540	161	42%	391	452	60	15%	365	450	85	23%	371	401	30	8%	456	453	-3	-1%
Below Normal (13%)	457	537	80	18%	437	494	56	13%	403	425	21	5%	373	391	17	5%	441	376	-64	-15%	581	474	-107	-18%
Dry (24%)	537	581	44	8%	486	488	2	0%	406	428	22	5%	414	405	-9	-2%	538	436	-102	-19%	584	554	-30	-5%
Critical (15%)	642	652	10	1%	570	556	-14	-2%	478	494	16	3%	487	483	-3	-1%	574	552	-22	-4%	638	669	31	5%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

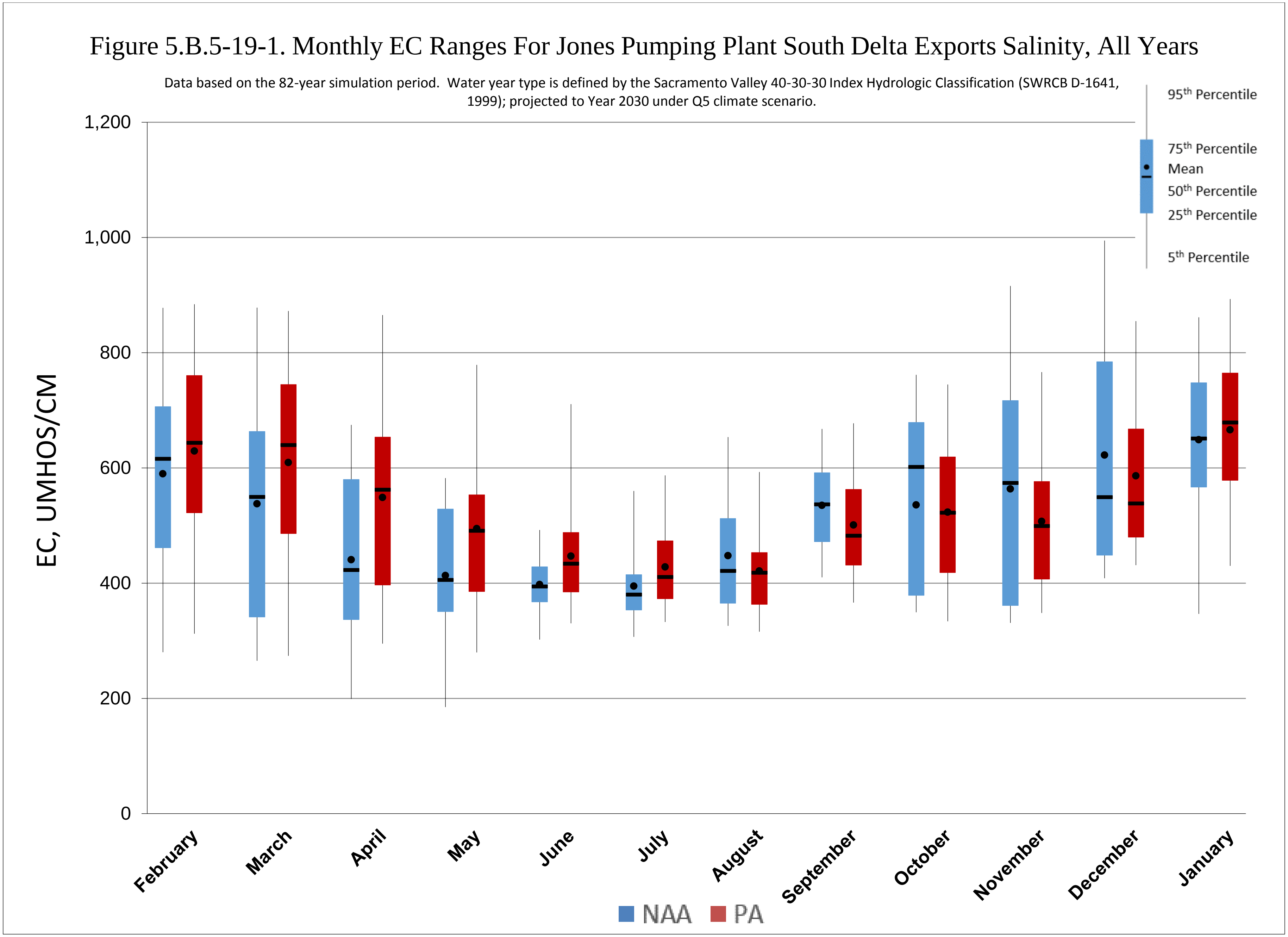


Figure 5.B.5-19-1. Monthly EC Ranges For Jones Pumping Plant South Delta Exports Salinity, All Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario.
EC, UMHOS/CM
1,200
1,000
800
600
400
200
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile

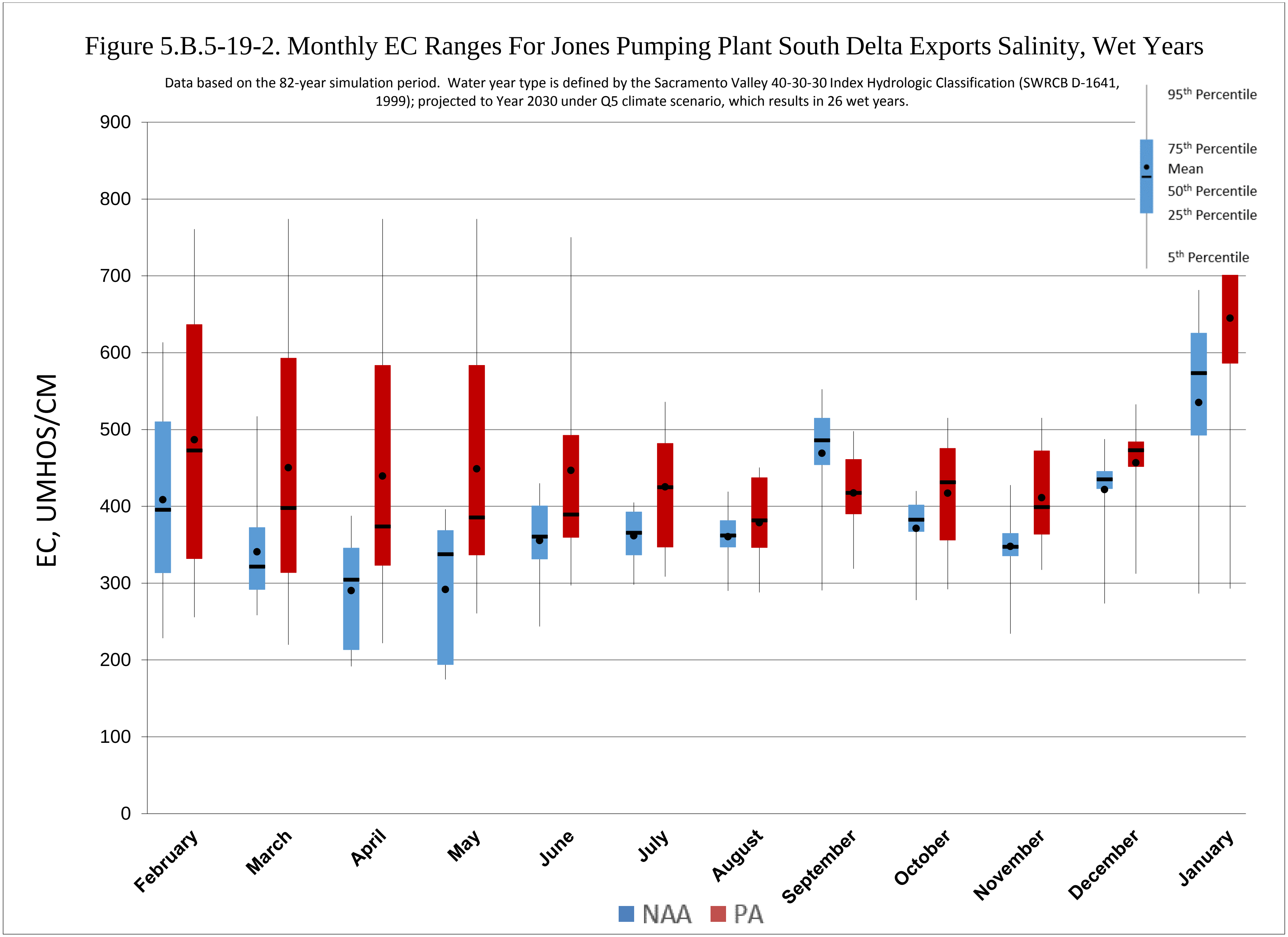


Figure 5.B.5-19-2. Monthly EC Ranges For Jones Pumping Plant South Delta Exports Salinity, Wet Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 26 wet years.
EC, UMHOS/CM
900
800
700
600
500
400
300
200
100
0
February
March
April
May
June
July
August
September
October
November
December
January
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
NAA
PA

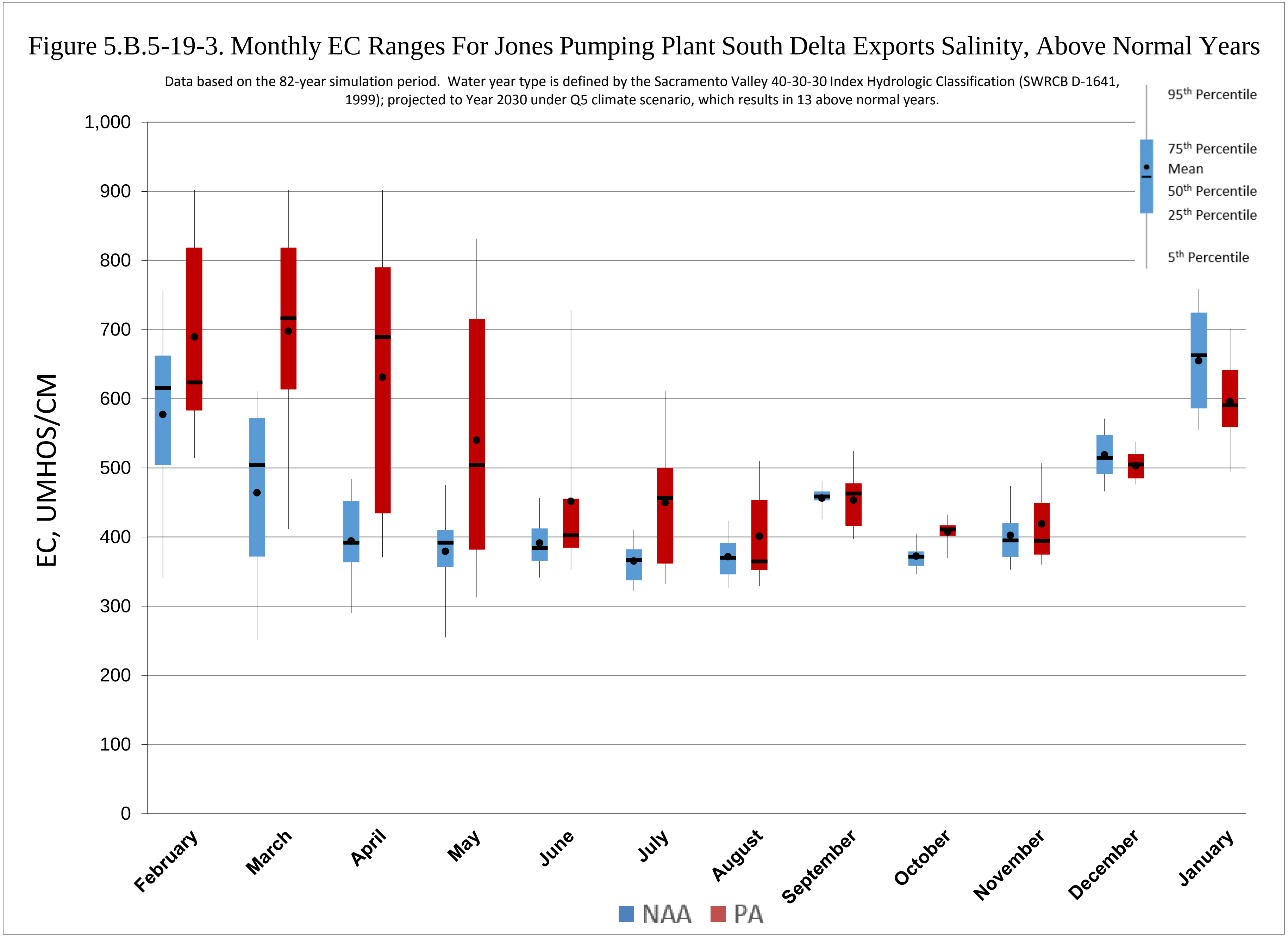


Figure 5.B.5-19-3. Monthly EC Ranges For Jones Pumping Plant South Delta Exports Salinity, Above Normal Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 13 above normal years.
EC, UMHOS/CM
1,000
900
800
700
600
500
400
300
200
100
0
February
March
April
May
June
July
August
September
October
November
December
January
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
NAA
PA

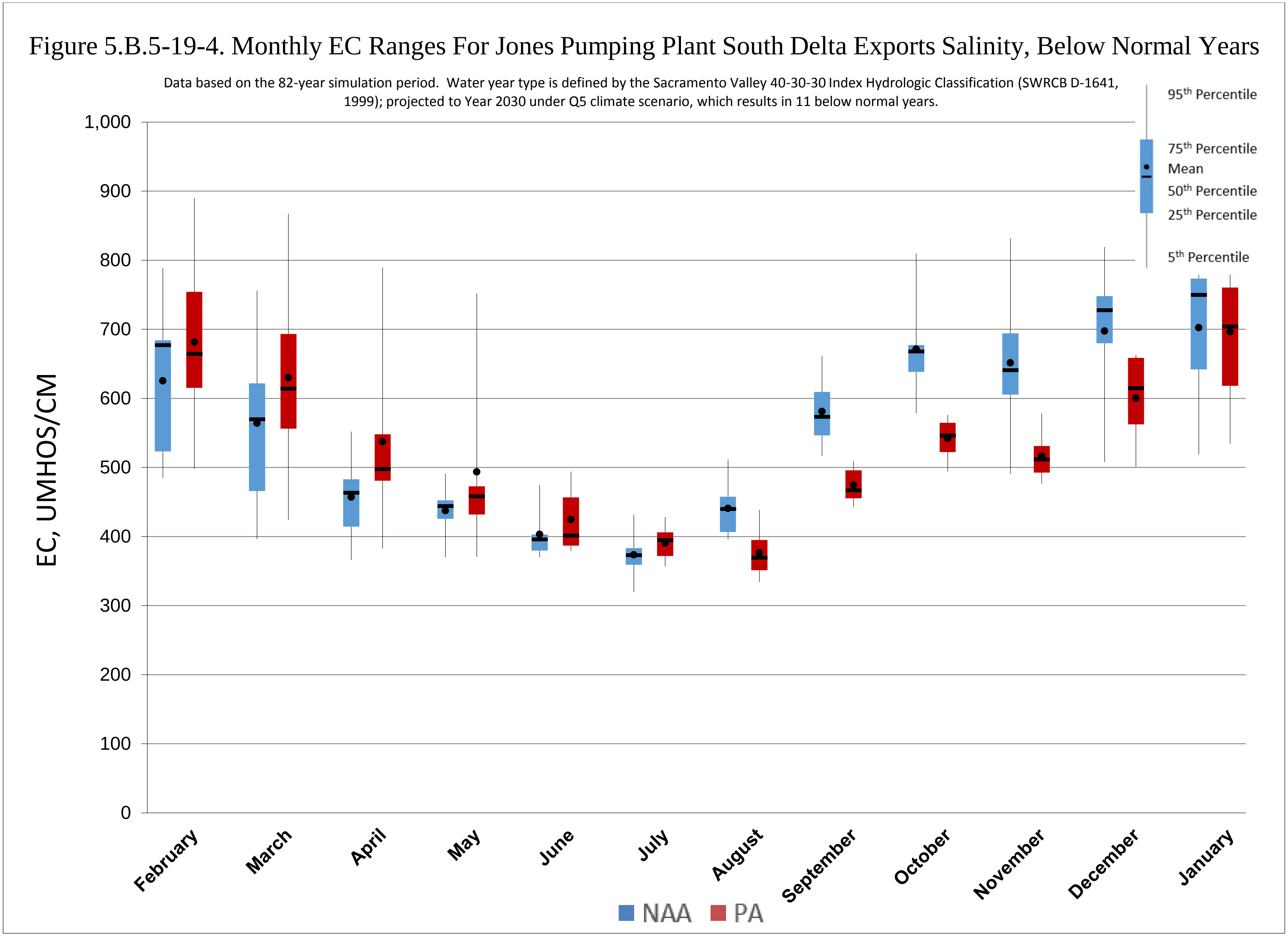


Figure 5.B.5-19-4. Monthly EC Ranges For Jones Pumping Plant South Delta Exports Salinity, Below Normal Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 11 below normal years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
EC, UMHOS/CM
1,000
900
800
700
600
500
400
300
200
100
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-19-5. Monthly EC Ranges For Jones Pumping Plant South Delta Exports Salinity, Dry Years

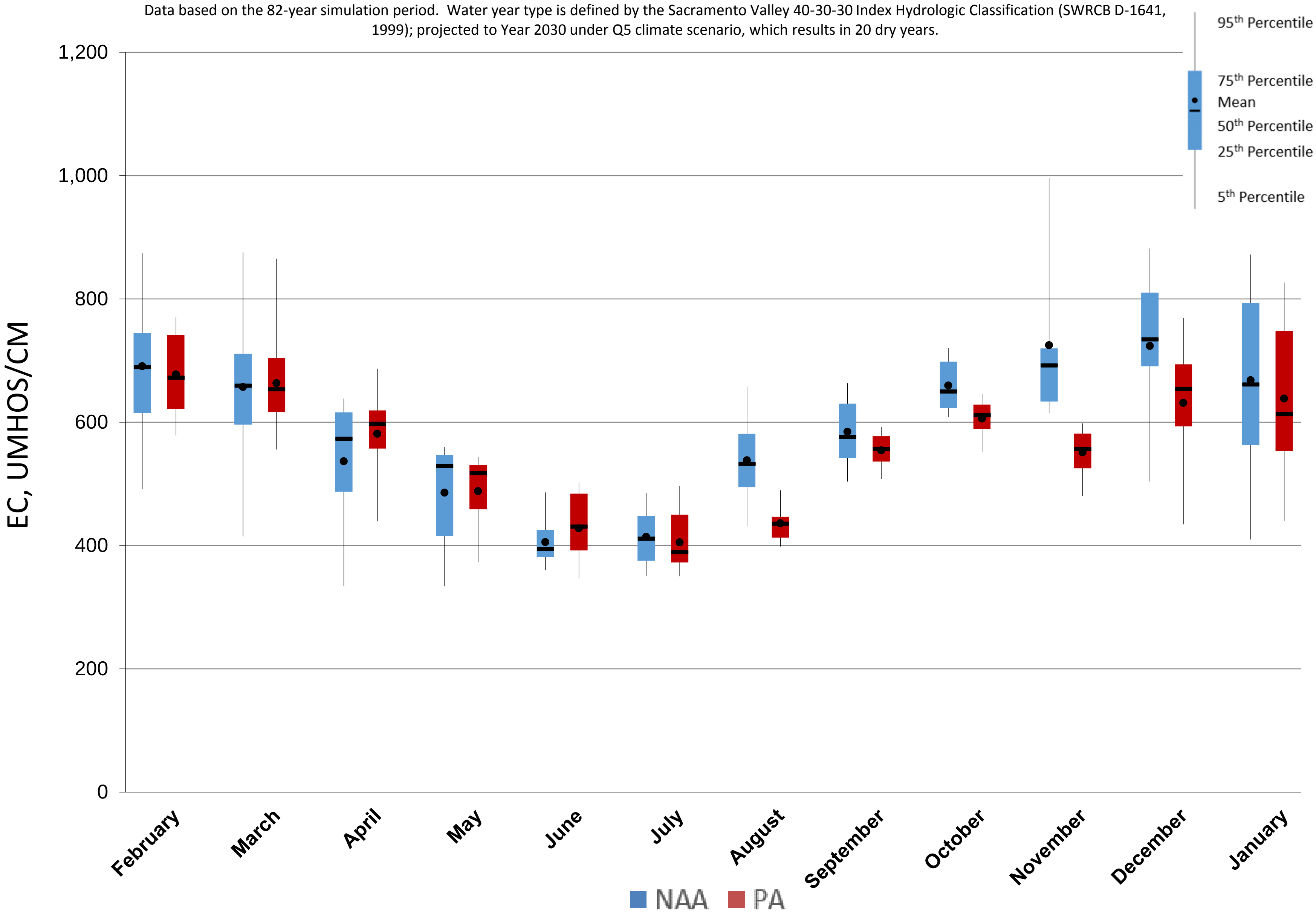


Figure 5.B.5-19-6. Monthly EC Ranges For Jones Pumping Plant South Delta Exports Salinity, Critical Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 12 critical years.

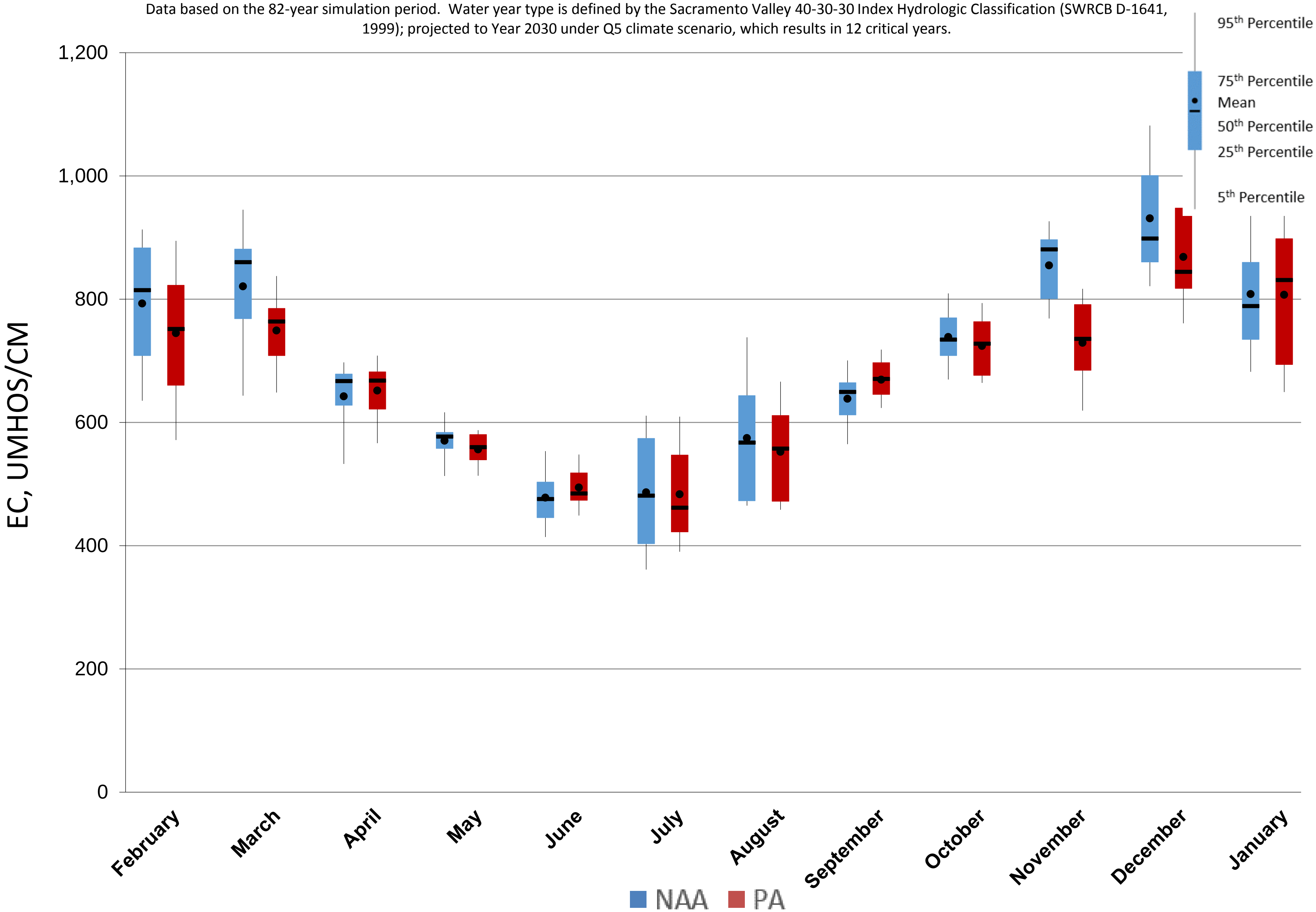
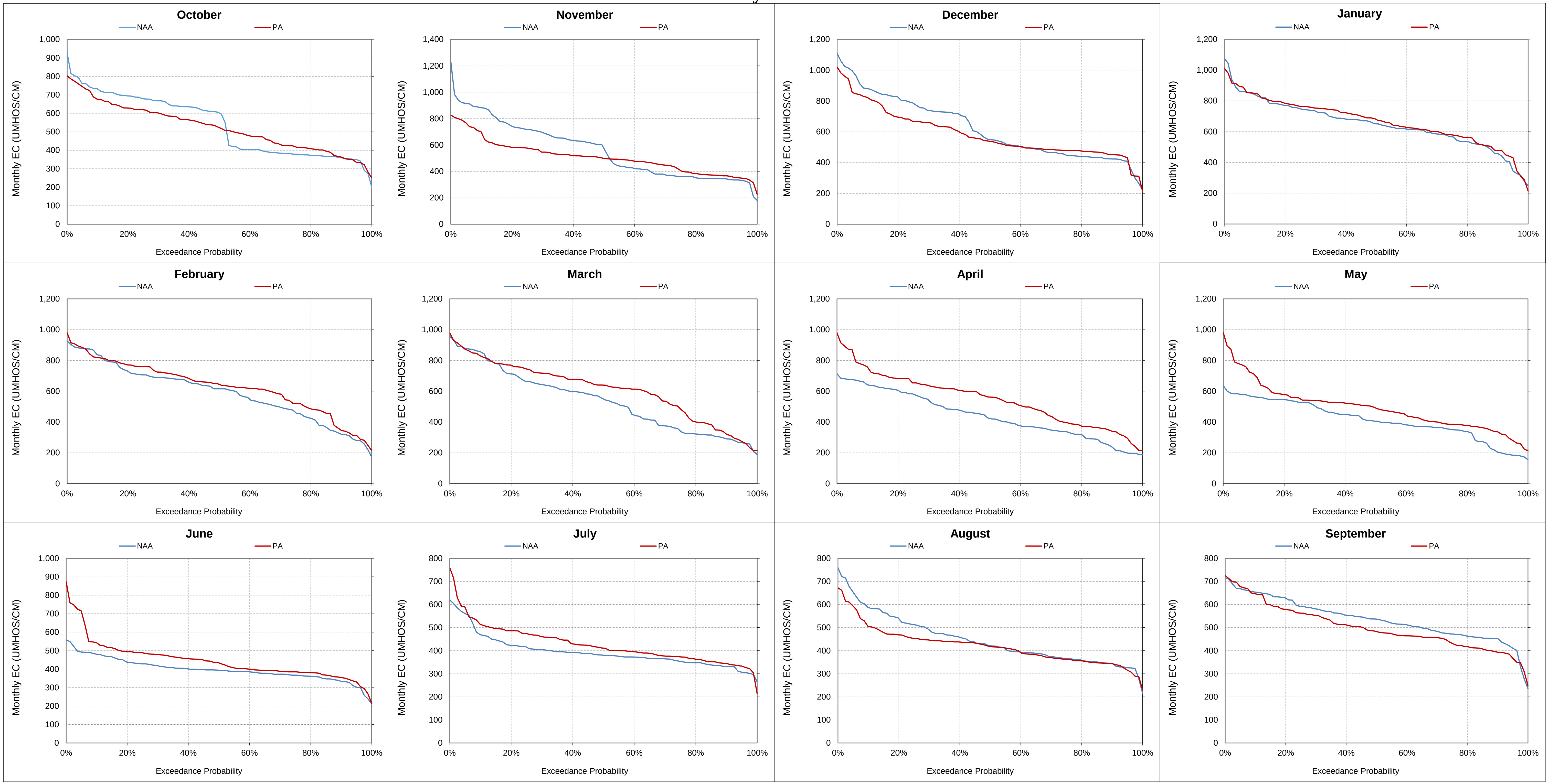
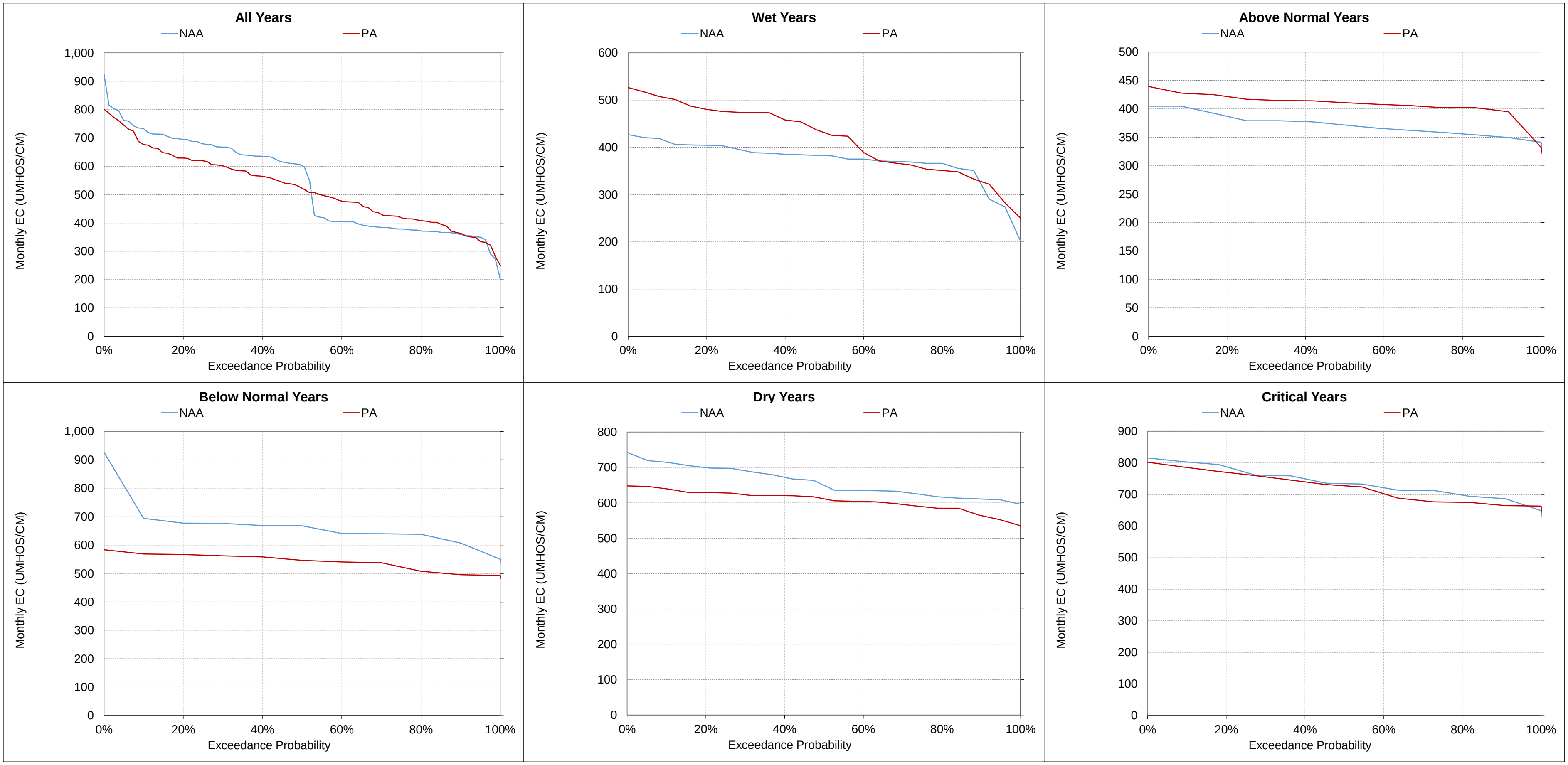


Figure 5.B.5-19-7. Jones Pumping Plant South Delta Exports Salinity, Monthly EC Probability of Exceedance



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-19-8. Jones Pumping Plant South Delta Exports Salinity, Monthly EC October



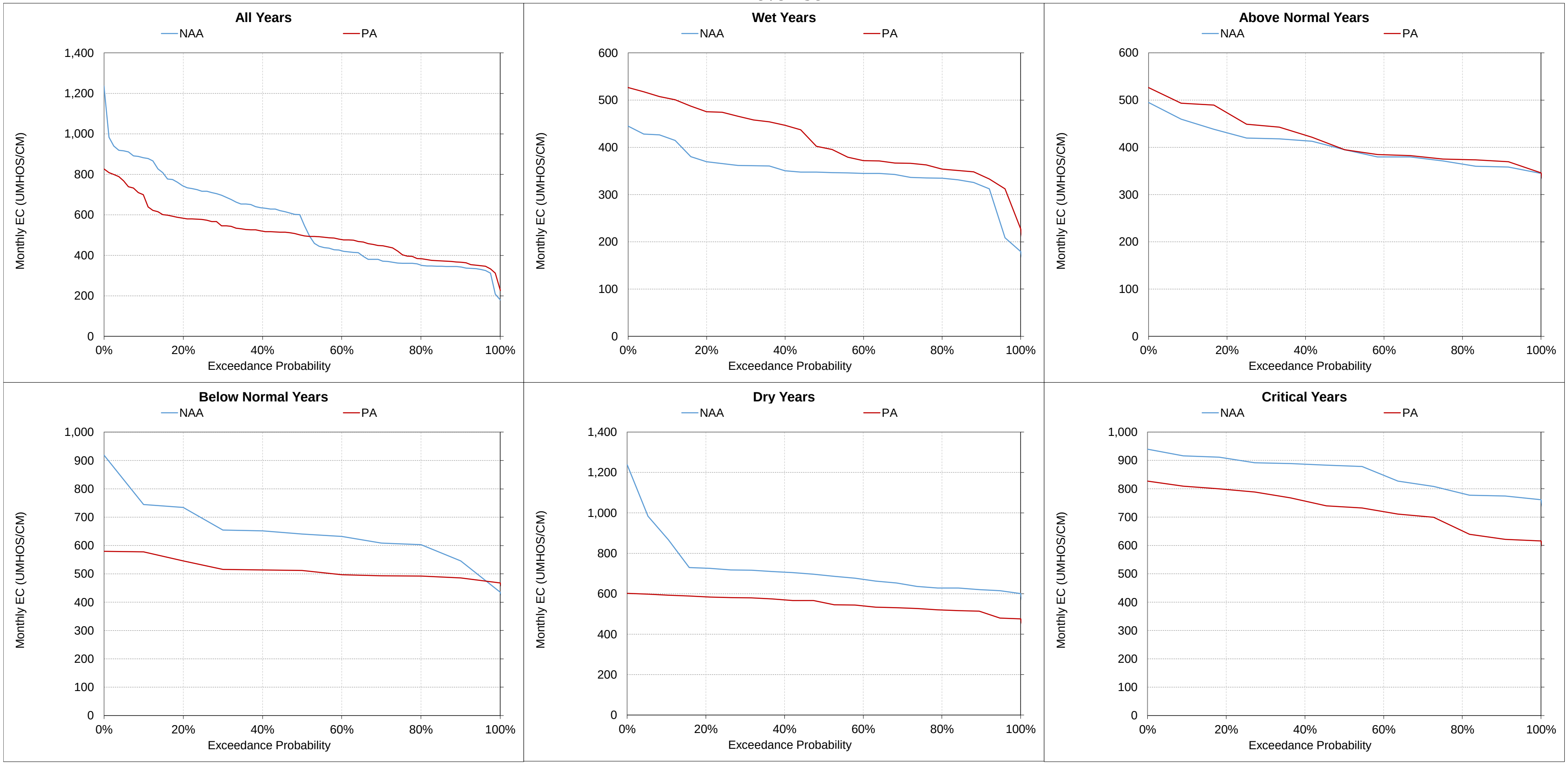
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

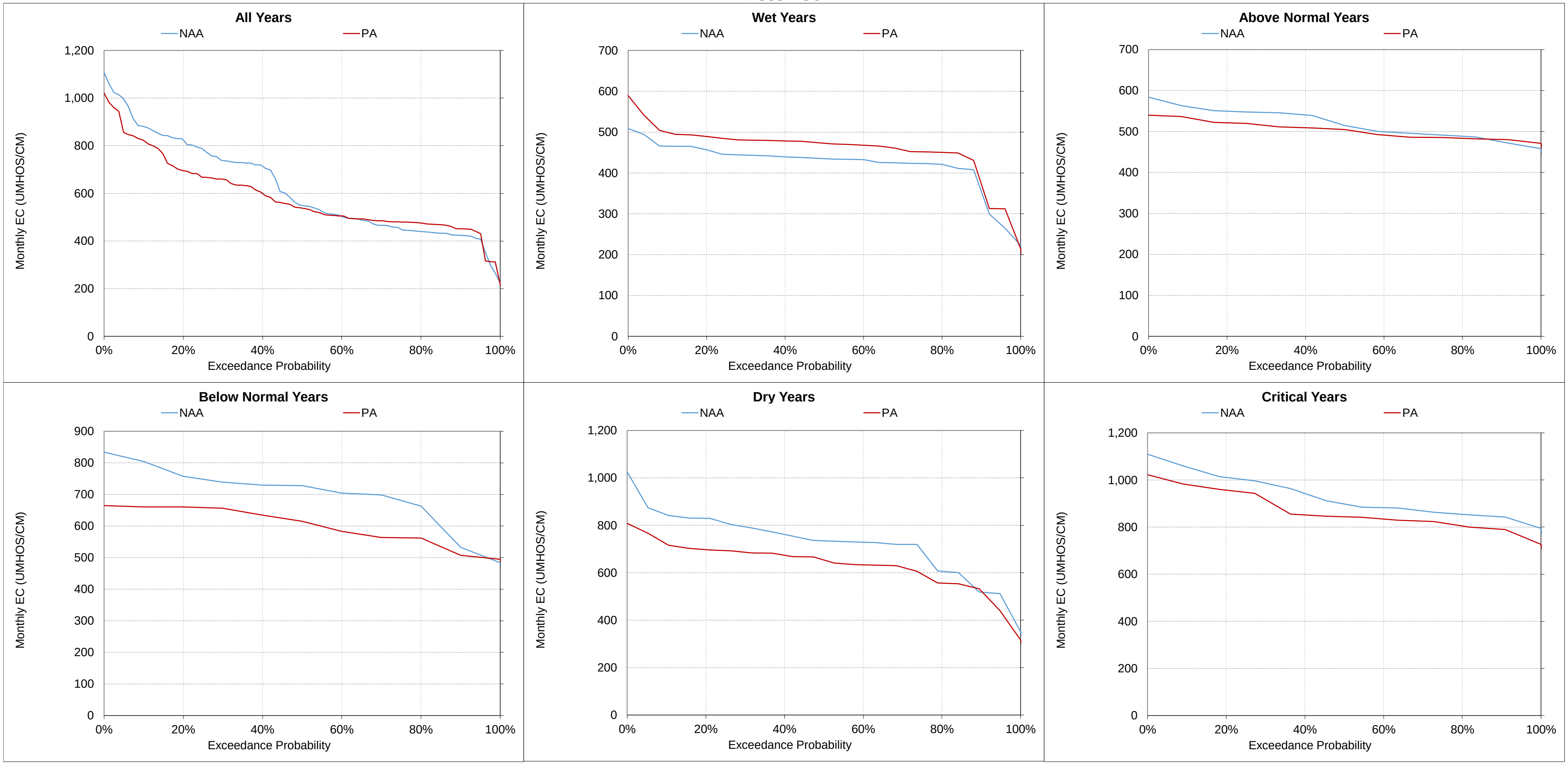
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-19-9. Jones Pumping Plant South Delta Exports Salinity, Monthly EC November



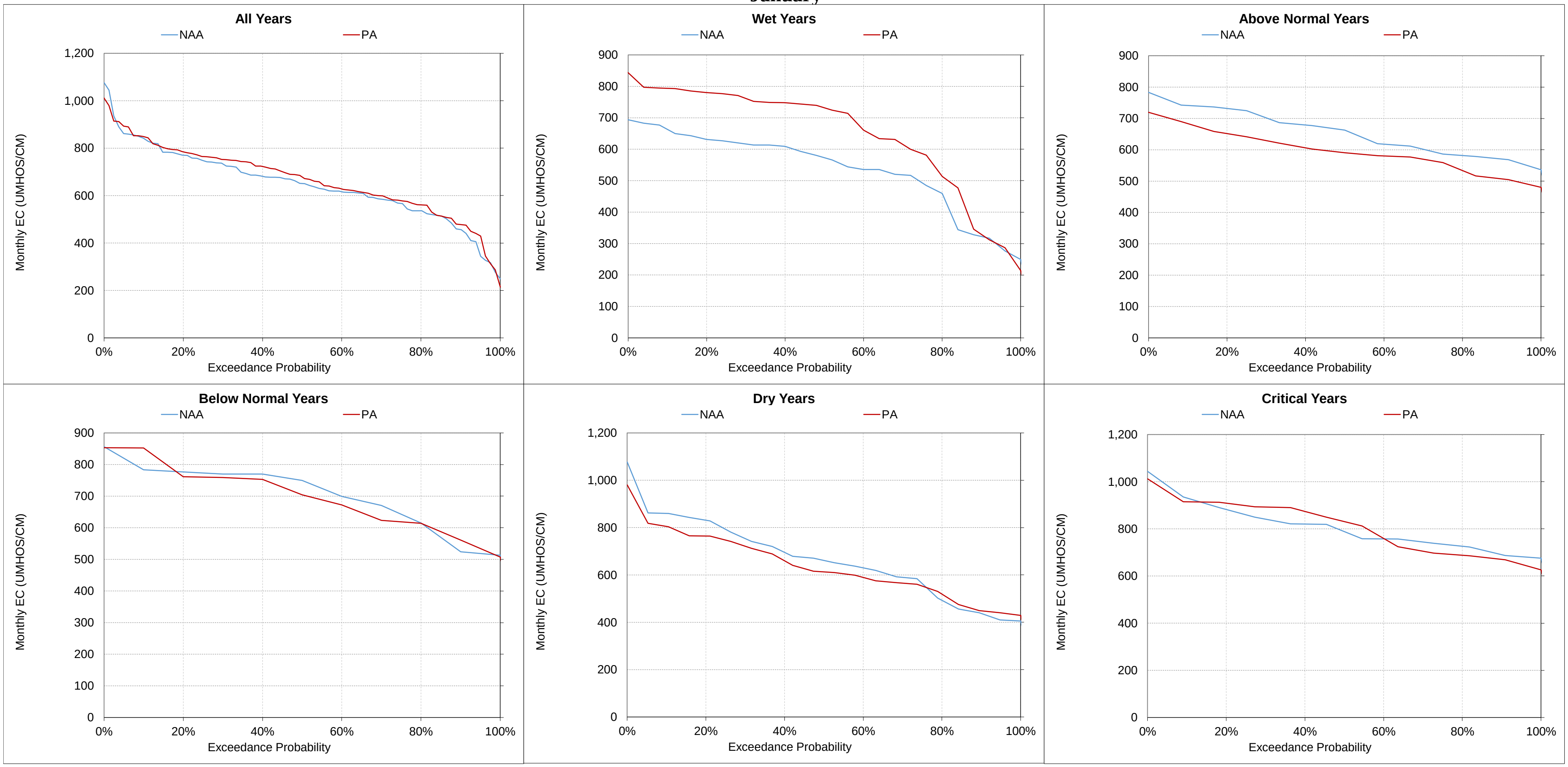
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-19-10. Jones Pumping Plant South Delta Exports Salinity, Monthly EC December



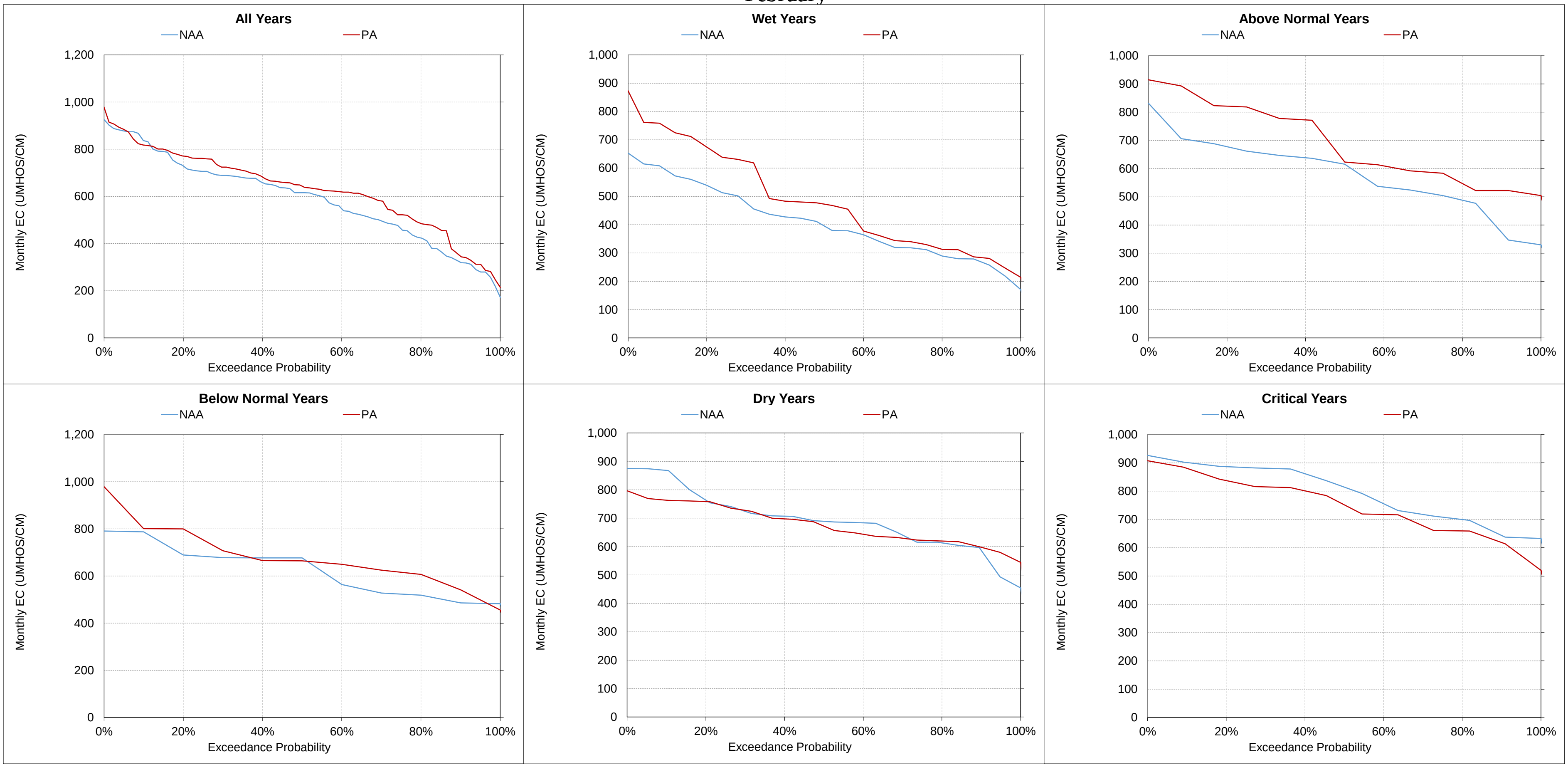
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-19-11. Jones Pumping Plant South Delta Exports Salinity, Monthly EC
January



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-19-12. Jones Pumping Plant South Delta Exports Salinity, Monthly EC February



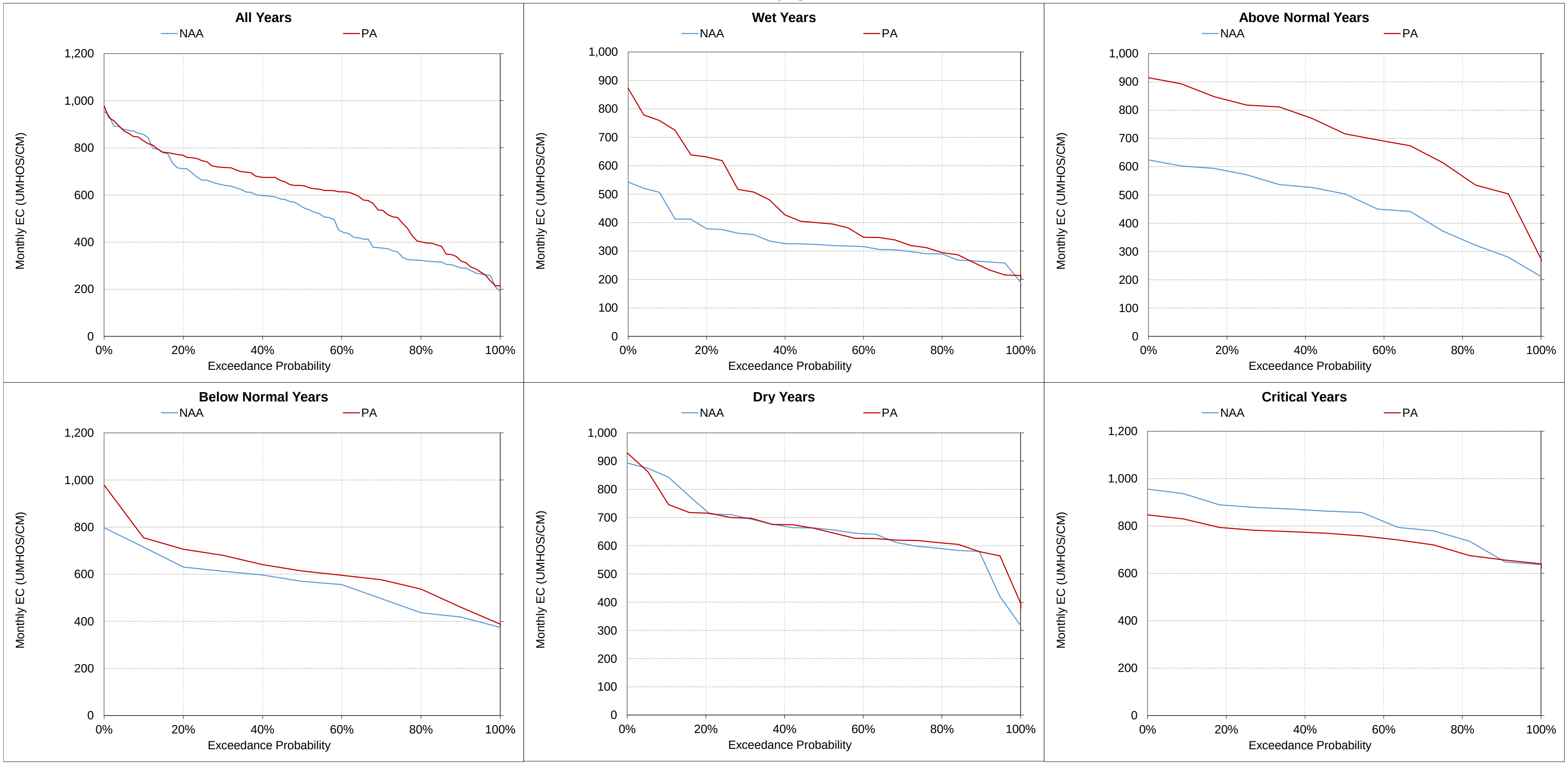
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

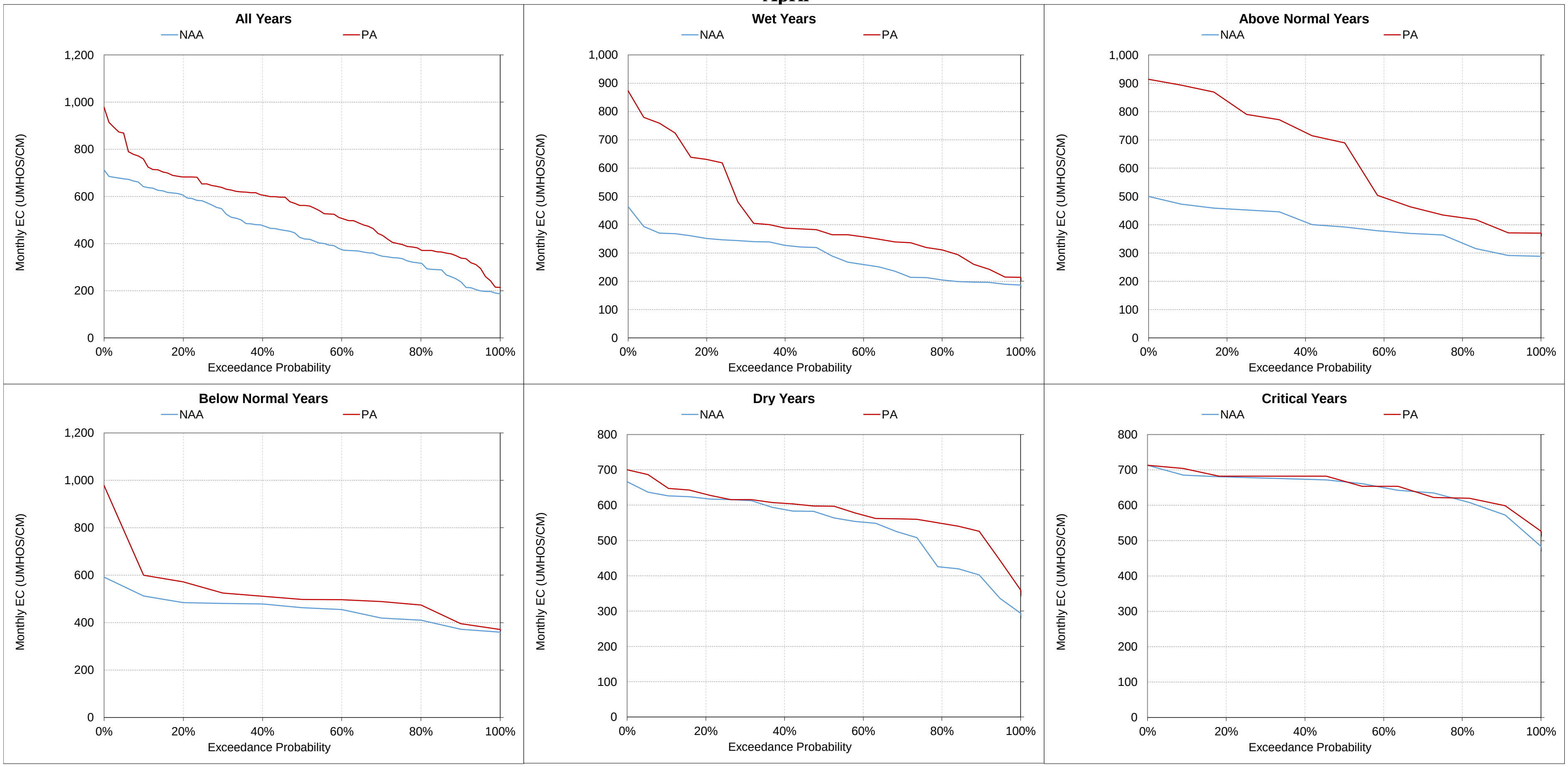
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-19-13. Jones Pumping Plant South Delta Exports Salinity, Monthly EC
March



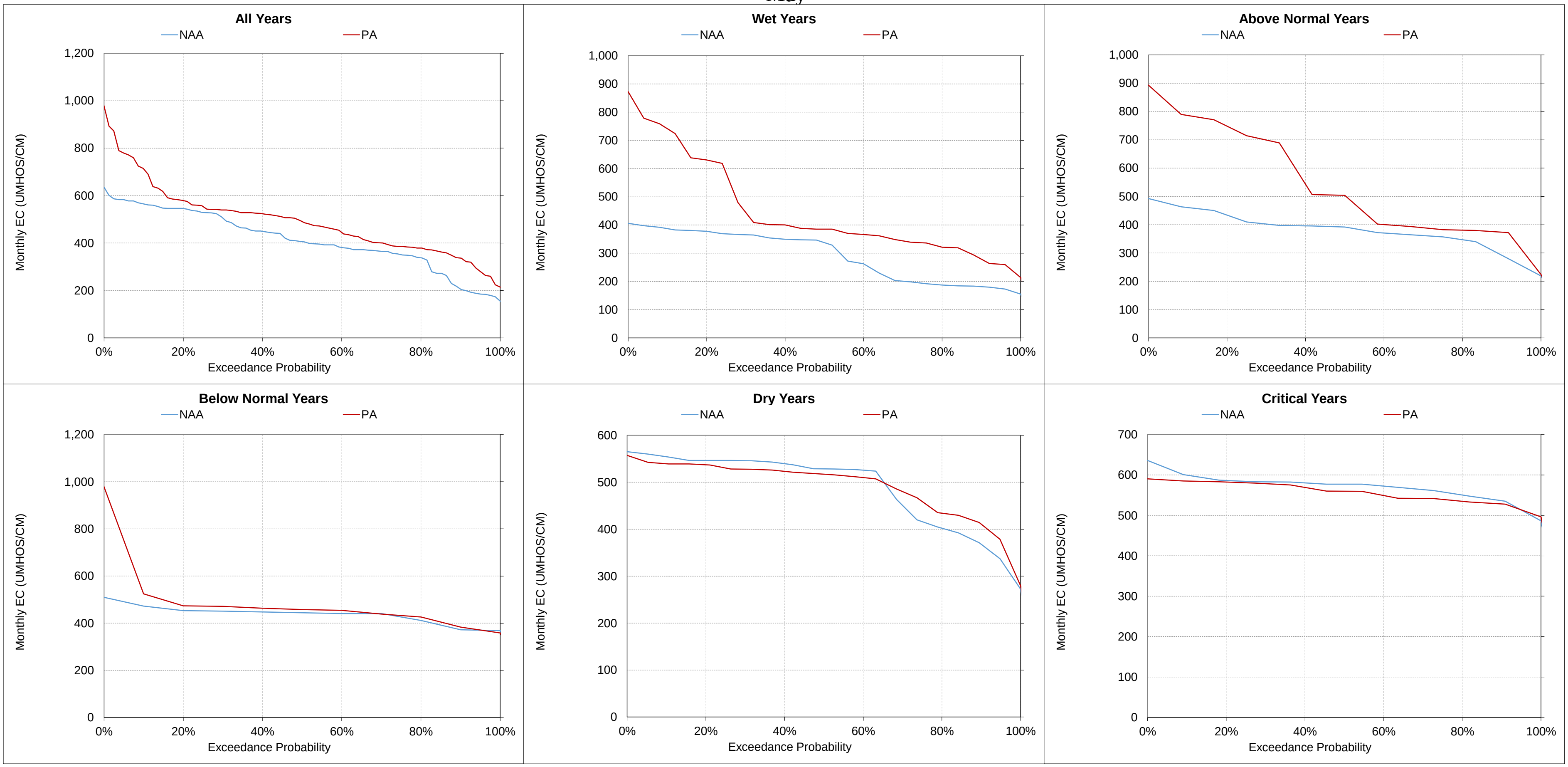
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-19-14. Jones Pumping Plant South Delta Exports Salinity, Monthly EC
April



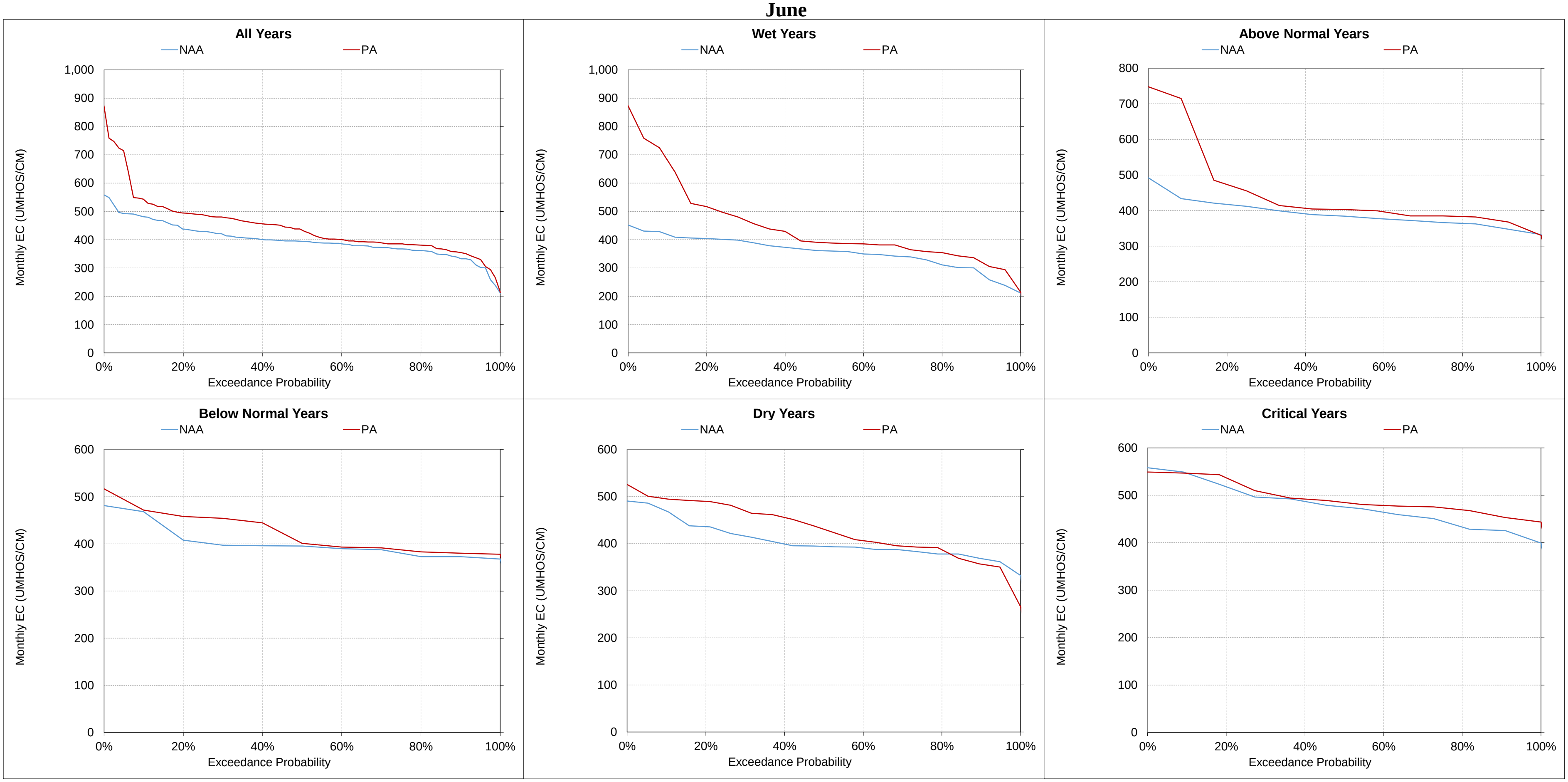
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-19-15. Jones Pumping Plant South Delta Exports Salinity, Monthly EC May



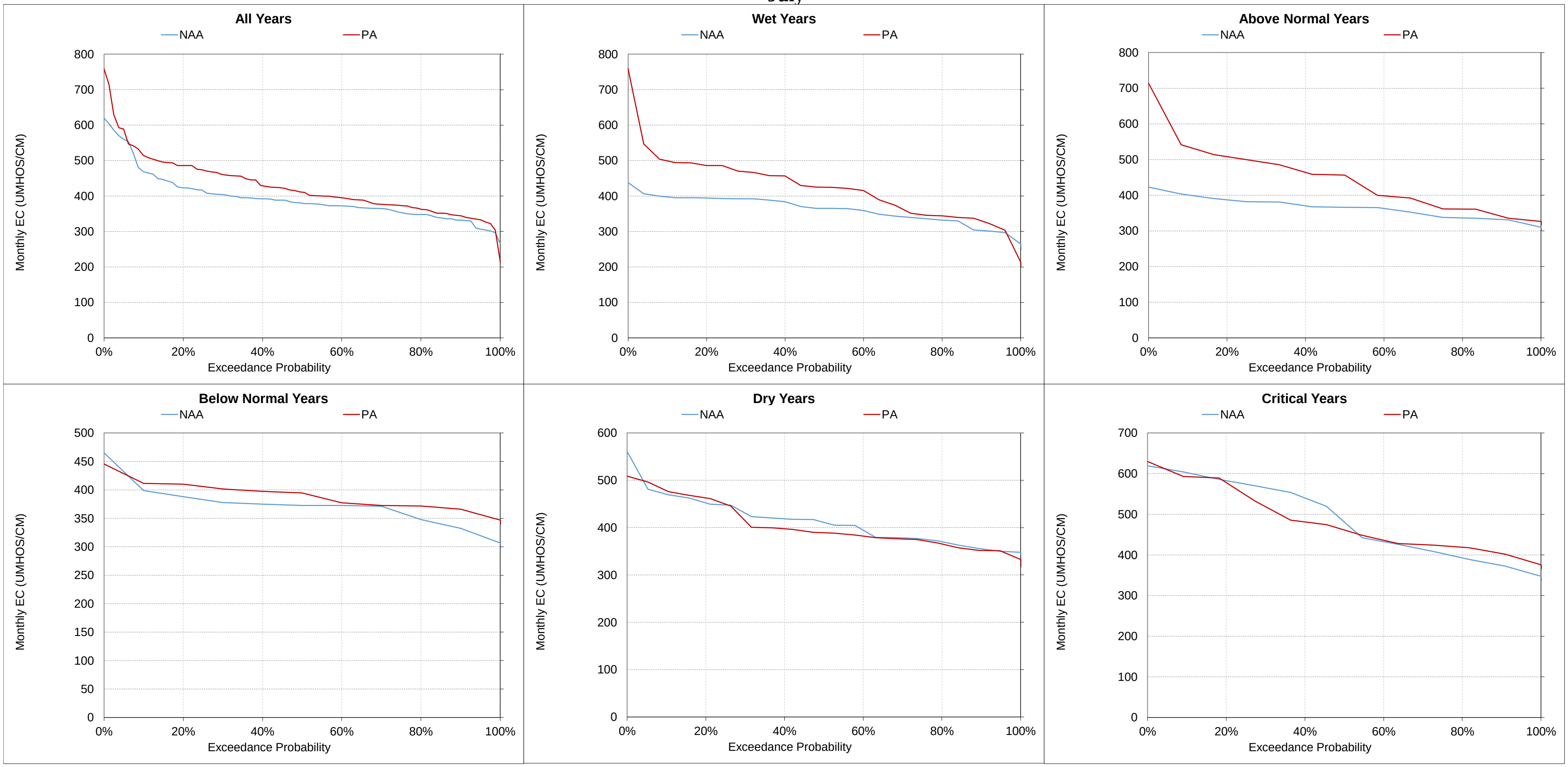
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-19-16. Jones Pumping Plant South Delta Exports Salinity, Monthly EC June



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-19-17. Jones Pumping Plant South Delta Exports Salinity, Monthly EC July



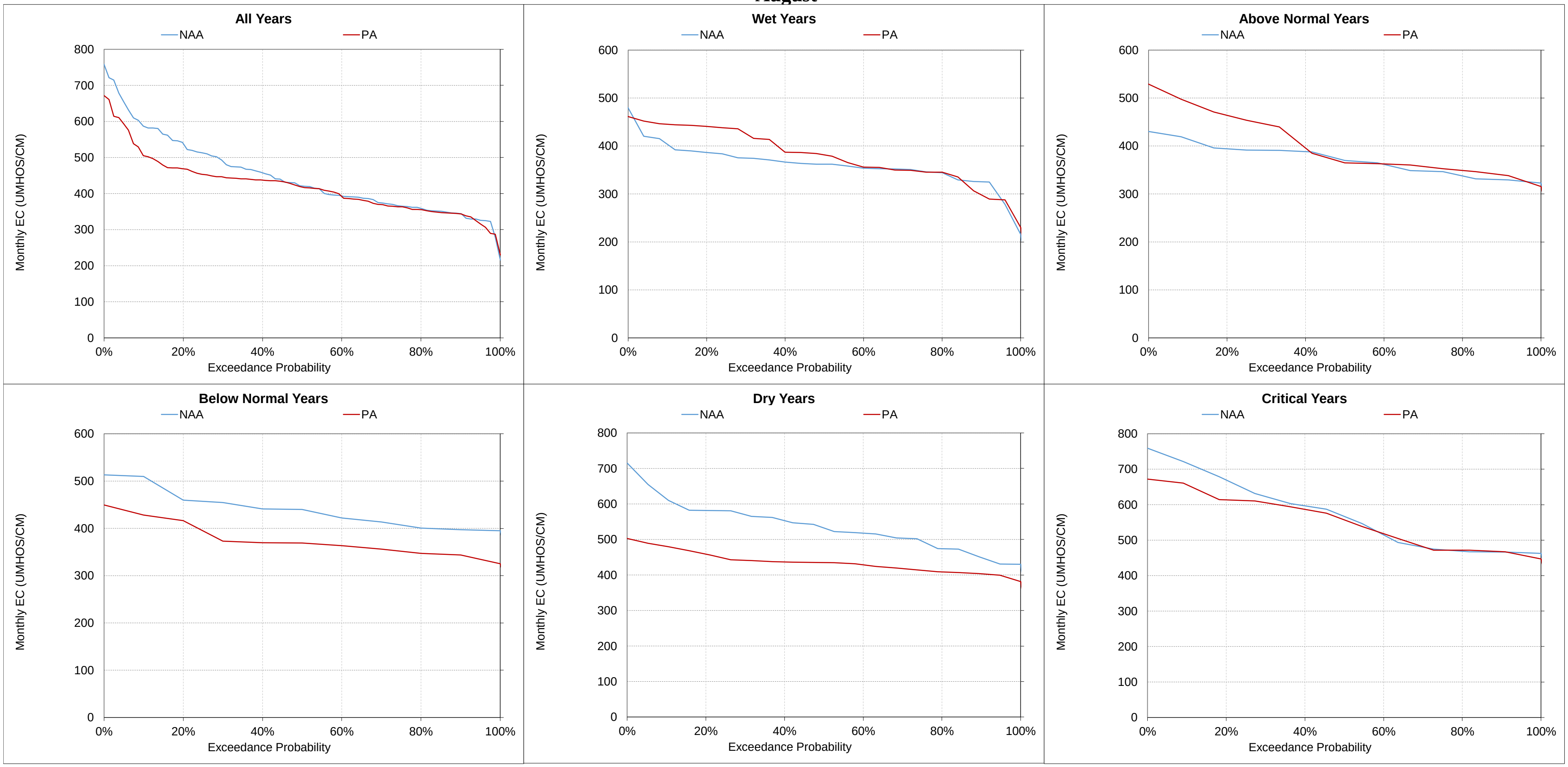
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

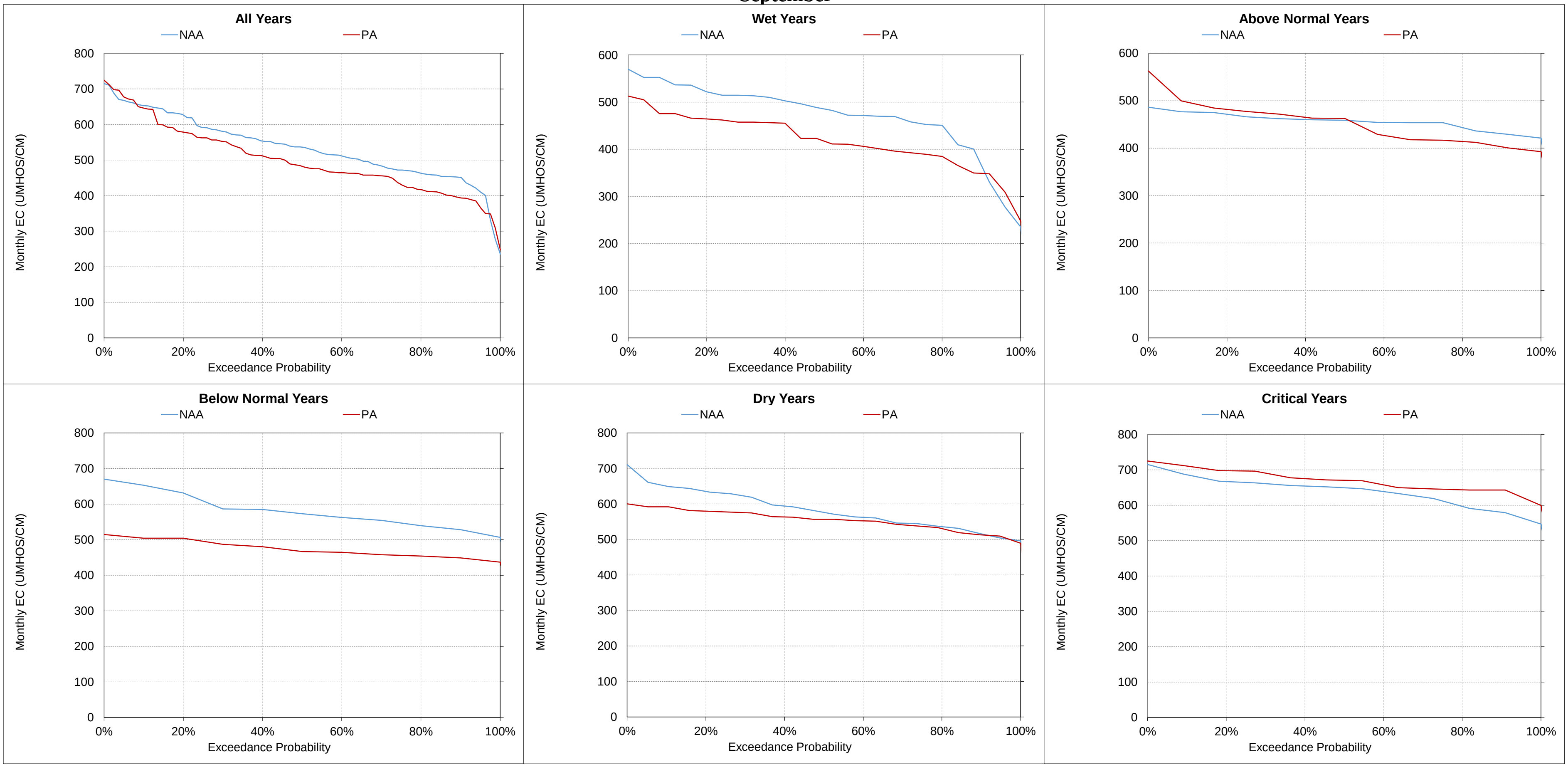
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-19-18. Jones Pumping Plant South Delta Exports Salinity, Monthly EC August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-19-19. Jones Pumping Plant South Delta Exports Salinity, Monthly EC September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-20. Banks Pumping Plant South Delta Exports Salinity, Monthly EC

Statistic	Monthly EC (UMHOS/CM)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	766	723	-42	-6%	900	695	-205	-23%	965	823	-142	-15%	876	855	-21	-2%	673	719	46	7%	611	712	101	17%
20%	708	647	-60	-9%	746	569	-177	-24%	839	638	-201	-24%	753	679	-74	-10%	621	656	35	6%	545	634	89	16%
30%	685	601	-84	-12%	705	541	-164	-23%	723	557	-166	-23%	684	610	-74	-11%	571	619	48	8%	495	599	105	21%
40%	641	550	-92	-14%	653	499	-153	-23%	669	489	-180	-27%	592	576	-16	-3%	553	601	48	9%	462	570	108	23%
50%	581	505	-76	-13%	588	451	-137	-23%	465	438	-27	-6%	541	531	-10	-2%	518	574	55	11%	428	545	117	27%
60%	382	401	20	5%	354	424	70	20%	382	396	15	4%	510	475	-35	-7%	490	549	58	12%	398	508	111	28%
70%	367	388	21	6%	330	402	71	22%	344	380	36	10%	475	454	-21	-4%	434	534	100	23%	358	474	116	32%
80%	347	372	26	7%	318	388	70	22%	314	363	49	16%	437	428	-10	-2%	388	511	123	32%	340	398	58	17%
90%	323	364	41	13%	308	368	61	20%	292	348	56	19%	387	390	4	1%	335	406	71	21%	300	339	39	13%
Long Term Full Simulation Period[b]	534	509	-25	-5%	555	490	-65	-12%	575	514	-61	-11%	599	565	-34	-6%	516	572	56	11%	446	528	81	18%
Water Year Types[c]																								
Wet (32%)	355	376	21	6%	311	386	76	24%	306	356	51	17%	440	424	-16	-4%	393	495	101	26%	327	431	104	32%
Above Normal (16%)	336	375	39	12%	357	385	28	8%	408	399	-9	-2%	578	516	-62	-11%	507	570	64	13%	415	549	133	32%
Below Normal (13%)	706	530	-176	-25%	670	492	-178	-27%	671	508	-163	-24%	653	635	-17	-3%	537	587	50	9%	474	550	76	16%
Dry (24%)	679	617	-63	-9%	740	537	-203	-27%	719	563	-155	-22%	649	591	-58	-9%	585	608	23	4%	502	561	59	12%
Critical (15%)	735	744	9	1%	885	750	-135	-15%	1,014	905	-110	-11%	833	816	-17	-2%	658	671	13	2%	619	636	17	3%

Statistic	Monthly EC (UMHOS/CM)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	590	685	95	16%	518	623	105	20%	475	545	69	15%	436	482	46	11%	593	470	-124	-21%	650	632	-18	-3%
20%	505	646	141	28%	493	595	103	21%	435	512	78	18%	421	442	20	5%	503	410	-93	-18%	610	542	-68	-11%
30%	454	579	124	27%	464	572	108	23%	397	490	94	24%	358	414	56	16%	456	395	-60	-13%	573	479	-95	-17%
40%	431	558	127	29%	444	529	86	19%	383	471	88	23%	345	393	47	14%	417	368	-48	-12%	543	429	-114	-21%
50%	415	527	112	27%	406	506	101	25%	368	440	72	19%	332	375	43	13%	386	354	-32	-8%	518	403	-115	-22%
60%	378	504	126	33%	373	484	112	30%	360	432	72	20%	321	365	45	14%	358	344	-15	-4%	504	378	-126	-25%
70%	339	452	114	34%	353	442	90	25%	349	410	61	17%	312	353	41	13%	334	336	2	1%	478	368	-110	-23%
80%	309	376	67	22%	329	395	66	20%	326	382	56	17%	299	336	38	13%	319	326	7	2%	458	361	-97	-21%
90%	259	337	78	30%	199	329	130	65%	291	350	60	21%	286	323	37	13%	302	315	12	4%	436	351	-86	-20%
Long Term Full Simulation Period[b]	411	516	104	25%	399	496	97	24%	381	450	69	18%	355	393	37	11%	419	380	-39	-9%	526	443	-83	-16%
Water Year Types[c]																								
Wet (32%)	289	419	131	45%	283	412	129	45%	317	388	71	22%	306	365	59	19%	330	335	5	2%	473	358	-115	-24%
Above Normal (16%)	379	560	181	48%	378	543	165	44%	361	473	112	31%	306	393	87	28%	329	337	8	2%	443	366	-76	-17%
Below Normal (13%)	437	524	86	20%	439	510	71	16%	399	448	49	12%	341	347	6	2%	408	338	-70	-17%	574	411	-164	-28%
Dry (24%)	474	544	70	15%	453	511	58	13%	391	457	66	17%	378	377	-1	0%	523	398	-125	-24%	574	500	-73	-13%
Critical (15%)	584	622	38	6%	545	589	43	8%	505	547	43	8%	489	520	30	6%	548	533	-14	-3%	610	643	33	5%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

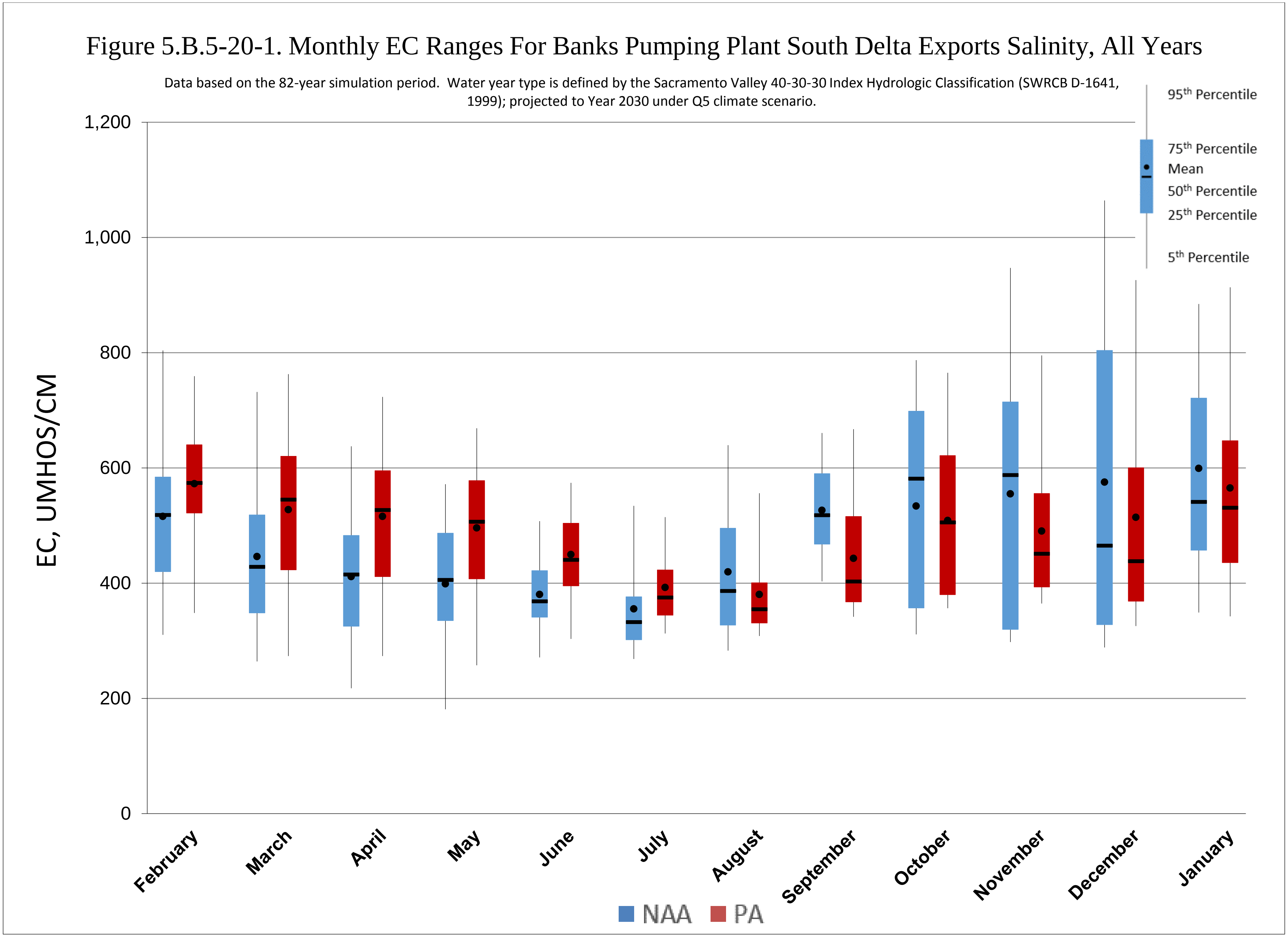


Figure 5.B.5-20-1. Monthly EC Ranges For Banks Pumping Plant South Delta Exports Salinity, All Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario.
EC, UMHOS/CM
1,200
1,000
800
600
400
200
0
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-20-2. Monthly EC Ranges For Banks Pumping Plant South Delta Exports Salinity, Wet Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 26 wet years.

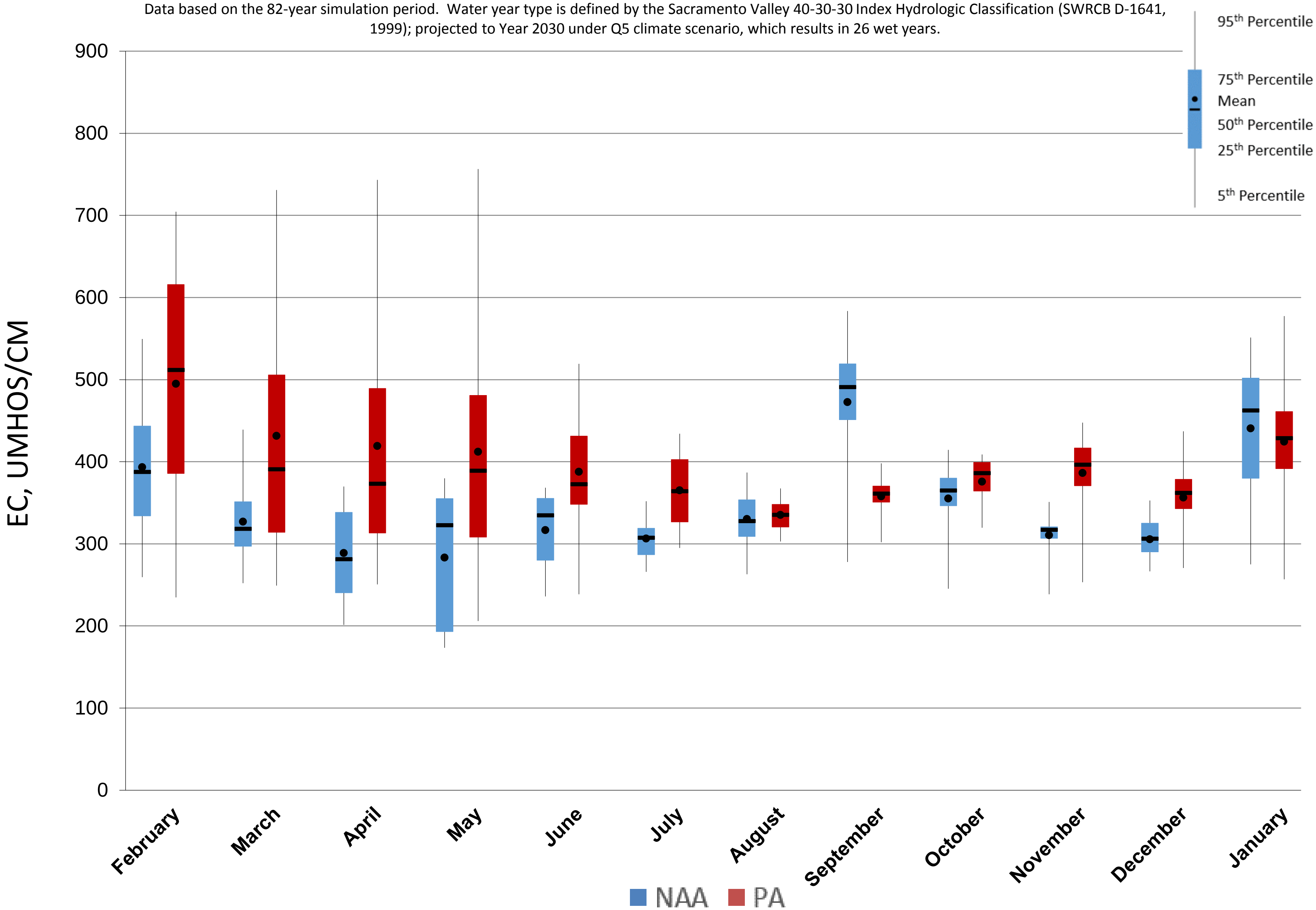
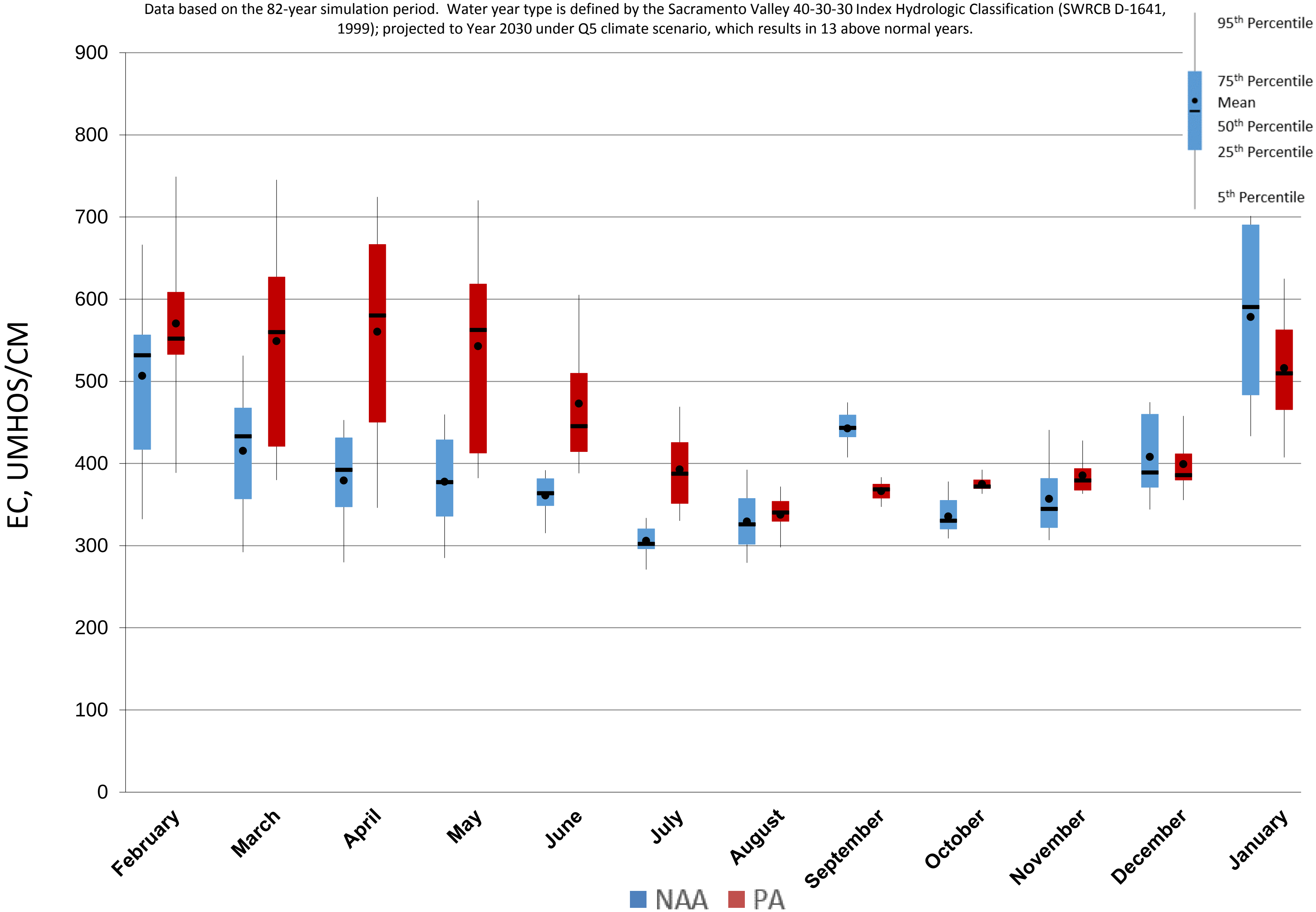


Figure 5.B.5-20-3. Monthly EC Ranges For Banks Pumping Plant South Delta Exports Salinity, Above Normal Years



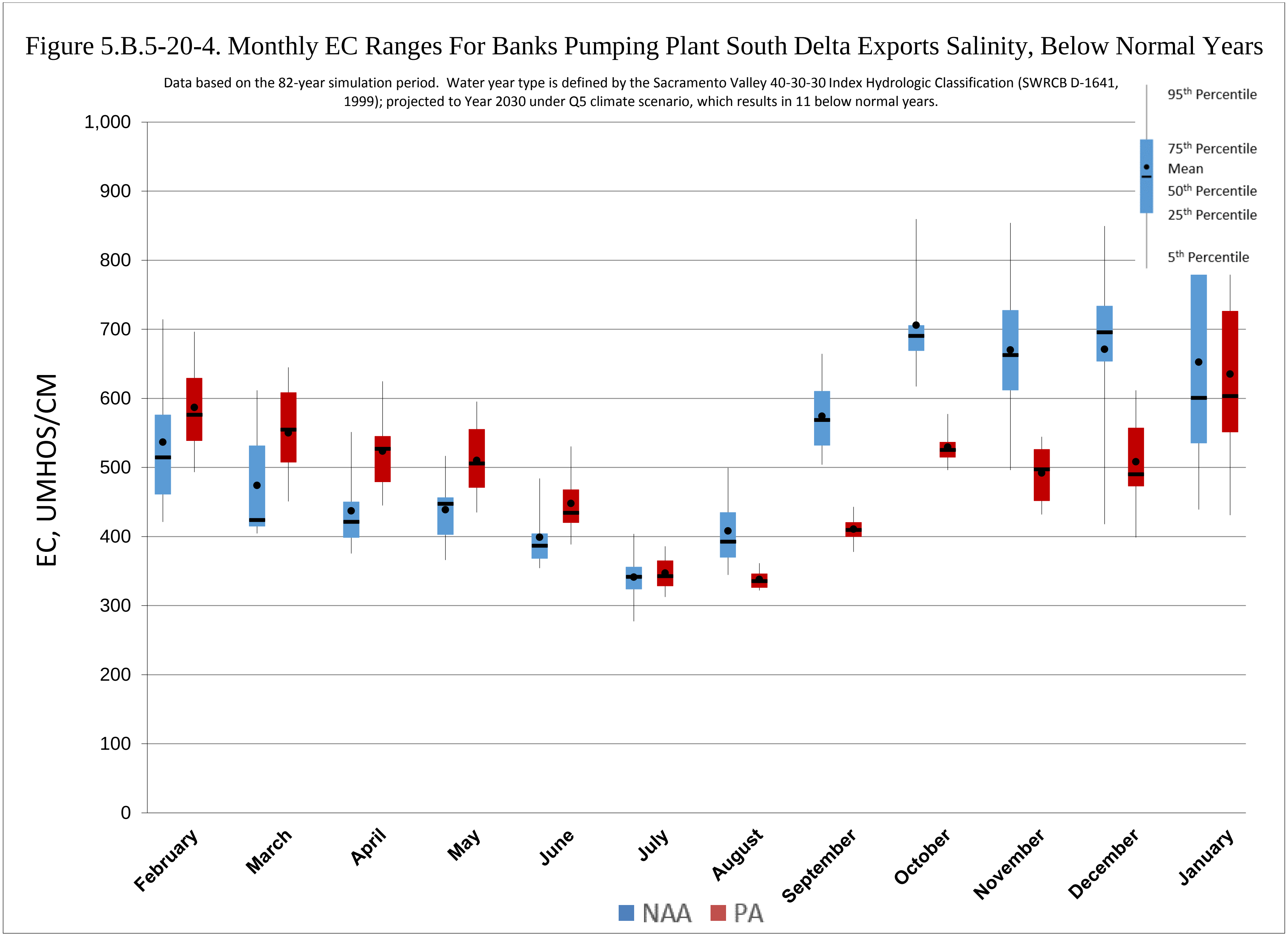


Figure 5.B.5-20-4. Monthly EC Ranges For Banks Pumping Plant South Delta Exports Salinity, Below Normal Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 11 below normal years.
EC, UMHOS/CM
1,000
900
800
700
600
500
400
300
200
100
0
February
March
April
May
June
July
August
September
October
November
December
January
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
NAA
PA

Figure 5.B.5-20-5. Monthly EC Ranges For Banks Pumping Plant South Delta Exports Salinity, Dry Years

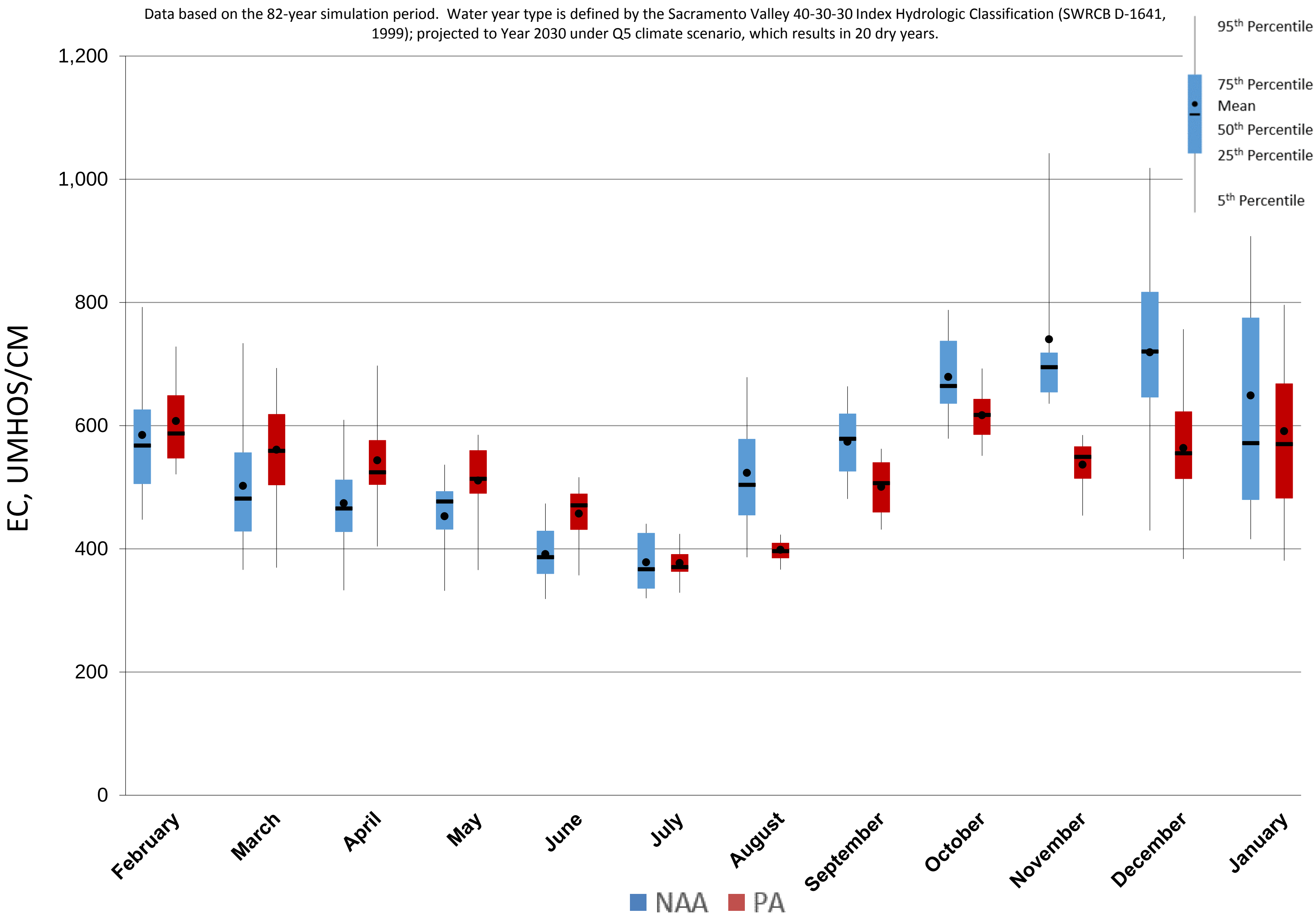


Figure 5.B.5-20-6. Monthly EC Ranges For Banks Pumping Plant South Delta Exports Salinity, Critical Years

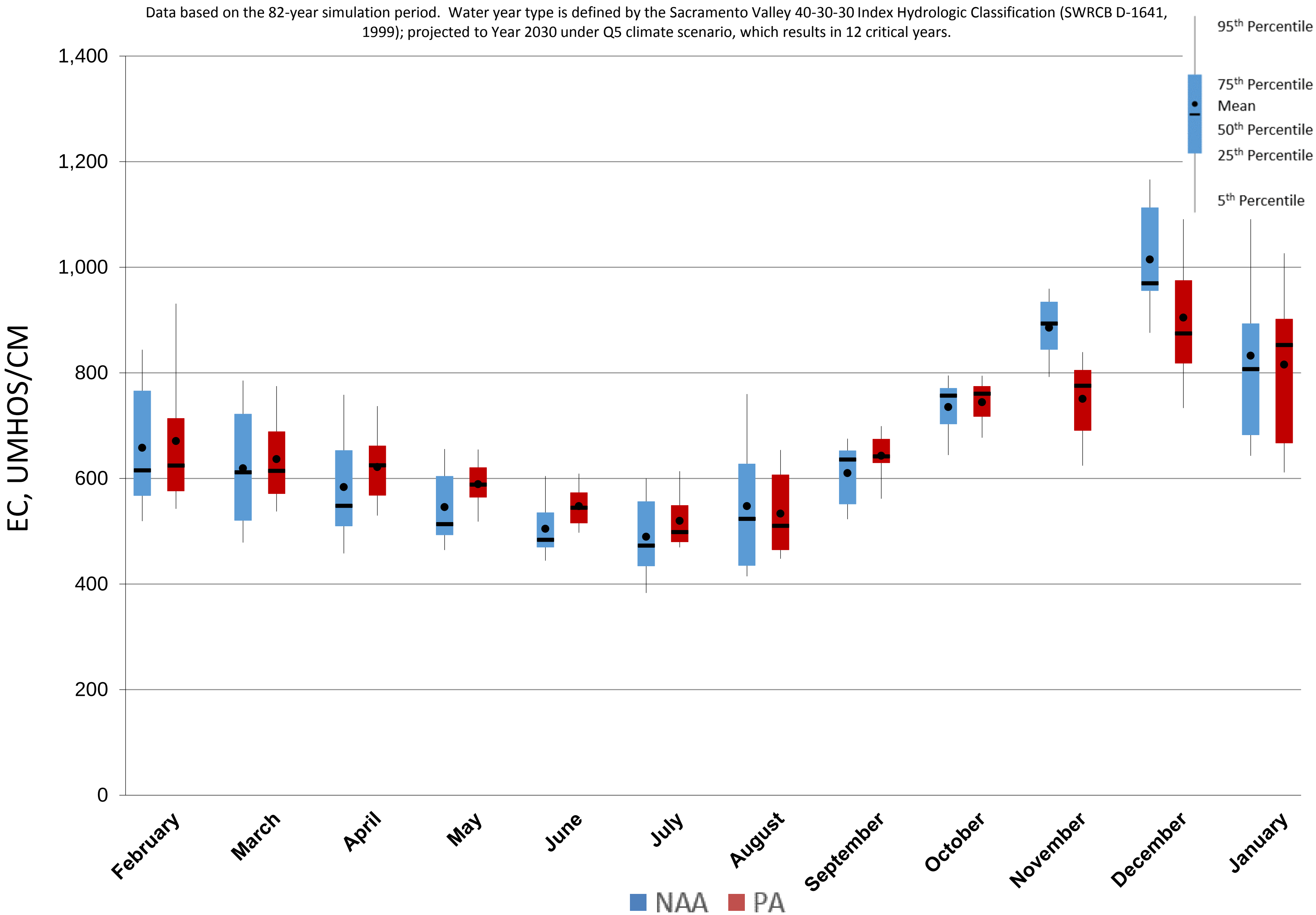
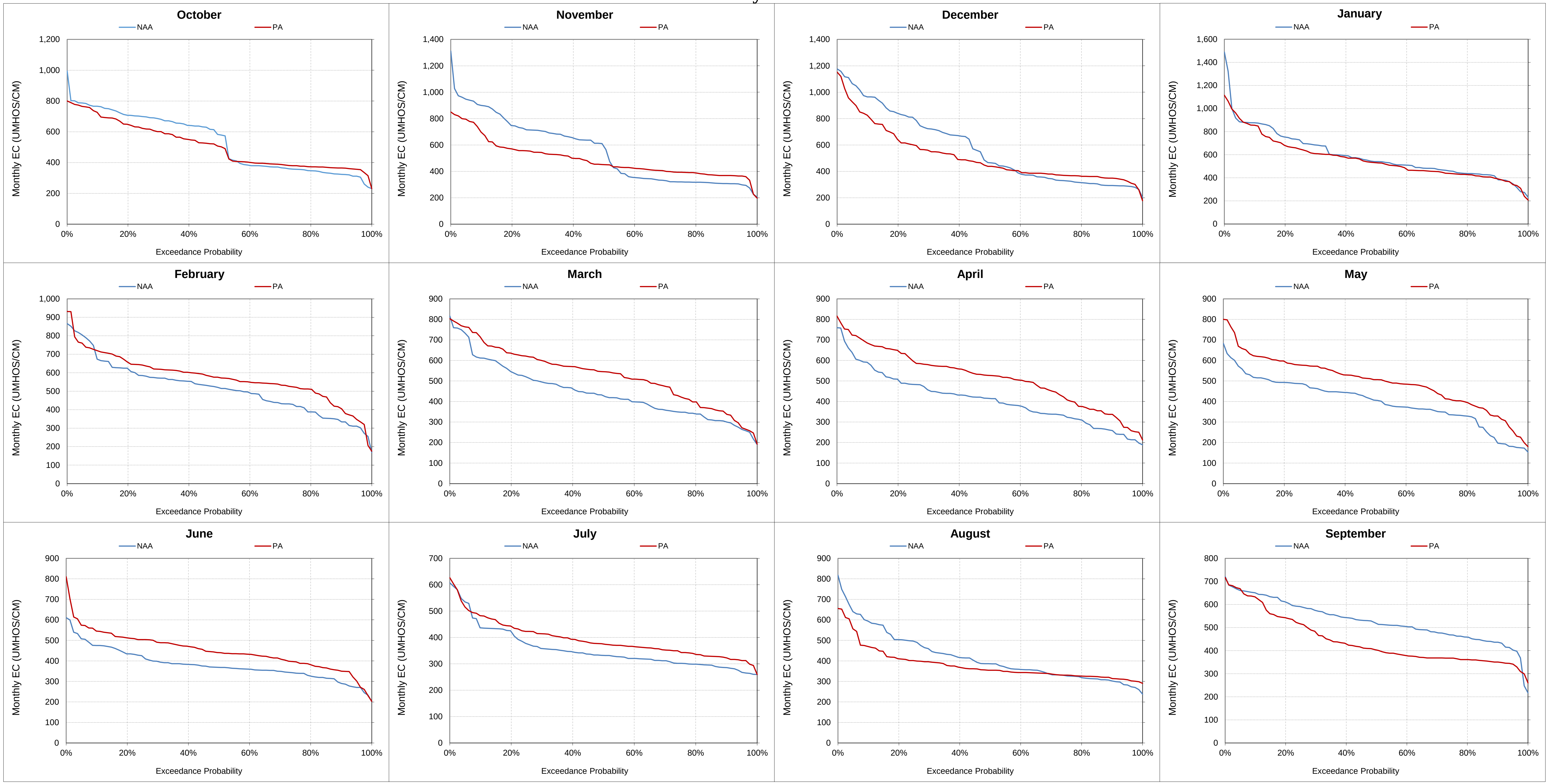
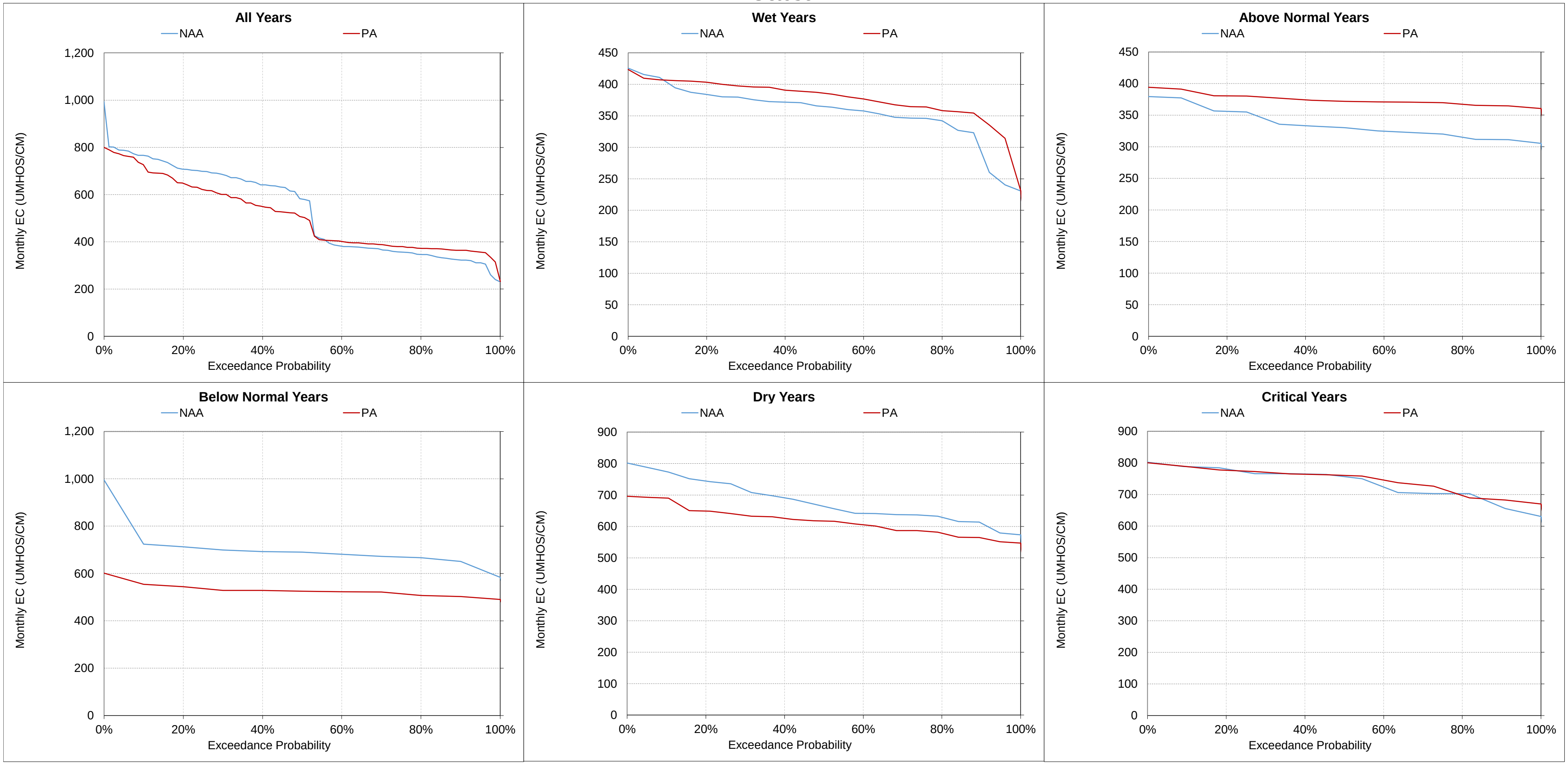


Figure 5.B.5-20-7. Banks Pumping Plant South Delta Exports Salinity, Monthly EC Probability of Exceedance



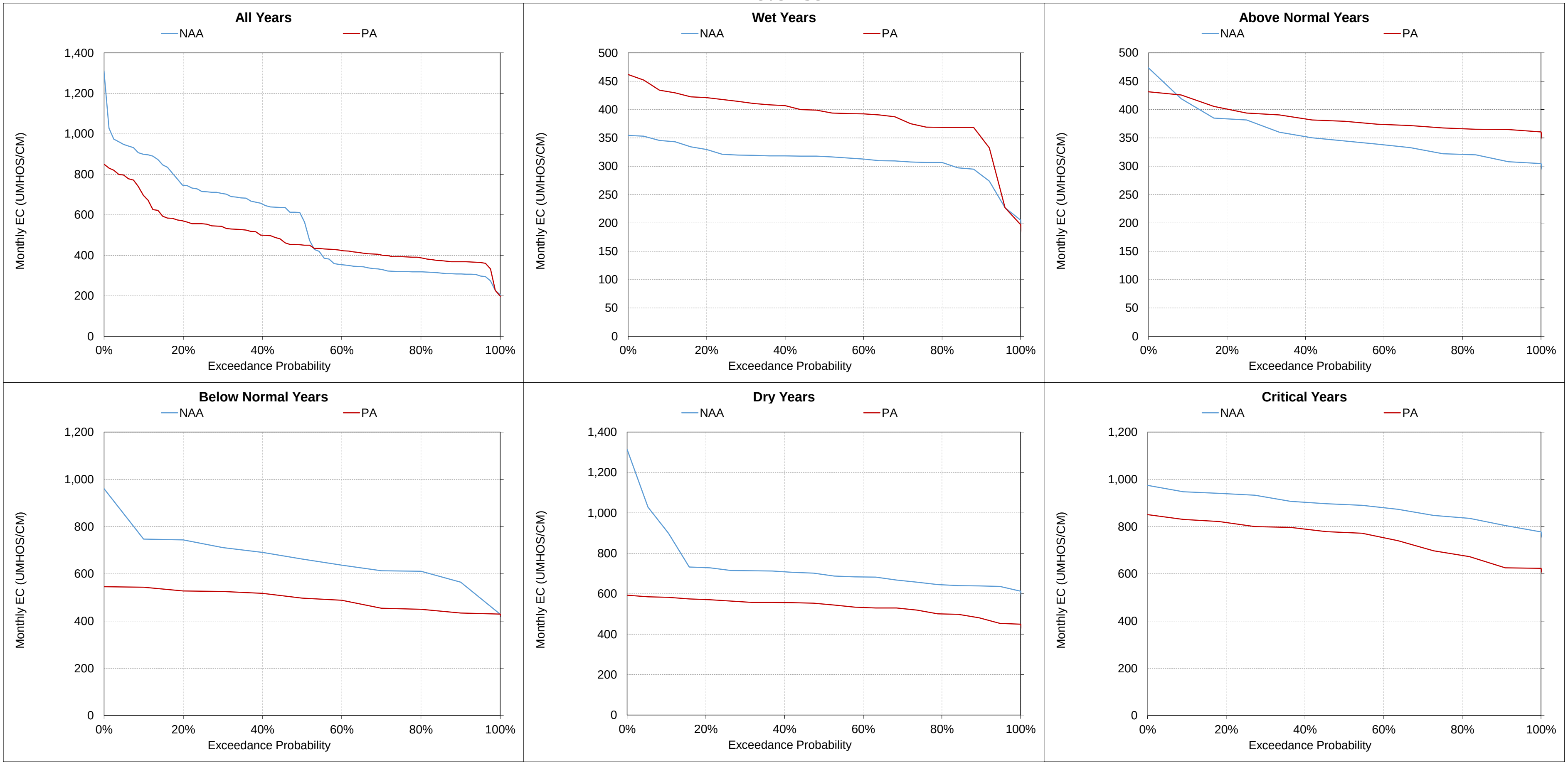
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-20-8. Banks Pumping Plant South Delta Exports Salinity, Monthly EC October



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-20-9. Banks Pumping Plant South Delta Exports Salinity, Monthly EC November



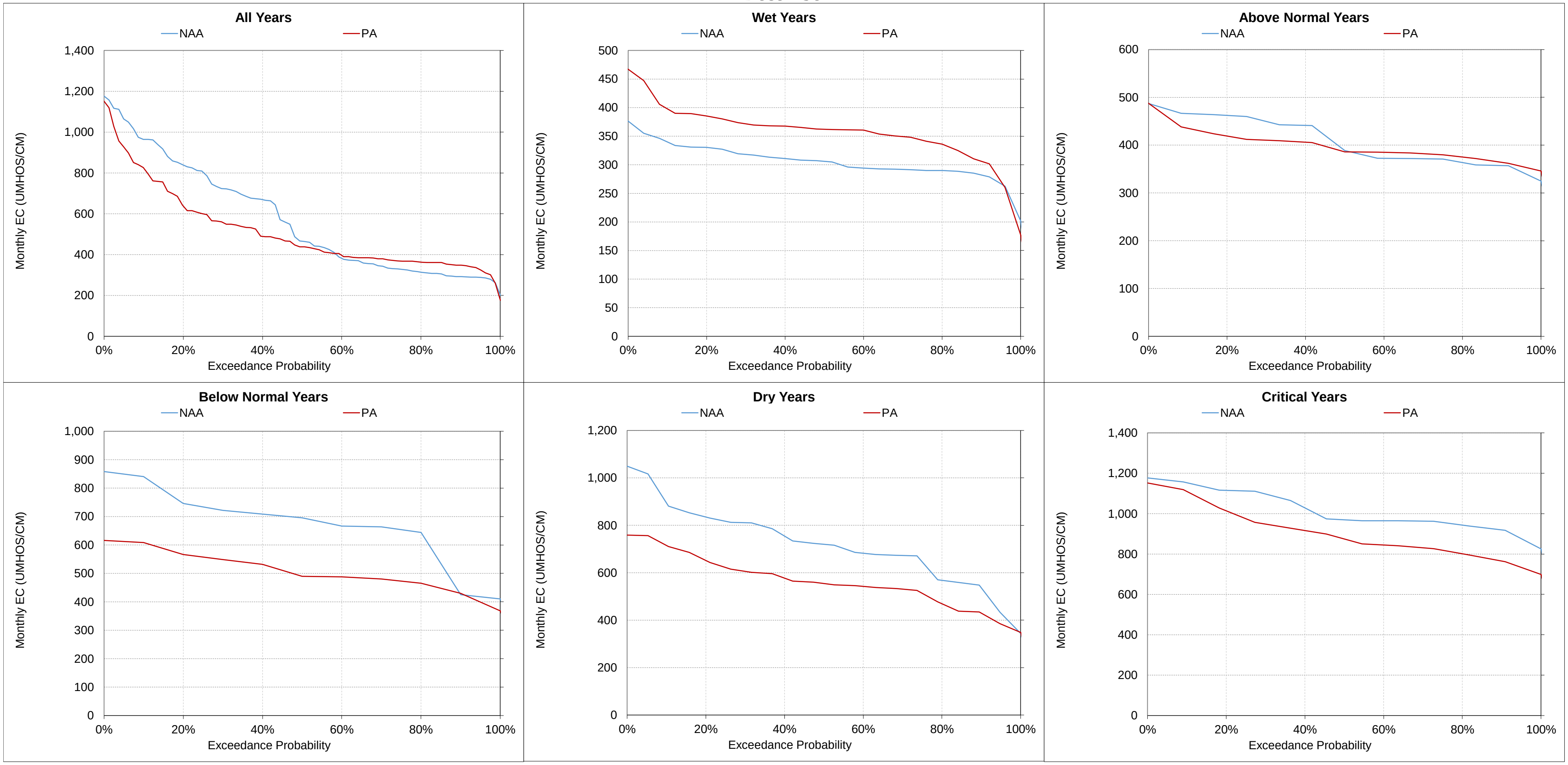
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

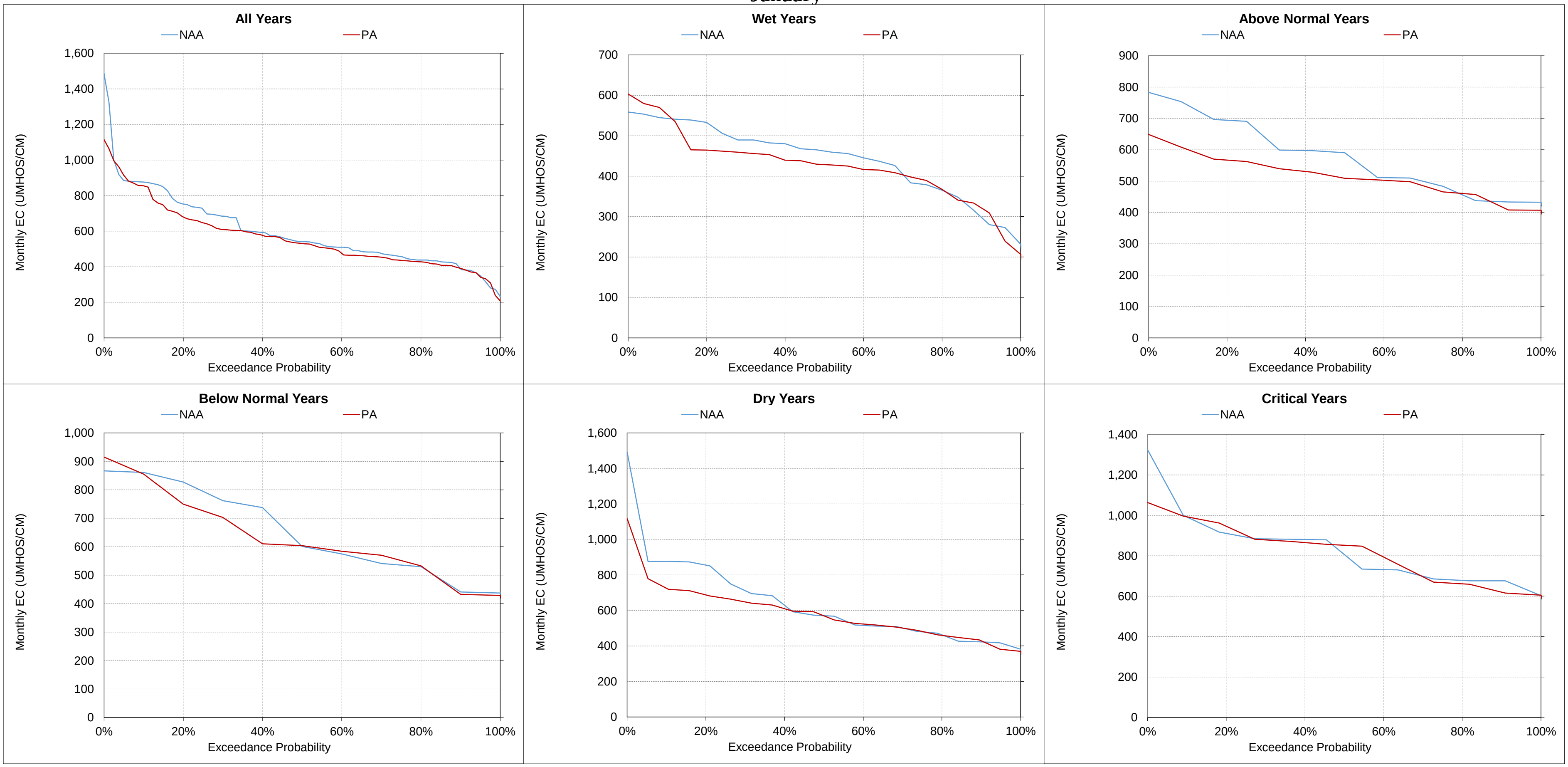
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-20-10. Banks Pumping Plant South Delta Exports Salinity, Monthly EC December



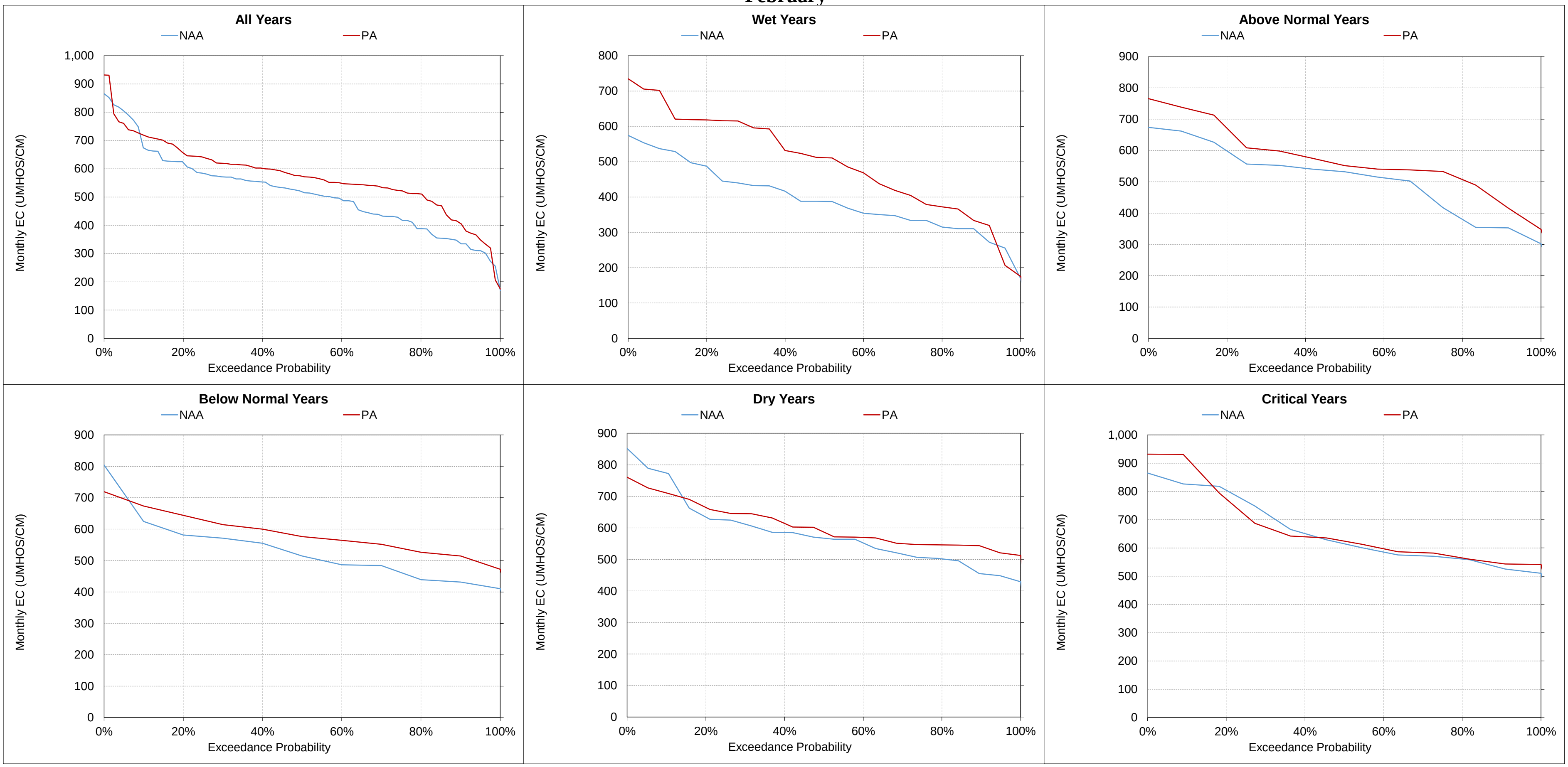
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-20-11. Banks Pumping Plant South Delta Exports Salinity, Monthly EC January



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-20-12. Banks Pumping Plant South Delta Exports Salinity, Monthly EC
February



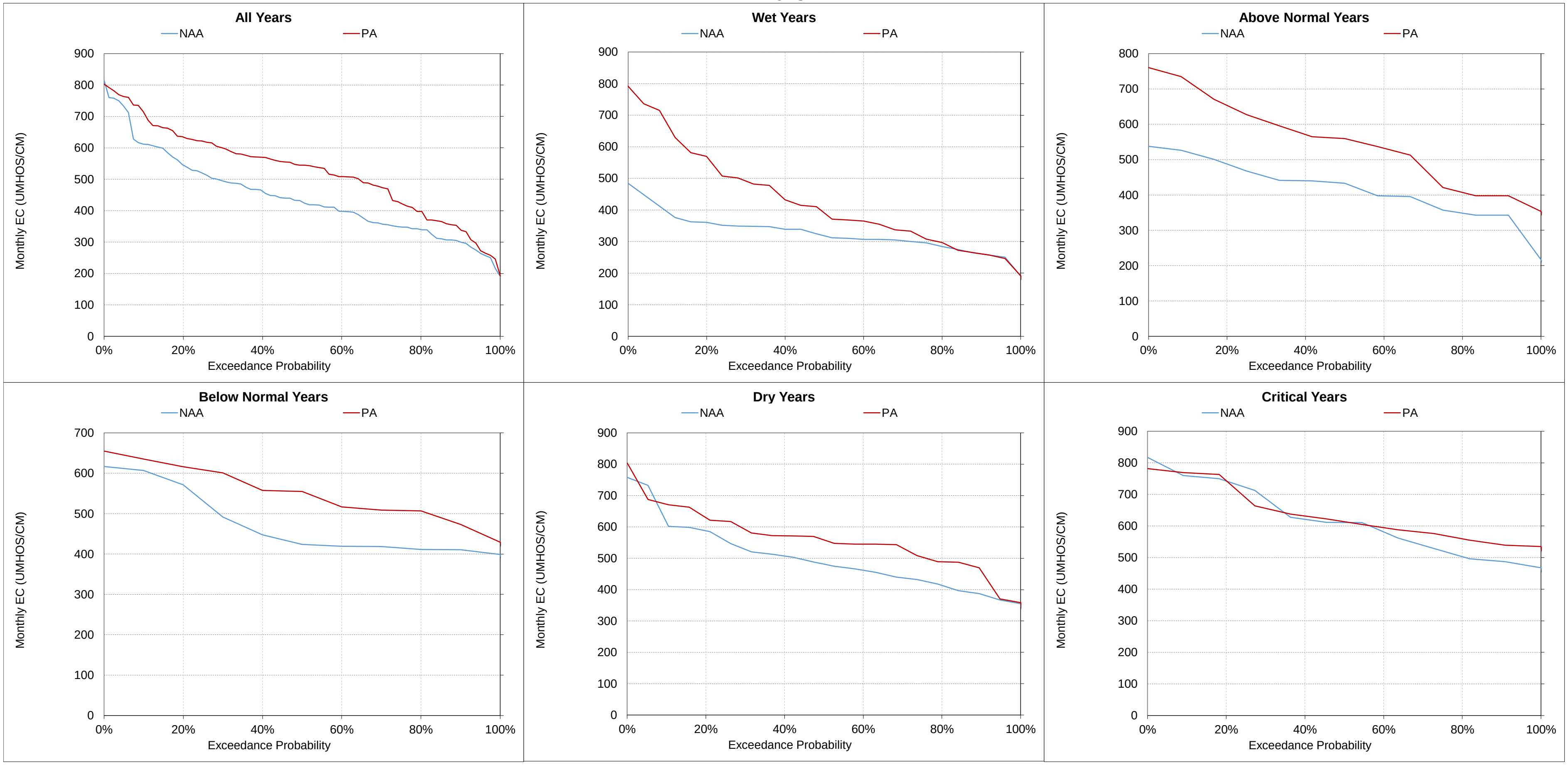
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

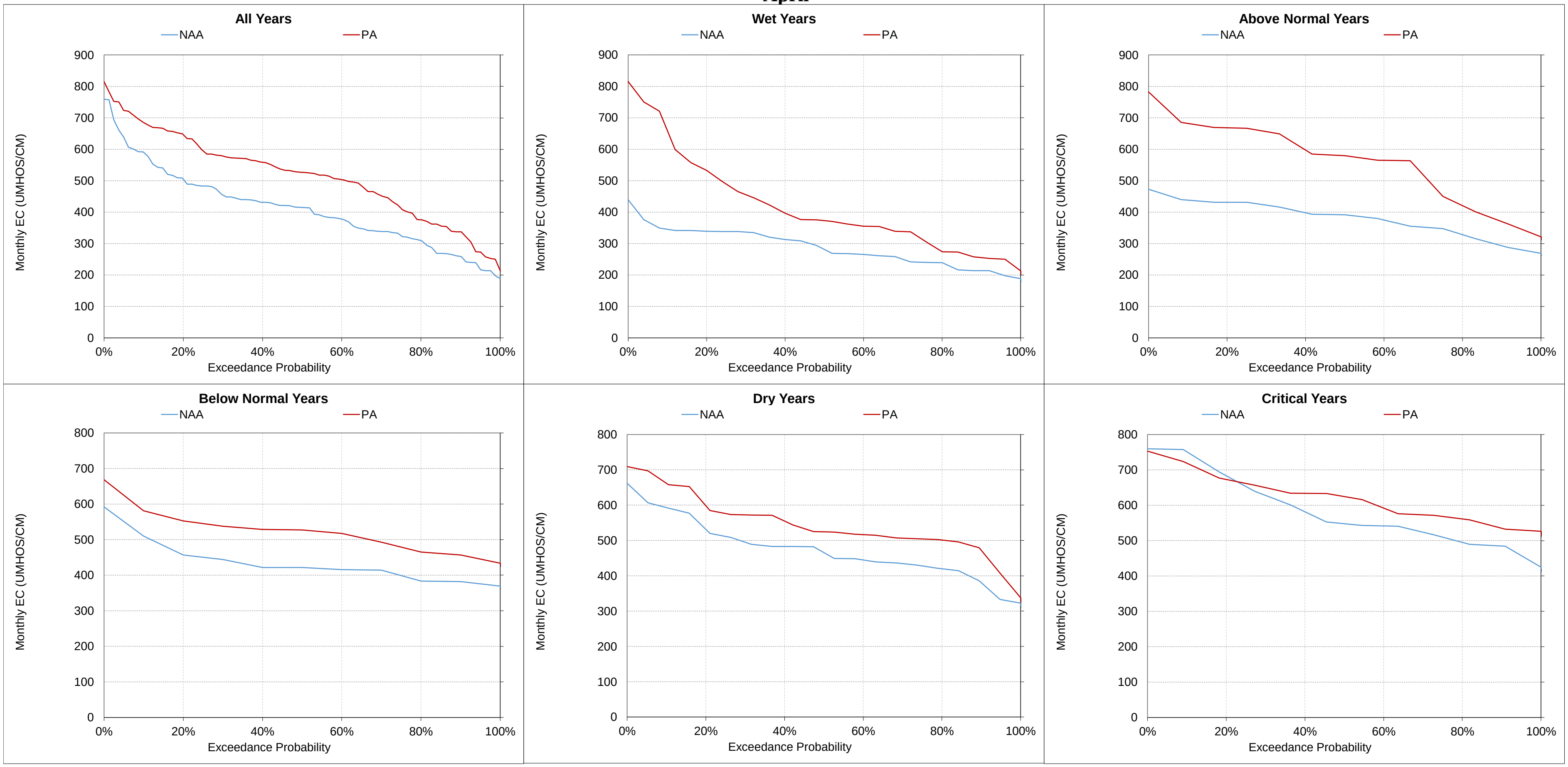
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-20-13. Banks Pumping Plant South Delta Exports Salinity, Monthly EC March



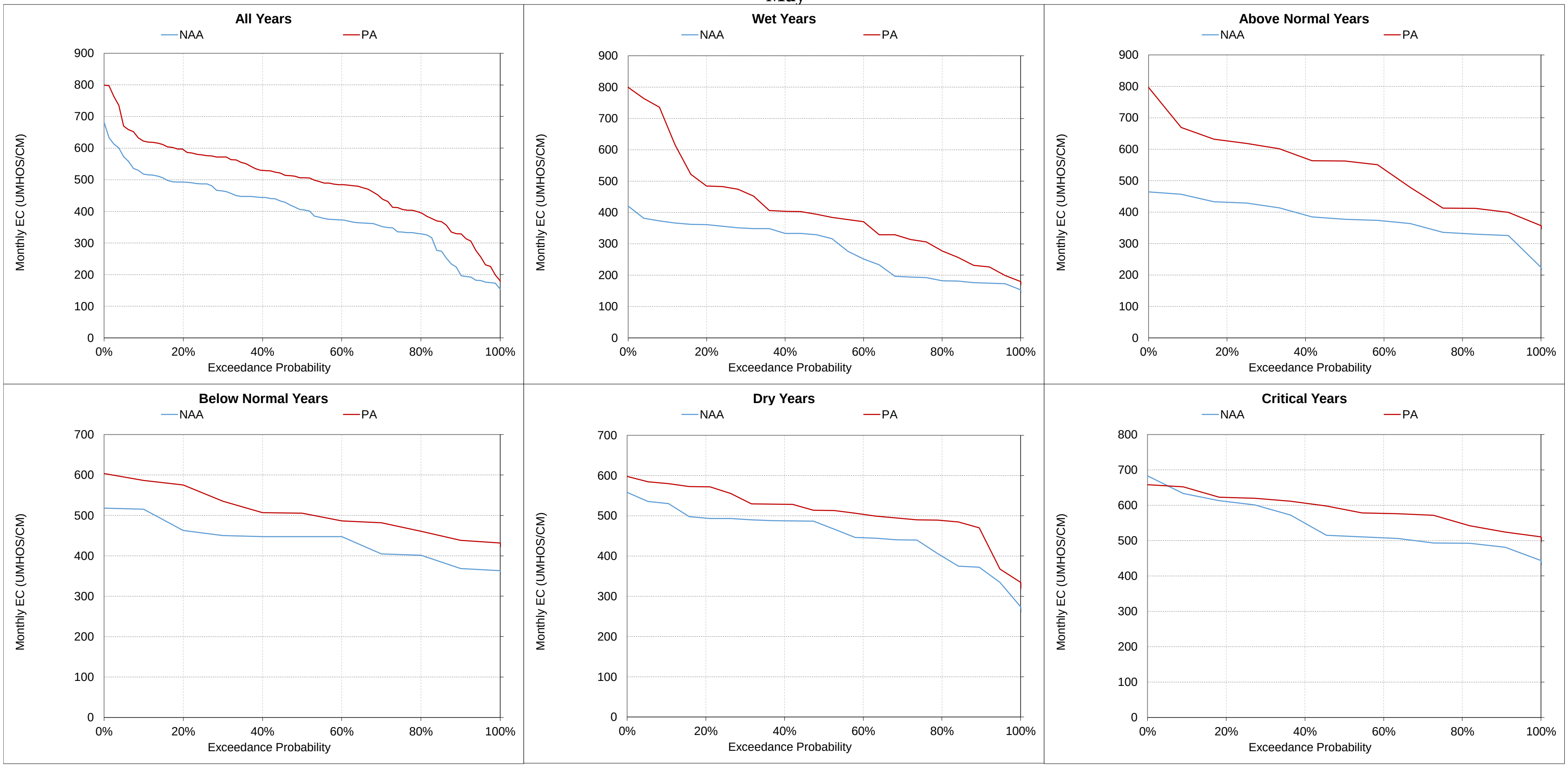
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-20-14. Banks Pumping Plant South Delta Exports Salinity, Monthly EC
April



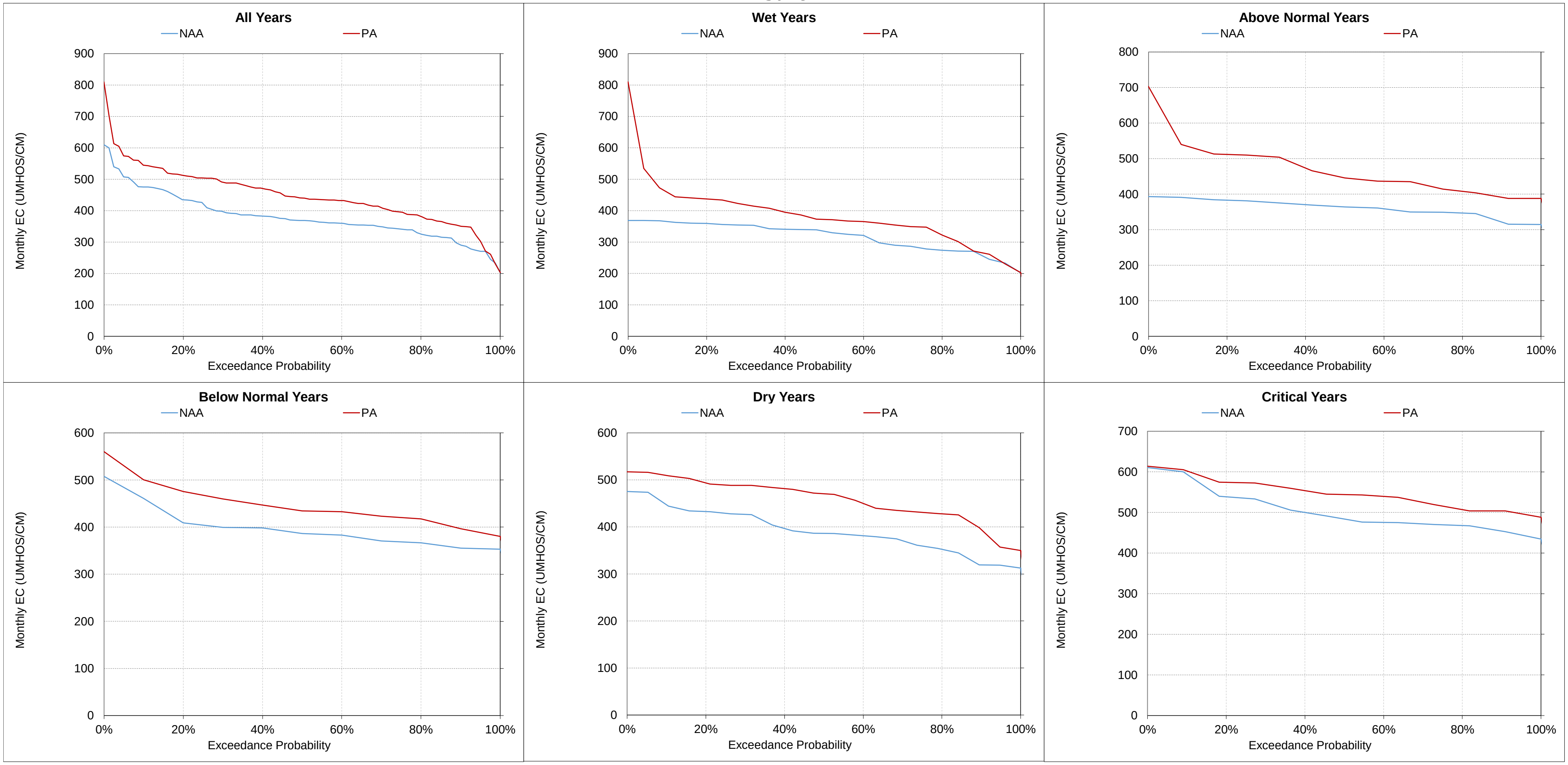
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-20-15. Banks Pumping Plant South Delta Exports Salinity, Monthly EC May



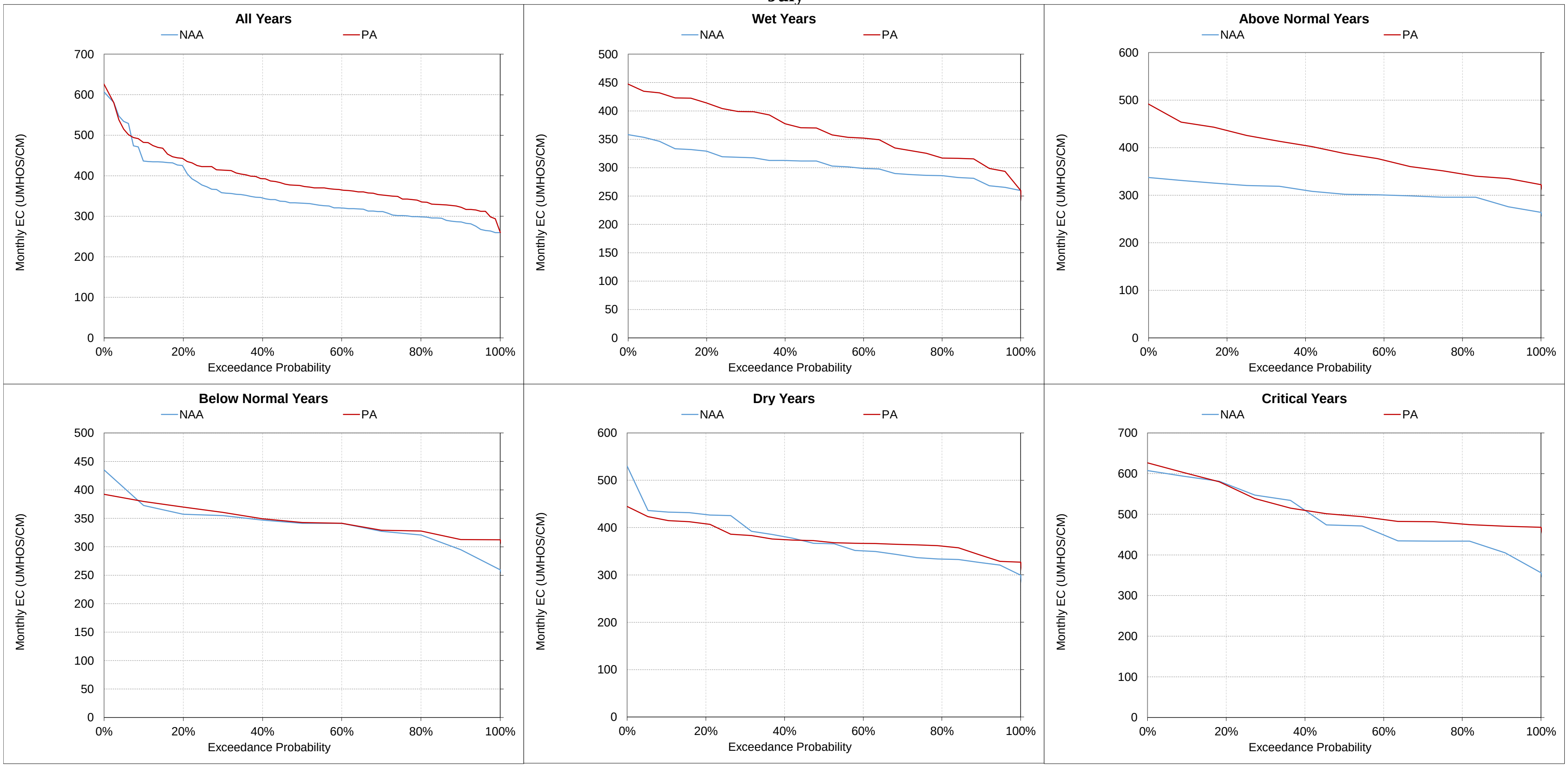
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-20-16. Banks Pumping Plant South Delta Exports Salinity, Monthly EC
June



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-20-17. Banks Pumping Plant South Delta Exports Salinity, Monthly EC July



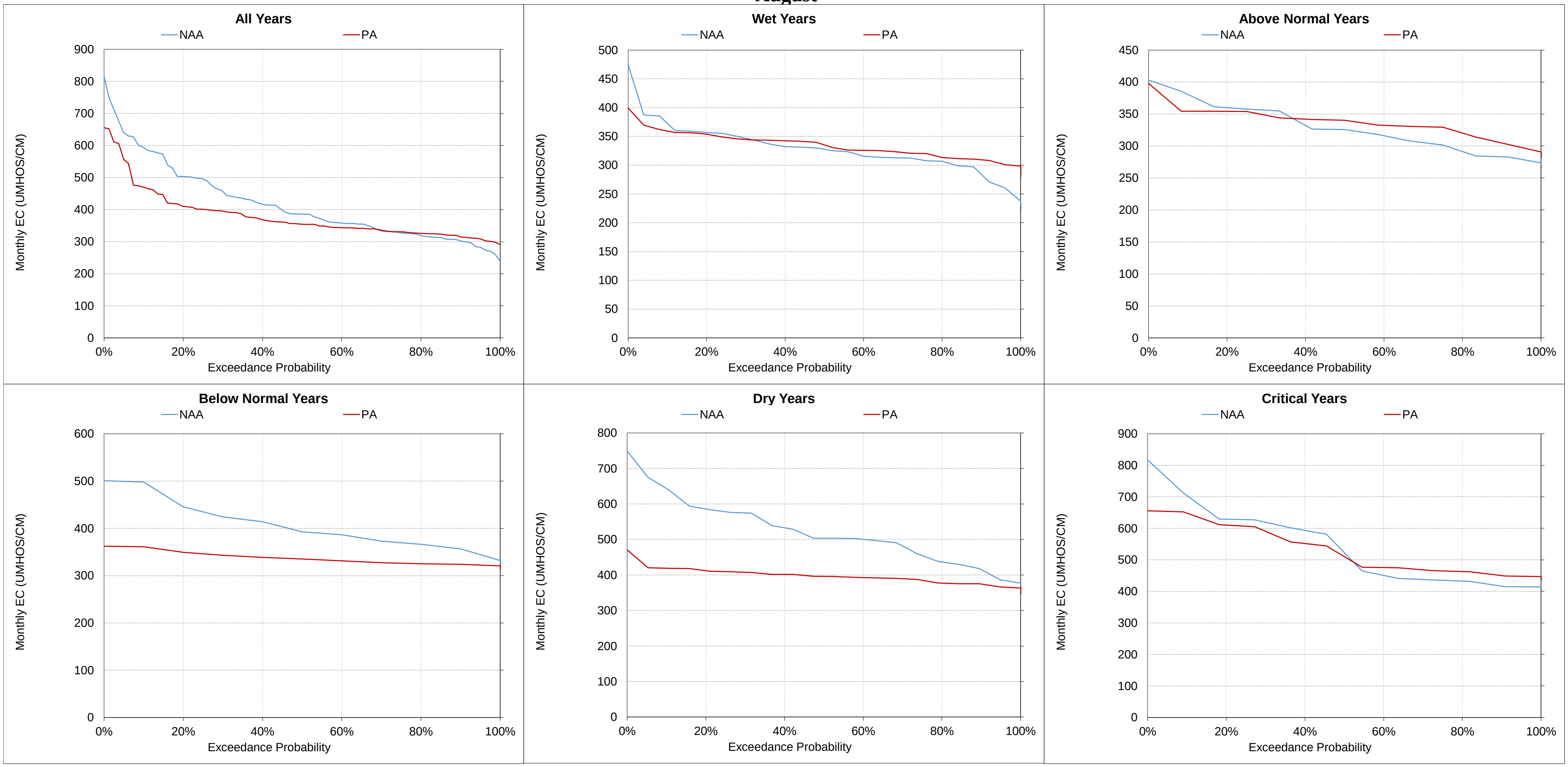
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-20-18. Banks Pumping Plant South Delta Exports Salinity, Monthly EC August



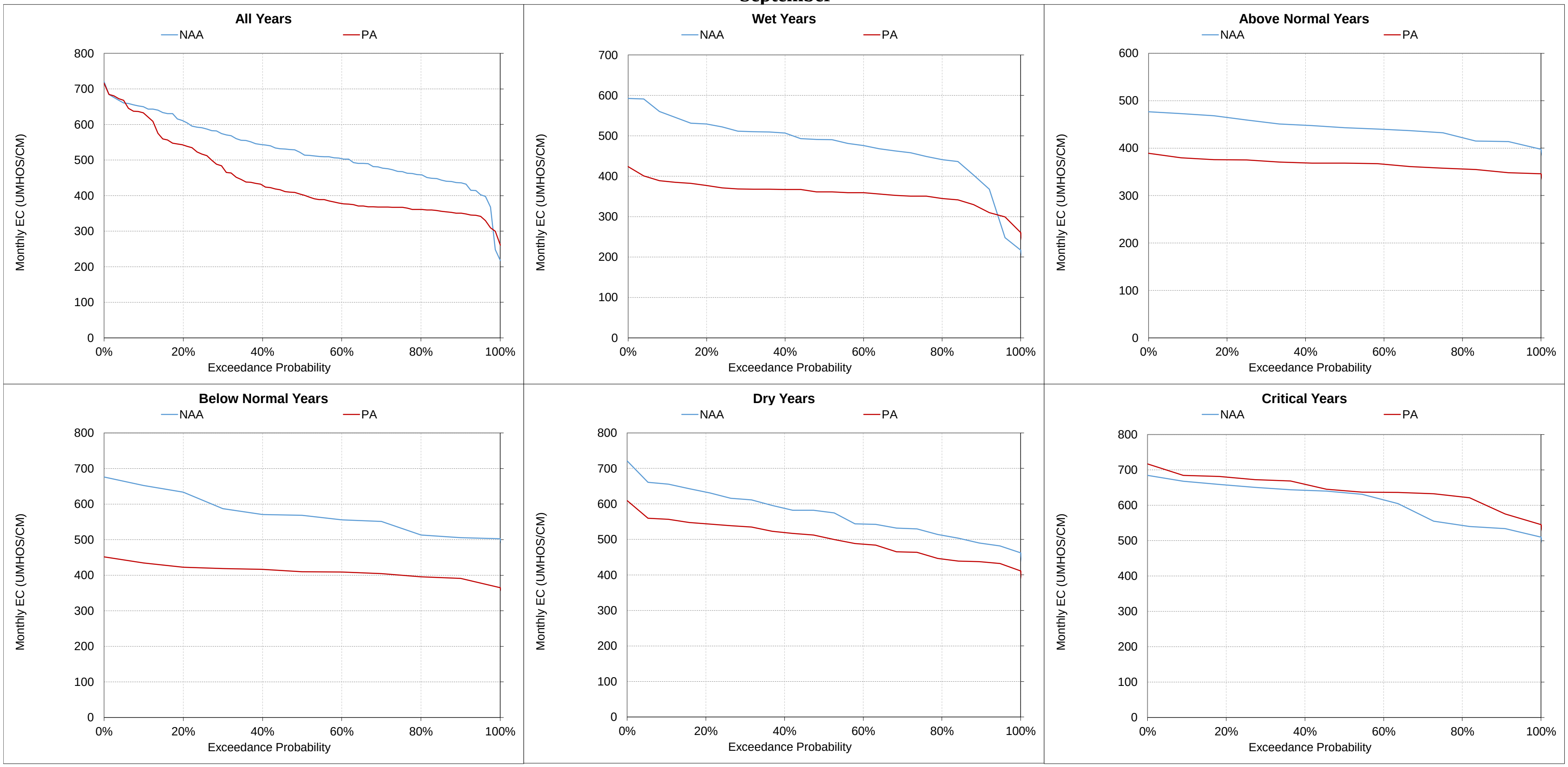
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-20-19. Banks Pumping Plant South Delta Exports Salinity, Monthly EC
September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-21. Sacramento River at Collinsville Sacramento River plus Yolo Bypass Volumetric Fingerprinting, Monthly Percent

Statistic	Monthly Percent (%)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	88	84	-4	-5%	89	78	-11	-12%	96	92	-3	-3%	96	95	-1	-1%	96	94	-2	-2%	96	93	-4	-4%
20%	88	83	-5	-6%	87	75	-13	-14%	92	88	-3	-3%	95	92	-3	-3%	95	93	-3	-3%	95	91	-4	-4%
30%	86	80	-6	-7%	83	74	-9	-11%	87	82	-5	-6%	93	91	-2	-2%	95	91	-4	-4%	94	89	-5	-5%
40%	78	75	-3	-3%	78	72	-6	-8%	79	78	-2	-2%	91	89	-2	-2%	93	89	-4	-4%	93	87	-6	-6%
50%	57	59	2	3%	75	70	-5	-7%	77	73	-4	-5%	86	86	0	0%	92	88	-4	-4%	92	86	-6	-7%
60%	52	57	6	11%	61	58	-3	-5%	75	68	-7	-10%	82	81	-1	-1%	90	86	-4	-4%	91	85	-6	-7%
70%	50	56	5	10%	52	56	3	7%	71	64	-7	-10%	77	77	-1	-1%	88	84	-3	-4%	89	80	-9	-10%
80%	50	55	5	10%	50	54	3	7%	62	59	-4	-6%	72	74	2	3%	85	83	-2	-3%	85	77	-8	-10%
90%	44	50	6	14%	43	47	3	7%	53	53	0	0%	68	69	1	2%	83	80	-3	-3%	80	75	-6	-7%
Long Term Full Simulation Period[b]	66	67	0	0%	68	65	-4	-6%	76	73	-4	-5%	84	84	0	-1%	90	87	-3	-3%	90	84	-6	-7%
Water Year Types[c]																								
Wet (32%)	88	82	-6	-6%	87	75	-12	-14%	83	77	-6	-7%	85	85	0	0%	94	89	-5	-5%	91	82	-9	-10%
Above Normal (16%)	78	77	-1	-1%	78	72	-6	-8%	80	75	-5	-6%	83	83	0	0%	93	90	-3	-3%	94	87	-7	-8%
Below Normal (13%)	55	59	4	7%	59	60	0	1%	73	71	-2	-3%	84	83	-1	-1%	88	86	-3	-3%	90	84	-5	-6%
Dry (24%)	51	56	5	9%	58	60	2	3%	75	73	-2	-2%	85	83	-2	-2%	89	87	-2	-2%	90	86	-4	-4%
Critical (15%)	44	48	4	9%	43	45	3	6%	62	60	-2	-3%	81	81	0	0%	84	82	-1	-1%	84	82	-2	-2%

Statistic	Monthly Percent (%)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	93	88	-4	-4%	87	81	-5	-6%	81	71	-11	-13%	80	68	-12	-15%	73	65	-8	-11%	91	87	-4	-4%
20%	91	86	-5	-6%	82	79	-3	-4%	74	70	-5	-6%	78	66	-12	-15%	72	63	-9	-12%	89	84	-5	-6%
30%	89	85	-5	-5%	79	76	-3	-4%	72	68	-4	-6%	76	64	-12	-16%	70	61	-9	-12%	86	80	-6	-7%
40%	87	82	-4	-5%	78	74	-3	-4%	70	67	-3	-5%	74	62	-12	-16%	69	60	-9	-13%	81	78	-3	-4%
50%	85	81	-5	-6%	76	73	-4	-5%	69	65	-4	-6%	71	60	-11	-15%	66	59	-7	-11%	62	53	-8	-14%
60%	84	79	-6	-7%	75	71	-4	-6%	68	64	-4	-6%	66	59	-6	-10%	63	57	-6	-9%	58	51	-7	-13%
70%	83	76	-6	-8%	74	68	-6	-8%	67	59	-8	-11%	64	57	-6	-10%	60	54	-6	-10%	55	50	-5	-9%
80%	81	73	-8	-10%	70	64	-6	-9%	65	57	-8	-13%	62	56	-6	-10%	57	51	-6	-10%	53	49	-4	-8%
90%	77	69	-8	-10%	66	60	-6	-9%	58	52	-6	-11%	57	52	-6	-10%	52	48	-4	-8%	50	48	-2	-3%
Long Term Full Simulation Period[b]	85	80	-5	-6%	76	72	-4	-6%	69	63	-6	-9%	69	60	-9	-13%	64	57	-7	-11%	70	65	-5	-7%
Water Year Types[c]																								
Wet (32%)	85	78	-7	-9%	77	71	-6	-8%	73	61	-11	-16%	75	61	-14	-19%	68	57	-11	-16%	90	85	-5	-6%
Above Normal (16%)	89	80	-9	-10%	78	72	-7	-8%	69	61	-7	-11%	77	64	-12	-16%	72	63	-8	-12%	81	77	-3	-4%
Below Normal (13%)	86	81	-5	-6%	77	73	-4	-5%	69	65	-3	-5%	74	65	-9	-13%	69	62	-7	-11%	59	52	-8	-13%
Dry (24%)	86	83	-3	-4%	77	74	-2	-3%	70	67	-3	-4%	63	59	-5	-7%	61	56	-5	-8%	54	49	-5	-9%
Critical (15%)	79	78	-1	-2%	70	69	-2	-2%	62	60	-1	-2%	55	53	-2	-4%	52	49	-3	-5%	50	48	-2	-4%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-21-1. Monthly Percent Ranges For Sacramento River at Collinsville Sacramento River plus Yolo Bypass Volumetric Fingerprinting, All Years

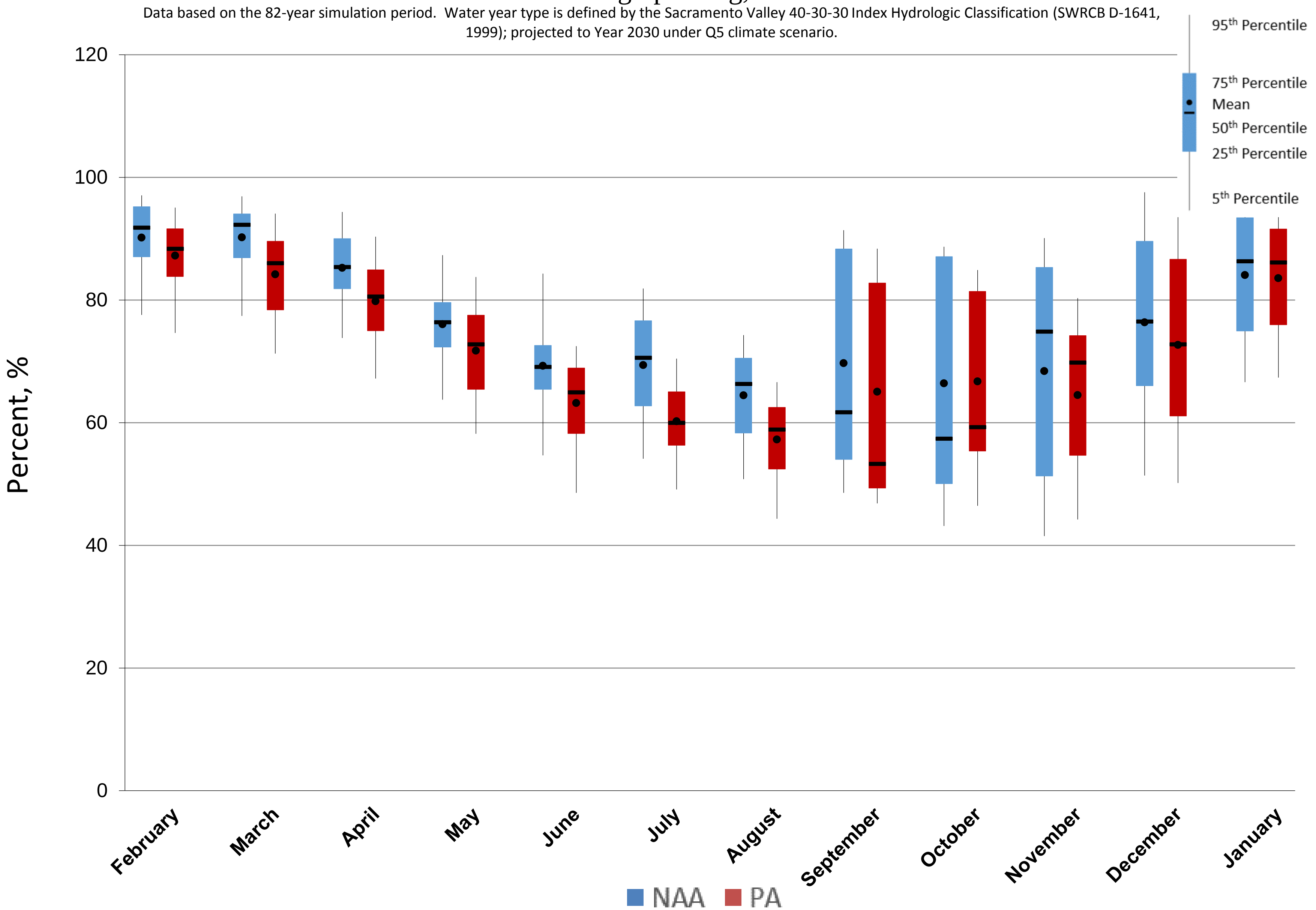
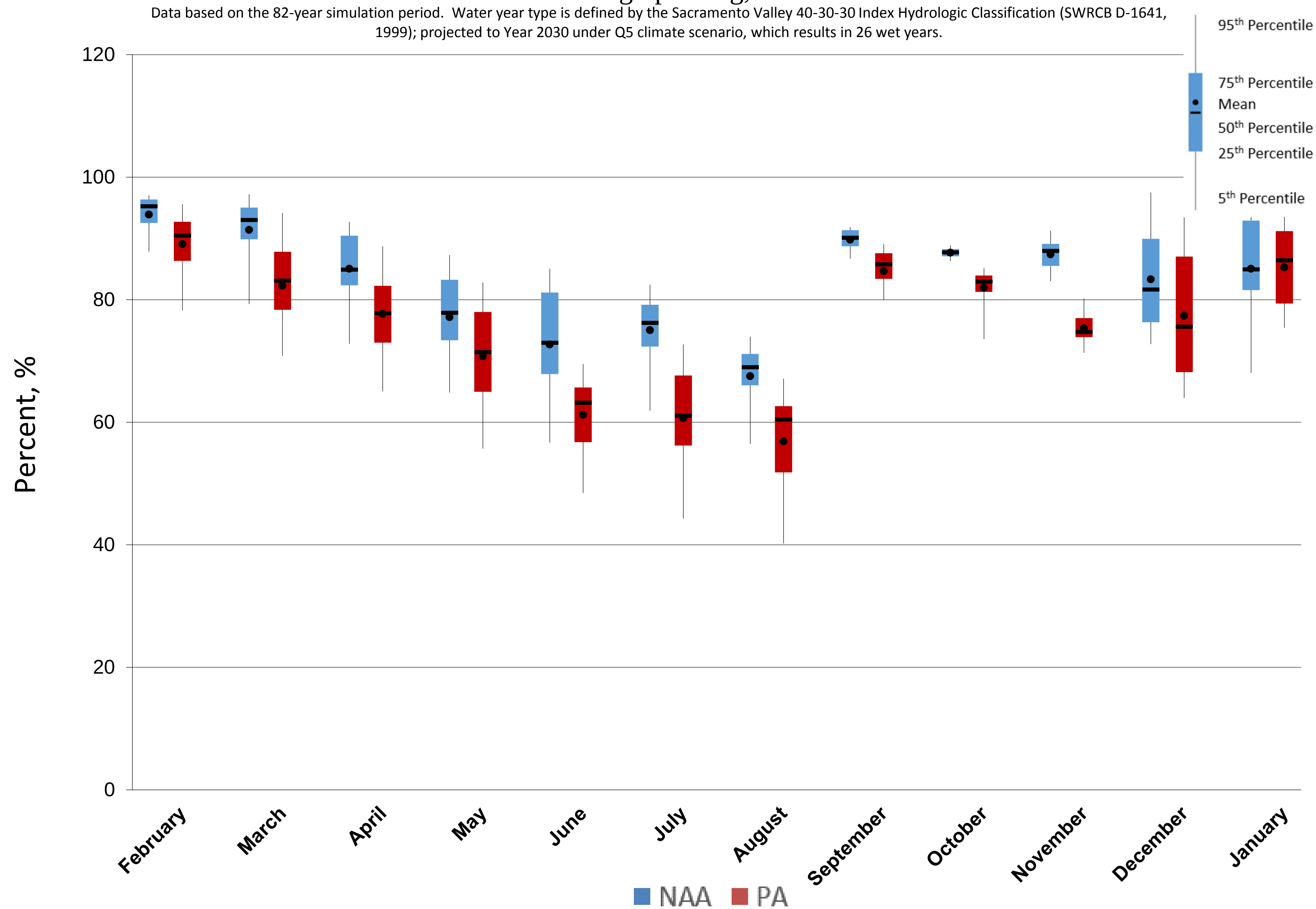


Figure 5.B.5-21-2. Monthly Percent Ranges For Sacramento River at Collinsville Sacramento River plus Yolo Bypass Volumetric Fingerprinting, Wet Years



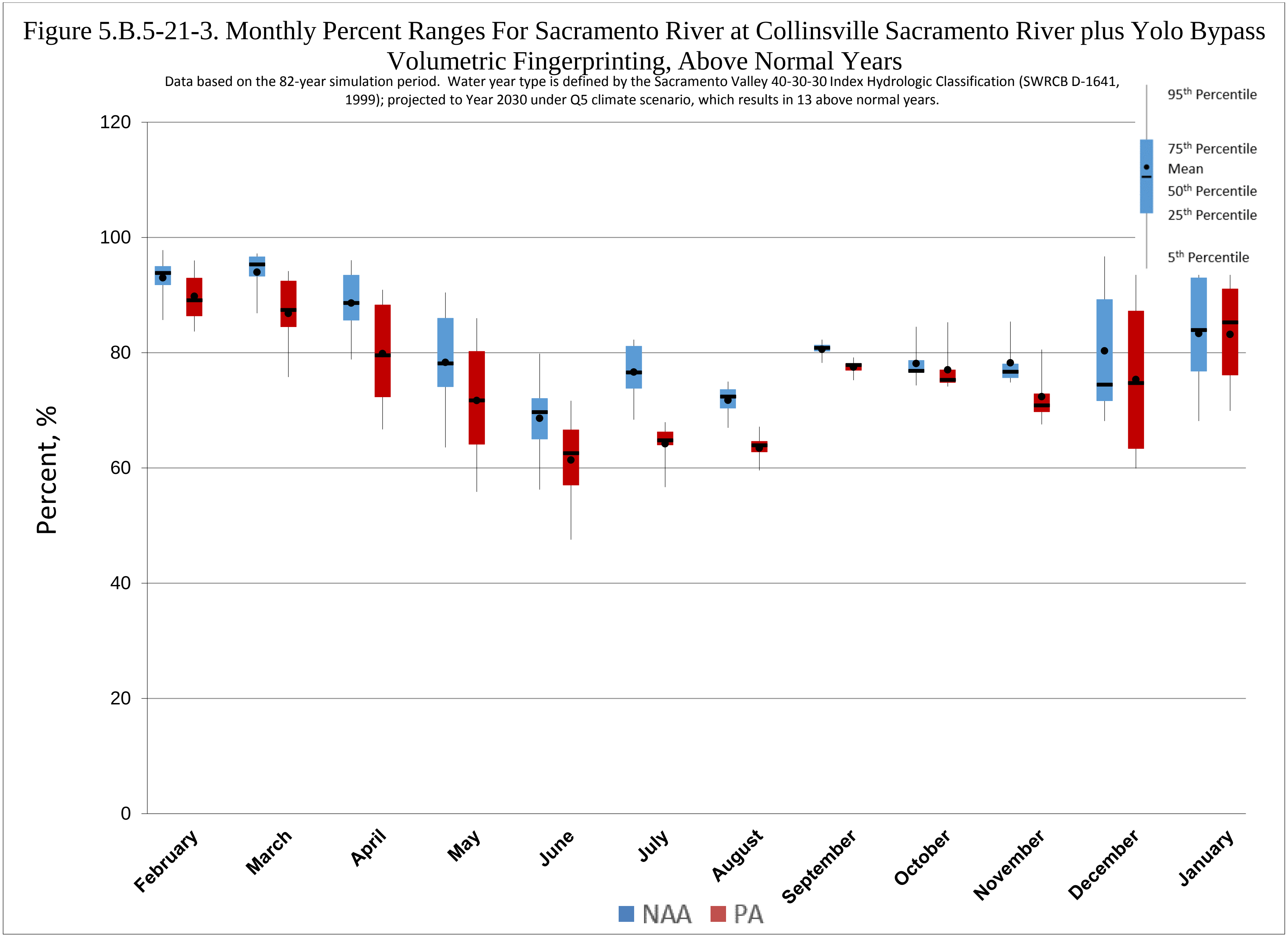


Figure 5.B.5-21-3. Monthly Percent Ranges For Sacramento River at Collinsville Sacramento River plus Yolo Bypass Volumetric Fingerprinting, Above Normal Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 13 above normal years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
Percent, %
120
100
80
60
40
20
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-21-4. Monthly Percent Ranges For Sacramento River at Collinsville Sacramento River plus Yolo Bypass Volumetric Fingerprinting, Below Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 11 below normal years.

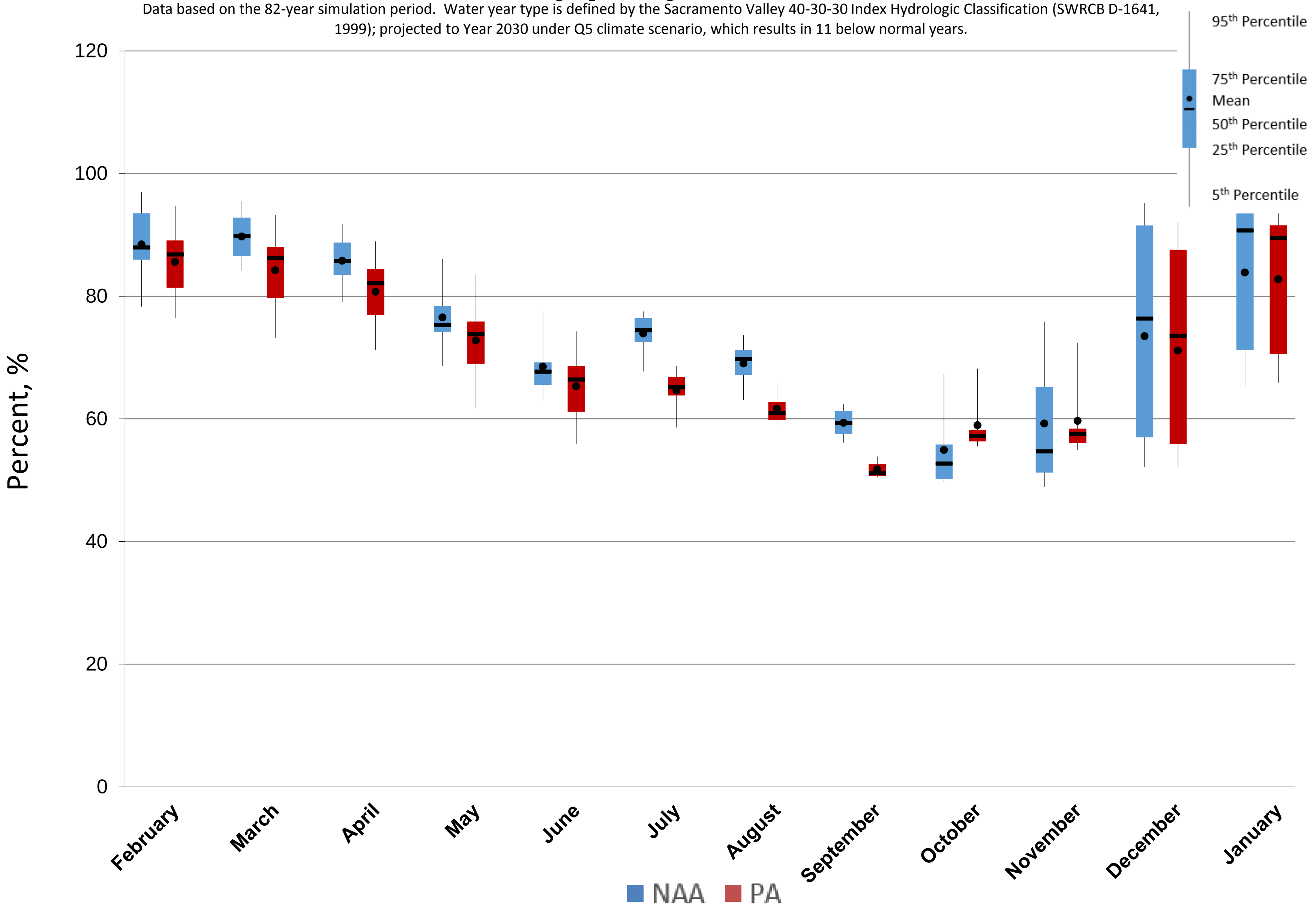


Figure 5.B.5-21-5. Monthly Percent Ranges For Sacramento River at Collinsville Sacramento River plus Yolo Bypass Volumetric Fingerprinting, Dry Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 20 dry years.

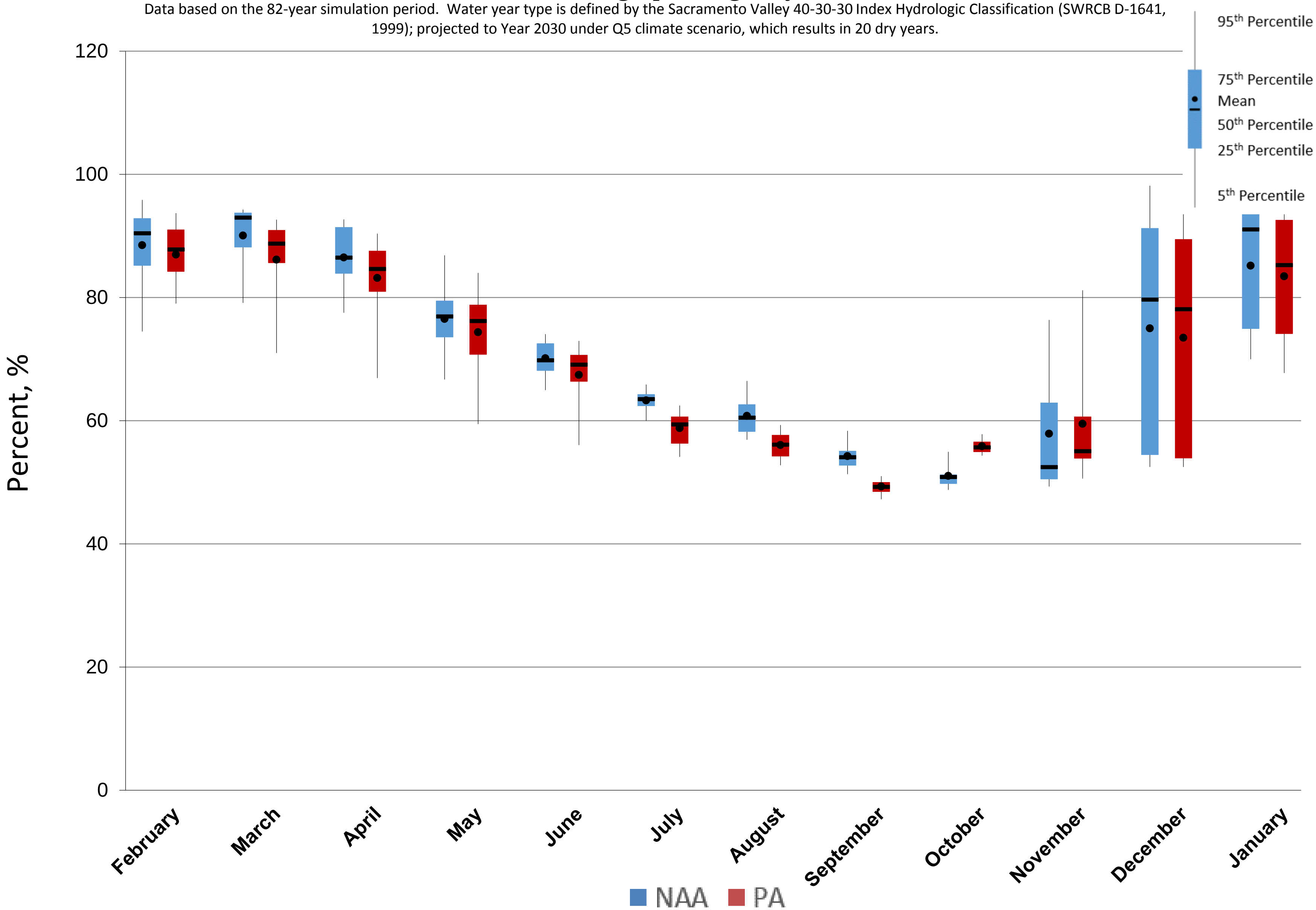


Figure 5.B.5-21-6. Monthly Percent Ranges For Sacramento River at Collinsville Sacramento River plus Yolo Bypass Volumetric Fingerprinting, Critical Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 12 critical years.

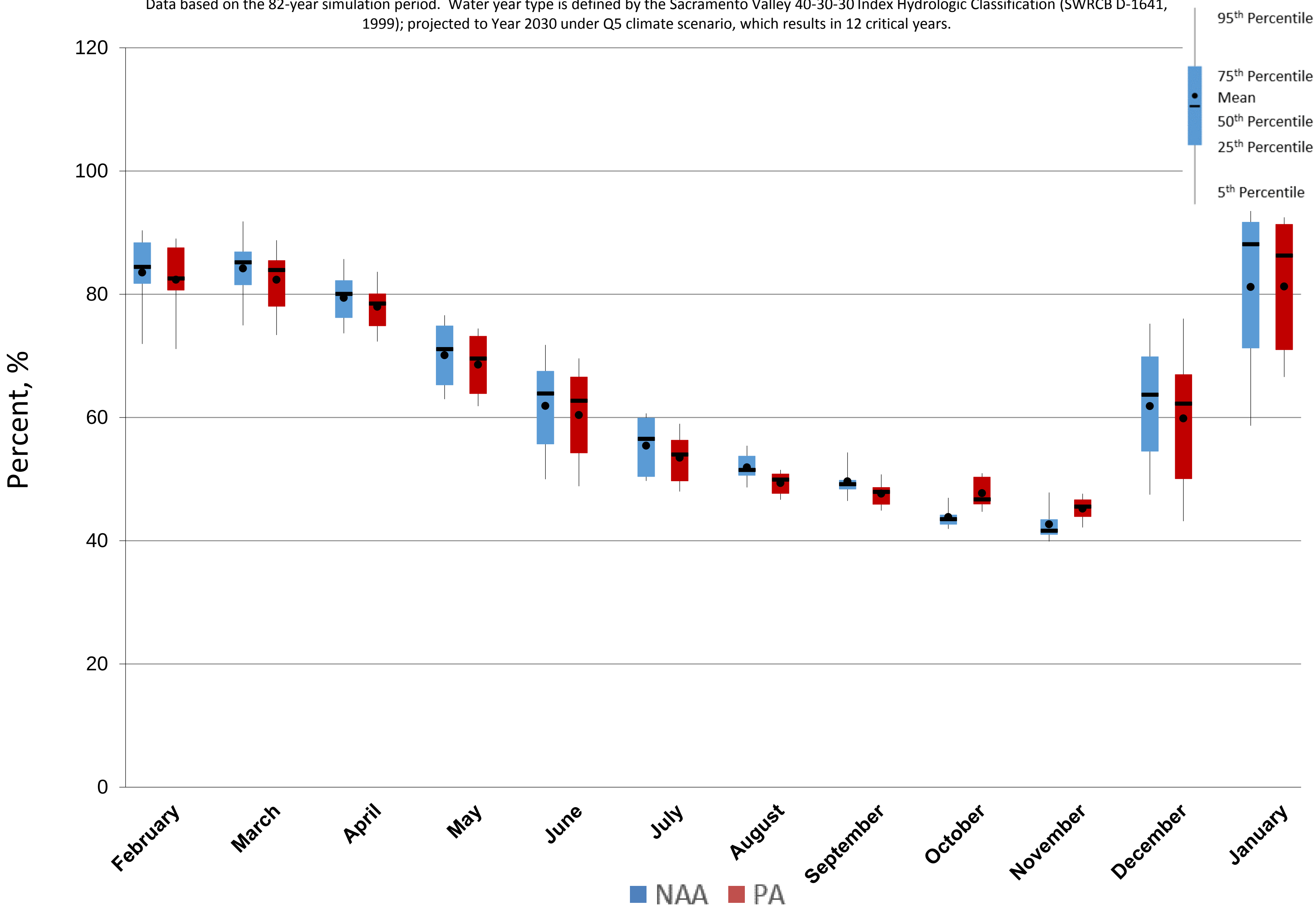
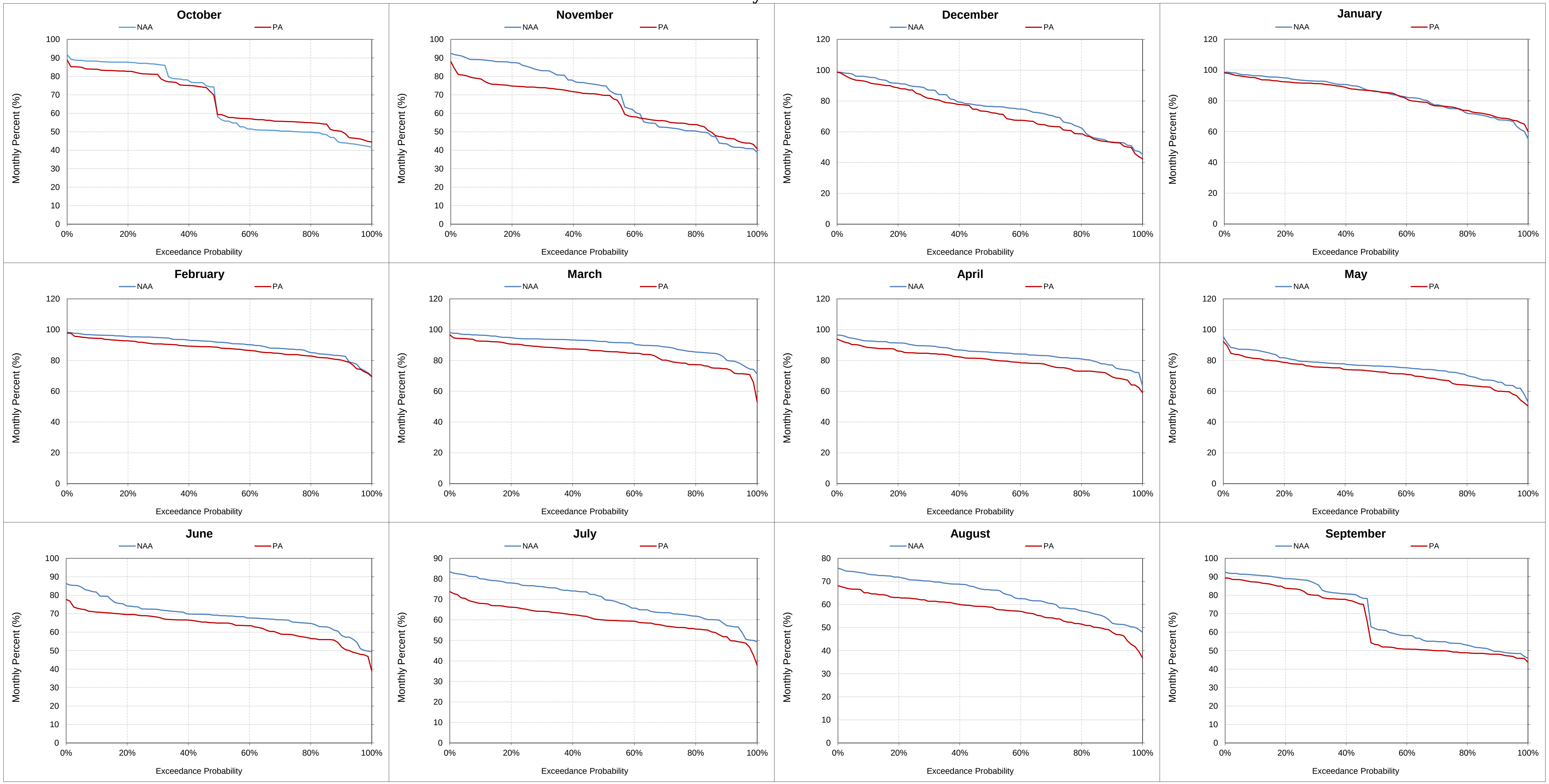
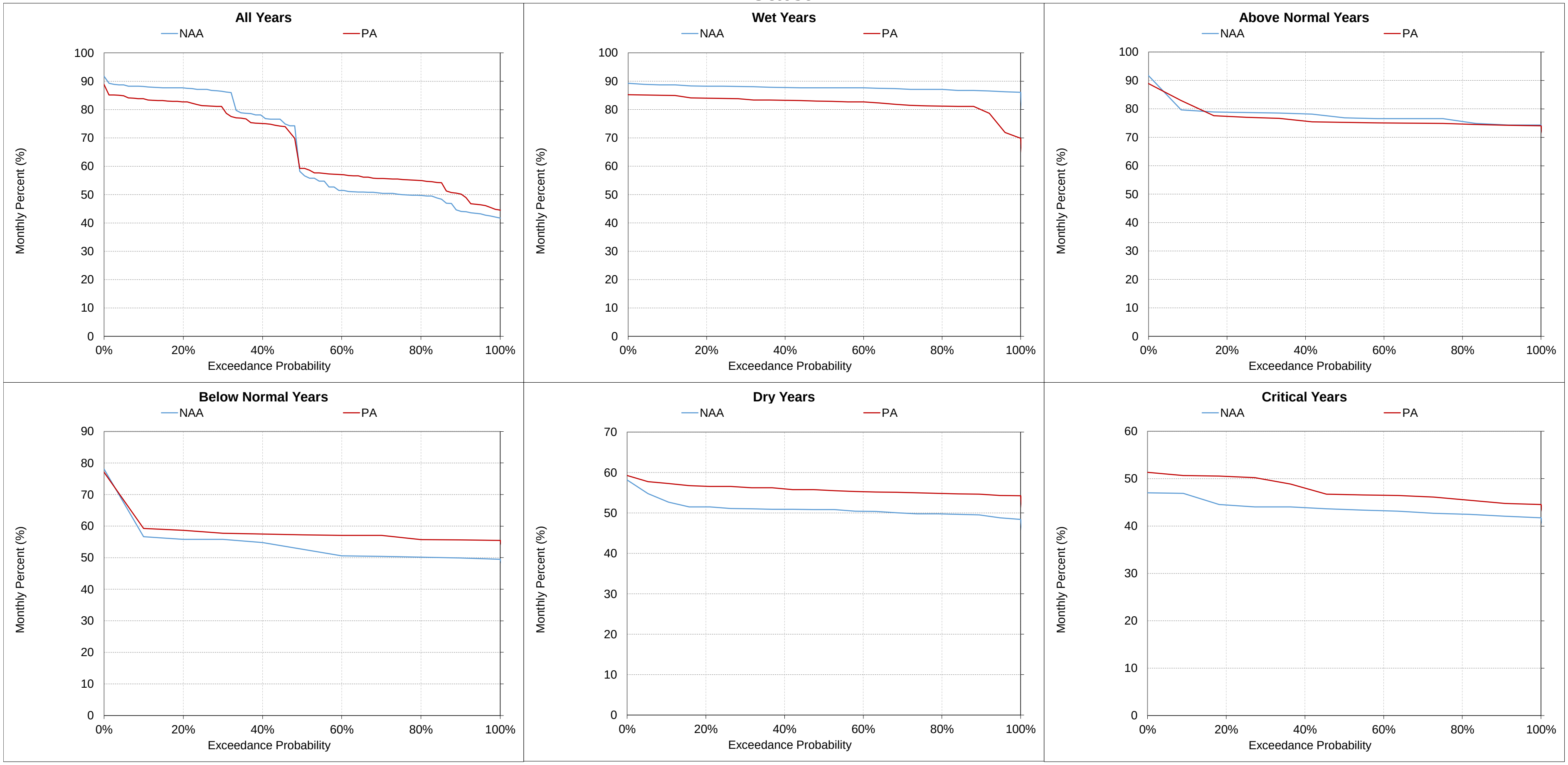


Figure 5.B.5-21-7. Sacramento River at Collinsville Sacramento River plus Yolo Bypass Volumetric Fingerprinting, Monthly Percent Probability of Exceedance



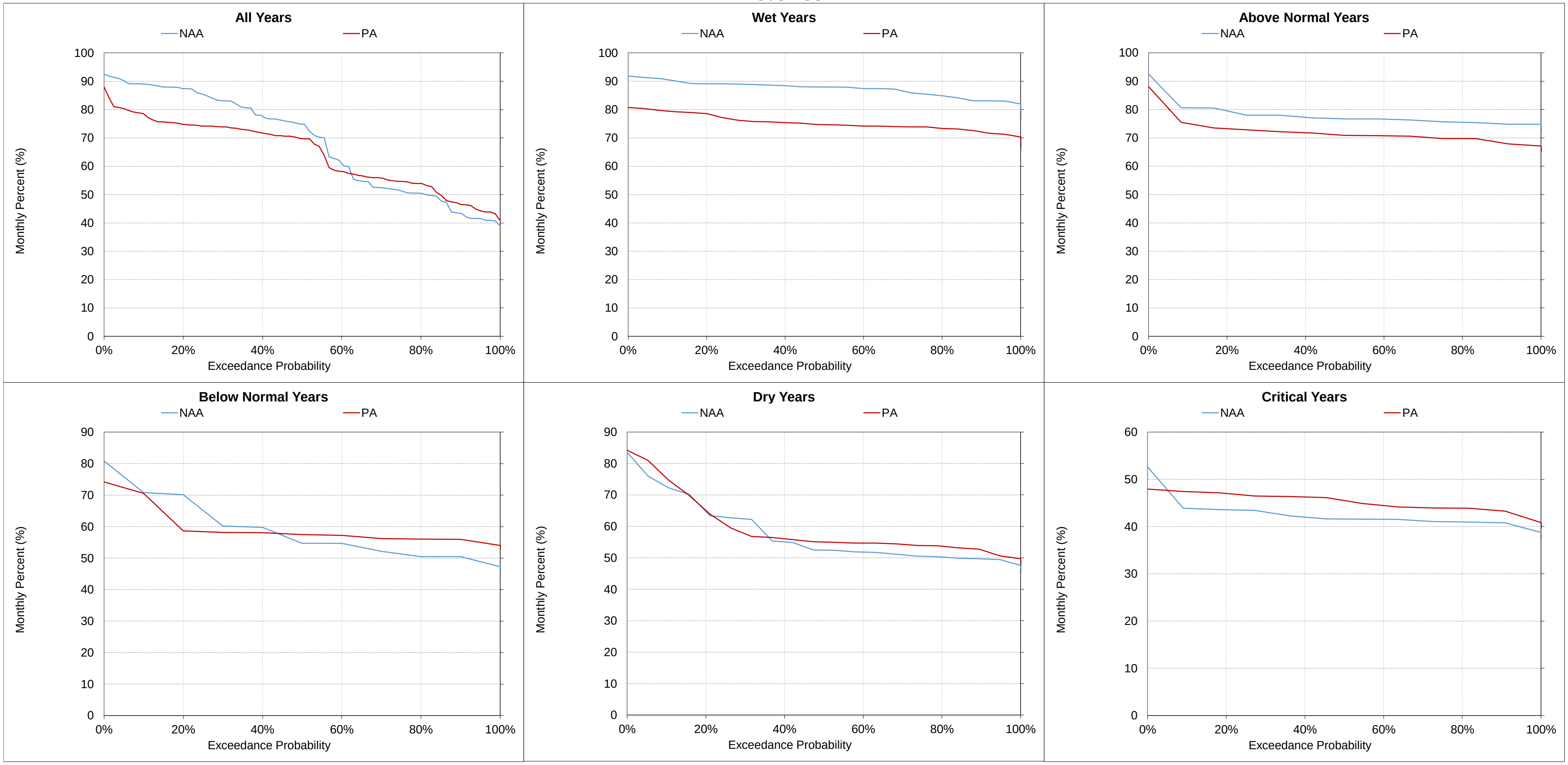
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-21-8. Sacramento River at Collinsville Sacramento River plus Yolo Bypass Volumetric Fingerprinting, Monthly Percent October



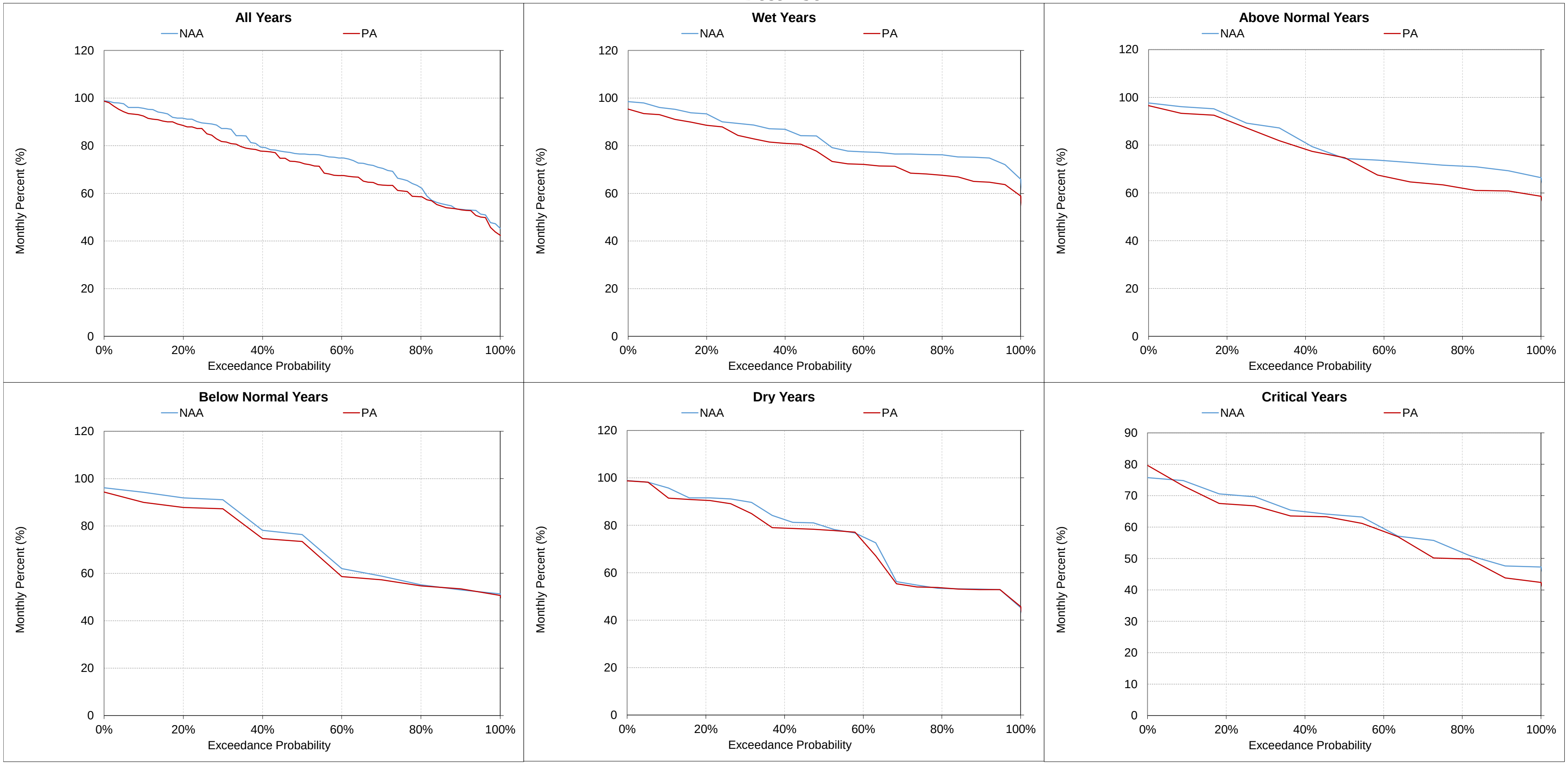
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-21-9. Sacramento River at Collinsville Sacramento River plus Yolo Bypass Volumetric Fingerprinting, Monthly Percent November



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-21-10. Sacramento River at Collinsville Sacramento River plus Yolo Bypass Volumetric Fingerprinting, Monthly Percent December



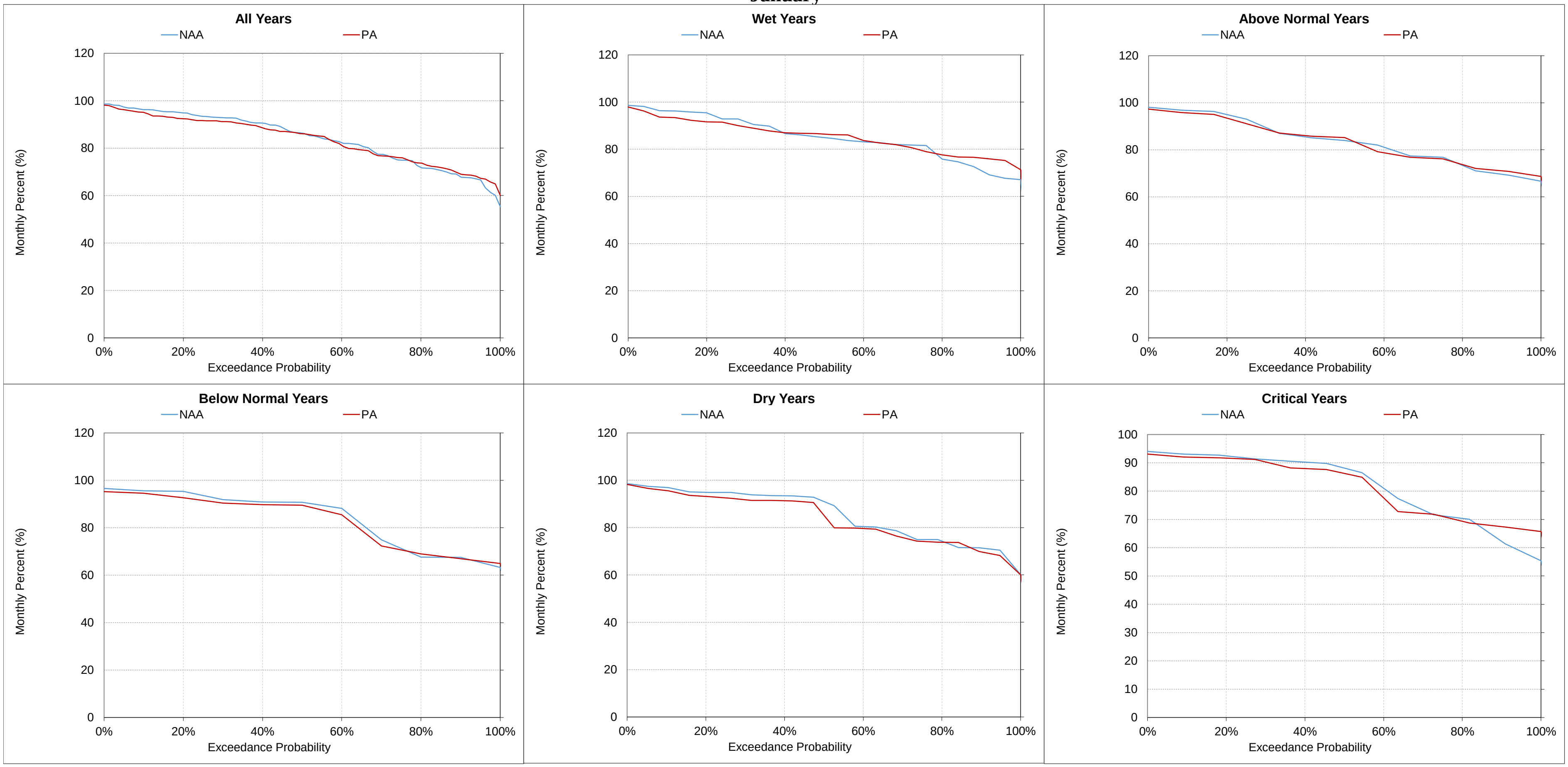
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-21-11. Sacramento River at Collinsville Sacramento River plus Yolo Bypass Volumetric Fingerprinting, Monthly Percent January



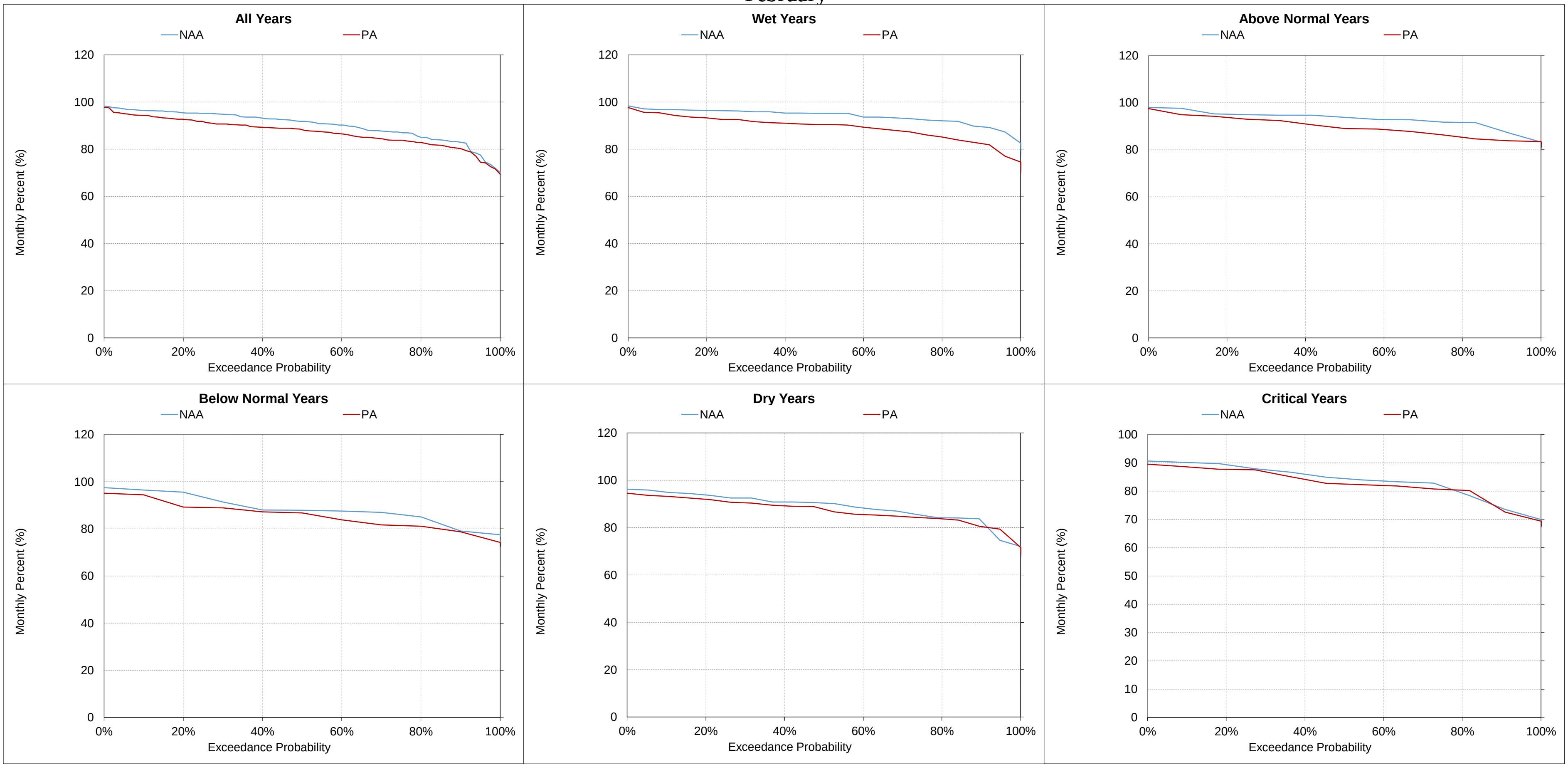
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

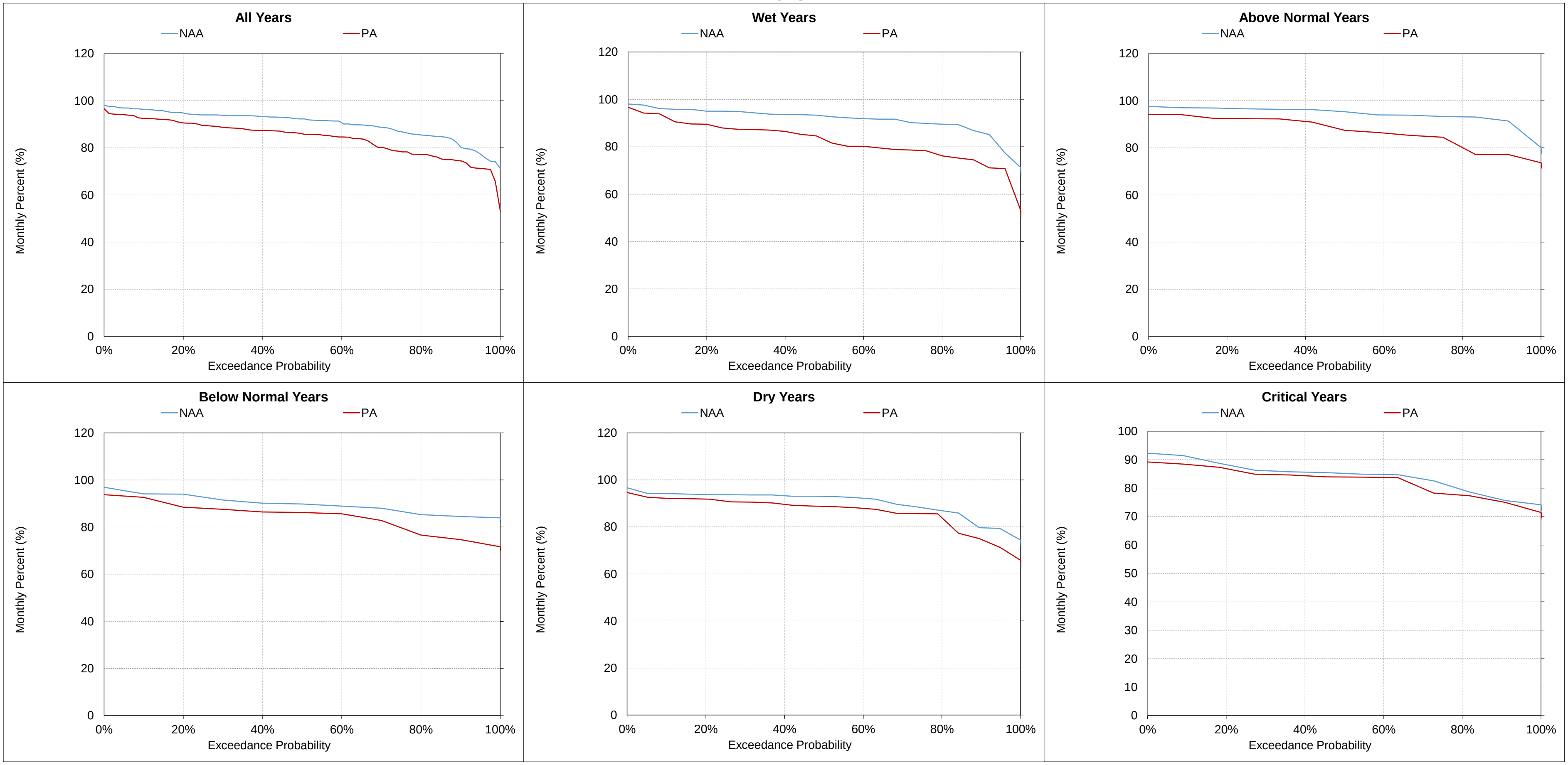
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-21-12. Sacramento River at Collinsville Sacramento River plus Yolo Bypass Volumetric Fingerprinting, Monthly Percent February



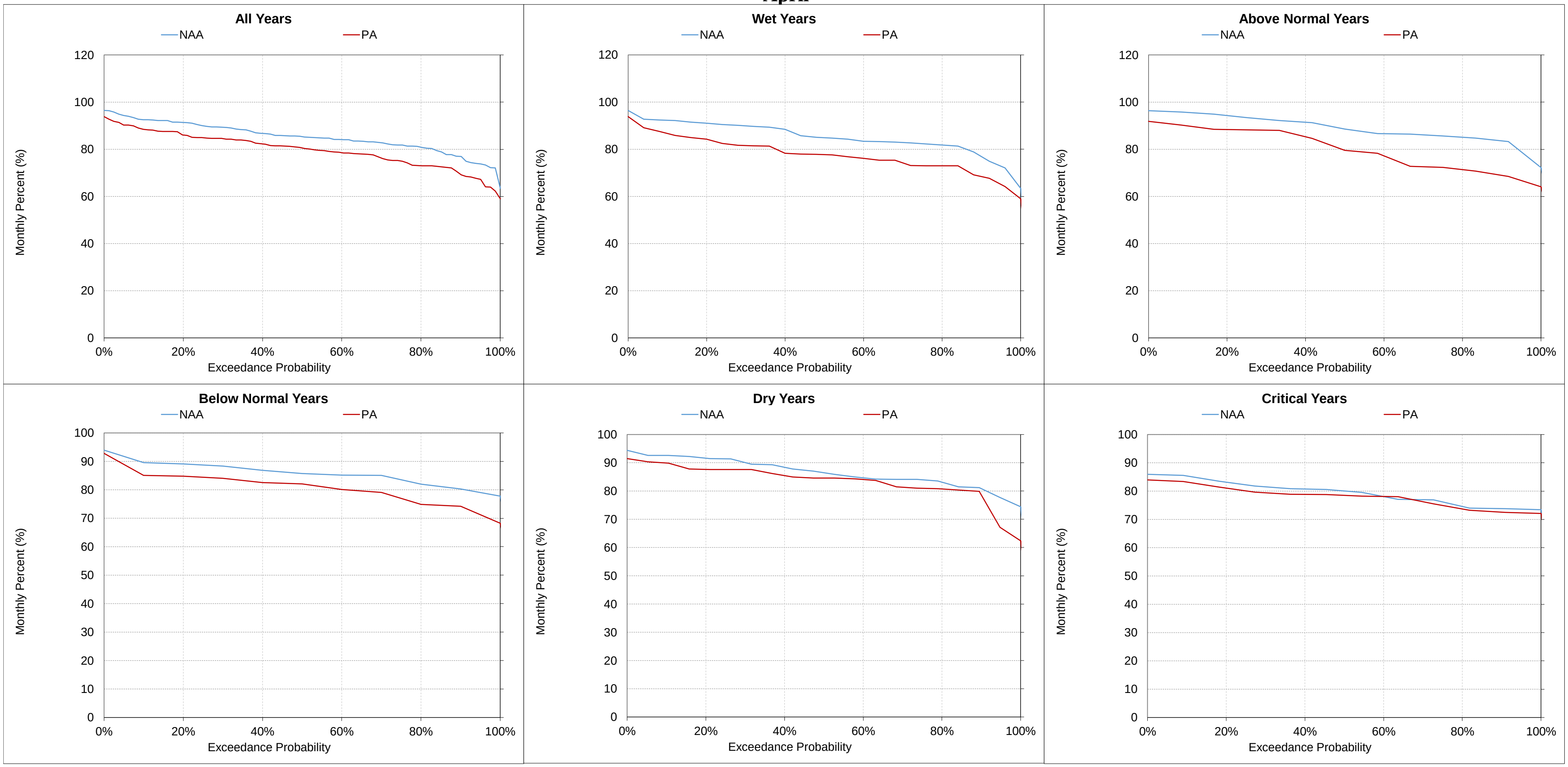
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-21-13. Sacramento River at Collinsville Sacramento River plus Yolo Bypass Volumetric Fingerprinting, Monthly Percent March



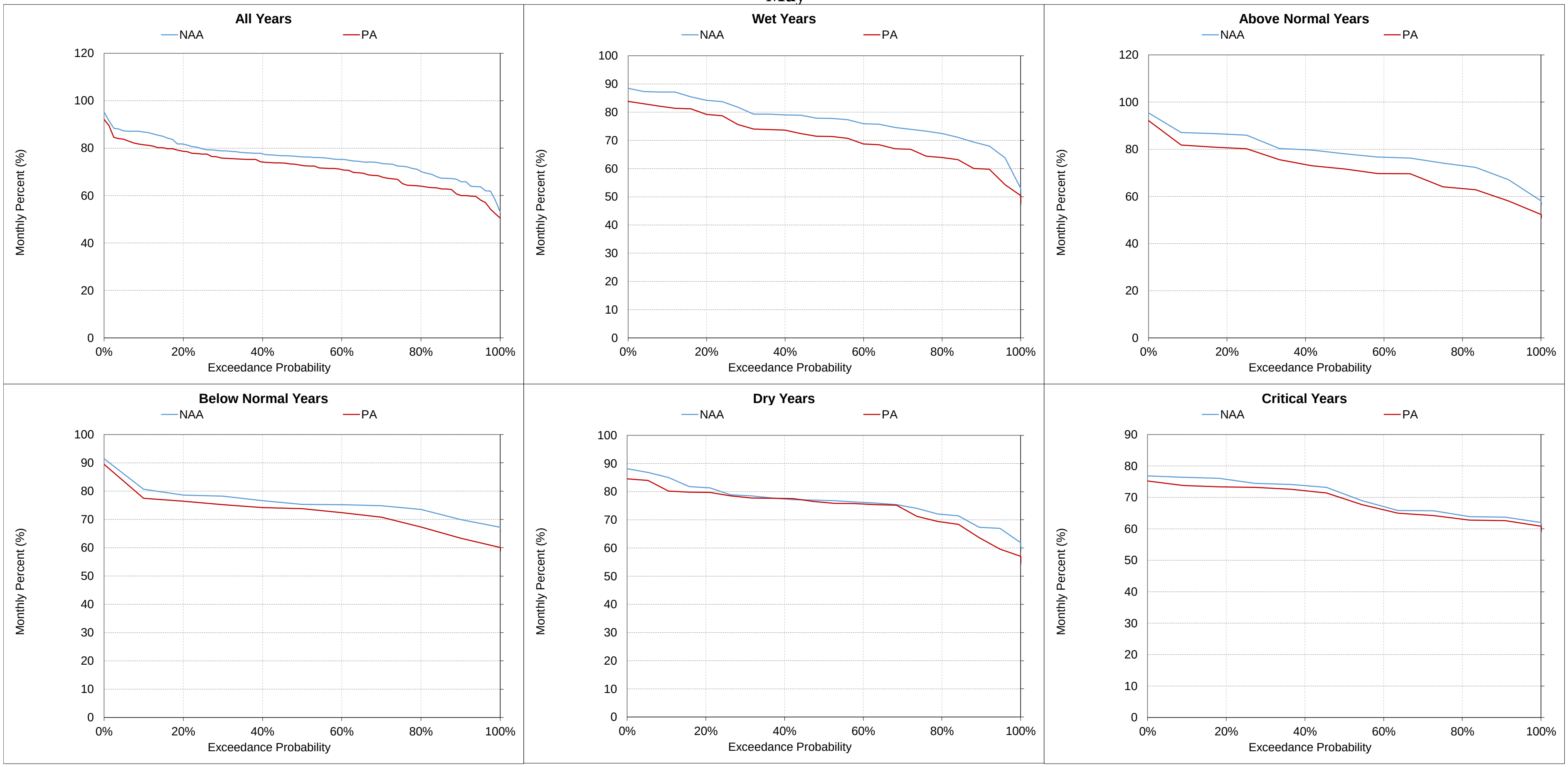
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-21-14. Sacramento River at Collinsville Sacramento River plus Yolo Bypass Volumetric Fingerprinting, Monthly Percent April



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-21-15. Sacramento River at Collinsville Sacramento River plus Yolo Bypass Volumetric Fingerprinting, Monthly Percent May



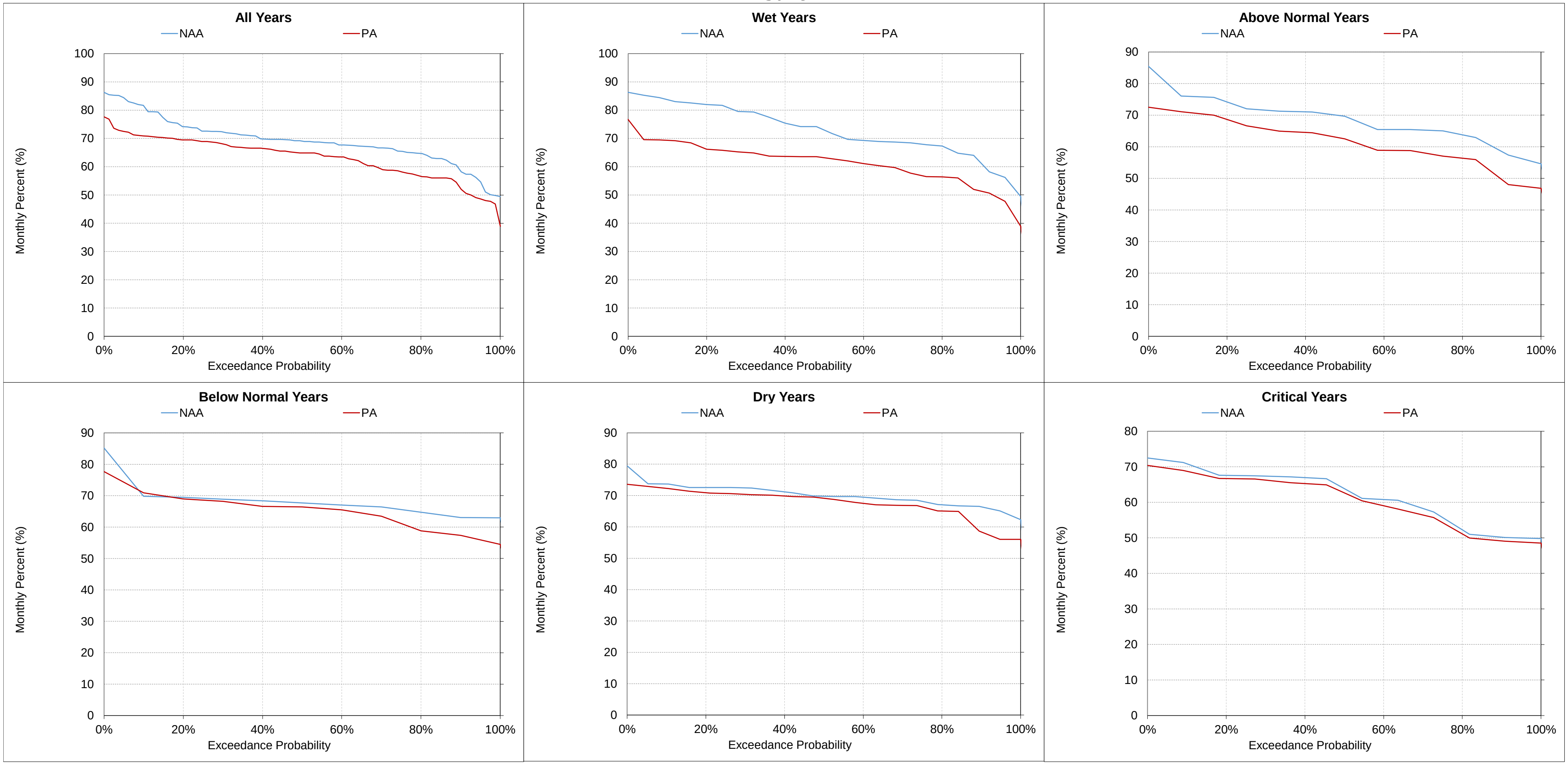
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

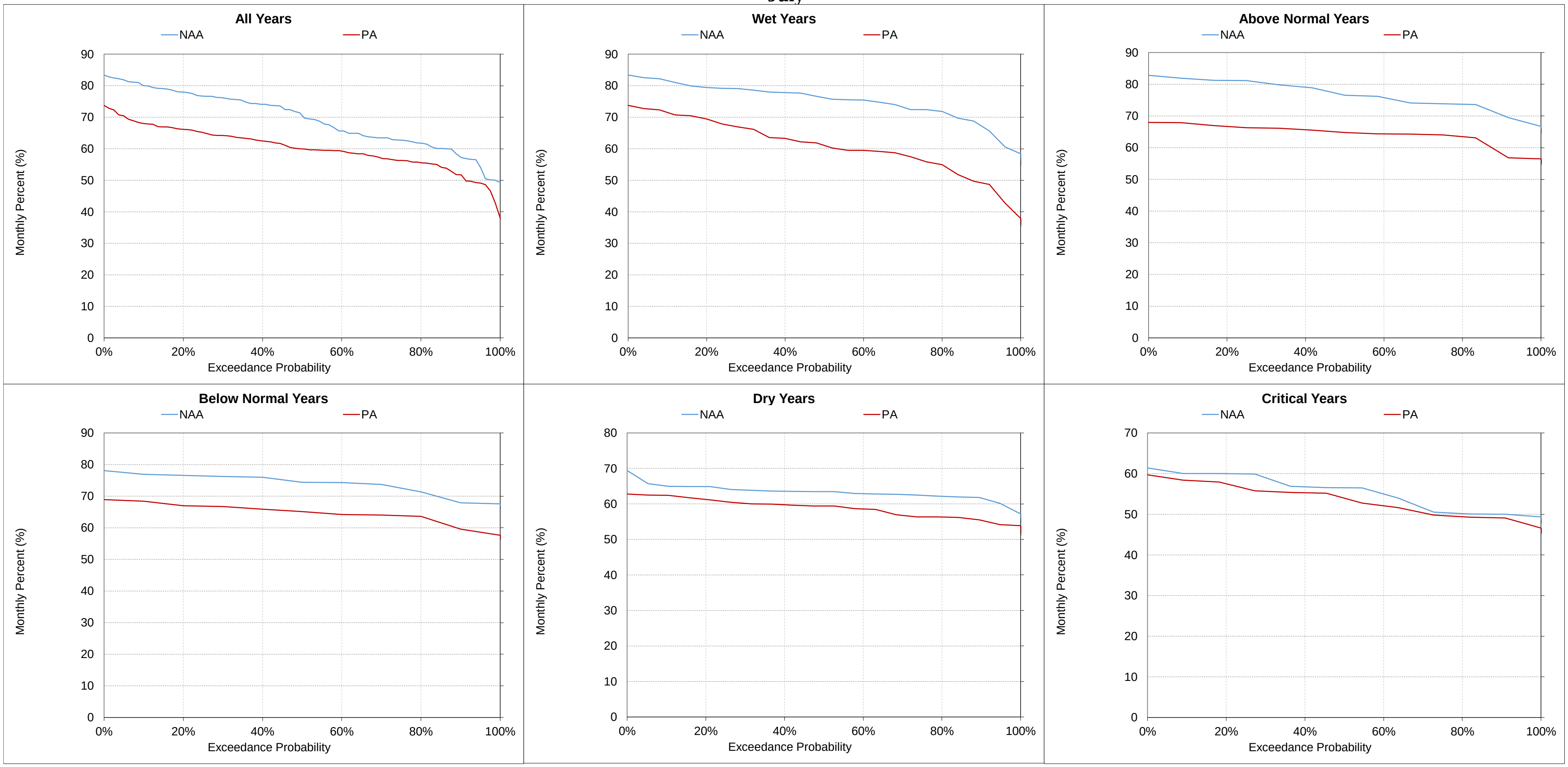
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-21-16. Sacramento River at Collinsville Sacramento River plus Yolo Bypass Volumetric Fingerprinting, Monthly Percent June



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-21-17. Sacramento River at Collinsville Sacramento River plus Yolo Bypass Volumetric Fingerprinting, Monthly Percent July



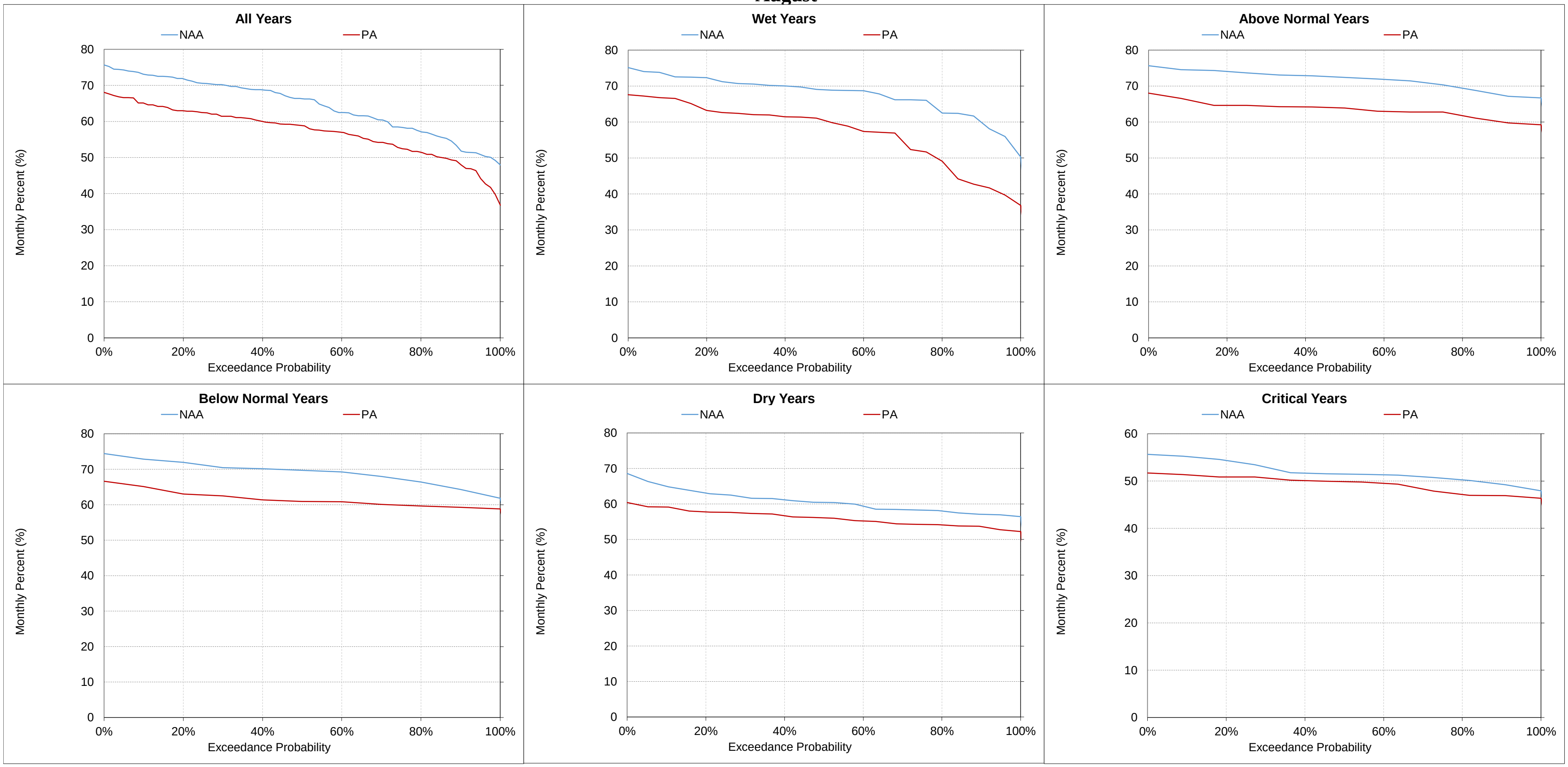
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

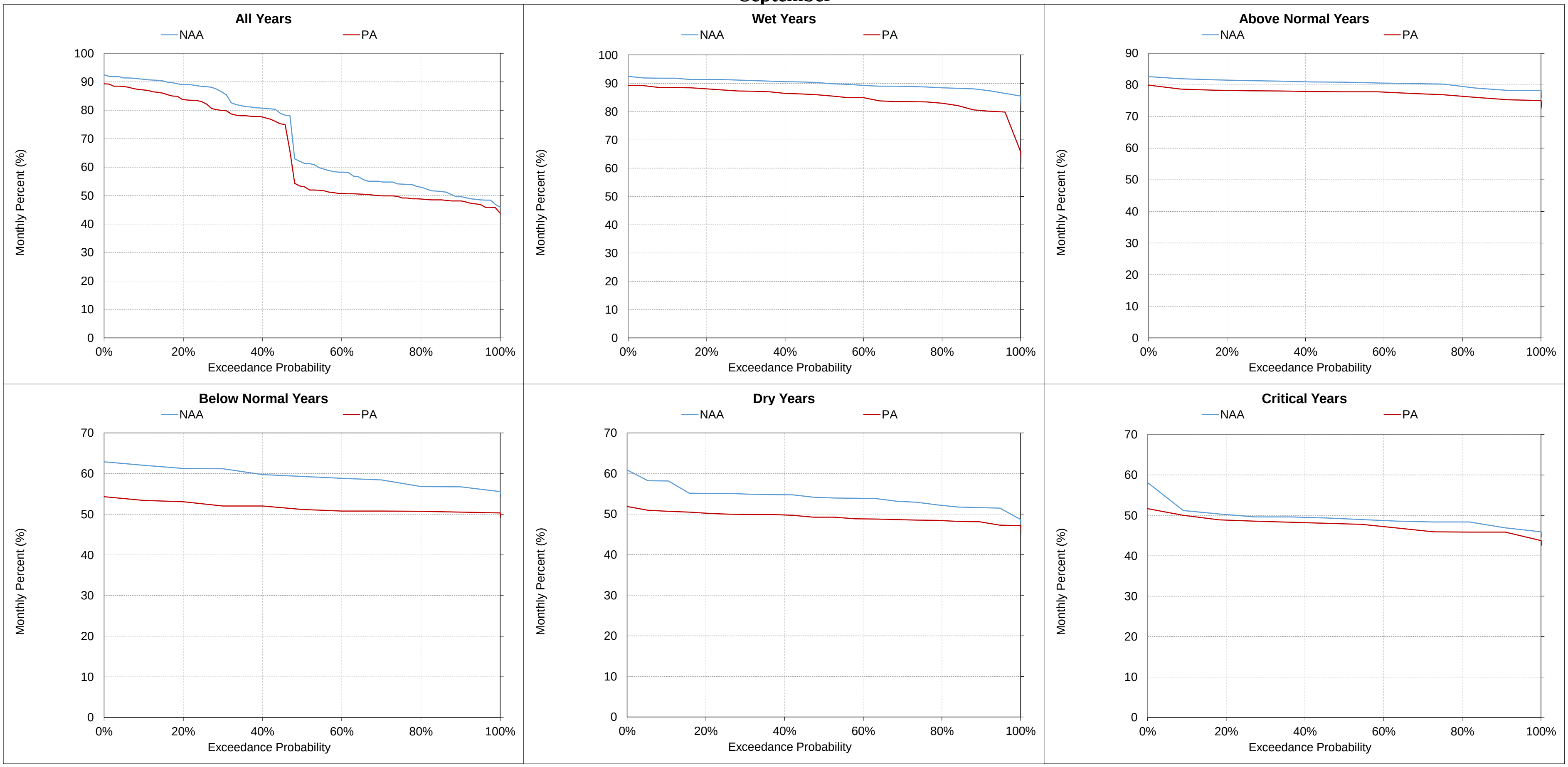
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-21-18. Sacramento River at Collinsville Sacramento River plus Yolo Bypass Volumetric Fingerprinting, Monthly Percent August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-21-19. Sacramento River at Collinsville Sacramento River plus Yolo Bypass Volumetric Fingerprinting, Monthly Percent September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-22. Sacramento River at Collinsville San Joaquin River Volumetric Fingerprinting, Monthly Percent

Statistic	Monthly Percent (%)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	0	3	2	2490%	0	11	11	2710%	0	6	6	1420%	1	3	2	230%	3	8	5	172%	5	15	10	192%
20%	0	2	2	1700%	0	8	8	3810%	0	5	5	2370%	0	2	1	464%	1	5	4	354%	3	12	9	347%
30%	0	1	1	1070%	0	6	5	2700%	0	4	3	1685%	0	1	1	588%	1	3	3	417%	2	8	6	385%
40%	0	1	1	-	0	4	4	3720%	0	2	2	1600%	0	1	1	800%	1	2	2	360%	1	5	4	710%
50%	0	1	1	-	0	2	2	1900%	0	1	1	950%	0	1	1	500%	0	2	2	1550%	0	3	2	500%
60%	0	0	0	-	0	1	1	900%	0	1	1	600%	0	0	0	-	0	1	1	1000%	0	2	2	527%
70%	0	0	0	-	0	1	1	600%	0	0	0	-	0	0	0	-	0	1	1	1900%	0	1	1	600%
80%	0	0	0	-	0	1	1	-	0	0	0	-	0	0	0	-	0	0	0	-	0	1	1	800%
90%	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	0	1	1	6000%
Long Term Full Simulation Period[b]	0	1	1	2312%	0	4	4	1478%	0	2	2	576%	1	2	1	183%	1	3	2	204%	2	6	4	203%
Water Year Types[c]																								
Wet (32%)	0	3	3	2796%	1	10	9	1469%	1	5	4	519%	1	3	2	167%	2	6	3	162%	4	11	7	179%
Above Normal (16%)	0	1	1	5100%	0	4	4	3738%	0	3	3	5571%	0	1	1	1533%	1	3	2	199%	2	7	5	260%
Below Normal (13%)	0	0	0	-	0	1	1	1800%	0	1	1	789%	0	1	0	224%	0	3	2	478%	1	5	4	262%
Dry (24%)	0	0	0	617%	0	1	1	914%	0	1	0	250%	0	1	1	173%	0	1	1	388%	1	3	2	203%
Critical (15%)	0	0	0	217%	0	0	0	165%	0	0	0	56%	0	0	0	32%	0	0	0	179%	0	1	1	250%

Statistic	Monthly Percent (%)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	11	19	8	71%	19	26	7	38%	15	27	12	79%	6	17	11	186%	1	6	5	469%	0	1	1	595%
20%	8	17	9	116%	14	21	7	49%	10	22	12	110%	3	11	8	245%	1	3	3	512%	0	1	1	780%
30%	5	13	8	173%	10	18	8	78%	9	17	8	84%	2	6	4	164%	0	2	1	386%	0	1	1	500%
40%	3	10	7	220%	8	14	6	68%	7	13	6	91%	2	5	3	177%	0	1	1	380%	0	0	0	260%
50%	1	5	4	333%	5	10	5	111%	4	9	5	124%	1	3	2	210%	0	1	1	300%	0	0	0	-
60%	1	3	2	264%	3	6	4	150%	3	6	3	101%	1	2	2	230%	0	1	1	540%	0	0	0	-
70%	1	2	2	338%	1	4	2	178%	2	4	2	137%	1	2	1	226%	0	1	0	400%	0	0	0	-
80%	0	2	1	400%	1	2	1	160%	1	2	1	181%	0	1	1	225%	0	0	0	300%	0	0	0	-
90%	0	1	1	700%	0	1	1	228%	1	1	1	182%	0	1	1	333%	0	0	0	-	0	0	0	-
Long Term Full Simulation Period[b]	4	9	5	116%	8	12	4	58%	7	12	6	85%	3	7	4	167%	1	3	2	270%	0	1	1	694%
Water Year Types[c]																								
Wet (32%)	9	16	7	83%	14	20	6	46%	11	21	10	89%	6	14	9	162%	2	6	5	252%	0	2	2	808%
Above Normal (16%)	4	12	8	180%	10	17	7	66%	8	15	7	79%	2	6	4	211%	0	2	1	544%	0	0	0	1900%
Below Normal (13%)	2	6	4	208%	6	10	4	72%	5	9	4	75%	1	3	2	162%	0	1	1	375%	0	0	0	725%
Dry (24%)	2	4	2	155%	4	7	3	77%	3	6	3	83%	1	2	2	163%	0	1	1	308%	0	0	0	391%
Critical (15%)	1	2	1	209%	1	2	1	150%	1	2	1	122%	1	2	1	137%	0	1	0	147%	0	0	0	158%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-22-1. Monthly Percent Ranges For Sacramento River at Collinsville San Joaquin River Volumetric Fingerprinting, All Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario.

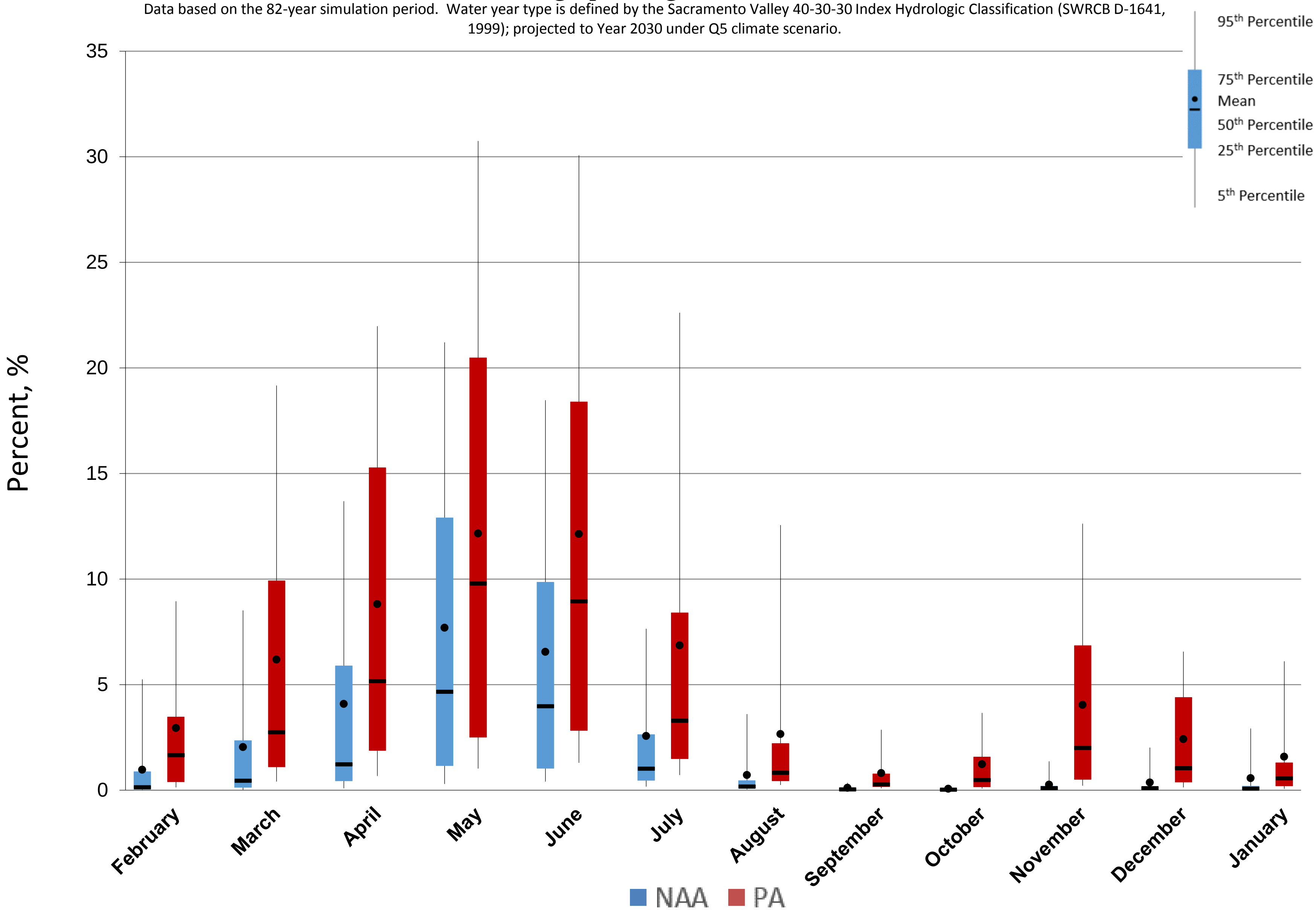


Figure 5.B.5-22-2. Monthly Percent Ranges For Sacramento River at Collinsville San Joaquin River Volumetric Fingerprinting, Wet Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 26 wet years.

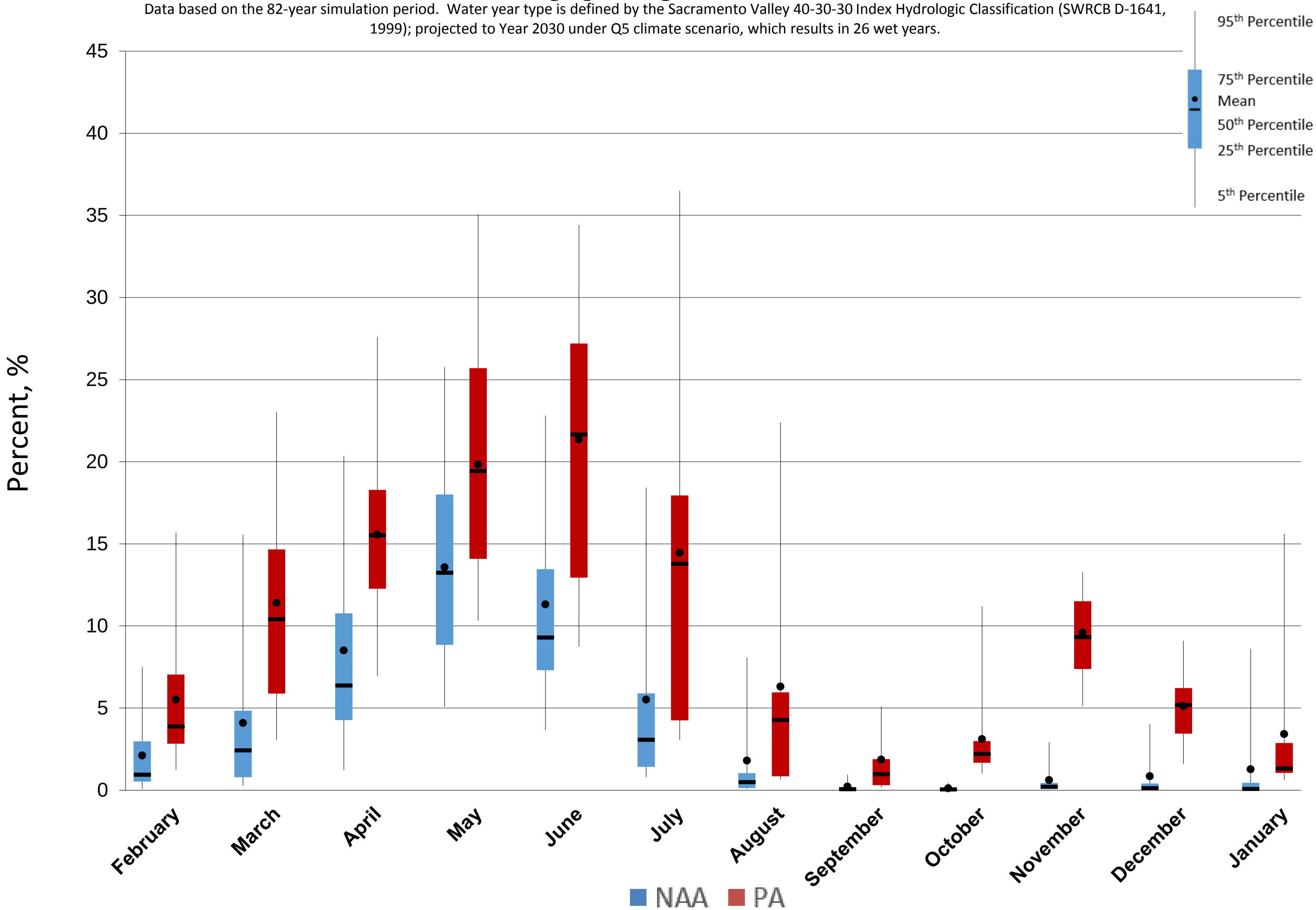


Figure 5.B.5-22-3. Monthly Percent Ranges For Sacramento River at Collinsville San Joaquin River Volumetric Fingerprinting, Above Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 13 above normal years.

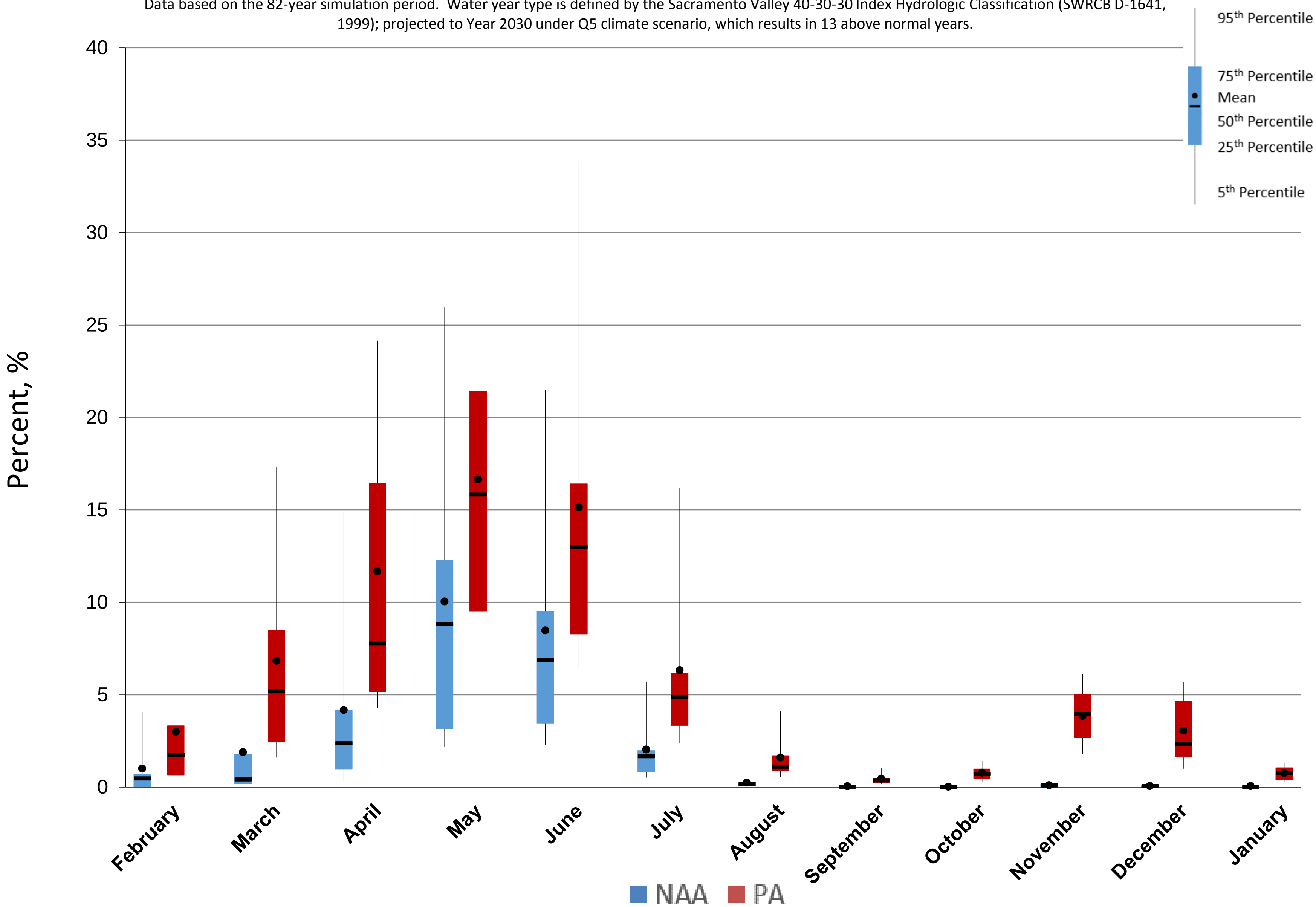


Figure 5.B.5-22-4. Monthly Percent Ranges For Sacramento River at Collinsville San Joaquin River Volumetric Fingerprinting, Below Normal Years

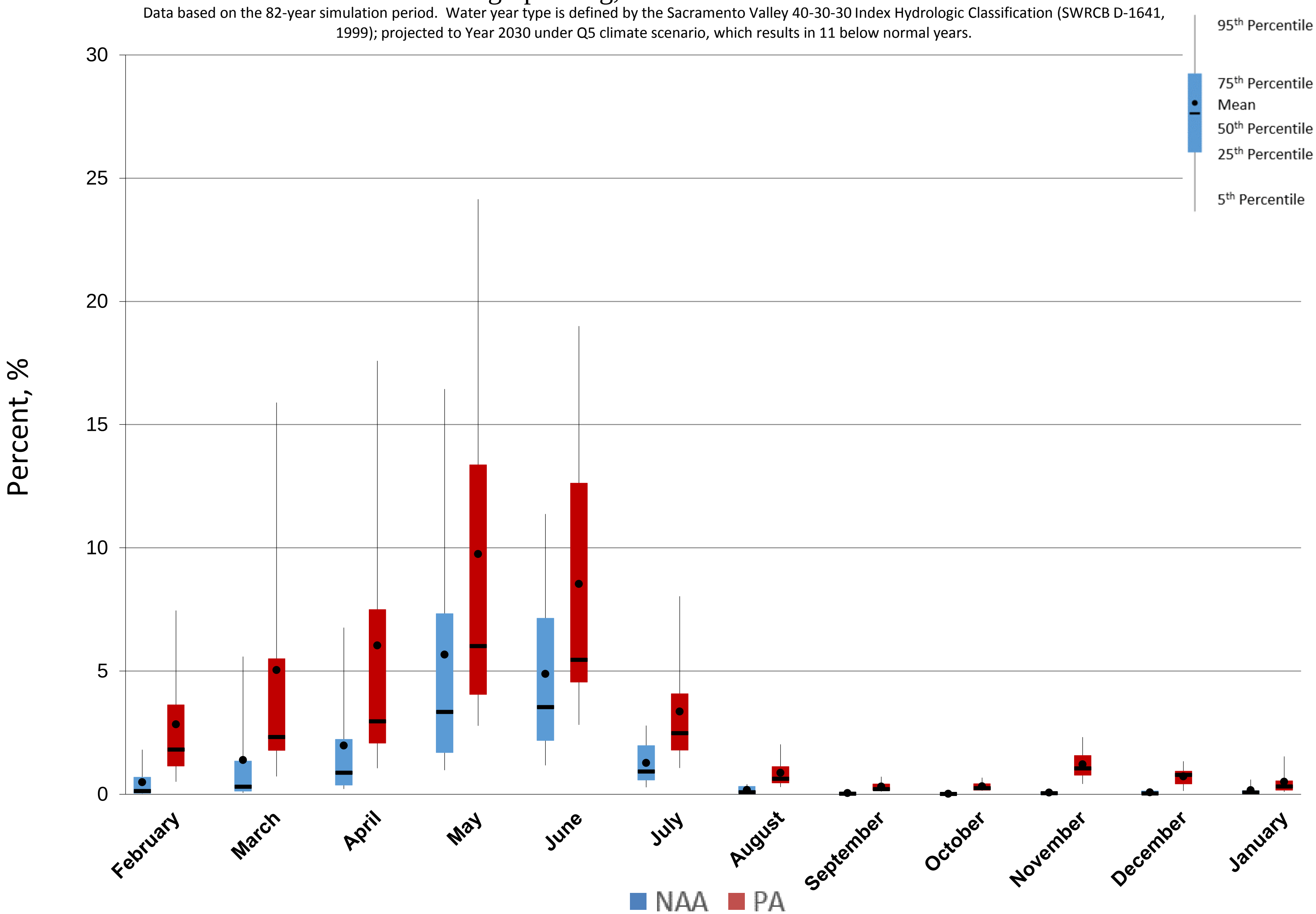


Figure 5.B.5-22-5. Monthly Percent Ranges For Sacramento River at Collinsville San Joaquin River Volumetric Fingerprinting, Dry Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 20 dry years.

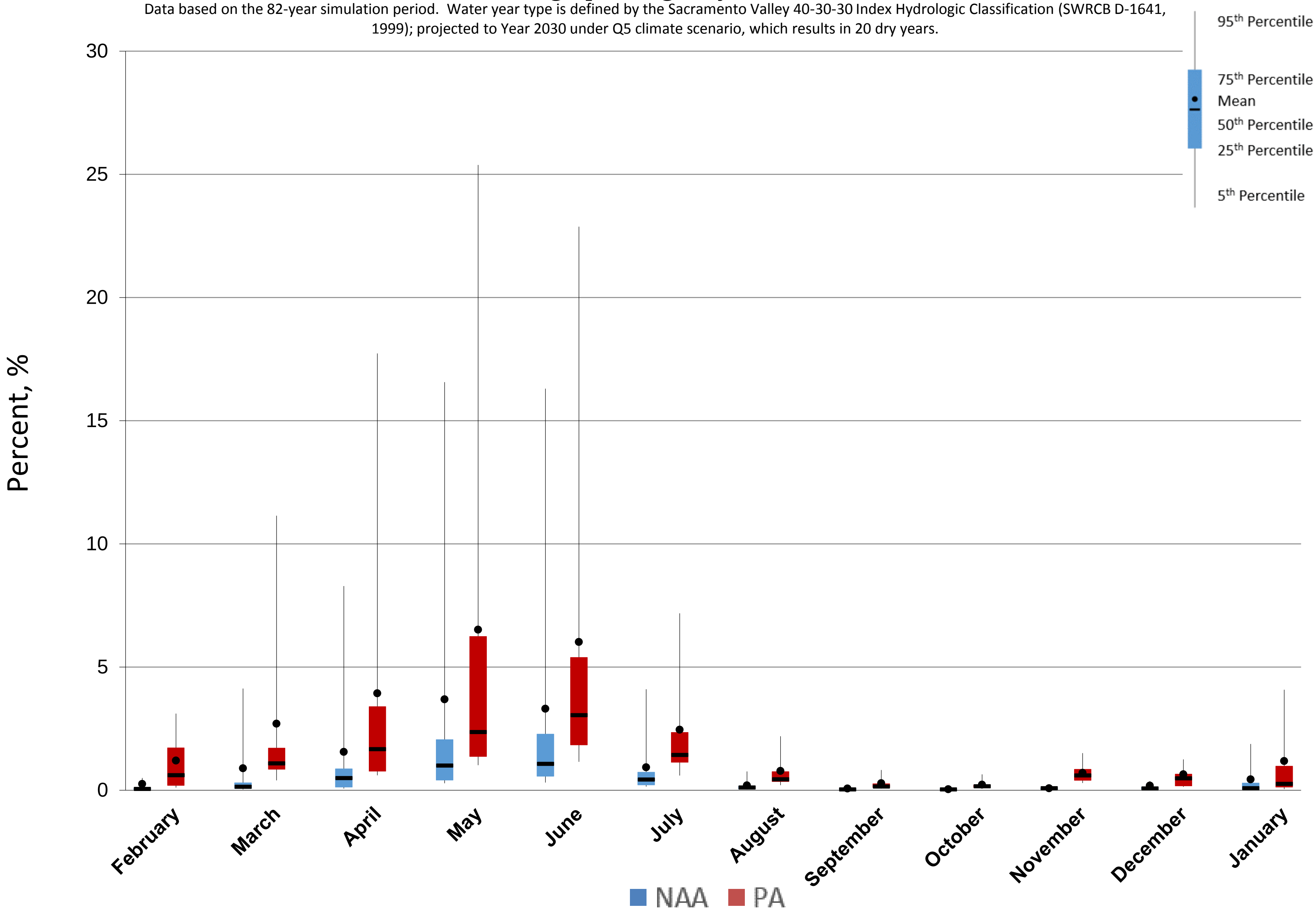


Figure 5.B.5-22-6. Monthly Percent Ranges For Sacramento River at Collinsville San Joaquin River Volumetric Fingerprinting, Critical Years

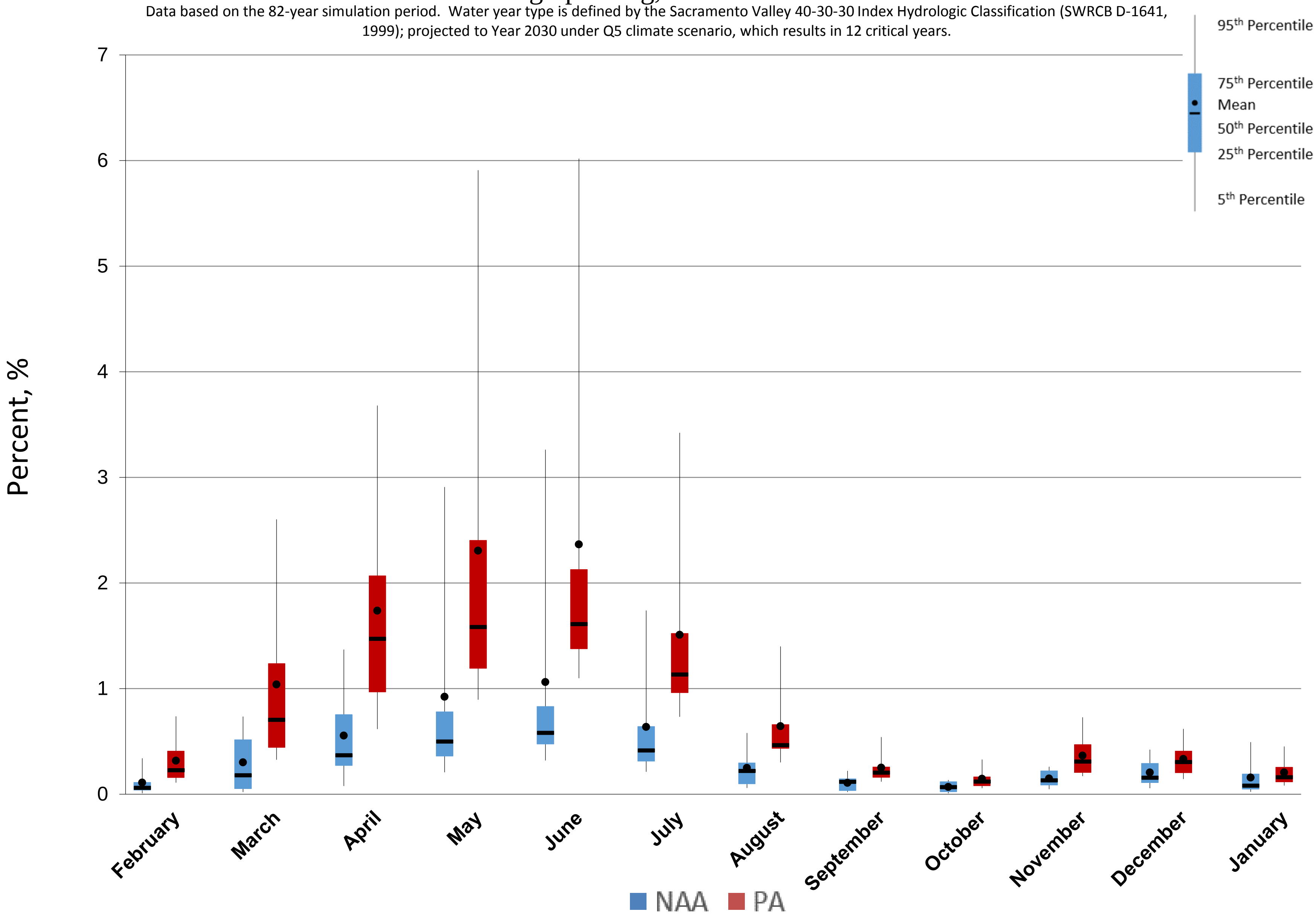
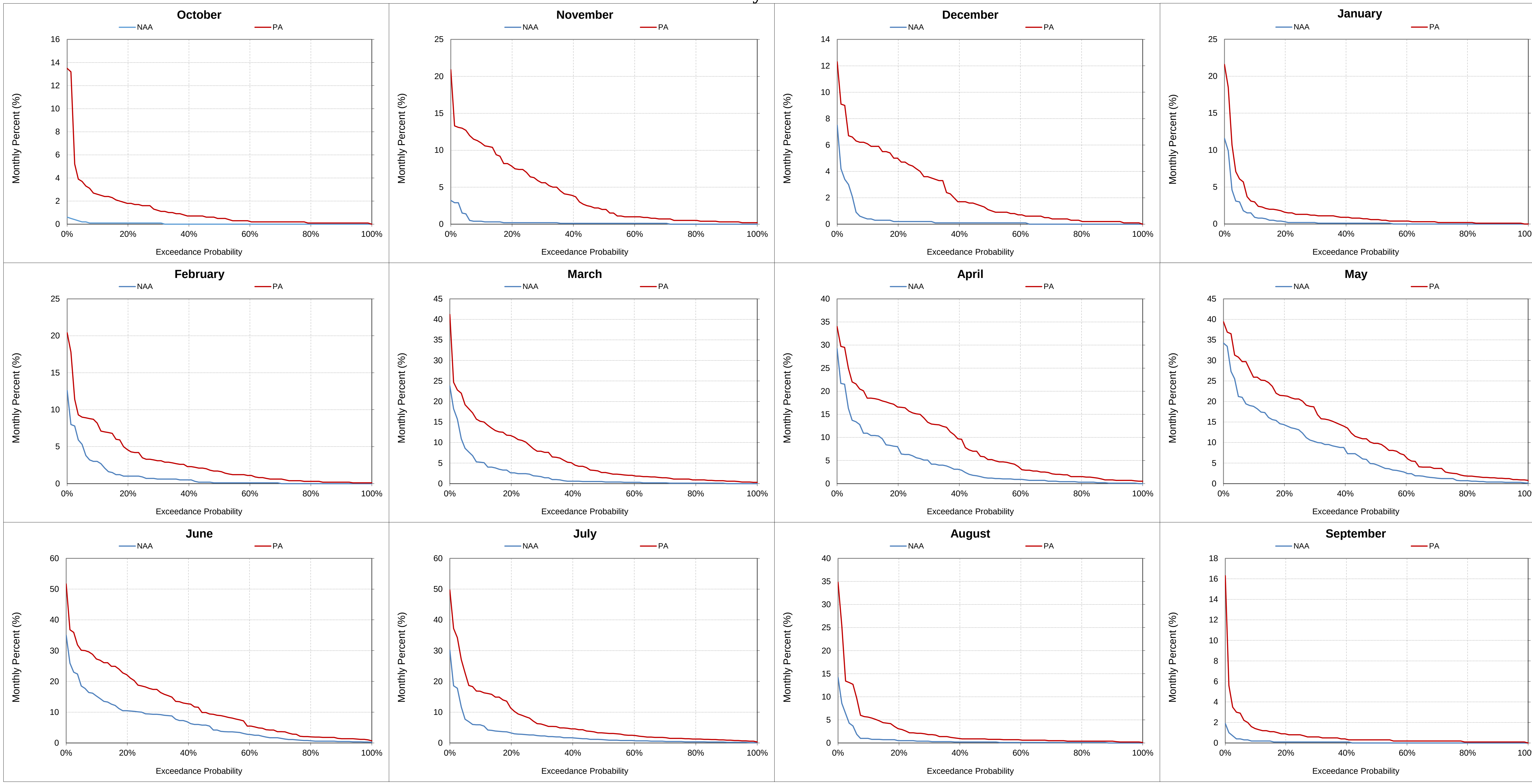
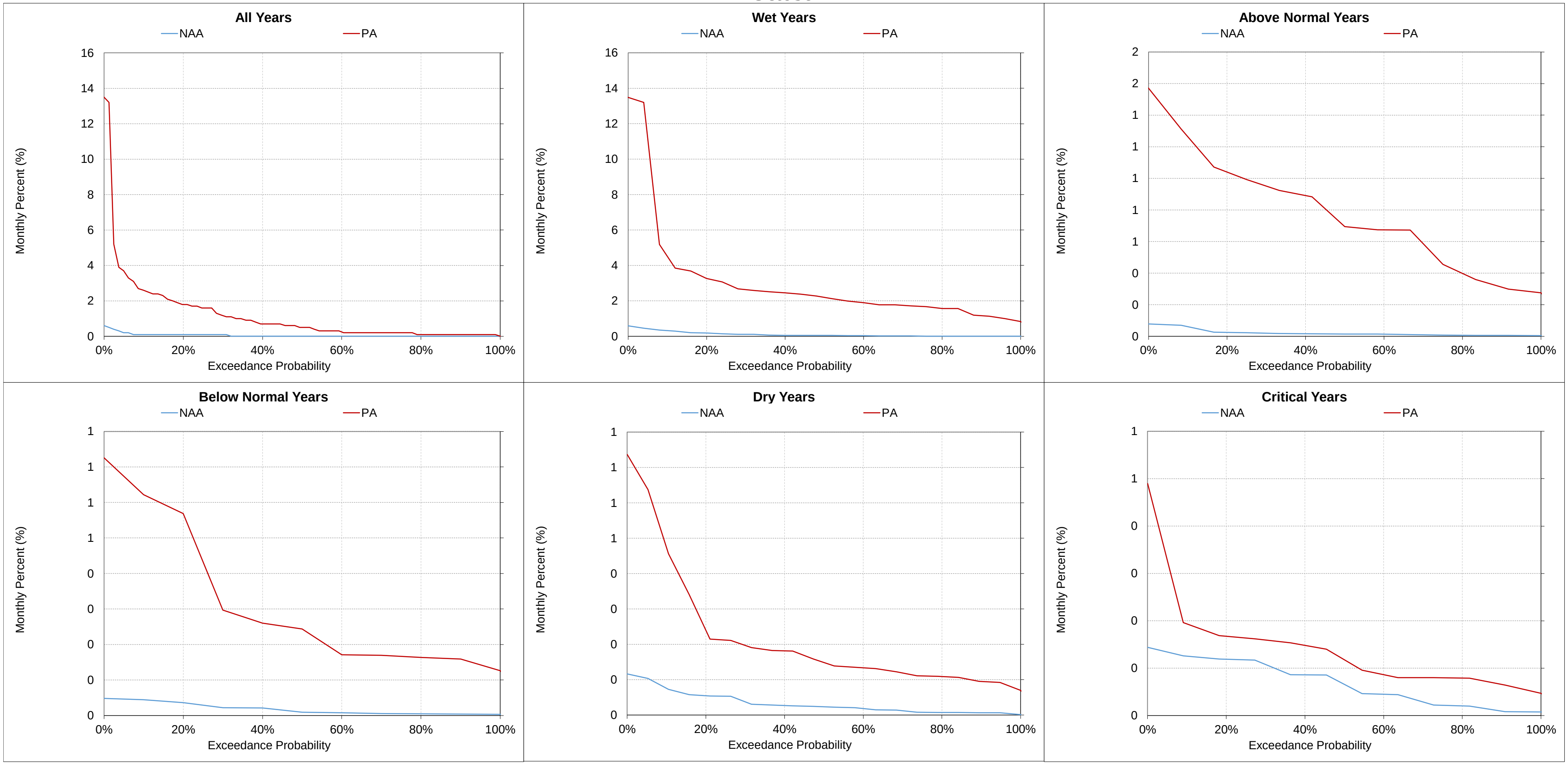


Figure 5.B.5-22-7. Sacramento River at Collinsville San Joaquin River Volumetric Fingerprinting, Monthly Percent Probability of Exceedance



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-22-8. Sacramento River at Collinsville San Joaquin River Volumetric Fingerprinting, Monthly Percent October



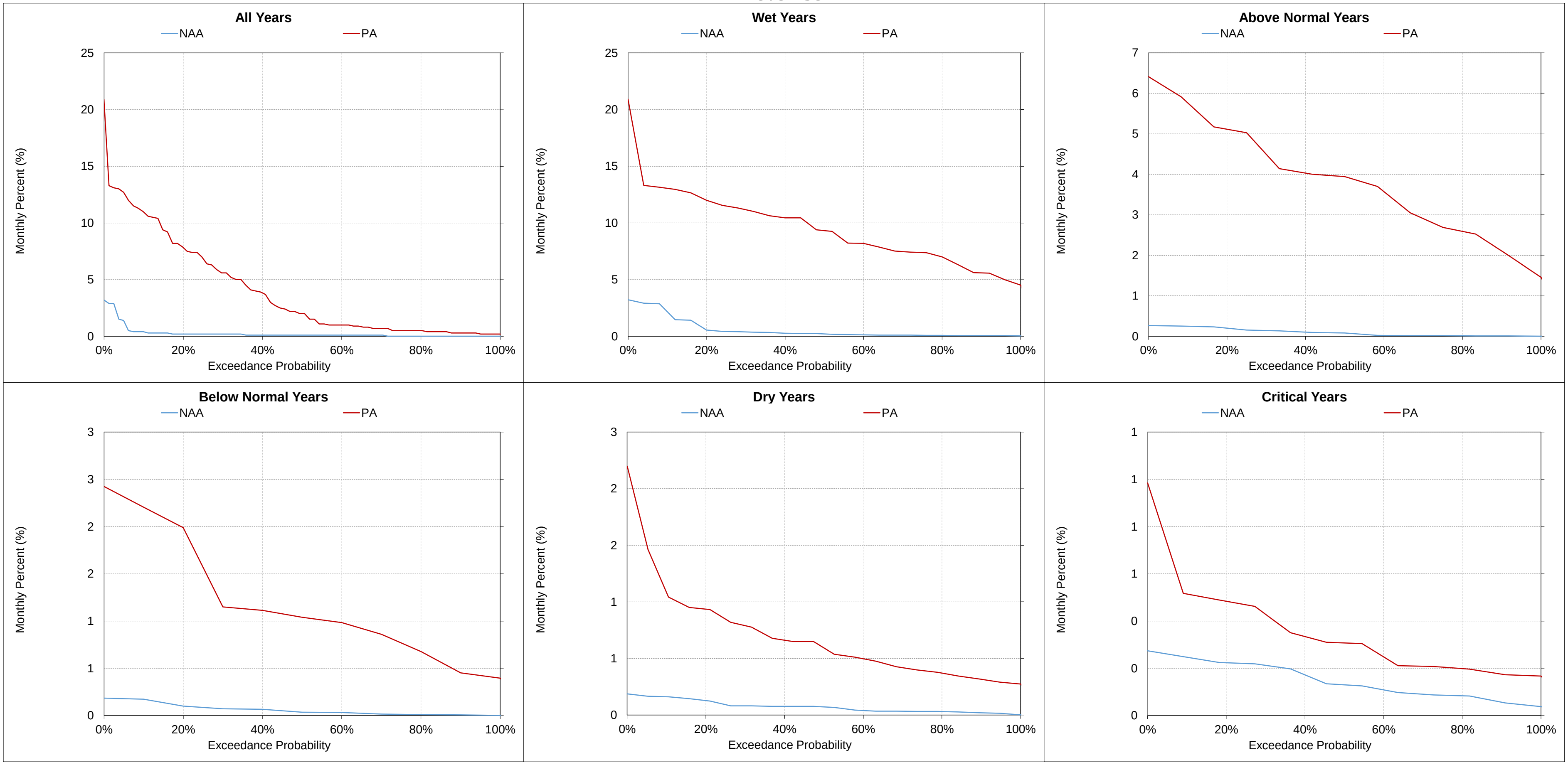
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

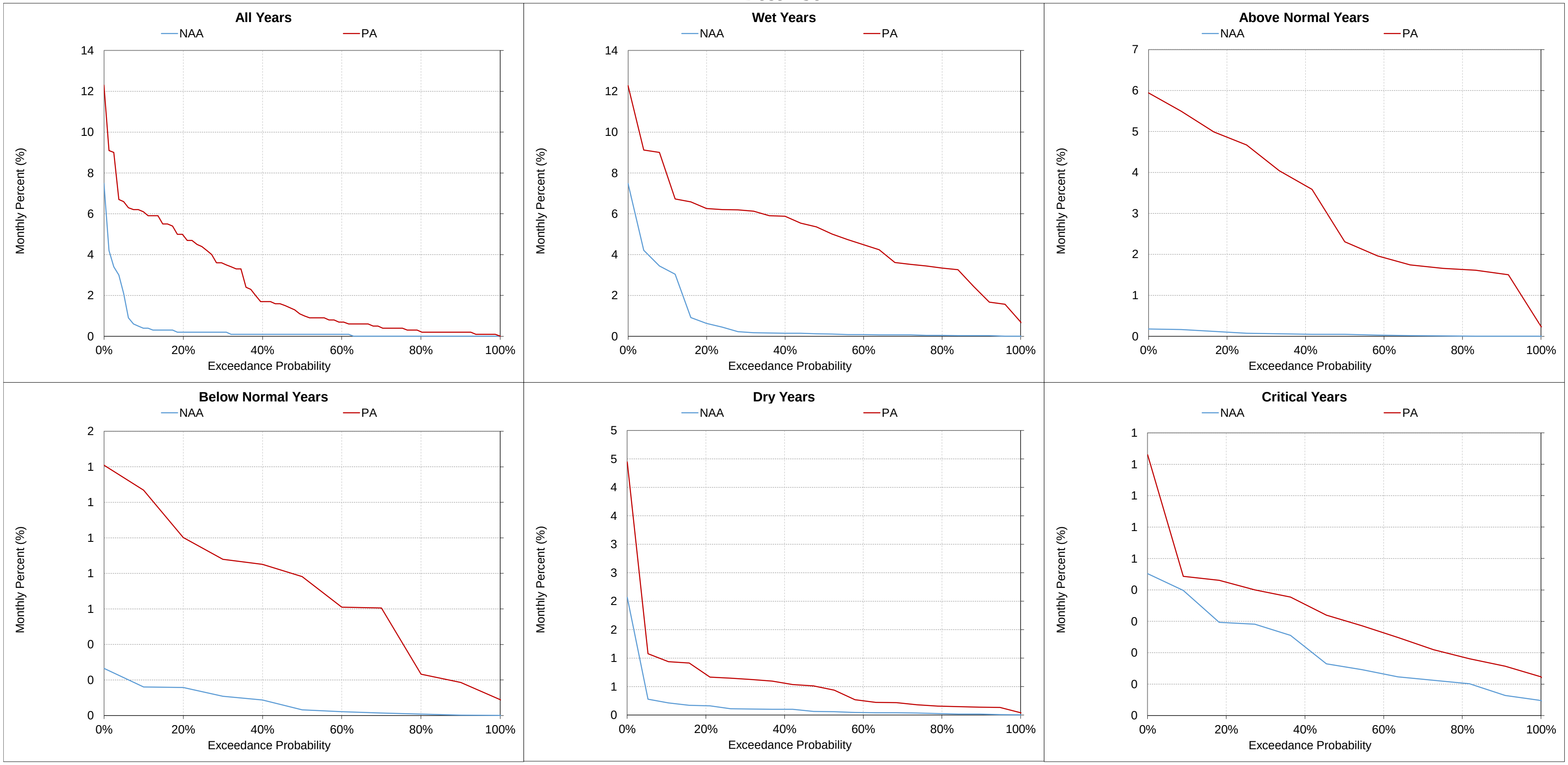
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-22-9. Sacramento River at Collinsville San Joaquin River Volumetric Fingerprinting, Monthly Percent November



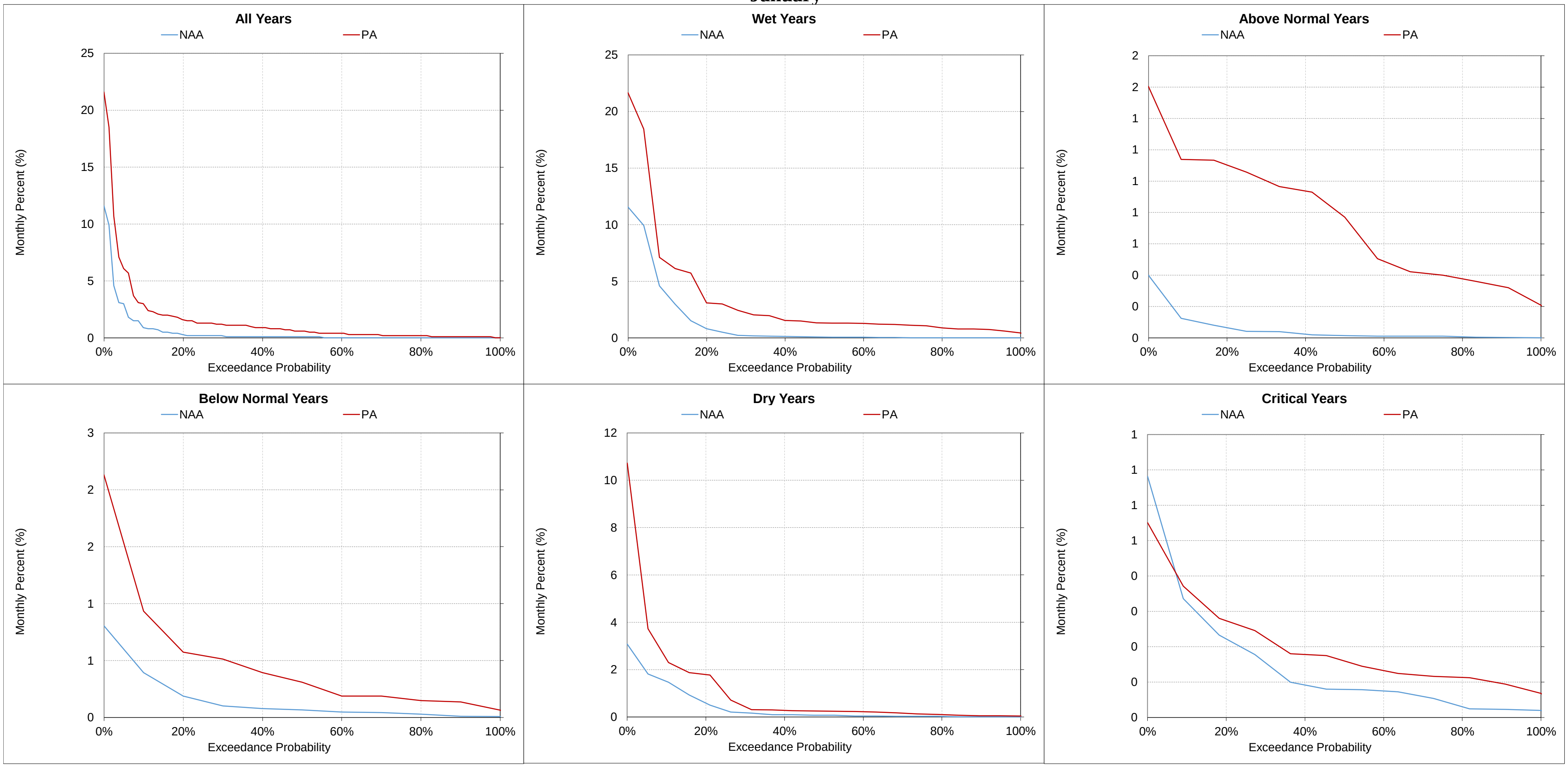
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-22-10. Sacramento River at Collinsville San Joaquin River Volumetric Fingerprinting, Monthly Percent December



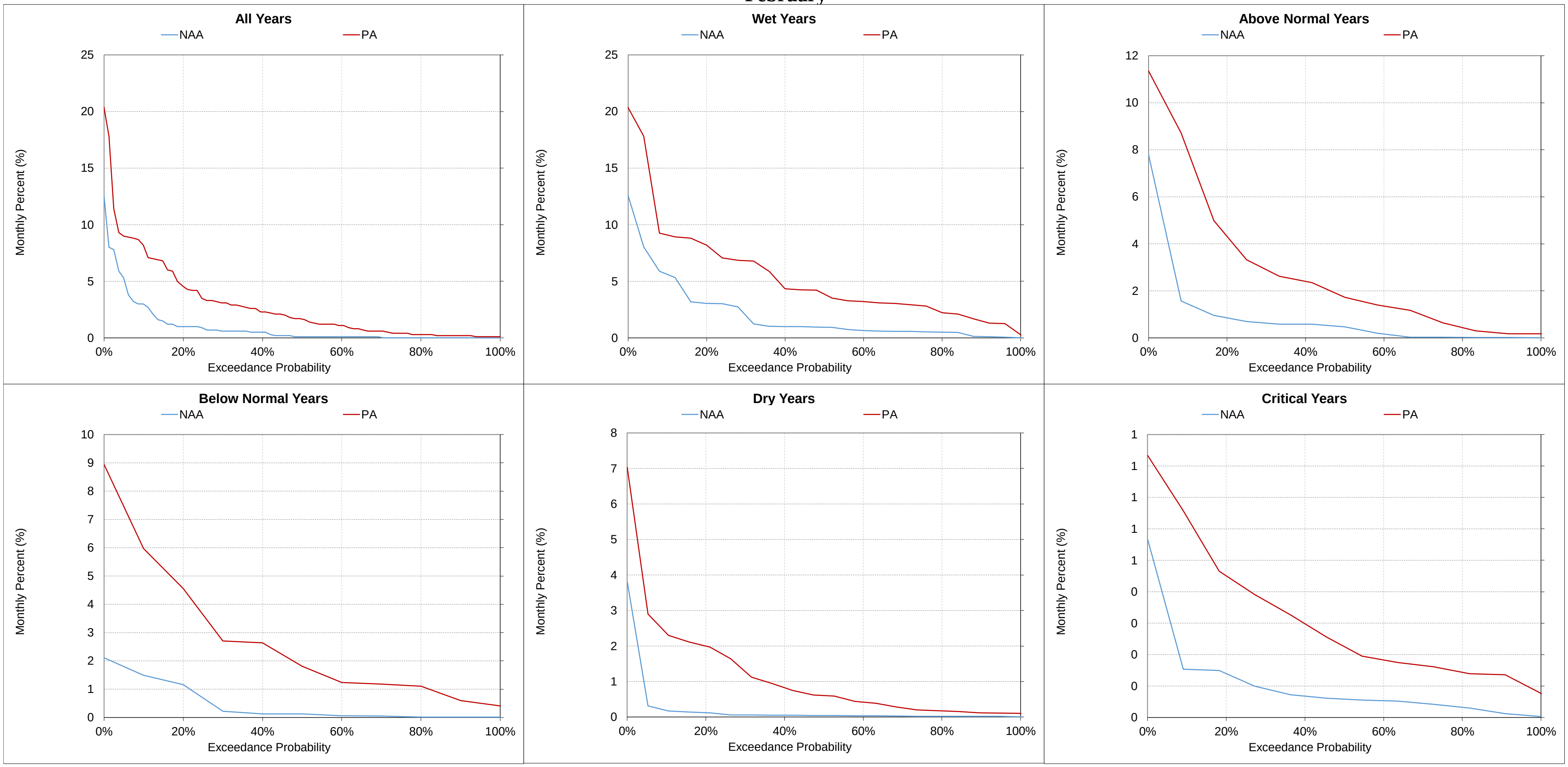
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-22-11. Sacramento River at Collinsville San Joaquin River Volumetric Fingerprinting, Monthly Percent
January



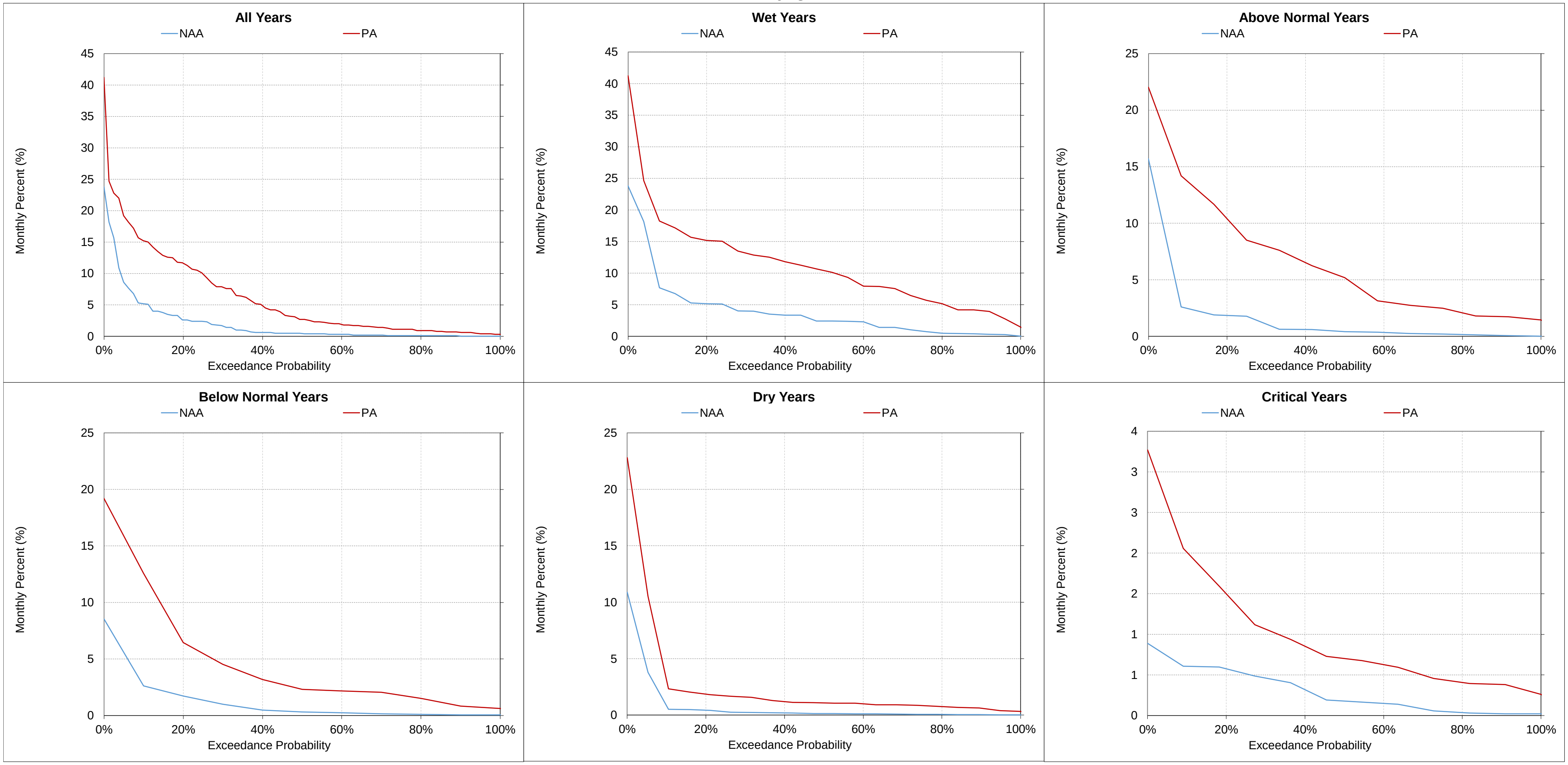
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-22-12. Sacramento River at Collinsville San Joaquin River Volumetric Fingerprinting, Monthly Percent February



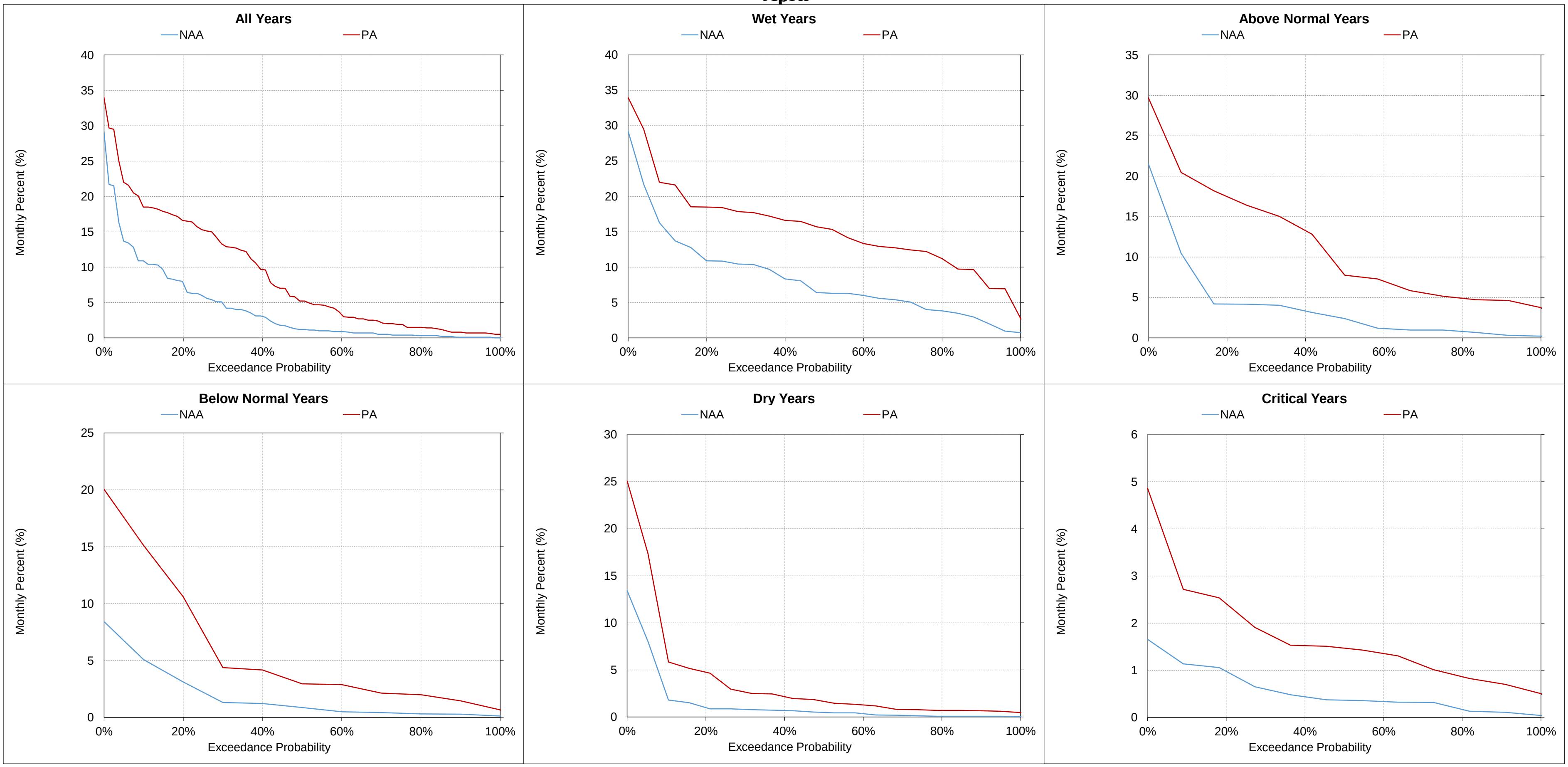
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-22-13. Sacramento River at Collinsville San Joaquin River Volumetric Fingerprinting, Monthly Percent
March



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-22-14. Sacramento River at Collinsville San Joaquin River Volumetric Fingerprinting, Monthly Percent April



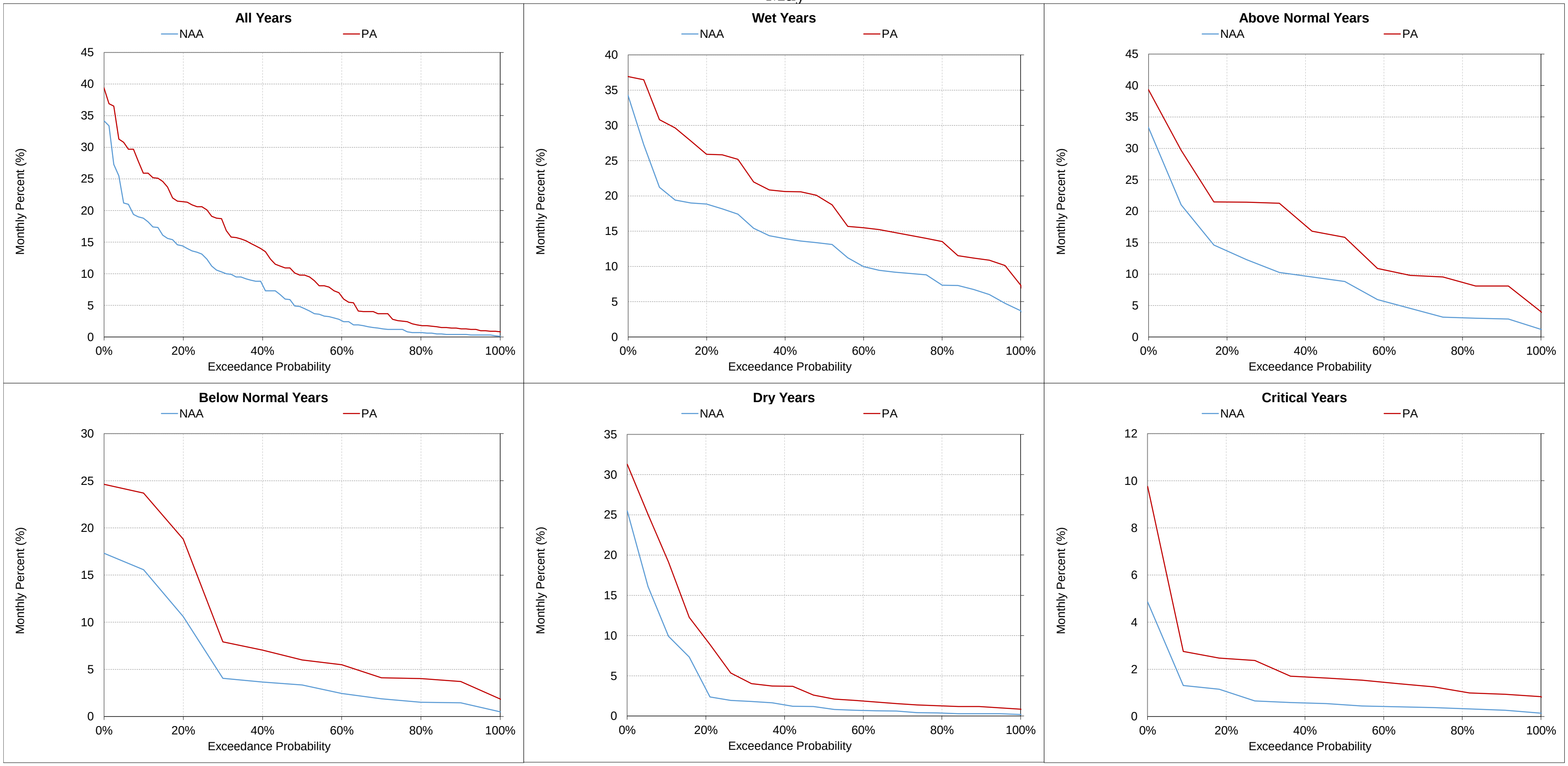
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

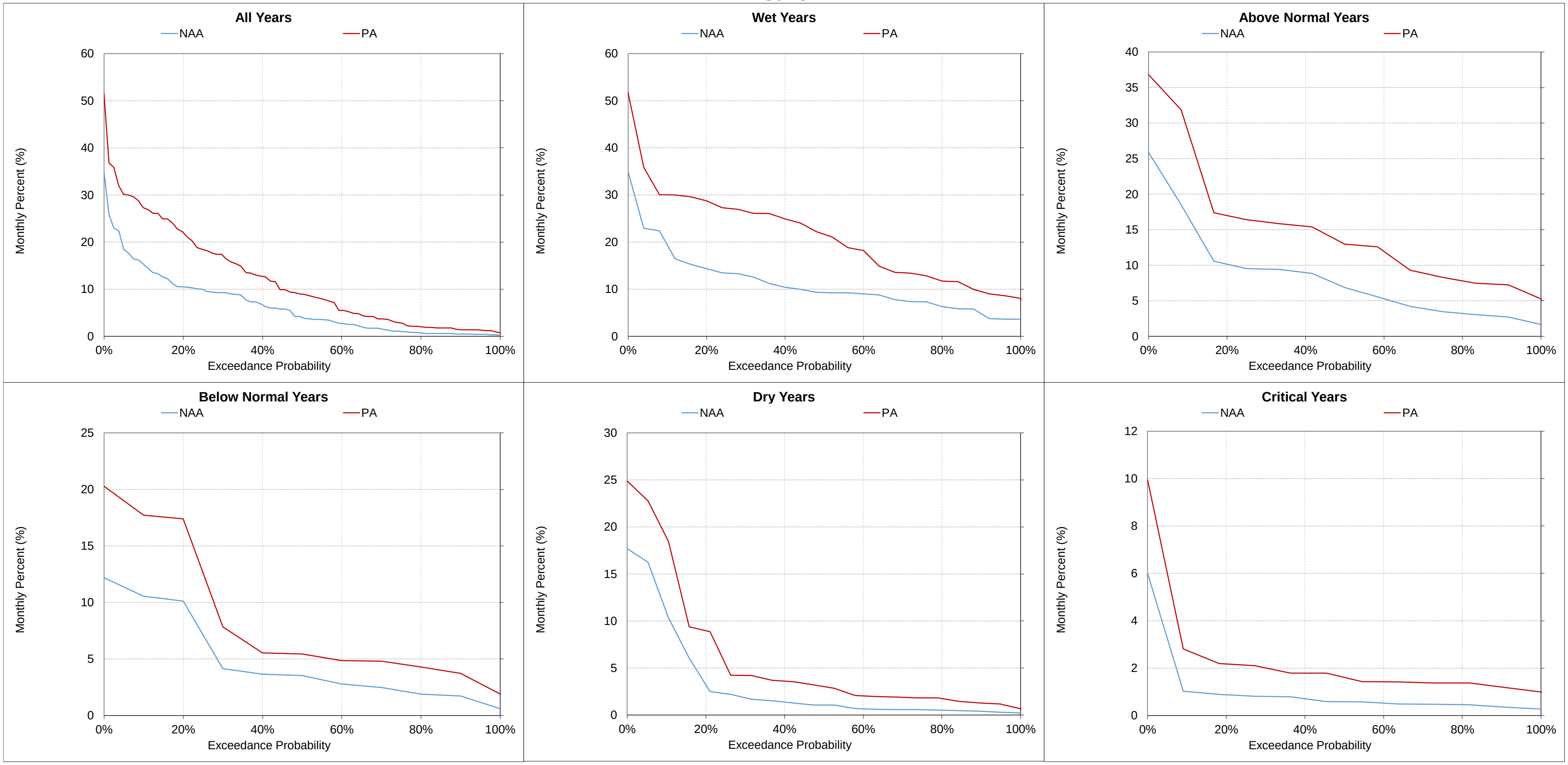
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-22-15. Sacramento River at Collinsville San Joaquin River Volumetric Fingerprinting, Monthly Percent May



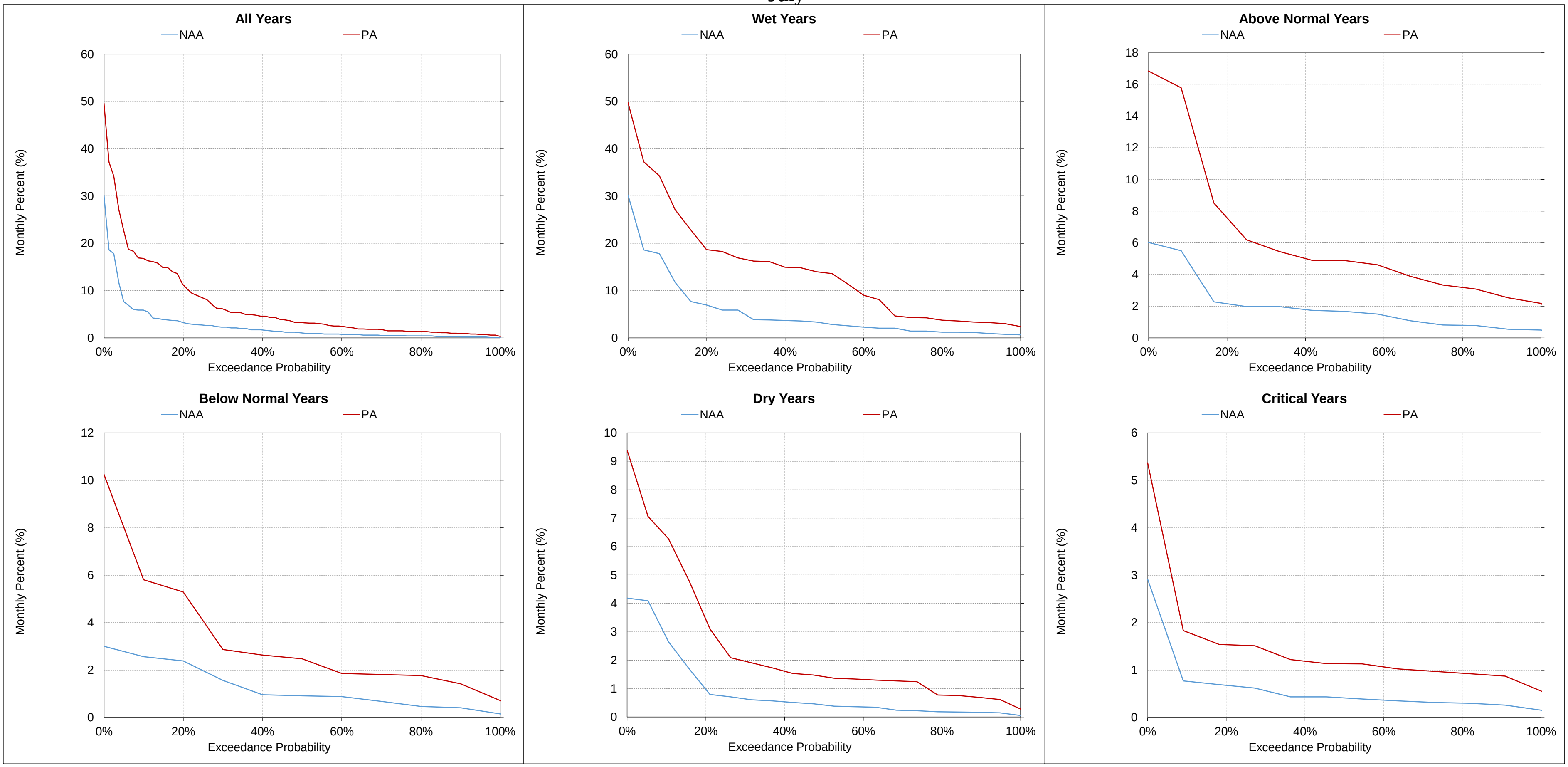
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-22-16. Sacramento River at Collinsville San Joaquin River Volumetric Fingerprinting, Monthly Percent
June



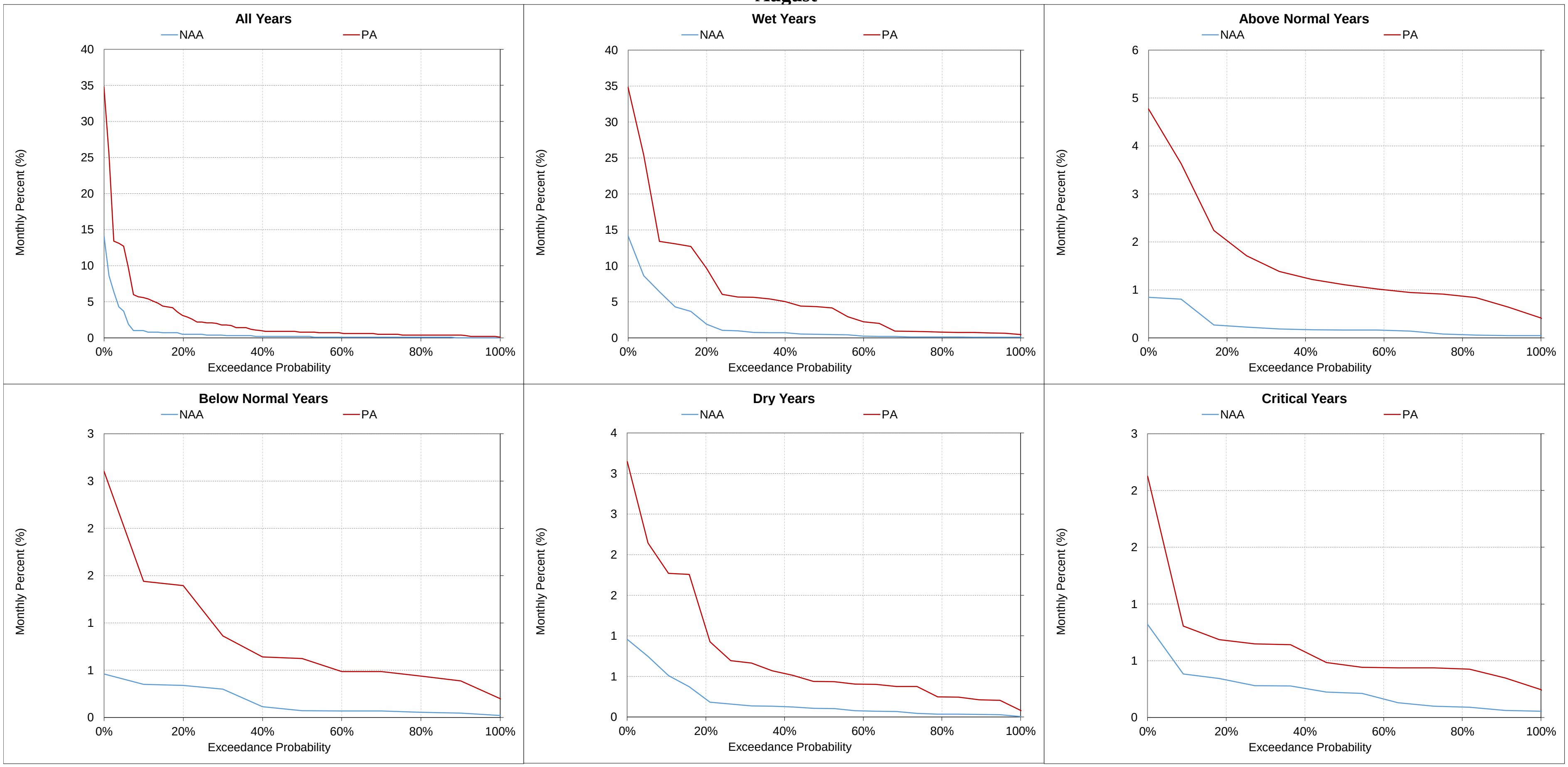
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-22-17. Sacramento River at Collinsville San Joaquin River Volumetric Fingerprinting, Monthly Percent
July



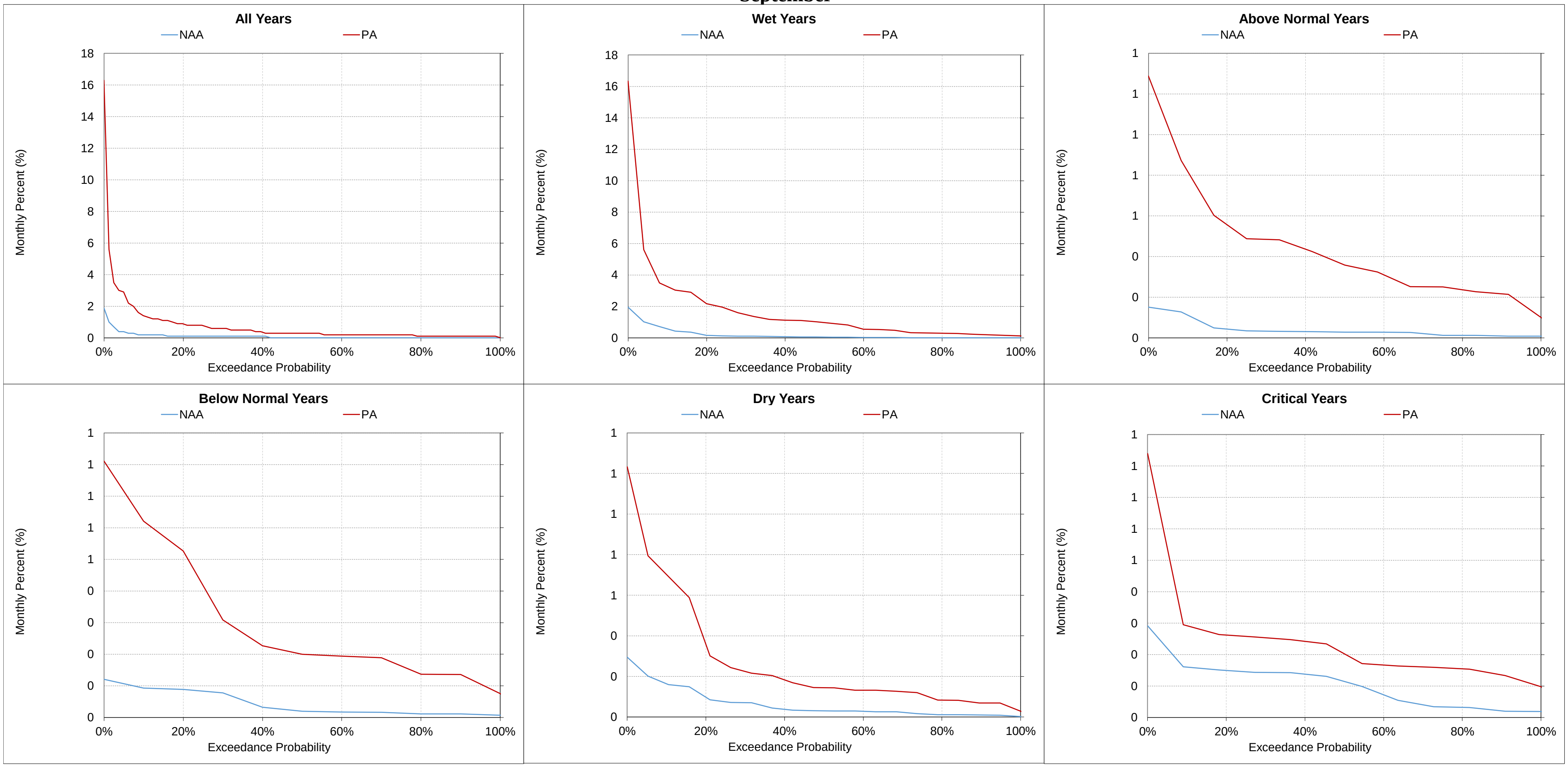
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-22-18. Sacramento River at Collinsville San Joaquin River Volumetric Fingerprinting, Monthly Percent August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-22-19. Sacramento River at Collinsville San Joaquin River Volumetric Fingerprinting, Monthly Percent September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-23. Sacramento River at Collinsville Martinez Volumetric Fingerprinting, Monthly Percent

Statistic	Monthly Percent (%)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	53	46	-6	-12%	54	50	-4	-8%	45	44	-1	-2%	30	27	-3	-10%	13	13	0	-3%	10	10	0	-2%
20%	48	42	-6	-13%	48	43	-5	-11%	36	37	1	4%	26	23	-2	-8%	9	9	-1	-10%	7	7	0	1%
30%	47	41	-7	-14%	45	41	-5	-11%	28	30	2	7%	20	18	-3	-13%	6	7	0	6%	4	4	1	19%
40%	46	39	-7	-15%	37	37	0	1%	24	24	1	3%	15	12	-3	-22%	5	4	0	-5%	3	3	0	8%
50%	41	36	-5	-12%	23	23	-1	-4%	22	23	1	5%	9	9	-1	-9%	2	2	1	31%	2	2	1	33%
60%	21	20	-1	-5%	21	20	-1	-3%	19	19	-1	-3%	4	4	0	-8%	1	1	0	16%	1	1	0	8%
70%	12	11	-1	-5%	14	14	-1	-4%	10	10	0	-1%	1	1	0	10%	0	0	0	0%	0	0	0	-23%
80%	11	11	0	-1%	11	10	-1	-6%	3	6	3	85%	0	0	0	20%	0	0	0	-	0	0	0	-
90%	10	10	0	-1%	9	9	0	-5%	1	1	0	51%	0	0	0	-	0	0	0	-	0	0	0	-
Long Term Full Simulation Period[b]	31	28	-3	-11%	29	28	-2	-6%	21	22	1	3%	12	11	-1	-11%	5	5	0	-4%	4	4	0	7%
Water Year Types[c]																								
Wet (32%)	10	10	0	-1%	10	10	0	-1%	14	14	0	1%	11	7	-4	-35%	0	0	0	-27%	0	0	0	-1%
Above Normal (16%)	20	19	-2	-8%	20	20	0	-2%	18	19	1	3%	14	13	-1	-9%	2	2	0	-3%	1	1	0	-10%
Below Normal (13%)	43	37	-6	-14%	39	36	-3	-8%	25	26	1	4%	12	13	0	2%	7	6	-1	-16%	4	4	0	3%
Dry (24%)	46	40	-6	-13%	40	37	-3	-8%	23	23	1	2%	11	12	0	3%	7	7	0	-6%	5	6	1	15%
Critical (15%)	53	49	-4	-8%	55	51	-3	-6%	35	37	2	5%	15	15	-1	-3%	13	13	0	4%	11	11	0	4%

Statistic	Monthly Percent (%)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	15	14	0	-2%	21	21	0	0%	27	27	0	0%	37	39	2	5%	43	44	2	4%	46	48	2	4%
20%	11	10	0	-1%	18	17	-1	-7%	24	23	0	-1%	33	34	1	4%	39	41	2	6%	44	47	3	8%
30%	7	8	1	8%	15	15	0	-1%	23	22	-1	-3%	31	32	2	5%	35	38	3	9%	42	46	4	9%
40%	5	5	0	2%	10	10	0	-3%	21	21	0	1%	24	28	4	17%	33	37	3	9%	39	45	6	15%
50%	3	3	0	-6%	6	6	0	-2%	18	17	-1	-6%	20	26	6	29%	30	35	5	15%	36	43	6	18%
60%	1	1	0	0%	4	4	0	-5%	16	16	0	-3%	19	23	4	22%	28	33	4	15%	17	18	0	2%
70%	1	1	0	-4%	2	2	0	-4%	13	12	-1	-7%	16	21	5	28%	27	31	4	13%	12	12	1	5%
80%	0	0	0	-17%	1	1	0	12%	9	8	-1	-10%	14	19	4	29%	26	30	4	17%	9	9	0	5%
90%	0	0	0	-	0	0	0	-	2	2	0	22%	13	15	2	16%	24	29	4	18%	8	8	1	8%
Long Term Full Simulation Period[b]	5	5	0	0%	9	9	0	-3%	18	17	0	-2%	23	27	3	13%	32	35	4	11%	28	30	2	8%
Water Year Types[c]																								
Wet (32%)	1	1	0	-4%	2	2	0	-3%	8	8	0	-4%	14	17	3	19%	28	31	4	13%	8	9	1	10%
Above Normal (16%)	2	1	0	-6%	4	4	0	-3%	16	15	0	-2%	17	23	6	34%	26	30	5	18%	18	18	0	2%
Below Normal (13%)	7	7	0	2%	11	10	0	-3%	20	19	-1	-3%	21	26	6	27%	28	33	5	17%	39	44	6	15%
Dry (24%)	7	7	0	3%	13	13	-1	-6%	21	20	0	-2%	32	34	2	6%	36	39	3	8%	43	47	4	10%
Critical (15%)	15	15	0	-1%	24	24	0	0%	32	32	0	0%	39	40	1	2%	44	45	2	4%	46	48	2	4%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-23-1. Monthly Percent Ranges For Sacramento River at Collinsville Martinez Volumetric Fingerprinting, All Years

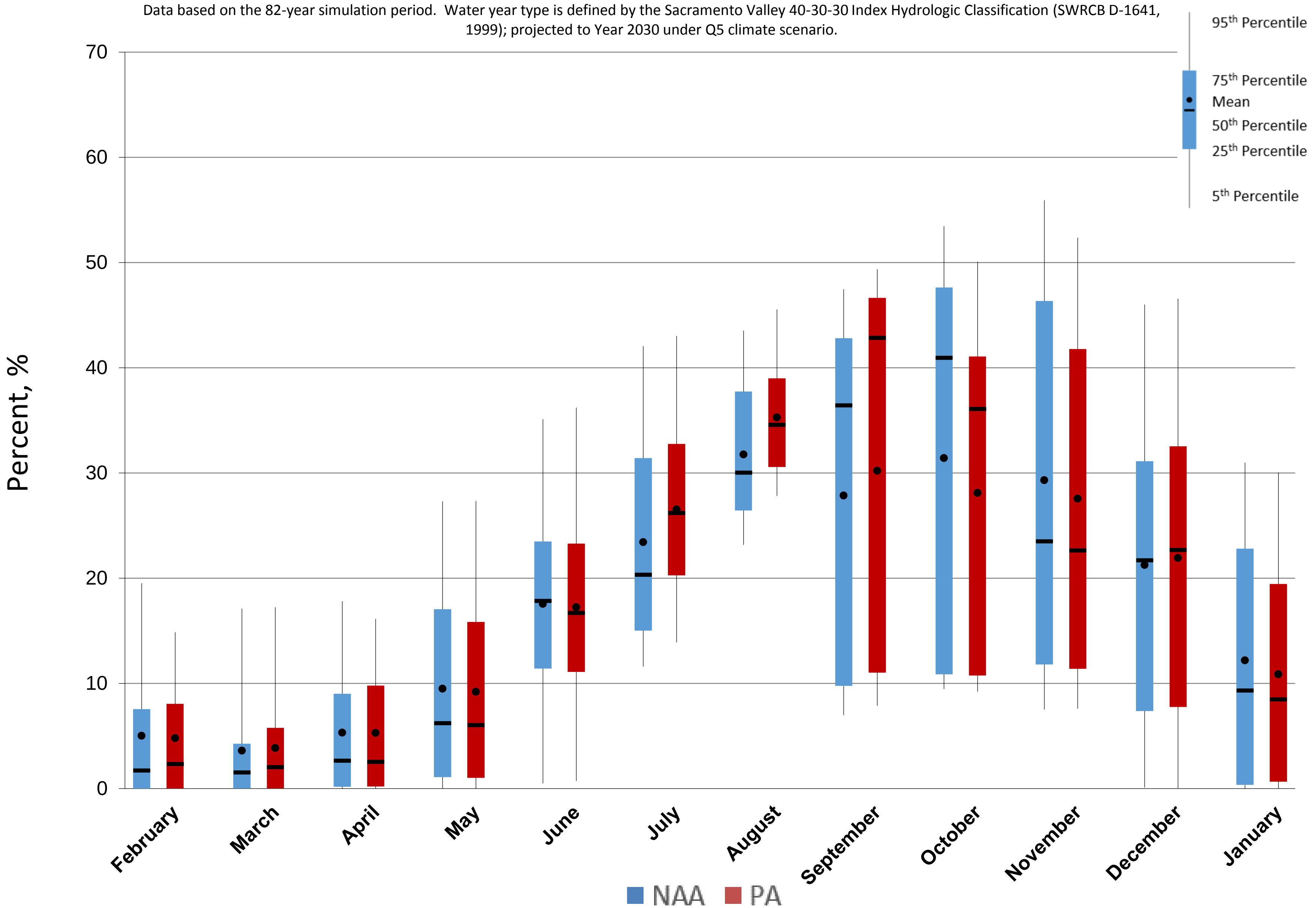


Figure 5.B.5-23-2. Monthly Percent Ranges For Sacramento River at Collinsville Martinez Volumetric Fingerprinting, Wet Years

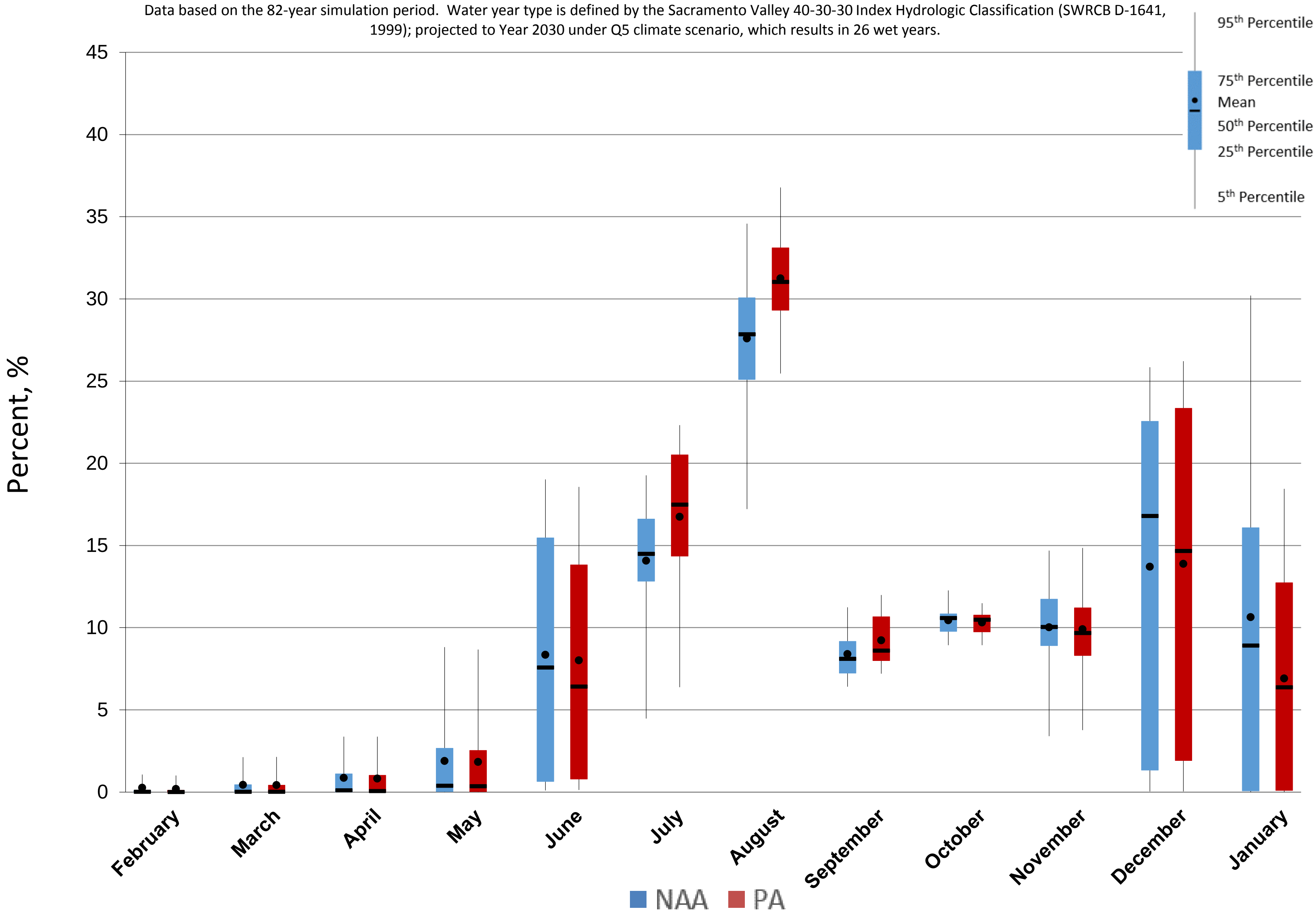


Figure 5.B.5-23-3. Monthly Percent Ranges For Sacramento River at Collinsville Martinez Volumetric Fingerprinting, Above Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 13 above normal years.

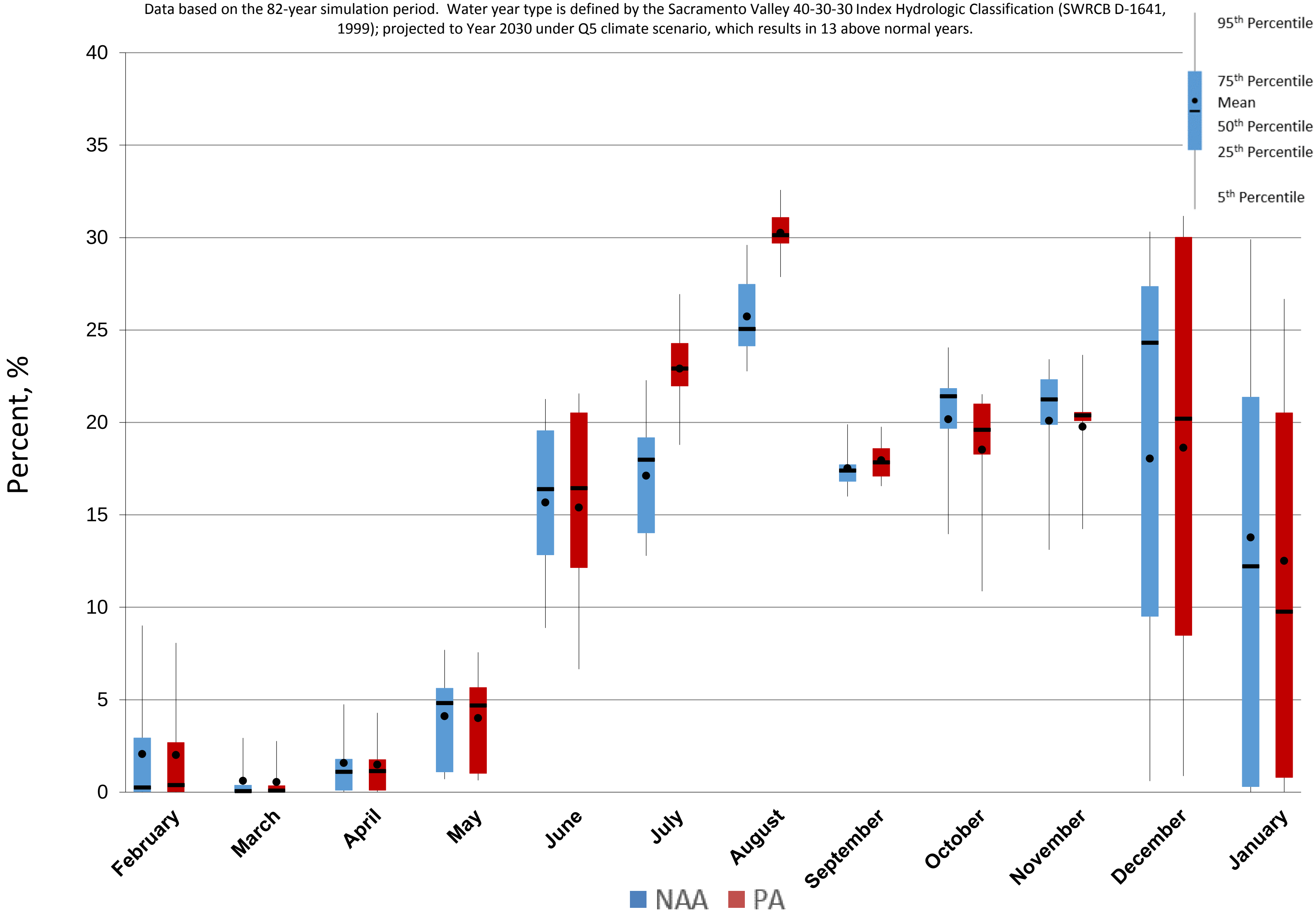


Figure 5.B.5-23-4. Monthly Percent Ranges For Sacramento River at Collinsville Martinez Volumetric Fingerprinting, Below Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 11 below normal years.

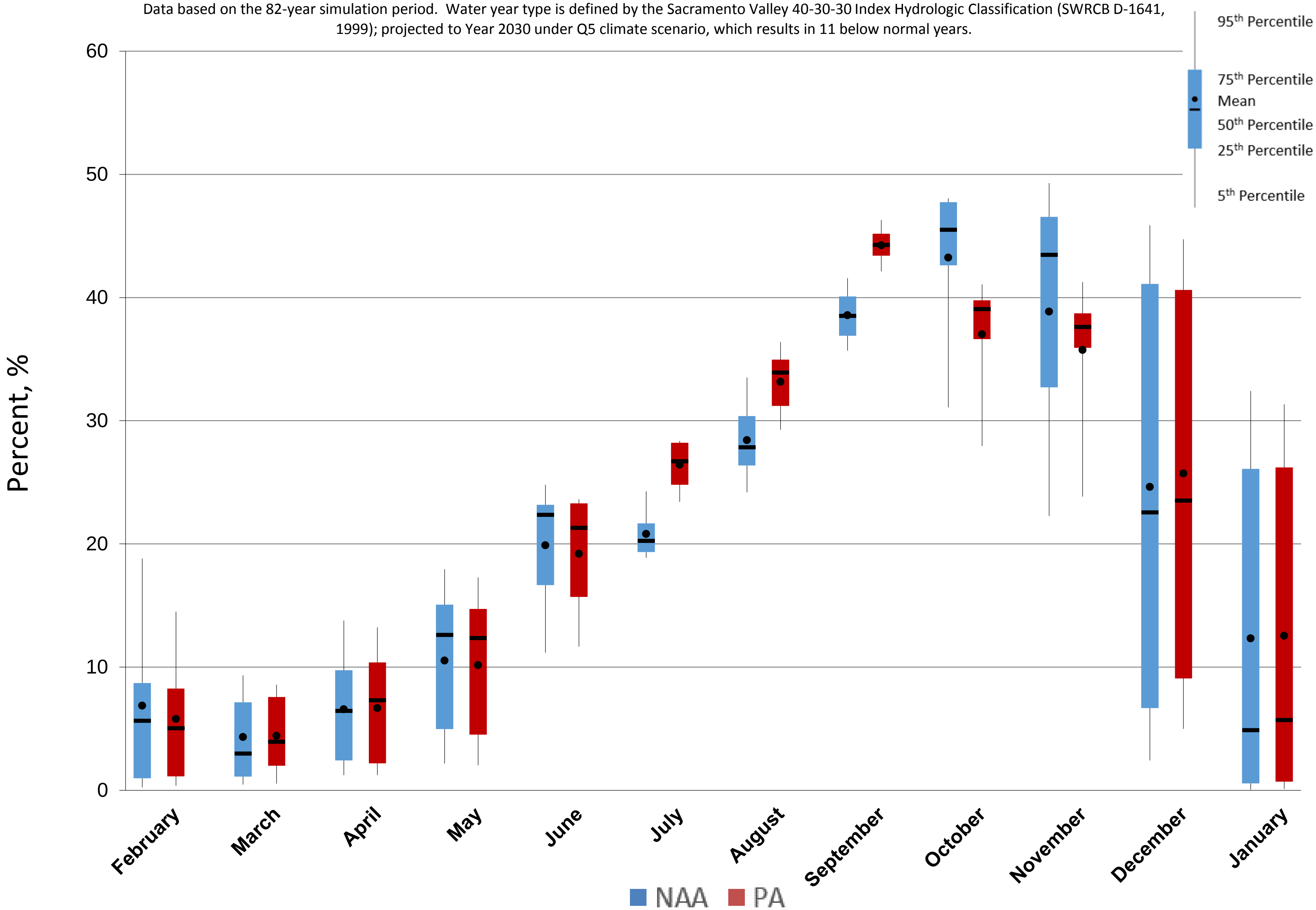


Figure 5.B.5-23-5. Monthly Percent Ranges For Sacramento River at Collinsville Martinez Volumetric Fingerprinting, Dry Years

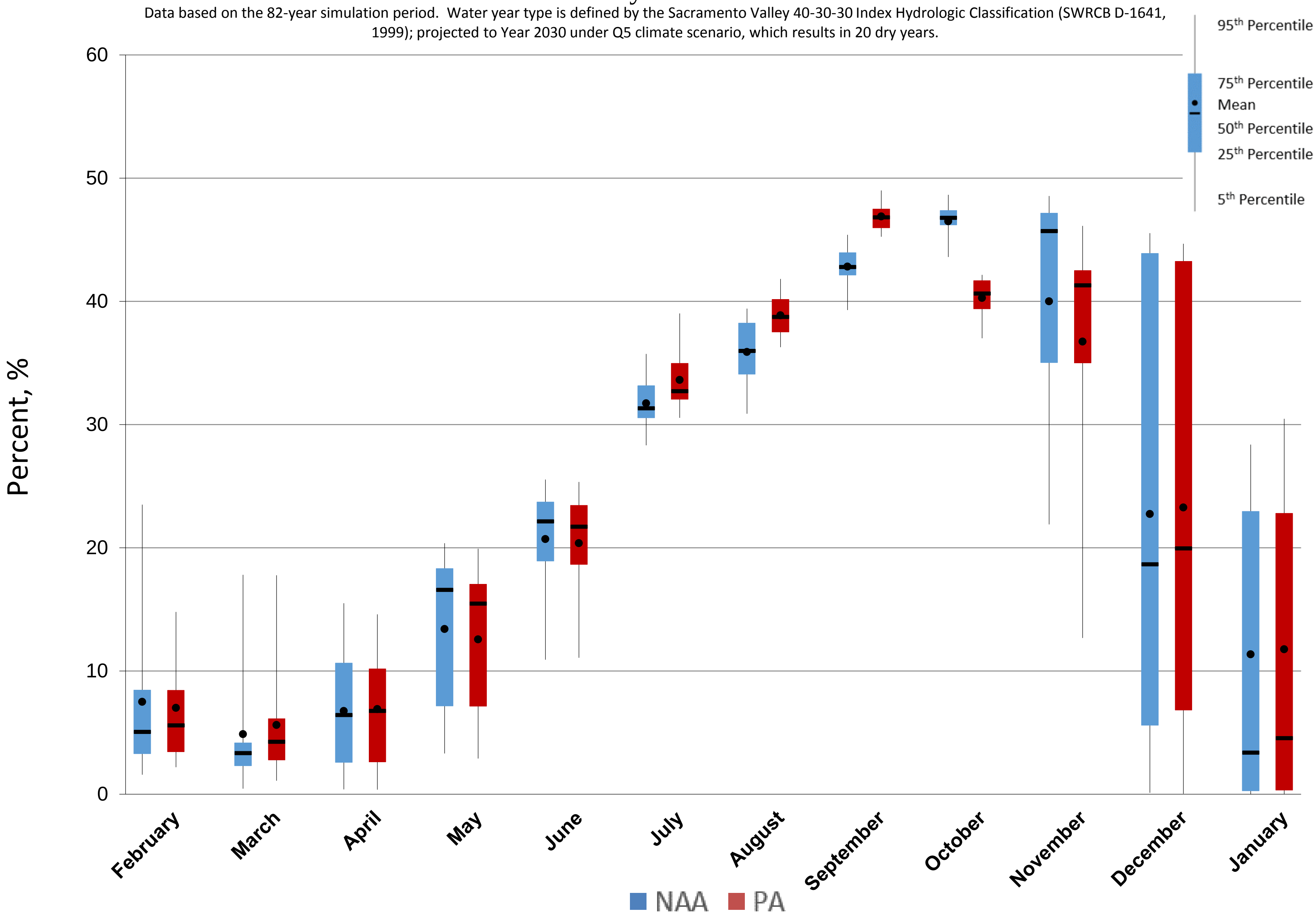


Figure 5.B.5-23-6. Monthly Percent Ranges For Sacramento River at Collinsville Martinez Volumetric Fingerprinting, Critical Years

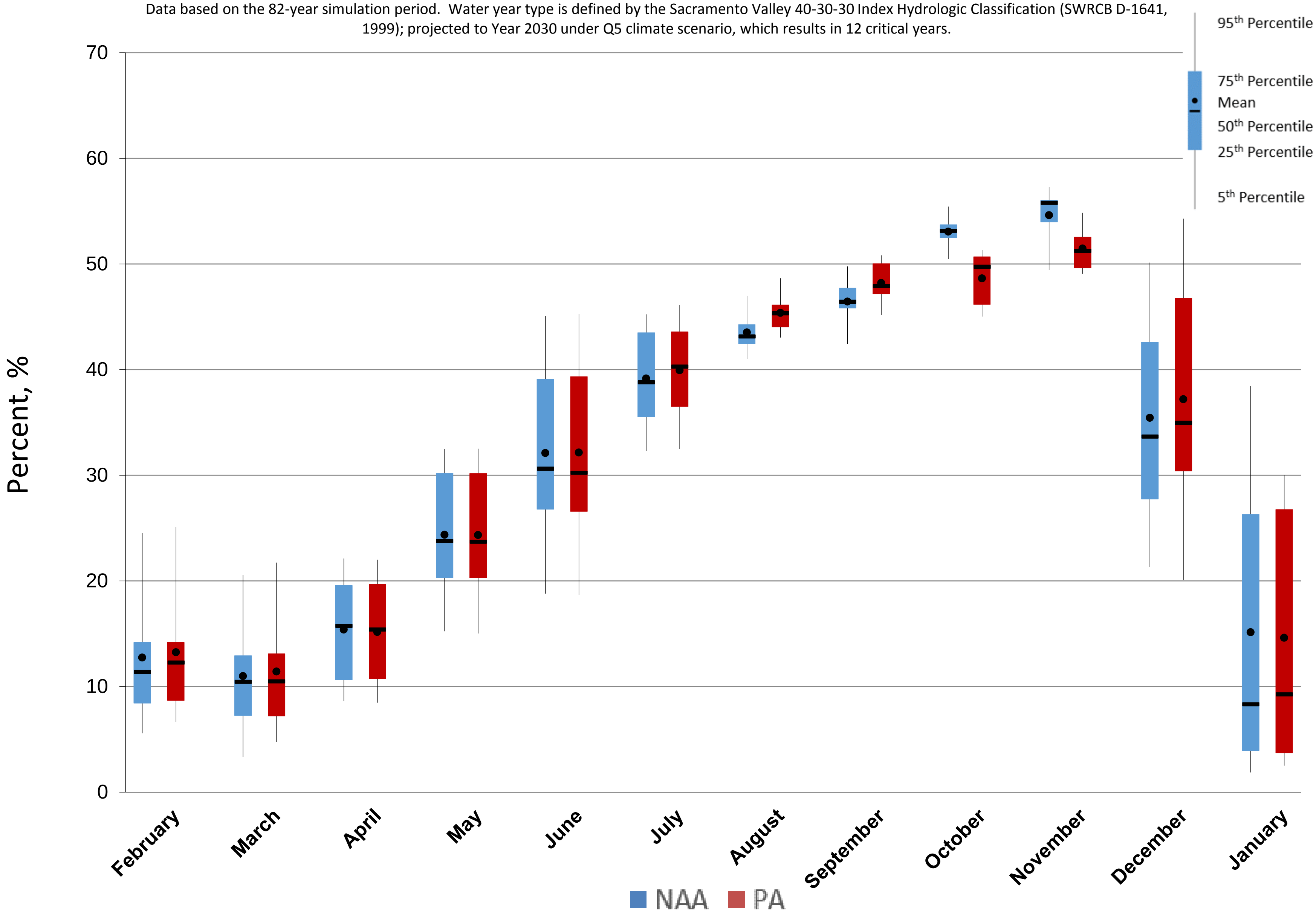
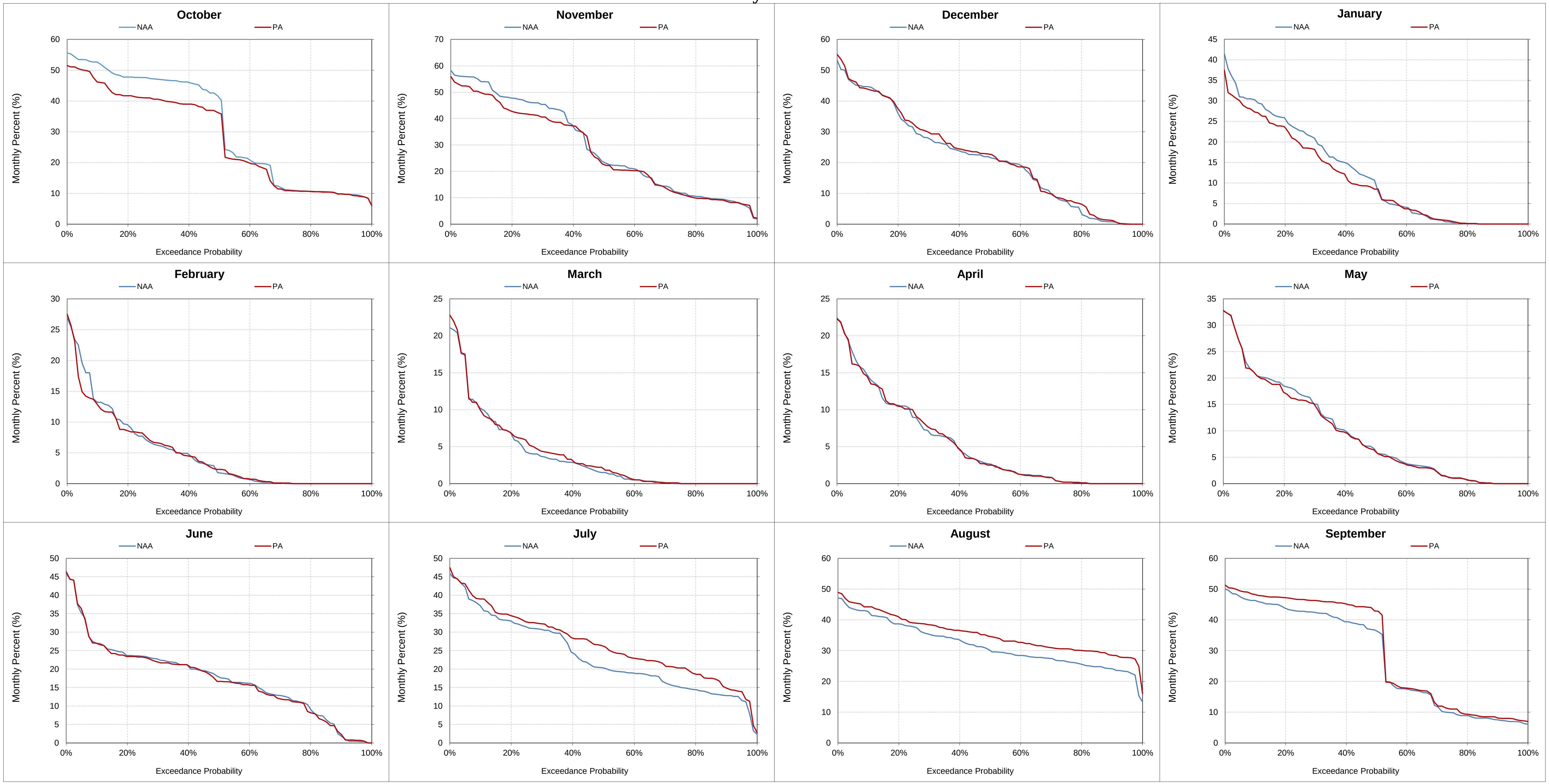
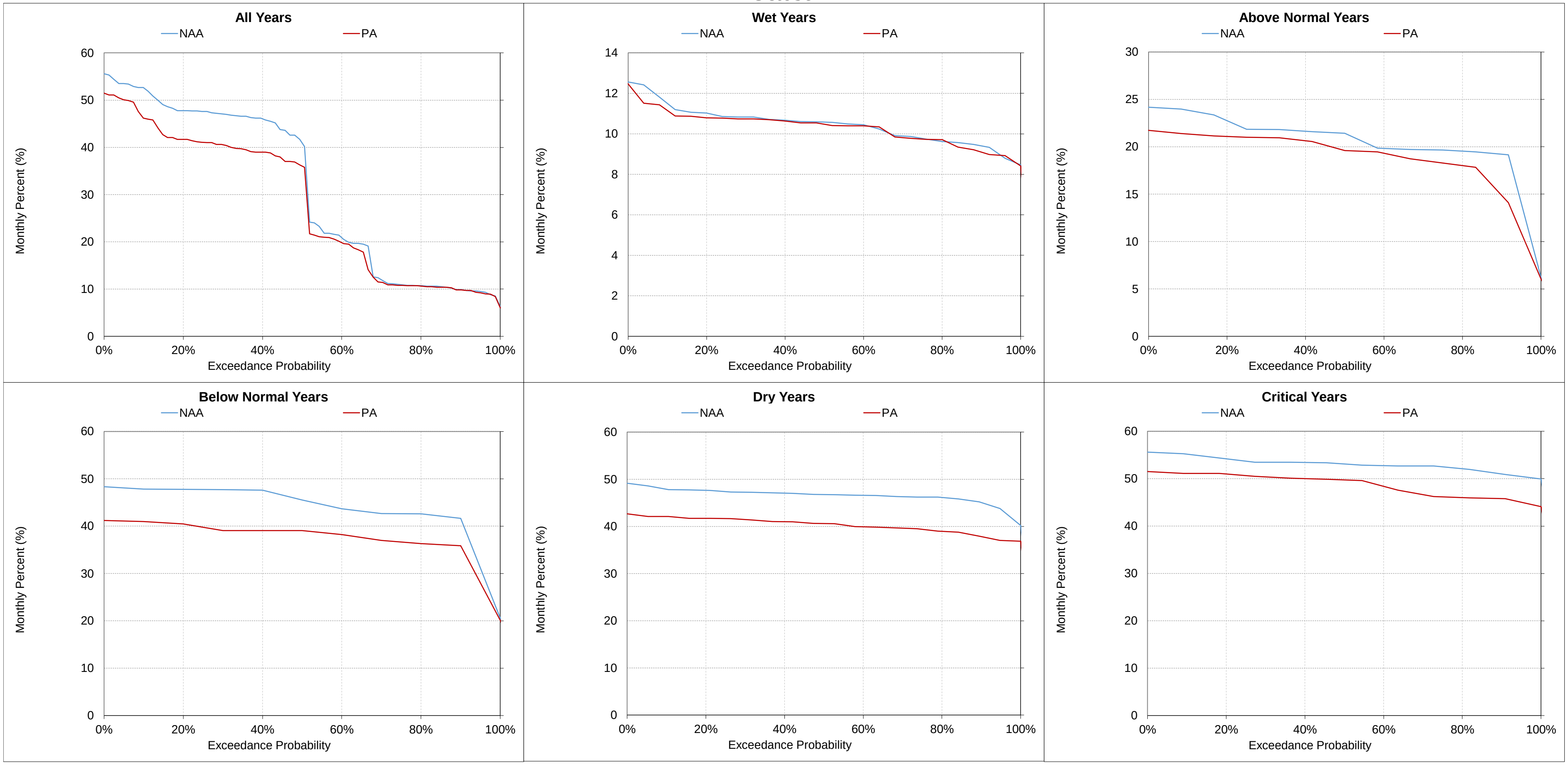


Figure 5.B.5-23-7. Sacramento River at Collinsville Martinez Volumetric Fingerprinting, Monthly Percent Probability of Exceedance



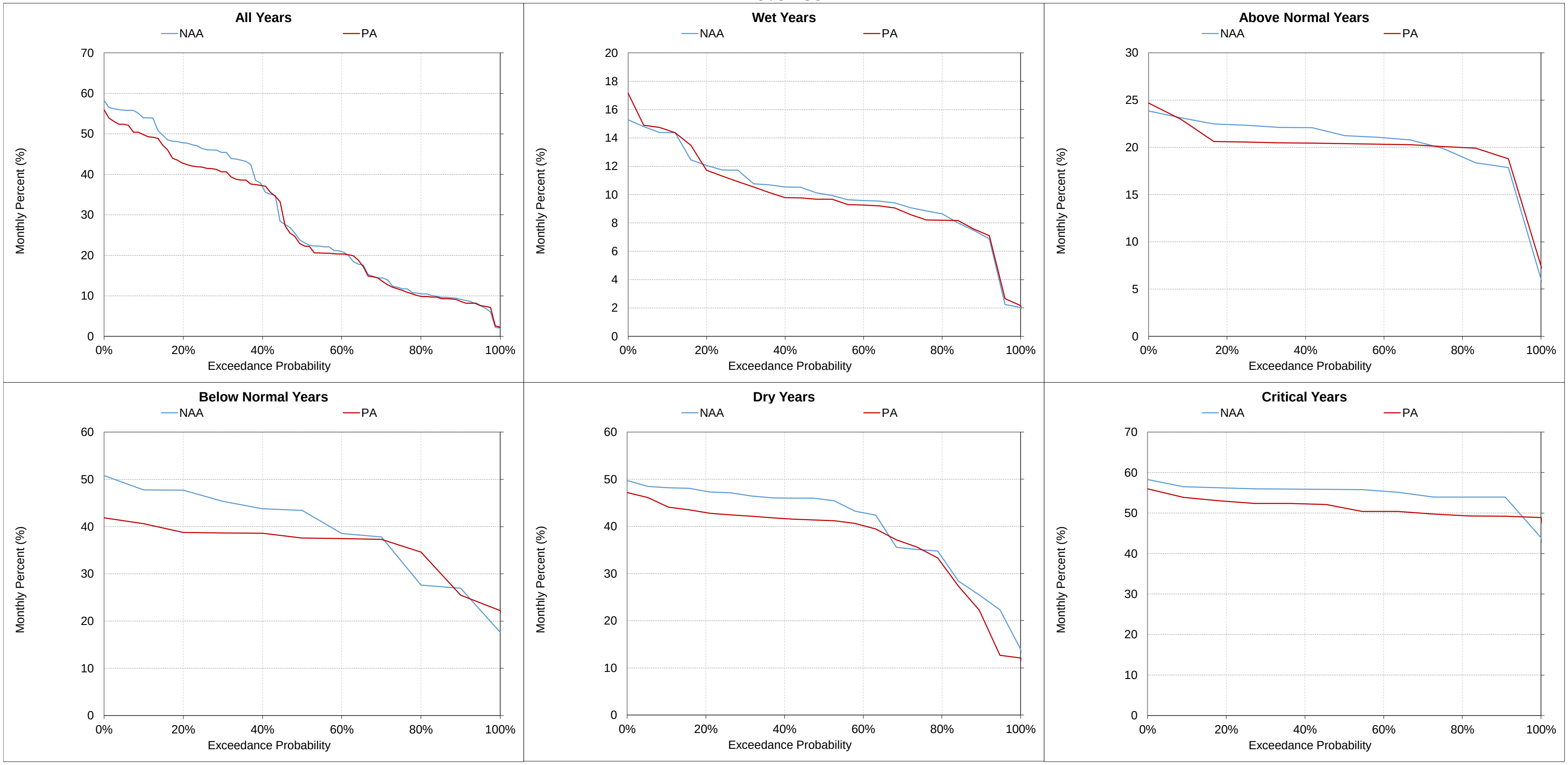
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-23-8. Sacramento River at Collinsville Martinez Volumetric Fingerprinting, Monthly Percent October



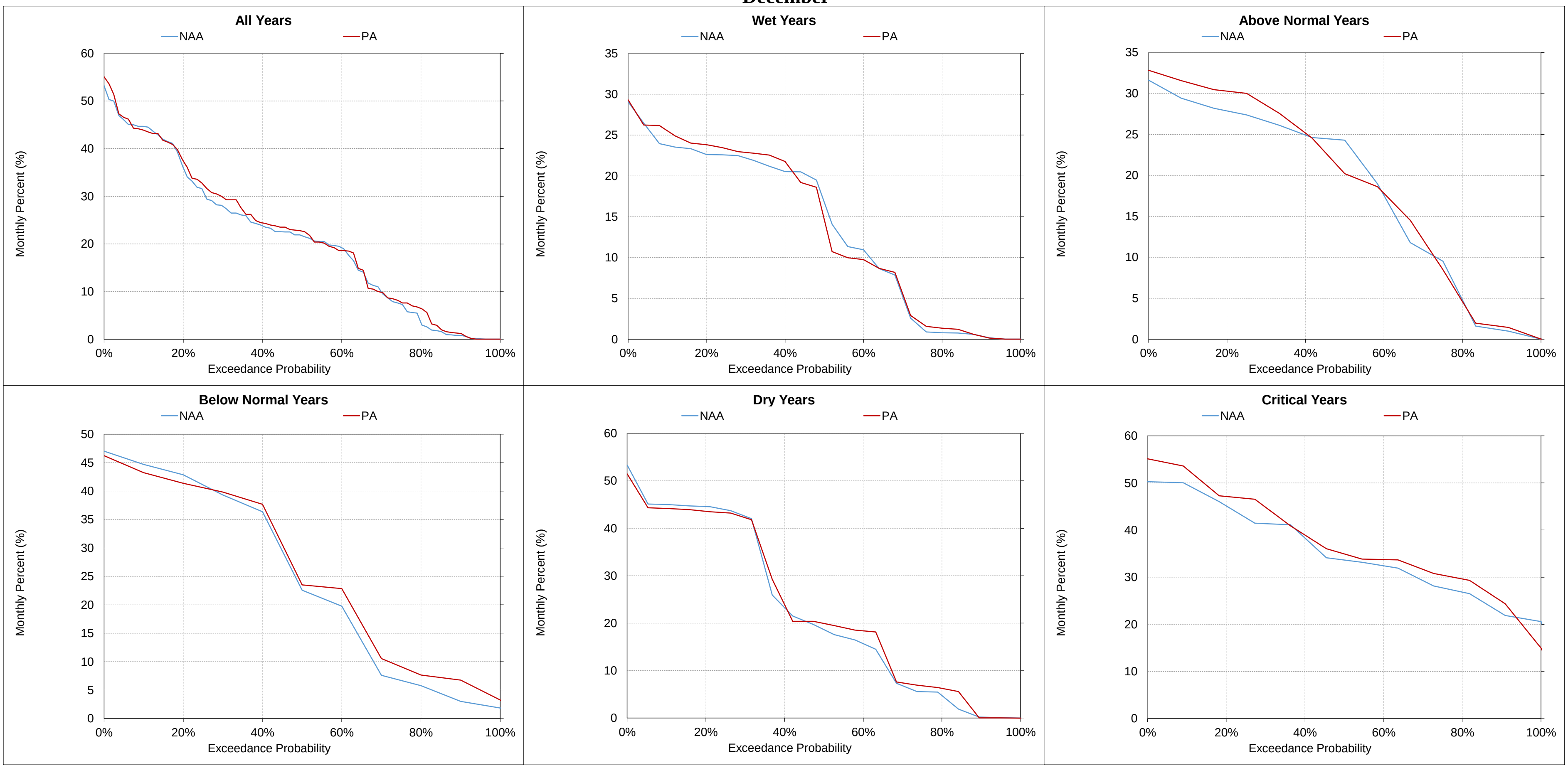
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-23-9. Sacramento River at Collinsville Martinez Volumetric Fingerprinting, Monthly Percent November



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-23-10. Sacramento River at Collinsville Martinez Volumetric Fingerprinting, Monthly Percent December



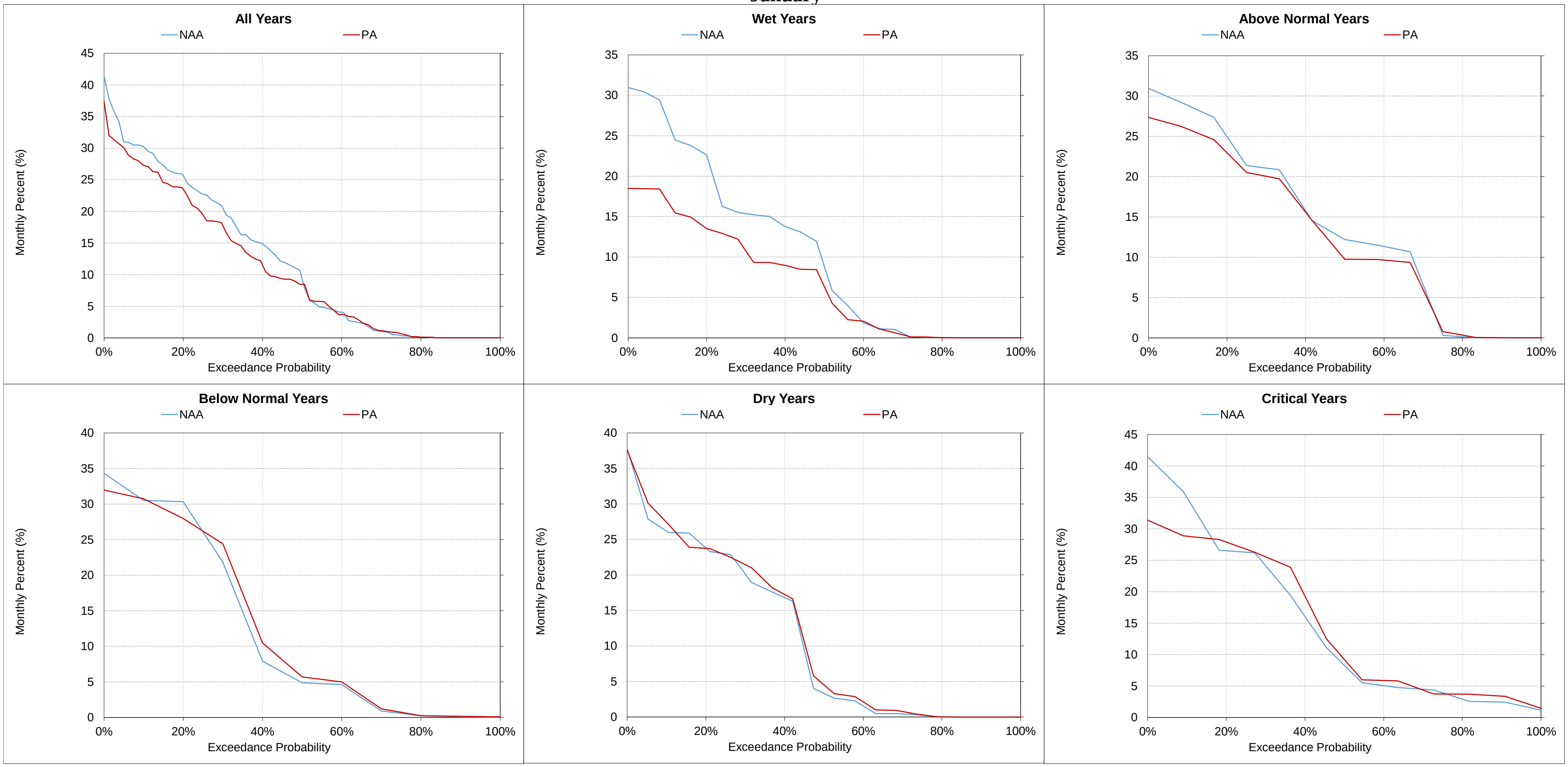
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

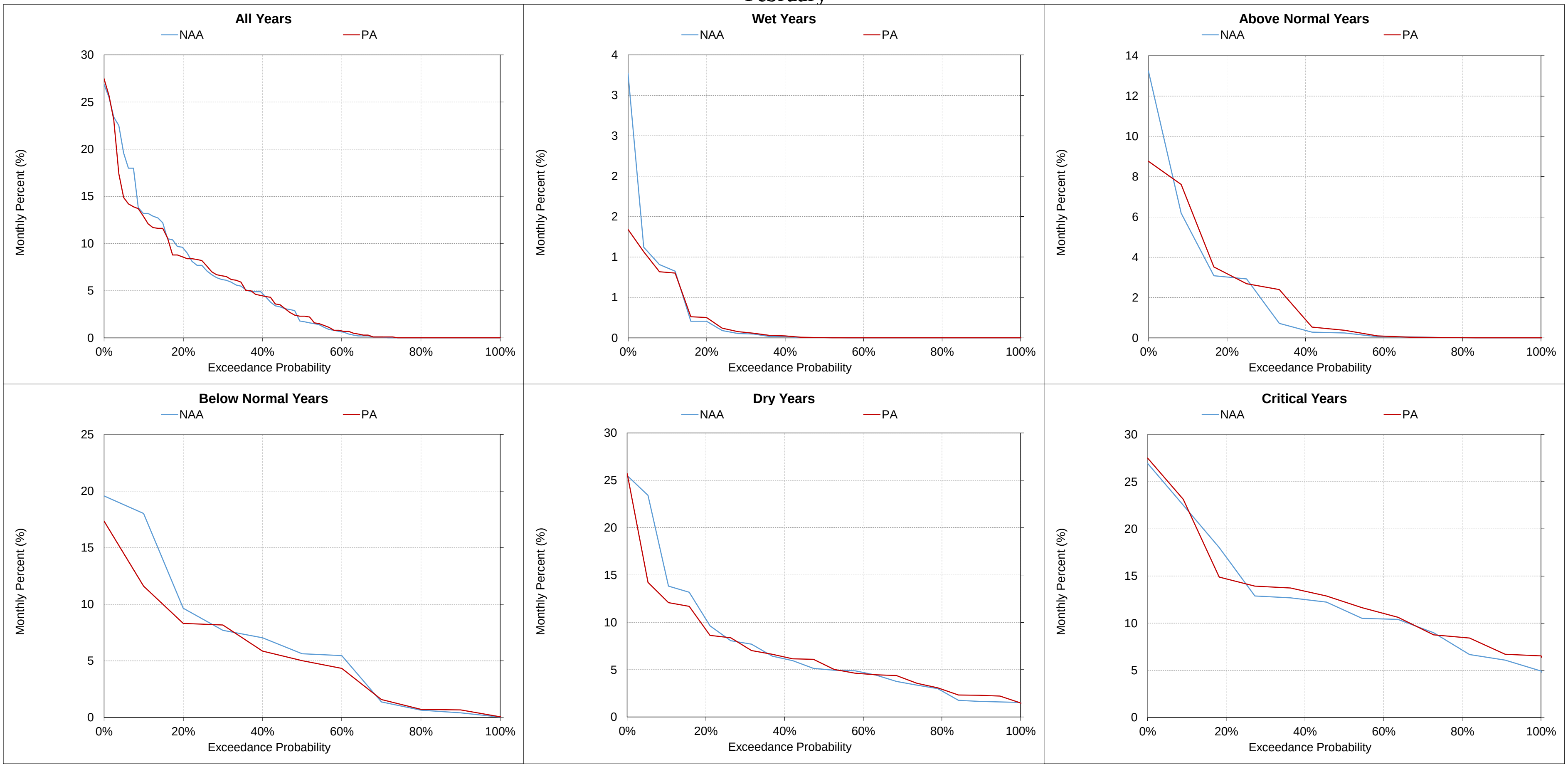
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-23-11. Sacramento River at Collinsville Martinez Volumetric Fingerprinting, Monthly Percent
January



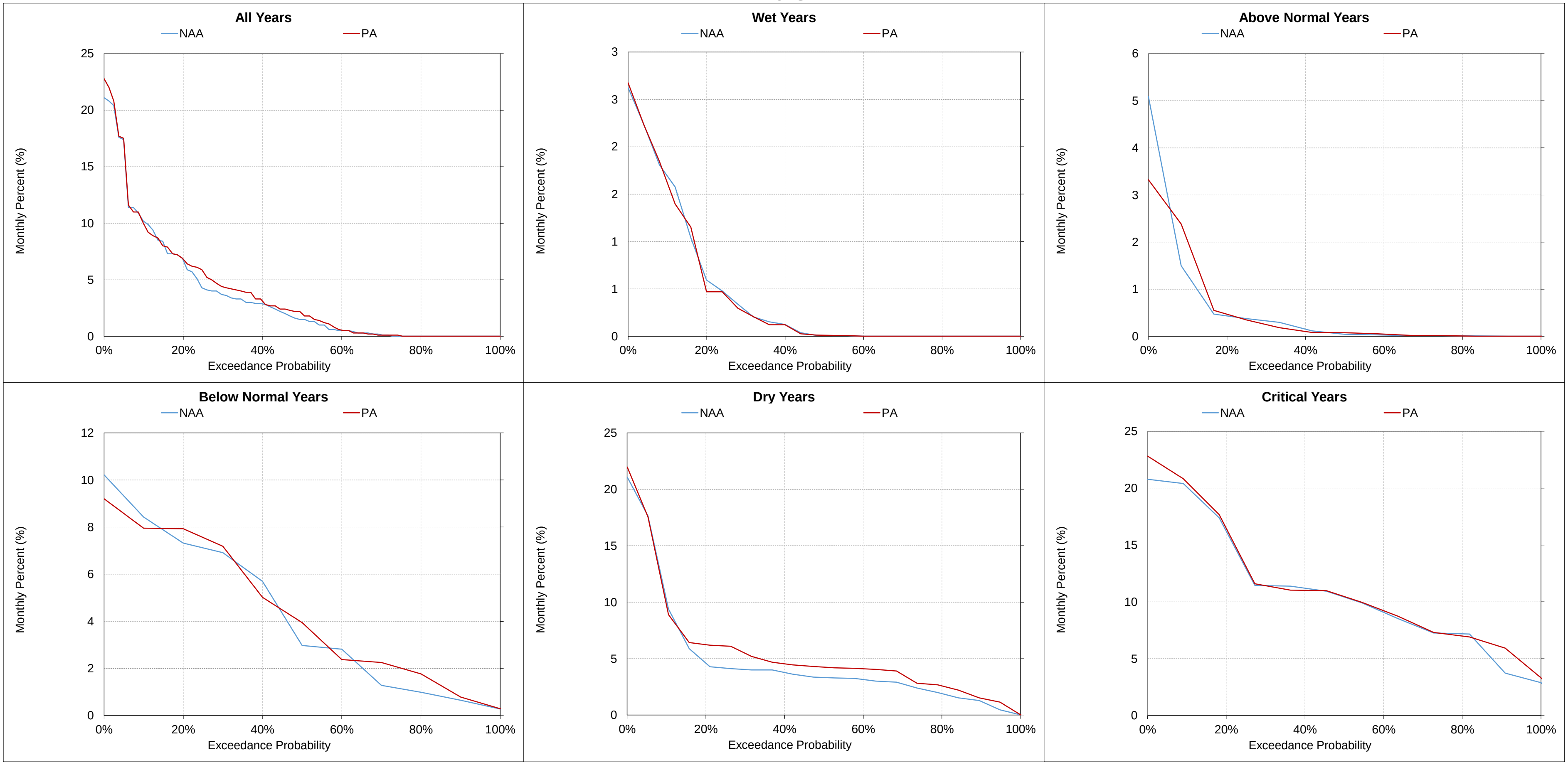
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-23-12. Sacramento River at Collinsville Martinez Volumetric Fingerprinting, Monthly Percent February



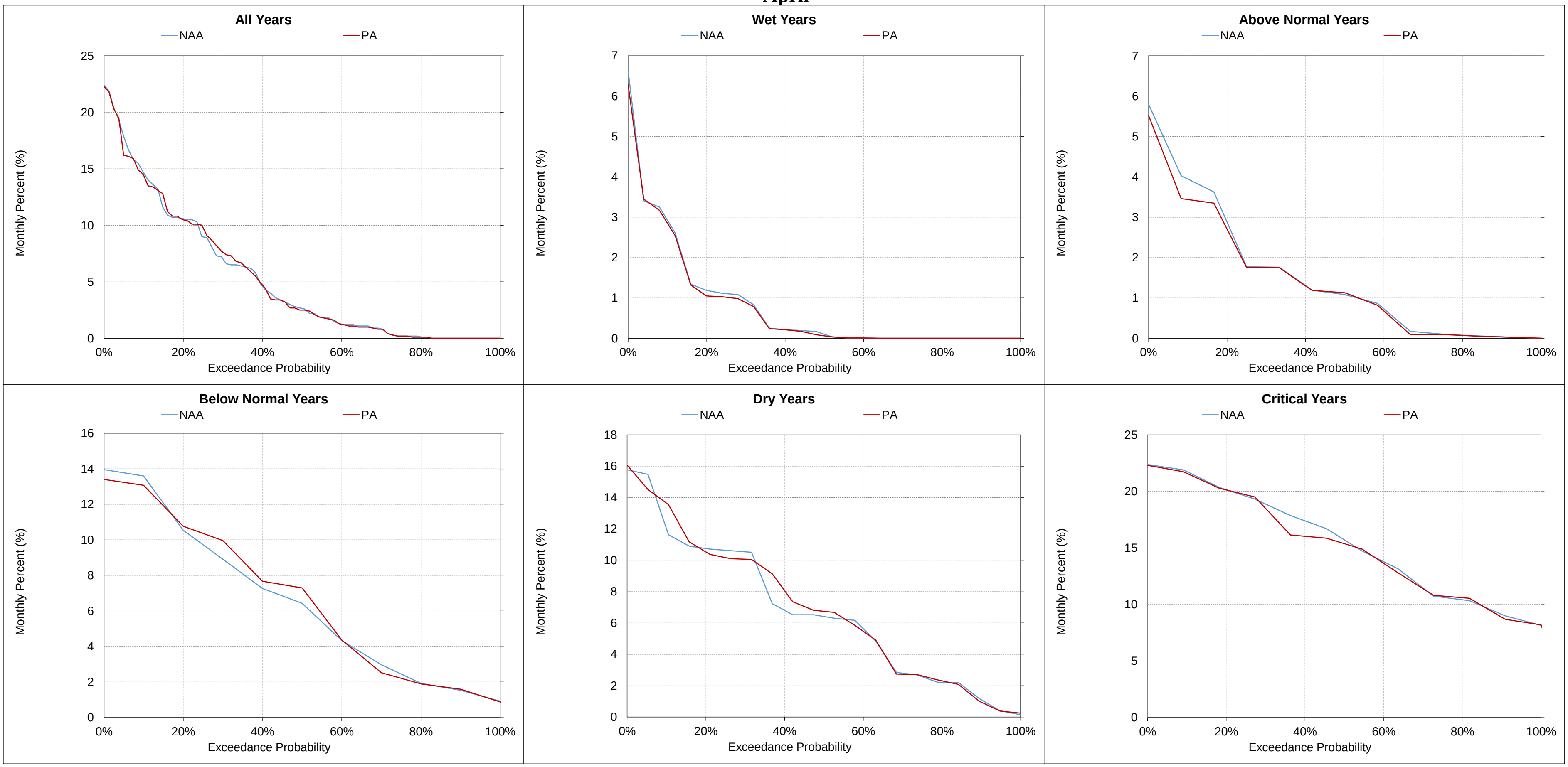
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-23-13. Sacramento River at Collinsville Martinez Volumetric Fingerprinting, Monthly Percent
March



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-23-14. Sacramento River at Collinsville Martinez Volumetric Fingerprinting, Monthly Percent April



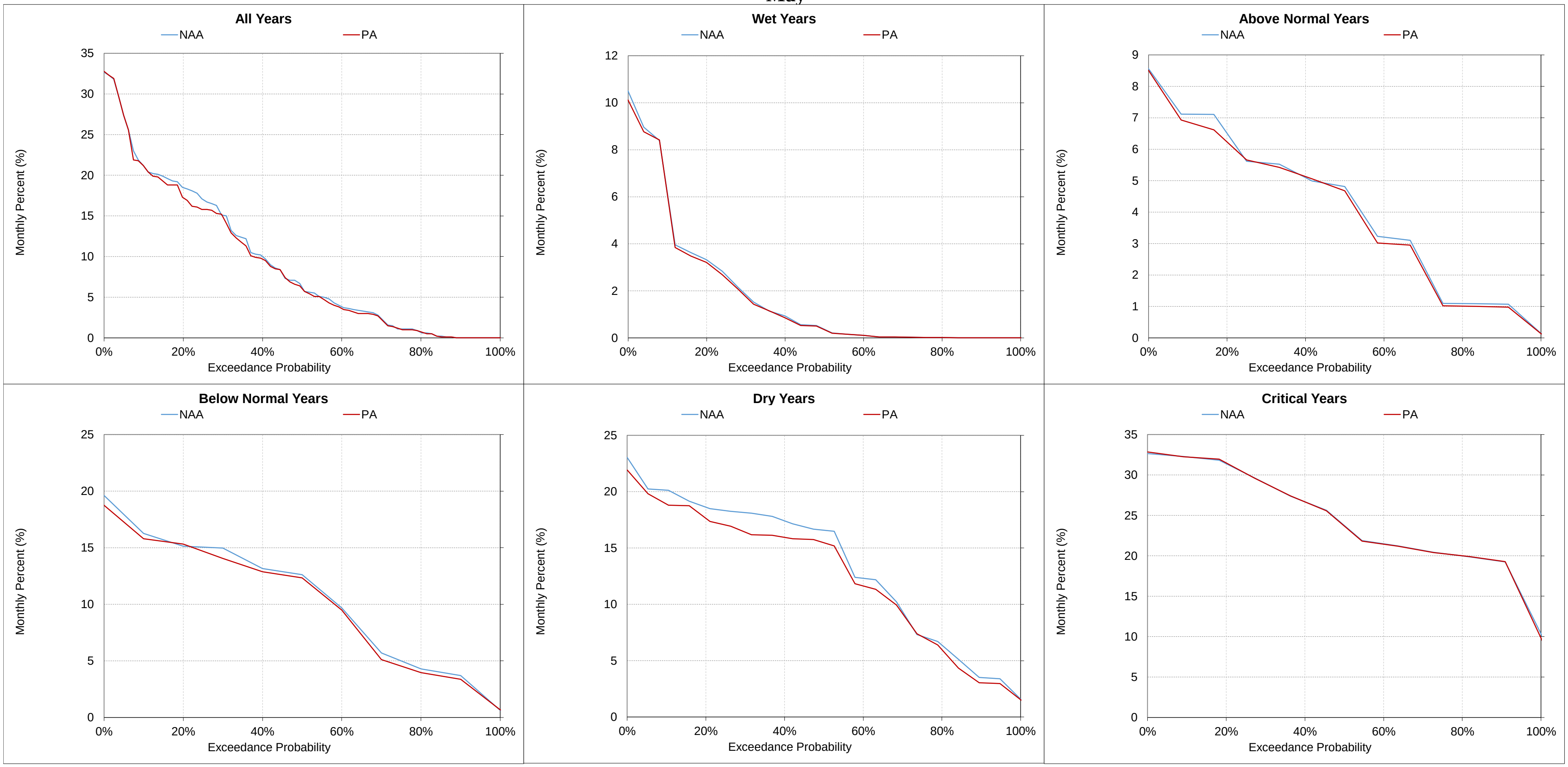
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

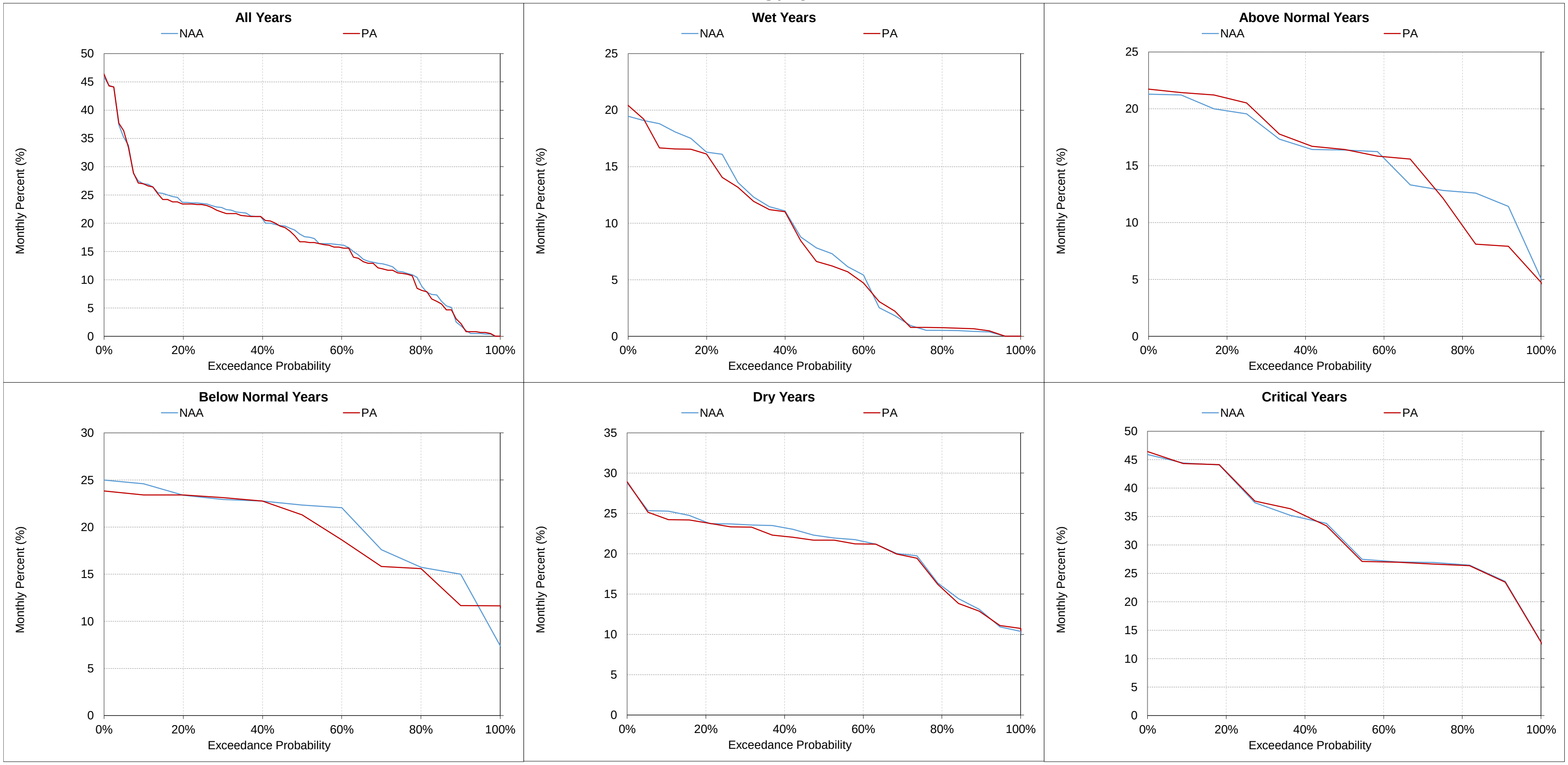
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-23-15. Sacramento River at Collinsville Martinez Volumetric Fingerprinting, Monthly Percent May



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-23-16. Sacramento River at Collinsville Martinez Volumetric Fingerprinting, Monthly Percent
June



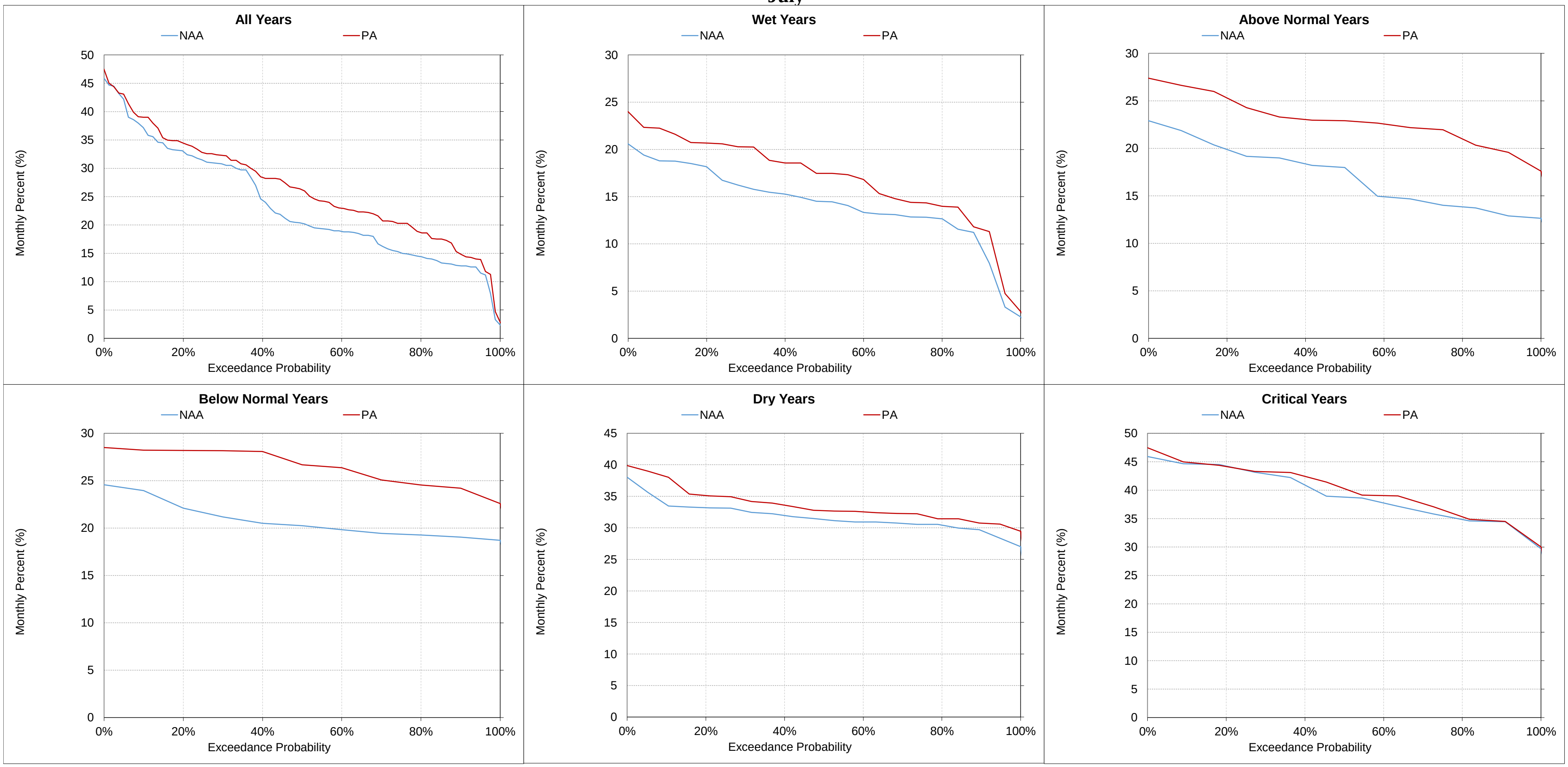
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

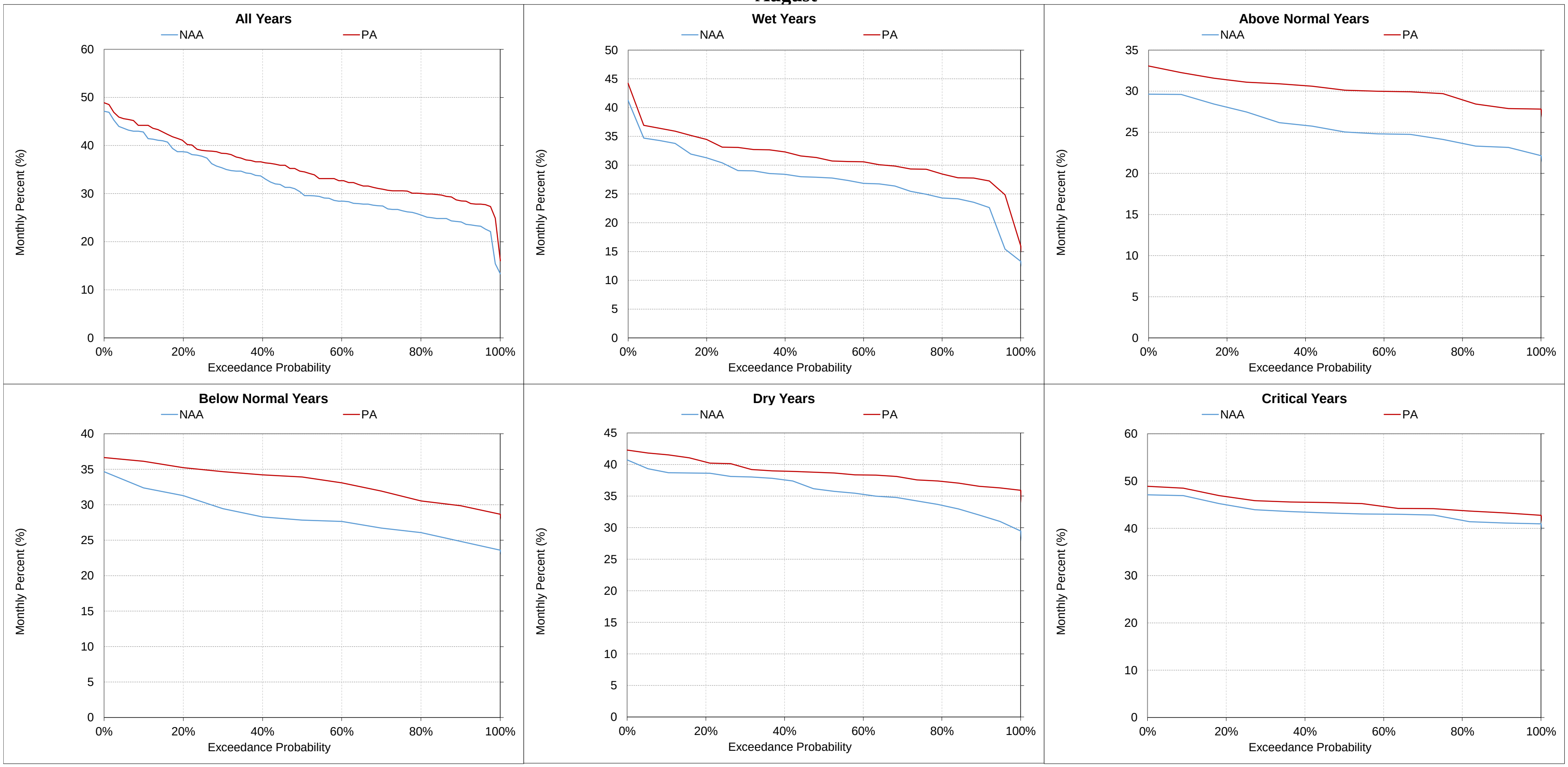
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-23-17. Sacramento River at Collinsville Martinez Volumetric Fingerprinting, Monthly Percent
July



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-23-18. Sacramento River at Collinsville Martinez Volumetric Fingerprinting, Monthly Percent August



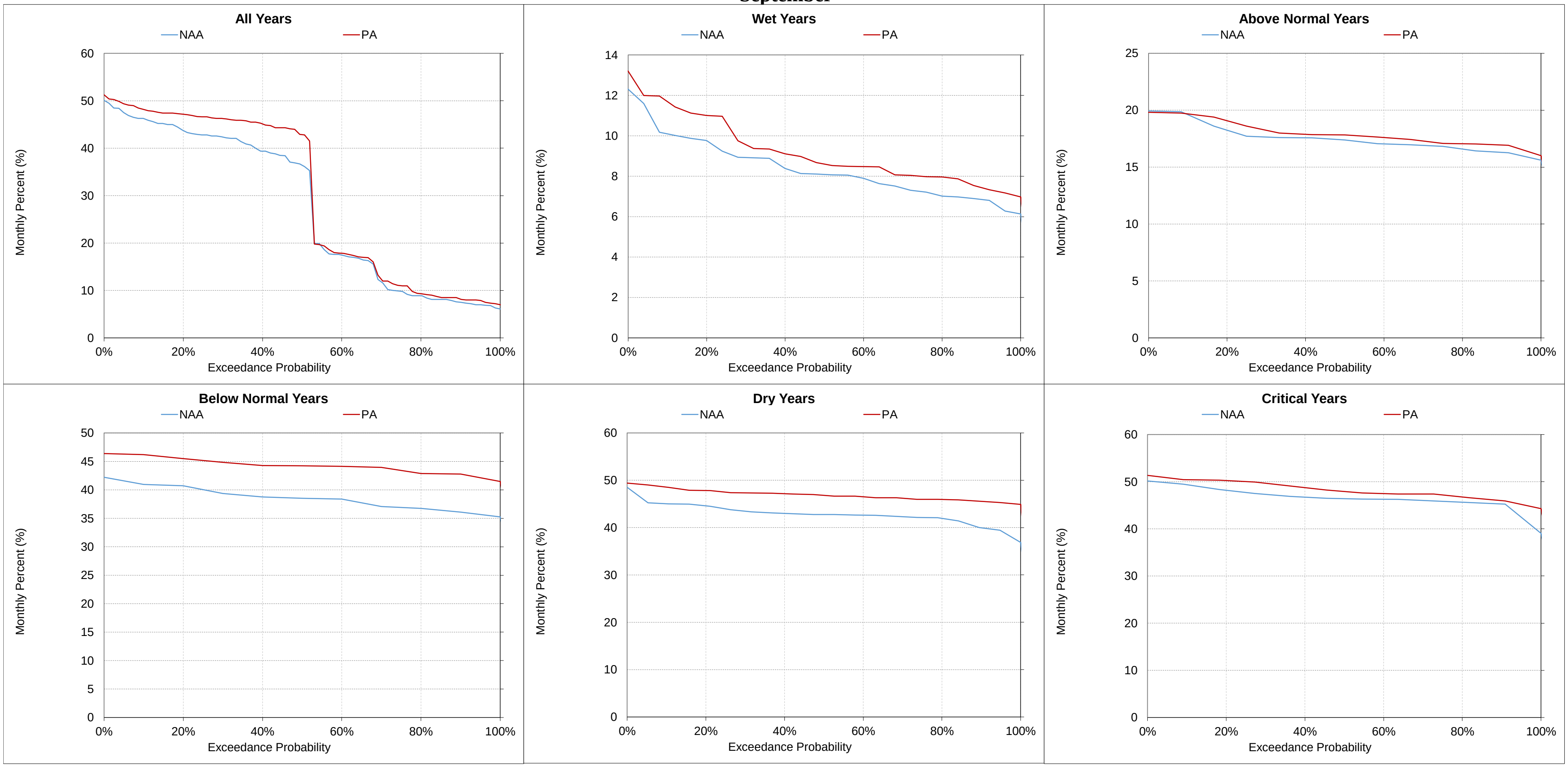
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-23-19. Sacramento River at Collinsville Martinez Volumetric Fingerprinting, Monthly Percent September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-24. Delta Cross Channel, Average Number of Days Gates Open

Statistic	Average Number of Days Gates Open (days)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	31	31	0	0%	20	20	0	0%	14	14	0	0%	0	0	0	-	0	0	0	-	0	0	0	-
20%	31	31	0	0%	20	20	0	0%	13	14	1	8%	0	0	0	-	0	0	0	-	0	0	0	-
30%	31	31	0	0%	17	20	3	20%	12	13	1	8%	0	0	0	-	0	0	0	-	0	0	0	-
40%	31	31	0	0%	14	16	2	18%	8	8	0	0%	0	0	0	-	0	0	0	-	0	0	0	-
50%	29	31	2	7%	10	15	6	58%	4	5	1	13%	0	0	0	-	0	0	0	-	0	0	0	-
60%	27	30	3	11%	4	11	7	185%	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-
70%	24	28	4	17%	2	9	7	350%	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-
80%	18	26	8	43%	0	3	3	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-
90%	13	18	5	36%	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-
Long Term																								
Full Simulation Period[b]	25	27	2	8%	10	12	3	26%	6	6	0	4%	0	0	0	-	0	0	0	-	0	0	0	-
Water Year Types[c]																								
Wet (32%)	19	24	5	25%	3	7	4	150%	6	6	0	8%	0	0	0	-	0	0	0	-	0	0	0	-
Above Normal (16%)	24	27	3	13%	7	12	5	66%	5	5	0	5%	0	0	0	-	0	0	0	-	0	0	0	-
Below Normal (13%)	28	28	0	1%	15	16	1	8%	7	7	0	-1%	0	0	0	-	0	0	0	-	0	0	0	-
Dry (24%)	29	30	1	2%	12	13	1	11%	5	5	0	2%	0	0	0	-	0	0	0	-	0	0	0	-
Critical (15%)	31	31	0	-1%	19	19	0	0%	8	8	0	2%	0	0	0	-	0	0	0	-	0	0	0	-

Statistic	Average Number of Days Gates Open (days)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	0	0	0	-	0	0	0	-	26	26	0	0%	31	31	0	0%	31	31	0	0%	30	30	0	0%
20%	0	0	0	-	0	0	0	-	26	26	0	0%	31	31	0	0%	31	31	0	0%	30	30	0	0%
30%	0	0	0	-	0	0	0	-	26	26	0	0%	31	31	0	0%	31	31	0	0%	30	30	0	0%
40%	0	0	0	-	0	0	0	-	26	26	0	0%	31	31	0	0%	31	31	0	0%	30	30	0	0%
50%	0	0	0	-	0	0	0	-	26	26	0	0%	31	31	0	0%	31	31	0	0%	30	30	0	0%
60%	0	0	0	-	0	0	0	-	26	26	0	0%	31	31	0	0%	31	31	0	0%	30	30	0	0%
70%	0	0	0	-	0	0	0	-	26	26	0	0%	26	31	5	18%	31	31	0	0%	25	30	5	19%
80%	0	0	0	-	0	0	0	-	26	26	0	0%	23	31	8	34%	31	31	0	0%	0	30	30	-
90%	0	0	0	-	0	0	0	-	25	26	1	4%	19	31	12	62%	31	31	0	0%	0	27	27	-
Long Term																								
Full Simulation Period[b]	0	0	0	-	0	0	0	-	24	25	1	6%	28	31	3	12%	31	31	0	0%	21	29	8	36%
Water Year Types[c]																								
Wet (32%)	0	0	0	-	0	0	0	-	19	23	4	23%	26	31	5	19%	31	31	0	0%	3	27	24	686%
Above Normal (16%)	0	0	0	-	0	0	0	-	26	26	0	2%	24	31	7	28%	31	31	0	0%	29	30	1	3%
Below Normal (13%)	0	0	0	-	0	0	0	-	26	26	0	0%	27	31	4	17%	31	31	0	0%	30	30	0	0%
Dry (24%)	0	0	0	-	0	0	0	-	26	26	0	0%	31	31	0	1%	31	31	0	0%	30	30	0	0%
Critical (15%)	0	0	0	-	0	0	0	-	26	26	0	0%	31	31	0	0%	31	31	0	0%	30	30	0	0%

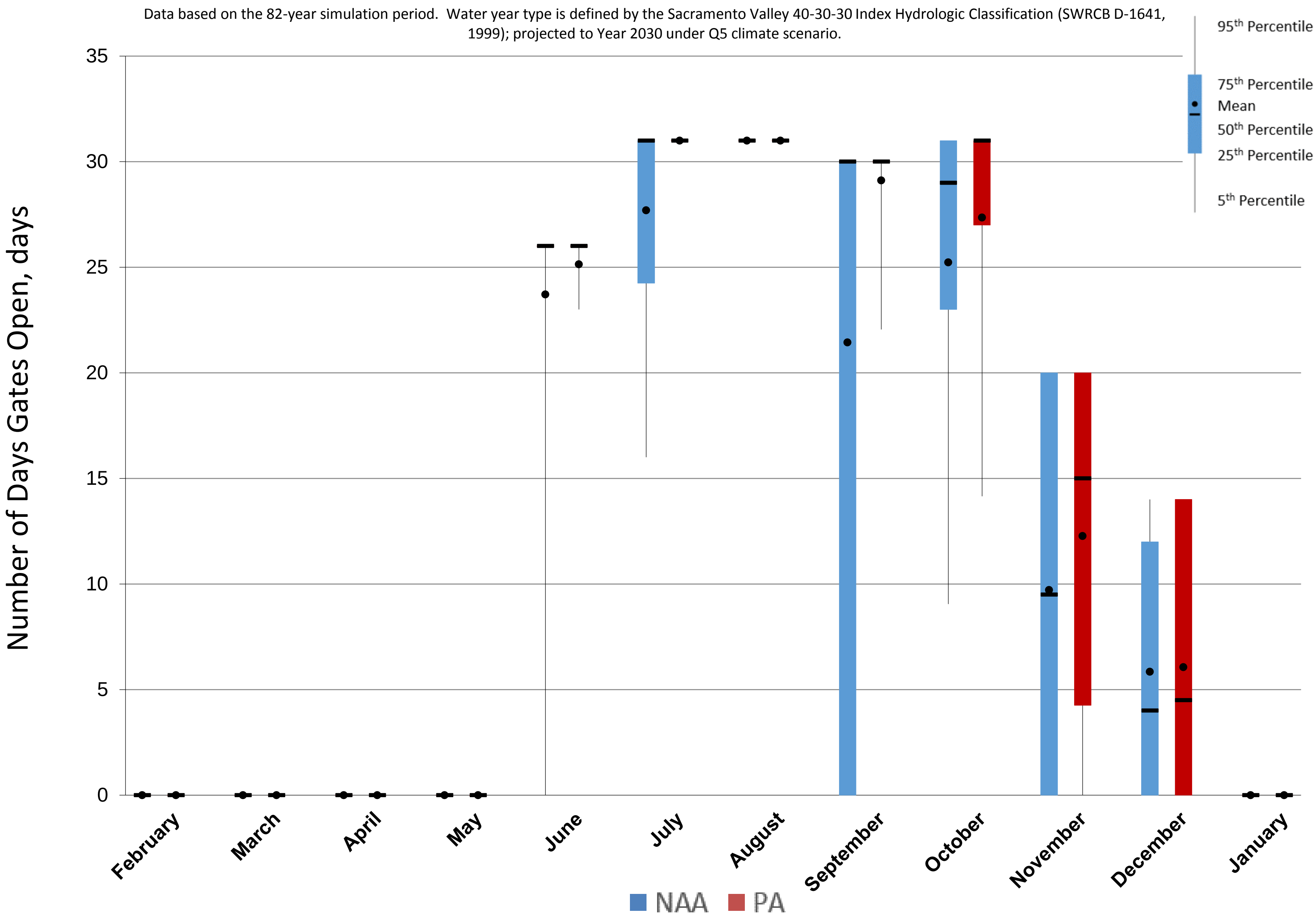
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-24-1. Average Number of Days Gates Open Ranges For Delta Cross Channel, All Years



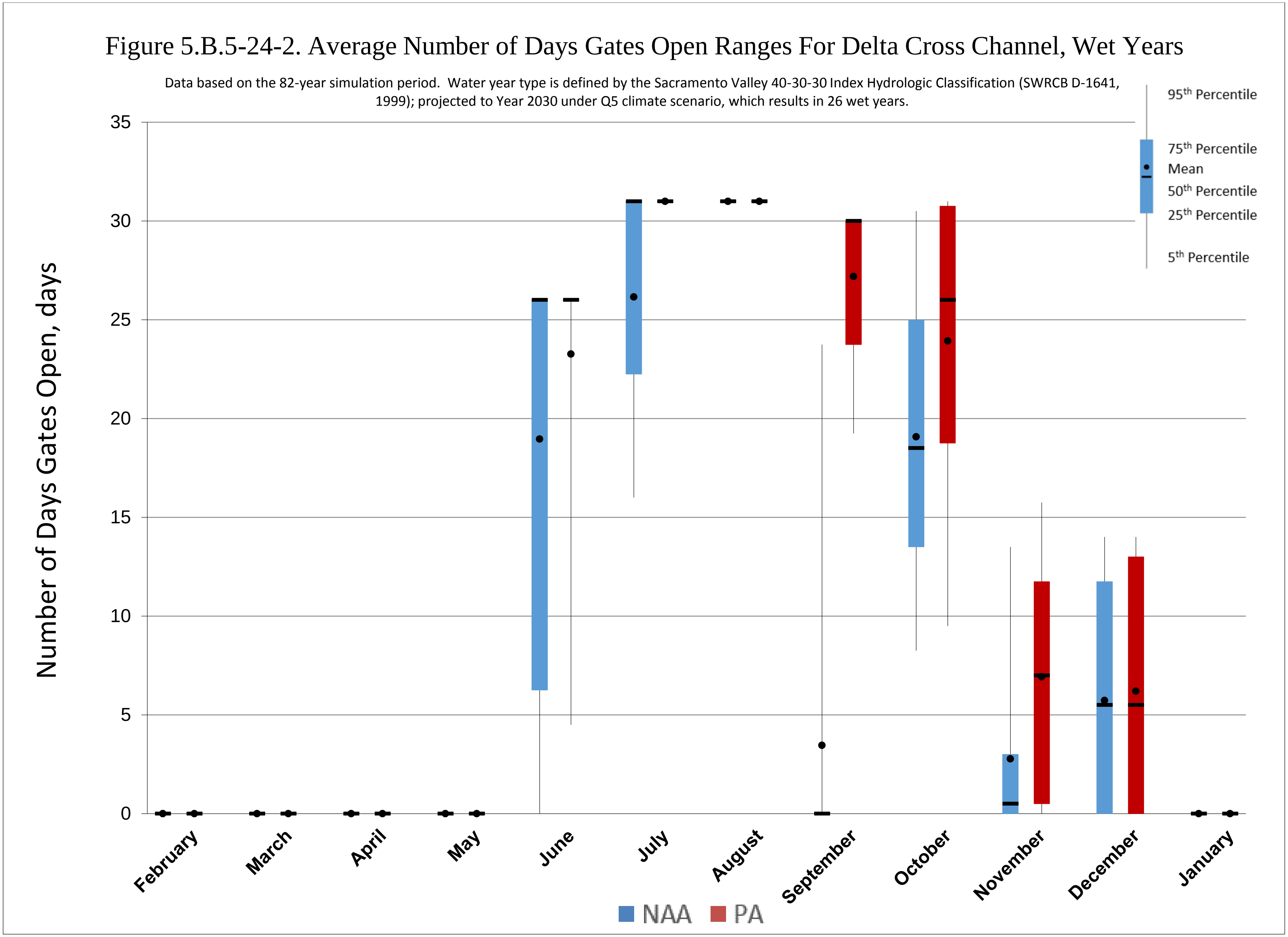


Figure 5.B.5-24-2. Average Number of Days Gates Open Ranges For Delta Cross Channel, Wet Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 26 wet years.
Number of Days Gates Open, days
0
5
10
15
20
25
30
35
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile

Figure 5.B.5-24-3. Average Number of Days Gates Open Ranges For Delta Cross Channel, Above Normal Years

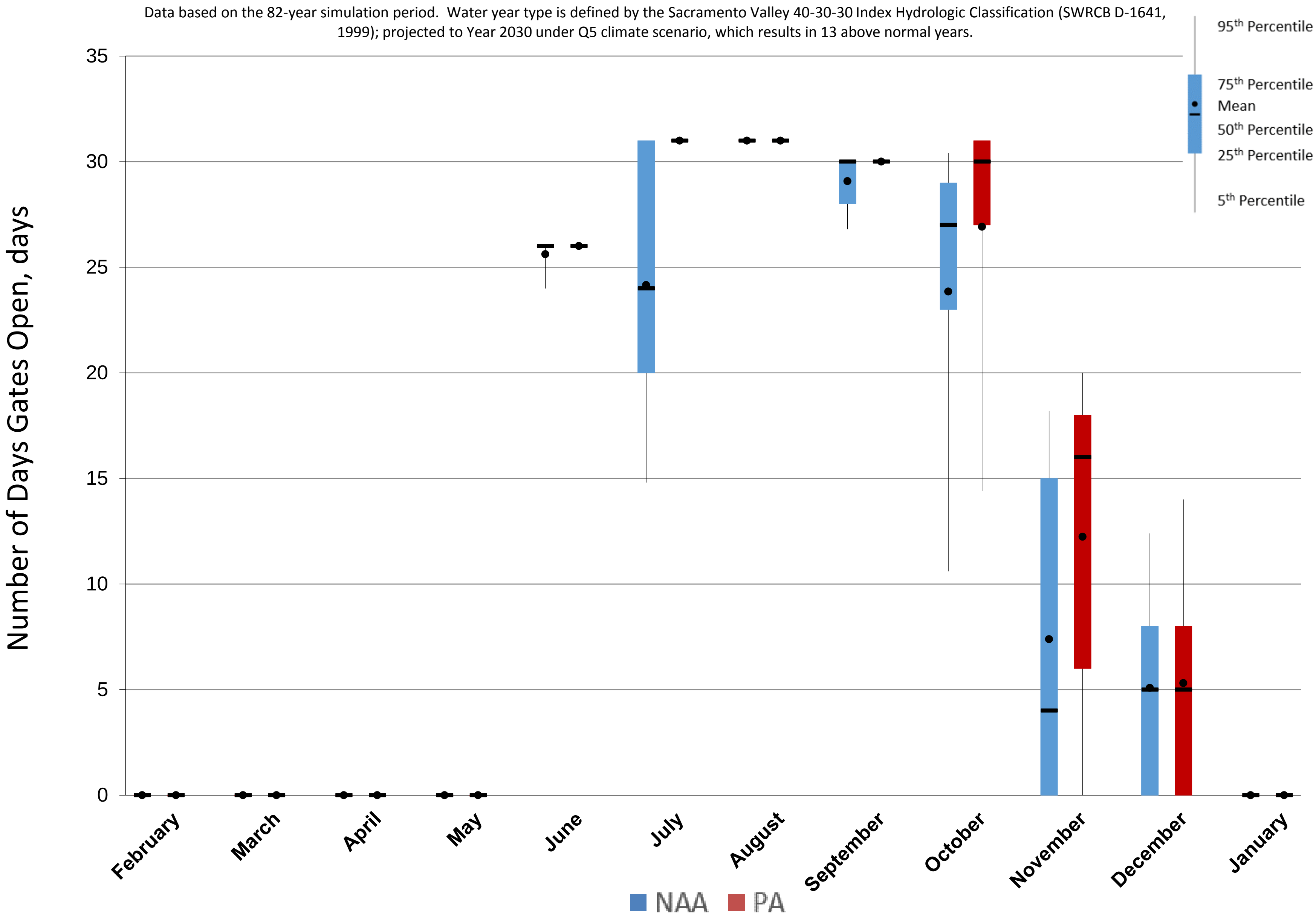
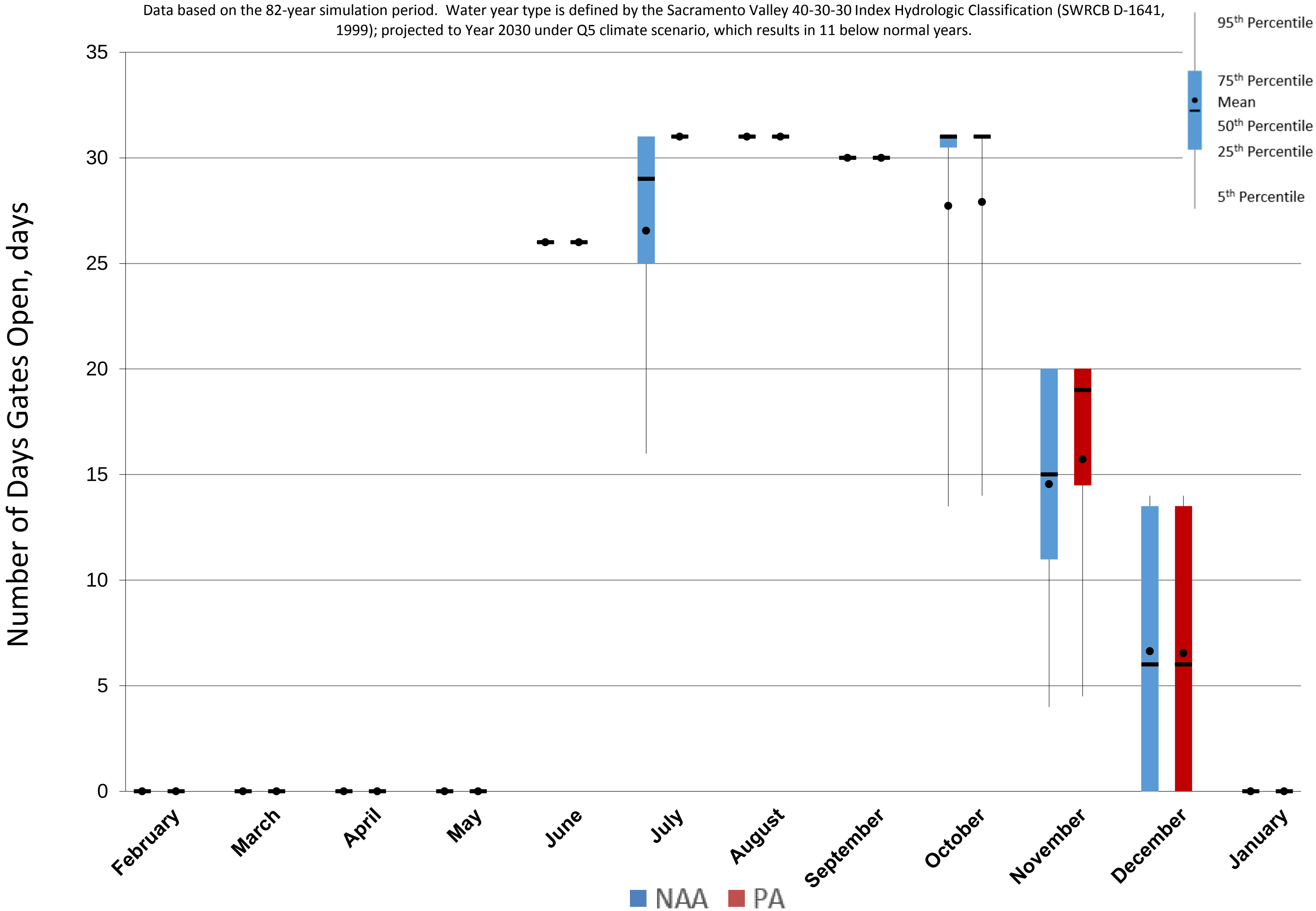


Figure 5.B.5-24-4. Average Number of Days Gates Open Ranges For Delta Cross Channel, Below Normal Years



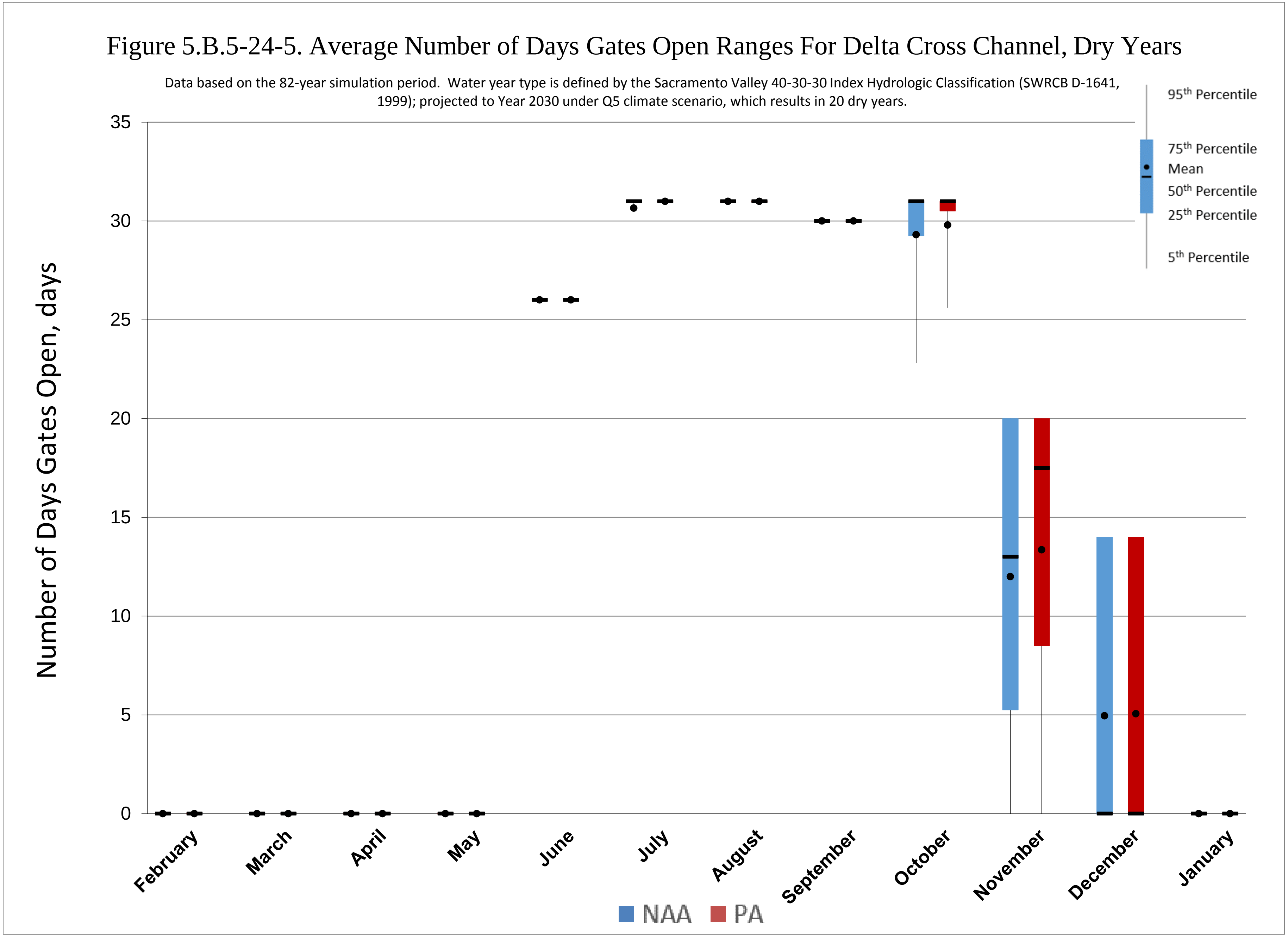


Figure 5.B.5-24-5. Average Number of Days Gates Open Ranges For Delta Cross Channel, Dry Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 20 dry years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
Number of Days Gates Open, days
35
30
25
20
15
10
5
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-24-6. Average Number of Days Gates Open Ranges For Delta Cross Channel, Critical Years

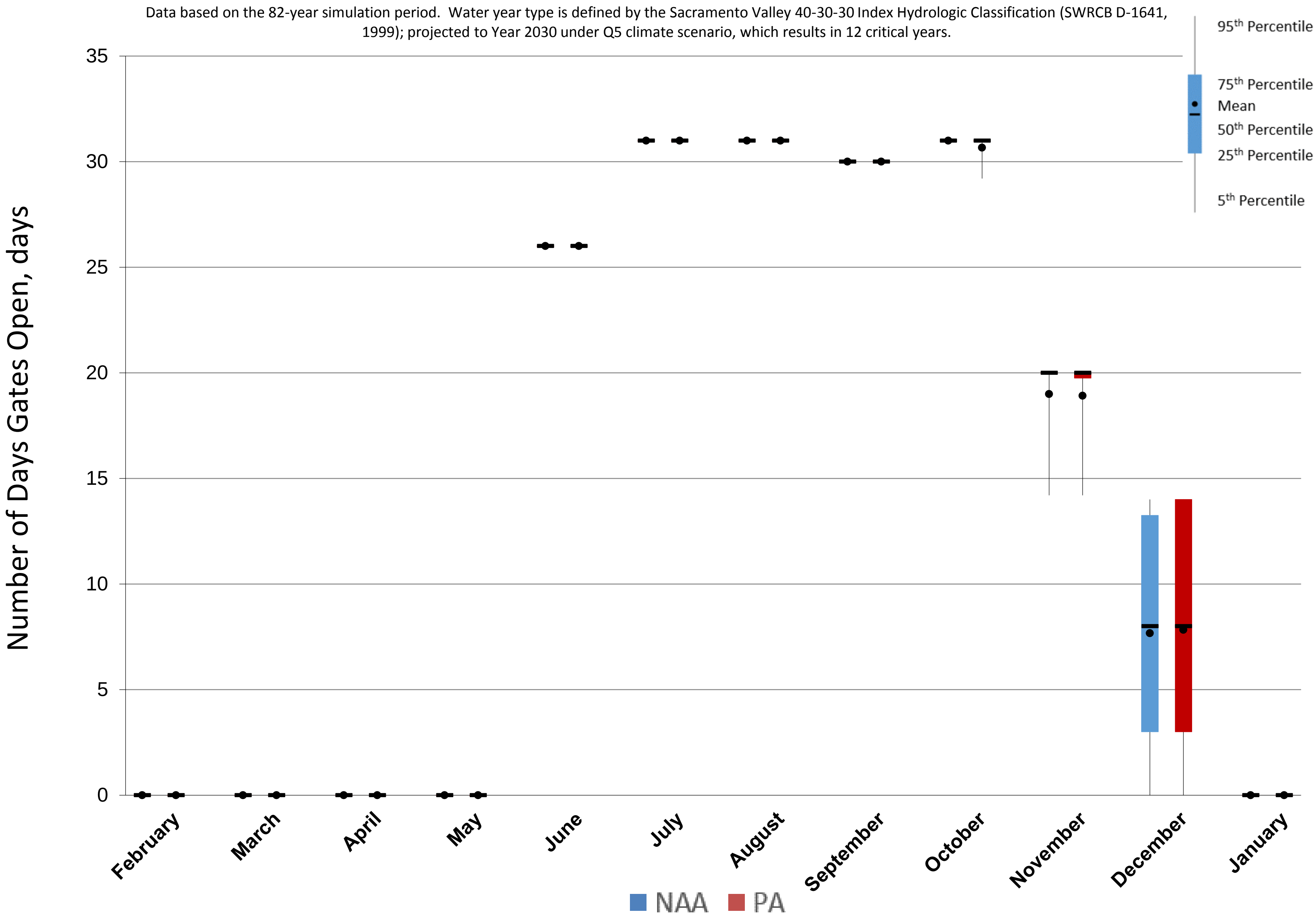
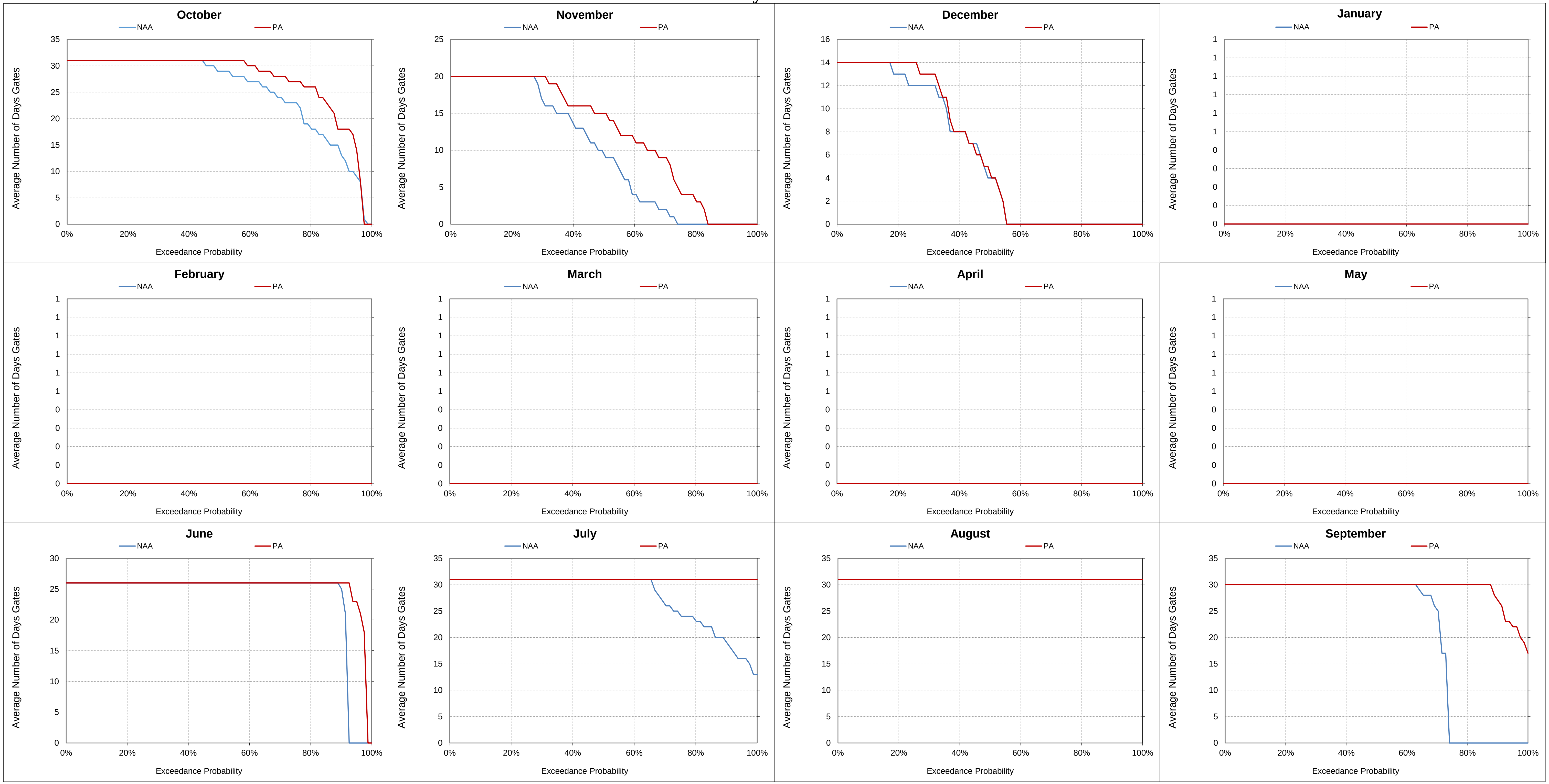
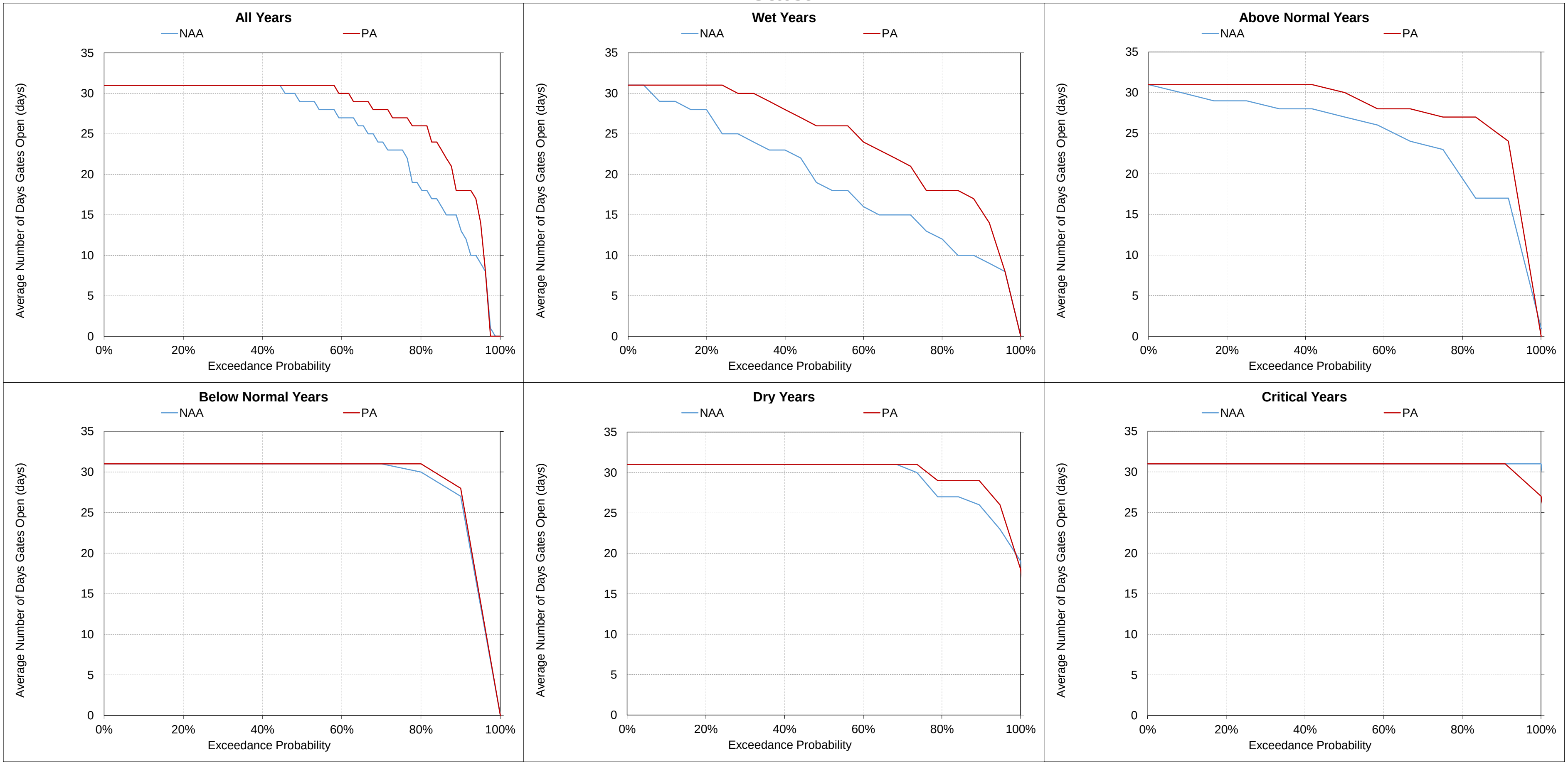


Figure 5.B.5-24-7. Delta Cross Channel, Average Number of Days Gates Open Probability of Exceedance



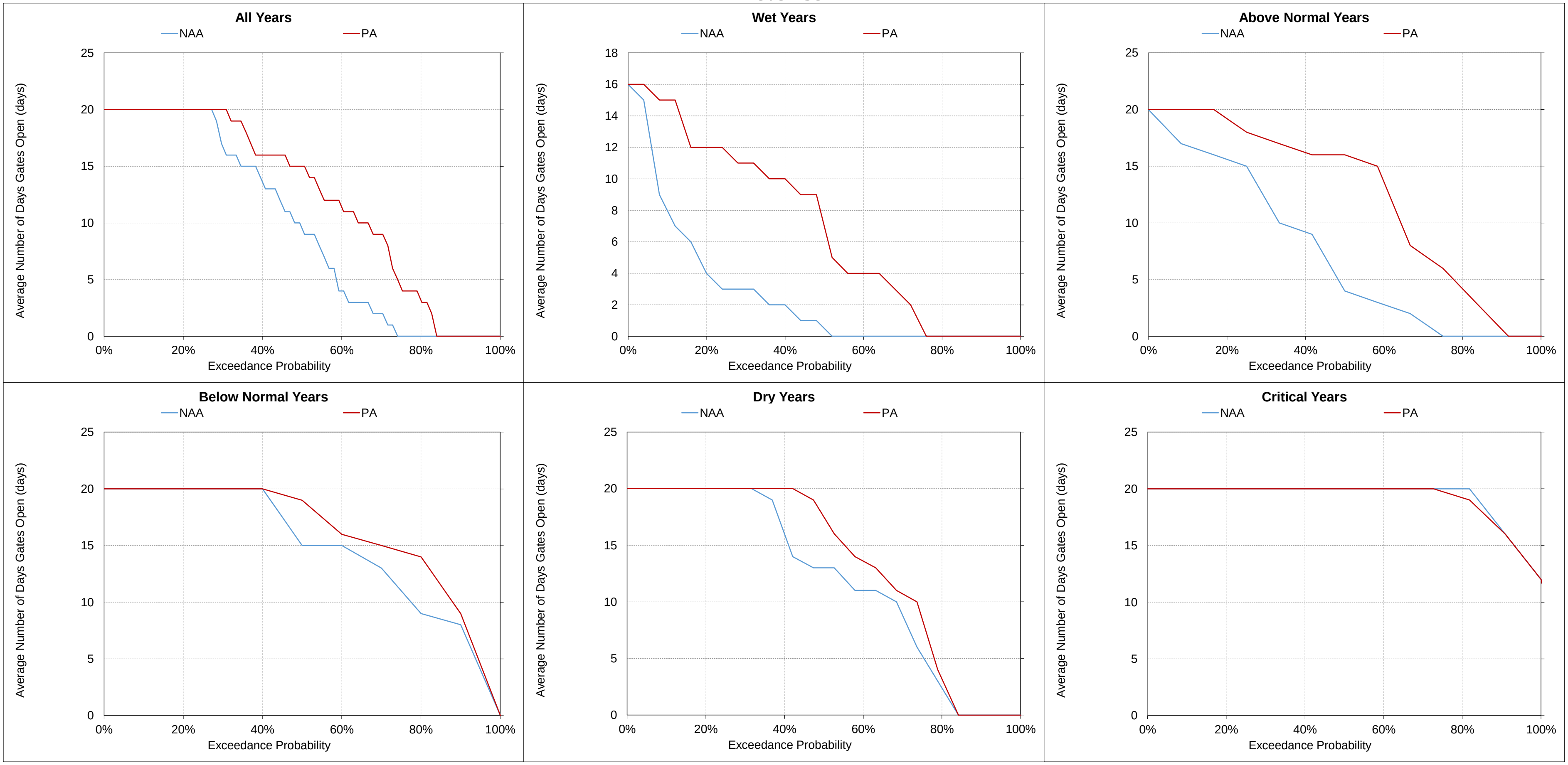
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-24-8. Delta Cross Channel, Average Number of Days Gates Open October



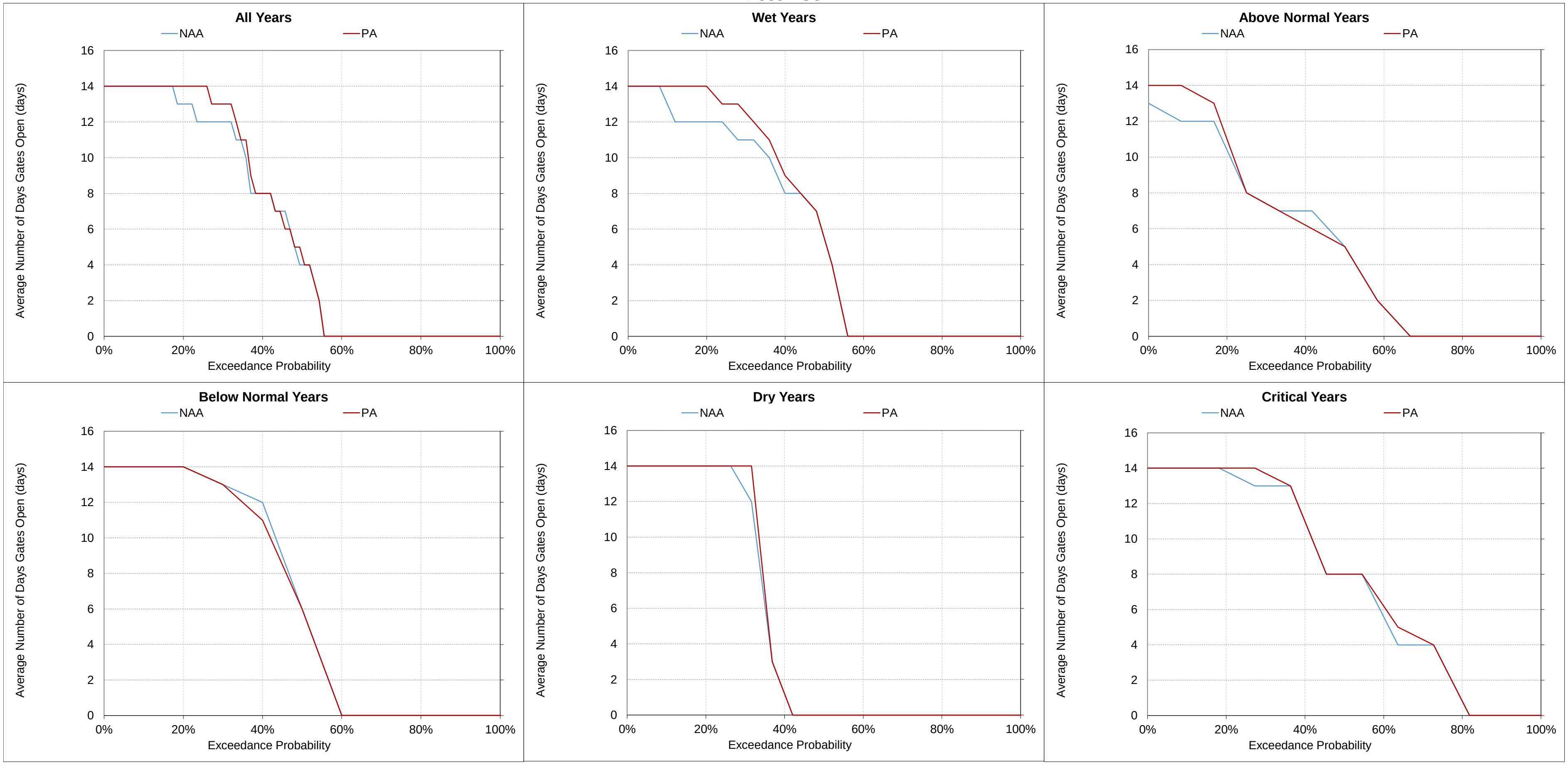
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-24-9. Delta Cross Channel, Average Number of Days Gates Open November



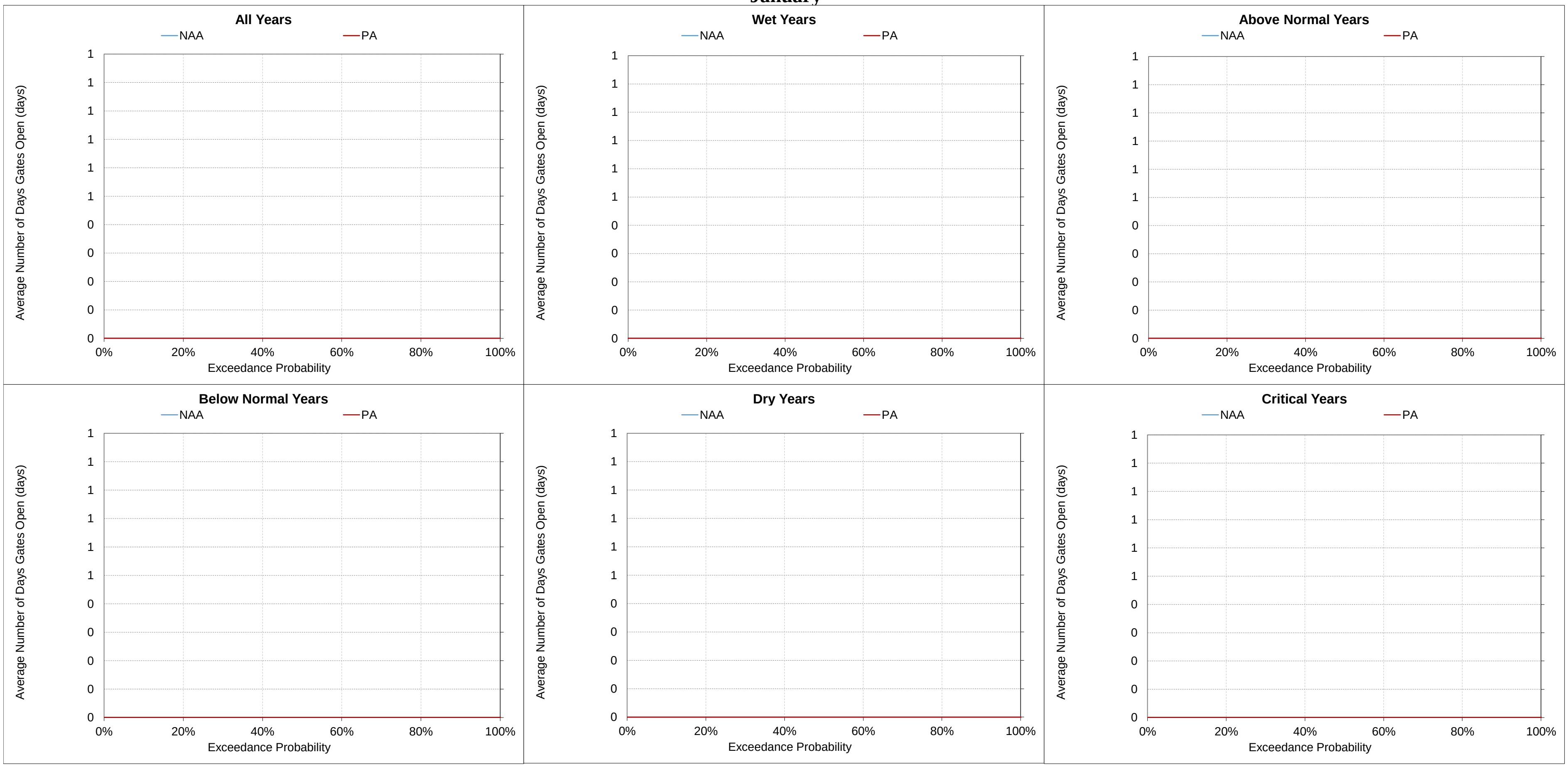
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-24-10. Delta Cross Channel, Average Number of Days Gates Open December



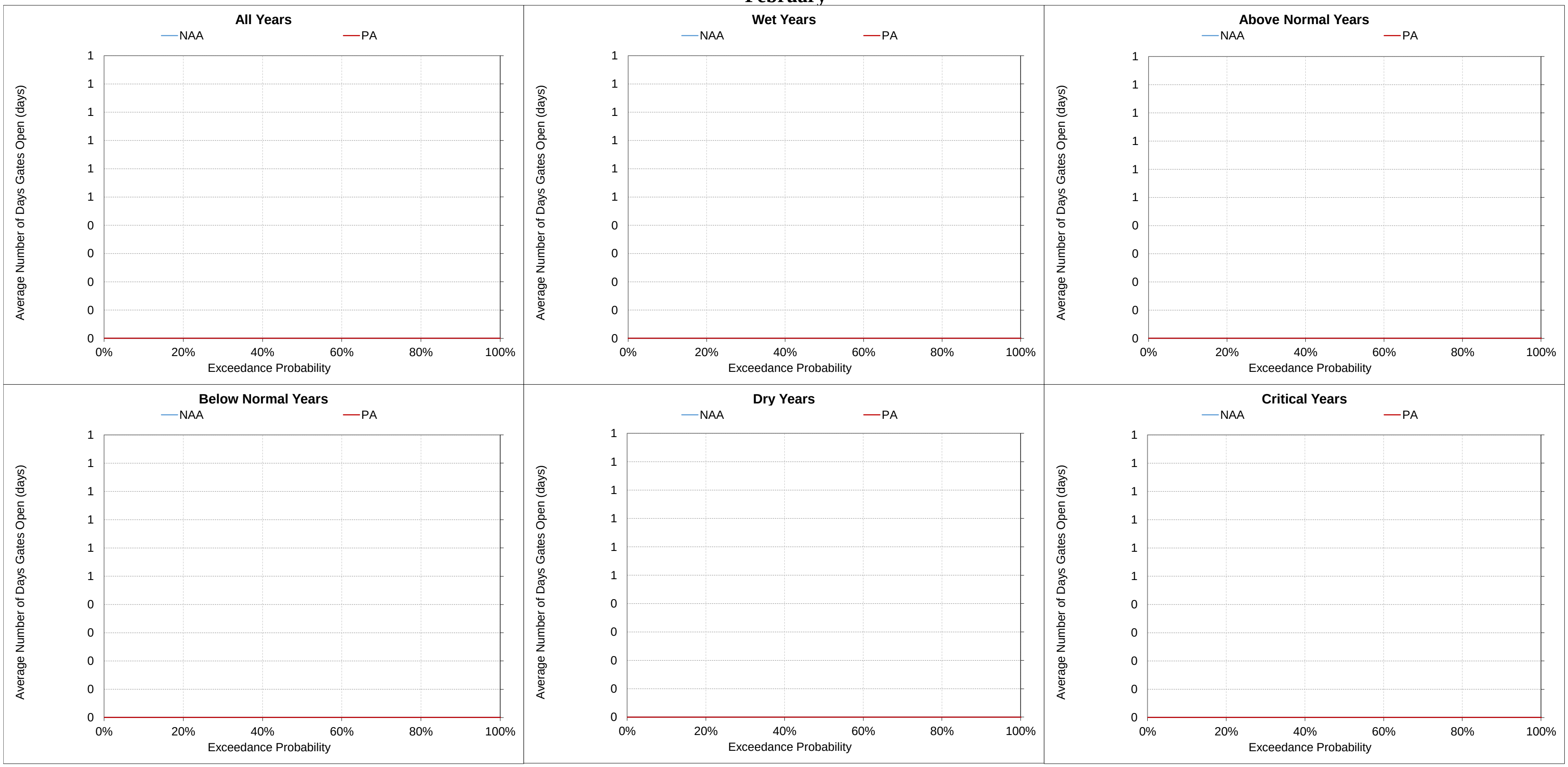
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-24-11. Delta Cross Channel, Average Number of Days Gates Open
January



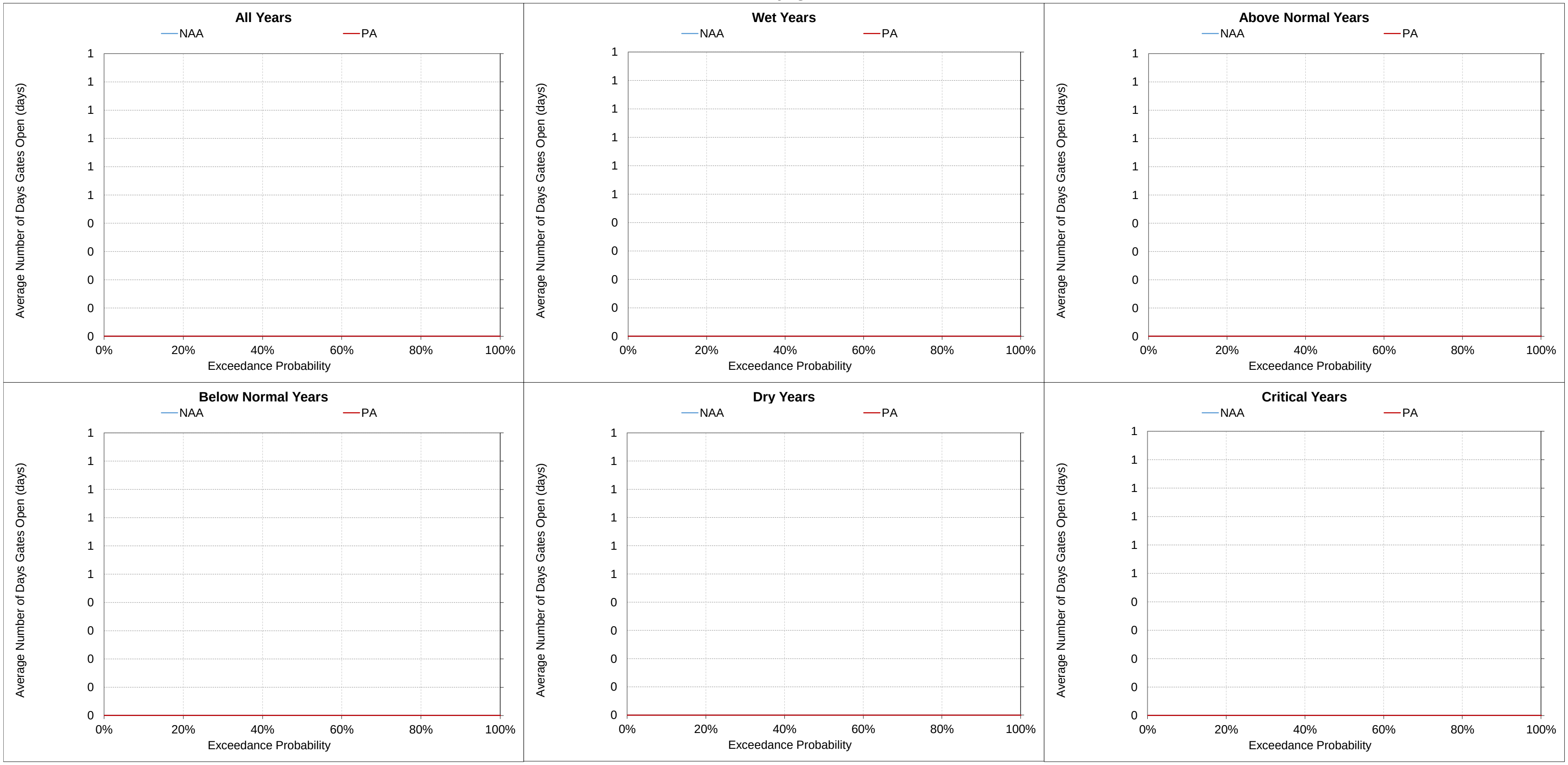
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-24-12. Delta Cross Channel, Average Number of Days Gates Open
February



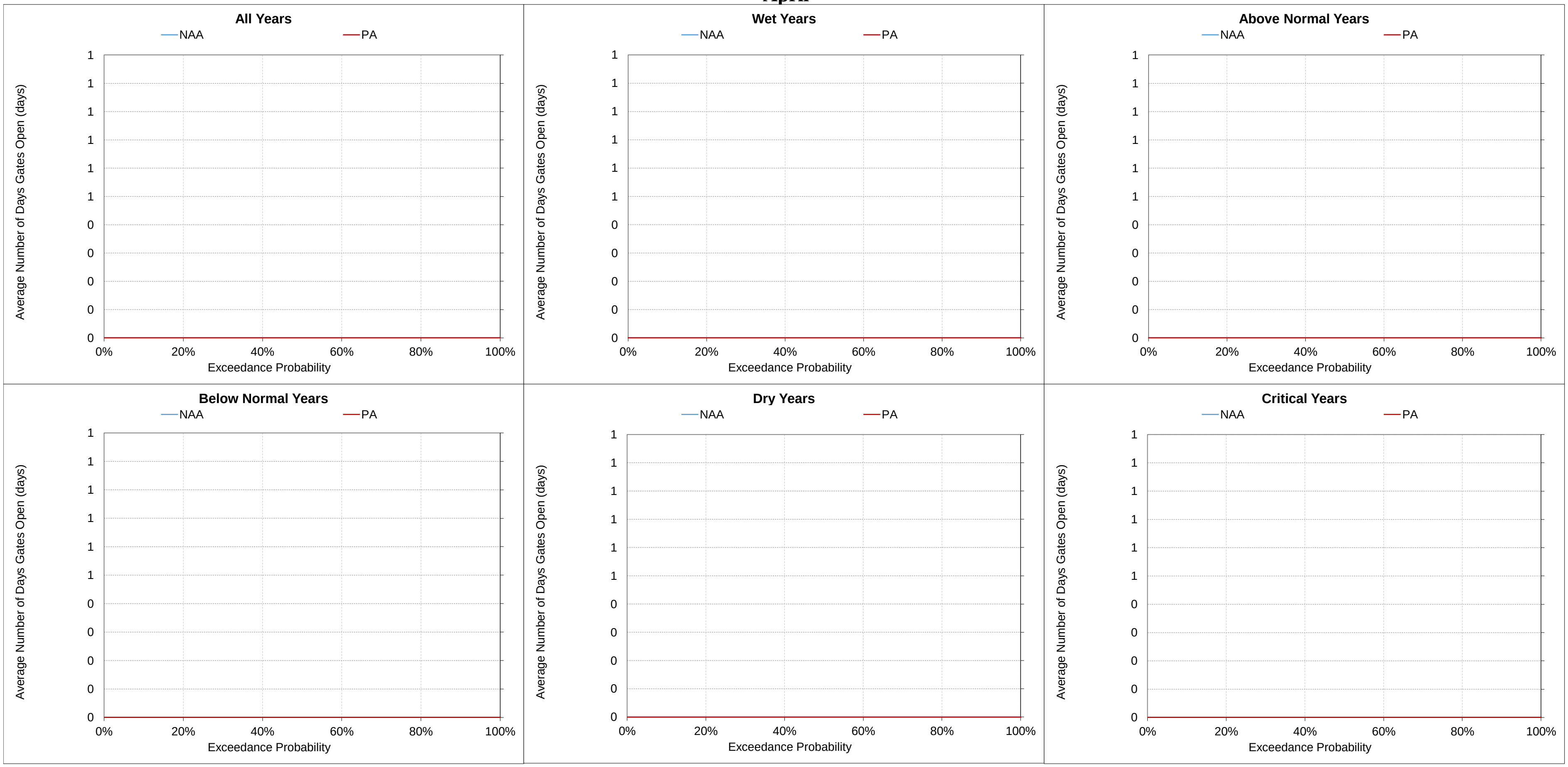
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-24-13. Delta Cross Channel, Average Number of Days Gates Open
March



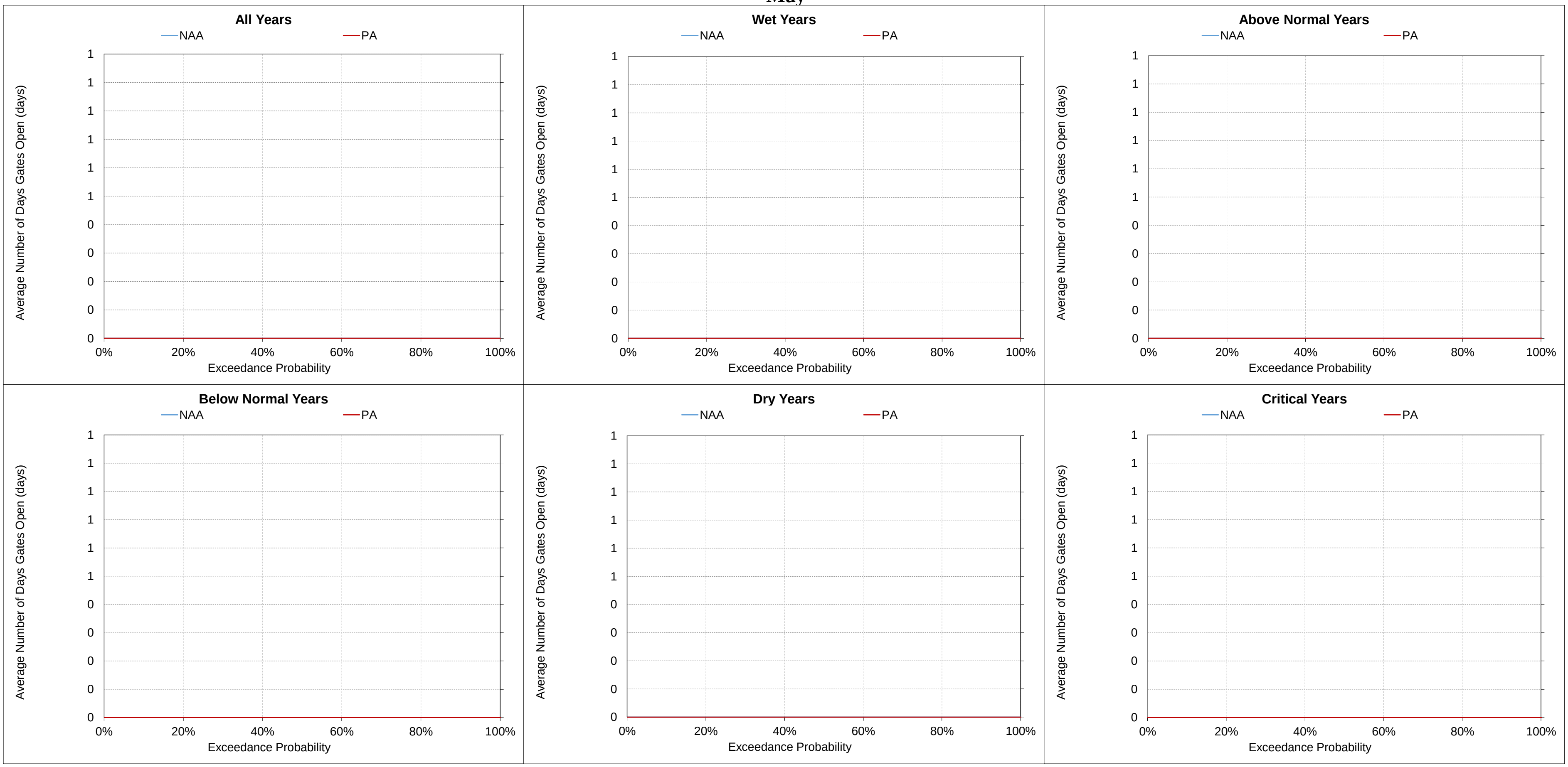
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-24-14. Delta Cross Channel, Average Number of Days Gates Open
April



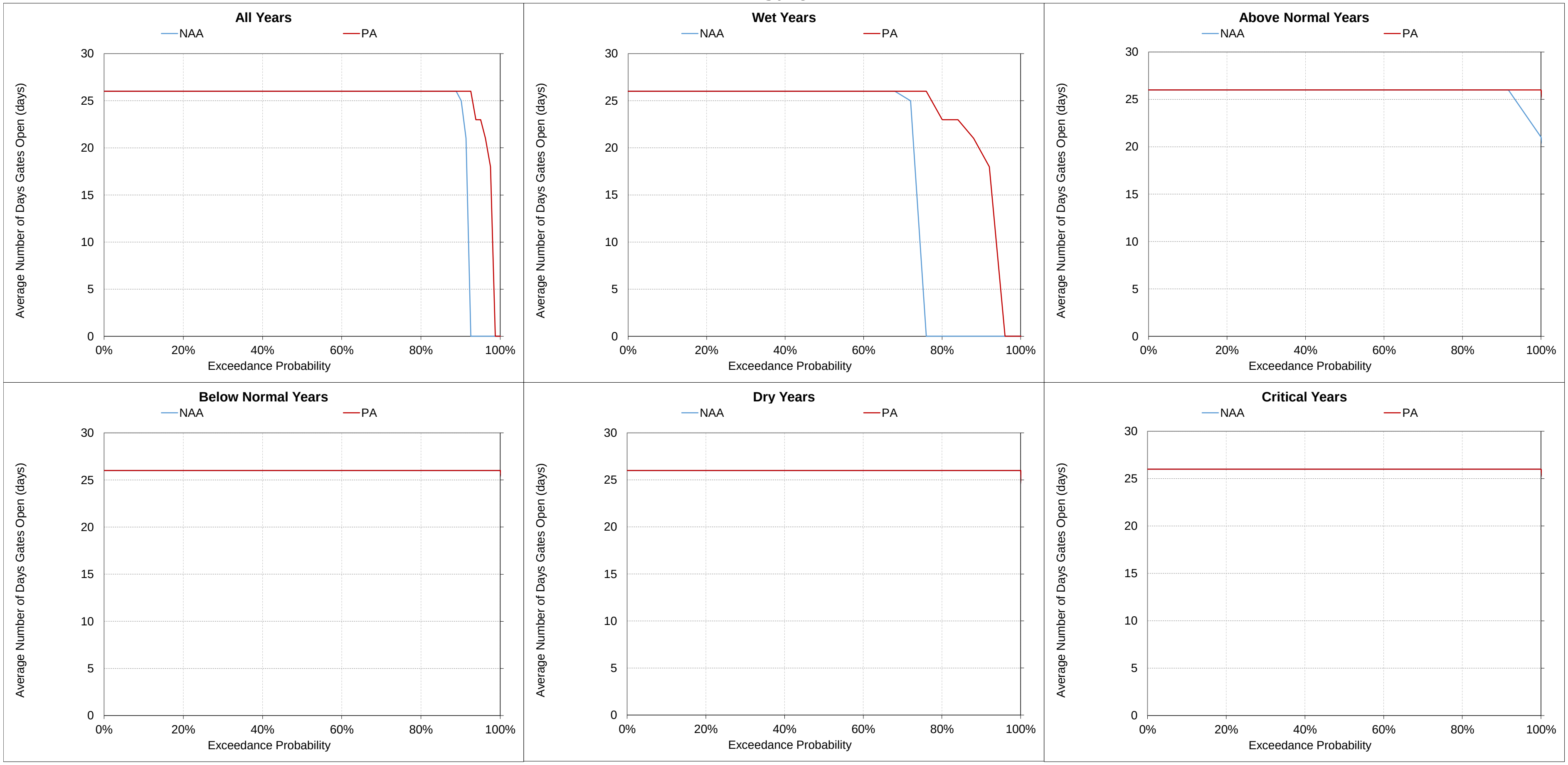
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-24-15. Delta Cross Channel, Average Number of Days Gates Open May



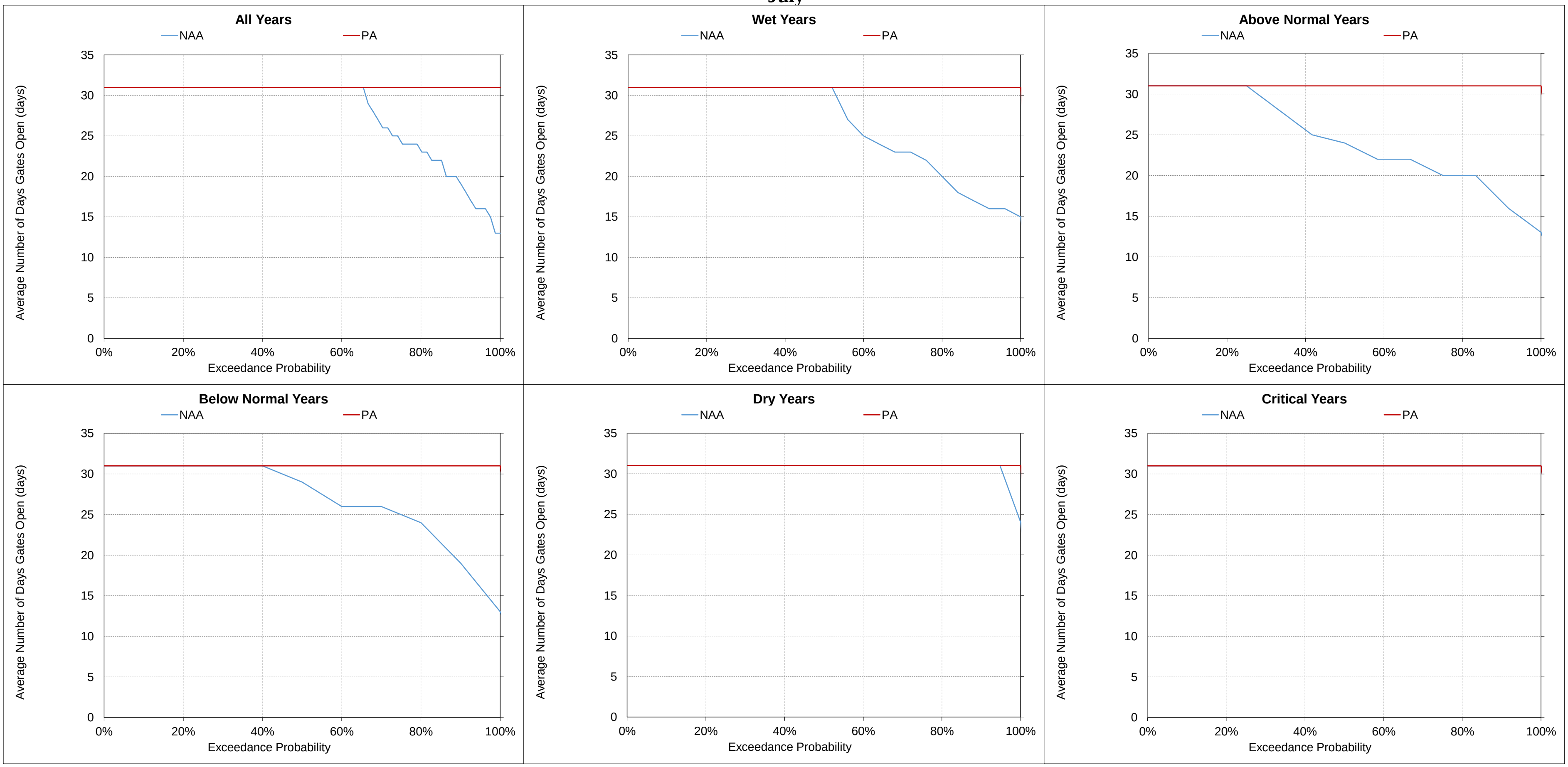
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-24-16. Delta Cross Channel, Average Number of Days Gates Open
June



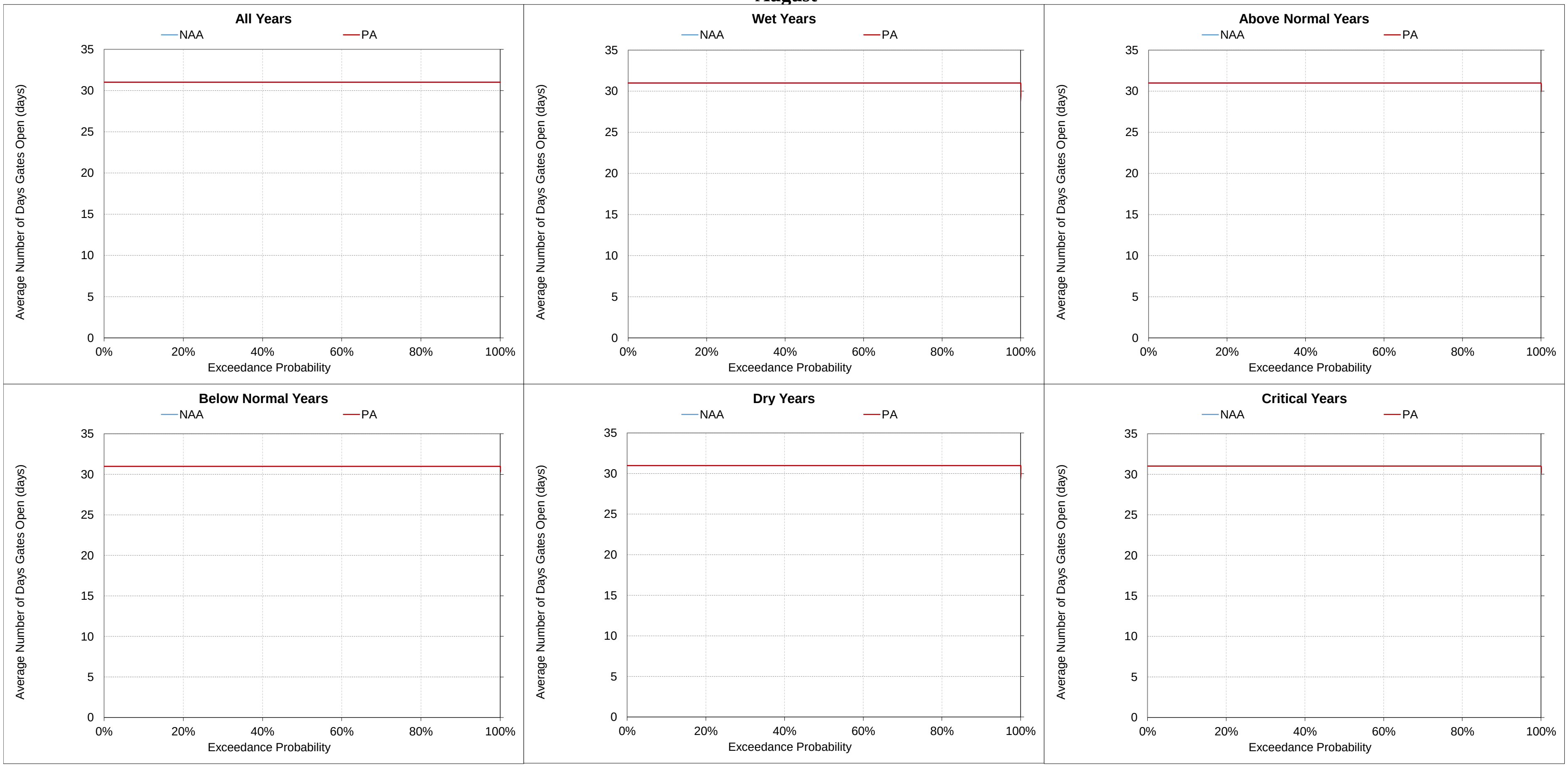
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-24-17. Delta Cross Channel, Average Number of Days Gates Open
July



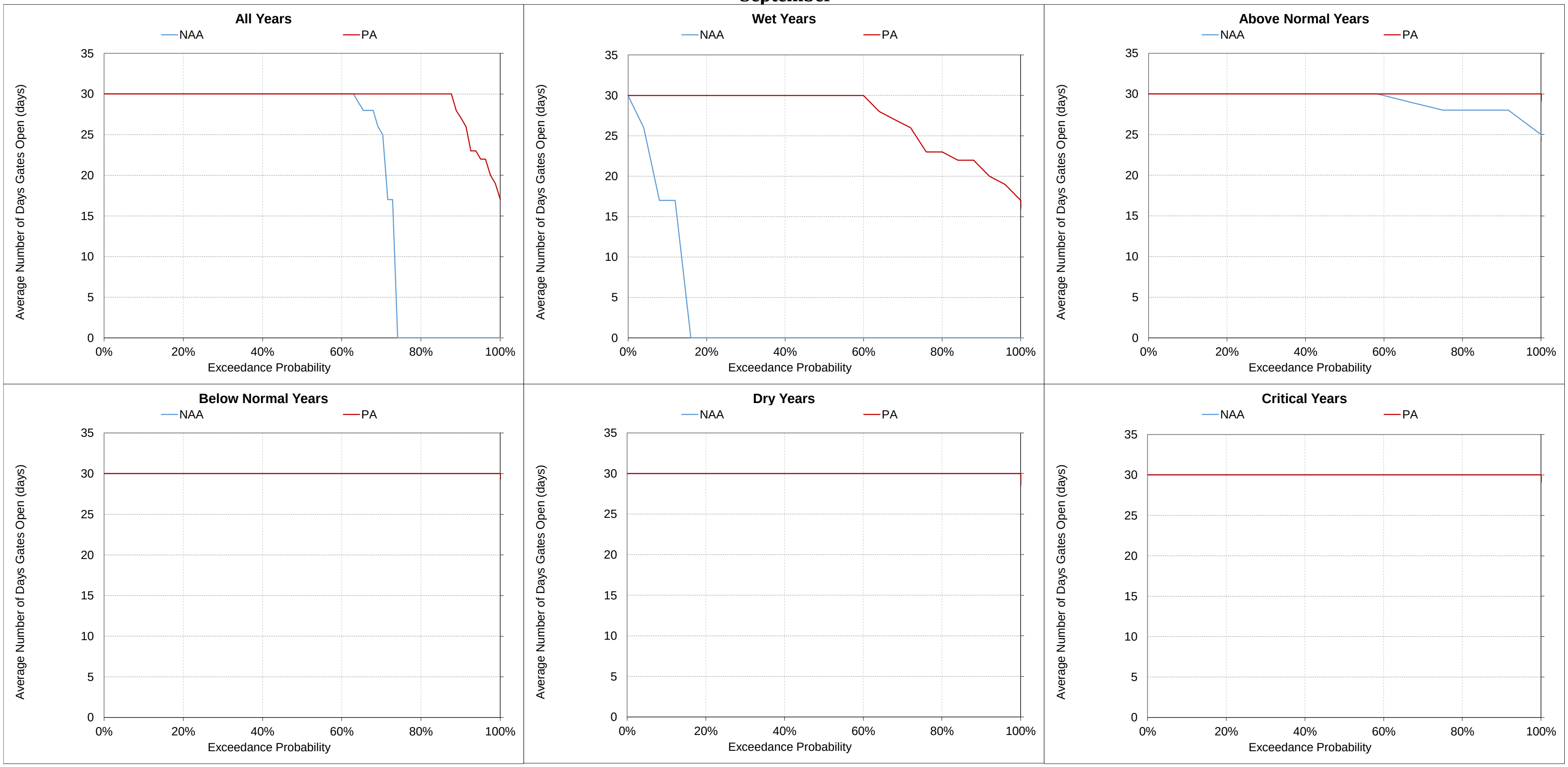
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-24-18. Delta Cross Channel, Average Number of Days Gates Open August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-24-19. Delta Cross Channel, Average Number of Days Gates Open September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-25. Chadborne Sl at Sunrise Duck Club, Monthly EC

Statistic	Monthly EC (UMHOS/CM)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	15,595	15,530	-64	0%	15,104	14,087	-1,016	-7%	13,146	12,742	-405	-3%	10,979	10,742	-237	-2%	7,696	7,166	-530	-7%	6,069	6,252	183	3%
20%	14,693	14,580	-113	-1%	13,661	12,561	-1,099	-8%	12,677	11,930	-748	-6%	8,952	9,084	133	1%	6,726	6,364	-362	-5%	5,183	4,915	-268	-5%
30%	14,505	14,362	-144	-1%	13,040	11,927	-1,113	-9%	11,289	10,687	-602	-5%	8,110	8,214	104	1%	5,375	5,136	-238	-4%	3,703	3,900	197	5%
40%	13,906	13,934	28	0%	12,545	11,281	-1,264	-10%	8,772	8,776	4	0%	7,429	7,267	-162	-2%	4,600	4,180	-420	-9%	2,888	2,962	75	3%
50%	12,590	13,214	624	5%	10,735	9,315	-1,420	-13%	7,313	7,505	192	3%	6,787	6,544	-242	-4%	3,339	3,251	-88	-3%	2,076	2,376	300	14%
60%	8,818	8,983	165	2%	7,978	7,736	-242	-3%	6,205	6,316	111	2%	5,394	5,243	-151	-3%	2,705	2,671	-33	-1%	1,377	1,424	47	3%
70%	6,483	6,647	165	3%	6,088	6,130	42	1%	5,769	5,786	18	0%	3,361	3,881	520	15%	1,787	1,804	17	1%	1,130	1,185	55	5%
80%	6,277	6,429	153	2%	5,711	5,664	-47	-1%	5,127	4,953	-174	-3%	2,193	2,406	212	10%	1,046	1,079	33	3%	632	687	55	9%
90%	6,068	6,256	188	3%	5,438	5,400	-38	-1%	3,492	3,544	52	1%	1,425	1,401	-24	-2%	682	725	43	6%	435	455	21	5%
Long Term																								
Full Simulation Period[b]	10,912	10,986	74	1%	9,971	9,353	-618	-6%	8,222	8,094	-128	-2%	6,191	6,116	-75	-1%	3,913	3,760	-153	-4%	2,793	2,845	52	2%
Water Year Types[c]																								
Wet (32%)	6,104	6,271	167	3%	5,490	5,500	10	0%	4,682	4,728	46	1%	4,631	4,335	-296	-6%	1,370	1,346	-24	-2%	793	808	16	2%
Above Normal (16%)	8,539	8,651	112	1%	7,708	7,484	-224	-3%	6,591	6,646	55	1%	6,064	5,991	-73	-1%	2,557	2,482	-75	-3%	1,429	1,430	2	0%
Below Normal (13%)	13,304	13,554	250	2%	12,048	10,947	-1,102	-9%	9,969	9,721	-248	-2%	6,960	7,005	45	1%	4,753	4,258	-496	-10%	3,471	3,362	-110	-3%
Dry (24%)	14,441	14,400	-41	0%	12,965	11,741	-1,223	-9%	9,804	9,476	-329	-3%	6,428	6,425	-4	0%	5,574	5,400	-174	-3%	3,784	3,932	148	4%
Critical (15%)	15,825	15,688	-137	-1%	15,238	14,285	-952	-6%	13,422	13,160	-262	-2%	8,608	8,778	170	2%	7,352	7,185	-167	-2%	6,329	6,504	176	3%

Statistic	Monthly EC (UMHOS/CM)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	7,816	7,530	-285	-4%	8,842	8,688	-154	-2%	10,796	10,813	17	0%	12,624	12,627	4	0%	15,059	15,070	12	0%	16,686	17,098	412	2%
20%	4,874	5,167	294	6%	7,221	7,215	-5	0%	9,242	8,956	-286	-3%	11,442	11,382	-60	-1%	13,581	13,641	60	0%	15,593	15,992	399	3%
30%	3,758	4,230	472	13%	6,228	6,348	120	2%	8,381	8,254	-126	-2%	10,607	10,594	-14	0%	13,010	13,260	250	2%	15,236	15,734	499	3%
40%	3,010	3,278	268	9%	4,277	4,213	-63	-1%	6,886	6,857	-29	0%	9,687	10,042	356	4%	11,509	12,253	745	6%	14,248	15,001	753	5%
50%	2,377	2,365	-12	0%	3,341	3,317	-24	-1%	5,421	5,281	-140	-3%	8,338	8,686	348	4%	10,610	11,570	960	9%	13,240	14,226	985	7%
60%	1,129	1,248	119	10%	2,180	2,175	-5	0%	4,231	4,189	-41	-1%	7,891	8,150	259	3%	9,221	10,519	1,298	14%	11,068	11,697	629	6%
70%	888	856	-33	-4%	1,315	1,317	2	0%	3,566	3,490	-77	-2%	7,156	7,365	209	3%	8,815	9,914	1,099	12%	10,149	10,464	315	3%
80%	661	658	-3	0%	736	743	6	1%	2,274	2,240	-35	-2%	5,636	5,966	330	6%	8,469	9,394	925	11%	9,464	10,167	703	7%
90%	368	390	22	6%	320	325	5	2%	704	786	82	12%	3,380	3,515	136	4%	8,088	8,418	329	4%	9,269	9,754	485	5%
Long Term																								
Full Simulation Period[b]	3,014	3,114	100	3%	4,033	4,049	16	0%	5,852	5,795	-58	-1%	8,559	8,695	135	2%	10,942	11,565	623	6%	12,704	13,290	587	5%
Water Year Types[c]																								
Wet (32%)	756	776	19	3%	1,102	1,103	1	0%	2,251	2,245	-7	0%	4,881	5,067	186	4%	8,045	8,724	678	8%	9,142	9,654	512	6%
Above Normal (16%)	1,253	1,233	-20	-2%	2,044	2,022	-22	-1%	4,217	4,168	-49	-1%	7,410	7,810	399	5%	9,046	10,310	1,264	14%	10,977	11,757	780	7%
Below Normal (13%)	4,058	4,109	51	1%	4,984	5,003	19	0%	6,940	6,824	-116	-2%	9,320	9,509	189	2%	10,866	11,826	960	9%	13,659	14,584	925	7%
Dry (24%)	3,761	4,082	321	9%	5,414	5,470	56	1%	7,580	7,446	-134	-2%	10,659	10,590	-69	-1%	13,168	13,394	226	2%	15,326	15,851	525	3%
Critical (15%)	7,613	7,695	81	1%	9,362	9,382	20	0%	11,549	11,553	4	0%	13,577	13,609	31	0%	15,634	15,797	163	1%	17,045	17,375	330	2%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

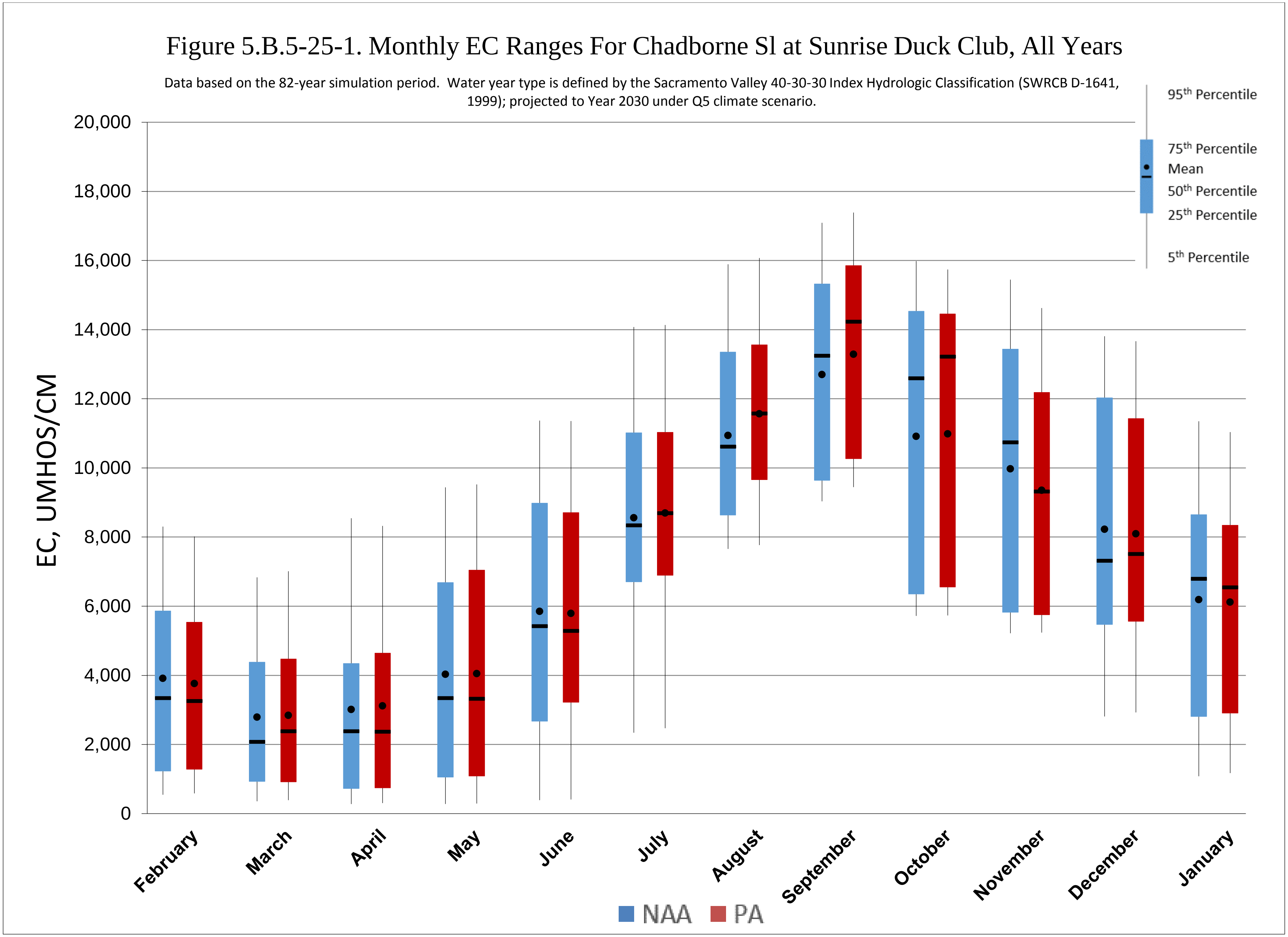


Figure 5.B.5-25-1. Monthly EC Ranges For Chadborne Sl at Sunrise Duck Club, All Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario.
EC, UMHOS/CM
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile

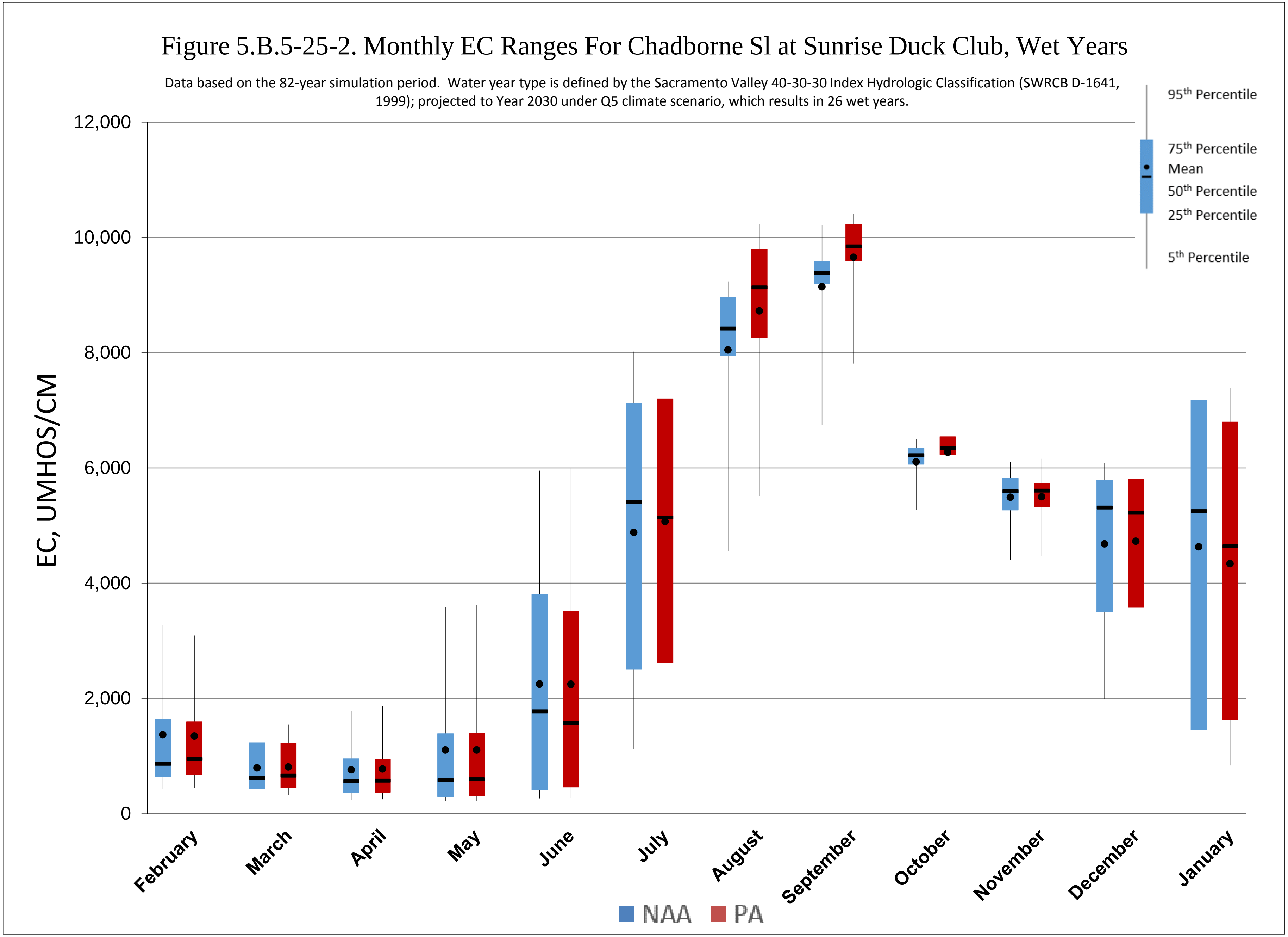


Figure 5.B.5-25-2. Monthly EC Ranges For Chadborne Sl at Sunrise Duck Club, Wet Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 26 wet years.
EC, UMHOS/CM
12,000
10,000
8,000
6,000
4,000
2,000
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile

Figure 5.B.5-25-3. Monthly EC Ranges For Chadborne Sl at Sunrise Duck Club, Above Normal Years

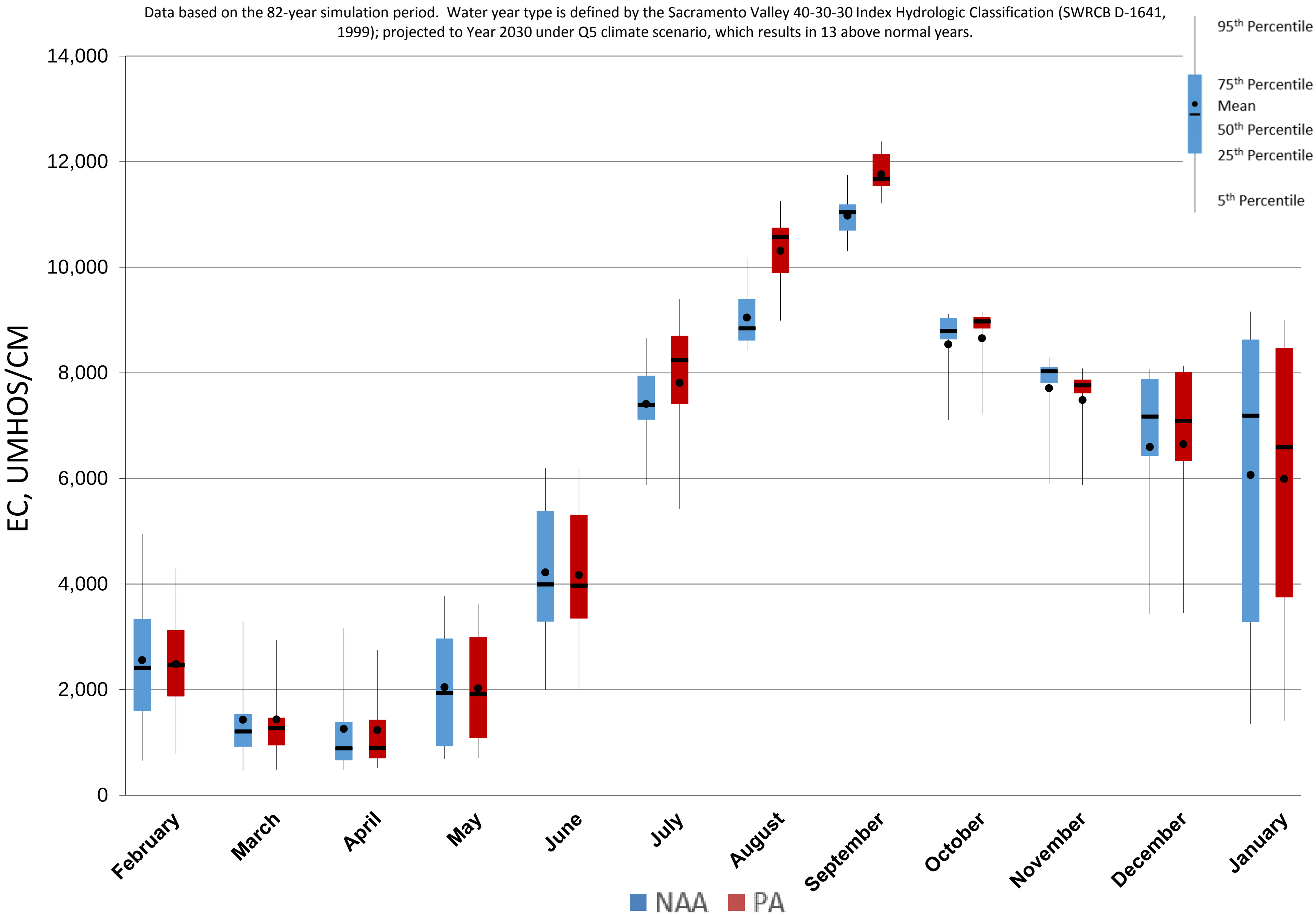


Figure 5.B.5-25-4. Monthly EC Ranges For Chadborne Sl at Sunrise Duck Club, Below Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 11 below normal years.

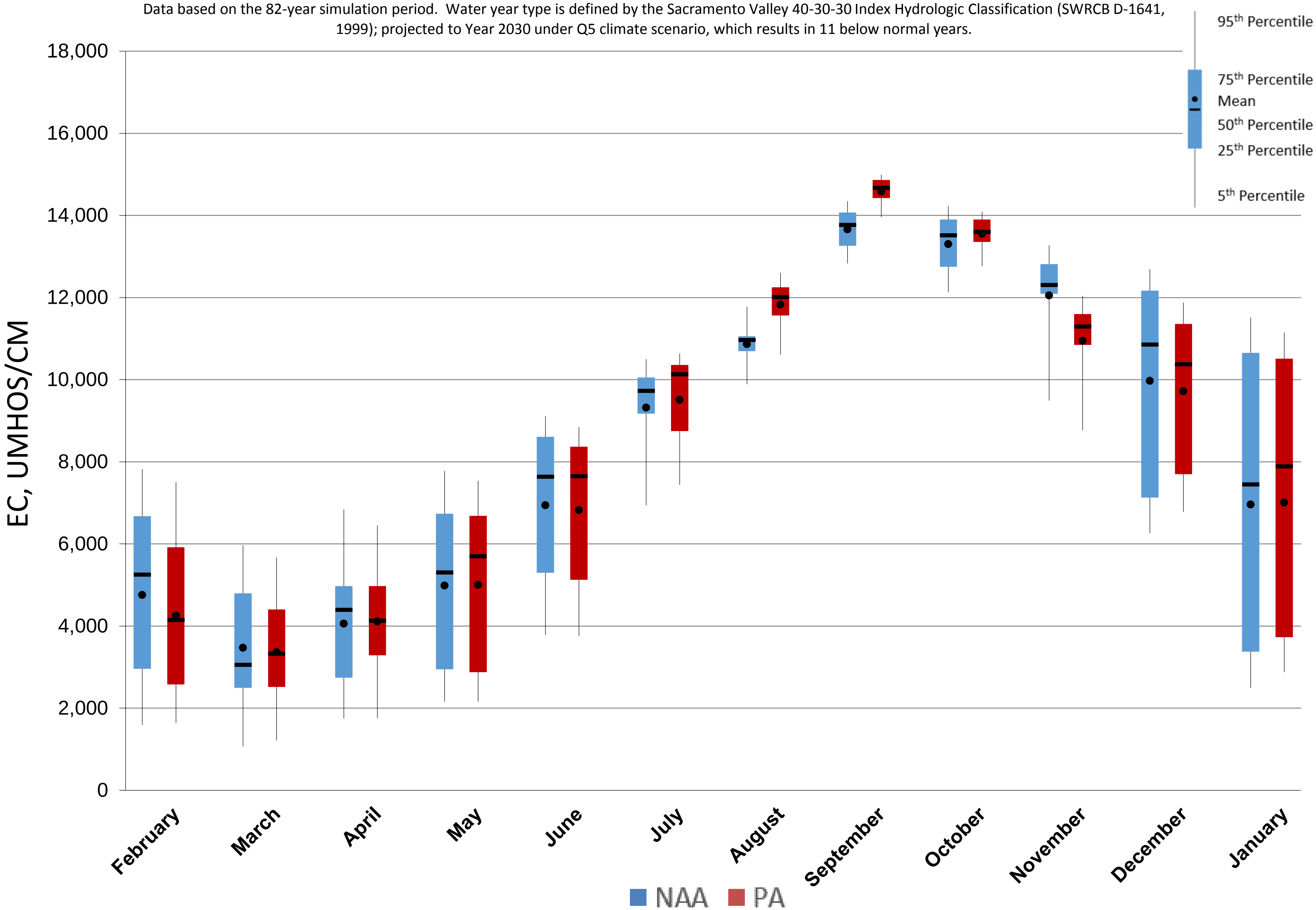


Figure 5.B.5-25-5. Monthly EC Ranges For Chadborne Sl at Sunrise Duck Club, Dry Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 20 dry years.

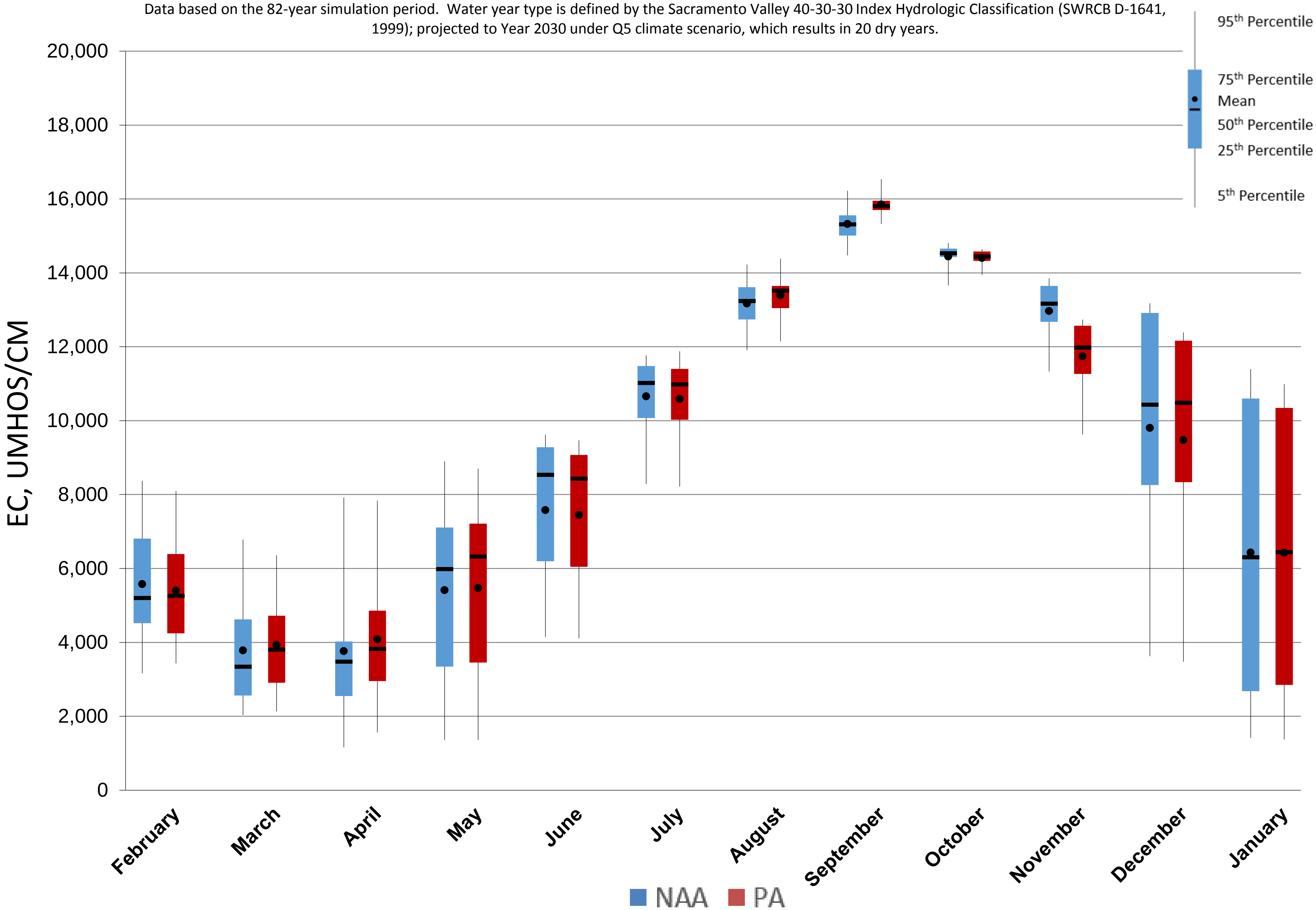


Figure 5.B.5-25-6. Monthly EC Ranges For Chadborne Sl at Sunrise Duck Club, Critical Years

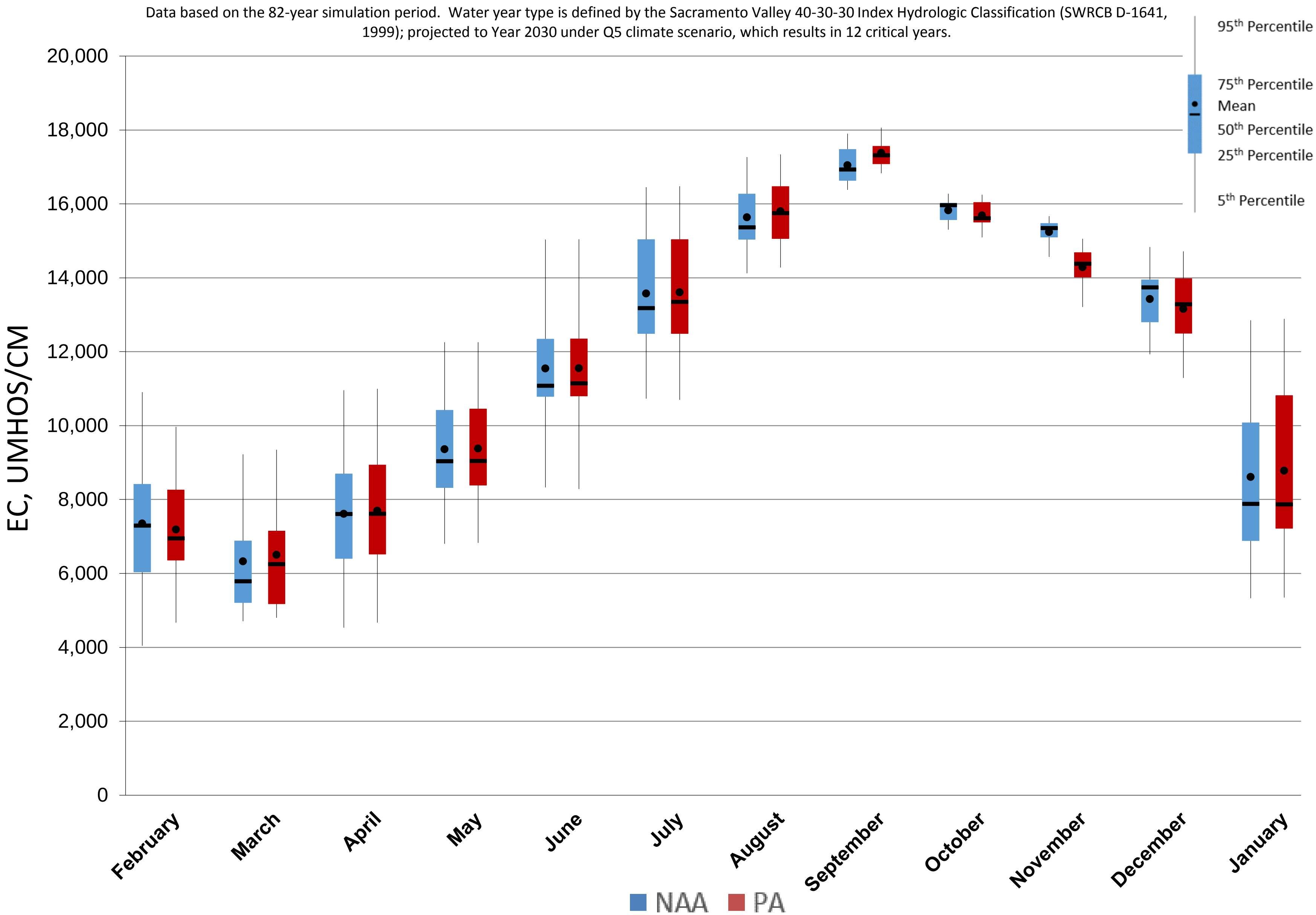
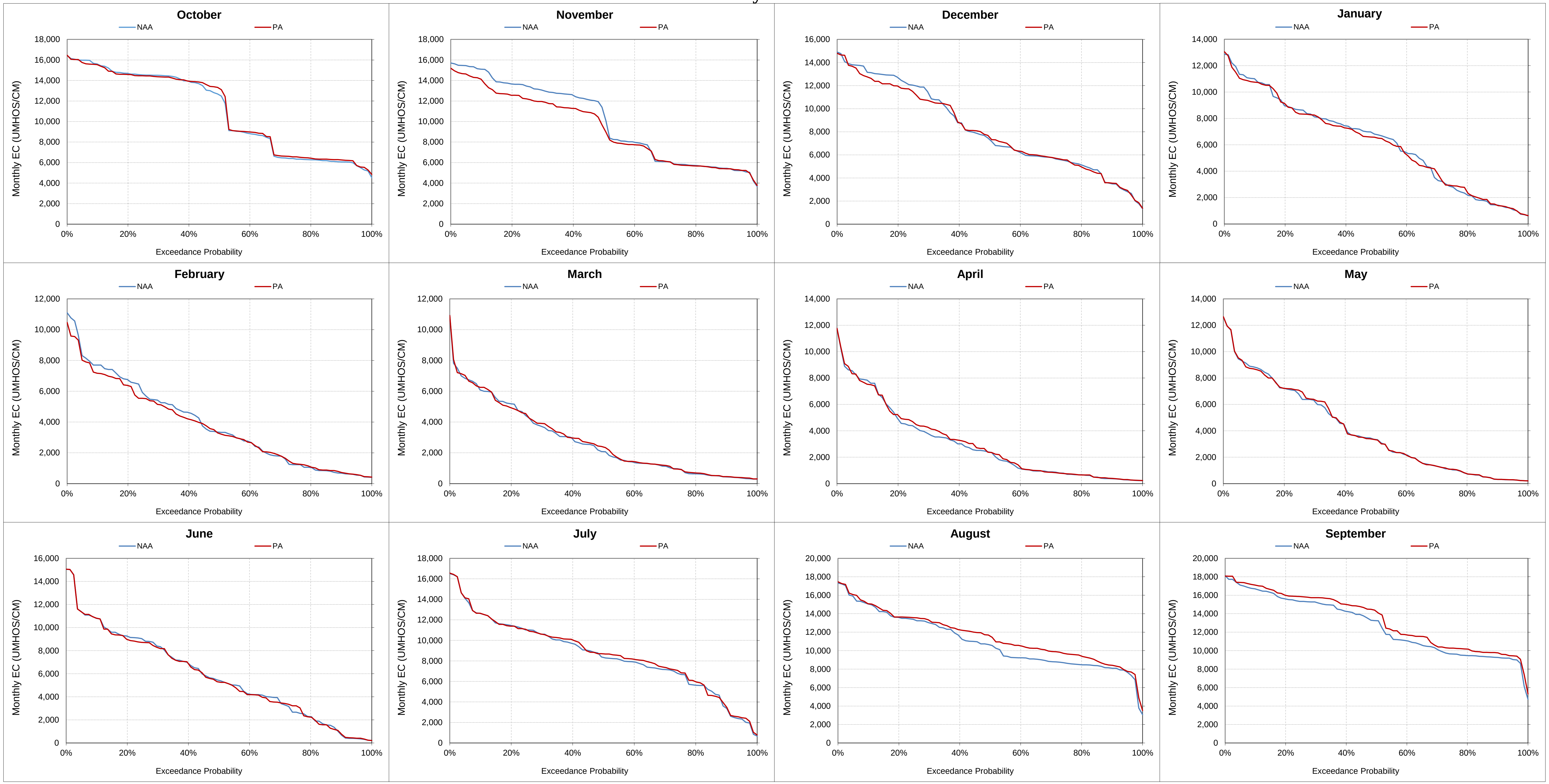
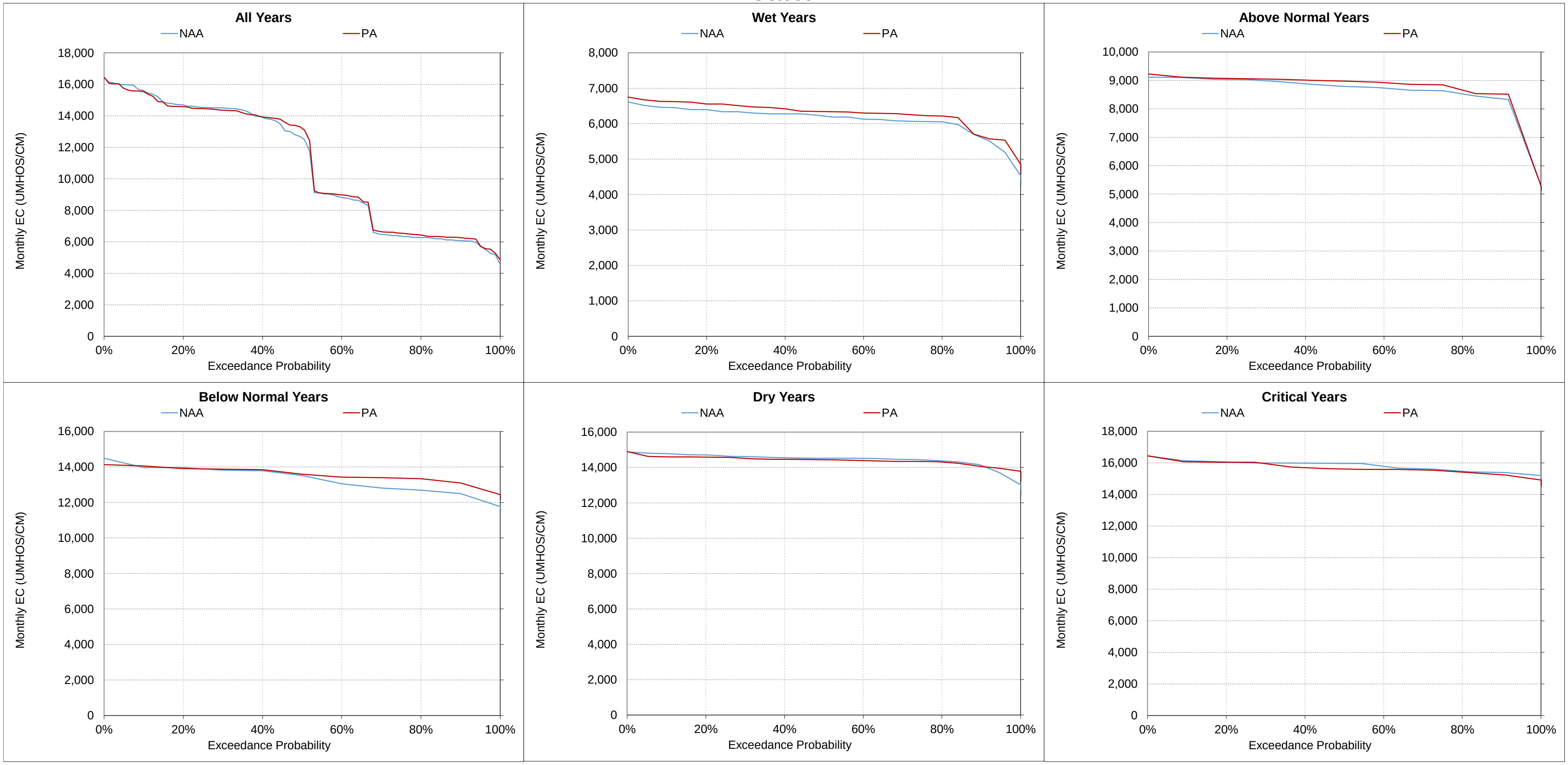


Figure 5.B.5-25-7. Chadborne Sl at Sunrise Duck Club, Monthly EC Probability of Exceedance



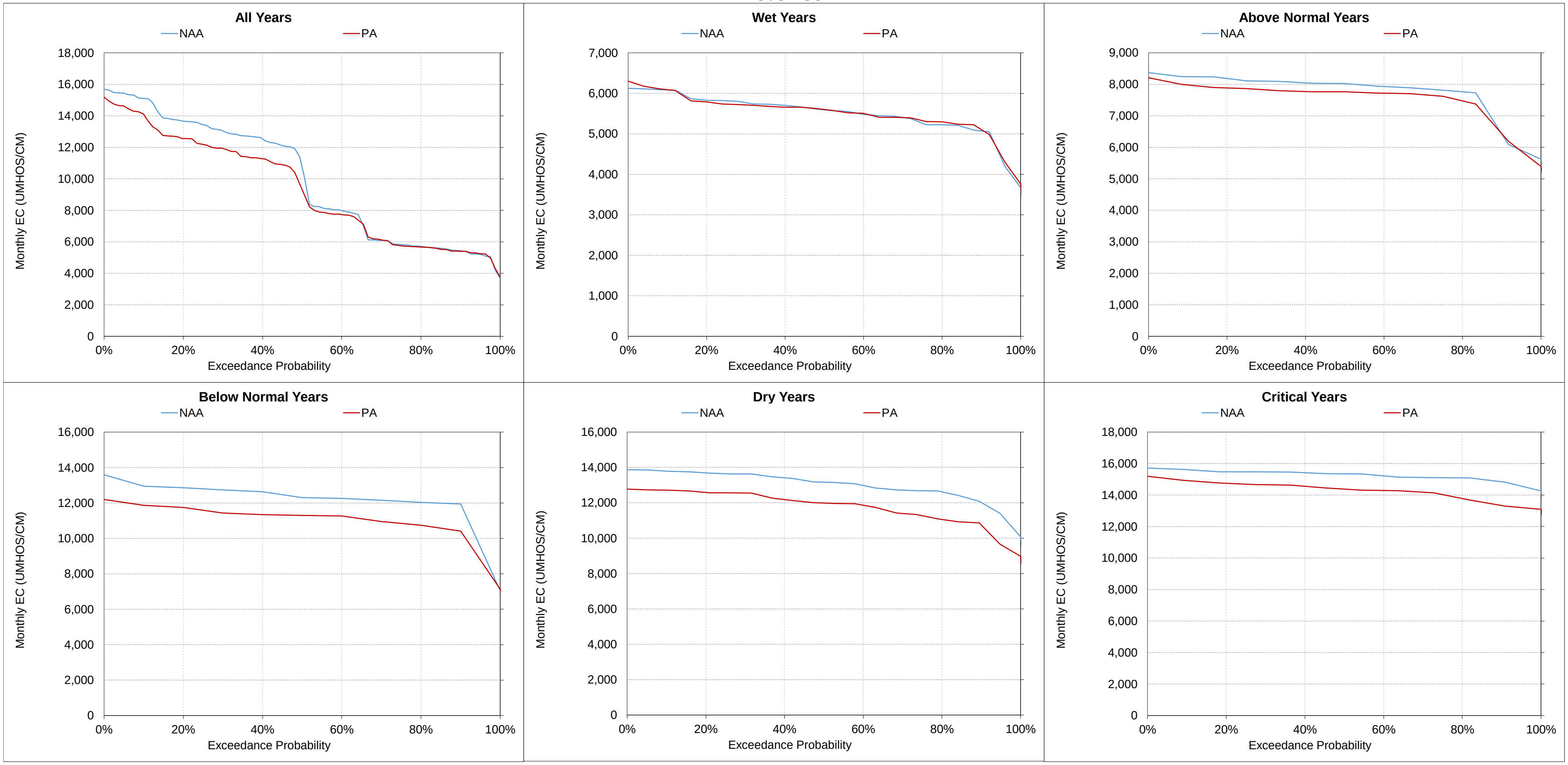
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-25-8. Chadborne Sl at Sunrise Duck Club, Monthly EC October



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-25-9. Chadborne Sl at Sunrise Duck Club, Monthly EC
November



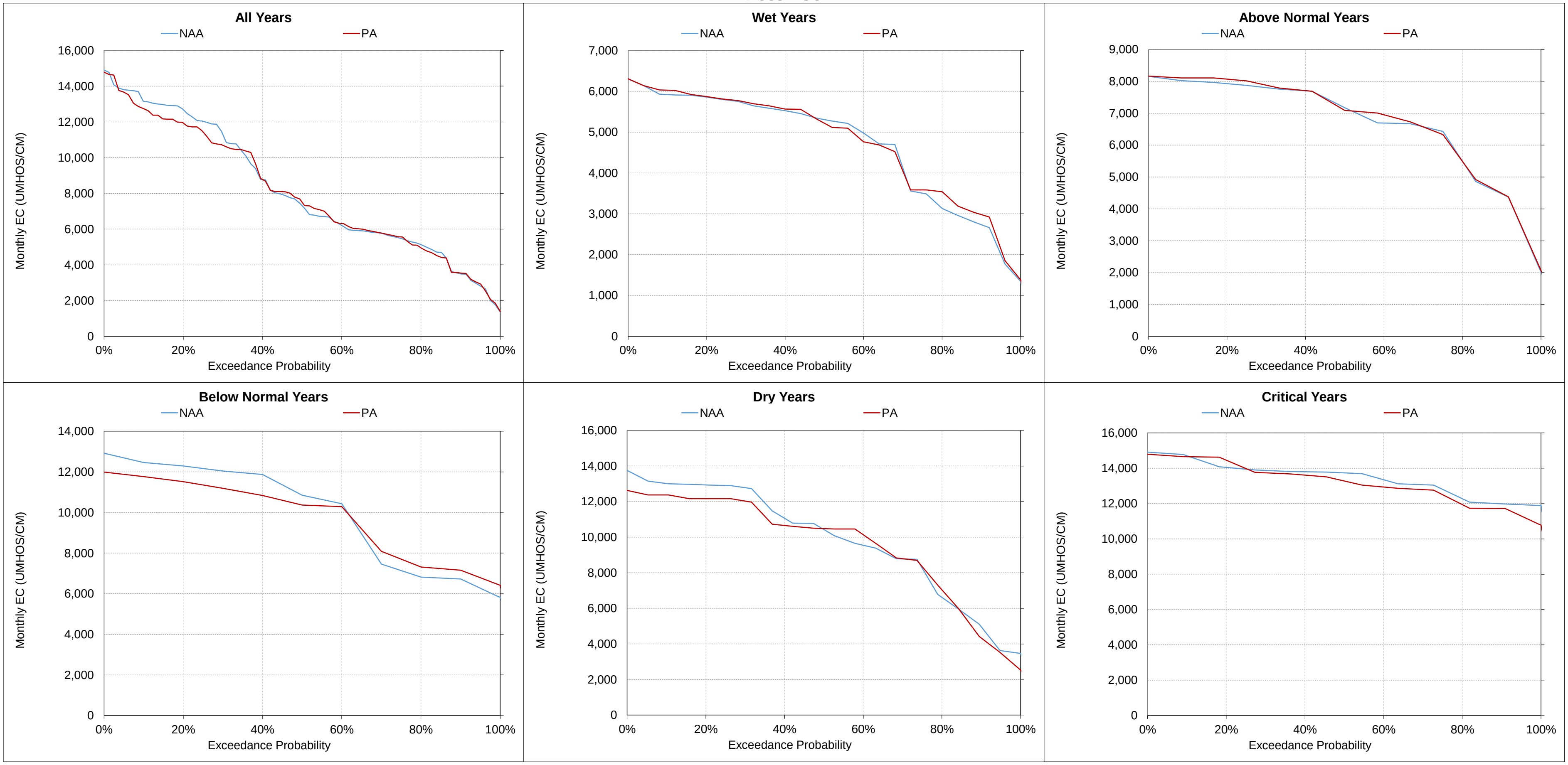
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

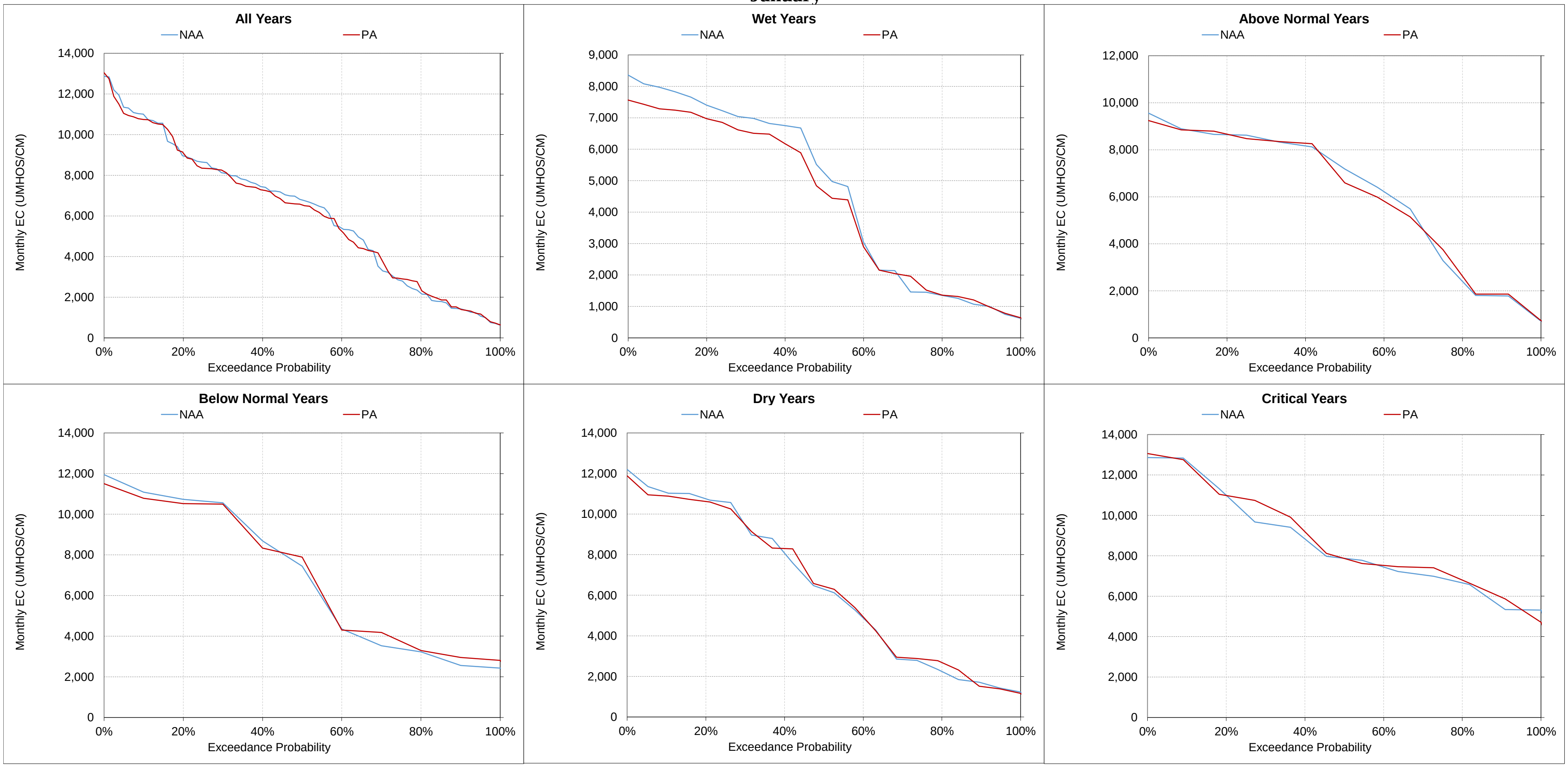
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-25-10. Chadborne Sl at Sunrise Duck Club, Monthly EC
December



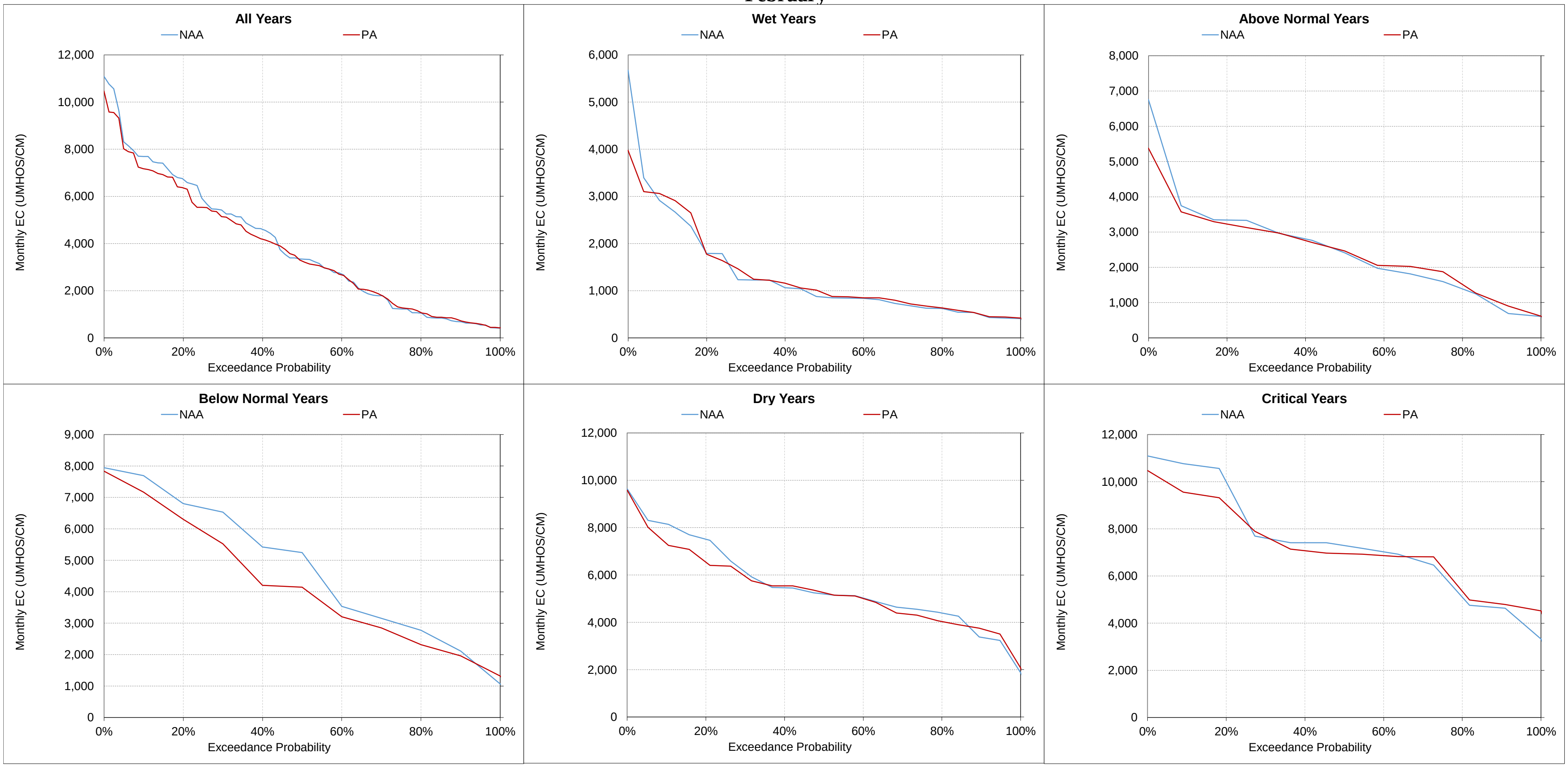
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-25-11. Chadborne Sl at Sunrise Duck Club, Monthly EC
January



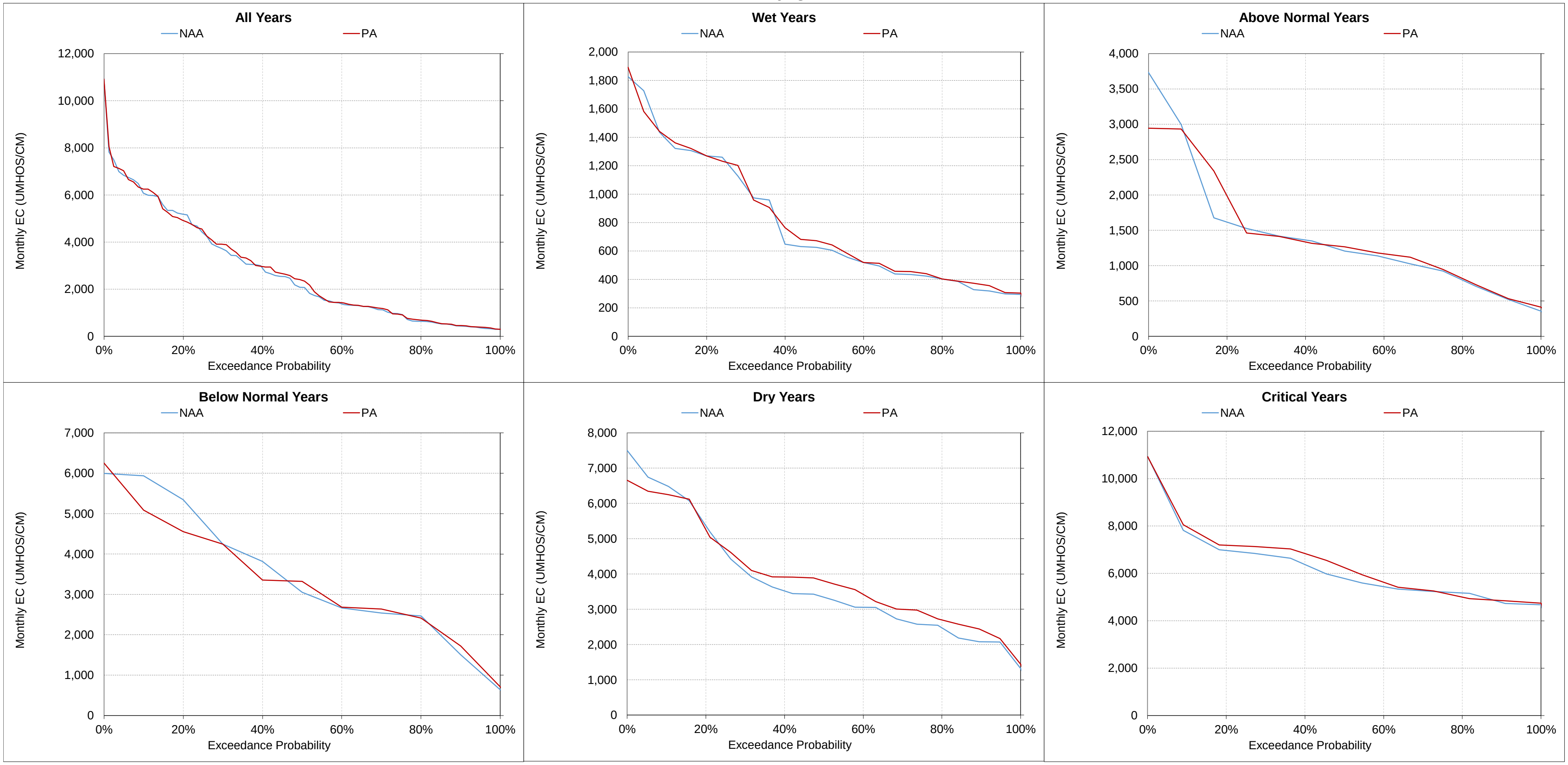
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-25-12. Chadborne Sl at Sunrise Duck Club, Monthly EC February



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-25-13. Chadborne Sl at Sunrise Duck Club, Monthly EC March



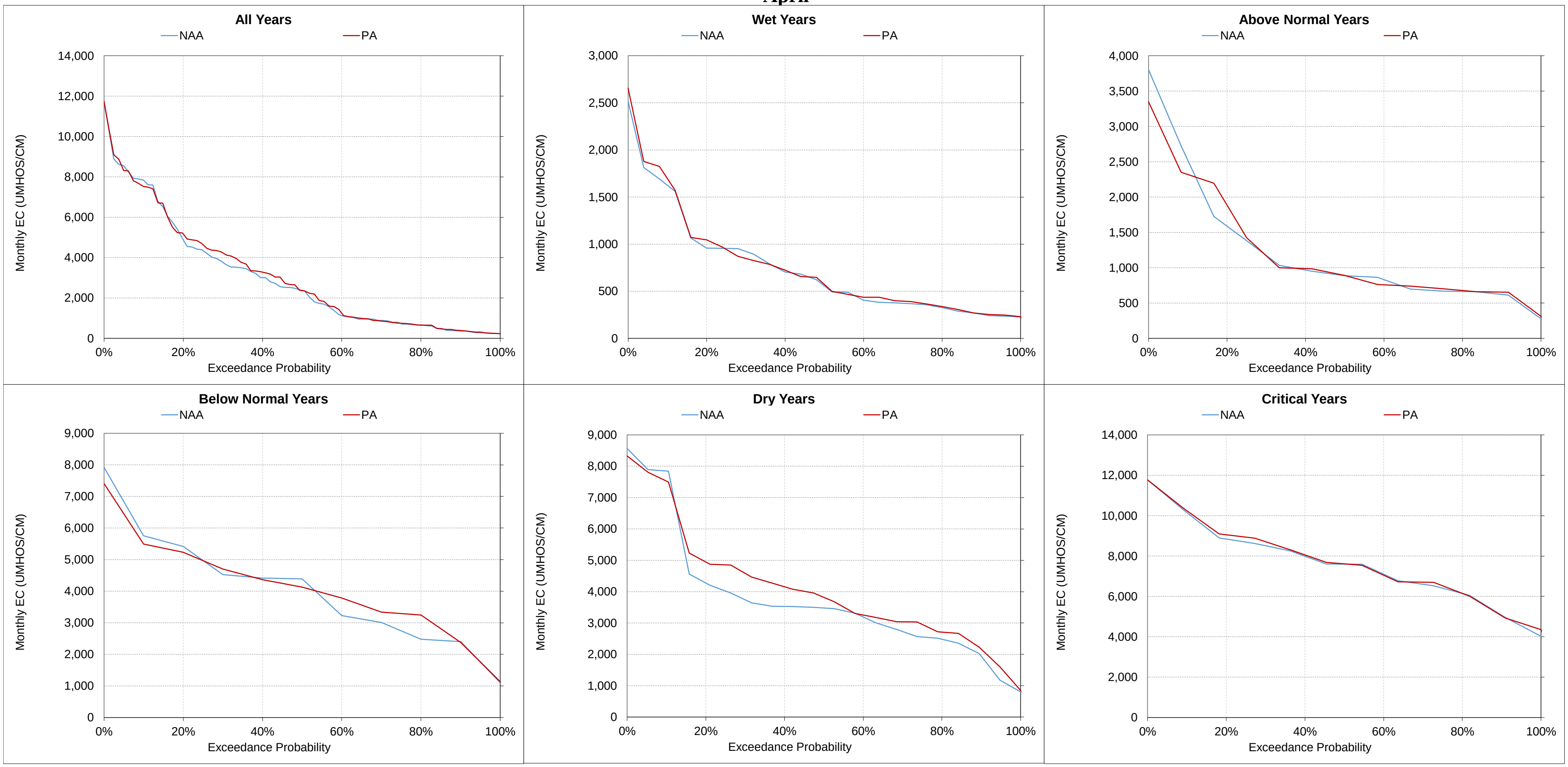
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

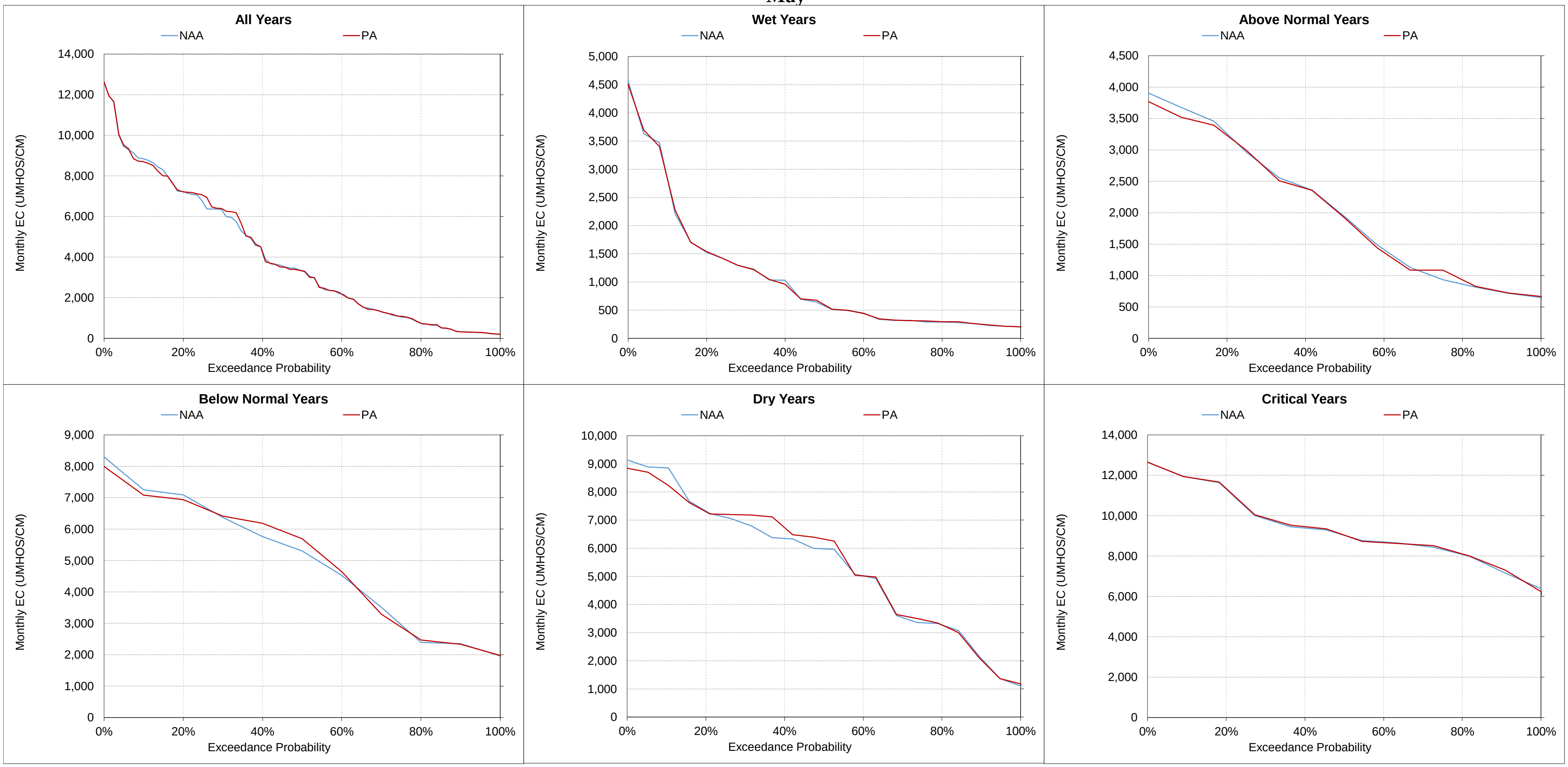
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-25-14. Chadborne Sl at Sunrise Duck Club, Monthly EC
April



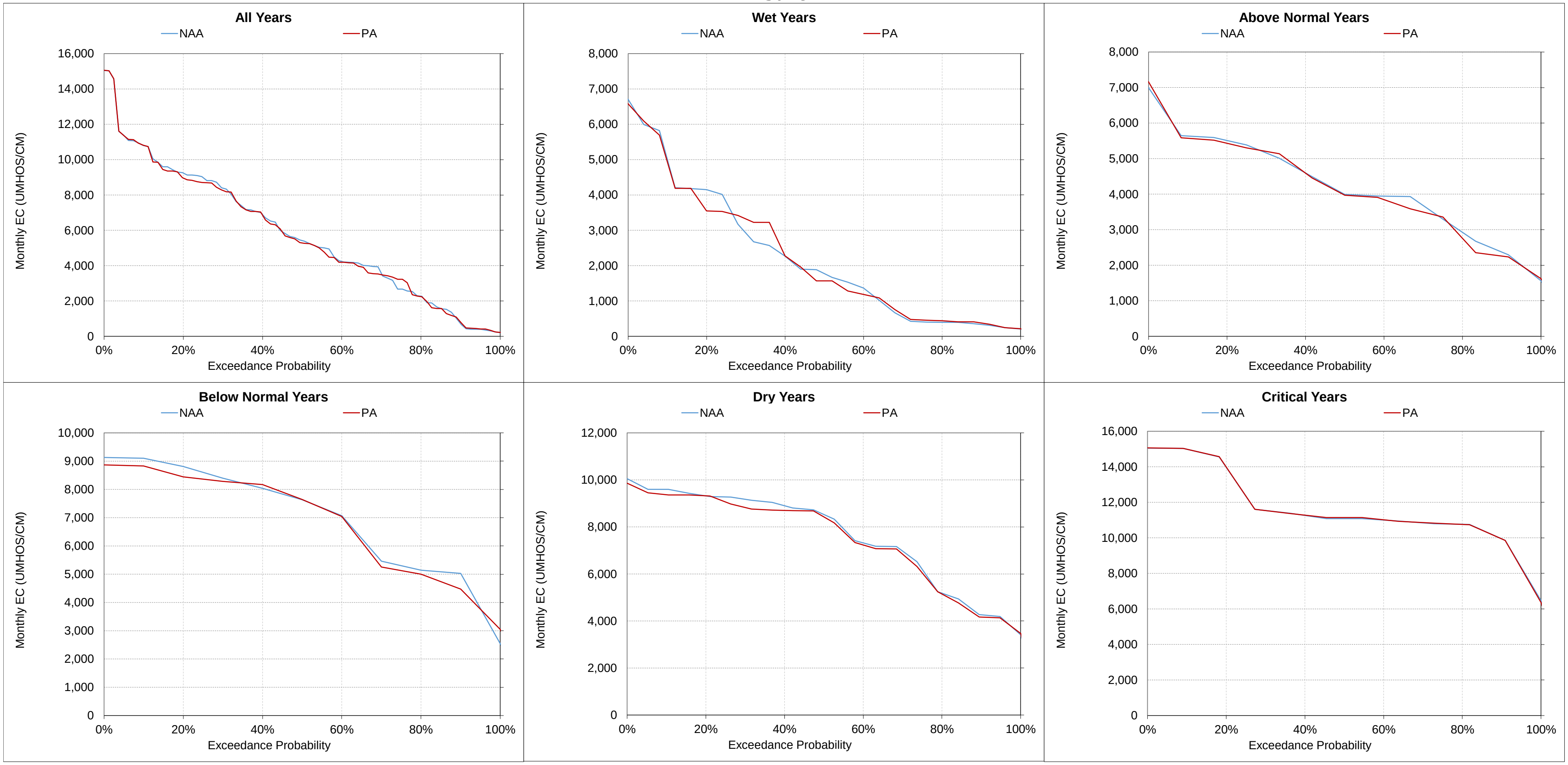
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-25-15. Chadborne Sl at Sunrise Duck Club, Monthly EC May



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-25-16. Chadborne Sl at Sunrise Duck Club, Monthly EC
June



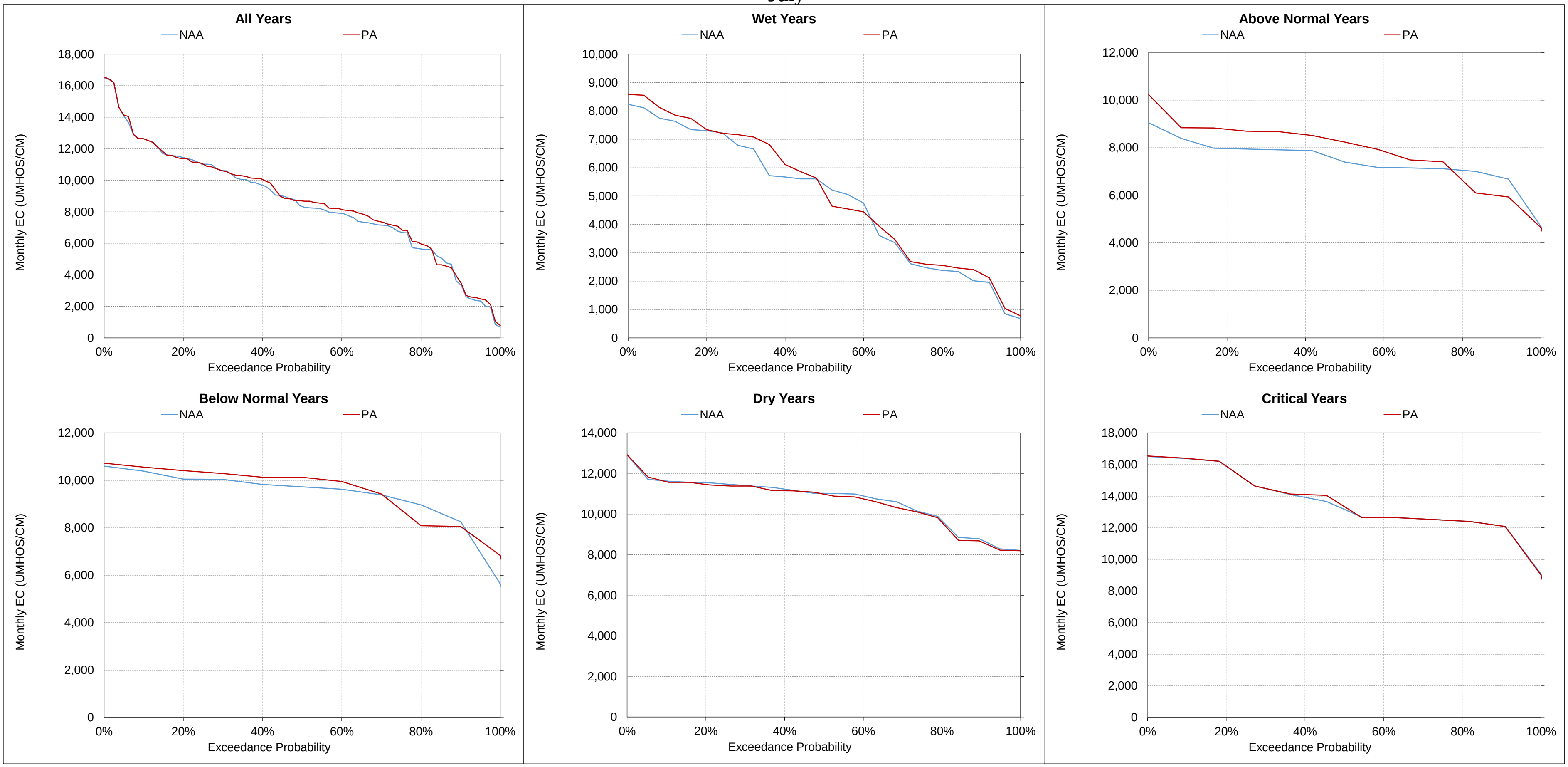
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

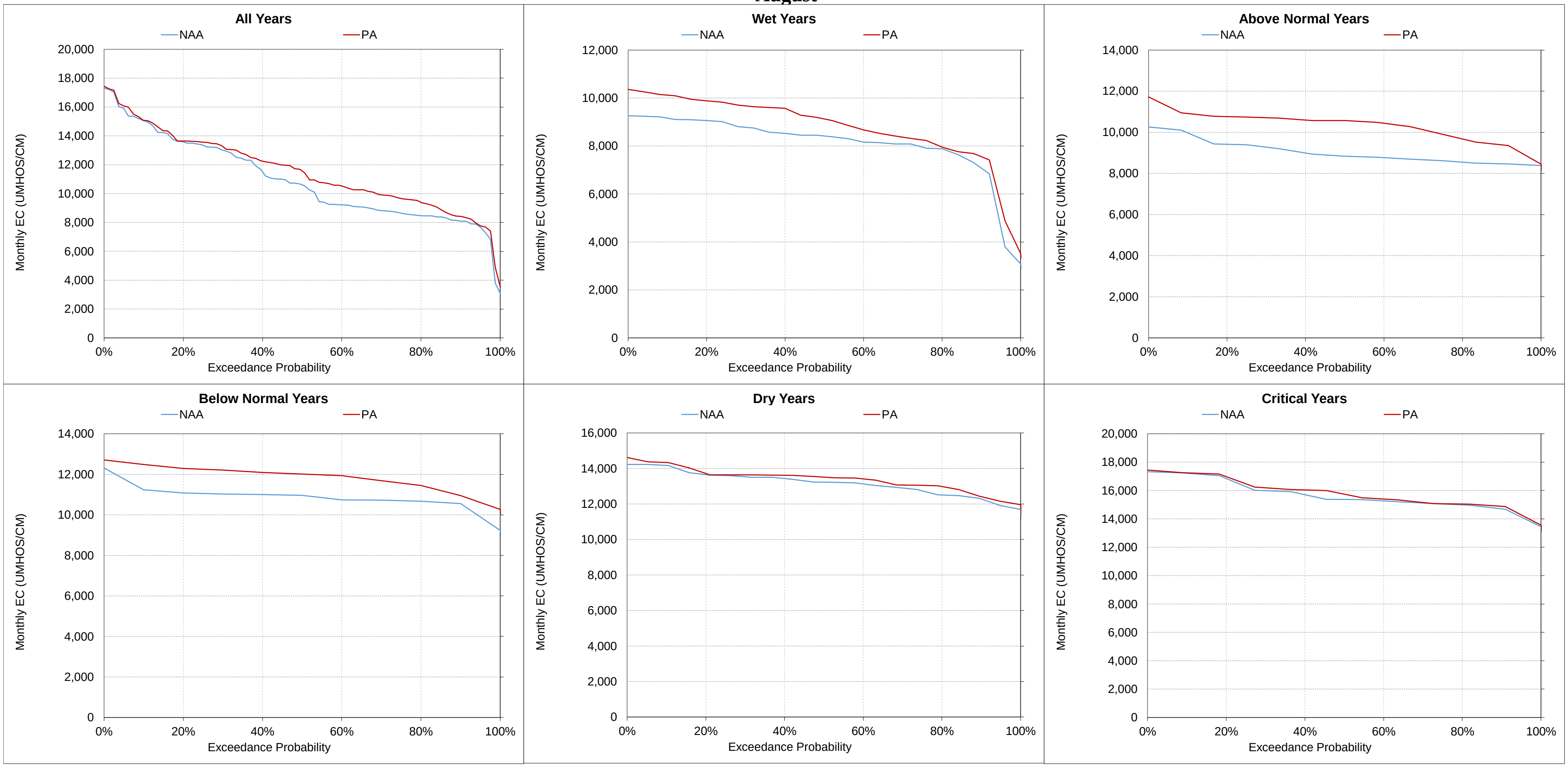
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-25-17. Chadborne Sl at Sunrise Duck Club, Monthly EC July



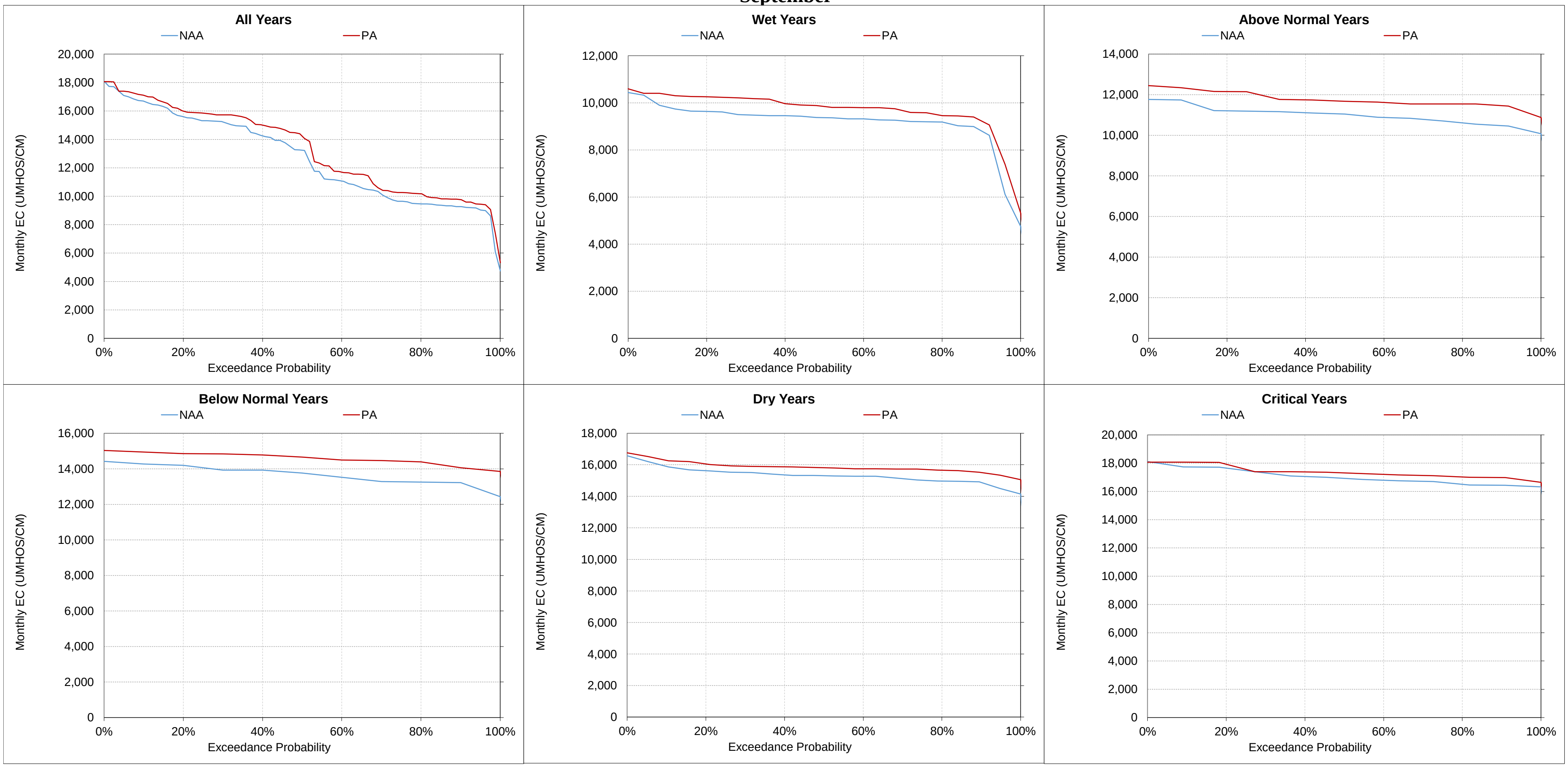
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-25-18. Chadborne Sl at Sunrise Duck Club, Monthly EC
August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-25-19. Chadborne Sl at Sunrise Duck Club, Monthly EC September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-26. Suisun Sl near Volanti Intake , Monthly EC

Statistic	Monthly EC (UMHOS/CM)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	14,735	14,663	-72	0%	14,038	12,863	-1,174	-8%	12,043	11,485	-558	-5%	9,851	9,593	-258	-3%	6,989	6,576	-414	-6%	6,169	5,955	-214	-3%
20%	13,829	13,697	-132	-1%	12,517	11,249	-1,268	-10%	11,396	10,758	-638	-6%	7,959	8,004	44	1%	6,109	5,880	-229	-4%	4,858	4,705	-154	-3%
30%	13,627	13,507	-121	-1%	12,072	10,681	-1,391	-12%	10,256	9,584	-672	-7%	7,527	7,231	-296	-4%	5,075	4,905	-170	-3%	3,570	3,796	226	6%
40%	13,085	13,063	-22	0%	11,540	10,105	-1,435	-12%	7,997	8,290	293	4%	6,707	6,440	-267	-4%	4,301	3,805	-496	-12%	2,850	2,950	100	3%
50%	11,768	12,436	668	6%	10,234	8,909	-1,325	-13%	6,555	6,778	224	3%	6,291	6,021	-269	-4%	3,405	3,221	-184	-5%	2,147	2,335	188	9%
60%	8,218	8,366	148	2%	7,097	6,865	-232	-3%	5,540	5,655	115	2%	5,121	4,872	-250	-5%	2,546	2,609	63	2%	1,495	1,499	3	0%
70%	6,165	6,304	139	2%	5,630	5,694	64	1%	5,024	5,042	17	0%	3,245	3,662	417	13%	1,660	1,871	211	13%	1,131	1,172	41	4%
80%	5,951	6,108	157	3%	5,224	5,153	-71	-1%	4,632	4,496	-136	-3%	2,163	2,376	213	10%	1,067	1,178	111	10%	673	731	58	9%
90%	5,754	5,938	184	3%	4,906	4,887	-20	0%	3,453	3,456	3	0%	1,494	1,477	-17	-1%	731	764	33	5%	473	504	31	6%
Long Term																								
Full Simulation Period[b]	10,300	10,371	71	1%	9,155	8,512	-643	-7%	7,428	7,322	-107	-1%	5,657	5,598	-59	-1%	3,687	3,543	-144	-4%	2,744	2,794	50	2%
Water Year Types[c]																								
Wet (32%)	5,797	5,963	166	3%	5,046	5,052	6	0%	4,198	4,245	47	1%	4,195	3,976	-218	-5%	1,349	1,325	-24	-2%	800	812	12	2%
Above Normal (16%)	7,992	8,143	150	2%	6,905	6,694	-211	-3%	5,787	5,860	73	1%	5,482	5,434	-49	-1%	2,525	2,455	-70	-3%	1,463	1,468	5	0%
Below Normal (13%)	12,535	12,773	238	2%	10,973	9,825	-1,147	-10%	8,957	8,734	-223	-2%	6,382	6,410	28	0%	4,460	4,041	-419	-9%	3,407	3,292	-115	-3%
Dry (24%)	13,576	13,514	-63	0%	11,941	10,678	-1,263	-11%	8,946	8,670	-277	-3%	5,930	5,896	-34	-1%	5,228	5,067	-161	-3%	3,740	3,886	146	4%
Critical (15%)	15,046	14,896	-151	-1%	14,185	13,166	-1,020	-7%	12,272	12,029	-243	-2%	7,894	8,047	153	2%	6,736	6,531	-206	-3%	6,074	6,246	172	3%

Statistic	Monthly EC (UMHOS/CM)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	7,648	7,446	-202	-3%	8,697	8,528	-170	-2%	10,374	10,400	26	0%	12,319	12,321	2	0%	14,821	14,896	75	1%	16,409	16,910	501	3%
20%	4,825	5,071	245	5%	7,039	7,021	-18	0%	8,997	8,763	-234	-3%	11,158	11,162	4	0%	13,418	13,489	71	1%	15,401	15,815	414	3%
30%	3,723	4,061	337	9%	5,864	6,142	279	5%	8,163	8,093	-70	-1%	10,466	10,406	-59	-1%	12,828	12,941	113	1%	15,073	15,612	540	4%
40%	2,957	3,246	289	10%	4,158	4,065	-93	-2%	6,427	6,419	-8	0%	9,406	9,749	343	4%	11,342	12,008	666	6%	13,920	14,726	806	6%
50%	2,291	2,343	52	2%	3,242	3,222	-21	-1%	5,192	5,052	-140	-3%	8,126	8,511	385	5%	10,407	11,122	715	7%	13,116	14,100	985	8%
60%	1,173	1,211	38	3%	2,146	2,163	17	1%	4,048	3,990	-59	-1%	7,719	7,841	122	2%	9,044	10,307	1,263	14%	10,911	11,669	758	7%
70%	916	855	-61	-7%	1,276	1,277	1	0%	3,281	3,217	-64	-2%	6,995	7,163	168	2%	8,569	9,658	1,089	13%	10,142	10,539	397	4%
80%	690	692	2	0%	695	710	14	2%	2,135	2,167	32	1%	5,488	5,759	272	5%	8,271	9,227	956	12%	9,498	10,217	720	8%
90%	391	403	12	3%	353	358	5	1%	656	735	78	12%	3,238	3,371	134	4%	7,882	8,179	297	4%	9,283	9,690	407	4%
Long Term																								
Full Simulation Period[b]	2,964	3,064	100	3%	3,920	3,939	19	0%	5,641	5,587	-54	-1%	8,343	8,460	117	1%	10,712	11,332	619	6%	12,597	13,184	587	5%
Water Year Types[c]																								
Wet (32%)	758	776	18	2%	1,073	1,074	2	0%	2,143	2,137	-7	0%	4,735	4,901	167	4%	7,822	8,501	679	9%	9,155	9,674	519	6%
Above Normal (16%)	1,259	1,242	-17	-1%	1,964	1,942	-22	-1%	3,977	3,929	-48	-1%	7,226	7,574	348	5%	8,819	10,082	1,263	14%	10,919	11,716	797	7%
Below Normal (13%)	4,014	4,060	46	1%	4,872	4,892	20	0%	6,699	6,593	-106	-2%	9,097	9,257	160	2%	10,644	11,595	951	9%	13,473	14,380	907	7%
Dry (24%)	3,717	4,041	325	9%	5,271	5,337	66	1%	7,314	7,187	-127	-2%	10,364	10,292	-71	-1%	12,929	13,149	220	2%	15,128	15,647	519	3%
Critical (15%)	7,376	7,456	79	1%	9,081	9,104	23	0%	11,265	11,270	6	0%	13,313	13,343	30	0%	15,393	15,549	156	1%	16,851	17,177	326	2%

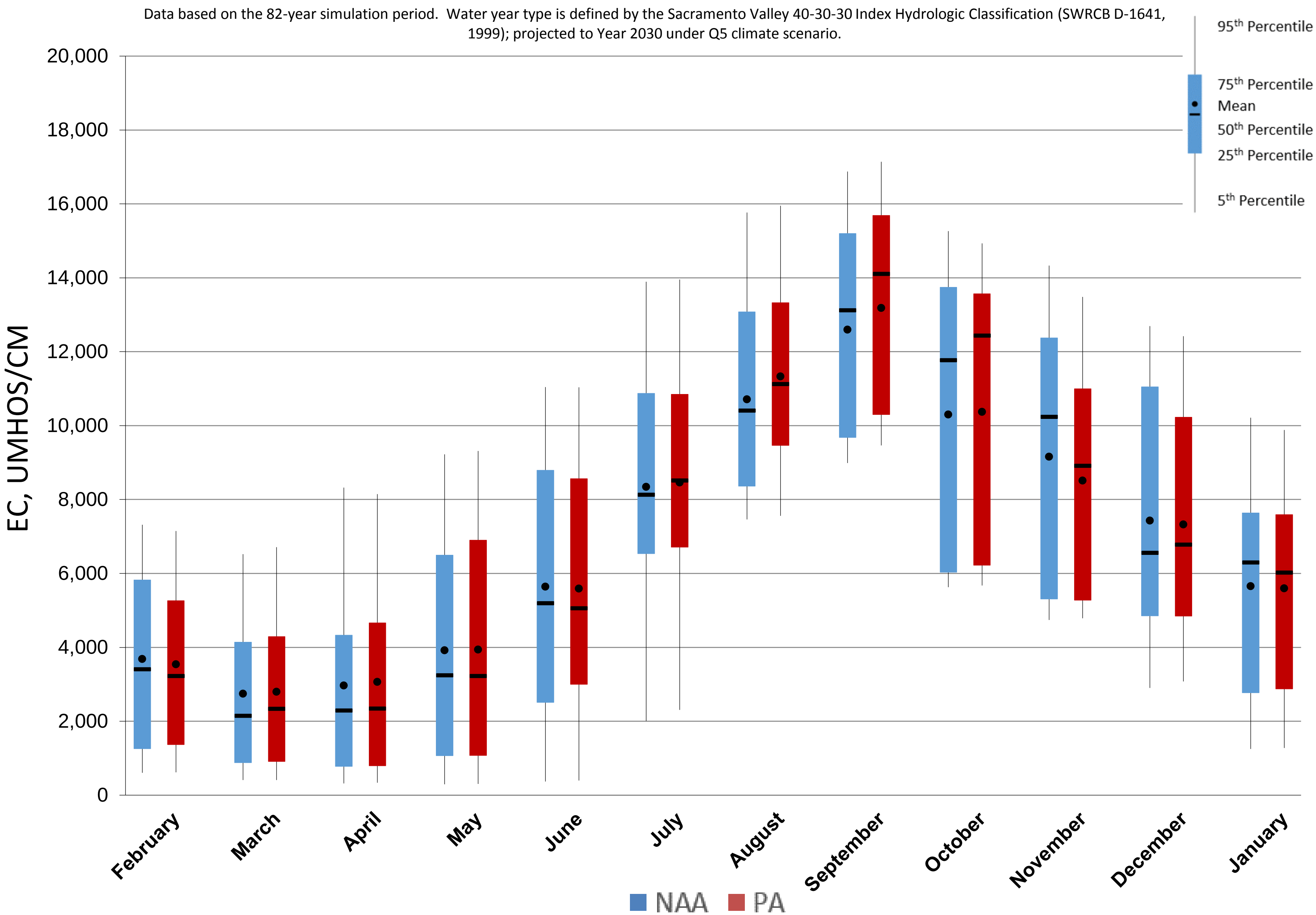
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-26-1. Monthly EC Ranges For Suisun Sl near Volanti Intake , All Years



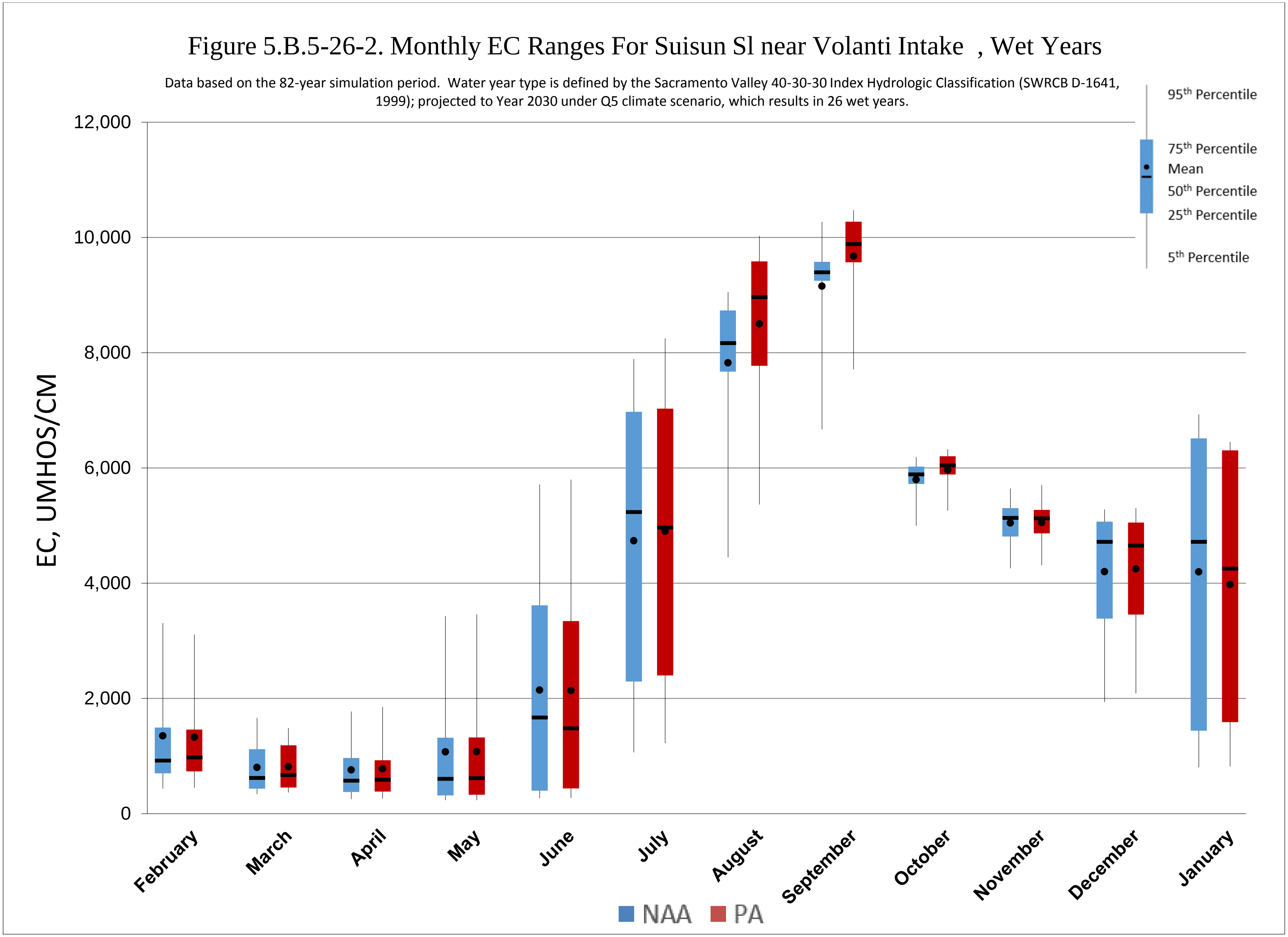


Figure 5.B.5-26-2. Monthly EC Ranges For Suisun Sl near Volanti Intake , Wet Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 26 wet years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
EC, UMHOS/CM
12,000
10,000
8,000
6,000
4,000
2,000
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-26-3. Monthly EC Ranges For Suisun Sl near Volanti Intake , Above Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 13 above normal years.

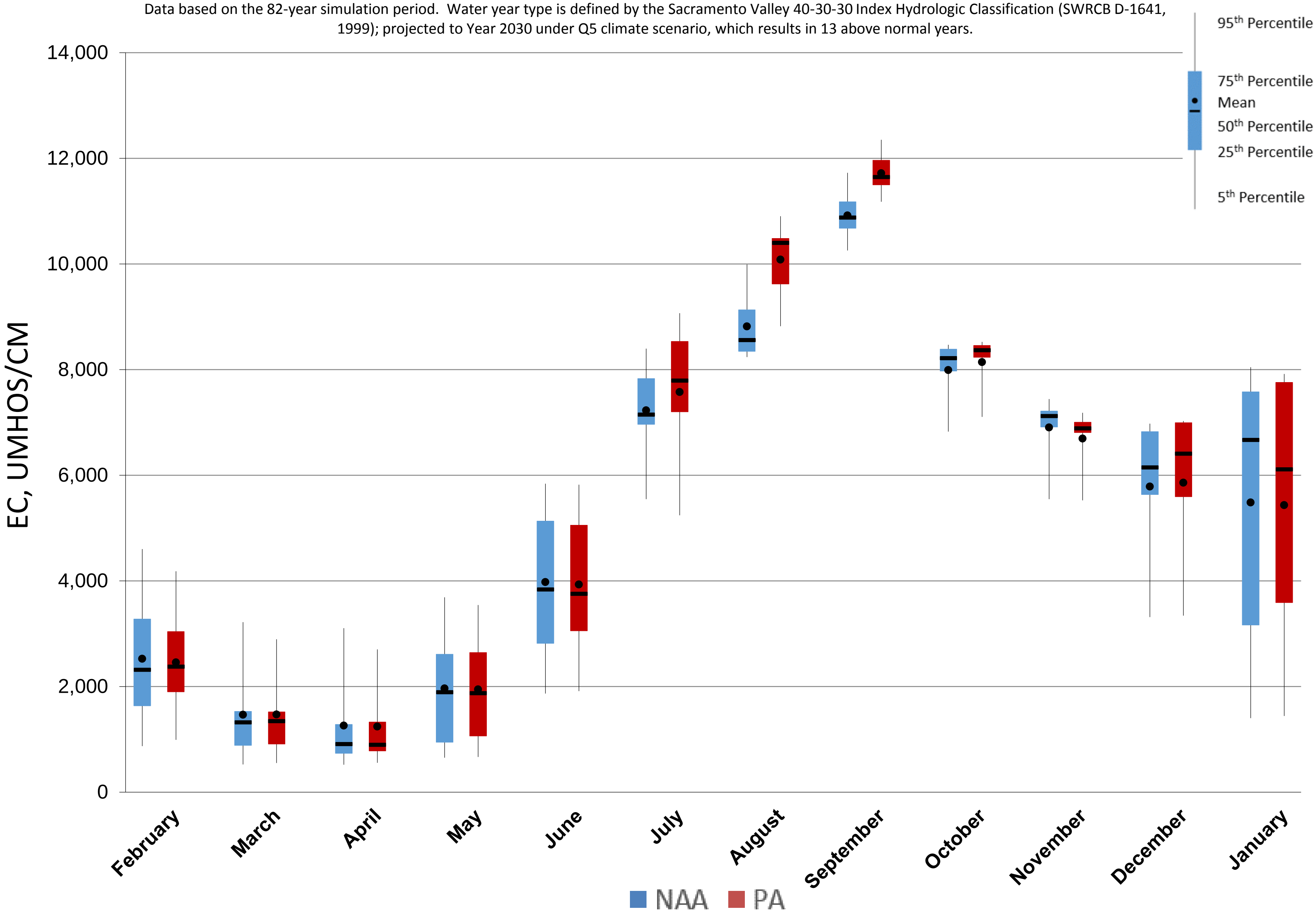
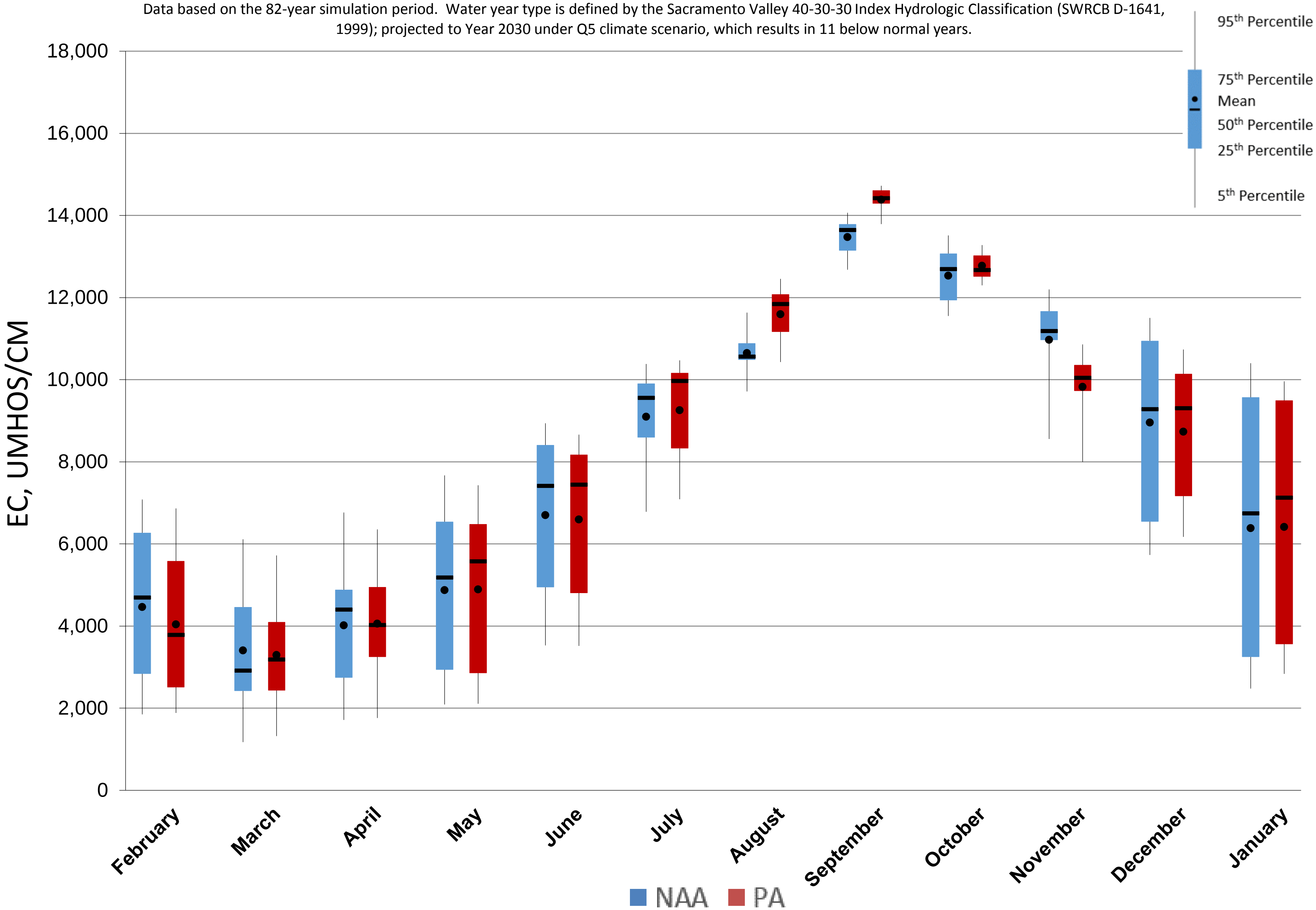


Figure 5.B.5-26-4. Monthly EC Ranges For Suisun Sl near Volanti Intake , Below Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 11 below normal years.



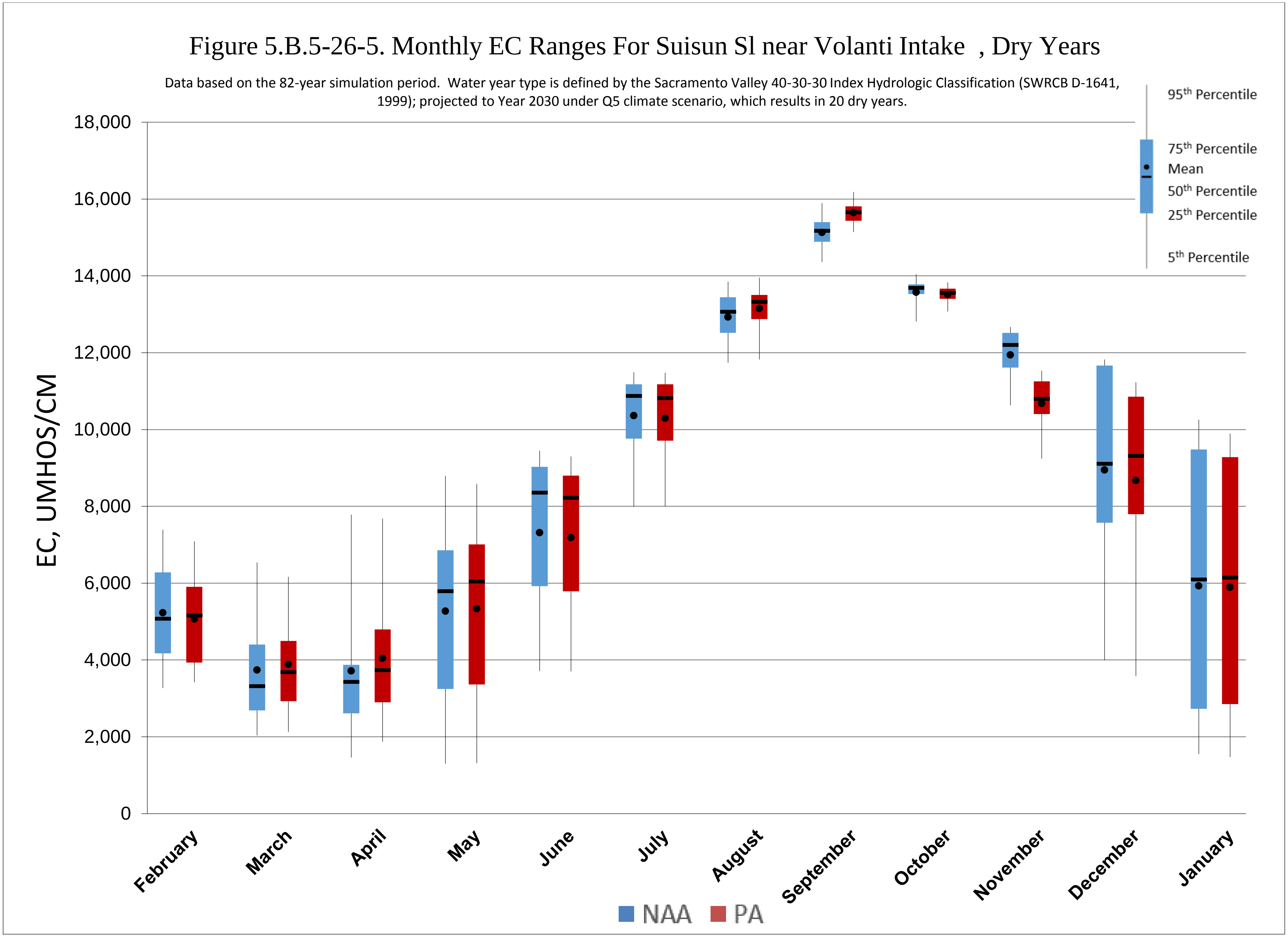


Figure 5.B.5-26-5. Monthly EC Ranges For Suisun Sl near Volanti Intake , Dry Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 20 dry years.
EC, UMHOS/CM
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
February
March
April
May
June
July
August
September
October
November
December
January
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
NAA
PA

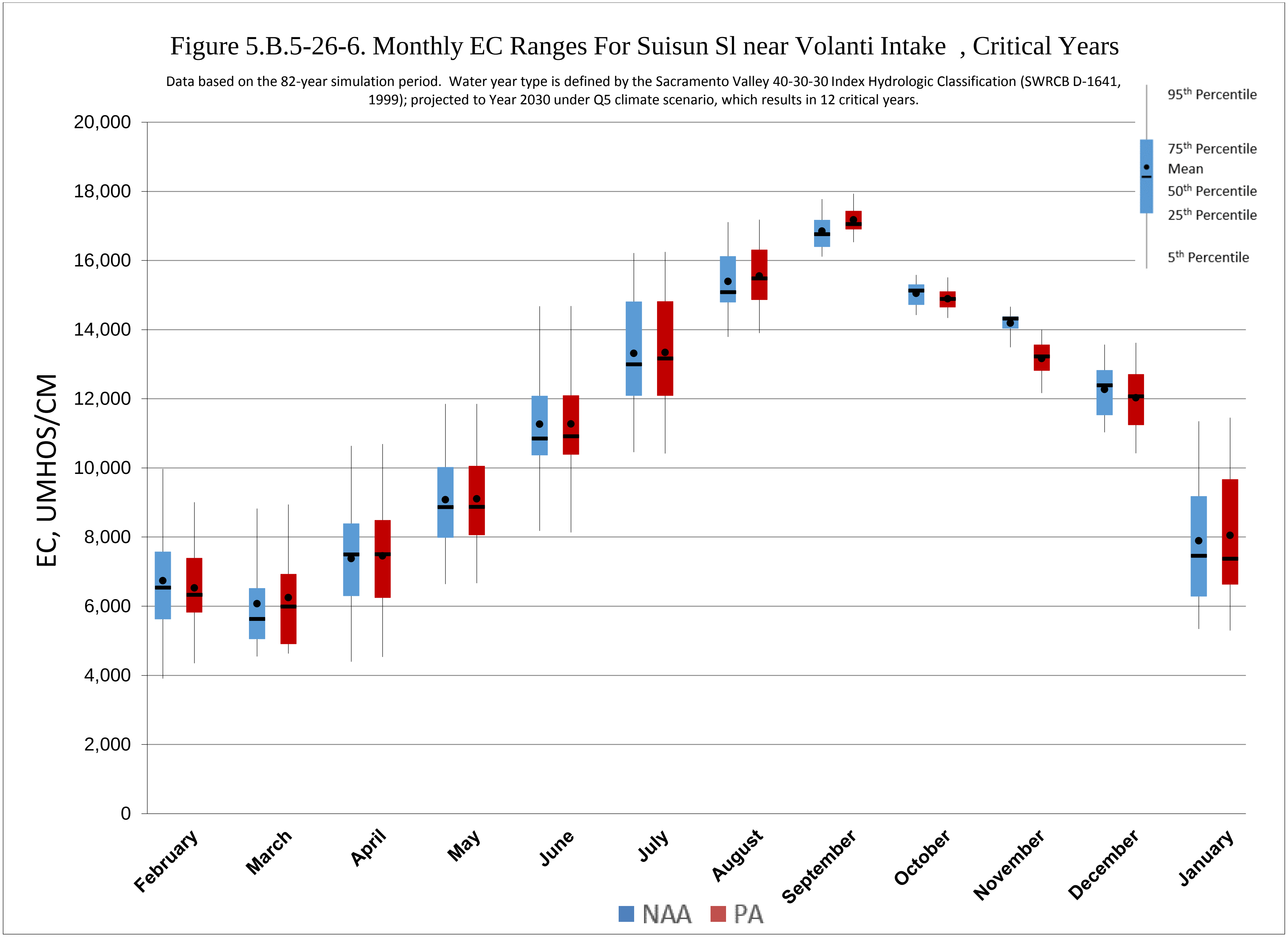
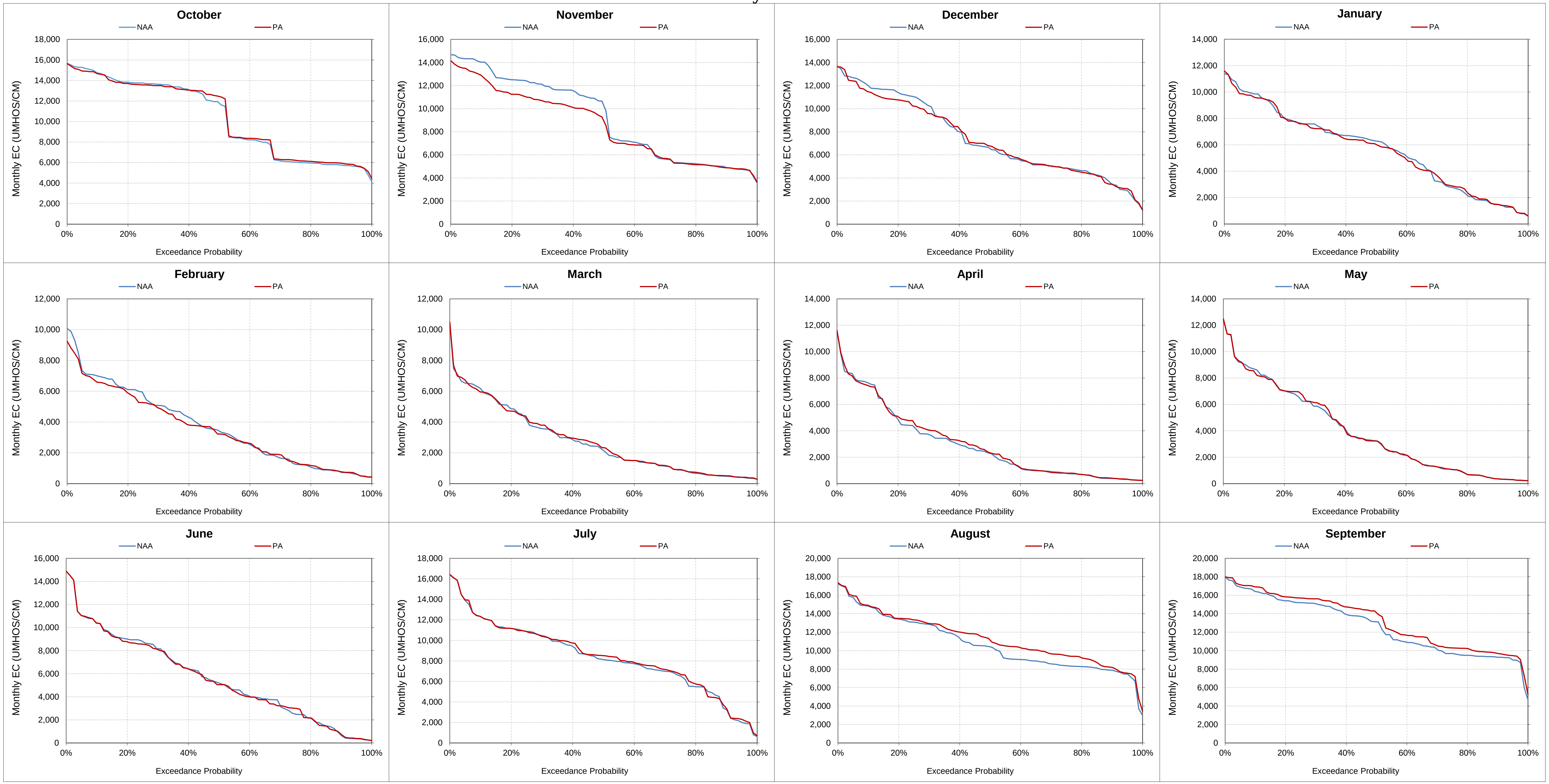


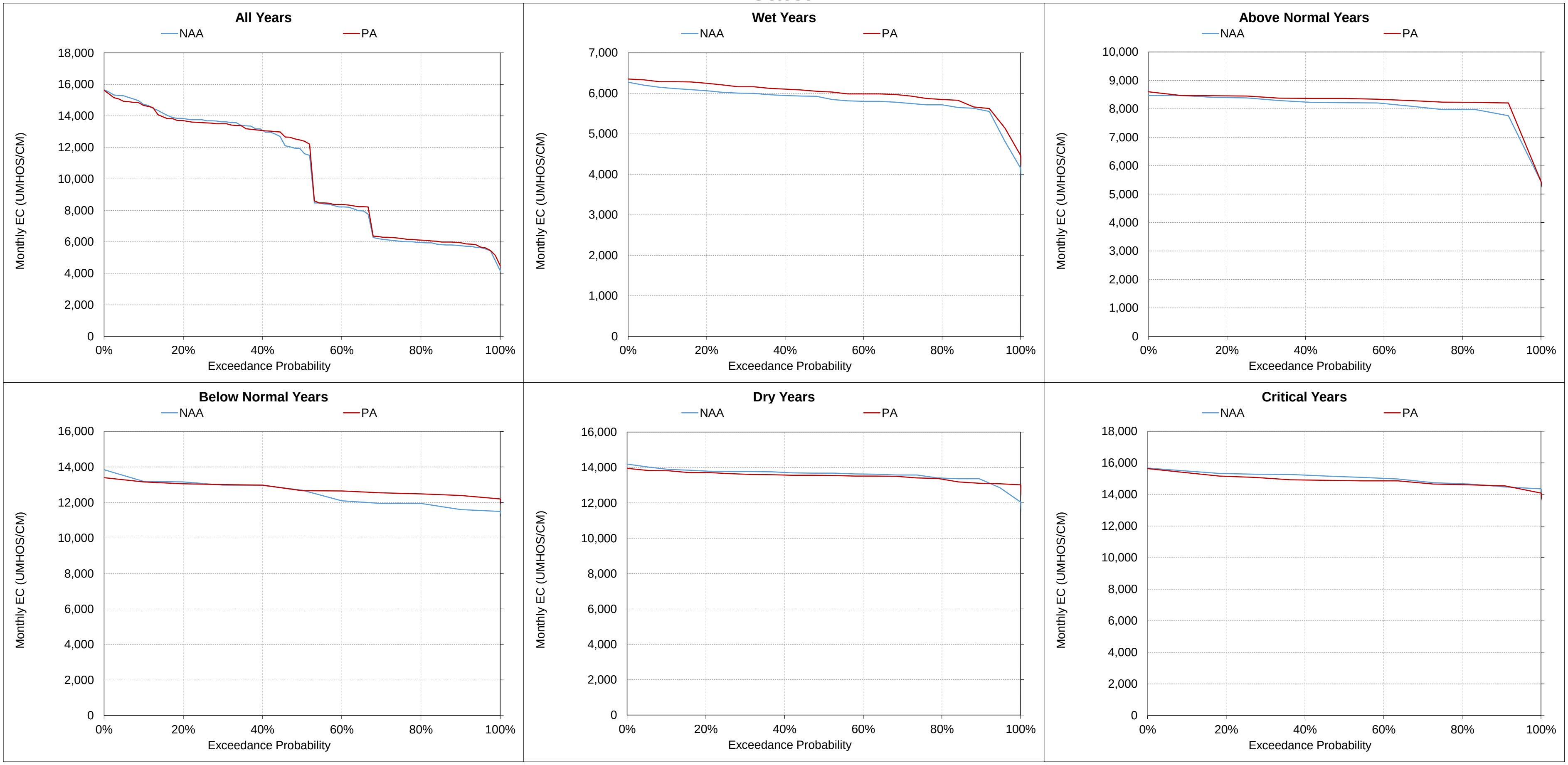
Figure 5.B.5-26-6. Monthly EC Ranges For Suisun Sl near Volanti Intake , Critical Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 12 critical years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
EC, UMHOS/CM
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-26-7. Suisun Sl near Volanti Intake , Monthly EC Probability of Exceedance



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-26-8. Suisun Sl near Volanti Intake , Monthly EC October



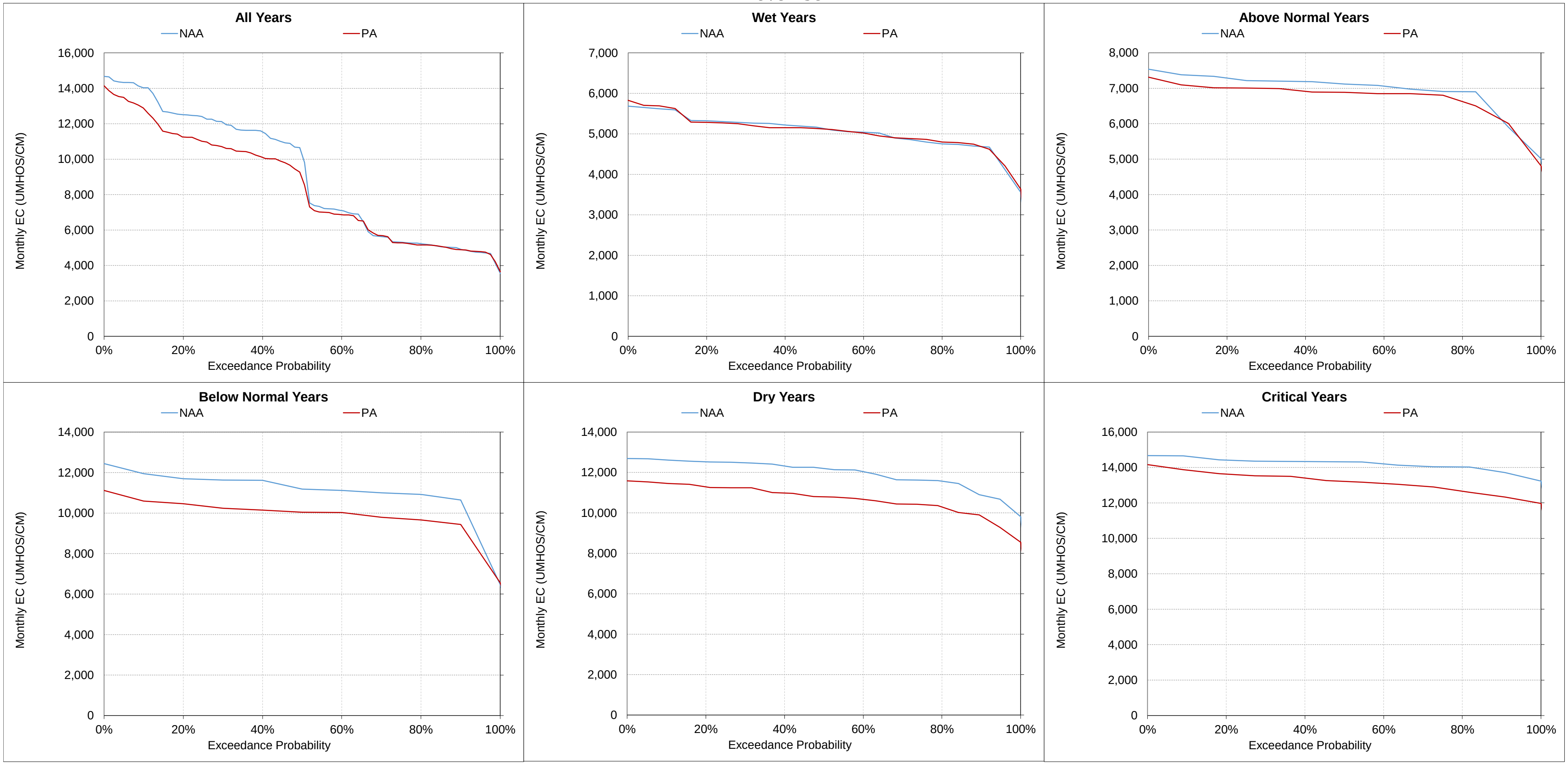
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

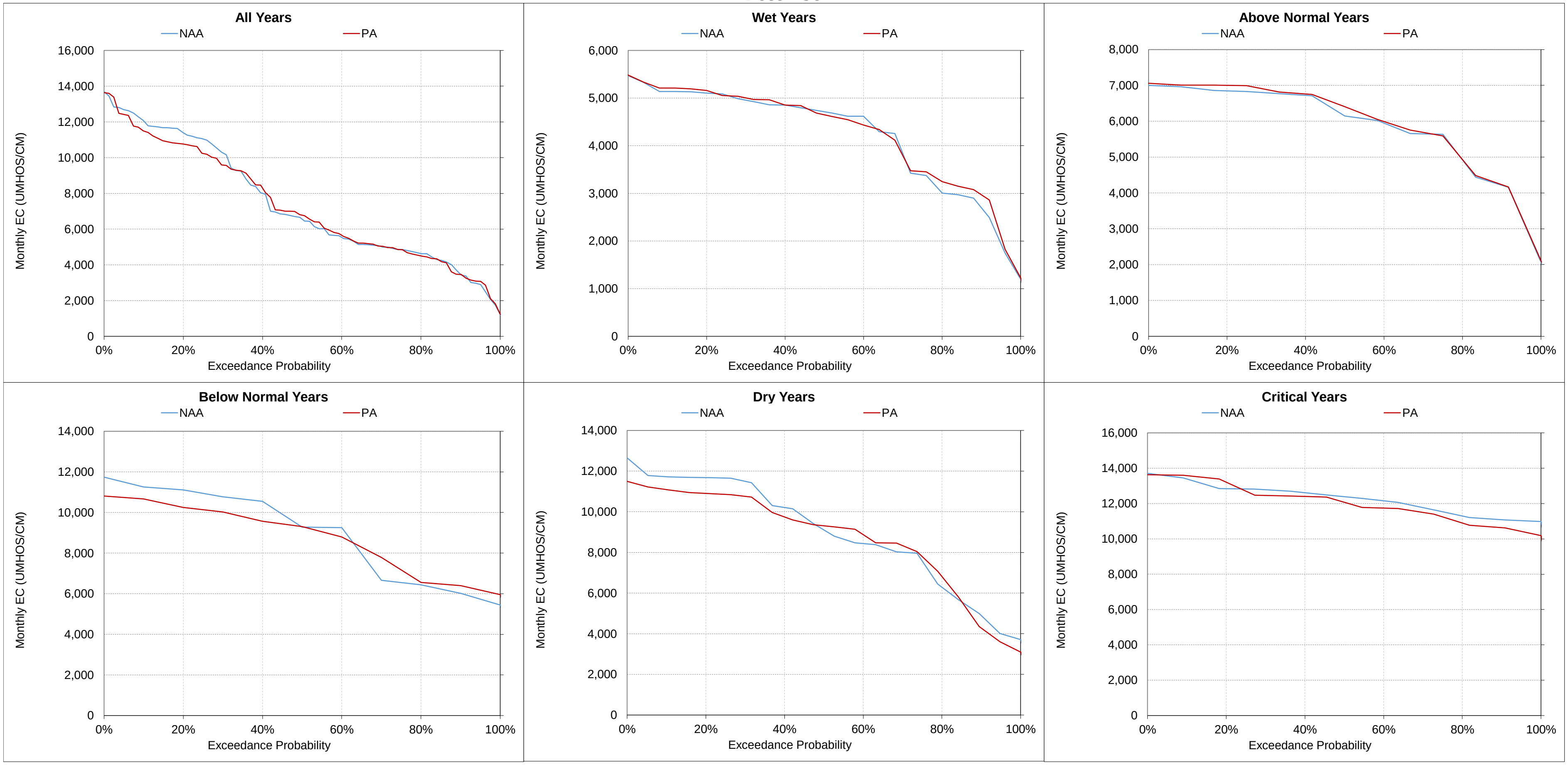
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-26-9. Suisun Sl near Volanti Intake , Monthly EC November



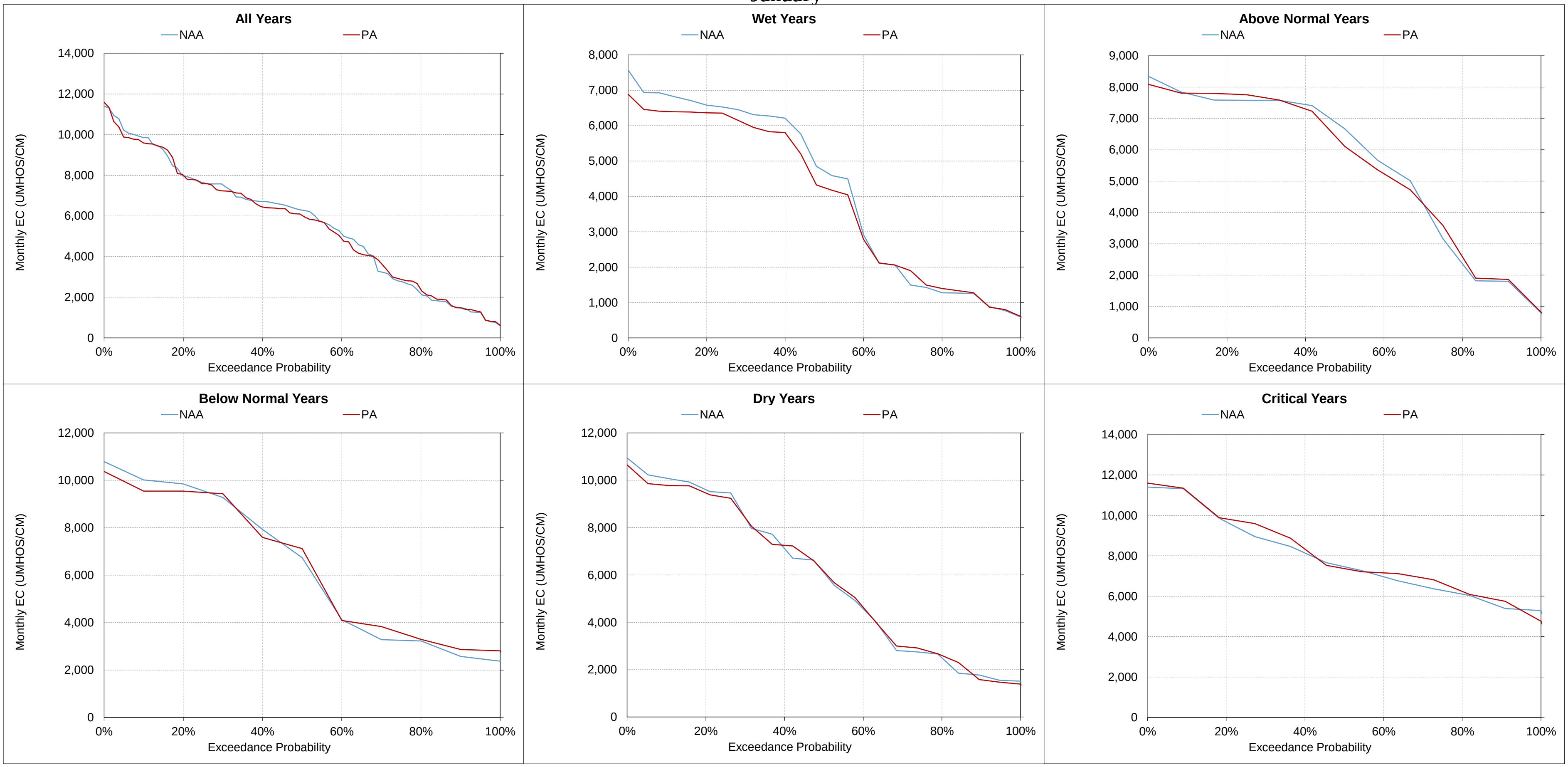
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-26-10. Suisun Sl near Volanti Intake , Monthly EC
December



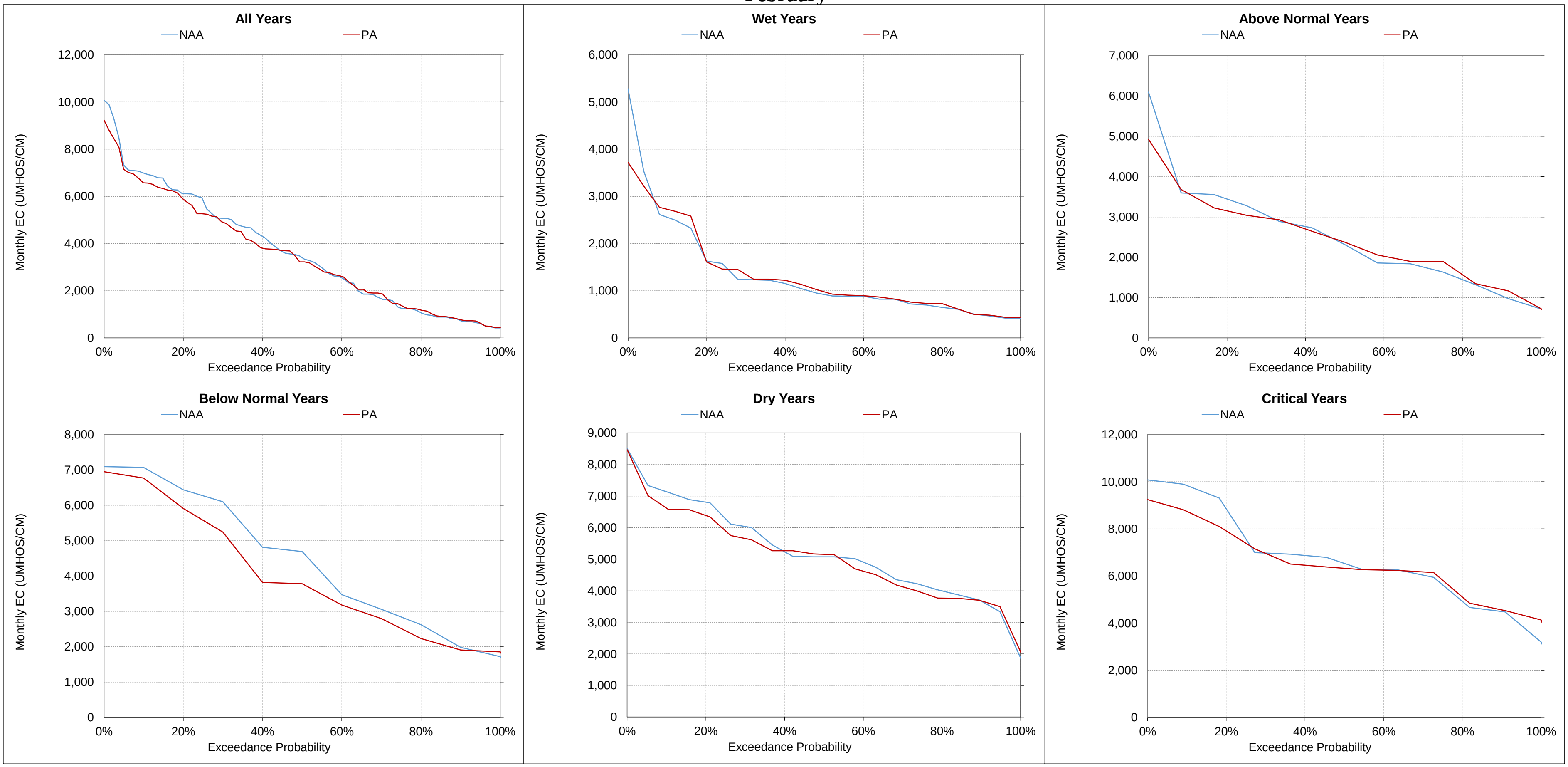
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-26-11. Suisun Sl near Volanti Intake , Monthly EC
January



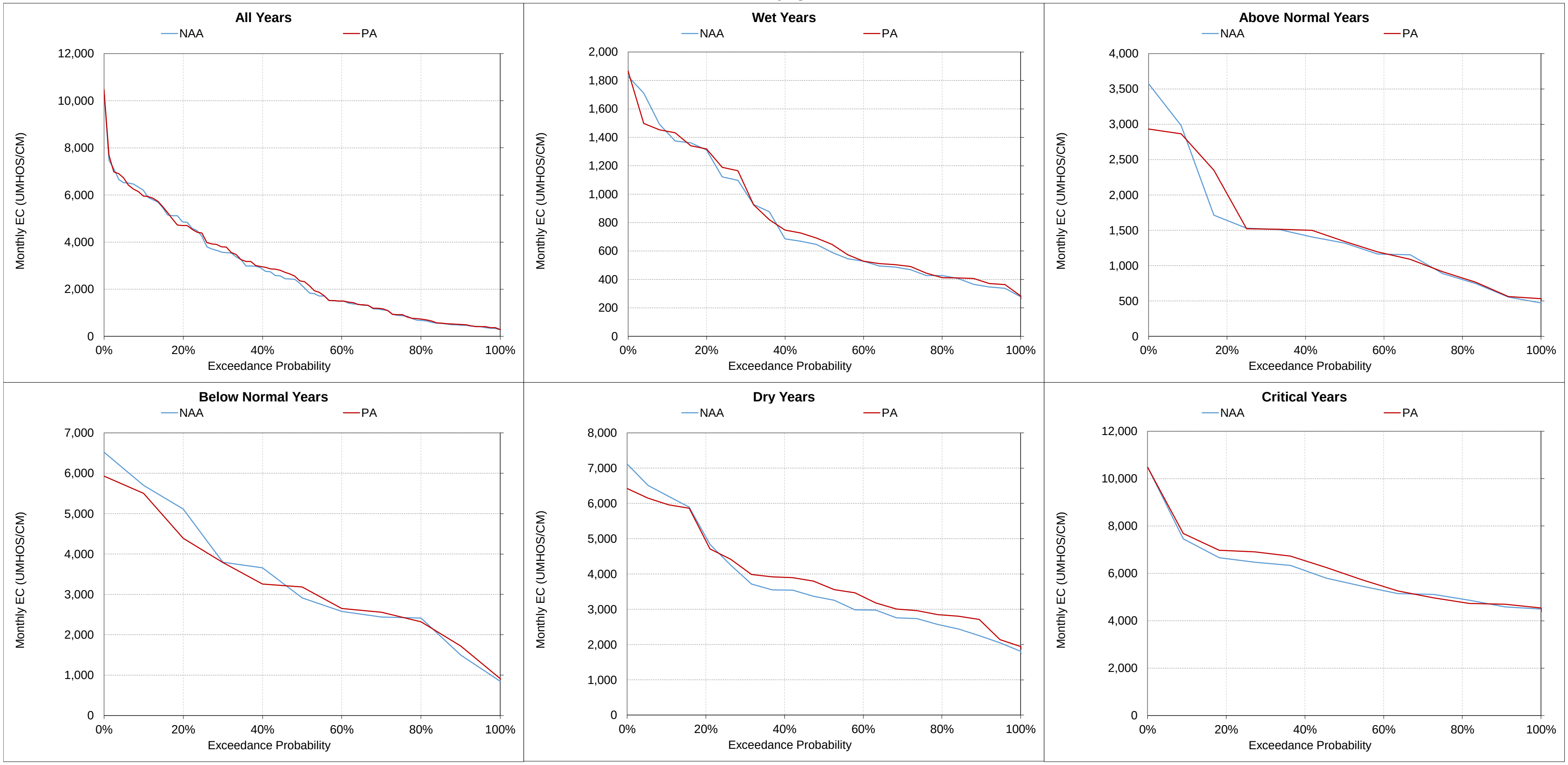
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-26-12. Suisun Sl near Volanti Intake , Monthly EC February



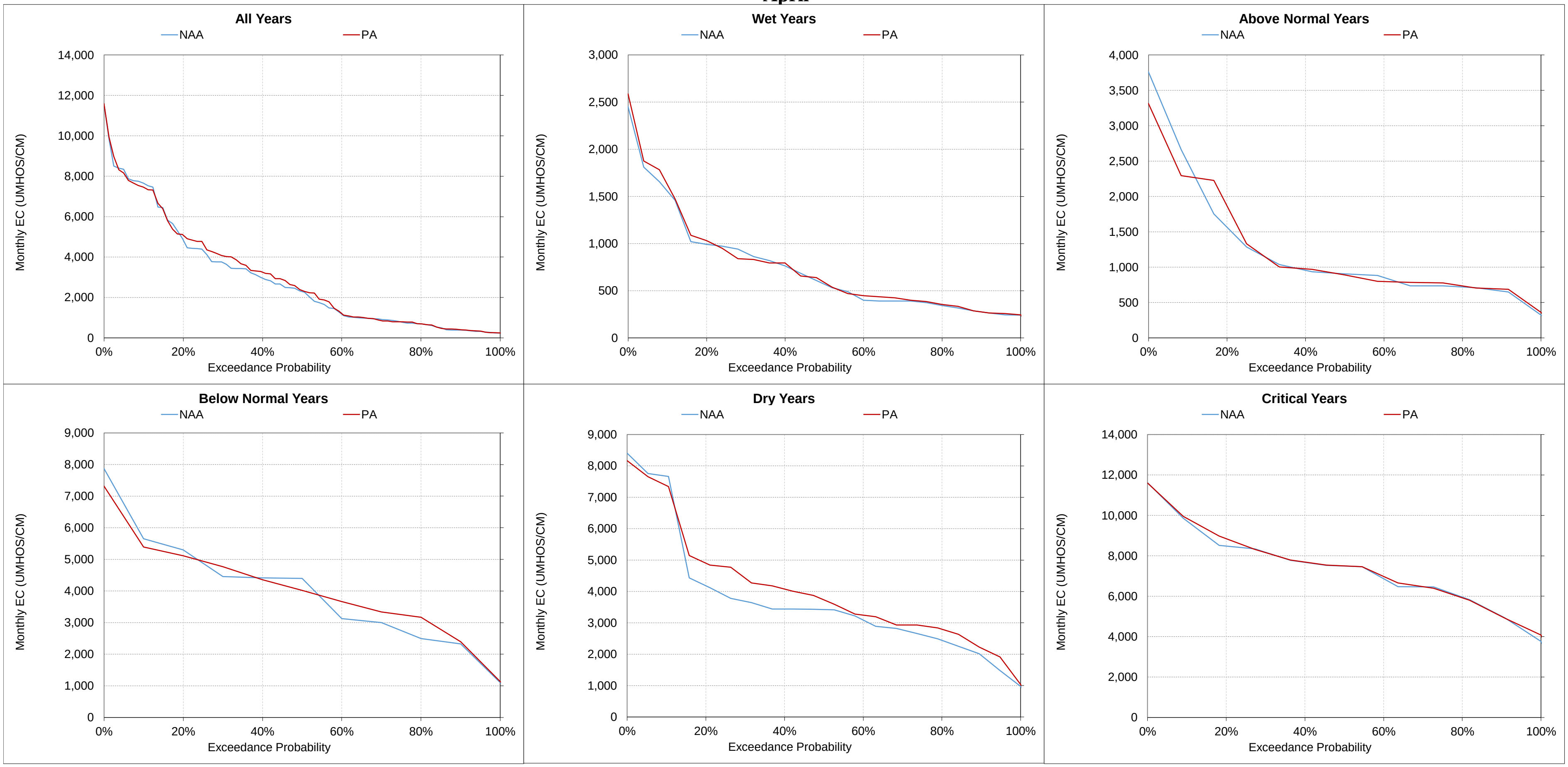
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-26-13. Suisun Sl near Volanti Intake , Monthly EC March



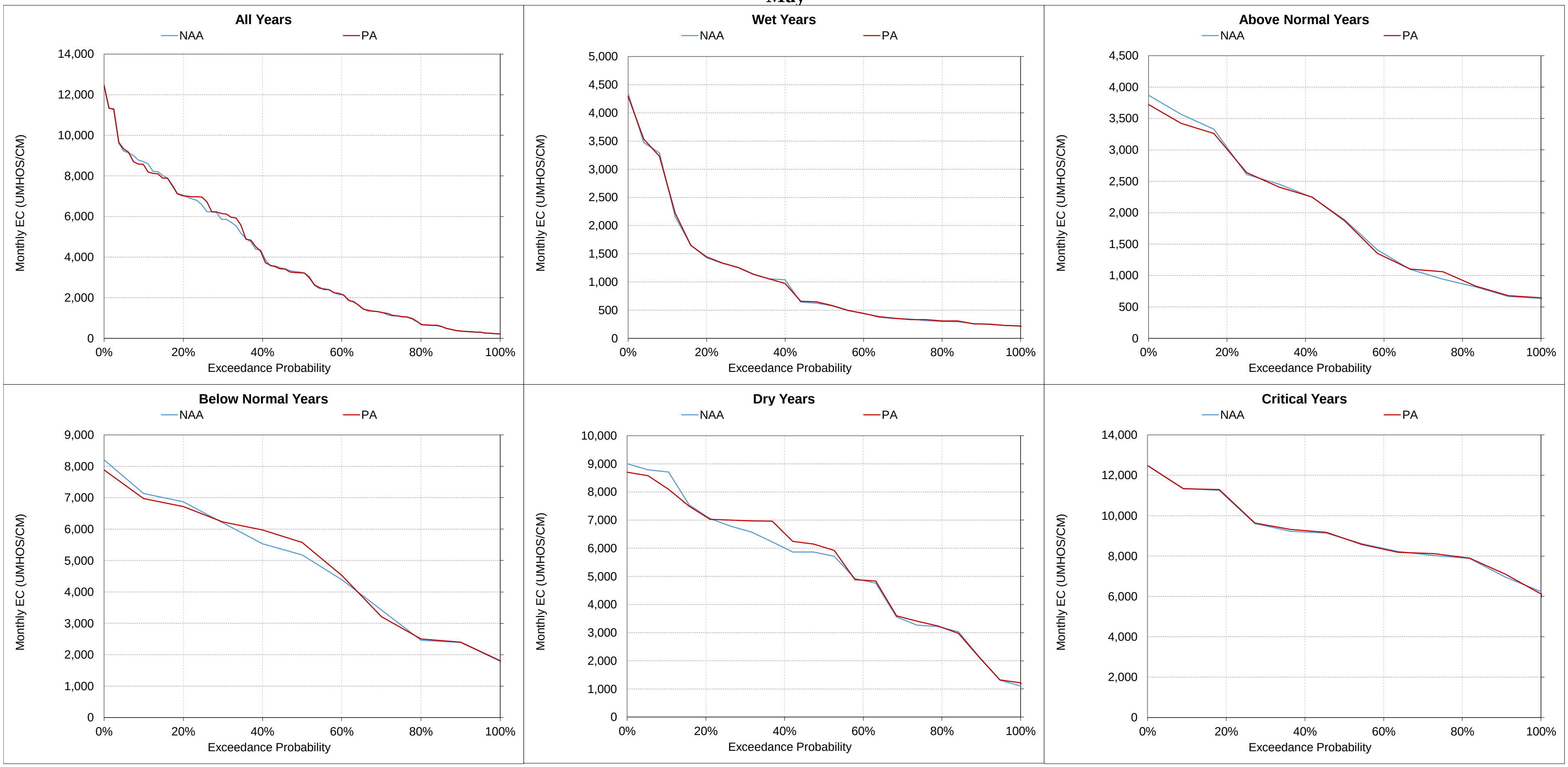
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-26-14. Suisun Sl near Volanti Intake , Monthly EC
April



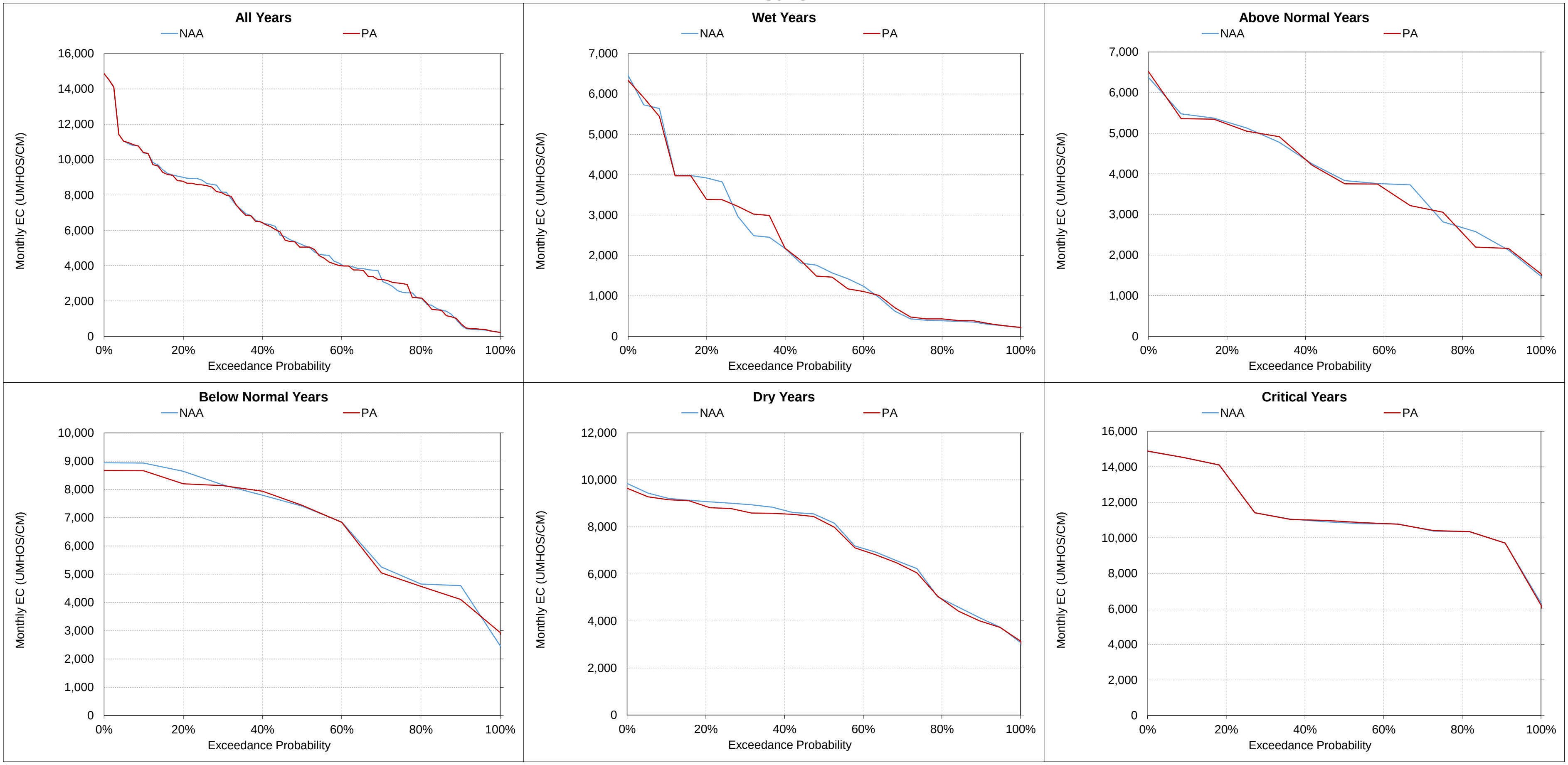
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-26-15. Suisun Sl near Volanti Intake , Monthly EC
May



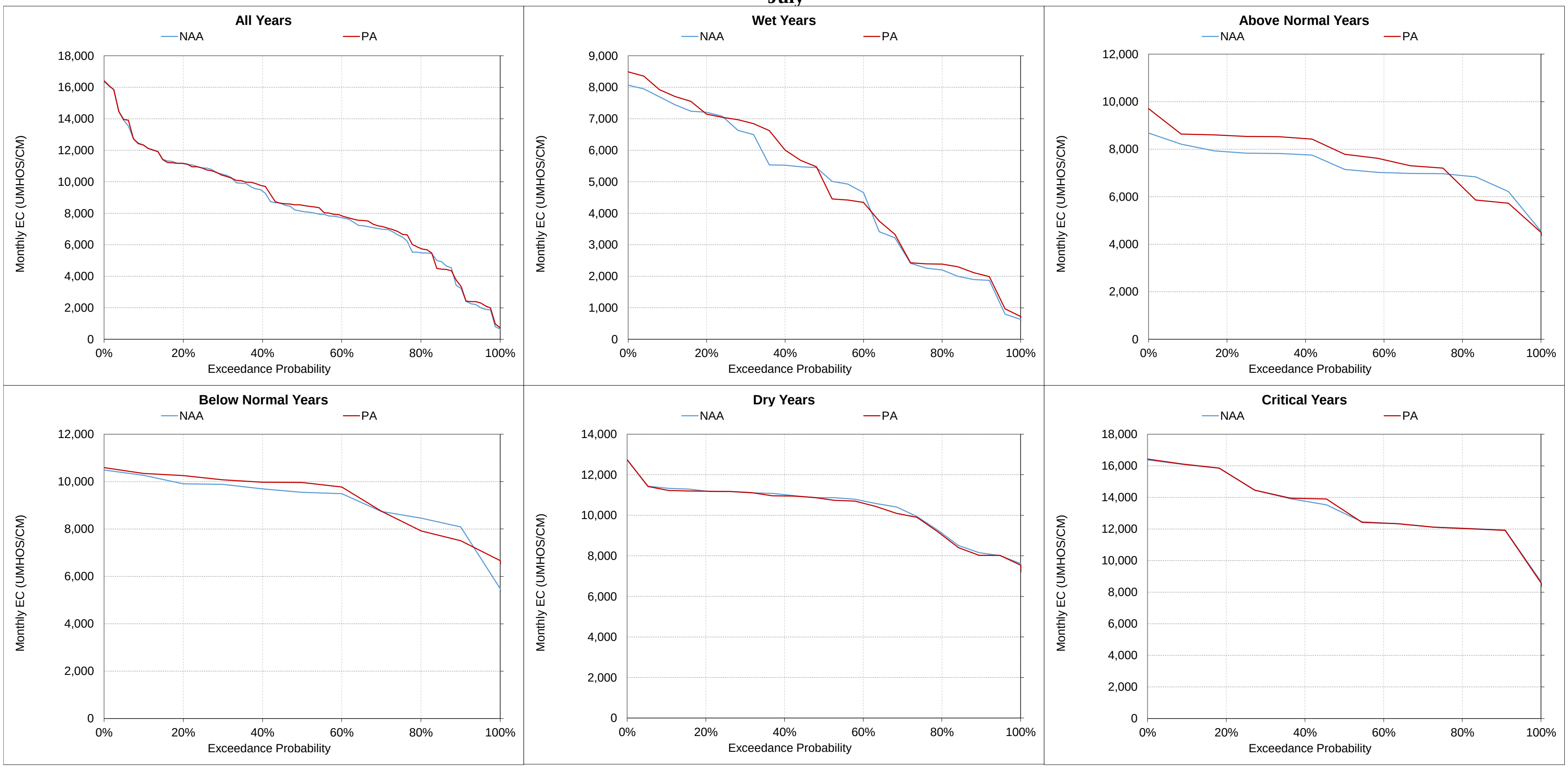
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-26-16. Suisun Sl near Volanti Intake , Monthly EC
June



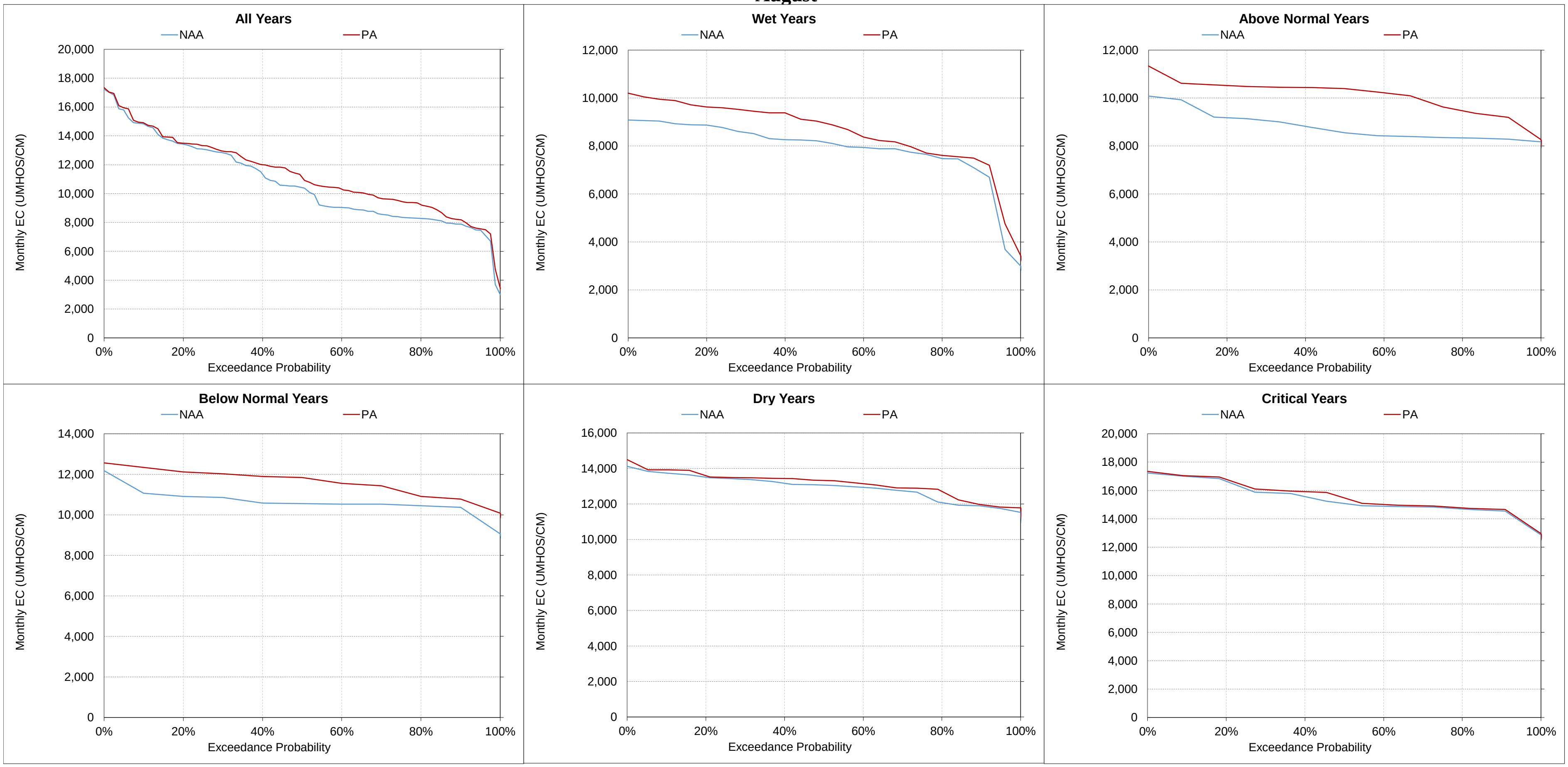
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-26-17. Suisun Sl near Volanti Intake , Monthly EC
July



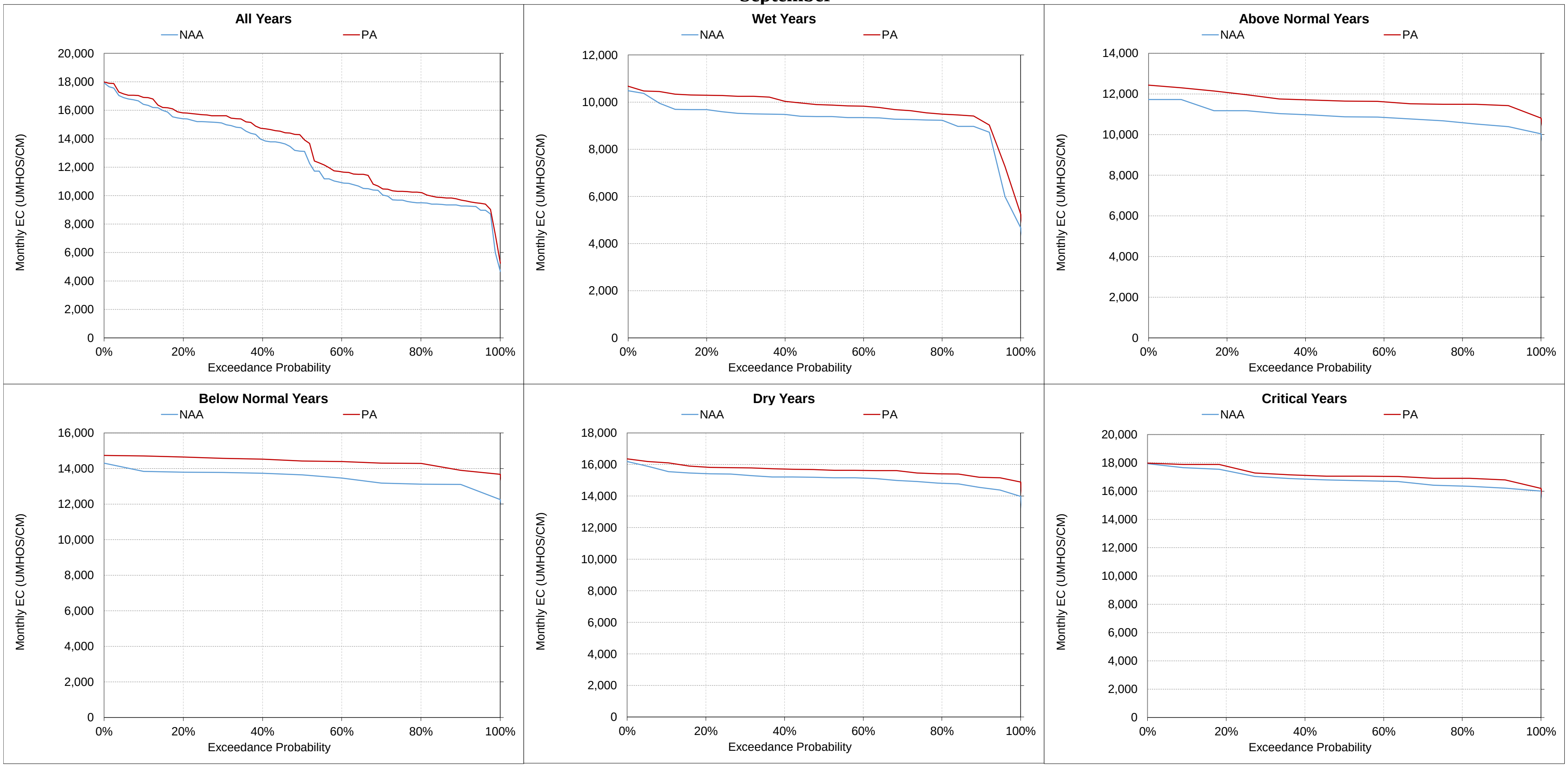
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-26-18. Suisun Sl near Volanti Intake , Monthly EC August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-26-19. Suisun Sl near Volanti Intake , Monthly EC
September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-27. Montezuma Slough at Beldon's Landing, Monthly EC

Statistic	Monthly EC (UMHOS/CM)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	11,189	10,301	-888	-8%	11,667	10,138	-1,529	-13%	8,920	8,454	-466	-5%	5,631	5,615	-16	0%	3,246	2,858	-387	-12%	4,627	4,577	-50	-1%
20%	10,072	9,180	-892	-9%	9,722	8,364	-1,358	-14%	7,770	7,654	-116	-1%	5,005	4,900	-105	-2%	2,604	2,436	-168	-6%	3,274	3,316	41	1%
30%	9,887	8,879	-1,007	-10%	9,202	7,633	-1,569	-17%	5,451	5,855	405	7%	4,419	4,002	-417	-9%	2,174	2,183	10	0%	2,135	2,380	245	11%
40%	9,748	8,503	-1,245	-13%	8,468	6,932	-1,536	-18%	4,220	4,598	378	9%	3,693	3,429	-265	-7%	1,700	1,561	-139	-8%	1,527	1,620	93	6%
50%	8,226	7,891	-335	-4%	6,081	4,876	-1,205	-20%	3,321	3,848	527	16%	2,719	2,411	-309	-11%	1,380	1,296	-84	-6%	1,057	1,152	95	9%
60%	4,156	4,050	-105	-3%	3,985	3,664	-321	-8%	2,981	3,161	179	6%	1,958	2,025	67	3%	608	680	72	12%	453	569	117	26%
70%	3,098	3,102	4	0%	3,201	3,191	-10	0%	2,618	2,783	165	6%	905	1,077	172	19%	325	370	45	14%	331	325	-5	-2%
80%	2,795	2,786	-9	0%	2,618	2,379	-238	-9%	1,925	1,892	-33	-2%	512	594	82	16%	233	249	16	7%	232	247	15	6%
90%	2,502	2,552	51	2%	2,256	2,252	-4	0%	958	1,159	201	21%	256	267	11	4%	213	227	14	7%	200	218	17	9%
Long Term																								
Full Simulation Period[b]	6,780	6,325	-454	-7%	6,326	5,640	-686	-11%	4,370	4,471	101	2%	2,903	2,797	-106	-4%	1,558	1,460	-98	-6%	1,709	1,809	100	6%
Water Year Types[c]																								
Wet (32%)	2,670	2,690	21	1%	2,467	2,437	-31	-1%	2,215	2,272	56	3%	2,408	2,070	-339	-14%	400	366	-35	-9%	376	396	20	5%
Above Normal (16%)	4,040	3,911	-129	-3%	3,901	3,664	-237	-6%	3,136	3,303	167	5%	3,133	3,007	-126	-4%	824	778	-46	-6%	590	606	16	3%
Below Normal (13%)	9,086	8,323	-763	-8%	7,947	6,686	-1,262	-16%	5,474	5,571	97	2%	3,190	3,220	30	1%	1,999	1,789	-210	-11%	2,184	2,160	-24	-1%
Dry (24%)	9,813	8,883	-930	-9%	8,759	7,515	-1,245	-14%	5,244	5,304	61	1%	2,738	2,780	42	2%	2,276	2,178	-98	-4%	2,268	2,490	222	10%
Critical (15%)	11,483	10,721	-762	-7%	11,774	10,639	-1,135	-10%	7,908	8,105	198	2%	3,736	3,783	47	1%	3,257	3,070	-187	-6%	4,444	4,718	274	6%

Statistic	Monthly EC (UMHOS/CM)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	6,877	6,696	-181	-3%	7,913	7,737	-175	-2%	9,622	9,640	18	0%	11,583	11,584	1	0%	14,366	14,544	178	1%	15,964	16,536	573	4%
20%	3,835	4,318	482	13%	6,611	6,519	-91	-1%	8,382	8,158	-224	-3%	10,749	10,644	-105	-1%	13,066	13,275	209	2%	15,033	15,530	498	3%
30%	2,841	3,192	351	12%	5,381	5,555	174	3%	7,620	7,488	-133	-2%	10,033	10,011	-22	0%	12,452	12,837	385	3%	14,761	15,446	685	5%
40%	2,088	2,439	351	17%	3,607	3,620	13	0%	6,002	5,995	-7	0%	8,907	9,358	450	5%	11,108	11,810	702	6%	13,779	14,538	759	6%
50%	1,579	1,647	67	4%	2,649	2,679	30	1%	4,891	4,872	-19	0%	7,845	8,294	449	6%	9,731	10,704	973	10%	12,868	14,037	1,169	9%
60%	810	929	118	15%	1,515	1,539	24	2%	3,872	3,771	-101	-3%	7,204	7,588	384	5%	8,993	10,007	1,015	11%	10,188	10,810	622	6%
70%	464	480	16	4%	962	967	5	1%	2,994	2,937	-57	-2%	6,701	7,093	392	6%	8,307	9,415	1,108	13%	9,318	9,387	69	1%
80%	279	314	35	13%	516	524	9	2%	1,925	1,993	68	4%	5,477	5,739	261	5%	7,969	9,154	1,184	15%	8,299	8,733	433	5%
90%	201	210	8	4%	212	215	3	2%	584	666	82	14%	3,380	3,499	119	4%	7,660	8,534	874	11%	8,011	8,392	381	5%
Long Term																								
Full Simulation Period[b]	2,397	2,495	98	4%	3,490	3,491	1	0%	5,288	5,220	-68	-1%	8,018	8,223	205	3%	10,407	11,163	756	7%	11,947	12,547	600	5%
Water Year Types[c]																								
Wet (32%)	501	518	17	3%	855	855	0	0%	2,015	1,999	-16	-1%	4,609	4,859	250	5%	7,852	8,653	800	10%	8,018	8,459	442	6%
Above Normal (16%)	846	834	-12	-1%	1,631	1,612	-19	-1%	3,756	3,705	-51	-1%	6,867	7,413	546	8%	8,359	9,816	1,456	17%	10,184	10,881	697	7%
Below Normal (13%)	3,279	3,348	69	2%	4,268	4,278	10	0%	6,227	6,097	-130	-2%	8,541	8,861	320	4%	10,047	11,208	1,161	12%	13,286	14,285	999	8%
Dry (24%)	2,935	3,246	311	11%	4,768	4,773	5	0%	6,810	6,653	-156	-2%	10,045	10,002	-43	0%	12,547	12,890	343	3%	14,827	15,477	650	4%
Critical (15%)	6,479	6,544	65	1%	8,371	8,384	13	0%	10,643	10,647	4	0%	12,792	12,838	46	0%	14,925	15,142	217	1%	16,340	16,728	388	2%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

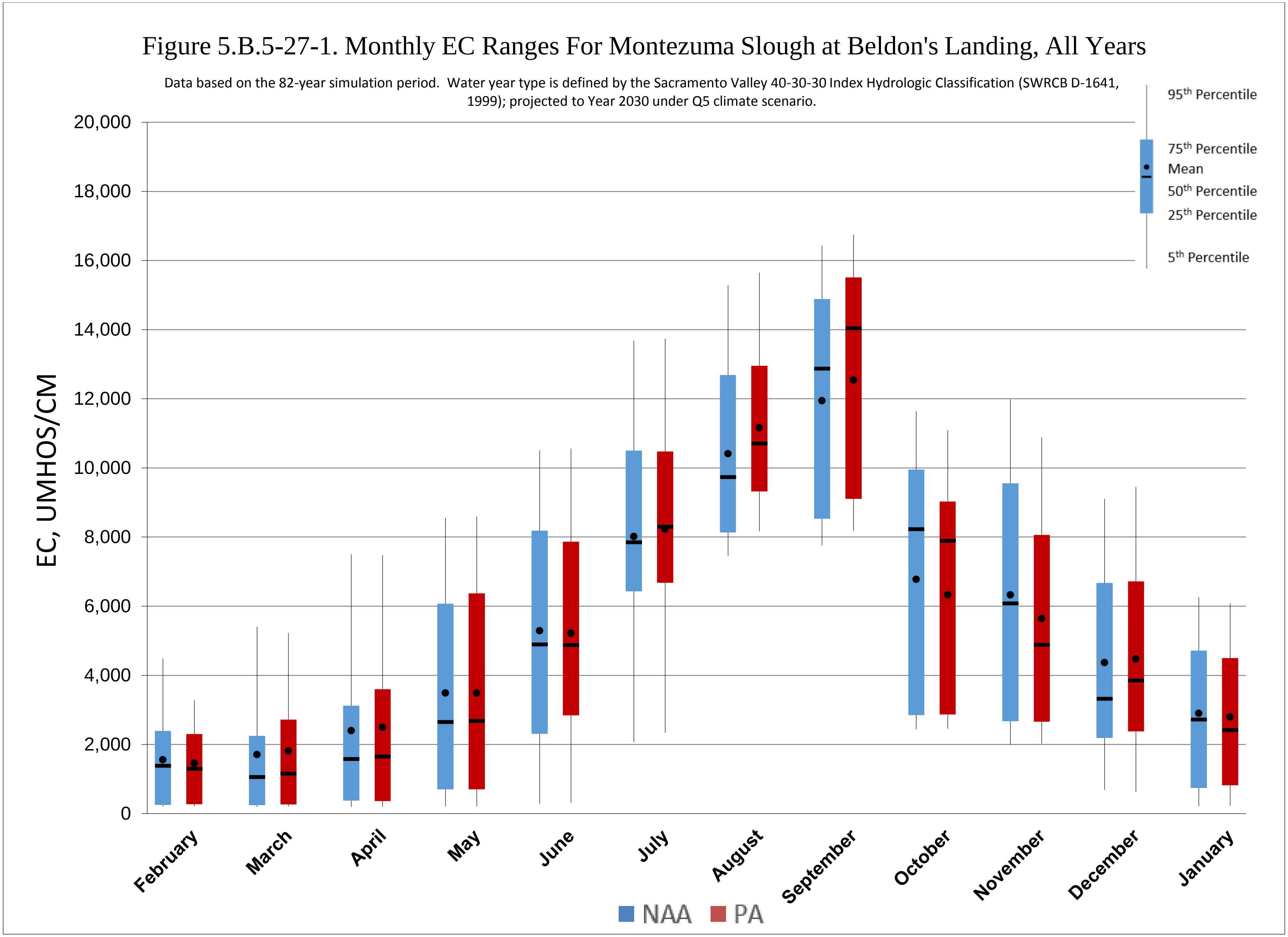


Figure 5.B.5-27-1. Monthly EC Ranges For Montezuma Slough at Beldon's Landing, All Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario.
EC, UMHOS/CM
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
February
March
April
May
June
July
August
September
October
November
December
January
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
NAA
PA

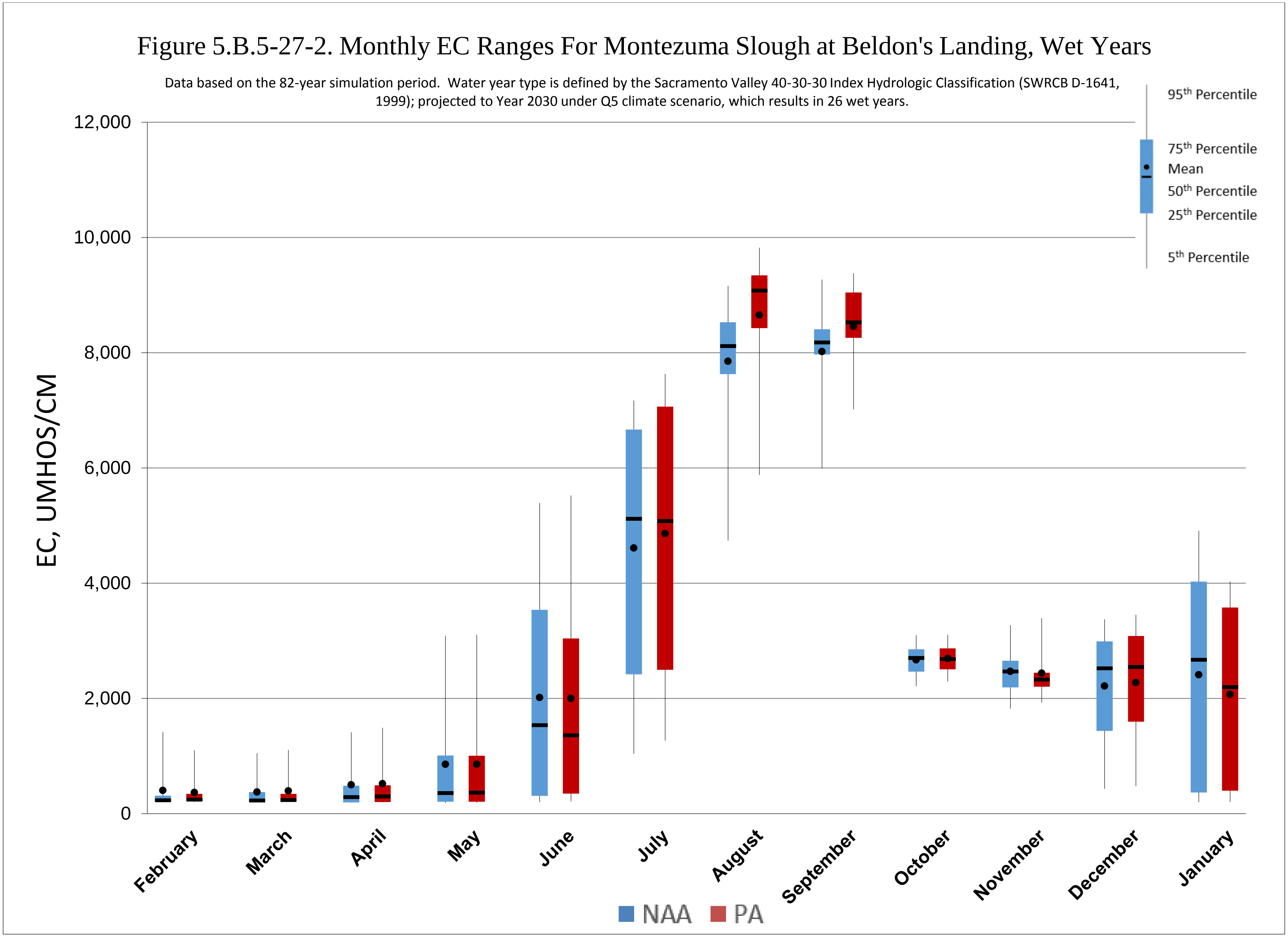


Figure 5.B.5-27-2. Monthly EC Ranges For Montezuma Slough at Beldon's Landing, Wet Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 26 wet years.
EC, UMHOS/CM
12,000
10,000
8,000
6,000
4,000
2,000
0
February
March
April
May
June
July
August
September
October
November
December
January
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
NAA
PA

Figure 5.B.5-27-3. Monthly EC Ranges For Montezuma Slough at Beldon's Landing, Above Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 13 above normal years.

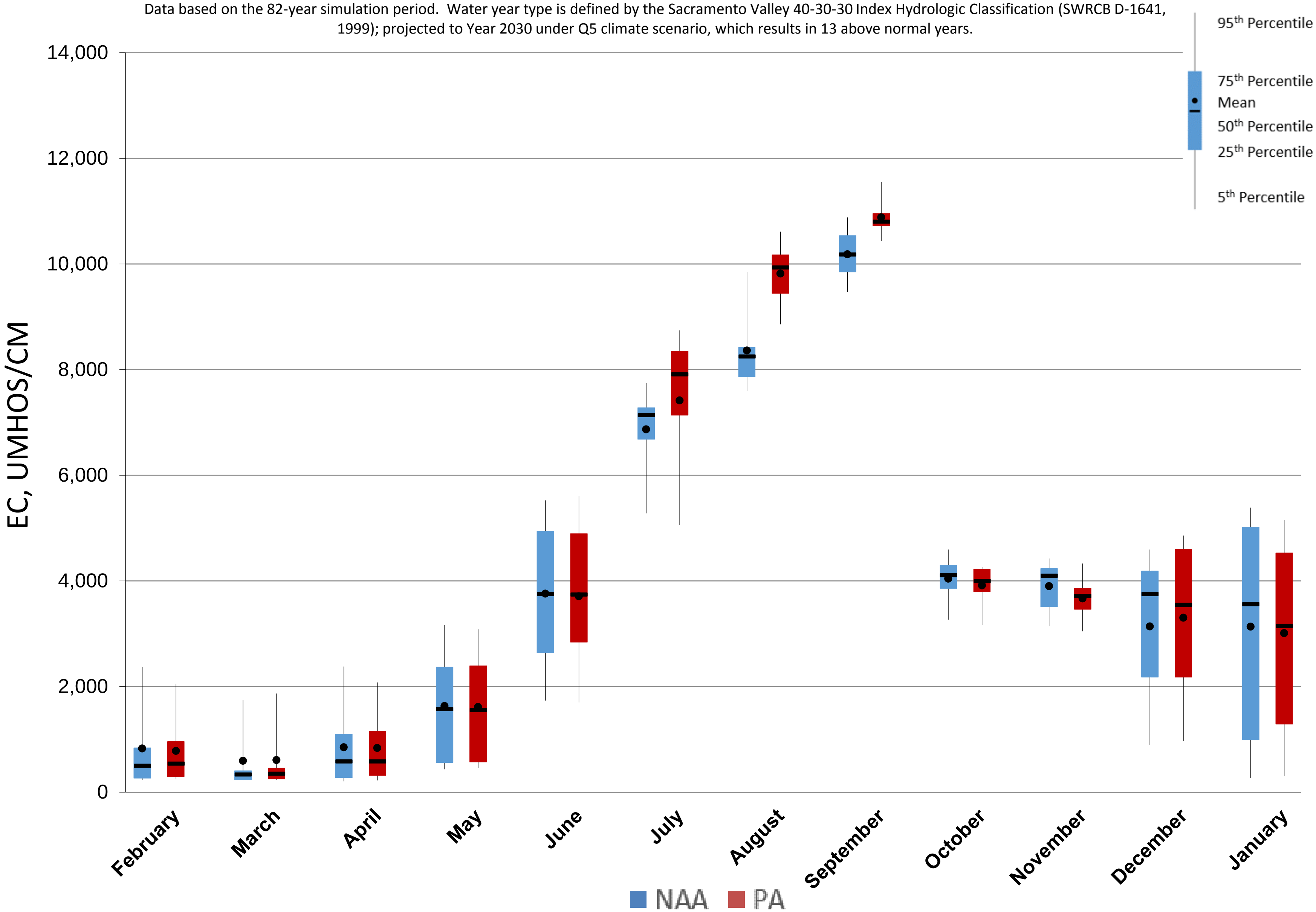
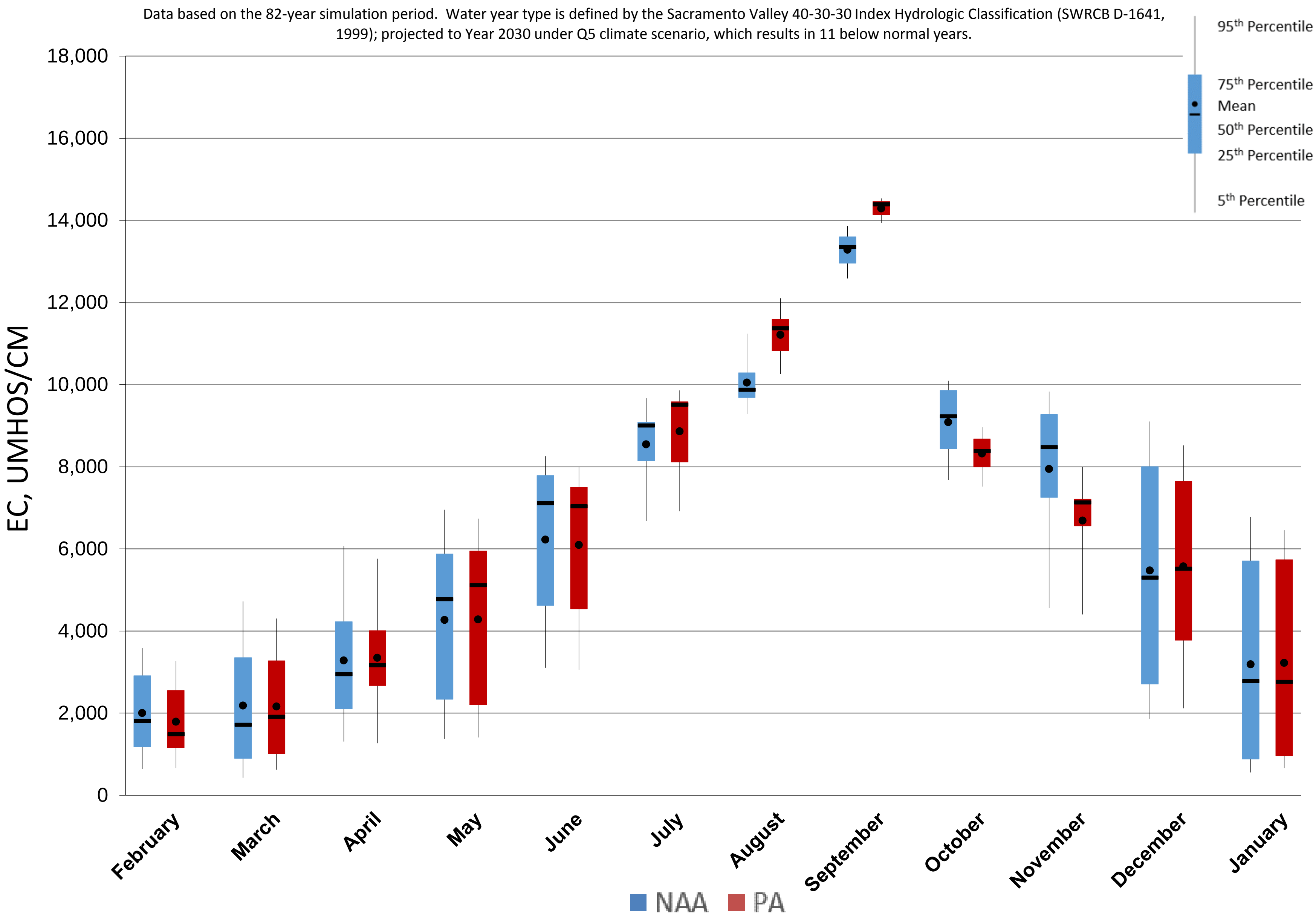


Figure 5.B.5-27-4. Monthly EC Ranges For Montezuma Slough at Beldon's Landing, Below Normal Years



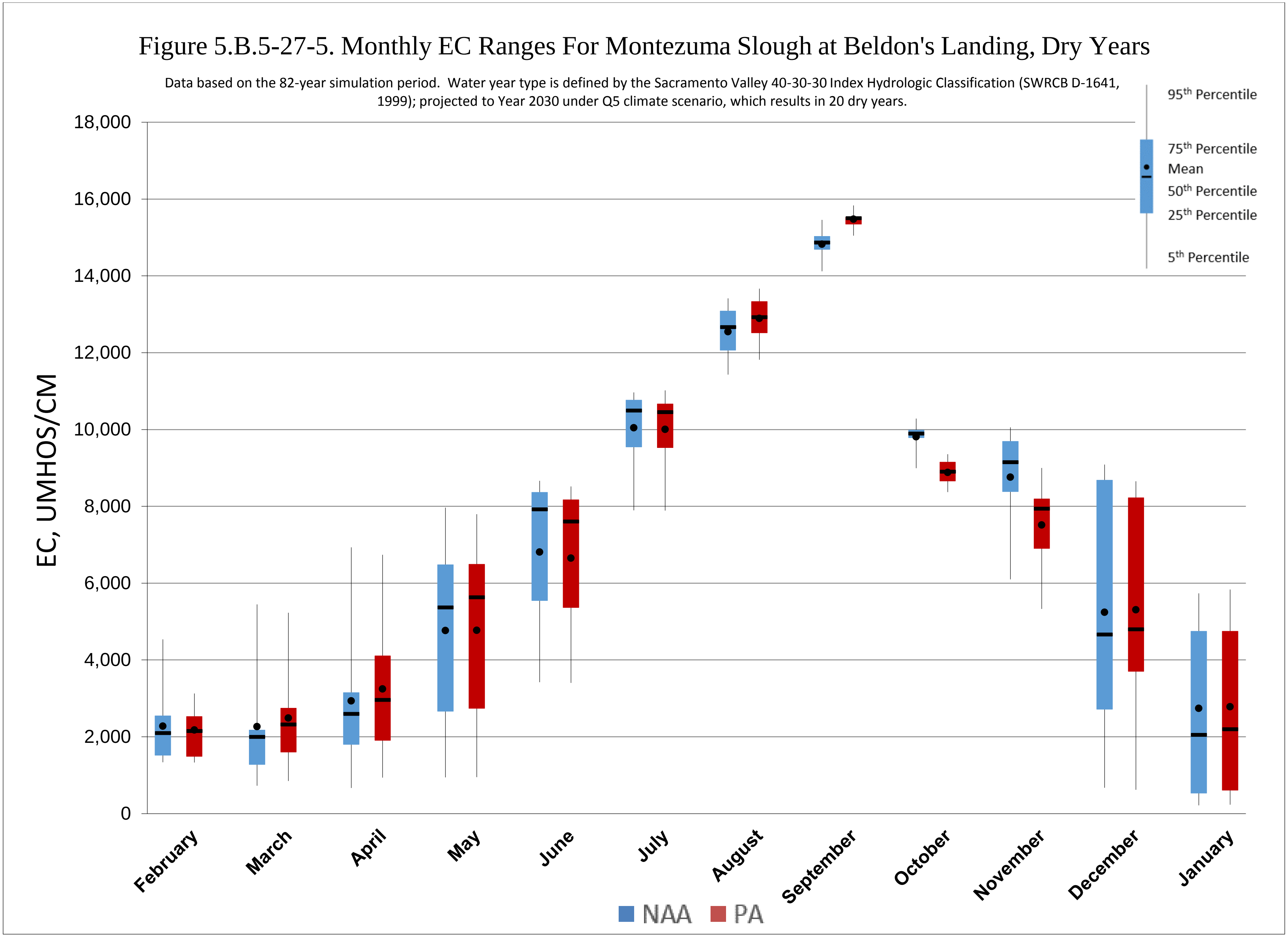


Figure 5.B.5-27-5. Monthly EC Ranges For Montezuma Slough at Beldon's Landing, Dry Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 20 dry years.
EC, UMHOS/CM
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile

Figure 5.B.5-27-6. Monthly EC Ranges For Montezuma Slough at Beldon's Landing, Critical Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 12 critical years.

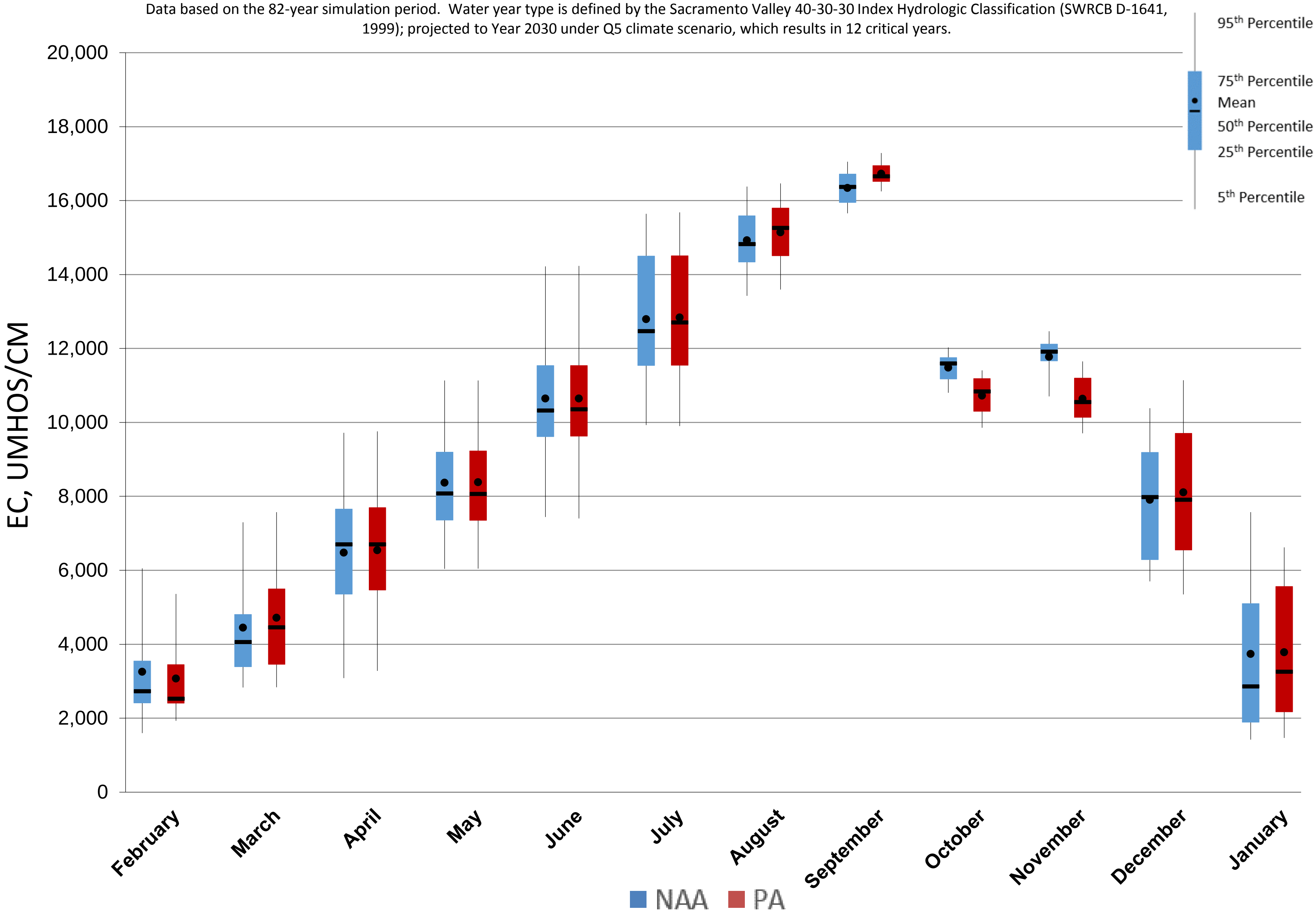
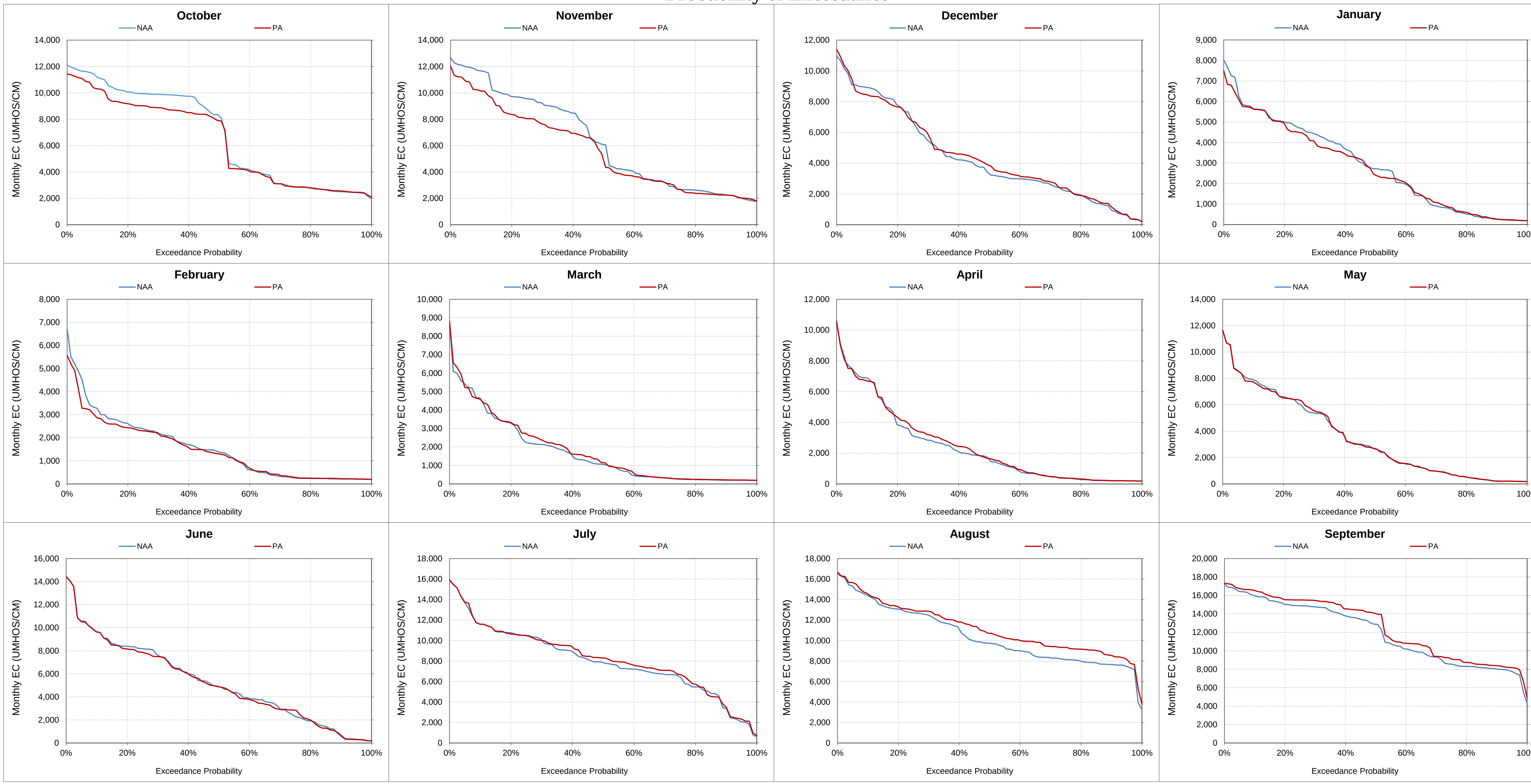
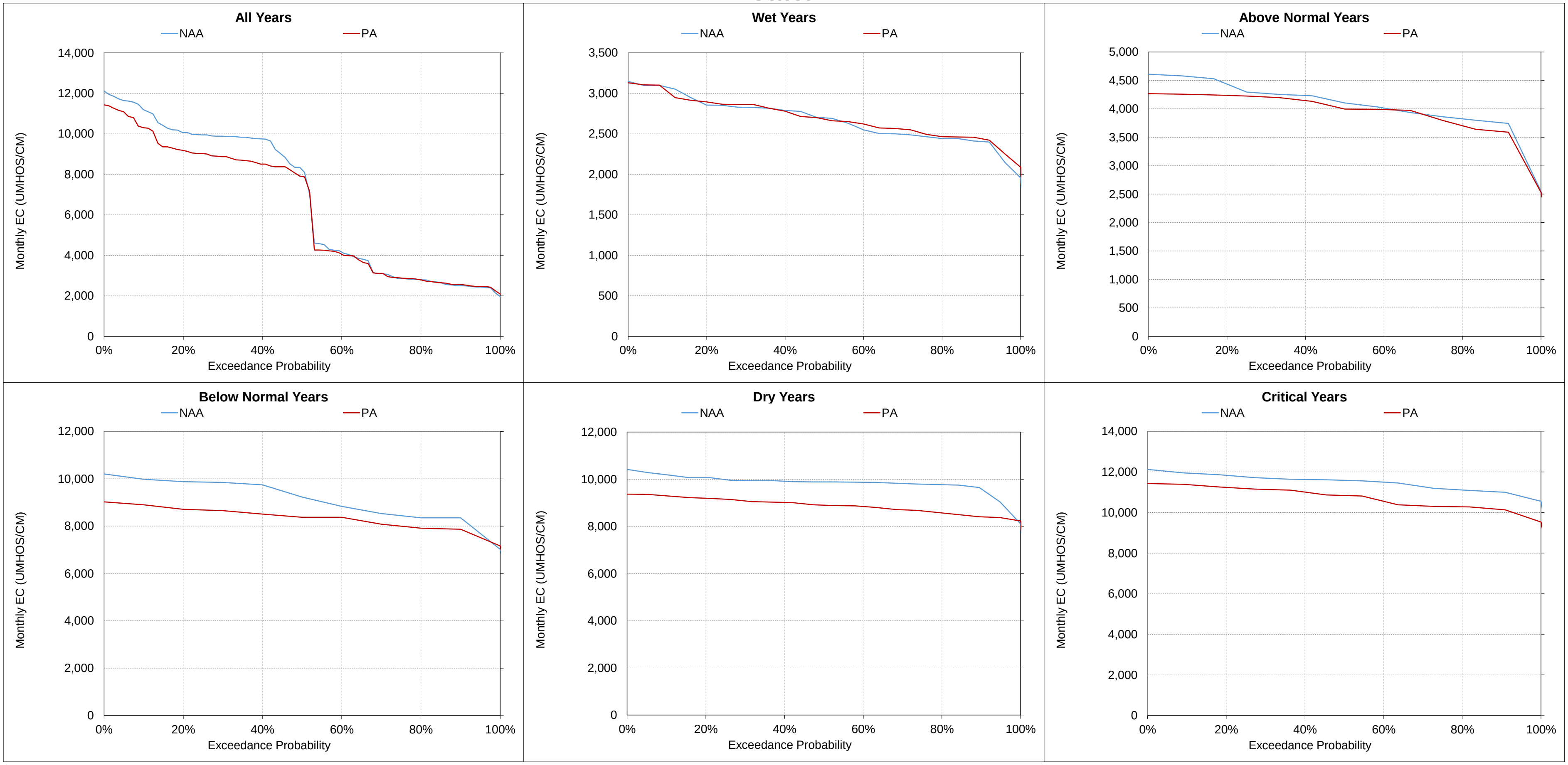


Figure 5.B.5-27-7. Montezuma Slough at Beldon's Landing, Monthly EC Probability of Exceedance



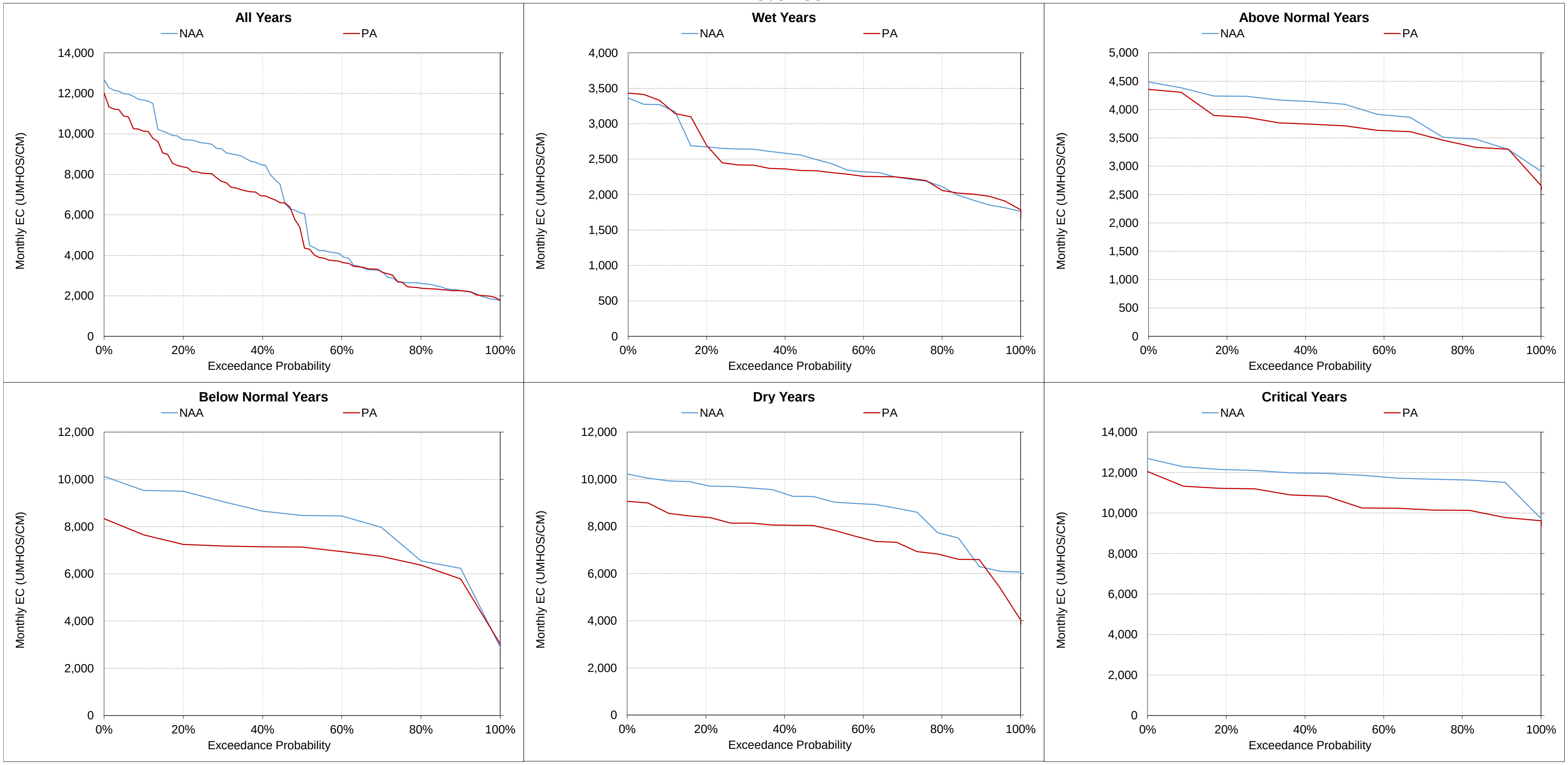
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-27-8. Montezuma Slough at Beldon's Landing, Monthly EC
October



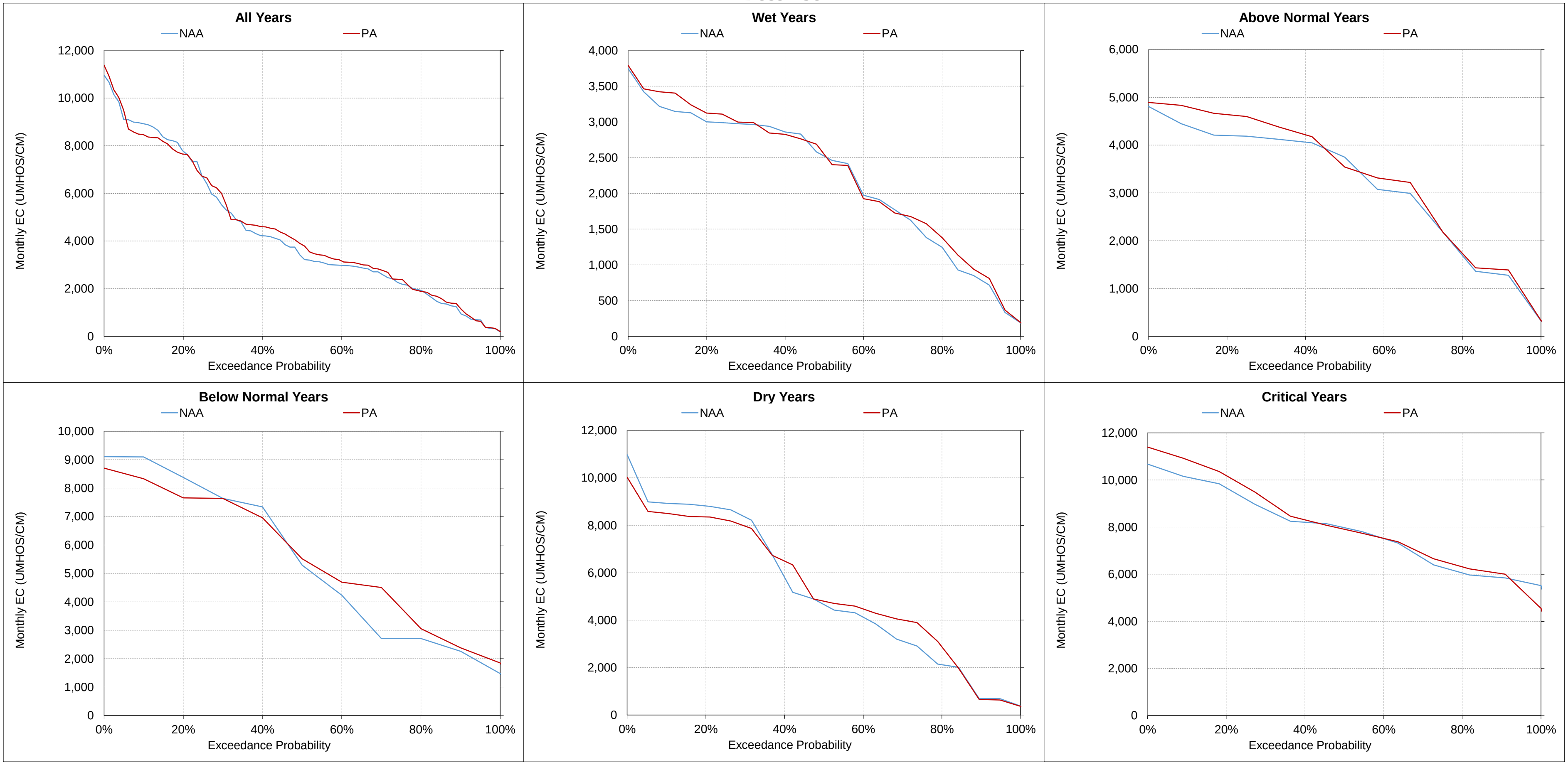
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-27-9. Montezuma Slough at Beldon's Landing, Monthly EC November



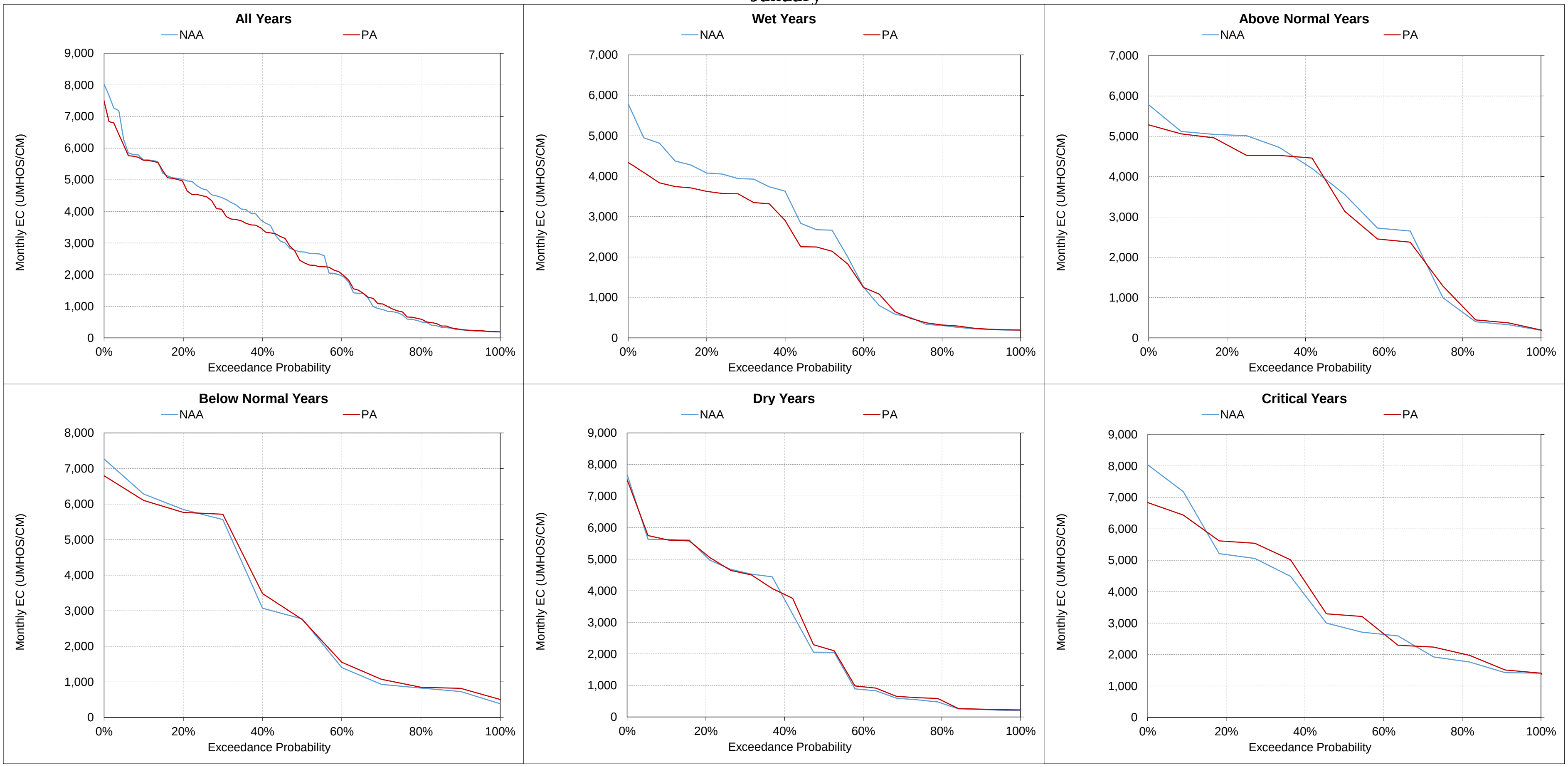
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-27-10. Montezuma Slough at Beldon's Landing, Monthly EC December



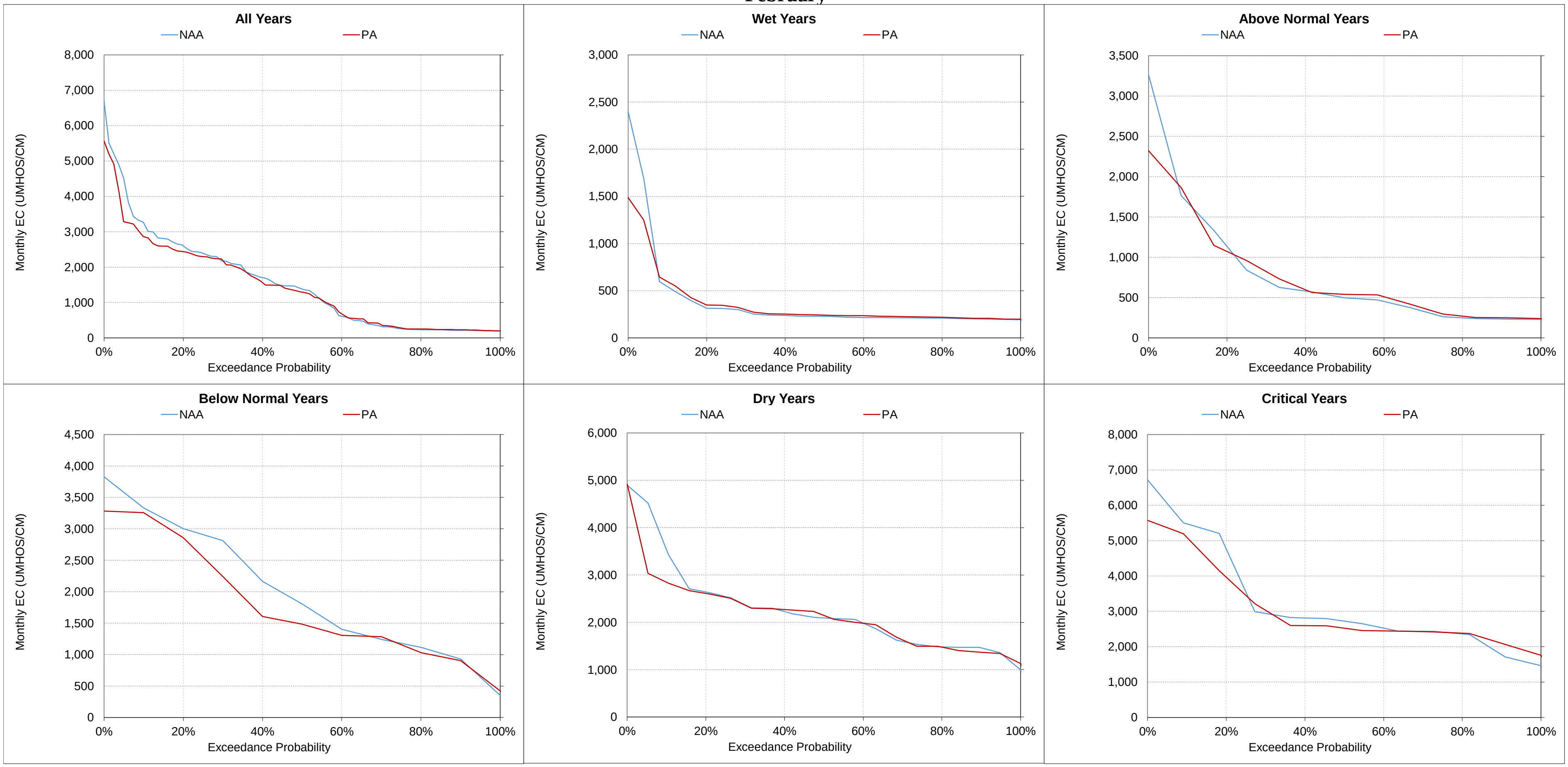
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-27-11. Montezuma Slough at Beldon's Landing, Monthly EC
January



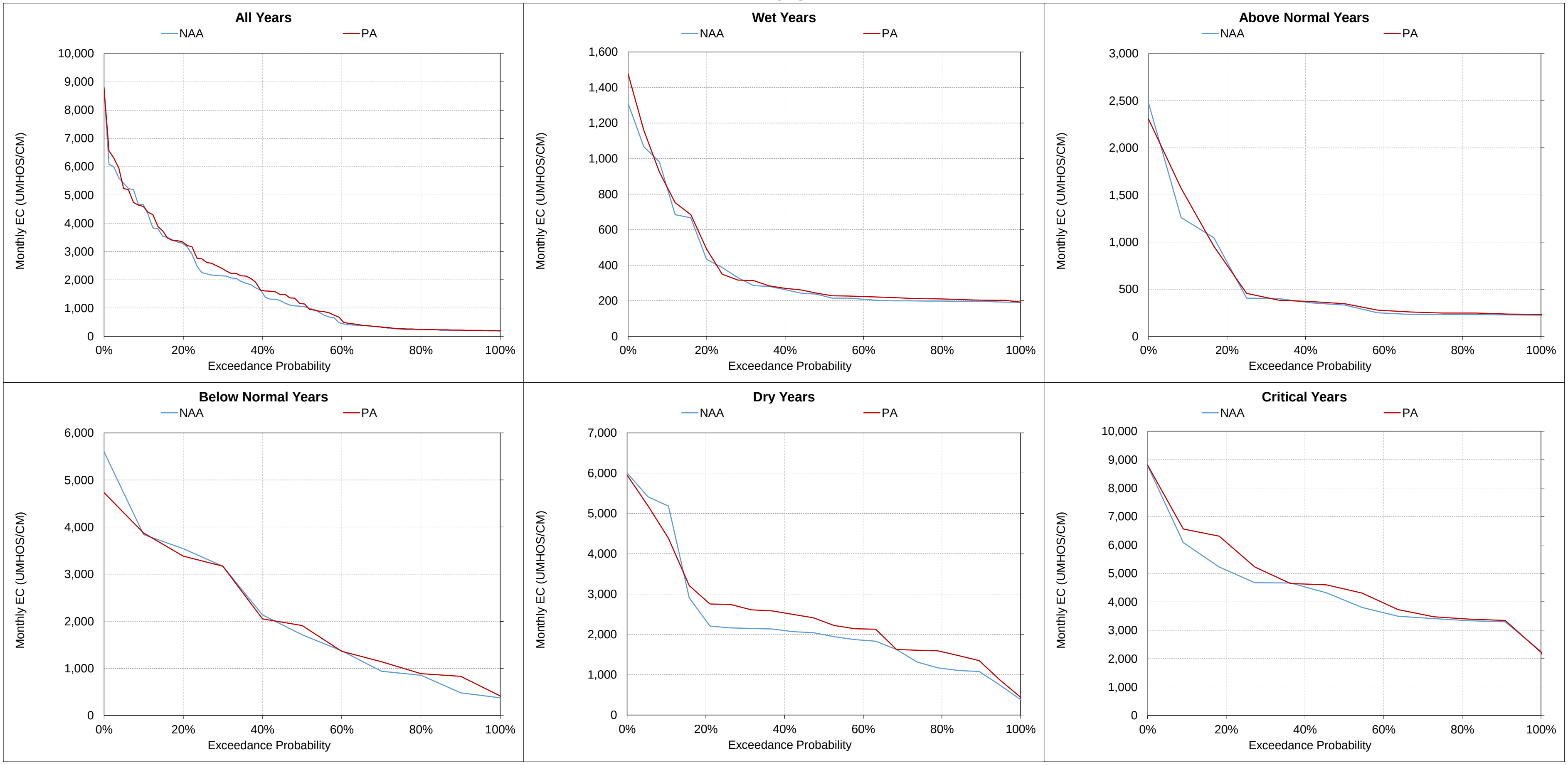
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-27-12. Montezuma Slough at Beldon's Landing, Monthly EC February



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-27-13. Montezuma Slough at Beldon's Landing, Monthly EC
March



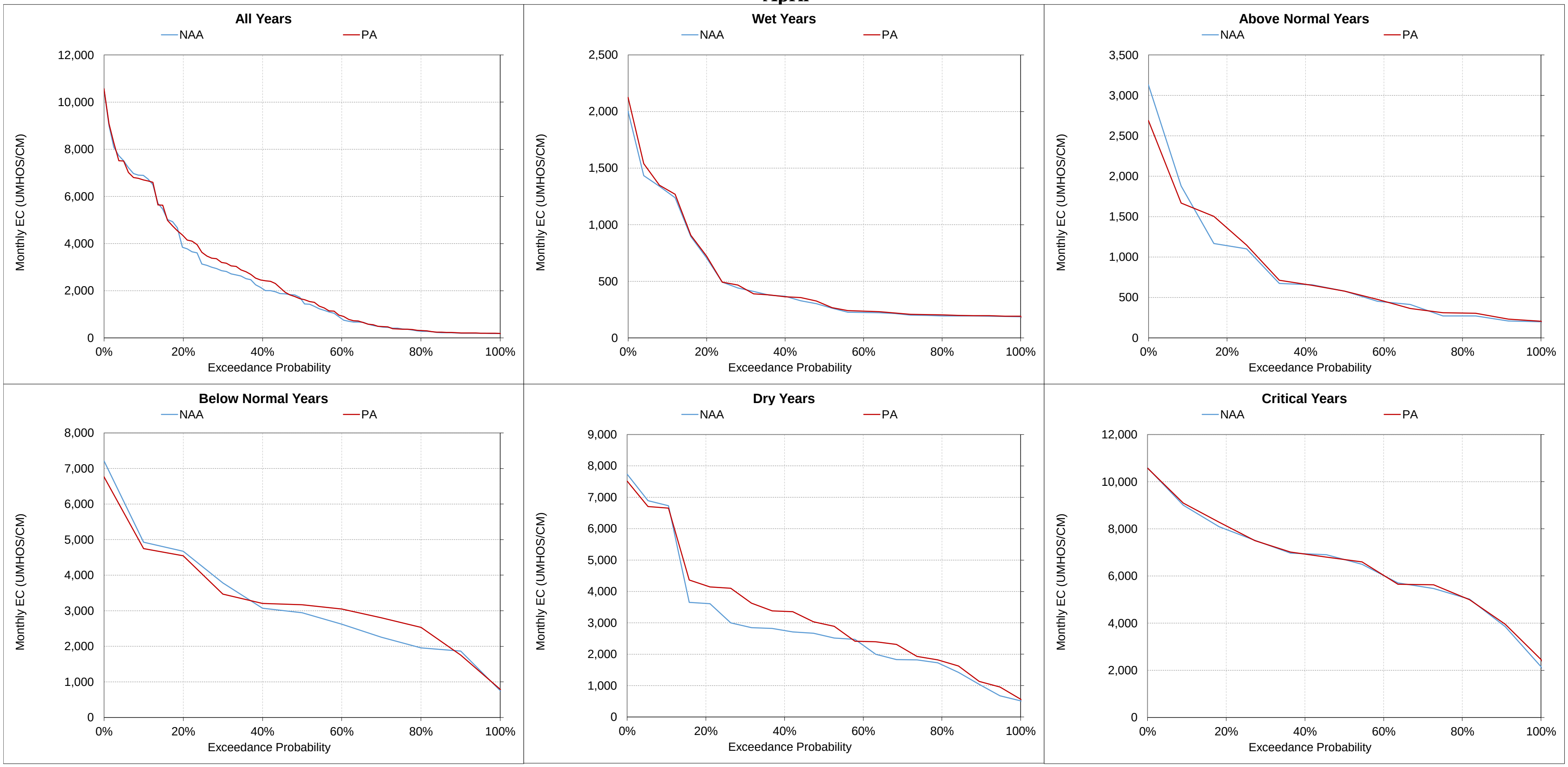
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

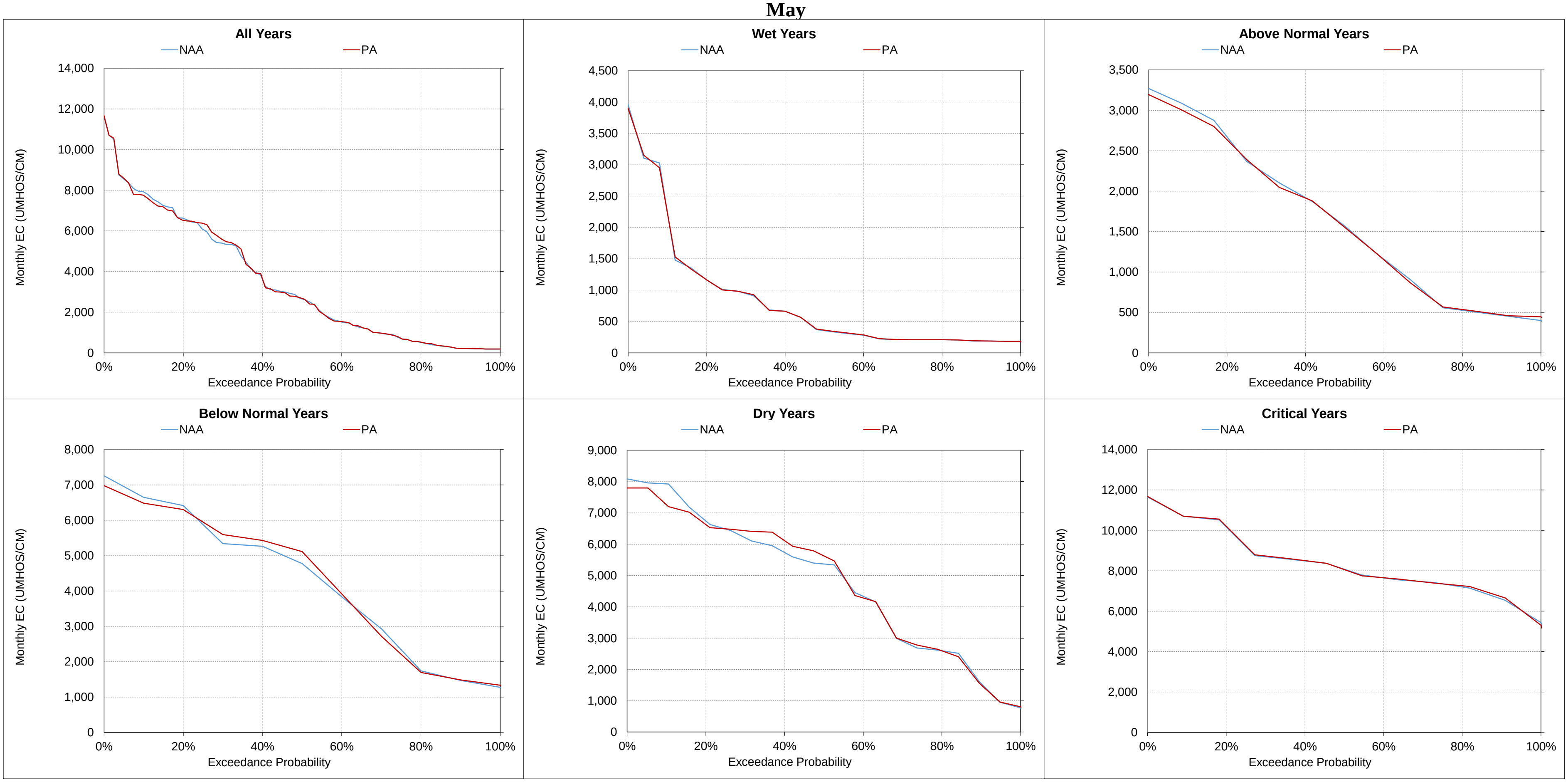
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-27-14. Montezuma Slough at Beldon's Landing, Monthly EC April



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-27-15. Montezuma Slough at Beldon's Landing, Monthly EC
May



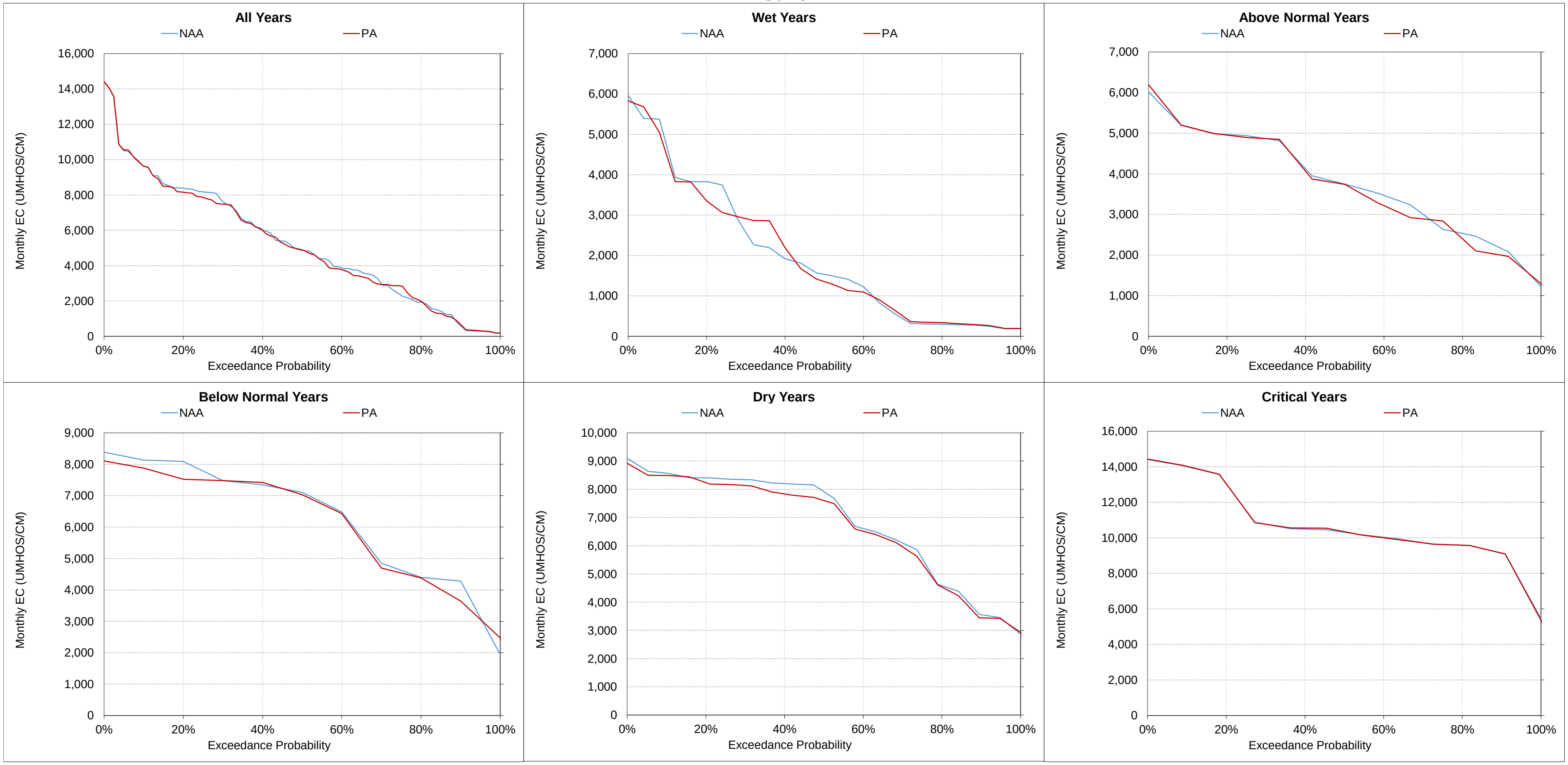
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

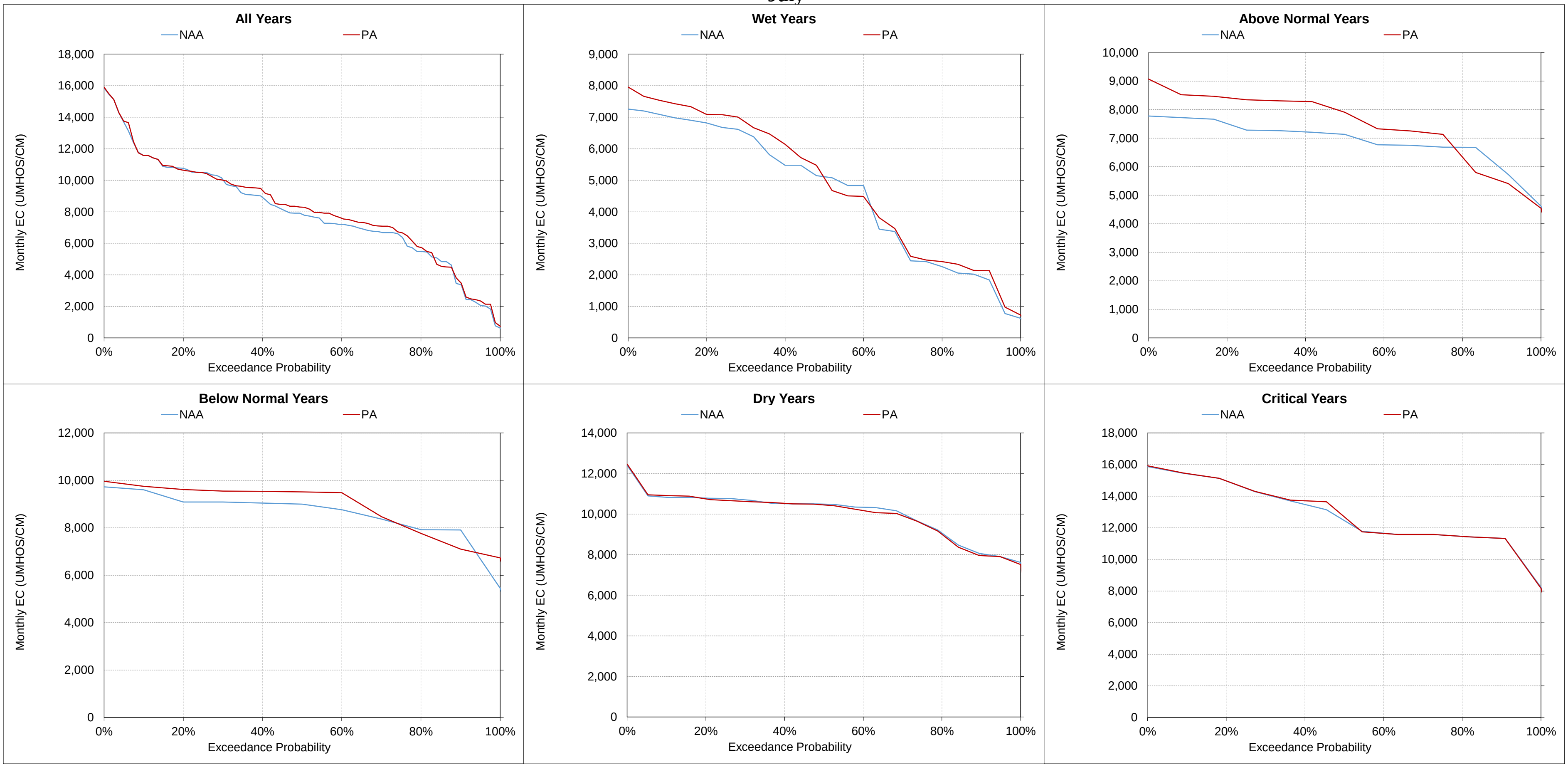
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-27-16. Montezuma Slough at Beldon's Landing, Monthly EC
June



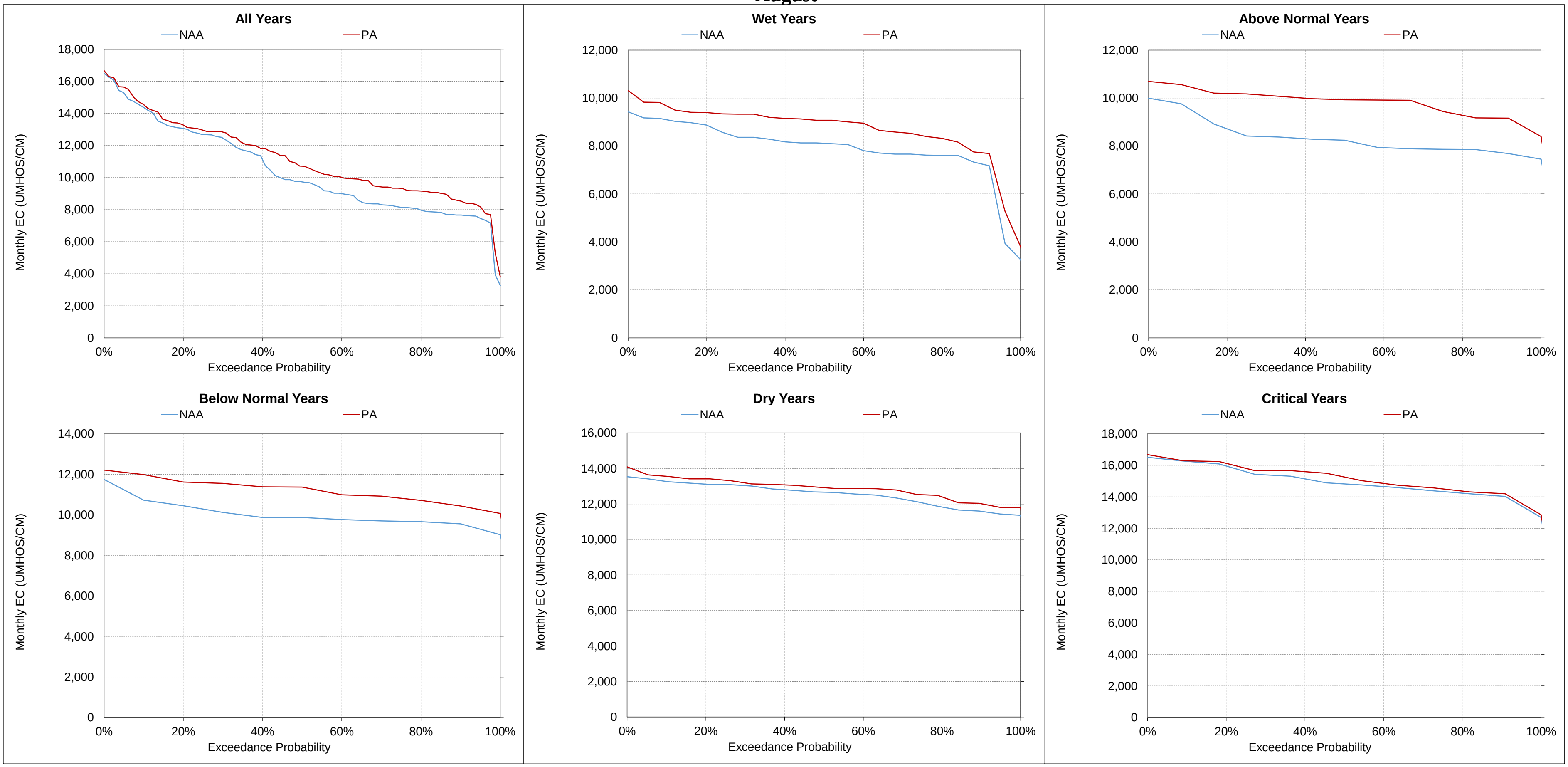
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-27-17. Montezuma Slough at Beldon's Landing, Monthly EC
July



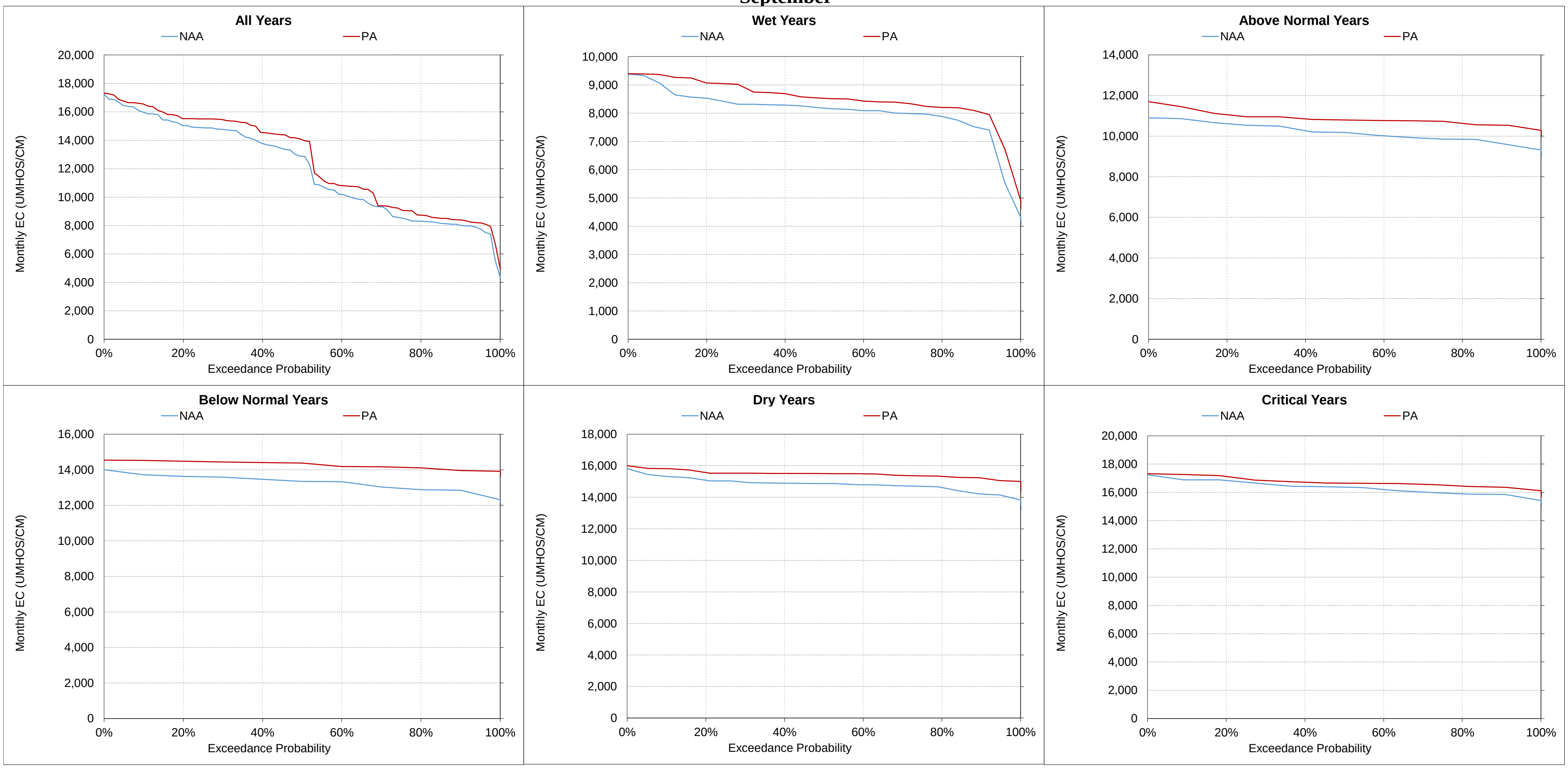
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-27-18. Montezuma Slough at Beldon's Landing, Monthly EC August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-27-19. Montezuma Slough at Beldon's Landing, Monthly EC
September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-28. Montezuma Slough at National Steel, Monthly EC

Statistic	Monthly EC (UMHOS/CM)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	10,892	9,731	-1,161	-11%	11,568	10,195	-1,373	-12%	8,855	8,406	-449	-5%	5,213	5,042	-171	-3%	2,514	2,219	-296	-12%	2,400	2,184	-216	-9%
20%	9,684	8,487	-1,197	-12%	9,591	8,372	-1,219	-13%	7,287	7,379	93	1%	4,759	4,139	-619	-13%	1,758	1,670	-88	-5%	1,446	1,512	66	5%
30%	9,469	8,184	-1,285	-14%	9,149	7,789	-1,360	-15%	4,745	5,092	347	7%	3,826	3,136	-690	-18%	1,085	987	-98	-9%	817	970	152	19%
40%	9,315	7,804	-1,512	-16%	7,662	6,889	-773	-10%	4,061	4,074	13	0%	2,520	2,175	-344	-14%	834	831	-3	0%	673	677	5	1%
50%	7,937	7,207	-730	-9%	4,533	4,073	-461	-10%	3,294	3,459	165	5%	1,749	1,459	-290	-17%	503	533	29	6%	379	489	111	29%
60%	3,525	3,321	-204	-6%	3,578	3,316	-261	-7%	2,935	3,015	80	3%	909	1,012	103	11%	250	299	49	19%	241	281	40	16%
70%	1,868	1,833	-35	-2%	2,296	2,313	17	1%	1,615	1,870	255	16%	334	401	67	20%	212	223	12	5%	206	222	16	8%
80%	1,637	1,625	-13	-1%	1,746	1,687	-58	-3%	1,149	1,229	80	7%	221	239	18	8%	196	209	12	6%	195	211	16	8%
90%	1,427	1,489	63	4%	1,503	1,503	0	0%	334	362	27	8%	195	207	12	6%	190	202	12	6%	191	201	11	6%
Long Term																								
Full Simulation Period[b]	6,108	5,478	-630	-10%	5,802	5,254	-549	-9%	3,976	4,064	88	2%	2,360	2,160	-200	-8%	1,031	958	-73	-7%	864	926	62	7%
Water Year Types[c]																								
Wet (32%)	1,583	1,571	-12	-1%	1,642	1,651	9	1%	1,974	2,016	42	2%	1,912	1,367	-544	-28%	255	240	-15	-6%	235	255	20	8%
Above Normal (16%)	3,341	3,090	-252	-8%	3,437	3,319	-119	-3%	2,939	3,064	125	4%	2,536	2,344	-193	-8%	463	412	-51	-11%	288	306	18	6%
Below Normal (13%)	8,579	7,481	-1,099	-13%	7,655	6,626	-1,029	-13%	4,927	5,007	80	2%	2,547	2,555	8	0%	1,313	1,113	-200	-15%	1,014	995	-19	-2%
Dry (24%)	9,396	8,175	-1,222	-13%	8,239	7,225	-1,014	-12%	4,667	4,680	13	0%	2,283	2,324	41	2%	1,397	1,287	-110	-8%	1,076	1,186	110	10%
Critical (15%)	11,161	10,199	-962	-9%	11,620	10,614	-1,007	-9%	7,416	7,696	280	4%	3,100	3,043	-57	-2%	2,463	2,417	-45	-2%	2,357	2,553	196	8%

Statistic	Monthly EC (UMHOS/CM)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	3,952	3,874	-78	-2%	4,826	4,643	-183	-4%	6,506	6,519	13	0%	8,794	8,814	20	0%	11,319	11,617	298	3%	12,812	13,245	433	3%
20%	2,005	2,160	155	8%	4,101	3,964	-137	-3%	5,492	5,333	-159	-3%	7,772	7,752	-19	0%	9,849	10,165	316	3%	11,748	12,485	737	6%
30%	1,260	1,446	186	15%	3,127	3,260	133	4%	4,844	4,820	-24	-1%	7,018	7,028	9	0%	9,067	9,575	508	6%	11,468	12,303	834	7%
40%	969	1,108	139	14%	1,778	1,818	40	2%	3,820	3,835	16	0%	5,696	6,464	768	13%	7,848	8,923	1,074	14%	10,518	11,513	995	9%
50%	689	711	22	3%	1,263	1,265	2	0%	2,984	2,938	-46	-2%	5,046	5,564	517	10%	6,704	7,672	968	14%	9,538	11,085	1,547	16%
60%	359	391	32	9%	674	675	2	0%	2,397	2,253	-144	-6%	4,102	4,831	729	18%	6,222	7,141	918	15%	6,132	6,607	475	8%
70%	253	279	26	10%	446	436	-10	-2%	1,676	1,728	52	3%	3,878	4,577	698	18%	5,818	6,837	1,020	18%	4,850	5,014	164	3%
80%	204	222	18	9%	270	280	10	4%	998	1,058	60	6%	3,212	3,570	359	11%	5,403	6,496	1,093	20%	4,205	4,333	129	3%
90%	190	198	9	5%	191	192	1	1%	304	347	43	14%	1,953	2,088	135	7%	5,141	6,126	985	19%	3,803	3,987	184	5%
Long Term																								
Full Simulation Period[b]	1,284	1,335	50	4%	2,069	2,061	-8	0%	3,462	3,407	-55	-2%	5,386	5,737	350	7%	7,522	8,289	767	10%	8,291	8,891	600	7%
Water Year Types[c]																								
Wet (32%)	286	300	14	5%	448	450	2	0%	1,205	1,184	-21	-2%	2,669	3,005	336	13%	5,430	6,195	765	14%	3,940	4,229	289	7%
Above Normal (16%)	408	414	6	2%	773	770	-3	0%	2,275	2,251	-25	-1%	4,043	4,821	778	19%	5,651	6,945	1,294	23%	6,121	6,621	500	8%
Below Normal (13%)	1,595	1,627	32	2%	2,360	2,351	-9	0%	3,973	3,846	-127	-3%	5,375	6,009	635	12%	6,967	8,122	1,156	17%	10,022	11,242	1,220	12%
Dry (24%)	1,473	1,621	149	10%	2,775	2,740	-36	-1%	4,361	4,242	-119	-3%	7,178	7,268	90	1%	9,272	9,755	483	5%	11,560	12,378	817	7%
Critical (15%)	3,800	3,828	27	1%	5,540	5,552	12	0%	7,675	7,685	9	0%	9,754	9,845	91	1%	11,673	11,992	319	3%	13,036	13,488	452	3%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

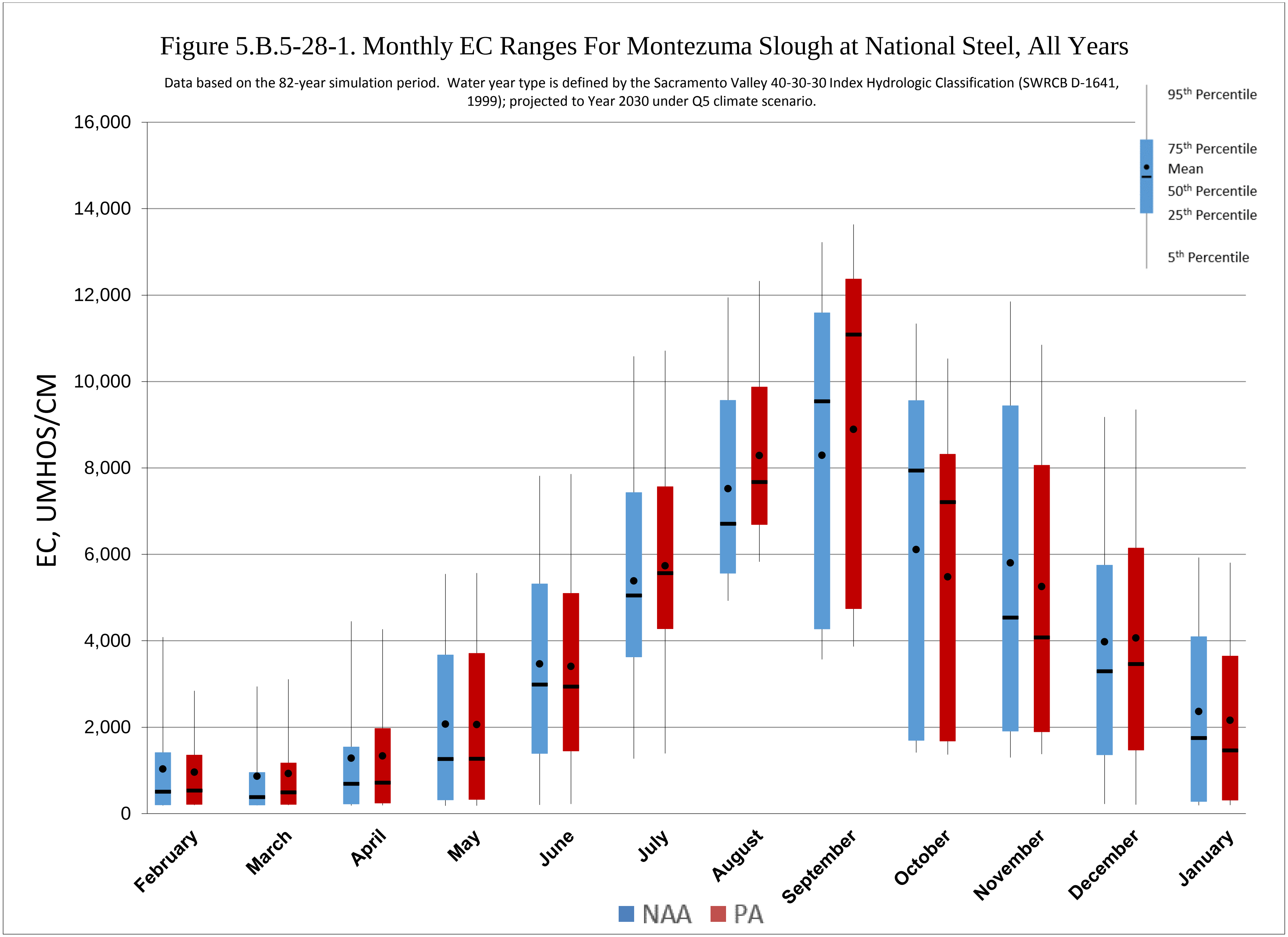


Figure 5.B.5-28-1. Monthly EC Ranges For Montezuma Slough at National Steel, All Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario.
EC, UMHOS/CM
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
February
March
April
May
June
July
August
September
October
November
December
January
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
NAA
PA

Figure 5.B.5-28-2. Monthly EC Ranges For Montezuma Slough at National Steel, Wet Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 26 wet years.

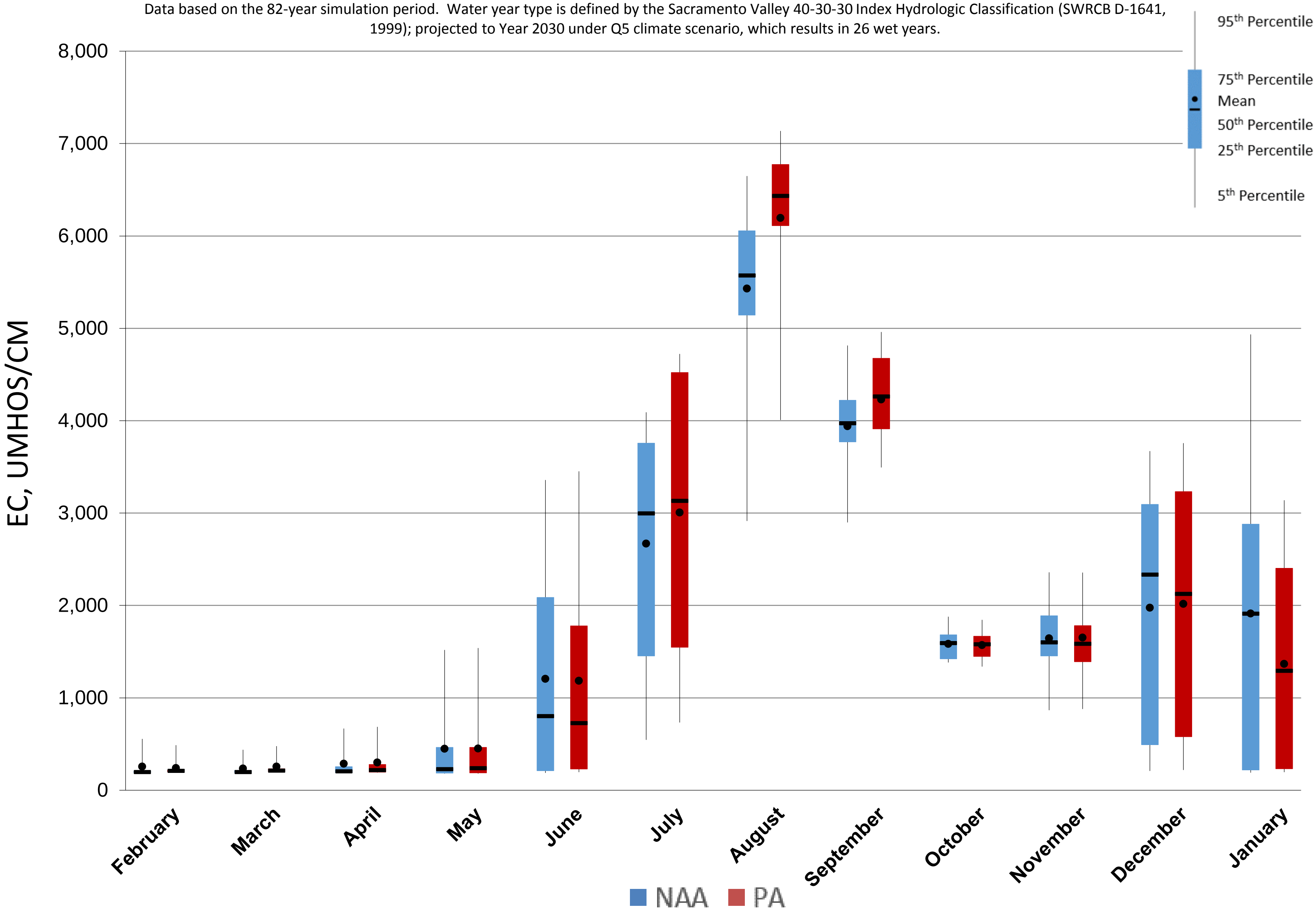


Figure 5.B.5-28-3. Monthly EC Ranges For Montezuma Slough at National Steel, Above Normal Years

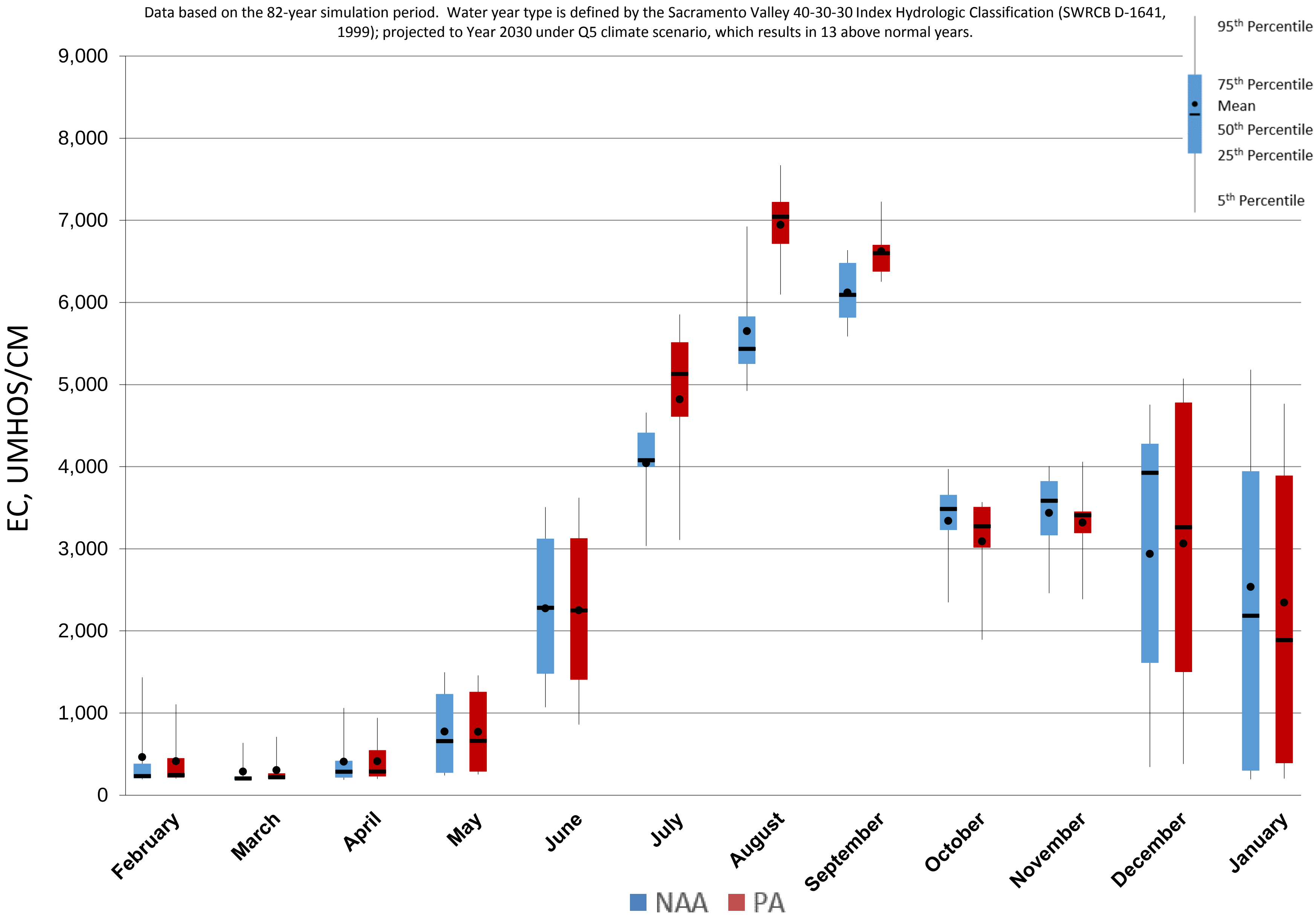


Figure 5.B.5-28-4. Monthly EC Ranges For Montezuma Slough at National Steel, Below Normal Years

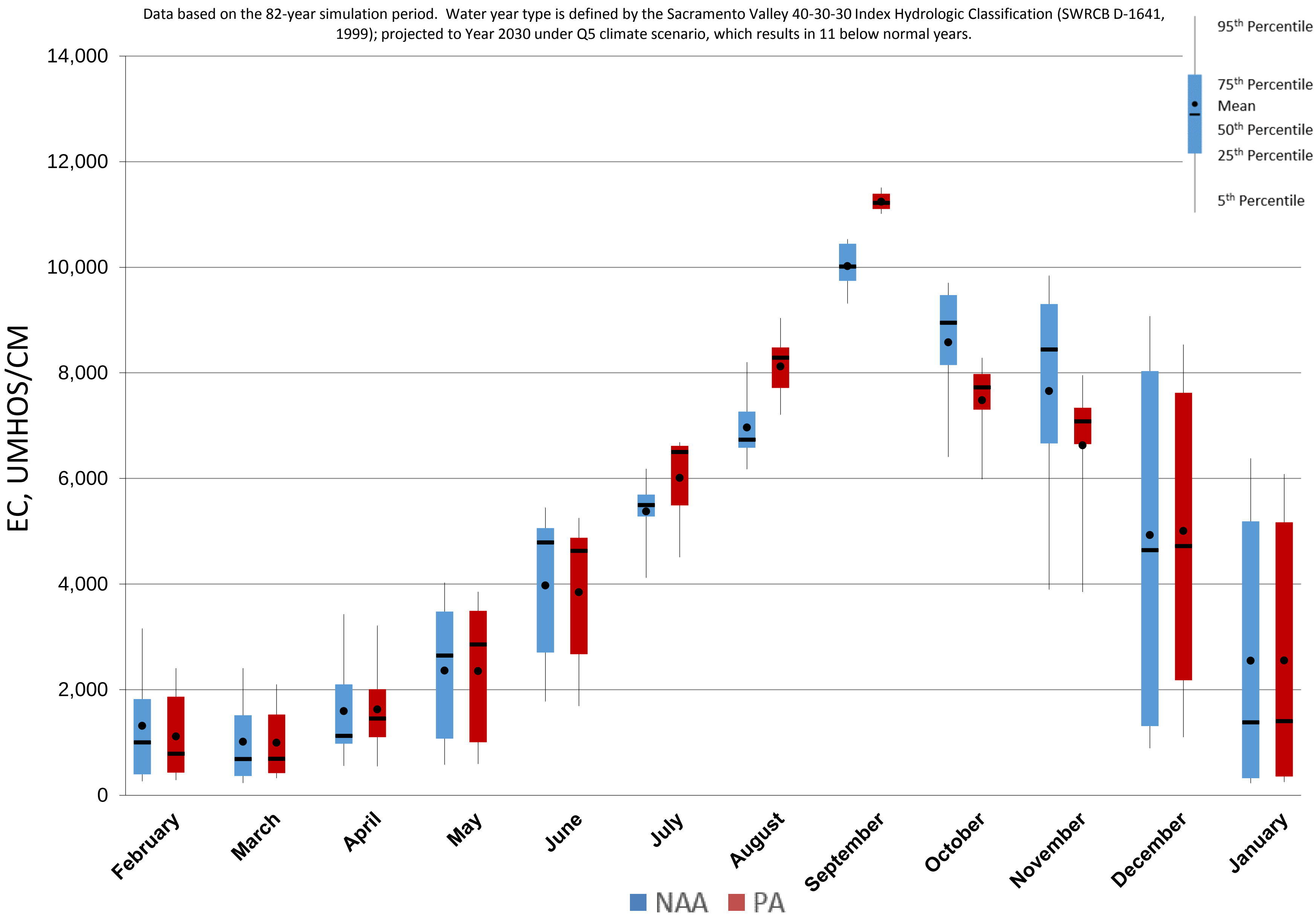
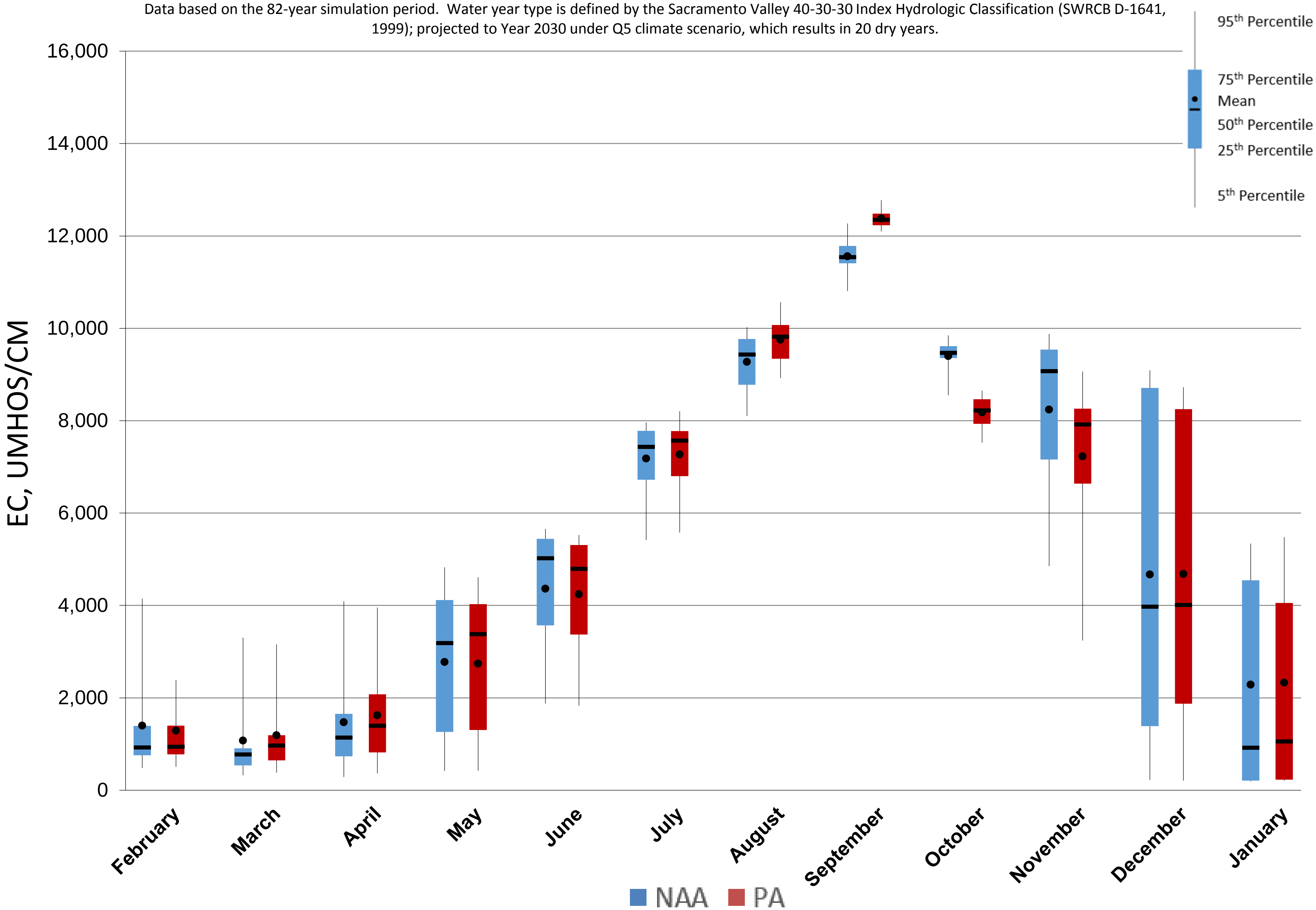


Figure 5.B.5-28-5. Monthly EC Ranges For Montezuma Slough at National Steel, Dry Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 20 dry years.



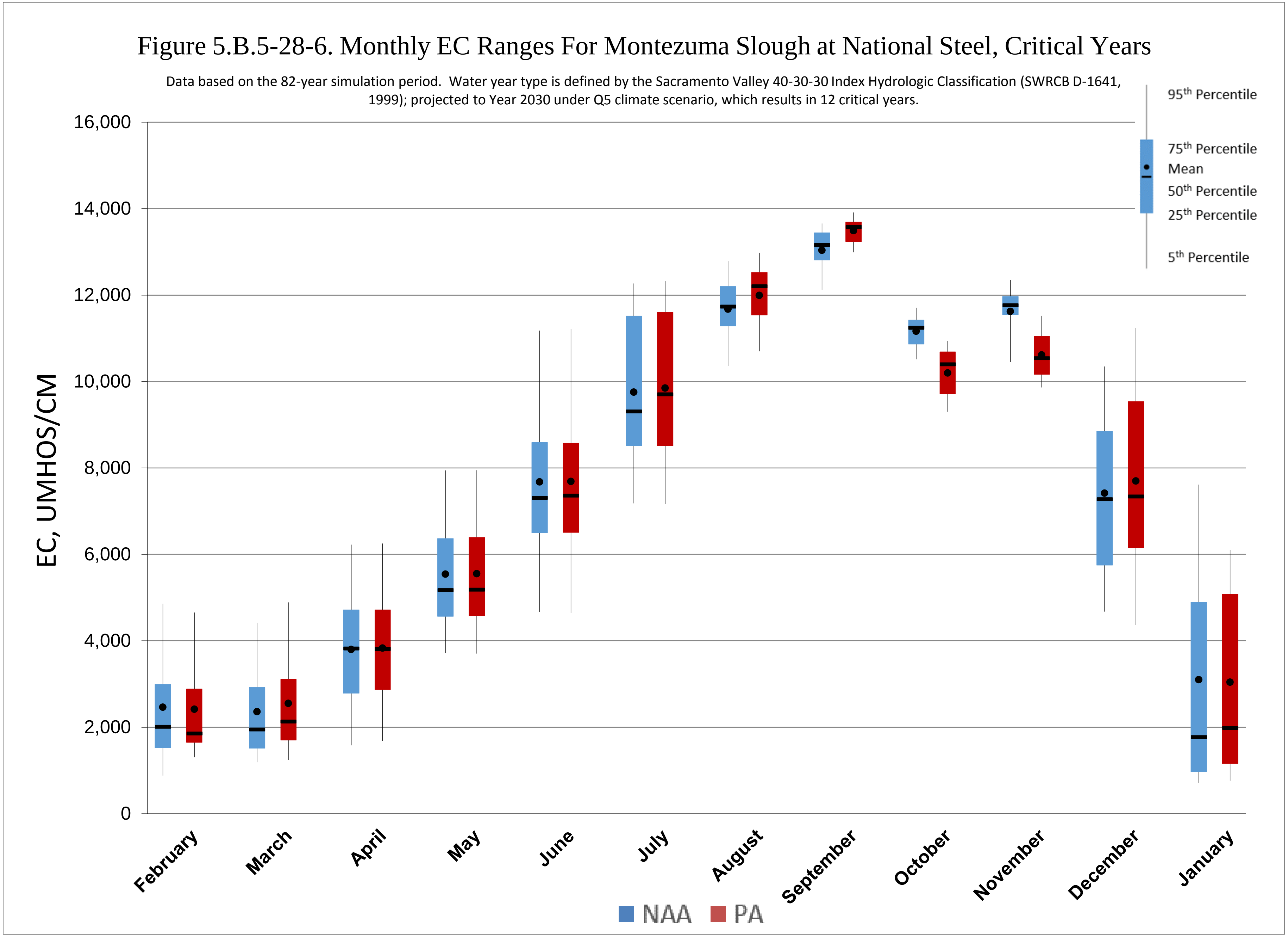
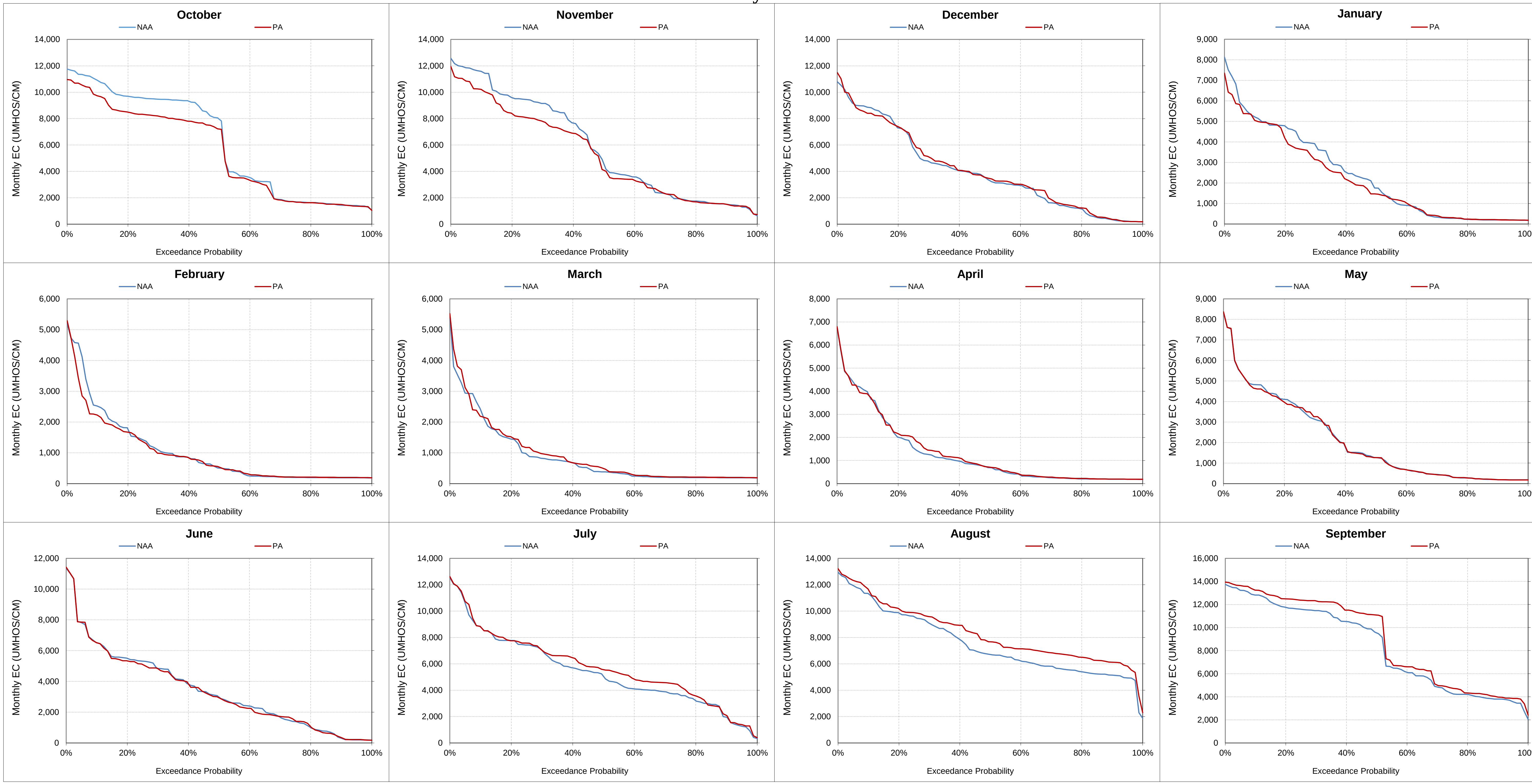


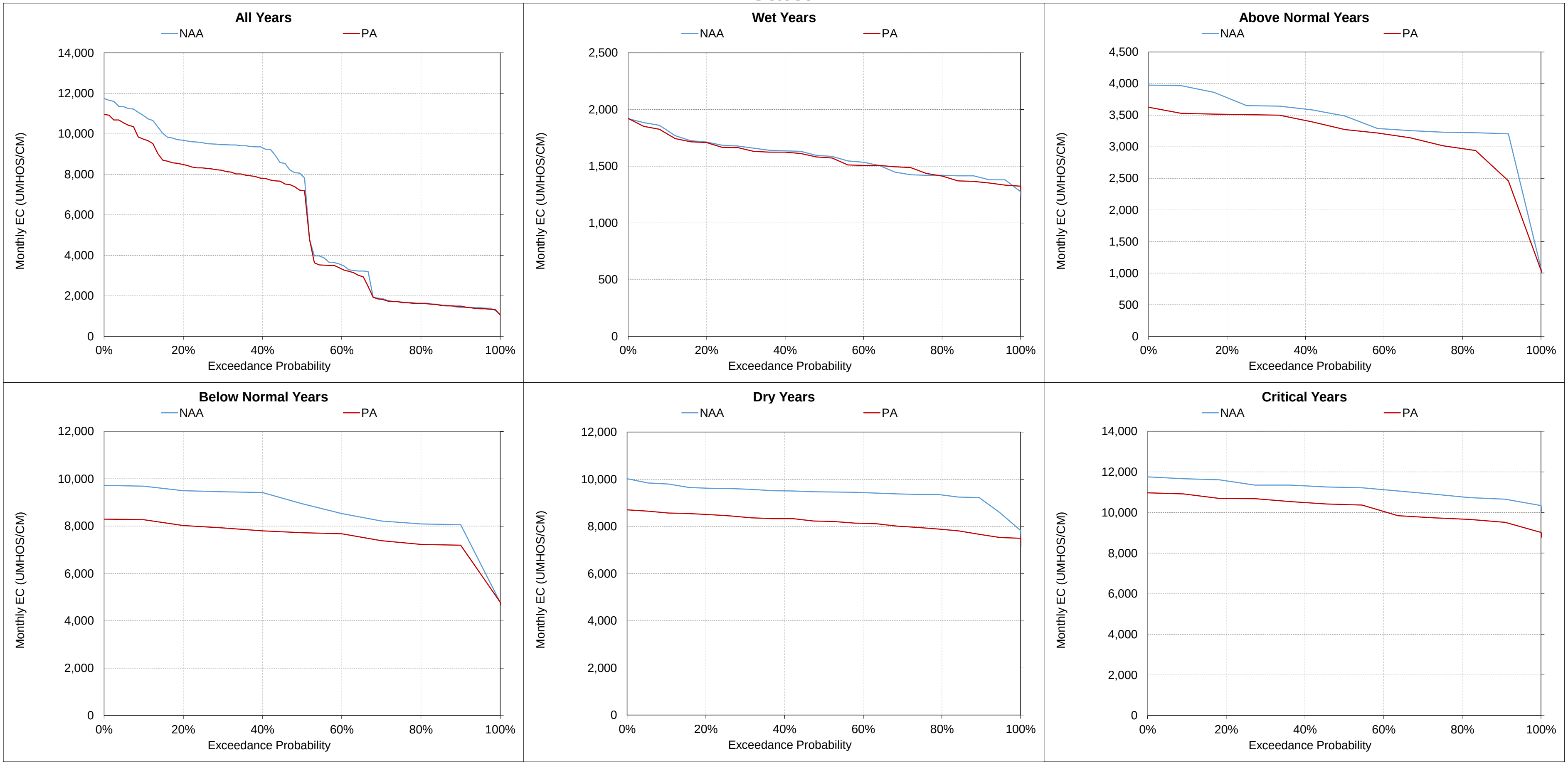
Figure 5.B.5-28-6. Monthly EC Ranges For Montezuma Slough at National Steel, Critical Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 12 critical years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
EC, UMHOS/CM
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-28-7. Montezuma Slough at National Steel, Monthly EC Probability of Exceedance



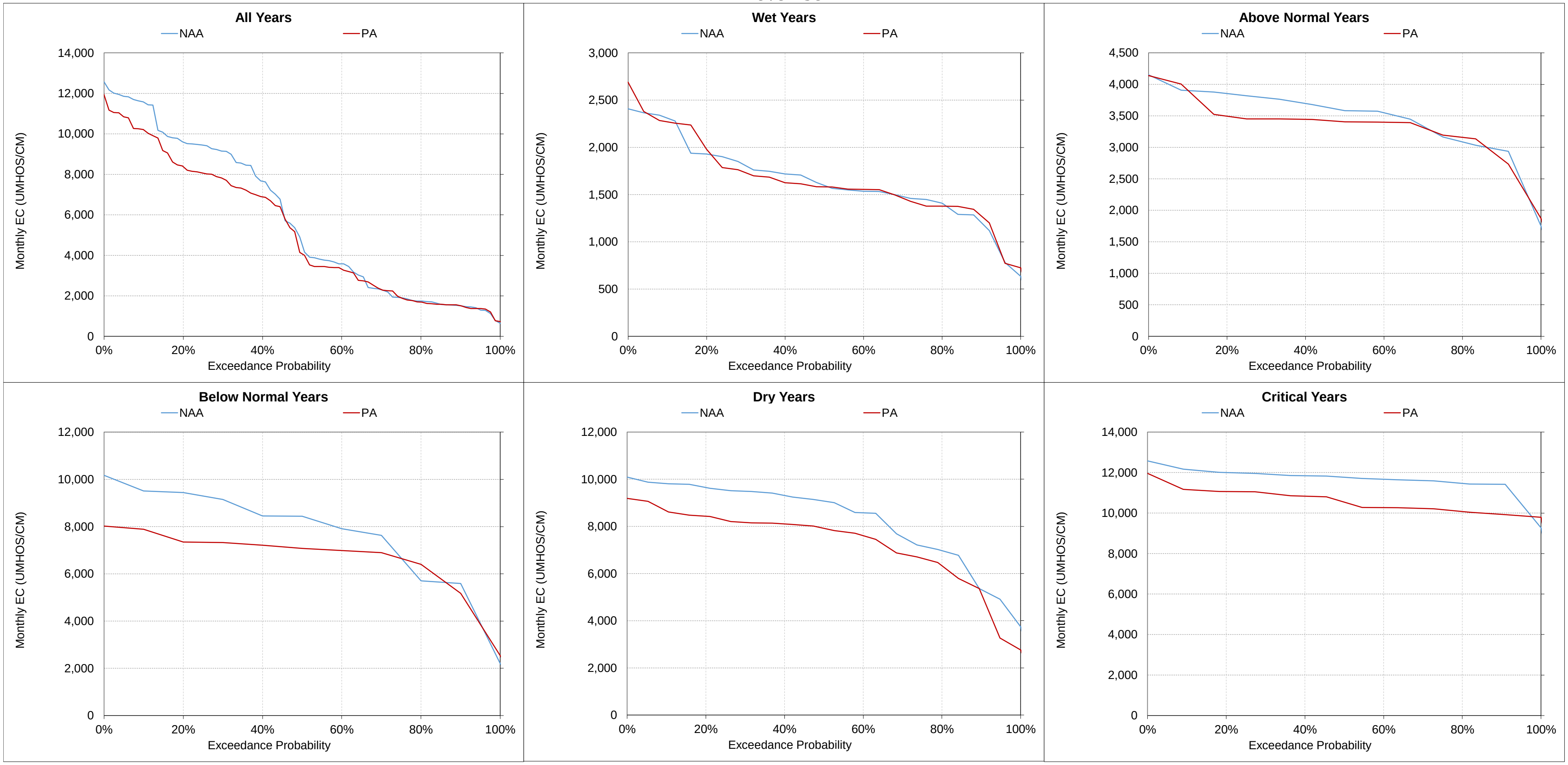
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-28-8. Montezuma Slough at National Steel, Monthly EC October



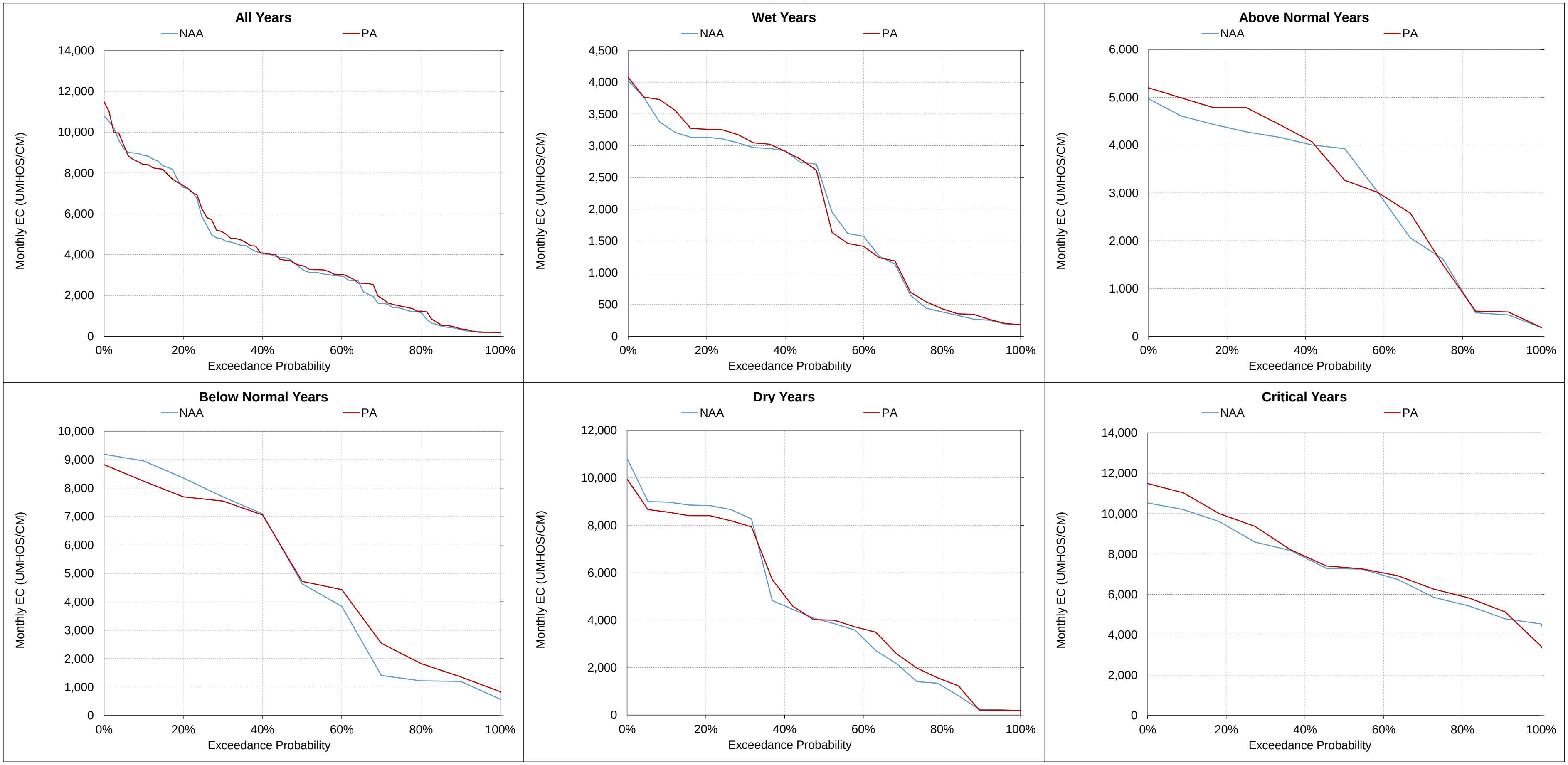
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-28-9. Montezuma Slough at National Steel, Monthly EC November



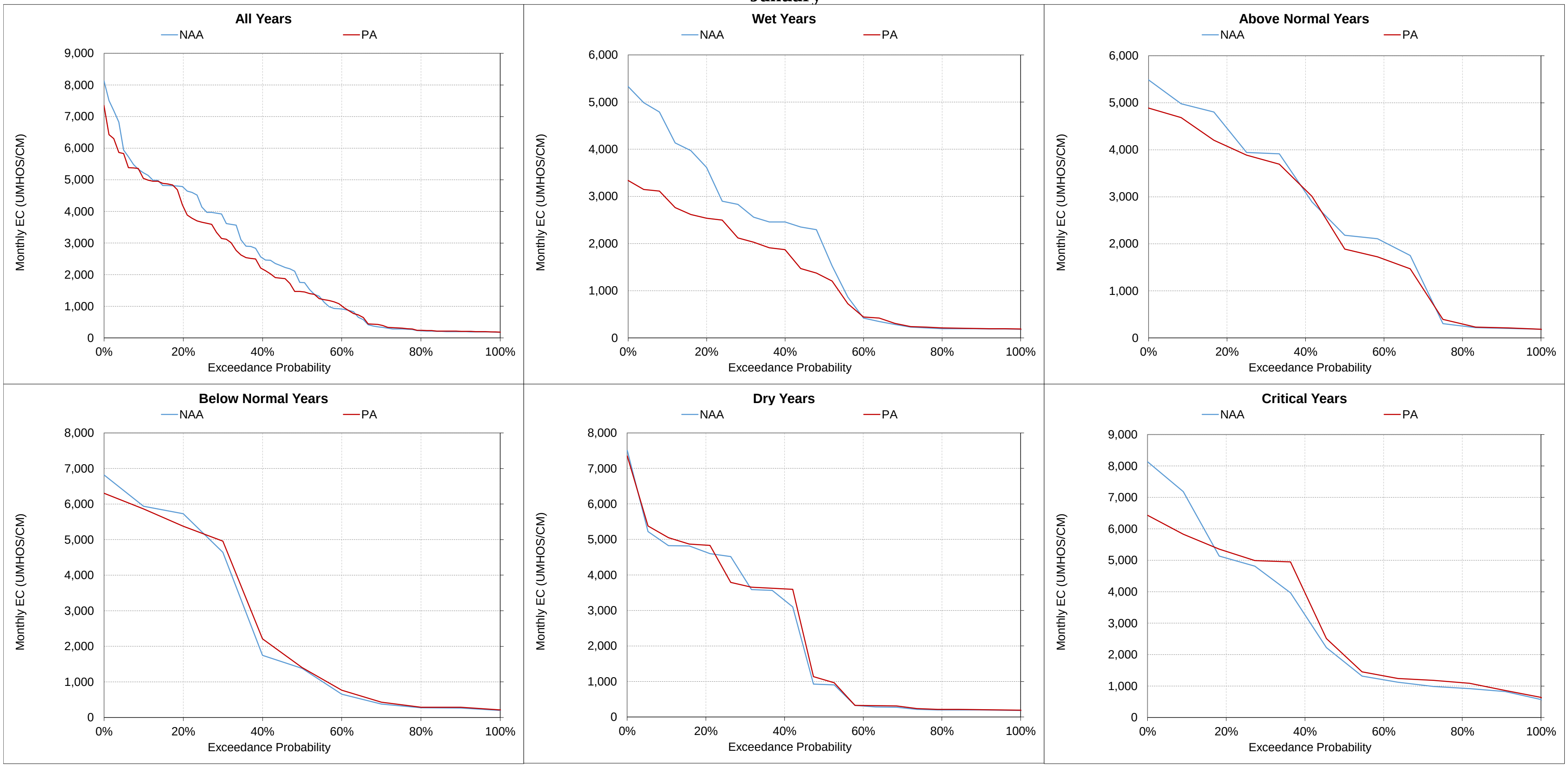
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-28-10. Montezuma Slough at National Steel, Monthly EC December



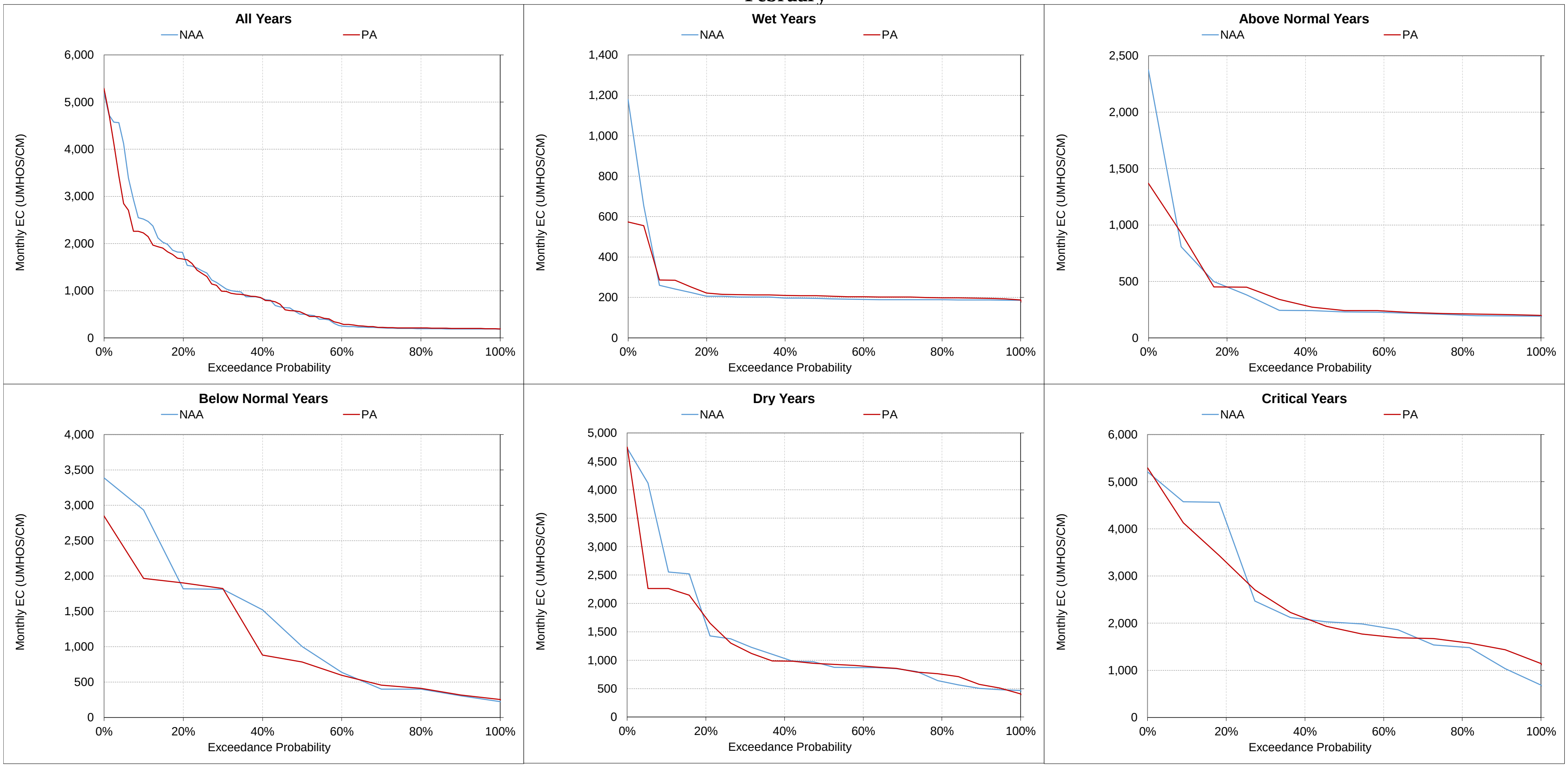
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-28-11. Montezuma Slough at National Steel, Monthly EC January



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-28-12. Montezuma Slough at National Steel, Monthly EC February



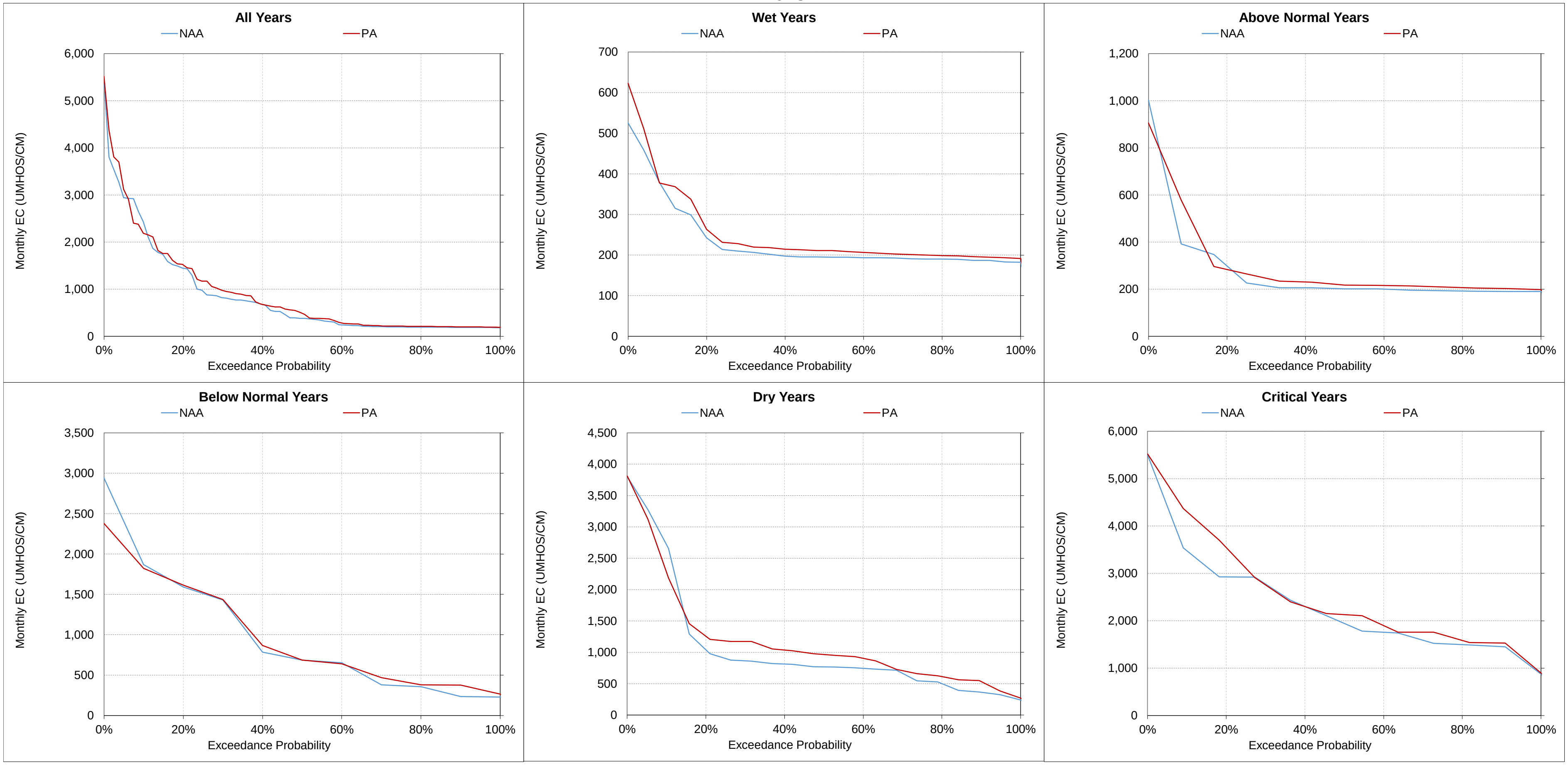
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

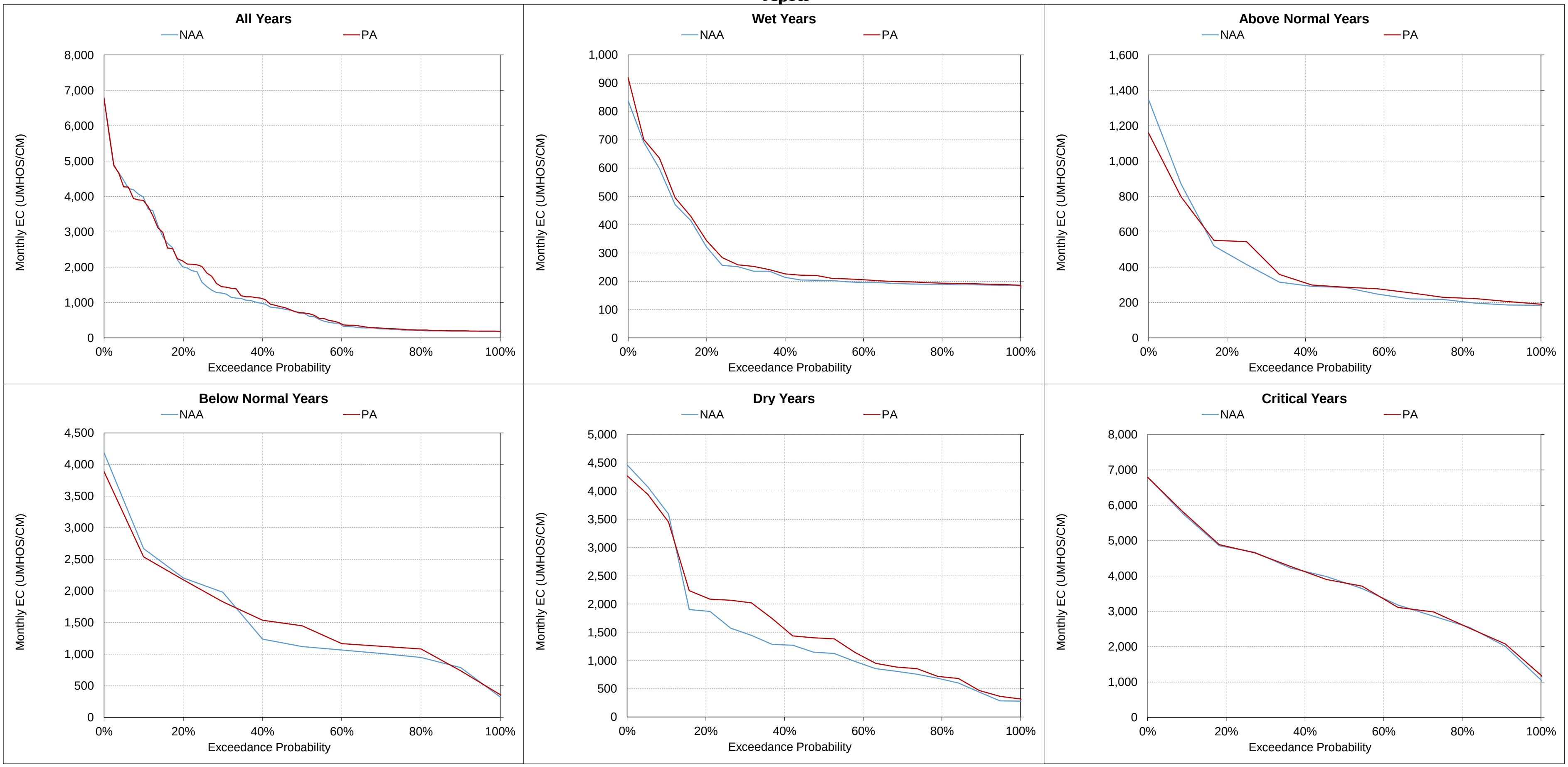
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-28-13. Montezuma Slough at National Steel, Monthly EC
March



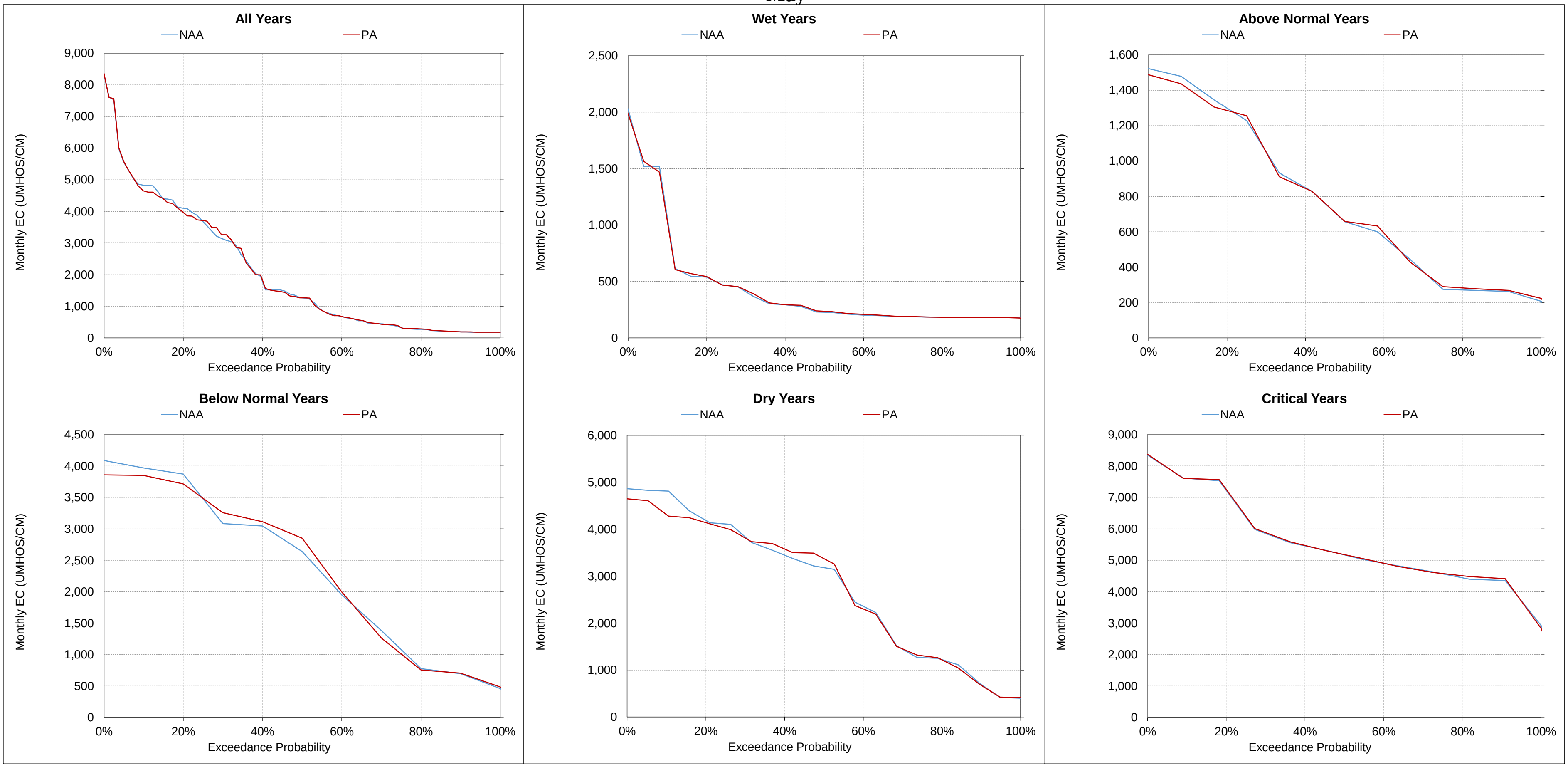
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-28-14. Montezuma Slough at National Steel, Monthly EC
April



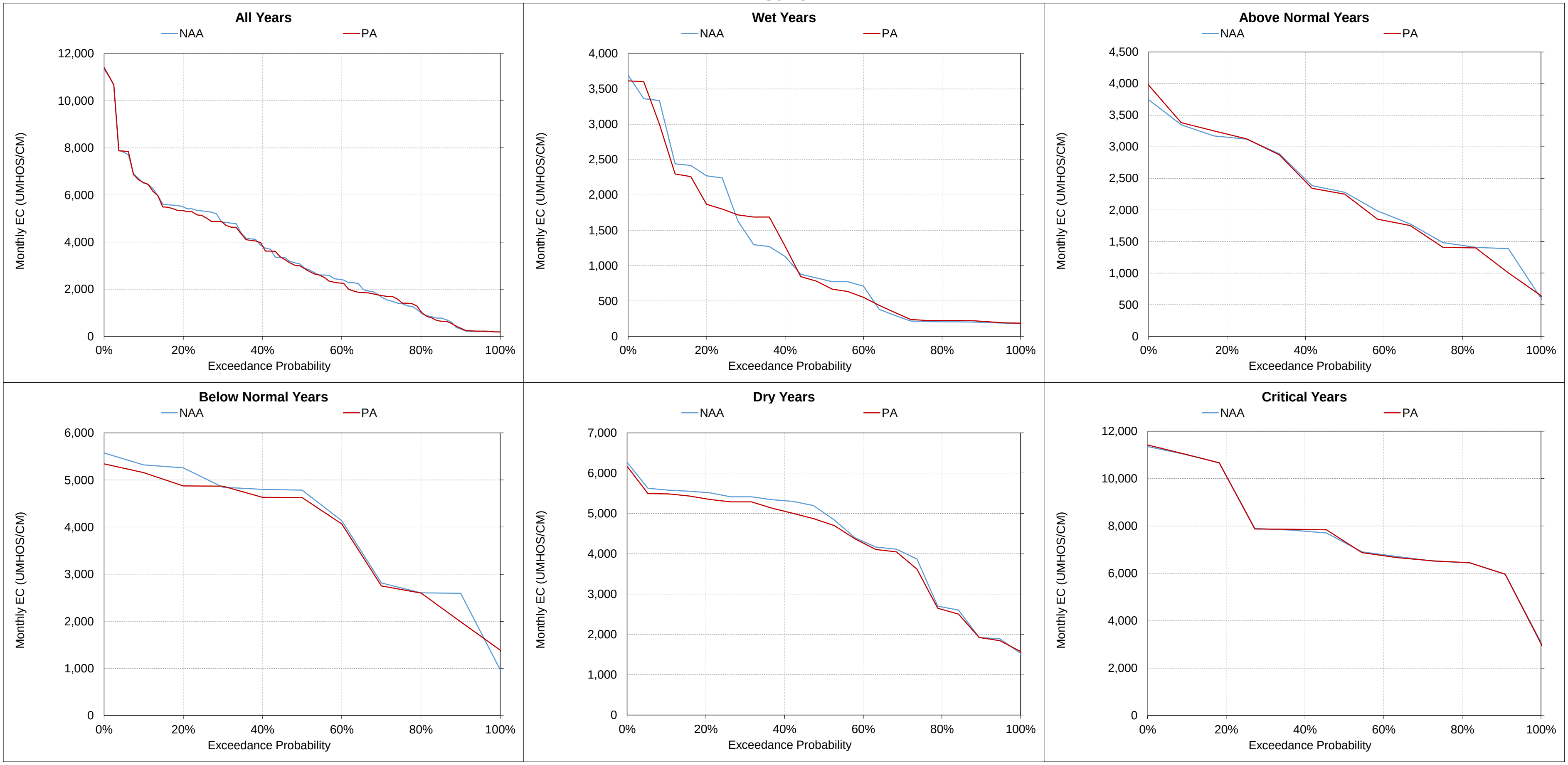
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-28-15. Montezuma Slough at National Steel, Monthly EC
May



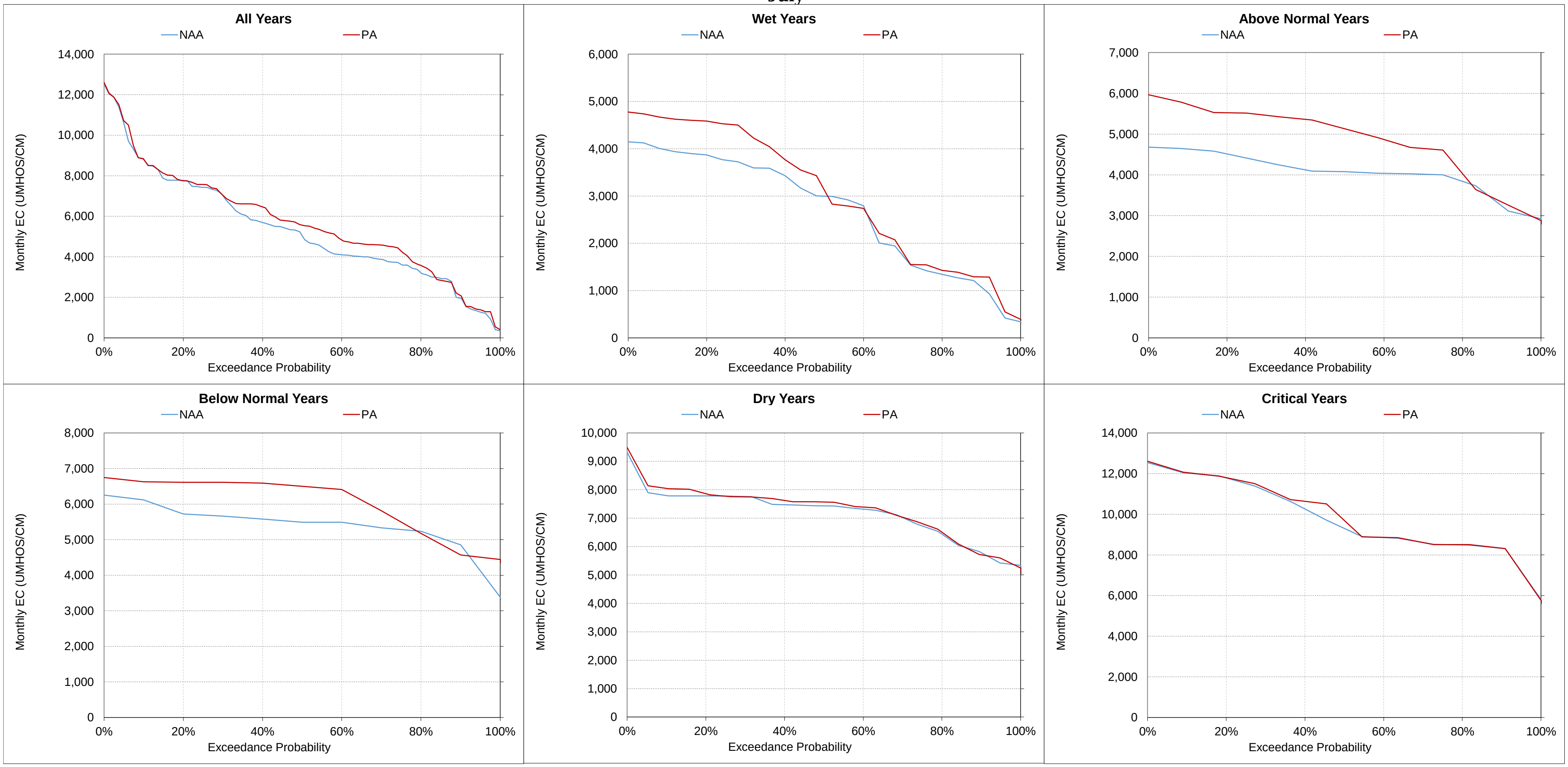
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-28-16. Montezuma Slough at National Steel, Monthly EC
June



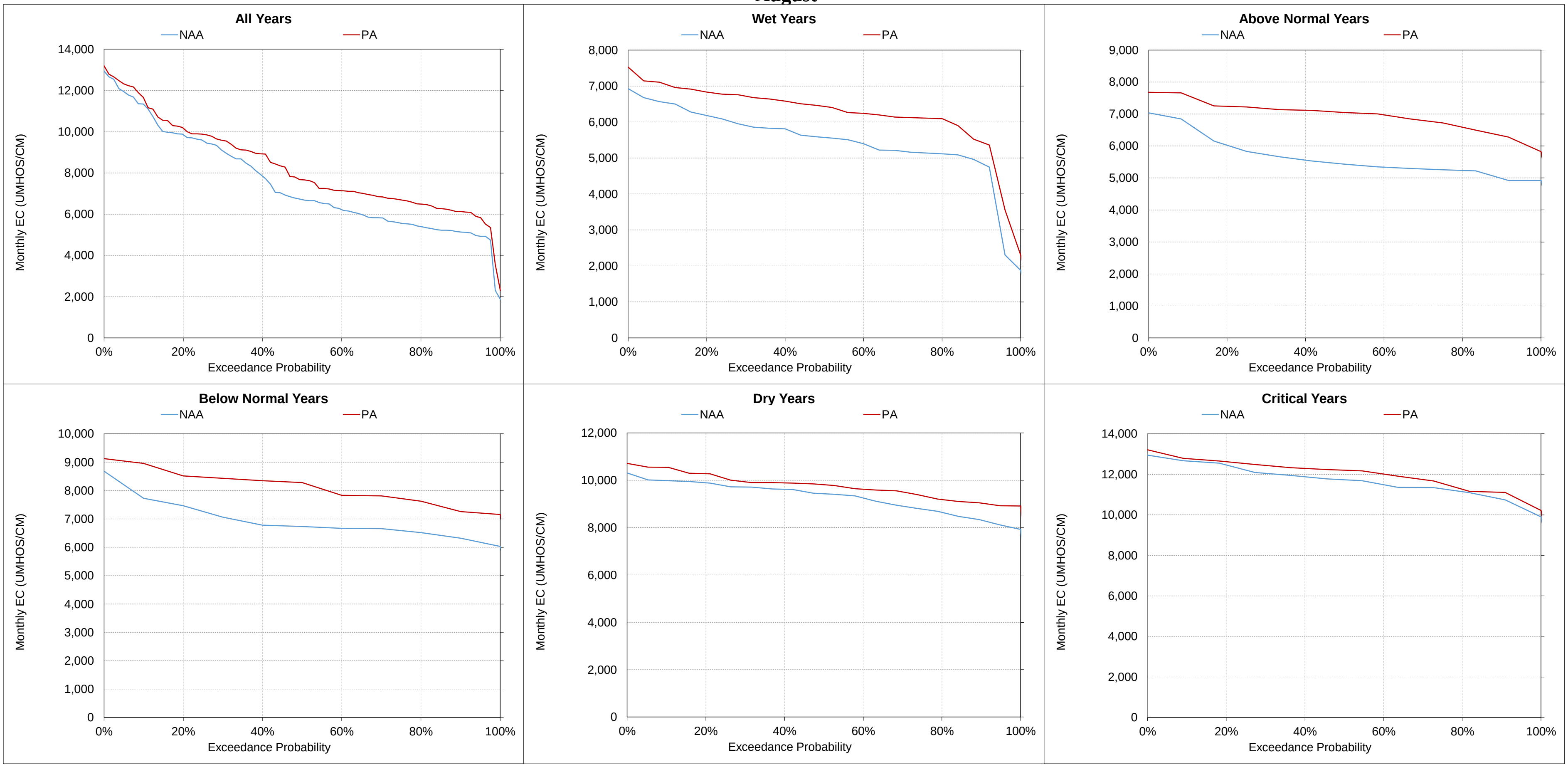
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-28-17. Montezuma Slough at National Steel, Monthly EC
July



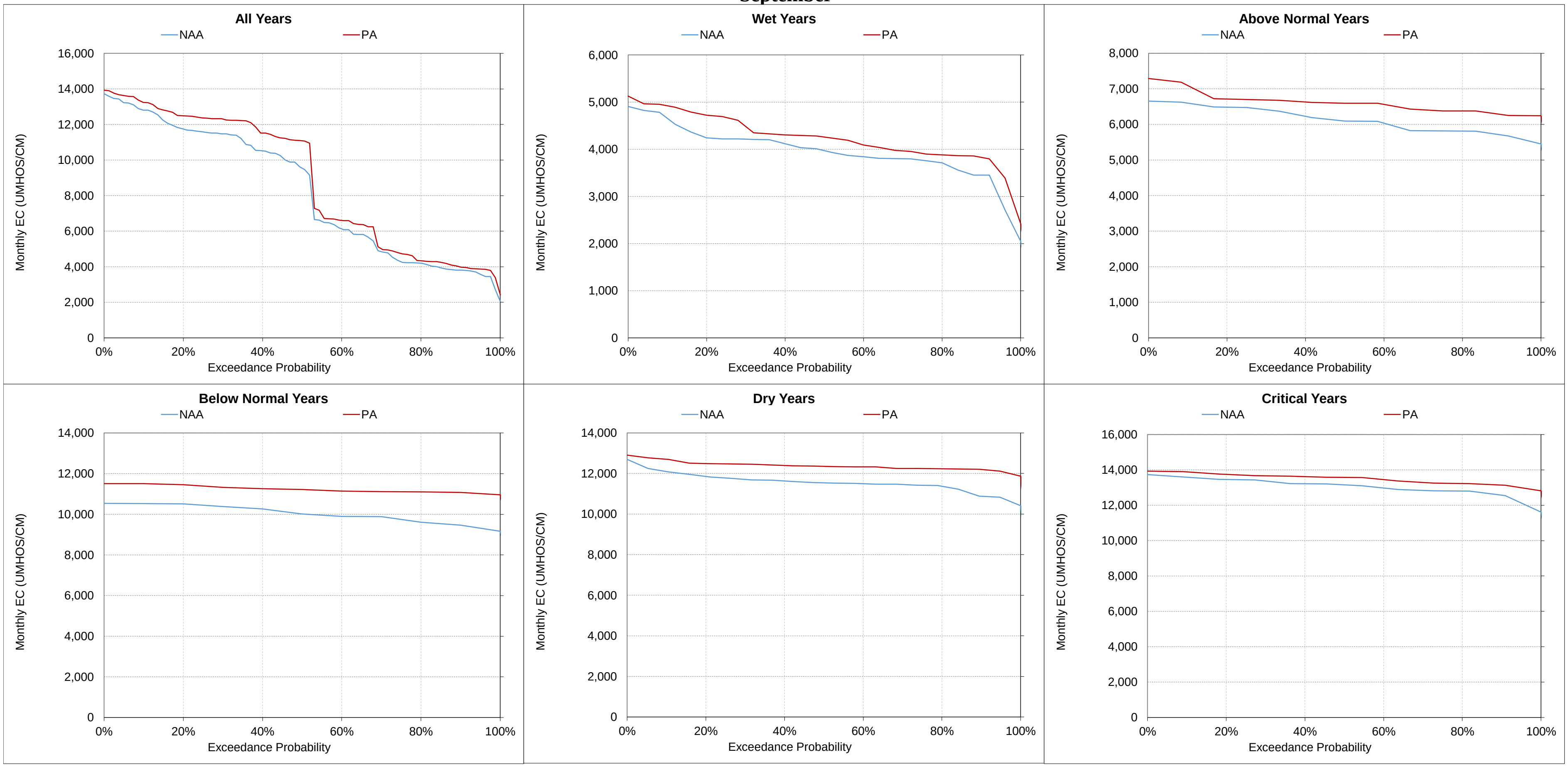
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-28-18. Montezuma Slough at National Steel, Monthly EC
August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-28-19. Montezuma Slough at National Steel, Monthly EC September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-29. Montezuma Slough upstream of Salinity Control Gate, Monthly Flow

Statistic	Monthly Flow (cfs)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	2,392	2,383	-8	0%	2,382	2,349	-33	-1%	2,376	2,361	-15	-1%	2,219	2,232	14	1%	2,154	2,089	-65	-3%	1,341	1,321	-21	-2%
20%	2,366	2,358	-8	0%	2,358	2,322	-36	-2%	2,306	2,299	-7	0%	2,039	2,030	-8	0%	1,802	1,653	-149	-8%	974	987	13	1%
30%	2,346	2,344	-3	0%	2,314	2,301	-13	-1%	2,110	2,133	24	1%	1,952	1,822	-130	-7%	1,389	1,340	-49	-4%	551	528	-24	-4%
40%	2,325	2,322	-3	0%	2,280	2,252	-28	-1%	1,937	1,935	-2	0%	1,729	1,626	-103	-6%	1,160	1,115	-45	-4%	364	355	-8	-2%
50%	2,259	2,267	8	0%	1,824	1,787	-37	-2%	1,740	1,749	10	1%	1,400	1,292	-107	-8%	984	960	-25	-2%	246	176	-70	-28%
60%	1,776	1,730	-46	-3%	1,719	1,697	-21	-1%	1,499	1,513	15	1%	1,186	1,107	-79	-7%	848	779	-69	-8%	144	113	-31	-22%
70%	1,078	1,076	-2	0%	1,168	1,174	6	1%	1,295	1,236	-59	-5%	1,104	1,040	-63	-6%	693	698	4	1%	75	58	-17	-23%
80%	1,040	1,031	-9	-1%	1,087	1,095	7	1%	1,033	1,055	23	2%	926	951	25	3%	586	552	-33	-6%	31	19	-12	-39%
90%	996	999	3	0%	1,017	1,005	-12	-1%	797	781	-16	-2%	648	666	18	3%	433	424	-9	-2%	-10	-10	0	-3%
Long Term Full Simulation Period[b]	1,816	1,808	-8	0%	1,766	1,741	-25	-1%	1,666	1,663	-3	0%	1,521	1,461	-59	-4%	1,189	1,153	-35	-3%	526	515	-11	-2%
Water Year Types[c]																								
Wet (32%)	1,026	1,028	2	0%	1,045	1,059	14	1%	1,278	1,277	-2	0%	1,510	1,350	-160	-11%	1,512	1,508	-4	0%	1,136	1,141	5	0%
Above Normal (16%)	1,710	1,667	-43	-3%	1,661	1,657	-4	0%	1,525	1,527	2	0%	1,478	1,413	-64	-4%	1,020	981	-40	-4%	670	681	11	2%
Below Normal (13%)	2,246	2,231	-16	-1%	2,186	2,132	-53	-2%	1,780	1,805	25	1%	1,451	1,461	9	1%	960	840	-120	-12%	106	86	-20	-19%
Dry (24%)	2,355	2,349	-6	0%	2,192	2,106	-86	-4%	1,820	1,801	-19	-1%	1,518	1,511	-7	0%	908	843	-65	-7%	174	129	-45	-26%
Critical (15%)	2,351	2,361	10	0%	2,347	2,344	-4	0%	2,296	2,285	-11	0%	1,660	1,673	13	1%	1,348	1,376	28	2%	20	15	-5	-26%

Statistic	Monthly Flow (cfs)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	994	991	-3	0%	577	575	-2	0%	134	113	-22	-16%	45	1	-44	-97%	-86	-89	-3	-3%	131	149	19	14%
20%	553	553	0	0%	261	257	-4	-2%	24	19	-5	-22%	17	-18	-35	-207%	-94	-101	-7	-7%	112	131	19	17%
30%	291	293	1	0%	131	132	2	1%	-18	-6	12	65%	-5	-37	-32	-680%	-103	-105	-2	-2%	70	90	20	29%
40%	178	178	0	0%	72	74	2	3%	-35	-32	3	8%	-21	-46	-25	-121%	-106	-110	-4	-4%	10	14	3	34%
50%	115	115	-1	-1%	28	31	4	14%	-49	-45	3	7%	-44	-57	-13	-28%	-111	-115	-4	-4%	-93	-107	-14	-15%
60%	46	46	1	2%	-1	1	2	360%	-54	-53	1	3%	-60	-71	-11	-18%	-115	-120	-5	-5%	-113	-118	-4	-4%
70%	9	1	-8	-92%	-22	-15	6	29%	-65	-59	6	9%	-82	-83	-1	-1%	-121	-126	-4	-4%	-119	-125	-6	-5%
80%	-16	-15	1	5%	-49	-42	7	14%	-75	-72	3	4%	-92	-95	-3	-3%	-127	-132	-5	-4%	-126	-130	-4	-3%
90%	-43	-41	2	4%	-60	-57	4	6%	-89	-89	0	0%	-107	-108	-1	-1%	-133	-136	-3	-2%	-136	-139	-3	-2%
Long Term Full Simulation Period[b]	290	291	1	0%	150	151	1	1%	8	8	-1	-10%	-35	-55	-20	-56%	-109	-114	-6	-5%	-25	-22	3	10%
Water Year Types[c]																								
Wet (32%)	694	693	0	0%	441	437	-4	-1%	140	134	-6	-4%	8	-17	-25	-321%	-103	-106	-4	-3%	120	135	15	12%
Above Normal (16%)	312	318	6	2%	120	121	1	1%	-30	-26	5	15%	15	-30	-45	-306%	-110	-113	-3	-2%	8	15	8	101%
Below Normal (13%)	62	61	0	-1%	16	18	3	18%	-53	-50	3	6%	-26	-55	-29	-110%	-101	-105	-5	-5%	-113	-125	-13	-11%
Dry (24%)	72	71	0	0%	-2	6	7	429%	-55	-56	-1	-1%	-85	-87	-2	-3%	-114	-123	-10	-8%	-124	-130	-7	-5%
Critical (15%)	-37	-36	0	1%	-73	-73	0	0%	-73	-73	0	-1%	-110	-112	-2	-2%	-120	-127	-7	-6%	-126	-126	0	0%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

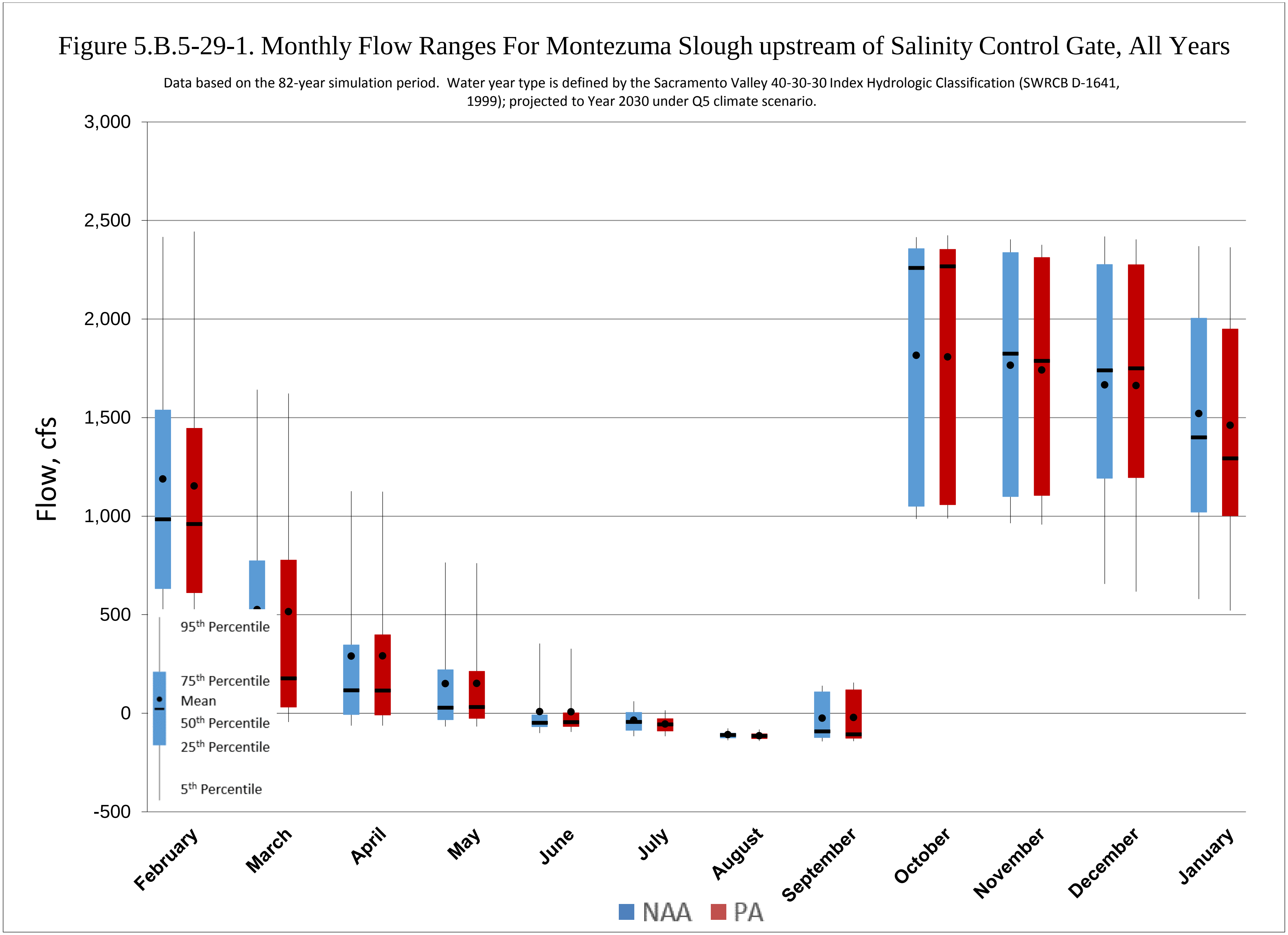


Figure 5.B.5-29-1. Monthly Flow Ranges For Montezuma Slough upstream of Salinity Control Gate, All Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario.
Flow, cfs
3,000
2,500
2,000
1,500
1,000
500
0
-500
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-29-2. Monthly Flow Ranges For Montezuma Slough upstream of Salinity Control Gate, Wet Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 26 wet years.

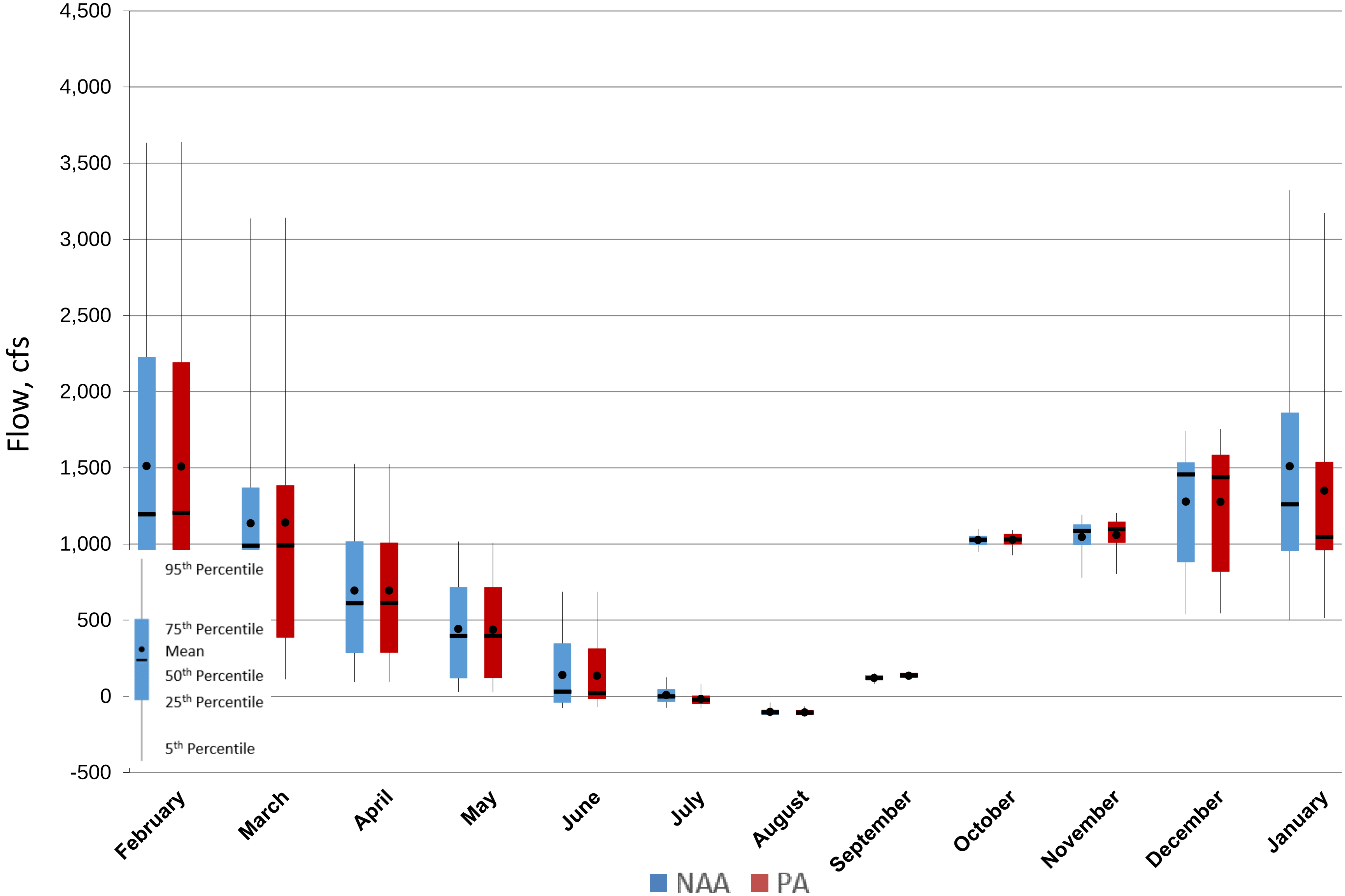


Figure 5.B.5-29-3. Monthly Flow Ranges For Montezuma Slough upstream of Salinity Control Gate, Above Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 13 above normal years.

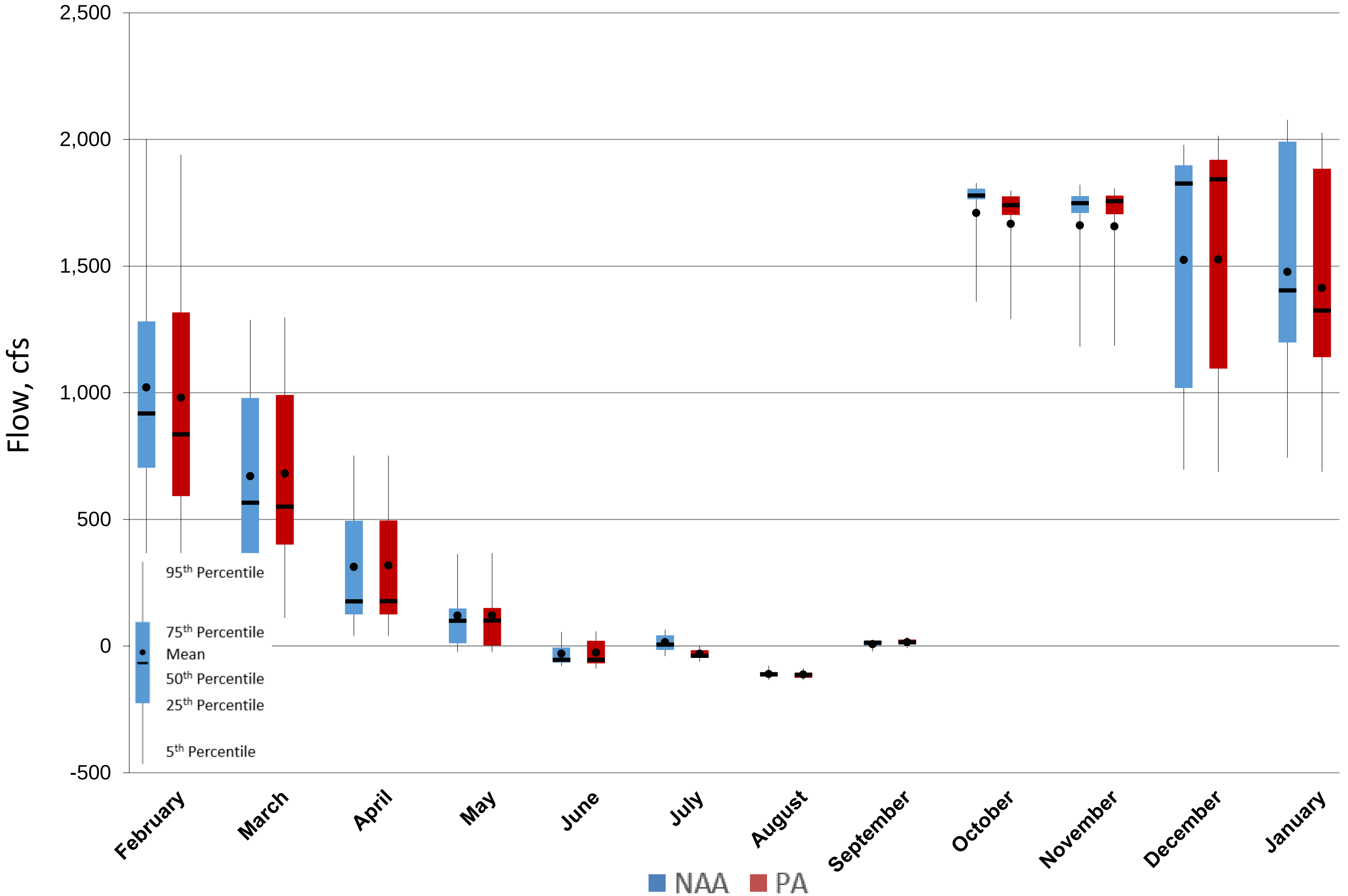


Figure 5.B.5-29-4. Monthly Flow Ranges For Montezuma Slough upstream of Salinity Control Gate, Below Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 11 below normal years.

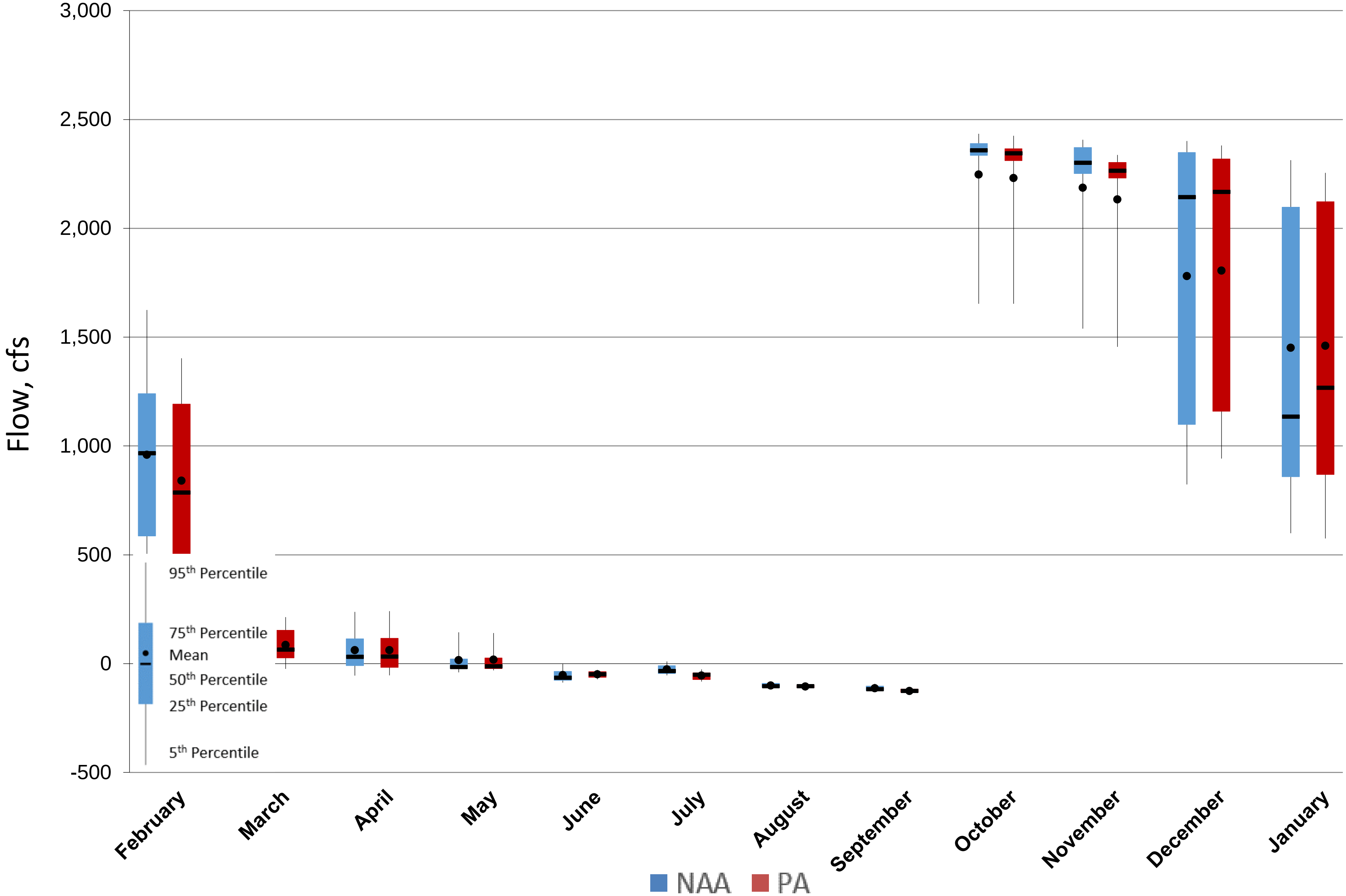


Figure 5.B.5-29-5. Monthly Flow Ranges For Montezuma Slough upstream of Salinity Control Gate, Dry Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 20 dry years.

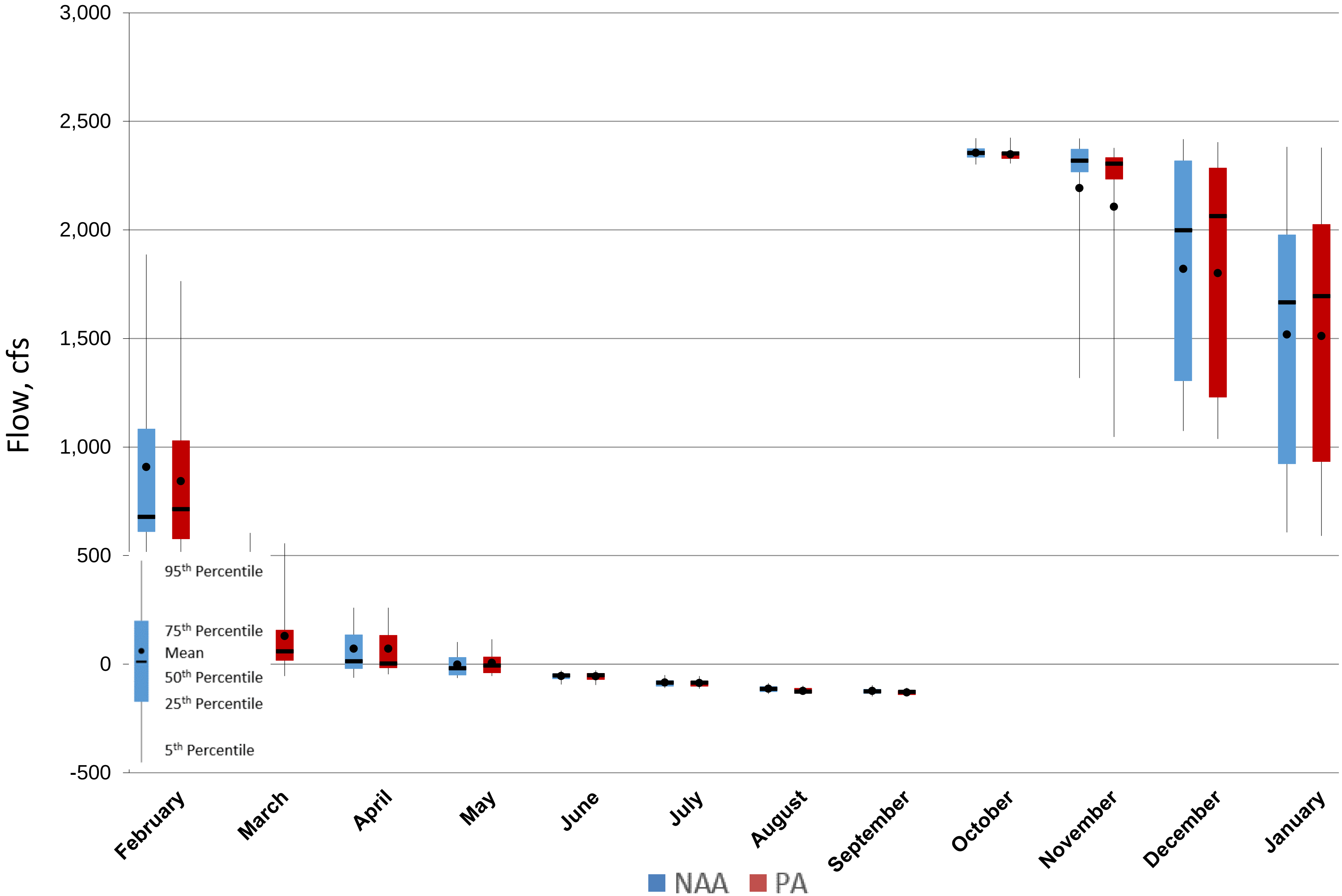


Figure 5.B.5-29-6. Monthly Flow Ranges For Montezuma Slough upstream of Salinity Control Gate, Critical Years

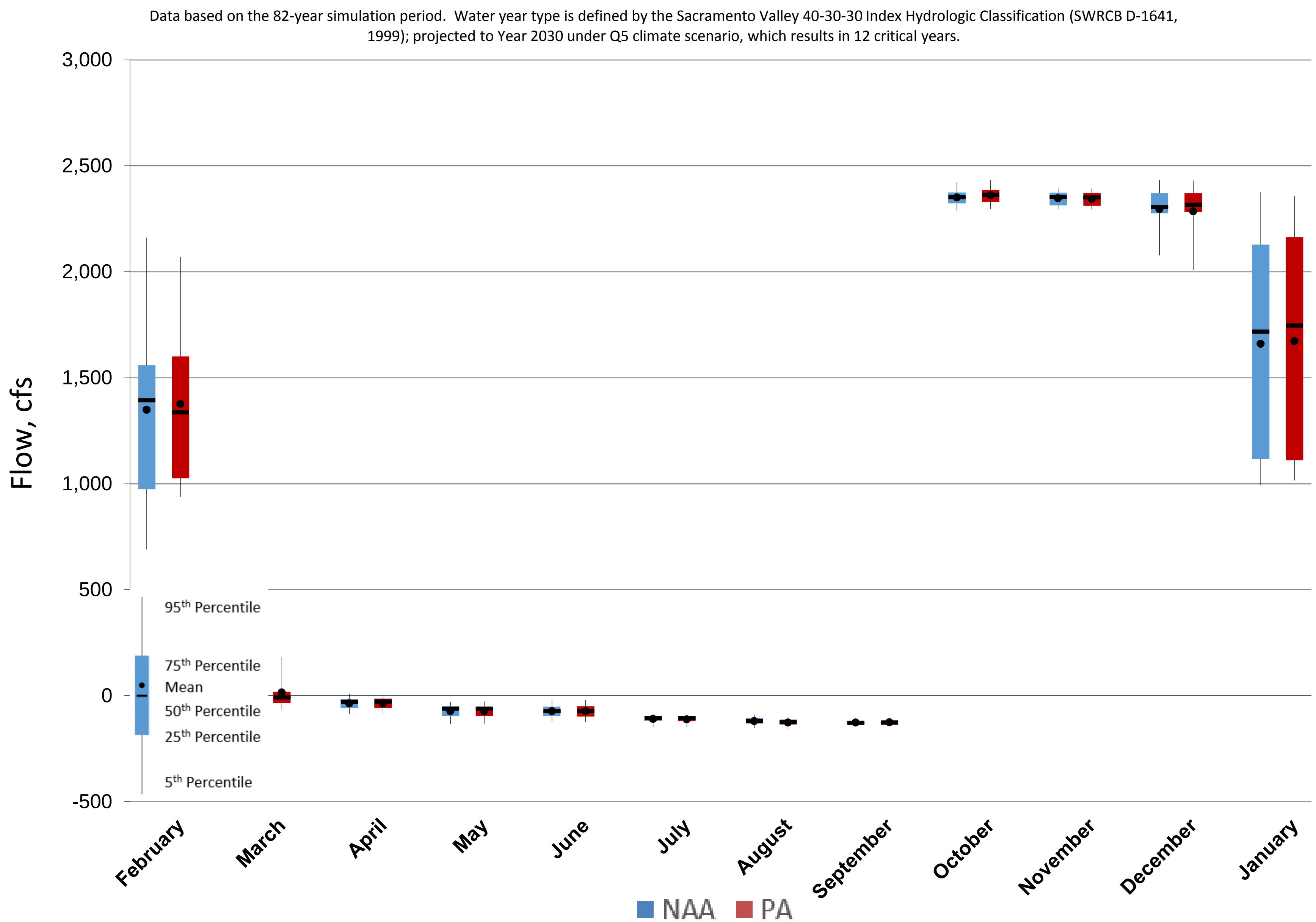
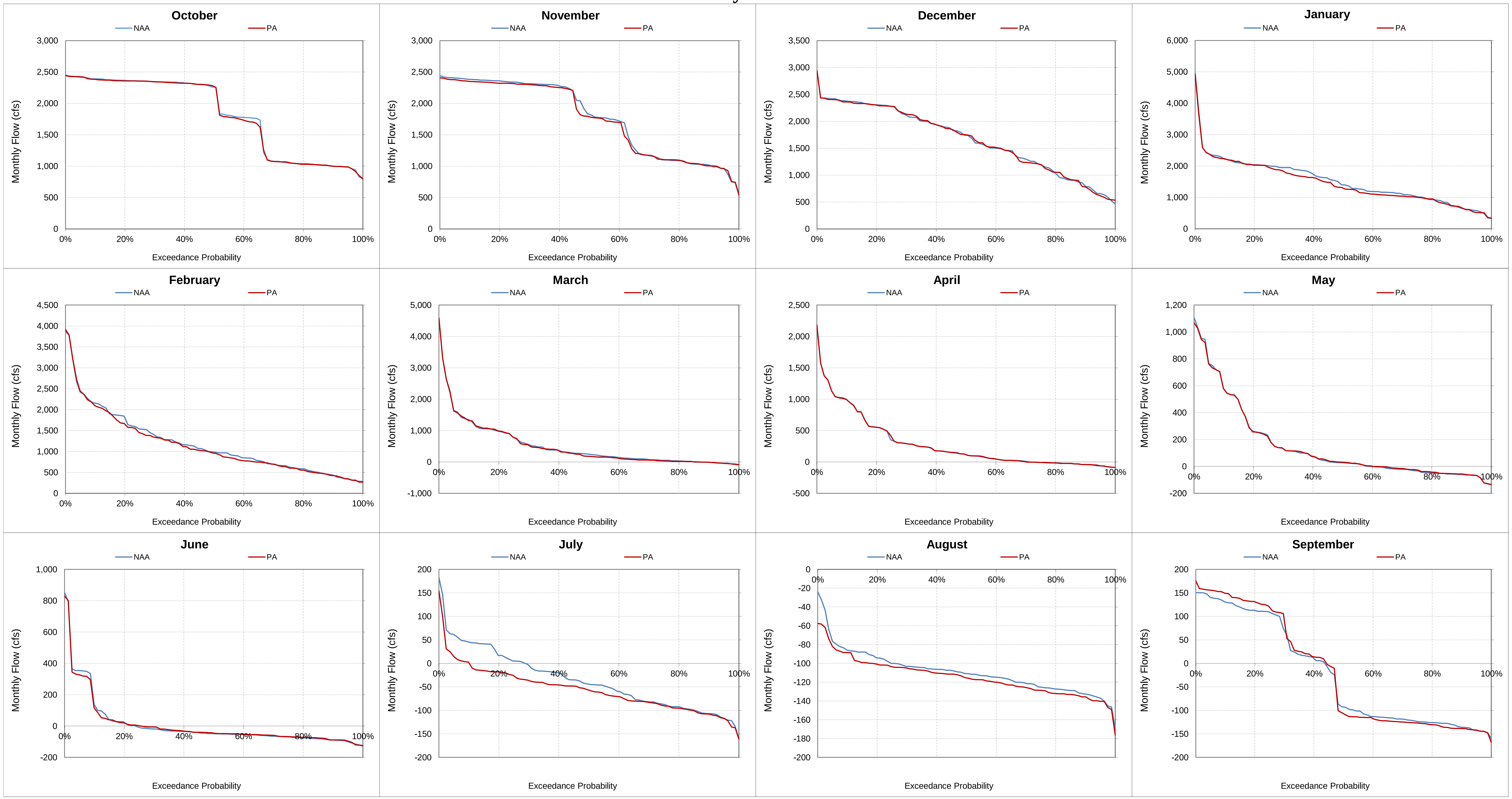
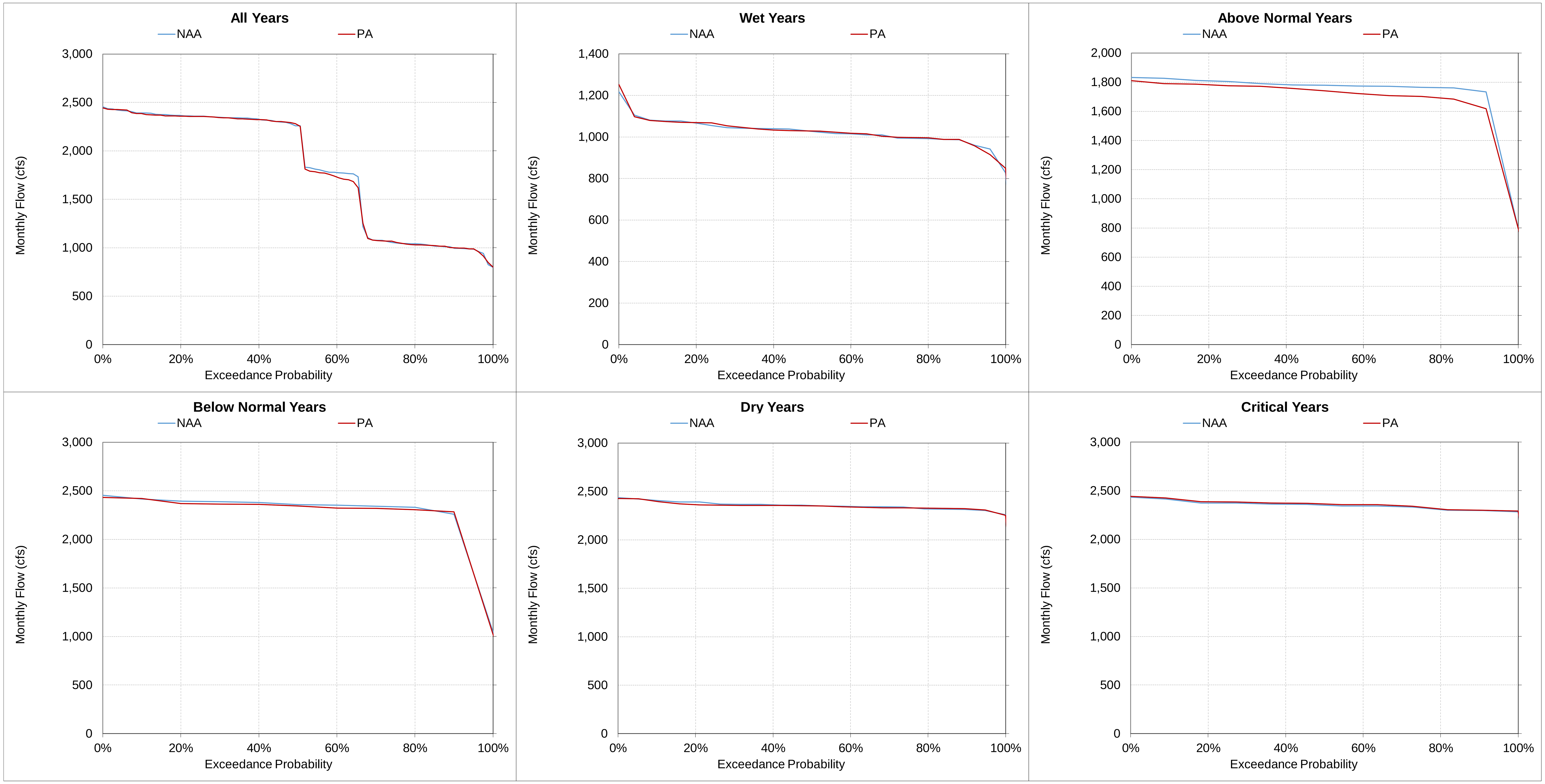


Figure 5.B.5-29-7. Montezuma Slough upstream of Salinity Control Gate, Monthly Flow Probability of Exceedance



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-29-8. Montezuma Slough upstream of Salinity Control Gate, Monthly Flow October



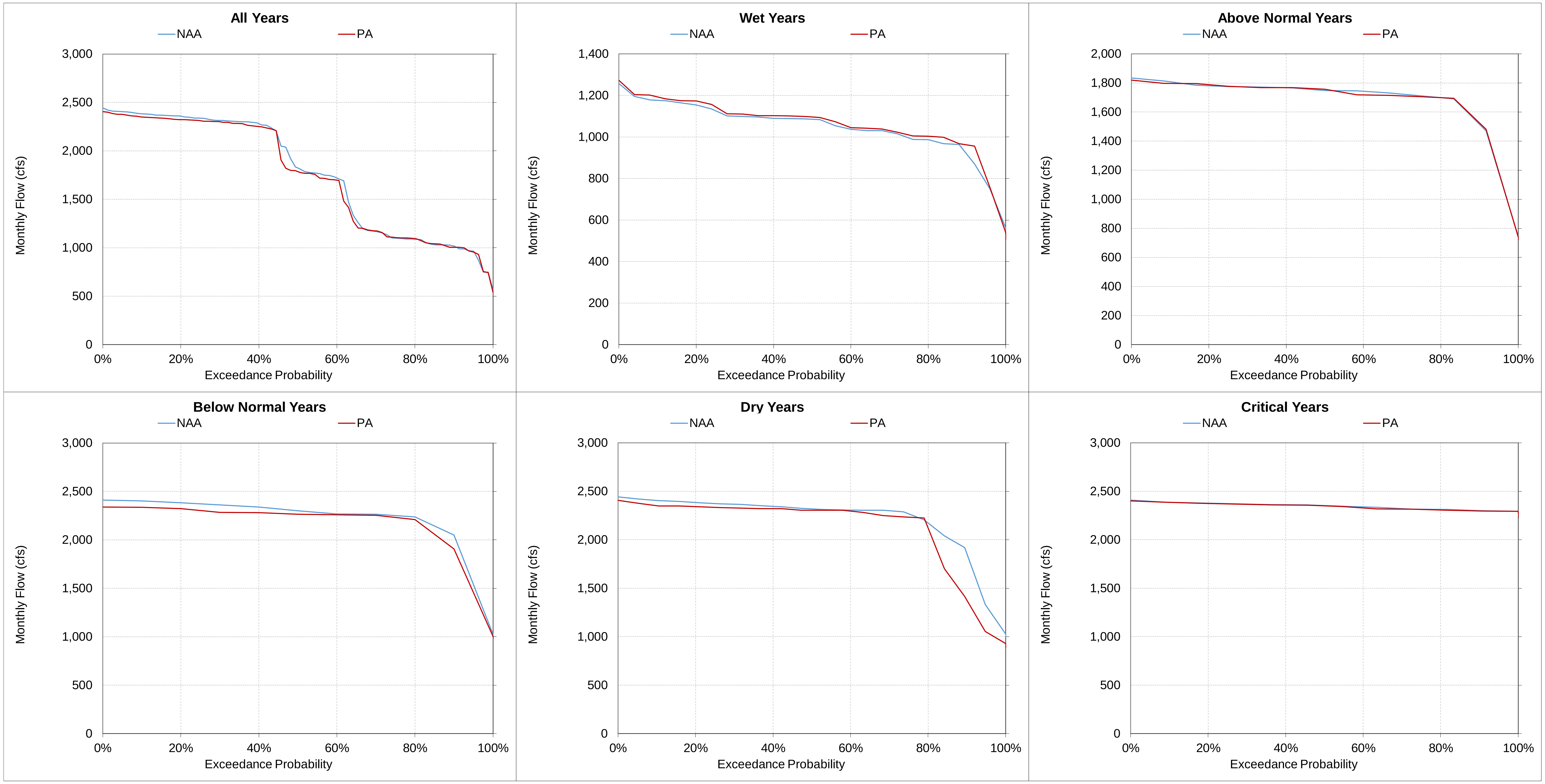
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-29-9. Montezuma Slough upstream of Salinity Control Gate, Monthly Flow November



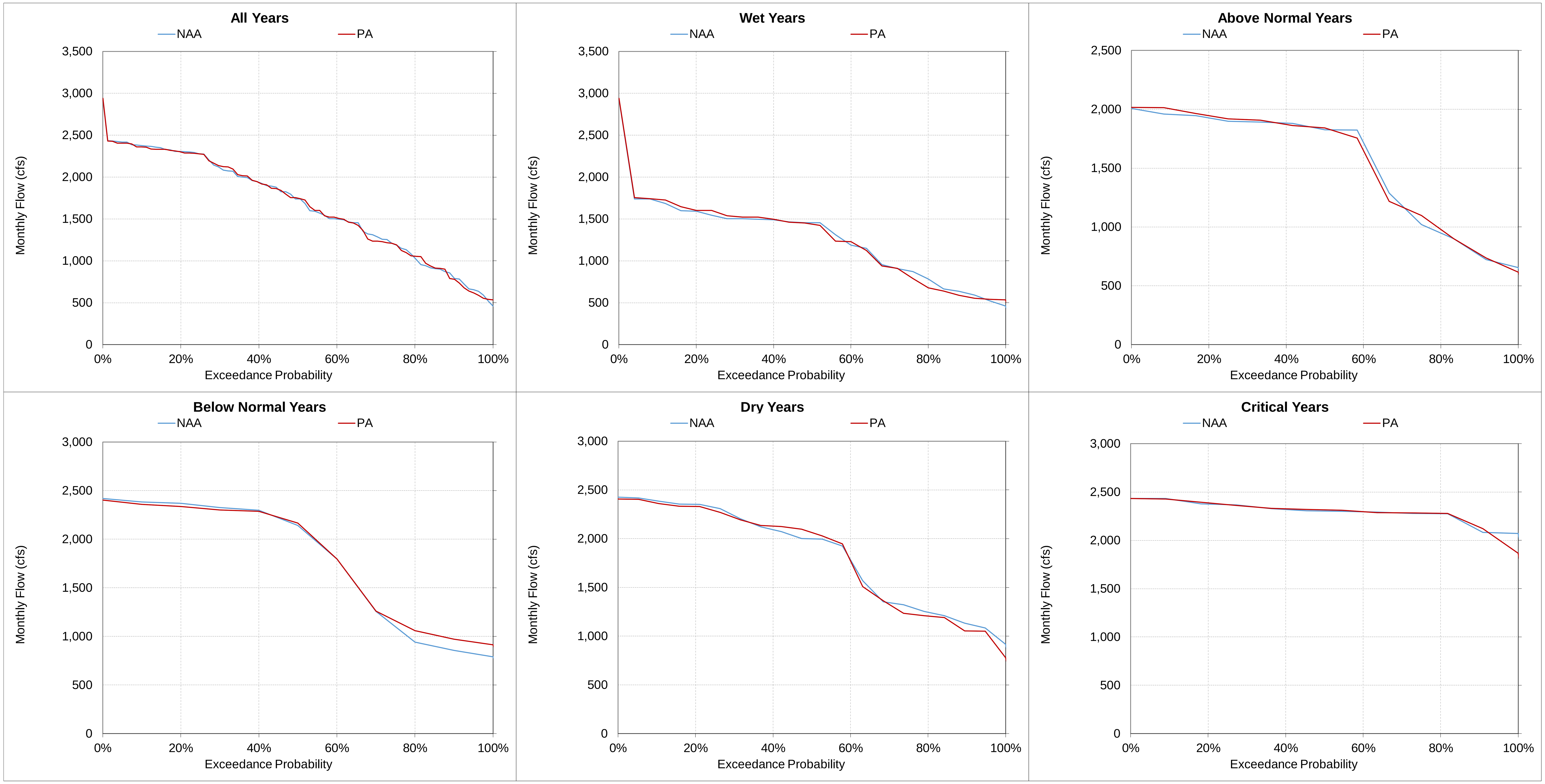
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

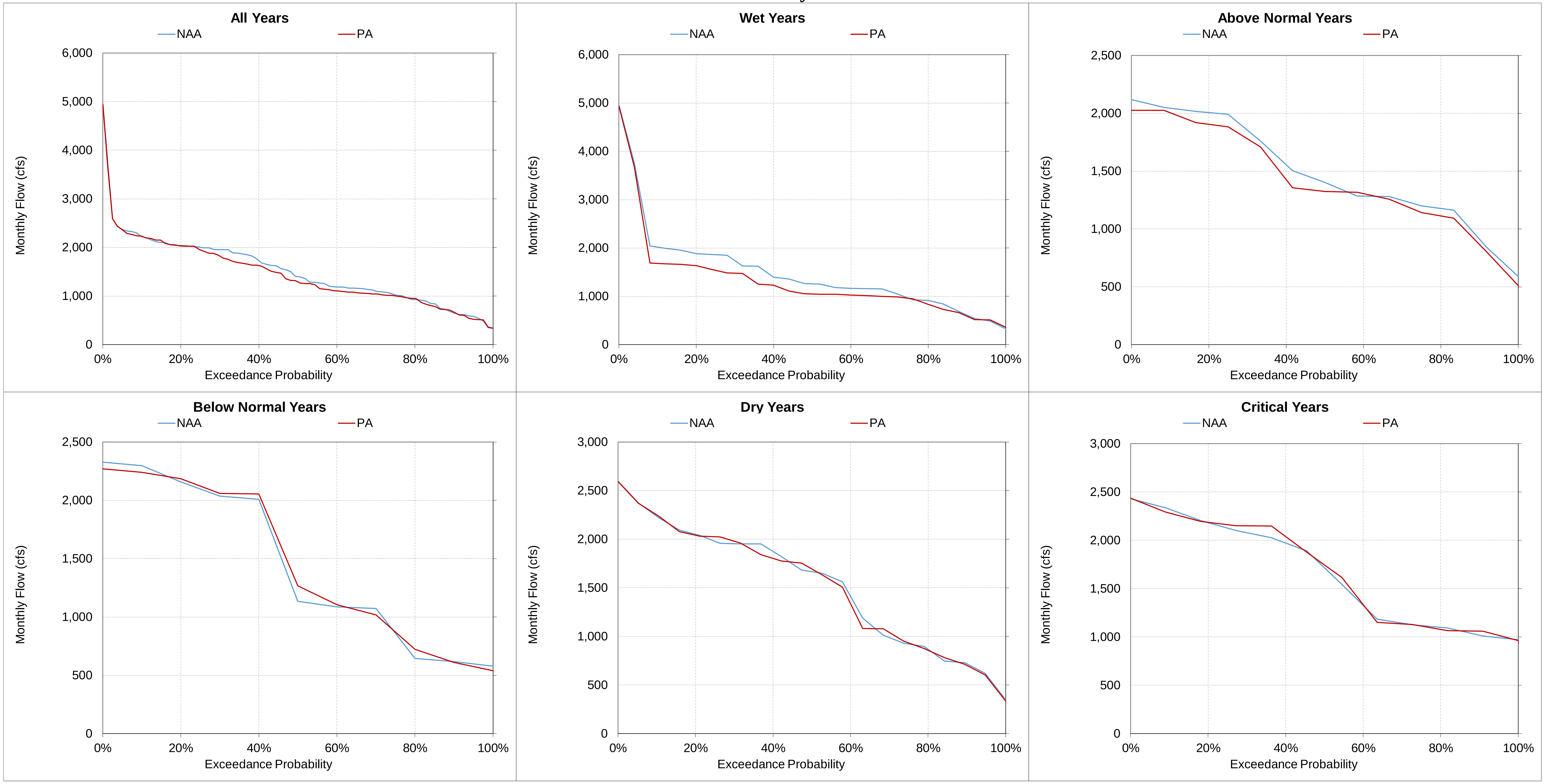
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-29-10. Montezuma Slough upstream of Salinity Control Gate, Monthly Flow December



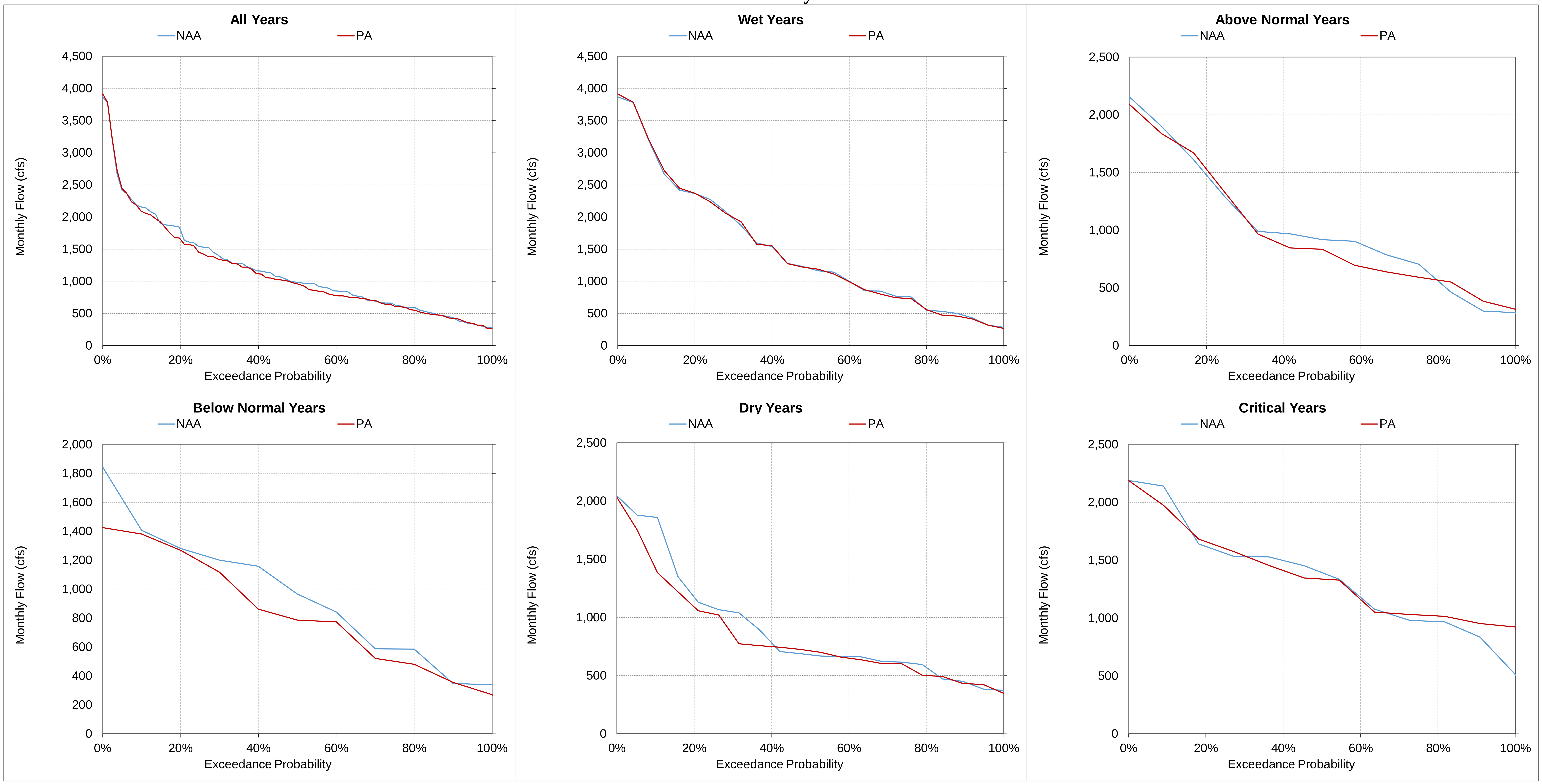
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-29-11. Montezuma Slough upstream of Salinity Control Gate, Monthly Flow
January



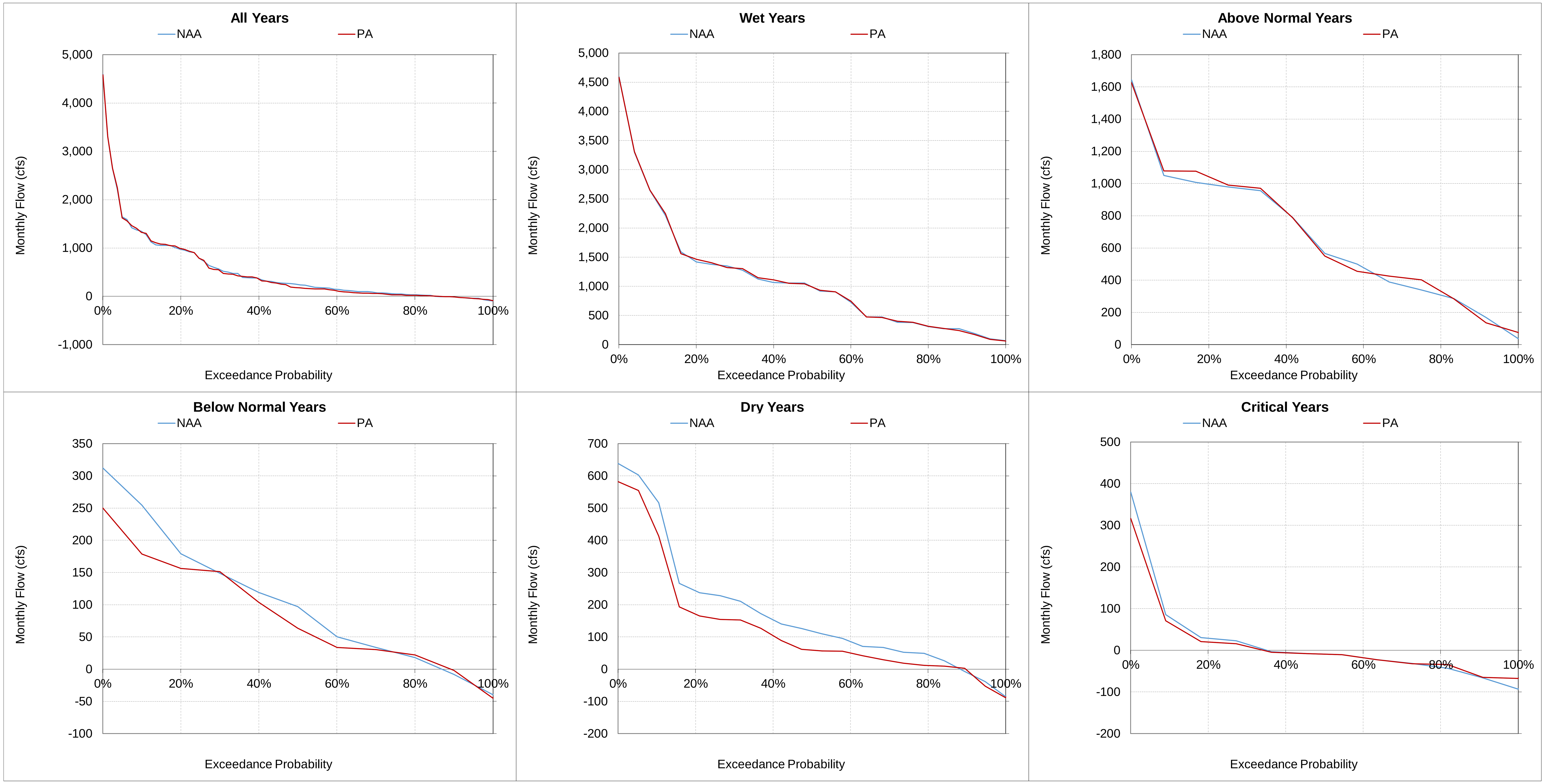
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-29-12. Montezuma Slough upstream of Salinity Control Gate, Monthly Flow February



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-29-13. Montezuma Slough upstream of Salinity Control Gate, Monthly Flow March



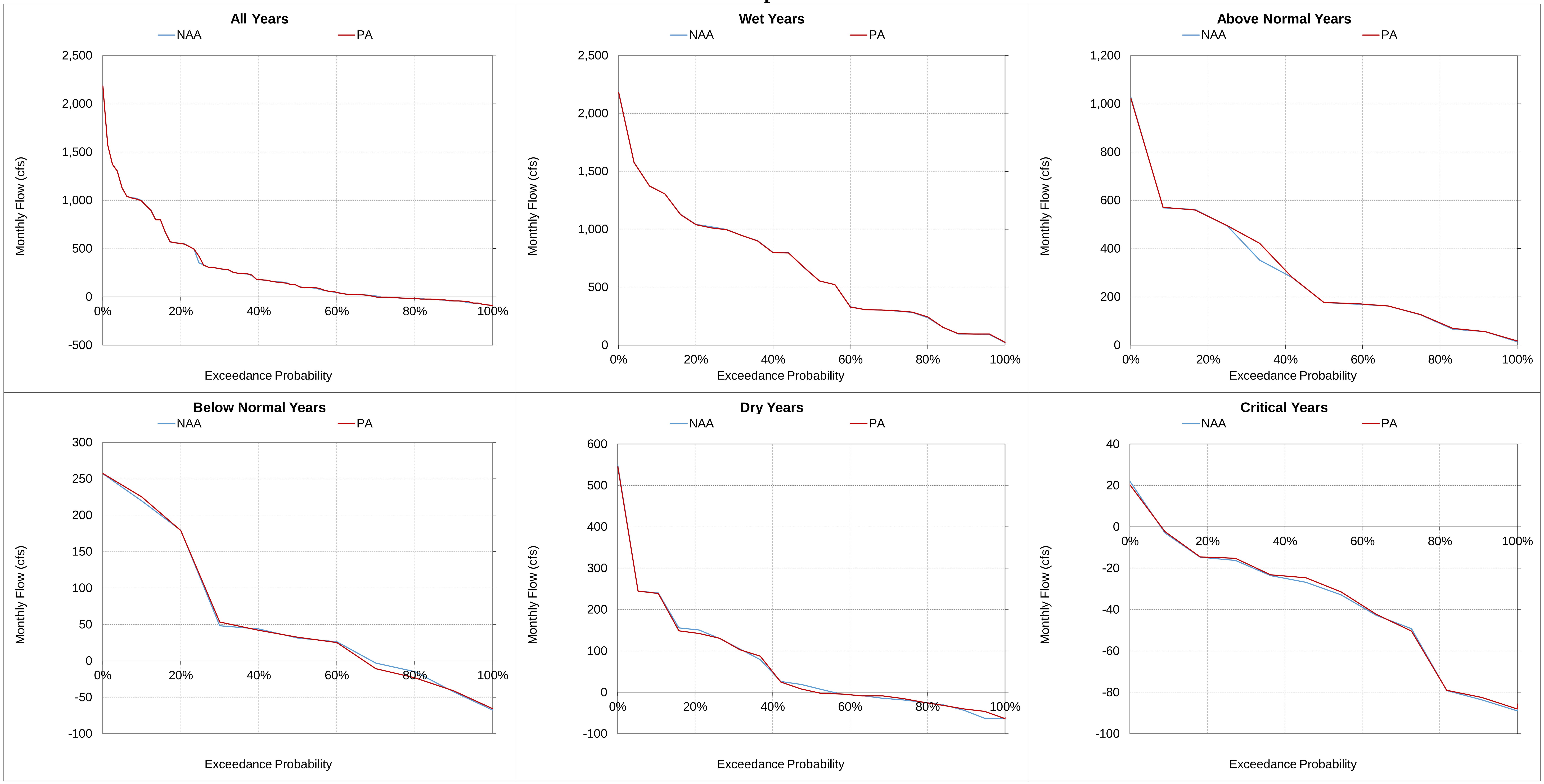
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

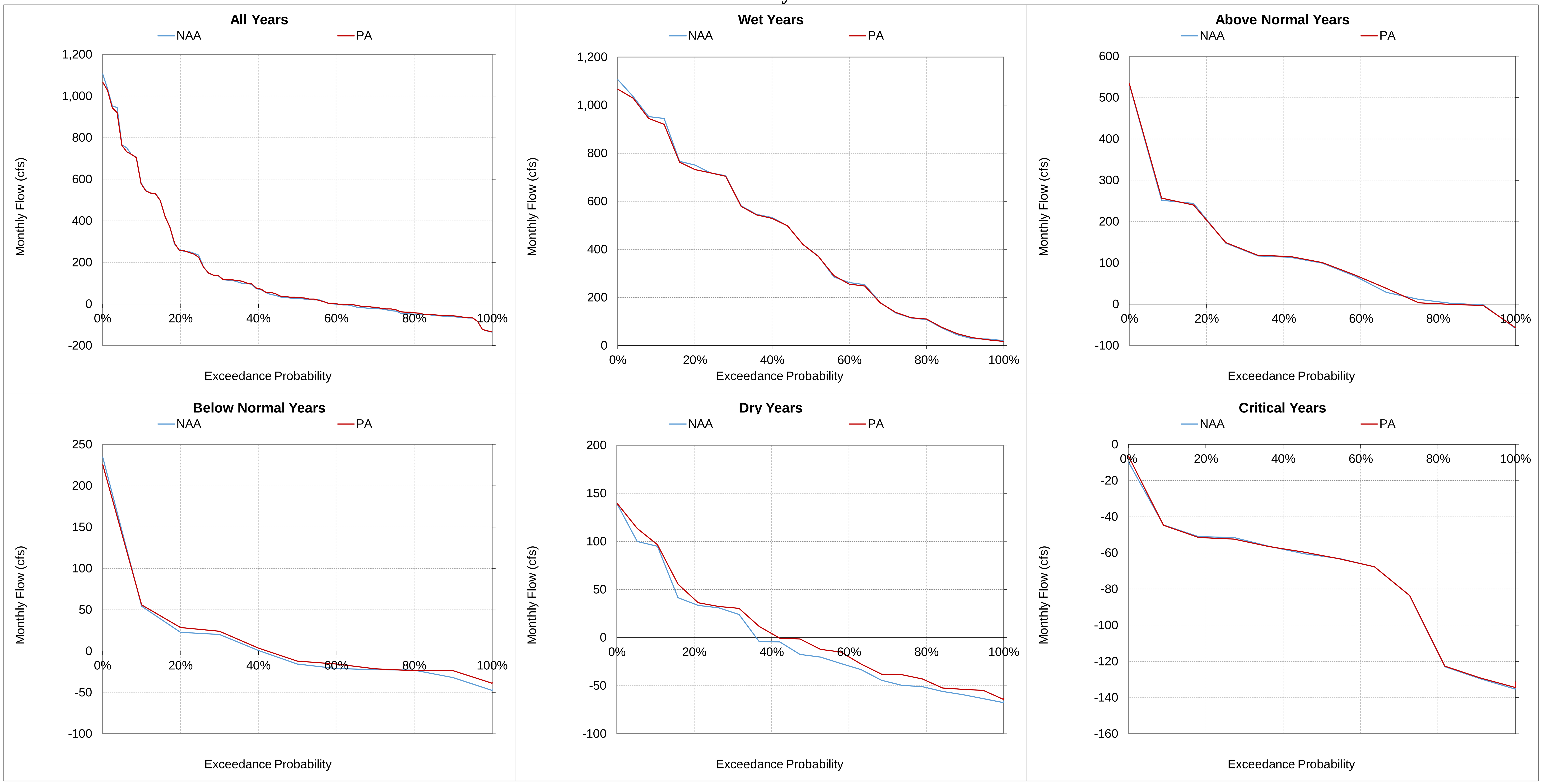
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-29-14. Montezuma Slough upstream of Salinity Control Gate, Monthly Flow April



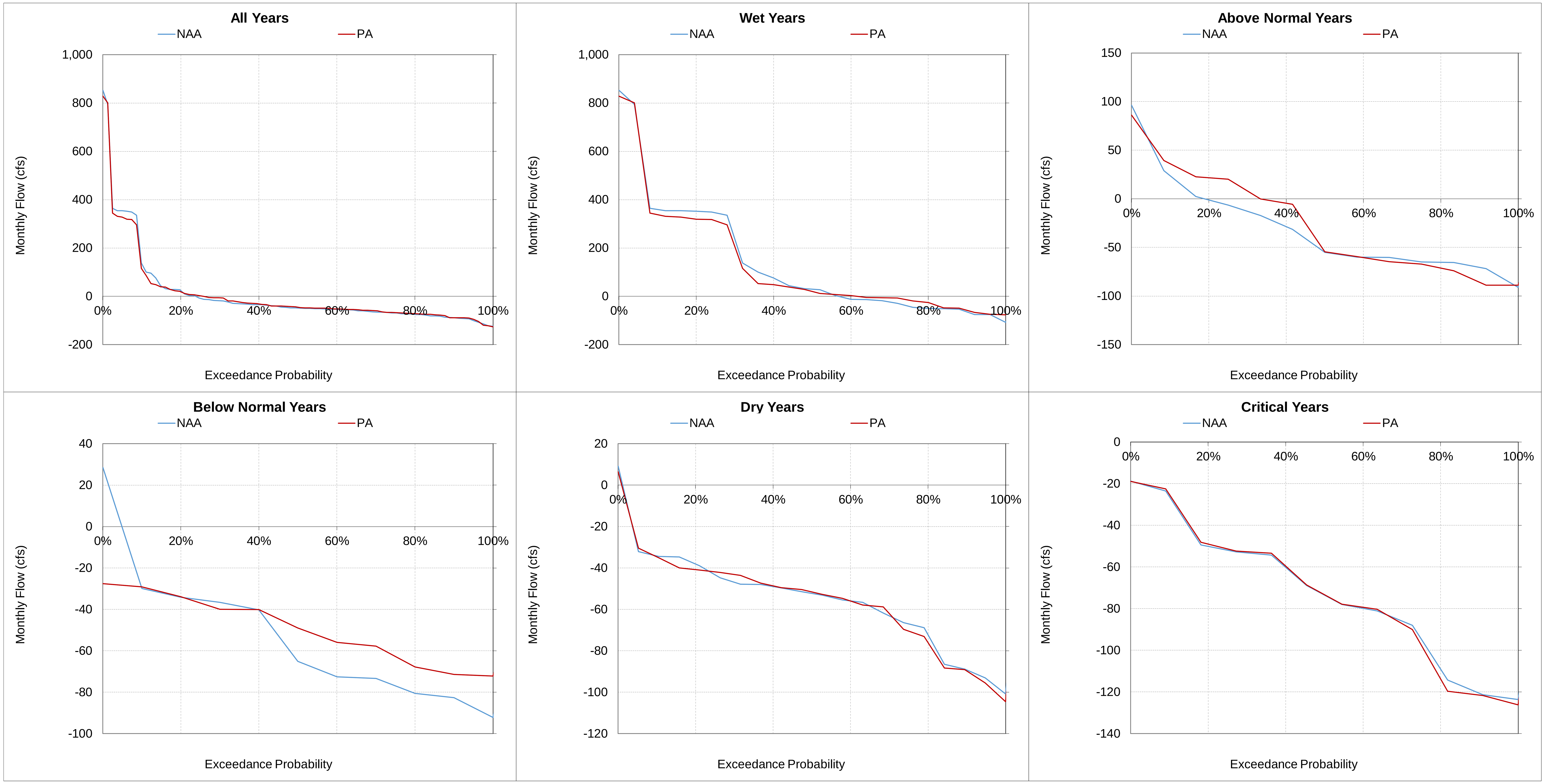
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-29-15. Montezuma Slough upstream of Salinity Control Gate, Monthly Flow
May



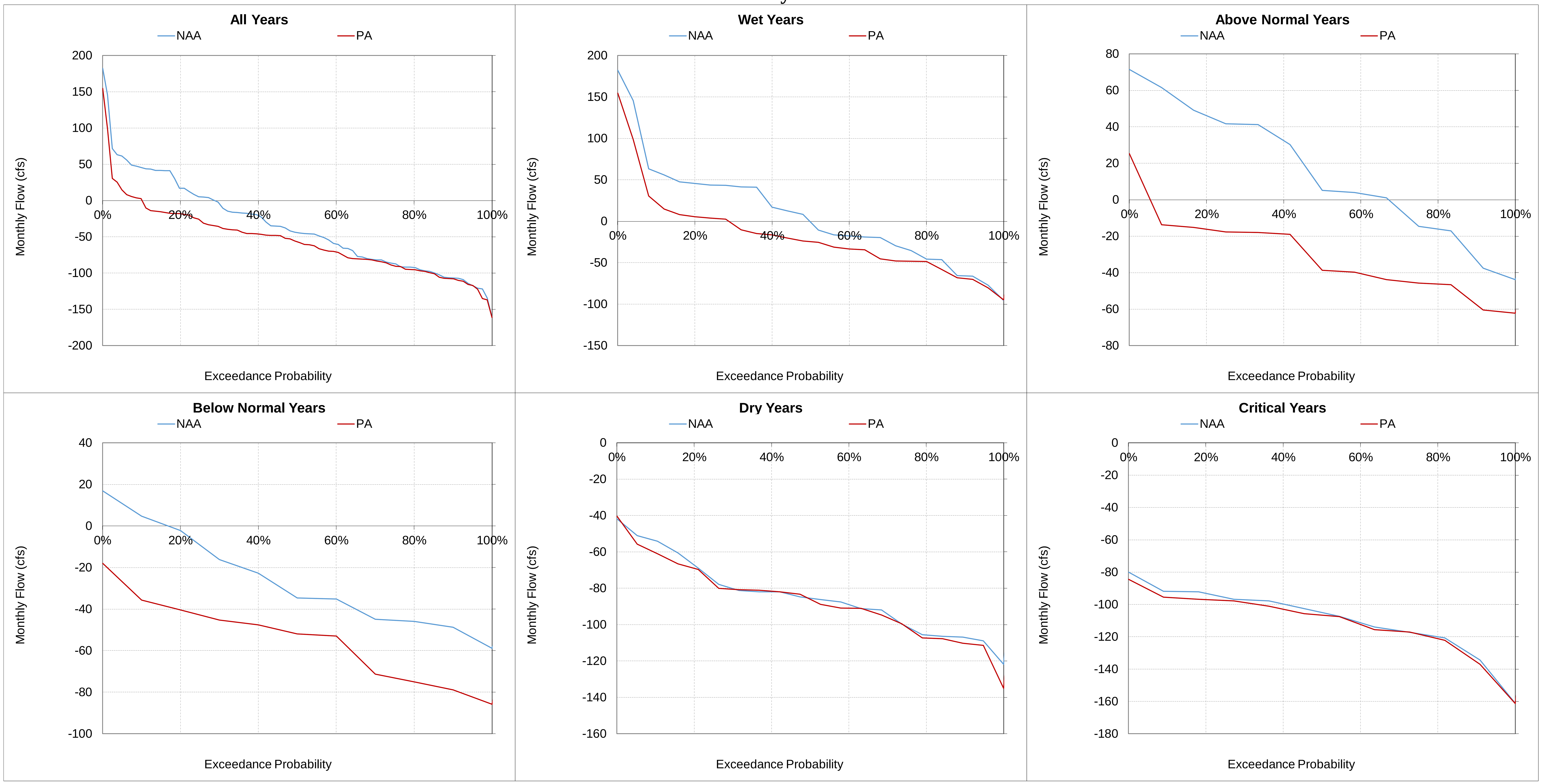
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-29-16. Montezuma Slough upstream of Salinity Control Gate, Monthly Flow
June



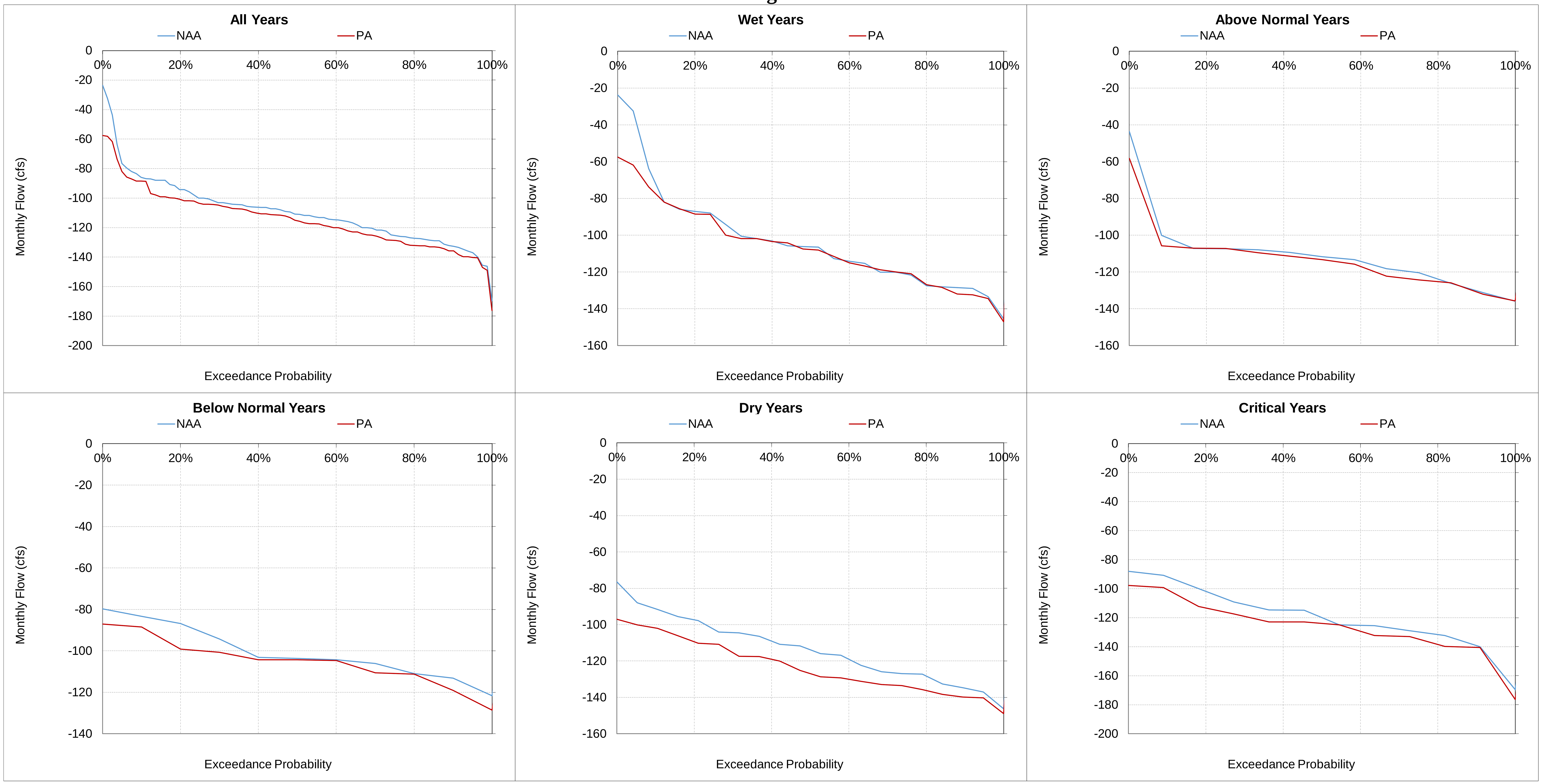
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-29-17. Montezuma Slough upstream of Salinity Control Gate, Monthly Flow July



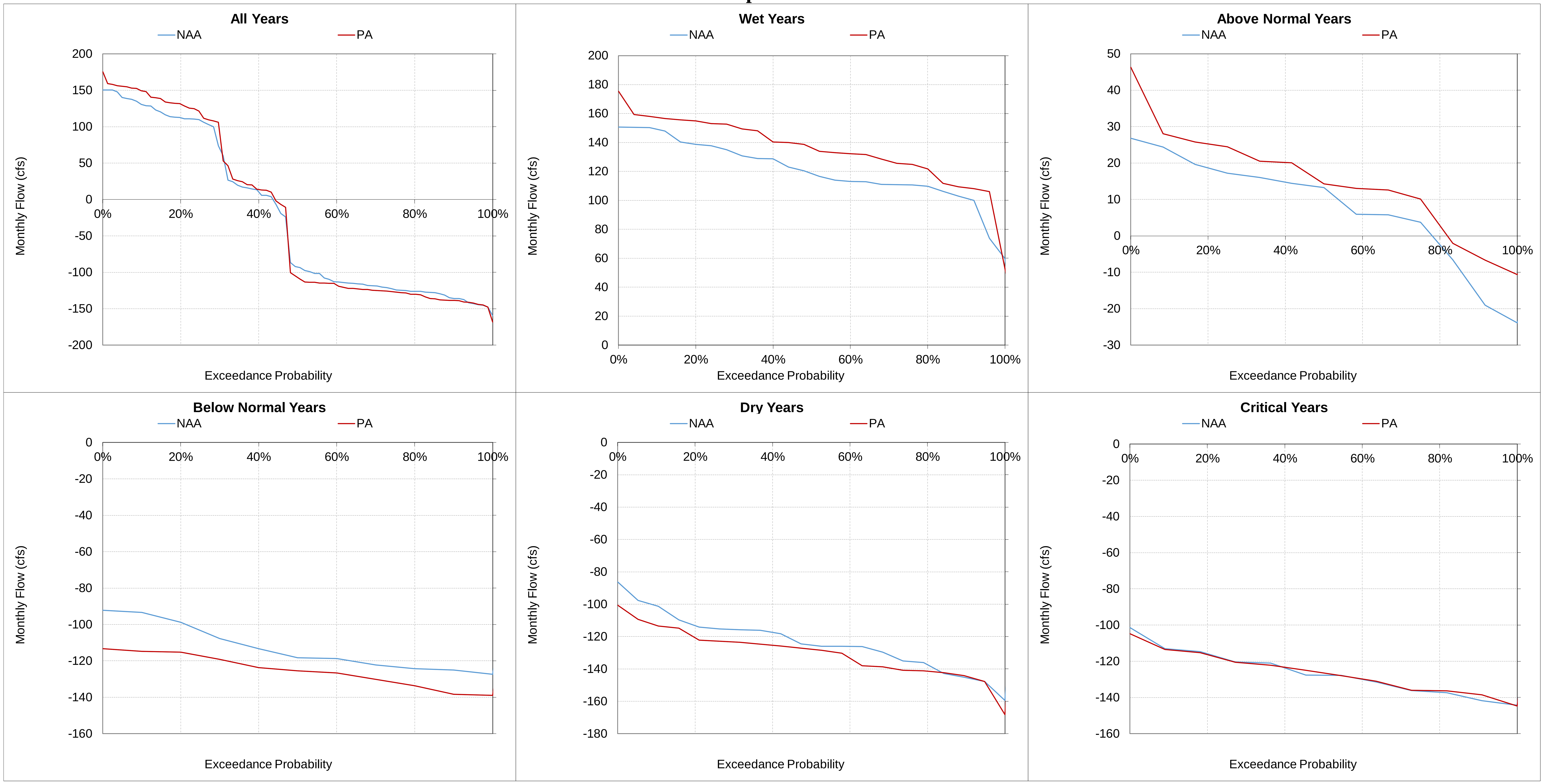
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-29-18. Montezuma Slough upstream of Salinity Control Gate, Monthly Flow August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-29-19. Montezuma Slough upstream of Salinity Control Gate, Monthly Flow September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-30. Roaring Slough upstream of Roaring River Distribution System, Monthly Flow

Statistic	Monthly Flow (cfs)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-
20%	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-
30%	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-
40%	0	0	0	-	0	0	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	0	0	-	0	0	0	-
60%	0	0	0	-	0	0	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	0	0	-	0	0	0	-
80%	0	0	0	-	0	0	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	0	0	-	0	0	0	-
Long Term Full Simulation Period[b]	0	0	0	-20%	0	0	0	-50%	0	0	0	-23%	0	0	0	20%	0	0	0	17%	0	0	0	-
Water Year Types[c]																								
Wet (32%)	0	0	0	-	0	0	0	0%	0	0	0	-33%	0	0	0	17%	0	0	0	-	0	0	0	-
Above Normal (16%)	0	0	0	-20%	0	0	0	-50%	0	0	0	-20%	0	0	0	-	0	0	0	0%	0	0	0	-
Below Normal (13%)	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	100%	0	0	0	-
Dry (24%)	0	0	0	-	0	0	0	-100%	0	0	0	-	0	0	0	0%	0	0	0	-	0	0	0	-
Critical (15%)	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	33%	0	0	0	-	0	0	0	-

Statistic	Monthly Flow (cfs)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-
20%	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-
30%	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-
40%	0	0	0	-	0	0	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	0	0	-	0	0	0	-
60%	0	0	0	-	0	0	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	0	0	-	0	0	0	-
80%	0	0	0	-	0	0	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	0	0	-	0	0	0	-
Long Term Full Simulation Period[b]	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-
Water Year Types[c]																								
Wet (32%)	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-
Above Normal (16%)	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-
Below Normal (13%)	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-
Dry (24%)	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-
Critical (15%)	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-30-1. Monthly Flow Ranges For Roaring Slough upstream of Roaring River Distribution System, All Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario.

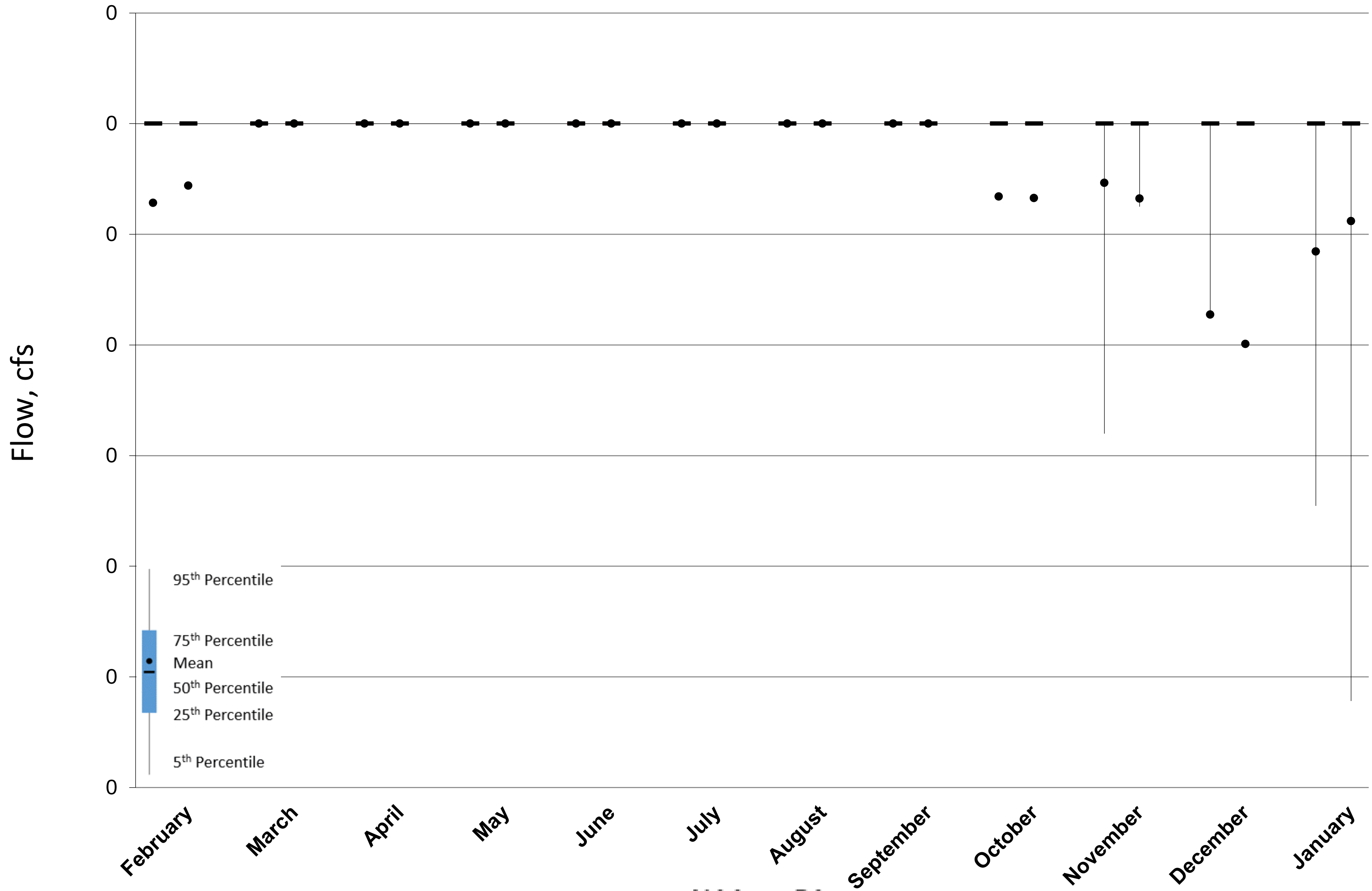


Figure 5.B.5-30-2. Monthly Flow Ranges For Roaring Slough upstream of Roaring River Distribution System, Wet Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 26 wet years.

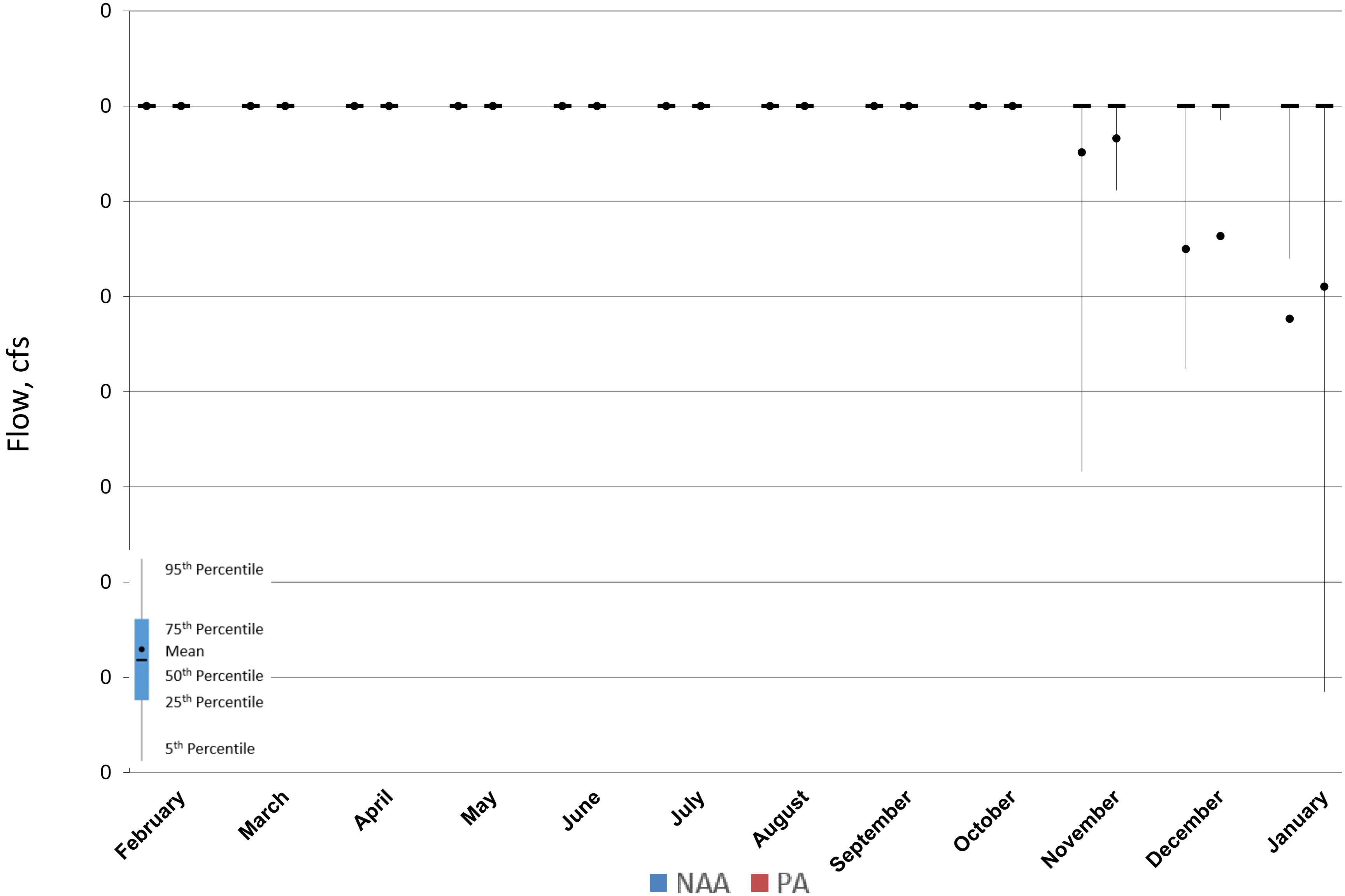


Figure 5.B.5-30-3. Monthly Flow Ranges For Roaring Slough upstream of Roaring River Distribution System, Above Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 13 above normal years.

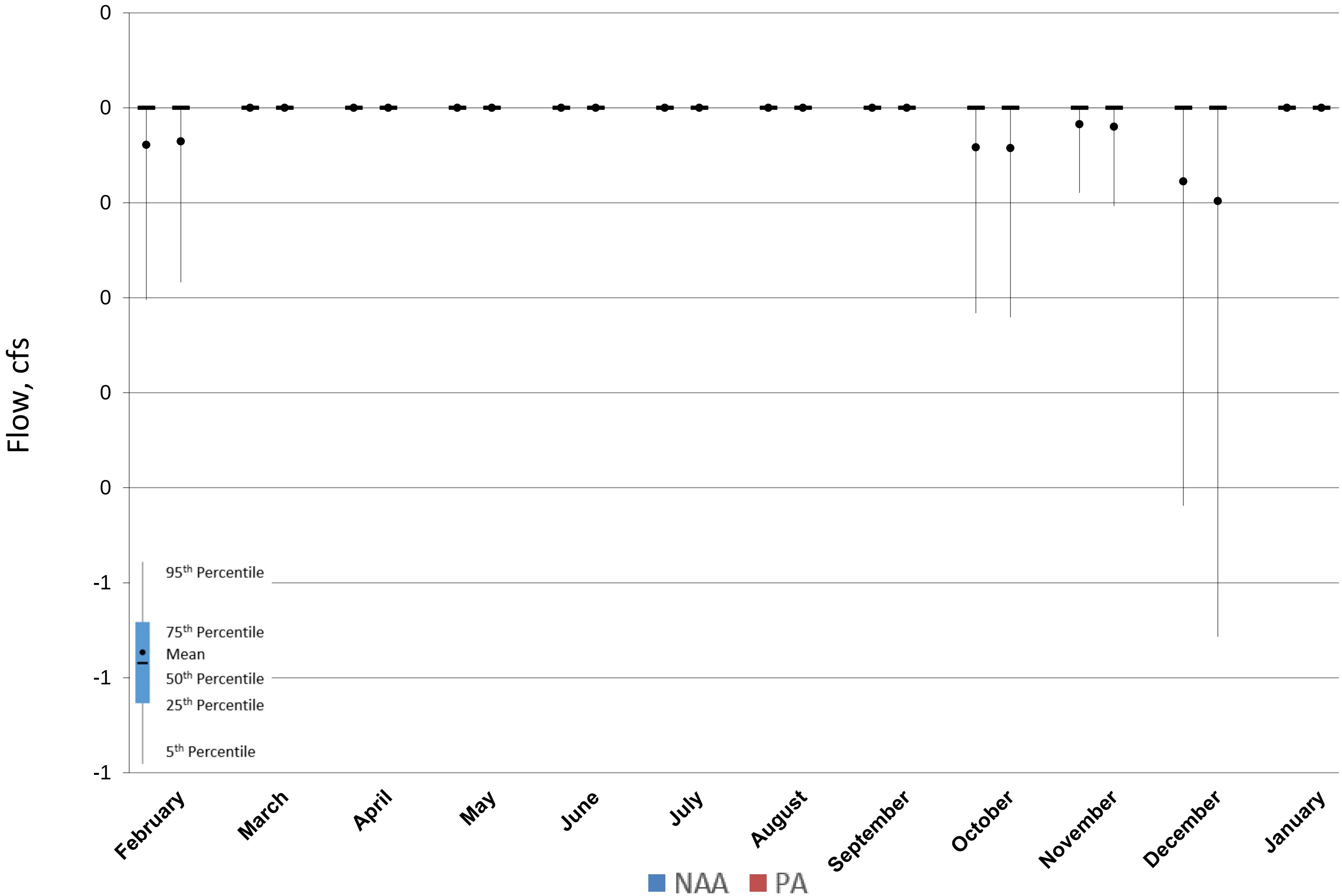


Figure 5.B.5-30-4. Monthly Flow Ranges For Roaring Slough upstream of Roaring River Distribution System, Below Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 11 below normal years.

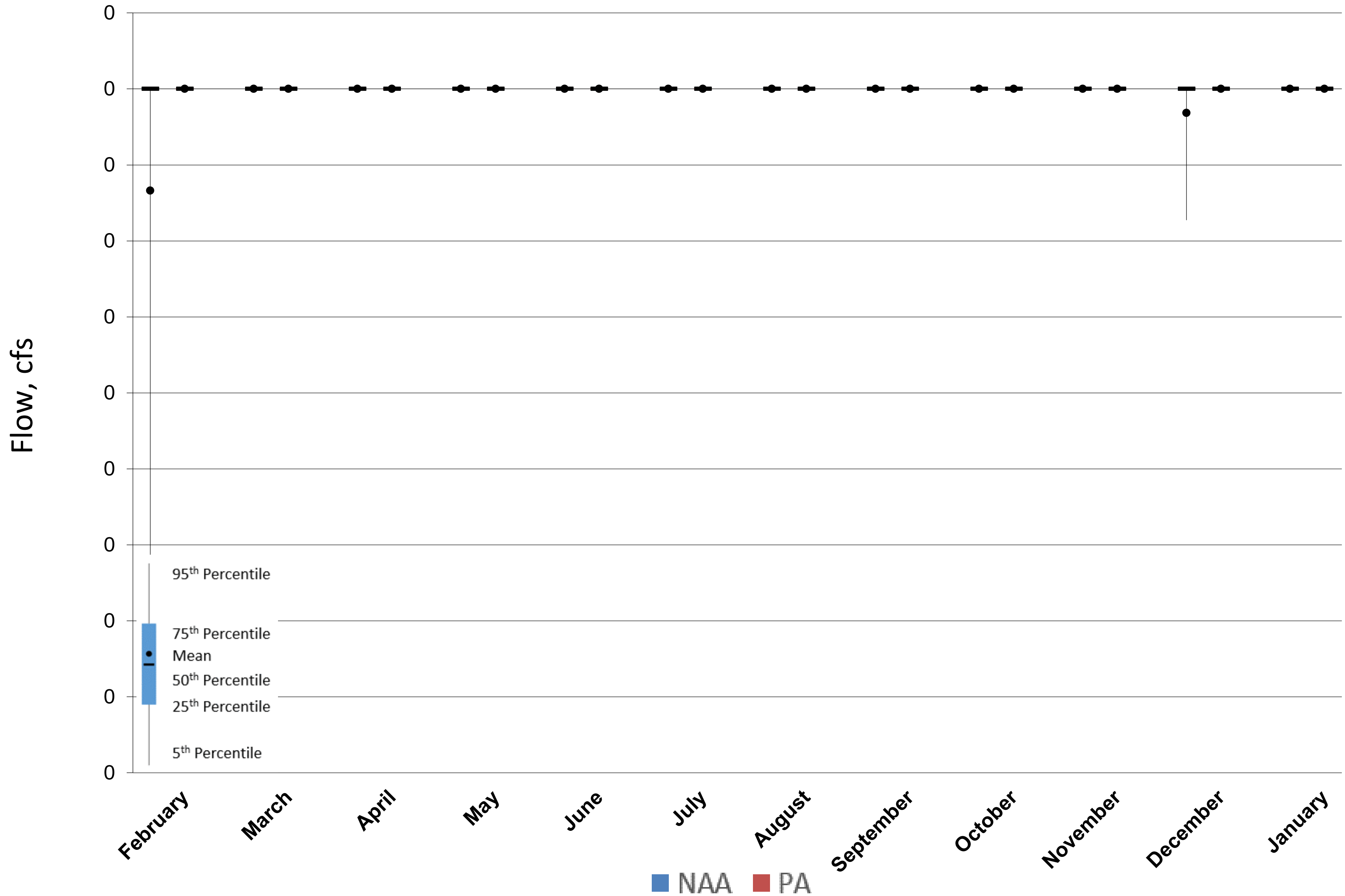


Figure 5.B.5-30-5. Monthly Flow Ranges For Roaring Slough upstream of Roaring River Distribution System, Dry Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 20 dry years.

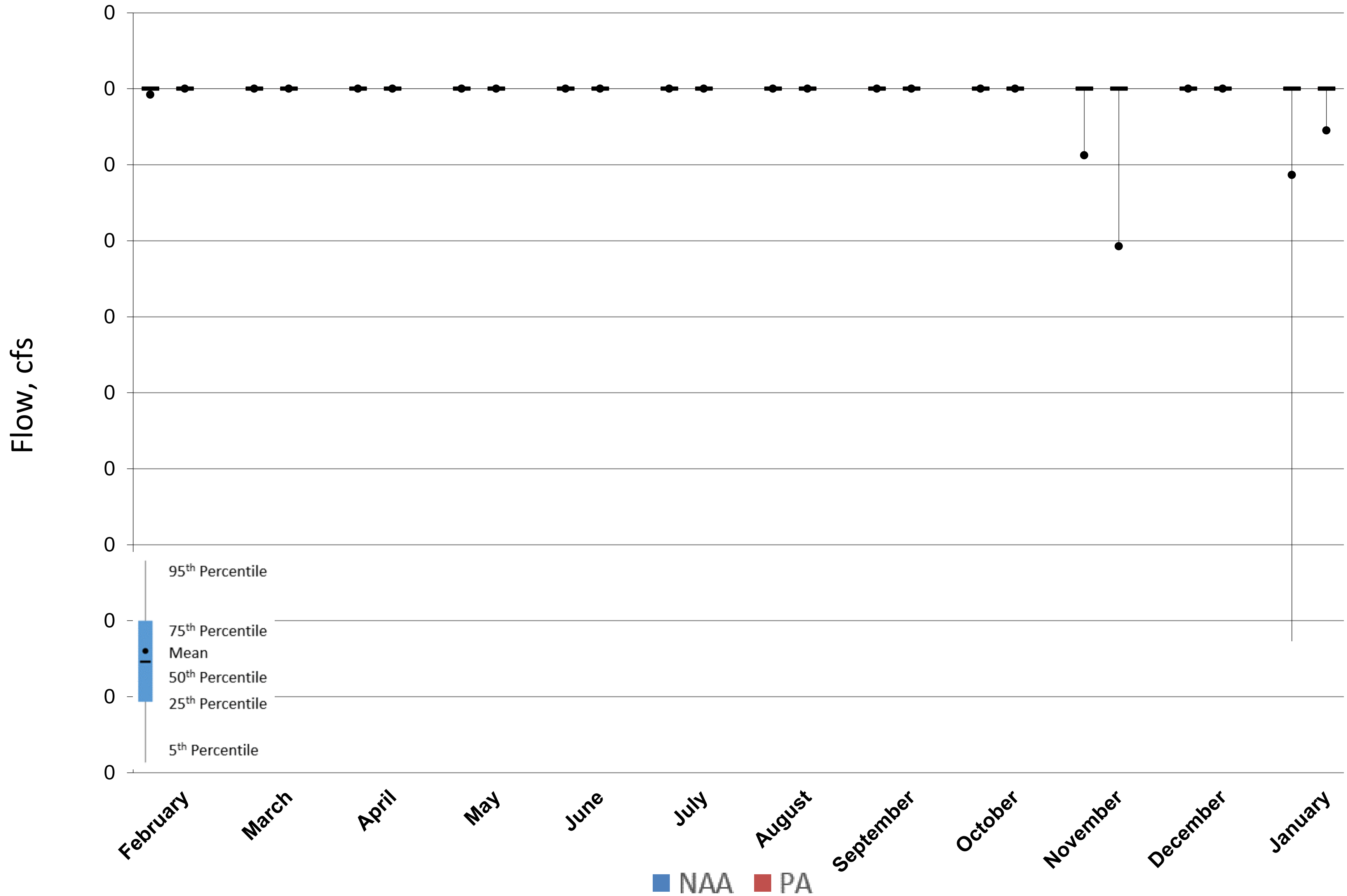


Figure 5.B.5-30-6. Monthly Flow Ranges For Roaring Slough upstream of Roaring River Distribution System, Critical Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 12 critical years.

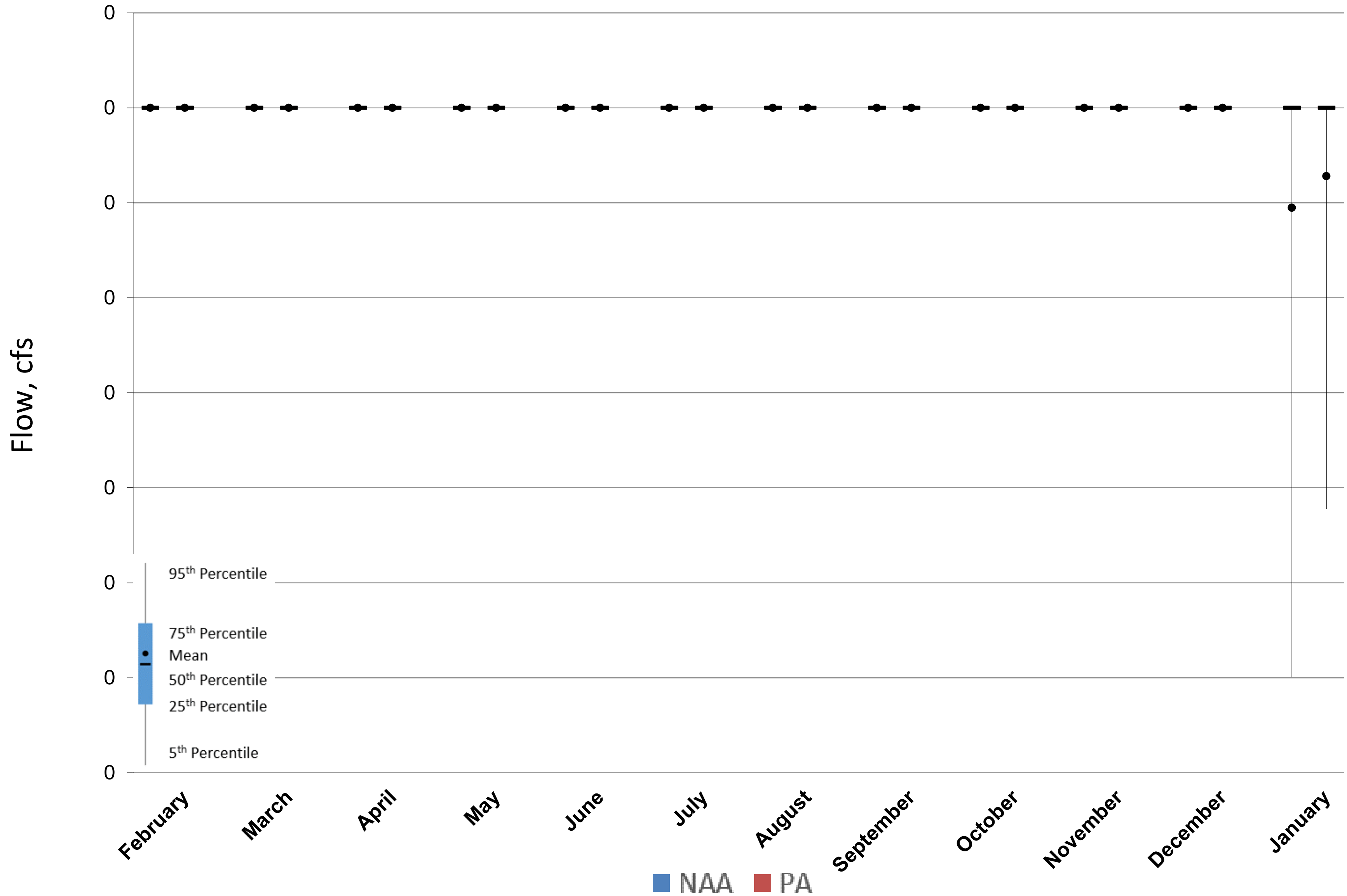
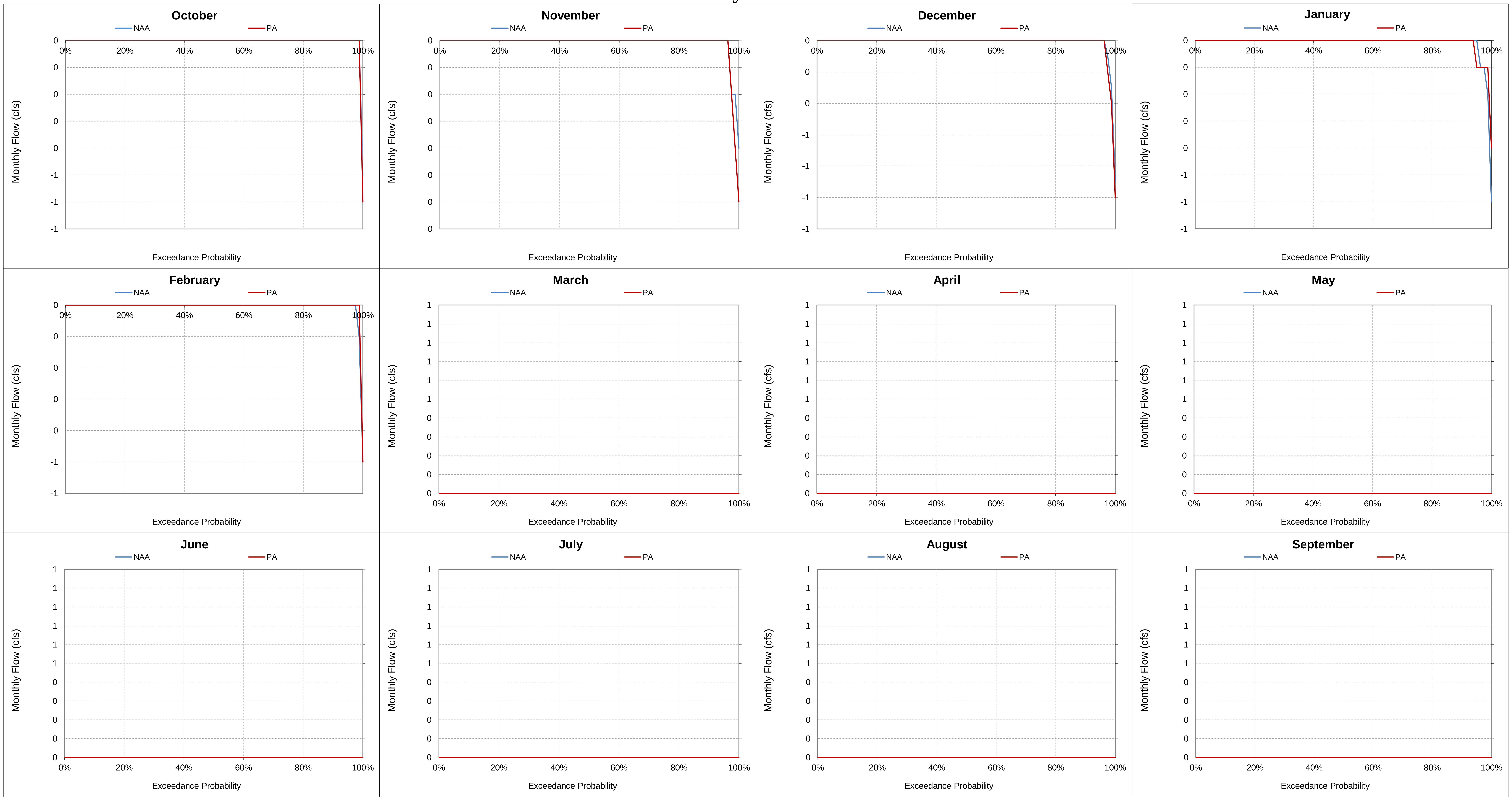
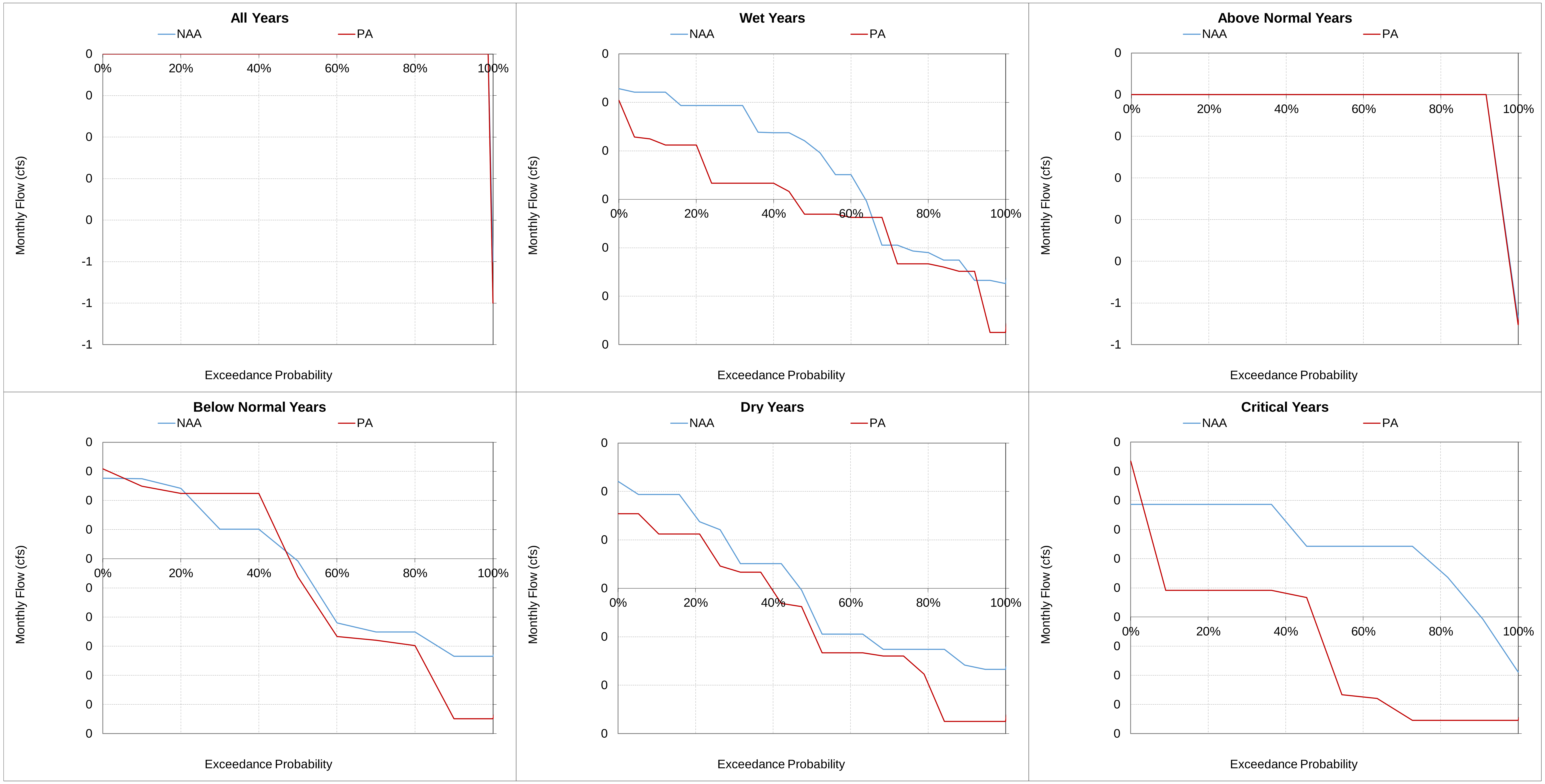


Figure 5.B.5-30-7. Roaring Slough upstream of Roaring River Distribution System, Monthly Flow Probability of Exceedance



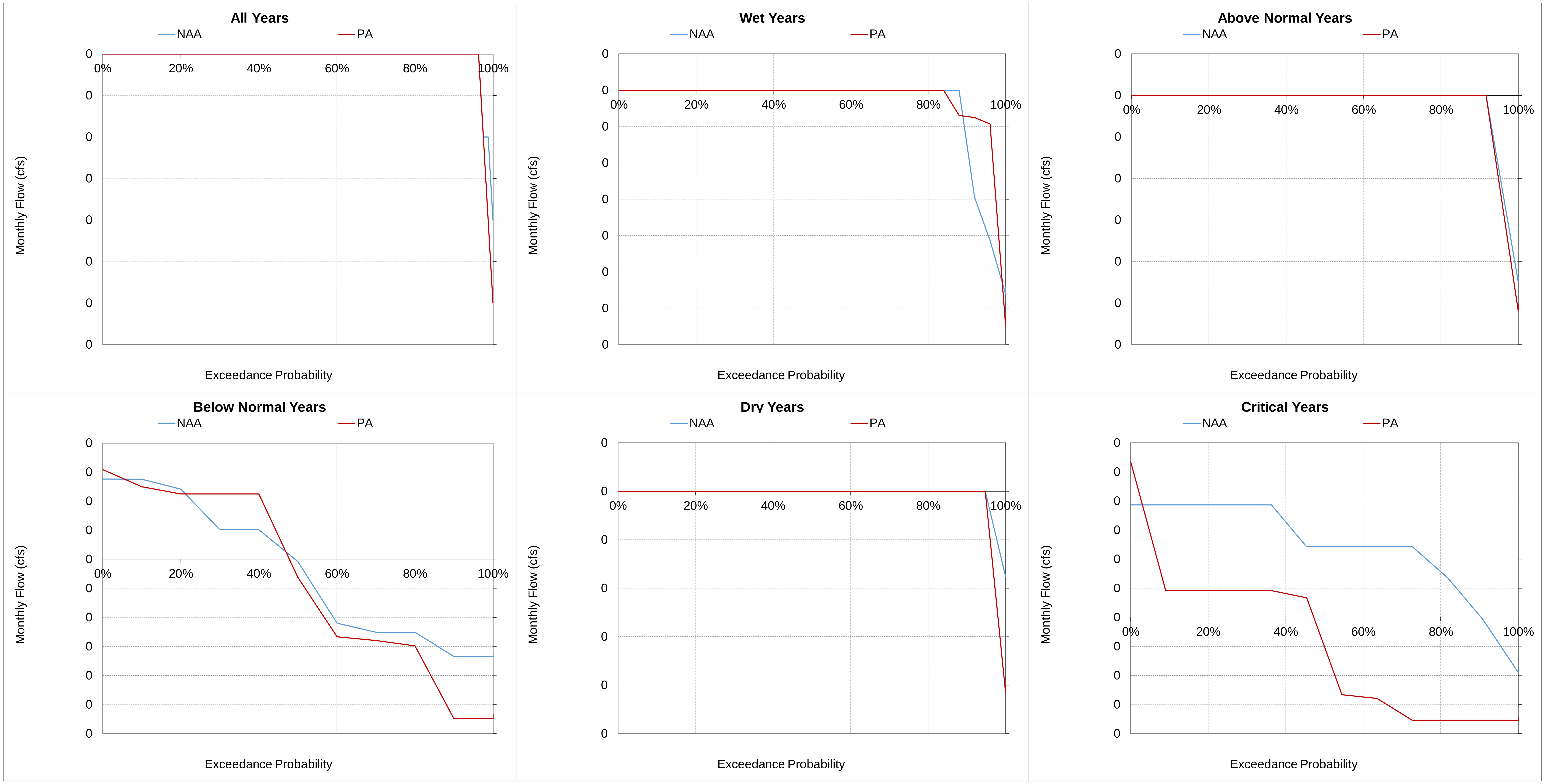
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-30-8. Roaring Slough upstream of Roaring River Distribution System, Monthly Flow October



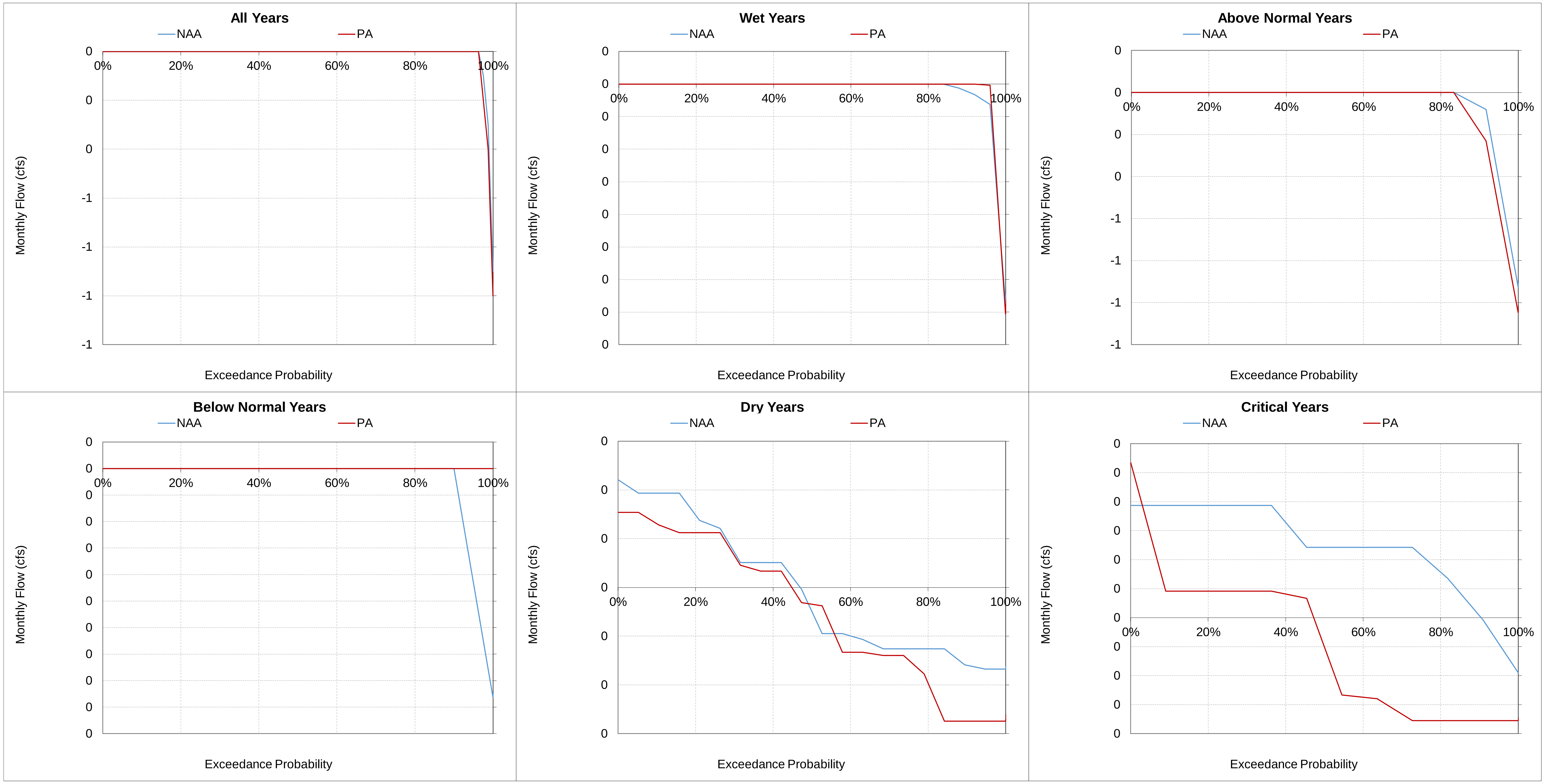
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-30-9. Roaring Slough upstream of Roaring River Distribution System, Monthly Flow
November



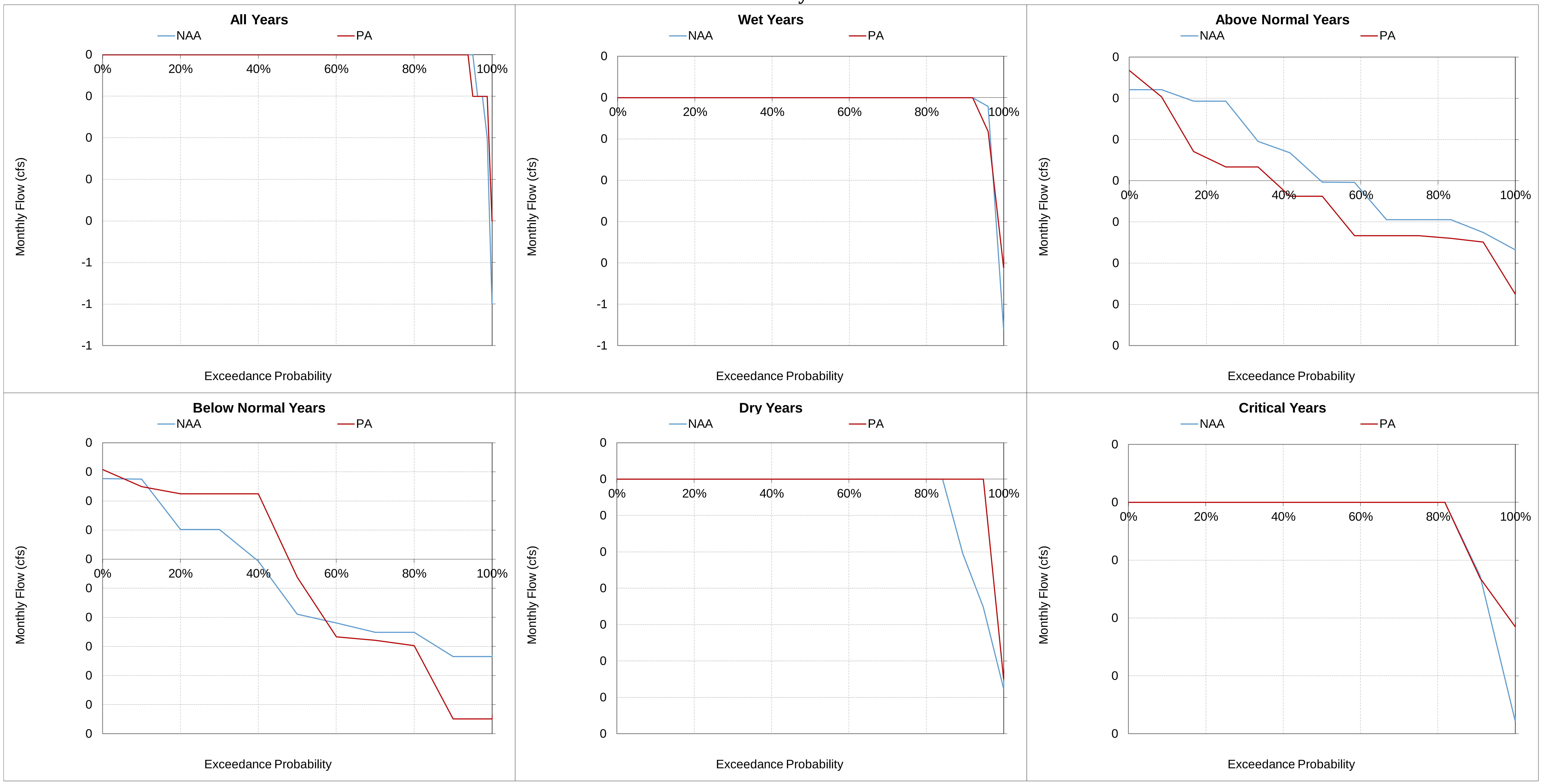
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-30-10. Roaring Slough upstream of Roaring River Distribution System, Monthly Flow December



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-30-11. Roaring Slough upstream of Roaring River Distribution System, Monthly Flow January



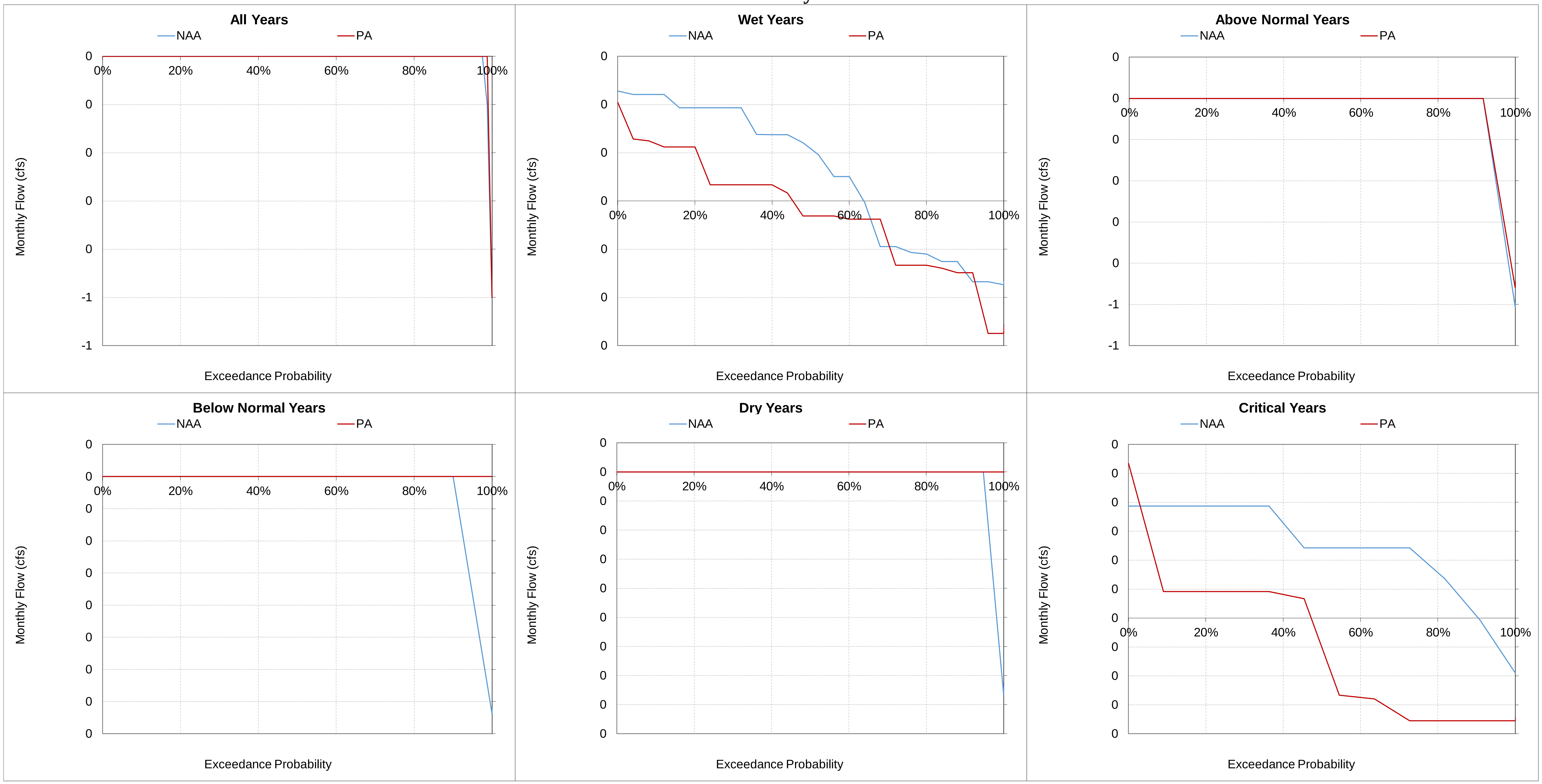
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

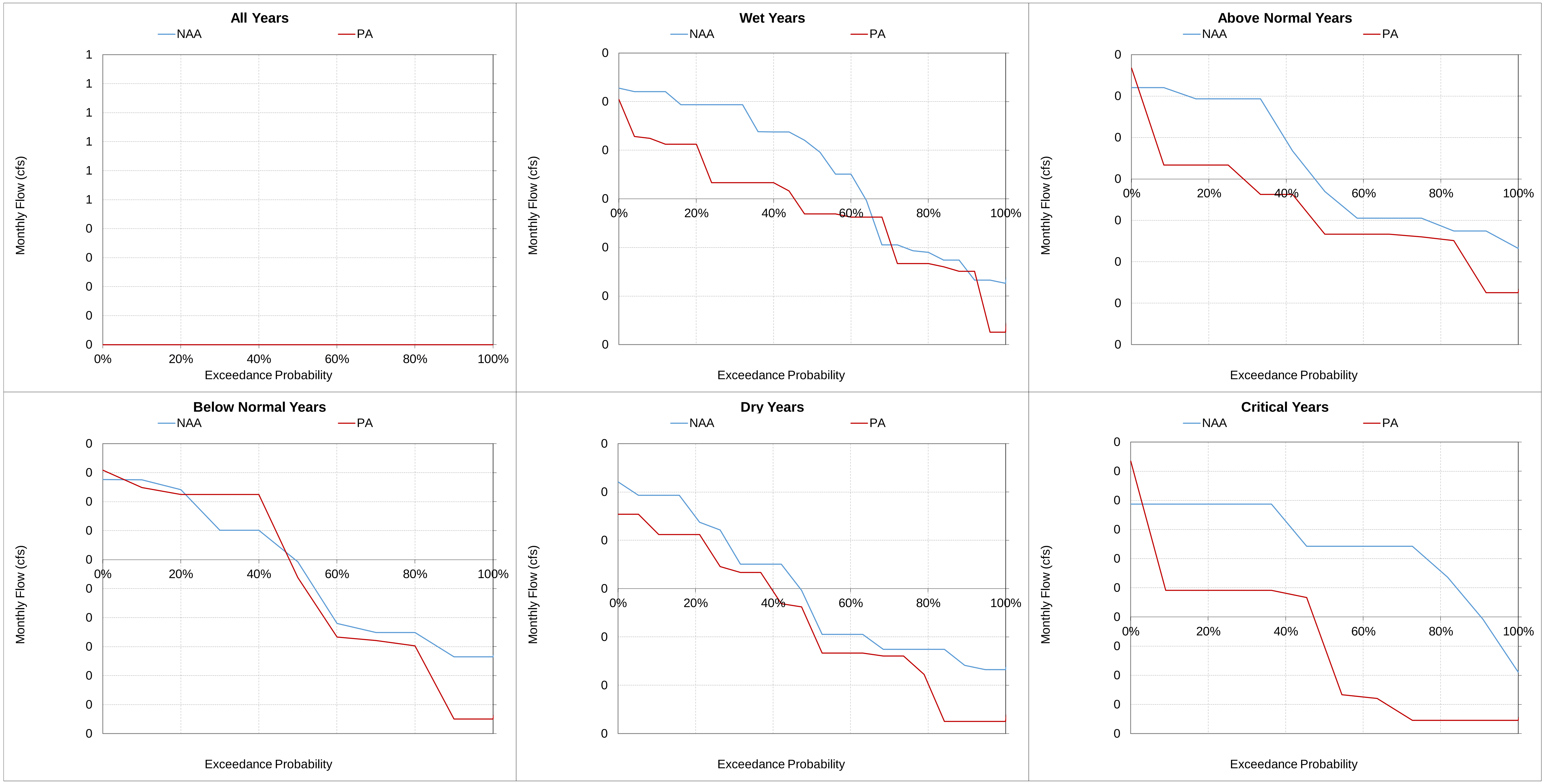
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-30-12. Roaring Slough upstream of Roaring River Distribution System, Monthly Flow February



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-30-13. Roaring Slough upstream of Roaring River Distribution System, Monthly Flow March



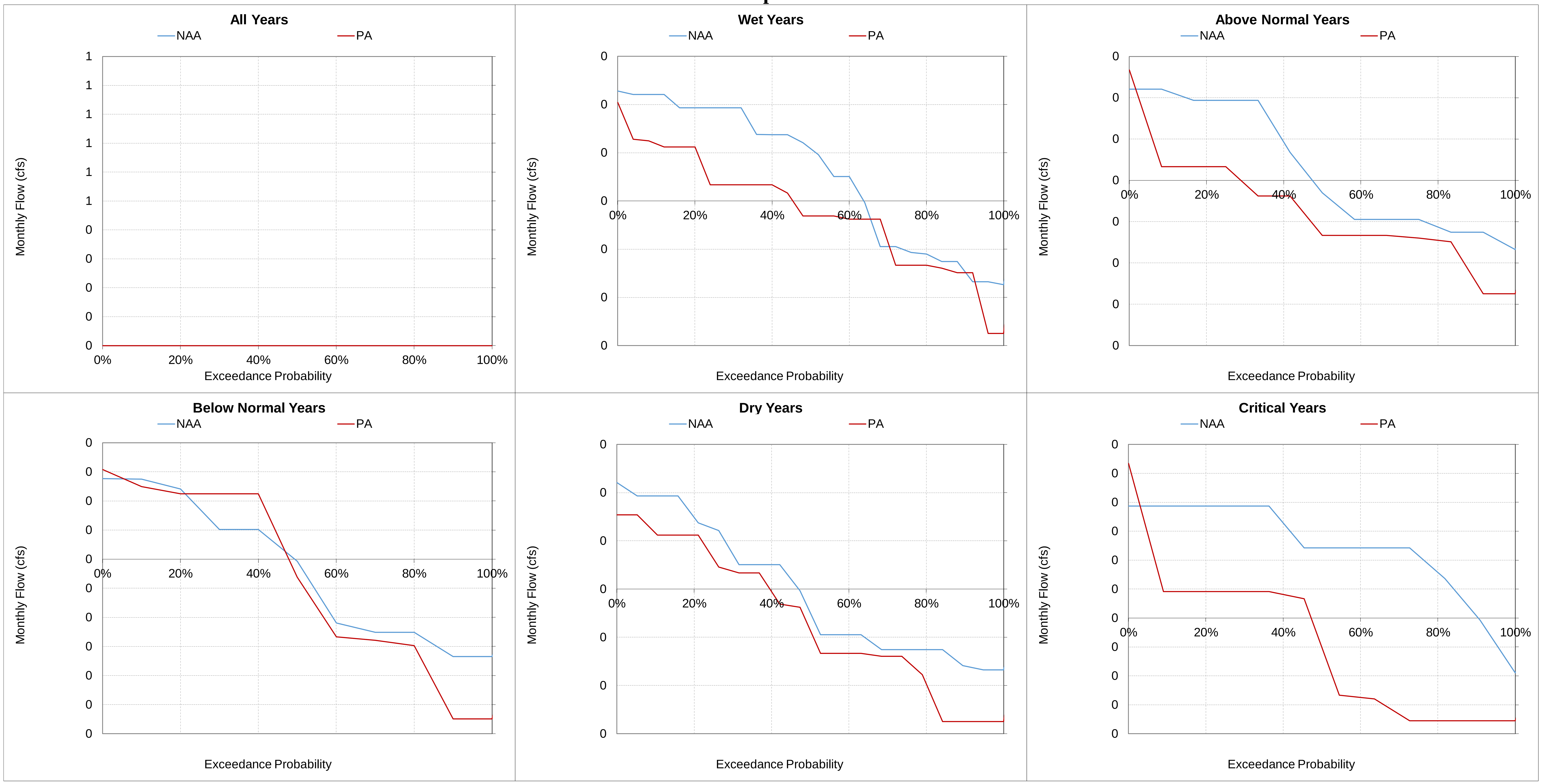
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

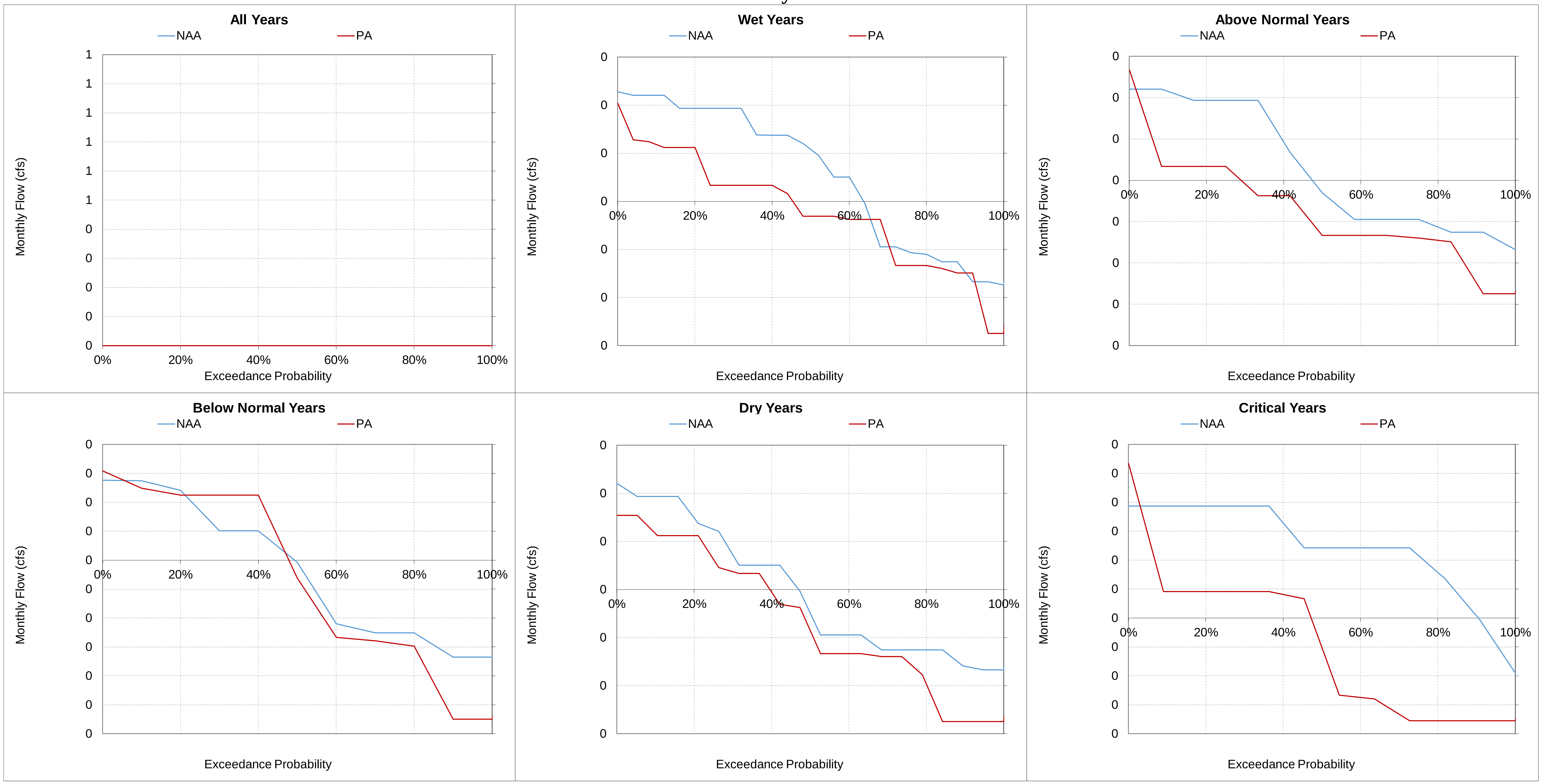
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-30-14. Roaring Slough upstream of Roaring River Distribution System, Monthly Flow April



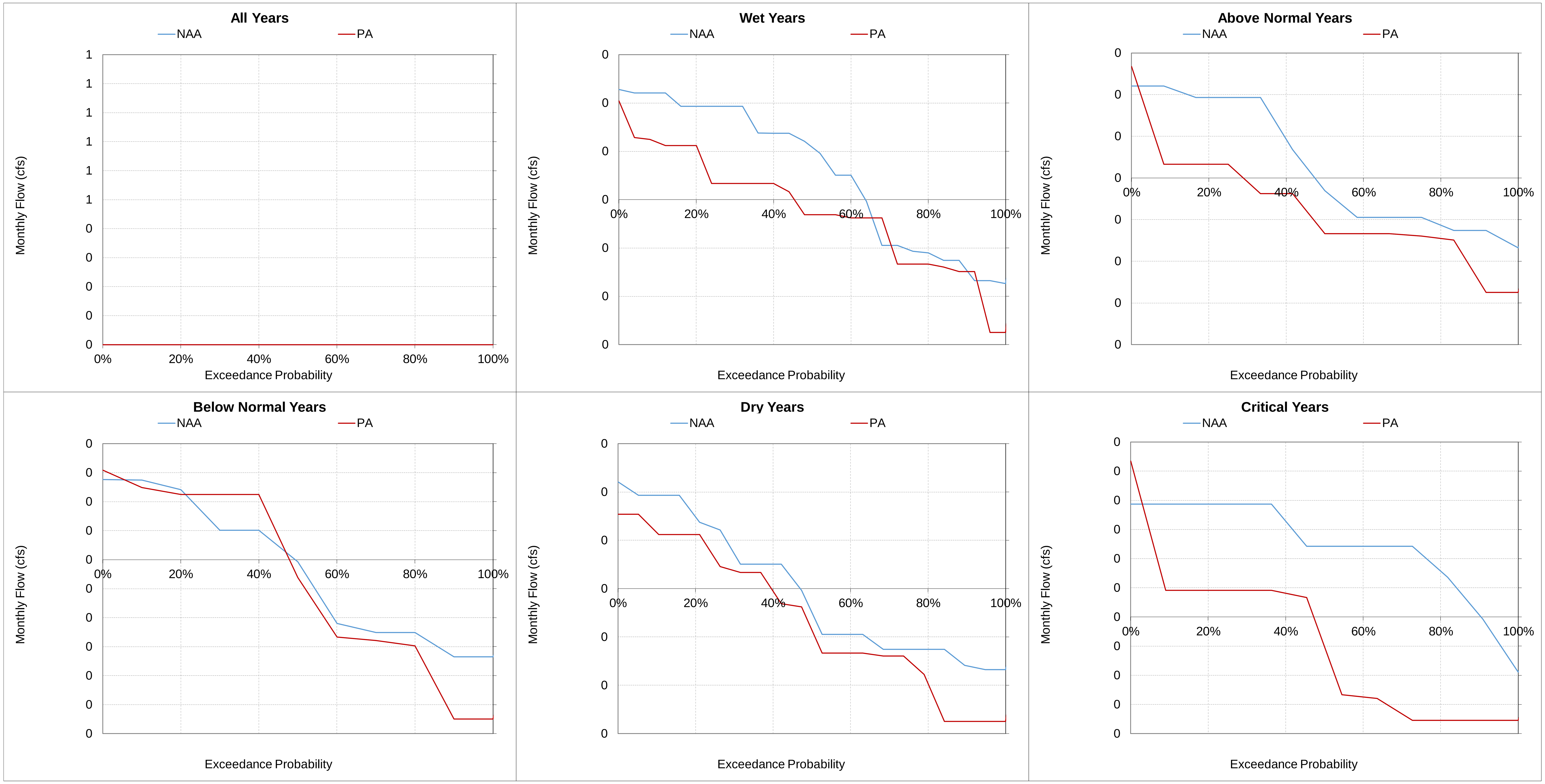
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-30-15. Roaring Slough upstream of Roaring River Distribution System, Monthly Flow May



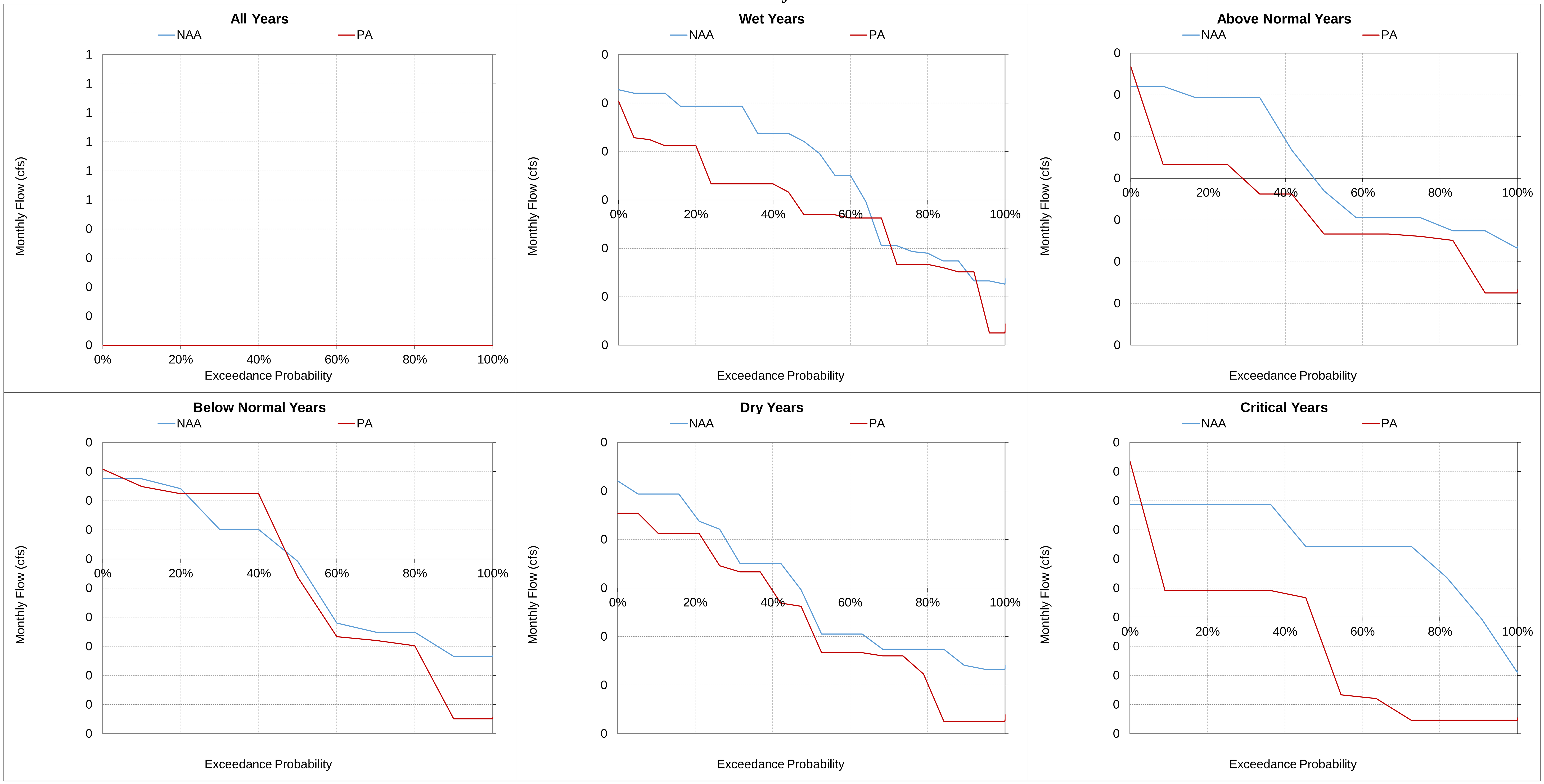
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-30-16. Roaring Slough upstream of Roaring River Distribution System, Monthly Flow
June



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-30-17. Roaring Slough upstream of Roaring River Distribution System, Monthly Flow July



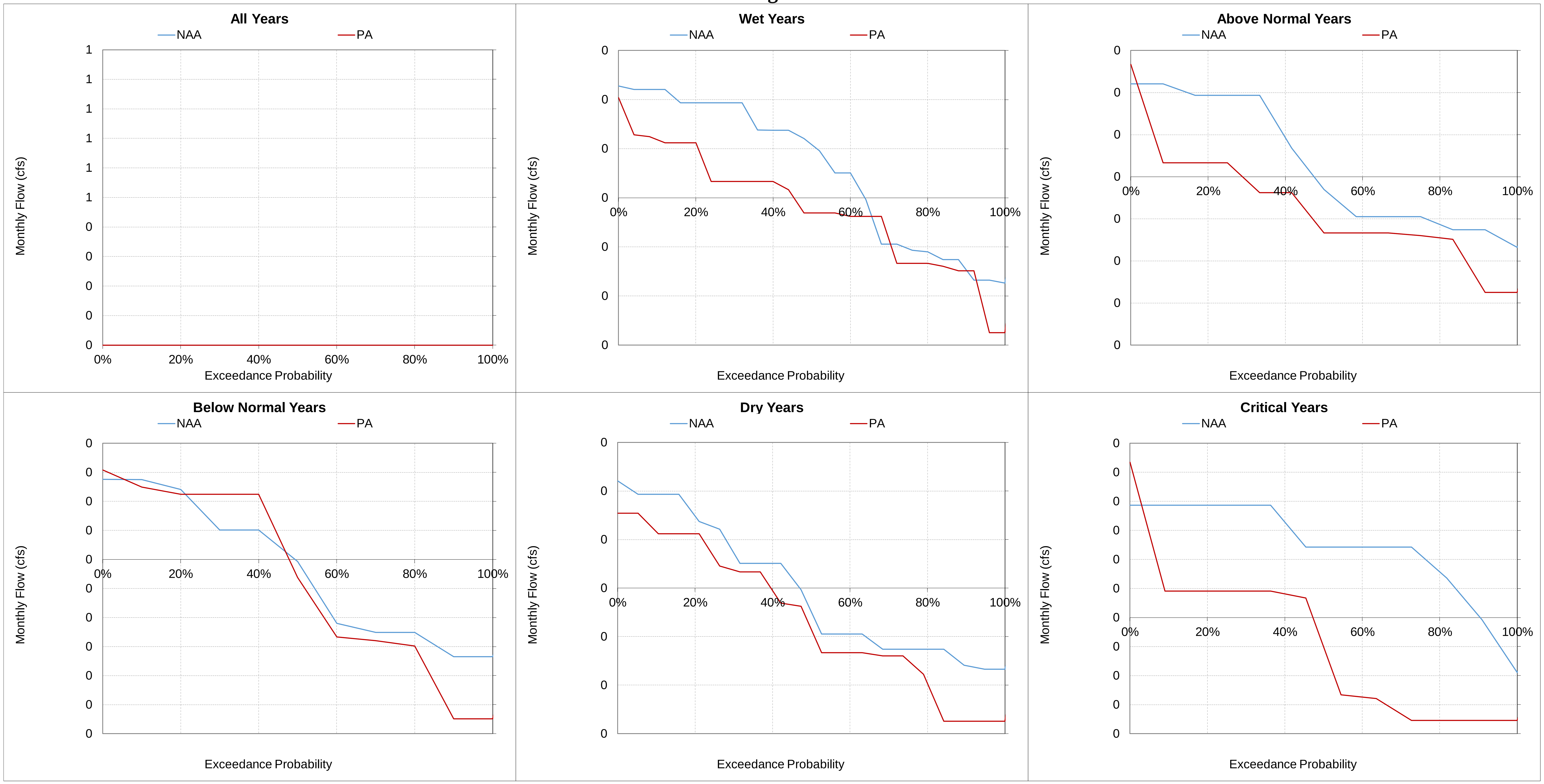
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-30-18. Roaring Slough upstream of Roaring River Distribution System, Monthly Flow August



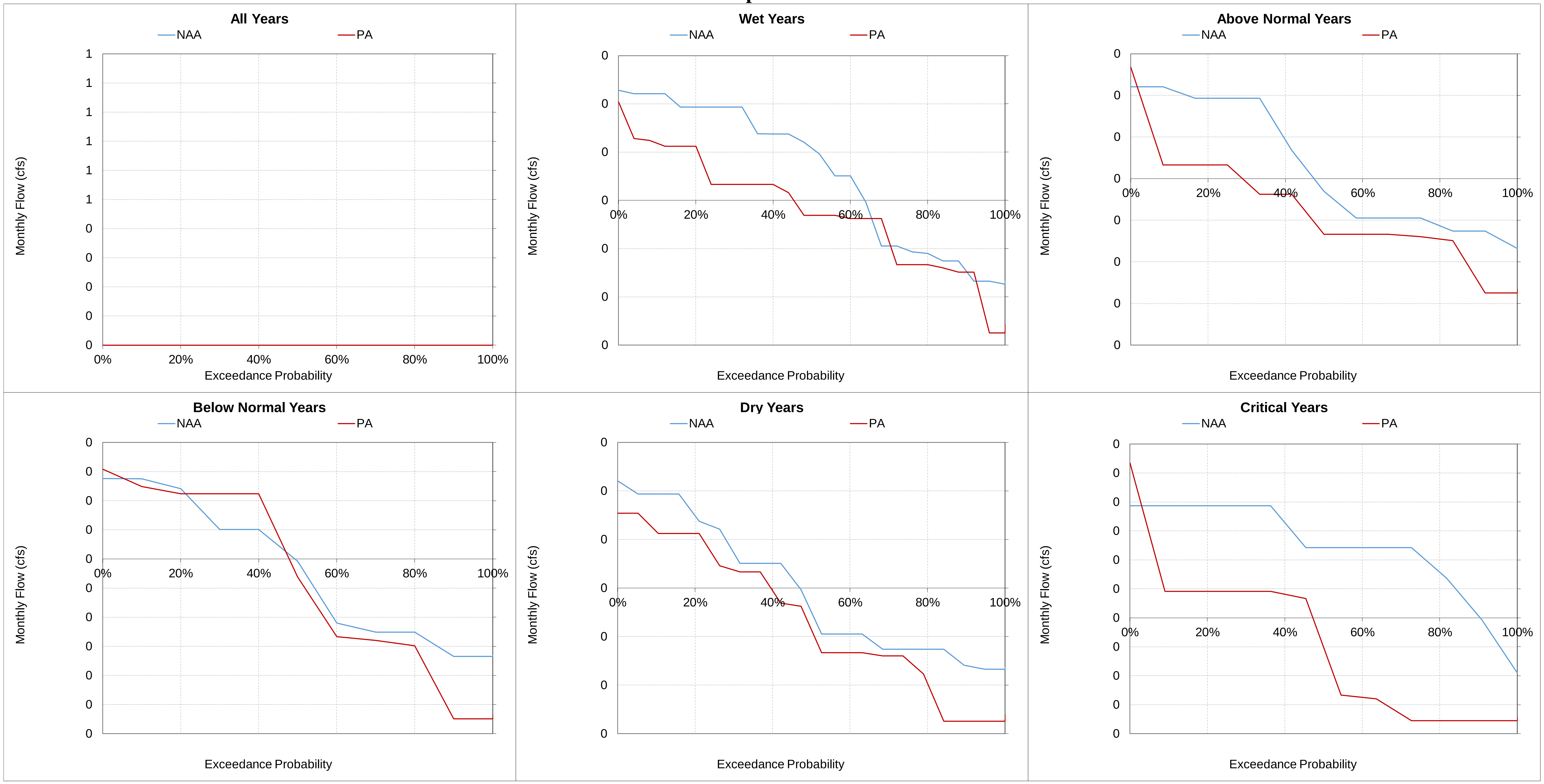
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-30-19. Roaring Slough upstream of Roaring River Distribution System, Monthly Flow September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-31. Morrow Island Distribution System M-line towards Goodyear Slough, Monthly Flow

Statistic	Monthly Flow (cfs)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	81	81	0	0%	81	81	0	0%	82	82	0	0%	81	81	0	0%	80	80	0	0%	79	79	0	0%
20%	81	81	0	0%	81	81	0	0%	81	81	0	0%	80	80	0	0%	80	80	0	0%	79	79	0	0%
30%	81	81	0	0%	81	81	0	0%	81	81	0	0%	80	80	0	0%	79	79	0	0%	79	79	0	0%
40%	80	80	0	0%	81	81	0	0%	81	81	0	0%	80	80	0	0%	79	79	0	0%	78	78	0	0%
50%	80	80	0	0%	80	80	0	0%	80	80	0	0%	79	79	0	0%	78	78	0	0%	78	78	0	0%
60%	80	80	0	0%	80	80	0	0%	80	80	0	0%	79	79	0	0%	78	78	0	0%	78	78	0	0%
70%	80	80	0	0%	80	80	0	0%	80	80	0	0%	79	79	0	0%	77	77	0	0%	77	77	0	0%
80%	79	79	0	0%	80	80	0	0%	79	79	0	0%	78	78	0	0%	76	76	0	0%	76	76	0	0%
90%	79	79	0	0%	79	79	0	0%	78	78	0	0%	76	76	0	0%	75	75	0	0%	75	75	0	0%
Long Term Full Simulation Period[b]	80	80	0	0%	80	80	0	0%	80	80	0	0%	79	79	0	0%	78	78	0	0%	78	78	0	0%
Water Year Types[c]																								
Wet (32%)	80	80	0	0%	80	80	0	0%	80	80	0	0%	79	79	0	0%	76	76	0	0%	76	76	0	0%
Above Normal (16%)	80	80	0	0%	80	80	0	0%	80	80	0	0%	79	79	0	0%	78	78	0	0%	77	77	0	0%
Below Normal (13%)	80	80	0	0%	80	80	0	0%	80	80	0	0%	79	79	0	0%	78	78	0	0%	78	78	0	0%
Dry (24%)	80	80	0	0%	80	80	0	0%	80	80	0	0%	79	79	0	0%	79	79	0	0%	79	79	0	0%
Critical (15%)	80	80	0	0%	80	80	0	0%	80	80	0	0%	79	79	0	0%	79	79	0	0%	79	79	0	0%

Statistic	Monthly Flow (cfs)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	80	80	0	0%	81	81	0	0%	81	81	0	0%	82	82	0	0%	81	81	0	0%	81	81	0	0%
20%	80	80	0	0%	80	80	0	0%	81	81	0	0%	81	81	0	0%	81	81	0	0%	81	81	0	0%
30%	79	79	0	0%	80	80	0	0%	80	80	0	0%	81	81	0	0%	80	80	0	0%	80	80	0	0%
40%	79	79	0	0%	80	80	0	0%	80	80	0	0%	81	81	0	0%	80	80	0	0%	80	80	0	0%
50%	79	79	0	0%	80	80	0	0%	80	80	0	0%	80	80	0	0%	80	80	0	0%	80	80	0	0%
60%	78	78	0	0%	79	79	0	0%	80	80	0	0%	80	80	0	0%	80	80	0	0%	80	80	0	0%
70%	78	78	0	0%	79	79	0	0%	79	79	0	0%	80	80	0	0%	80	80	0	0%	79	79	0	0%
80%	77	77	0	0%	78	78	0	0%	79	79	0	0%	80	80	0	0%	79	79	0	0%	79	79	0	0%
90%	76	76	0	0%	78	78	0	0%	78	78	0	0%	79	79	0	0%	79	79	0	0%	79	79	0	0%
Long Term Full Simulation Period[b]	78	78	0	0%	79	79	0	0%	80	80	0	0%	80	80	0	0%	80	80	0	0%	80	80	0	0%
Water Year Types[c]																								
Wet (32%)	77	77	0	0%	79	79	0	0%	79	79	0	0%	80	80	0	0%	80	80	0	0%	80	80	0	0%
Above Normal (16%)	78	78	0	0%	80	80	0	0%	80	80	0	0%	81	81	0	0%	80	80	0	0%	80	80	0	0%
Below Normal (13%)	79	79	0	0%	80	80	0	0%	80	80	0	0%	80	80	0	0%	80	80	0	0%	80	80	0	0%
Dry (24%)	79	79	0	0%	80	80	0	0%	80	80	0	0%	80	80	0	0%	80	80	0	0%	80	80	0	0%
Critical (15%)	79	79	0	0%	80	80	0	0%	80	80	0	0%	81	81	0	0%	80	80	0	0%	80	80	0	0%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-31-1. Monthly Flow Ranges For Morrow Island Distribution System M-line towards Goodyear Slough, All Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario.

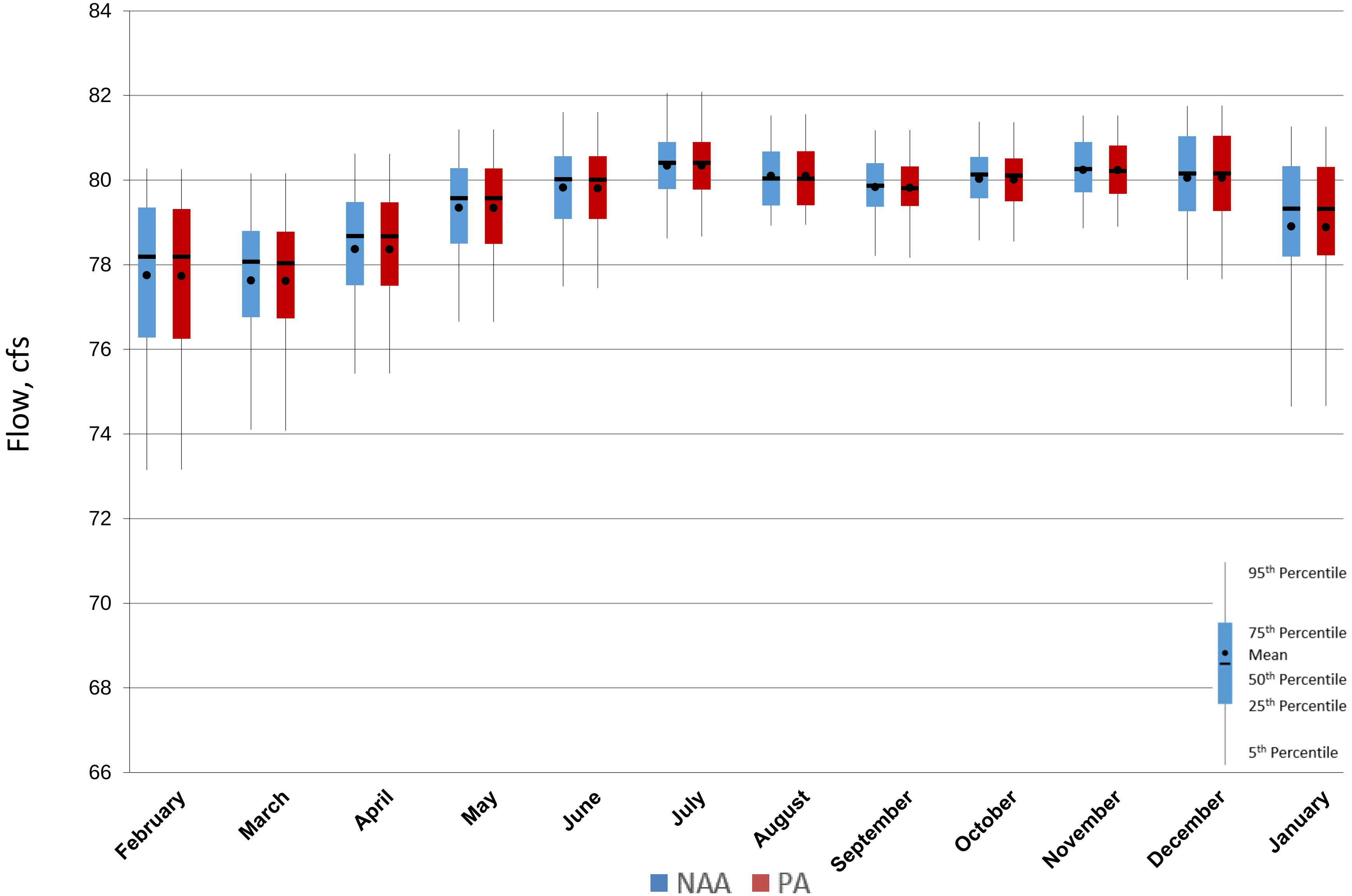


Figure 5.B.5-31-2. Monthly Flow Ranges For Morrow Island Distribution System M-line towards Goodyear Slough, Wet Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 26 wet years.

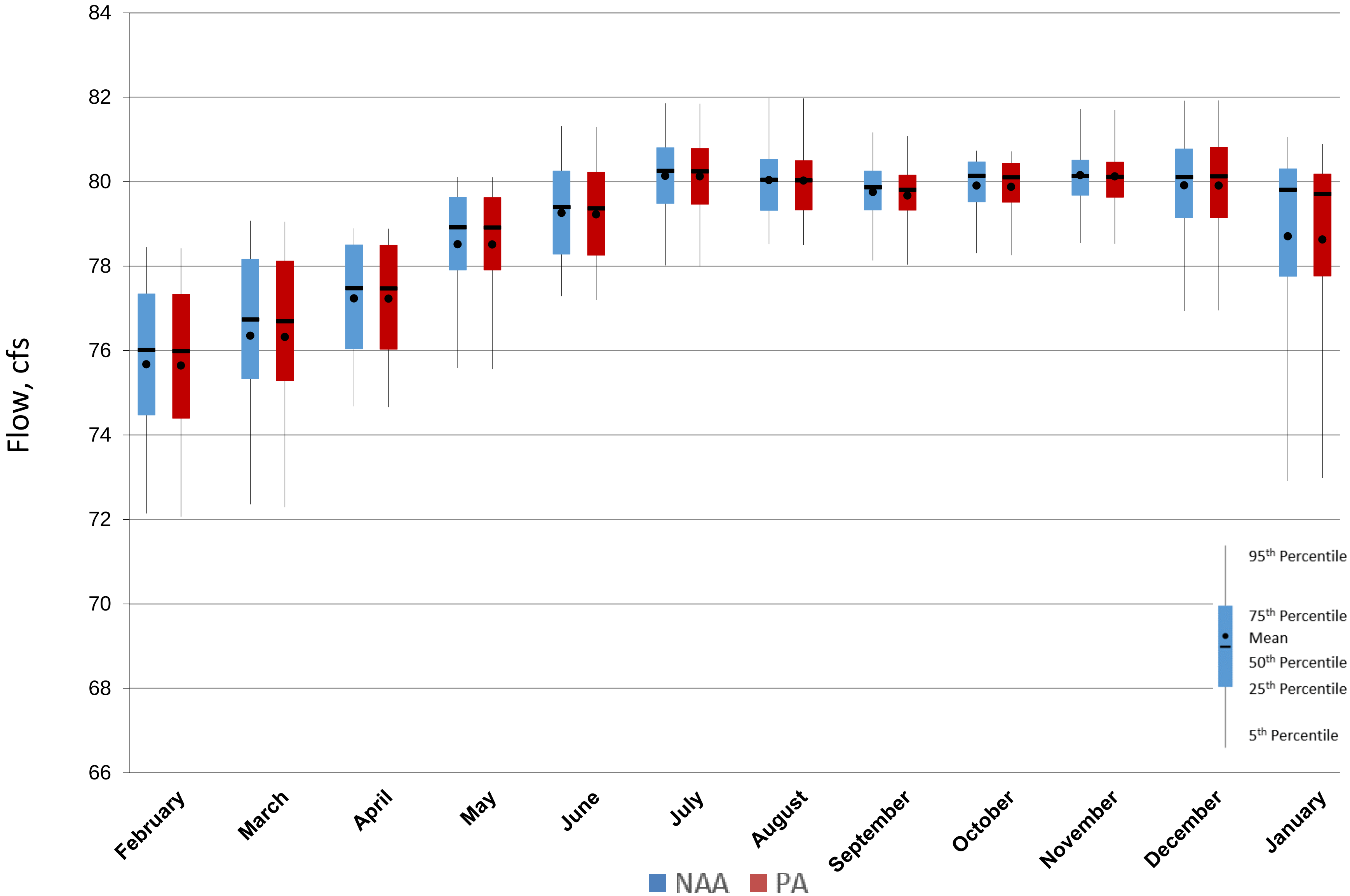


Figure 5.B.5-31-3. Monthly Flow Ranges For Morrow Island Distribution System M-line towards Goodyear Slough, Above Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 13 above normal years.

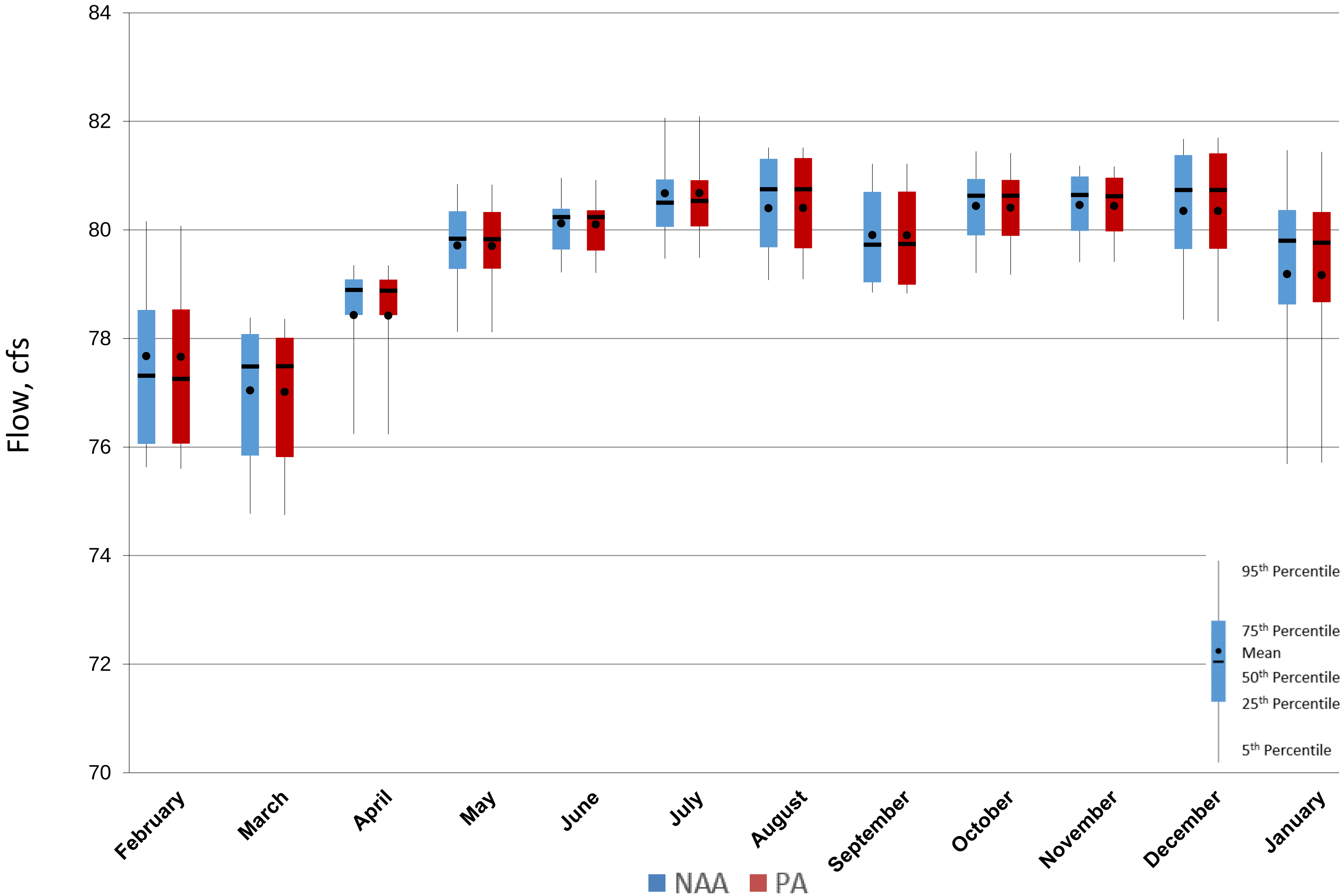


Figure 5.B.5-31-4. Monthly Flow Ranges For Morrow Island Distribution System M-line towards Goodyear Slough, Below Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 11 below normal years.

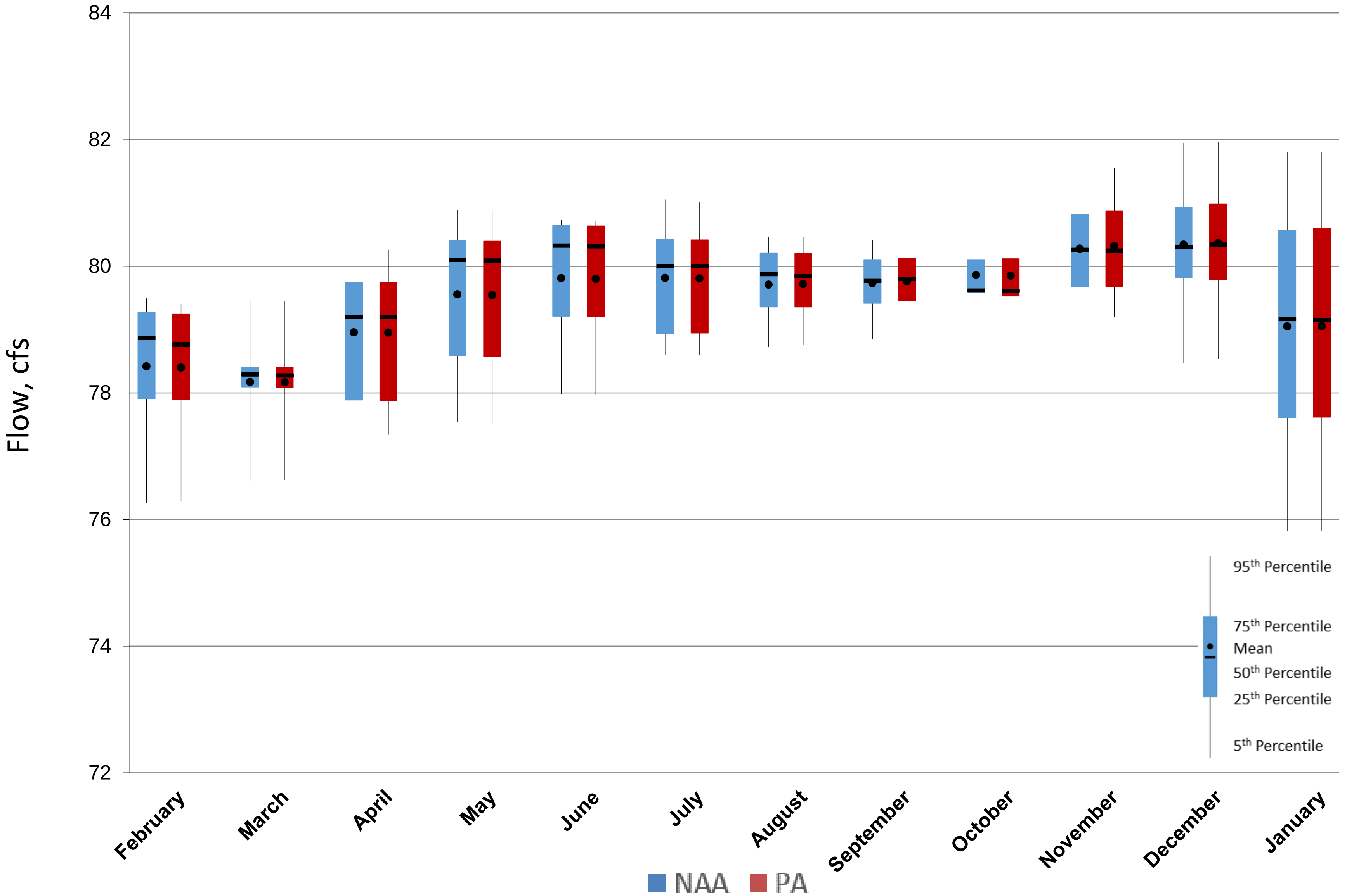


Figure 5.B.5-31-5. Monthly Flow Ranges For Morrow Island Distribution System M-line towards Goodyear Slough, Dry Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 20 dry years.

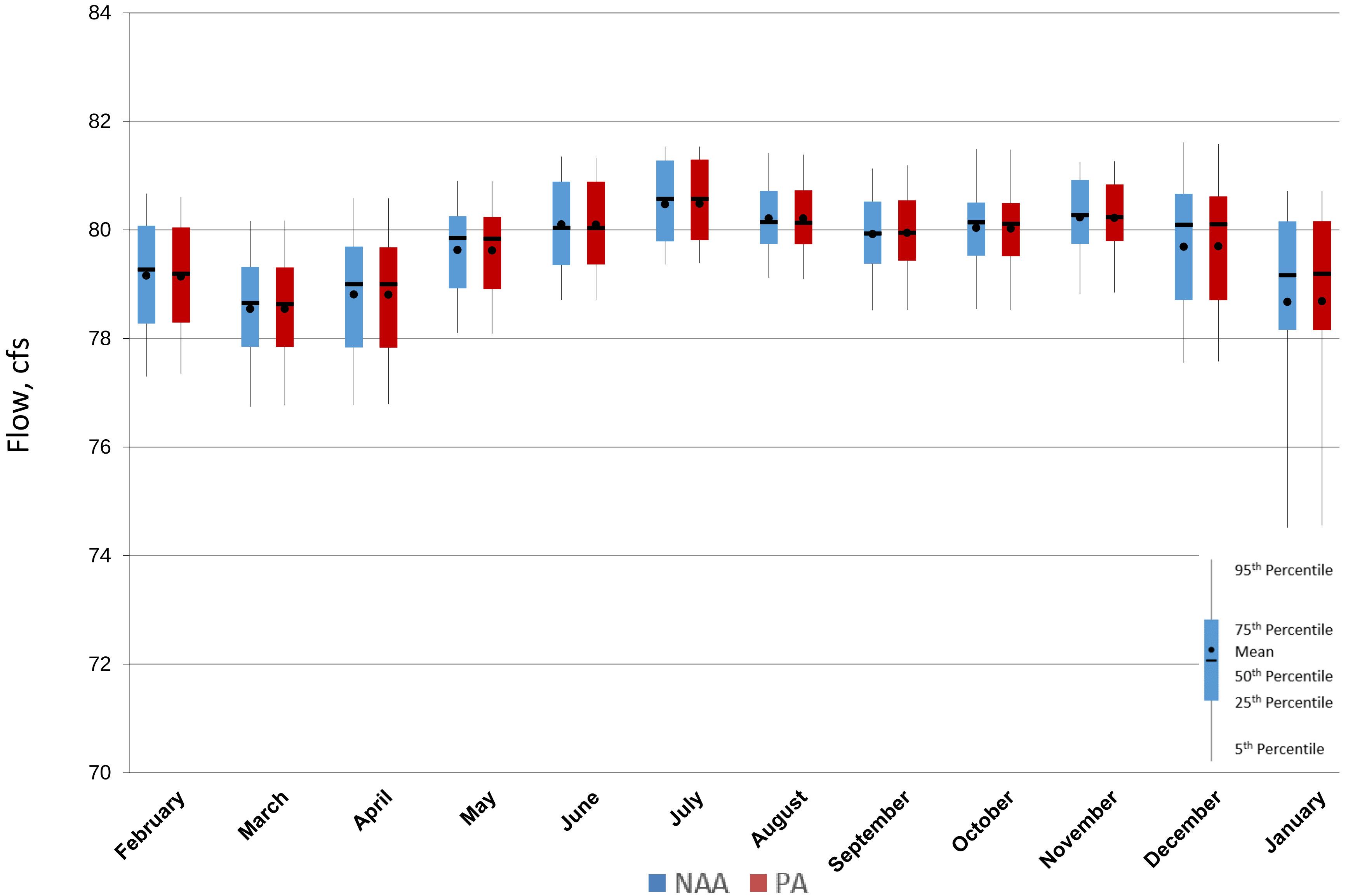


Figure 5.B.5-31-6. Monthly Flow Ranges For Morrow Island Distribution System M-line towards Goodyear Slough, Critical Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 12 critical years.

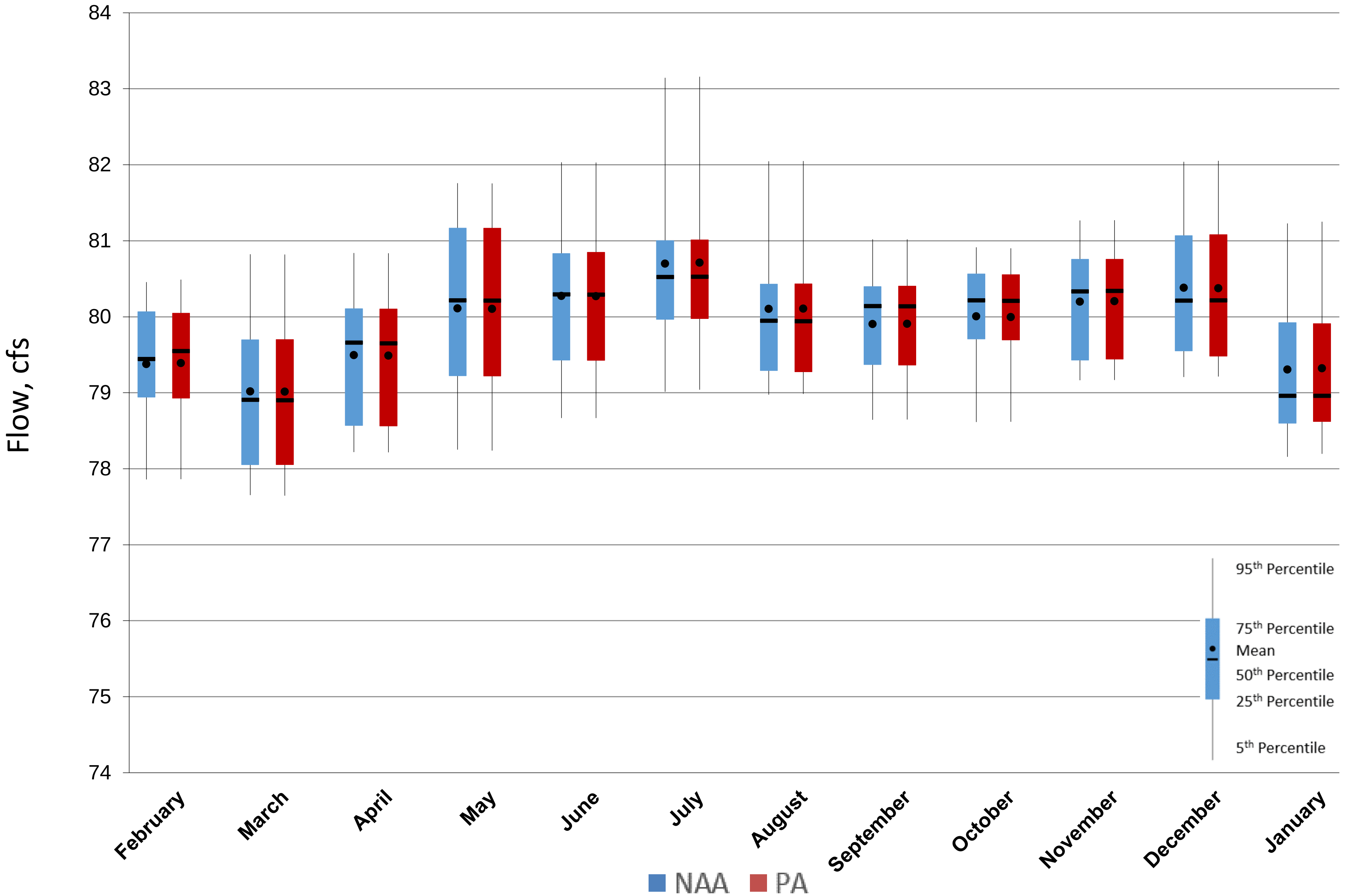
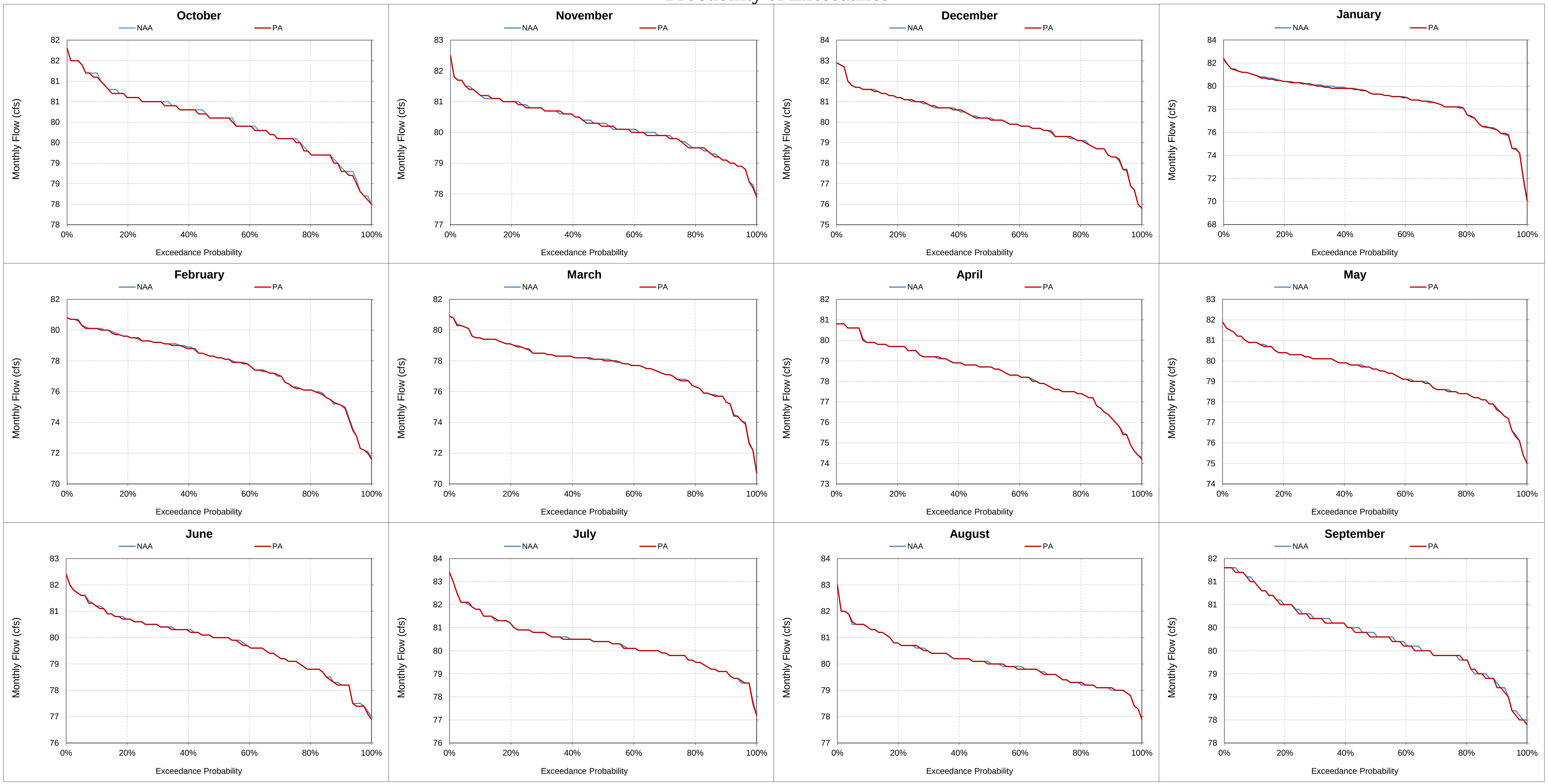
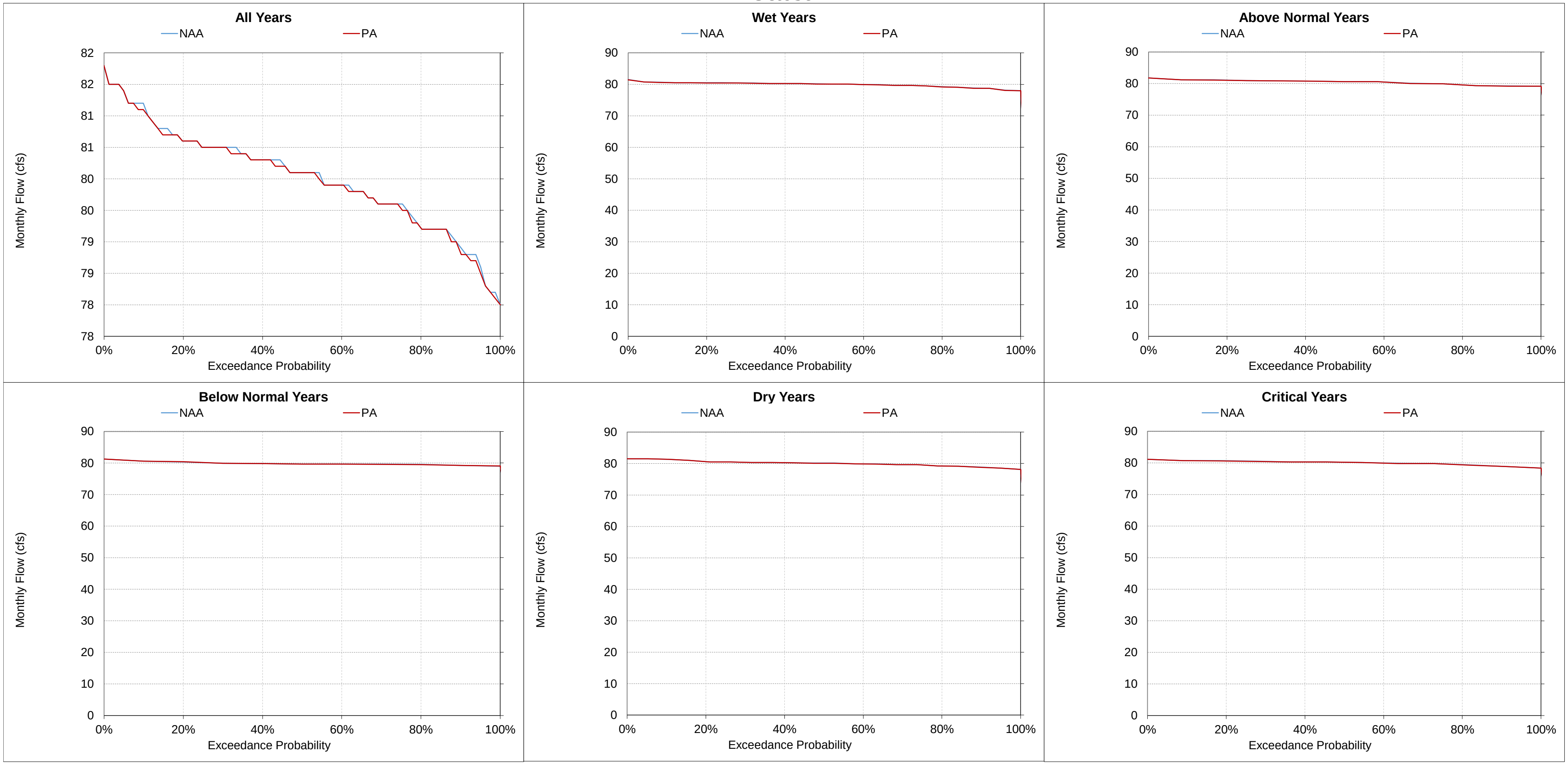


Figure 5.B.5-31-7. Morrow Island Distribution System M-line towards Goodyear Slough, Monthly Flow Probability of Exceedance



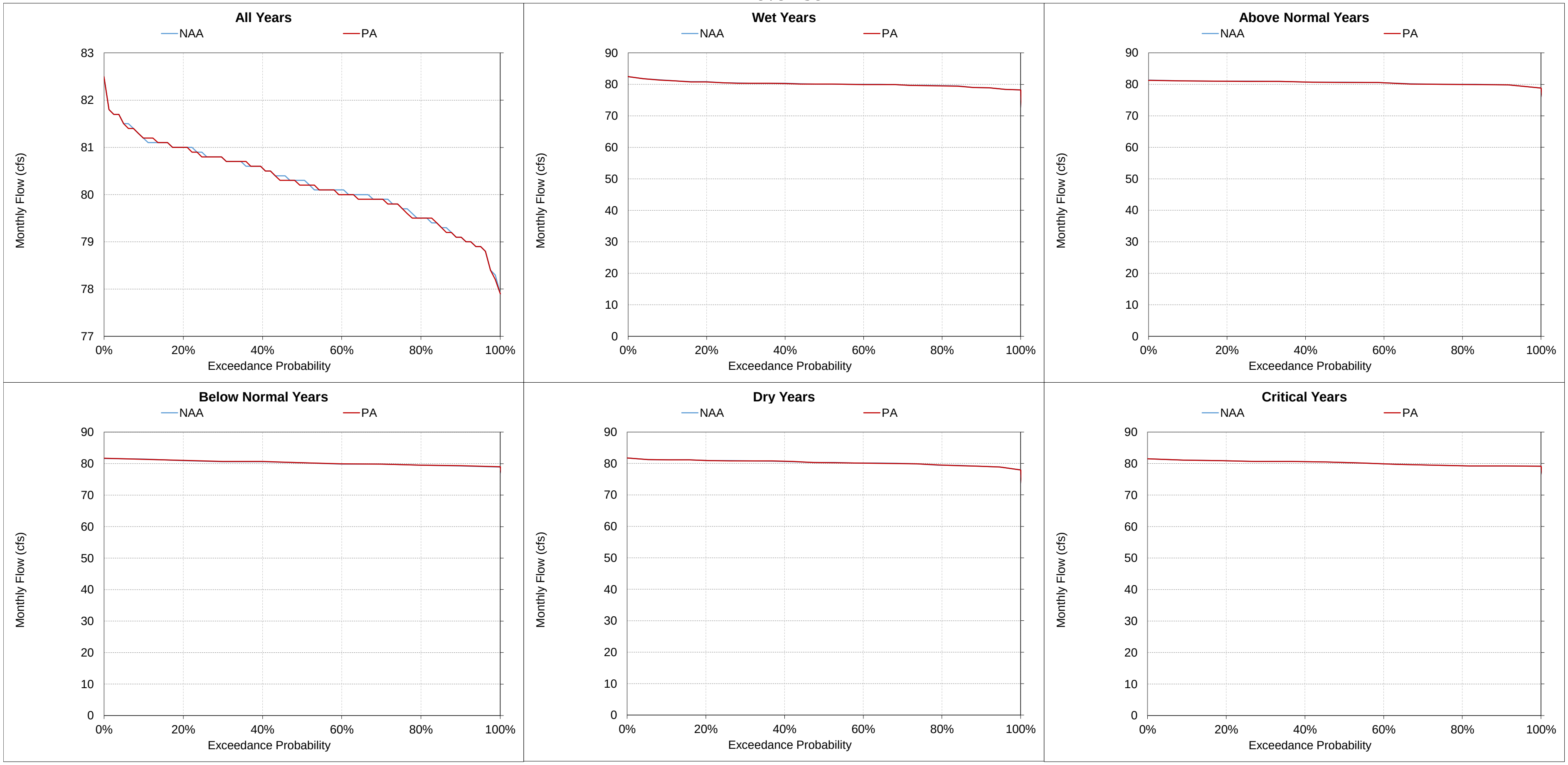
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-31-8. Morrow Island Distribution System M-line towards Goodyear Slough, Monthly Flow October



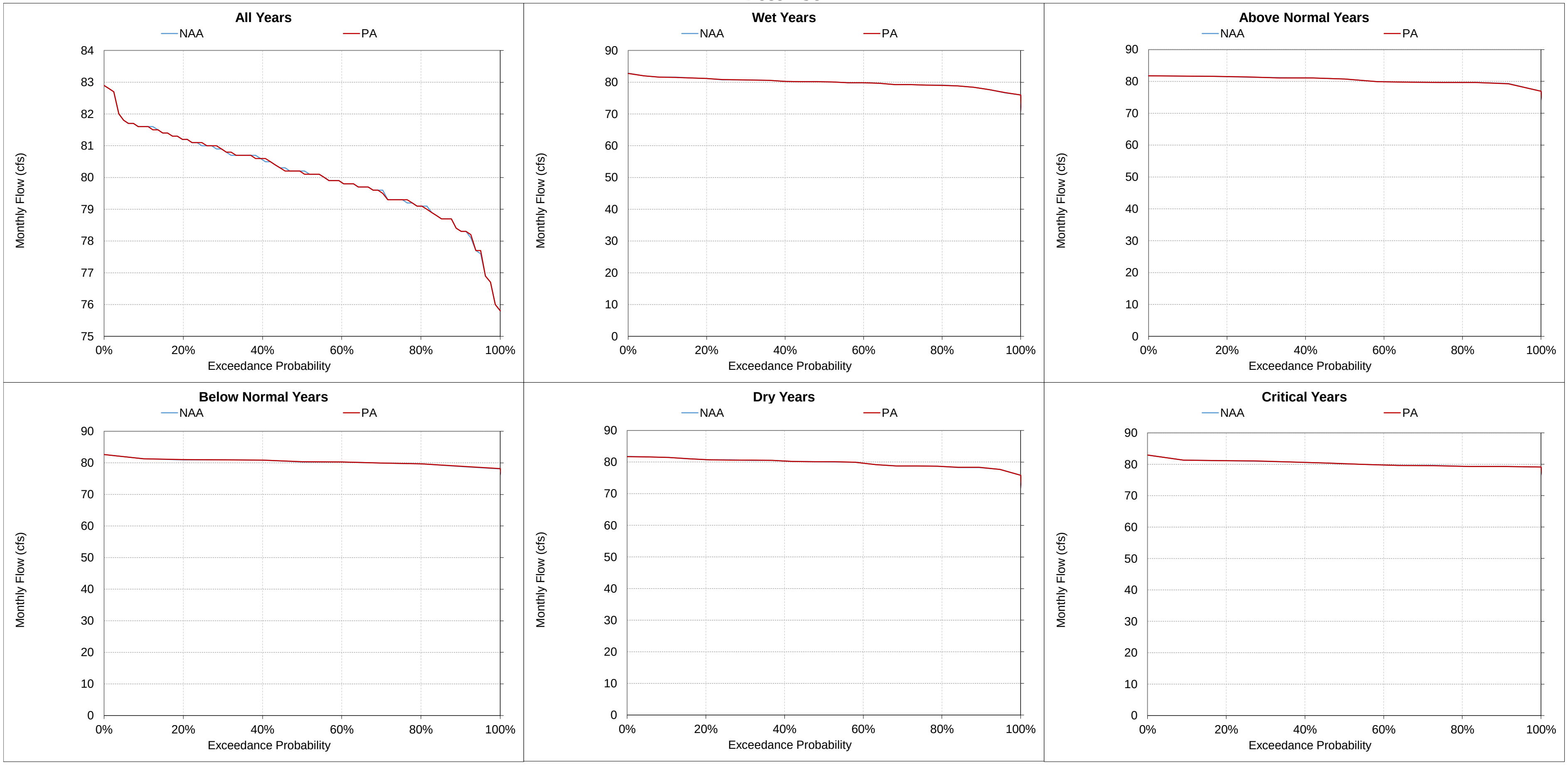
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-31-9. Morrow Island Distribution System M-line towards Goodyear Slough, Monthly Flow November



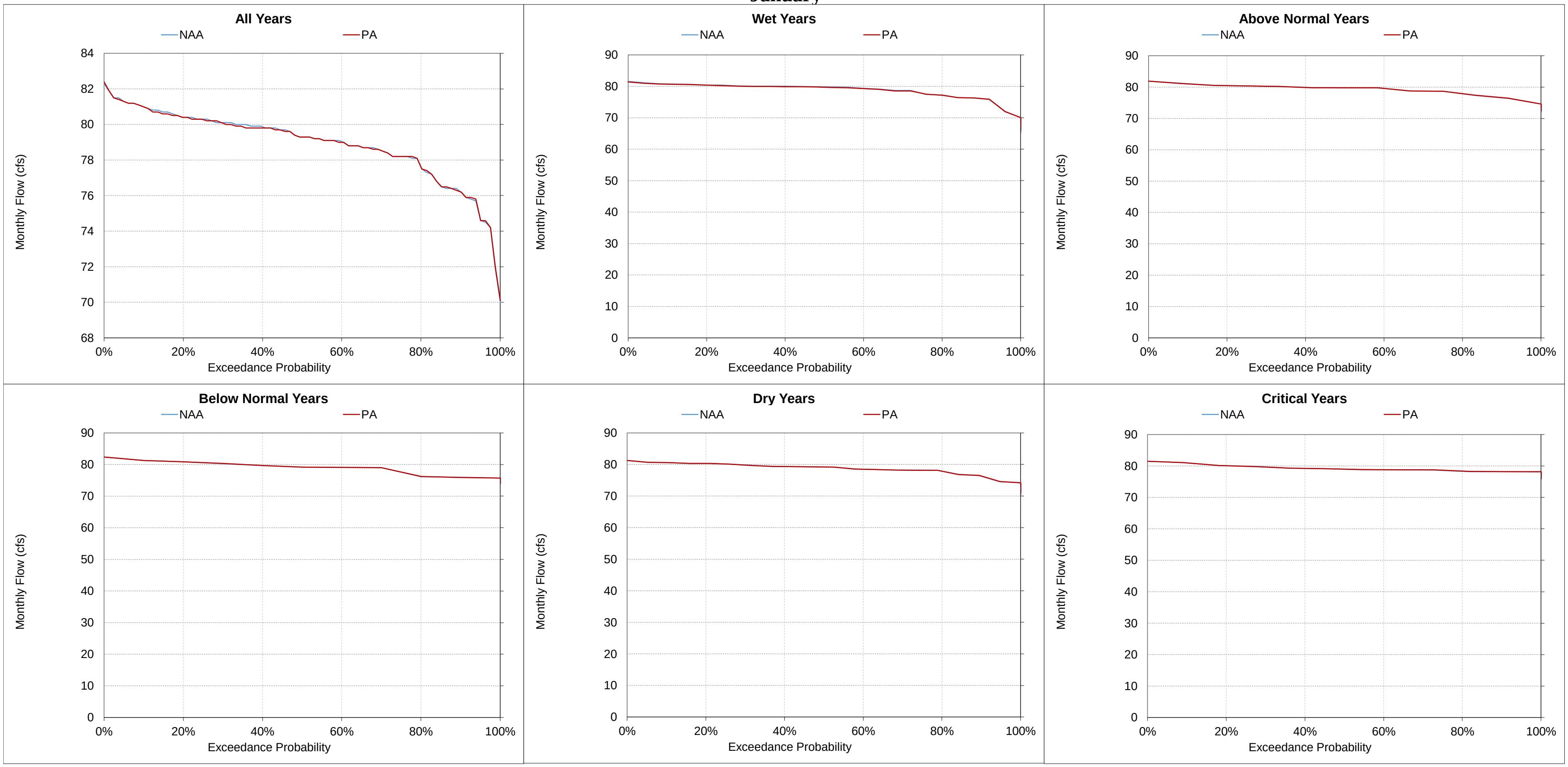
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-31-10. Morrow Island Distribution System M-line towards Goodyear Slough, Monthly Flow December



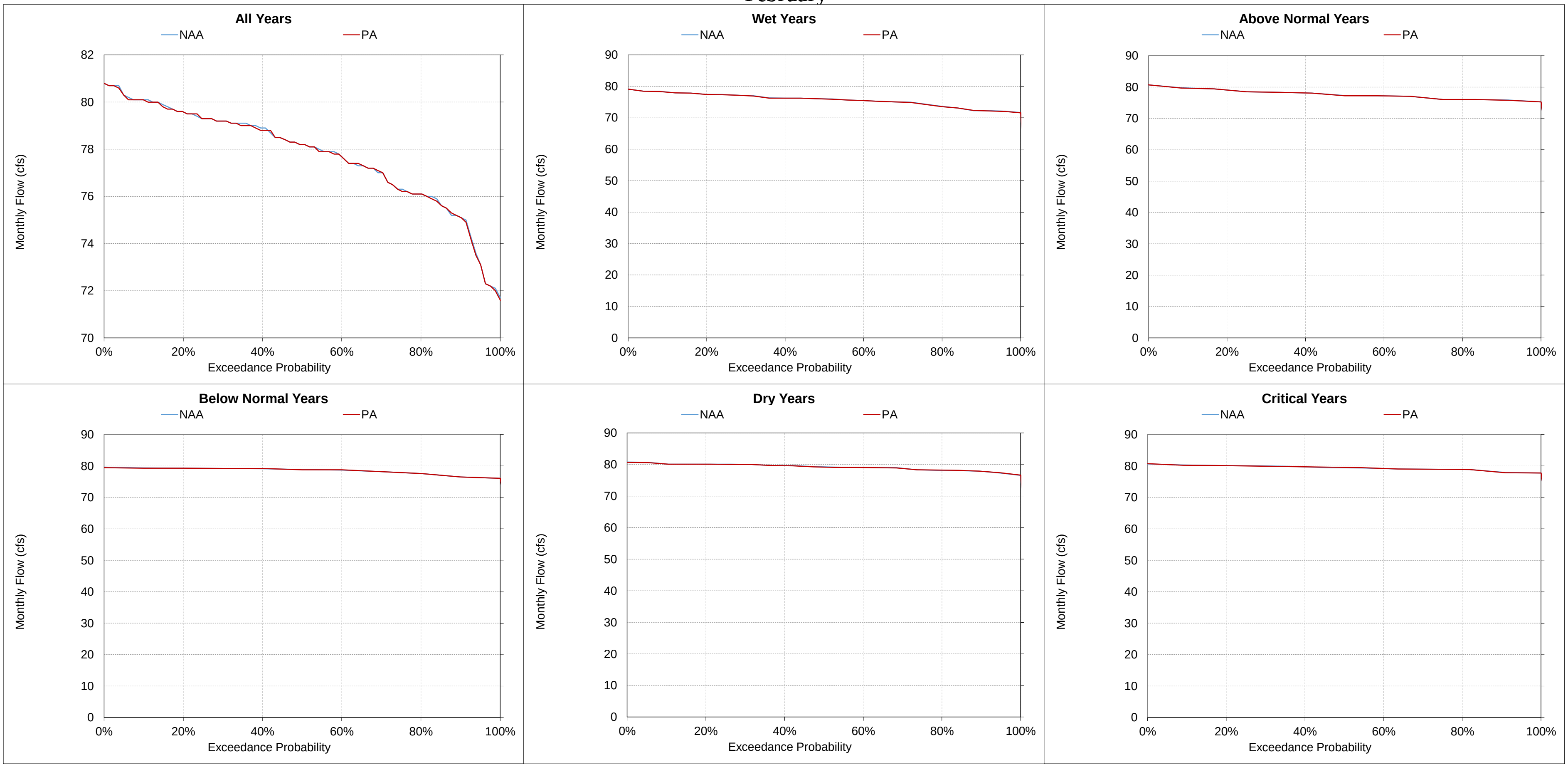
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-31-11. Morrow Island Distribution System M-line towards Goodyear Slough, Monthly Flow
January



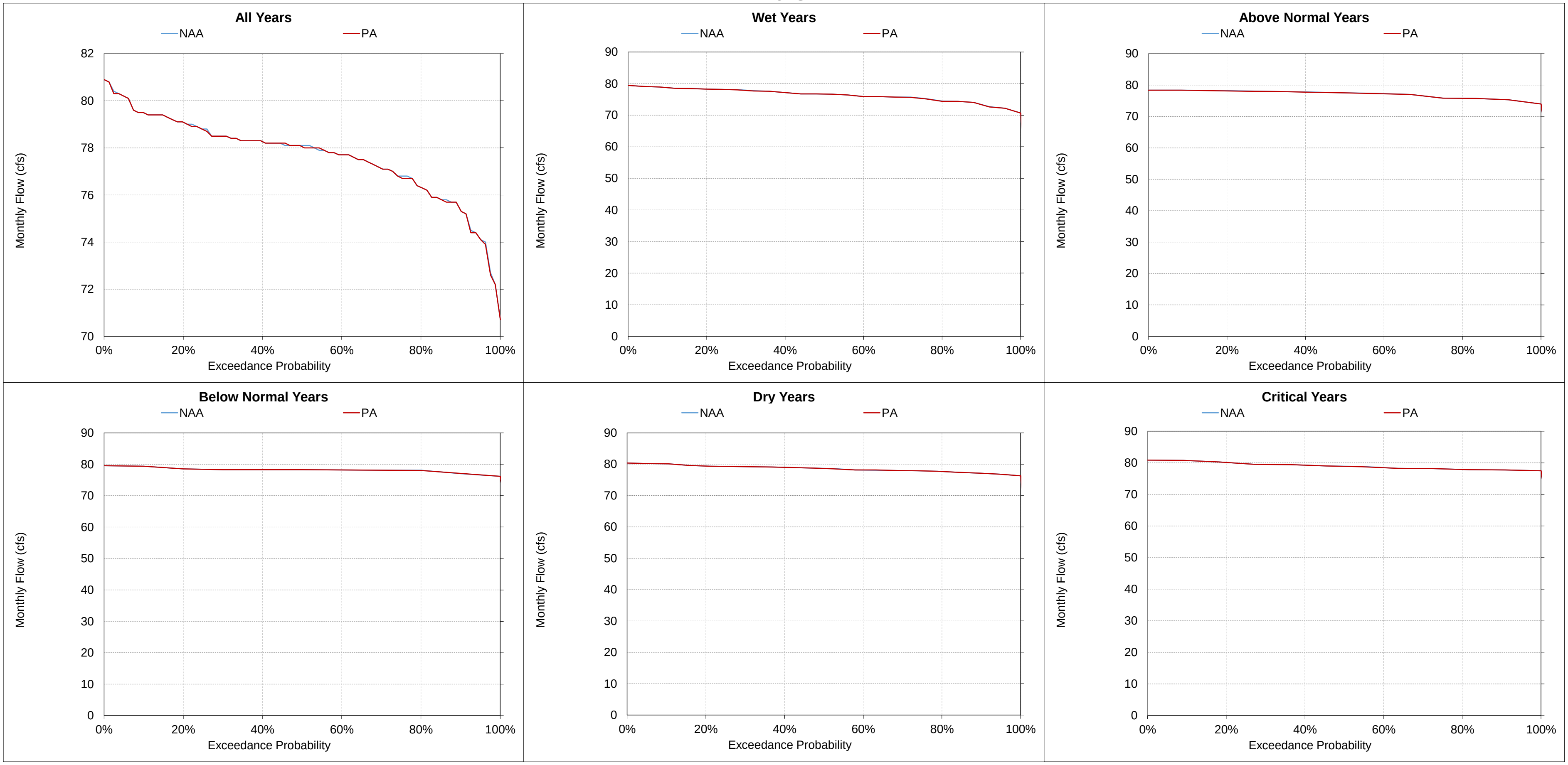
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-31-12. Morrow Island Distribution System M-line towards Goodyear Slough, Monthly Flow February



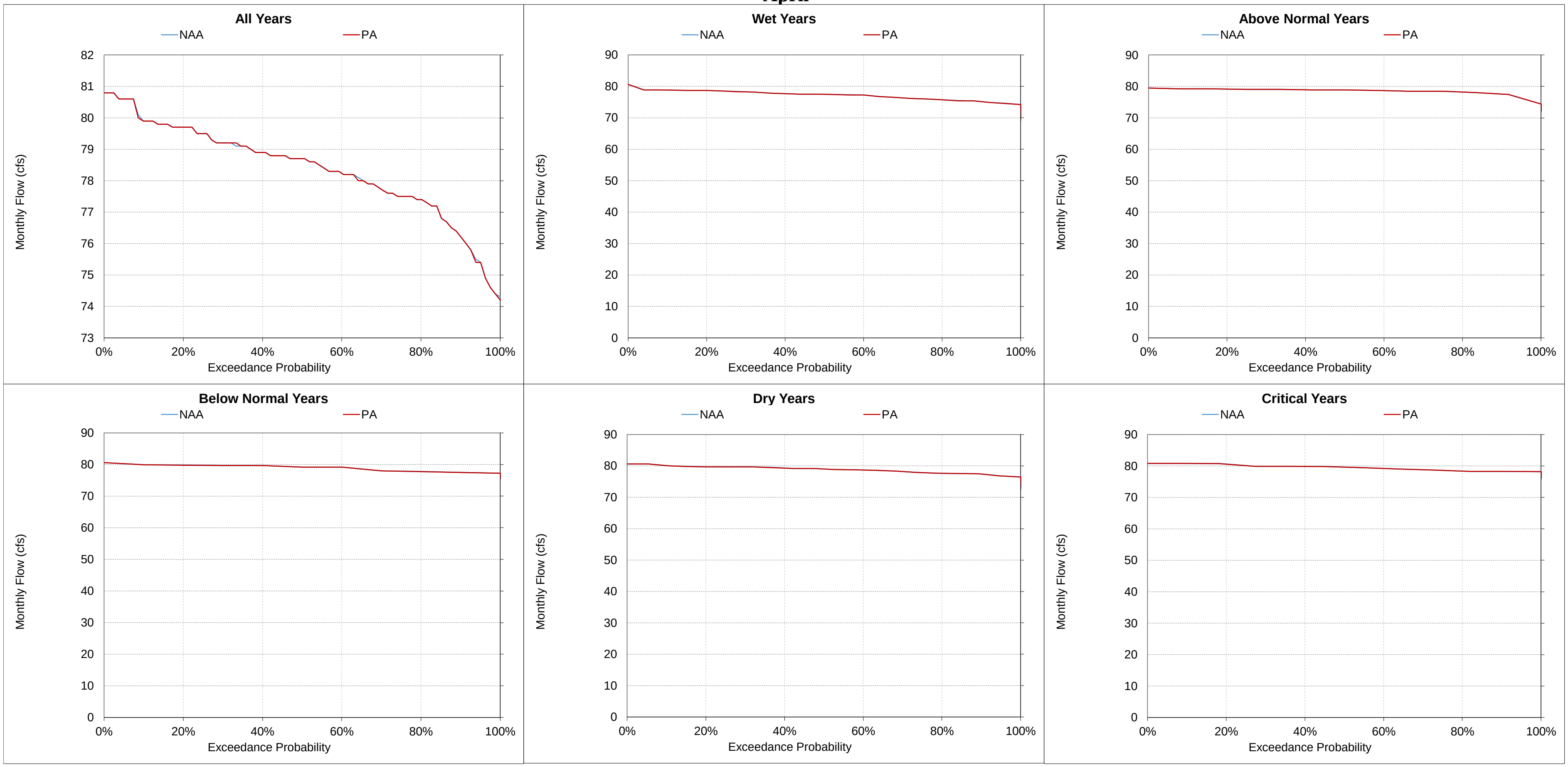
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-31-13. Morrow Island Distribution System M-line towards Goodyear Slough, Monthly Flow
March



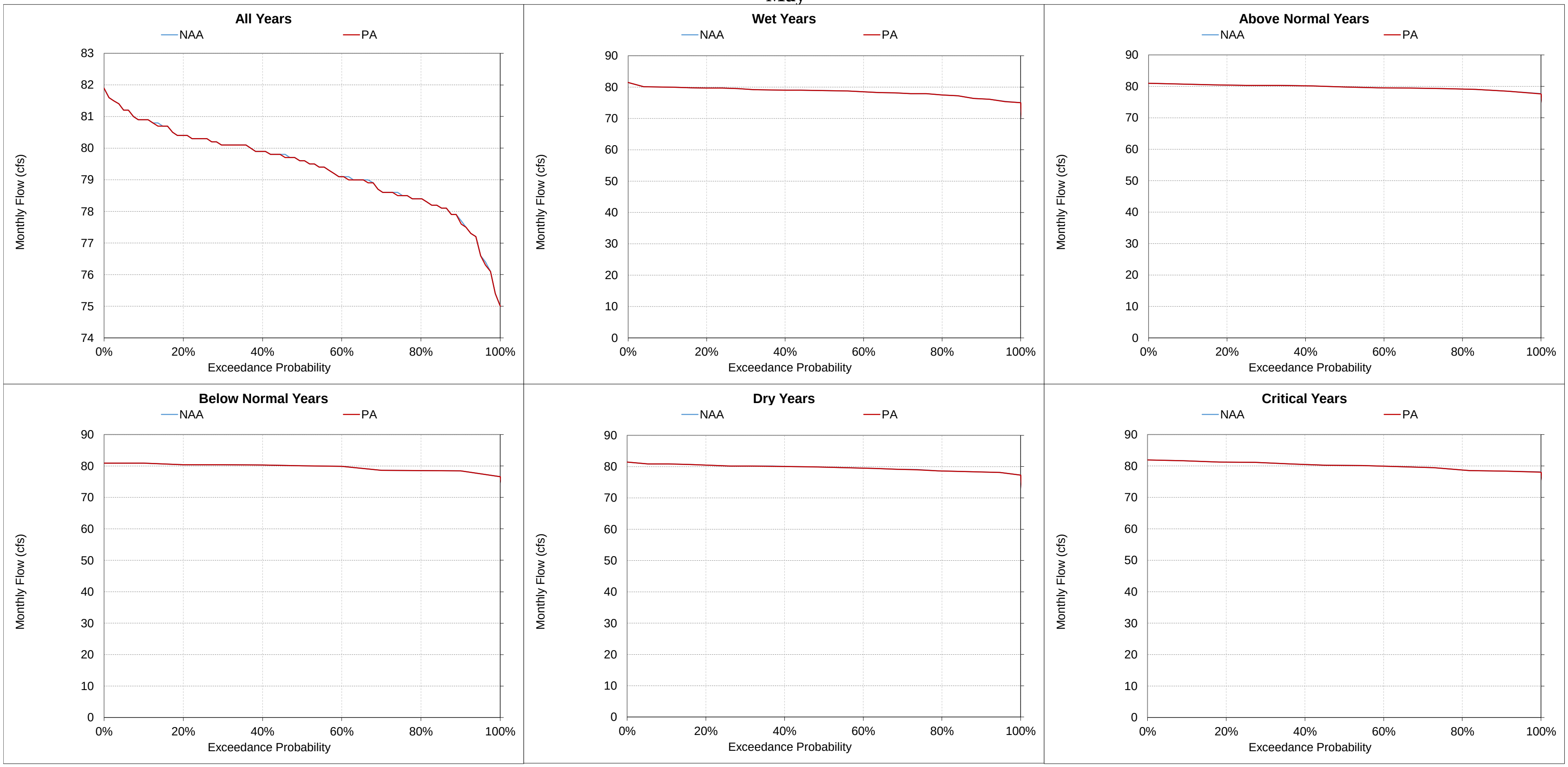
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-31-14. Morrow Island Distribution System M-line towards Goodyear Slough, Monthly Flow April



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-31-15. Morrow Island Distribution System M-line towards Goodyear Slough, Monthly Flow May



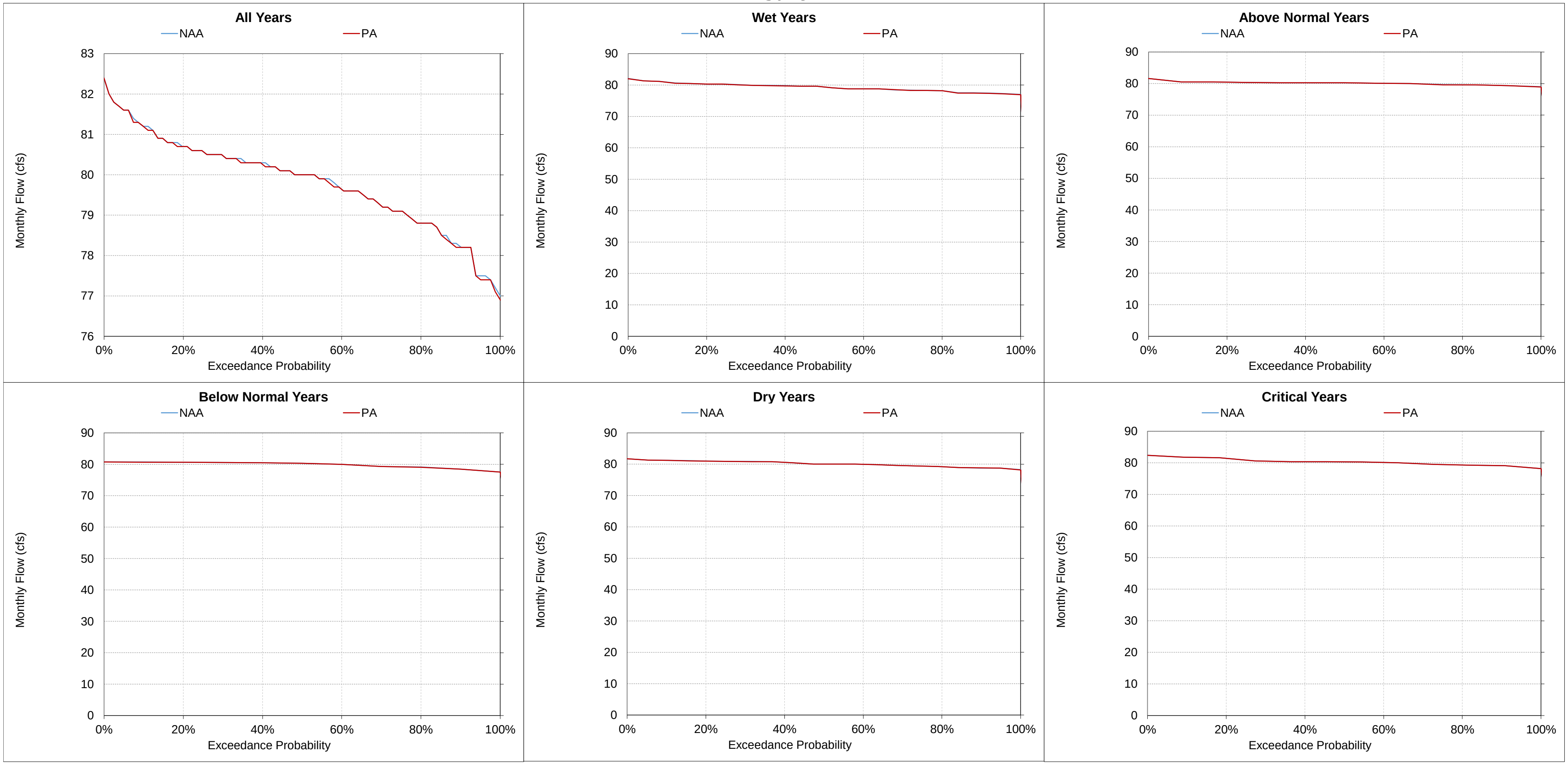
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

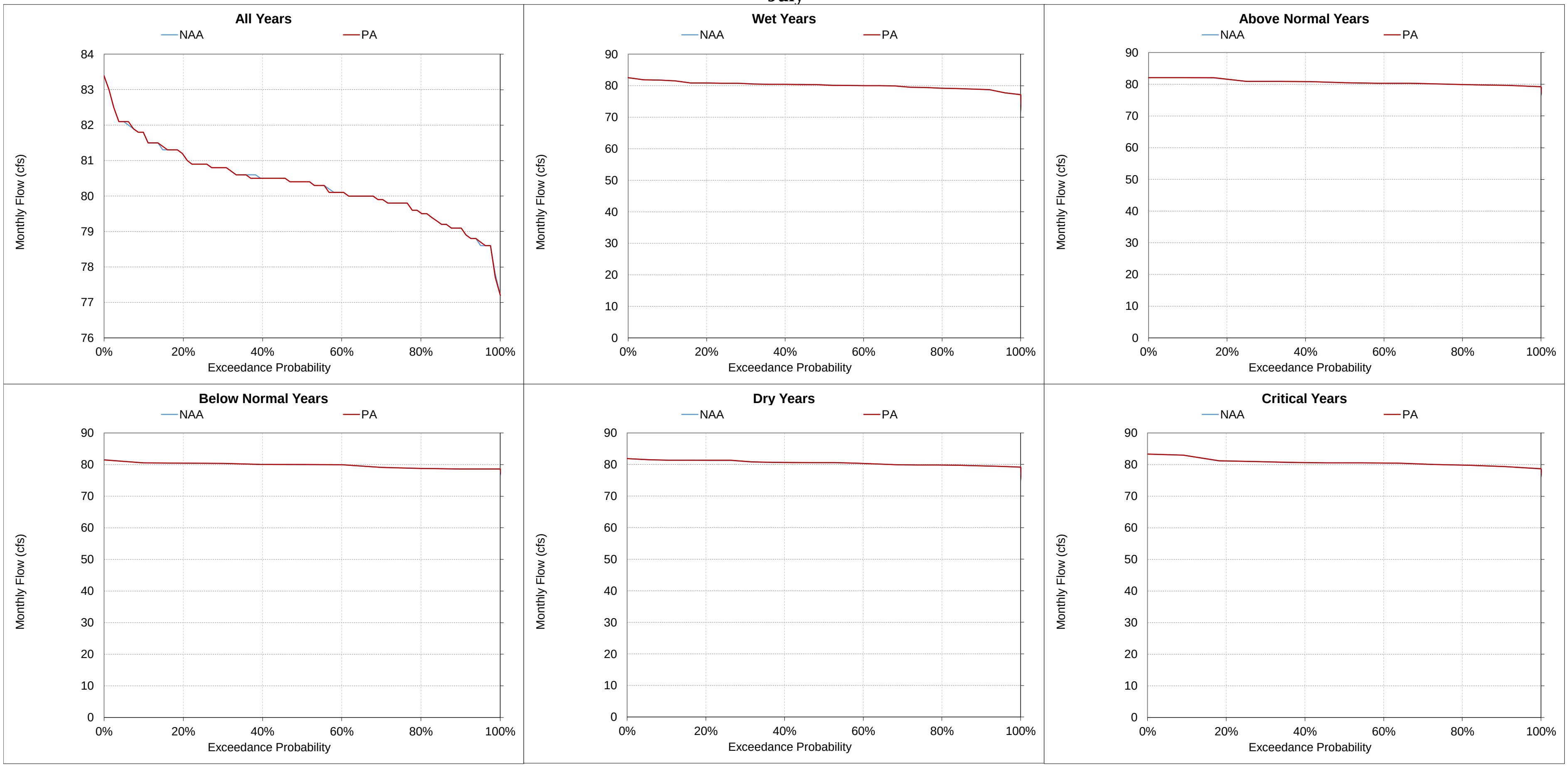
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-31-16. Morrow Island Distribution System M-line towards Goodyear Slough, Monthly Flow
June



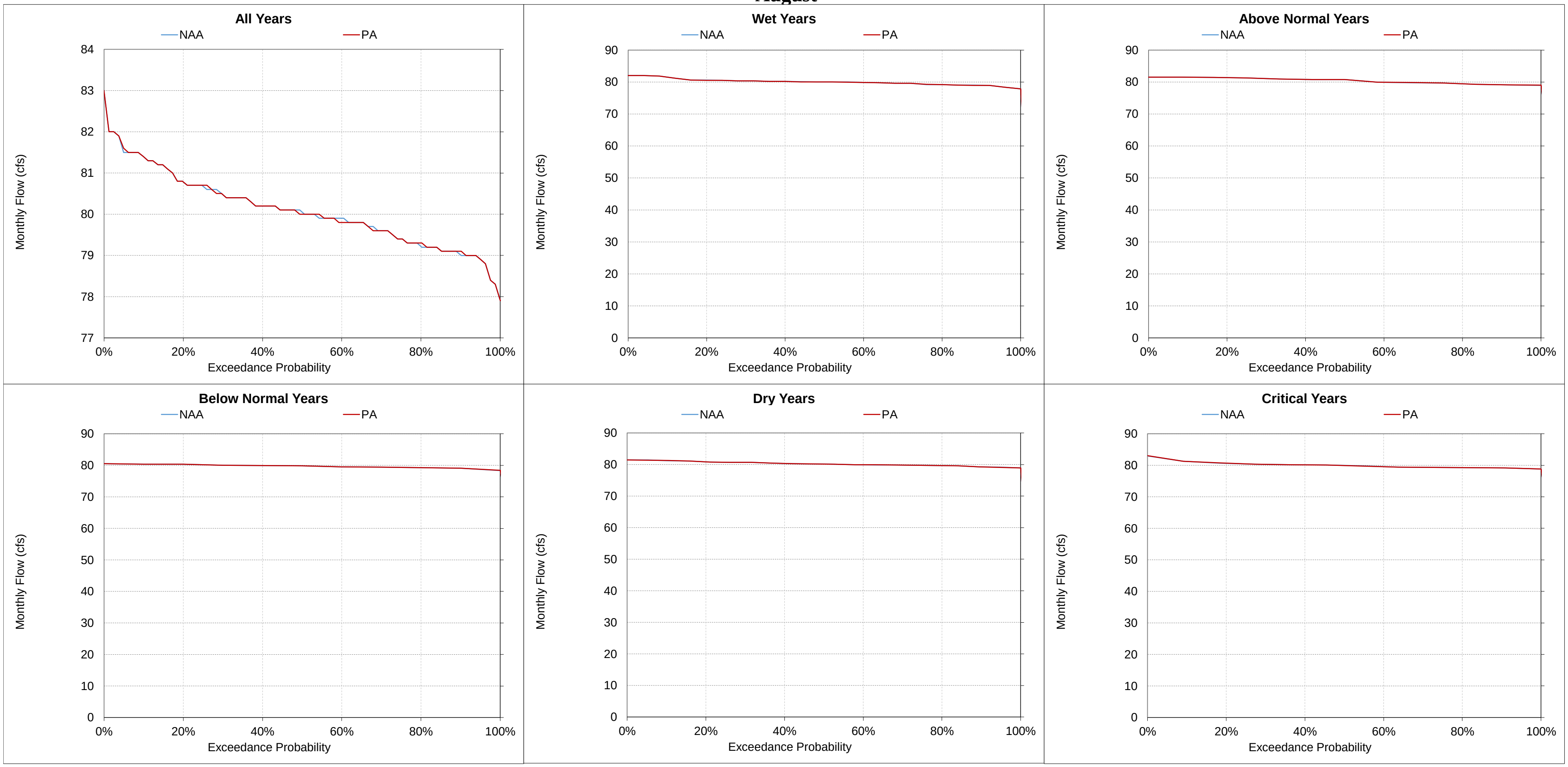
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-31-17. Morrow Island Distribution System M-line towards Goodyear Slough, Monthly Flow July



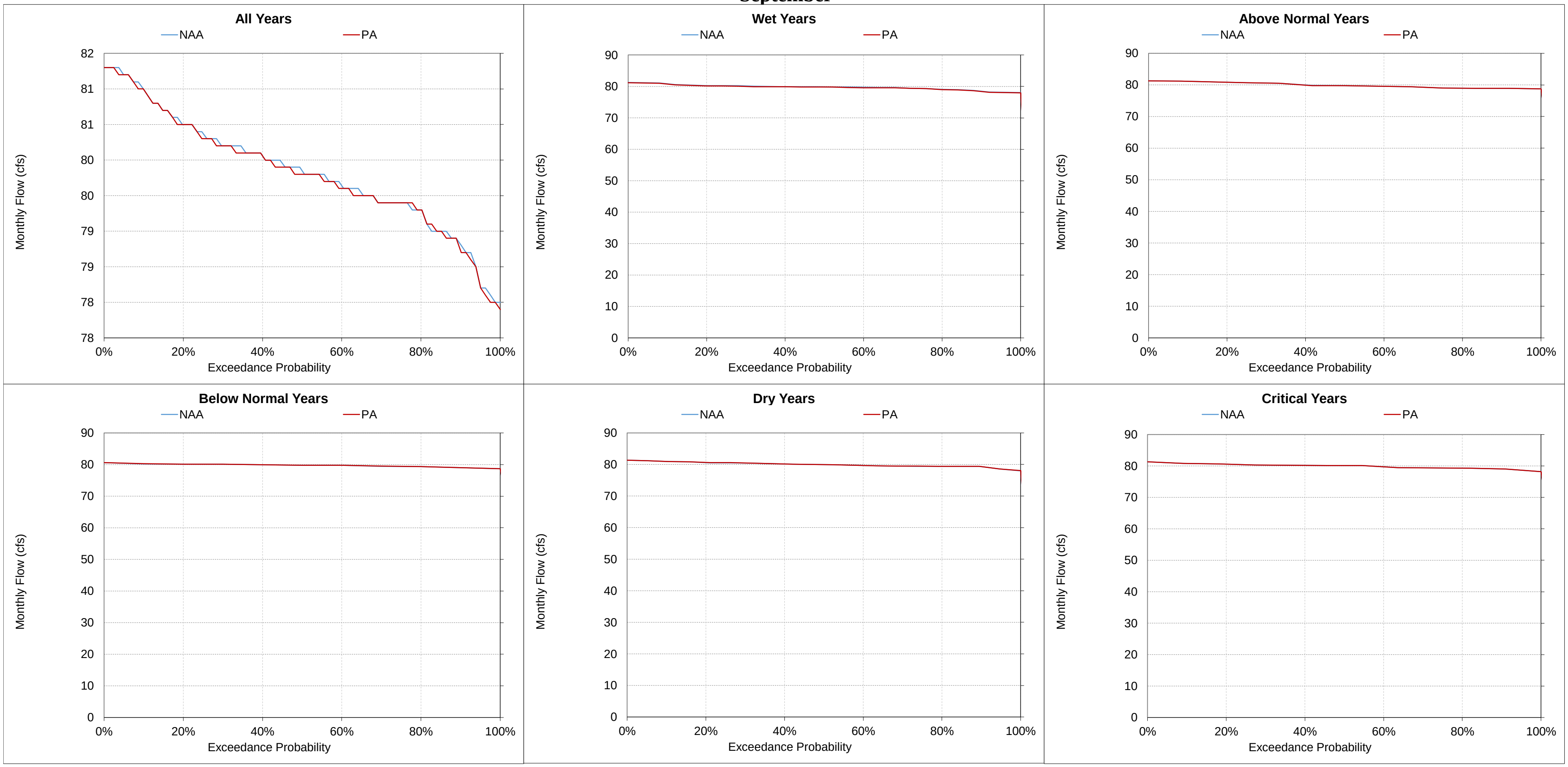
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-31-18. Morrow Island Distribution System M-line towards Goodyear Slough, Monthly Flow
August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-31-19. Morrow Island Distribution System M-line towards Goodyear Slough, Monthly Flow September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-32. Morrow Island Distribution System M-line towards Suisun Bay, Monthly Flow

Statistic	Monthly Flow (cfs)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	58	58	0	0%	59	59	0	0%	59	59	0	0%	59	59	0	0%	58	58	0	0%	58	58	0	0%
20%	58	58	0	0%	59	59	0	0%	59	59	0	0%	58	58	0	0%	58	58	0	0%	57	57	0	0%
30%	58	58	0	0%	58	59	0	0%	59	59	0	0%	58	58	0	0%	57	57	0	0%	57	57	0	0%
40%	58	58	0	0%	58	58	0	0%	58	58	0	0%	58	58	0	0%	57	57	0	0%	57	57	0	0%
50%	58	58	0	0%	58	58	0	0%	58	58	0	0%	57	57	0	0%	57	57	0	0%	57	57	0	0%
60%	58	58	0	0%	58	58	0	0%	58	58	0	0%	57	57	0	0%	56	56	0	0%	56	56	0	0%
70%	58	58	0	0%	58	58	0	0%	58	58	0	0%	57	57	0	0%	56	56	0	0%	56	56	0	0%
80%	57	57	0	0%	58	58	0	0%	57	57	0	0%	56	56	0	0%	55	55	0	0%	55	55	0	0%
90%	57	57	0	0%	57	57	0	0%	57	57	0	0%	55	55	0	0%	54	54	0	0%	55	54	0	0%
Long Term Full Simulation Period[b]	58	58	0	0%	58	58	0	0%	58	58	0	0%	57	57	0	0%	56	56	0	0%	56	56	0	0%
Water Year Types[c]																							0	
Wet (32%)	58	58	0	0%	58	58	0	0%	58	58	0	0%	57	57	0	0%	55	55	0	0%	55	55	0	0%
Above Normal (16%)	58	58	0	0%	58	58	0	0%	58	58	0	0%	57	57	0	0%	56	56	0	0%	56	56	0	0%
Below Normal (13%)	58	58	0	0%	58	58	0	0%	58	58	0	0%	57	57	0	0%	57	57	0	0%	57	57	0	0%
Dry (24%)	58	58	0	0%	58	58	0	0%	58	58	0	0%	57	57	0	0%	57	57	0	0%	57	57	0	0%
Critical (15%)	58	58	0	0%	58	58	0	0%	58	58	0	0%	57	57	0	0%	57	57	0	0%	57	57	0	0%

Statistic	Monthly Flow (cfs)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	58	58	0	0%	59	59	0	0%	59	59	0	0%	59	59	0	0%	59	59	0	0%	58	58	0	0%
20%	58	58	0	0%	59	58	0	0%	59	59	0	0%	59	59	0	0%	58	58	0	0%	58	58	0	0%
30%	58	58	0	0%	58	58	0	0%	58	58	0	0%	58	58	0	0%	58	58	0	0%	58	58	0	0%
40%	57	57	0	0%	58	58	0	0%	58	58	0	0%	58	58	0	0%	58	58	0	0%	58	58	0	0%
50%	57	57	0	0%	58	58	0	0%	58	58	0	0%	58	58	0	0%	58	58	0	0%	58	58	0	0%
60%	57	57	0	0%	57	57	0	0%	58	58	0	0%	58	58	0	0%	58	58	0	0%	57	57	0	0%
70%	56	56	0	0%	57	57	0	0%	57	57	0	0%	58	58	0	0%	58	57	0	0%	57	57	0	0%
80%	56	56	0	0%	57	57	0	0%	57	57	0	0%	58	58	0	0%	57	57	0	0%	57	57	0	0%
90%	55	55	0	0%	56	56	0	0%	57	57	0	0%	57	57	0	0%	57	57	0	0%	57	57	0	0%
Long Term Full Simulation Period[b]	57	57	0	0%	58	58	0	0%	58	58	0	0%	58	58	0	0%	58	58	0	0%	58	58	0	0%
Water Year Types[c]																							0	
Wet (32%)	56	56	0	0%	57	57	0	0%	57	57	0	0%	58	58	0	0%	58	58	0	0%	57	57	0	0%
Above Normal (16%)	57	57	0	0%	58	58	0	0%	58	58	0	0%	58	58	0	0%	58	58	0	0%	58	58	0	0%
Below Normal (13%)	57	57	0	0%	58	58	0	0%	58	58	0	0%	58	58	0	0%	58	58	0	0%	57	57	0	0%
Dry (24%)	57	57	0	0%	58	58	0	0%	58	58	0	0%	58	58	0	0%	58	58	0	0%	58	58	0	0%
Critical (15%)	58	58	0	0%	58	58	0	0%	58	58	0	0%	58	58	0	0%	58	58	0	0%	58	58	0	0%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-32-1. Monthly Flow Ranges For Morrow Island Distribution System M-line towards Suisun Bay, All Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario.

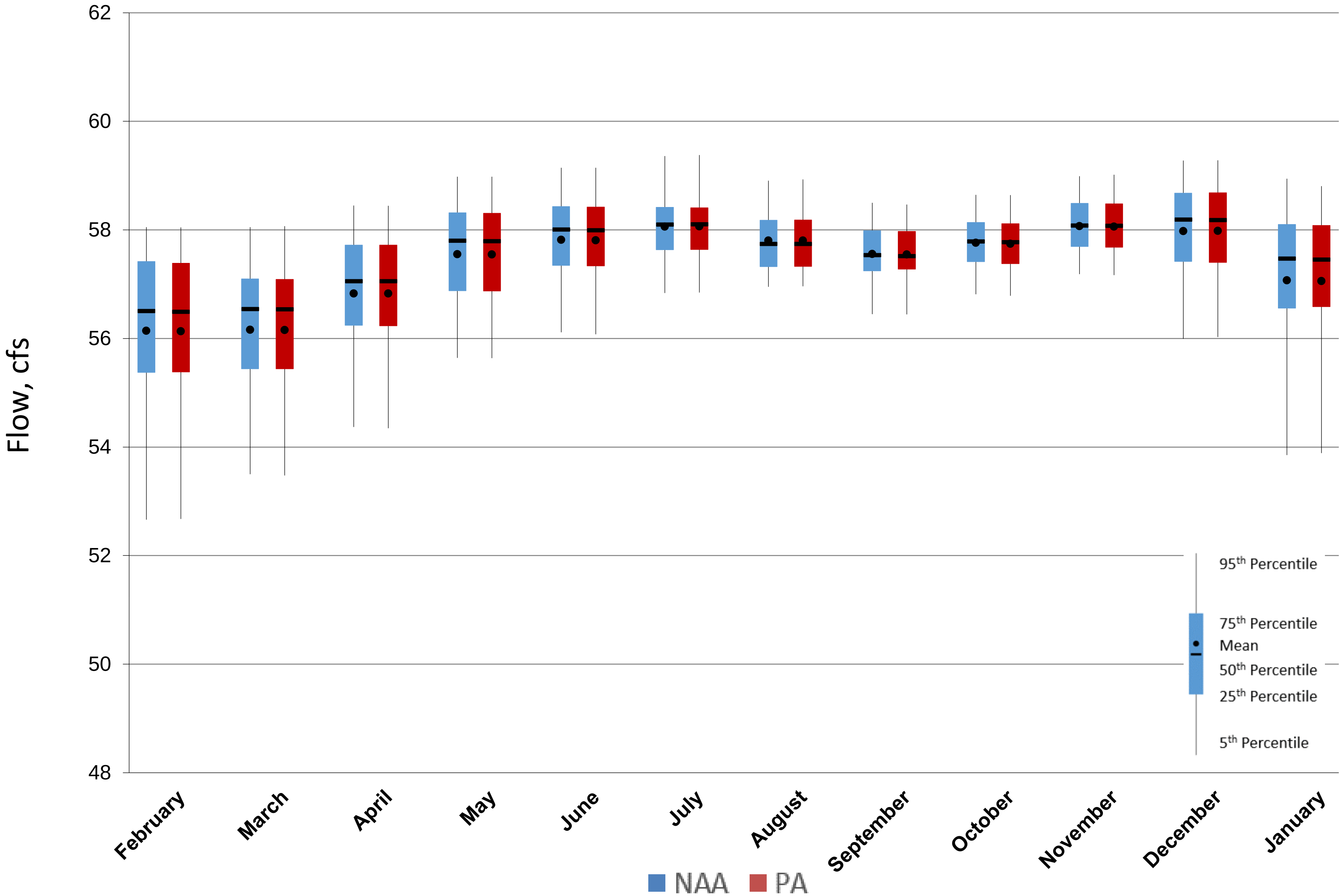


Figure 5.B.5-32-2. Monthly Flow Ranges For Morrow Island Distribution System M-line towards Suisun Bay, Wet Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 26 wet years.

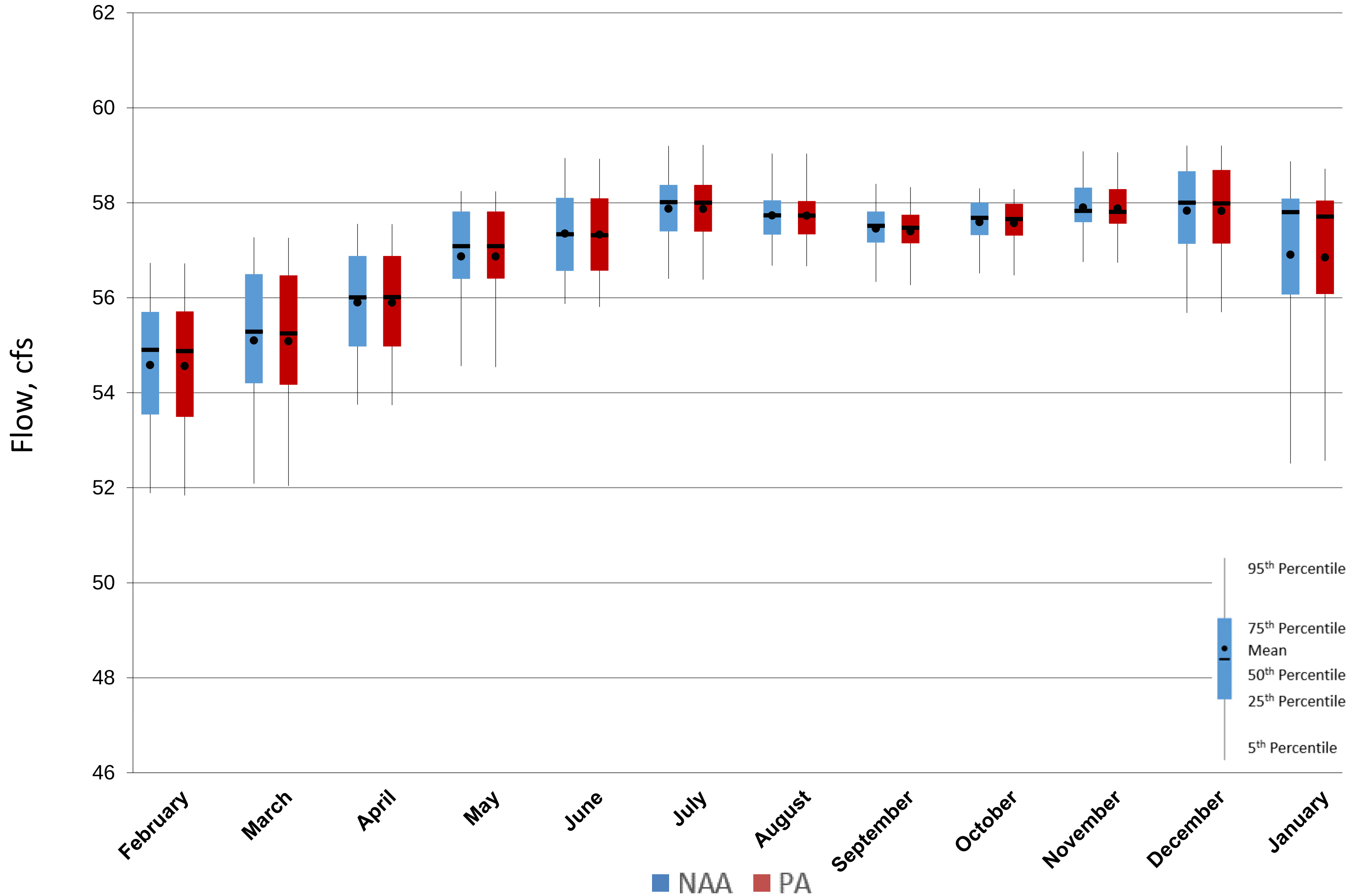


Figure 5.B.5-32-3. Monthly Flow Ranges For Morrow Island Distribution System M-line towards Suisun Bay, Above Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 13 above normal years.

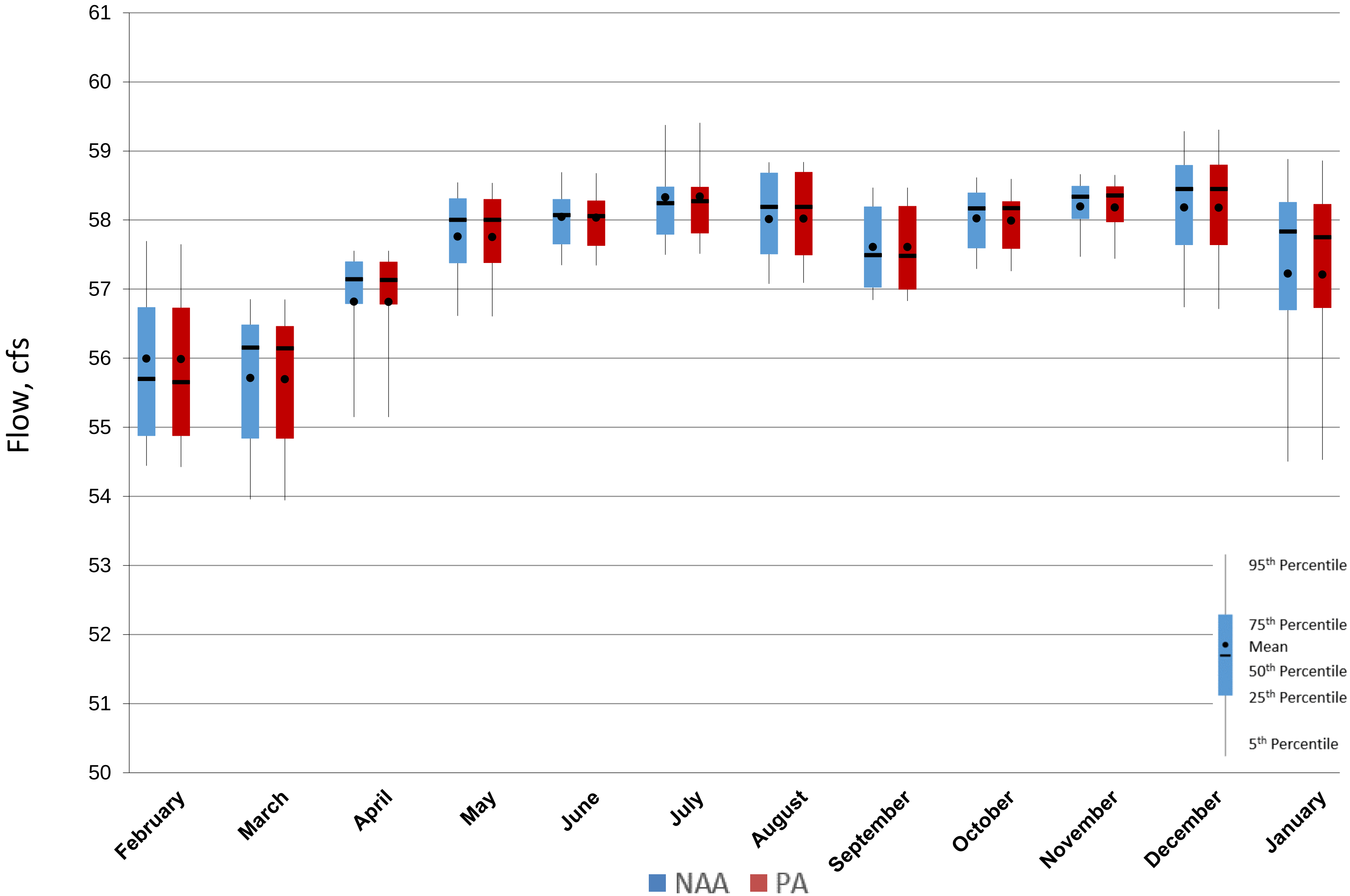


Figure 5.B.5-32-4. Monthly Flow Ranges For Morrow Island Distribution System M-line towards Suisun Bay, Below Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 11 below normal years.

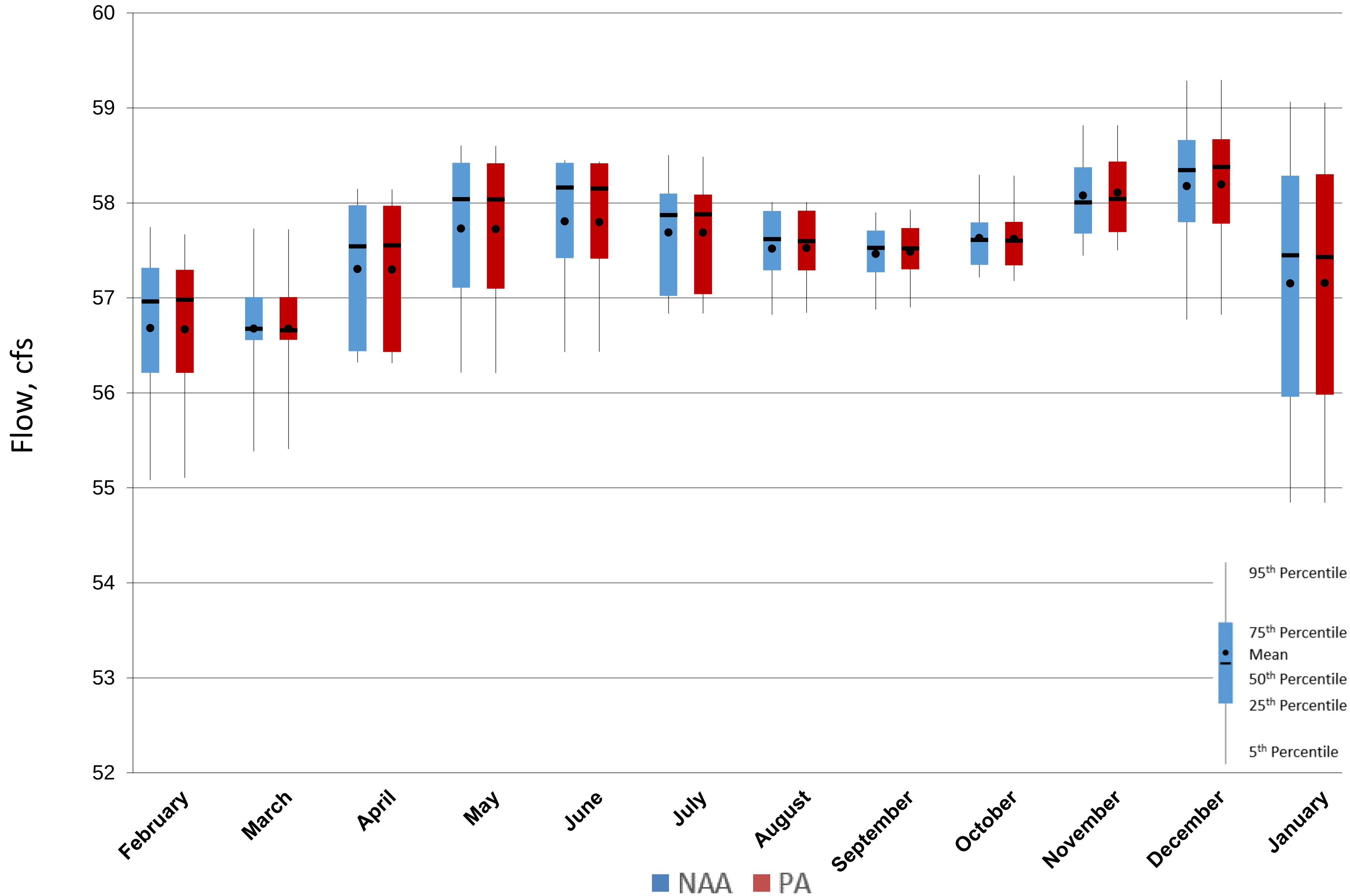


Figure 5.B.5-32-5. Monthly Flow Ranges For Morrow Island Distribution System M-line towards Suisun Bay, Dry Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 20 dry years.

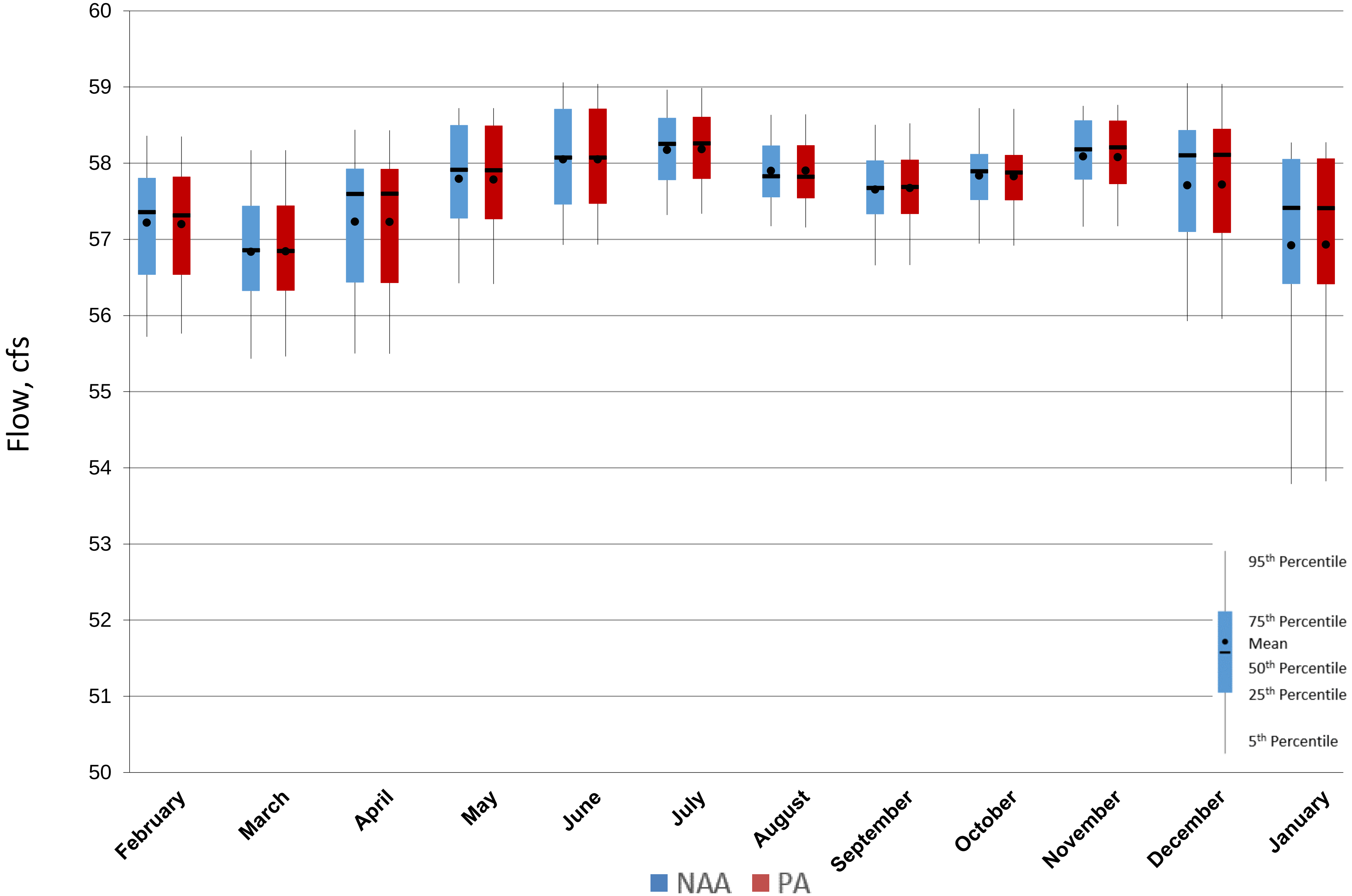


Figure 5.B.5-32-6. Monthly Flow Ranges For Morrow Island Distribution System M-line towards Suisun Bay, Critical Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 12 critical years.

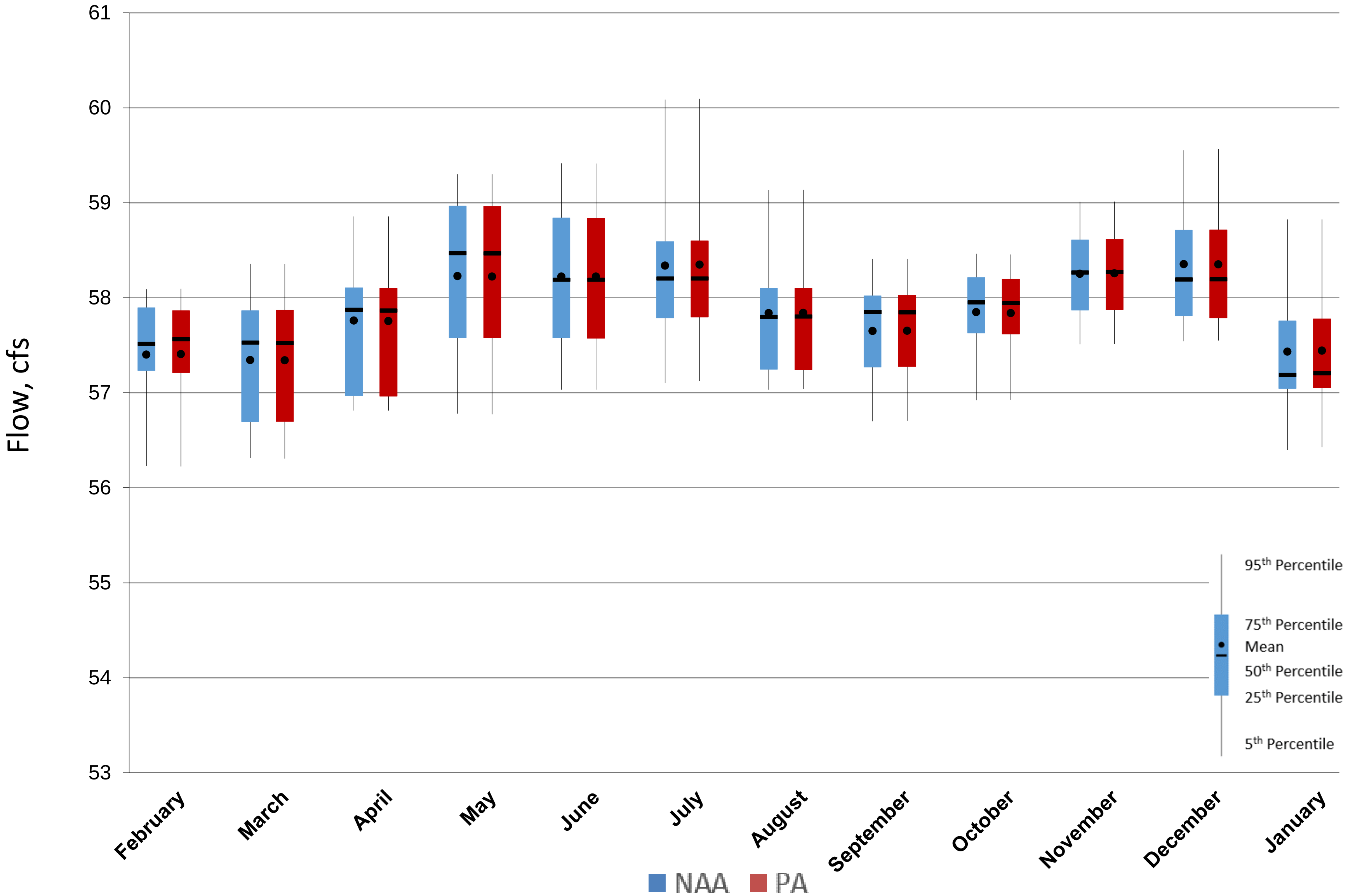
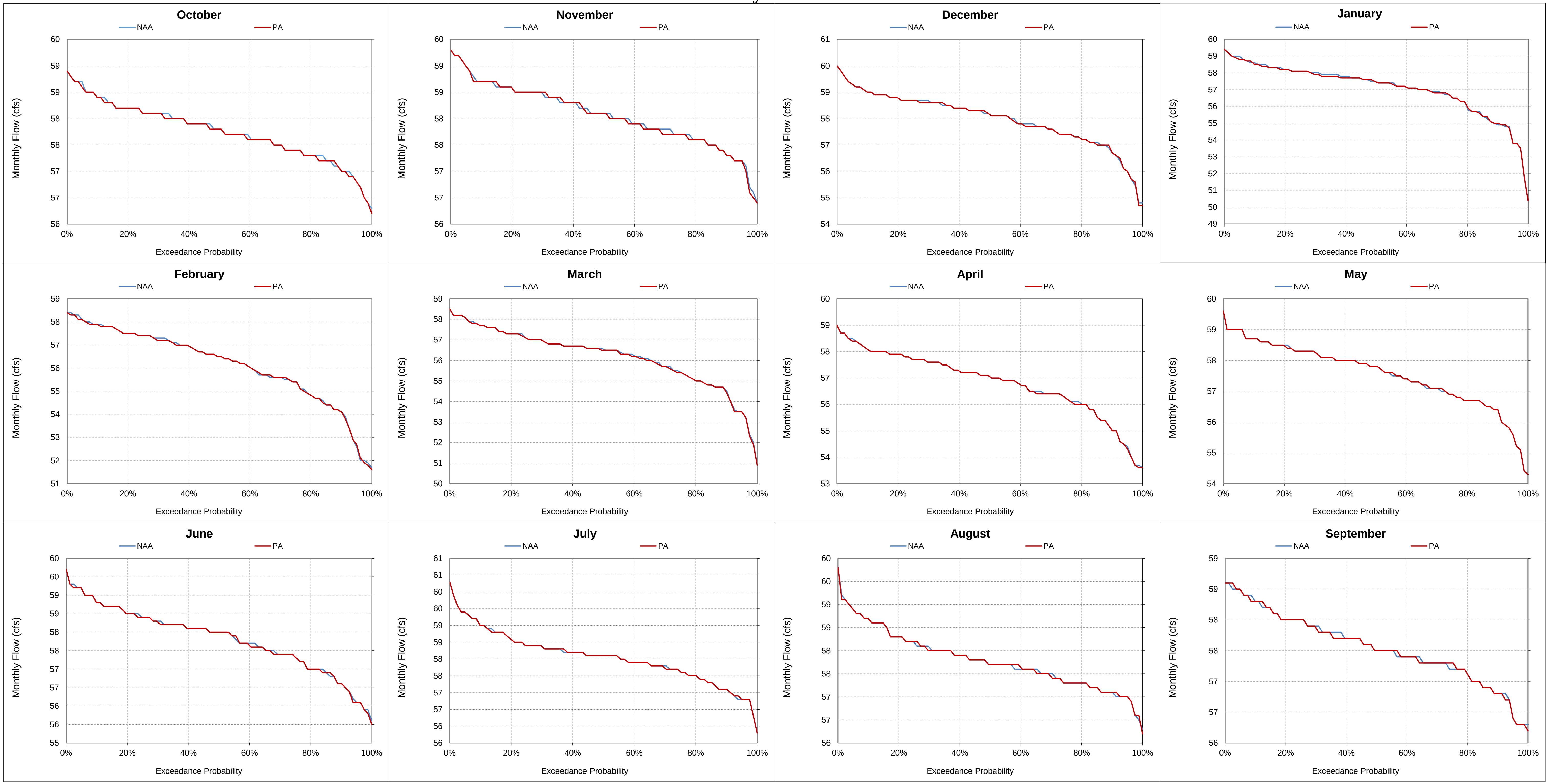
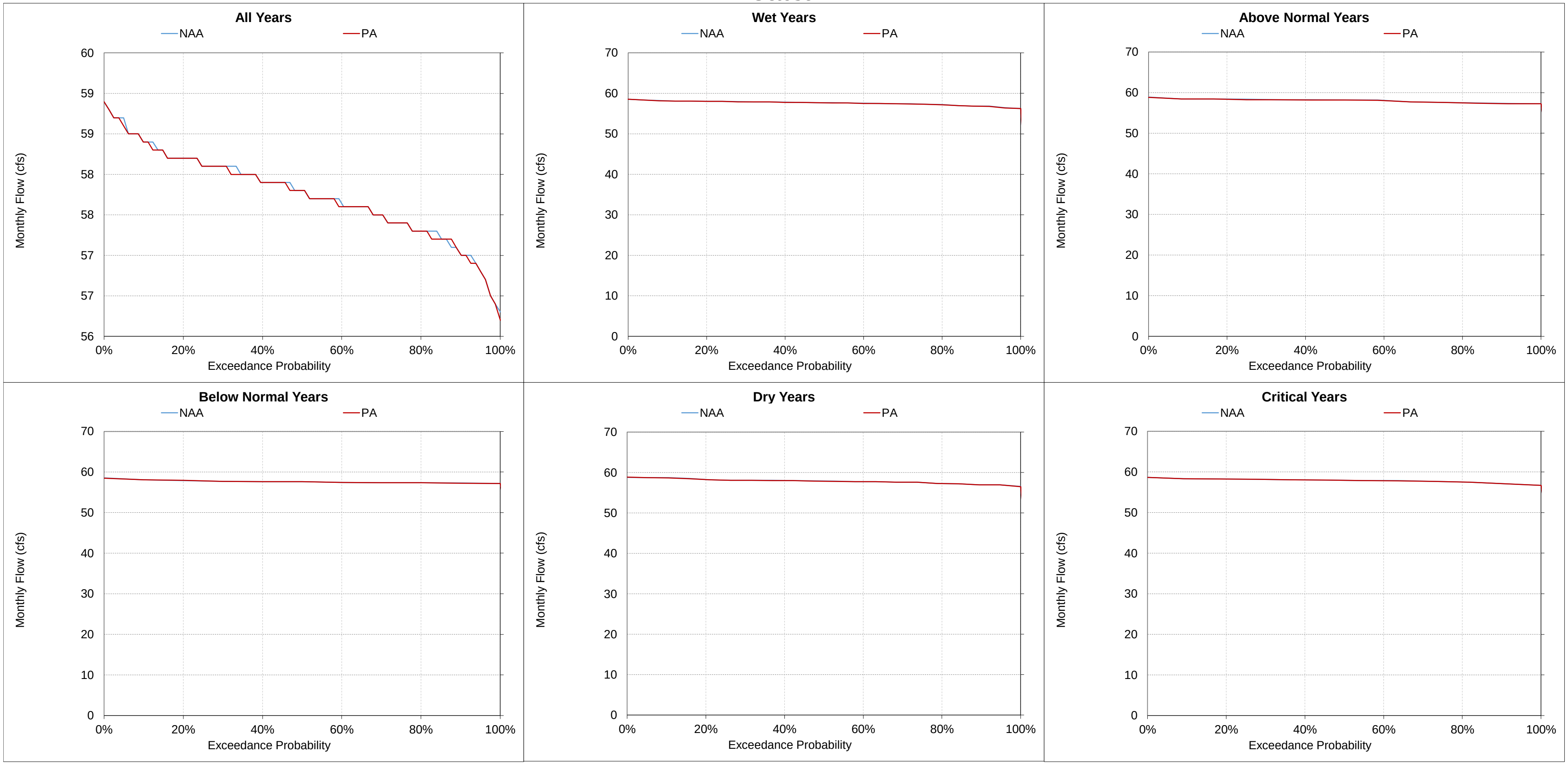


Figure 5.B.5-32-7. Morrow Island Distribution System M-line towards Suisun Bay, Monthly Flow Probability of Exceedance



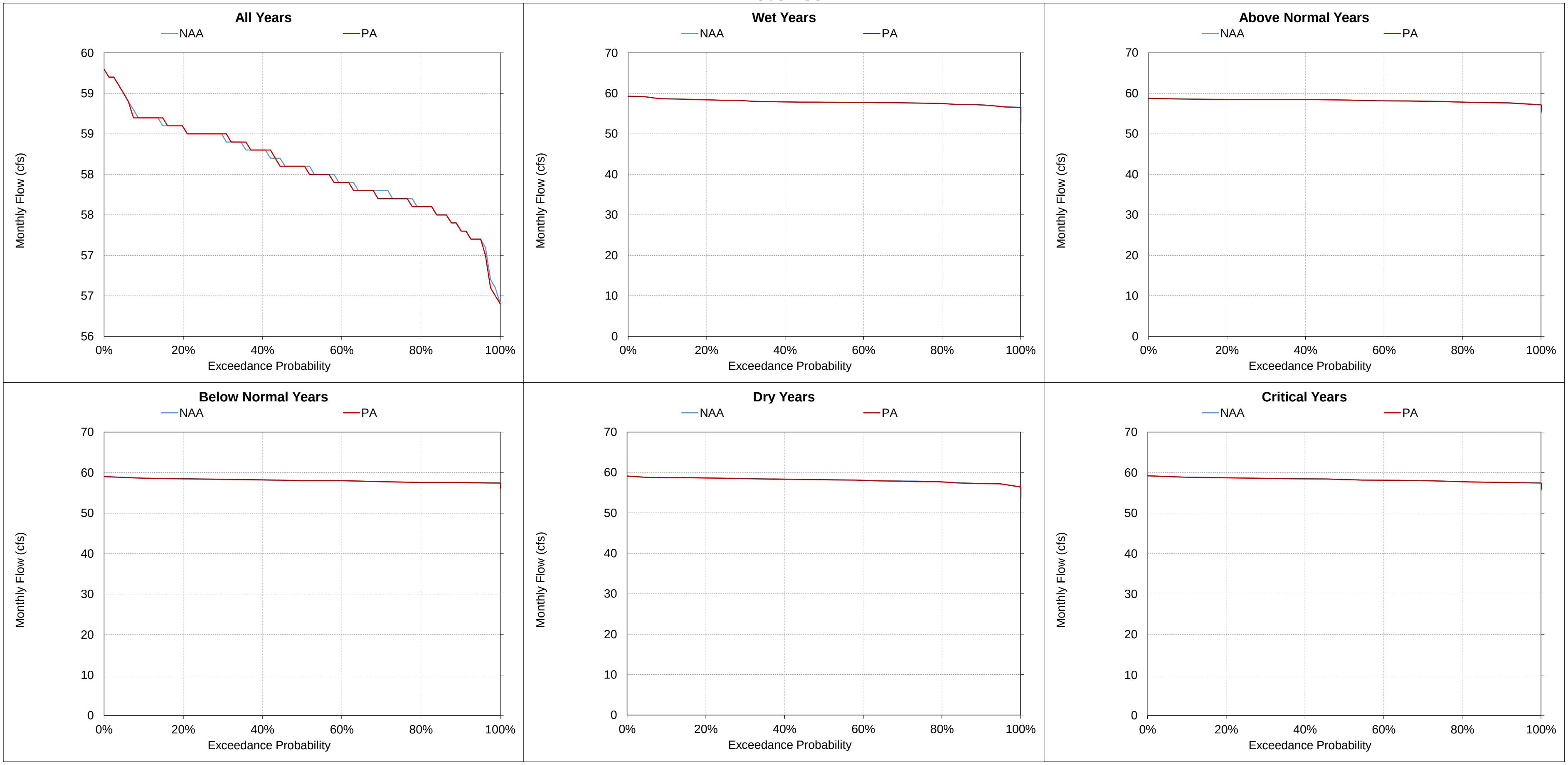
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-32-8. Morrow Island Distribution System M-line towards Suisun Bay, Monthly Flow October



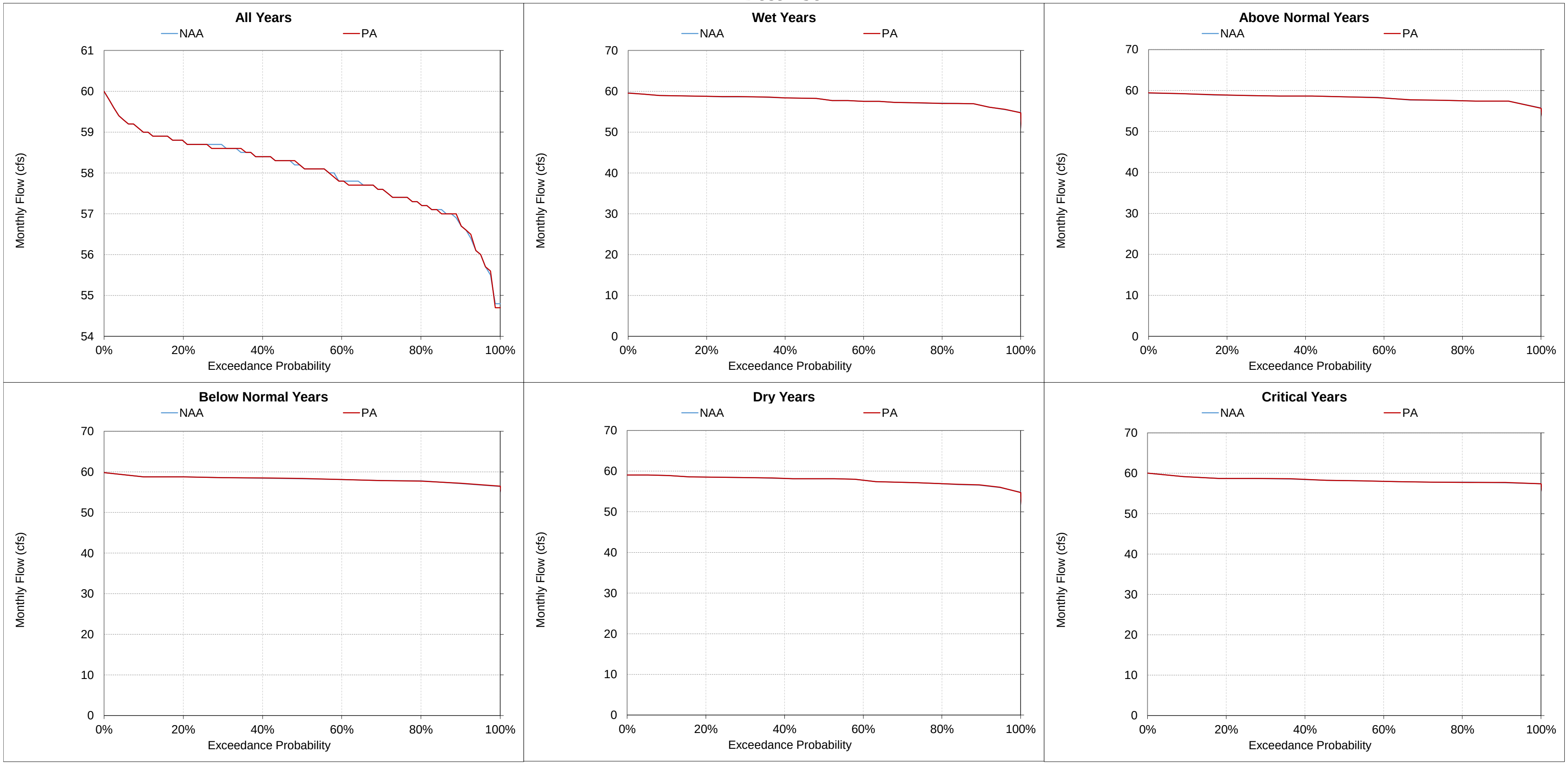
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-32-9. Morrow Island Distribution System M-line towards Suisun Bay, Monthly Flow November



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-32-10. Morrow Island Distribution System M-line towards Suisun Bay, Monthly Flow December



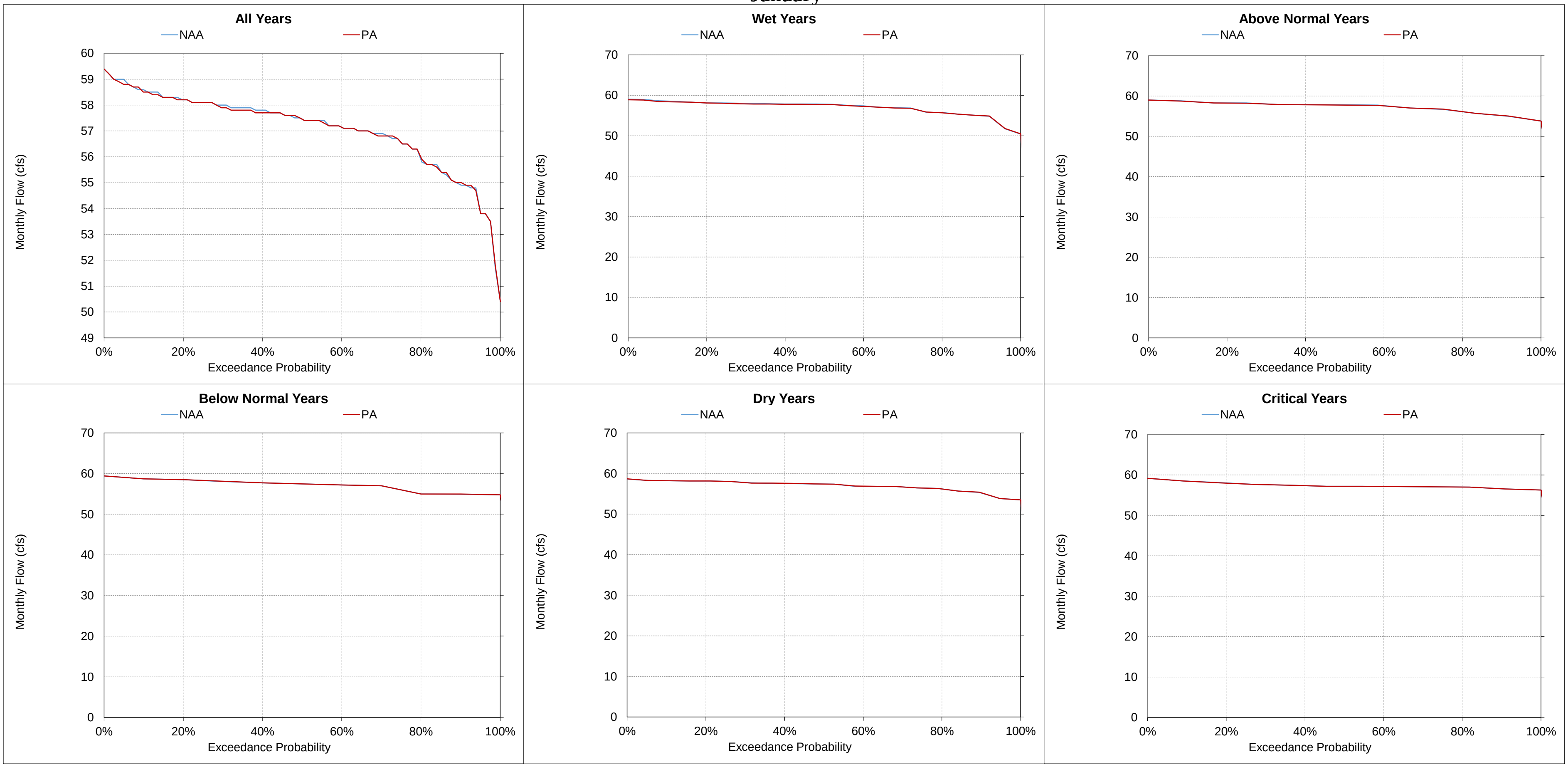
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

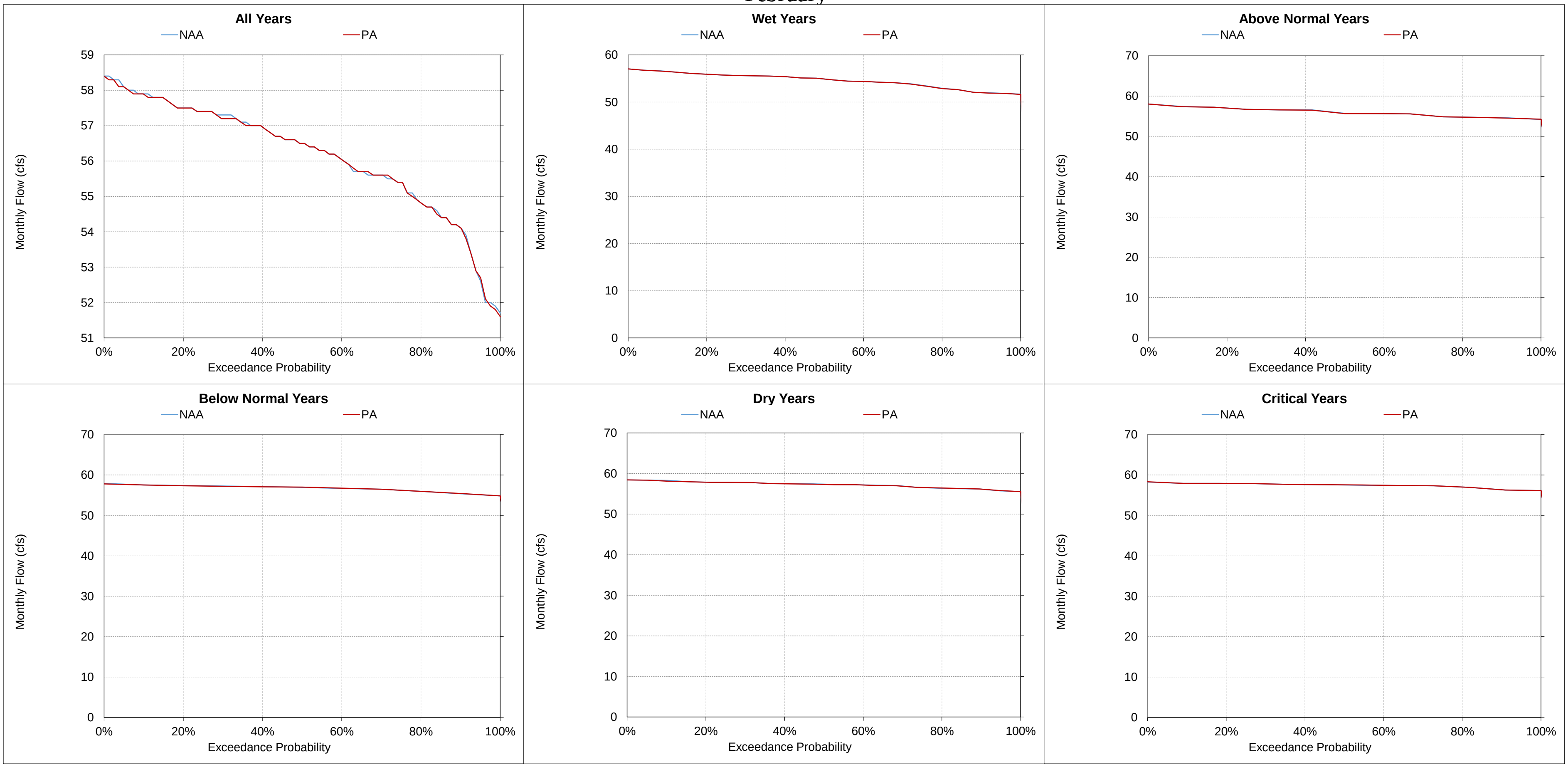
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-32-11. Morrow Island Distribution System M-line towards Suisun Bay, Monthly Flow
January



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-32-12. Morrow Island Distribution System M-line towards Suisun Bay, Monthly Flow February



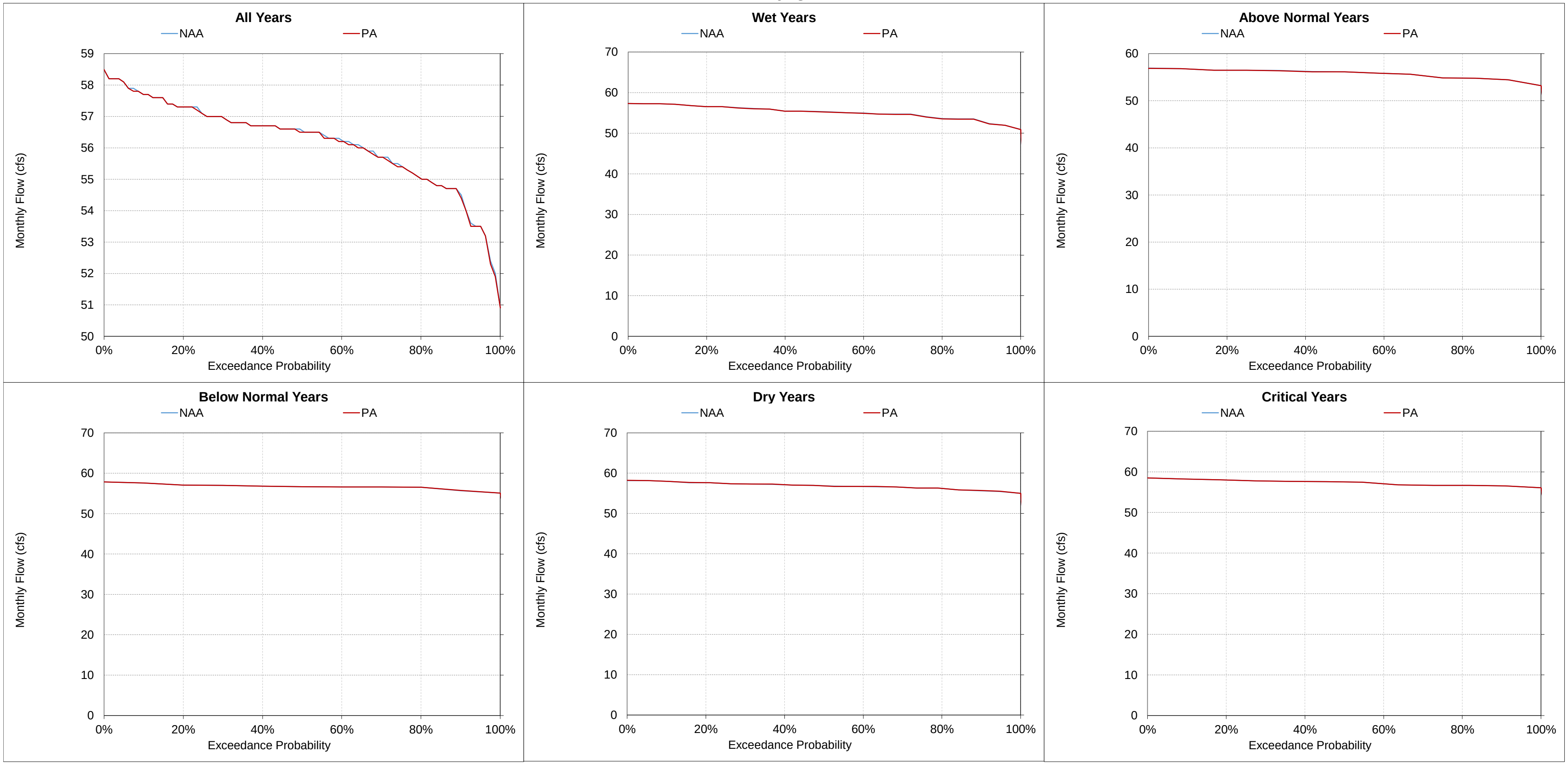
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

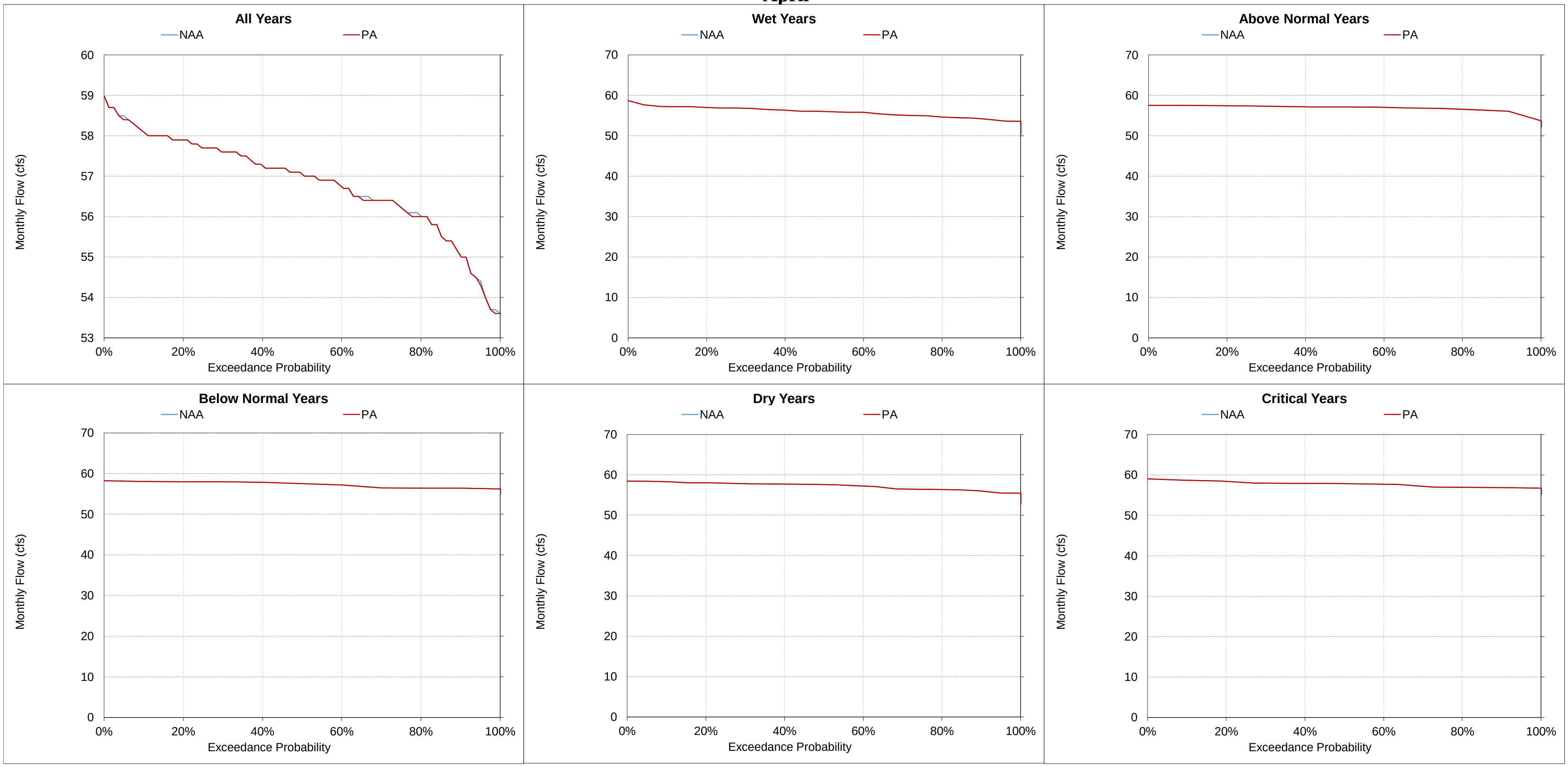
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-32-13. Morrow Island Distribution System M-line towards Suisun Bay, Monthly Flow
March



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-32-14. Morrow Island Distribution System M-line towards Suisun Bay, Monthly Flow April



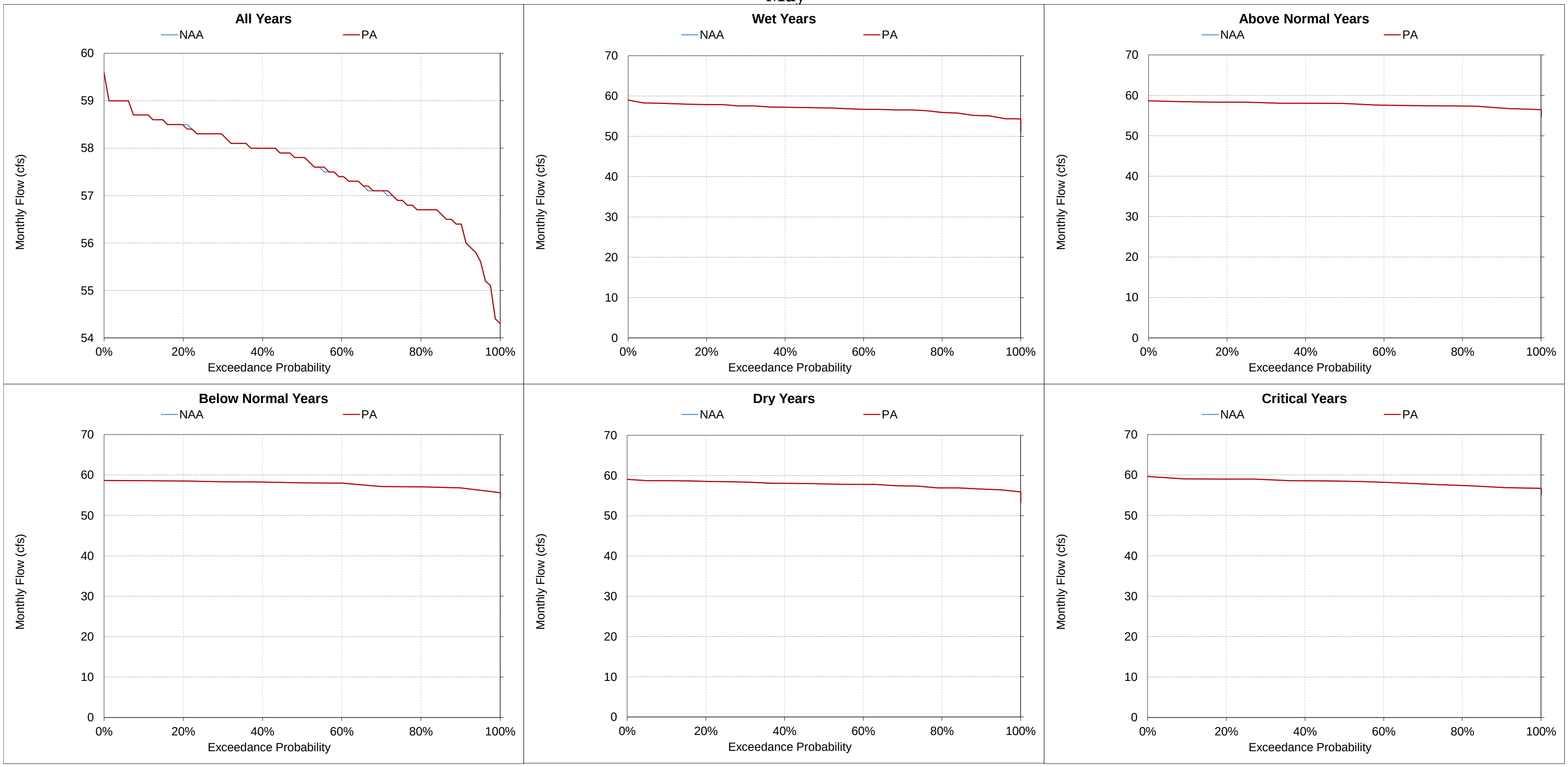
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

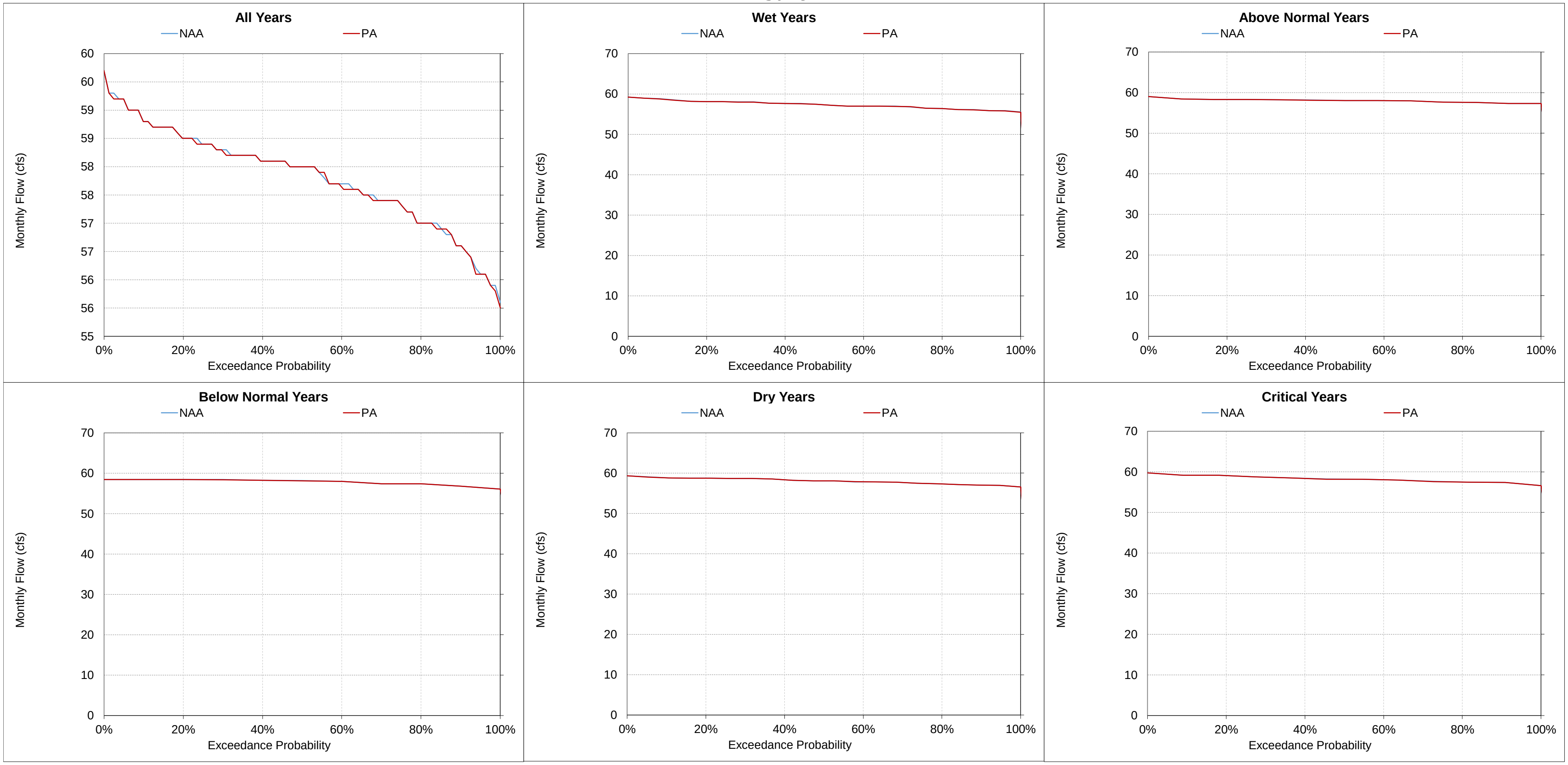
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-32-15. Morrow Island Distribution System M-line towards Suisun Bay, Monthly Flow May



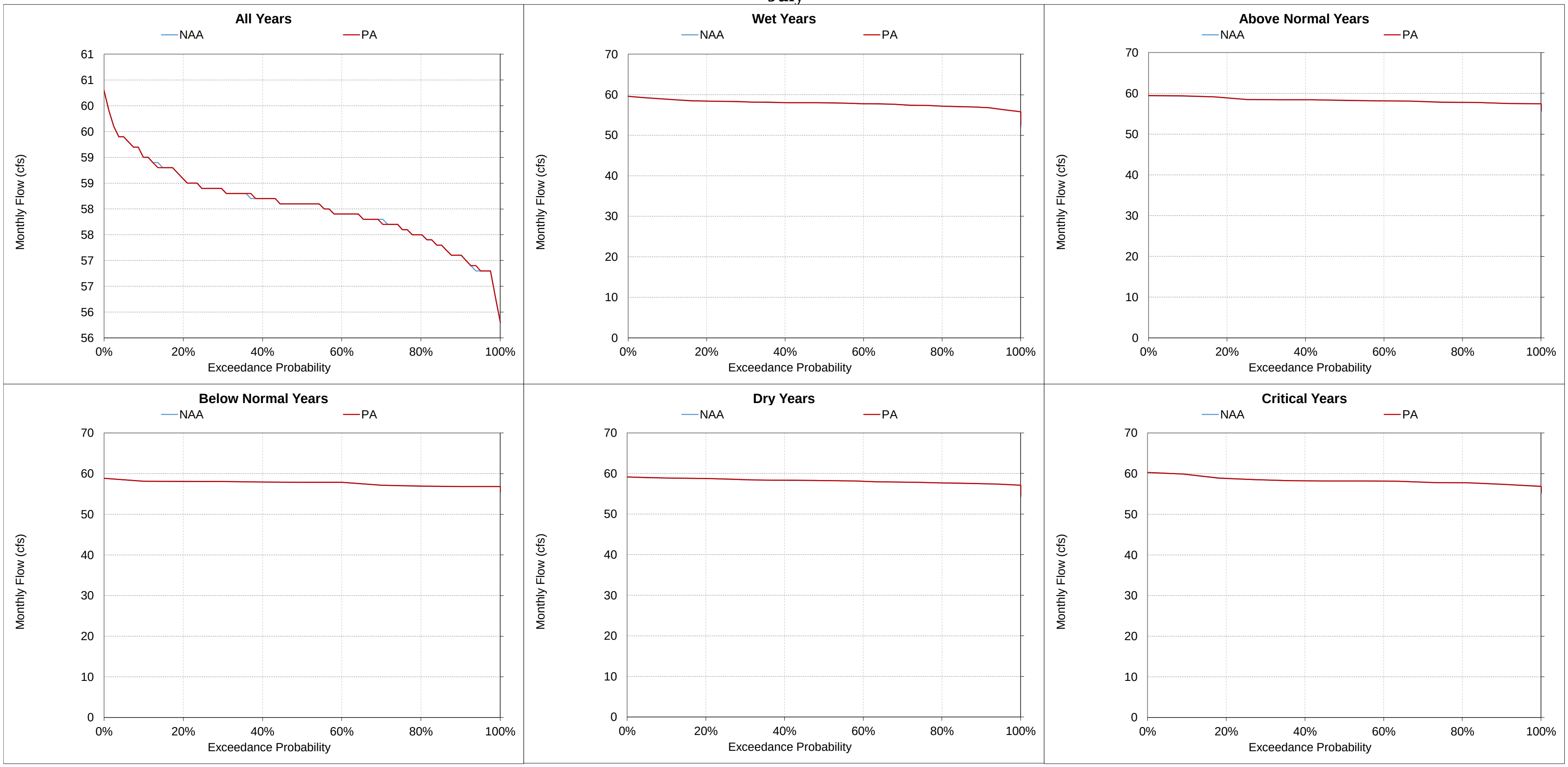
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-32-16. Morrow Island Distribution System M-line towards Suisun Bay, Monthly Flow June



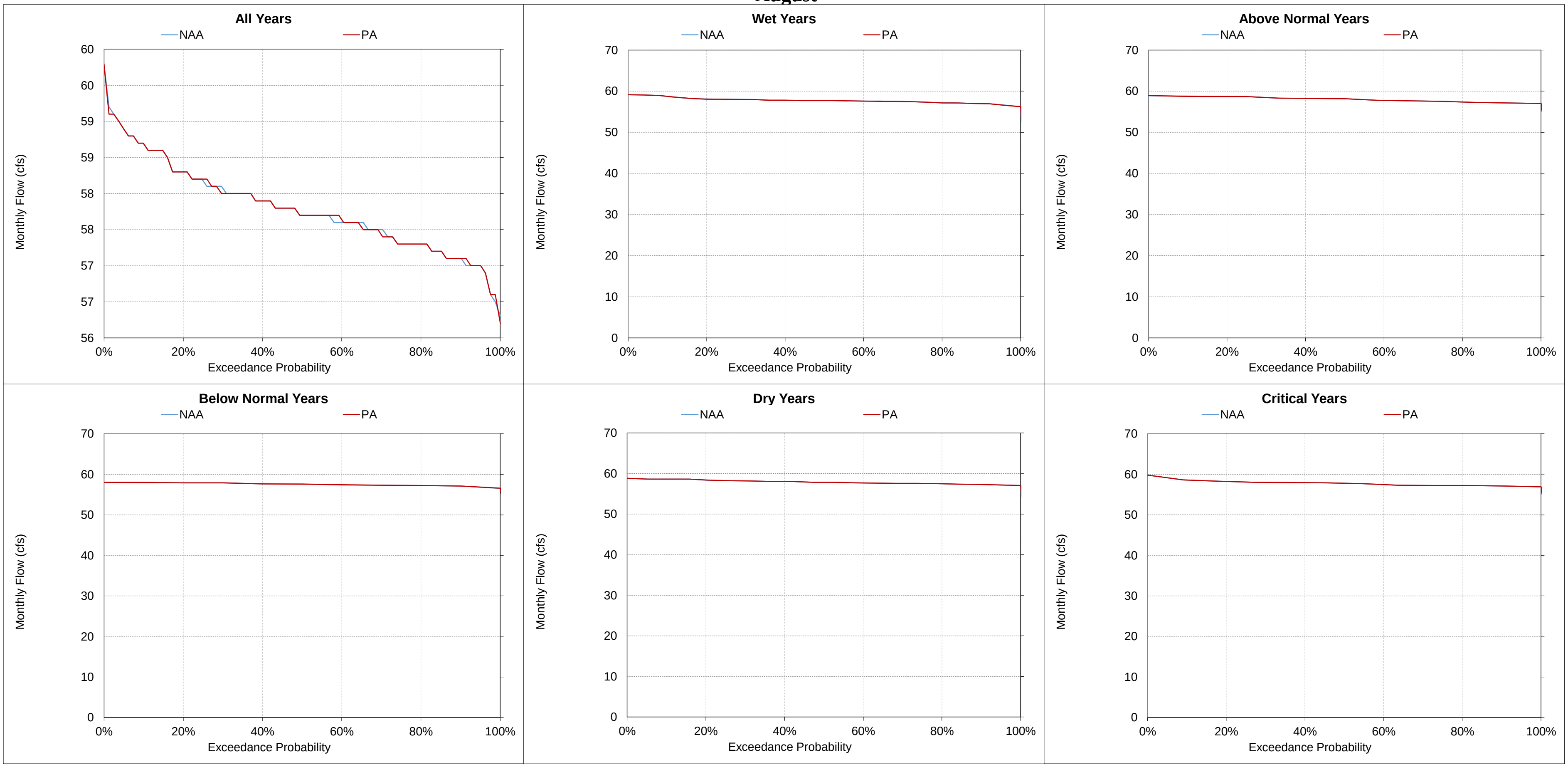
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-32-17. Morrow Island Distribution System M-line towards Suisun Bay, Monthly Flow
July



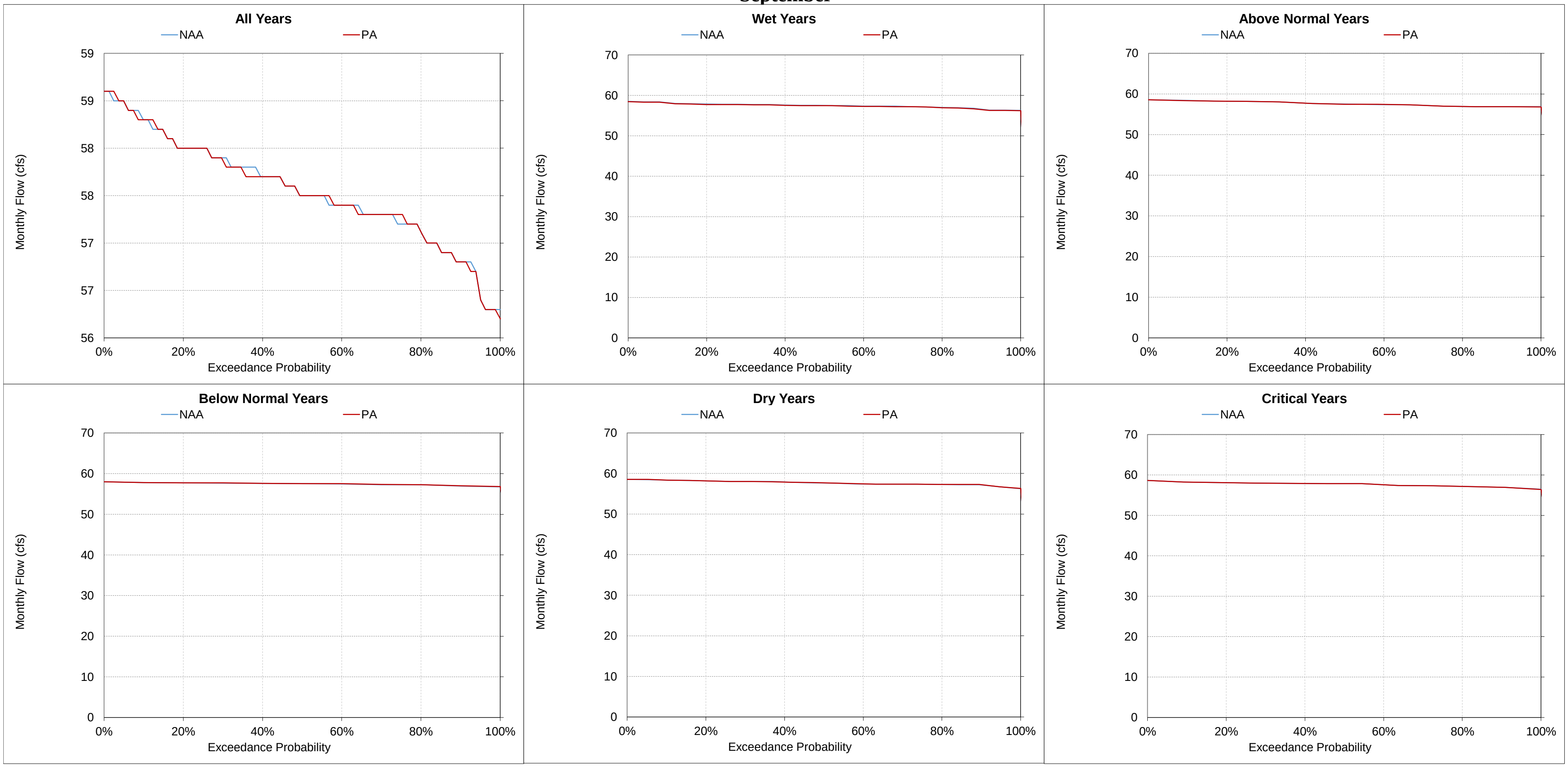
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-32-18. Morrow Island Distribution System M-line towards Suisun Bay, Monthly Flow
August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-32-19. Morrow Island Distribution System M-line towards Suisun Bay, Monthly Flow September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-33. Morrow Island Distribution System C-line, Monthly Flow

Statistic	Monthly Flow (cfs)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	23	23	0	0%	23	23	0	0%	23	23	0	0%	23	22	0	0%	22	22	0	0%	22	22	0	0%
20%	23	23	0	0%	23	23	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%
30%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%
40%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%
50%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%
60%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%
70%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	21	21	0	0%	21	21	0	0%
80%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	21	21	0	0%	21	21	0	0%
90%	22	22	0	0%	22	22	0	0%	22	22	0	0%	21	21	0	0%	21	21	0	0%	21	21	0	0%
Long Term Full Simulation Period[b]	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	21	21	0	0%
Water Year Types[c]																							0	
Wet (32%)	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	21	21	0	0%	21	21	0	0%
Above Normal (16%)	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	21	21	0	0%
Below Normal (13%)	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%
Dry (24%)	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%
Critical (15%)	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%

Statistic	Monthly Flow (cfs)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	22	22	0	0%	22	22	0	0%	22	22	0	0%	23	23	0	0%	23	23	0	0%	23	23	0	0%
20%	22	22	0	0%	22	22	0	0%	22	22	0	0%	23	23	0	0%	23	23	0	0%	23	23	0	0%
30%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	23	23	0	0%	22	22	0	0%
40%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%
50%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%
60%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%
70%	21	21	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%
80%	21	21	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%
90%	21	21	0	0%	21	21	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%
Long Term Full Simulation Period[b]	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%
Water Year Types[c]																							0	
Wet (32%)	21	21	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%
Above Normal (16%)	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%
Below Normal (13%)	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%
Dry (24%)	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%
Critical (15%)	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%	22	22	0	0%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-33-1. Monthly Flow Ranges For Morrow Island Distribution System C-line, All Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario.

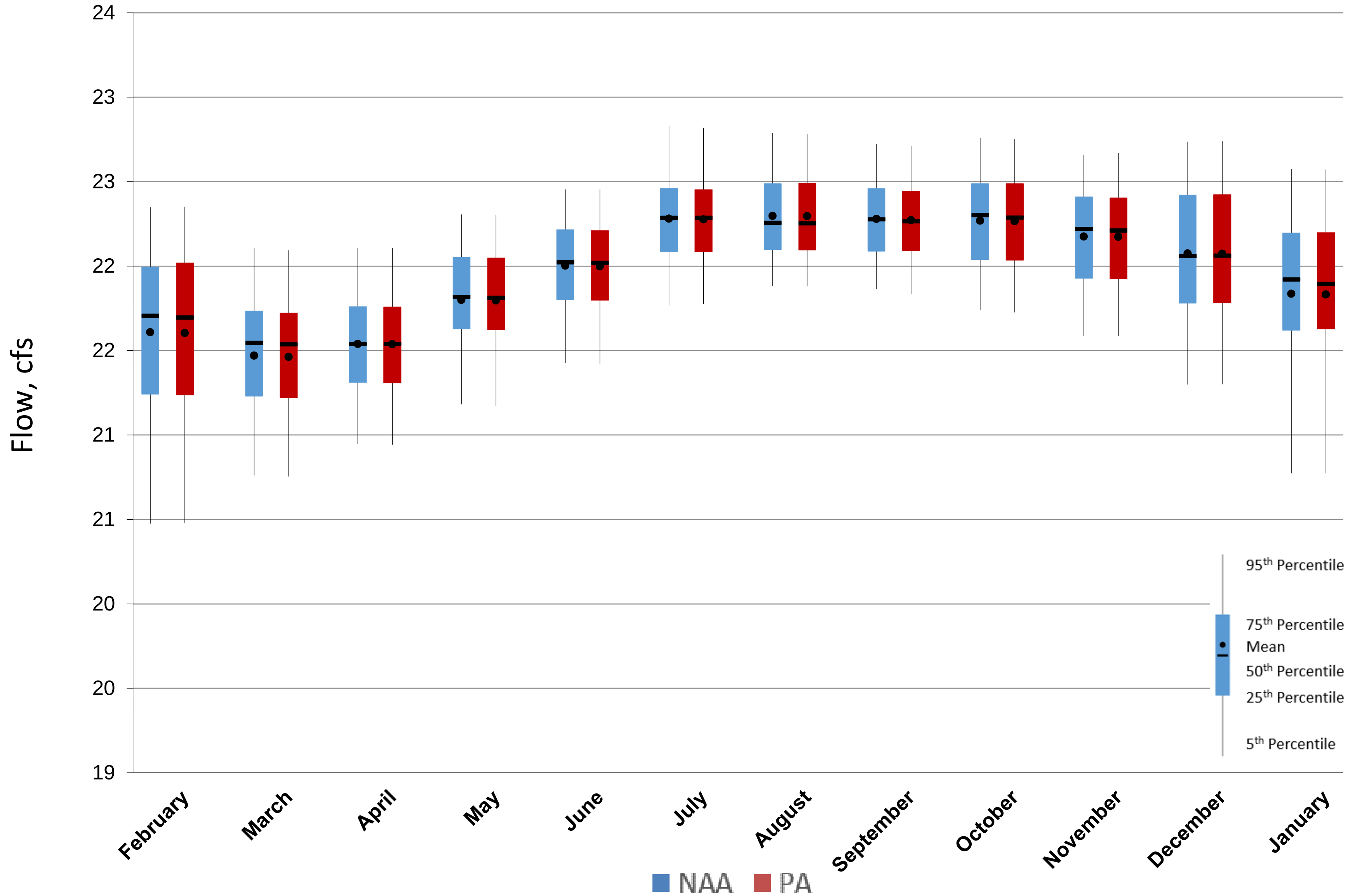


Figure 5.B.5-33-2. Monthly Flow Ranges For Morrow Island Distribution System C-line, Wet Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 26 wet years.

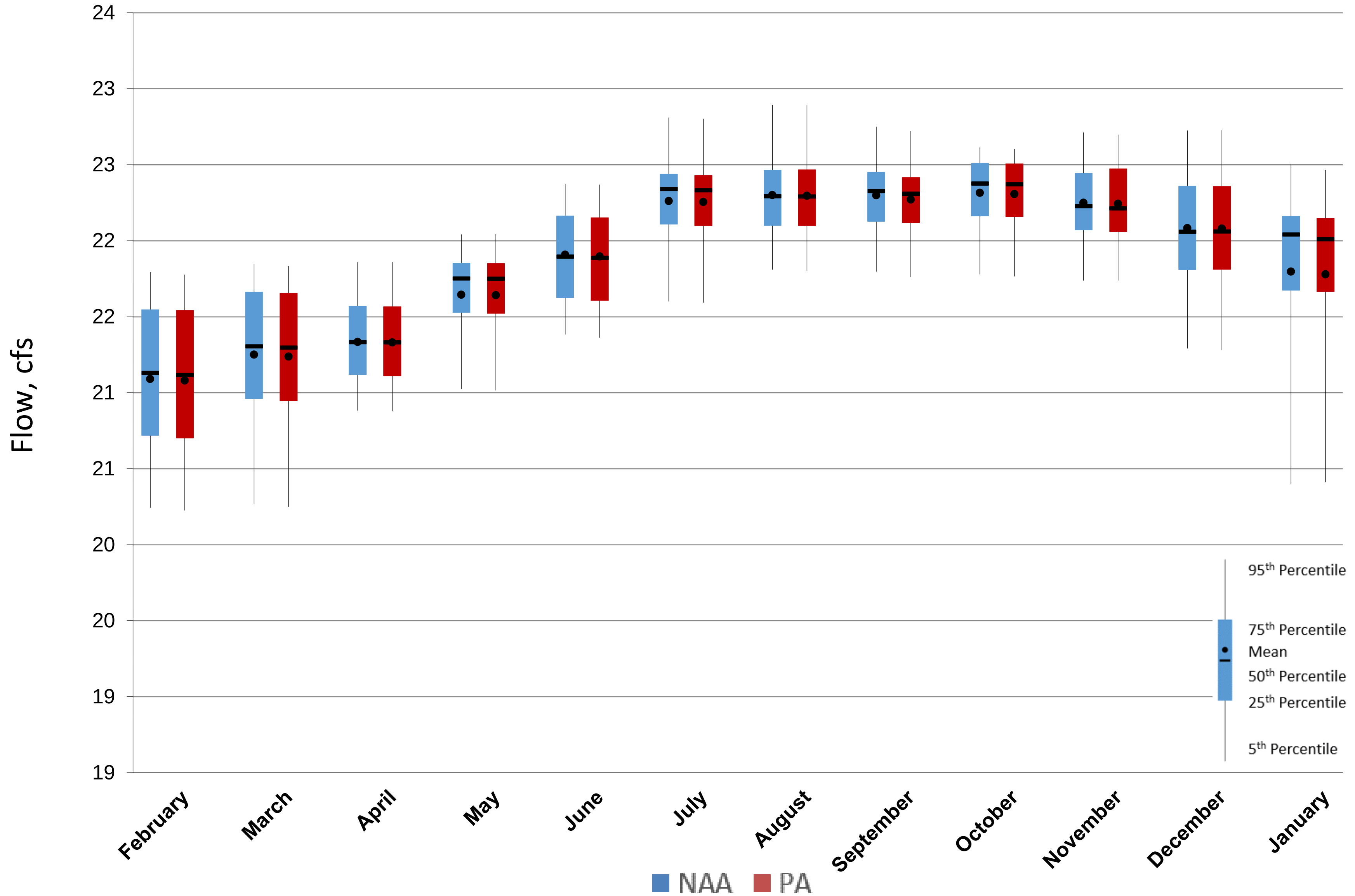


Figure 5.B.5-33-3. Monthly Flow Ranges For Morrow Island Distribution System C-line, Above Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 13 above normal years.

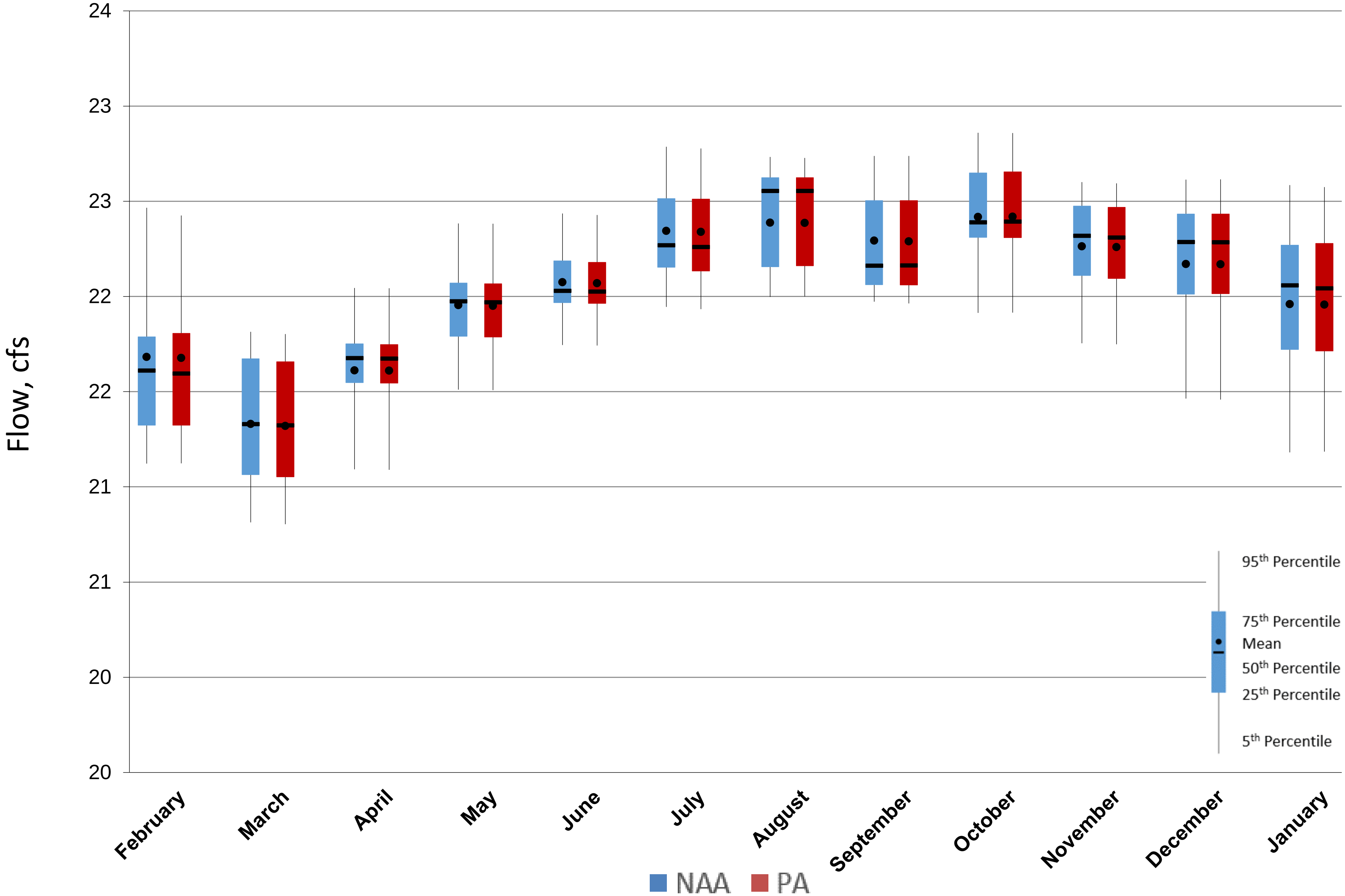


Figure 5.B.5-33-4. Monthly Flow Ranges For Morrow Island Distribution System C-line, Below Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 11 below normal years.

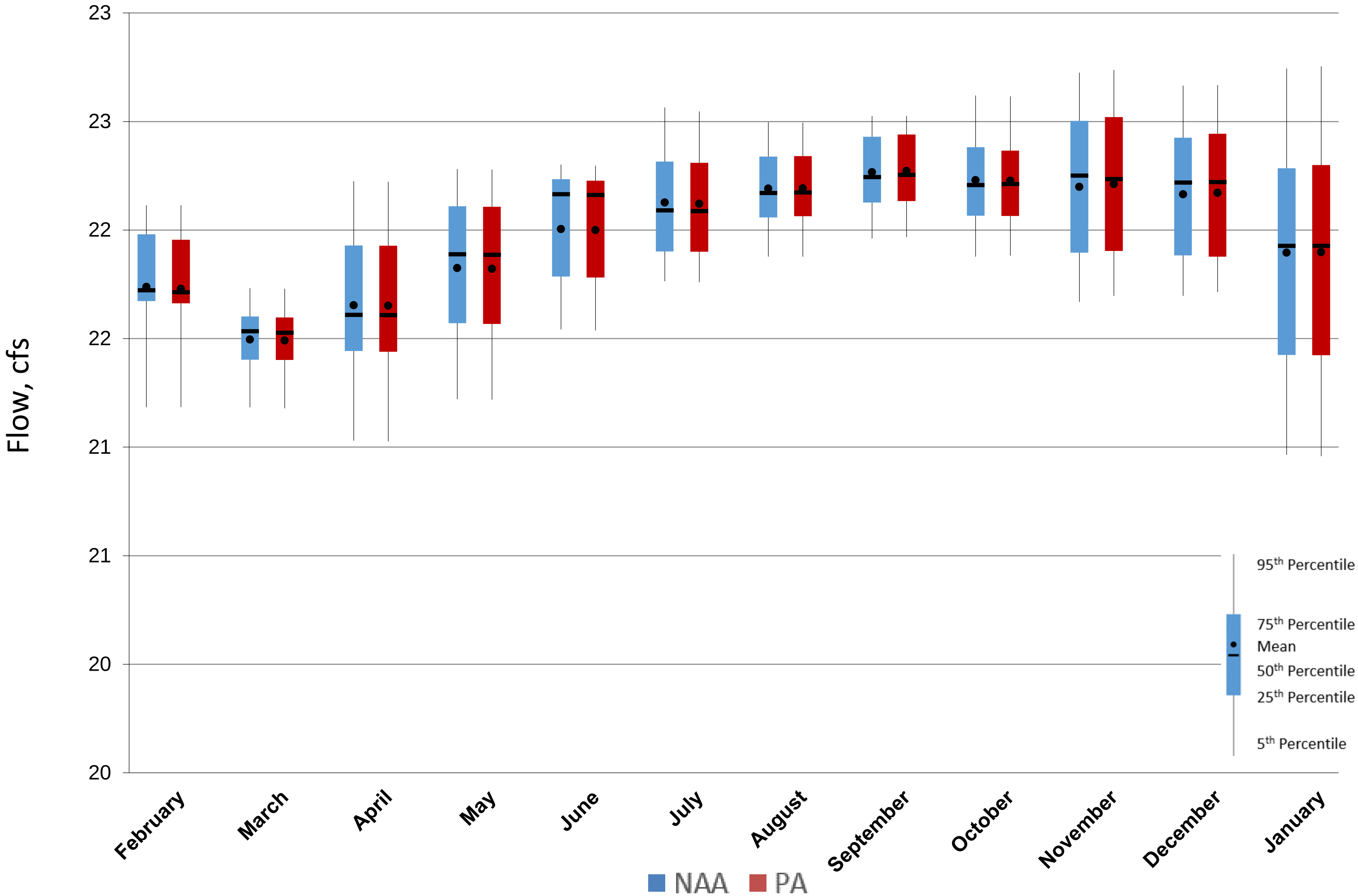


Figure 5.B.5-33-5. Monthly Flow Ranges For Morrow Island Distribution System C-line, Dry Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 20 dry years.

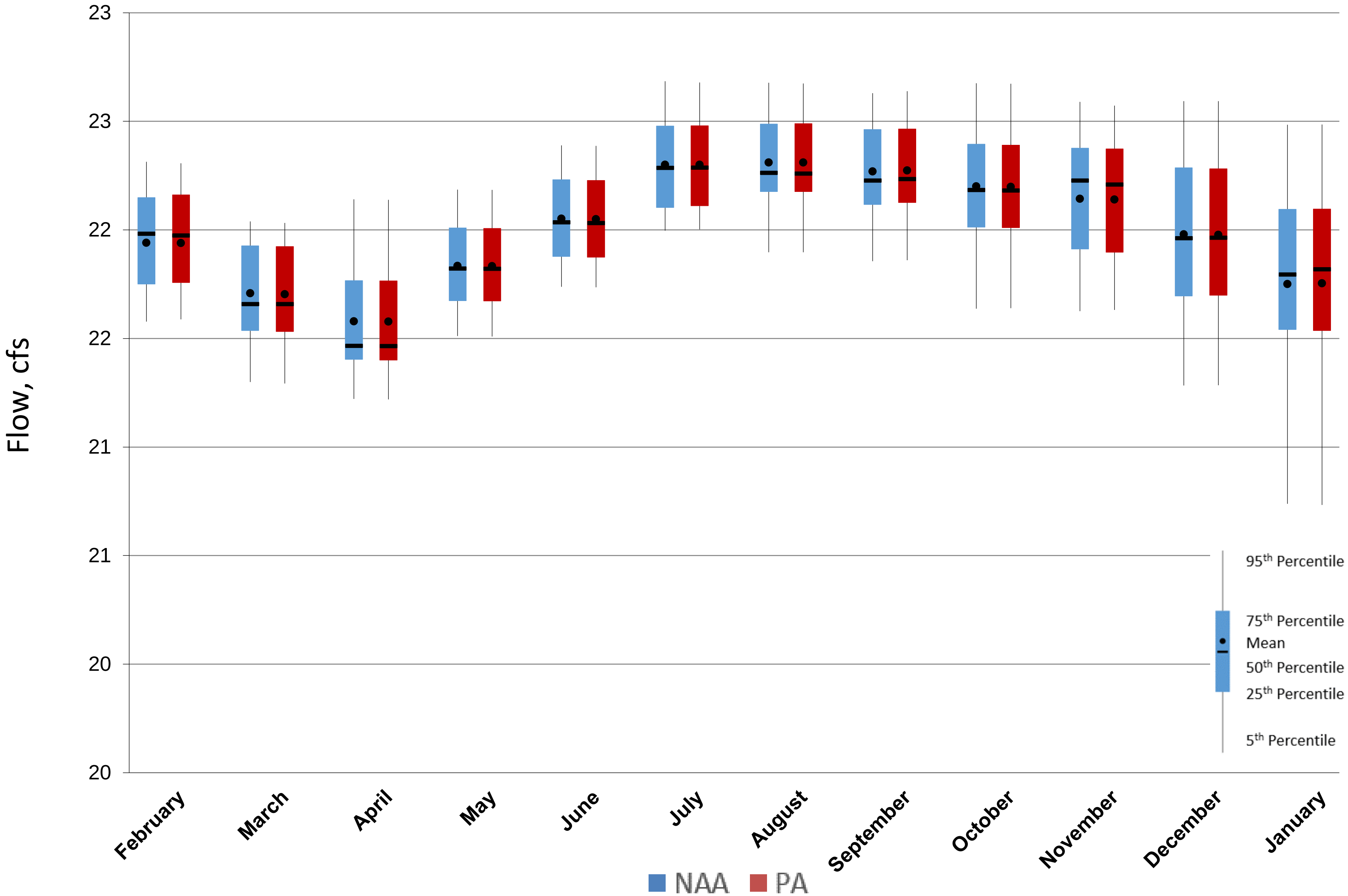


Figure 5.B.5-33-6. Monthly Flow Ranges For Morrow Island Distribution System C-line, Critical Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 12 critical years.

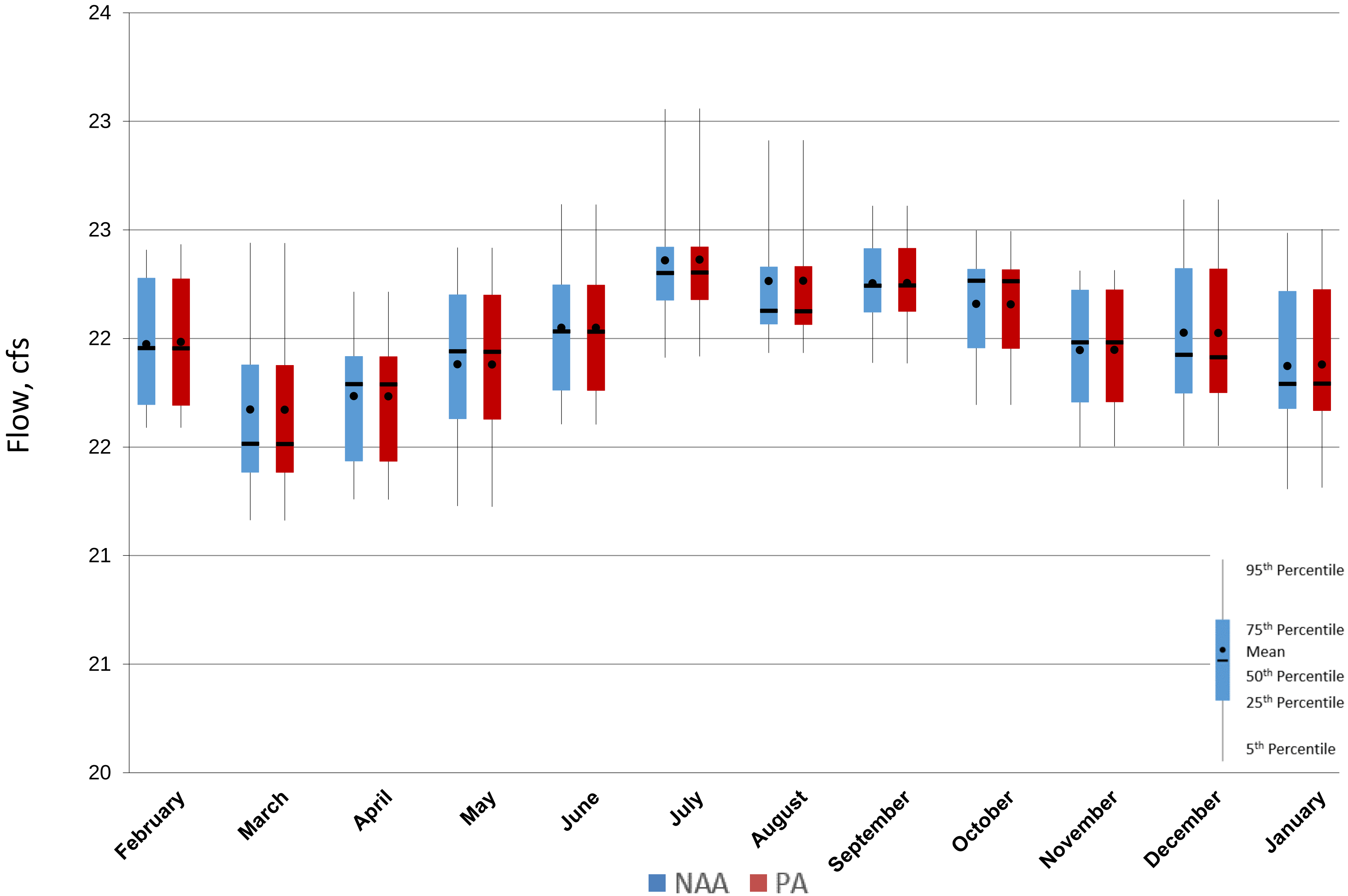
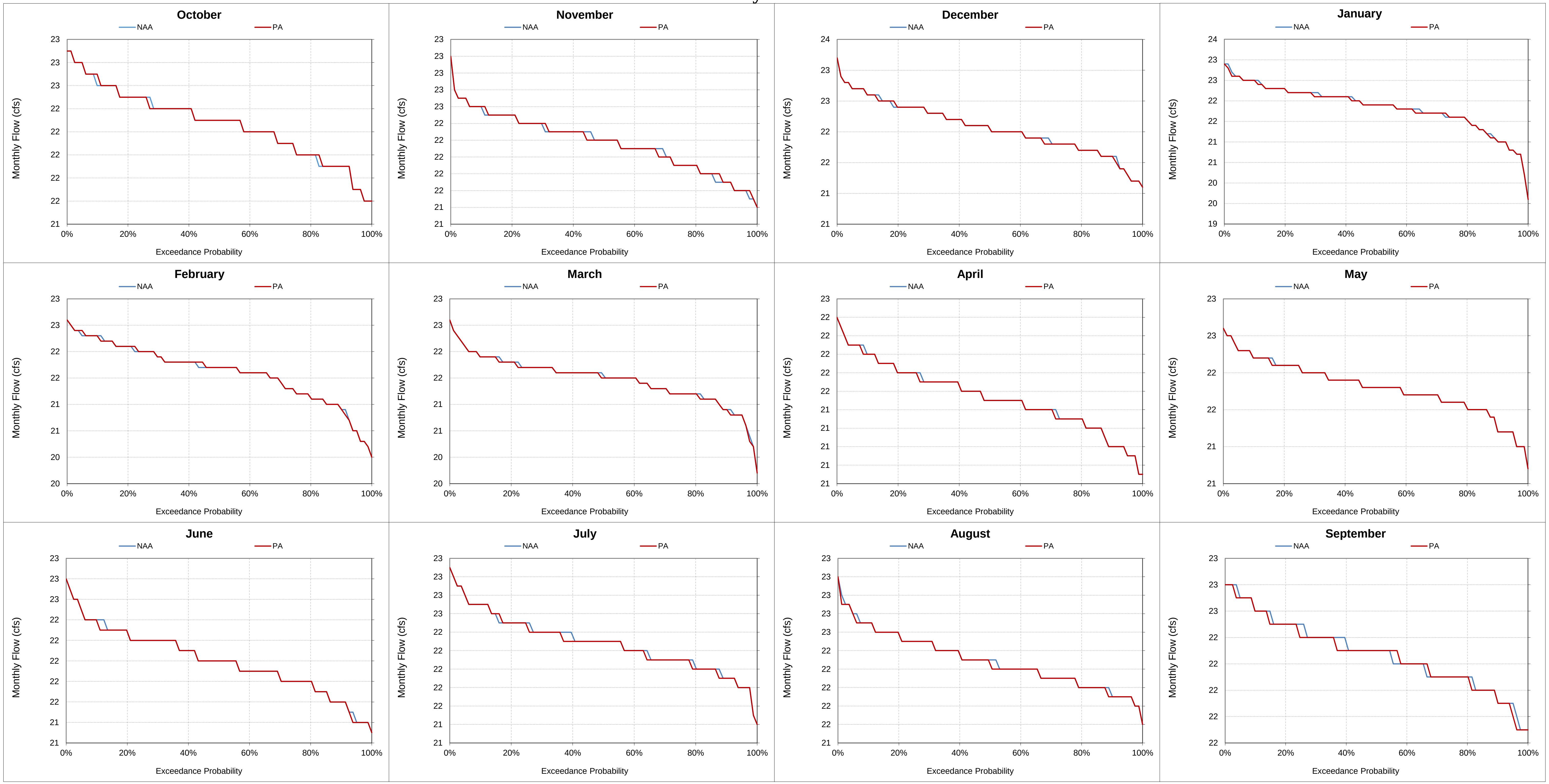
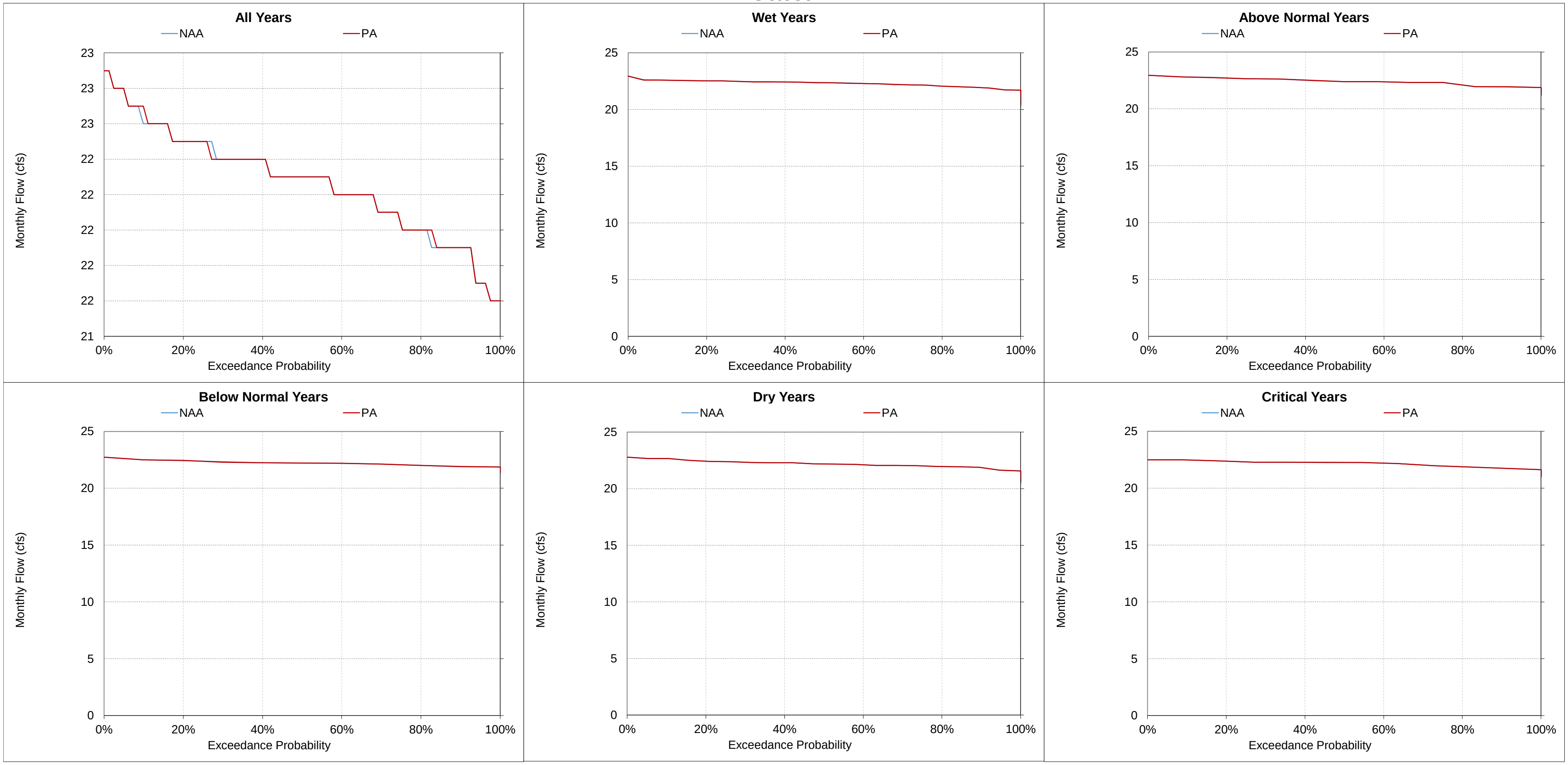


Figure 5.B.5-33-7. Morrow Island Distribution System C-line, Monthly Flow Probability of Exceedance



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-33-8. Morrow Island Distribution System C-line, Monthly Flow October



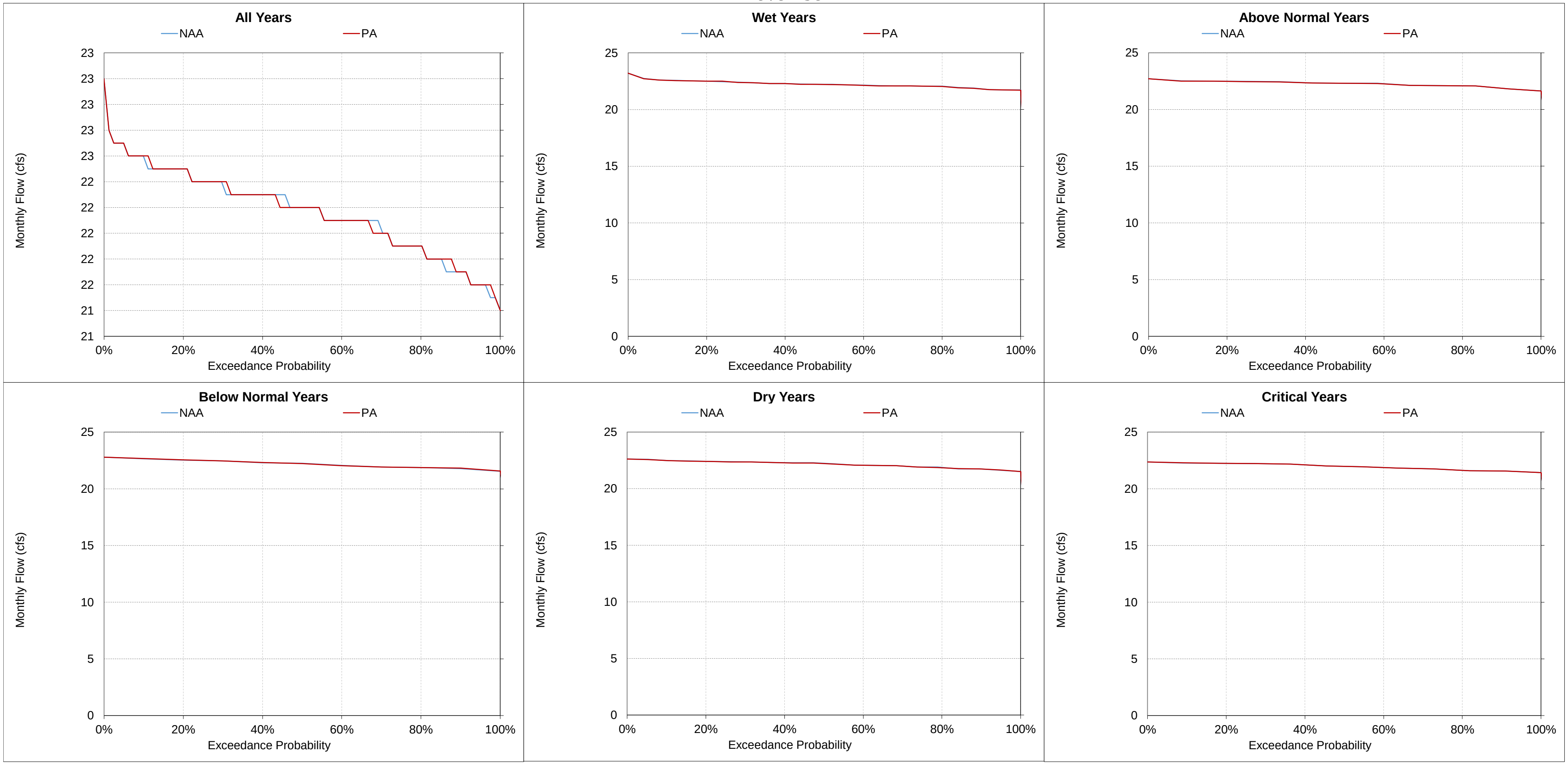
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

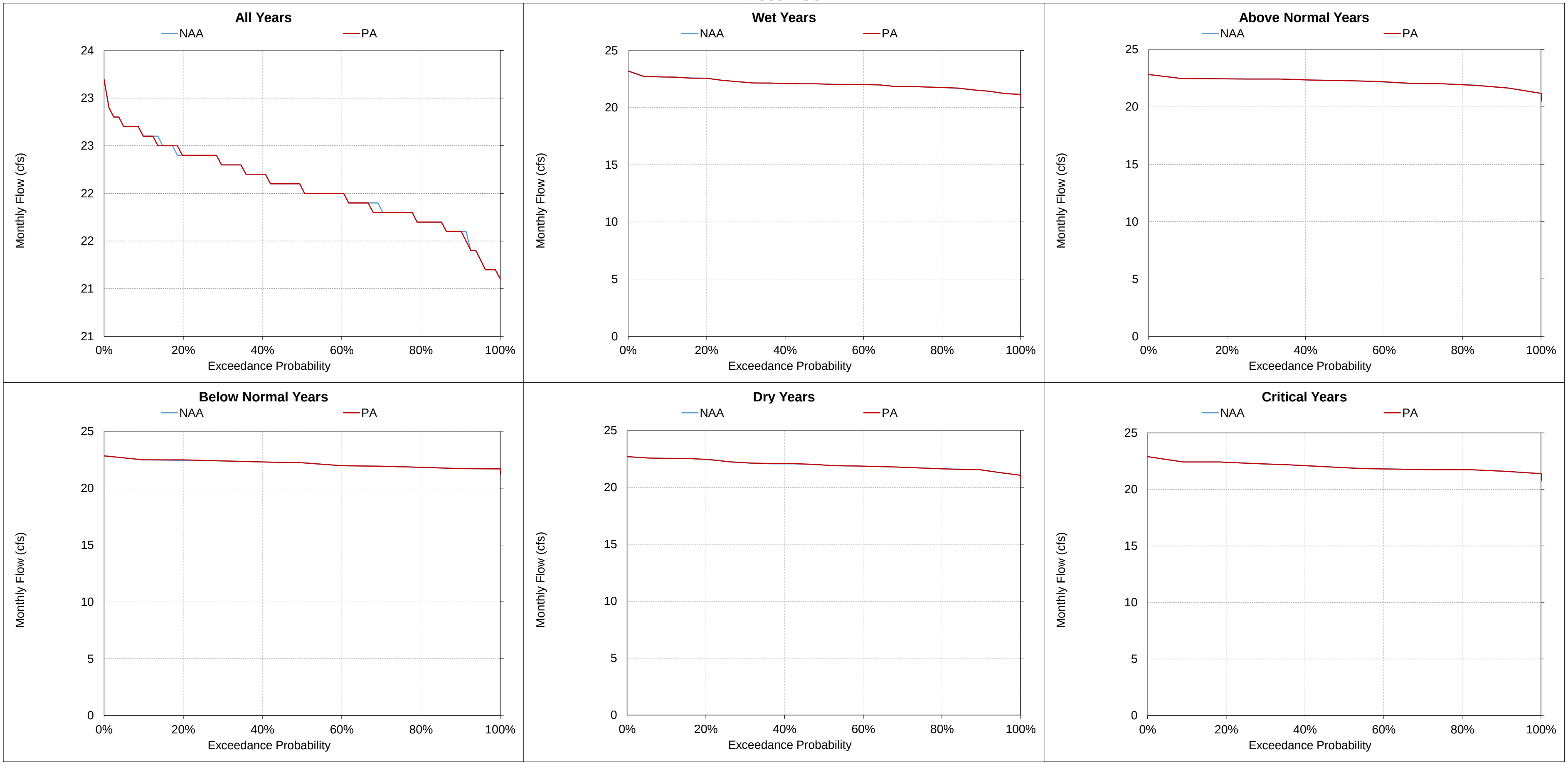
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-33-9. Morrow Island Distribution System C-line, Monthly Flow
November



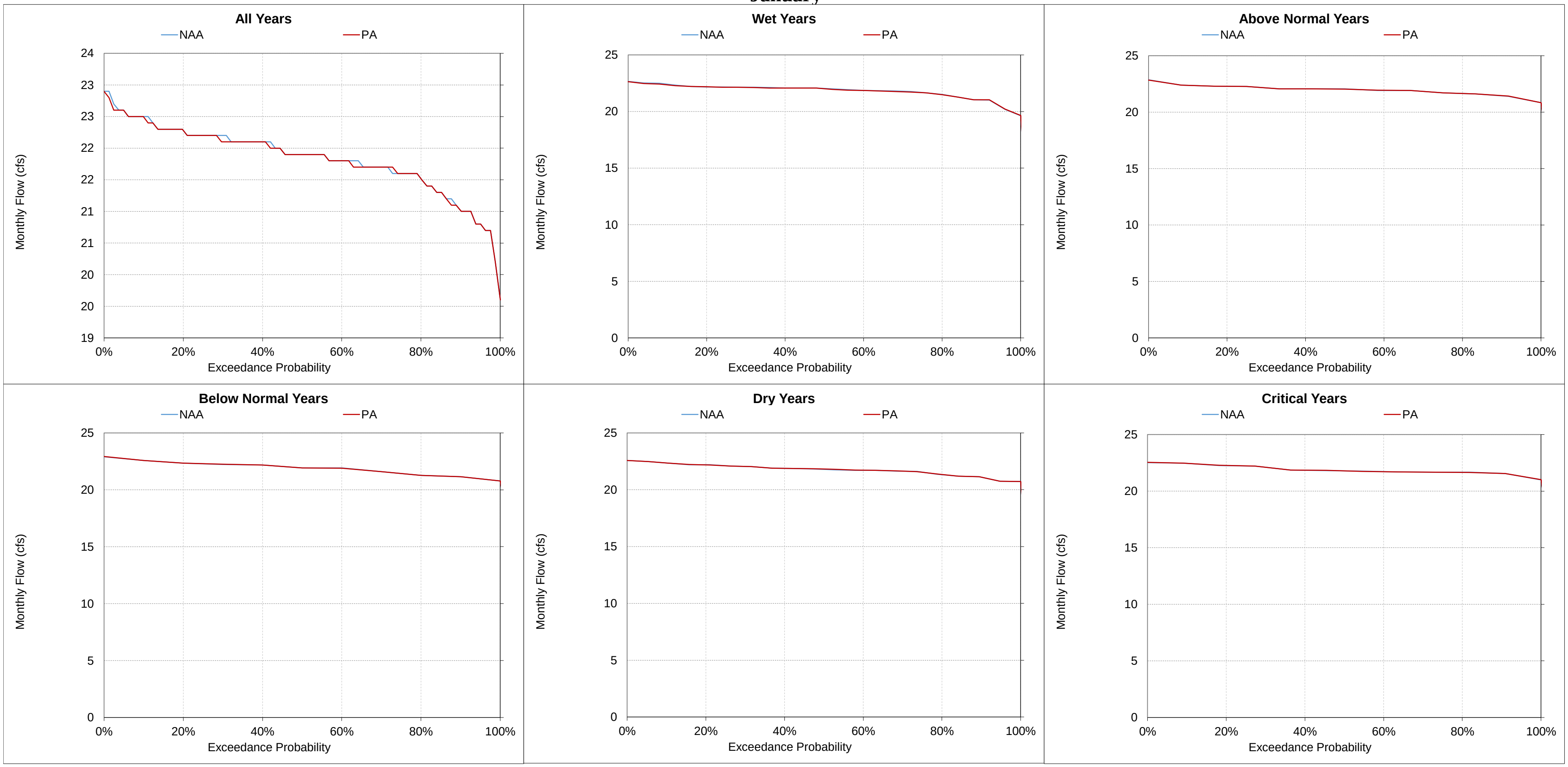
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-33-10. Morrow Island Distribution System C-line, Monthly Flow December



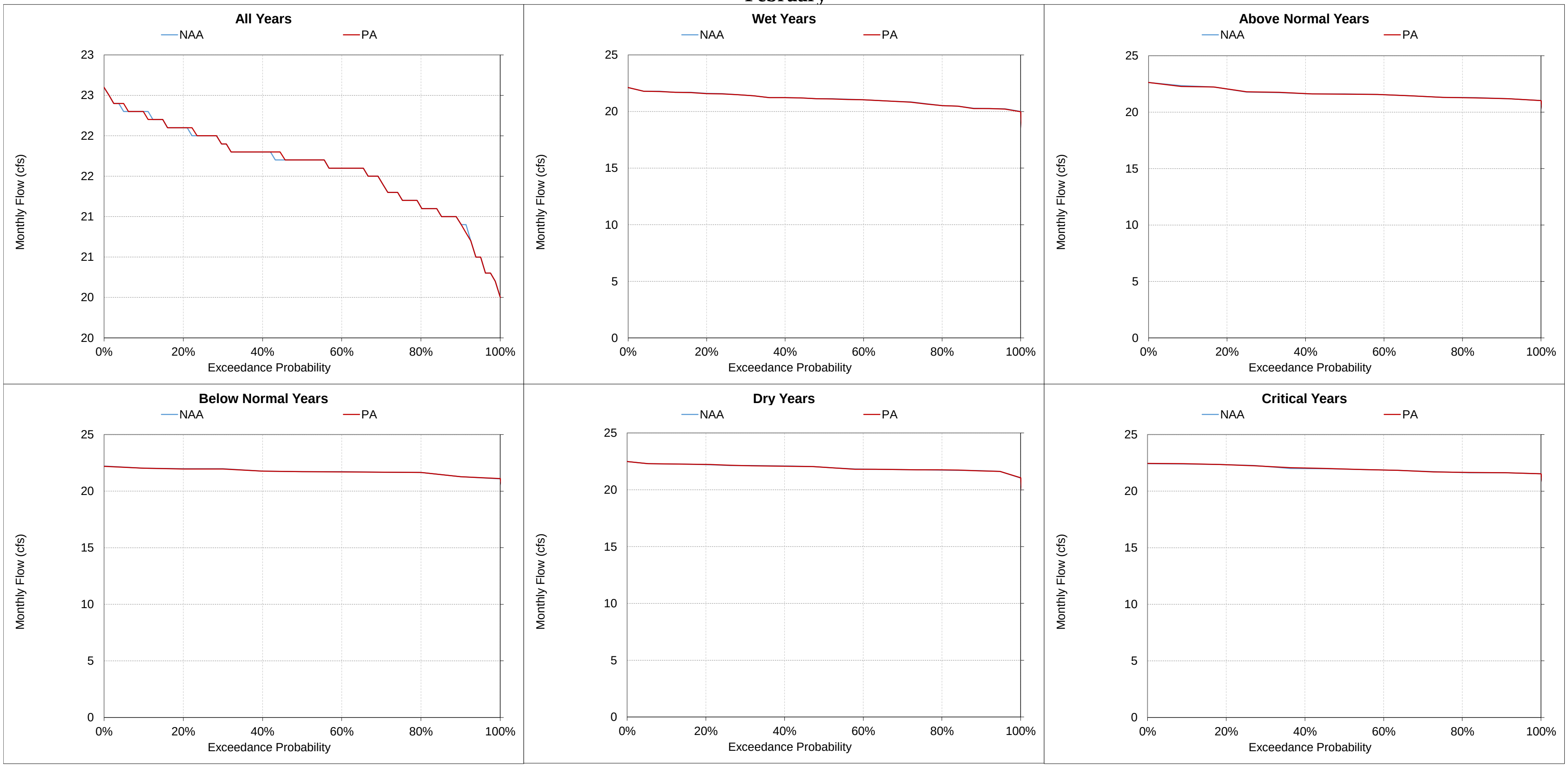
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-33-11. Morrow Island Distribution System C-line, Monthly Flow
January



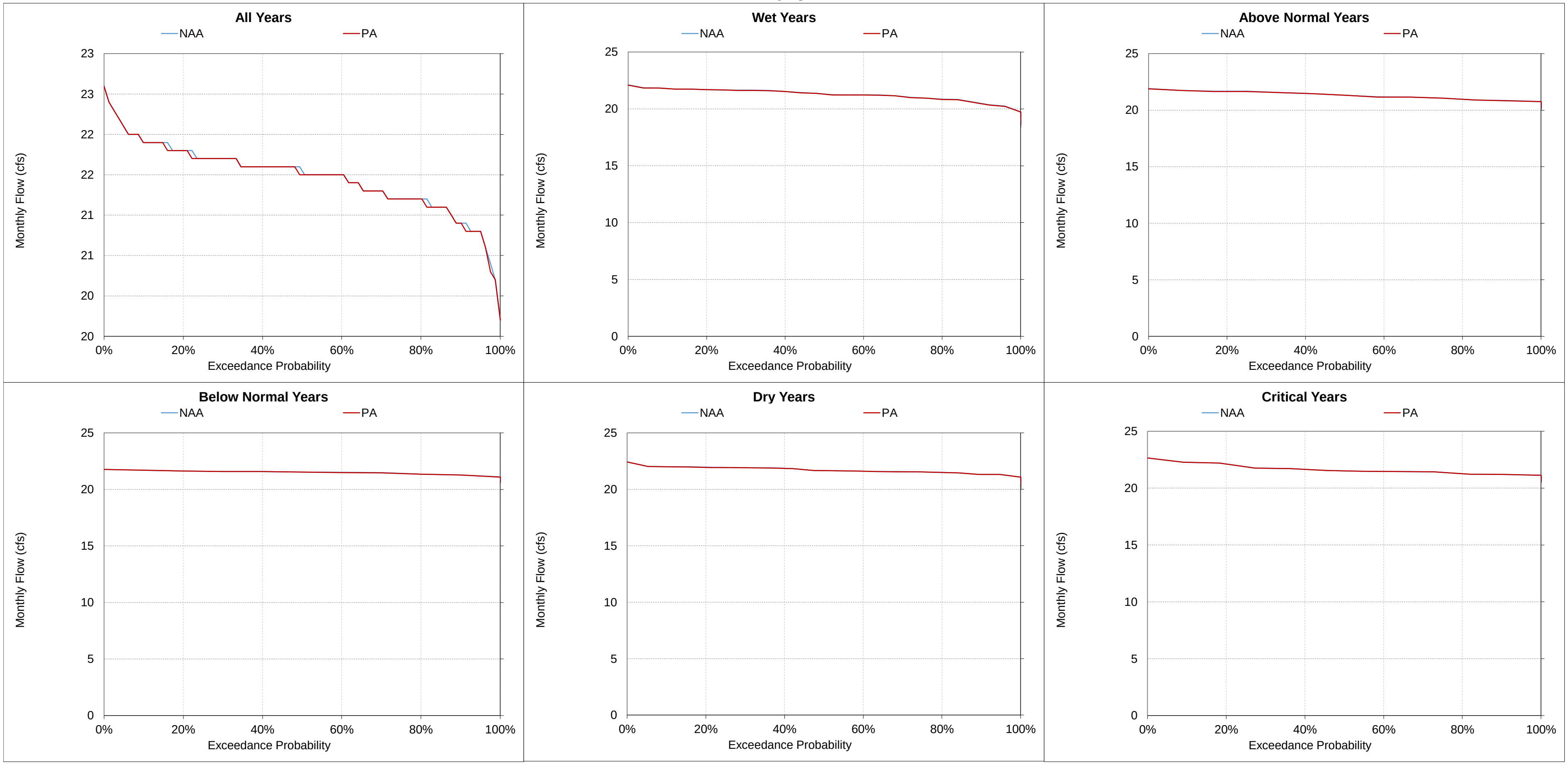
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-33-12. Morrow Island Distribution System C-line, Monthly Flow February



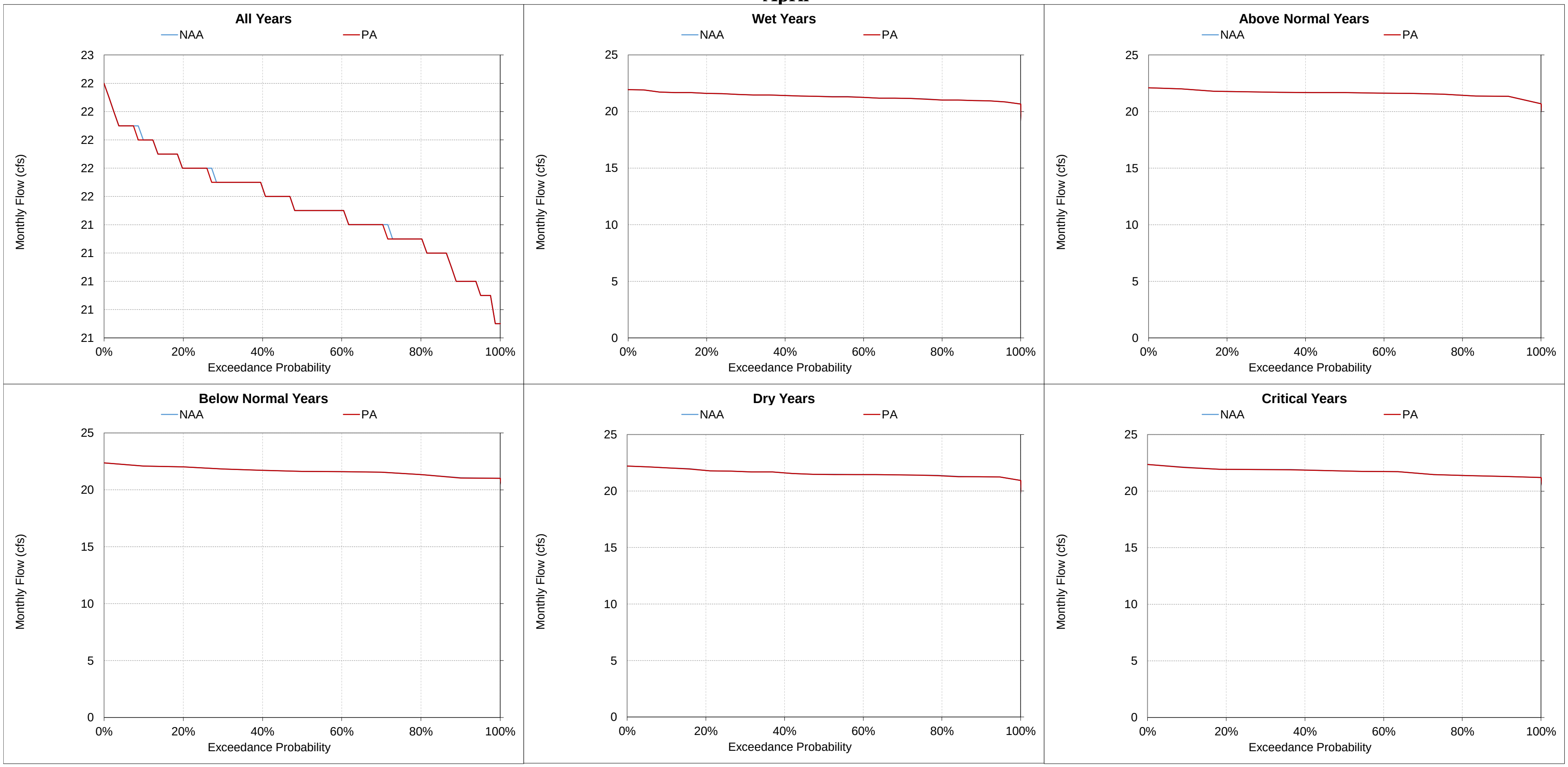
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-33-13. Morrow Island Distribution System C-line, Monthly Flow
March



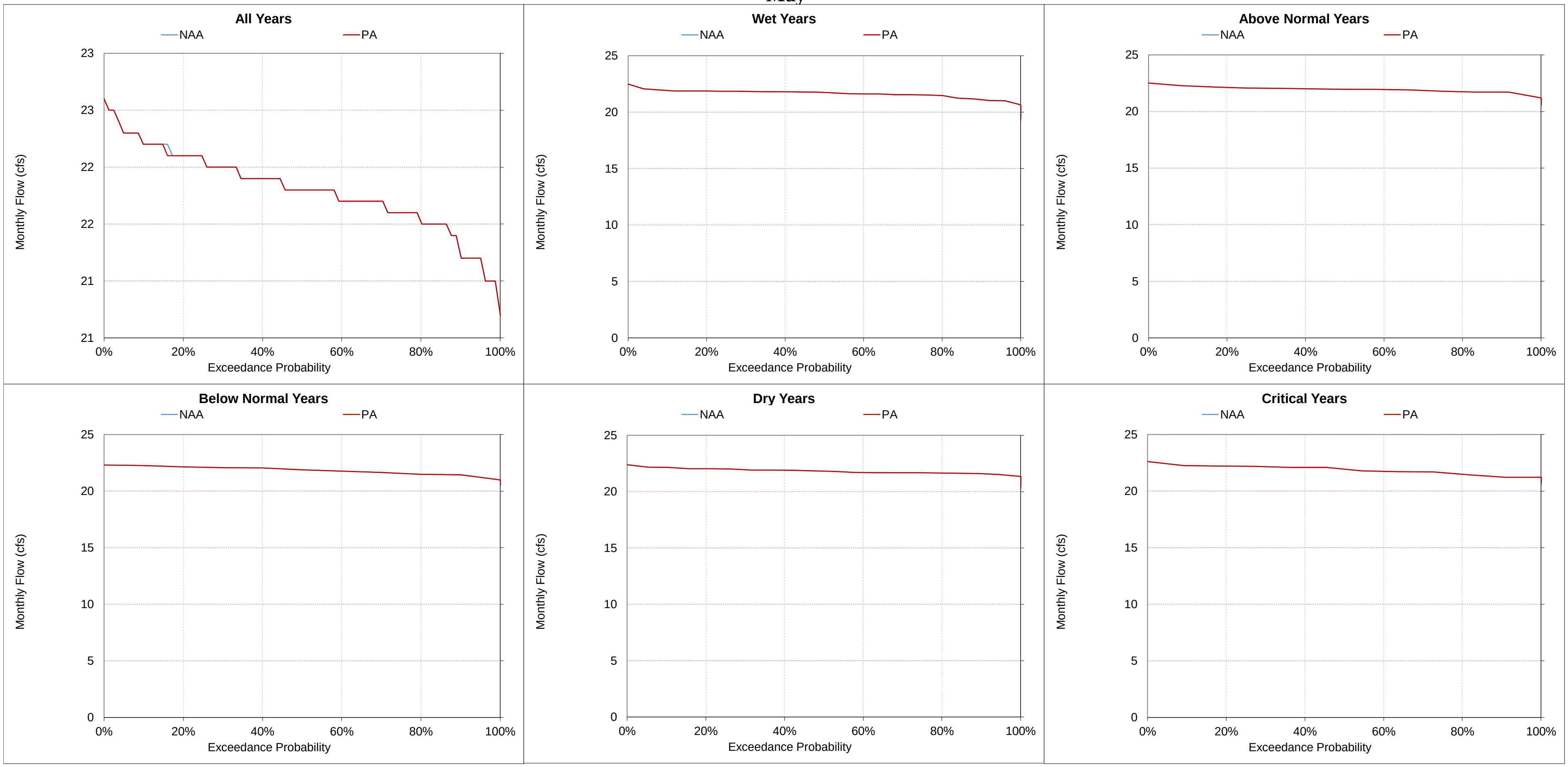
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-33-14. Morrow Island Distribution System C-line, Monthly Flow
April



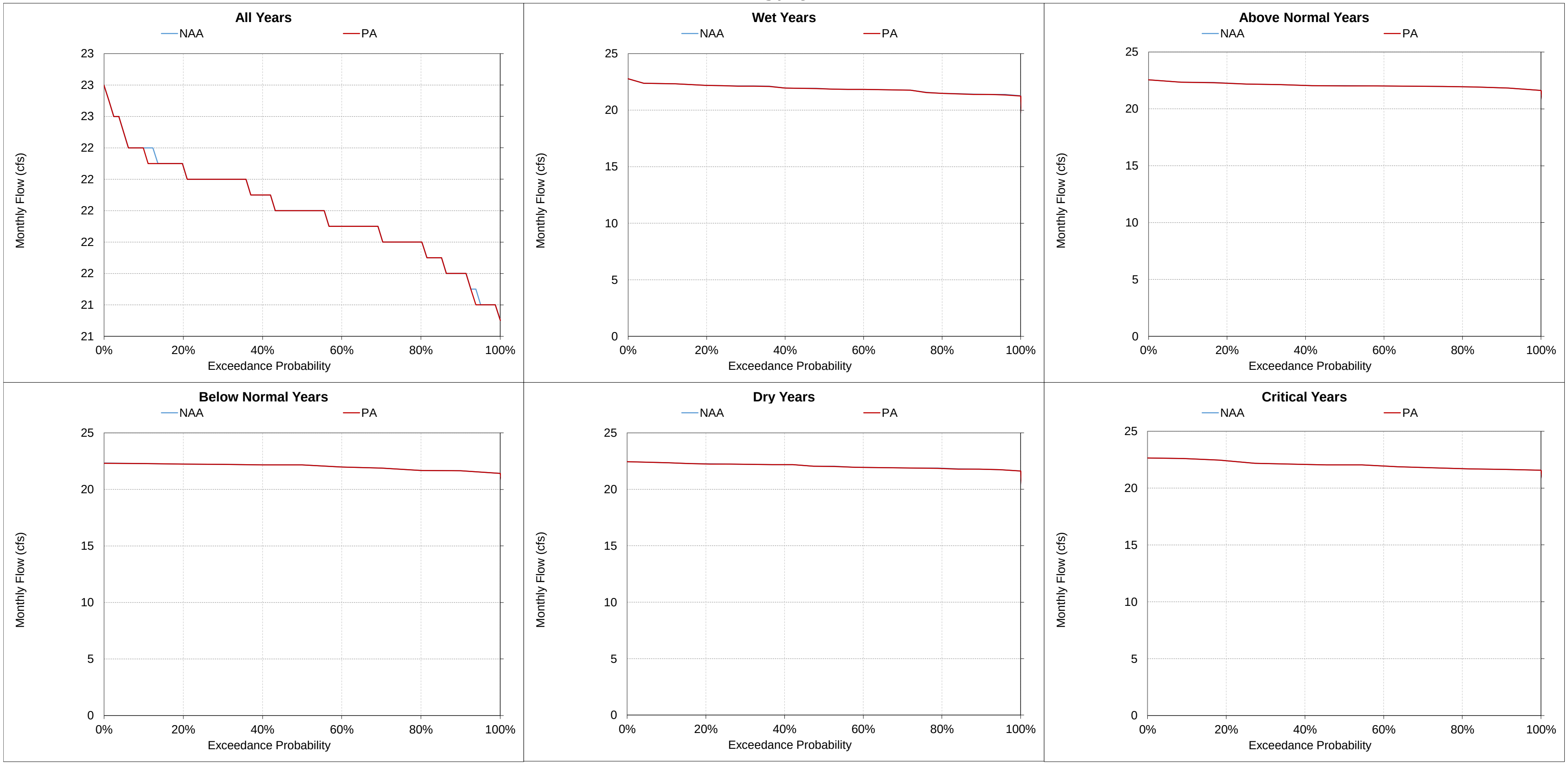
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-33-15. Morrow Island Distribution System C-line, Monthly Flow May



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-33-16. Morrow Island Distribution System C-line, Monthly Flow
June



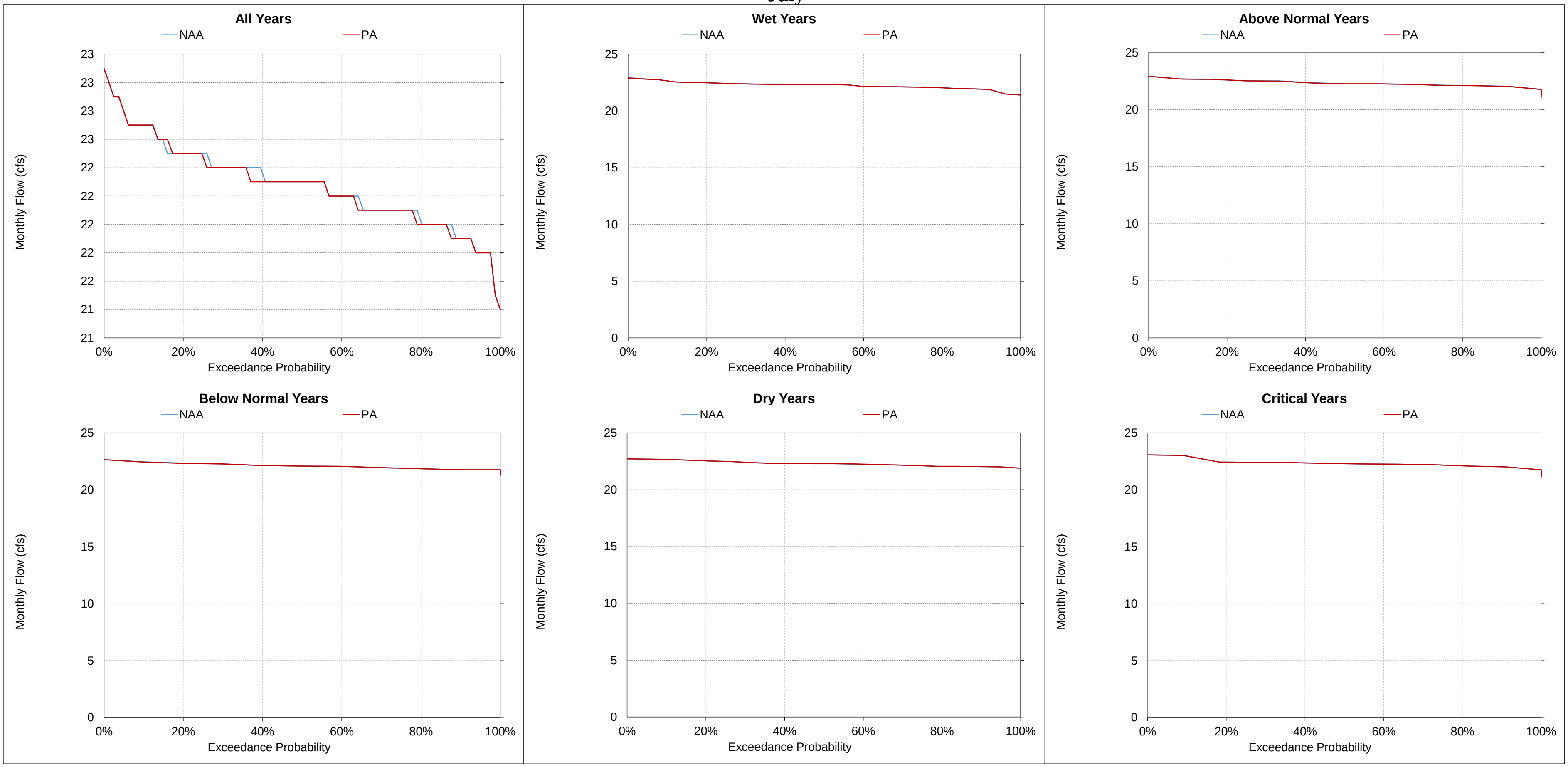
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

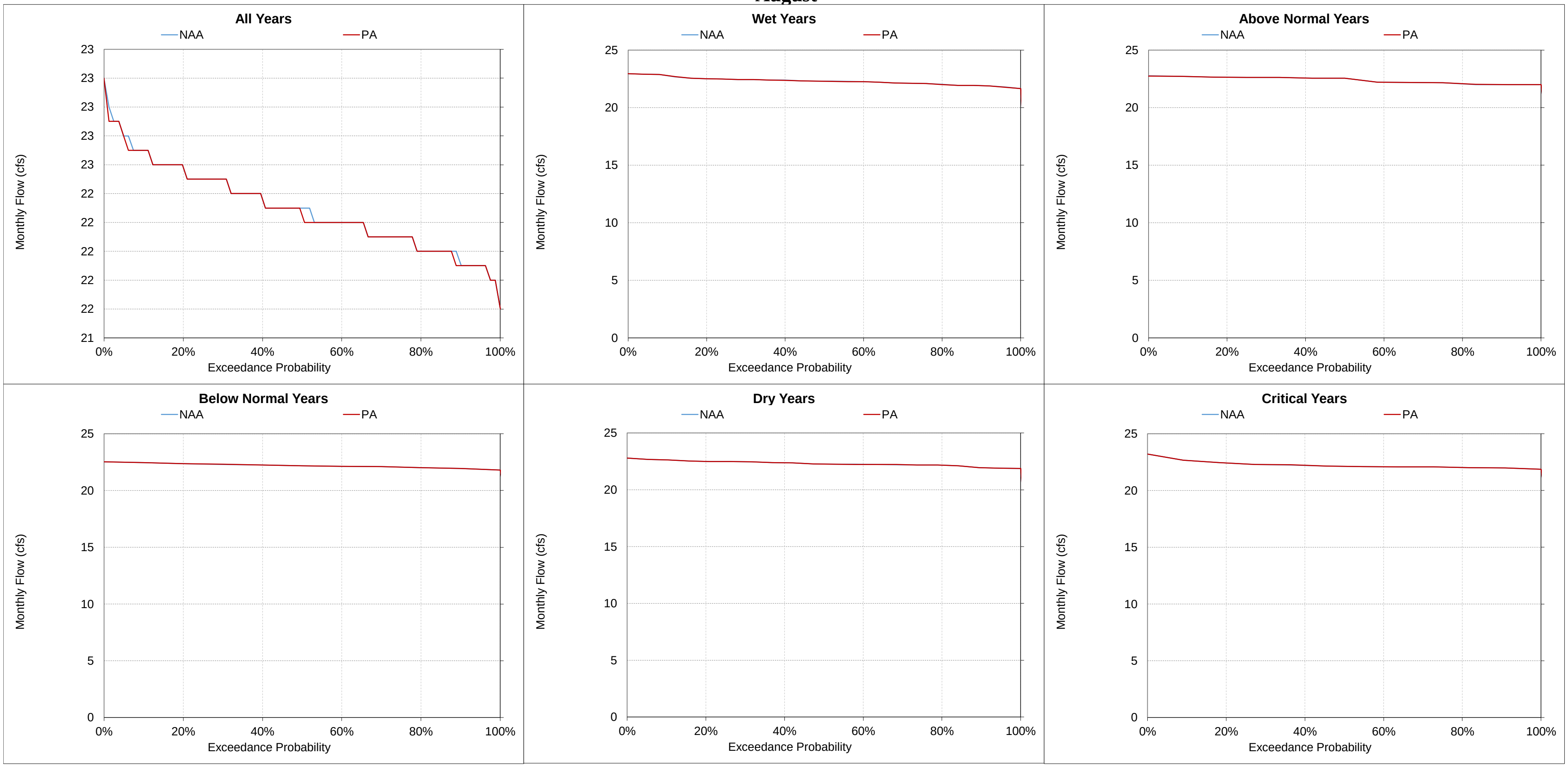
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-33-17. Morrow Island Distribution System C-line, Monthly Flow
July



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-33-18. Morrow Island Distribution System C-line, Monthly Flow August



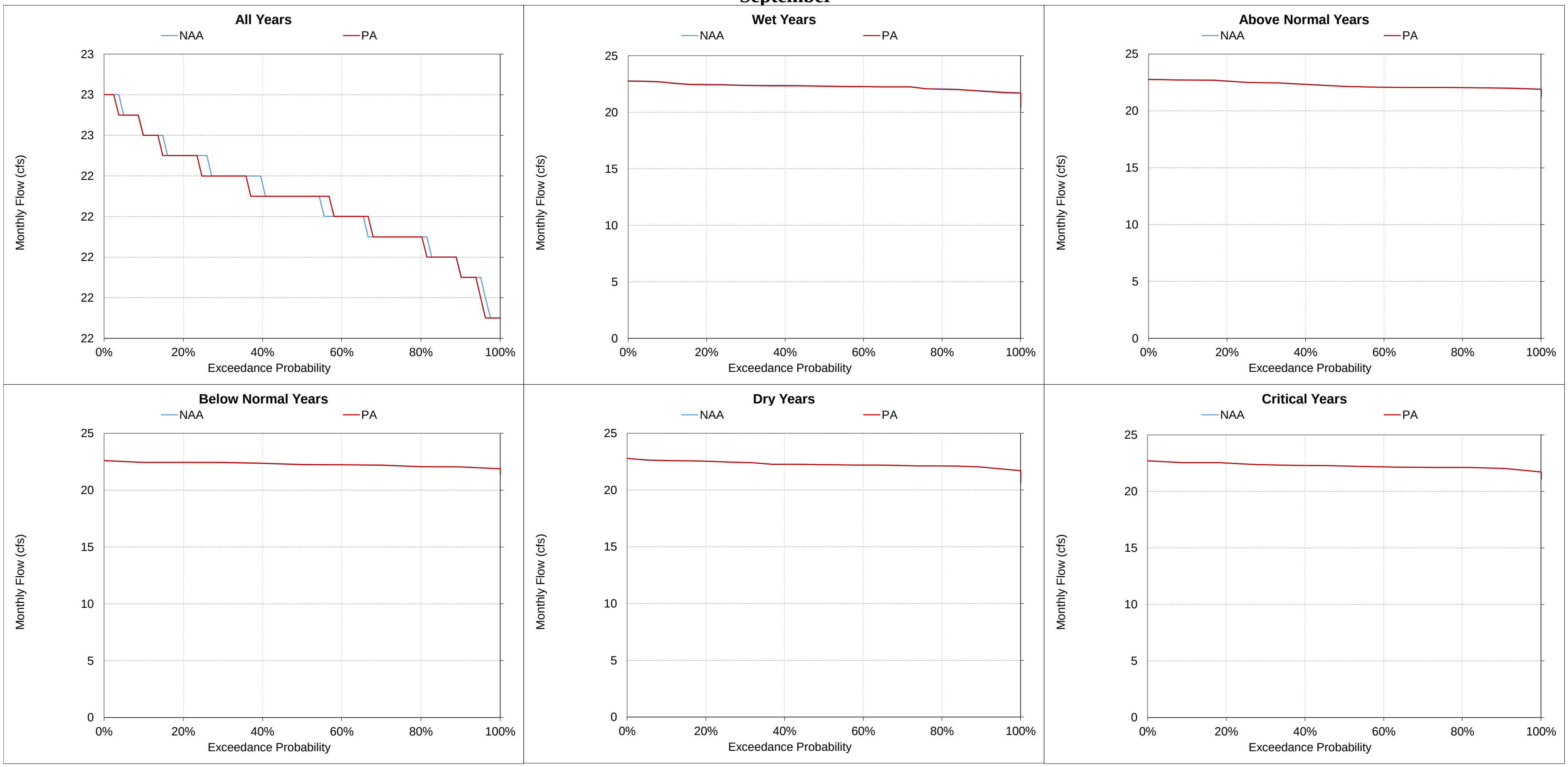
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-33-19. Morrow Island Distribution System C-line, Monthly Flow
September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-34. Goodyear Slough upstream of Goodyear Outfall, Monthly Flow

Statistic	Monthly Flow (cfs)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	-44	-44	0	0%	-44	-44	0	0%	-44	-44	0	0%	-44	-44	0	0%	-44	-44	0	0%	-43	-43	0	0%
20%	-45	-45	0	0%	-44	-44	0	0%	-44	-45	0	0%	-45	-45	0	0%	-44	-44	0	0%	-43	-43	0	0%
30%	-45	-45	0	0%	-45	-45	0	0%	-45	-45	0	0%	-45	-45	0	0%	-45	-45	0	0%	-44	-44	0	0%
40%	-45	-45	0	0%	-45	-45	0	0%	-45	-45	0	0%	-45	-45	0	0%	-46	-45	0	1%	-44	-44	0	0%
50%	-45	-45	0	0%	-45	-45	0	0%	-45	-45	0	0%	-46	-46	0	0%	-46	-46	0	0%	-44	-44	0	0%
60%	-45	-45	0	0%	-45	-45	0	0%	-46	-46	0	0%	-46	-46	0	0%	-46	-46	0	0%	-45	-45	0	0%
70%	-46	-46	0	0%	-46	-45	0	0%	-46	-46	0	0%	-46	-46	0	0%	-47	-47	0	0%	-45	-45	0	0%
80%	-46	-46	0	0%	-46	-46	0	0%	-46	-46	0	0%	-47	-47	0	1%	-48	-48	0	1%	-47	-47	0	0%
90%	-46	-46	0	0%	-46	-46	0	0%	-48	-47	0	1%	-50	-50	0	1%	-51	-51	0	0%	-48	-48	0	0%
Long Term Full Simulation Period[b]	-45	-45	0	0%	-45	-45	0	0%	-46	-46	0	0%	-46	-46	0	0%	-47	-47	0	0%	-45	-45	0	0%
Water Year Types[c]																								
Wet (32%)	-45	-45	0	0%	-45	-45	0	0%	-46	-46	0	0%	-47	-47	0	0%	-49	-49	0	0%	-48	-47	0	0%
Above Normal (16%)	-45	-45	0	0%	-45	-45	0	0%	-45	-45	0	0%	-46	-46	0	0%	-47	-47	0	0%	-45	-45	0	0%
Below Normal (13%)	-45	-45	0	0%	-45	-45	0	0%	-46	-45	0	0%	-46	-46	0	0%	-45	-45	0	0%	-43	-43	0	0%
Dry (24%)	-45	-45	0	0%	-45	-45	0	0%	-46	-46	0	0%	-46	-46	0	0%	-45	-45	0	0%	-44	-44	0	0%
Critical (15%)	-45	-45	0	0%	-44	-44	0	0%	-45	-45	0	0%	-46	-46	0	0%	-45	-45	0	0%	-44	-44	0	0%

Statistic	Monthly Flow (cfs)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	-43	-43	0	0%	-43	-43	0	0%	-43	-43	0	0%	-44	-44	0	0%	-44	-44	0	0%	-44	-44	0	0%
20%	-43	-43	0	0%	-43	-43	0	0%	-43	-43	0	0%	-44	-44	0	0%	-44	-44	0	0%	-44	-44	0	0%
30%	-43	-43	0	0%	-43	-43	0	0%	-44	-44	0	0%	-44	-44	0	0%	-44	-44	0	0%	-44	-44	0	0%
40%	-44	-44	0	0%	-44	-44	0	0%	-44	-44	0	0%	-45	-44	0	0%	-45	-44	0	0%	-45	-45	0	0%
50%	-44	-44	0	0%	-44	-44	0	0%	-44	-44	0	0%	-45	-45	0	0%	-45	-45	0	0%	-45	-45	0	0%
60%	-44	-44	0	0%	-44	-44	0	0%	-44	-44	0	0%	-45	-45	0	0%	-45	-45	0	0%	-45	-45	0	0%
70%	-45	-45	0	0%	-44	-44	0	0%	-44	-44	0	0%	-45	-45	0	0%	-45	-45	0	0%	-45	-45	0	0%
80%	-45	-45	0	0%	-45	-45	0	0%	-45	-45	0	0%	-45	-45	0	0%	-45	-45	0	0%	-46	-46	0	0%
90%	-46	-46	0	0%	-46	-46	0	0%	-45	-45	0	0%	-46	-46	0	0%	-46	-46	0	0%	-46	-46	0	0%
Long Term Full Simulation Period[b]	-44	-44	0	0%	-44	-44	0	0%	-44	-44	0	0%	-45	-45	0	0%	-45	-45	0	0%	-45	-45	0	0%
Water Year Types[c]																								
Wet (32%)	-45	-45	0	0%	-45	-45	0	0%	-44	-44	0	0%	-45	-45	0	0%	-45	-45	0	0%	-46	-45	0	0%
Above Normal (16%)	-44	-44	0	0%	-44	-44	0	0%	-44	-44	0	0%	-45	-45	0	1%	-45	-45	0	0%	-45	-45	0	0%
Below Normal (13%)	-43	-43	0	0%	-43	-43	0	0%	-44	-44	0	0%	-44	-44	0	0%	-45	-44	0	0%	-45	-44	0	0%
Dry (24%)	-43	-43	0	0%	-44	-44	0	0%	-44	-44	0	0%	-45	-45	0	0%	-45	-45	0	0%	-44	-44	0	0%
Critical (15%)	-43	-43	0	0%	-43	-43	0	0%	-44	-44	0	0%	-45	-45	0	0%	-44	-44	0	0%	-44	-44	0	0%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-34-1. Monthly Flow Ranges For Goodyear Slough upstream of Goodyear Outfall, All Years

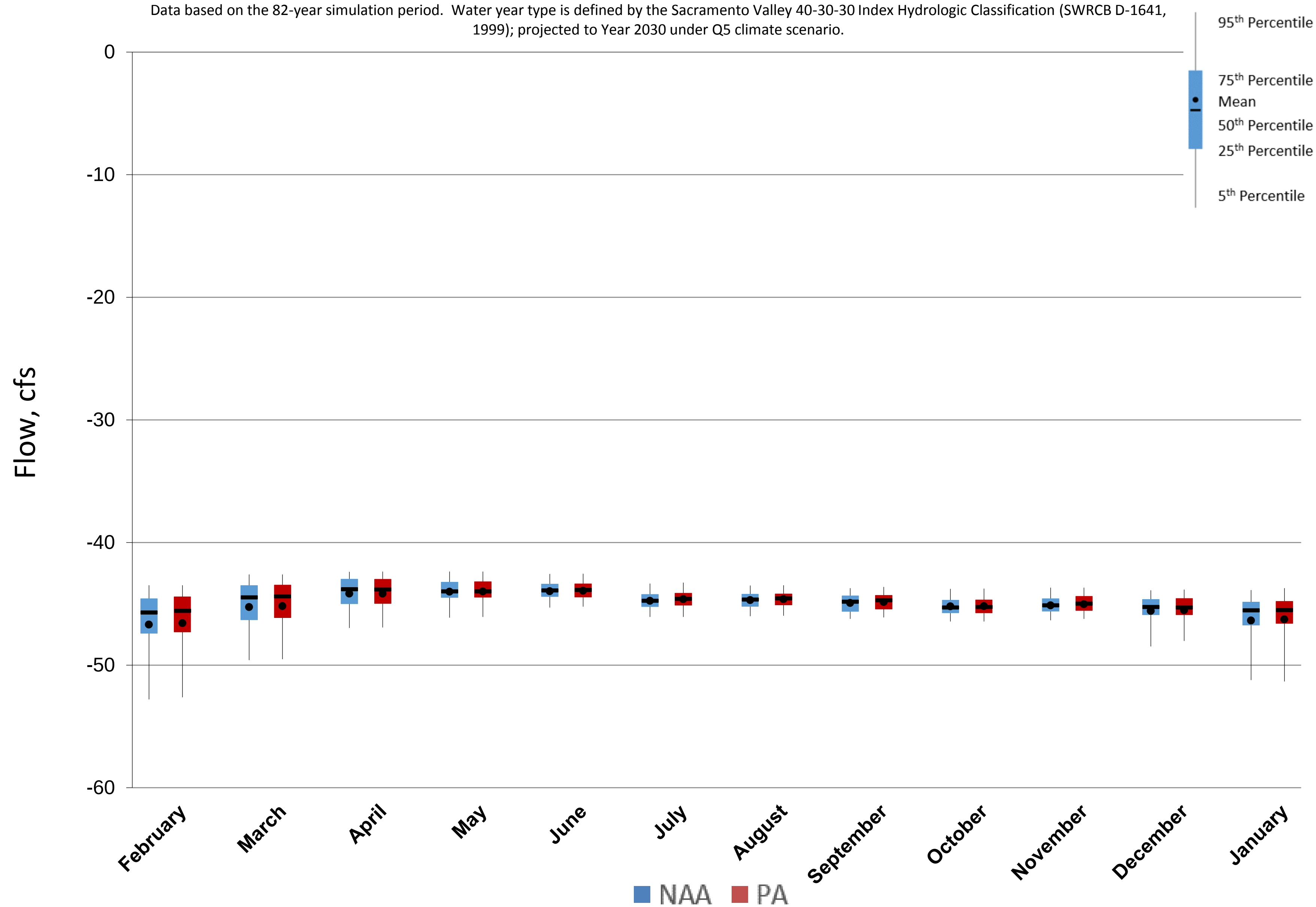


Figure 5.B.5-34-2. Monthly Flow Ranges For Goodyear Slough upstream of Goodyear Outfall, Wet Years

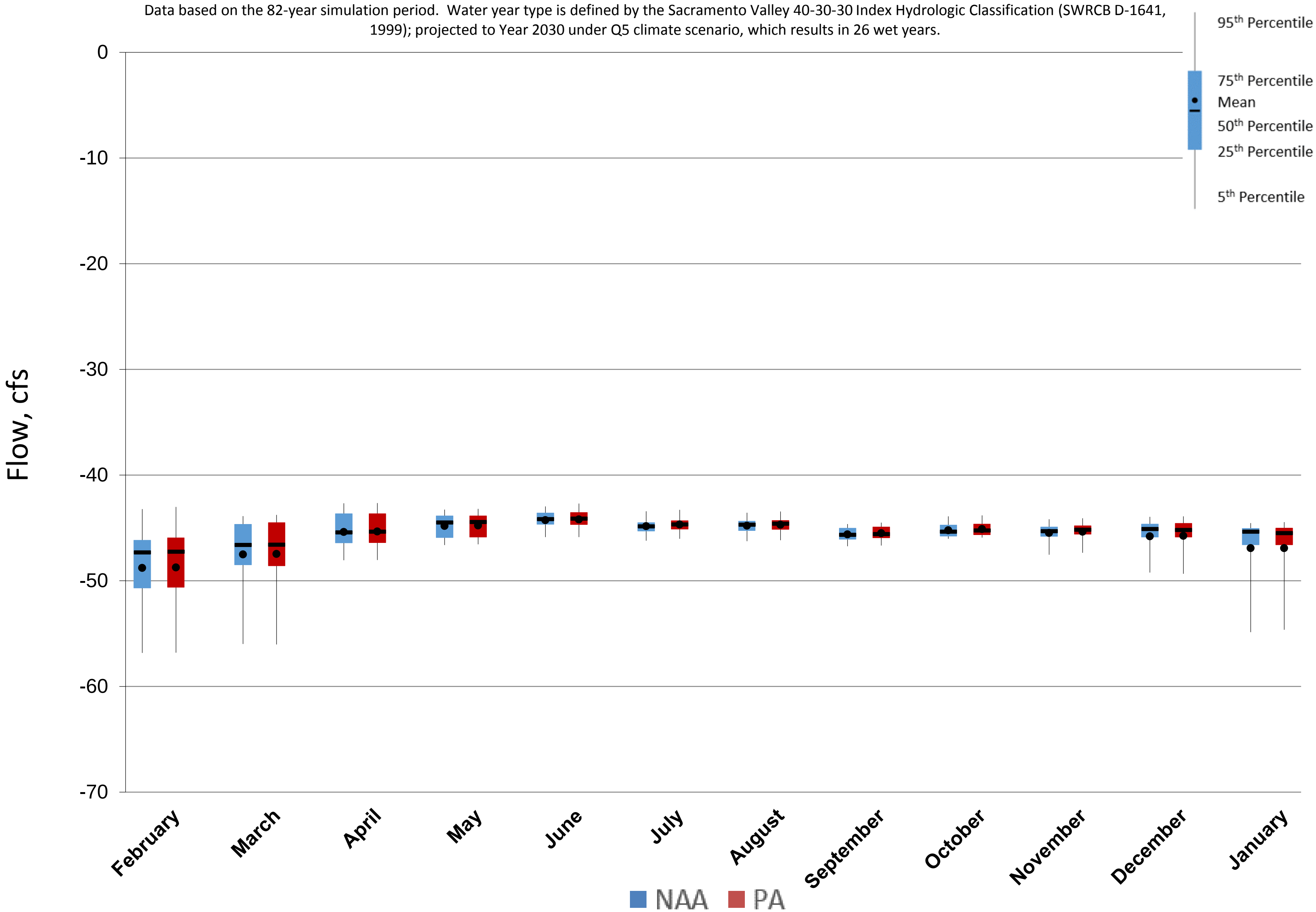


Figure 5.B.5-34-3. Monthly Flow Ranges For Goodyear Slough upstream of Goodyear Outfall, Above Normal Years

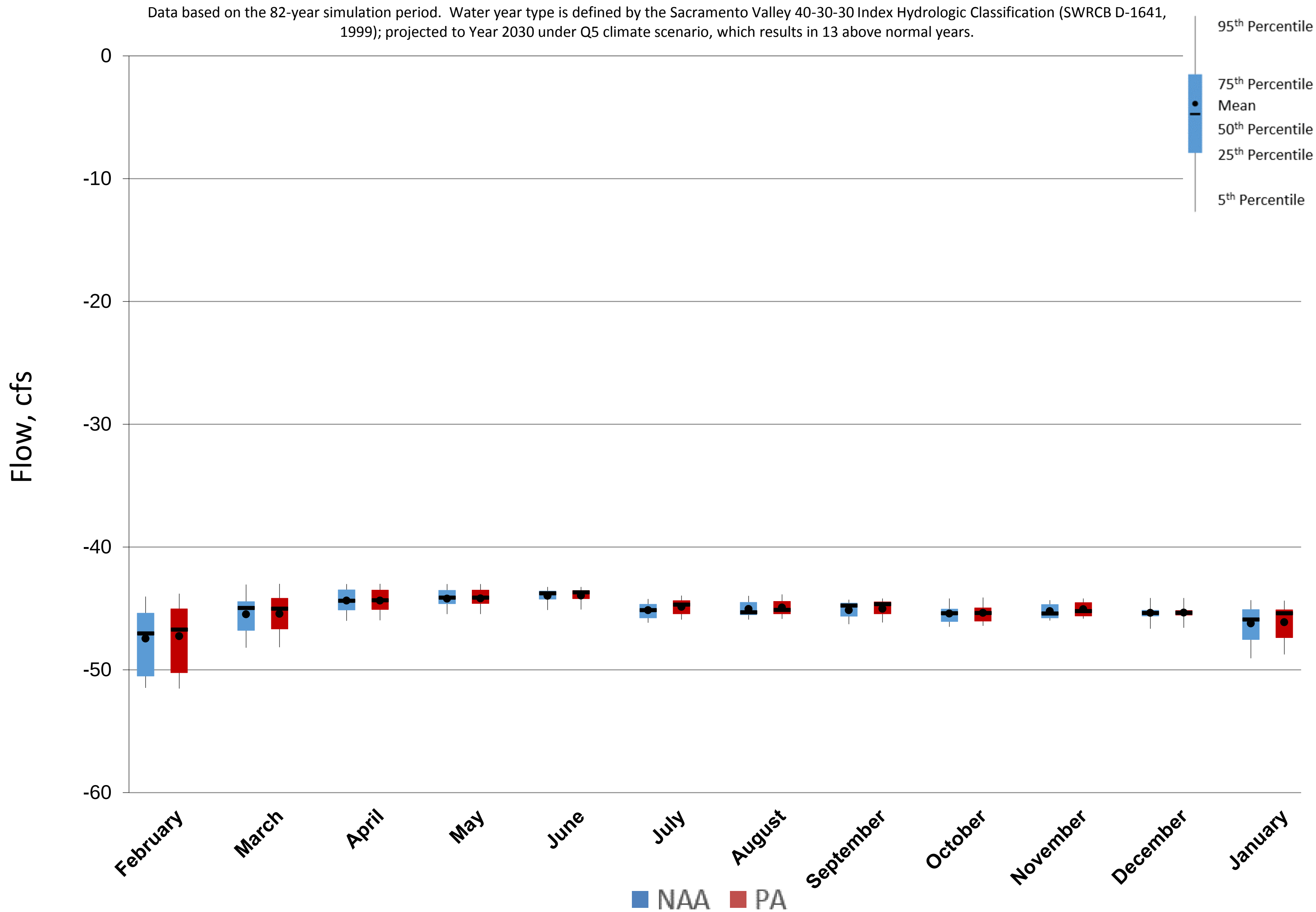


Figure 5.B.5-34-4. Monthly Flow Ranges For Goodyear Slough upstream of Goodyear Outfall, Below Normal Years

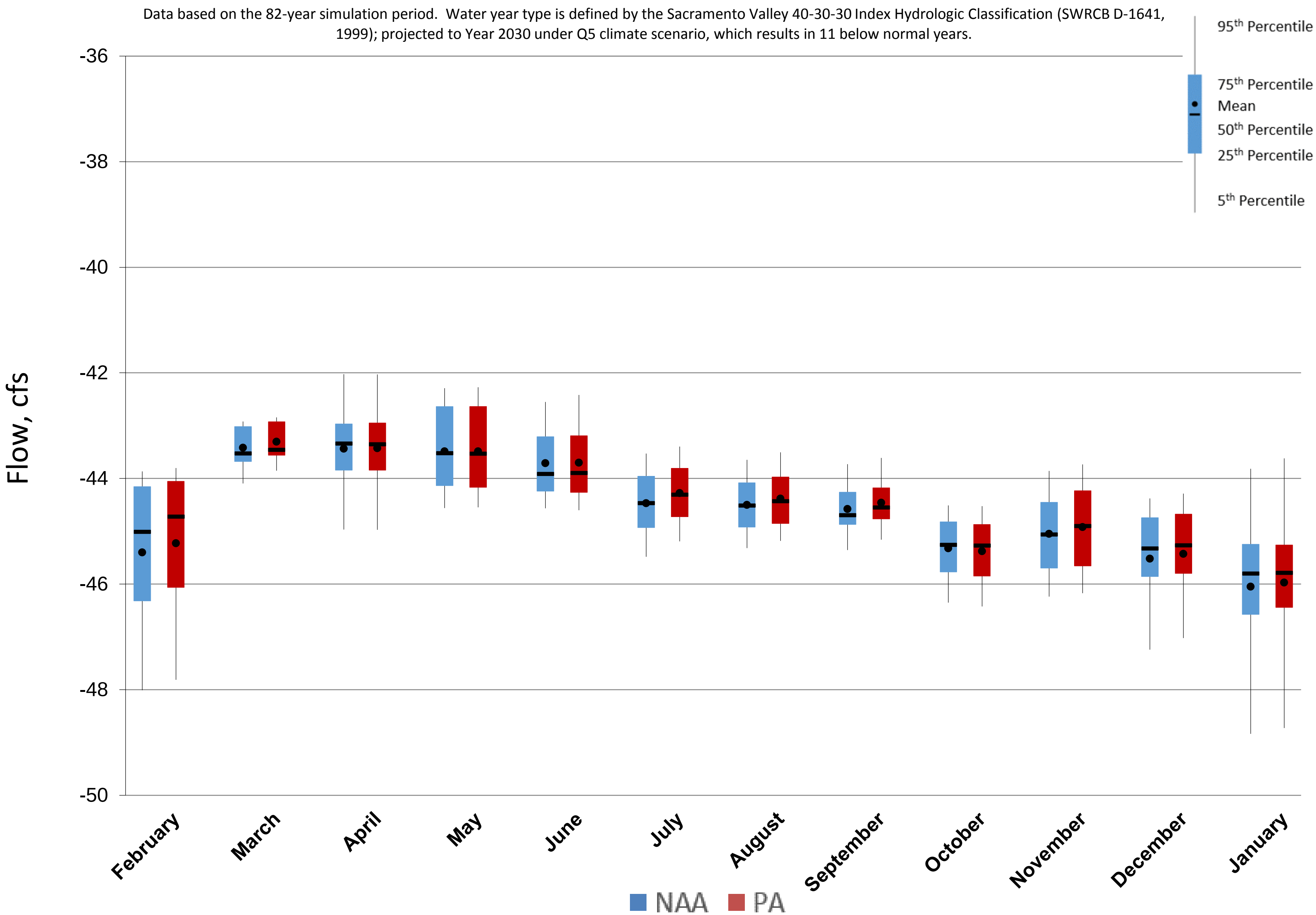


Figure 5.B.5-34-5. Monthly Flow Ranges For Goodyear Slough upstream of Goodyear Outfall, Dry Years

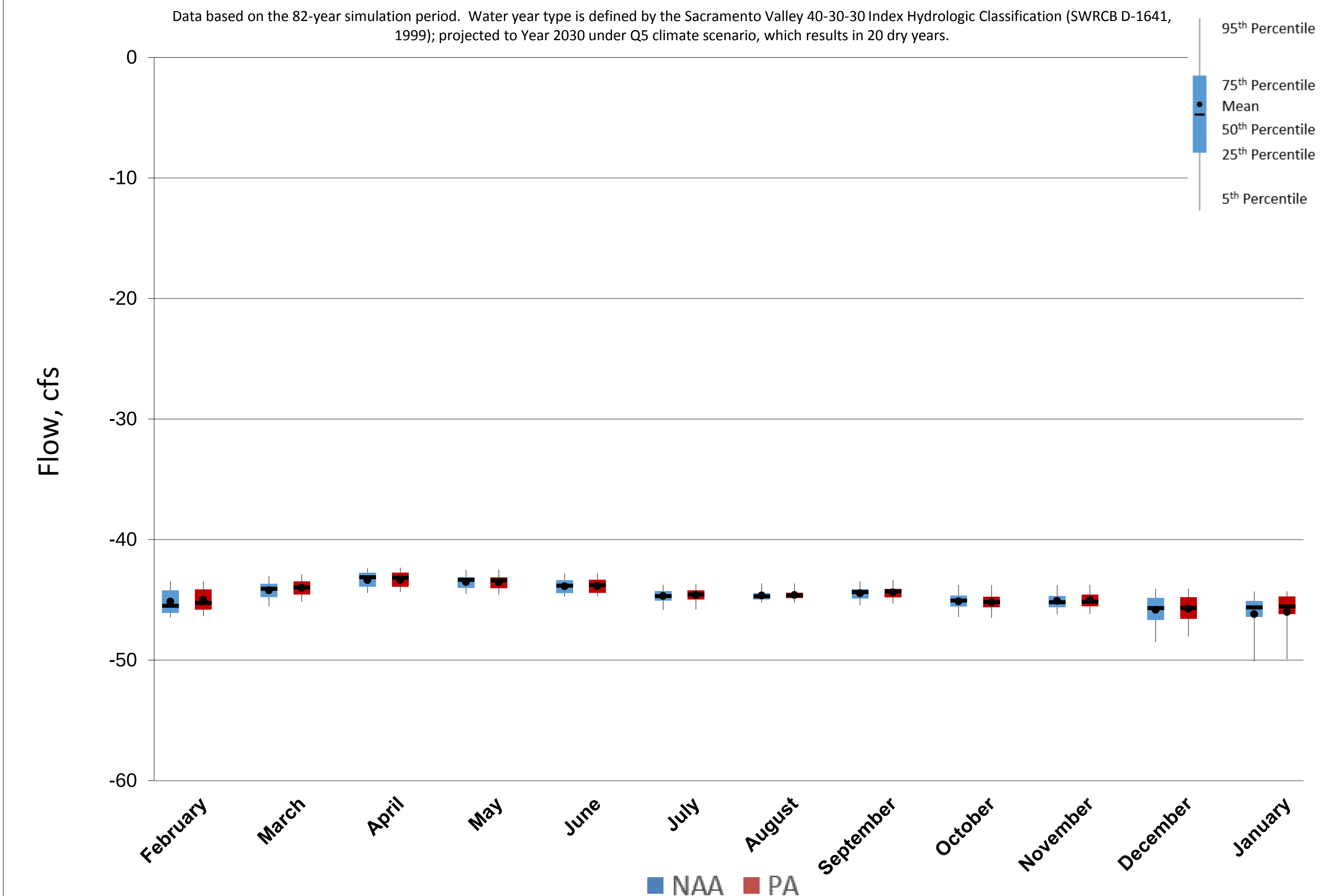


Figure 5.B.5-34-6. Monthly Flow Ranges For Goodyear Slough upstream of Goodyear Outfall, Critical Years

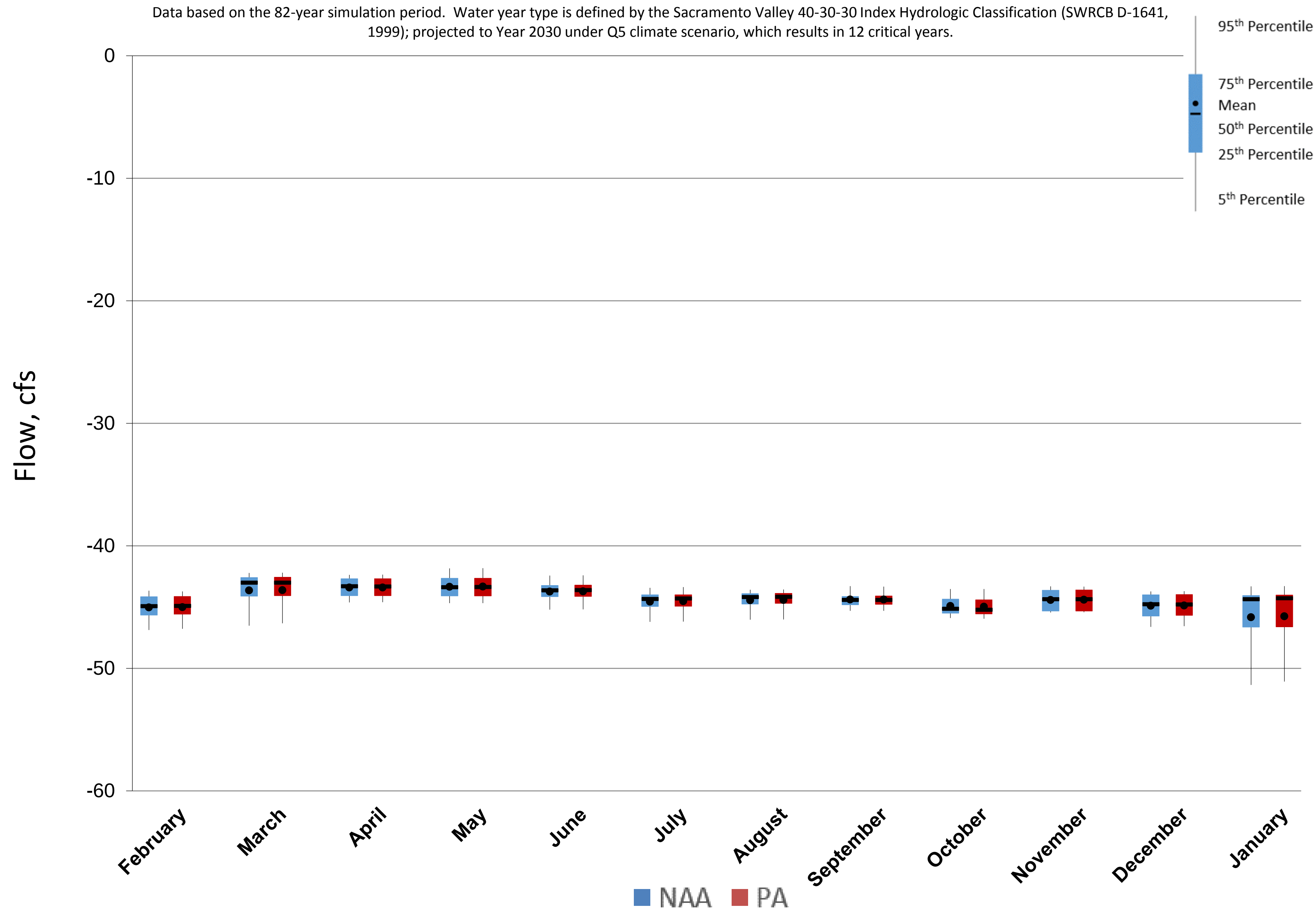
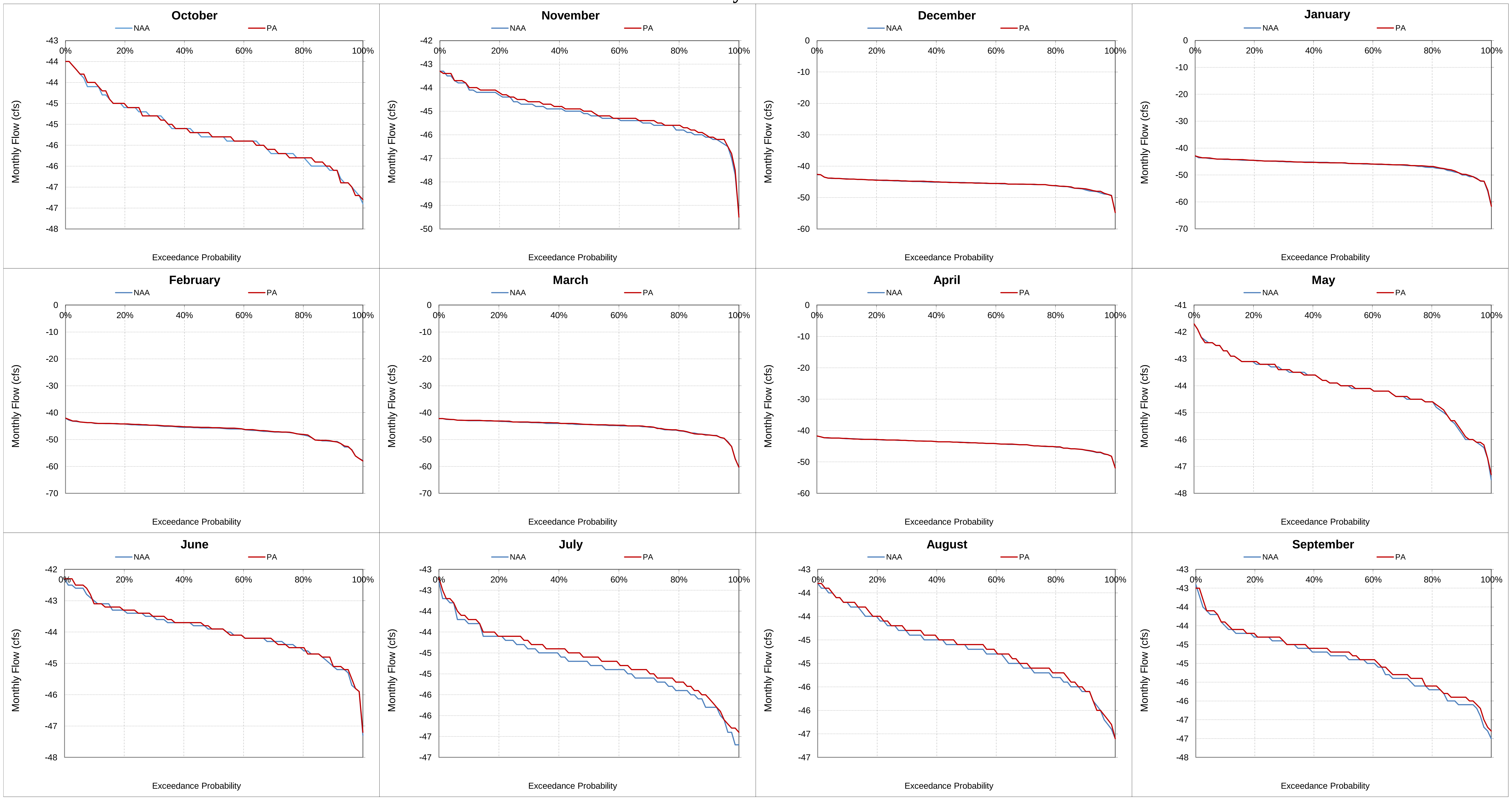
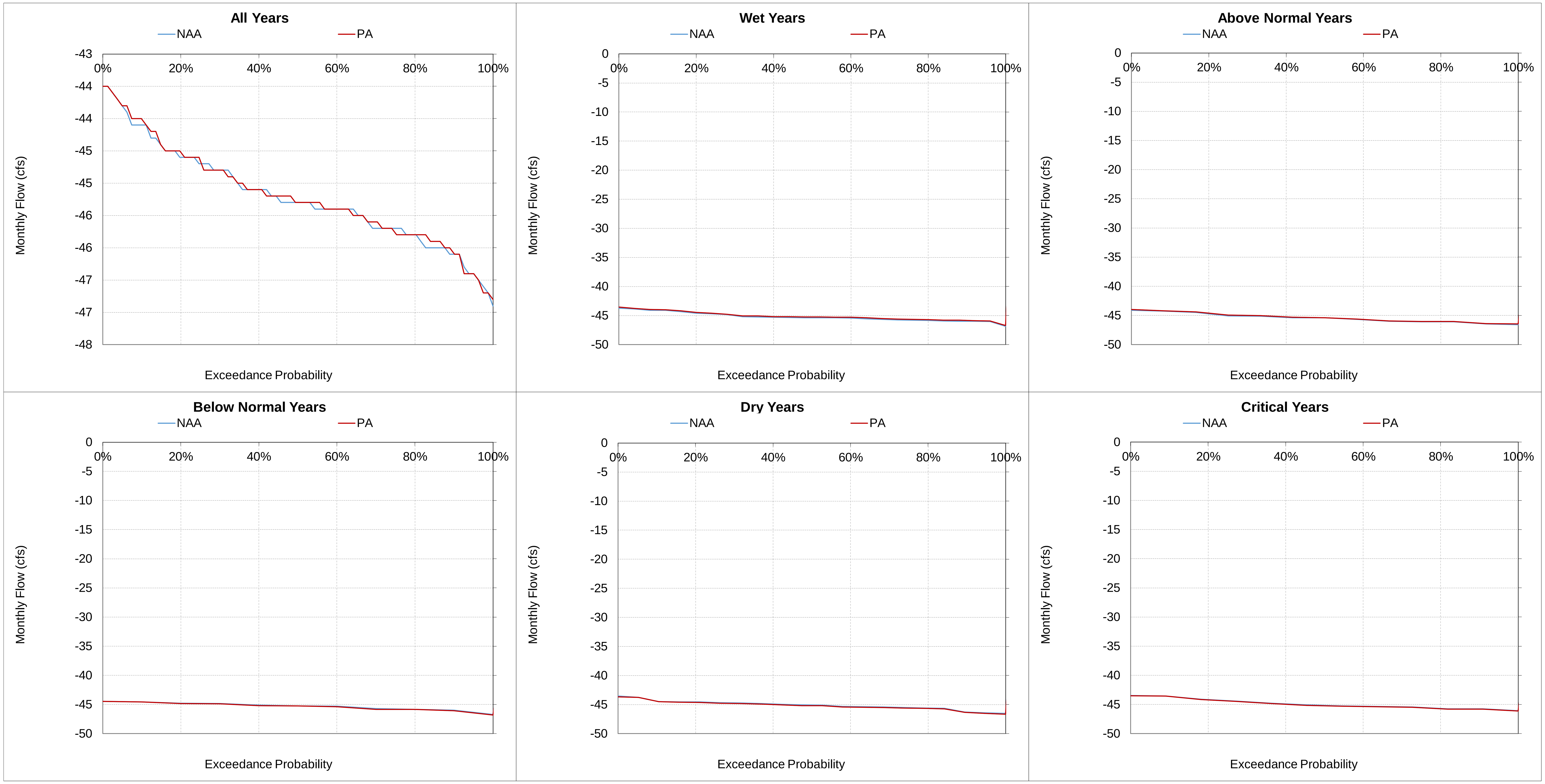


Figure 5.B.5-34-7. Goodyear Slough upstream of Goodyear Outfall, Monthly Flow Probability of Exceedance



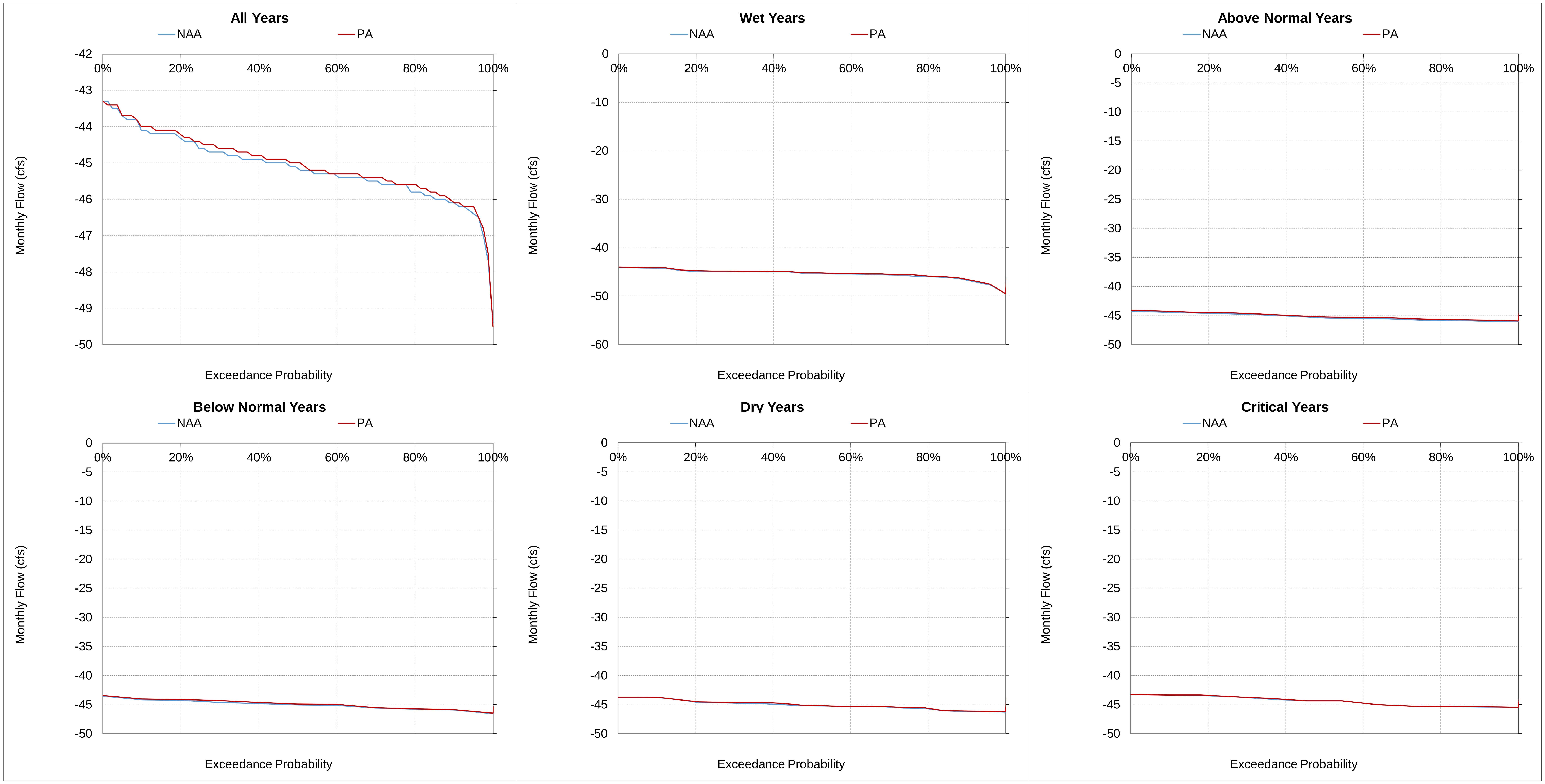
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-34-8. Goodyear Slough upstream of Goodyear Outfall, Monthly Flow
October



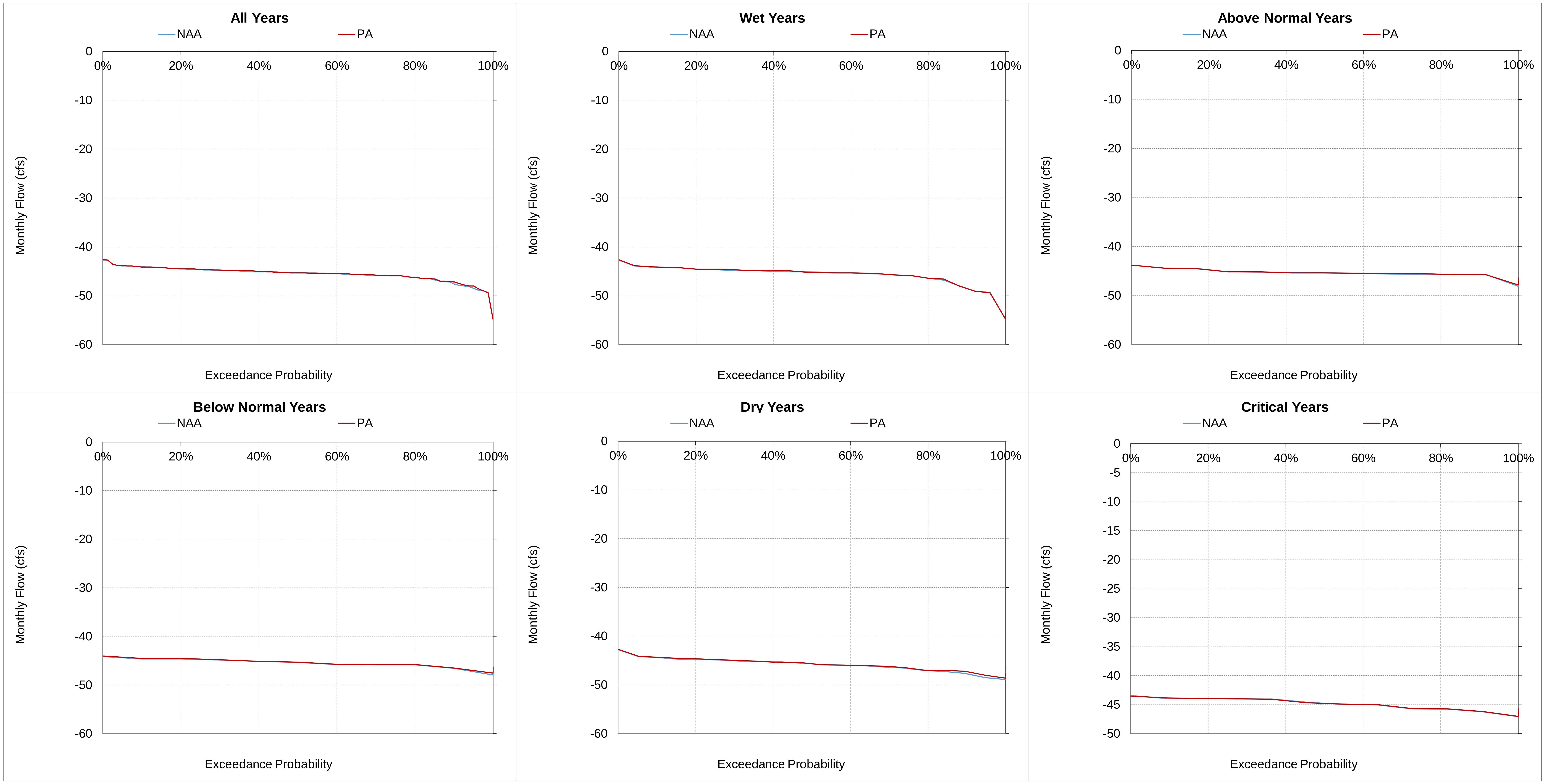
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-34-9. Goodyear Slough upstream of Goodyear Outfall, Monthly Flow
November



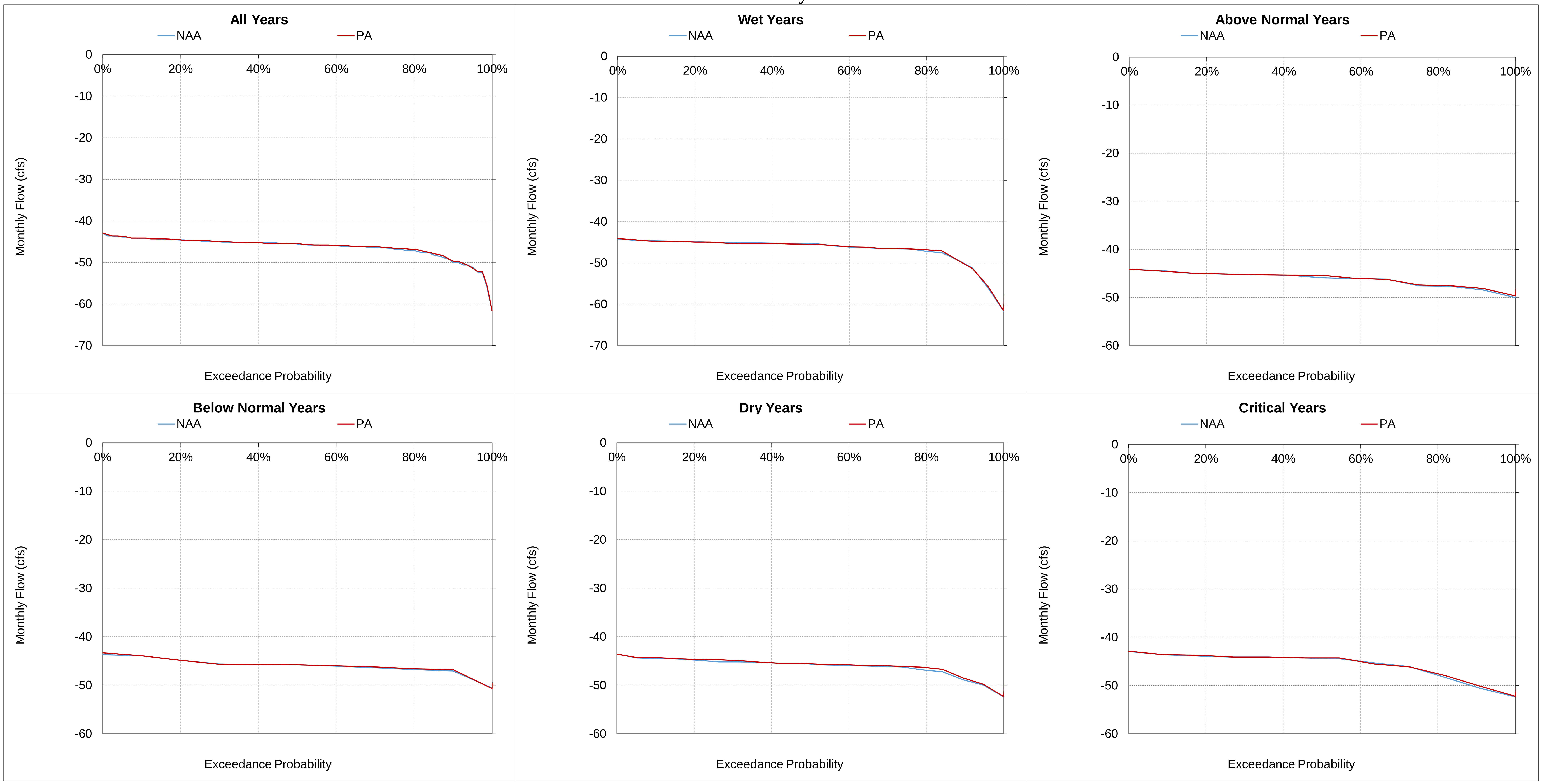
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-34-10. Goodyear Slough upstream of Goodyear Outfall, Monthly Flow December



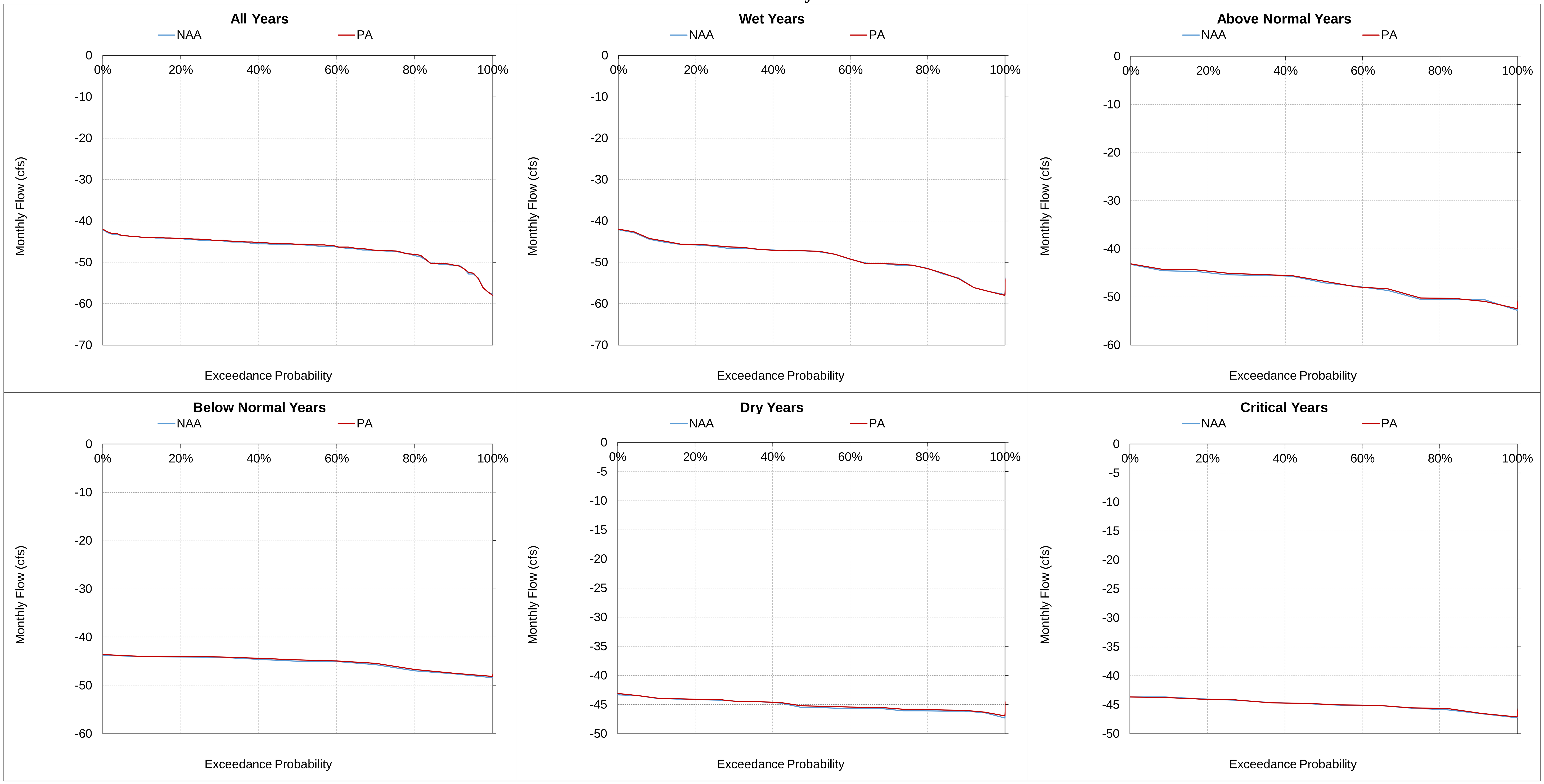
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-34-11. Goodyear Slough upstream of Goodyear Outfall, Monthly Flow
January



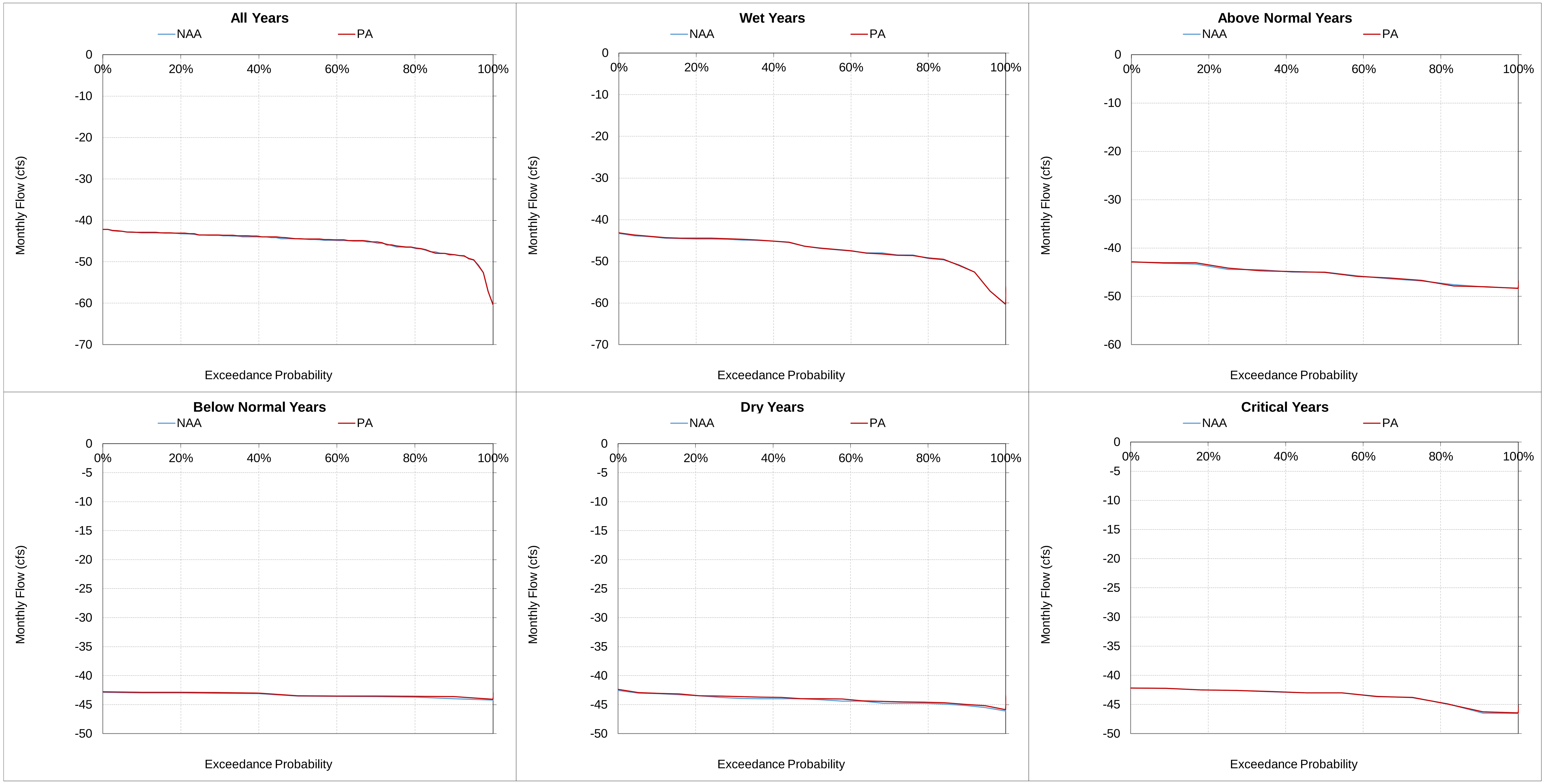
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-34-12. Goodyear Slough upstream of Goodyear Outfall, Monthly Flow February



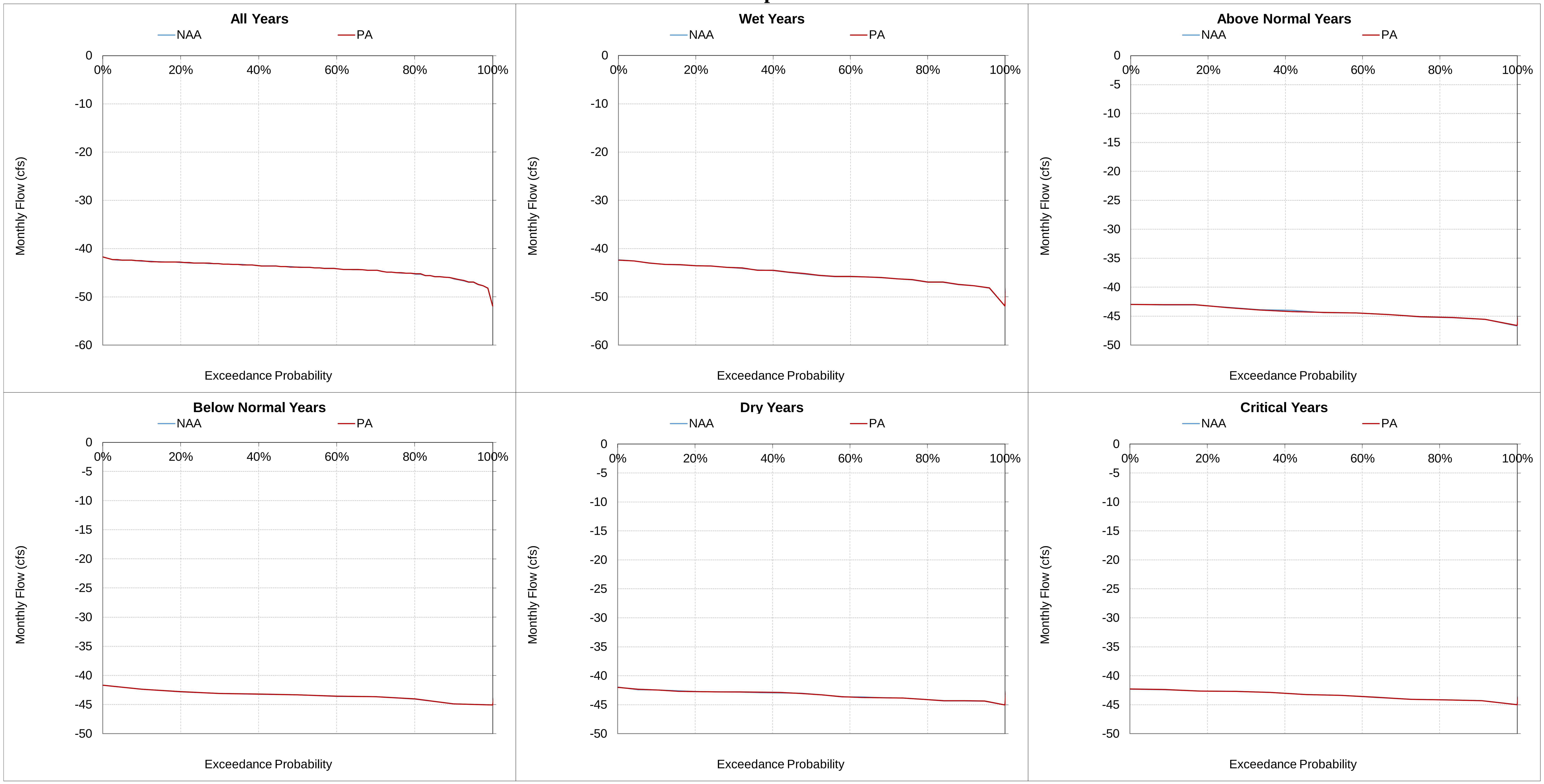
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-34-13. Goodyear Slough upstream of Goodyear Outfall, Monthly Flow
March



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-34-14. Goodyear Slough upstream of Goodyear Outfall, Monthly Flow April



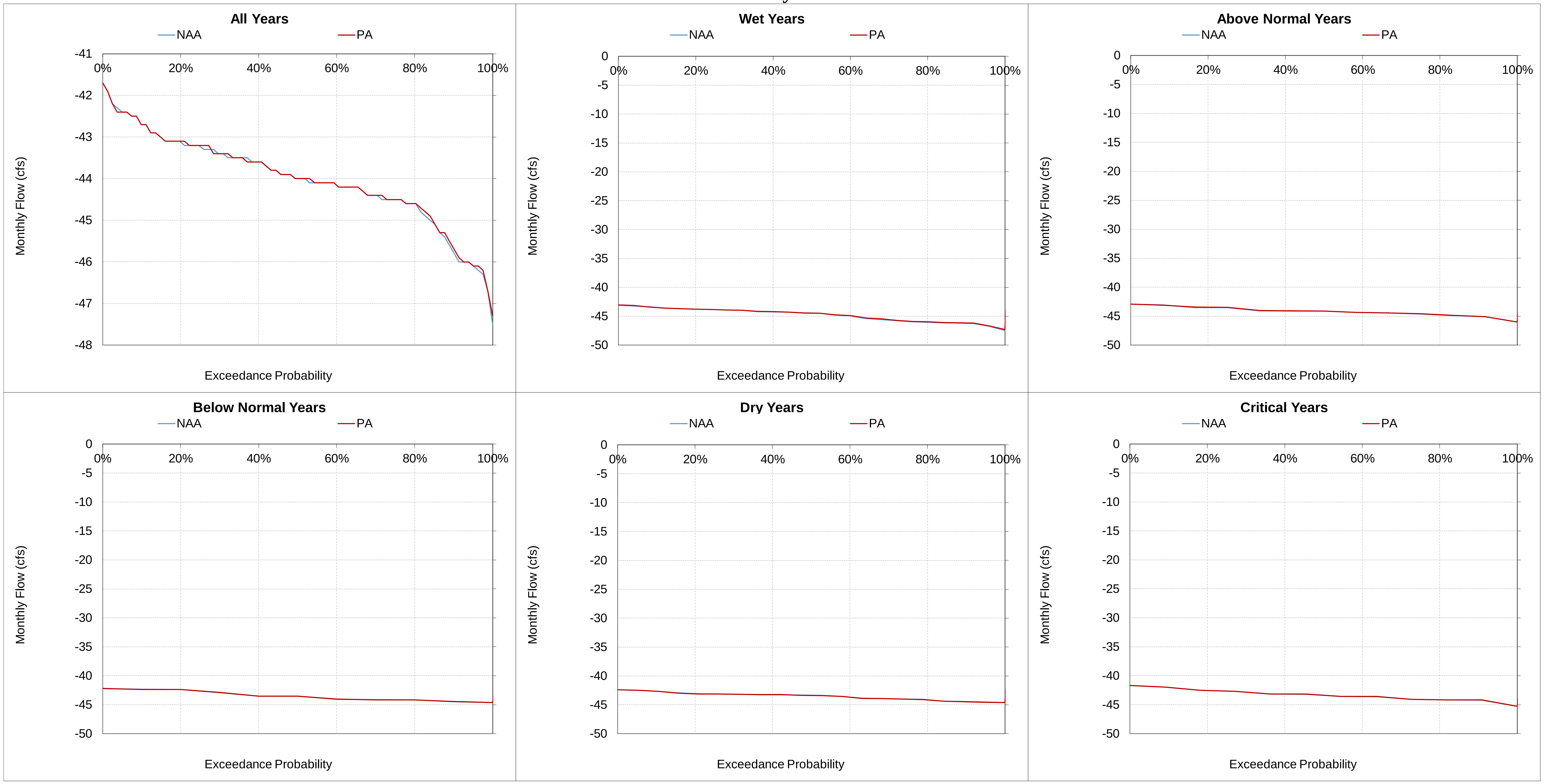
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-34-15. Goodyear Slough upstream of Goodyear Outfall, Monthly Flow May



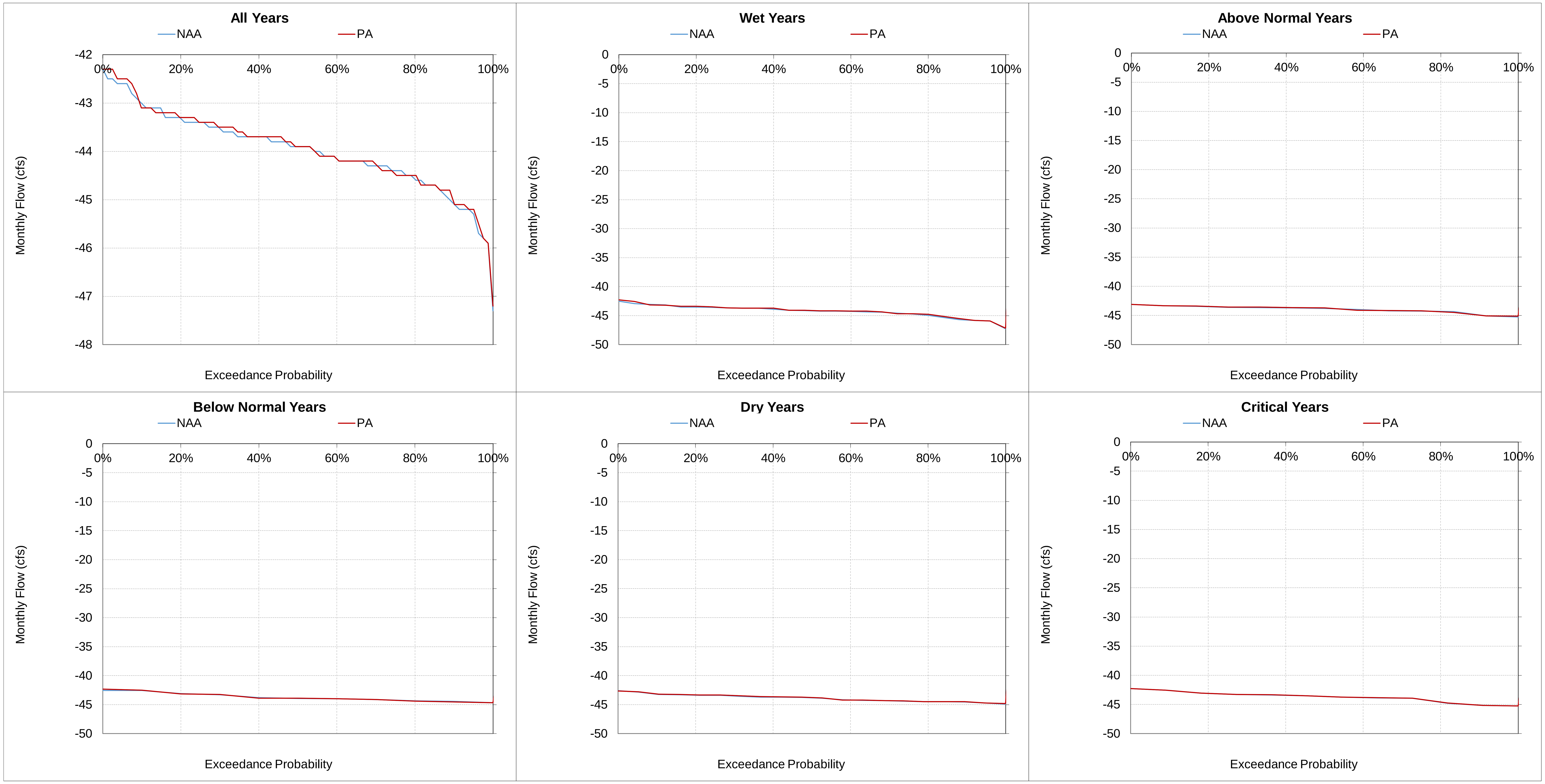
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

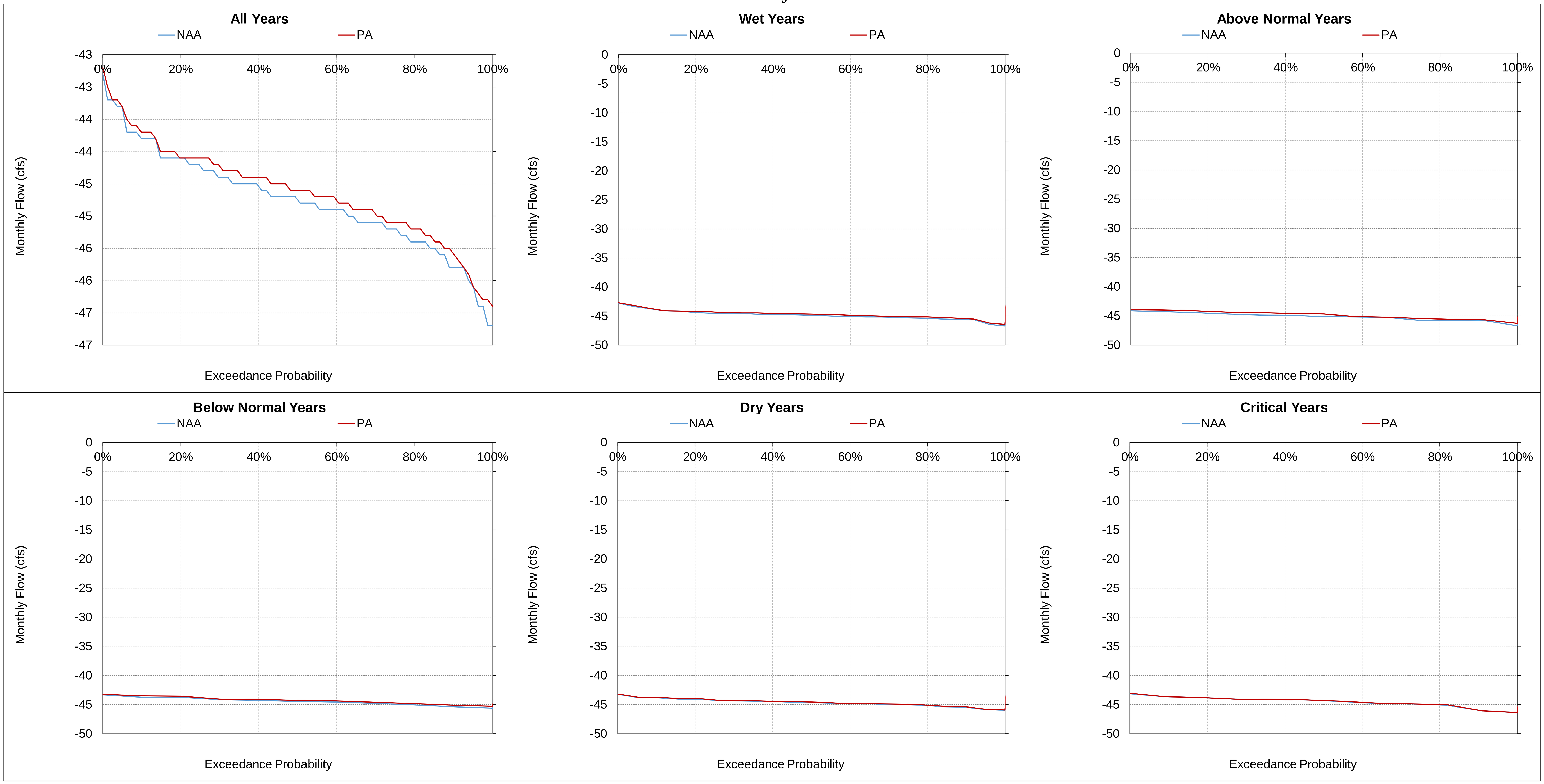
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-34-16. Goodyear Slough upstream of Goodyear Outfall, Monthly Flow
June



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-34-17. Goodyear Slough upstream of Goodyear Outfall, Monthly Flow July



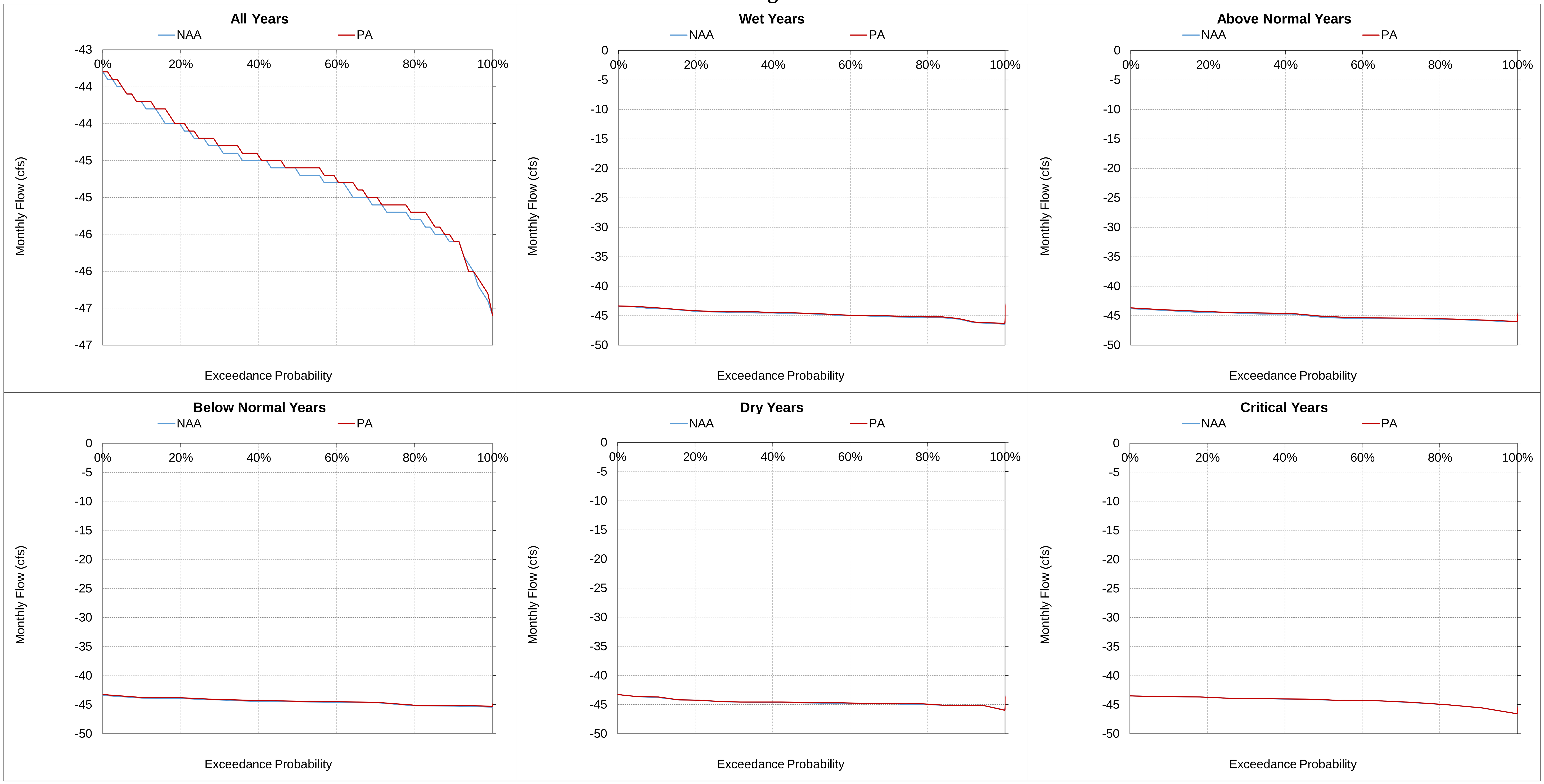
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

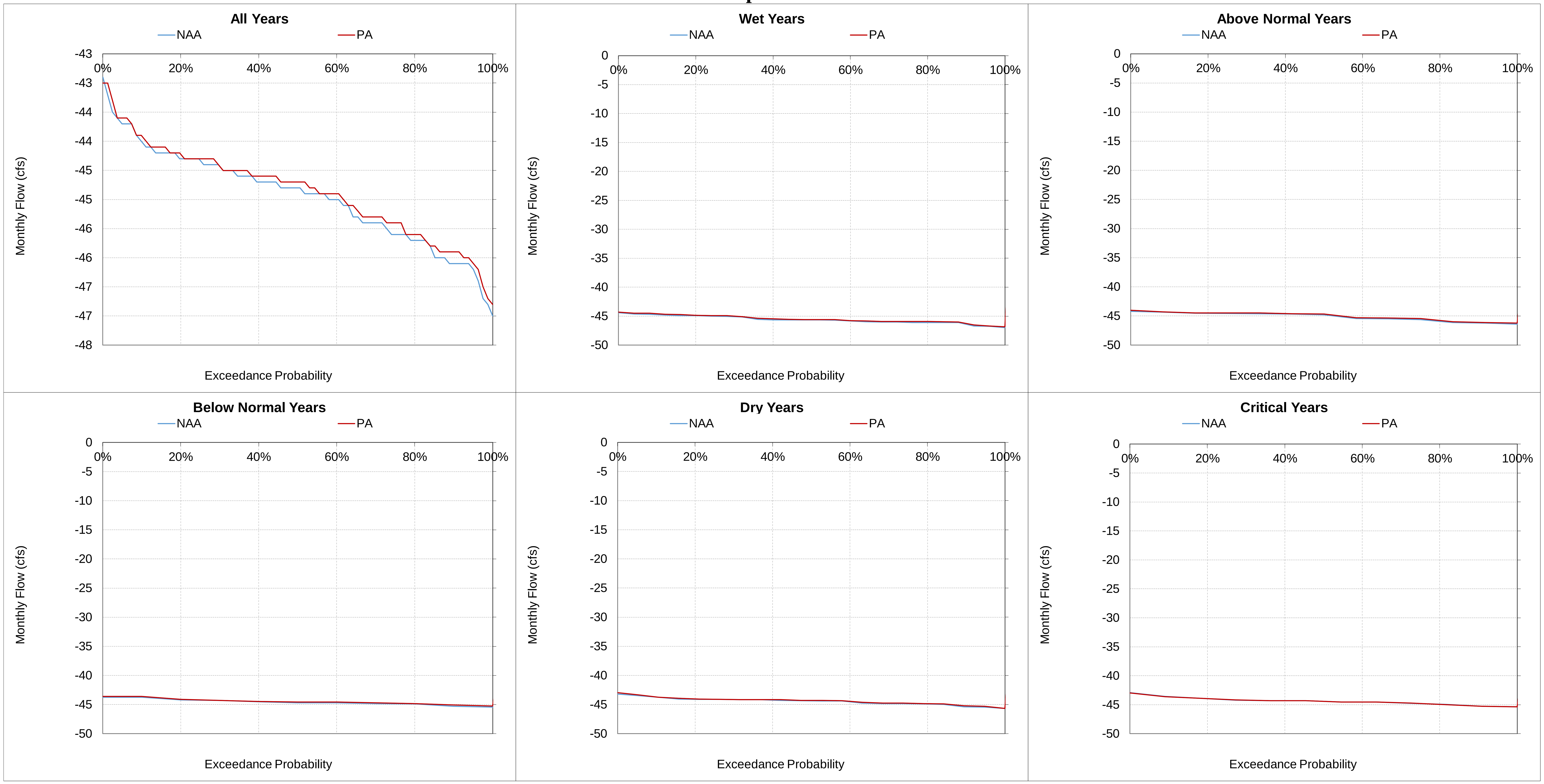
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-34-18. Goodyear Slough upstream of Goodyear Outfall, Monthly Flow
August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-34-19. Goodyear Slough upstream of Goodyear Outfall, Monthly Flow September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-35. Barker Slough at North Bay Aqueduct Intake, Monthly Flow

Statistic	Monthly Flow (cfs)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Percent Diff.	NAA	PA	Diff.	Percent Diff.	NAA	PA	Diff.	Percent Diff.	NAA	PA	Diff.	Percent Diff.	NAA	PA	Diff.	Percent Diff.	NAA	PA	Diff.	Percent Diff.
Probability of Exceedance[a]																								
10%	-38	-46	-8	20%	-37	-31	6	-16%	-58	-51	7	-12%	-76	-76	0	0%	-81	-81	0	0%	-76	-76	0	0%
20%	-59	-57	2	-4%	-45	-39	6	-14%	-94	-93	2	-2%	-76	-76	0	0%	-81	-82	0	0%	-76	-76	0	0%
30%	-66	-62	4	-6%	-59	-48	11	-19%	-106	-98	8	-8%	-76	-76	0	0%	-84	-84	0	0%	-76	-76	0	0%
40%	-86	-86	0	0%	-65	-65	-1	1%	-111	-109	2	-2%	-76	-76	0	0%	-84	-84	0	0%	-76	-76	0	0%
50%	-92	-100	-8	8%	-72	-70	3	-4%	-120	-115	5	-4%	-77	-77	0	0%	-84	-84	0	0%	-77	-82	-6	7%
60%	-98	-103	-5	5%	-82	-73	9	-11%	-128	-130	-2	2%	-77	-77	0	0%	-84	-84	0	0%	-85	-106	-21	24%
70%	-106	-107	-1	1%	-99	-85	14	-14%	-131	-135	-4	3%	-77	-77	0	0%	-92	-115	-23	25%	-103	-107	-5	5%
80%	-120	-122	-2	1%	-117	-105	12	-10%	-137	-138	-1	0%	-78	-102	-24	31%	-114	-119	-5	5%	-106	-110	-4	3%
90%	-139	-142	-3	2%	-138	-118	20	-15%	-155	-157	-3	2%	-113	-117	-4	4%	-118	-120	-2	1%	-108	-111	-3	3%
Long Term Full Simulation Period[b]	-89	-91	-2	2%	-80	-72	7	-9%	-113	-111	1	-1%	-82	-84	-2	3%	-88	-91	-3	4%	-82	-85	-3	3%
Water Year Types[c]																								
Wet (32%)	-113	-118	-5	5%	-86	-88	-2	2%	-133	-135	-2	2%	-87	-90	-3	3%	-108	-115	-8	7%	-103	-107	-5	4%
Above Normal (16%)	-101	-112	-11	11%	-74	-78	-5	7%	-123	-121	2	-2%	-82	-83	-1	1%	-93	-101	-8	9%	-91	-100	-9	10%
Below Normal (13%)	-86	-85	1	-1%	-89	-76	13	-14%	-102	-96	6	-6%	-82	-84	-2	3%	-72	-72	0	0%	-82	-87	-5	6%
Dry (24%)	-80	-69	12	-15%	-87	-69	18	-20%	-92	-90	2	-2%	-80	-82	-2	2%	-79	-76	3	-4%	-73	-69	4	-5%
Critical (15%)	-41	-48	-7	18%	-52	-35	17	-33%	-102	-99	3	-3%	-70	-73	-3	4%	-66	-70	-4	6%	-45	-45	0	0%

Statistic	Monthly Flow (cfs)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Percent Diff.	NAA	PA	Diff.	Percent Diff.	NAA	PA	Diff.	Percent Diff.	NAA	PA	Diff.	Percent Diff.	NAA	PA	Diff.	Percent Diff.	NAA	PA	Diff.	Percent Diff.
Probability of Exceedance[a]																								
10%	-2	-25	-22	928%	-28	-44	-16	57%	-47	-54	-7	15%	-50	-51	-1	1%	-75	-70	5	-6%	-43	-41	2	-4%
20%	-79	-79	0	0%	-58	-72	-14	24%	-77	-88	-11	14%	-81	-86	-5	6%	-105	-102	3	-3%	-71	-82	-11	15%
30%	-79	-79	0	0%	-95	-99	-4	4%	-111	-98	14	-12%	-109	-100	9	-8%	-114	-117	-3	3%	-102	-100	3	-3%
40%	-79	-81	-2	3%	-106	-112	-6	6%	-119	-119	0	0%	-121	-119	2	-2%	-121	-123	-2	2%	-122	-125	-3	2%
50%	-93	-141	-48	51%	-132	-142	-10	8%	-123	-123	0	0%	-131	-122	10	-7%	-127	-129	-2	2%	-128	-128	-1	0%
60%	-140	-141	-1	1%	-142	-142	0	0%	-136	-139	-3	2%	-146	-130	15	-10%	-132	-147	-15	11%	-134	-131	3	-2%
70%	-141	-141	0	0%	-142	-143	0	0%	-157	-158	0	0%	-150	-146	4	-3%	-149	-162	-12	8%	-141	-133	8	-5%
80%	-141	-141	0	0%	-143	-143	0	0%	-158	-158	0	0%	-155	-152	3	-2%	-156	-173	-18	11%	-141	-141	0	0%
90%	-141	-141	0	0%	-143	-143	0	0%	-158	-158	0	0%	-161	-160	1	-1%	-170	-175	-5	3%	-141	-142	0	0%
Long Term Full Simulation Period[b]	-98	-105	-7	7%	-107	-111	-4	4%	-118	-119	-1	1%	-121	-118	3	-2%	-126	-130	-4	3%	-110	-110	0	0%
Water Year Types[c]																								
Wet (32%)	-133	-138	-5	4%	-141	-141	0	0%	-149	-151	-1	1%	-148	-152	-4	3%	-137	-159	-21	15%	-134	-136	-2	1%
Above Normal (16%)	-117	-133	-16	14%	-129	-138	-9	7%	-136	-139	-3	2%	-149	-142	7	-5%	-139	-133	5	-4%	-130	-131	-1	1%
Below Normal (13%)	-88	-97	-9	11%	-110	-108	3	-2%	-134	-126	7	-5%	-140	-112	28	-20%	-136	-129	7	-5%	-131	-117	13	-10%
Dry (24%)	-79	-86	-7	8%	-85	-94	-9	11%	-93	-97	-4	4%	-94	-97	-3	3%	-125	-124	1	-1%	-94	-98	-4	4%
Critical (15%)	-40	-40	0	0%	-40	-47	-6	16%	-59	-59	0	0%	-57	-56	1	-1%	-81	-77	4	-5%	-47	-48	-1	1%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

e Negative flow indicates flow towards the North Bay Aqueduct.

Figure 5.B.5-35-1. Monthly Flow Ranges For Barker Slough at North Bay Aqueduct Intake, All Years

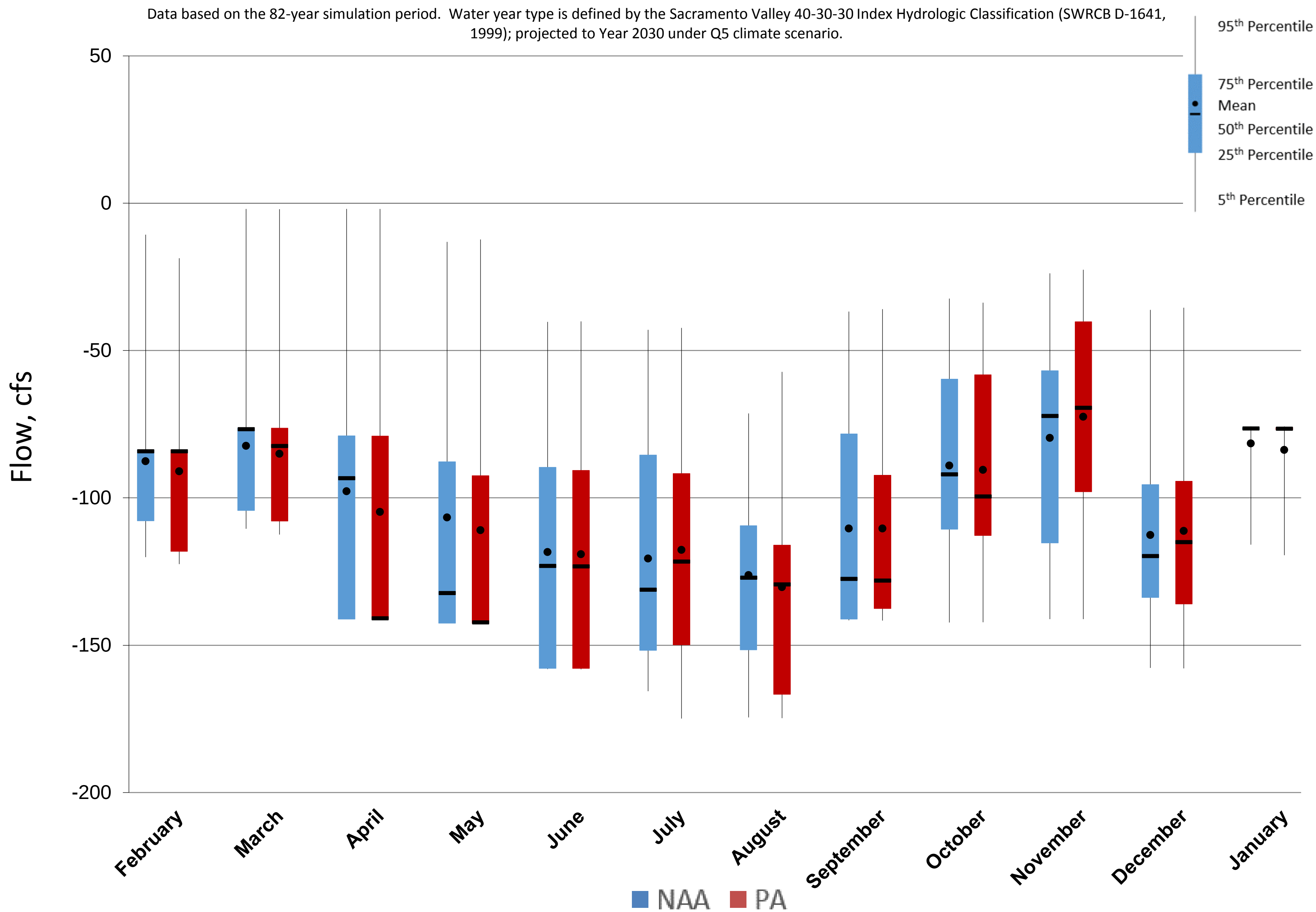


Figure 5.B.5-35-2. Monthly Flow Ranges For Barker Slough at North Bay Aqueduct Intake, Wet Years

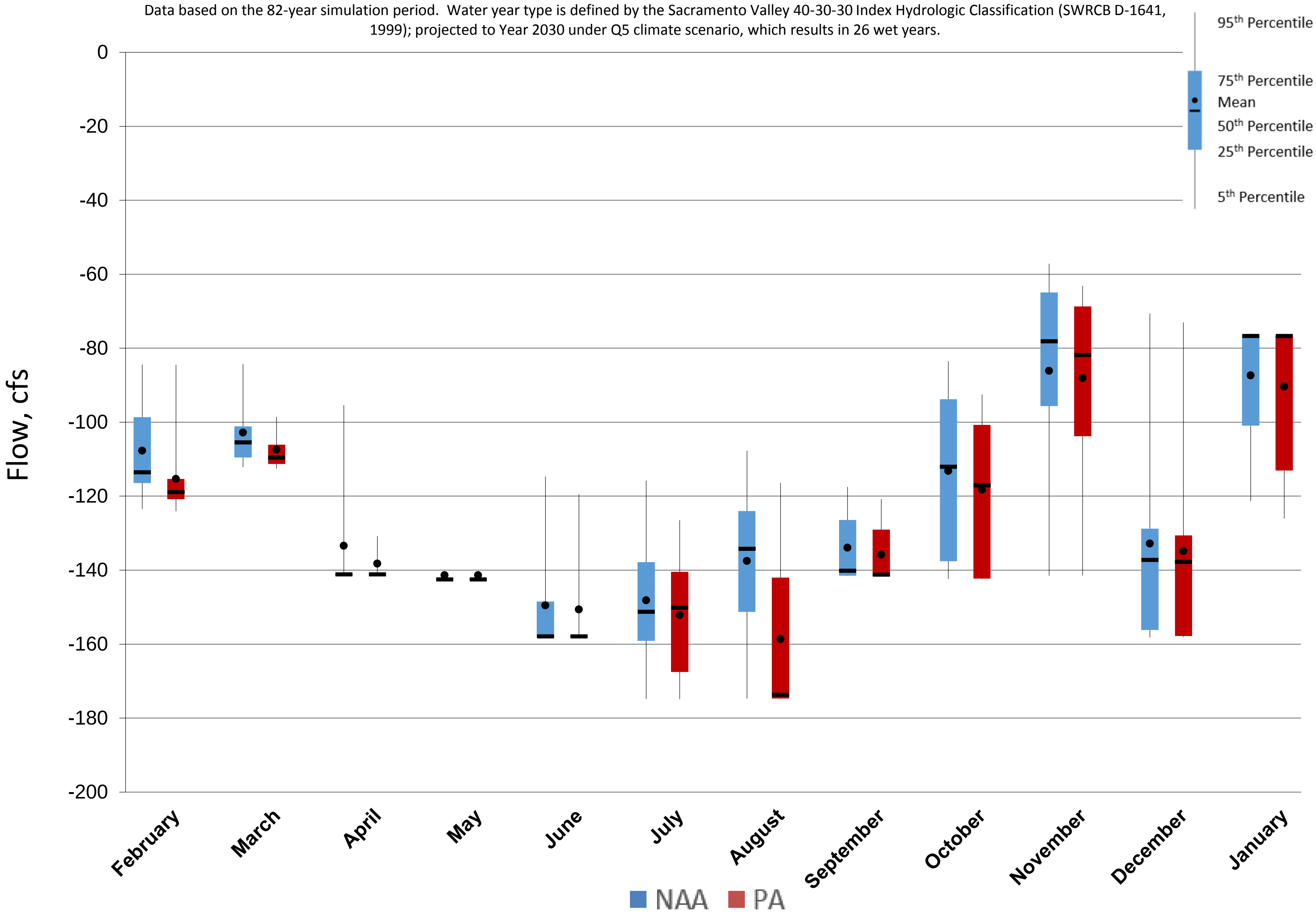


Figure 5.B.5-35-3. Monthly Flow Ranges For Barker Slough at North Bay Aqueduct Intake, Above Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 13 above normal years.

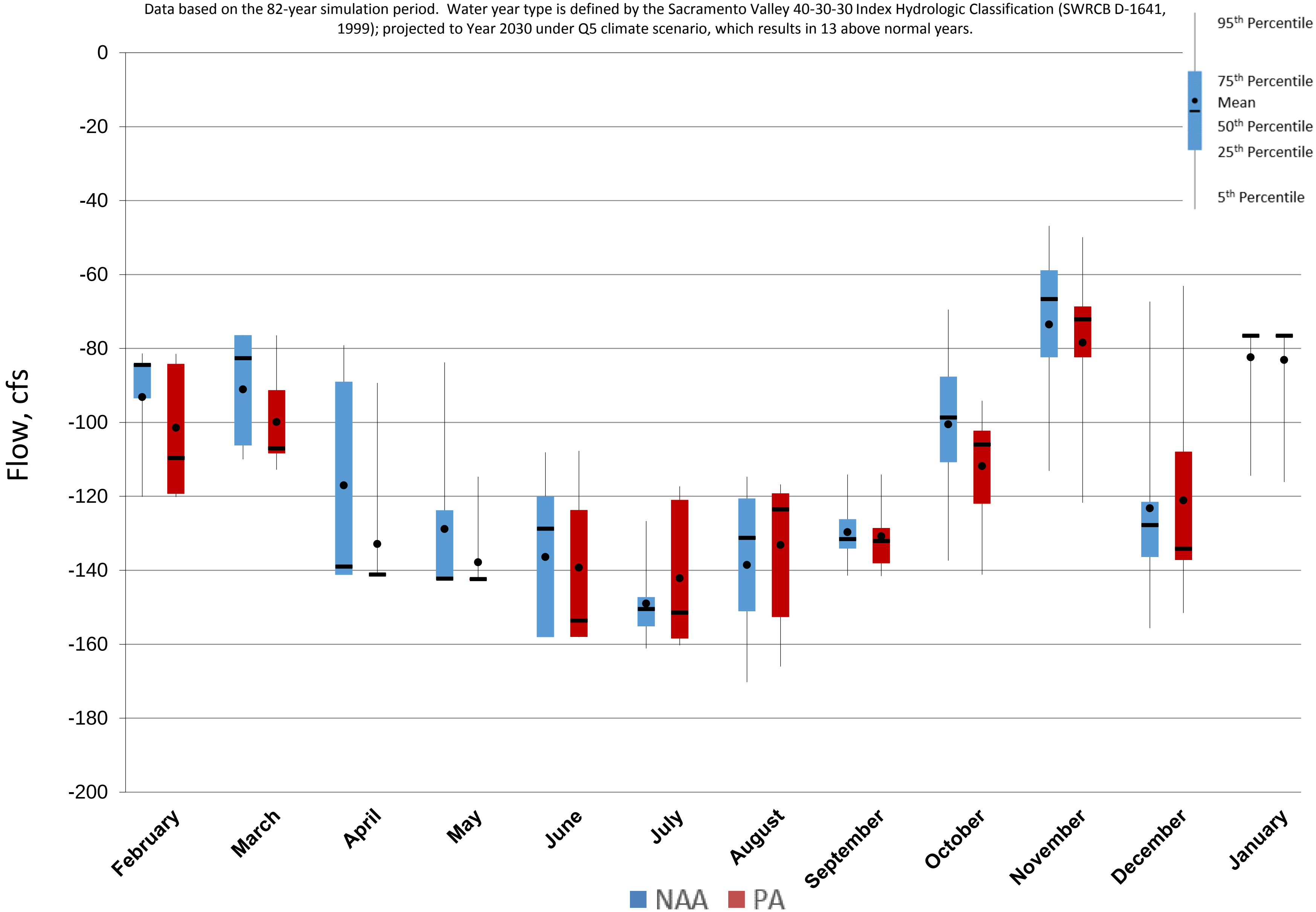


Figure 5.B.5-35-4. Monthly Flow Ranges For Barker Slough at North Bay Aqueduct Intake, Below Normal Years

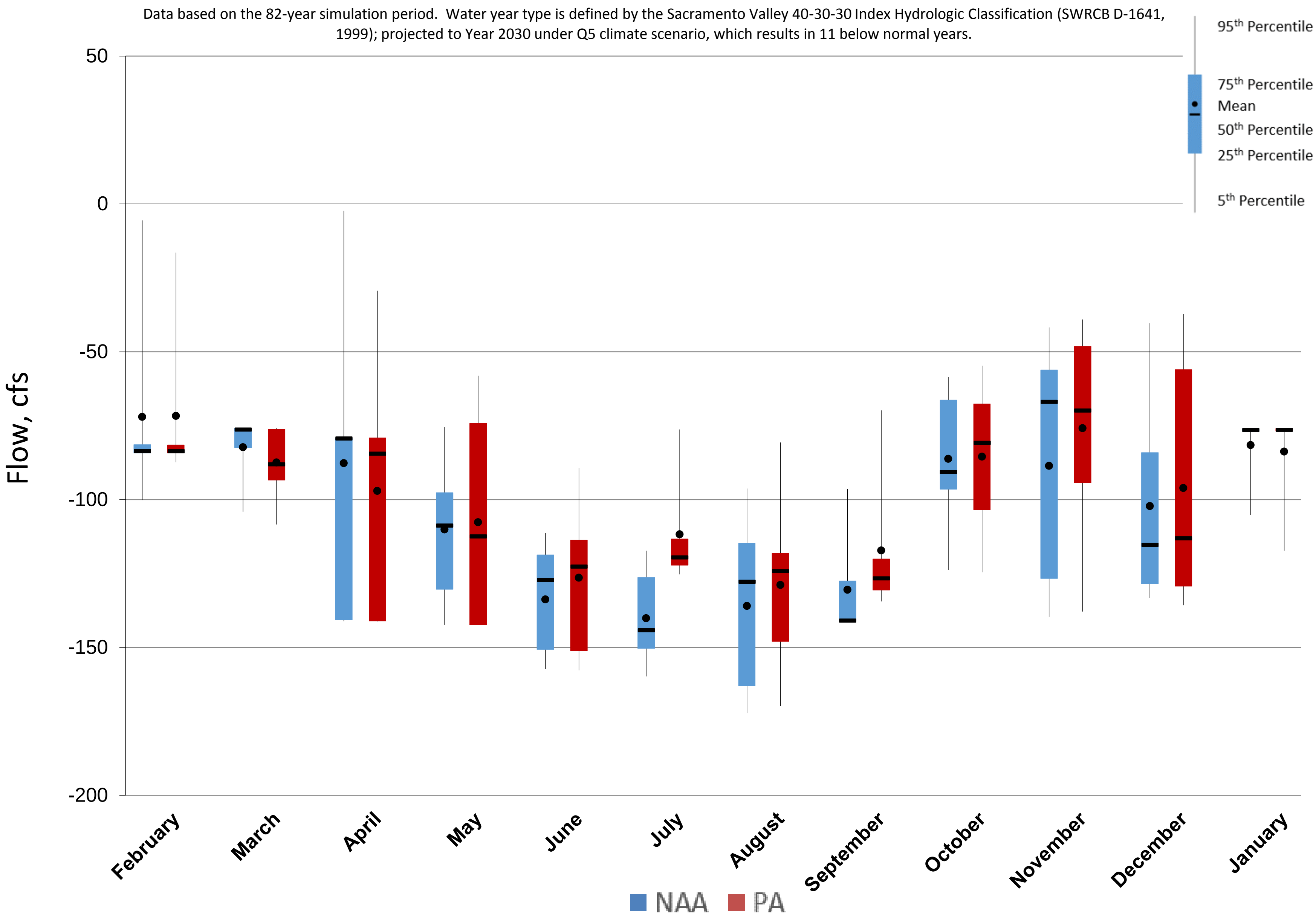
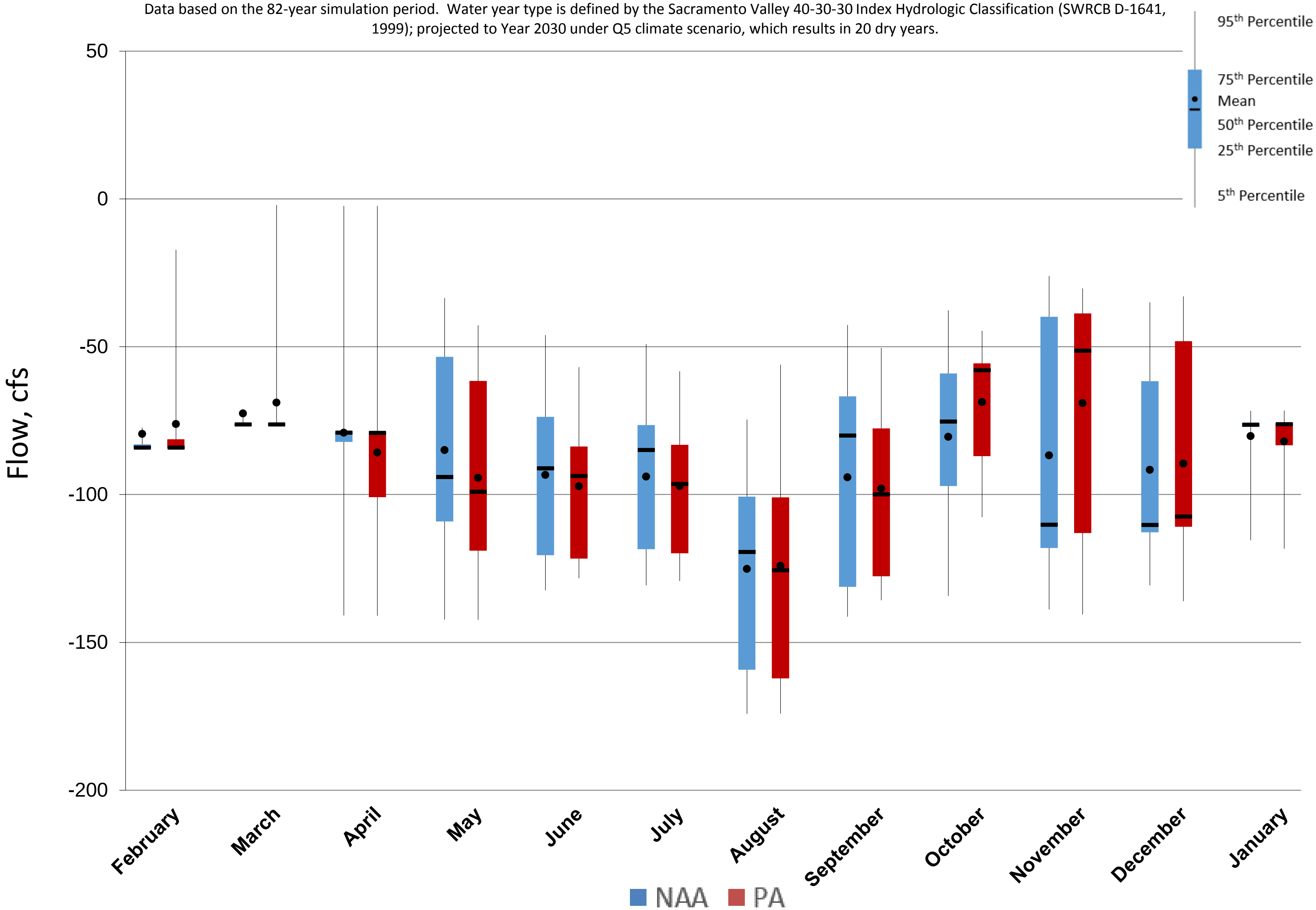


Figure 5.B.5-35-5. Monthly Flow Ranges For Barker Slough at North Bay Aqueduct Intake, Dry Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 20 dry years.



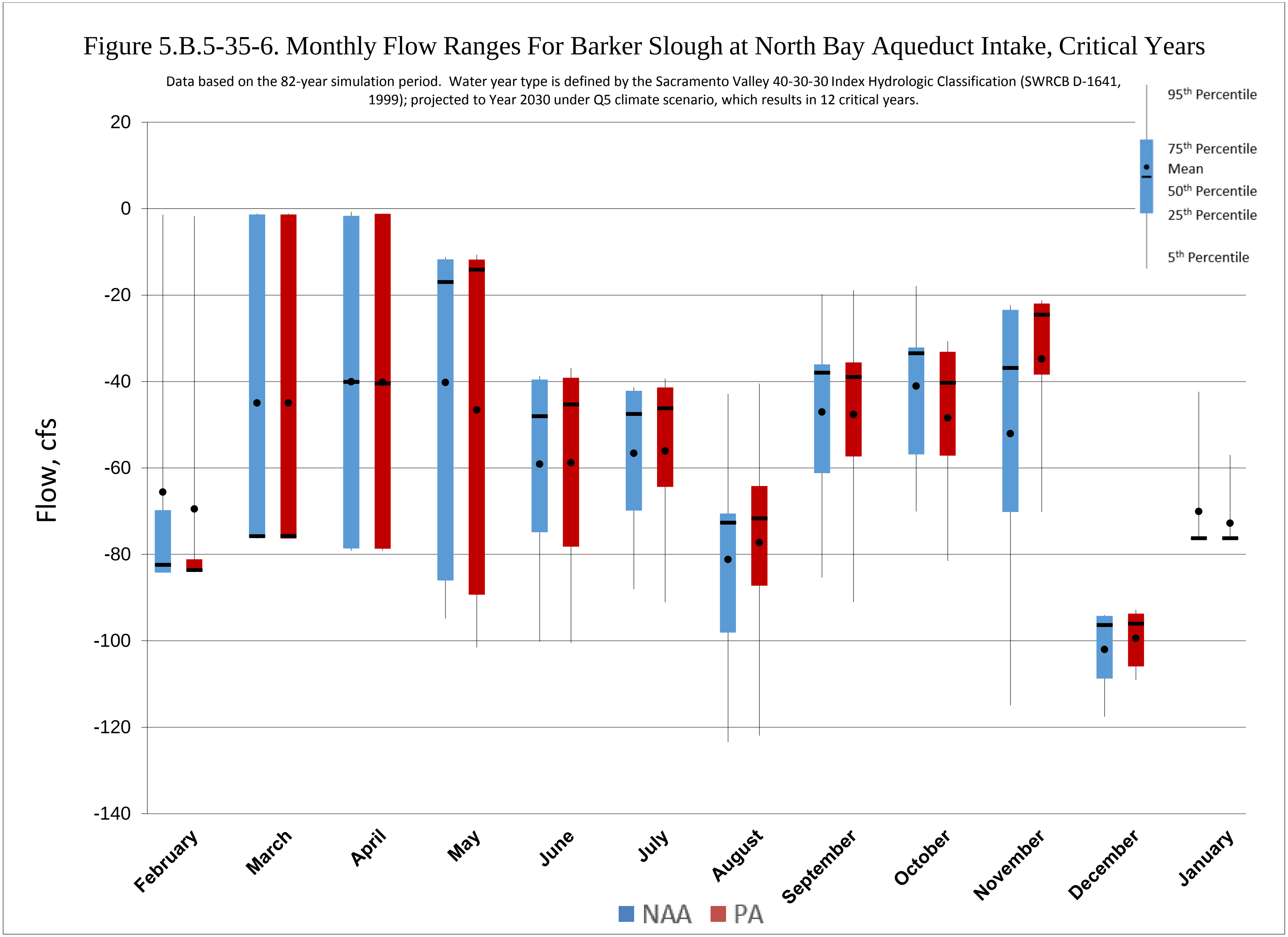
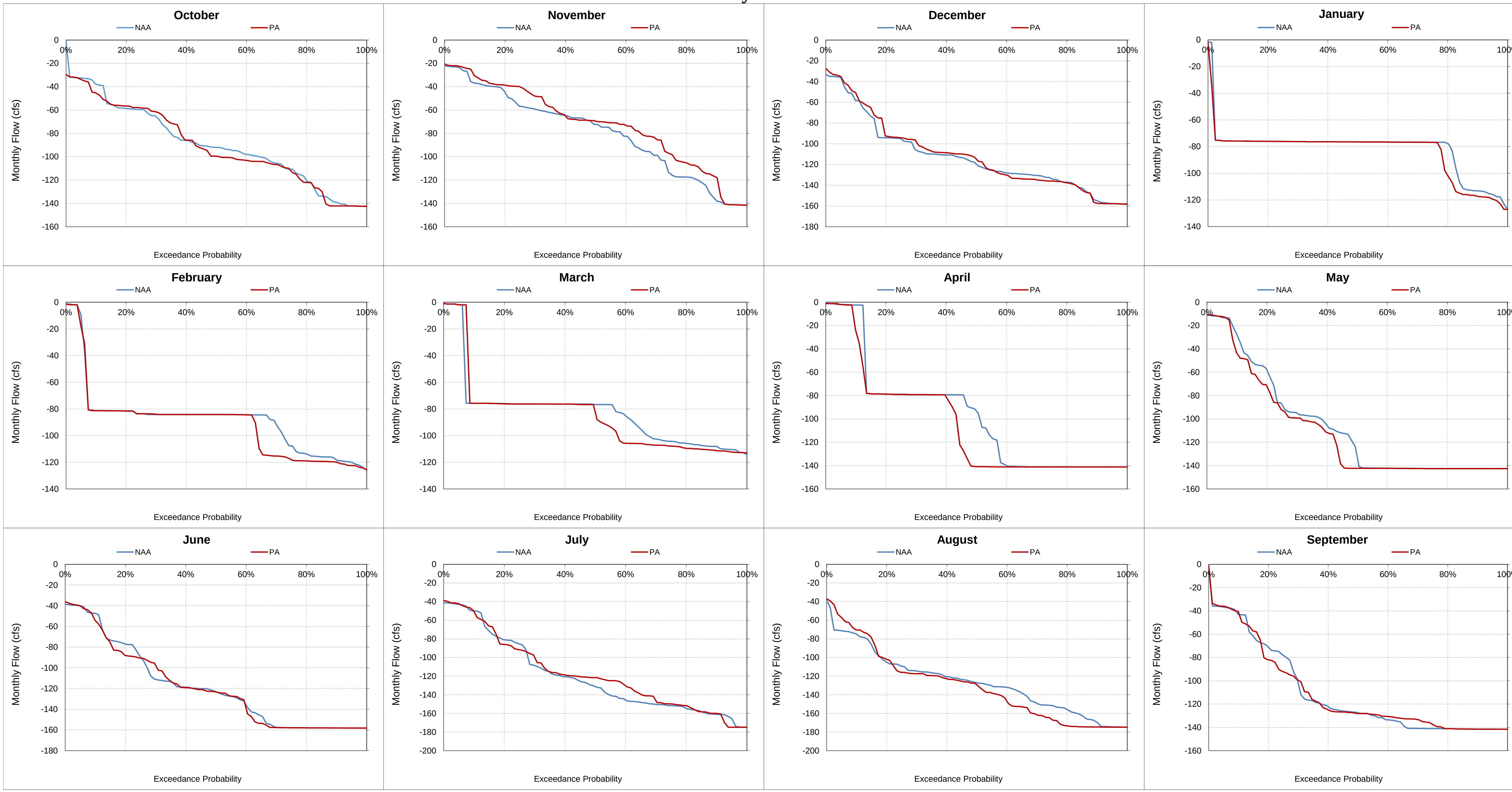


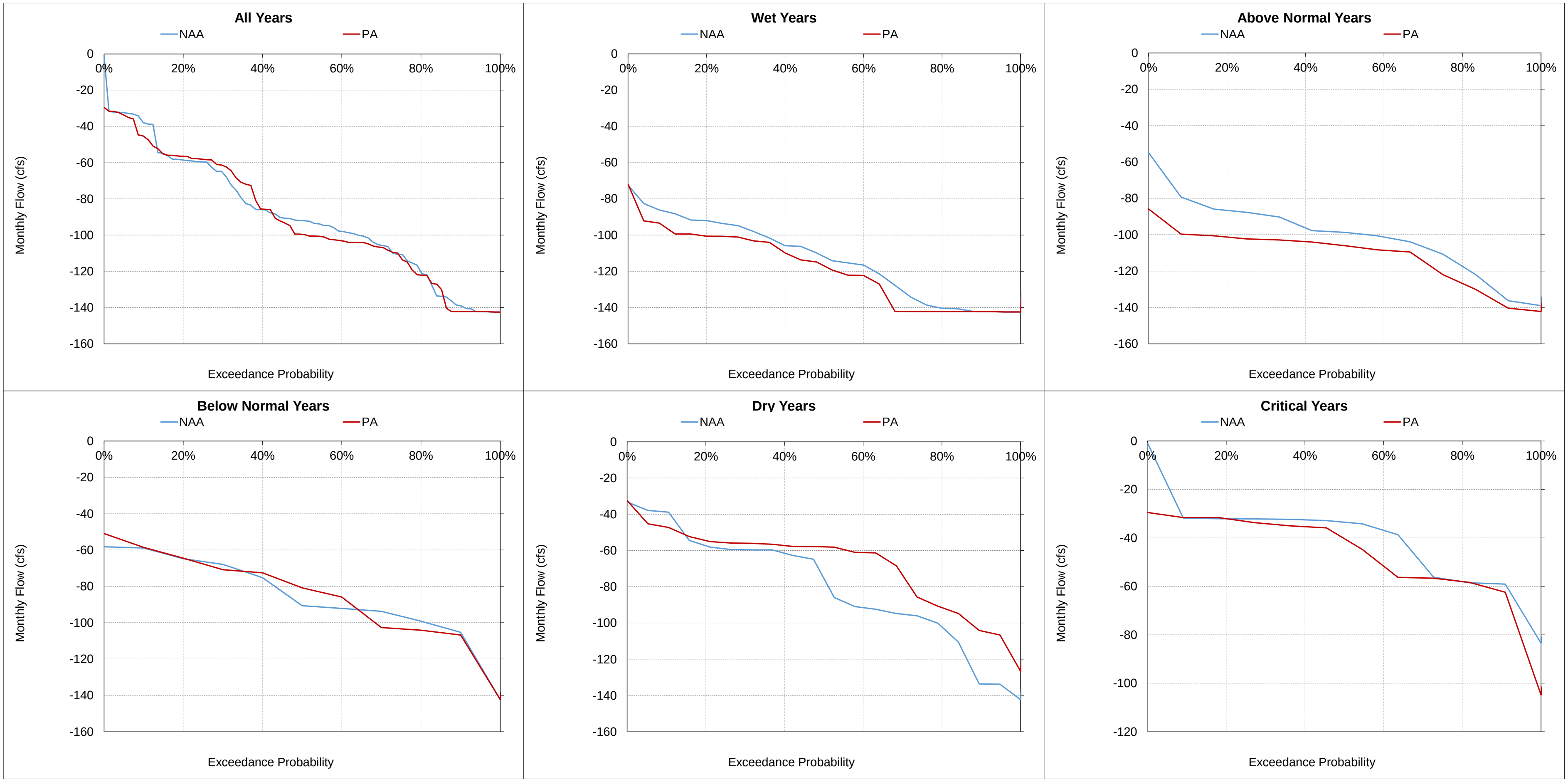
Figure 5.B.5-35-6. Monthly Flow Ranges For Barker Slough at North Bay Aqueduct Intake, Critical Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 12 critical years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
Flow, cfs
20
0
-20
-40
-60
-80
-100
-120
-140
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-35-7. Barker Slough at North Bay Aqueduct Intake, Monthly Flow Probability of Exceedance



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.
e Negative flow indicates flow towards the North Bay Aqueduct.

Figure 5.B.5-35-8. Barker Slough at North Bay Aqueduct Intake, Monthly Flow October



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

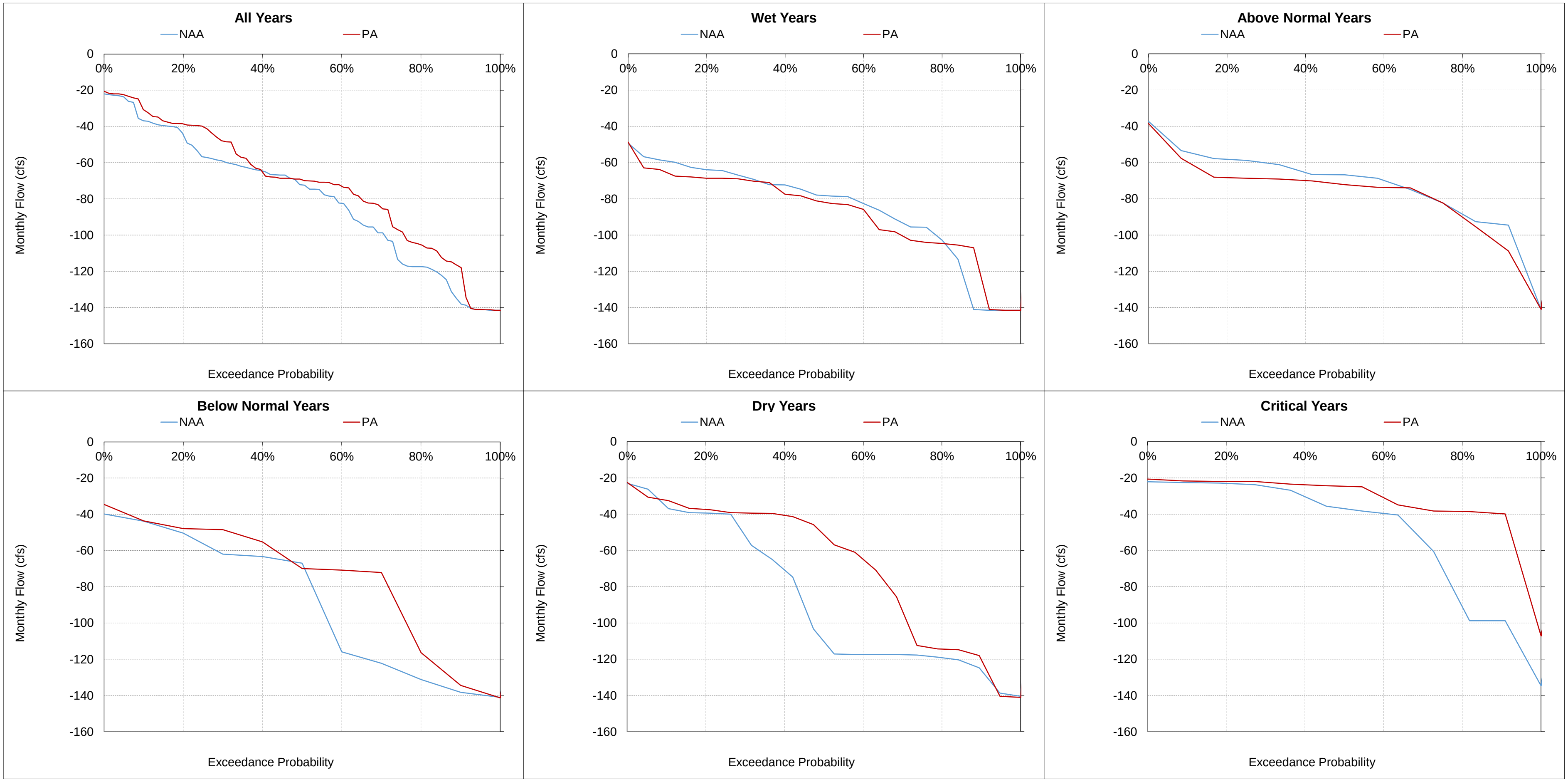
b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

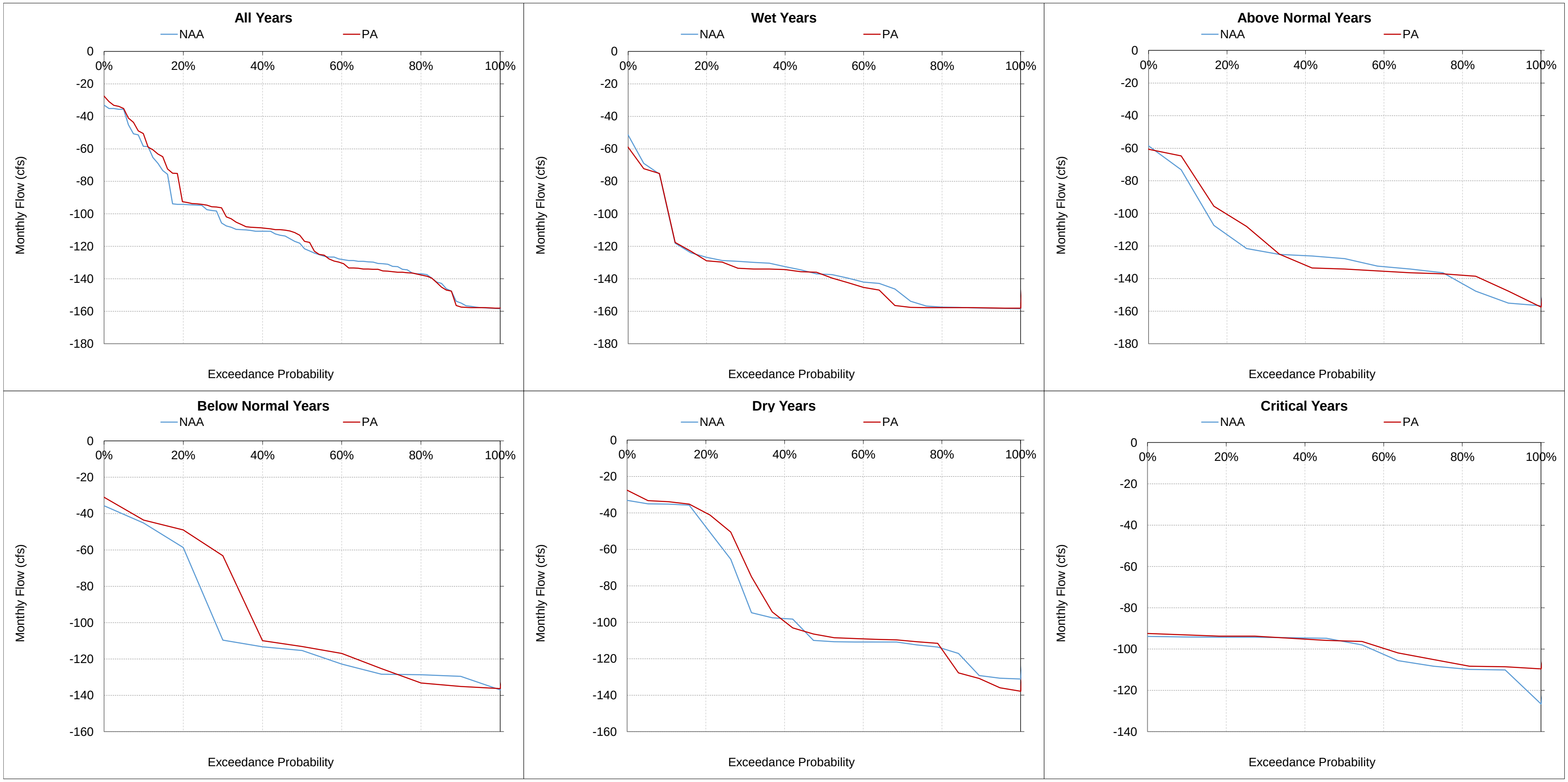
e Negative flow indicates flow towards the North Bay Aqueduct.

Figure 5.B.5-35-9. Barker Slough at North Bay Aqueduct Intake, Monthly Flow
November



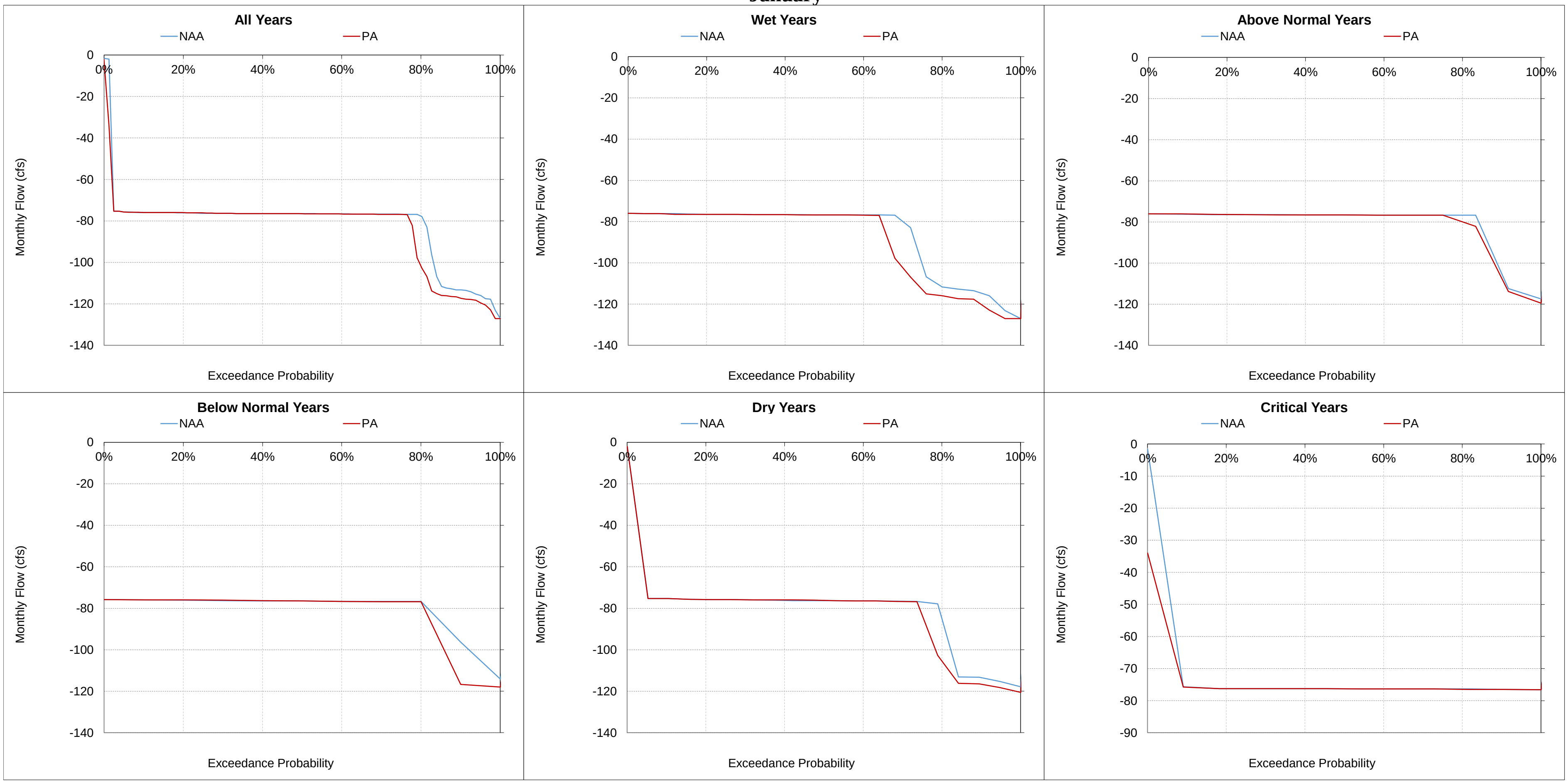
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.
e Negative flow indicates flow towards the North Bay Aqueduct.

Figure 5.B.5-35-10. Barker Slough at North Bay Aqueduct Intake, Monthly Flow
December



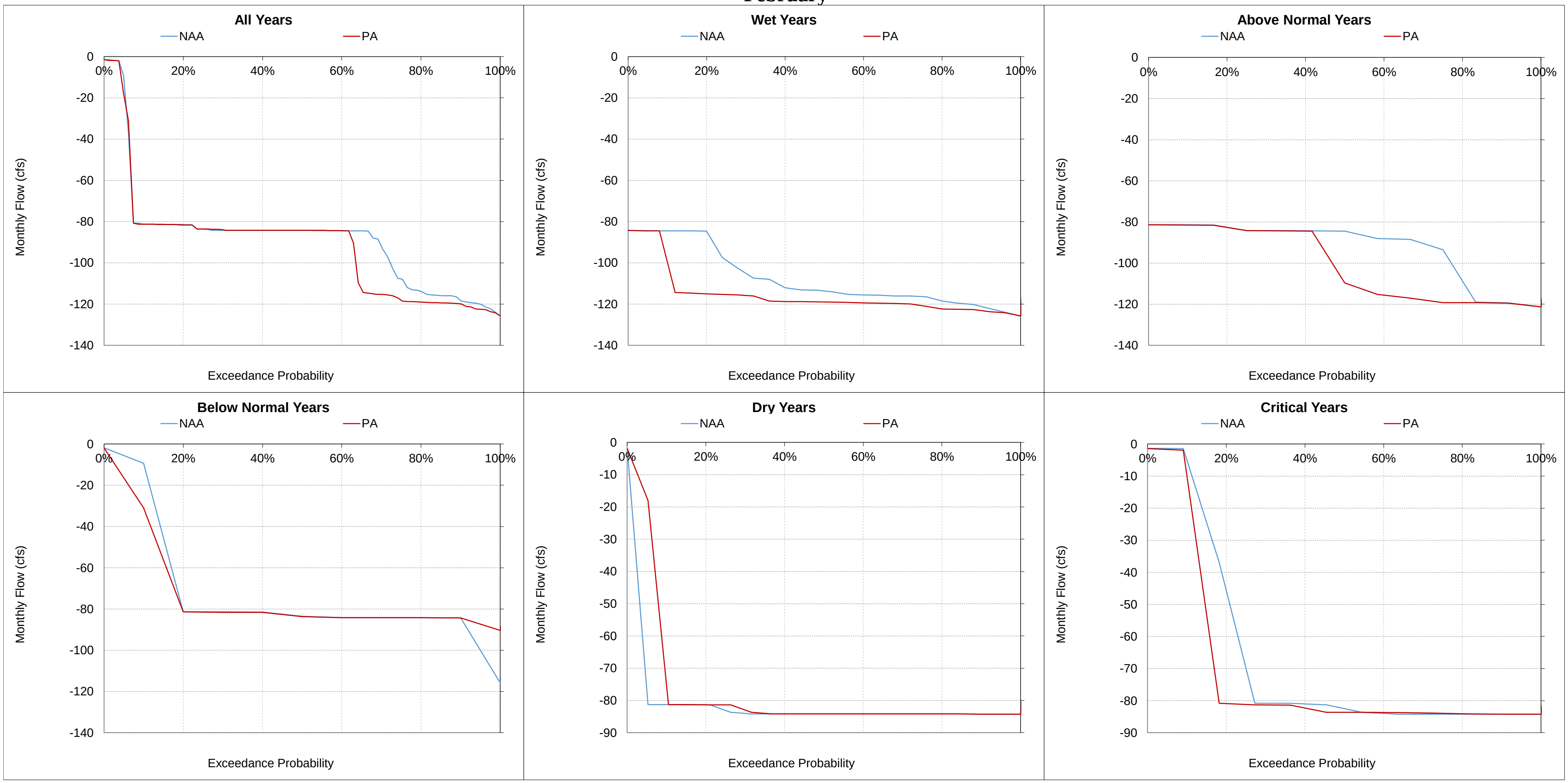
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.
e Negative flow indicates flow towards the North Bay Aqueduct.

Figure 5.B.5-35-11. Barker Slough at North Bay Aqueduct Intake, Monthly Flow
January



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.
e Negative flow indicates flow towards the North Bay Aqueduct.

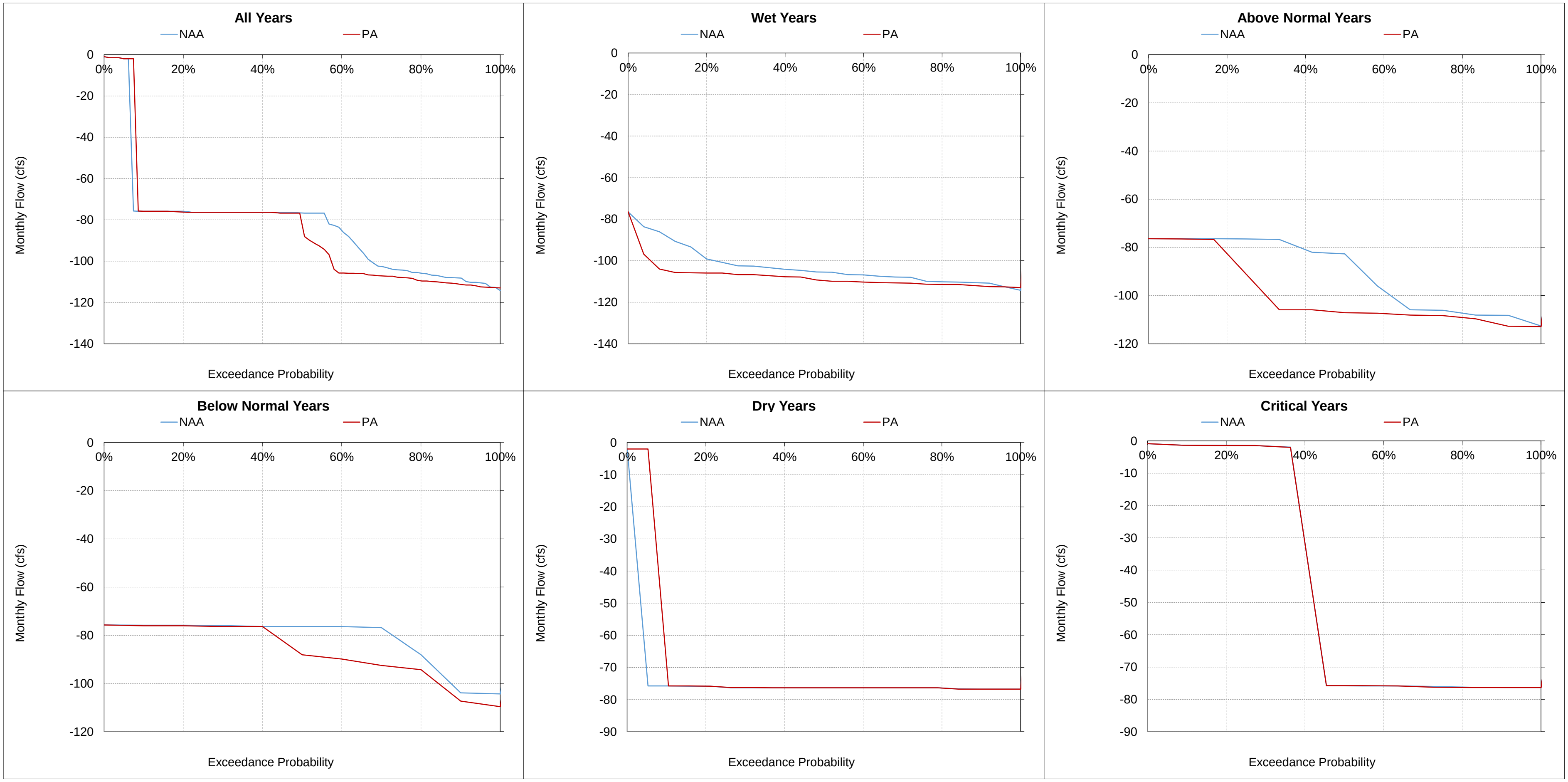
Figure 5.B.5-35-12. Barker Slough at North Bay Aqueduct Intake, Monthly Flow
February



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.
e Negative flow indicates flow towards the North Bay Aqueduct.

Figure 5.B.5-35-13. Barker Slough at North Bay Aqueduct Intake, Monthly Flow

March



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

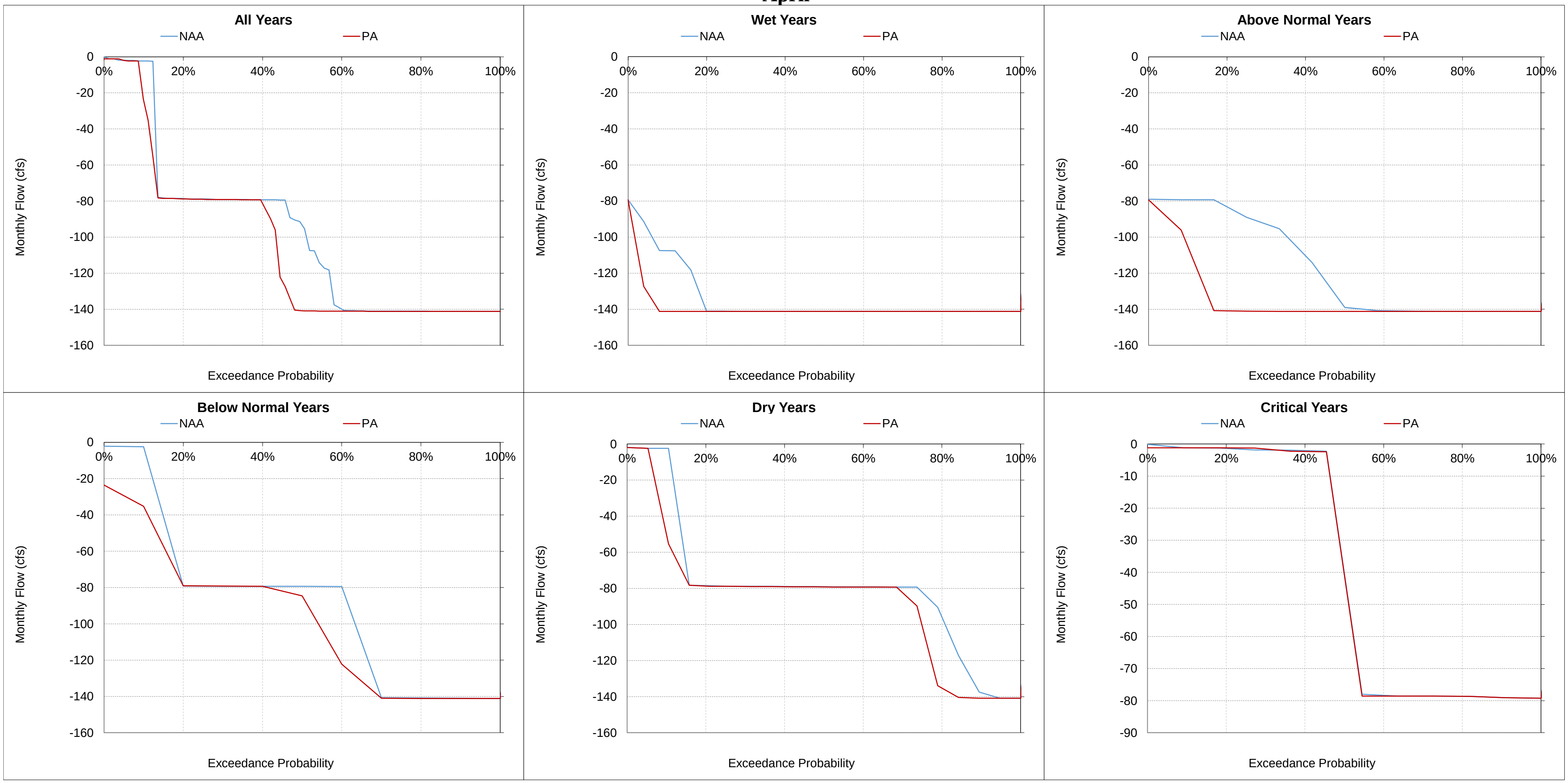
b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

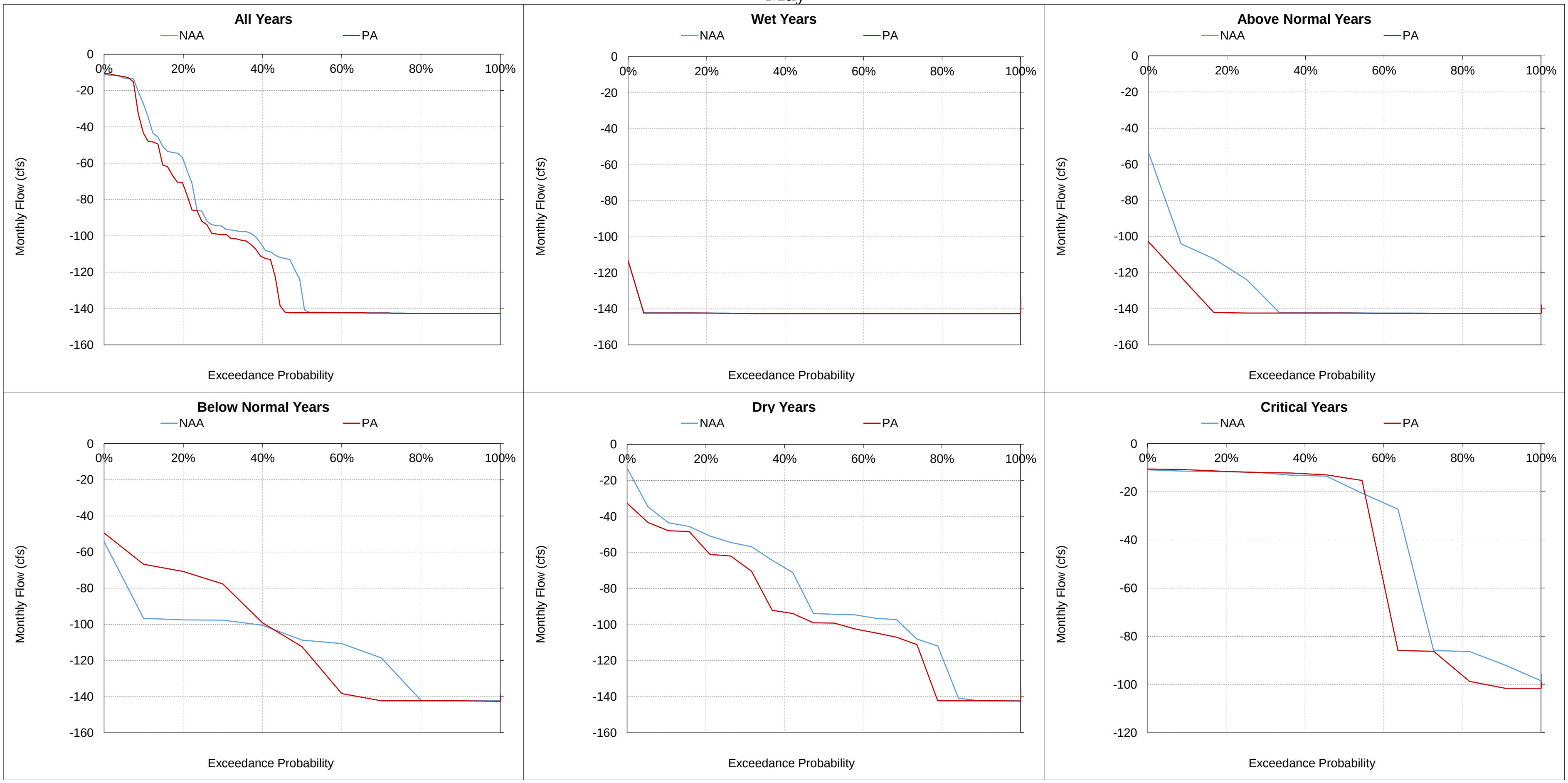
e Negative flow indicates flow towards the North Bay Aqueduct.

Figure 5.B.5-35-14. Barker Slough at North Bay Aqueduct Intake, Monthly Flow April



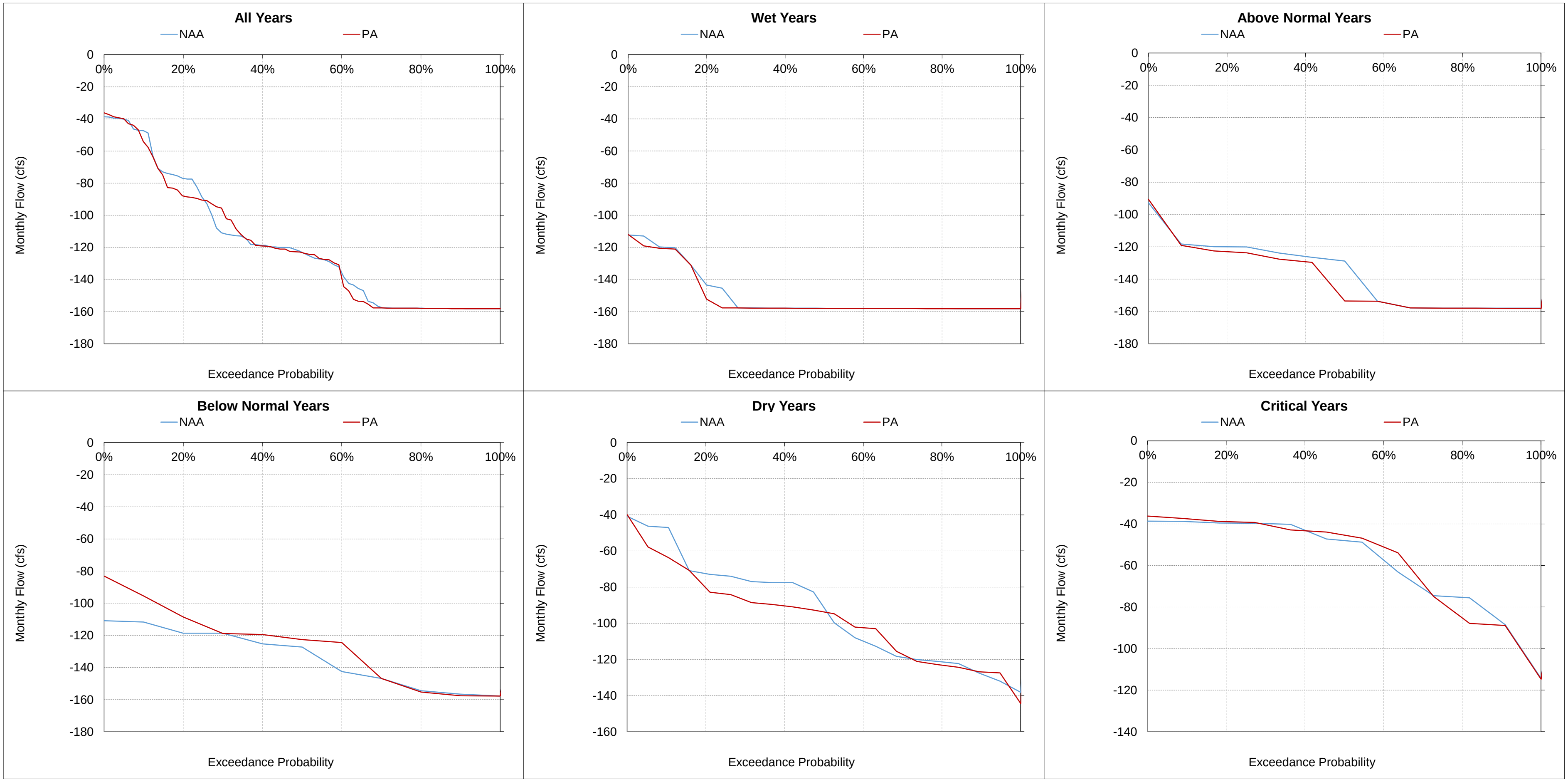
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.
e Negative flow indicates flow towards the North Bay Aqueduct.

Figure 5.B.5-35-15. Barker Slough at North Bay Aqueduct Intake, Monthly Flow
May



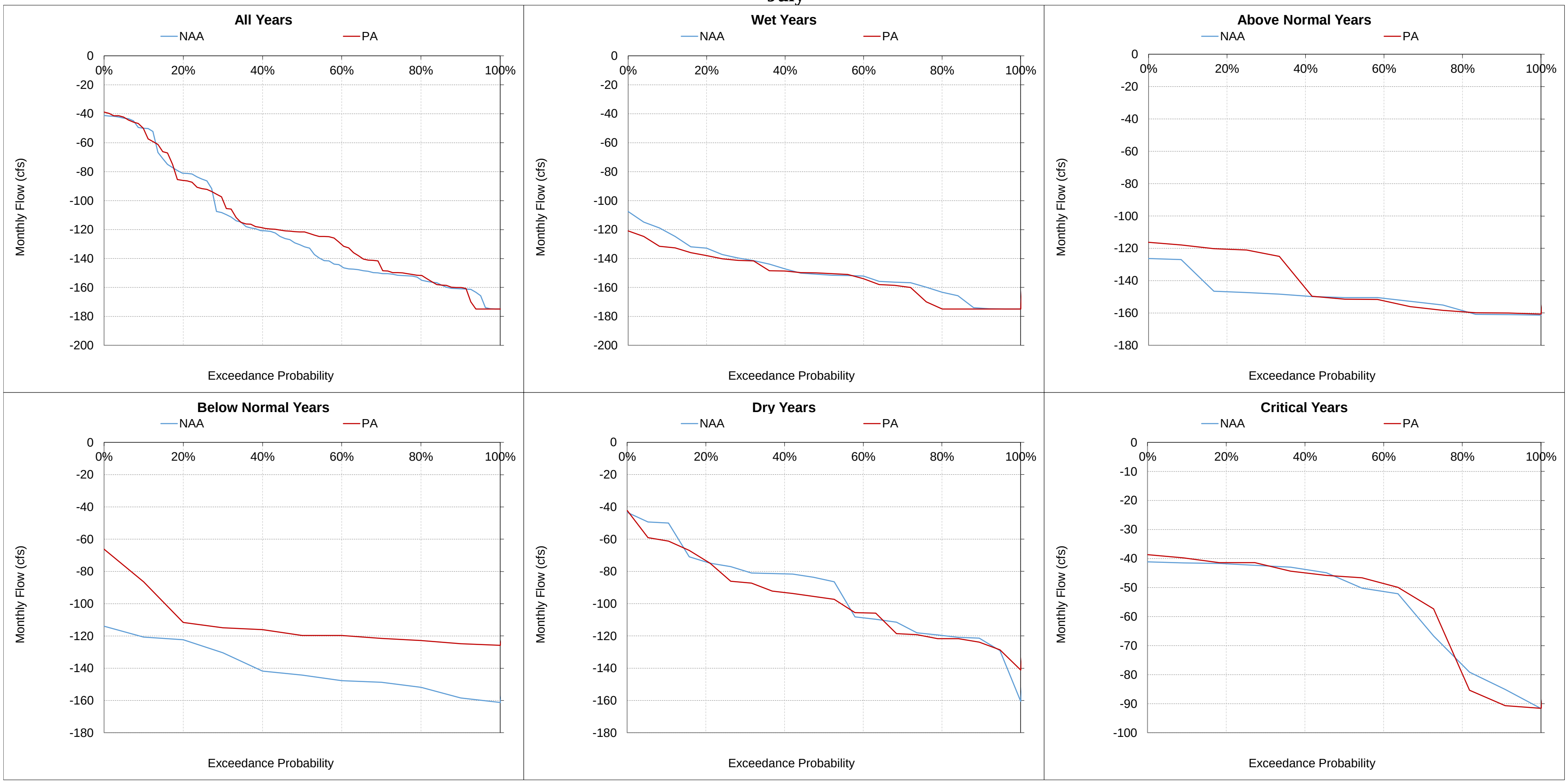
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.
e Negative flow indicates flow towards the North Bay Aqueduct.

Figure 5.B.5-35-16. Barker Slough at North Bay Aqueduct Intake, Monthly Flow
June



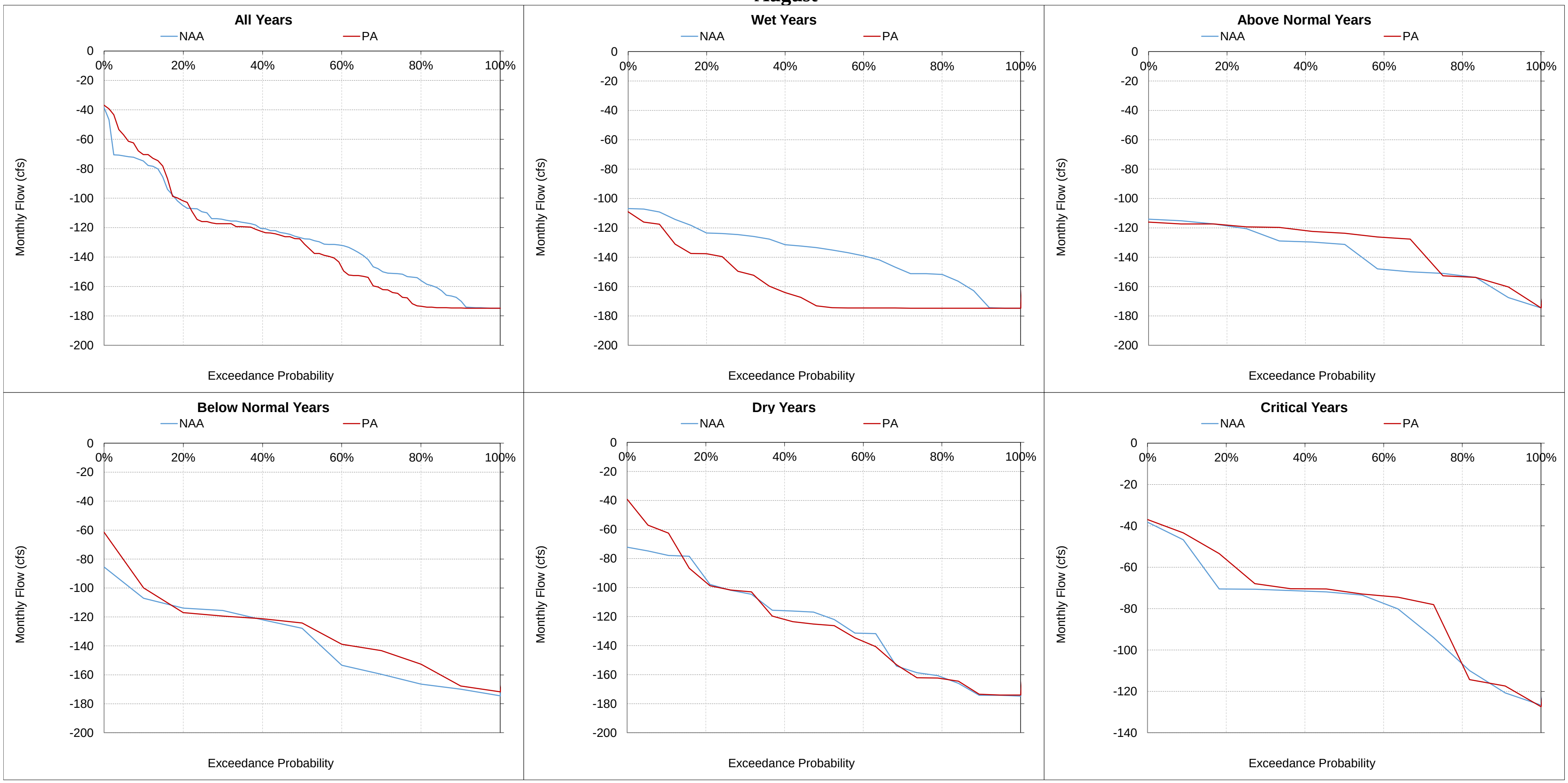
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.
e Negative flow indicates flow towards the North Bay Aqueduct.

Figure 5.B.5-35-17. Barker Slough at North Bay Aqueduct Intake, Monthly Flow
July



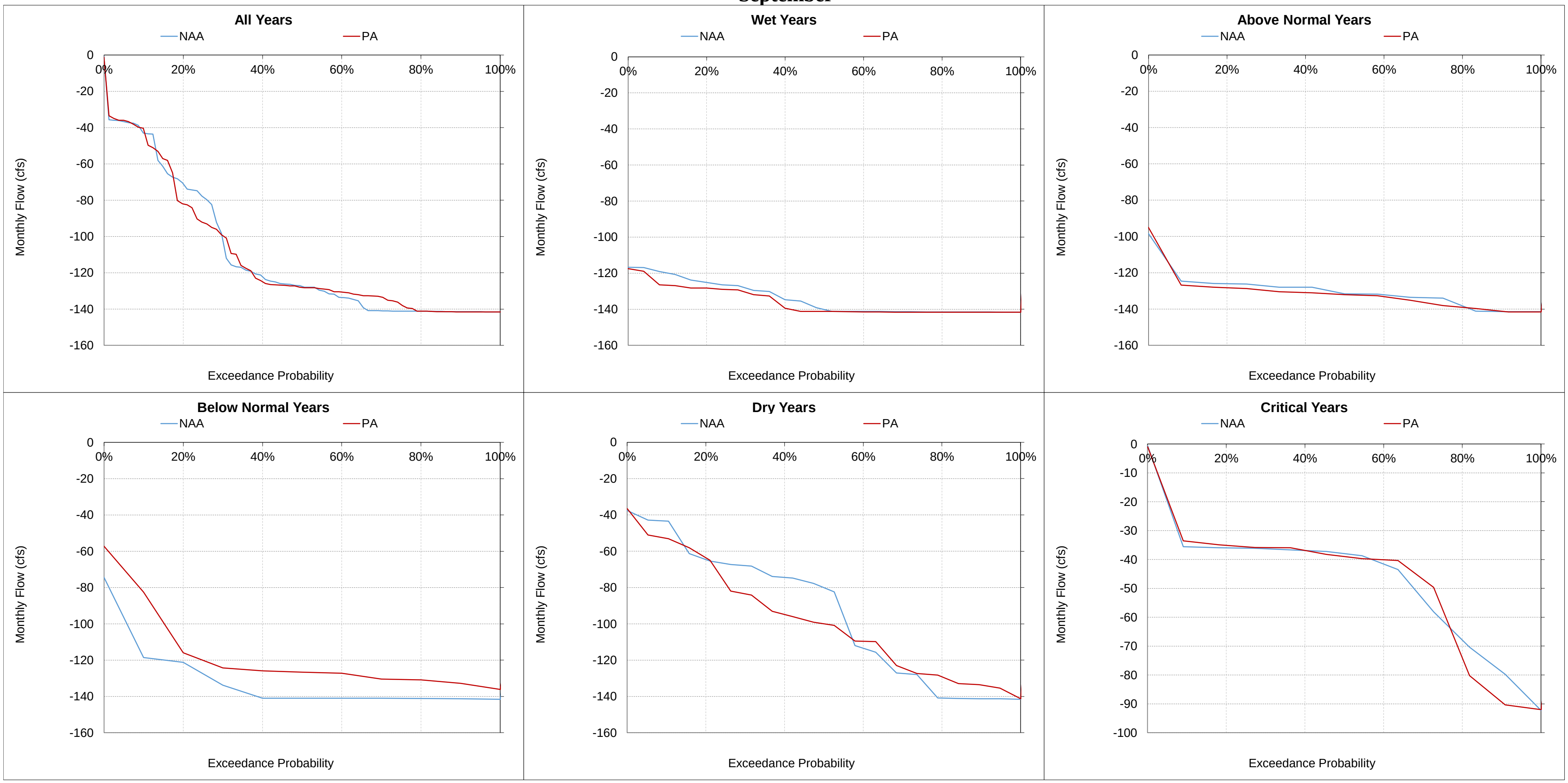
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.
e Negative flow indicates flow towards the North Bay Aqueduct.

Figure 5.B.5-35-18. Barker Slough at North Bay Aqueduct Intake, Monthly Flow August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.
e Negative flow indicates flow towards the North Bay Aqueduct.

Figure 5.B.5-35-19. Barker Slough at North Bay Aqueduct Intake, Monthly Flow
September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.
e Negative flow indicates flow towards the North Bay Aqueduct.

Table 5.B.5-36. Rock Slough at Contra Costa Canal Intake, Monthly Flow

Statistic	October				November				December				January				February				March			
	Monthly Flow (cfs)																							
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	-5	-5	0	0%	-3	-3	0	0%	-3	-3	0	0%	-3	-3	0	0%	-60	-46	14	-24%	-3	-3	0	0%
20%	-6	-6	0	0%	-4	-4	0	0%	-4	-4	0	0%	-4	-4	0	0%	-87	-85	2	-3%	-3	-4	0	4%
30%	-7	-7	0	0%	-4	-4	0	0%	-4	-4	0	0%	-4	-4	0	5%	-118	-104	14	-12%	-5	-5	0	-2%
40%	-7	-7	0	0%	-4	-4	0	0%	-4	-4	0	0%	-5	-35	-31	658%	-125	-125	0	0%	-5	-5	0	-1%
50%	-7	-7	0	0%	-4	-4	0	0%	-103	-103	0	0%	-47	-52	-5	11%	-130	-130	0	0%	-6	-6	0	0%
60%	-249	-249	0	0%	-164	-164	0	0%	-113	-113	0	0%	-89	-90	-1	1%	-131	-131	0	0%	-7	-7	0	0%
70%	-251	-251	0	0%	-169	-169	0	0%	-121	-121	0	0%	-112	-112	0	0%	-162	-162	0	0%	-8	-8	0	0%
80%	-252	-252	0	0%	-170	-170	0	0%	-122	-122	0	0%	-134	-134	0	0%	-174	-174	0	0%	-105	-112	-7	7%
90%	-257	-257	0	0%	-183	-183	0	0%	-167	-167	0	0%	-176	-176	0	0%	-203	-203	0	0%	-151	-152	-1	1%
Long Term Full Simulation Period[b]	-116	-116	0	0%	-78	-78	0	0%	-73	-73	0	0%	-67	-70	-3	4%	-127	-125	2	-2%	-36	-37	-1	3%
Water Year Types[c]																								
Wet (32%)	-251	-251	0	0%	-162	-162	0	0%	-116	-116	0	0%	-59	-68	-9	15%	-102	-100	2	-2%	-4	-4	0	0%
Above Normal (16%)	-210	-211	0	0%	-145	-145	0	0%	-131	-131	0	0%	-50	-50	0	1%	-148	-148	0	0%	-31	-31	0	0%
Below Normal (13%)	-6	-6	0	0%	-21	-21	0	0%	-27	-27	0	0%	-63	-63	0	0%	-123	-123	0	0%	-40	-41	0	0%
Dry (24%)	-6	-6	0	0%	-4	-4	0	0%	-45	-45	0	0%	-85	-85	0	0%	-137	-131	6	-4%	-38	-39	-1	3%
Critical (15%)	-7	-7	0	0%	-3	-3	0	0%	-4	-4	0	0%	-74	-74	0	0%	-148	-148	0	0%	-104	-108	-4	4%

Statistic	April				May				June				July				August				September			
	Monthly Flow (cfs)																							
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	-12	-15	-3	30%	-11	-15	-5	43%	-285	-285	0	0%	-61	-61	0	0%	-12	-12	0	0%	-7	-7	0	0%
20%	-38	-38	0	0%	-46	-97	-50	108%	-286	-286	-1	0%	-176	-176	0	0%	-13	-13	0	0%	-8	-8	0	0%
30%	-45	-45	-1	1%	-95	-210	-114	120%	-287	-287	0	0%	-224	-224	0	0%	-21	-21	0	0%	-8	-8	0	0%
40%	-66	-94	-28	43%	-97	-214	-117	120%	-308	-308	0	0%	-233	-233	0	0%	-46	-46	0	0%	-9	-9	0	0%
50%	-120	-124	-4	3%	-211	-215	-4	2%	-309	-309	0	0%	-333	-333	0	0%	-47	-48	0	1%	-9	-9	0	0%
60%	-171	-183	-12	7%	-225	-235	-10	4%	-310	-310	0	0%	-334	-334	0	0%	-66	-71	-4	7%	-10	-10	0	0%
70%	-211	-211	0	0%	-259	-269	-10	4%	-317	-317	0	0%	-335	-335	0	0%	-130	-130	0	0%	-11	-11	0	0%
80%	-222	-222	0	0%	-271	-272	0	0%	-319	-319	0	0%	-338	-338	0	0%	-225	-225	0	0%	-11	-11	0	0%
90%	-238	-238	0	0%	-288	-288	0	0%	-334	-334	0	0%	-339	-339	0	0%	-229	-229	0	0%	-78	-84	-6	8%
Long Term Full Simulation Period[b]	-125	-129	-4	3%	-165	-196	-31	19%	-295	-300	-4	1%	-252	-252	0	0%	-101	-101	0	0%	-30	-32	-1	4%
Water Year Types[c]																								
Wet (32%)	-33	-33	0	1%	-62	-113	-51	81%	-286	-286	0	0%	-324	-324	0	0%	-156	-156	0	0%	-62	-62	0	0%
Above Normal (16%)	-103	-108	-5	5%	-133	-184	-52	39%	-309	-309	0	0%	-320	-320	0	0%	-163	-163	0	0%	-41	-49	-8	20%
Below Normal (13%)	-142	-164	-22	15%	-202	-233	-31	15%	-309	-309	0	0%	-215	-215	0	0%	-75	-77	-2	3%	-8	-8	0	0%
Dry (24%)	-192	-192	0	0%	-237	-247	-10	4%	-303	-311	-8	3%	-189	-189	0	0%	-36	-36	0	0%	-8	-8	0	0%
Critical (15%)	-221	-221	0	0%	-271	-271	0	0%	-277	-292	-15	5%	-158	-159	0	0%	-43	-43	0	0%	-8	-8	0	0%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

e Negative values indicate flow towards the Contra Costa Canal.

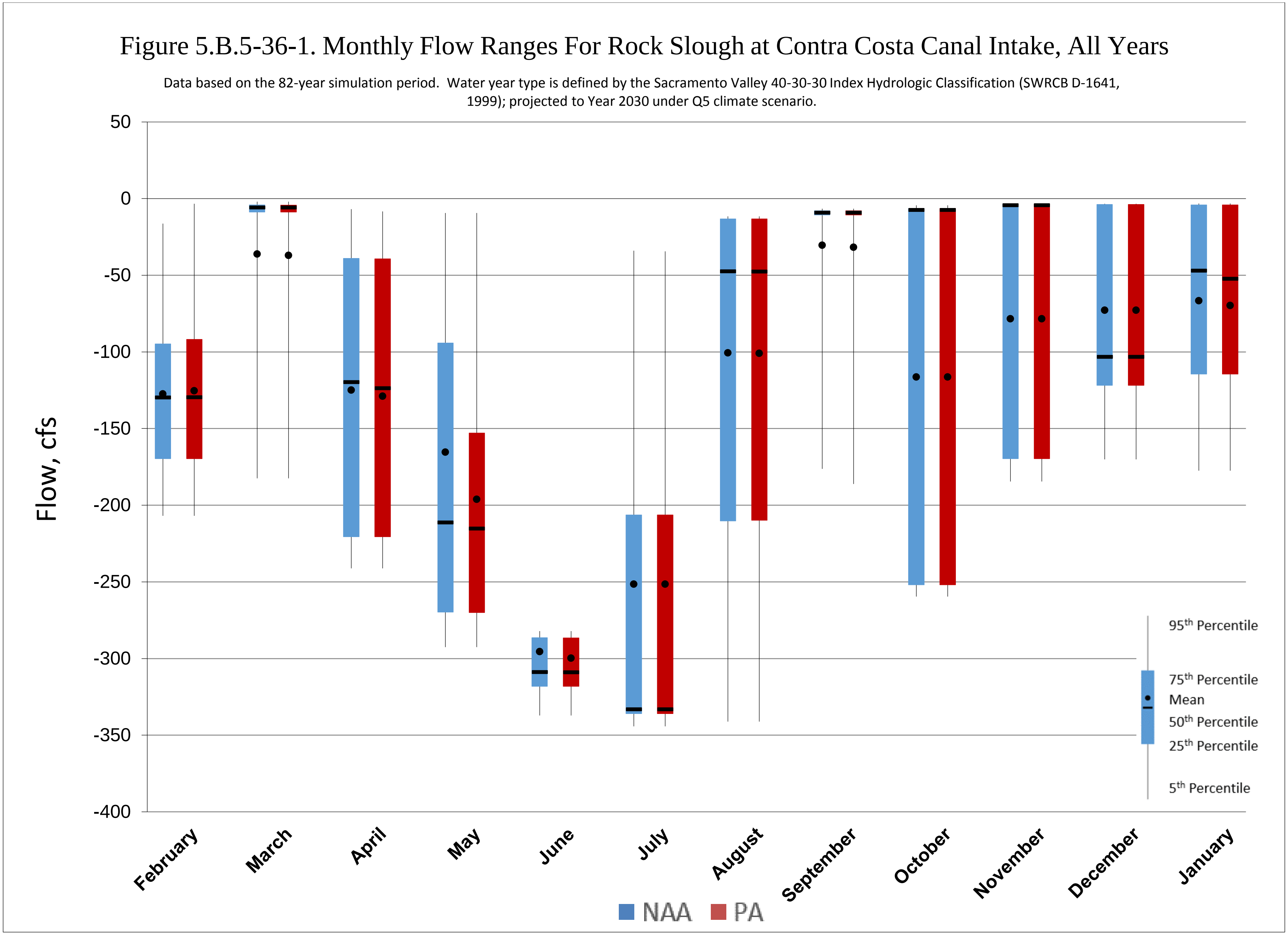


Figure 5.B.5-36-1. Monthly Flow Ranges For Rock Slough at Contra Costa Canal Intake, All Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario.
Flow, cfs
50
0
-50
-100
-150
-200
-250
-300
-350
-400
February
March
April
May
June
July
August
September
October
November
December
January
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
NAA
PA

Figure 5.B.5-36-2. Monthly Flow Ranges For Rock Slough at Contra Costa Canal Intake, Wet Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 26 wet years.

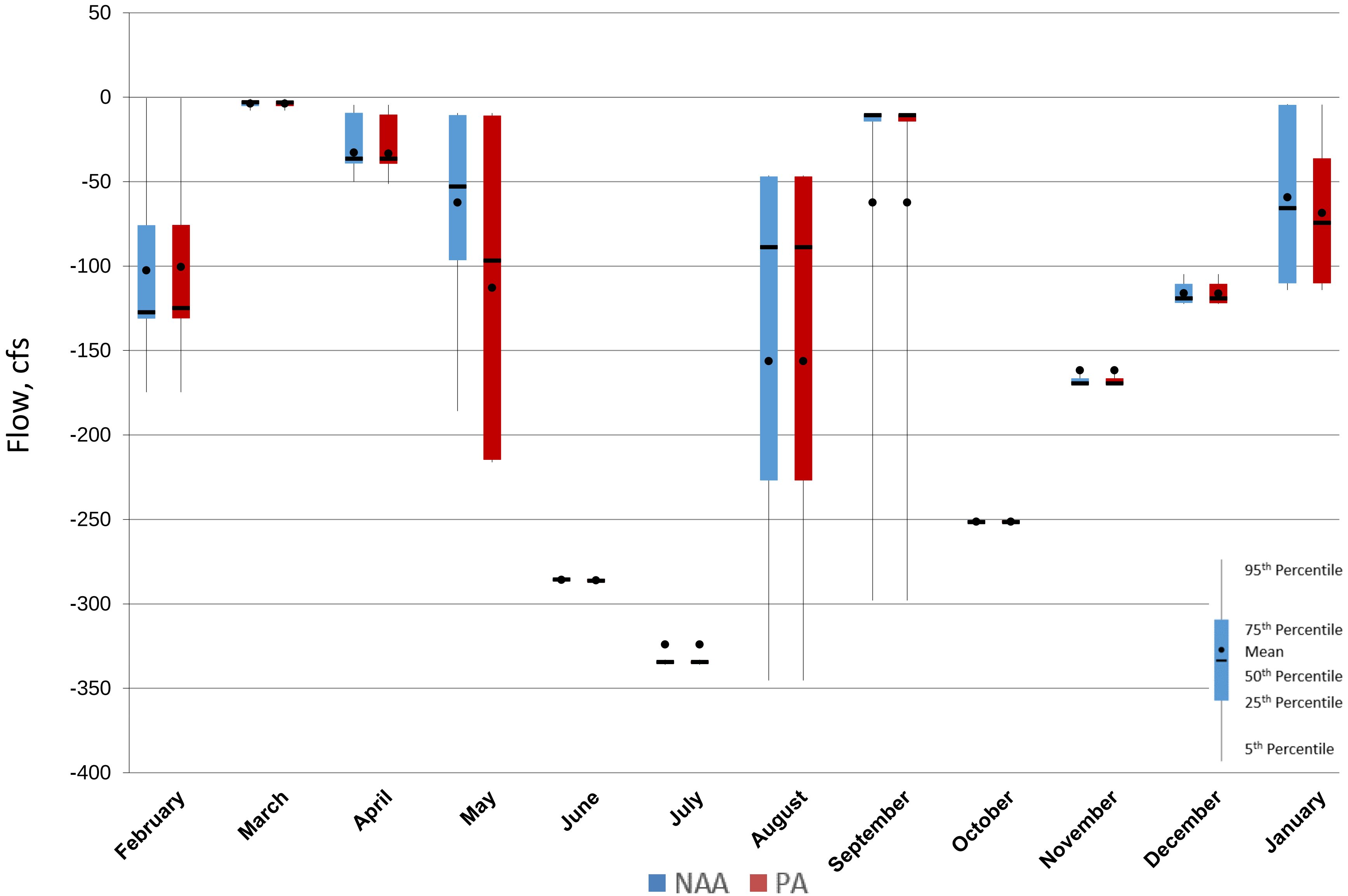


Figure 5.B.5-36-3. Monthly Flow Ranges For Rock Slough at Contra Costa Canal Intake, Above Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 13 above normal years.

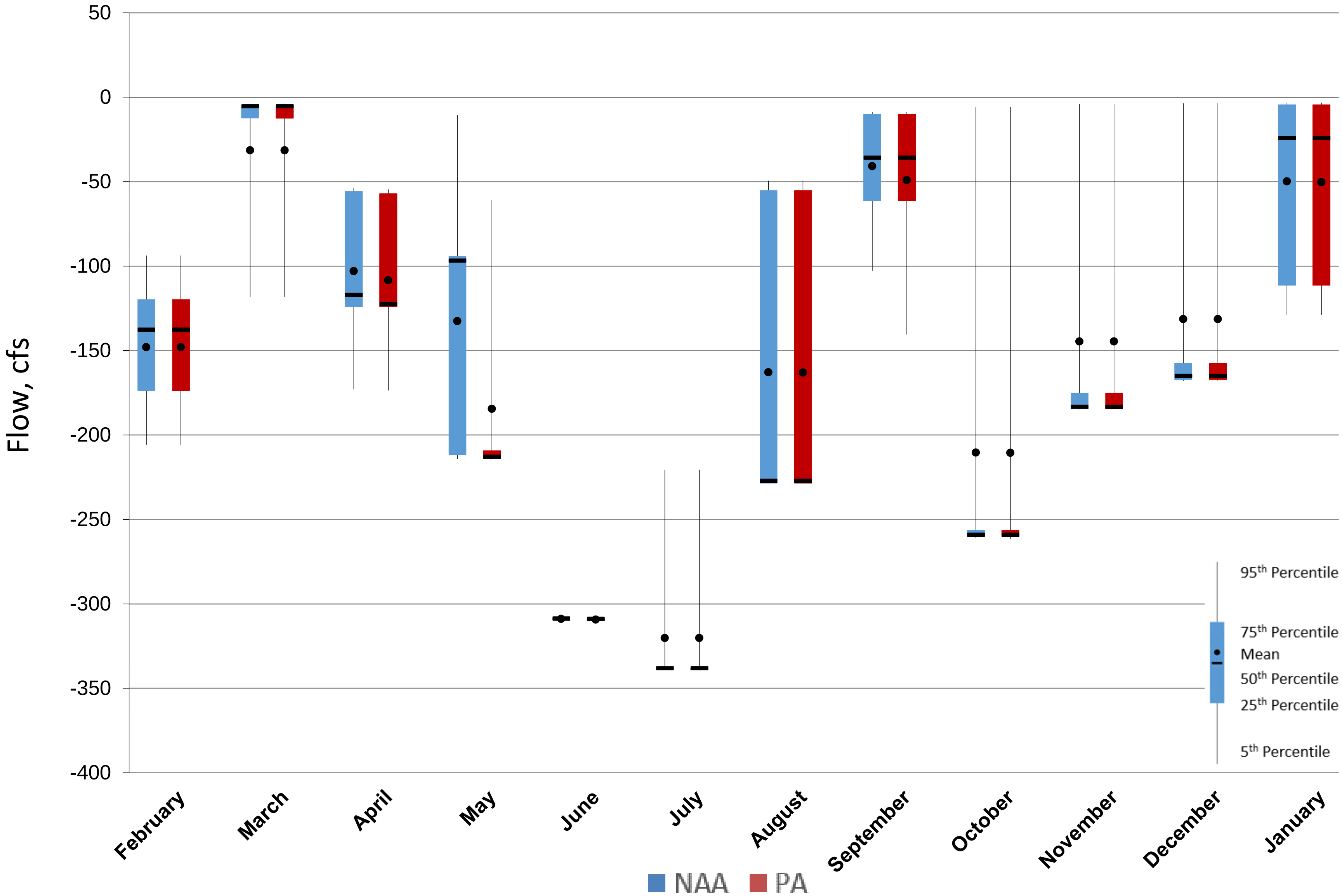
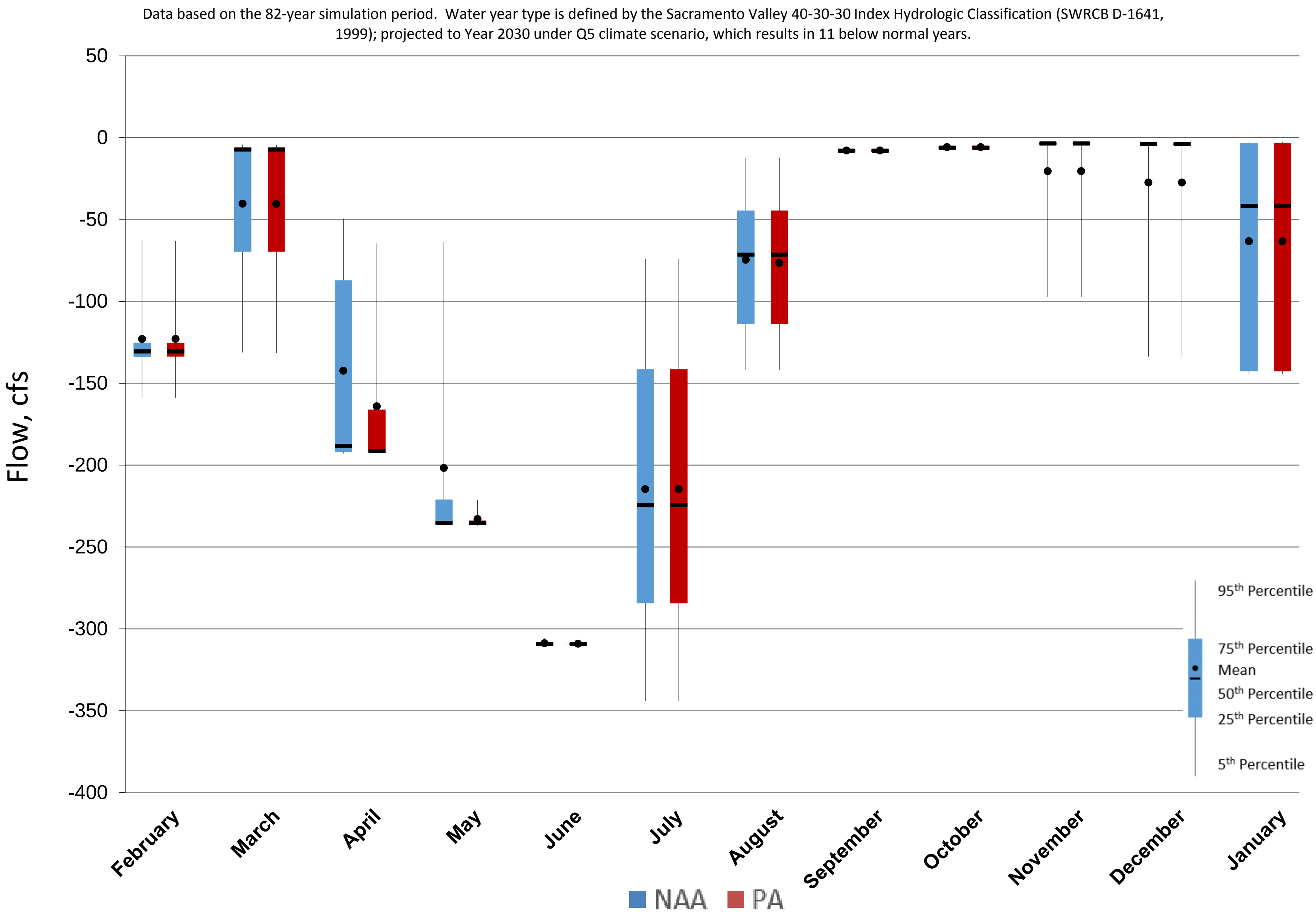


Figure 5.B.5-36-4. Monthly Flow Ranges For Rock Slough at Contra Costa Canal Intake, Below Normal Years



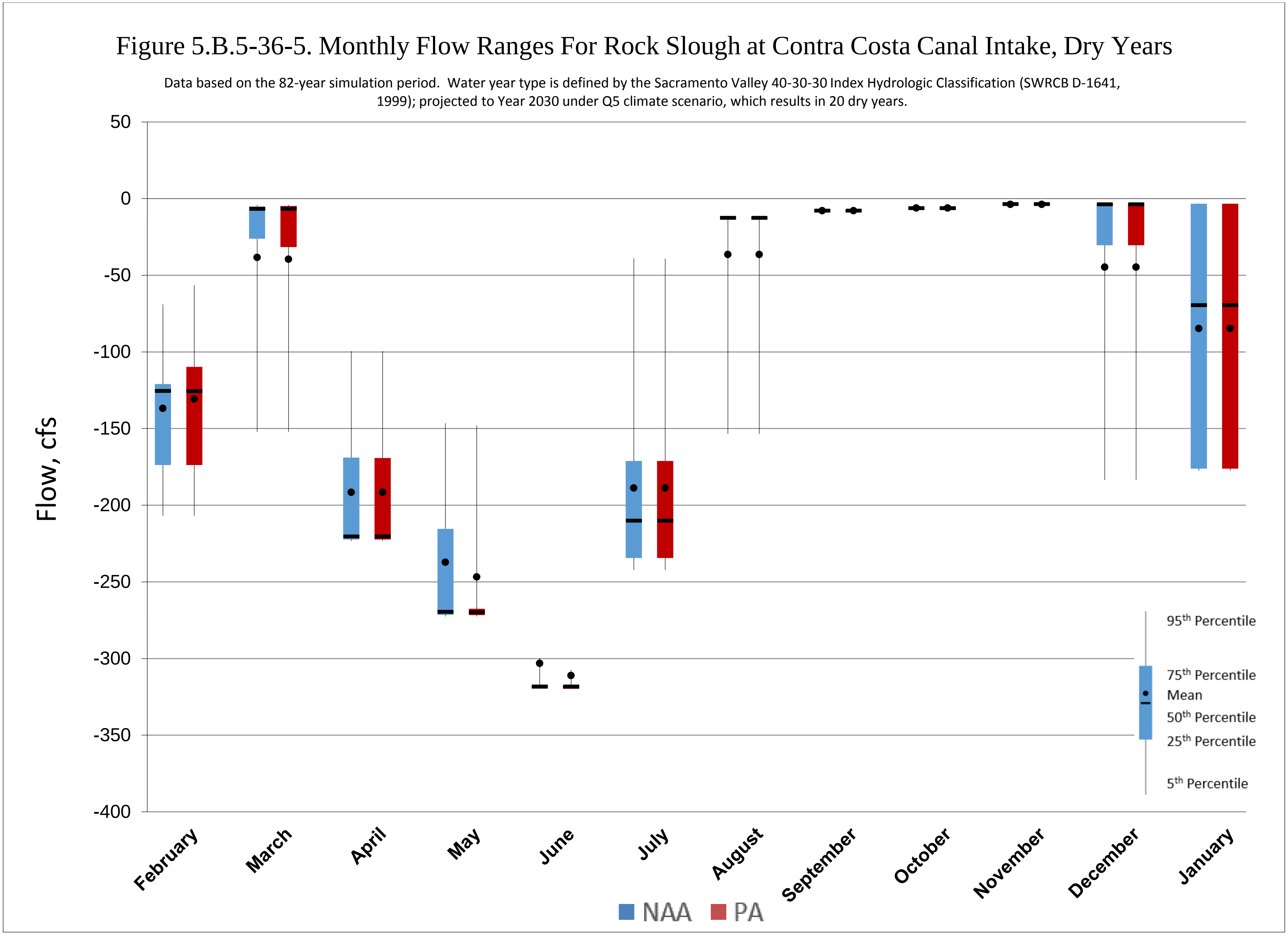


Figure 5.B.5-36-5. Monthly Flow Ranges For Rock Slough at Contra Costa Canal Intake, Dry Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 20 dry years.
Flow, cfs
50
0
-50
-100
-150
-200
-250
-300
-350
-400
February
March
April
May
June
July
August
September
October
November
December
January
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
NAA
PA

Figure 5.B.5-36-6. Monthly Flow Ranges For Rock Slough at Contra Costa Canal Intake, Critical Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 12 critical years.

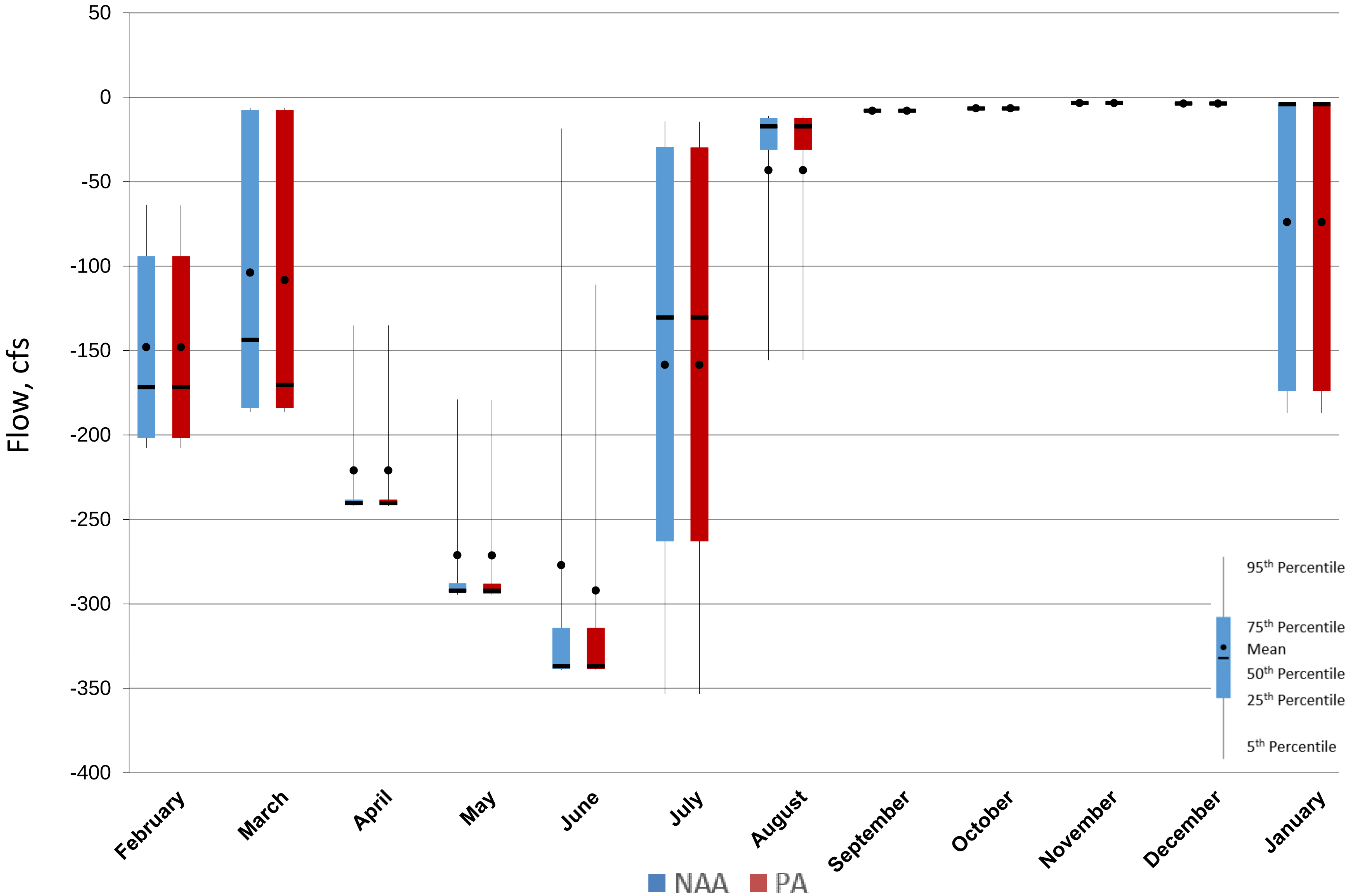
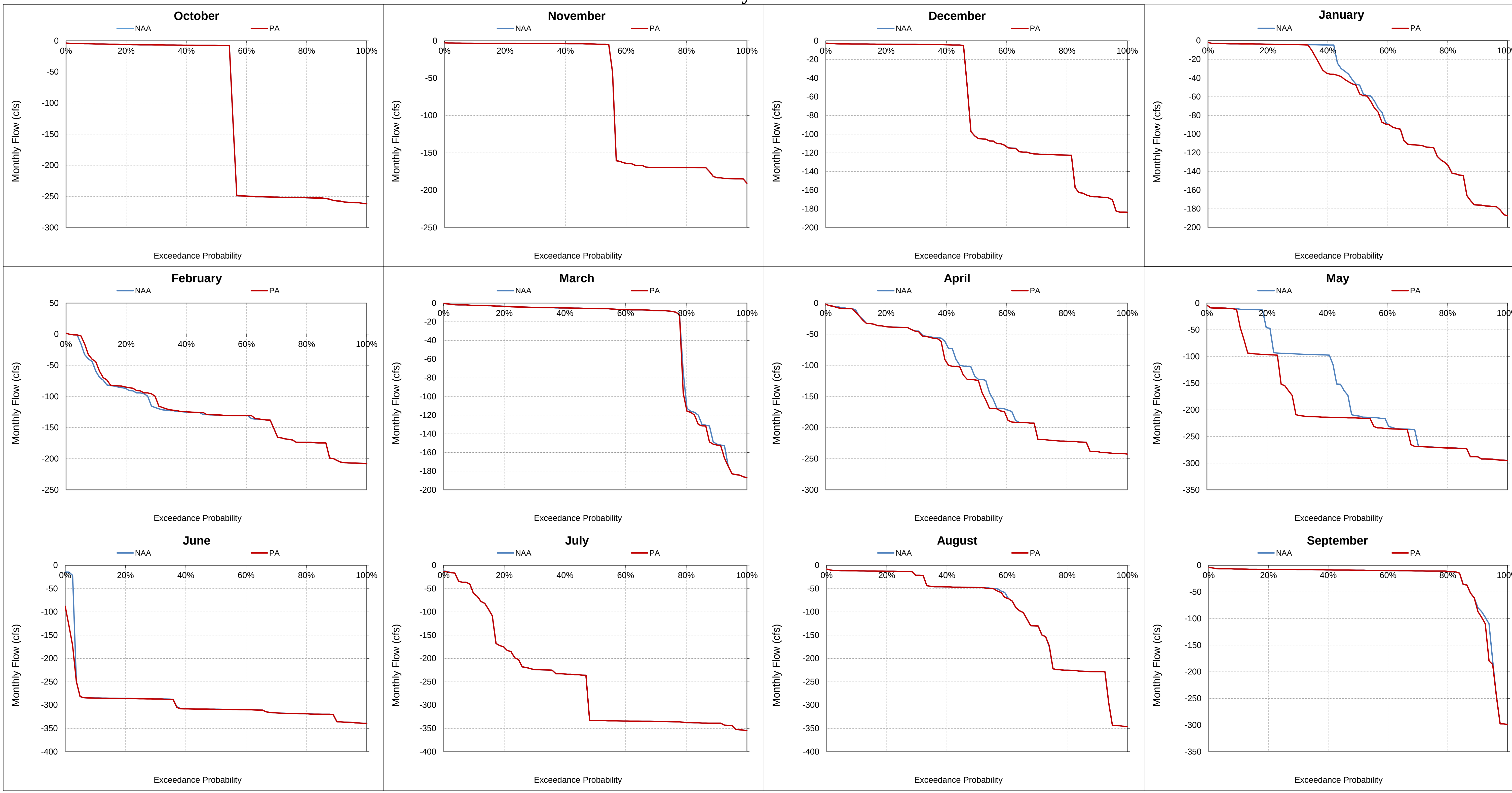
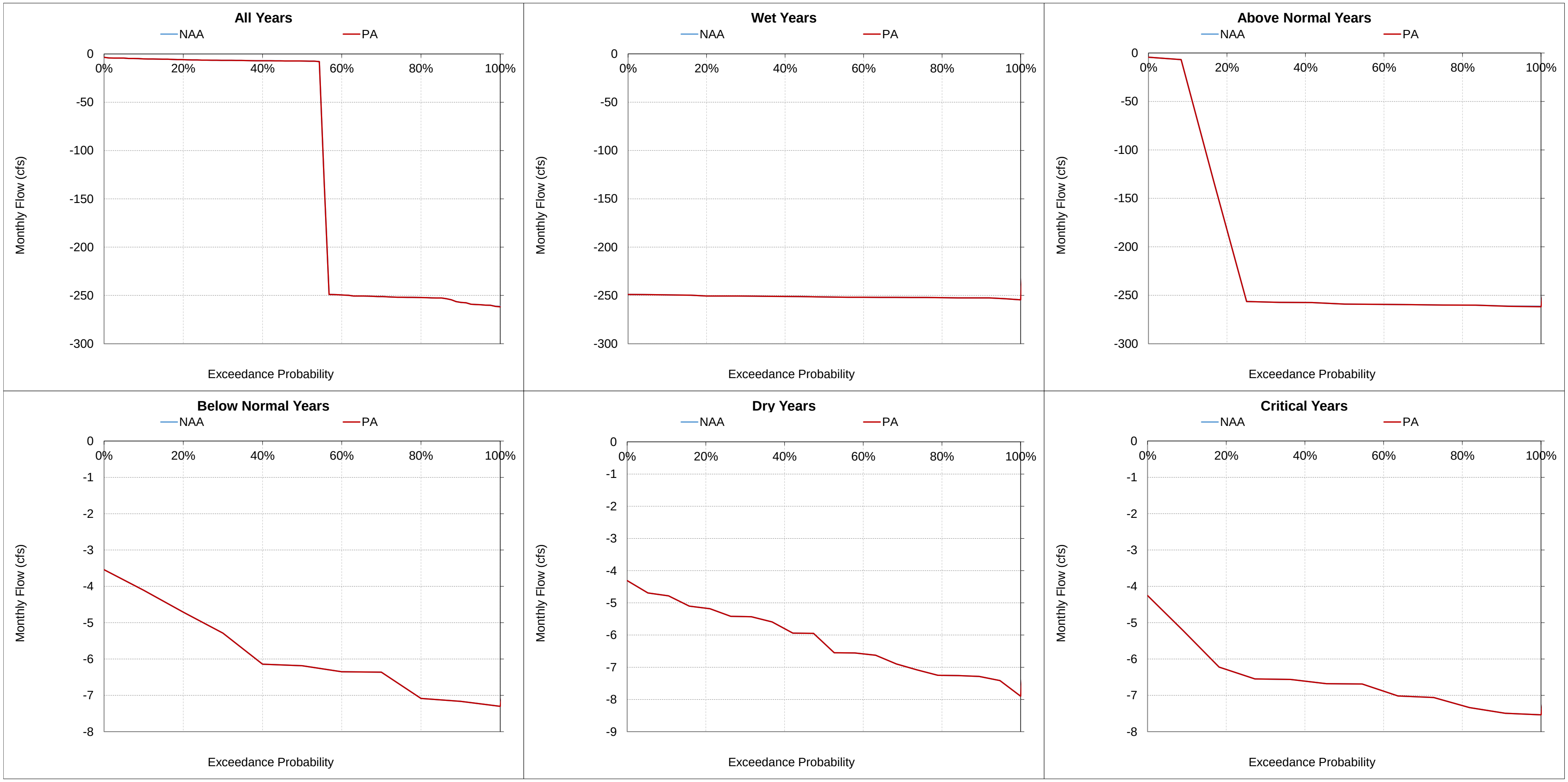


Figure 5.B.5-36-7. Rock Slough at Contra Costa Canal Intake, Monthly Flow Probability of Exceedance



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.
e Negative values indicate flow towards the Contra Costa Canal.

Figure 5.B.5-36-8. Rock Slough at Contra Costa Canal Intake, Monthly Flow October



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

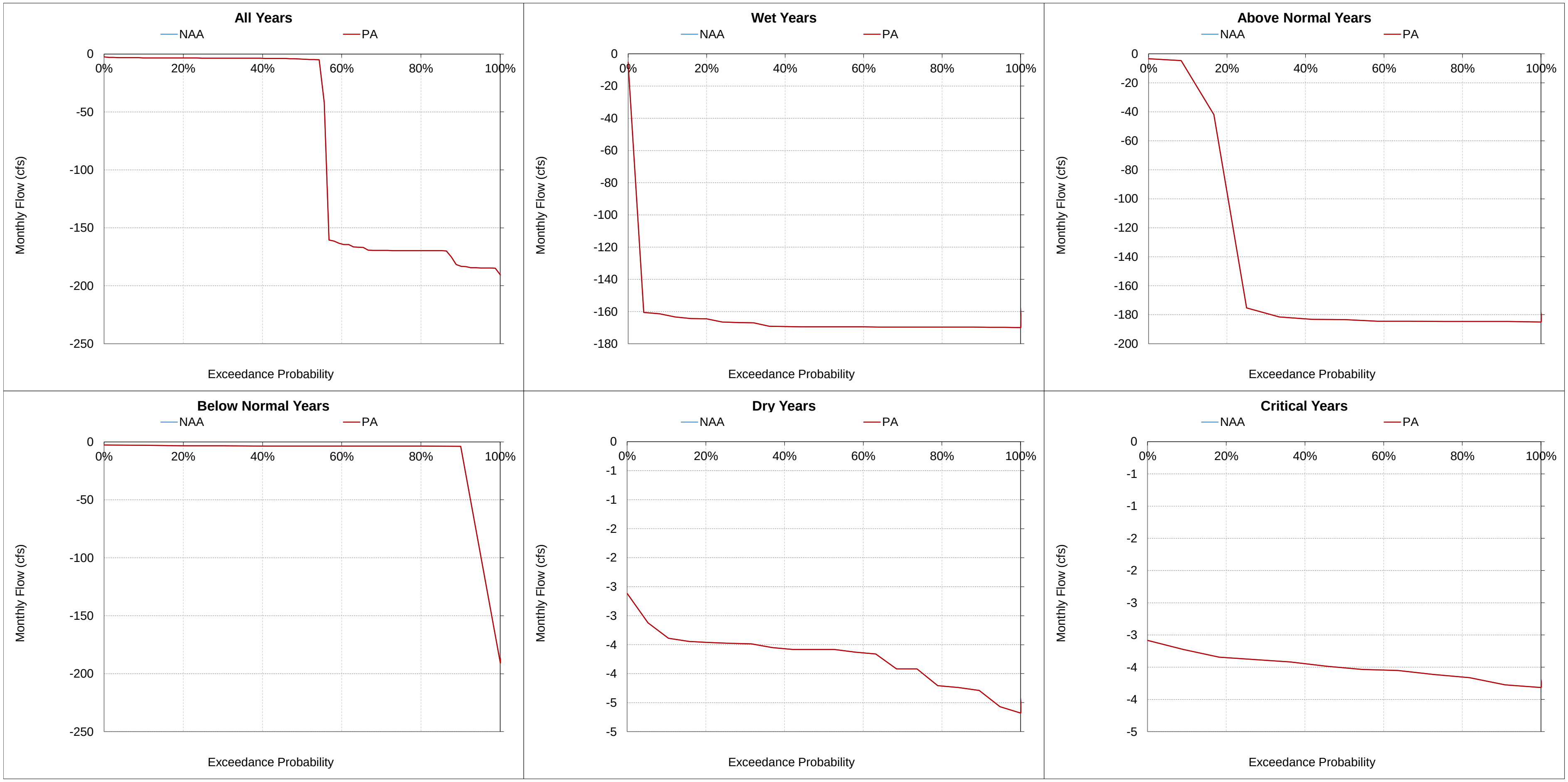
b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

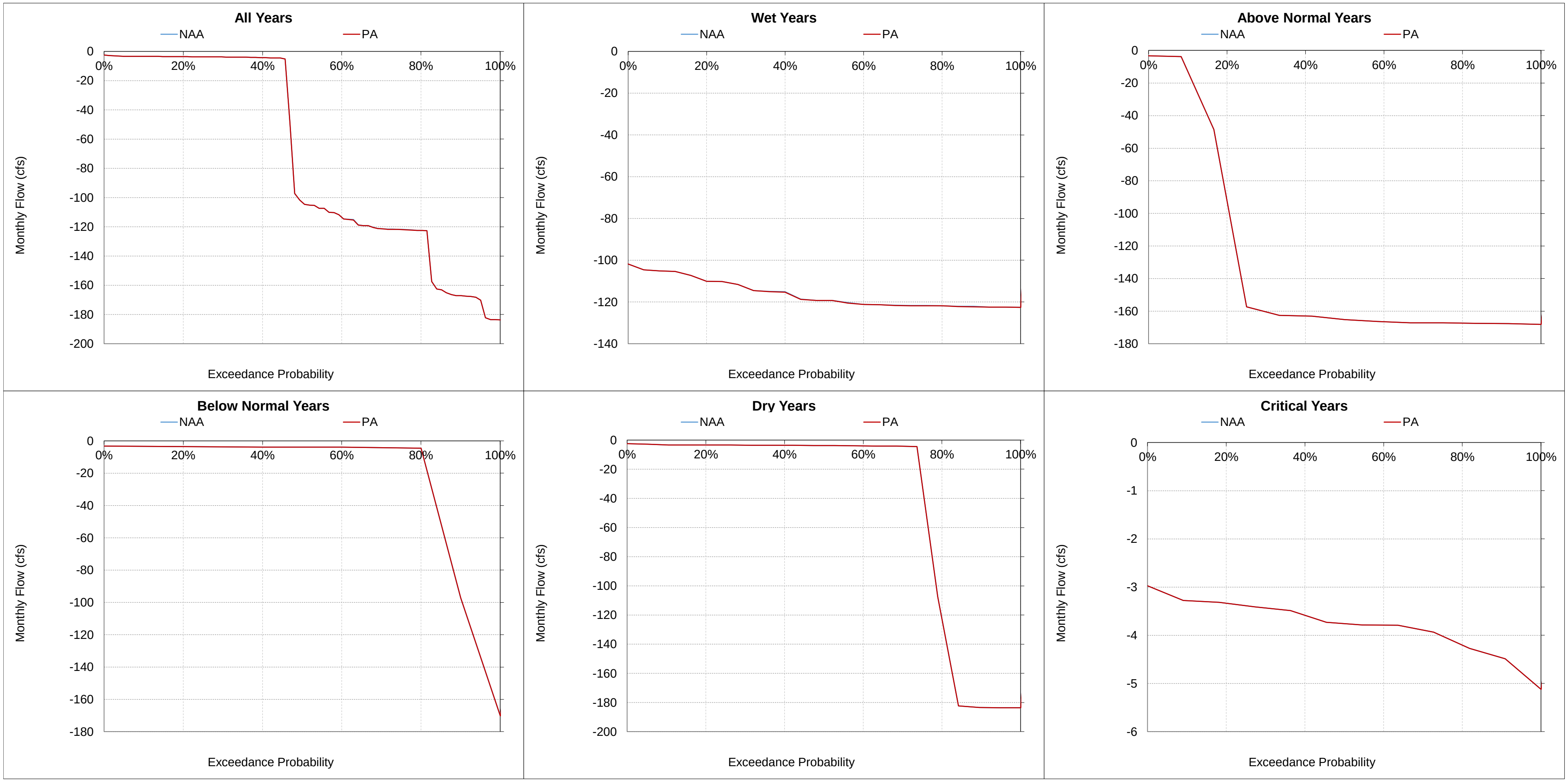
e Negative values indicate flow towards the Contra Costa Canal.

Figure 5.B.5-36-9. Rock Slough at Contra Costa Canal Intake, Monthly Flow
November



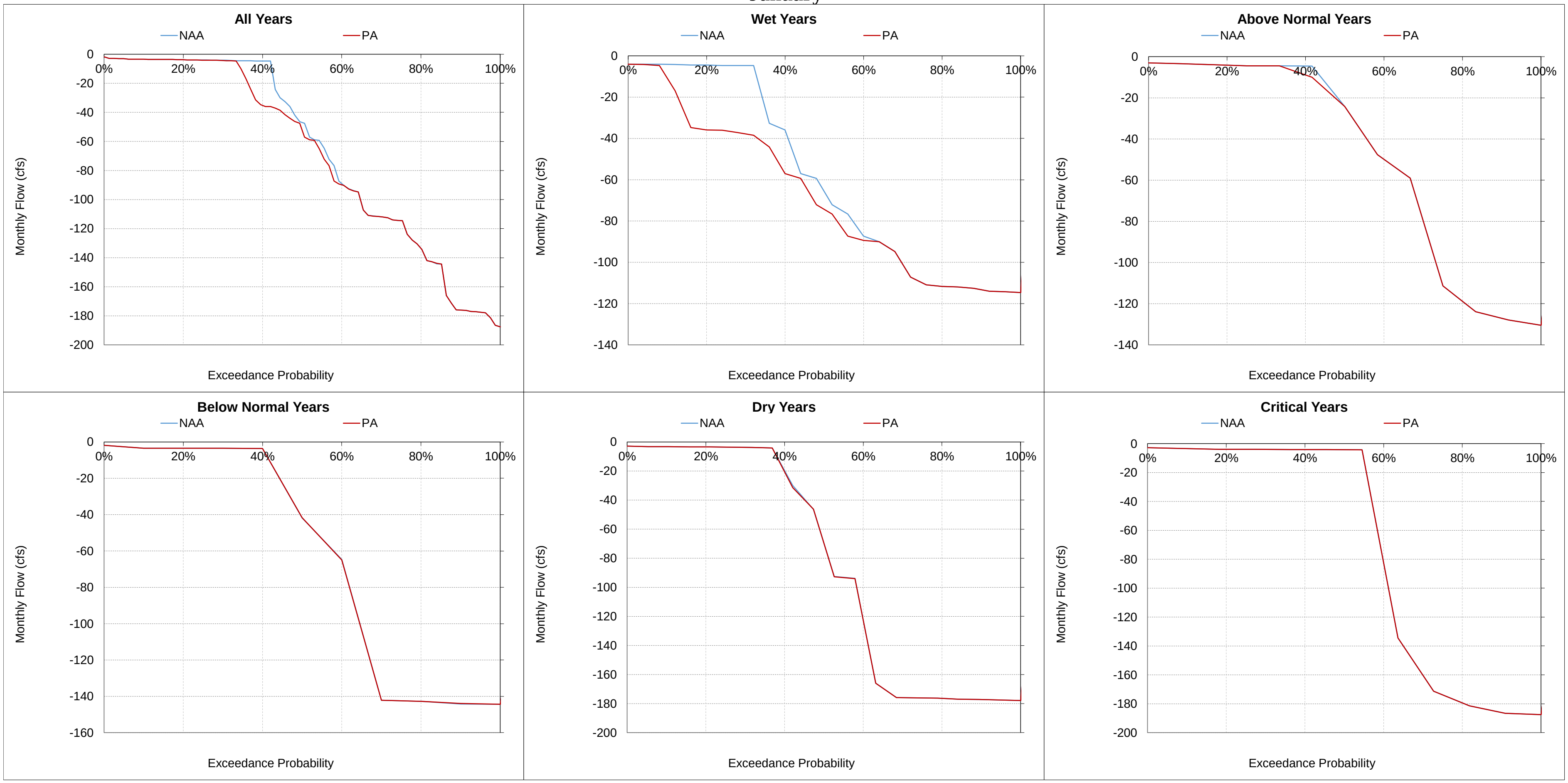
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.
e Negative values indicate flow towards the Contra Costa Canal.

Figure 5.B.5-36-10. Rock Slough at Contra Costa Canal Intake, Monthly Flow
December



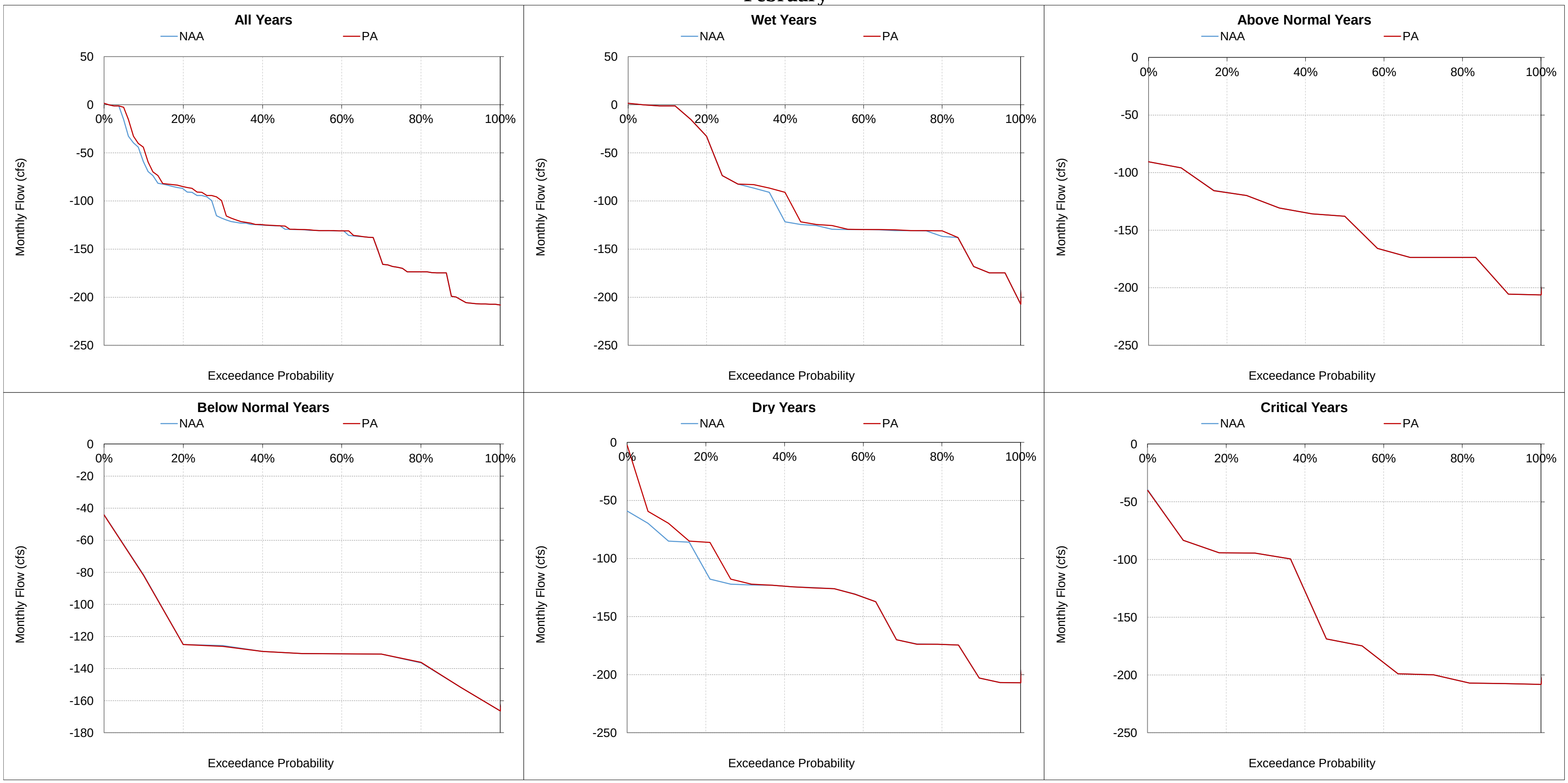
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.
e Negative values indicate flow towards the Contra Costa Canal.

Figure 5.B.5-36-11. Rock Slough at Contra Costa Canal Intake, Monthly Flow January



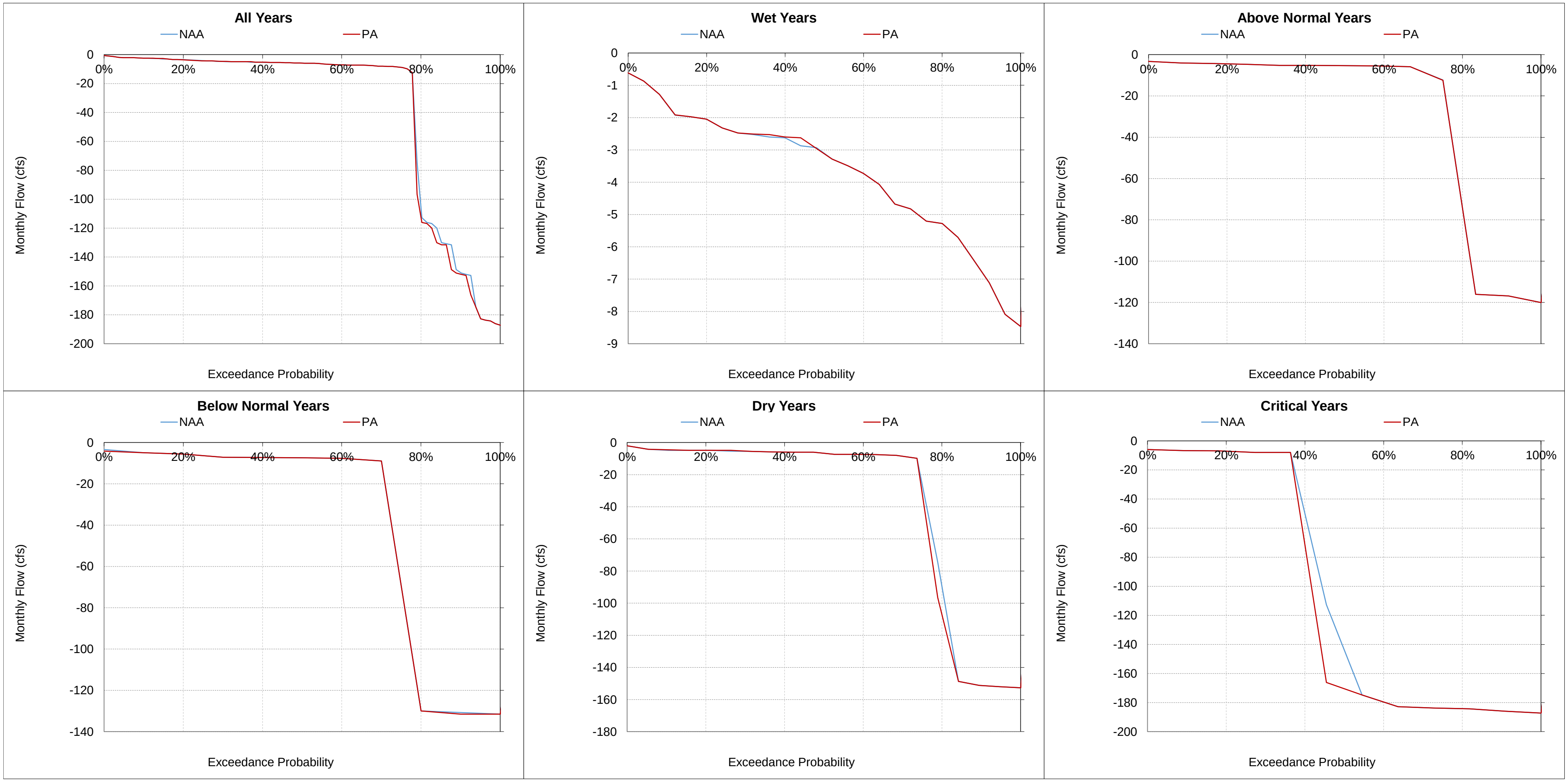
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.
e Negative values indicate flow towards the Contra Costa Canal.

Figure 5.B.5-36-12. Rock Slough at Contra Costa Canal Intake, Monthly Flow
February



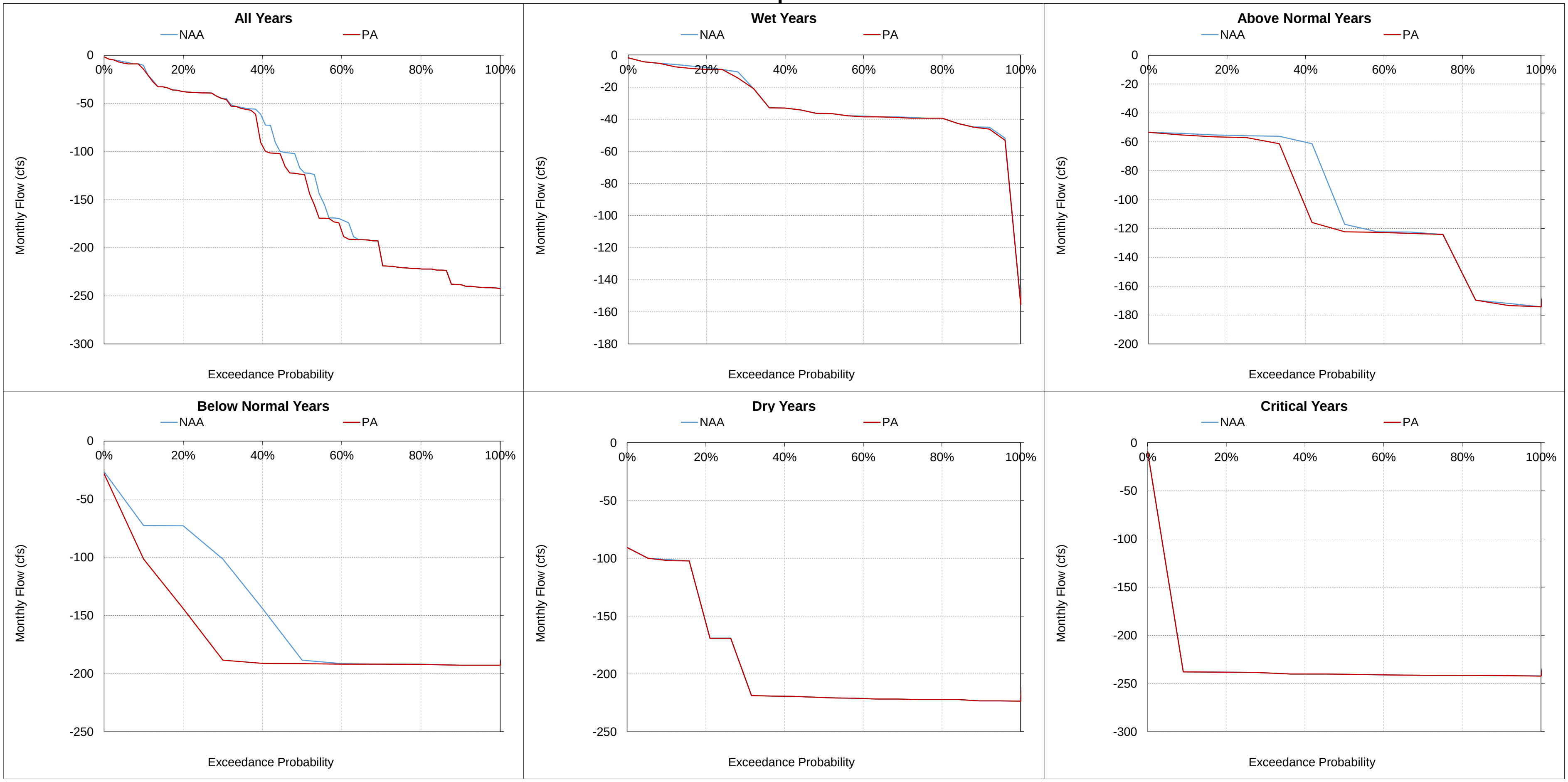
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.
e Negative values indicate flow towards the Contra Costa Canal.

Figure 5.B.5-36-13. Rock Slough at Contra Costa Canal Intake, Monthly Flow March



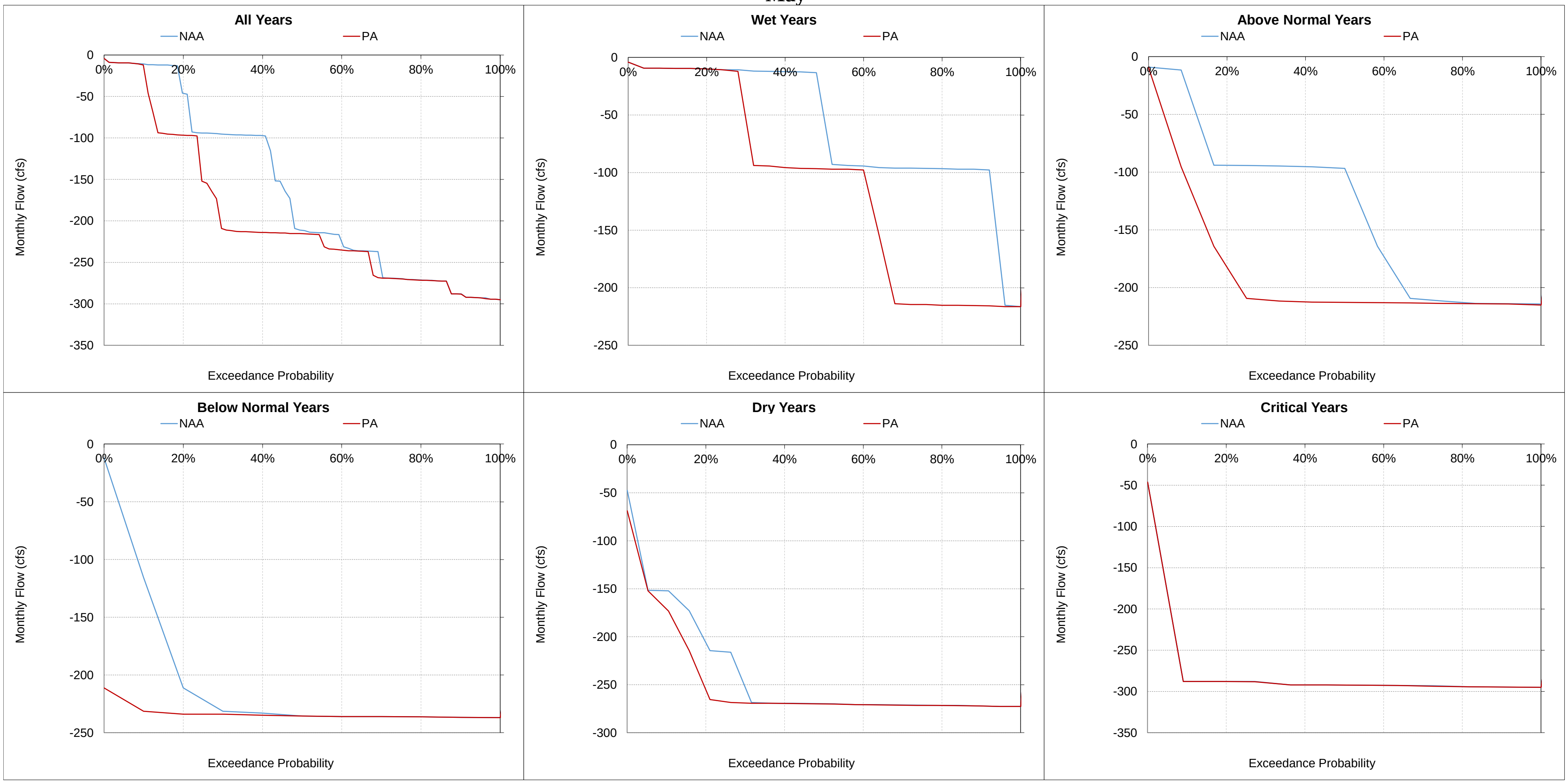
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.
e Negative values indicate flow towards the Contra Costa Canal.

Figure 5.B.5-36-14. Rock Slough at Contra Costa Canal Intake, Monthly Flow April



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.
e Negative values indicate flow towards the Contra Costa Canal.

Figure 5.B.5-36-15. Rock Slough at Contra Costa Canal Intake, Monthly Flow May



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

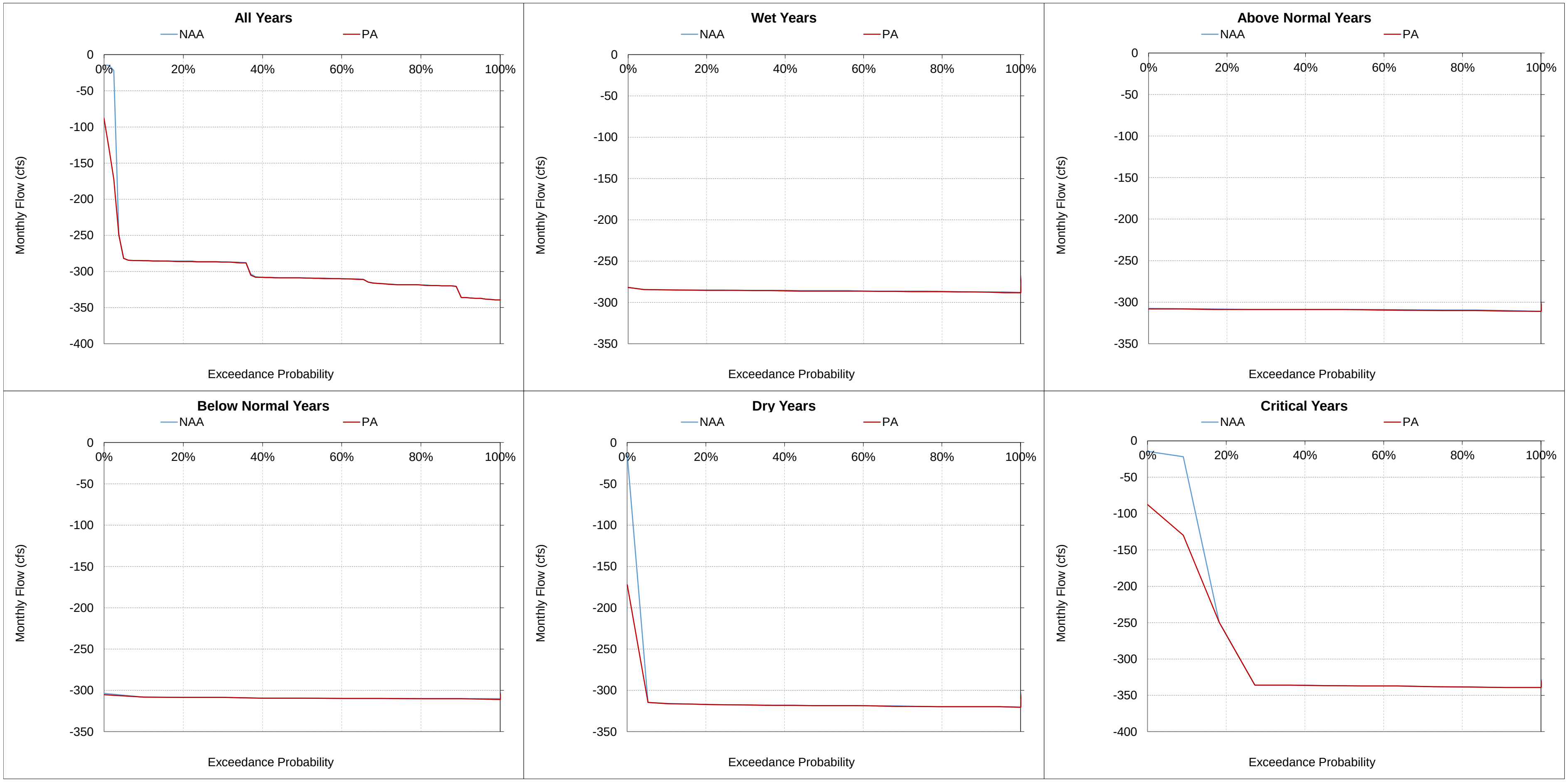
b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

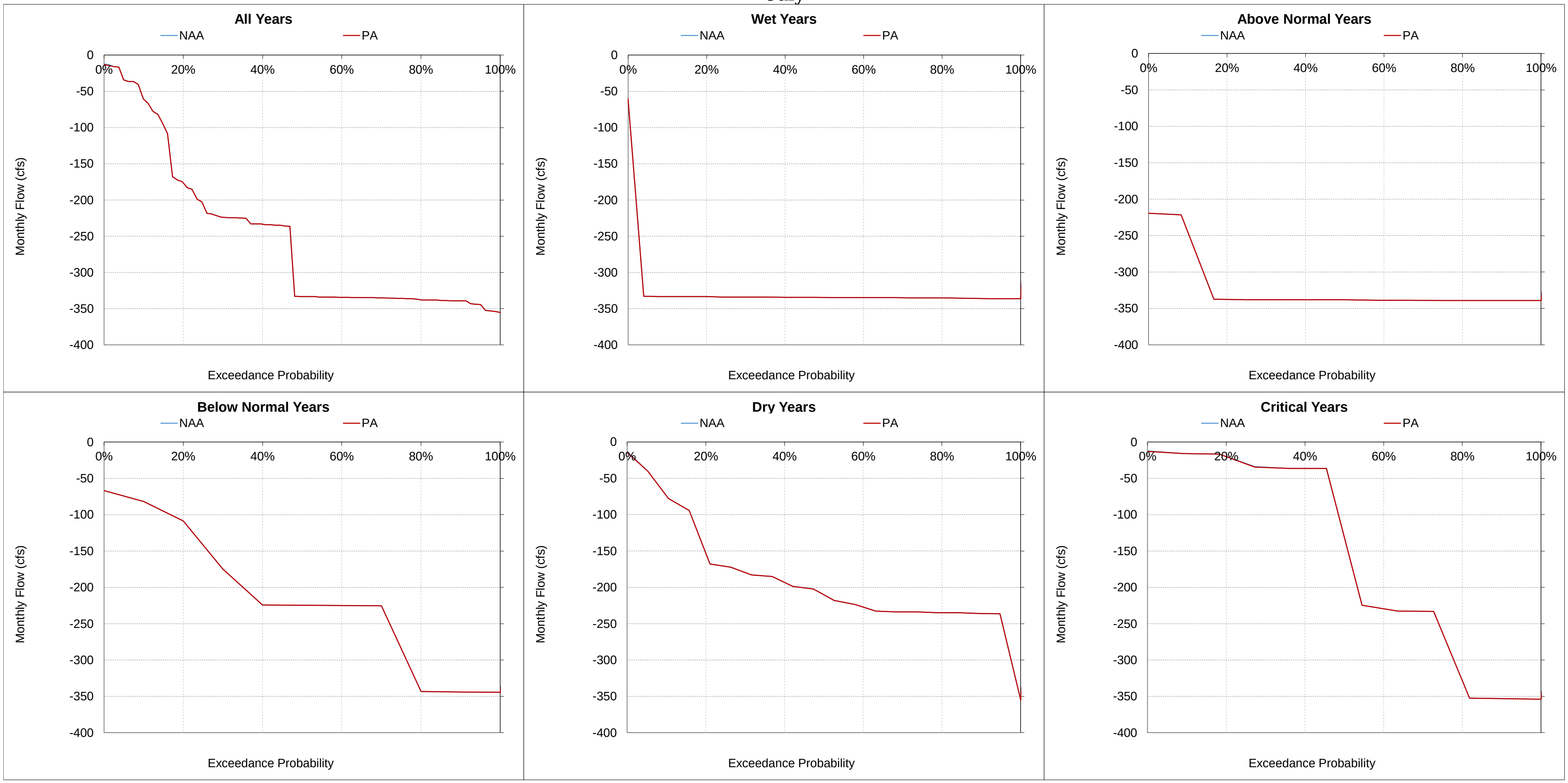
e Negative values indicate flow towards the Contra Costa Canal.

Figure 5.B.5-36-16. Rock Slough at Contra Costa Canal Intake, Monthly Flow
June



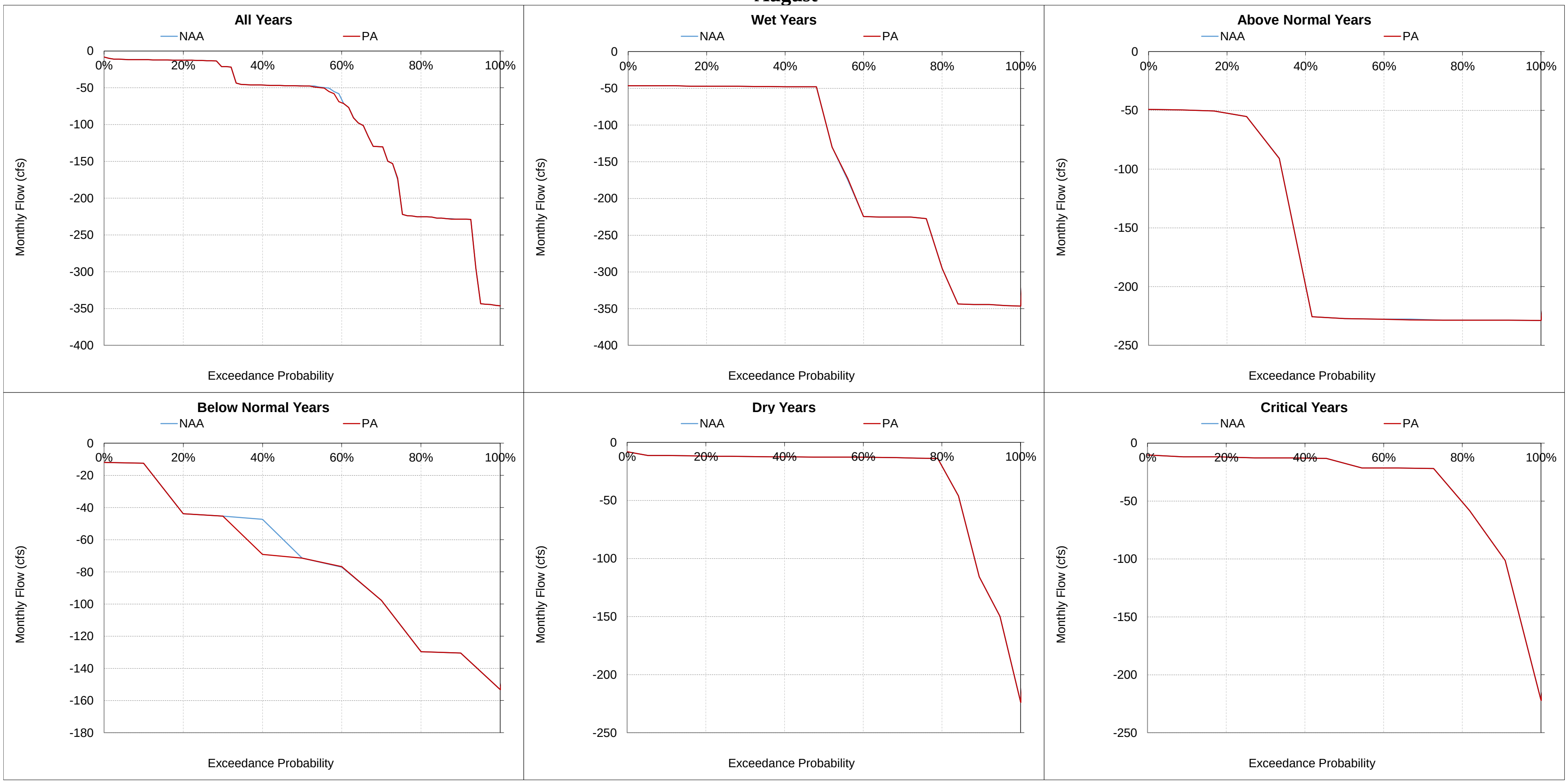
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.
e Negative values indicate flow towards the Contra Costa Canal.

Figure 5.B.5-36-17. Rock Slough at Contra Costa Canal Intake, Monthly Flow July



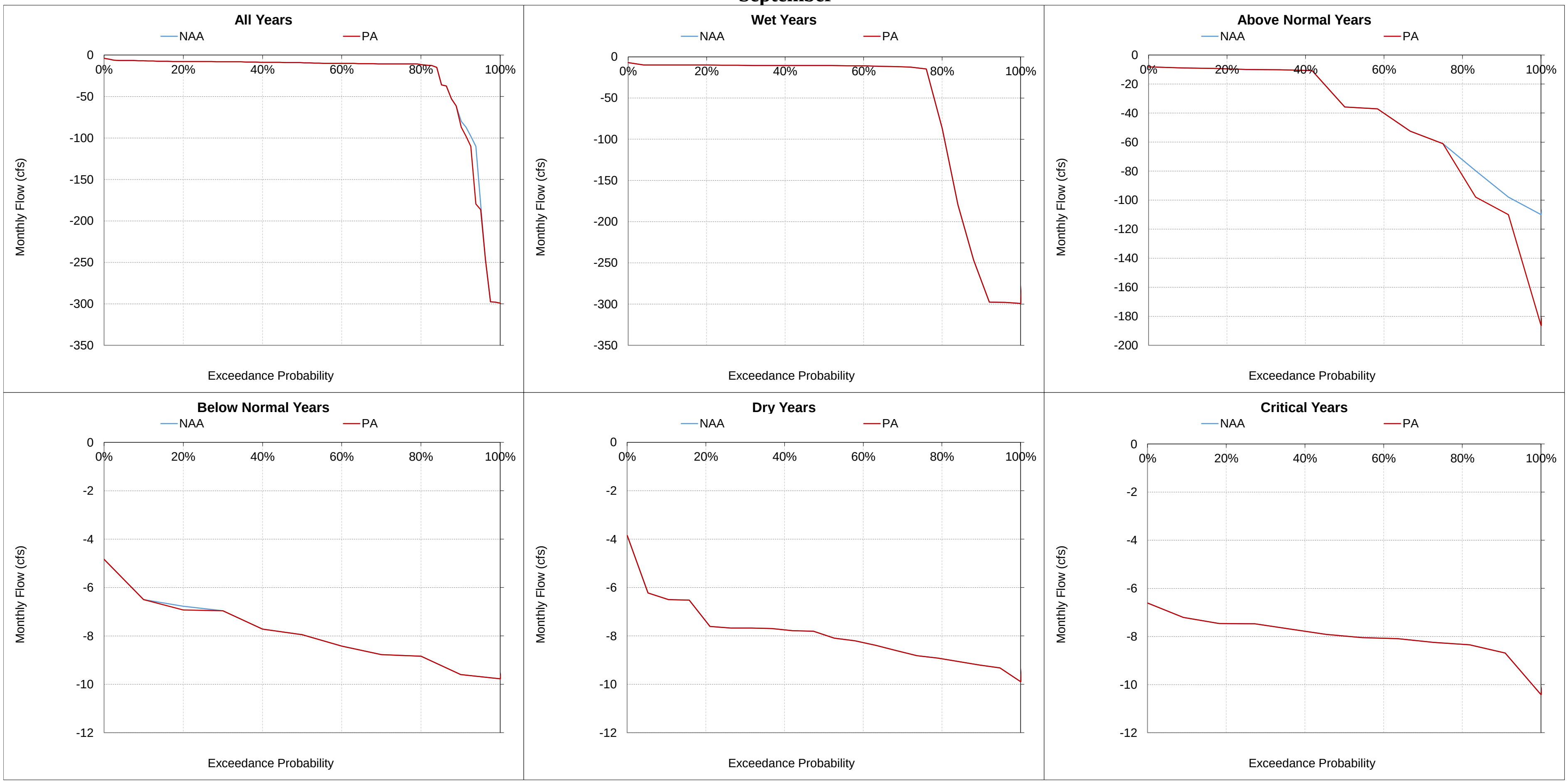
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.
e Negative values indicate flow towards the Contra Costa Canal.

Figure 5.B.5-36-18. Rock Slough at Contra Costa Canal Intake, Monthly Flow August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.
e Negative values indicate flow towards the Contra Costa Canal.

Figure 5.B.5-36-19. Rock Slough at Contra Costa Canal Intake, Monthly Flow
September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.
e Negative values indicate flow towards the Contra Costa Canal.

Table 5.B.5-37. San Joaquin River at Prisoner's Point, Monthly EC

Statistic	Monthly EC (UMHOS/CM)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	724	599	-125	-17%	903	637	-266	-29%	837	754	-83	-10%	712	665	-47	-7%	455	512	57	13%	370	514	144	39%
20%	675	523	-152	-23%	769	481	-288	-37%	719	583	-136	-19%	631	565	-67	-11%	416	499	83	20%	342	481	139	41%
30%	626	497	-129	-21%	665	419	-245	-37%	641	516	-125	-19%	540	492	-48	-9%	395	469	74	19%	327	456	129	40%
40%	585	469	-116	-20%	559	388	-171	-31%	547	423	-124	-23%	464	456	-8	-2%	367	452	85	23%	309	424	114	37%
50%	550	417	-134	-24%	481	379	-102	-21%	395	331	-64	-16%	413	434	21	5%	343	427	84	24%	290	402	112	39%
60%	282	335	54	19%	289	368	79	27%	319	290	-29	-9%	371	415	44	12%	331	394	63	19%	283	360	77	27%
70%	267	326	58	22%	254	362	108	42%	281	279	-2	-1%	347	403	56	16%	311	378	67	22%	270	338	68	25%
80%	259	311	51	20%	242	352	109	45%	262	273	11	4%	324	379	55	17%	288	356	68	24%	260	306	46	18%
90%	246	295	49	20%	229	330	101	44%	237	255	18	8%	287	339	51	18%	265	319	53	20%	242	291	48	20%
Long Term Full Simulation Period[b]	469	427	-42	-9%	508	427	-81	-16%	504	445	-60	-12%	466	469	3	1%	359	422	63	17%	303	396	93	31%
Water Year Types[c]																								
Wet (32%)	263	319	56	21%	242	352	110	45%	251	267	16	6%	373	405	32	9%	309	383	74	24%	273	341	68	25%
Above Normal (16%)	257	296	38	15%	303	351	48	16%	356	305	-50	-14%	476	444	-32	-7%	345	429	84	24%	294	443	149	51%
Below Normal (13%)	652	452	-200	-31%	610	382	-227	-37%	582	453	-129	-22%	510	515	6	1%	364	442	78	22%	313	419	107	34%
Dry (24%)	613	502	-111	-18%	703	428	-275	-39%	623	500	-124	-20%	486	464	-21	-4%	380	432	52	14%	311	398	87	28%
Critical (15%)	736	654	-82	-11%	889	711	-178	-20%	944	882	-62	-7%	583	596	13	2%	443	461	18	4%	357	439	82	23%

Statistic	Monthly EC (UMHOS/CM)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	374	461	87	23%	333	374	41	12%	296	366	71	24%	435	332	-103	-24%	532	458	-74	-14%	644	656	12	2%
20%	344	430	86	25%	324	357	33	10%	275	330	55	20%	359	309	-50	-14%	460	399	-62	-13%	594	568	-26	-4%
30%	334	415	80	24%	313	350	37	12%	262	304	42	16%	321	297	-23	-7%	433	361	-72	-17%	558	524	-34	-6%
40%	318	388	70	22%	307	341	34	11%	258	289	31	12%	292	281	-12	-4%	406	305	-101	-25%	527	438	-88	-17%
50%	306	368	62	20%	299	333	33	11%	253	278	26	10%	282	265	-17	-6%	364	275	-89	-24%	489	389	-100	-21%
60%	296	350	54	18%	293	326	33	11%	248	274	26	11%	265	254	-11	-4%	338	258	-80	-24%	458	278	-180	-39%
70%	285	332	47	17%	286	320	33	12%	243	272	29	12%	247	248	1	0%	320	249	-71	-22%	423	272	-151	-36%
80%	268	302	35	13%	268	299	31	11%	236	263	27	11%	235	240	5	2%	295	245	-50	-17%	389	266	-124	-32%
90%	236	242	7	3%	203	204	0	0%	226	252	26	12%	229	228	-1	0%	282	239	-43	-15%	355	256	-99	-28%
Long Term Full Simulation Period[b]	309	364	55	18%	291	319	29	10%	262	297	35	14%	310	285	-25	-8%	388	325	-63	-16%	493	411	-81	-17%
Water Year Types[c]																								
Wet (32%)	271	291	21	8%	253	265	12	5%	251	295	44	18%	248	269	21	9%	309	254	-55	-18%	420	261	-158	-38%
Above Normal (16%)	319	391	72	23%	306	334	28	9%	249	297	48	19%	252	251	0	0%	312	245	-67	-21%	368	272	-96	-26%
Below Normal (13%)	340	399	59	17%	322	347	25	8%	253	277	24	10%	307	247	-60	-20%	381	276	-105	-28%	565	412	-153	-27%
Dry (24%)	321	392	71	22%	296	339	43	14%	247	276	29	12%	365	282	-83	-23%	461	374	-88	-19%	558	541	-17	-3%
Critical (15%)	330	411	80	24%	316	363	47	15%	331	354	24	7%	419	399	-20	-5%	525	529	3	1%	612	671	58	10%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

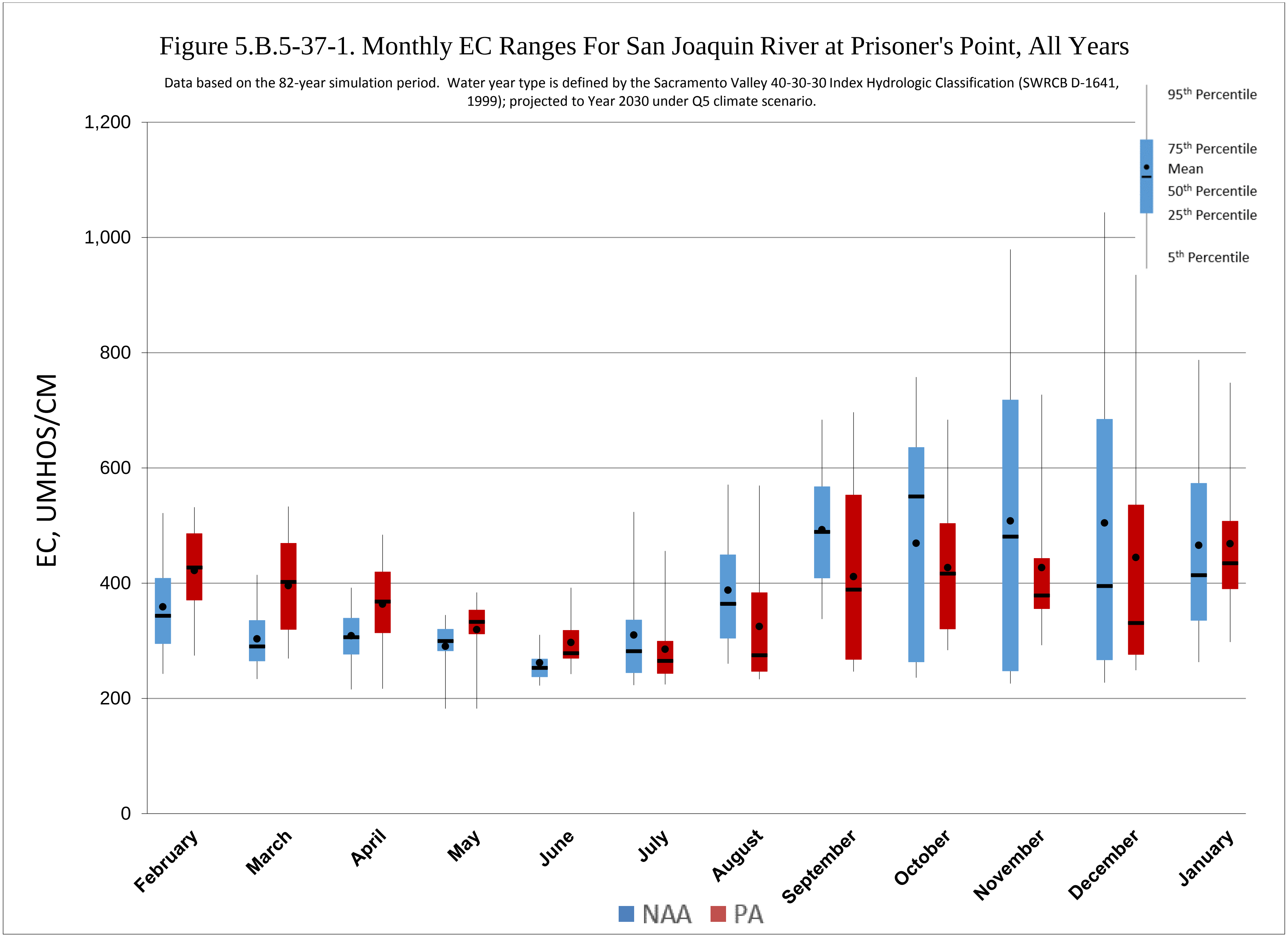


Figure 5.B.5-37-1. Monthly EC Ranges For San Joaquin River at Prisoner's Point, All Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario.
EC, UMHOS/CM
1,200
1,000
800
600
400
200
0
February
March
April
May
June
July
August
September
October
November
December
January
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
NAA
PA

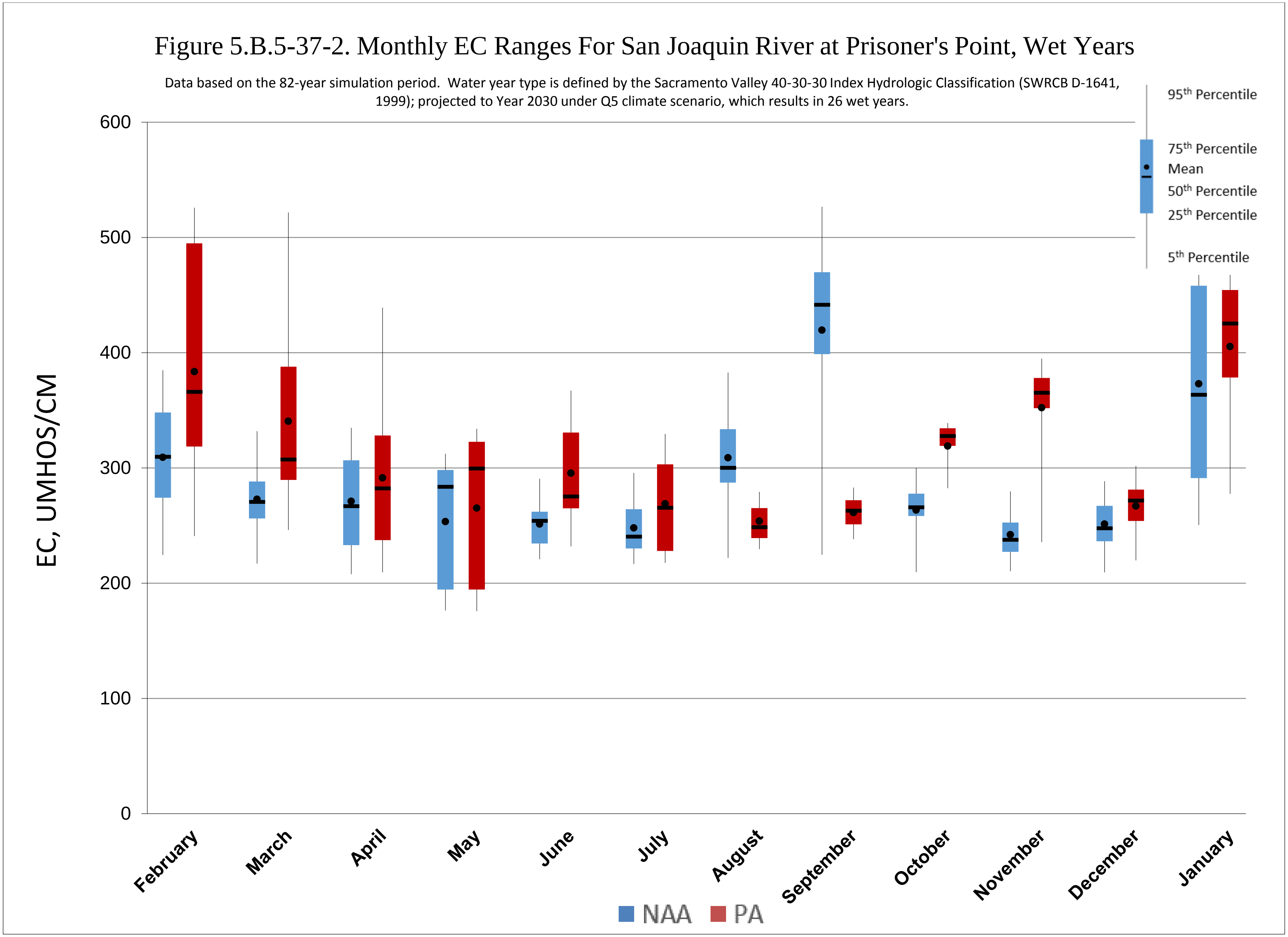


Figure 5.B.5-37-2. Monthly EC Ranges For San Joaquin River at Prisoner's Point, Wet Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 26 wet years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
EC, UMHOS/CM
600
500
400
300
200
100
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-37-3. Monthly EC Ranges For San Joaquin River at Prisoner's Point, Above Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 13 above normal years.

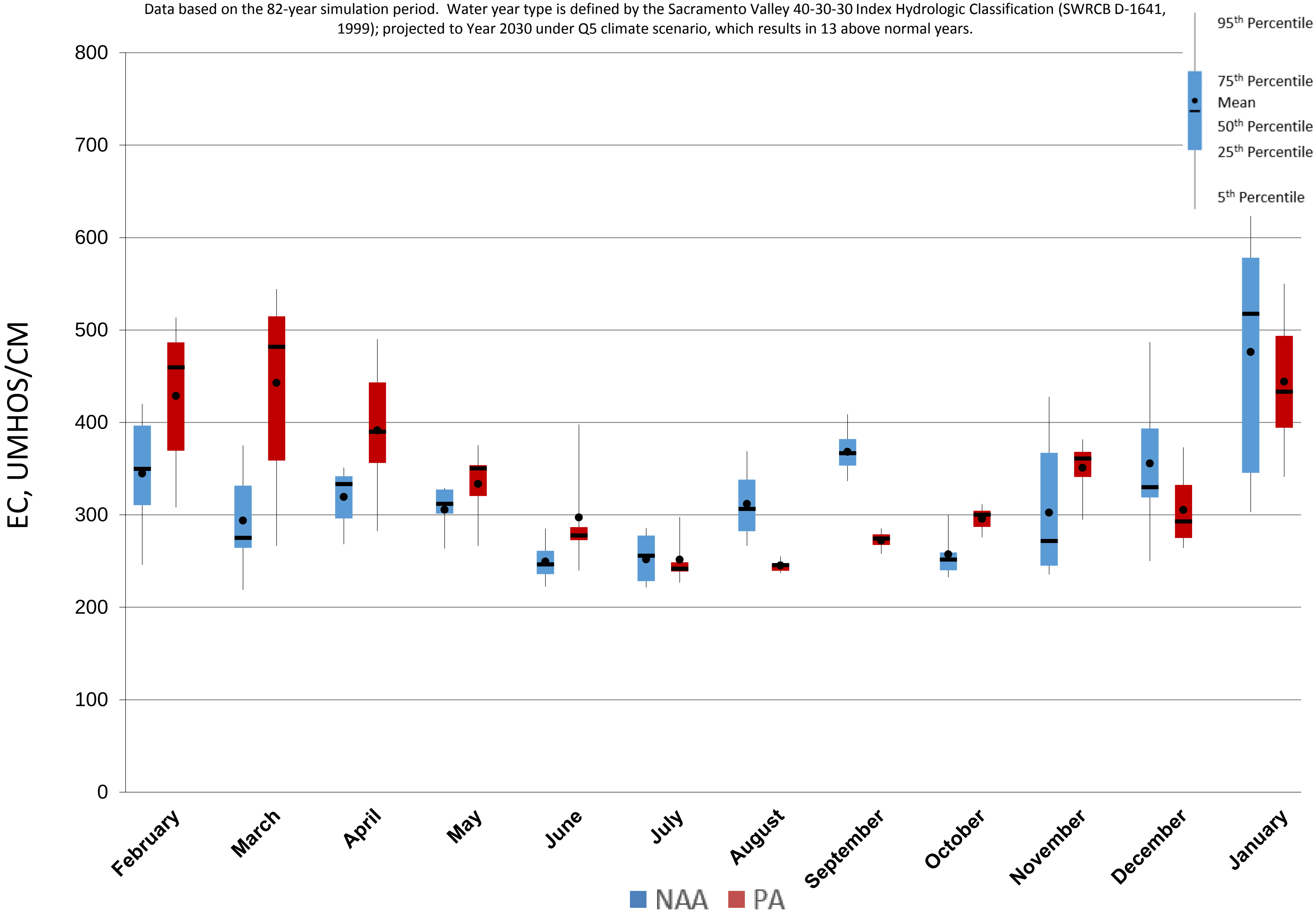
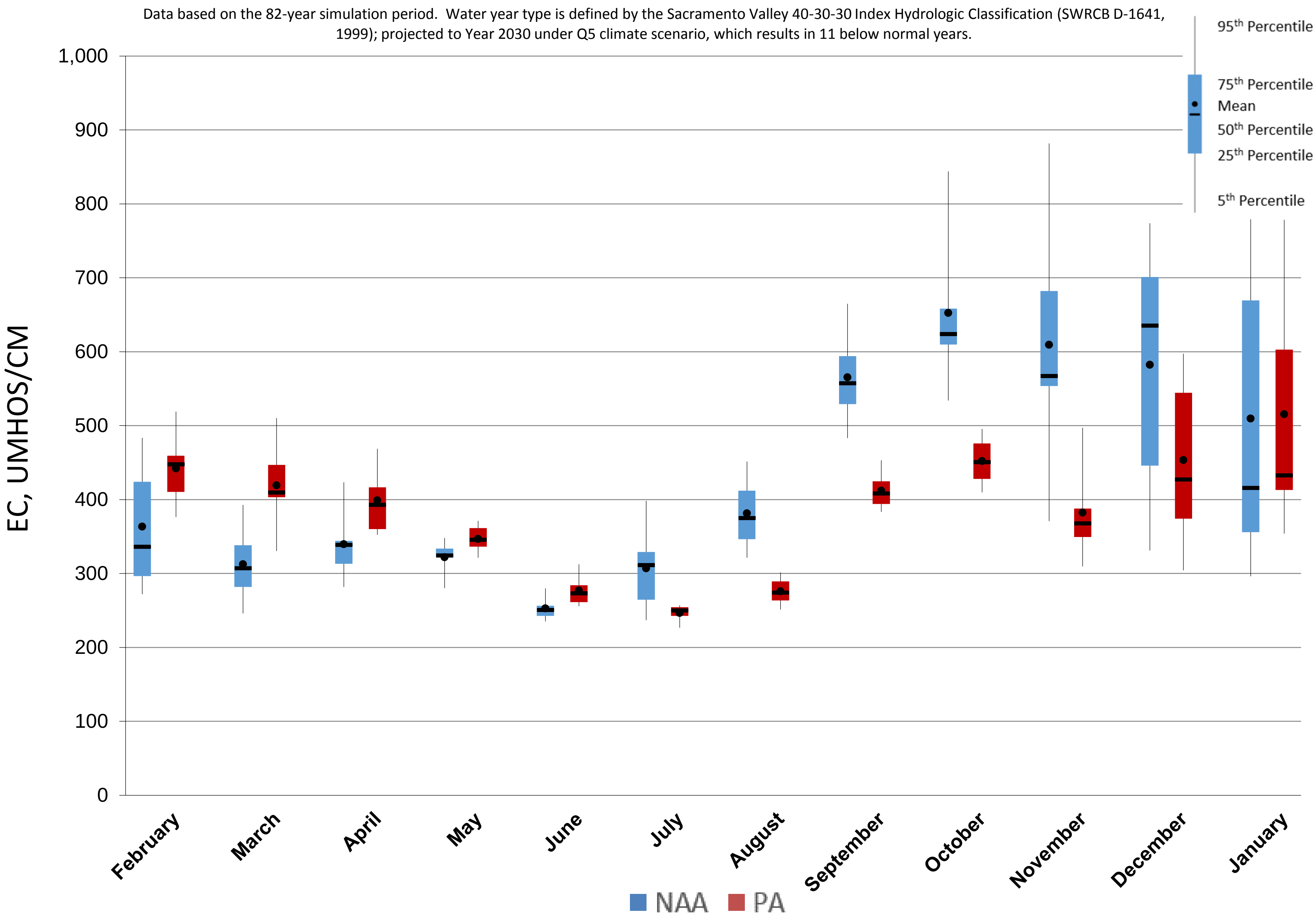


Figure 5.B.5-37-4. Monthly EC Ranges For San Joaquin River at Prisoner's Point, Below Normal Years



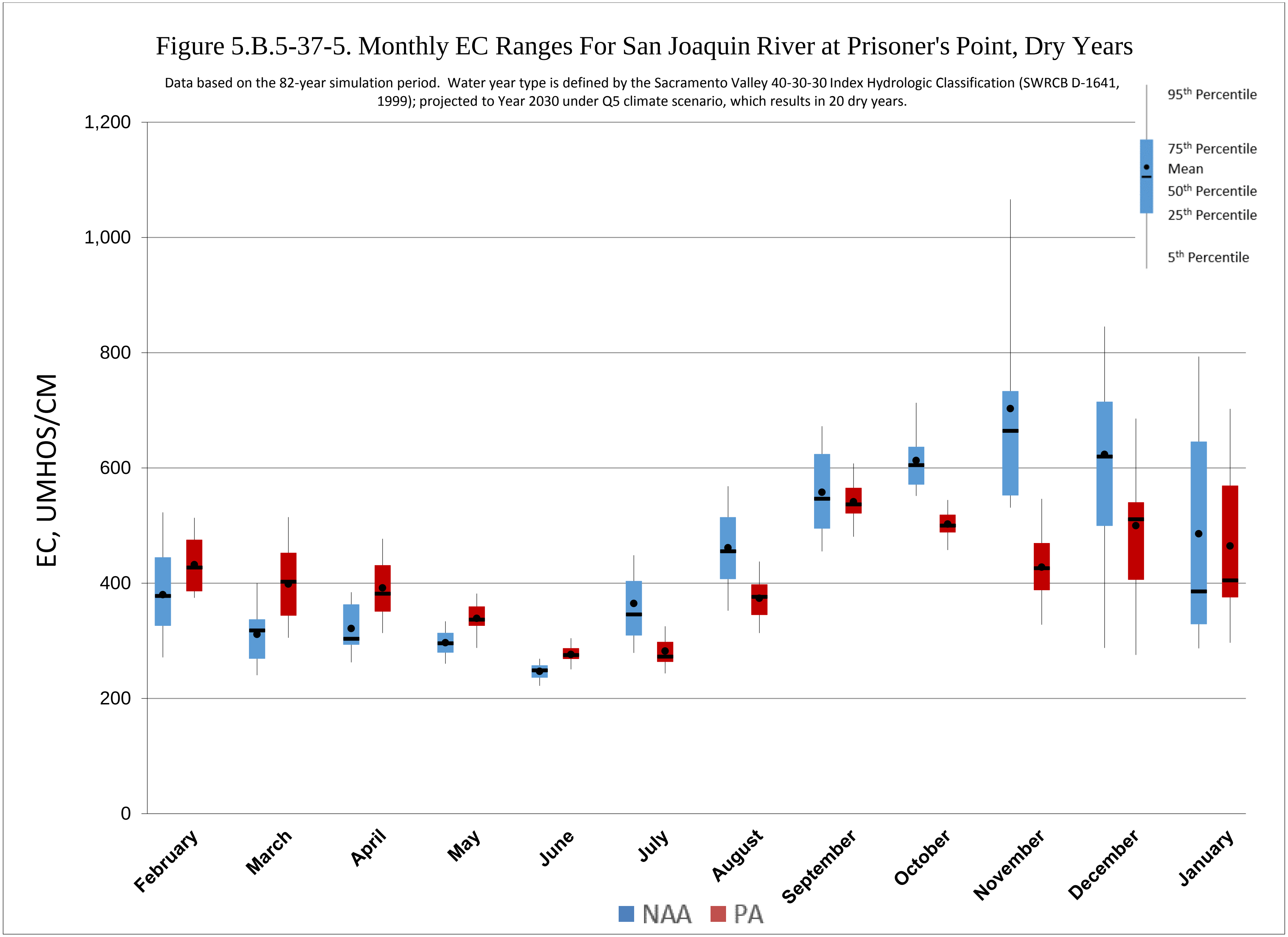


Figure 5.B.5-37-5. Monthly EC Ranges For San Joaquin River at Prisoner's Point, Dry Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 20 dry years.
EC, UMHOS/CM
1,200
1,000
800
600
400
200
0
February
March
April
May
June
July
August
September
October
November
December
January
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
NAA
PA

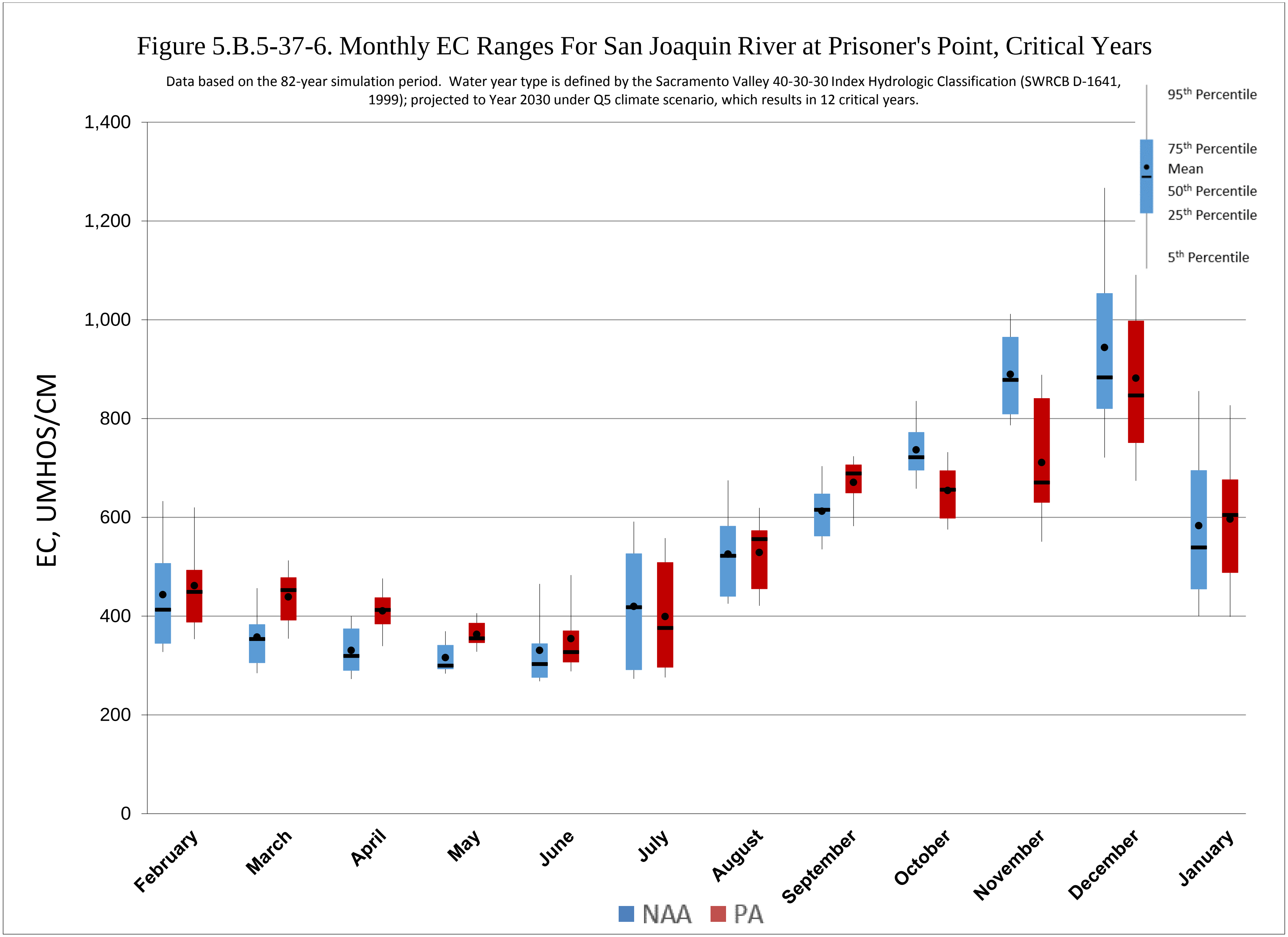
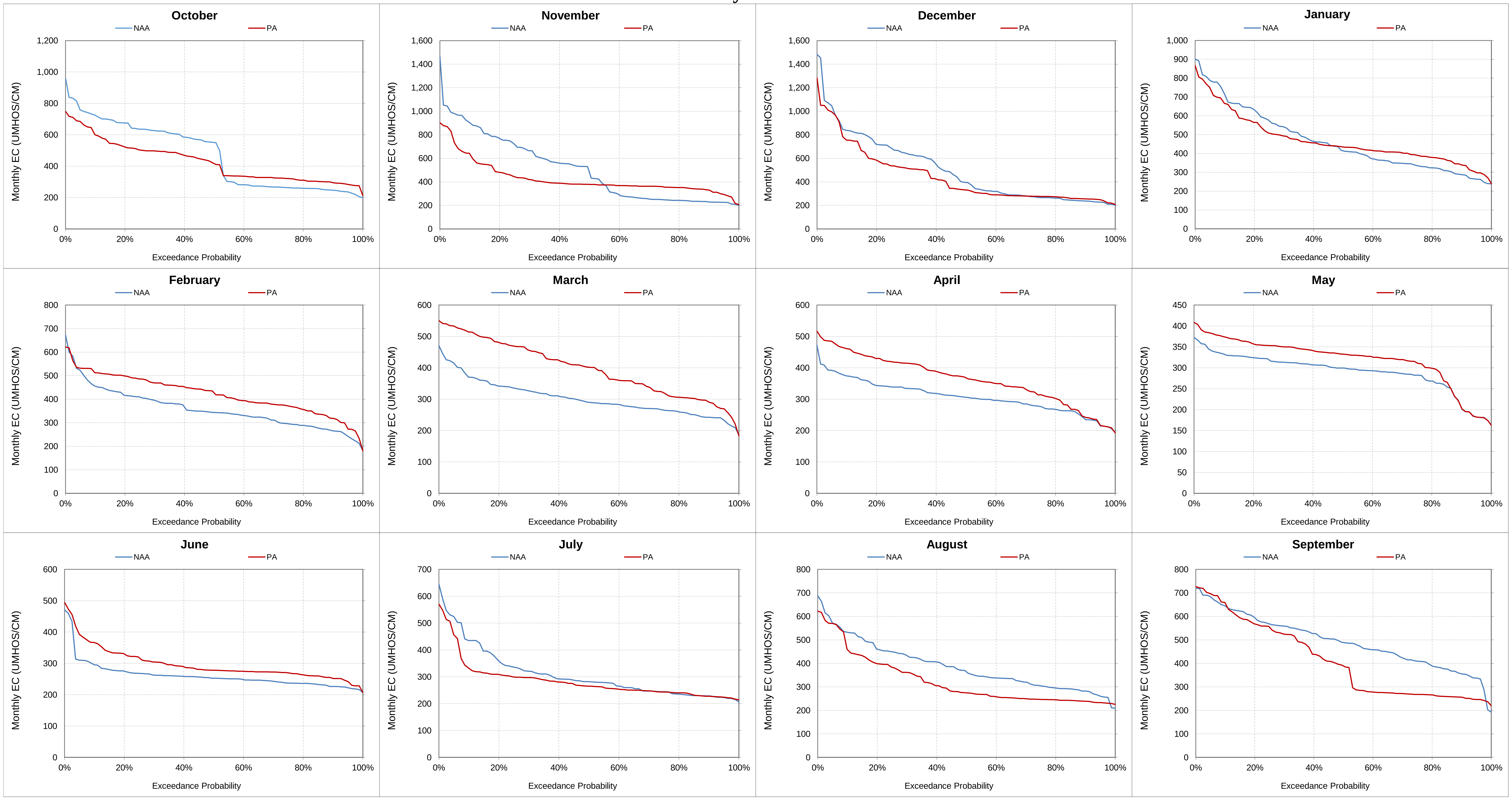


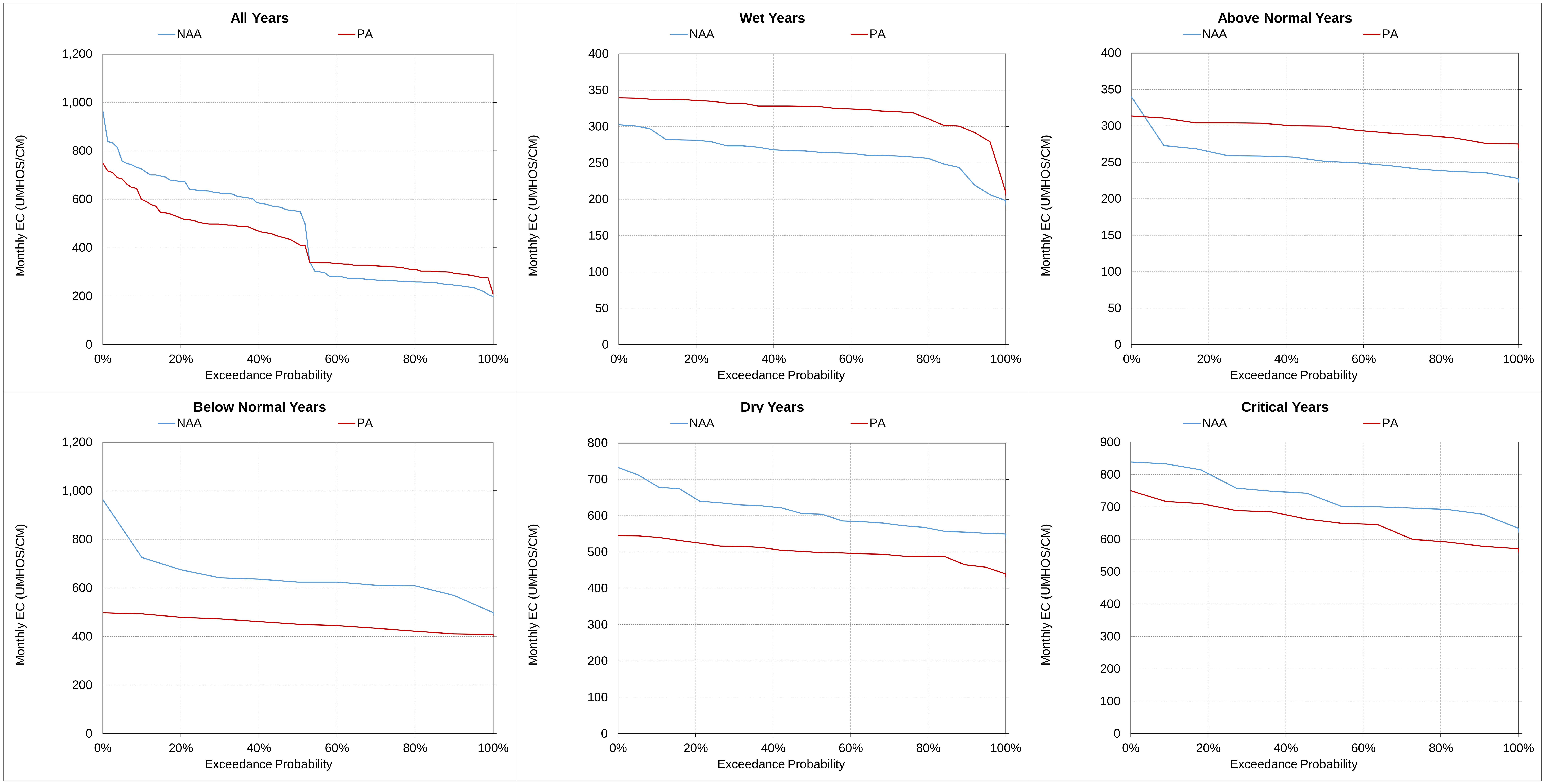
Figure 5.B.5-37-6. Monthly EC Ranges For San Joaquin River at Prisoner's Point, Critical Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 12 critical years.
EC, UMHOS/CM
1,400
1,200
1,000
800
600
400
200
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile

Figure 5.B.5-37-7. San Joaquin River at Prisoner's Point, Monthly EC Probability of Exceedance



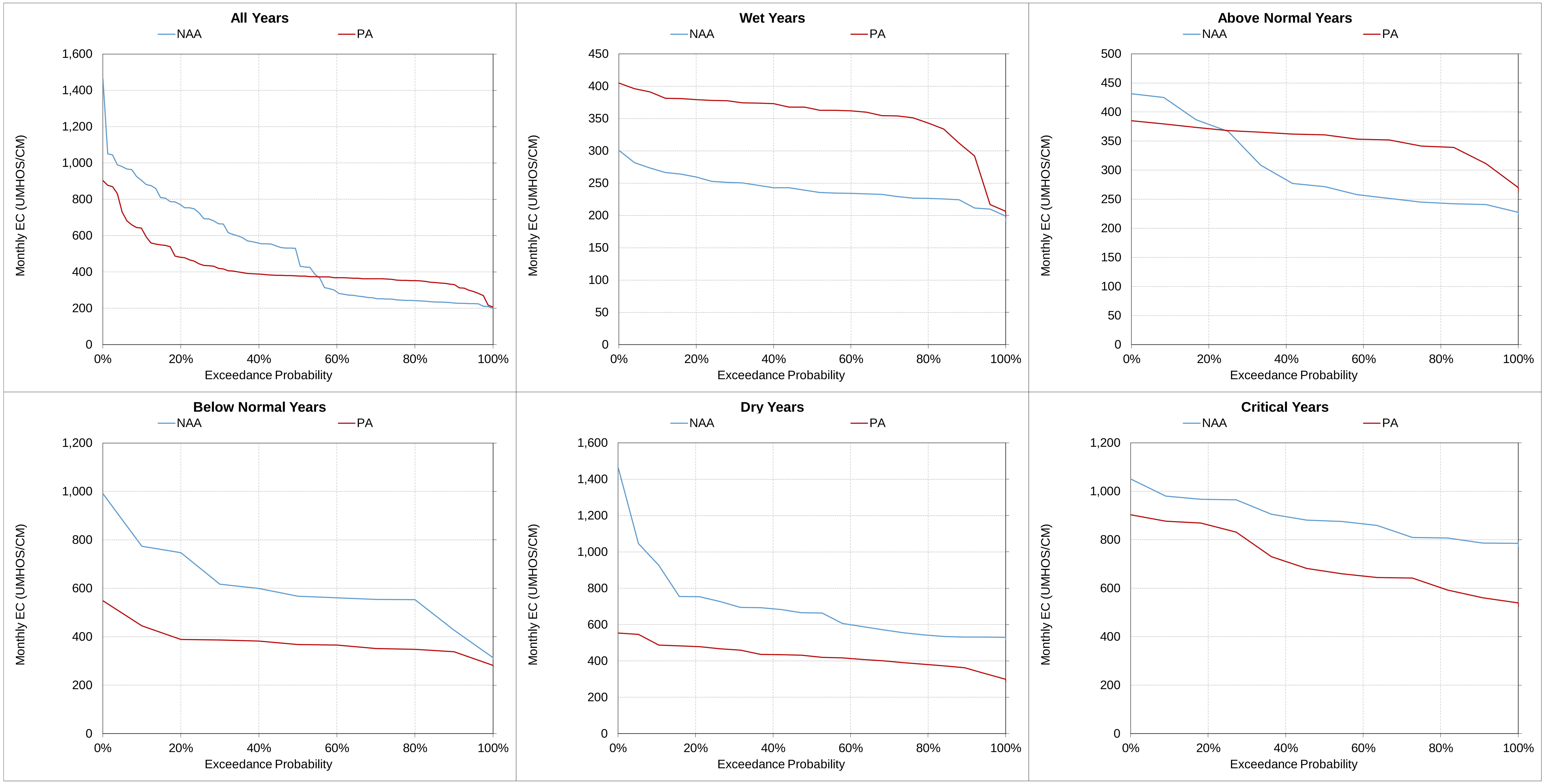
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-37-8. San Joaquin River at Prisoner's Point, Monthly EC
October



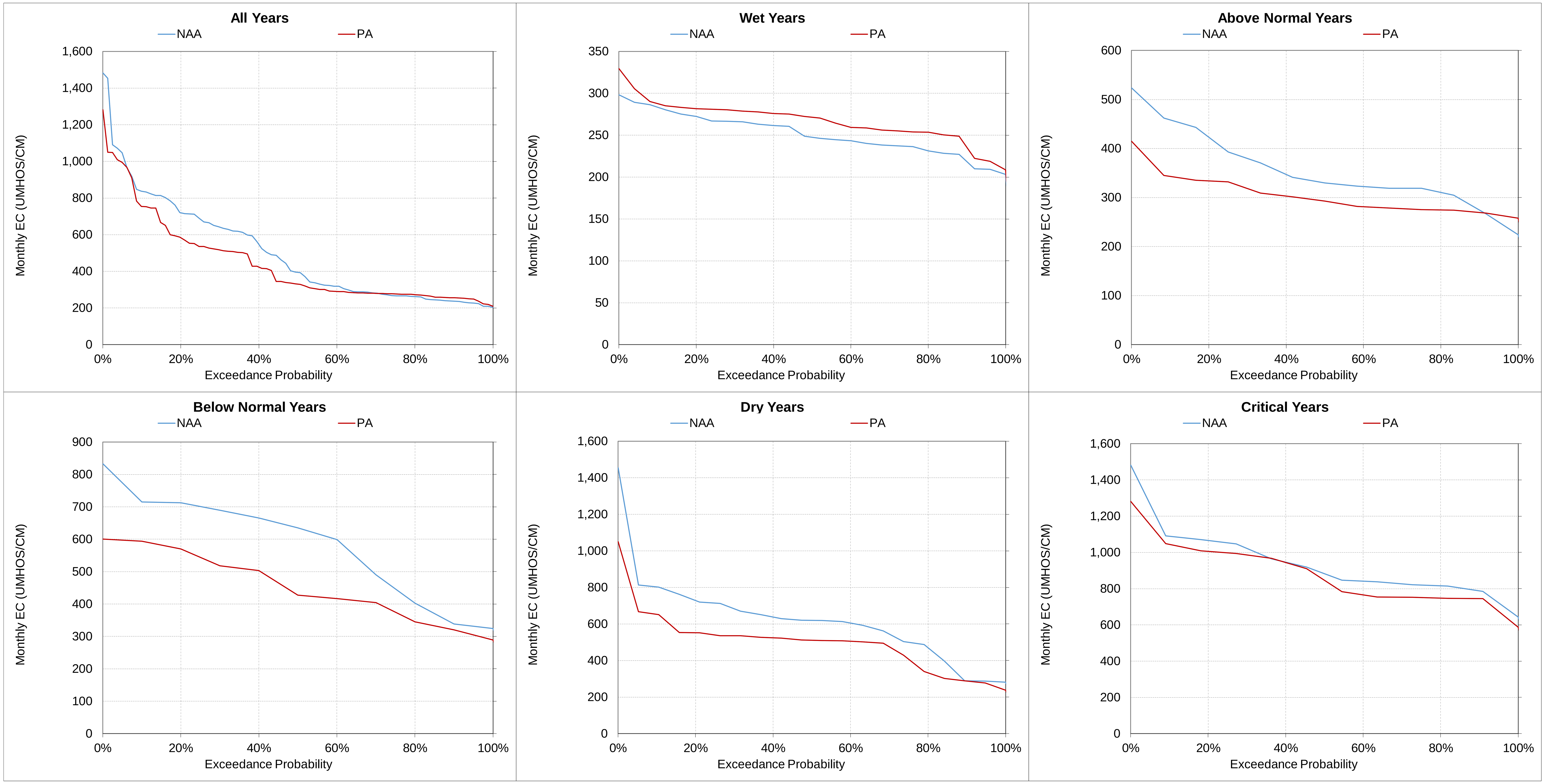
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-37-9. San Joaquin River at Prisoner's Point, Monthly EC November



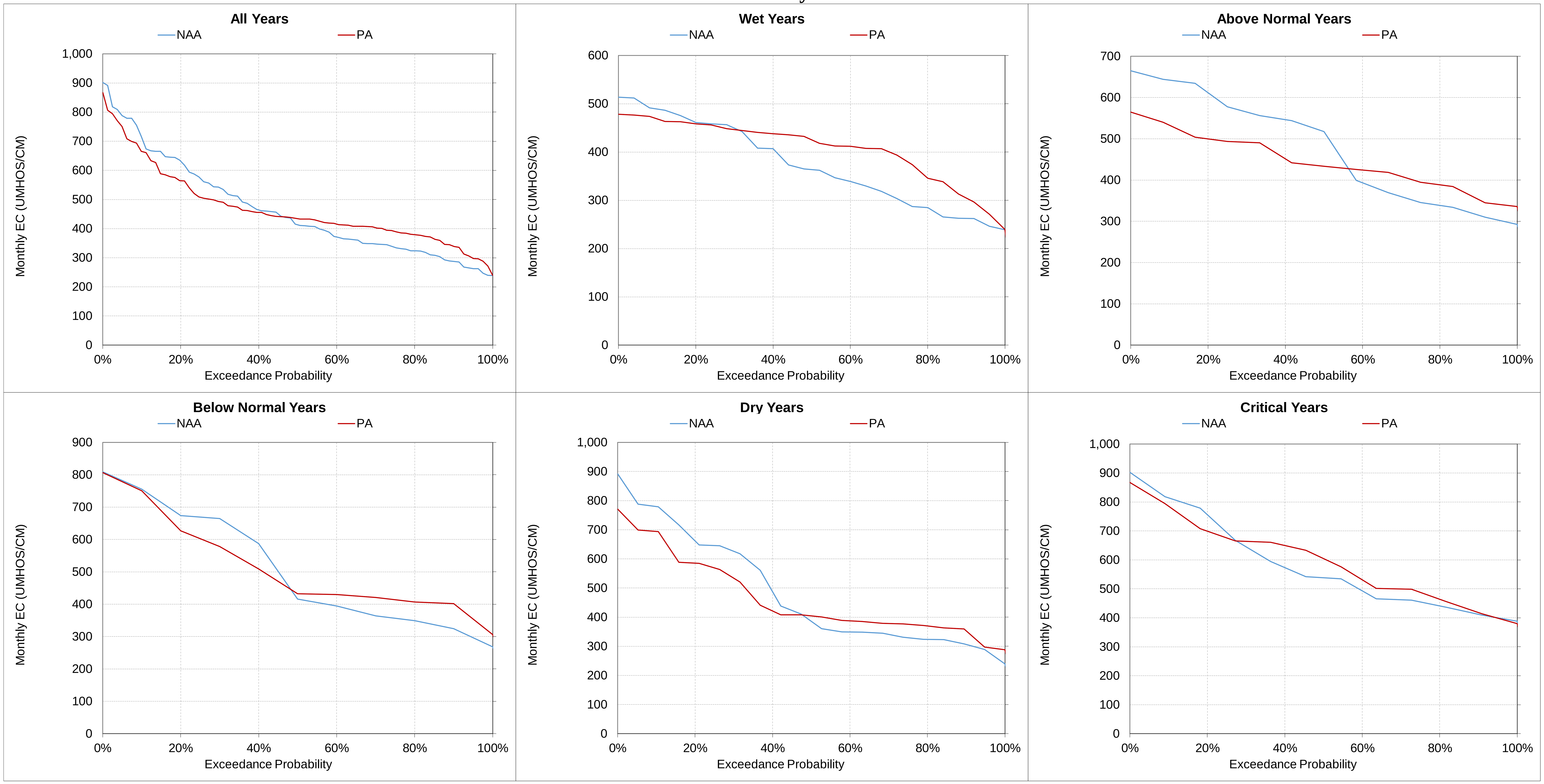
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-37-10. San Joaquin River at Prisoner's Point, Monthly EC
December



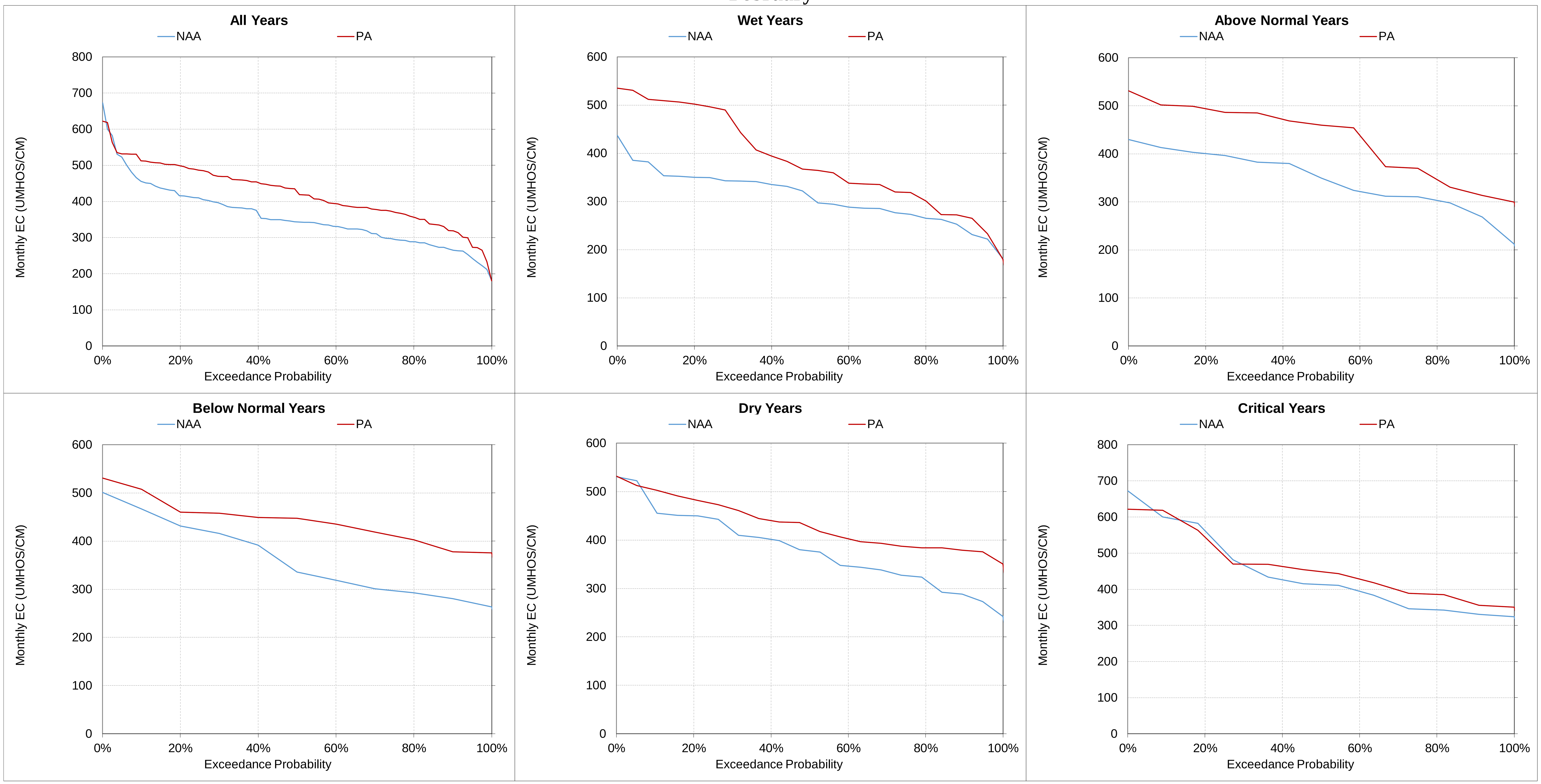
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-37-11. San Joaquin River at Prisoner's Point, Monthly EC
January



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-37-12. San Joaquin River at Prisoner's Point, Monthly EC February



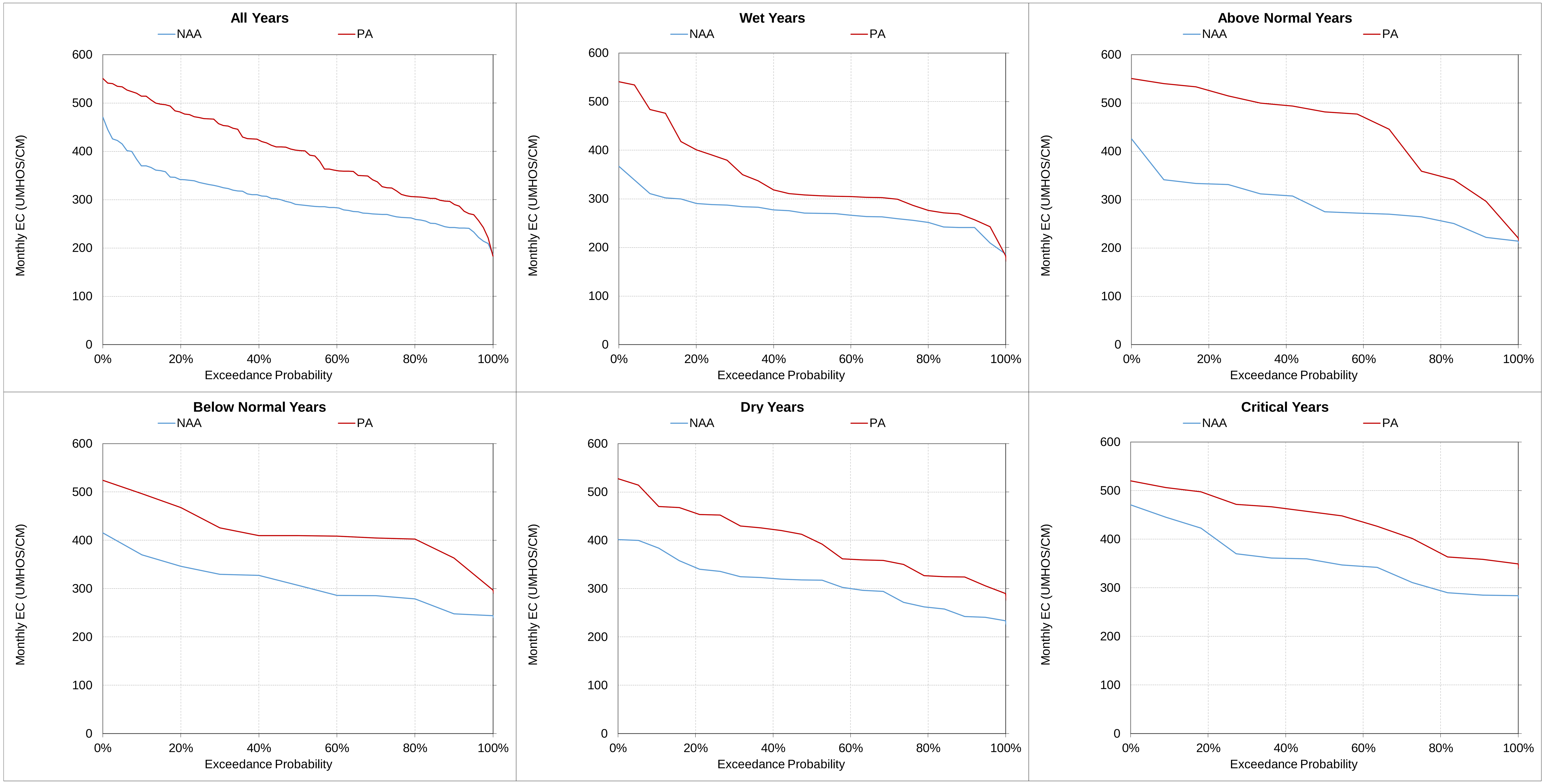
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

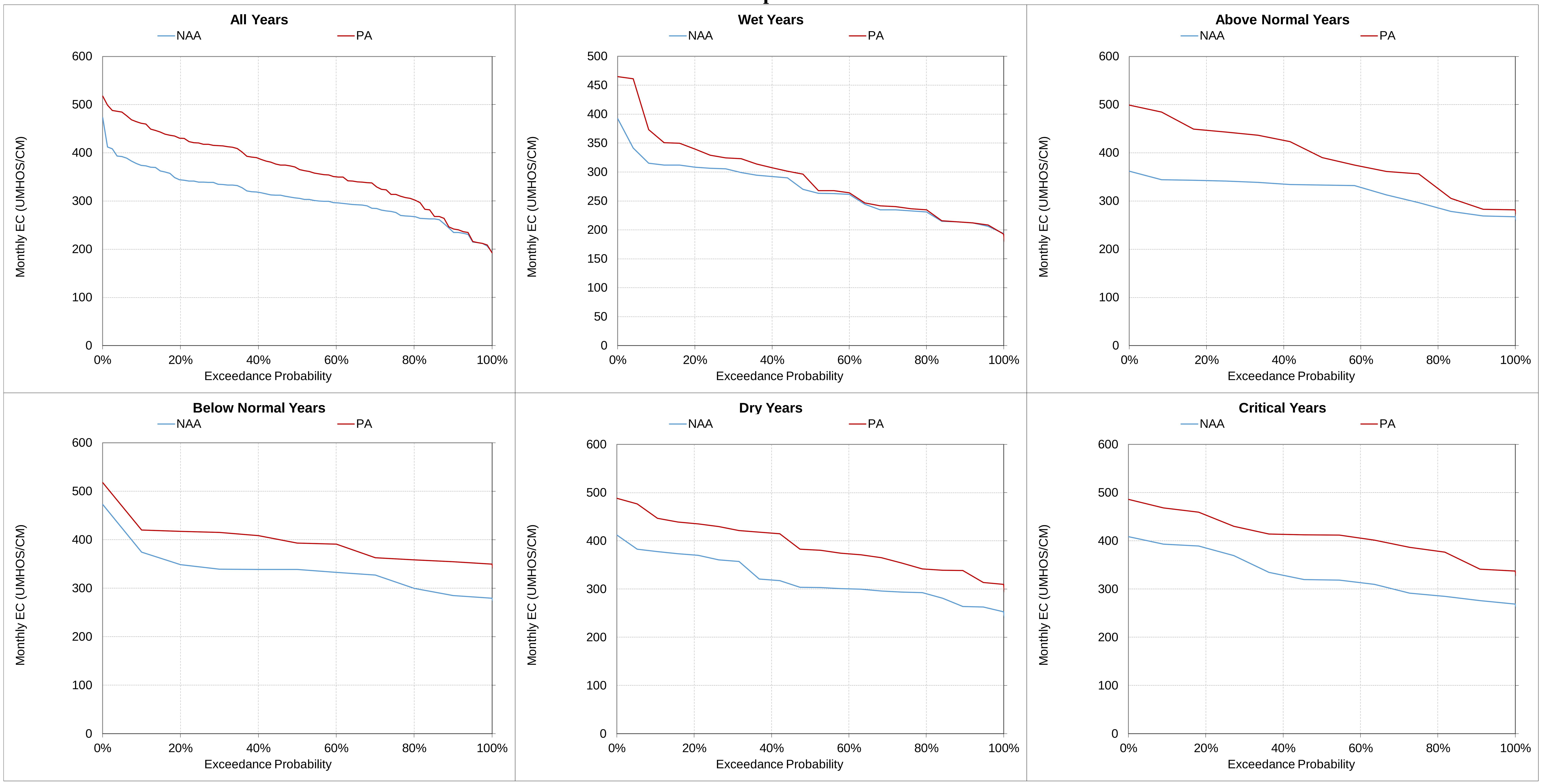
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-37-13. San Joaquin River at Prisoner's Point, Monthly EC March



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-37-14. San Joaquin River at Prisoner's Point, Monthly EC April



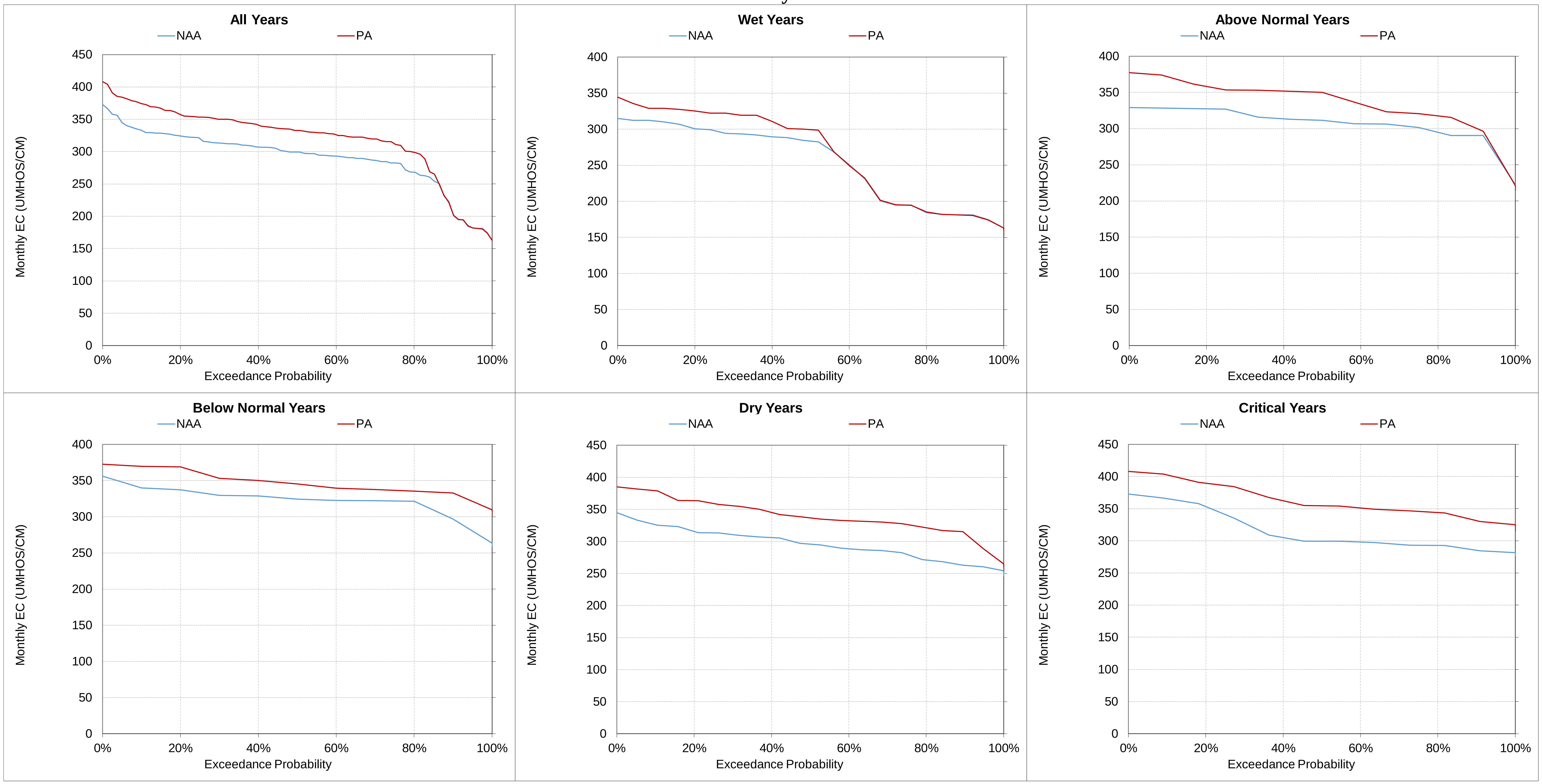
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

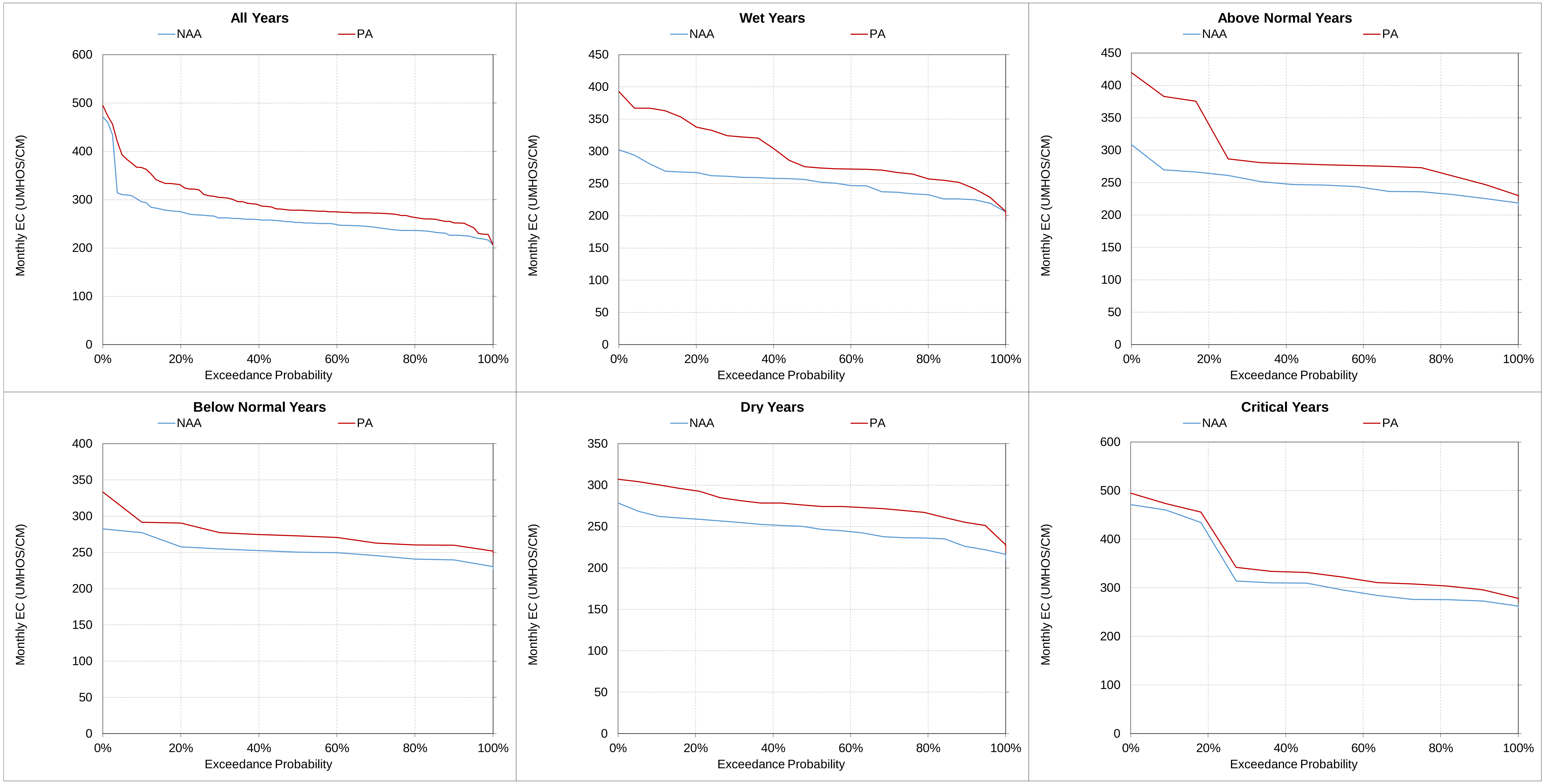
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-37-15. San Joaquin River at Prisoner's Point, Monthly EC May



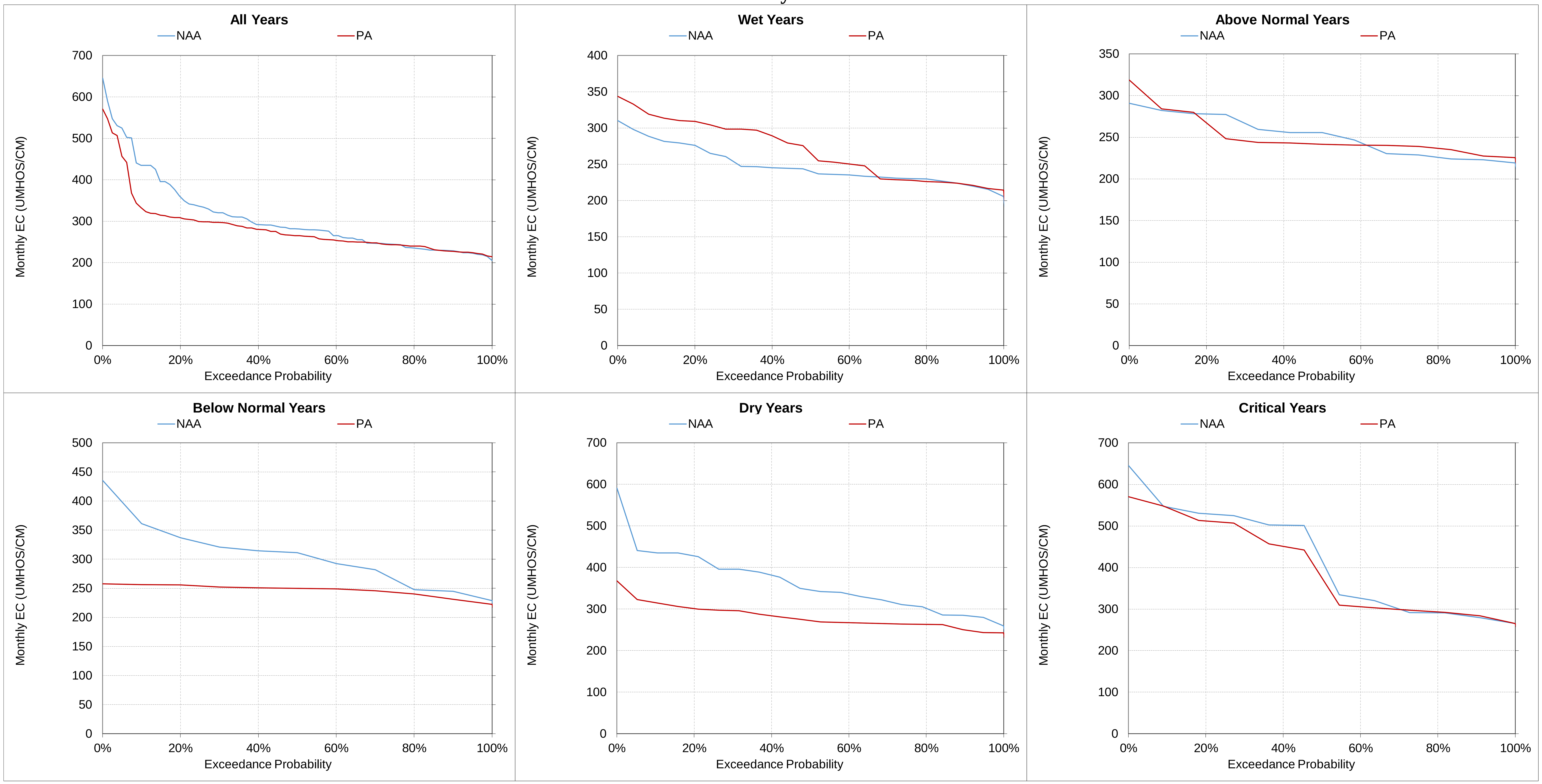
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-37-16. San Joaquin River at Prisoner's Point, Monthly EC
June



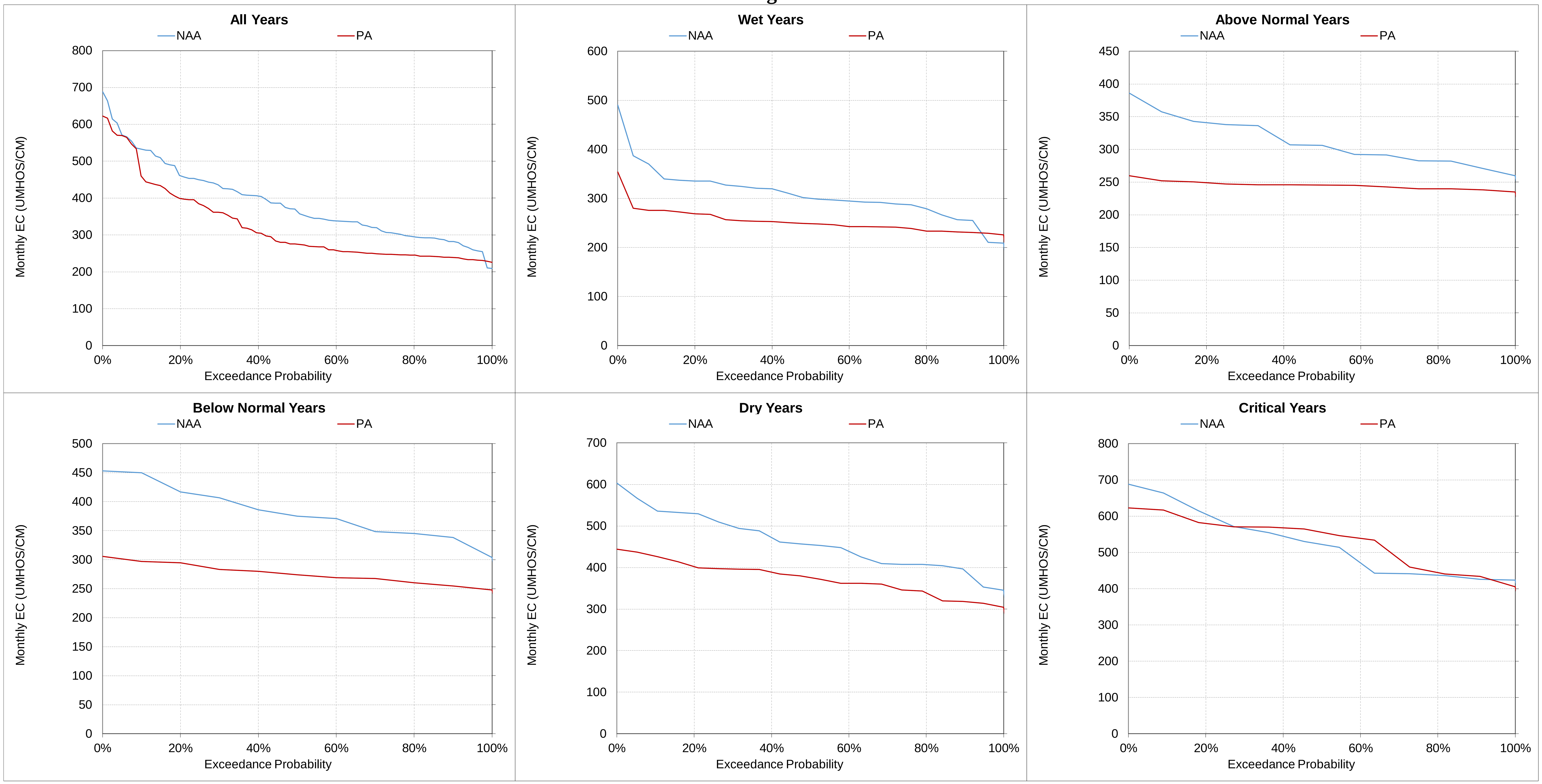
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-37-17. San Joaquin River at Prisoner's Point, Monthly EC July



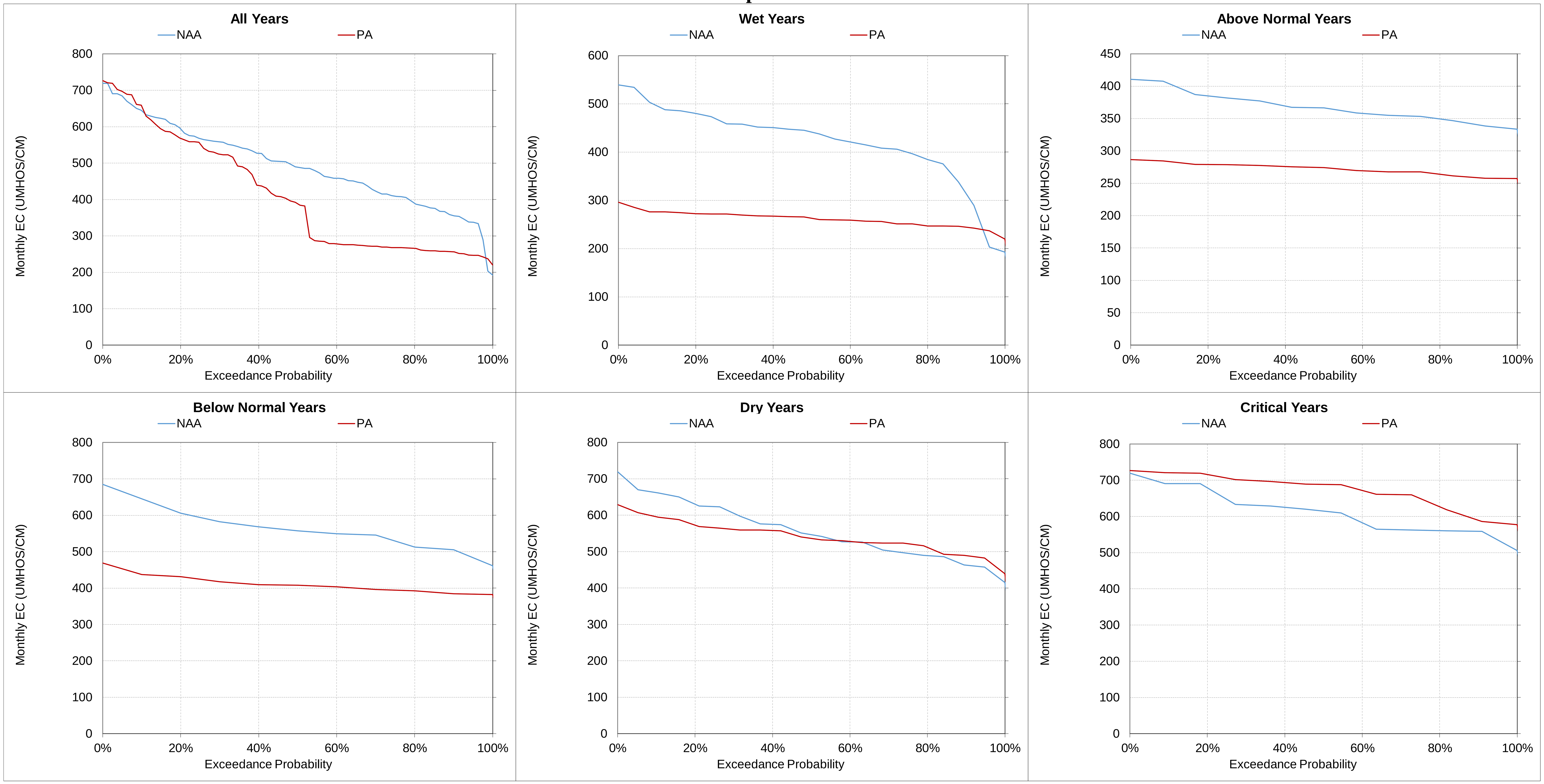
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-37-18. San Joaquin River at Prisoner's Point, Monthly EC August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-37-19. San Joaquin River at Prisoner's Point, Monthly EC September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-38. Sacramento River at Freeport Flow, Monthly Flow

Statistic	Monthly Flow (cfs)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	30,103	13,841	-16,261	-54%	31,235	20,727	-10,508	-34%	30,890	47,502	16,611	54%	30,320	62,755	32,435	107%	30,762	69,613	38,851	126%	31,466	63,767	32,301	103%
20%	25,071	13,316	-11,755	-47%	24,880	15,661	-9,219	-37%	24,955	33,568	8,613	35%	24,715	54,252	29,537	120%	24,359	62,219	37,861	155%	22,948	50,413	27,466	120%
30%	20,741	12,681	-8,060	-39%	19,675	14,651	-5,024	-26%	19,911	21,818	1,907	10%	20,408	37,425	17,017	83%	20,544	49,548	29,004	141%	21,447	38,908	17,461	81%
40%	16,915	12,063	-4,852	-29%	16,865	13,678	-3,186	-19%	16,896	18,169	1,273	8%	17,006	25,663	8,657	51%	17,056	43,550	26,494	155%	17,305	29,853	12,549	73%
50%	15,450	11,516	-3,933	-25%	15,215	12,460	-2,755	-18%	14,862	15,232	370	2%	14,847	21,366	6,519	44%	15,035	31,739	16,704	111%	15,038	24,255	9,217	61%
60%	14,305	10,265	-4,040	-28%	13,991	11,302	-2,689	-19%	13,711	13,897	186	1%	13,485	18,112	4,627	34%	13,782	25,167	11,386	83%	14,097	21,189	7,092	50%
70%	12,211	9,284	-2,927	-24%	12,275	9,920	-2,355	-19%	12,406	13,522	1,116	9%	12,590	14,705	2,115	17%	12,273	19,452	7,179	58%	12,449	18,556	6,108	49%
80%	11,028	8,108	-2,920	-26%	10,398	8,315	-2,083	-20%	10,264	10,718	453	4%	10,071	13,380	3,310	33%	9,725	16,172	6,447	66%	9,643	15,160	5,517	57%
90%	8,393	6,679	-1,714	-20%	8,489	7,448	-1,041	-12%	8,562	9,149	588	7%	8,253	11,772	3,518	43%	8,381	13,808	5,428	65%	8,494	11,479	2,985	35%
Long Term Full Simulation Period[b]	18,183	11,101	-7,082	-39%	18,082	14,036	-4,046	-22%	18,019	22,482	4,463	25%	17,971	30,448	12,477	69%	17,954	37,574	19,620	109%	18,048	31,707	13,659	76%
Water Year Types[c]																								
Wet (32%)	16,771	13,215	-3,556	-21%	16,858	17,308	450	3%	16,844	25,215	8,371	50%	16,723	32,295	15,573	93%	17,192	57,150	39,957	232%	16,747	48,296	31,549	188%
Above Normal (16%)	20,526	13,017	-7,510	-37%	19,941	15,326	-4,615	-23%	19,662	22,498	2,836	14%	19,433	28,720	9,287	48%	19,534	46,724	27,190	139%	19,319	42,378	23,059	119%
Below Normal (13%)	22,074	12,524	-9,550	-43%	22,061	11,891	-10,169	-46%	21,846	20,685	-1,162	-5%	21,780	28,414	6,634	30%	18,925	30,417	11,492	61%	19,356	18,960	-396	-2%
Dry (24%)	17,431	9,242	-8,189	-47%	17,247	14,024	-3,222	-19%	17,184	25,996	8,812	51%	17,085	33,498	16,413	96%	17,908	23,438	5,529	31%	18,267	21,526	3,259	18%
Critical (15%)	16,391	6,242	-10,149	-62%	16,466	7,539	-8,927	-54%	16,668	12,336	-4,332	-26%	17,074	25,098	8,024	47%	17,076	15,366	-1,710	-10%	17,925	12,855	-5,070	-28%

Statistic	Monthly Flow (cfs)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	29,829	46,643	16,814	56%	29,455	38,400	8,945	30%	31,735	21,769	-9,966	-31%	30,636	23,325	-7,311	-24%	29,852	18,439	-11,413	-38%	30,131	25,880	-4,251	-14%
20%	24,165	32,296	8,130	34%	23,689	25,304	1,614	7%	23,791	19,218	-4,573	-19%	23,124	22,294	-831	-4%	24,037	17,521	-6,517	-27%	24,454	23,844	-609	-2%
30%	21,250	23,368	2,118	10%	19,994	16,464	-3,530	-18%	19,464	18,231	-1,233	-6%	19,921	21,721	1,801	9%	19,416	16,350	-3,067	-16%	20,074	21,965	1,891	9%
40%	17,314	20,333	3,019	17%	17,155	13,618	-3,537	-21%	16,925	17,417	493	3%	16,953	21,105	4,152	24%	16,849	14,324	-2,525	-15%	17,030	16,537	-493	-3%
50%	15,119	16,303	1,183	8%	15,039	12,605	-2,434	-16%	14,997	16,326	1,330	9%	15,604	19,728	4,123	26%	15,655	12,851	-2,804	-18%	15,656	10,467	-5,189	-33%
60%	14,040	12,846	-1,194	-9%	13,829	11,643	-2,186	-16%	14,011	14,912	901	6%	14,043	18,320	4,277	30%	13,926	11,952	-1,974	-14%	13,969	9,486	-4,482	-32%
70%	12,141	11,952	-189	-2%	12,726	11,146	-1,580	-12%	12,820	13,251	431	3%	12,720	16,584	3,865	30%	12,541	10,954	-1,587	-13%	12,226	9,162	-3,064	-25%
80%	9,882	11,293	1,412	14%	9,809	10,393	584	6%	9,716	12,156	2,441	25%	9,826	13,539	3,713	38%	9,876	10,741	865	9%	10,316	8,317	-1,999	-19%
90%	8,644	10,255	1,611	19%	8,447	9,124	676	8%	8,429	9,935	1,505	18%	8,459	10,046	1,587	19%	8,493	9,676	1,183	14%	8,243	7,145	-1,099	-13%
Long Term Full Simulation Period[b]	18,063	22,309	4,246	24%	17,972	18,053	82	0%	17,977	16,895	-1,082	-6%	18,038	18,264	226	1%	18,001	13,667	-4,335	-24%	17,984	15,266	-2,718	-15%
Water Year Types[c]																								
Wet (32%)	16,220	35,444	19,224	119%	16,065	29,868	13,803	86%	16,242	21,793	5,551	34%	16,380	20,992	4,611	28%	16,579	16,099	-480	-3%	16,670	25,213	8,542	51%
Above Normal (16%)	19,168	24,637	5,470	29%	19,045	16,938	-2,107	-11%	19,179	17,007	-2,172	-11%	19,471	21,844	2,372	12%	19,661	16,174	-3,487	-18%	19,608	17,729	-1,879	-10%
Below Normal (13%)	19,467	14,218	-5,248	-27%	19,411	12,704	-6,707	-35%	20,057	15,682	-4,375	-22%	21,156	21,319	163	1%	21,518	14,209	-7,309	-34%	21,740	9,455	-12,285	-57%
Dry (24%)	18,641	15,222	-3,419	-18%	18,590	12,130	-6,460	-35%	18,294	14,991	-3,303	-18%	17,903	15,798	-2,105	-12%	17,508	11,320	-6,188	-35%	17,440	8,829	-8,611	-49%
Critical (15%)	18,612	10,556	-8,057	-43%	18,588	8,439	-10,148	-55%	18,000	10,445	-7,555	-42%	17,447	9,786	-7,661	-44%	16,886	9,095	-7,791	-46%	16,535	7,104	-9,431	-57%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-38-1. Monthly Flow Ranges For Sacramento River at Freeport Flow, All Years

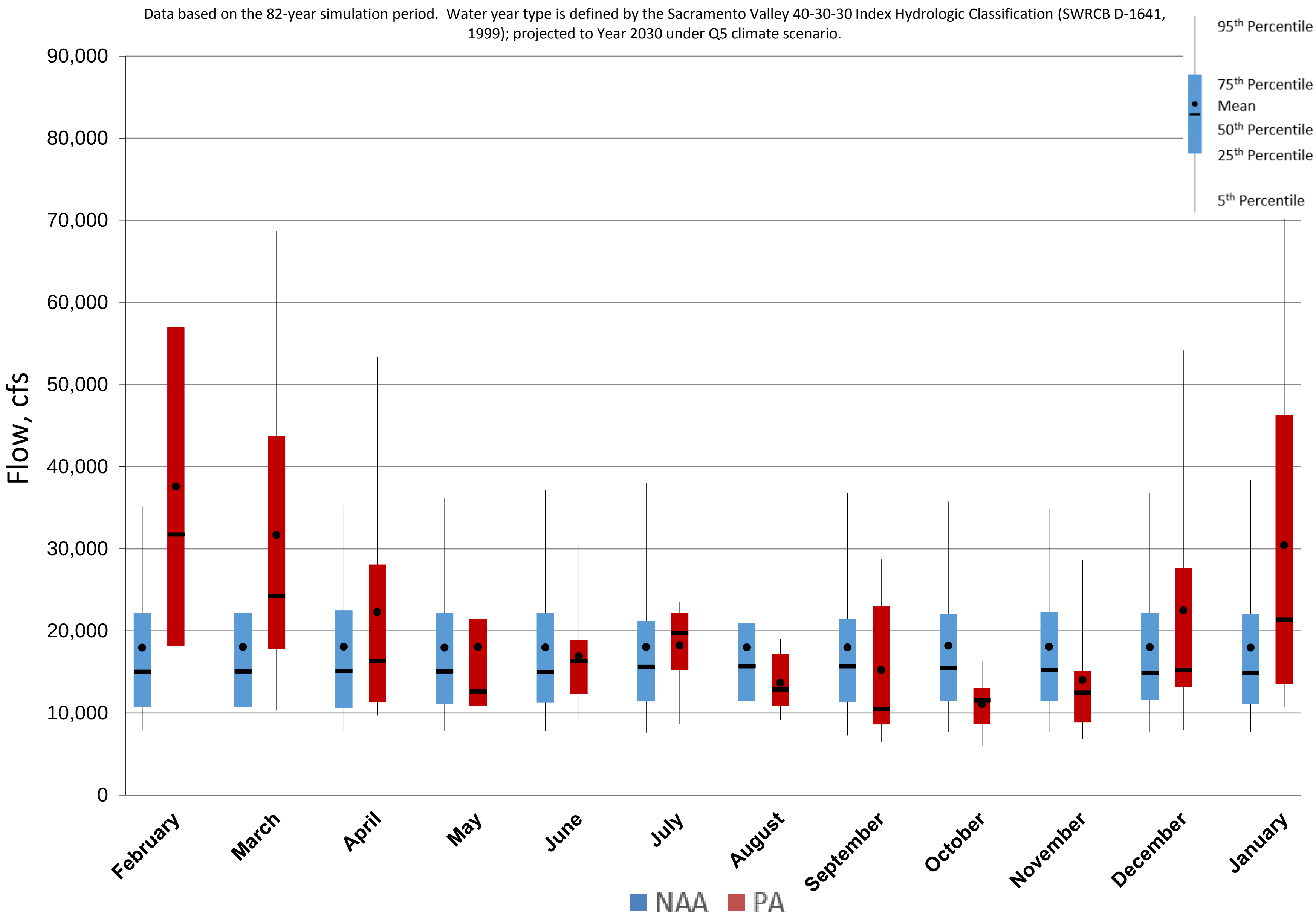
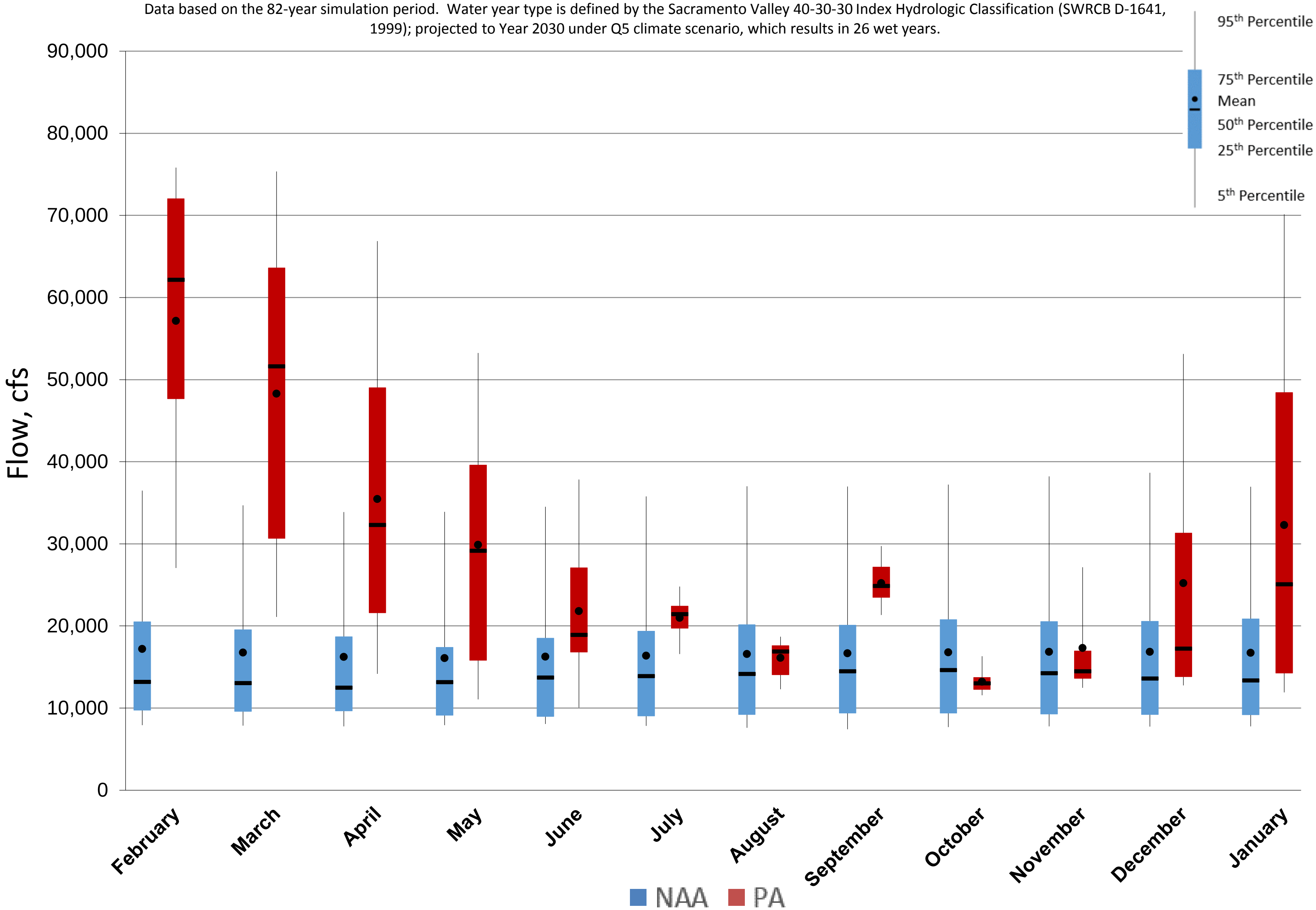


Figure 5.B.5-38-2. Monthly Flow Ranges For Sacramento River at Freeport Flow, Wet Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 26 wet years.



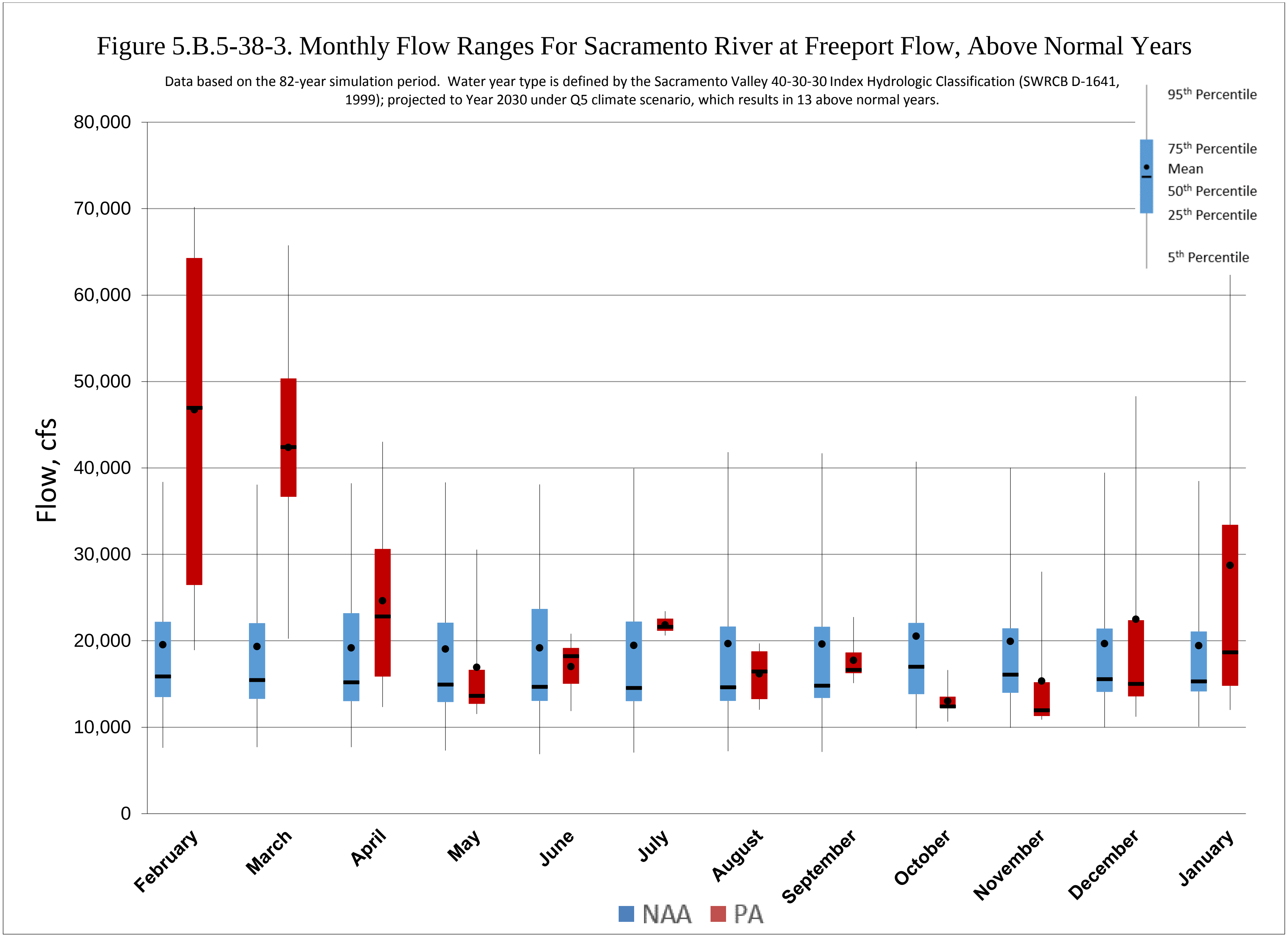


Figure 5.B.5-38-3. Monthly Flow Ranges For Sacramento River at Freeport Flow, Above Normal Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 13 above normal years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
Flow, cfs
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-38-4. Monthly Flow Ranges For Sacramento River at Freeport Flow, Below Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 11 below normal years.

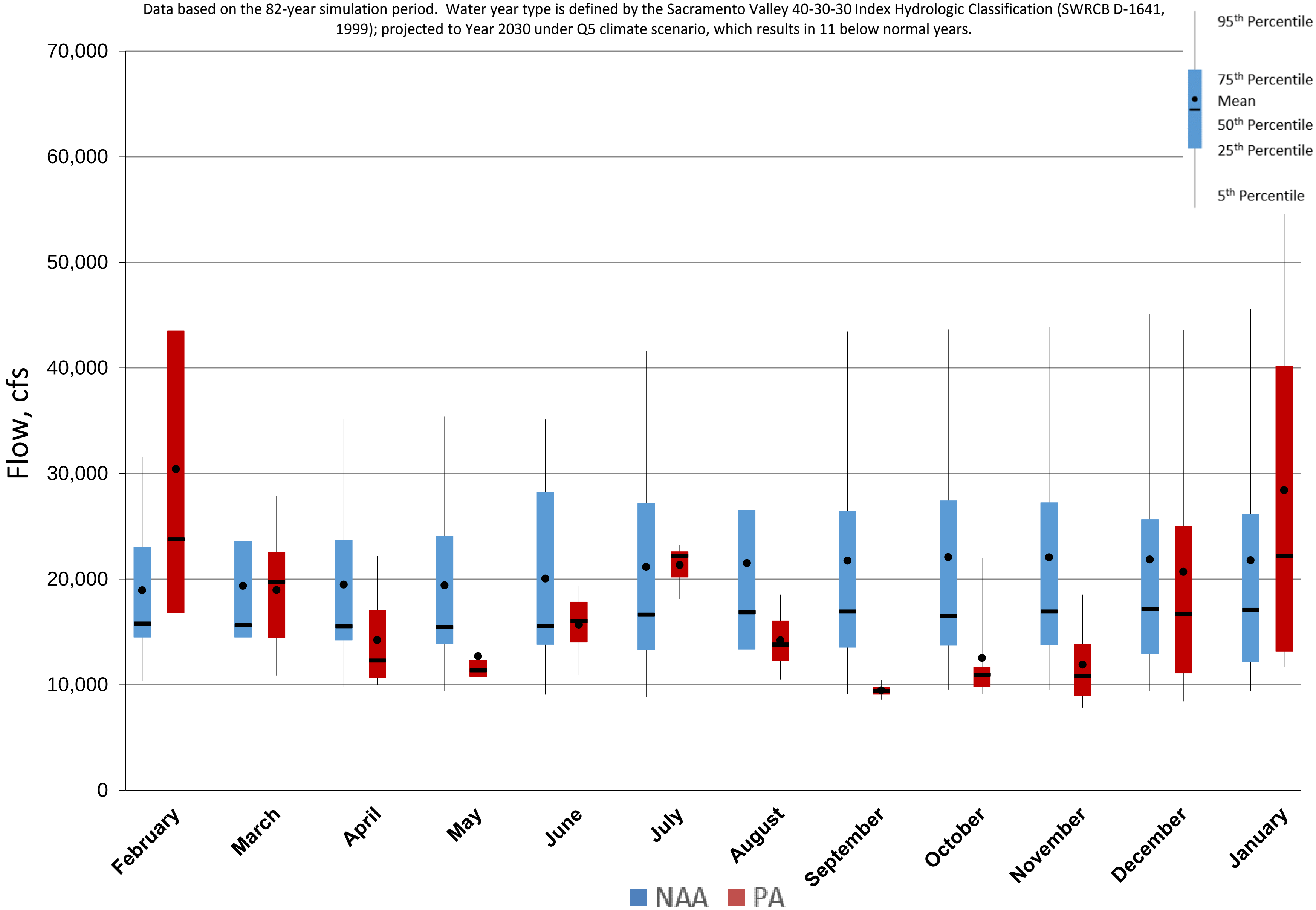
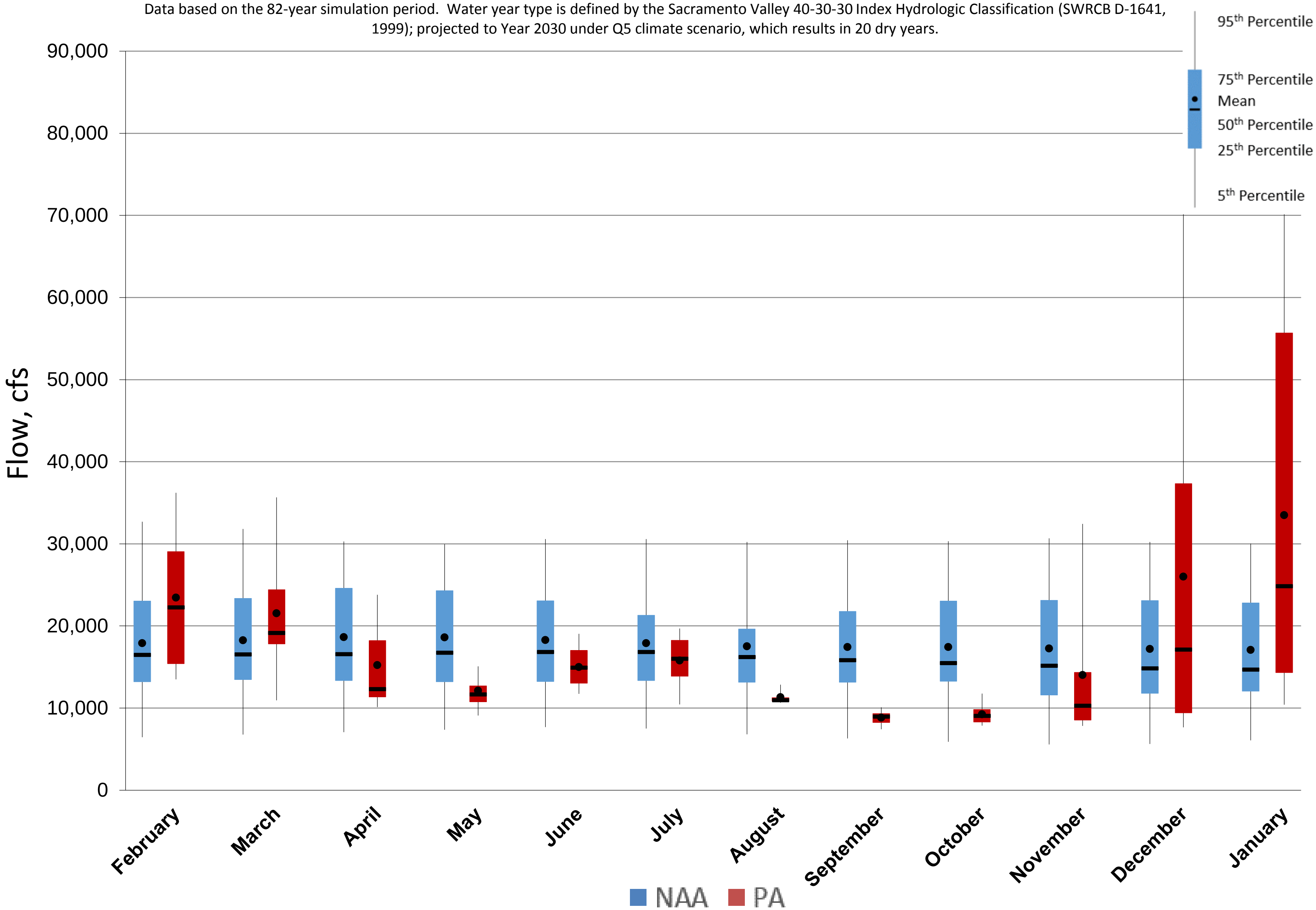


Figure 5.B.5-38-5. Monthly Flow Ranges For Sacramento River at Freeport Flow, Dry Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 20 dry years.



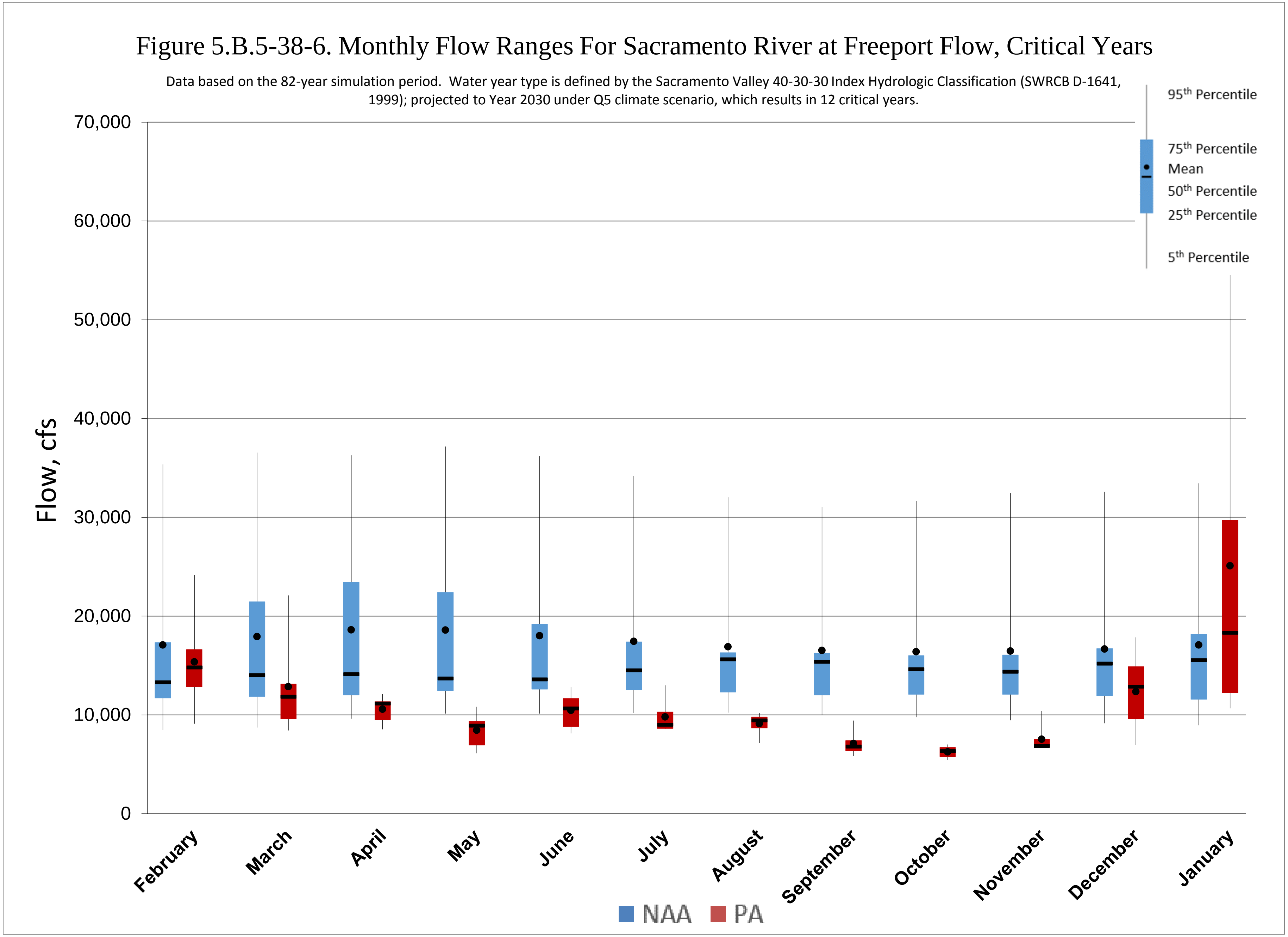
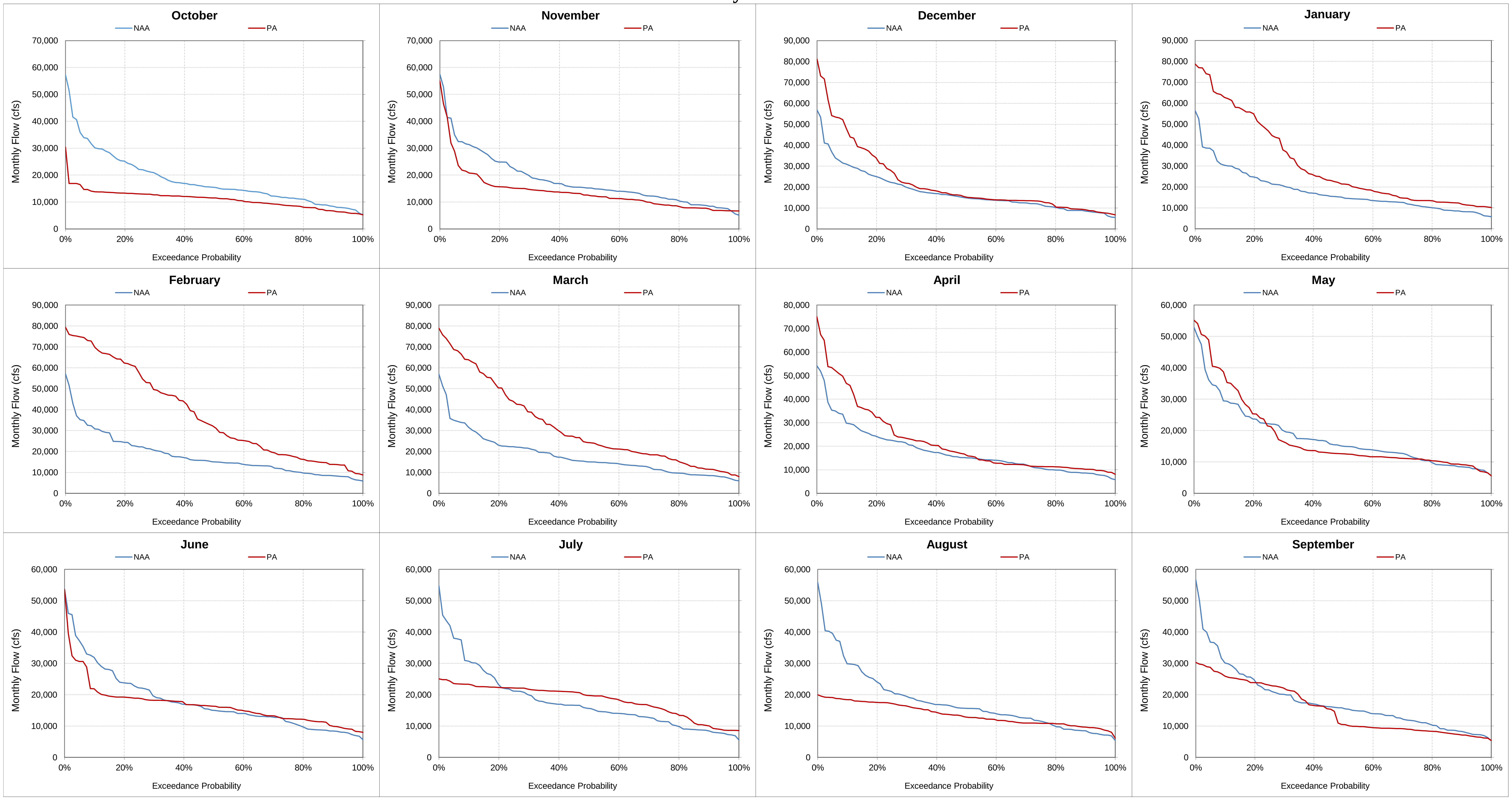


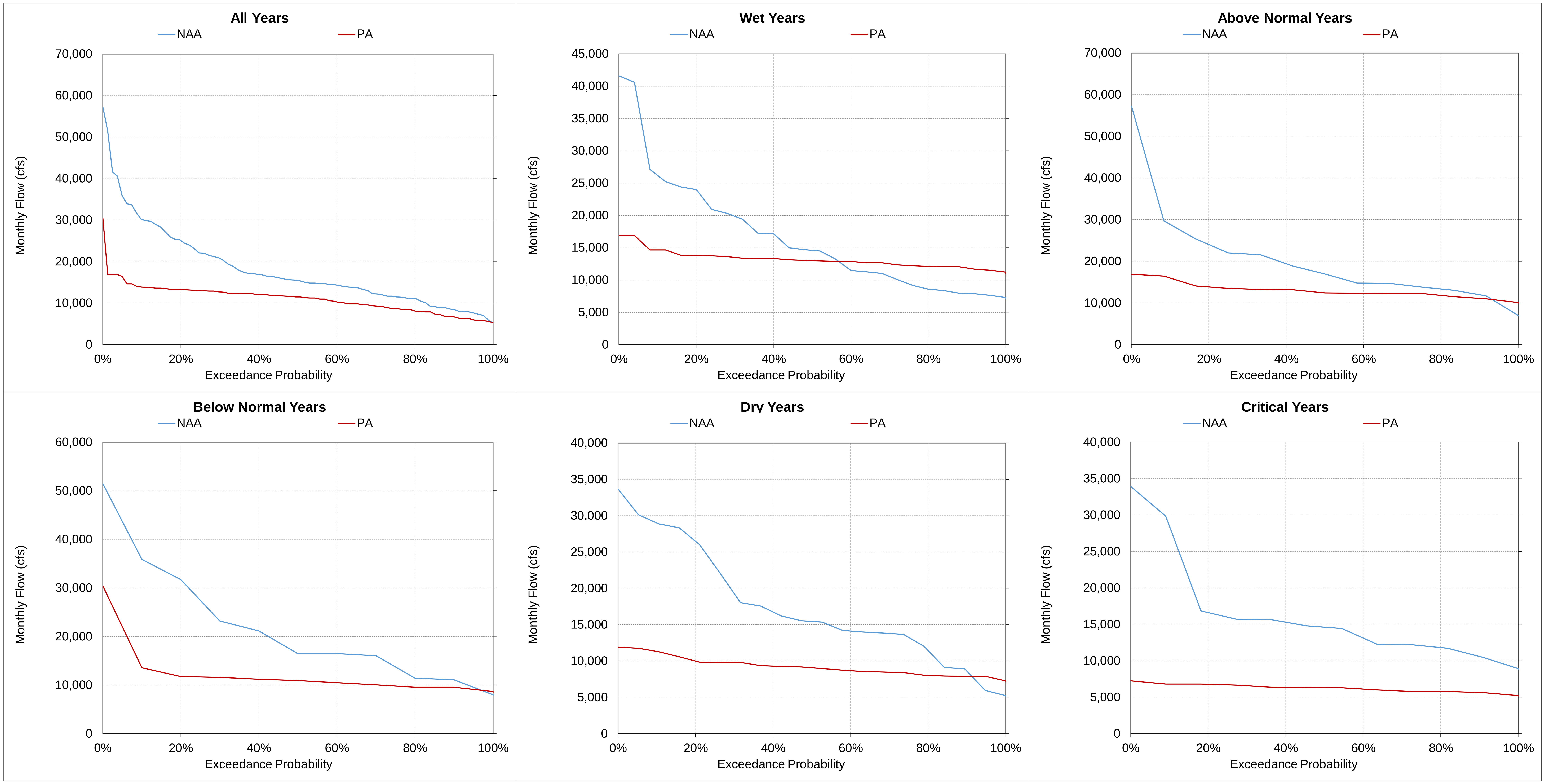
Figure 5.B.5-38-6. Monthly Flow Ranges For Sacramento River at Freeport Flow, Critical Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 12 critical years.
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
Flow, cfs
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
February
March
April
May
June
July
August
September
October
November
December
January
NAA
PA

Figure 5.B.5-38-7. Sacramento River at Freeport Flow, Monthly Flow Probability of Exceedance



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-38-8. Sacramento River at Freeport Flow, Monthly Flow October



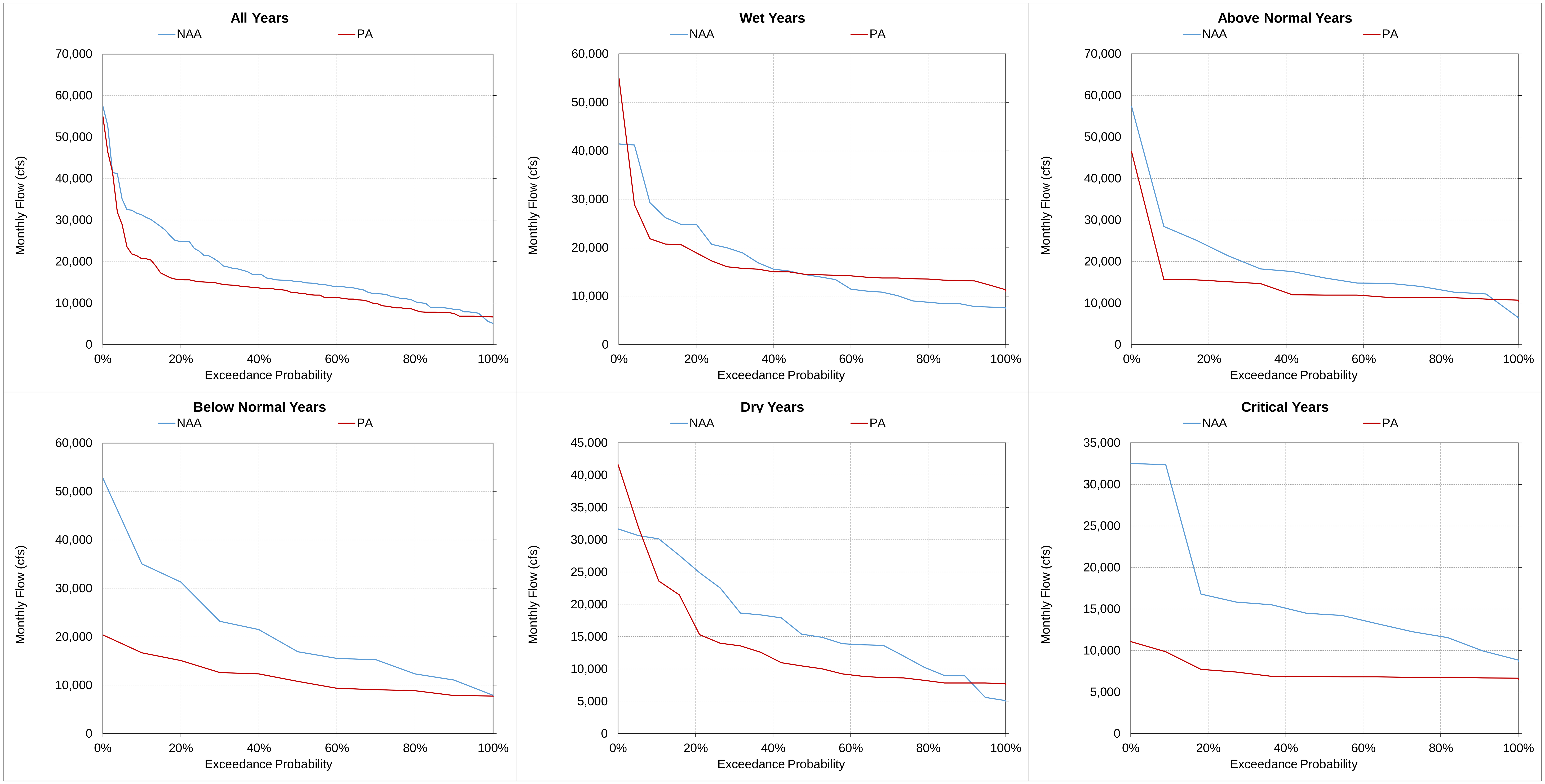
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

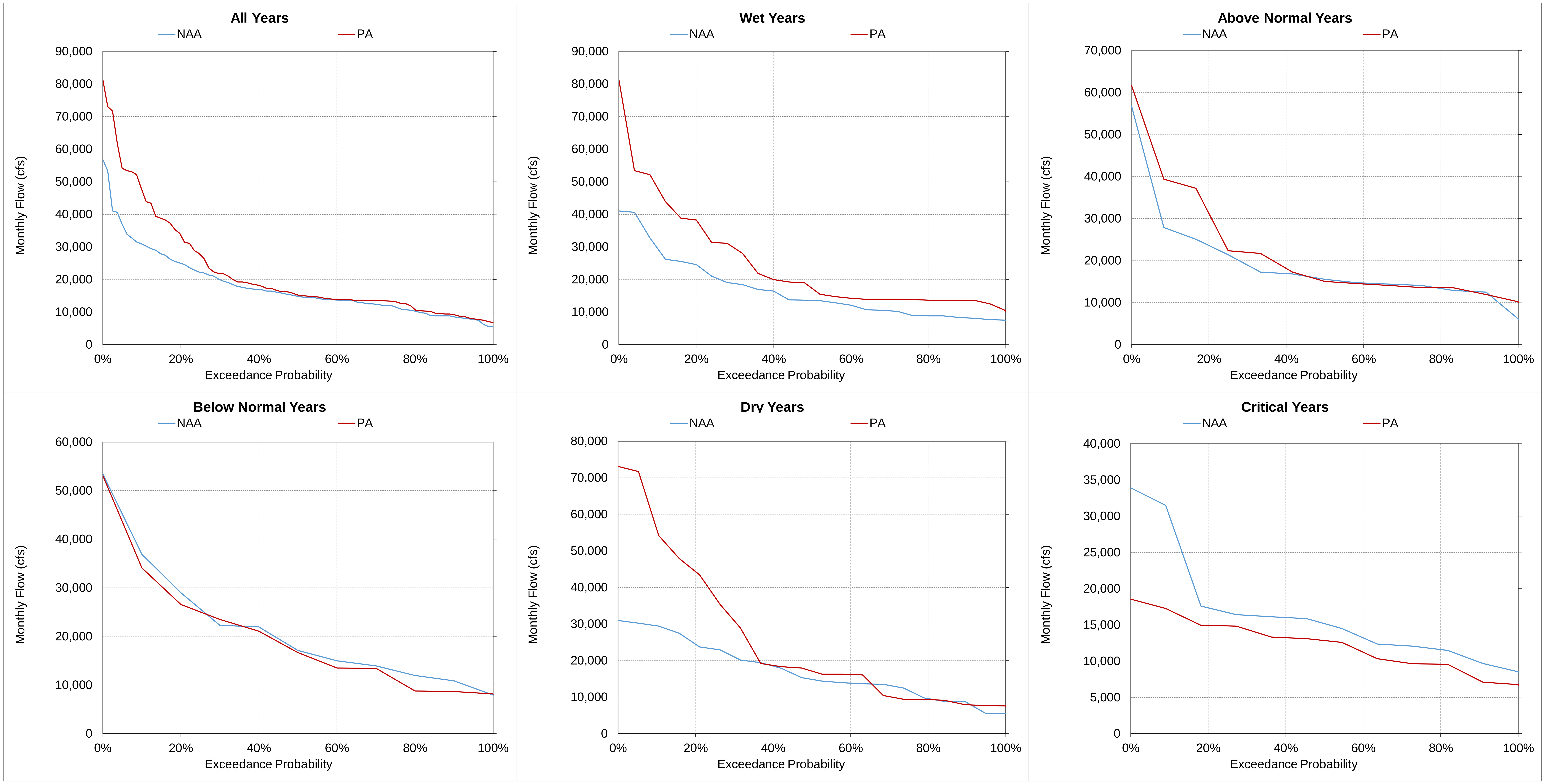
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-38-9. Sacramento River at Freeport Flow, Monthly Flow November



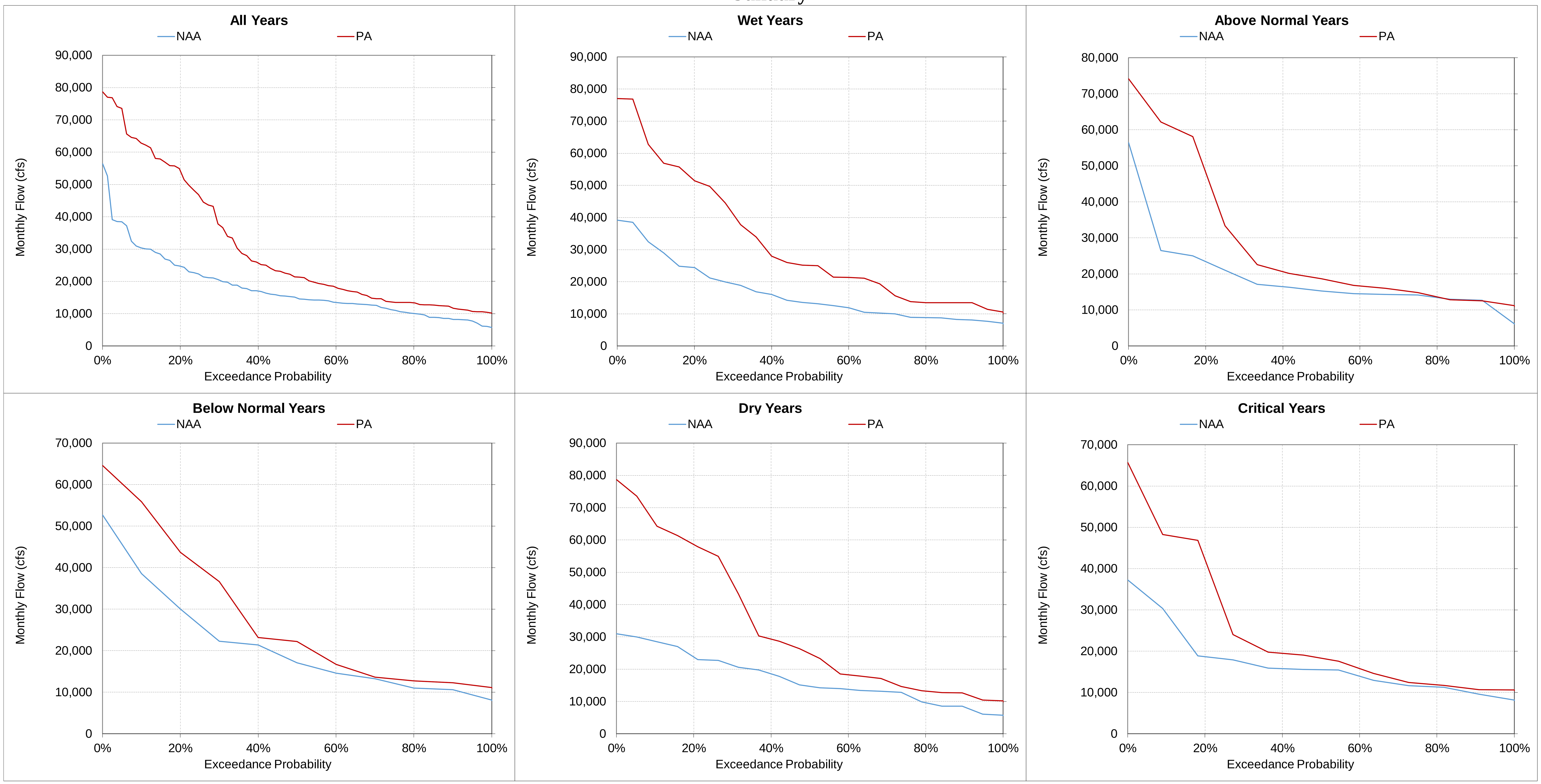
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-38-10. Sacramento River at Freeport Flow, Monthly Flow
December



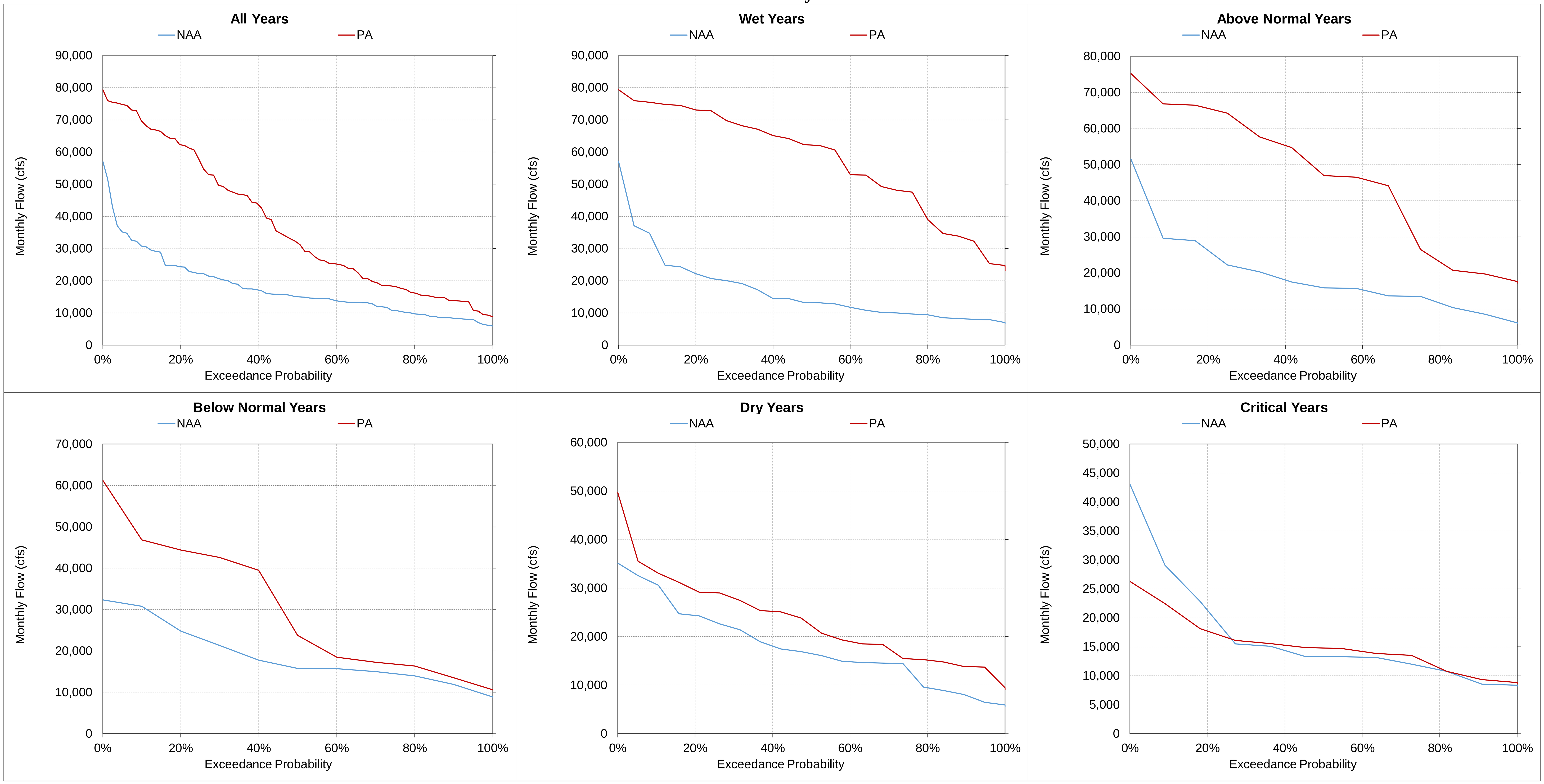
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-38-11. Sacramento River at Freeport Flow, Monthly Flow
January



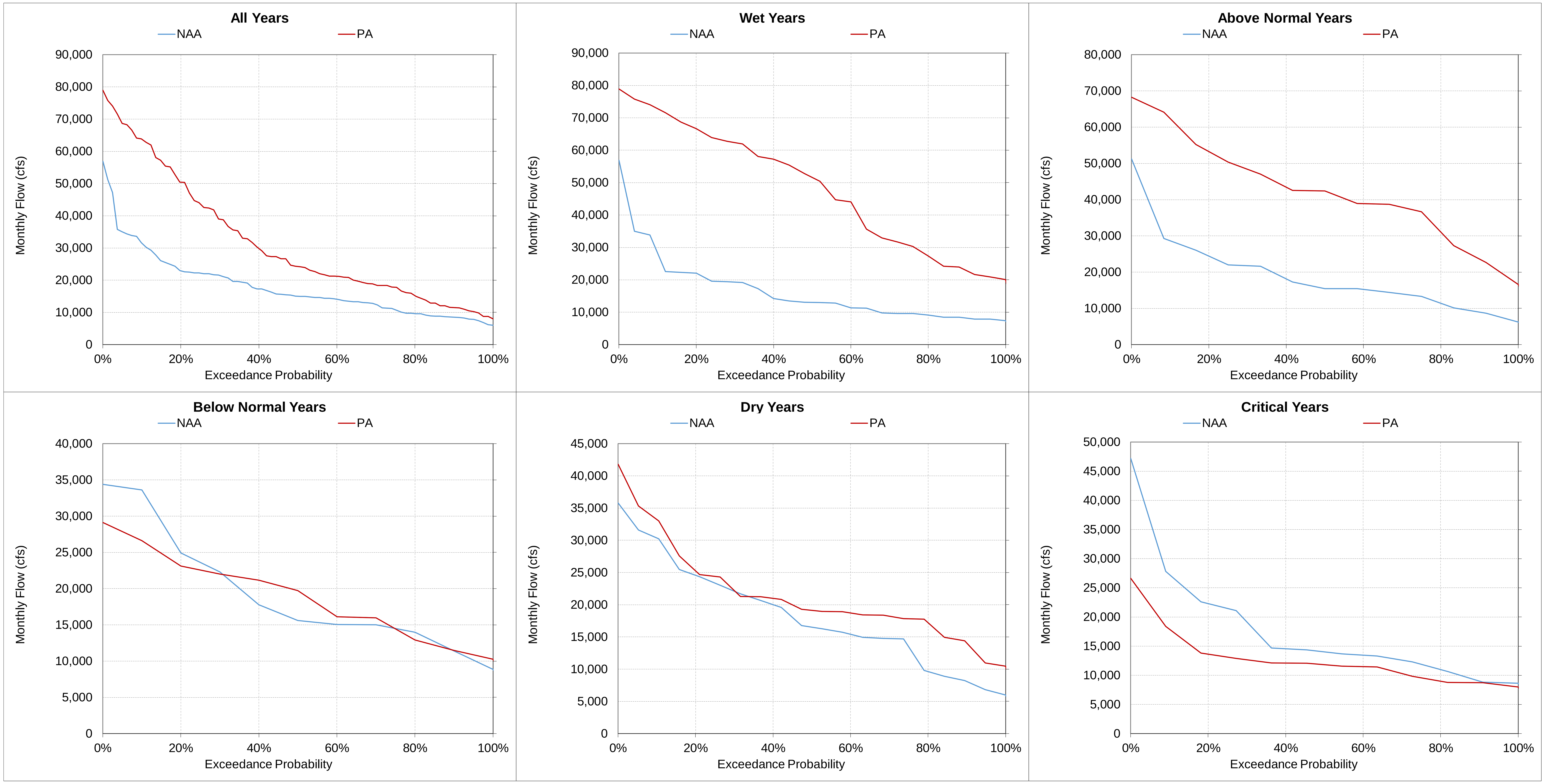
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-38-12. Sacramento River at Freeport Flow, Monthly Flow February



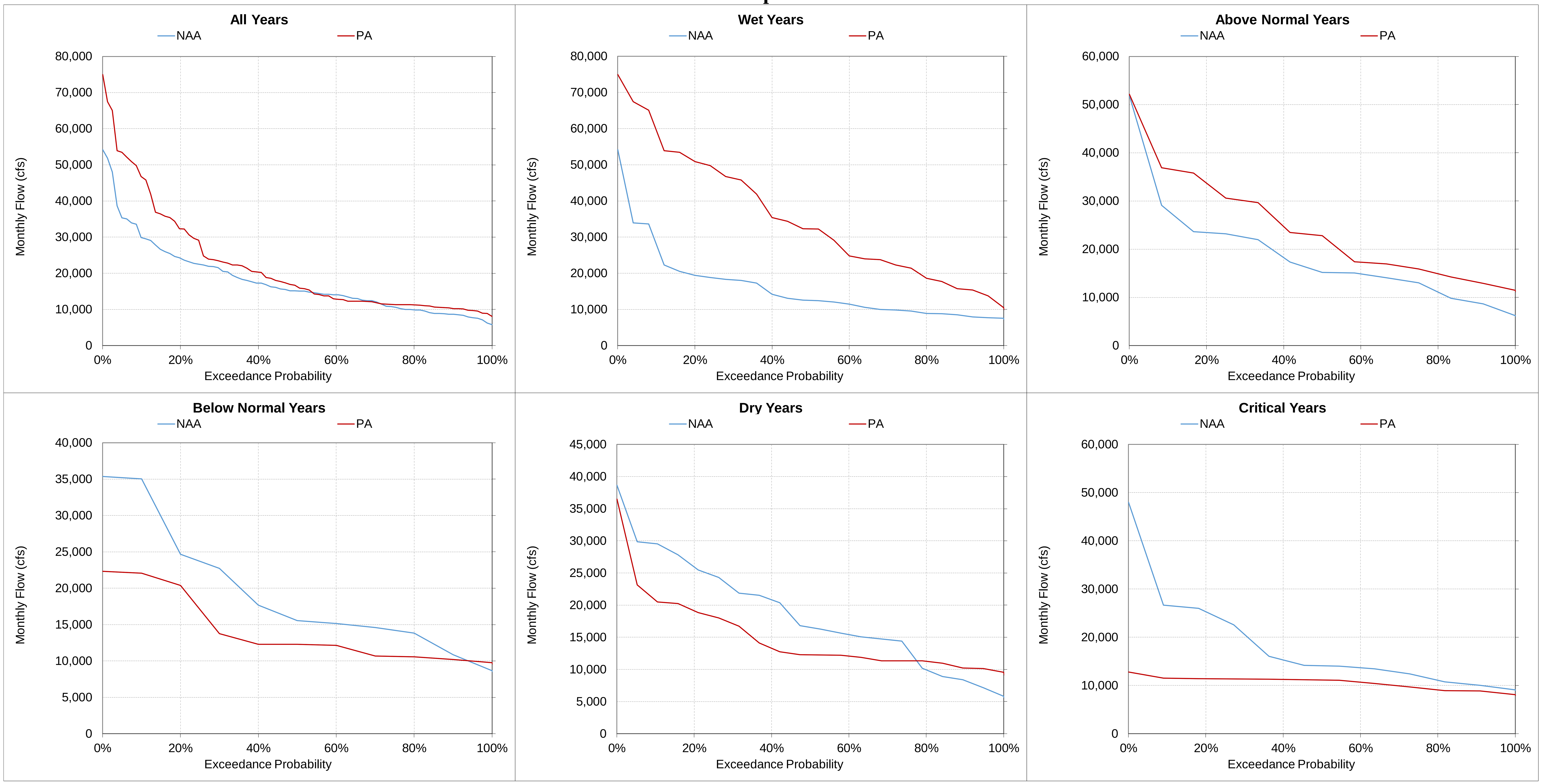
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-38-13. Sacramento River at Freeport Flow, Monthly Flow March



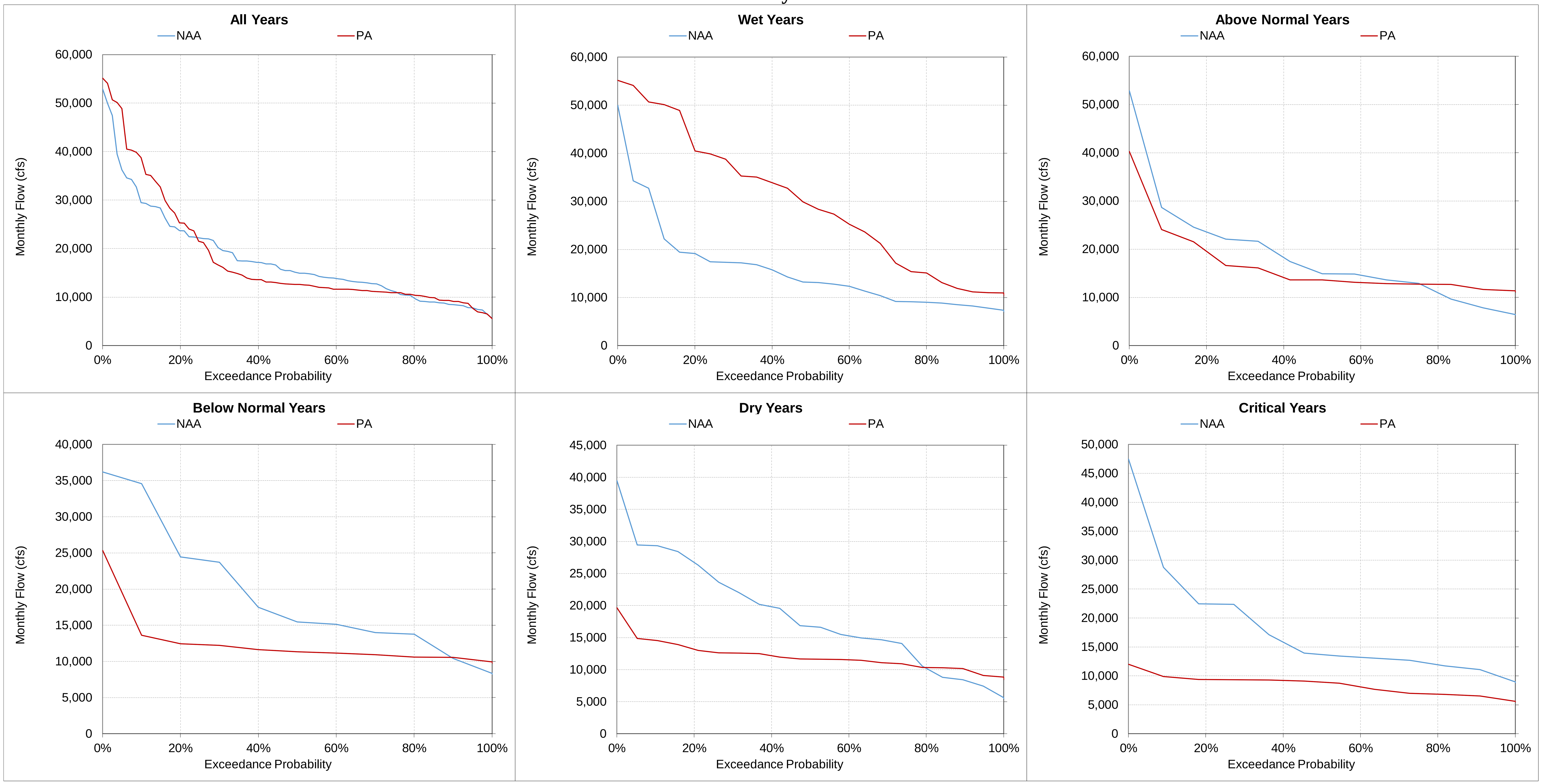
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-38-14. Sacramento River at Freeport Flow, Monthly Flow
April



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-38-15. Sacramento River at Freeport Flow, Monthly Flow May



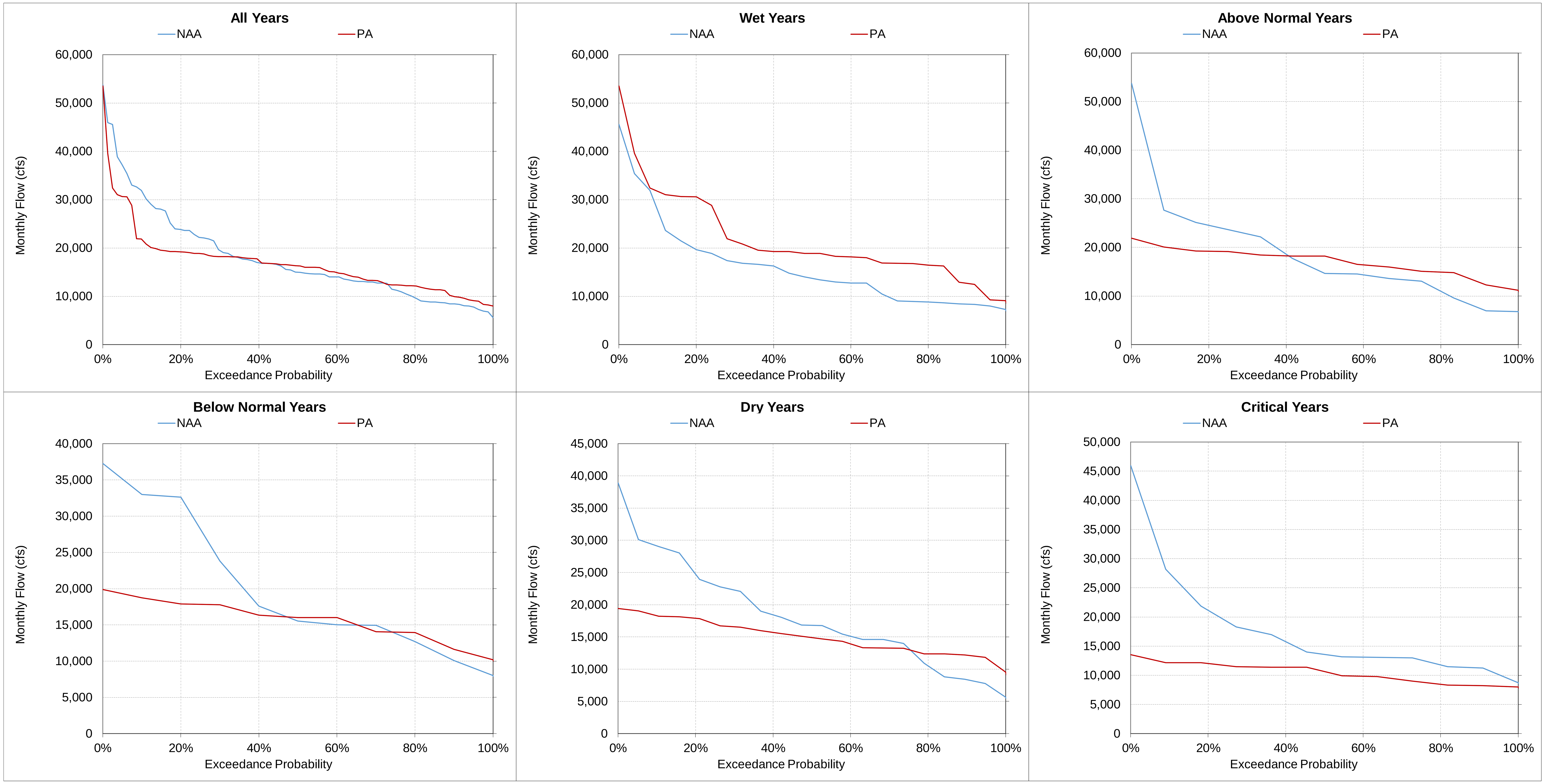
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

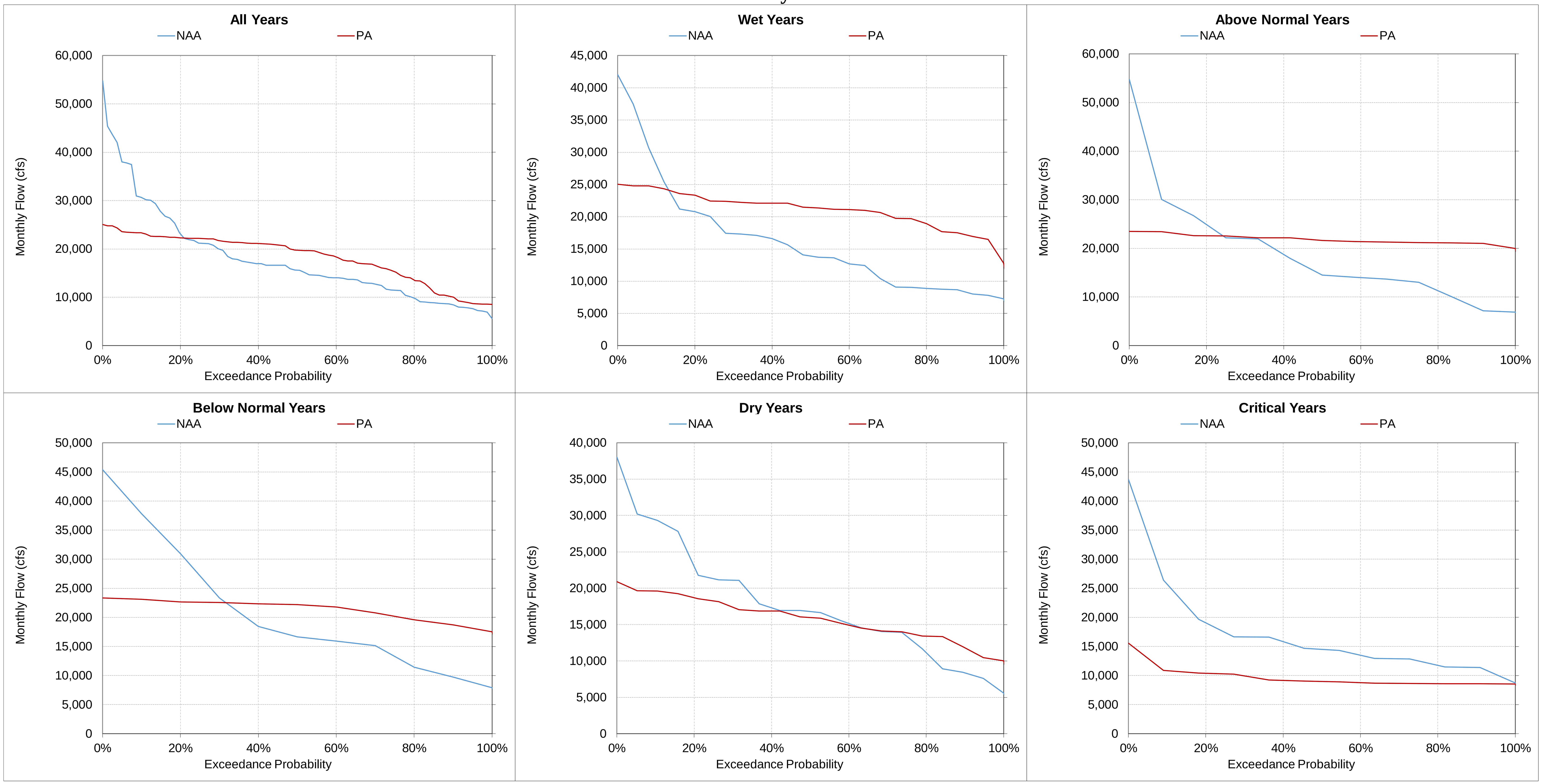
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-38-16. Sacramento River at Freeport Flow, Monthly Flow
June



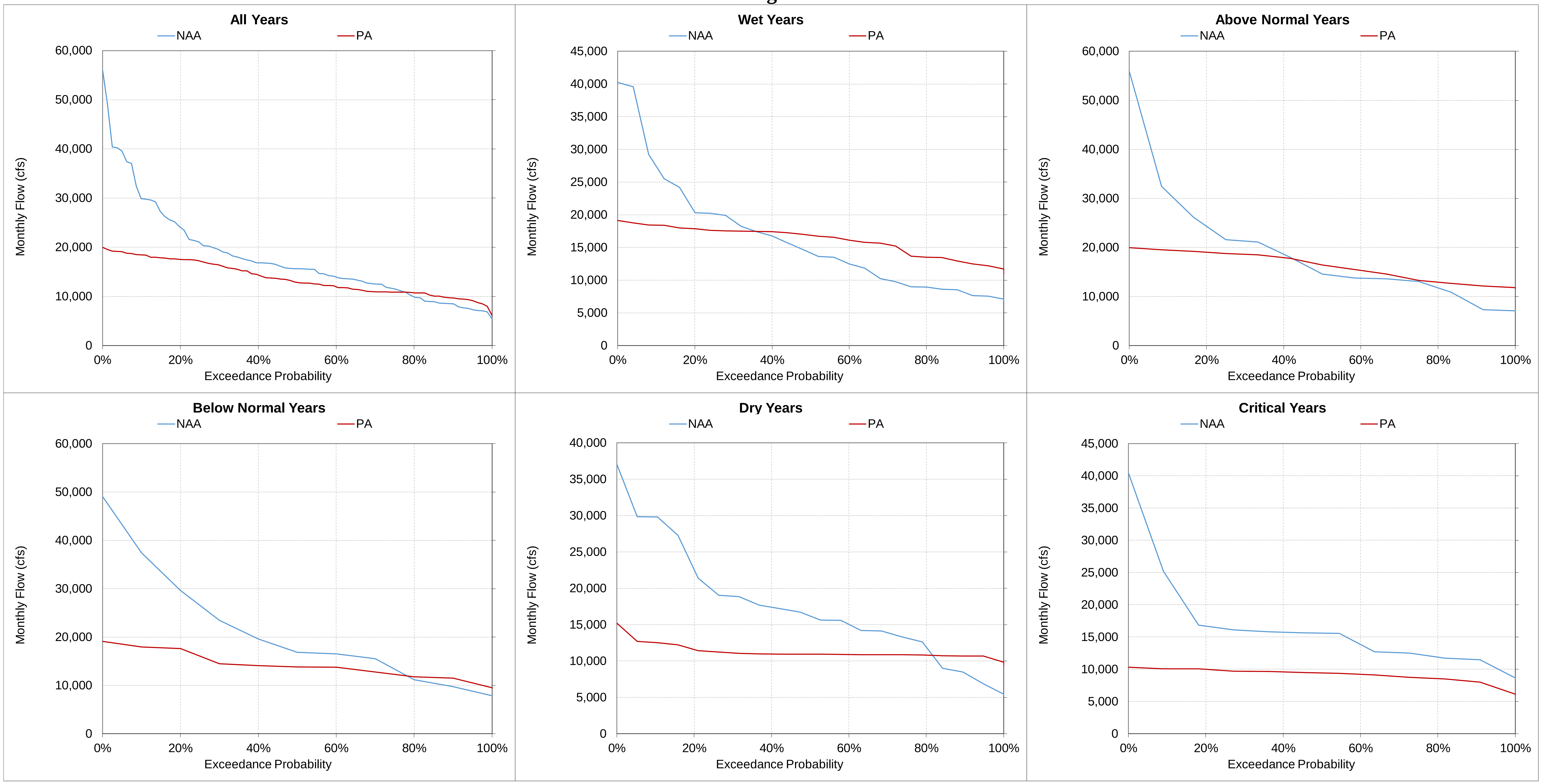
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-38-17. Sacramento River at Freeport Flow, Monthly Flow July



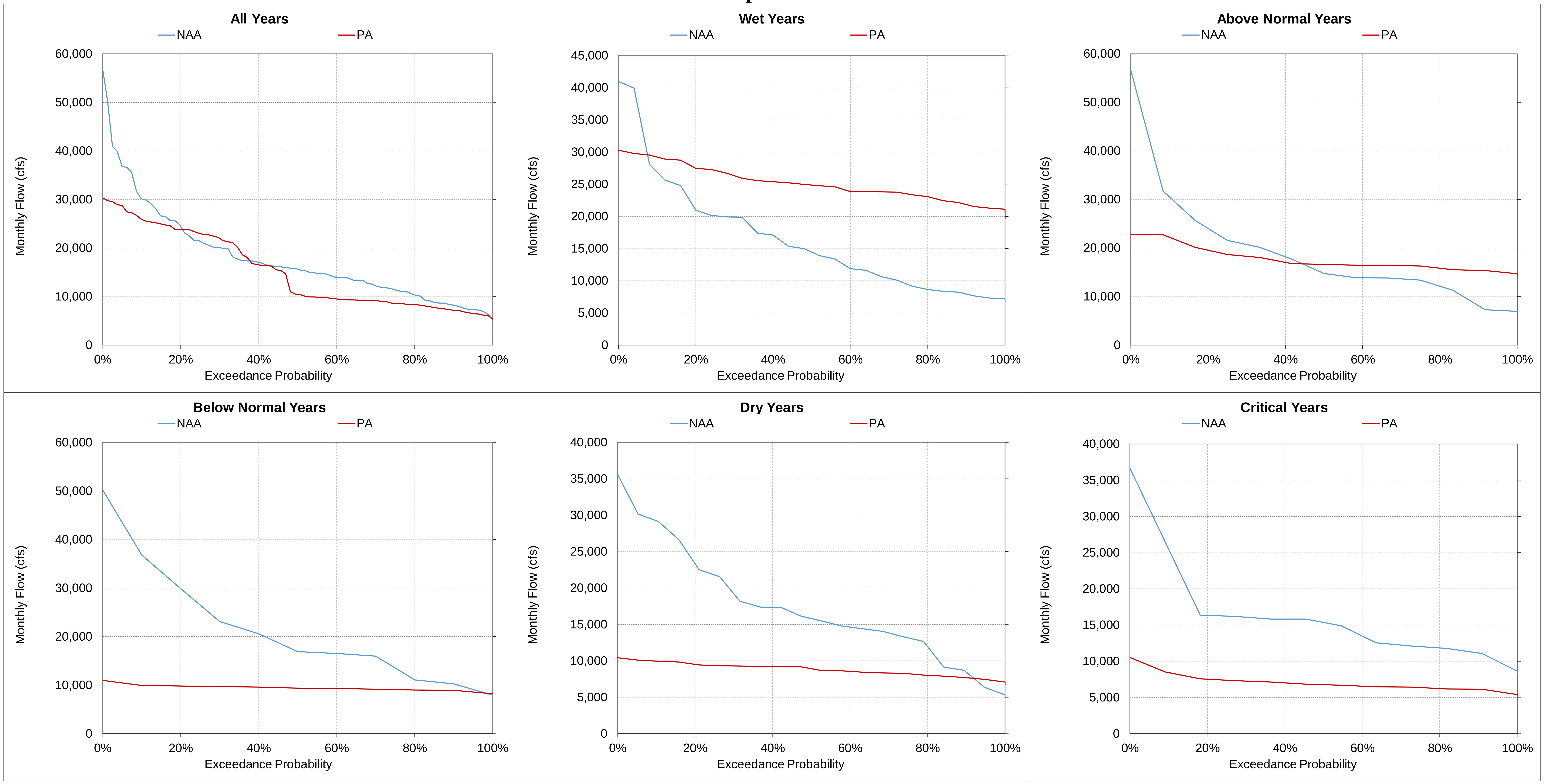
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-38-18. Sacramento River at Freeport Flow, Monthly Flow
August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-38-19. Sacramento River at Freeport Flow, Monthly Flow September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 5.B.5-39. North Delta Intakes Diversion Flow, Monthly Flow

Statistic	Monthly Flow (cfs)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	0	5,587	5,587	-	0	6,193	6,193	-	0	5,677	5,677	-	0	9,000	9,000	-	0	9,000	9,000	-	0	9,000	9,000	-
20%	0	5,094	5,094	-	0	4,626	4,626	-	0	4,329	4,329	-	0	8,262	8,262	-	0	9,000	9,000	-	0	8,944	8,944	-
30%	0	4,410	4,410	-	0	3,922	3,922	-	0	2,101	2,101	-	0	6,830	6,830	-	0	8,729	8,729	-	0	8,093	8,093	-
40%	0	3,772	3,772	-	0	3,196	3,196	-	0	1,237	1,237	-	0	4,967	4,967	-	0	7,254	7,254	-	0	7,480	7,480	-
50%	0	3,403	3,403	-	0	2,619	2,619	-	0	888	888	-	0	2,546	2,546	-	0	6,250	6,250	-	0	6,248	6,248	-
60%	0	2,394	2,394	-	0	1,778	1,778	-	0	826	826	-	0	1,299	1,299	-	0	4,861	4,861	-	0	4,734	4,734	-
70%	0	1,515	1,515	-	0	1,368	1,368	-	0	785	785	-	0	903	903	-	0	2,593	2,593	-	0	3,500	3,500	-
80%	0	572	572	-	0	421	421	-	0	614	614	-	0	815	815	-	0	1,071	1,071	-	0	1,616	1,616	-
90%	0	47	47	-	0	0	0	-	0	416	416	-	0	688	688	-	0	828	828	-	0	695	695	-
Long Term Full Simulation Period[b]	0	3,043	3,043	-	0	2,793	2,793	-	0	2,059	2,059	-	0	3,959	3,959	-	0	5,405	5,405	-	0	5,439	5,439	-
Water Year Types[c]																								
Wet (32%)	0	4,791	4,791	-	0	3,267	3,267	-	0	2,347	2,347	-	0	4,267	4,267	-	0	8,310	8,310	-	0	8,040	8,040	-
Above Normal (16%)	0	4,458	4,458	-	0	4,846	4,846	-	0	2,334	2,334	-	0	3,488	3,488	-	0	7,165	7,165	-	0	7,927	7,927	-
Below Normal (13%)	0	3,104	3,104	-	0	3,104	3,104	-	0	2,060	2,060	-	0	3,575	3,575	-	0	4,592	4,592	-	0	3,487	3,487	-
Dry (24%)	0	1,515	1,515	-	0	2,120	2,120	-	0	2,303	2,303	-	0	4,578	4,578	-	0	3,449	3,449	-	0	4,128	4,128	-
Critical (15%)	0	216	216	-	0	376	376	-	0	730	730	-	0	3,123	3,123	-	0	1,212	1,212	-	0	1,079	1,079	-

Statistic	Monthly Flow (cfs)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	0	3,678	3,678	-	0	3,328	3,328	-	0	7,780	7,780	-	0	8,551	8,551	-	0	7,765	7,765	-	0	7,902	7,902	-
20%	0	2,018	2,018	-	0	1,639	1,639	-	0	6,898	6,898	-	0	8,435	8,435	-	0	7,521	7,521	-	0	3,869	3,869	-
30%	0	1,613	1,613	-	0	1,437	1,437	-	0	6,219	6,219	-	0	8,243	8,243	-	0	7,117	7,117	-	0	3,291	3,291	-
40%	0	1,316	1,316	-	0	1,297	1,297	-	0	5,219	5,219	-	0	8,109	8,109	-	0	5,158	5,158	-	0	2,955	2,955	-
50%	0	616	616	-	0	662	662	-	0	4,082	4,082	-	0	7,077	7,077	-	0	4,802	4,802	-	0	2,501	2,501	-
60%	0	492	492	-	0	541	541	-	0	2,339	2,339	-	0	5,992	5,992	-	0	3,780	3,780	-	0	2,131	2,131	-
70%	0	231	231	-	0	372	372	-	0	1,357	1,357	-	0	4,878	4,878	-	0	1,467	1,467	-	0	1,710	1,710	-
80%	0	89	89	-	0	240	240	-	0	689	689	-	0	2,742	2,742	-	0	265	265	-	0	1,098	1,098	-
90%	0	5	5	-	0	108	108	-	0	639	639	-	0	15	15	-	0	250	250	-	0	405	405	-
Long Term Full Simulation Period[b]	0	1,331	1,331	-	0	1,414	1,414	-	0	4,023	4,023	-	0	5,837	5,837	-	0	4,179	4,179	-	0	2,994	2,994	-
Water Year Types[c]																								
Wet (32%)	0	2,604	2,604	-	0	3,030	3,030	-	0	6,250	6,250	-	0	7,234	7,234	-	0	6,629	6,629	-	0	4,485	4,485	-
Above Normal (16%)	0	1,383	1,383	-	0	1,252	1,252	-	0	5,335	5,335	-	0	7,898	7,898	-	0	6,159	6,159	-	0	3,580	3,580	-
Below Normal (13%)	0	524	524	-	0	534	534	-	0	3,183	3,183	-	0	7,630	7,630	-	0	5,216	5,216	-	0	2,899	2,899	-
Dry (24%)	0	718	718	-	0	570	570	-	0	2,783	2,783	-	0	4,801	4,801	-	0	1,419	1,419	-	0	2,172	2,172	-
Critical (15%)	0	280	280	-	0	299	299	-	0	612	612	-	0	662	662	-	0	373	373	-	0	588	588	-

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

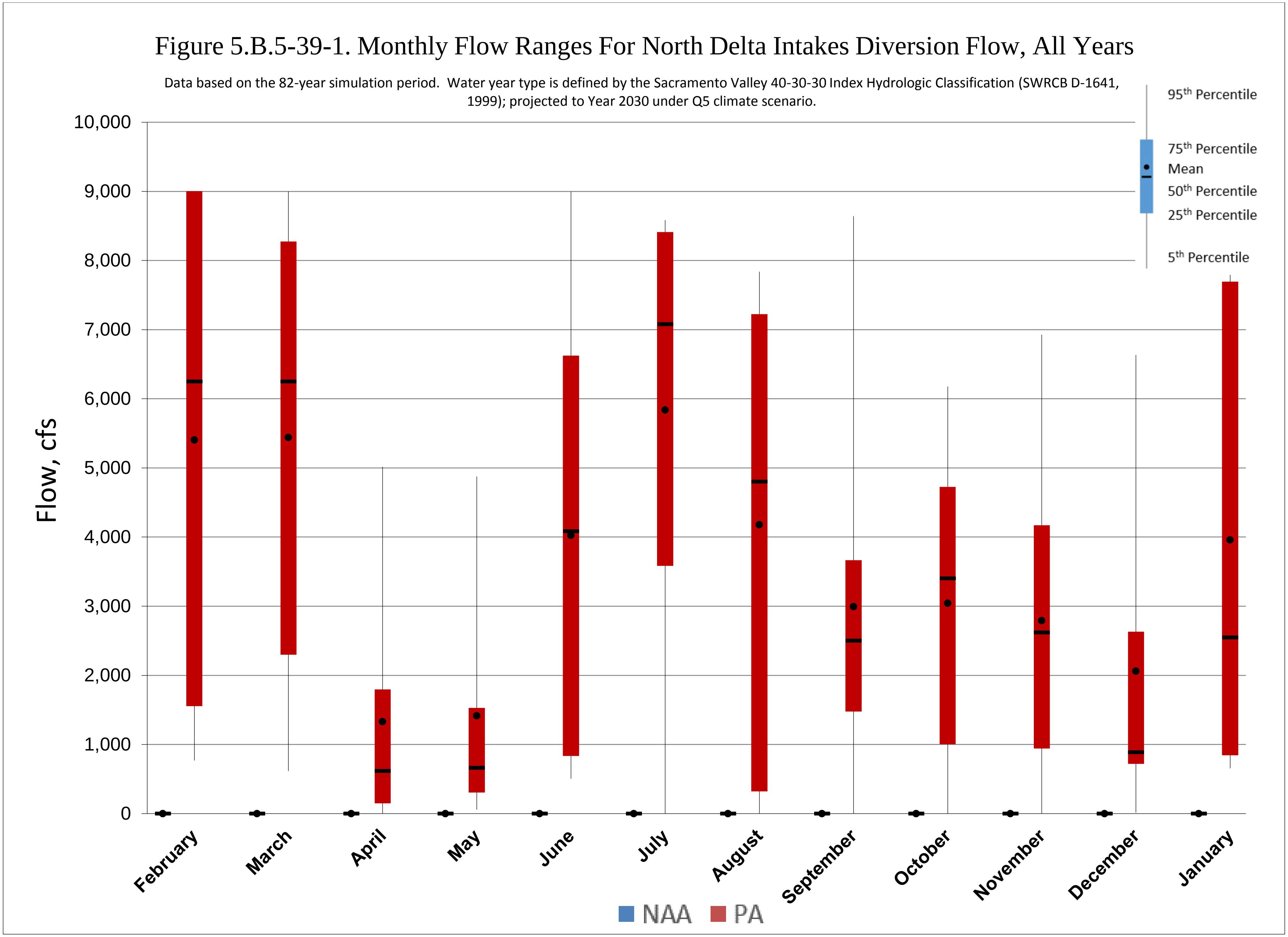


Figure 5.B.5-39-1. Monthly Flow Ranges For North Delta Intakes Diversion Flow, All Years
Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario.
Flow, cfs
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
February
March
April
May
June
July
August
September
October
November
December
January
95th Percentile
75th Percentile
Mean
50th Percentile
25th Percentile
5th Percentile
NAA
PA

Figure 5.B.5-39-2. Monthly Flow Ranges For North Delta Intakes Diversion Flow, Wet Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 26 wet years.

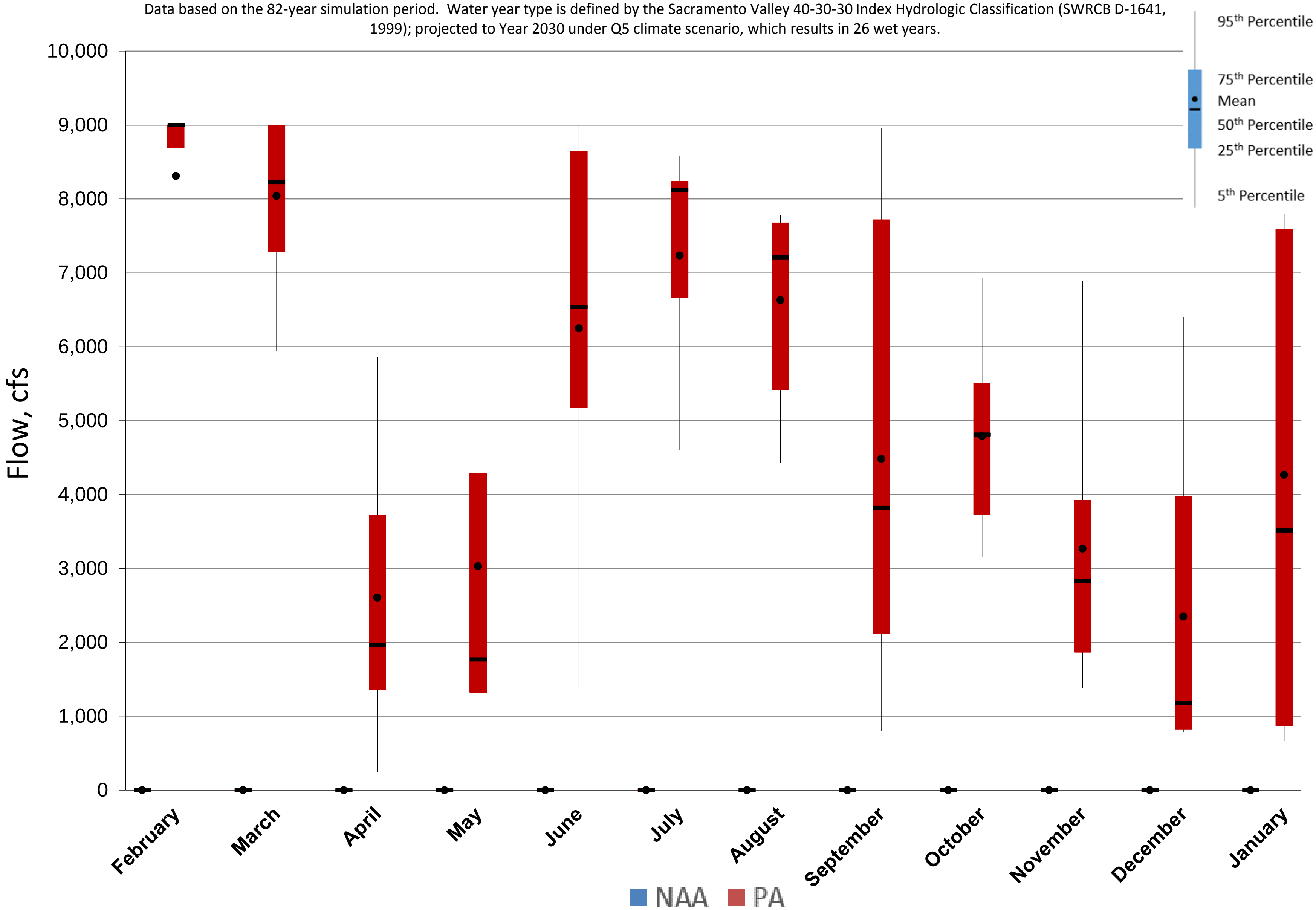


Figure 5.B.5-39-3. Monthly Flow Ranges For North Delta Intakes Diversion Flow, Above Normal Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 13 above normal years.

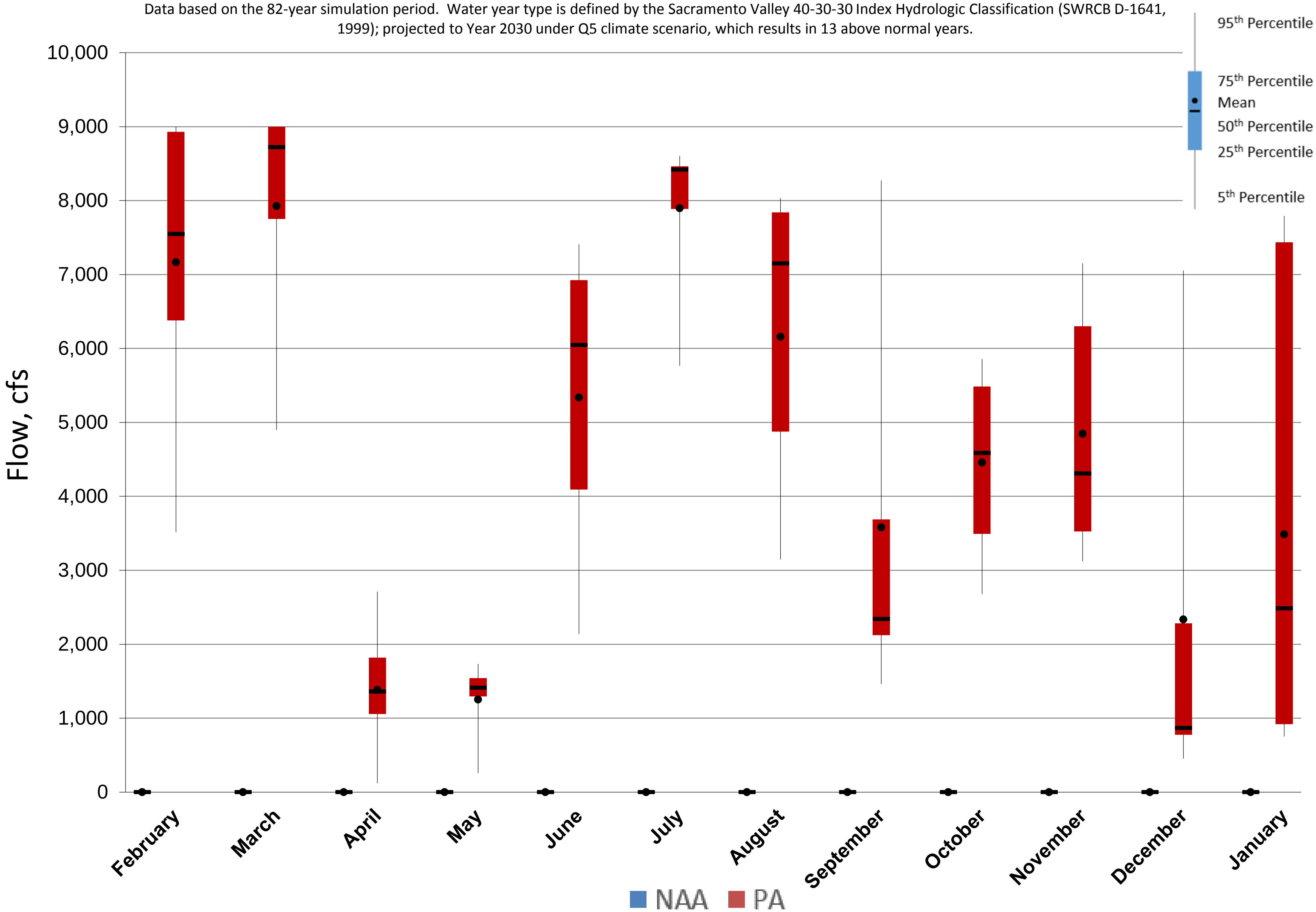


Figure 5.B.5-39-4. Monthly Flow Ranges For North Delta Intakes Diversion Flow, Below Normal Years

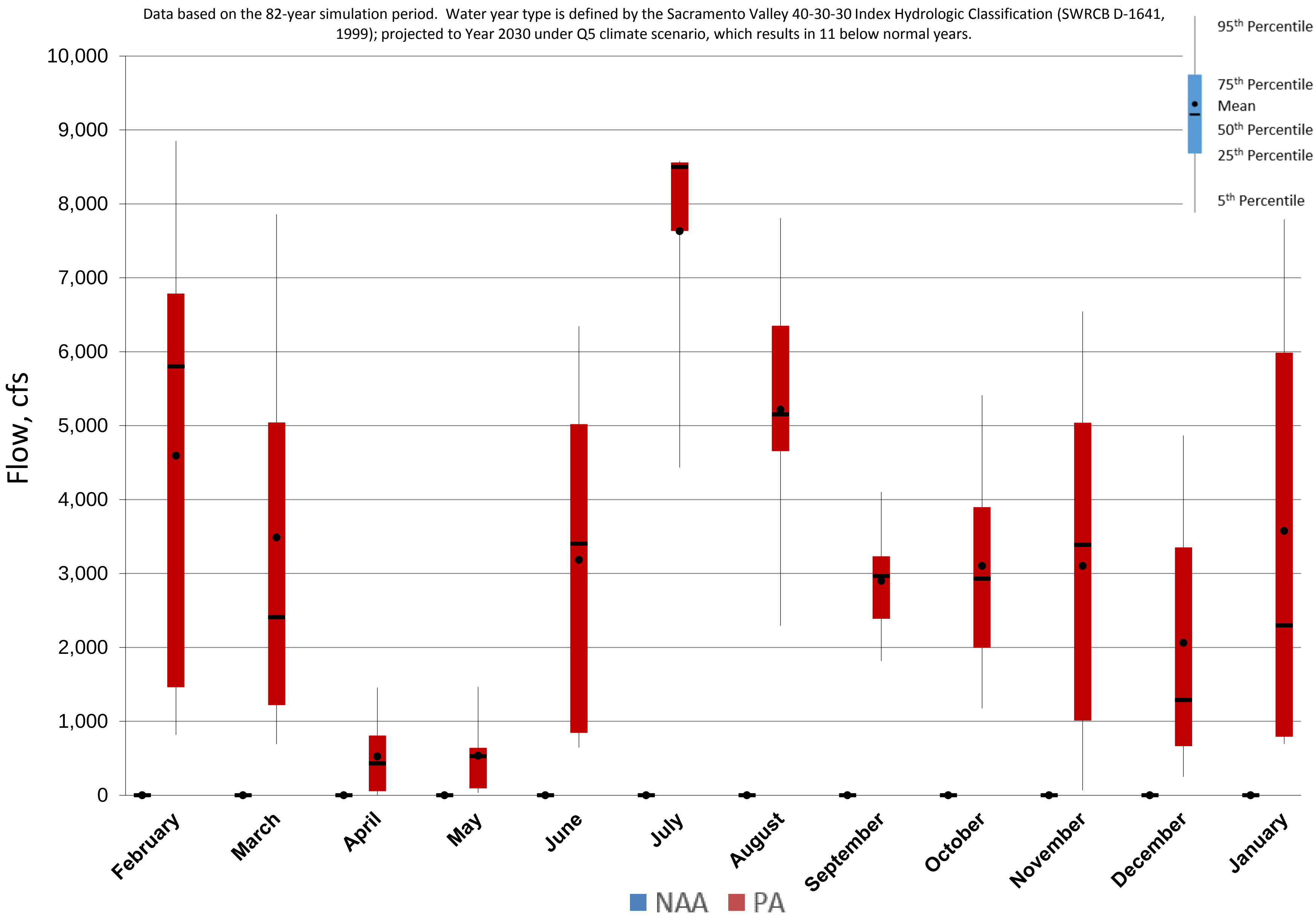


Figure 5.B.5-39-5. Monthly Flow Ranges For North Delta Intakes Diversion Flow, Dry Years

Data based on the 82-year simulation period. Water year type is defined by the Sacramento Valley 40-30-30 Index Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030 under Q5 climate scenario, which results in 20 dry years.

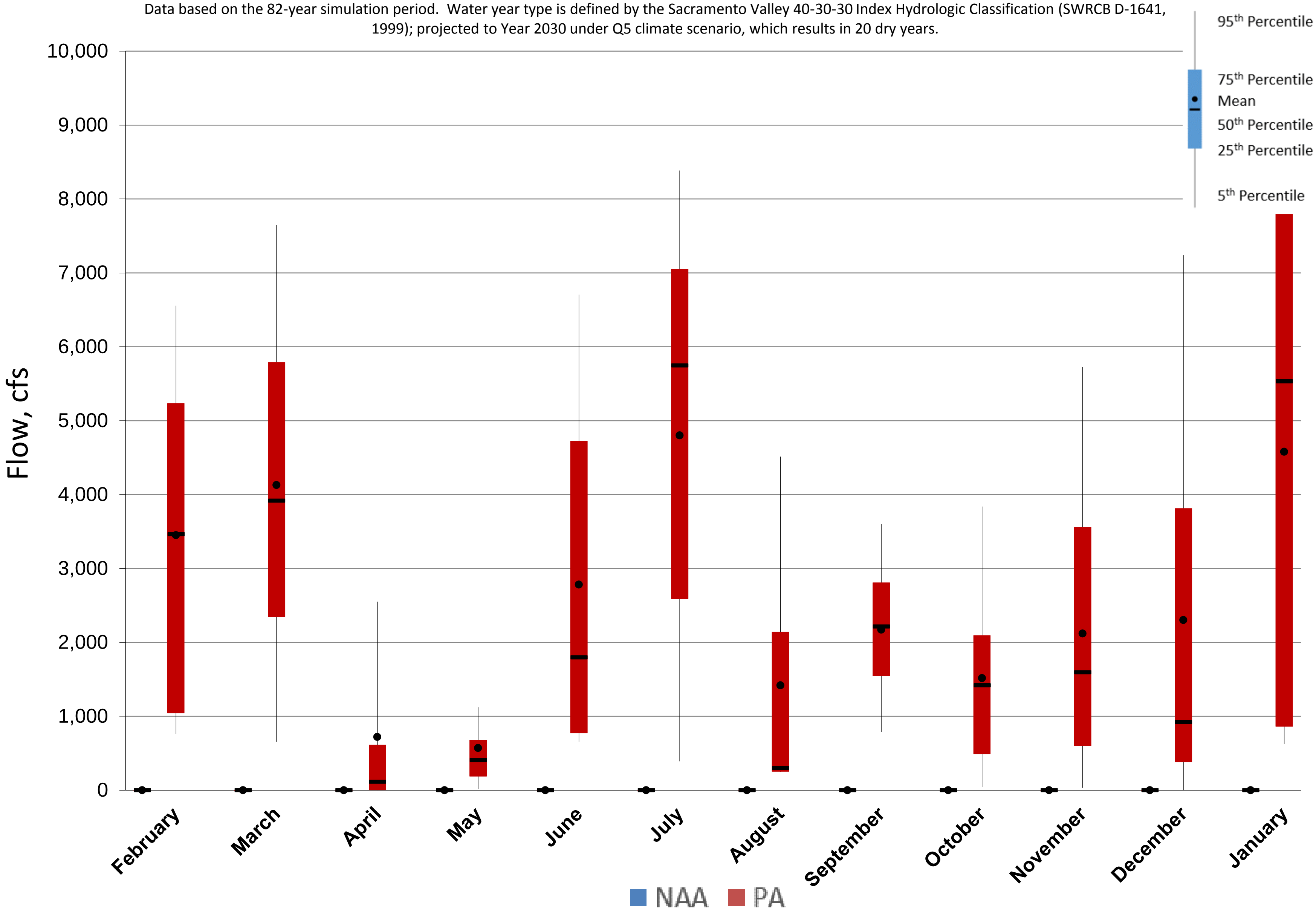


Figure 5.B.5-39-6. Monthly Flow Ranges For North Delta Intakes Diversion Flow, Critical Years

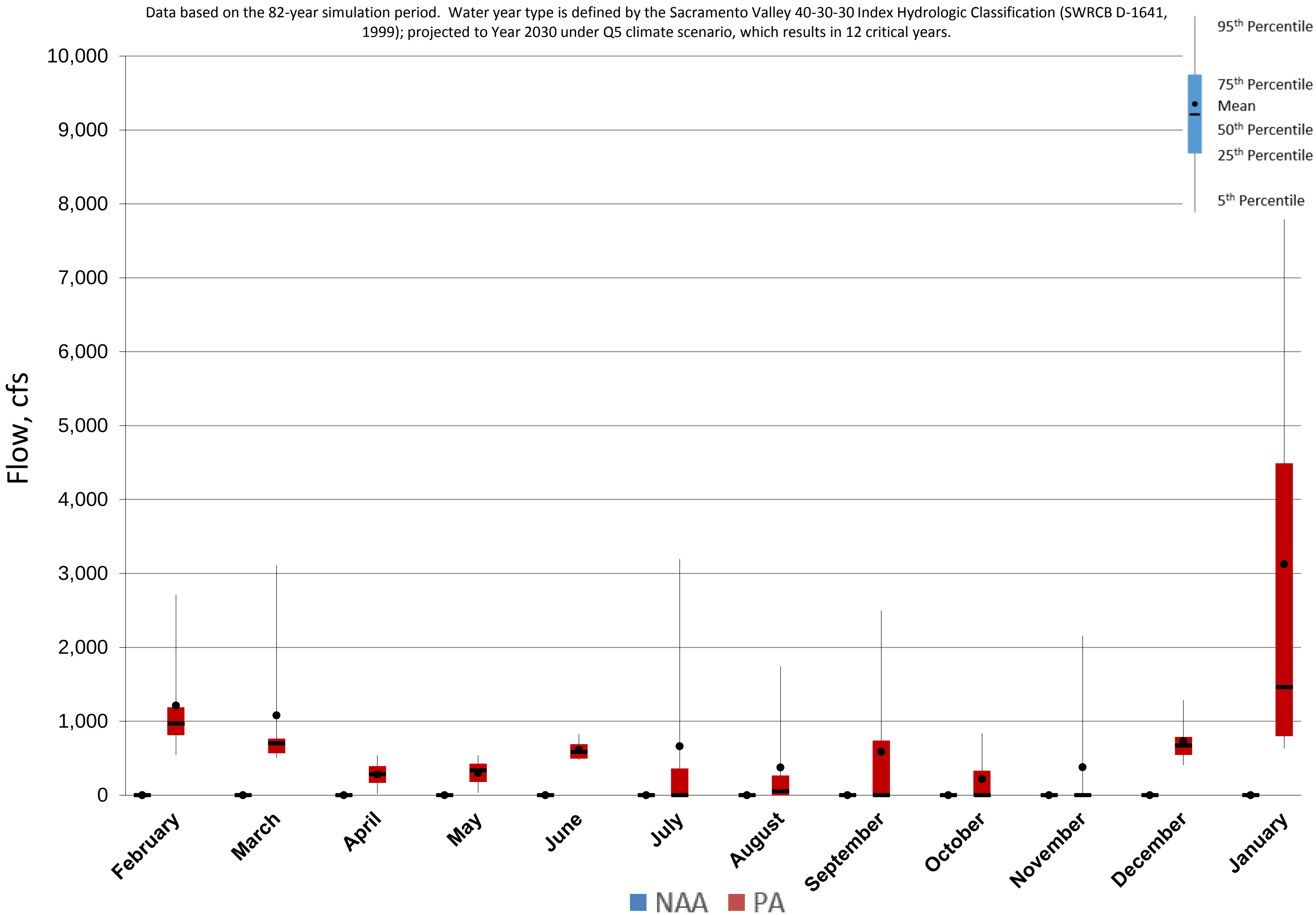
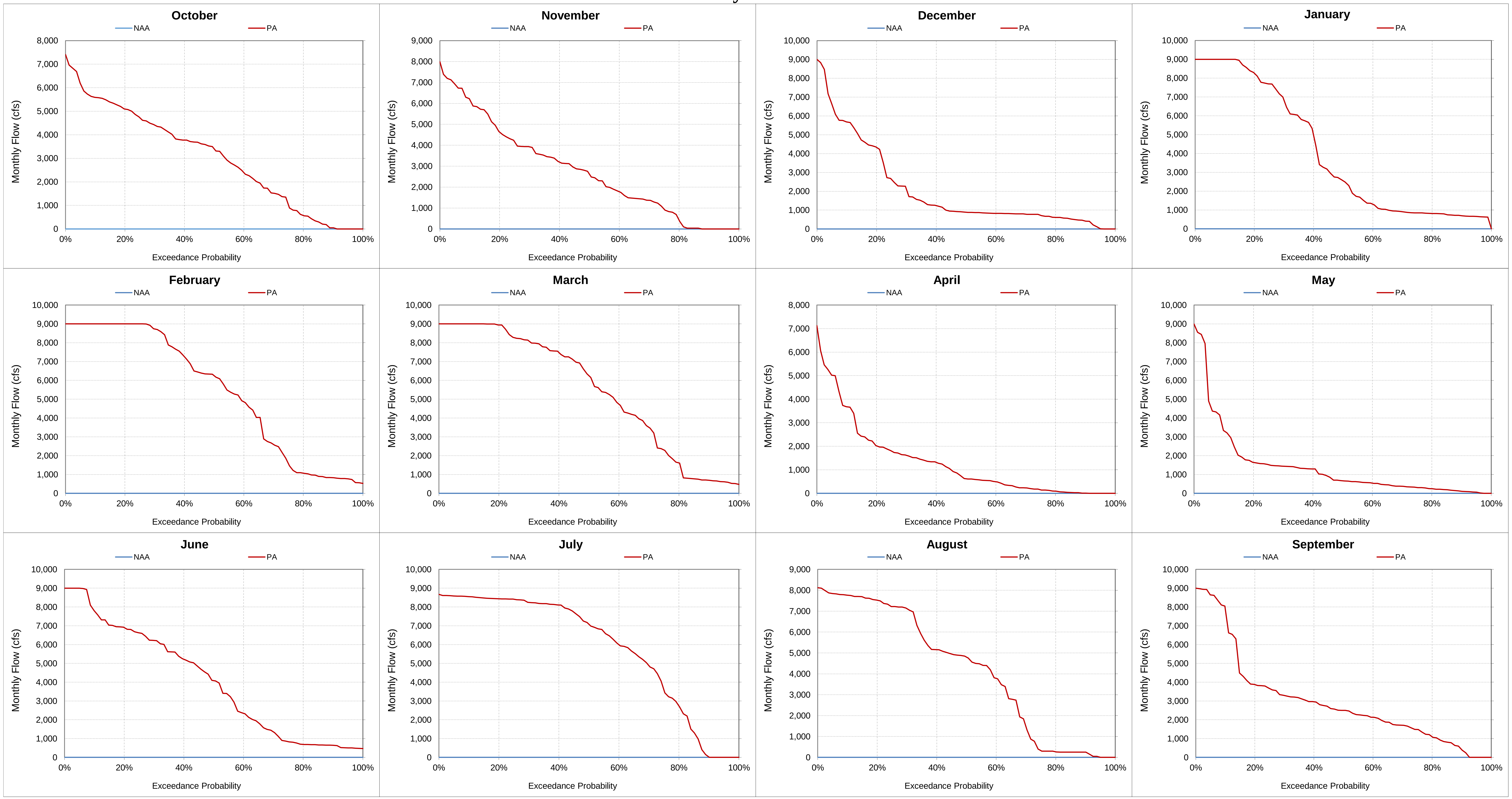
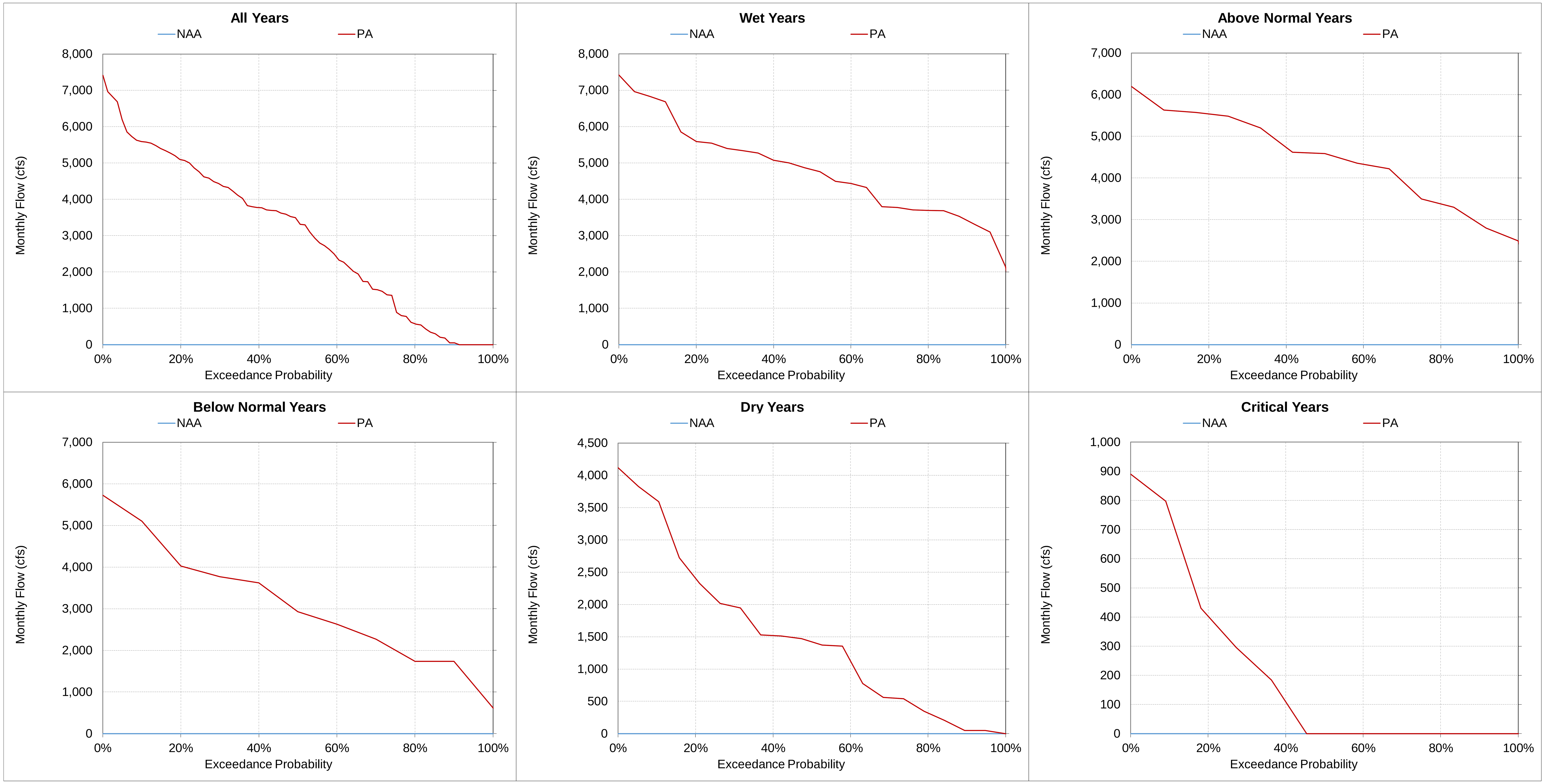


Figure 5.B.5-39-7. North Delta Intakes Diversion Flow, Monthly Flow Probability of Exceedance



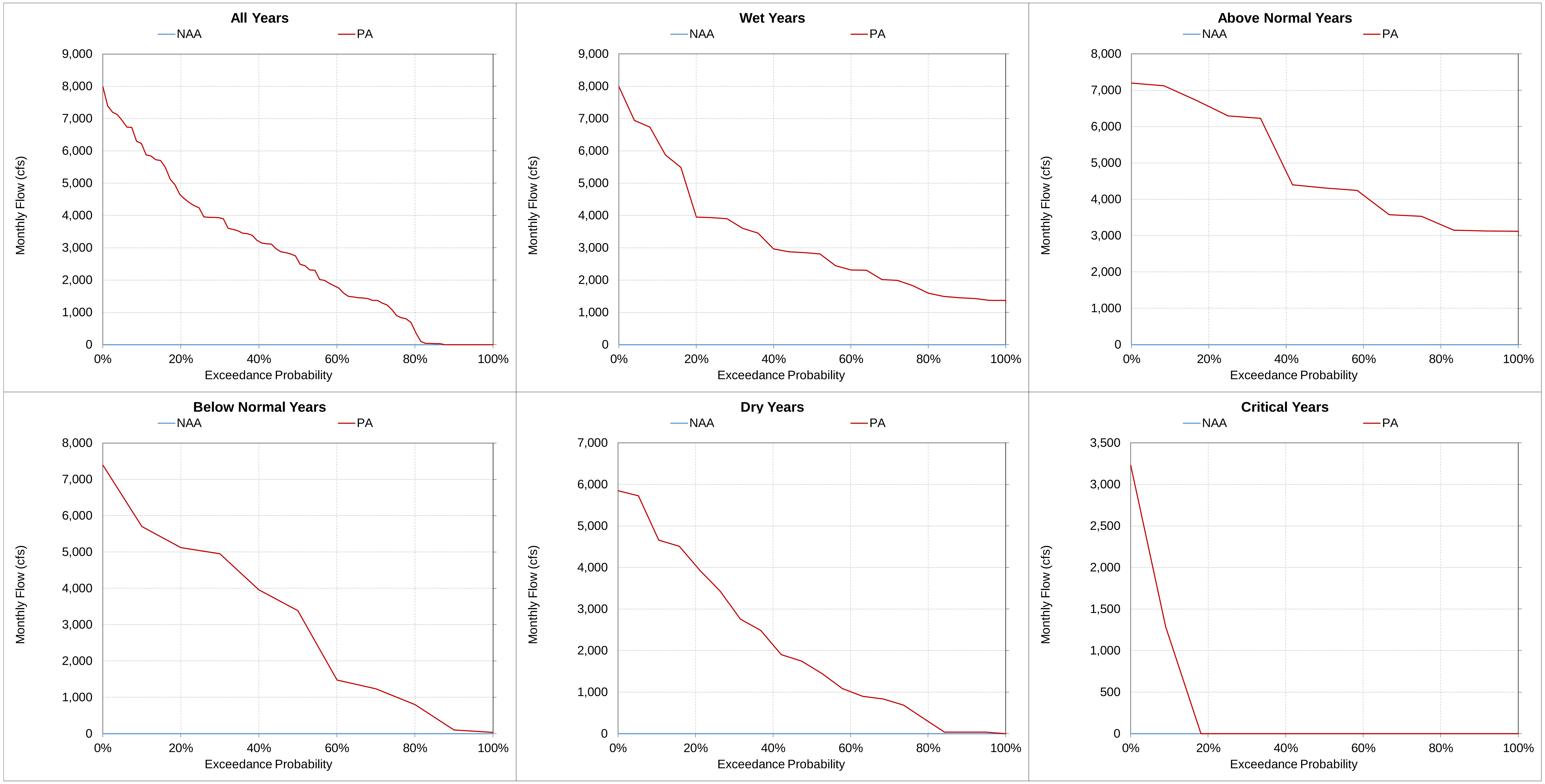
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-39-8. North Delta Intakes Diversion Flow, Monthly Flow October



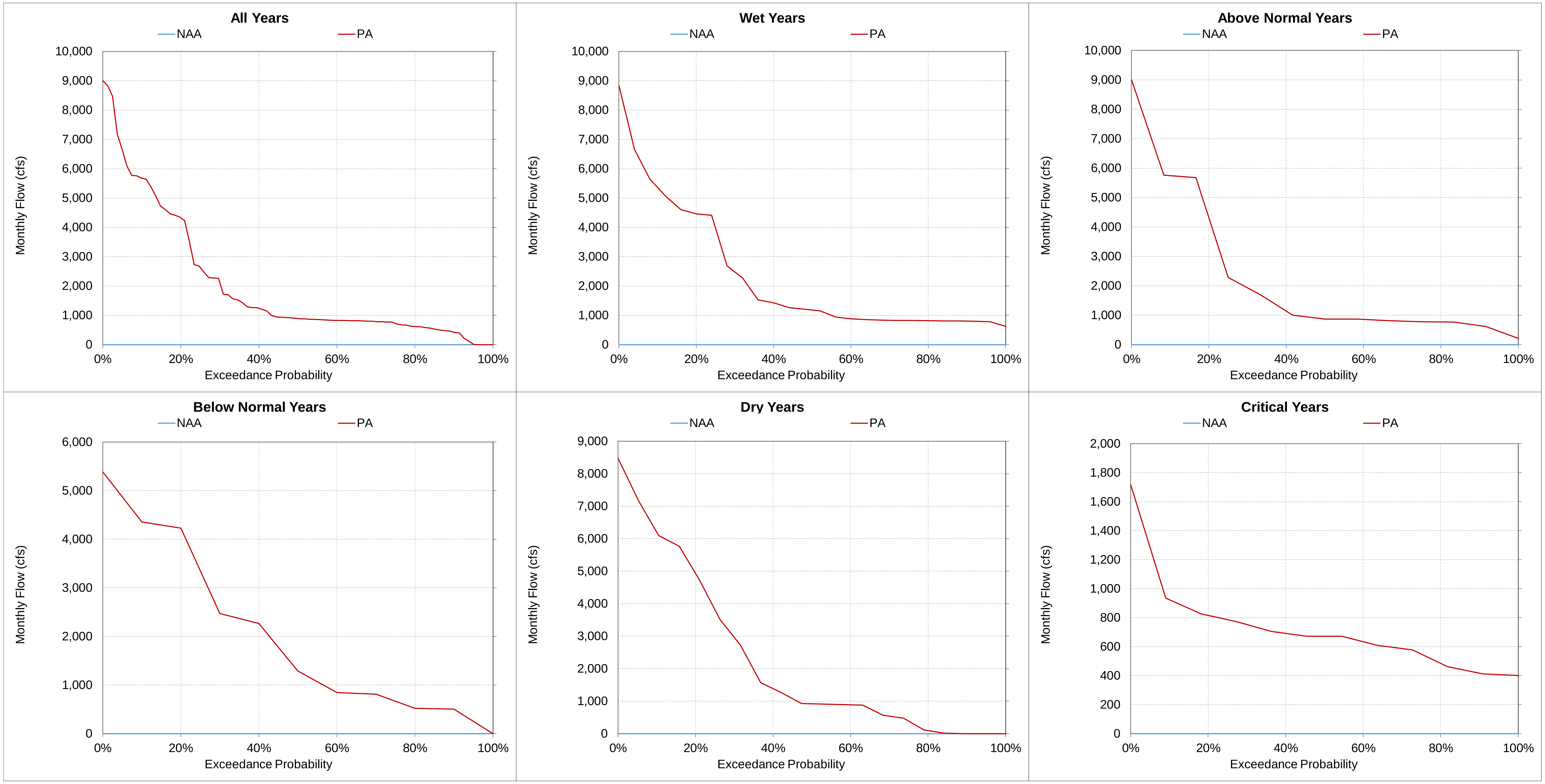
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-39-9. North Delta Intakes Diversion Flow, Monthly Flow
November



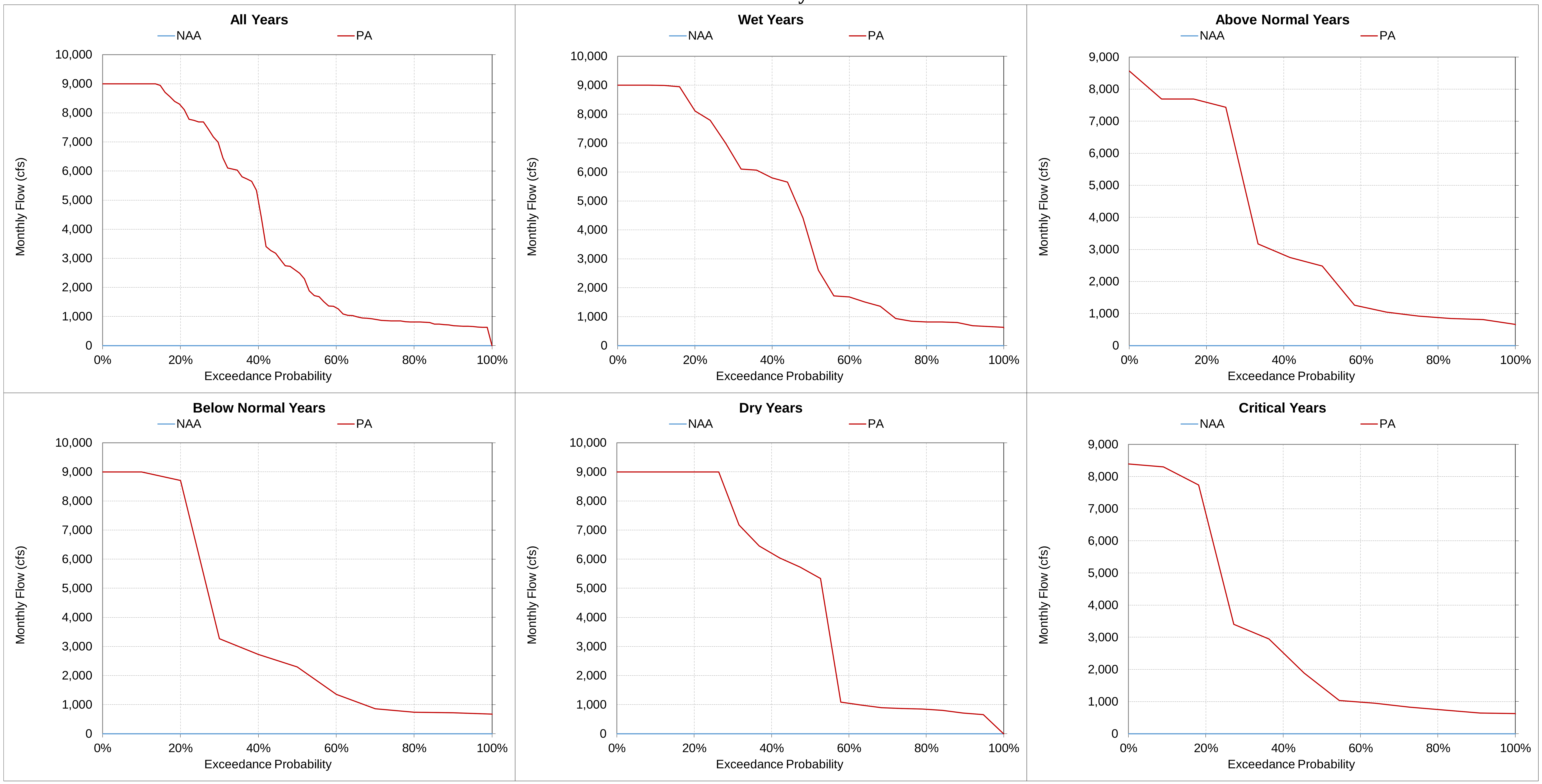
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-39-10. North Delta Intakes Diversion Flow, Monthly Flow December



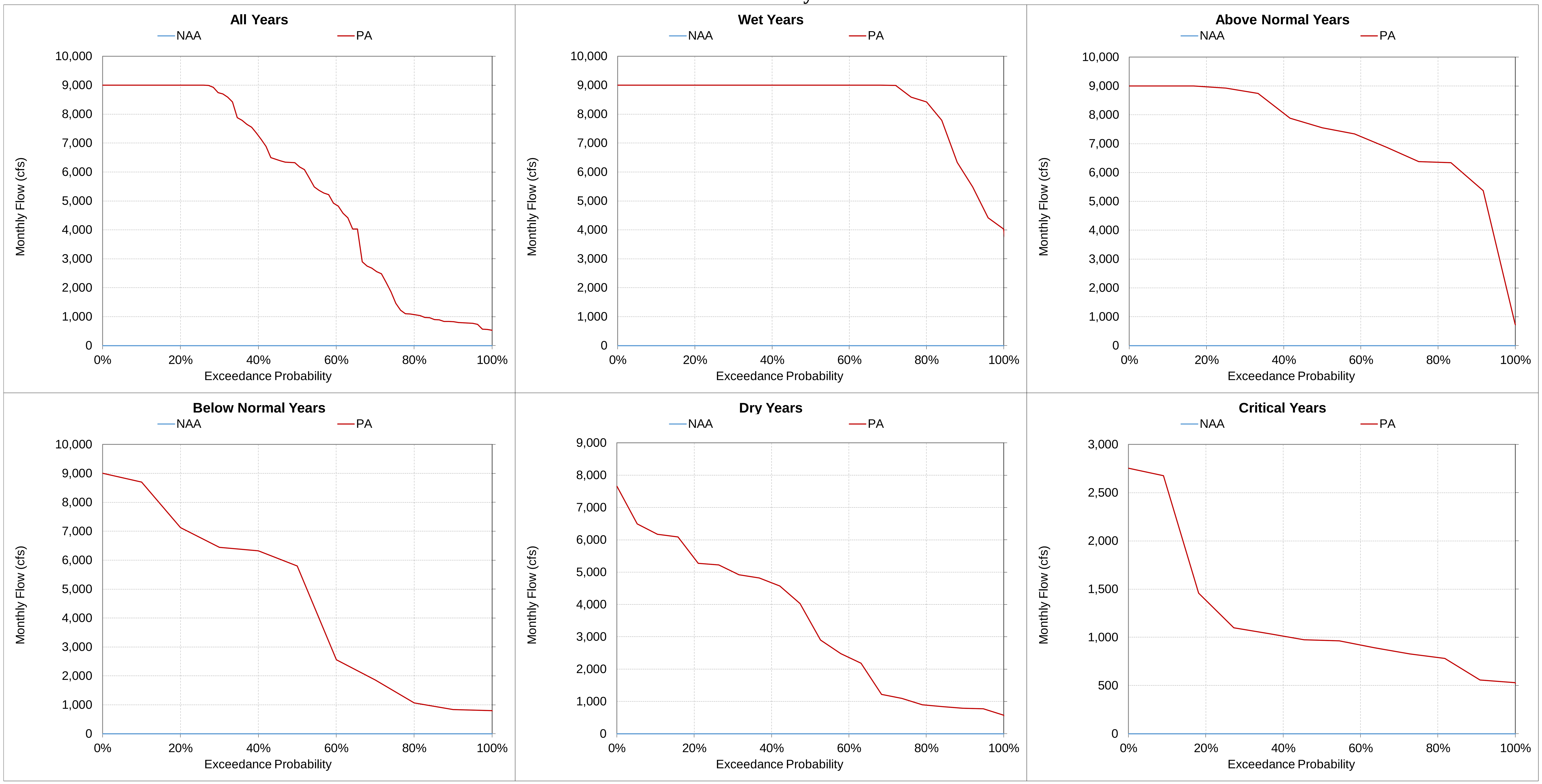
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-39-11. North Delta Intakes Diversion Flow, Monthly Flow
January



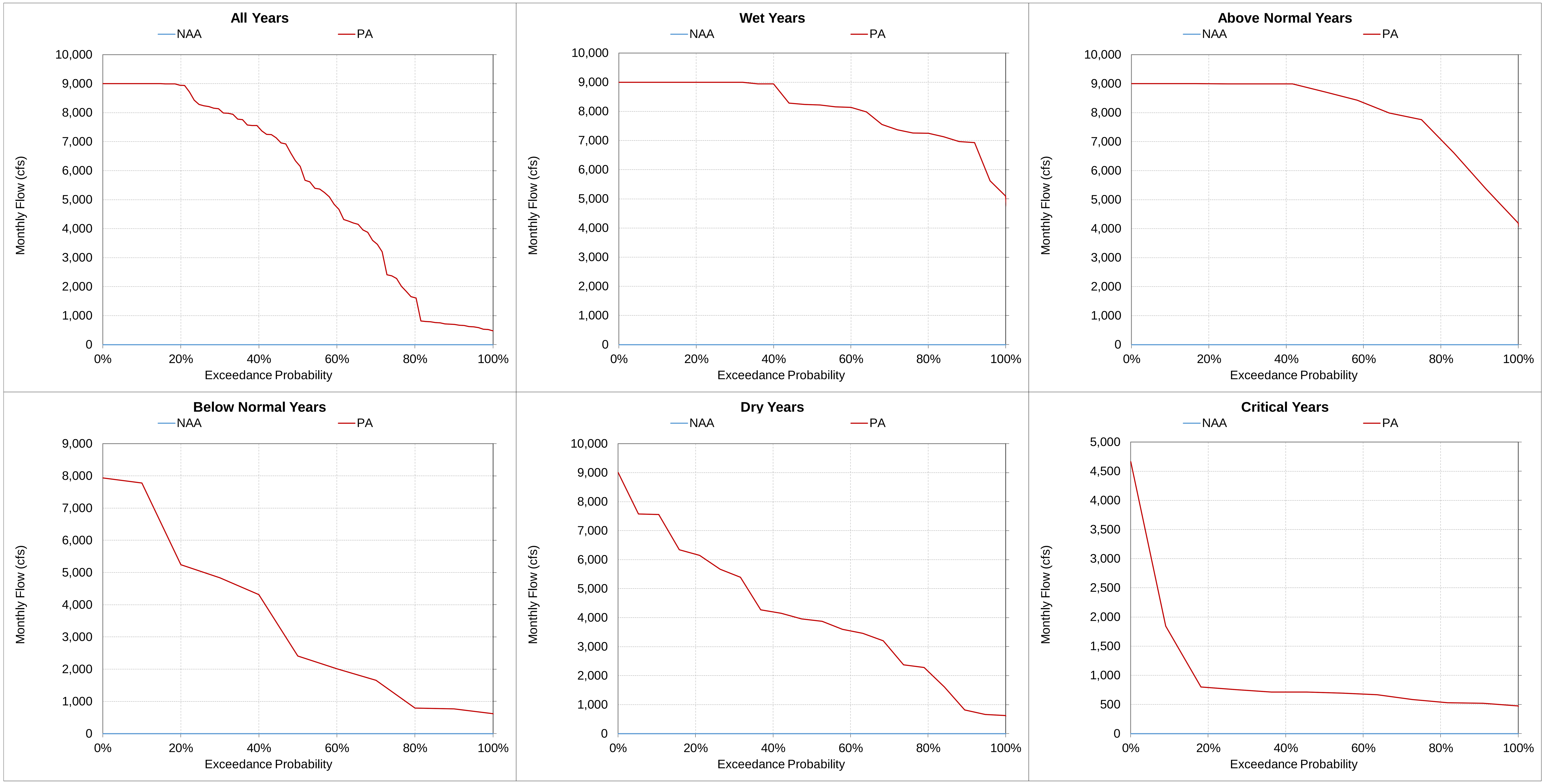
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-39-12. North Delta Intakes Diversion Flow, Monthly Flow February



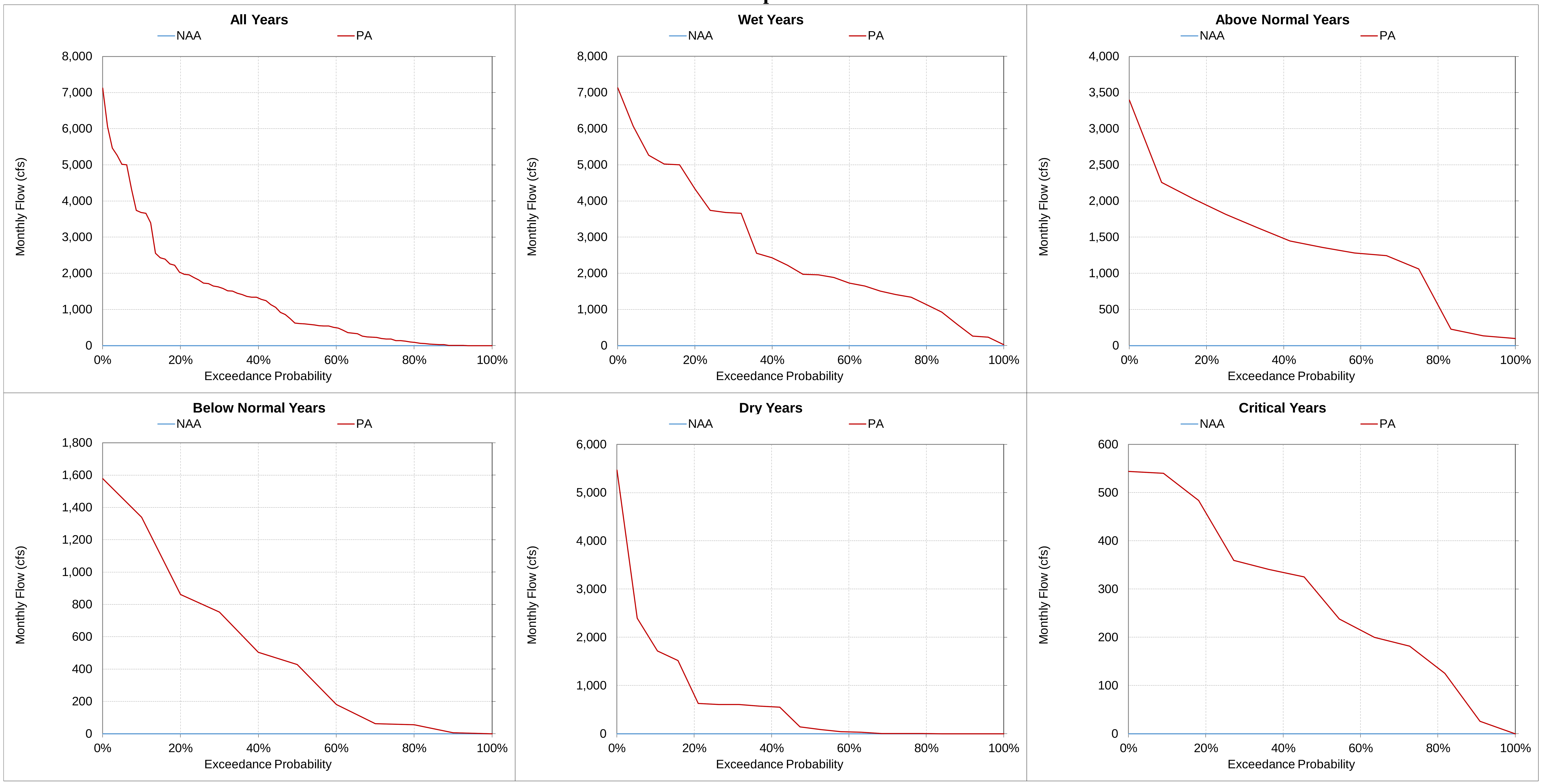
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-39-13. North Delta Intakes Diversion Flow, Monthly Flow March



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-39-14. North Delta Intakes Diversion Flow, Monthly Flow April



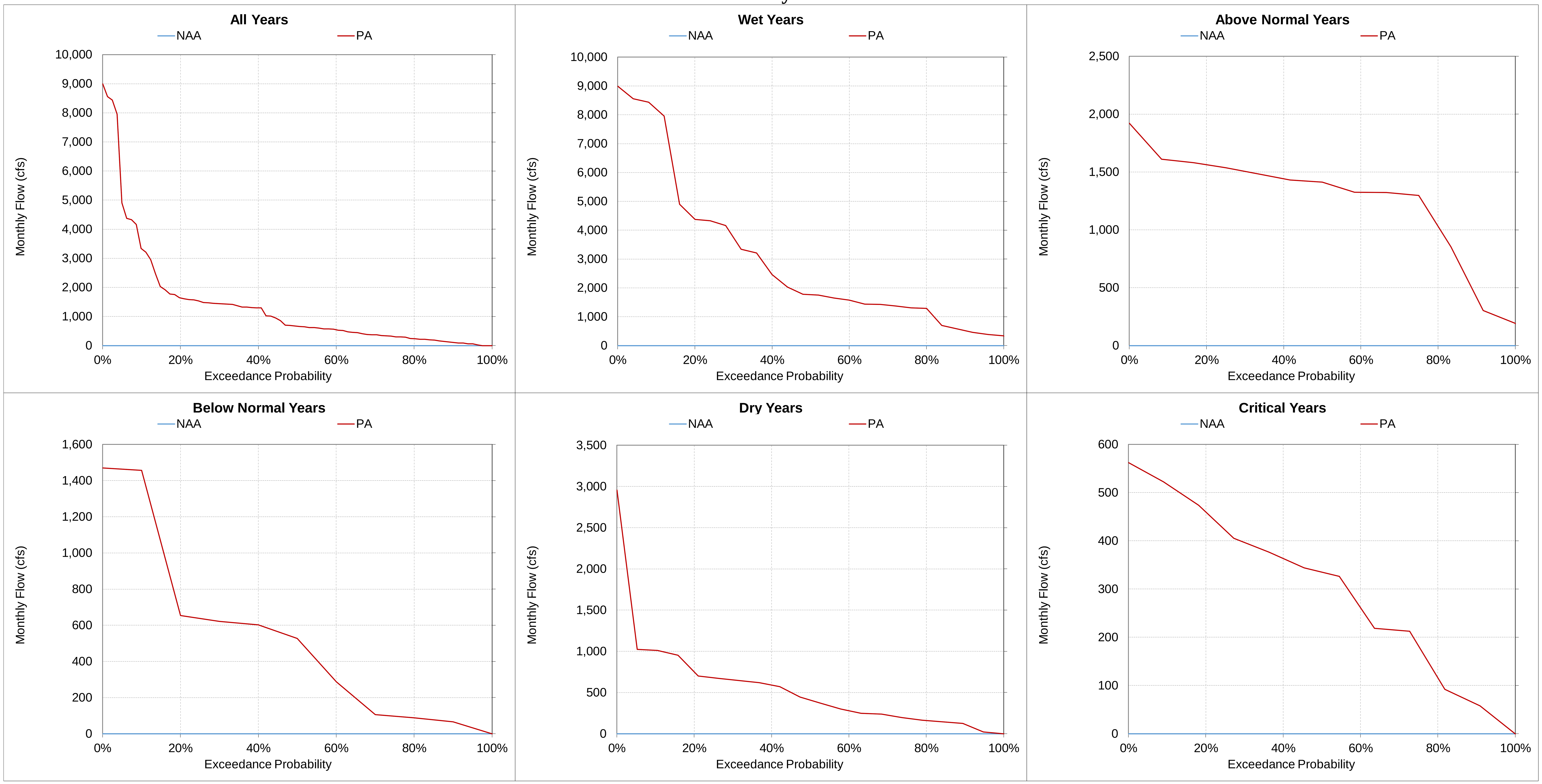
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

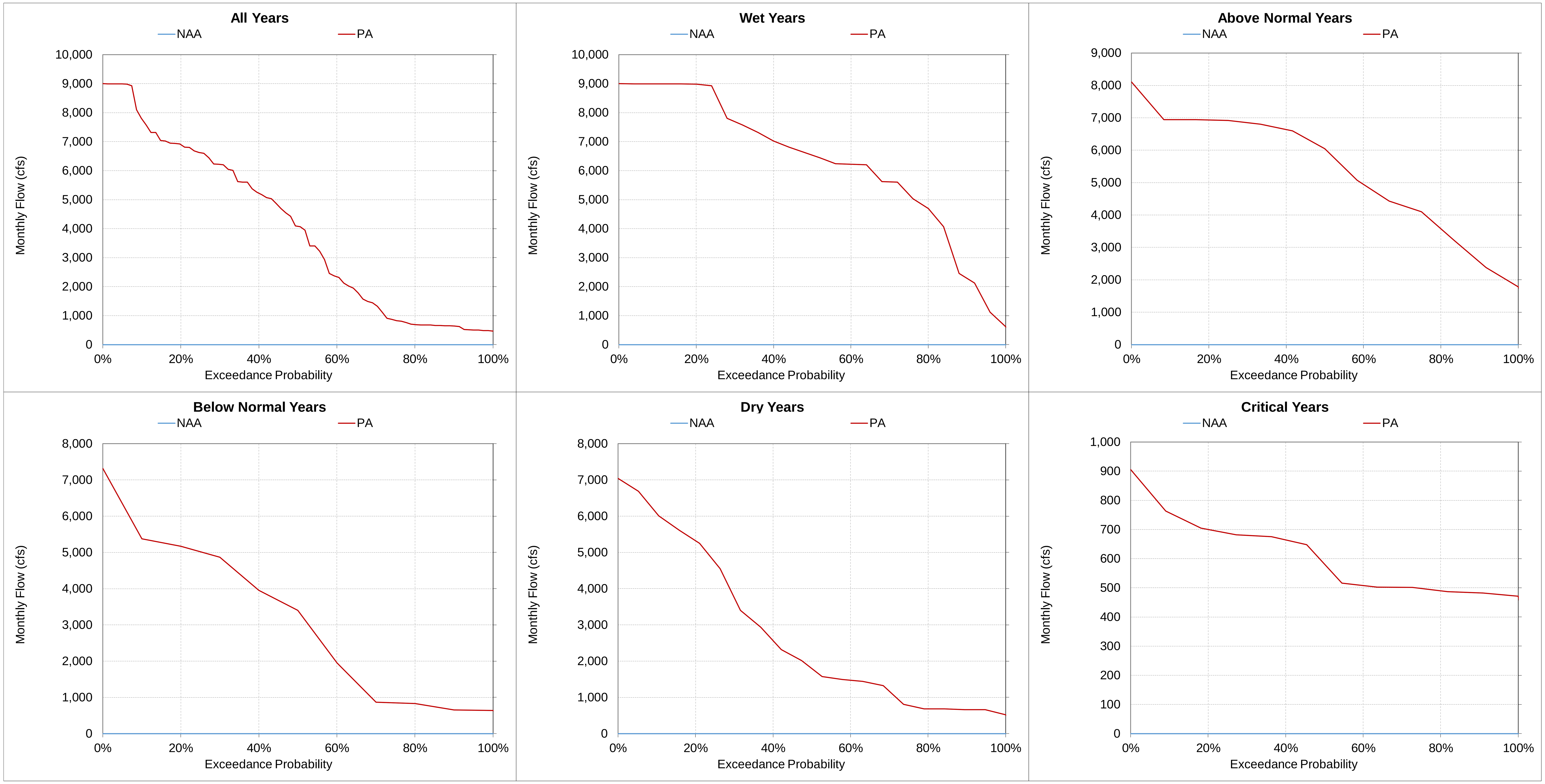
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-39-15. North Delta Intakes Diversion Flow, Monthly Flow May



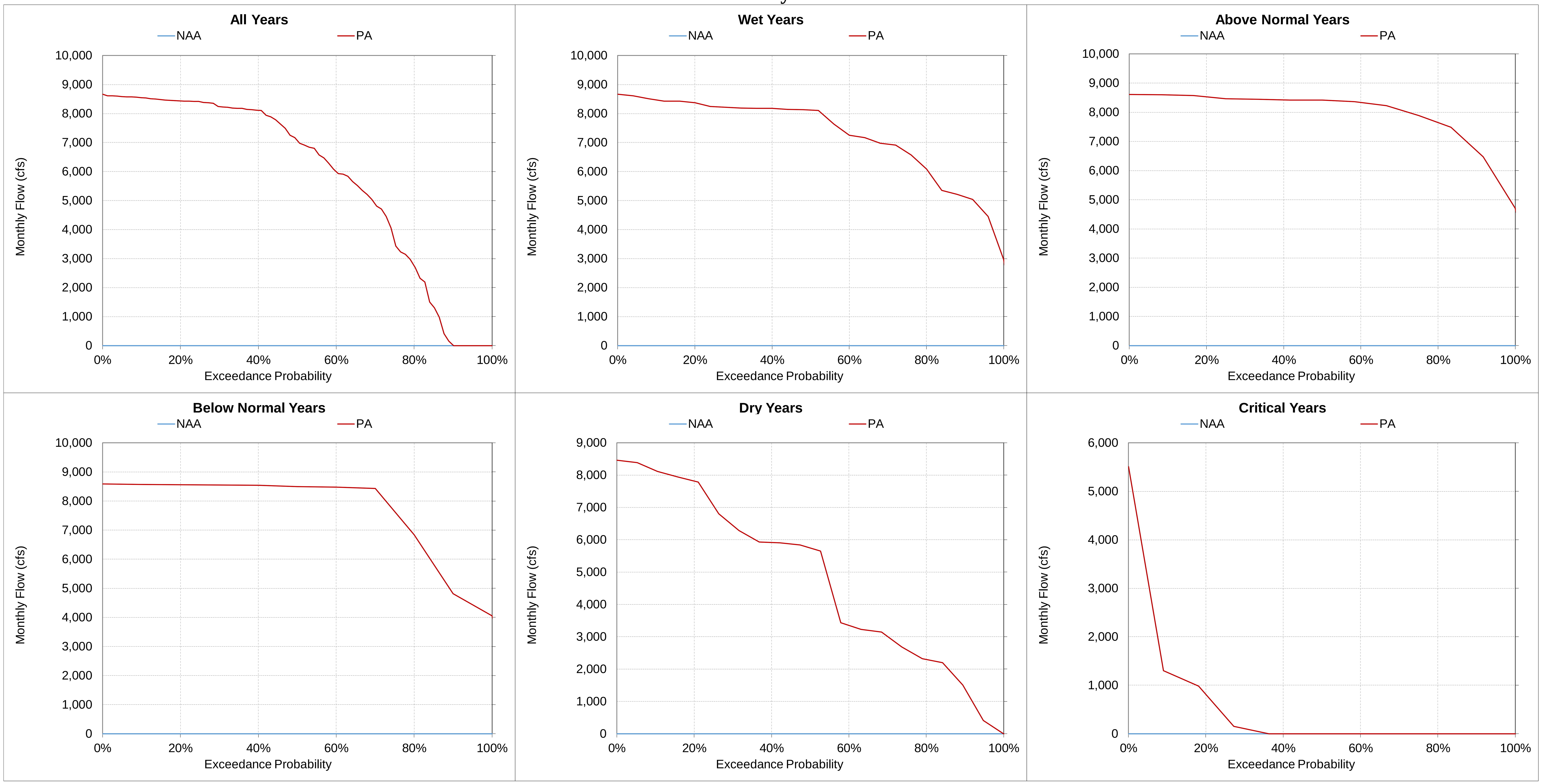
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-39-16. North Delta Intakes Diversion Flow, Monthly Flow
June



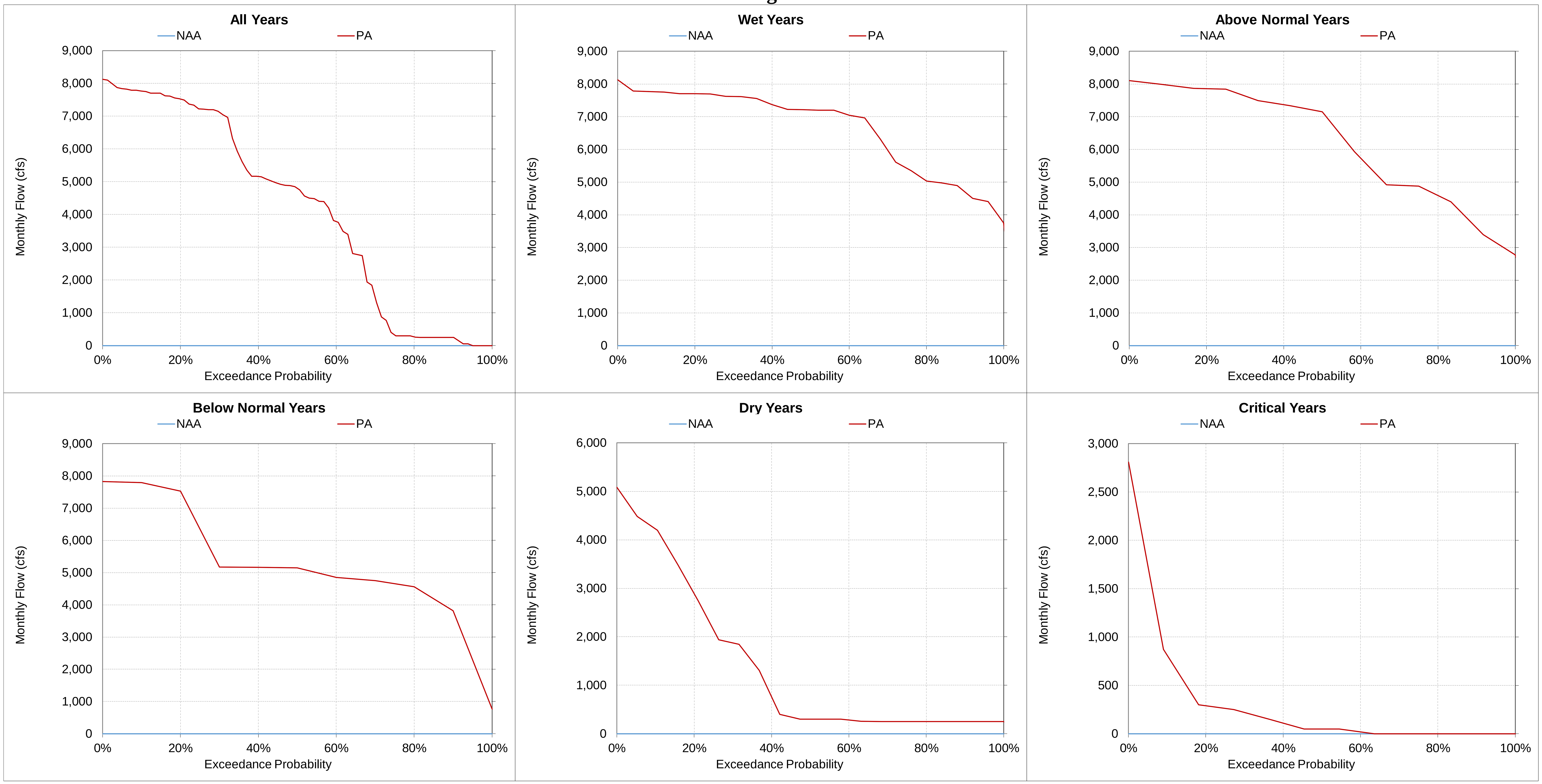
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-39-17. North Delta Intakes Diversion Flow, Monthly Flow July



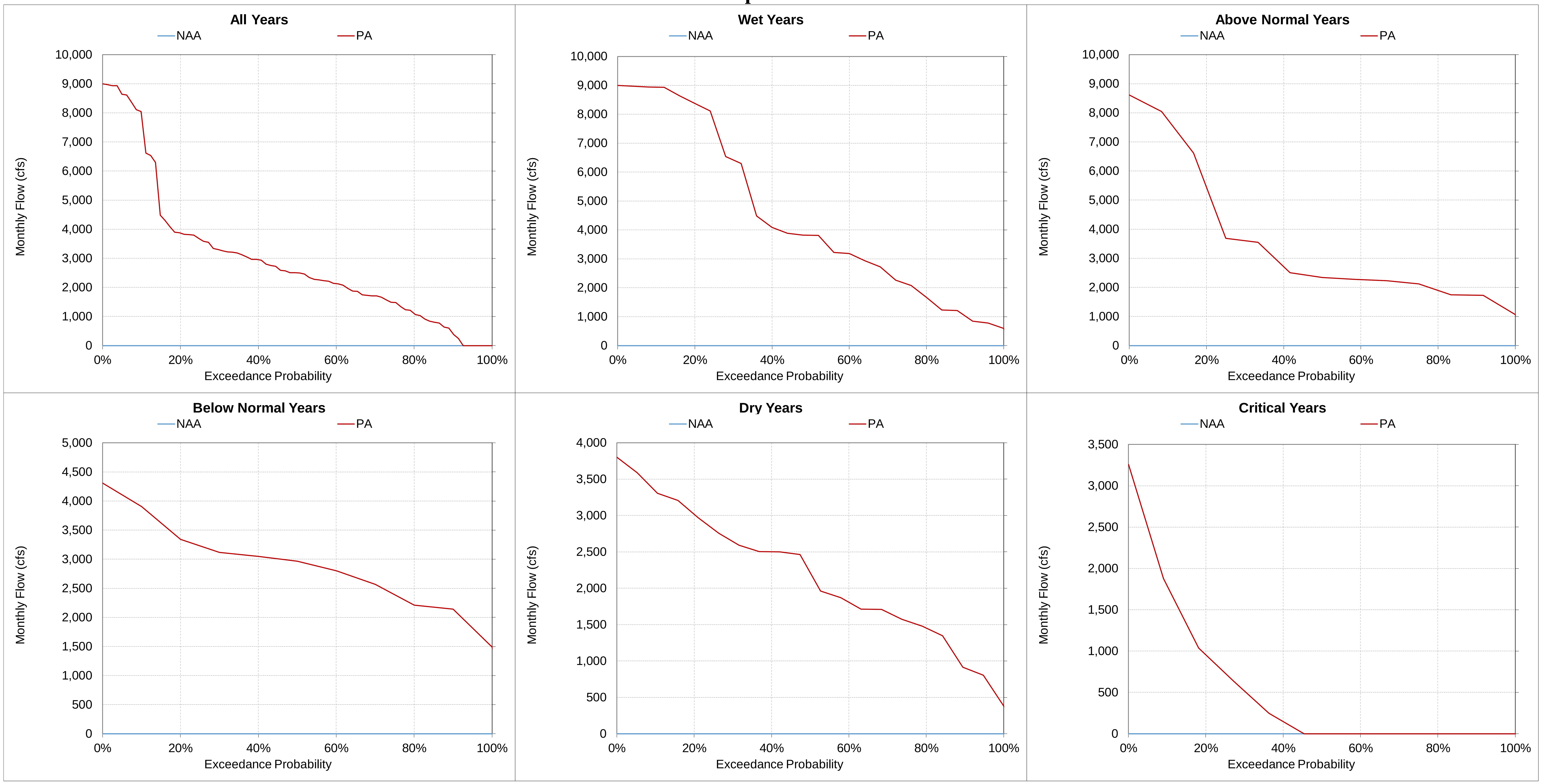
a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-39-18. North Delta Intakes Diversion Flow, Monthly Flow August



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5-39-19. North Delta Intakes Diversion Flow, Monthly Flow
September



a Exceedance probability is defined as the probability a given value will be exceeded in any one year.
b Based on the 82-year simulation period.
c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.
d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Figure 5.B.5.40-1 Sacramento River at Rio Vista Monthly Temperature Probability of Exceedance

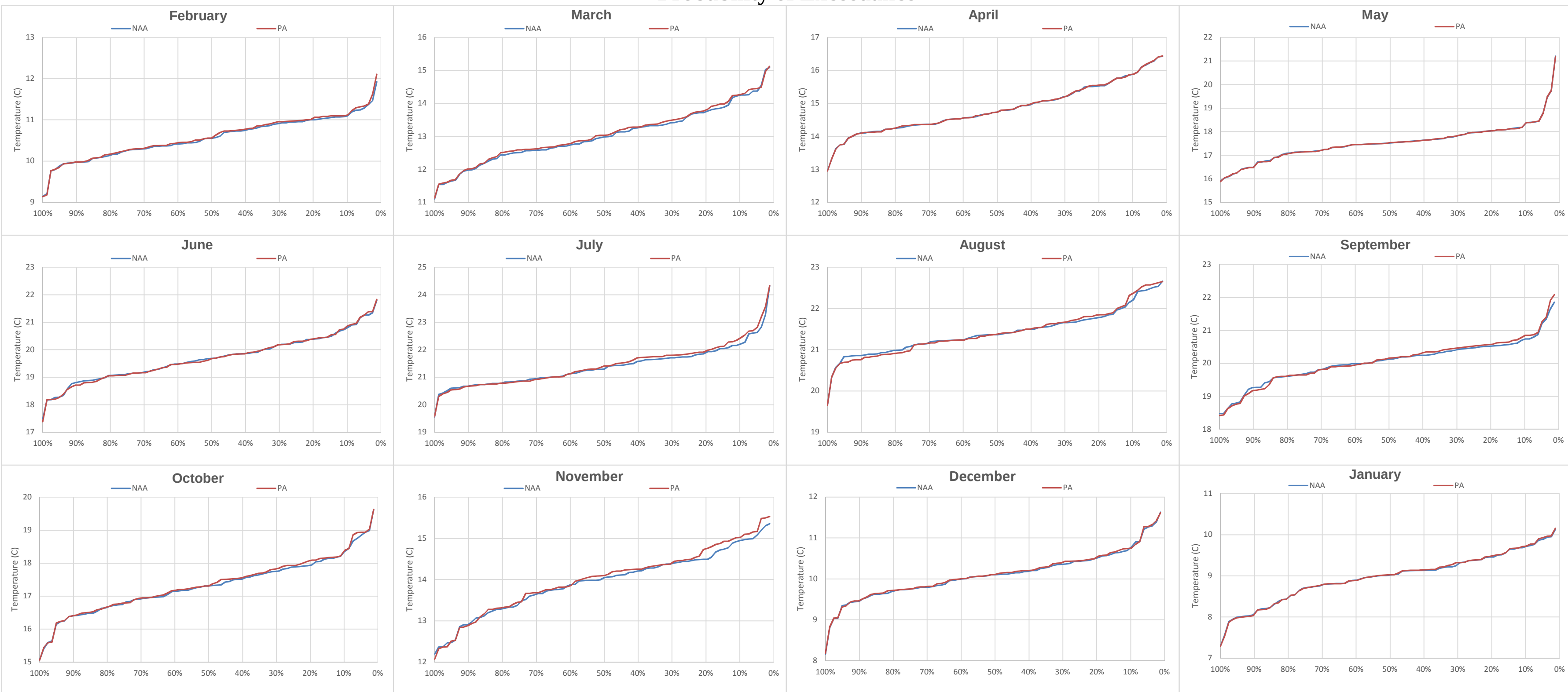


Figure 5.B.5.40-2 Sacramento River at Rio Vista Monthly Temperature

Figure 5.B.5.40-3 Sacramento River at Rio Vista Monthly Temperature February Daily Temperature Ranges

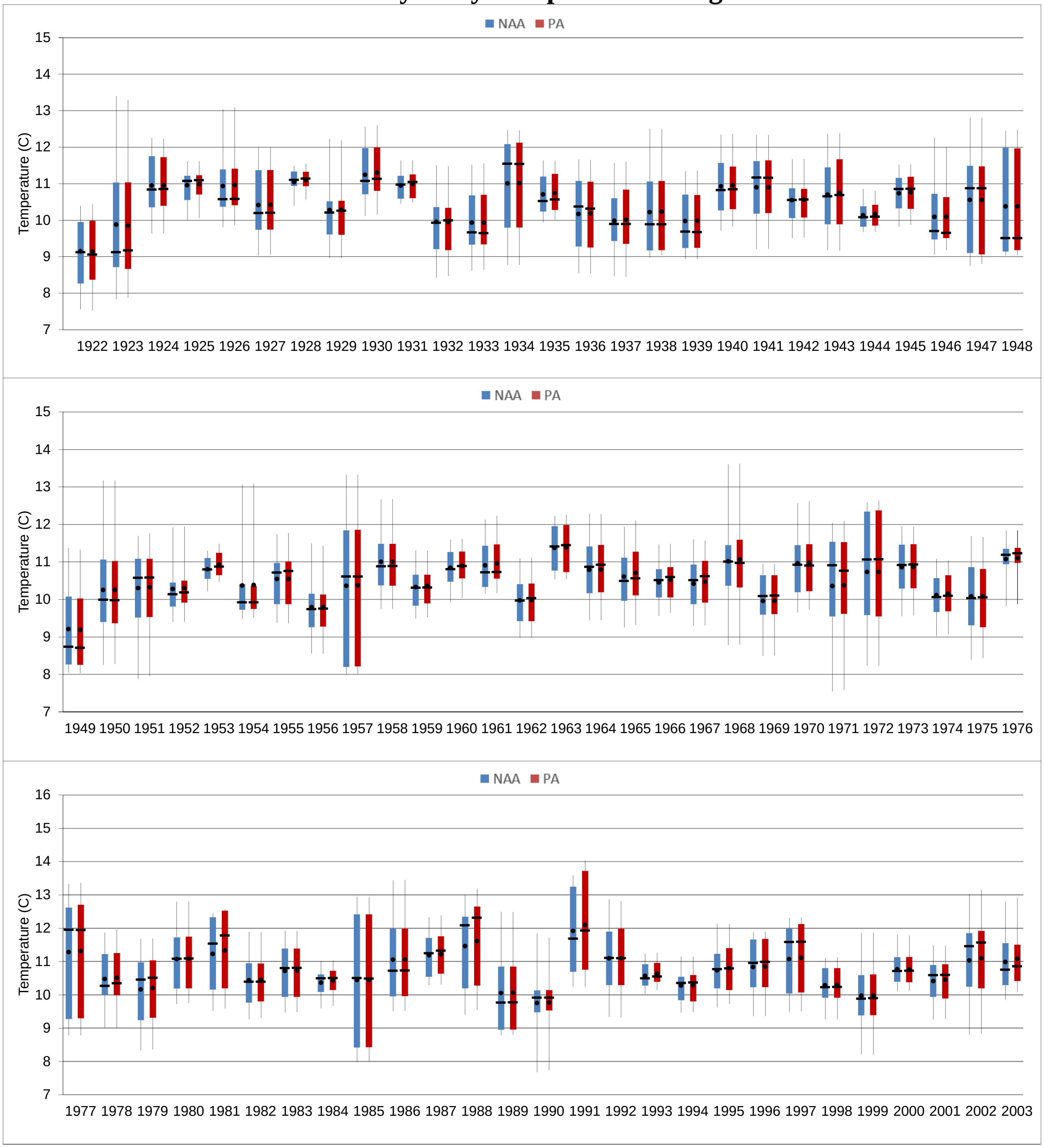


Figure 5.B.5.40-4 Sacramento River at Rio Vista Monthly Temperature March Daily Temperature Ranges

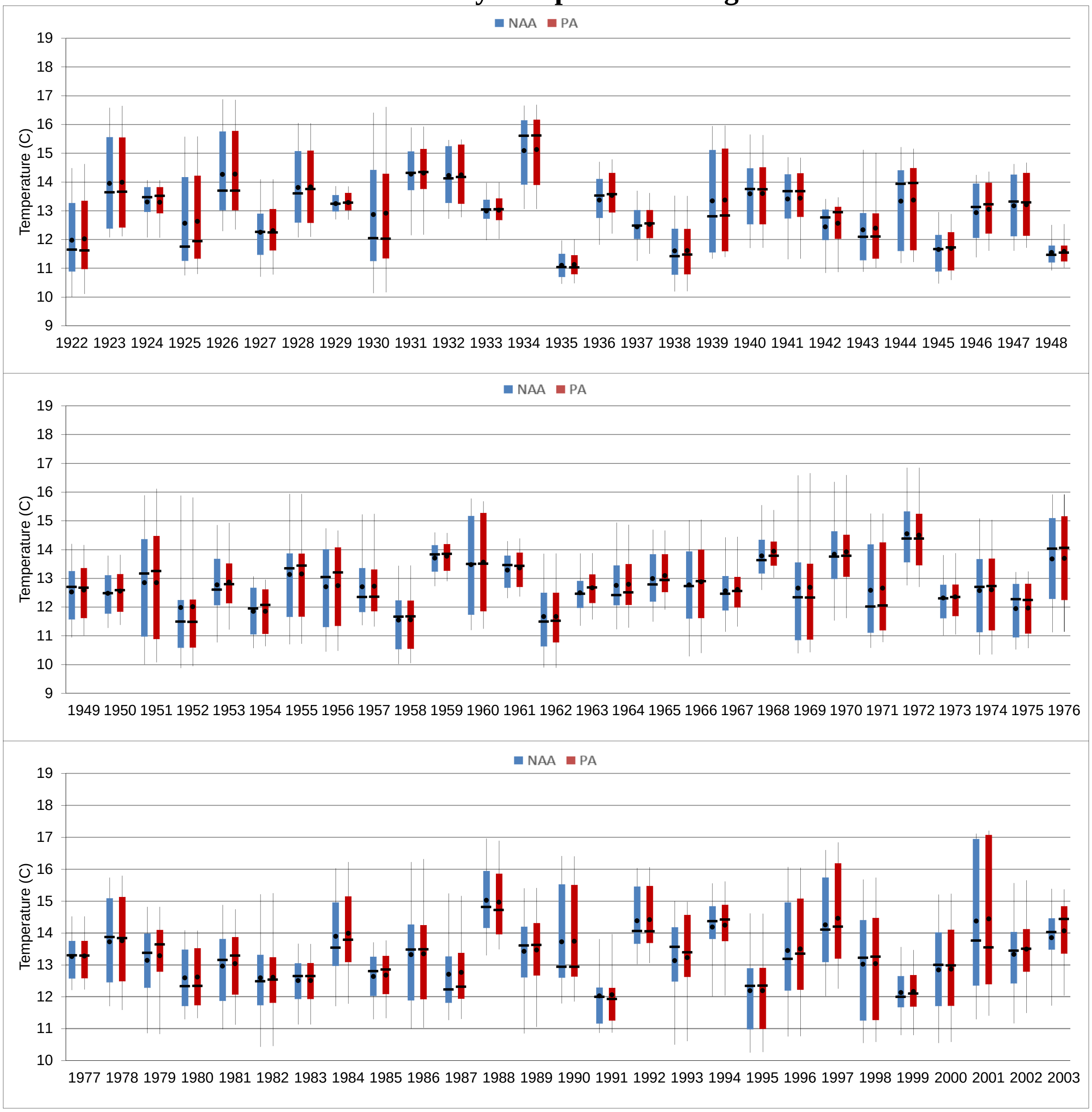


Figure 5.B.5.40-5 Sacramento River at Rio Vista Monthly Temperature April Daily Temperature Ranges

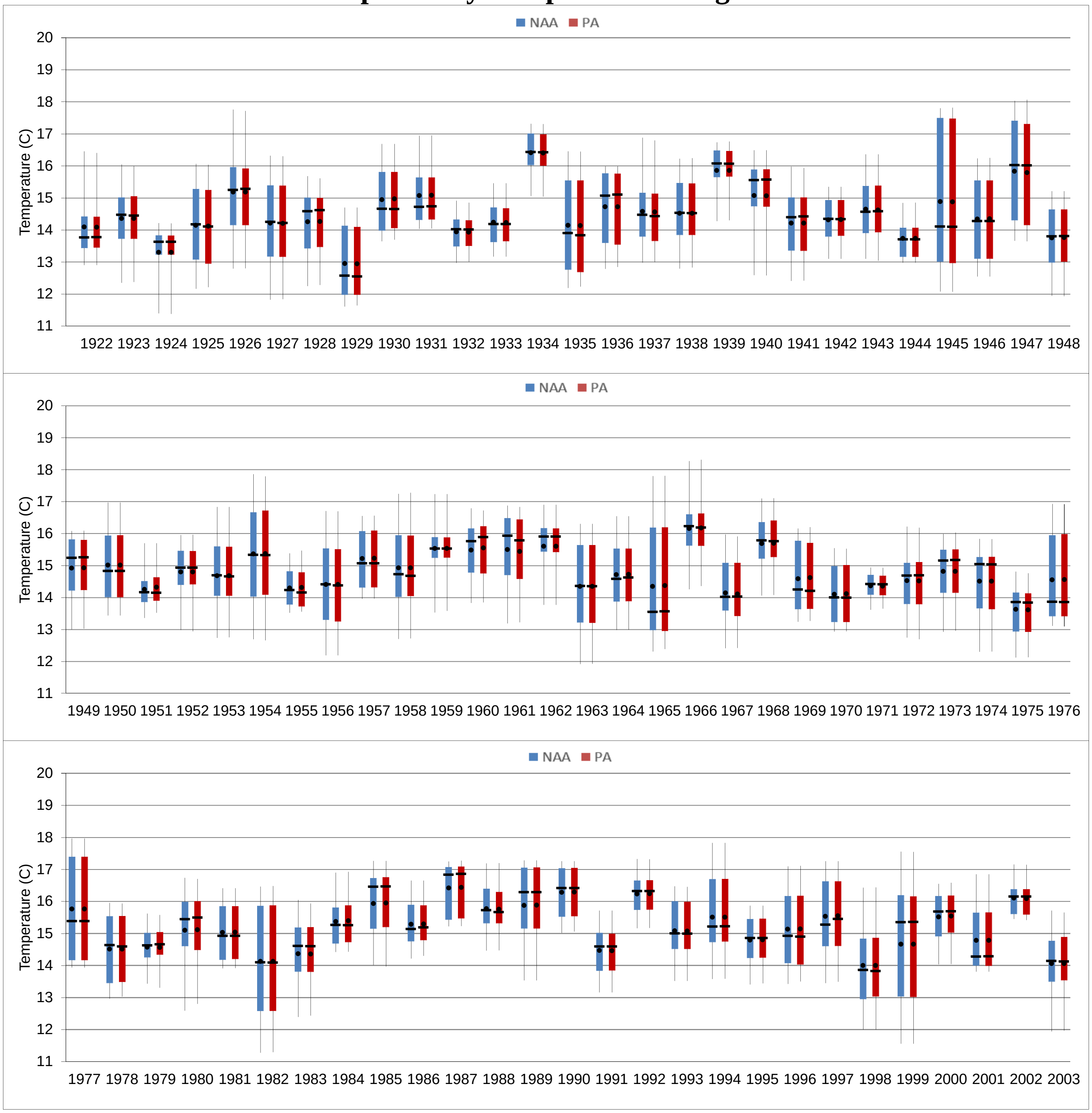


Figure 5.B.5.40-6 Sacramento River at Rio Vista Monthly Temperature May Daily Temperature Ranges

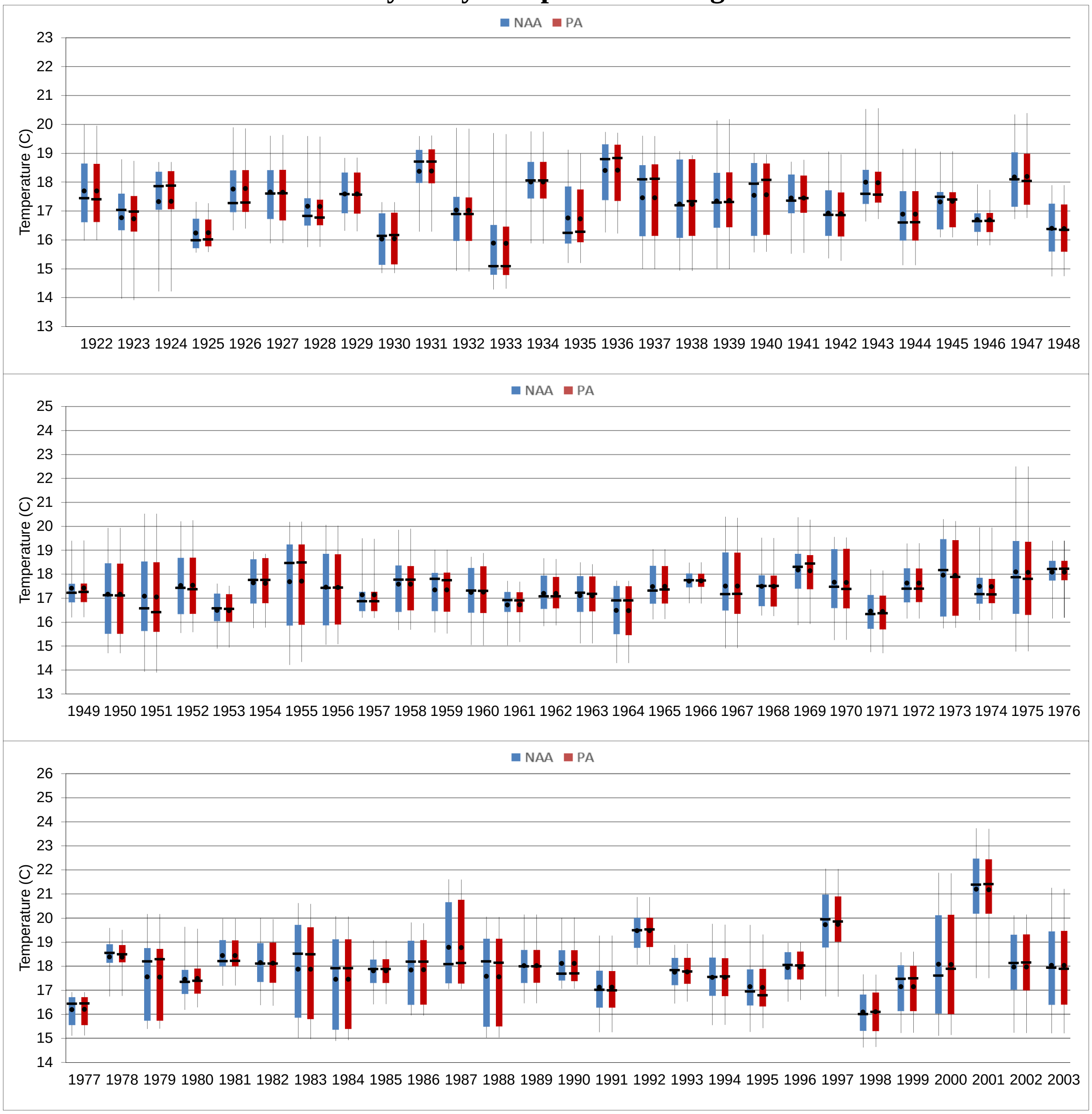


Figure 5.B.5.40-7 Sacramento River at Rio Vista Monthly Temperature June Daily Temperature Ranges

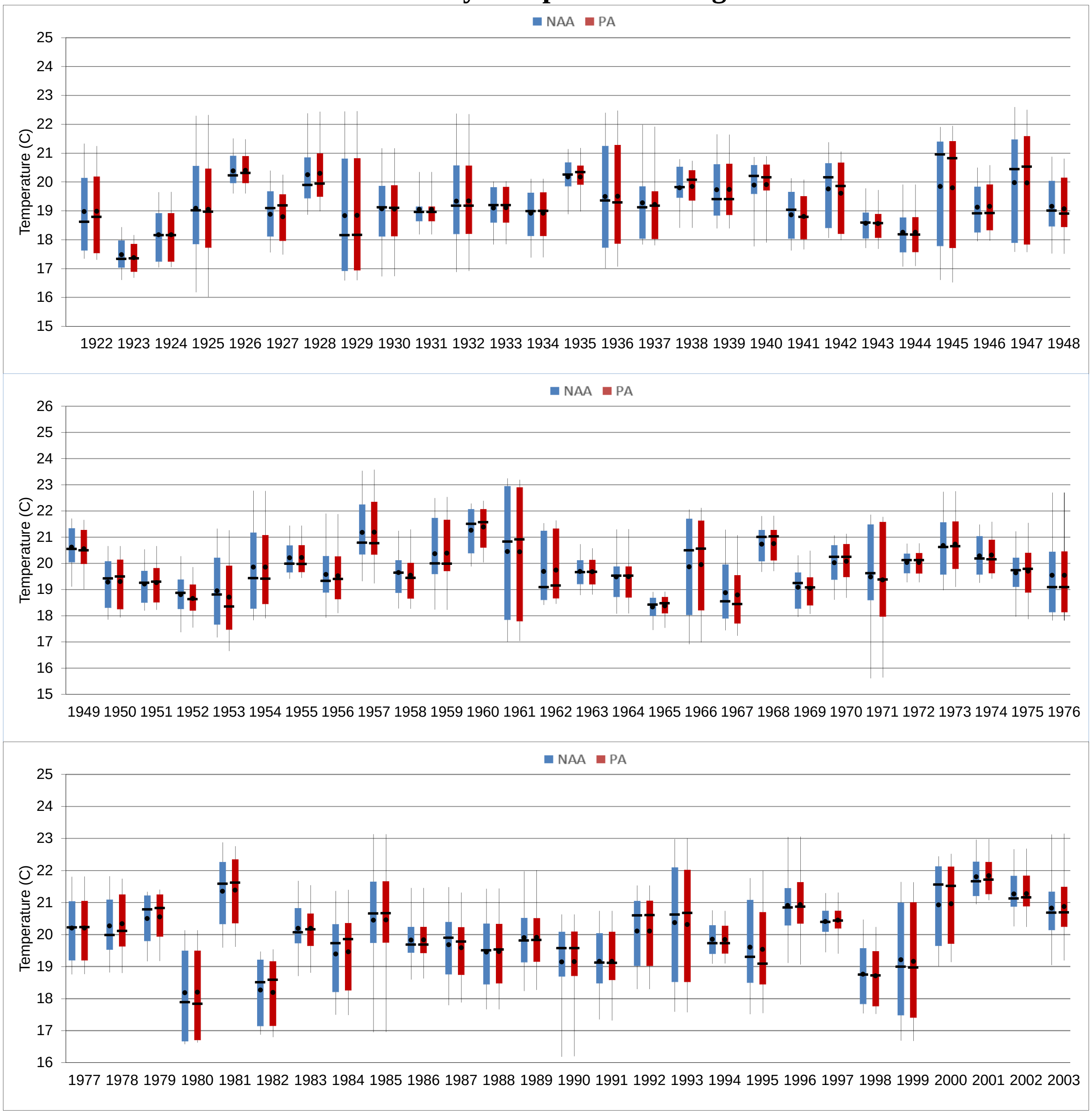


Figure 5.B.5.40-8 Sacramento River at Rio Vista Monthly Temperature
July Daily Temperature Ranges

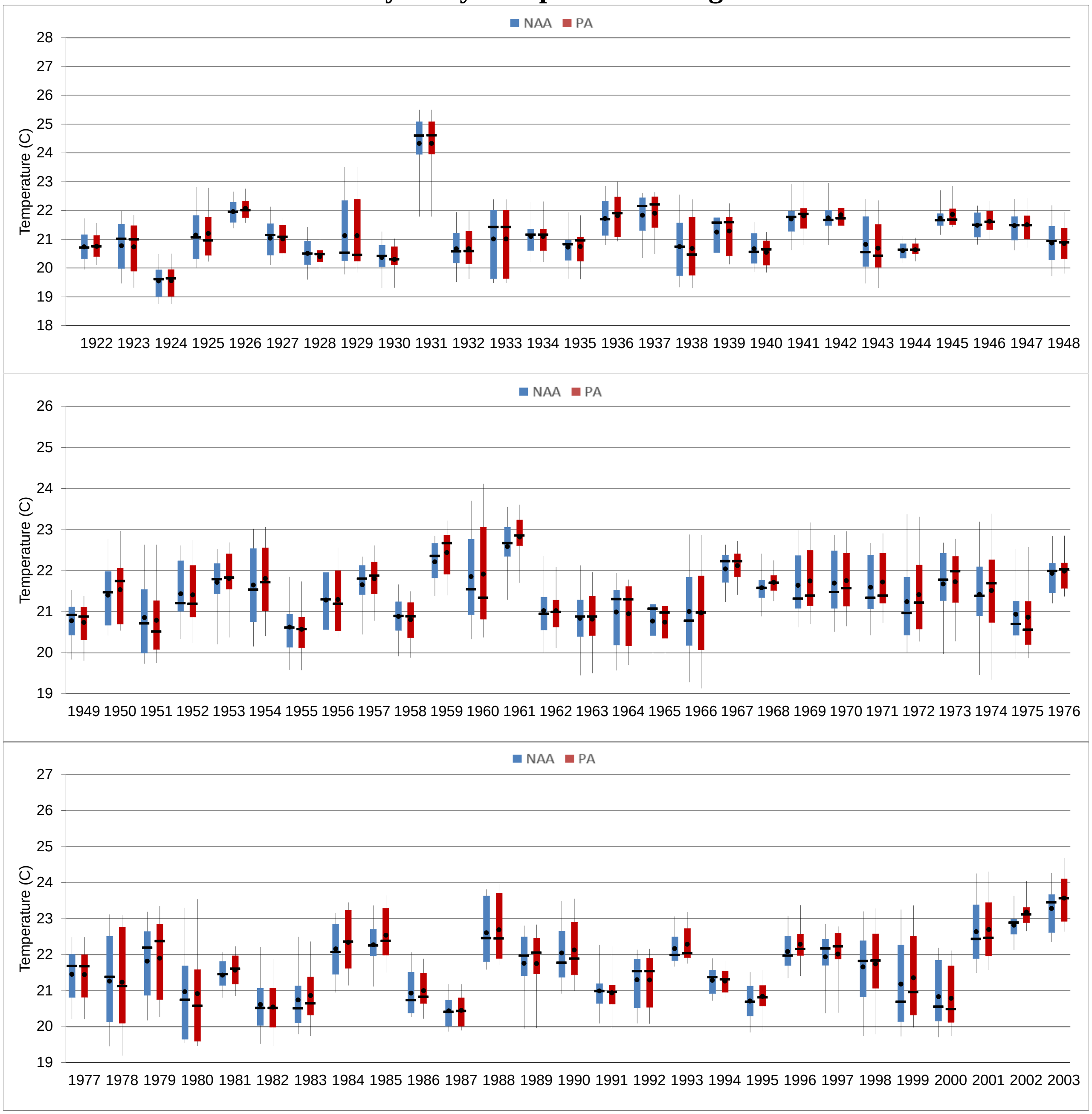
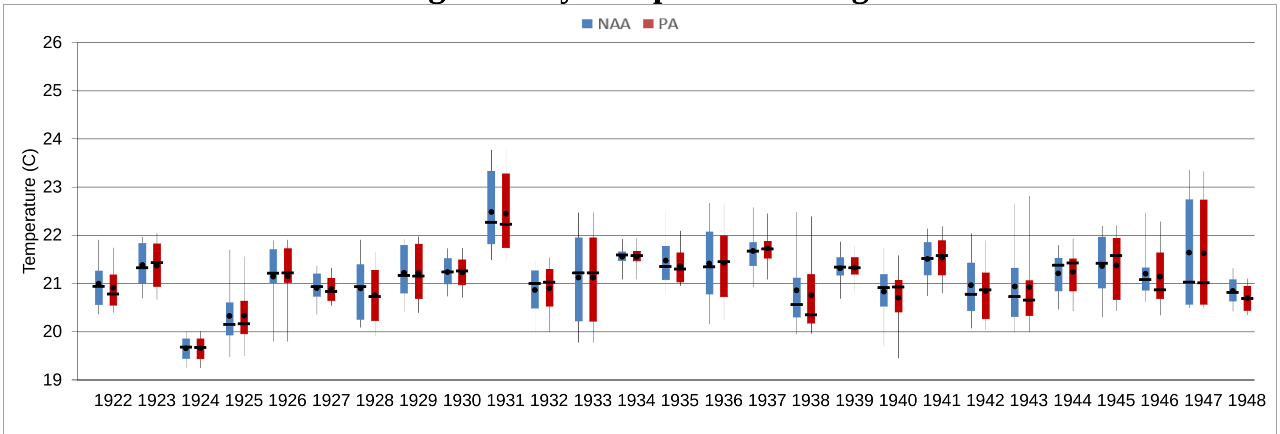
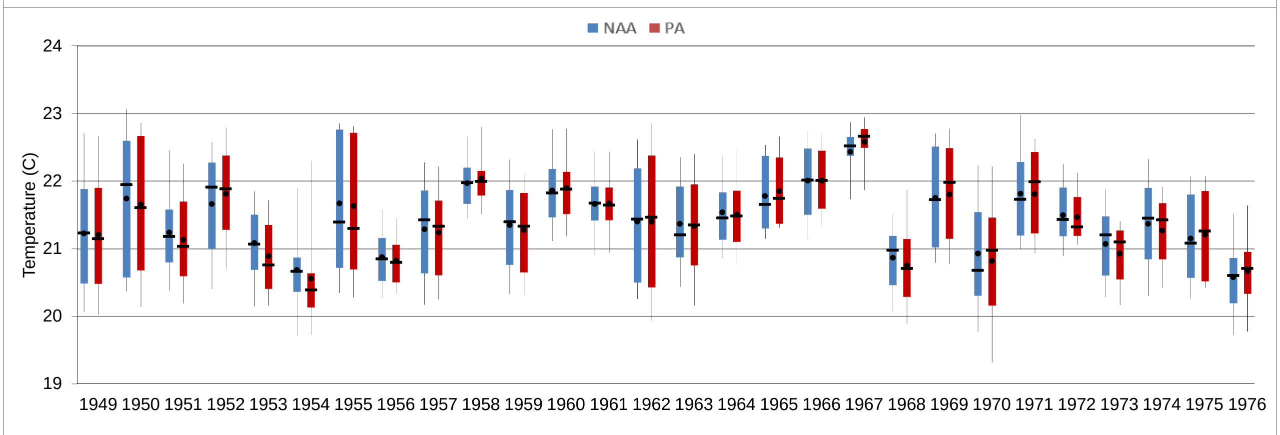


Figure 5.B.5.40-9 Sacramento River at Rio Vista Monthly Temperature
August Daily Temperature Ranges





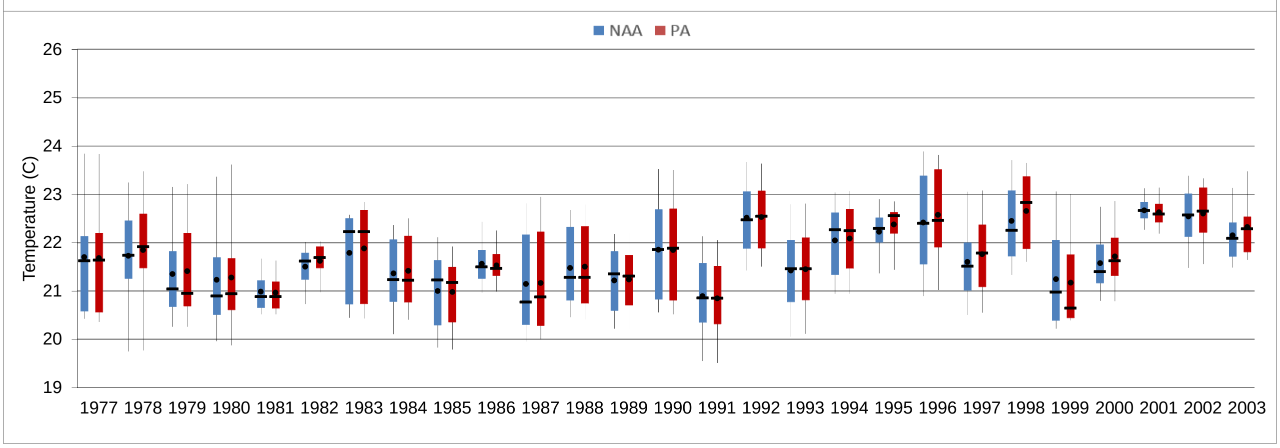


Figure 5.B.5.40-10 Sacramento River at Rio Vista Monthly Temperature September Daily Temperature Ranges

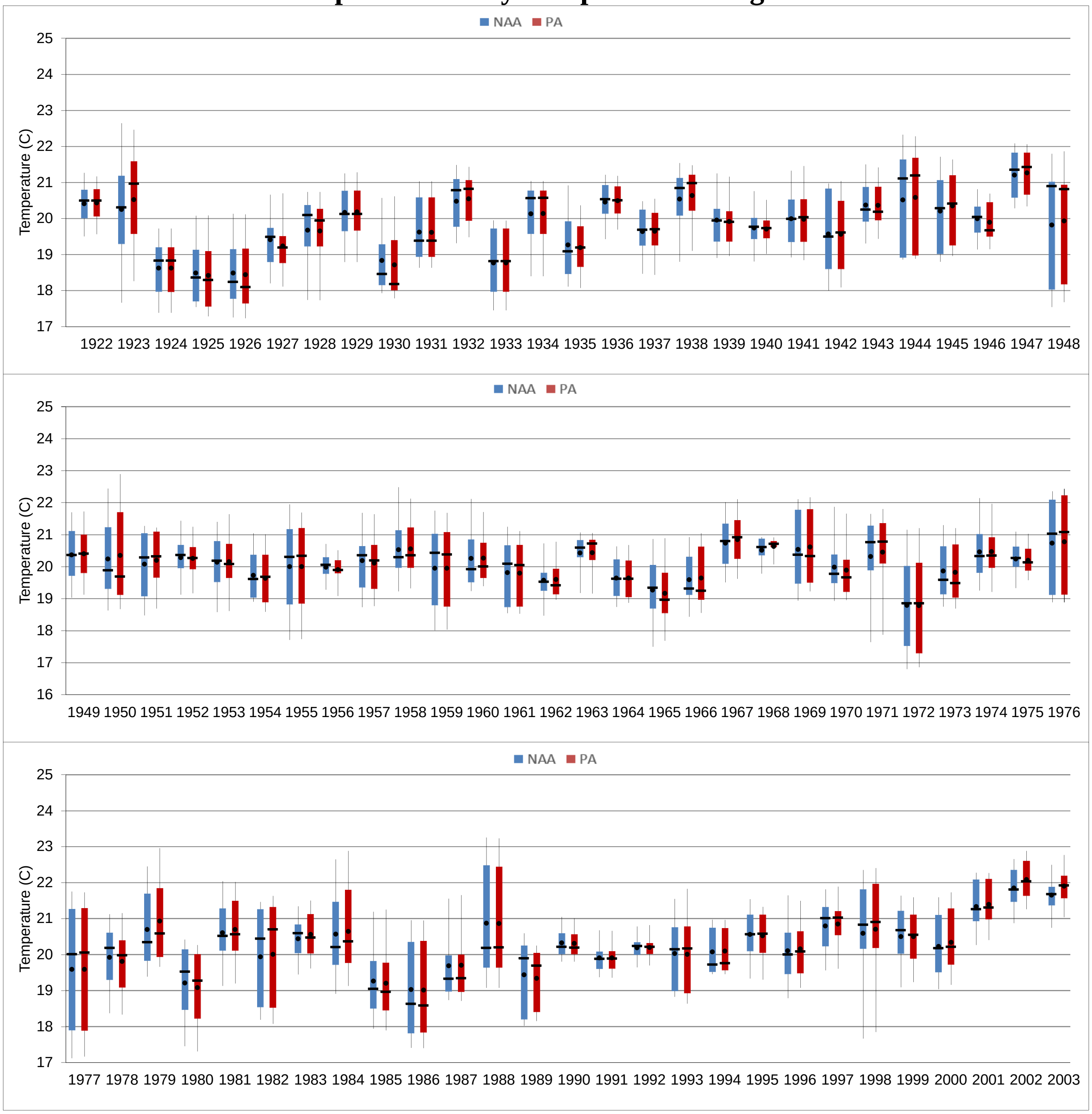


Figure 5.B.5.40-11 Sacramento River at Rio Vista Monthly Temperature October Daily Temperature Ranges

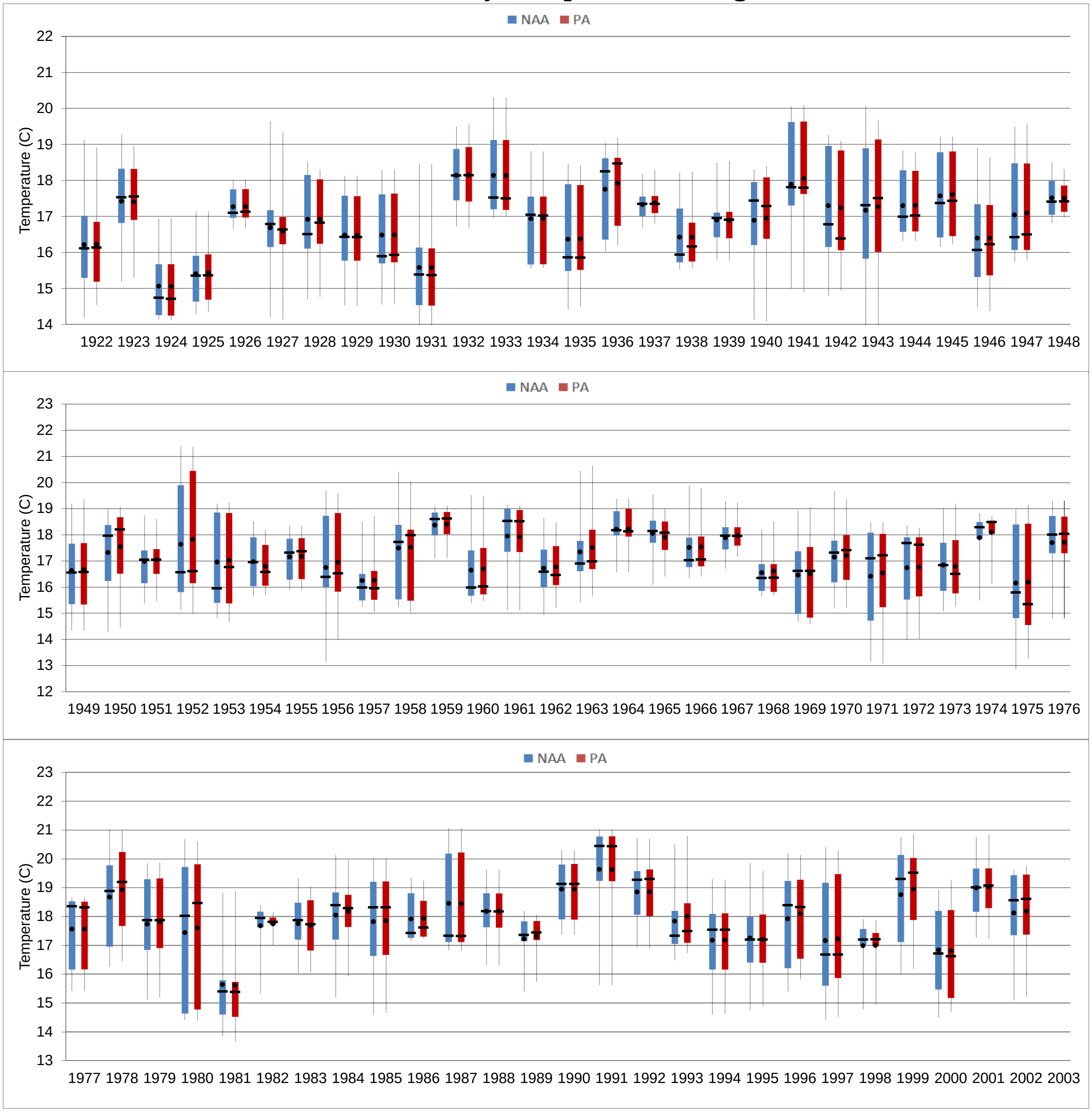


Figure 5.B.5.40-12 Sacramento River at Rio Vista Monthly Temperature November Daily Temperature Ranges

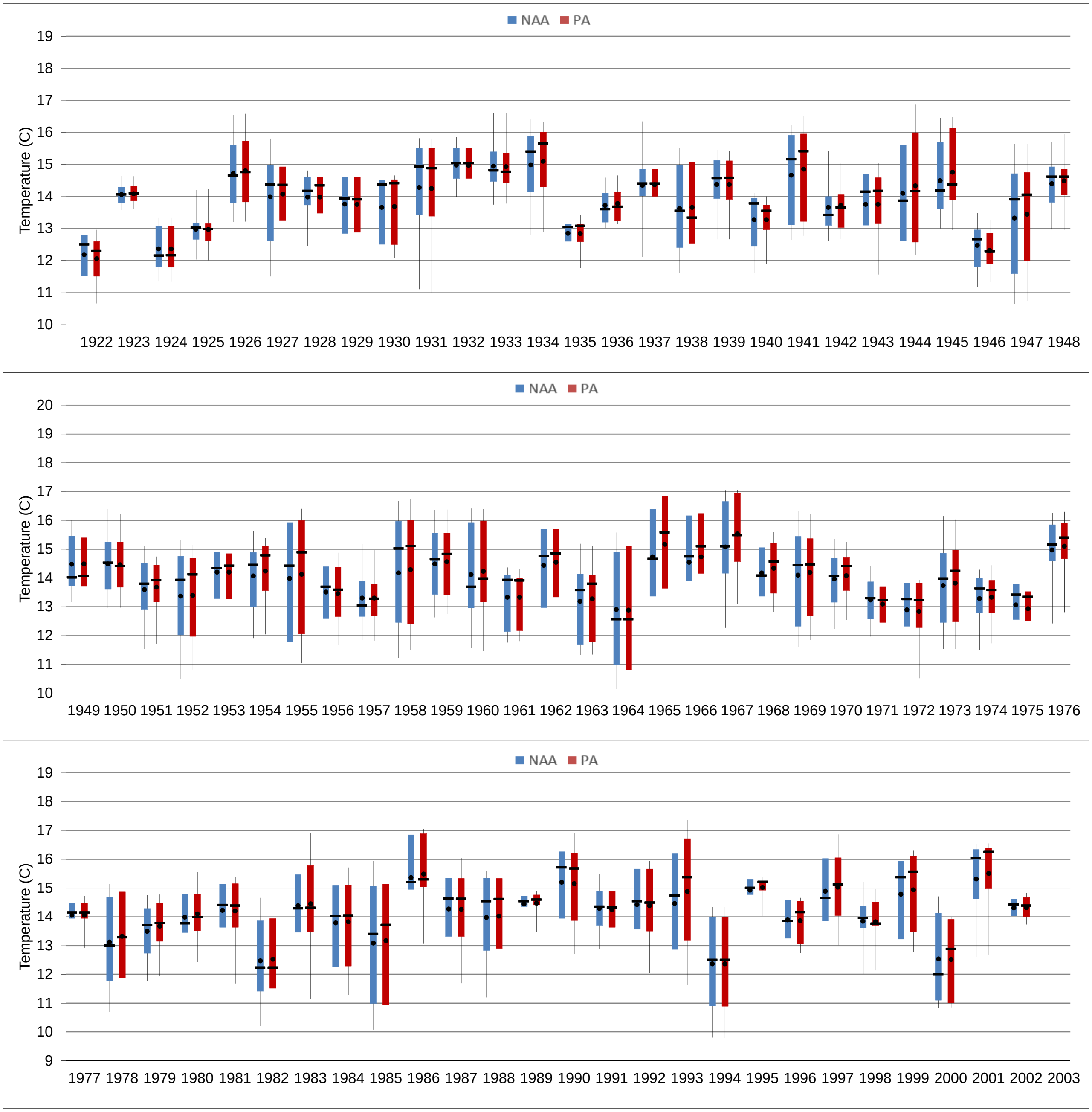


Figure 5.B.5.40-13 Sacramento River at Rio Vista Monthly Temperature December Daily Temperature Ranges

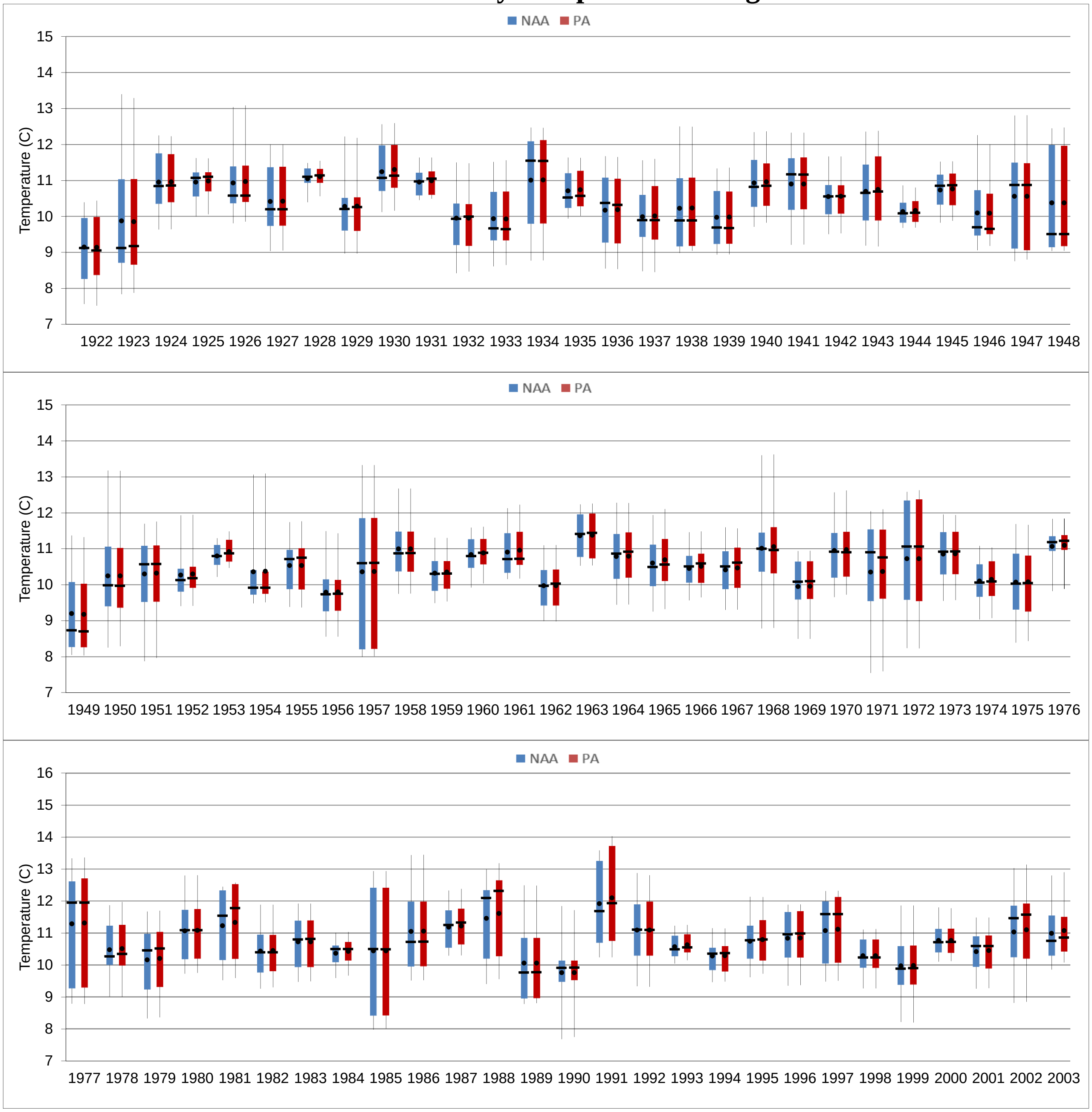


Figure 5.B.5.40-14 Sacramento River at Rio Vista Monthly Temperature January Daily Temperature Ranges

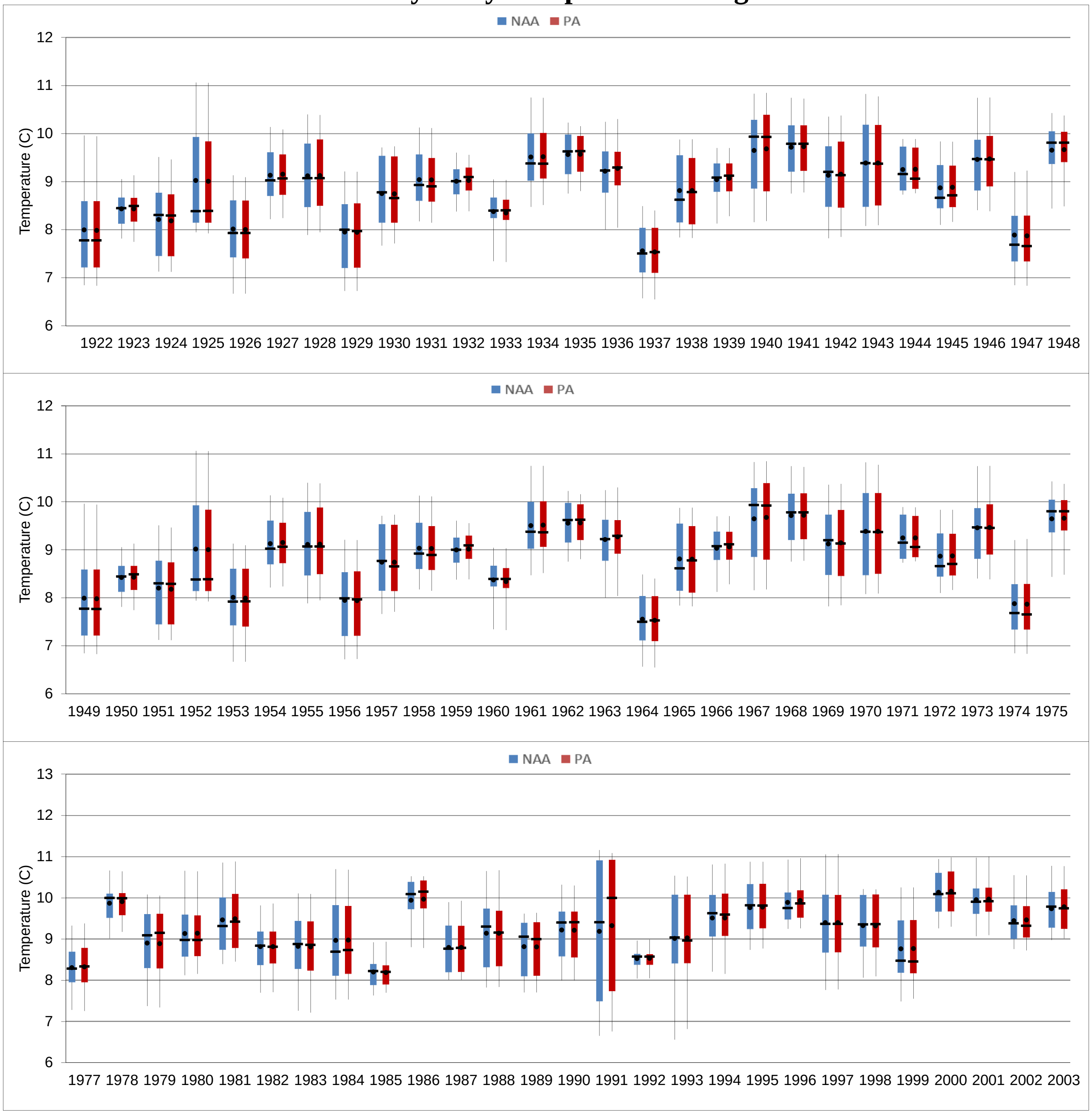


Figure 5.B.5.41-1 San Joaquin River at Prisoner's Point Monthly Temperature Probability of Exceedance

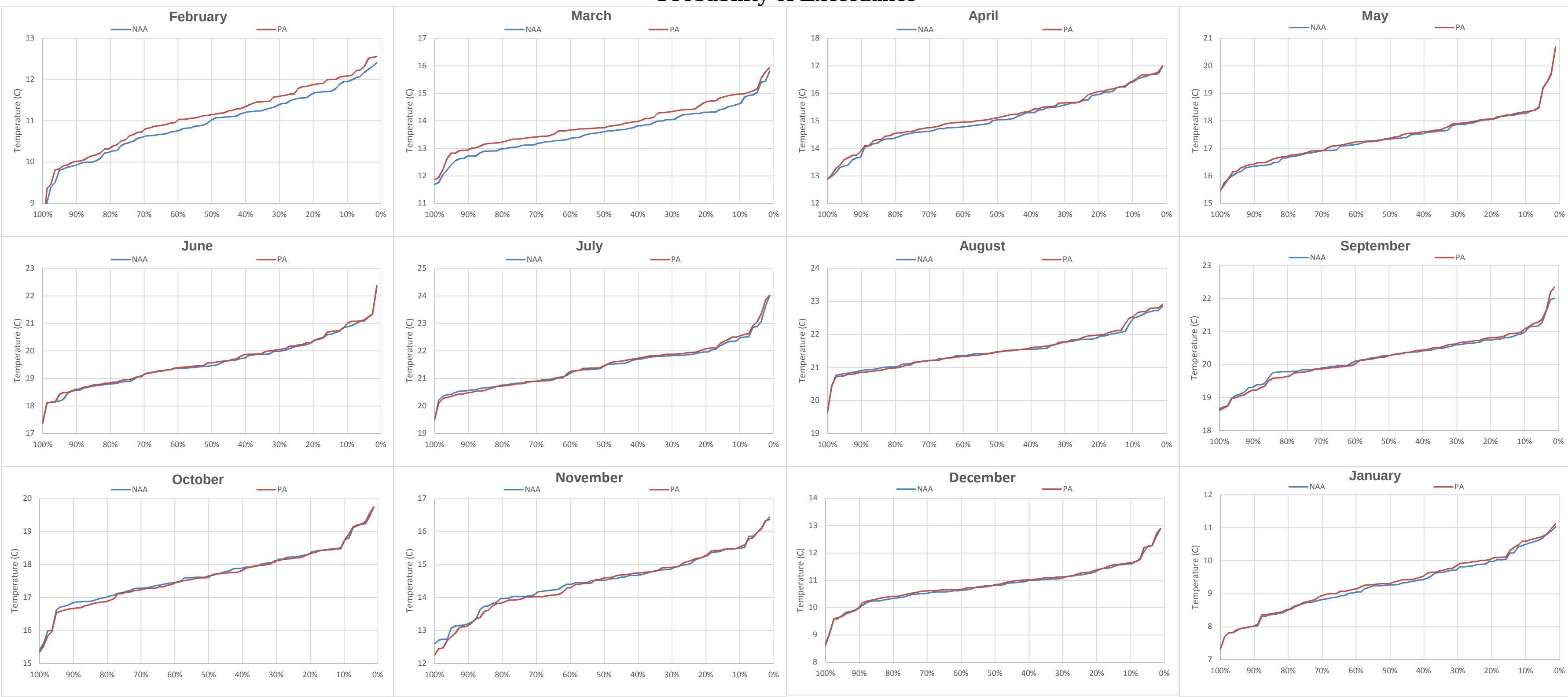


Figure 5.B.5.41-2 San Joaquin River at Prisoner's Point Monthly Temperature

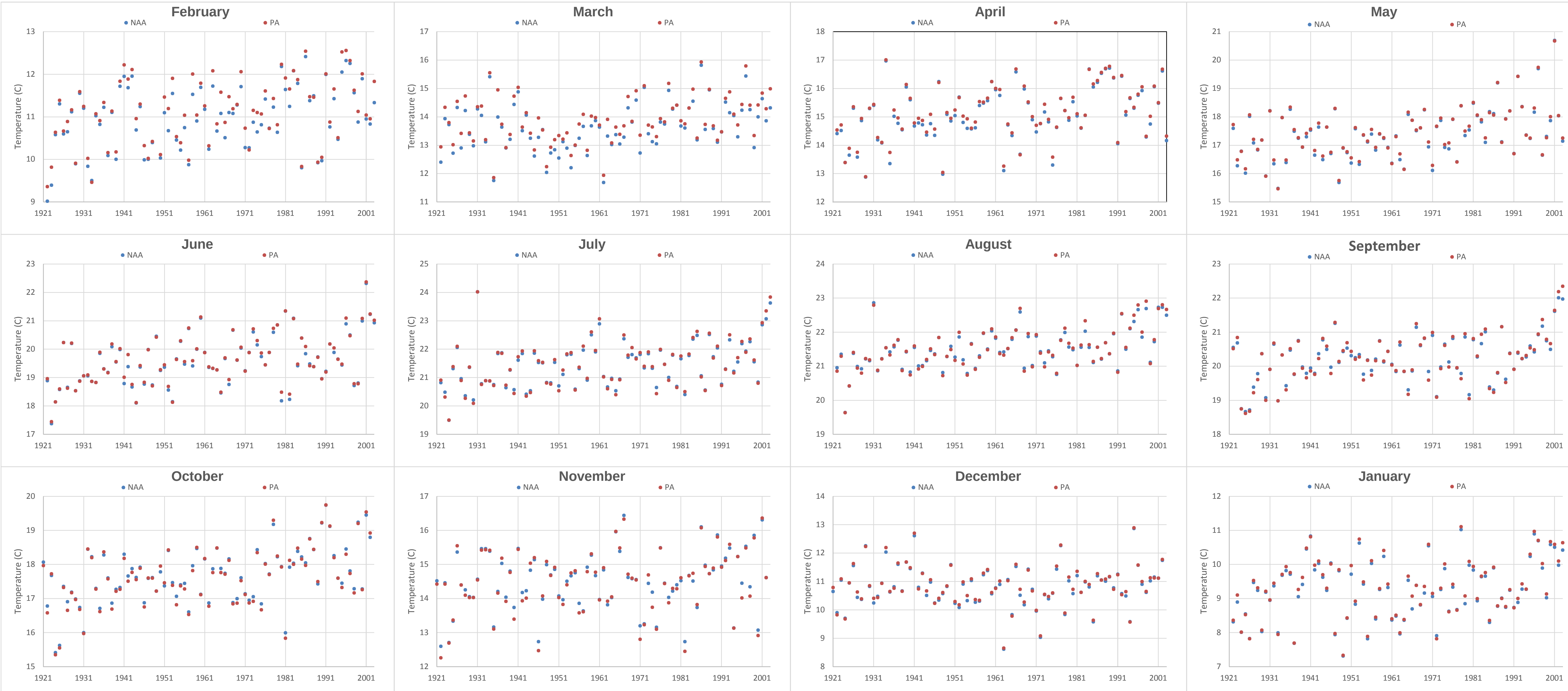


Figure 5.B.5.41-3 San Joaquin River at Prisoner's Point Monthly Temperature February Daily Temperature Ranges

Figure 5.B.5.41-4 San Joaquin River at Prisoner's Point Monthly Temperature March Daily Temperature Ranges

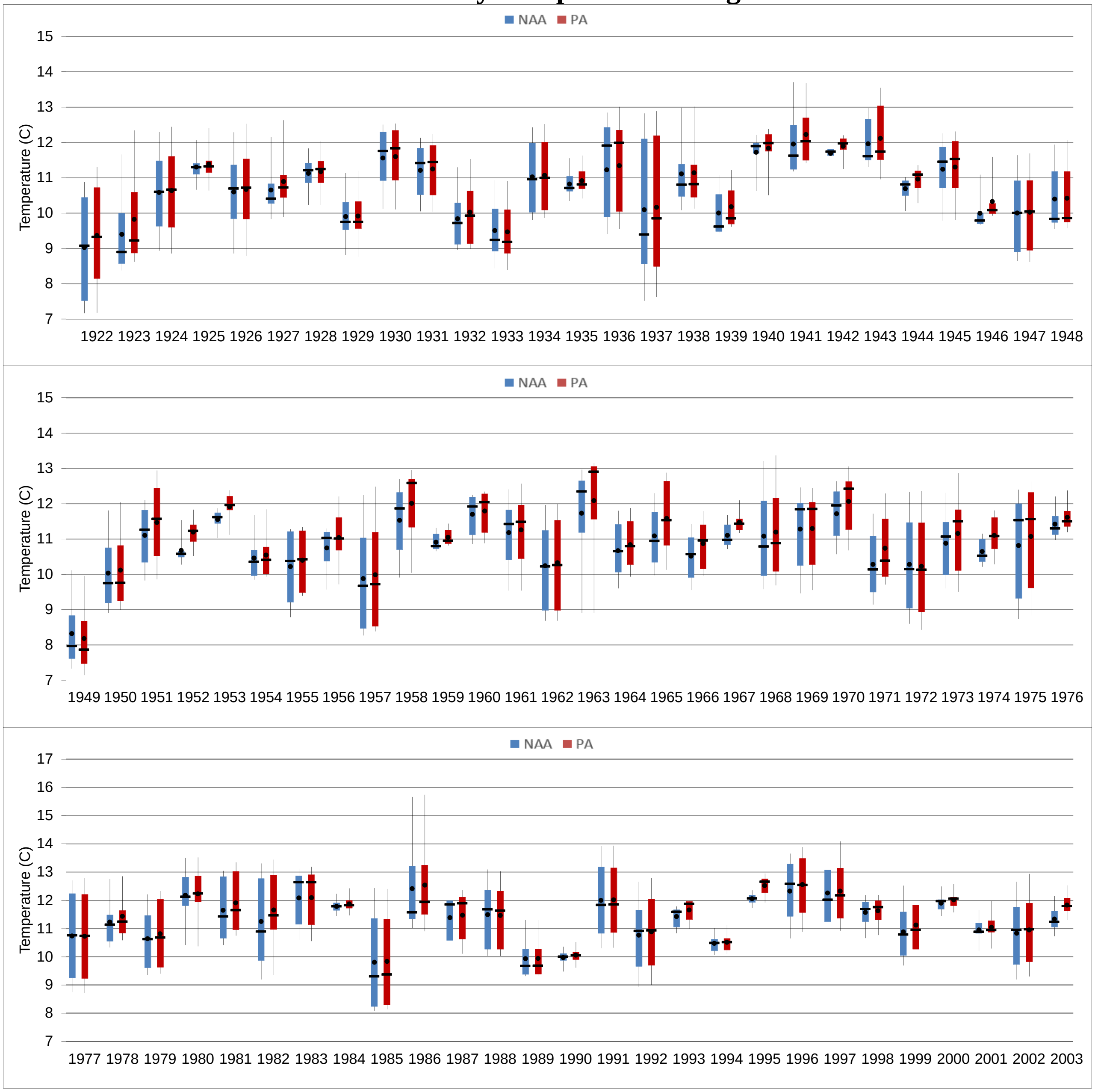


Figure 5.B.5.41-5 San Joaquin River at Prisoner's Point Monthly Temperature April Daily Temperature Ranges

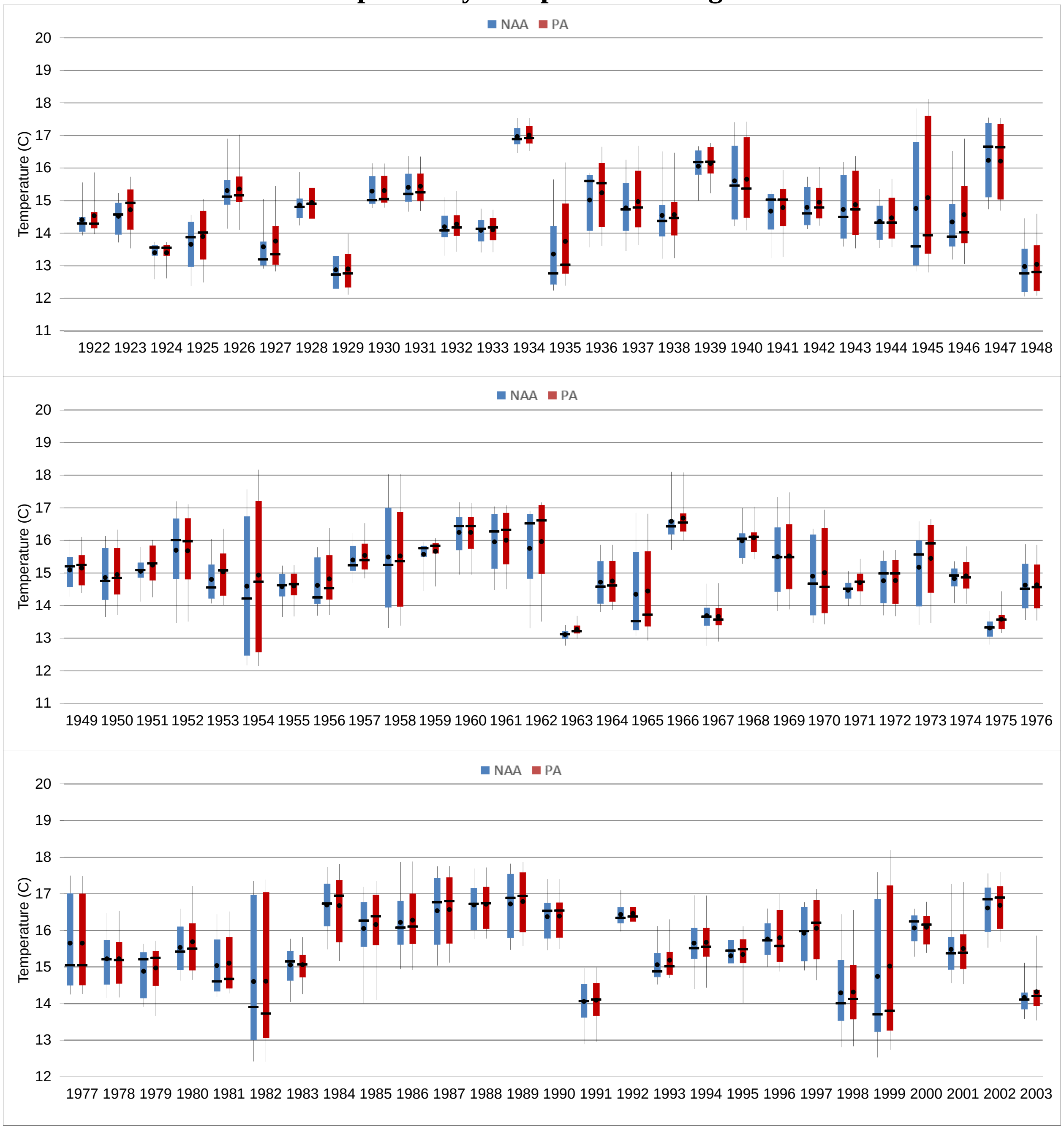


Figure 5.B.5.41-6 San Joaquin River at Prisoner's Point Monthly Temperature May Daily Temperature Ranges

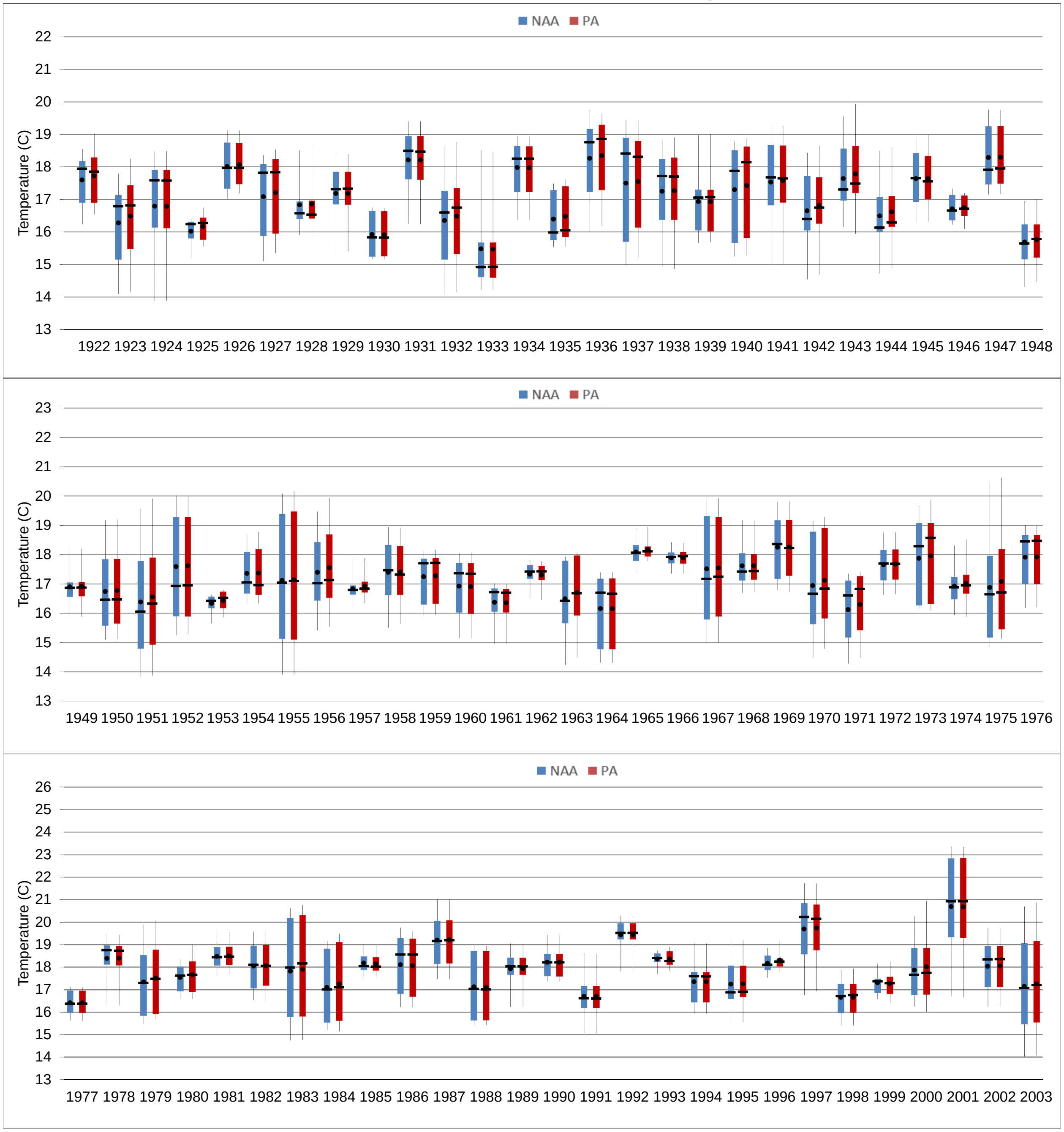


Figure 5.B.5.41-7 San Joaquin River at Prisoner's Point Monthly Temperature June Daily Temperature Ranges

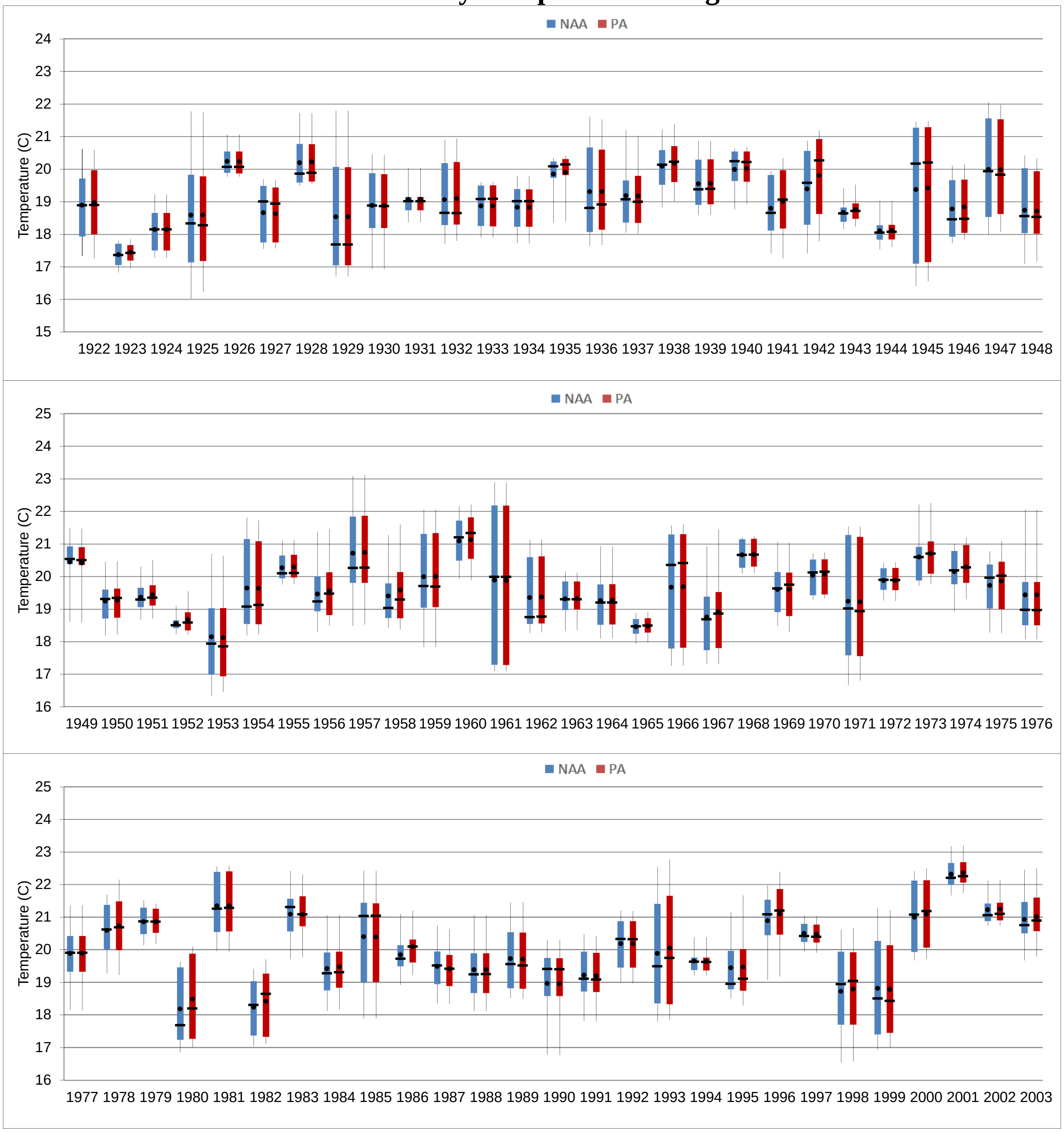


Figure 5.B.5.41-8 San Joaquin River at Prisoner's Point Monthly Temperature
July Daily Temperature Ranges

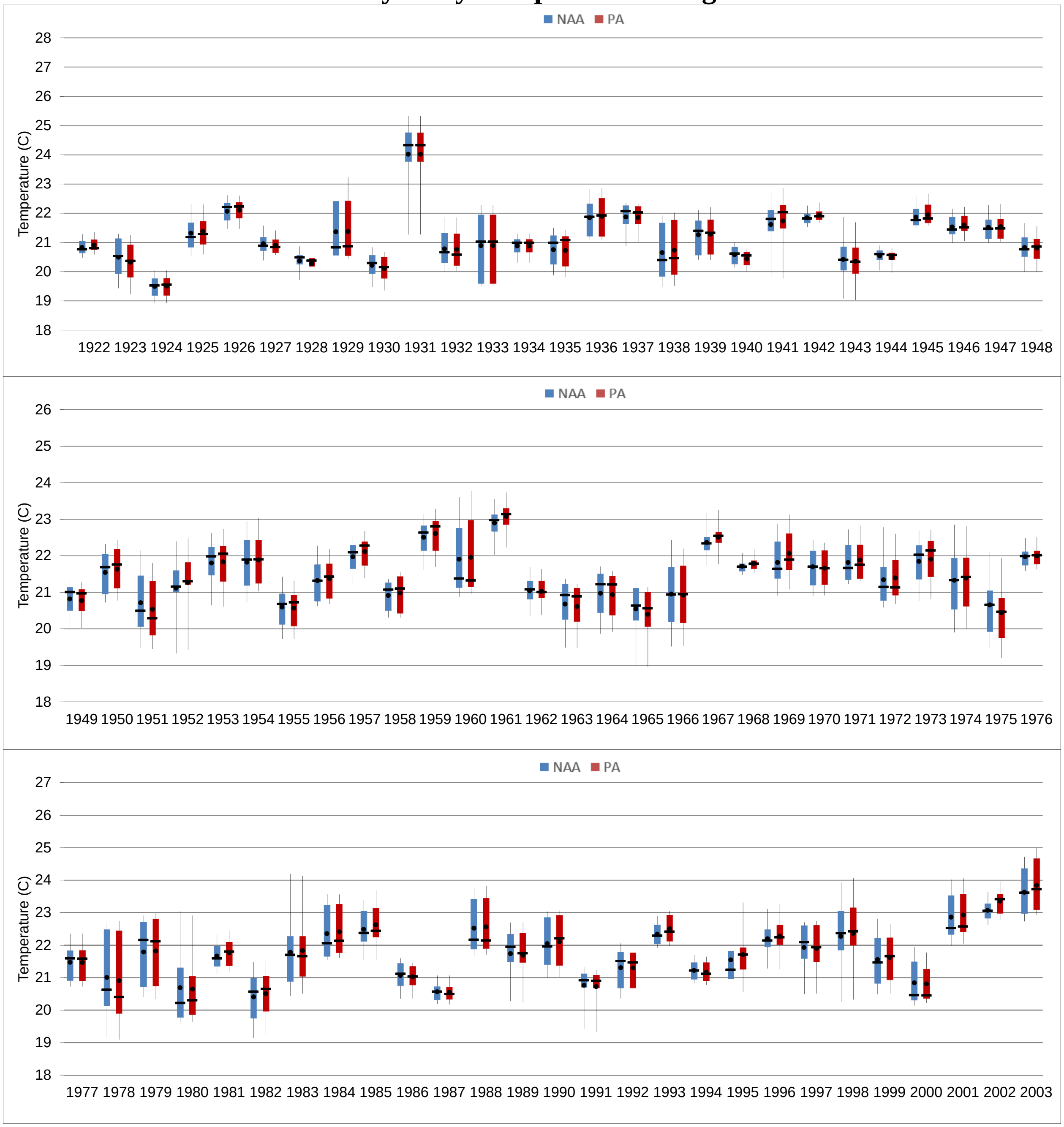


Figure 5.B.5.41-9 San Joaquin River at Prisoner's Point Monthly Temperature August Daily Temperature Ranges

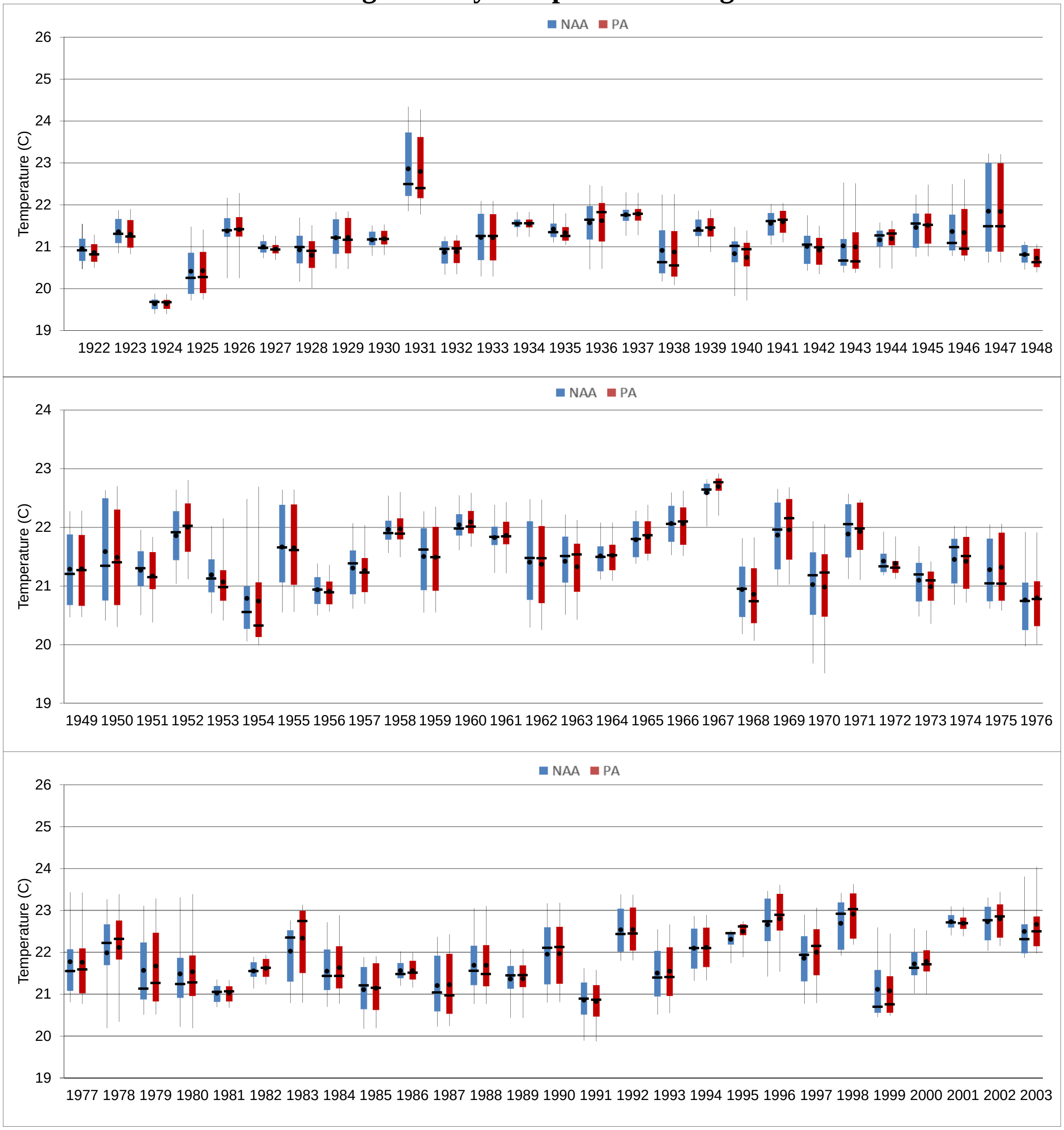


Figure 5.B.5.41-10 San Joaquin River at Prisoner's Point Monthly Temperature September Daily Temperature Ranges

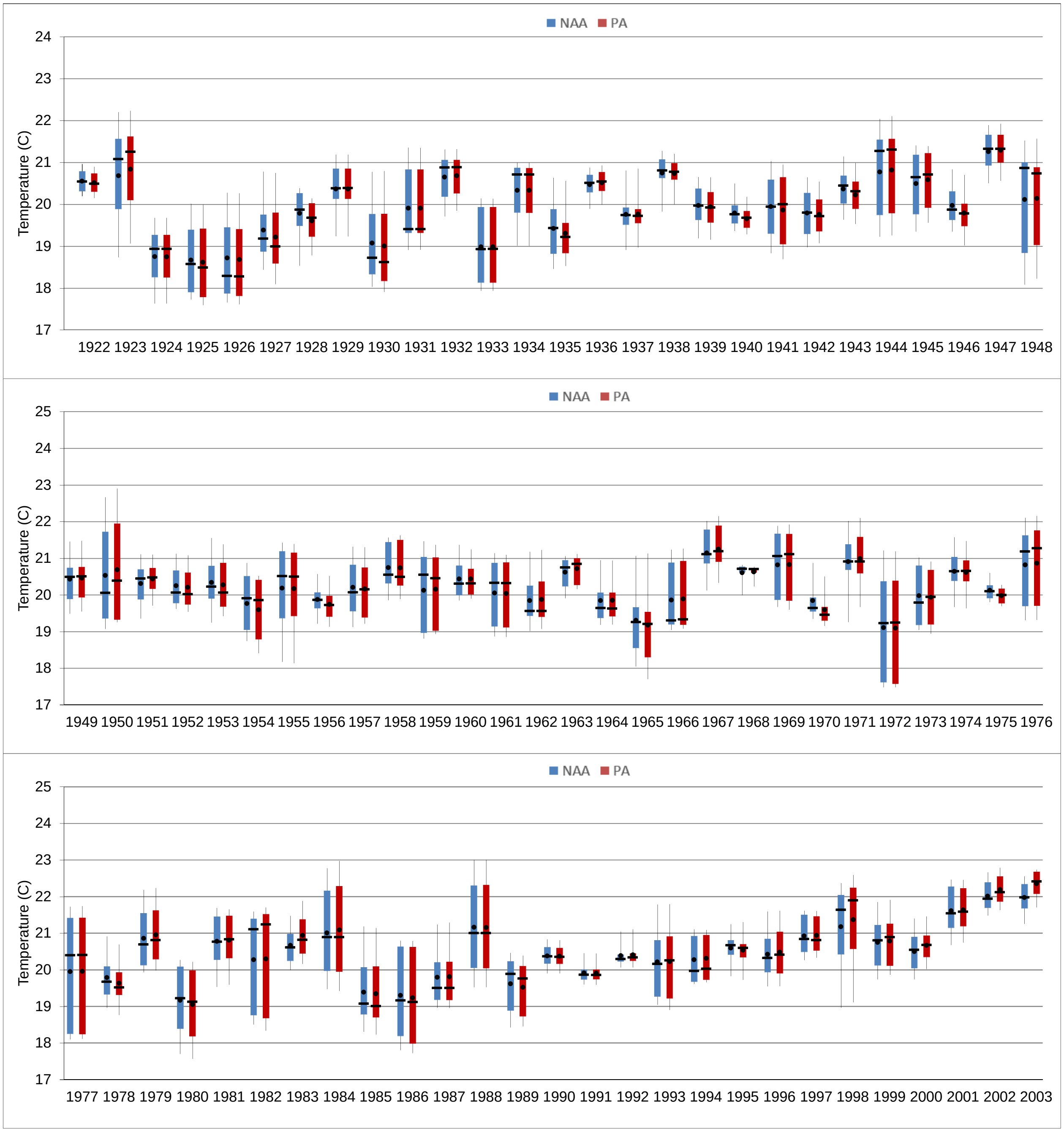
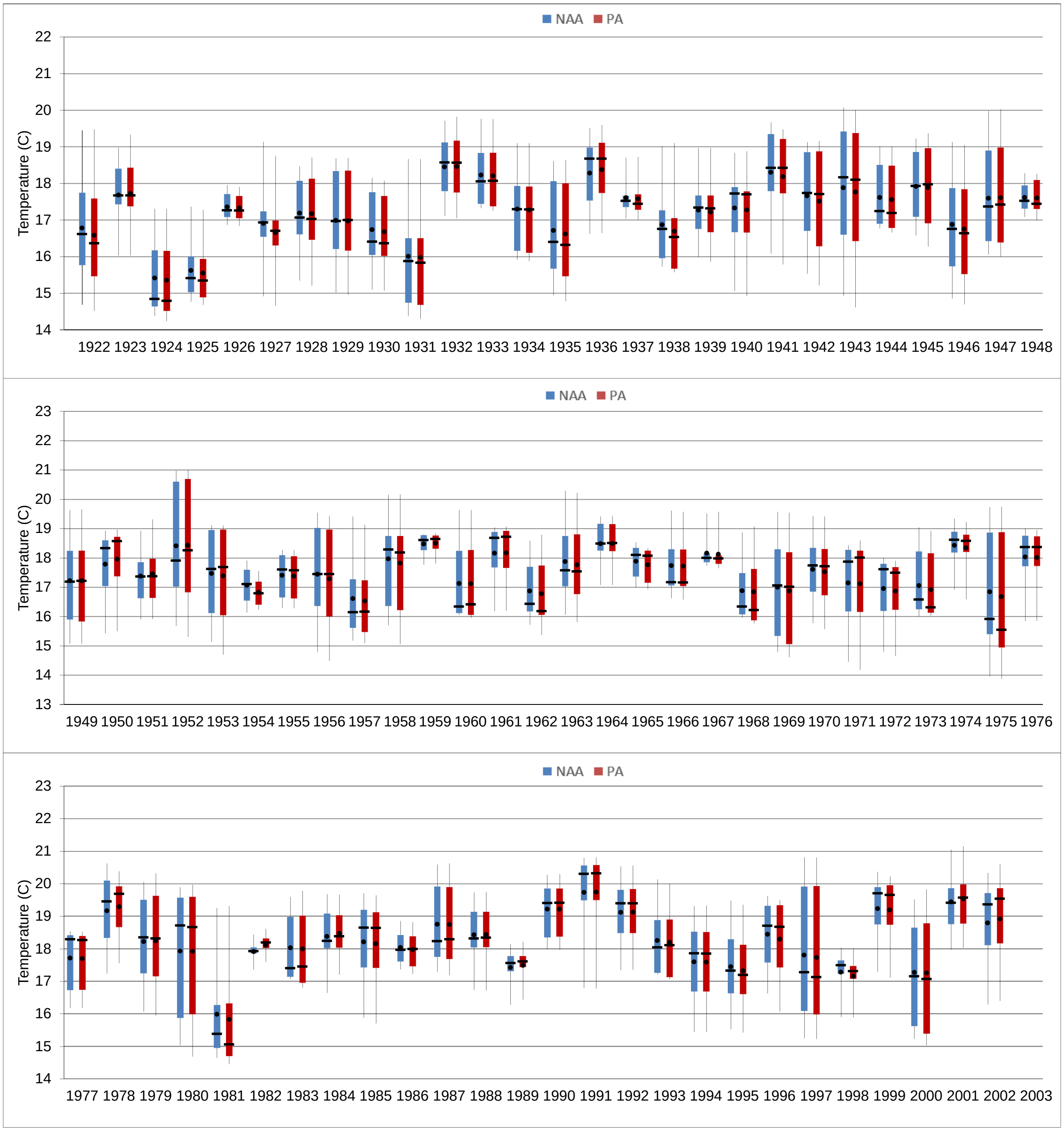


Figure 5.B.5.41-11 San Joaquin River at Prisoner's Point Monthly Temperature October Daily Temperature Ranges



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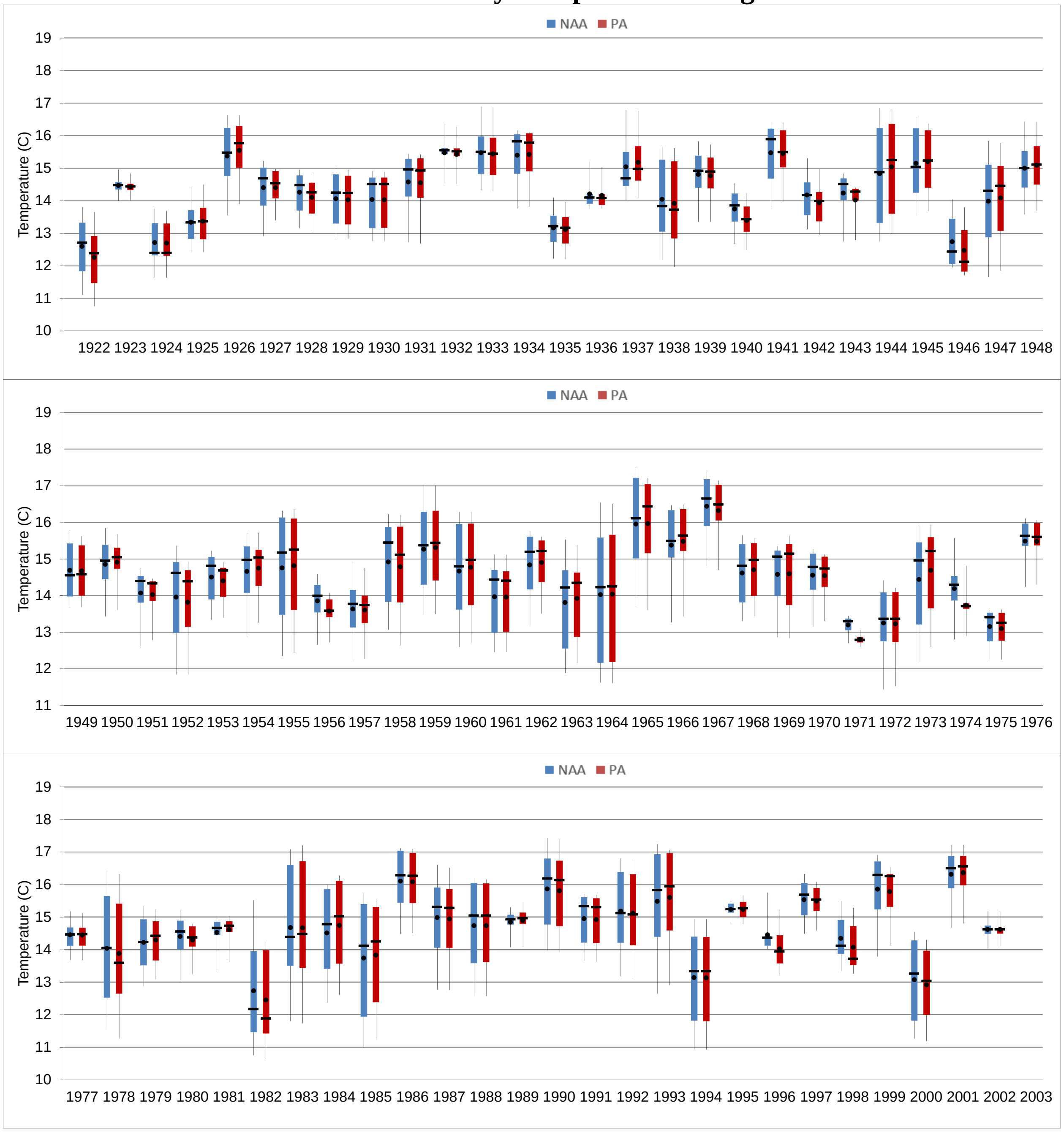


Figure 5.B.5.41-13 San Joaquin River at Prisoner's Point Monthly Temperature December Daily Temperature Ranges

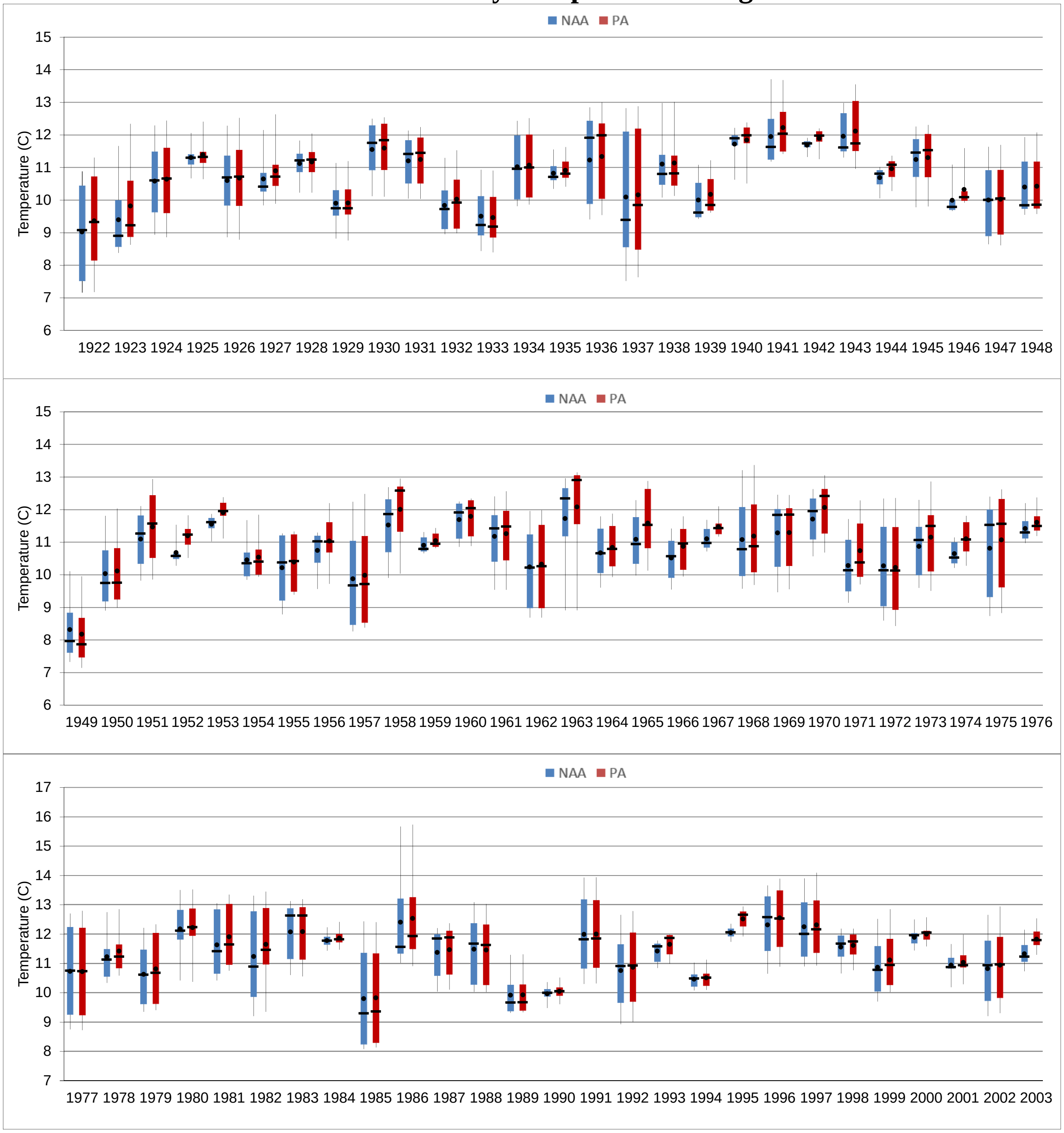


Figure 5.B.5.41-14 San Joaquin River at Prisoner's Point Monthly Temperature January Daily Temperature Ranges

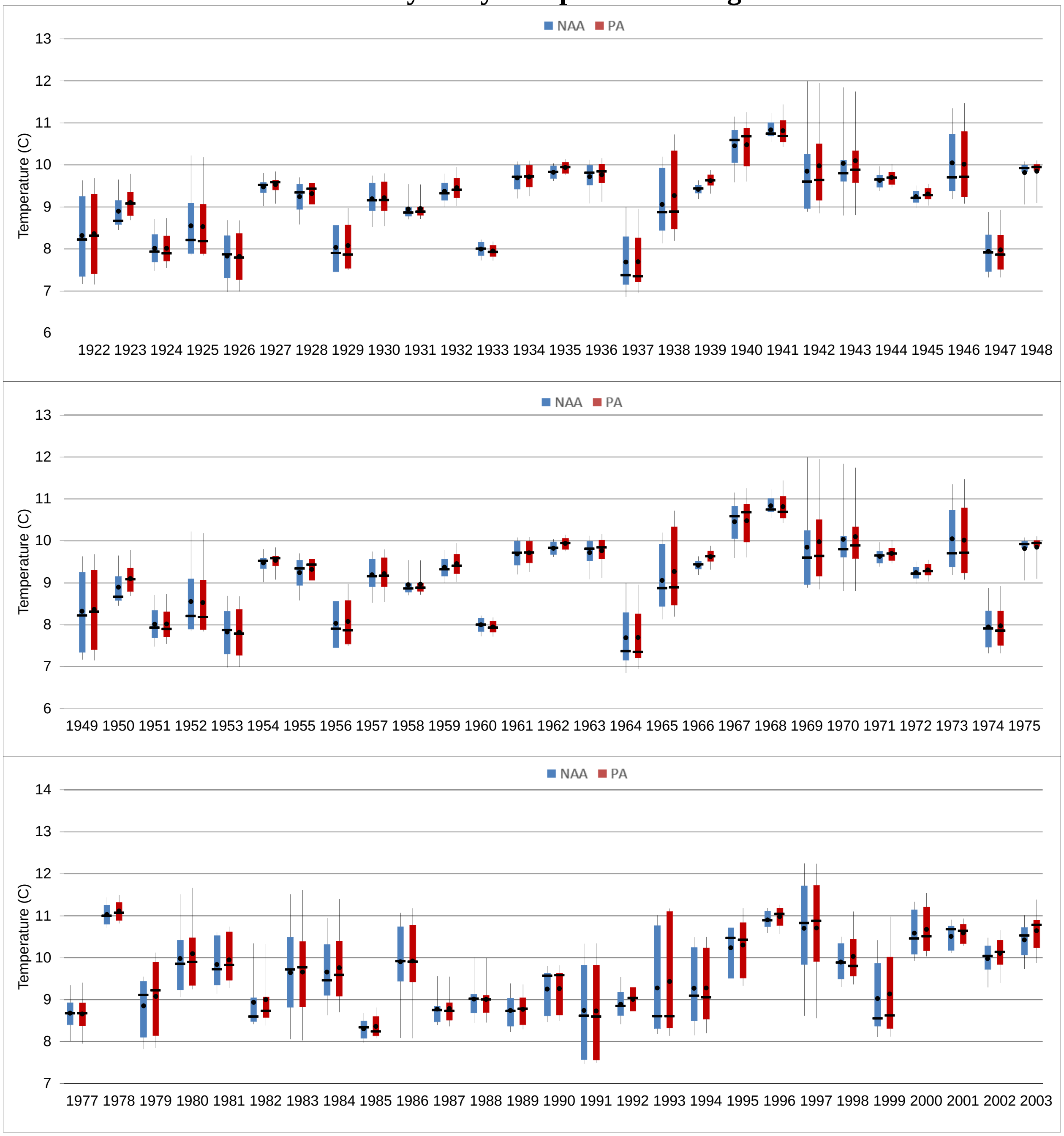
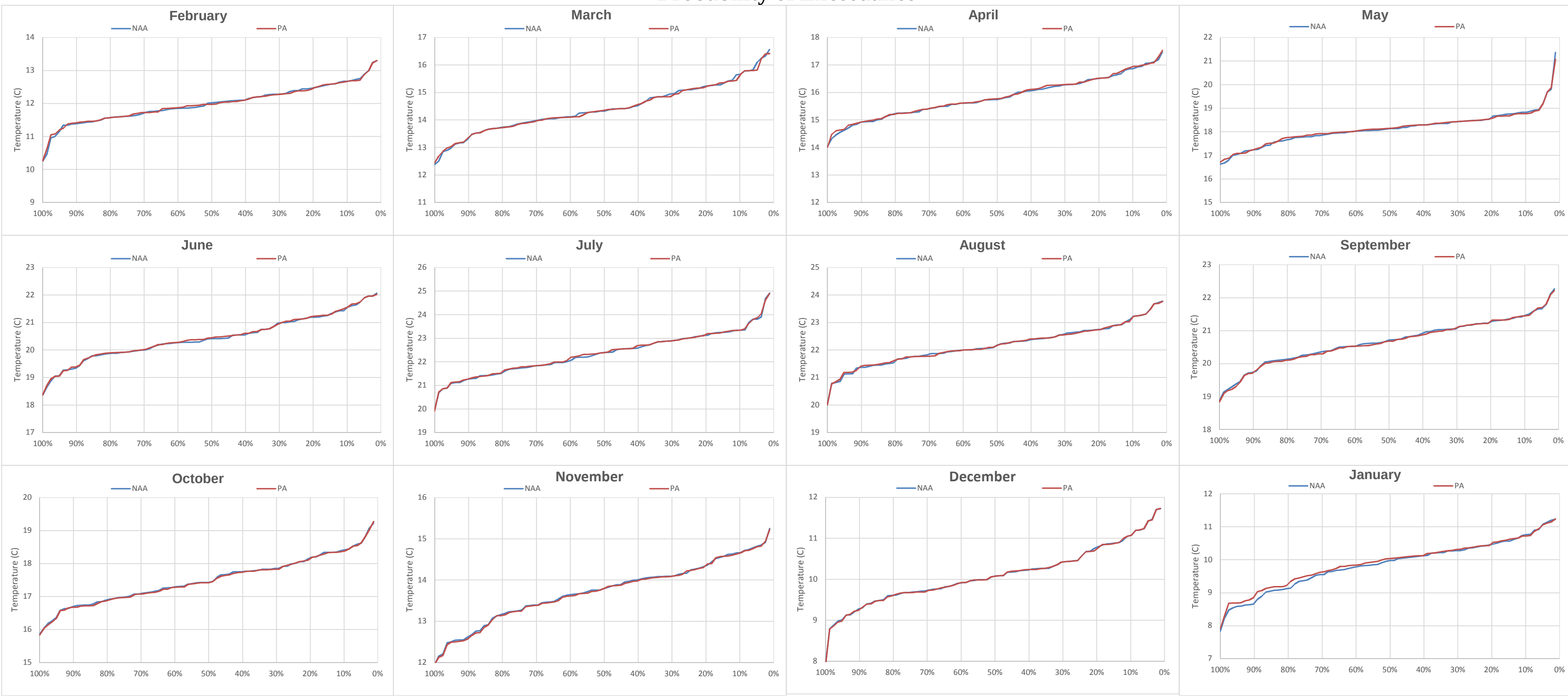


Figure 5.B.5.42-1 San Joaquin River at Brandt Bridge Monthly Temperature Probability of Exceedance



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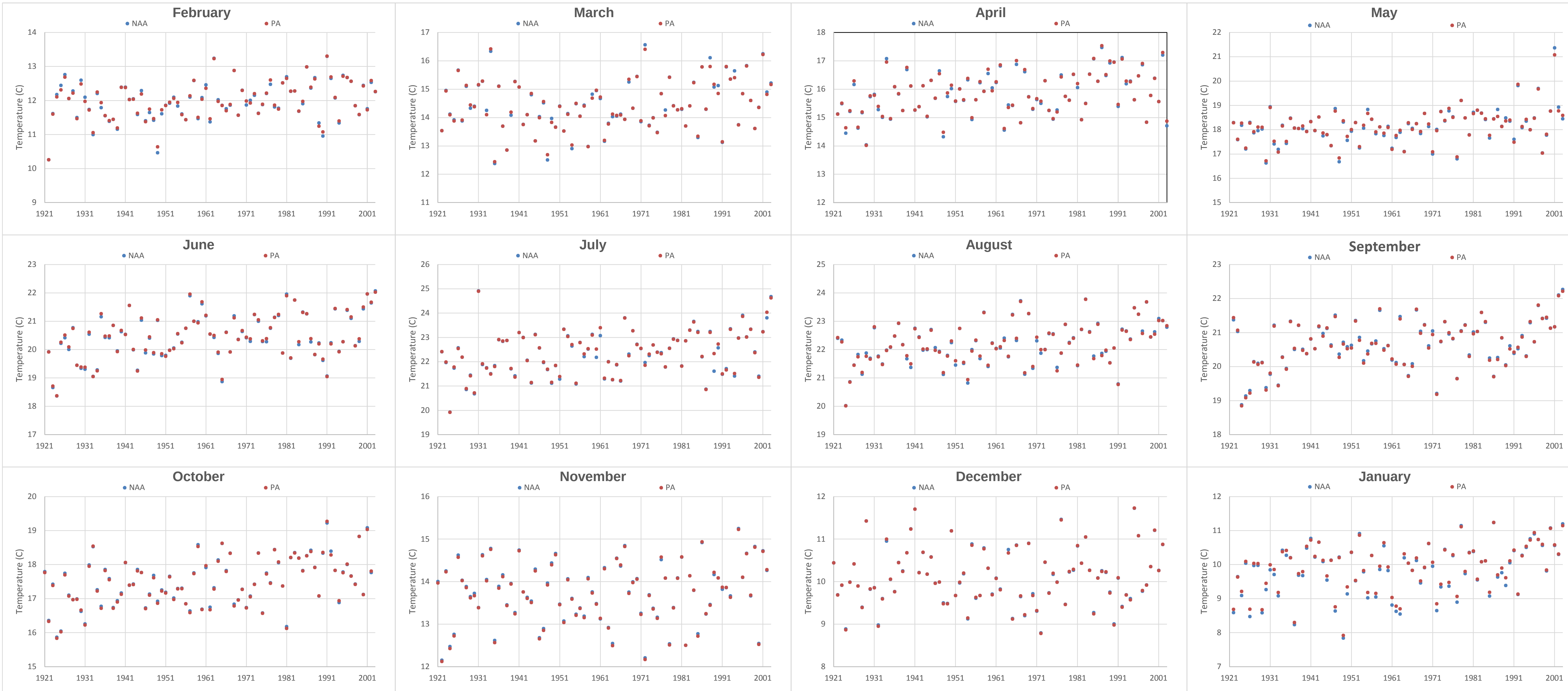
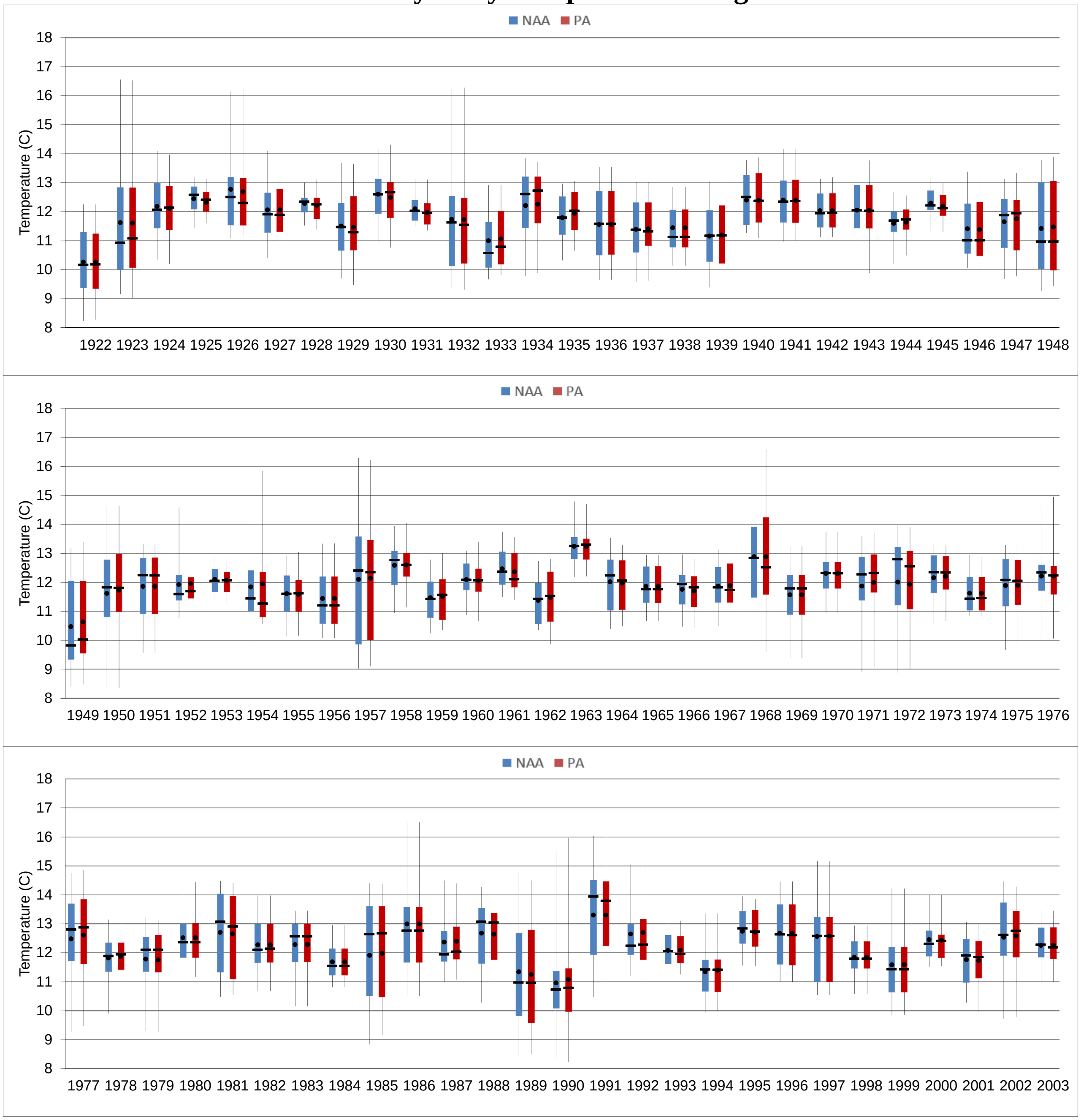


Figure 5.B.5.42-3 San Joaquin River at Brandt Bridge Monthly Temperature February Daily Temperature Ranges



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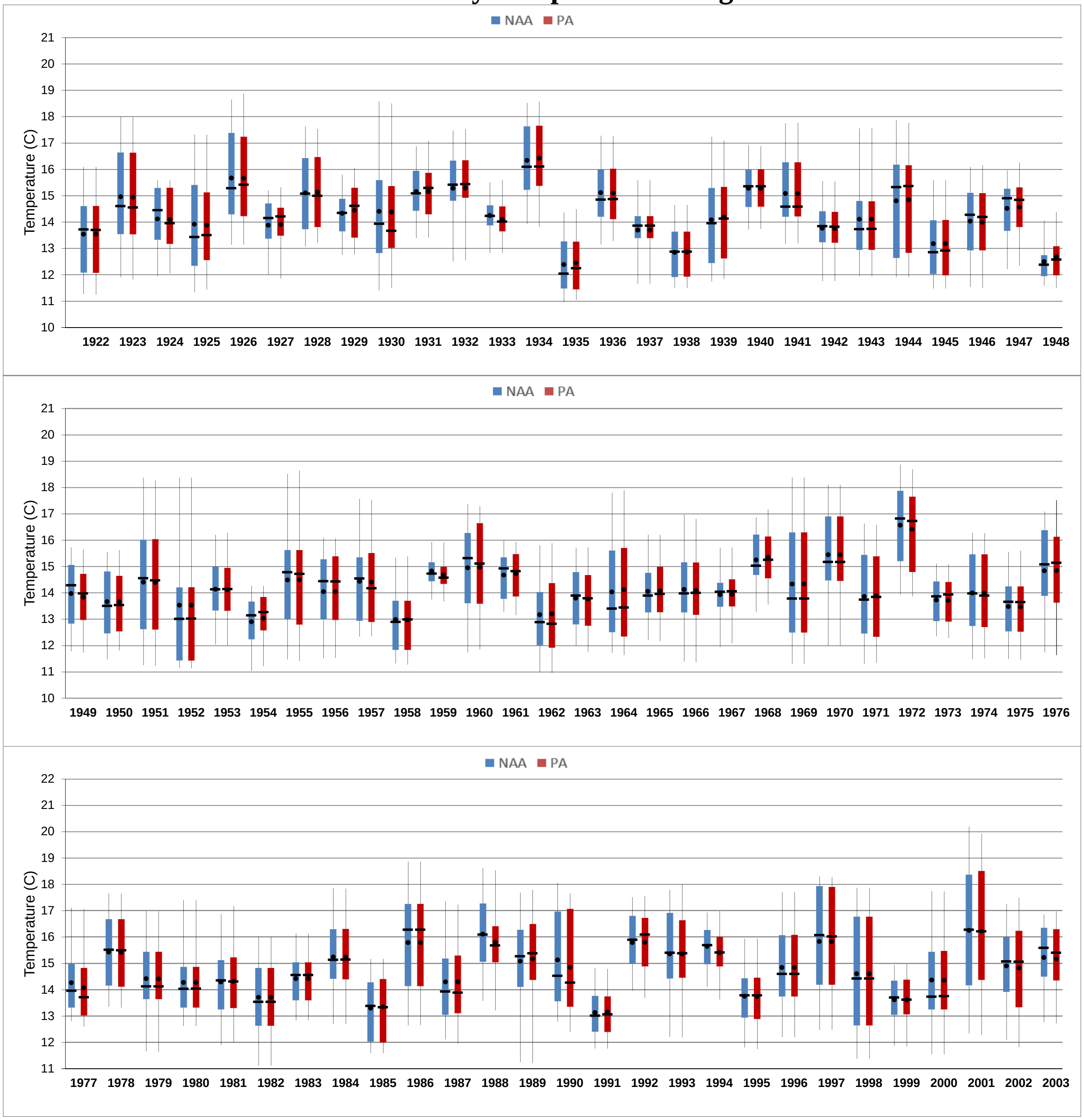


Figure 5.B.5.42-5 San Joaquin River at Brandt Bridge Monthly Temperature
April Daily Temperature Ranges

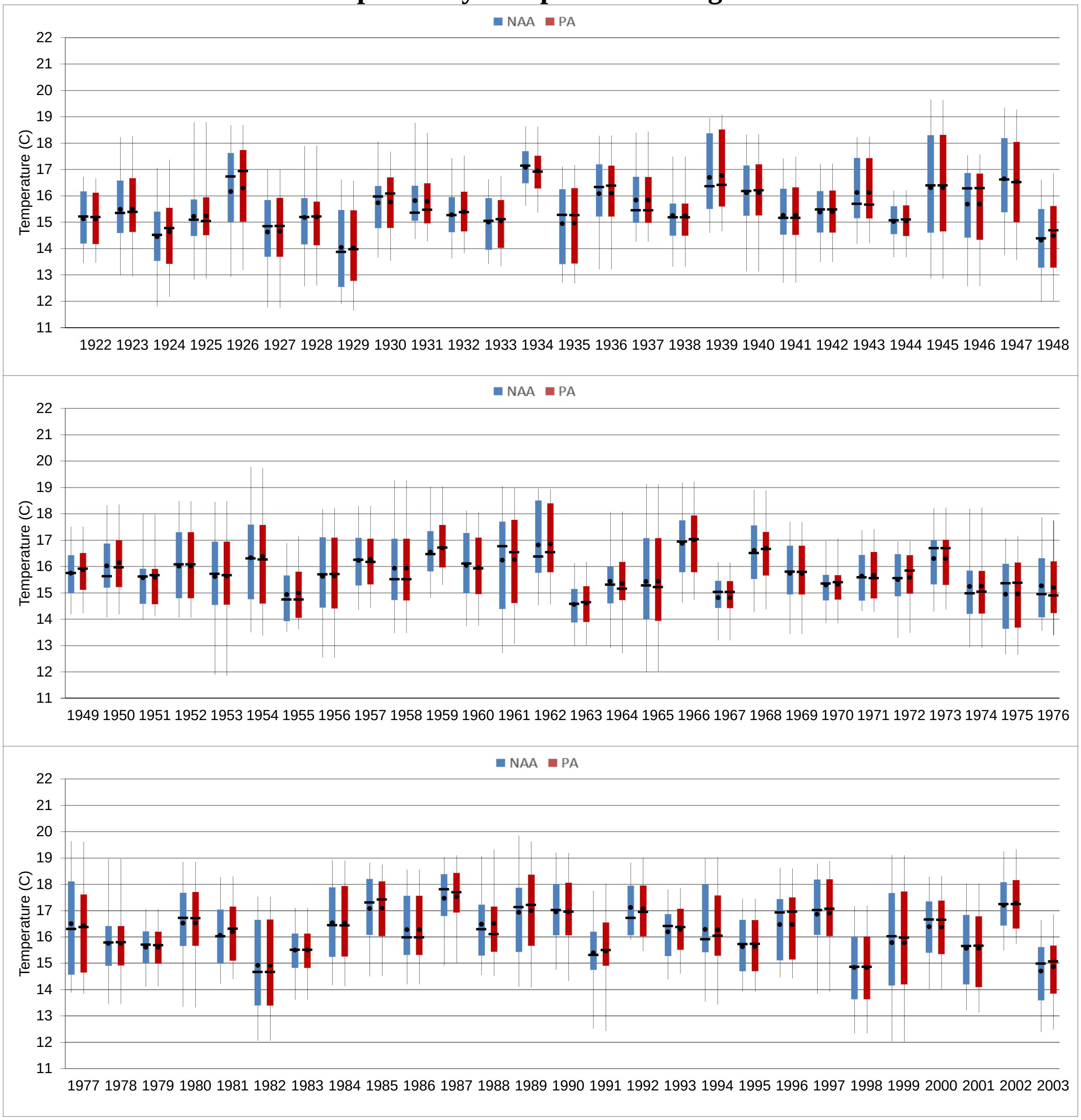


Figure 5.B.5.42-6 San Joaquin River at Brandt Bridge Monthly Temperature May Daily Temperature Ranges

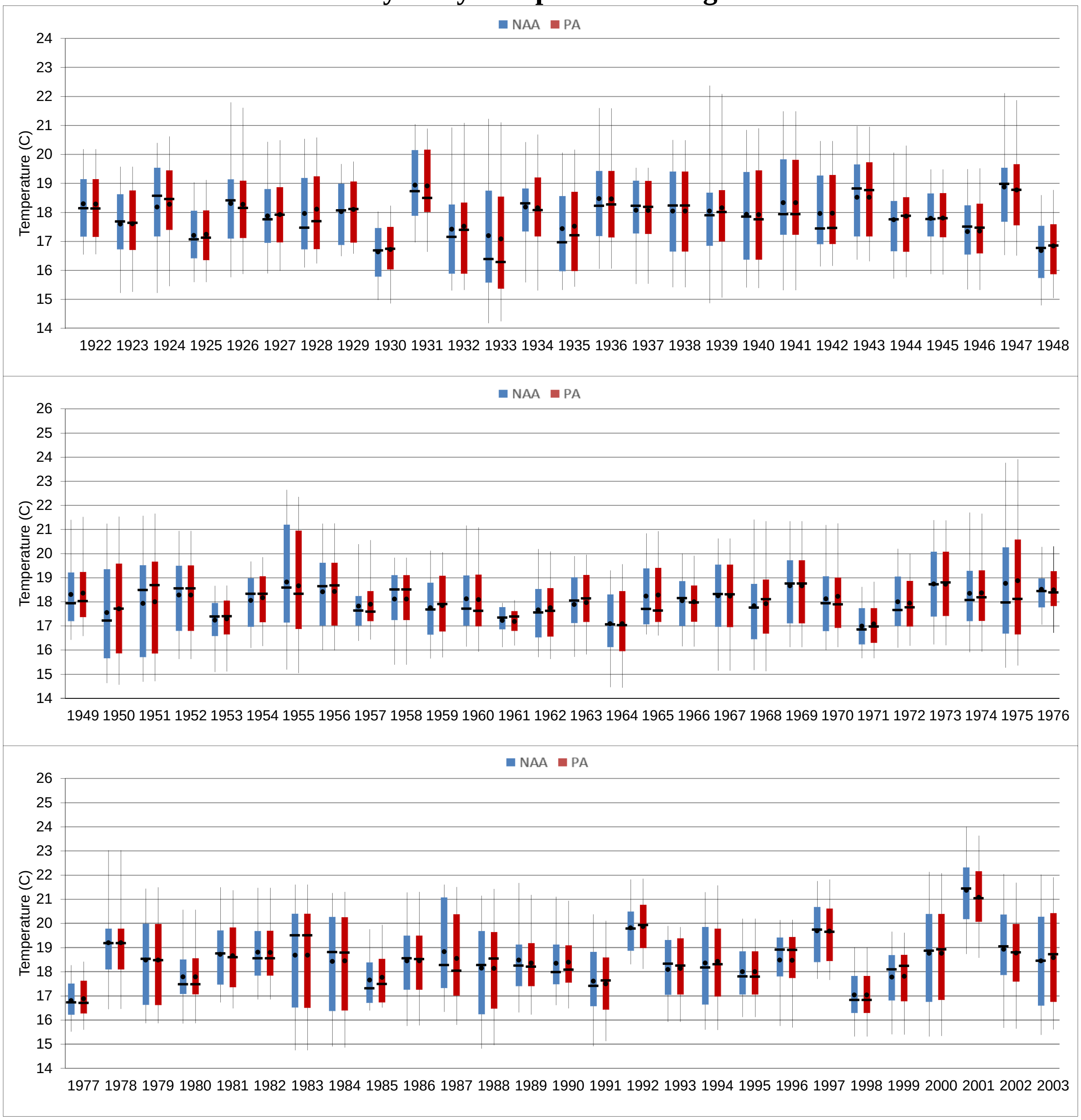


Figure 5.B.5.42-7 San Joaquin River at Brandt Bridge Monthly Temperature
June Daily Temperature Ranges

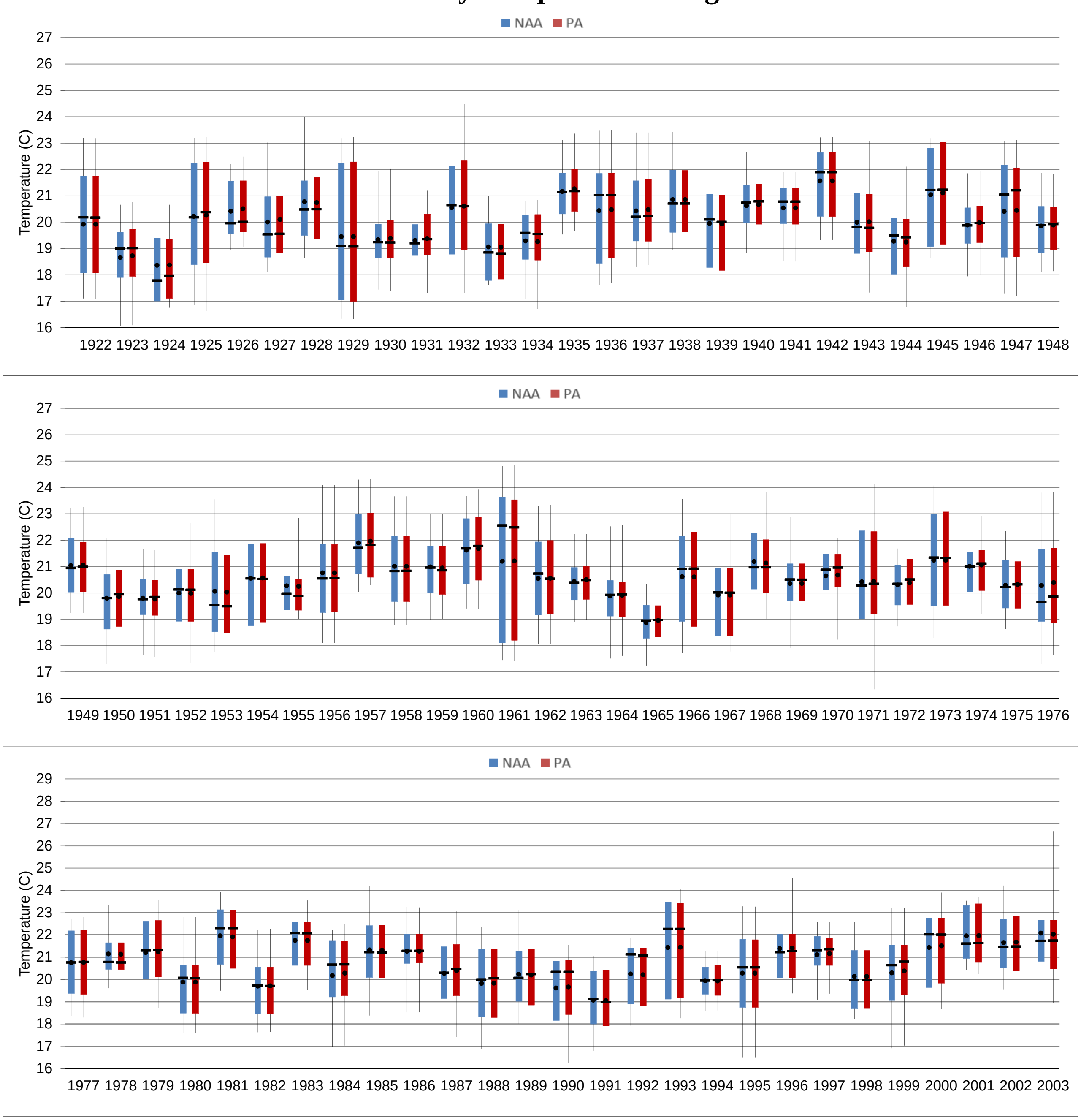


Figure 5.B.5.42-8 San Joaquin River at Brandt Bridge Monthly Temperature
July Daily Temperature Ranges

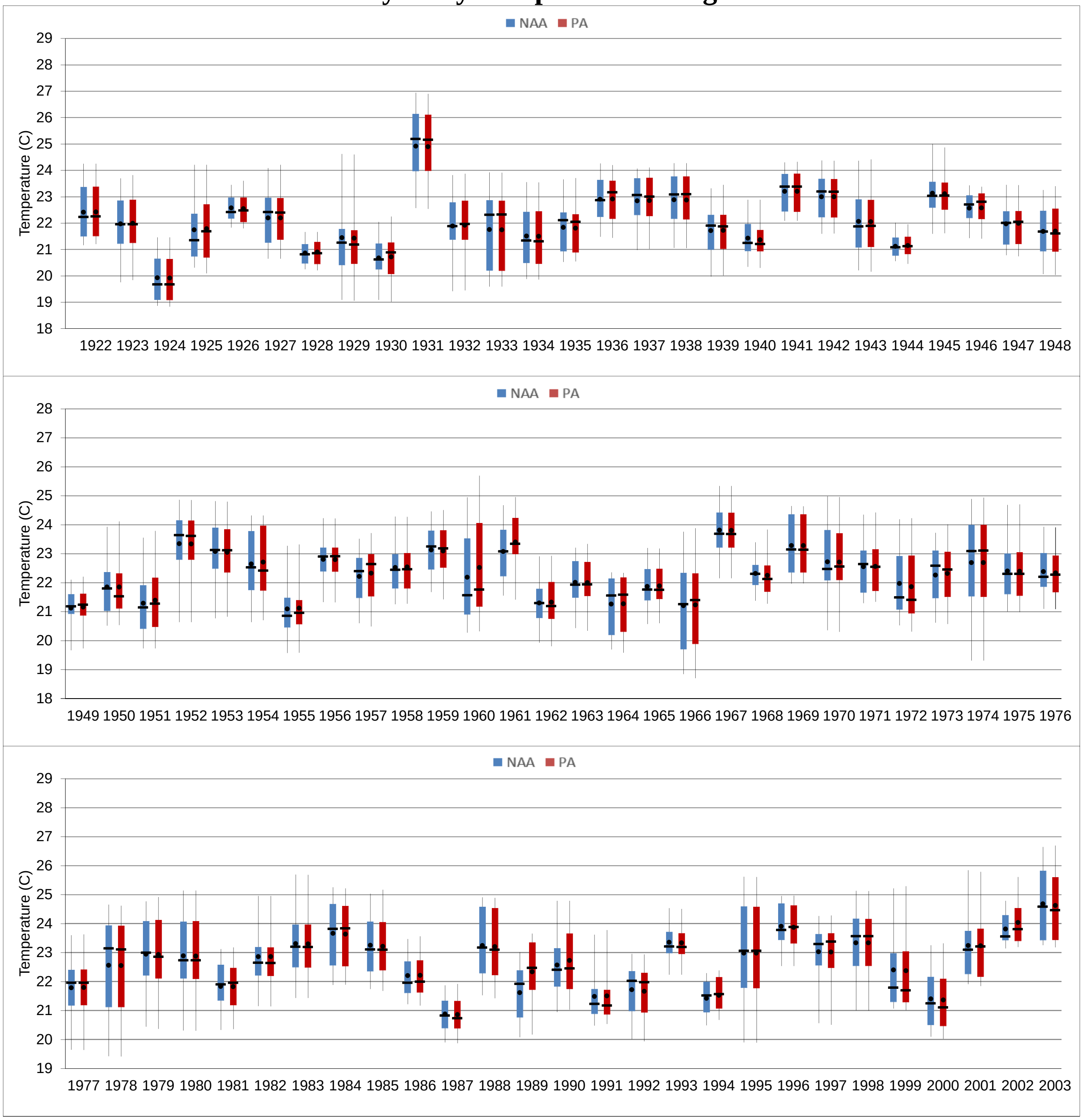


Figure 5.B.5.42-9 San Joaquin River at Brandt Bridge Monthly Temperature August Daily Temperature Ranges

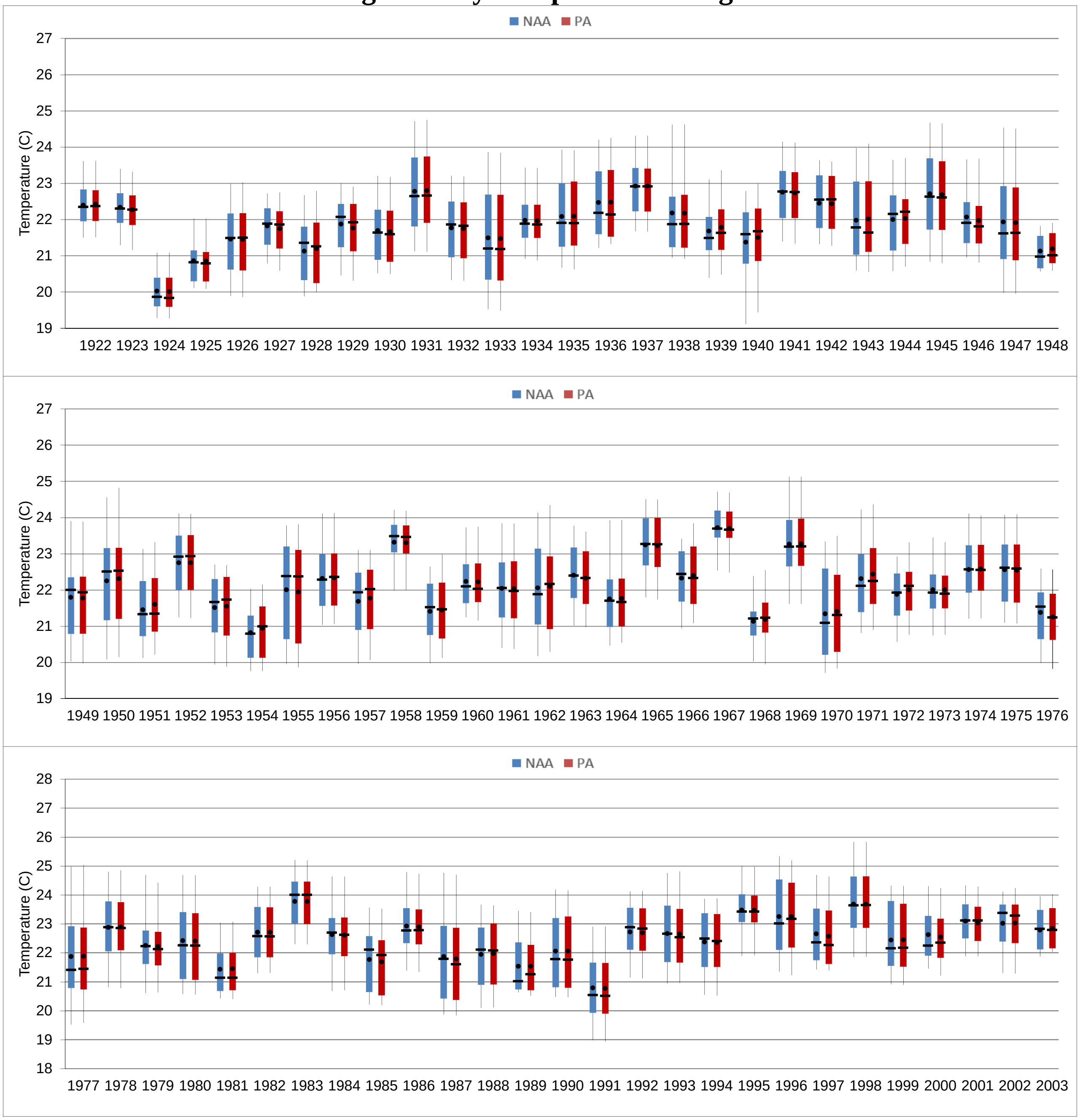


Figure 5.B.5.42-10 San Joaquin River at Brandt Bridge Monthly Temperature
September Daily Temperature Ranges

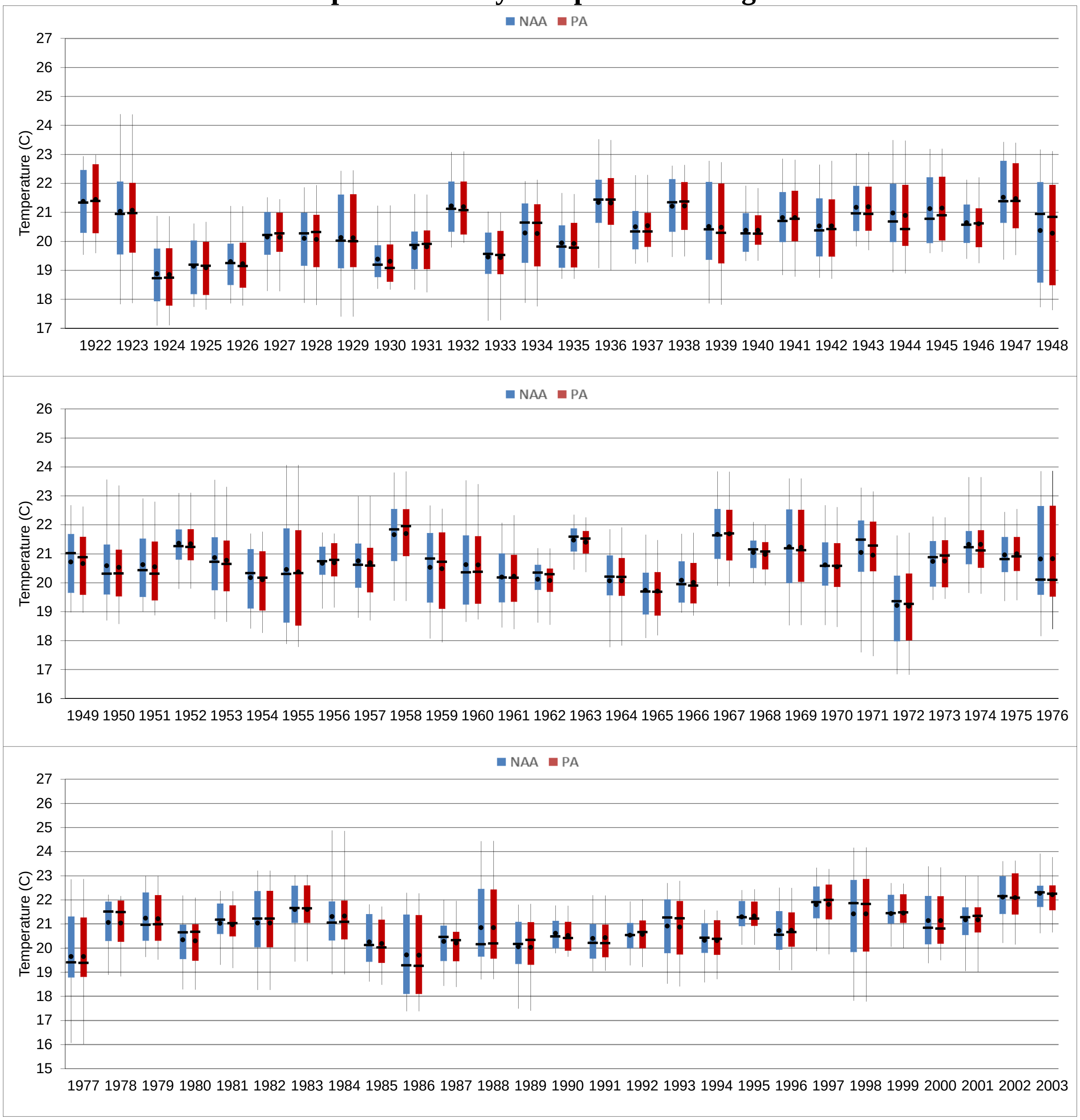
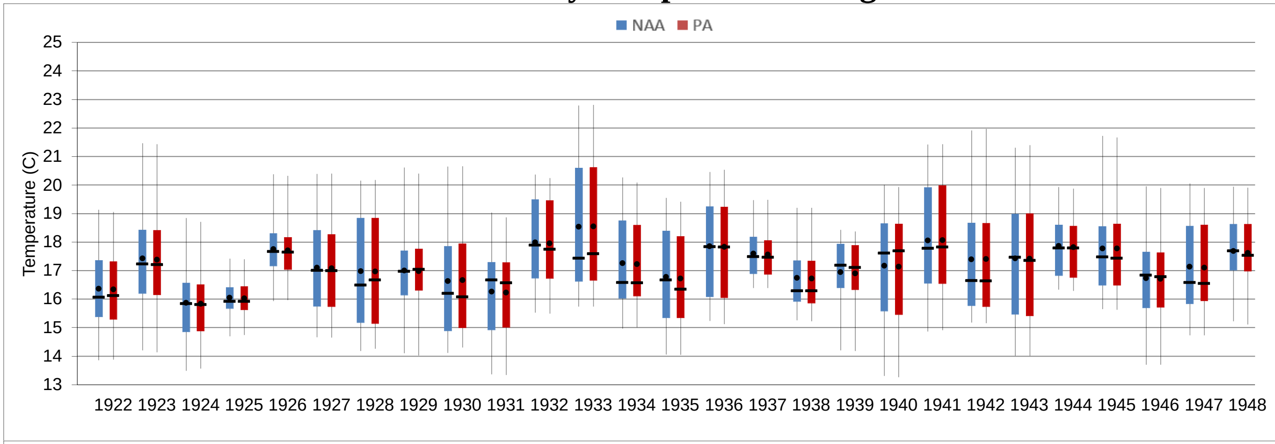
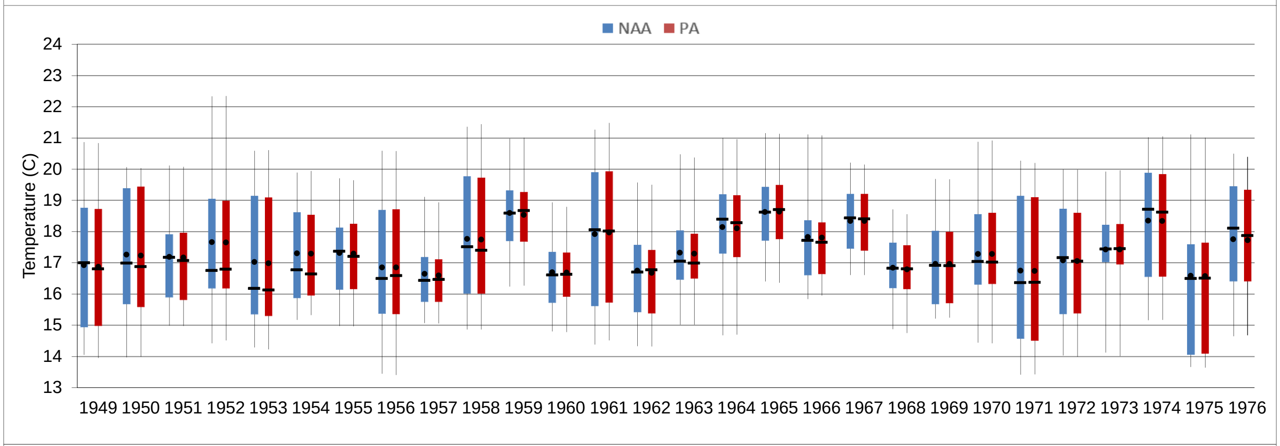


Figure 5.B.5.42-11 San Joaquin River at Brandt Bridge Monthly Temperature October Daily Temperature Ranges





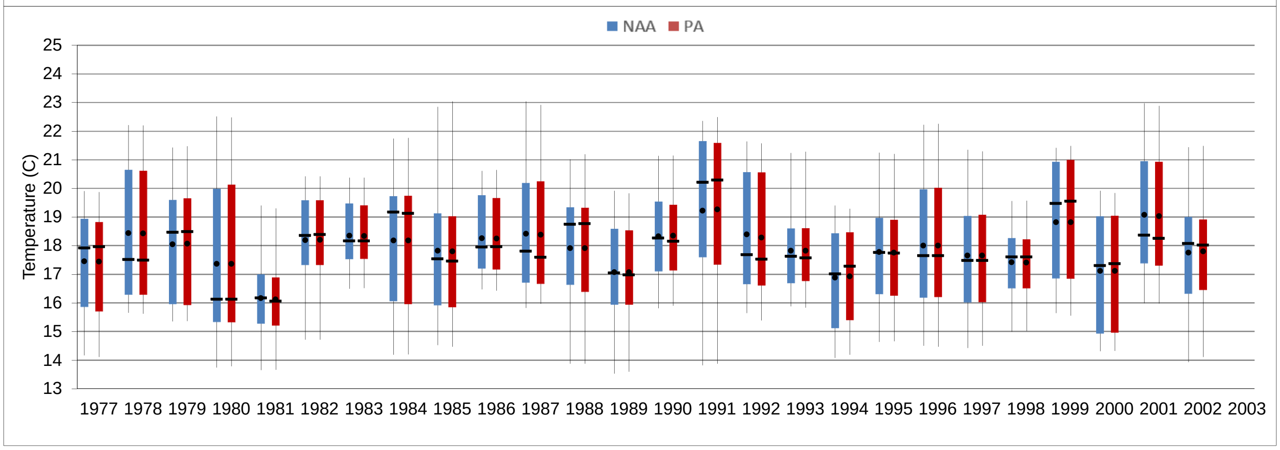


Figure 5.B.5.42-12 San Joaquin River at Brandt Bridge Monthly Temperature November Daily Temperature Ranges

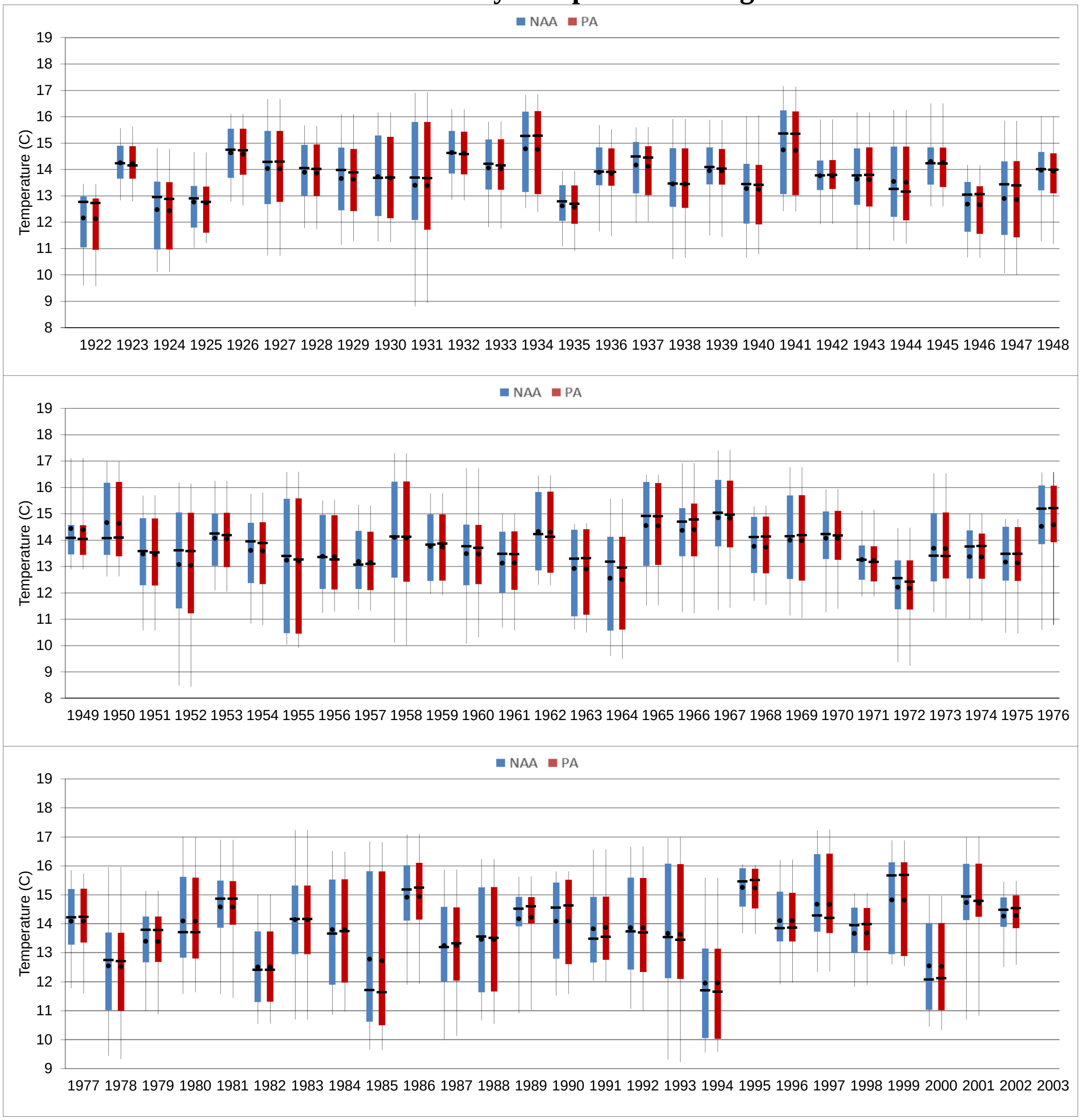


Figure 5.B.5.42-13 San Joaquin River at Brandt Bridge Monthly Temperature December Daily Temperature Ranges

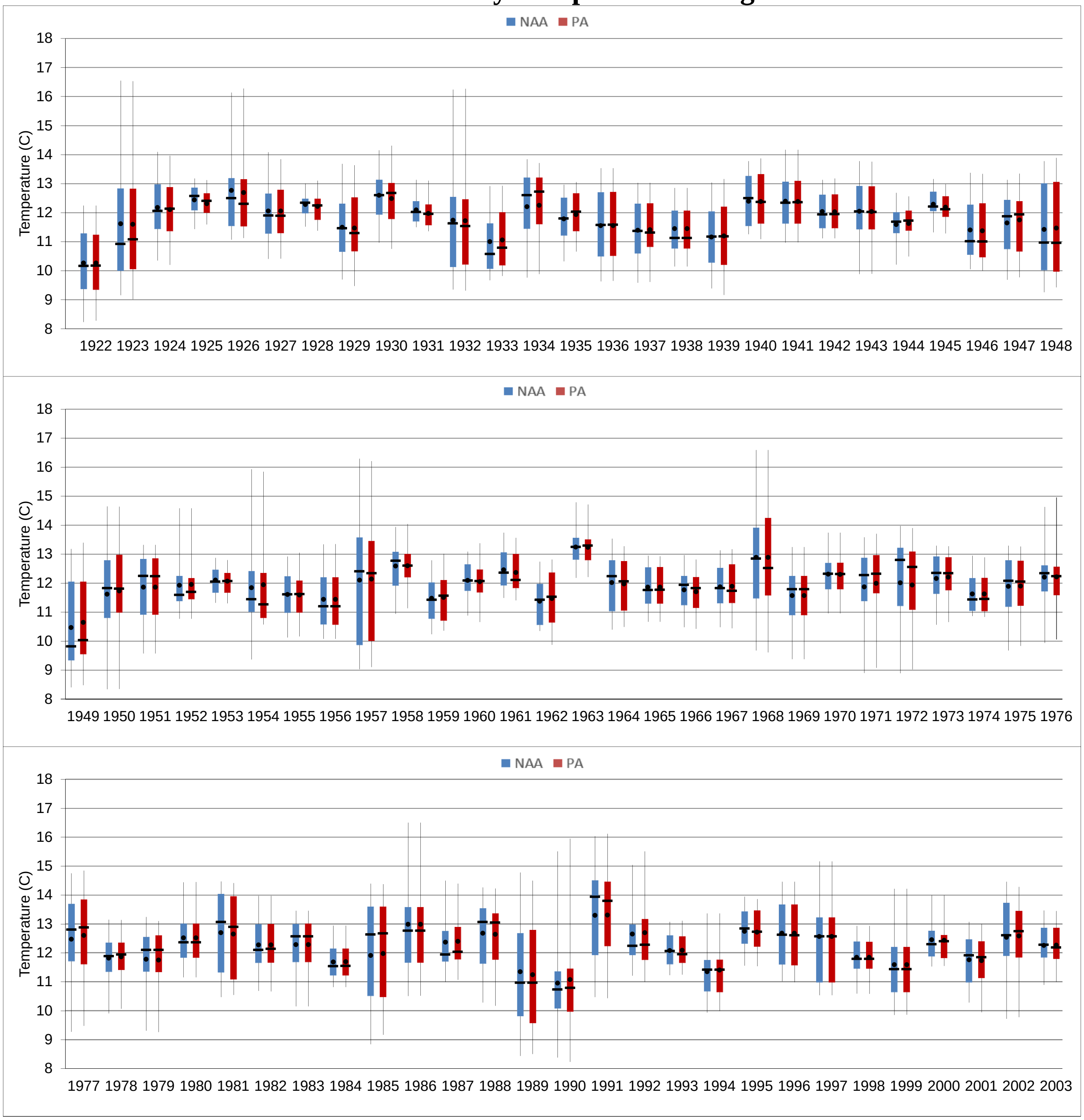


Figure 5.B.5.42-14 San Joaquin River at Brandt Bridge Monthly Temperature January Daily Temperature Ranges

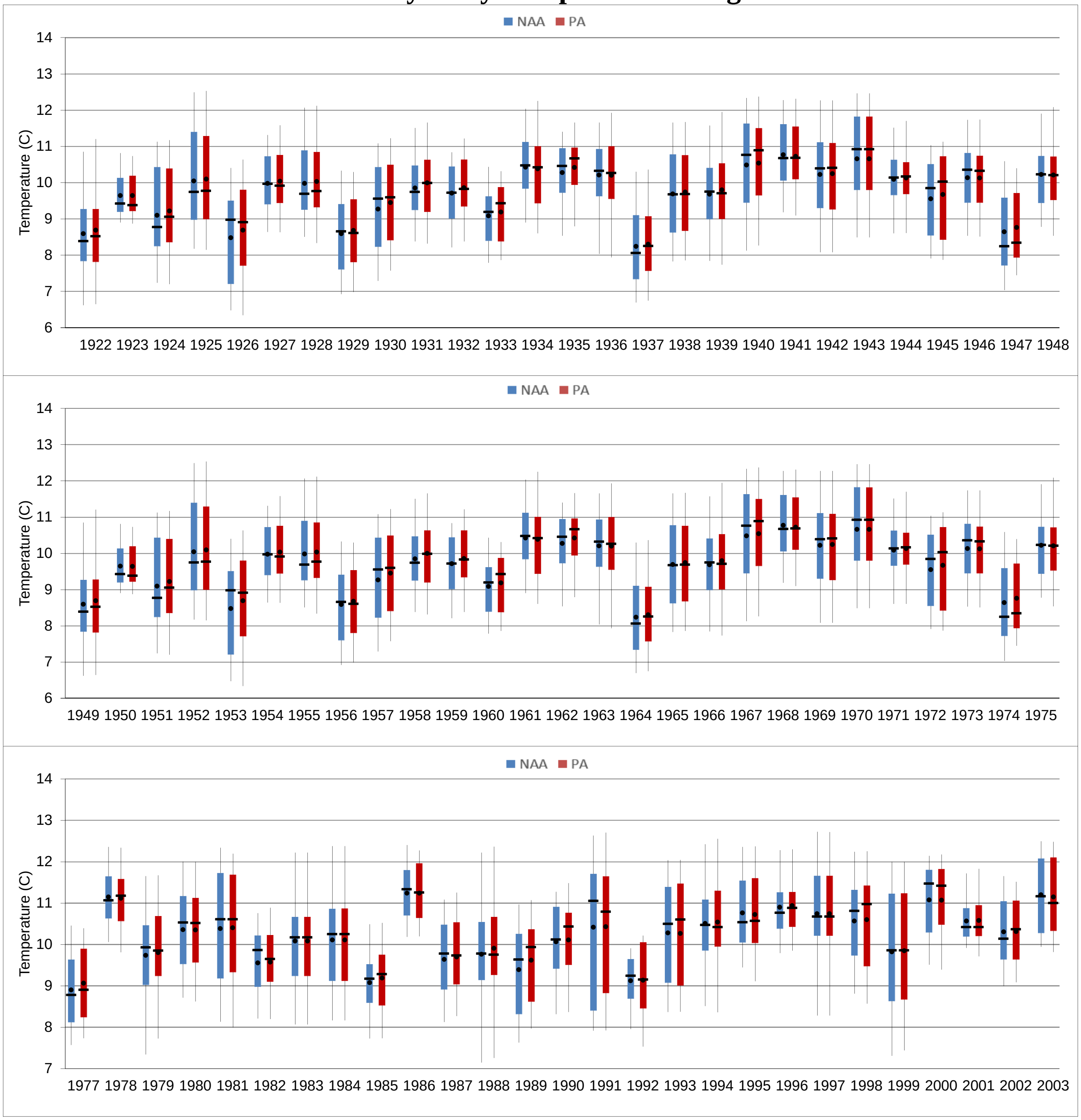


Figure 5.B.5.43-1 Stockton Deep Water Ship Channel Monthly Temperature Probability of Exceedance

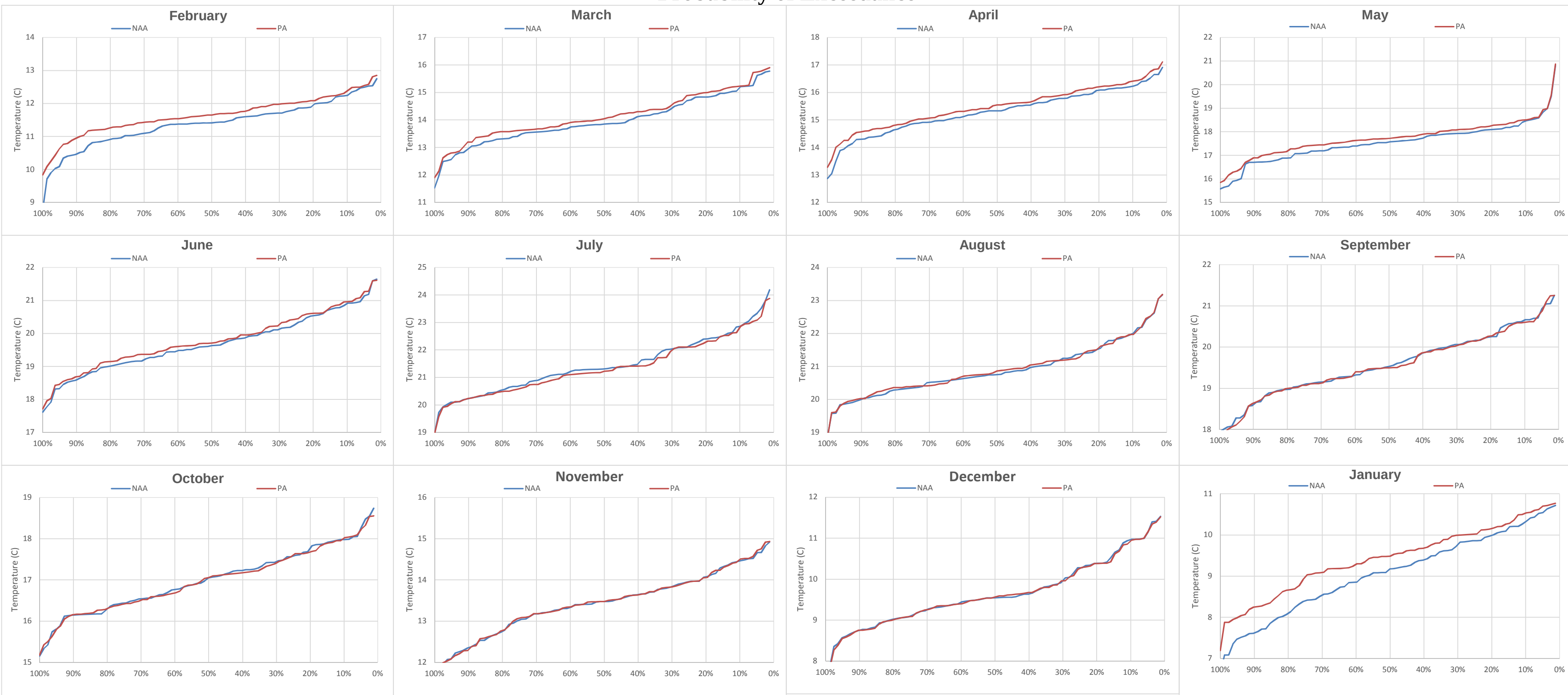


Figure 5.B.5.43-2 Stockton Deep Water Ship Channel Monthly Temperature

Figure 5.B.5.43-3 Stockton Deep Water Ship Channel Monthly Temperature February Daily Temperature Ranges

Figure 5.B.5.43-4 Stockton Deep Water Ship Channel Monthly Temperature March Daily Temperature Ranges

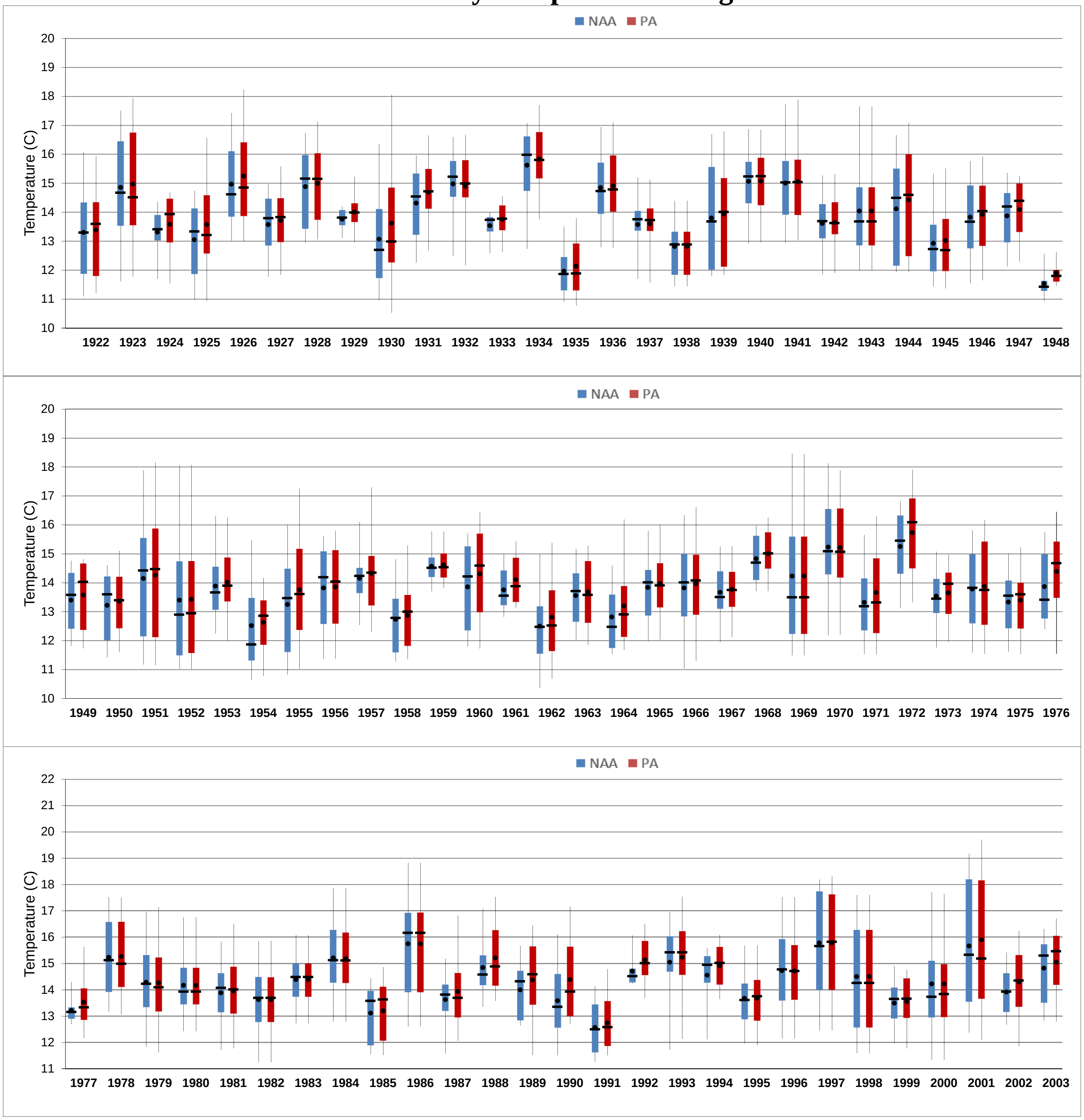


Figure 5.B.5.43-5 Stockton Deep Water Ship Channel Monthly Temperature April Daily Temperature Ranges

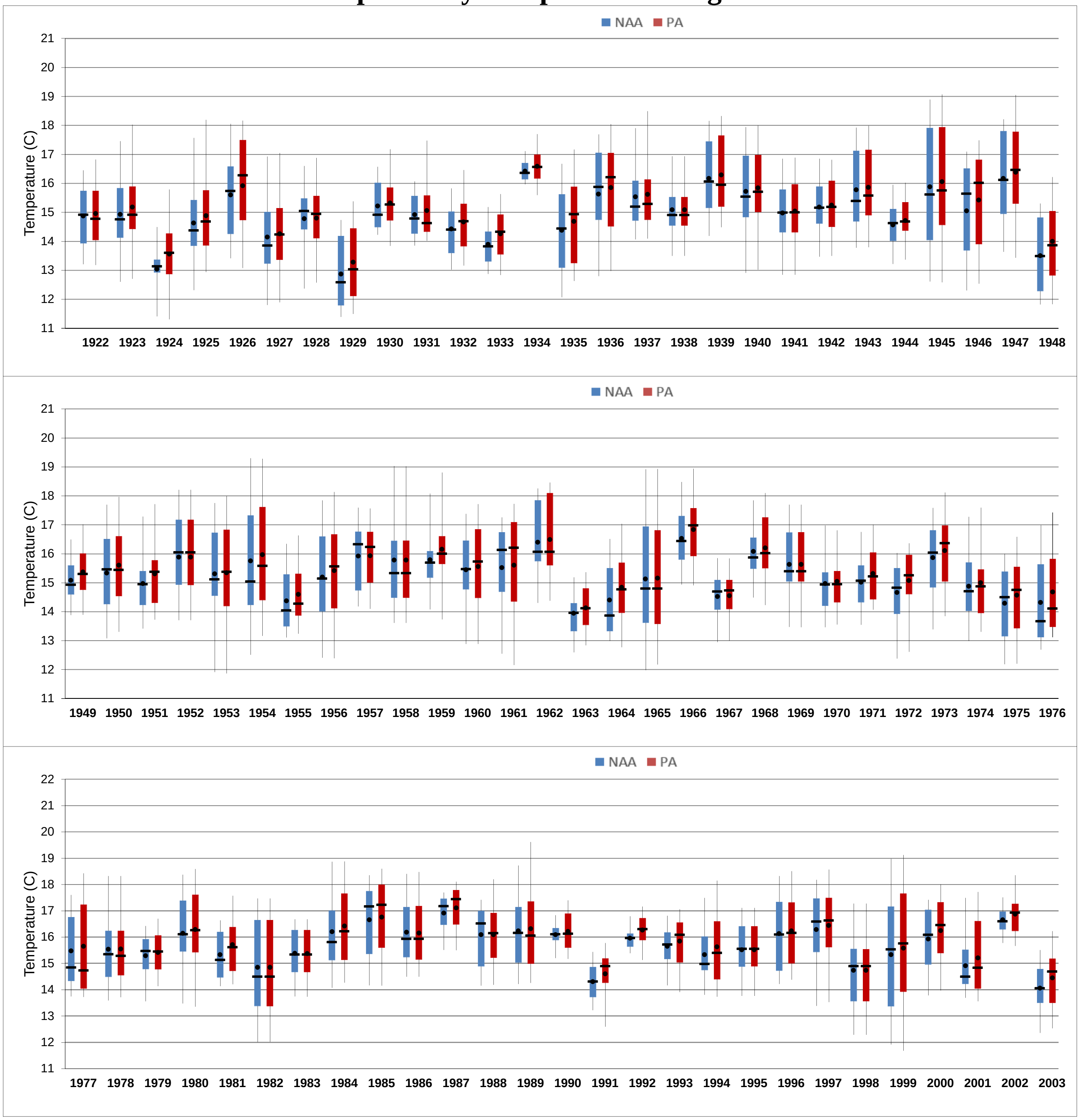


Figure 5.B.5.43-6 Stockton Deep Water Ship Channel Monthly Temperature May Daily Temperature Ranges

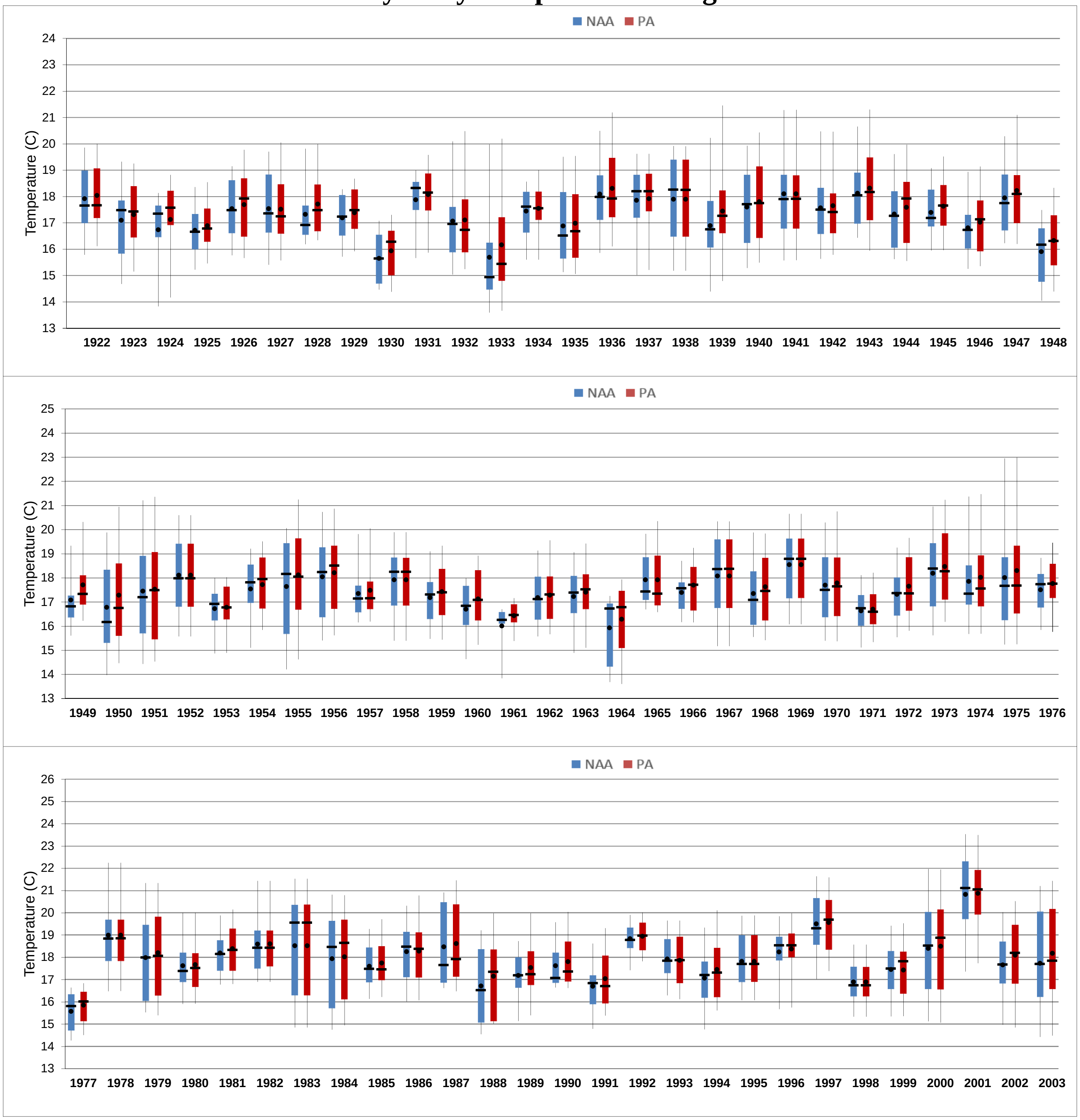
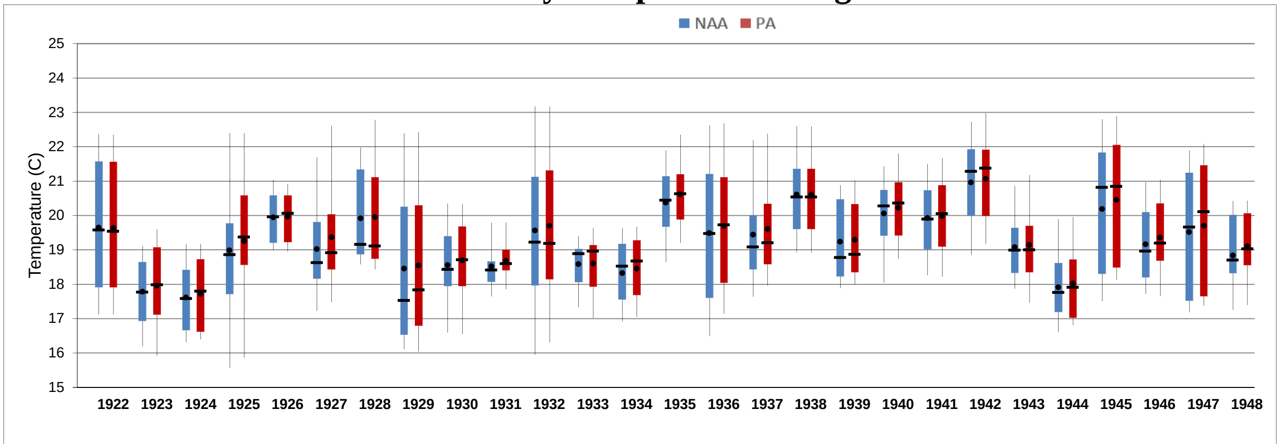
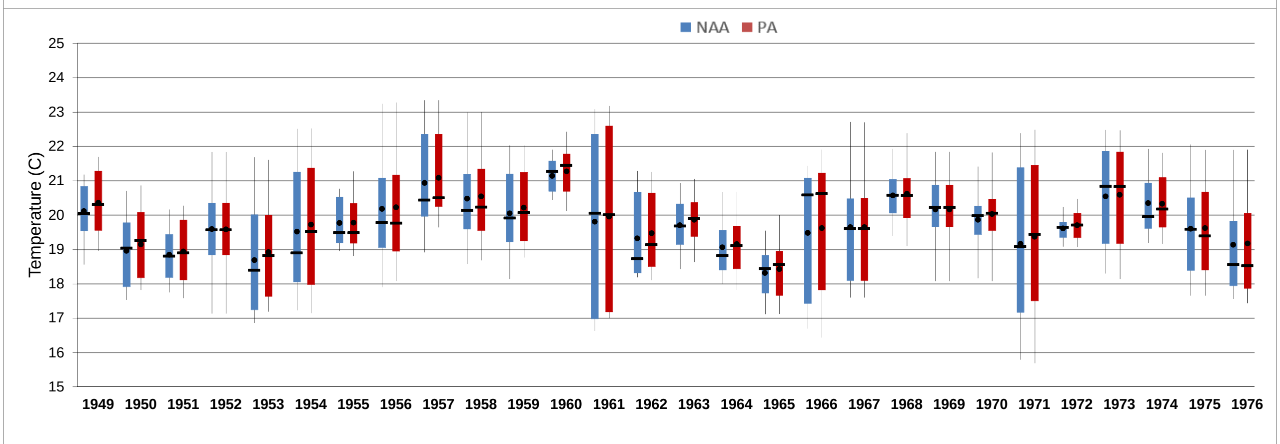


Figure 5.B.5.43-7 Stockton Deep Water Ship Channel Monthly Temperature June Daily Temperature Ranges





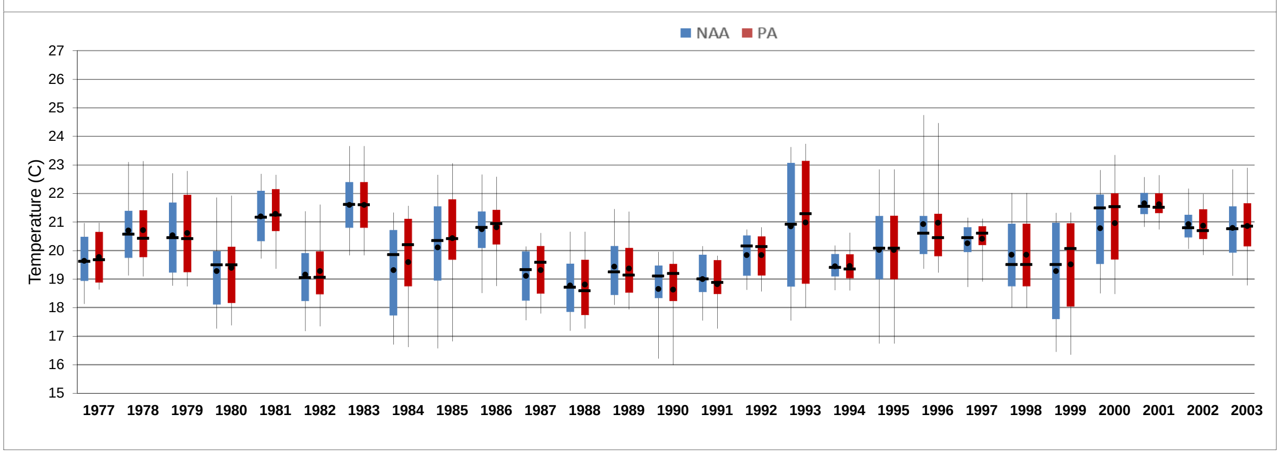


Figure 5.B.5.43-8 Stockton Deep Water Ship Channel Monthly Temperature July Daily Temperature Ranges

Figure 5.B.5.43-9 Stockton Deep Water Ship Channel Monthly Temperature August Daily Temperature Ranges

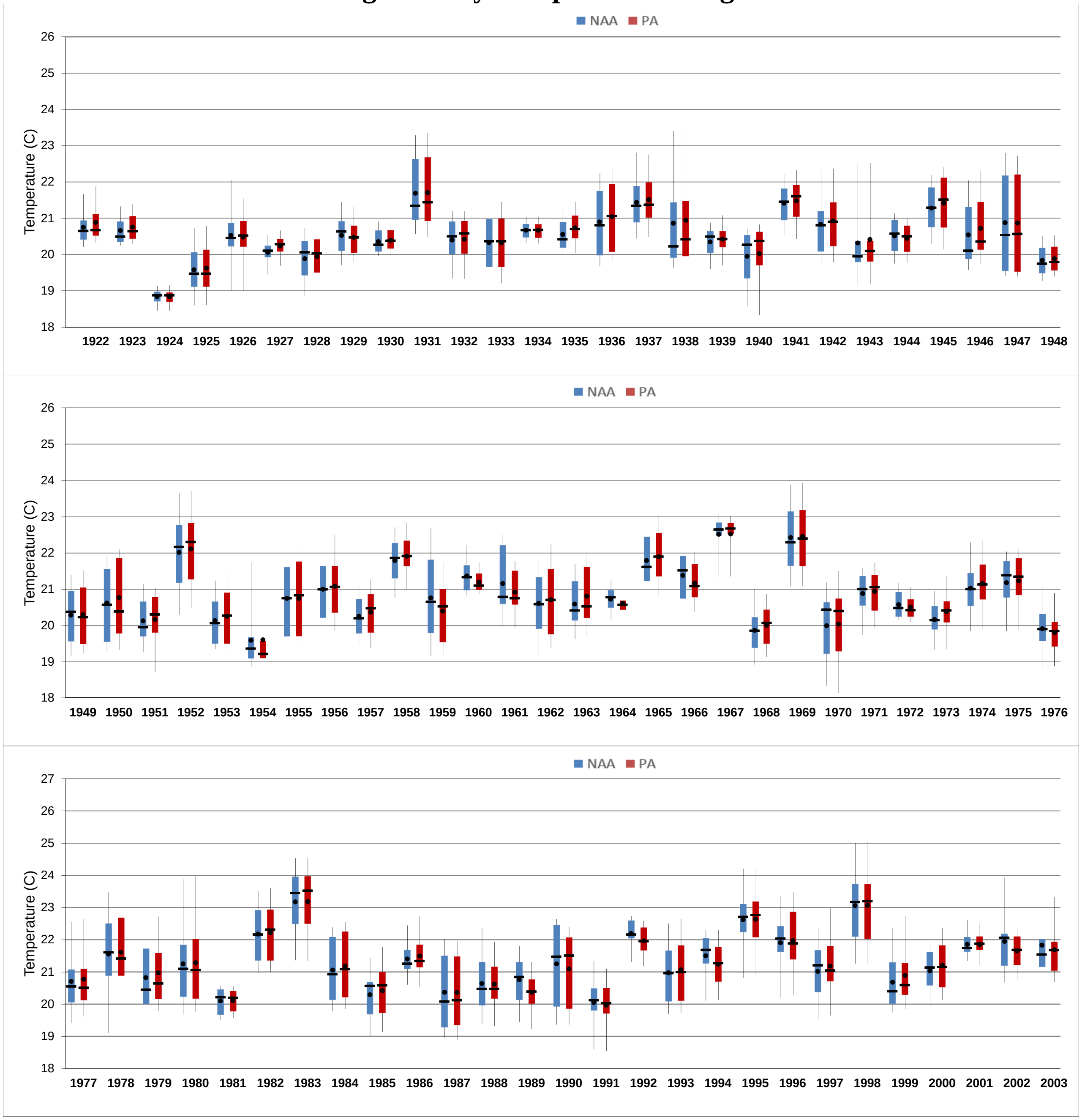
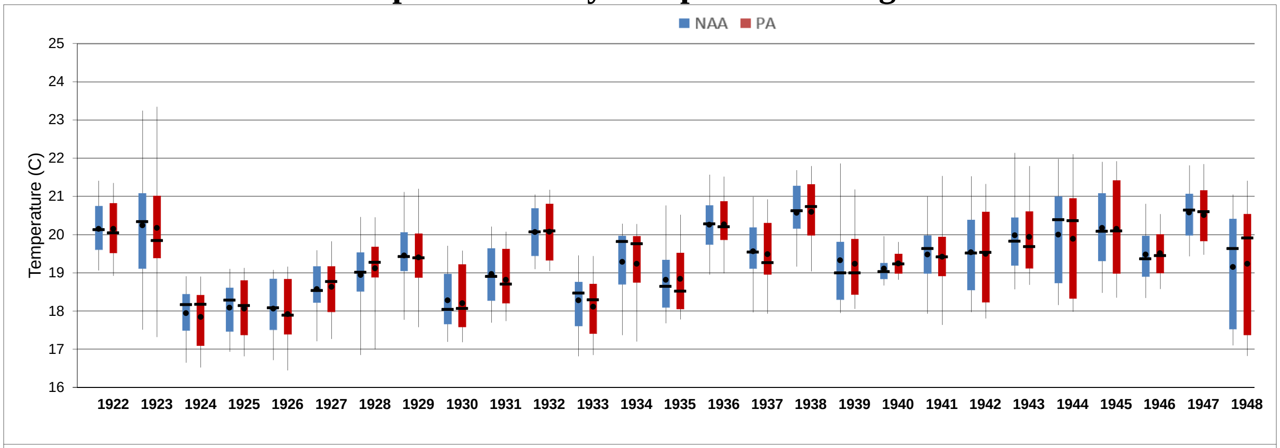
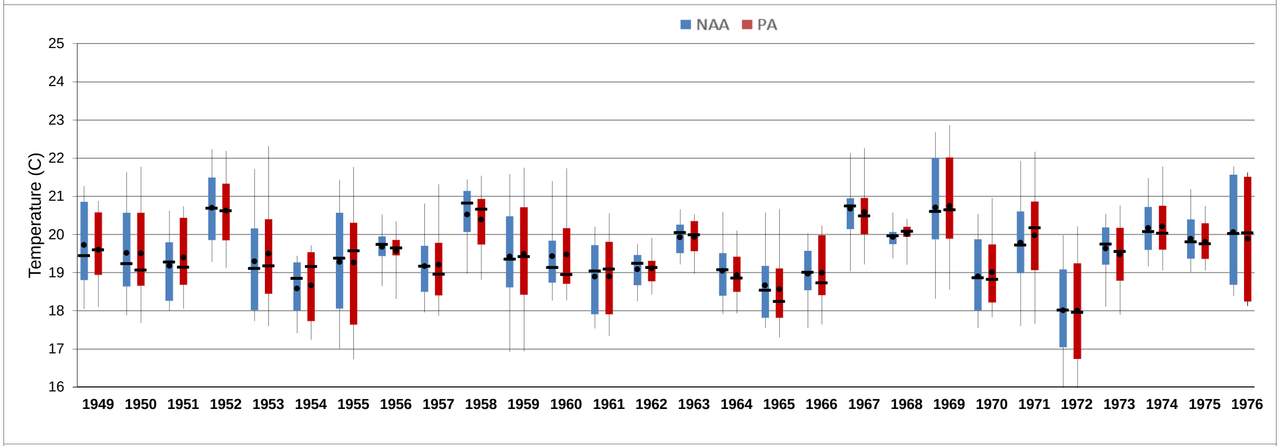


Figure 5.B.5.43-10 Stockton Deep Water Ship Channel Monthly Temperature September Daily Temperature Ranges





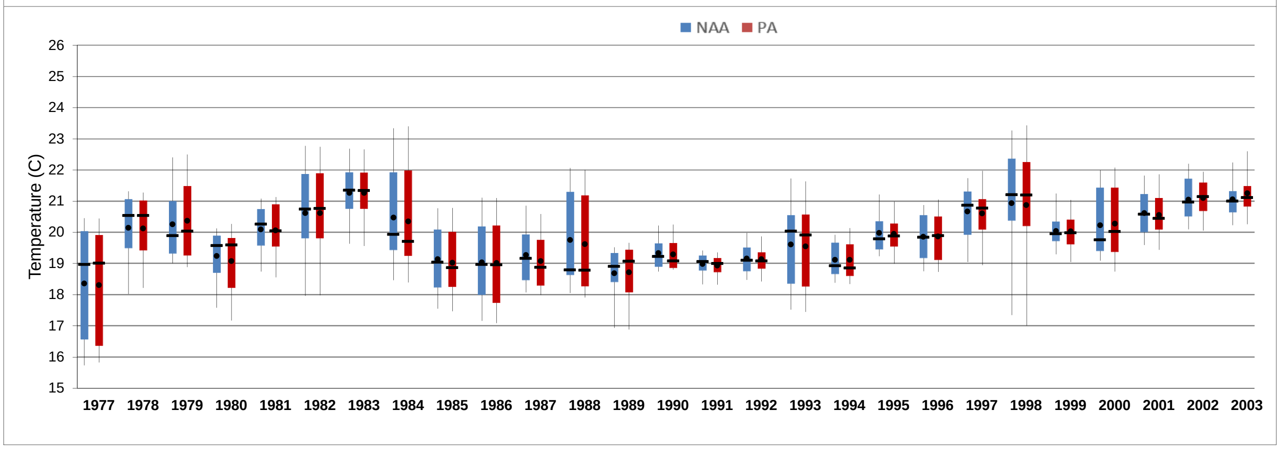


Figure 5.B.5.43-11 Stockton Deep Water Ship Channel Monthly Temperature October Daily Temperature Ranges

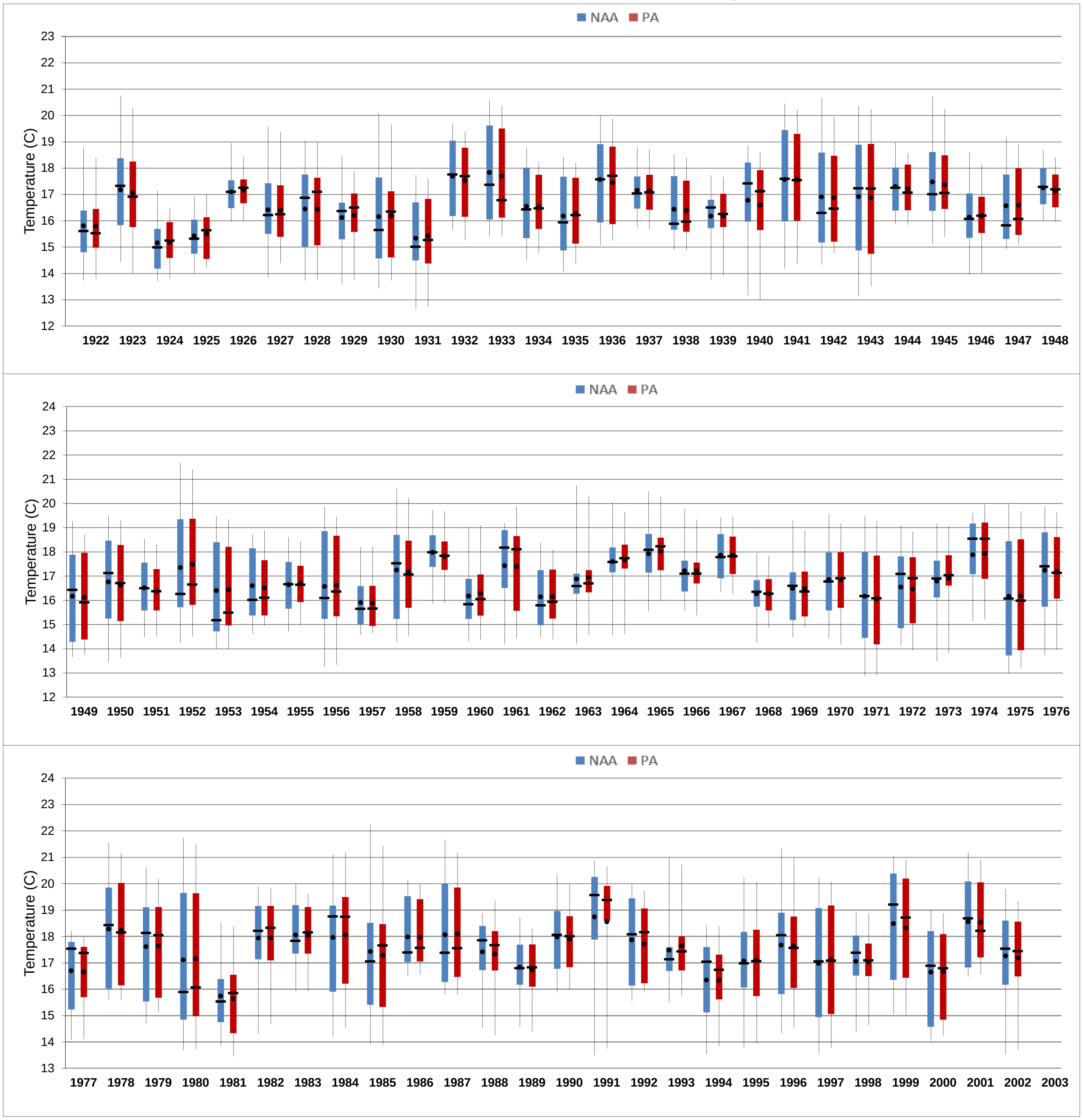
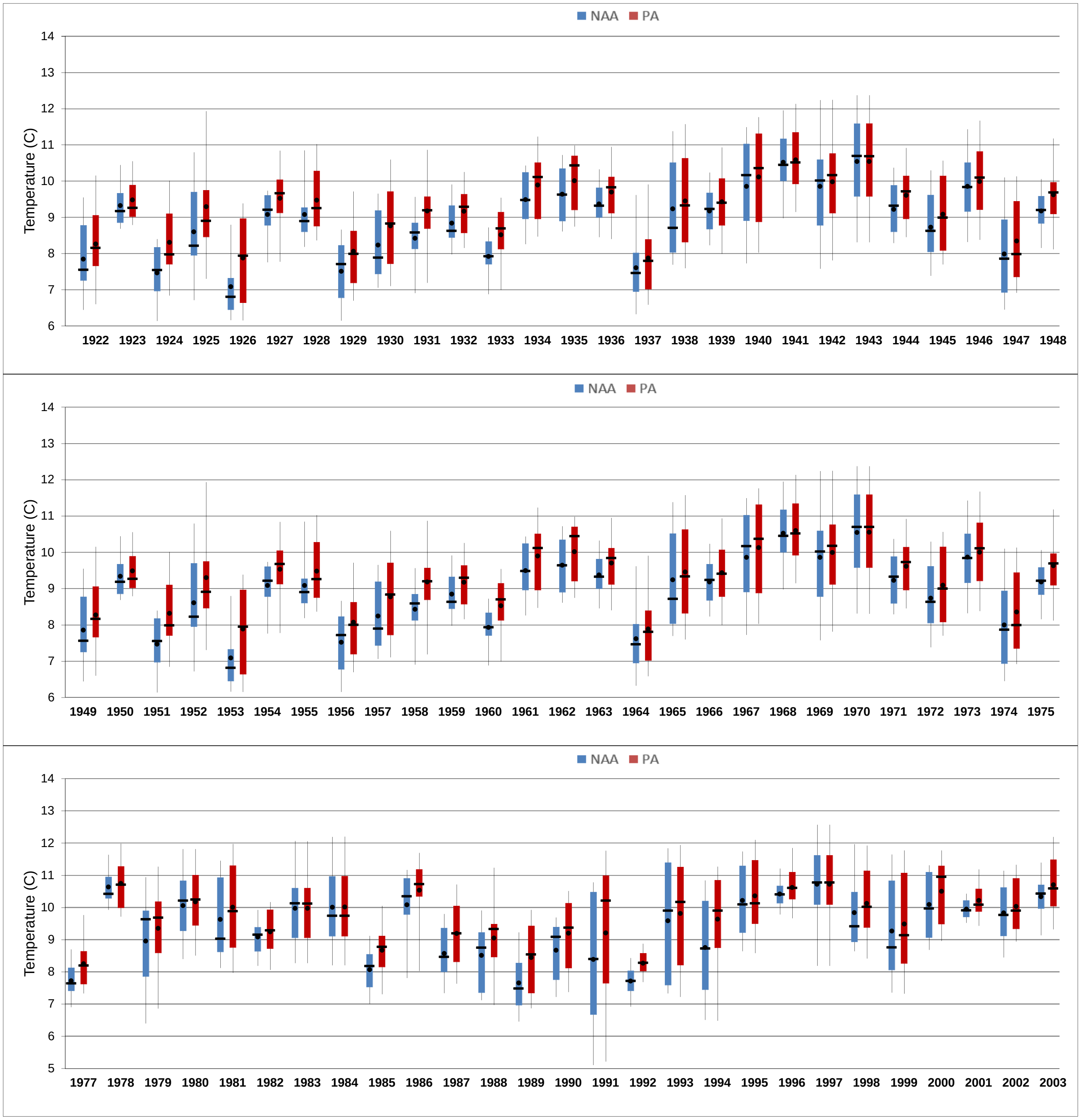


Figure 5.B.5.43-12 Stockton Deep Water Ship Channel Monthly Temperature November Daily Temperature Ranges

Figure 5.B.5.43-13 Stockton Deep Water Ship Channel Monthly Temperature December Daily Temperature Ranges

Figure 5.B.5.43-14 Stockton Deep Water Ship Channel Monthly Temperature
January Daily Temperature Ranges



DSM2 Recalibration

Prepared for

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Acronyms and Abbreviations

1D	one dimensional
2D	two dimensional
BDCP	Bay Delta Conservation Plan
BLTM	Branched Lagrangian Transport Model
CDEC	California Data Exchange Center
CCWD	Contra Costa Water District
CVP	Central Valley Project
DCC	Delta Cross Channel
DICU	Delta Island Consumptive Use
DSM2	Delta Simulation Model 2
DSM2PWT	Delta Simulation Model Project Work Team
DWR	California Department of Water Resources
EC	electrical conductivity
HEC-DSS	Hydrologic Engineering Center Data Storage System
HYDRO	DSM2 Hydrodynamics Module
IEP	Interagency Ecological Program
MWDSC	Metropolitan Water District of Southern California
NAVD88	North Atlantic Vertical Datum 1988
NGVD29	National Geodetic Vertical Datum 1929
QUAL	DSM2 Water Quality Module
RMSE	root mean squared error
SWP	State Water Project
USBR	United States Bureau of Reclamation
USGS	United States Geological Survey
WDL	Water Data Library
WY	Water Year

SECTION 1

Introduction

1.1 Background

Delta Simulation Model (DSM2) is a one-dimensional (1D) model capable of simulating hydrodynamics and water quality in Sacramento – San Joaquin Delta. The model was developed by California Department of Water Resources (DWR). DSM2 was originally calibrated and validated in 1997 (DWR, 1997). In 2000, a group of agencies, water users, and stakeholders recalibrated and validated DSM2 in an open process resulting in a model that could replicate the observed data more closely than the 1997 version (DSM2PWT, 2001). DSM2 is frequently used to ascertain impacts of potential changes in Delta conditions (salinity, flow, and water level) associated with changes in flow patterns caused by variations in boundary conditions such as river inflows, exports, diversions, or gate operations.

The Bay Delta Conservation Plan (BDCP) is considering several conservation strategies to restore habitat for Delta fisheries while continuing reliable water supply. Federal and state agencies, environmental organizations, fishery agencies, water agencies, and other organizations are working together to develop the Plan. DSM2 is one of the core analytical tools that will be used in the BDCP to evaluate the changes to Delta hydrodynamics and water quality associated with the elements of the Plan.

1.2 Purpose of DSM2 Recalibration

During the development of preliminary DSM2 modeling analyses for the BDCP analyses, several shortcomings were identified in the DSM2's capability of accurately simulating tidal flows in the Sacramento River and Cache Slough region. Several permanent morphological changes such as island flooding (Liberty Island) have occurred in the Delta since the previous DSM2 calibration in 2000. Updated bathymetric data were collected in parts of the Delta since the last calibration. In addition, new flow, stage, and electrical conductivity (EC) monitoring data are available since the last calibration providing a better spatial and temporal depiction of the hydrodynamics and water quality. The BDCP is considering the construction and operation of the new diversion intakes on the Sacramento River and large-scale restoration of tidal marsh in the Cache Slough region. The ability to accurately simulate tidal flows and salt transport in this region is of particular importance for the BDCP. These factors have called for recalibration of DSM2 to reflect the most recent configuration and data availability. A limited recalibration of DSM2 was undertaken to ensure adequacy of DSM2 for BDCP analyses and other applications. DWR is currently in the preparatory phase of a broader recalibration process based on the outcome of this recalibration effort.

1.3 Scope of DSM2 Recalibration

The main goal of this DSM2 recalibration is to rectify specific shortcomings in DSM2 that are critical for its use in BDCP analyses. The following primary objectives were set at the outset of the calibration effort:

- Accurate representation of tidal prism in DSM2 under the current physical conditions in the Delta
- Accurate simulation of tidal flows at Rio Vista, Jersey Point and Threemile Slough, in terms of magnitude and phase
- Adequate simulation of EC at Collinsville, Emmaton, Jersey Point, Rio Vista and in Rock Slough
- Identify and disclose strengths and weakness of DSM2 model, particularly as it relates to the BDCP process.

The scope of this recalibration is mainly focused on these primary objectives. For other locations in the Delta, the objective was established that the calibration should be consistent or better than that from the 2000 calibration.

SECTION 2

Model Configuration and Boundary Conditions

2.1 DSM2 Overview

DSM2 contains two modules, HYDRO and QUAL, that simulate Delta hydrodynamics and salt transport, respectively (DWR, 1997). The HYDRO module is a one-dimensional, implicit, four-point finite difference model developed originally by Lew DeLong of the USGS in Reston, Virginia (DeLong et. al., 1992). DWR adapted the model to the Sacramento-San Joaquin Delta by revising the input-output system, adapting Delta bathymetry, including open water elements, and incorporating water project facilities such as gates, barriers, and Clifton Court Forebay. The salt transport model, QUAL, is adapted from the Branched Lagrangian Transport Model (BLTM) model developed by Harvey Jobson of USGS, Reston Virginia (Jobson, 1980).

The spatial domain of DSM2 includes the river channels, sloughs, reservoirs and other open water areas within the Delta bounded by Sacramento, Vernalis and Martinez as shown in Figure 2-1. The spatial resolution of the model varies with channel lengths ranging from a few hundred feet to a few miles. Several cross-sections define the bathymetry within each DSM2 channel. The cross-section information is interpolated to provide adequate representation for the computation method.

Boundary conditions to the DSM2-HYDRO model are river inflows, exports, diversions, drainage, and tidal stage. In addition, several internal boundary conditions such as operable gates and permanent rock barriers are included. Boundary conditions to the DSM2-QUAL model are water quality of the river inflows, drainage, and the seawater at the downstream boundary. The boundary conditions in the historical model were updated from 1990 through 2008 to incorporate the most recently available information. The DSM2 model is most commonly simulated with a 15-minute computational time step. Sensitivity studies performed as part of the 2000 calibration indicate that the model results were insensitive to 3-, 5- or 15-minute time steps.

The sections that follow describe the physical changes, bathymetric updates, and boundary condition review that were conducted as the first step in the model calibration effort.

2.2 Physical Changes

This section provides a short description of the changes made to DSM2 grid before starting the calibration process. The grid modifications included a representation of the flooded Liberty Island, modification of channel lengths in the Sacramento River, inclusion of new bathymetry in Sacramento River channels, and extension of the rigid wall boundary on the Sacramento River further upstream. Figure 2-2 identifies the modifications performed to DSM2 grid. This section also discusses the rationale behind the changes and their impact on the DSM2 results.

2.2.1 Liberty Island Flooding

Liberty Island is an inundated island encompassing approximately 5,209 acres and located in Yolo and Solano counties, in the northern Sacramento-San Joaquin Delta adjacent to Prospect Island and Little Holland Tract. It is the southern outlet of the Yolo Bypass. Liberty Island has been flooded since 1998 when levees were breached during high flows through the bypass. The levees were not repaired by the landowners and the island has remained inundated and under tidal influence (USFWS, 2008). In the early 2000, the levee adjacent to Cache Slough failed, which significantly impacted the tidal prism in Cache Slough and the Sacramento River. The change in tidal prism can be visualized from the tidal flows measured in Sacramento River at Rio Vista just downstream of the confluence with Cache Slough. The tidal flow range has increased by approximately 25,000 cfs at Rio Vista as shown in the Figure 2-3. The existing DSM2 model grid did not include the flooded Liberty Island. This caused the model to under-predict the tidal prism significantly in the north Delta and impacted the hydrodynamics in the Sacramento River and many of the north Delta channels.

A representation of the flooded Liberty Island was incorporated into the DSM2 model. Due to the one-dimensional nature of the DSM2 model, open water bodies are simulated through a reservoir construct connected to the adjacent channels. A reservoir with a surface area of 5,209 acres was included in the DSM2 model (node 322) on Cache Slough to simulate the flooded Liberty Island as shown in Figure 2-2. The coefficients that govern the amount of flow entering and exiting the reservoir are set to 10,000 and 7,500 respectively. These coefficients were derived to best represent the observed change in tidal flows in the Sacramento River at Rio Vista. Comparisons were also performed between simulated and observed tidal flows on Cache Slough.

2.2.2 Extension of Model Boundaries on Sacramento River

Peak ebb tidal flows simulated in DSM2 near to the upstream boundary on the Sacramento River were attenuated as compared to the observed data. It was hypothesized, that one of the reasons for the ebb attenuation may be the proximity of the rigid upstream boundary on the Sacramento River, which is located at the City of Sacramento in the DSM2. The daily averaged flow measured at the Freeport gage south of the city is used as the inflow boundary for Sacramento River. At times of low inflow, tidal variation in stage and flow extend upstream beyond Sacramento. Therefore, the inflow boundary condition that is constant over a 24-hour period does not account for the effects of the miles of channels above the upstream boundary that are under tidal influence. In addition, since DSM2 does not allow propagation of tidal waves at the boundary, an incoming tidal wave would be reflected at the boundary rather than to continue propagating upstream and be dissipated. The reflected wave could lead to errors in simulated stage and flow near the upstream end of the Sacramento River (Shum, 2006).

In an effort to reduce the reflective wave issue, the rigid boundary on Sacramento River was extended upstream while keeping the location of the boundary inflow unchanged in DSM2 as shown in Figure 2-2. Four new channels of 10,000 feet each were added to the existing DSM2 grid. The channel cross-sections for this 40,000-foot reach were derived from the 2002 Comprehensive Study Sacramento River UNET model (USACE, 2002). This modification to the grid was found to partly mitigate the errors caused due to the reflected wave and allowed improvement in the simulation of peak ebb tide flows in Sacramento River channels around Hood as shown in the Figure 2-4.

2.2.3 Updated Sacramento River Grid

The DSM2 grid was refined in the north delta in anticipation of the need to simulate proposed diversion intakes. The highlighted nodes in Figure 2-2 on the Sacramento River were relocated. Table 2-1 shows the modified channel lengths resulted from the relocation of DSM2 nodes to match the proposed points of diversion. In this process the total length of the river channel from City of Sacramento to the Sutter Slough confluence was ensured to be unchanged.

In DSM2, bathymetry of a channel is represented by irregular cross-sections spaced over the length of the channel. DSM2 requires an optimum number of irregular cross-sections defined in a channel to accurately represent the bathymetry of the channel and for the accuracy in computations. This number depends on the length of the channel. With the channel lengths modified, the number of the irregular cross-sections within each channel was reviewed in the channels upstream of Delta Cross Channel (DCC). Additional cross-sections were added to the channels, when the number was fewer than the optimum. The new cross-sections were extracted using the Cross-Section Development Program (CSDP) based on the recent bathymetry data collected by DWR in 2008. More information about the recent bathymetry data is presented in the Section 2.2.4. Table 2-2 shows the existing and modified cross-section locations in the DSM2 grid. The cross-section location within a channel is shown as a fraction of the channel length measured from the upstream end of the channel. The new cross-sections that were added to the existing grid are shown with an asterisk (*) on the cross-section location distance.

The definitions provided in DSM2 (translations) for the locations along the Sacramento River (e.g. RSAC101) in the model falling between nodes 332 and 339 were modified to reflect the changes in channel lengths. The resulting Sacramento River flows were compared between the two simulations with existing and modified grids. The comparison showed that the changes in the flows and stage in Sacramento River channels were minor (less than 1 percent), mainly around the modified channels. No changes were found further downstream.

2.2.4 Updated Sacramento River Bathymetry

DWR collected bathymetry data on the upper Sacramento River between Sacramento and the Walnut Grove in 2008 (DWR, 2008). This recent bathymetric dataset was compared to the existing DSM2 bathymetry using CSDP. Figure 2-5 shows the extent and the resolution of the bathymetric data in the two datasets. On the whole, the two datasets showed no differences in terms of the channel cross-sections. Therefore, existing DSM2 cross-sections were not updated with the recent bathymetry data. However, the data in the existing bathymetry, is very sparse upstream of Sutter Slough junction. Therefore, the new bathymetry was used to extract the new irregular cross-sections to improve the resolution in the channels upstream of Sutter Slough on the Sacramento River, as described in the previous section.

2.3 Boundary Condition Review

The time series data used for the inflow, export, and stage boundary conditions in the existing DSM2 model were verified using the observed gage data collected from different sources for water years (WYs) 2001 to 2004. Existing inflow and exports data at each boundary were compared to the observed gage data on a daily time step for Sacramento, San Joaquin, Mokelumne, Cosumnes, and Calaveras Rivers; Banks Pumping Plant, Jones Pumping Plant, Contra Costa Water District Rock Slough, and Old River Intakes. Boundary conditions were modified to ensure accuracy with the observations for the days when the absolute difference was greater than 1 percent. Stage boundary data at Martinez were verified by comparing the model simulated stage output with the observed gage data. EC boundary condition data were not verified using gage data. Table 2-3 shows the boundary locations where the existing time series data were compared with the observed gage data and the number of days the data has been replaced with the observed data.

In summary, most of the existing boundary condition data matched the observed records. The mismatched data were mainly in fall and winter months of WY 2001 for the Sacramento River and the Mokelumne River inflows. For Calaveras boundary, existing data is different than observed data for 31 days. These differences are mainly in the WY 2004, from February through May, and were corrected to match observed flows.

Tables

TABLE 2-1
Comparison of Existing and Modified Channel Lengths

DSM2 Channel #	DSM2 Node at d/s of the Channel	DSM2 Existing Channel Lengths (ft)	DSM2 Modified Channel Lengths (ft)
411	332	18,620	18,620
412	333	14,386	17,340
413	334	14,323	11,828
414	335	17,612	24,177
415	336	12,285	6,300
416	337	17,389	25,418
417	338	12,716	6,133
418	339	16,047	13,562

TABLE 2-2
Translation of Existing Cross-section Locations to Modified Cross-section Locations

Existing Irregular Cross-section Locations			Modified Irregular Cross-section Locations		
DSM2 Channel	**Channel Length (ft)**	**Cross-section Location**	**DSM2 Channel**	**Channel Length (ft)**	**Cross-section Location**
412	14,386	0.27053	412	17,340	0.22444
		0.58263			0.48337
		0.87590			0.72668
413	14,323	0.05145			0.87214
		0.19211			0.98833
		0.55768	413	11,828	0.42557
		0.83269			0.75859
414	17,612	0.03831	414	24,177	0.00892
		0.30709			0.20472
		0.41170			0.28092
		0.66276			0.46381
		0.86416			0.61052
		0.95902*			0.67962*
415	12,285	0.11477			0.76779
		0.40885			0.91722
		0.60497	415	6,300	0.06477
		0.90451			0.64887
416	17,389	0.18735	416	25,418	0.08729
		0.28725*			0.15564*
		0.37797			0.21770
		0.64429			0.39990
		0.77274			0.48777
		0.84153*			0.53483*
417	12,716	0.01444*			0.65047*
		0.28395			0.78530
		0.49394			0.89035
		0.63939*			0.96312*
		0.78870*	417	6,133	0.15672*
418	16,047	0.02079*			0.64922*
		0.26257*	418	13,562	0.12745*
		0.53364			0.44819
		0.78081			0.74065
		0.98668			0.98424

* New cross-sections defined using 2008 DWR bathymetry.

TABLE 2-3
Boundary Locations Where the Existing Data is Replaced by Observed Data

Location ID	Description	Parameter	Gage Data Source	Number of Days Data Replaced by Gage Data
RSAC155	Sacramento River at Freeport	Flow	IEP (DWR-OM-JOC-DSM2)	16
RSAN112	San Joaquin River at Vernalis	Flow	IEP (DWR-OM-JOC-DSM2)	3
RCSM075	Cosumnes River	Flow	IEP (DWR-OM-JOC-DSM2)	5
RMKL070	Mokelumne River at Woodbridge	Flow	IEP (DWR-OM-JOC-DSM2)	128
RCAL009	Calaveras River at Stockton	Flow	IEP (DWR-OM-JOC-DSM2)	31
BYOLO040	Yolo Bypass	Flow	IEP (DWR-OM-JOC-DSM2)	0
CHSWP003	Clifton Court Forebay	Exports	IEP (DWR-OM-JOC-DSM2) IEP (DWR-OM-JOC) CDEC (CLC)	0
CHDMC004	Delta Mendota Canal	Exports	IEP (DWR-OM-JOC-DSM2) IEP (DWR-OM-JOC) CDEC (DMC)	2
ROLD034	Old River near Byron	Diversions	IEP (DWR-OM-JOC-DSM2)	1
CHCCC006	Delta Mendota Canal at Tracy Pumping Plant	Diversions	IEP (DWR-OM-JOC-DSM2)	2
SLBAR002	Barker Slough	Diversions	IEP (DWR-OM-JOC-DSM2) IEP (DWR-OM-JOC)	0

Figures

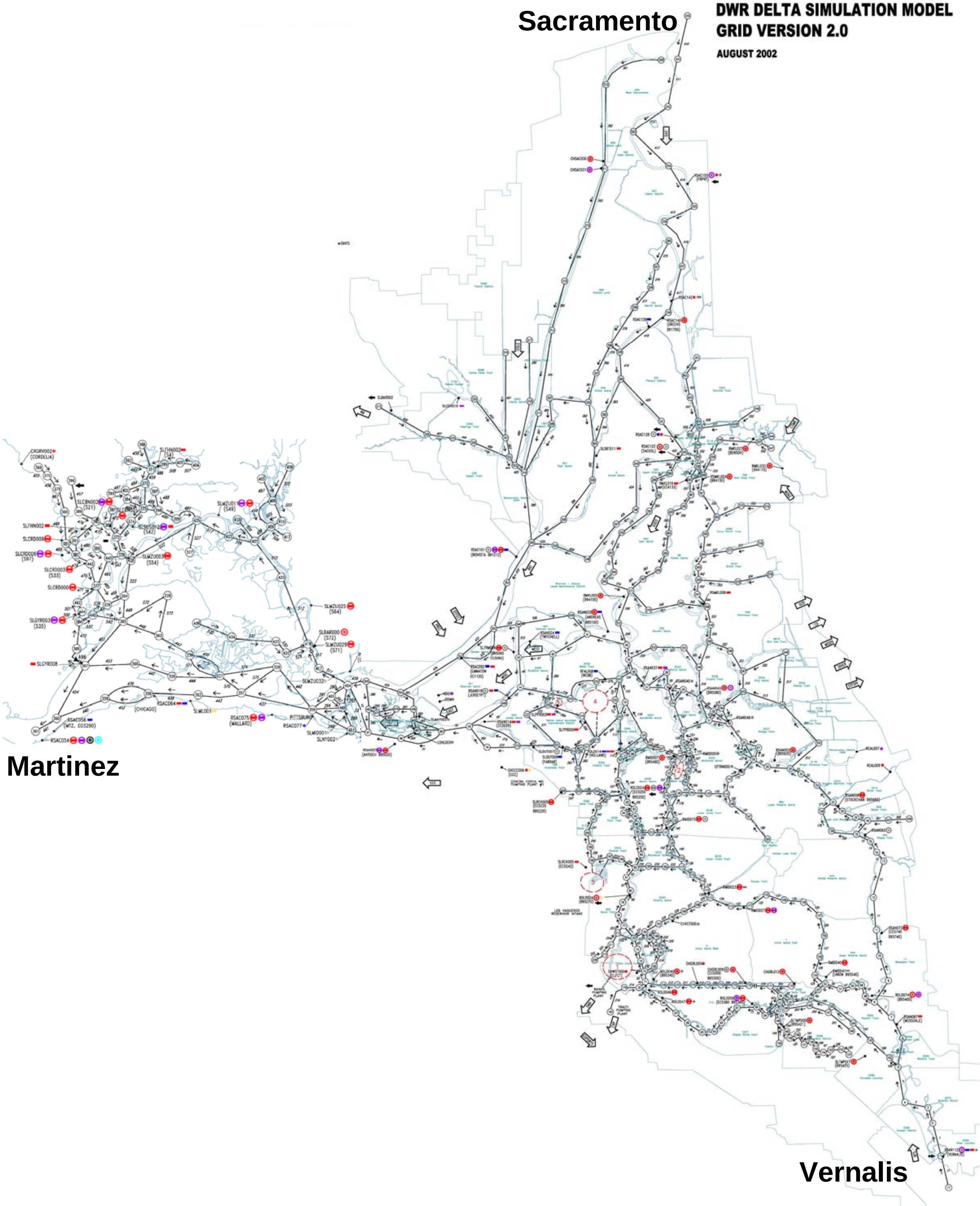


FIGURE 2-1
Spatial Domain of the DSM2 Model

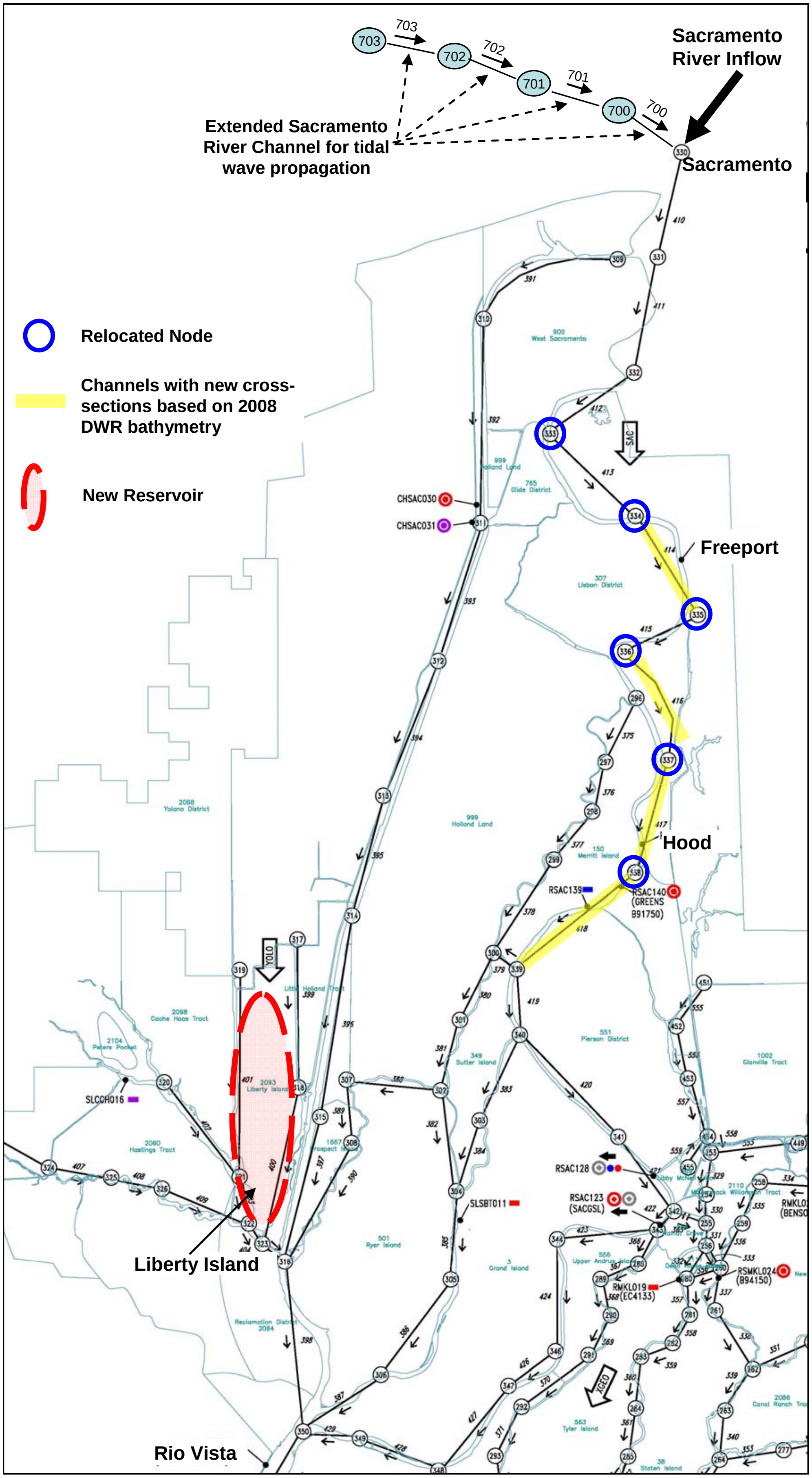


FIGURE 2-2
DSM2 Model Grid in the North Delta Showing the Grid Modifications Performed as Part of the Recalibration Effort

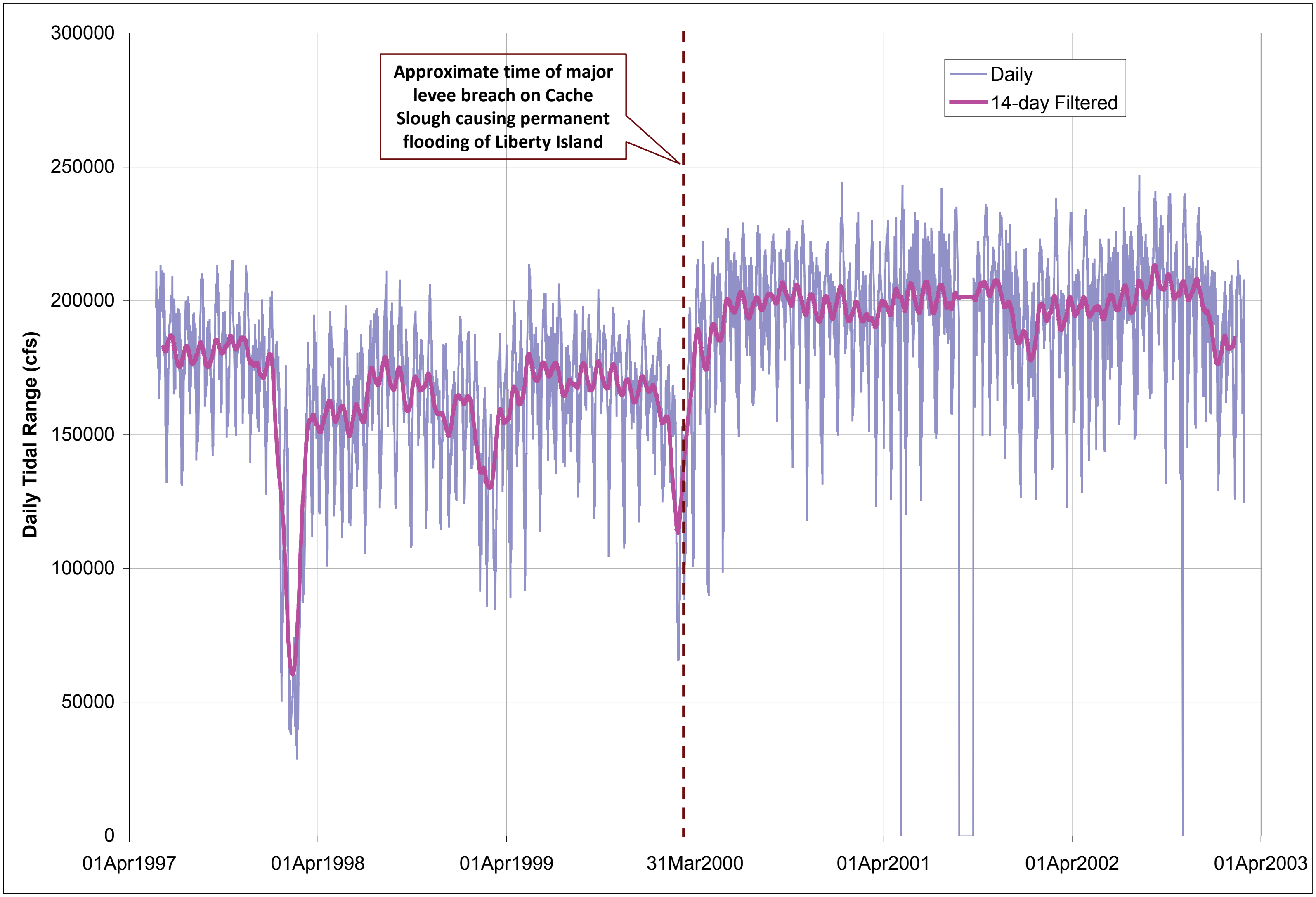


FIGURE 2-3
Observed Tidal Flow Range in Sacramento River at Rio Vista

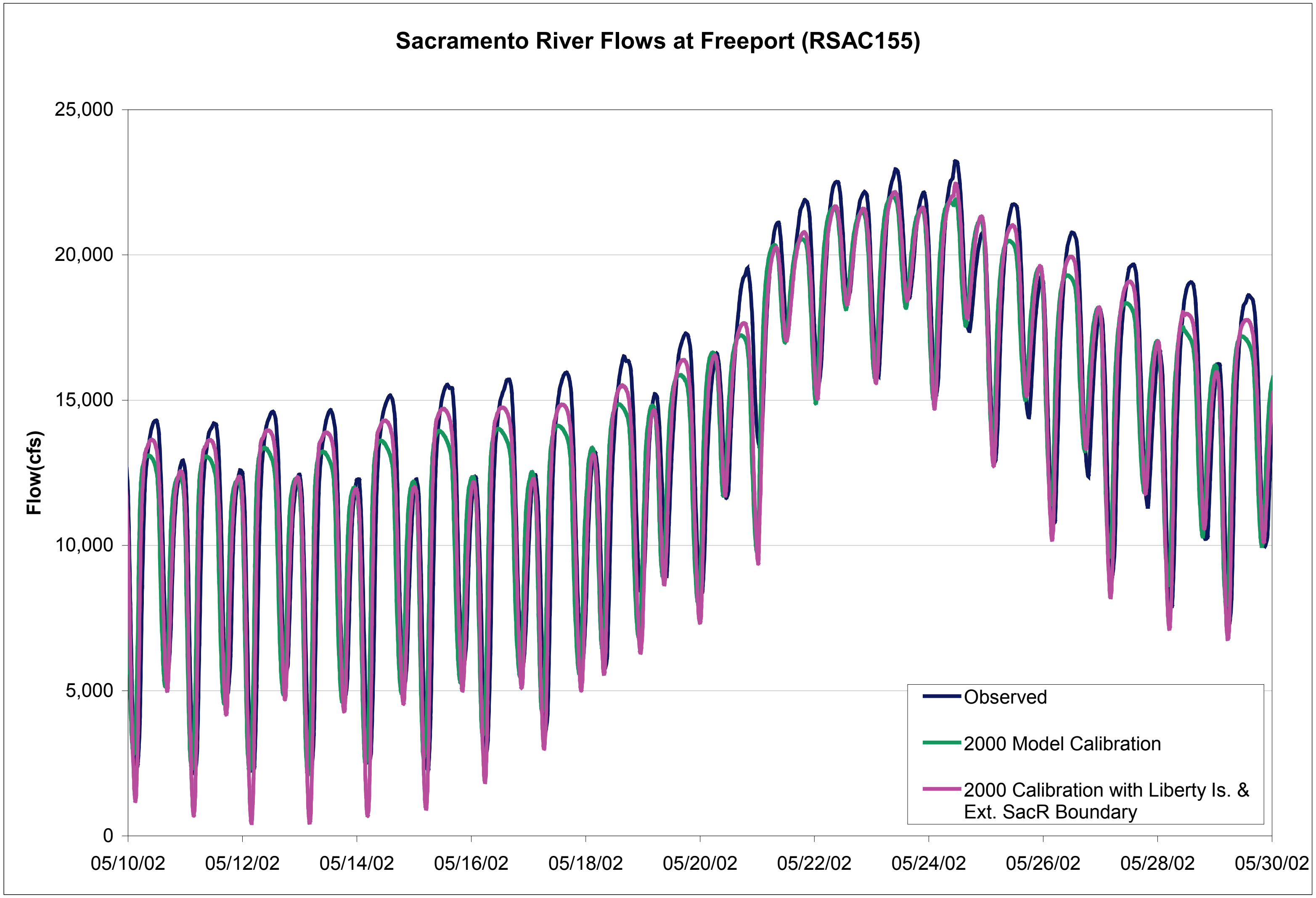


FIGURE 2-4
Simulated and Observed Tidal Flow in Sacramento River at Freeport With and Without Extended Channels Upstream of Sacramento River Boundary

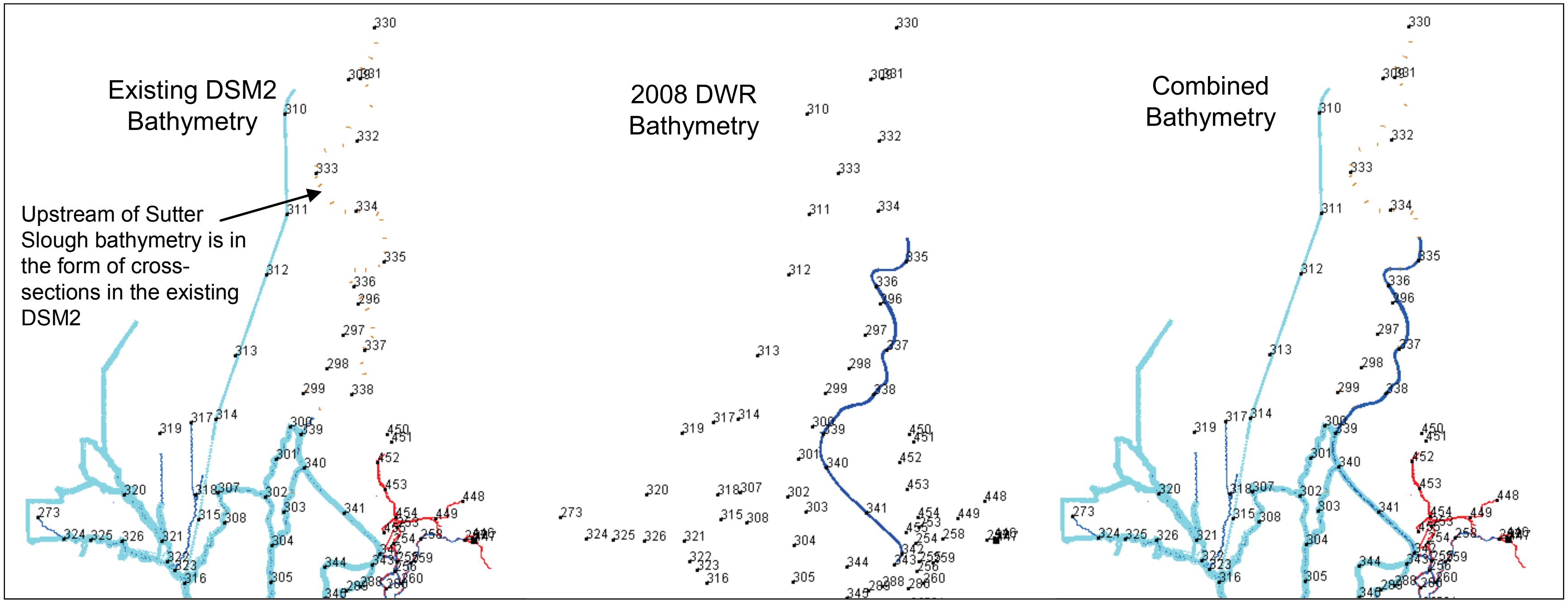


FIGURE 2-5
DSM2 and DWR Bathymetry Extent in Delta

SECTION 3

Calibration Details

3.1 Observed Data

An observed dataset was compiled for the purpose of evaluating the simulated model results. The dataset contains 15-minute average and hourly average data of flow, stage, and electrical conductivity (EC). The data has been collected at several locations in the Delta that were determined to be critical to the evaluation of performance of the model.

The sources for the observed data included United States Geological Survey (USGS), United States Bureau of Reclamation (USBR), DWR's California Data Exchange Center (CDEC), Interagency Ecological Program (IEP), and DWR's Water Data Library (WDL).

The model was calibrated based on the goodness of fit measures computed using the observed dataset. Hence, the accuracy of the observed data is very critical for evaluating the performance of the model. To ensure the accuracy of the collected observed dataset, quality assurance has been performed. Each time series dataset was visually inspected for anomalies in the data that were eliminated.

Table 3-1 is the inventory of the datasets collected for the purpose of DSM2 model calibration. The table lists the source of each data record, which sometimes is the agency maintaining the gage, gage identification number, location of the measurement, the parameters measured and the period of available data for every record in the observed dataset.

3.2 Period Selection

The calibration and validation periods for this DSM2 calibration effort was selected such that a variety of conditions were included in terms of the hydrology, exports and gate operations within the identified period. In addition, the period was selected such that it represented the existing structure of the Delta and had sufficient observed flow, stage, and EC data collected at various locations in the Delta. These criteria are generally consistent with the recommendations by USGS (Ruhl, 2007). A brief description of the key factors used in deciding the calibration and validation periods is provided below.

1. Current physical conditions: Representation of current structural configuration of the Delta in DSM2 is important from using the model for future planning efforts. The permanent flooding of Liberty Island that occurred in early 2000 was a significant change to the Delta configuration since the previous calibration. Therefore, based on this factor, any period after WY 2000 is desirable for current DSM2 calibration.
2. Hydrology: Periods with low flows are desirable for calibration of hydrodynamic and water quality models in estuaries. At low flows the tides are the dominant process determining the hydrodynamics and the transport in the Delta. Based on this factor,

Table 3-2 shows that WYs 2001, 2002, 2004, 2007, and 2008 are reasonable years for calibration.

3. Exports: Periods with variable export regimes would provide contrast in terms of the hydrodynamics and water quality in the South and Central Delta. Based on this criterion, WYs 2001, 2002, 2004, 2007, and 2008 are good for the calibration as shown in the Table 3-2.
4. Availability of observed data: The availability of observed flow, stage, and EC data at various locations in the Delta is critical for the calibration. In addition to the daily average data, availability of some instantaneous data is important. As shown in the Table 3-2, WYs 2002 through 2008 have abundant observed flow, stage, and EC data. Based on the availability of both daily and instantaneous data at key locations identified for the calibration, it was decided which year was fair, good or sparse.

Based on the above four factors it was determined that the WYs 2001 to 2008 would be an appropriate period for the calibration and validation of DSM2. The selection of calibration versus validation periods is discussed separately under the Sections 4 through 6.

3.3 Calibration Metrics

The success of calibration was evaluated based on a combination of quantitative metrics and the qualitative assessment. Goodness-of-fit measures were computed both on a tidal scale and on a net daily scale for hydrodynamics. However, for EC simulation, the computed measures were limited to daily and monthly scales, since significant uncertainty exists in the agricultural drainage inputs at the tidal scales.

The evaluation of calibration and validation performance for flow and stage were summarized through the following metrics:

- **Time series inspection of tidal flow and stage.** 15-minute modeled and observed time series data are plotted over one month to visually judge the model performance. This plot provides an initial sense of the quality of the calibration or validation on a tidal scale, in terms of amplitude, phase, and mean.
- **Bias in simulated peak ebb and peak flood.** This metric allows assessing any bias in the modeled tidal highs or tidal lows compared to the observed data. The scatter plot shows the goodness-of-fit between the observed and simulated tidal peak ebbs and lows for the entire calibration or validation period. This plot does not account for the phase error that may exist between the modeled and observed data. The slope of the linear trend line through the scatter indicates the bias.
- **Error in Tidal amplitude.** This metric is a measure of the difference in the modeled and observed tidal amplitude or range. A percent error histogram is plotted for the modeled and observed tidal range over the entire calibration or validation period, which provides an indication of the bias in the simulated tidal range. An average amplitude error is also computed over the full calibration or validation period.
- **Error in Tidal phase.** This metric is a measure of the difference in the modeled and observed timing of the peak tidal ebbs or floods. An error histogram is plotted for the

phase difference in minutes, between the modeled and observed flow and stage over the entire calibration or validation period. The histogram provides an indication of whether the model data is leading or lagging the observed data most often. An average phase error is also computed over the full calibration or validation period.

- **Time series inspection of tidally-averaged flow and stage.** Tidally filtered daily averages of the modeled and observed data are plotted as a time series over the full calibration or validation period. This plot gives an indication of how well the model is simulating the flows and stages on a net basis. The net flow is especially important, because it is an indicator of the transport of water quality constituents. Since the observed stage data often exhibits erroneous datum shifts due to subsidence of the monitoring sites, comparing the modeled and observed net stage data is not very useful for evaluating stage calibration.
- **Mean Error in tidally-averaged flow and stage.** Mean error is computed as the difference between the long-term average of the modeled and observed tidally filtered net daily data, over the full calibration or validation period. Mean error is a good measure to show any bias in the modeled net flows compared to the observed data. The mean error, however, averages both positive (over-prediction) and negative errors (under-prediction), and can lead to a smaller computed error than through other metrics or seasonal analysis.
- **Root Mean Squared Error (RMSE) in tidally-averaged flow and stage.** RMSE is computed using the tidally filtered daily modeled and observed data over the full calibration period. RMSE provides an indication of the error variance including the errors in the magnitude and time shift. RMS error provides a more realistic measure of prediction errors, and is not subject to balancing positive and negative errors as described above. However, the RMS error does not discern between over- and under-predictions.

The goodness-of-fit measures for flow and stage outputs were summarized on a set of plots that are specific to each location, as shown in the Figure 3-1. The top panel compares the observed and simulated time series of tidal flow (or stage) for several days within the calibration period. The middle panel includes three plots that allow analysis of the model performance on a tidal scale. The scatter plot shows the goodness-of-fit between the observed and simulated tidal peak ebbs and lows for the entire calibration period. The two error histograms show the amplitude errors as a percentage and the phase errors in minutes between the simulated and observed data within each tidal cycle over the calibration period. The bottom panel shows the tidally filtered daily average flow (or stage) time series comparison over the full calibration period. The Root Mean Squared Error (RMSE) and the means computed using the daily modeled and observed data over the full calibration period are included as an inset on the bottom plot. Due to the known datum issues in the observed stage data, the RMSE and the mean error are not very useful for evaluating stage calibration. Therefore, only the metrics computed on the tidal scale were used for evaluating the stage calibration.

Figure 3-2 shows the definition of the average amplitude and phase error computations used in this process. In general, both the amplitude and the phase error were computed between the modeled and observed data for each tidal cycle and averaged over the full calibration period.

The evaluation of calibration performance for EC was summarized through the following metrics:

- **Bias in simulated monthly averaged EC.** This metric allows assessing any bias in the modeled monthly averaged EC compared to the observed data. The scatter plot shows the goodness-of-fit between the observed and simulated monthly averaged EC for the entire calibration period. The slope of the linear trend line through the scatter indicates the bias.
- **Error in monthly averaged EC.** This metric is a measure of the difference in the modeled and observed monthly averaged EC. A percent error histogram is plotted for the modeled and observed monthly averaged EC over the entire calibration period. The histogram is an additional indicator of the bias in the simulated monthly averaged EC. A long-term average error is also computed over the full calibration.
- **Time series inspection of tidally-averaged EC.** Tidally filtered daily averages of the modeled and observed EC data are plotted as a time series over the full calibration period. This plot gives an indication of how well the model is simulating the EC on a net basis. It also shows any seasonal bias in the simulated data.
- **Mean Error in tidally-averaged EC.** Mean error is computed as the difference between the long-term averages of the modeled and observed tidally filtered net daily EC data, over the full calibration period. Mean error is a good measure to show an overall bias in the modeled daily EC compared to the observed data. The mean error, however, averages both positive (over-prediction) and negative errors (under-prediction), and can lead to a smaller computed error than through other metrics or seasonal analysis.
- **Root Mean Squared Error (RMSE) in tidally-averaged EC.** RMSE is computed using the tidally filtered daily modeled and observed EC data over the full calibration period. As noted earlier, RMSE is an indicator of the error variance including the errors in the magnitude and time shift. RMS error provides a more realistic measure of prediction errors, and is not subject to balancing positive and negative errors as described above. However, the RMS error does not discern between over and under-predictions.

The goodness-of-fit measures for EC were summarized on location-specific plots similar to the one shown in Figure 3-3. The two plots in the top panel summarize the performance of the simulated EC in comparison to the observed values on a monthly scale. The scatter plot compares the monthly averaged simulated EC with the observed EC. The histogram shows the error between the monthly averaged simulated and observed EC as percentage. The bottom plot shows a time series comparison of the tidally-filtered daily averaged simulated and observed EC. The RMSE and the mean averages computed over the full period of QUAL calibration between the simulated and observed daily EC values are shown as an inset in the bottom plot.

Tables

TABLE 3-1
Inventory of the Collected Observed Data in Delta

S.No.	Location ID	Description	Agency/ID	Parameter	Time Step	Period Available
1	RSAC155	Sacramento River at Freeport	IEP/RSAC155	FLOW	1HOUR	04/01/2000 – 01/01/2008
			CDEC/FPT	STAGE	15MIN	12/01/1983 – 11/01/2008
2	RSAC139	Sacramento River at Green's Landing	CDEC/GLN	EC	1HOUR	04/01/1999 – 10/01/2003
3	RSAC128	Sacramento River above Delta Cross Channel	USGS/11447890	FLOW	15MIN	12/01/1991 – 02/01/2003
			IEP/RSAC128	FLOW	15MIN	02/01/2003 – 10/01/2004
			CDEC/SDC	FLOW	15MIN	09/01/2003 – 08/01/2008
			USGS/11447890	STAGE	15MIN	12/01/1992 – 02/01/2003
			CDEC/SDC	STAGE	15MIN	02/01/2003 – 11/01/2004
4	RSAC123	Sacramento River below Georgiana Slough	IEP/RSAC123	FLOW	15MIN	01/01/1993 – 10/01/2004
			CDEC/GES	FLOW	15MIN	05/01/2006 – 06/01/2009
			IEP/RSAC123	STAGE	15MIN	01/01/1993 – 10/01/2004
5	RSAC101	Sacramento River at Rio Vista	IEP/RSAC101	FLOW	15MIN	04/01/1995 – 02/01/2003
			CDEC/SRV	FLOW	15MIN	10/01/2003 – 12/01/2008
			IEP/RSAC101	STAGE	15MIN	04/01/1995 – 02/01/2003
			WDL/B91212	STAGE	15MIN	02/01/2003 – 10/01/2004
			CDEC/RIV	EC	1HOUR	03/01/1988 – 02/01/2009
6	RSAC092	Sacramento River at Emmaton	IEP/RSAC092	EC	1HOUR	04/01/2000 – 01/01/2008
7	RSAC081	Sacramento River at Collinsville	IEP/RSAC081	EC	1HOUR	04/01/2000 – 01/01/2008
8	RSAC064	Sacramento River at Port Chicago	IEP/RSAC064	EC	1HOUR	04/01/2000 – 01/01/2008
9	RSAC054	Sacramento River at Martinez	IEP/RSAC054	STAGE	15MIN	08/01/1988 – 09/01/2002
			CDEC/MRZ	STAGE	1HOUR	06/01/1994 – 10/01/2008
			CDEC/MRZ	EC	1HOUR	06/01/1994 – 10/01/2008
10	RSAN112	San Joaquin River at Vernalis	IEP/RSAN112	EC	1HOUR	04/01/2000 – 01/01/2008
11	RSAN087	San Joaquin River at Mossdale	IEP/RSAN112	STAGE	1HOUR	01/01/1999 – 12/01/2005
			CDEC/MSD	EC	1HOUR	04/01/2002 – 02/01/2009
12	RSAN072	San Joaquin River at Brandt Bridge	CDEC/BDT	EC	15MIN	04/01/2005 – 02/01/2009
13	RSAN063	San Joaquin River at Stockton	IEP/RSAN063	FLOW	15MIN	07/01/1995 – 02/01/2003
			CDEC/SJG	FLOW	15MIN	08/01/2003 – 07/01/2009
			IEP/RSAN063	STAGE	15MIN	07/01/1995 – 02/01/2003
			CDEC/SJG	STAGE	15MIN	08/01/2003 – 10/01/2004
14	RSAN058	San Joaquin River at Burns Cutoff	CDEC/RRI	STAGE	15MIN	12/01/2000 – 11/01/2008
			CDEC/RRI	EC	15MIN	11/01/2002 – 10/01/2008

TABLE 3-1
Inventory of the Collected Observed Data in Delta

S.No.	Location ID	Description	Agency/ID	Parameter	Time Step	Period Available
15	RSAN032	San Joaquin River at San Andreas Landing	IEP/RSAN032	STAGE	15MIN	08/01/1982 – 10/01/2004
			CDEC/SAL	EC	1HOUR	03/01/1988 – 02/01/2009
16	RSAN018	San Joaquin River at Jersey Point	IEP/RSAN018	FLOW	15MIN	05/01/1994 – 02/01/2003
			CDEC/SJJ	FLOW	15MIN	12/01/2003 – 07/01/2009
			IEP/RSAN018	STAGE	15MIN	05/01/1994 – 02/01/2003
			IEP/RSAN018	EC	1HOUR	04/01/2000 – 01/01/2008
17	RSAN007	San Joaquin River at Antioch	CDEC/ANH	STAGE	1HOUR	12/01/1983 – 11/01/2008
			CDEC/ANH	EC	1HOUR	09/01/1999 – 06/01/2009
18	SLTRM004	Three Mile Slough	IEP/SLTRM004	FLOW	15MIN	01/01/1997 – 02/01/2003
			CDEC/TSL	FLOW	15MIN	01/01/2008 – 12/01/2008
			WDL/B95060	STAGE	15MIN	09/01/2001 – 10/01/2004
			CDEC/TMS	EC	15MIN	03/01/1999 – 02/01/2009
19	ROLD074	Old River at Head	CDEC/OH1	STAGE	15MIN	07/01/2000 – 11/01/2008
20	ROLD059	Old River at Tracy Boulevard	CDEC/OLD	STAGE	1HOUR	08/01/2001 – 10/01/2004
			CDEC/OLD	EC	15MIN	08/01/2006 – 06/01/2009
21	ROLD047	Old River near Delta Mendota Canal	IEP/ROLD047	STAGE	15MIN	09/01/1991 – 01/01/2003
			IEP/ROLD047	STAGE	15MIN	09/01/1999 – 12/01/2002
			CDEC/OBD	STAGE	15MIN	08/01/2001 – 10/01/2004
22	ROLD034	Old River near Byron (Highway 4)	USGS/11313405	FLOW	15MIN	01/01/2000 – 02/01/2003
			CDEC/OH4	FLOW	15MIN	10/01/2003 – 10/01/2004
			IEP/ROLD034	STAGE	15MIN	08/01/1982 – 01/01/2003
			WDL/B95270	STAGE	15MIN	01/01/2003 – 10/01/2004
23	ROLD024	Old River at Bacon Island	IEP/ROLD024	FLOW	15MIN	01/01/1987 – 02/01/2003
			CDEC/OBI	FLOW	15MIN	02/01/2003 – 10/01/2004
			IEP/ROLD024	STAGE	15MIN	01/01/1987 – 02/01/2003
			WDL/B95270	STAGE	15MIN	02/01/2003 – 10/01/2004
			IEP/ROLD024	EC	1HOUR	04/01/2000 – 01/01/2008
24	ROLD014	Old River at Holland Cut	CDEC/HLL	EC	1HOUR	03/01/1988 – 10/01/2008
25	RMID040	Middle River at Mowery Bridge	CDEC/UNI	EC	1HOUR	12/01/1999 – 06/01/2009
26	RMID027	Middle River at Tracy Blvd	CDEC/MTB	EC	1HOUR	10/01/1999 – 06/01/2009
27	RMID023	Middle River at Borden Highway	IEP/RMID023	STAGE	15MIN	09/01/1982 – 01/01/2003
			CDEC/MTB	STAGE	15MIN	01/01/2003 – 10/01/2004
			IEP/RMID023	EC	1HOUR	01/01/2000 – 05/01/2005

TABLE 3-1
Inventory of the Collected Observed Data in Delta

S.No.	Location ID	Description	Agency/ID	Parameter	Time Step	Period Available
28	RMID015	Middle River at Middle River	USGS/11312676	FLOW	15MIN	01/01/1987 – 06/01/2002
			CDEC/MDM	FLOW	15MIN	10/01/2003 – 10/01/2004
			WDL/B95468	EC	15MIN	10/01/2000 – 10/01/2008
29	RMKL019	Mokelumne River at Snodgrass Slough	IEP/RMKL019	EC	15MIN	10/01/1982 – 08/01/2004
30	CHGRL009	Grant Line Canal	IEP/CHGRL009	FLOW	15MIN	05/01/1999 – 02/01/2003
			CDEC/GLC	FLOW	15MIN	02/01/2003 – 10/01/2004
			IEP/CHGRL009	STAGE	15MIN	05/01/1999 – 02/01/2003
			WDL/B95300	STAGE	15MIN	02/01/2003 – 10/01/2004
			WDL/B95300	EC	15MIN	01/01/2000 – 09/01/2008
31	SLMZU011	Montezuma Slough at Beldons	CDEC/BDL	STAGE	1HOUR	01/01/1987 – 03/01/2009
			CDEC/BDL	EC	1HOUR	09/01/1988 – 02/01/2008
32	CHSWP003	Clifton Court Forebay	CDEC/CLC	EC	1HOUR	12/01/2000 – 02/01/2009
33	CHDMC006	Delta Mendota Canal at Tracy Pumping Plant	CDEC/DMC	EC	15MIN	04/01/1999 – 02/01/2009
34	SLDUT007	Dutch Slough	IEP/SLDUT007	FLOW	15MIN	02/01/1996 – 02/01/2003
			CDEC/FRP	FLOW	15MIN	02/01/2003 – 10/01/2004
			IEP/SLDUT007	STAGE	15MIN	02/01/1996 – 02/01/2003
			CDEC/FRP	STAGE	15MIN	02/01/2003 – 10/01/2004
			CDEC/FRP	EC	1HOUR	02/01/1999 – 06/01/2009
35	GEORG_SL	Georgiana Slough at Sacramento River	IEP/GEORG_SL	FLOW	15MIN	08/01/2001 – 12/01/2002
			CDEC/GSS	FLOW	15MIN	07/01/2004 – 12/01/2008
			IEP/GEORG_SL	STAGE	15MIN	08/01/2001 – 09/01/2003
			CDEC/GSS	STAGE	15MIN	09/01/2003 – 10/01/2004
36	STMBT_SL	Steamboat Slough	CDEC/SSS	FLOW	15MIN	09/25/2003 – 10/01/2008
37	SUTR_SL	Sutter Slough at Courtland	CDEC/SUT	FLOW	15MIN	05/30/2006 – 10/01/2008
38	CACHE_SL	Cache Slough at Ryer Island	CDEC/RYI	FLOW	15MIN	05/01/2006 – 10/01/2008

TABLE 3-2
Selection of Calibration Period Based on Hydrology, Exports, and Observed Data Availability

Water Year	Sacramento Valley[a]	Annual Exports (cfs)[b]	Data Availability[c]		
			Flow	Stage	EC
2001	D	7,067	Sparse	Sparse	Good
2002	D	7,698	Good	Good	Good
2003	AN	8,734	Good	Good	Good
2004	BN	8,464	Fair	Fair	Good
2005	AN	8,936	Fair	Fair	Good
2006	W	8,722	Fair	Fair	Good
2007	D	8,020	Good	Good	Good
2008	C	5,146	Good	Good	Good

[a] Based on CDEC data (http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST)
[b] Based on DAYFLOW data from IEP website (http://www.iep.water.ca.gov/dayflow/output/index.html)
[c] Based on data availability from IEP, CDEC and USGS at several locations in the Delta

Figures

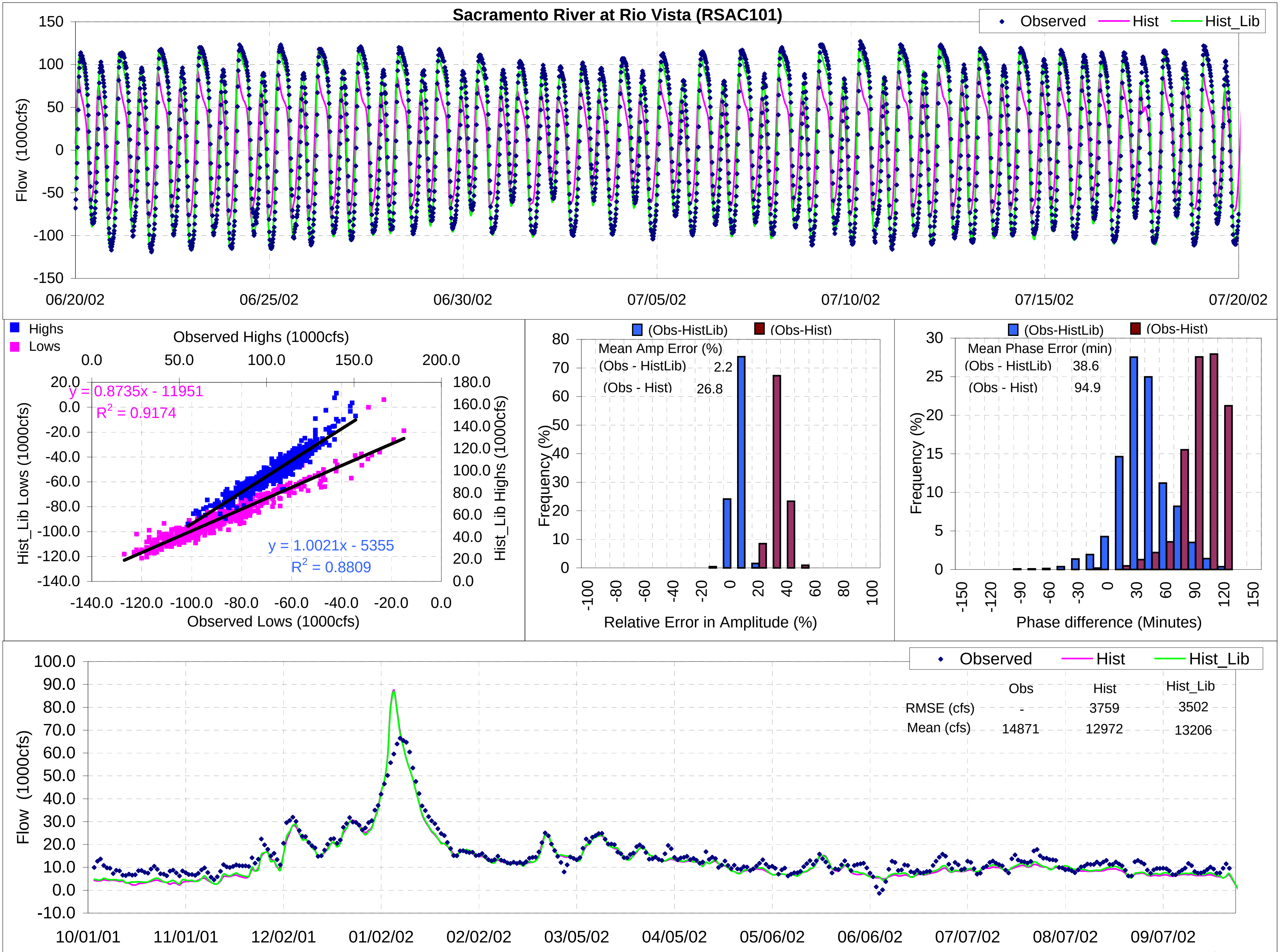
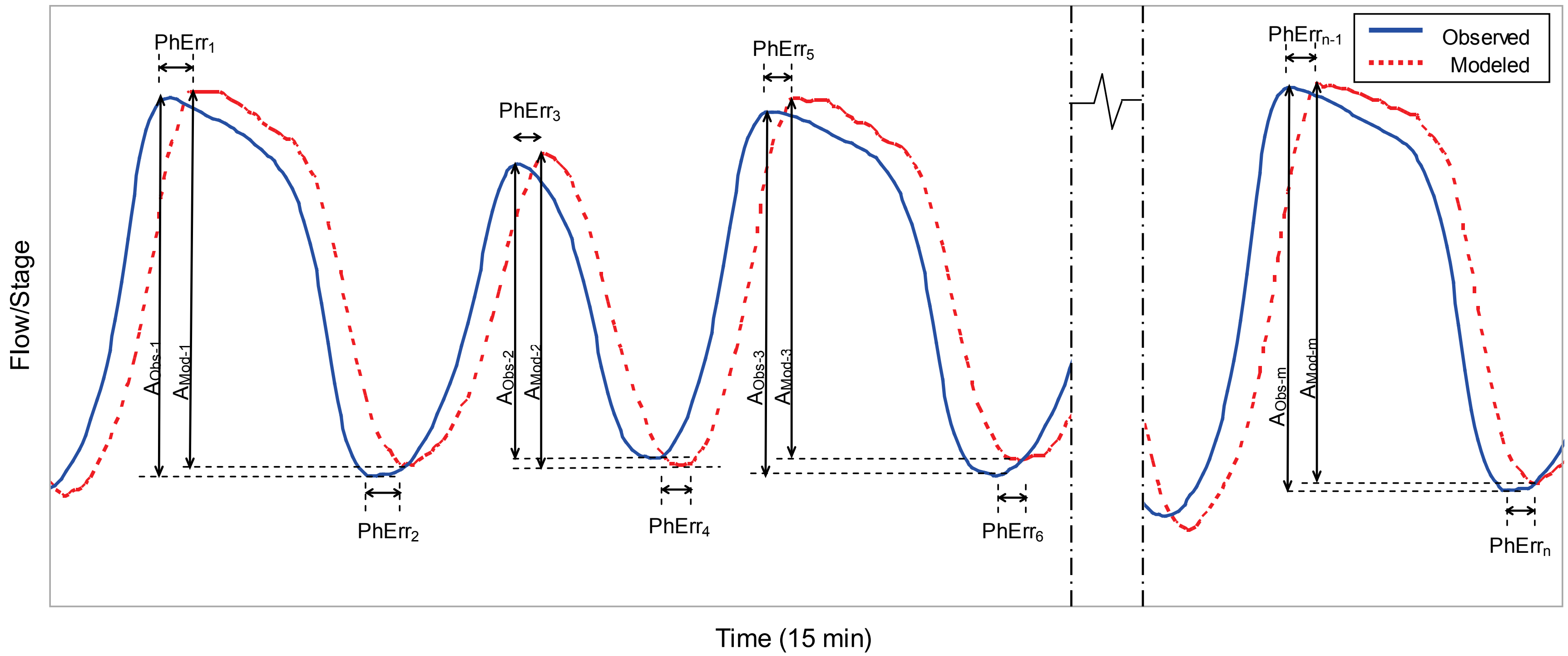


FIGURE 3-1

Sample Plot Showing the Metrics for Evaluating HYDRO Calibration



$$AvgAmplitudeError = \left\{ \frac{(A_{MOD-1} - A_{OBS-1}) + (A_{MOD-2} - A_{OBS-2}) + (A_{MOD-3} - A_{OBS-3}) + \ldots (A_{MOD-m} - A_{OBS-m})}{m} \right\}$$

$$AvgPhaseError = \left\{ \frac{PhError_1 + PhError_2 + PhError_3 + \ldots PhError_{n-1} + PhError_n}{n} \right\}$$

FIGURE 3-2
Definition of Average Amplitude Error and Average Phase Error

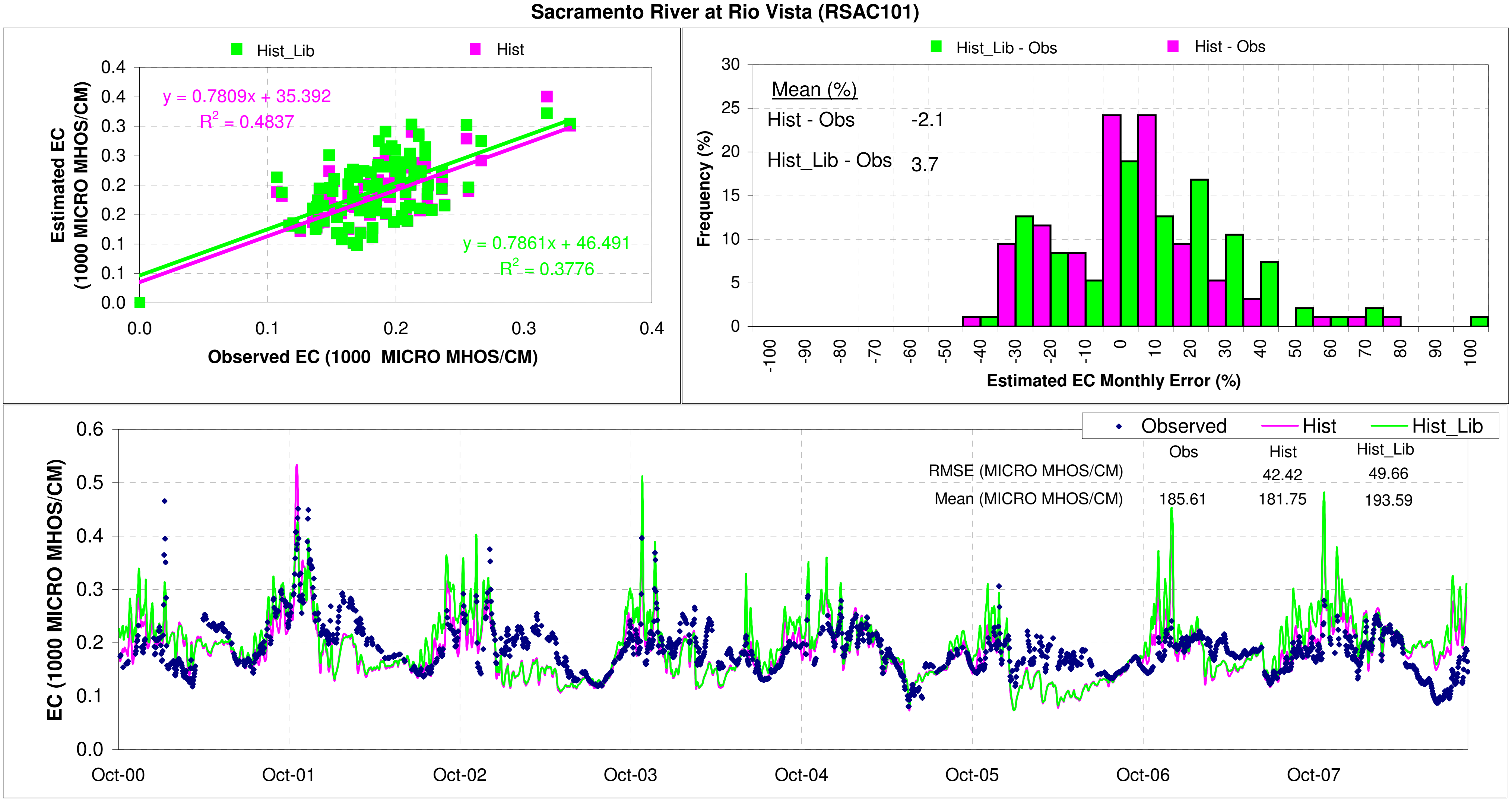


FIGURE 3-3
Sample Plot Showing the Metrics for Evaluating EC Calibration

SECTION 4

Hydrodynamics Calibration

4.1 Calibration Period

HYDRO was calibrated for one year period, using the data from WY 2002 (October 2001 to September 2002). WY 2002 was a dry year and has flow and stage data available at most locations in the Delta. Table 4-1 shows the summary of rim flows and the gate operations for this one year. Figure 4-1 shows the daily inflows and exports for WY 2002.

4.2 Key Calibration Parameters

4.2.1 Manning's n

Manning's roughness coefficient or Manning's n was the main calibration parameter used in the Hydro calibration. In 2000 calibration, DSM2PWT divided the Delta into regions of common roughness and modified the roughness regionally in the calibration process. This approach implies that the errors in the model are only associated with channel roughness; all other model errors, such as improper representation of the physical Delta in the model or the model's inability to simulate momentum at channel junctions, are only addressed to the extent the channel friction can address these limitations. In the current calibration, changes were made to both channel friction and the structural representation of the Delta. Starting from the final roughness map from 2000 calibration, Manning's n was modified in key channels to improve the DSM2's ability to simulate the observed hydrodynamics. Table 4-2 shows the list of channels with the modified Manning's n value in the current calibration.

4.2.2 Geometry Modifications

In 2000 calibration, DSM2PWT modified the channel geometry in a few key channels to get the best agreement with the observed data. These changes were justified since there were dramatic variations in the channel cross-sections within the datasets from multiple bathymetric surveys. Moreover, the process of fitting a cross-section to bathymetric data is very subjective and if there are significant changes in the data from one survey to the other, then it may lead to different interpretations of what would be a best fit for a cross-section. One of the final steps in the 2000 calibration was to decrease the Threemile Slough cross-sectional area by 20 percent at the Sacramento end and increase the area by 20 percent on the San Joaquin end.

In the current calibration, based on the discussions with DWR staff, it was decided that the cross-sections in the existing Delta channels may be modified, if necessary. The Threemile Slough cross-section at the Sacramento end was modified to provide a better fit with the bathymetry compared to the 2000 calibration. Figure 4-2 shows the cross-section profiles assumed in the 2000 calibration and current recalibration for the Threemile Slough at Sacramento River. This modification led to an increase in cross-sectional area by 16 percent compared to the 2000 calibration. It was found that increasing the area of this cross-section also helped the overall calibration in the Delta and especially in Threemile Slough. Apart from this one geometric change, the existing channels have not been modified as part of calibration process.

4.3 Key Steps in the Calibration

HYDRO calibration was started with the physical and boundary condition changes incorporated into the 2000 calibration model, as described in Section 2. The roughness coefficient was modified progressively based on the goodness-of-fit with observed data at each step. The key steps in the calibration included:

- Decreased Manning's n in
  - Sacramento River channels upstream of Sutter Slough confluence
  - San Joaquin River channels from Threemile Slough to Antioch
- Increased Threemile Slough cross-sectional area at the Sacramento River end by approximately 16 percent
- Decreased Manning's n in
  - Georgina Slough channels from Sacramento River to Mokelumne River
  - Delta Cross Channel
- Increased Manning's n in Sacramento River channel between Delta Cross Channel and Georgiana Slough to match with upstream and downstream channels

A total of 15 runs were required to get the best goodness-of-fit metrics. At the end of Run 15, it was clearly evident that the hydrodynamic results from Run 15 were improved as compared to the 2000 version.

4.4 Hydrodynamics Calibration Locations

Figure 4-3 shows the locations where the performance of DSM2 HYDRO was assessed in simulating flow and stage. A total of 12 locations for flow and 22 locations for stage were selected. Table 4-3 lists the locations including their short names used in the results discussion in the following section.

4.5 Results

Results of the hydrodynamic recalibration effort are presented below. Plots contain various metrics that were used to compare the results from the current calibration to both the observed data and to the previous calibration effort. These plots reflect model performance for WY 2002. Statistics for the 2000 calibration are included for reference and to demonstrate areas of improvement and locations where the errors increased in the current recalibration runs as compared to the previous calibration. The detailed hydrodynamics calibration results for all the locations in the Delta are included in the Appendix A.

4.5.1 Flow Calibration Metrics

The DSM2 grid modifications performed in the recalibration effort are located in the north Delta region. The inclusion of flooded Liberty Island showed the biggest impact on the tidal dynamics in this region. The result of this change can be seen in the flow metrics for Sacramento River at Rio Vista location, in Figure 4-4. On an average the simulated flow range is less than the observed data by 2.2 percent. This is a significant improvement compared to the 2000 calibration, which was under-predicting the flow range by 26.8 percent. The simulated peak flood tide flows at Rio Vista are slightly less than the observed in the latest calibration. The simulated tidal flow is lagging the observed data by 38 minutes in the current calibration compared to the 95 minutes in 2000 calibration. The simulated net flows at Rio Vista did not significantly change compared to the 2000 calibration. The RMSE is 3,502 cfs and the mean error is 1,665 cfs, which are slightly lower than the 2000 calibration.

The inclusion of Liberty Island also impacted the DSM2 performance in Georgiana Slough. The modification of channel roughness in Sacramento River upstream of Rio Vista may also have contributed to the improvements at Georgiana Slough. The flow metrics for Georgiana Slough are shown in Figure 4-5. The error in the tidal flow range, though still high, has dropped from 78 percent in 2000 calibration to 30 percent. The mean error in phase has dropped to 0.8 minutes compared from 16 minutes in the 2000 calibration. Again, the simulated net flows did not change significantly from 2000 calibration, with mean error at 211 cfs and the RMSE at 330 cfs in the current calibration.

The extension of the rigid boundary on the Sacramento River along with other channel roughness changes, improved the simulated tidal flows in Sacramento River at Freeport as shown in the Figure 4-6. The biggest concern in this reach was under prediction of peak ebb flows in DSM2. In the current calibration, the mean error in the tidal flow range has dropped to 2.5 percent from 12 percent in the 2000 calibration. Similarly, the mean phase error was reduced by nearly half from 60 minutes in the 2000 calibration. The net flows did not change as expected, because of the proximity to the boundary. However, the RMSE has increased slightly in the current calibration from 268 to 388 cfs, which is still only 2 percent of the mean flow.

The changes in the north Delta (grid and the channel roughness) resulted in better representation of the net Cross Delta flow. Cross Delta flow is the flow exiting from the Sacramento River through Georgiana Slough and the DCC, and is measured as the change in the Sacramento River flow from upstream of the DCC to downstream of Georgiana Slough. Figure 4-7 shows the calibration metrics for the Cross Delta flows. The mean error has decreased from 259 to 188 cfs and the RMSE dropped from 217 to 156 cfs in the current calibration compared to the 2000 calibration.

Figure 4-8 shows four plots with a summary of the key flow calibration metrics at several locations in the north Delta region. The plots in the top panel (a, b) present summary of the tidal flow metrics. The mean amplitude errors at all the locations in the north Delta is less than 5 percent except in Georgiana Slough. The mean phase error at all the locations in the north Delta is less than 40 minutes. Overall tidal metrics from current calibration show a significant reduction in the errors compared to the 2000 calibration at all the locations in the north Delta. The plots in the bottom panel (c, d) present summary of net flow metrics, which did not change significantly from the 2000 calibration. Slight improvements can be seen in mean error at Freeport, Rio Vista and Cross Delta flows and slight increases in locations around Georgiana Slough. RMSE has decreased for the locations downstream of DCC and increased very slightly upstream. These improvements are a direct result of increasing the tidal prism in Cache Slough via the addition of Liberty Island.

The inclusion of Liberty Island in DSM2 also impacted the flow results in west Delta region and, to a limited extent, in central Delta locations. However, modification of the Threemile Slough cross-section resulted in the largest change in these two regions of the Delta. Figure 4-9 shows the flow metrics for Threemile Slough near San Joaquin River. The mean error in tidal flow range is around 1 percent compared to 14.5 percent in 2000 calibration. The mean phase error is 24 minutes and did not appreciably change from 2000 calibration. The simulated net flow in Threemile Slough is approximately 1,000 cfs more than the observed and about 100 cfs more than the 2000 calibration. The RMSE increased from 1,015 cfs in the 2000 calibration to 1,185 cfs. Accurate simulation of the tidal flows in Threemile Slough was considered more important than net flows due to the relative magnitude of tidal flows compared to the net flows (up to 10 times the net flows).

The flow metrics for San Joaquin River at Jersey Point are shown in Figure 4-10. The errors in tidal flow range (1.6 percent) and phase (15 minutes) are very small. However, the errors in the tidally-averaged flows are relatively high at this location. The mean error is 1,287 cfs and the RMSE is 2,979 cfs, which are significant compared to the mean flow. However, comparable errors in tidally-averaged flow at Jersey Point were also present in the 2000 calibration. It is important to note that tidal flows at Jersey Point are roughly 150,000 cfs; nearly 100 times the tidally-averaged.

Figure 4-11 shows the summary of flow metrics in the central and western Delta regions. Plots a and b show the tidal metrics. The mean error in the flow range has reduced significantly in Threemile Slough and Dutch Slough and slightly increased at Jersey Point compared to the 2000 calibration. However, the errors at all three locations are less than 7 percent. The mean phase error at all the three locations is less than 30 minutes. The mean phase error increased at Jersey Point and in Dutch Slough and remained unchanged in Threemile Slough compared to the 2000 calibration. Plot c and d show the net flow metrics. Again, the changes compared to the 2000 calibration are minimal. However, the errors in the net flow are high at all the locations. The simulated net flow in Dutch Slough is in the opposite direction to the observed, although the observed net average flow in this channel is only 13 cfs.

The summary of flow metrics in the South Delta are shown in the Figure 4-12. The net flow metrics remained nearly unchanged in the South Delta and on the upper San Joaquin River compared to the 2000 calibration. Both the RMS errors and mean errors show minimal differences between the two calibration efforts. This is expected, since the changes incorporated in the recalibration effort were focused on improving model results in the north Delta. The amplitude errors, though slightly higher than 2000 calibration in the South Delta, remained low. The phase errors in the 2000 calibration effort were generally small; the recalibration results indicate slightly larger phase errors in the South Delta, but the errors remained less than 20 minutes.

4.5.2 Stage Calibration Metrics

In addition to predicted flows, the recalibration effort also included analysis of predicted stages at key locations in the Delta. The recalibration effort attempted to reduce amplitude and phase errors in predicted stage. While RMS errors in tidally-averaged water level were analyzed, potential discrepancies in datum data lessened the importance of this parameter.

The recalibration process resulted in improved DSM2 stage predictions at all the locations in the north Delta. Figure 4-13 shows the stage metrics for Rio Vista location. The mean error in tidal range has dropped from 46 percent in the 2000 calibration to 11 percent. Similarly, the mean phase error in the recalibrated DSM2 has dropped from 17 to 4 minutes. However, the mean tidally-averaged stage is 0.66 foot lower than the observed data. These results are not significantly different from the 2000 calibration, which had an error of 0.71 foot. It is uncertain whether this error is related to any datum issues. In Georgiana Slough the mean error in tidal range is at 10 percent compared to the 36 percent in the 2000 calibration as shown in Figure 4-14. The mean phase error decreased from 26 minutes in the 2000 calibration to 15 minutes. Georgiana Slough is a good example to show how the discrepancies in datum result in high RMSE and mean error even though the tidal metrics show significant improvement. Therefore, tidally-averaged metrics were not used as the key metric in assessing the stage calibration.

Figure 4-15 summarizes the tidal stage metrics for several locations in the north Delta. Plot a shows the mean error in the tidal range as percentage of the mean observed tidal range for the current recalibration and the 2000 calibration. The mean error in the tidal range is less than 13 percent at all the locations in the north Delta with significant improvements compared to the 2000 calibration. Similarly, the mean phase error has decreased significantly at all the locations in the north Delta compared to 2000 calibration, with the highest error of 32 minutes at Freeport.

Figure 4-16 shows the summary of tidal metrics for stage at several locations in the western and central Delta. Again, the mean error in the tidal range has reduced significantly compared to 2000 calibration with the highest error at 17 percent. With the exception of Antioch, the mean phase error has also reduced at all the locations with highest error at 5 minutes. At Antioch, the error has increased by 5 minutes compared to 2000 calibration to 25 minutes.

The mean error in the tidal range for all the locations in the South Delta and upper San Joaquin River have slightly reduced compared to 2000 calibration as shown in the plot a of Figure 4-17. However, the phase errors have increased in the current recalibration with the maximum error of 32 minutes at the Head of Old River.

Overall, the recalibration effort yielded consistent improvements in the predicted tidal range over the previous calibration, with the most notable improvements seen on the Sacramento River. Changes in the South Delta show only minor improvements, as expected, considering the changes to the model were confined to the North Delta. The improvements on the Sacramento River are considerable in terms of the phase difference in the predicted stage, but the improvements are not consistent as they were for tidal amplitude. Phase errors increase slightly on Old River and the upper San Joaquin River, but remain below 35 minutes and average less than 20 minutes.

Tables

TABLE 4-1
Summary of Period-Averaged Boundary Flows and Gate Operations Over the Calibration Period

Boundary Inflows, Exports and Gate Operations	Calibration Period (Oct 01, 2001 – Sep 30, 2002)
Sacramento River	18,091 cfs
San Joaquin River	1,935 cfs
Total Exports	7,433 cfs
Delta Cross Channel	Variable
Old River at Head Barrier	Installed from October to mid-November in 2001 and mid-April to mid-May in 2002
South Delta Agricultural Barriers	Gates are removed from mid-November 2001 to mid-April 2002 and installed from mid-April to end of September, 2002. (Grant Line Canal barrier was installed from mid-June)

TABLE 4-2
List of Channels with Modified Manning's Roughness Coefficient in the Current Calibration

DSM2 Channel Number	Manning's n from 2000 Calibration	Manning's n from Current Calibration
48	0.026	0.022
49	0.026	0.022
50	0.026	0.022
51	0.026	0.022
83	0.026	0.022
284	0.026	0.022
365	0.028	0.022
366	0.030	0.028
367	0.030	0.028
368	0.030	0.028
369	0.030	0.028
370	0.030	0.028
371	0.030	0.028
372	0.030	0.028
373	0.030	0.028
374	0.030	0.028
410	0.033	0.028
411	0.033	0.028
412	0.033	0.028
413	0.033	0.028
414	0.033	0.028
415	0.033	0.028
416	0.033	0.028
417	0.033	0.028
418	0.033	0.028
422	0.022	0.028

TABLE 4-3
List of Hydrodynamics Calibration Locations

Location	Short Name	Flow	Stage
Sacramento River at Freeport	RSAC155	✓	✓
Sacramento River above Delta Cross Channel	RSAC128	✓	✓
Sacramento River downstream from Georgiana Slough	RSAC123	✓	✓
Sacramento River at Rio Vista	RSAC101	✓	✓
Sacramento River at Martinez	RSAC054		✓
San Joaquin River at Mossdale	RSAN087		✓
San Joaquin River at Stockton	RSAN063	✓	✓
Stockton Ship Channel at Burns Cutoff	RSAN058		✓
San Joaquin River at San Andreas Landing	RSAN032		✓
Three Mile Slough	SLTRM004	✓	✓
San Joaquin River at Jersey Point	RSAN018	✓	✓
San Joaquin River at Antioch	RSAN007		✓
Old River at Head	ROLD074		✓
Old River at Tracy Boulevard	ROLD059		✓
Old river near Delta Mendota Canal	ROLD047		✓
Old River at Highway 4 (near Byron)	ROLD034	✓	✓
Old River at Bacon Island	ROLD024	✓	✓
Middle River at Borden Highway	RMID023		✓
Grant Line Canal at Tracy Boulevard Bridge	CHGRL009	✓	✓
Georgiana Slough	GEORG_SL	✓	✓
Montezuma Slough at Beldons	SLMZU011		✓
Dutch Slough	SLDUT007	✓	✓
Cross Delta Flow (RSAC128 - RSAC123)	X-Delta Flow	✓	

Figures

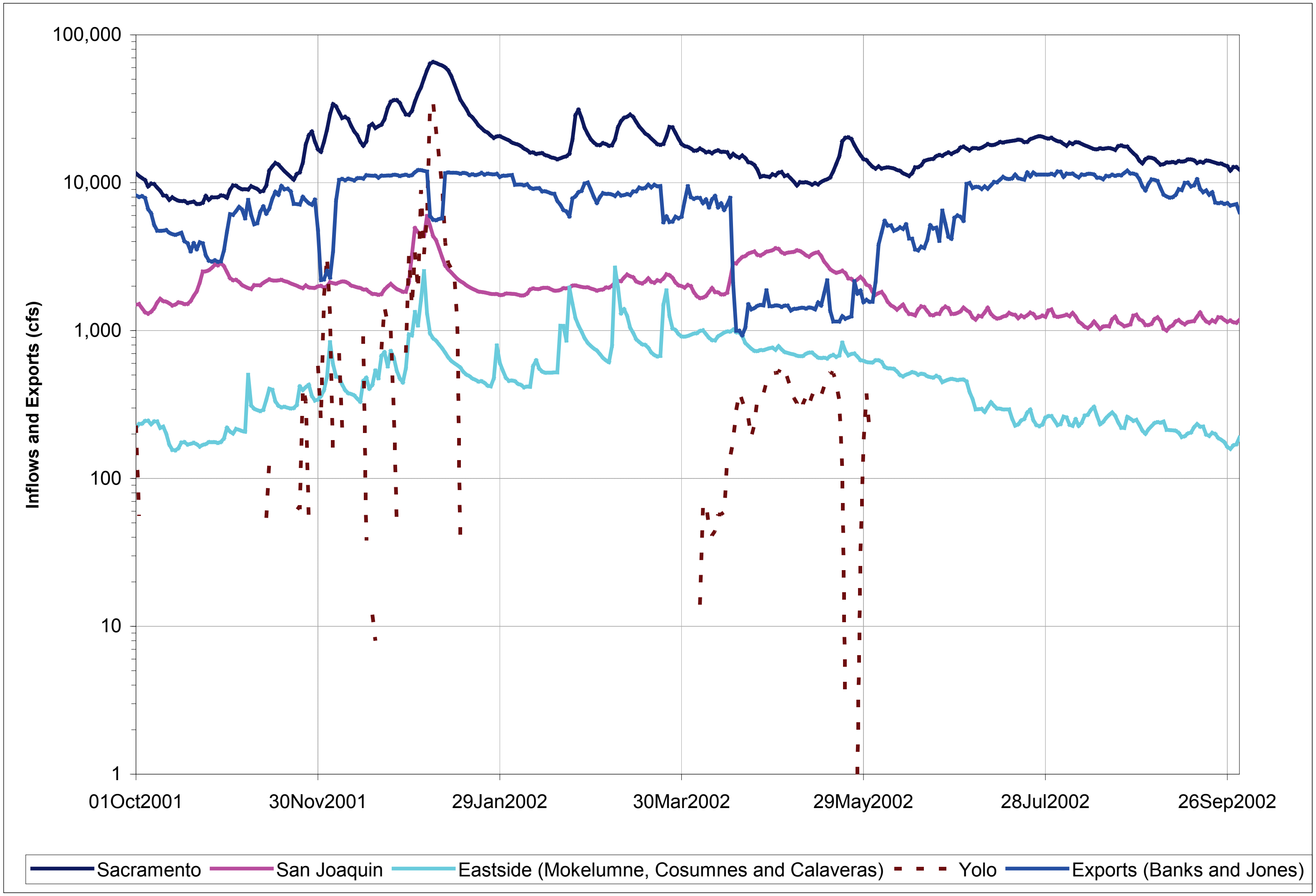


FIGURE 4-1
Daily Time Series of Boundary Inflows and Exports over the Calibration Period (WY 2002)

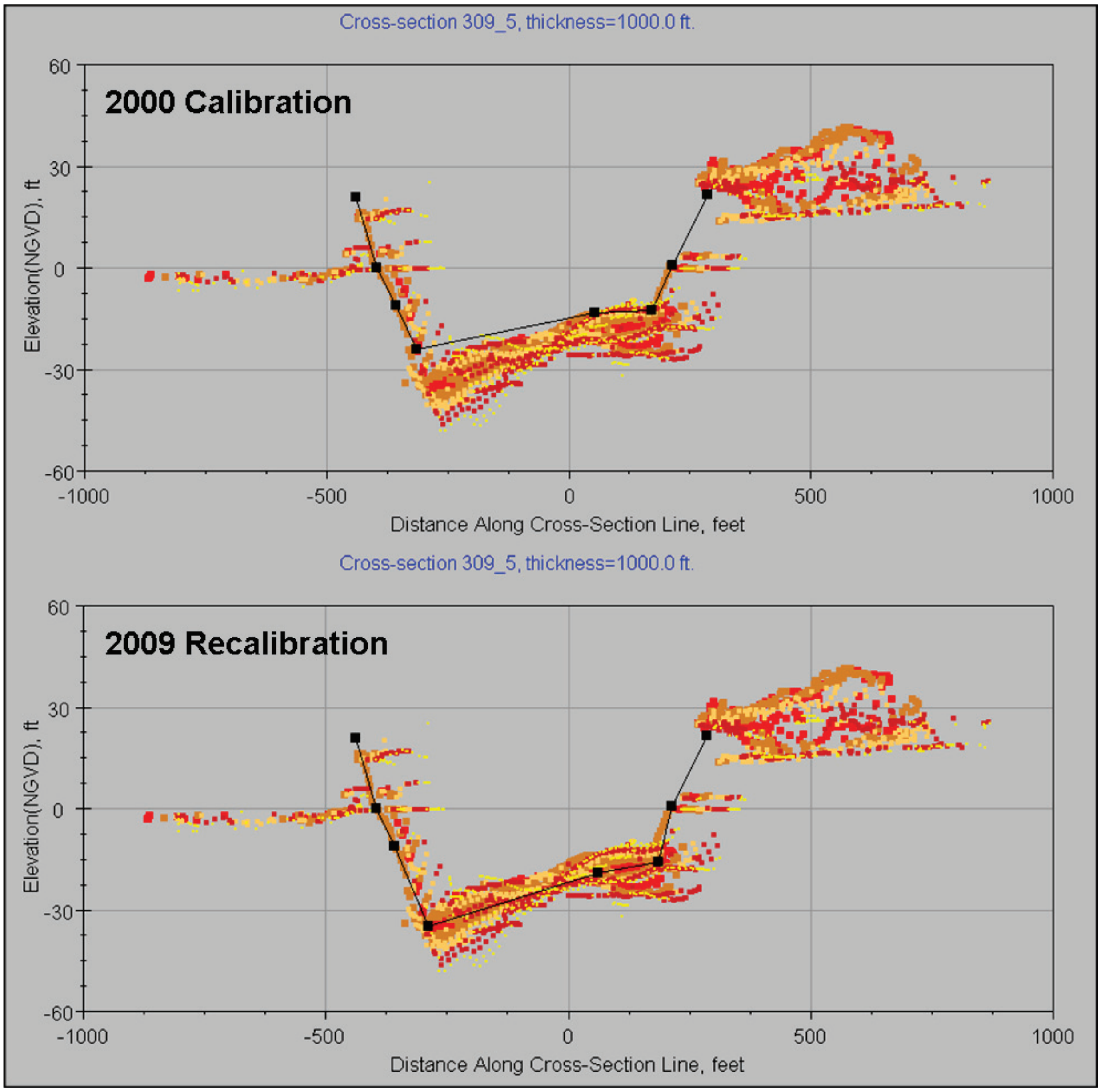


FIGURE 4-2
Comparison of Cross-section Profiles for Threemile Slough at Sacramento River, Between 2000 Calibration and 2009 Recalibration

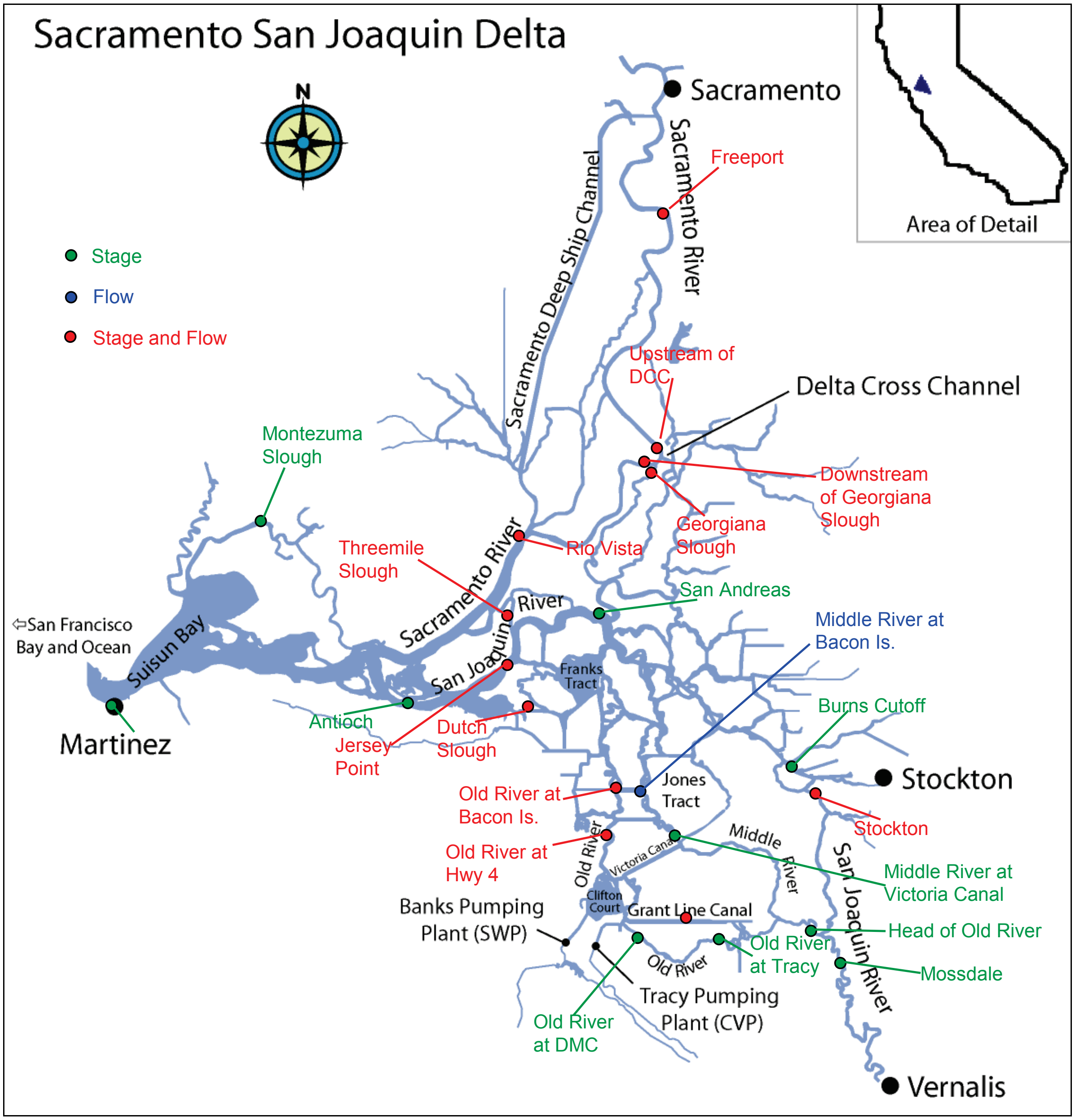


FIGURE 4-3
Map Showing Hydrodynamics Calibration Locations

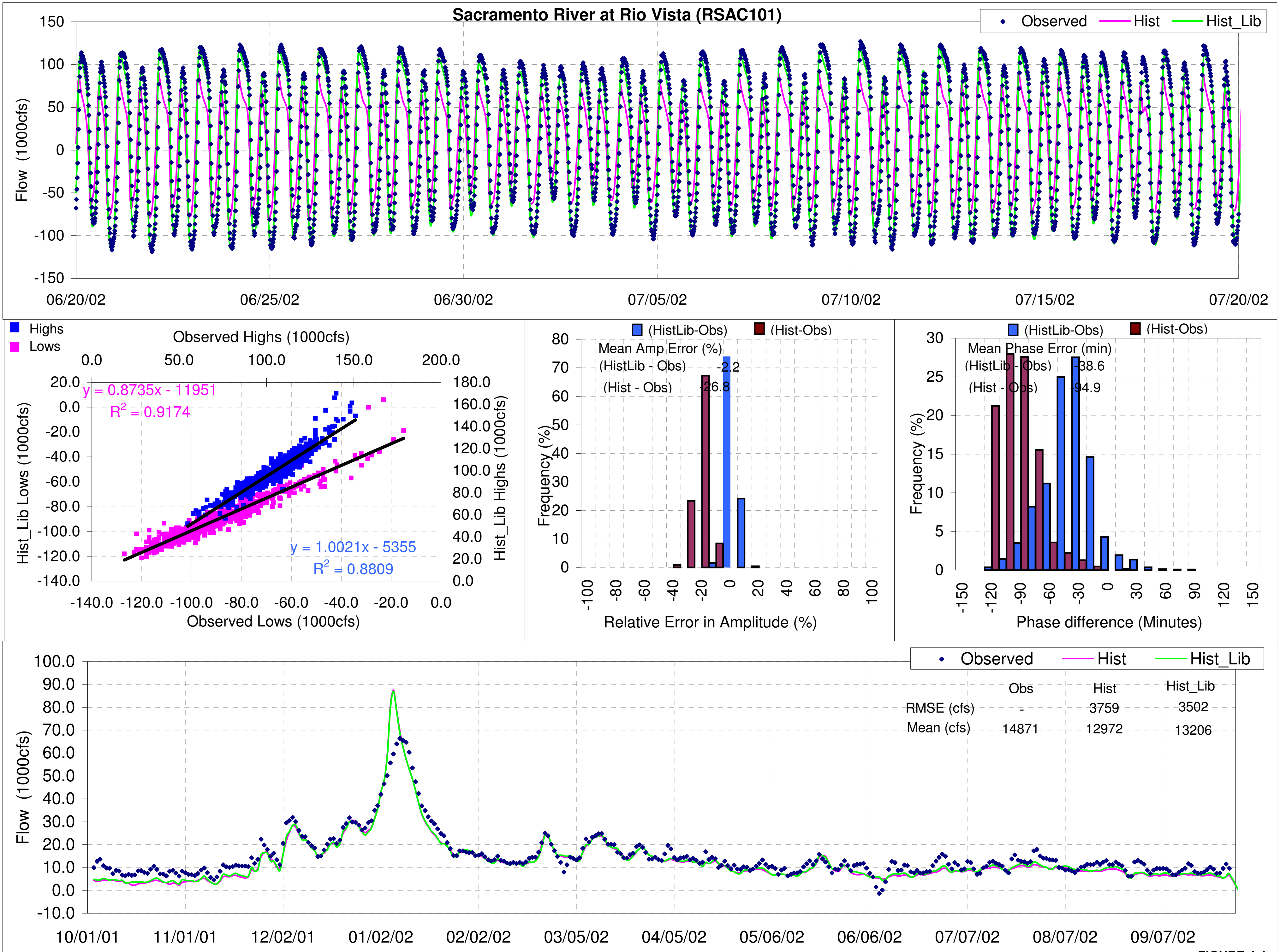


FIGURE 4-4

Flow Calibration Metrics for Sacramento River at Rio Vista

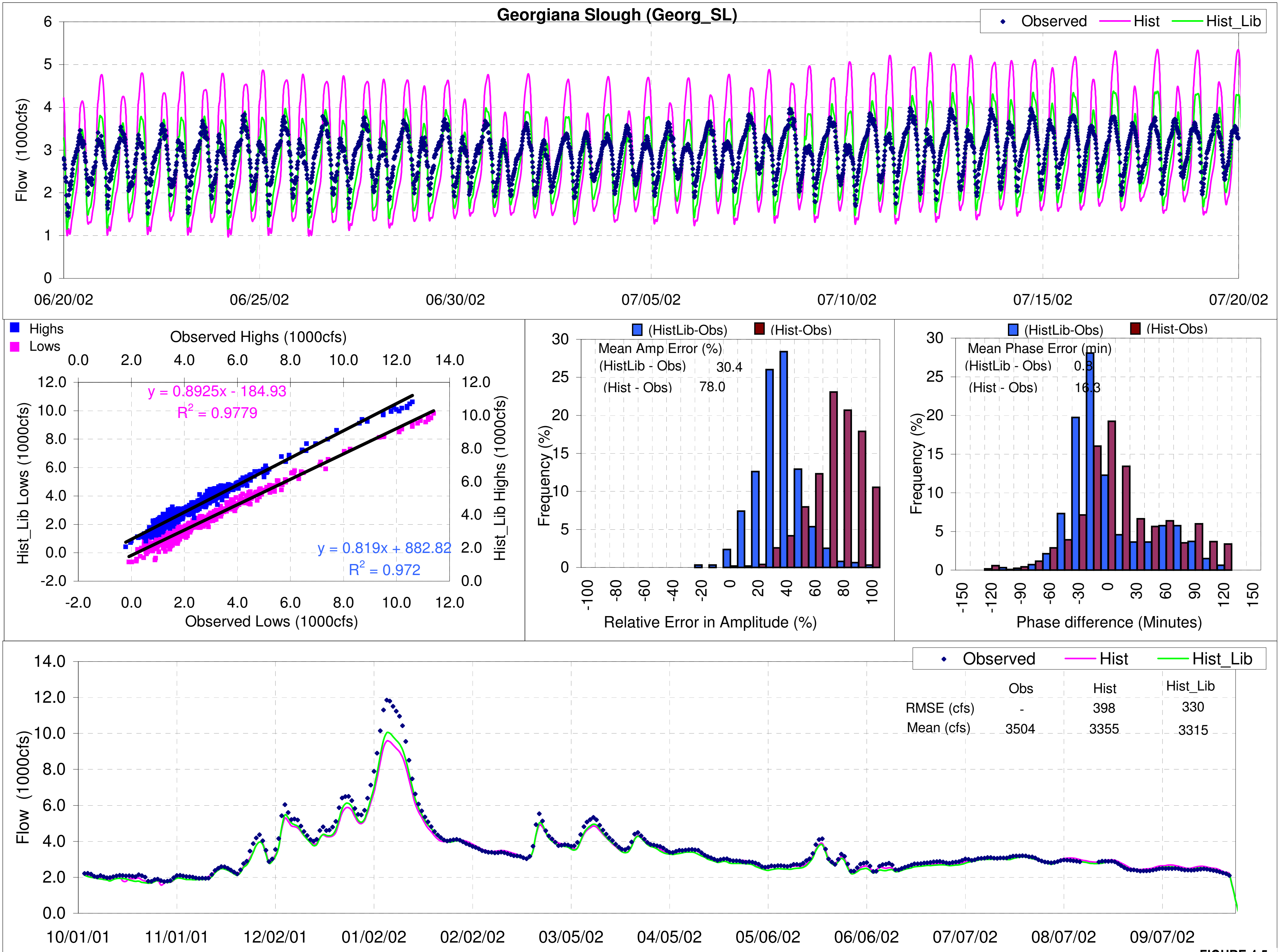


FIGURE 4-5

Flow Calibration Metrics for Georgiana Slough

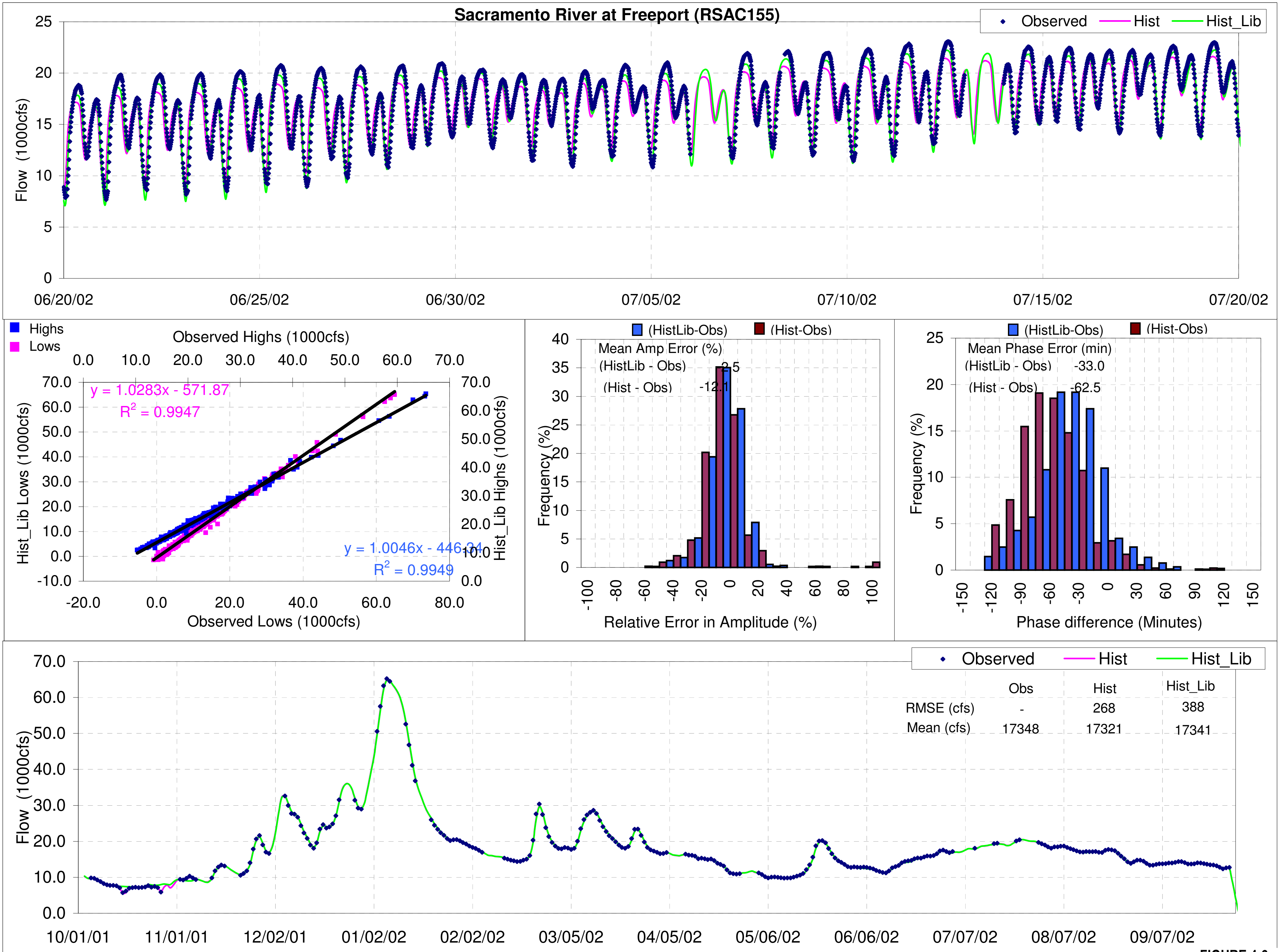
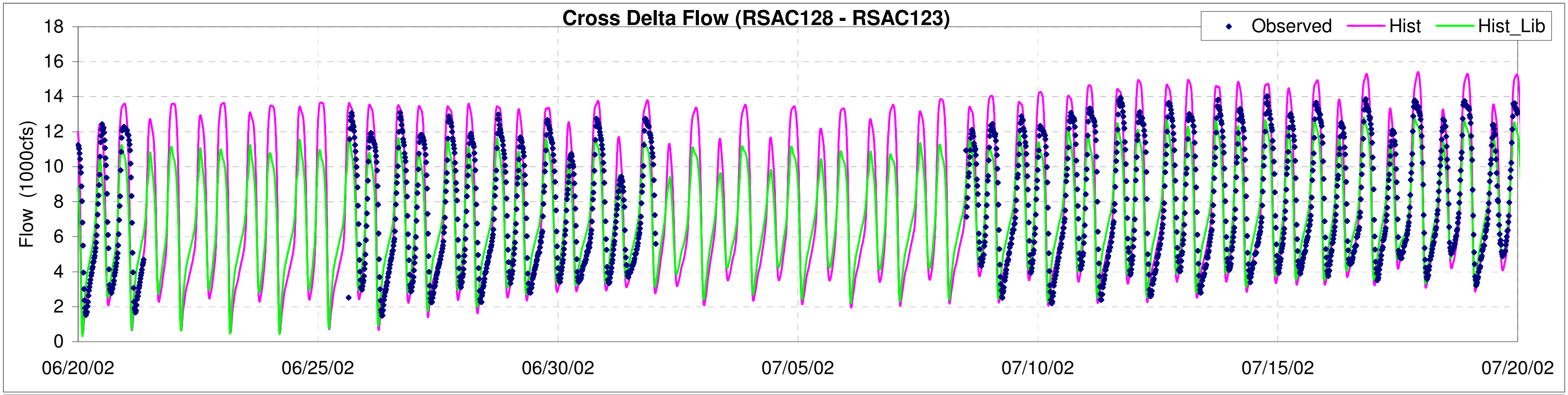


FIGURE 4-6

Flow Calibration Metrics for Sacramento River at Freeport



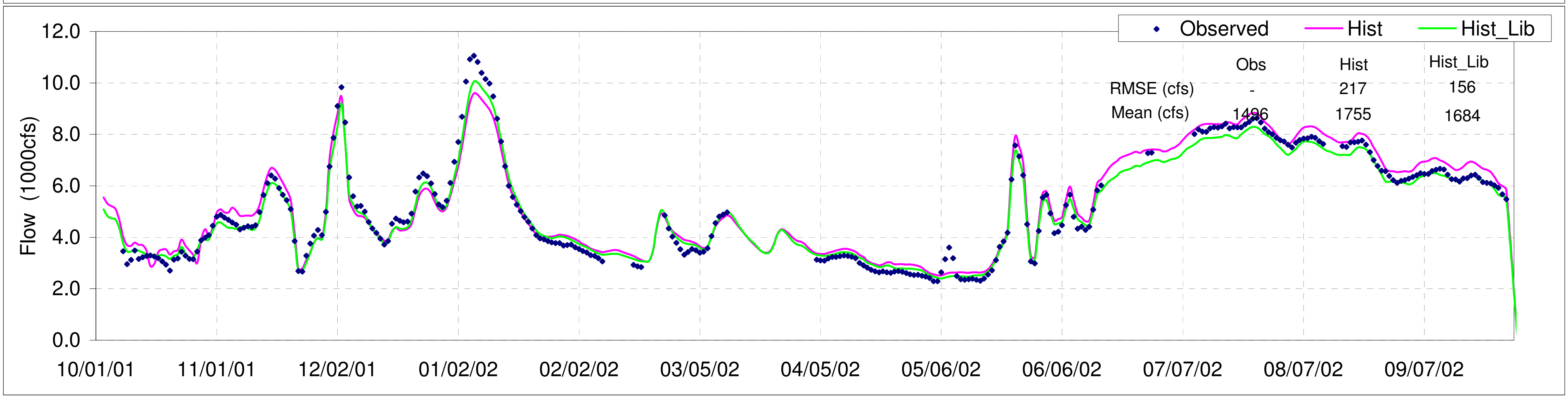


FIGURE 4-7

Flow Calibration Metrics for Cross Delta Flow (Total Flow Exiting from Sacramento River through DCC and Georgiana Slough)

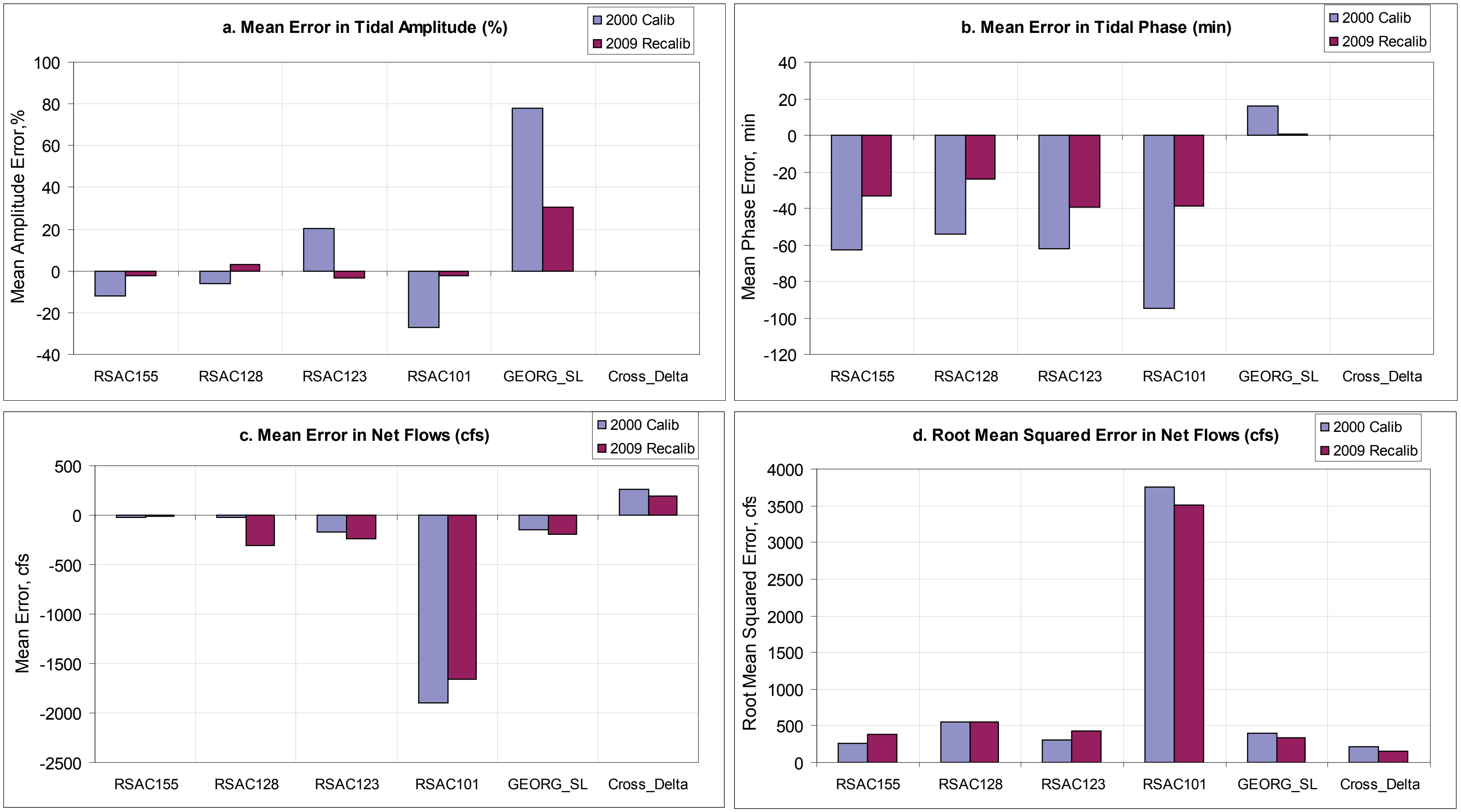


FIGURE 4-8
Summary of Flow Calibration Metrics for Locations in the North Delta Region

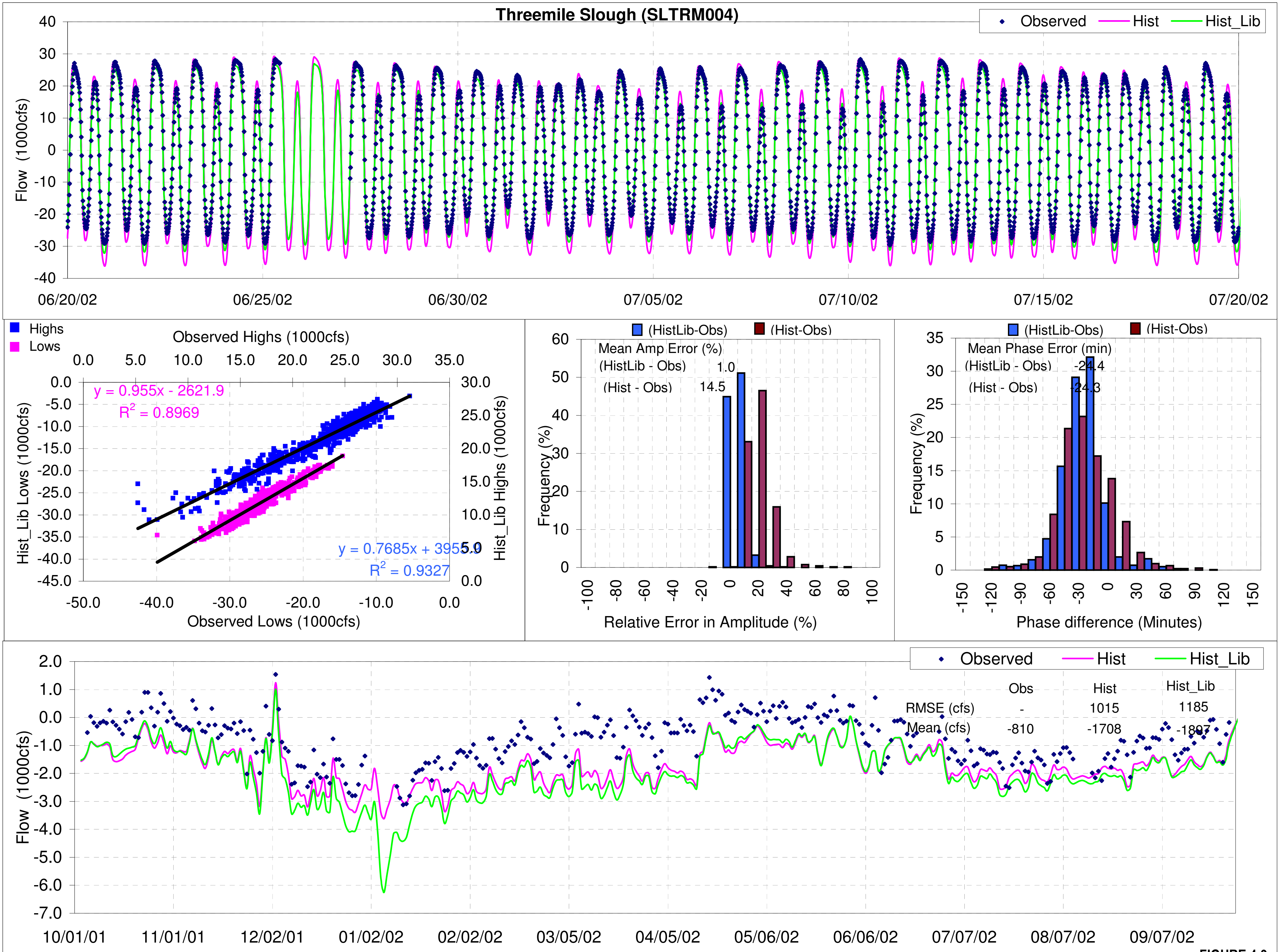


FIGURE 4-9

Flow Calibration Metrics for Threemile Slough near San Joaquin River

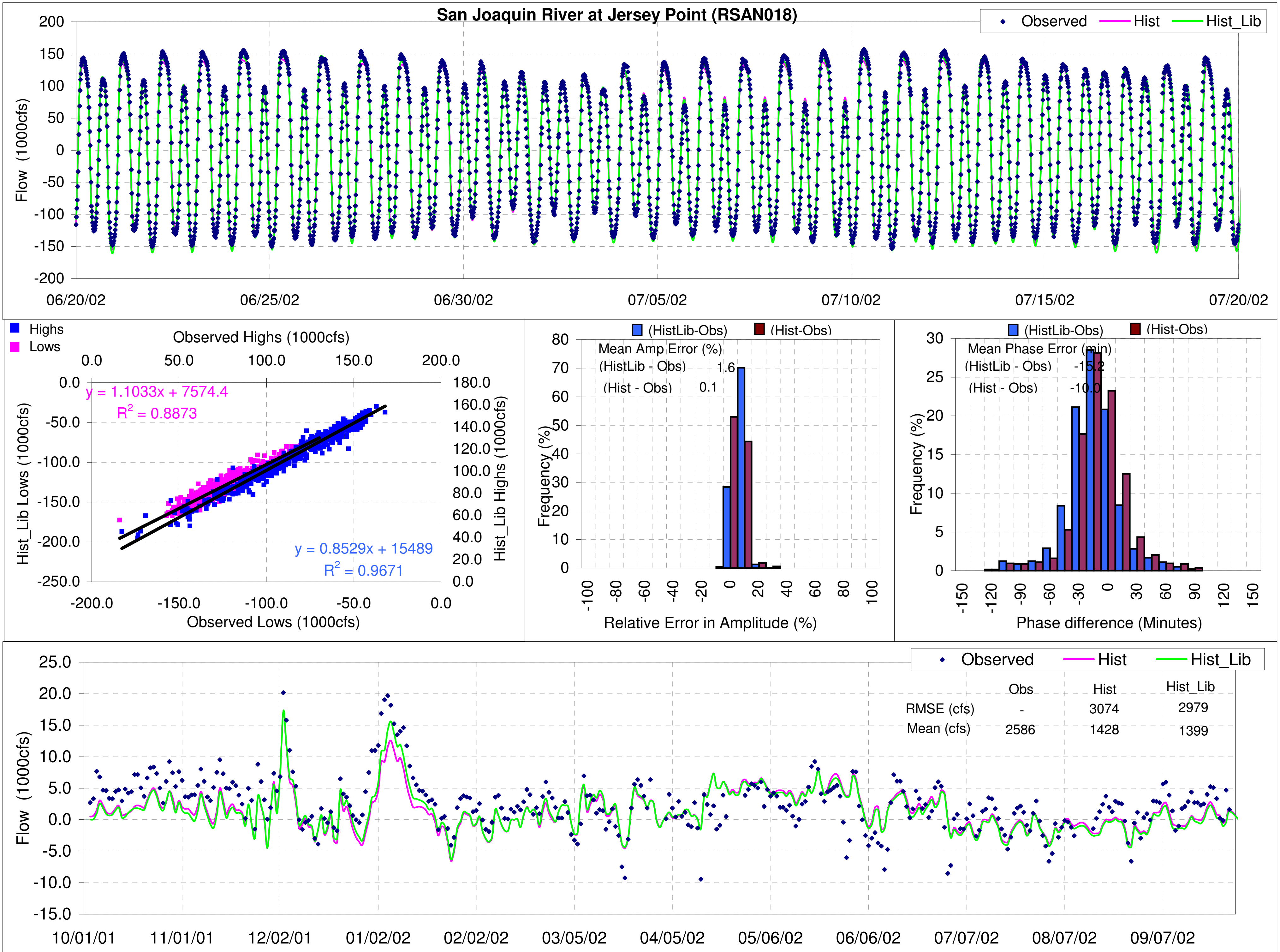


FIGURE 4-10
Flow Calibration Metrics for San Joaquin River at Jersey Point

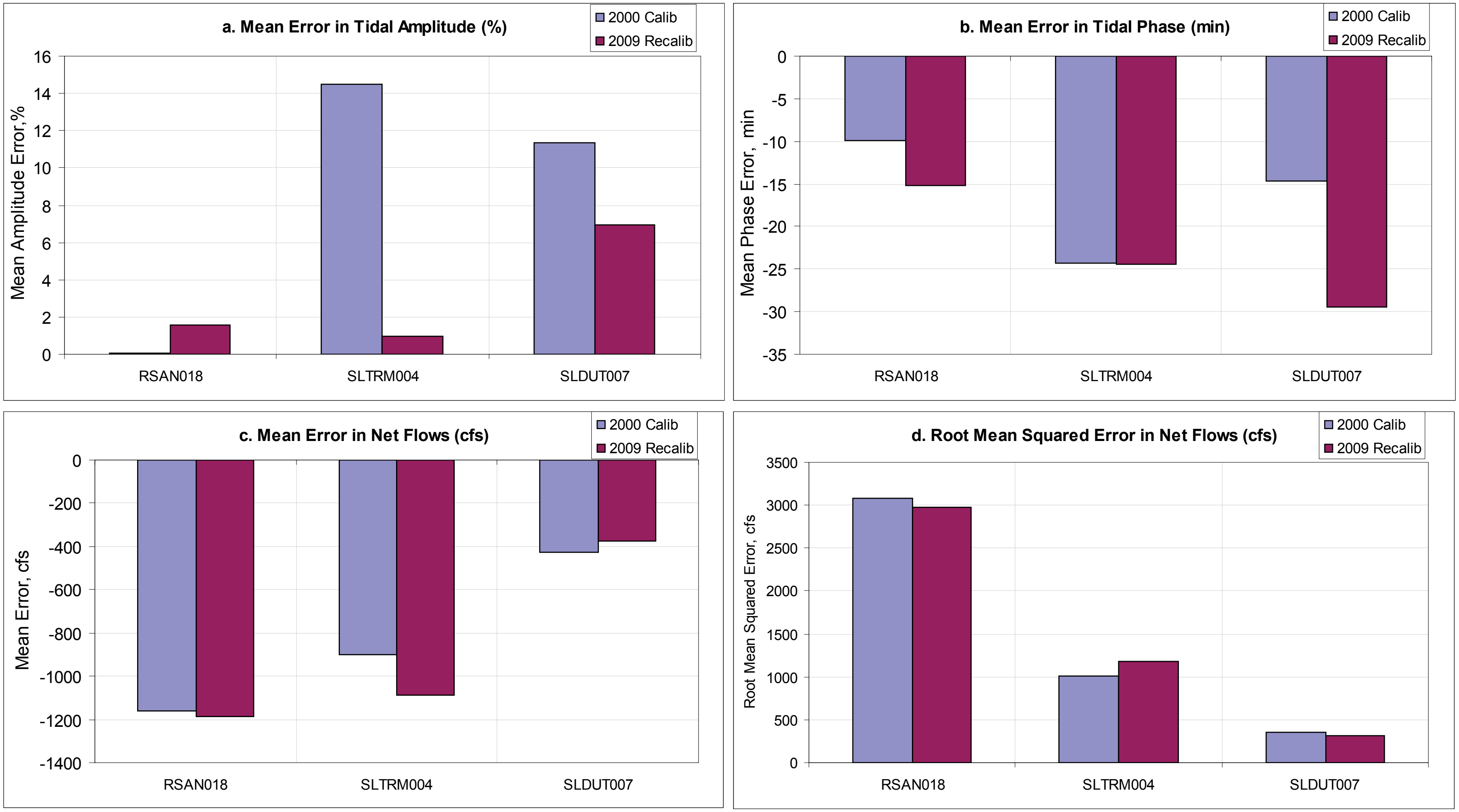


FIGURE 4-11
Summary of Flow Calibration Metrics for Locations in the Western and Central Delta Regions

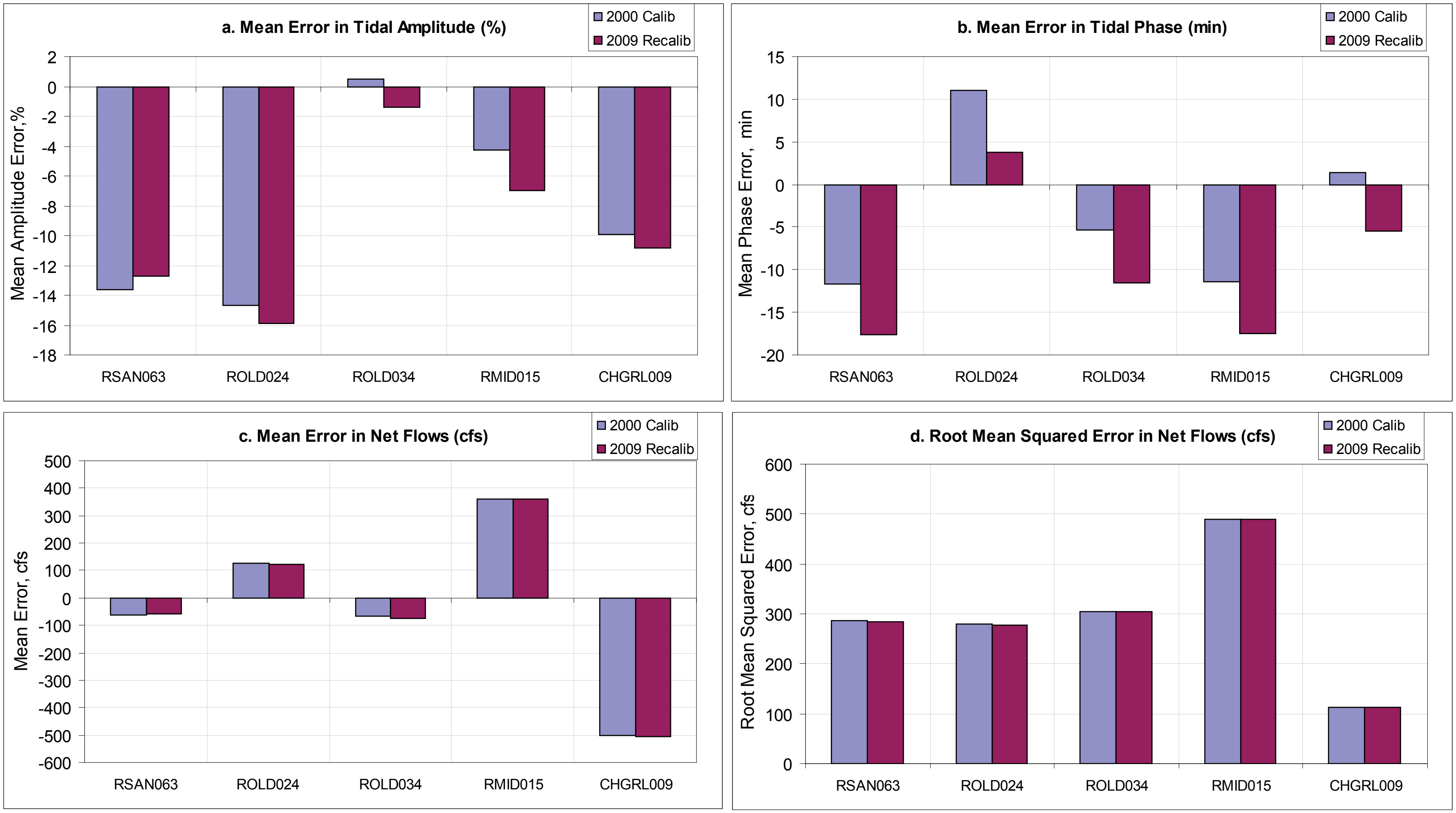


FIGURE 4-12
Summary of Flow Calibration Metrics for Locations in the South Delta Region

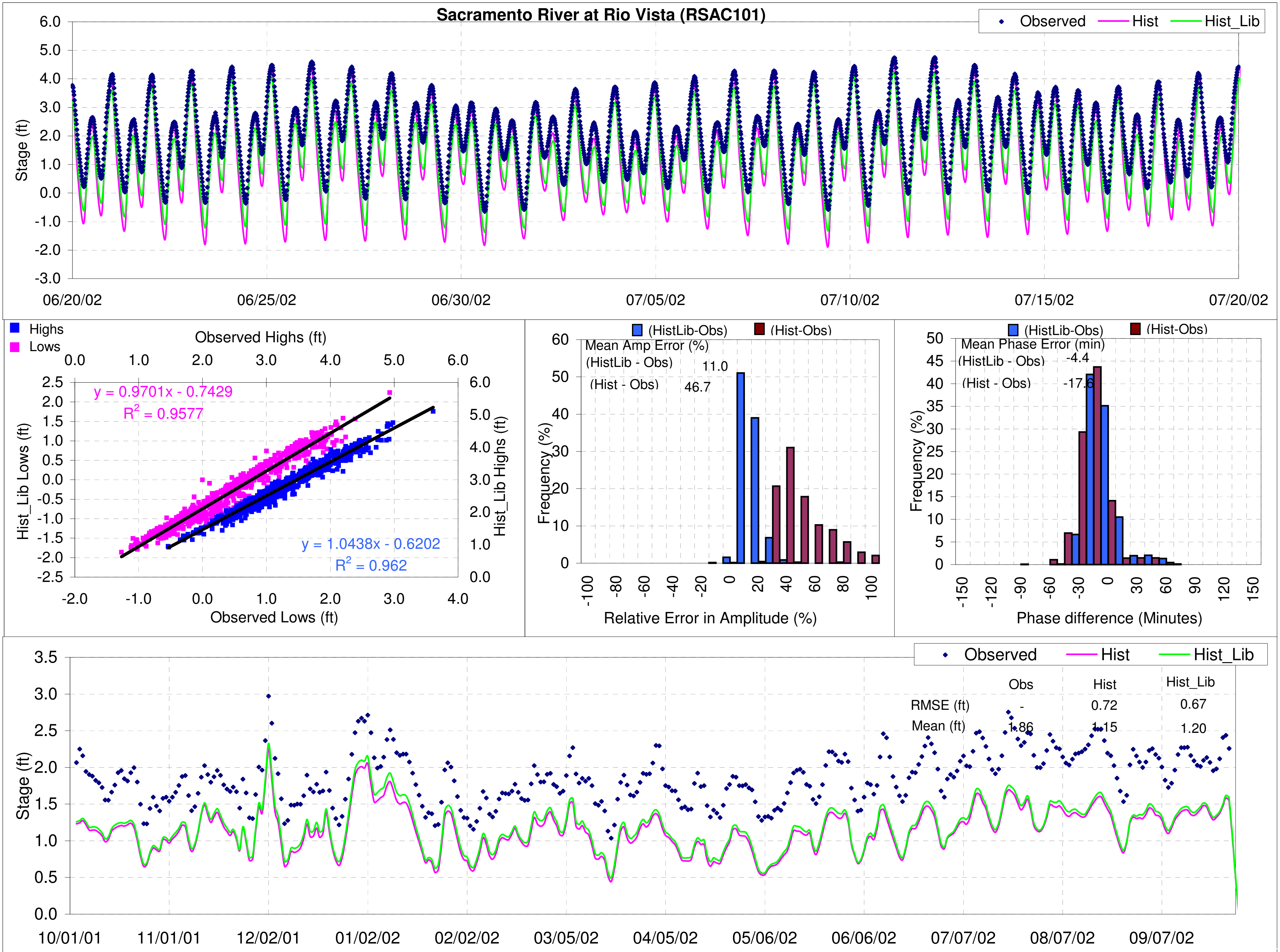


FIGURE 4-13

Stage Calibration Metrics for Sacramento River at Rio Vista

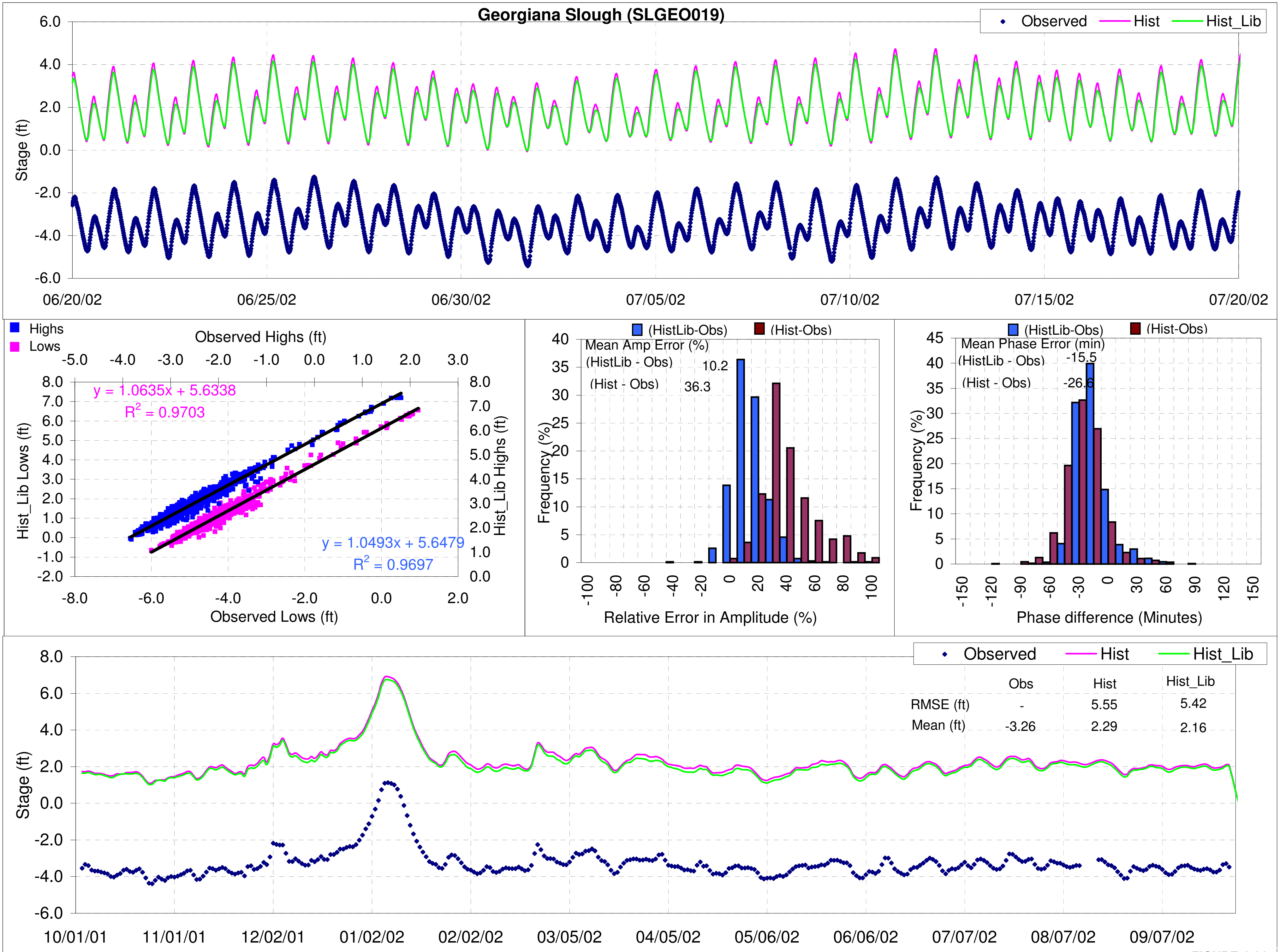


FIGURE 4-14

Stage Calibration Metrics for Georgiana Slough

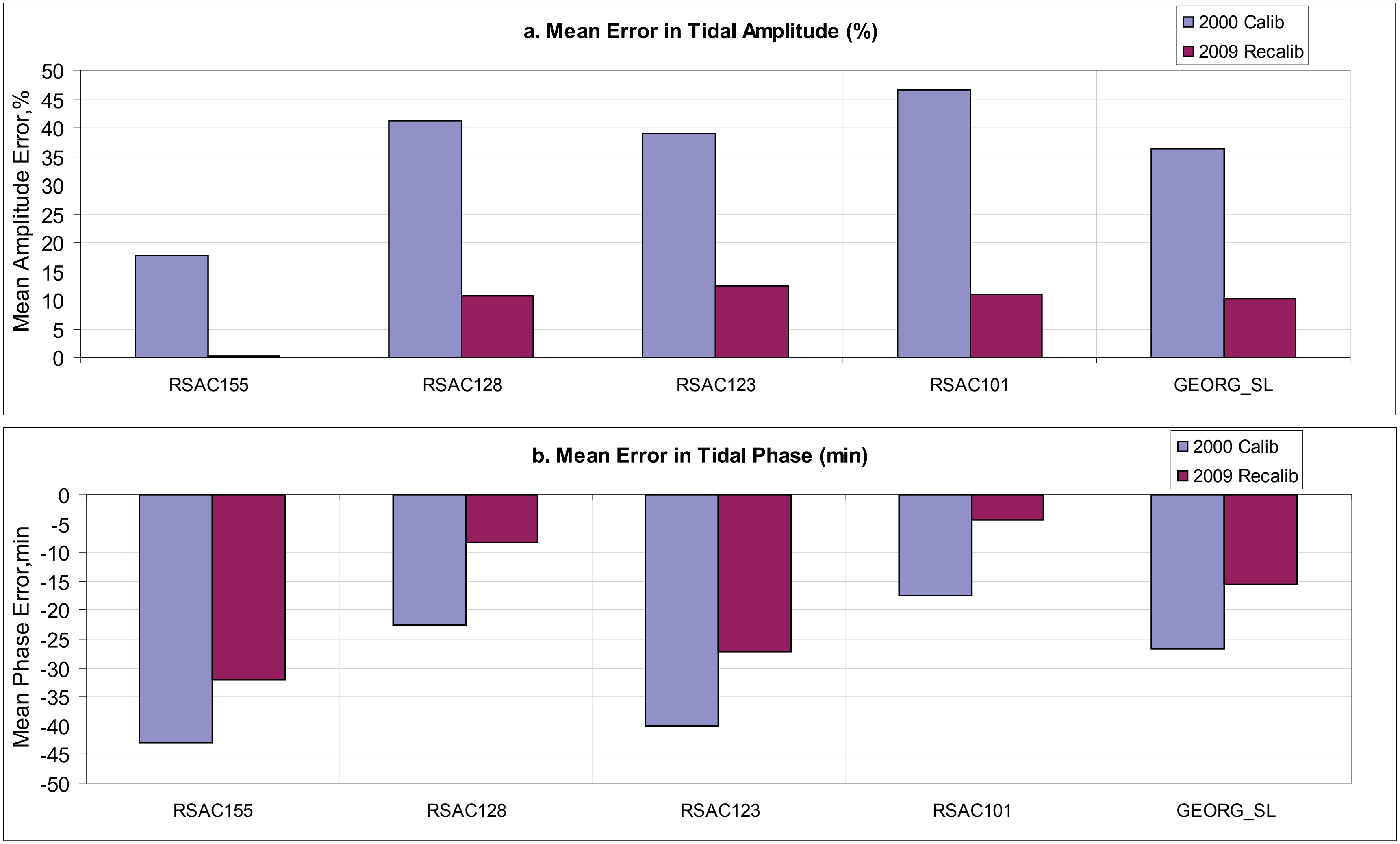


FIGURE 4-15
Summary of Stage Calibration Metrics for Locations in the North Delta Region

FIGURE 4-16
Summary of Stage Calibration Metrics for Locations in the Western and Central Delta Regions

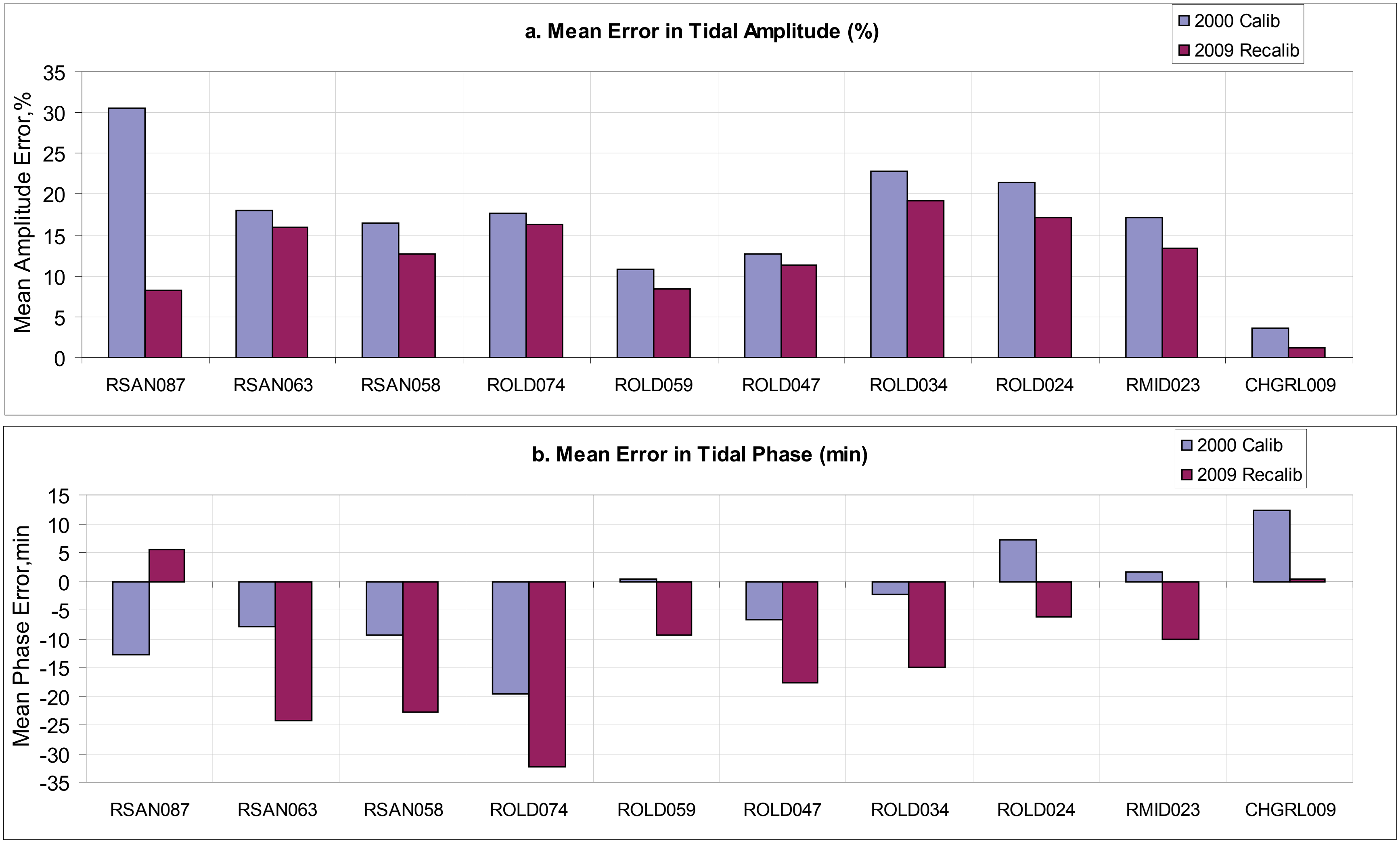


FIGURE 4-17
Summary of Stage Calibration Metrics for Locations in the South Delta Region

SECTION 5

Hydrodynamics Validation

5.1 Validation Period

Two validation runs were performed for DSM2 HYDRO. HYDRO was validated for a two year period from WY 2003 to WY 2004. HYDRO was also validated for an 8-year period from WY 2001 through WY 2008 to cover a wider variety of conditions in the Delta. The 8-year validation period included the calibration period (WY 2002). The model parameters were unchanged from calibration Run 15 for the validation simulations.

5.2 Hydrodynamics Validation Locations

Figure 5-1 shows the locations where the performance of DSM2 HYDRO was validated in simulating flow and stage. A total of 15 locations for flow and 22 locations for stage were selected. Table 5-1 lists the locations including their short names used in the results discussion in the following section.

5.3 Results

The flow and stage validation metrics are summarized in this section. The results for the flow validation are presented from the 8-year simulation. The results for the stage validation are presented from the 2-year simulation. The results from the two validation runs are compared to the results from equivalent simulations based on the 2000 calibration. The detailed hydrodynamics validation results for all the locations in the Delta are included in the Appendix B.

Figure 5-2 shows the summary of flow validation metrics for various locations in the North Delta region. Both the tidal and net flow metrics show similar trend compared to the calibration results. Three additional locations in the North Delta are included in the validation metrics: Steamboat Slough (STMBT_SL), Sutter Slough (SUTR_SL), and Cache Slough (CacheSl). The key flow metrics have improved compared to the validation results based on the 2000 calibration.

Flow validation metrics for Threemile Slough and Dutch Slough are similar to the calibration as shown in Figure 5-3. However, for Jersey Point, the results from validation did not hold the same trends as the calibration; the error in tidal flow range has decreased while the mean phase error has increased. In the net flow metrics, both the mean error and RMSE are very similar to the calibration.

In the south Delta and the upper San Joaquin River, the flow calibration trends are held in the net flow metrics from the validation simulation as shown in the Figure 5-4. However, the tidal metrics show small incremental errors at most locations, unlike the calibration results. Peak phase errors remain under 15 minutes, and peak flow amplitude errors remain under 15 percent.

Statistics were calculated for flow metrics on the 8-year validation period. Figures are presented below comparing the RMS error, mean amplitude error, and mean phase error at all the locations in the Delta where the model performance was assessed. Two plots are shown for each statistic, the first compares the results of the 1-year recalibration to the 8-year validation, and the second compares results from the 8-year validation of the recalibration to results of an 8-year validation simulation of the previous calibration effort conducted by DWR in 2000. The extended validation period contains a larger range in hydrologic influences than the 1-year calibration period, and thus RMS errors are generally expected to be larger for the validation period.

Figure 5-5 compares the RMS errors in the net flows, for WY 2002 recalibration and the corresponding 8-year validation simulations. In general, the RMS errors are larger for the longer validation simulation. The RMS errors in the upper Sacramento River are noticeably smaller for WY 2002 as compared to the 8-year period. The validation simulation actually lowered the RMS error slightly at Rio Vista and Threemile Slough.

Figure 5-6 compares the RMS error in tidally averaged flow for the two 8-year validation runs based on the 2000 calibration and the 2009 recalibration. Although the RMS errors are higher in the validation period, the relative performance of the validation simulations is similar to that presented for the WY 2002 simulations. Improvements in RMS error are seen at Rio Vista, Jersey Point, Georgiana Slough, and Cross Delta flow.

Figures 5-7 and 5-8 compare the mean errors in flow amplitude. Figure 5-7 shows the variations in mean flow amplitude errors between the one year recalibration and the 8-year validation simulations. On average, the mean percent errors are lower for the validation period as compared to the one year recalibration period; the average absolute percent error at the 13 locations in Figure 5-7 is reduced from 16 percent in the 2002 recalibration to 7 percent in the eight year validation.

Figure 5-8 compares mean errors in tidal flow range for the two validation simulations based on 2000 calibration and current recalibration. The recalibration simulation has significantly lower errors than the 2000 calibration simulation over the 8-year period. The reductions are similar to those presented for the one year calibration period. The recalibration simulation achieved considerable reductions in mean amplitude error on the Sacramento River and its side channels, including Georgiana Slough, Steamboat Slough, Sutter Slough, and Cache Slough. This is of critical performance for proper simulation of the effects of diversions off the Sacramento River and the new tidal marsh in the North Delta region proposed under BDCP.

The errors in the phasing of the predicted tidal flow are compared in Figures 5-9 and 5-10. The phase errors are similar for the one year and eight year simulations with the recalibrated model (Figure 5-9). Errors in phase are higher on the Sacramento River in general than in the South Delta. When compared to the results from 8-year validation based on the 2000 calibration, the validation results from the recalibrated model show consistent improvement throughout the Delta. Errors in the Sacramento River are cut in half in the recalibrated model, and show even greater improvement in channels branching off of the Sacramento River in the North Delta.

The improvement in the DSM2's ability to reproduce the measured daily range in water levels is summarized in Figure 5-11. Over the eight year validation period, the average errors in predicted tidal range are reduced by over 40 percent in the recalibrated model as compared to the previous calibration.

Table

TABLE 5-1
List of Hydrodynamics Validation Locations

Location	Short Name	Flow	Stage
Sacramento River at Freeport	RSAC155	✓	✓
Sacramento River above Delta Cross Channel	RSAC128	✓	✓
Sacramento River downstream from Georgiana Slough	RSAC123	✓	✓
Sacramento River at Rio Vista	RSAC101	✓	✓
Sacramento River at Martinez	RSAC054		✓
San Joaquin River at Mossdale	RSAN087		✓
San Joaquin River at Stockton	RSAN063	✓	✓
Stockton Ship Channel at Burns Cutoff	RSAN058		✓
San Joaquin River at San Andreas Landing	RSAN032		✓
Three Mile Slough	SLTRM004	✓	✓
San Joaquin River at Jersey Point	RSAN018	✓	✓
San Joaquin River at Antioch	RSAN007		✓
Old River at Head	ROLD074		✓
Old River at Tracy Boulevard	ROLD059		✓
Old river near Delta Mendota Canal	ROLD047		✓
Old River at Highway 4 (near Byron)	ROLD034	✓	✓
Old River at Bacon Island	ROLD024	✓	✓
Middle River at Bacon Island	RMID015	✓	✓
Middle River at Borden Highway	RMID023		✓
Grant Line Canal at Tracy Boulevard Bridge	CHGRL009	✓	✓
Georgiana Slough	GEORG_SL	✓	✓
Montezuma Slough at Beldons	SLMZU011		✓
Dutch Slough	SLDUT007	✓	✓
Cross Delta Flow	X-Delta Flow	✓	
Steamboat Slough	STEAMBT_SL	✓	
Sutter Slough	SUTTER_SL	✓	
Cache Slough at Ryer Island	CACHE	✓	

Figures

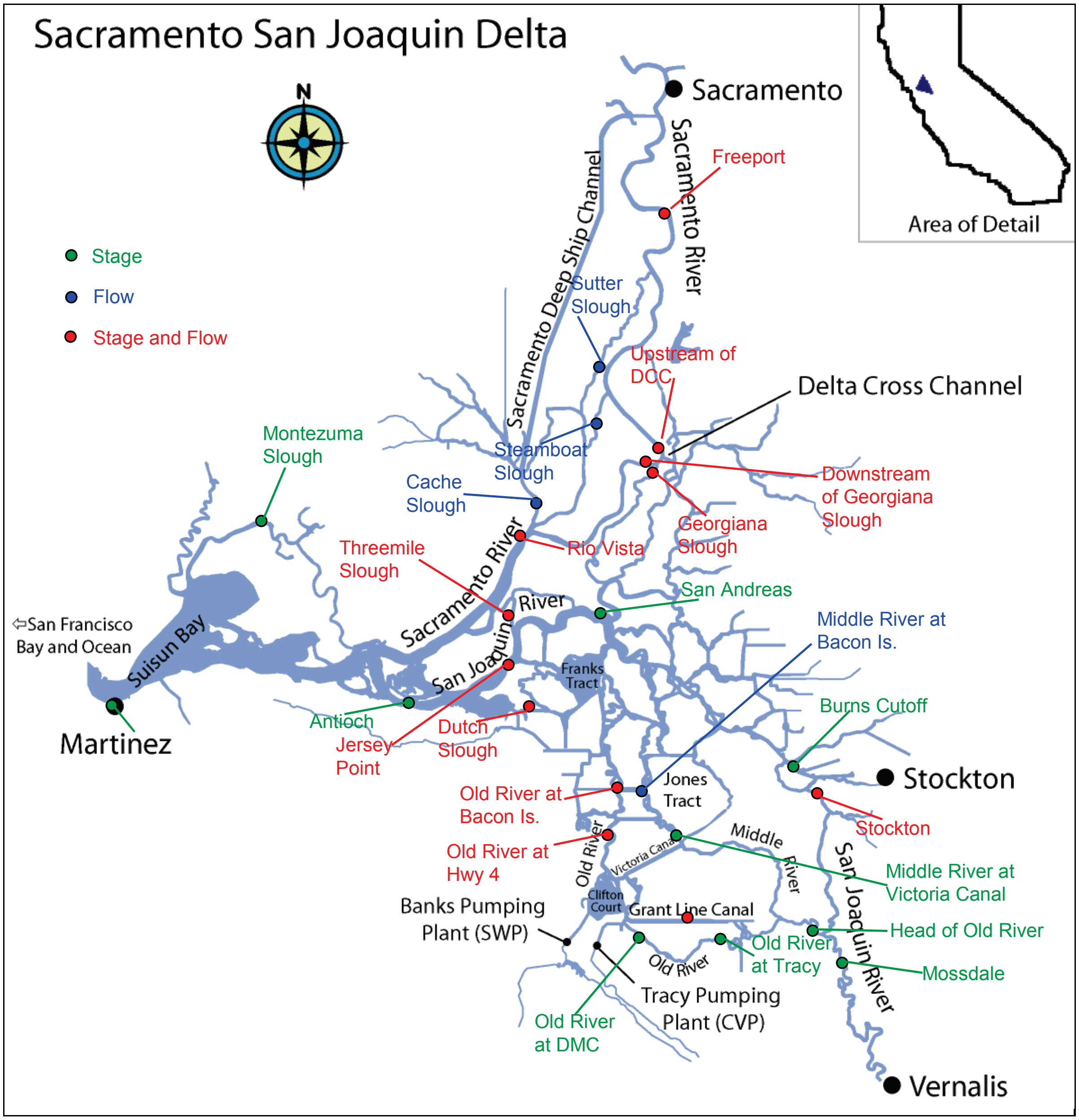


FIGURE 5-1
Map Showing Hydrodynamics Validation Locations

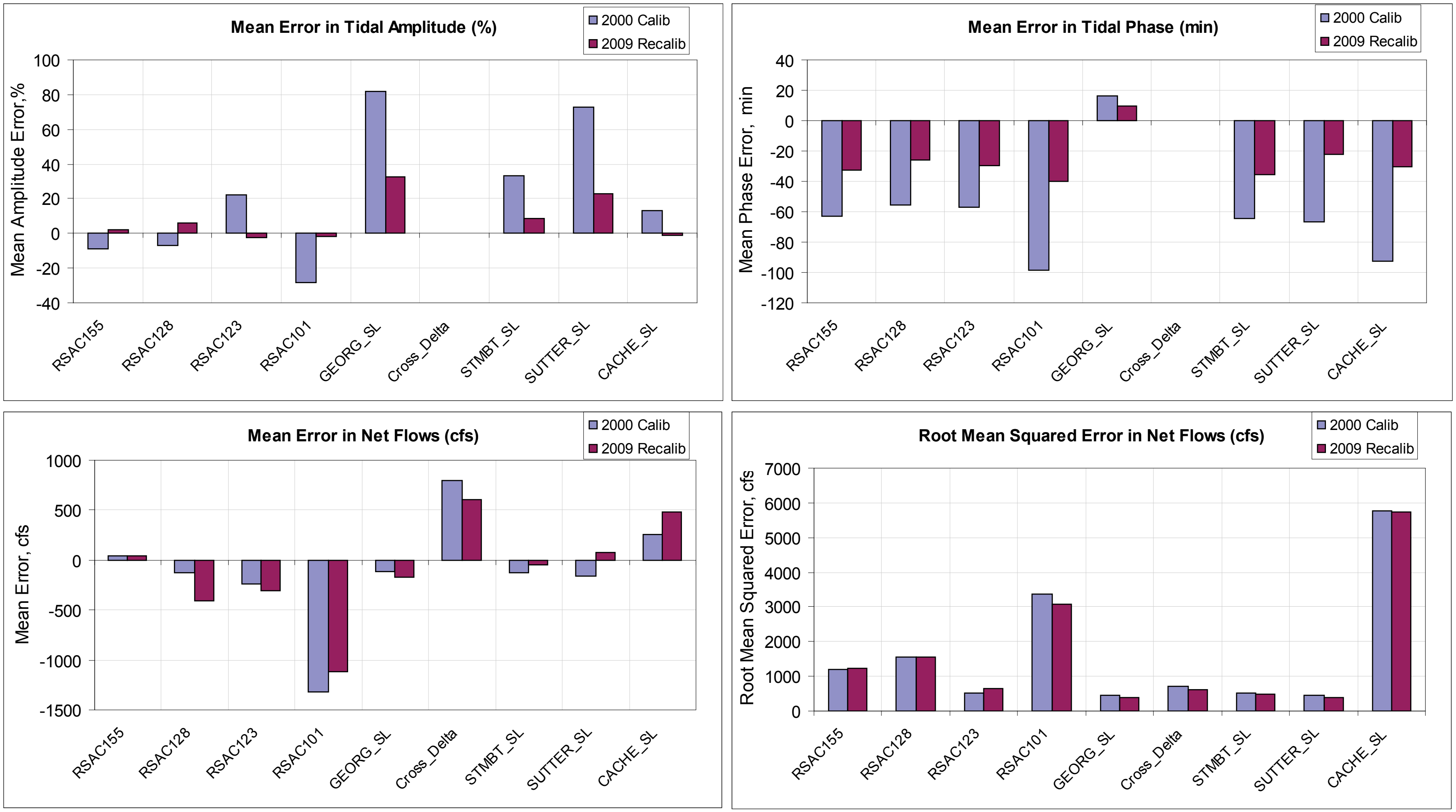


FIGURE 5-2

Summary of Flow Validation Metrics for Locations in the North Delta Region

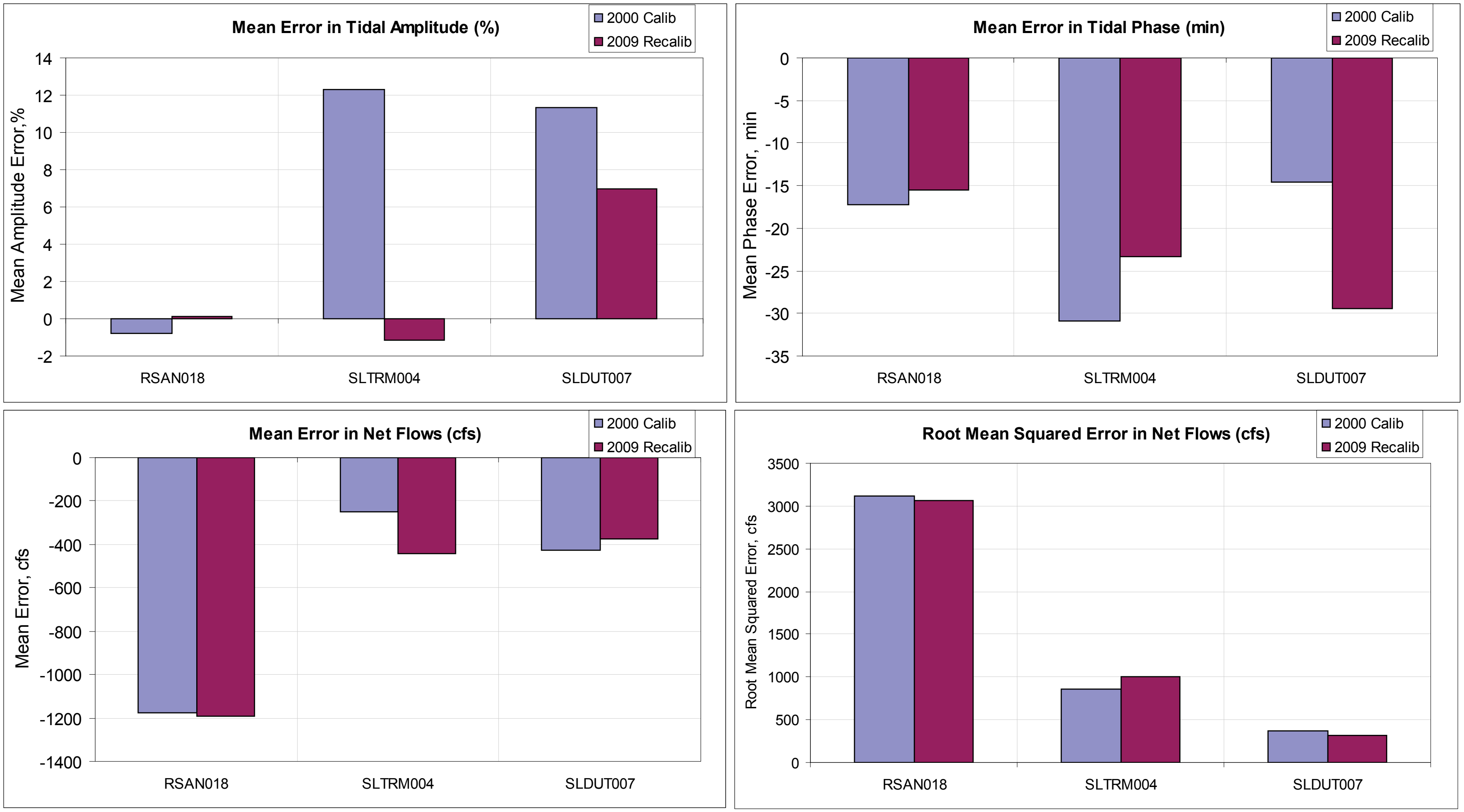


FIGURE 5-3
Summary of Flow Validation Metrics for Locations in the Western and Central Delta Regions

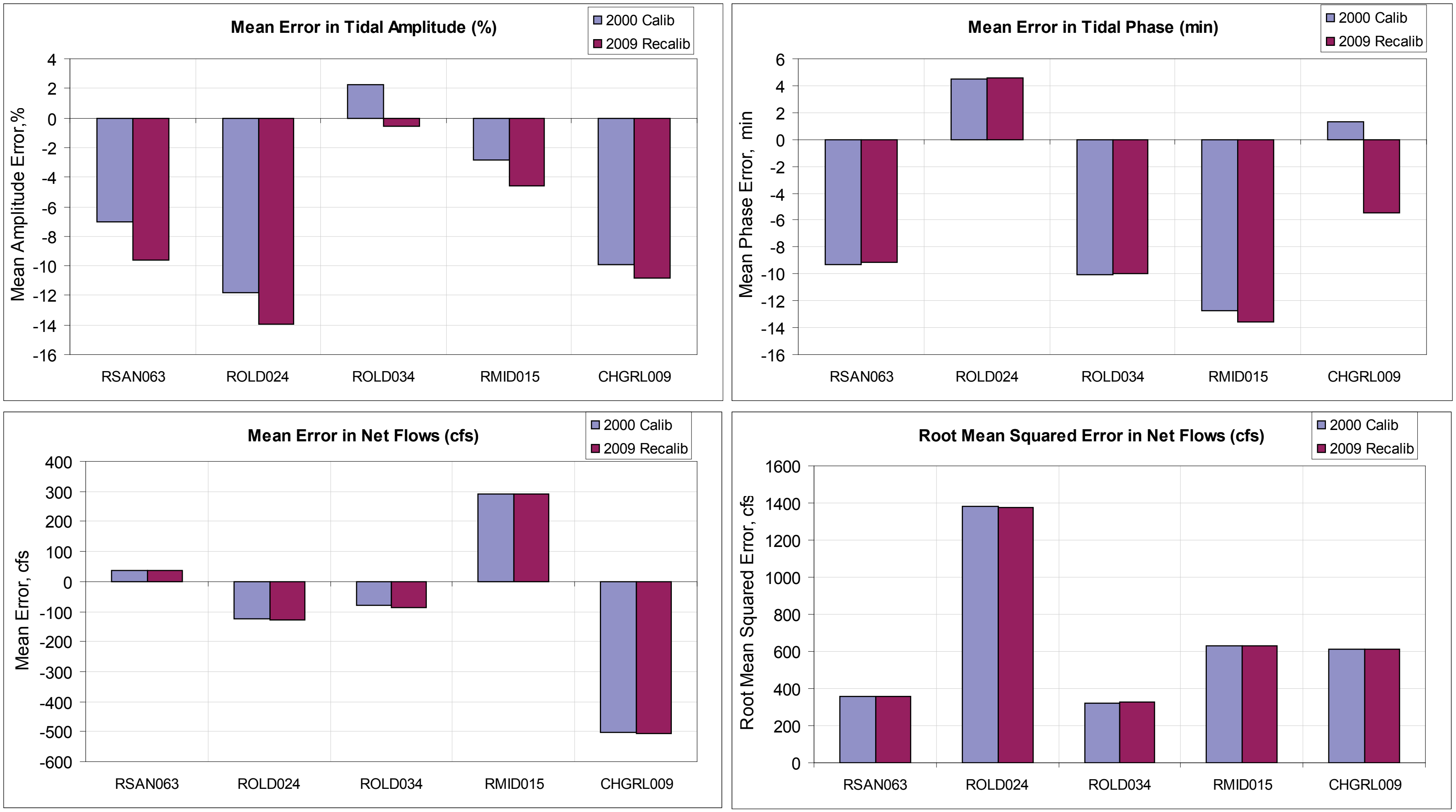


FIGURE 5-4
Summary of Flow Validation Metrics for Locations in the South Delta Region

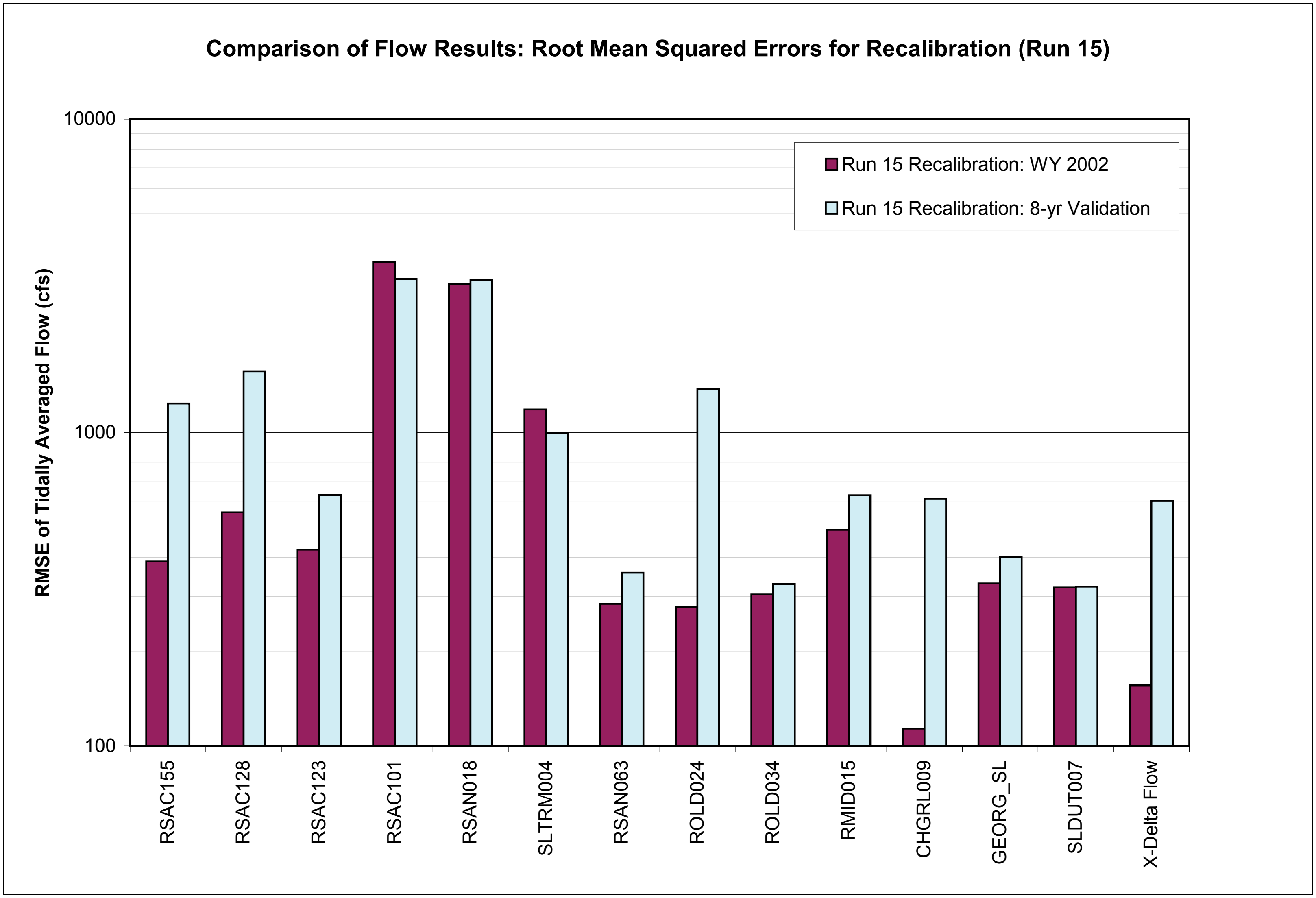


FIGURE 5-5
Comparison of RMS Errors in Flow for Recalibration and Extended Validation

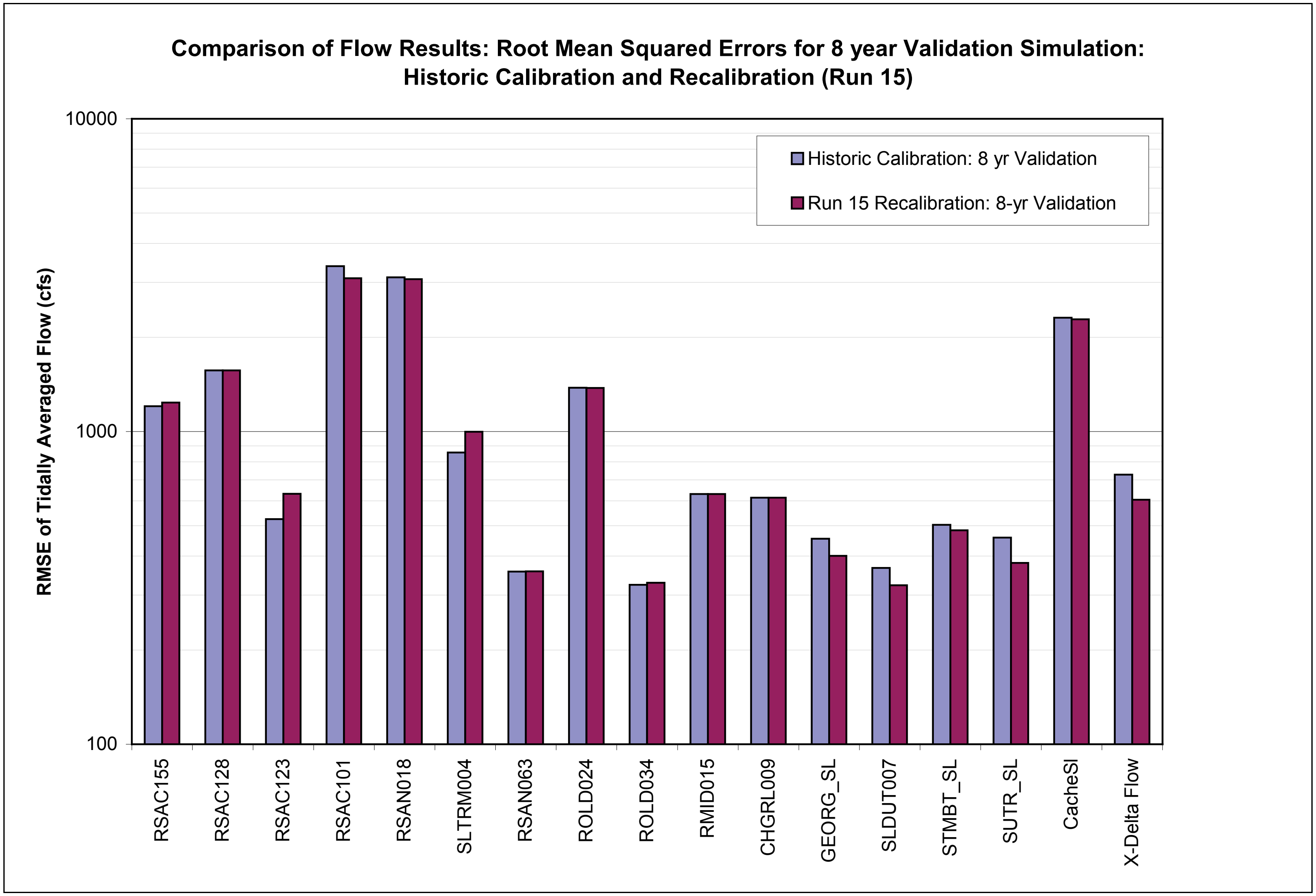


FIGURE 5-6
Comparison of RMS Errors in Flow for Extended Validation Period
(2000 Calibration and 2009 Recalibration Simulations)

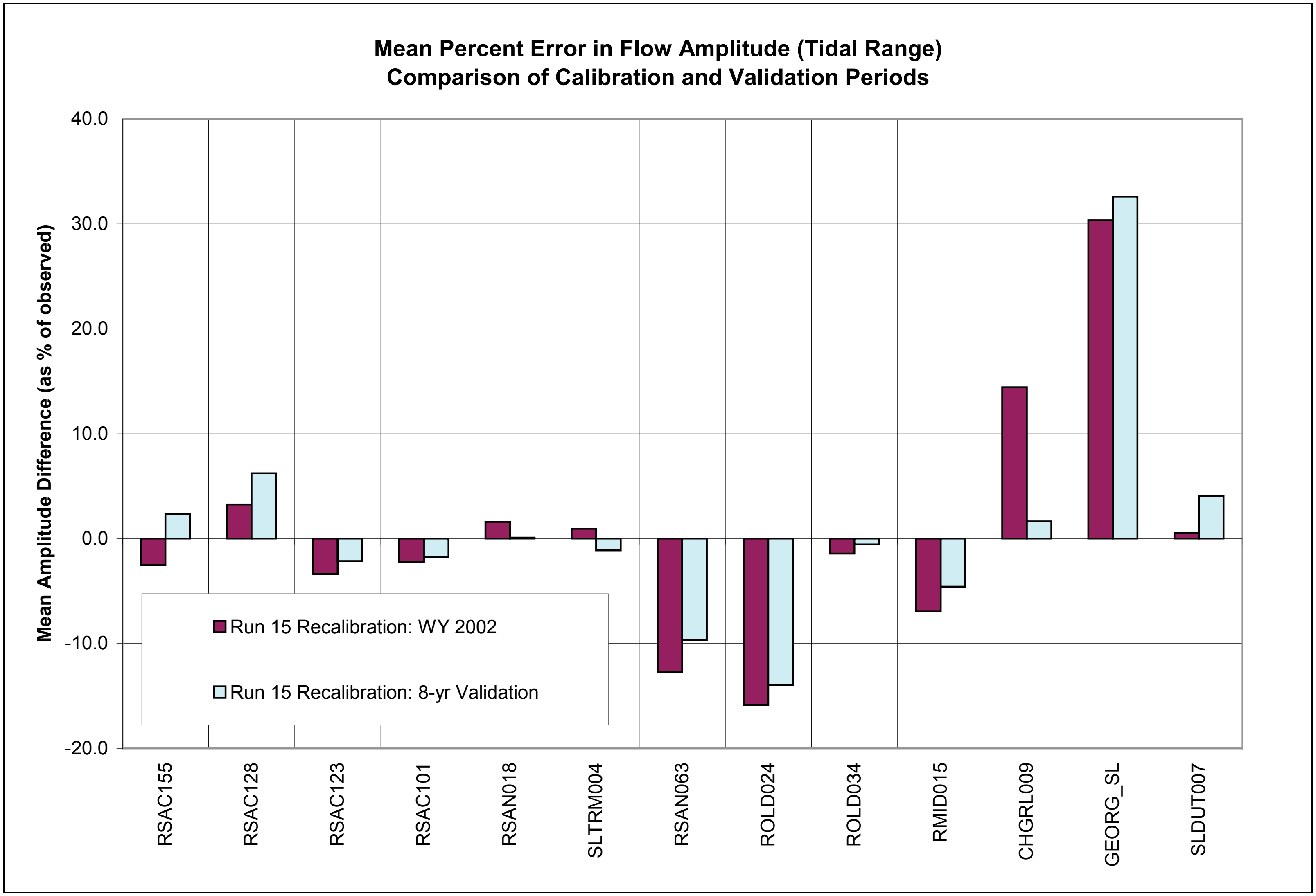


FIGURE 5-7
Comparison of Mean Amplitude Errors in Flow for Recalibration and Extended Validation

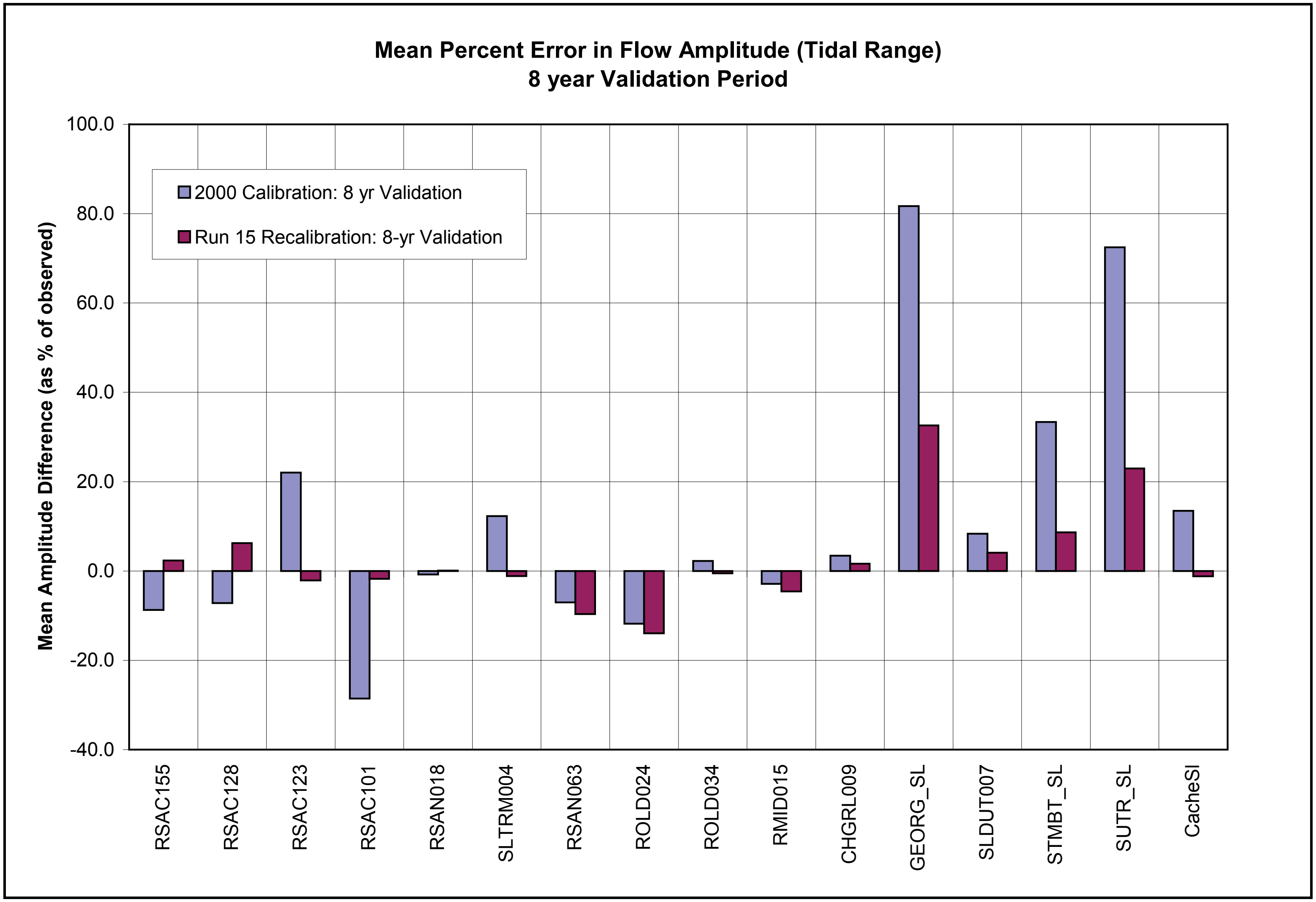


FIGURE 5-8
Comparison of RMS Errors in Flow for Extended Validation Period
(2000 Calibration and 2009 Recalibration Simulations)

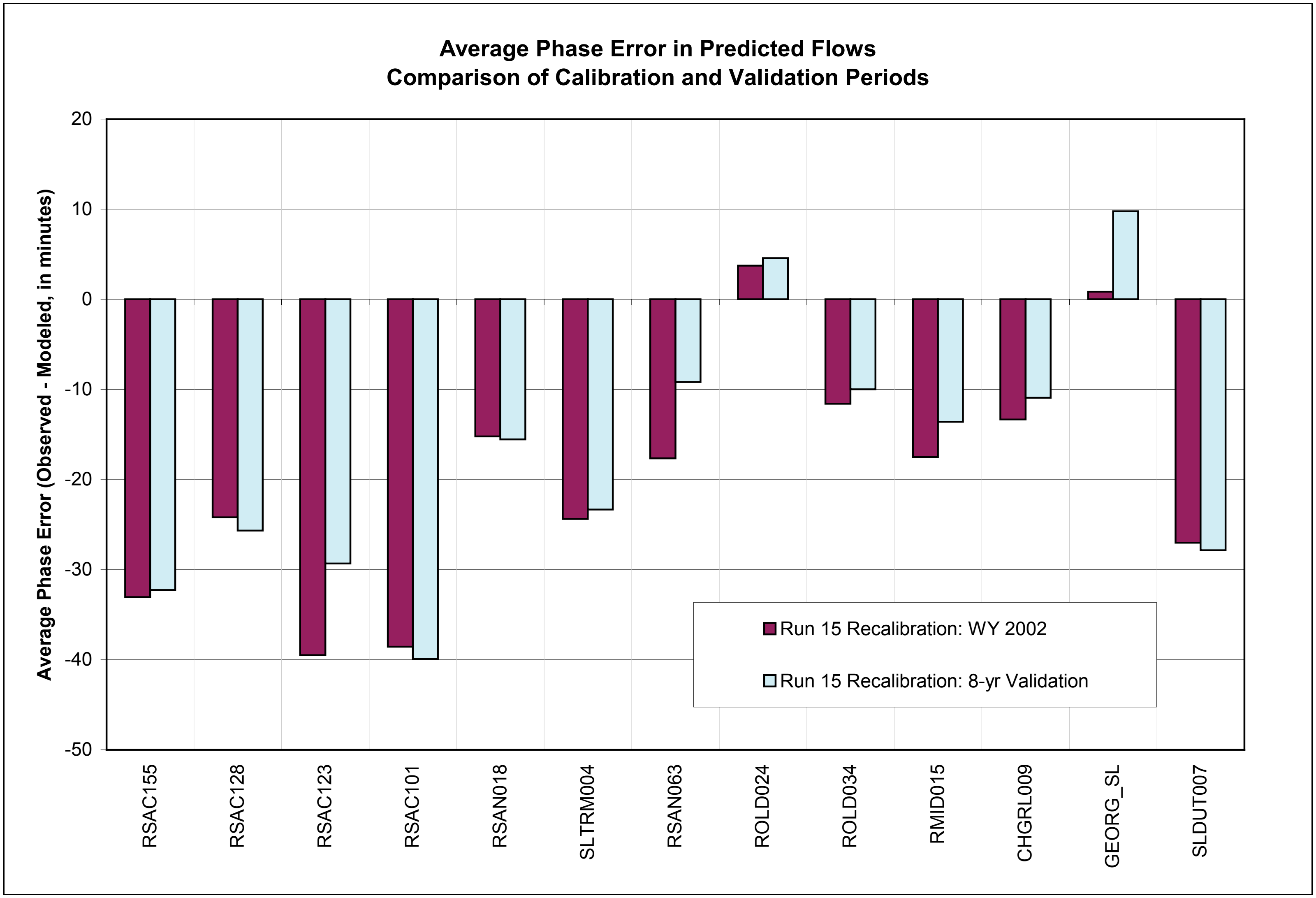


FIGURE 5-9
Comparison of Mean Phase Errors in Flow for Recalibration and Extended Validation

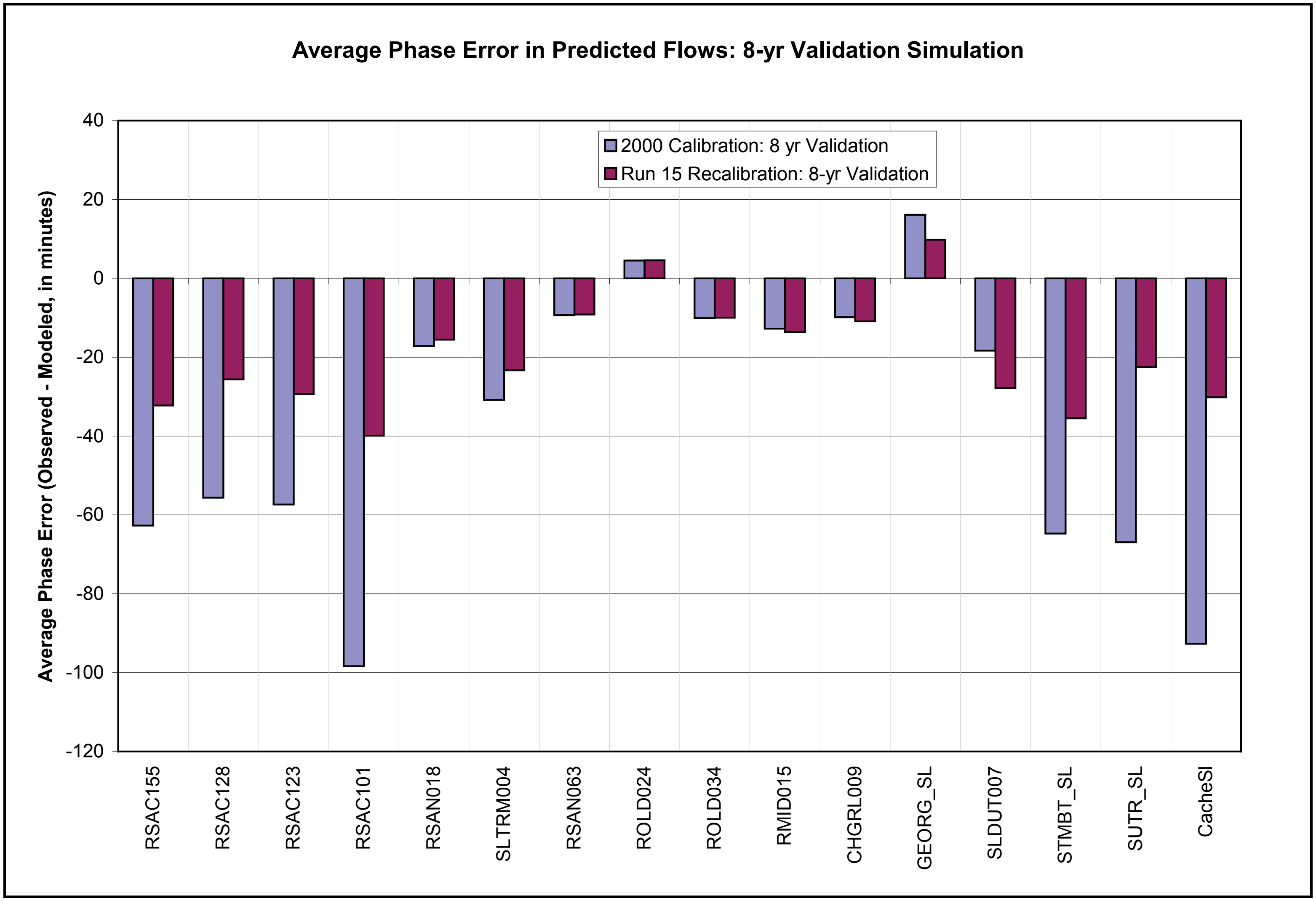


FIGURE 5-10
Comparison of RMS Errors in Flow for Extended Validation Period
(2000 Calibration and 2009 Recalibration Simulations)

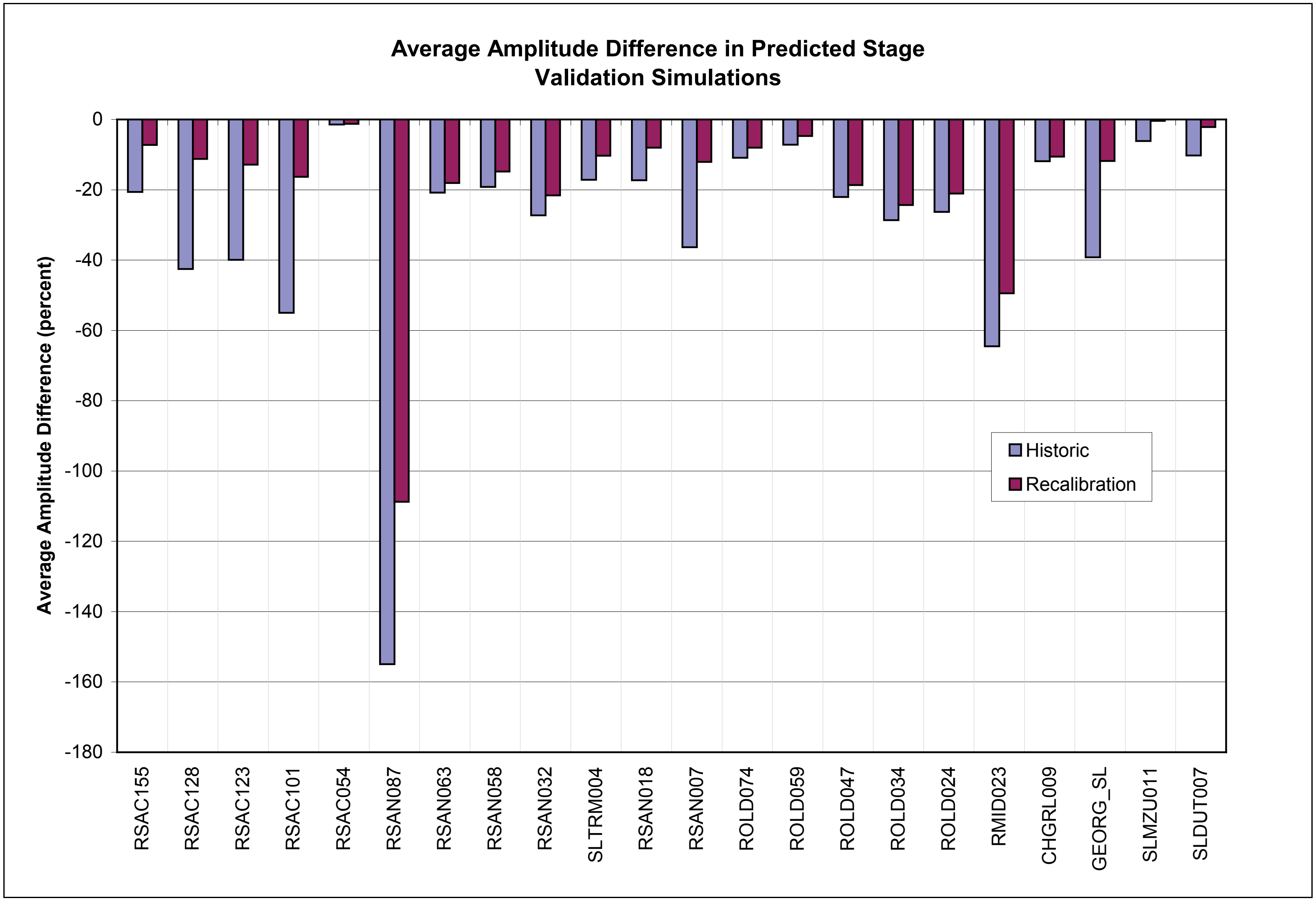


FIGURE 5-11
Comparison of Errors in Predicted Tidal Amplitude (Stage) for 2-year Validation Period
(2000 Calibration and 2009 Recalibration Simulations)

SECTION 6

Water Quality Calibration and Validation

6.1 Calibration Period

Based on the discussions with DWR staff, it was decided that the QUAL calibration period should be as long as practical and contain recent dry periods. During the dry periods the salinity intrusion occurs in the Delta and the salinity varies significantly in the interior of the Delta. It is important that the model can predict the EC well for these periods. Therefore, the 8-year period used for the HYDRO validation, WY 2001 through WY 2008, was used for the QUAL calibration. This period included five below-normal, dry, or critical years when high-salinity intrusions were recorded. A separate validation period was not developed since sufficient observed EC data was not available beyond the long EC calibration period.

6.2 Key Calibration Parameters

Channel dispersion factors were the calibration parameter used in the QUAL calibration. Increased dispersion allows higher mixing in the channels, which translates to higher salinity transport. This is especially true when high salinity gradients exist. The dispersion factor in QUAL is a ratio of dispersion to advection within a channel. In the 2000 calibration, the Delta was divided into 22 regions, each containing several channels with the same dispersion factor. In the current calibration, starting with the final dispersion map from 2000 calibration, the dispersion factors were adjusted in key channels to achieve the best match with the observed data. Table 6-1 lists the channels where dispersion factors were modified in the current calibration.

6.3 Key Steps in the Calibration

QUAL calibration used the output from the 8-year HYDRO validation run, which was based on the calibration Run 15. With the dispersion factors unchanged from 2000 calibration, the results from the first QUAL run showed consistent over prediction of EC in both Sacramento and San Joaquin Rivers. The key changes made as part of the QUAL calibration include:

- Dispersion factors were reduced in Sacramento River channels from Rio Vista to Chipps Island
- Dispersion factors were increased in San Joaquin River channels from Mokelumne River to Broad Slough
- Dispersion factors were increased in Dutch Slough near San Joaquin River
- Dispersion factors were reduced in Sacramento River channels from Port Chicago to Martinez

A total of 18 runs were simulated to get the best match with the observed data at all locations in the Delta. Run EC_3L_15 was the final QUAL calibration run.

6.4 EC Calibration Locations

Figure 6-1 shows the locations where the performance of DSM2 QUAL in simulating EC was evaluated in the current recalibration. A total of 27 locations were selected. Table 6-2 lists the locations including their short names used in the results discussion in the following section.

6.5 Results

The improvements made in the recalibration of Delta hydrodynamics are expected to carry over into the water quality modeling. By more accurately representing the tidal hydrodynamics in the system, the errors in water quality predictions should be reduced to the extent that the errors are related to the hydrodynamics and not other boundary conditions such as DICU.

The recalibration effort focused on improving predictions at several key locations in the Delta, including Emmaton and Jersey Point (two water quality compliance locations). In general, the thesis behind the recalibration effort was that by improving model predictions on the lower Sacramento and San Joaquin Rivers, conditions in the South Delta and other interior locations would also improve.

Figures 6-2 to 6-6 show the detailed EC calibration metrics for Collinsville, Emmaton, Rio Vista, Jersey Point, and Old River at Rock Slough (Bacon Island). The results show that the simulated EC at Emmaton and Jersey Point match well with the observed data and have improved compared to the 2000 calibration. The errors in the mean EC at Collinsville and Rio Vista are slightly higher in the current recalibration compared to 2000 calibration, especially in the fall months, although, the errors are less than 7 percent. The detailed EC calibration metrics for all the locations in the Delta are included in the Appendix C.

Figure 6-7 compares the average percent change in EC from observed data for both the 2000 calibration and the current recalibration simulations. Negative numbers indicate the model is producing lower EC values than observed data, and positive numbers indicate the model is predicting saltier conditions than those measured in the field. The largest improvements came at the targeted locations, namely Emmaton and Jersey Point. Antioch also saw a considerable reduction in average error. Errors in the recalibration run increased from the previous calibration at Old River at Holland Cut and at the South Delta export locations. Despite the considerable hydrodynamic improvements at Rio Vista, the EC results indicate slightly worse performance compared to the previous calibration. The increase in dispersion coefficients required to improve EC predictions at Emmaton (Run 3G_15) brought more salt to Rio Vista. To address this, the dispersion coefficients in channels 430 and 431 were lowered to 0.05. This improved EC predictions at Rio Vista, but the model still predicts higher salinity at Rio Vista in the summer and fall months. The final dispersion coefficients used in the Sacramento River have a low point in the vicinity of Rio Vista; this may not be justifiable from a physics standpoint, and should be addressed in subsequent analyses. Even though, the 2000 calibration resulted in slightly better EC values at Rio Vista compared to the current calibration, it is important to note that the current calibration has accurate hydrodynamics unlike the 2000 calibration.

Model performance at the lower Sacramento River stations should be viewed as a group. Average error in the tidally averaged EC for the recalibration simulation is 4.3 percent at Rio Vista, 0.3 percent at Emmaton, and 7.0 percent at Collinsville. Note that there is no consistent bias, in that the lowest error is in the middle of the three stations.

Figure 6-8 presents the RMS errors in predicted EC for both the 2000 calibration and the 2009 recalibration. The RMS errors vary considerably throughout the Delta, with elevated errors seen in the western Delta and in Suisun Marsh. In general, the RMS errors are higher on the Sacramento River than on the San Joaquin River and in the South Delta. Significant improvements are seen at Emmaton, Jersey Point, Antioch, and Old River at Bacon Island. Errors increased compared to the 2000 calibration run at Rio Vista, Clifton Court, Old River at Holland Cut, and Threemile Slough.

There is considerable variation in the RMS errors when viewed on a monthly basis, as demonstrated in Figures 6-9 through 6-11, which present more detailed model results at Emmaton, Rio Vista, and Jersey Point. In general, the RMS errors are higher in the summer and fall months and lower in the winter and spring months. Errors in these three plots are presented as percent errors normalized by the average EC at a given station.

At Emmaton, the peak errors in the summer months have been reduced considerably in the recalibration simulation. The months of July through September are generally when the EC is steadily increasing in the central Delta. The reduction in RMS error during these months indicates that the model is more accurately predicting the build up of EC in the summer months. The average RMS errors decrease in the winter and spring months. The recalibration effort improves the average errors during the 6 months span from January to June, but from a low error to start with.

Figure 6-10 presents the average monthly performance at Rio Vista. Here, the performance is more uniform throughout the year, without the strong seasonal pattern seen at Emmaton. Errors in the summer and fall months are higher in the recalibration simulation than in the previous calibration effort, for reasons discussed above.

The performance at Jersey Point is shown in Figure 6-11. The seasonal pattern visible at Emmaton is also seen here, with peak errors in the summer months and small errors in the spring. The peak errors in July through October are reduced considerably in the recalibration simulation.

An overview of the monthly model performance at eight key locations is provided in Figure 6-12. There is a general seasonal trend visible in the model results, where the model underestimates the salinity in the winter and spring months and overestimates the salinity in the summer and fall months. This pattern is influenced through the specification of dispersion coefficients in the model, and the optimization of model performance was primarily conducted through the adjustment of this parameter. However, given the general trend seen in the results, it is not possible to continue to correct both the overestimation of salt in the summer/fall period and the underestimation of salt in the winter/spring period by adjusting the dispersion coefficient. A decrease in the dispersion coefficient could lower the salt transport into the Delta during the low flow months, but would likely lead to increased errors during the winter/spring period when the model is already underestimating the salt content.

The performance of DSM2 regionally in predicting the EC is shown in Figures 6-13 to 6-15. The tidally averaged mean error and RMSE are plotted for both the 2000 calibration and the current recalibration for North Delta, Western and Central Delta, and South Delta regions. The mean errors in the North Delta are less than 4 percent in the current recalibration with RMSE as high as 45 percent as shown in Figure 6-13. Compared to the 2000 calibration, the performance is inconsistent in the current calibration, with significant improvement at Emmaton, slight degradation at Rio Vista and unchanged EC at Green's Landing. Figure 6-14 summarizes the mean error and RMSE in the tidally averaged EC for the western and central Delta locations. The mean errors are less than 10 percent in the western Delta locations with RMSE up to 45 percent. With exception of Mokelumne River (25 percent), the mean error in the central Delta locations is less than 15 percent. Compared to the 2000 calibration, the changes in the errors are fairly minimal at most locations; however, the change is inconsistent. As noted earlier, while Threemile Slough shows slight degradation, Jersey Point and Antioch show significant improvements. The summary of EC performance for south Delta is shown in Figure 6-15. For the most part, the EC predictions remain unchanged from 2000 calibration. Noticeable improvements in Old River at Bacon Island EC exist, while slightly higher EC is seen at the pumps. Except for Old River at Tracy (25 percent), Holland Cut (15 percent) and Grant Line Canal (15 percent), all the errors are around 10 percent in the South Delta. The upper San Joaquin locations show errors up to 15 percent.

Figure 6-16 presents a summary of the recalibration effort as compared to the previous calibration. For a select set of locations, Figure 6-16 shows the percent change in tidally average RMS error in predicted EC for the recalibration simulation, relative to the RMSE from the previous calibration. The RMS error increases by more than 10 percent at Rio Vista (17 percent) and Old River at Holland Cut (12 percent). The RMS error decreases by more than 10 percent at Collinsville, Martinez, Antioch, Jersey Point, Old River at Bacon Island, and Dutch Slough. Overall, the improvements outweigh the locations where the errors increased in the recalibration effort. Table 6-3 shows the numerical values used to generate Figure 6-16.

Figure 6-17 compares model performance by water year for the 8-year extended validation simulations. There is considerable variation in model performance in different water years. The average errors are highest in WY 2007, and second highest in the hydro calibration year (2002). The recalibration provided the largest reduction errors in these 2 years, which were both classified as dry years. The best performance for both the previous calibration and the recalibration simulation was in 2008, a critical year with average annual exports of only 5,100 cfs. Although the eight year period is a small sample set, it appears that the model performance may be influenced by water year type.

Two series of eight plots each have been developed to demonstrate the annual patterns in model predicted EC. These plots were developed to provide insight into the seasonal performance of the model such that future calibration efforts can address months with larger errors. The first set of plots (Figures 6-18 to 6-25) shows average monthly EC at eight key locations in the Delta. The bar charts include observed data, results from the 2000 calibration simulation, and results from the recalibrated model. The second set of plots (Figures 6-26 to 6-33) presents the average percent error in the monthly EC for both the 2000 calibration and the 2009 recalibration. Locations presented include:

- Collinsville
- Emmaton
- Rio Vista
- Antioch
- Jersey Point
- Old River at Rock Slough (Bacon Island)
- Old River at Clifton Court (Banks Pumping Plant)
- Jones Pumping Plant (CVP)

Tables

TABLE 6-1
List of Channels with Modified Dispersion Factor in the Current Calibration

DSM2 Channel Number	Dispersion Factor from 2000 Calibration	Dispersion Factor from Current Calibration
45	0.5	0.7
46	0.5	0.7
47	0.5	0.7
48	0.05	0.07
49	0.05	0.07
50	0.05	0.07
51	0.05	0.07
52	0.05	0.07
53	0.05	0.07
83	0.05	0.07
215	0.6	0.75
260	0.6	0.75
274	0.6	0.75
275	0.6	0.75
284	0.05	0.07
285	0.05	0.07
286	0.05	0.07
290	0.8	0.3
291	0.8	0.3
300	0.05	0.07
430	0.4	0.05
431	0.4	0.05
432	0.4	0.2
433	0.4	0.2
434	1.0	0.5
435	1.0	0.5
436	0.8	0.3
439	1.5	1.3
440	1.5	1.3
452	1.5	1.3

TABLE 6-2
List of EC Calibration Locations

Location	Short Name
Sacramento River at Greens Landing	RSAC139
Sacramento River at Rio Vista	RSAC101
Sacramento River at Emmaton	RSAC092
Sacramento River at Collinsville	RSAC081
Sacramento River at Port Chicago	RSAC064
Sacramento River at Martinez	RSAC054
San Joaquin River at Vernalis	RSAN112
San Joaquin River at Mossdale	RSAN087
San Joaquin River at Brandt Bridge	RSAN072
Stockton Ship Channel at Burns Cutoff	RSAN058
San Joaquin River at San Andreas Landing	RSAN032
San Joaquin River at Jersey Point	RSAN018
San Joaquin River at Antioch	RSAN007
Old River at Tracy Road	ROLD059
Old River at Bacon Island	ROLD024
Old River at Holland Cut	ROLD014
Middle River at Mowery Bridge	RMID040
Middle River at Tracy Boulevard	RMID027
Middle River at Borden Highway	RMID023
Middle River at Middle River	RMID015
Mokelumne River at Snodgrass Slough	RMKL019
Grant Line Canal at Tracy Boulevard Bridge	CHGRL009
Montezuma Slough at Beldons	SLMZU011
Old River at Clifton Court Forebay	CHSWP003
Delta Mendota Canal at Tracy Pumping Plant	CHDMC006
Three Mile Slough at San Joaquin River	SLTRM004
Dutch Slough	SLDUT007

TABLE 6-3
Comparison of RMS Error between the 2000 Calibration and 2009 Recalibration

Location	Tidal Average RMSE (micro mhos/cm)		Percent Change in RMSE vs. Historical
	Historical	Recalibration 3L_15	
RSAC101	42	50	17.1
RSAC092	350	307	-12.3
RSAC081	796	796	0.0
RSAC064	2,849	2,887	1.3
RSAC054	1,913	1,621	-15.3
RSAN032	72	72	0.6
RSAN018	322	270	-16.3
RSAN007	686	585	-14.7
ROLD024	89	79	-10.7
ROLD014	105	118	12.1
RMID023	62	65	4.9
RMID015	52	54	2.5
SLMZU011	1,740	1,706	-2.0
CHSWP003	64	69	7.6
CHDMC006	63	63	-0.7
SLTRM004	216	223	3.0
SLDUT007	190	165	-13.4

(yellow) = reduced error vs. historical
(red) = increased error vs. historical
(light blue) = negligible change vs. historical

Figures

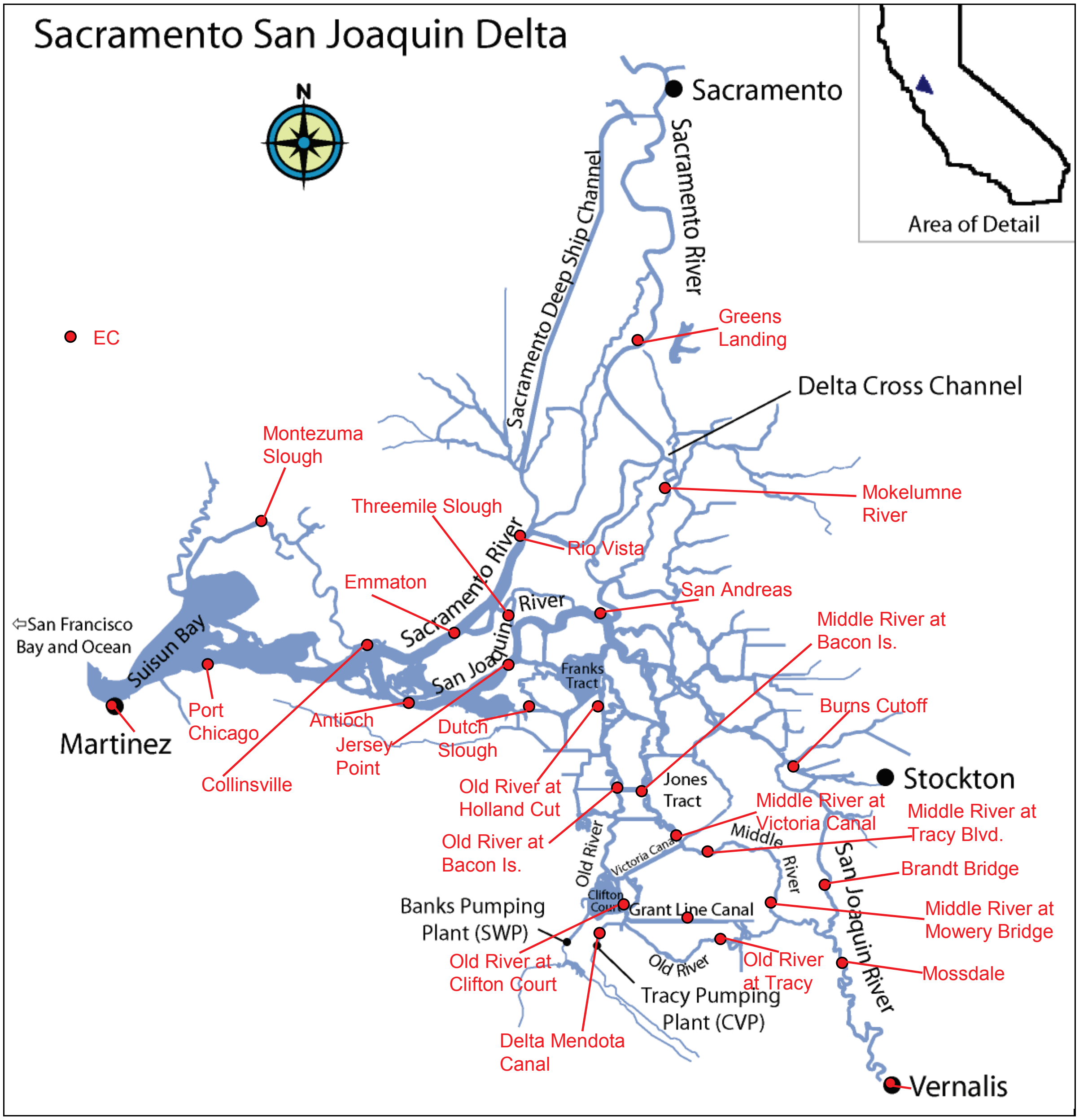


FIGURE 6-1
Map Showing EC Calibration Locations

Sacramento River at Collinsville (RSAC081)

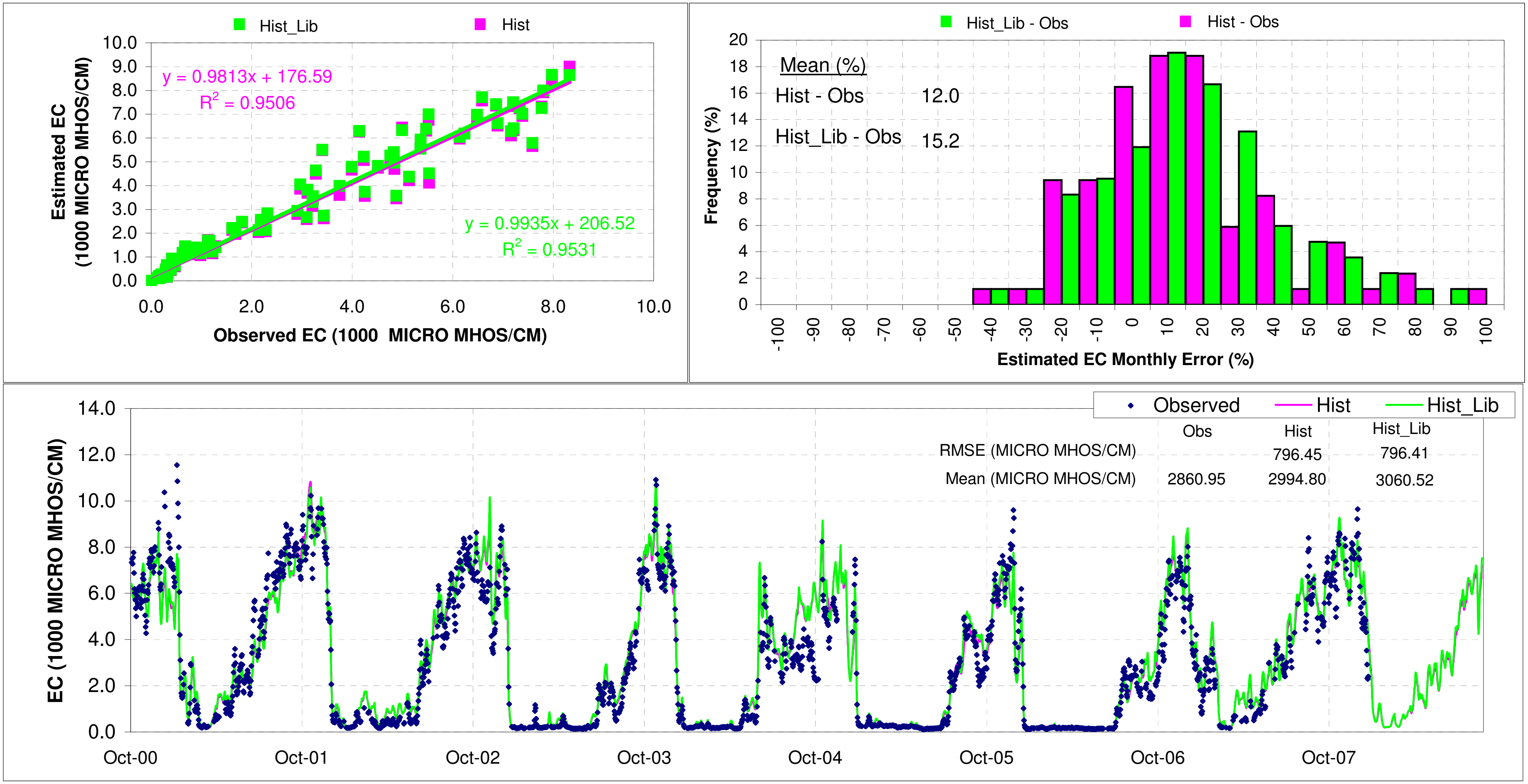
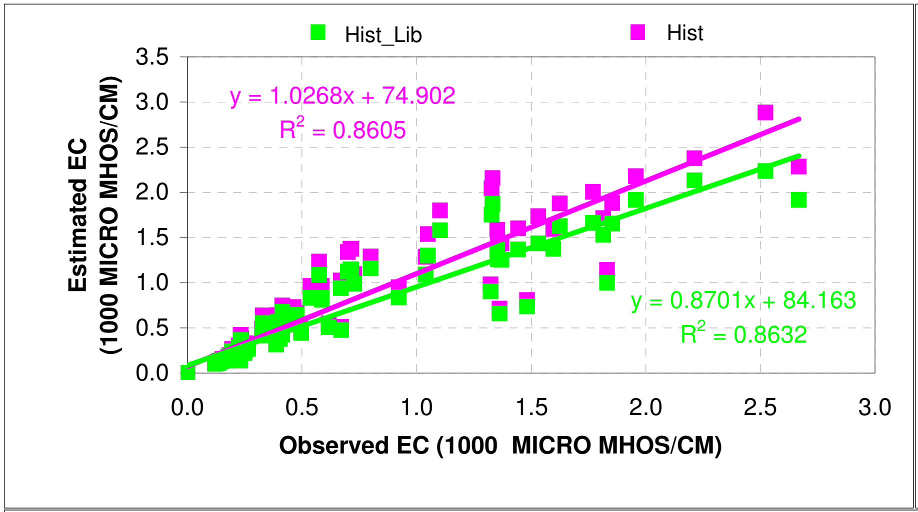
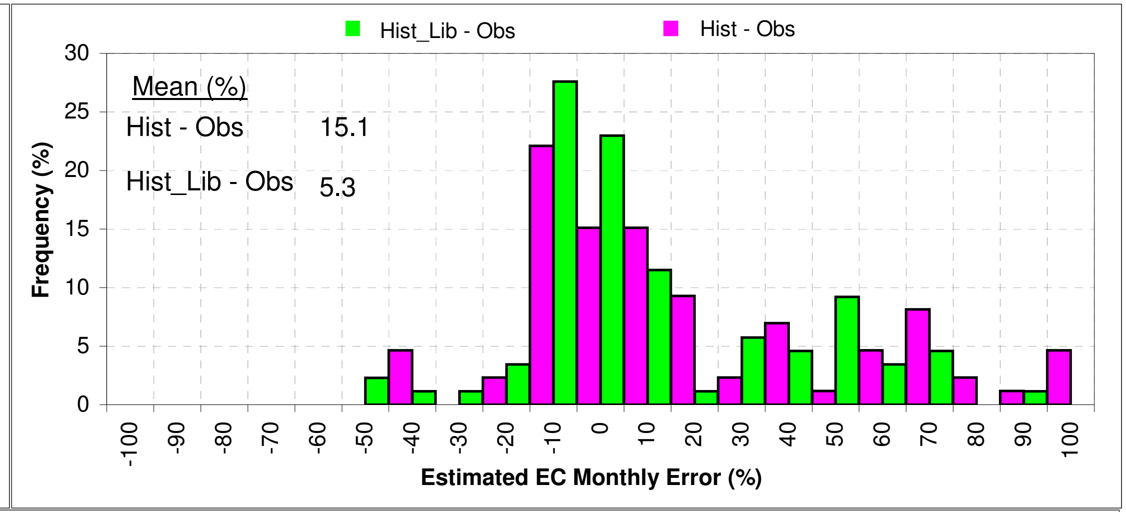


FIGURE 6-2
EC Calibration Metrics for Sacramento River at Collinsville

Sacramento River at Emmaton (RSAC092)





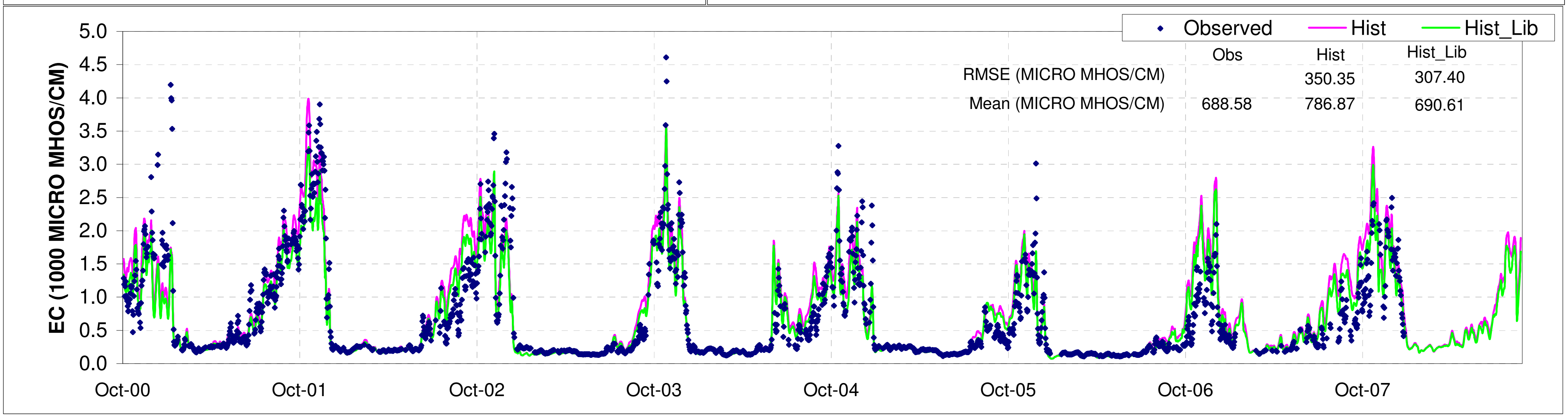


FIGURE 6-3
EC Calibration Metrics for Sacramento River at Emmaton

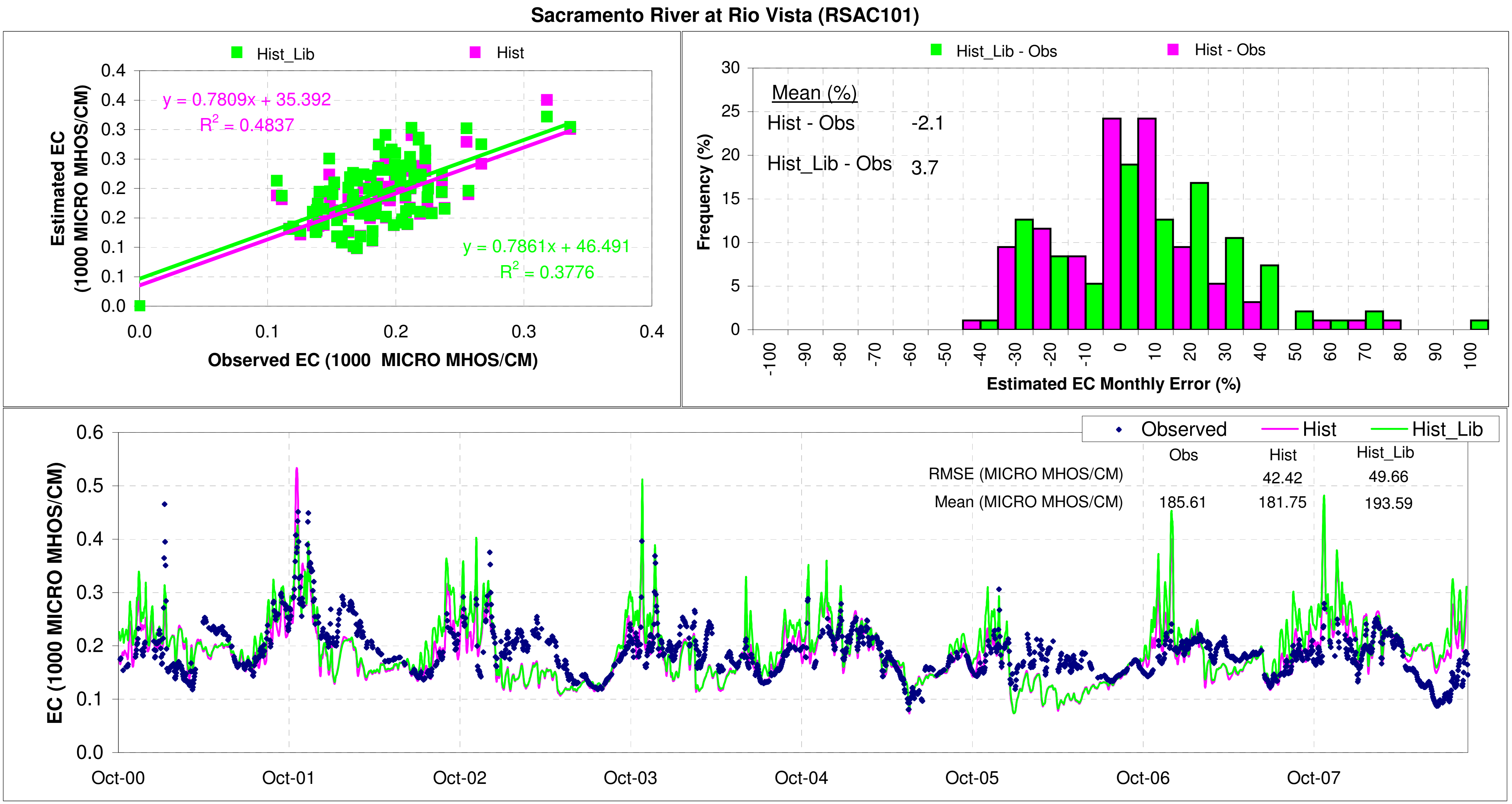


FIGURE 6-4
EC Calibration Metrics for Sacramento River at Rio Vista

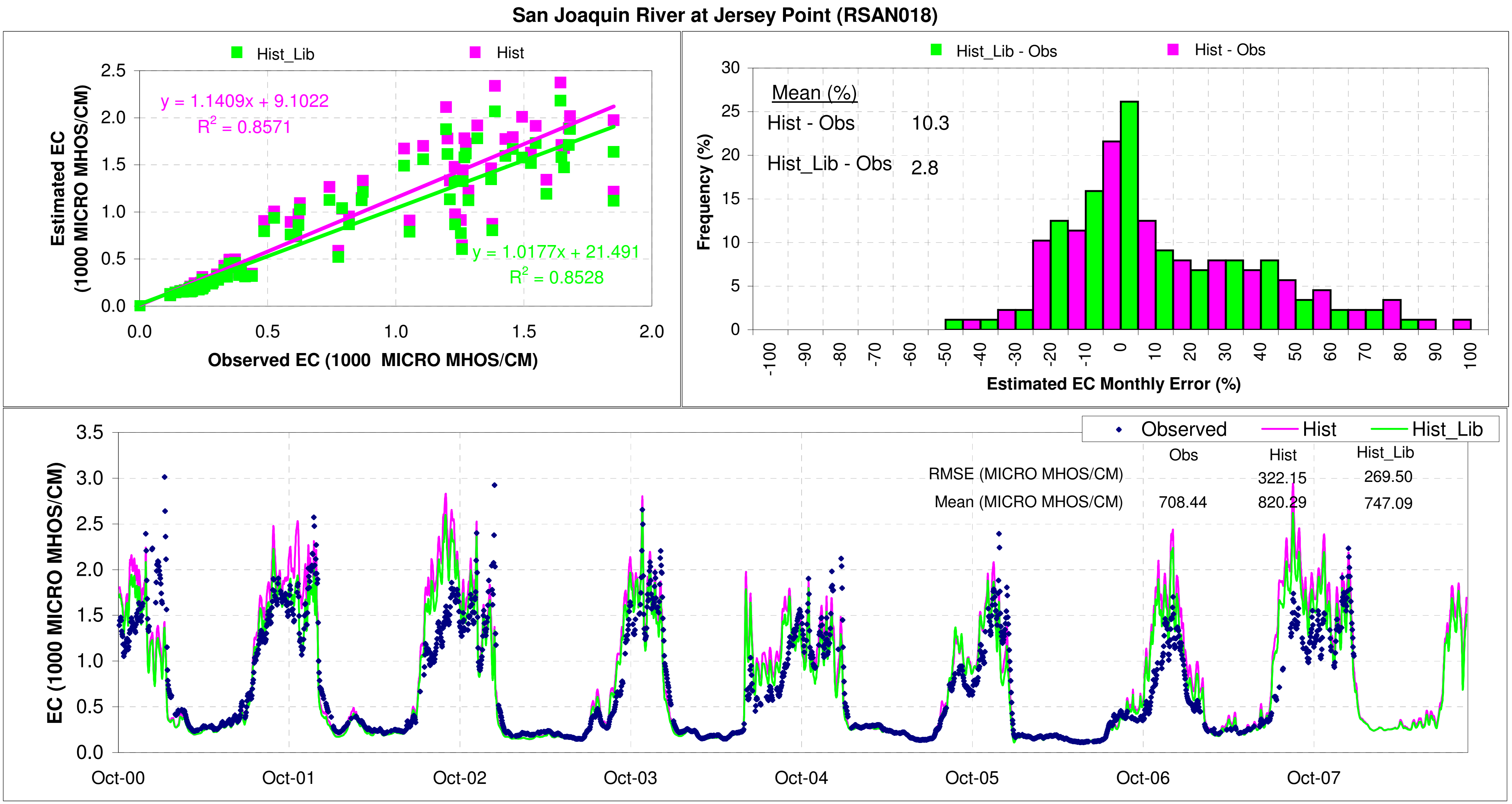


FIGURE 6-5
EC Calibration Metrics for San Joaquin River at Jersey Point

Old River at Bacon Island (ROLD024)

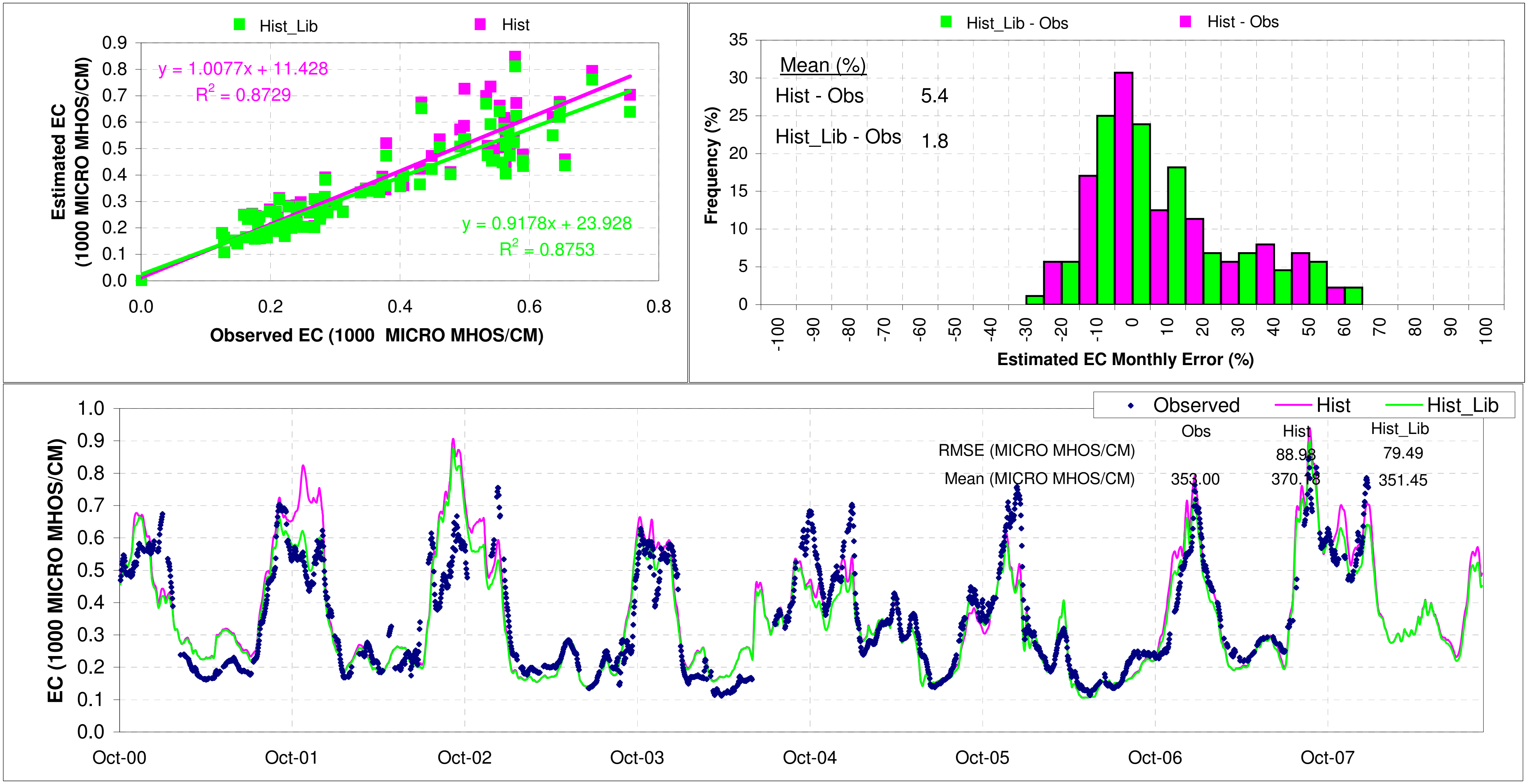


FIGURE 6-6
EC Calibration Metrics for Old River at Rock Slough (Bacon Island)

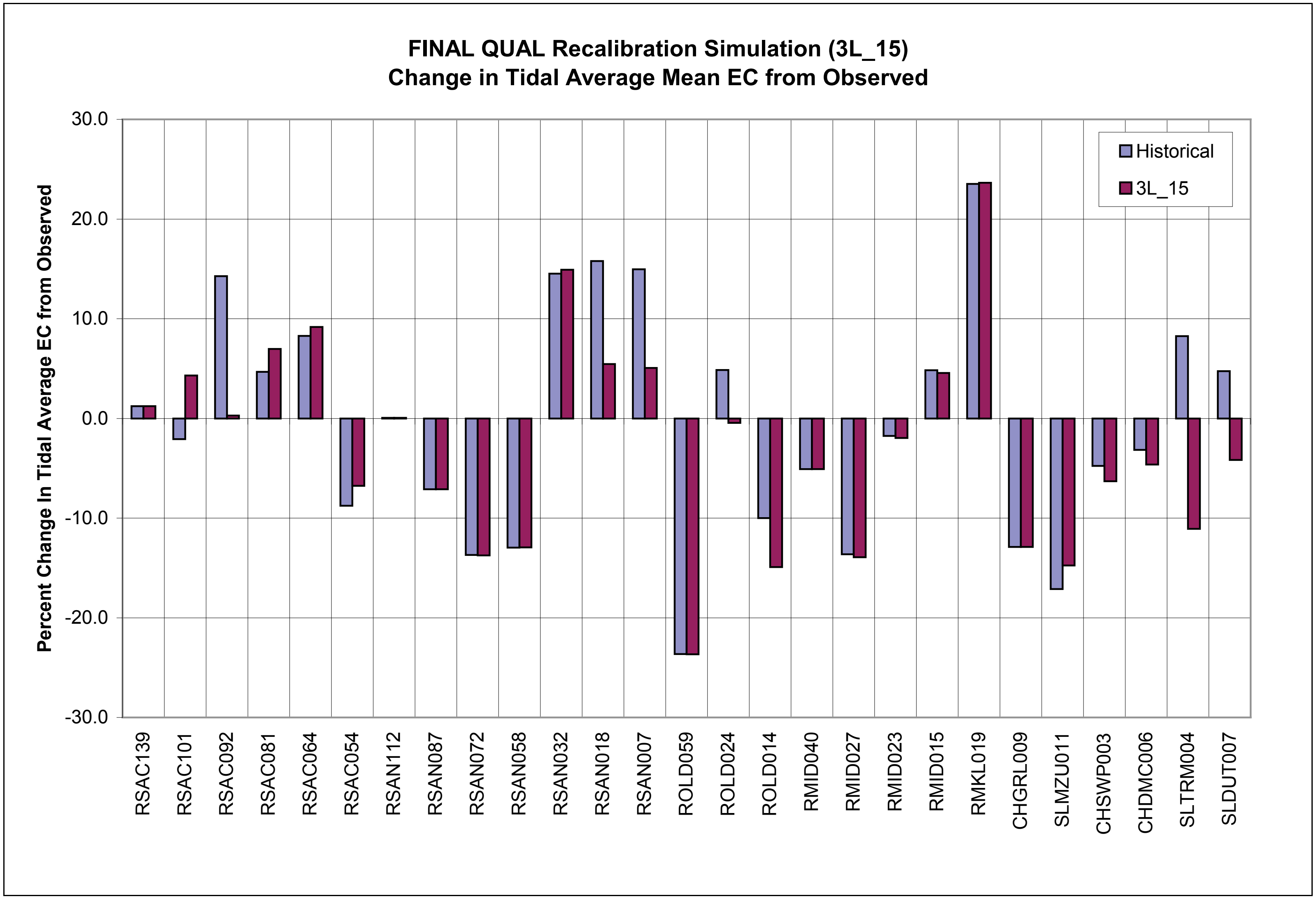


FIGURE 6-7
Comparison of Average Percent Difference in Predicted EC for 2000 Calibration Model and 2009 Recalibrated Model (Run 3L_15)

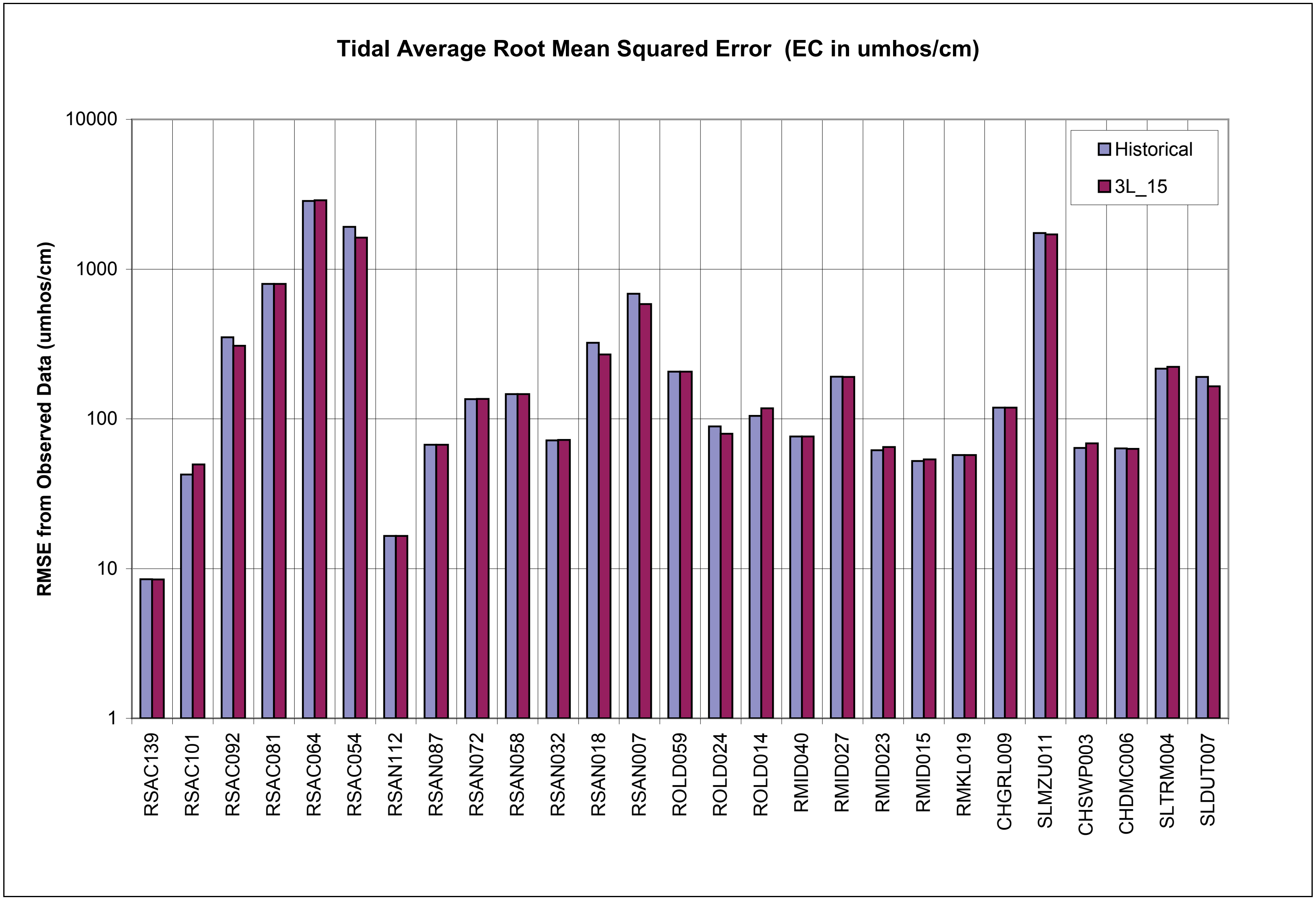


FIGURE 6-8
Comparison of RMS Error in Predicted EC for 2000 Calibration and 2009 Recalibration

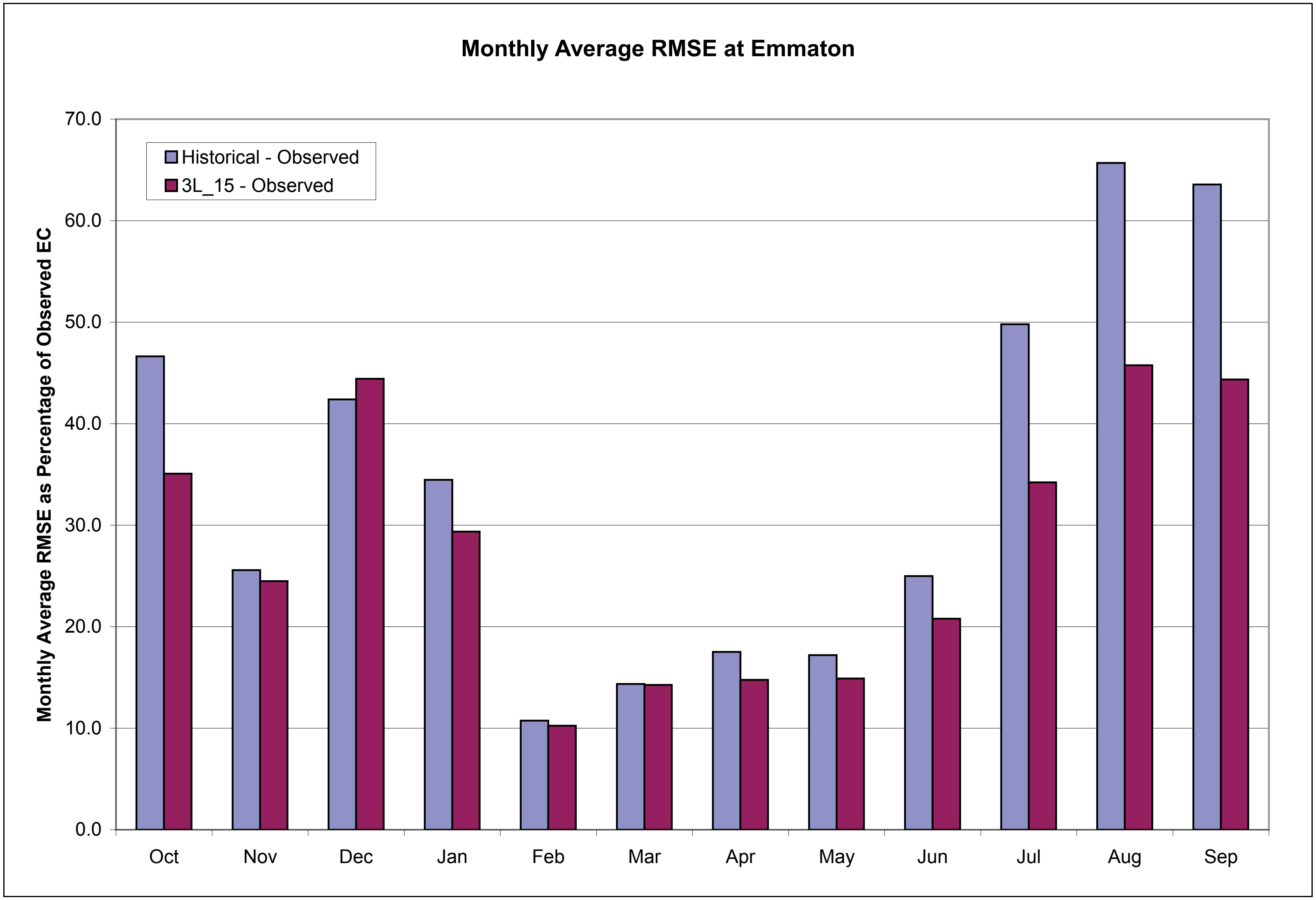


FIGURE 6-9
Monthly Average RMS Errors at Emmaton

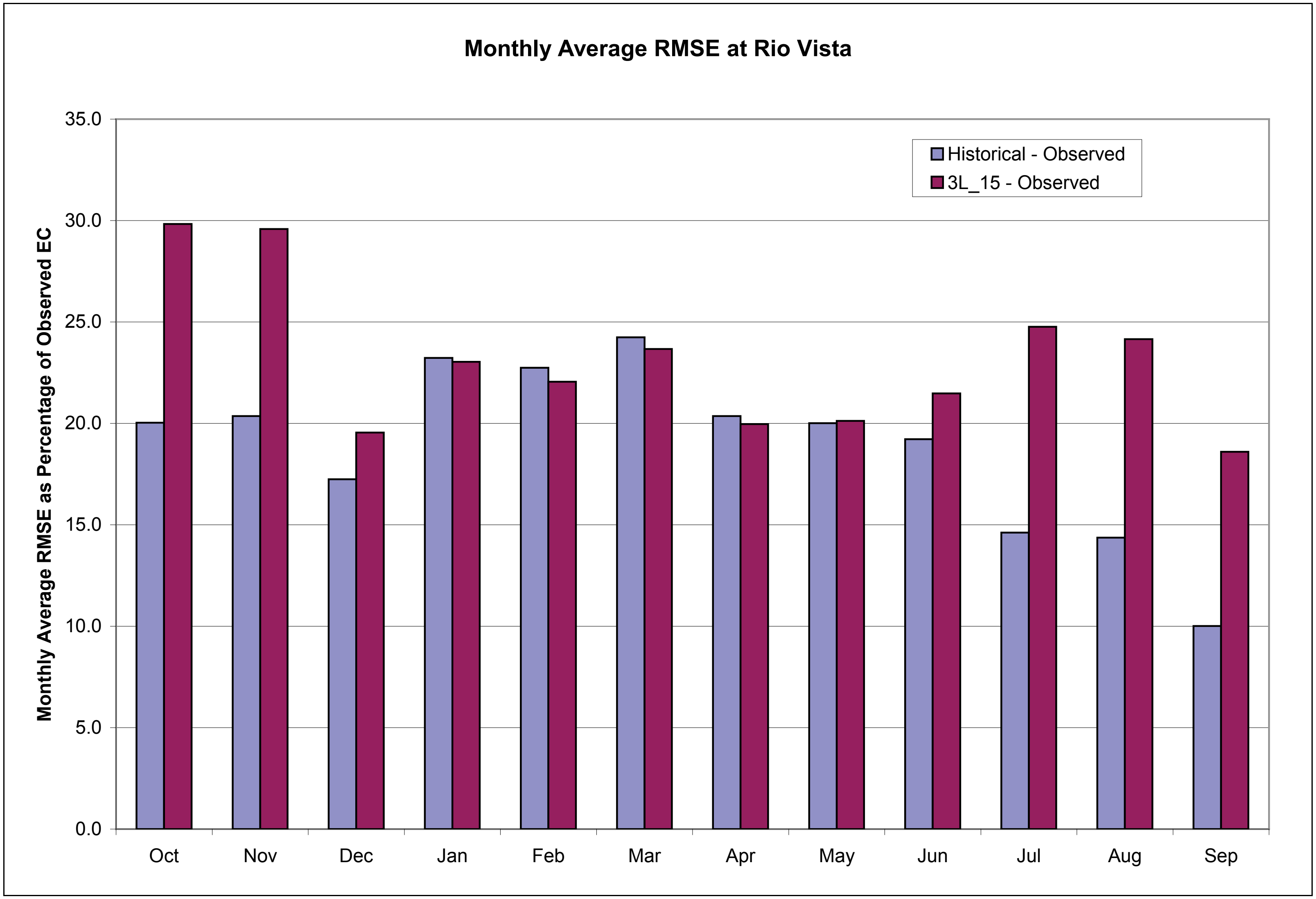


FIGURE 6-10
Monthly Average RMS Errors at Rio Vista

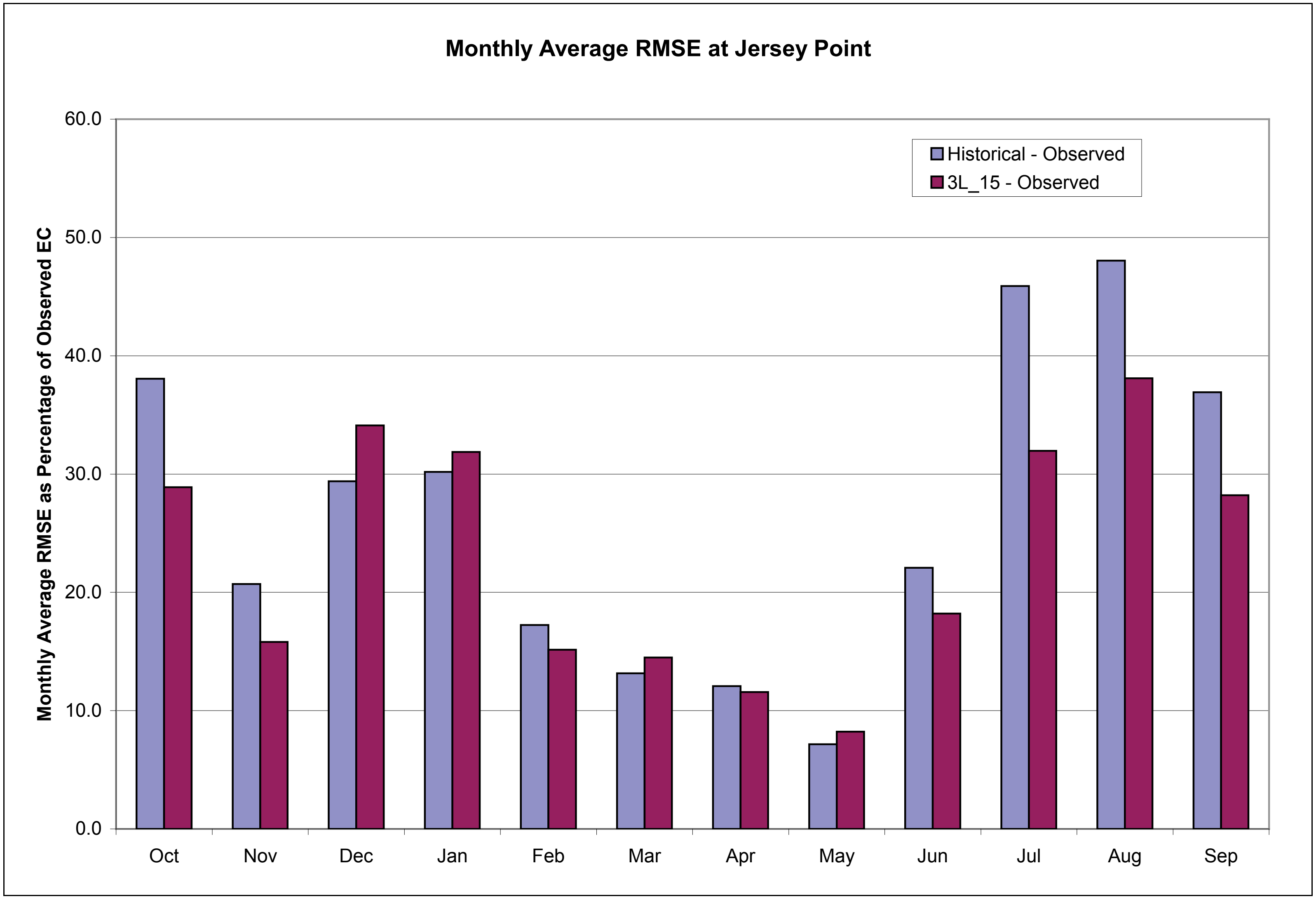


FIGURE 6-11
Monthly Average RMS Errors at Jersey Point

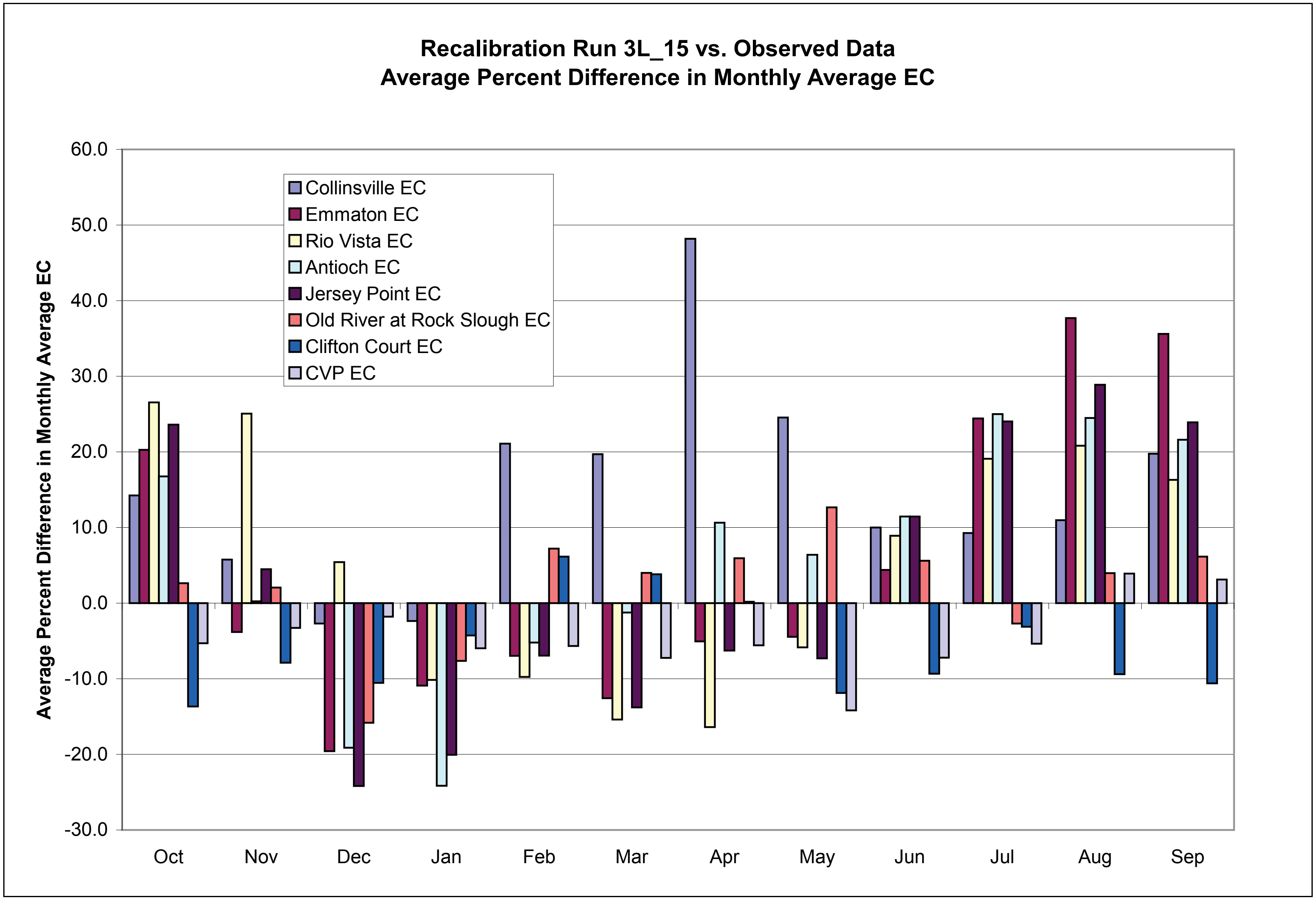
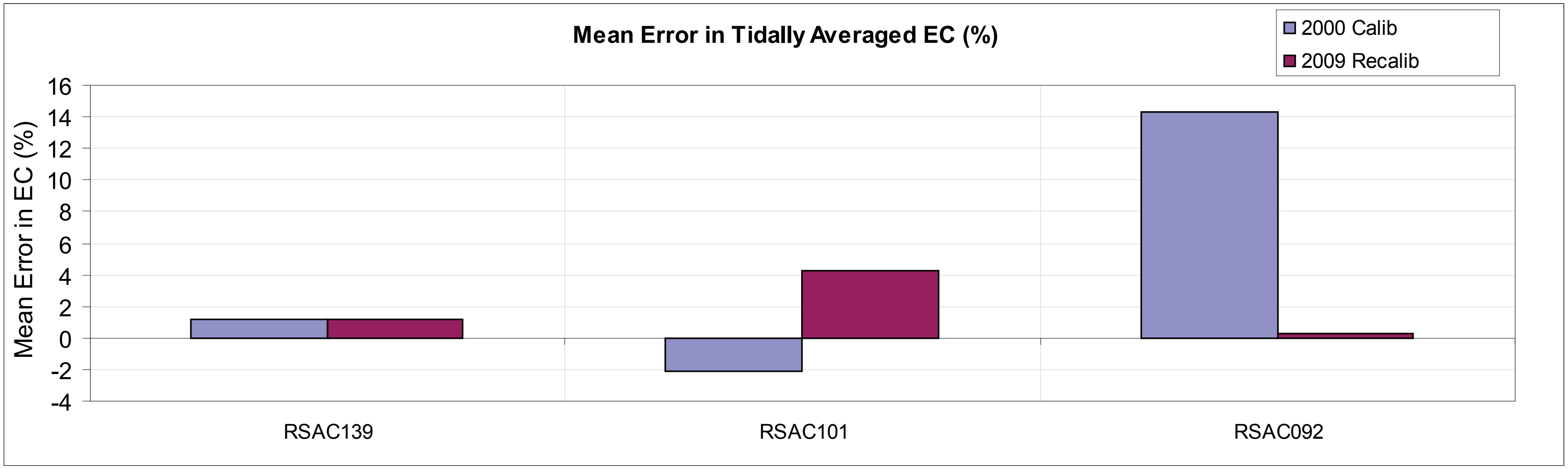


FIGURE 6-12
Overview of Monthly Model Performance – Recalibration



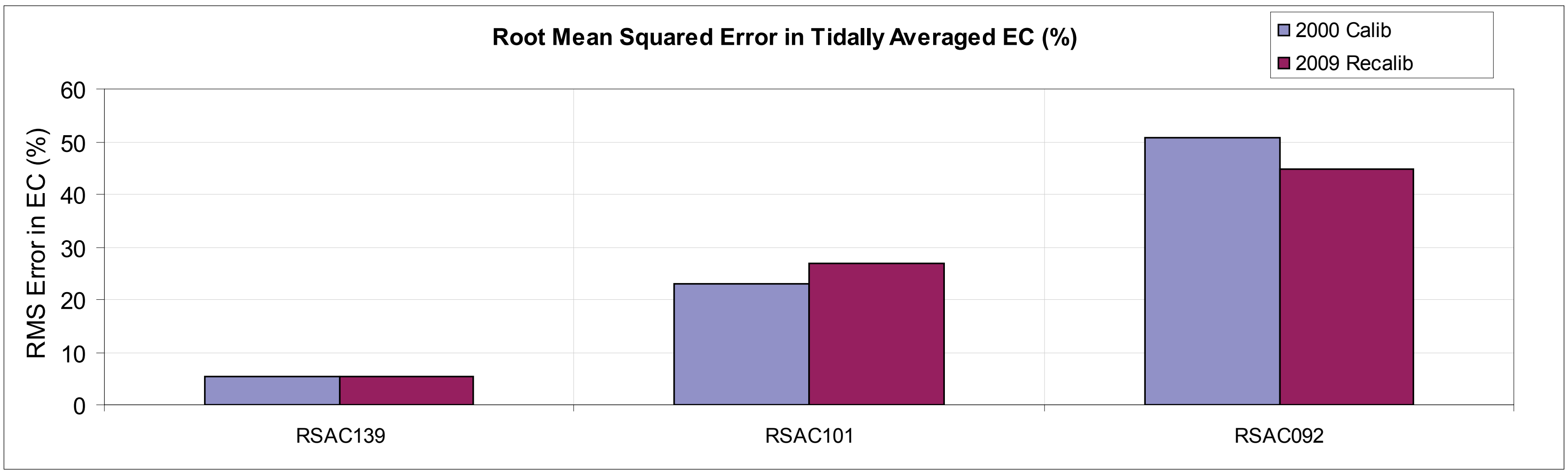
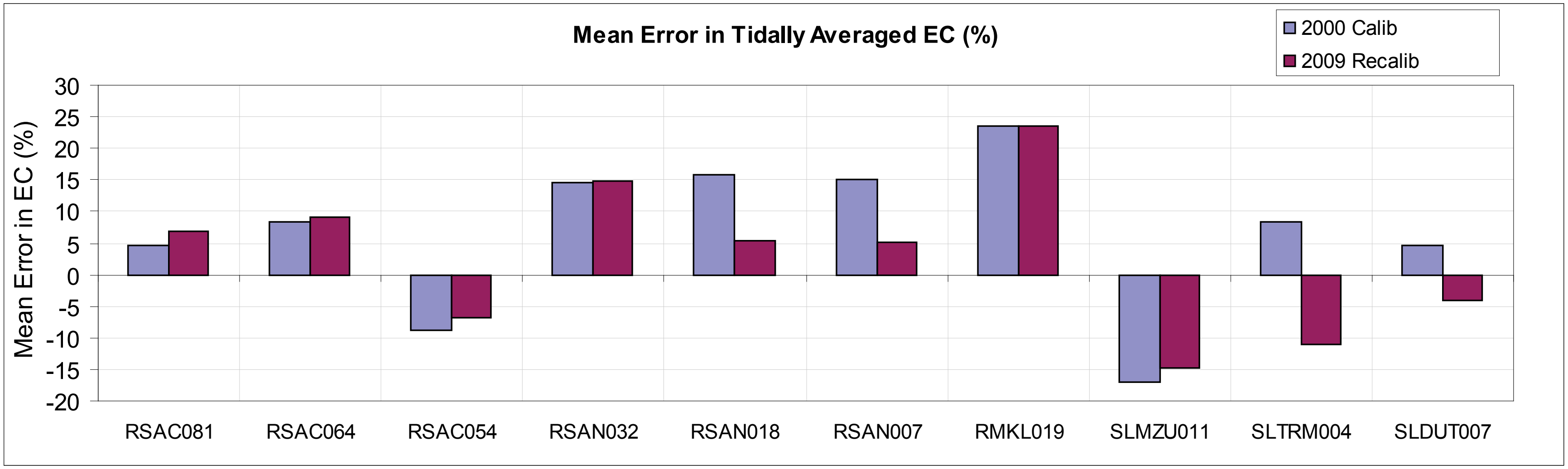


FIGURE 6-13
Summary of EC Calibration Metrics for Locations in the North Delta Region



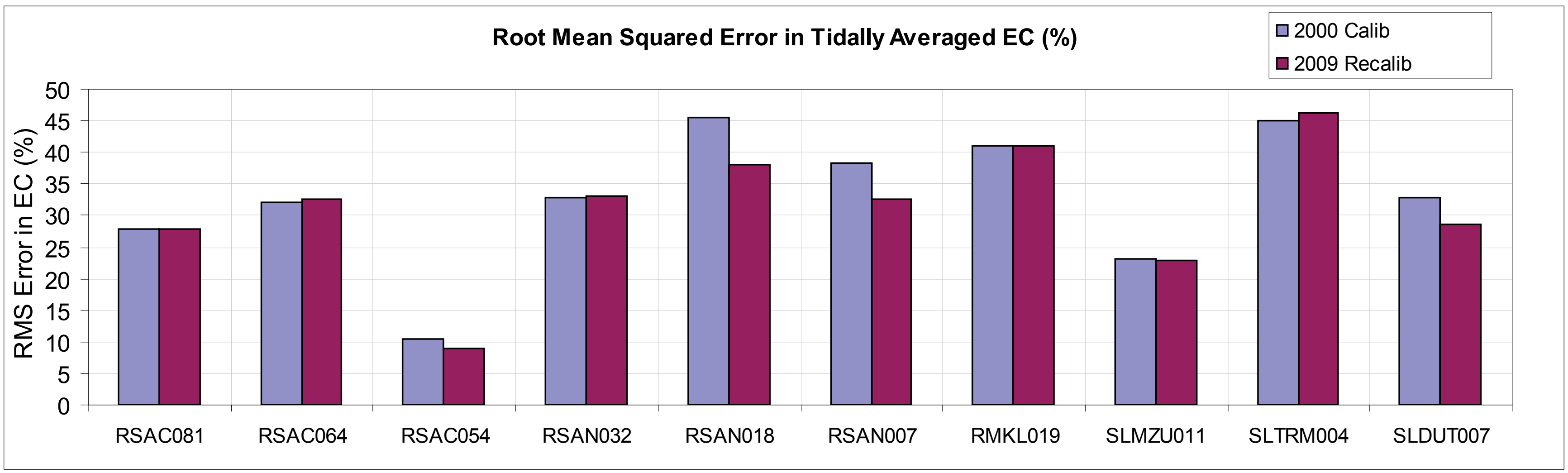
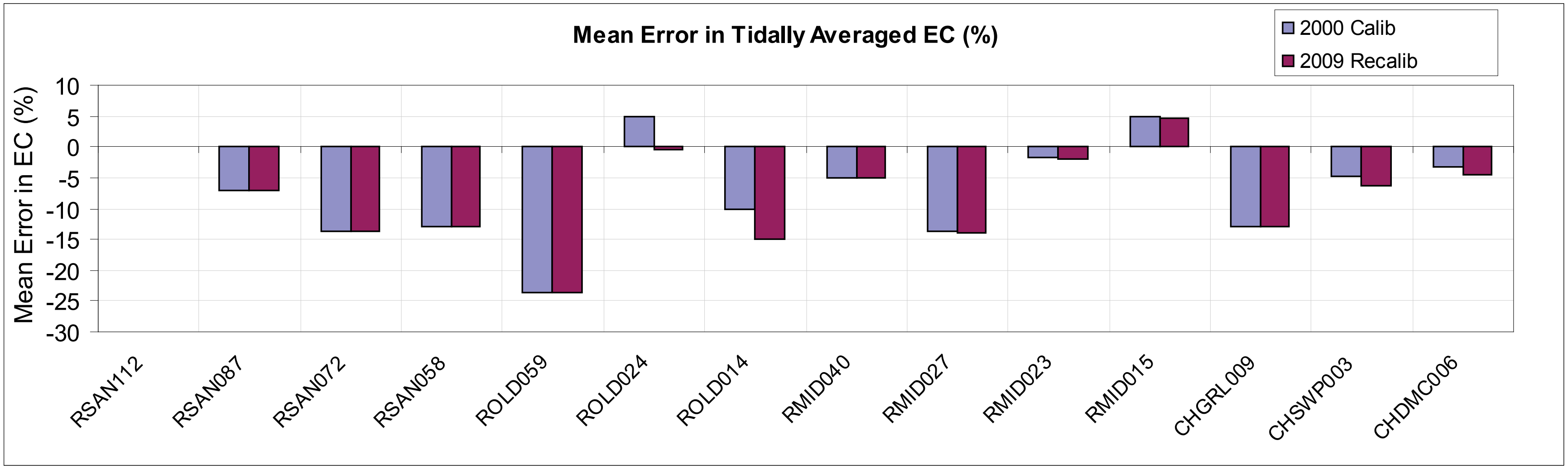


FIGURE 6-14
Summary of EC Calibration Metrics for Locations in the Western and Central Delta Regions



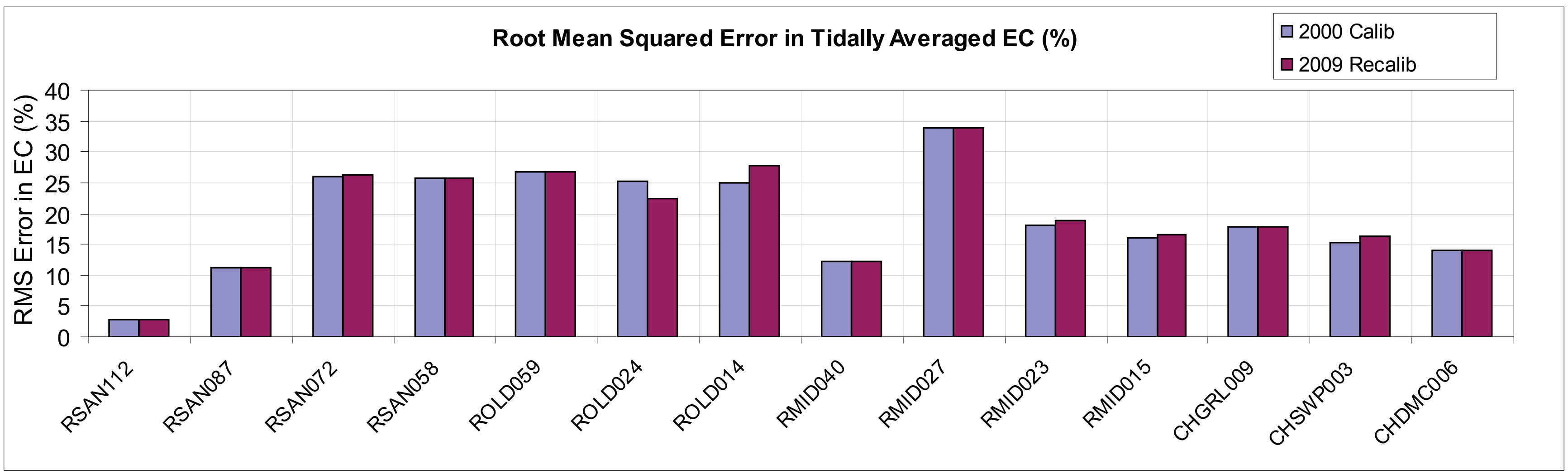


FIGURE 6-15
Summary of EC Calibration Metrics for Locations in the South Delta Region

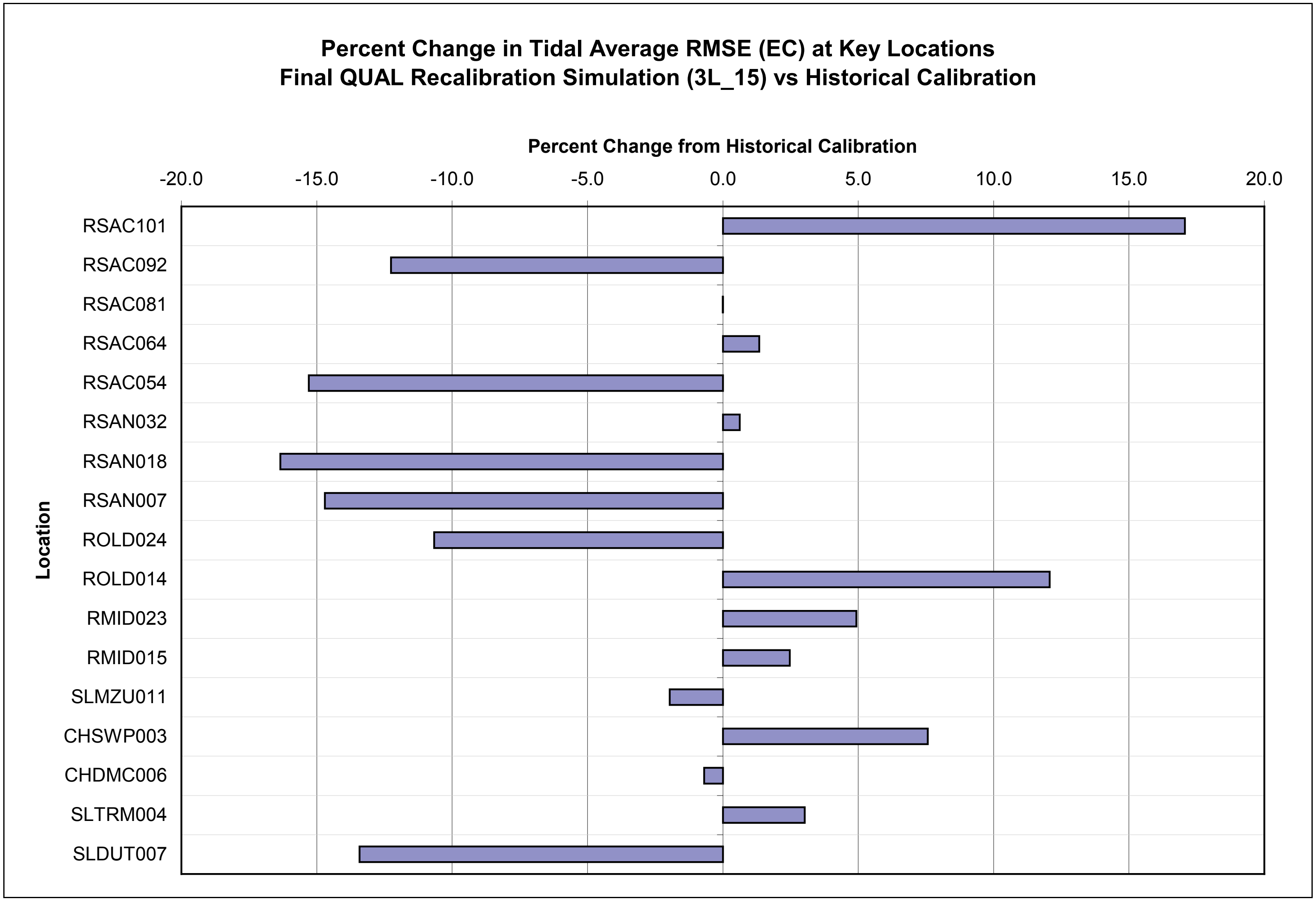


FIGURE 6-16
Percent Change in RMS Error (EC) between Recalibrated Model and 2000 Calibration

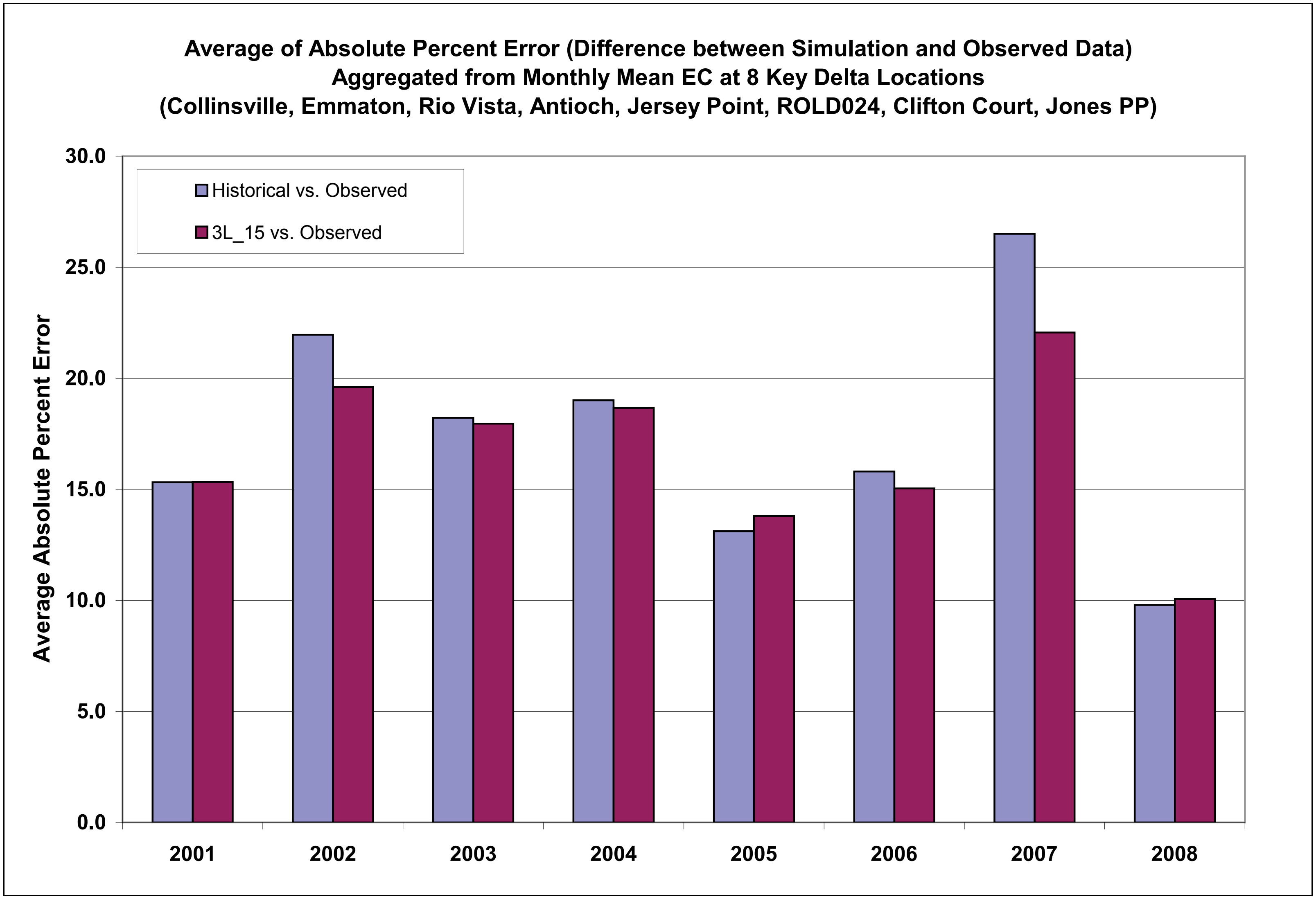


FIGURE 6-17
Model Performance by Water Year

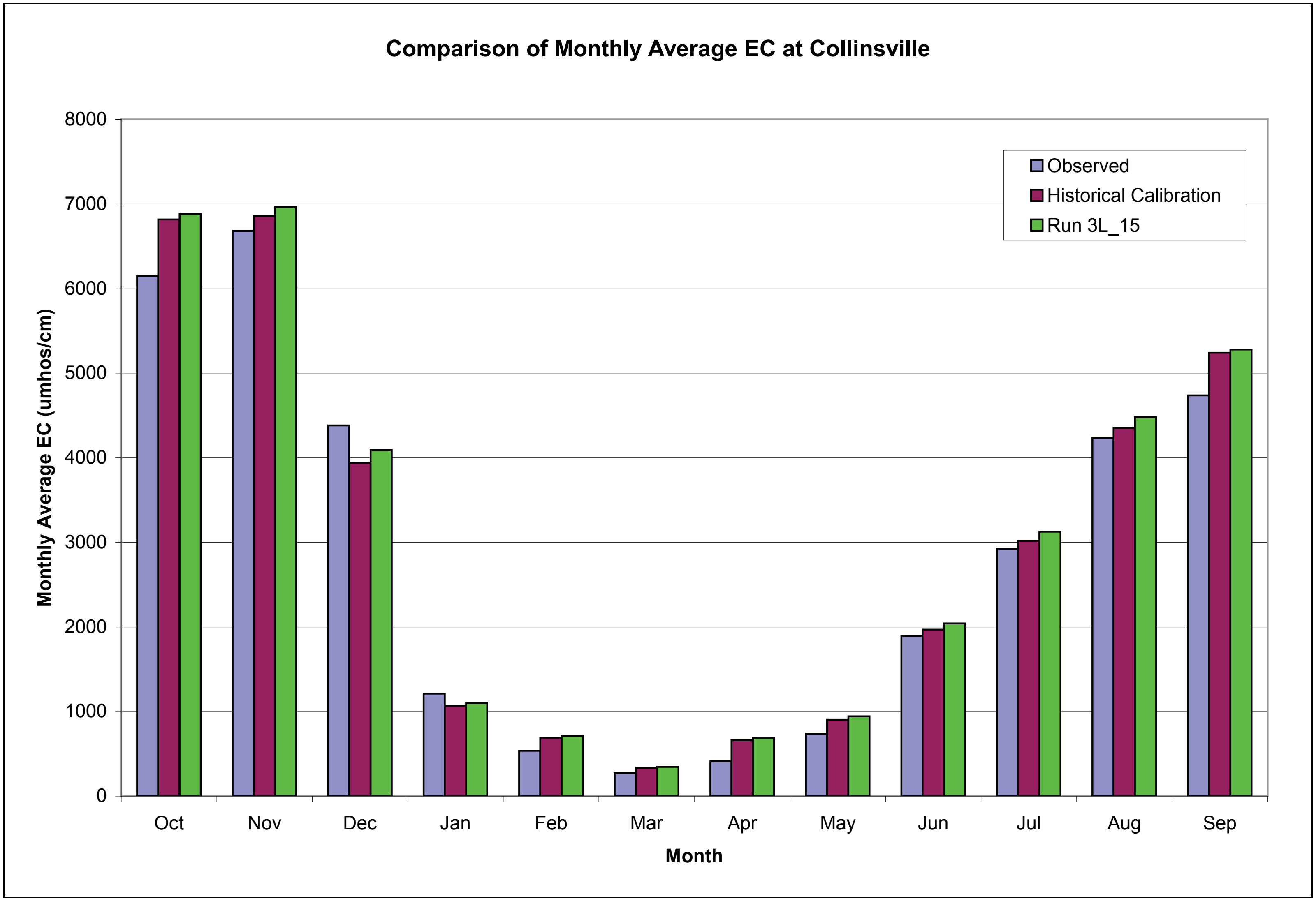


FIGURE 6-18
Monthly Average EC at Collinsville

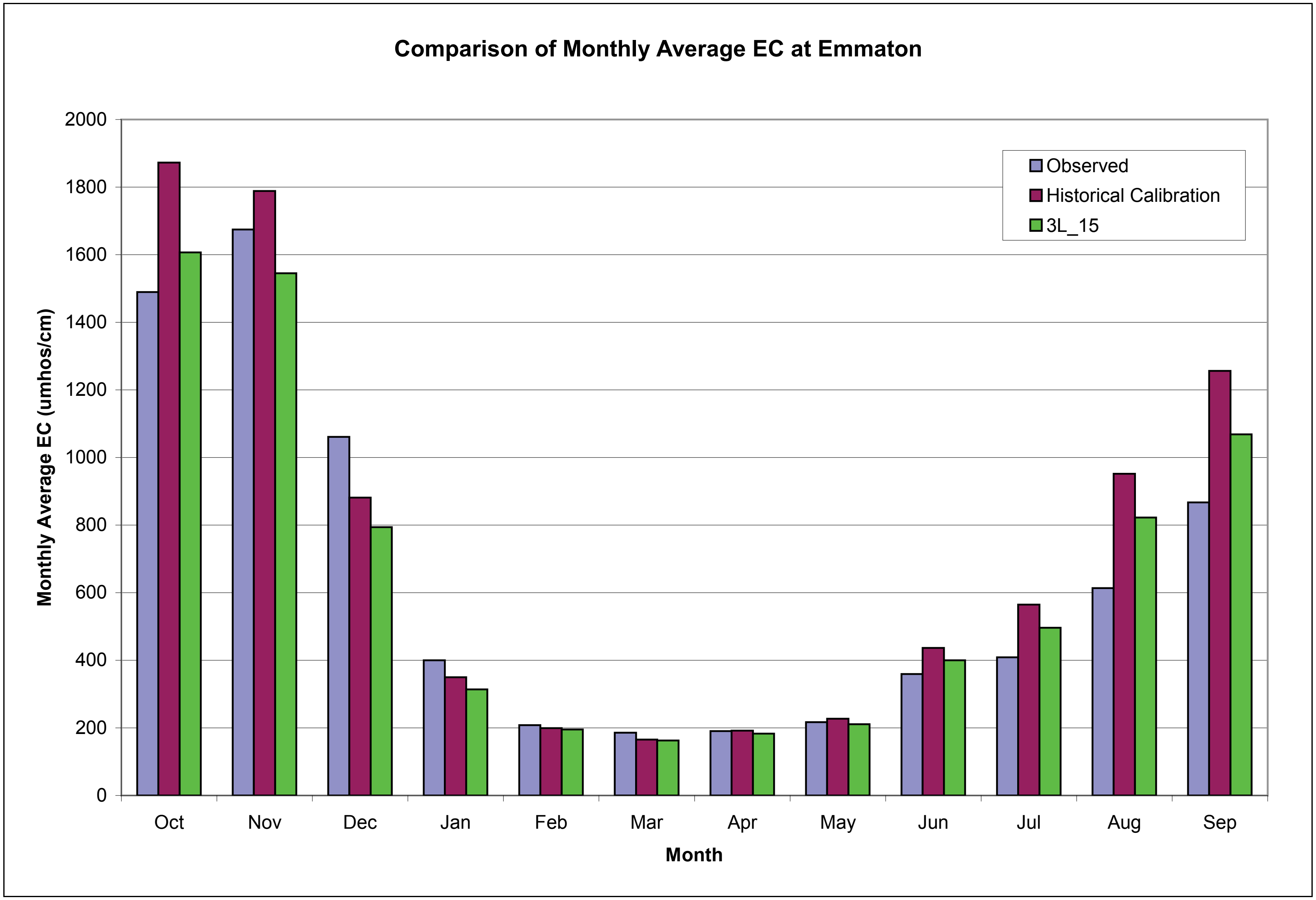


FIGURE 6-19
Monthly Average EC at Emmaton

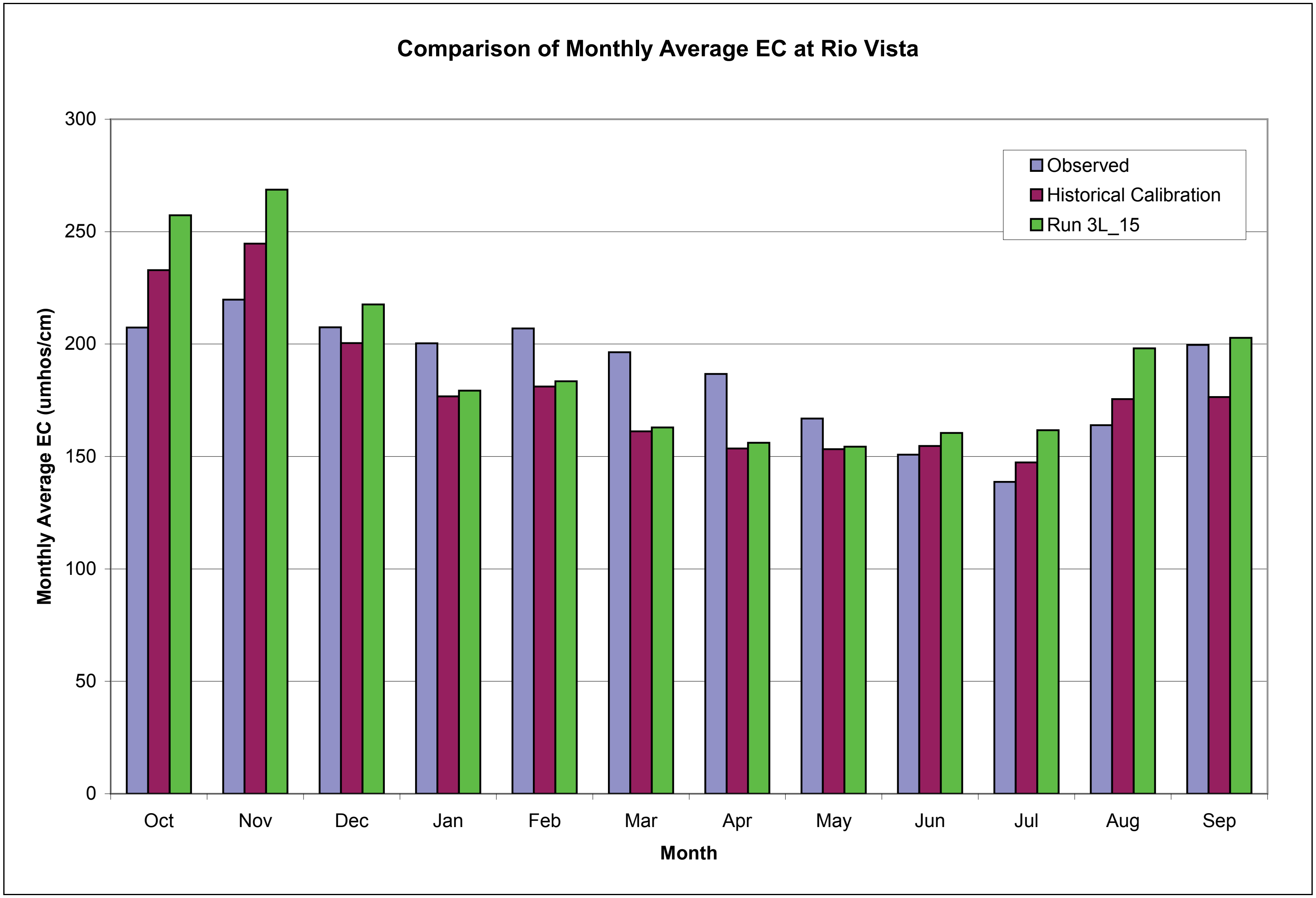


FIGURE 6-20
Monthly Average EC at Rio Vista

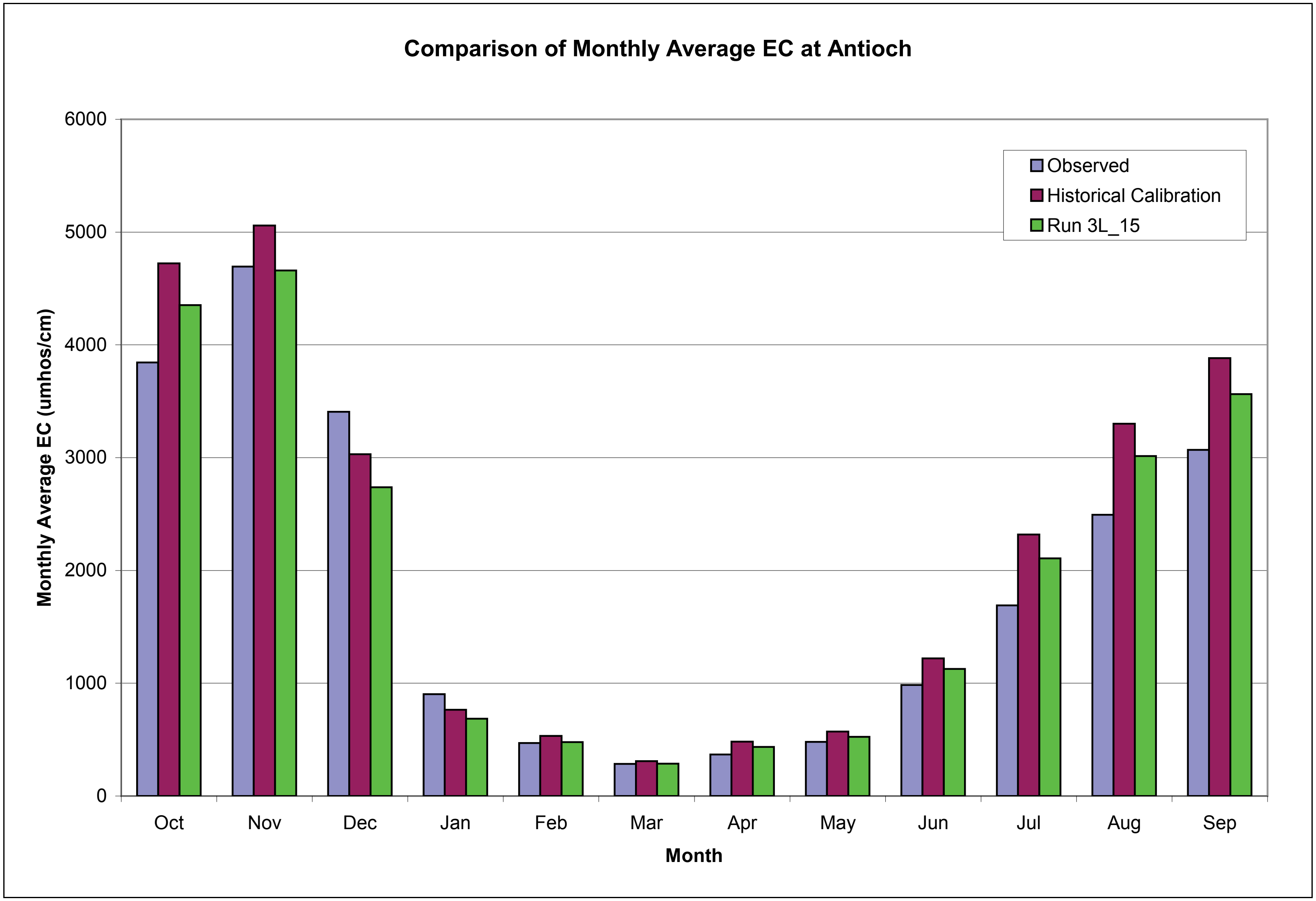


FIGURE 6-21
Monthly Average EC at Antioch

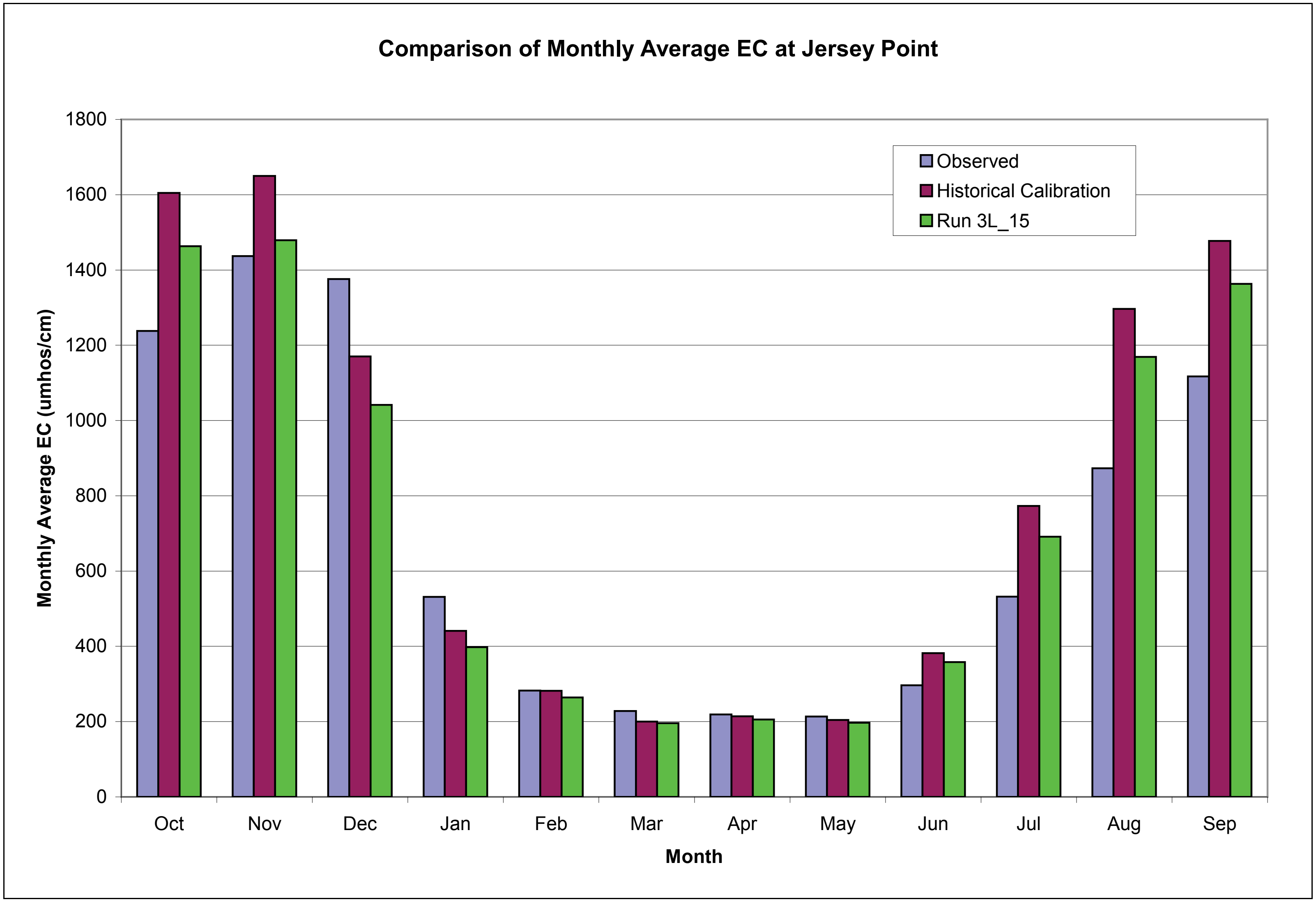


FIGURE 6-22
Monthly Average EC at Jersey Point

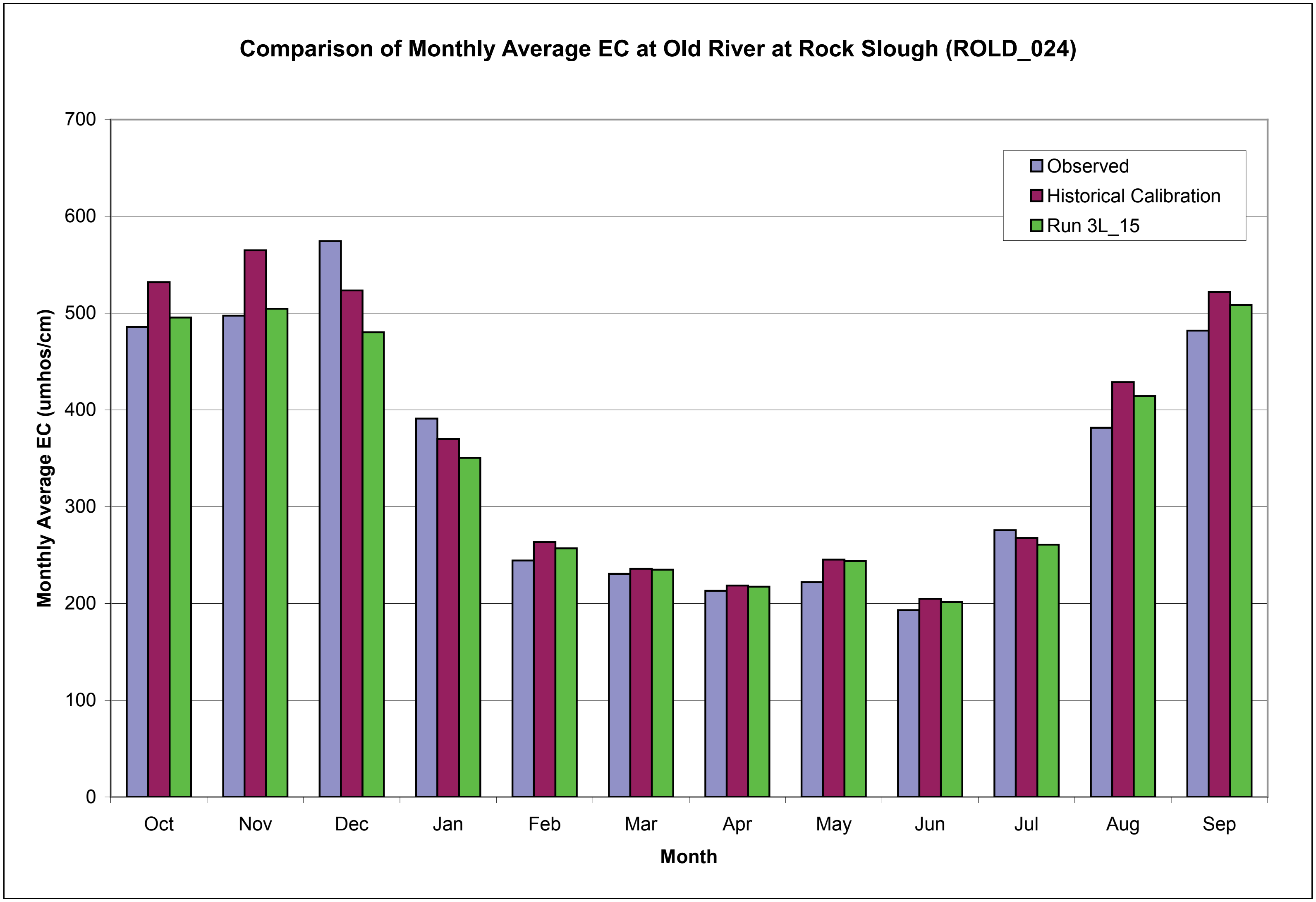


FIGURE 6-23
Monthly Average EC at Old River (ROLD024)

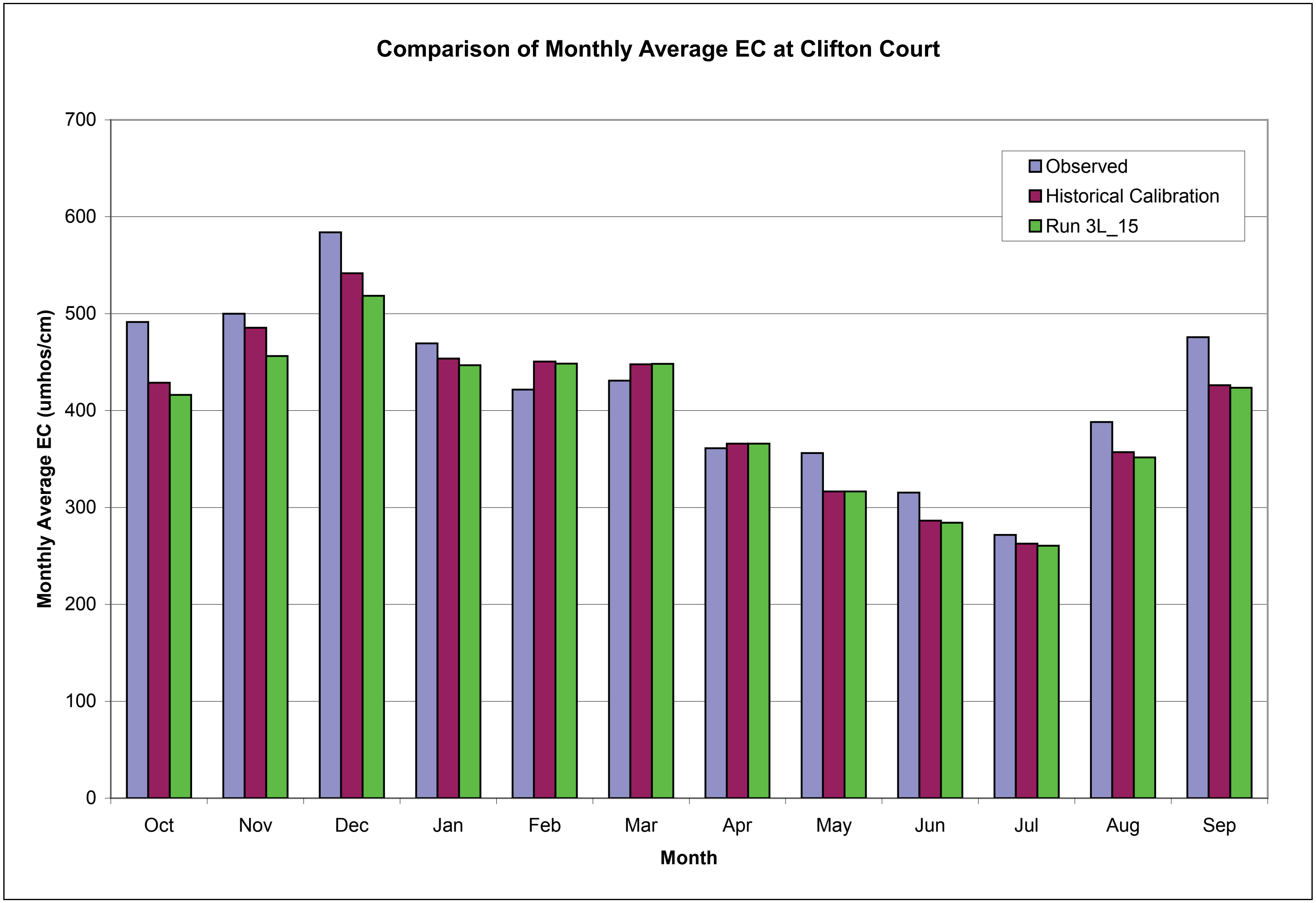


FIGURE 6-24
Monthly Average EC at Old River at Clifton Court

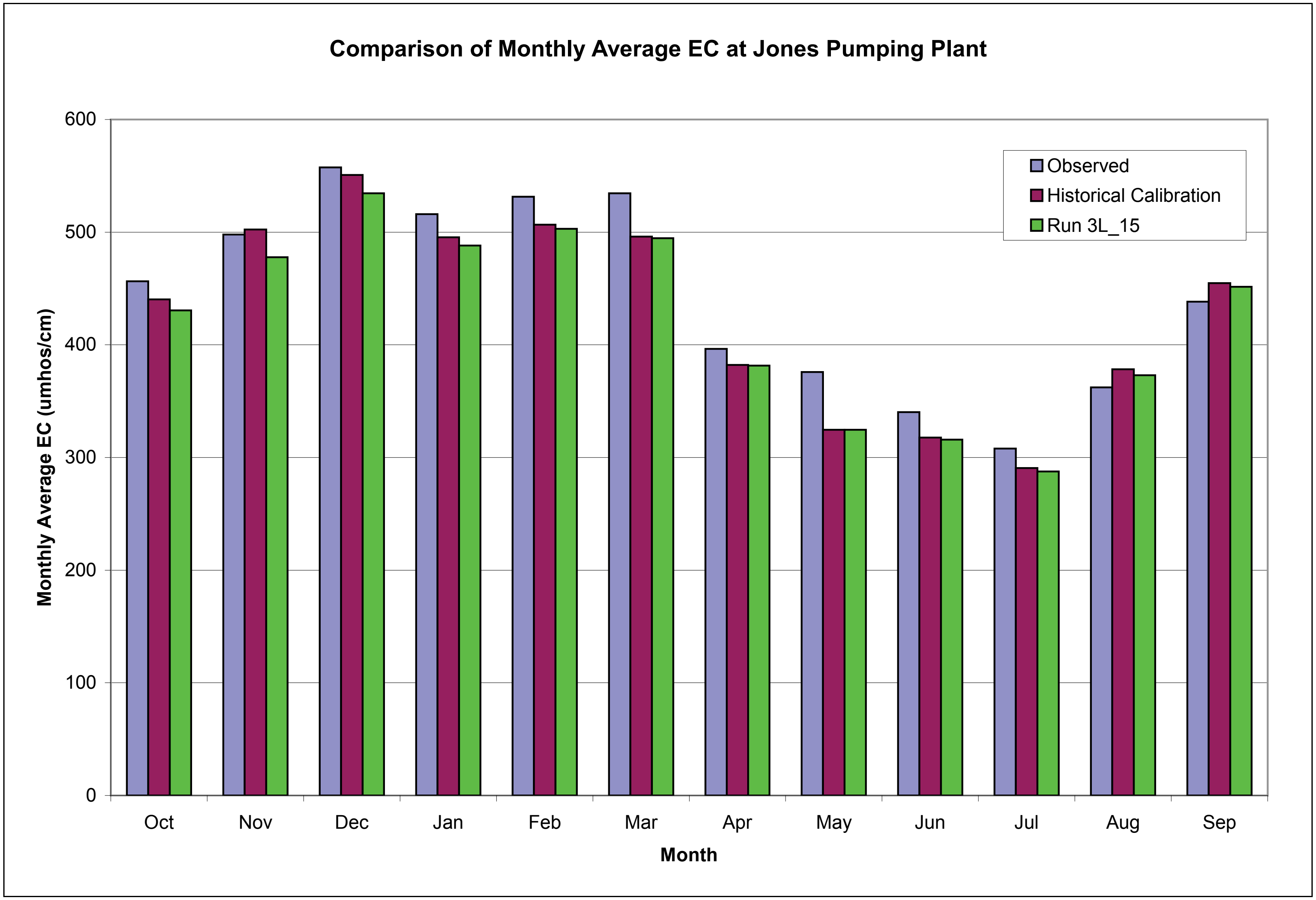


FIGURE 6-25
Monthly Average EC at Jones Pumping Plant

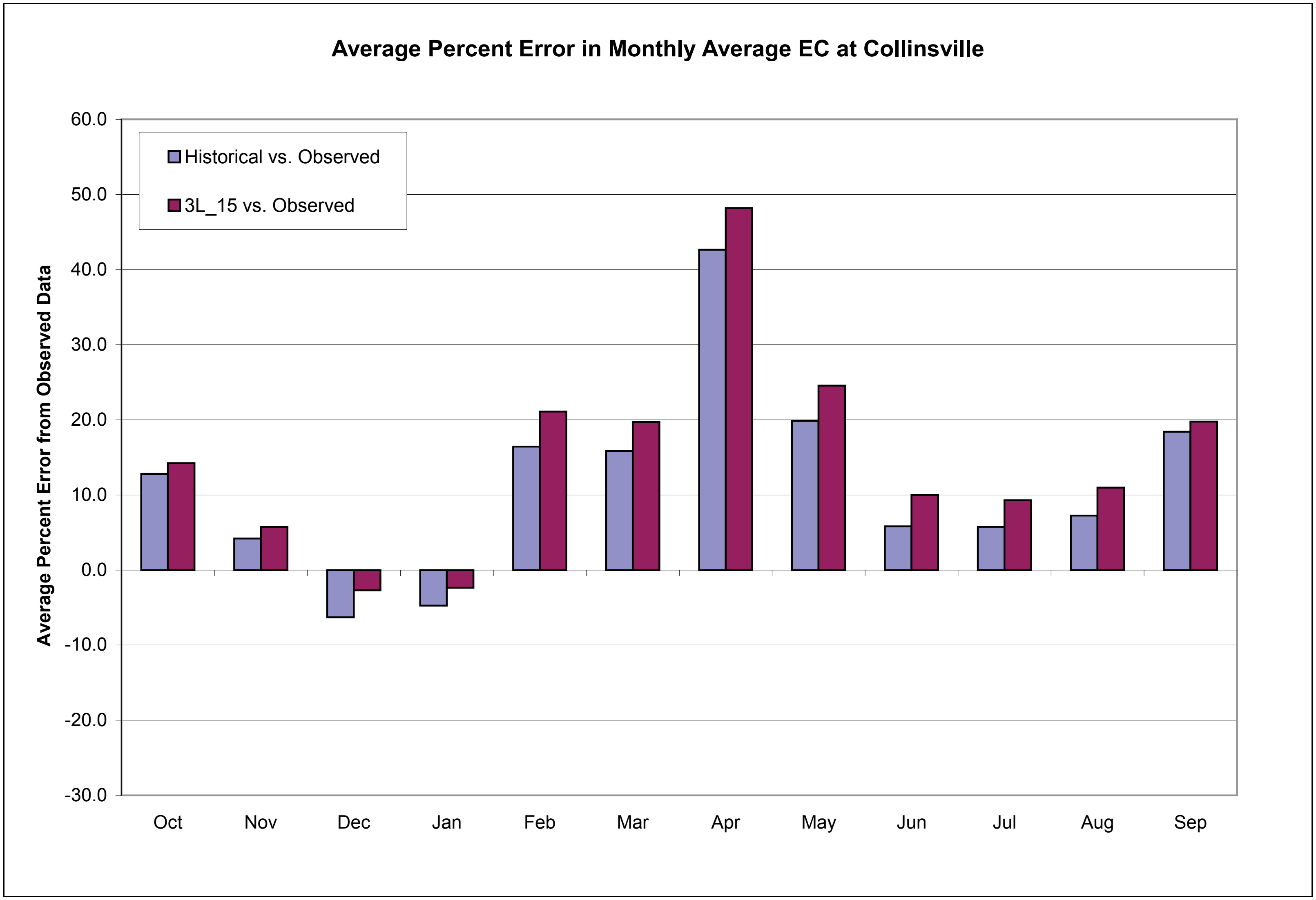


FIGURE 6-26
Monthly Percent Error in Predicted EC at Collinsville

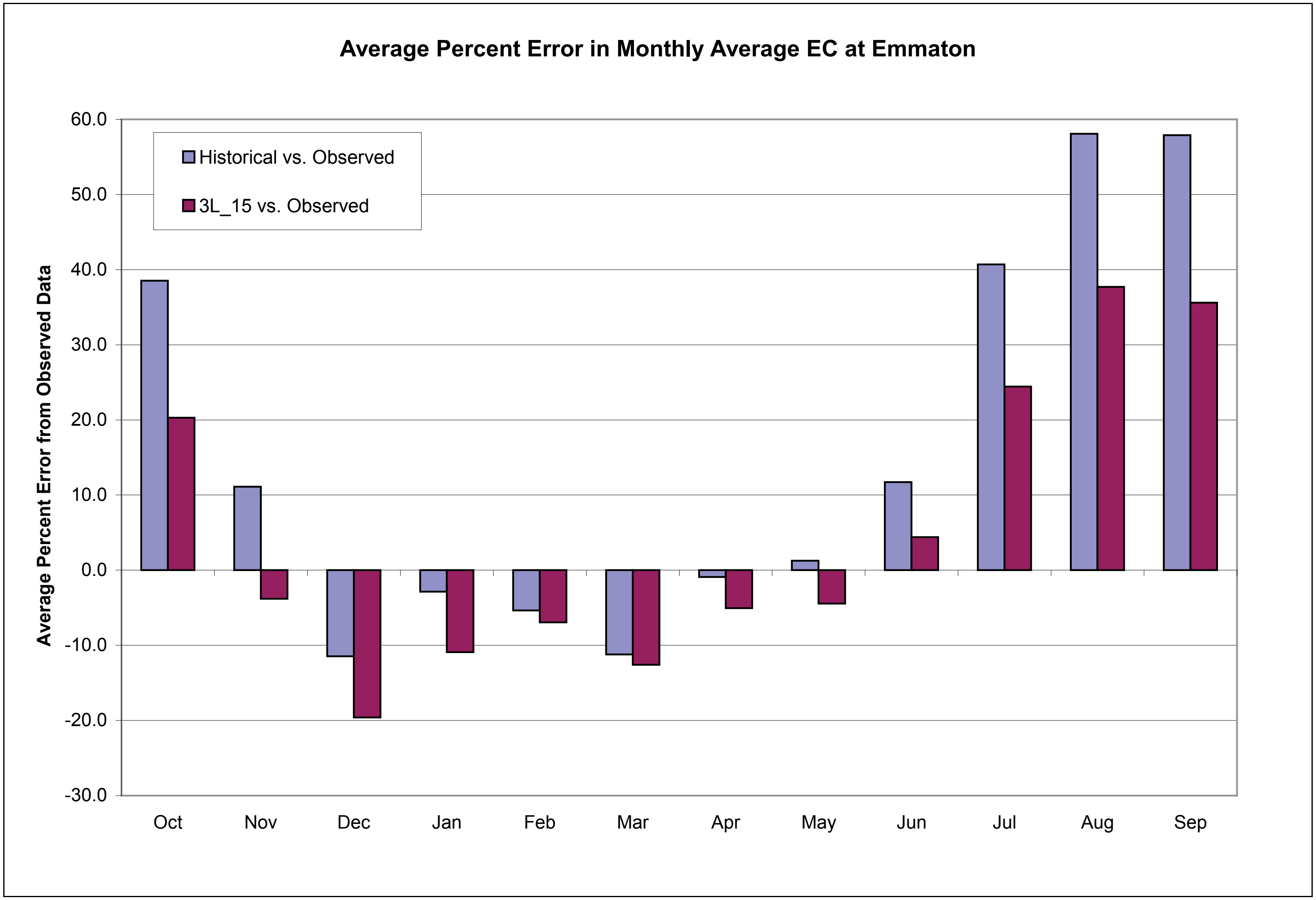


FIGURE 6-27
Monthly Percent Error in Predicted EC at Emmaton

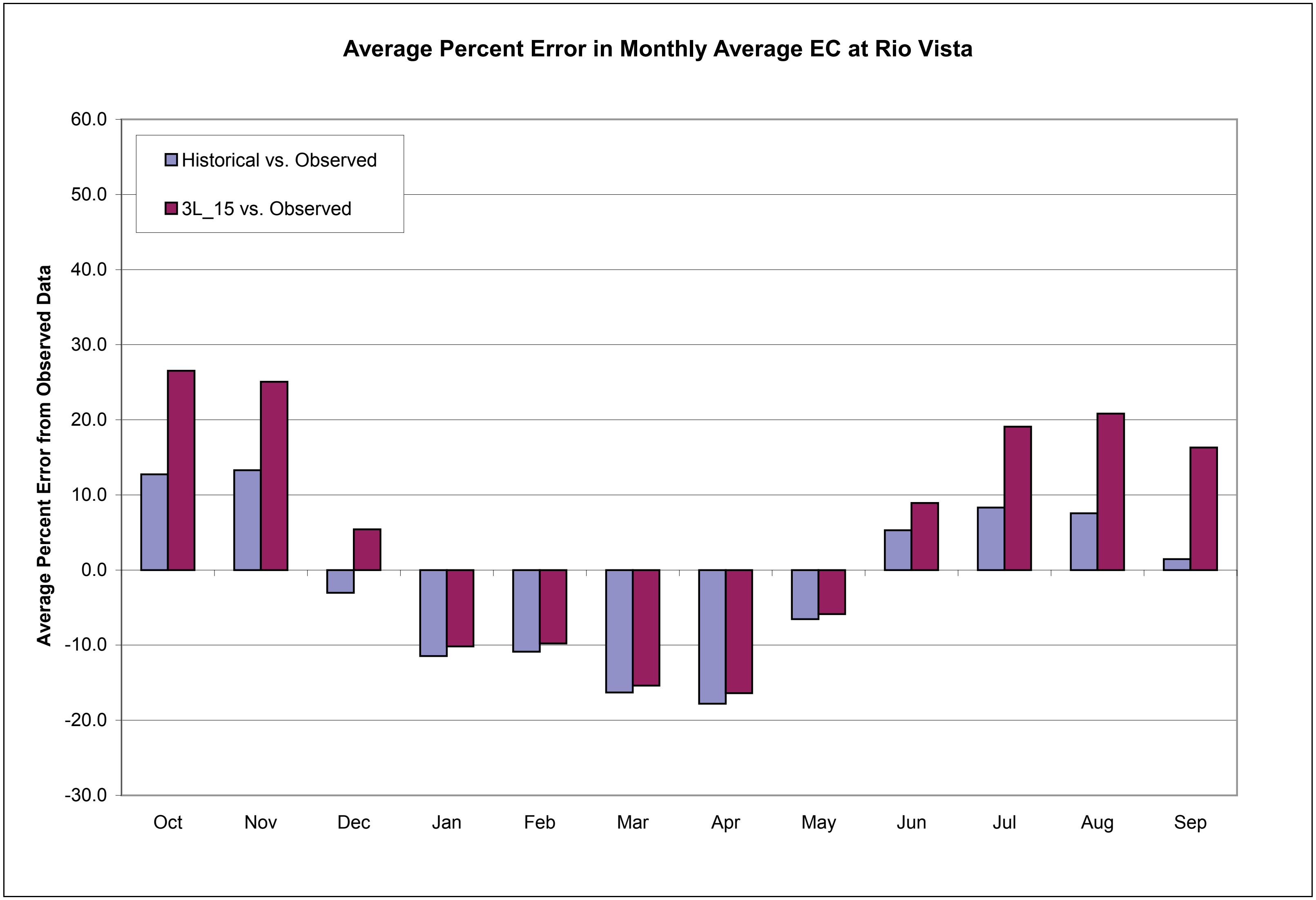


FIGURE 6-28
Monthly Percent Error in Predicted EC at Rio Vista

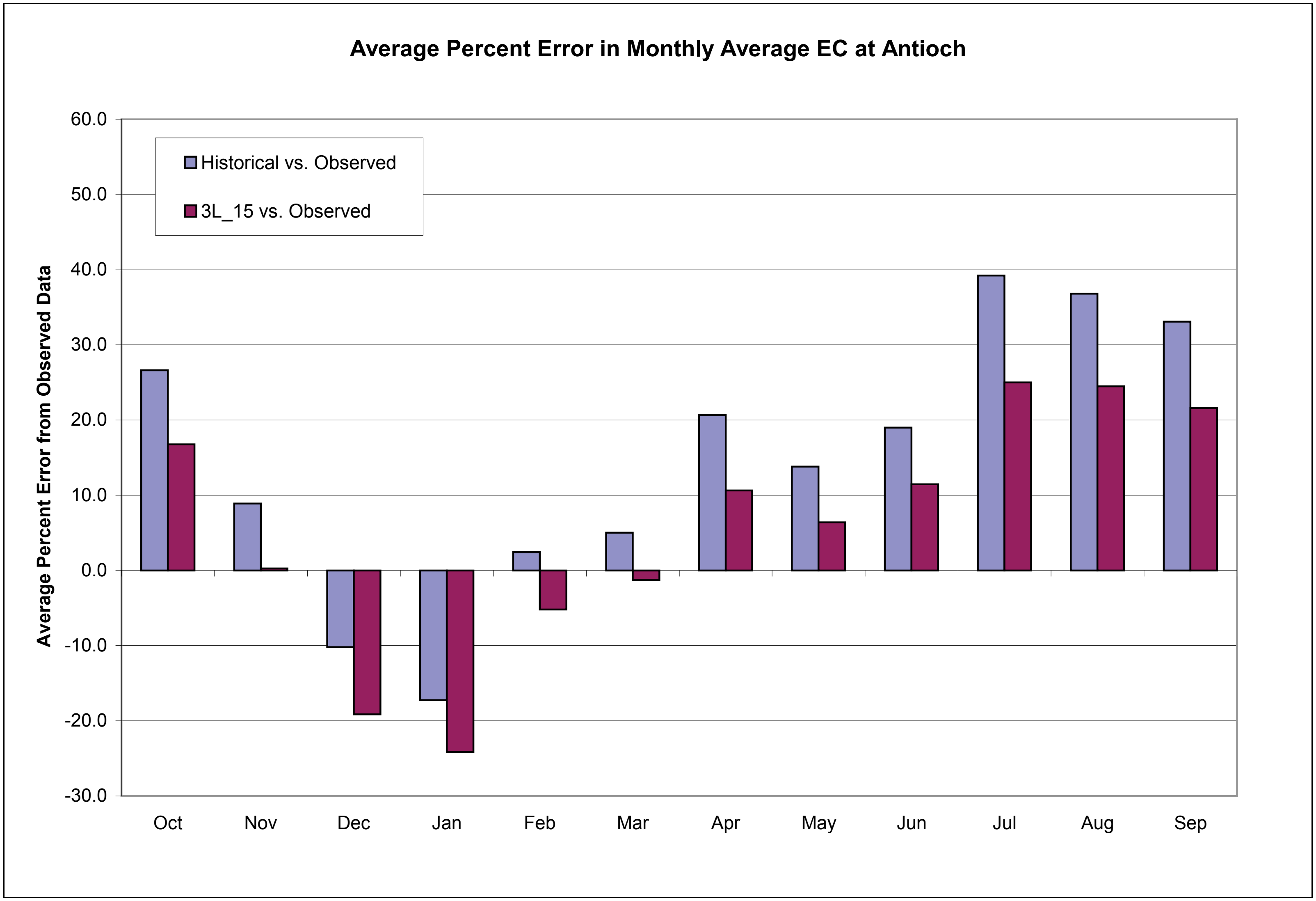


FIGURE 6-29
Monthly Percent Error in Predicted EC at Antioch

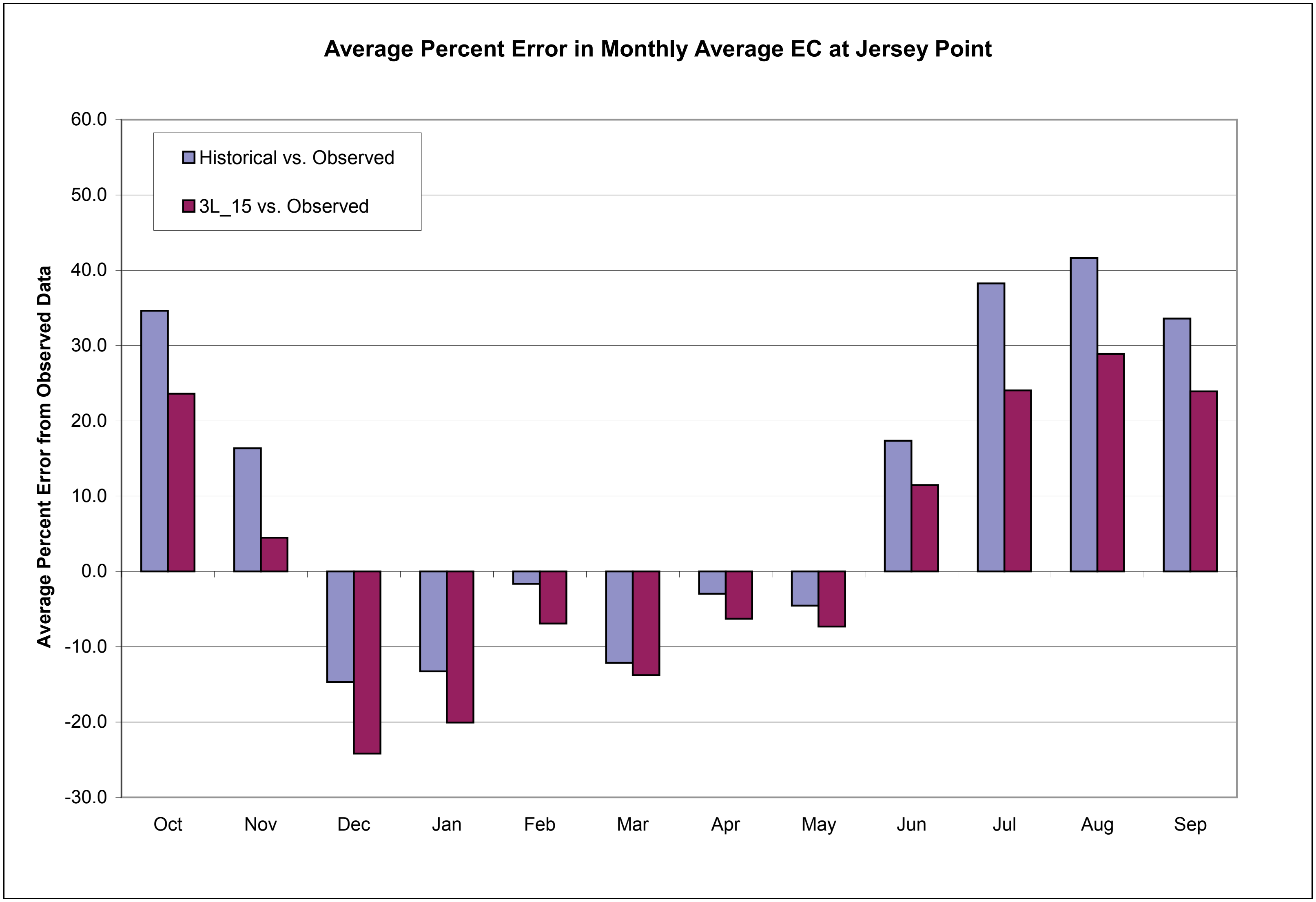


FIGURE 6-30
Monthly Percent Error in Predicted EC at Jersey Point

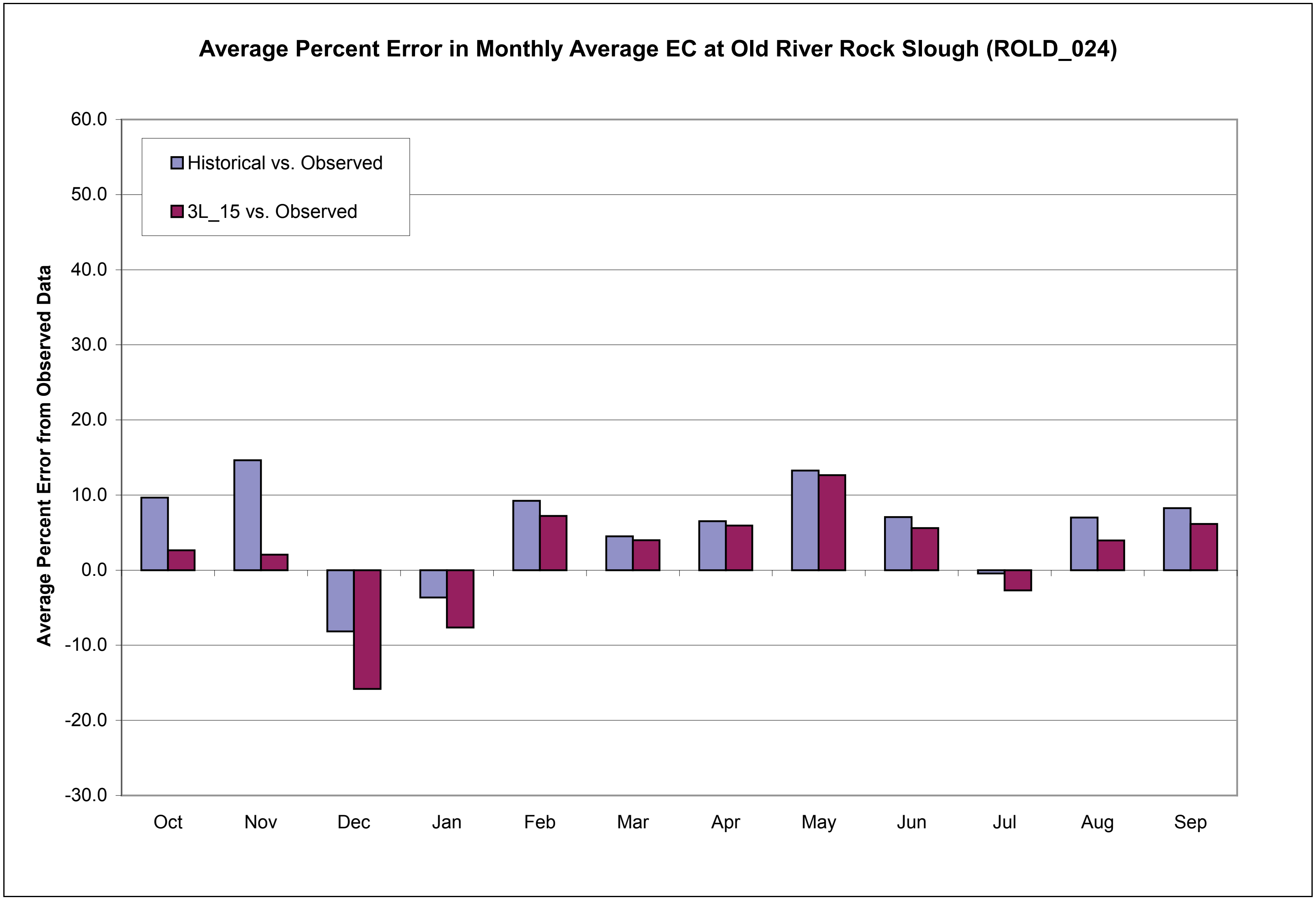


FIGURE 6-31
Monthly Percent Error in Predicted EC at Old River (ROLD024)

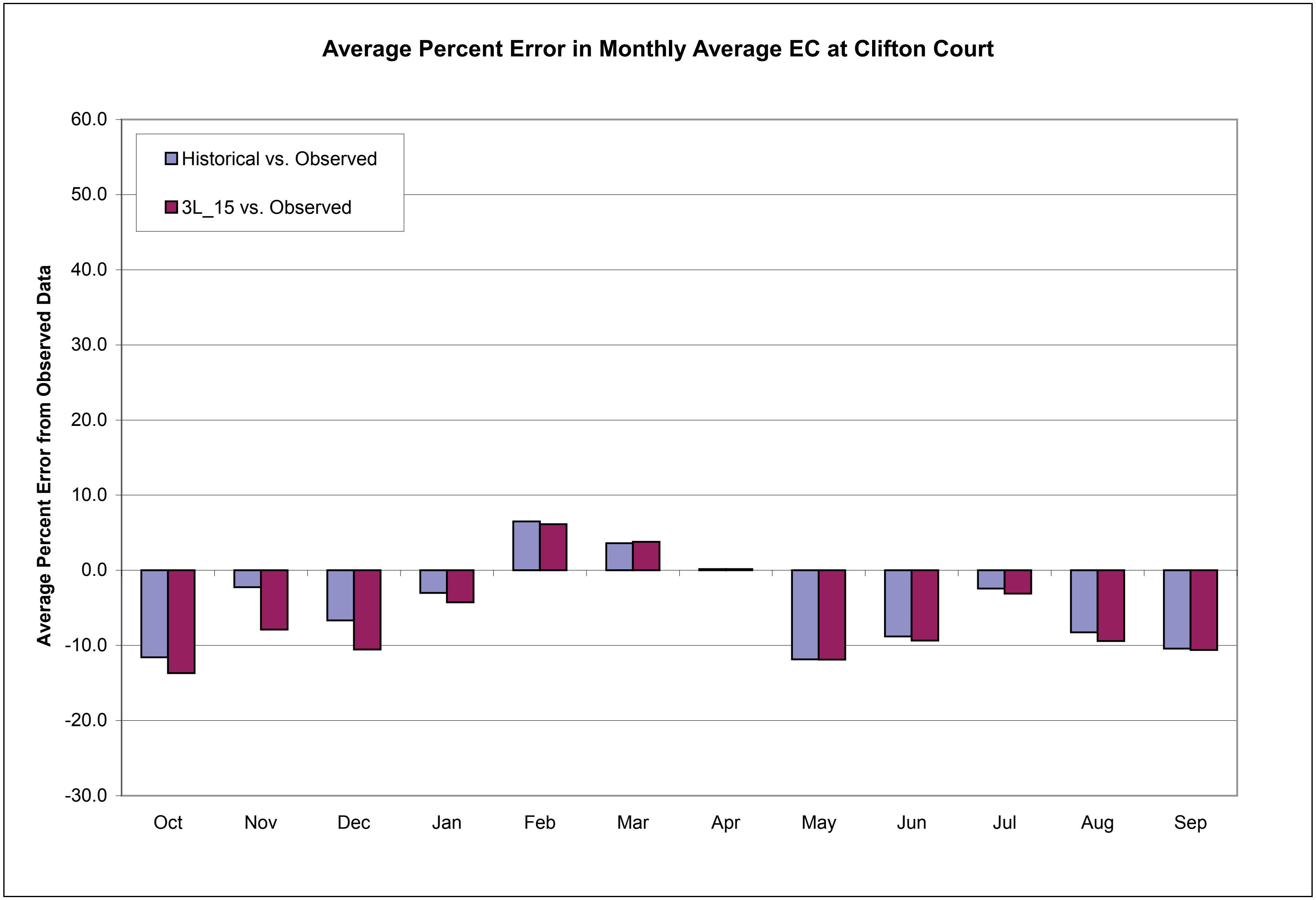


FIGURE 6-32
Monthly Percent Error in Predicted EC at Clifton Court

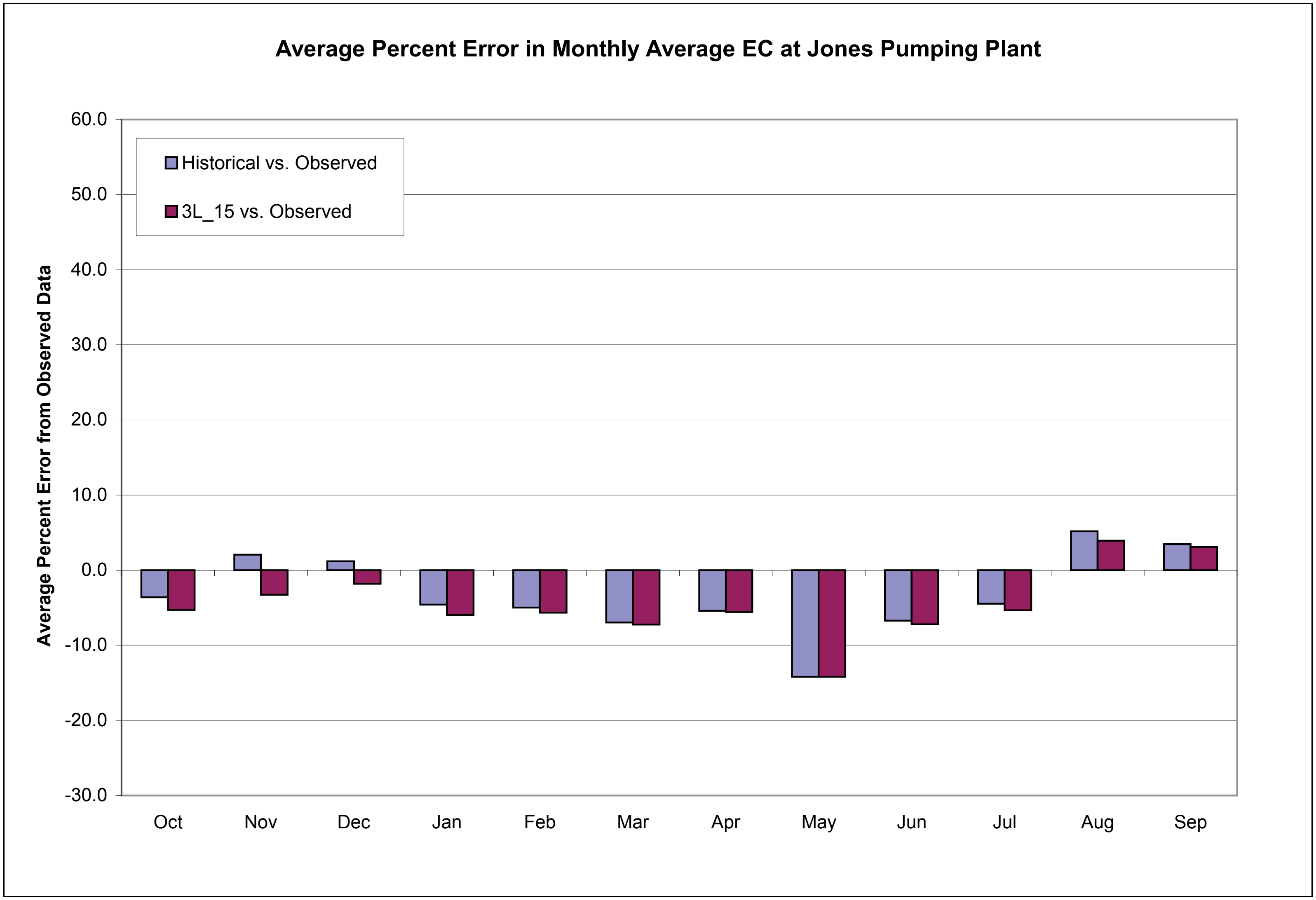


FIGURE 6-33
Monthly Percent Error in Predicted EC at Jones Pumping Plant

SECTION 7

Conclusions and Recommendations

7.1 Conclusions

The current recalibration of DSM2 was undertaken for two main reasons: Liberty Island flooding caused noticeable impact on the hydrodynamics in the north Delta and the 2000 DSM2 calibration did not include this morphological change and therefore do not accurately simulate hydrodynamics in the north Delta. This recalibration was started with an objective to improve the performance of DSM2 in simulating hydrodynamics and water quality at Emmaton, Rio Vista, Jersey Point and Threemile Slough.

The DSM2 model from the 2000 calibration was modified to incorporate the physical changes and boundary condition changes as described in earlier sections. The DSM2-HYDRO with the modified grid was then successfully calibrated with the observed flow and stage data for WY 2002, by mainly modifying Manning's roughness coefficient in the channels. The recalibrated DSM2-HYDRO was then successfully validated for an 8-year period (WY 2001 to WY 2008). DSM2-QUAL was calibrated for WY 2001 to WY 2008 using the results from HYDRO validation. The channel dispersion factors were modified to simulate EC accurately.

At the end of this process, the results from recalibrated DSM2 model have better agreement with observed data than the 2000 calibration overall in the Delta and specifically at the key locations identified in the objectives, in terms of tidal hydrodynamics. It is important to note that the simulated hydrodynamics in the Cache Slough and Steamboat Slough have significantly improved in the recalibrated DSM2. The simulated net flows in Sacramento River at Rio Vista and the Cross Delta flows have improved compared to the 2000 calibration. However, the net flows in Threemile Slough from the Sacramento River to the San Joaquin River in the recalibrated DSM2 are higher than the 2000 calibration. Net flows in Dutch Slough have improved with recalibration; however, they still continue to be in the wrong direction compared to the observed data.

The recalibration process yielded improvement in the QUAL results at Jersey Point, Emmaton and Rock Slough, along with many other locations throughout the Delta. The RMSE is slightly worse at Rio Vista and Threemile Slough for the recalibrated model than the 2000 calibration. The simulated EC is slightly lower in Old River at Holland Cut and near Clifton Court Forebay. Analysis of the calibration metrics indicates that the model performs better during dry and critical years.

Overall, this recalibration effort resulted in a marked improvement in the performance of DSM2-HYDRO and DSM2-QUAL compared to the 2000 calibration.

7.2 Recommendations

A somewhat common pattern in the model results is to over-predict salinity in the summer and fall and under-predict salinity in the winter and spring. The model generally predicts EC in the late summer that rises too quickly compared to the observed data. This is clearly evident at Rio Vista and Jersey Point. This may indicate that the model is over-predicting the tidal mixing or that the dispersion values are too high during periods of low flow. Currently, the dispersion values prescribed for a given channel are held constant for the simulation in DSM2, irrespective of changes in flow. The ability to use a variable dispersion coefficient may improve model predictions. It is recommended that the evaluation and implementation of variable dispersion coefficients to improve seasonally-biased model predictions be considered in the future.

The dispersion values adopted in the final calibration simulation can have significant step changes from one channel to the next. It is hard to justify such a change from a physics perspective. The targeted adjustments of dispersion values required to improve the calibration may indicate that other factors aside from the dispersion coefficients are controlling the errors. The errors may stem from errors in the hydrodynamic predictions, or errors in internal loads (DICU). In future, it is recommended that the Delta agricultural diversion and drainage flow data be obtained from a more realistic model than DICU.

The calibration process is quite complex in that model predictions are generally not consistently biased. For example, predicted fall EC at Rio Vista is higher than observed values in most years, but in 2002, the model predictions are below measured EC. Efforts made to improve conditions at one location or for a certain period can end up making conditions worse at other locations or during other time periods. Future analyses could investigate correlations between predicted errors and other variables such as net flows and average EC, to see if any relationships can be seen that could be used to improve model predictions.

7.3 Limitations

DSM2 is a 1D model with inherent limitations in simulating hydrodynamic and transport processes in a complex estuarine environment such as the Sacramento – San Joaquin Delta. DSM2 assumes that velocity in a channel can be adequately represented by a single average velocity over the channel cross-section, meaning that variations both across the width of the channel and through the water column are negligible. DSM2 does not have the ability to model short-circuiting of flow through a reach, where a majority of the flow in a cross-section is confined to a small portion of the cross-section. DSM2 does not conserve momentum at the channel junctions and does not model the secondary currents in a channel. DSM2 also does not explicitly account for dispersion due to flow accelerating through channel bends. It cannot model the vertical salinity stratification in the channels. For open water bodies DSM2 assumes uniform and instantaneous mixing over entire open water area. Thus it does not account for the any salinity gradients that may exist within the open water bodies. Significant uncertainty exists in flow and EC input data related to in-Delta agriculture, which leads to uncertainty in the simulated EC values. Caution needs to be exercised when using EC outputs on a sub-monthly scale.

SECTION 8

References

Delong, L.L., D.B. Thompson, and J.K. Lee. 1997. The computer program FOURPT (Version 95.01)—a model for simulating one-dimensional, unsteady, open-channel flow: U.S. Geological Survey Water-Resources Investigations Report 97-4016, 69 pp.

DSM2PWT. 2001. Enhanced Calibration and Validation of DSM2 HYDRO and QUAL, Draft Final Report, Interagency Ecological Program for the Sacramento-San Joaquin Estuary. November.

DWR. 1997. 18th Annual Progress Report. June

DWR. 2008. DWR Sacramento Bathymetry. October. (Email from SAIC on March 18, 2009)

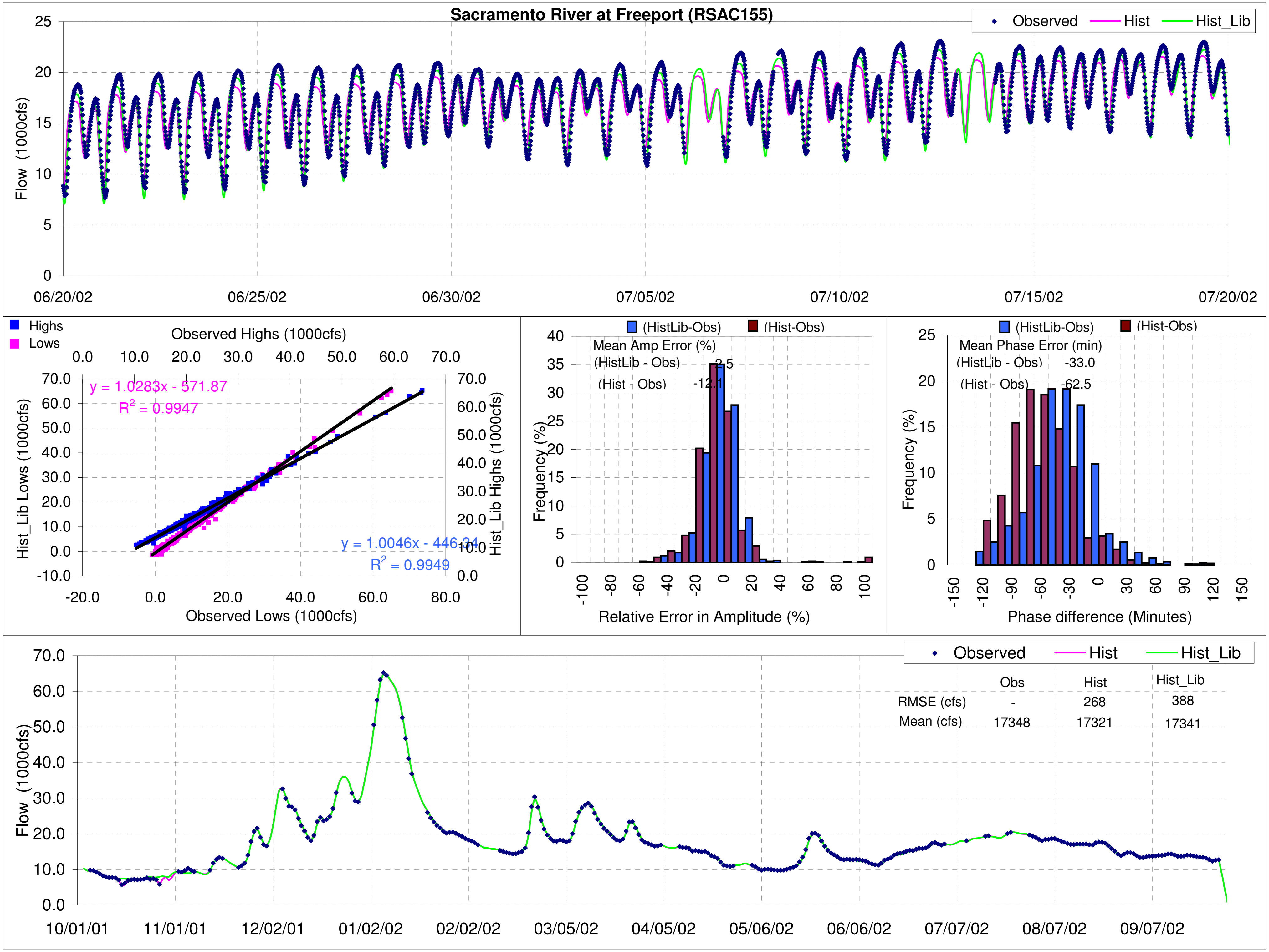
Jobson, Harvey E. 1980. Temperature and Solute-Transport Simulation in Streamflow using a Lagrangian Reference Frame, US Geological Survey, Water Resources Division, Water Resources Investigations, 81-2

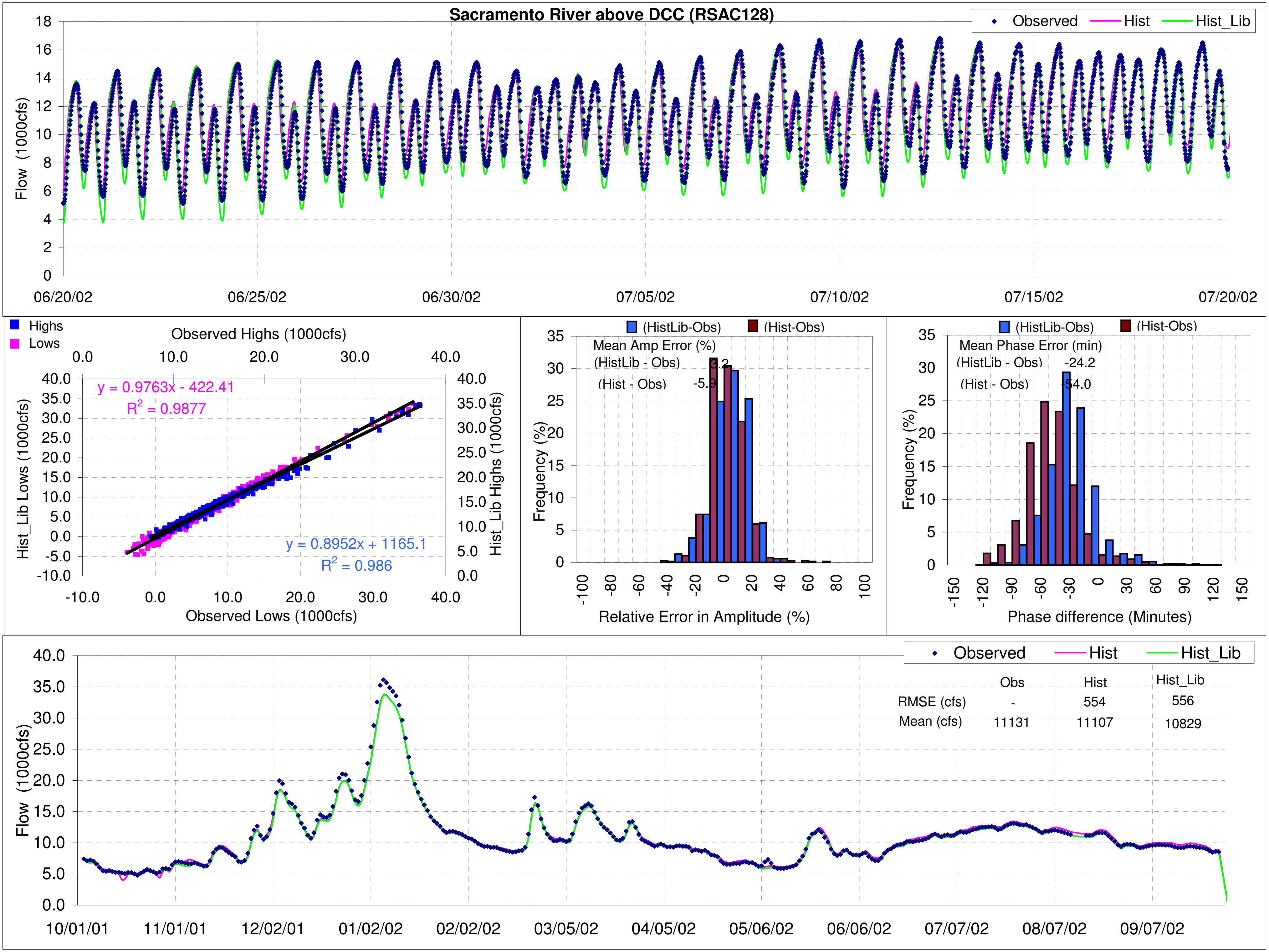
Ruhl, Cathy. 2007. Delta Flow: Data and Calibrations, Presentation at: CWEMF Modeling Issues of the Delta Technical Workshop. February.

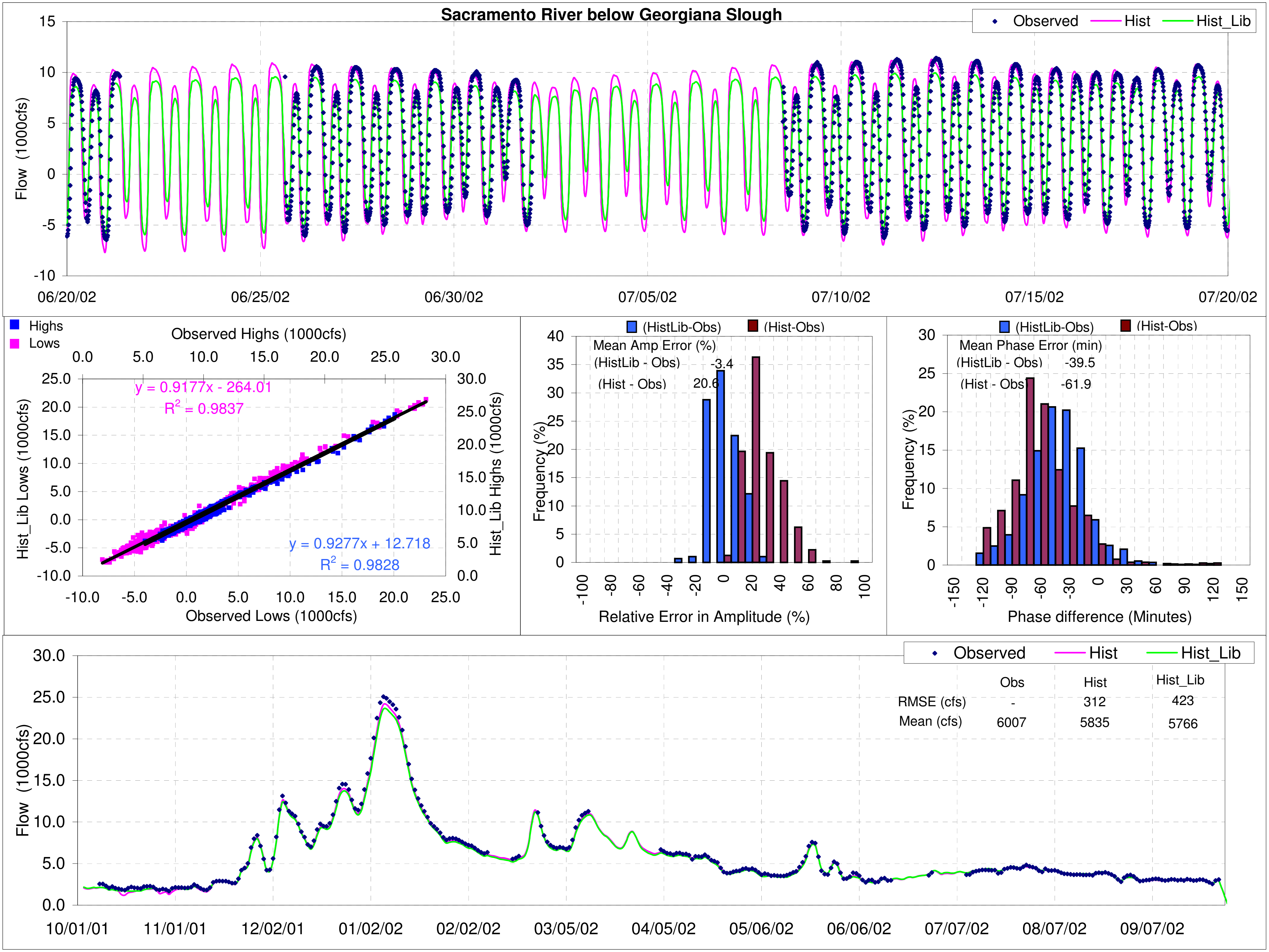
Shum, K.T. 2006. Issues Affecting the Predictive Ability of One-Dimensional Delta Hydrodynamic and Water Quality Models, DRAFT Report. October

USFWS. 2008. http://www.fws.gov/stockton/jfmp/libertyisland.asp, last modified December 2008

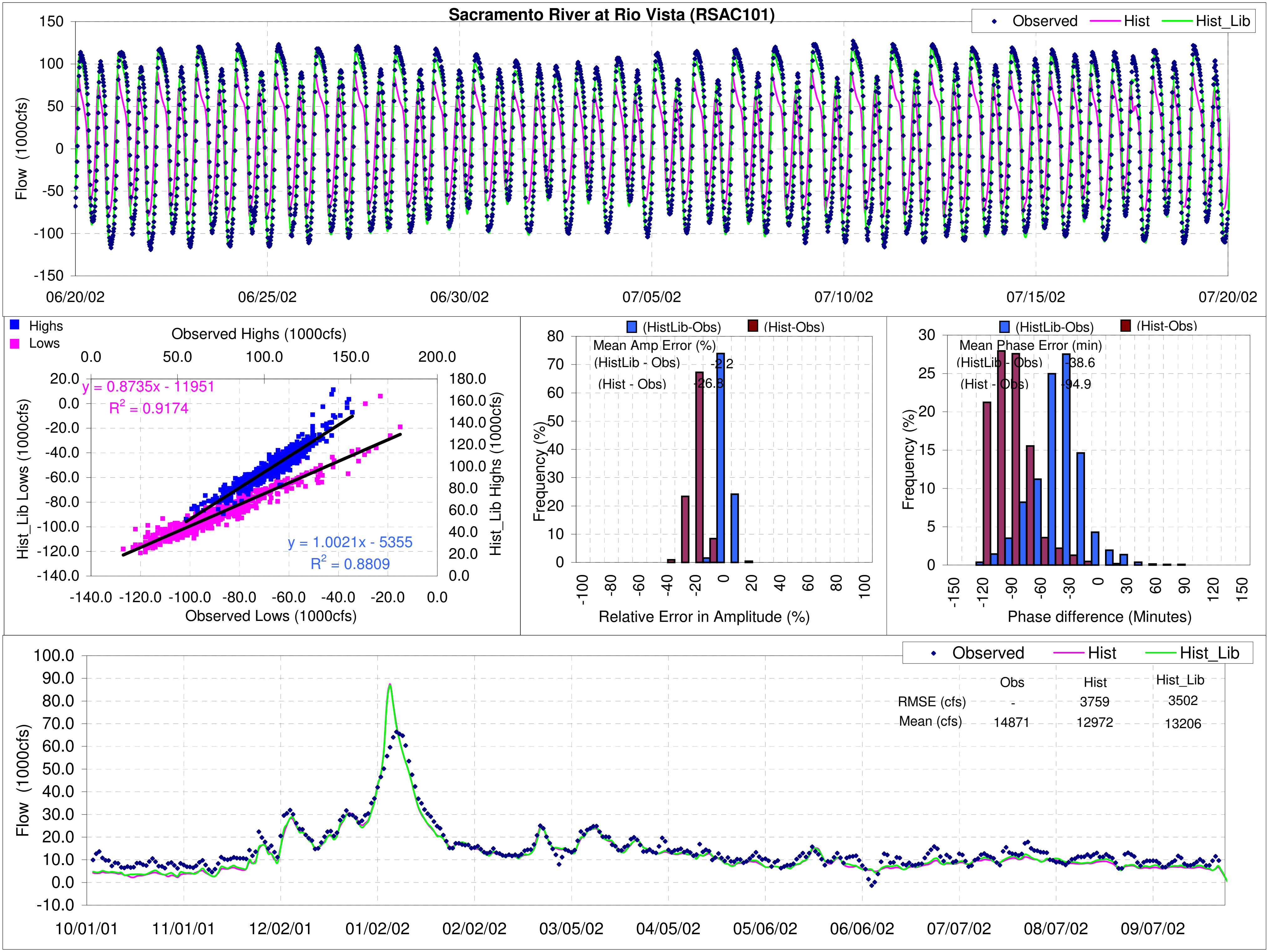
Appendix A
Detailed HYDRO Calibration Results

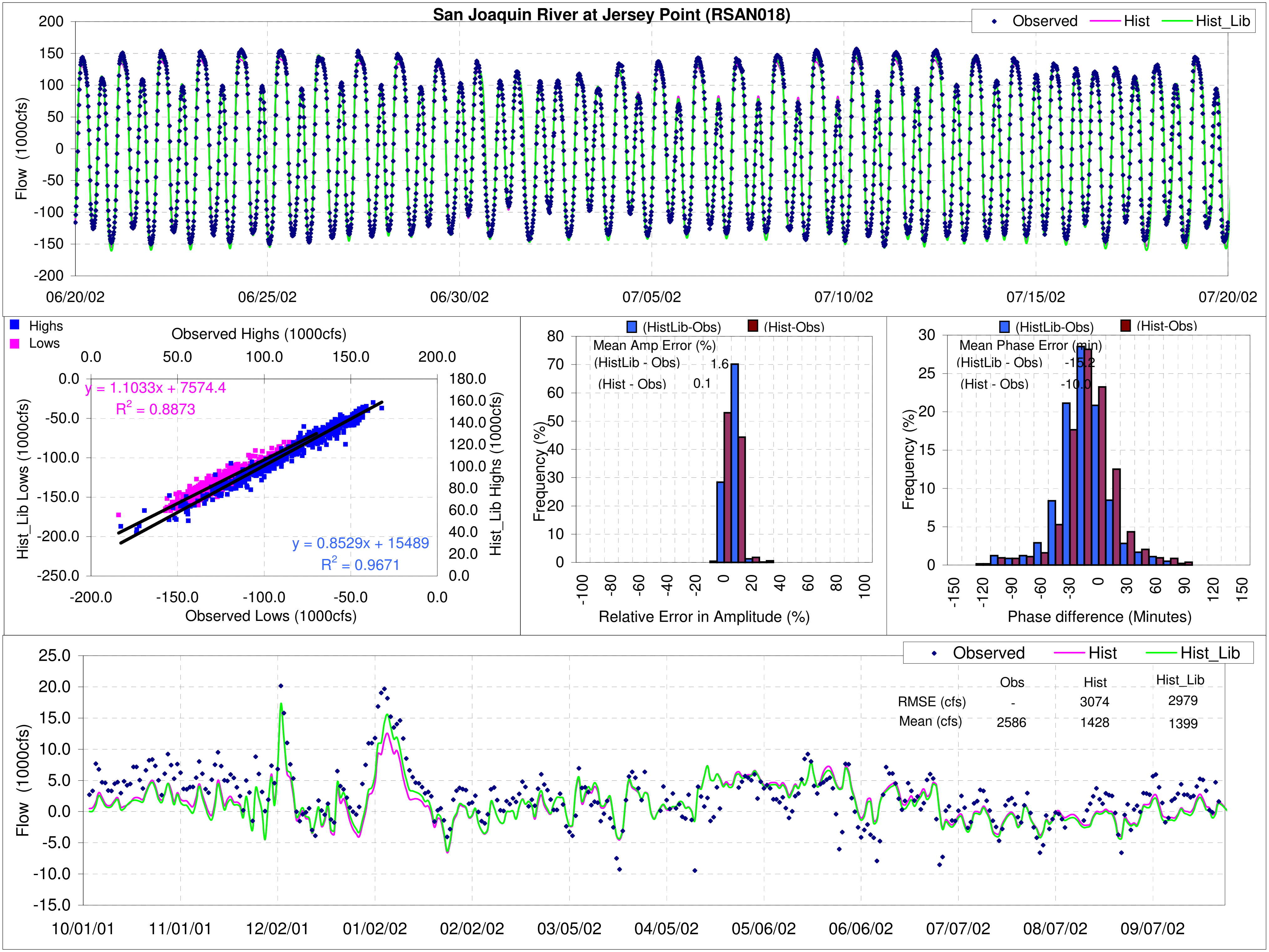

Sacramento River at Freeport (RSAC155)
Observed
Hist
Hist_Lib
Flow (1000cfs)
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (1000cfs)
y = 1.0283x - 571.87
R^2 = 0.9947
y = 1.0046x - 446.34
R^2 = 0.9949
Hist_Lib Lows (1000cfs)
Hist_Lib Highs (1000cfs)
Observed Lows (1000cfs)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) -2.5
(Hist - Obs) -12.1
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -33.0
(Hist - Obs) -62.5
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (cfs)
-
268
388
Mean (cfs)
17348
17321
17341
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02

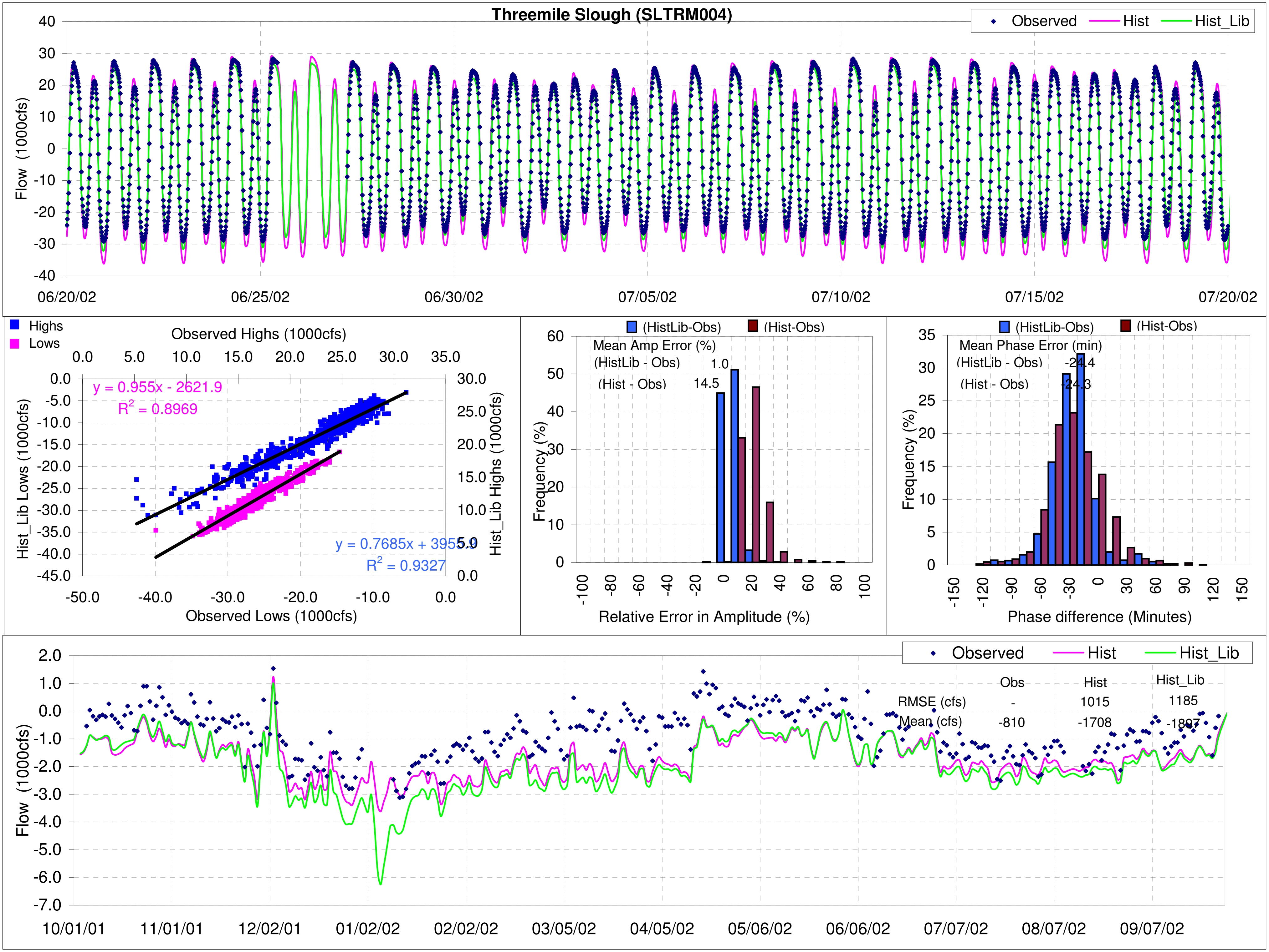

Sacramento River above DCC (RSAC128)
Observed
Hist
Hist_Lib
Flow (1000cfs)
18
16
14
12
10
8
6
4
2
0
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (1000cfs)
0.0
10.0
20.0
30.0
40.0
y = 0.9763x - 422.41
R^2 = 0.9877
y = 0.8952x + 1165.1
R^2 = 0.986
Hist_Lib Lows (1000cfs)
Hist_Lib Highs (1000cfs)
Observed Lows (1000cfs)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 3.2
(Hist - Obs) -5.9
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -24.2
(Hist - Obs) -54.0
Phase difference (Minutes)
Observed
Hist
Hist_Lib
Obs
Hist
Hist_Lib
RMSE (cfs) - 554 556
Mean (cfs) 11131 11107 10829
Flow (1000cfs)
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02



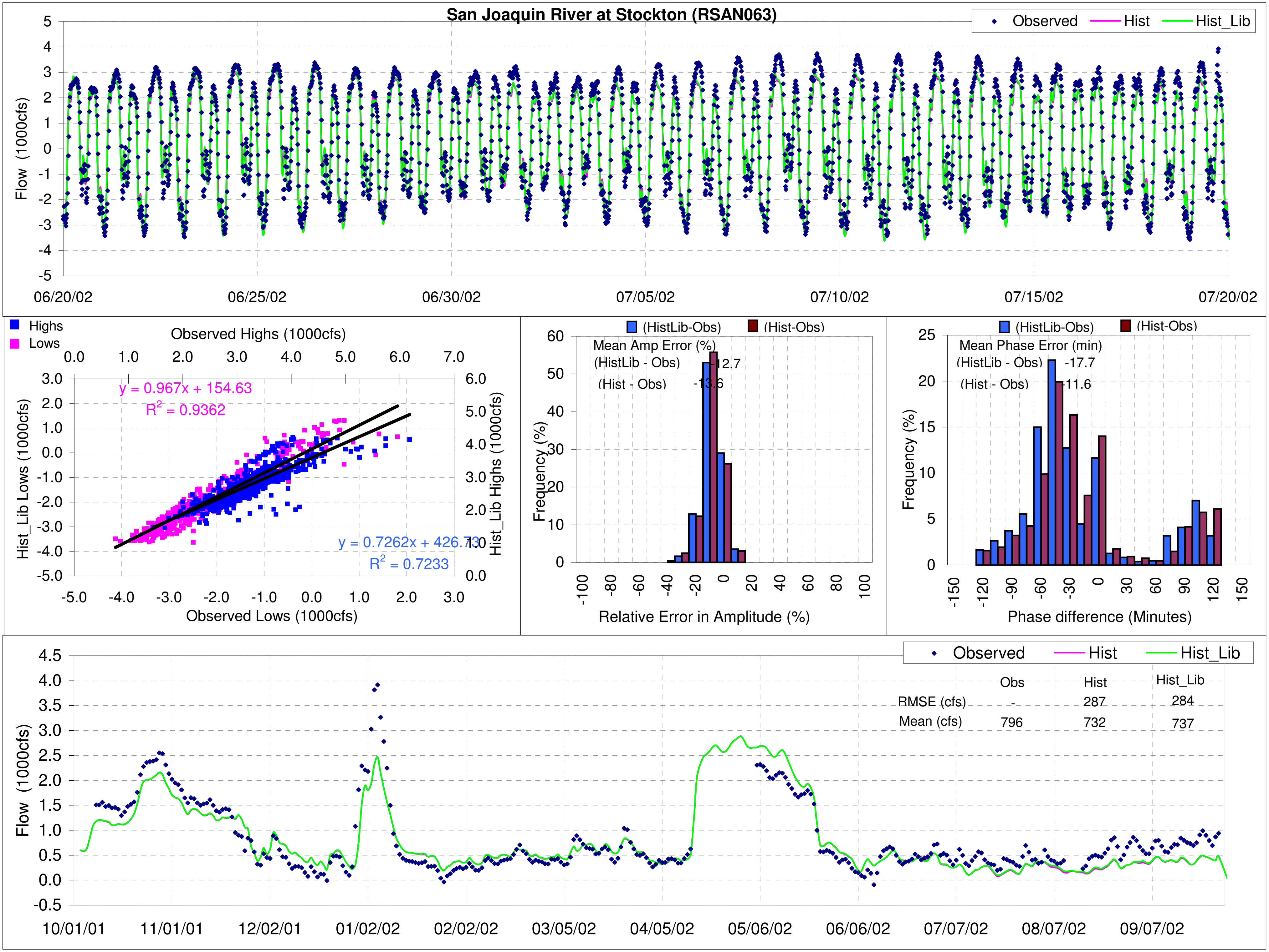
Sacramento River below Georgiana Slough
Observed
Hist
Hist_Lib
Flow (1000cfs)
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (1000cfs)
y = 0.9177x - 264.01
R2 = 0.9837
y = 0.9277x + 12.718
R2 = 0.9828
Hist_Lib Lows (1000cfs)
Hist_Lib Highs (1000cfs)
Observed Lows (1000cfs)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) -3.4
(Hist - Obs) 20.6
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -39.5
(Hist - Obs) -61.9
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (cfs)
-
312
423
Mean (cfs)
6007
5835
5766
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02

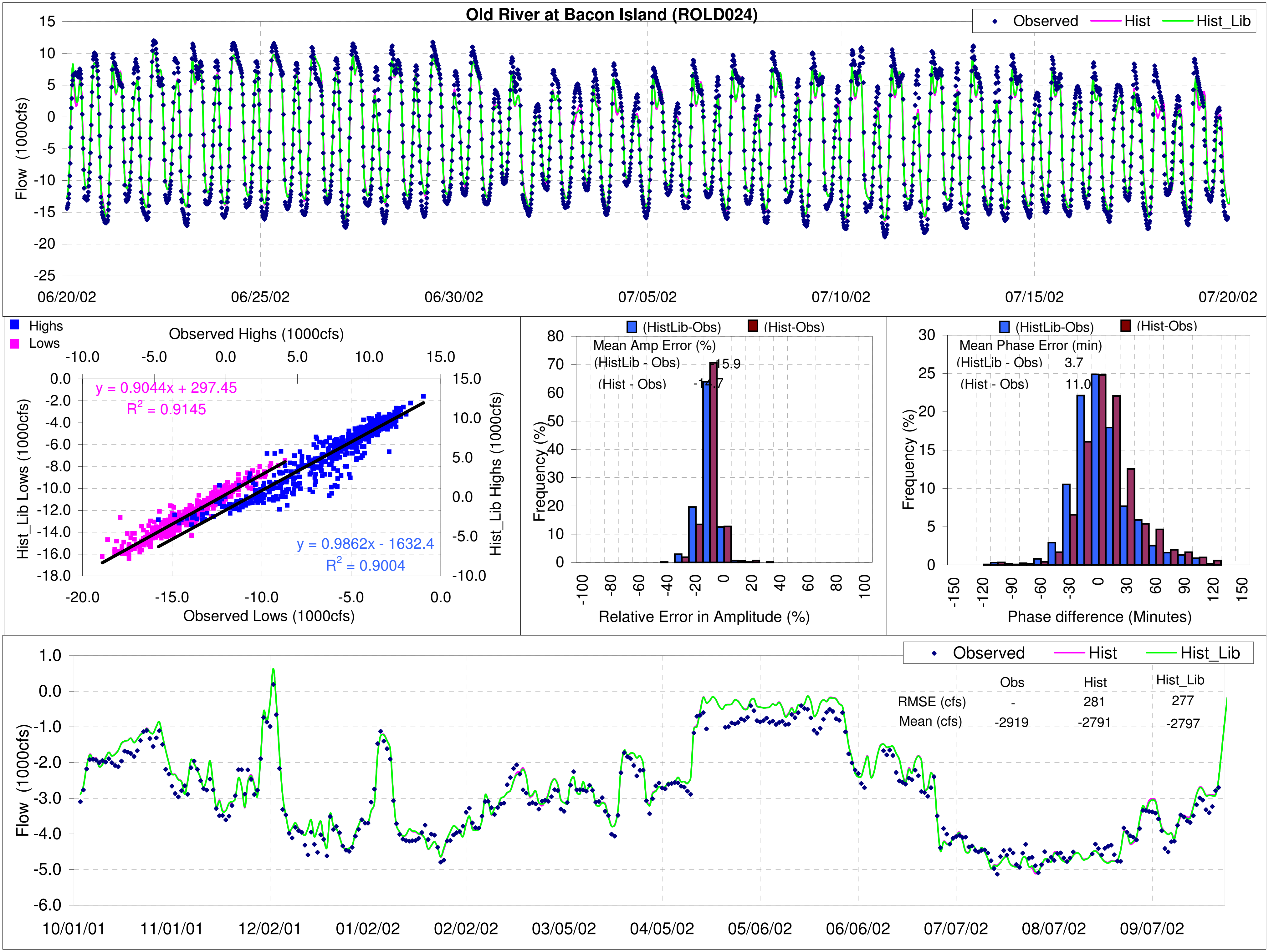

Sacramento River at Rio Vista (RSAC101)
Observed
Hist
Hist_Lib
Flow (1000cfs)
150
100
50
0
-50
-100
-150
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (1000cfs)
0.0
50.0
100.0
150.0
200.0
y = 0.8735x - 11951
R2 = 0.9174
y = 1.0021x - 5355
R2 = 0.8809
Hist_Lib Lows (1000cfs)
Hist_Lib Highs (1000cfs)
Observed Lows (1000cfs)
-140.0
-120.0
-100.0
-80.0
-60.0
-40.0
-20.0
0.0
20.0
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) -2.2
(Hist - Obs) -26.8
Frequency (%)
Relative Error in Amplitude (%)
-100
-80
-60
-40
-20
0
20
40
60
80
100
Mean Phase Error (min)
(HistLib - Obs) -38.6
(Hist - Obs) -94.9
Phase difference (Minutes)
-150
-120
-90
-60
-30
0
30
60
90
120
150
Flow (1000cfs)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
-10.0
Obs
Hist
Hist_Lib
RMSE (cfs) - 3759 3502
Mean (cfs) 14871 12972 13206
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02


San Joaquin River at Jersey Point (RSAN018)
Observed
Hist
Hist_Lib
Flow (1000cfs)
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (1000cfs)
y = 1.1033x + 7574.4
R^2 = 0.8873
y = 0.8529x + 15489
R^2 = 0.9671
Hist_Lib Lows (1000cfs)
Hist_Lib Highs (1000cfs)
Observed Lows (1000cfs)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 1.6
(Hist - Obs) 0.1
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -15.2
(Hist - Obs) -10.0
Frequency (%)
Phase difference (Minutes)
Observed
Hist
Hist_Lib
Obs
Hist
Hist_Lib
RMSE (cfs)
-
3074
2979
Mean (cfs)
2586
1428
1399
Flow (1000cfs)
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02

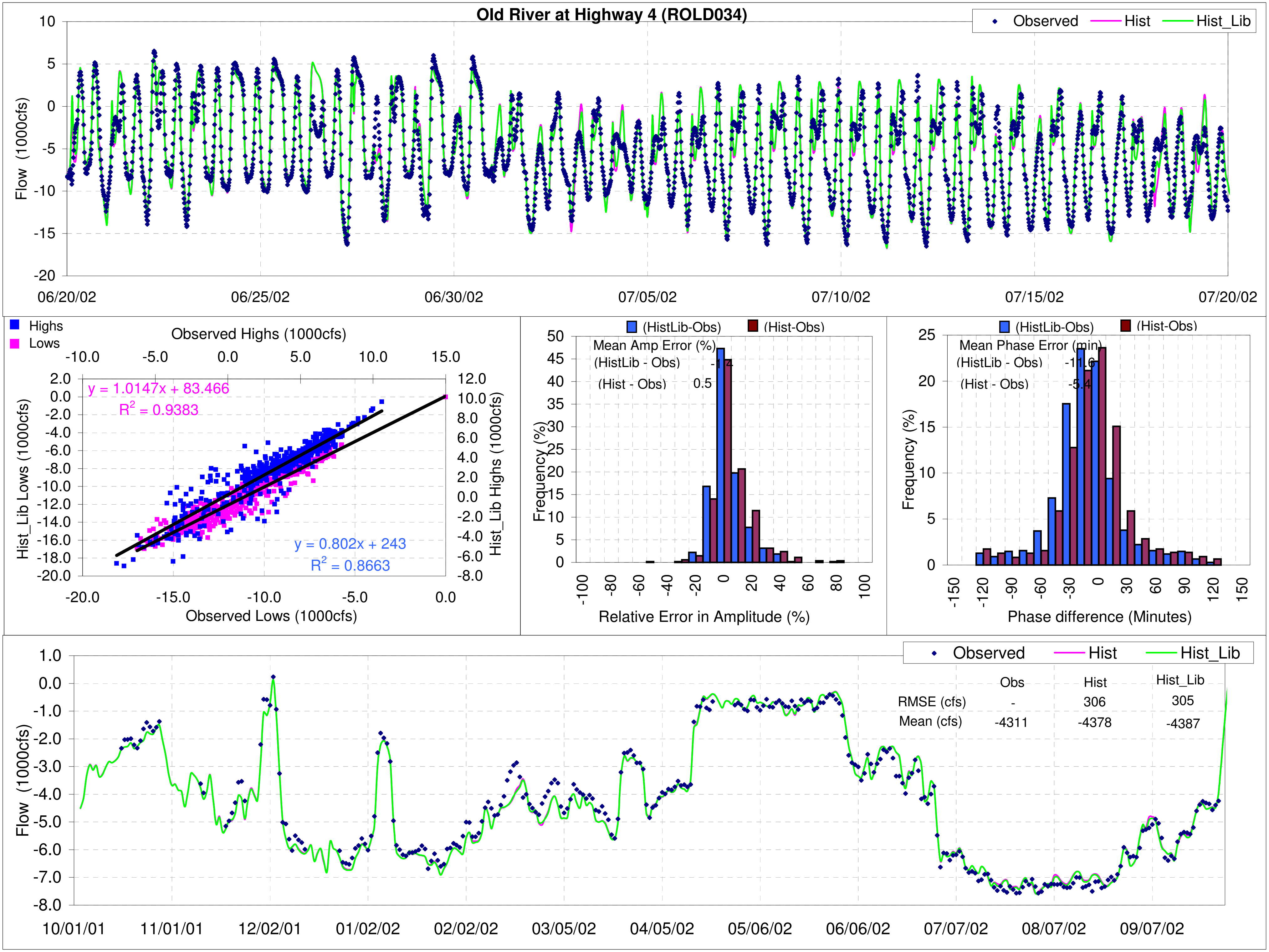


Threemile Slough (SLTRM004)
Observed
Hist
Hist_Lib
Flow (1000cfs)
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (1000cfs)
y = 0.955x - 2621.9
R2 = 0.8969
y = 0.7685x + 3955.9
R2 = 0.9327
Hist_Lib Lows (1000cfs)
Hist_Lib Highs (1000cfs)
Observed Lows (1000cfs)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 1.0
(Hist - Obs) 14.5
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -24.4
(Hist - Obs) -24.3
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (cfs) - 1015 1185
Mean (cfs) -810 -1708 -1807
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02

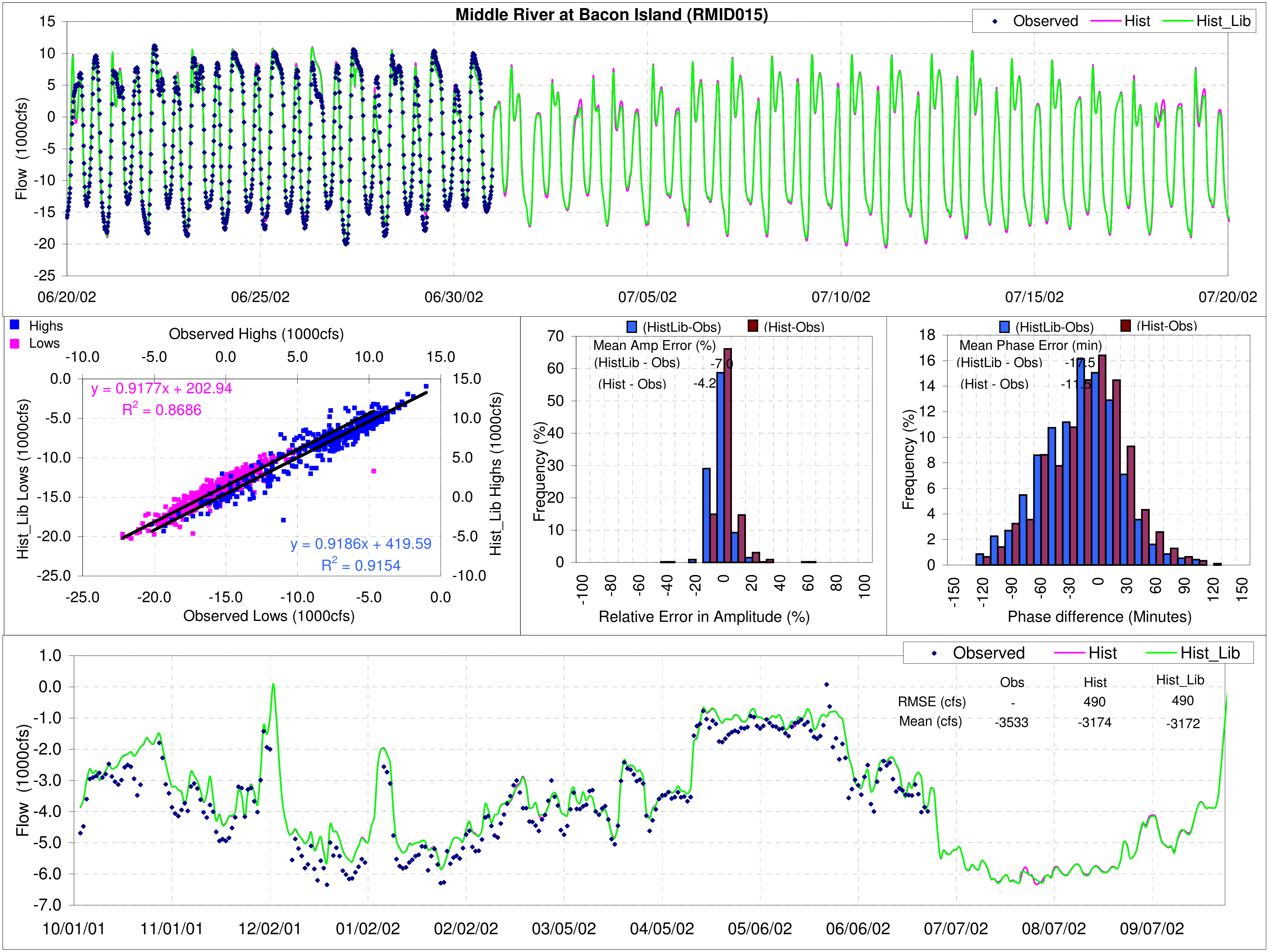

San Joaquin River at Stockton (RSAN063)
Observed
Hist
Hist_Lib
Flow (1000cfs)
5
4
3
2
1
0
-1
-2
-3
-4
-5
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (1000cfs)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
y = 0.967x + 154.63
R² = 0.9362
y = 0.7262x + 426.73
R² = 0.7233
Hist_Lib Lows (1000cfs)
Hist_Lib Highs (1000cfs)
Observed Lows (1000cfs)
-5.0
-4.0
-3.0
-2.0
-1.0
0.0
1.0
2.0
3.0
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) -12.7
(Hist - Obs) -13.6
Frequency (%)
Relative Error in Amplitude (%)
-100
-80
-60
-40
-20
0
20
40
60
80
100
Mean Phase Error (min)
(HistLib - Obs) -17.7
(Hist - Obs) -11.6
Phase difference (Minutes)
-150
-120
-90
-60
-30
0
30
60
90
120
150
Obs
Hist
Hist_Lib
RMSE (cfs) - 287 284
Mean (cfs) 796 732 737
Flow (1000cfs)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02

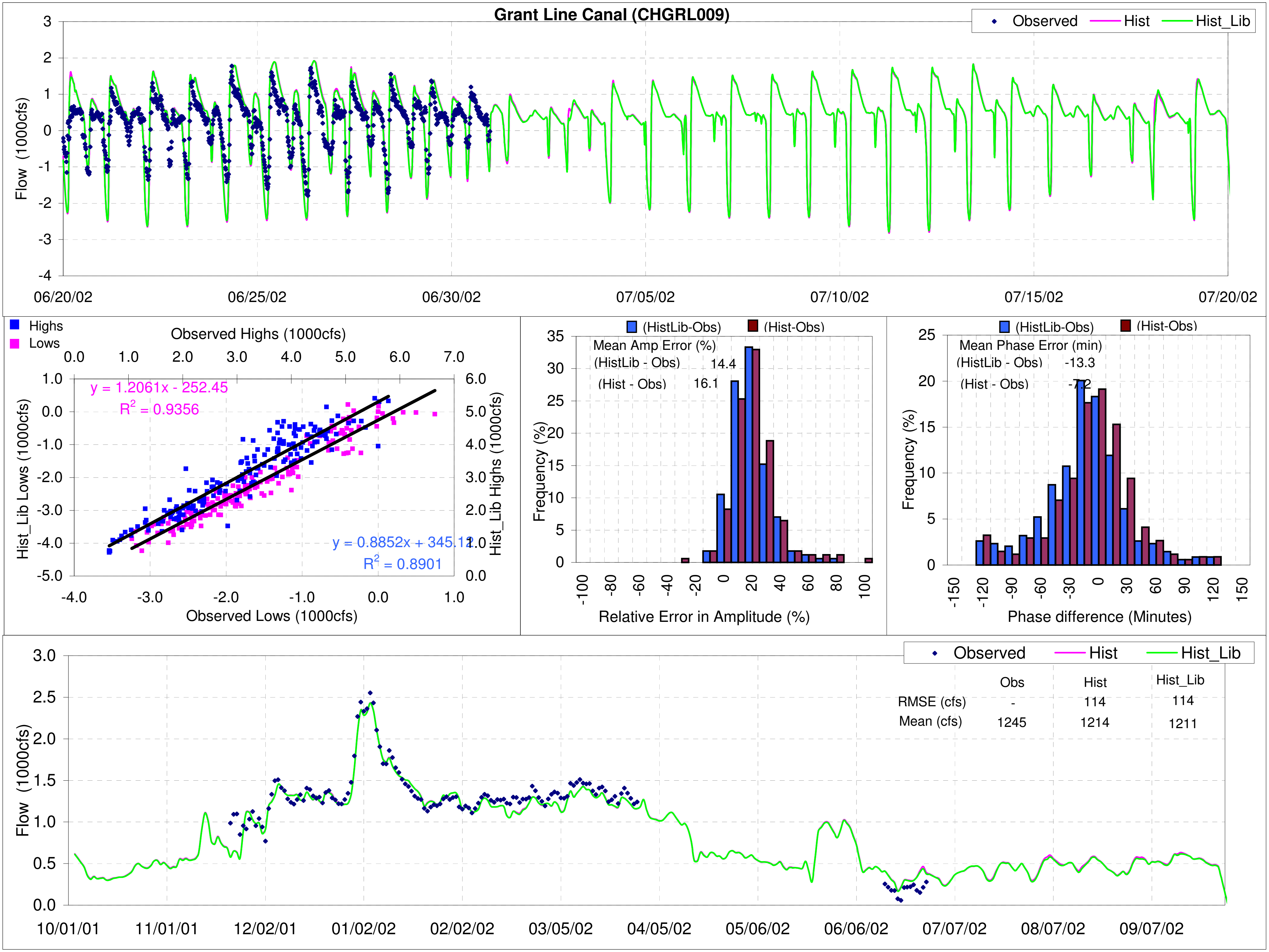


Old River at Bacon Island (ROLD024)
Observed
Hist
Hist_Lib
Flow (1000cfs)
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (1000cfs)
y = 0.9044x + 297.45
R^2 = 0.9145
y = 0.9862x - 1632.4
R^2 = 0.9004
Hist_Lib Lows (1000cfs)
Hist_Lib Highs (1000cfs)
Observed Lows (1000cfs)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) -15.9
(Hist - Obs) -14.7
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) 3.7
(Hist - Obs) 11.0
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (cfs) - 281 277
Mean (cfs) -2919 -2791 -2797
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02

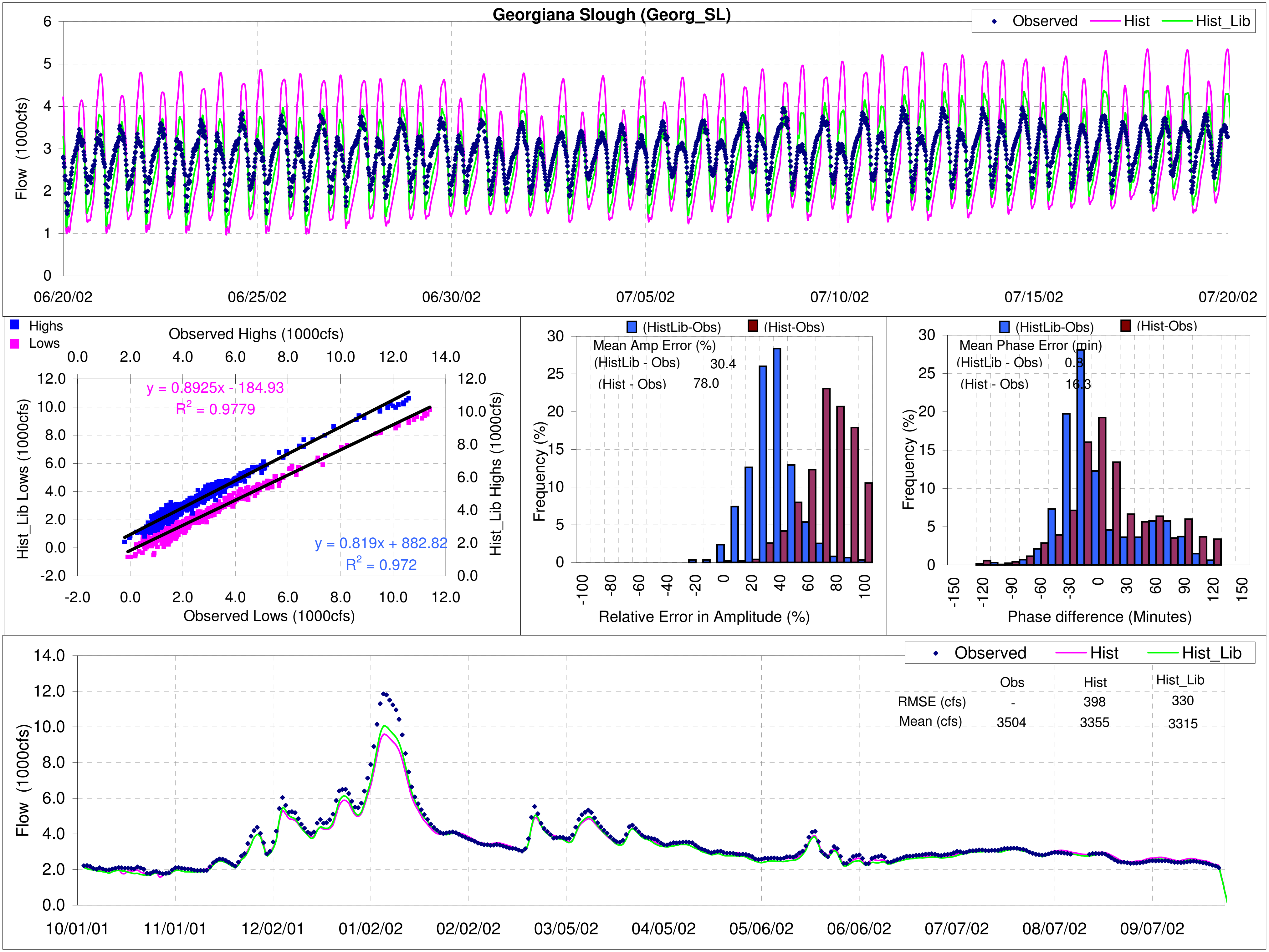


Old River at Highway 4 (ROLD034)
Observed
Hist
Hist_Lib
Flow (1000cfs)
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (1000cfs)
y = 1.0147x + 83.466
R^2 = 0.9383
y = 0.802x + 243
R^2 = 0.8663
Hist_Lib Lows (1000cfs)
Hist_Lib Highs (1000cfs)
Observed Lows (1000cfs)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) -1.4
(Hist - Obs) 0.5
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -11.6
(Hist - Obs) -5.4
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (cfs) - 306 305
Mean (cfs) -4311 -4378 -4387
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02

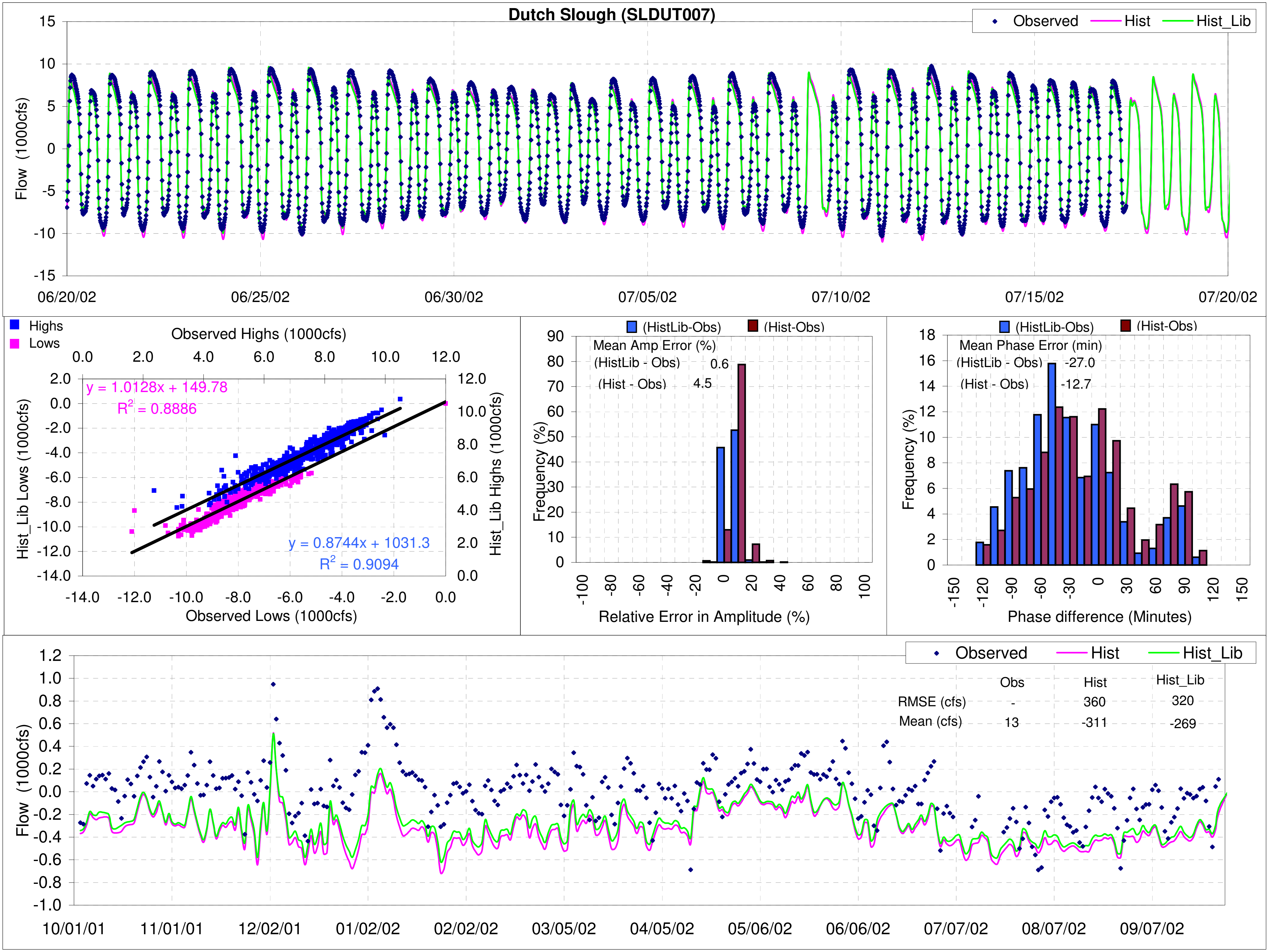

Middle River at Bacon Island (RMID015)
Observed
Hist
Hist_Lib
Flow (1000cfs)
15
10
5
0
-5
-10
-15
-20
-25
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (1000cfs)
-10.0
-5.0
0.0
5.0
10.0
15.0
y = 0.9177x + 202.94
R2 = 0.8686
y = 0.9186x + 419.59
R2 = 0.9154
Hist_Lib Lows (1000cfs)
Hist_Lib Highs (1000cfs)
-25.0
-20.0
-15.0
-10.0
-5.0
0.0
Observed Lows (1000cfs)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) -7.0
(Hist - Obs) -4.2
Frequency (%)
70
60
50
40
30
20
10
0
-100
-80
-60
-40
-20
0
20
40
60
80
100
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -17.5
(Hist - Obs) -11.5
Frequency (%)
18
16
14
12
10
8
6
4
2
0
-150
-120
-90
-60
-30
0
30
60
90
120
150
Phase difference (Minutes)
Observed
Hist
Hist_Lib
Flow (1000cfs)
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02
	Obs	Hist	Hist_Lib
RMSE (cfs)	-	490	490
Mean (cfs)	-3533	-3174	-3172



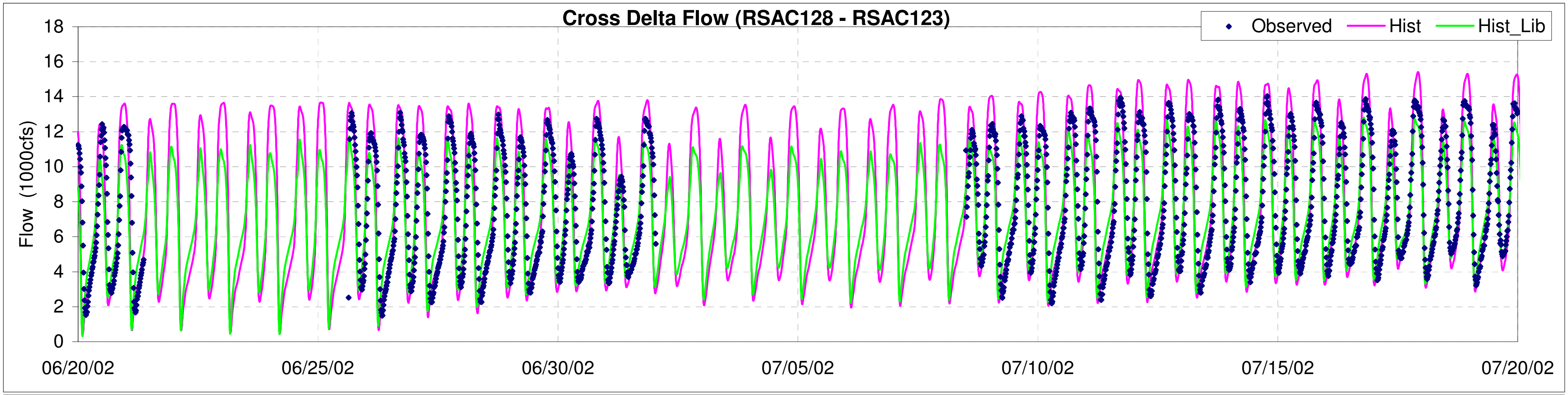
Grant Line Canal (CHGRL009)
Observed
Hist
Hist_Lib
Flow (1000cfs)
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (1000cfs)
y = 1.2061x - 252.45
R^2 = 0.9356
y = 0.8852x + 345.12
R^2 = 0.8901
Hist_Lib Lows (1000cfs)
Hist_Lib Highs (1000cfs)
Observed Lows (1000cfs)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 14.4
(Hist - Obs) 16.1
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -13.3
(Hist - Obs) -7.2
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (cfs) - 114 114
Mean (cfs) 1245 1214 1211
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02



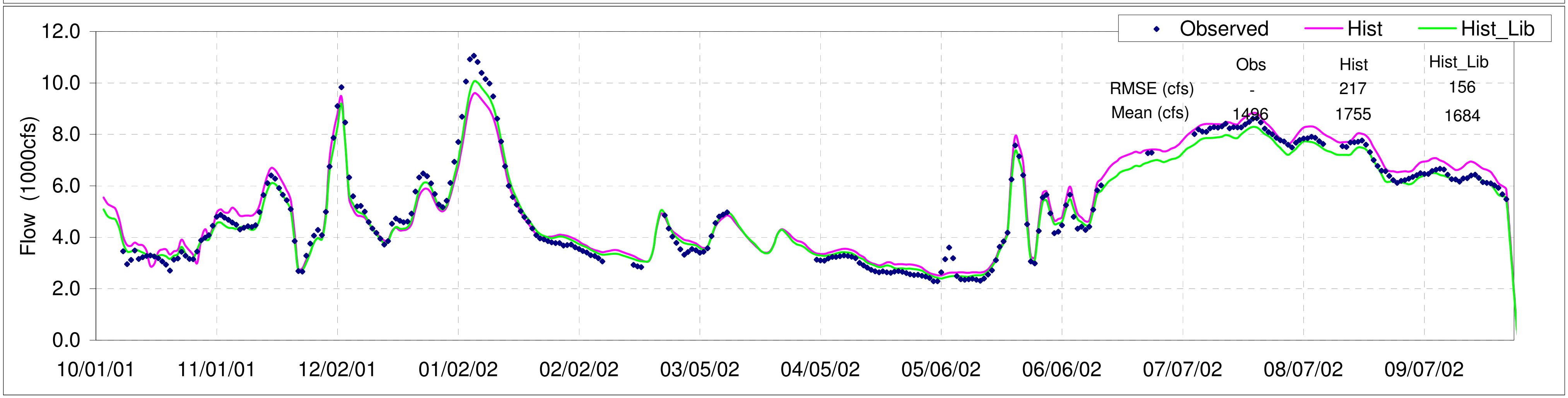
Georgiana Slough (Georg_SL)
Observed
Hist
Hist_Lib
Flow (1000cfs)
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (1000cfs)
y = 0.8925x - 184.93
R^2 = 0.9779
y = 0.819x + 882.82
R^2 = 0.972
Hist_Lib Lows (1000cfs)
Hist_Lib Highs (1000cfs)
Observed Lows (1000cfs)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 30.4
(Hist - Obs) 78.0
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) 0.3
(Hist - Obs) 16.3
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (cfs) - 398 330
Mean (cfs) 3504 3355 3315
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02



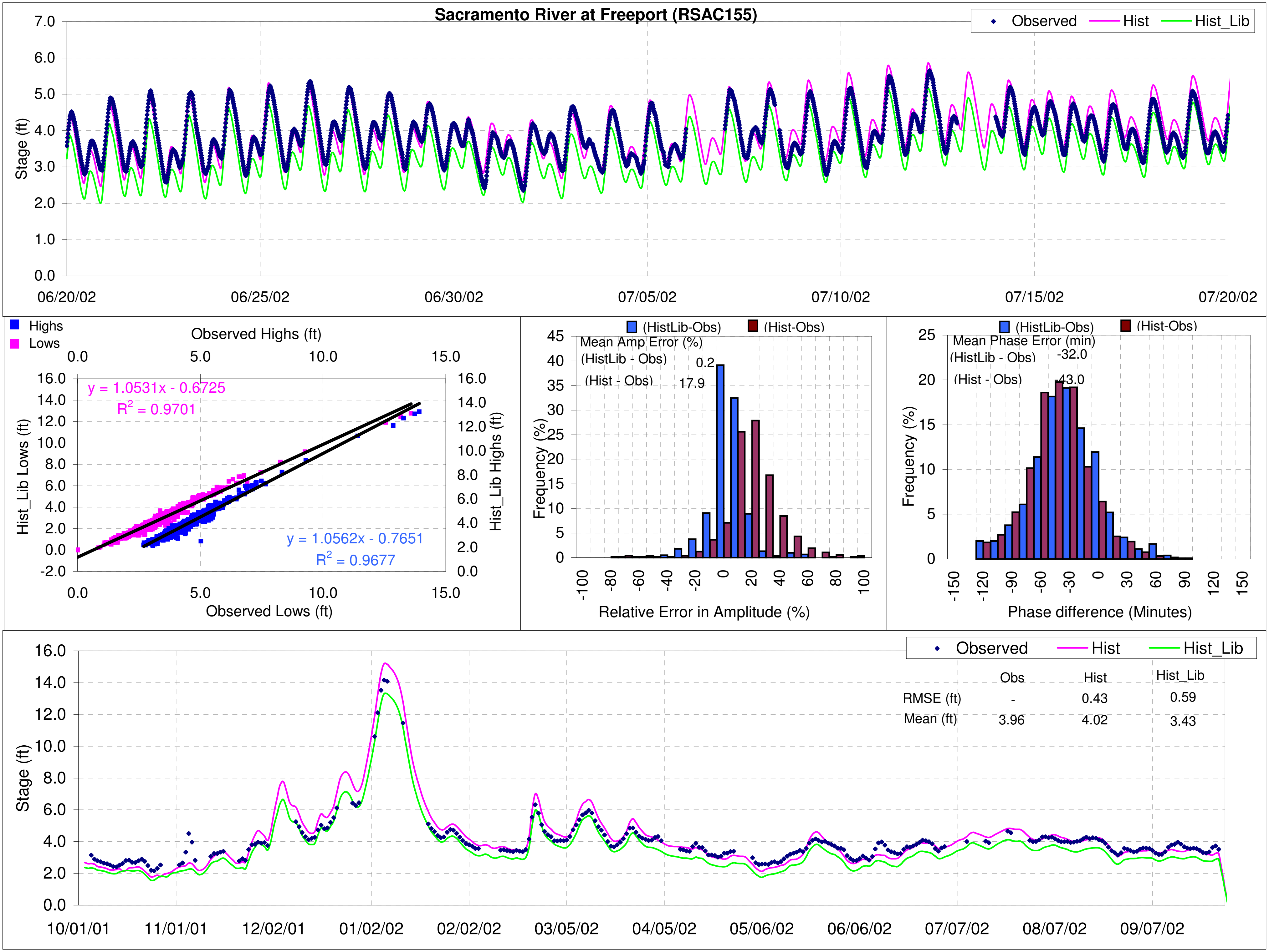
Dutch Slough (SLDUT007)
Observed
Hist
Hist_Lib
Flow (1000cfs)
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (1000cfs)
y = 1.0128x + 149.78
R2 = 0.8886
y = 0.8744x + 1031.3
R2 = 0.9094
Hist_Lib Lows (1000cfs)
Hist_Lib Highs (1000cfs)
Observed Lows (1000cfs)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 0.6
(Hist - Obs) 4.5
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -27.0
(Hist - Obs) -12.7
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (cfs) - 360 320
Mean (cfs) 13 -311 -269
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02

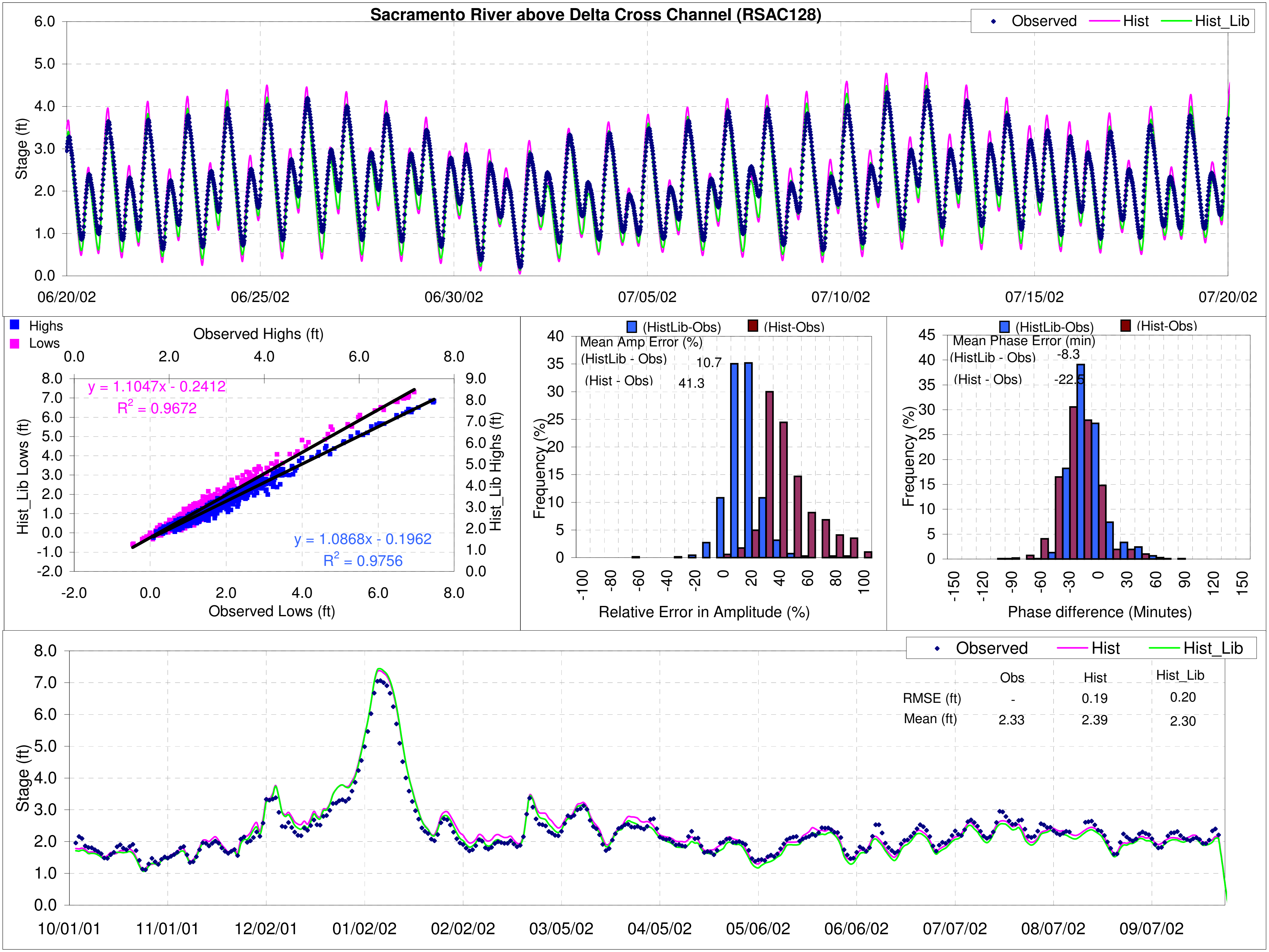


Cross Delta Flow (RSAC128 - RSAC123)
Observed
Hist
Hist_Lib
Flow (1000cfs)
18
16
14
12
10
8
6
4
2
0
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02

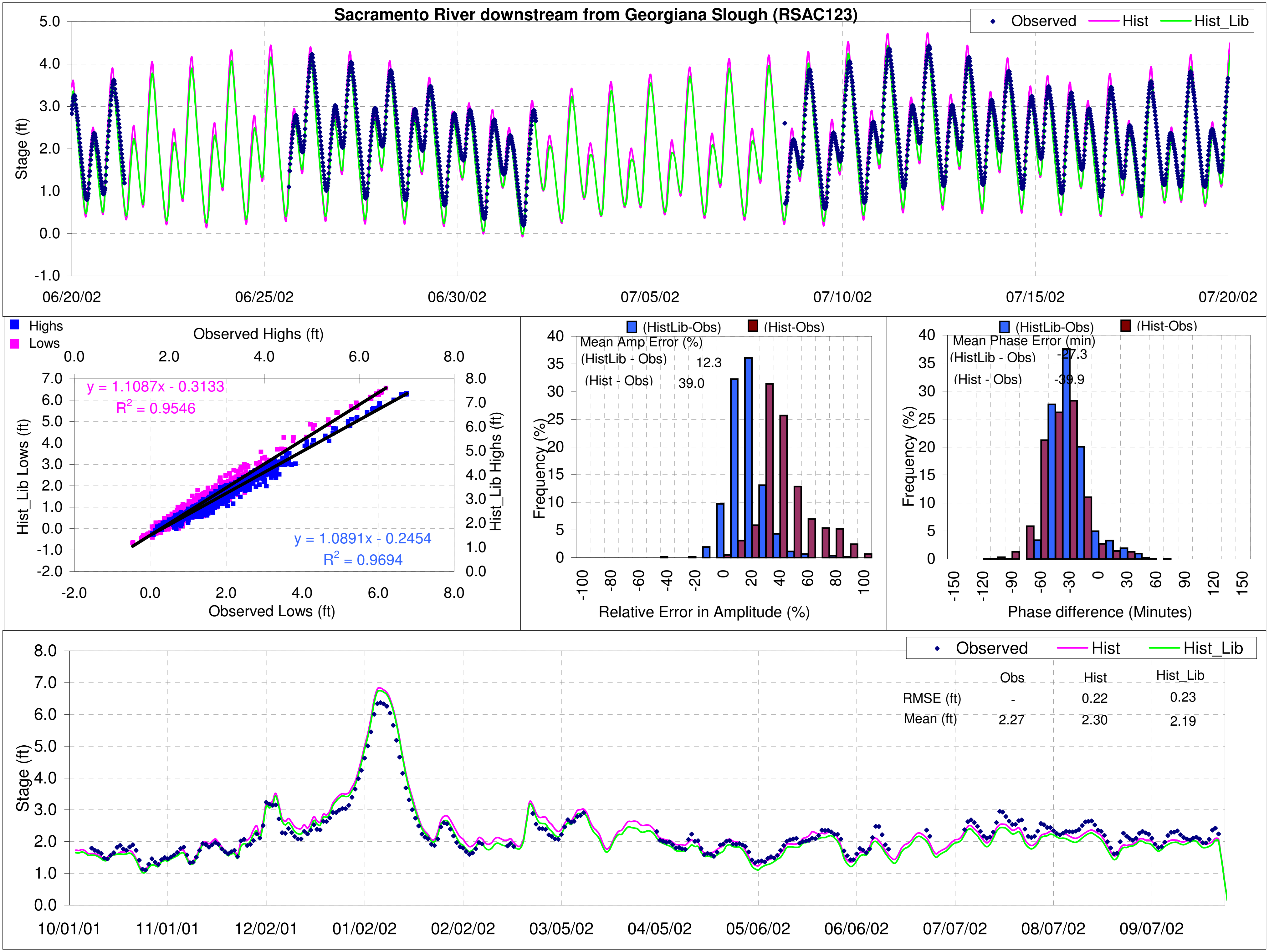


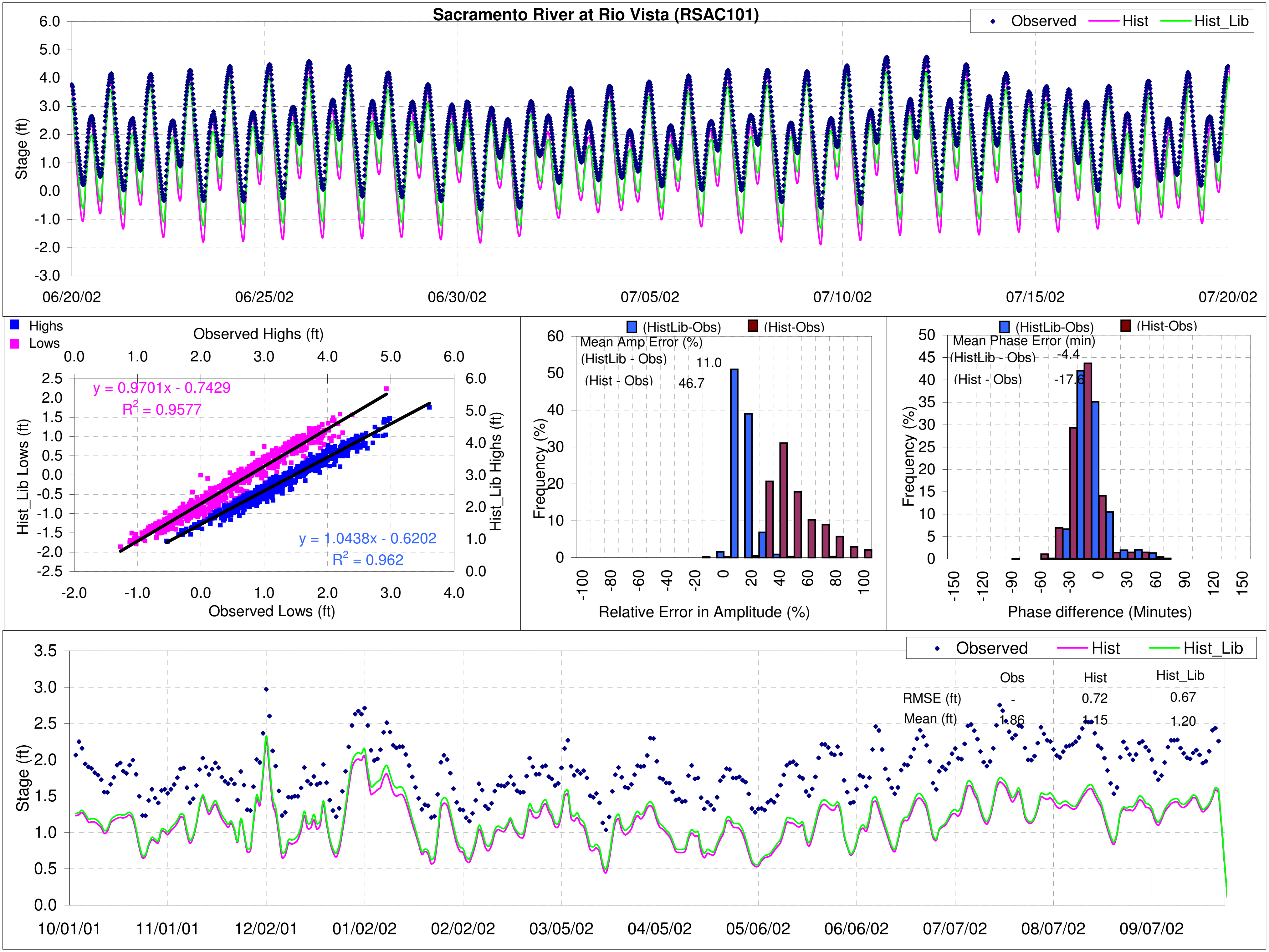
Observed
Hist
Hist_Lib
Flow (1000cfs)
12.0
10.0
8.0
6.0
4.0
2.0
0.0
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02
Obs
Hist
Hist_Lib
RMSE (cfs)
-
217
156
Mean (cfs)
1496
1755
1684


Sacramento River at Freeport (RSAC155)
Observed
Hist
Hist_Lib
Stage (ft)
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (ft)
y = 1.0531x - 0.6725
R^2 = 0.9701
y = 1.0562x - 0.7651
R^2 = 0.9677
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 0.2
(Hist - Obs) 17.9
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -32.0
(Hist - Obs) -43.0
Phase difference (Minutes)
Observed
Hist
Hist_Lib
Obs Hist Hist_Lib
RMSE (ft) - 0.43 0.59
Mean (ft) 3.96 4.02 3.43
Stage (ft)
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02

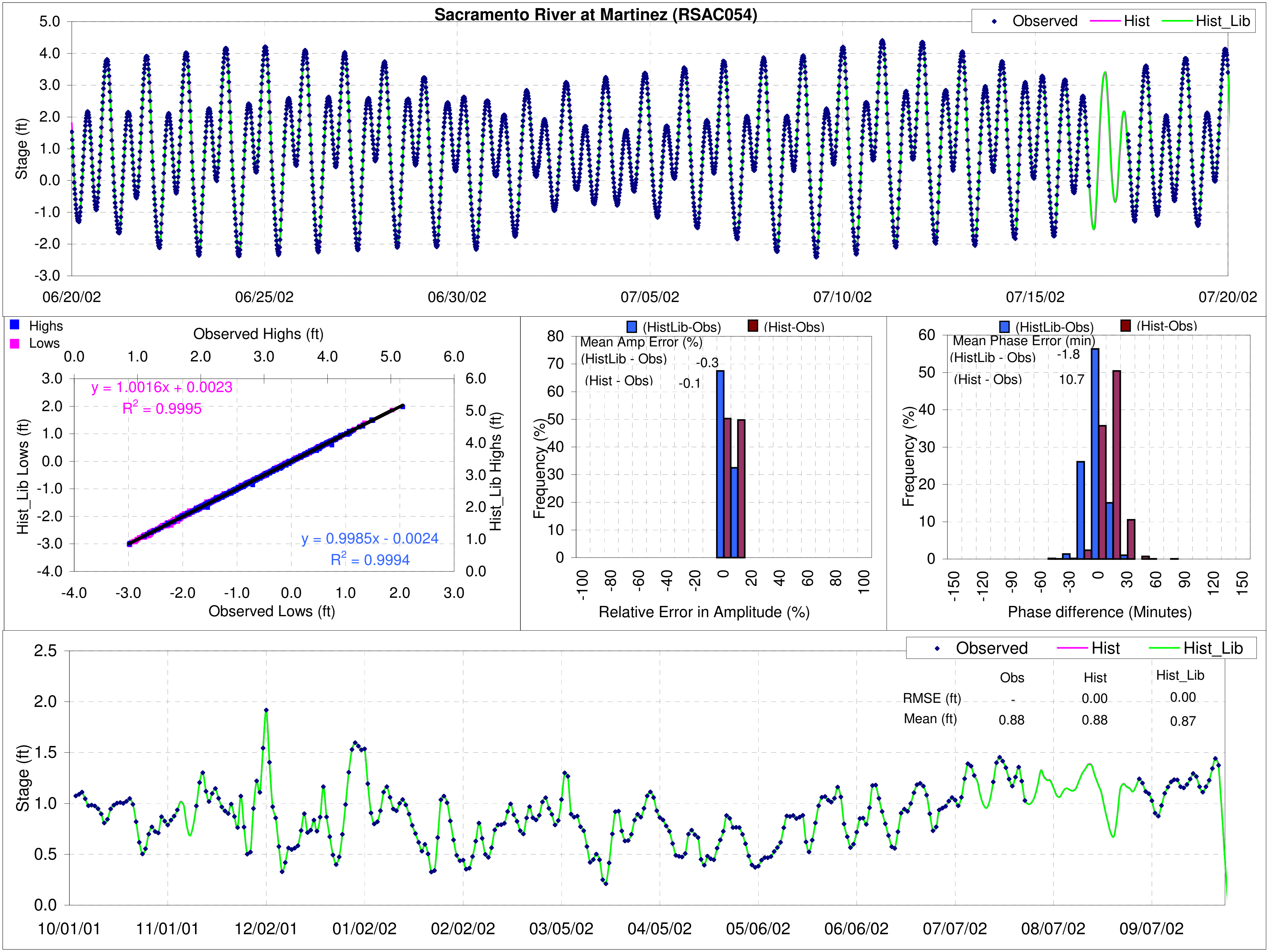


Sacramento River above Delta Cross Channel (RSAC128)
Observed
Hist
Hist_Lib
Stage (ft)
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (ft)
y = 1.1047x - 0.2412
R^2 = 0.9672
y = 1.0868x - 0.1962
R^2 = 0.9756
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 10.7
(Hist - Obs) 41.3
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -8.3
(Hist - Obs) -22.5
Phase difference (Minutes)
Obs Hist Hist_Lib
RMSE (ft) - 0.19 0.20
Mean (ft) 2.33 2.39 2.30
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02

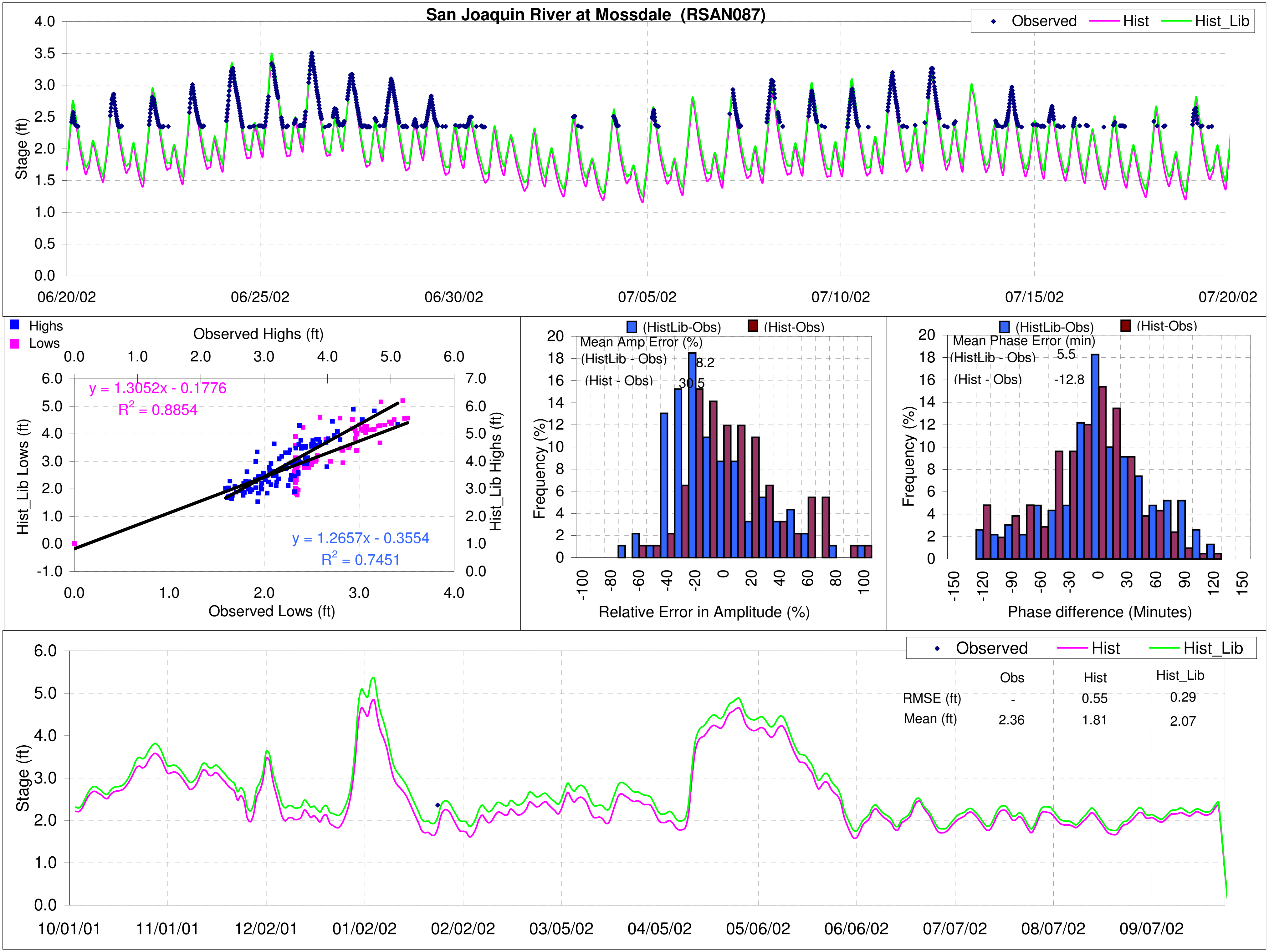

Sacramento River downstream from Georgiana Slough (RSAC123)
Observed
Hist
Hist_Lib
Stage (ft)
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (ft)
0.0
2.0
4.0
6.0
8.0
y = 1.1087x - 0.3133
R^2 = 0.9546
y = 1.0891x - 0.2454
R^2 = 0.9694
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 12.3
(Hist - Obs) 39.0
Frequency (%)
Relative Error in Amplitude (%)
-100
-80
-60
-40
-20
0
20
40
60
80
100
Mean Phase Error (min)
(HistLib - Obs) -27.3
(Hist - Obs) -39.9
Phase difference (Minutes)
-150
-120
-90
-60
-30
0
30
60
90
120
150
Obs
Hist
Hist_Lib
RMSE (ft) - 0.22 0.23
Mean (ft) 2.27 2.30 2.19
8.0
7.0
6.0
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02



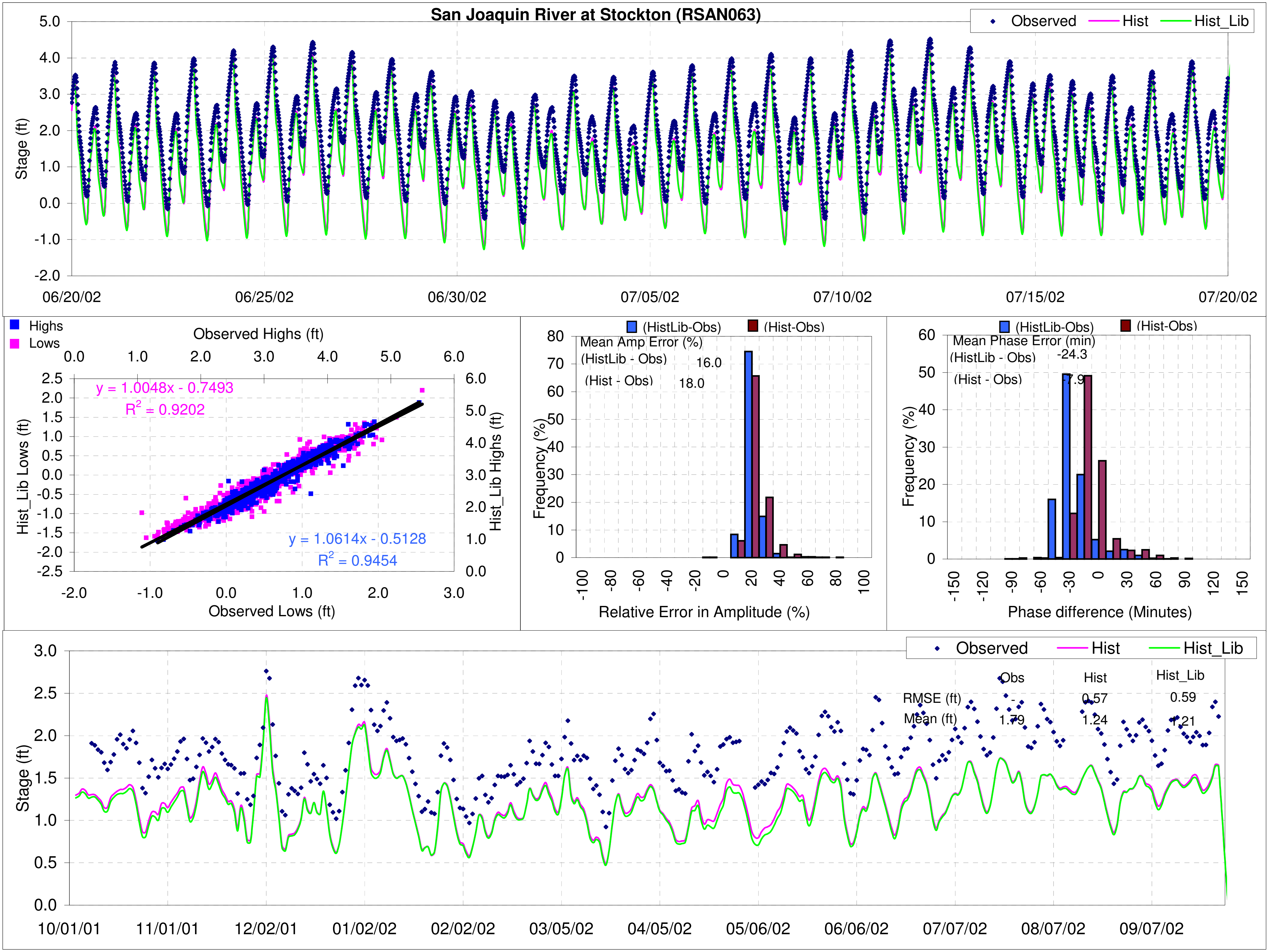
Sacramento River at Rio Vista (RSAC101)
Observed
Hist
Hist_Lib
Stage (ft)
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (ft)
y = 0.9701x - 0.7429
R2 = 0.9577
y = 1.0438x - 0.6202
R2 = 0.962
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 11.0
(Hist - Obs) 46.7
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -4.4
(Hist - Obs) -17.6
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) - 0.72 0.67
Mean (ft) 1.86 1.15 1.20
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02

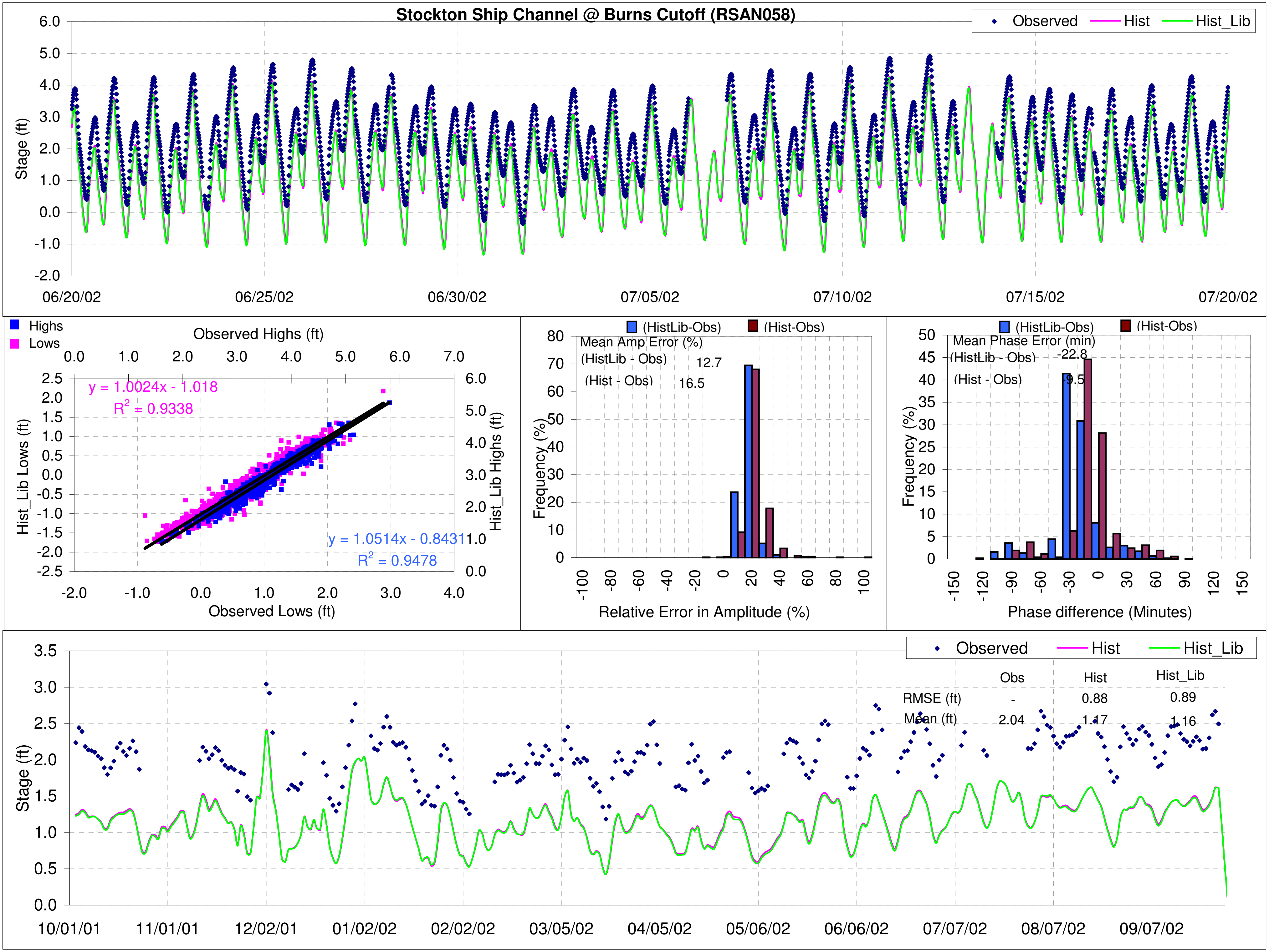


Sacramento River at Martinez (RSAC054)
Observed
Hist
Hist_Lib
Stage (ft)
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (ft)
y = 1.0016x + 0.0023
R^2 = 0.9995
y = 0.9985x - 0.0024
R^2 = 0.9994
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) -0.3
(Hist - Obs) -0.1
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -1.8
(Hist - Obs) 10.7
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) - 0.00 0.00
Mean (ft) 0.88 0.88 0.87
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02

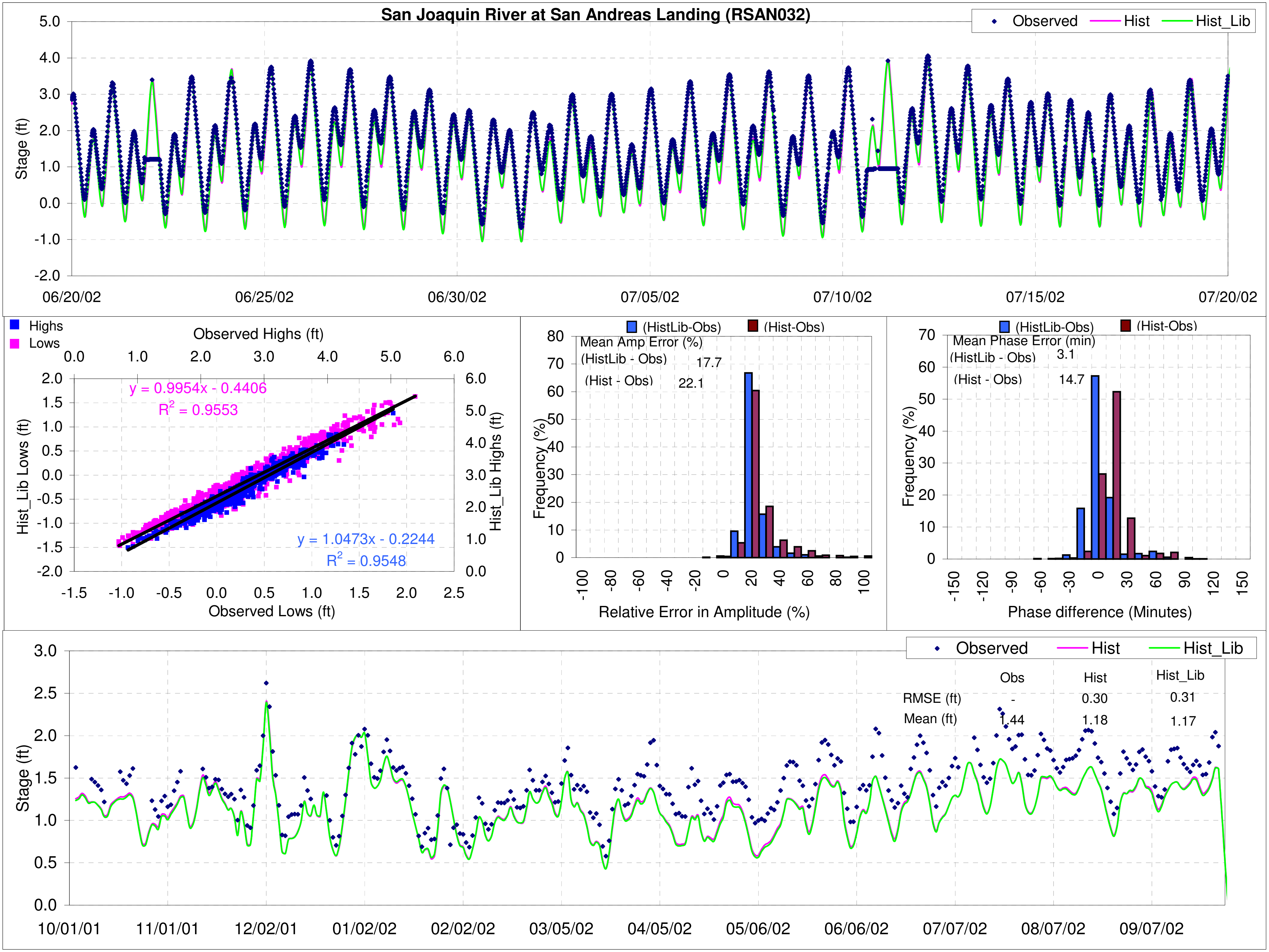


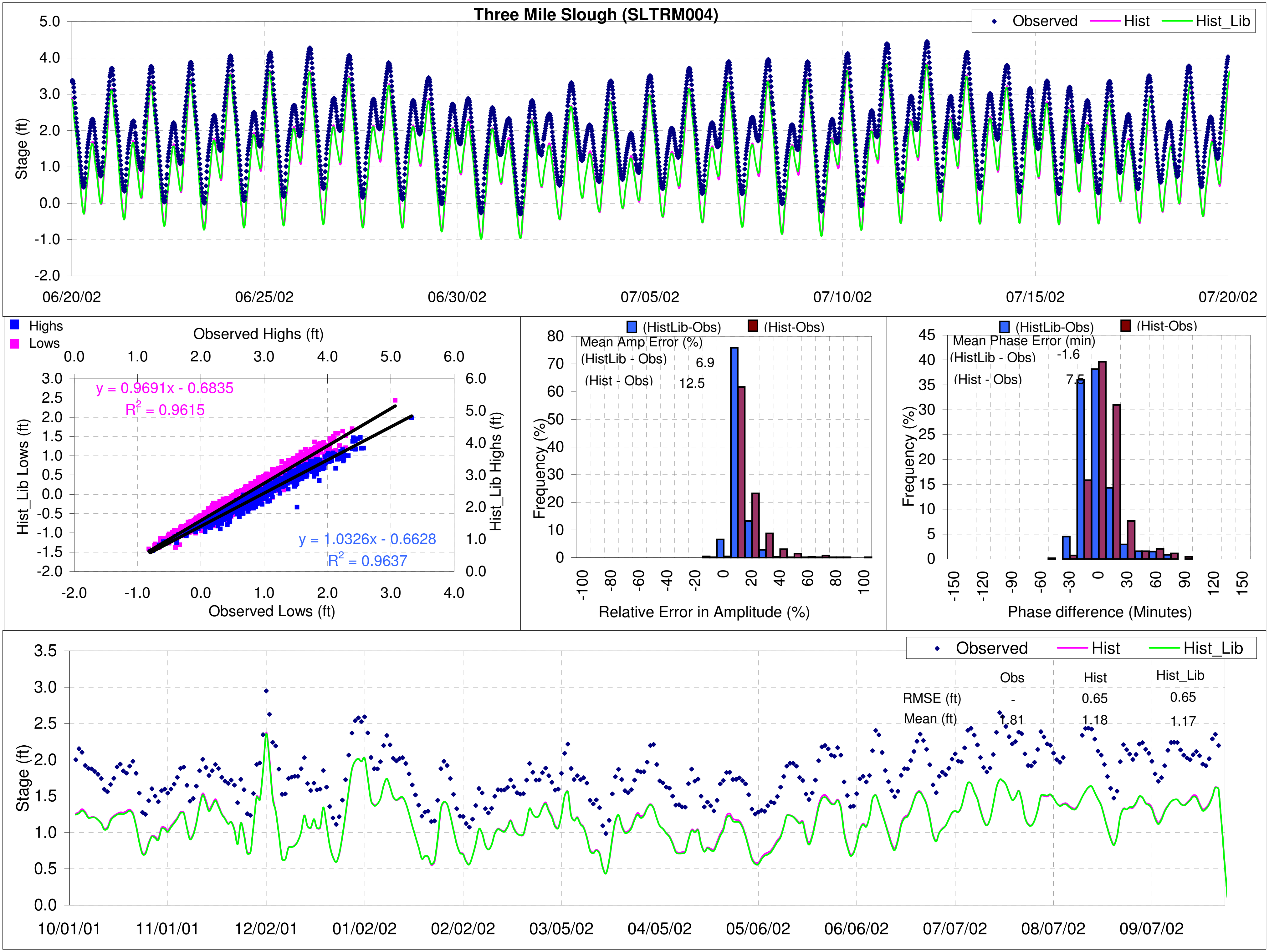
	Obs	Hist	Hist_Lib
RMSE (ft)	-	0.55	0.29
Mean (ft)	2.36	1.81	2.07


San Joaquin River at Stockton (RSAN063)
Observed
Hist
Hist_Lib
Stage (ft)
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (ft)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
y = 1.0048x - 0.7493
R2 = 0.9202
y = 1.0614x - 0.5128
R2 = 0.9454
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 16.0
(Hist - Obs) 18.0
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -24.3
(Hist - Obs) -7.9
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) - 0.57 0.59
Mean (ft) 1.79 1.24 1.21
3.0
2.5
2.0
1.5
1.0
0.5
0.0
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02

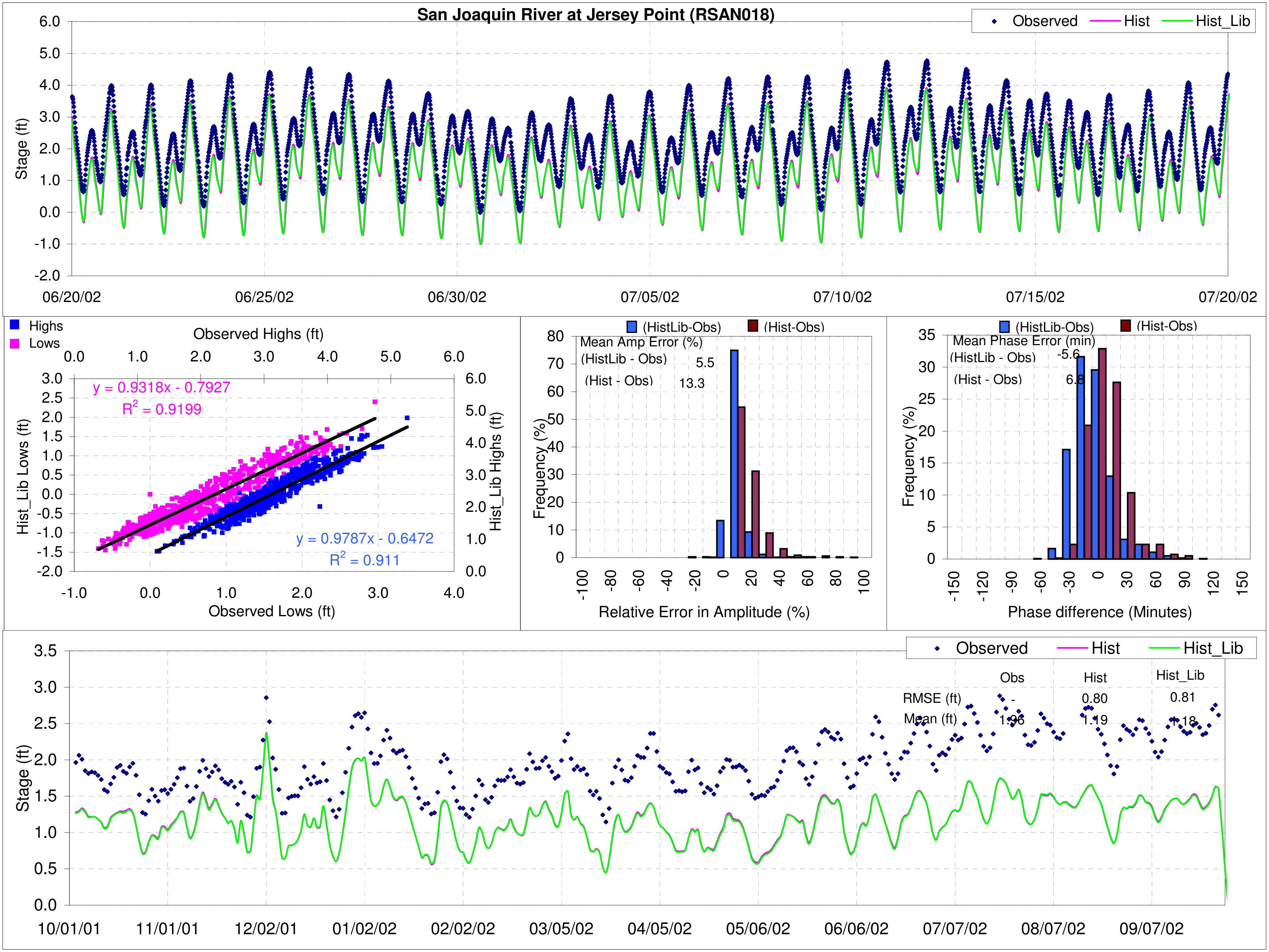


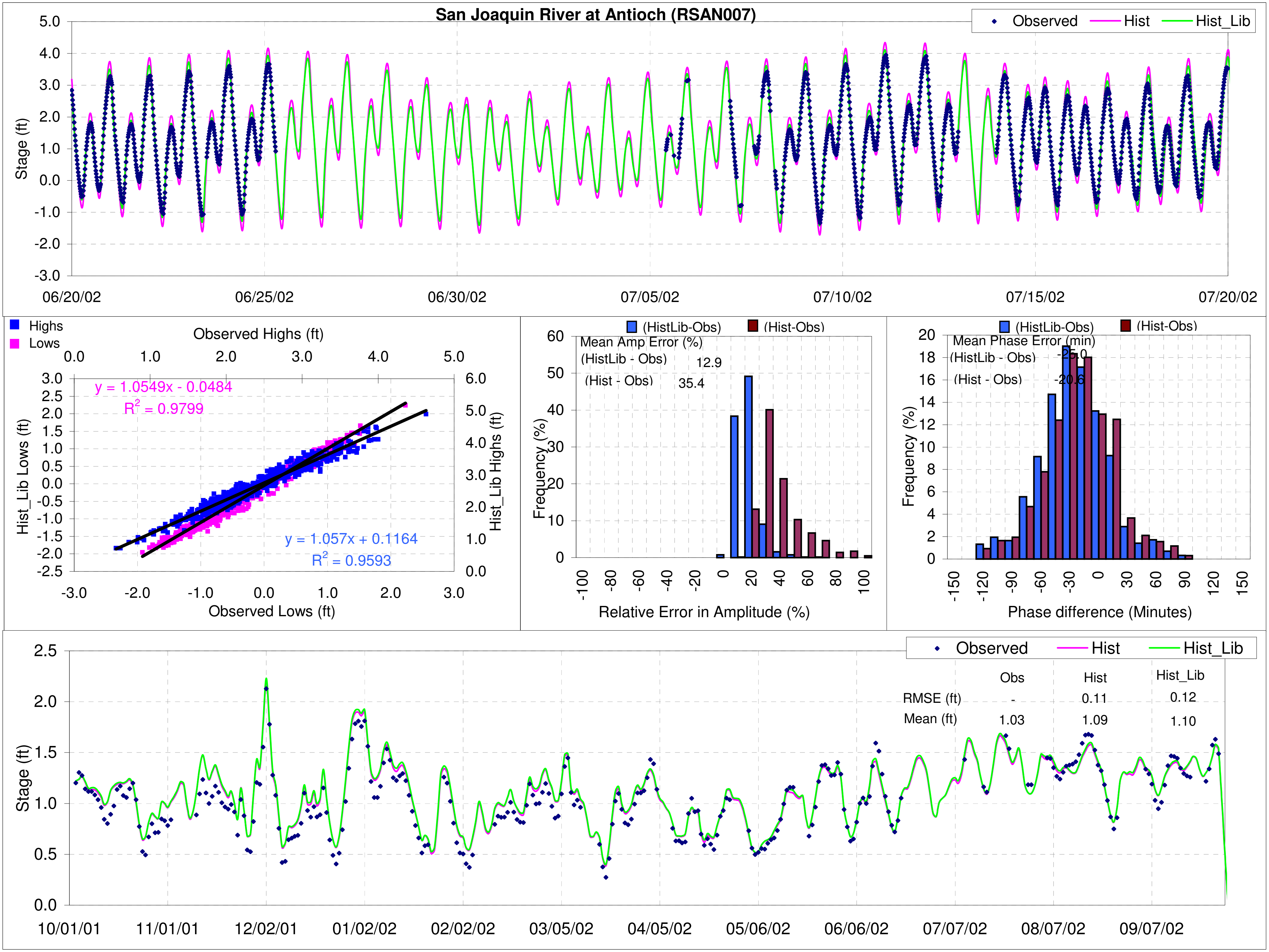
Stockton Ship Channel @ Burns Cutoff (RSAN058)
Observed
Hist
Hist_Lib
Stage (ft)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (ft)
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0
y = 1.0024x - 1.018
R^2 = 0.9338
y = 1.0514x - 0.8431
R^2 = 0.9478
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
-2.0 -1.0 0.0 1.0 2.0 3.0 4.0
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 12.7
(Hist - Obs) 16.5
Frequency (%)
Relative Error in Amplitude (%)
-100 -80 -60 -40 -20 0 20 40 60 80 100
Mean Phase Error (min)
(HistLib - Obs) -22.8
(Hist - Obs) -9.5
Phase difference (Minutes)
-150 -120 -90 -60 -30 0 30 60 90 120 150
Observed
Hist
Hist_Lib
Obs
Hist
Hist_Lib
RMSE (ft) - 0.88 0.89
Mean (ft) 2.04 1.17 1.16
Stage (ft)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02

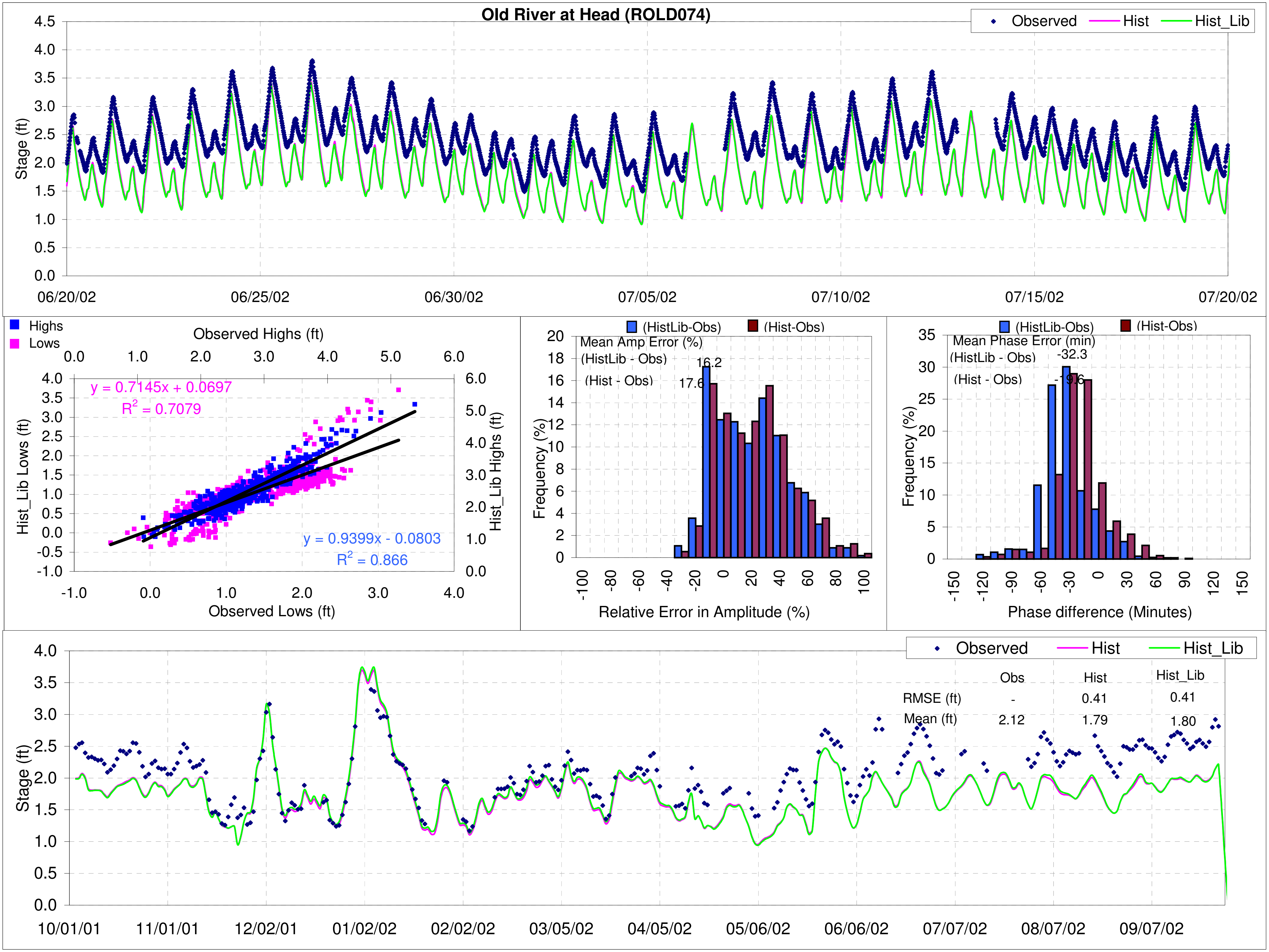

San Joaquin River at San Andreas Landing (RSAN032)
Observed
Hist
Hist_Lib
Stage (ft)
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (ft)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
y = 0.9954x - 0.4406
R2 = 0.9553
y = 1.0473x - 0.2244
R2 = 0.9548
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 17.7
(Hist - Obs) 22.1
Frequency (%)
Relative Error in Amplitude (%)
-100
-80
-60
-40
-20
0
20
40
60
80
100
(HistLib-Obs)
(Hist-Obs)
Mean Phase Error (min)
(HistLib - Obs) 3.1
(Hist - Obs) 14.7
Frequency (%)
Phase difference (Minutes)
-150
-120
-90
-60
-30
0
30
60
90
120
150
Observed
Hist
Hist_Lib
Obs
Hist
Hist_Lib
RMSE (ft) - 0.30 0.31
Mean (ft) 1.44 1.18 1.17
Stage (ft)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02



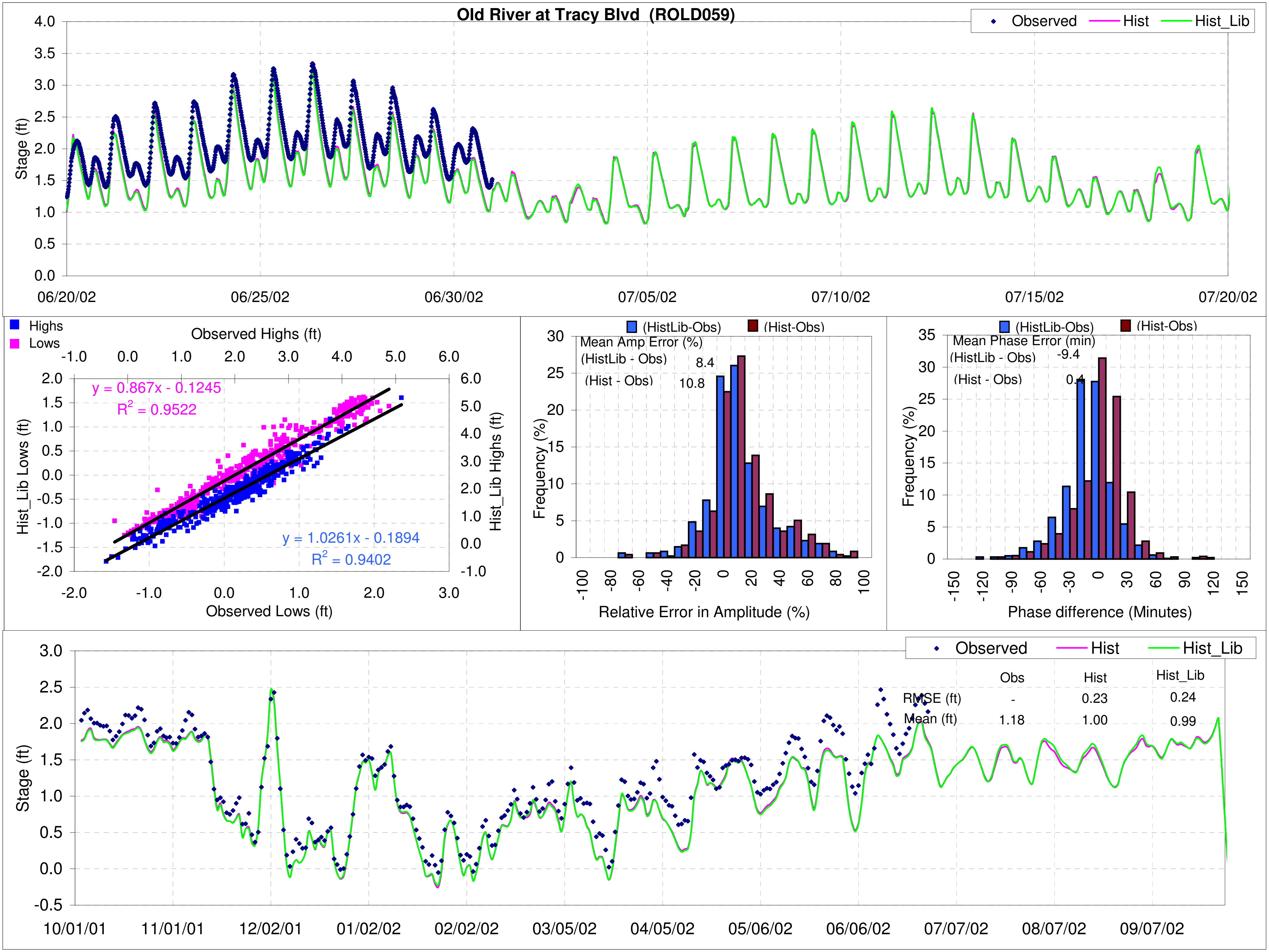
Three Mile Slough (SLTRM004)
Observed
Hist
Hist_Lib
Stage (ft)
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (ft)
y = 0.9691x - 0.6835
R^2 = 0.9615
y = 1.0326x - 0.6628
R^2 = 0.9637
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 6.9
(Hist - Obs) 12.5
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -1.6
(Hist - Obs) 7.5
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) - 0.65 0.65
Mean (ft) 1.81 1.18 1.17
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02

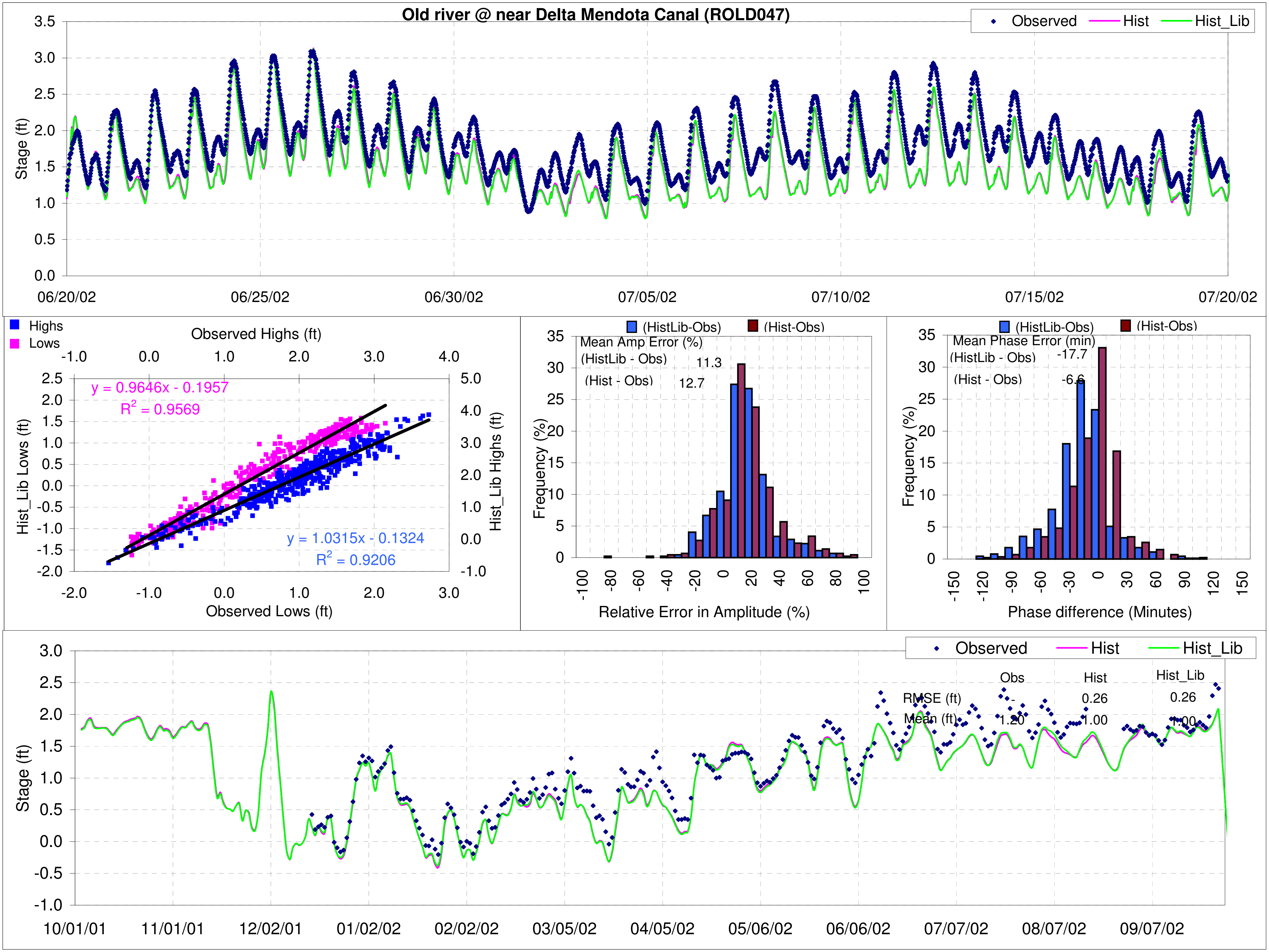

San Joaquin River at Jersey Point (RSAN018)
Observed
Hist
Hist_Lib
Stage (ft)
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (ft)
y = 0.9318x - 0.7927
R^2 = 0.9199
y = 0.9787x - 0.6472
R^2 = 0.911
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 5.5
(Hist - Obs) 13.3
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -5.6
(Hist - Obs) 6.8
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) - 0.80 0.81
Mean (ft) 1.96 1.19 1.18
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02


San Joaquin River at Antioch (RSAN007)
Observed
Hist
Hist_Lib
Stage (ft)
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (ft)
y = 1.0549x - 0.0484
R2 = 0.9799
y = 1.057x + 0.1164
R2 = 0.9593
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 12.9
(Hist - Obs) 35.4
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -25.0
(Hist - Obs) -20.6
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) - 0.11 0.12
Mean (ft) 1.03 1.09 1.10
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02

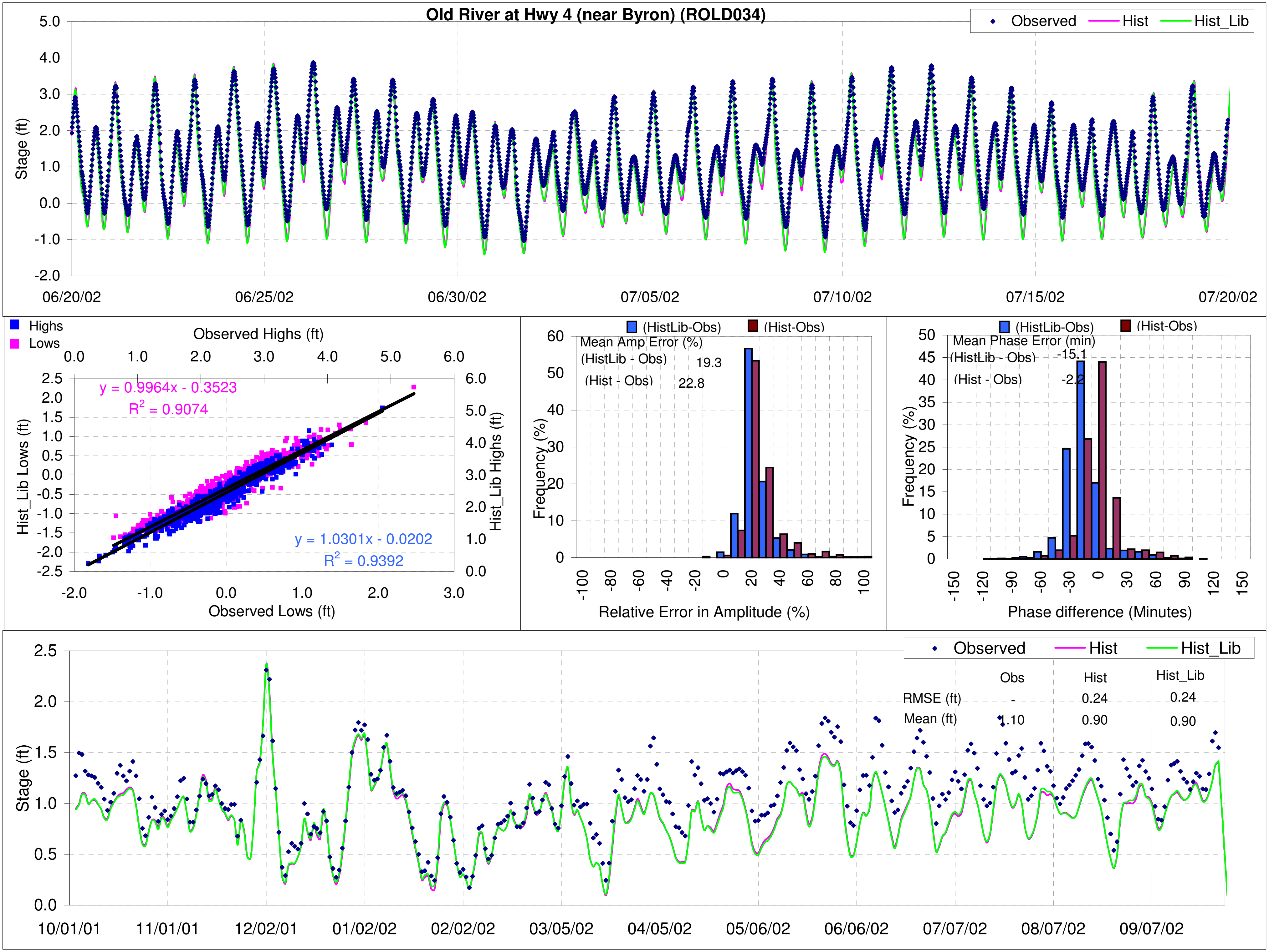


Old River at Head (ROLD074)
Observed
Hist
Hist_Lib
Stage (ft)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (ft)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
y = 0.7145x + 0.0697
R2 = 0.7079
y = 0.9399x - 0.0803
R2 = 0.866
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
-1.0
0.0
1.0
2.0
3.0
4.0
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs)
16.2
(Hist - Obs)
17.6
Frequency (%)
-100
-80
-60
-40
-20
0
20
40
60
80
100
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs)
-32.3
(Hist - Obs)
-19.6
-150
-120
-90
-60
-30
0
30
60
90
120
150
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft)
-
0.41
0.41
Mean (ft)
2.12
1.79
1.80
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02

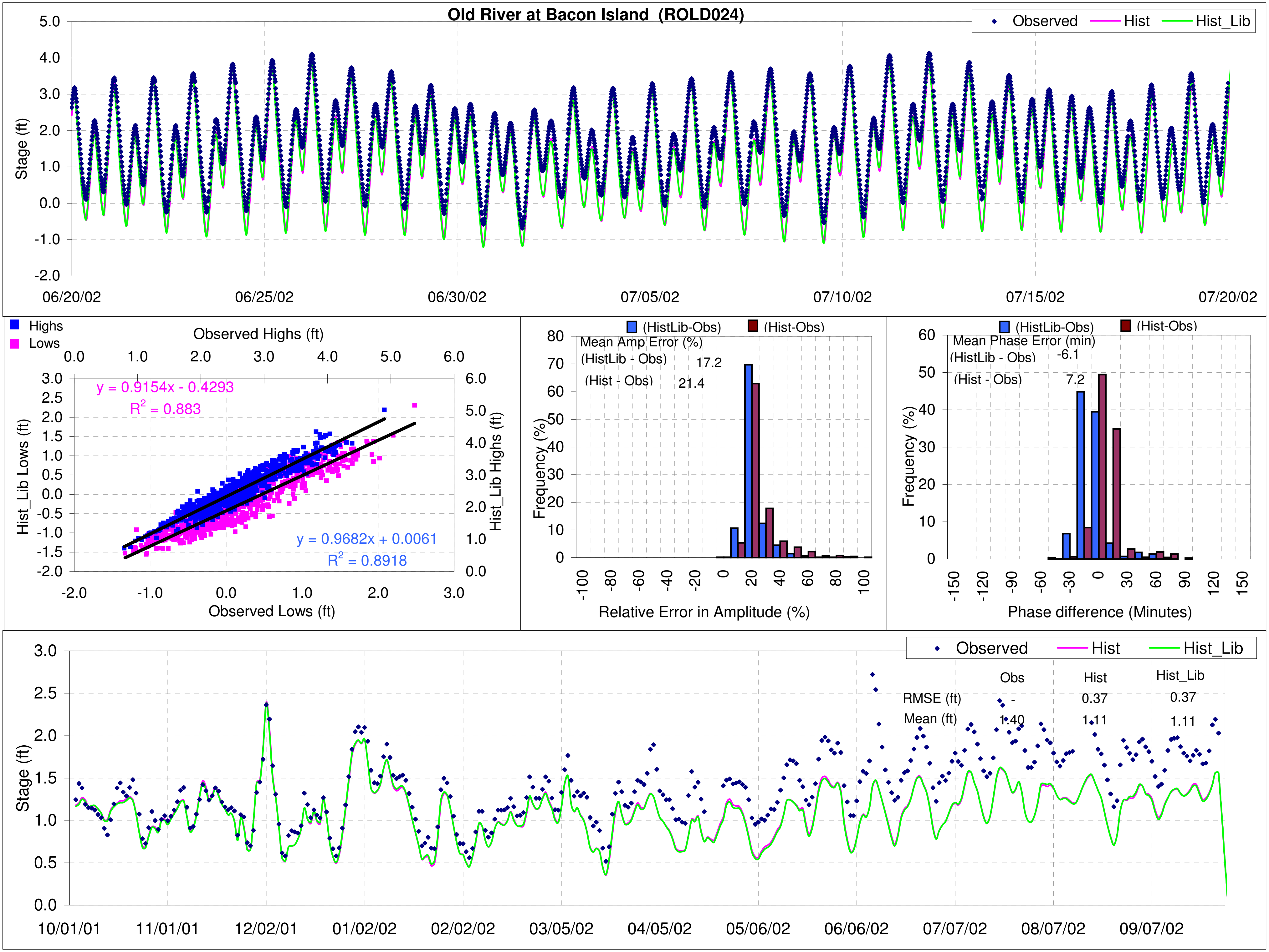

Old River at Tracy Blvd (ROLD059)
Observed
Hist
Hist_Lib
Stage (ft)
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (ft)
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
y = 0.867x - 0.1245
R2 = 0.9522
y = 1.0261x - 0.1894
R2 = 0.9402
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 8.4
(Hist - Obs) 10.8
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -9.4
(Hist - Obs) 0.4
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) - 0.23 0.24
Mean (ft) 1.18 1.00 0.99
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02

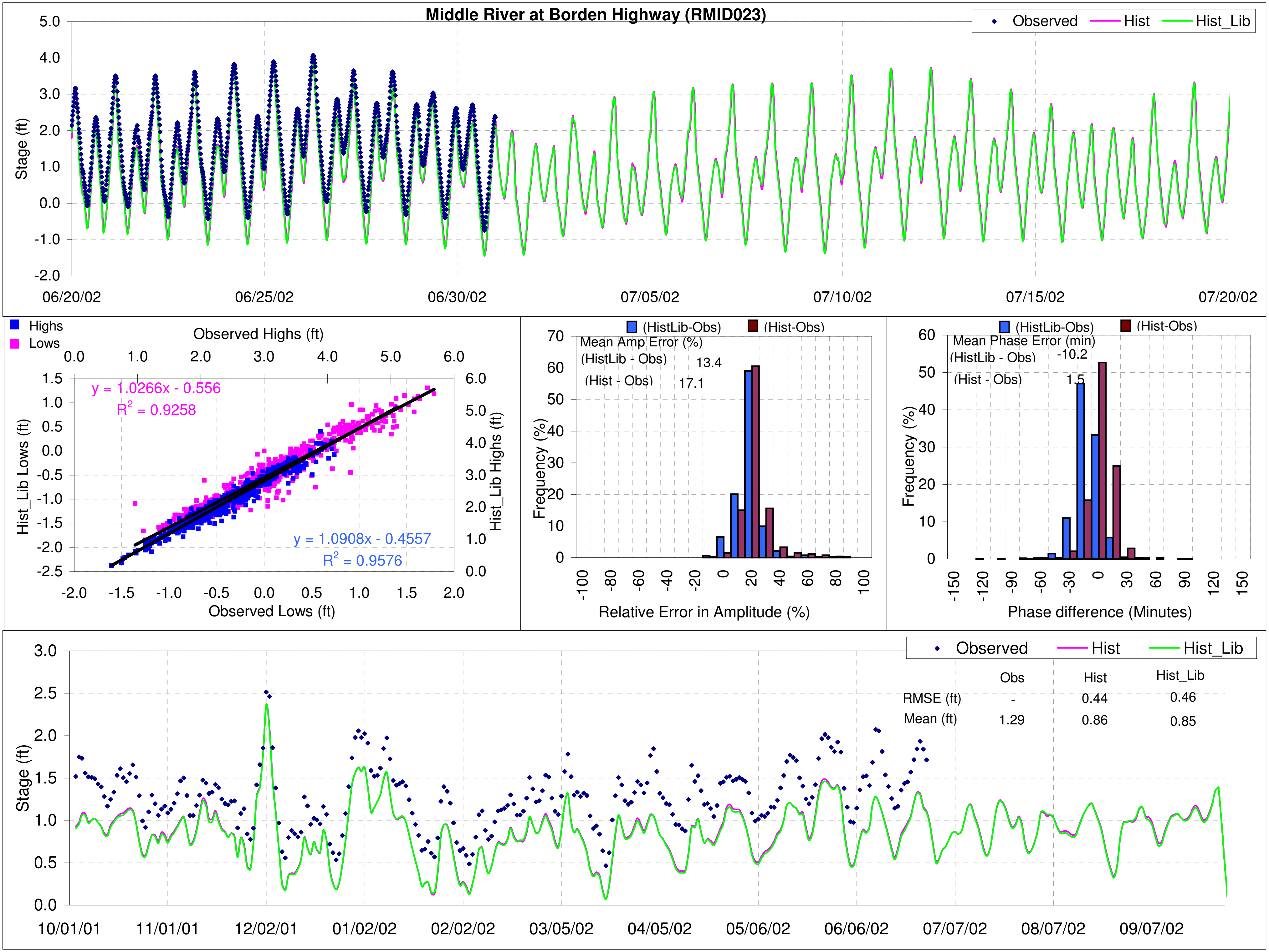


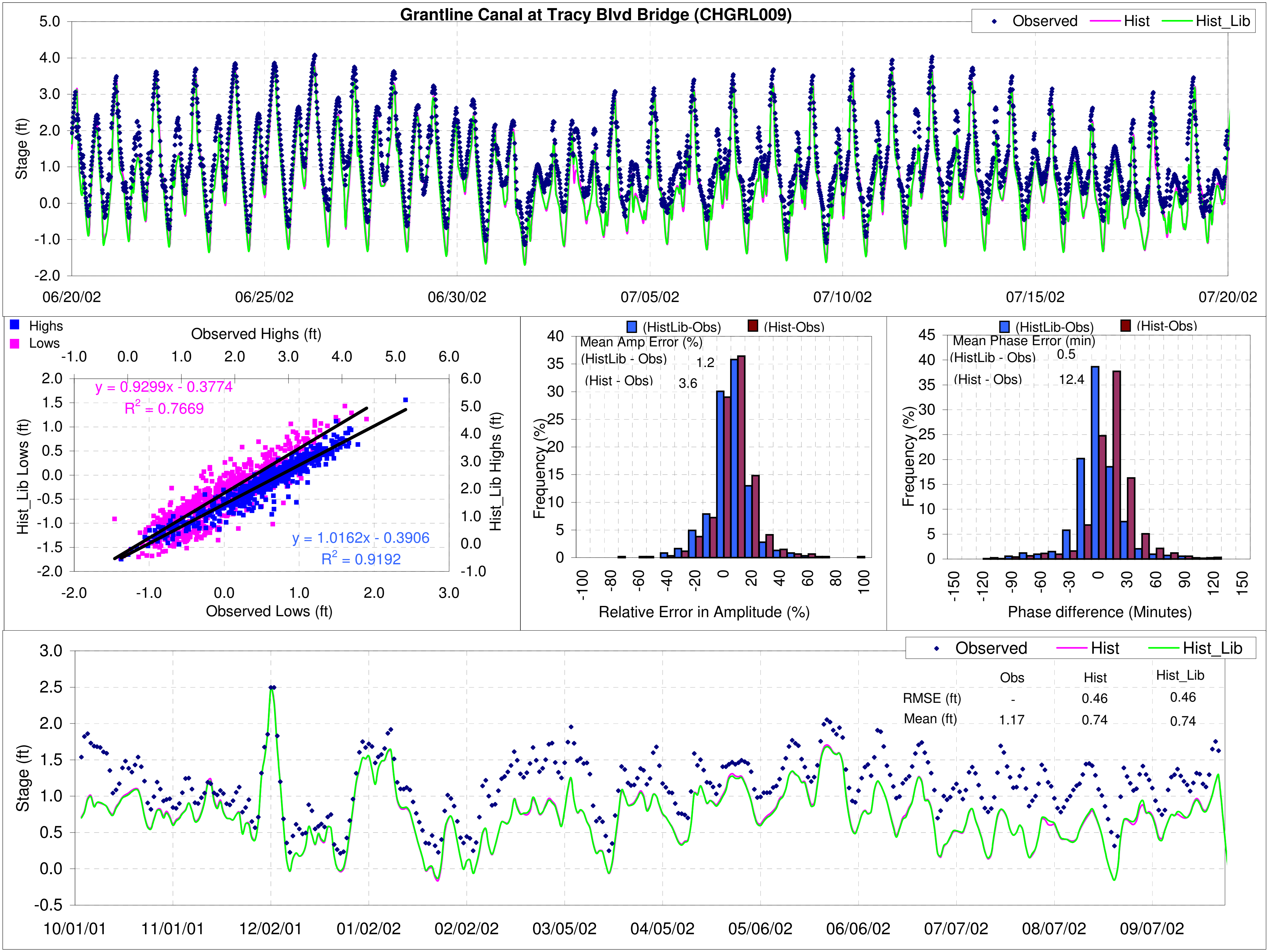
Old river @ near Delta Mendota Canal (ROLD047)
Observed
Hist
Hist_Lib
Stage (ft)
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (ft)
y = 0.9646x - 0.1957
R^2 = 0.9569
y = 1.0315x - 0.1324
R^2 = 0.9206
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 11.3
(Hist - Obs) 12.7
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -17.7
(Hist - Obs) -6.6
Phase difference (Minutes)
Observed
Hist
Hist_Lib
Obs
Hist
Hist_Lib
RMSE (ft) - 0.26 0.26
Mean (ft) 1.20 1.00 1.00
Stage (ft)
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02

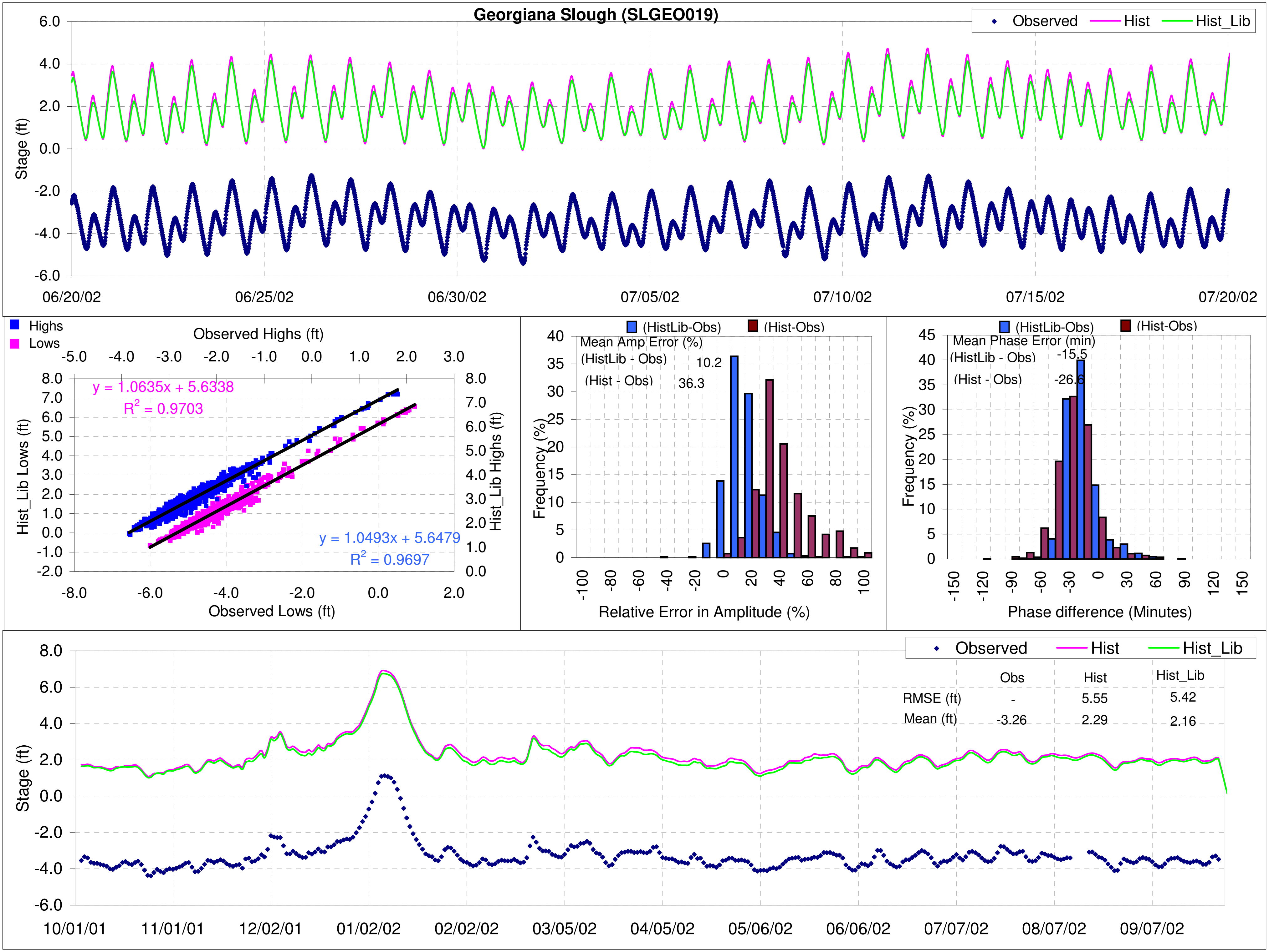


Old River at Hwy 4 (near Byron) (ROLD034)
Observed
Hist
Hist_Lib
Stage (ft)
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (ft)
y = 0.9964x - 0.3523
R2 = 0.9074
y = 1.0301x - 0.0202
R2 = 0.9392
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 19.3
(Hist - Obs) 22.8
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -15.1
(Hist - Obs) -2.2
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) - 0.24 0.24
Mean (ft) 1.10 0.90 0.90
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02

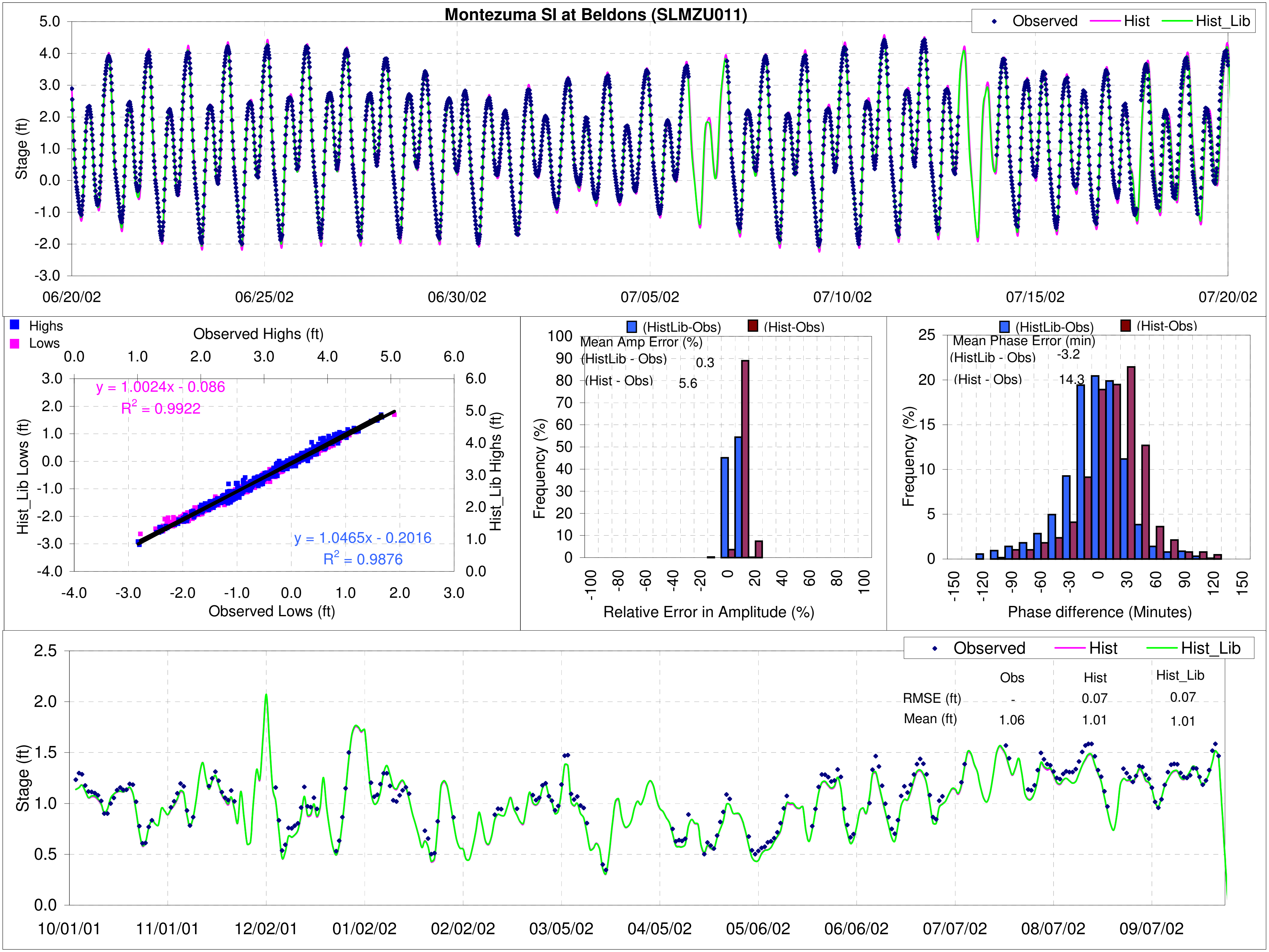

Old River at Bacon Island (ROLD024)
Observed
Hist
Hist_Lib
Stage (ft)
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (ft)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
y = 0.9154x - 0.4293
R2 = 0.883
y = 0.9682x + 0.0061
R2 = 0.8918
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
-2.0
-1.0
0.0
1.0
2.0
3.0
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 17.2
(Hist - Obs) 21.4
Frequency (%)
Relative Error in Amplitude (%)
-100
-80
-60
-40
-20
0
20
40
60
80
100
Mean Phase Error (min)
(HistLib - Obs) -6.1
(Hist - Obs) 7.2
Phase difference (Minutes)
-150
-120
-90
-60
-30
0
30
60
90
120
150
Obs
Hist
Hist_Lib
RMSE (ft) - 0.37 0.37
Mean (ft) 1.40 1.11 1.11
3.0
2.5
2.0
1.5
1.0
0.5
0.0
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02


Middle River at Borden Highway (RMID023)
Observed
Hist
Hist_Lib
Stage (ft)
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (ft)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
y = 1.0266x - 0.556
R2 = 0.9258
y = 1.0908x - 0.4557
R2 = 0.9576
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 13.4
(Hist - Obs) 17.1
Frequency (%)
70
60
50
40
30
20
10
0
-100
-80
-60
-40
-20
0
20
40
60
80
100
Relative Error in Amplitude (%)
(HistLib-Obs)
(Hist-Obs)
Mean Phase Error (min)
(HistLib - Obs) -10.2
(Hist - Obs) 1.5
Frequency (%)
60
50
40
30
20
10
0
-150
-120
-90
-60
-30
0
30
60
90
120
150
Phase difference (Minutes)
Observed
Hist
Hist_Lib
Stage (ft)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02
Obs
Hist
Hist_Lib
RMSE (ft) - 0.44 0.46
Mean (ft) 1.29 0.86 0.85

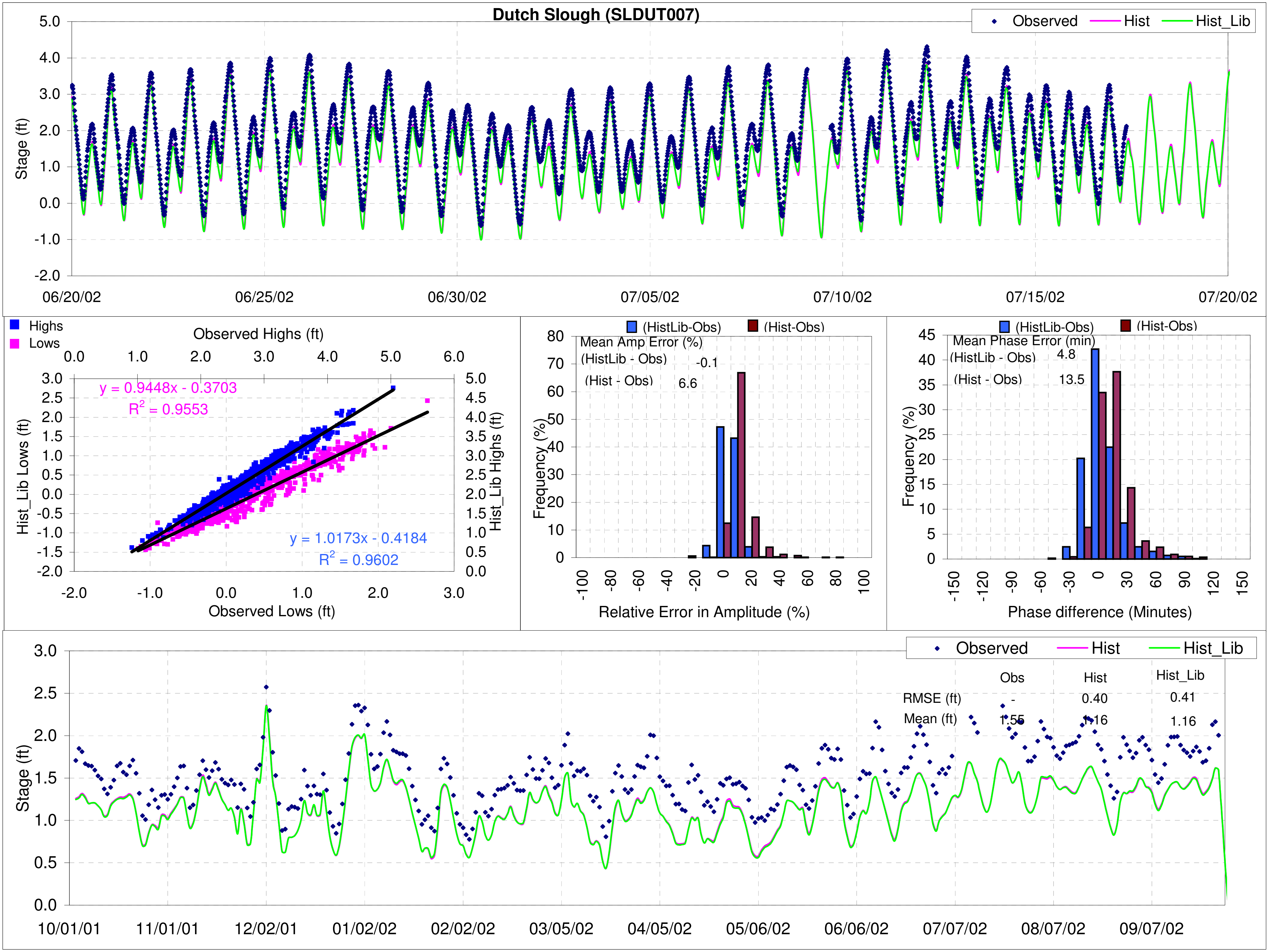

Grantline Canal at Tracy Blvd Bridge (CHGRL009)
Observed
Hist
Hist_Lib
Stage (ft)
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (ft)
y = 0.9299x - 0.3774
R2 = 0.7669
y = 1.0162x - 0.3906
R2 = 0.9192
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 1.2
(Hist - Obs) 3.6
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) 0.5
(Hist - Obs) 12.4
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) - 0.46 0.46
Mean (ft) 1.17 0.74 0.74
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02



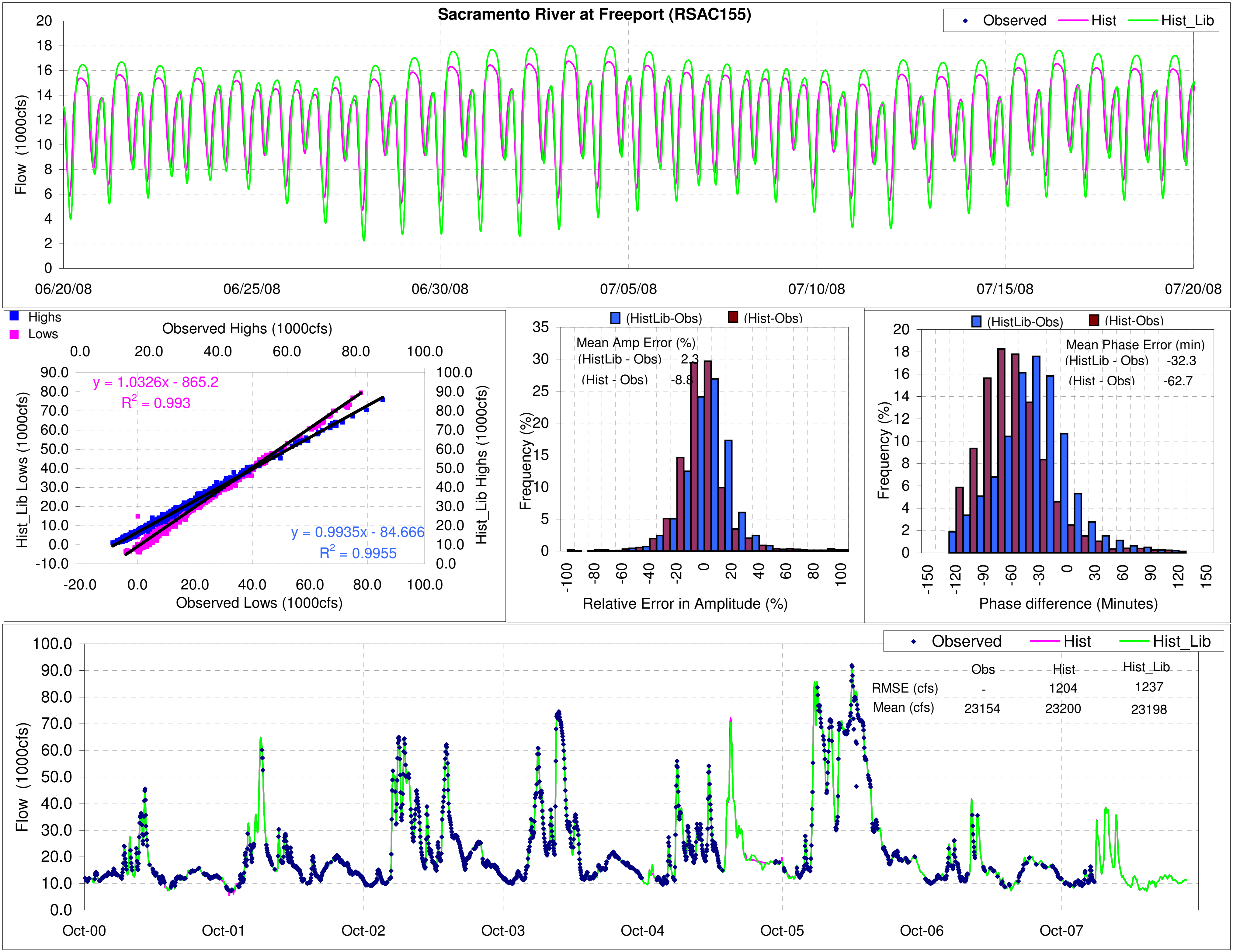
Georgiana Slough (SLGEO019)
Observed
Hist
Hist_Lib
Stage (ft)
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (ft)
-5.0 -4.0 -3.0 -2.0 -1.0 0.0 1.0 2.0 3.0
y = 1.0635x + 5.6338
R2 = 0.9703
y = 1.0493x + 5.6479
R2 = 0.9697
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
-8.0 -6.0 -4.0 -2.0 0.0 2.0
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 10.2
(Hist - Obs) 36.3
Frequency (%)
Relative Error in Amplitude (%)
-100 -80 -60 -40 -20 0 20 40 60 80 100
Mean Phase Error (min)
(HistLib - Obs) -15.5
(Hist - Obs) -26.6
Phase difference (Minutes)
-150 -120 -90 -60 -30 0 30 60 90 120 150
Obs
Hist
Hist_Lib
RMSE (ft) - 5.55 5.42
Mean (ft) -3.26 2.29 2.16
8.0
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02



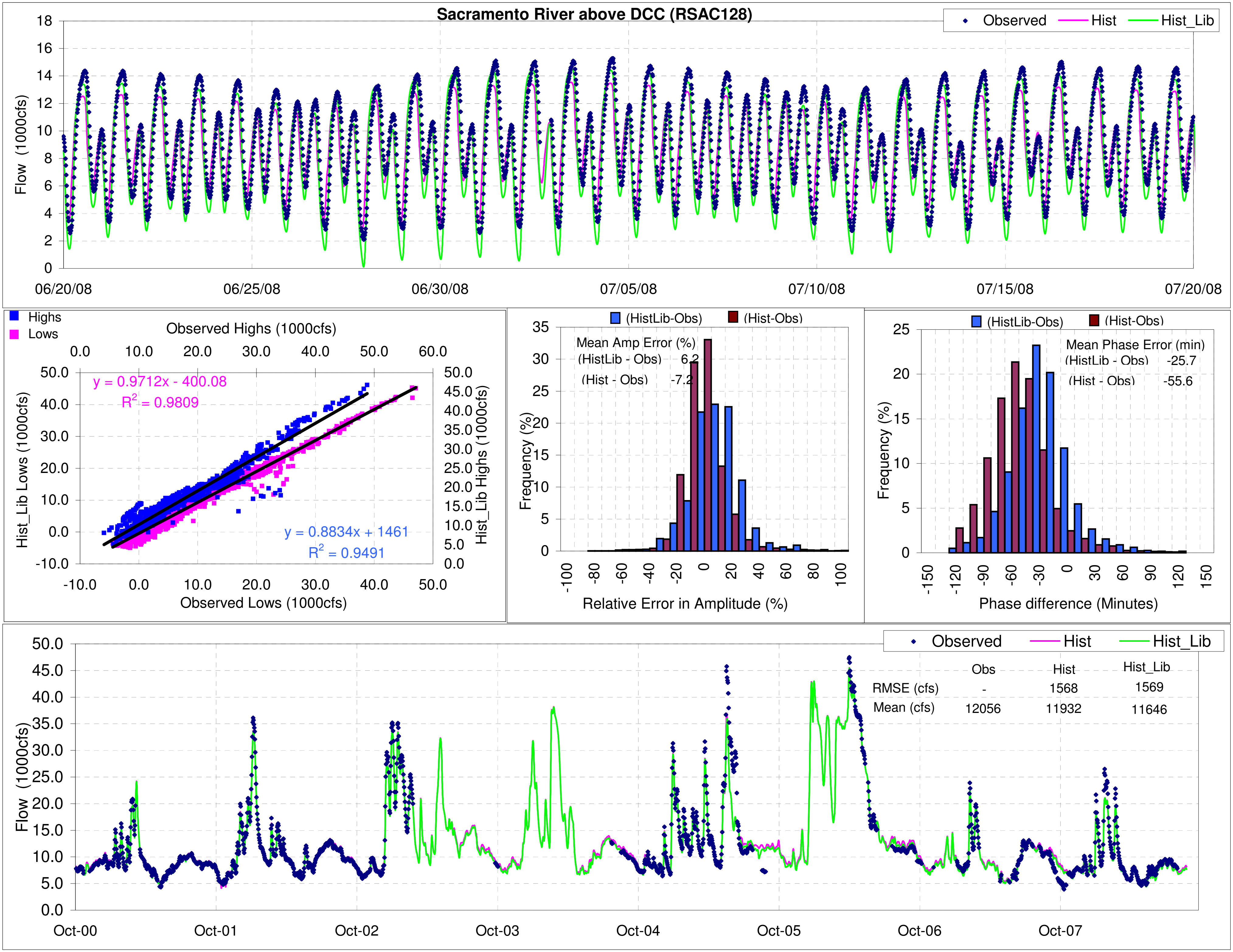
Montezuma Sl at Beldons (SLMZU011)
Observed
Hist
Hist_Lib
Stage (ft)
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (ft)
y = 1.0024x - 0.086
R^2 = 0.9922
y = 1.0465x - 0.2016
R^2 = 0.9876
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 0.3
(Hist - Obs) 5.6
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -3.2
(Hist - Obs) 14.3
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) - 0.07 0.07
Mean (ft) 1.06 1.01 1.01
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02

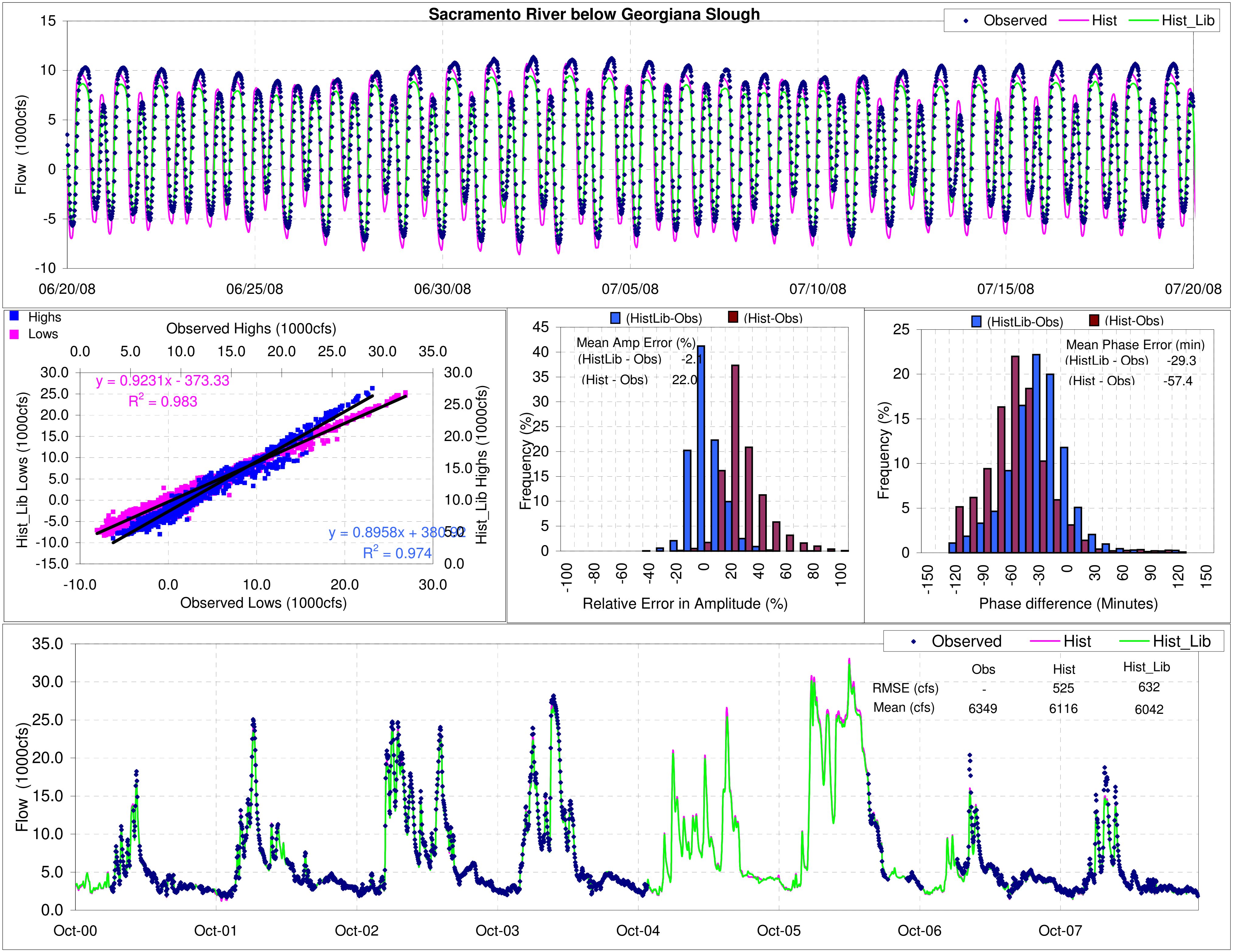

Dutch Slough (SLDUT007)
Observed
Hist
Hist_Lib
Stage (ft)
06/20/02
06/25/02
06/30/02
07/05/02
07/10/02
07/15/02
07/20/02
Highs
Lows
Observed Highs (ft)
y = 0.9448x - 0.3703
R^2 = 0.9553
y = 1.0173x - 0.4184
R^2 = 0.9602
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) -0.1
(Hist - Obs) 6.6
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) 4.8
(Hist - Obs) 13.5
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) - 0.40 0.41
Mean (ft) 1.55 1.16 1.16
10/01/01
11/01/01
12/02/01
01/02/02
02/02/02
03/05/02
04/05/02
05/06/02
06/06/02
07/07/02
08/07/02
09/07/02

Appendix B
Detailed HYDRO Validation Results

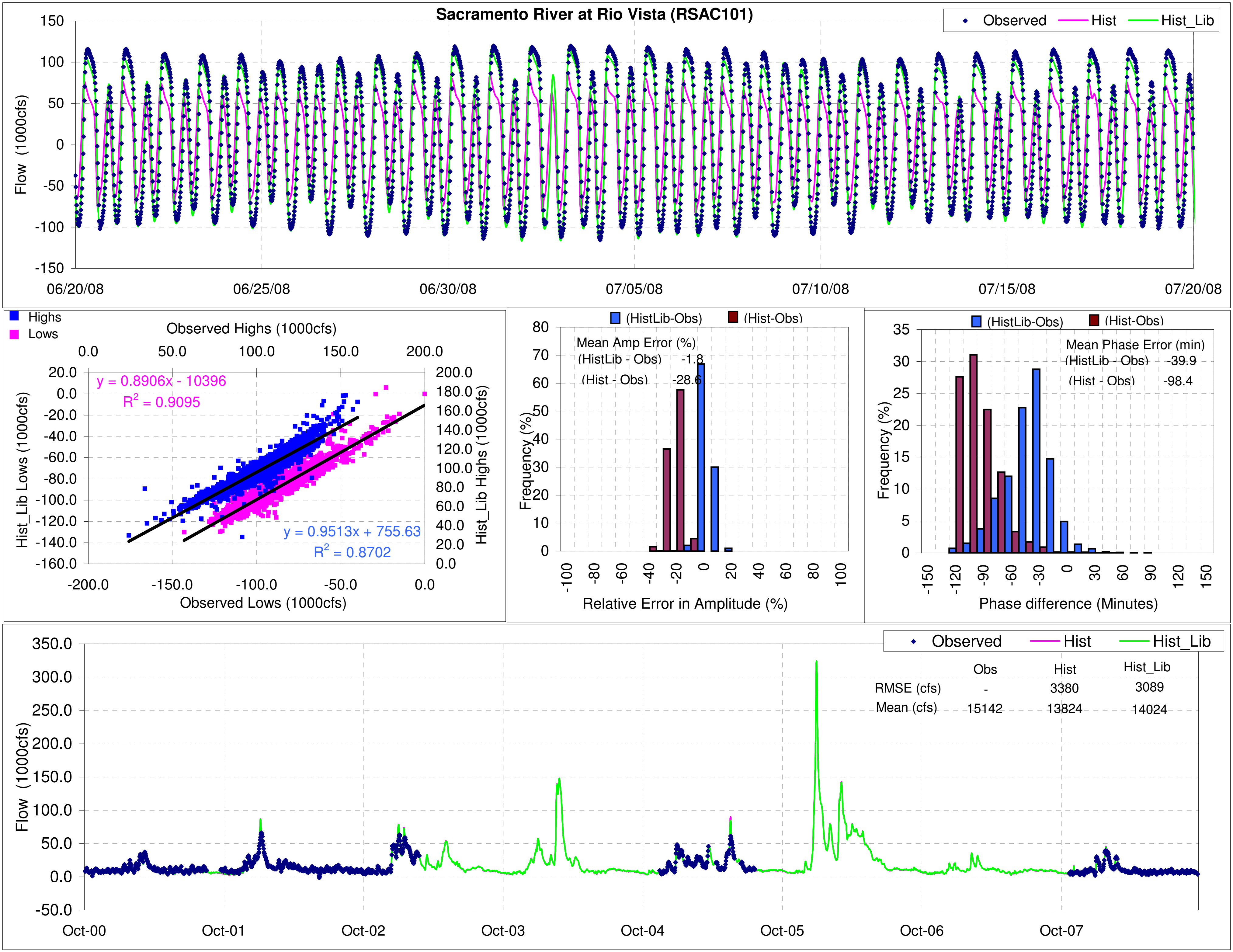


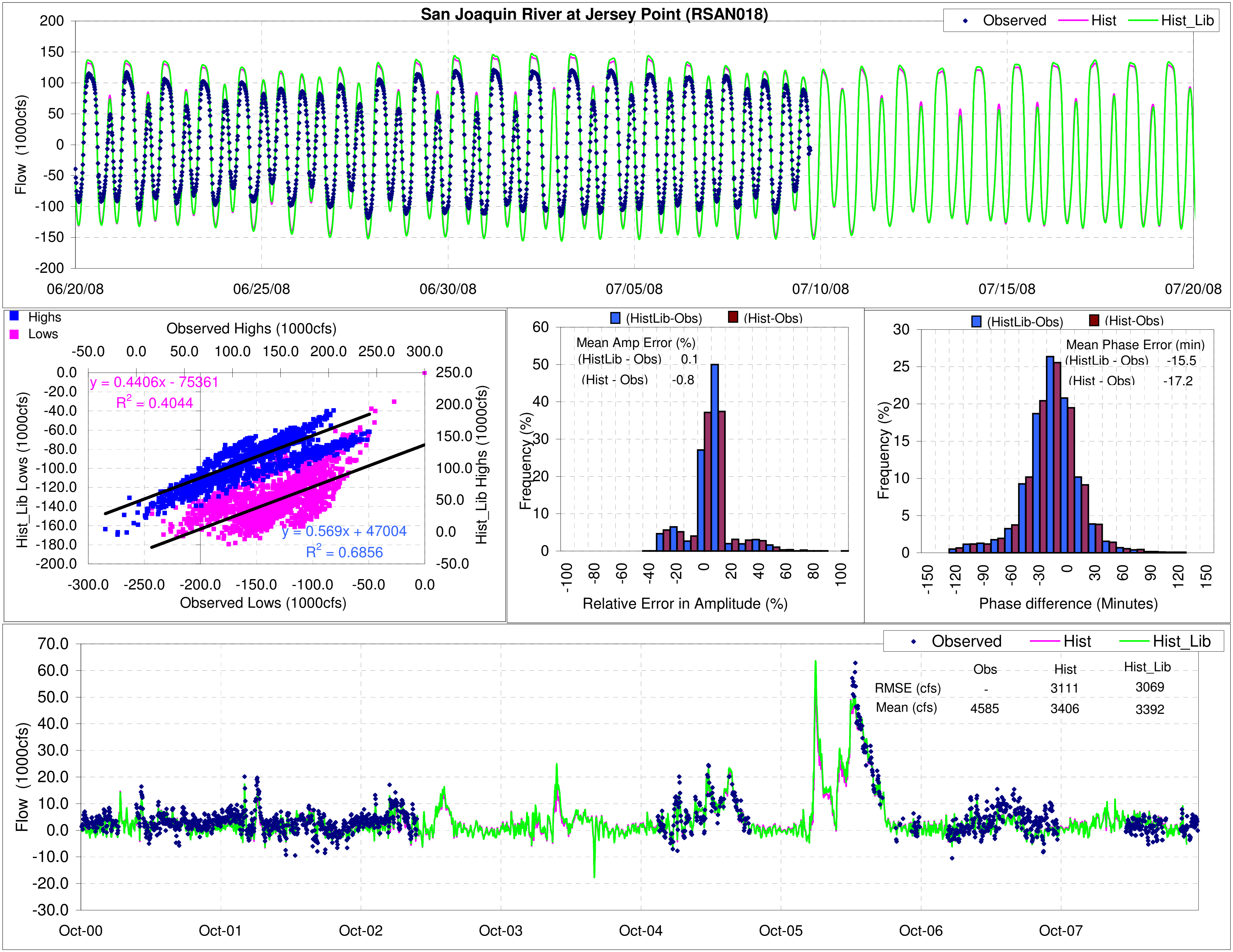
Sacramento River at Freeport (RSAC155)
Observed
Hist
Hist_Lib
Flow (1000cfs)
06/20/08
06/25/08
06/30/08
07/05/08
07/10/08
07/15/08
07/20/08
Highs
Lows
Observed Highs (1000cfs)
Hist_Lib Lows (1000cfs)
Hist_Lib Highs (1000cfs)
Observed Lows (1000cfs)
y = 1.0326x - 865.2
R2 = 0.993
y = 0.9935x - 84.666
R2 = 0.9955
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 2.3
(Hist - Obs) -8.8
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -32.3
(Hist - Obs) -62.7
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (cfs) - 1204 1237
Mean (cfs) 23154 23200 23198
Oct-00
Oct-01
Oct-02
Oct-03
Oct-04
Oct-05
Oct-06
Oct-07


Sacramento River above DCC (RSAC128)
Observed
Hist
Hist_Lib
Flow (1000cfs)
18
16
14
12
10
8
6
4
2
0
06/20/08
06/25/08
06/30/08
07/05/08
07/10/08
07/15/08
07/20/08
Highs
Lows
Observed Highs (1000cfs)
0.0
10.0
20.0
30.0
40.0
50.0
60.0
Hist_Lib Lows (1000cfs)
Hist_Lib Highs (1000cfs)
y = 0.9712x - 400.08
R^2 = 0.9809
y = 0.8834x + 1461
R^2 = 0.9491
-10.0
0.0
10.0
20.0
30.0
40.0
50.0
Observed Lows (1000cfs)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 6.2
(Hist - Obs) -7.2
Frequency (%)
-100
-80
-60
-40
-20
0
20
40
60
80
100
Relative Error in Amplitude (%)
(HistLib-Obs)
(Hist-Obs)
Mean Phase Error (min)
(HistLib - Obs) -25.7
(Hist - Obs) -55.6
Frequency (%)
-150
-120
-90
-60
-30
0
30
60
90
120
150
Phase difference (Minutes)
Observed
Hist
Hist_Lib
Obs
Hist
Hist_Lib
RMSE (cfs) - 1568 1569
Mean (cfs) 12056 11932 11646
Flow (1000cfs)
Oct-00
Oct-01
Oct-02
Oct-03
Oct-04
Oct-05
Oct-06
Oct-07

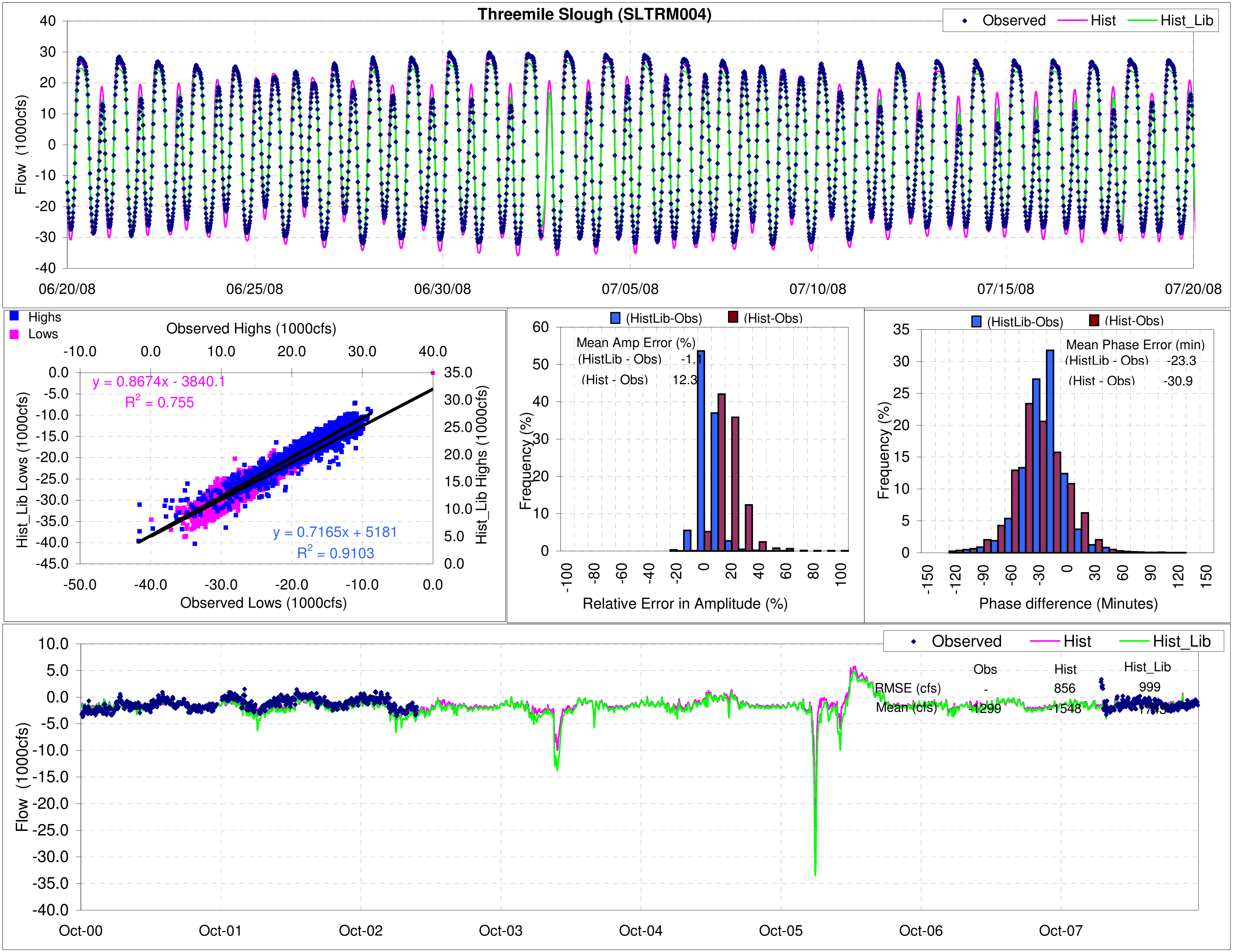


Sacramento River below Georgiana Slough
Observed
Hist
Hist_Lib
Flow (1000cfs)
15
10
5
0
-5
-10
06/20/08
06/25/08
06/30/08
07/05/08
07/10/08
07/15/08
07/20/08
Highs
Lows
Observed Highs (1000cfs)
0.0 5.0 10.0 15.0 20.0 25.0 30.0 35.0
y = 0.9231x - 373.33
R² = 0.983
y = 0.8958x + 380.92
R² = 0.974
Hist_Lib Lows (1000cfs)
Hist_Lib Highs (1000cfs)
-10.0 0.0 10.0 20.0 30.0
Observed Lows (1000cfs)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) -2.1
(Hist - Obs) 22.0
Frequency (%)
Relative Error in Amplitude (%)
-100 -80 -60 -40 -20 0 20 40 60 80 100
Mean Phase Error (min)
(HistLib - Obs) -29.3
(Hist - Obs) -57.4
Frequency (%)
-150 -120 -90 -60 -30 0 30 60 90 120 150
Phase difference (Minutes)
Observed
Hist
Hist_Lib
Obs Hist Hist_Lib
RMSE (cfs) - 525 632
Mean (cfs) 6349 6116 6042
Flow (1000cfs)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Oct-00
Oct-01
Oct-02
Oct-03
Oct-04
Oct-05
Oct-06
Oct-07

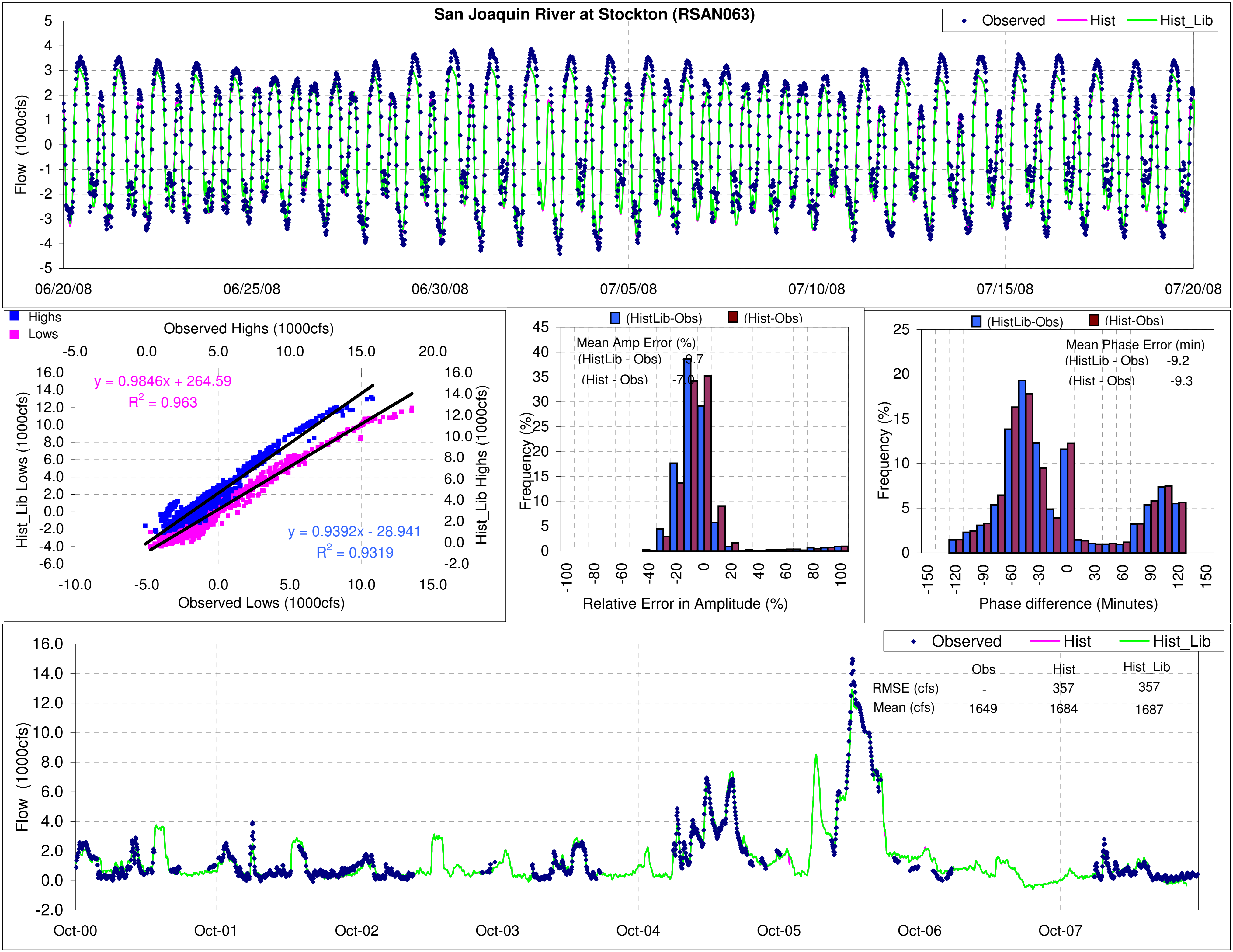

Sacramento River at Rio Vista (RSAC101)
Observed
Hist
Hist_Lib
Flow (1000cfs)
150
100
50
0
-50
-100
-150
06/20/08
06/25/08
06/30/08
07/05/08
07/10/08
07/15/08
07/20/08
Highs
Lows
Observed Highs (1000cfs)
0.0
50.0
100.0
150.0
200.0
y = 0.8906x - 10396
R² = 0.9095
y = 0.9513x + 755.63
R² = 0.8702
Hist_Lib Lows (1000cfs)
Hist_Lib Highs (1000cfs)
20.0
0.0
-20.0
-40.0
-60.0
-80.0
-100.0
-120.0
-140.0
-160.0
200.0
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
-200.0
-150.0
-100.0
-50.0
0.0
Observed Lows (1000cfs)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) -1.8
(Hist - Obs) -28.6
Frequency (%)
80
70
60
50
40
30
20
10
0
-100
-80
-60
-40
-20
0
20
40
60
80
100
Relative Error in Amplitude (%)
(HistLib-Obs)
(Hist-Obs)
Mean Phase Error (min)
(HistLib - Obs) -39.9
(Hist - Obs) -98.4
Frequency (%)
35
30
25
20
15
10
5
0
-150
-120
-90
-60
-30
0
30
60
90
120
150
Phase difference (Minutes)
Observed
Hist
Hist_Lib
Obs Hist Hist_Lib
RMSE (cfs) - 3380 3089
Mean (cfs) 15142 13824 14024
Flow (1000cfs)
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
-50.0
Oct-00
Oct-01
Oct-02
Oct-03
Oct-04
Oct-05
Oct-06
Oct-07



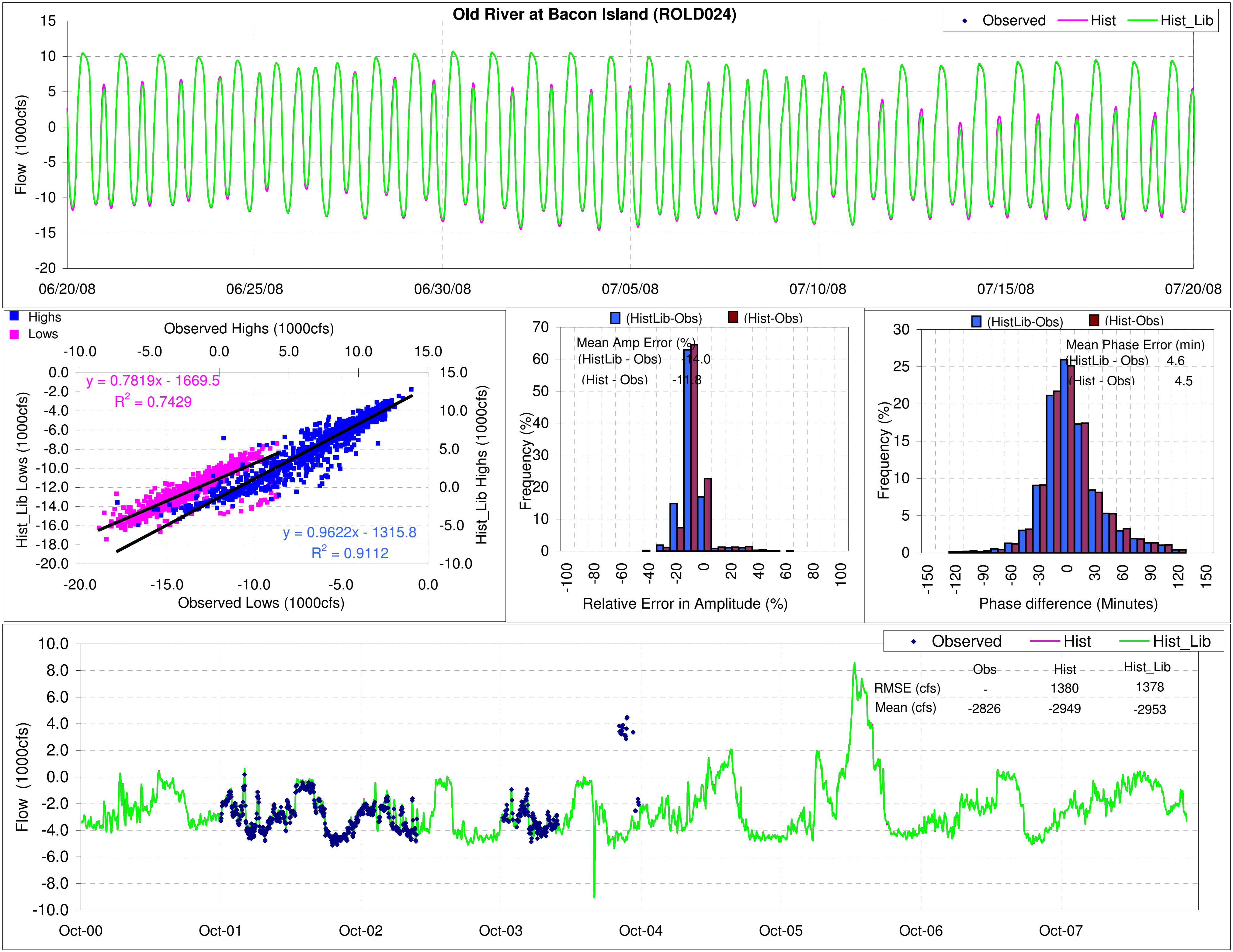
San Joaquin River at Jersey Point (RSAN018)
Observed
Hist
Hist_Lib
Flow (1000cfs)
06/20/08
06/25/08
06/30/08
07/05/08
07/10/08
07/15/08
07/20/08
Highs
Lows
Observed Highs (1000cfs)
Hist_Lib Lows (1000cfs)
Hist_Lib Highs (1000cfs)
Observed Lows (1000cfs)
y = 0.4406x - 75361
R2 = 0.4044
y = 0.569x + 47004
R2 = 0.6856
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 0.1
(Hist - Obs) -0.8
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -15.5
(Hist - Obs) -17.2
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (cfs) - 3111 3069
Mean (cfs) 4585 3406 3392
Oct-00
Oct-01
Oct-02
Oct-03
Oct-04
Oct-05
Oct-06
Oct-07



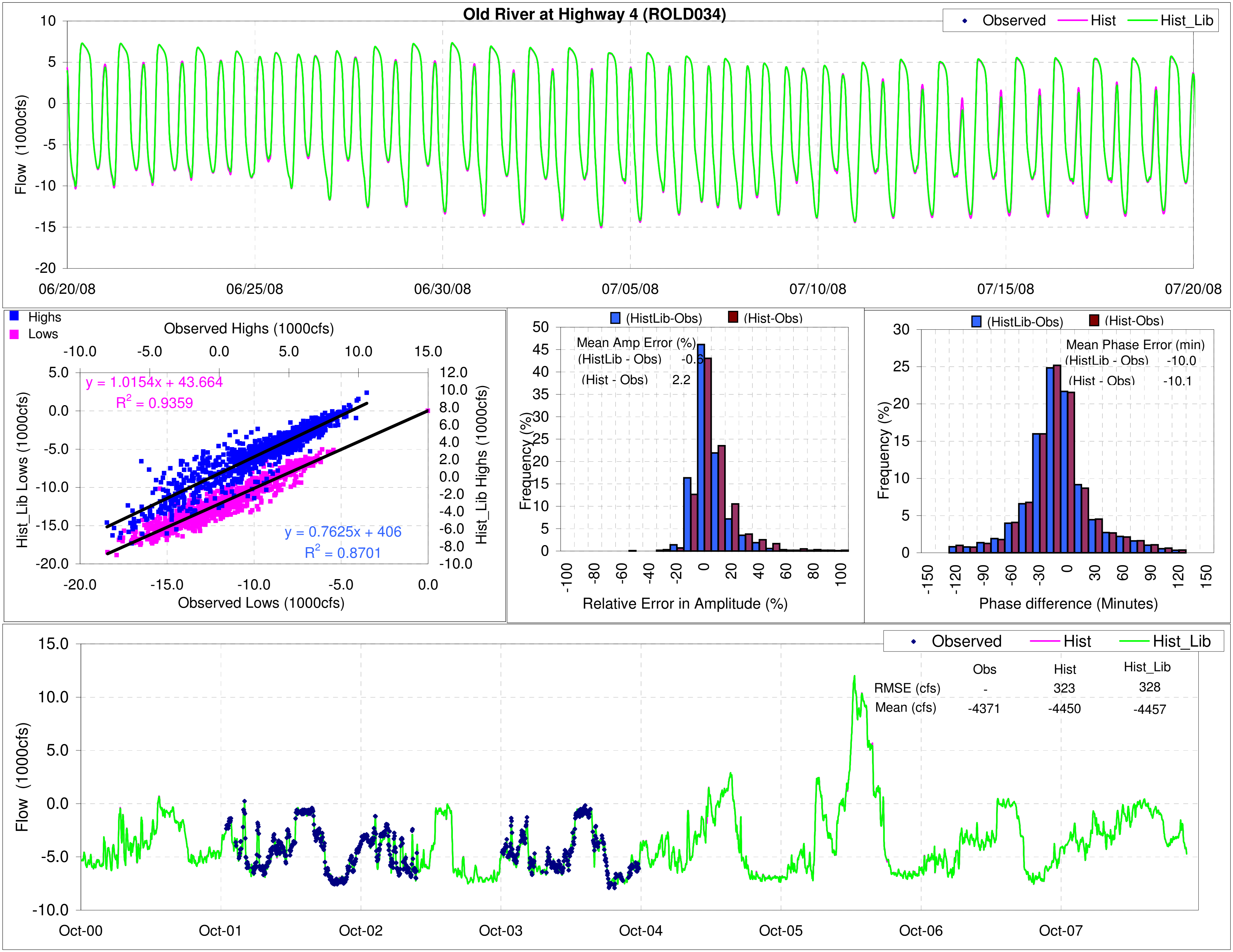
Threemile Slough (SLTRM004)
Observed
Hist
Hist_Lib
Flow (1000cfs)
06/20/08
06/25/08
06/30/08
07/05/08
07/10/08
07/15/08
07/20/08
Highs
Lows
Observed Highs (1000cfs)
y = 0.8674x - 3840.1
R2 = 0.755
y = 0.7165x + 5181
R2 = 0.9103
Hist_Lib Lows (1000cfs)
Hist_Lib Highs (1000cfs)
Observed Lows (1000cfs)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) -1.1
(Hist - Obs) 12.3
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -23.3
(Hist - Obs) -30.9
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (cfs)
-
856
999
Mean (cfs)
-1299
-1548
-1743
Flow (1000cfs)
Oct-00
Oct-01
Oct-02
Oct-03
Oct-04
Oct-05
Oct-06
Oct-07

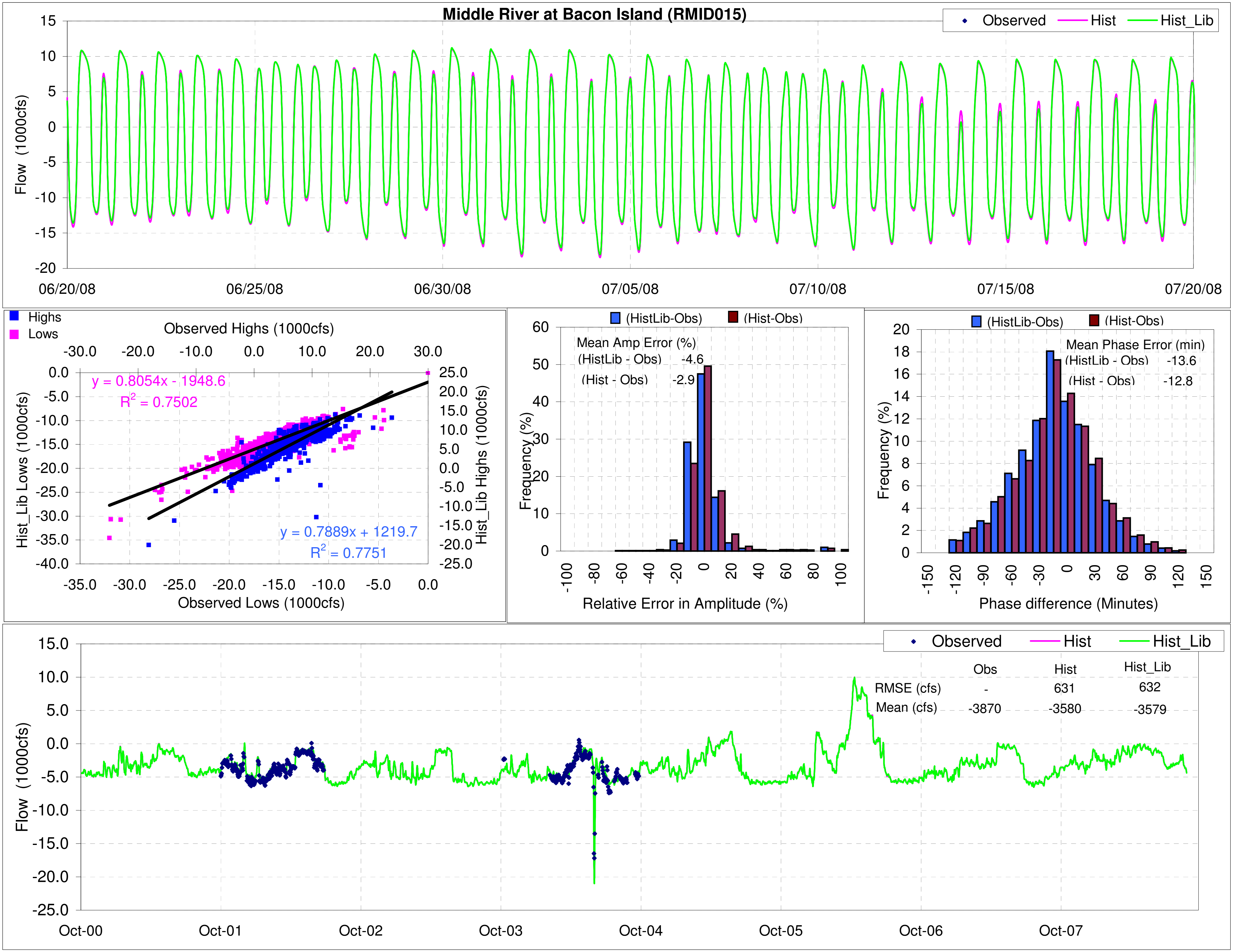


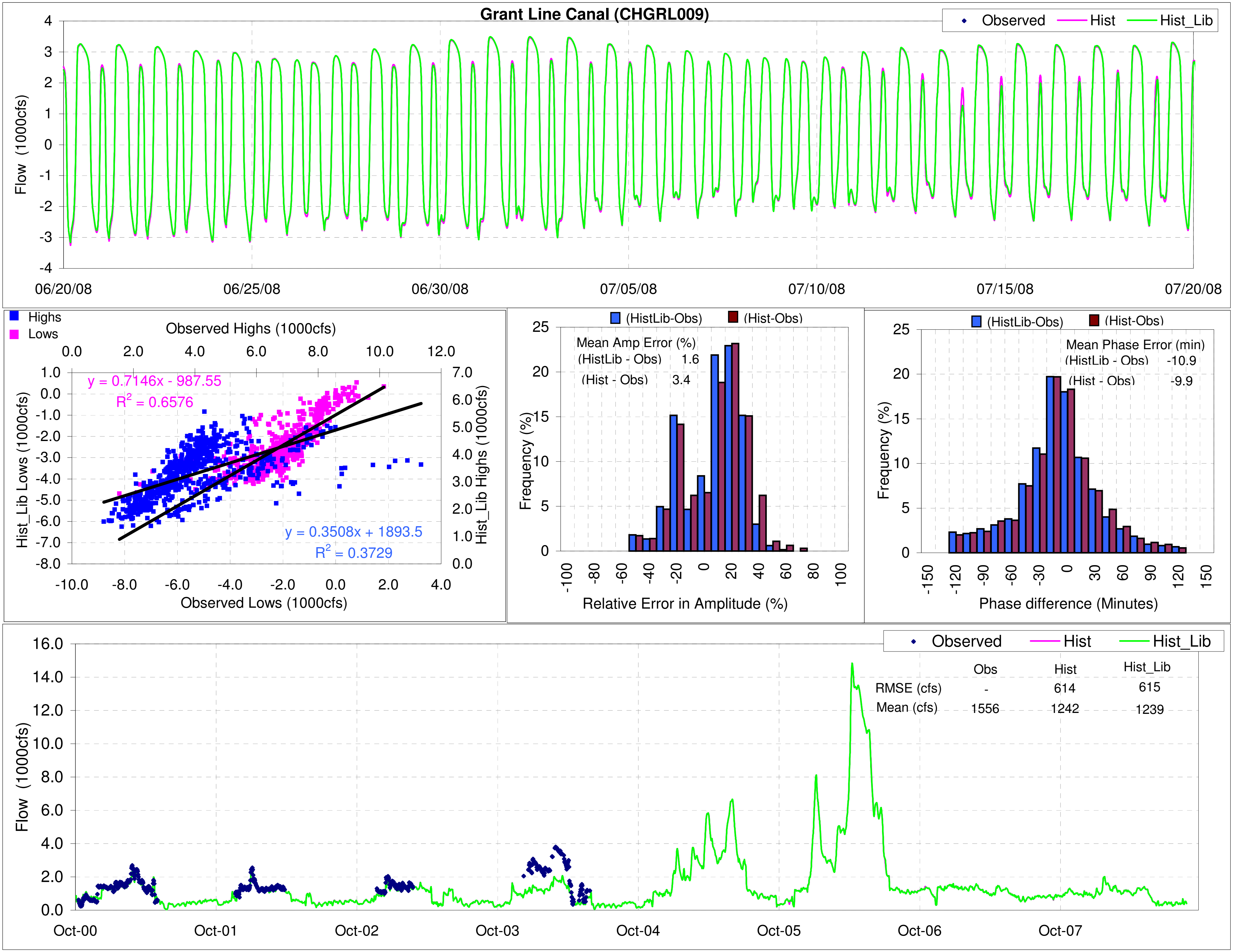
San Joaquin River at Stockton (RSAN063)
Observed
Hist
Hist_Lib
Flow (1000cfs)
06/20/08
06/25/08
06/30/08
07/05/08
07/10/08
07/15/08
07/20/08
Highs
Lows
Observed Highs (1000cfs)
y = 0.9846x + 264.59
R^2 = 0.963
y = 0.9392x - 28.941
R^2 = 0.9319
Hist_Lib Lows (1000cfs)
Hist_Lib Highs (1000cfs)
Observed Lows (1000cfs)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) -9.7
(Hist - Obs) -7.0
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -9.2
(Hist - Obs) -9.3
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (cfs) - 357 357
Mean (cfs) 1649 1684 1687
Oct-00
Oct-01
Oct-02
Oct-03
Oct-04
Oct-05
Oct-06
Oct-07



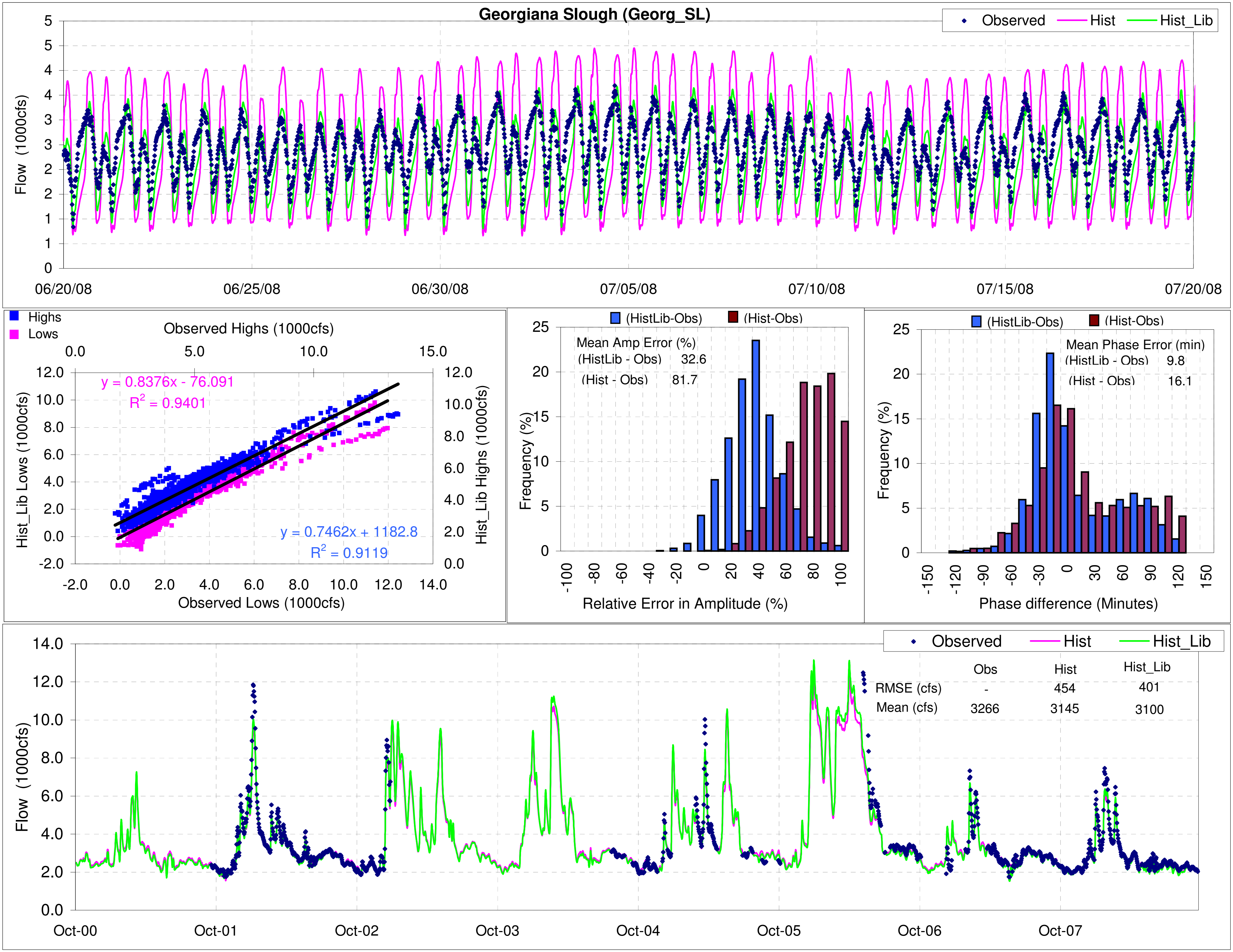
Old River at Bacon Island (ROLD024)
Observed
Hist
Hist_Lib
Flow (1000cfs)
06/20/08
06/25/08
06/30/08
07/05/08
07/10/08
07/15/08
07/20/08
Highs
Lows
Observed Highs (1000cfs)
y = 0.7819x - 1669.5
R2 = 0.7429
y = 0.9622x - 1315.8
R2 = 0.9112
Hist_Lib Lows (1000cfs)
Hist_Lib Highs (1000cfs)
Observed Lows (1000cfs)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) -14.0
(Hist - Obs) -11.8
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) 4.6
(Hist - Obs) 4.5
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (cfs)
-
1380
1378
Mean (cfs)
-2826
-2949
-2953
Oct-00
Oct-01
Oct-02
Oct-03
Oct-04
Oct-05
Oct-06
Oct-07

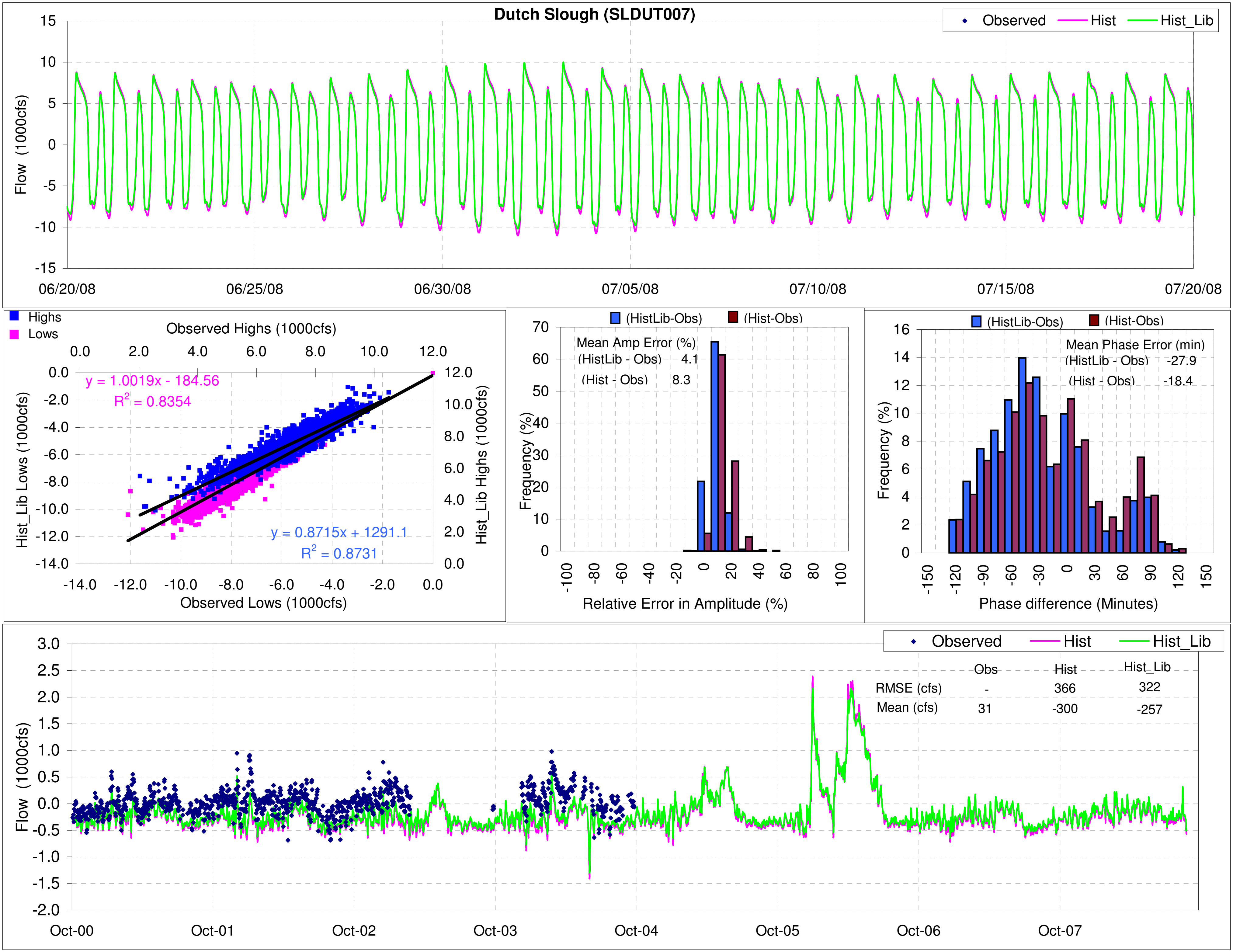

Old River at Highway 4 (ROLD034)
Observed
Hist
Hist_Lib
Flow (1000cfs)
06/20/08
06/25/08
06/30/08
07/05/08
07/10/08
07/15/08
07/20/08
Highs
Lows
Observed Highs (1000cfs)
y = 1.0154x + 43.664
R^2 = 0.9359
y = 0.7625x + 406
R^2 = 0.8701
Hist_Lib Lows (1000cfs)
Hist_Lib Highs (1000cfs)
Observed Lows (1000cfs)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) -0.6
(Hist - Obs) 2.2
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -10.0
(Hist - Obs) -10.1
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (cfs) - 323 328
Mean (cfs) -4371 -4450 -4457
Oct-00
Oct-01
Oct-02
Oct-03
Oct-04
Oct-05
Oct-06
Oct-07

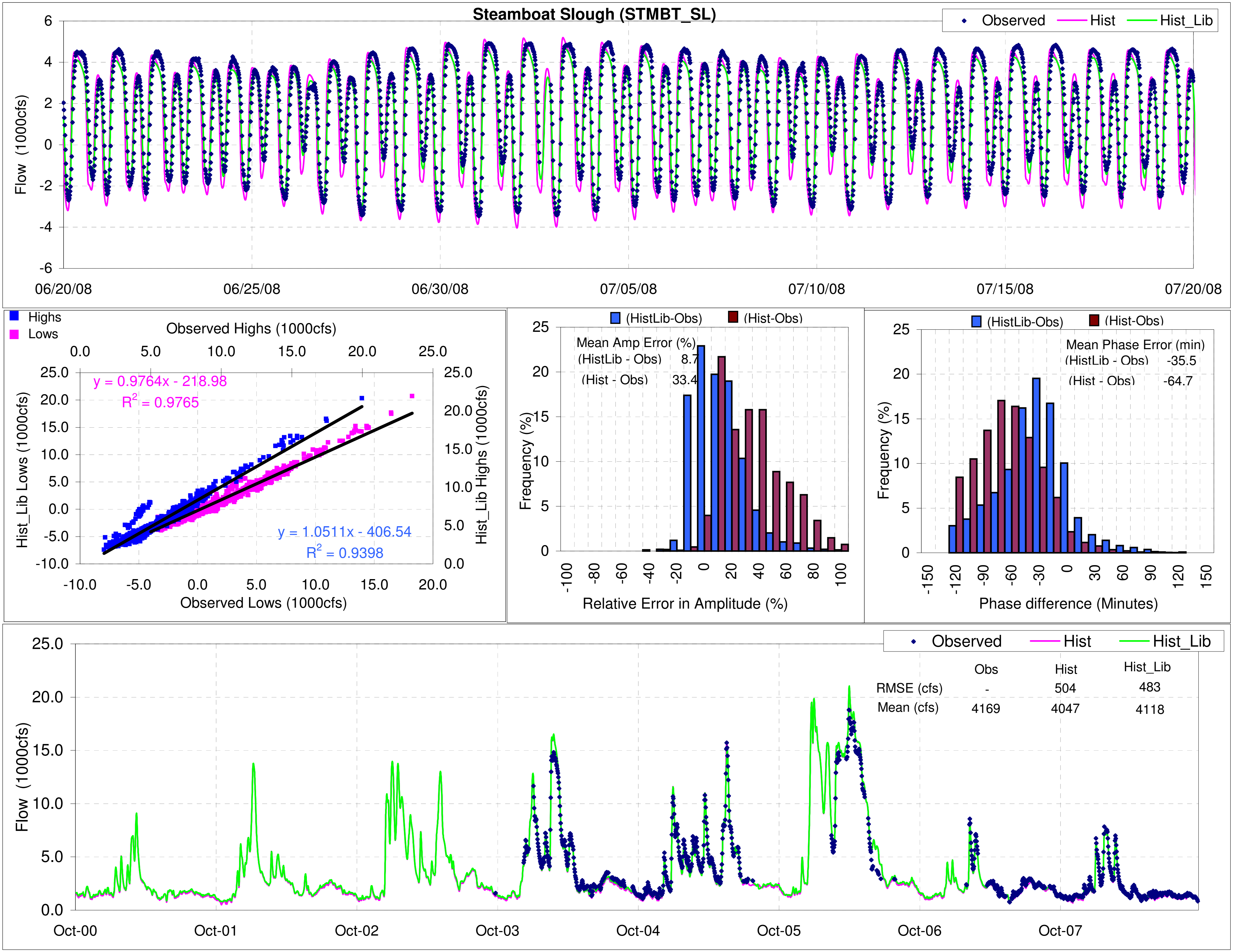

Middle River at Bacon Island (RMID015)
Observed
Hist
Hist_Lib
Flow (1000cfs)
06/20/08
06/25/08
06/30/08
07/05/08
07/10/08
07/15/08
07/20/08
Highs
Lows
Observed Highs (1000cfs)
Observed Lows (1000cfs)
Hist_Lib Lows (1000cfs)
Hist_Lib Highs (1000cfs)
y = 0.8054x - 1948.6
R2 = 0.7502
y = 0.7889x + 1219.7
R2 = 0.7751
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) -4.6
(Hist - Obs) -2.9
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -13.6
(Hist - Obs) -12.8
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (cfs) - 631 632
Mean (cfs) -3870 -3580 -3579
Oct-00
Oct-01
Oct-02
Oct-03
Oct-04
Oct-05
Oct-06
Oct-07

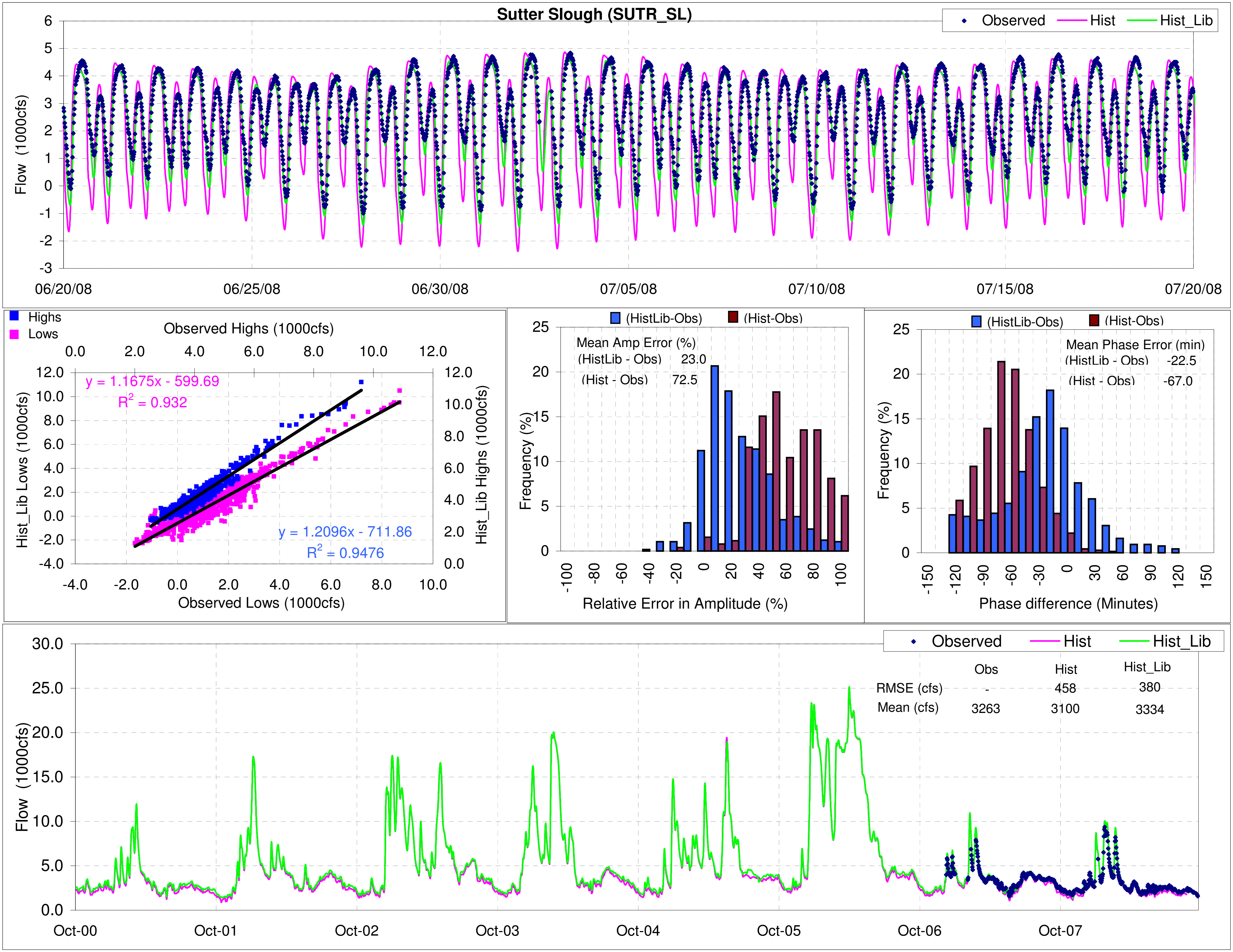


Grant Line Canal (CHGRL009)
Observed
Hist
Hist_Lib
Flow (1000cfs)
06/20/08
06/25/08
06/30/08
07/05/08
07/10/08
07/15/08
07/20/08
Highs
Lows
Observed Highs (1000cfs)
y = 0.7146x - 987.55
R^2 = 0.6576
y = 0.3508x + 1893.5
R^2 = 0.3729
Hist_Lib Lows (1000cfs)
Hist_Lib Highs (1000cfs)
Observed Lows (1000cfs)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 1.6
(Hist - Obs) 3.4
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -10.9
(Hist - Obs) -9.9
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (cfs)
-
614
615
Mean (cfs)
1556
1242
1239
Oct-00
Oct-01
Oct-02
Oct-03
Oct-04
Oct-05
Oct-06
Oct-07

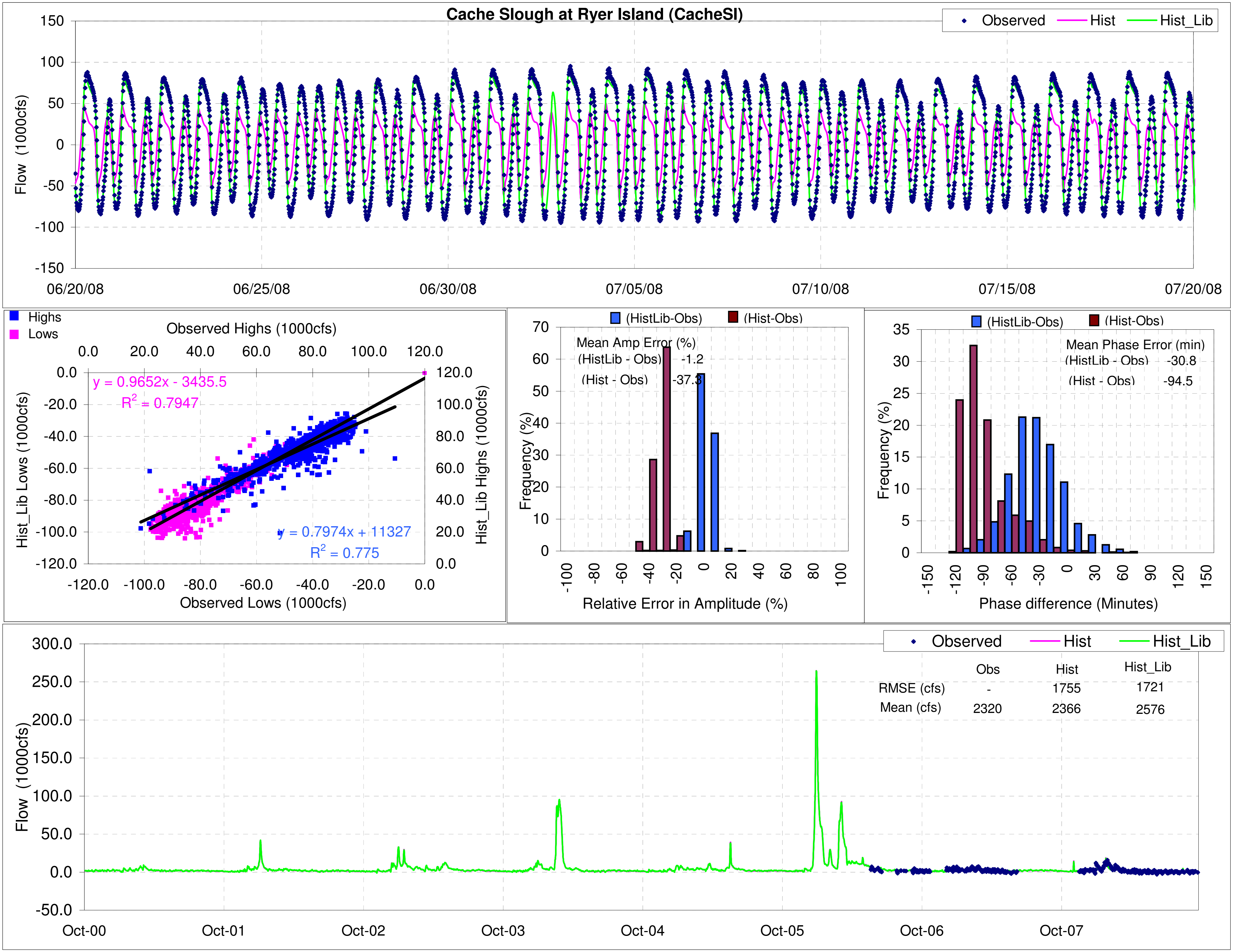

Georgiana Slough (Georg_SL)
Observed
Hist
Hist_Lib
Flow (1000cfs)
06/20/08
06/25/08
06/30/08
07/05/08
07/10/08
07/15/08
07/20/08
Highs
Lows
Observed Highs (1000cfs)
y = 0.8376x - 76.091
R^2 = 0.9401
y = 0.7462x + 1182.8
R^2 = 0.9119
Hist_Lib Lows (1000cfs)
Hist_Lib Highs (1000cfs)
Observed Lows (1000cfs)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 32.6
(Hist - Obs) 81.7
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) 9.8
(Hist - Obs) 16.1
Phase difference (Minutes)
Obs Hist Hist_Lib
RMSE (cfs) - 454 401
Mean (cfs) 3266 3145 3100
Flow (1000cfs)
Oct-00
Oct-01
Oct-02
Oct-03
Oct-04
Oct-05
Oct-06
Oct-07

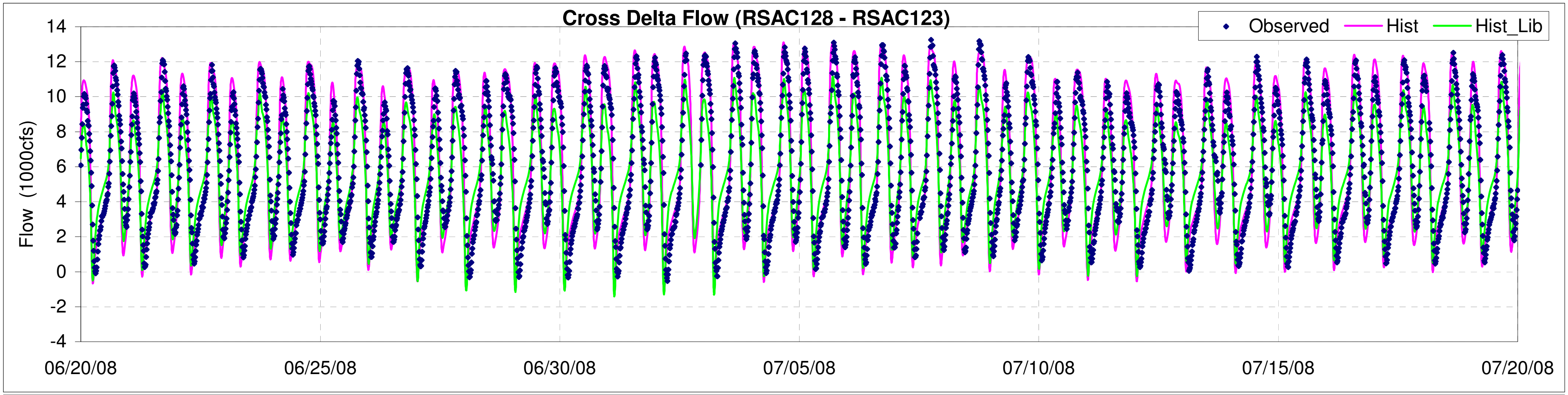

Dutch Slough (SLDUT007)
Observed
Hist
Hist_Lib
Flow (1000cfs)
06/20/08
06/25/08
06/30/08
07/05/08
07/10/08
07/15/08
07/20/08
Highs
Lows
Observed Highs (1000cfs)
y = 1.0019x - 184.56
R2 = 0.8354
y = 0.8715x + 1291.1
R2 = 0.8731
Hist_Lib Lows (1000cfs)
Hist_Lib Highs (1000cfs)
Observed Lows (1000cfs)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 4.1
(Hist - Obs) 8.3
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -27.9
(Hist - Obs) -18.4
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (cfs) - 366 322
Mean (cfs) 31 -300 -257
Oct-00
Oct-01
Oct-02
Oct-03
Oct-04
Oct-05
Oct-06
Oct-07


Steamboat Slough (STMBT_SL)
Observed
Hist
Hist_Lib
Flow (1000cfs)
06/20/08
06/25/08
06/30/08
07/05/08
07/10/08
07/15/08
07/20/08
Highs
Lows
Observed Highs (1000cfs)
Hist_Lib Lows (1000cfs)
Hist_Lib Highs (1000cfs)
Observed Lows (1000cfs)
y = 0.9764x - 218.98
R2 = 0.9765
y = 1.0511x - 406.54
R2 = 0.9398
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 8.7
(Hist - Obs) 33.4
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -35.5
(Hist - Obs) -64.7
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (cfs) - 504 483
Mean (cfs) 4169 4047 4118
Oct-00
Oct-01
Oct-02
Oct-03
Oct-04
Oct-05
Oct-06
Oct-07

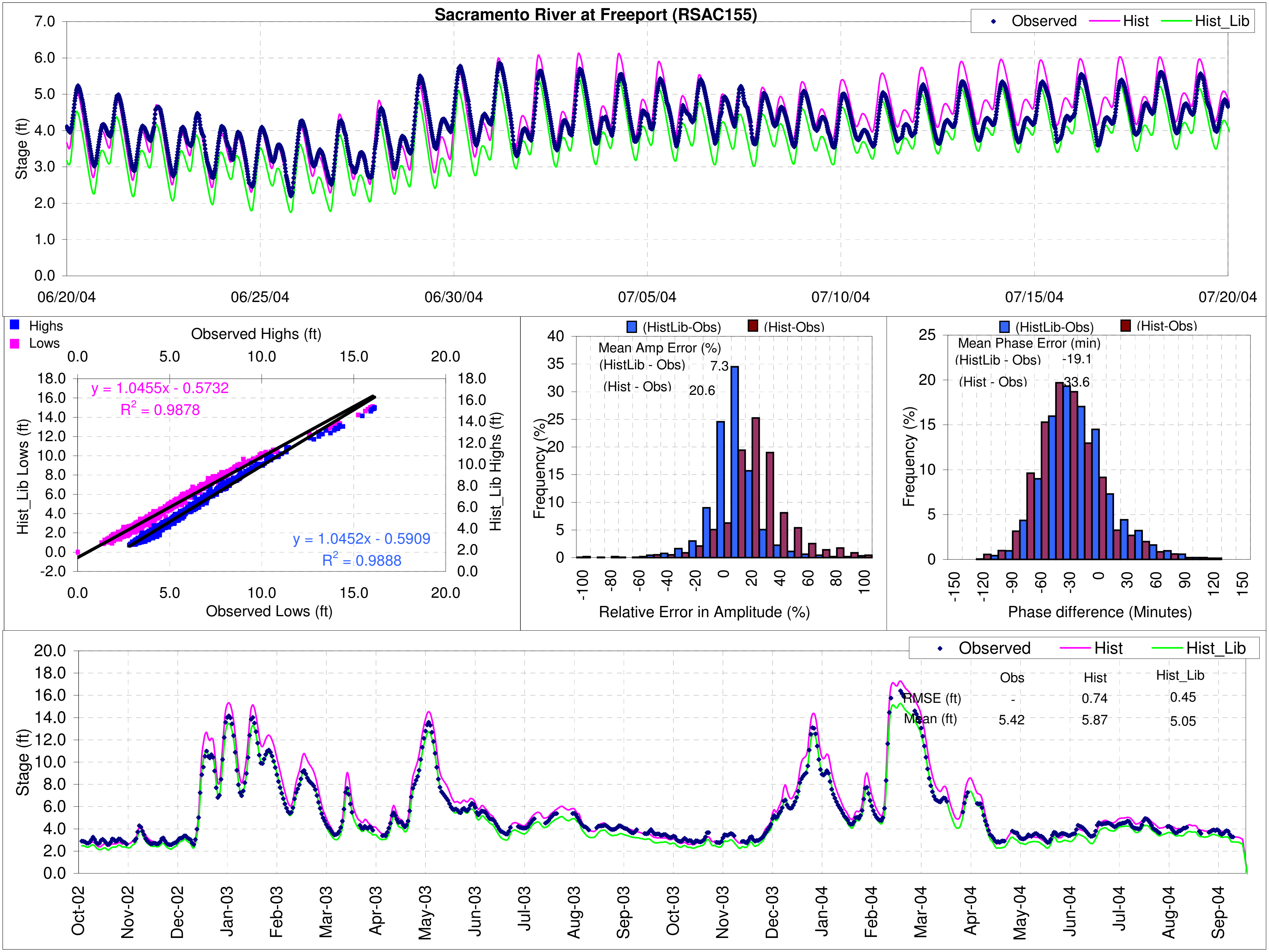


Sutter Slough (SUTR_SL)
Observed
Hist
Hist_Lib
Flow (1000cfs)
06/20/08
06/25/08
06/30/08
07/05/08
07/10/08
07/15/08
07/20/08
Highs
Lows
Observed Highs (1000cfs)
y = 1.1675x - 599.69
R^2 = 0.932
y = 1.2096x - 711.86
R^2 = 0.9476
Hist_Lib Lows (1000cfs)
Hist_Lib Highs (1000cfs)
Observed Lows (1000cfs)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 23.0
(Hist - Obs) 72.5
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -22.5
(Hist - Obs) -67.0
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (cfs) - 458 380
Mean (cfs) 3263 3100 3334
Flow (1000cfs)
Oct-00
Oct-01
Oct-02
Oct-03
Oct-04
Oct-05
Oct-06
Oct-07

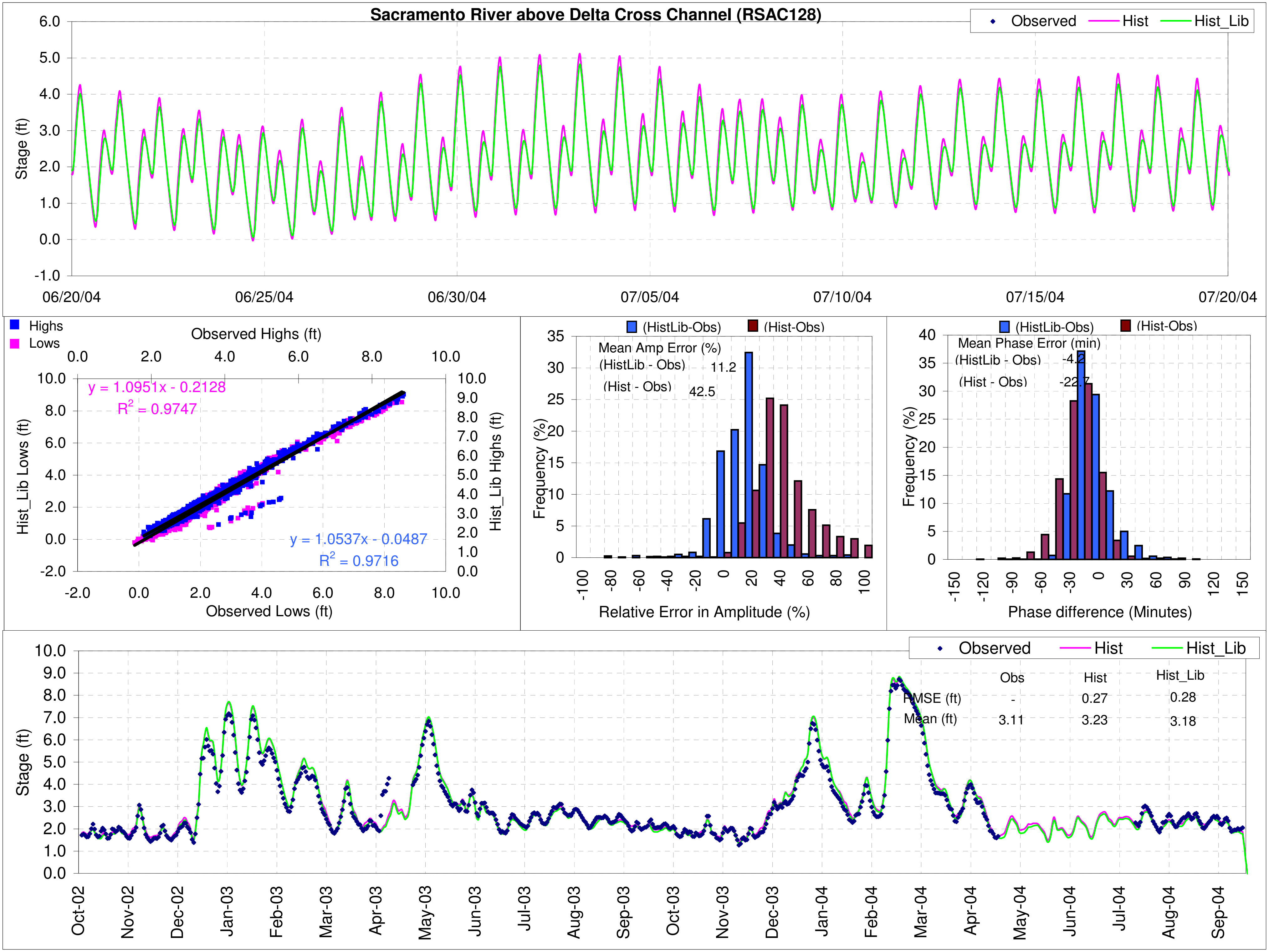

Cache Slough at Ryer Island (CacheSI)
Observed
Hist
Hist_Lib
Flow (1000cfs)
150
100
50
0
-50
-100
-150
06/20/08
06/25/08
06/30/08
07/05/08
07/10/08
07/15/08
07/20/08
Highs
Lows
Observed Highs (1000cfs)
0.0
20.0
40.0
60.0
80.0
100.0
120.0
y = 0.9652x - 3435.5
R^2 = 0.7947
y = 0.7974x + 11327
R^2 = 0.775
Hist_Lib Lows (1000cfs)
Hist_Lib Highs (1000cfs)
-120.0
-100.0
-80.0
-60.0
-40.0
-20.0
0.0
Observed Lows (1000cfs)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) -1.2
(Hist - Obs) -37.3
Frequency (%)
Relative Error in Amplitude (%)
-100
-80
-60
-40
-20
0
20
40
60
80
100
(HistLib-Obs)
(Hist-Obs)
Mean Phase Error (min)
(HistLib - Obs) -30.8
(Hist - Obs) -94.5
Frequency (%)
Phase difference (Minutes)
-150
-120
-90
-60
-30
0
30
60
90
120
150
Observed
Hist
Hist_Lib
Obs
Hist
Hist_Lib
RMSE (cfs) - 1755 1721
Mean (cfs) 2320 2366 2576
Flow (1000cfs)
300.0
250.0
200.0
150.0
100.0
50.0
0.0
-50.0
Oct-00
Oct-01
Oct-02
Oct-03
Oct-04
Oct-05
Oct-06
Oct-07


Cross Delta Flow (RSAC128 - RSAC123)
Observed
Hist
Hist_Lib
Flow (1000cfs)
14
12
10
8
6
4
2
0
-2
-4
06/20/08
06/25/08
06/30/08
07/05/08
07/10/08
07/15/08
07/20/08

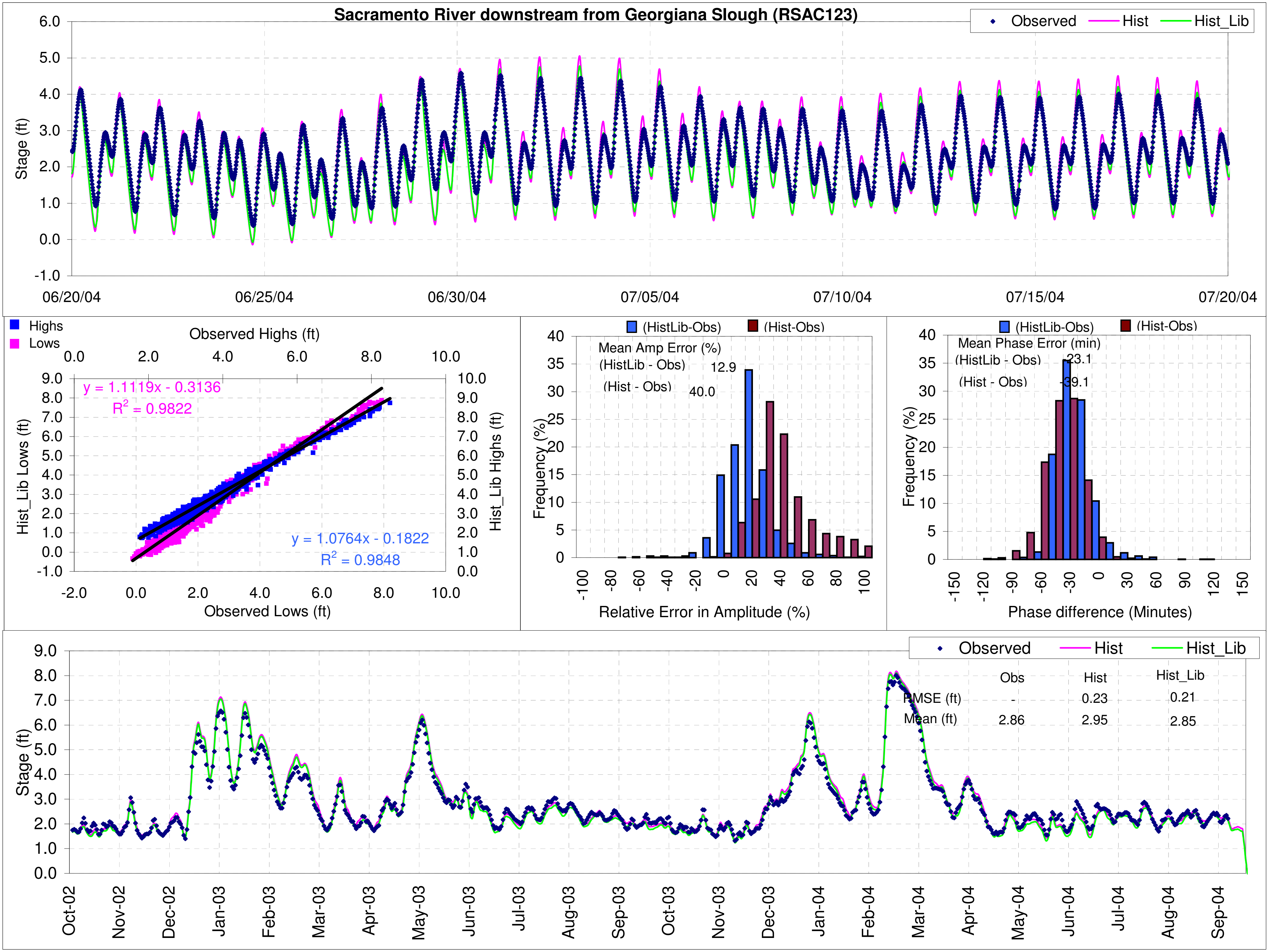

Observed
Hist
Hist_Lib
Obs
Hist
Hist_Lib
RMSE (cfs)
-
728
605
Mean (cfs)
4988
5789
5596
Flow (1000cfs)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Oct-00
Oct-01
Oct-02
Oct-03
Oct-04
Oct-05
Oct-06
Oct-07



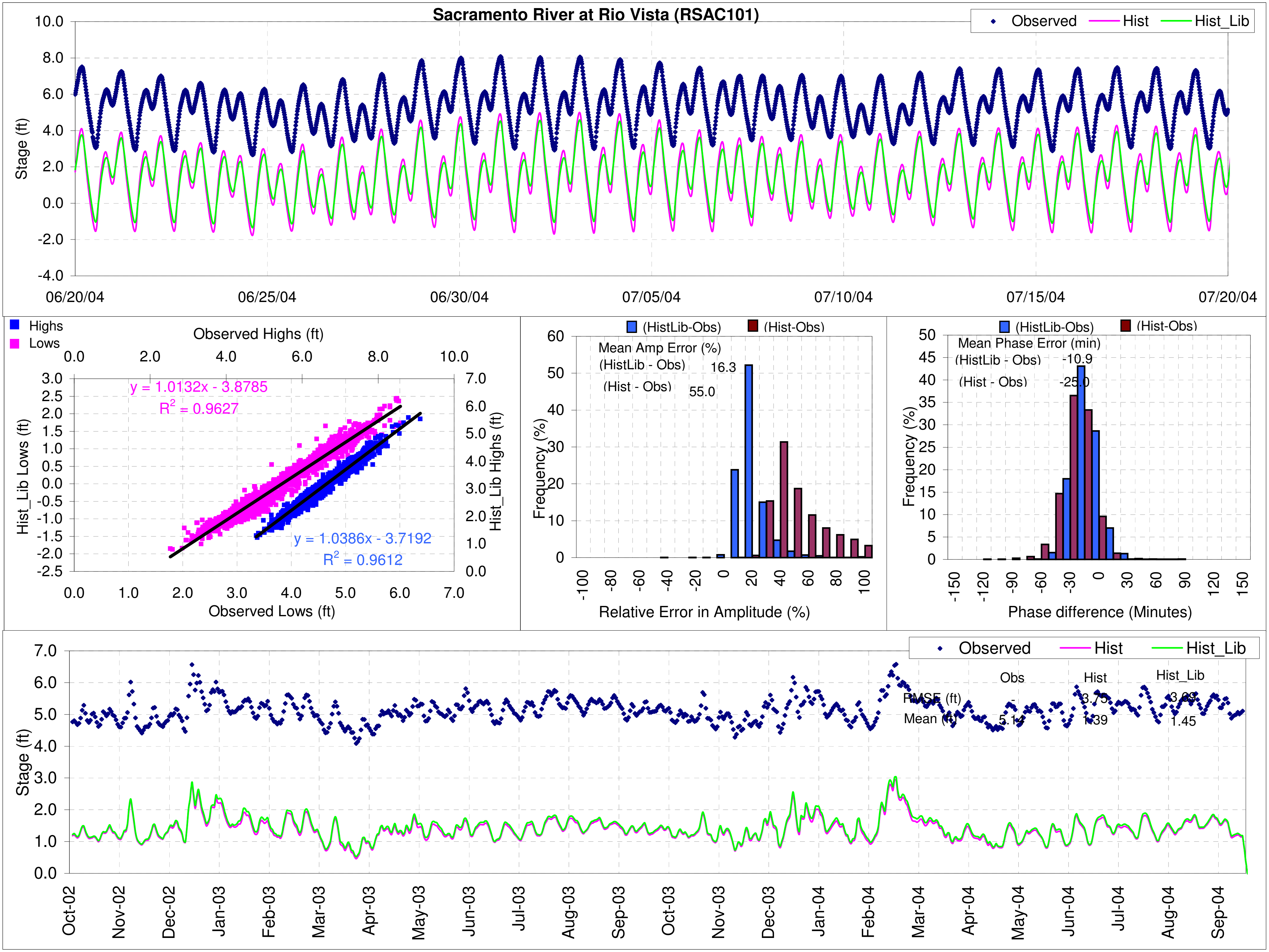
Sacramento River at Freeport (RSAC155)
Observed
Hist
Hist_Lib
Stage (ft)
06/20/04
06/25/04
06/30/04
07/05/04
07/10/04
07/15/04
07/20/04
Highs
Lows
Observed Highs (ft)
y = 1.0455x - 0.5732
R² = 0.9878
y = 1.0452x - 0.5909
R² = 0.9888
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 7.3
(Hist - Obs) 20.6
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -19.1
(Hist - Obs) -33.6
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) - 0.74 0.45
Mean (ft) 5.42 5.87 5.05
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04



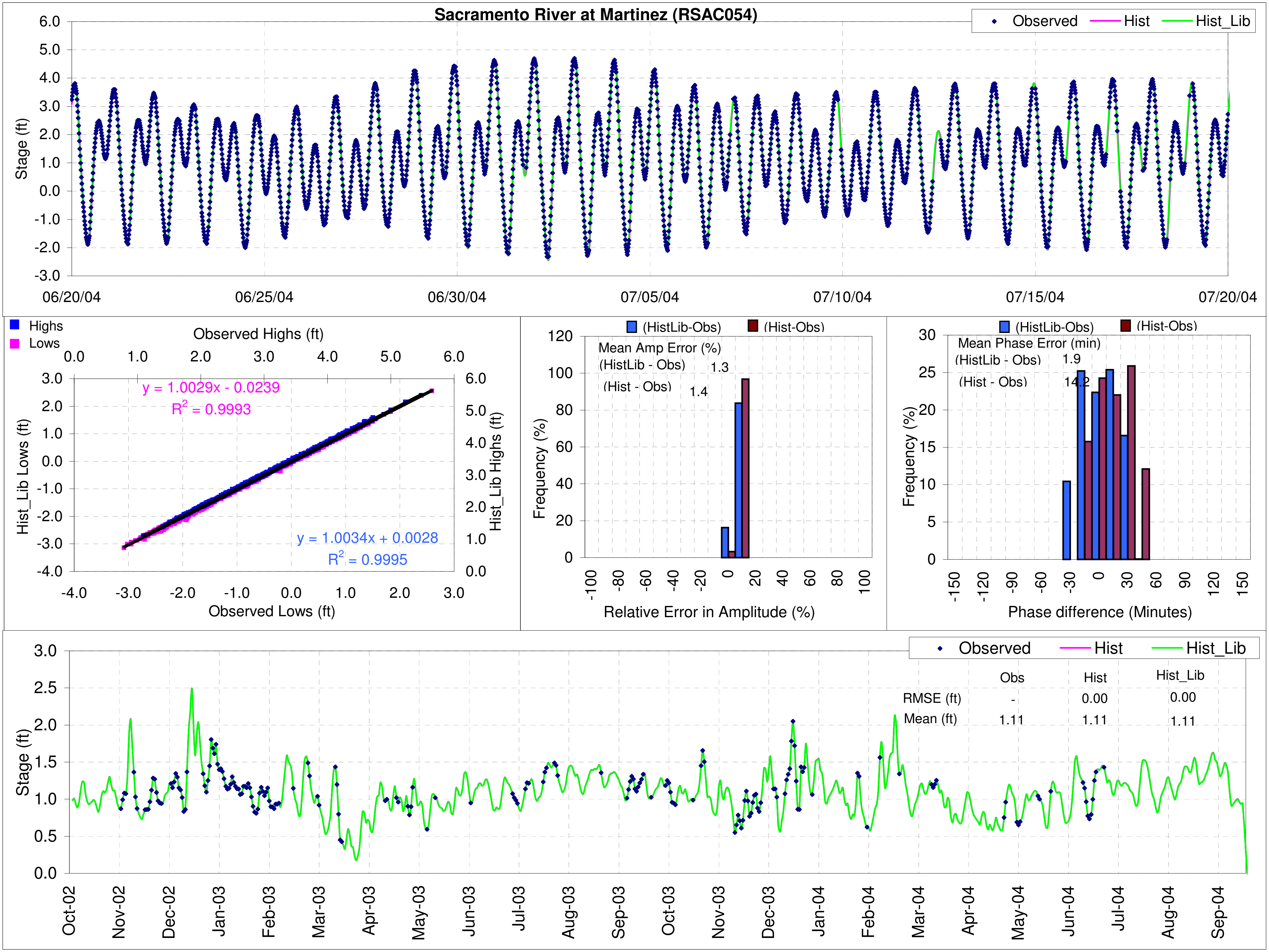
Sacramento River above Delta Cross Channel (RSAC128)
Observed
Hist
Hist_Lib
Stage (ft)
06/20/04
06/25/04
06/30/04
07/05/04
07/10/04
07/15/04
07/20/04
Highs
Lows
Observed Highs (ft)
y = 1.0951x - 0.2128
R2 = 0.9747
y = 1.0537x - 0.0487
R2 = 0.9716
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 11.2
(Hist - Obs) 42.5
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -4.2
(Hist - Obs) -22.7
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) - 0.27 0.28
Mean (ft) 3.11 3.23 3.18
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04



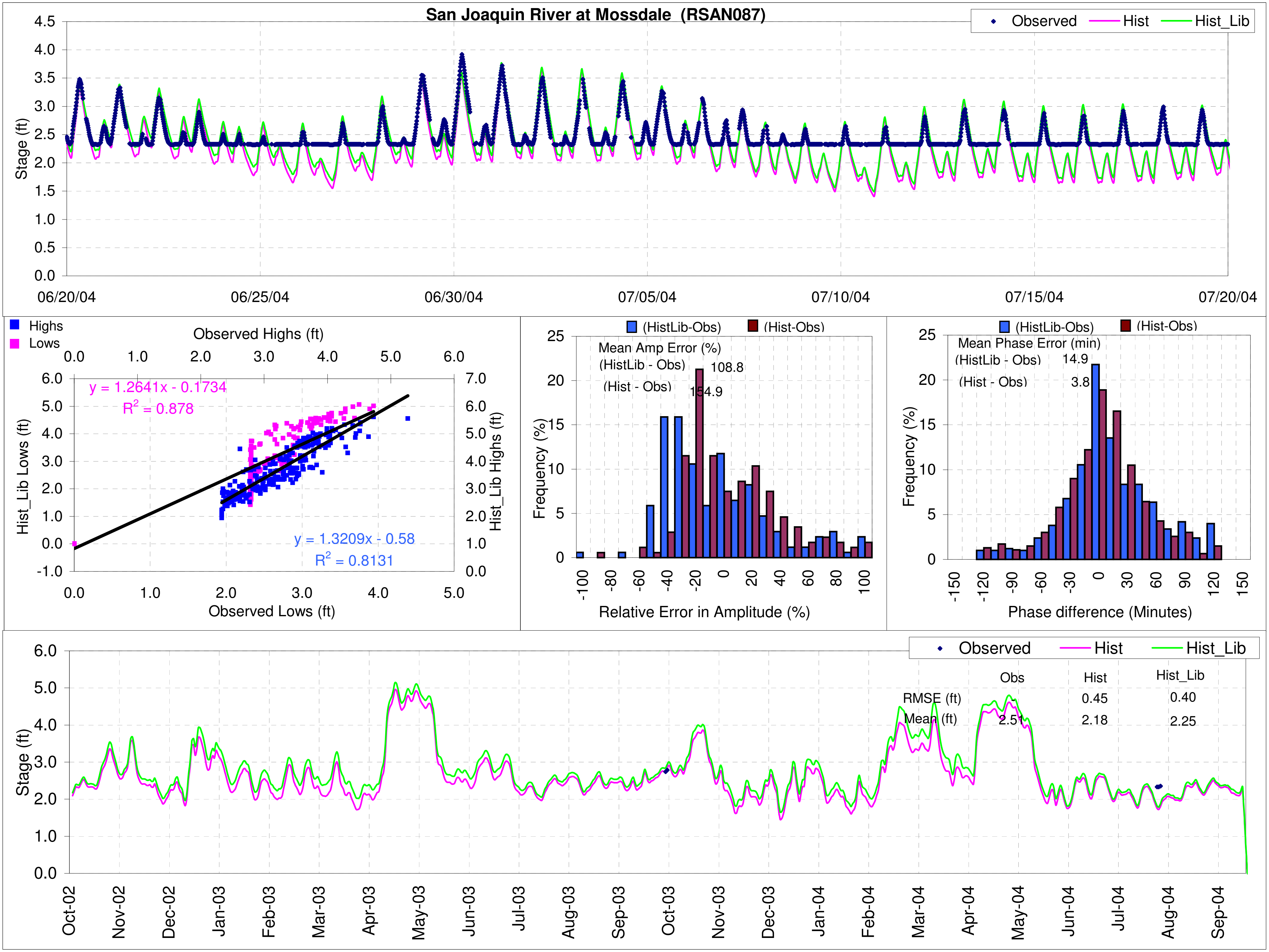
Sacramento River downstream from Georgiana Slough (RSAC123)
Observed
Hist
Hist_Lib
Stage (ft)
06/20/04
06/25/04
06/30/04
07/05/04
07/10/04
07/15/04
07/20/04
Highs
Lows
Observed Highs (ft)
y = 1.1119x - 0.3136
R2 = 0.9822
y = 1.0764x - 0.1822
R2 = 0.9848
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 12.9
(Hist - Obs) 40.0
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -23.1
(Hist - Obs) -39.1
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) - 0.23 0.21
Mean (ft) 2.86 2.95 2.85
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04



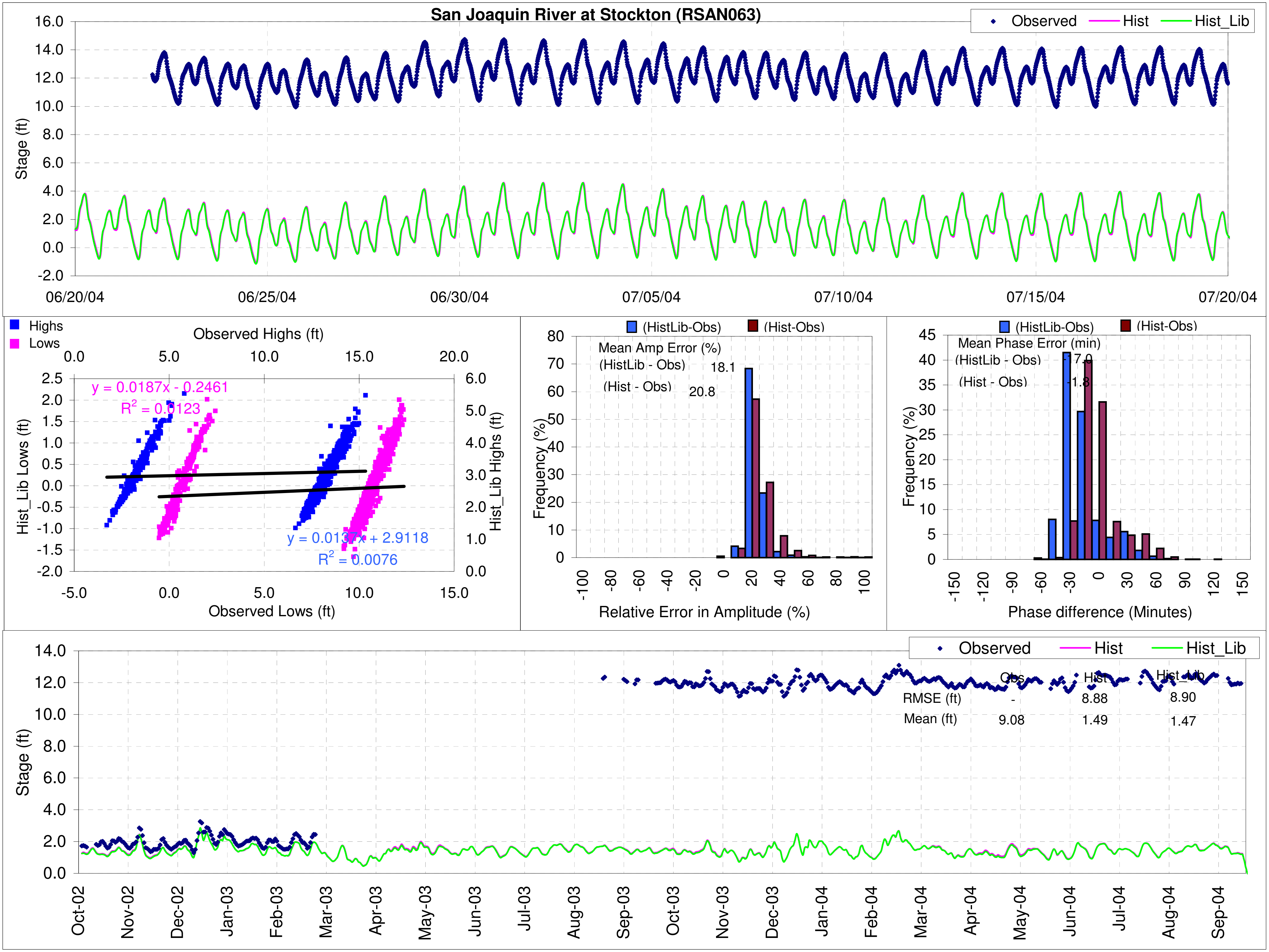
Sacramento River at Rio Vista (RSAC101)
Observed
Hist
Hist_Lib
Stage (ft)
06/20/04
06/25/04
06/30/04
07/05/04
07/10/04
07/15/04
07/20/04
Highs
Lows
Observed Highs (ft)
y = 1.0132x - 3.8785
R2 = 0.9627
y = 1.0386x - 3.7192
R2 = 0.9612
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 16.3
(Hist - Obs) 55.0
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -10.9
(Hist - Obs) -25.0
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft)
Mean (ft)
5.14
3.75
3.69
1.39
1.45
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04

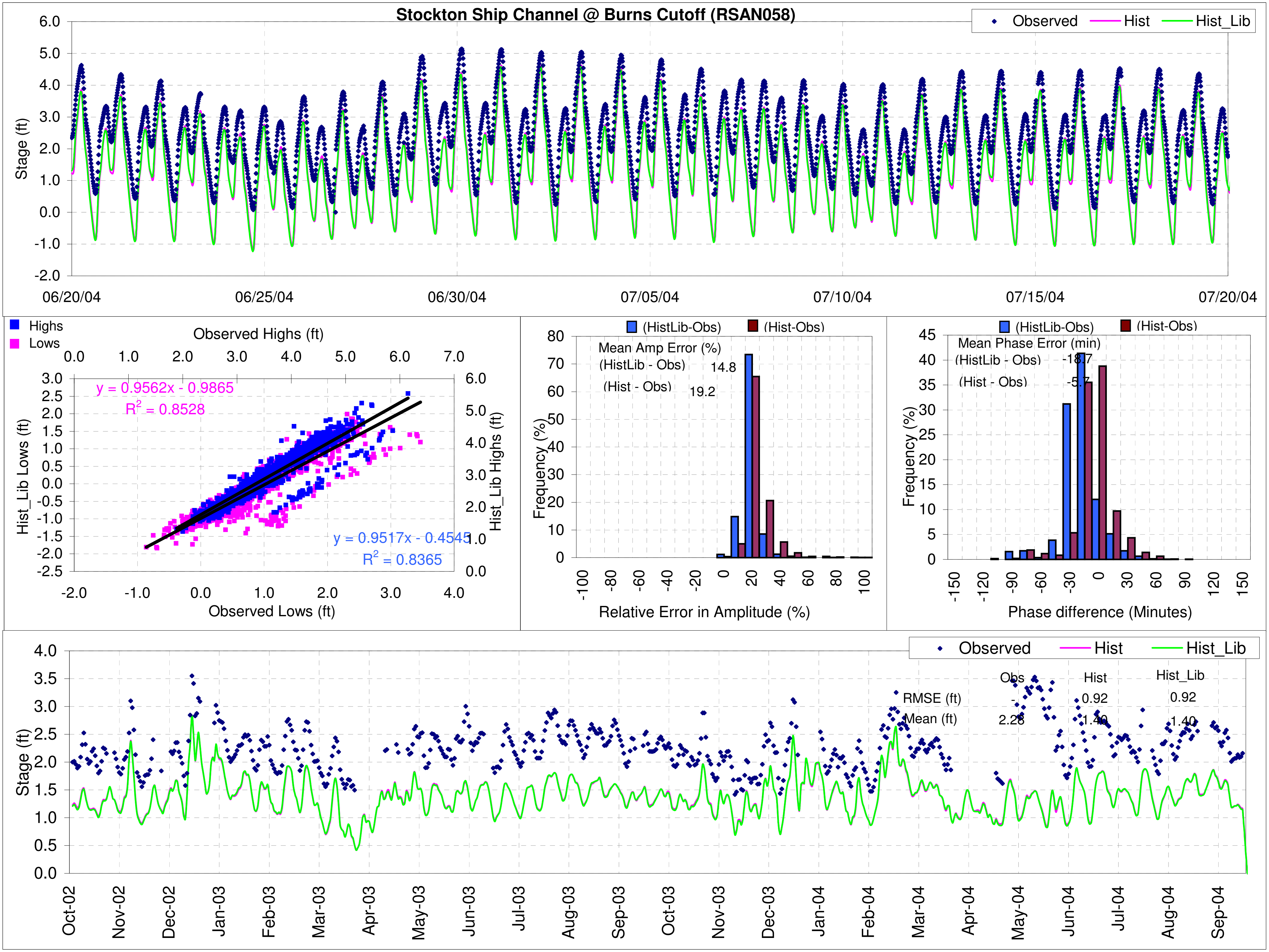


Sacramento River at Martinez (RSAC054)
Observed
Hist
Hist_Lib
Stage (ft)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
06/20/04
06/25/04
06/30/04
07/05/04
07/10/04
07/15/04
07/20/04
Highs
Lows
Observed Highs (ft)
y = 1.0029x - 0.0239
R2 = 0.9993
y = 1.0034x + 0.0028
R2 = 0.9995
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 1.3
(Hist - Obs) 1.4
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) 1.9
(Hist - Obs) 14.2
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) - 0.00 0.00
Mean (ft) 1.11 1.11 1.11
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04

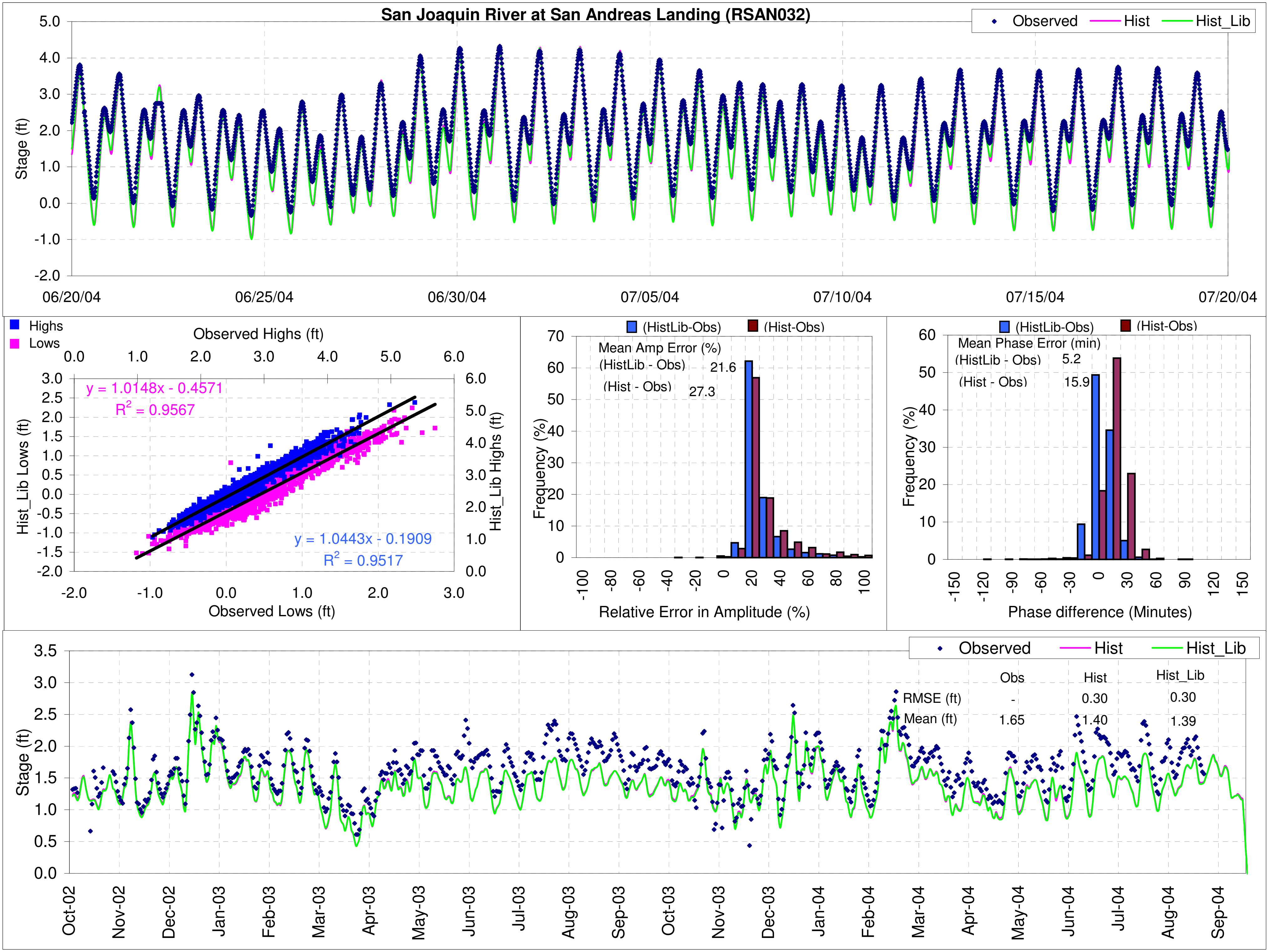


San Joaquin River at Mossdale (RSAN087)
Observed
Hist
Hist_Lib
Stage (ft)
06/20/04
06/25/04
06/30/04
07/05/04
07/10/04
07/15/04
07/20/04
Highs
Lows
Observed Highs (ft)
Observed Lows (ft)
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
y = 1.2641x - 0.1734
R2 = 0.878
y = 1.3209x - 0.58
R2 = 0.8131
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 108.8
(Hist - Obs) 154.9
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) 14.9
(Hist - Obs) 3.8
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) 0.45 0.40
Mean (ft) 2.51 2.18 2.25
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04

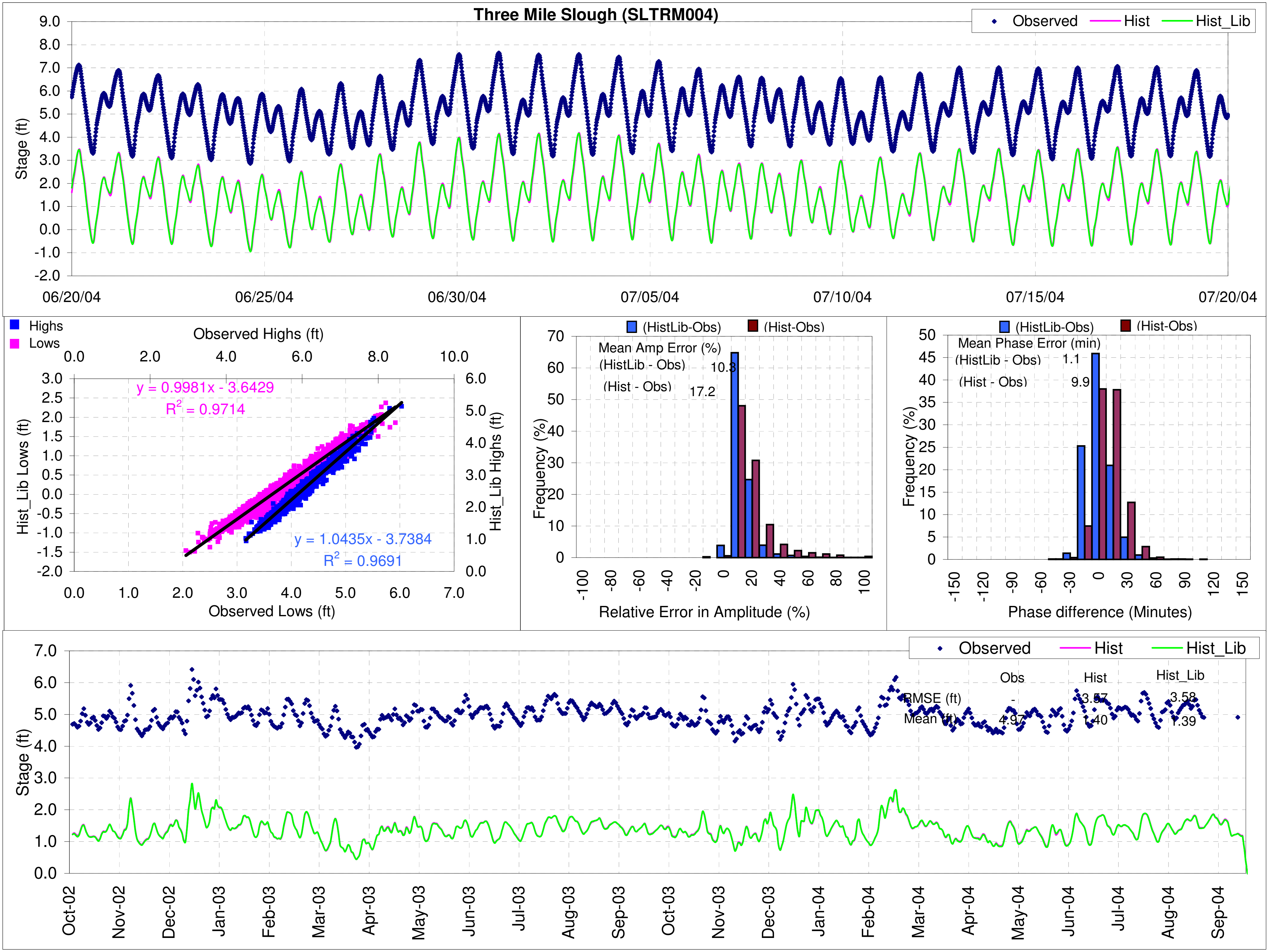

San Joaquin River at Stockton (RSAN063)
Observed
Hist
Hist_Lib
Stage (ft)
06/20/04
06/25/04
06/30/04
07/05/04
07/10/04
07/15/04
07/20/04
Highs
Lows
Observed Highs (ft)
Observed Lows (ft)
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
y = 0.0187x - 0.2461
R^2 = 0.0123
y = 0.0137x + 2.9118
R^2 = 0.0076
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 18.1
(Hist - Obs) 20.8
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -17.0
(Hist - Obs) -1.8
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) - 8.88 8.90
Mean (ft) 9.08 1.49 1.47
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04



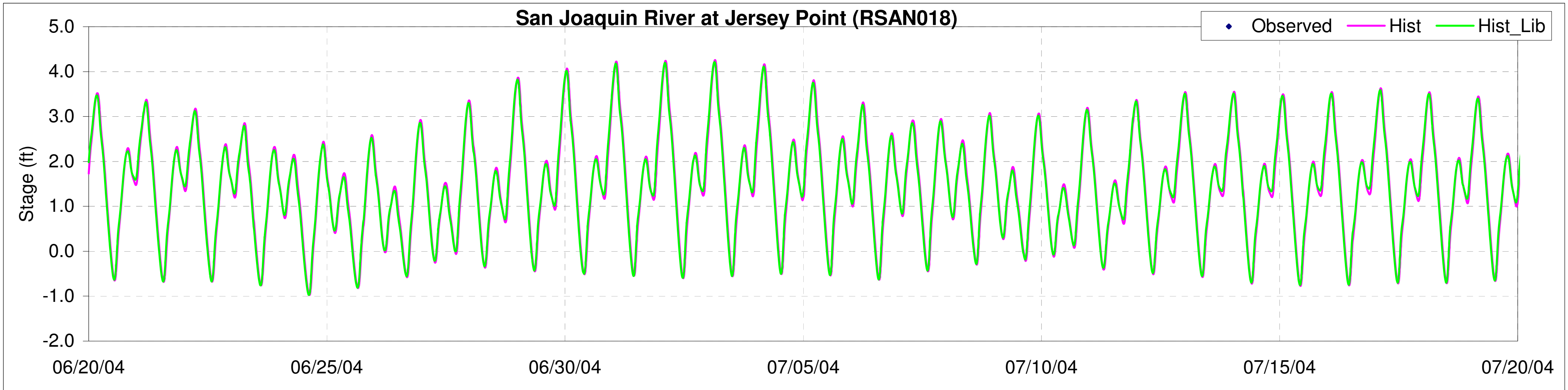
Stockton Ship Channel @ Burns Cutoff (RSAN058)
Observed
Hist
Hist_Lib
Stage (ft)
06/20/04
06/25/04
06/30/04
07/05/04
07/10/04
07/15/04
07/20/04
Highs
Lows
Observed Highs (ft)
y = 0.9562x - 0.9865
R2 = 0.8528
y = 0.9517x - 0.4545
R2 = 0.8365
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 14.8
(Hist - Obs) 19.2
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -18.7
(Hist - Obs) -5.7
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) - 0.92 0.92
Mean (ft) 2.28 1.40 1.40
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04

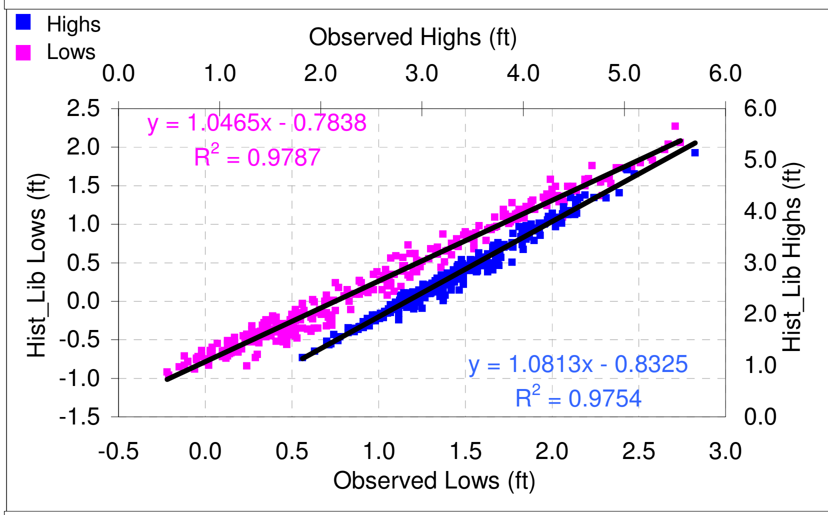


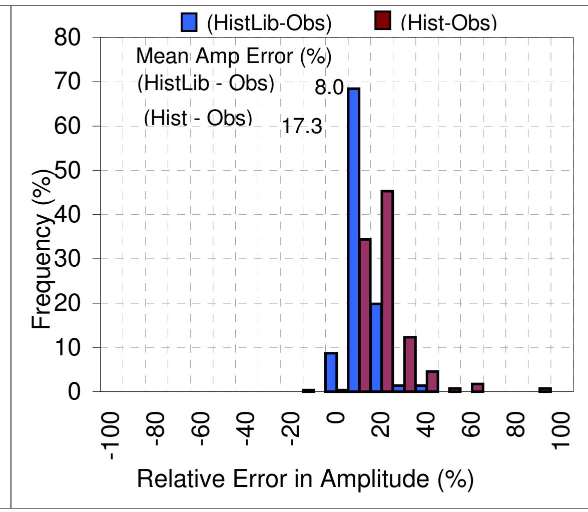
San Joaquin River at San Andreas Landing (RSAN032)
Observed
Hist
Hist_Lib
Stage (ft)
06/20/04
06/25/04
06/30/04
07/05/04
07/10/04
07/15/04
07/20/04
Highs
Lows
Observed Highs (ft)
y = 1.0148x - 0.4571
R^2 = 0.9567
y = 1.0443x - 0.1909
R^2 = 0.9517
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 21.6
(Hist - Obs) 27.3
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) 5.2
(Hist - Obs) 15.9
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) - 0.30 0.30
Mean (ft) 1.65 1.40 1.39
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04

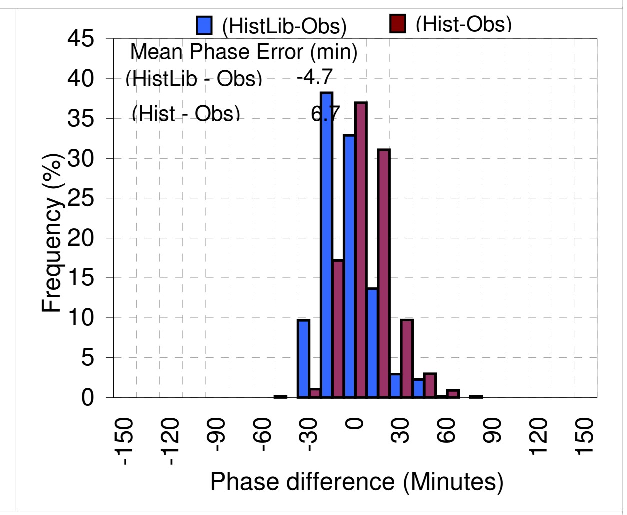


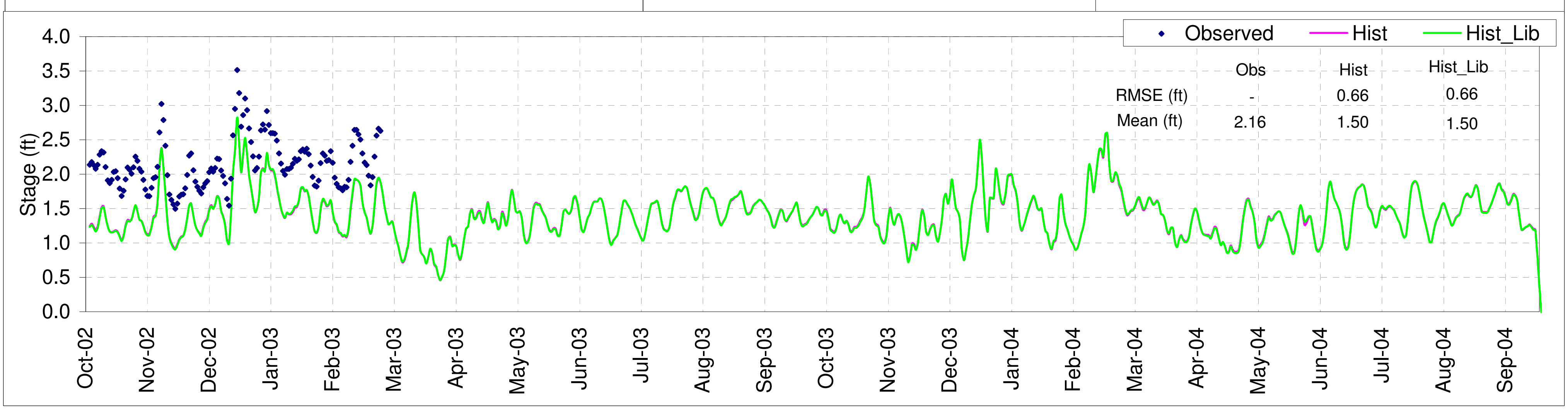
Three Mile Slough (SLTRM004)
Observed
Hist
Hist_Lib
Stage (ft)
06/20/04
06/25/04
06/30/04
07/05/04
07/10/04
07/15/04
07/20/04
Highs
Lows
Observed Highs (ft)
y = 0.9981x - 3.6429
R2 = 0.9714
y = 1.0435x - 3.7384
R2 = 0.9691
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 10.3
(Hist - Obs) 17.2
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) 1.1
(Hist - Obs) 9.9
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) - 3.57 3.58
Mean (ft) 4.97 1.40 1.39
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04

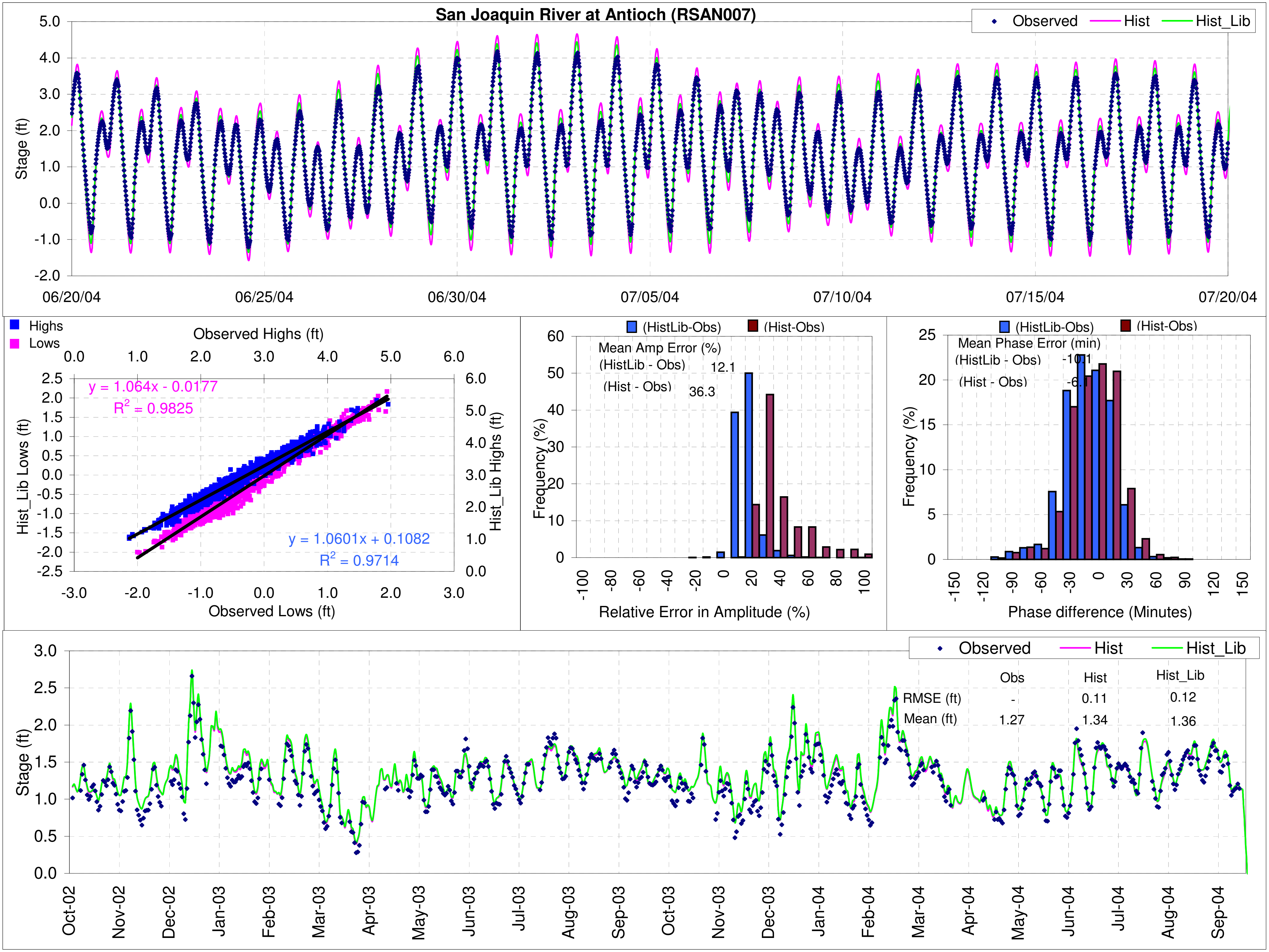

San Joaquin River at Jersey Point (RSAN018)
Observed
Hist
Hist_Lib
Stage (ft)
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
06/20/04
06/25/04
06/30/04
07/05/04
07/10/04
07/15/04
07/20/04


Highs
Lows
Observed Highs (ft)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
y = 1.0465x - 0.7838
R^2 = 0.9787
y = 1.0813x - 0.8325
R^2 = 0.9754
Hist_Lib Lows (ft)
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
Hist_Lib Highs (ft)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Observed Lows (ft)

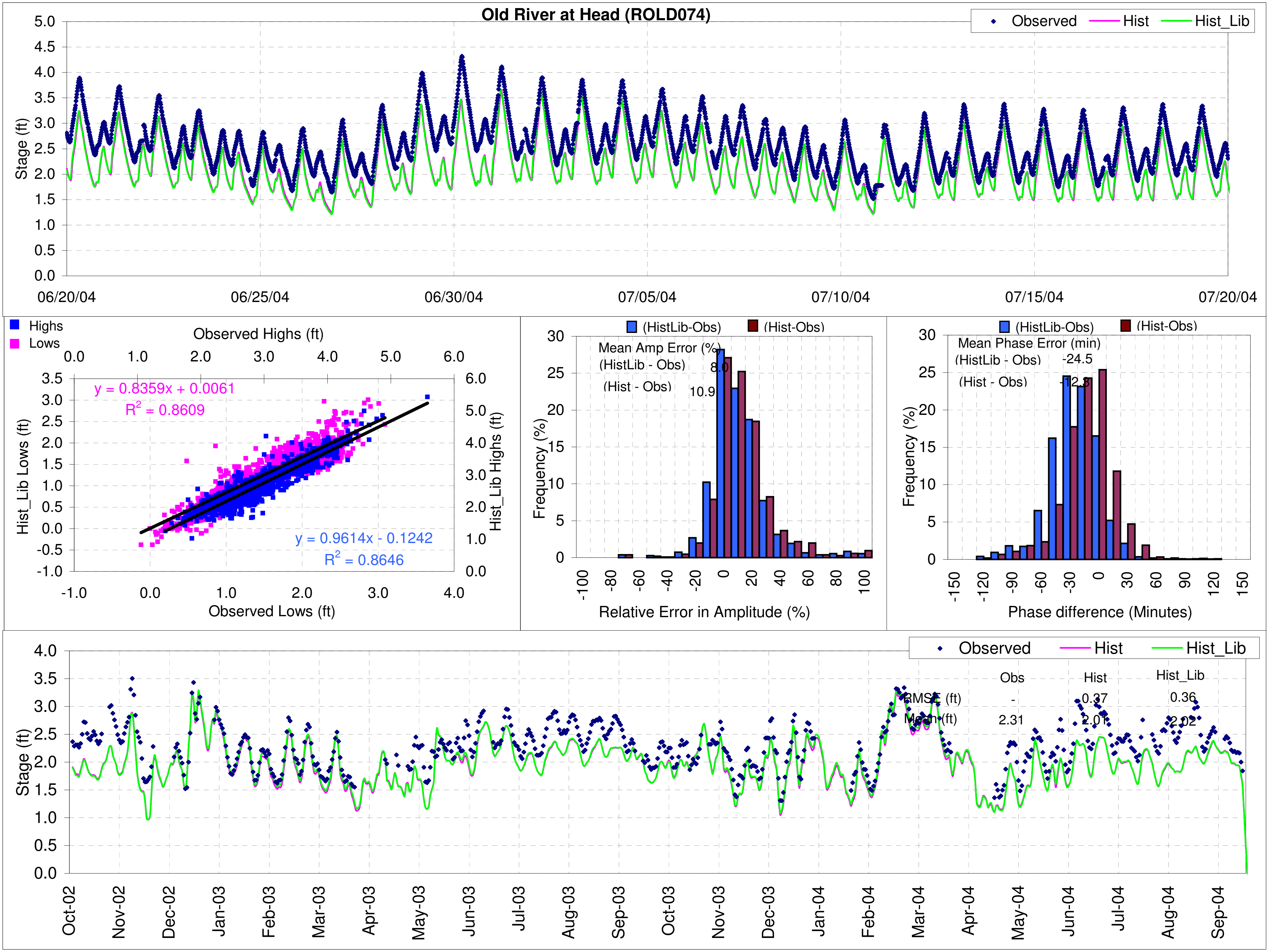

(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 8.0
(Hist - Obs) 17.3
Frequency (%)
80
70
60
50
40
30
20
10
0
-100
-80
-60
-40
-20
0
20
40
60
80
100
Relative Error in Amplitude (%)


(HistLib-Obs)
(Hist-Obs)
Mean Phase Error (min)
(HistLib - Obs) -4.7
(Hist - Obs) 6.7
Frequency (%)
45
40
35
30
25
20
15
10
5
0
-150
-120
-90
-60
-30
0
30
60
90
120
150
Phase difference (Minutes)

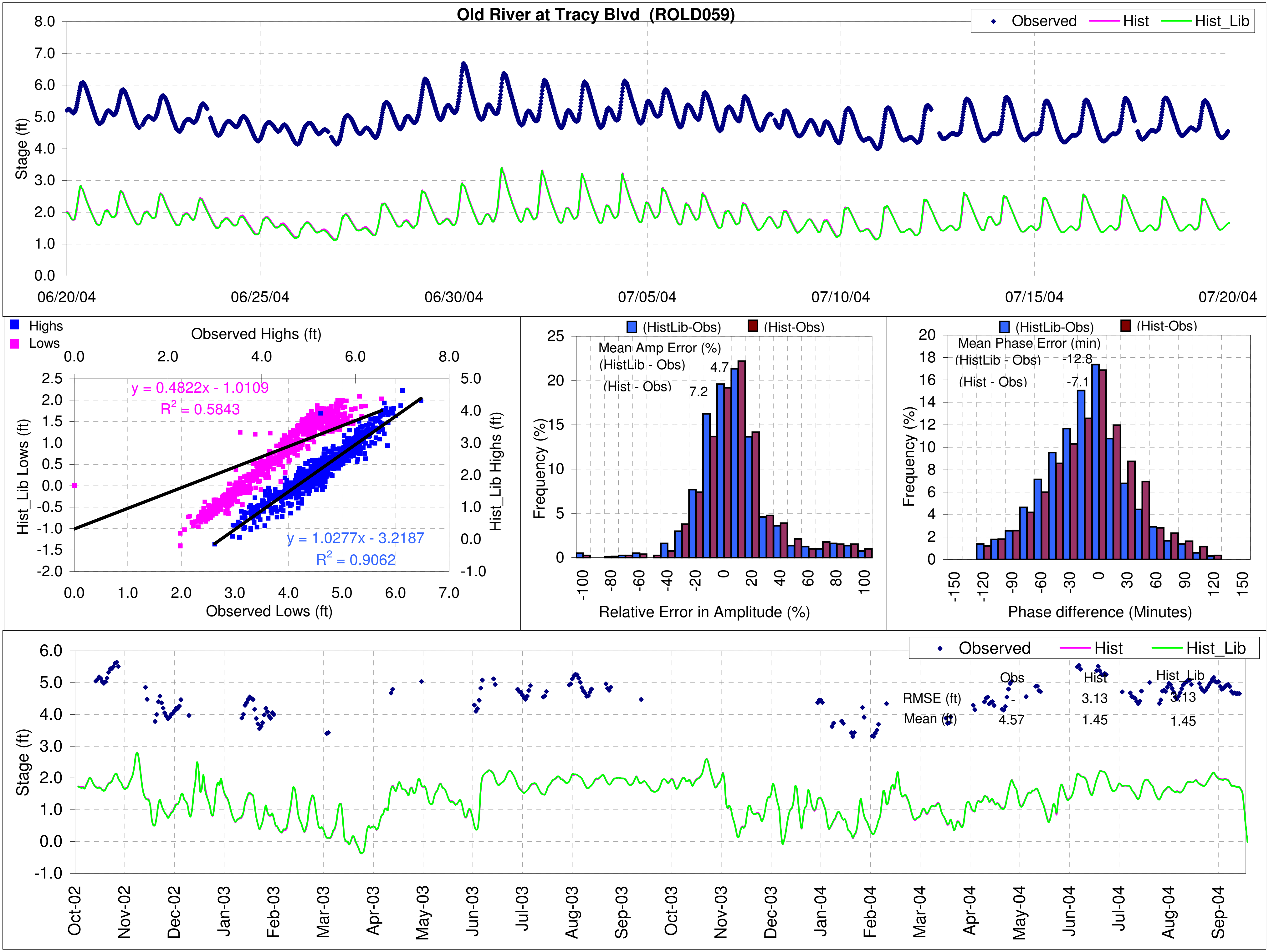

Observed
Hist
Hist_Lib
Obs
Hist
Hist_Lib
RMSE (ft) - 0.66 0.66
Mean (ft) 2.16 1.50 1.50
Stage (ft)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04



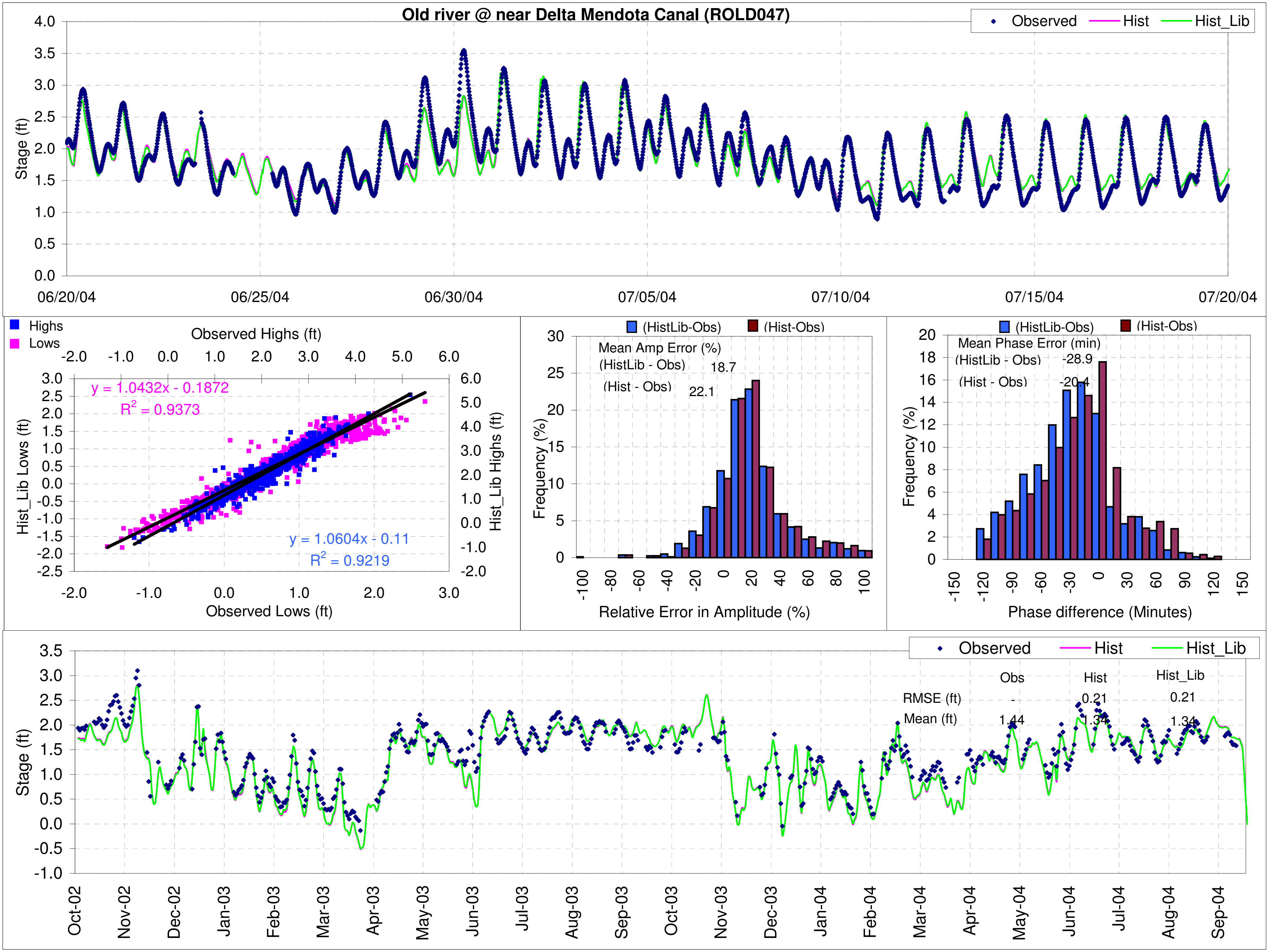
San Joaquin River at Antioch (RSAN007)
Observed
Hist
Hist_Lib
Stage (ft)
06/20/04
06/25/04
06/30/04
07/05/04
07/10/04
07/15/04
07/20/04
Highs
Lows
Observed Highs (ft)
y = 1.064x - 0.0177
R2 = 0.9825
y = 1.0601x + 0.1082
R2 = 0.9714
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 12.1
(Hist - Obs) 36.3
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -10.1
(Hist - Obs) -6.
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) - 0.11 0.12
Mean (ft) 1.27 1.34 1.36



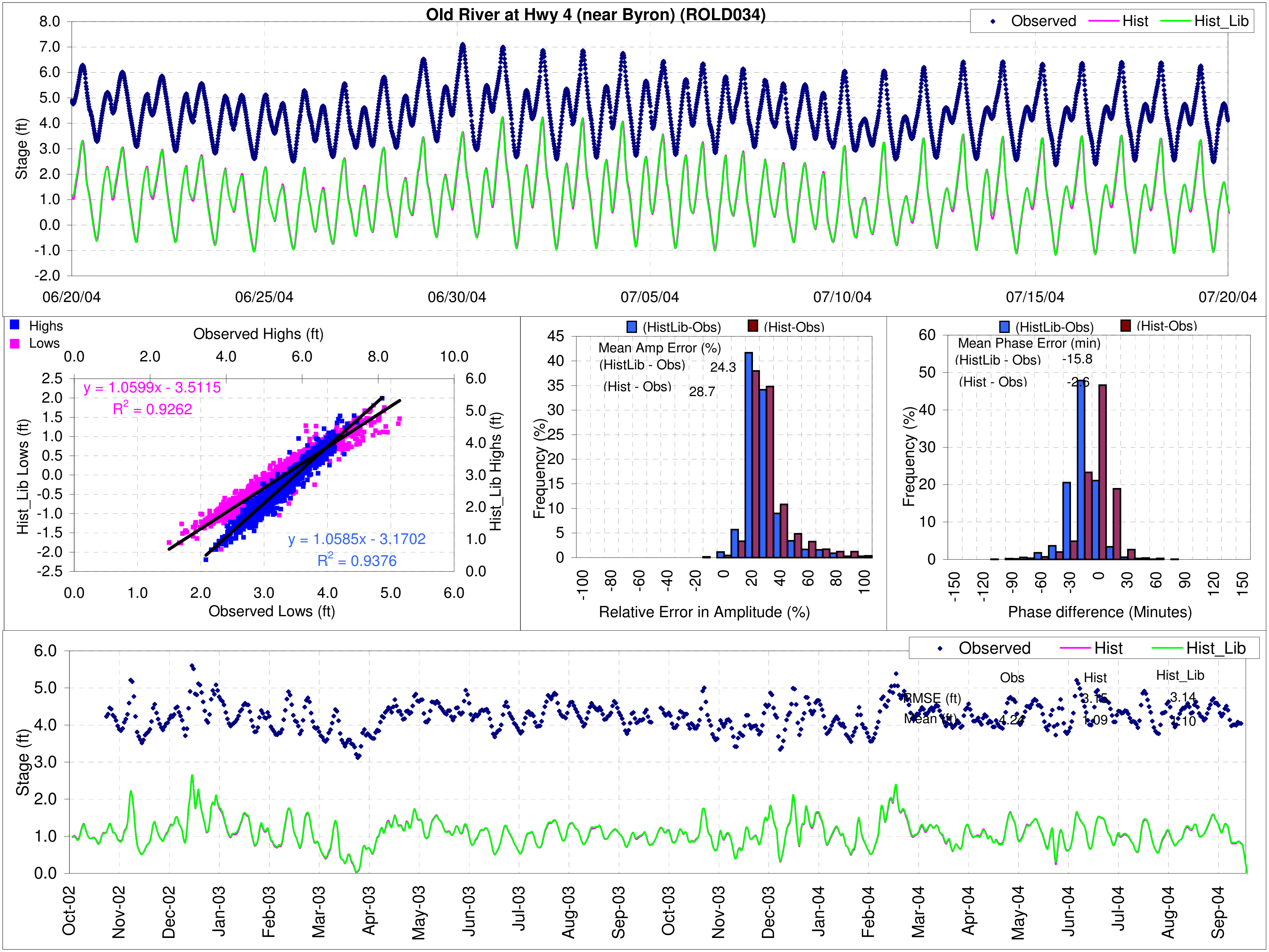
Old River at Head (ROLD074)
Observed
Hist
Hist_Lib
Stage (ft)
06/20/04
06/25/04
06/30/04
07/05/04
07/10/04
07/15/04
07/20/04
Highs
Lows
Observed Highs (ft)
y = 0.8359x + 0.0061
R² = 0.8609
y = 0.9614x - 0.1242
R² = 0.8646
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 8.0
(Hist - Obs) 10.9
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -24.5
(Hist - Obs) -12.3
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) - 0.37 0.36
Mean (ft) 2.31 2.01 2.02
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04

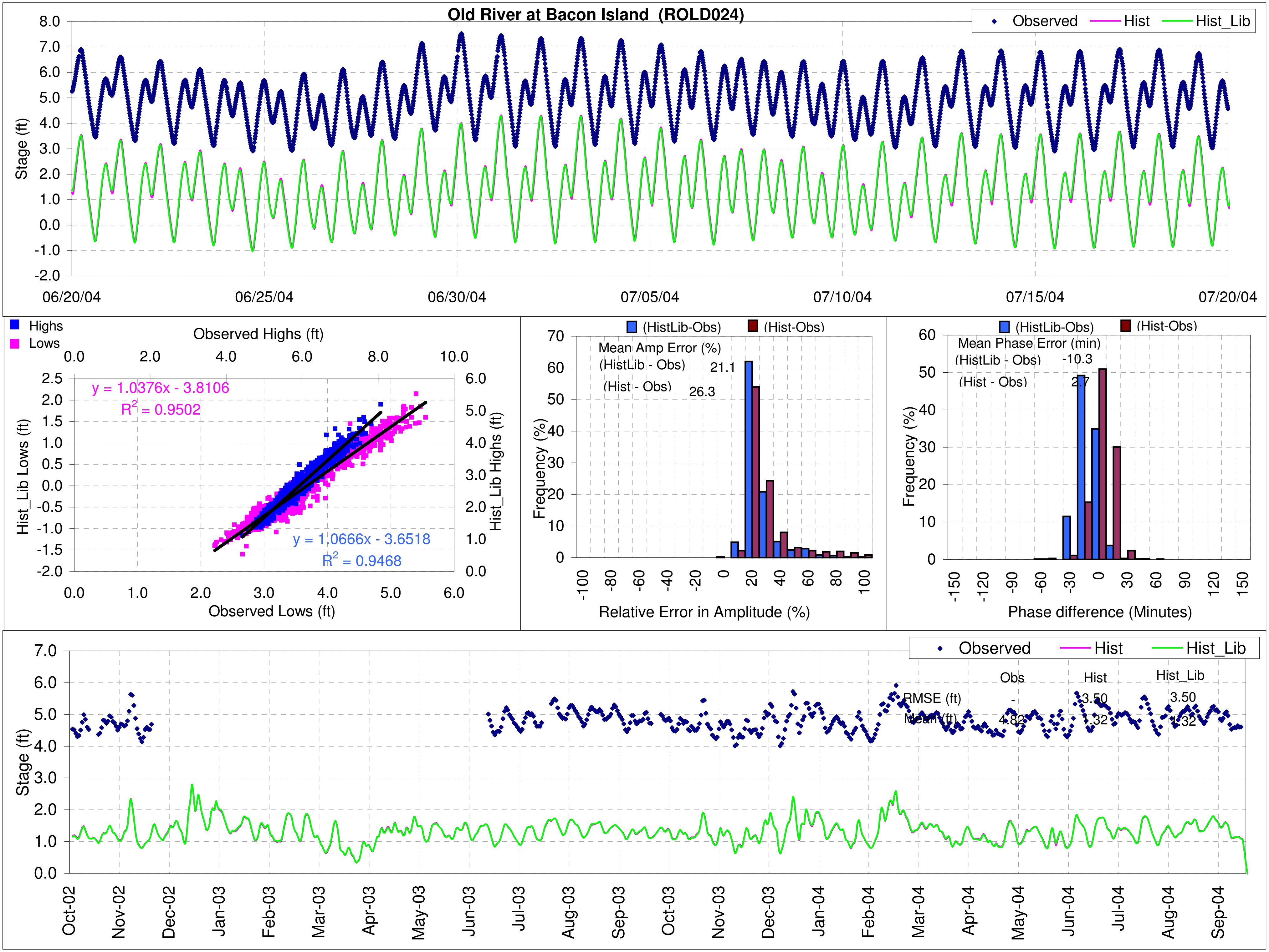


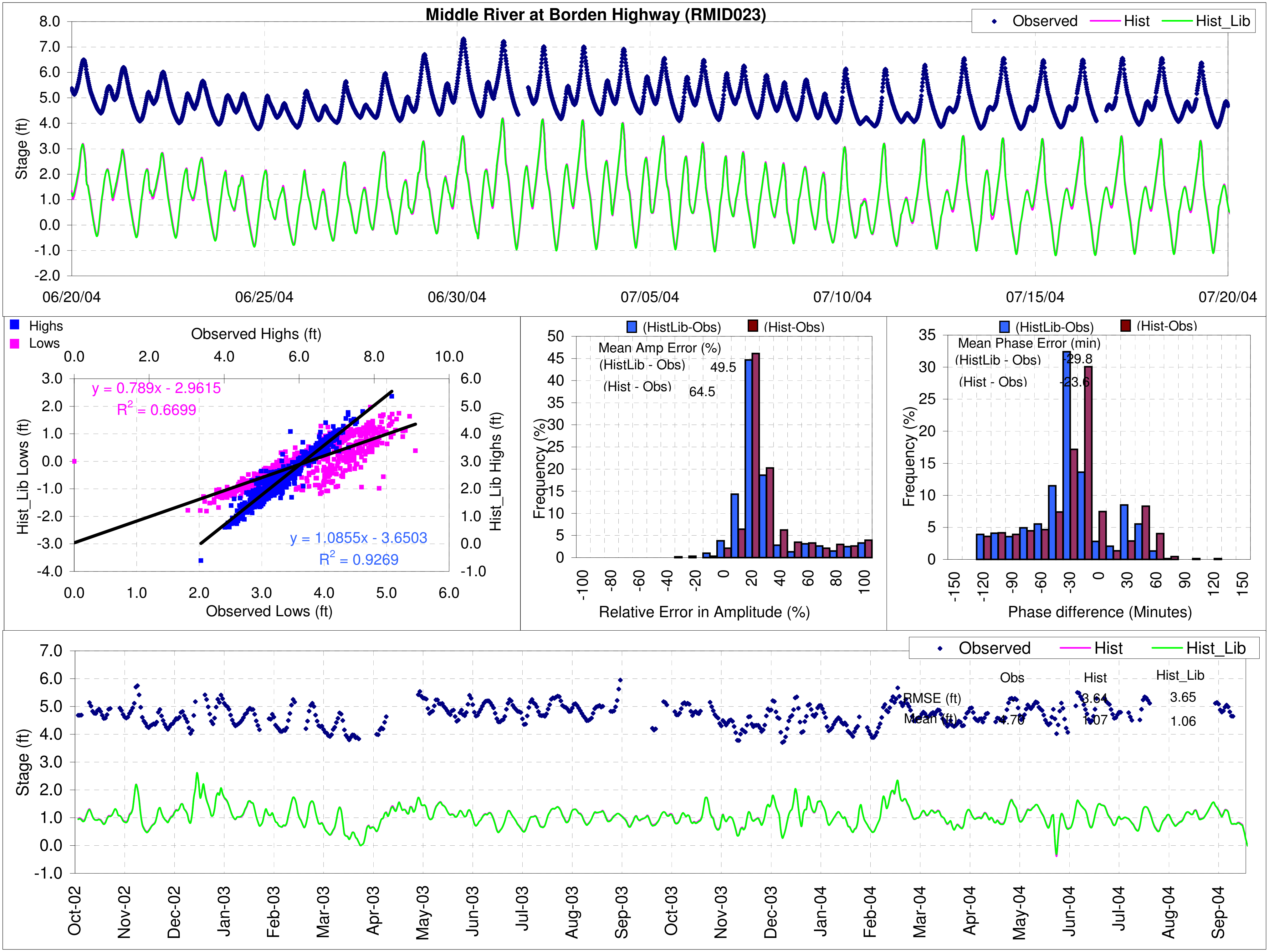
Old River at Tracy Blvd (ROLD059)
Observed
Hist
Hist_Lib
Stage (ft)
06/20/04
06/25/04
06/30/04
07/05/04
07/10/04
07/15/04
07/20/04
Highs
Lows
Observed Highs (ft)
y = 0.4822x - 1.0109
R2 = 0.5843
y = 1.0277x - 3.2187
R2 = 0.9062
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 4.7
(Hist - Obs) 7.2
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -12.8
(Hist - Obs) -7.1
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) - 3.13 3.13
Mean (ft) 4.57 1.45 1.45
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04



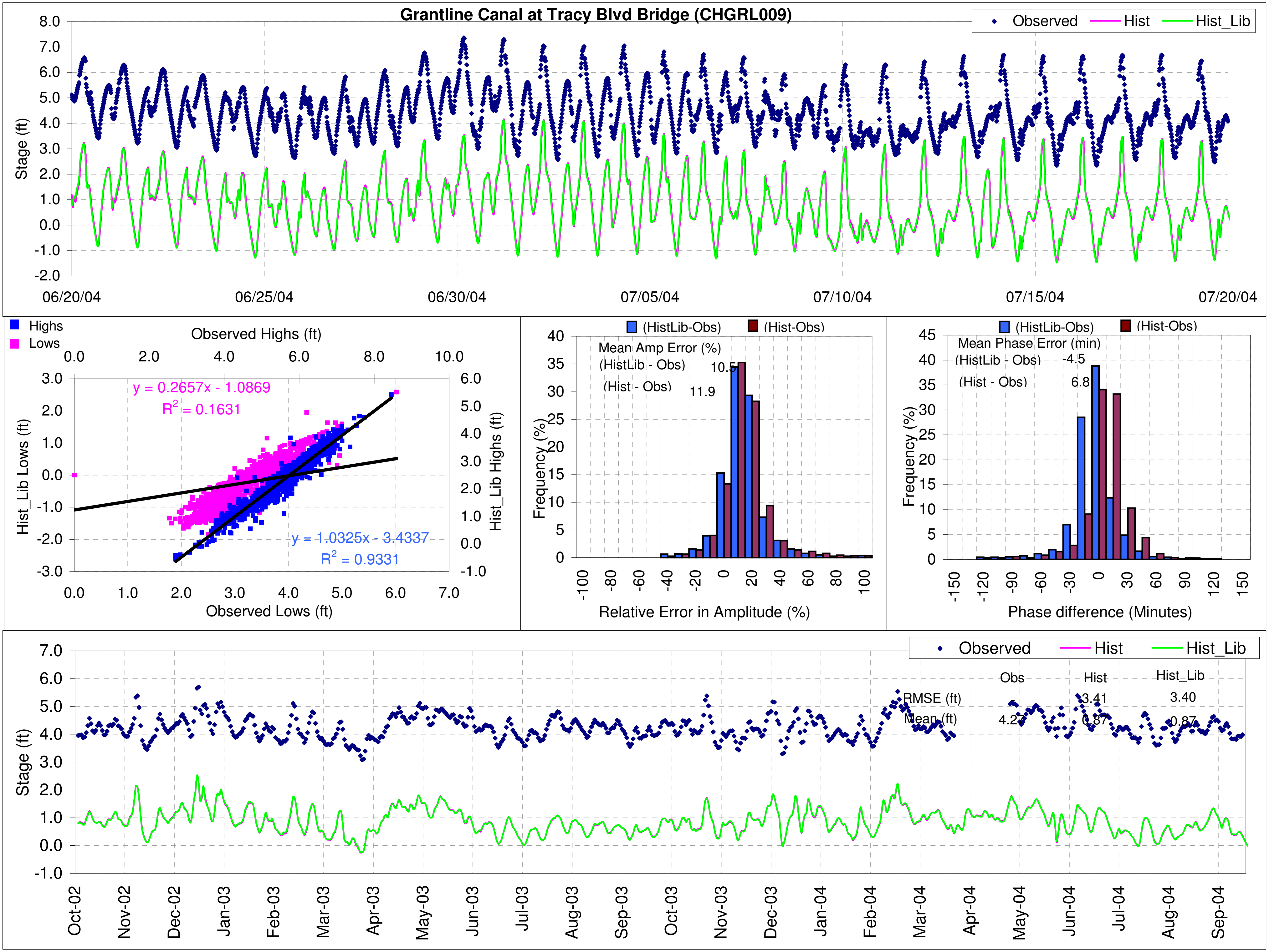
Old river @ near Delta Mendota Canal (ROLD047)
Observed
Hist
Hist_Lib
Stage (ft)
06/20/04
06/25/04
06/30/04
07/05/04
07/10/04
07/15/04
07/20/04
Highs
Lows
Observed Highs (ft)
y = 1.0432x - 0.1872
R2 = 0.9373
y = 1.0604x - 0.11
R2 = 0.9219
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 18.7
(Hist - Obs) 22.1
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -28.9
(Hist - Obs) -20.4
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) - 0.21 0.21
Mean (ft) 1.44 1.34 1.34
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04


Old River at Hwy 4 (near Byron) (ROLD034)
Observed
Hist
Hist_Lib
Stage (ft)
06/20/04
06/25/04
06/30/04
07/05/04
07/10/04
07/15/04
07/20/04
Highs
Lows
Observed Highs (ft)
y = 1.0599x - 3.5115
R^2 = 0.9262
y = 1.0585x - 3.1702
R^2 = 0.9376
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 24.3
(Hist - Obs) 28.7
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -15.8
(Hist - Obs) -2.6
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) 3.15 3.14
Mean (ft) 4.24 1.09 1.10
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04

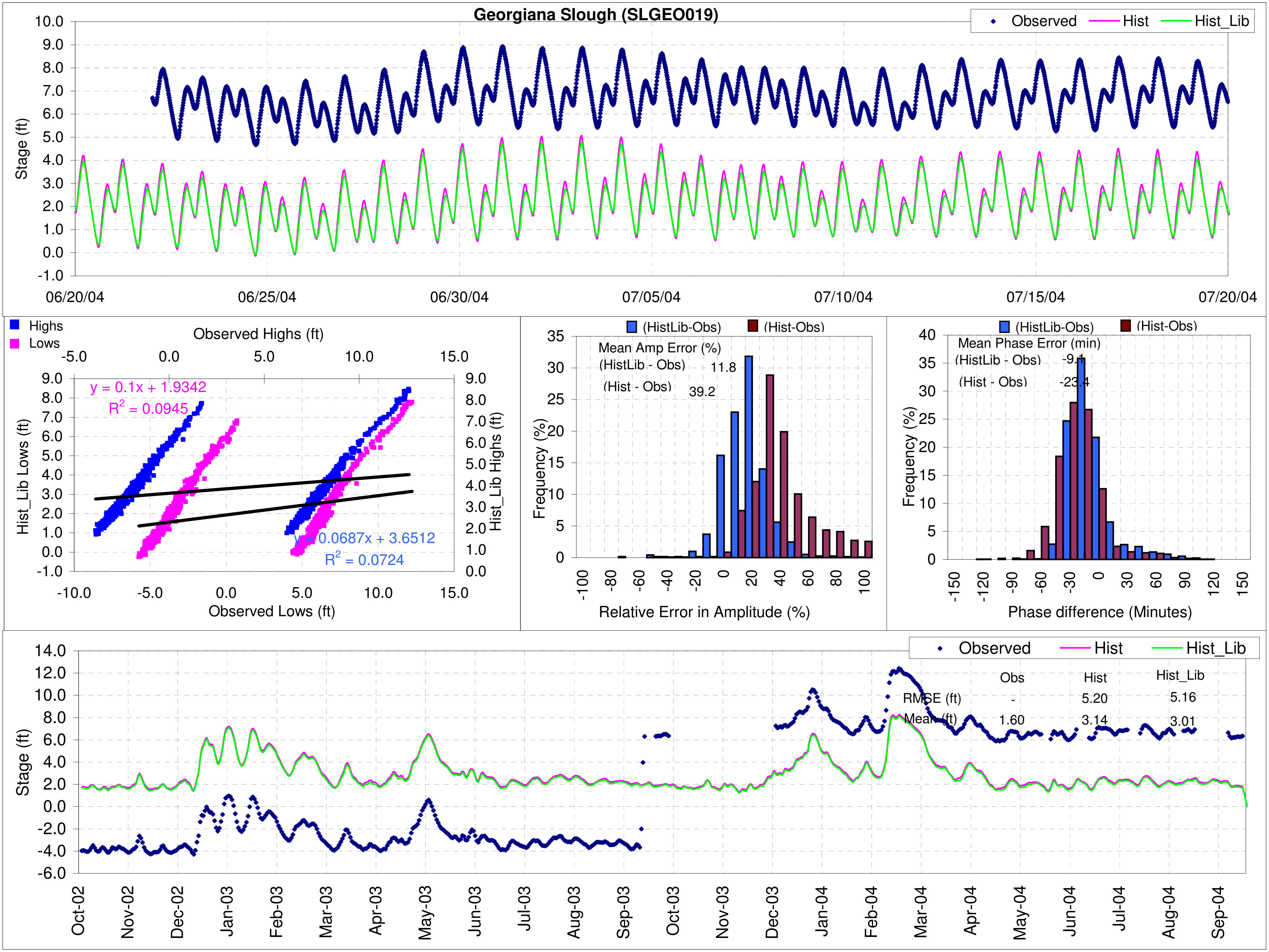

Old River at Bacon Island (ROLD024)
Observed
Hist
Hist_Lib
Stage (ft)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
06/20/04
06/25/04
06/30/04
07/05/04
07/10/04
07/15/04
07/20/04
Highs
Lows
Observed Highs (ft)
y = 1.0376x - 3.8106
R^2 = 0.9502
y = 1.0666x - 3.6518
R^2 = 0.9468
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 21.1
(Hist - Obs) 26.3
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -10.3
(Hist - Obs) 2.7
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) - 3.50 3.50
Mean (ft) 4.82 1.32 1.32
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04



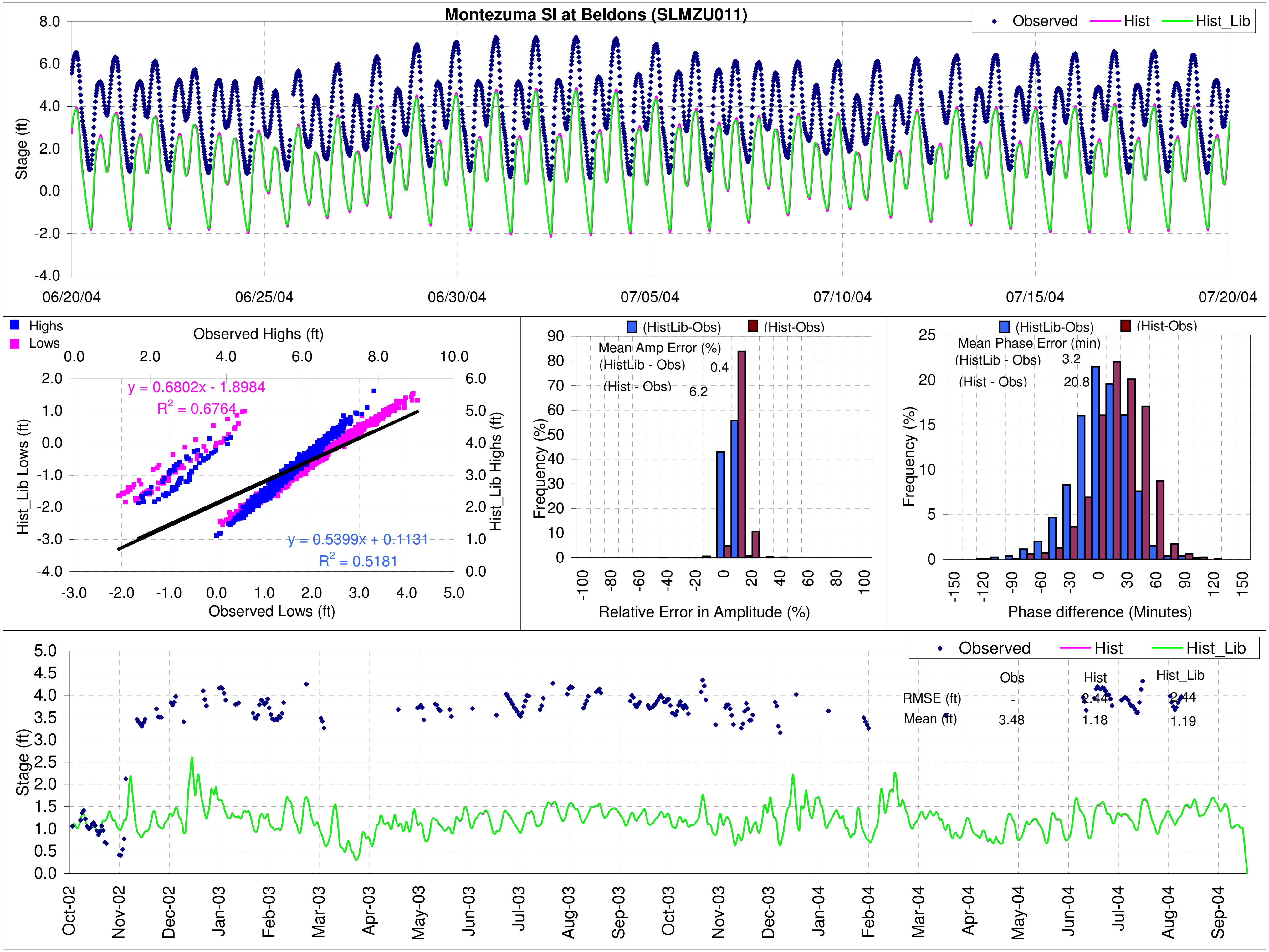
Middle River at Borden Highway (RMID023)
Observed
Hist
Hist_Lib
Stage (ft)
06/20/04
06/25/04
06/30/04
07/05/04
07/10/04
07/15/04
07/20/04
Highs
Lows
Observed Highs (ft)
y = 0.789x - 2.9615
R^2 = 0.6699
y = 1.0855x - 3.6503
R^2 = 0.9269
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 49.5
(Hist - Obs) 64.5
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -29.8
(Hist - Obs) -23.6
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) 3.64 3.65
Mean (ft) 4.70 1.07 1.06
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04

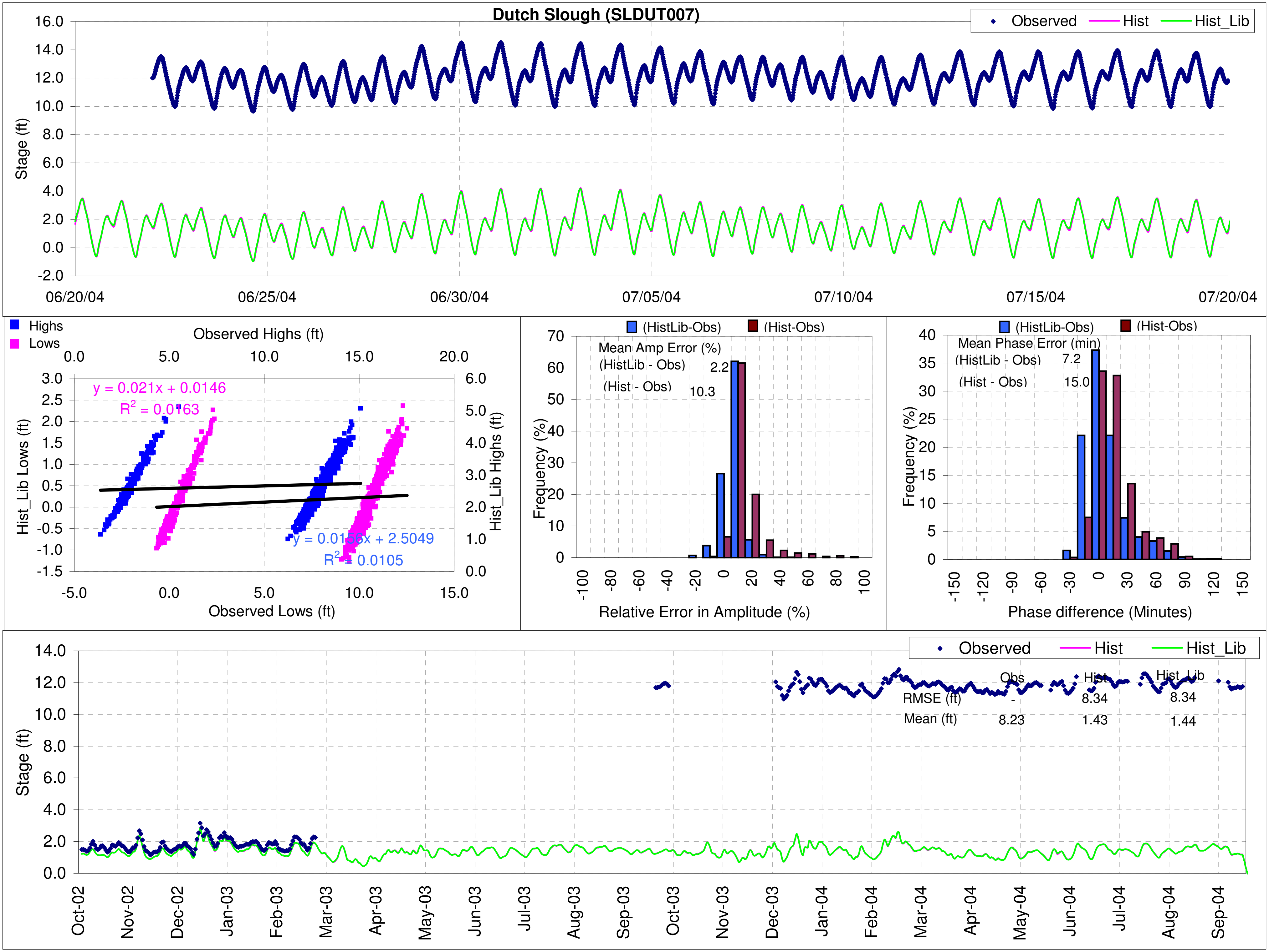


Grantline Canal at Tracy Blvd Bridge (CHGRL009)
Observed
Hist
Hist_Lib
Stage (ft)
06/20/04
06/25/04
06/30/04
07/05/04
07/10/04
07/15/04
07/20/04
Highs
Lows
Observed Highs (ft)
y = 0.2657x - 1.0869
R^2 = 0.1631
y = 1.0325x - 3.4337
R^2 = 0.9331
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 10.5
(Hist - Obs) 11.9
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -4.5
(Hist - Obs) 6.8
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) 3.41 3.40
Mean (ft) 4.27 0.87 0.87
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04



Georgiana Slough (SLGEO019)
Observed
Hist
Hist_Lib
Stage (ft)
06/20/04
06/25/04
06/30/04
07/05/04
07/10/04
07/15/04
07/20/04
Highs
Lows
Observed Highs (ft)
y = 0.1x + 1.9342
R^2 = 0.0945
y = 0.0687x + 3.6512
R^2 = 0.0724
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 11.8
(Hist - Obs) 39.2
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) -9.4
(Hist - Obs) -23.4
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) - 5.20 5.16
Mean (ft) 1.60 3.14 3.01
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04

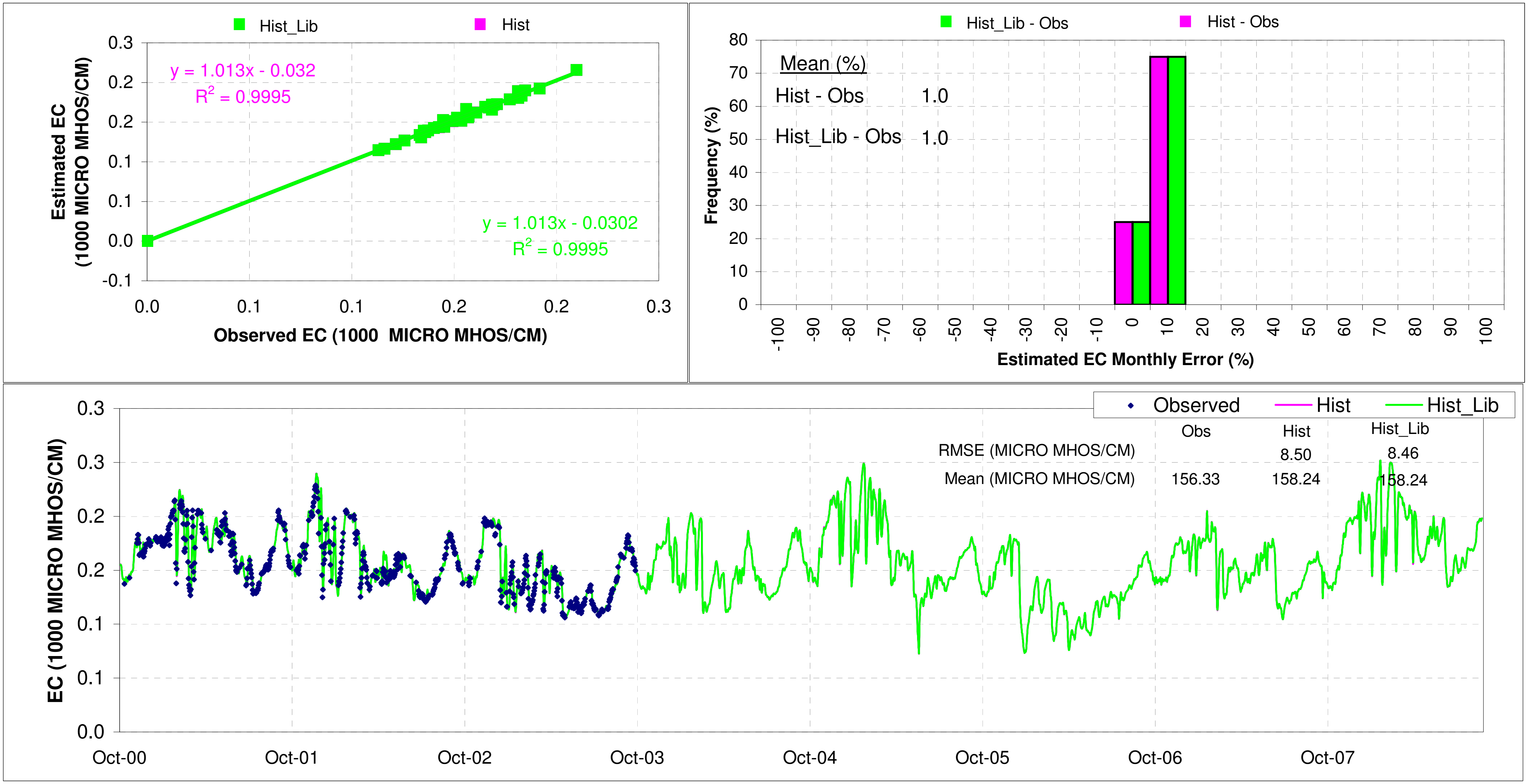

Montezuma Sl at Beldons (SLMZU011)
Observed
Hist
Hist_Lib
Stage (ft)
06/20/04
06/25/04
06/30/04
07/05/04
07/10/04
07/15/04
07/20/04
Highs
Lows
Observed Highs (ft)
y = 0.6802x - 1.8984
R^2 = 0.6764
y = 0.5399x + 0.1131
R^2 = 0.5181
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 0.4
(Hist - Obs) 6.2
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) 3.2
(Hist - Obs) 20.8
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) - 2.44 2.44
Mean (ft) 3.48 1.18 1.19
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04



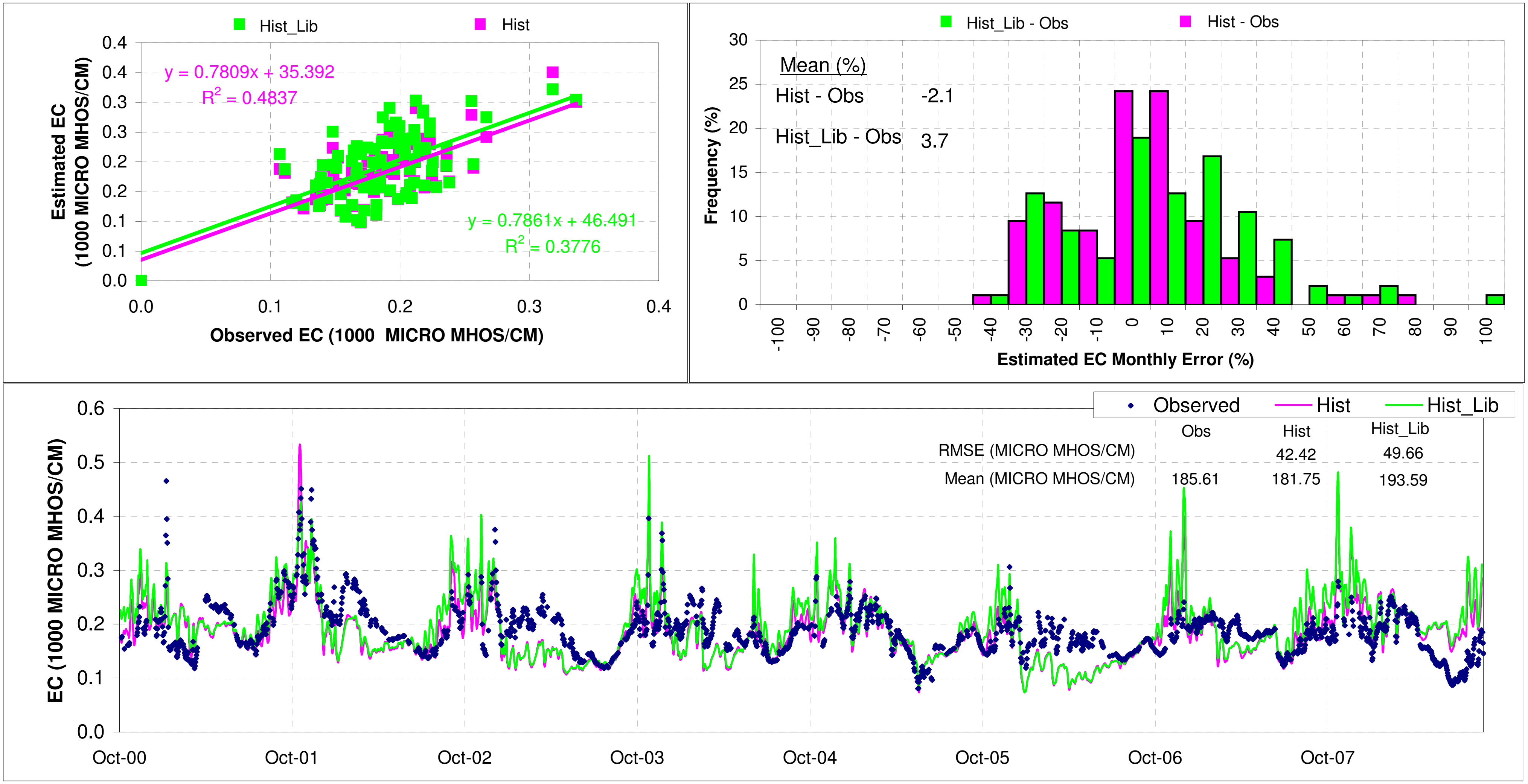
Dutch Slough (SLDUT007)
Observed
Hist
Hist_Lib
Stage (ft)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
-2.0
06/20/04
06/25/04
06/30/04
07/05/04
07/10/04
07/15/04
07/20/04
Highs
Lows
Observed Highs (ft)
y = 0.021x + 0.0146
R^2 = 0.0163
y = 0.0156x + 2.5049
R^2 = 0.0105
Hist_Lib Lows (ft)
Hist_Lib Highs (ft)
Observed Lows (ft)
(HistLib-Obs)
(Hist-Obs)
Mean Amp Error (%)
(HistLib - Obs) 2.2
(Hist - Obs) 10.3
Frequency (%)
Relative Error in Amplitude (%)
Mean Phase Error (min)
(HistLib - Obs) 7.2
(Hist - Obs) 15.0
Frequency (%)
Phase difference (Minutes)
Obs
Hist
Hist_Lib
RMSE (ft) - 8.34 8.34
Mean (ft) 8.23 1.43 1.44
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04

Appendix C
Detailed QUAL Calibration Results

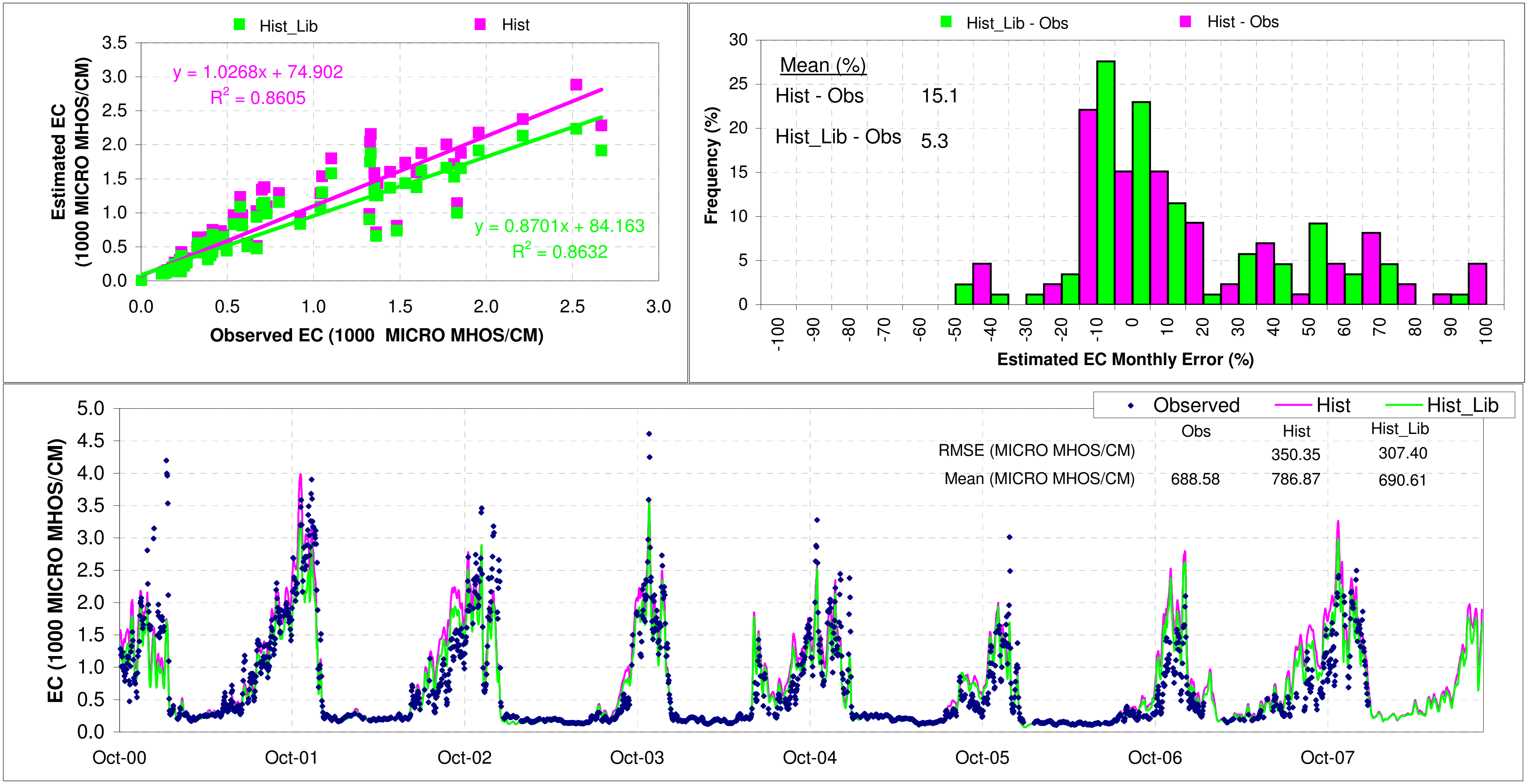
Sacramento River at Greens Landing (RSAC139)



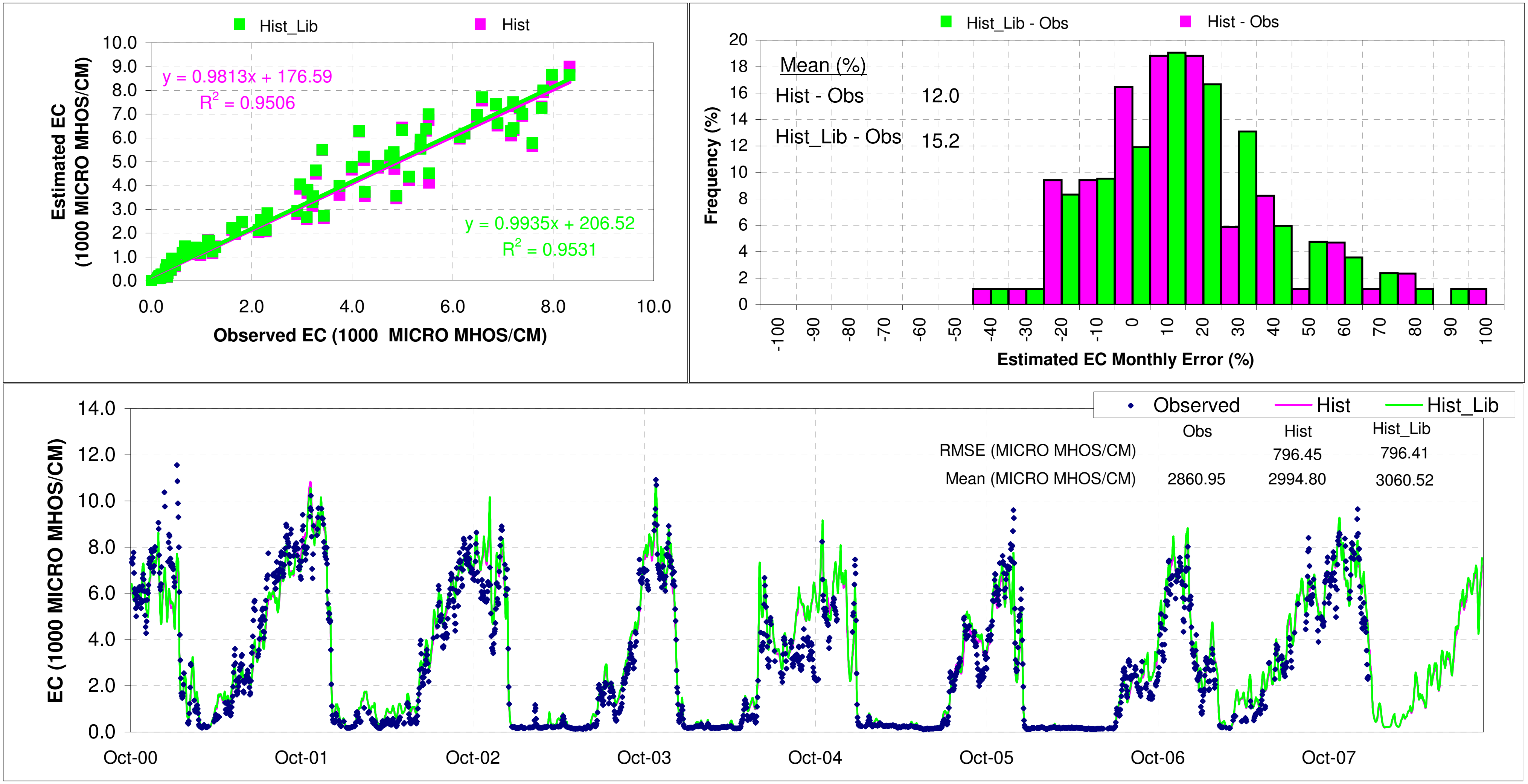
Sacramento River at Rio Vista (RSAC101)



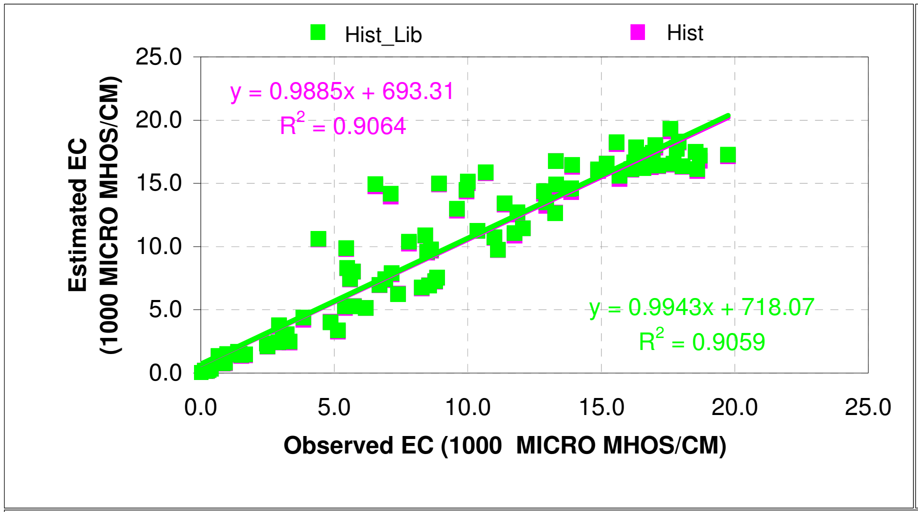
Sacramento River at Emmaton (RSAC092)

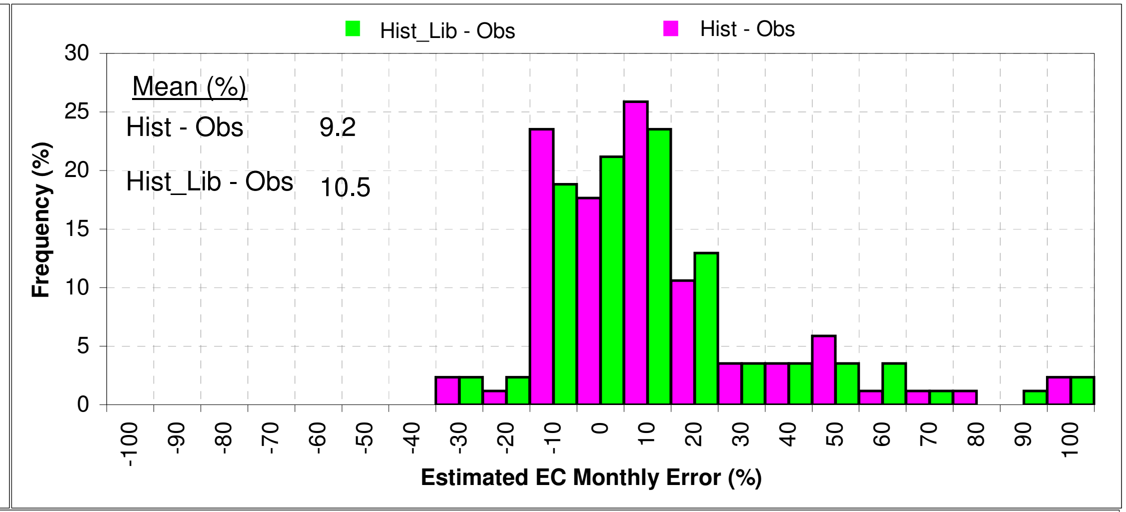


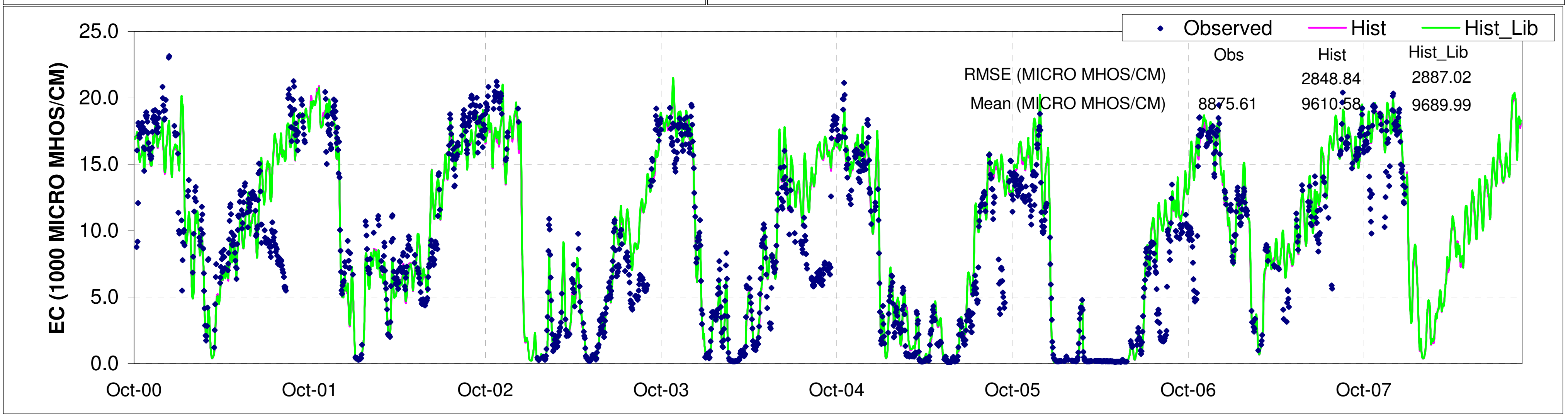
Sacramento River at Collinsville (RSAC081)



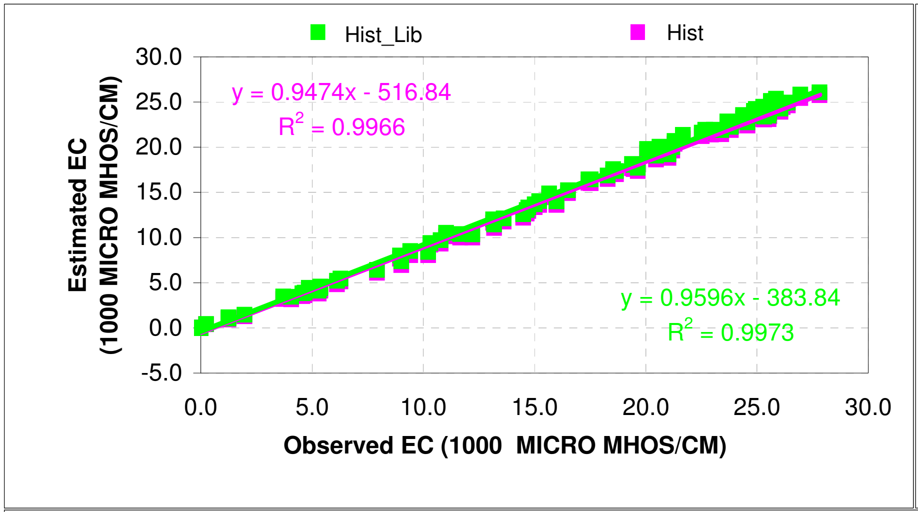
Sacramento River at Port Chicago (RSAC064)

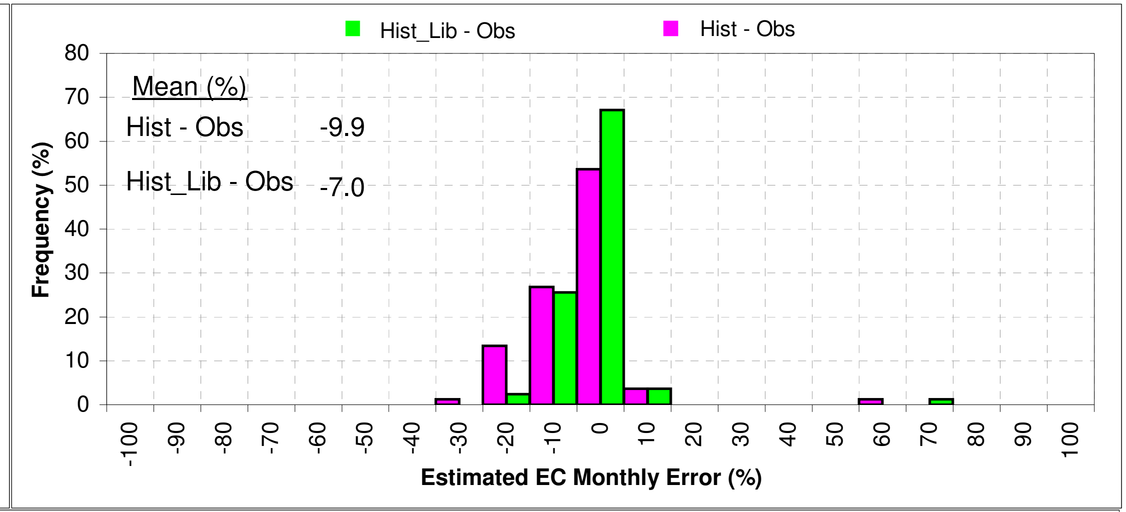


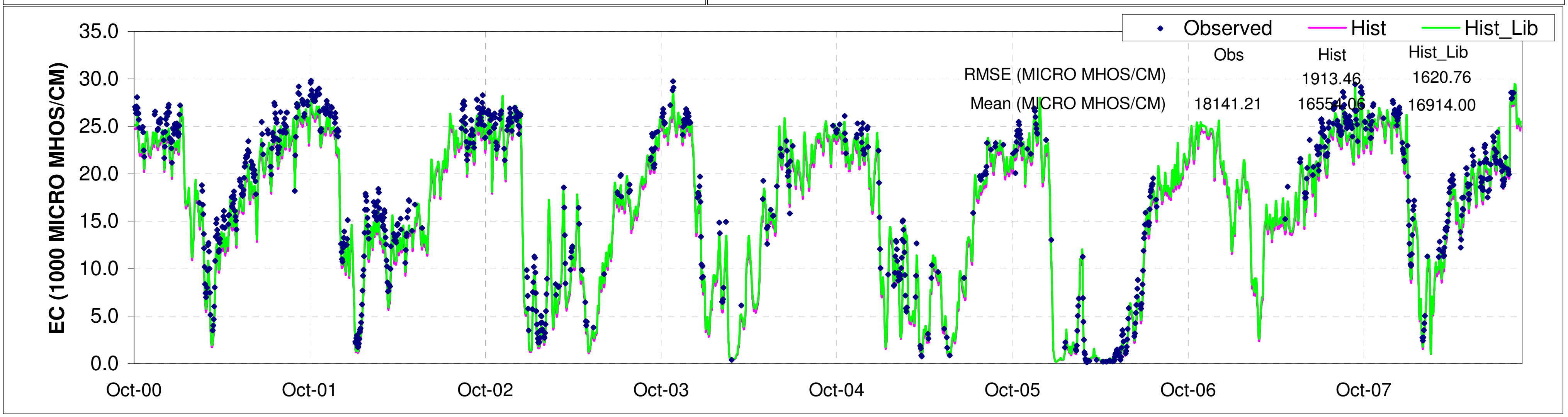




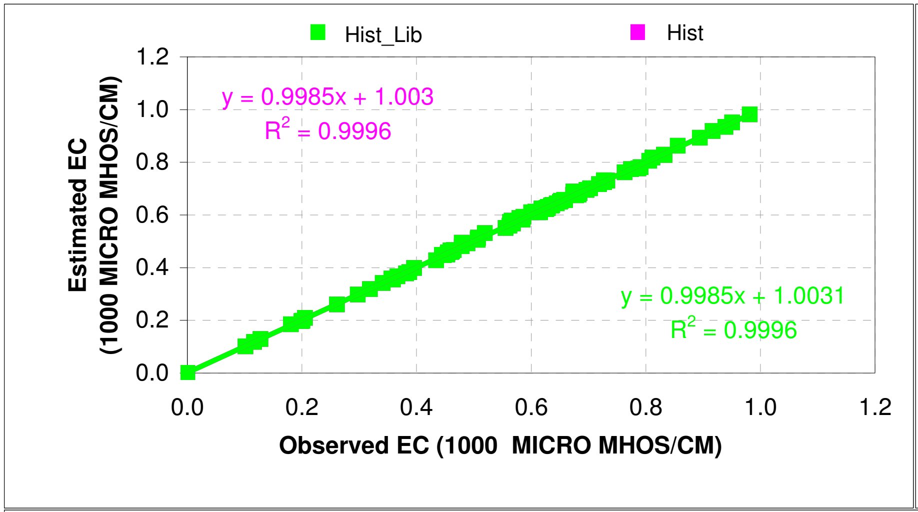
Sacramento River at Martinez (RSAC054)

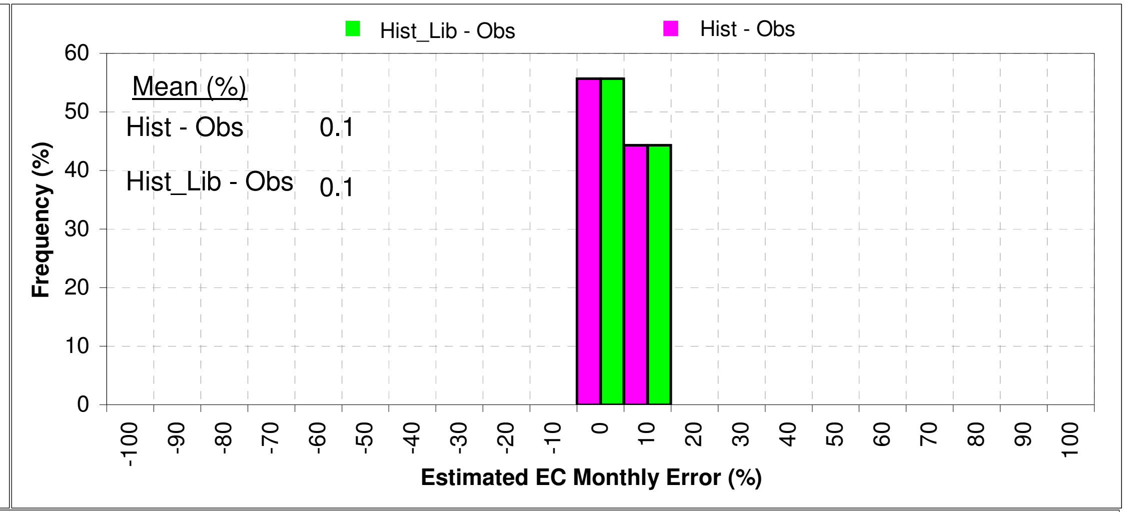


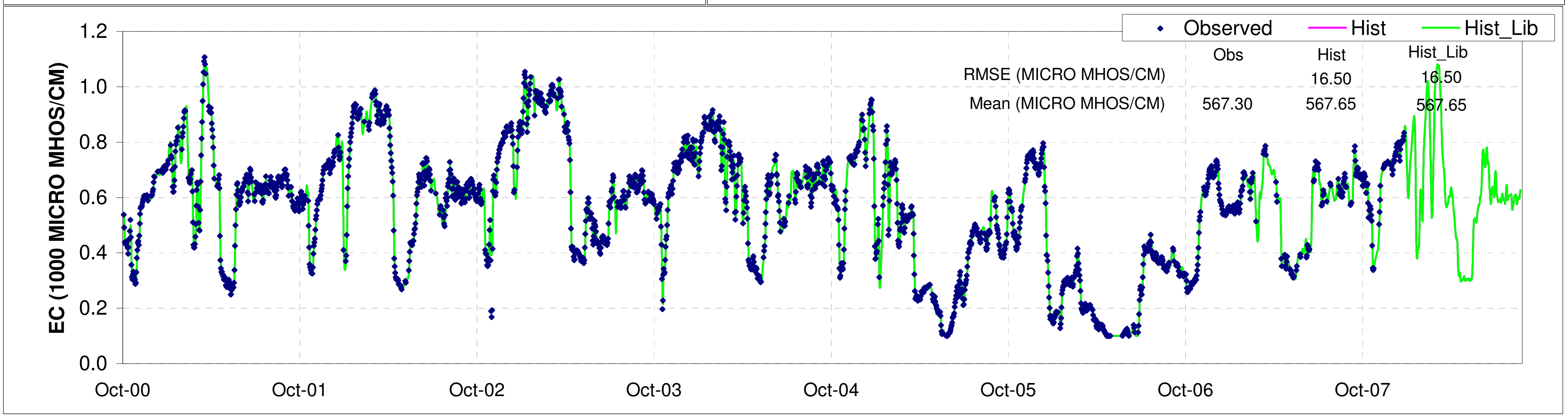




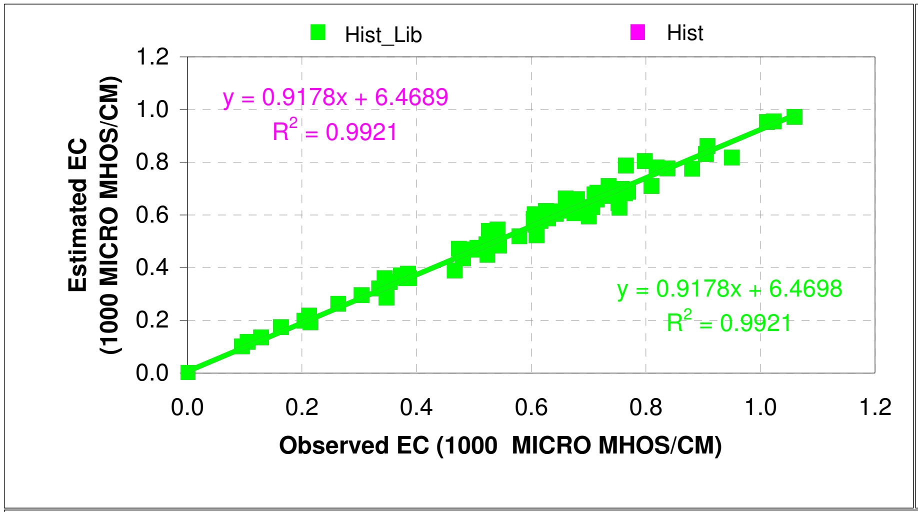
San Joaquin River at Vernalis (RSAN112)

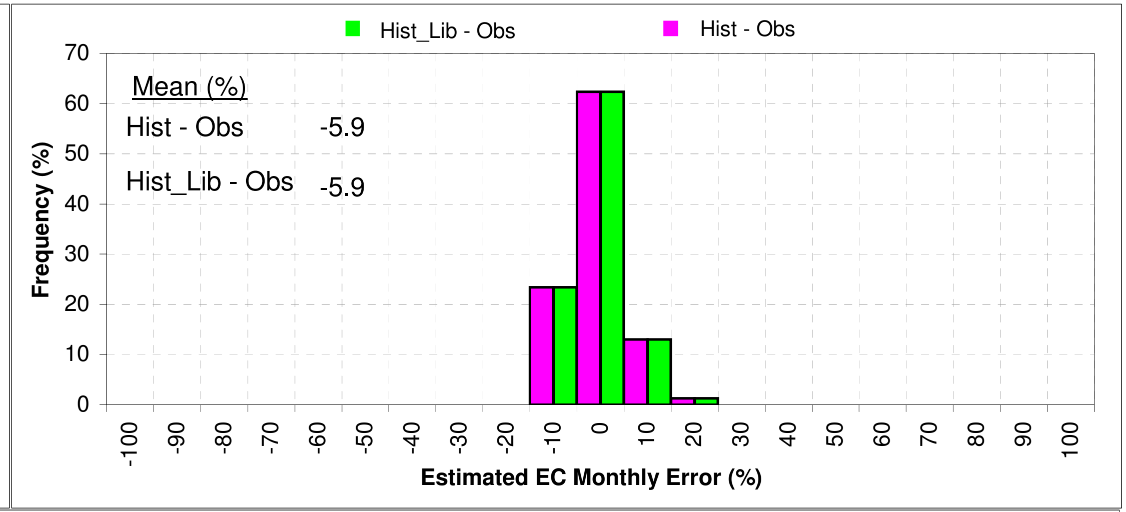


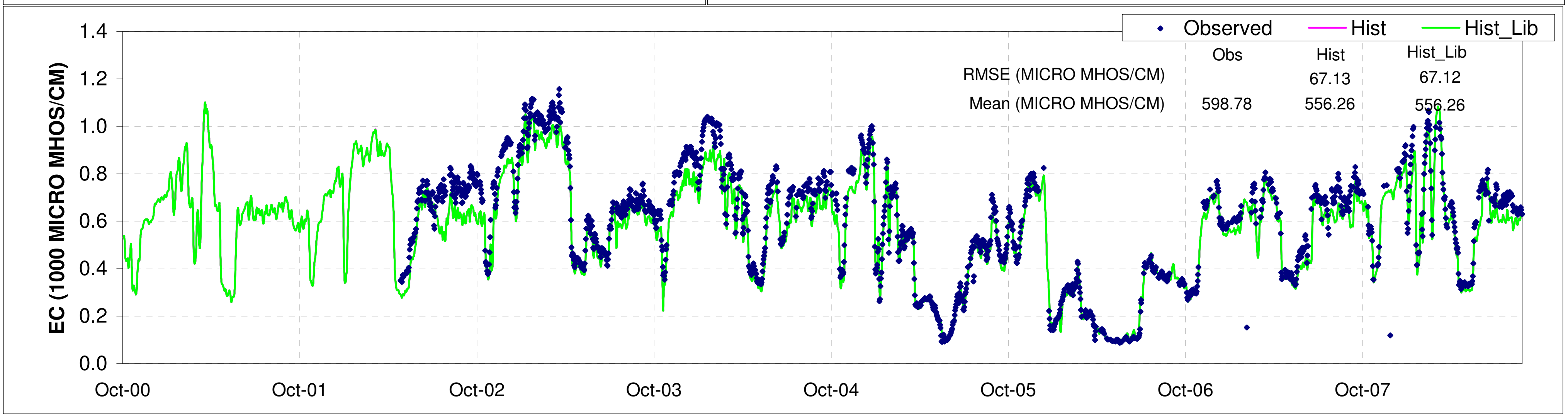




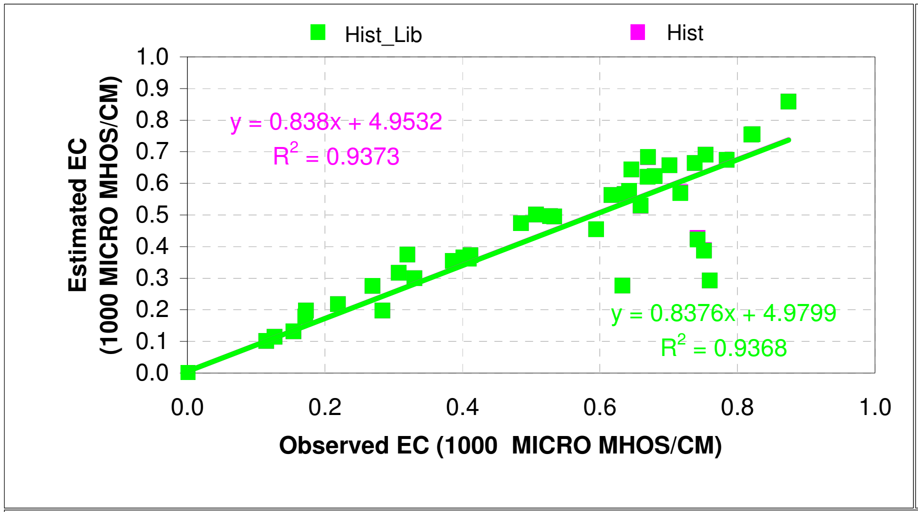
San Joaquin River at Mossdale (RSAN087)

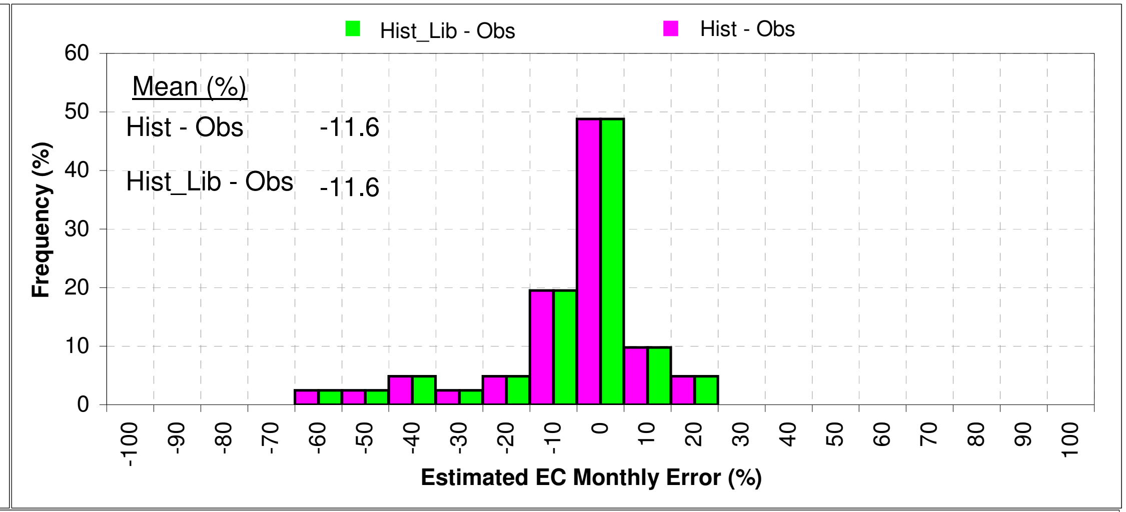


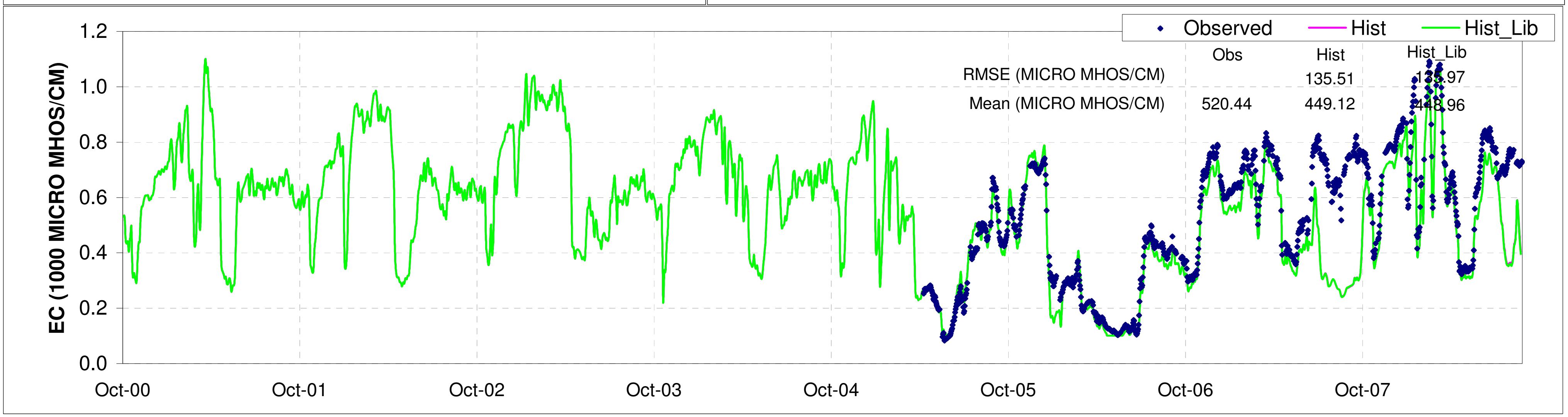




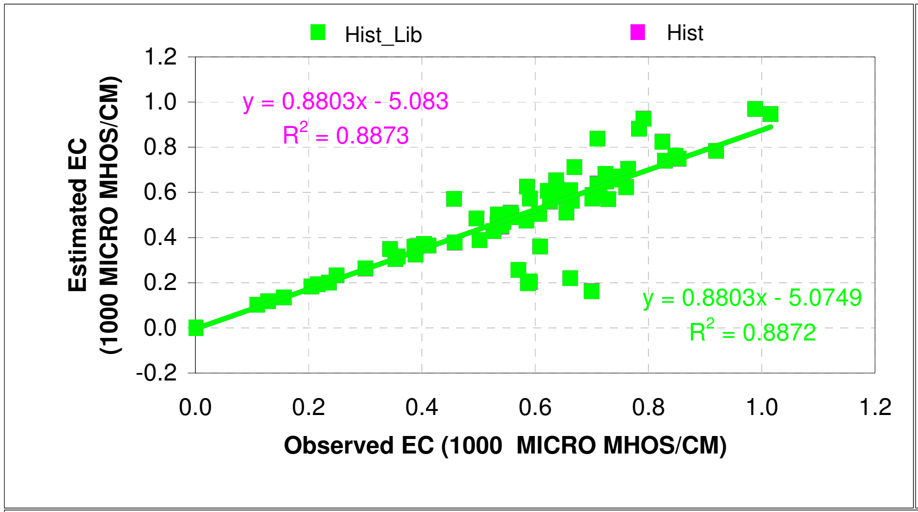
San Joaquin River at Brandt Bridge (RSAN072)

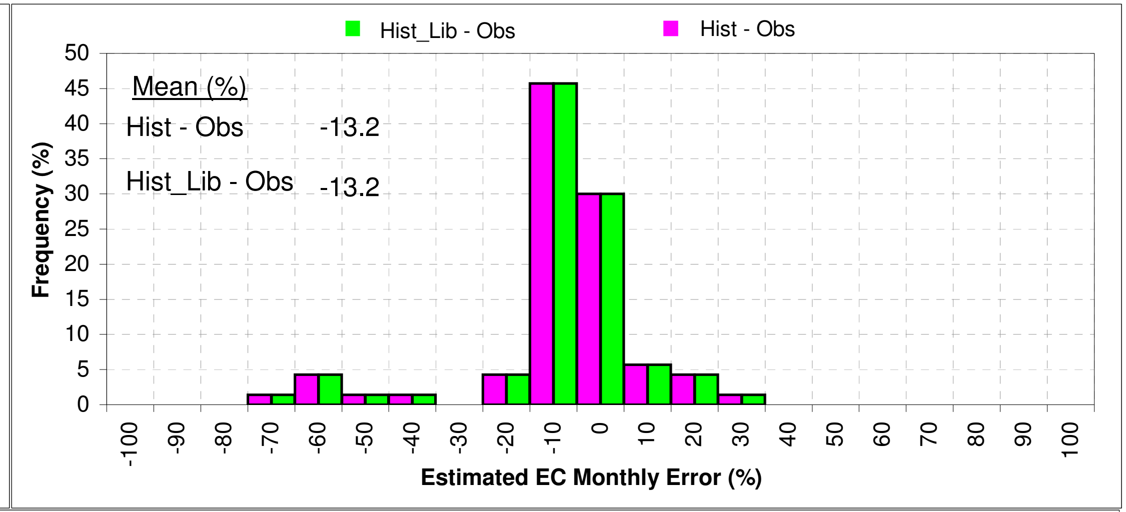


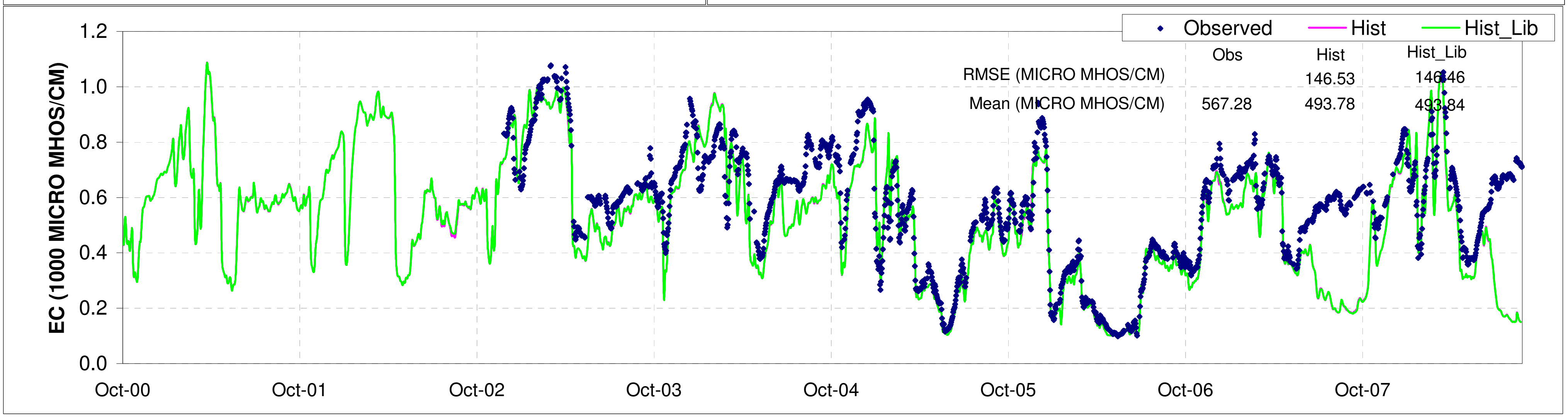




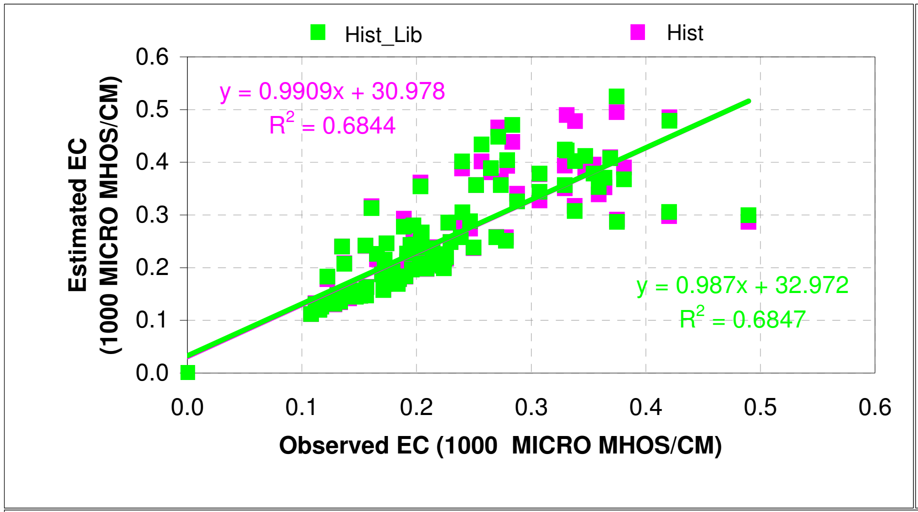
Stockton Ship Channel at Burns Cutoff (RSAN058)

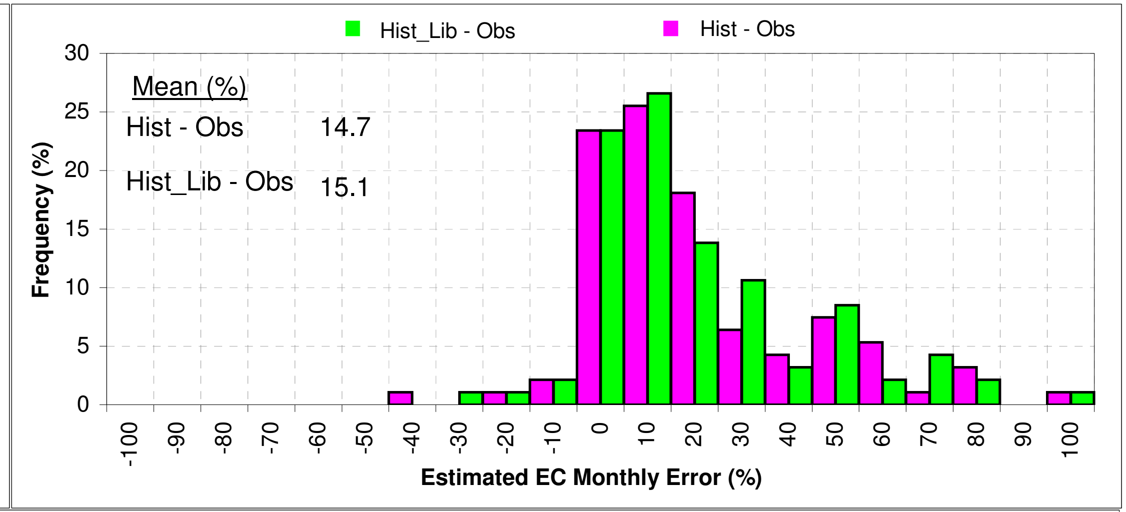


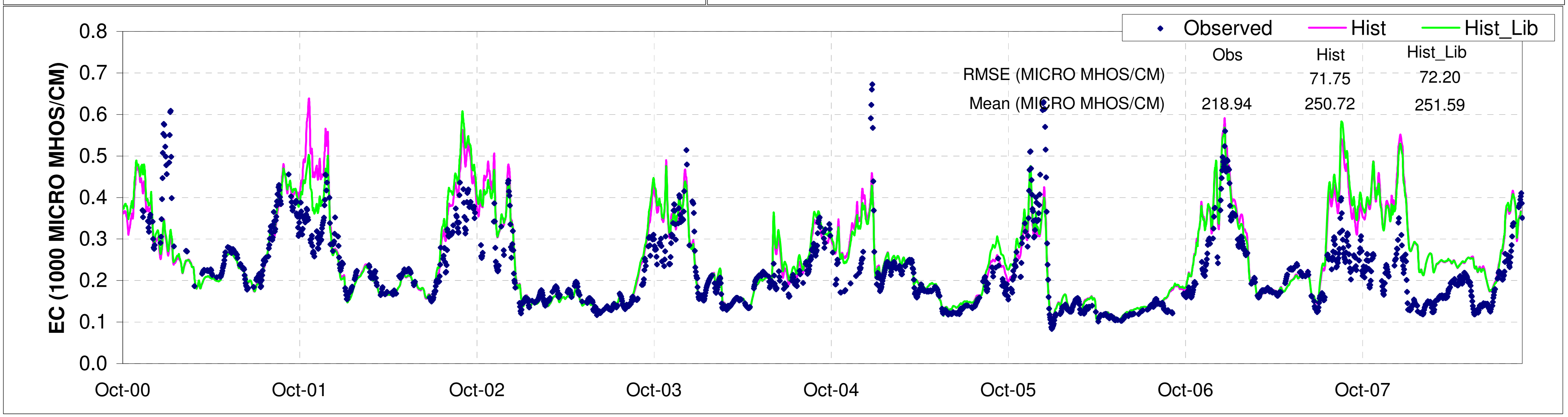




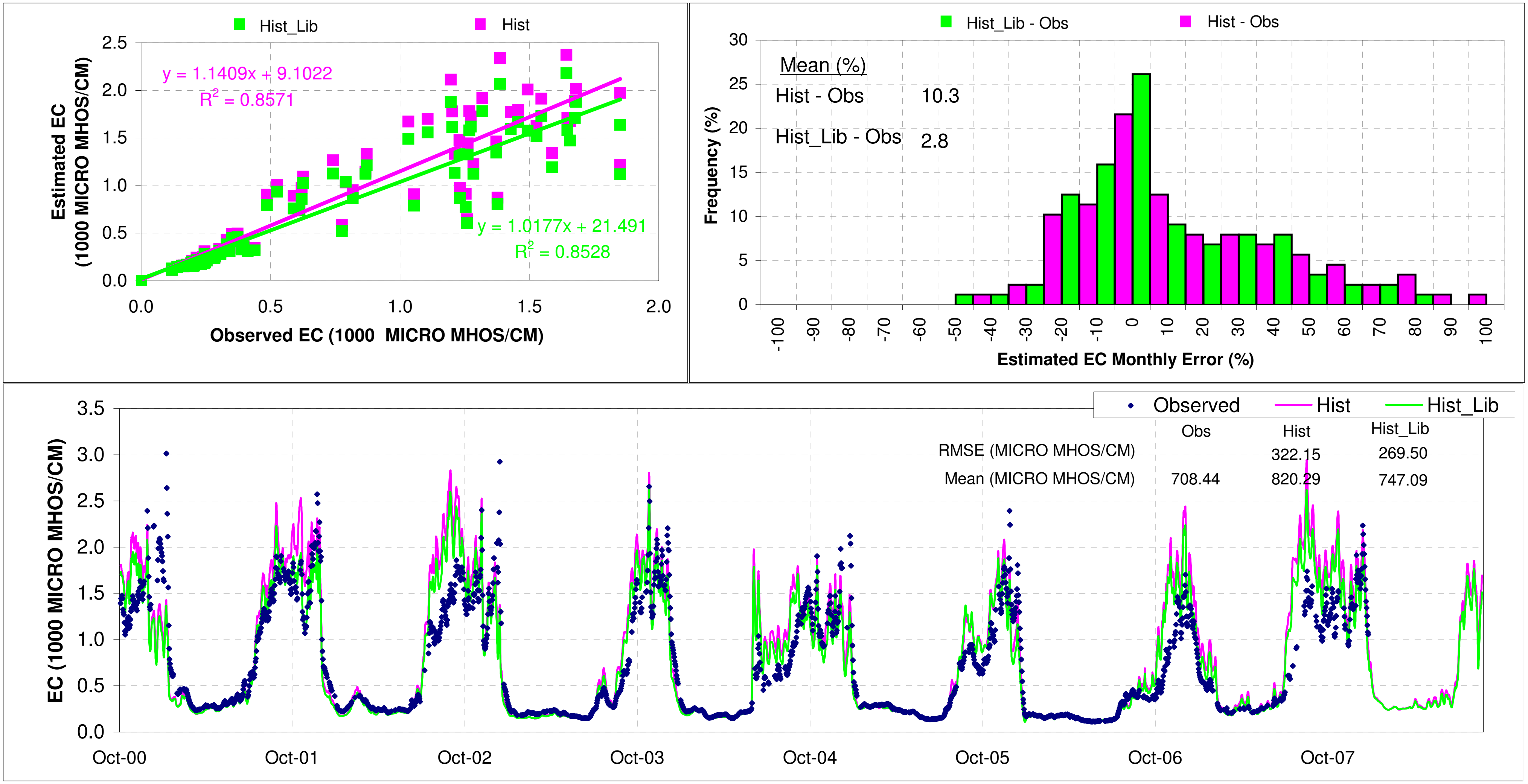
San Joaquin River at San Andreas Landing (RSAN032)



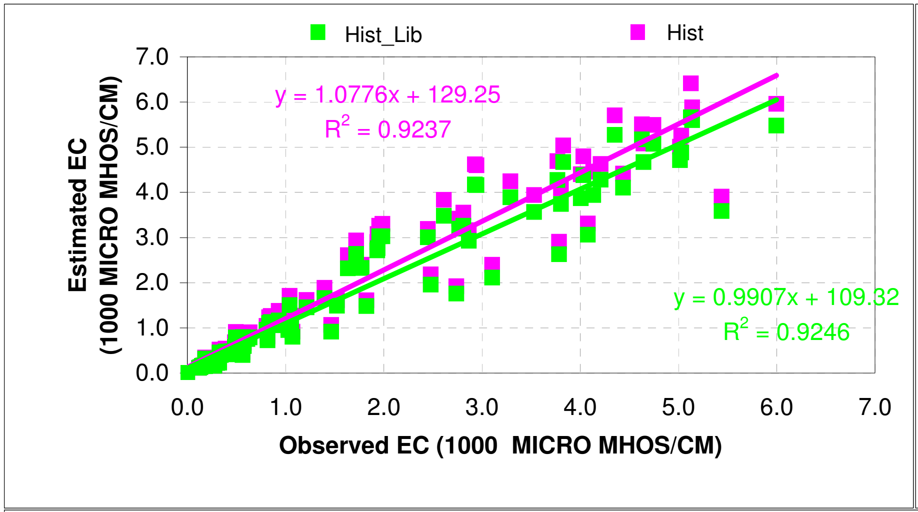


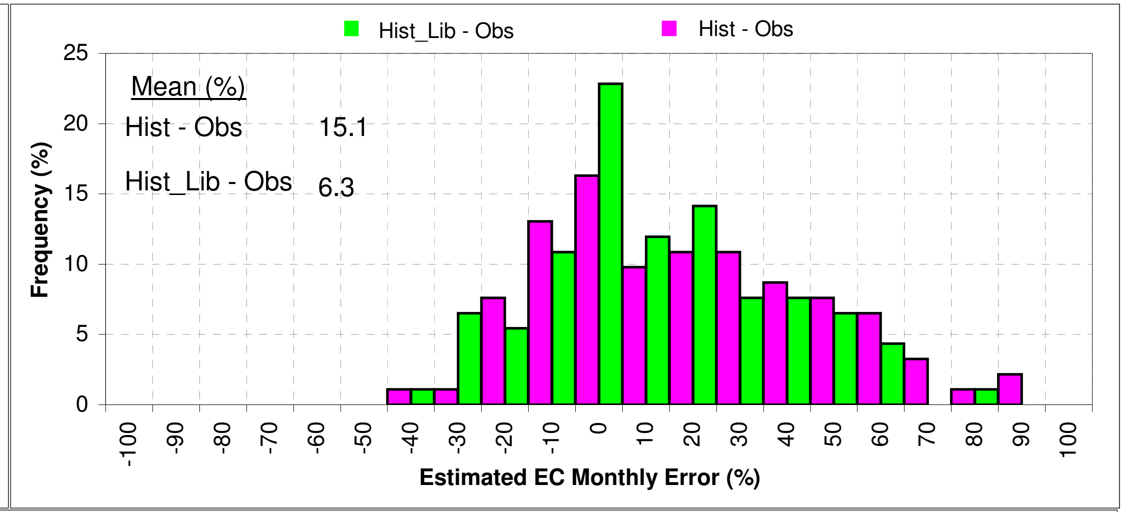


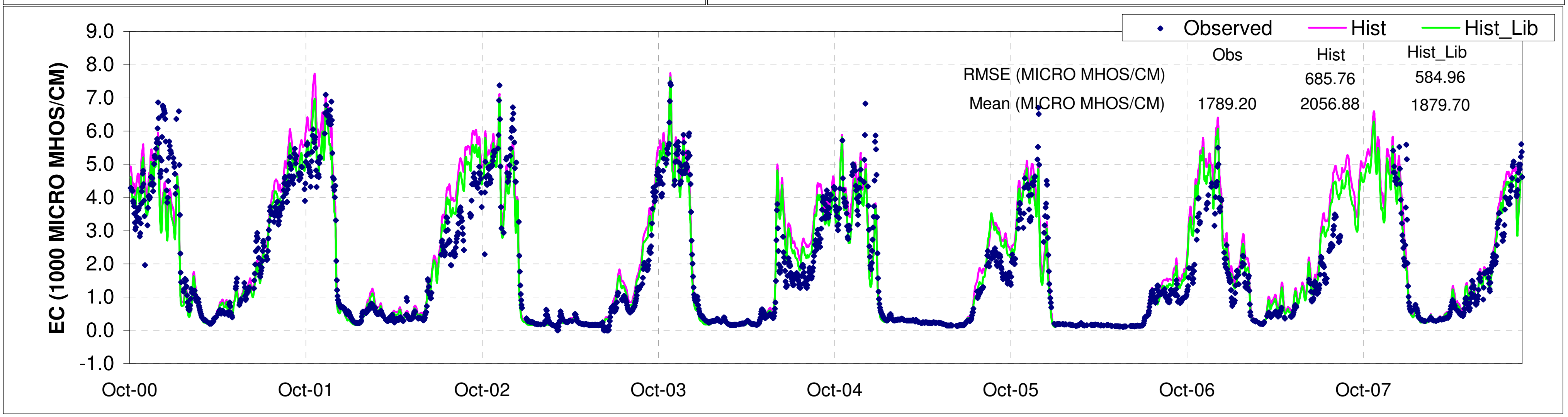
San Joaquin River at Jersey Point (RSAN018)



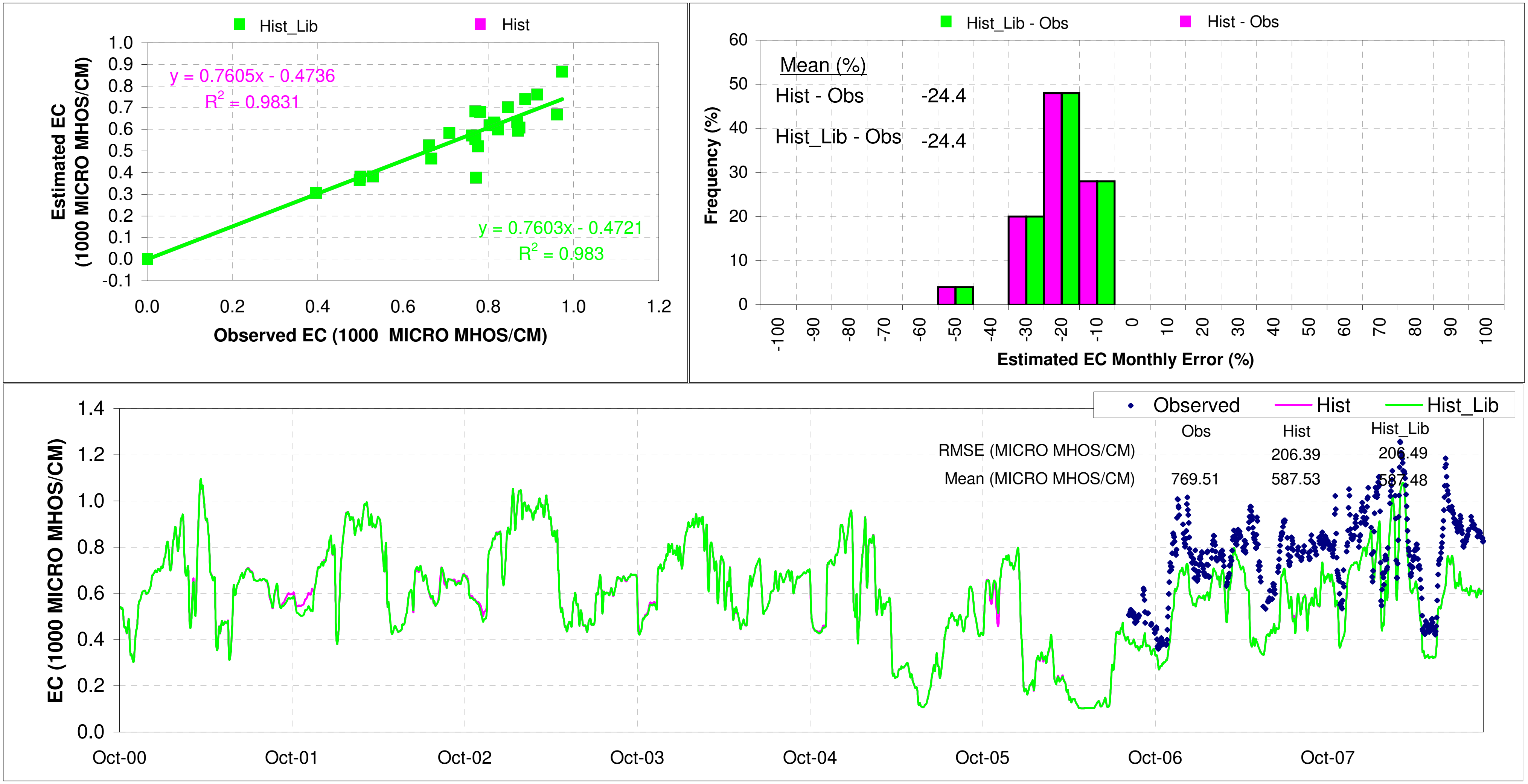
San Joaquin River at Antioch (RSAN007)



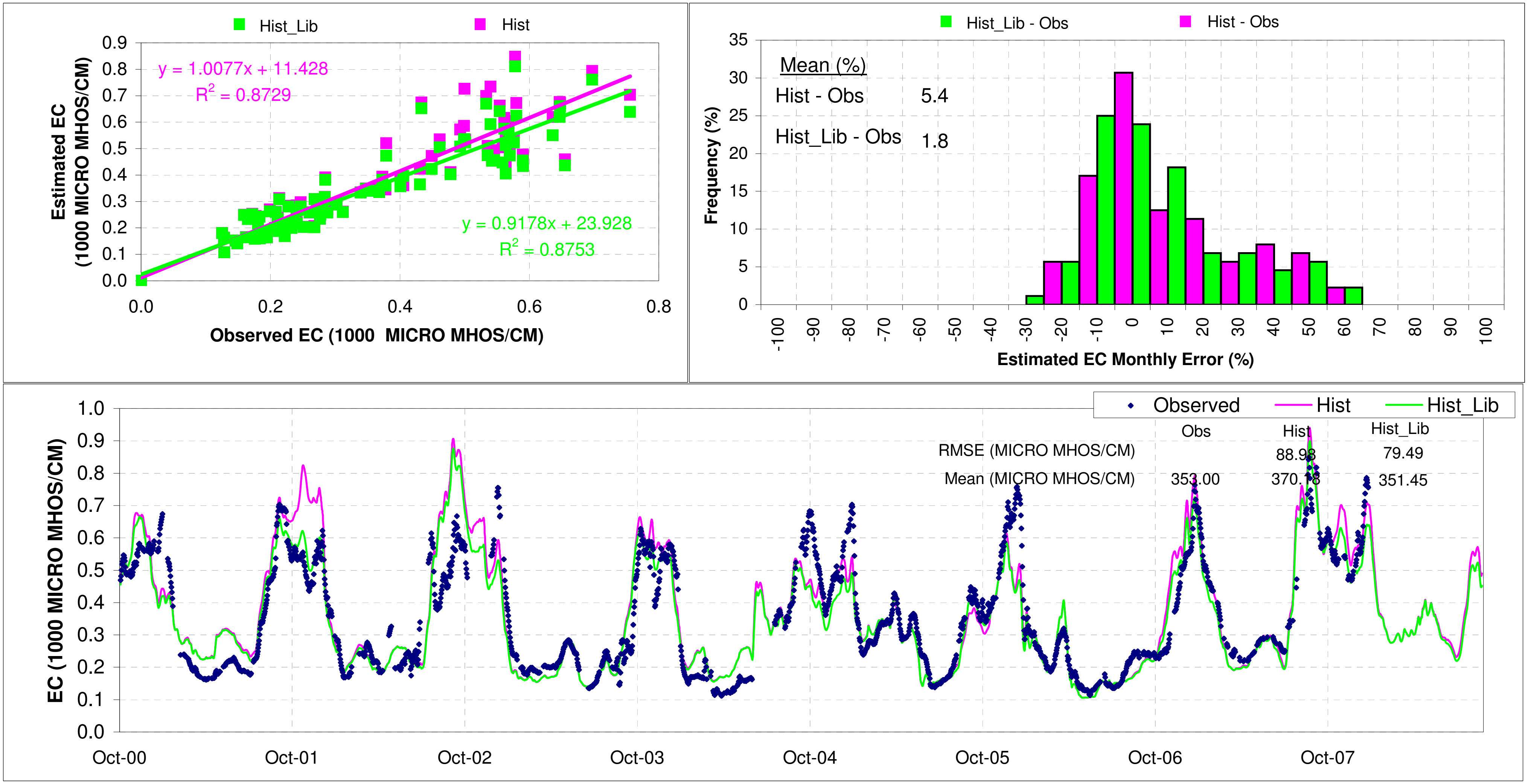




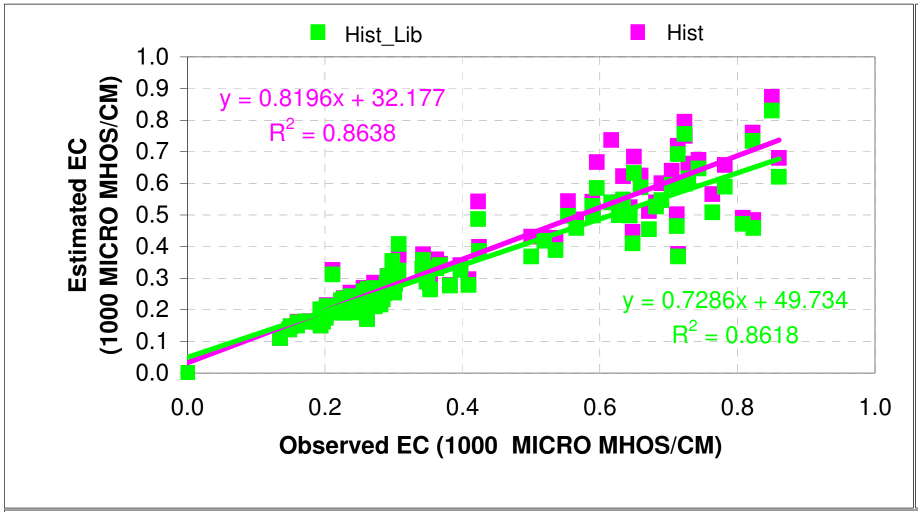
Old River at Tracy Road (ROLD059)

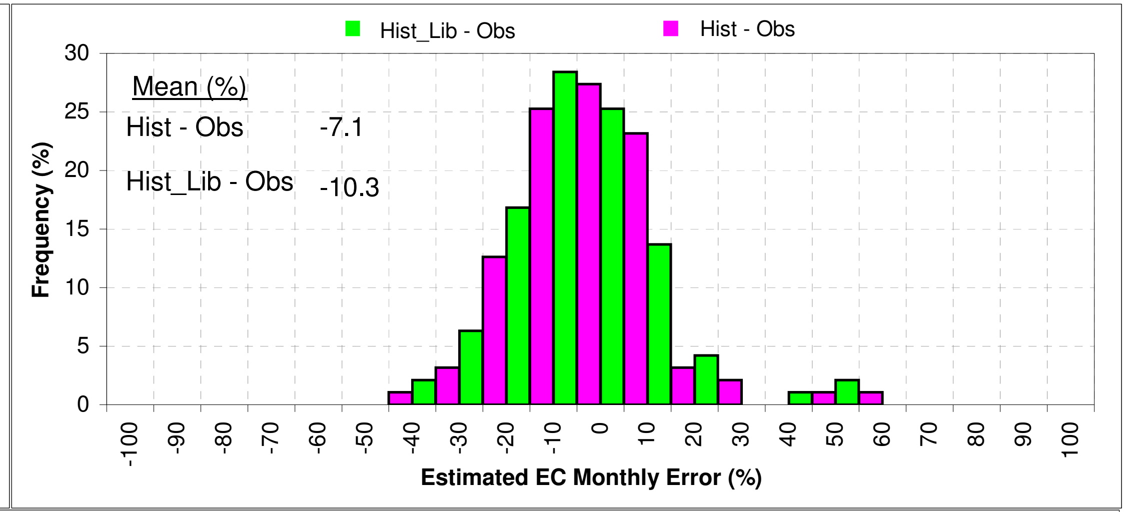


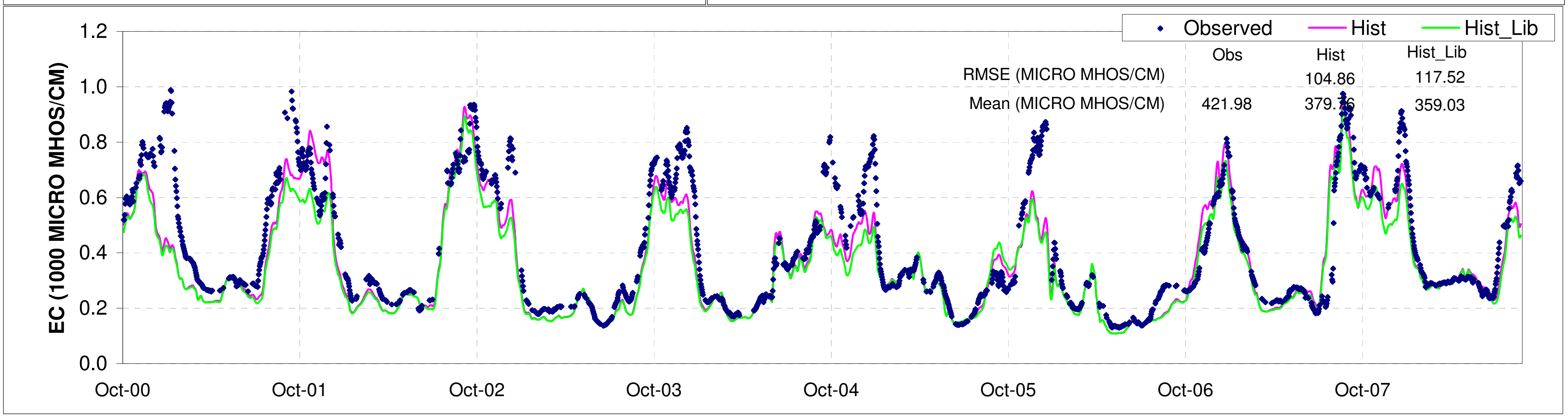
Old River at Bacon Island (ROLD024)



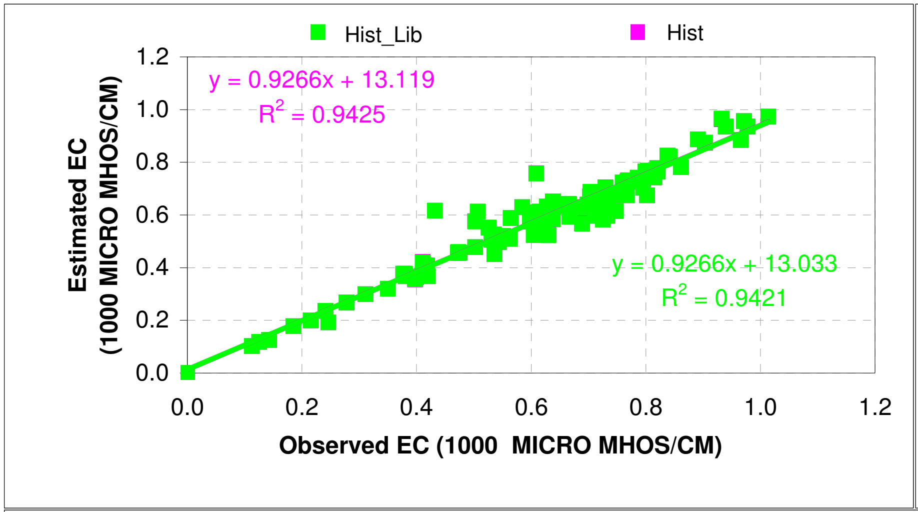
Old River at Holland Cut (ROLD014)

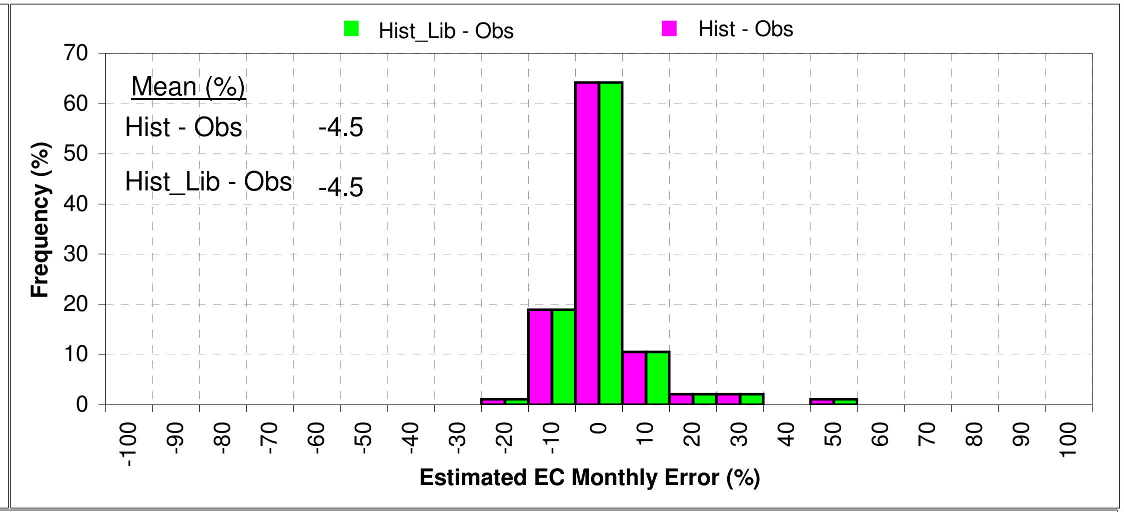


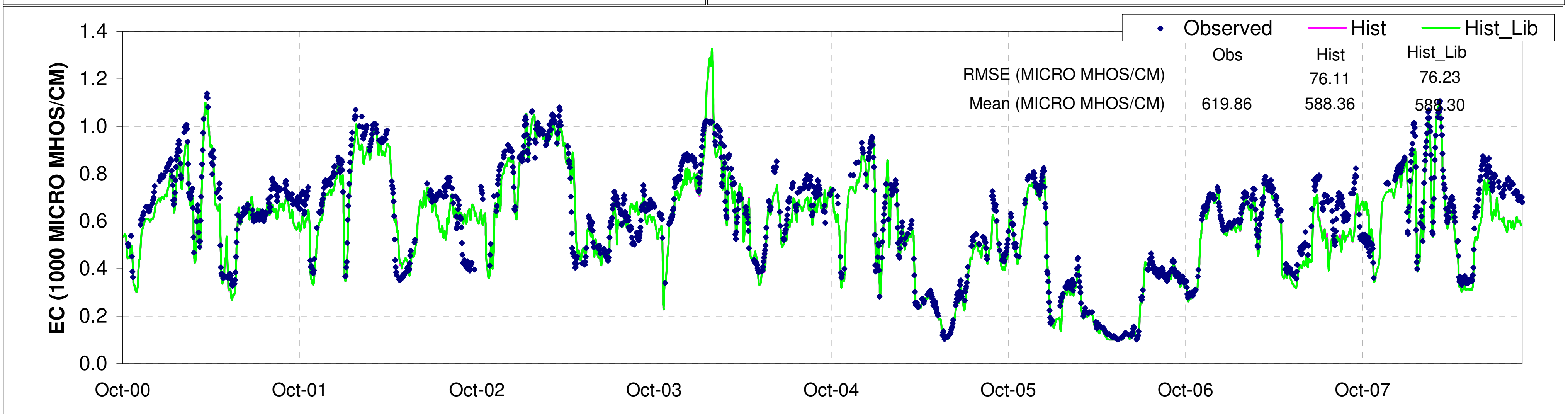




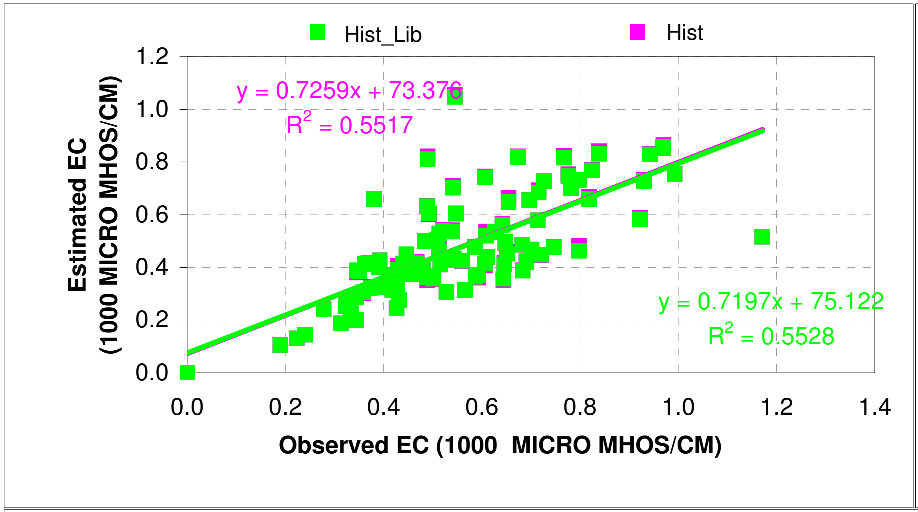
Middle River at Mowery Bridge (RMID040)

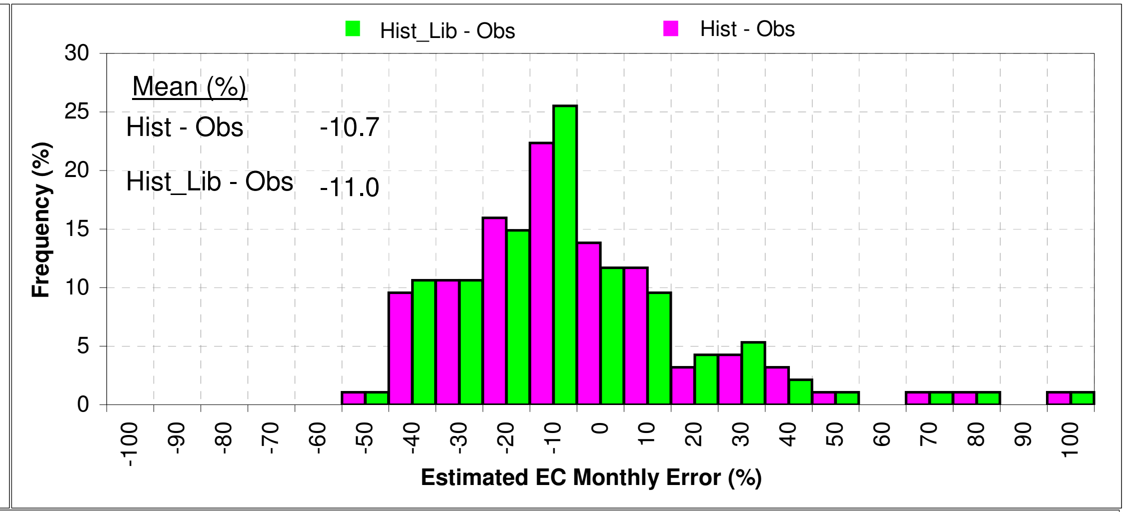


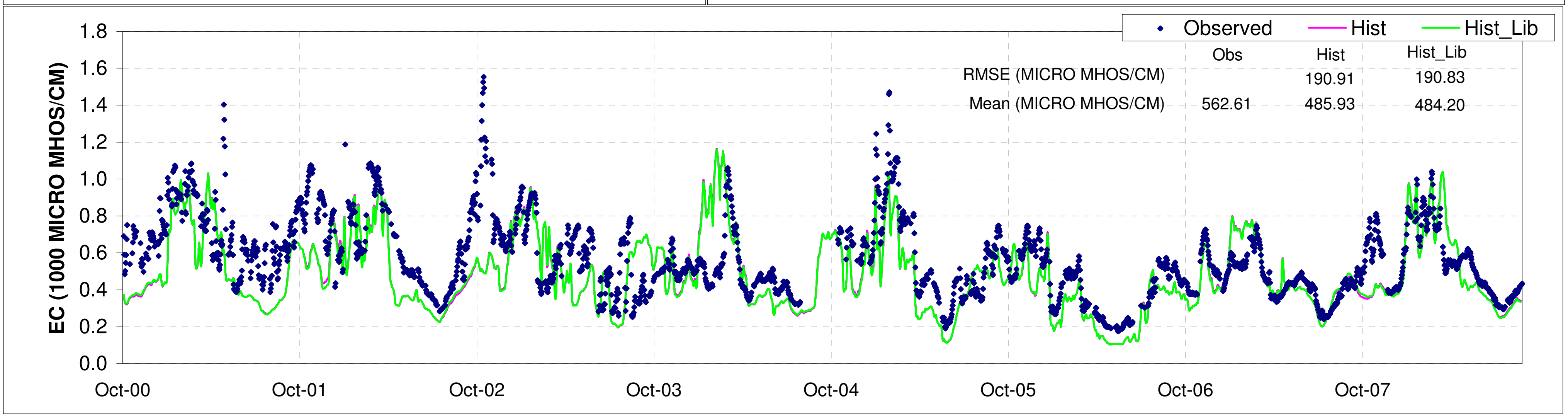




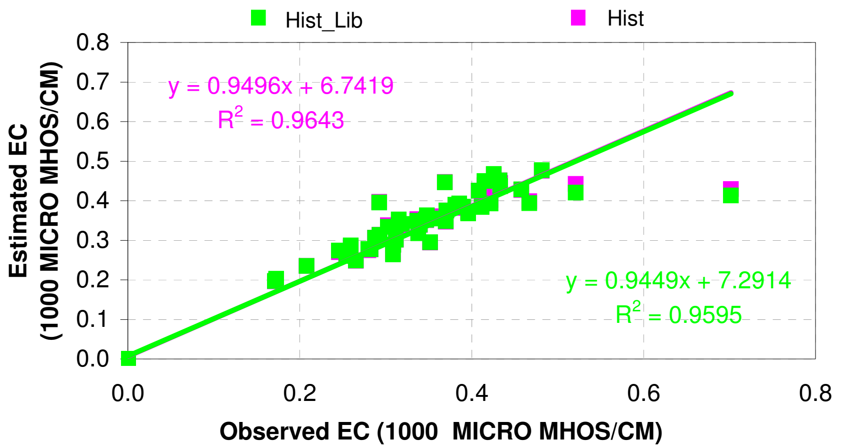
Middle River at Tracy Blvd (RMID027)

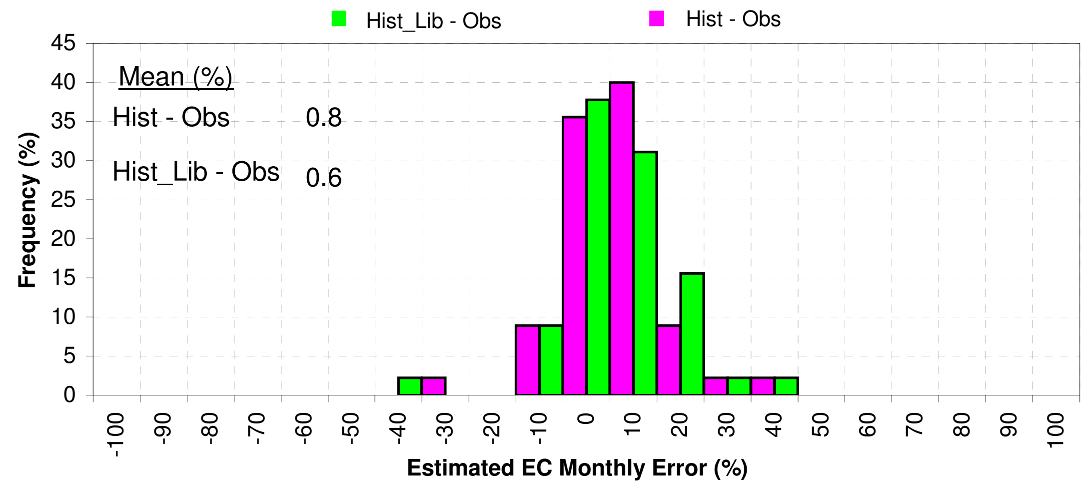


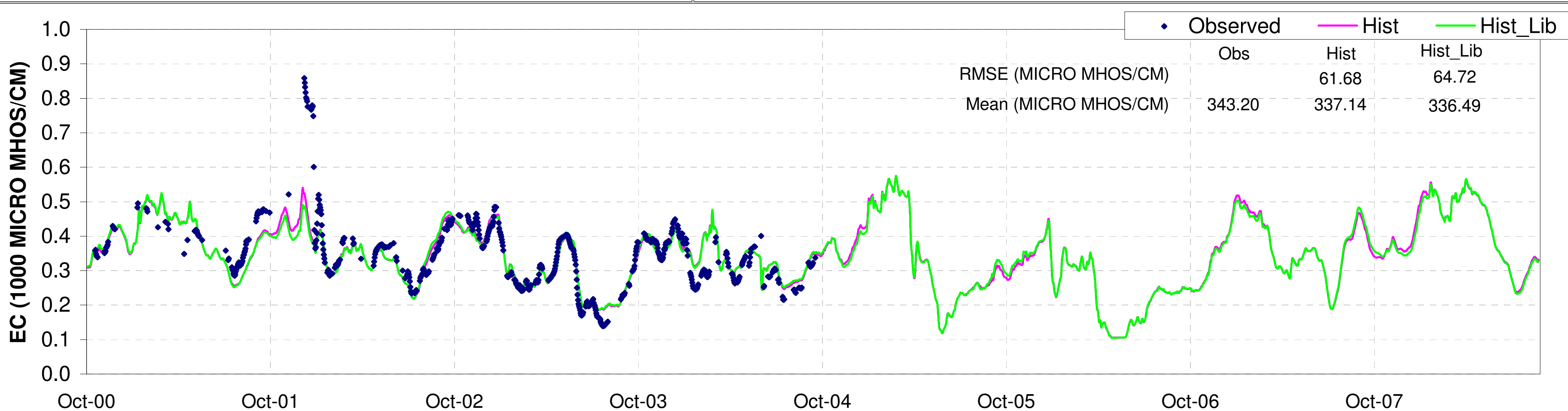




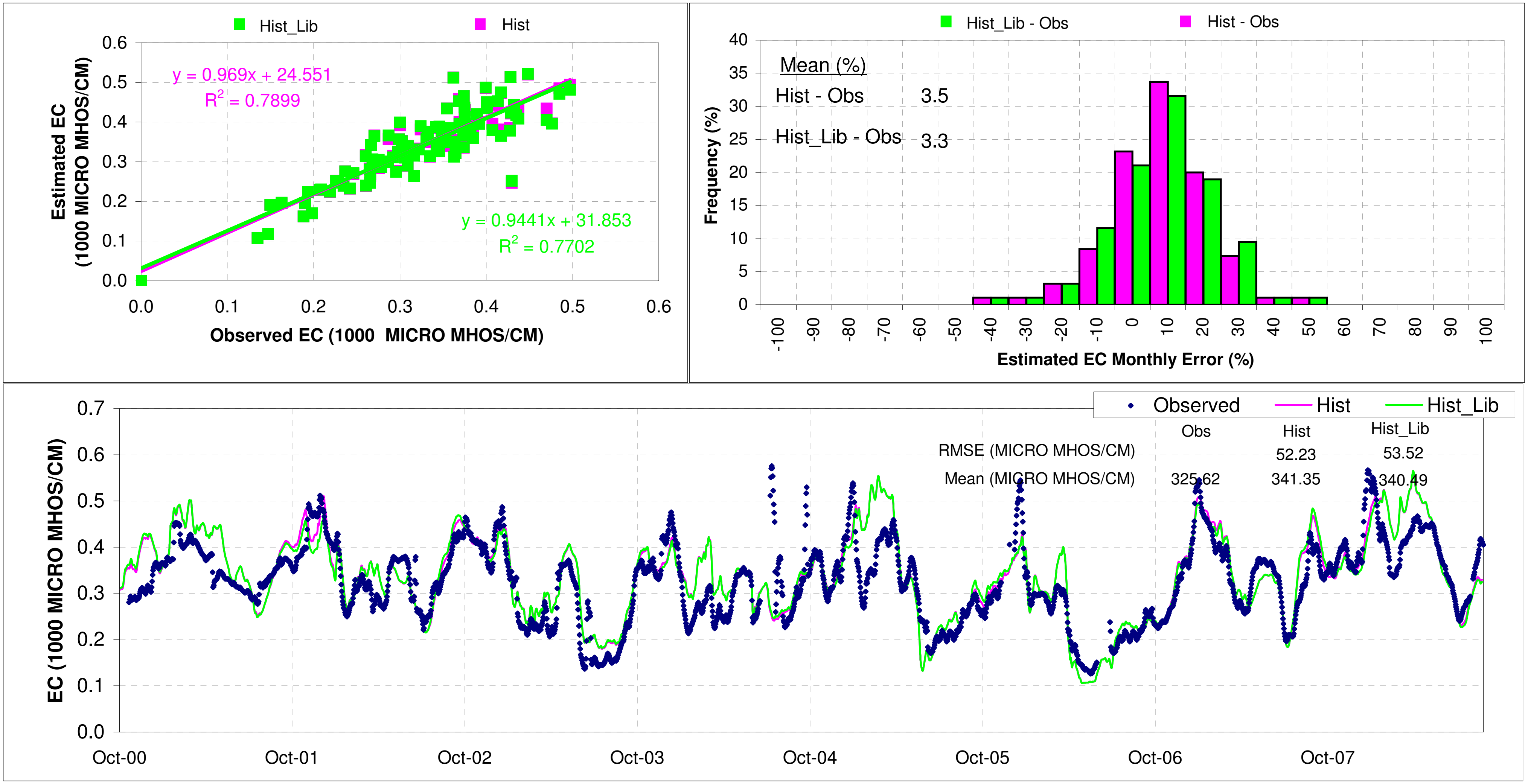
Middle River at Borden Highway (RMID023)



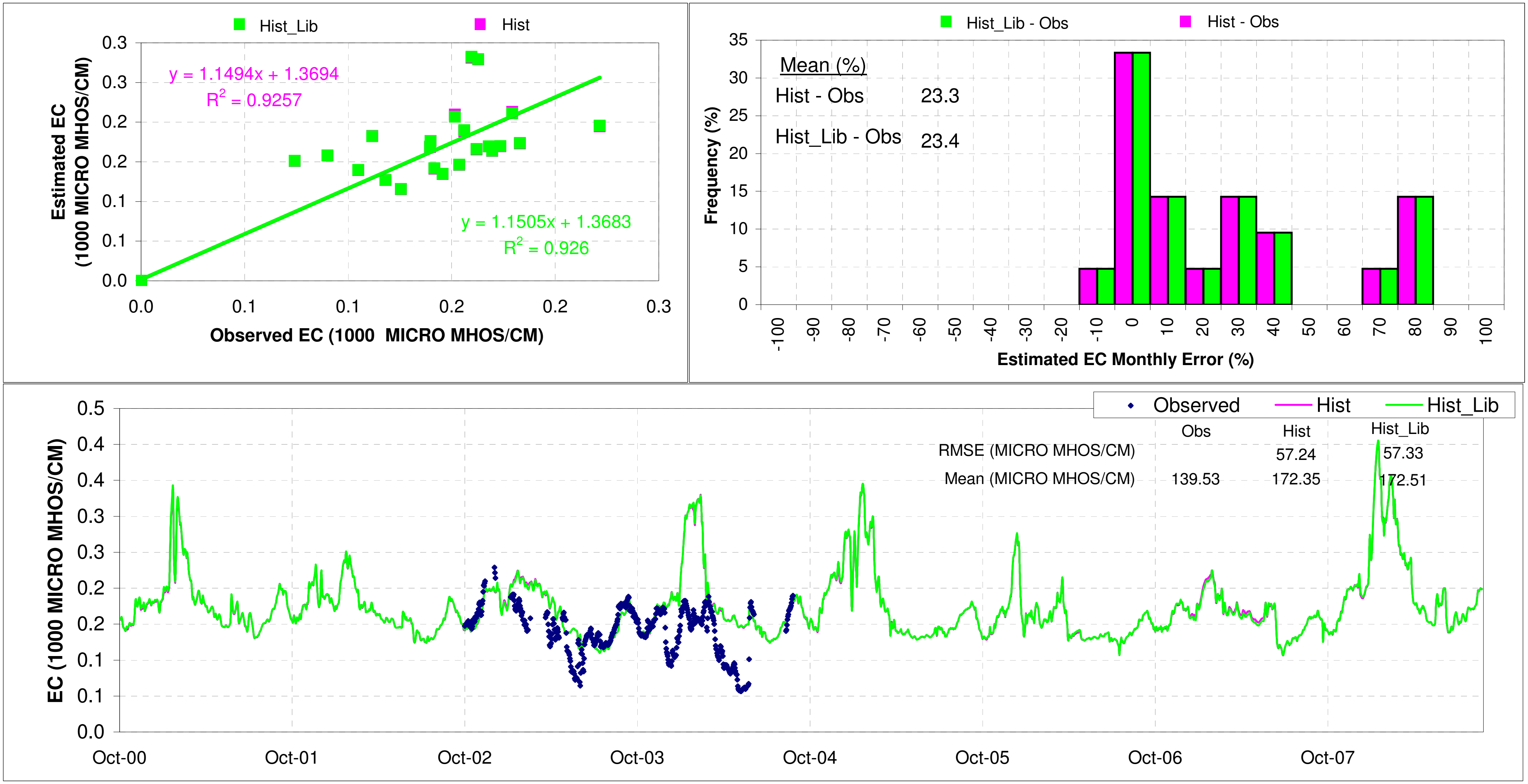




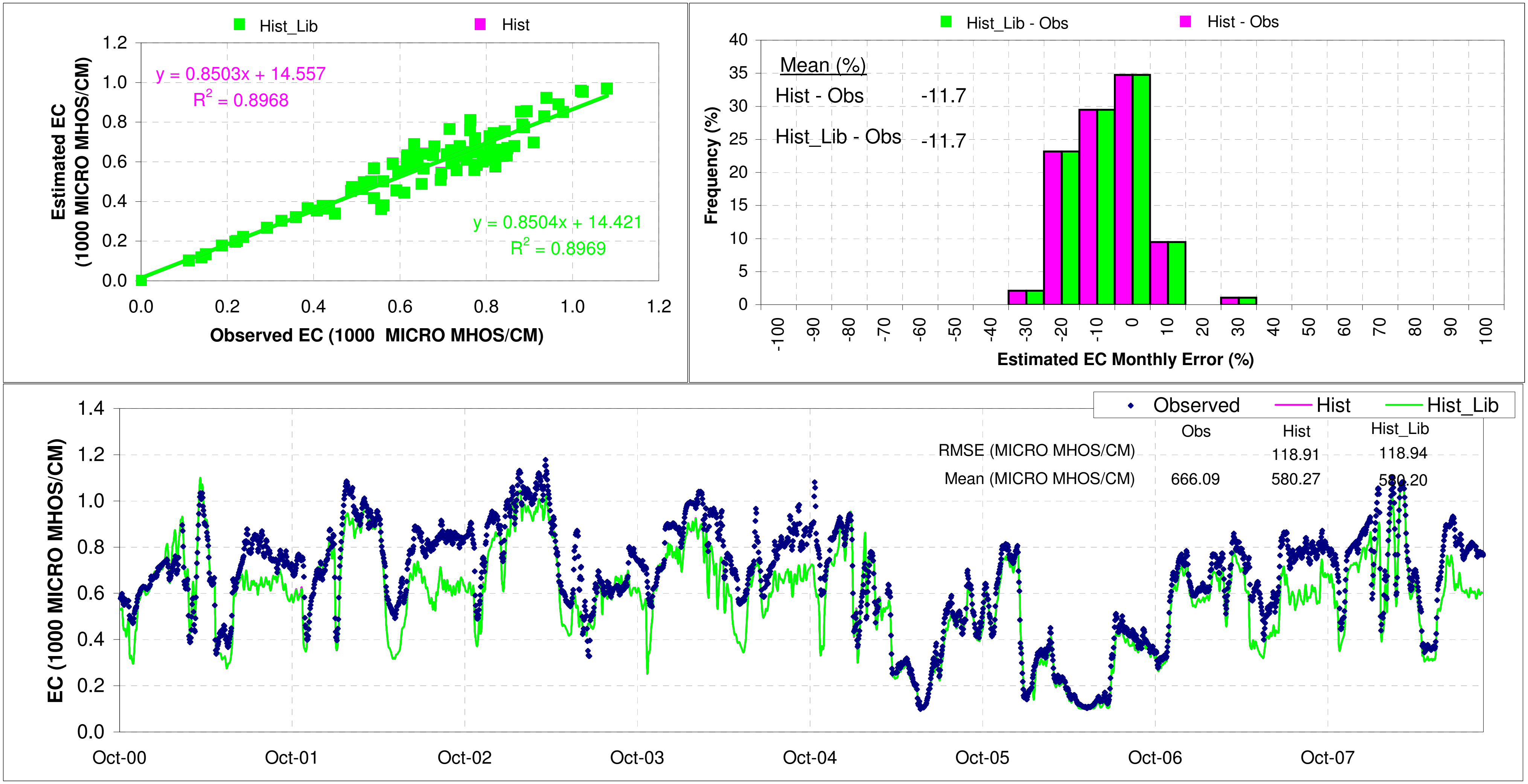
Middle River at Middle River (RMID015)



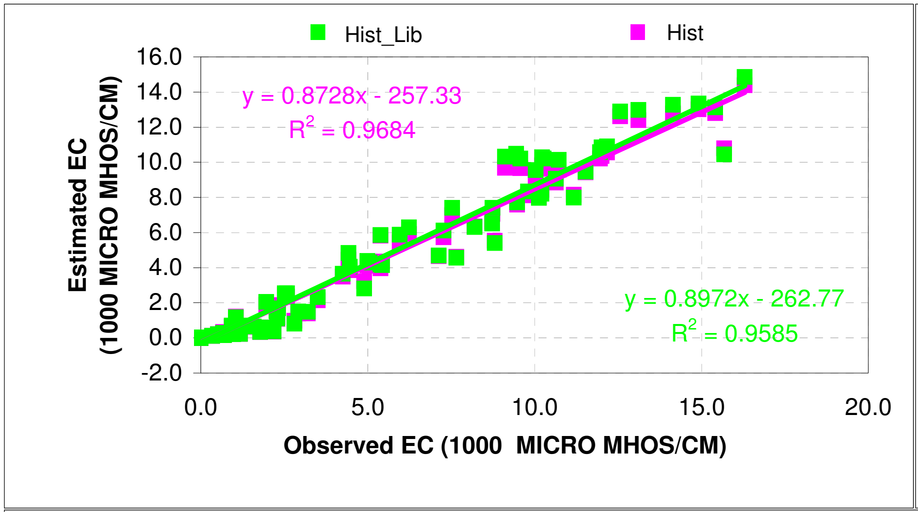
Mokelumne River at Snodgrass Sl (RMKL019)

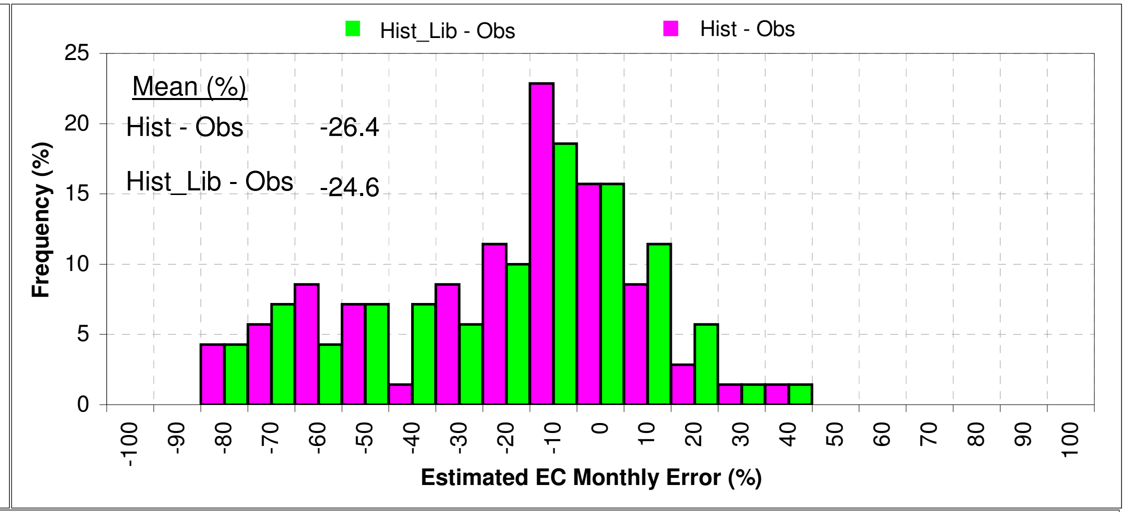


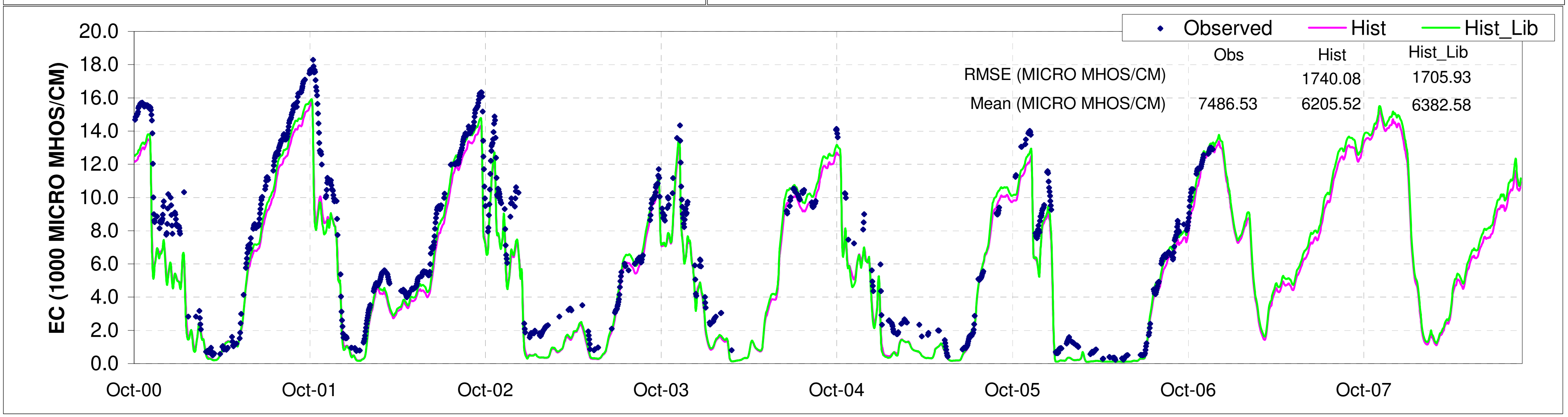
Grantline Canal at Tracy Blvd Bridge (CHGRL009)



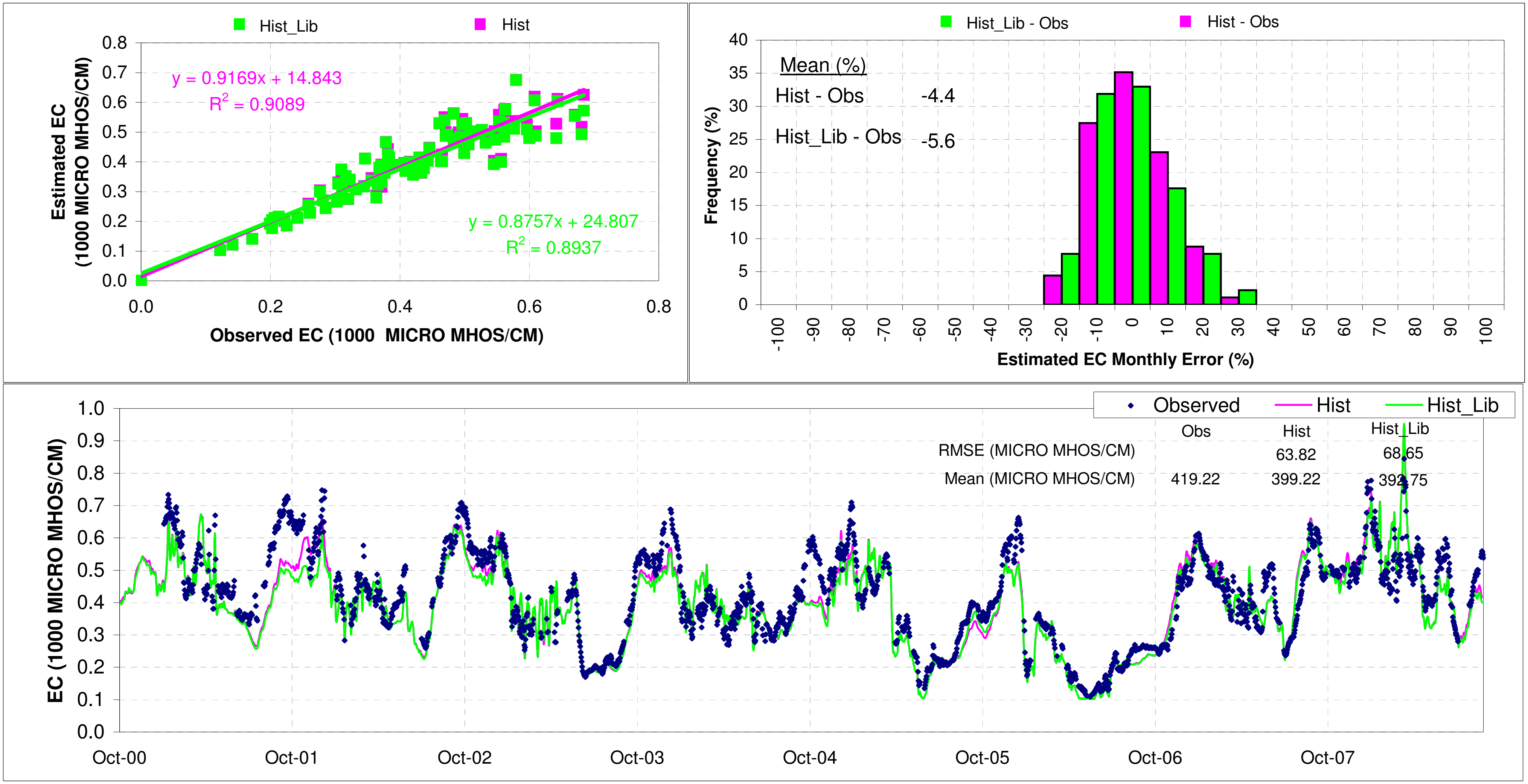
Montezuma Sl at Beldons (SLMZU011)



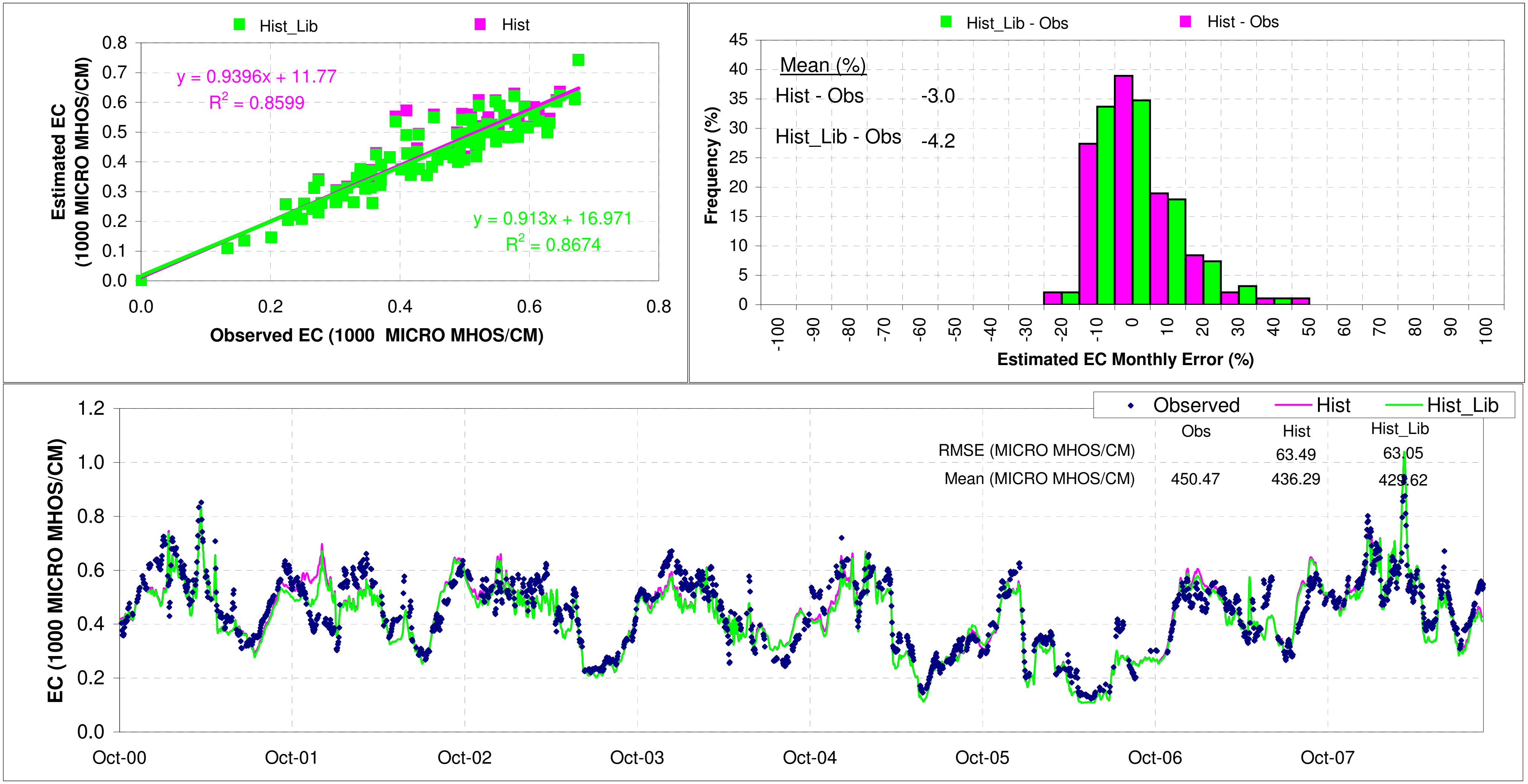




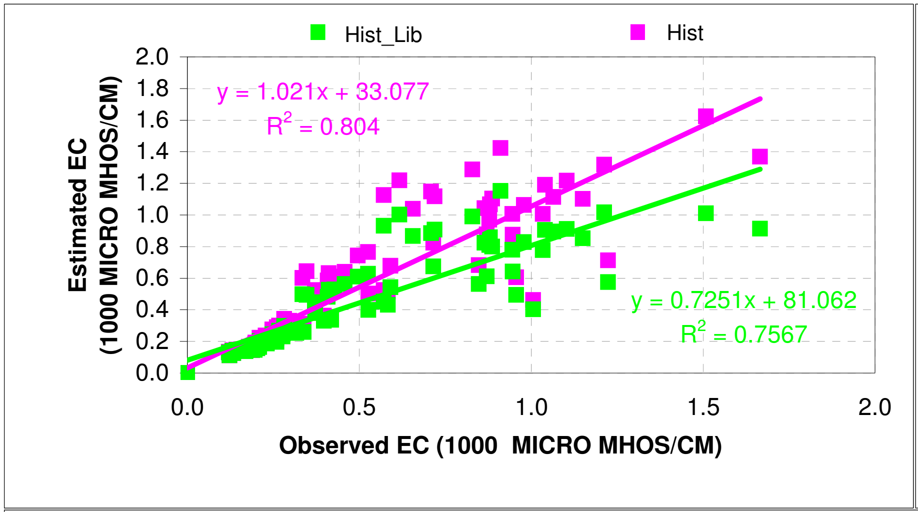
CliftonCourt Forebay (CHSWP003)

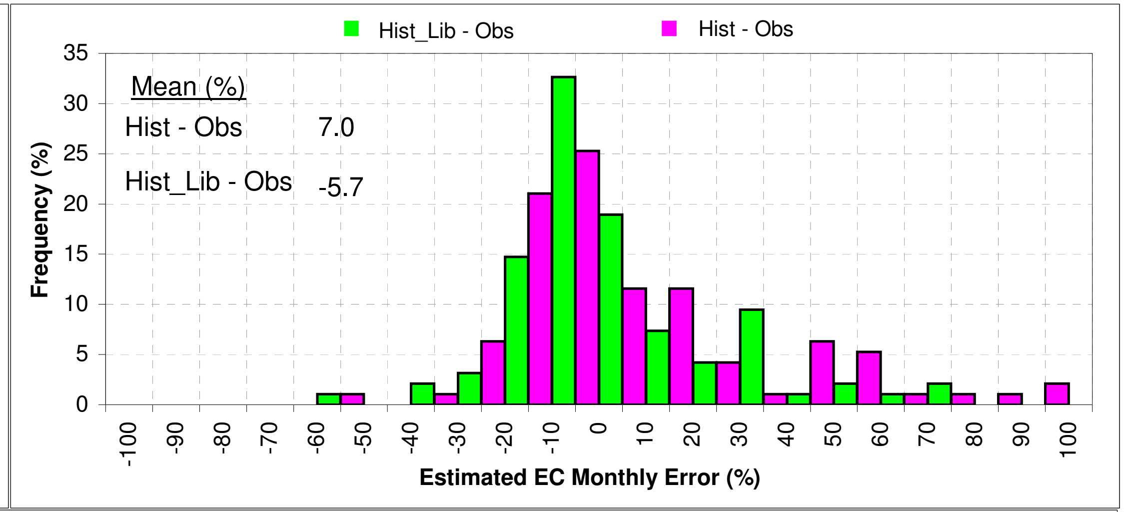


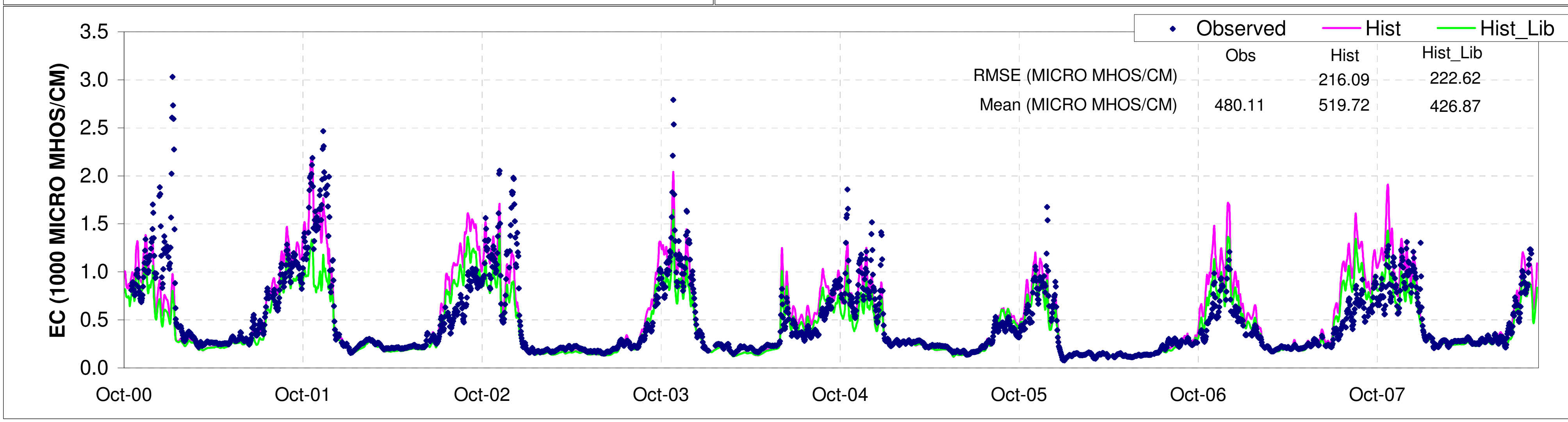
Delta Mendota Canal at Tracy Pumping Plant (CHDMC006)



Three Mile Slough at San Joaquin River (SLTRM004)

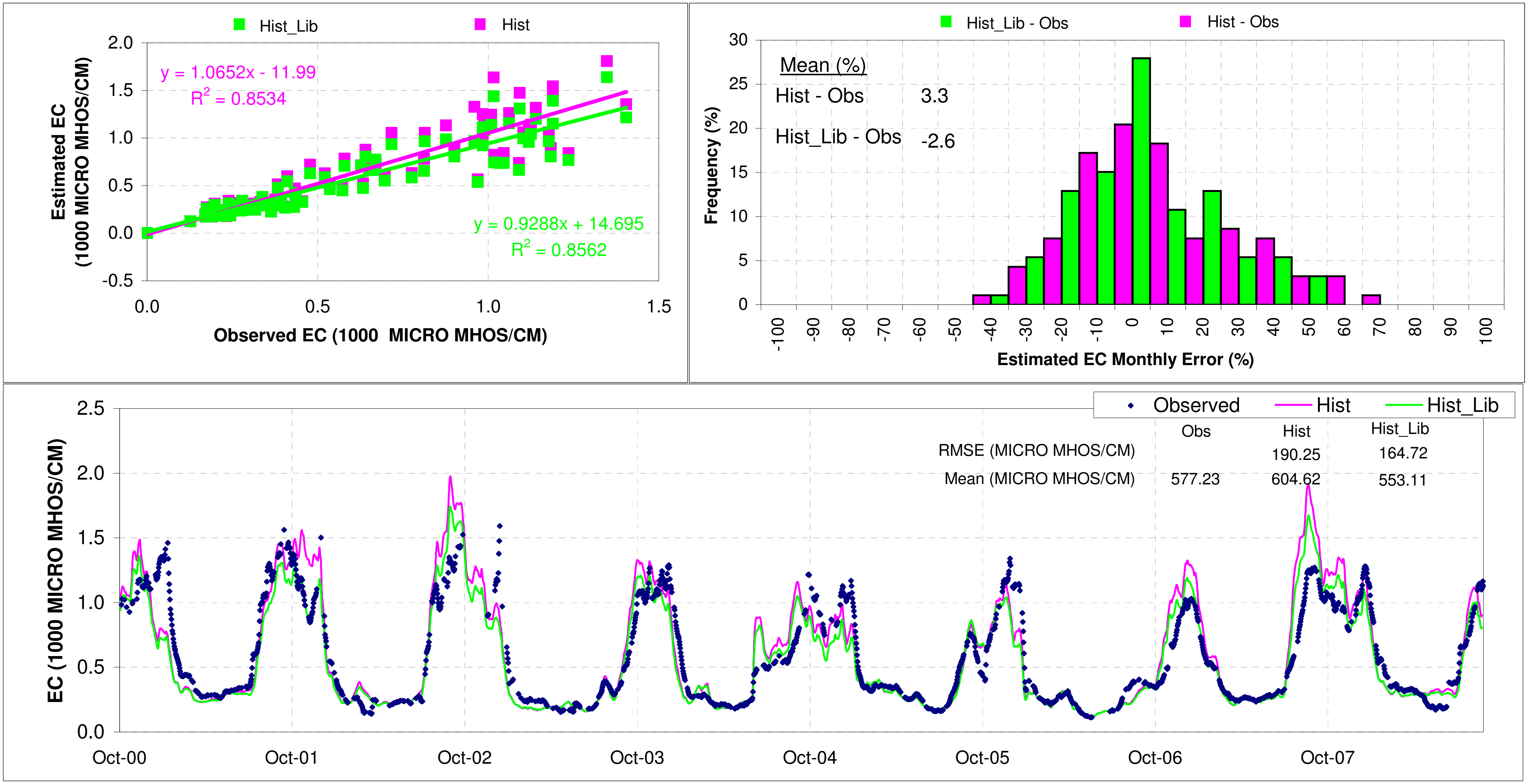






	Obs	Hist	Hist_Lib
RMSE (MICRO MHOS/CM)		216.09	222.62
Mean (MICRO MHOS/CM)	480.11	519.72	426.87

Dutch Slough (SLDUT007)



Appendix D
DSM2 Output Location for EC at San Andreas Landing in the San Joaquin River

DSM2 Output Location for EC at San Andreas Landing in the San Joaquin River

PREPARED FOR: Parviz Nader/DWR

PREPARED BY: CH2M HILL

DATE: September 9, 2009

The salinity measurement gage at San Andreas Landing (CDEC SAL) in the San Joaquin River is located near the confluence of Mokelumne and San Joaquin Rivers as shown in the Figure D1. Even though the gage is located on the San Joaquin River, the salinity reading is likely from the Mokelumne plume. This plume separation is possible since the gage is very close to the confluence, as shown in the Figure D2. A 1-D model such as DSM2 cannot capture the plume separation along the channel. It assumes full mixing at any given location.

Figure D1: Location of the San Andreas Landing Salinity Gage in the San Joaquin River

During the DSM2 recalibration effort, the appropriate channel output location in DSM2 that would correspond to the observed salinity data at San Joaquin River at San Andreas Landing was determined. The observed EC was compared to various DSM2 locations on the San Joaquin River and on the Mokelumne River around San Andreas Landing.

Figure D2: Separation of the Mokelumne River Plume near the San Andreas Landing Salinity Gage in the San Joaquin River

The observed salinity data for San Andreas Landing was compared to the following output locations from DSM2. These locations are shown on the DSM2 grid in Figure D3.

- Channel 348 at upstream end (348_0) – Mokelumne River
- Channel 348 at downstream end (348_length) – Mokelumne River
- Channel 349 at upstream end (349_0) – Mokelumne River
- Channel 349 at downstream end (RSAN032) – Mokelumne River
- Channel 45 at downstream end (SJR_SAN_AND) – San Joaquin River

The observed and simulated 15 minute EC data were tidally filtered and daily averages were computed. Time series plots comparing the observed data to various DSM2 locations were prepared as shown in the Figures D4 and D5.

In Figure D4, the observed EC data is plotted along with the simulated EC at SJR_SAN_AND and RSAN032 locations. It is obvious that the simulated EC at the mouth of Mokelumne River (RSAN032) matches well with the observed data than that from the San Joaquin River (SJR_SAN_AND). The San Joaquin River values are too saline compared to the observed data.

Figure D5 compares the observed EC data at San Andreas Landing with simulated EC at various output locations on the Mokelumne River channels. Again, RSAN032 yields the best match with the observed data. Other locations are fresher than the observed data.

Therefore, simulated EC at the mouth of Mokelumne River (RSAN032) in DSM2 is the most appropriate output location corresponding to San Andreas Landing salinity gage in San Joaquin River.

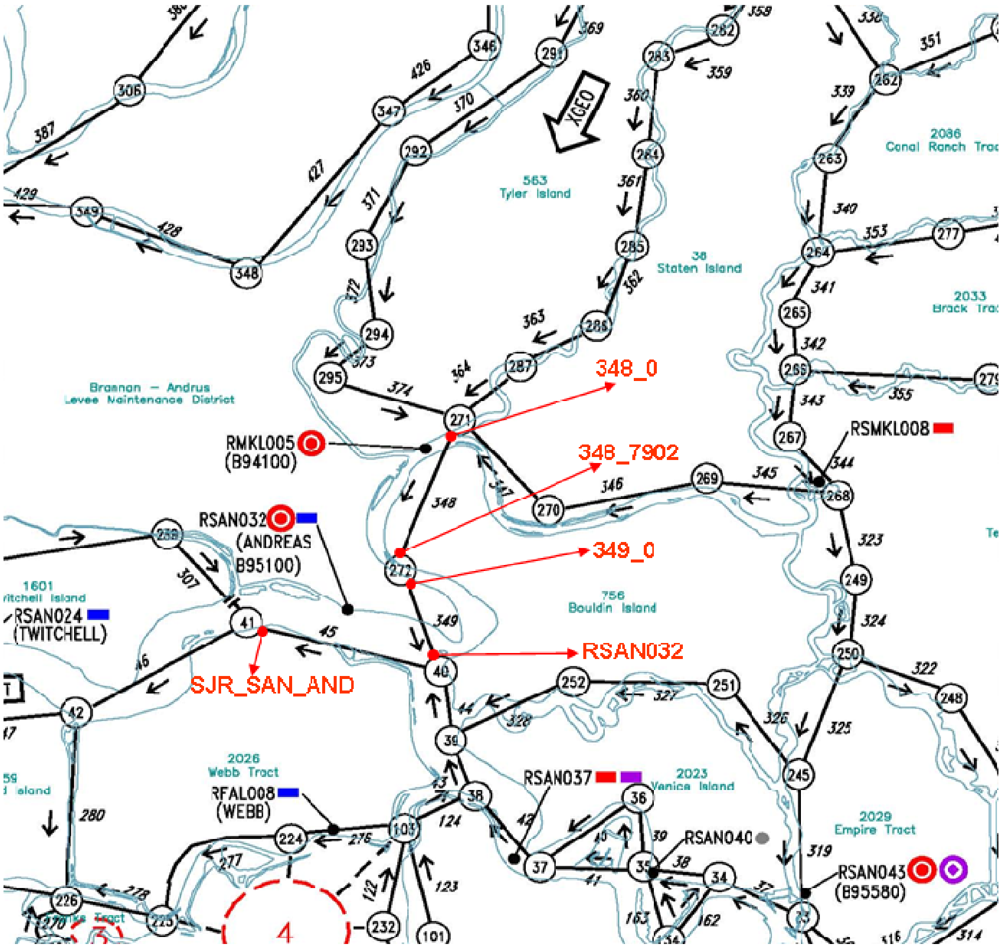


Figure D3: DSM2 Grid Showing the Channel Locations Used in the Comparison

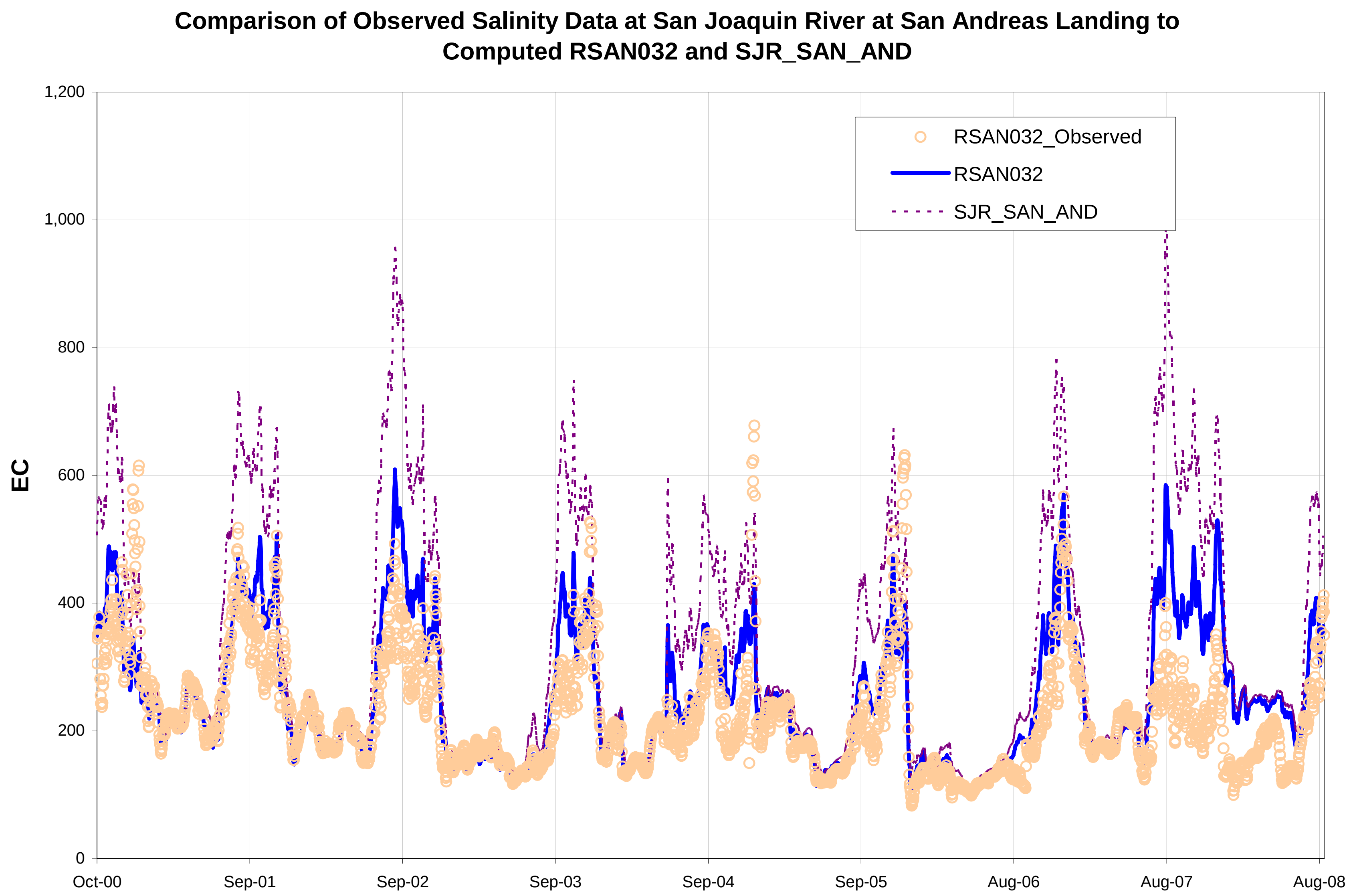


Figure D4: Comparison of RSAN032_Observed to RSAN032 computed and SJR_SAN_AND

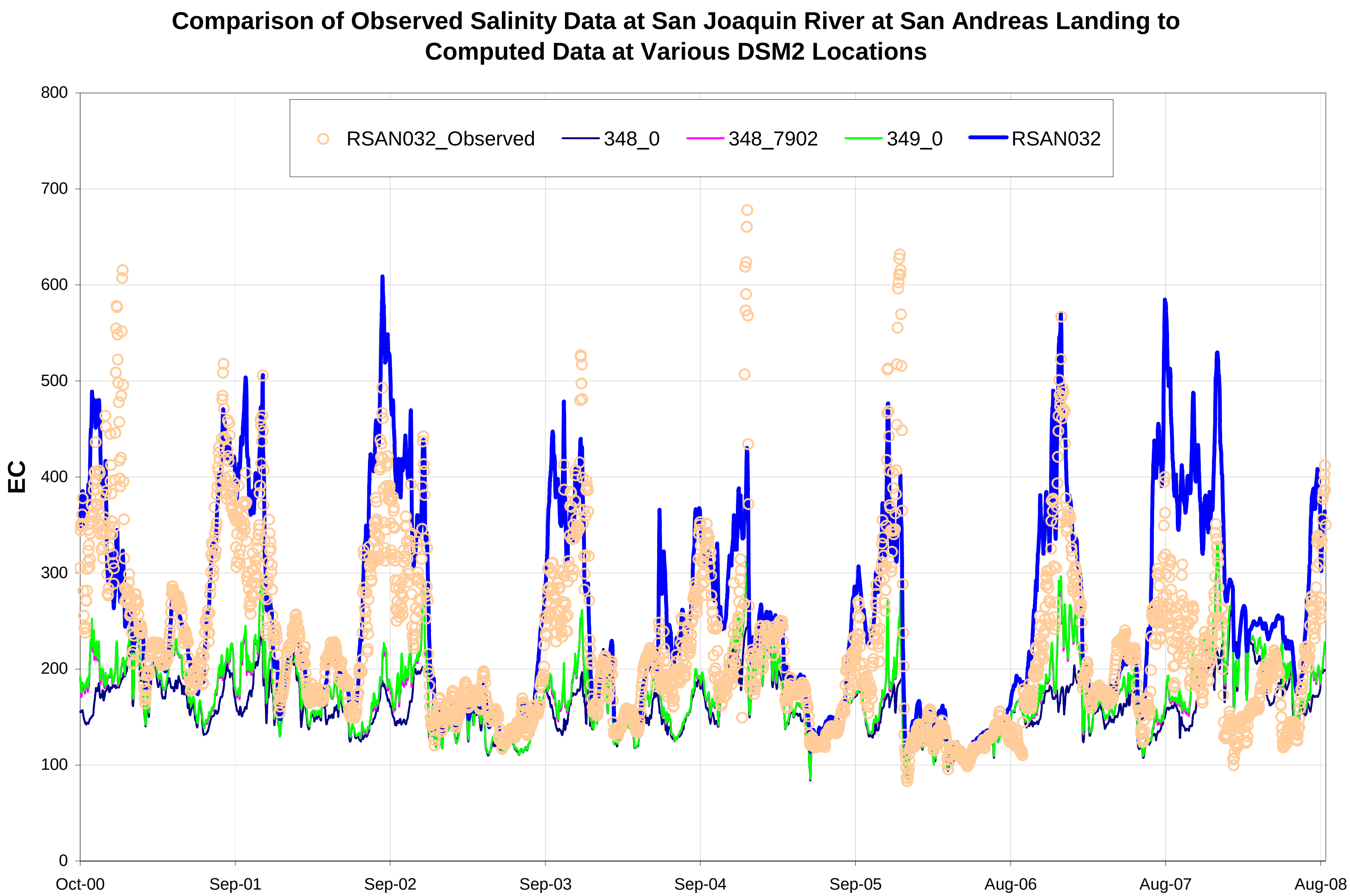


Figure D5: Comparison of RSAN032_Observed to RSAN032 computed, 348_0, 348_7902 and 349_0

BAY DELTA CONSERVATION PLAN

UnTRIM San Francisco Bay-Delta Model Sea Level Rise Scenario Modeling Report

Prepared For:

Science Applications International Corporation
and
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FINAL REPORT

July 16, 2010

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Executive Summary

As part of the Bay Delta Conservation Plan (BDCP), future conditions simulations are planned which will need to incorporate the potential effects of sea level rise on salinity intrusion in the Sacramento-San Joaquin Delta. In support of this effort, three-dimensional hydrodynamic and salinity simulations using the UnTRIM Bay-Delta model were made to provide a reference condition for re-calibration of appropriate dispersion factors for the 1-D and 2-D models which are the primary tools being used in the BDCP planning process. The 3-D UnTRIM Bay-Delta model provides an already established and well-documented hydrodynamic model which is suitable for a detailed assessment of the potential salinity impacts of Sea Level Rise (SLR) in San Francisco Bay and the Sacramento-San Joaquin Delta.

The UnTRIM Bay-Delta model used for this project builds on previous applications (e.g., MacWilliams et al., 2007; MacWilliams et al., 2008; MacWilliams et al., 2009), and was further refined as part of this study to increase the model grid resolution in Suisun Marsh. The UnTRIM Bay-Delta model was used to simulate hydrodynamics and salinity under baseline conditions and for six levels of SLR. The baseline simulation period spans from October 15, 2001 through January 1, 2003. The analysis of sea level rise impacts spans a one-year period from January 1, 2002 through January 1, 2003. This report presents the results of the sea level rise impacts on salinity in San Francisco Bay and the Sacramento-San Joaquin Delta that were predicted using the UnTRIM Bay-Delta model. The relative contributions of different transport processes, including gravitational circulation and tidal dispersion, to salt intrusion were investigated with a salt flux analysis. A full set of hydrodynamic and salinity model results were also provided to CH2M Hill for use in recalibration of the DSM2 and RMA2 models to incorporate the effects of SLR into the lower dimensional models being used as part of the BDCP technical studies.

Questions, comments, or suggestions for future improvements to the UnTRIM Bay-Delta model should be addressed to Michael MacWilliams at: michael@rivermodeling.com.

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Abbreviations

1D	One-Dimensional
2D	Two-Dimensional
3D	Three-Dimensional
BBID	Byron Bethany Irrigation District
BDCP	Bay Delta Conservation Plan
CCWD	Contra Costa Water District
CDEC	California Data Exchange Center
CVP	Central Valley Project
DICU	Delta Island Consumptive Use
DFG	Department of Fish and Game
DRMS	Delta Risk Management Strategy
DSS	Data Storage System
DWR	Department of Water Resources
DWSC	Deep Water Ship Channel
EC	Electrical Conductivity
GLS	Generic Length Scale
IEP	Interagency Ecological Program
NOAA	National Oceanic & Atmospheric Administration
PSU	Practical Salinity Unit
SLR	Seal Level Rise
SMSCG	Suisun Marsh Salinity Control Gates
SWP	State Water Project
TRIM	Tidal, Residual, Intertidal & Mudflat Model
UnTRIM	Unstructured Tidal, Residual, Intertidal & Mudflat Model
USACE	United States Army Corps of Engineers
USBR	United States Bureau of Reclamation
USGS	United States Geological Survey
WPCP	Water Pollution Control Plant

1. Introduction

As part of the Bay Delta Conservation Plan (BDCP), future conditions simulations are planned which will need to incorporate the potential effects of sea level rise on salinity intrusion in the Sacramento-San Joaquin Delta. This report presents the results of the UnTRIM Bay-Delta model simulations of sea level rise impacts on salinity in San Francisco Bay and the Sacramento-San Joaquin Delta. The UnTRIM Bay-Delta model used for this project builds on previous applications (e.g., MacWilliams et al., 2007; MacWilliams et al., 2008; MacWilliams et al., 2009).

The report includes a brief overview of the UnTRIM Bay-Delta model, a description of the sea level rise scenarios and the sea level rise scenario results, a discussion of the regression relationships used to characterize the effects of SLR at the DSM2 and RMA2 model boundaries, and a brief summary and conclusions section. Hydrodynamic and salinity comparison figures for the 2002 baseline simulation period are included as an appendix.

This report is divided into nine major sections and one appendix:

- **Section 1. Introduction.** This section presents the project approach and objectives, as well as a summary of the scope and organization of the report.

- **Section 2. UnTRIM Bay-Delta Model Description.** This section provides a description of the UnTRIM hydrodynamic model, and an overview of the UnTRIM Bay-Delta model.

- **Section 3. Sea Level Rise Scenario Descriptions.** This section describes the sea level rise scenarios that were simulated for this study.

- **Section 4. Sea Level Rise Impacts on Daily-averaged Depth-average Salinity.** This section evaluates the impacts of sea level rise on daily-averaged depth-average salinity in San Francisco Bay and the Sacramento-San Joaquin Delta.

- **Section 5. Evaluation of Impact of Sea Level Rise on X2.** This section evaluates the impacts of sea level rise on X2.

- **Section 6. Sea Level Rise Impacts on Salinity at Continuous Monitoring Locations.** This section evaluates the impacts of sea level rise on salinity at a set of continuous monitoring stations in San Francisco Bay and the Sacramento-San Joaquin Delta.

- **Section 7. Stage and Salinity Relationships for SLR at Fort Point and Martinez.** This section presents the regression relationships developed to characterize the effects of SLR on stage and salinity at Fort Point and Martinez.

- **Section 8. Analysis of Salt Flux Mechanisms.** This section presents a detailed analysis of the effect of SLR on the mechanisms responsible for salt transport in San Francisco Bay and the Sacramento-San Joaquin Delta.

- **Section 9. Summary and Conclusions.** This section presents a brief summary of the simulation results and analysis presented in this report.

- **Appendix A. Model Comparison Figures for 2002 simulation period.** This section presents a set of hydrodynamic and salinity validation figures for the 2002 simulation period.

2. UnTRIM Bay-Delta Model Description

The primary tool used in this technical study was the three-dimensional hydrodynamic model UnTRIM (Casulli and Zanolli, 2002). A complete description of the governing equations, numerical discretization, and numerical properties of UnTRIM is presented in Casulli and Zanolli (2002; 2005), Casulli (1999), and Casulli and Walters (2000). A complete description of the UnTRIM Bay-Delta model can be found in MacWilliams et al. (2009). This section provides a brief summary of the UnTRIM hydrodynamic model formulation and a brief description of the UnTRIM Bay-Delta model.

The UnTRIM model solves the three-dimensional Navier-Stokes equations on an unstructured grid in the horizontal plane. The boundaries between vertical layers are at fixed elevations, and cell heights can be varied vertically to provide increased resolution near the surface or other vertical locations. Volume conservation is satisfied by a volume integration of the incompressible continuity equation, and the free-surface is calculated by integrating the continuity equation over the depth, and using a kinematic condition at the free-surface as described in Casulli (1990). The numerical method allows full wetting and drying of cells in the vertical and horizontal directions. The governing equations are discretized using a finite difference – finite volume algorithm. Discretization of the governing equations and model boundary conditions are presented in detail by Casulli and Zanolli (2002). All details and numerical properties of this state-of-the-art three-dimensional model are well-documented in peer reviewed literature (Casulli and Zanolli, 2002; Casulli and Zanolli, 2005).

The UnTRIM San Francisco Bay-Delta model (UnTRIM Bay-Delta model) is a three-dimensional hydrodynamic model of San Francisco Bay and the Sacramento-San Joaquin Delta, which has been developed using the UnTRIM hydrodynamic model (MacWilliams et al., 2007; MacWilliams et al., 2008; MacWilliams et al., 2009). The UnTRIM Bay-Delta model extends from the Pacific Ocean through the entire Sacramento-San Joaquin Delta (Figure 2-1). The UnTRIM Bay-Delta model takes advantage of the grid flexibility allowed in an unstructured mesh by gradually varying grid cell sizes, beginning with large grid cells in the Pacific Ocean and gradually transitioning to finer grid resolution in the smaller channels of the Sacramento-San Joaquin Delta. This approach offers significant advantages both in terms of numerical efficiency and accuracy, and allows for local grid refinement for detailed analysis of local hydrodynamics, while still incorporating the overall hydrodynamics of the larger estuary in a single model. The UnTRIM Bay-Delta model has been calibrated using water level, flow, and salinity data collected in San Francisco Bay and the Sacramento-San Joaquin Delta (MacWilliams et al., 2008; MacWilliams et al., 2009).

The model calibration and validation results (MacWilliams et al., 2008; MacWilliams et al., 2009) demonstrate that the UnTRIM Bay-Delta model is accurately predicting flow, stage, and salinity in San Francisco Bay and the Sacramento-San Joaquin Delta under a wide range of hydrologic conditions and is suitable for evaluating the potential salinity impacts resulting from sea level rise.

Some aspects of the boundary conditions used in the application of the UnTRIM Bay-Delta model in this study differ from the commonly used boundary conditions described by

MacWilliams et al. (2008; 2009). In general, these modifications were made so that the boundary conditions used in this application of the UnTRIM Bay-Delta model were as close to identical as possible to the boundary conditions used in DSM2 for the DSM2 recalibration (CH2M Hill, 2009). The most significant change was that the flow though the radial gates into Clifton Court Forebay were applied using the exact flows calculated by DSM2. This modification results in a much lower level of agreement between observed and predicted water levels inside Clifton Court Forebay, than in previous applications of the UnTRIM Bay-Delta model (e.g., MacWilliams et al., 2009). In addition, the agreement between observed and predicted tidal time scale flows in Old River is decreased relative to the three periods simulated by MacWilliams et al. (2008) or the three periods simulated by MacWilliams et al. (2009). This largely results because the gate equations used in DSM2 are not nearly as accurate at determining the instantaneous flow through the radial gates as the historical SWP flow values which are based in part the daily change in volume inside Clifton Court Forebay. Additionally, the time interpolation of inflow boundaries was modified to reflect the stepwise application of these boundaries in DSM2. The effect of this change is evident in the stage comparisons at Verona and Vernalis, and some of the computed phase differences in the calibration, but this change is not expected to have a significant impact on the overall model results. Lastly, additional inflows were applied in Suisun Marsh to be consistent with the flows used in the RMA2 model.

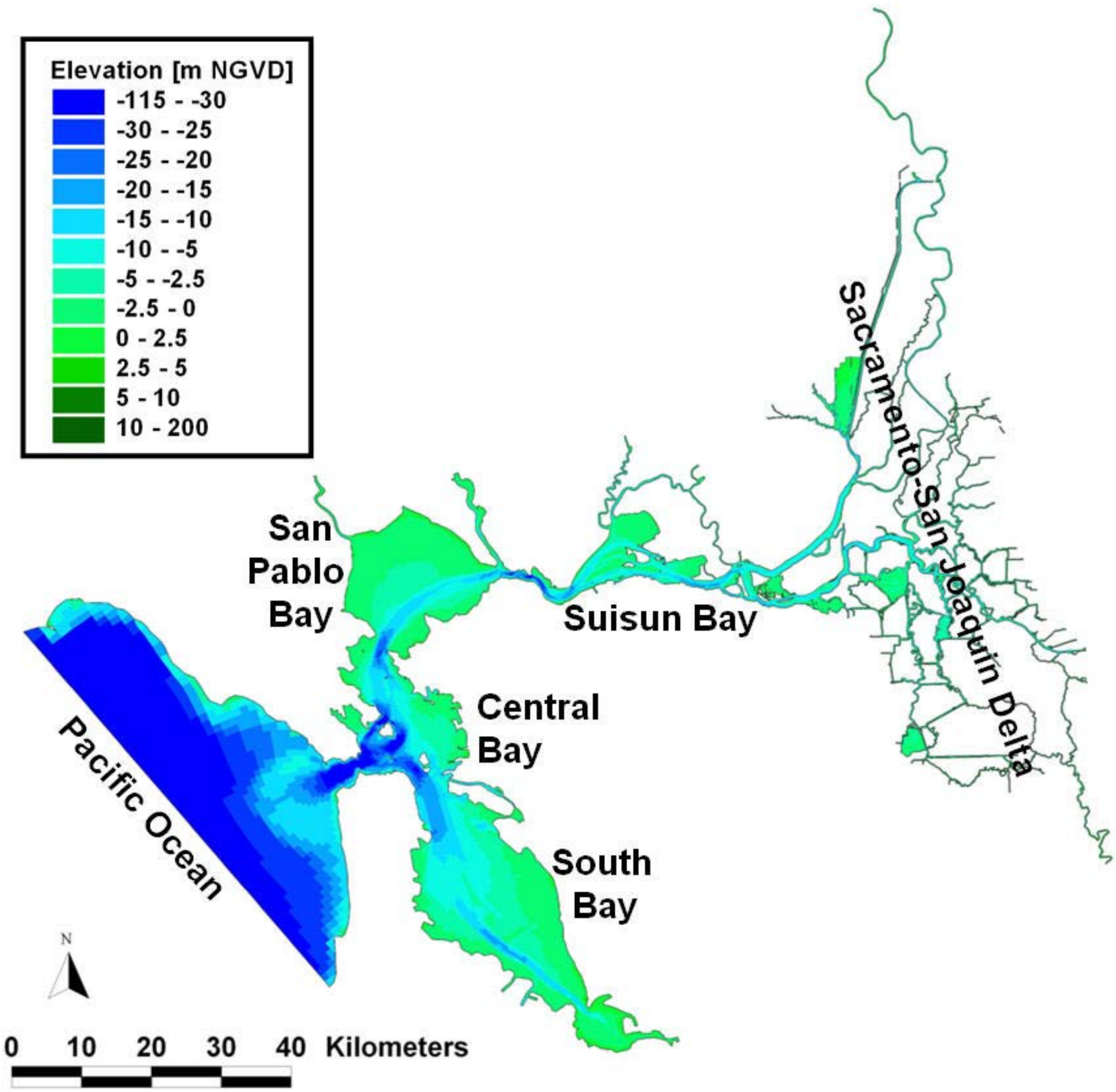


Figure 2-1 Model domain for the UnTRIM Bay-Delta model.

3. Sea Level Rise Scenario Descriptions

3.1 UnTRIM Bay-Delta Model Approach

The UnTRIM Bay-Delta model was used to simulate a 14.5 month period spanning from October 15, 2001 through January 1, 2003. The model was allowed to spin-up from the initial condition for 2.5 months and the analysis period used in the SLR comparisons spans from January 1, 2002 through January 1, 2003.

The specification of the Delta boundary conditions and operations were modified from the standard approach described by MacWilliams et al. (2008; 2009) in order to more closely match the exact boundary conditions and time interpolation of daily values used in DSM2 for the DSM2 Recalibration (CH2M Hill, 2009). The most significant change was that the flow though the radial gates into Clifton Court Forebay were applied using the exact flows calculated by DSM2, and daily inflow values were specified uniformly across each day. Additional inflows were also applied in Suisun Marsh to be consistent with the flows used in the RMA2 model. These changes to the standard UnTRIM Bay-Delta model implementation were all made to facilitate inter-comparisons between the UnTRIM Bay-Delta model, RMA2, and DSM2, and to facilitate the recalibration of dispersion factors in DSM2.

In regions of the UnTRIM Bay-Delta model that are not included in the DSM2 model domain, the standard boundary conditions described by MacWilliams et al. (2008; 2009) were applied. These include spatially variable evaporation and precipitation in the non-Delta portion of the San Francisco Estuary (evaporation and precipitation are included as part of DICU in the Delta), spatially variable wind, and other non-Delta inflows, including Napa River, Sonoma Creek, Petaluma River, Novato River, San Lorenzo Creek, Alameda Creek, San Francisquito Creek, Matadero Creek, Saratoga Creek, Guadalupe River, Coyote Creek, and flows from the San Jose/Santa Clara WPCP.

3.2 Baseline Scenario Validation

Detailed calibration and validation of the UnTRIM Bay-Delta model has been conducted over a range of simulation periods as part of previous studies (e.g., MacWilliams et al., 2007; MacWilliams et al., 2008; MacWilliams et al., 2009). As a result, no additional calibration was conducted as part of this study. MacWilliams et al. (2008) provide flow and stage comparisons for the summer 2002 period, however salinity validation of the UnTRIM Bay-Delta model for 2002 period has not been previously conducted.

Because some boundary conditions have been changed from the standard UnTRIM Bay-Delta implementation, comparison of observed and predicted stage, flow, and salinity for this study may differ from the standard implementation. Flow, stage and salinity comparisons were made for the 2002 analysis period to verify that the modified implementation of the UnTRIM Bay-Delta model used in this study accurately predicted stage, flow, and salinity in San Francisco Bay and the Sacramento-San Joaquin Delta. In this context, comparison of predicted water levels, flows, and salinity with observations during this simulation provides an additional validation of the previous calibration and validation studies.

Appendix A provides a set of validation figures that provide a measure of the ability of the UnTRIM Bay-Delta model to accurately predict water levels (stage), flows, and salinity in San Francisco Bay and the Sacramento-San Joaquin Delta. For the 2002 simulation period, observed and predicted stage were compared at 56 continuous stage monitoring locations, flow was compared at 25 flow monitoring stations, and predicted salinity was compared to observed salinity at 59 continuous salinity monitoring locations. Predicted salinity was also compared to observed salinity along the axis of San Francisco Bay on each of the days during the analysis period when the USGS collected synoptic salinity profiles.

Accurate prediction of water levels in San Francisco Bay demonstrates that tides are accurately propagating through the Bay and into the Delta. Comparison of predicted flows to observations in the Delta demonstrate the degree that the model captures both the instantaneous and net flows in specific channels within the Delta. Accurate prediction of salinity in San Francisco Bay and the western Delta demonstrate the degree to which the model is accurately predicting salinity intrusion due to gravitational circulation and other processes. Within the Sacramento-San Joaquin Delta, prediction of salinity is strongly dependent on consumptive use and the outflow salinity from agricultural diversions, both of which introduce a significant level of uncertainty.

3.3 Sea Level Rise Scenario Descriptions

The Baseline (0 cm SLR) simulation was made assuming historic operations and inflows, as applied in the DSM2 recalibration (CH2M Hill, 2009). Tides at the Pacific Ocean boundary of the UnTRIM Bay-Delta model were applied using observed stage at Fort Point (NOAA 9454290), with a phase and amplitude offset applied to account for phase differences between the ocean boundary and Fort Point. These offsets were calibrated by MacWilliams et al. (2009) to achieve nearly exact agreement between observed and predicted stage at Fort Point, in terms of mean water level, tidal amplitude, and tidal phase as seen in Figure A.3-2.

Six sea level rise scenarios were simulated. For the sea level rise scenarios, a constant offset was added to the tides applied at the Pacific Ocean boundary for the Baseline (0 cm SLR) scenario. For the 15 cm SLR scenario, a constant offset of 15 cm was applied at the ocean boundary; for the 30 cm SLR scenario, a constant offset of 45 cm was applied at the ocean boundary; for the 45 cm SLR scenario, a constant offset of 45 cm was applied at the ocean boundary; for the 60 cm SLR scenario, a constant offset of 60 cm was applied at the ocean boundary; for the 140 cm SLR scenario, a constant offset of 140 cm was applied at the ocean boundary. For the sixth scenario, 140 cm SLR with 5% Amplification, a constant offset of 140 cm was applied at the ocean boundary and the tidal range was amplified by 5%. All other boundary conditions were identical between the six sea level rise scenarios and the Baseline scenario. Thus, the simulations assume historical operations, with no re-operation to account for changes in water quality resulting from SLR.

3.4 Sea Level Rise Scenario Analysis Approach

The impacts are evaluated through comparison of daily-averaged depth-average salinity maps (Section 4), comparison of X2 (Section 5), and comparison of predicted salinity at a set of fixed monitoring locations (Section 6). Relationships between predicted stage and salinity between the Baseline scenario and each of the sea level rise scenarios are developed at both Martinez and the Golden Gate (Section 7) to facilitate the implementation of appropriate boundary conditions for sea level rise scenarios in DSM2 and the RMA2 models. Lastly, a detailed analysis of salt flux is included (Section 8) to evaluate the mechanisms responsible for increase salt intrusion with sea level rise.

A full set of flow and section averaged salinity predictions for the Baseline scenario, the 15 cm SLR scenario, and the 45 cm SLR scenario at stations throughout the Delta were provided to CH2M Hill for comparison to predicted flow and salinity from DSM2. These output include the section averaged salinity at the locations shown on Figure 3-1, depth-averaged and surface point salinity data, daily-averaged depth-average salinity transects along the axis of San Francisco Bay, the Sacramento River and the San Joaquin River, and instantaneous flow data at a set of 36 cross-sections. A similar set of model predictions was provided to RMA, Inc. for recalibration of the RMA2 model for the 140 cm sea level rise scenario.

The UnTRIM Bay-Delta model simulates salinity in Practical Salinity Units (psu), while DSM2 simulates salinity electrical conductivity (EC). Salinity is a conservative quantity, whereas electrical conductivity is not conservative (as seen in Table 3-1). For example if a volume of water with salinity of 25 psu were mixed with an equal volume of water with salinity of 5 psu, the resulting salinity in UnTRIM would be 15 psu. However if the same volume of water with EC 39269 [μmhos cm^{-1}] (corresponding to 25 psu) were mixed with an equal volume of water with EC 8961 [μmhos cm^{-1}] (corresponding to 5 psu), the resulting EC in DSM2 would be 24115 [μmhos cm^{-1}], which corresponds to 14.61 psu. Thus, the non-conservative nature of EC introduces a 2.4% error in this case if EC is simulated instead of salinity. As a result, there are significant advantages to simulating salinity in psu as opposed to simulating EC. Because water quality standards in the Delta are typically based on EC, salinity can be converted to EC following the inverse of the approach used by the USGS in San Francisco Bay to convert from measured specific conductance (EC at 25 degrees Celsius) to salinity (Schoellhamer and Buchanan, 2010). The measured electrical conductivity (EC) and temperature data collected in the field are converted to electrical conductance, which is the EC at 25 degrees Celsius. The specific conductance data is converted to salinity using the 1985 UNESCO standard (UNESCO, 1985) in the range of 2-42 practical salinity units (psu). Salinities below 2 psu are computed using the extension of the practical salinity scale proposed by Hill et al. (1986). For reference, conversions between salinity in psu and electrical conductivity in [μmhos cm^{-1}] are provided in Table 3-1. In this table and throughout the report, EC refers to EC at 25 degrees Celsius.

Table 3-1 Electrical Conductivity values corresponding to a range of salinity values.

Salinity [psu]	Electrical Conductivity [µmhos cm-1]
0.05	108
0.10	213
0.20	418
0.30	620
0.50	1015
0.75	1497
1.0	1970
5.0	8961
10.0	17025
15.0	24697
20.0	32093
25.0	39269
30.0	46256

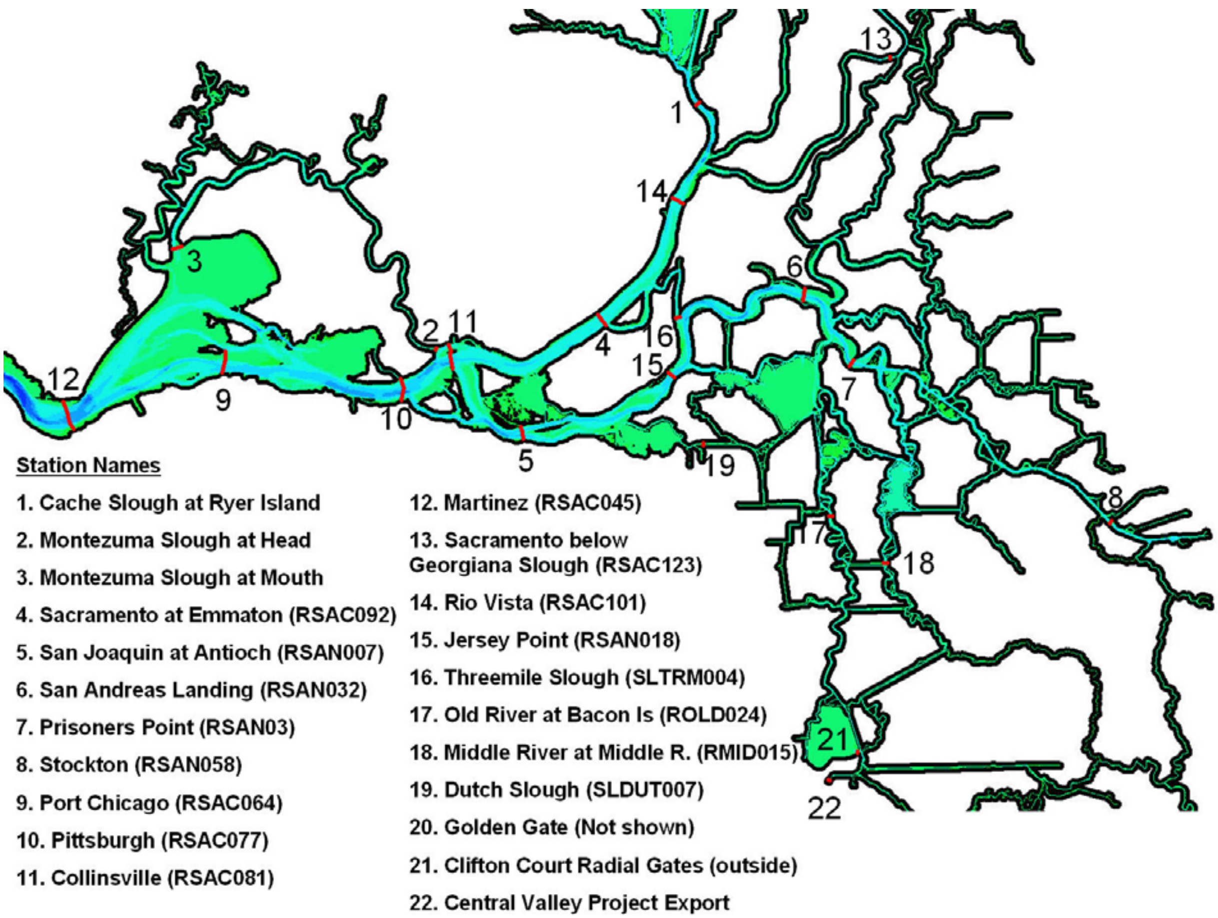


Figure 3-1 Locations of section averaged salinity output provided to CH2M Hill for DSM2 comparisons.

4. Sea Level Rise Impacts on Daily-averaged Depth-average Salinity

Daily-averaged depth-average salinity maps provide an effective way to make visual comparisons between predicted salinity under a range of scenarios. For each sea level rise scenario, the depth-averaged salinity is computed at each model time step and then averaged over each day. The resulting daily-averaged depth-average salinity maps for each sea level rise scenario can then be compared to the Baseline salinity to show the spatial distribution of the predicted increase in daily-average salinity. In the following sections, the salinity map comparisons are made on the first day of each month during the simulation period, spanning from January 1, 2002 through January 1, 2003.

4.1 Predicted Increase in Salinity for 15 cm SLR Scenario

Figure 4.1-1 through 4.1-13 show the predicted salinity along the northern portion of the San Francisco Estuary, spanning from San Pablo Bay through the Sacramento-San Joaquin Delta for the 15 cm SLR scenario. The top panel of each figure shows the predicted daily-averaged depth-average salinity for the 15 cm SLR scenario. The lower panel shows the predicted salinity increase computed by subtracting the predicted daily-averaged depth-average salinity for the Baseline (0 cm SLR) scenario from the predicted daily-averaged depth-average salinity for the 15 cm SLR scenario. Figures 4.1-14 through 4.1-26 show the predicted salinity increases resulting from the 15 cm SLR scenario in the Sacramento-San Joaquin Delta.

At the beginning of the analysis period on January 1, 2002, salinity increases between 0.05 and 0.10 psu are predicted between Chipps Island and Collinsville and predicted salinity increases are less than 0.05 psu throughout the remaining portions of the Delta. Salinity increases between 0.20 and 0.50 psu are predicted through Carquinez Strait and salinity increases between 0.05 and 0.35 psu are predicted throughout Suisun Bay. Larger salinity increases of up to more than 1.5 psu are predicted in San Pablo Bay. During the first half of the year, predicted salinity increases in Suisun Bay and the Delta remain similar to the predicted salinity increases seen on January 1, 2002, though the predicted salinity is increasing throughout this period. Larger salinity increases are predicted in the Delta between July and December, with the largest predicted salinity increases in December prior to the first flush. In December, salinity increases of between 0.20 and 0.50 psu are predicted between Chipps Island and Emmaton, and salinity increases of between 0.05 and 0.10 psu are predicted in Franks Tract. Following high flows which occurred in December, predicted salinity on January 1, 2003 shows that the 0.50 psu isohaline is on the western side of Suisun Bay near Martinez, and predicted salinity increases are less than 0.05 psu throughout the Delta.

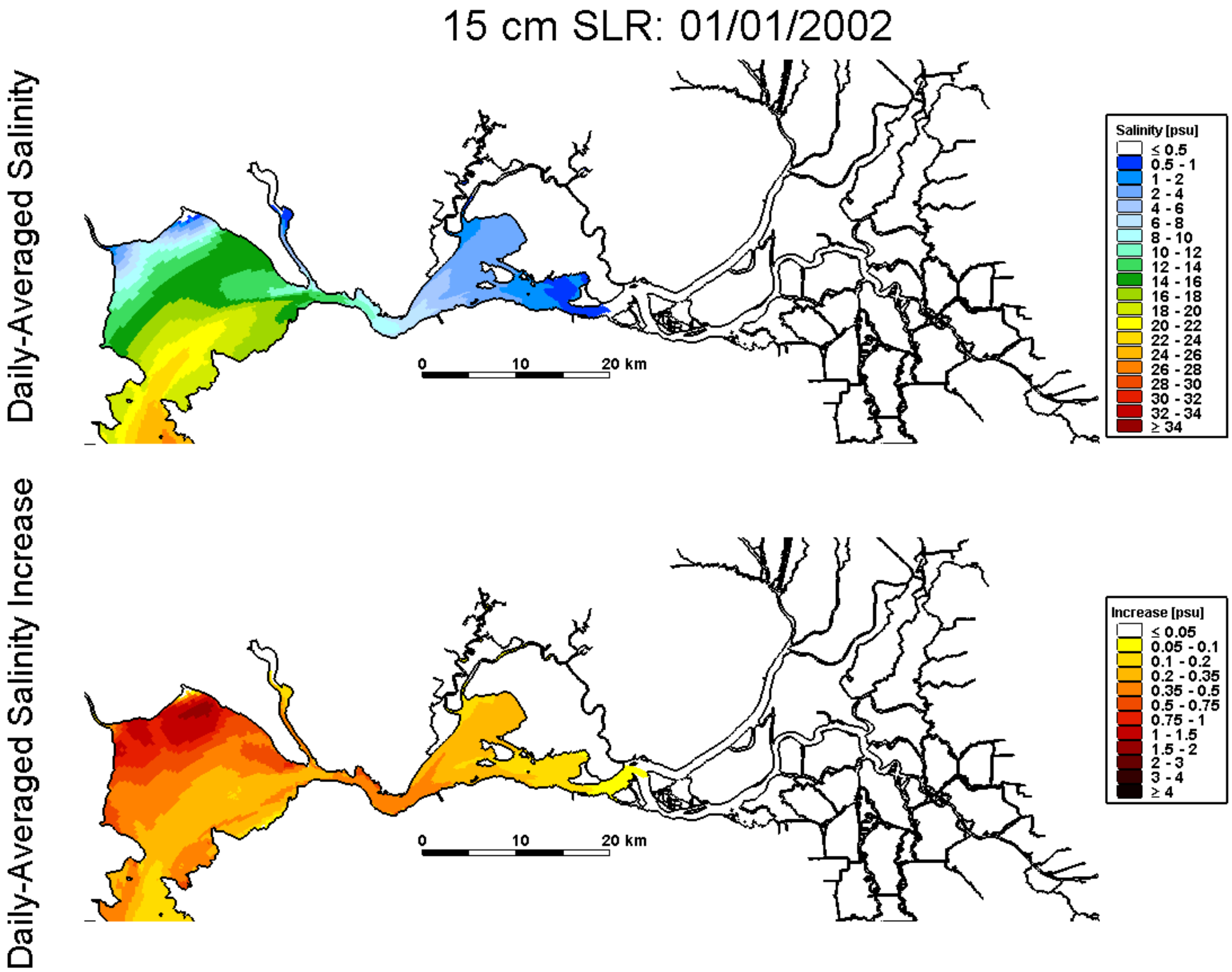


Figure 4.1-1 Predicted daily-averaged depth-average salinity on January 1, 2002 for the 15 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on January 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 15 cm SLR scenario.

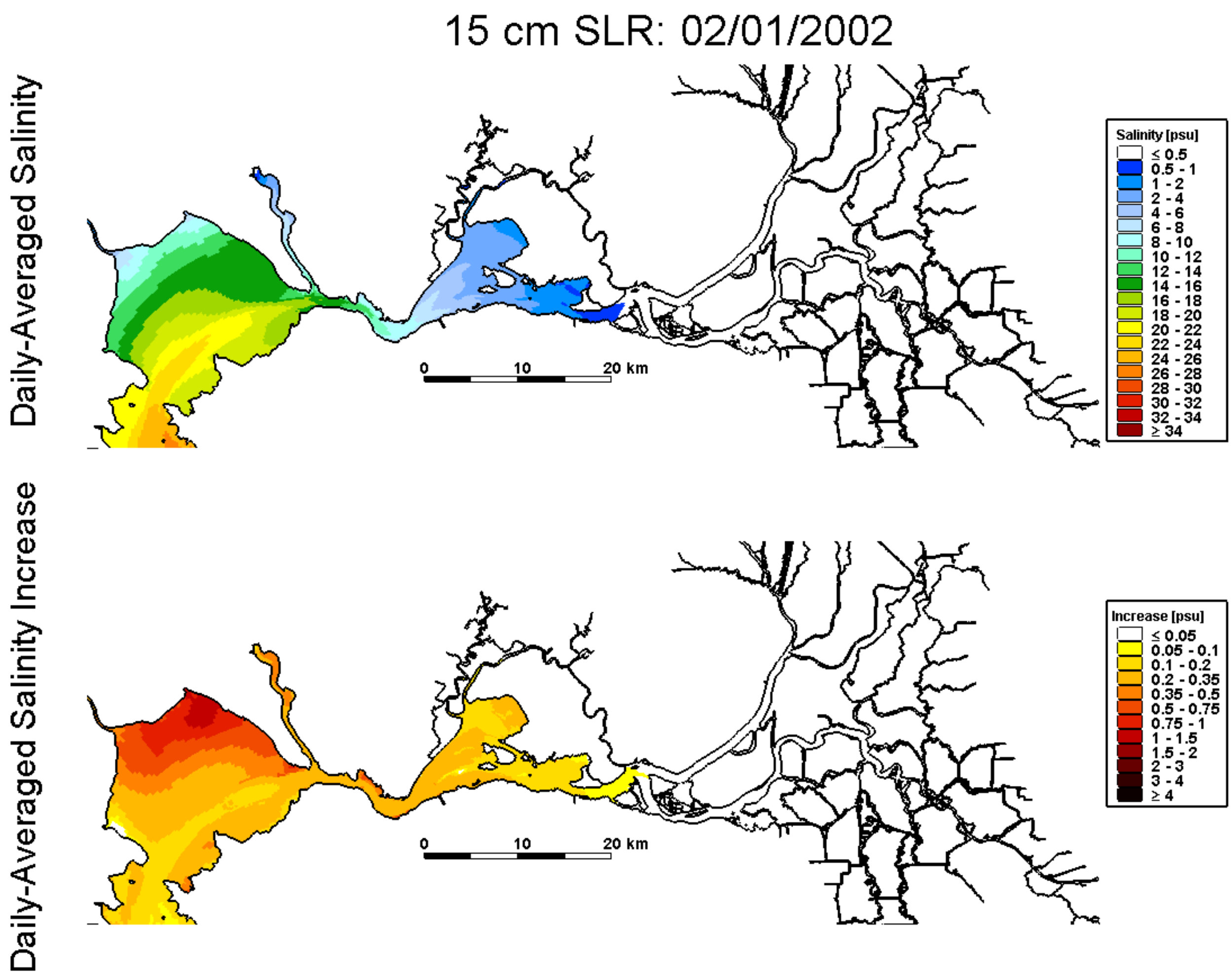


Figure 4.1-2 Predicted daily-averaged depth-average salinity on February 1, 2002 for the 15 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on February 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 15 cm SLR scenario.

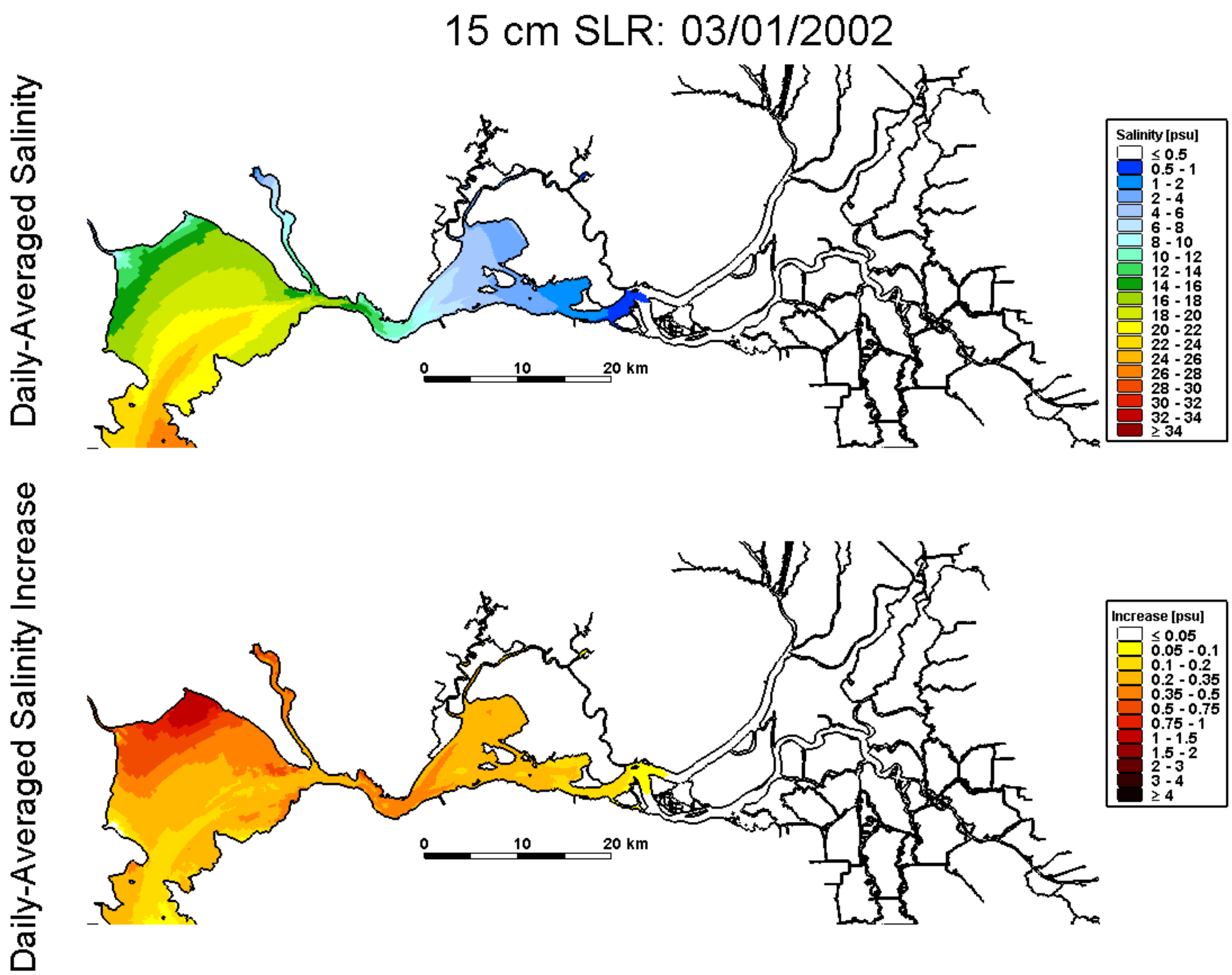


Figure 4.1-3 Predicted daily-averaged depth-average salinity on March 1, 2002 for the 15 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on March 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 15 cm SLR scenario.

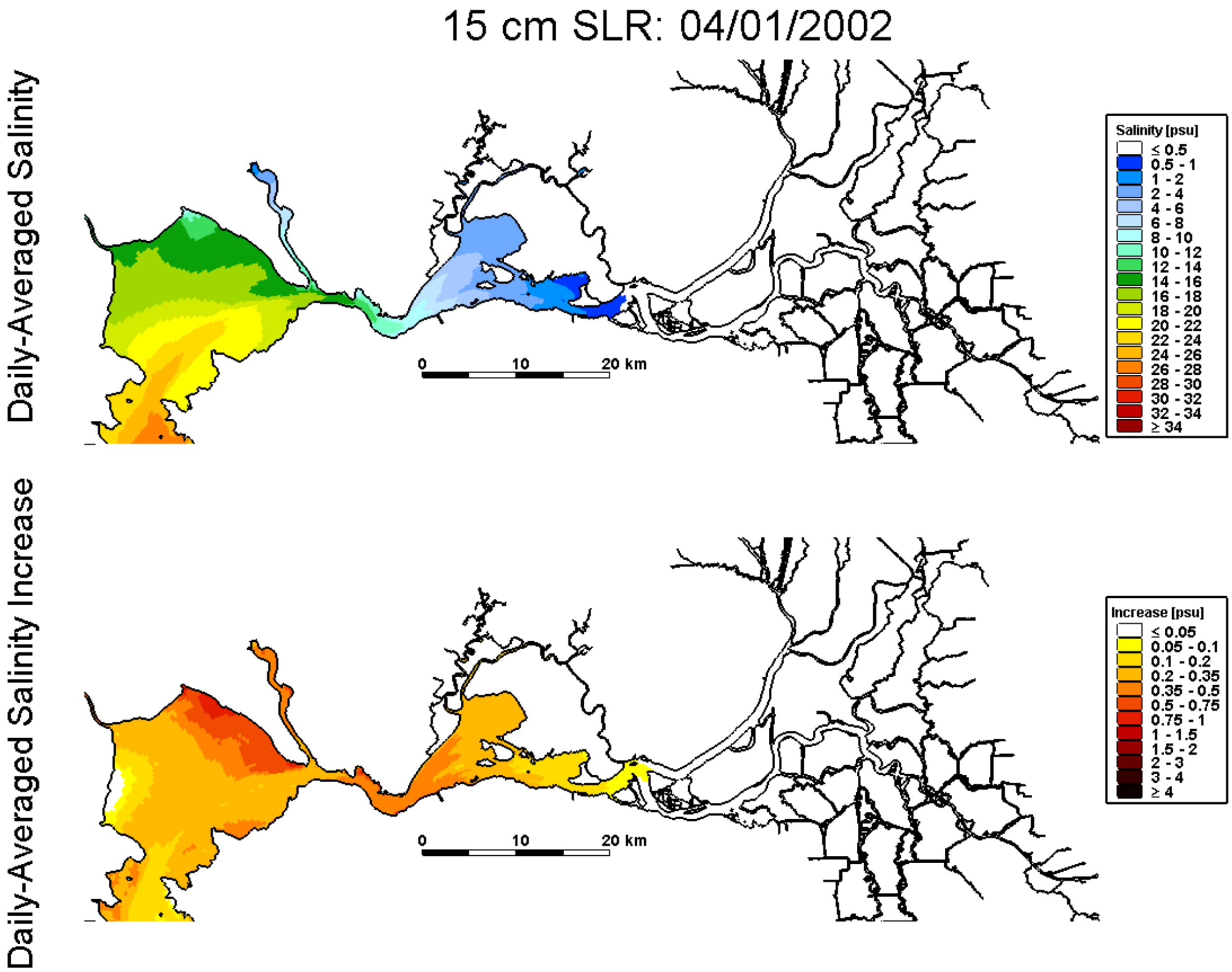


Figure 4.1-4 Predicted daily-averaged depth-average salinity on April 1, 2002 for the 15 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on April 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 15 cm SLR scenario.

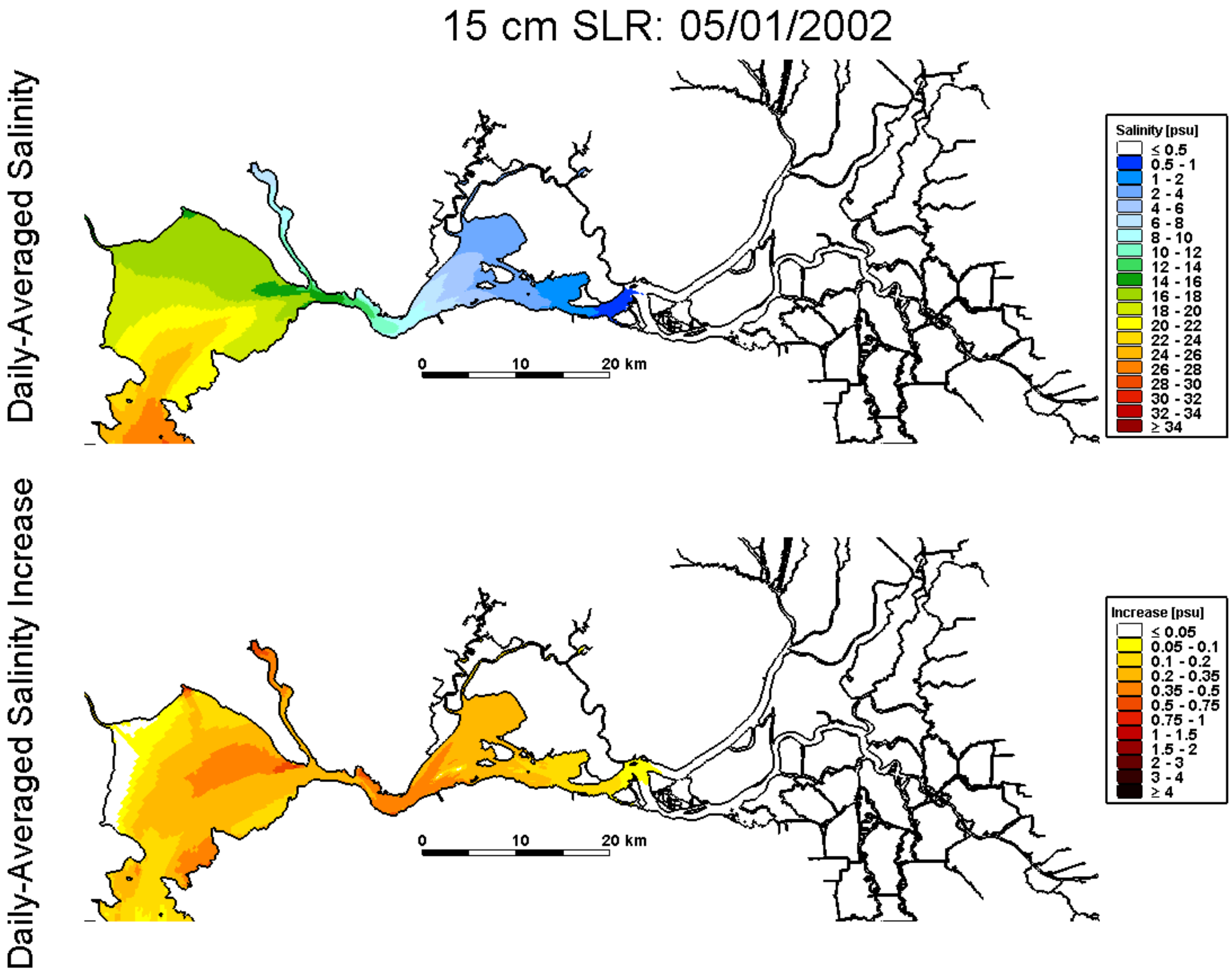


Figure 4.1-5 Predicted daily-averaged depth-average salinity on May 1, 2002 for the 15 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on May 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 15 cm SLR scenario.

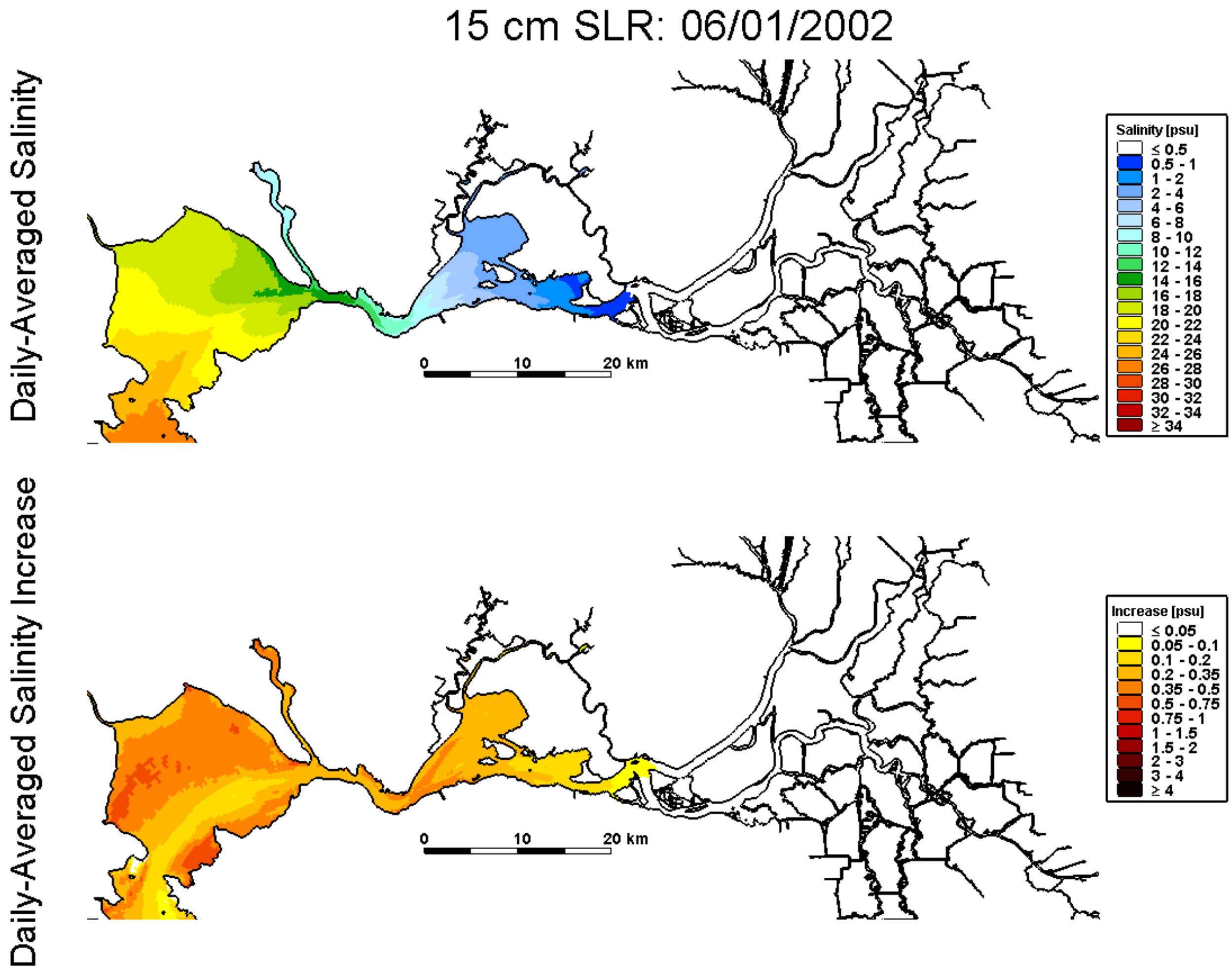


Figure 4.1-6 Predicted daily-averaged depth-average salinity on June 1, 2002 for the 15 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on June 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 15 cm SLR scenario.

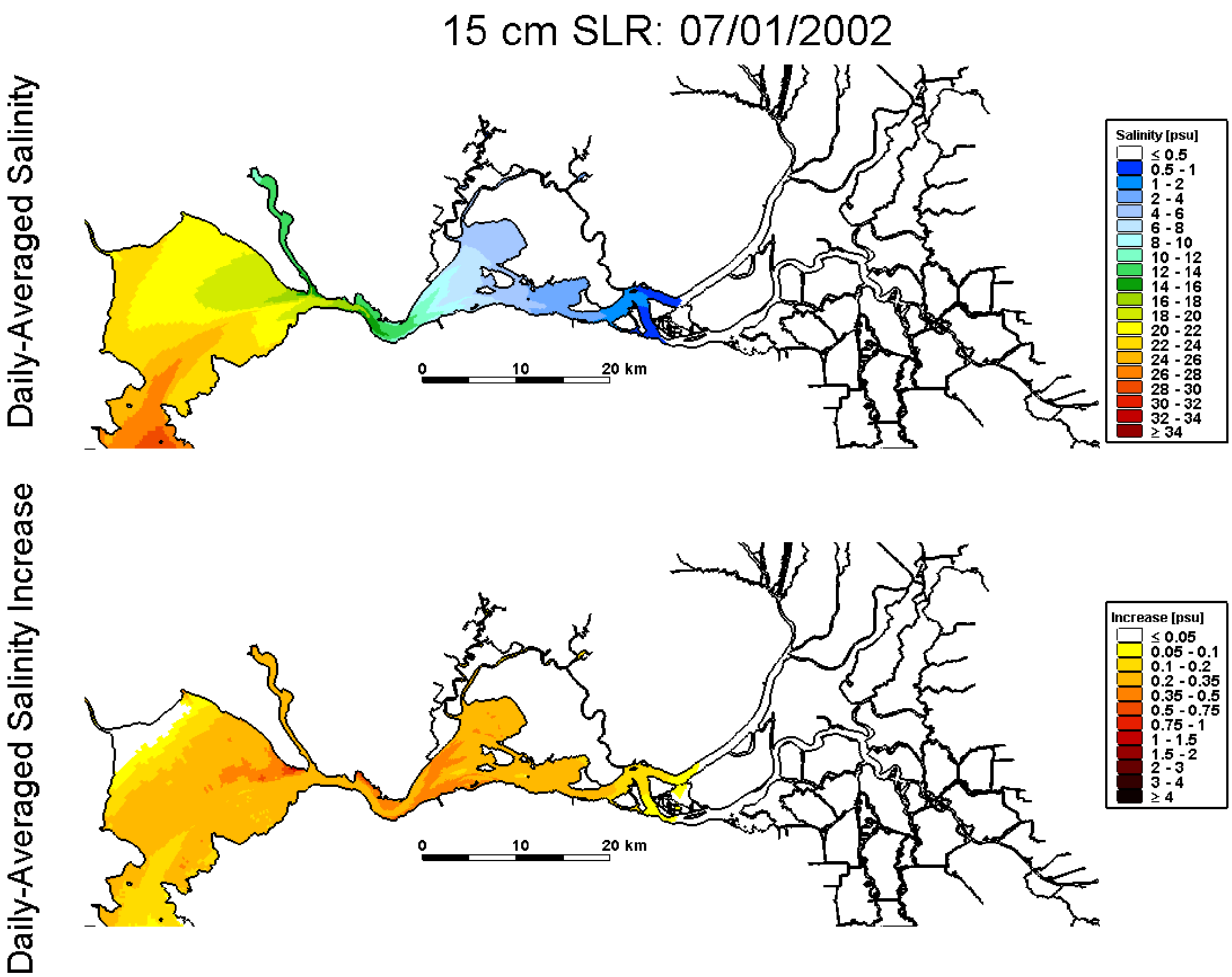


Figure 4.1-7 Predicted daily-averaged depth-average salinity on July 1, 2002 for the 15 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on July 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 15 cm SLR scenario.

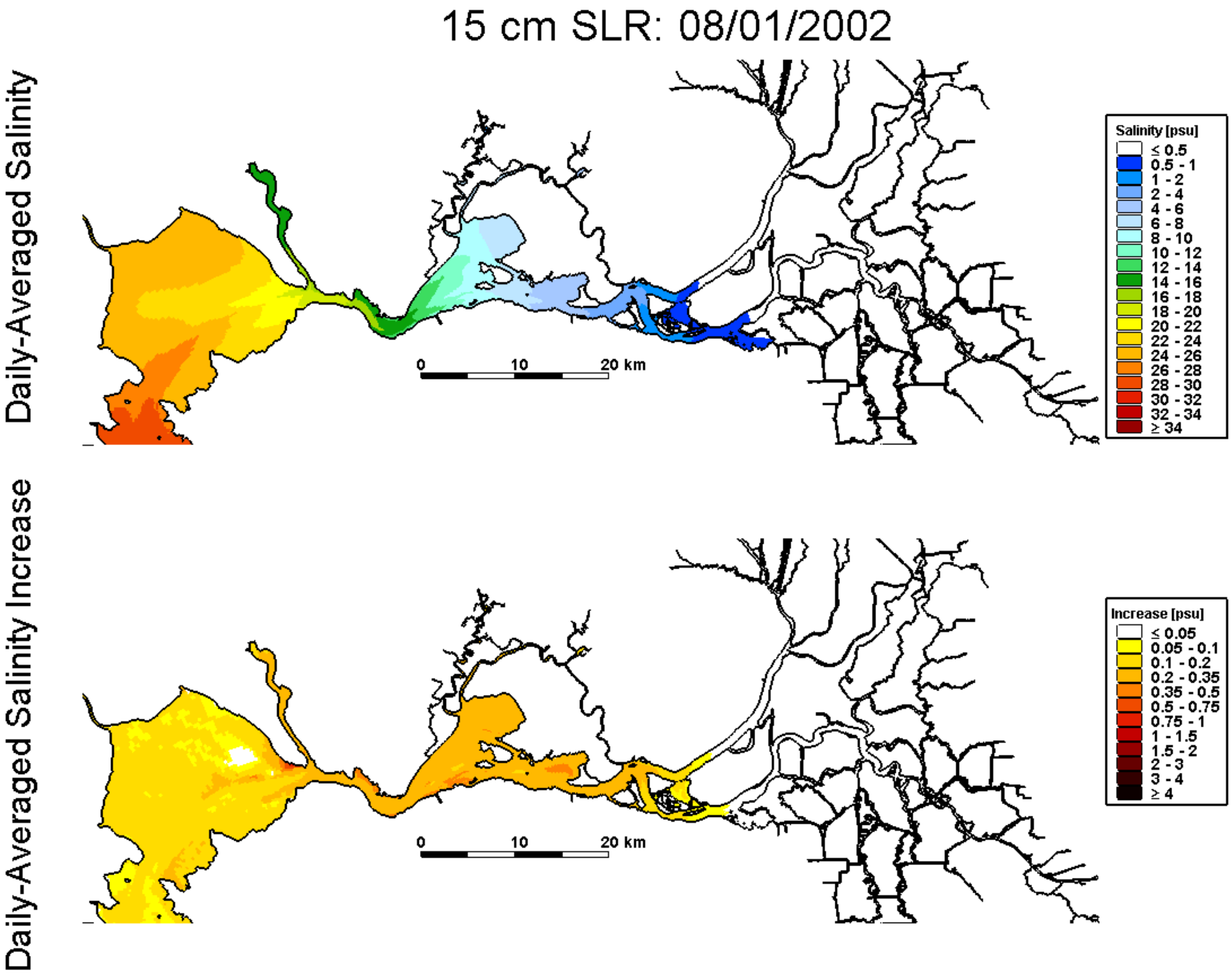


Figure 4.1-8 Predicted daily-averaged depth-average salinity on August 1, 2002 for the 15 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on August 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 15 cm SLR scenario.

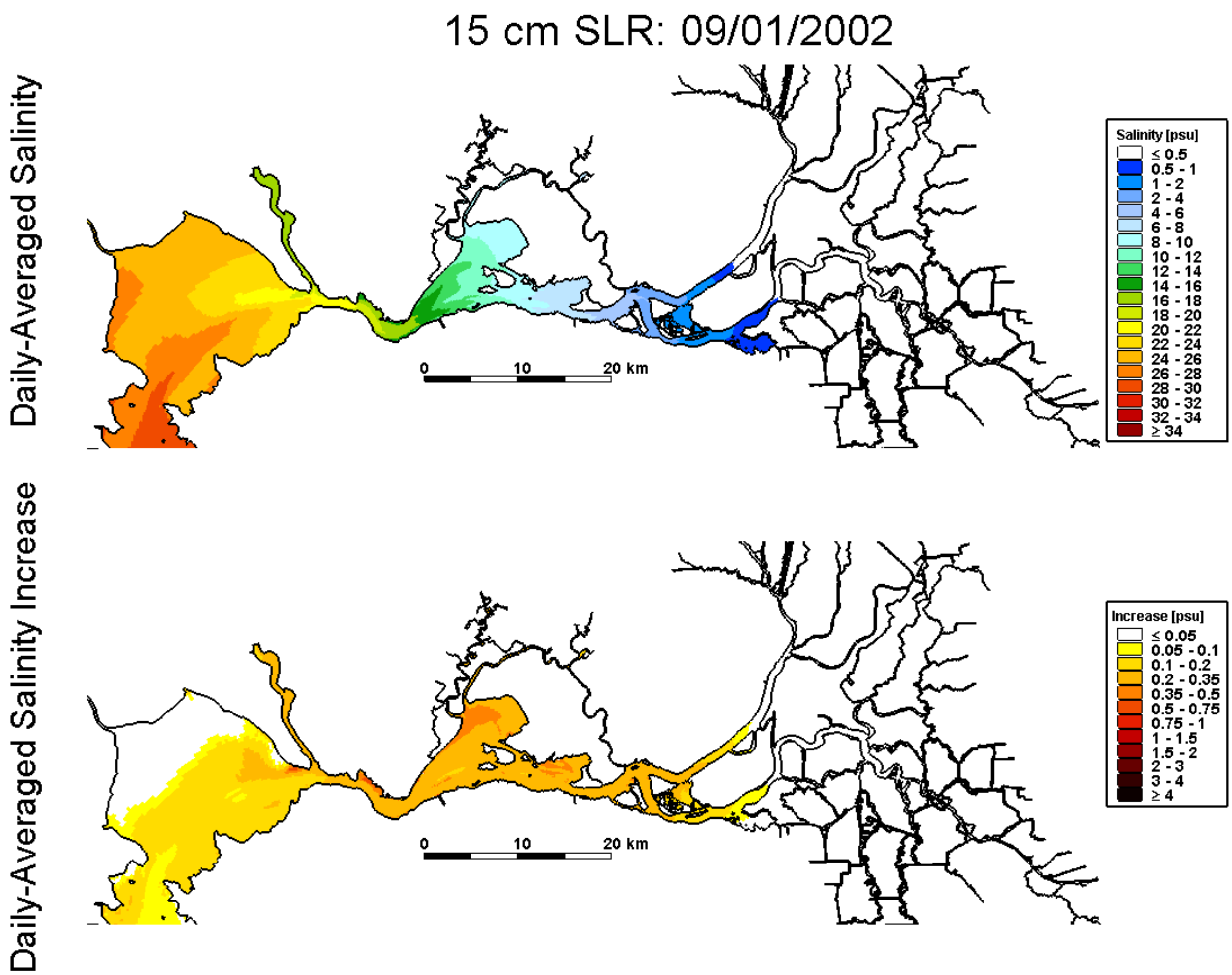


Figure 4.1-9 Predicted daily-averaged depth-average salinity on September 1, 2002 for the 15 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on September 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 15 cm SLR scenario.

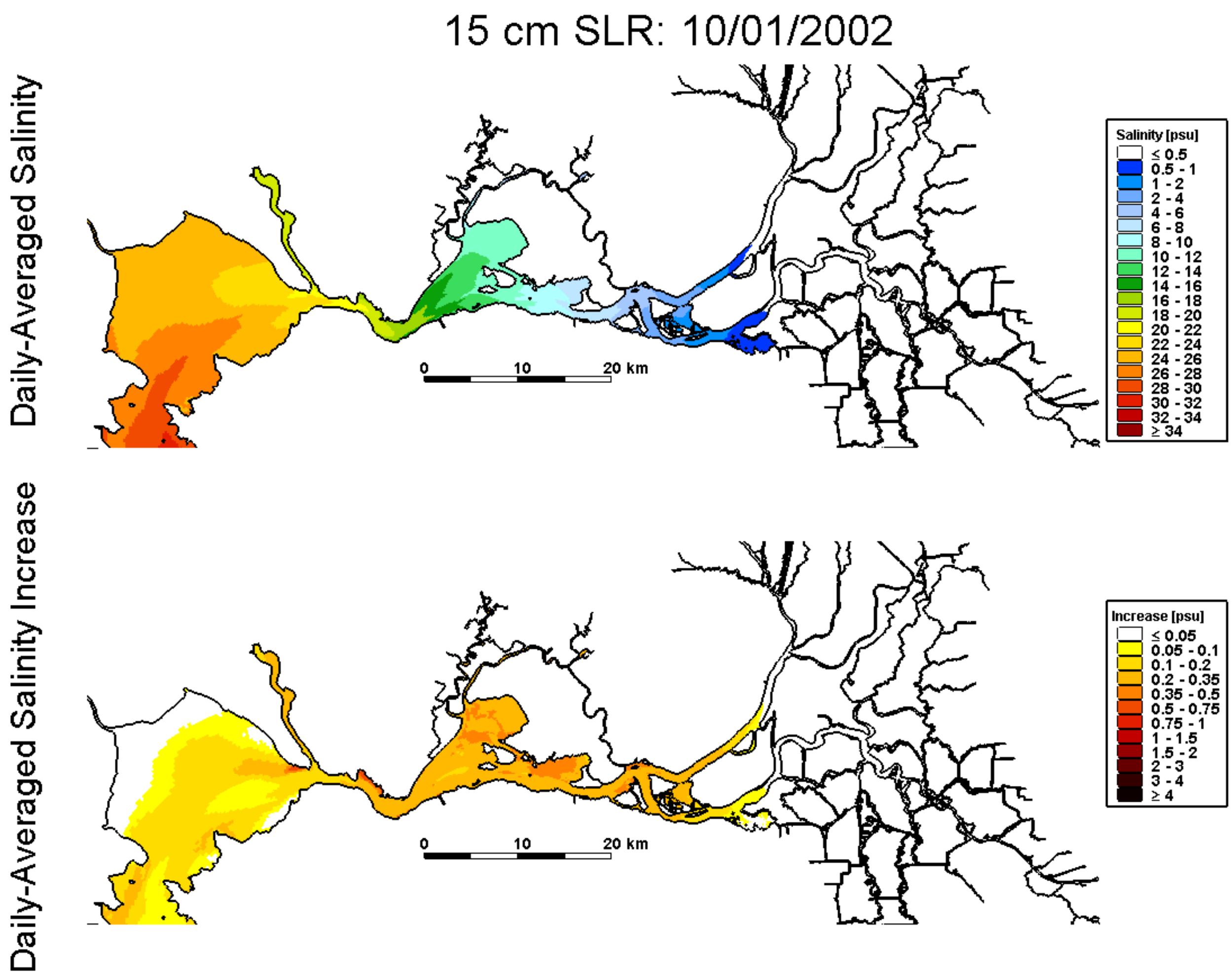


Figure 4.1-10 Predicted daily-averaged depth-average salinity on October 1, 2002 for the 15 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on October 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 15 cm SLR scenario.

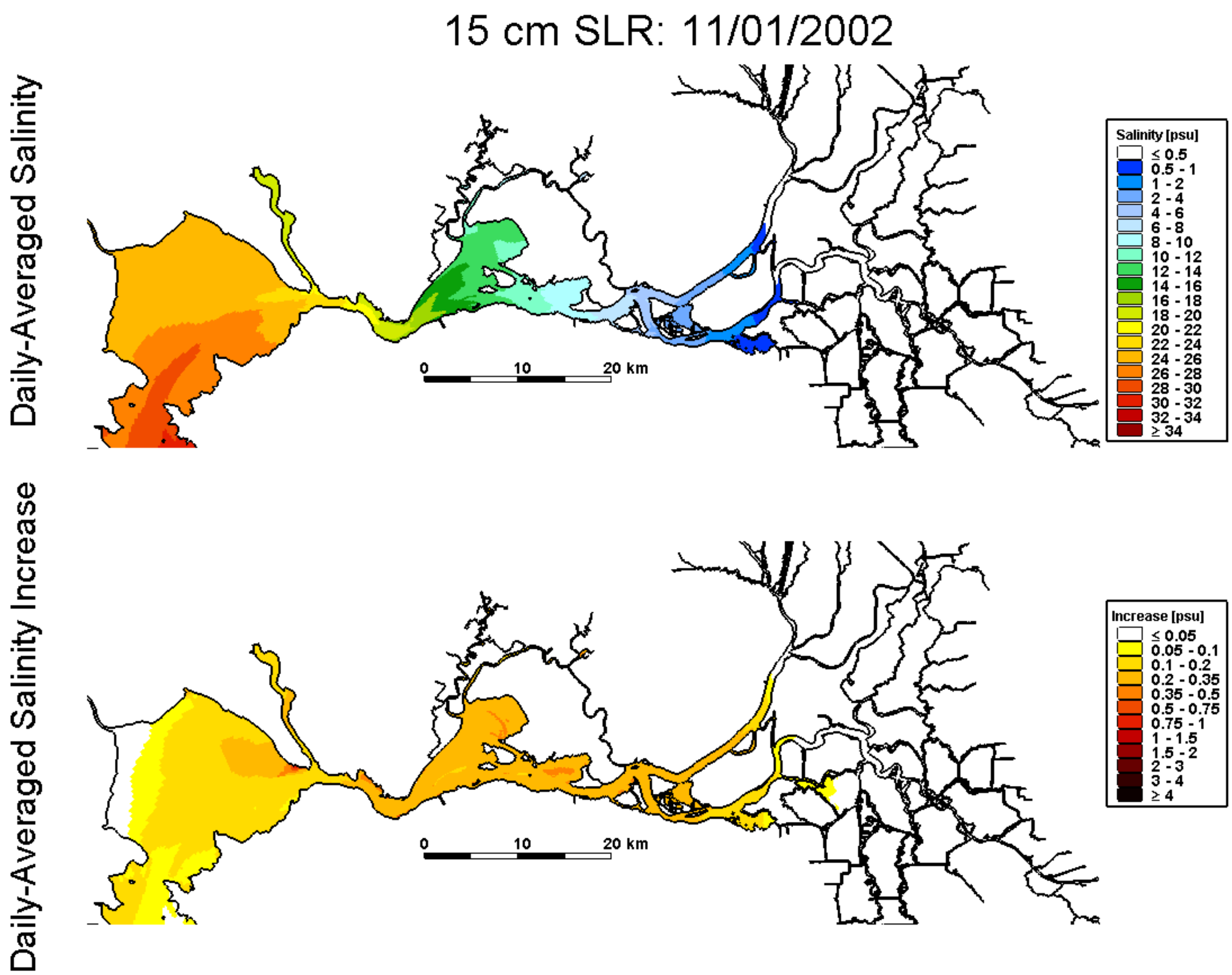


Figure 4.1-11 Predicted daily-averaged depth-average salinity on November 1, 2002 for the 15 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on November 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 15 cm SLR scenario.

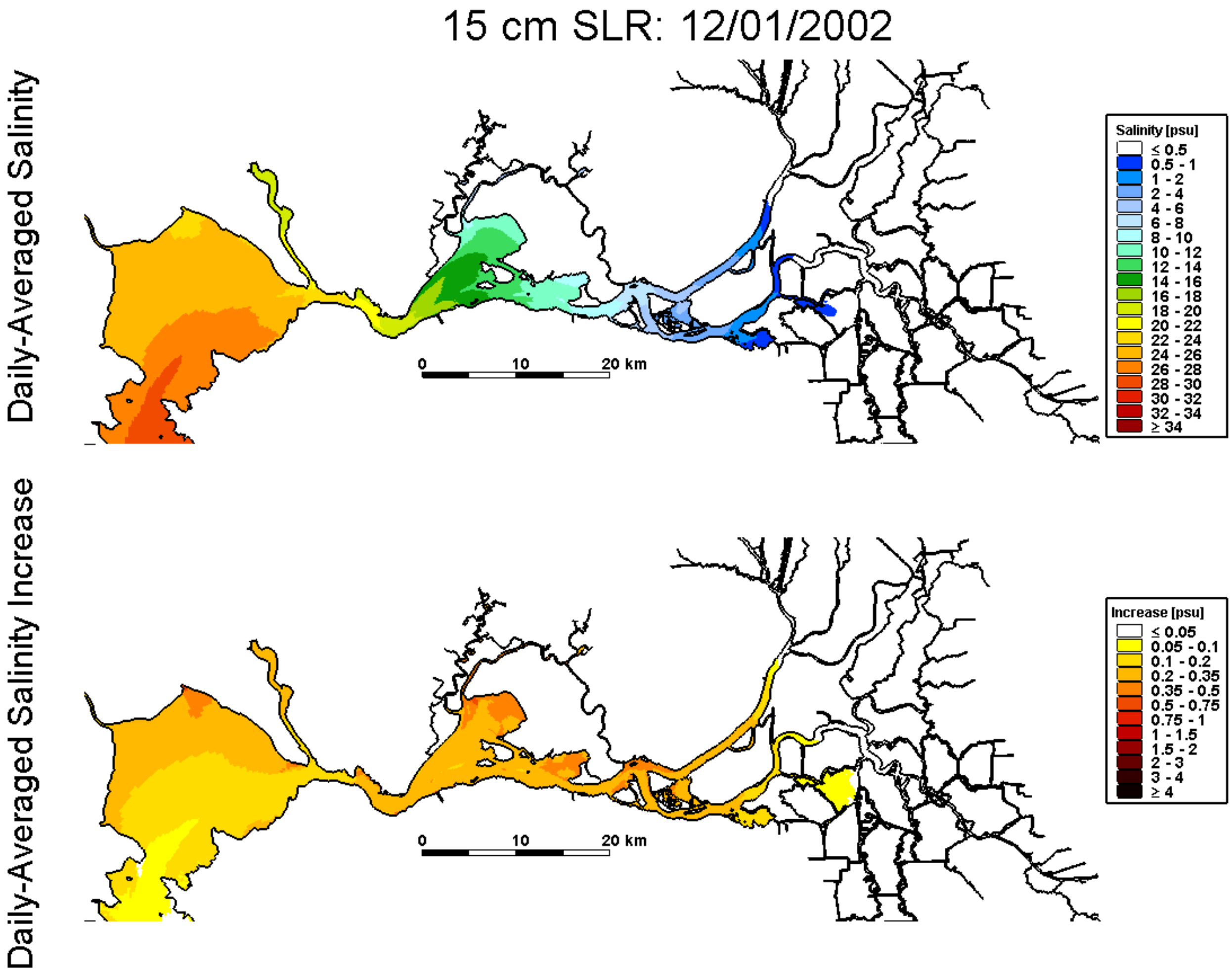


Figure 4.1-12 Predicted daily-averaged depth-average salinity on December 1, 2002 for the 15 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on December 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 15 cm SLR scenario.

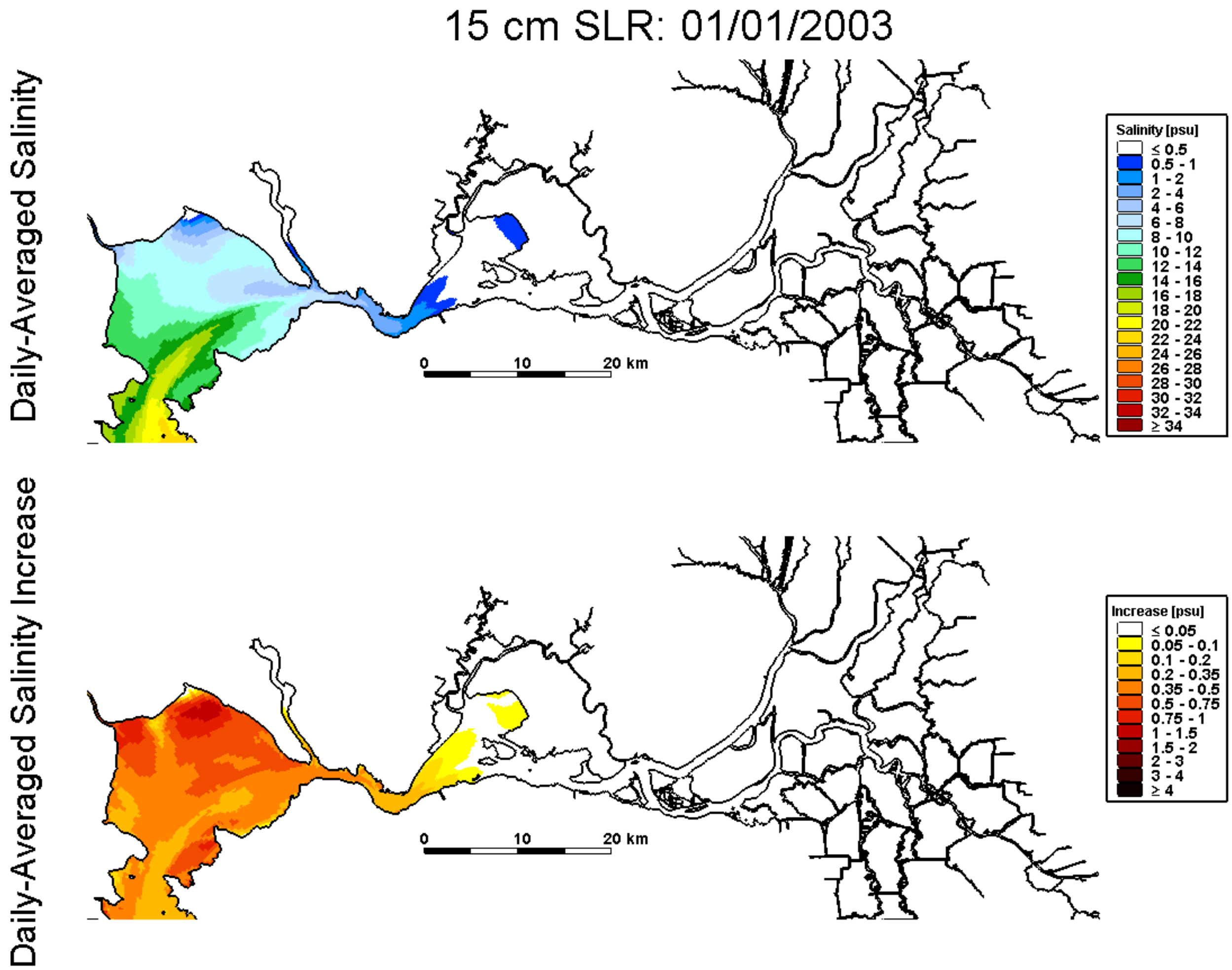


Figure 4.1-13 Predicted daily-averaged depth-average salinity on January 1, 2003 for the 15 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on January 1, 2003 relative to the Baseline (0 cm SLR) scenario for the 15 cm SLR scenario.

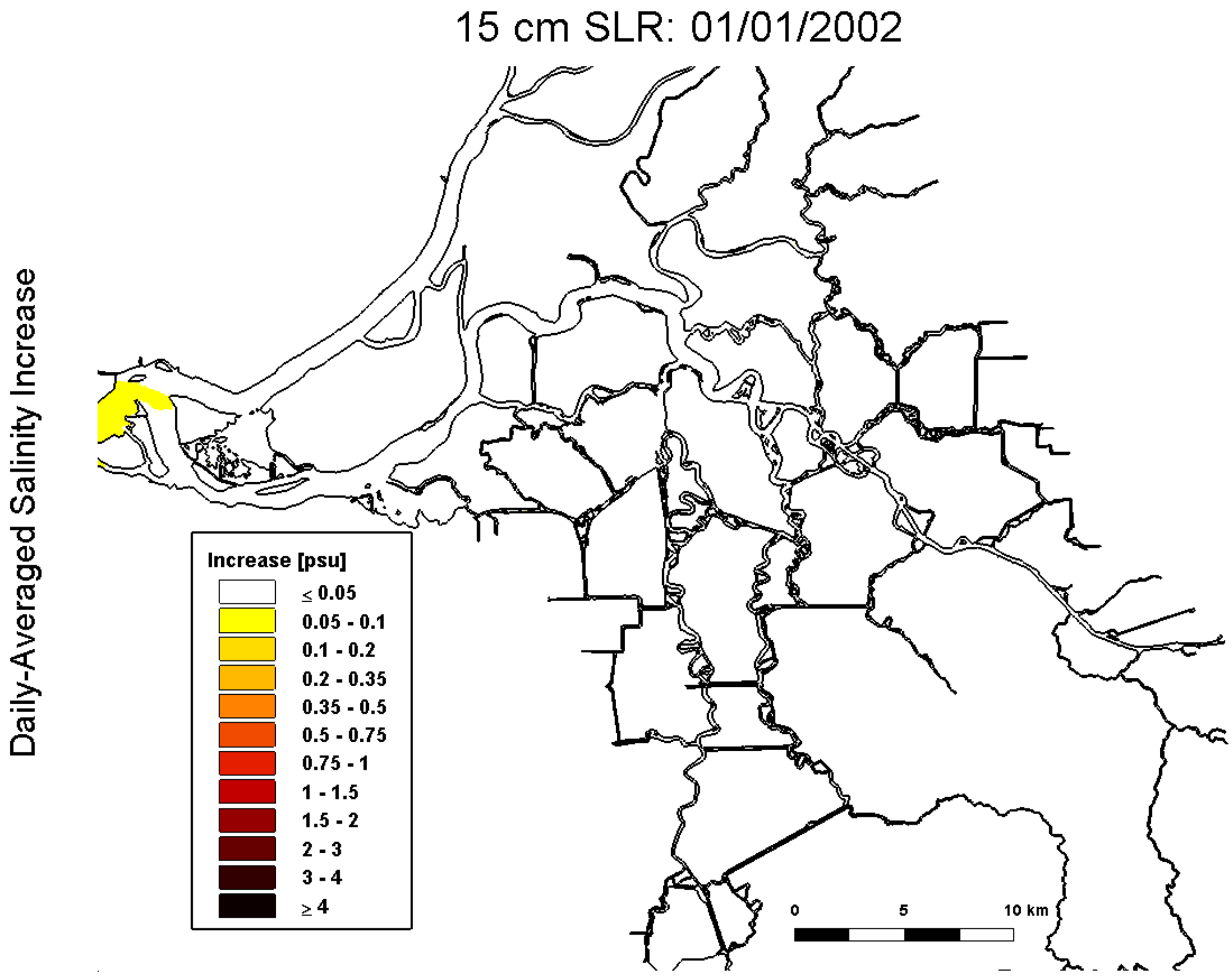


Figure 4.1-14 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on January 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 15 cm SLR scenario.

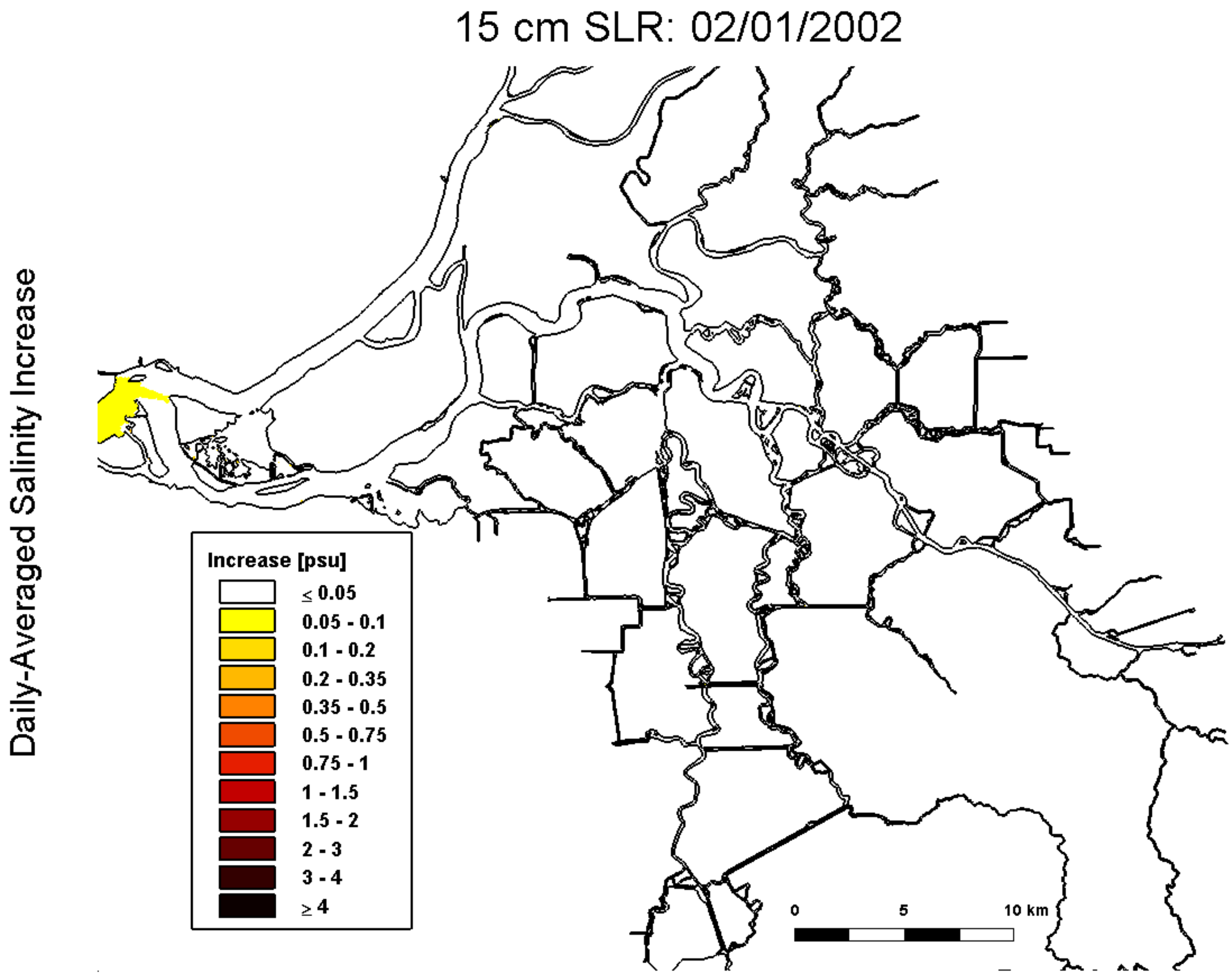


Figure 4.1-15 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on February 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 15 cm SLR scenario.

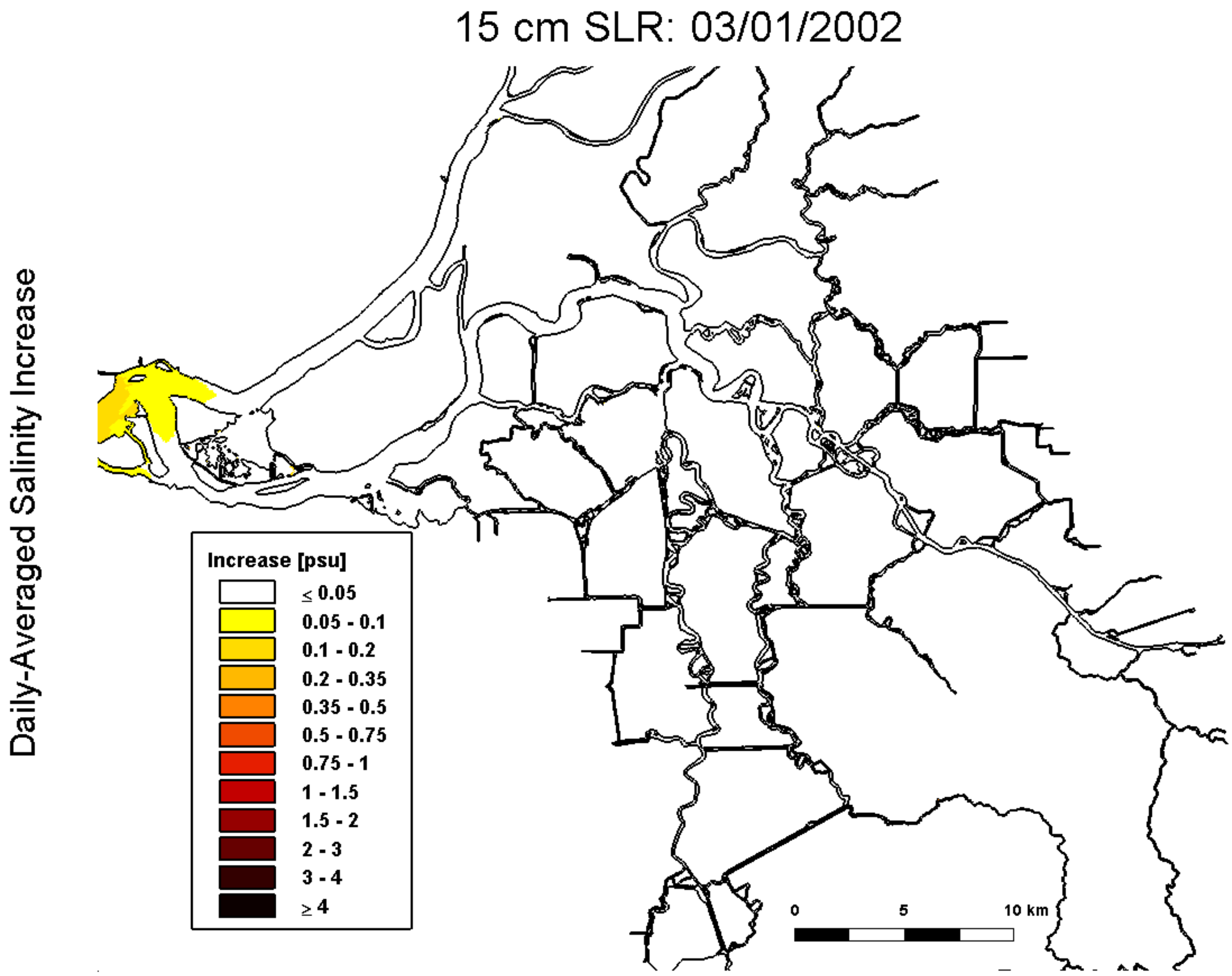


Figure 4.1-16 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on March 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 15 cm SLR scenario.

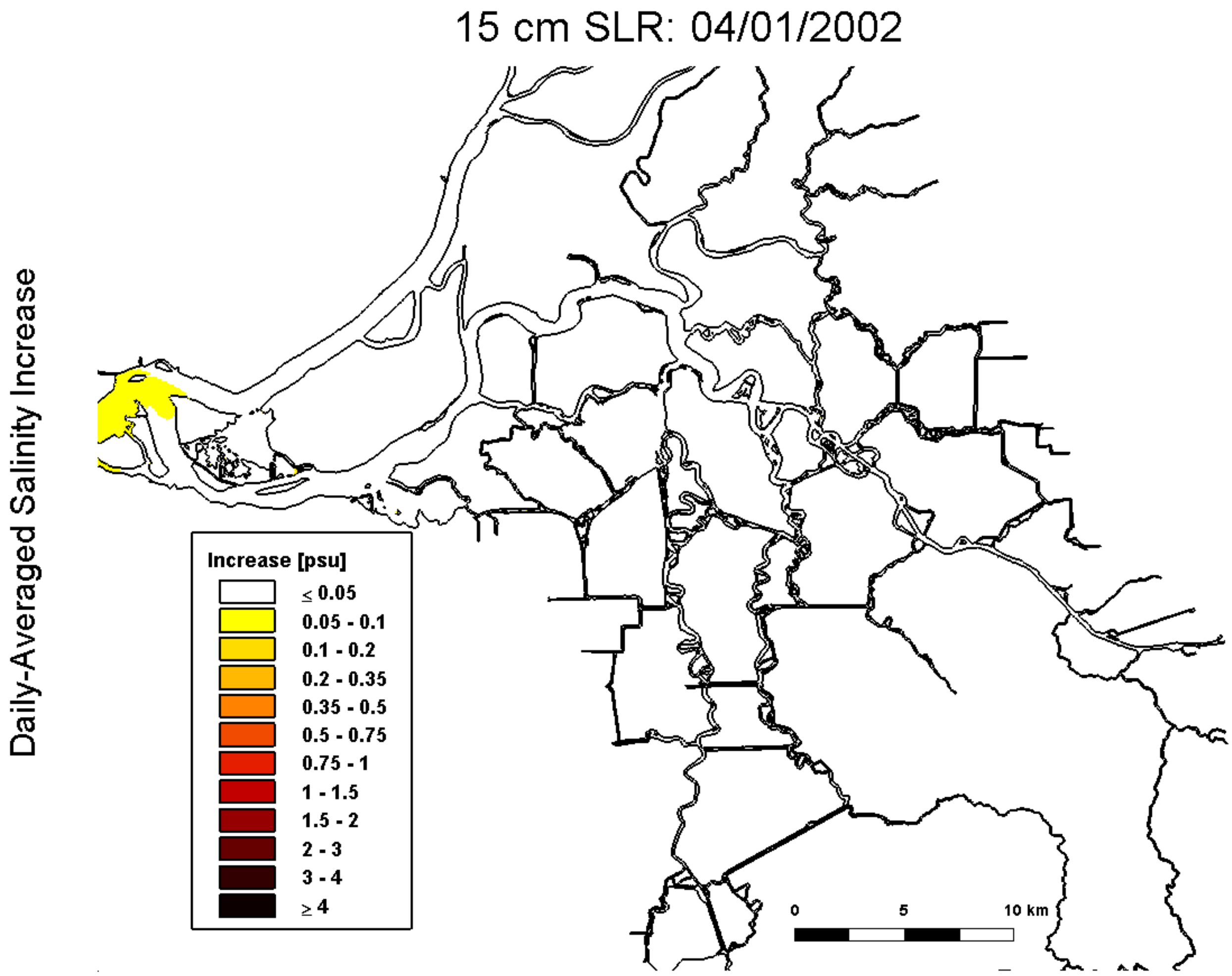


Figure 4.1-17 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on April 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 15 cm SLR scenario.

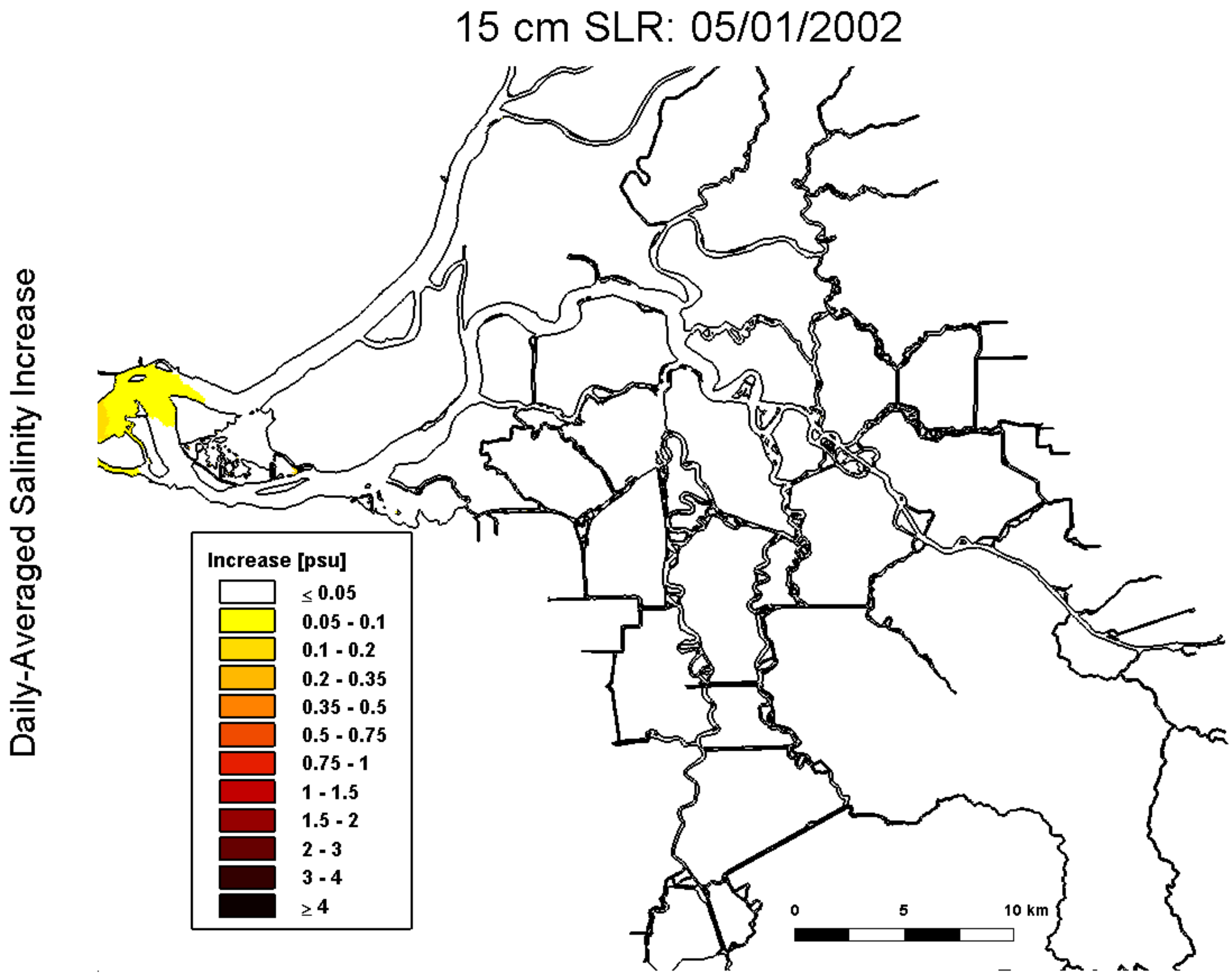


Figure 4.1-18 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on May 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 15 cm SLR scenario.

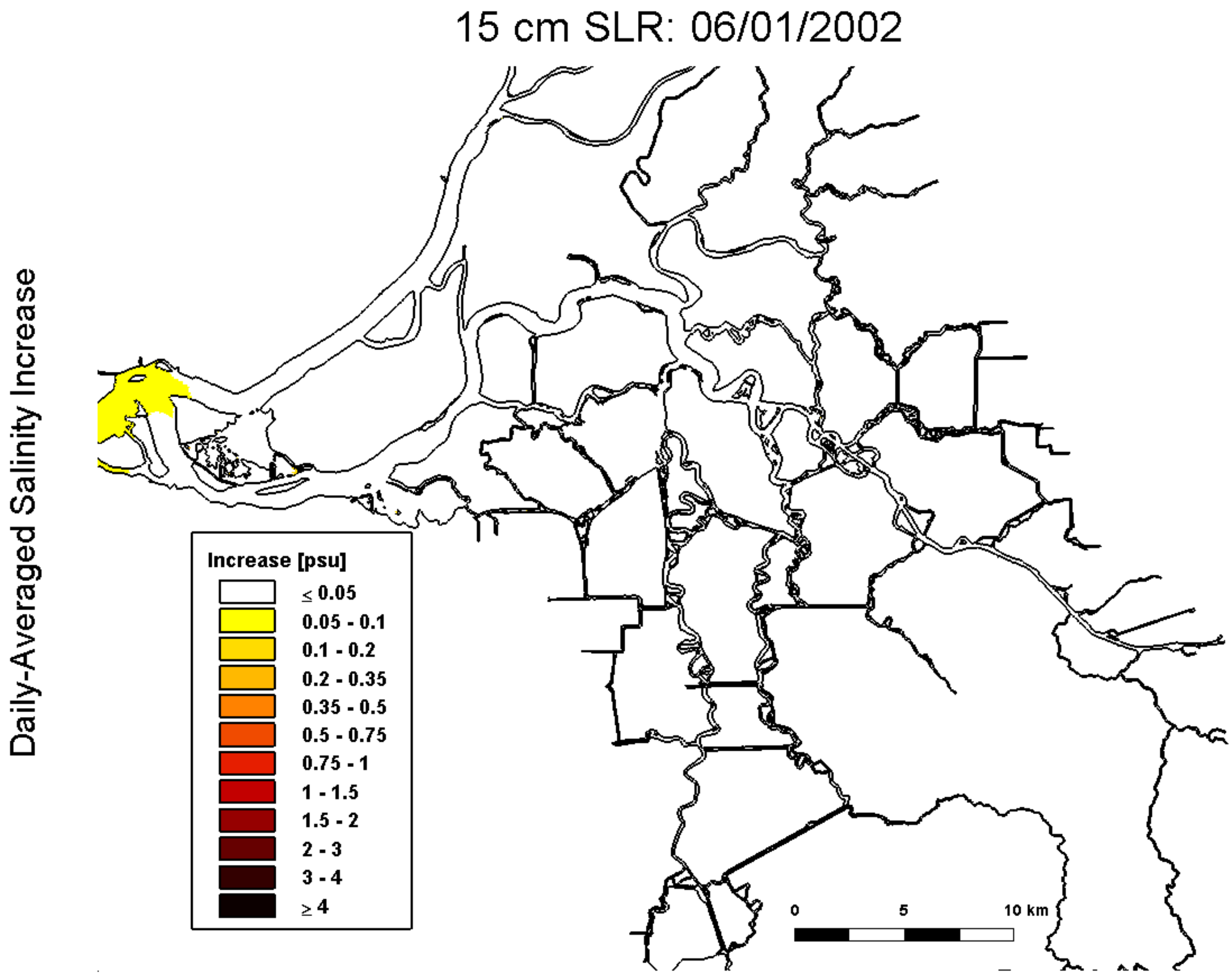


Figure 4.1-19 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on June 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 15 cm SLR scenario.

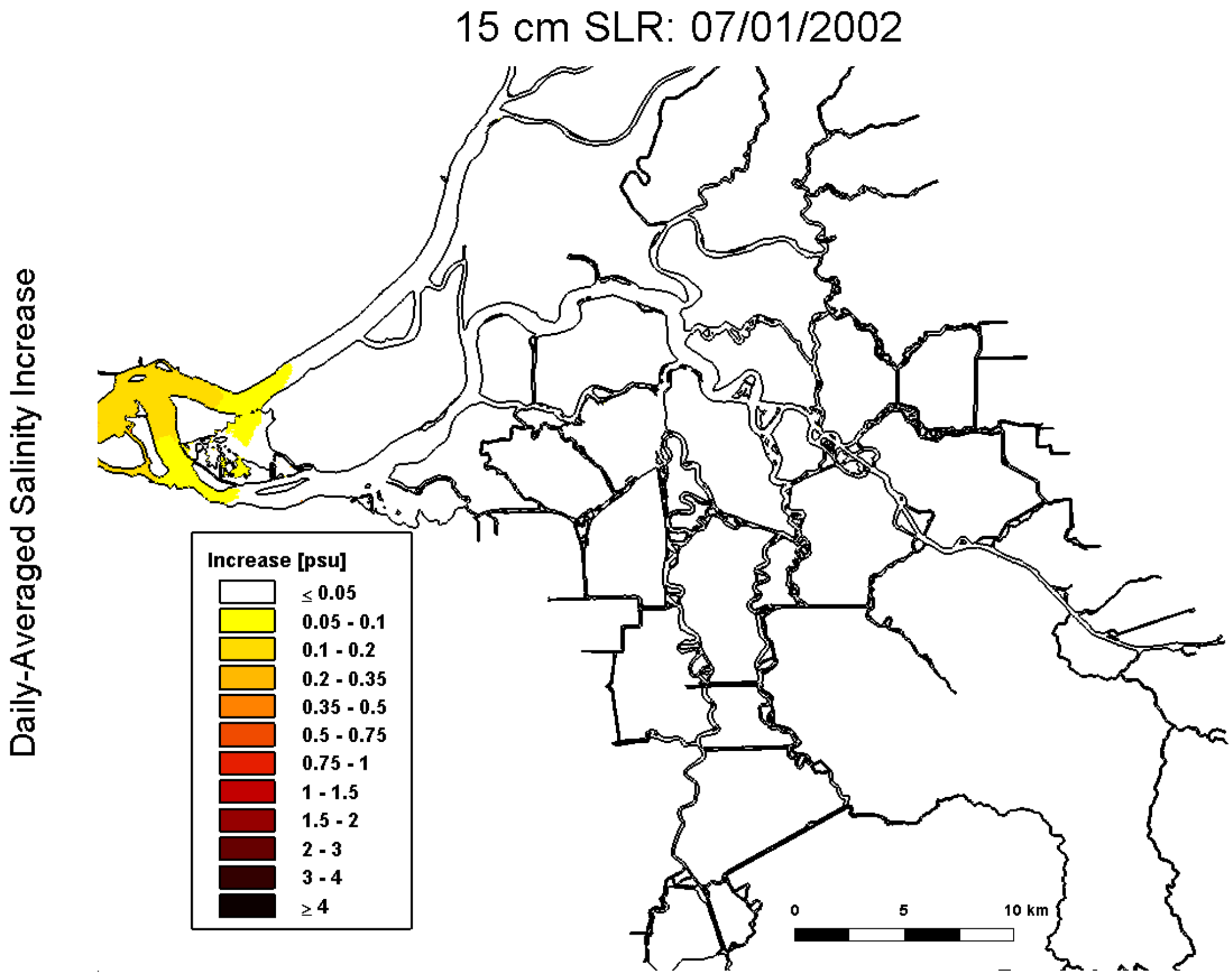


Figure 4.1-20 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on July 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 15 cm SLR scenario.

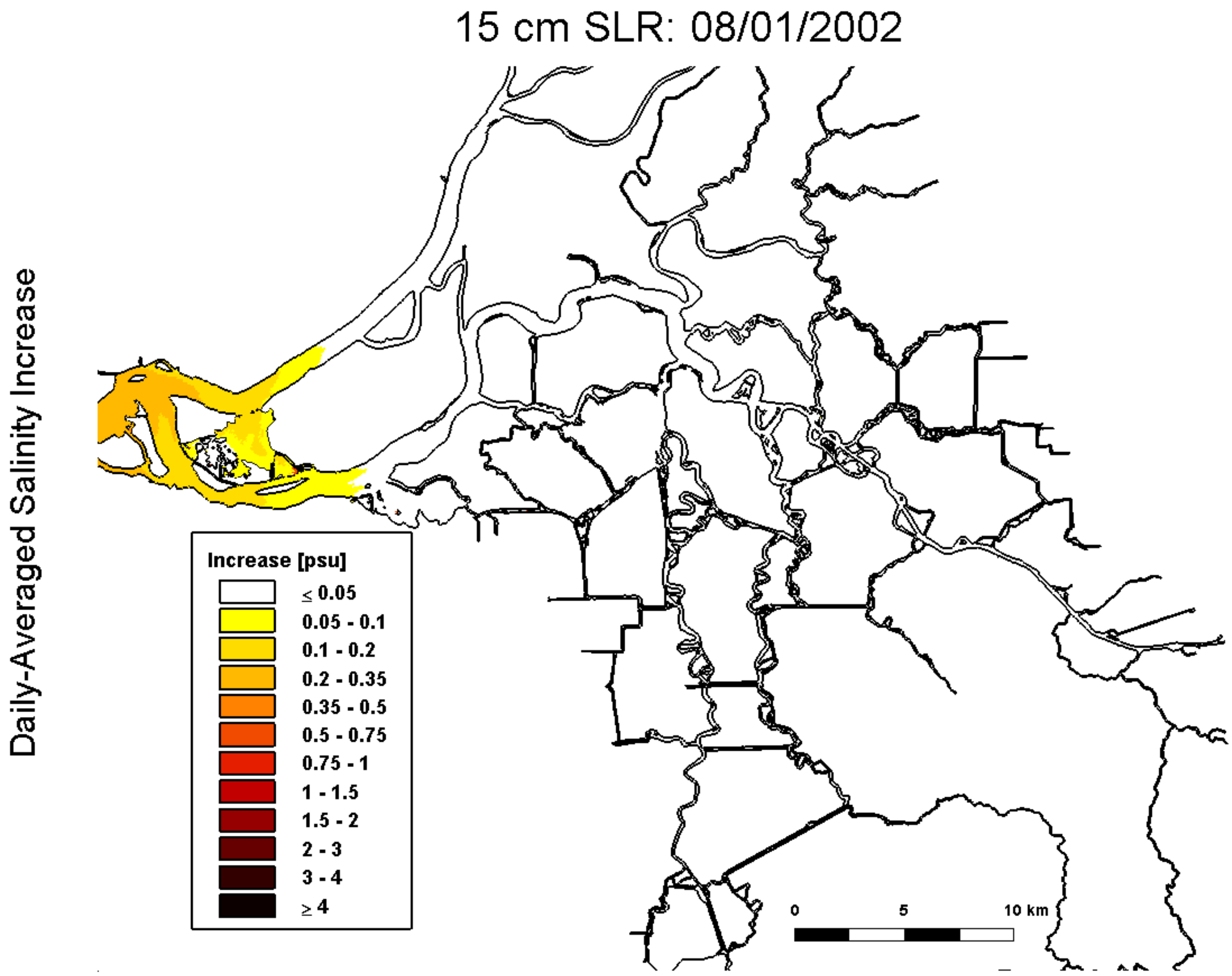


Figure 4.1-21 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on August 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 15 cm SLR scenario.

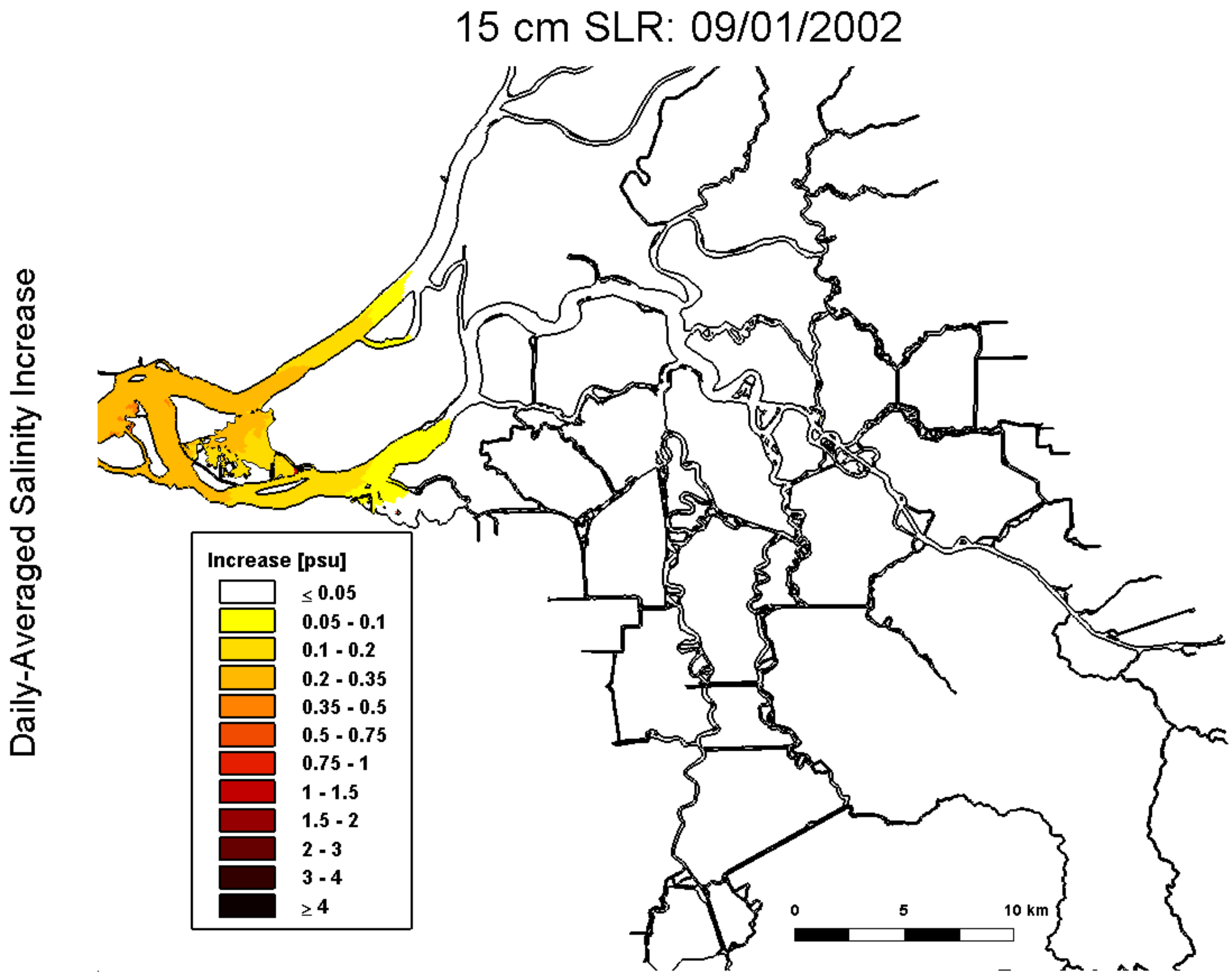


Figure 4.1-22 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on September 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 15 cm SLR scenario.

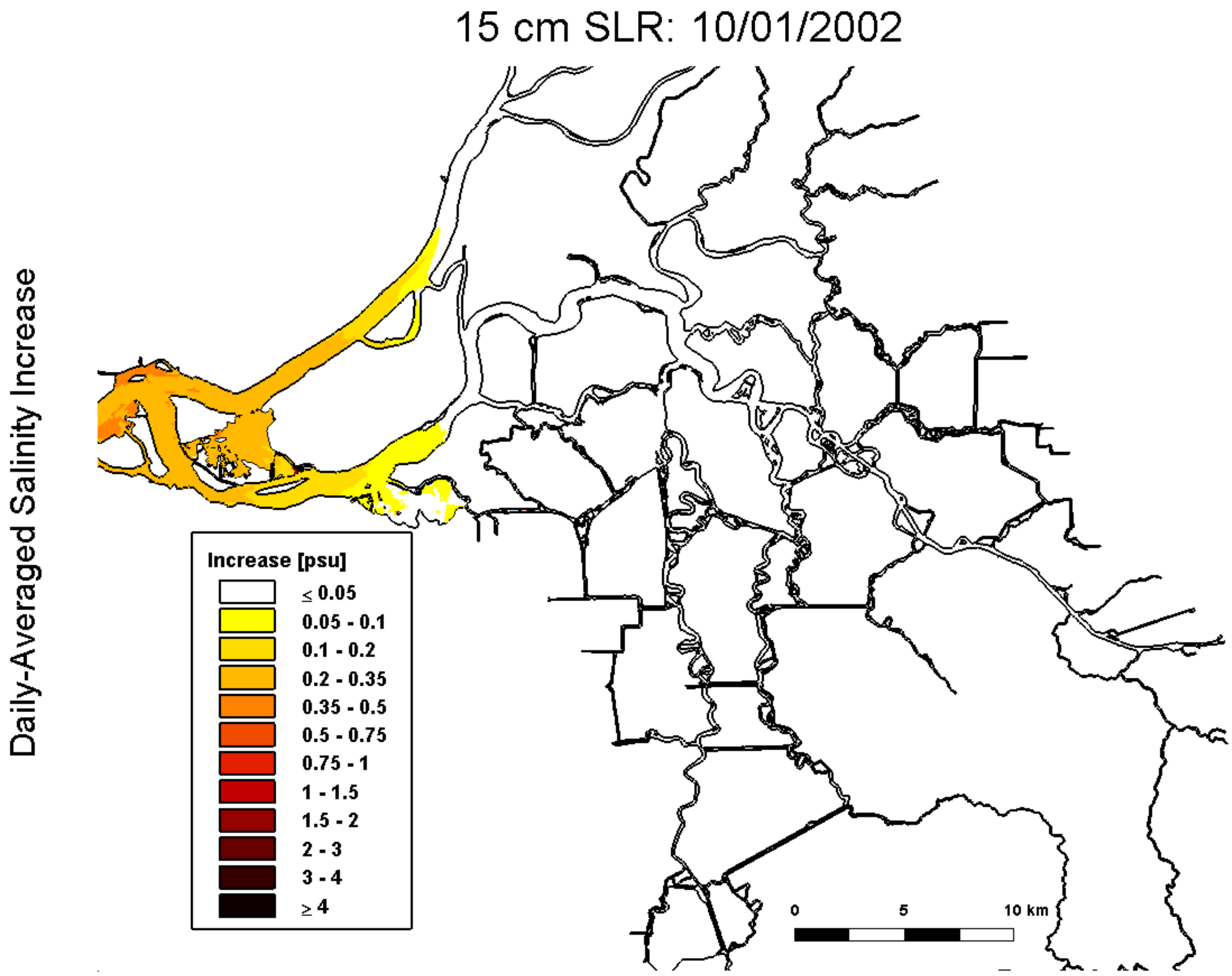


Figure 4.1-23 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on October 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 15 cm SLR scenario.

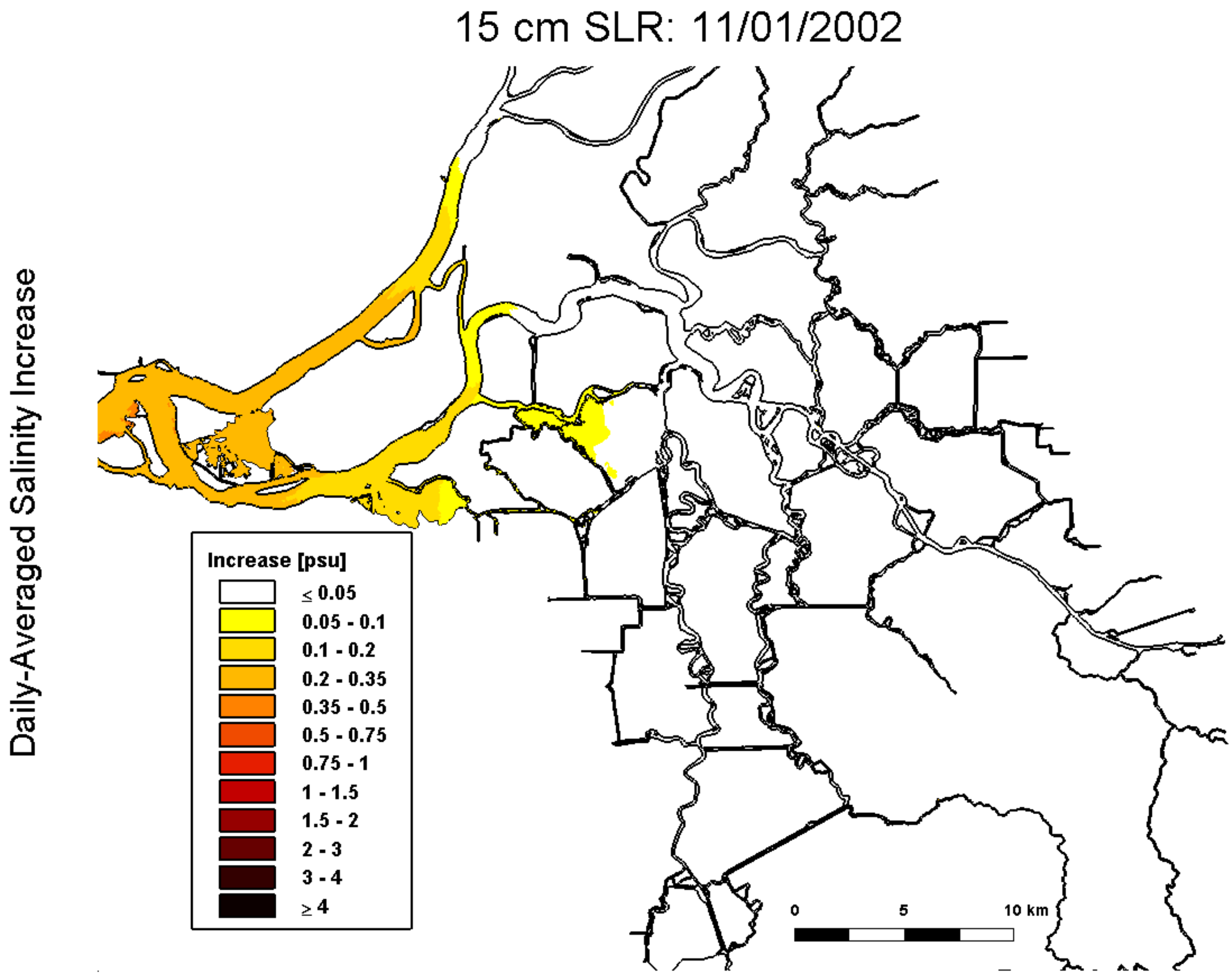


Figure 4.1-24 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on November 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 15 cm SLR scenario.

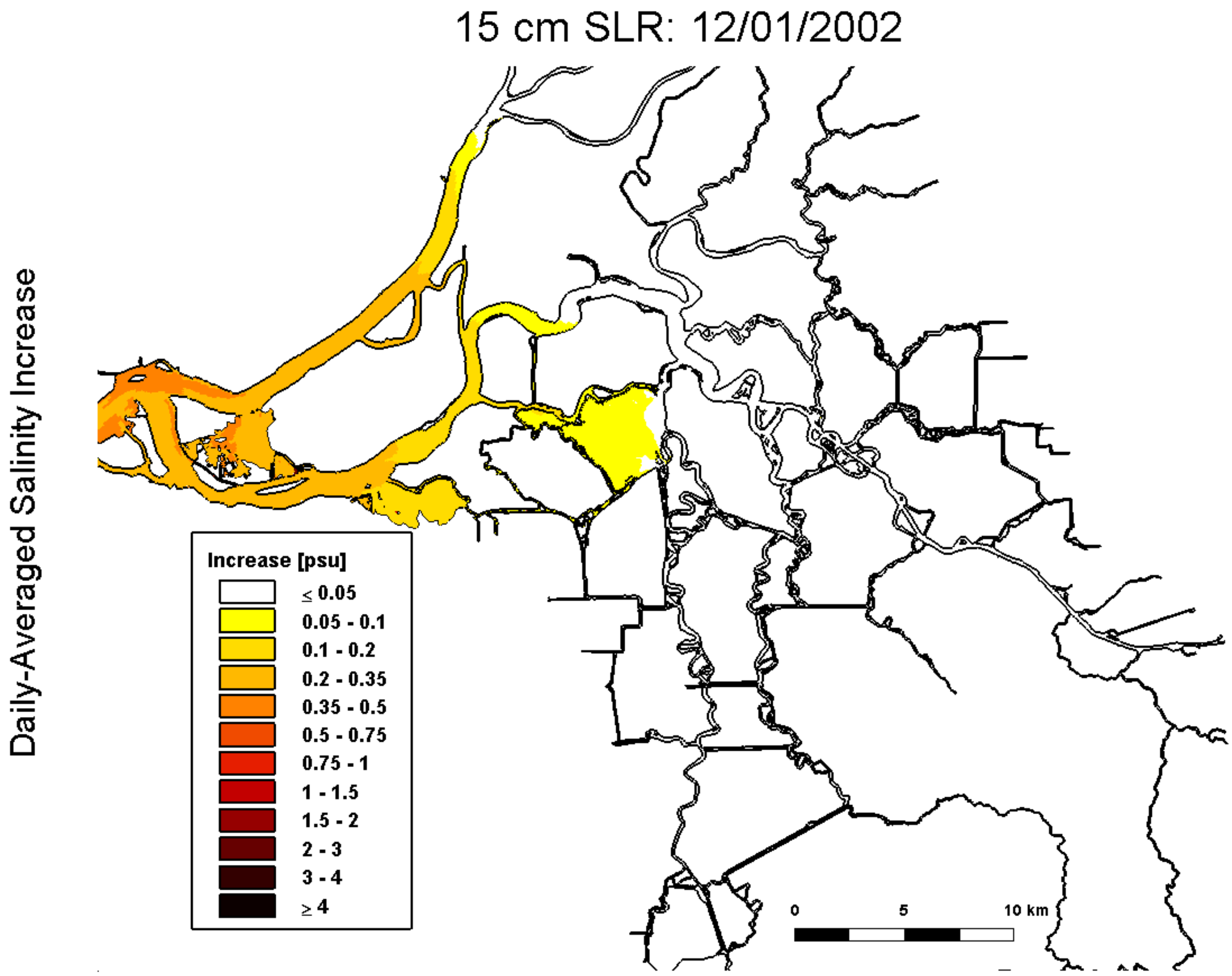


Figure 4.1-25 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on December 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 15 cm SLR scenario.

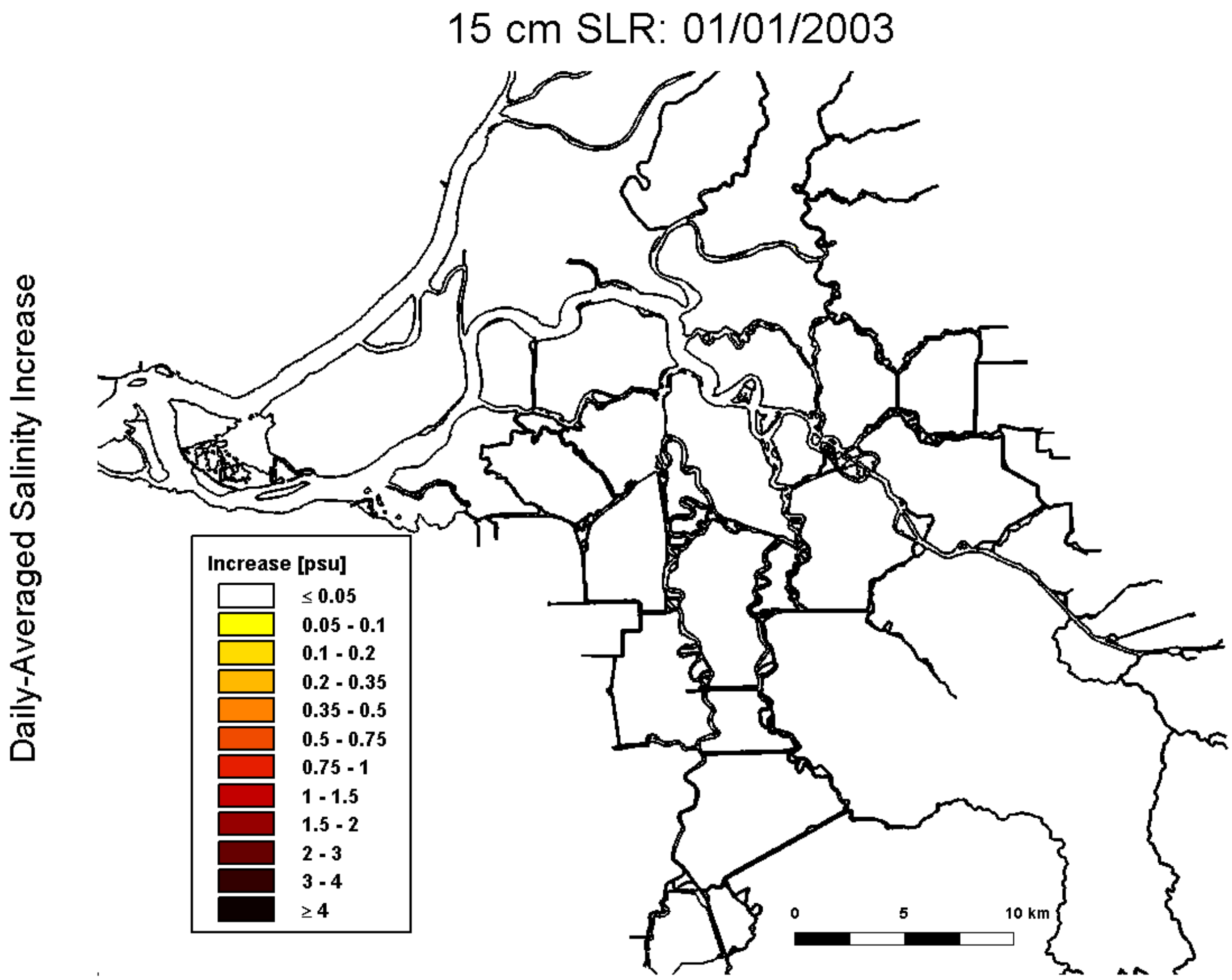


Figure 4.1-26 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on January 1, 2003 relative to the Baseline (0 cm SLR) scenario for the 15 cm SLR scenario.

4.2 Predicted Increase in Salinity for 30 cm SLR Scenario

Figure 4.2-1 through 4.2-13 show the predicted salinity along the northern portion of the San Francisco Estuary, spanning from San Pablo Bay through the Sacramento-San Joaquin Delta for the 30 cm SLR scenario. The top panel of each figure shows the predicted daily-averaged depth-average salinity for the 30 cm SLR scenario. The lower panel shows the predicted salinity increase computed by subtracting the predicted daily-averaged depth-average salinity for the Baseline (0 cm SLR) scenario from the predicted daily-averaged depth-average salinity for the 30 cm SLR scenario. Figures 4.2-14 through 4.2-26 show the predicted salinity increases resulting from the 30 cm SLR scenario in the Sacramento-San Joaquin Delta.

At the beginning of the analysis period on January 1, 2002, salinity increases between 0.10 and 0.35 psu are predicted between Chipps Island and Collinsville and predicted salinity increases of up to 0.05 psu are predicted upstream to the western end of Sherman Lake. Predicted salinity increases are less than 0.05 psu throughout the remaining portions of the Delta. Salinity increases between 0.75 and 1.0 psu are predicted through Carquinez Strait and salinity increases between 0.35 and 1.0 psu are predicted throughout Suisun Bay. Larger salinity increases of more than 1.0 psu are predicted in much of San Pablo Bay, and more than 3 psu in northern San Pablo Bay. During the first half of the year, predicted salinity increases in Suisun Bay and the Delta remain similar to the predicted salinity increases seen on January 1, 2002, though the predicted salinity is increasing throughout this period. Larger salinity increases are predicted in the Delta between July and December, with the largest predicted salinity increases in December prior to the first flush. In December, salinity increases of between 0.50 and 0.75 psu are predicted between Chipps Island and Emmaton, and salinity increases of between 0.05 and 0.20 psu are predicted in Franks Tract. South of Franks Tract, predicted salinity increases between 0.05 and 0.10 psu extend down Old River to Italian Slough. Following high flows which occurred in December, predicted salinity on January 1, 2003 shows that the 0.50 psu isohaline is on the western side of Suisun Bay near Martinez. Predicted salinity increases of between 0.05 and 0.10 psu persist in Big Break, a portion of Little Mandeville Island, and some reaches of Dutch Slough. Predicted salinity increases are less than 0.05 psu throughout the remaining portions of the Delta.

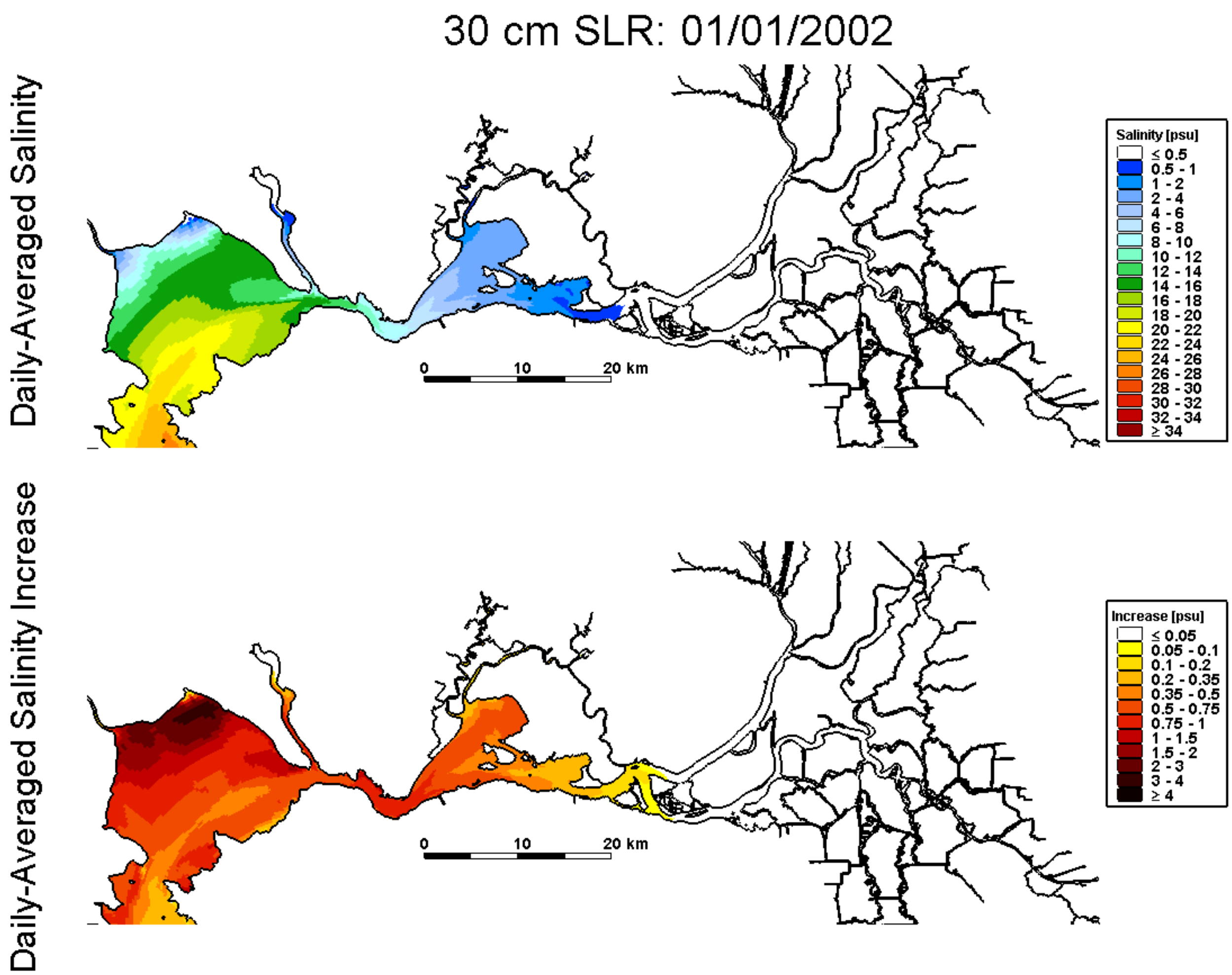


Figure 4.2-1 Predicted daily-averaged depth-average salinity on January 1, 2002 for the 30 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on January 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 30 cm SLR scenario.

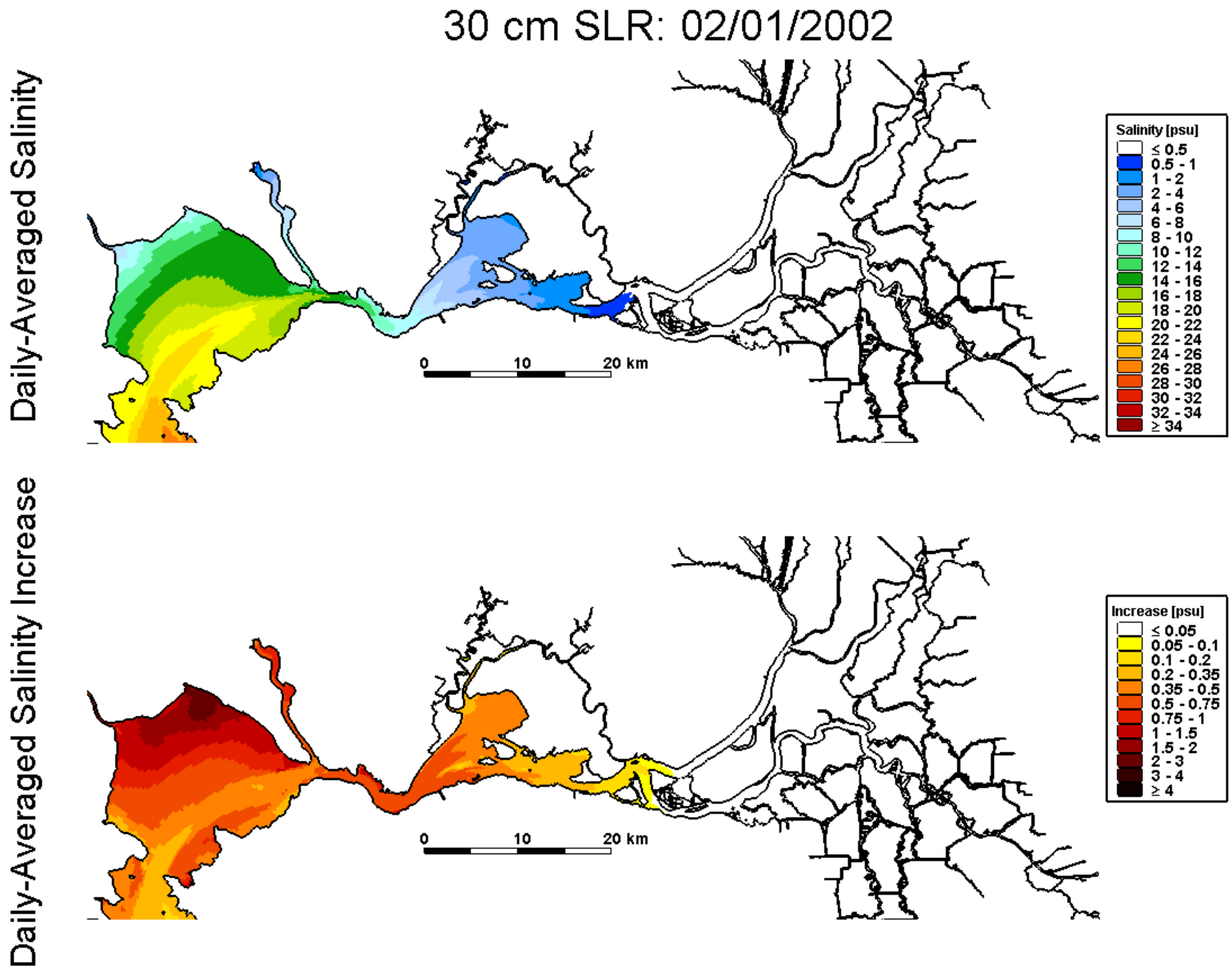


Figure 4.2-2 Predicted daily-averaged depth-average salinity on February 1, 2002 for the 30 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on February 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 30 cm SLR scenario.

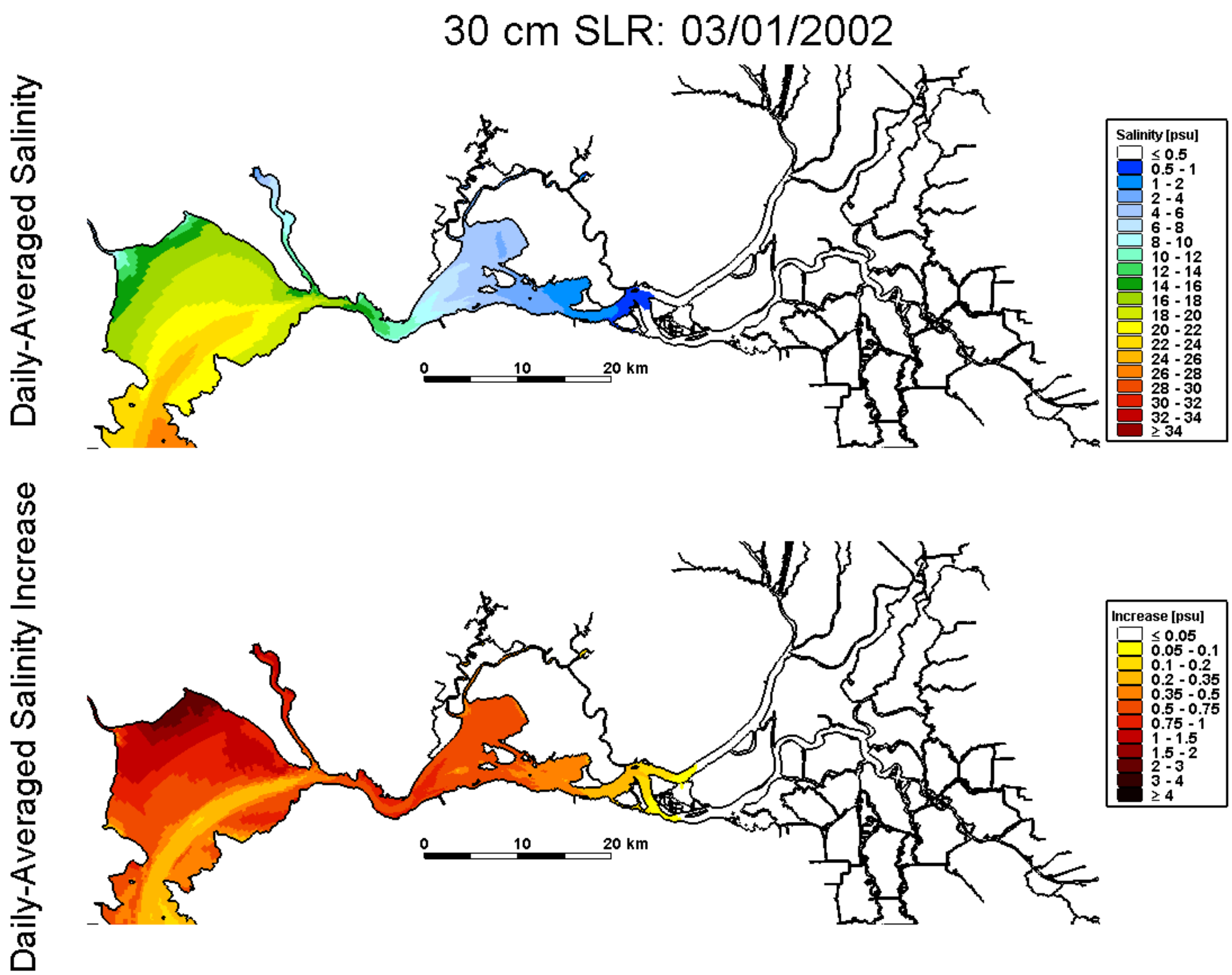


Figure 4.2-3 Predicted daily-averaged depth-average salinity on March 1, 2002 for the 30 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on March 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 30 cm SLR scenario.

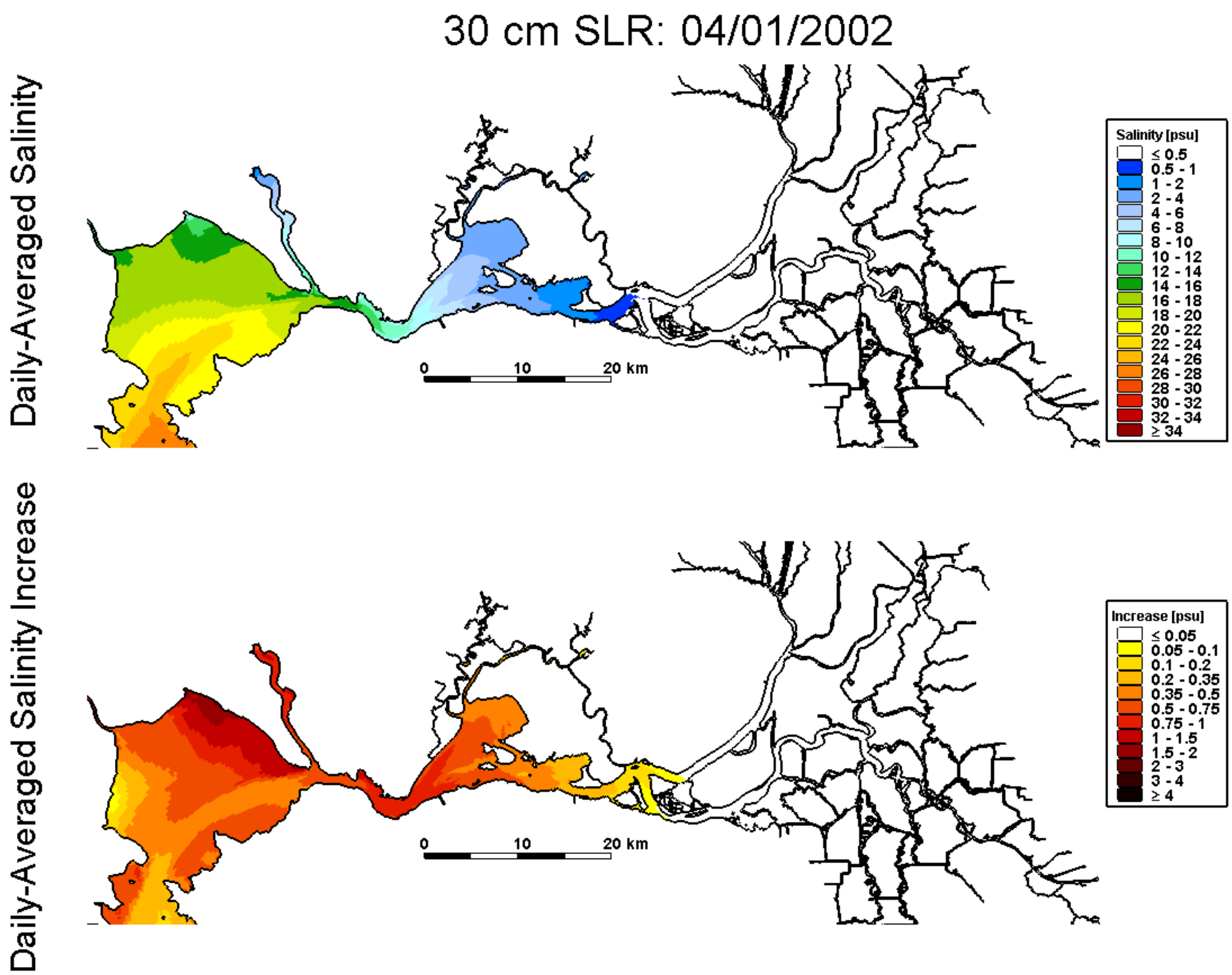


Figure 4.2-4 Predicted daily-averaged depth-average salinity on April 1, 2002 for the 30 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on April 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 30 cm SLR scenario.

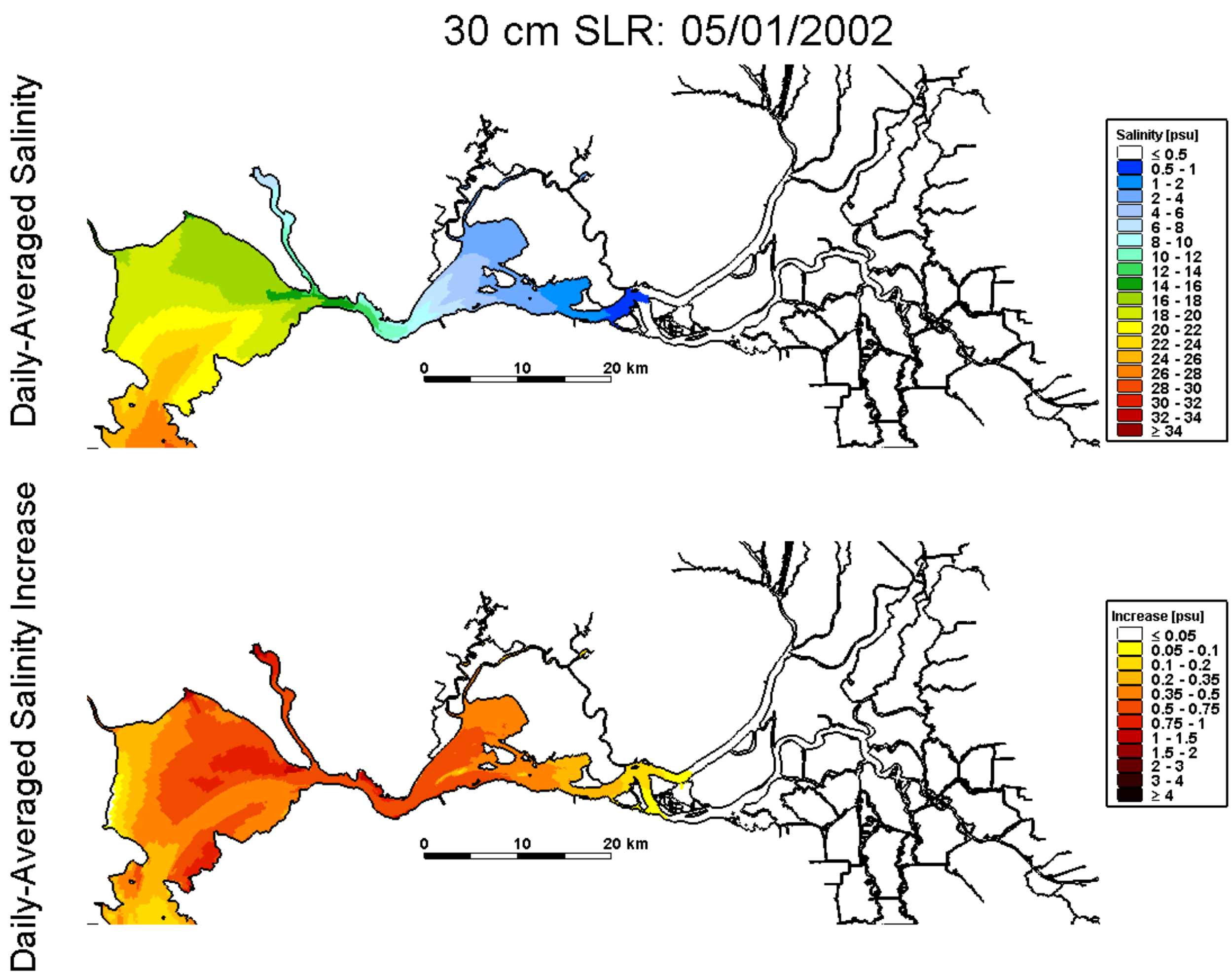


Figure 4.2-5 Predicted daily-averaged depth-average salinity on May 1, 2002 for the 30 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on May 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 30 cm SLR scenario.

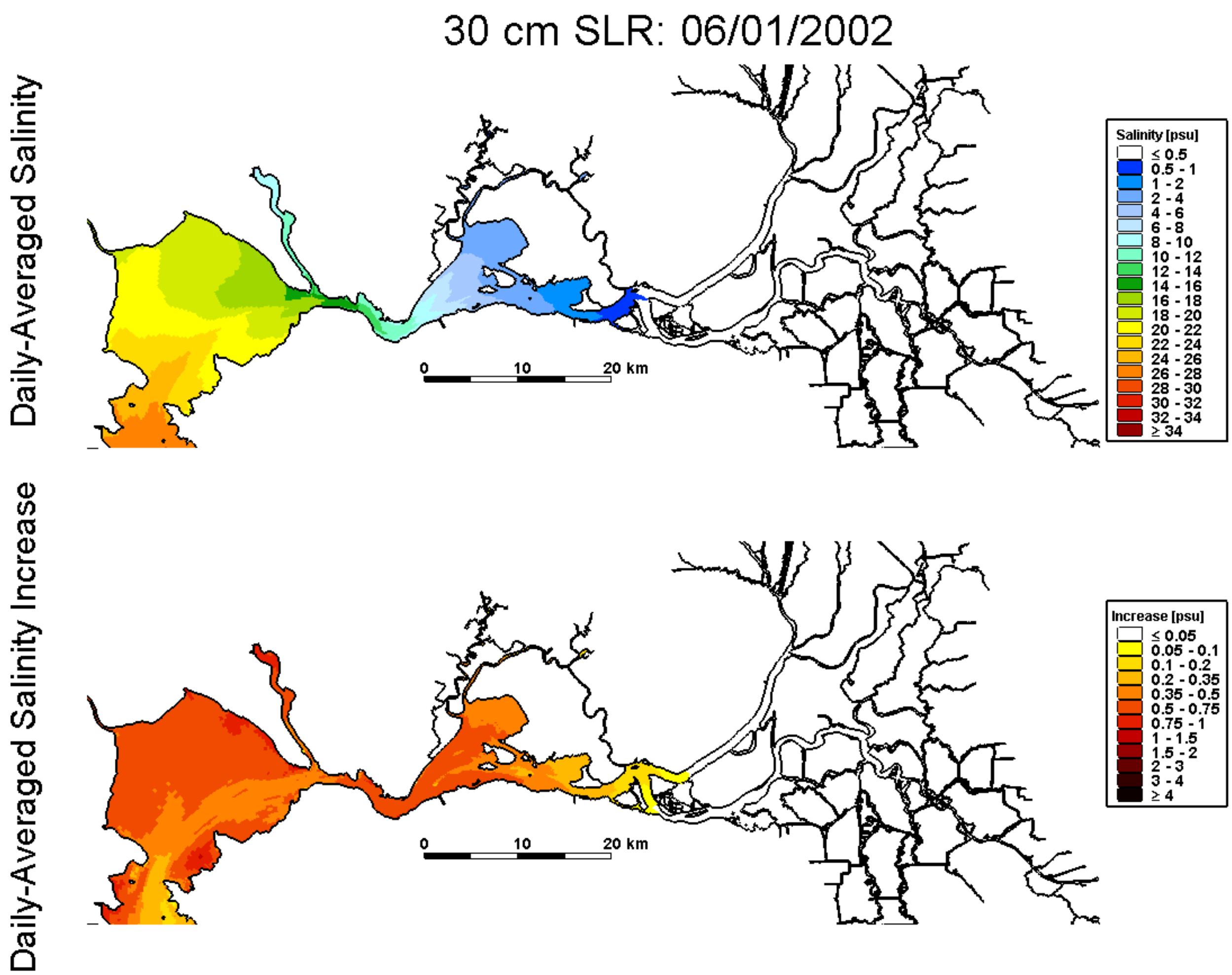


Figure 4.2-6 Predicted daily-averaged depth-average salinity on June 1, 2002 for the 30 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on June 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 30 cm SLR scenario.

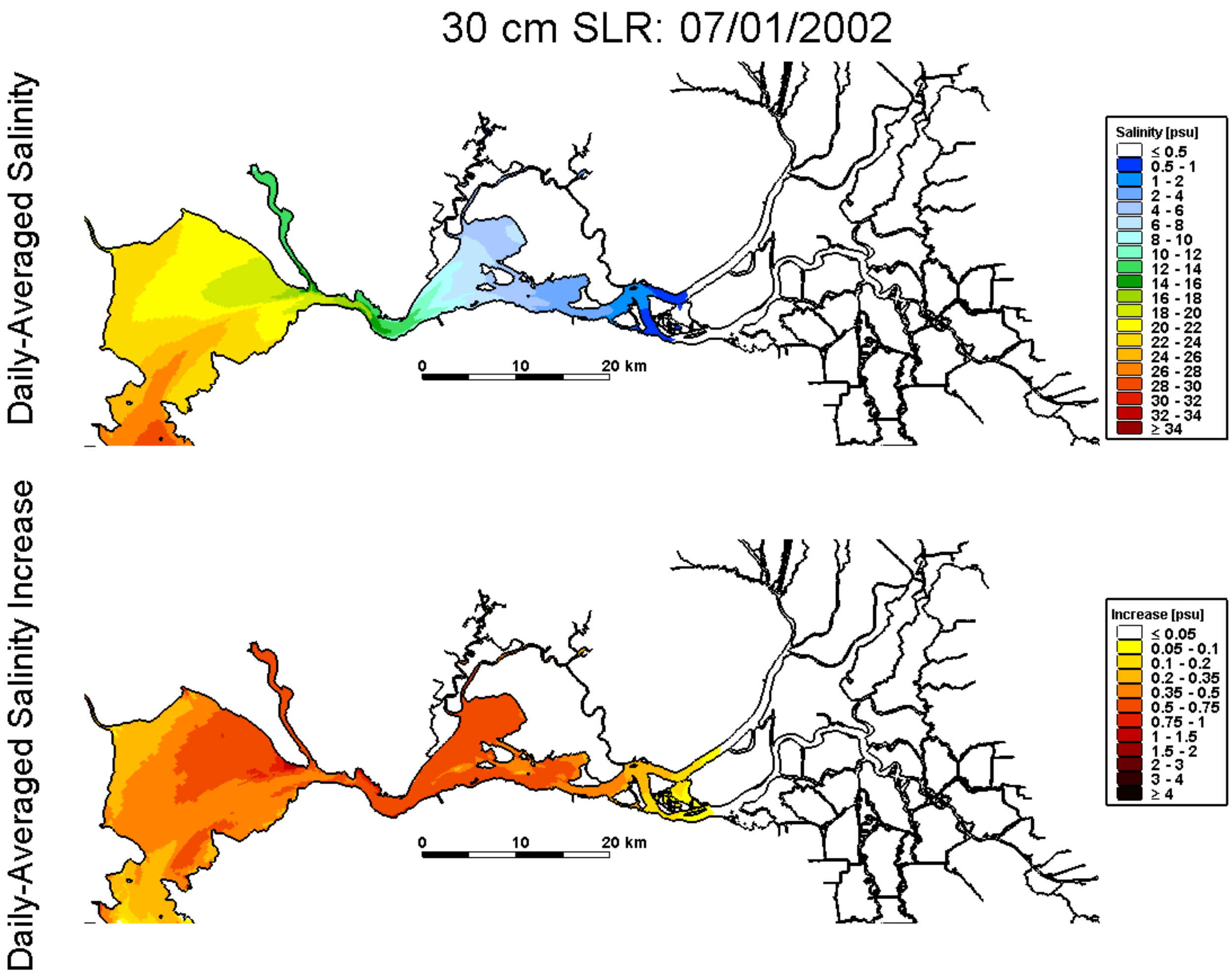


Figure 4.2-7 Predicted daily-averaged depth-average salinity on July 1, 2002 for the 30 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on July 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 30 cm SLR scenario.

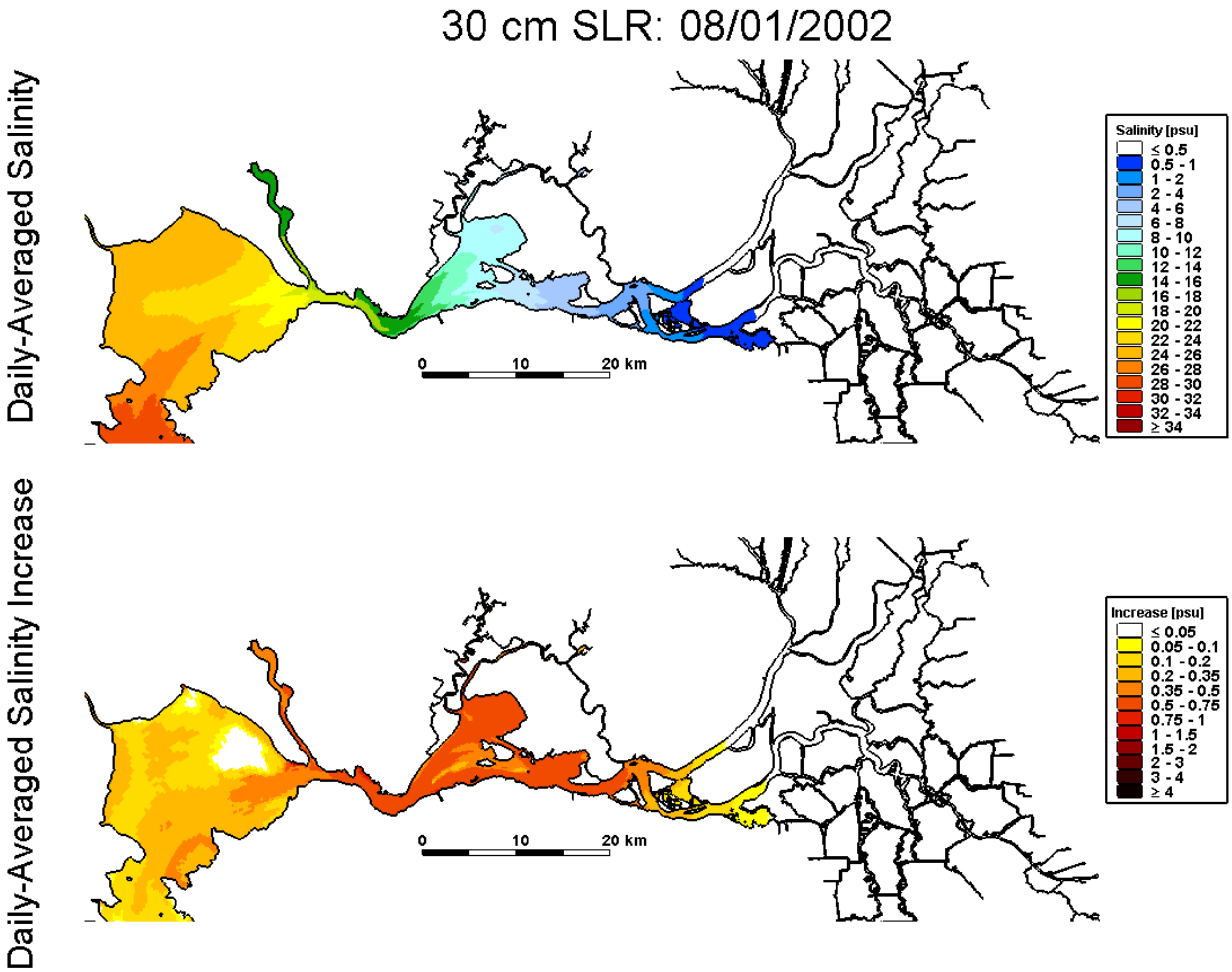


Figure 4.2-8 Predicted daily-averaged depth-average salinity on August 1, 2002 for the 30 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on August 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 30 cm SLR scenario.

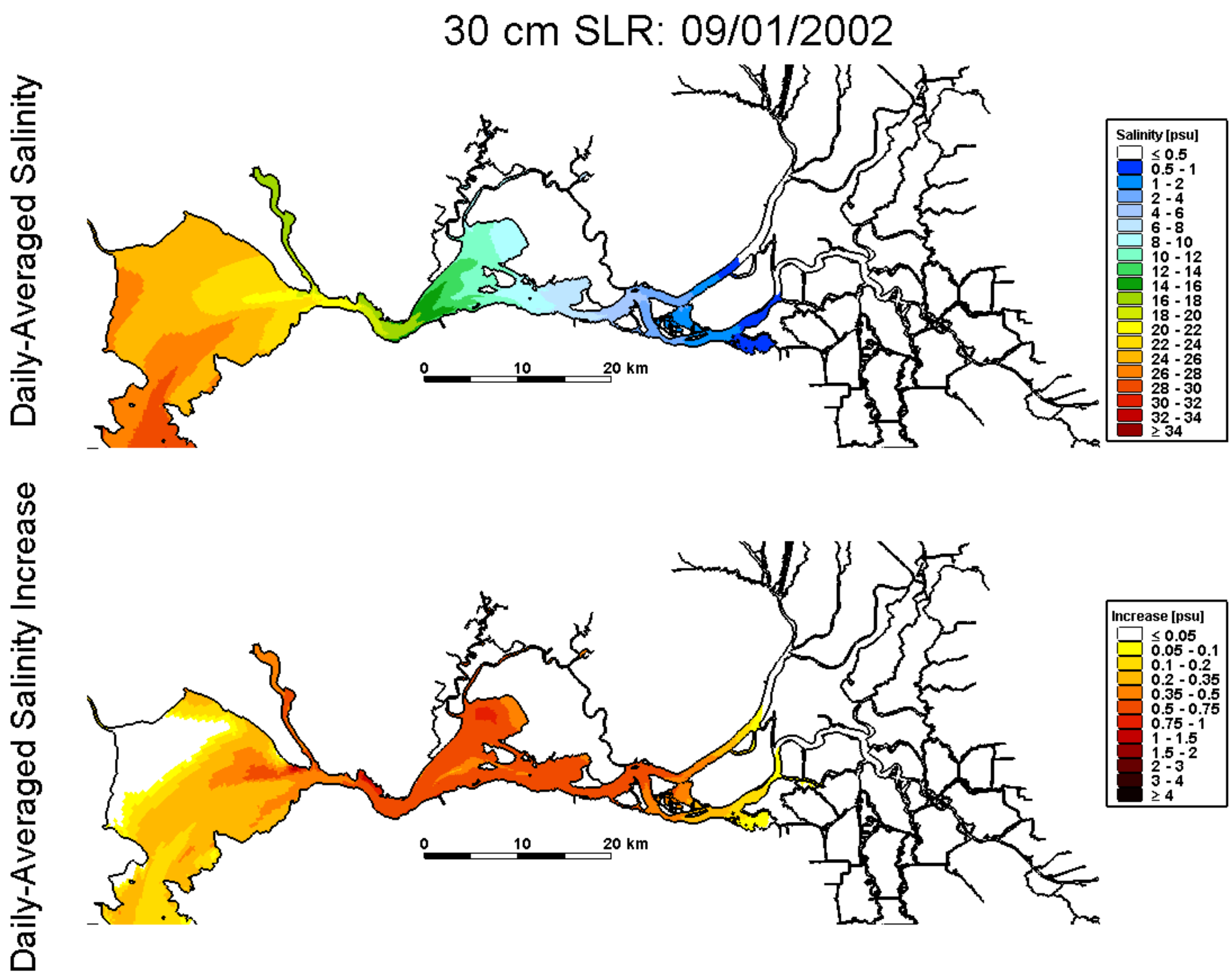


Figure 4.2-9 Predicted daily-averaged depth-average salinity on September 1, 2002 for the 30 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on September 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 30 cm SLR scenario.

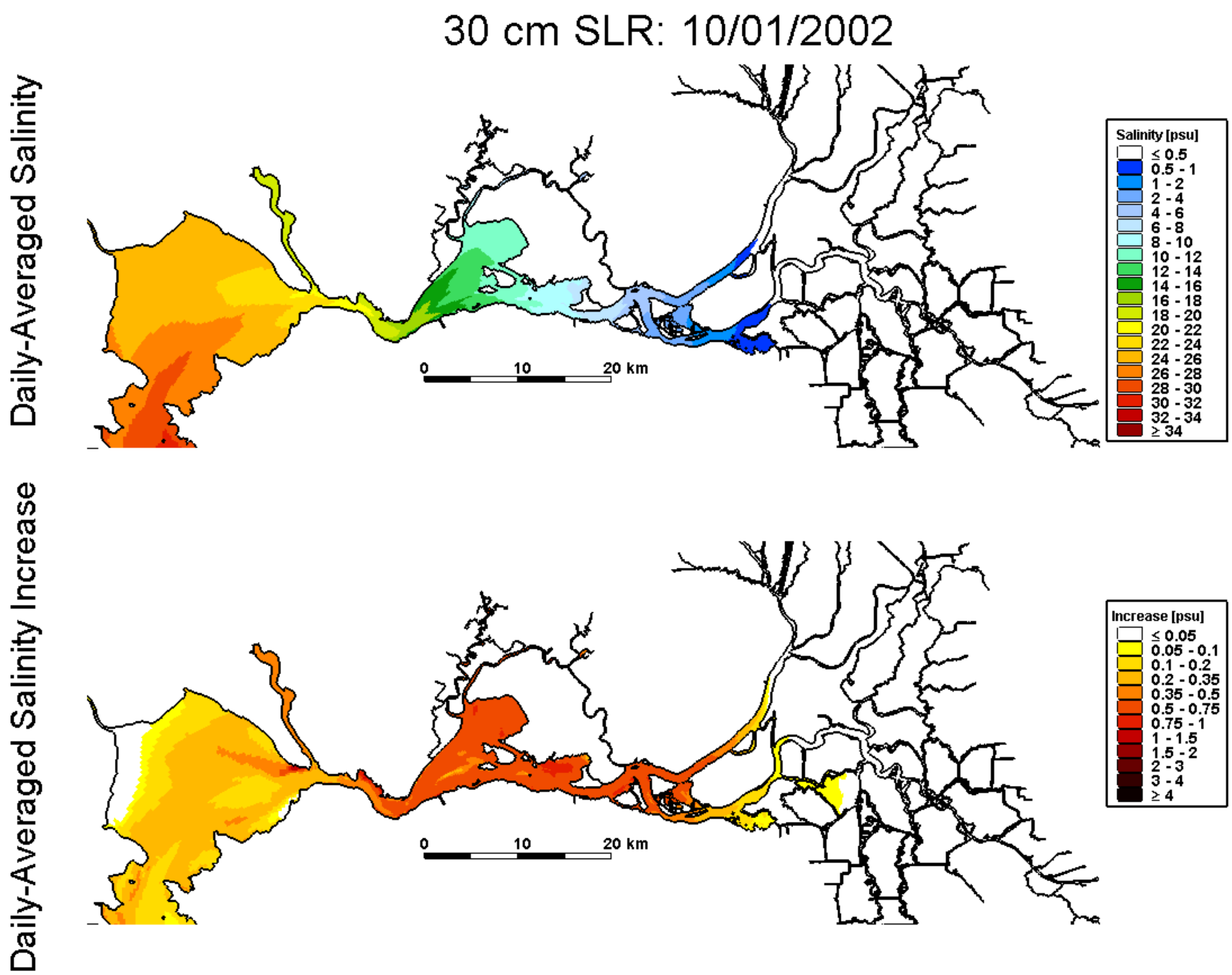


Figure 4.2-10 Predicted daily-averaged depth-average salinity on October 1, 2002 for the 30 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on October 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 30 cm SLR scenario.

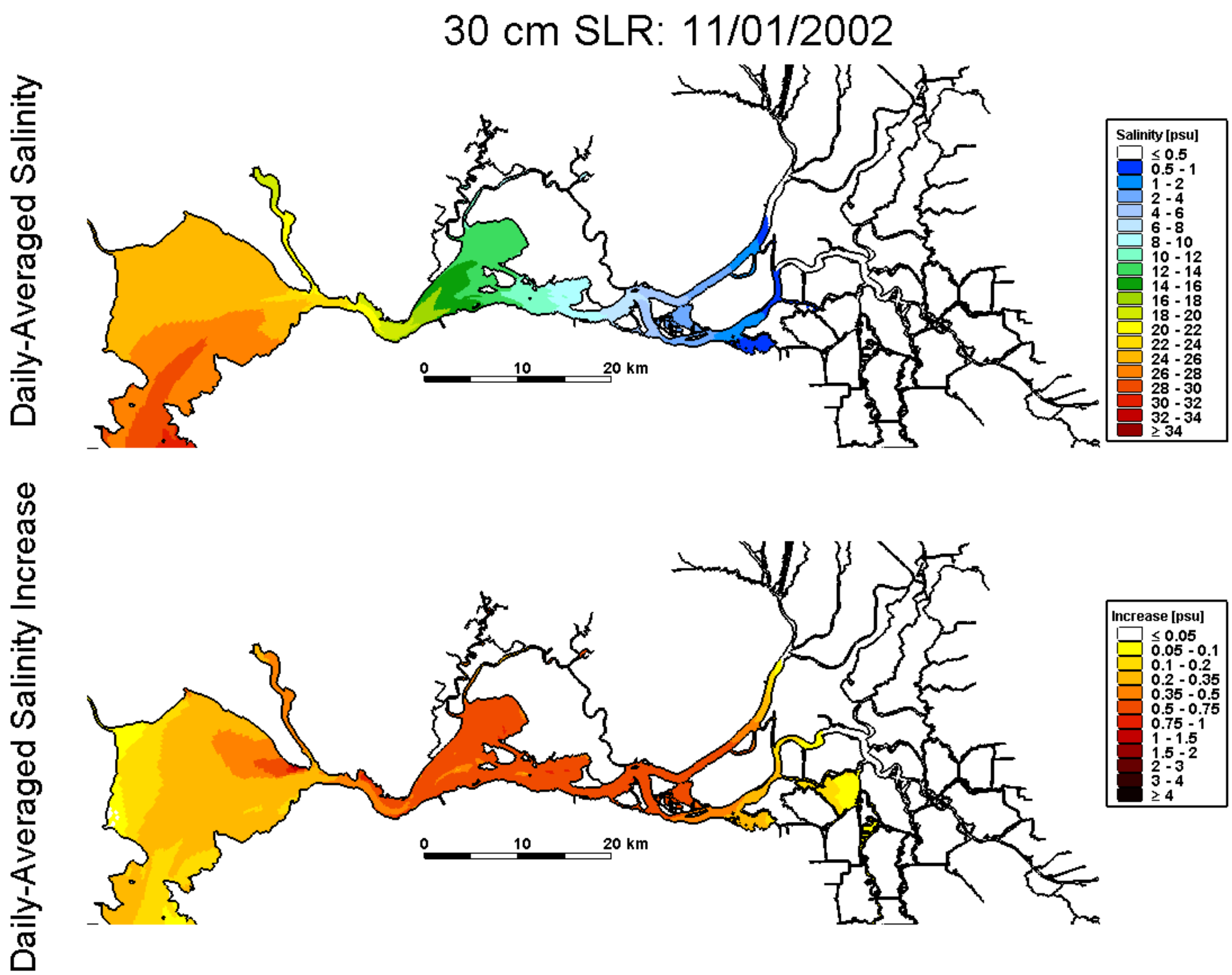


Figure 4.2-11 Predicted daily-averaged depth-average salinity on November 1, 2002 for the 30 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on November 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 30 cm SLR scenario.

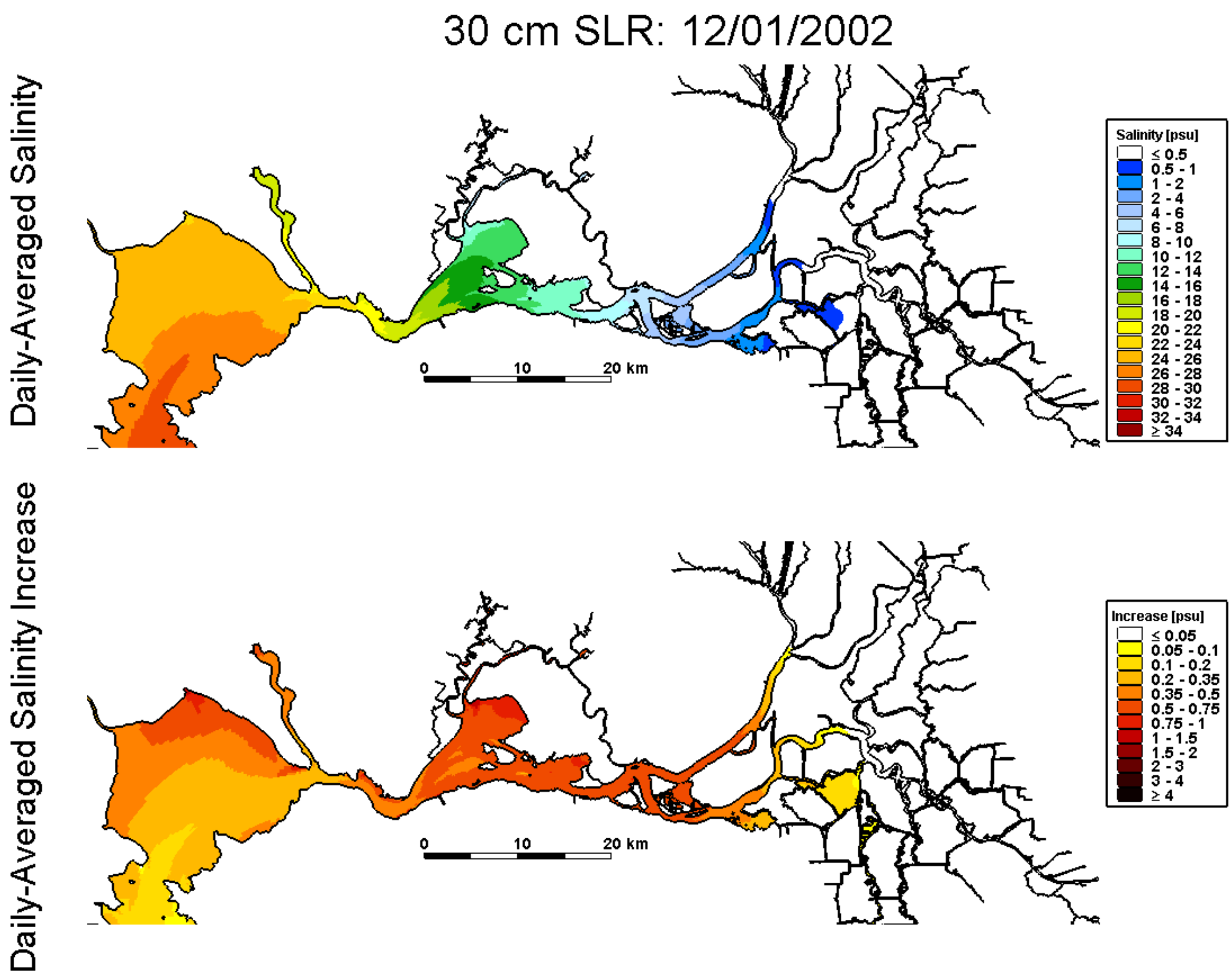


Figure 4.2-12 Predicted daily-averaged depth-average salinity on December 1, 2002 for the 30 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on December 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 30 cm SLR scenario.

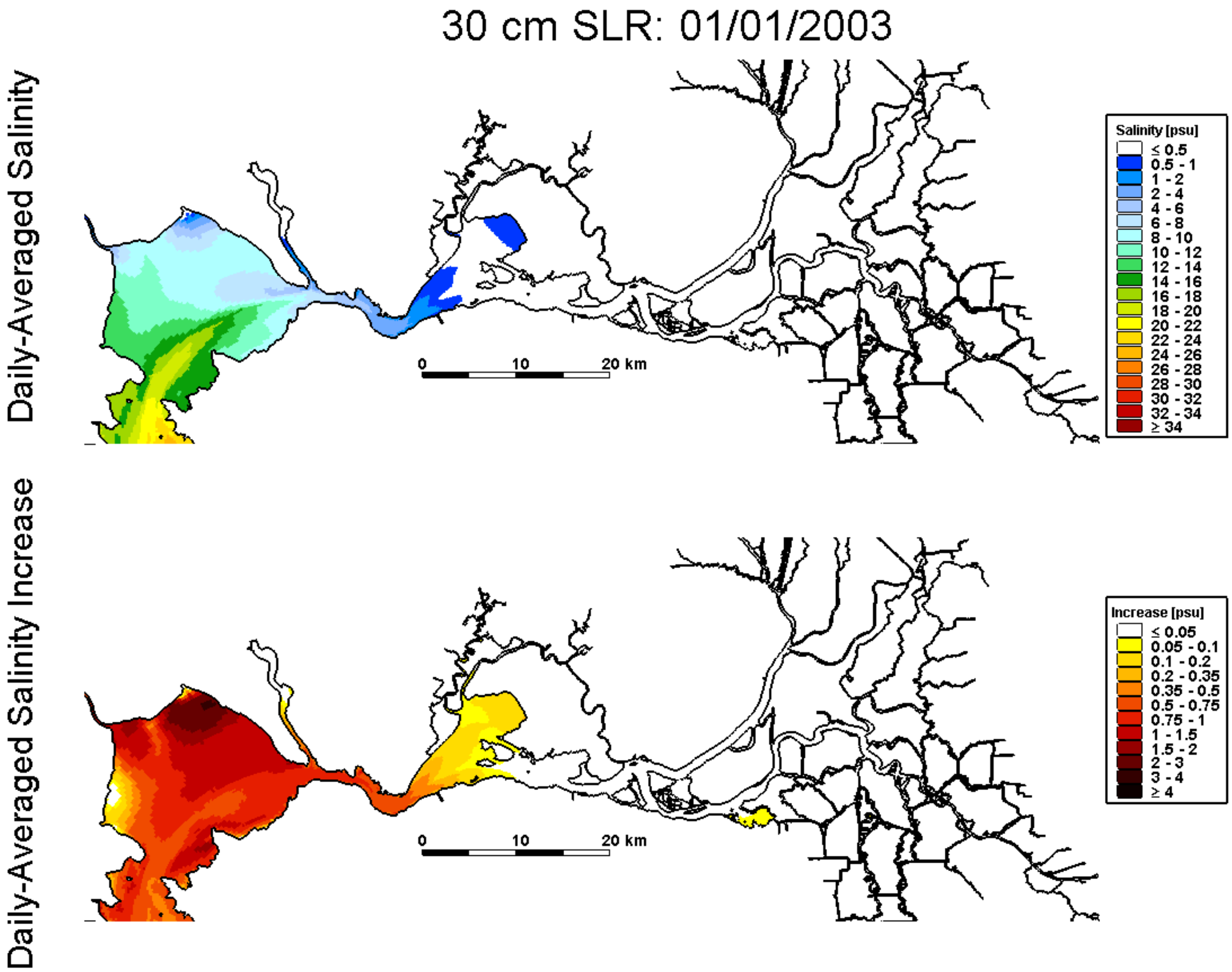


Figure 4.2-13 Predicted daily-averaged depth-average salinity on January 1, 2003 for the 30 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on January 1, 2003 relative to the Baseline (0 cm SLR) scenario for the 30 cm SLR scenario.

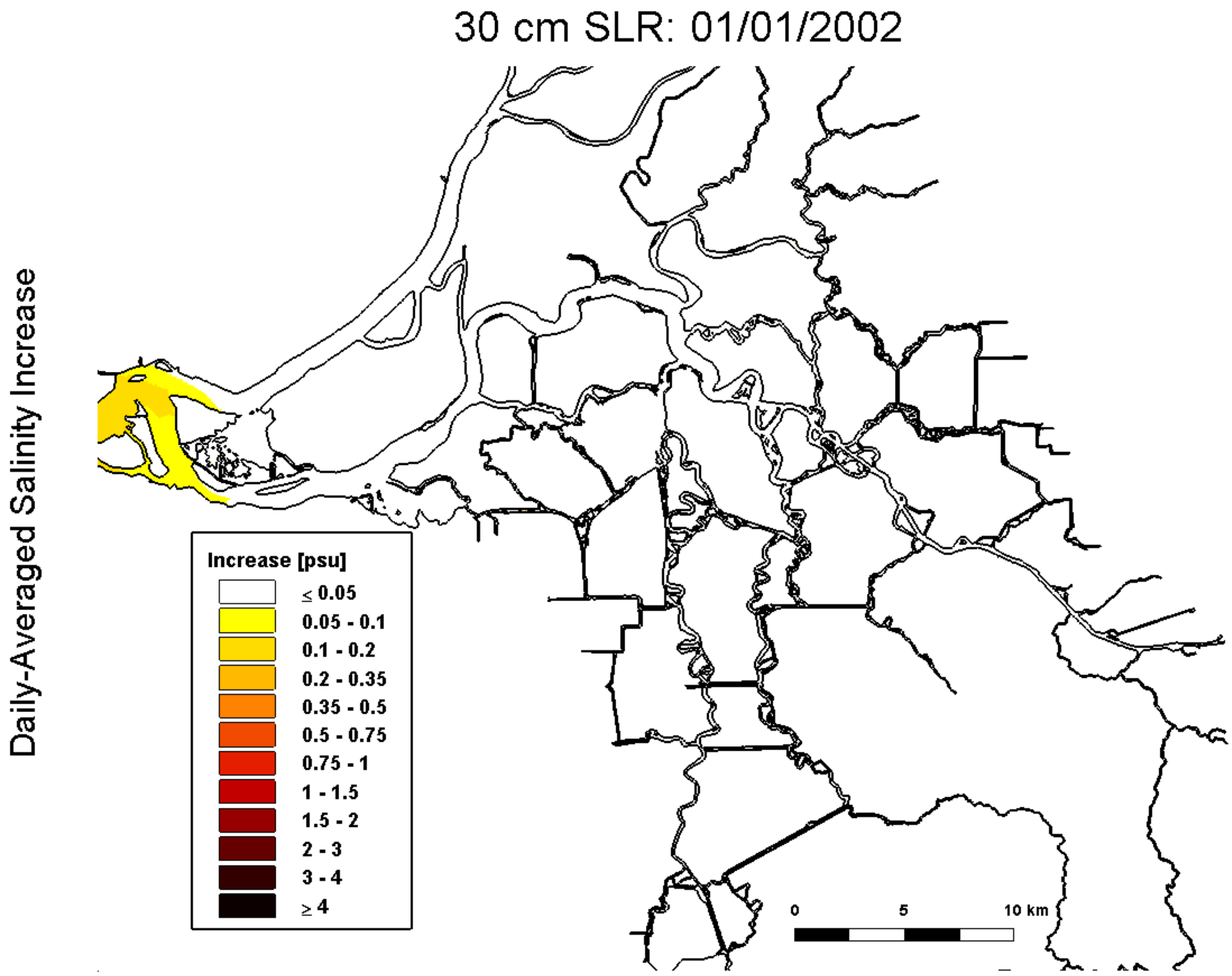


Figure 4.2-14 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on January 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 30 cm SLR scenario.

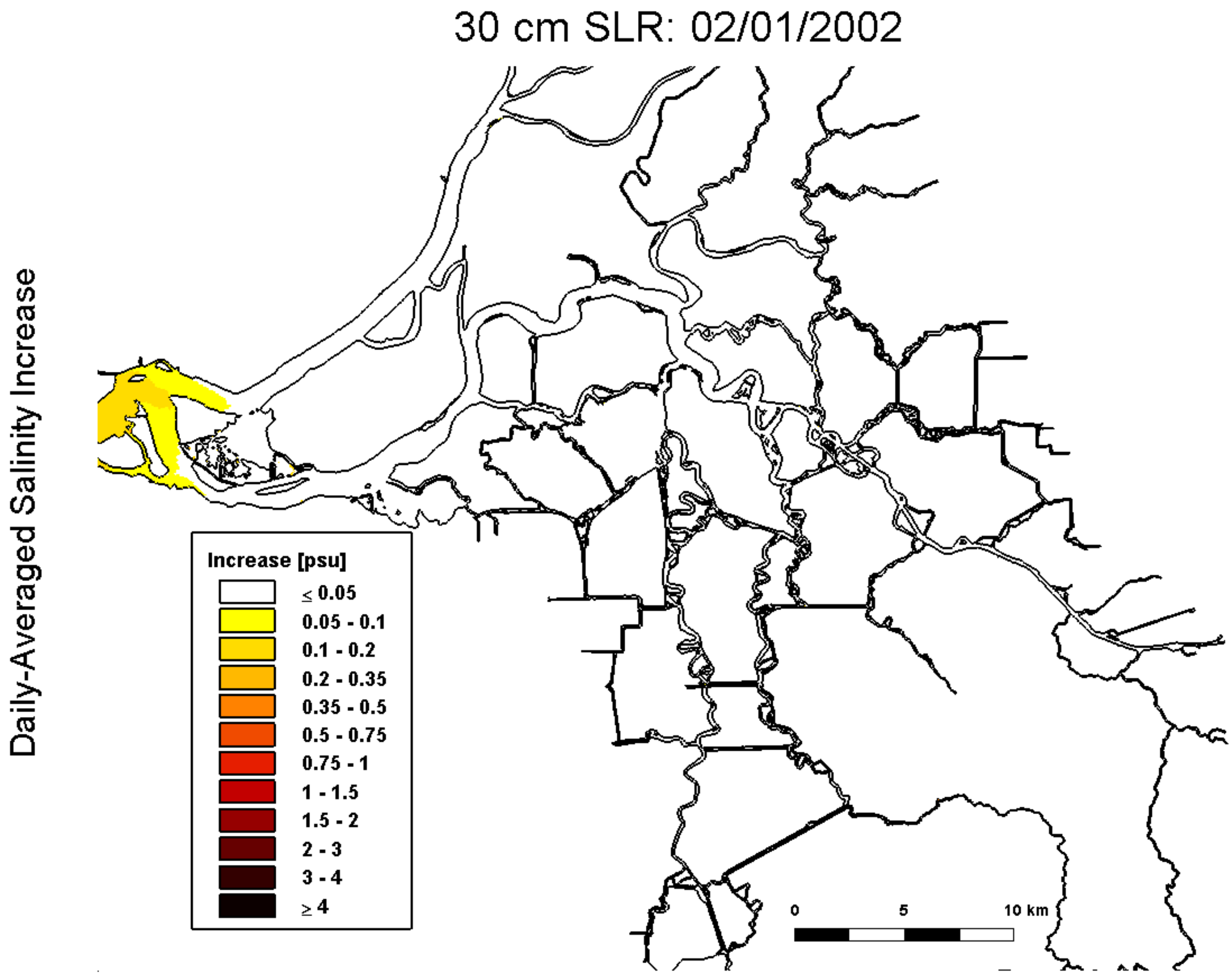


Figure 4.2-15 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on February 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 30 cm SLR scenario.

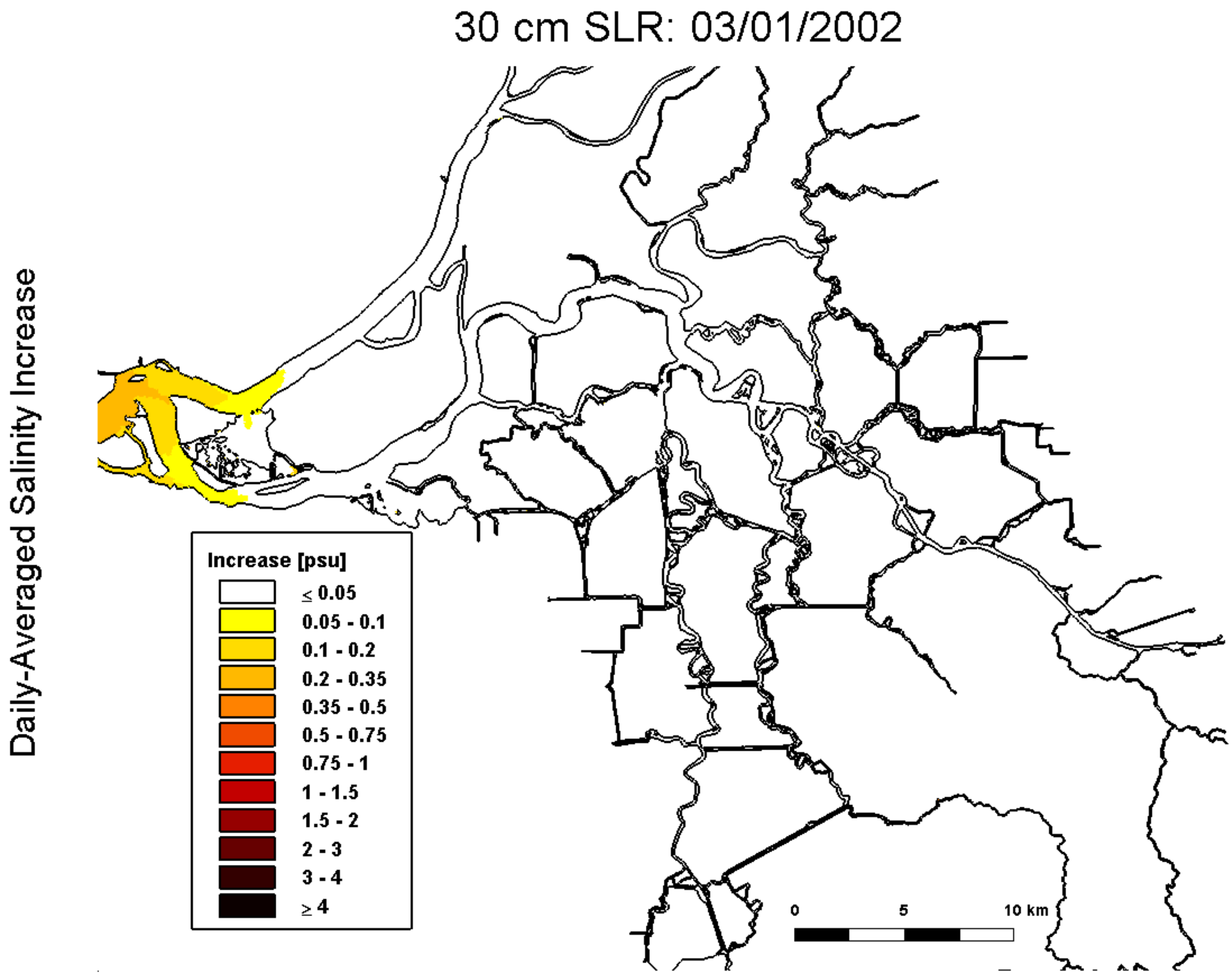


Figure 4.2-16 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on March 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 30 cm SLR scenario.

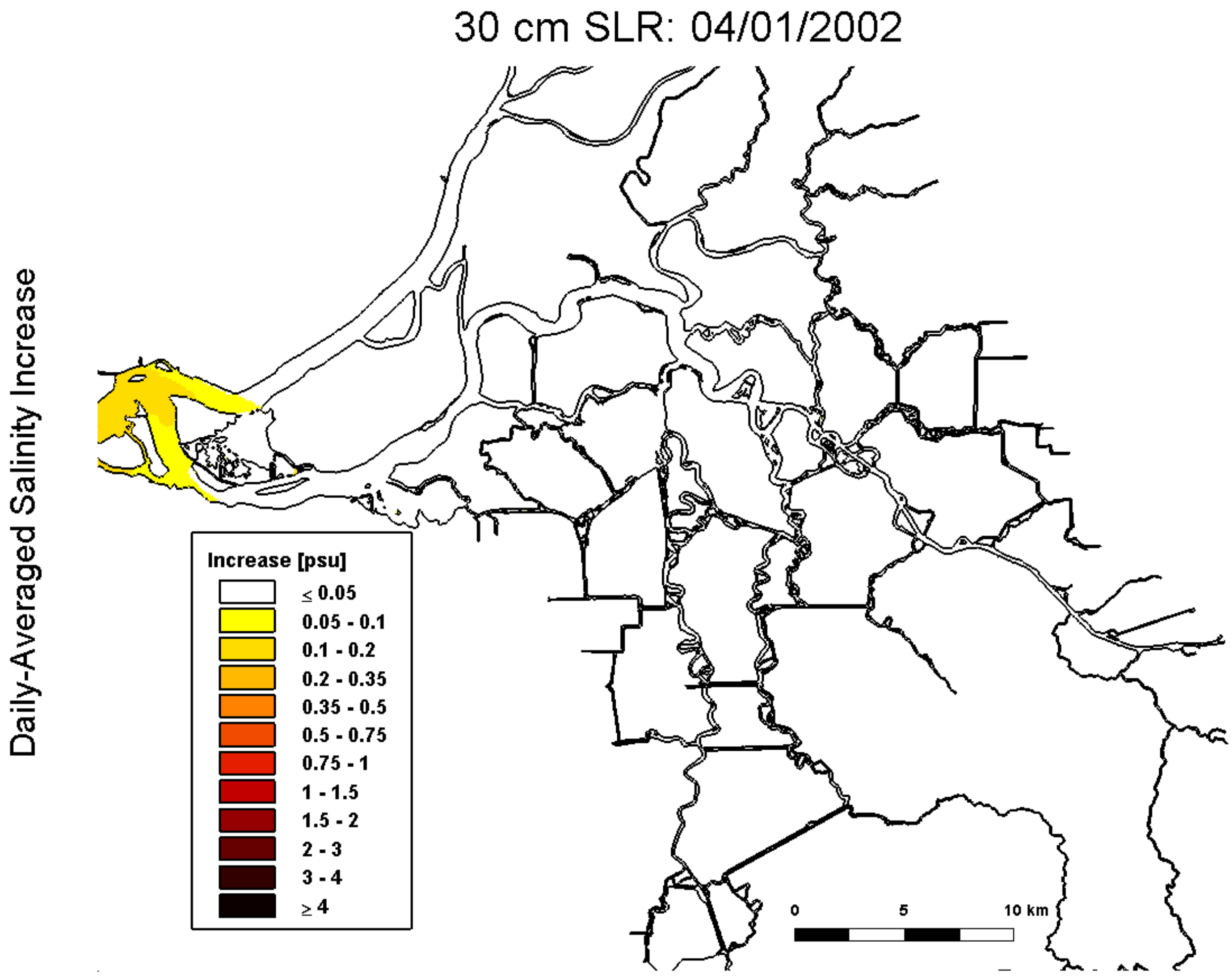


Figure 4.2-17 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on April 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 30 cm SLR scenario.

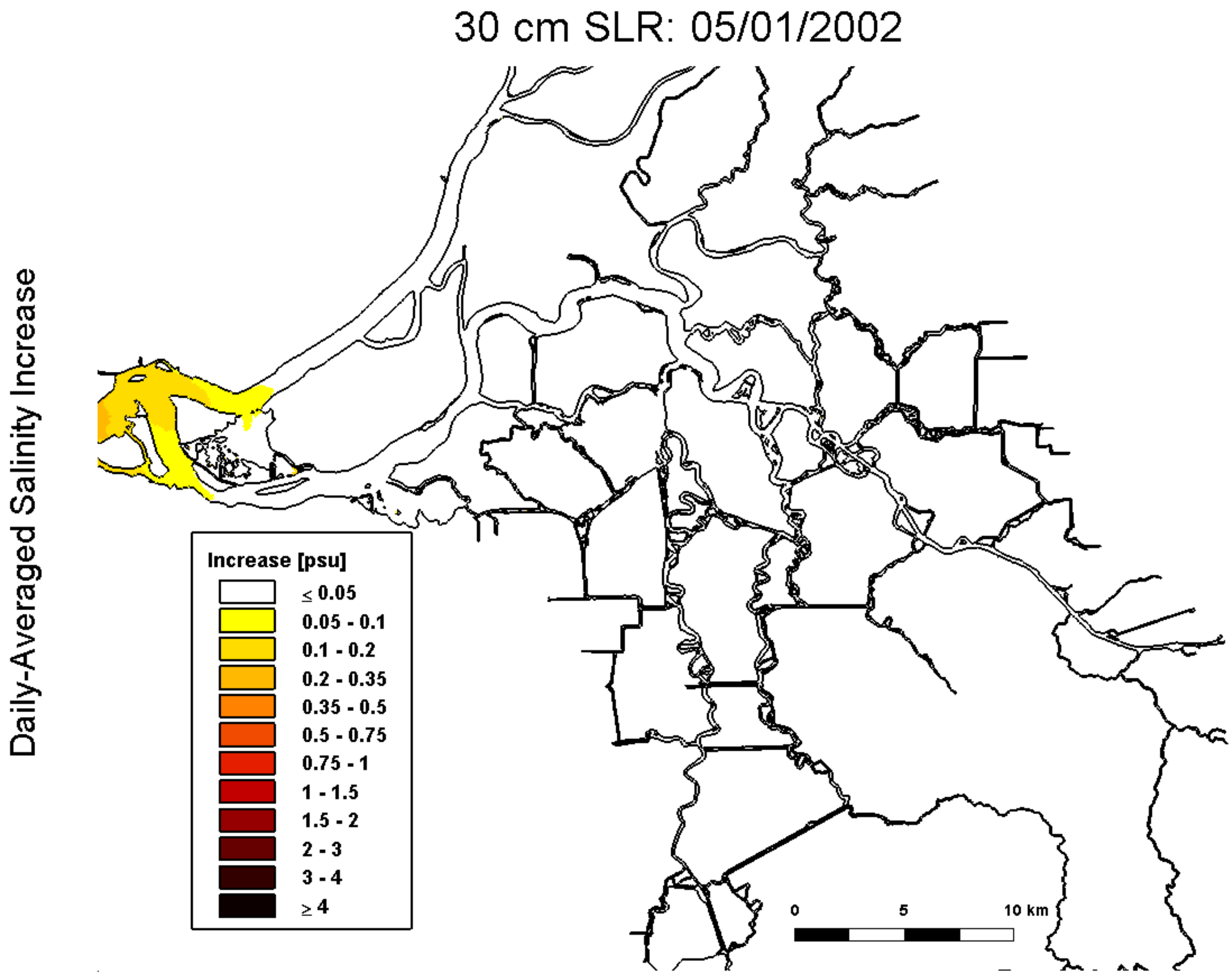


Figure 4.2-18 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on May 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 30 cm SLR scenario.

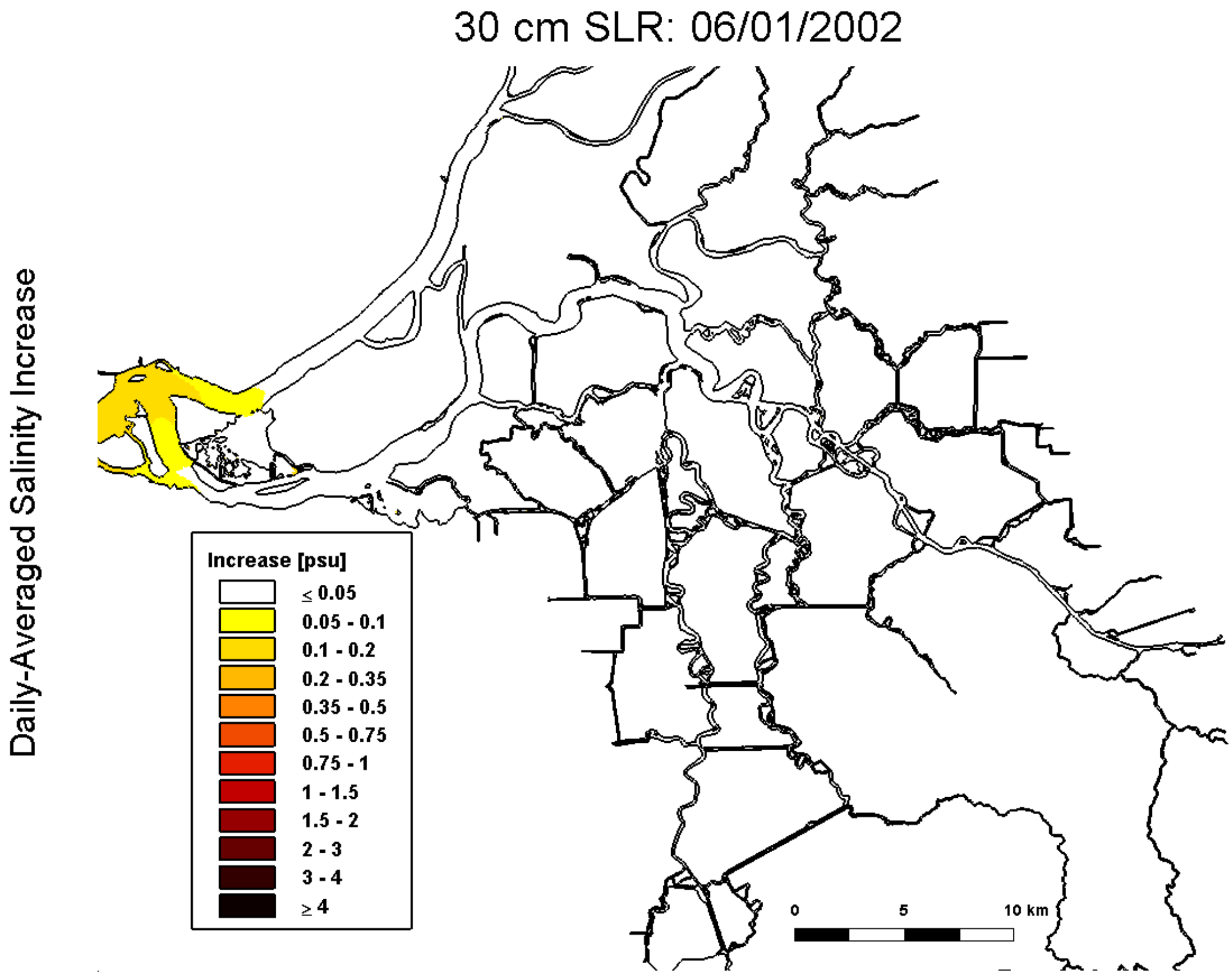


Figure 4.2-19 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on June 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 30 cm SLR scenario.

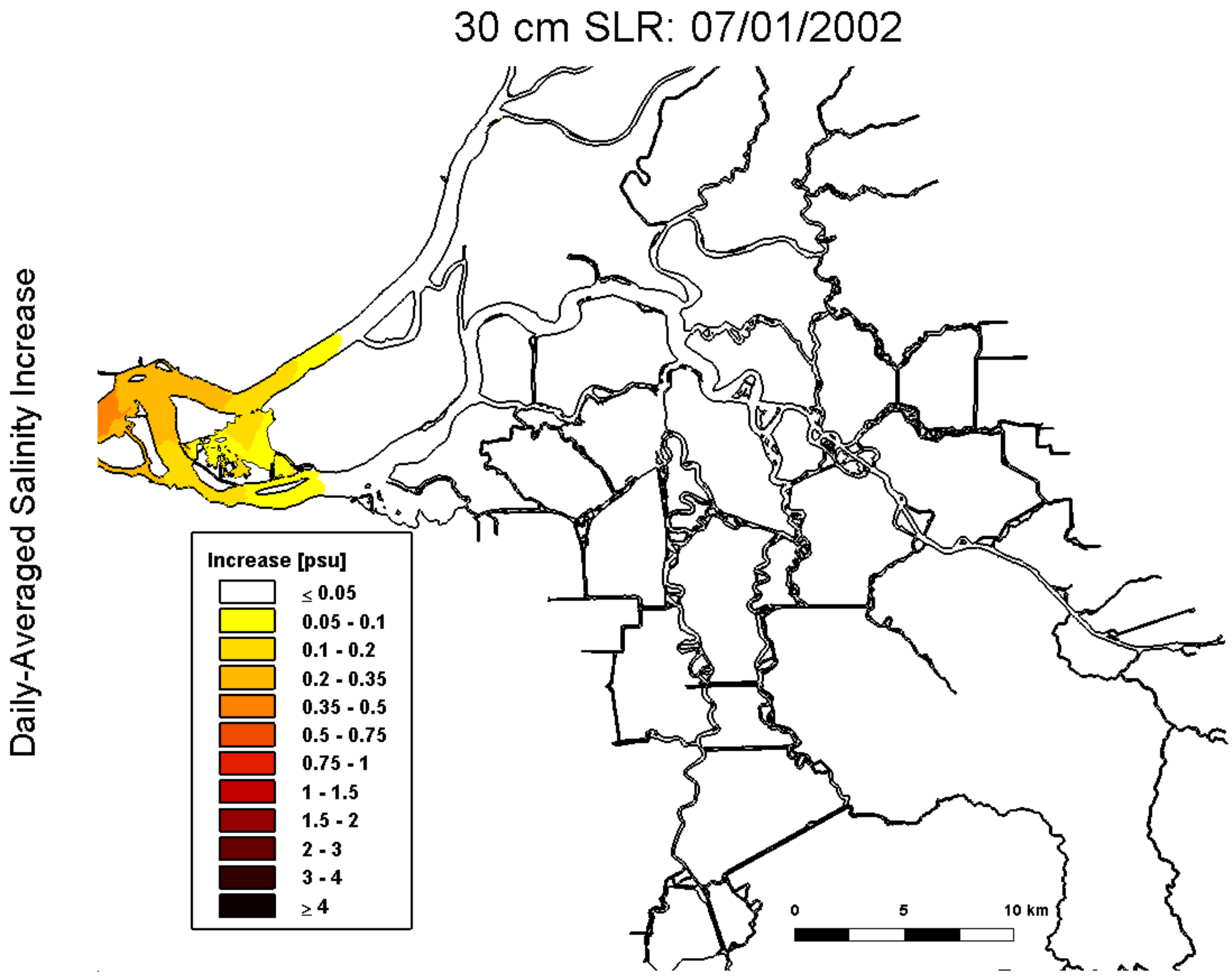


Figure 4.2-20 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on July 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 30 cm SLR scenario.

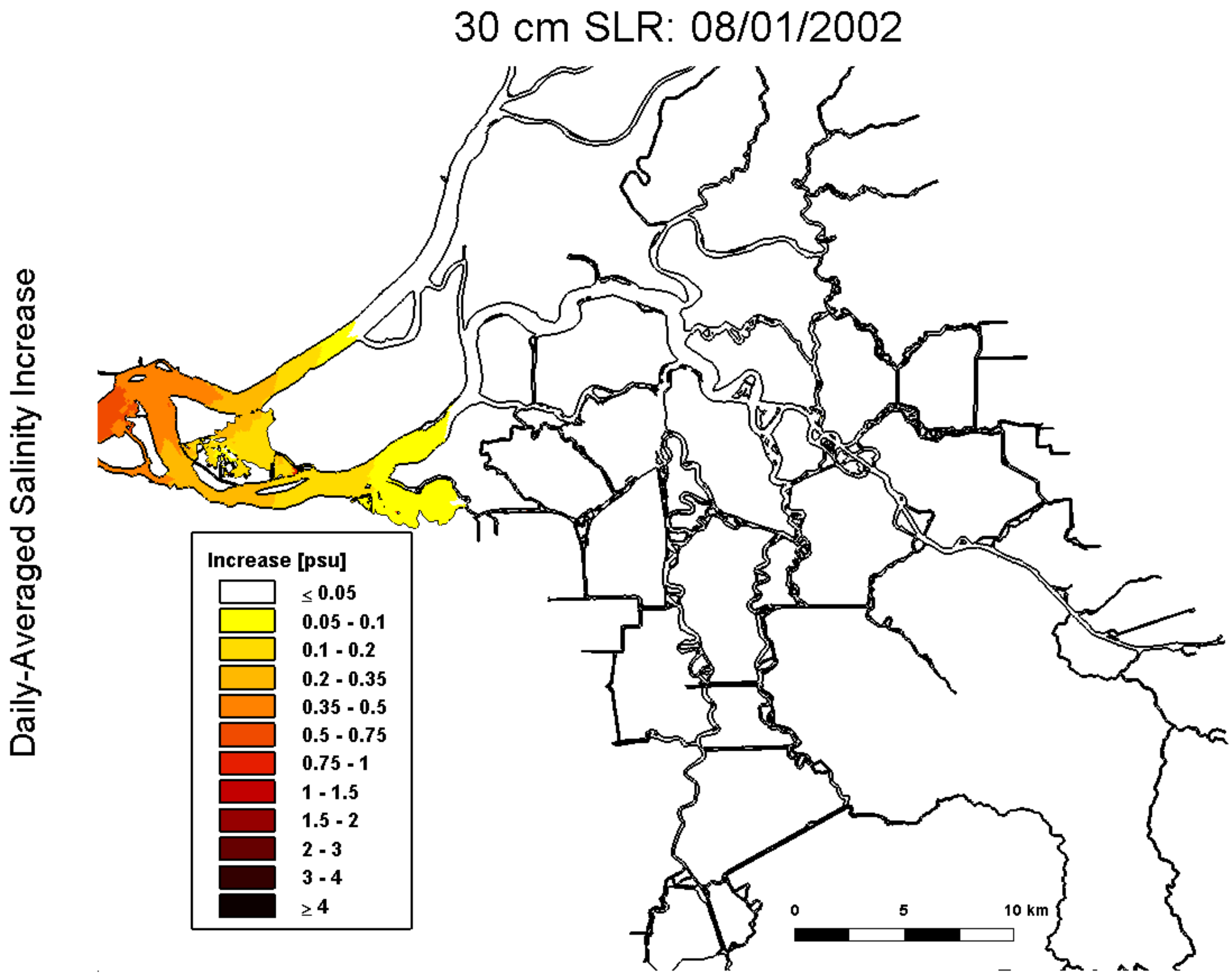


Figure 4.2-21 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on August 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 30 cm SLR scenario.

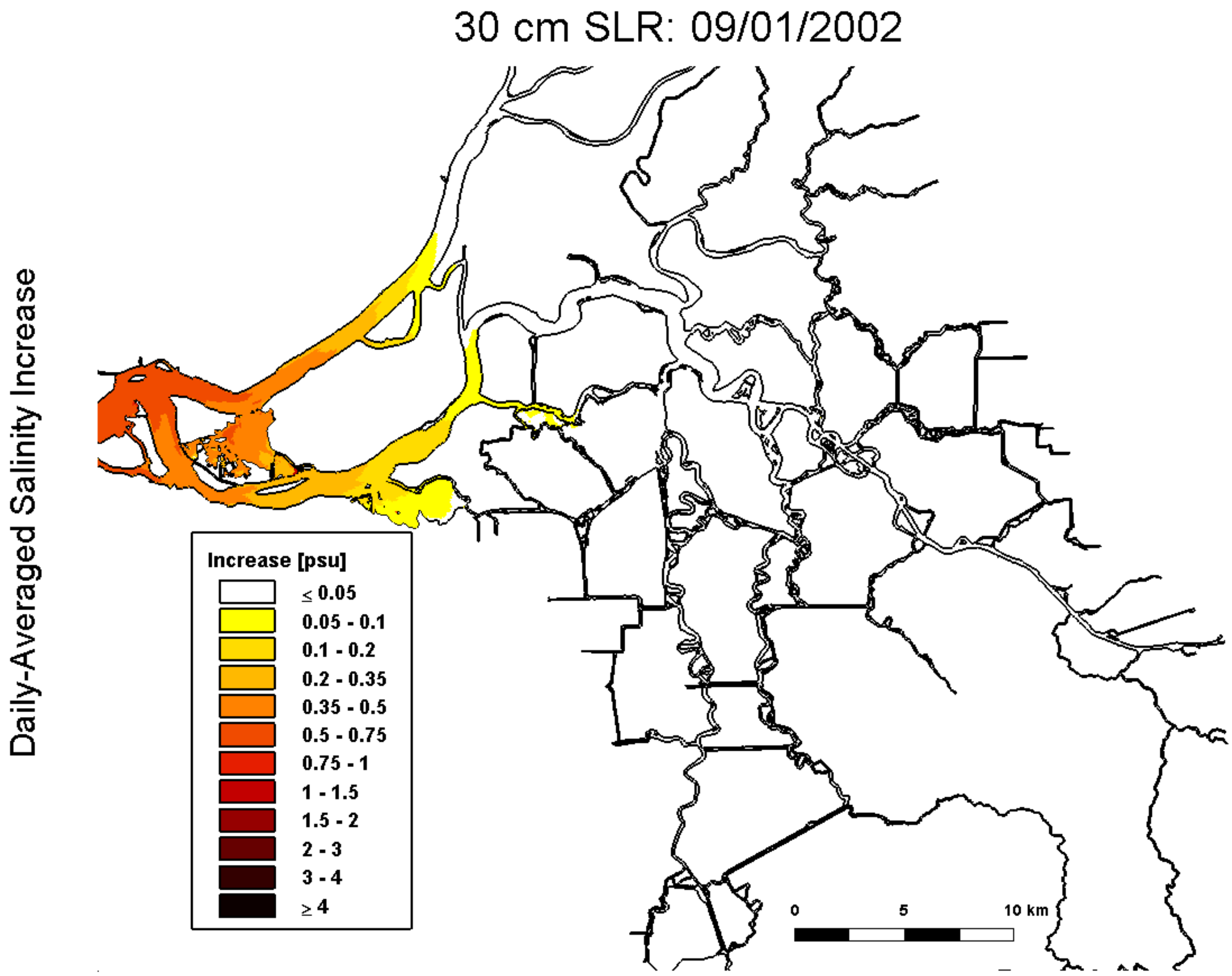


Figure 4.2-22 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on September 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 30 cm SLR scenario.

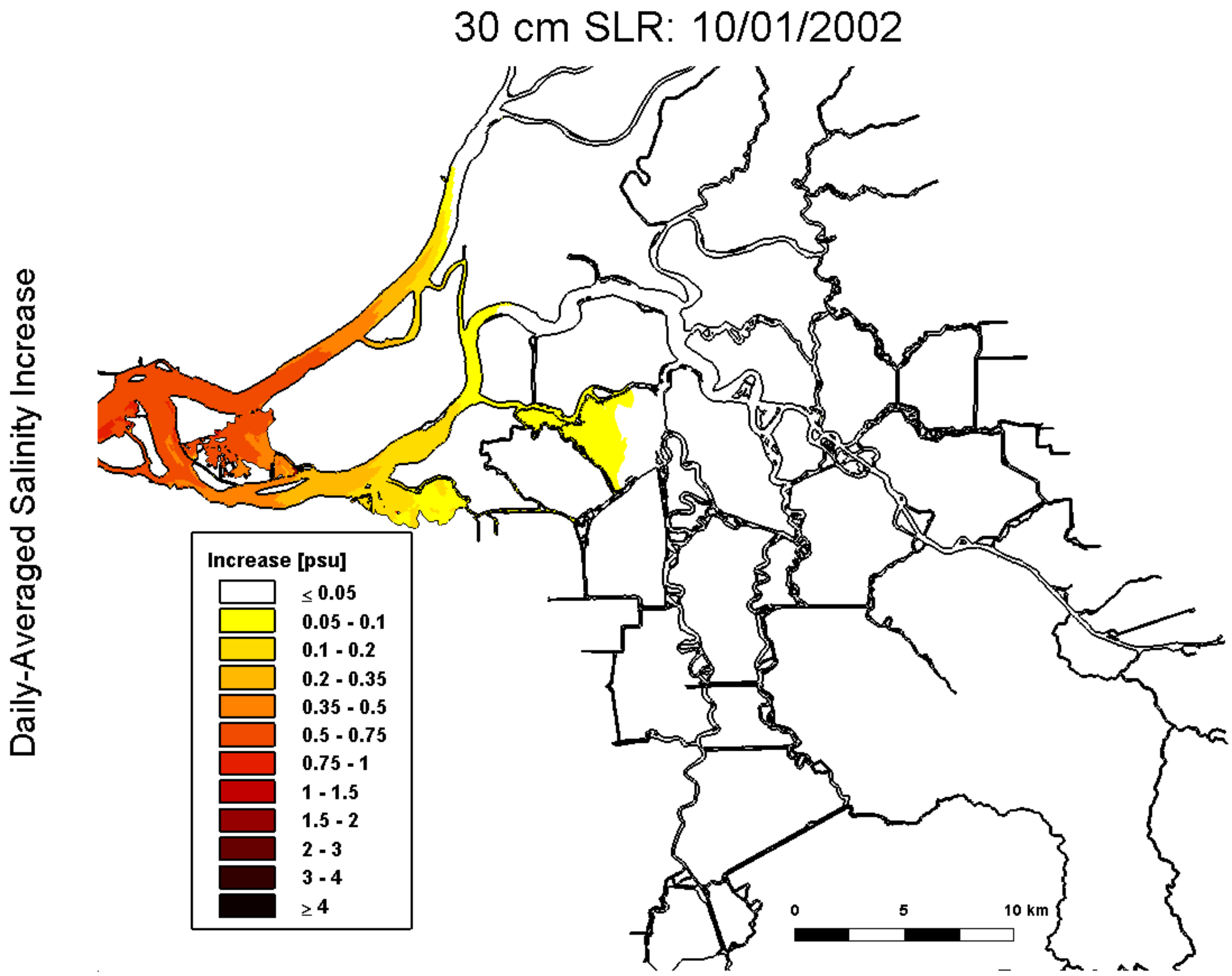


Figure 4.2-23 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on October 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 30 cm SLR scenario.

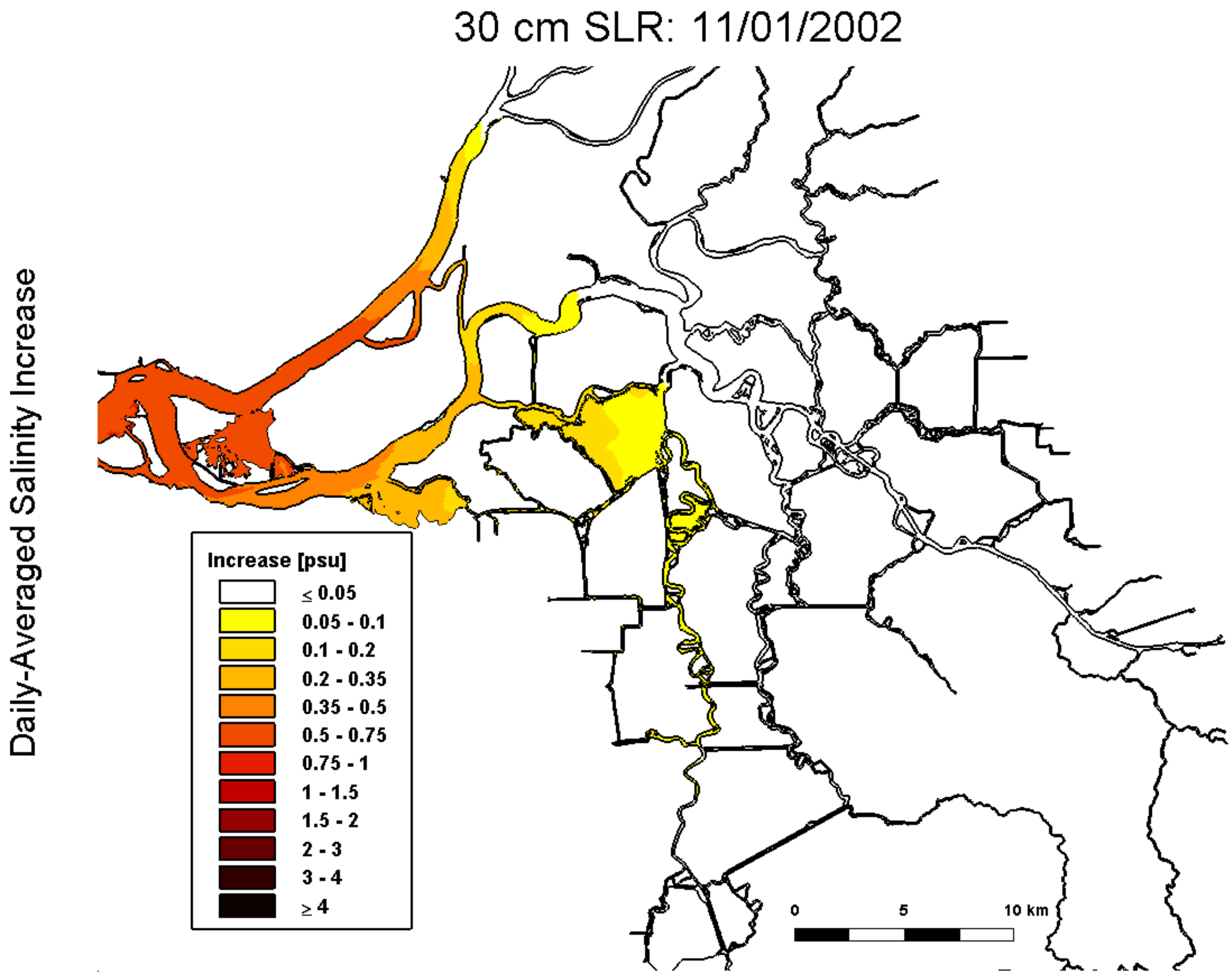


Figure 4.2-24 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on November 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 30 cm SLR scenario.

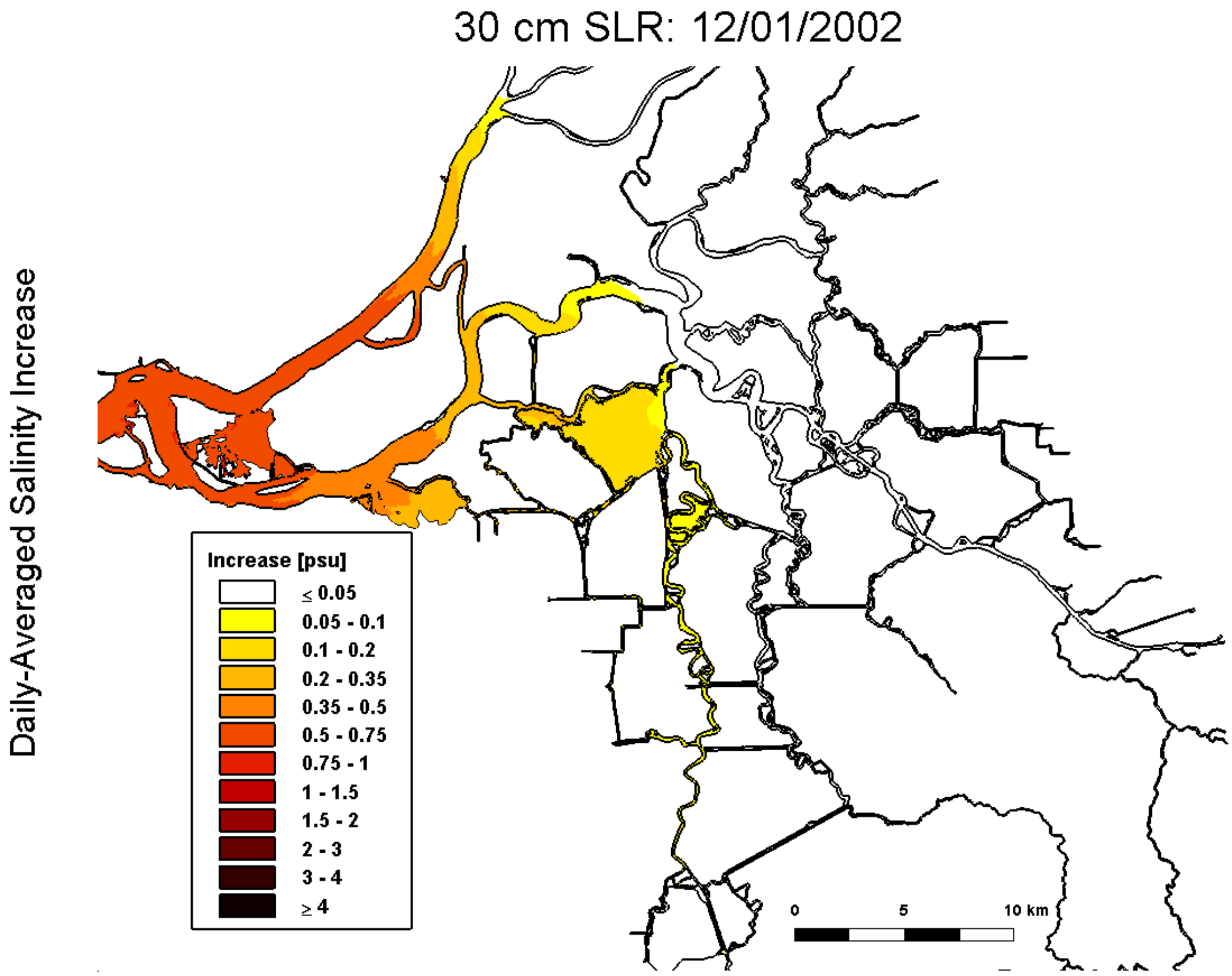


Figure 4.2-25 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on December 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 30 cm SLR scenario.

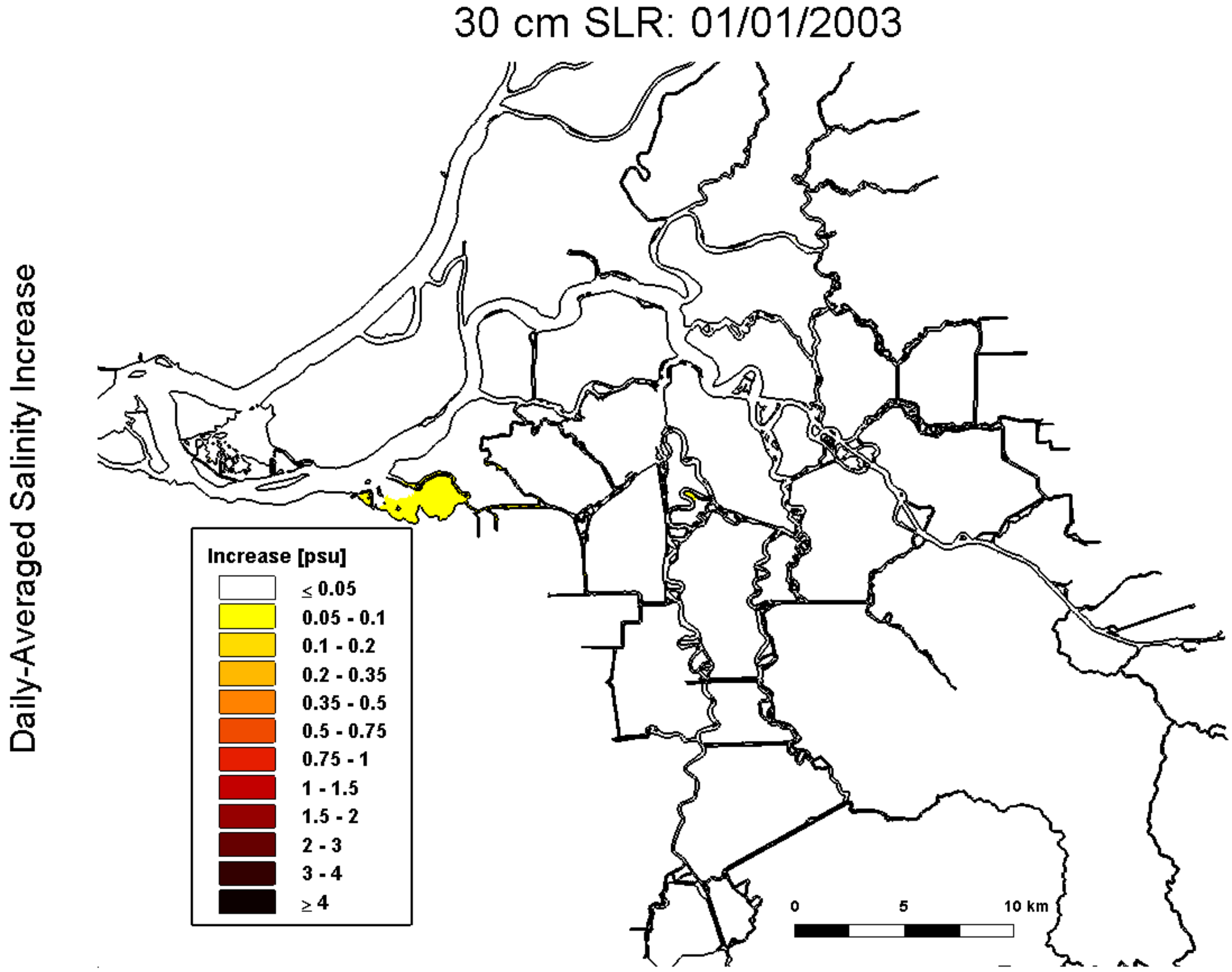


Figure 4.2-26 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on January 1, 2003 relative to the Baseline (0 cm SLR) scenario for the 30 cm SLR scenario.

4.3 Predicted Increase in Salinity for 45 cm SLR Scenario

Figure 4.3-1 through 4.3-13 show the predicted salinity along the northern portion of the San Francisco Estuary, spanning from San Pablo Bay through the Sacramento-San Joaquin Delta for the 45 cm SLR scenario. The top panel of each figure shows the predicted daily-averaged depth-average salinity for the 45 cm SLR scenario. The lower panel shows the predicted salinity increase computed by subtracting the predicted daily-averaged depth-average salinity for the Baseline (0 cm SLR) scenario from the predicted daily-averaged depth-average salinity for the 45 cm SLR scenario. Figures 4.3-14 through 4.3-26 show the predicted salinity increases resulting from the 45 cm SLR scenario in the Sacramento-San Joaquin Delta.

At the beginning of the analysis period on January 1, 2002, salinity increases between 0.20 and 0.35 psu are predicted between Chipps Island and Collinsville and predicted salinity increases of up to 0.05 psu are predicted upstream to the western end of Sherman Island. Predicted salinity increases are less than 0.05 psu throughout the remaining portions of the Delta. Salinity increases between 1.0 and 1.50 psu are predicted through Carquinez Strait and salinity increases between 0.35 and 1.50 psu are predicted throughout Suisun Bay. Larger salinity increases of more than 1.0 psu are predicted in much of San Pablo Bay, with increase of more than 4.0 psu predicted in northern San Pablo Bay. During the first half of the year, predicted salinity increases in Suisun Bay and the Delta remain similar to the predicted salinity increases seen on January 1, 2002, though the predicted salinity is increasing throughout this period. Larger salinity increases are predicted in the Delta between July and December, with the largest predicted salinity increases in December prior to the first flush. In December, salinity increases of between 0.75 and 1.50 psu are predicted between Chipps Island and Emmaton, and salinity increases of between 0.10 and 0.35 psu are predicted in Franks Tract. South of Franks Tract, predicted salinity increases between 0.10 and 0.20 psu extend down Old River to Clifton Court Forebay, and salinity increases of between 0.05 and 0.10 psu are predicted inside Clifton Court Forebay. These simulations assumed no operational response to sea level rise, however it is expected significant operational response will be required to maintain water quality standards for 45 cm of sea level rise. Following high flows which occurred in December, predicted salinity on January 1, 2003 shows that the 0.50 psu isohaline is on the western side of Suisun Bay near Martinez. Predicted salinity increases of between 0.05 and 0.10 psu persist in some regions of the Delta, primarily in Big Break and south of Franks Tract.

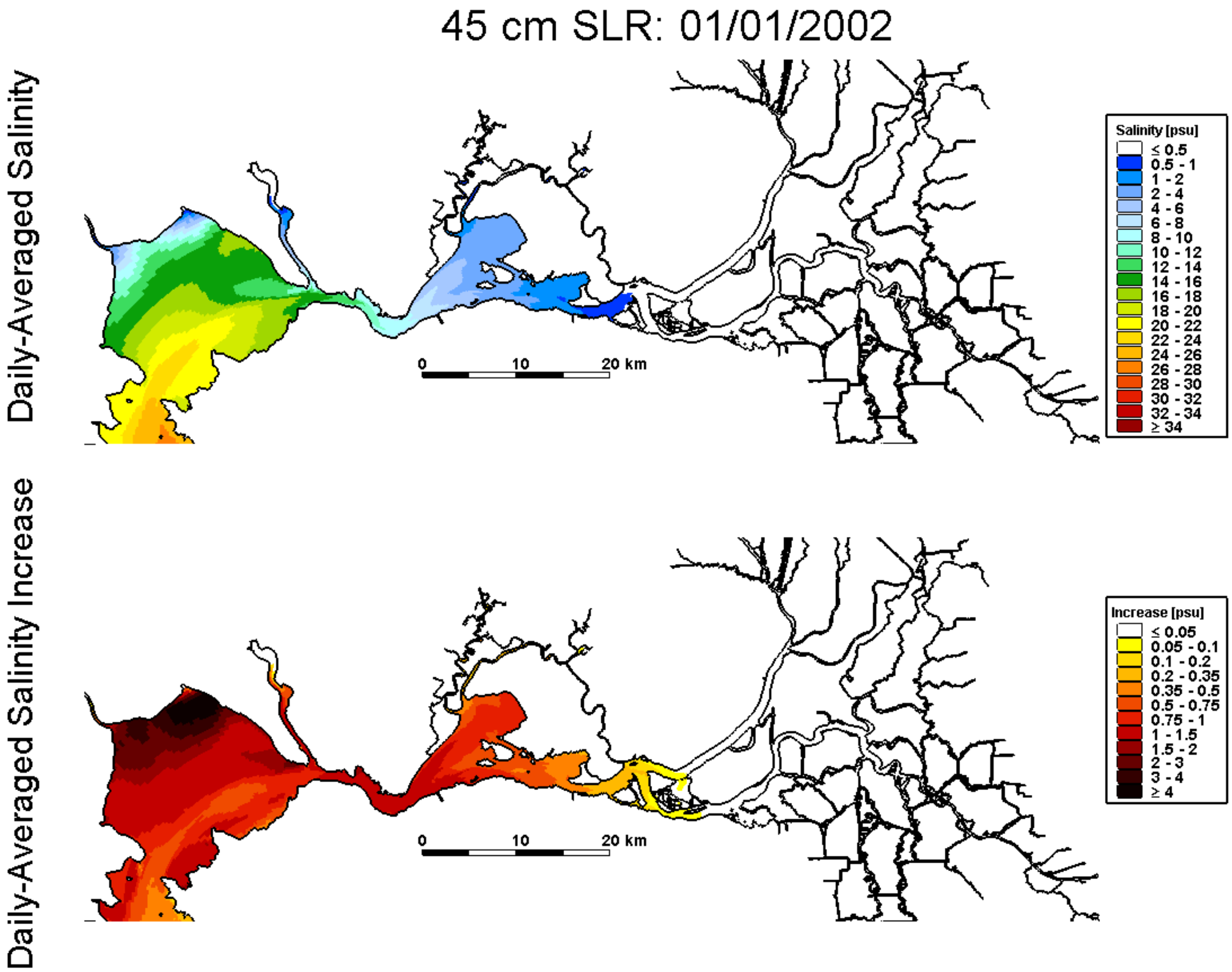


Figure 4.3-1 Predicted daily-averaged depth-average salinity on January 1, 2002 for the 45 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on January 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 45 cm SLR scenario.

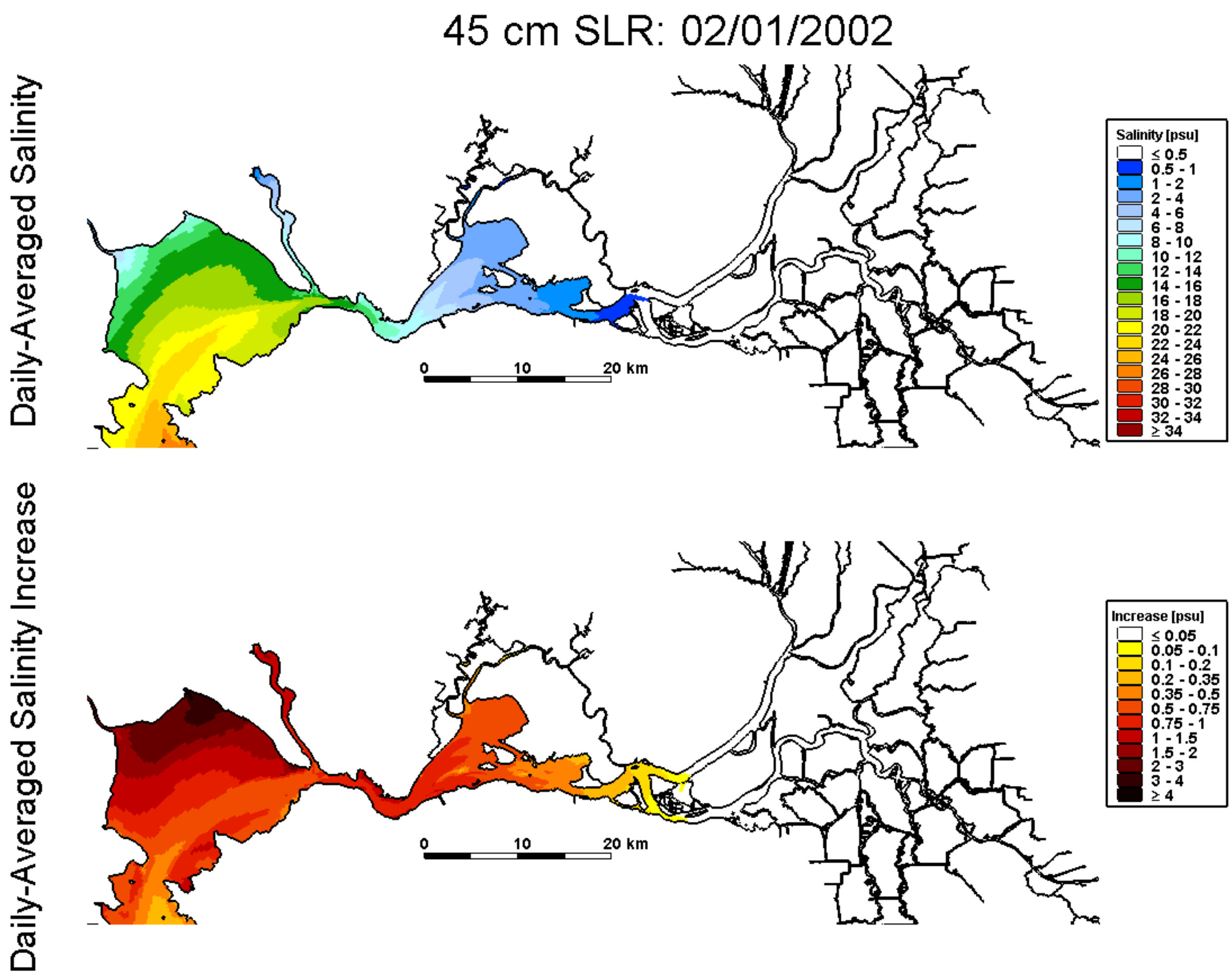


Figure 4.3-2 Predicted daily-averaged depth-average salinity on February 1, 2002 for the 45 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on February 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 45 cm SLR scenario.

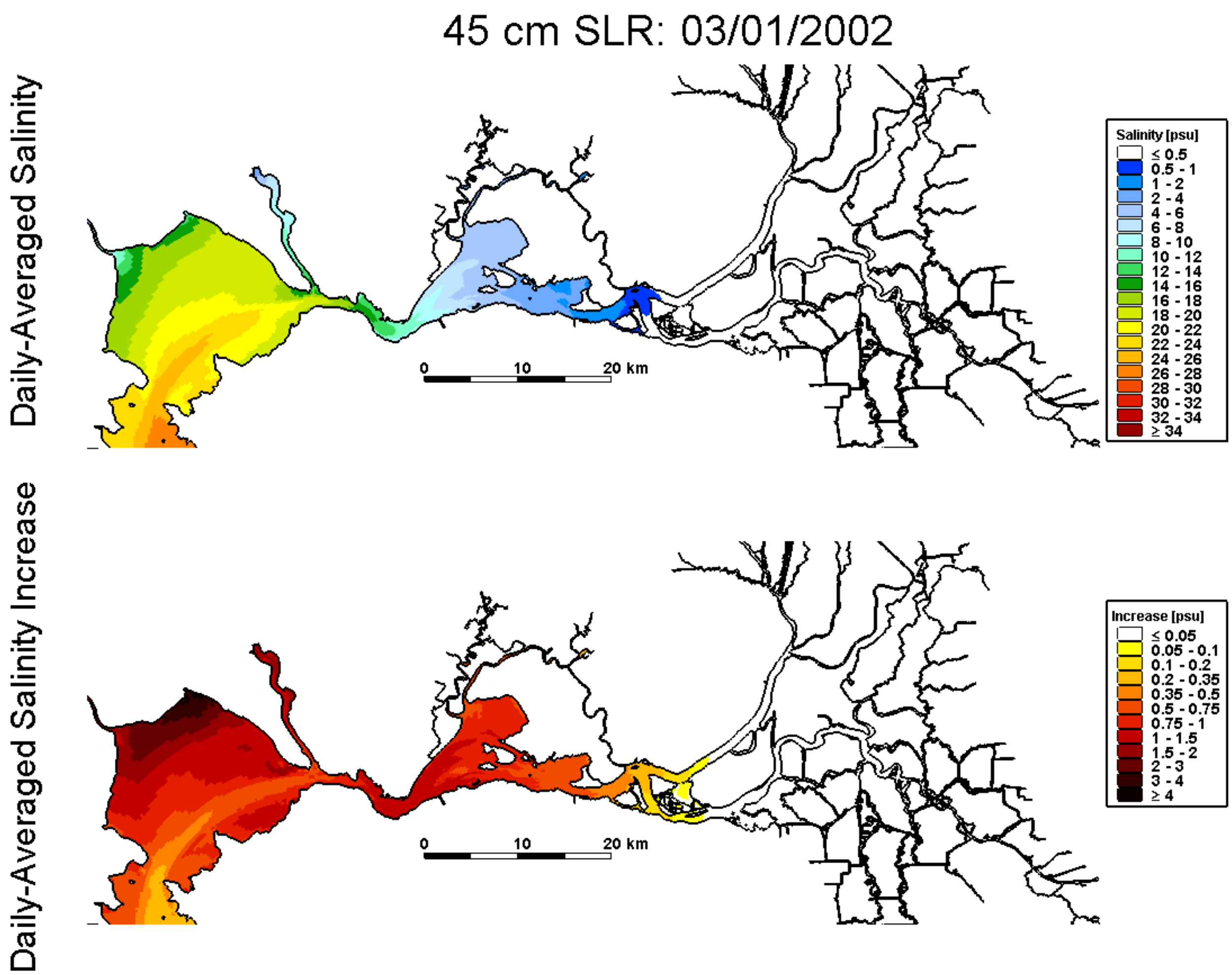


Figure 4.3-3 Predicted daily-averaged depth-average salinity on March 1, 2002 for the 45 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on March 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 45 cm SLR scenario.

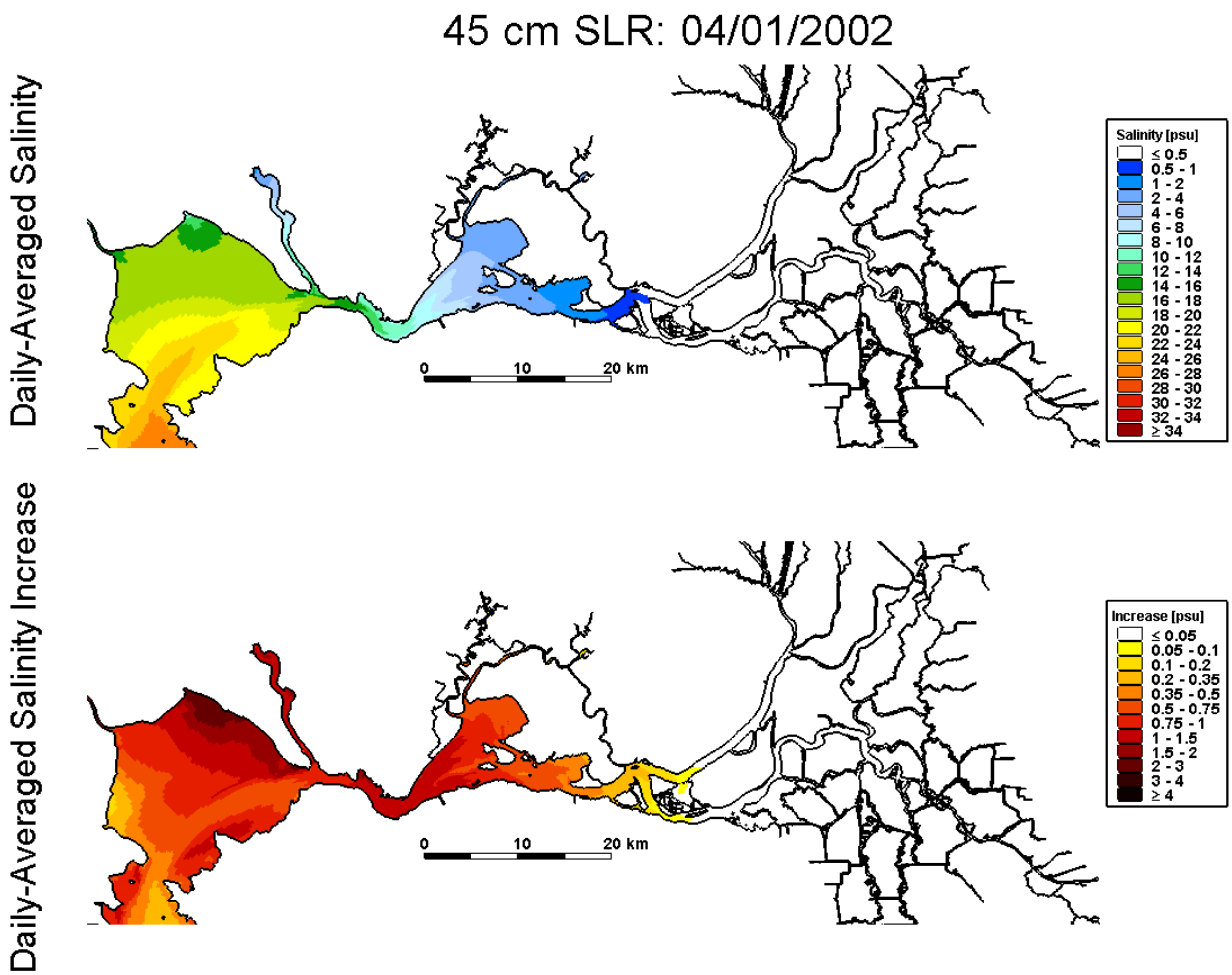


Figure 4.3-4 Predicted daily-averaged depth-average salinity on April 1, 2002 for the 45 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on April 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 45 cm SLR scenario.

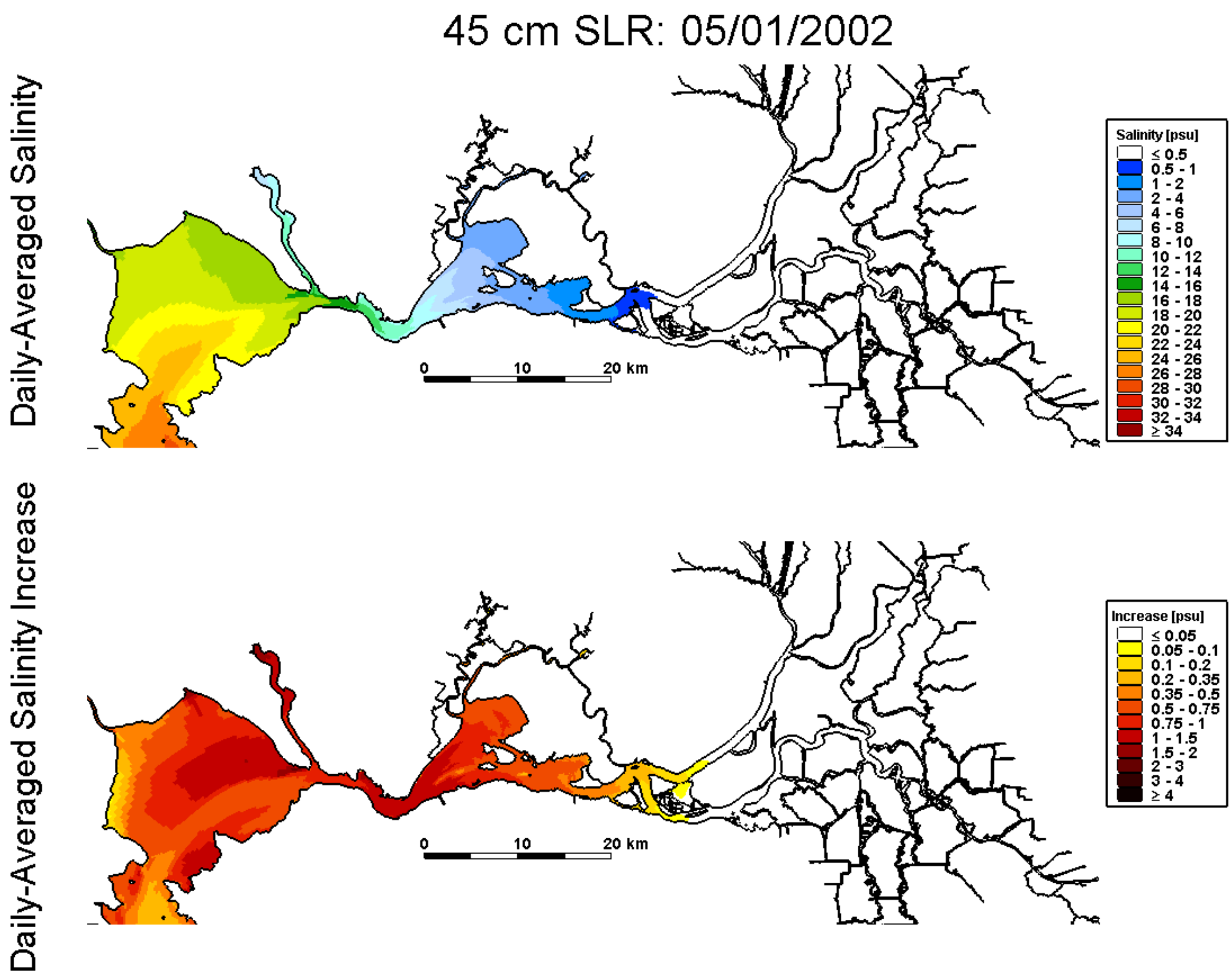


Figure 4.3-5 Predicted daily-averaged depth-average salinity on May 1, 2002 for the 45 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on May 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 45 cm SLR scenario.

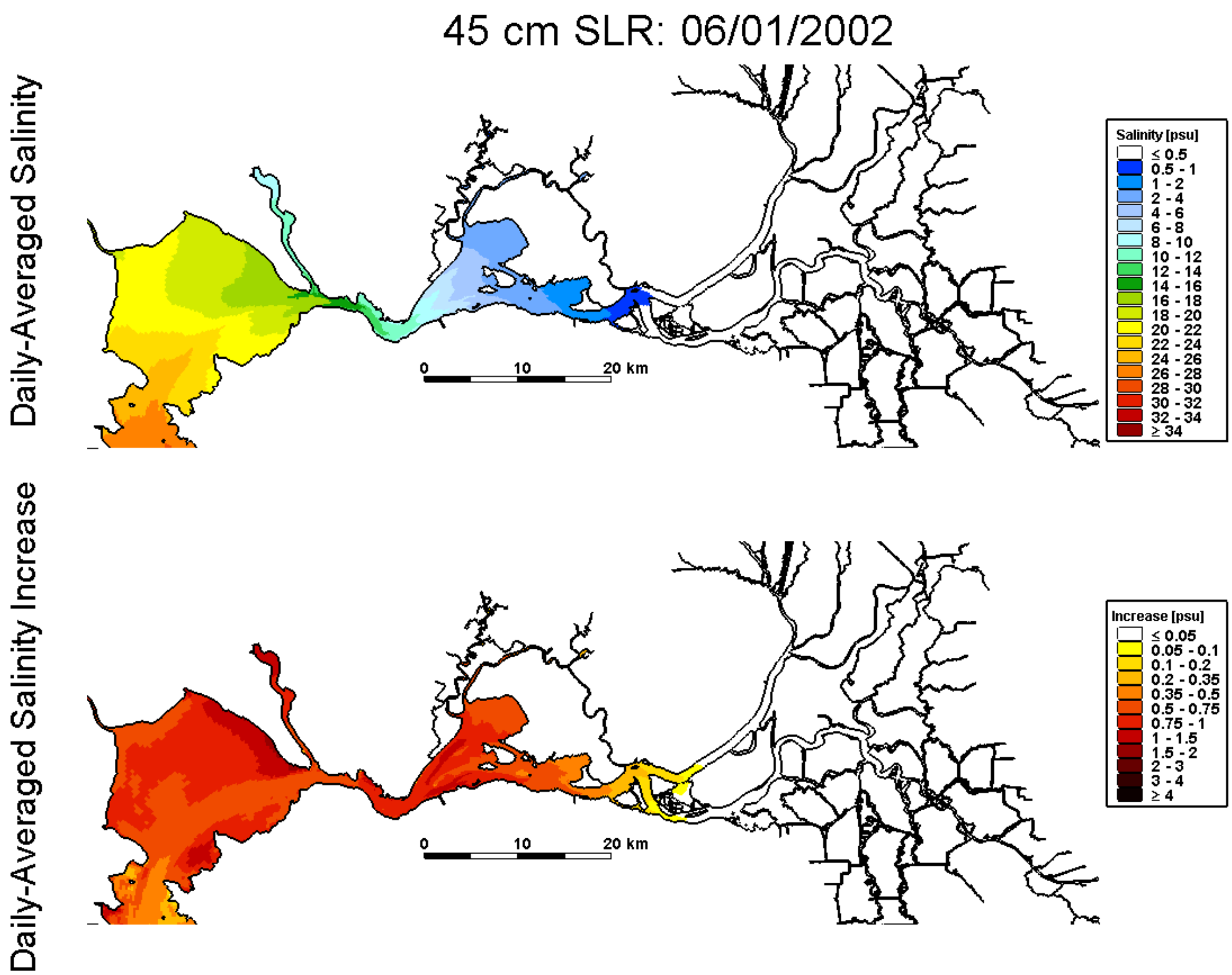


Figure 4.3-6 Predicted daily-averaged depth-average salinity on June 1, 2002 for the 45 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on June 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 45 cm SLR scenario.

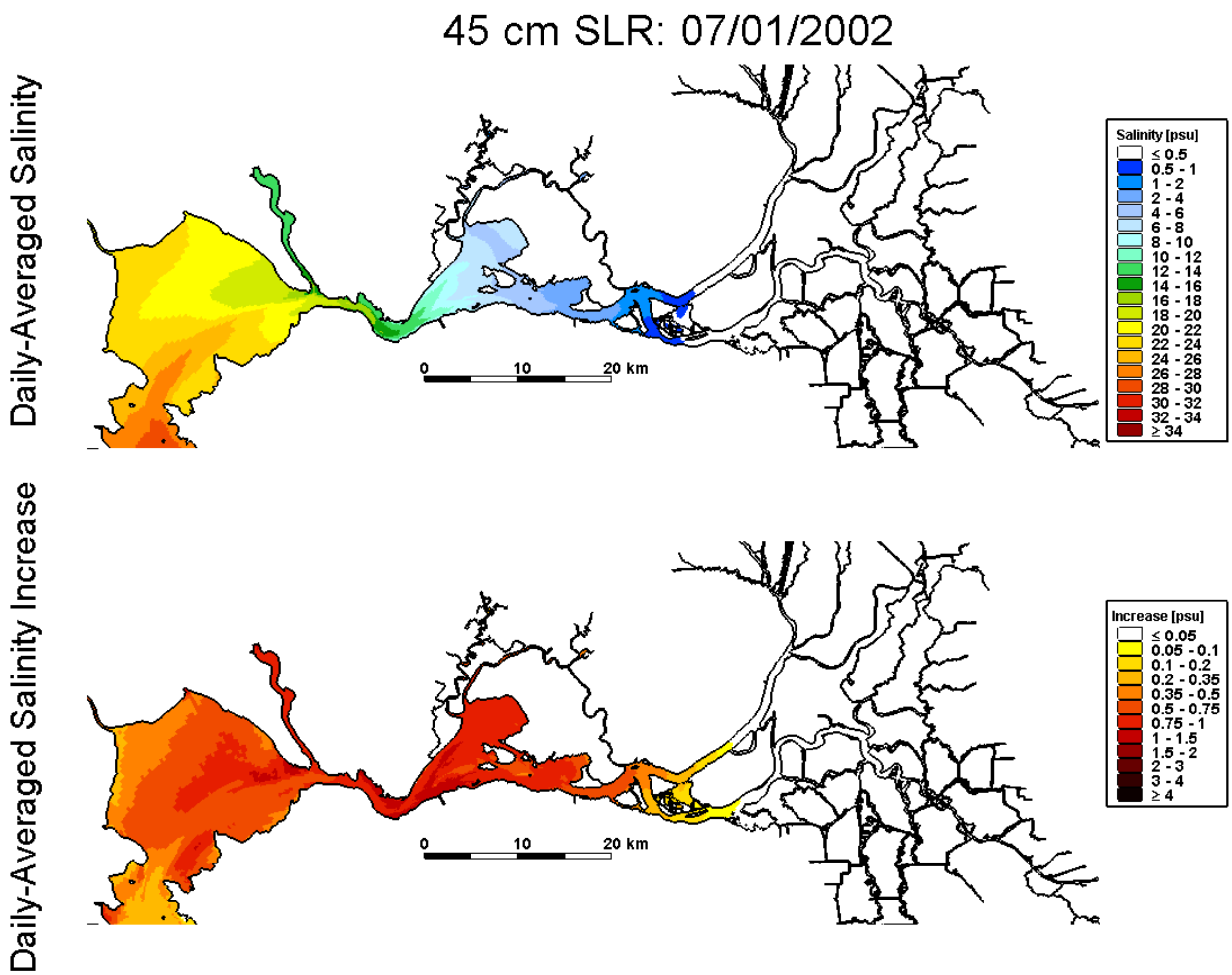


Figure 4.3-7 Predicted daily-averaged depth-average salinity on July 1, 2002 for the 45 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on July 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 45 cm SLR scenario.

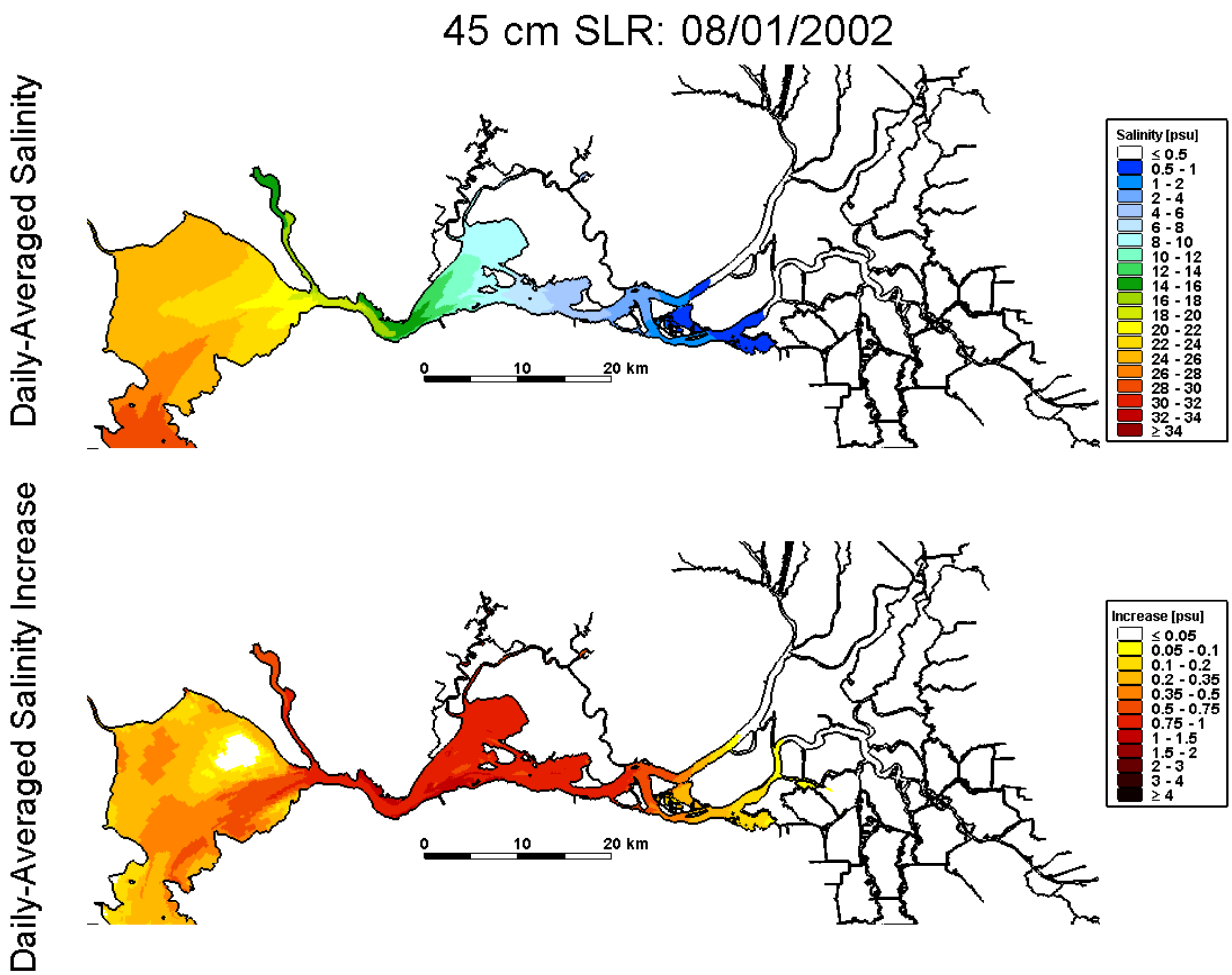


Figure 4.3-8 Predicted daily-averaged depth-average salinity on August 1, 2002 for the 45 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on August 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 45 cm SLR scenario.

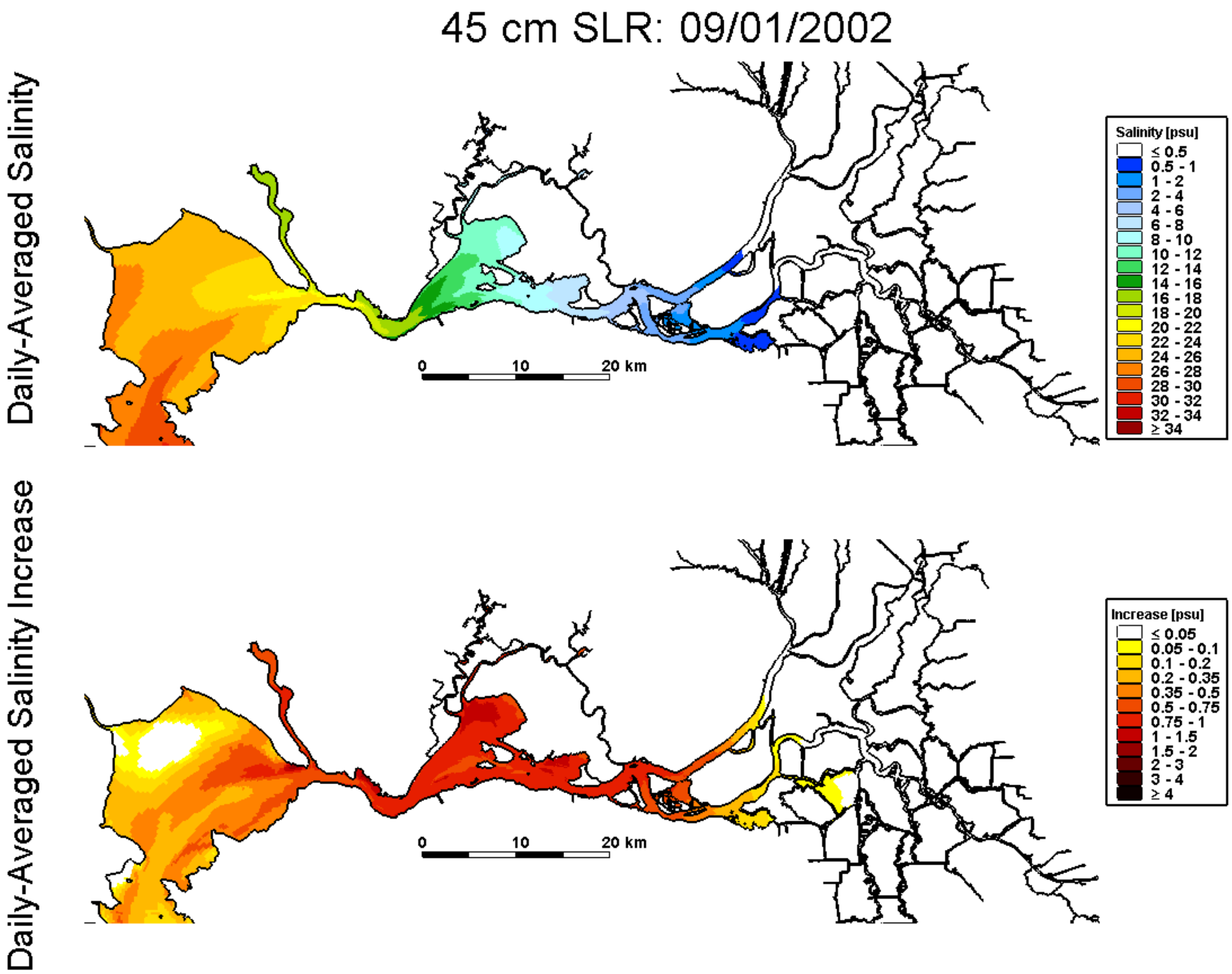


Figure 4.3-9 Predicted daily-averaged depth-average salinity on September 1, 2002 for the 45 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on September 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 45 cm SLR scenario.

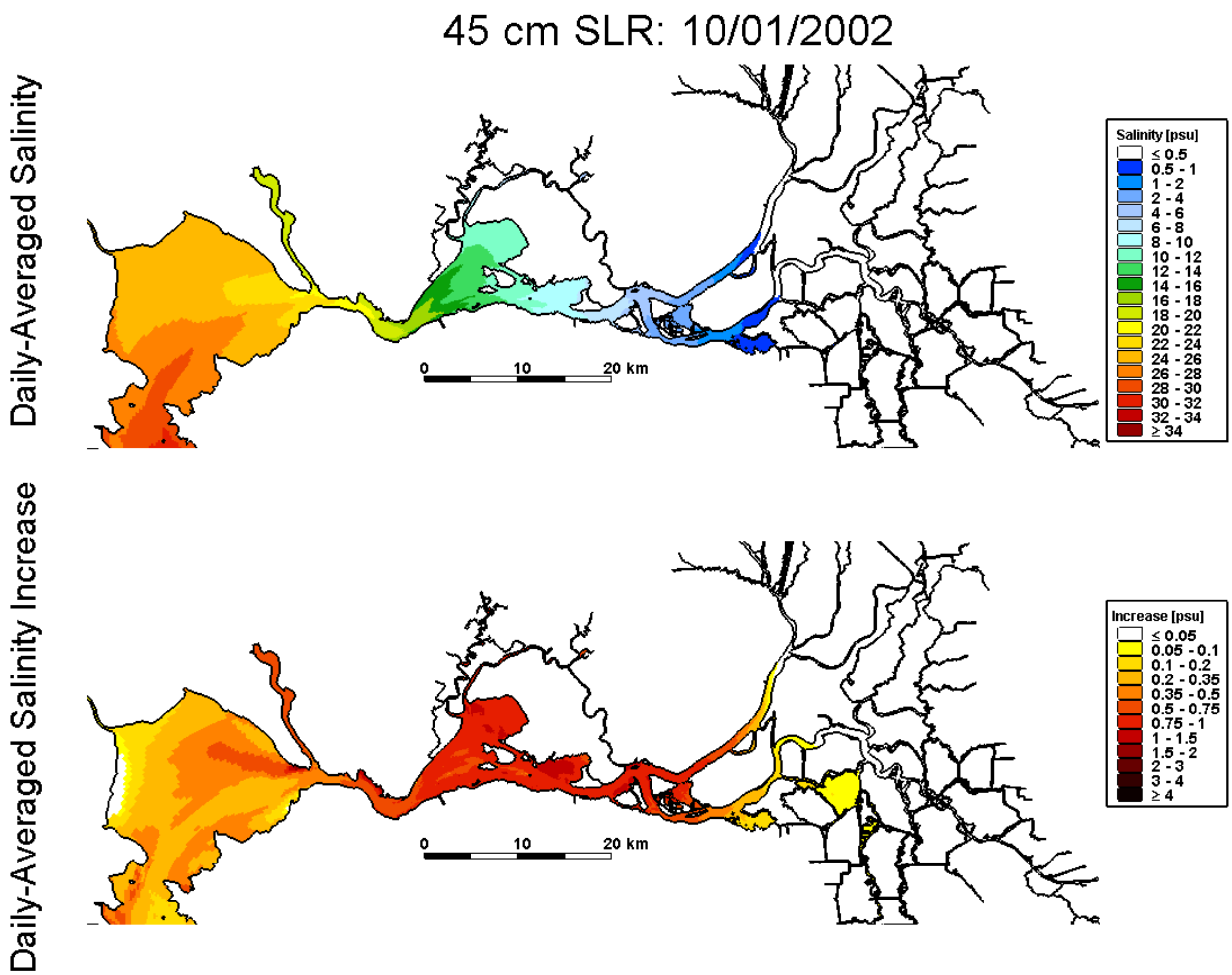


Figure 4.3-10 Predicted daily-averaged depth-average salinity on October 1, 2002 for the 45 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on October 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 45 cm SLR scenario.

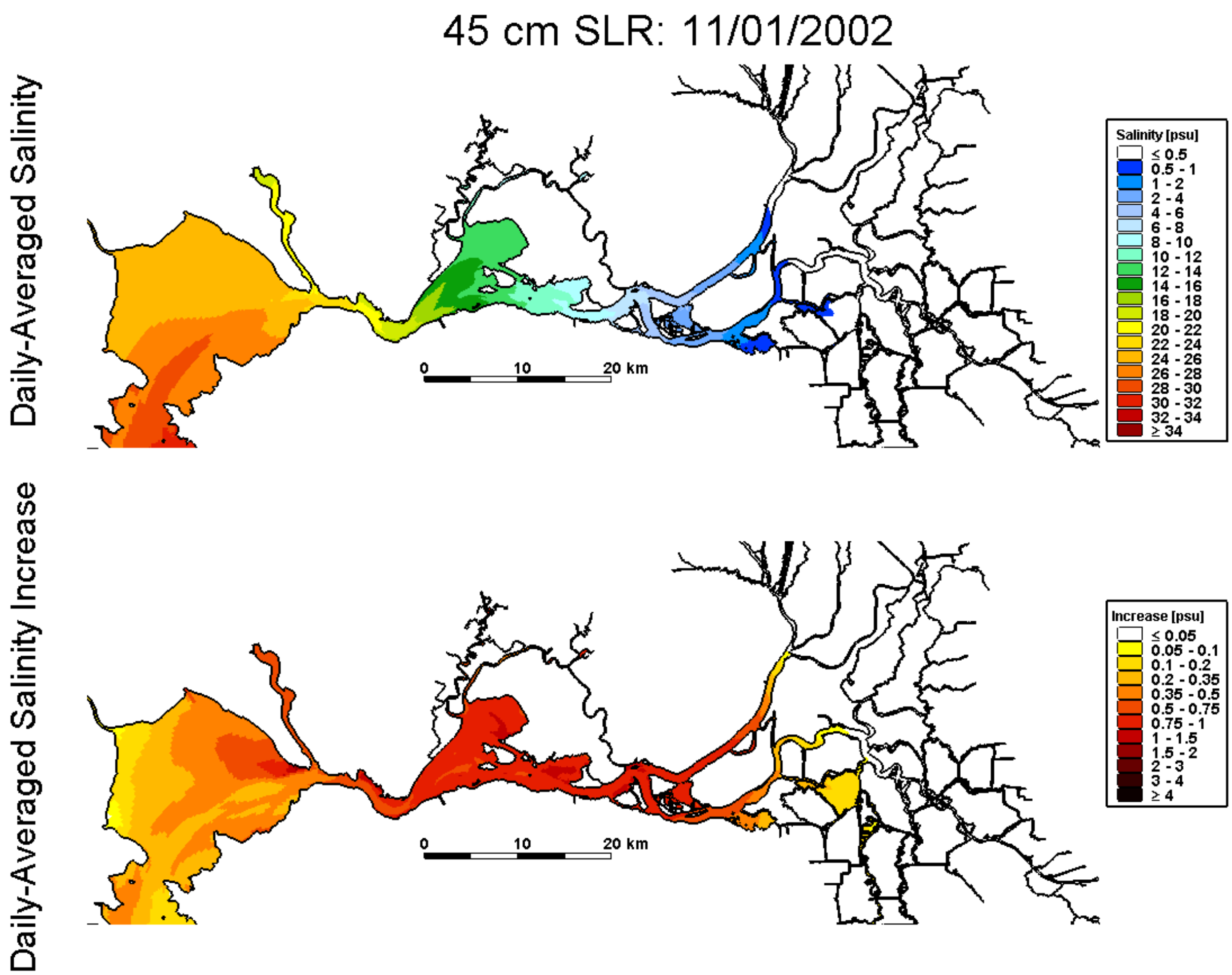


Figure 4.3-11 Predicted daily-averaged depth-average salinity on November 1, 2002 for the 45 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on November 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 45 cm SLR scenario.

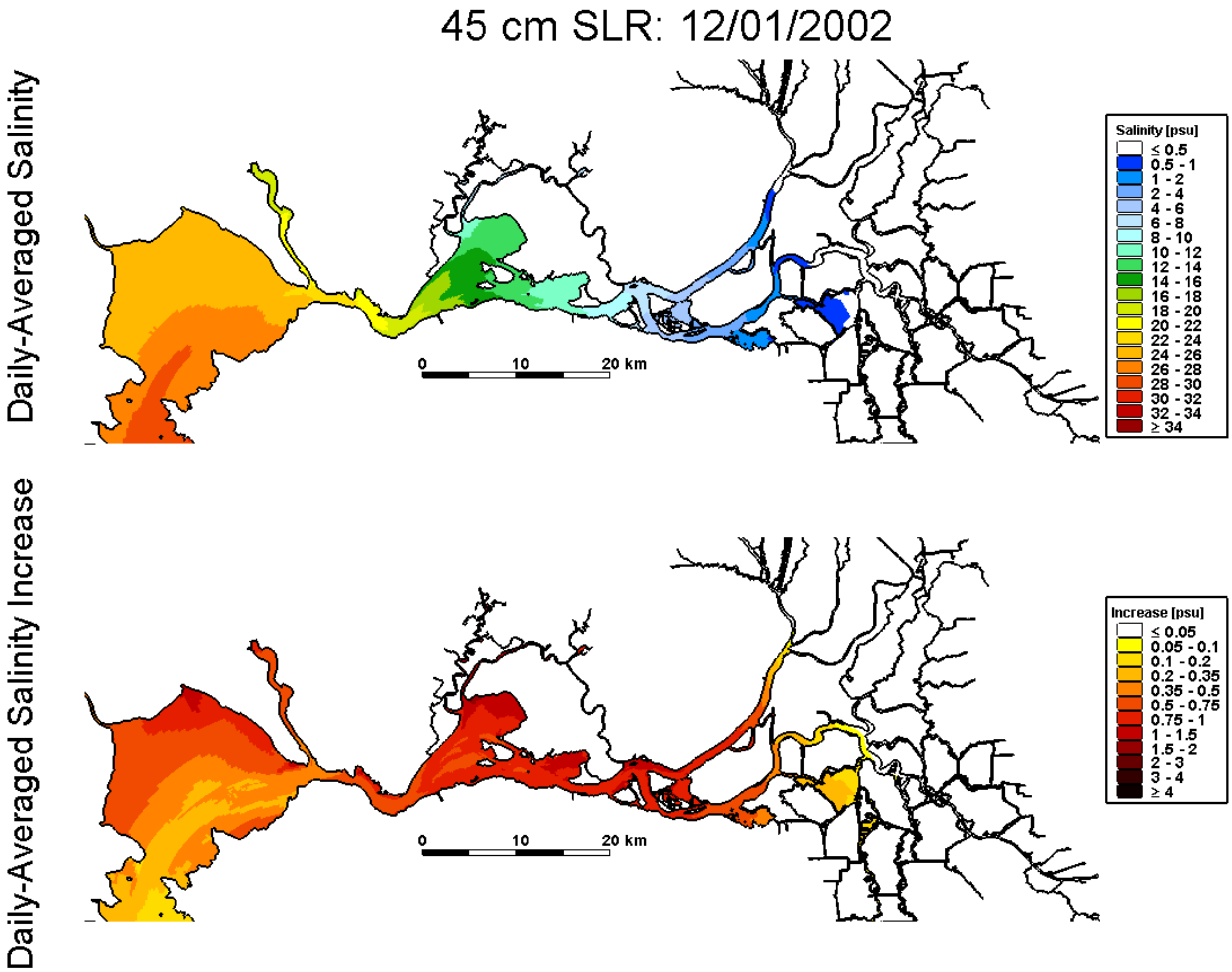


Figure 4.3-12 Predicted daily-averaged depth-average salinity on December 1, 2002 for the 45 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on December 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 45 cm SLR scenario.

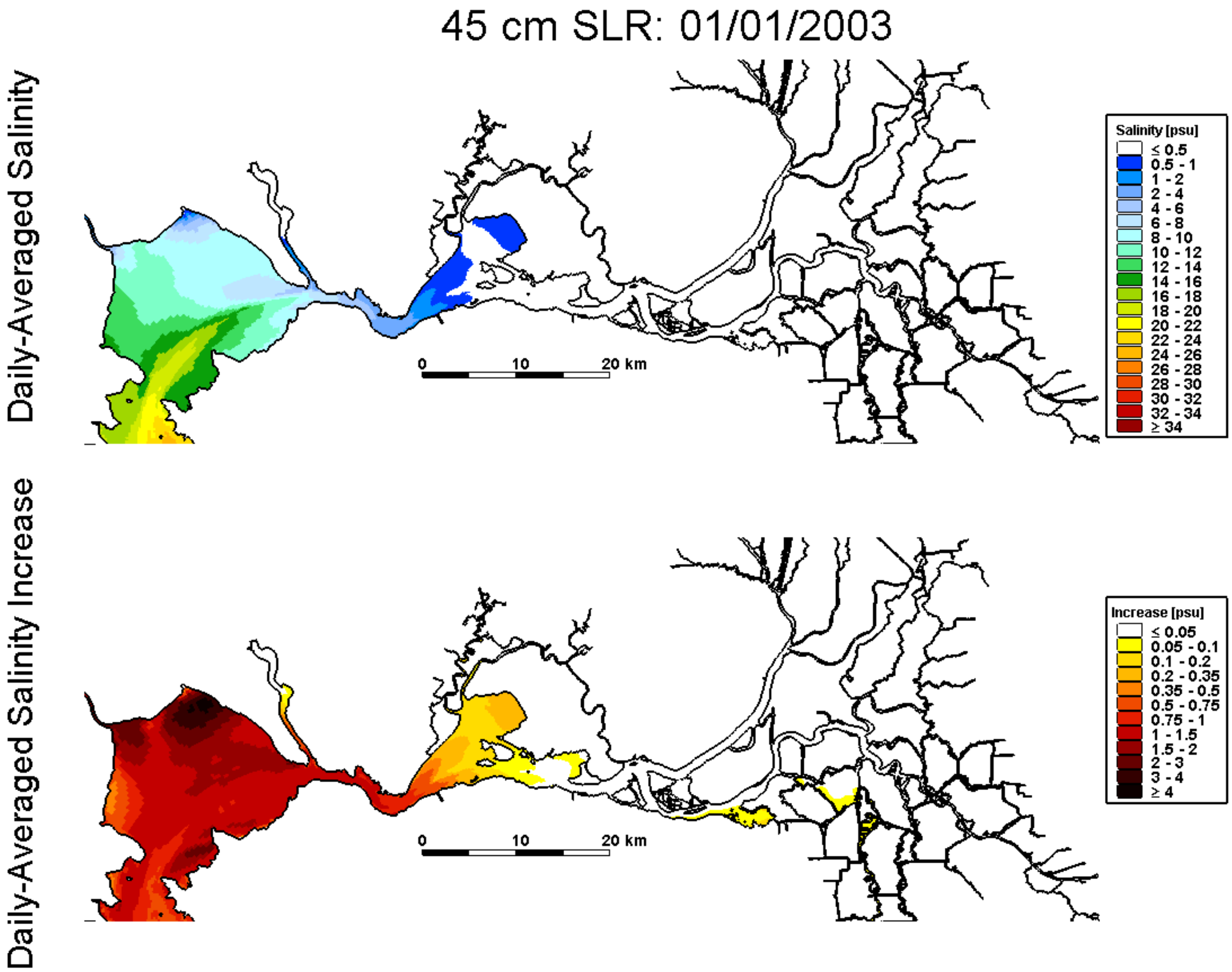


Figure 4.3-13 Predicted daily-averaged depth-average salinity on January 1, 2003 for the 45 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on January 1, 2003 relative to the Baseline (0 cm SLR) scenario for the 45 cm SLR scenario.

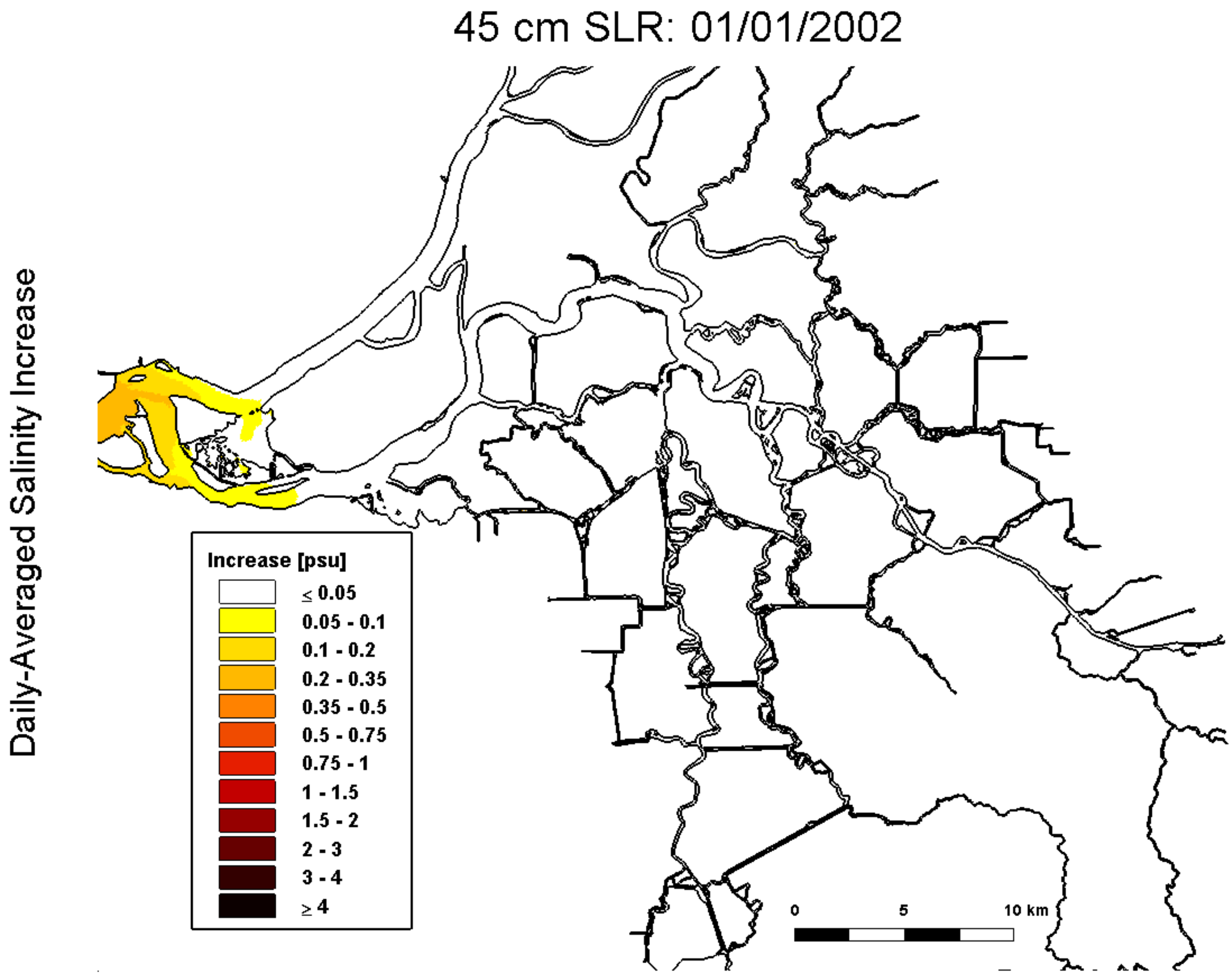


Figure 4.3-14 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on January 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 45 cm SLR scenario.

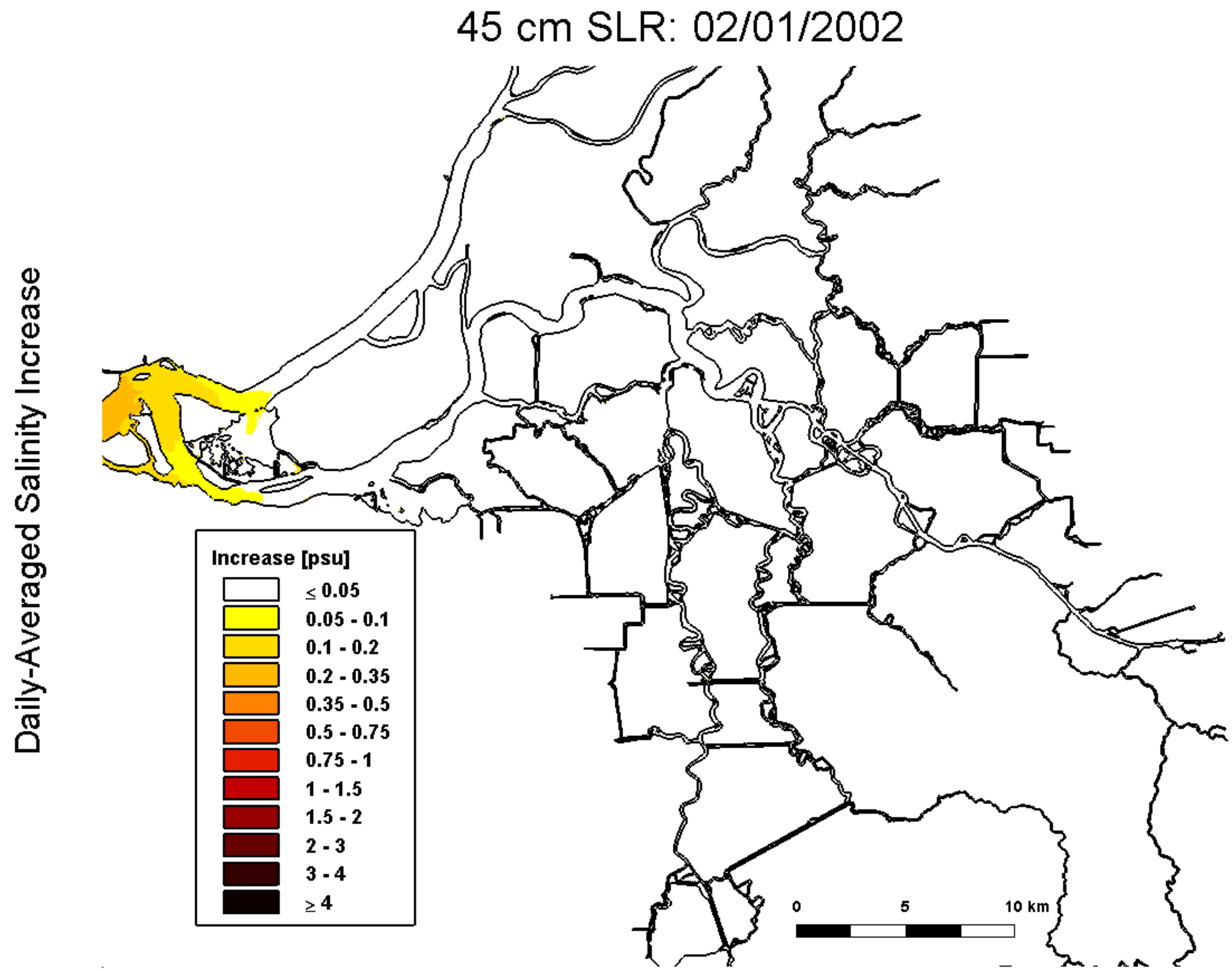


Figure 4.3-15 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on February 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 45 cm SLR scenario.

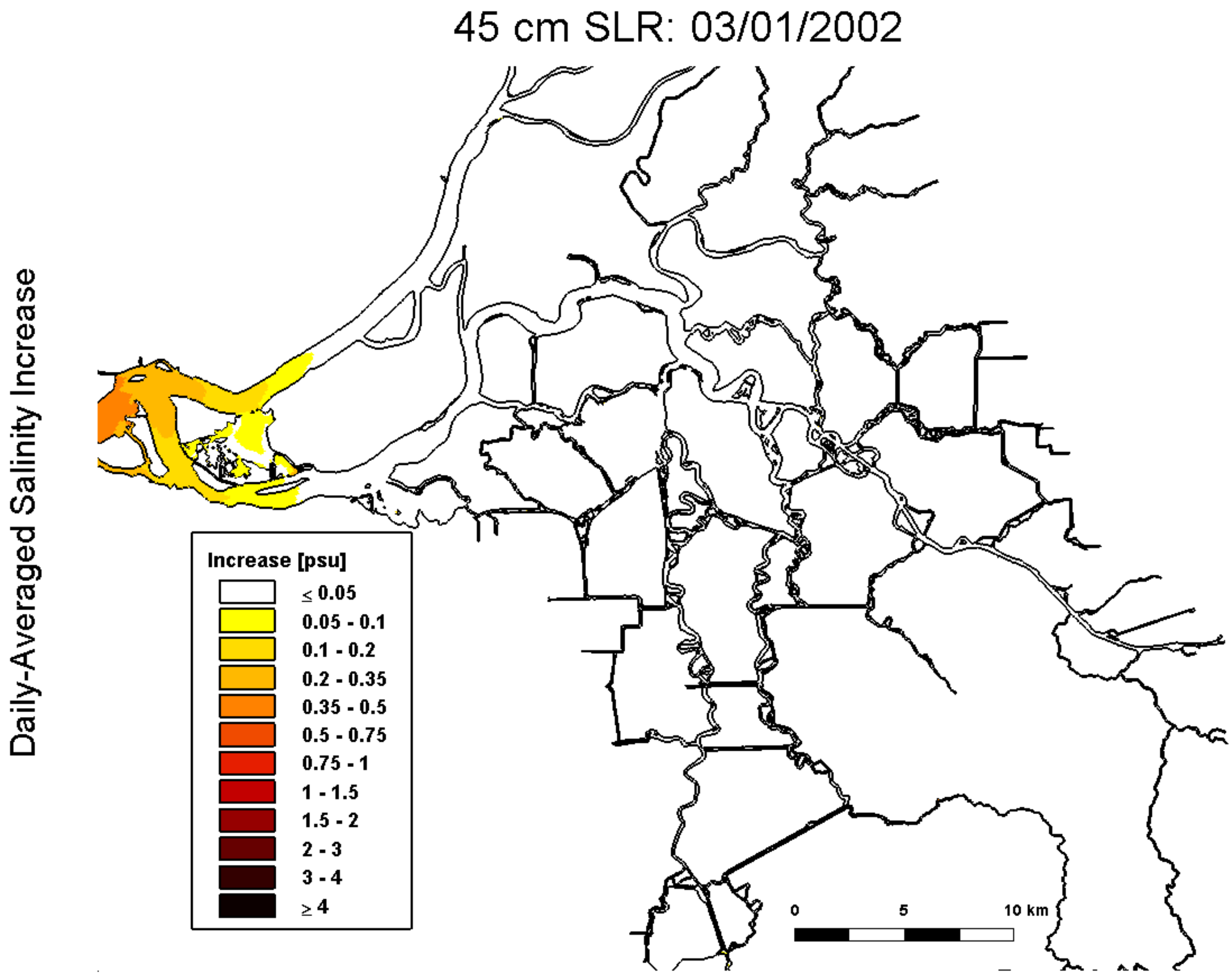


Figure 4.3-16 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on March 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 45 cm SLR scenario.

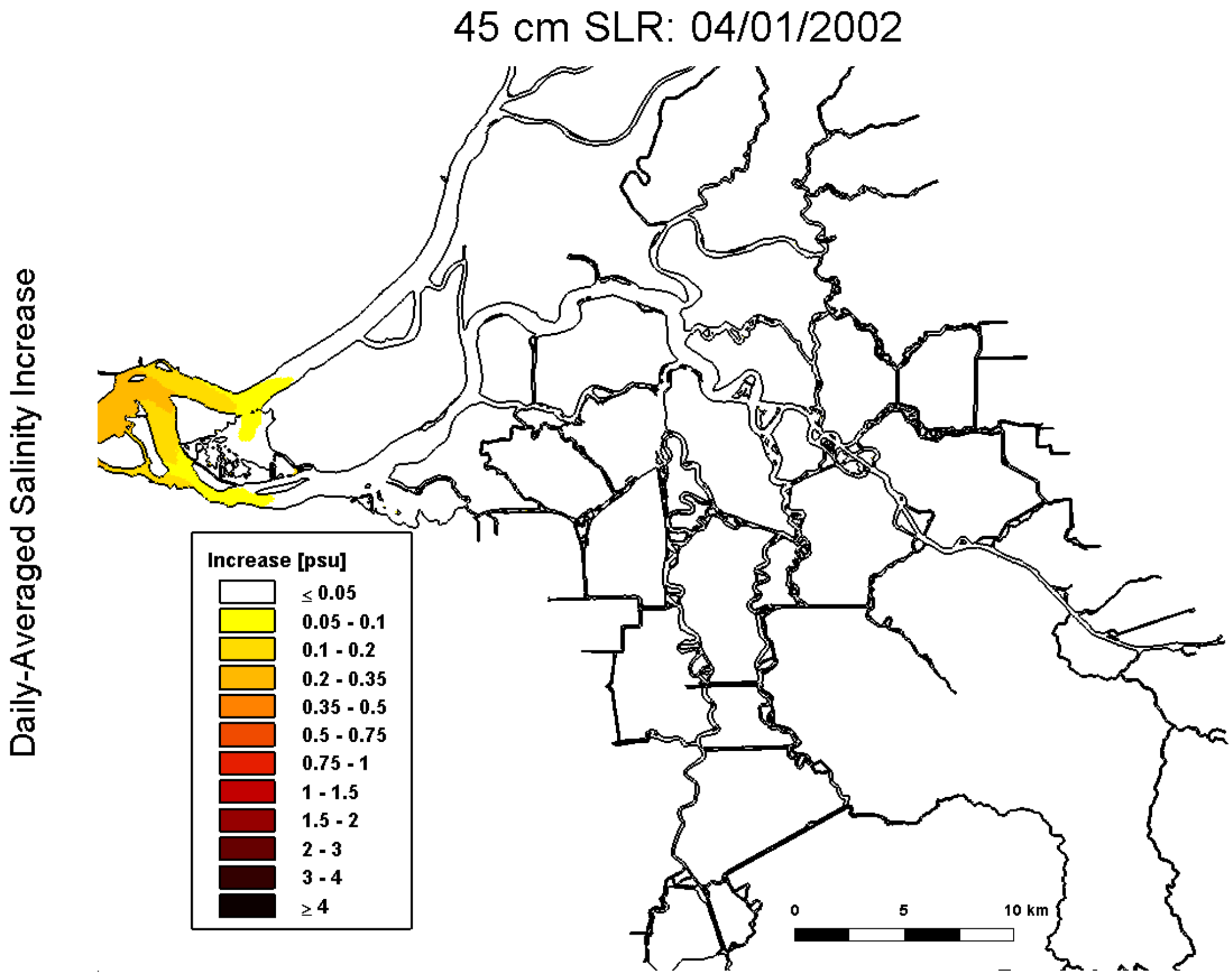


Figure 4.3-17 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on April 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 45 cm SLR scenario.

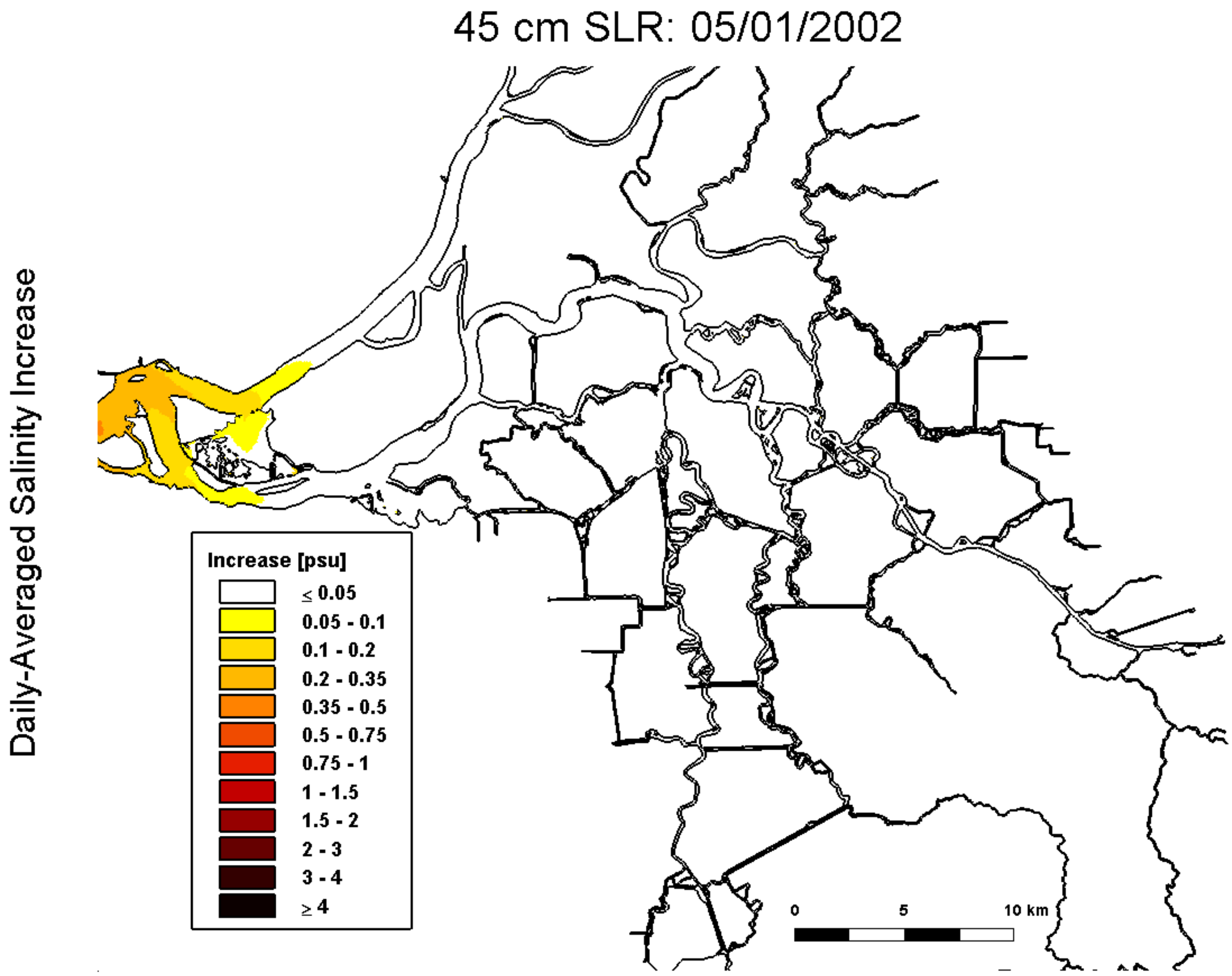


Figure 4.3-18 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on May 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 45 cm SLR scenario.

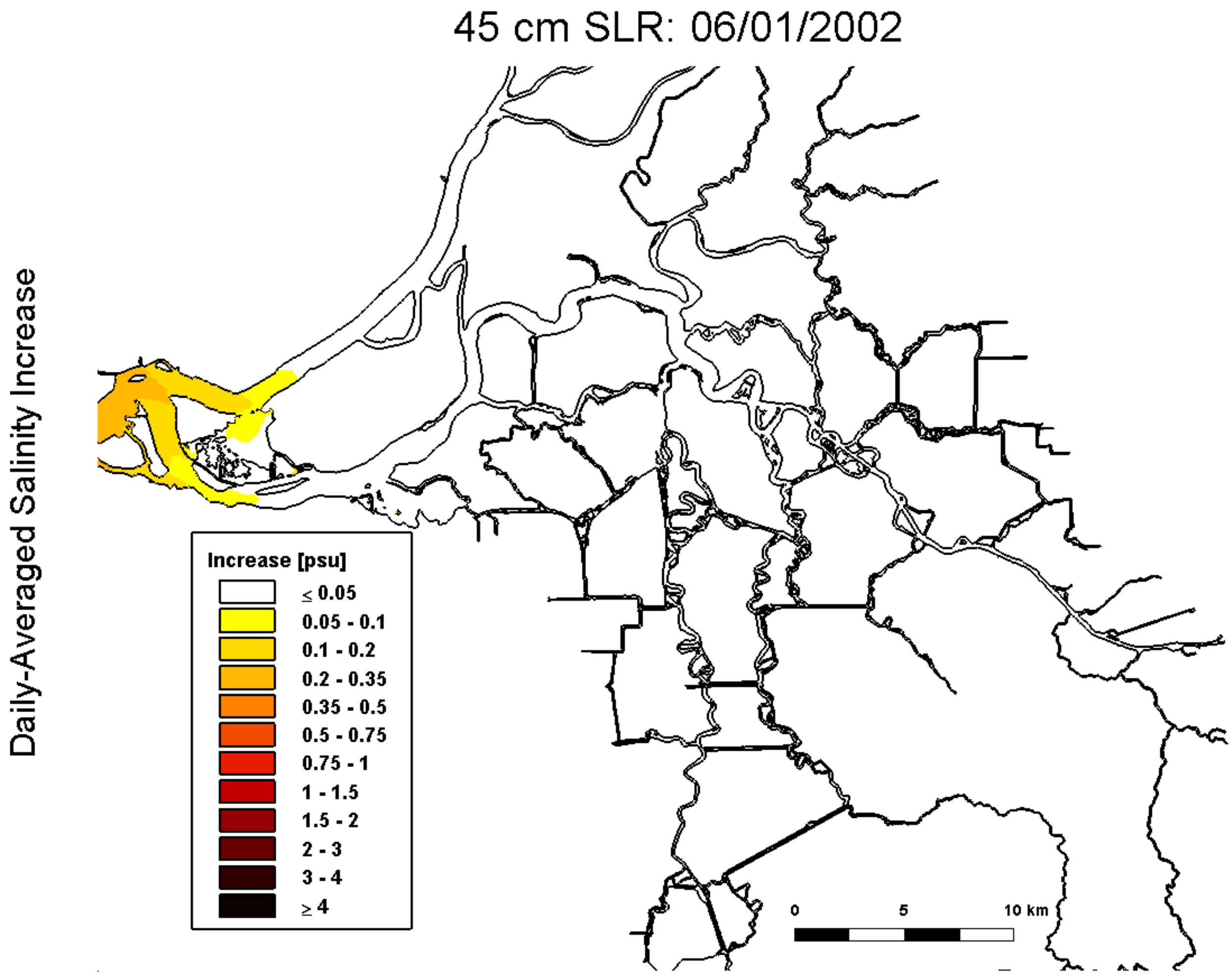


Figure 4.3-19 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on June 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 45 cm SLR scenario.

45 cm SLR: 07/01/2002

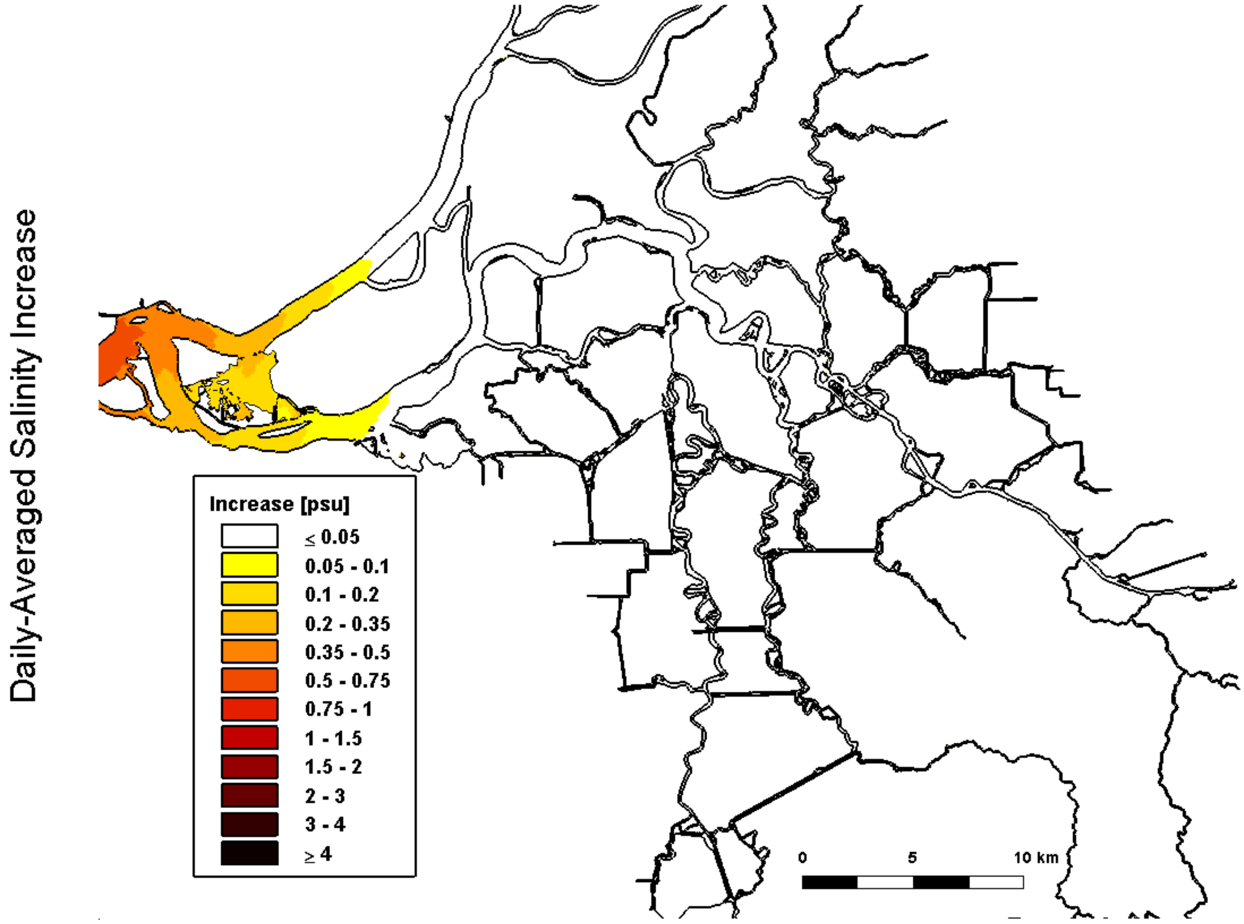


Figure 4.3-20 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on July 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 45 cm SLR scenario.

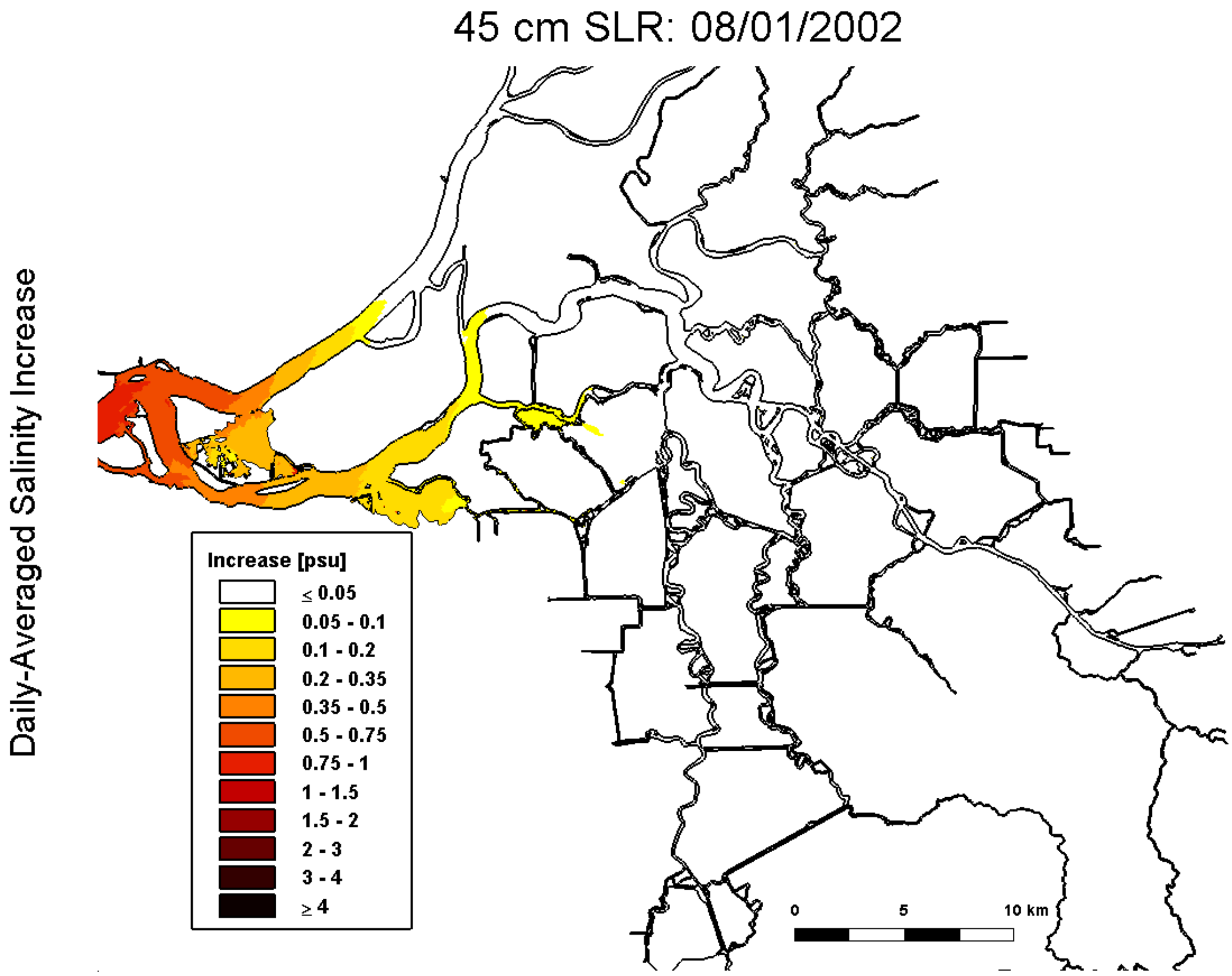


Figure 4.3-21 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on August 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 45 cm SLR scenario.

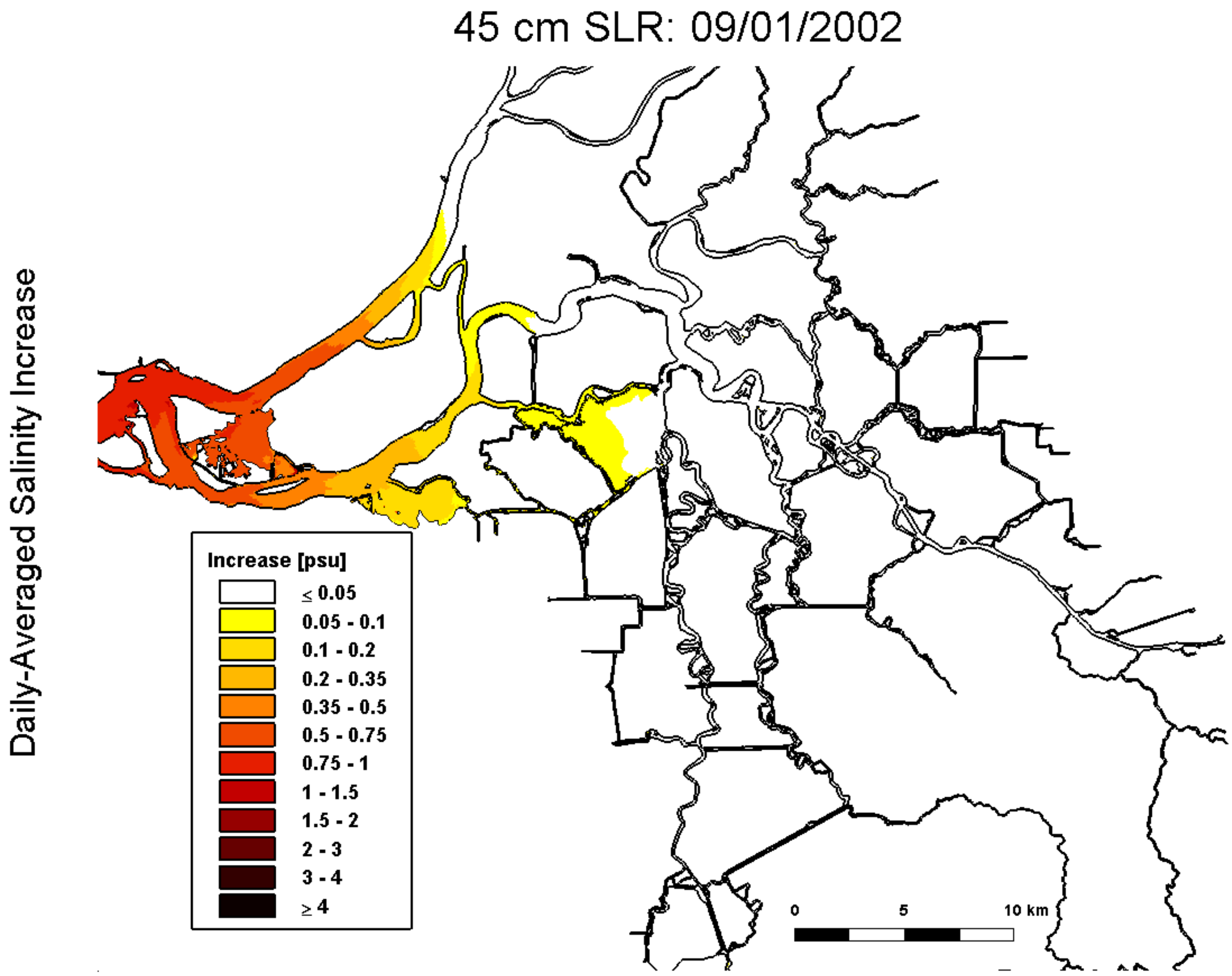


Figure 4.3-22 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on September 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 45 cm SLR scenario.

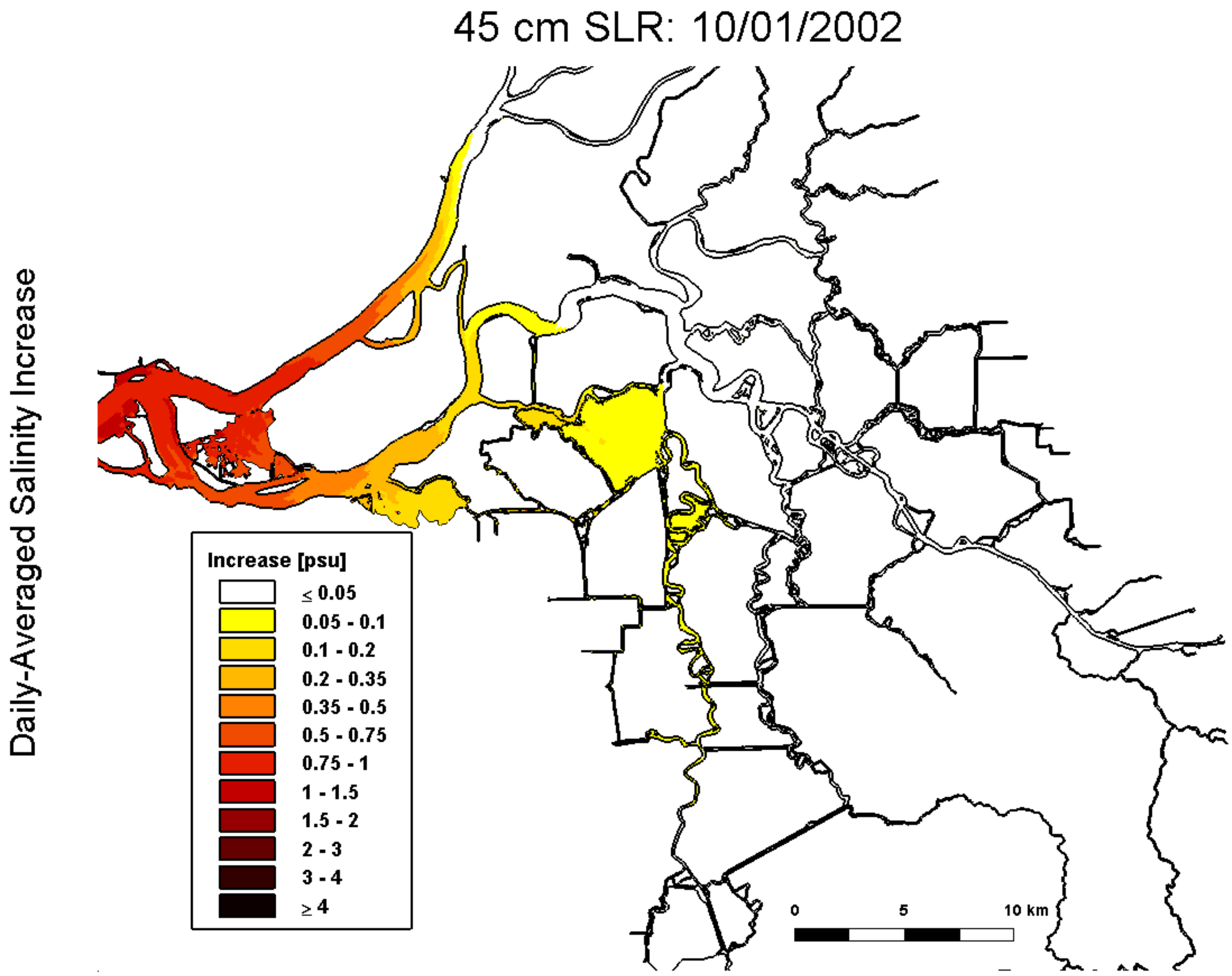


Figure 4.3-23 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on October 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 45 cm SLR scenario.

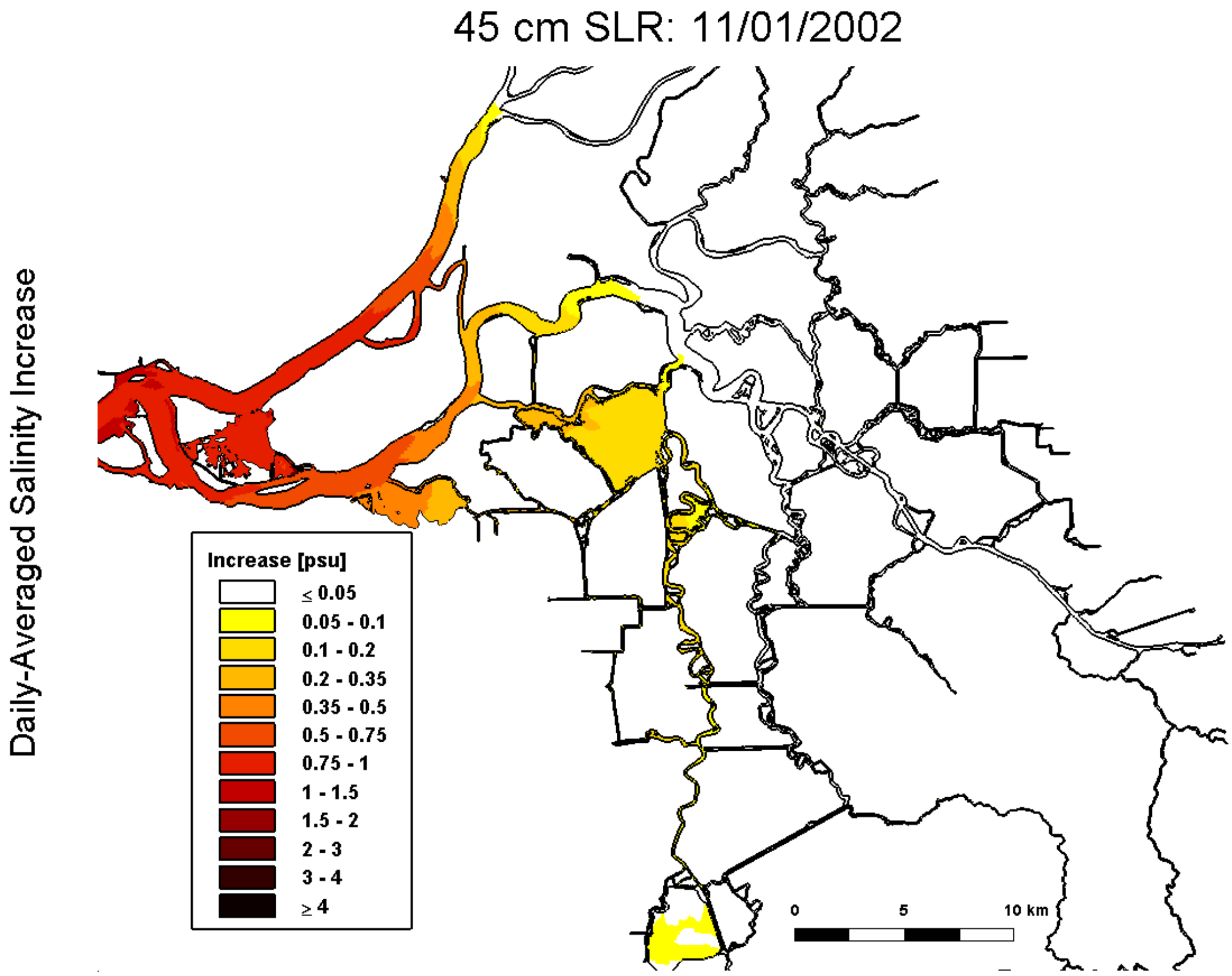


Figure 4.3-24 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on November 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 45 cm SLR scenario.

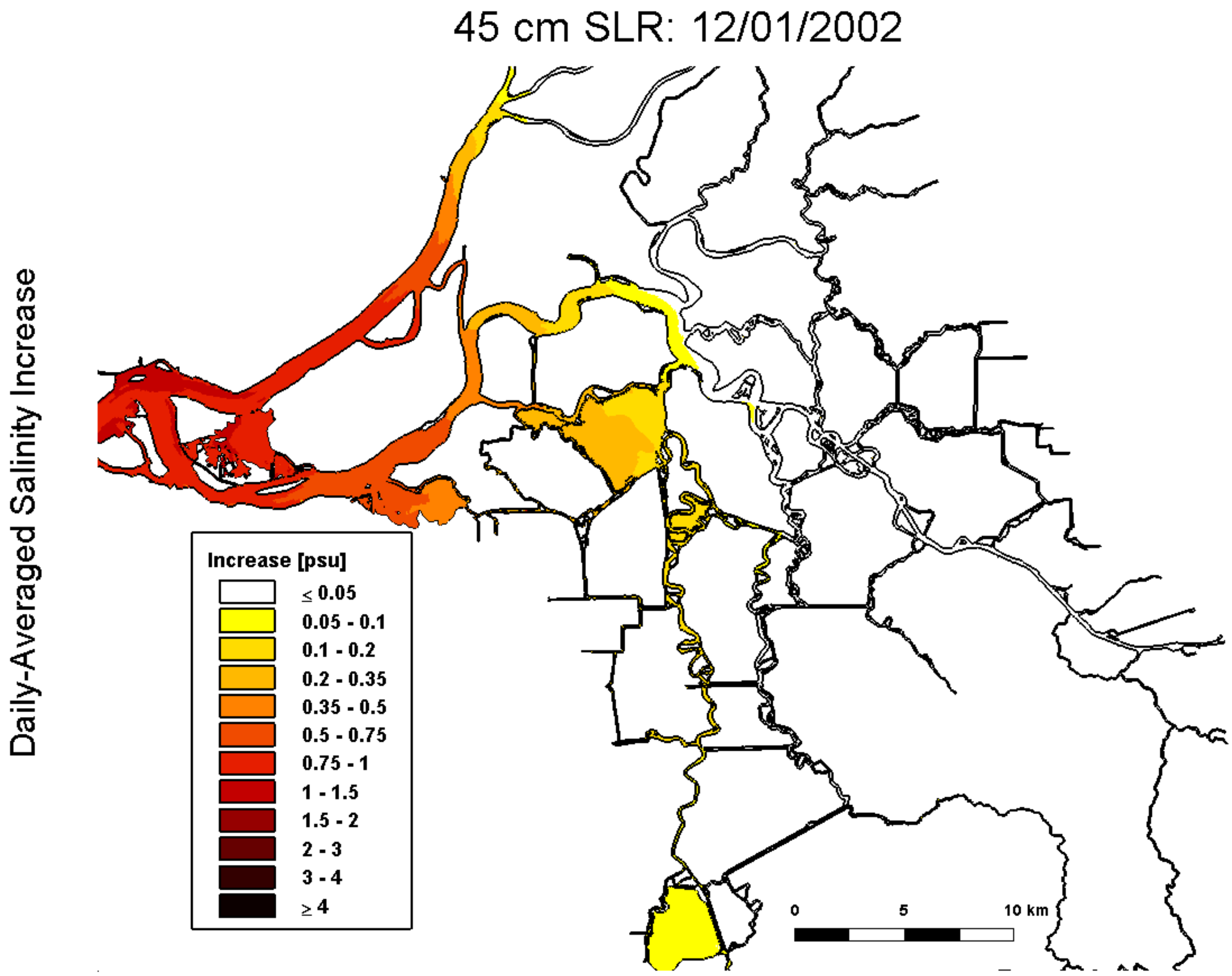


Figure 4.3-25 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on December 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 45 cm SLR scenario.

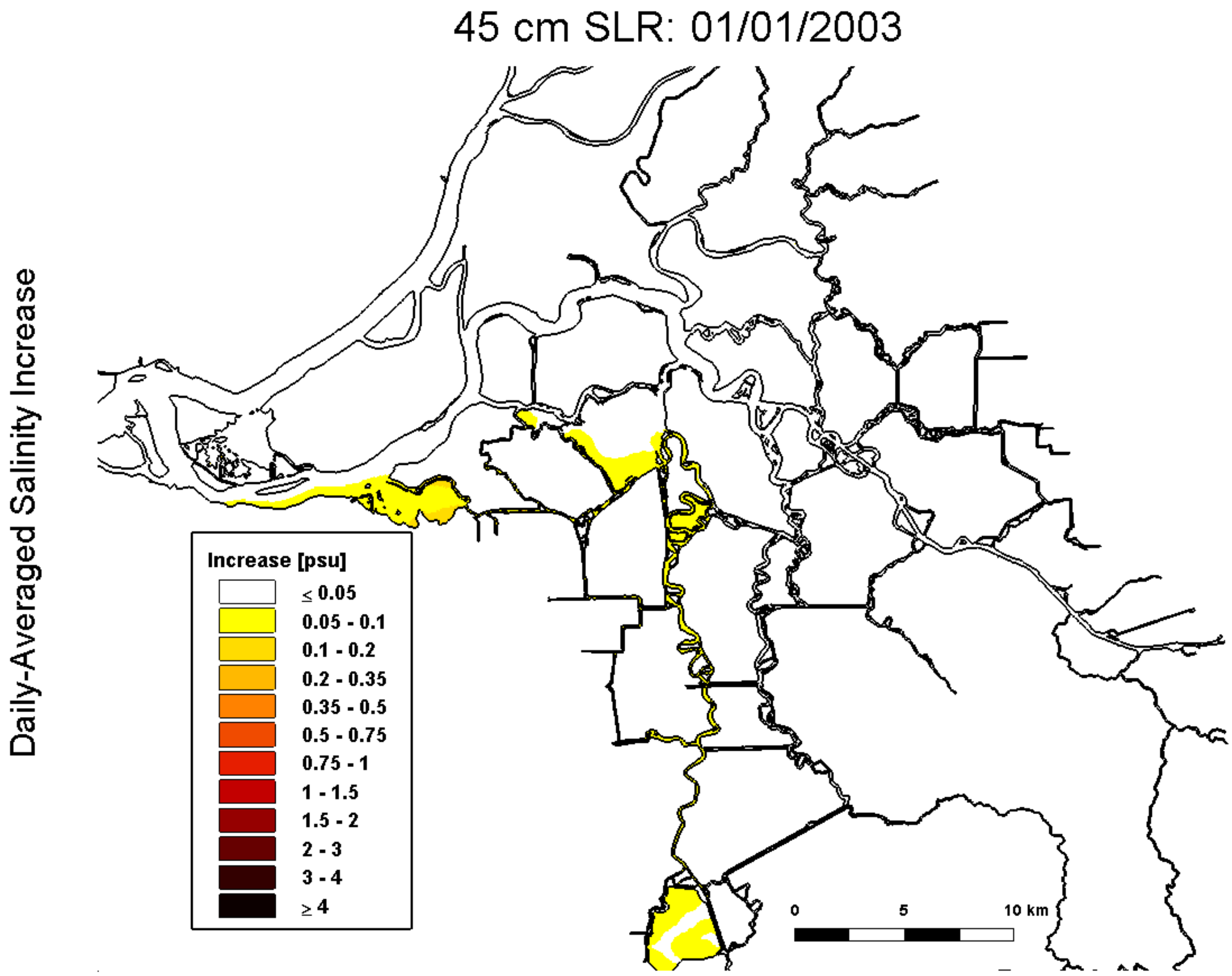


Figure 4.3-26 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on January 1, 2003 relative to the Baseline (0 cm SLR) scenario for the 45 cm SLR scenario.

4.4 Predicted Increase in Salinity for 60 cm SLR Scenario

Figure 4.4-1 through 4.4-13 show the predicted salinity along the northern portion of the San Francisco Estuary, spanning from San Pablo Bay through the Sacramento-San Joaquin Delta for the 60 cm SLR scenario. The top panel of each figure shows the predicted daily-averaged depth-average salinity for the 60 cm SLR scenario. The lower panel shows the predicted salinity increase computed by subtracting the predicted daily-averaged depth-average salinity for the Baseline (0 cm SLR) scenario from the predicted daily-averaged depth-average salinity for the 60 cm SLR scenario. Figures 4.4-14 through 4.4-26 show the predicted salinity increases resulting from the 60 cm SLR scenario in the Sacramento-San Joaquin Delta.

At the beginning of the analysis period on January 1, 2002, salinity increases between 0.35 and 0.50 psu are predicted between Chipps Island and Collinsville and predicted salinity increases of up to 0.05 psu are predicted upstream along the western end of Sherman Island to Big Break. Predicted salinity increases are less than 0.05 psu throughout the remaining portions of the Delta. Salinity increases between 1.5 and 2.0 psu are predicted through Carquinez Strait and salinity increases between 0.50 and 1.5 psu are predicted throughout Suisun Bay. Larger salinity increases of more than 1.0 psu are predicted in much of San Pablo Bay, with salinity increases of more than 4 psu predicted in northern San Pablo Bay. During the first half of the year, predicted salinity increases in Suisun Bay and the Delta remain similar to the predicted salinity increases seen on January 1, 2002, though the predicted salinity is increasing throughout this period. Larger salinity increases are predicted in the Delta between July and December, with the largest predicted salinity increases in December prior to the first flush. In December, salinity increases of between 1.0 and 1.5 psu are predicted between Chipps Island and Emmaton, and salinity increases of between 0.20 and 0.50 psu are predicted in Franks Tract. South of Franks Tract, predicted salinity increases between 0.20 and 0.35 psu extend down Old River to Clifton Court Forebay, and salinity increases of between 0.10 and 0.20 psu are predicted inside Clifton Court Forebay. These simulations assumed no operational response to sea level rise, however it is expected significant operational response will be required to maintain water quality standards for 60 cm of sea level rise. Following high flows which occurred in December, predicted salinity on January 1, 2003 shows that the 0.50 psu isohaline is on the western side of Suisun Bay near Martinez. Predicted salinity increases of between 0.05 and 0.20 psu persist in some regions of the Delta, primarily along the San Joaquin River between Antioch and False River, in Big Break, south of Franks Tract along Old River, and in Clifton Court Forebay.

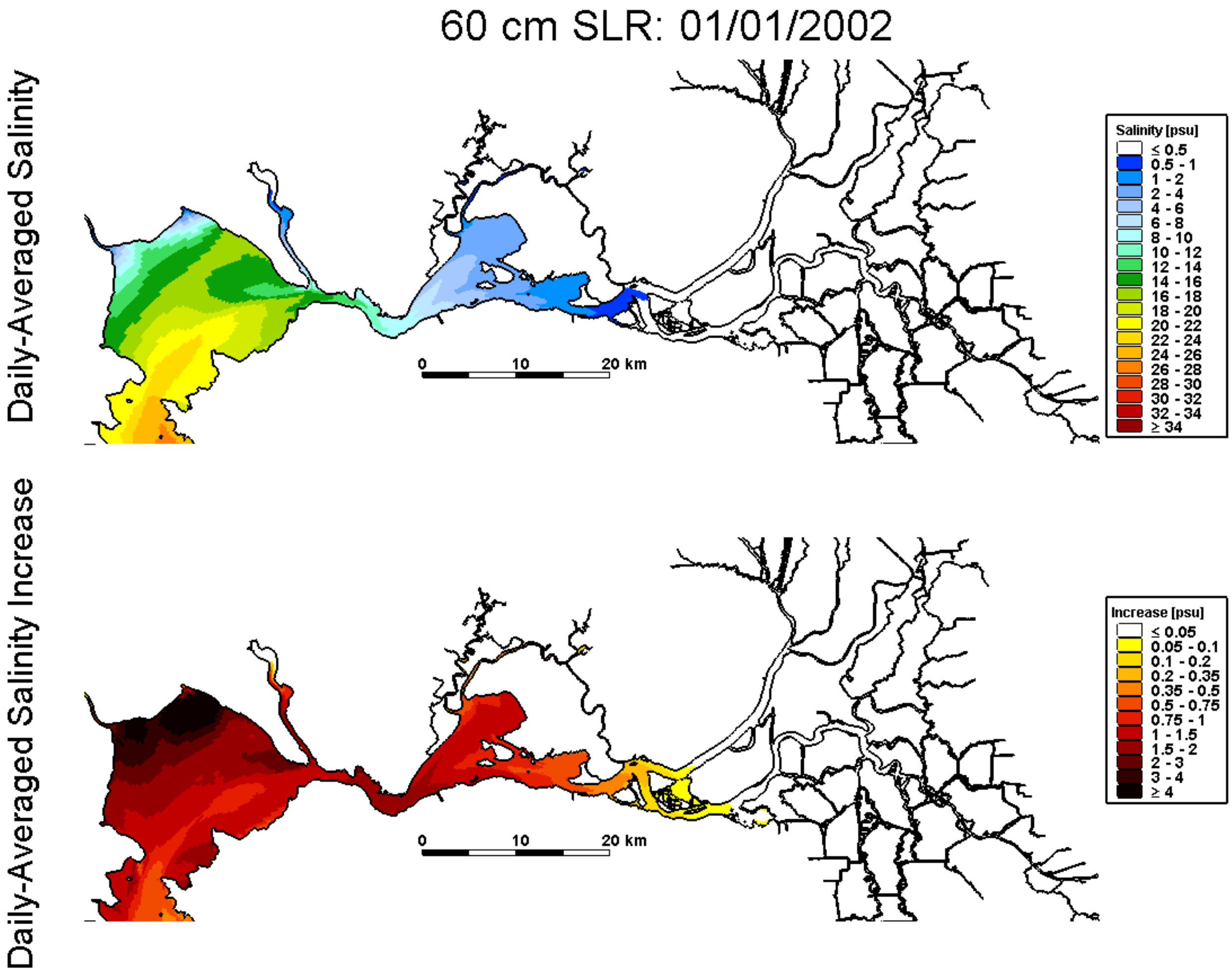


Figure 4.4-1 Predicted daily-averaged depth-average salinity on January 1, 2002 for the 60 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on January 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 60 cm SLR scenario.

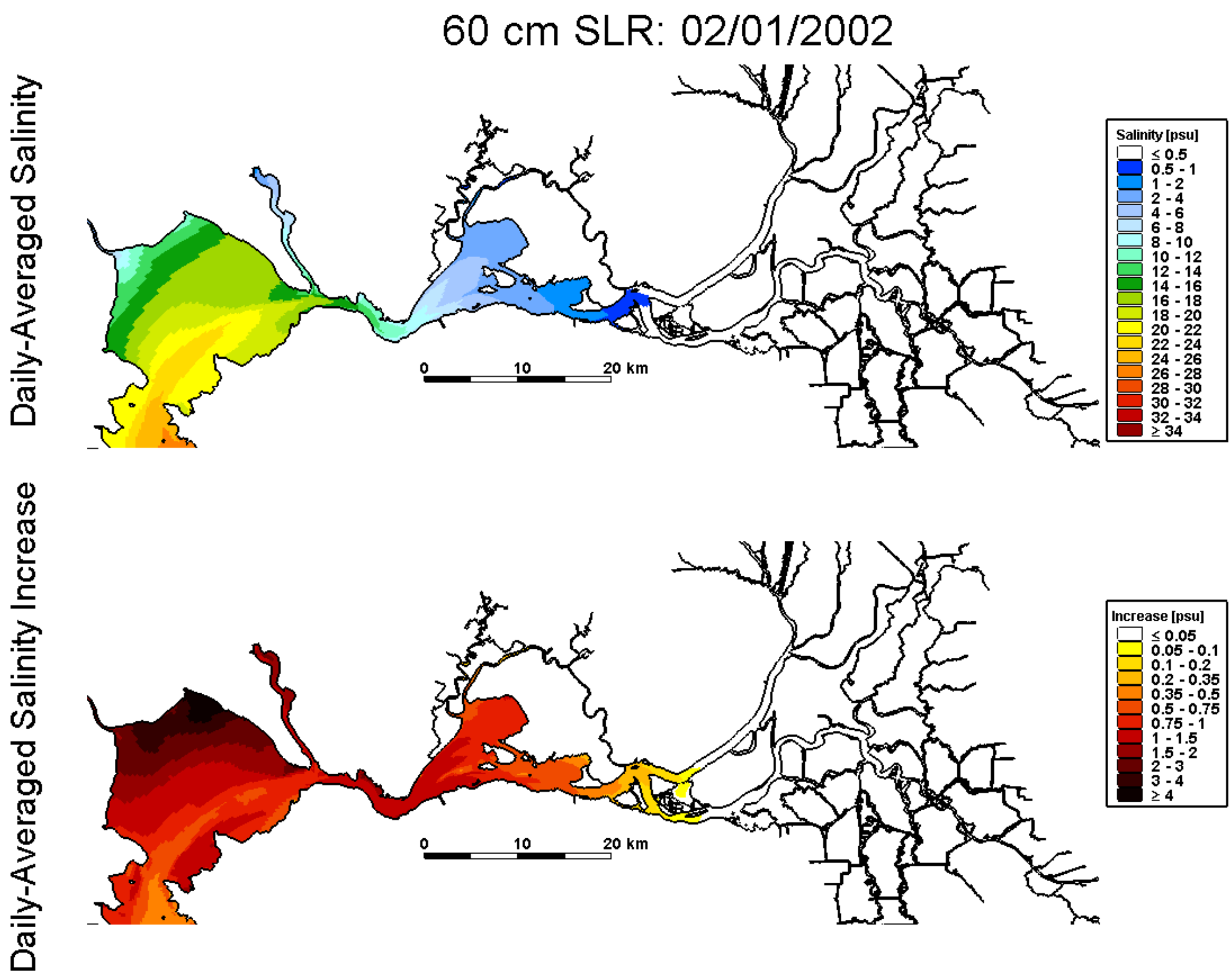


Figure 4.4-2 Predicted daily-averaged depth-average salinity on February 1, 2002 for the 60 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on February 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 60 cm SLR scenario.

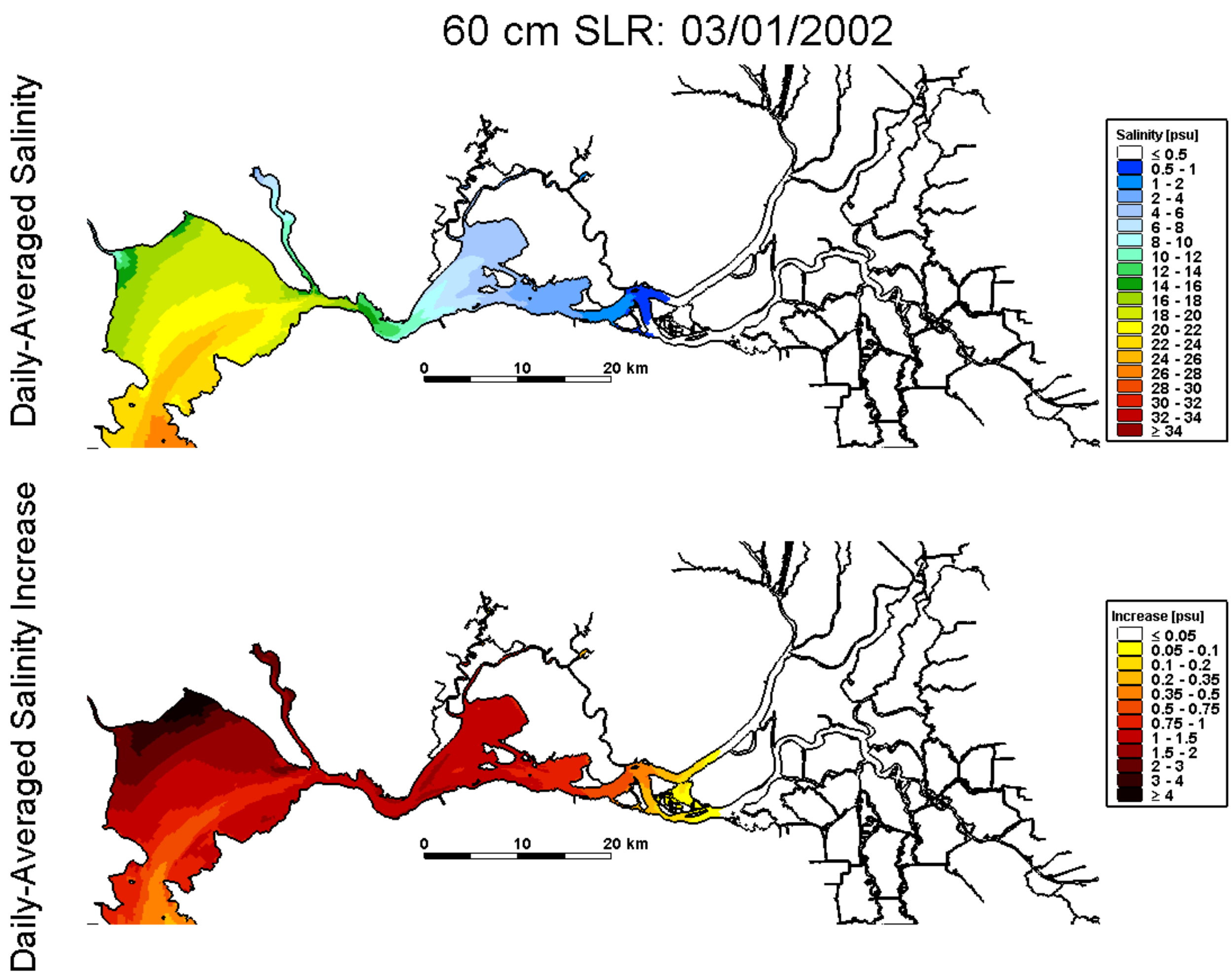


Figure 4.4-3 Predicted daily-averaged depth-average salinity on March 1, 2002 for the 60 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on March 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 60 cm SLR scenario.

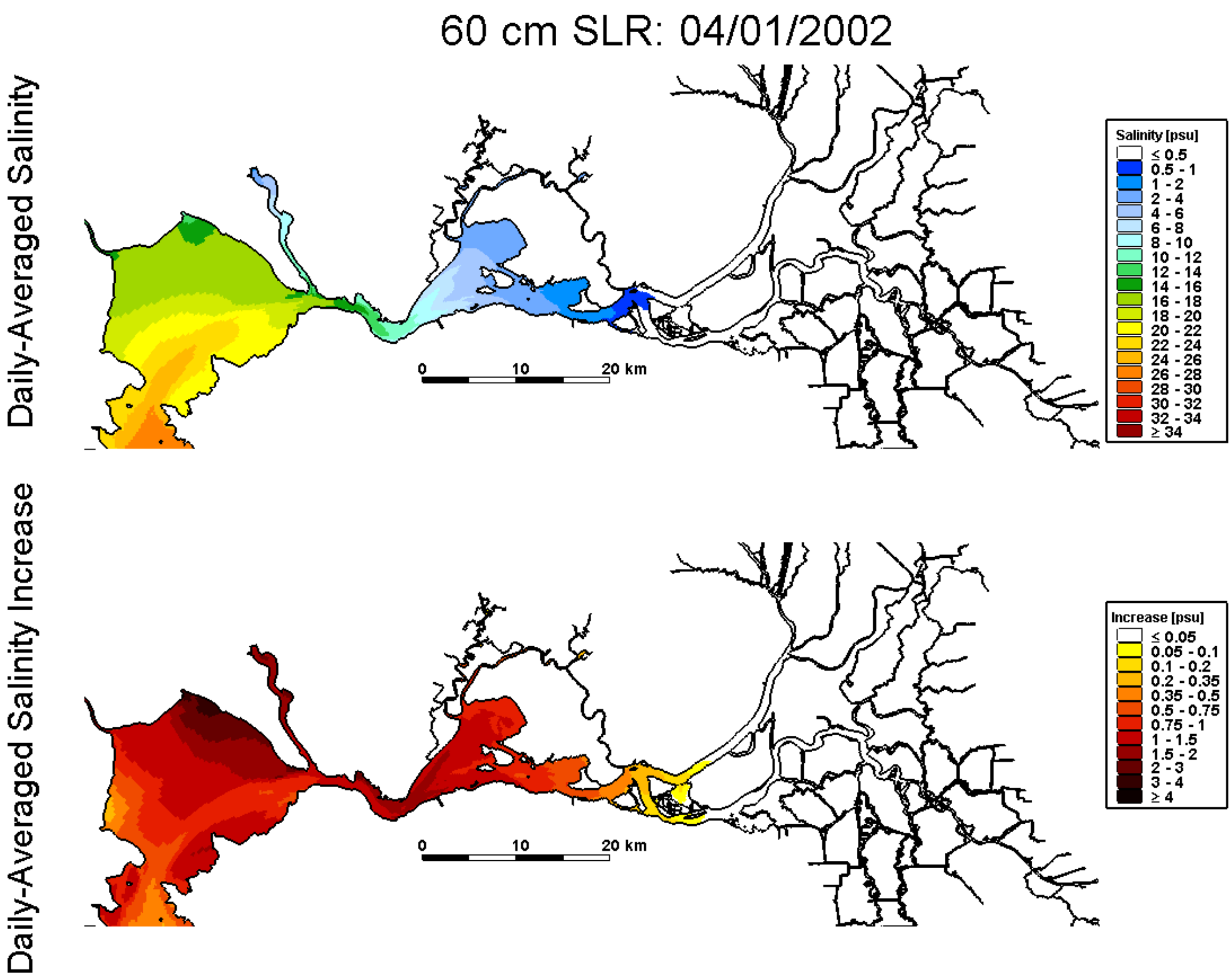


Figure 4.4-4 Predicted daily-averaged depth-average salinity on April 1, 2002 for the 60 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on April 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 60 cm SLR scenario.

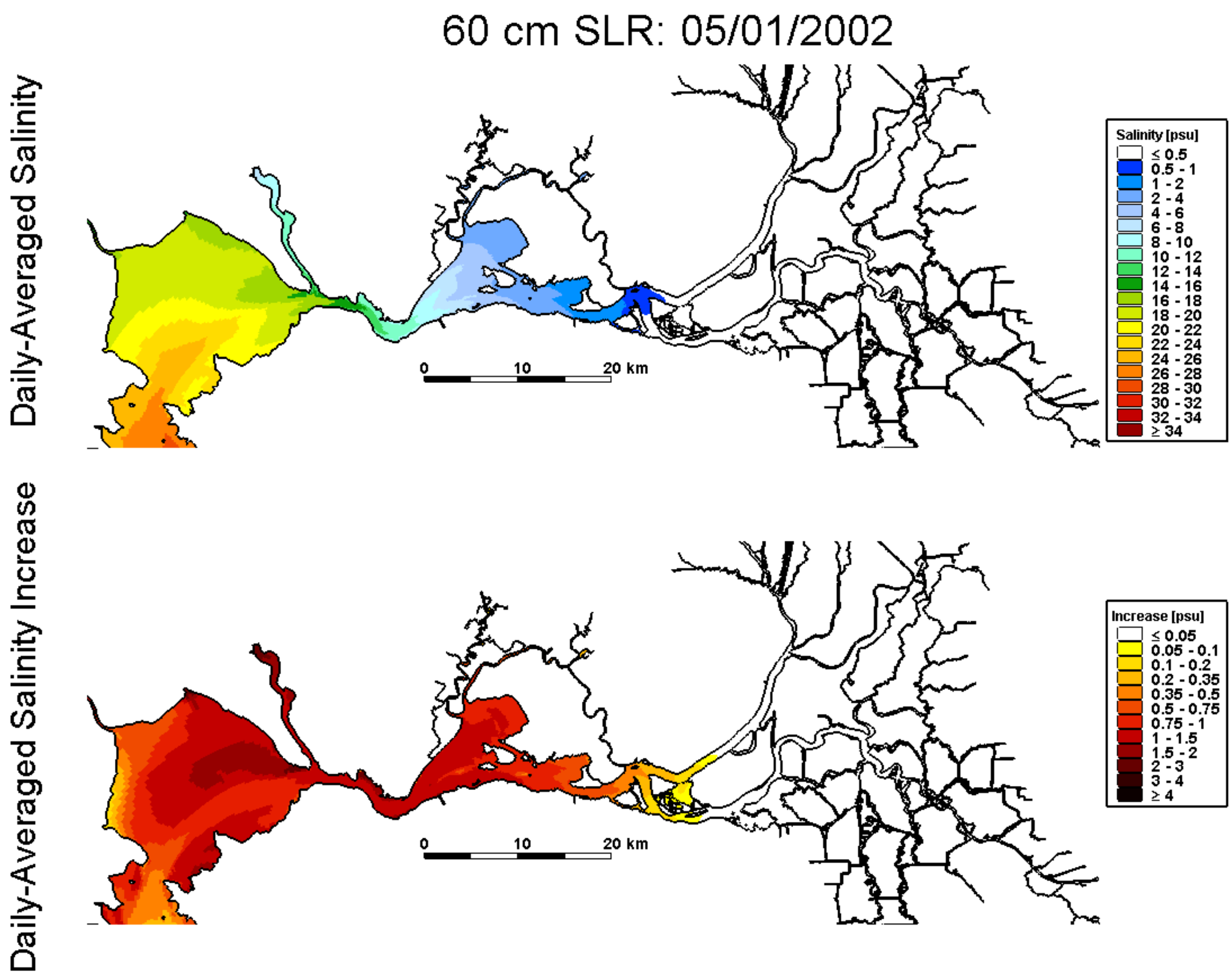


Figure 4.4-5 Predicted daily-averaged depth-average salinity on May 1, 2002 for the 60 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on May 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 60 cm SLR scenario.

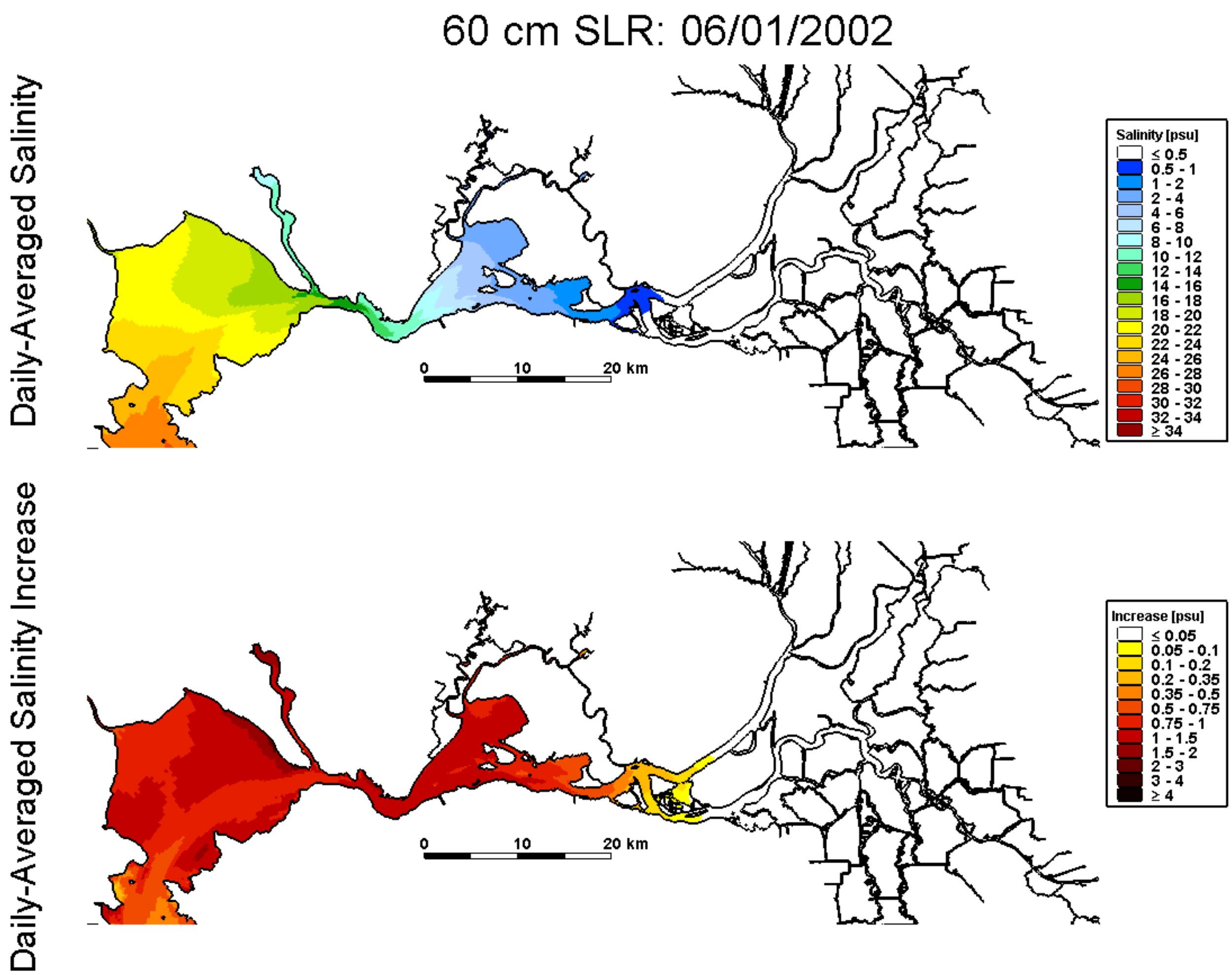


Figure 4.4-6 Predicted daily-averaged depth-average salinity on June 1, 2002 for the 60 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on June 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 60 cm SLR scenario.

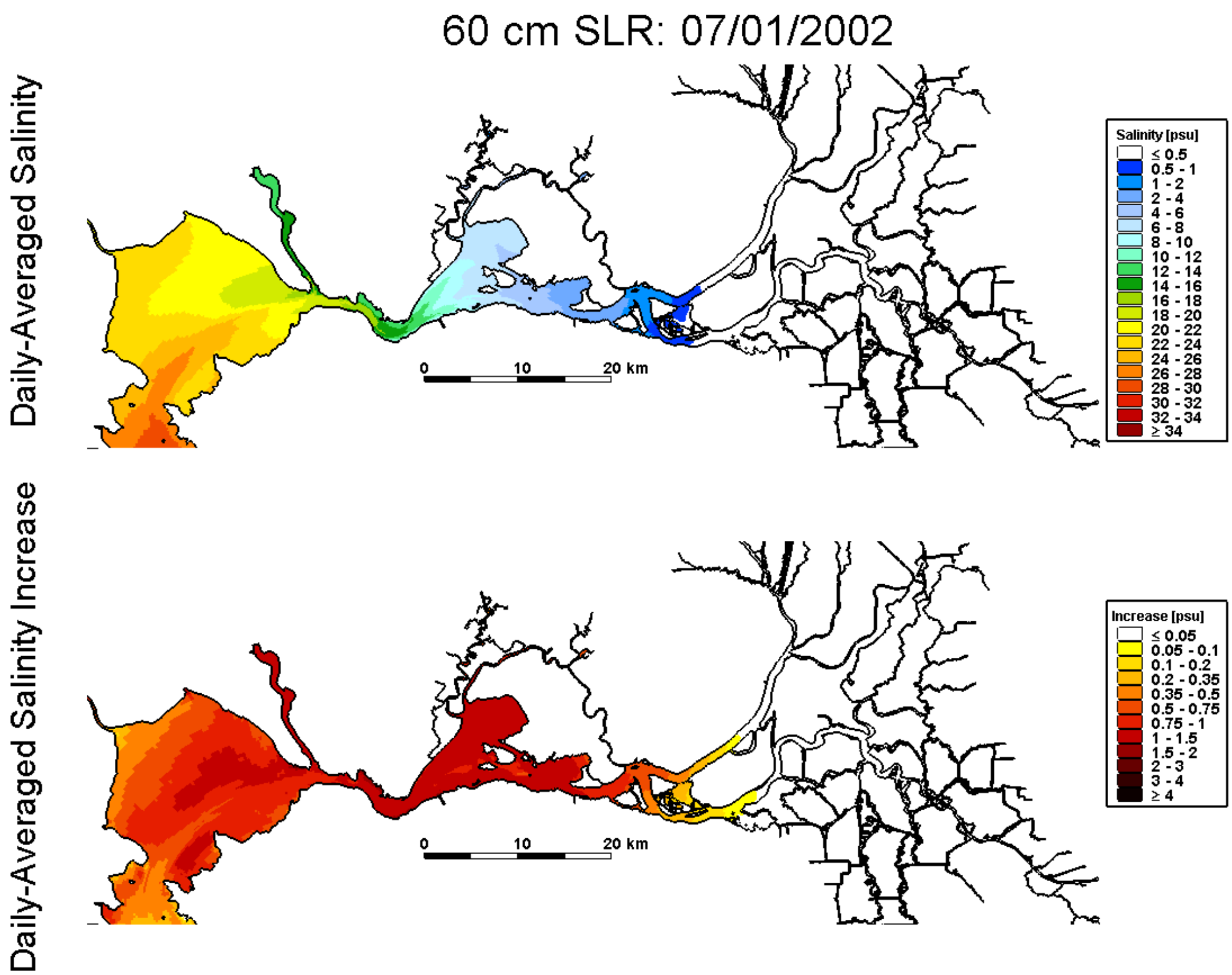


Figure 4.4-7 Predicted daily-averaged depth-average salinity on July 1, 2002 for the 60 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on July 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 60 cm SLR scenario.

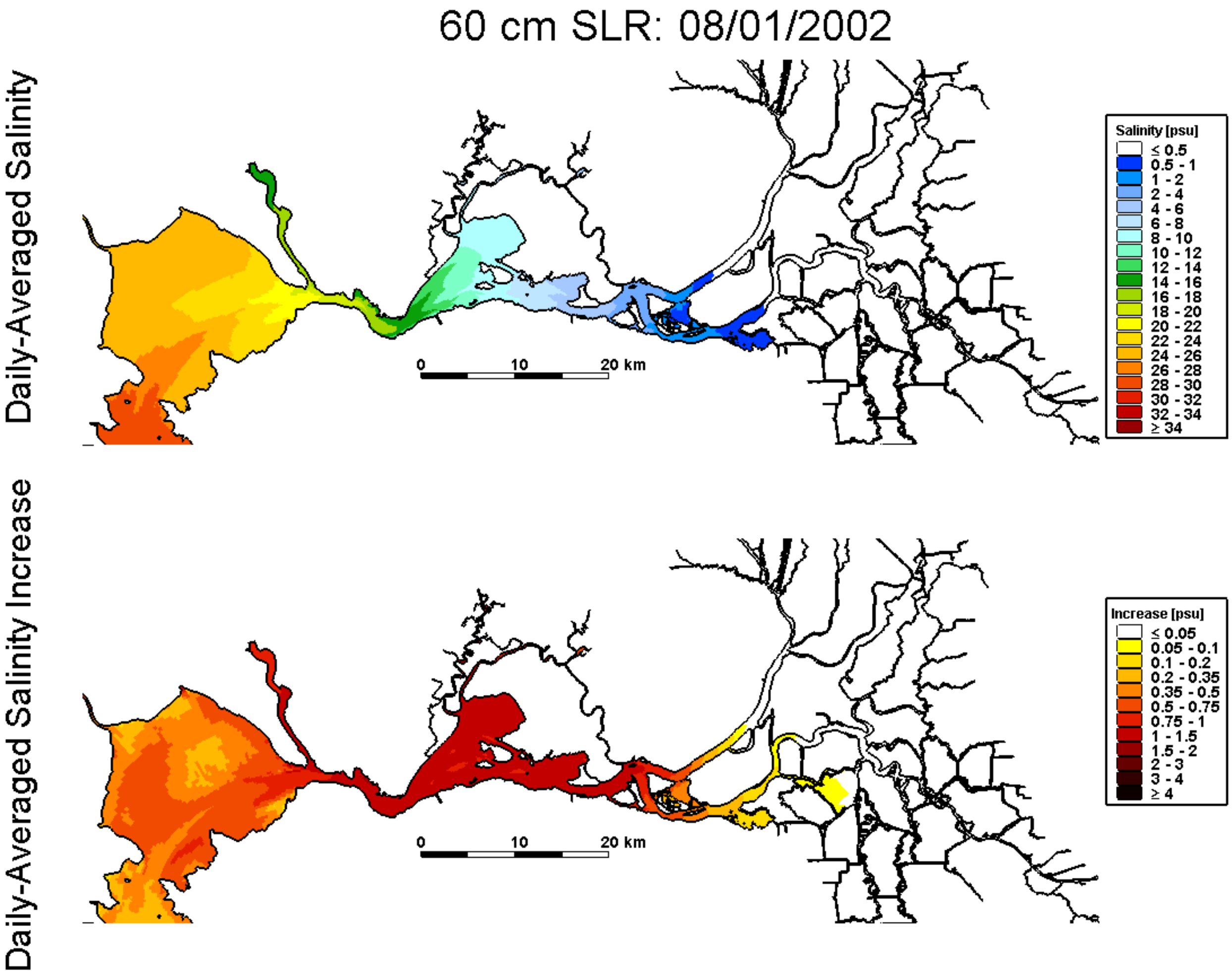


Figure 4.4-8 Predicted daily-averaged depth-average salinity on August 1, 2002 for the 60 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on August 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 60 cm SLR scenario.

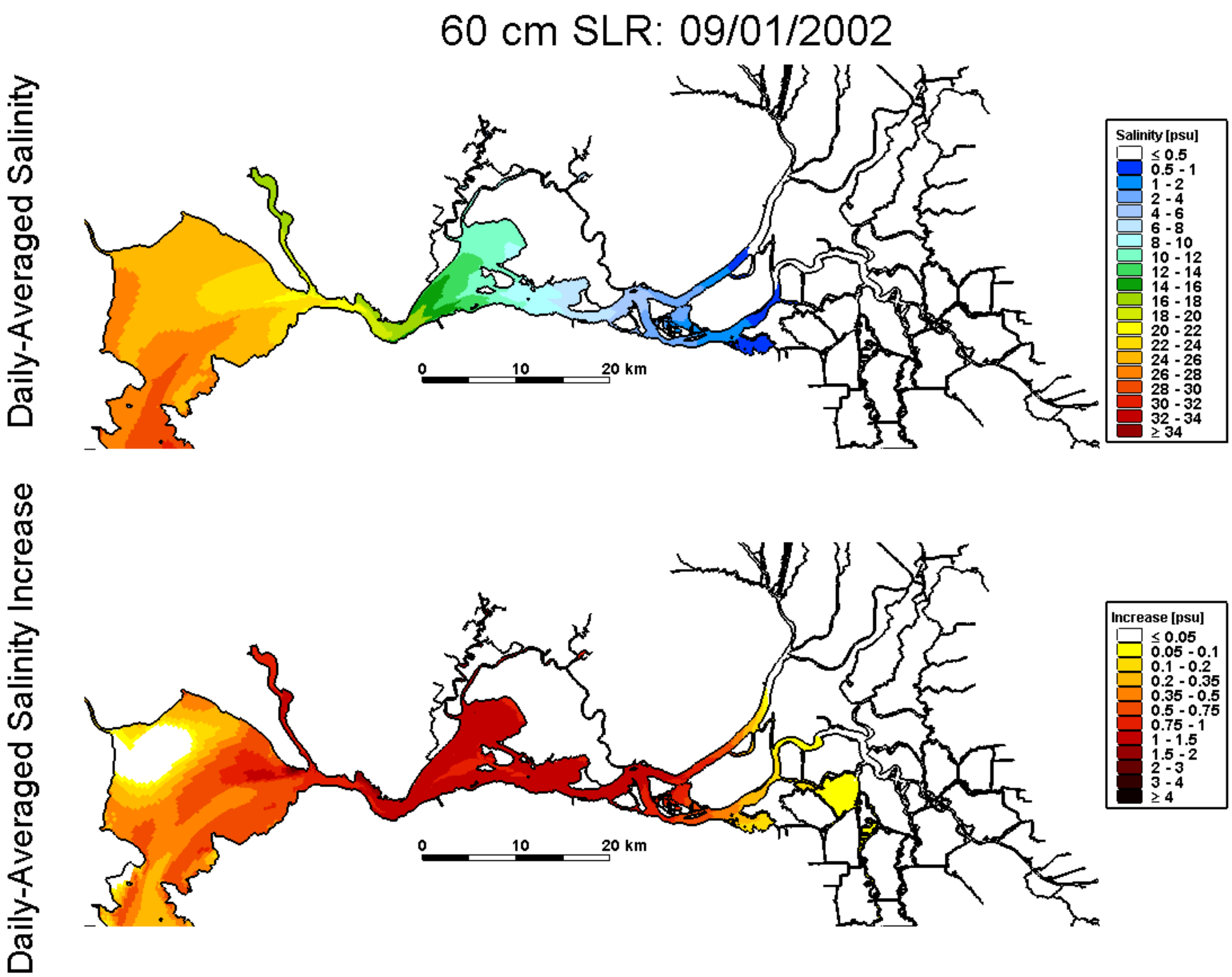


Figure 4.4-9 Predicted daily-averaged depth-average salinity on September 1, 2002 for the 60 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on September 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 60 cm SLR scenario.

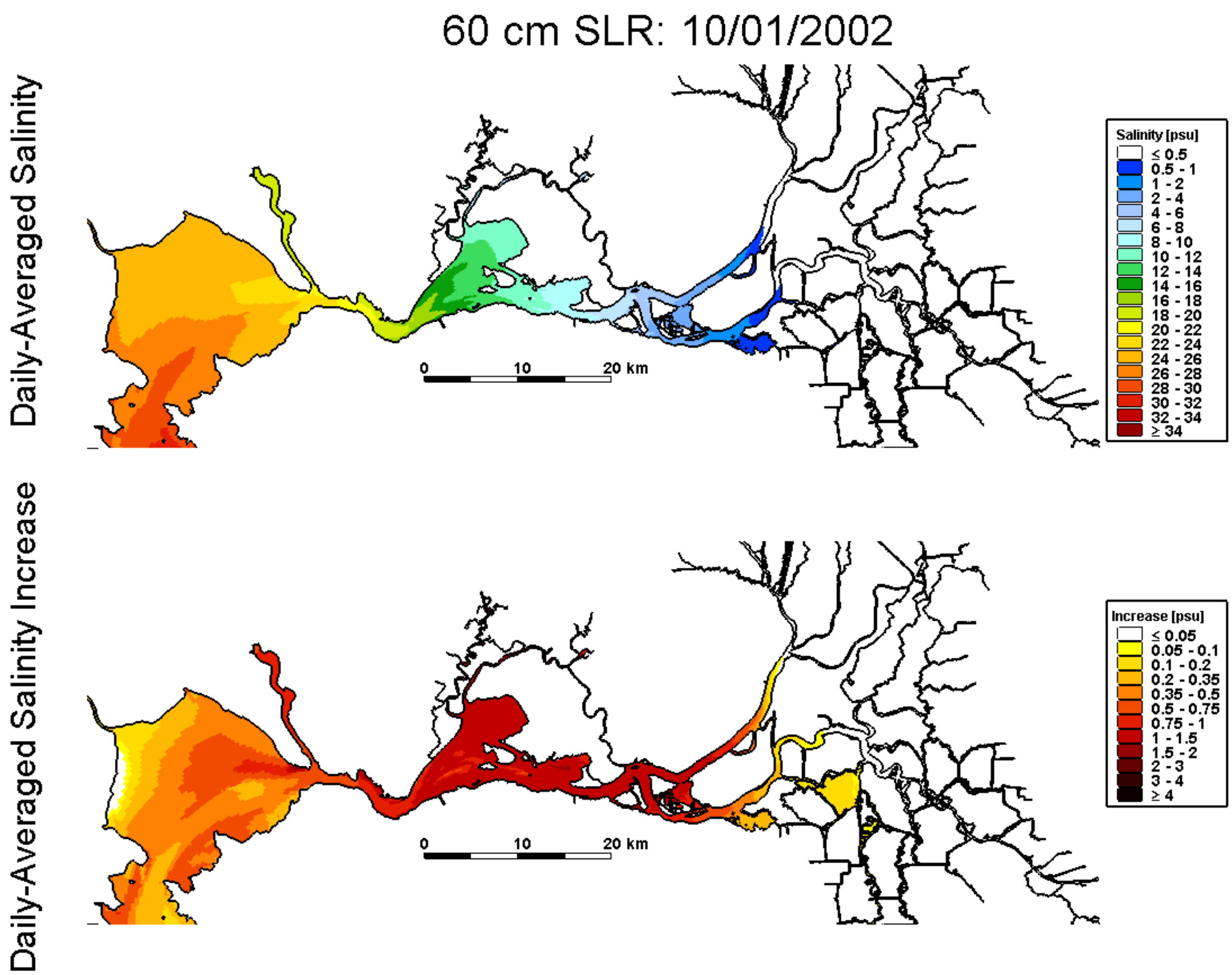


Figure 4.4-10 Predicted daily-averaged depth-average salinity on October 1, 2002 for the 60 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on October 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 60 cm SLR scenario.

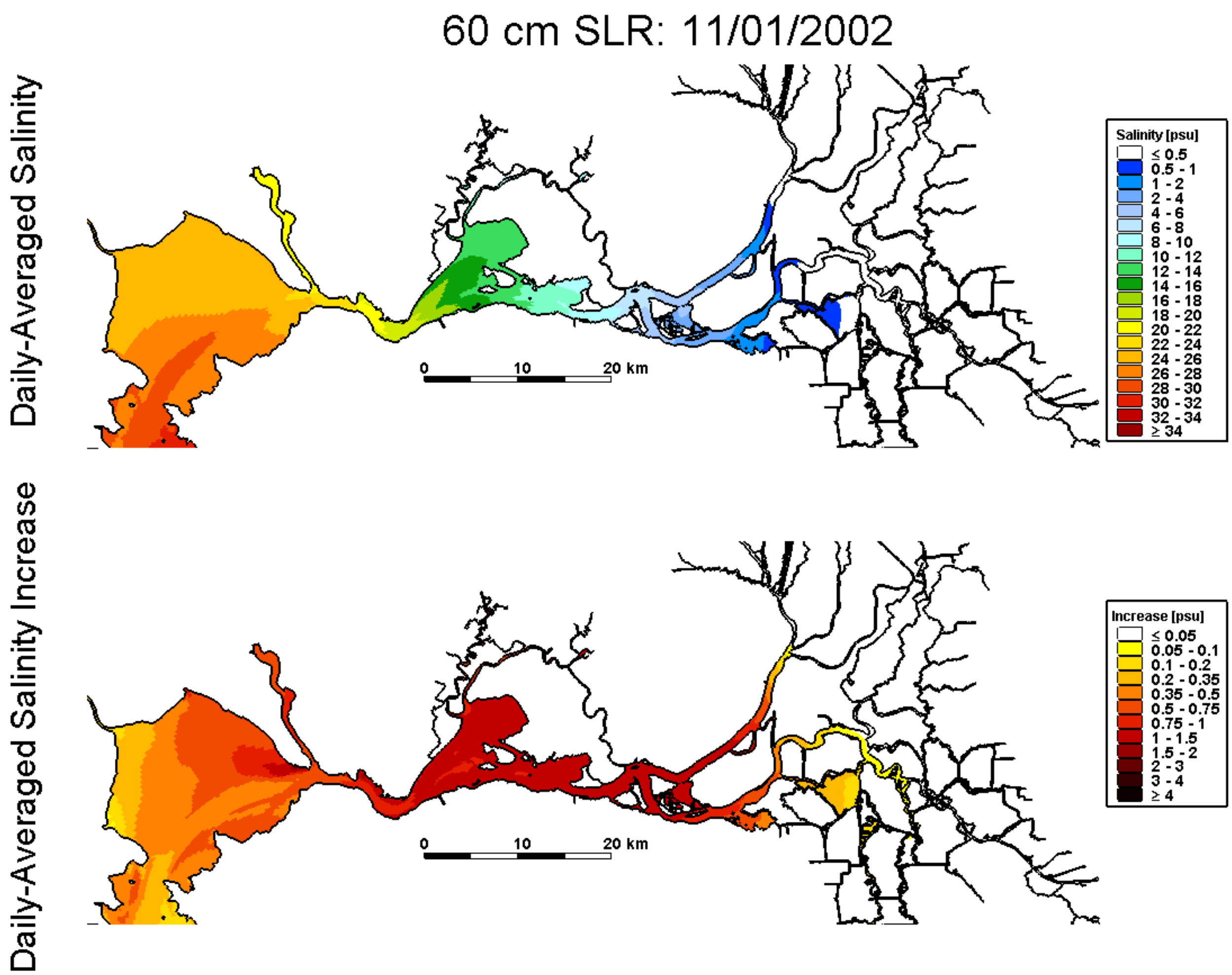


Figure 4.4-11 Predicted daily-averaged depth-average salinity on November 1, 2002 for the 60 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on November 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 60 cm SLR scenario.

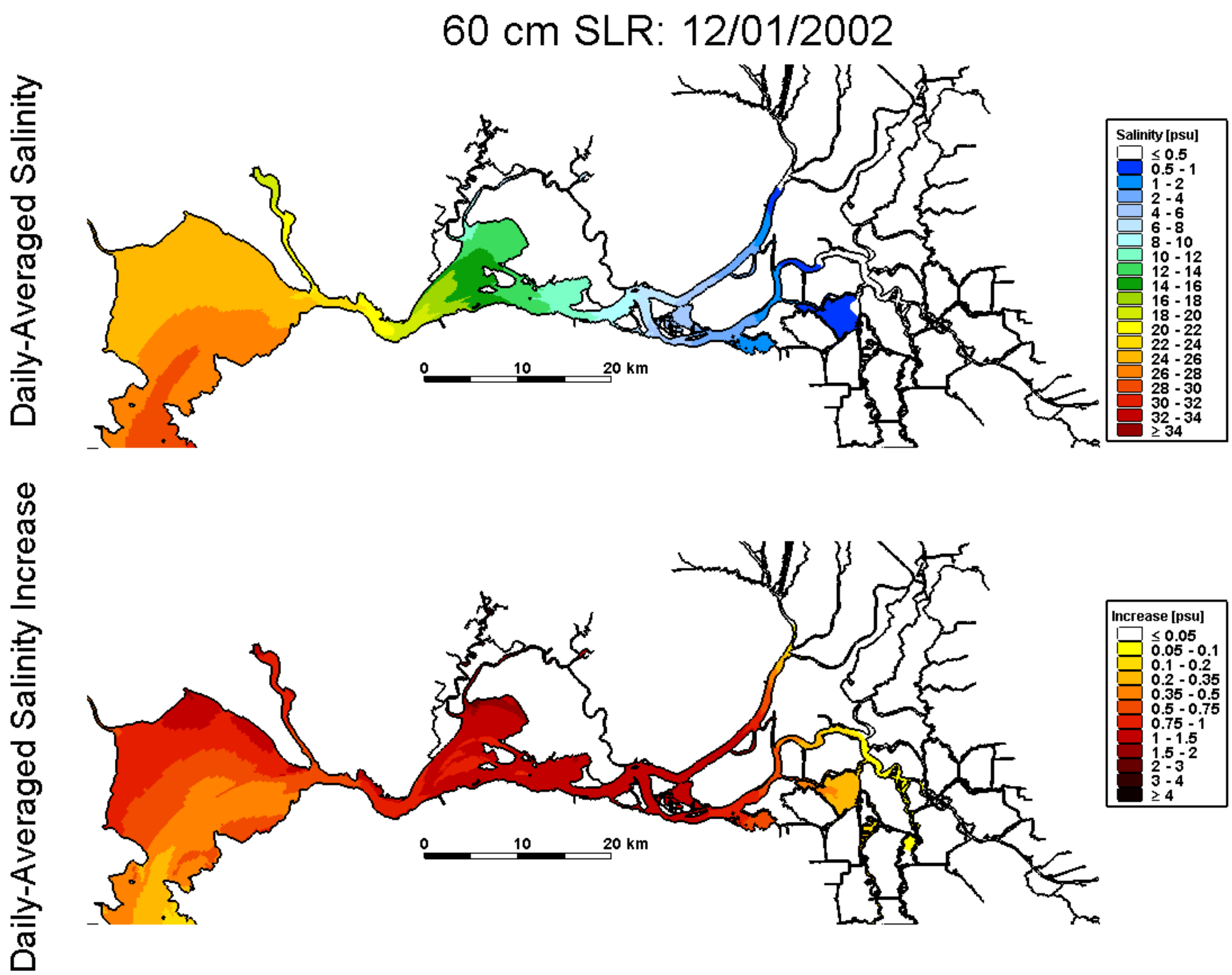


Figure 4.4-12 Predicted daily-averaged depth-average salinity on December 1, 2002 for the 60 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on December 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 60 cm SLR scenario.

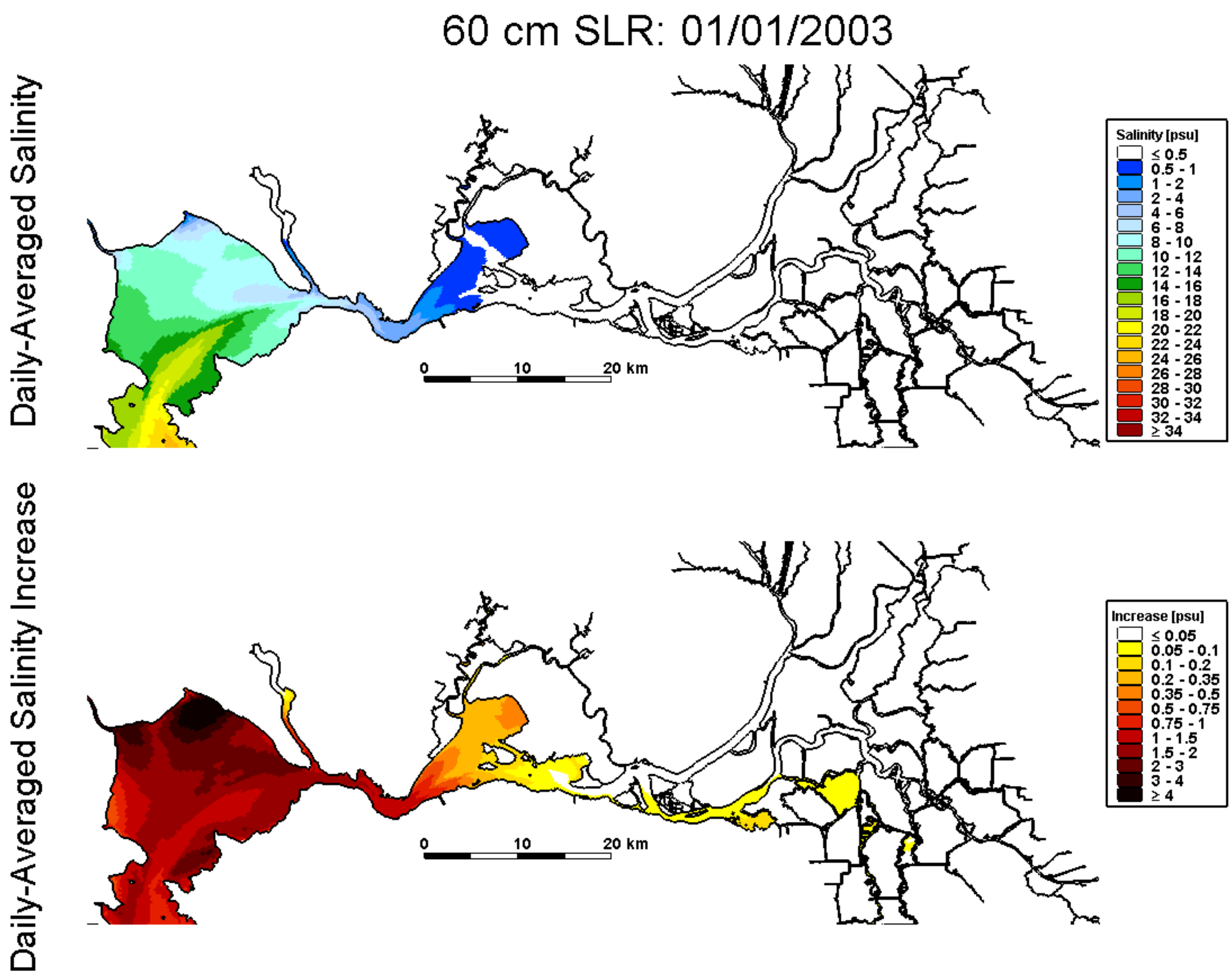


Figure 4.4-13 Predicted daily-averaged depth-average salinity on January 1, 2003 for the 60 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on January 1, 2003 relative to the Baseline (0 cm SLR) scenario for the 60 cm SLR scenario.

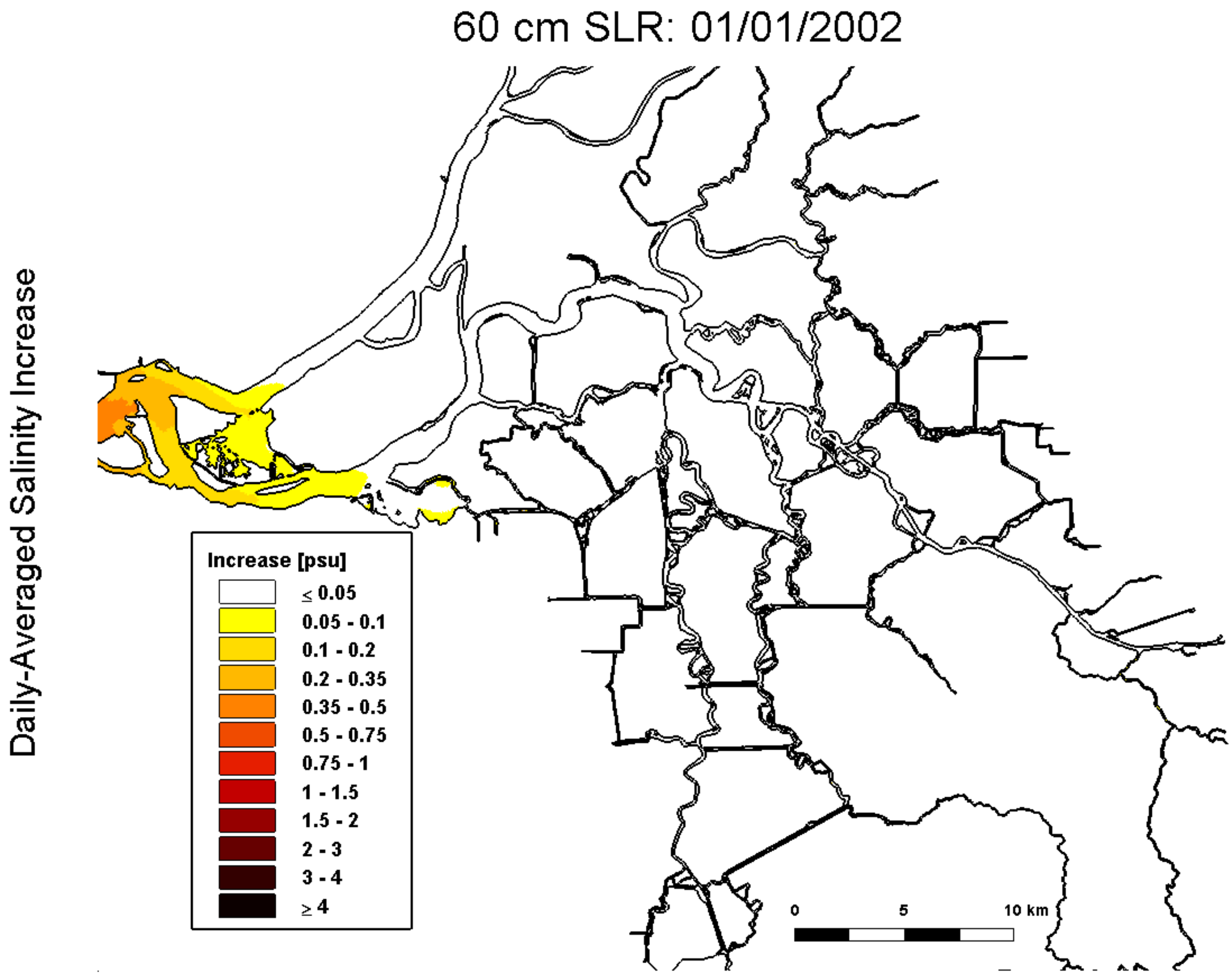


Figure 4.4-14 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on January 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 60 cm SLR scenario.

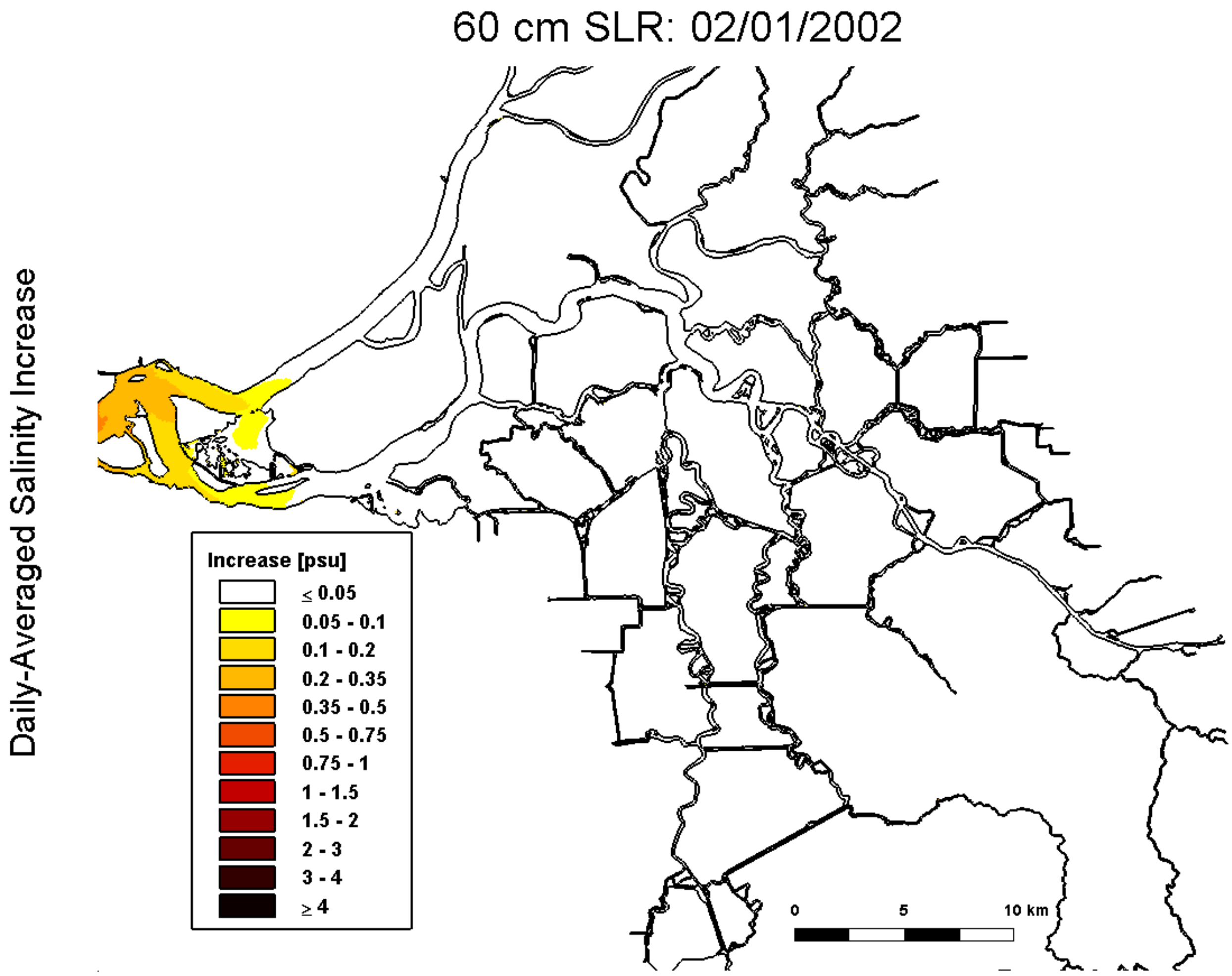


Figure 4.4-15 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on February 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 60 cm SLR scenario.

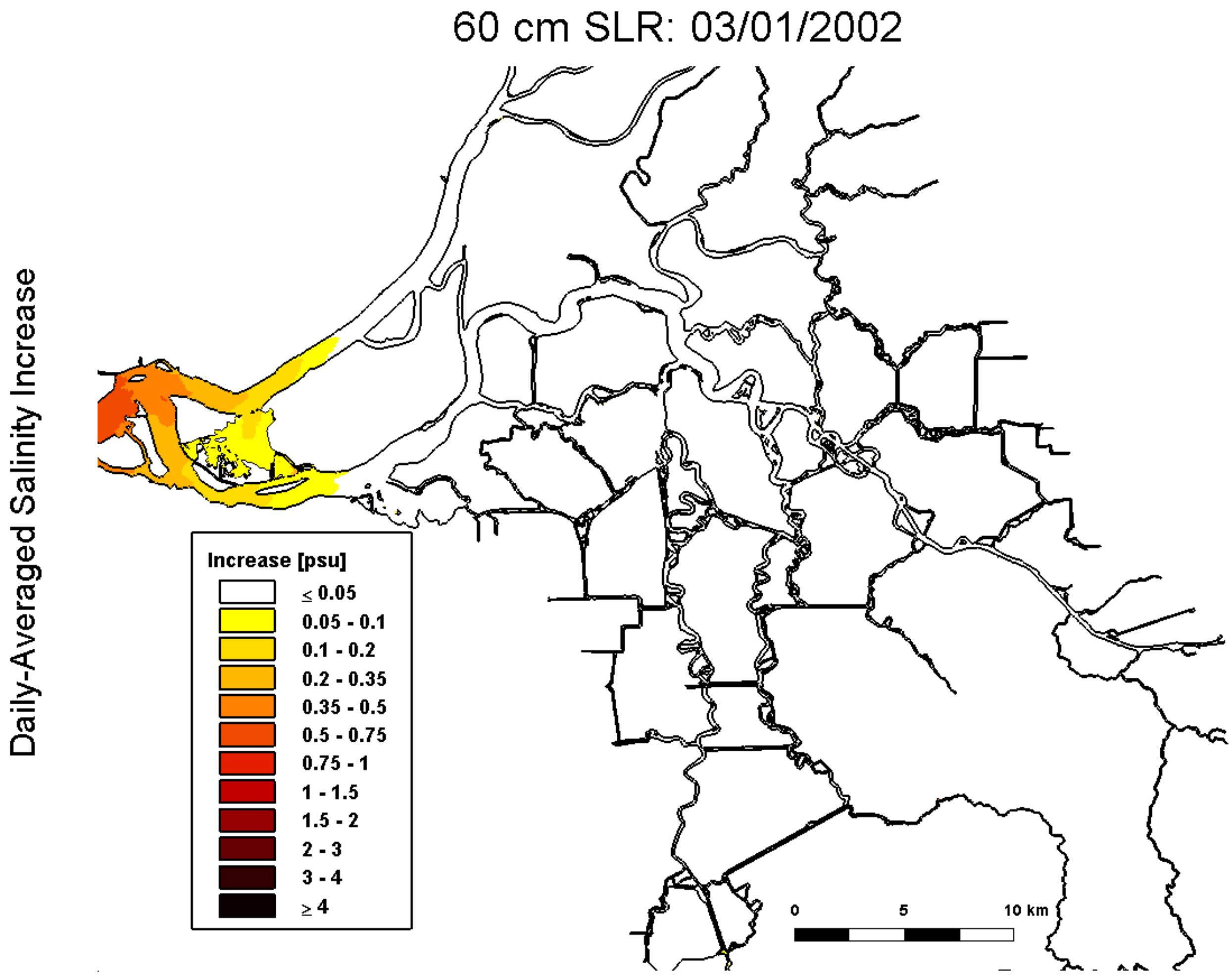


Figure 4.4-16 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on March 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 60 cm SLR scenario.

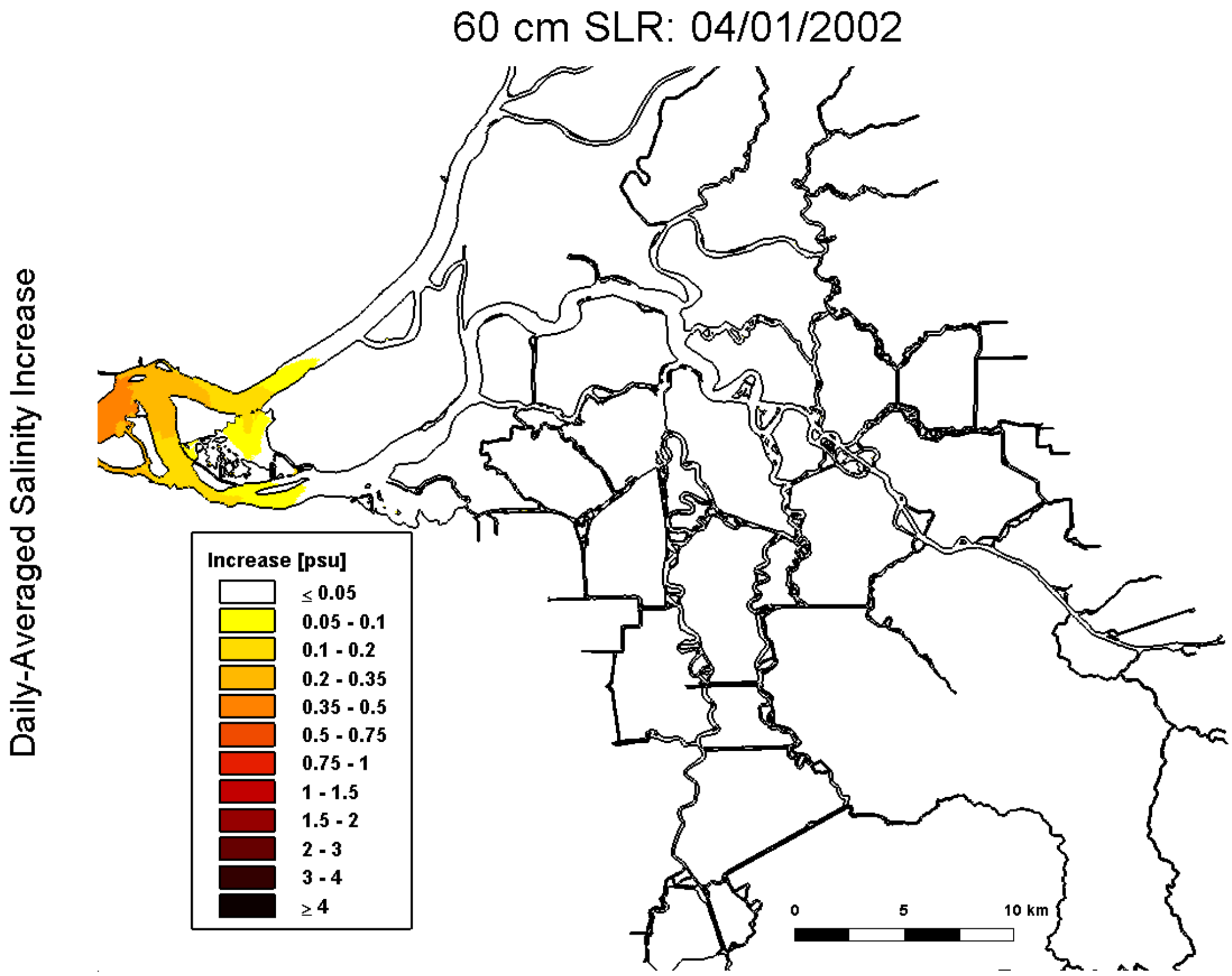


Figure 4.4-17 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on April 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 60 cm SLR scenario.

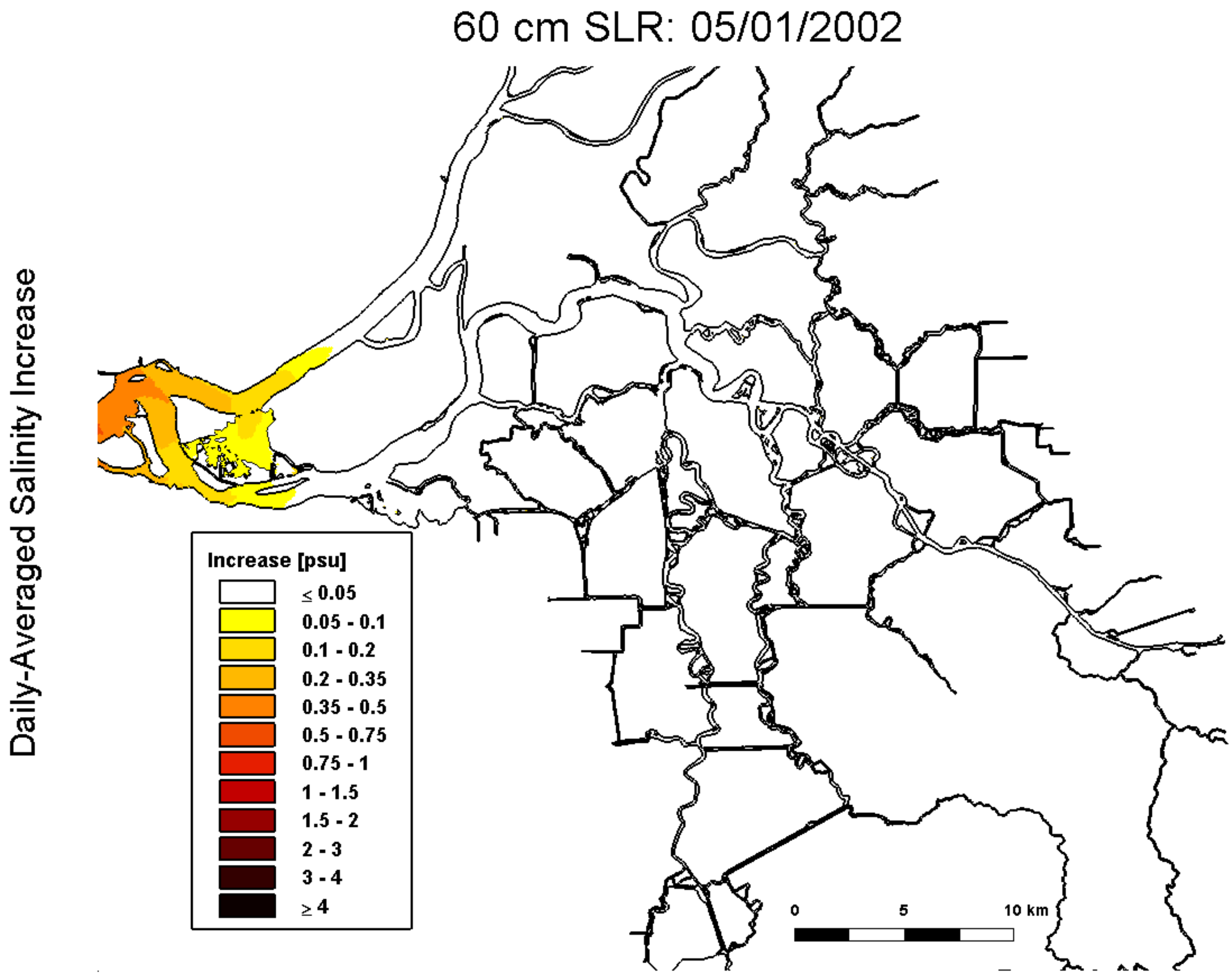


Figure 4.4-18 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on May 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 60 cm SLR scenario.

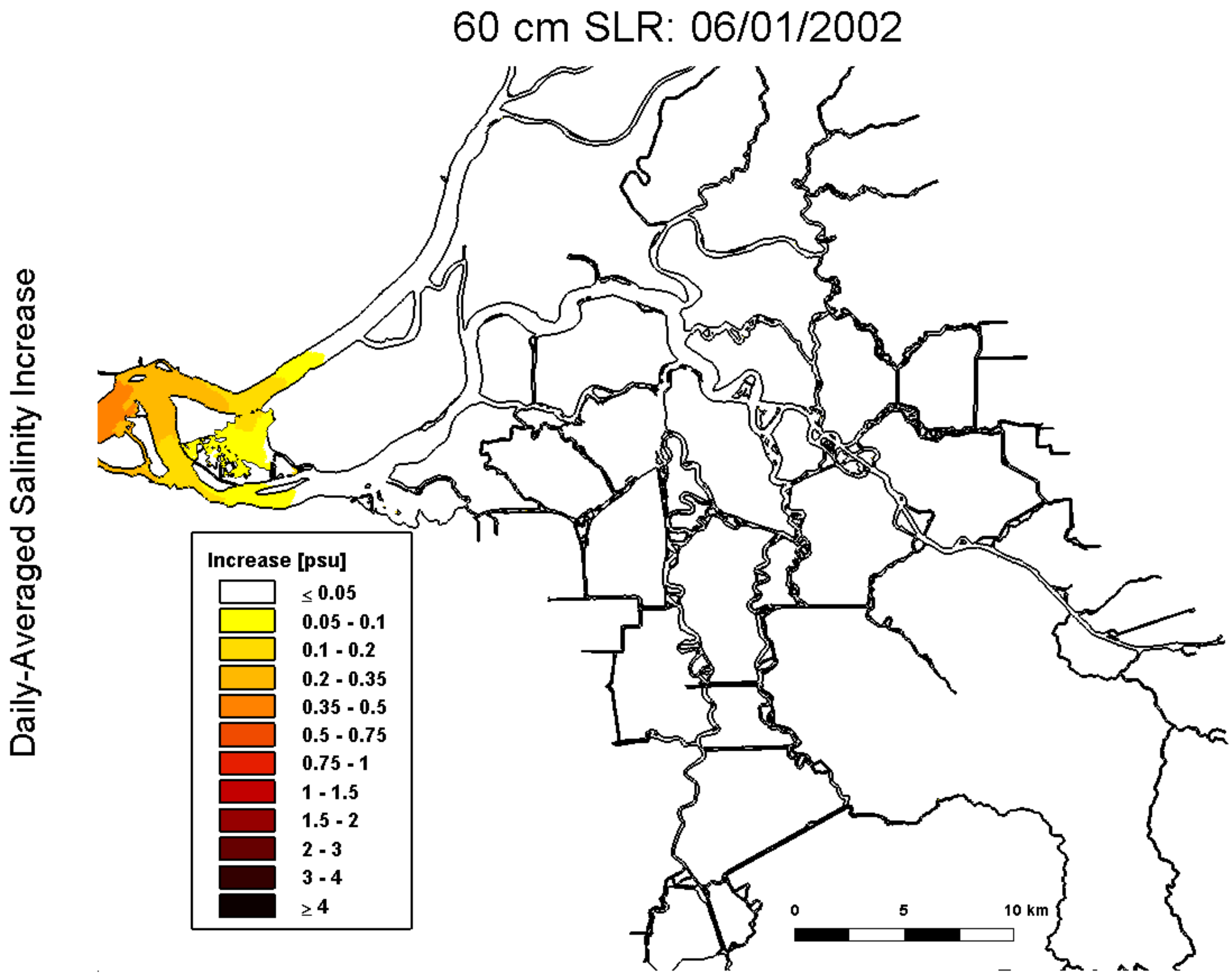


Figure 4.4-19 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on June 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 60 cm SLR scenario.

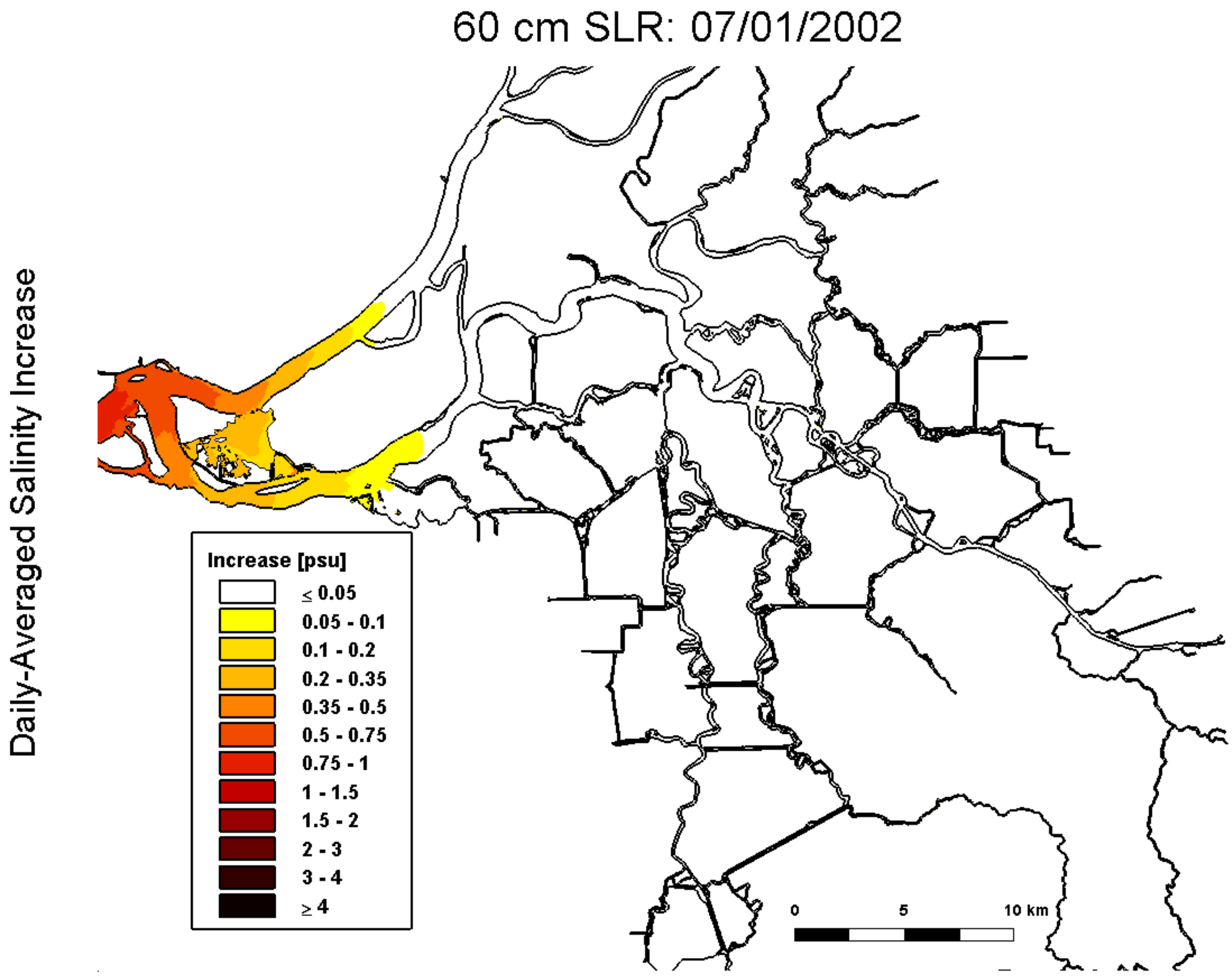


Figure 4.4-20 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on July 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 60 cm SLR scenario.

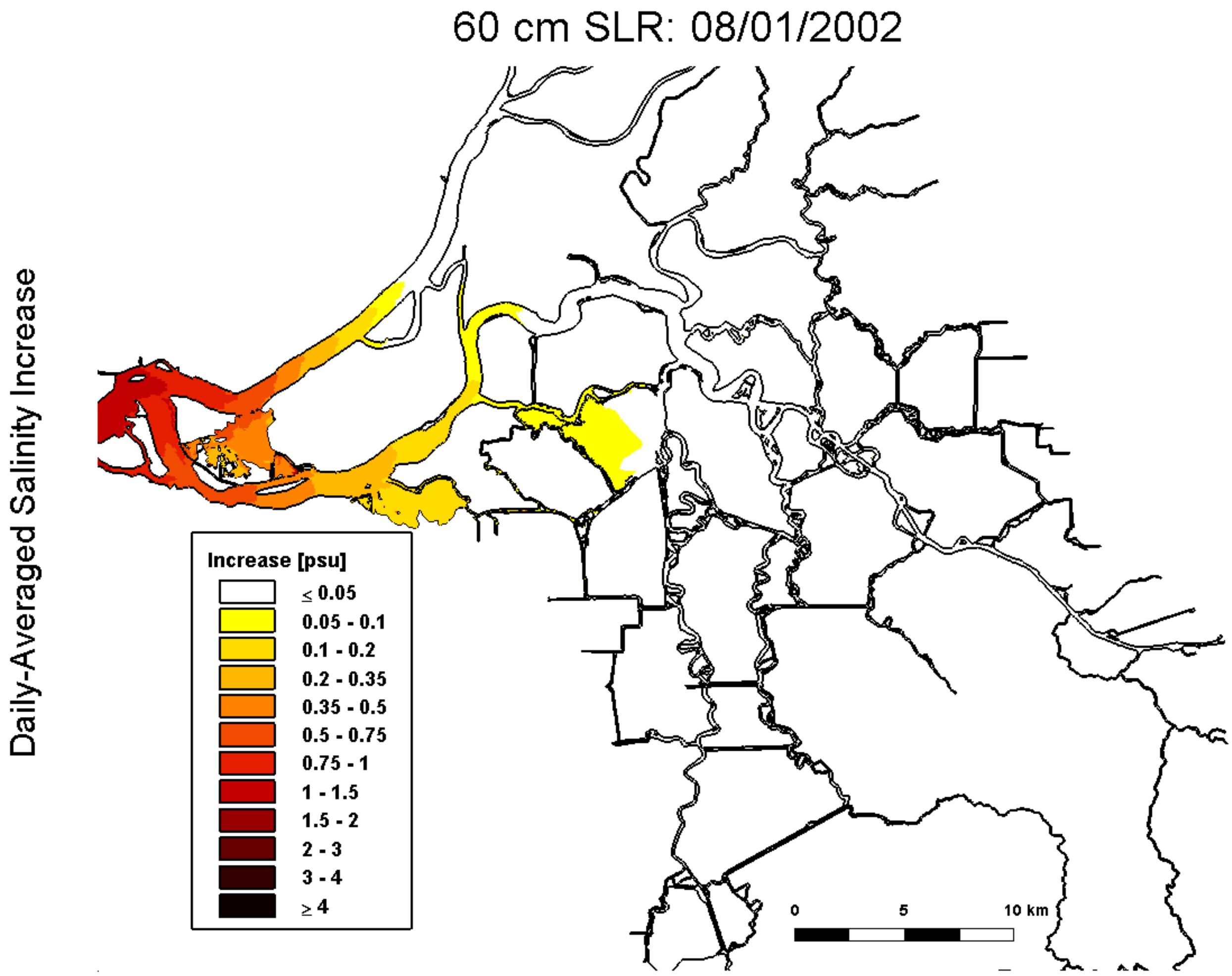


Figure 4.4-21 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on August 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 60 cm SLR scenario.

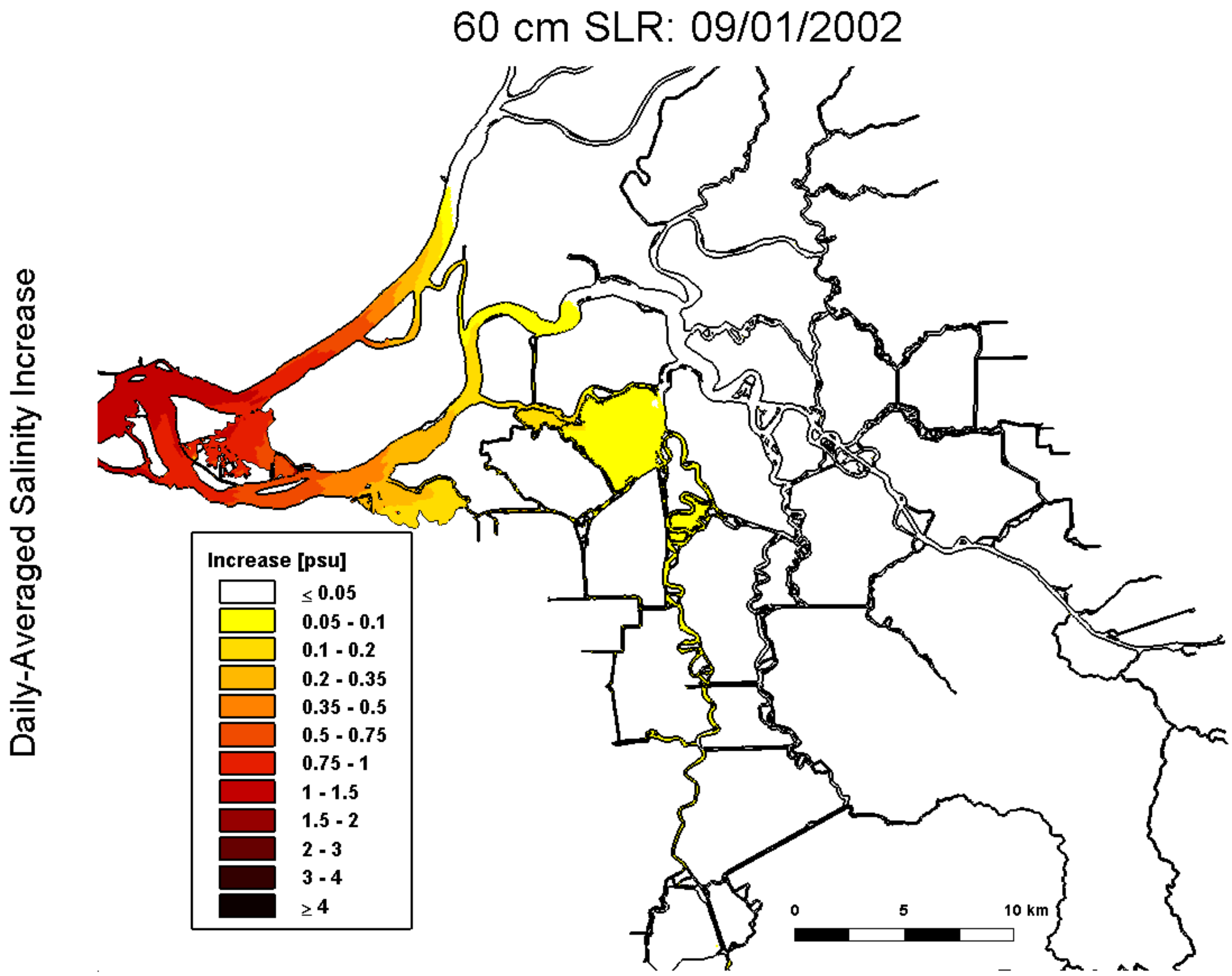


Figure 4.4-22 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on September 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 60 cm SLR scenario.

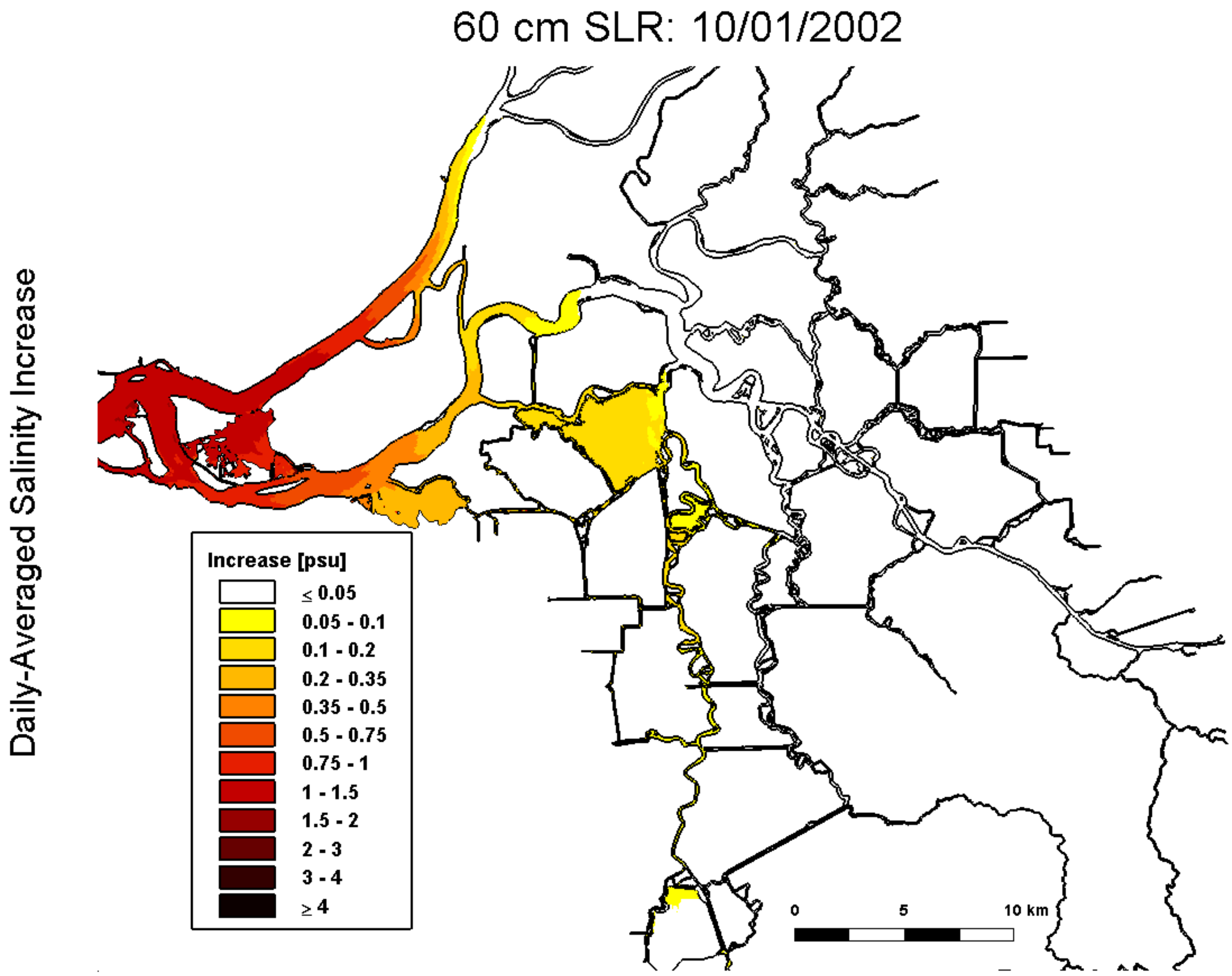


Figure 4.4-23 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on October 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 60 cm SLR scenario.

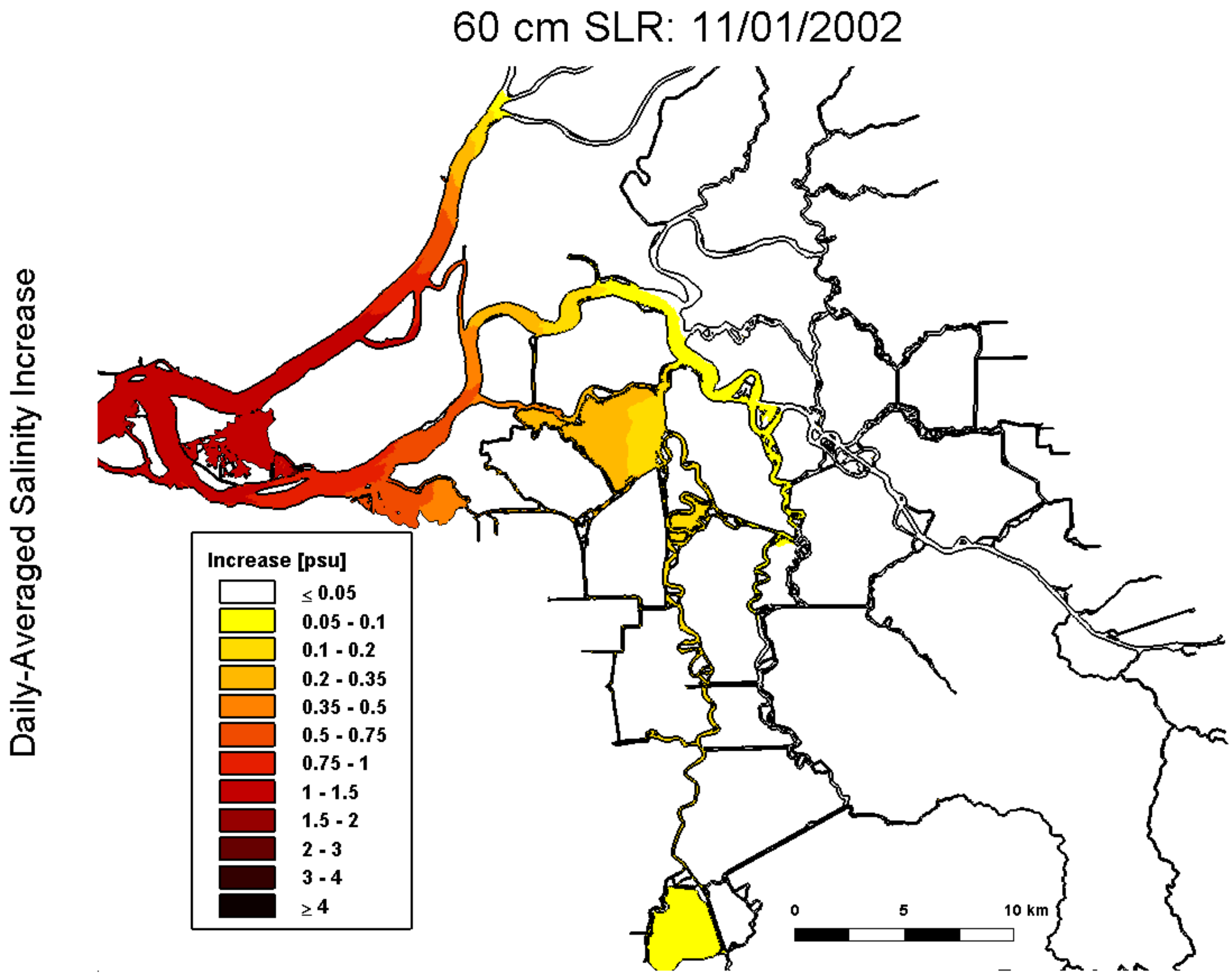


Figure 4.4-24 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on November 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 60 cm SLR scenario.

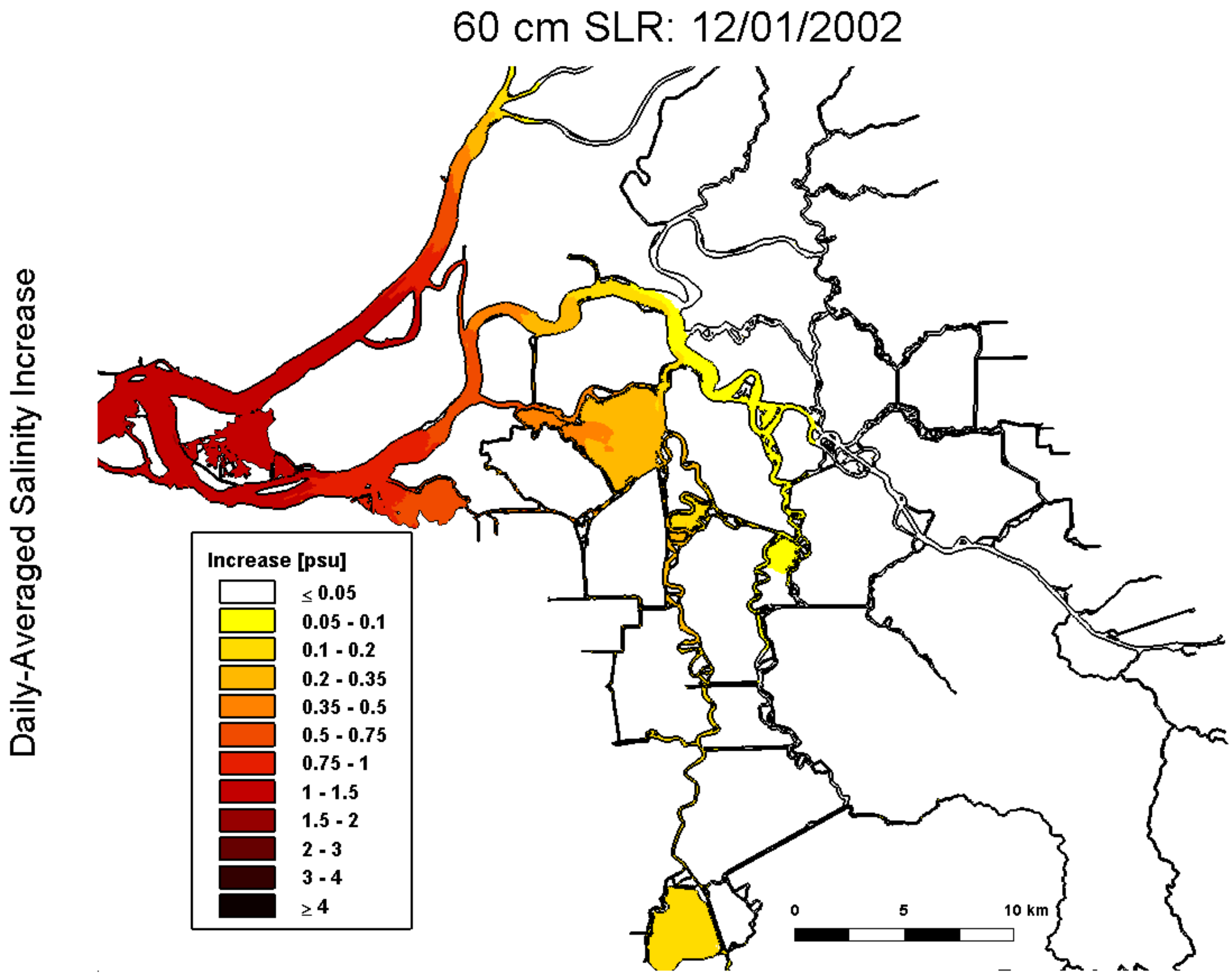


Figure 4.4-25 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on December 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 60 cm SLR scenario.

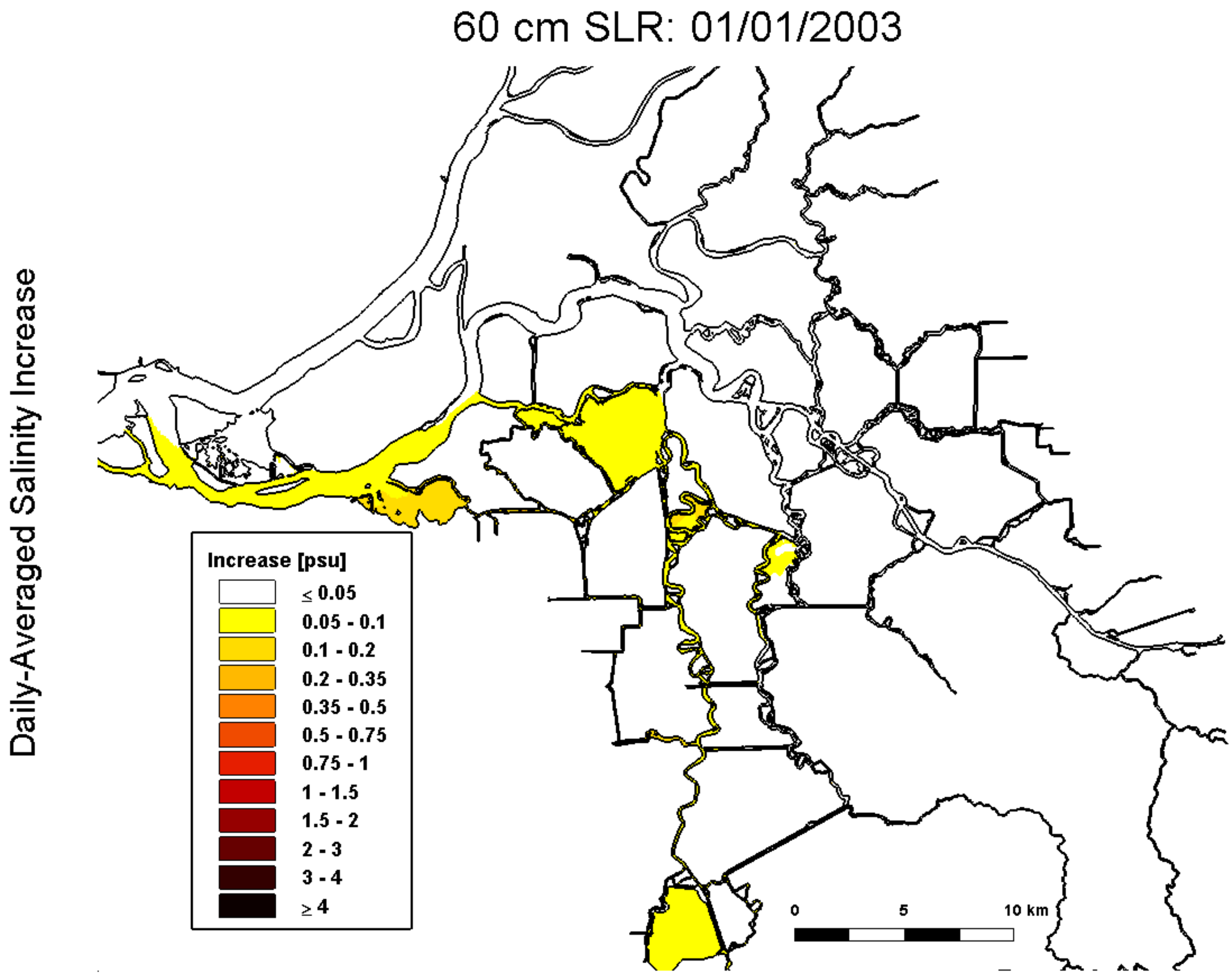


Figure 4.4-26 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on January 1, 2003 relative to the Baseline (0 cm SLR) scenario for the 60 cm SLR scenario.

4.5 Predicted Increase in Salinity for 140 cm SLR Scenario

Figure 4.5-1 through 4.5-13 show the predicted salinity along the northern portion of the San Francisco Estuary, spanning from San Pablo Bay through the Sacramento-San Joaquin Delta for the 140 cm SLR scenario. The top panel of each figure shows the predicted daily-averaged depth-average salinity for the 140 cm SLR scenario. The lower panel shows the predicted salinity increase computed by subtracting the predicted daily-averaged depth-average salinity for the Baseline (0 cm SLR) scenario from the predicted daily-averaged depth-average salinity for the 140 cm SLR scenario. Figures 4.5-14 through 4.5-26 show the predicted salinity increases resulting from the 140 cm SLR scenario in the Sacramento-San Joaquin Delta.

At the beginning of the analysis period on January 1, 2002, significant salinity increases are evident in the Delta, indicating that the salinity increases from the previous fall period have not been fully flushed out. Salinity increases between 1. 0 and 1.50 psu are predicted between Chipps Island and Collinsville and predicted salinity increases of up to 0.05 psu are predicted upstream to Emmaton on the Sacramento River. Along the San Joaquin River predicted salinity increases of 0.1 and 0.2 psu extend from Big Break to False River and predicted salinity increases of between 0.05 psu and 1.0 psu extend upstream to Sevenmile Slough. Salinity increases of between 0.05 and 0.10 psu are predicted in Franks Tract. South of Franks Tract, predicted salinity increases between 0.10 and 0.20 psu extend down Old River to Clifton Court Forebay, and salinity increases of between 0.10 and 0.20 psu are predicted inside Clifton Court Forebay. Predicted salinity increases are less than 0.05 psu throughout the remaining portions of the Delta. Salinity increases between 3.0 and 4.0 psu are predicted through Carquinez Strait and salinity increases between 1.5 and 3.0 psu are predicted throughout Suisun Bay. Larger salinity increases of more than 2.0 psu are predicted in much of San Pablo Bay, with salinity increases of more than 4.0 psu predicted in northern San Pablo Bay. By February 1, 2002 much of the salinity increases have been flushed out of the Delta following the high flows in January. During the first half of the year, predicted salinity increases in Suisun Bay and the Delta remain similar to the predicted salinity increases seen on February 1, 2002, while predicted salinity increases in San Pablo Bay decrease, though the predicted salinity is increasing throughout this period. Larger salinity increases are predicted in the Delta between July and December, with the largest predicted salinity increases in December prior to the first flush. In December, salinity increases of between 1.50 and 3.0 psu are predicted between Chipps Island and Emmaton, and salinity increases of between 0.75 and 1.5 psu are predicted in Franks Tract. South of Franks Tract, predicted salinity increases between 0.50 and 1.0 psu extend down Old River to Clifton Court Forebay, and salinity increases of between 0.35 and 0.50 psu are predicted inside Clifton Court Forebay. Predicted salinity increases extend up the San Joaquin River as far as Turner Cut. These simulations assumed no operational response to sea level rise, however it is expected significant operational response will be required to maintain water quality standards for 140 cm of sea level rise. Following high flows which occurred in December, predicted salinity on January 1, 2003 shows that the 0.50 psu isohaline is in central Suisun Bay near Port Chicago, which is much further east than in the Baseline scenario. On January 1, 2003 (Figure 4.5-26) salinity increases are predicted throughout much of the Delta indicating that the high flows in December were not sufficient to push all of the salt out of the Delta for the 140 cm SLR scenario. Similar incomplete flushing of salt from the Delta for the 140 cm SLR scenario was observed on January 1, 2002 (Figure 4.5-14).

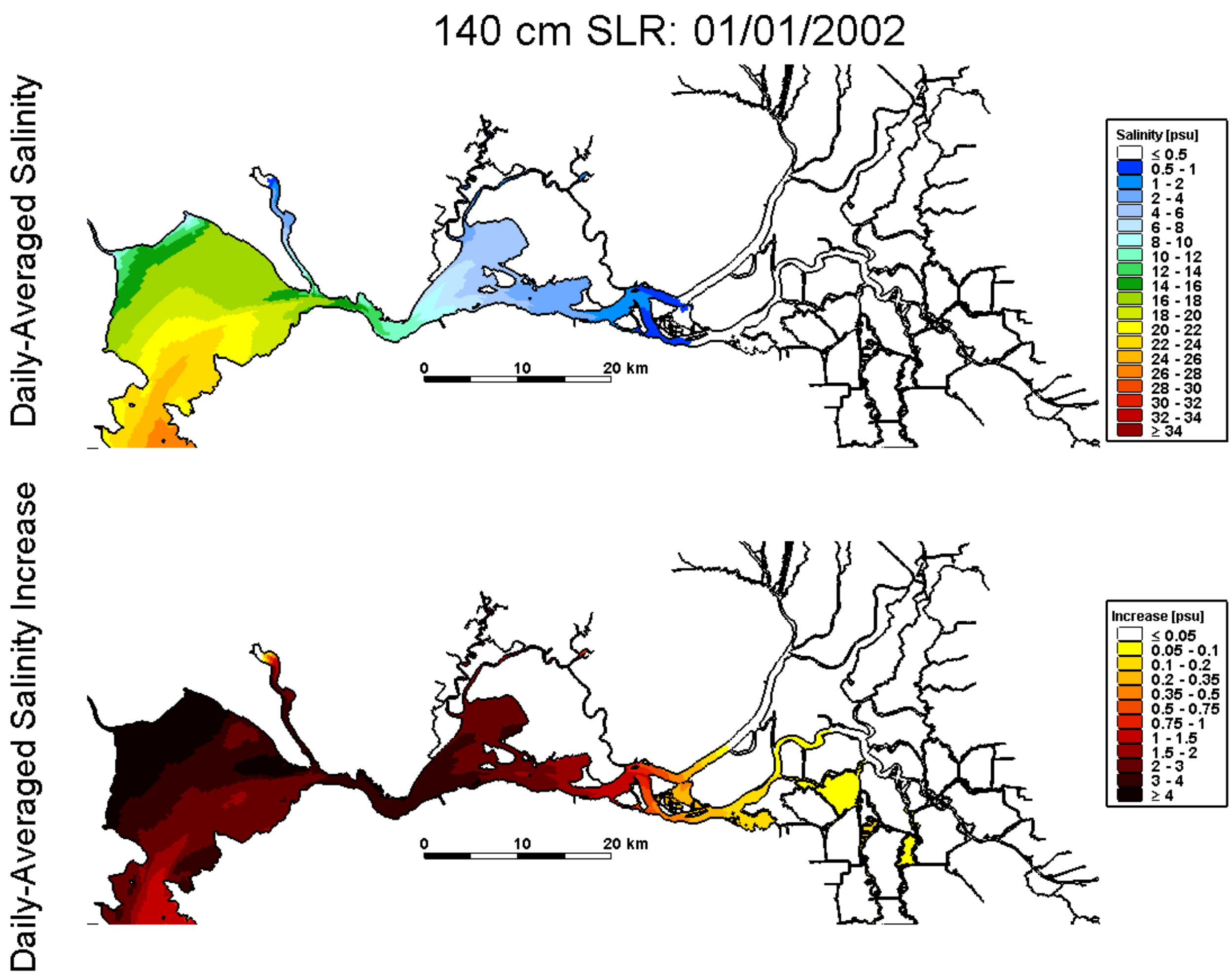


Figure 4.5-1 Predicted daily-averaged depth-average salinity on January 1, 2002 for the 140 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on January 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR scenario.

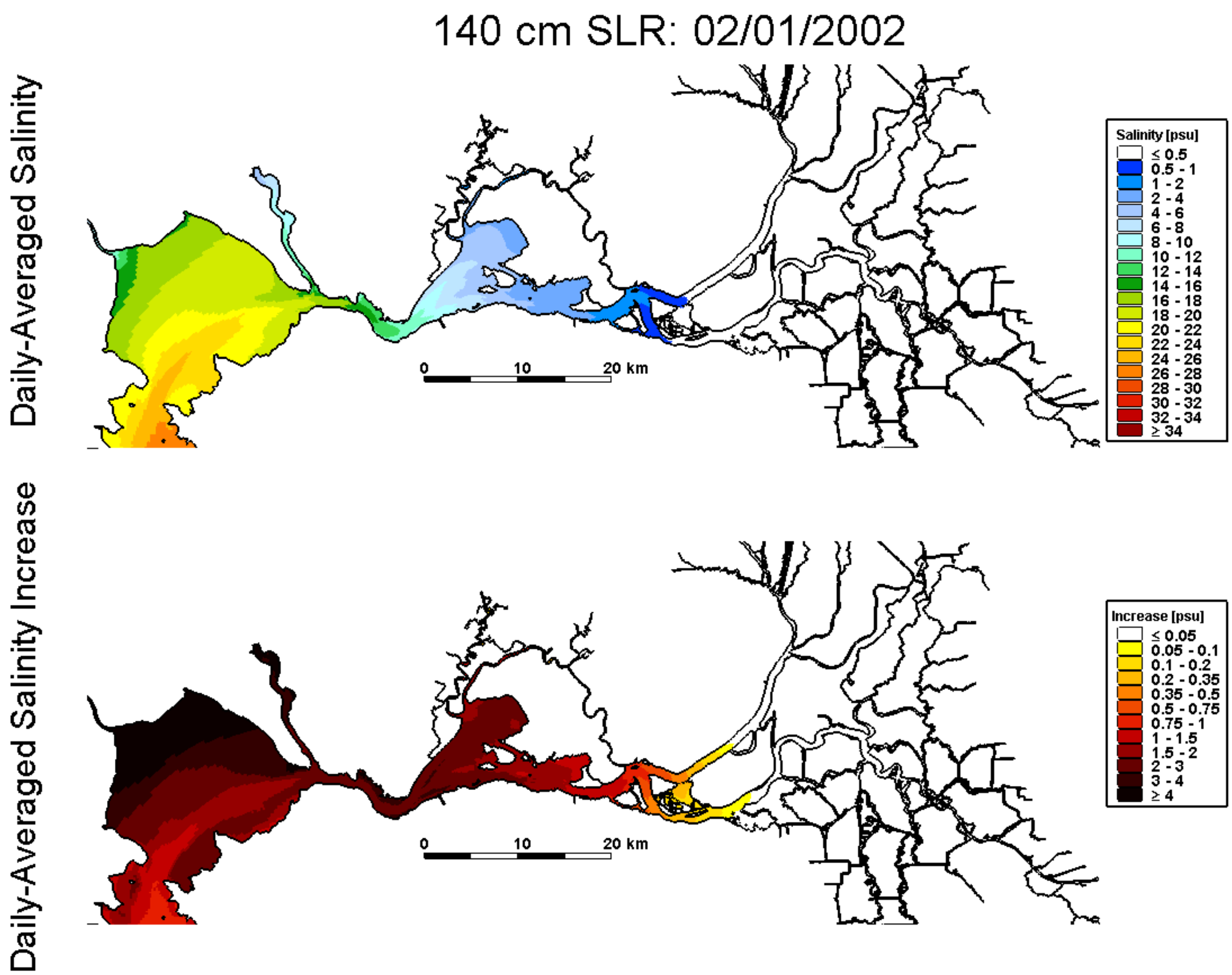


Figure 4.5-2 Predicted daily-averaged depth-average salinity on February 1, 2002 for the 140 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on February 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR scenario.

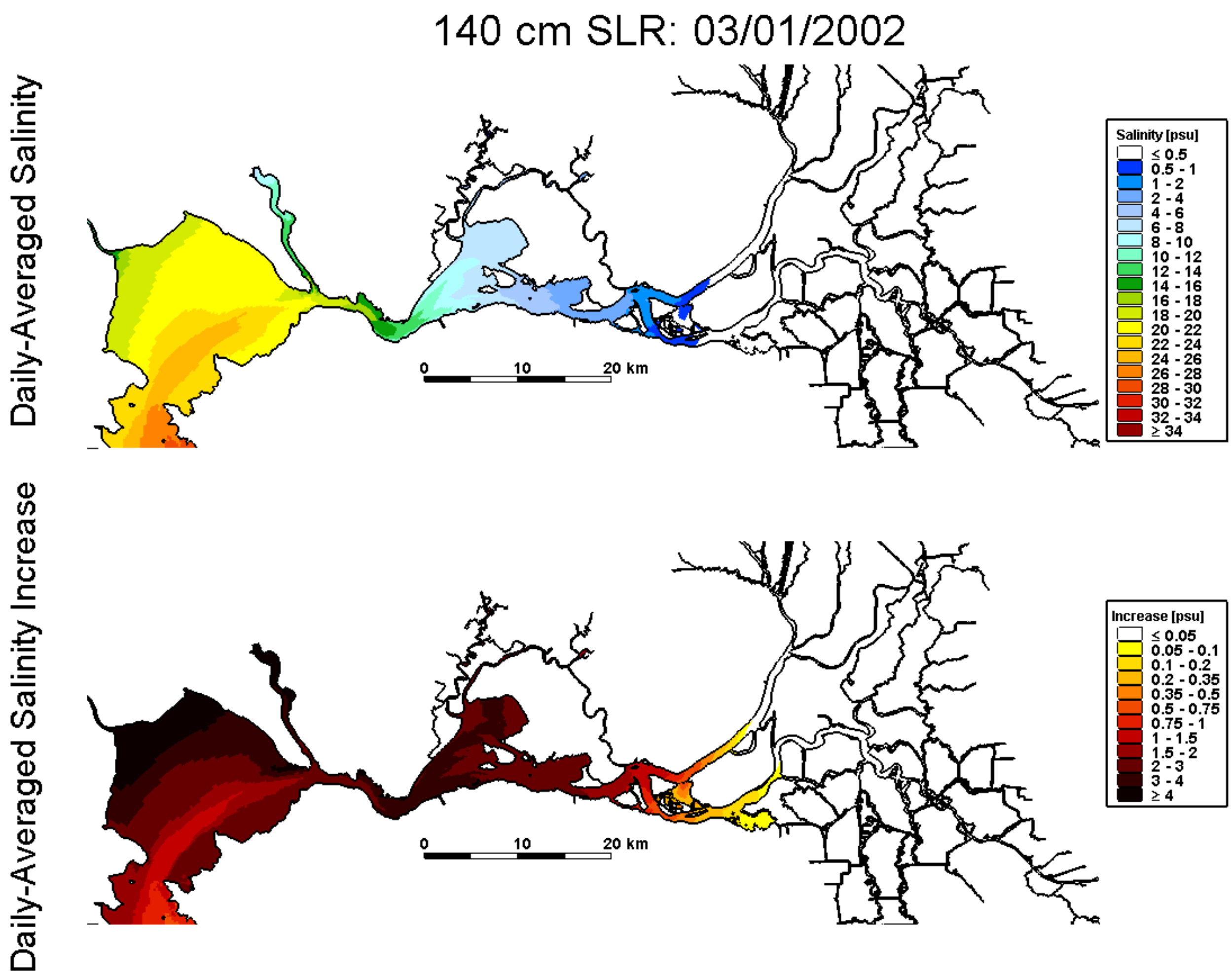


Figure 4.5-3 Predicted daily-averaged depth-average salinity on March 1, 2002 for the 140 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on March 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR scenario.

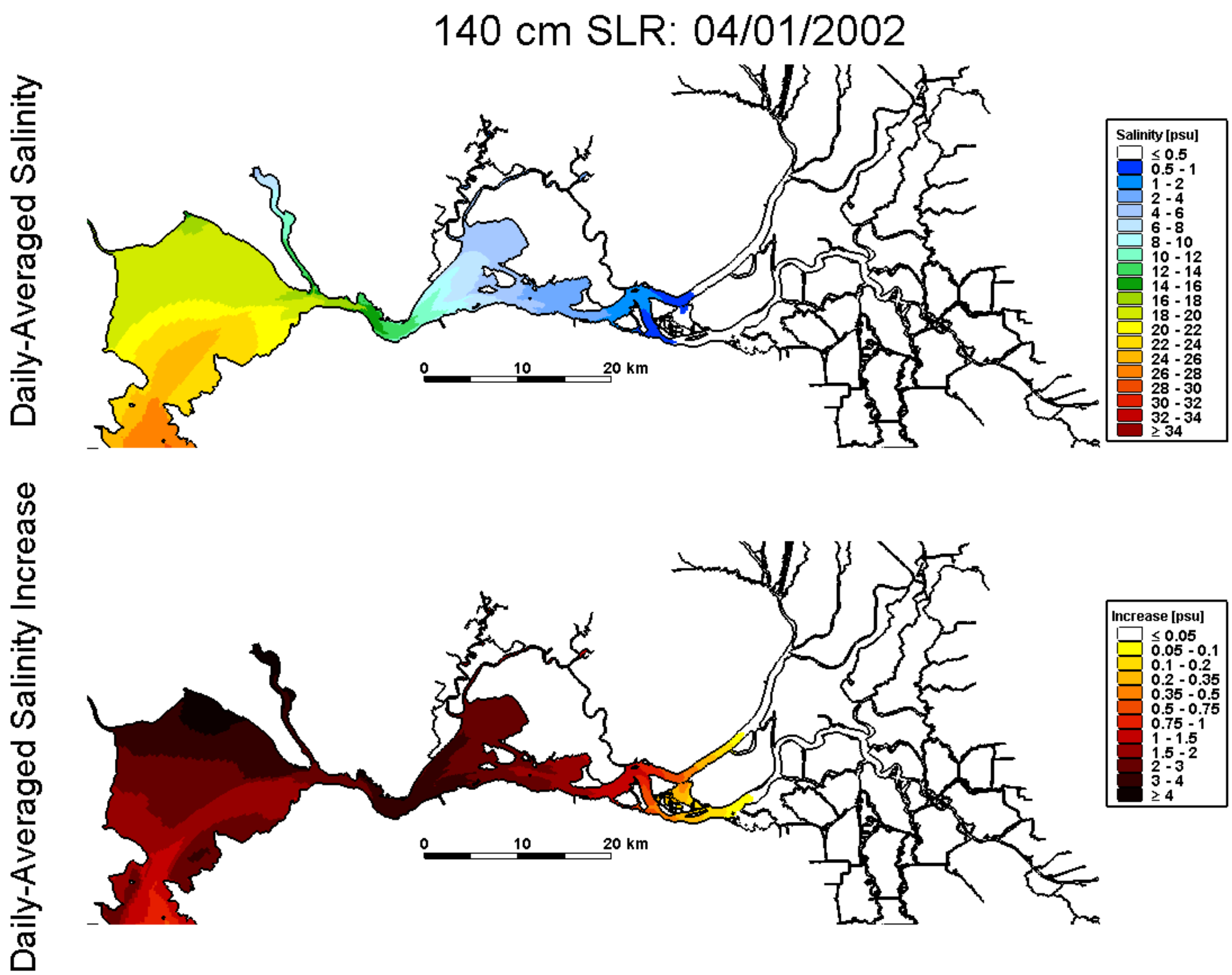


Figure 4.5-4 Predicted daily-averaged depth-average salinity on April 1, 2002 for the 140 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on April 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR scenario.

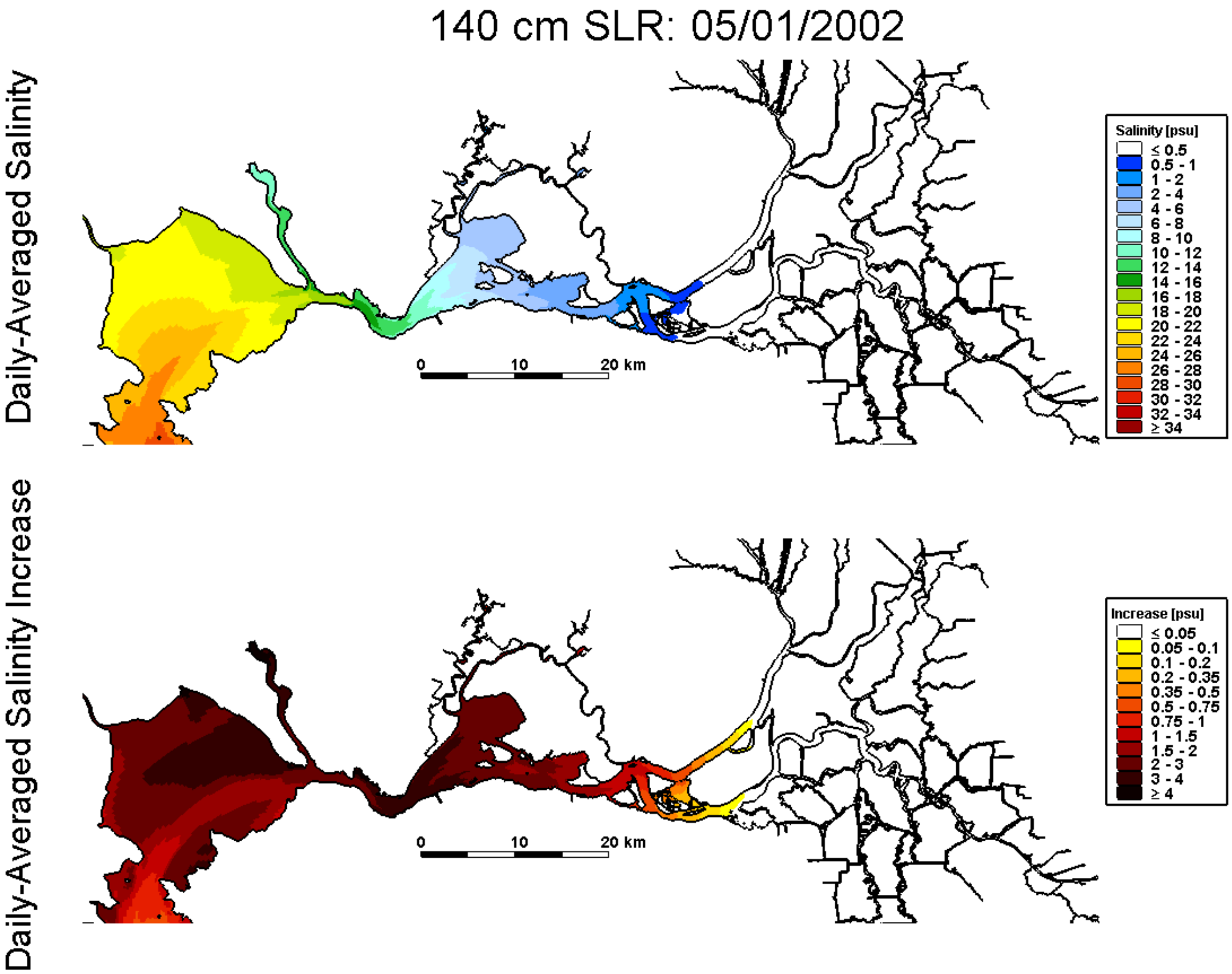


Figure 4.5-5 Predicted daily-averaged depth-average salinity on May 1, 2002 for the 140 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on May 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR scenario.

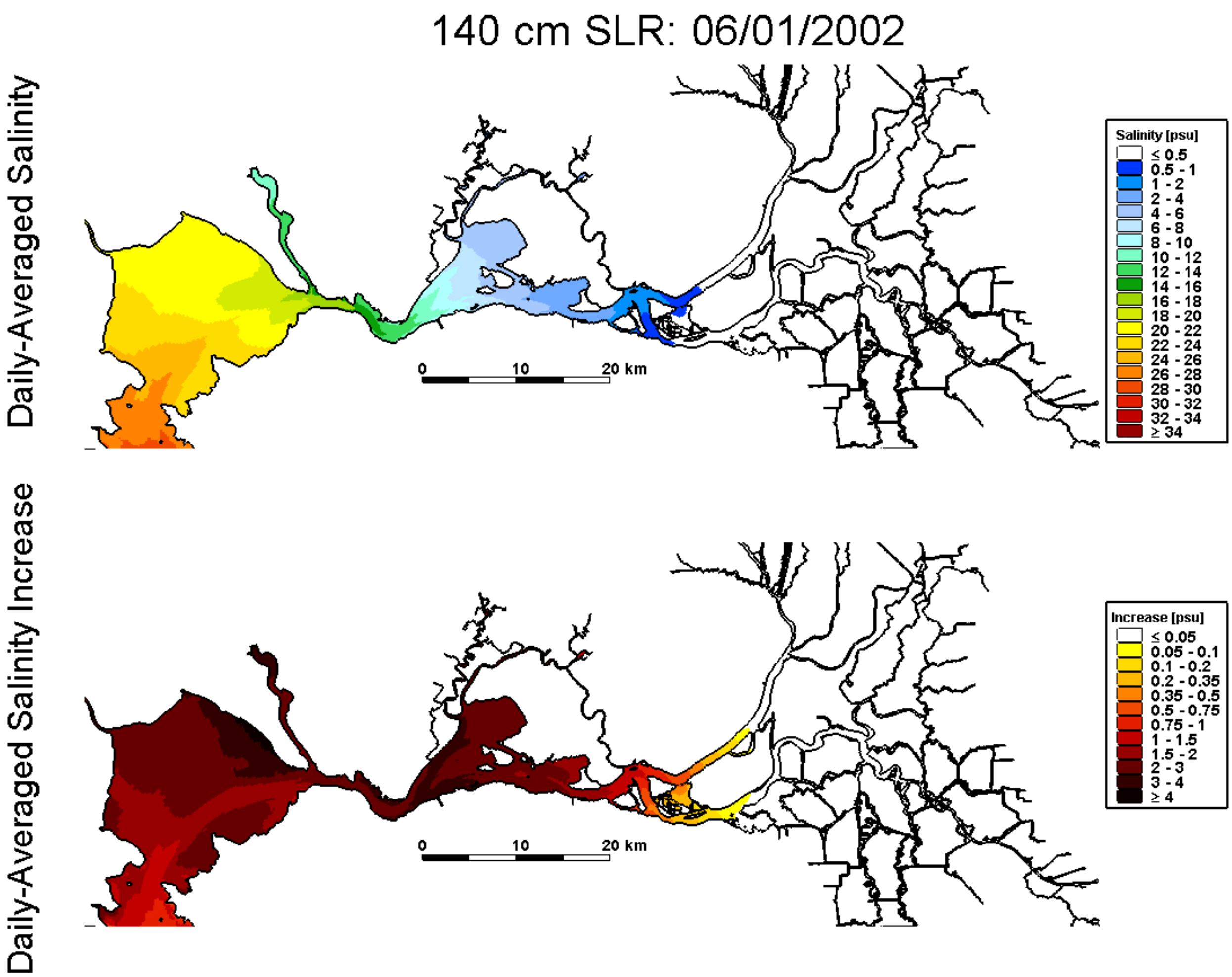


Figure 4.5-6 Predicted daily-averaged depth-average salinity on June 1, 2002 for the 140 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on June 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR scenario.

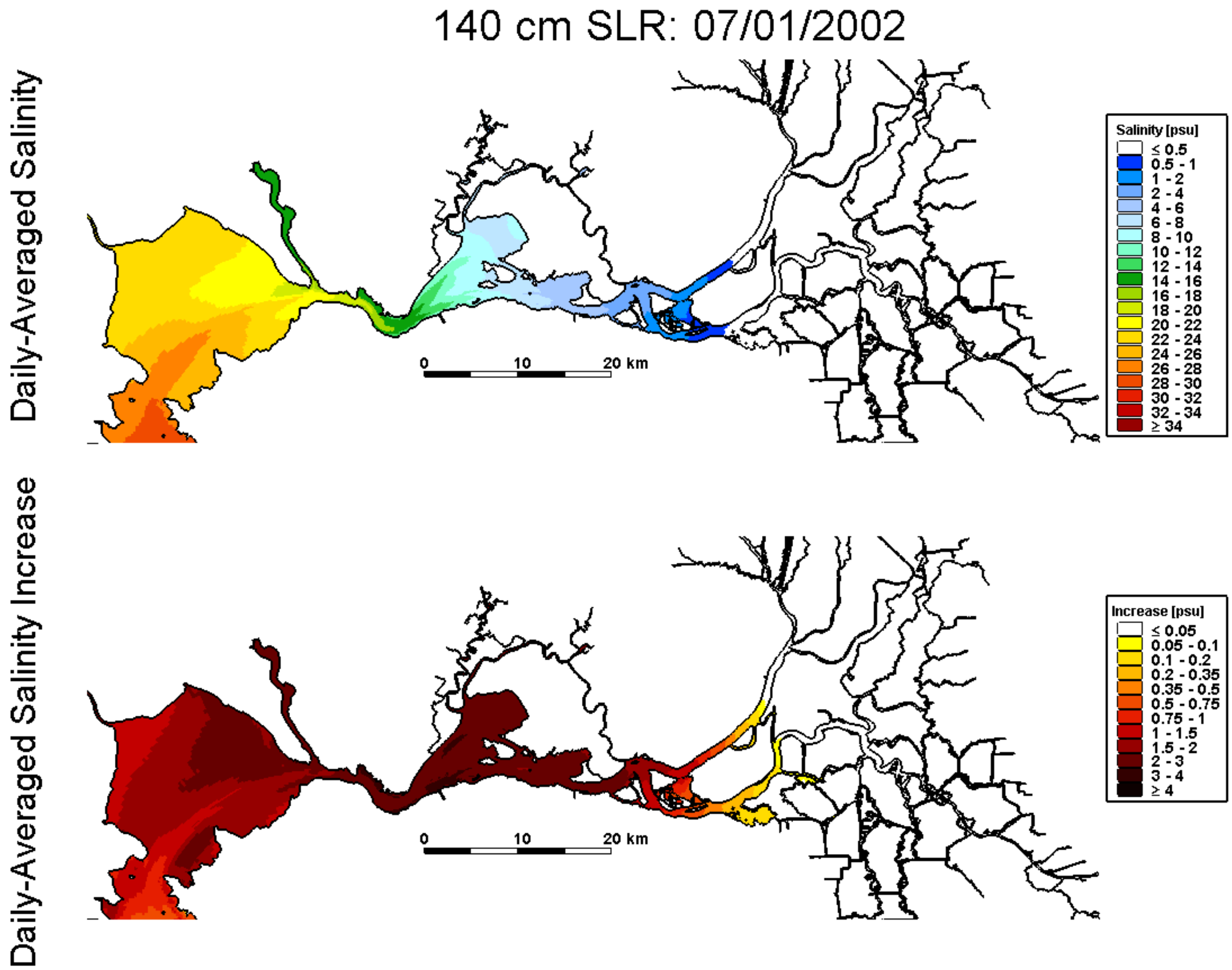


Figure 4.5-7 Predicted daily-averaged depth-average salinity on July 1, 2002 for the 140 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on July 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR scenario.

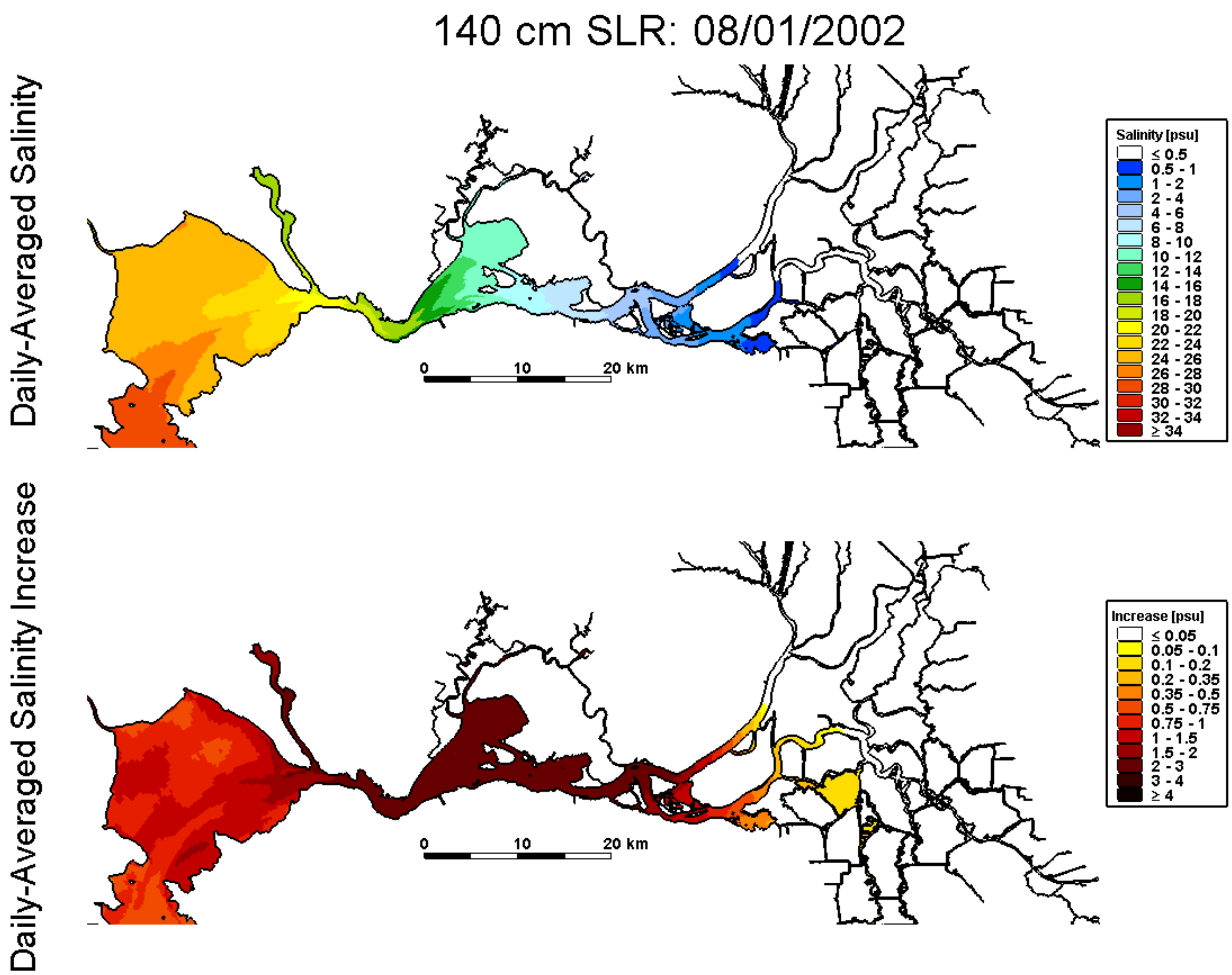


Figure 4.5-8 Predicted daily-averaged depth-average salinity on August 1, 2002 for the 140 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on August 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR scenario.

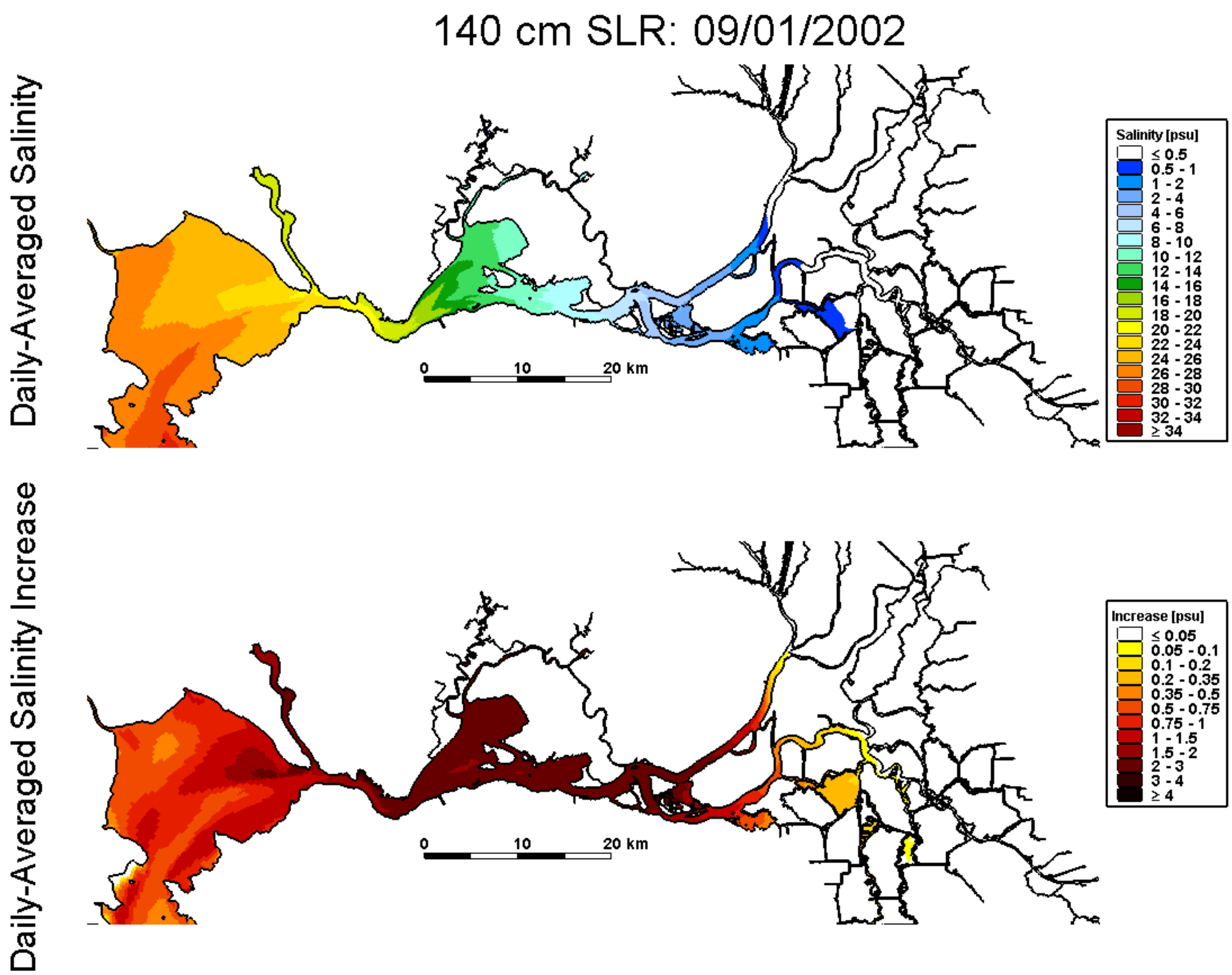


Figure 4.5-9 Predicted daily-averaged depth-average salinity on September 1, 2002 for the 140 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on September 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR scenario.

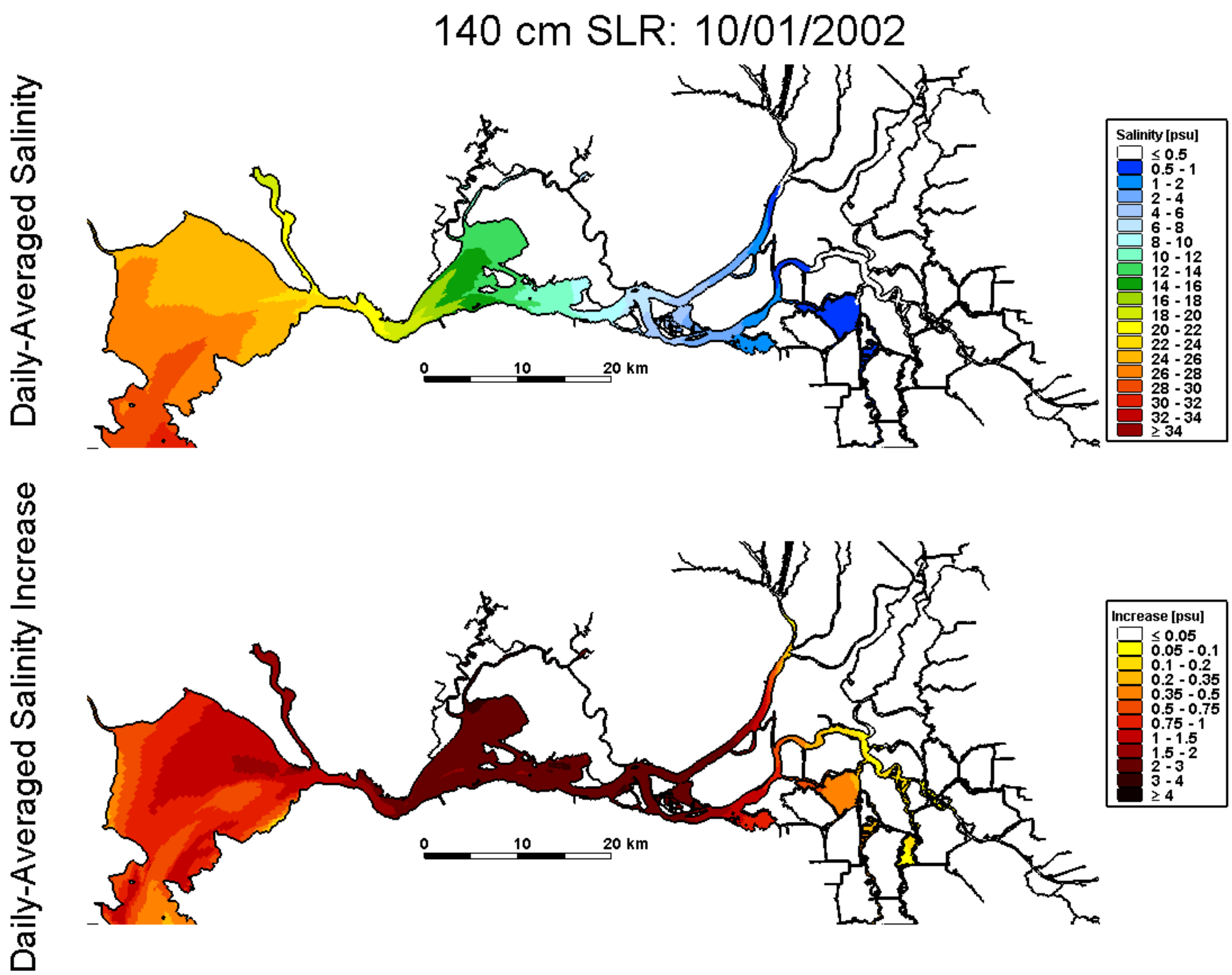


Figure 4.5-10 Predicted daily-averaged depth-average salinity on October 1, 2002 for the 140 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on October 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR scenario.

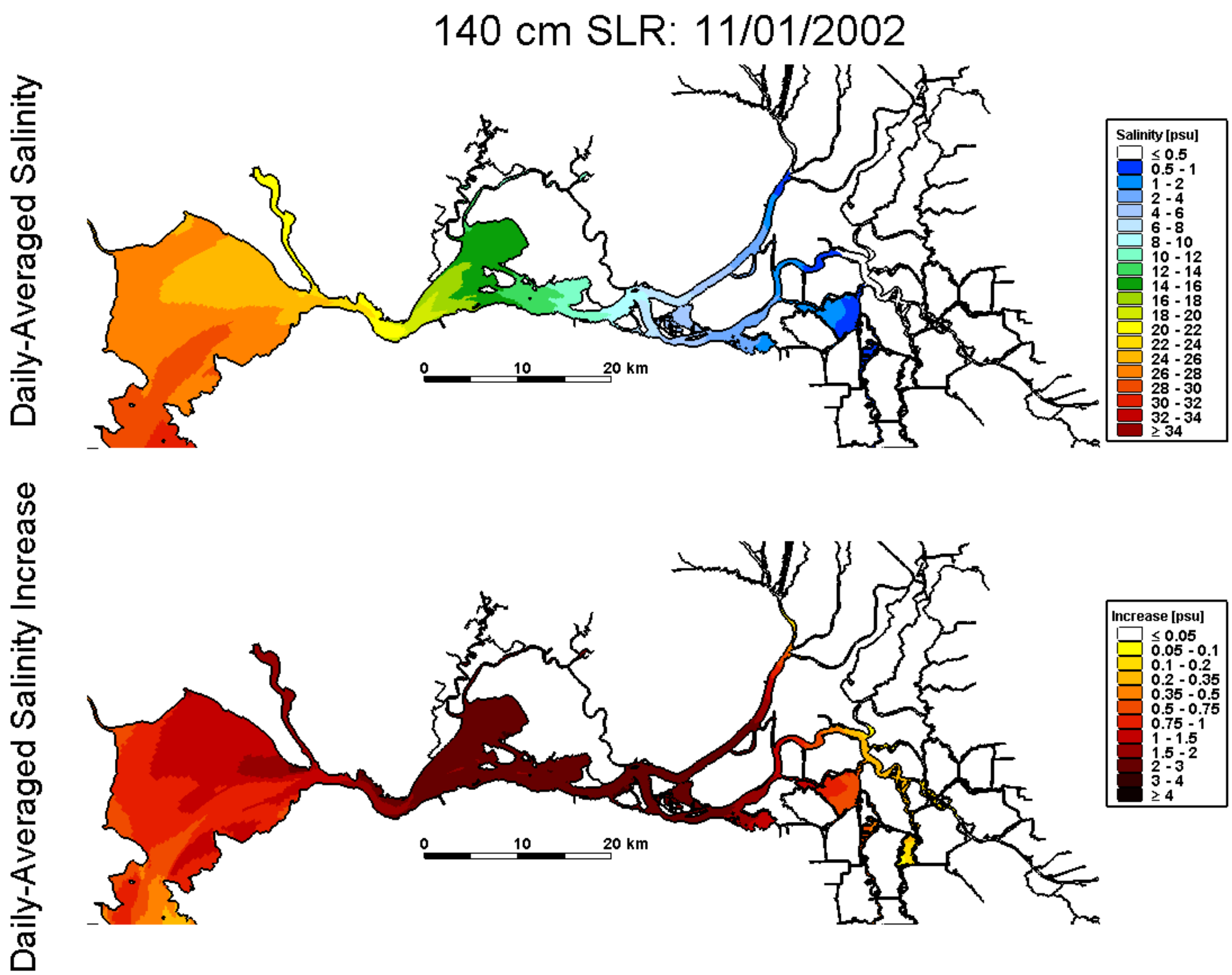


Figure 4.5-11 Predicted daily-averaged depth-average salinity on November 1, 2002 for the 140 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on November 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR scenario.

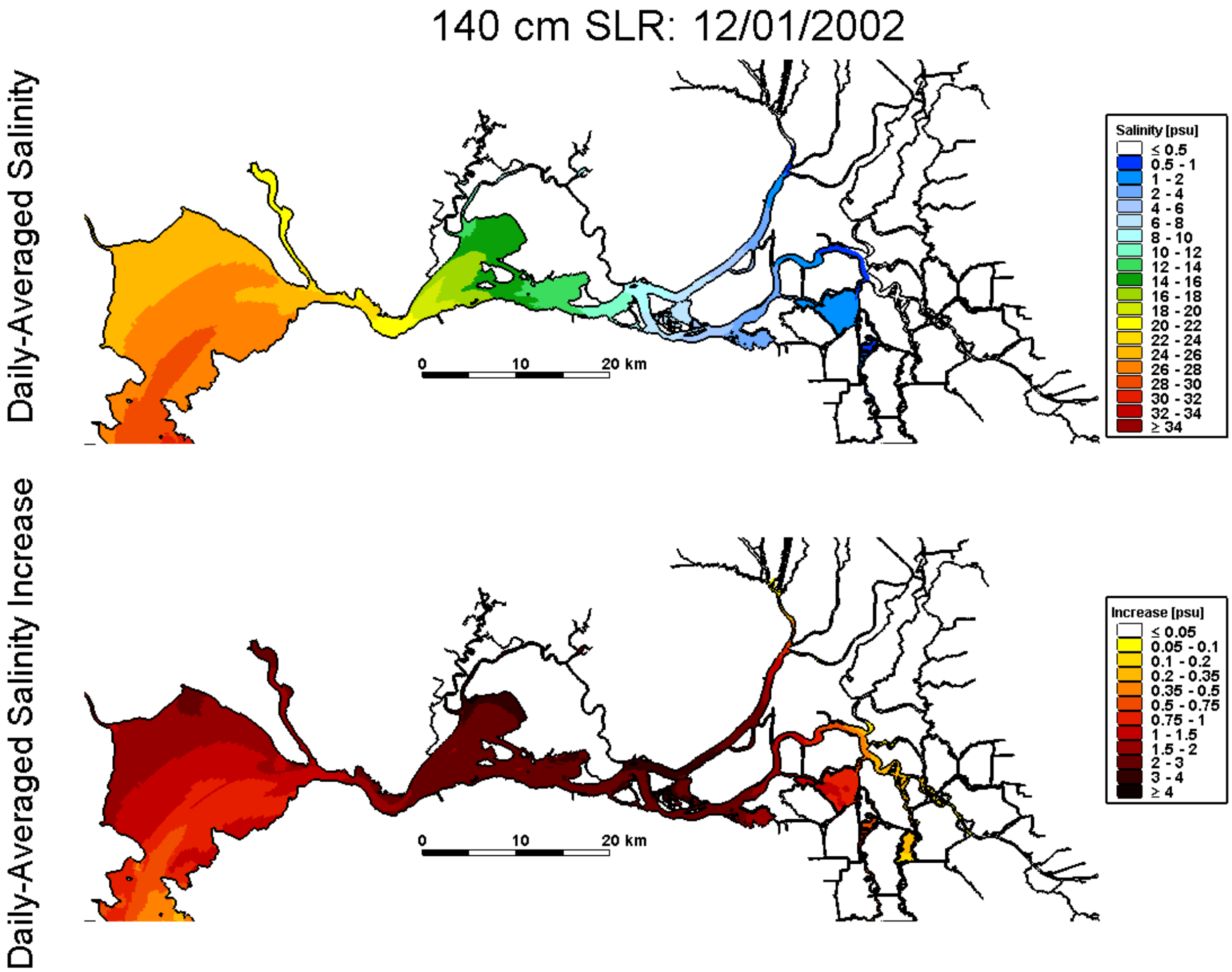


Figure 4.5-12 Predicted daily-averaged depth-average salinity on December 1, 2002 for the 140 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on December 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR scenario.

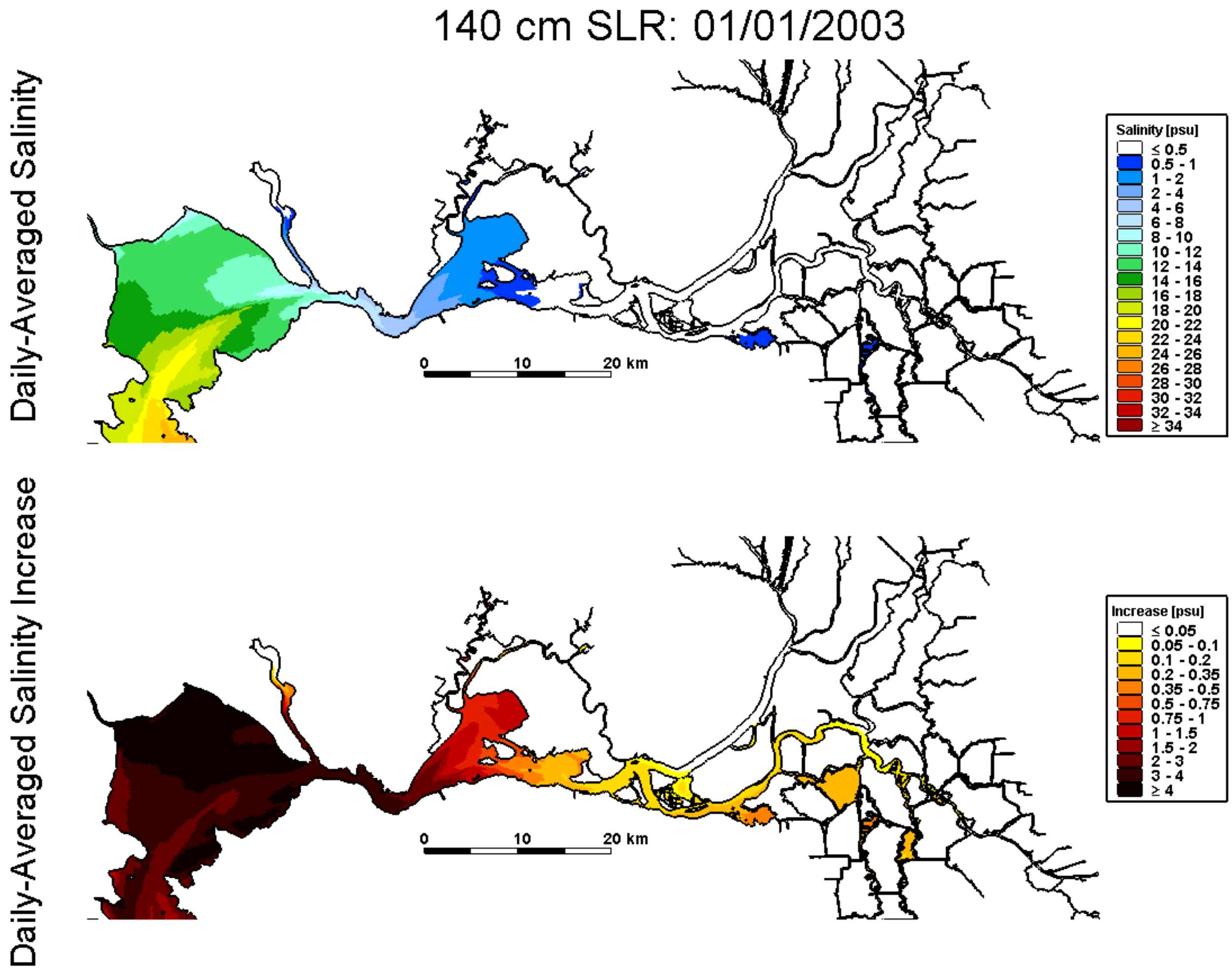


Figure 4.5-13 Predicted daily-averaged depth-average salinity on January 1, 2003 for the 140 cm SLR scenario (top); predicted increase in daily-averaged depth-average salinity on January 1, 2003 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR scenario.

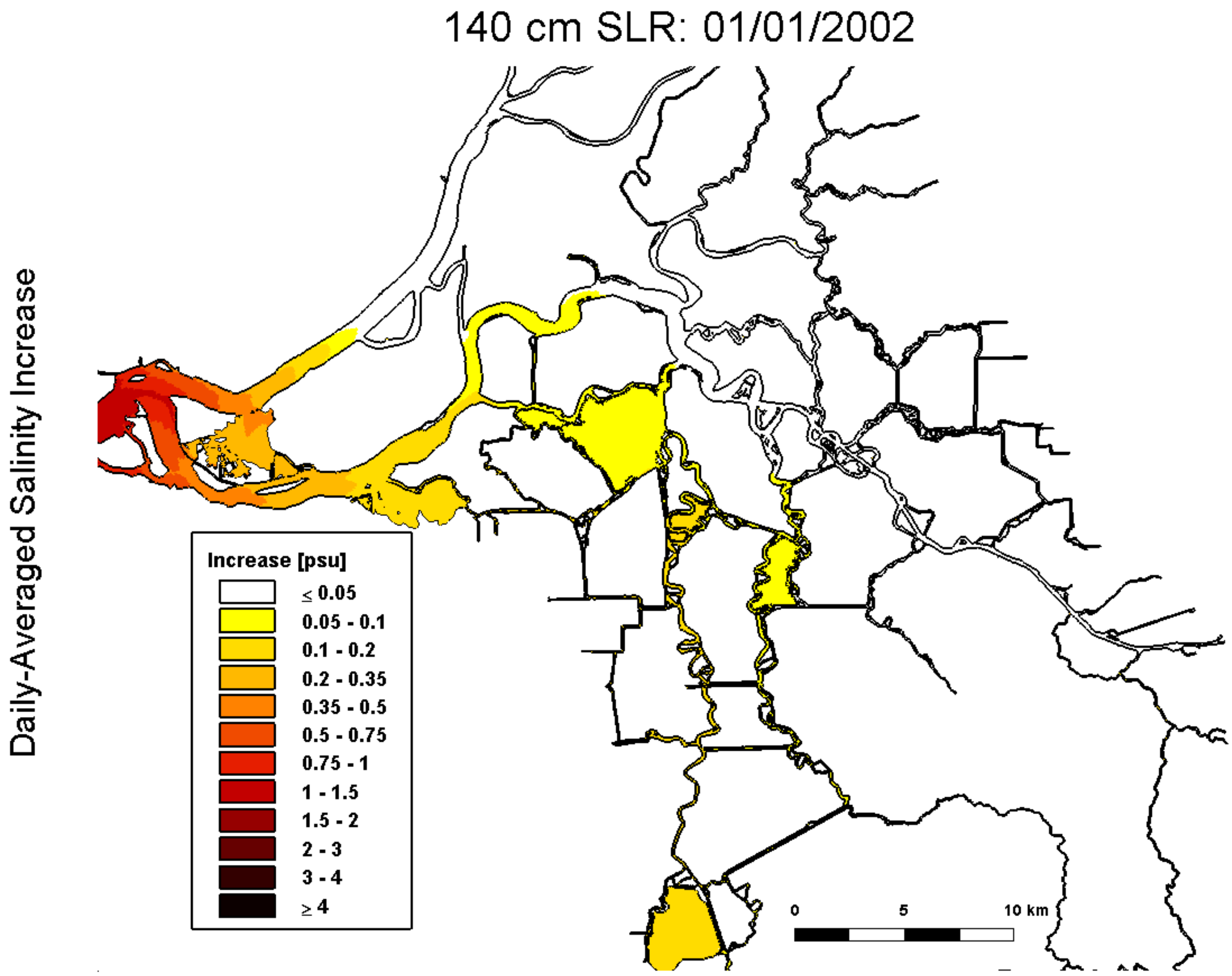


Figure 4.5-14 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on January 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR scenario.

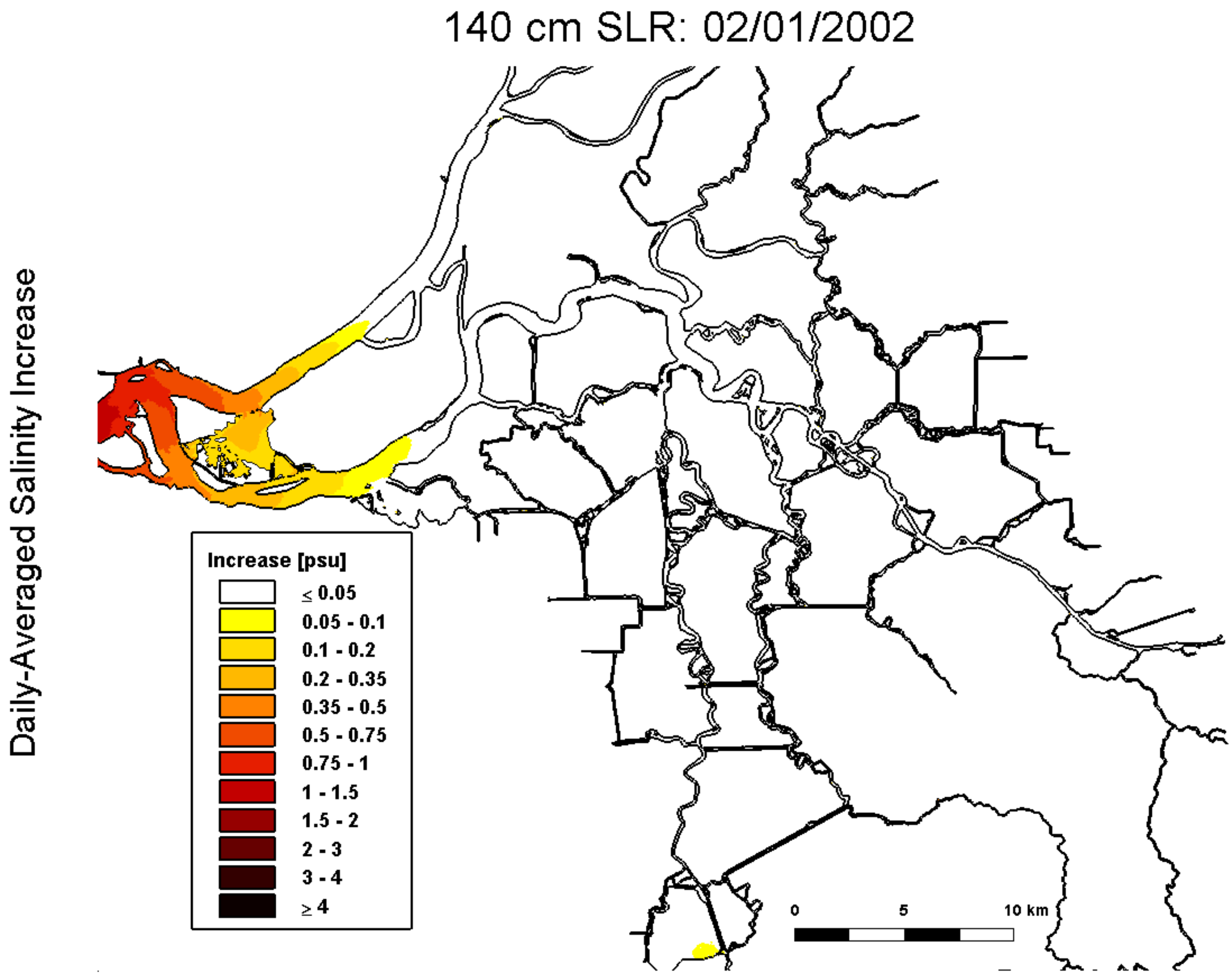


Figure 4.5-15 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on February 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR scenario.

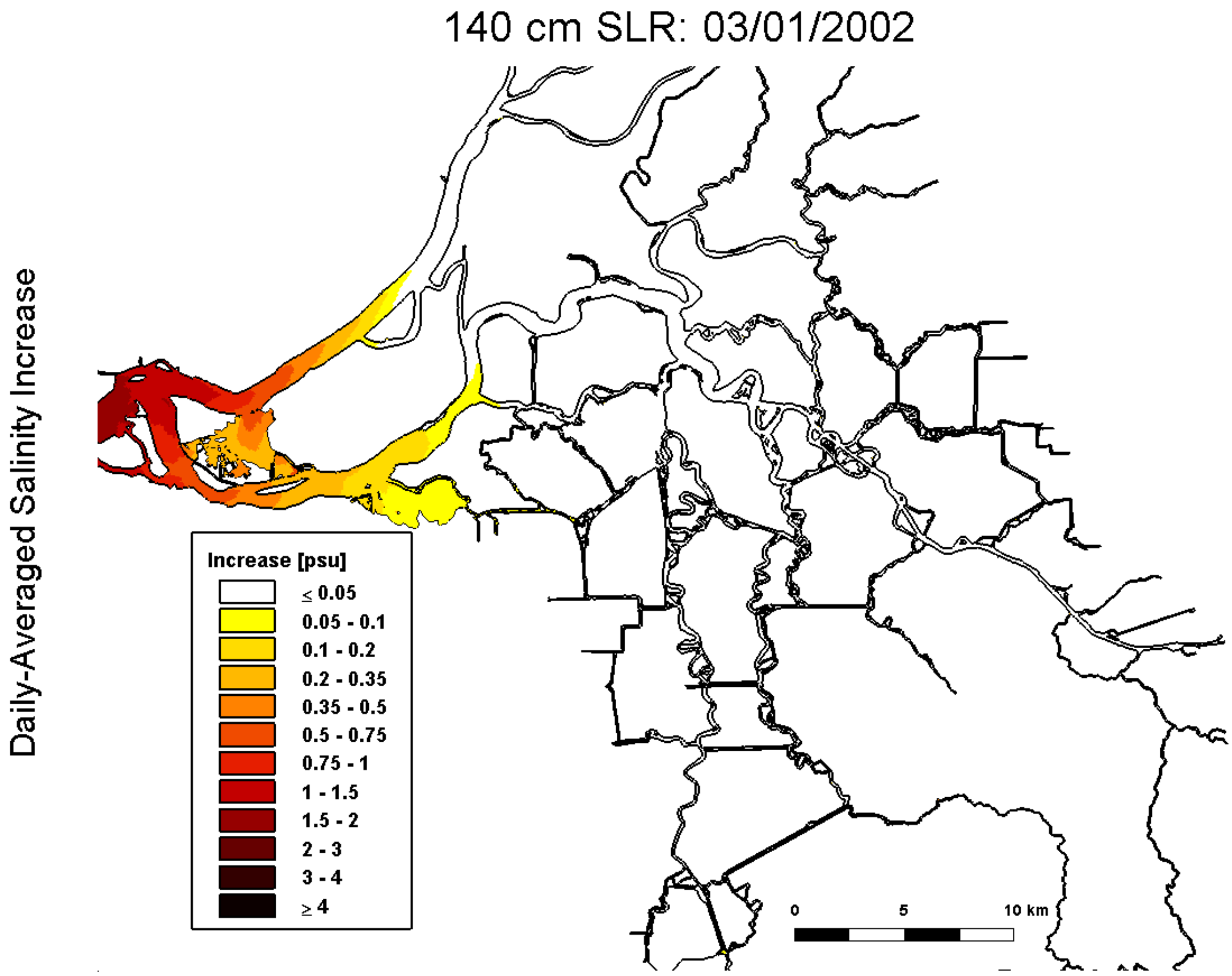


Figure 4.5-16 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on March 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR scenario.

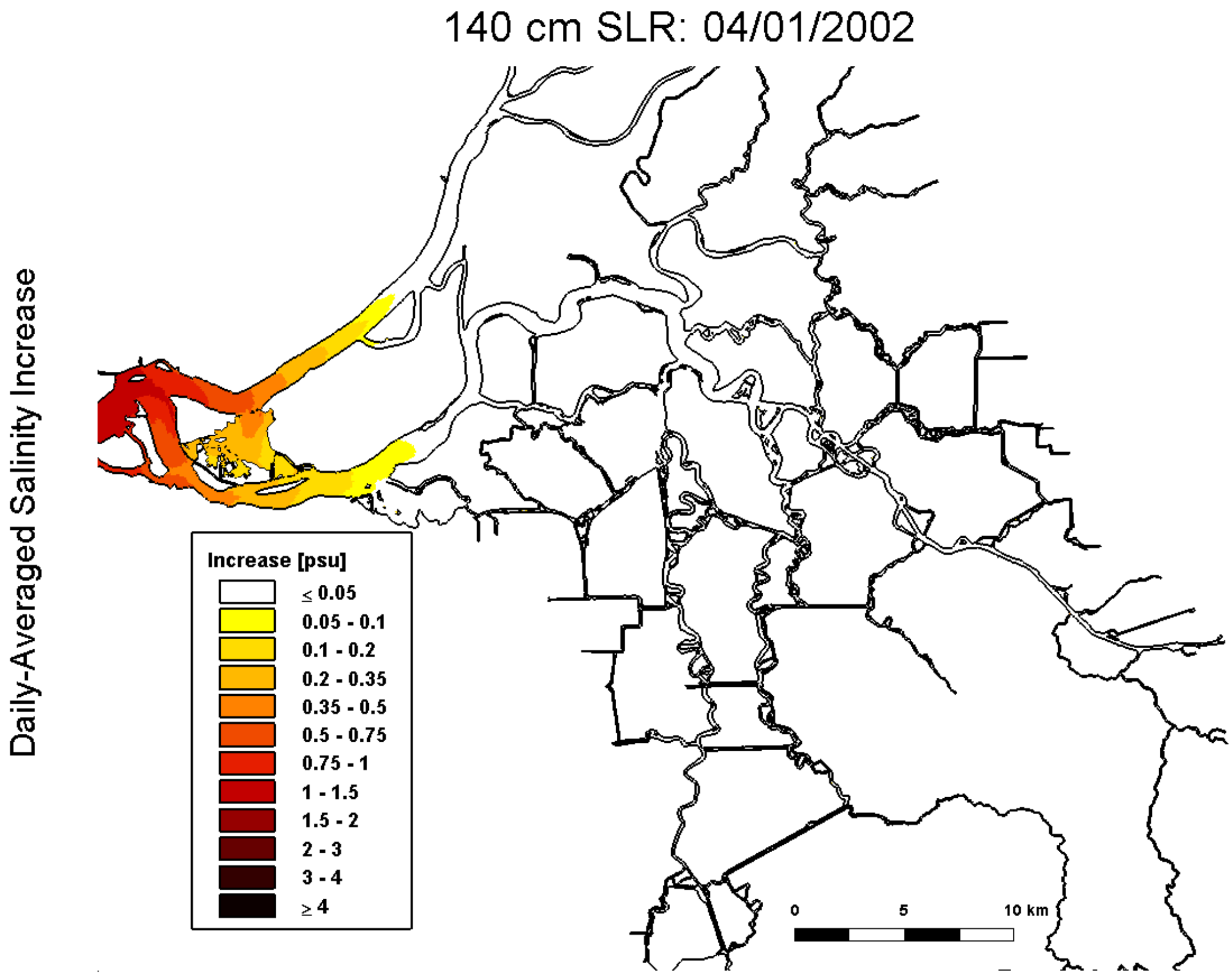


Figure 4.5-17 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on April 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR scenario.

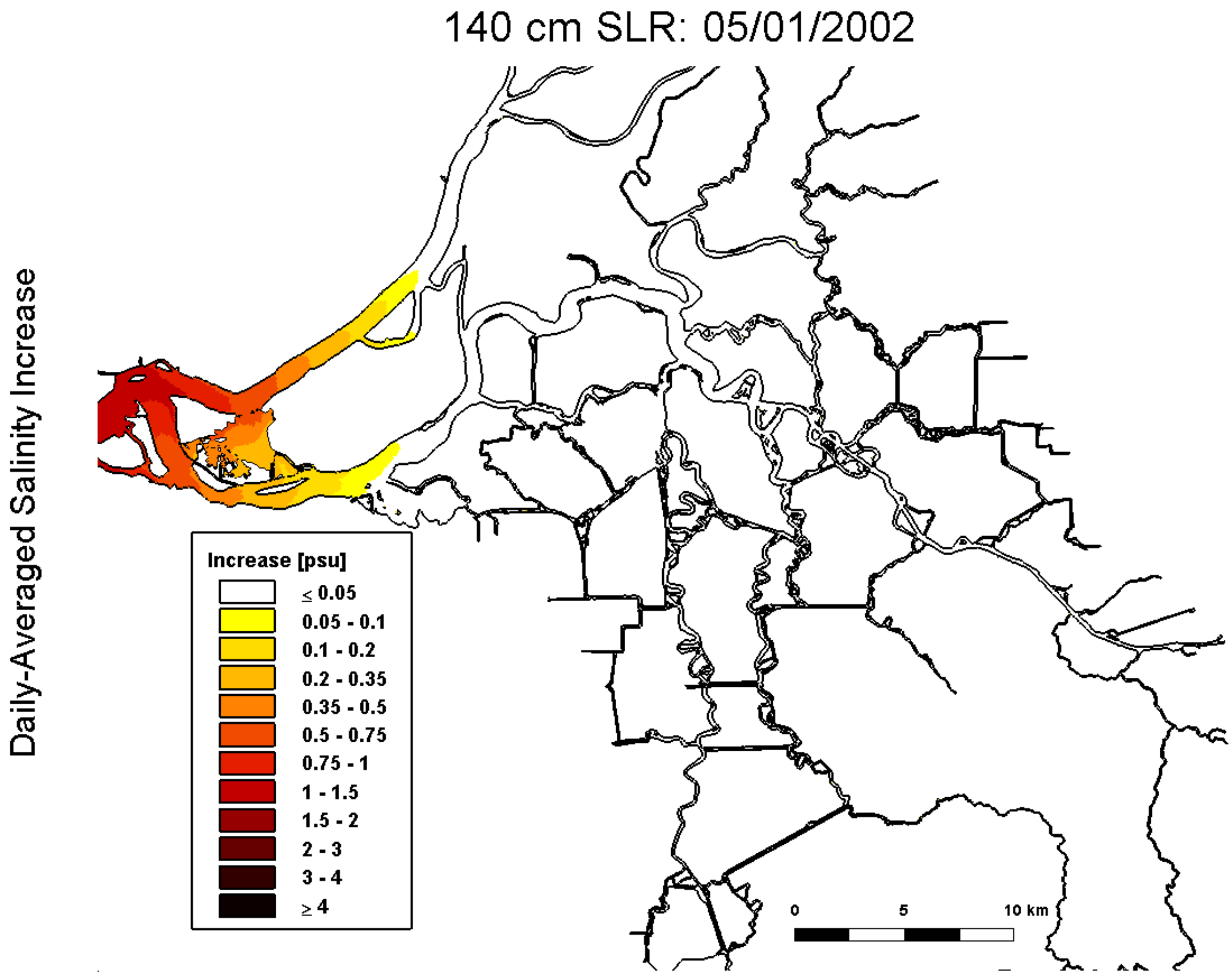


Figure 4.5-18 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on May 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR scenario.

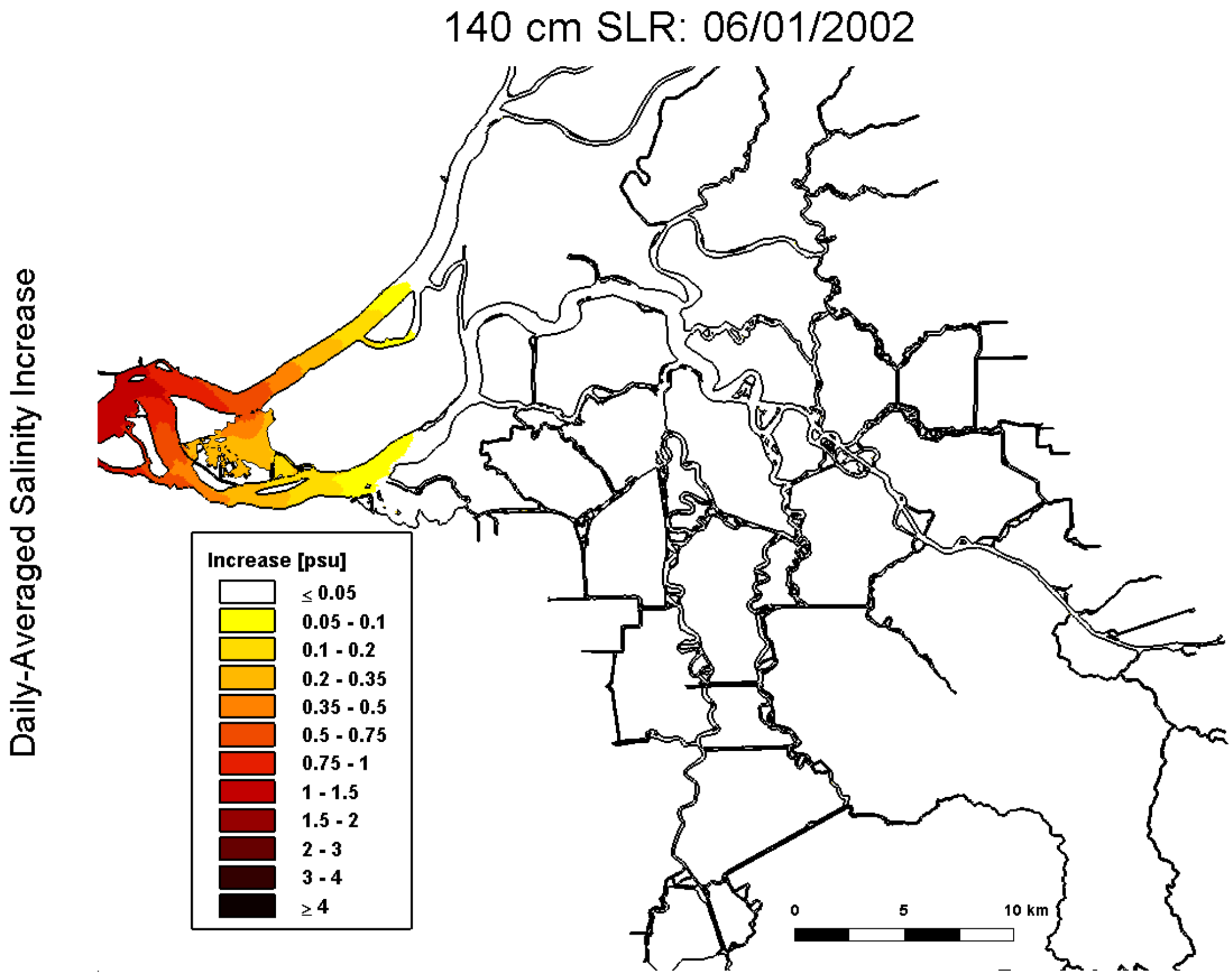


Figure 4.5-19 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on June 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR scenario.

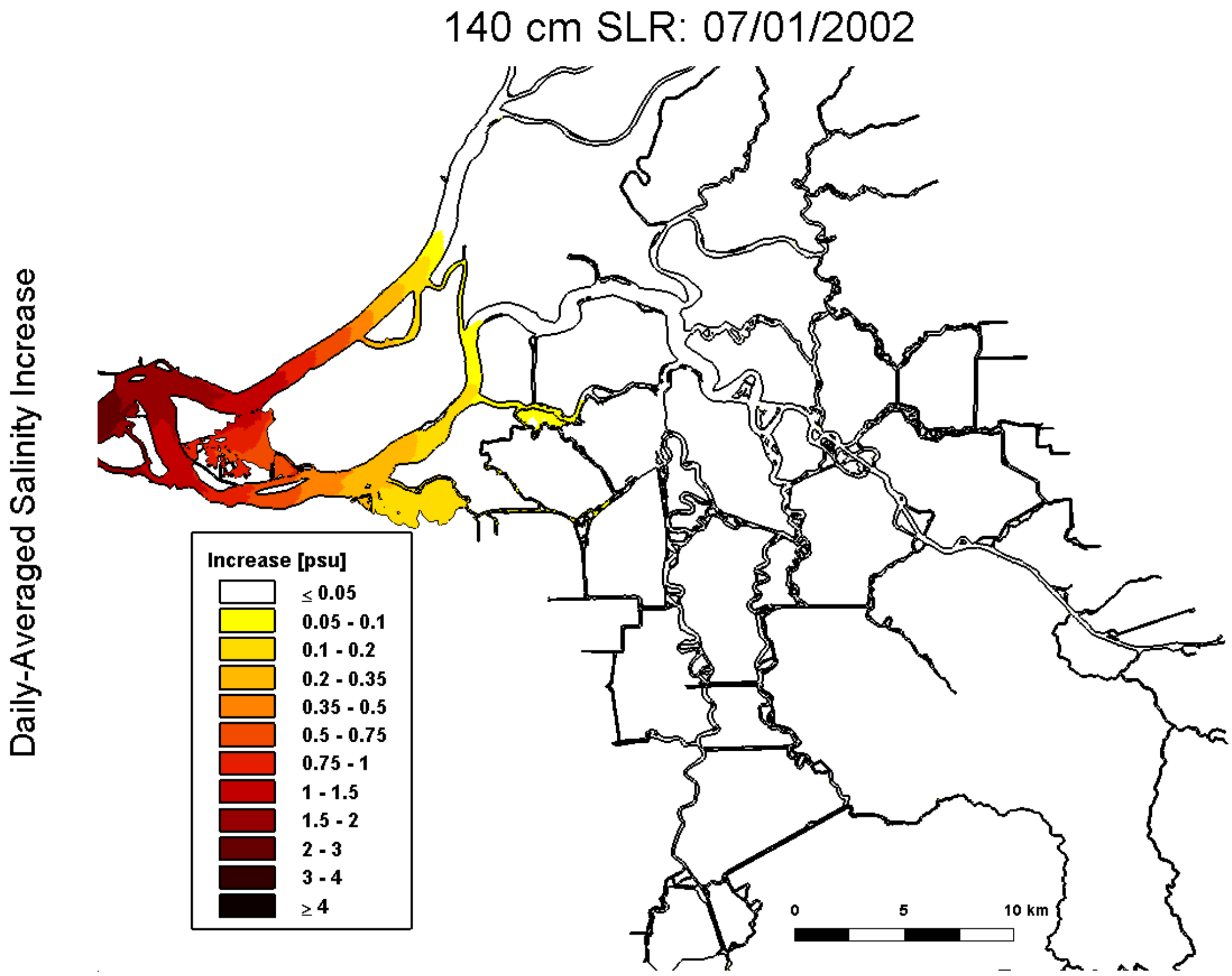


Figure 4.5-20 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on July 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR scenario.

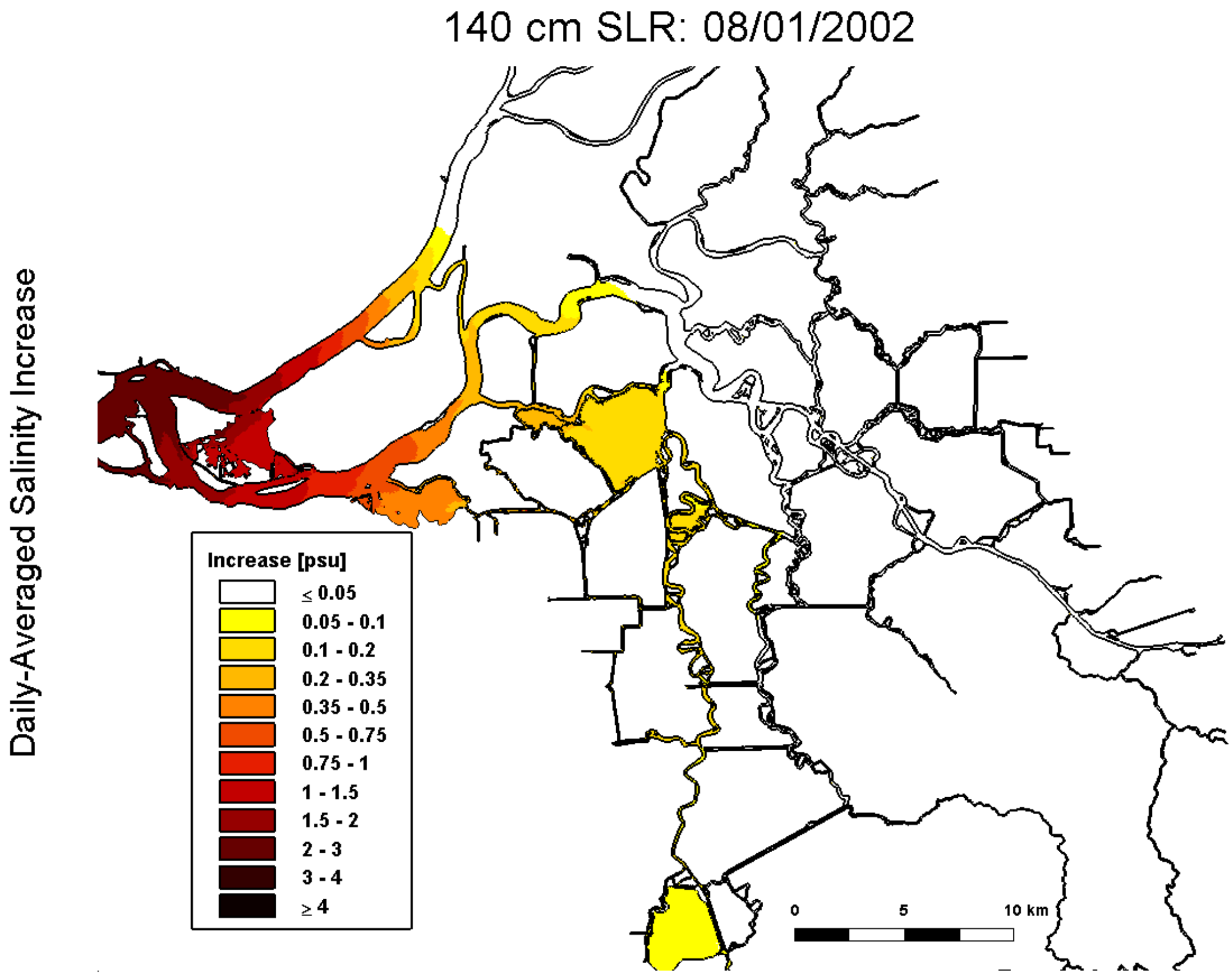


Figure 4.5-21 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on August 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR scenario.

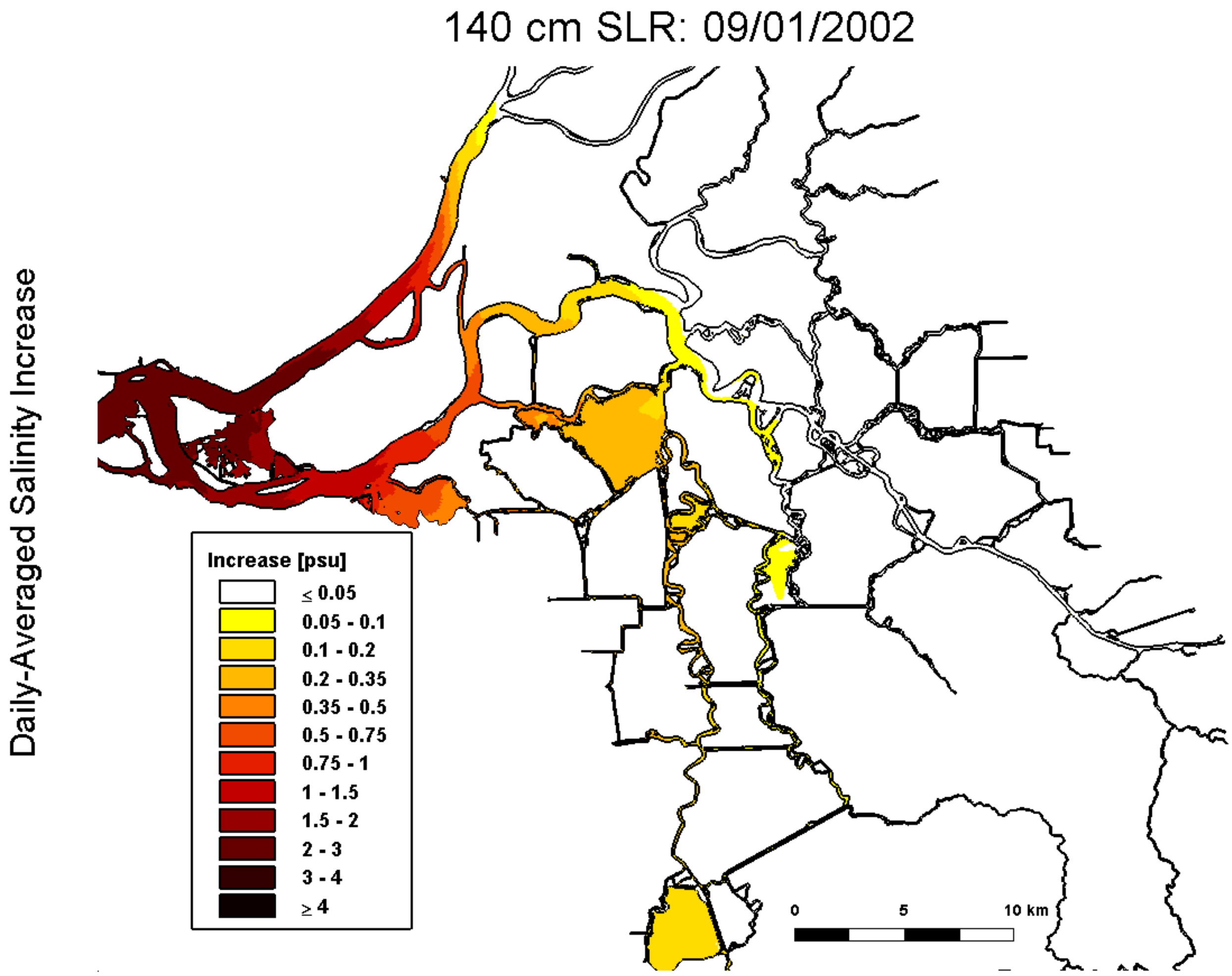


Figure 4.5-22 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on September 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR scenario.

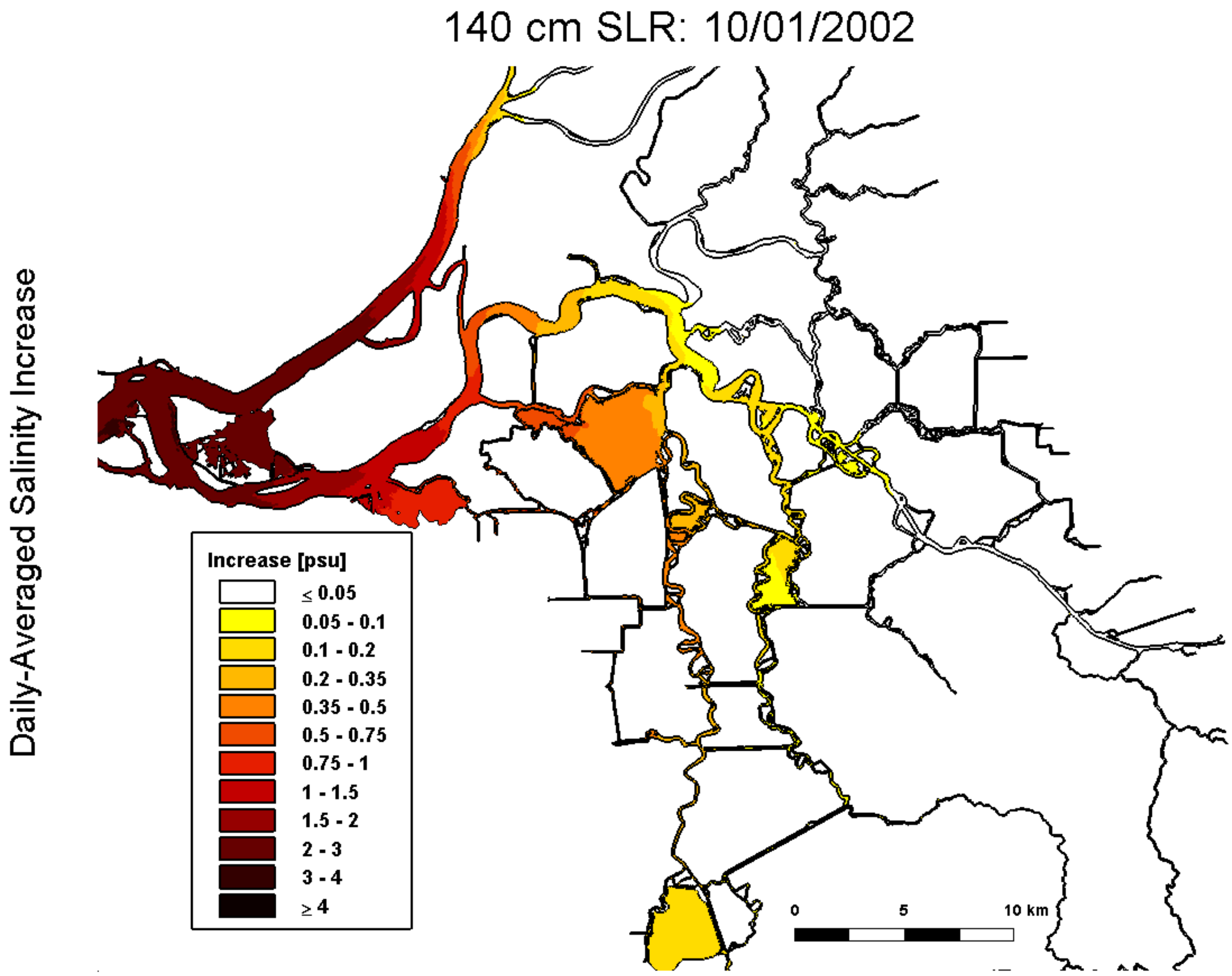


Figure 4.5-23 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on October 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR scenario.

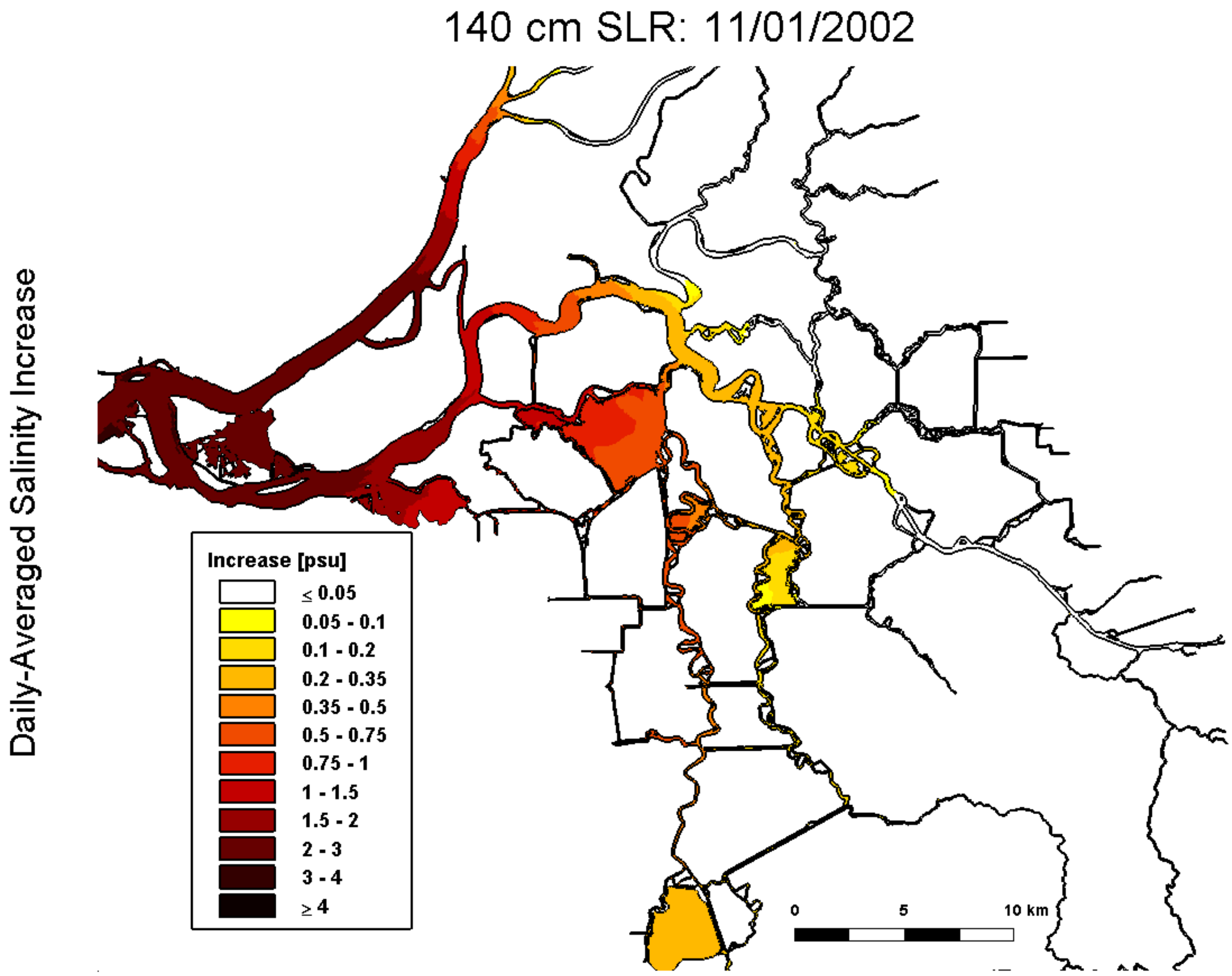


Figure 4.5-24 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on November 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR scenario.

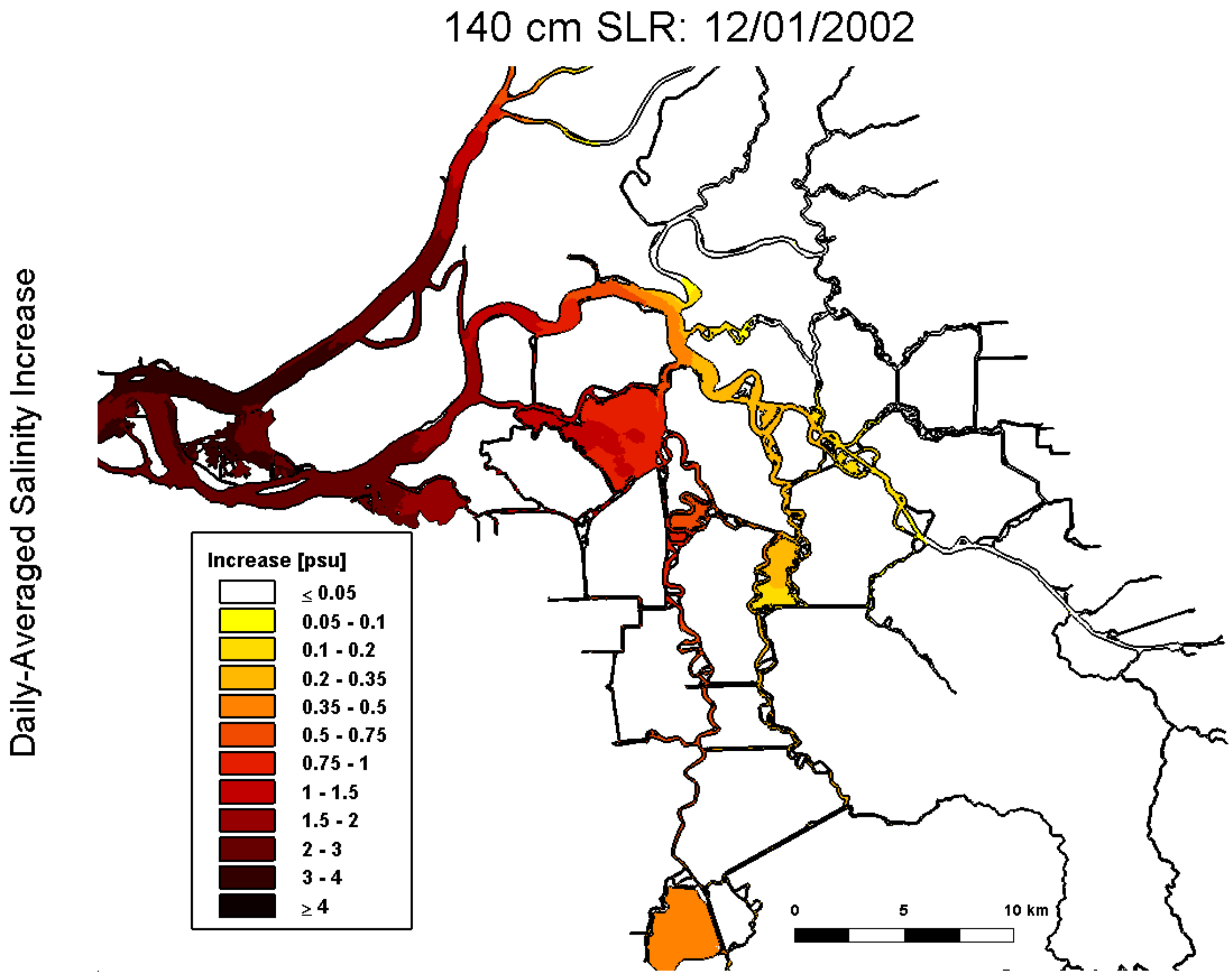


Figure 4.5-25 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on December 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR scenario.

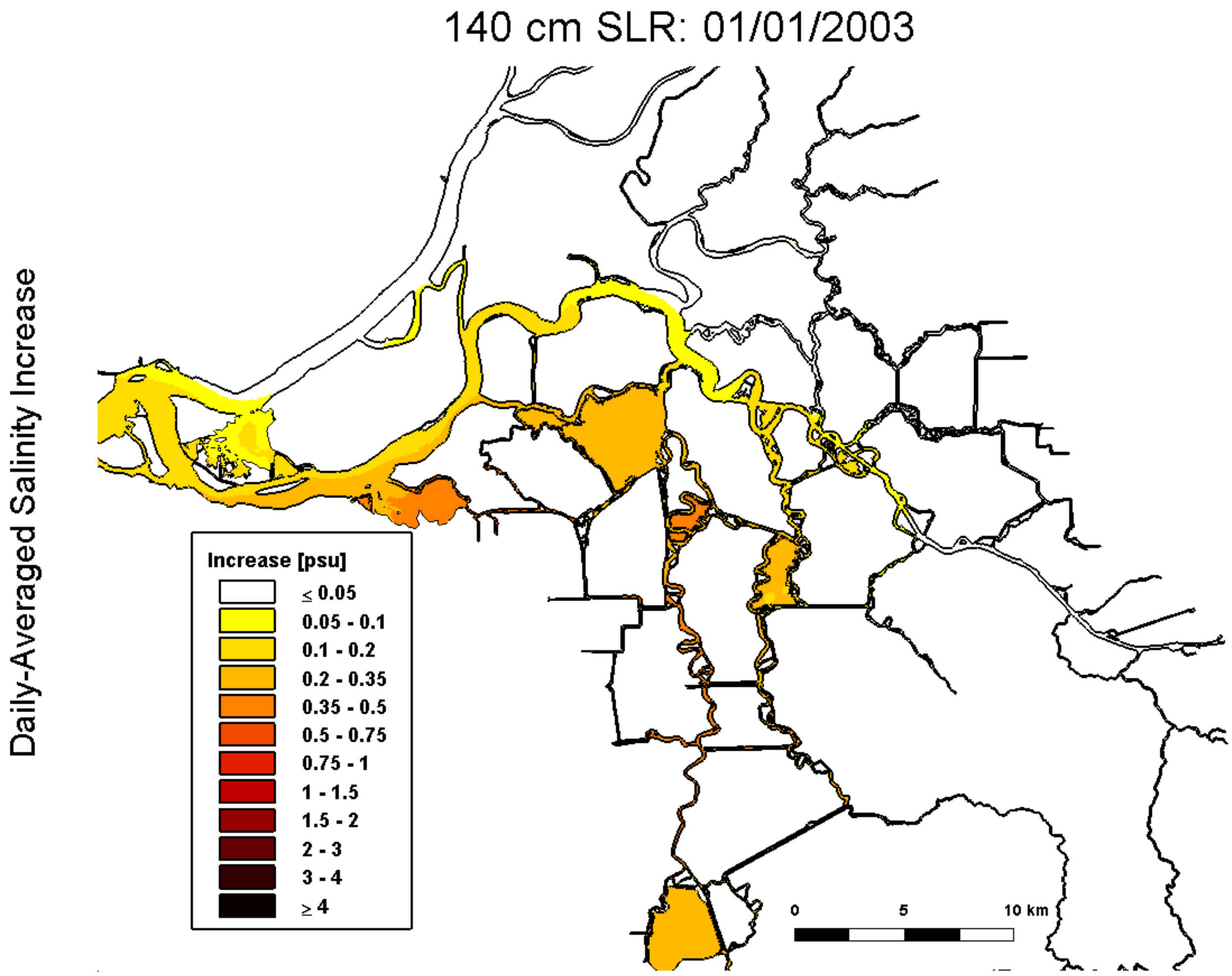


Figure 4.5-26 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on January 1, 2003 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR scenario.

4.6 Predicted Increase in Salinity for 140 cm SLR with 5% Amplification Scenario

Figure 4.6-1 through 4.6-13 show the predicted salinity along the northern portion of the San Francisco Estuary, spanning from San Pablo Bay through the Sacramento-San Joaquin Delta for the 140 cm SLR with 5% Amplification scenario. The top panel of each figure shows the predicted daily-averaged depth-average salinity for the 140 cm SLR with 5% Amplification scenario. The lower panel shows the predicted salinity increase computed by subtracting the predicted daily-averaged depth-average salinity for the Baseline (0 cm SLR) scenario from the predicted daily-averaged depth-average salinity for the 140 cm SLR with 5% Amplification scenario. Figures 4.6-14 through 4.6-26 show the predicted salinity increases resulting from the 140 cm SLR with 5% Amplification scenario in the Sacramento-San Joaquin Delta.

At the beginning of the analysis period on January 1, 2002, significant salinity increases are evident in the Delta, indicating that the salinity increases from the previous fall period have not been fully flushed out. Salinity increases between 1. 0 and 1.50 psu are predicted between Chipps Island and Collinsville and predicted salinity increases of up to 0.05 psu are predicted upstream to Emmaton on the Sacramento River. Along the San Joaquin River predicted salinity increases of 0.1 and 0.2 psu extend from Big Break to False River and predicted salinity increases of between 0.05 psu and 1.0 psu extend upstream to Sevenmile Slough. salinity increases of between 0.05 and 0.10 psu are predicted in Franks Tract. South of Franks Tract, predicted salinity increases between 0.10 and 0.20 psu extend down Old River to Clifton Court Forebay, and salinity increases of between 0.10 and 0.20 psu are predicted inside Clifton Court Forebay. Predicted salinity increases are less than 0.05 psu throughout the remaining portions of the Delta. Salinity increases between 3.0 and 4.0 psu are predicted through Carquinez Strait and salinity increases between 1.5 and 3.0 psu are predicted throughout Suisun Bay. Larger salinity increases of more than 2.0 psu are predicted in much of San Pablo Bay, with salinity increases of more than 4.0 psu predicted in northern San Pablo Bay. By February 1, 2002 much of the salinity increases have been flushed out of the Delta following the high flows in January. During the first half of the year, predicted salinity increases in Suisun Bay and the Delta remain similar to the predicted salinity increases seen on February 1, 2002, while predicted salinity increases in San Pablo Bay decrease, though the predicted salinity is increasing throughout this period.

Larger salinity increases are predicted in the Delta between July and December, with the largest predicted salinity increases in December prior to the first flush. In December, salinity increases of between 1.50 and 3.0 psu are predicted between Chipps Island and Emmaton, and salinity increases of between 0.75 and 1.5 psu are predicted in Franks Tract. South of Franks Tract, predicted salinity increases between 0.50 and 1.0 psu extend down Old River to Clifton Court Forebay, and salinity increases of between 0.55 and 0.50 psu are predicted inside Clifton Court Forebay. Predicted salinity increases extend up the San Joaquin River as far as Turner Cut. These simulations assumed no operational response to sea level rise, however it is expected significant operational response will be required to maintain water quality standards for 140 cm of sea level rise. Following high flows which occurred in December, predicted salinity on January 1, 2003 shows that the 0.50 psu isohaline is in central Suisun Bay near Port Chicago, which is much further east than in the Baseline scenario. On January 1, 2003 (Figure 4.6-26) salinity increases are predicted throughout much of the Delta indicating that the high flows in

December were not sufficient to push all of the salt out of the Delta for the 140 cm SLR with 5% Amplification scenario. Similar incomplete flushing of salt from the Delta for the 140 cm SLR with 5% Amplification scenario was observed on January 1, 2002 (Figure 4.6-14).

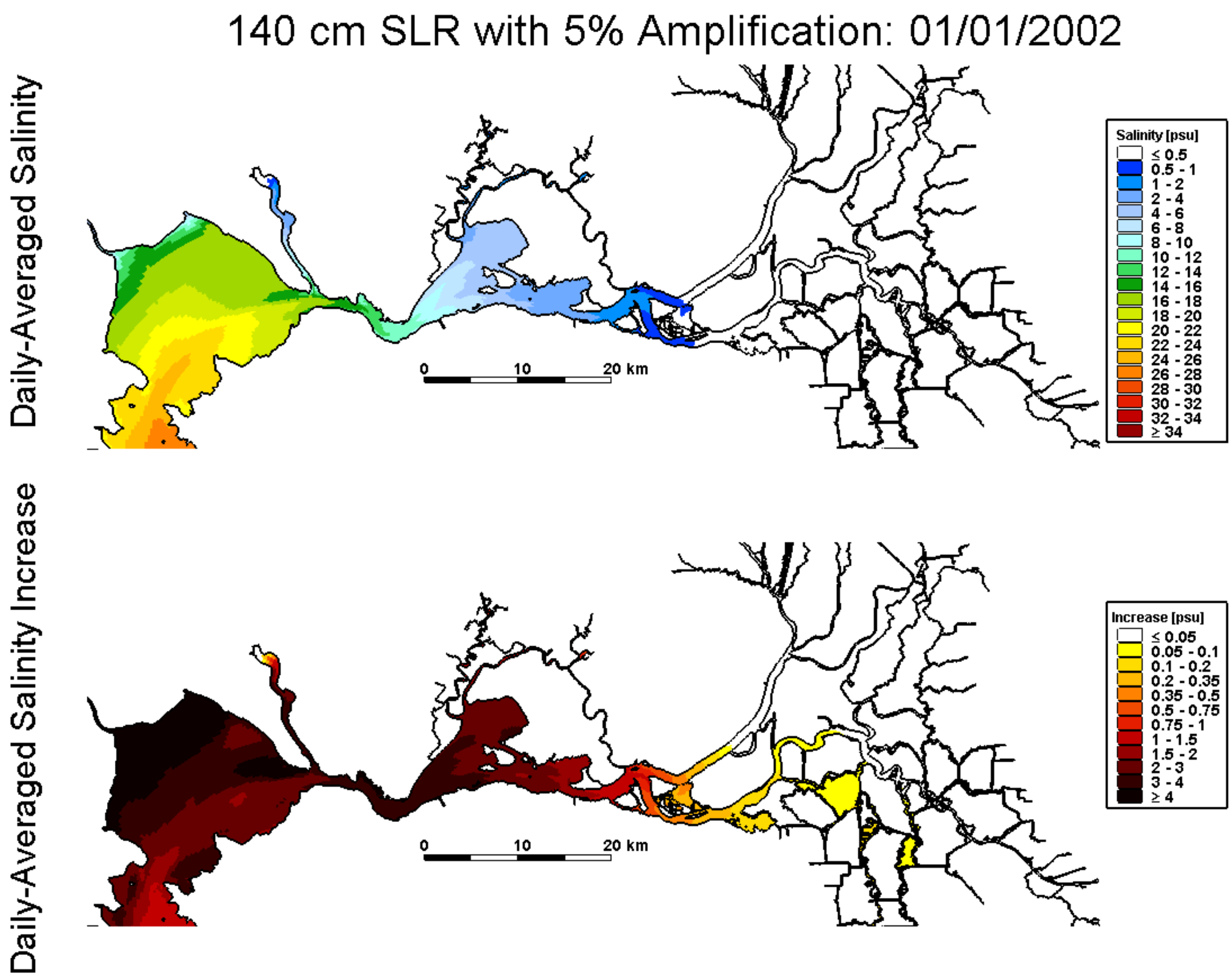


Figure 4.6-1 Predicted daily-averaged depth-average salinity on January 1, 2002 for the 140 cm SLR with 5% Amplification scenario (top); predicted increase in daily-averaged depth-average salinity on January 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR with 5% Amplification scenario.

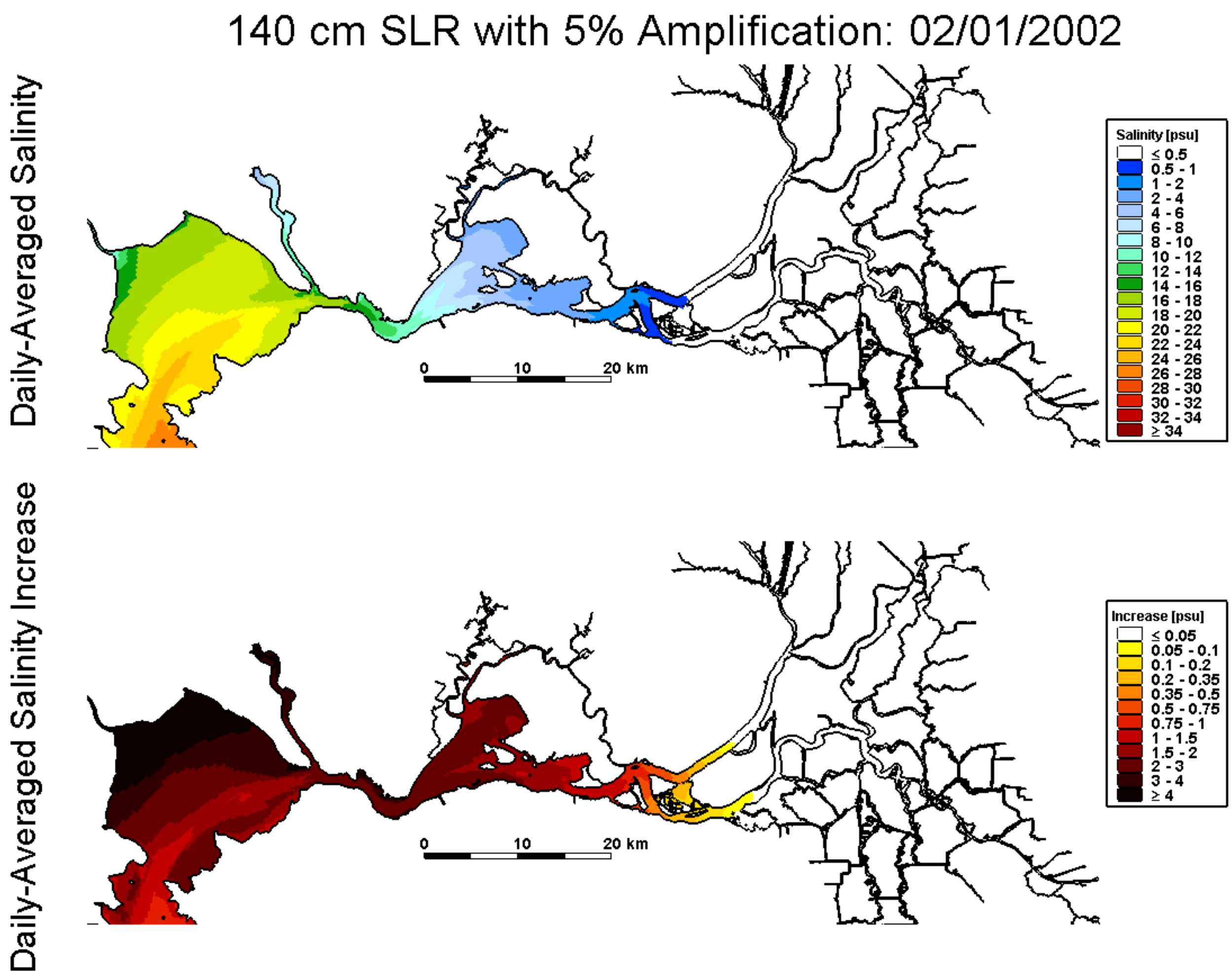


Figure 4.6-2 Predicted daily-averaged depth-average salinity on February 1, 2002 for the 140 cm SLR with 5% Amplification scenario (top); predicted increase in daily-averaged depth-average salinity on February 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR with 5% Amplification scenario.

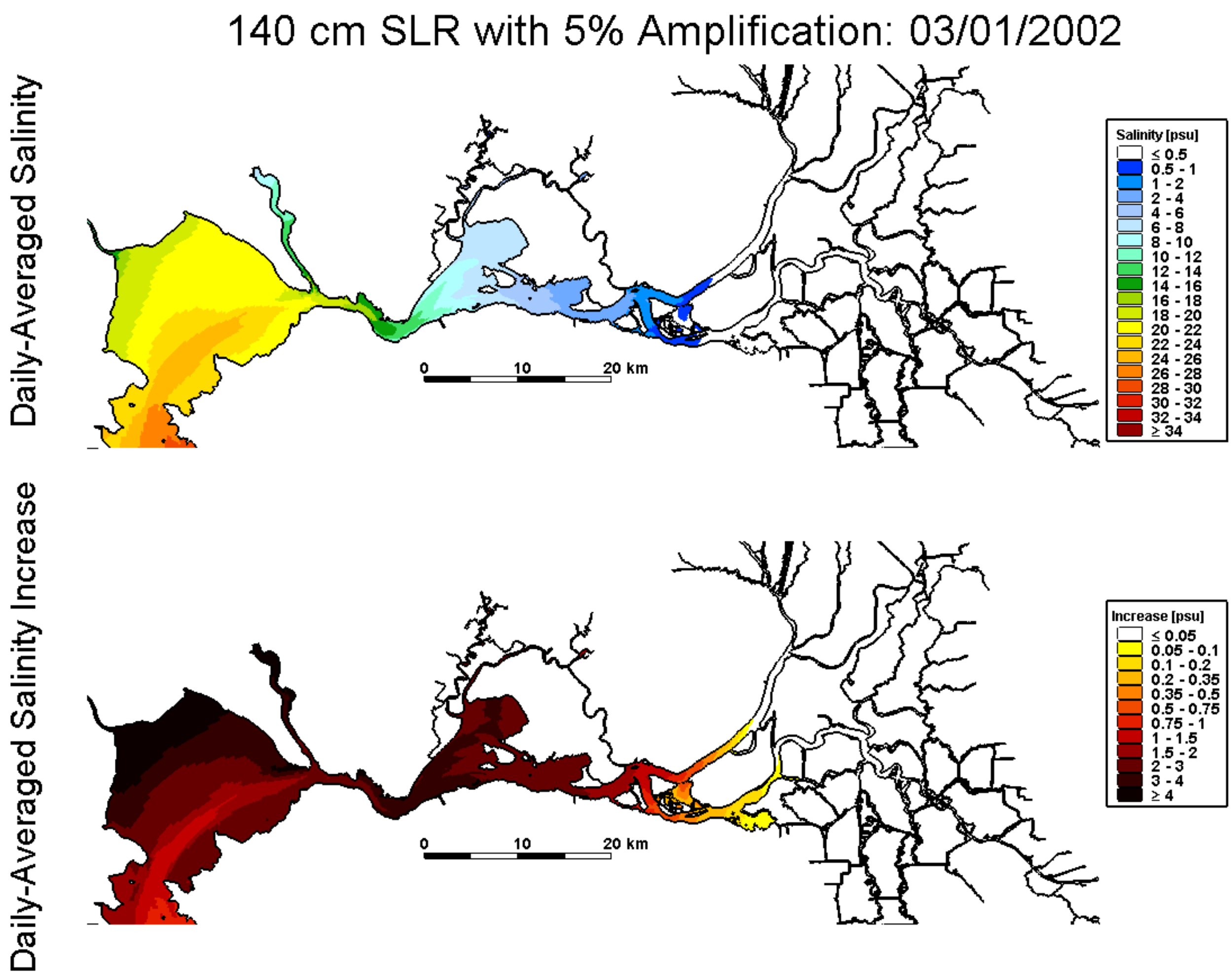


Figure 4.6-3 Predicted daily-averaged depth-average salinity on March 1, 2002 for the 140 cm SLR with 5% Amplification scenario (top); predicted increase in daily-averaged depth-average salinity on March 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR with 5% Amplification scenario.

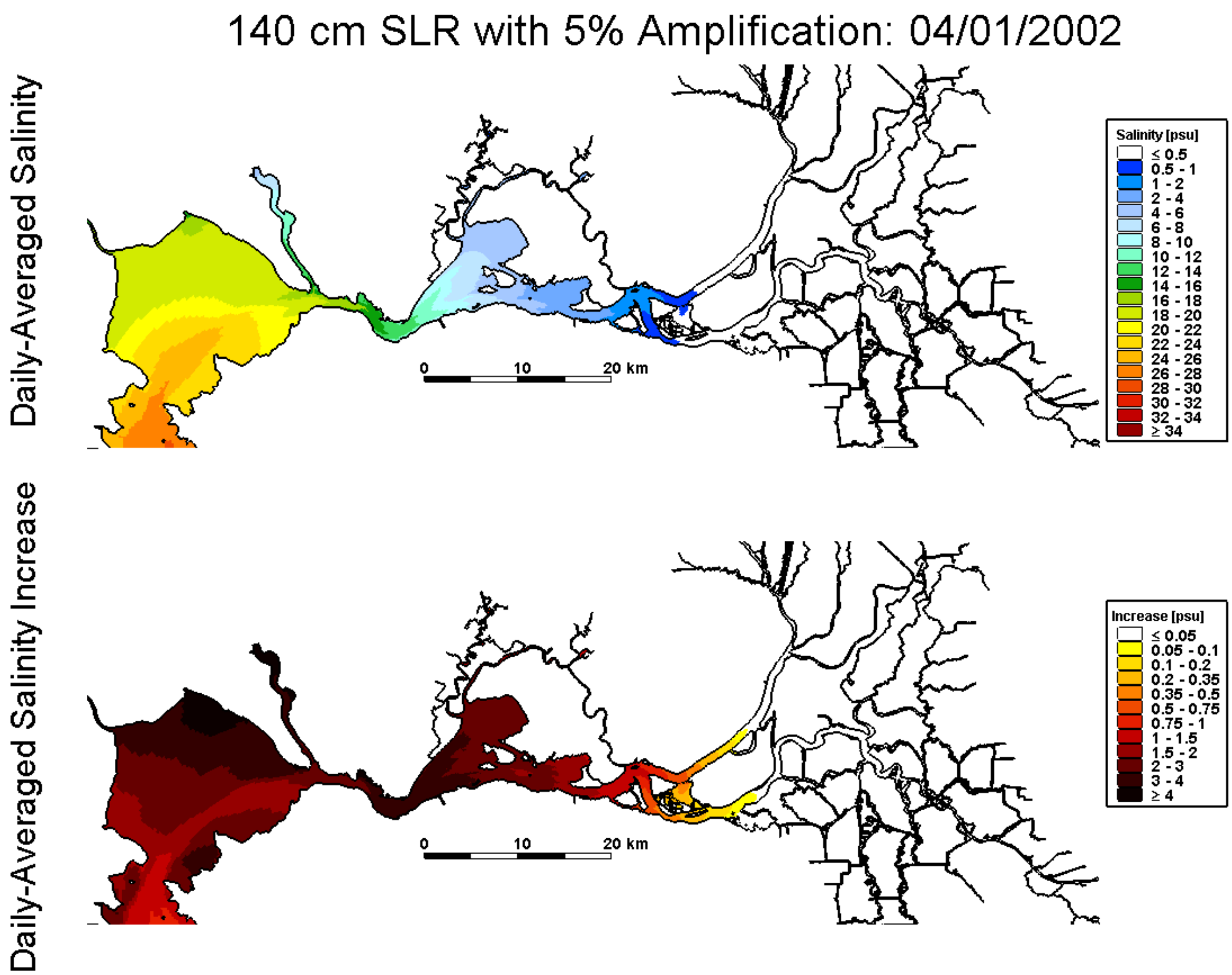


Figure 4.6-4 Predicted daily-averaged depth-average salinity on April 1, 2002 for the 140 cm SLR with 5% Amplification scenario (top); predicted increase in daily-averaged depth-average salinity on April 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR with 5% Amplification scenario.

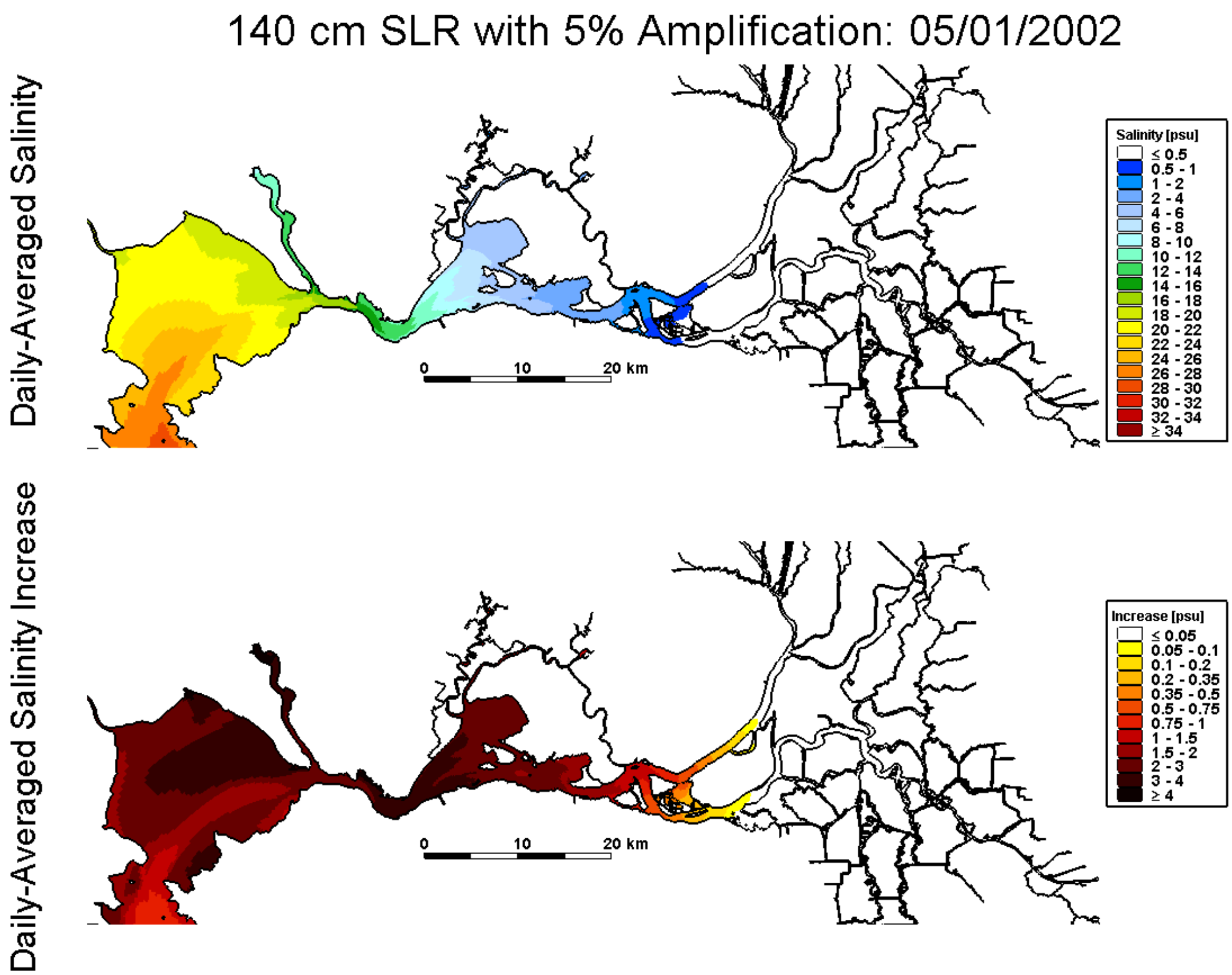


Figure 4.6-5 Predicted daily-averaged depth-average salinity on May 1, 2002 for the 140 cm SLR with 5% Amplification scenario (top); predicted increase in daily-averaged depth-average salinity on May 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR with 5% Amplification scenario.

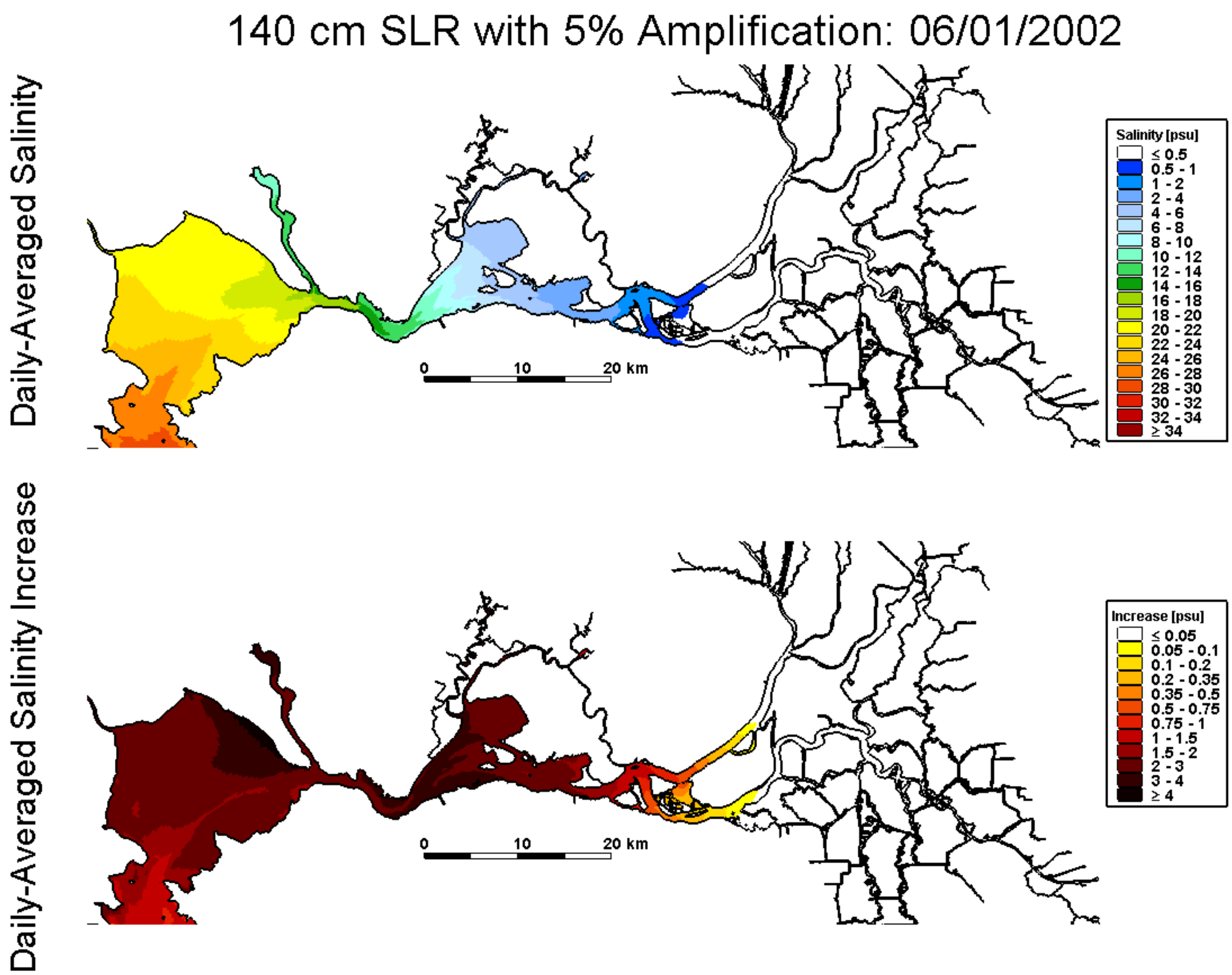


Figure 4.6-6 Predicted daily-averaged depth-average salinity on June 1, 2002 for the 140 cm SLR with 5% Amplification scenario (top); predicted increase in daily-averaged depth-average salinity on June 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR with 5% Amplification scenario.

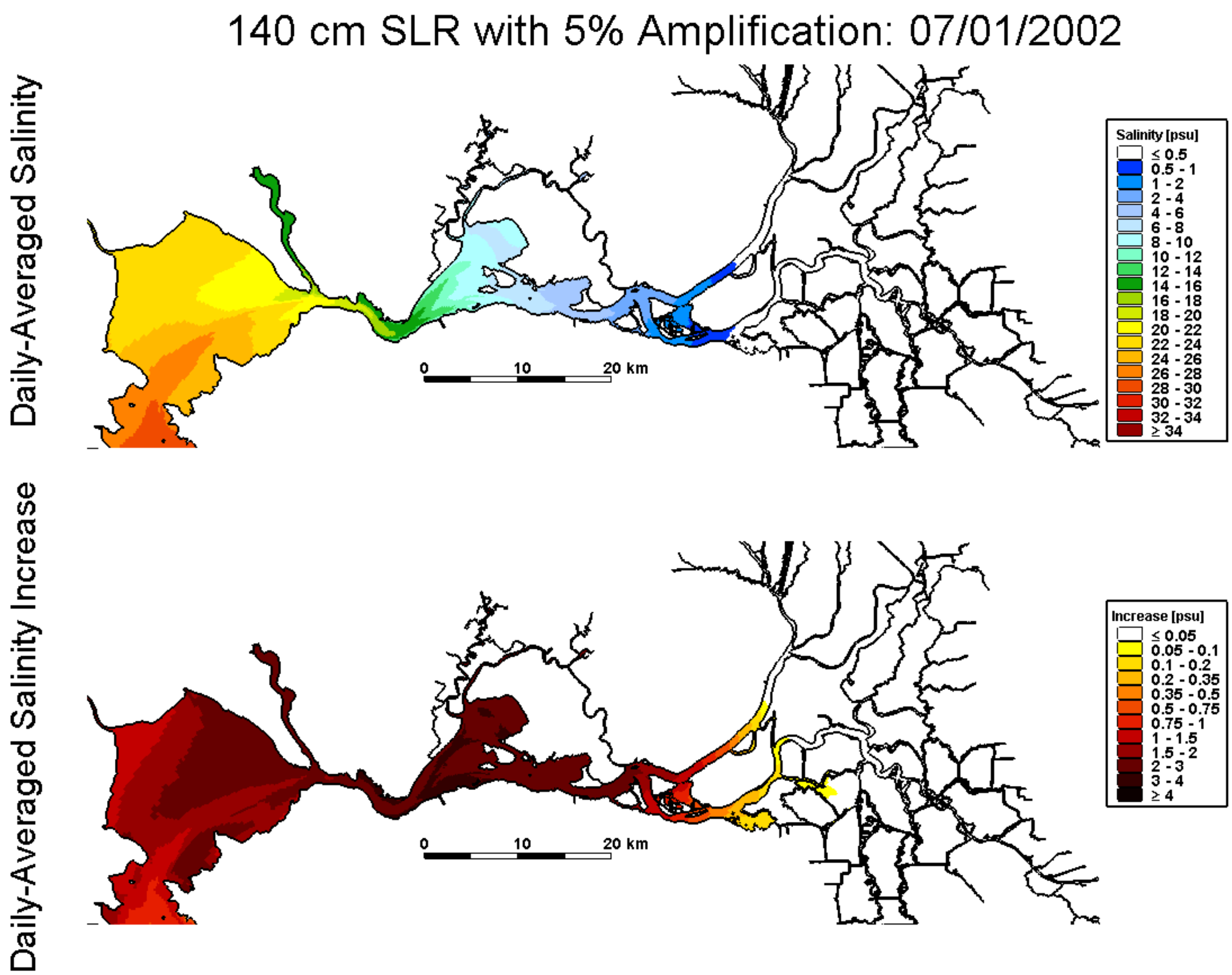


Figure 4.6-7 Predicted daily-averaged depth-average salinity on July 1, 2002 for the 140 cm SLR with 5% Amplification scenario (top); predicted increase in daily-averaged depth-average salinity on July 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR with 5% Amplification scenario.

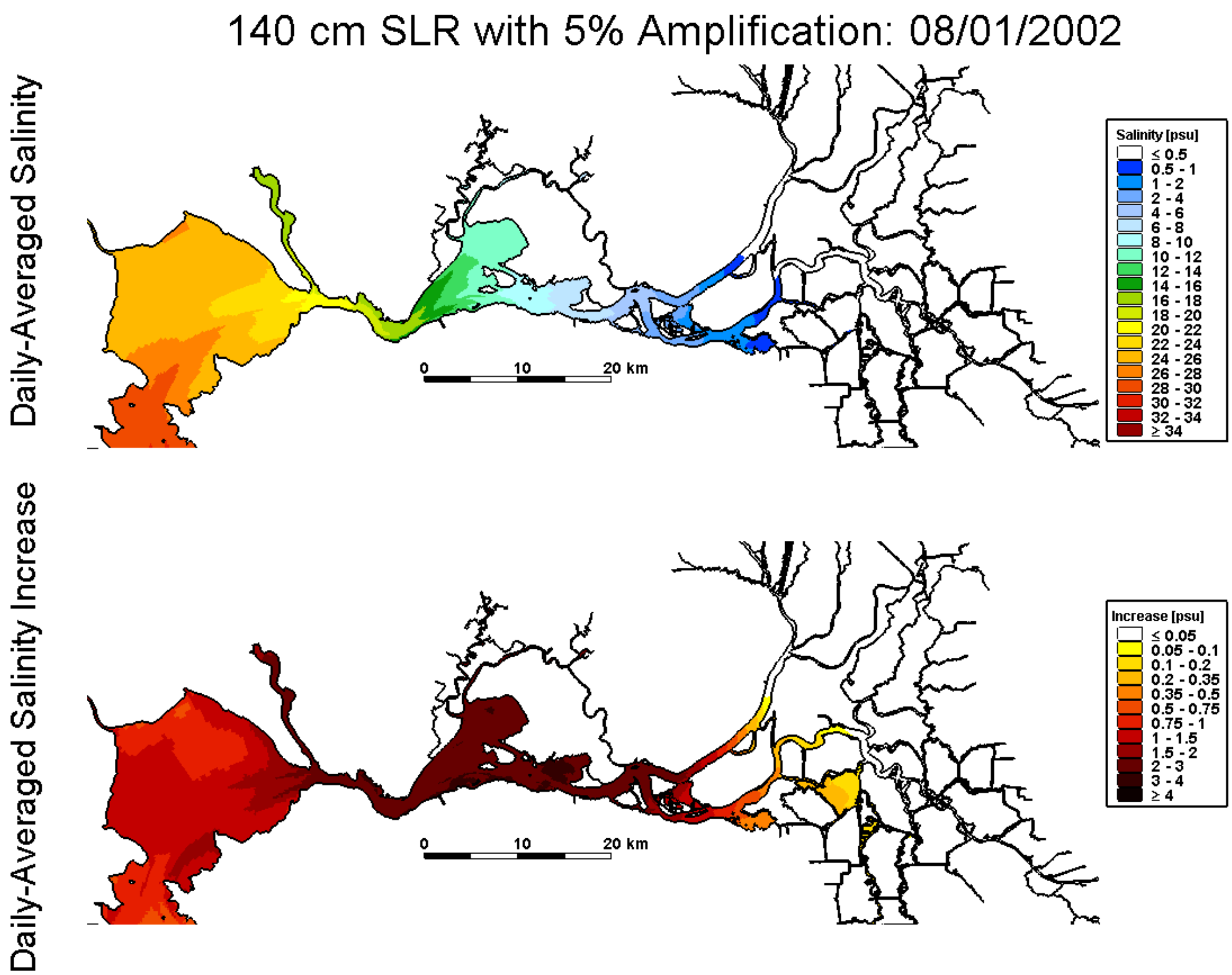


Figure 4.6-8 Predicted daily-averaged depth-average salinity on August 1, 2002 for the 140 cm SLR with 5% Amplification scenario (top); predicted increase in daily-averaged depth-average salinity on August 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR with 5% Amplification scenario.

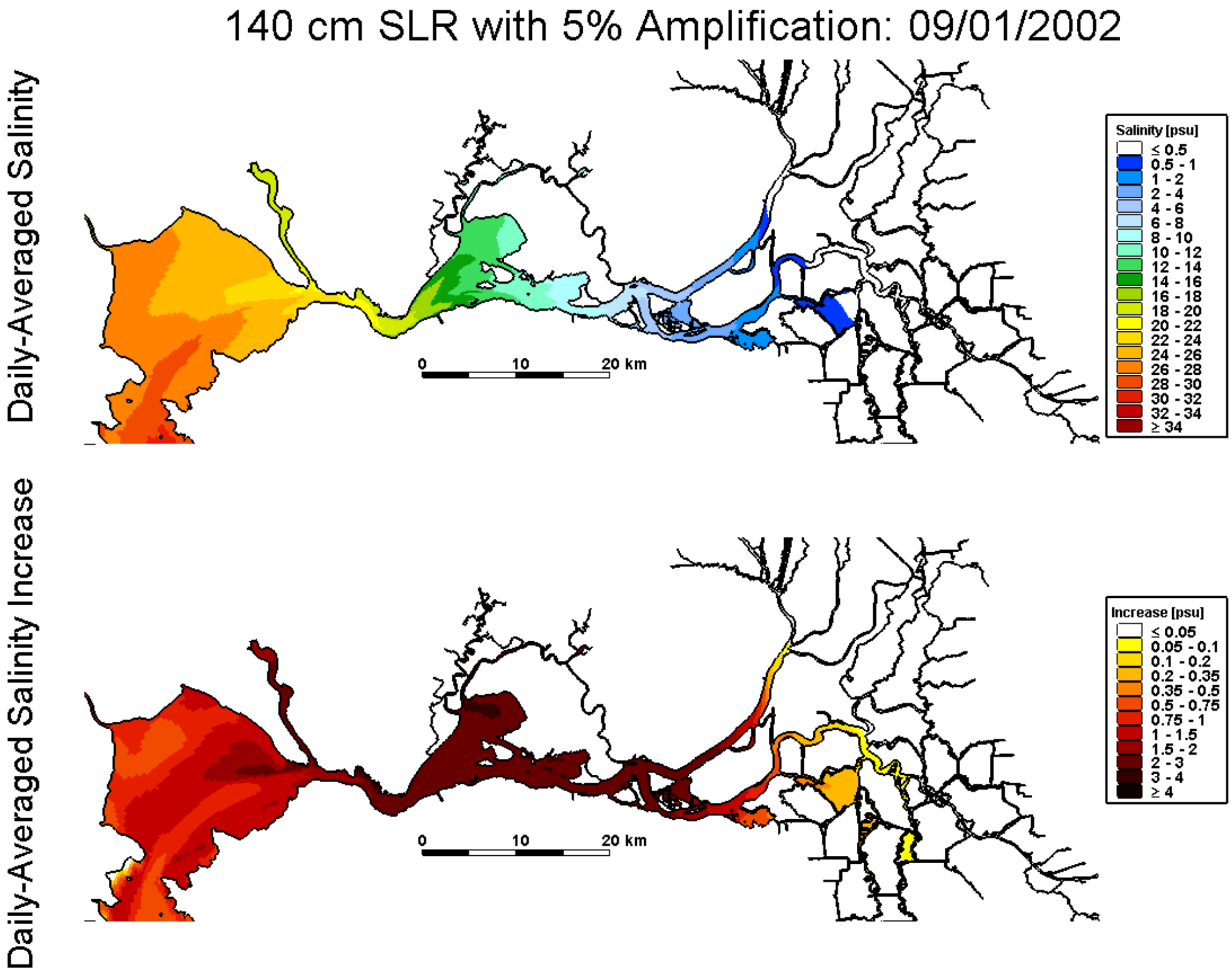


Figure 4.6-9 Predicted daily-averaged depth-average salinity on September 1, 2002 for the 140 cm SLR with 5% Amplification scenario (top); predicted increase in daily-averaged depth-average salinity on September 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR with 5% Amplification scenario.

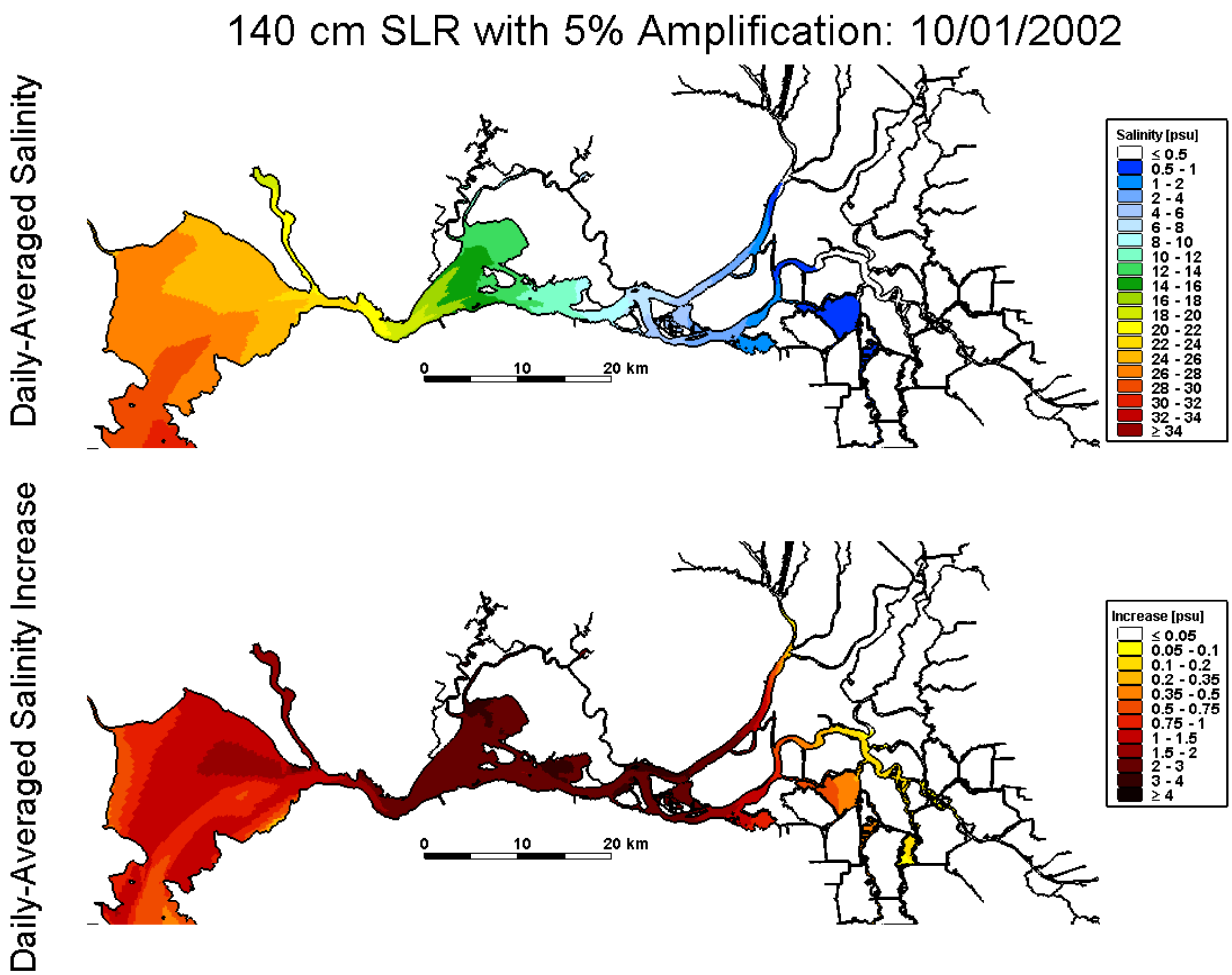


Figure 4.6-10 Predicted daily-averaged depth-average salinity on October 1, 2002 for the 140 cm SLR with 5% Amplification scenario (top); predicted increase in daily-averaged depth-average salinity on October 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR with 5% Amplification scenario.

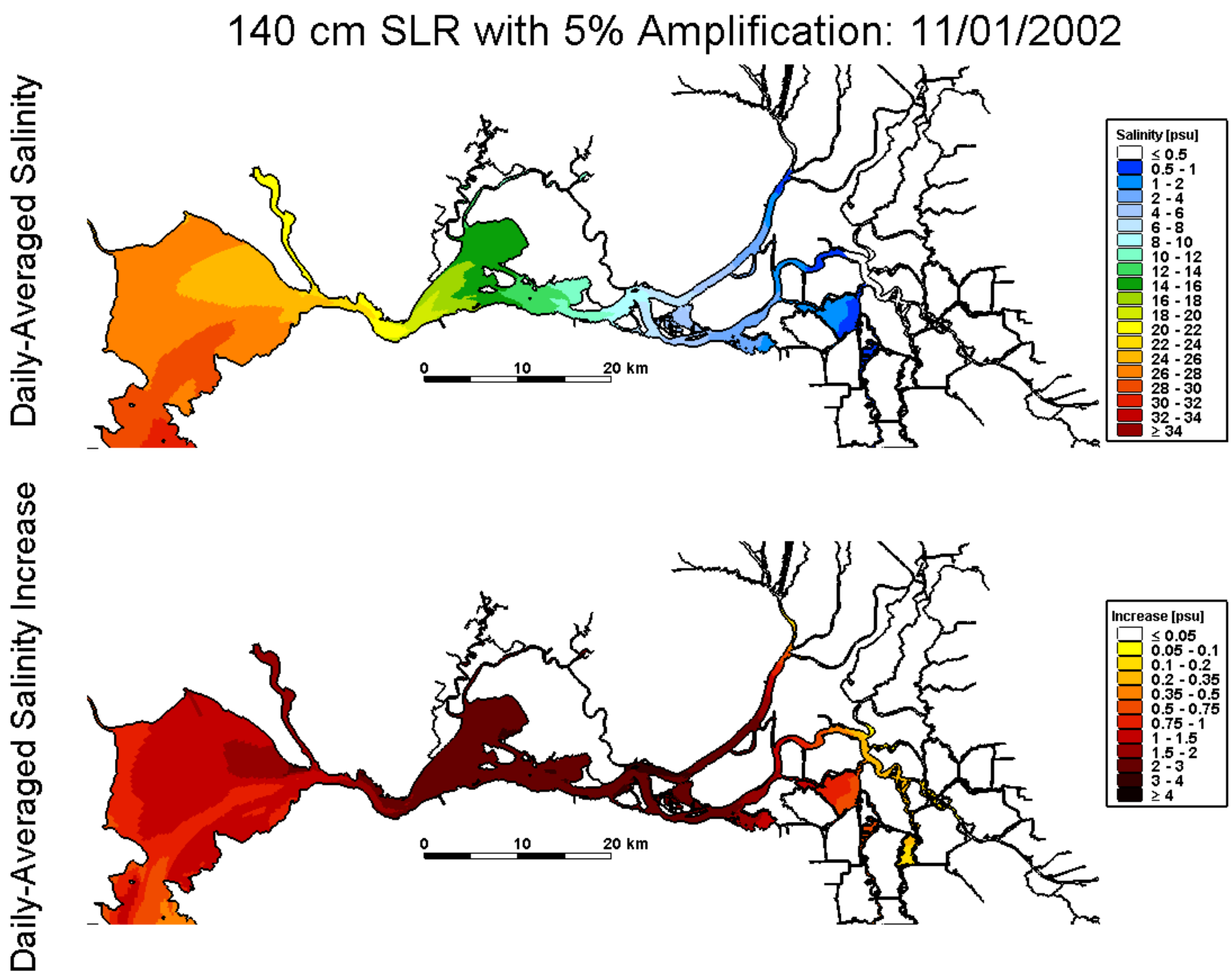


Figure 4.6-11 Predicted daily-averaged depth-average salinity on November 1, 2002 for the 140 cm SLR with 5% Amplification scenario (top); predicted increase in daily-averaged depth-average salinity on November 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR with 5% Amplification scenario.

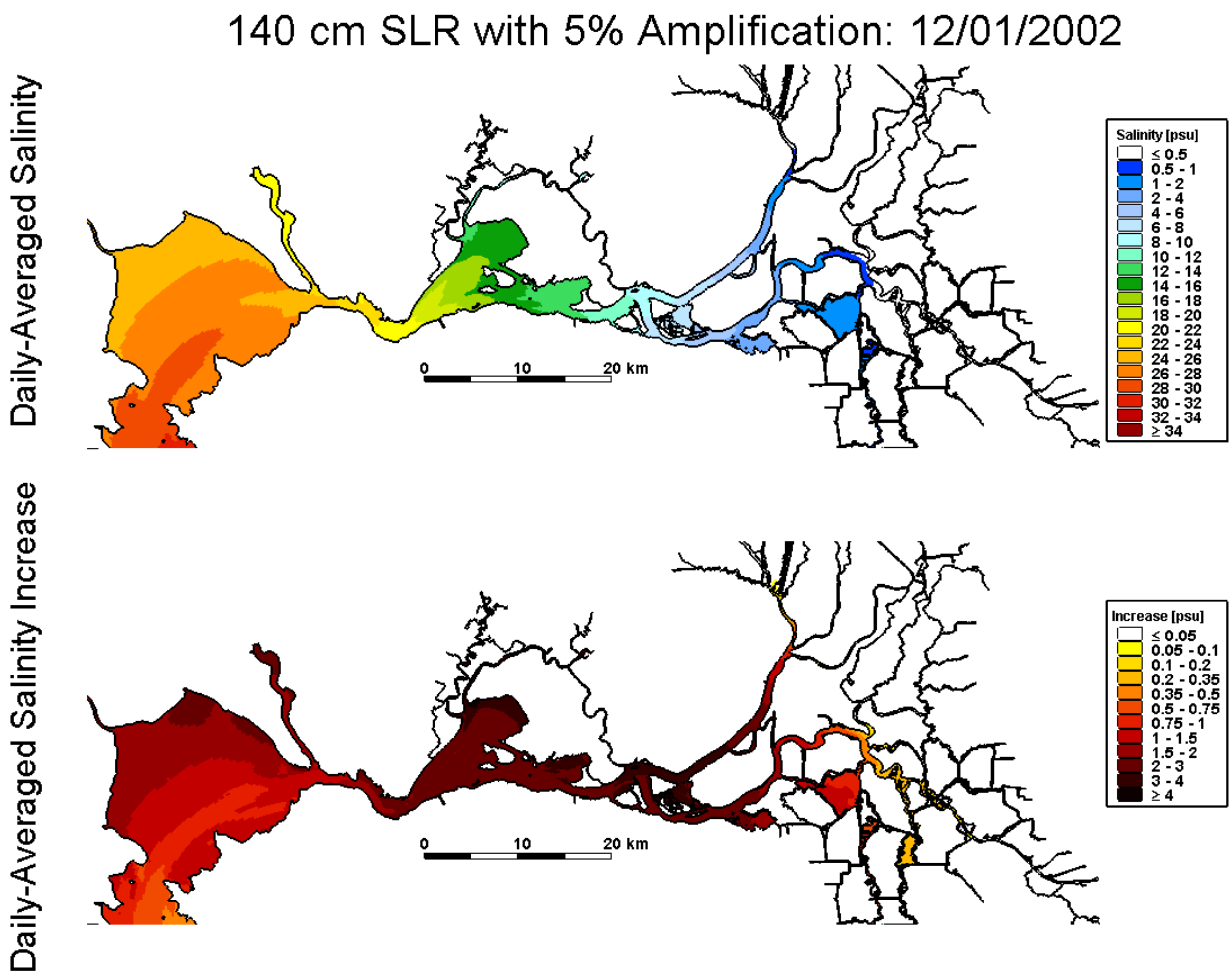


Figure 4.6-12 Predicted daily-averaged depth-average salinity on December 1, 2002 for the 140 cm SLR with 5% Amplification scenario (top); predicted increase in daily-averaged depth-average salinity on December 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR with 5% Amplification scenario.

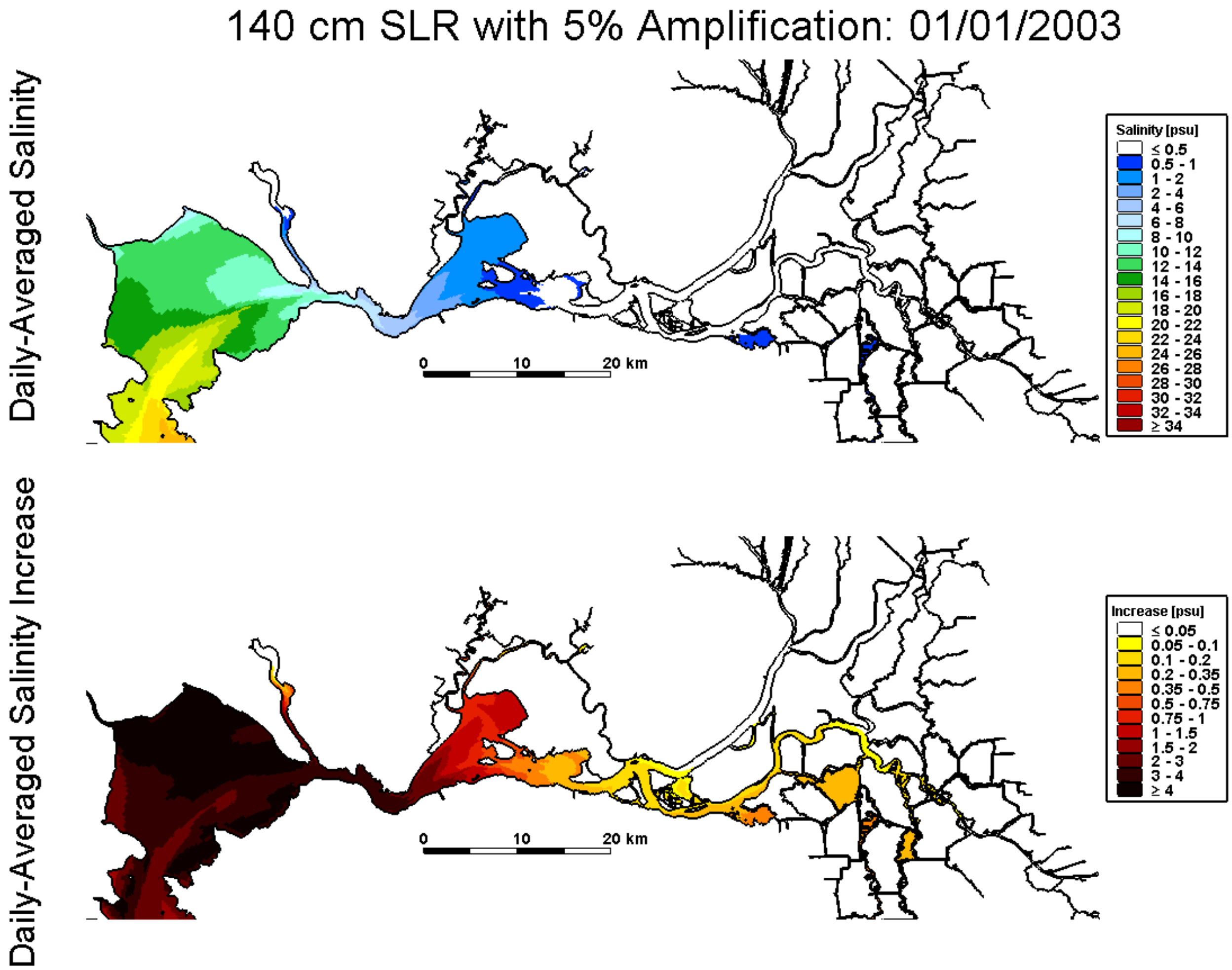


Figure 4.6-13 Predicted daily-averaged depth-average salinity on January 1, 2003 for the 140 cm SLR with 5% Amplification scenario (top); predicted increase in daily-averaged depth-average salinity on January 1, 2003 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR with 5% Amplification scenario.

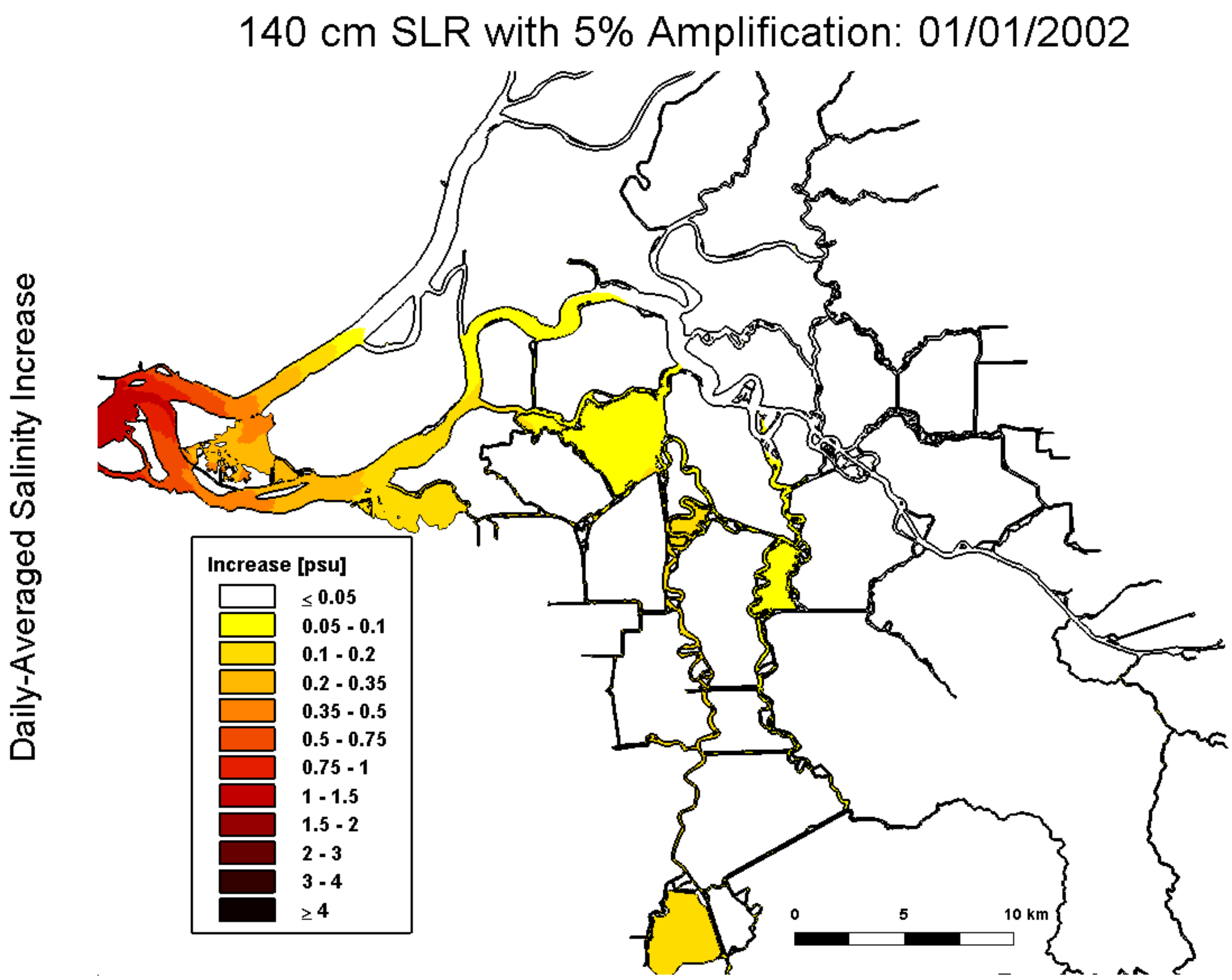


Figure 4.6-14 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on January 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR with 5% Amplification scenario.

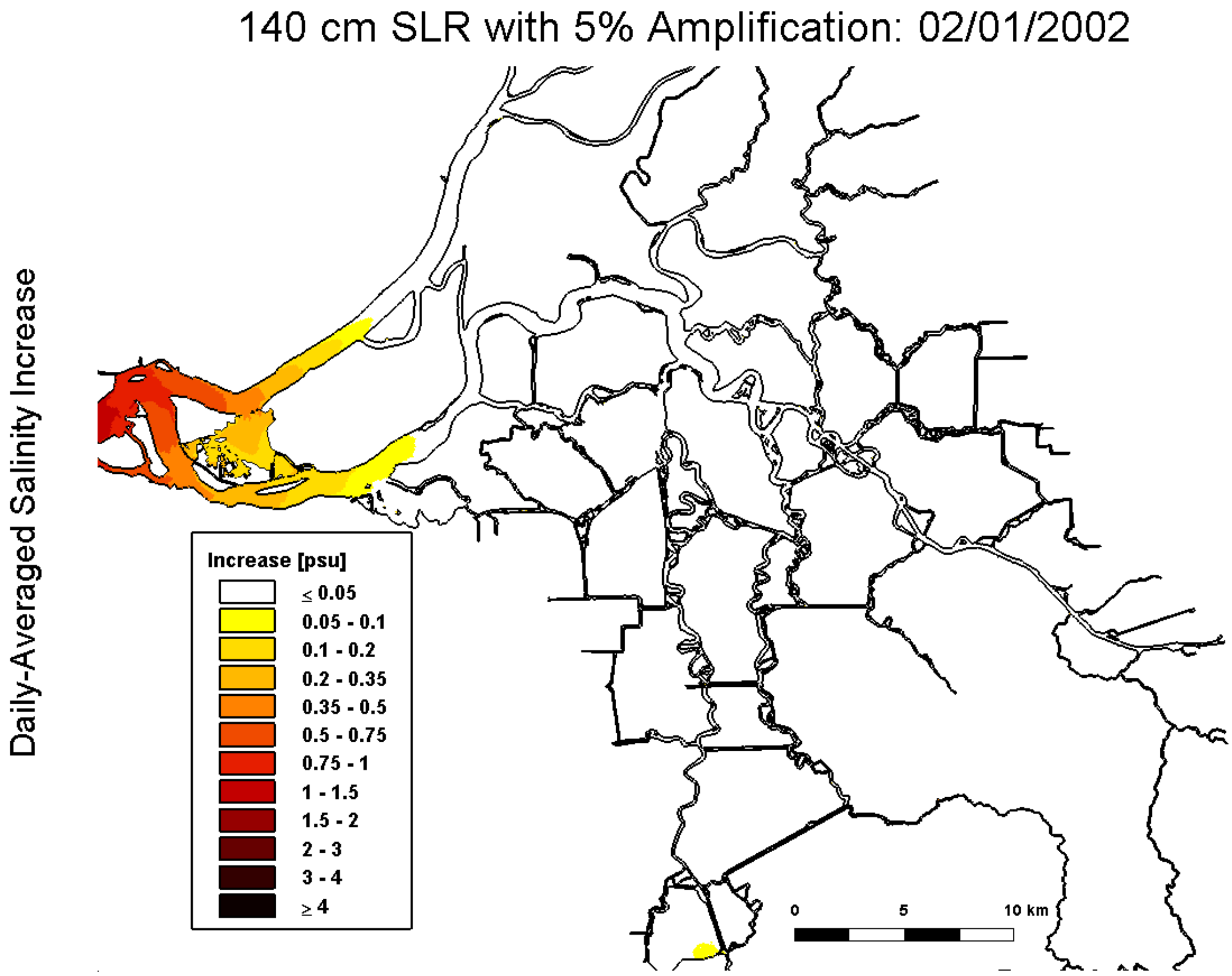


Figure 4.6-15 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on February 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR with 5% Amplification scenario.

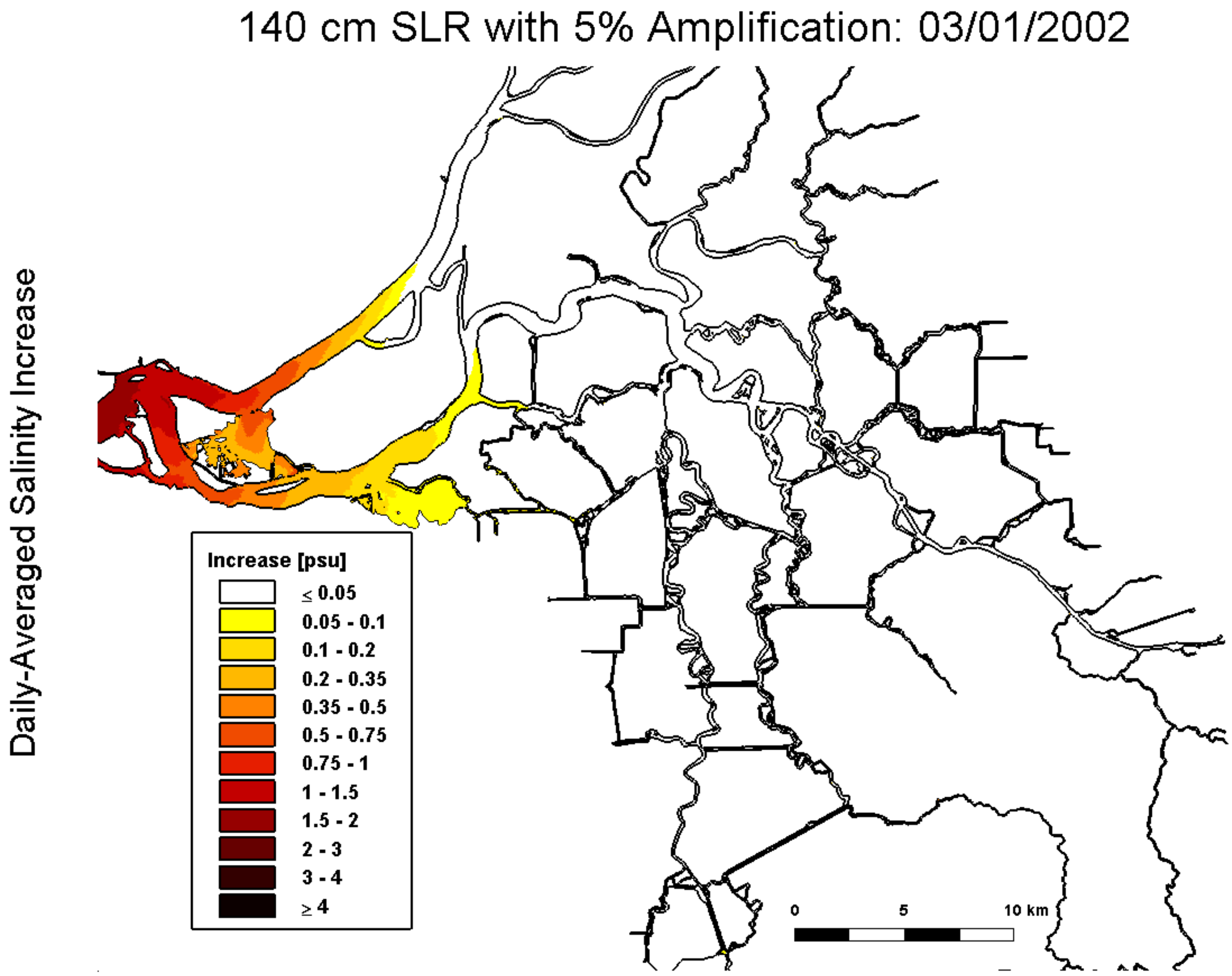


Figure 4.6-16 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on March 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR with 5% Amplification scenario.

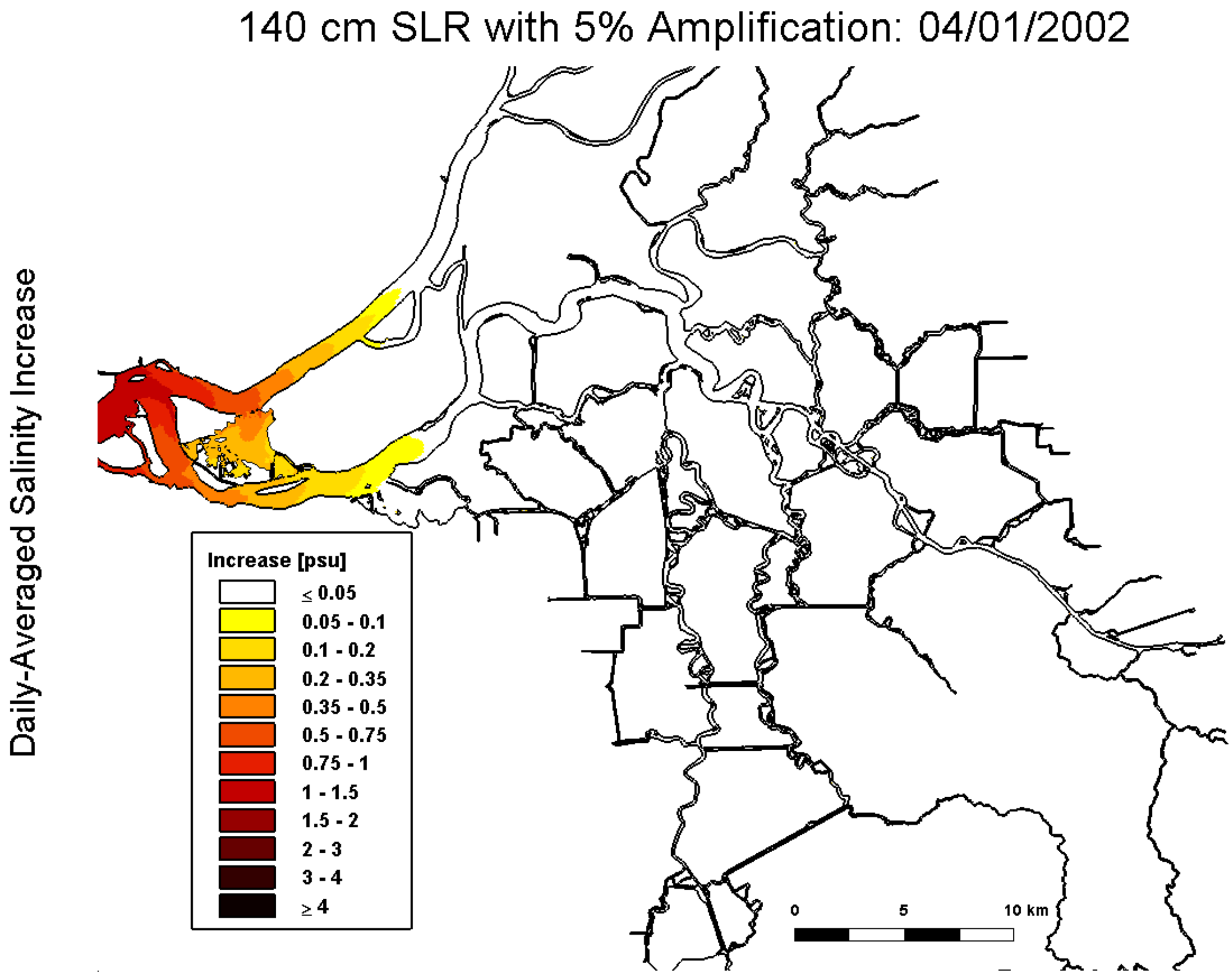


Figure 4.6-17 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on April 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR with 5% Amplification scenario.

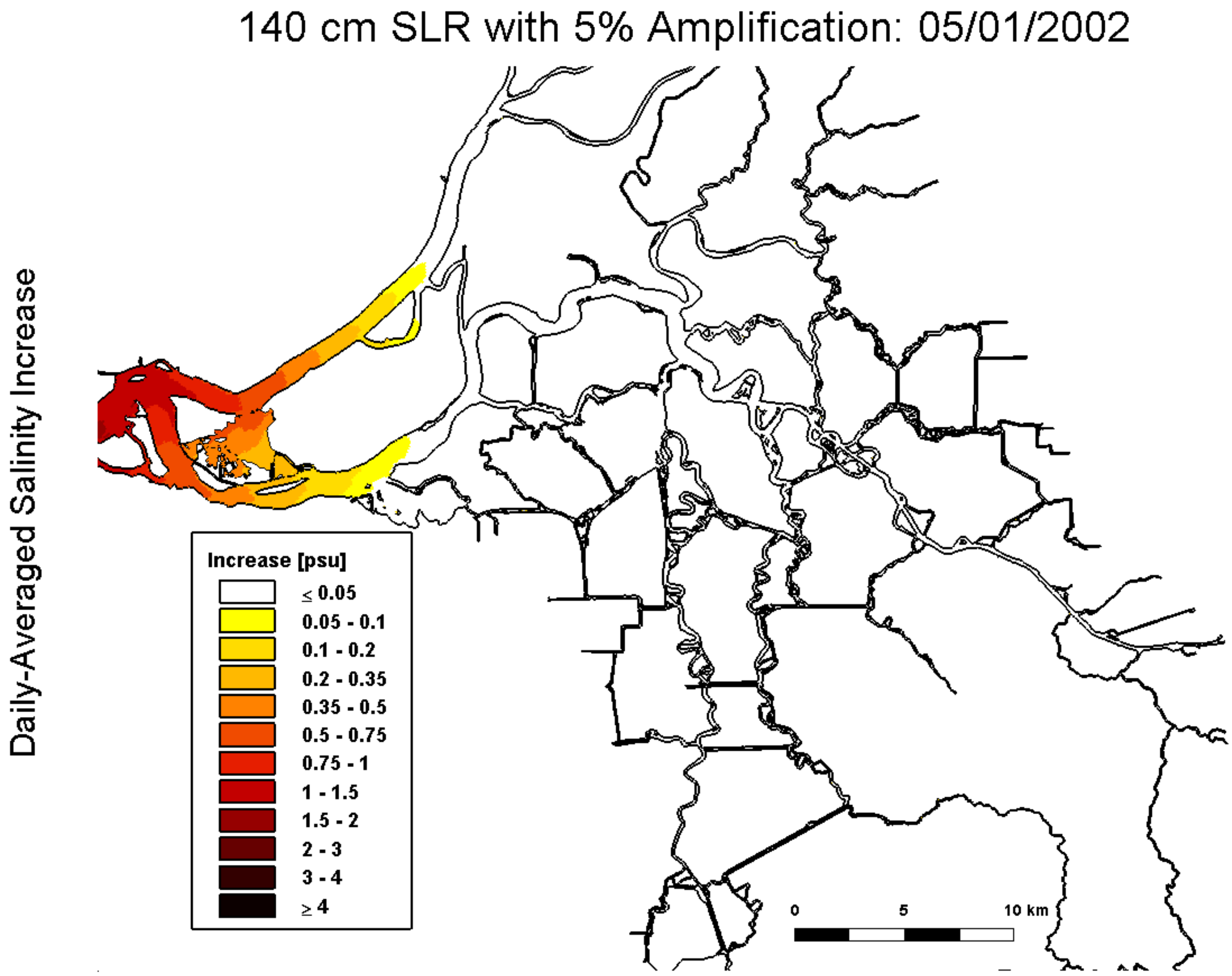


Figure 4.6-18 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on May 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR with 5% Amplification scenario.

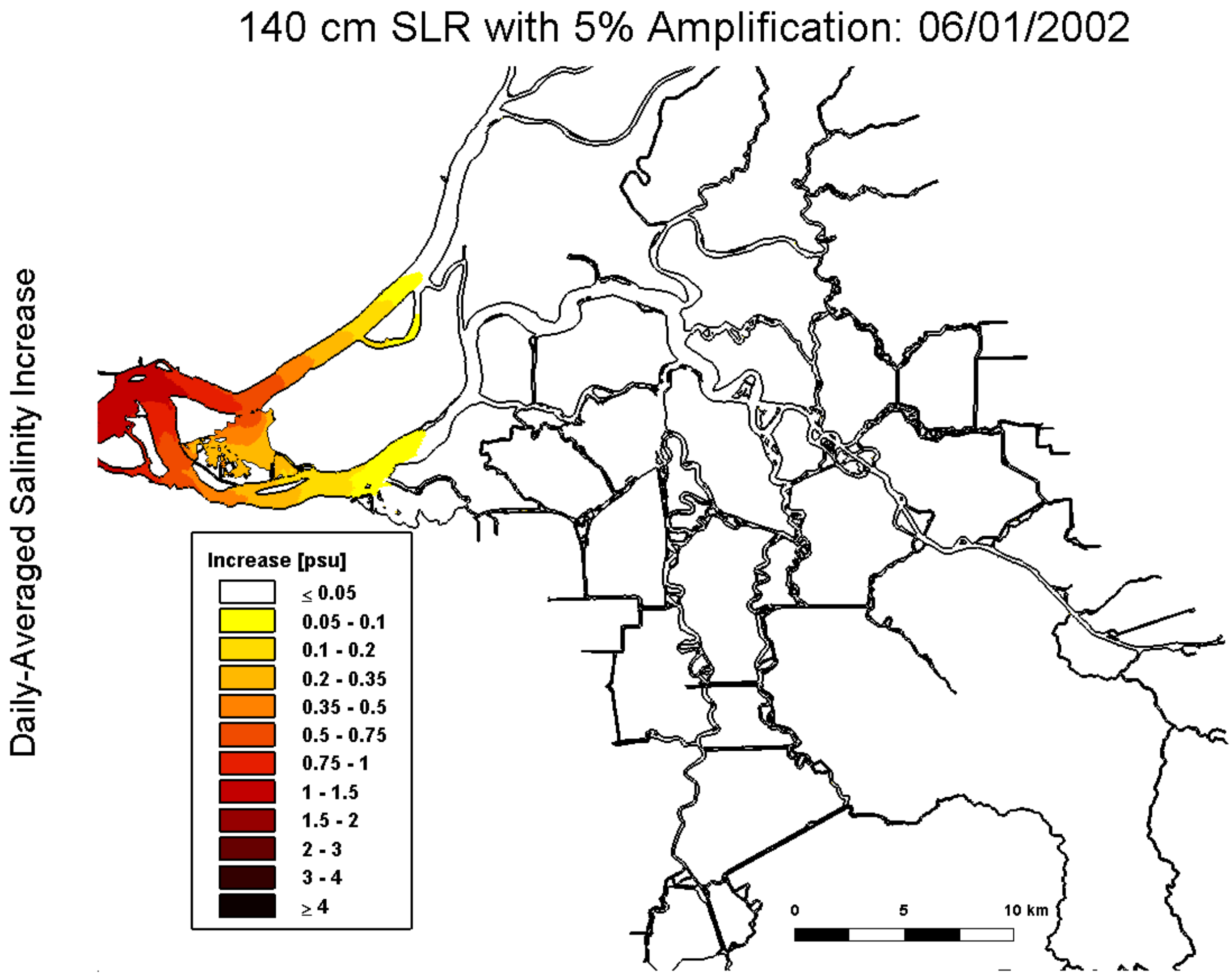


Figure 4.6-19 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on June 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR with 5% Amplification scenario.

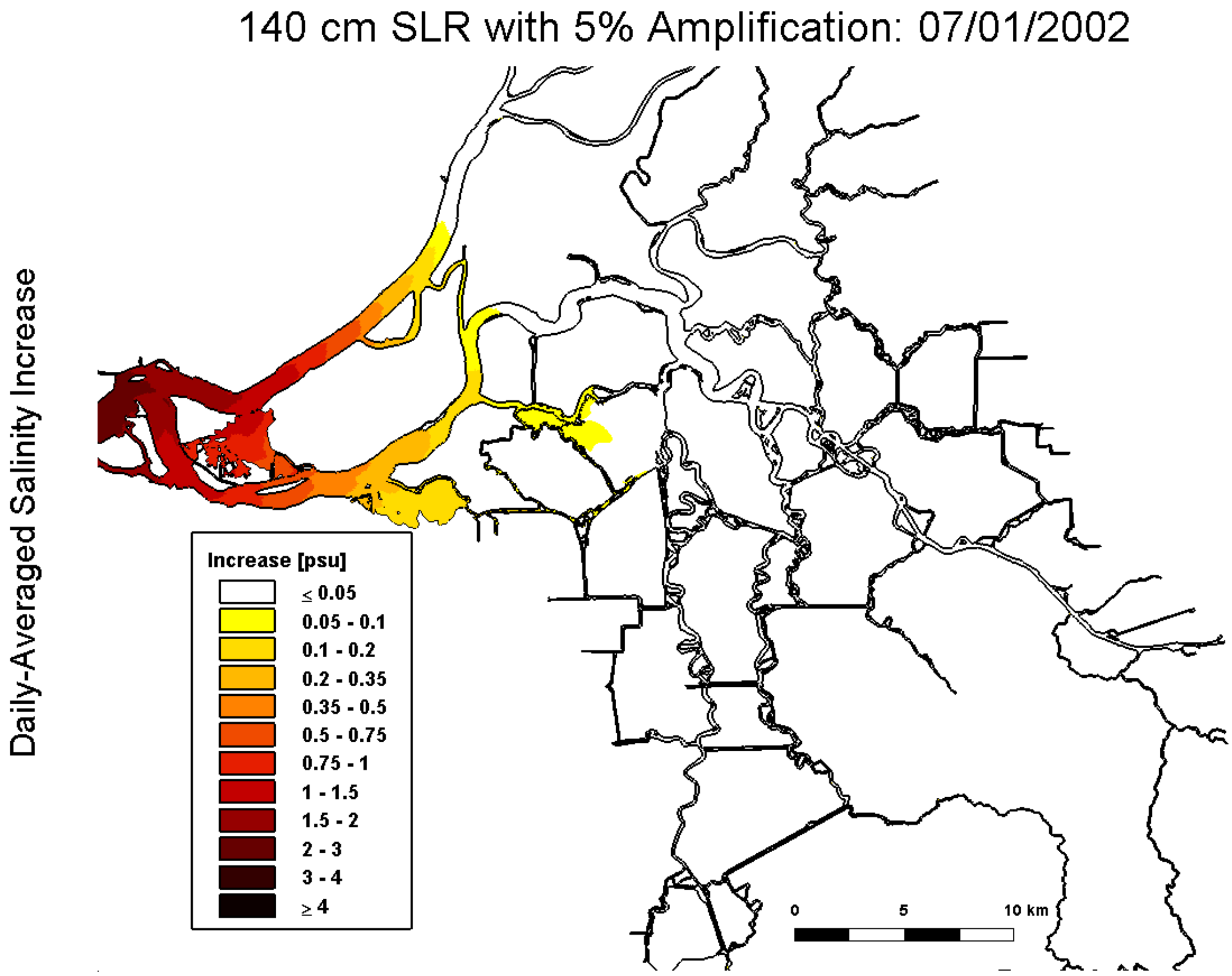


Figure 4.6-20 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on July 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR with 5% Amplification scenario.

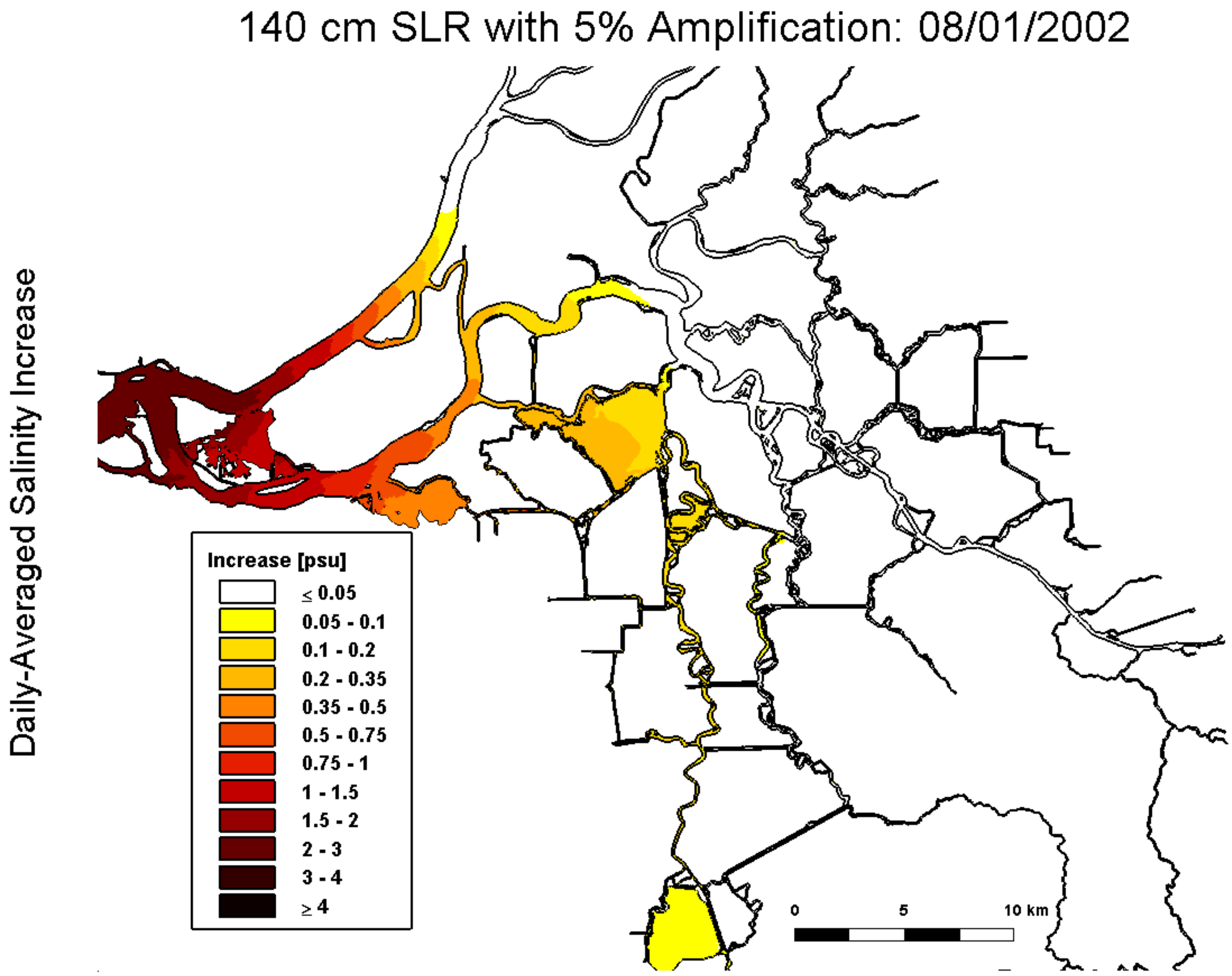


Figure 4.6-21 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on August 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR with 5% Amplification scenario.

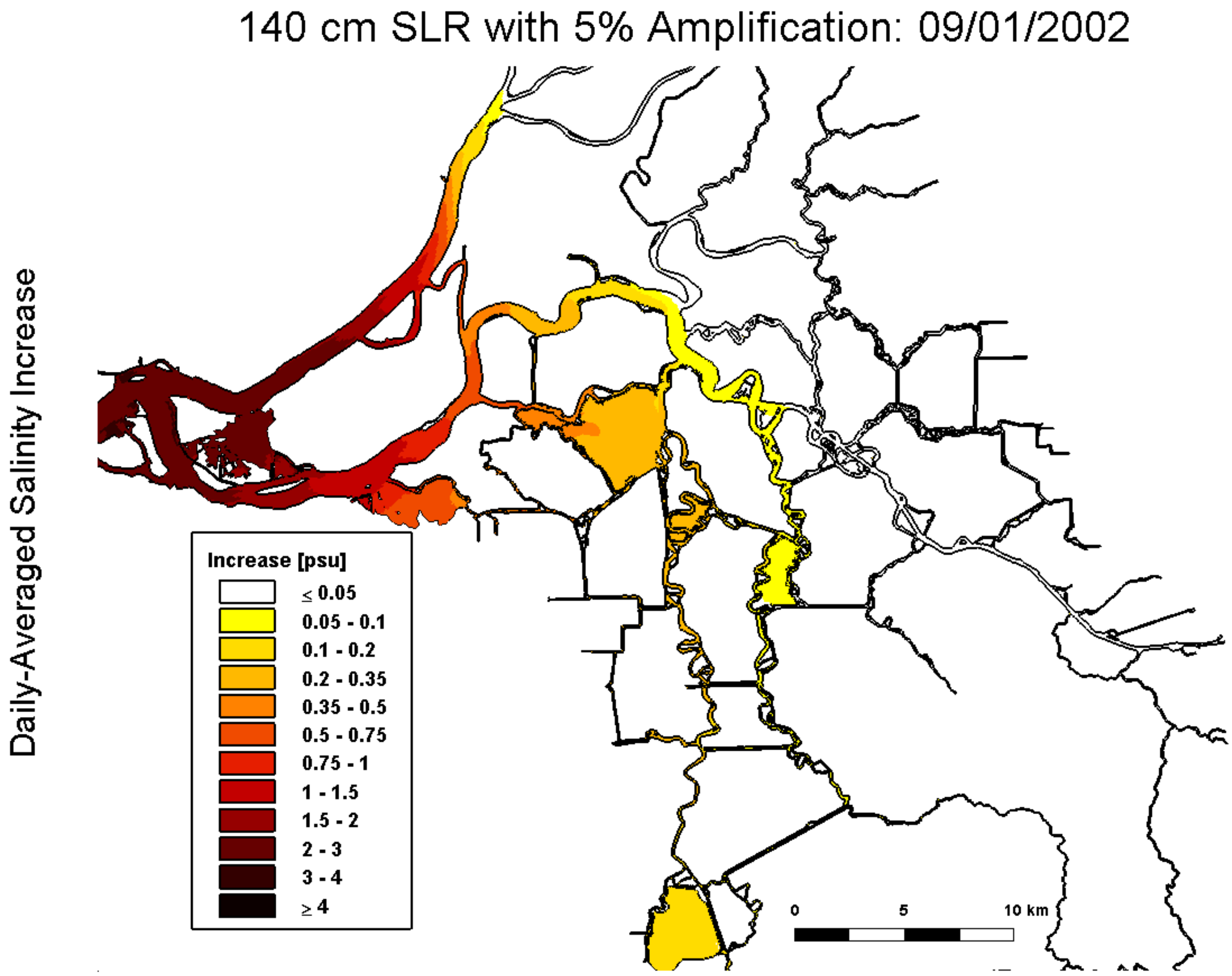


Figure 4.6-22 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on September 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR with 5% Amplification scenario.

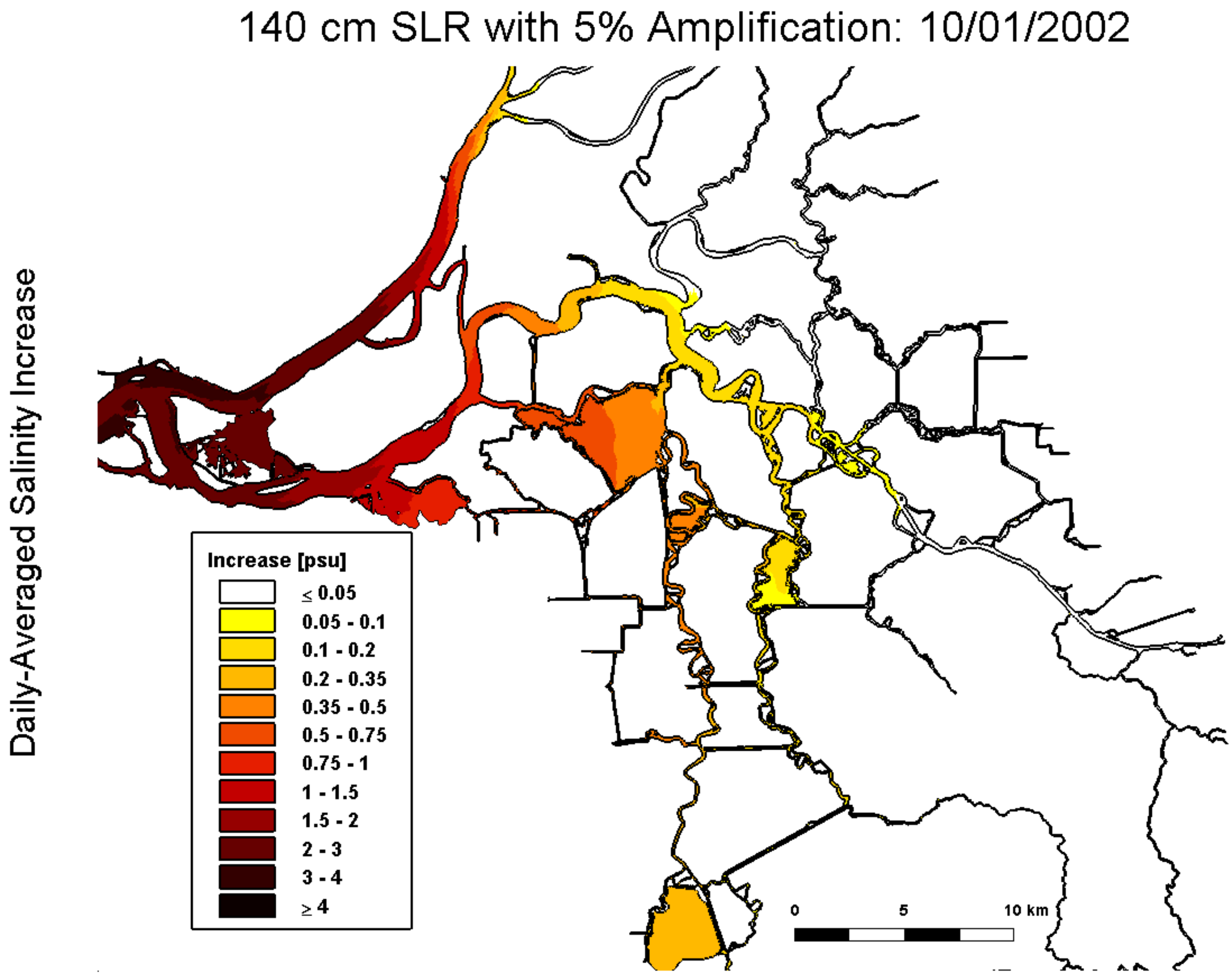


Figure 4.6-23 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on October 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR with 5% Amplification scenario.

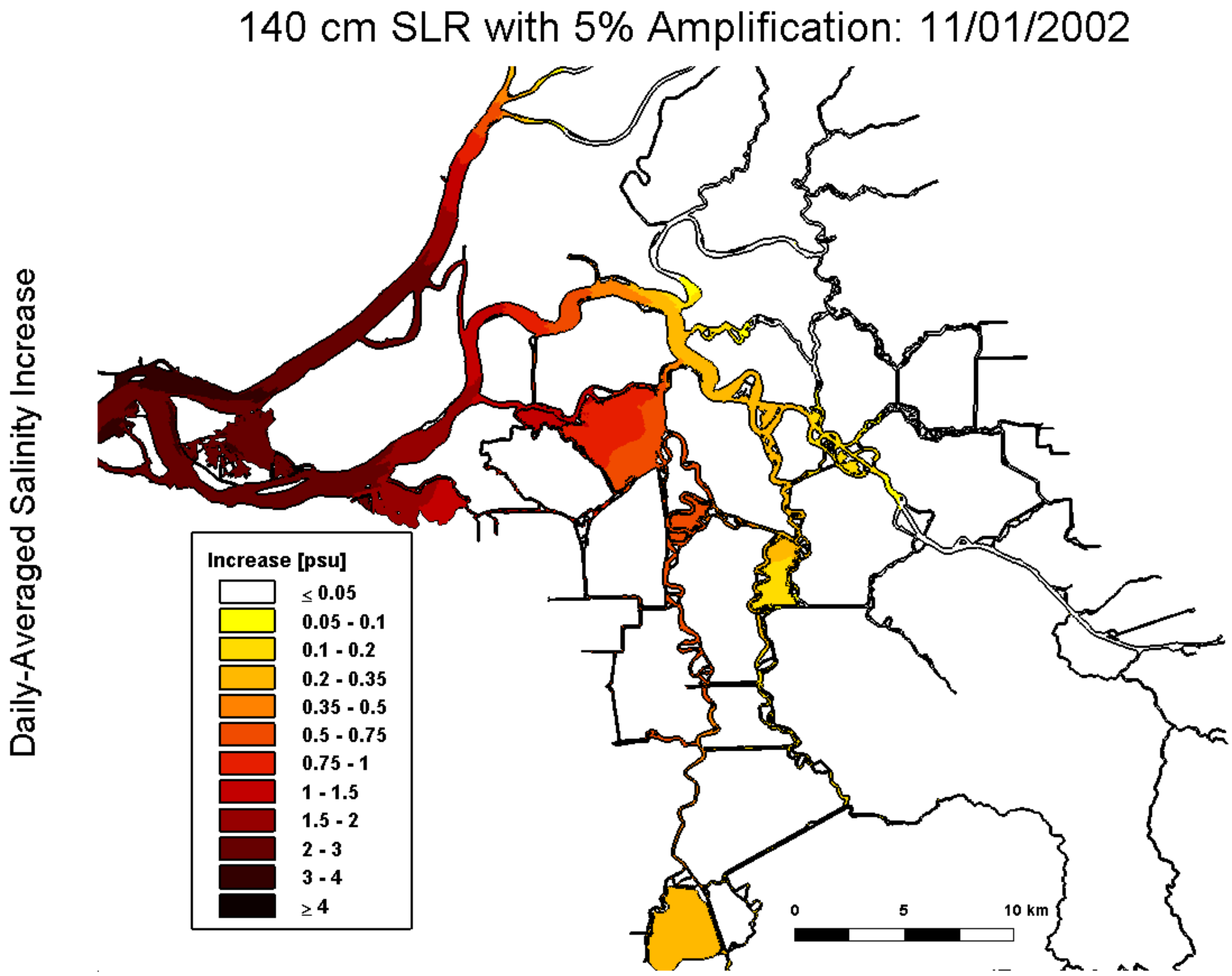


Figure 4.6-24 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on November 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR with 5% Amplification scenario.

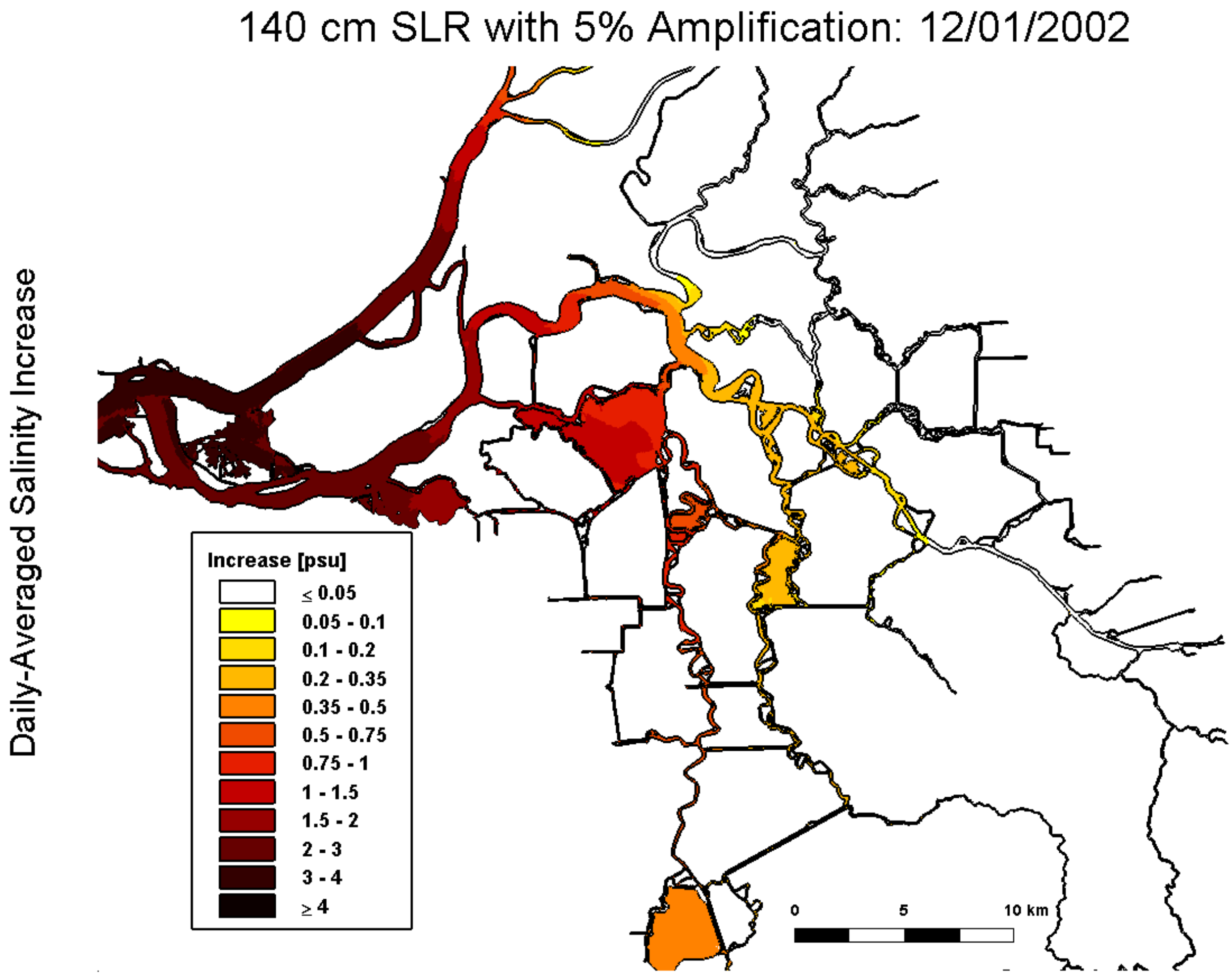


Figure 4.6-25 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on December 1, 2002 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR with 5% Amplification scenario.

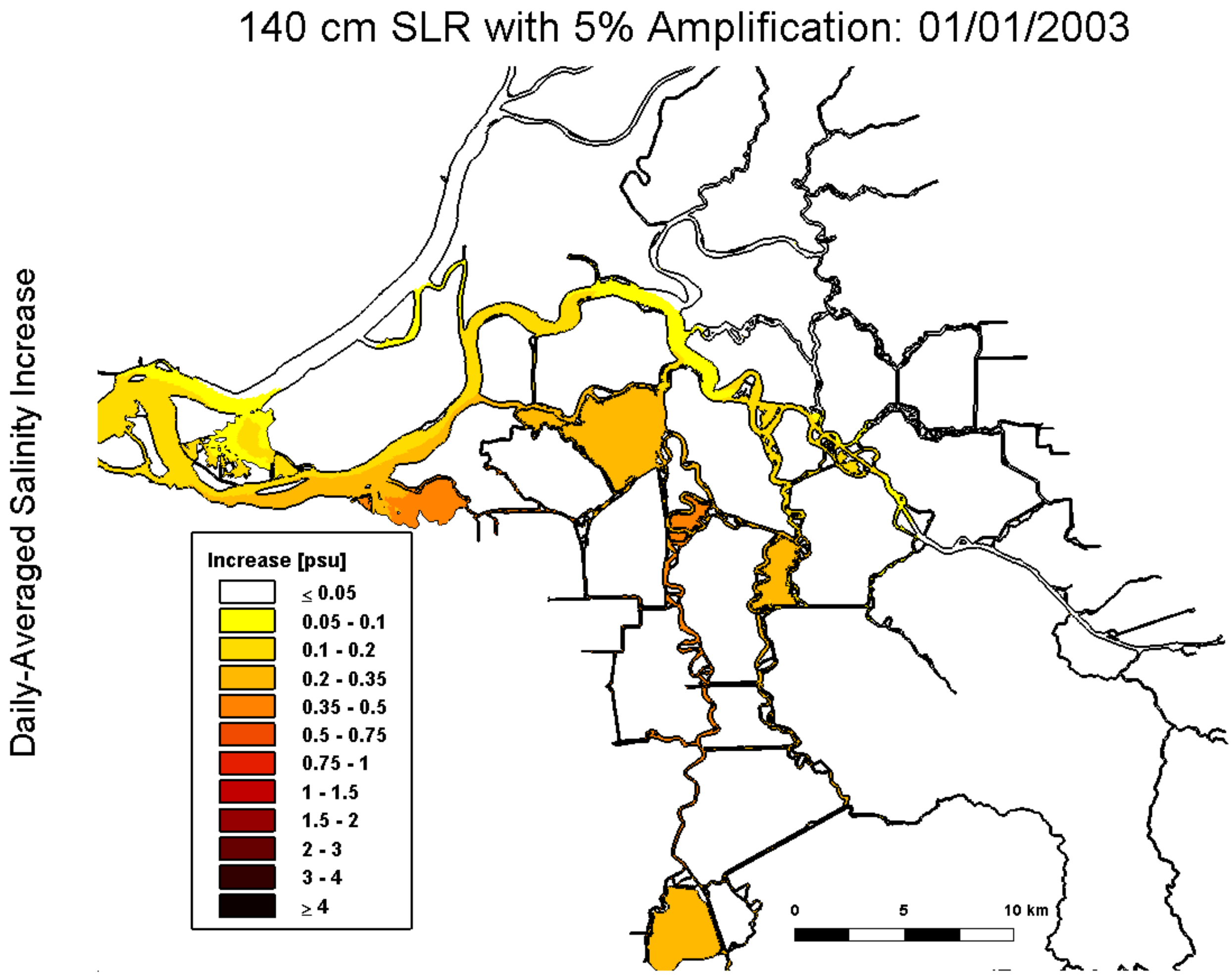


Figure 4.6-26 Predicted increase in daily-averaged depth-average salinity in the Sacramento-San Joaquin Delta on January 1, 2003 relative to the Baseline (0 cm SLR) scenario for the 140 cm SLR with 5% Amplification scenario.

4.7 Effect of Tidal Range Amplification on Daily-averaged Depth-average Salinity

This section evaluates the effect of the amplification of tidal range on daily-averaged depth-average salinity through the comparison of the predicted daily-averaged depth-average salinity for the 140 cm SLR scenario and the 140 cm SLR with 5% Amplification scenario.

The top panel of Figure 4.5-1 through Figure 4.5-13 shows the predicted daily-averaged depth-average salinity for the 140 cm SLR scenario on the first day of each month during the 2002 simulation period. The predicted daily-averaged depth-average salinity for the 140 cm SLR with 5% Amplification scenario on the first day of each month during the 2002 simulation period is shown on the top panel of Figure 4.6-1 through Figure 4.6-13. By subtracting the predicted depth-averaged salinity for the 140 cm SLR scenario from the predicted depth-averaged salinity from the 140 cm SLR with 5% Amplification scenario, the salinity increase resulting from the 5% amplification of tidal range can be computed. Figures 4.7-1 through 4.7-13 show the predicted increase in daily-averaged depth-average salinity for the140 cm SLR with 5% Amplification scenario relative to the 140 cm SLR scenario on the first day of each month during the 2002 simulation period. Note that the color scale shows only salinity increases and not salinity decreases.

On January 1, 2002 (Figure 4.7-1) salinity increases of between 0.05 and 0.2 psu are predicted in western San Pablo Bay and Central Bay. Salinity increases of between 0.05 and 0.10 psu are predicted in small regions of Suisun Bay. Following the high flows in January, smaller salinity increases are predicted on February 1, 2002 (Figure 4.7-2). Predicted salinity increases resulting from the tidal range amplification increase throughout the spring and summer. By June 1, 2002 (Figure 4.7-6), salinity increases of between 0.1 and 0.2 psu are predicted in most of Suisun Bay. By October 1, 2002 (Figure 4.7-10) and November 1, 2002 (Figure 4.7-11) salinity increases of between 0.05 and 0.10 psu extend upstream into Franks Tract and salinity increases of between 0.10 and 0.20 psu are predicted along the Sacramento River between Collinsville and Emmaton. Following the high flows in December, predicted salinity increases throughout the Delta are less than 0.05 psu on January 1, 2003 (Figure 4.7-13). The mechanisms responsible for the increased salt intrusion for the 140 cm SLR with 5% Amplification scenario relative to the 140 cm SLR scenario are discussed in Section 8.5.

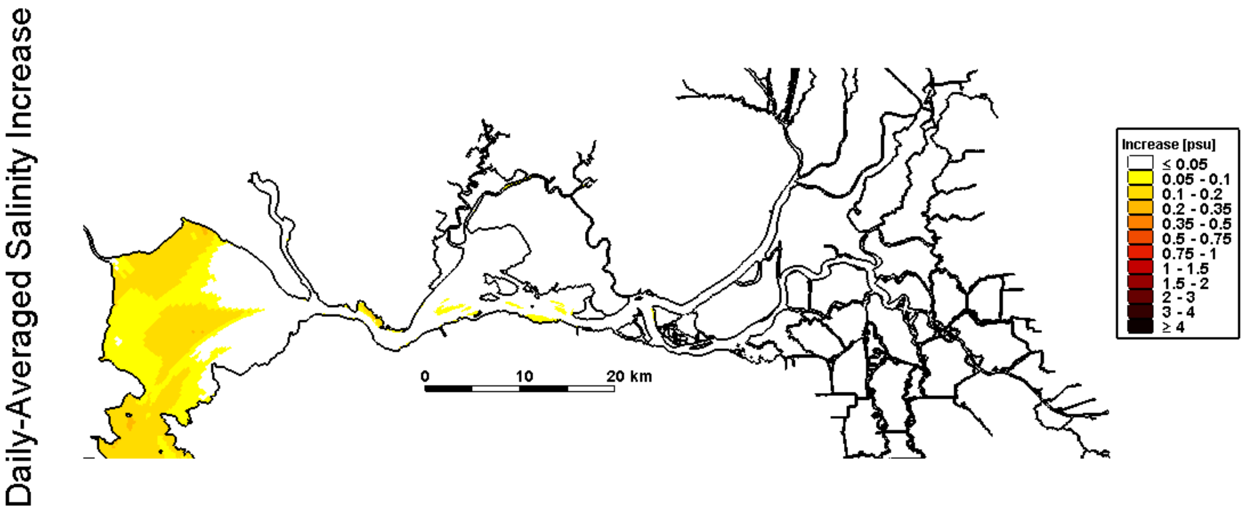


Figure 4.7-1 Predicted increase in daily-averaged depth-average salinity on January 1, 2002 for the 140 cm SLR with 5% Amplification scenario relative to the 140 cm SLR scenario.

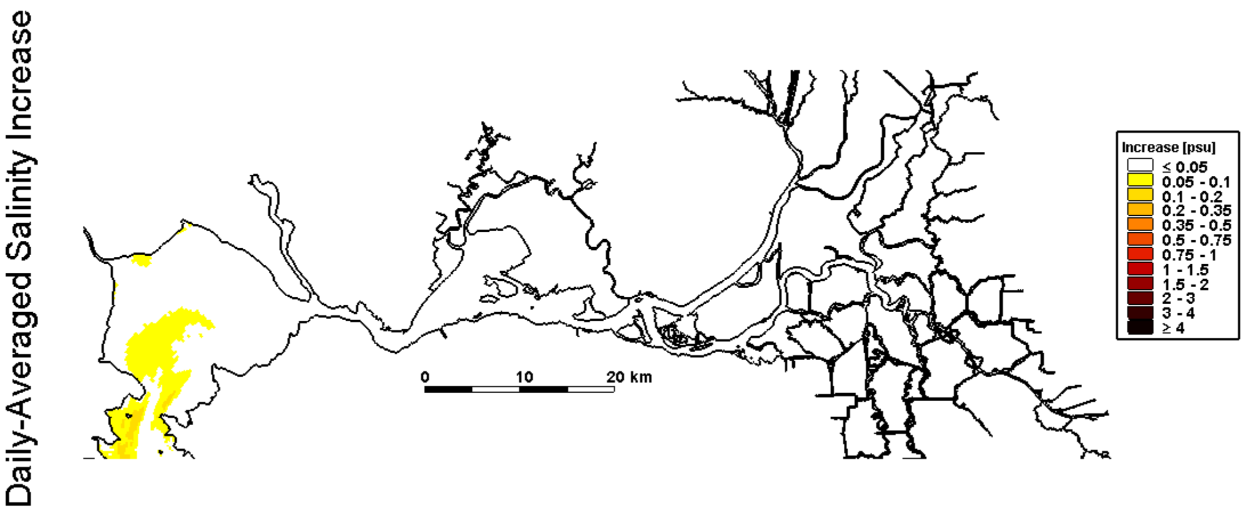


Figure 4.7-2 Predicted increase in daily-averaged depth-average salinity on February 1, 2002 for the 140 cm SLR with 5% Amplification scenario relative to the 140 cm SLR scenario.

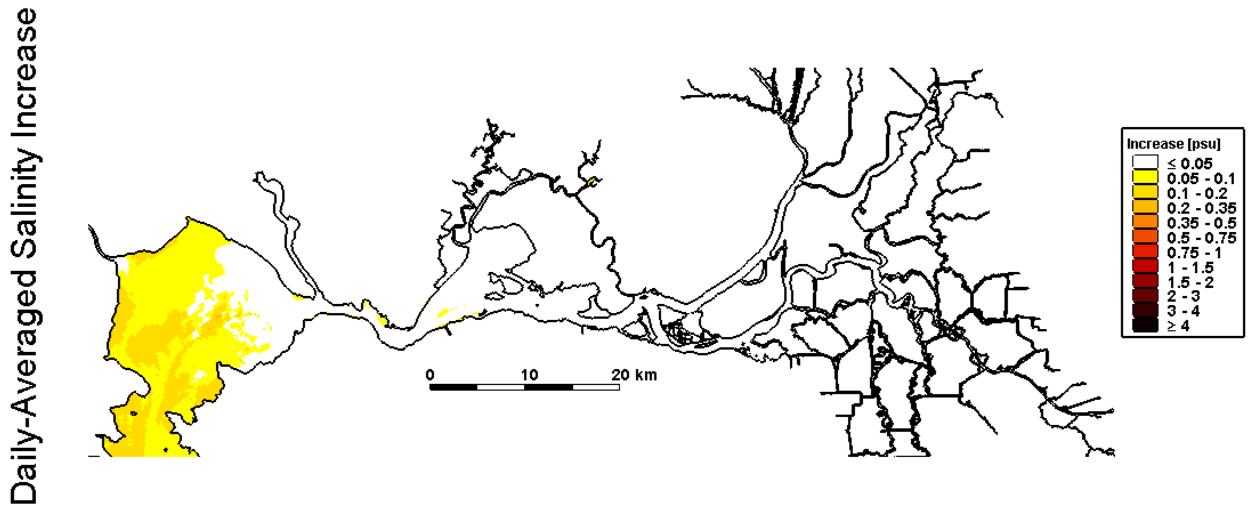


Figure 4.7-3 Predicted increase in daily-averaged depth-average salinity on March 1, 2002 for the 140 cm SLR with 5% Amplification scenario relative to the 140 cm SLR scenario.

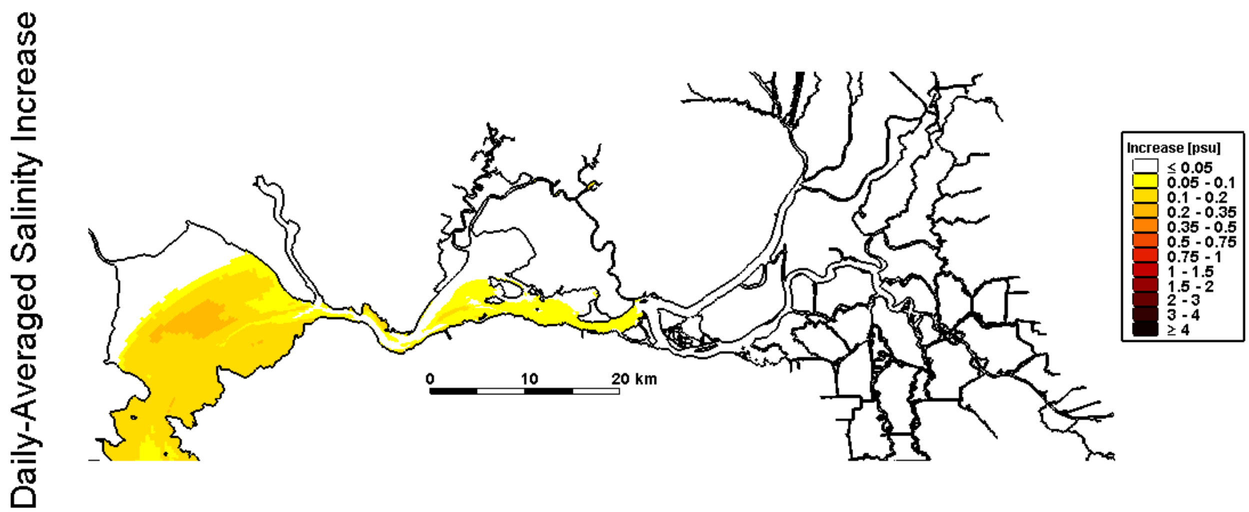


Figure 4.7-4 Predicted increase in daily-averaged depth-average salinity on April 1, 2002 for the 140 cm SLR with 5% Amplification scenario relative to the 140 cm SLR scenario.

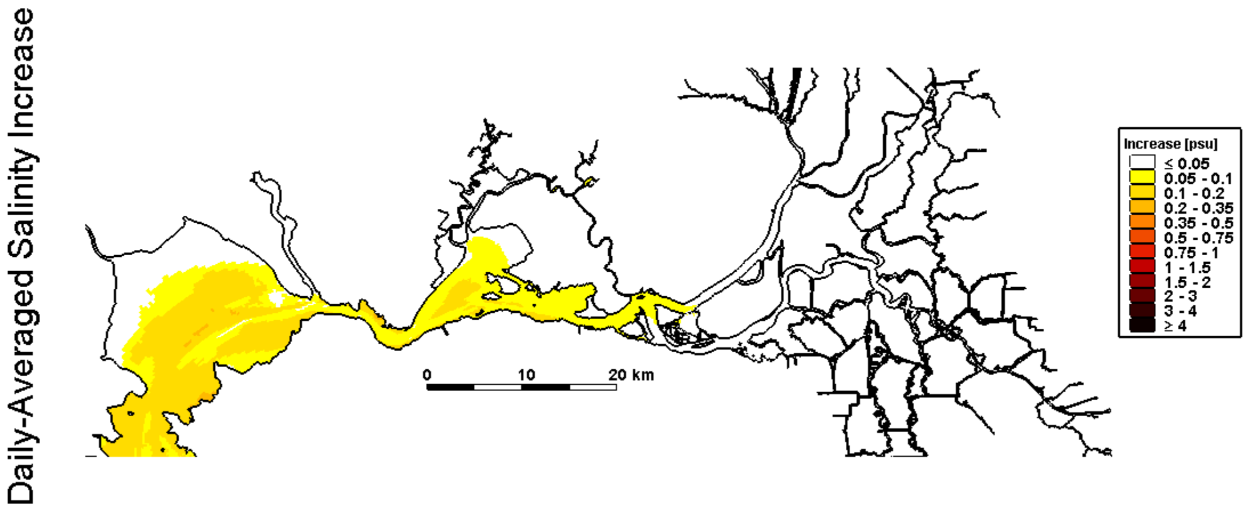


Figure 4.7-5 Predicted increase in daily-averaged depth-average salinity on May 1, 2002 for the 140 cm SLR with 5% Amplification scenario relative to the 140 cm SLR scenario.

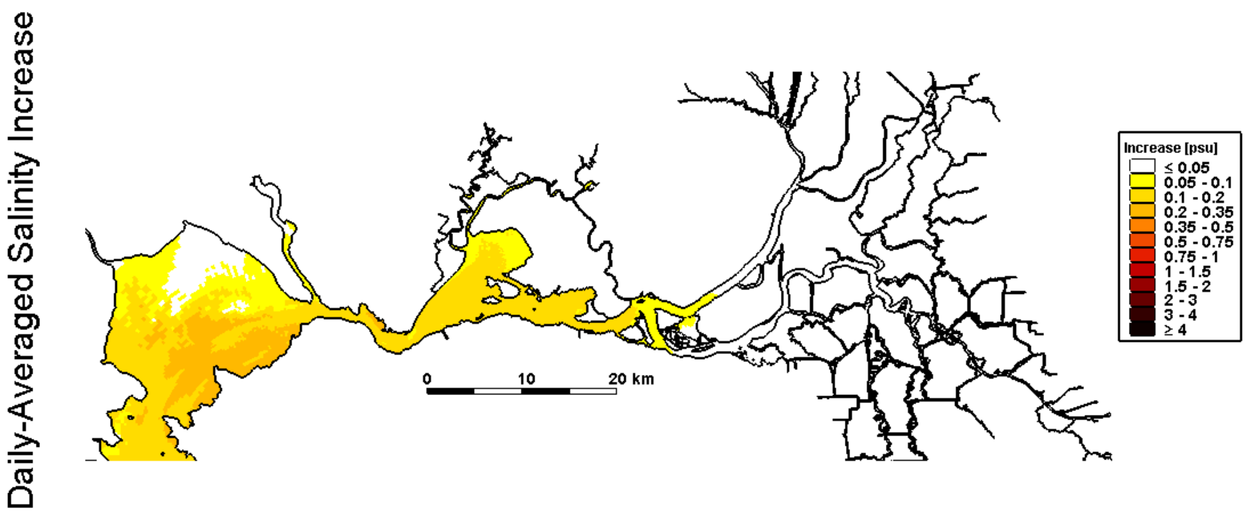


Figure 4.7-6 Predicted increase in daily-averaged depth-average salinity on June 1, 2002 for the 140 cm SLR with 5% Amplification scenario relative to the 140 cm SLR scenario.

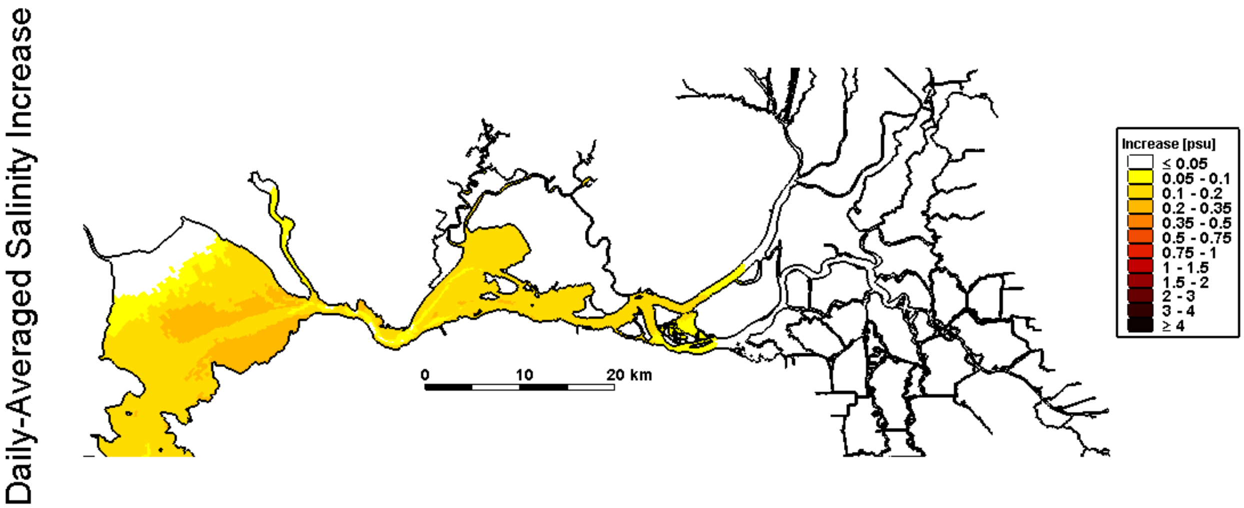


Figure 4.7-7 Predicted increase in daily-averaged depth-average salinity on July 1, 2002 for the 140 cm SLR with 5% Amplification scenario relative to the 140 cm SLR scenario.

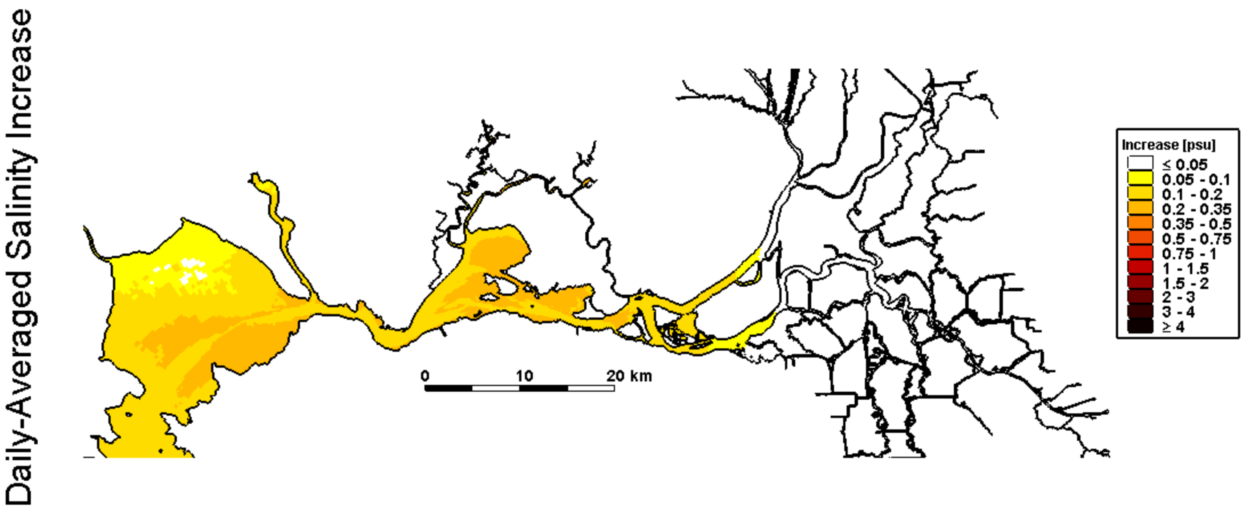


Figure 4.7-8 Predicted increase in daily-averaged depth-average salinity on August 1, 2002 for the 140 cm SLR with 5% Amplification scenario relative to the 140 cm SLR scenario.

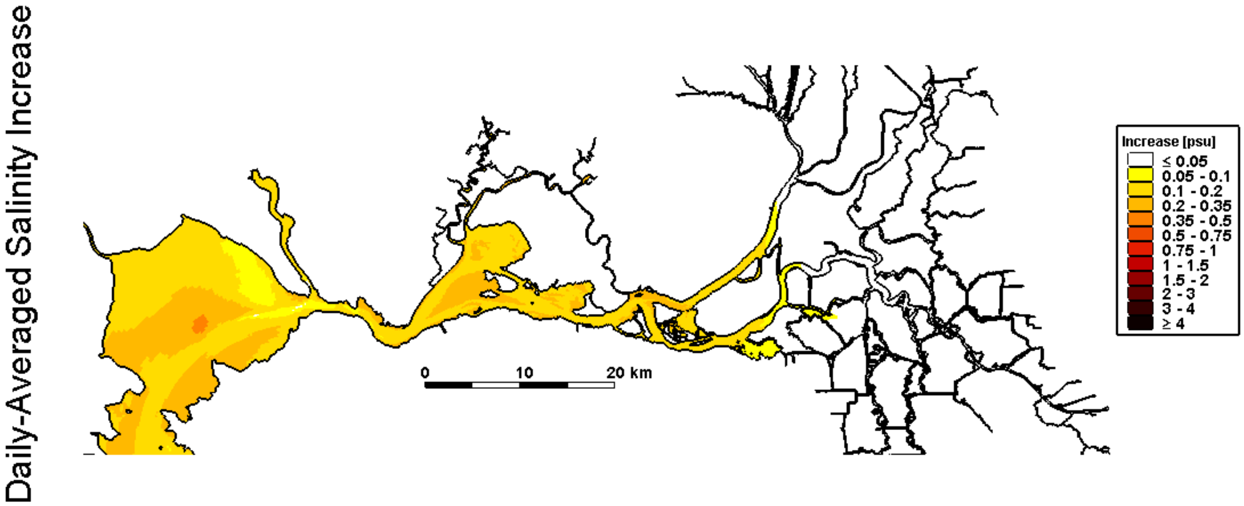


Figure 4.7-9 Predicted increase in daily-averaged depth-average salinity on September 1, 2002 for the 140 cm SLR with 5% Amplification scenario relative to the 140 cm SLR scenario.

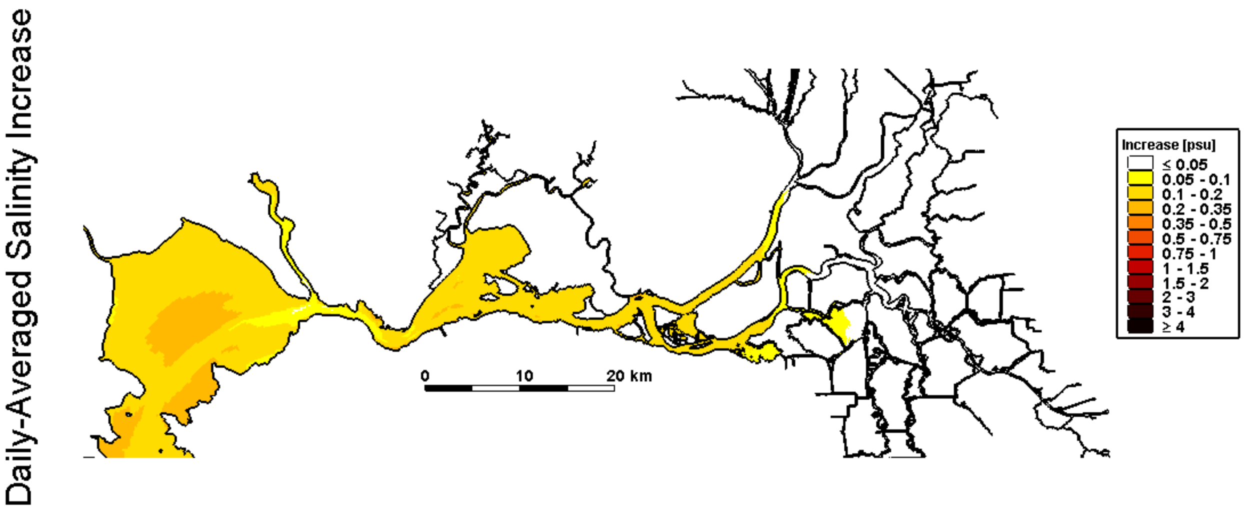


Figure 4.7-10 Predicted increase in daily-averaged depth-average salinity on October 1, 2002 for the 140 cm SLR with 5% Amplification scenario relative to the 140 cm SLR scenario.

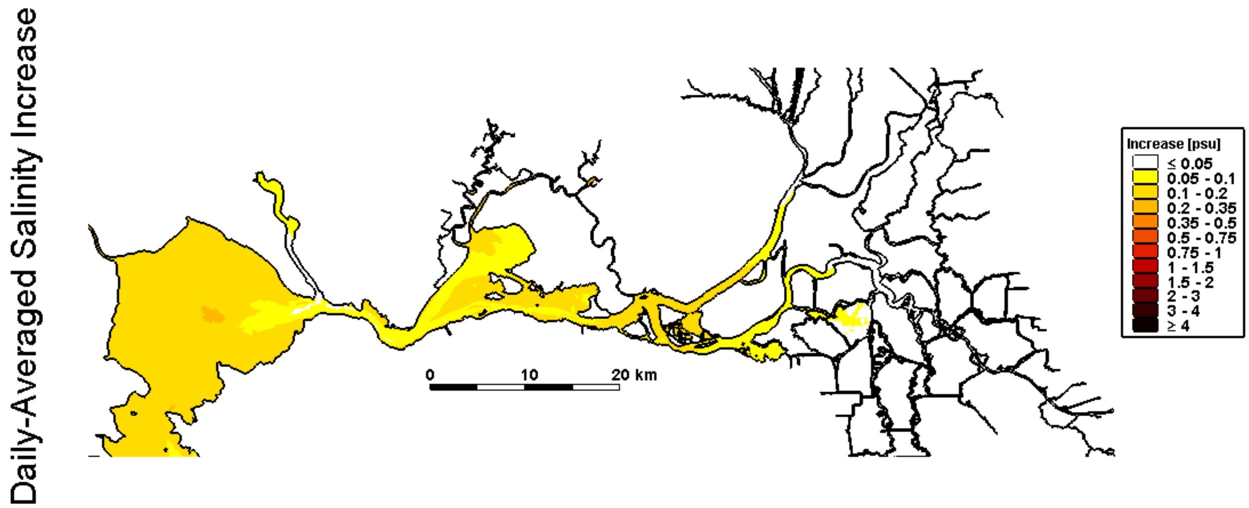


Figure 4.7-11 Predicted increase in daily-averaged depth-average salinity on November 1, 2002 for the 140 cm SLR with 5% Amplification scenario relative to the 140 cm SLR scenario.

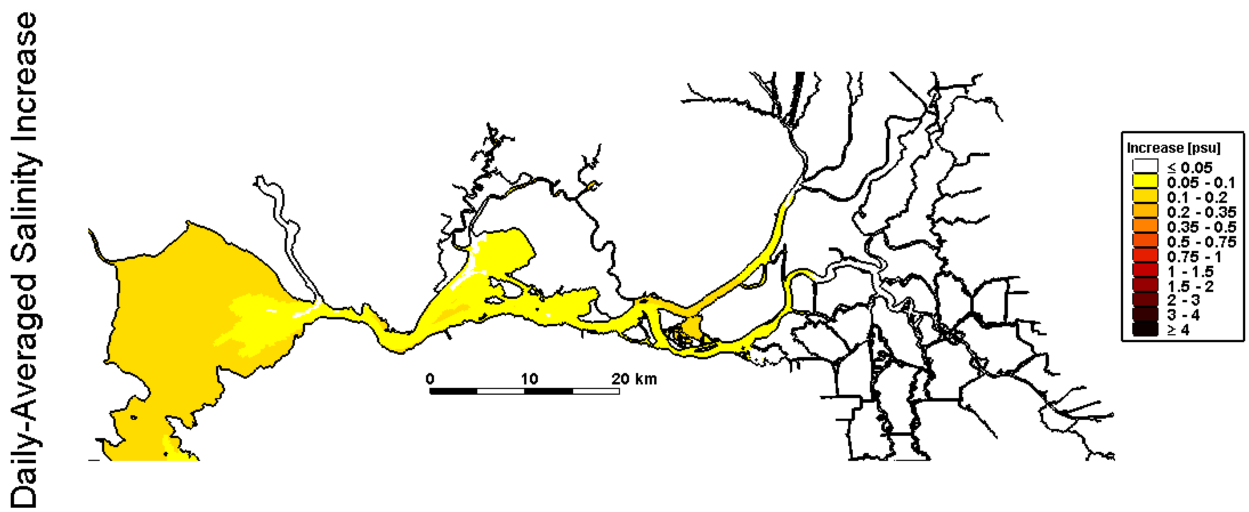


Figure 4.7-12 Predicted increase in daily-averaged depth-average salinity on December 1, 2002 for the 140 cm SLR with 5% Amplification scenario relative to the 140 cm SLR scenario.

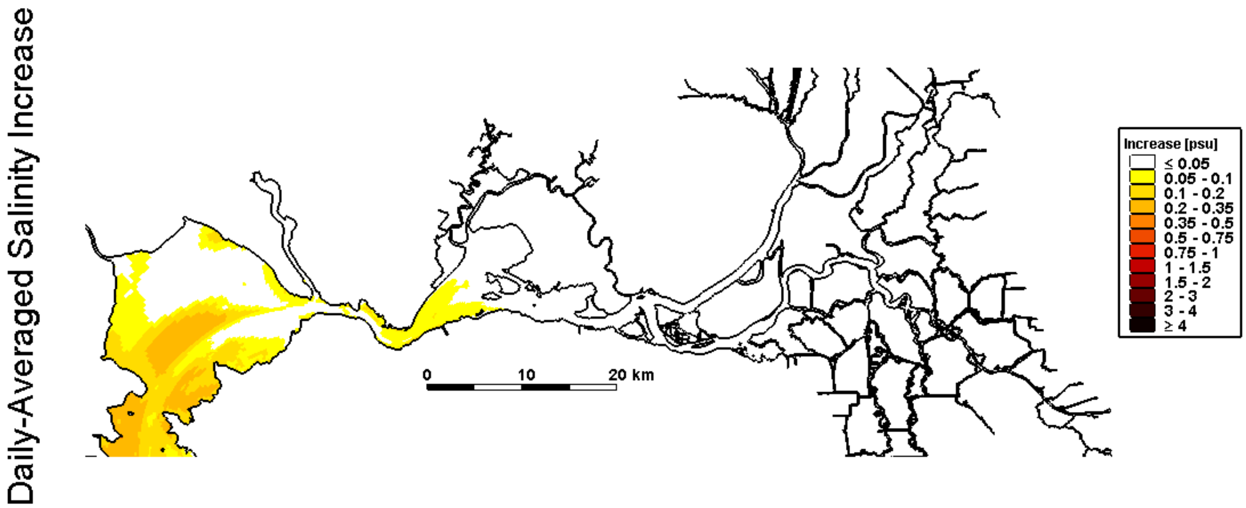


Figure 4.7-13 Predicted increase in daily-averaged depth-average salinity on January 1, 2003 for the 140 cm SLR with 5% Amplification scenario relative to the 140 cm SLR scenario.

5. Evaluation of Impact of Sea Level Rise on X2

5.1 X2 Comparison Approach

By definition X2 is the distance, in kilometers, from the Golden Gate to the tidally averaged near-bed 2 psu isohaline. The 1995 Bay-Delta agreement established standards for salinity in the estuary. Specifically, the standards determine the degree to which salinity is allowed to penetrate up-estuary, with salinity to be controlled through Delta outflow (IEP, 2009). This regulation is based on observations that the abundance or survival of several estuarine biological populations in the San Francisco Estuary is positively related to freshwater flow (Jassby et al. 1995), although recent studies suggest that some of these relationships have changed (Sommer et al. 2007).

As reported in the Water Rights Decision 1641 (D-1641; SWRCB, 2000), diversion by the USBR at Banks Pumping Plant is not authorized when the Delta is in excess conditions (excess conditions exist when upstream reservoir releases plus unregulated natural flow exceed Sacramento Valley in-basin uses, plus exports) and such diversion causes the location of X2 to shift upstream so far that:

> (a) It is east of Chipps Island (75 river kilometers upstream of the Golden Gate) during the months of February through May, or
>
> (b) It is east of Collinsville (81 kilometers upstream of the Golden Gate) during the months of January, June, July, and August, or
>
> (c) During December it is east of Collinsville and delta smelt are present at Contra Costa Water District's point of diversion under Permits 20749 and 20750 (Application 20245).

For the purposes of this standard, X2 is the most downstream location of either the maximum daily-average or the 14-day running average of the 2.64 mmhos/cm isohaline (SWRCB, 2000). Additional restrictions reported in D-1641 restrict CCWD from refilling Los Vaqueros Reservoir during the months of February through May if X2 is east of Chipps Island. In January, June, and August, CCWD is restricted from filling Los Vaqueros if X2 is east of Collinsville. Further restrictions apply in December if delta smelt are present at the intake on Old River and X2 is east of Collinsville (SWRCB, 2000).

Jassby et al. (1995) provide a graphical depiction of X2 locations (Figure 5.1-1), showing X2 distance measured from the Golden Gate. The inset figure shows an X2 of about 75 km at Chipps Island and 81 km at Collinsville. In the UnTRIM Bay-Delta model, X2 is calculated along the axis of the estuary along the transects shown in Figure 5.2-1. For X2 distances greater than 75 km, the distance from the Golden Gate to the location of 2 psu bottom salinity is measured along both the Sacramento and San Joaquin transects, and the reported predicted X2 is the average of the Sacramento and San Joaquin X2 distances.

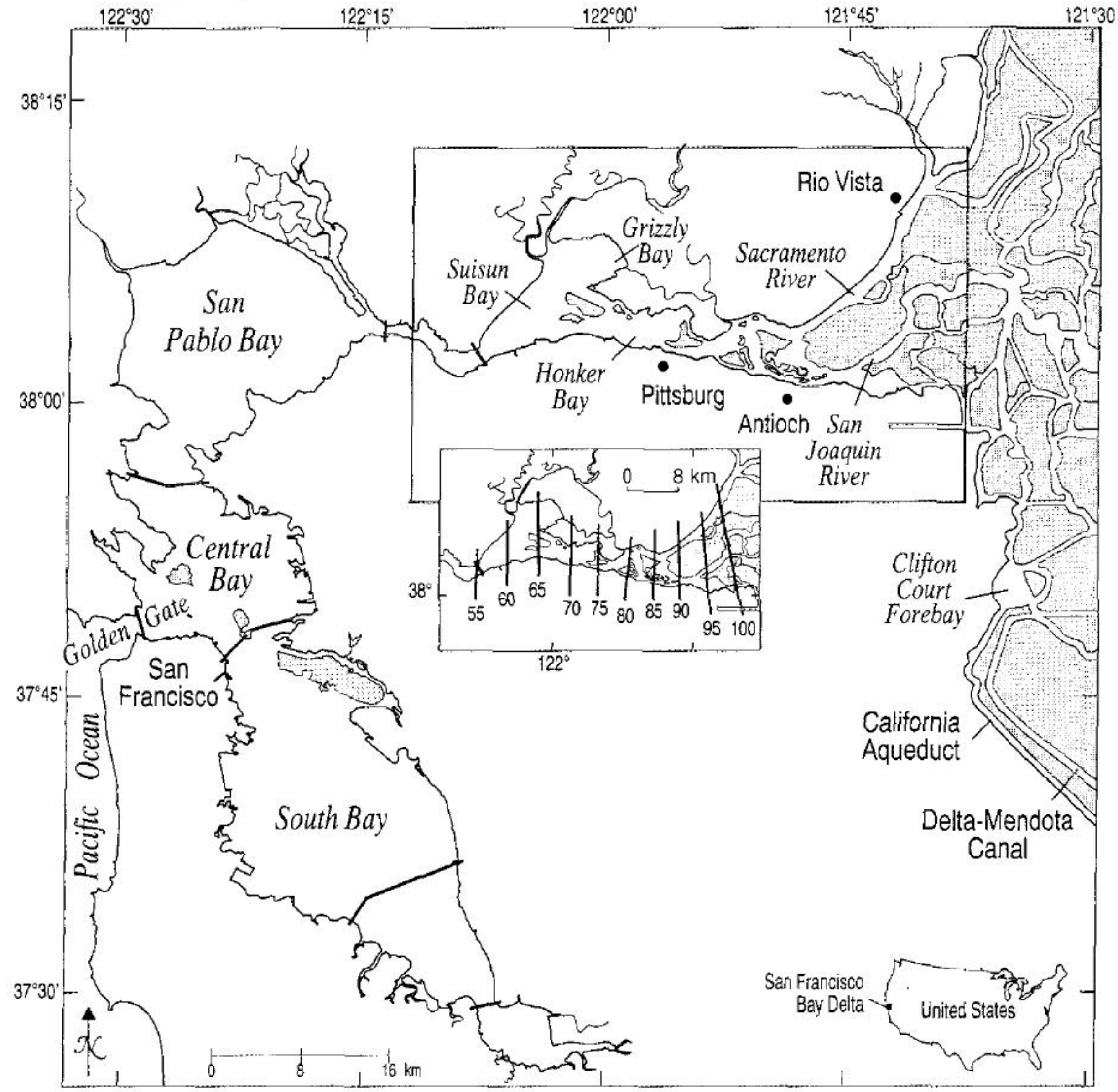


Figure 5.1-1 Map of San Francisco Bay and the Sacramento-San Joaquin Delta, with inset showing X2 locations in Suisun Bay and the western Delta (from Jassby et al., 1995).

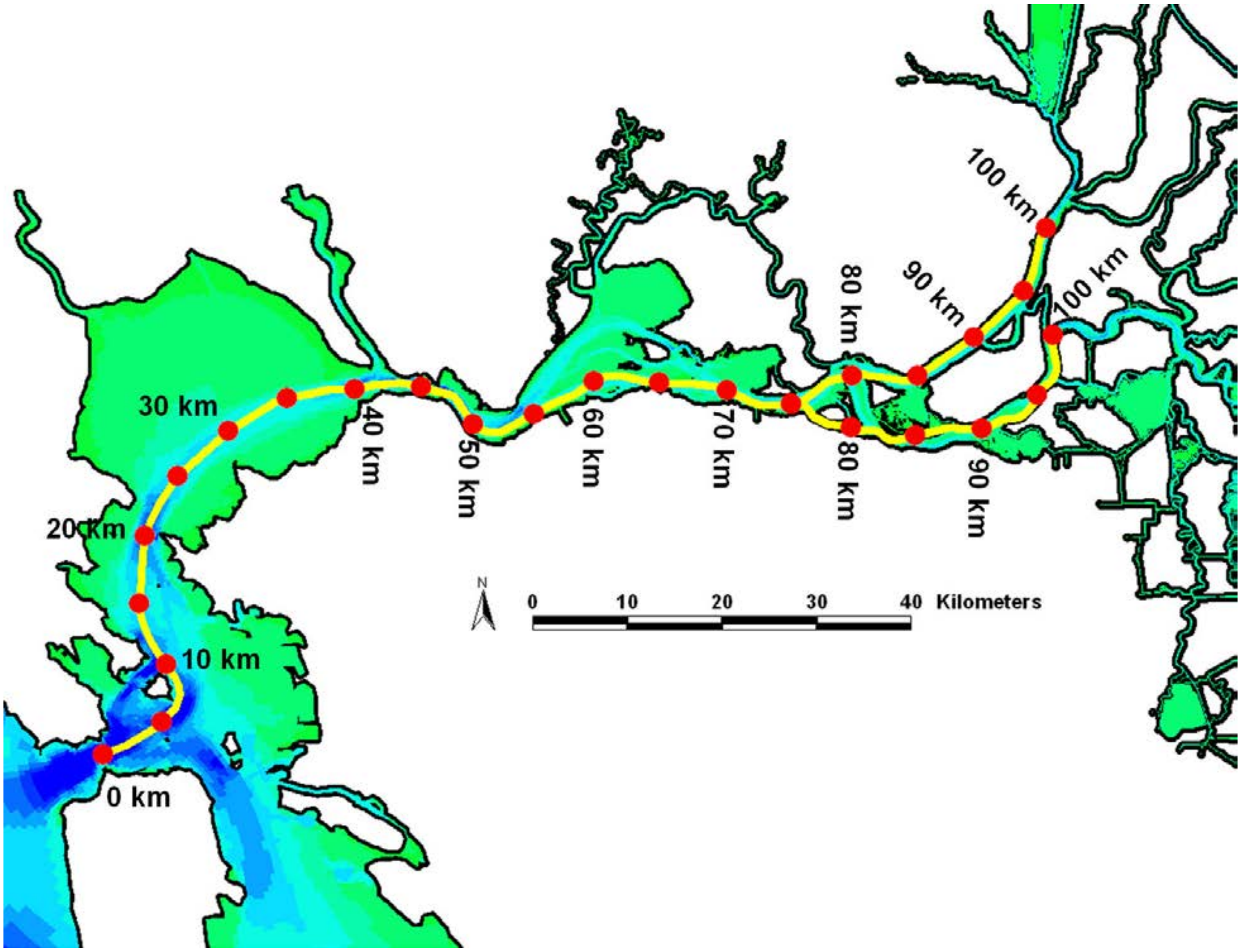


Figure 5.1-2 Transects along the axis of northern San Francisco Bay used to measure X2 in the UnTRIM Bay-Delta model.

5.2 X2 Comparison Results

Figure 5.2-1 shows the predicted X2 distance for the Baseline scenario, the 15 cm SLR scenario, the 30 cm SLR scenario, the 45 cm SLR scenario, the 60 cm SLR scenario, the 140 cm SLR scenario, and the 140 cm SLR with 5% Amplification scenario during the one-year analysis period. The lower panel of Figure 5.2-1 shows the predicted change in X2 relative to the Baseline scenario the 15 cm SLR scenario, the 30 cm SLR scenario, the 45 cm SLR scenario, the 60 cm SLR scenario, the 140 cm SLR scenario, and the 140 cm SLR with 5% Amplification scenario. Relative to the Baseline X2, all six of the sea level ruse scenarios show an increase in X2 throughout the year. For easier visual evaluation of the change in X2 for the SLR scenarios with 60 cm SLR or less, Figure 5.2-2 shows the predicted X2 distance for the Baseline scenario, the 15 cm SLR scenario, the 30 cm SLR scenario, the 45 cm SLR scenario, and the 60 cm SLR scenario.

For the 15 cm SLR scenario, an increase in X2 of between 0.5 km and 1 km is predicted throughout most of the year. X2 increases of up to 1.53 km are predicted in January and December during high flow periods. These increases in X2 indicate that the flushing flows become less efficient at pushing salt out of the estuary with increasing sea level rise. For the 30 cm SLR, an increase in X2 of between 1 km and 2 km is predicted throughout most of the year. X2 increases of up to 2.73 km are predicted in January and December during high flow periods. For the 45 cm SLR scenario, an increase in X2 of between 2 and 3 km is predicted throughout most of the year. The highest predicted increases in X2 occur in January and December during high flows, again indicating that the flushing flows become less efficient at pushing salt out of the estuary with increasing sea level rise. For the 60 cm SLR scenario, an increase in X2 of between 3 km and 4 km is predicted throughout most of the year. X2 increases of up to 4.99 km are predicted in January and December during high flow periods. For the 140 cm SLR scenario and the 140 cm SLR with 5% Amplification scenario, an increase in X2 of between 6 km and 8 km is predicted throughout most of the year. X2 increases of more than 11 km are predicted in January and December during high flow periods. These results show a relatively uniform increase in X2 throughout the year for each of the SLR scenarios, with the exception of the higher flow periods which tend to show the largest increases in X2.

Figure 5.2-3 shows the cumulative number of days during 2002 that the change in predicted X2 for the 15 cm SLR scenario, 30 cm SLR scenario, 45 cm SLR scenario, 60 cm SLR scenario, 140 cm SLR scenario, and 140 cm SLR with 5% Amplification scenario exceeds the corresponding X2 predicted under the Baseline scenario by a specific distance.

The maximum increase in X2 under the 15 cm SLR scenario is 1.53 km and the median predicted change in X2 under the 15 cm SLR scenario is 0.69 km. The median predicted change in X2 indicates that for 182 days during 2002 under the 15 cm SLR scenario the predicted change in average X2 is more than 0.69 km, whereas for 182 days the predicted change in average X2 under the 15 cm SLR scenario is less than 0.69 km. The maximum increase in X2 under the 30 cm SLR scenario is 2.73 km and the median predicted change in X2 under the 30 cm SLR scenario is 1.39 km. The maximum increase in X2 under the 45 cm SLR scenario is 4.00 km and the median predicted change in X2 under the 45 cm SLR scenario is 2.12 km. The maximum increase in X2 under the 60 cm SLR scenario is 4.99 km and the median predicted change in X2 under the 60 cm SLR scenario is 2.91 km. The maximum increase in X2 under the 140 cm SLR scenario is 11.31 km and the median predicted change in X2 under the 140 cm SLR scenario is 7.03 km. The maximum increase in X2 under the 140 cm SLR with 5% Amplification scenario is 11.64 km and the median predicted change in X2 under the 140 cm SLR with 5% Amplification scenario is 7.32 km. The median and maximum increase in X2 for each of the sea level rise scenarios during 2002 is summarized in Table 5-1.

Figure 5.4-4 shows a scatter plot of the predicted increase in X2 for each day during 2002 for each of the sea level rise scenarios. The median increase and maximum increase are also plotted for each scenario. Both the median and the maximum increase in X2 lines show a nearly linear slope as a function of sea level rise, however the maximum increase has a steeper slope than the median increase.

Table 5-1 Median predicted increase in X2 and maximum predicted increase in X2 during the 2002 simulation period for each SLR scenario.

Scenario Name	**Median Increase in X2 [km]**	**Max Increase in X2 [km]**
15 cm SLR	0.69	1.53
30 cm SLR	1.39	2.73
45 cm SLR	2.12	4.00
60 cm SLR	2.91	4.99
140 cm SLR	7.03	11.31
140 cm SLR with 5% Amp	7.32	11.64

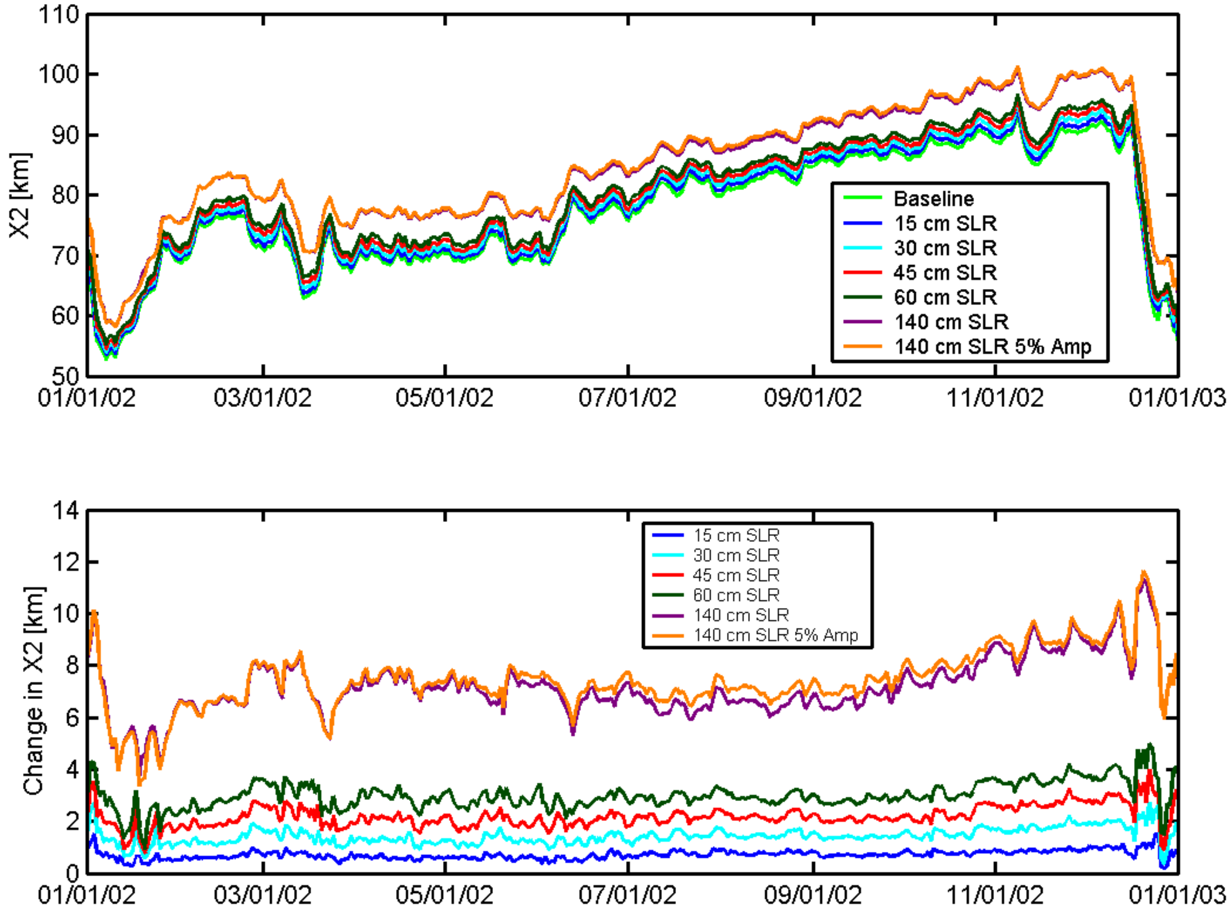


Figure 5.2-1 Predicted X2 for Baseline (0 cm SLR) scenario, 15 cm SLR scenario, 30 cm SLR scenario, 45 cm SLR scenario, 60 cm SLR scenario, 140 cm SLR scenario, and 140 cm SLR with 5% Amplification scenario (top); Predicted change in X2 relative to Baseline scenario for 15 cm SLR scenario, 30 cm SLR scenario, 45 cm SLR scenario, 60 cm SLR scenario, 140 cm SLR scenario, and 140 cm SLR with 5% Amplification scenario (bottom).

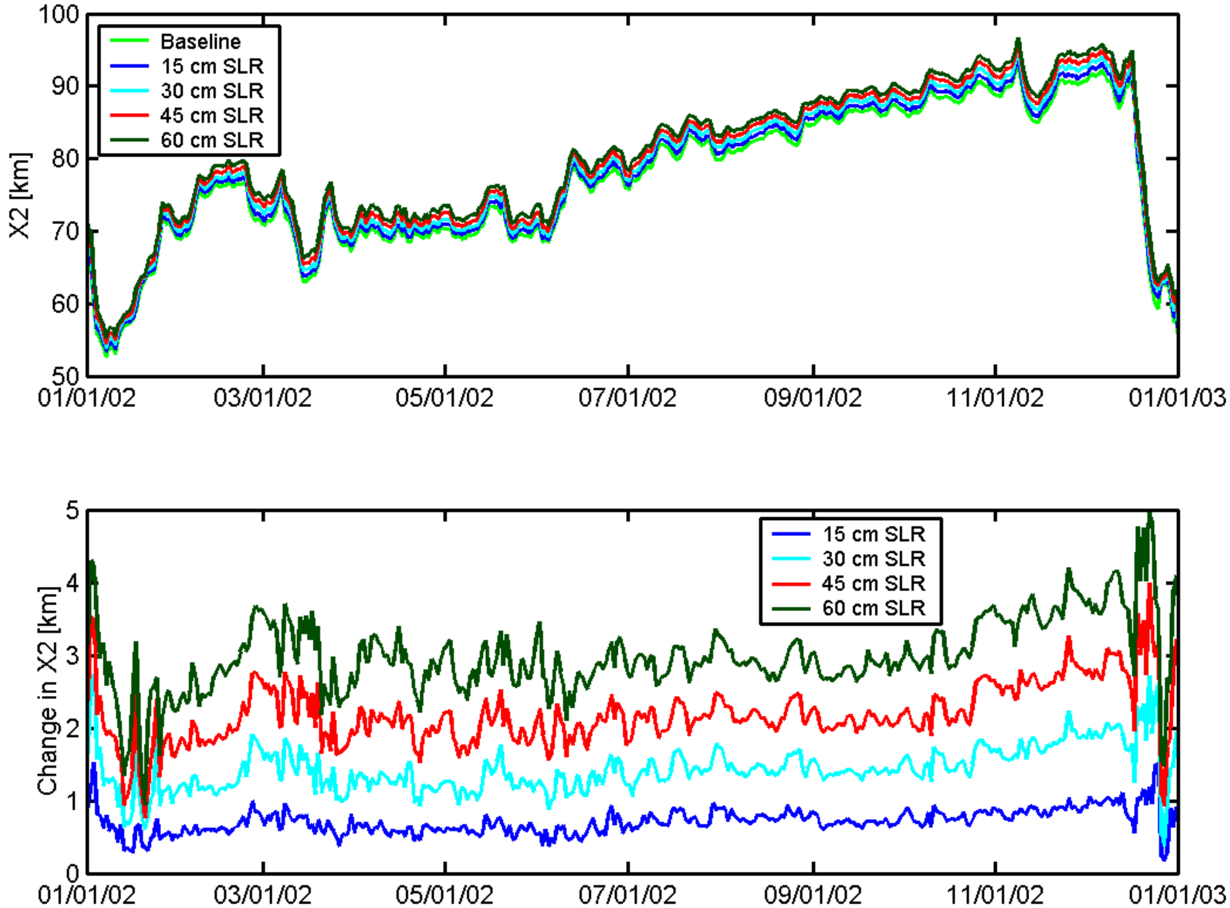


Figure 5.2-2 Predicted X2 for Baseline (0 cm SLR) scenario, 15 cm SLR scenario, 30 cm SLR scenario, 45 cm SLR scenario, and 60 cm SLR scenario (top); Predicted change in X2 relative to Baseline scenario for 15 cm SLR scenario, 30 cm SLR scenario, 45 cm SLR scenario, and 60 cm SLR scenario (bottom).

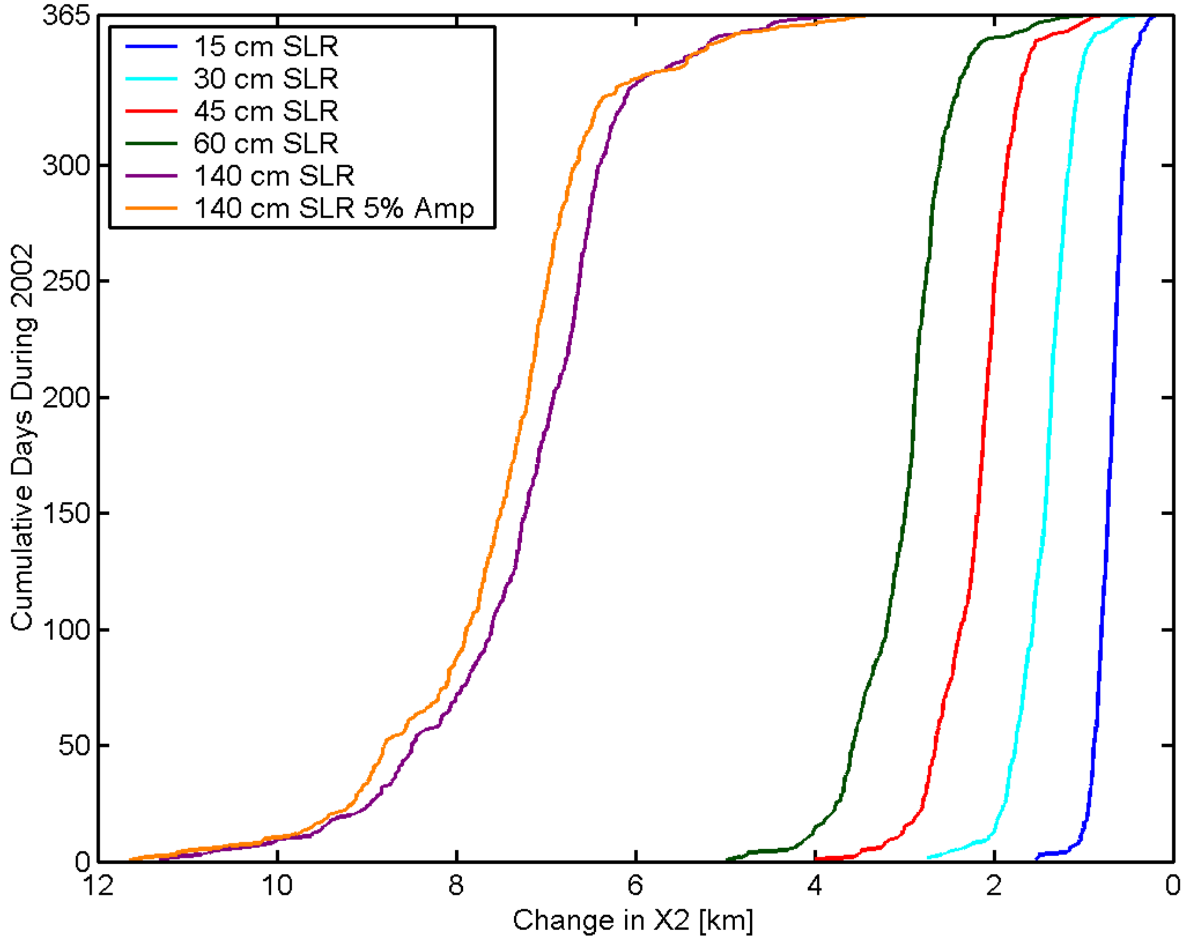


Figure 5.2-3 Cumulative number of days during 2002 that the change in predicted X2 for the 15 cm SLR scenario, 30 cm SLR scenario, 45 cm SLR scenario, 60 cm SLR scenario, 140 cm SLR scenario, and 140 cm SLR with 5% Amplification scenario exceeds the corresponding X2 predicted under the Baseline (0 cm SLR) scenario by a specific distance.

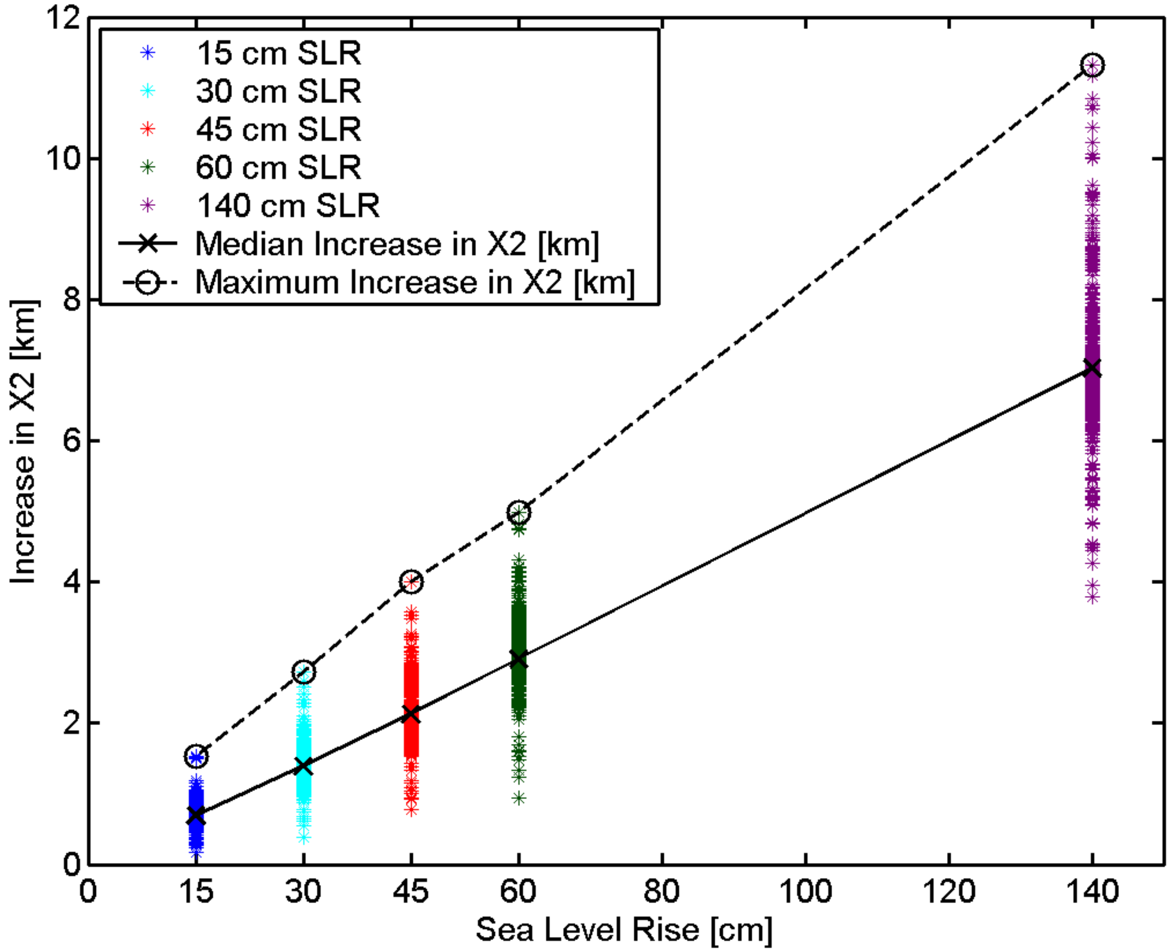


Figure 5.2-4 Scatter plot of the predicted increase in X2 for each day during 2002 for each of the sea level rise scenarios; solid black line shows the median increase in X2 for each SLR scenario and the dashed black line shows the maximum increase in X2 for each SLR scenario.

5.3 Effect of Tidal Range Amplification on X2

This section evaluates the effect of the amplification of tidal range on X2 through the comparison of X2 for the 140 cm SLR scenario and X2 for the the 140 cm SLR with 5% Amplification scenario.

Figure 5.3-1 shows the predicted X2 for 140 cm SLR scenario and 140 cm SLR with 5% Amplification scenario and the predicted change in X2 for the 140 cm SLR with 5% Amplification scenario relative to the 140 cm SLR scenario. During the high flow period during January, the predicted X2 for the 140 cm SLR with 5% Amplification scenario is less than the X2 for the 140 cm SLR scenario resulting in a decrease in X2 with tidal amplification (shown as a negative change in X2 on Figure 5.3-1). During periods when the change in X2 is negative, X2 is typically between Martinez and Port Chicago, and strong stratification is present in Carquinez Strait, as is typical during high flows. The increased tidal prism resulting from the 140 cm SLR with 5% Amplification scenario (see Section 8.4) results in higher tidal currents and, therefore, stronger vertical mixing and less stratification. Since gravitational circulation associated with this strong stratification is responsible for much of the salt intrusion during high flows (see Section 8), the reduced strength of stratification resulting from the stronger vertical mixing results in a decrease in X2 during high flows as a result of the amplification of tidal range. During summer and fall conditions, the predicted X2 for the 140 cm SLR with 5% Amplification scenario is greater than the X2 for the 140 cm SLR scenario resulting in an increase in X2 with tidal amplification. From July through November an increase of X2 of approximately 0.5 km is predicted as a result of the 5% tidal amplification. The mechanisms responsible for the increased salt intrusion for the 140 cm SLR with 5% Amplification scenario relative to the 140 cm SLR scenario are discussed in Section 8.5.

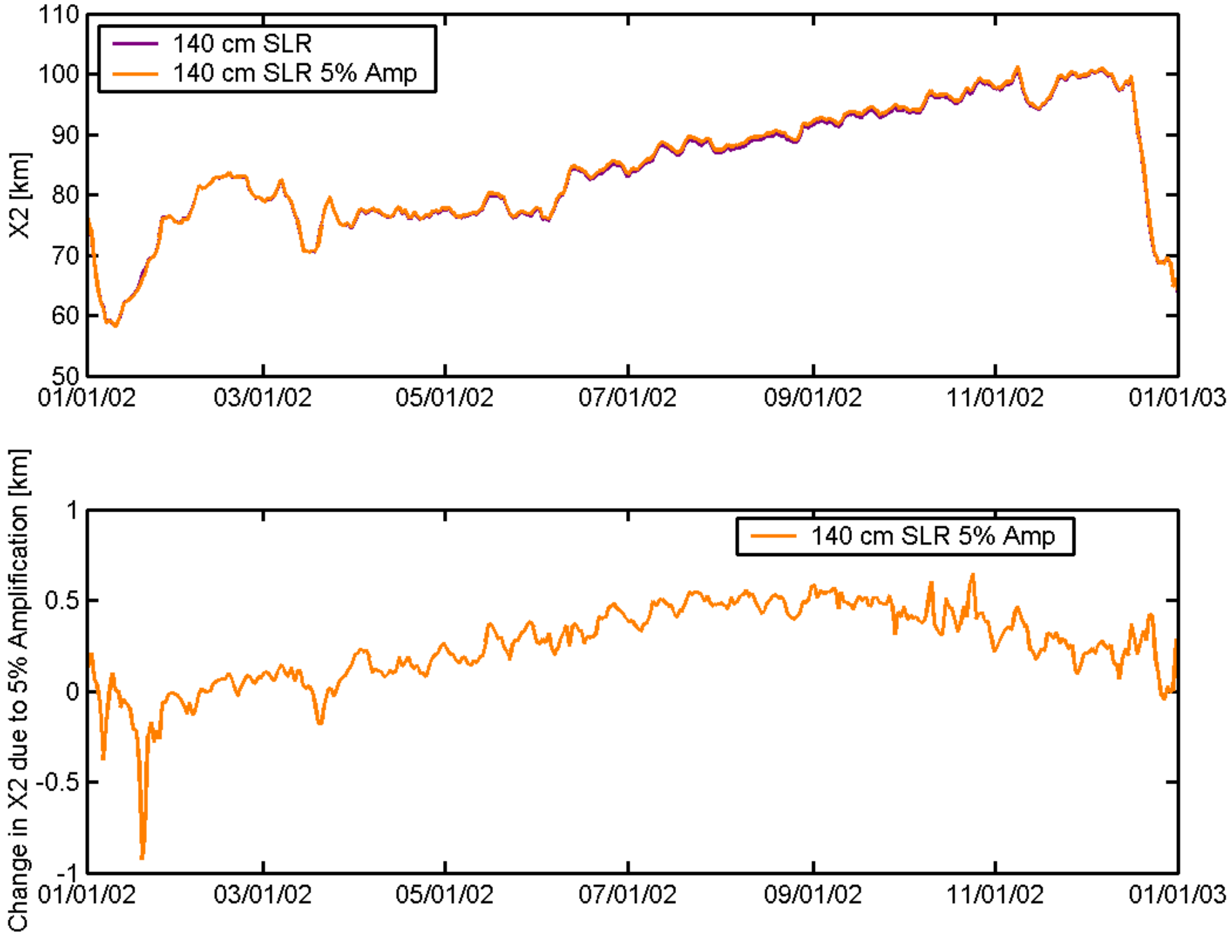


Figure 5.3-1 Predicted X2 for 140 cm SLR scenario and 140 cm SLR with 5% Amplification scenario (top); Predicted change in X2 relative to 140 cm SLR scenario for 140 cm SLR with 5% Amplification scenario (bottom).

6. Sea Level Rise Impacts on Salinity at Continuous Monitoring Locations

Salinity time series provide information about potential salinity impacts over time at a fixed location. Time series comparisons of predicted salinity were made at ten continuous salinity monitoring stations in San Francisco Bay and the Sacramento-San Joaquin Delta.

6.1 Salinity Time Series Comparisons

For each sea level rise scenario, salinity time series comparisons were made at ten continuous salinity monitoring stations in San Francisco Bay and the Sacramento-San Joaquin Delta, shown on Figure 6.1-1. For each comparison, three separate plots are shown. The top plot shows the tidal time-scale variability over a 15-day period for each sea level rise scenario. The middle plot shows daily-average salinity during the full simulation year for each sea level rise scenario. The bottom plot shows the predicted change in daily-average salinity for each of the sea level rise scenarios relative to the Baseline (0 cm SLR) scenario. The figures provide a quantitative measure of potential impacts of sea level rise on salinity in San Francisco Bay and the Sacramento-San Joaquin Delta on both tidal and annual time scales.

Figure 6.1-2 shows the predicted salinity at the Presidio for the Baseline scenario and the six sea level rise scenarios. The increase in salinity at the Presidio resulting from sea level rise is relatively small, with predicted increases in daily-average salinity of less than 0.5 psu during the entire year for the 15 cm SLR scenario and the 30 cm SLR scenario. The largest increases in daily-average salinity under all of the sea level rise scenarios occur during the high flow periods in January and December, due to the decreased ability of high flows to flush salt out of the estuary with increasing sea level rise.

Figure 6.1-3 shows the predicted salinity at Point San Pablo Upper Sensor for the Baseline scenario and the six sea level rise scenarios. The predicted increases in daily-average salinity at Point San Pablo show a similar pattern to the predicted salinity increases at the Presidio, with the largest predicted increases in daily-average salinity during the high flows during January and December. The predicted increases in daily-average salinity at Point San Pablo are larger than the predicted salinity increases at the Presidio.

Figure 6.1-4 shows the predicted salinity at the Sacramento River at the Martinez Surface Sensor (RSAC054) for the Baseline scenario and the six sea level rise scenarios. In each of the scenarios, the predicted increase in daily-average salinity at the Martinez Surface Sensor is relatively constant throughout the year, with the exception of the high flow periods.

Figure 6.1-5 shows the predicted salinity at the Sacramento River near Mallard Island Surface Sensor (RSAC075) for the Baseline scenario and the six sea level rise scenarios. The predicted increase in daily-average salinity is close to zero during January following the high flows and gradually increases throughout the summer. The predicted salinity increase for all scenarios approaches zero during December as salt is pushed out of Suisun Bay by high Delta outflows.

Figure 6.1-6 shows the predicted salinity at the Sacramento River at Emmaton Surface Sensor (RSAC092) for the Baseline scenario and the six sea level rise scenarios. With the exception of the 140 cm SLR and 140 cm SLR with 5% Amplification scenarios, the predicted increase in daily-average salinity at Emmaton is close to 0 psu from January through May, and following the high flows in December. The predicted increase in daily-average salinity gradually increases throughout the summer for all scenarios, with larger increases predicted with increasing SLR.

Figure 6.1-7 shows the predicted salinity at Sacramento River at Rio Vista (RSAC101) for the Baseline scenario and the six sea level rise scenarios. The predicted increase in daily-average salinity at Rio Vista is close to 0 psu from January through May for all scenarios. The predicted increase in daily-average salinity gradually increases throughout the summer, beginning in July for the 140 cm SLR and 140 cm SLR with 5% Amplification scenarios, and beginning in September for the other SLR scenarios. The largest predicted increases in daily-average salinity for all scenarios occur in November.

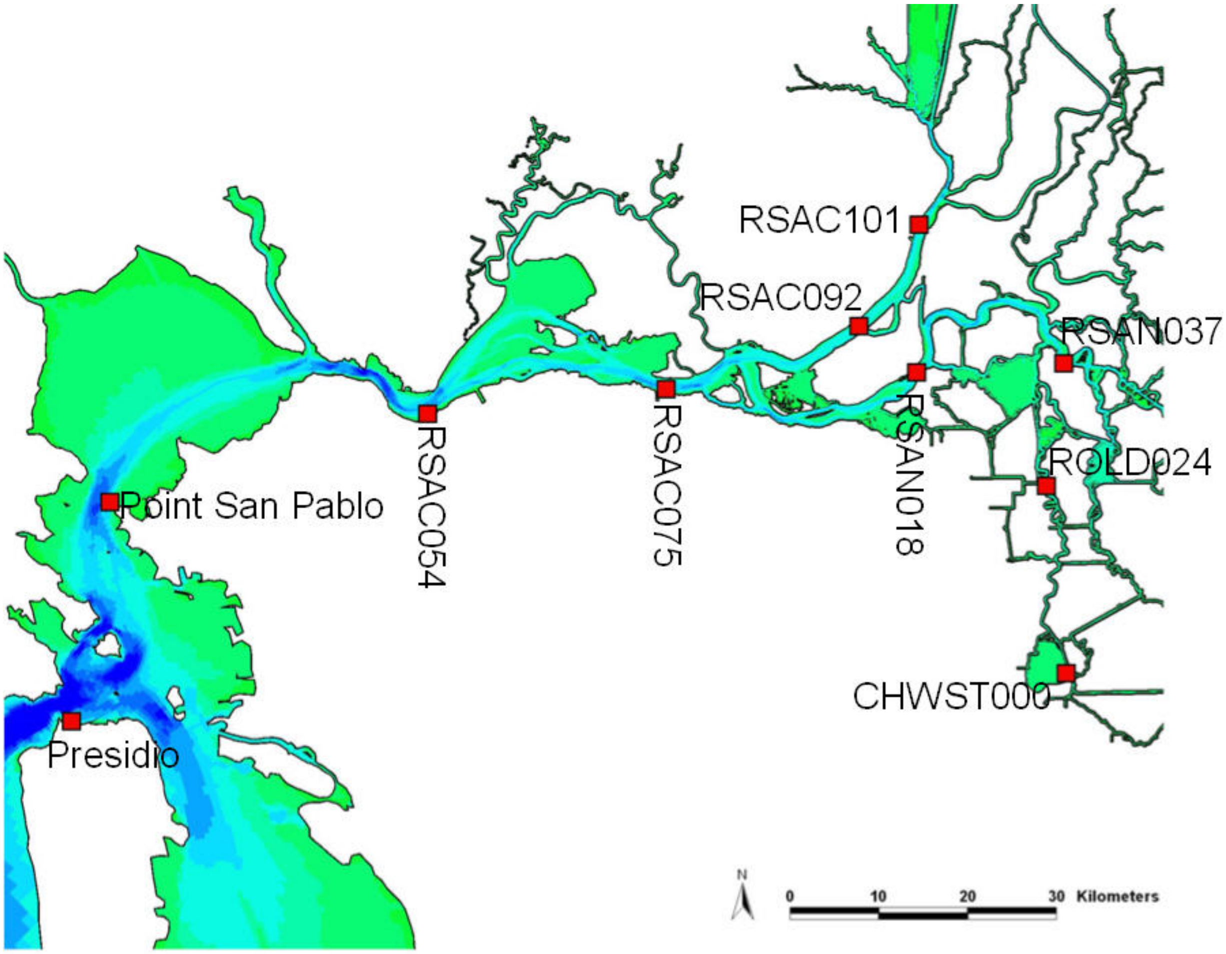
Figure 6.1-8 shows the predicted salinity at San Joaquin River at Jersey Point (RSAN018) for the Baseline scenario and the six sea level rise scenarios. The predicted increase in daily-average salinity at Jersey Point is close to 0 psu from January through May for all scenarios. The predicted increase in daily-average salinity gradually increases throughout the summer, beginning in June for the 140 cm SLR and 140 cm SLR with 5% Amplification scenarios, and beginning later in the summer for the other SLR scenarios. The largest predicted increases in daily-average salinity for all scenarios occur in November and December.

Figure 6.1-9 shows the predicted salinity at San Joaquin River before Prisoner’s Point (RSAN037) for the Baseline scenario and the six sea level rise scenarios. The predicted increase in daily-average salinity at Prisoner’s Point is close to 0 psu from January through June for all scenarios. The predicted increase in daily-average salinity gradually increases throughout the late-summer and fall, beginning in July for the 140 cm SLR and 140 cm SLR with 5% Amplification scenarios, and beginning later in the summer for the other SLR scenarios. The largest predicted increases in daily-average salinity for all scenarios occur in early December.

Figure 6.1-10 shows the predicted salinity at Old River at Bacon Island (ROLD024) for the Baseline scenario and the six sea level rise scenarios. The predicted increase in daily-average salinity at Old River at Bacon Island is close to 0 psu from January through June for all scenarios. The predicted increase in daily-average salinity gradually increases throughout the late-summer and fall, beginning in July for the 140 cm SLR and 140 cm SLR with 5% Amplification scenarios, and beginning later in the summer for the other SLR scenarios. The largest predicted increases in daily-average salinity for all scenarios occur in early December.

Figure 6.1-11 shows the predicted salinity at Clifton Court Forebay Radial Gates (CHWST000) for the Baseline scenario and the six sea level rise scenarios. The predicted increase in daily-average salinity at the Clifton Court Forebay Radial gates is close to 0 psu from January through June for all scenarios except for the 140 cm SLR scenario and the 140 cm SLR with 5 % Amplification scenarios. The predicted increase in daily-average salinity gradually increases throughout the late-summer and fall, beginning in July for the 140 cm SLR and 140 cm SLR with 5% Amplification scenarios, and beginning later in the summer for the other SLR scenarios.

The largest predicted increases in daily-average salinity for all scenarios occur in early December.



Station Names

RSAC054, Sacramento River at Martinez

RSAN007, Sacramento River near Mallard Island

RSAC092, Sacramento River at Emmaton

RSAC101, Sacramento River at Rio Vista

RSAN018, San Joaquin River at Jersey Point

RSAN037, San Joaquin River before Prisoners Point

ROLD024, Old River at Bacon Island

CHWST000, Clifton Court Forebay

Figure 6.1-1 Location of continuous monitoring stations in San Francisco Bay and the Sacramento-San Joaquin Delta where time series comparisons were made to evaluate potential salinity impacts resulting from sea level rise scenarios.

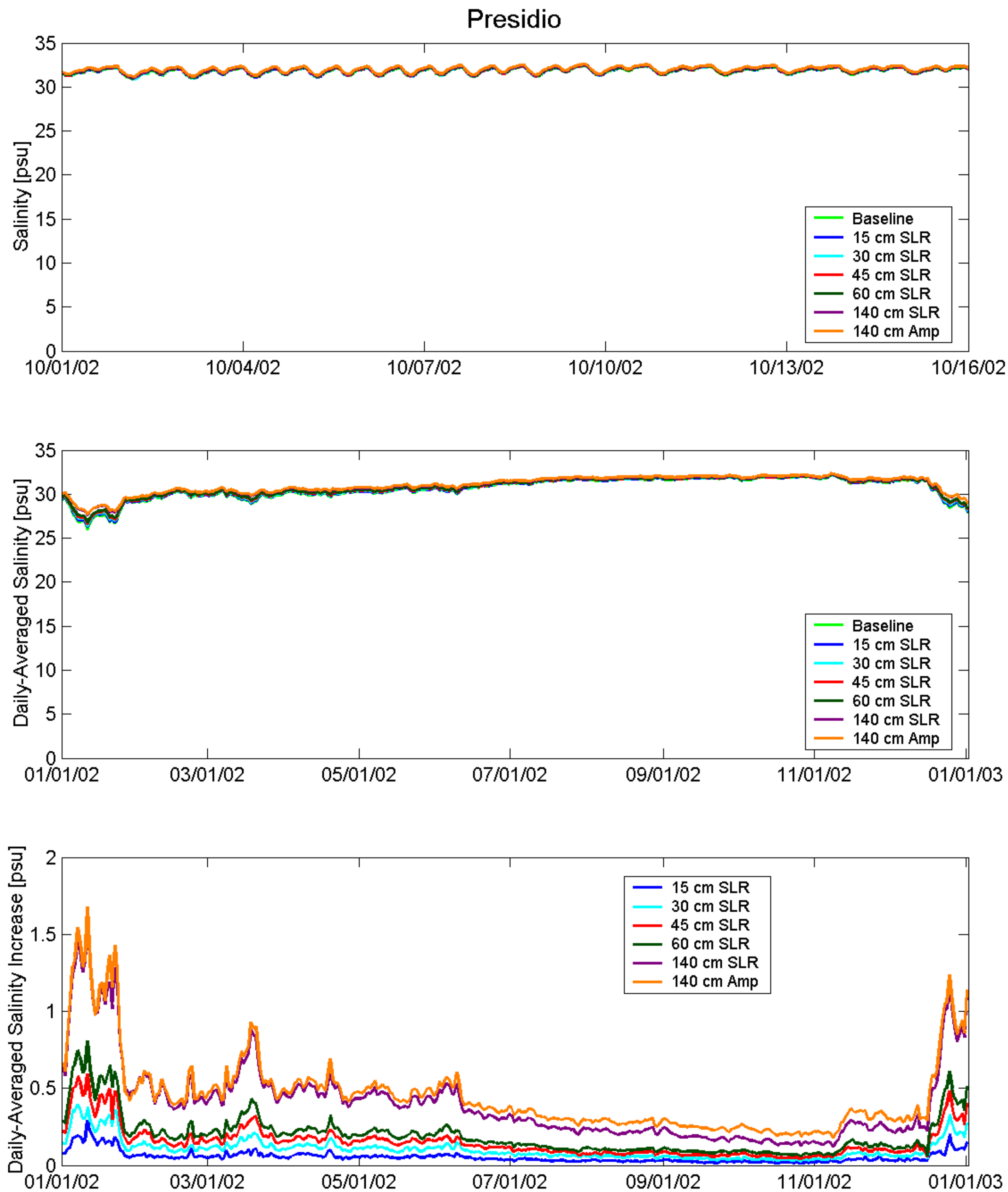


Figure 6.1-2 Predicted salinity at the Presidio for each of the sea level rise scenarios: tidal time-scale variability over a 15-day period (top); daily-average salinity during the 2002 simulation period (middle); predicted increase in daily-average salinity for each of the sea level rise scenarios relative to the Baseline scenario (bottom).

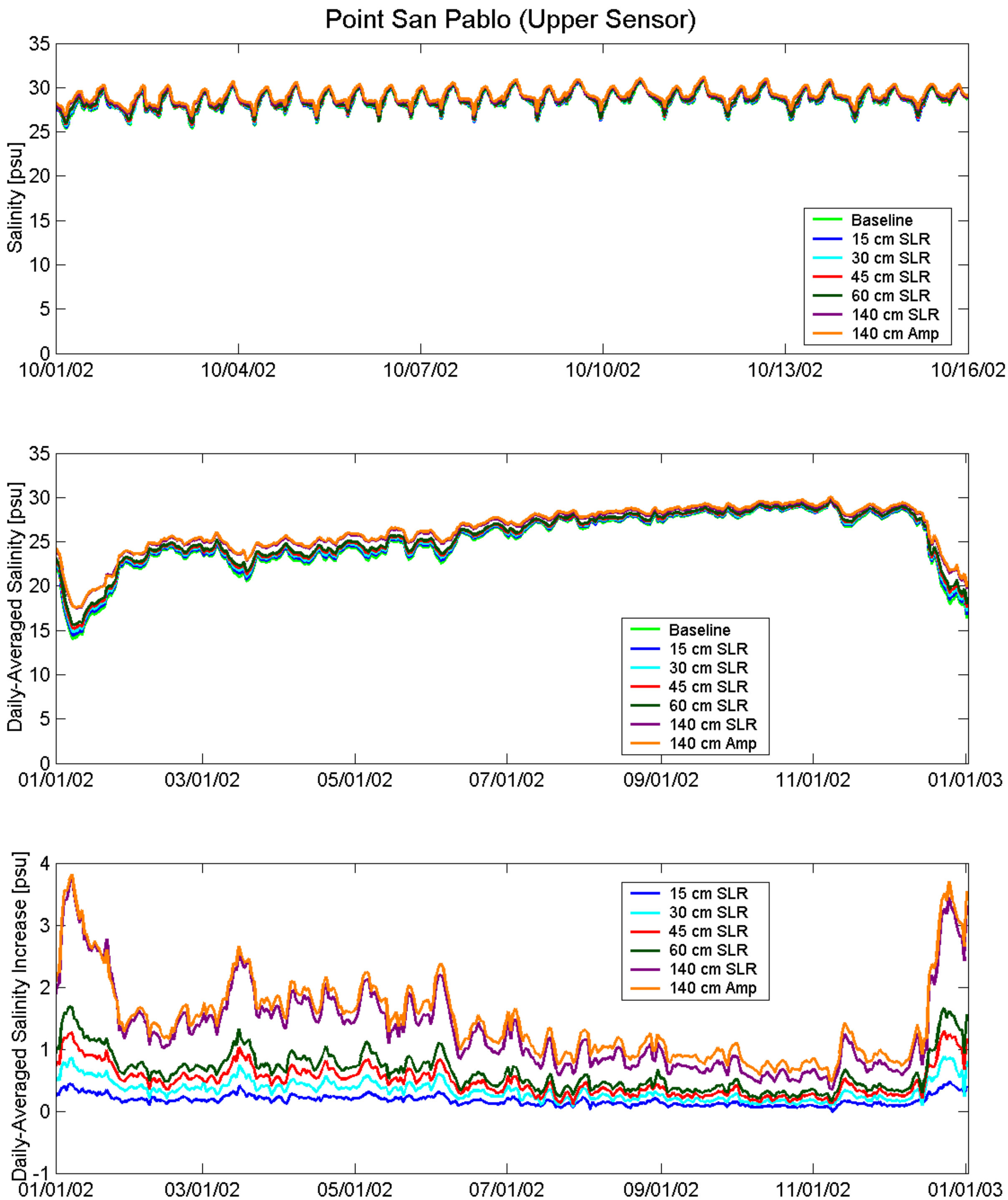


Figure 6.1-3 Predicted salinity at Point San Pablo for each of the sea level rise scenarios: tidal time-scale variability over a 15-day period (top); daily-average salinity during the 2002 simulation period (middle); predicted increase in daily-average salinity for each of the sea level rise scenarios relative to the Baseline scenario (bottom).

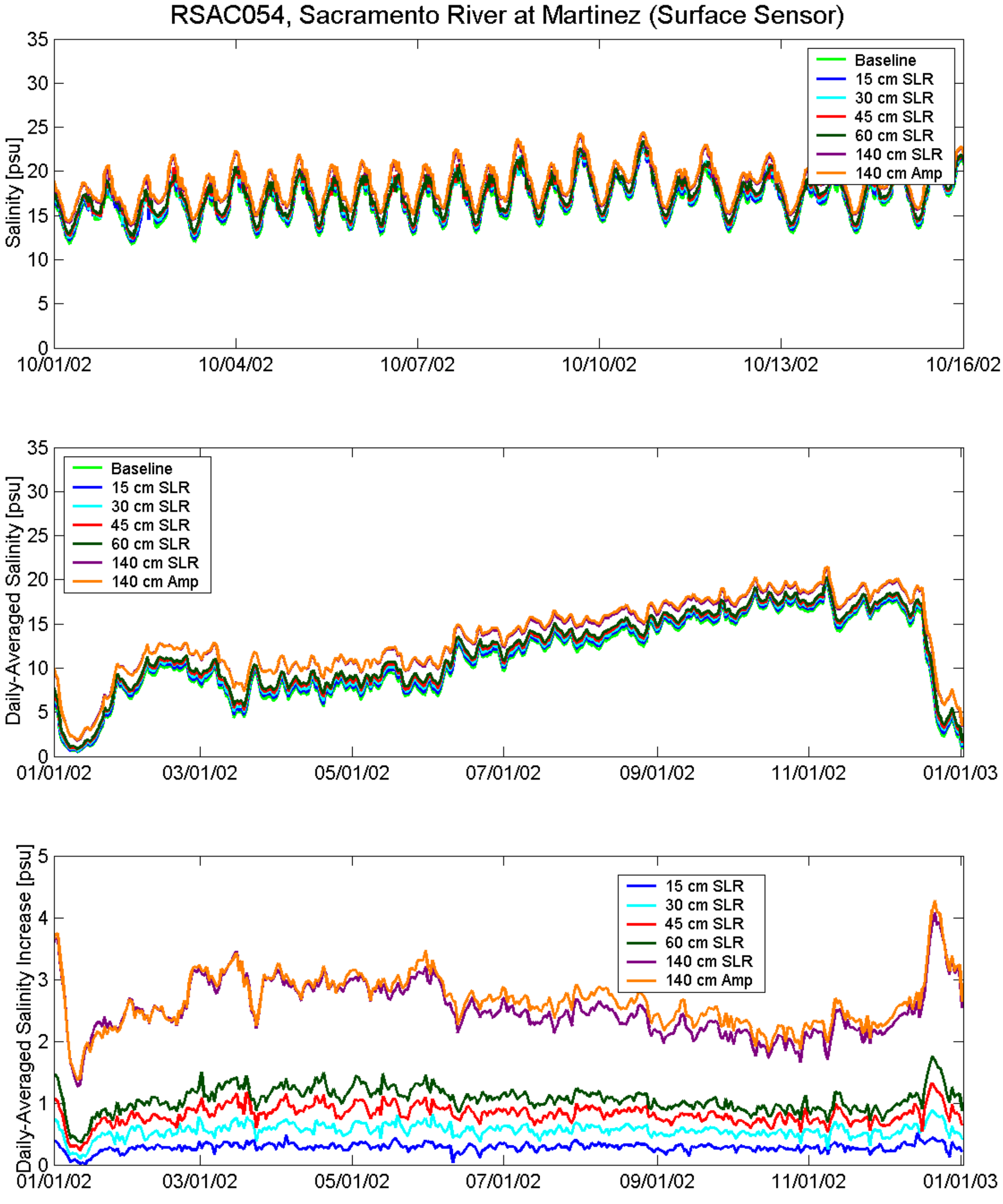


Figure 6.1-4 Predicted salinity at Sacramento River at Martinez (RSAC054) for each of the sea level rise scenarios: tidal time-scale variability over a 15-day period (top); daily-average salinity during the 2002 simulation period (middle); predicted increase in daily-average salinity for each of the sea level rise scenarios relative to the Baseline scenario (bottom).

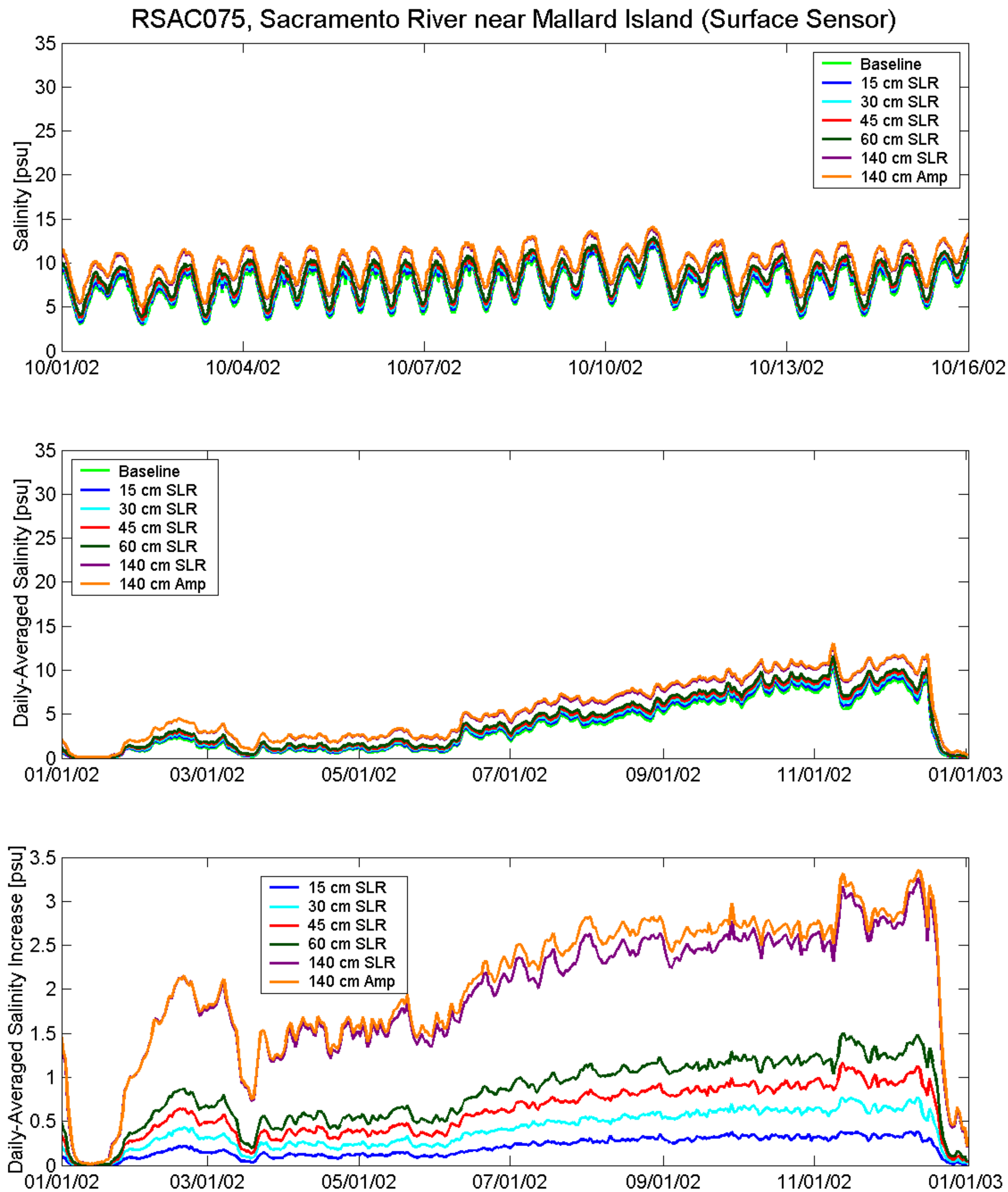


Figure 6.1-5 Predicted salinity at Sacramento River near Mallard Island (RSAC075) for each of the sea level rise scenarios: tidal time-scale variability over a 15-day period (top); daily-average salinity during the 2002 simulation period (middle); predicted increase in daily-average salinity for each of the sea level rise scenarios relative to the Baseline scenario (bottom).

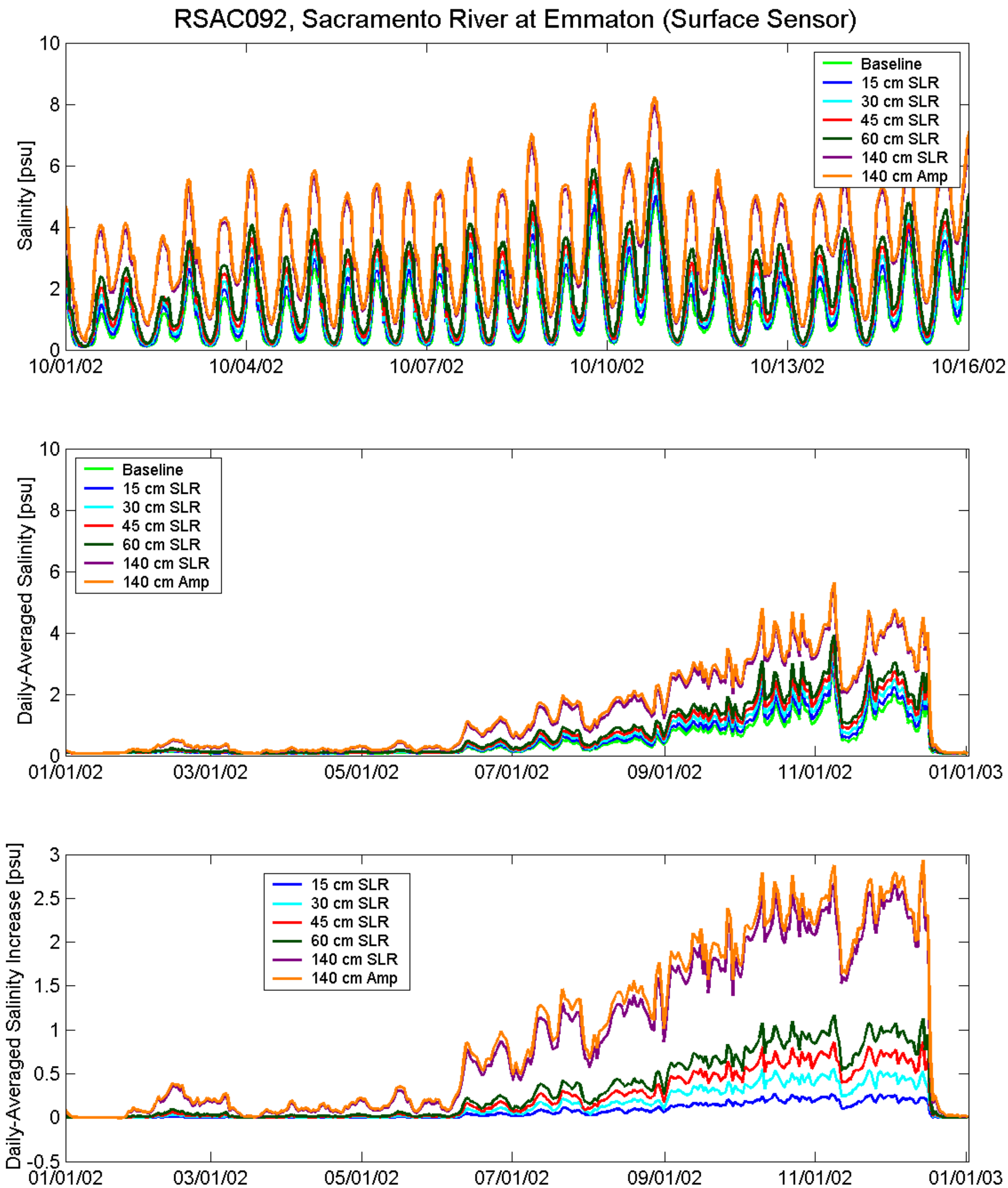


Figure 6.1-6 Predicted salinity at Sacramento River at Emmaton (RSAC092) for each of the sea level rise scenarios: tidal time-scale variability over a 15-day period (top); daily-average salinity during the 2002 simulation period (middle); predicted increase in daily-average salinity for each of the sea level rise scenarios relative to the Baseline scenario (bottom).

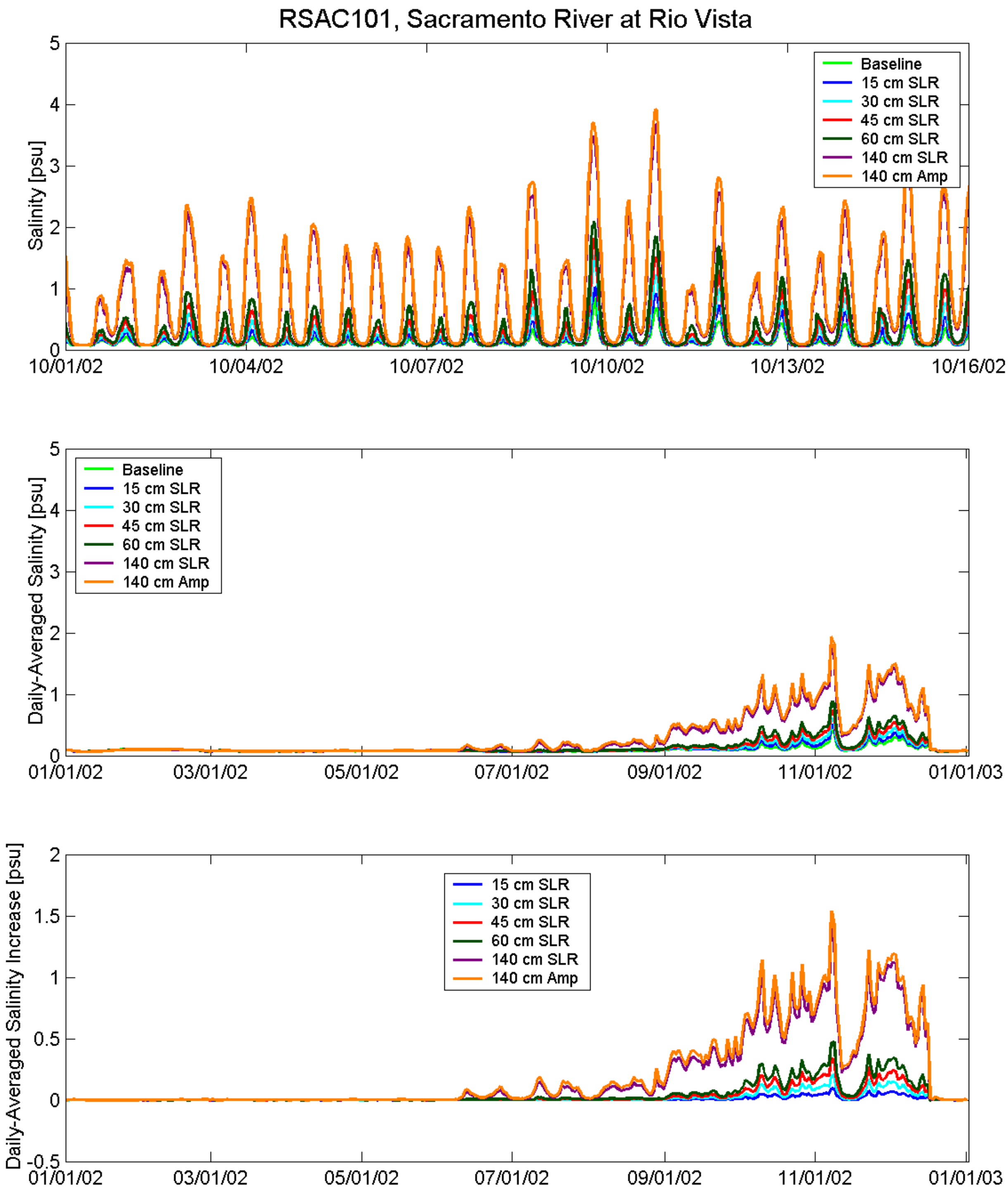


Figure 6.1-7 Predicted salinity at Sacramento River at Rio Vista (RSAC101) for each of the sea level rise scenarios: tidal time-scale variability over a 15-day period (top); daily-average salinity during the 2002 simulation period (middle); predicted increase in daily-average salinity for each of the sea level rise scenarios relative to the Baseline scenario (bottom).

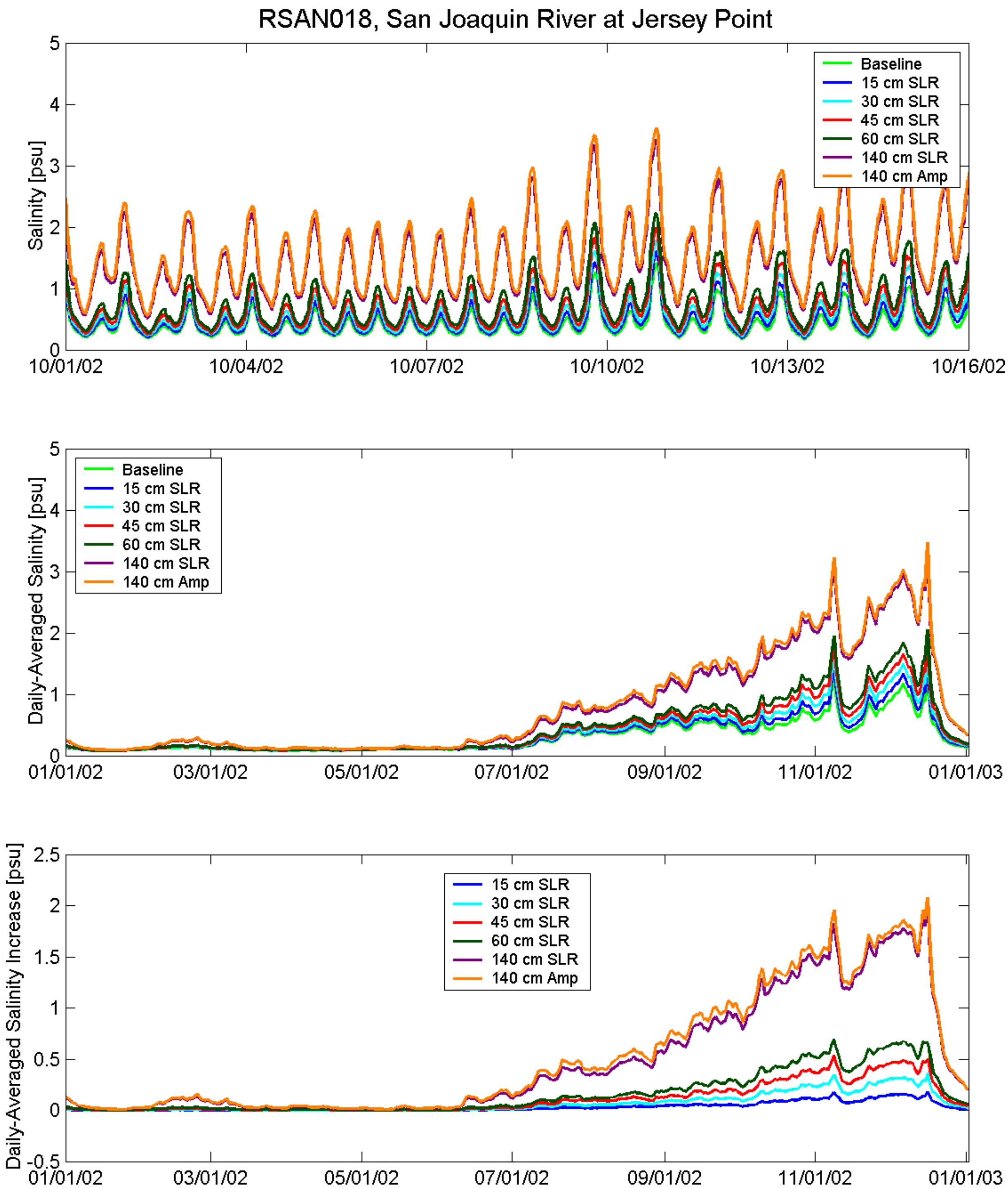


Figure 6.1-8 Predicted salinity at San Joaquin River at Jersey Point (RSAN018) for each of the sea level rise scenarios: tidal time-scale variability over a 15-day period (top); daily-average salinity during the 2002 simulation period (middle); predicted increase in daily-average salinity for each of the sea level rise scenarios relative to the Baseline scenario (bottom).

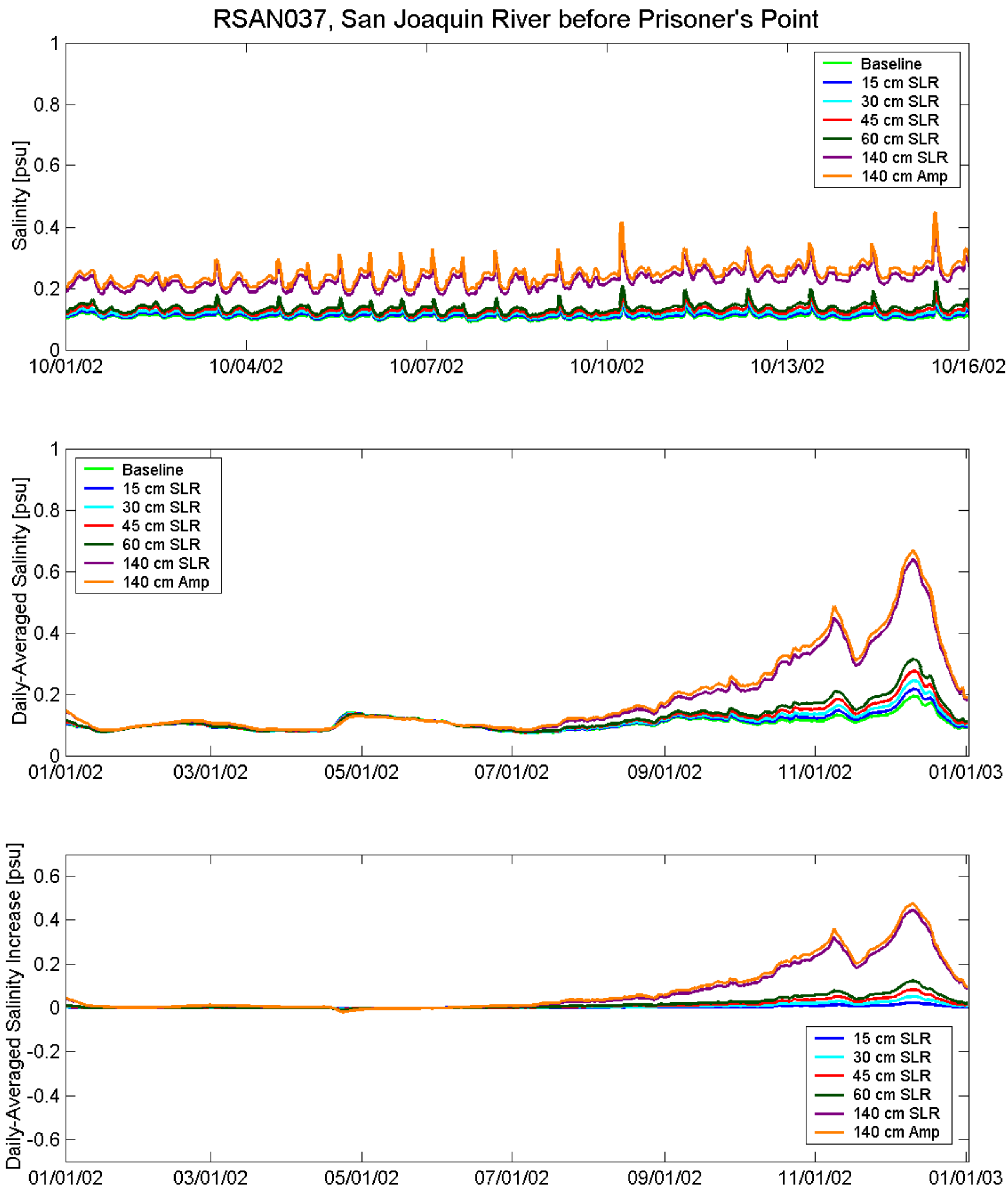


Figure 6.1-9 Predicted salinity at San Joaquin River before Prisoner's Point (RSAN037) for each of the sea level rise scenarios: tidal time-scale variability over a 15-day period (top); daily-average salinity during the 2002 simulation period (middle); predicted increase in daily-average salinity for each of the sea level rise scenarios relative to the Baseline scenario (bottom).

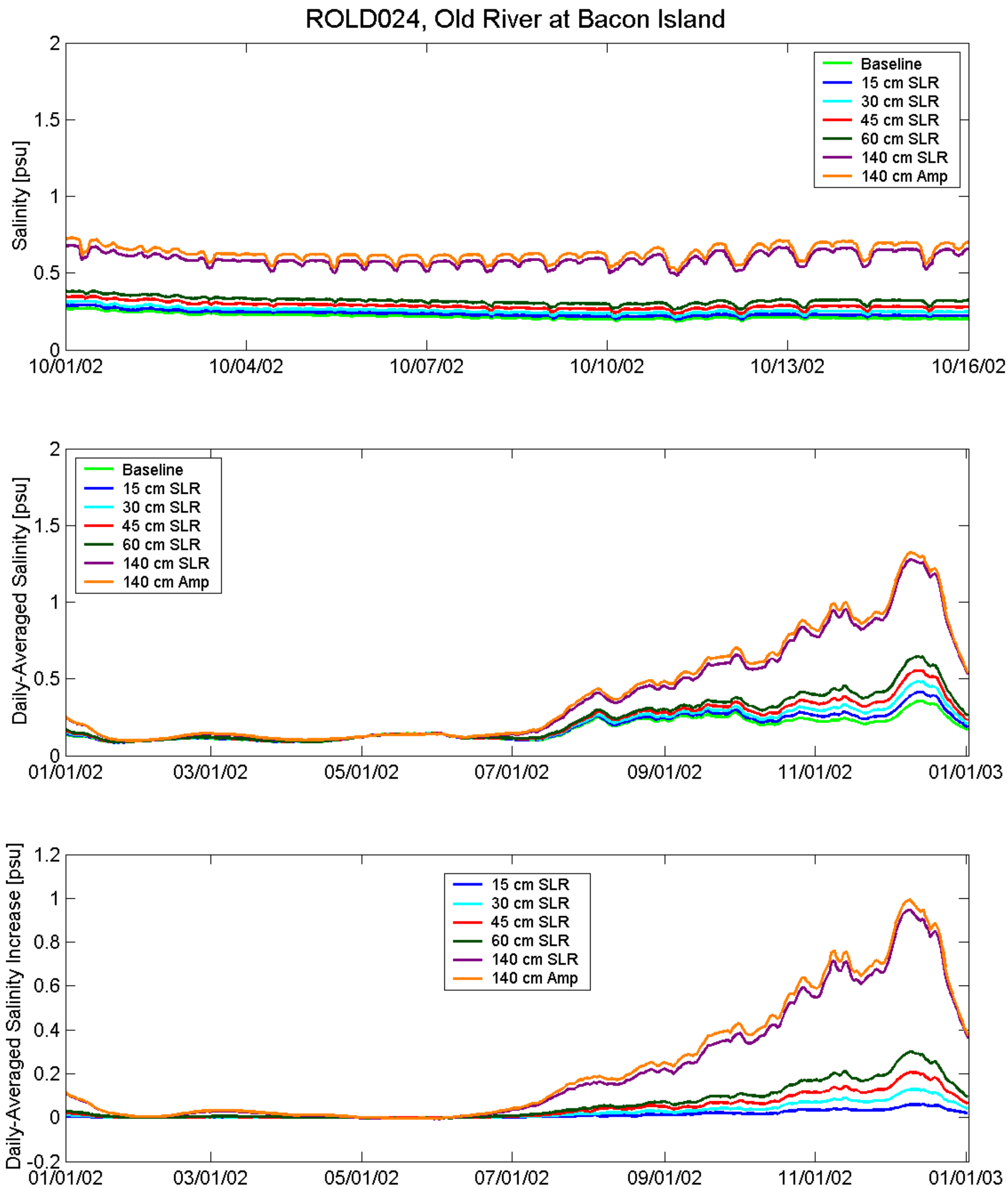


Figure 6.1-10 Predicted salinity at Old River at Bacon Island (ROLD024) for each of the sea level rise scenarios: tidal time-scale variability over a 15-day period (top); daily-average salinity during the 2002 simulation period (middle); predicted increase in daily-average salinity for each of the sea level rise scenarios relative to the Baseline scenario (bottom).

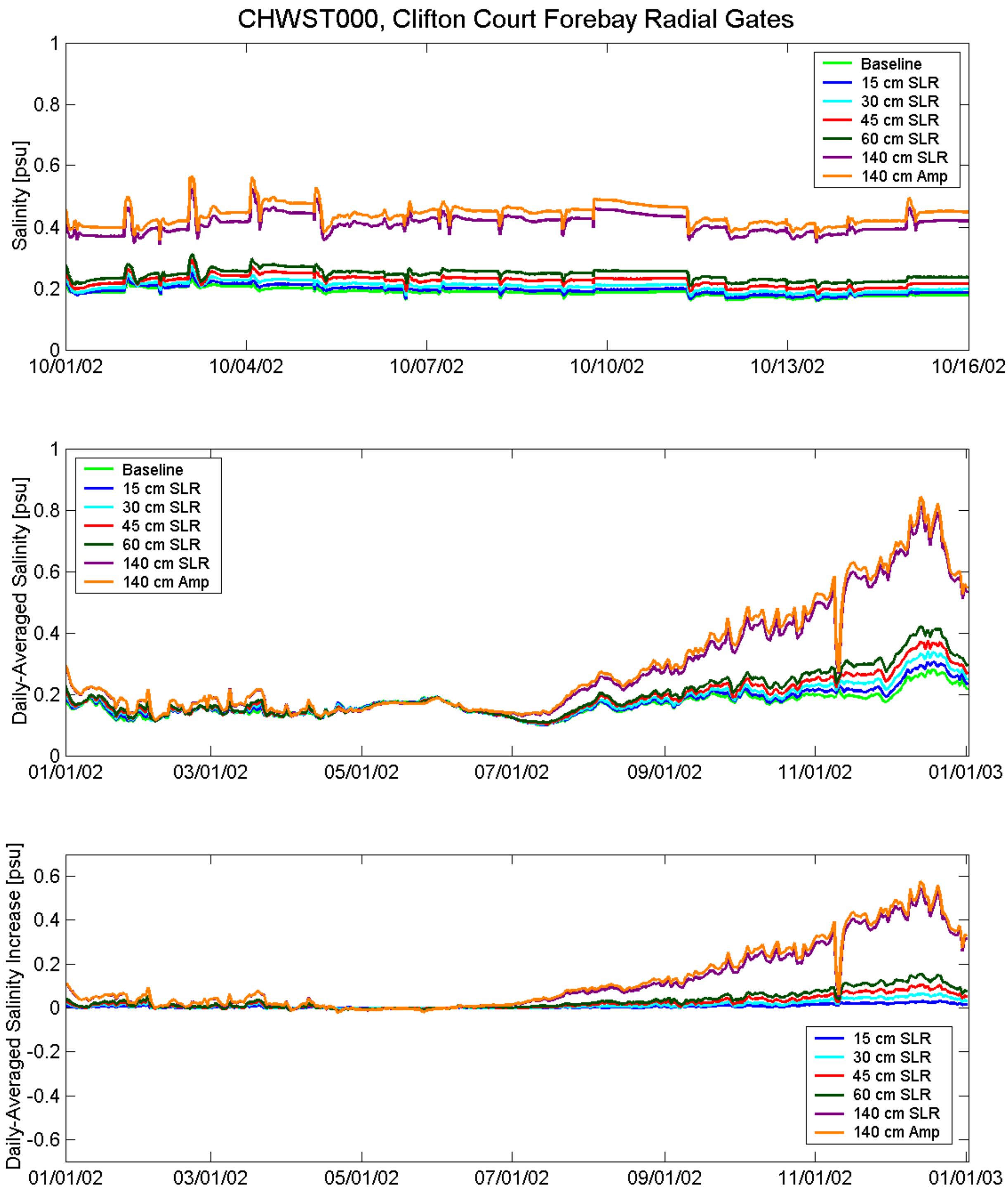


Figure 6.1-11 Predicted salinity at Clifton Court Forebay Radial Gates (CHWST000) for each of the sea level rise scenarios: tidal time-scale variability over a 15-day period (top); daily-average salinity during the 2002 simulation period (middle); predicted increase in daily-average salinity for each of the sea level rise scenarios relative to the Baseline scenario (bottom).

7. Stage and Salinity Relationships for SLR at Fort Point and Martinez

Because the DSM2 model and the RMA2 Delta models have their downstream boundary at Martinez, the effects of SLR on water levels and salinity at the UnTRIM ocean boundary have to be translated to Martinez in order to allow for simulation of SLR scenarios using the DSM2 or the RMA2 Delta model. Similarly, the RMA2 Bay-Delta model has its boundary at the Golden Gate, so it is necessary to translate predicted changes in water levels and salinity at the Golden Gate to the boundary conditions used in the RMA2 Bay-Delta model. Additionally, because the UnTRIM Bay-Delta model SLR simulations only span one year, these relationships allow for simulation of SLR affects using either DSM2 or RMA2 over either longer or different time periods. This section presents some regression relationships developed using the cross-correlation procedure described in section A.1. Further development of these relationships is being conducted by CH2M Hill. Anderson and Miller (2005) used a similar approach to develop relationships to estimate electrical conductivity at Martinez for sea level rise conditions simulated using the RMA2 Bay-Delta model for 1 foot of SLR. The relationships developed in this section apply to 15 cm of SLR, 30 cm SLR, 45 cm of SLR, 60 cm SLR, 140 cm SLR, and 140 cm SLR with 5% Amplification. Because the impact on salinity due to SLR is non-linear, additional simulations would be required to estimate these relationships for other levels of SLR or for simulations that included either an operational response to SLR or significant changes to the structure or operation of the Delta.

7.1 Establishing Stage Relationships for Sea Level Rise at Fort Point and Martinez

This section presents linear regression relationships developed using the cross-correlation procedure described in section A.1 to describe the effect of SLR at the ocean boundary on predicted stage at Fort Point and Martinez.

7.1.1 Stage Relationships for Sea Level Rise at Fort Point

Figure 7.1-1 shows the predicted stage and tidally averaged stage at Fort Point for the Baseline and 15 cm SLR scenarios. The cross-correlation yields a best linear fit of

[Stage 15 cm SLR] = 0.9993 x *[Stage Baseline] + 0.1500* (7-1)

with an R^2 value of 1.000 and no phase difference. Because this relationship is linear with a slope very close to 1.000, this shows that the 15 cm stage offset applied at the ocean boundary is translating almost exactly to a 15 cm stage offset at Fort Point. This is also reflected by the difference between the annual mean stage for the Baseline scenario and the annual mean stage of 15 cm SLR scenario which is 14.9 cm.

Figure 7.1-2 shows the predicted stage and tidally averaged stage at Fort Point for the Baseline and 30 cm SLR scenarios. The cross-correlation yields a best linear fit of

[Stage 30 cm SLR] = 0.9986 x *[Stage Baseline] + 0.3001* (7-2)

with an R^2 value of 1.000 and a phase lag of 1 minute. Because this relationship is linear with a slope very close to 1.000, this shows that the 30 cm stage offset applied at the ocean boundary is translating almost exactly to a 30 cm stage offset at Fort Point. This is also reflected by the difference between the annual mean stage for the Baseline scenario and the annual mean stage of 30 cm SLR scenario which is 29.9 cm.

Figure 7.1-3 shows the predicted stage and tidally averaged stage at Fort Point for the Baseline and 45 cm SLR scenarios. The cross-correlation yields a best linear fit of

[Stage 45 cm SLR] = 0.9987 x *[Stage Baseline] + 0.4494* (7-3)

with an R^2 value of 1.000 and a phase lag of 1 minute. Because this relationship is linear with a slope very close to 1.000, this shows that the 45 cm stage offset applied at the ocean boundary is translating almost exactly to a 45 cm stage offset at Fort Point. This is also reflected by the difference between the annual mean stage for the Baseline scenario and the annual mean stage of 45 cm SLR scenario which is 44.8 cm.

Figure 7.1-4 shows the predicted stage and tidally averaged stage at Fort Point for the Baseline and 60 cm SLR scenarios. The cross-correlation yields a best linear fit of

[Stage 60 cm SLR] = 0.9992 x *[Stage Baseline] + 0.5986* (7-4)

with an R^2 value of 1.000 and a phase lag of 1 minute. Because this relationship is linear with a slope very close to 1.000, this shows that the 60 cm stage offset applied at the ocean boundary is translating almost exactly to a 60 cm stage offset at Fort Point. This is also reflected by the difference between the annual mean stage for the Baseline scenario and the annual mean stage of 60 cm SLR scenario which is 59.8 cm.

Figure 7.1-5 shows the predicted stage and tidally averaged stage at Fort Point for the Baseline and 140 cm SLR scenarios. The cross-correlation yields a best linear fit of

[Stage 140 cm SLR] = 1.0050 x *[Stage Baseline] + 1.3915* (7-5)

with an R^2 value of 1.000 and a phase lag of 1 minute. Because this relationship is linear with a slope very close to 1.000, this shows that the 140 cm stage offset applied at the ocean boundary is translating almost exactly to a 140 cm stage offset at Fort Point. This is also reflected by the difference between the annual mean stage for the Baseline scenario and the annual mean stage of 140 cm SLR scenario which is 139.6 cm.

Figure 7.1-6 shows the predicted stage and tidally averaged stage at Fort Point for the Baseline and 140 cm SLR with 5% Amplification scenarios. The cross-correlation yields a best linear fit of

[Stage 140 cm SLR with 5% Amplification] = 1.0470 x *[Stage Baseline] + 1.3497* (7-6)

with an R^2 value of 1.000 and a phase lag of 2 minute. Because this scenario includes both an offset and amplification of tidal range at the ocean boundary, the slope of the linear fit is not as close to 1.000 as in the other scenarios, and is closer to 1.05 indicating the higher amplitude of tidal range. However the offset in the linear fit is 1.3497 m which is not as similar to the 140 cm stage offset applied at the ocean boundary as the corresponding offset in Equation 7-5 for the 140 cm SLR scenario.

7.1.2 Stage Relationships for Sea Level Rise at Martinez

Figure 7.1-7 shows the predicted stage and tidally averaged stage at Martinez for the Baseline and 15 cm SLR scenarios. The cross-correlation yields a best linear fit of

[Stage 15 cm SLR] = 1.0033 x *[Stage Baseline] + 0.1435* (7-7)

with an R^2 value of 1.000 and a phase lead of 1 minute. Because this relationship is linear with a slope very close to 1.000 and an offset of 0.1435 m, this shows that the 15 cm stage offset applied at the ocean boundary is translating to slightly less than 15 cm of stage offset at Martinez. This is also reflected by the difference between the annual mean stage for the Baseline scenario and the annual mean stage of 15 cm SLR scenario which is 14.7 cm.

Figure 7.1-8 shows the predicted stage and tidally averaged stage at Martinez for the Baseline and 30 cm SLR scenarios. The cross-correlation yields a best linear fit of

[Stage 30 cm SLR] = 1.0074 x *[Stage Baseline] + 0.2862* (7-8)

with an R^2 value of 1.000 and a phase lead of 1 minute. Because this relationship is linear with a slope very close to 1.000 and an offset of 0.2862 m, this shows that the 30 cm stage offset applied at the ocean boundary is translating to slightly less than 30 cm of stage offset at Martinez. This is also reflected by the difference between the annual mean stage for the Baseline scenario and the annual mean stage of 30 cm SLR scenario which is 29.4 cm.

Figure 7.1-9 shows the predicted stage and tidally averaged stage at Martinez for the Baseline and 45 cm SLR scenarios. The cross-correlation yields a best linear fit of

[Stage 45 cm SLR] = 1.0113 x *[Stage Baseline] + 0.4290* (7-9)

with an R^2 value of 1.000 and a phase lead of 2 minutes. Because this relationship is linear with a slope very close to 1.000 and an offset of 0.4290 m, this shows that the 45 cm stage offset applied at the ocean boundary is translating to slightly less than 45 cm of stage offset at Martinez. This is also reflected by the difference between the annual mean stage for the Baseline scenario and the annual mean stage of 45 cm SLR scenario which is 44.1 cm.

Figure 7.1-10 shows the predicted stage and tidally averaged stage at Martinez for the Baseline and 60 cm SLR scenarios. The cross-correlation yields a best linear fit of

[Stage 60 cm SLR] = 1.0156 x *[Stage Baseline] + 0.5714* (7-10)

with an R^2 value of 1.000 and a phase lead of 3 minute. Because this relationship is linear with a slope close to 1.000 and an offset of 0.5714 m, this shows that the 60 cm stage offset applied at the ocean boundary is translating to slightly less than 60 cm of stage offset at Martinez. This is also reflected by the difference between the annual mean stage for the Baseline scenario and the annual mean stage of 60 cm SLR scenario which is 58.9 cm.

Figure 7.1-11 shows the predicted stage and tidally averaged stage at Martinez for the Baseline and 140 cm SLR scenarios. The cross-correlation yields a best linear fit of

[Stage 140 cm SLR] = 1.0382 x *[Stage Baseline] + 1.3361* (7-11)

with an R^2 value of 0.999 and a phase lead of 10 minutes. Because this relationship is linear with a slope greater than 1.000 and an offset of 1.3361 m, this shows that the 140 cm stage offset applied at the ocean boundary is translating to slightly less than 140 cm of stage offset at Martinez, and resulting in some differences in both phase and amplitude at Martinez. The difference between the annual mean stage for the Baseline scenario and the annual mean stage of 140 cm SLR scenario is 137.8 cm.

Figure 7.1-12 shows the predicted stage and tidally averaged stage at Martinez for the Baseline and 140 cm SLR with 5% Amplification scenarios. The cross-correlation yields a best linear fit of

[Stage 140 cm SLR with 5% Amplification] = 1.0718 x *[Stage Baseline] + 1.3013* (7-12)

with an R^2 value of 0.999 and a phase lead of 9 minutes. Because this relationship is linear with a slope greater than 1.000 and an offset of 1.3013 m, this shows that the 140 cm stage offset with 5% tidal range amplification applied at the ocean boundary is translating to slightly less than 140 cm of stage offset at Martinez and is resulting in differences in both phase and amplitude at Martinez. The difference between the annual mean stage for the Baseline scenario and the annual mean stage of 140 cm SLR scenario is 138.0 cm. These results suggest that a linear fit is not appropriate for developing a tidal stage relationship at Martinez for a scenario which includes amplification of the tidal range in addition to sea level rise.

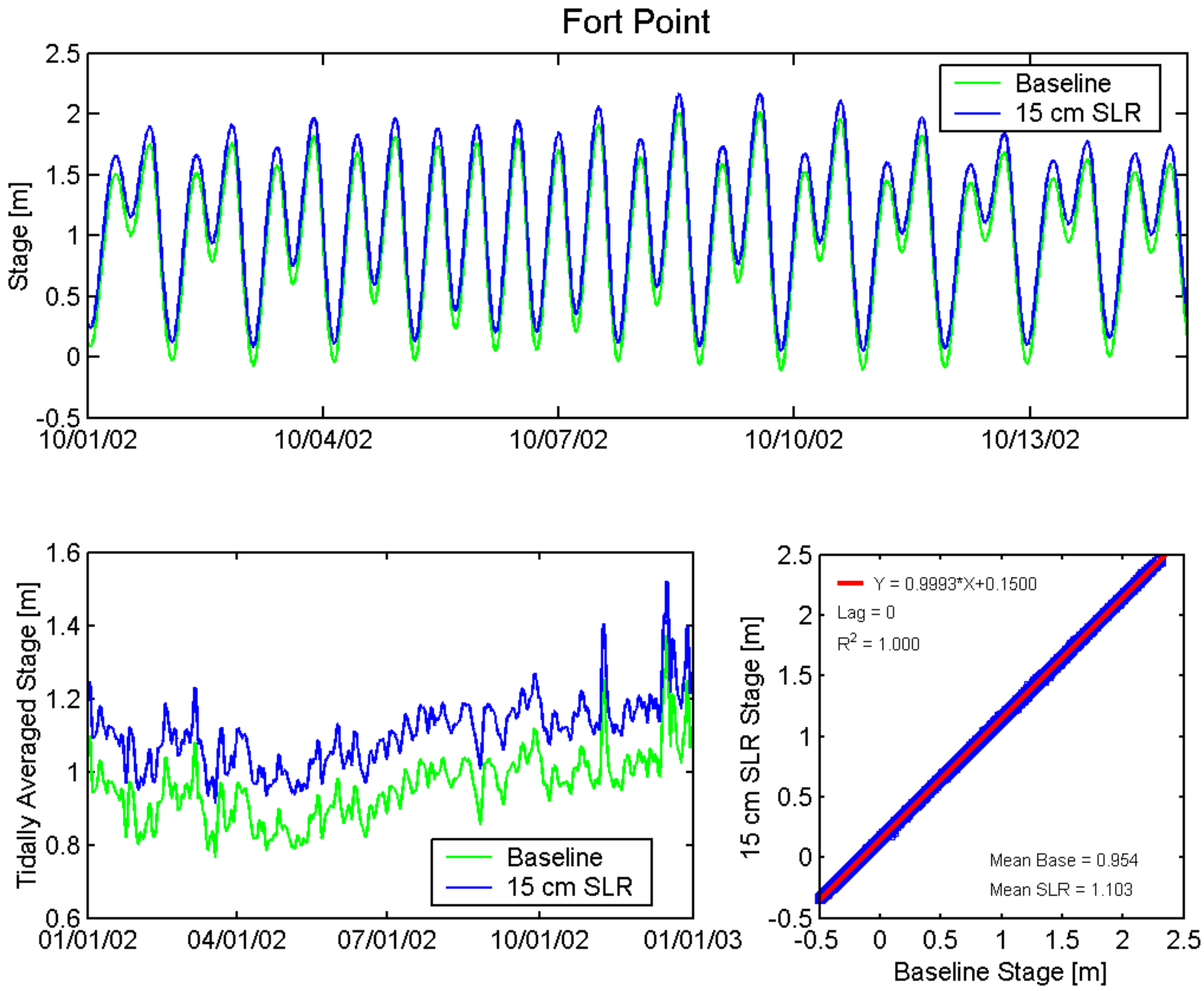


Figure 7.1-1 Predicted stage (top) and tidally averaged stage (lower left) at Fort Point for Baseline and 15 cm SLR scenarios. Regression (lower right) shows the best linear fit for the effect on stage at Fort Point resulting from 15 cm of SLR at the Pacific Ocean boundary.

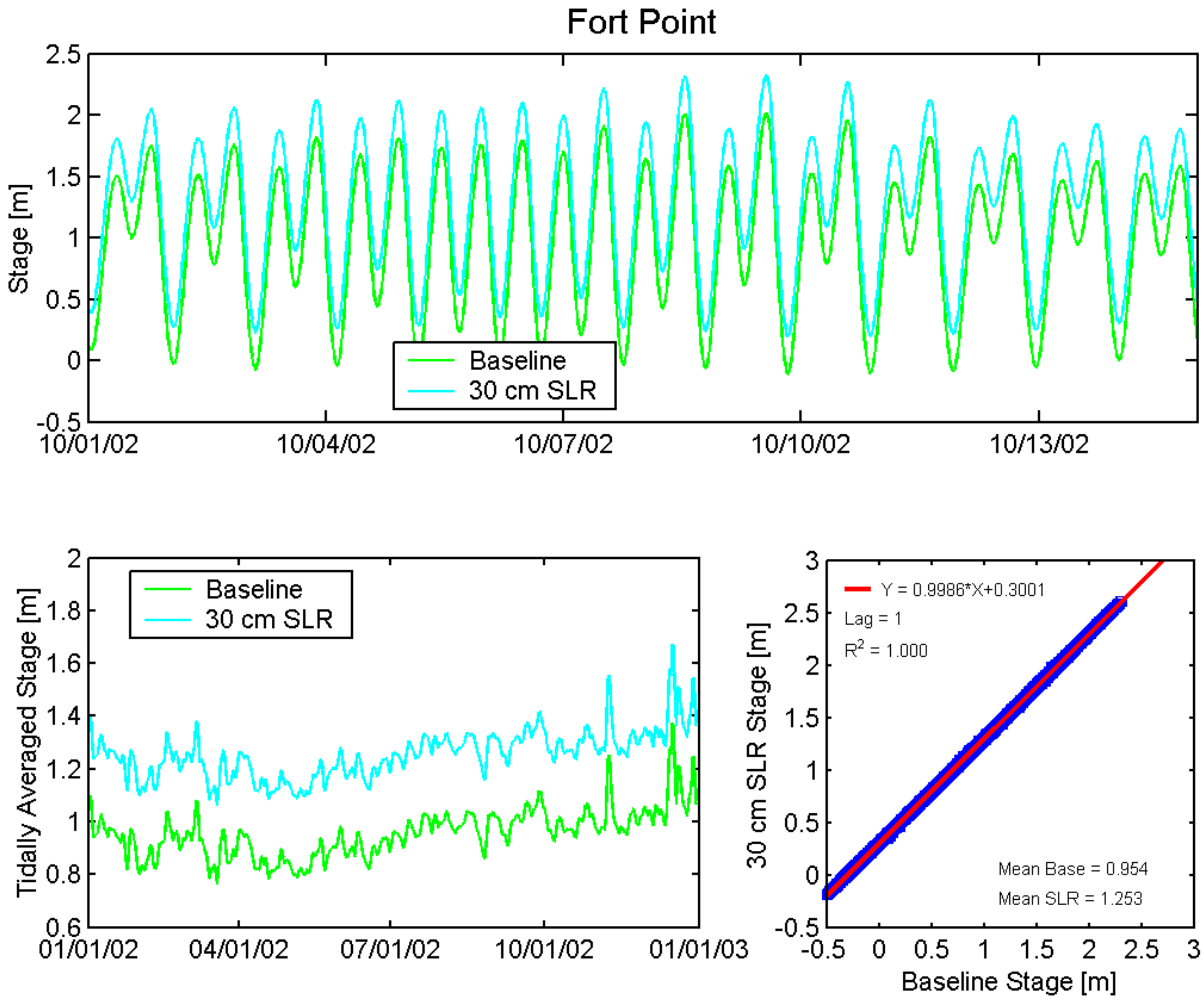


Figure 7.1-2 Predicted stage (top) and tidally averaged stage (lower left) at Fort Point for Baseline and 30 cm SLR scenarios. Regression (lower right) shows the best linear fit for the effect on stage at Fort Point resulting from 30 cm of SLR at the Pacific Ocean boundary.

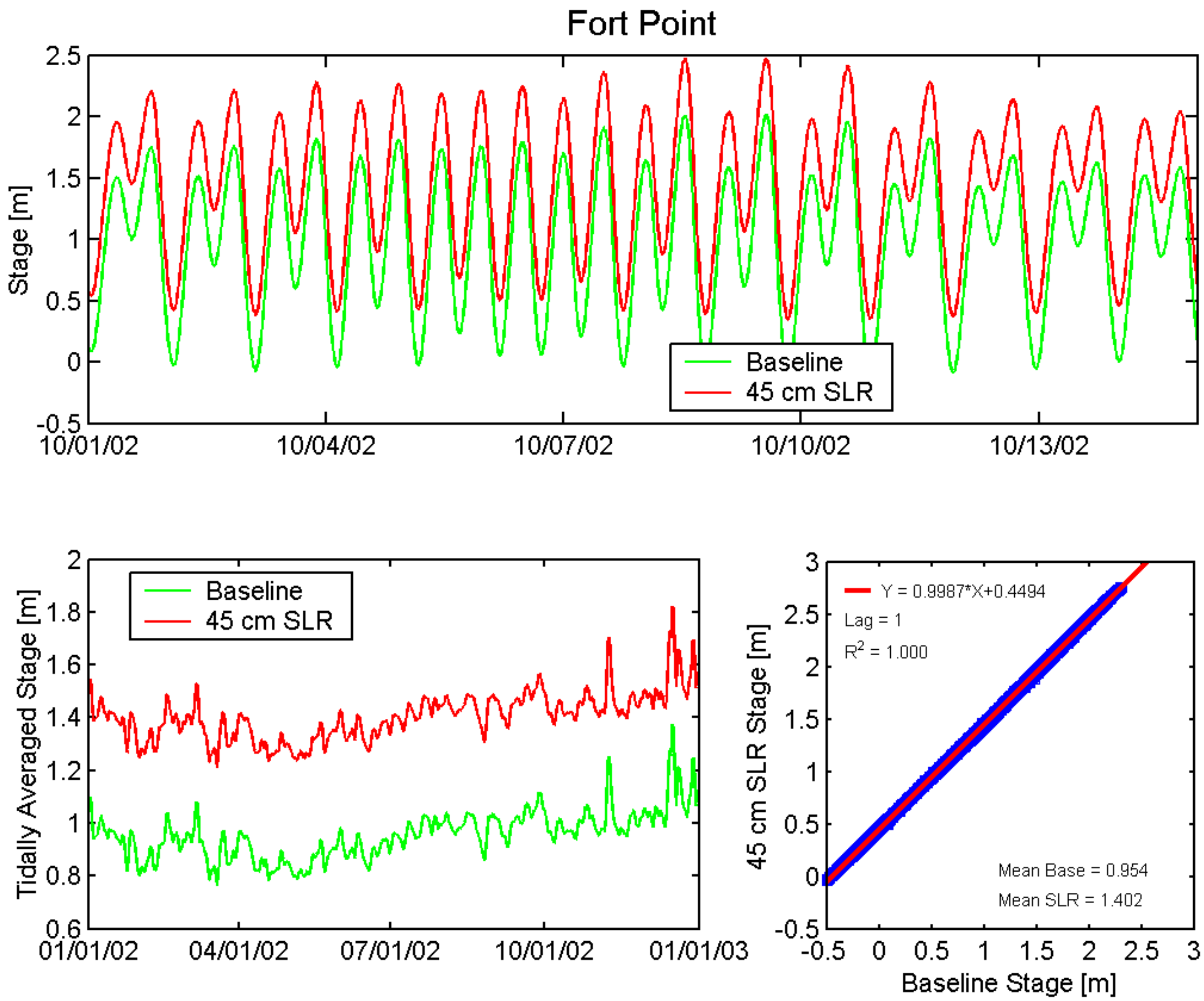


Figure 7.1-3 Predicted stage (top) and tidally averaged stage (lower left) at Fort Point for Baseline and 45 cm SLR scenarios. Regression (lower right) shows the best linear fit for the effect on stage at Fort Point resulting from 45 cm of SLR at the Pacific Ocean boundary.

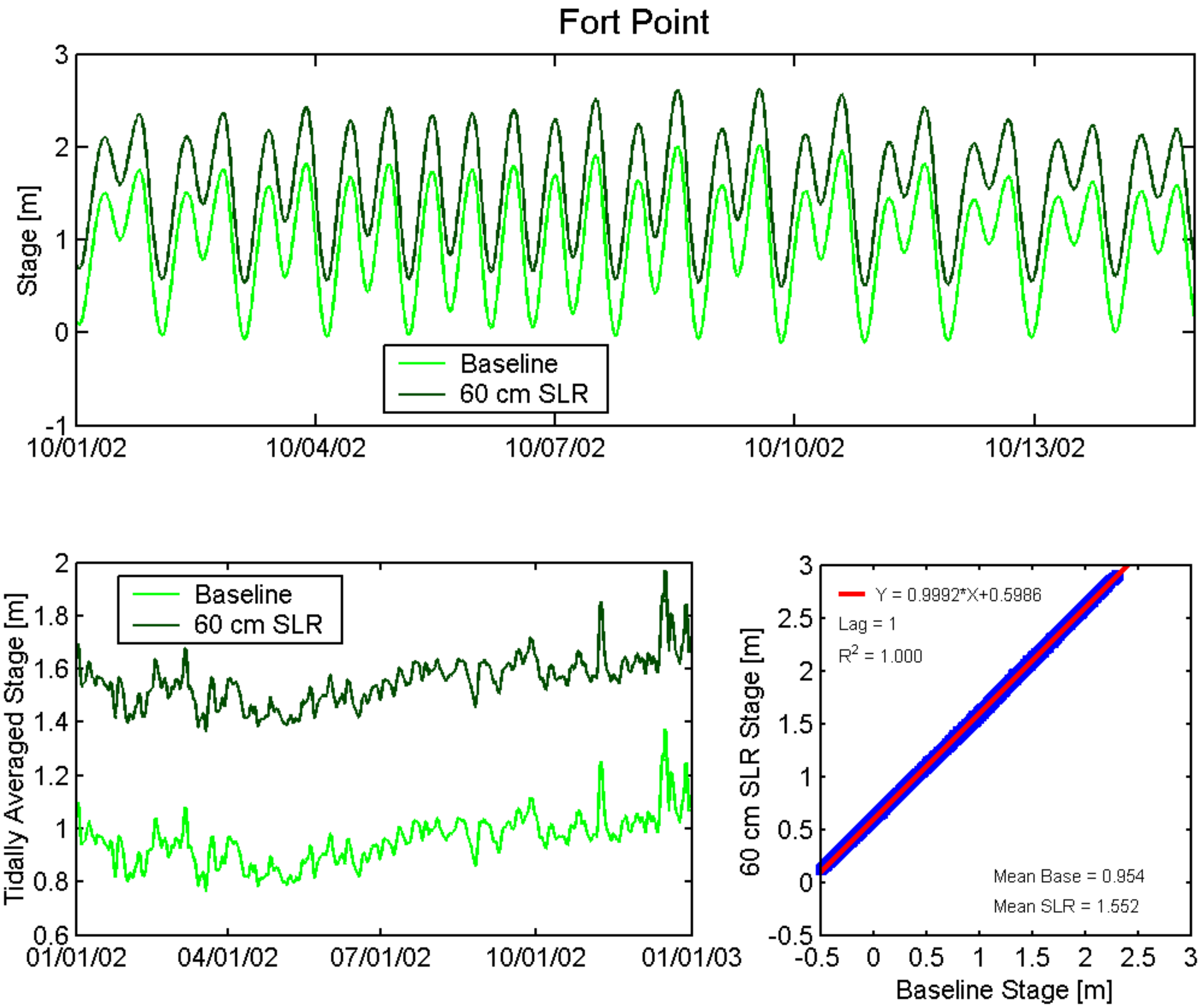


Figure 7.1-4 Predicted stage (top) and tidally averaged stage (lower left) at Fort Point for Baseline and 60 cm SLR scenarios. Regression (lower right) shows the best linear fit for the effect on stage at Fort Point resulting from 60 cm of SLR at the Pacific Ocean boundary.

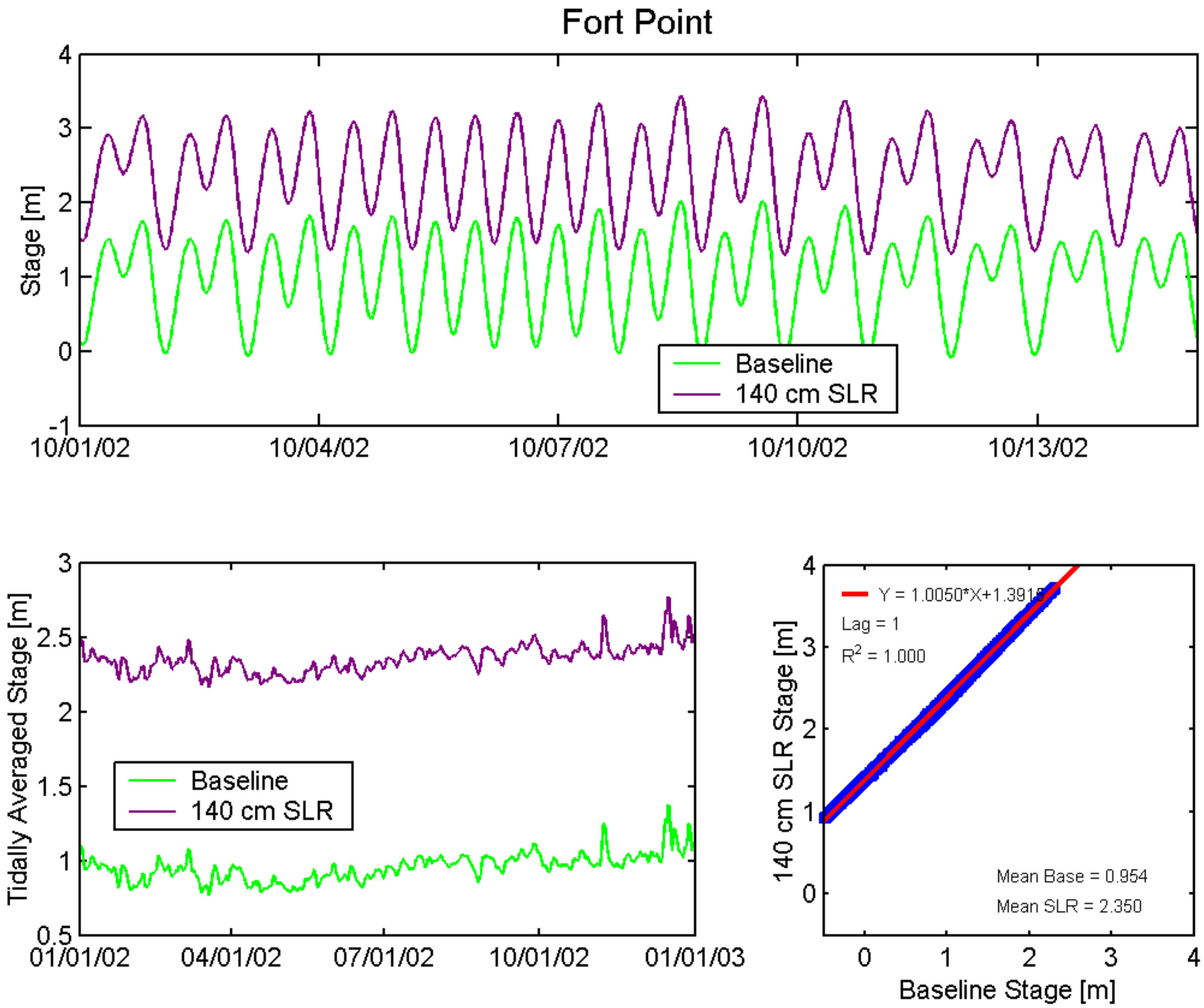


Figure 7.1-5 Predicted stage (top) and tidally averaged stage (lower left) at Fort Point for Baseline and 140 cm SLR scenarios. Regression (lower right) shows the best linear fit for the effect on stage at Fort Point resulting from 140 cm of SLR at the Pacific Ocean boundary.

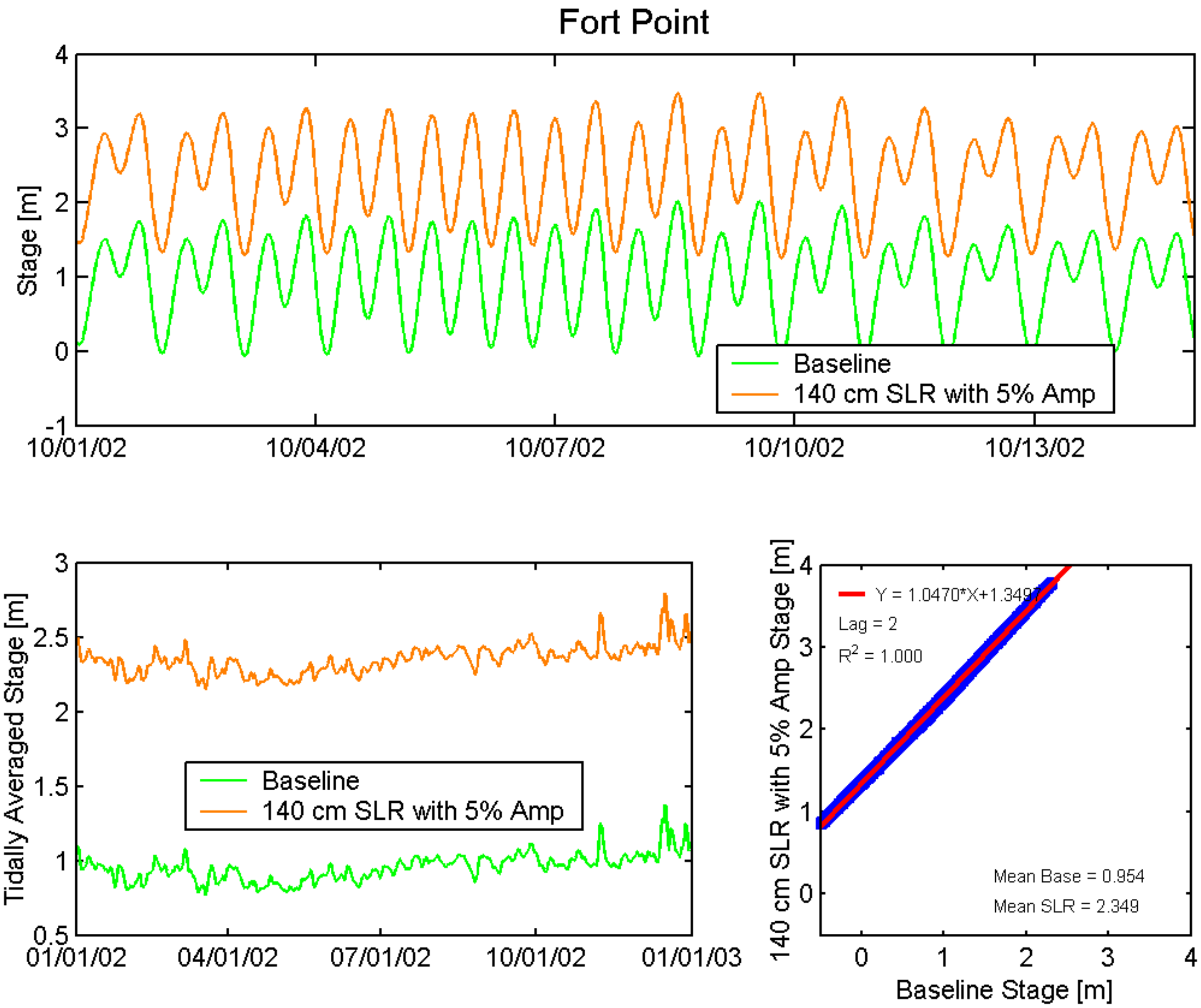


Figure 7.1-6 Predicted stage (top) and tidally averaged stage (lower left) at Fort Point for Baseline and 140 cm of SLR with 5% Amplification scenarios. Regression (lower right) shows the best linear fit for the effect on stage at Fort Point resulting from 140 cm of SLR with 5% Amplification at the Pacific Ocean boundary.

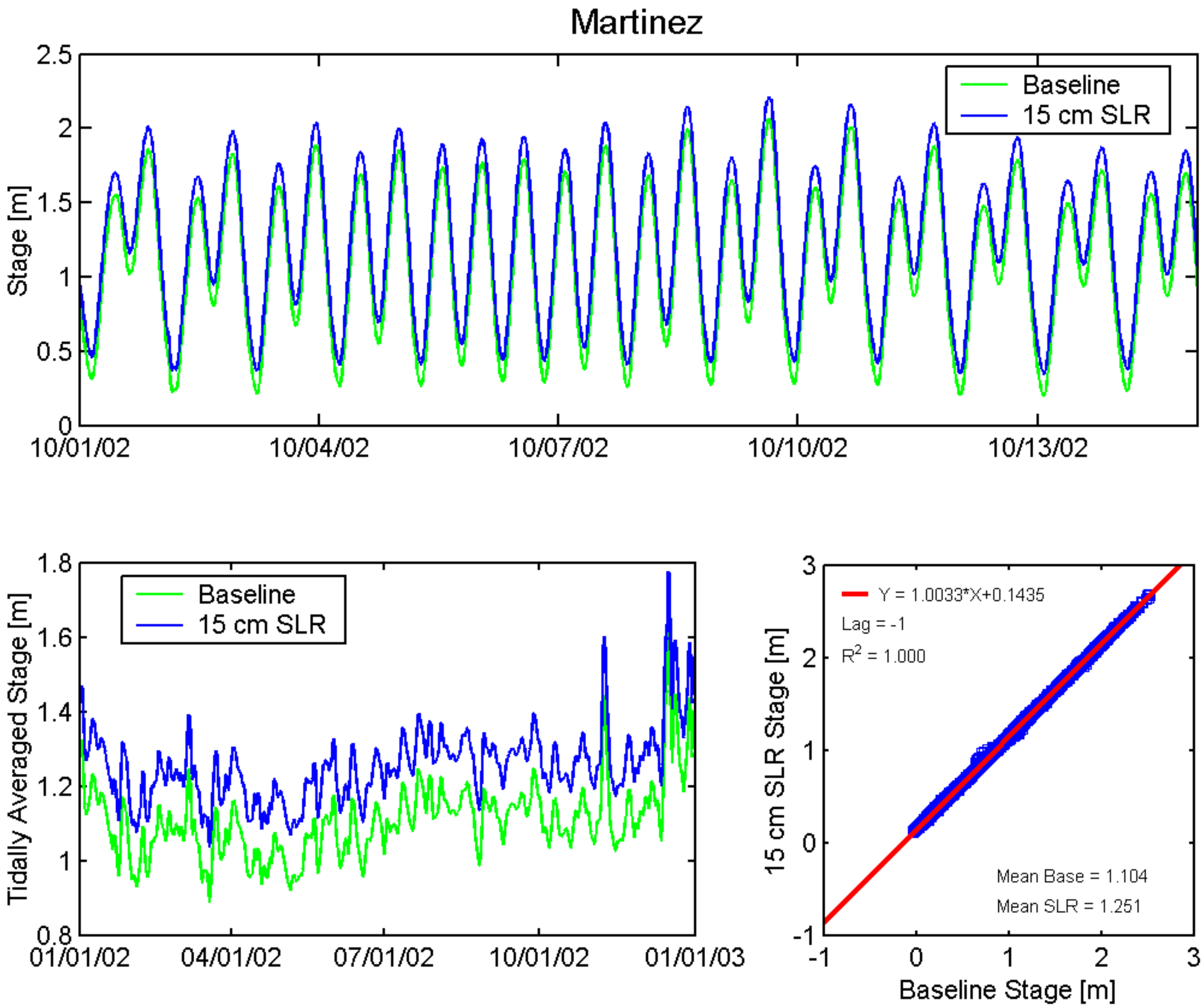


Figure 7.1-7 Predicted stage (top) and tidally averaged stage (lower left) at Martinez for Baseline and 15 cm SLR scenarios. Regression (lower right) shows the best linear fit for the effect on stage at Martinez resulting from 15 cm of SLR at the Pacific Ocean boundary.

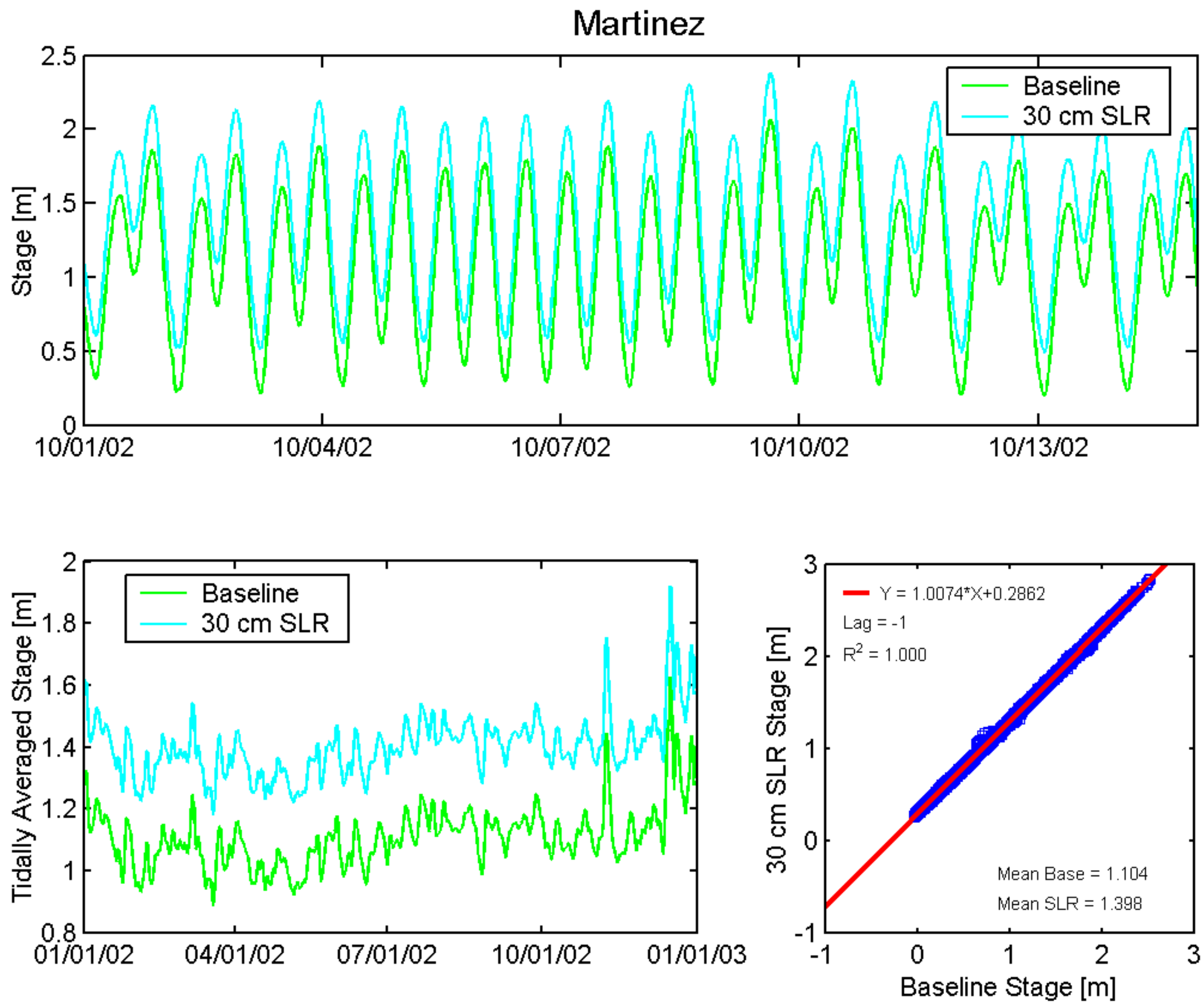


Figure 7.1-8 Predicted stage (top) and tidally averaged stage (lower left) at Martinez for Baseline and 30 cm SLR scenarios. Regression (lower right) shows the best linear fit for the effect on stage at Martinez resulting from 30 cm of SLR at the Pacific Ocean boundary.

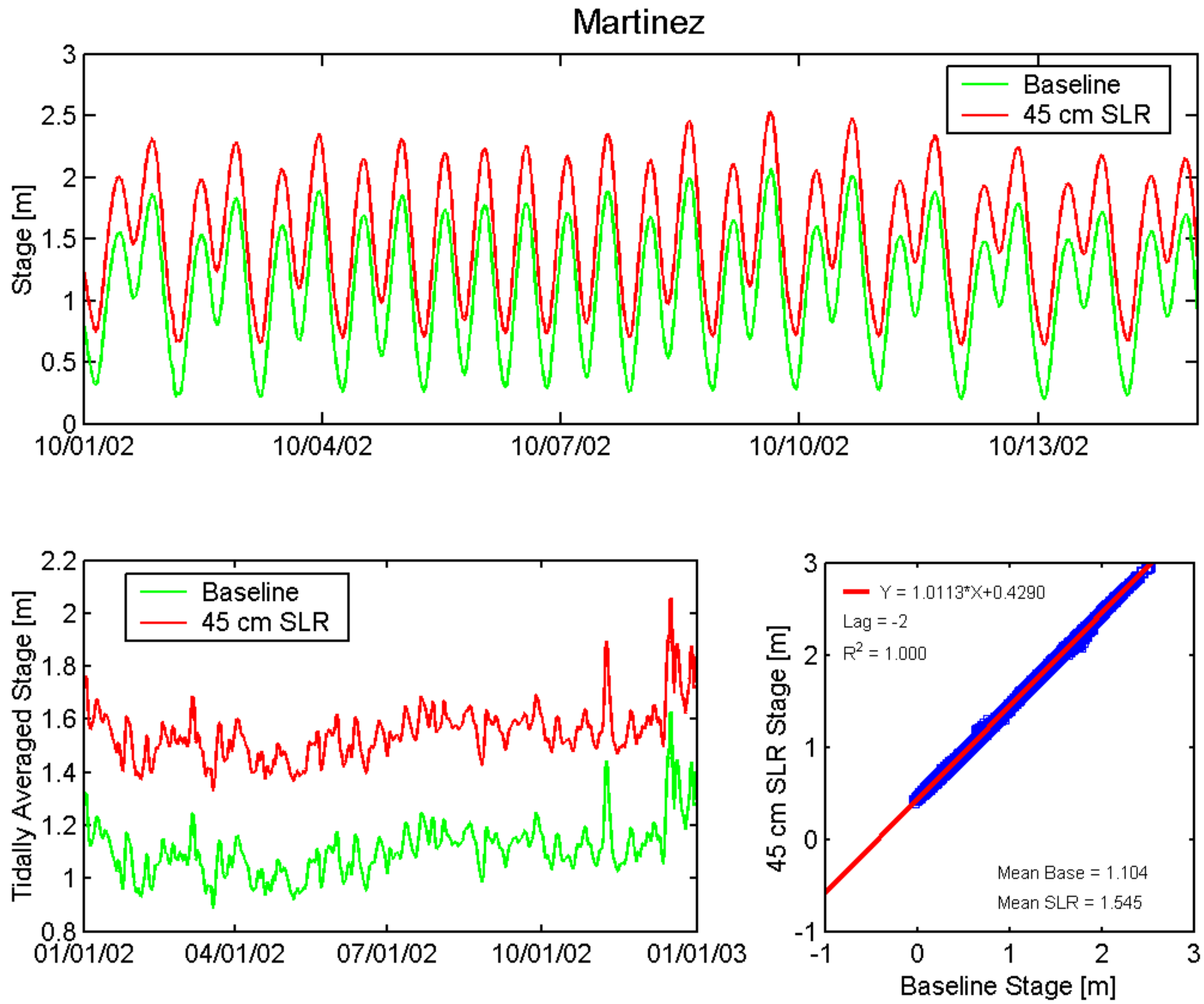


Figure 7.1-9 Predicted stage (top) and tidally averaged stage (lower left) at Martinez for Baseline and 45 cm SLR scenarios. Regression (lower right) shows the best linear fit for the effect on stage at Martinez resulting from 45 cm of SLR at the Pacific Ocean boundary.

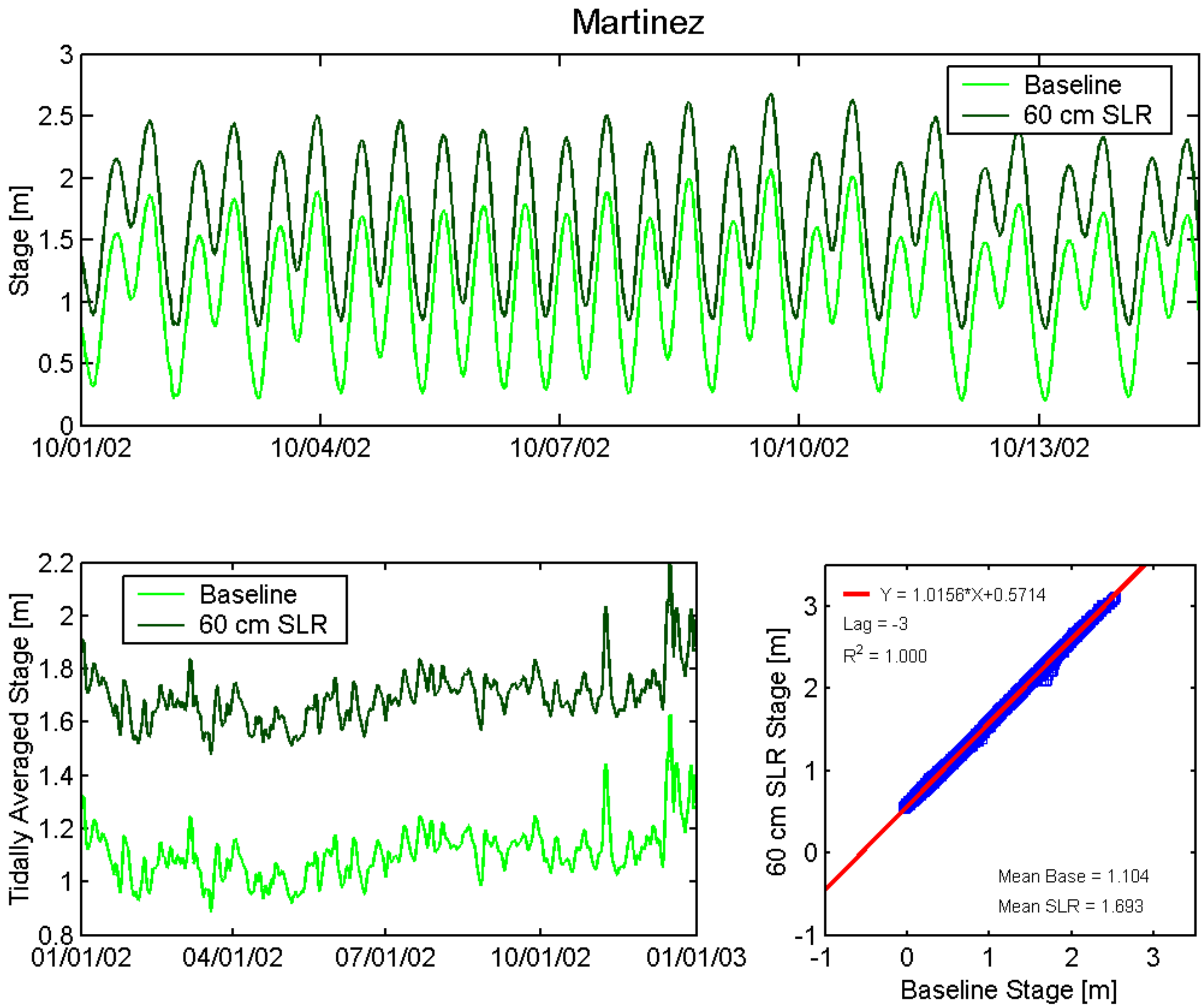


Figure 7.1-10 Predicted stage (top) and tidally averaged stage (lower left) at Martinez for Baseline and 60 cm SLR scenarios. Regression (lower right) shows the best linear fit for the effect on stage at Martinez resulting from 60 cm of SLR at the Pacific Ocean boundary.

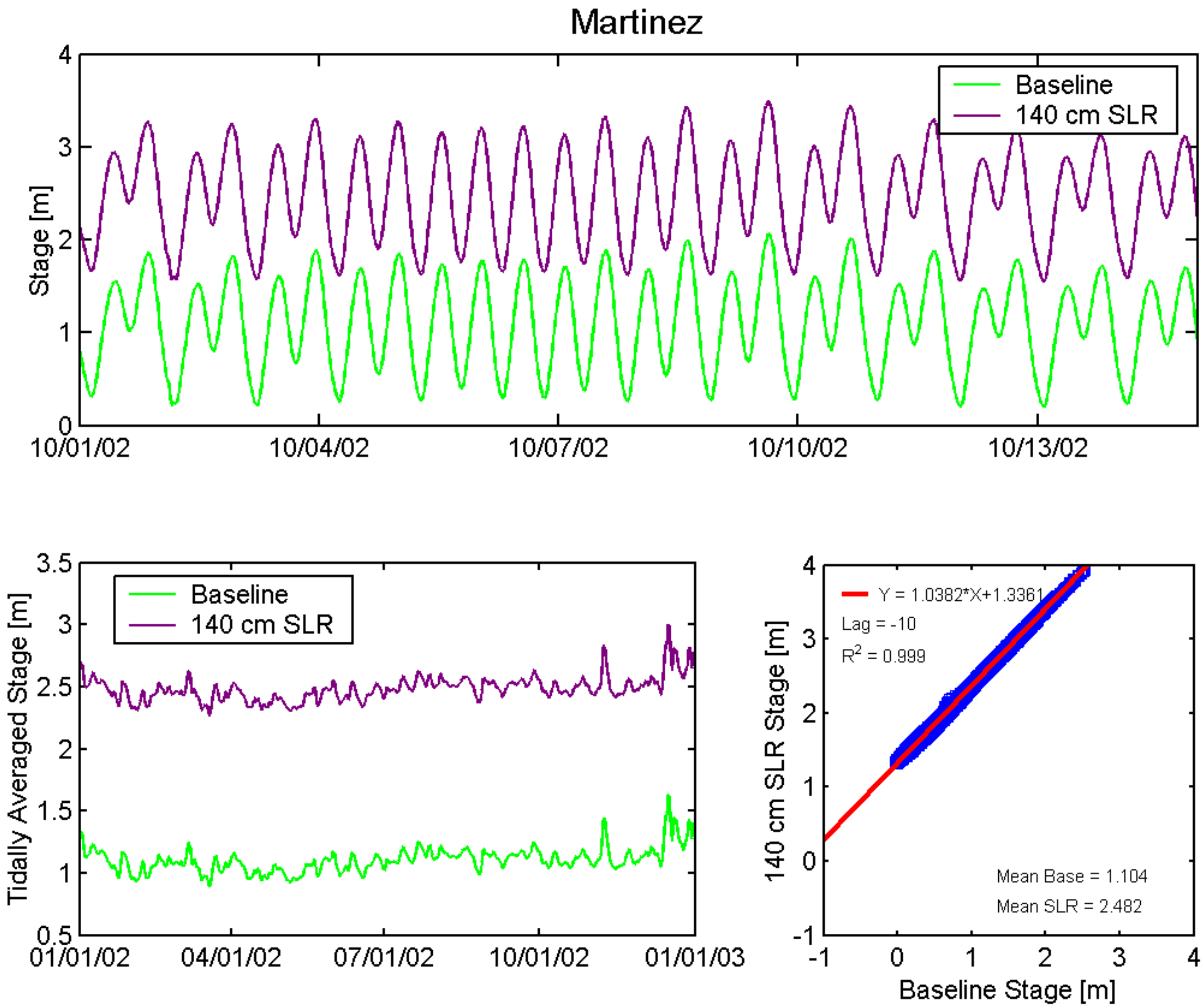


Figure 7.1-11 Predicted stage (top) and tidally averaged stage (lower left) at Martinez for Baseline and 140 cm SLR scenarios. Regression (lower right) shows the best linear fit for the effect on stage at Martinez resulting from 140 cm of SLR at the Pacific Ocean boundary.

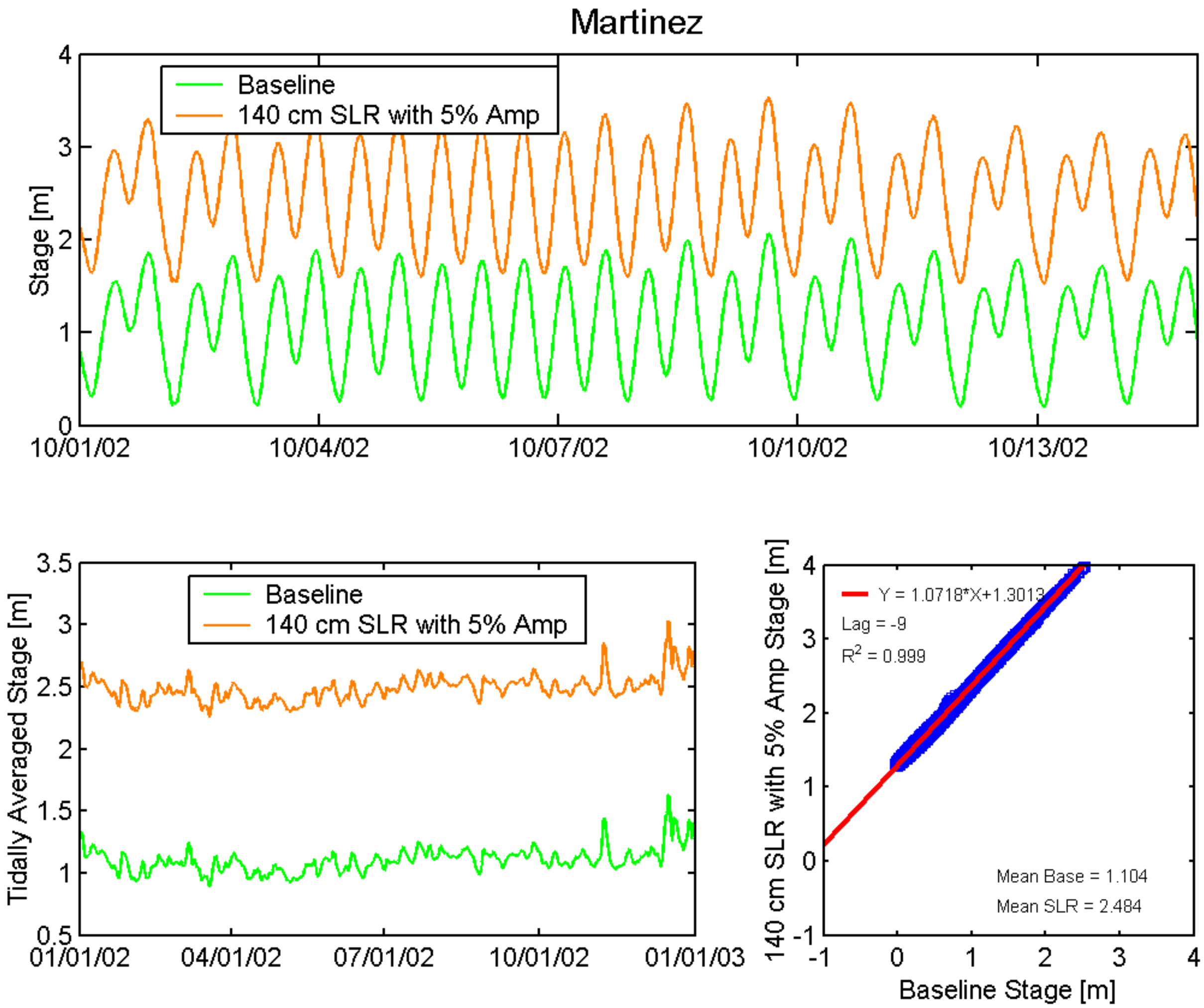


Figure 7.1-12 Predicted stage (top) and tidally averaged stage (lower left) at Martinez for Baseline and 140 cm of SLR with 5% Amplification scenarios. Regression (lower right) shows the best linear fit for the effect on stage at Martinez resulting from 140 cm of SLR with 5% Amplification at the Pacific Ocean boundary.

7.2 Establishing Salinity Relationships for Sea Level Rise at the Golden Gate and Martinez

This section presents linear regression relationships developed using the cross-correlation procedure described in section A.1 to describe the effect of SLR at the ocean boundary on predicted salinity the Golden Gate and at Martinez. No change was made to the ocean boundary salinity for the sea level rise scenarios; a constant salinity of 33.5 psu was applied at the ocean boundary for all scenarios.

7.2.1 Salinity Relationships for Sea Level Rise at the Golden Gate

Figure 7.2-1 shows the predicted cross-section average salinity and tidally averaged cross-section average salinity at the Golden Gate for the Baseline and 15 cm SLR scenarios. The cross-correlation yields a best linear fit of

[Salinity 15 cm SLR] = 0.9883 x *[Salinity Baseline] + 0.3973* (7-13)

with an R^2 value of 1.000 and no phase difference. The slope of the salinity relationship at the Golden Gate for 15 cm SLR is 0.9883 which is not as close to 1.00 as for the stage relationship suggesting that the salinity difference is not accurately represented by a constant offset. This is also reflected by the difference between the annual mean salinity for the Baseline scenario and the annual mean salinity for the 15 cm SLR scenario which is 0.032 psu; this difference is significantly less than the offset of 0.3973 psu in Equation 7-13.

Figure 7.2-2 shows the predicted cross-section average salinity and tidally averaged cross-section average salinity at the Golden Gate for the Baseline and 30 cm SLR scenarios. The cross-correlation yields a best linear fit of

[Salinity 30 cm SLR] = 0.9765 x *[Salinity Baseline] + 0.7960* (7-14)

with an R^2 value of 1.000 and no phase difference. The slope of the salinity relationship at the Golden Gate for 30 cm SLR is 0.9765 which is not as close to 1.00 as for the stage relationship suggesting that the salinity difference is not accurately represented by a constant offset. This is also reflected by the difference between the annual mean salinity for the Baseline scenario and the annual mean salinity for the 30 cm SLR scenario which is 0.063 psu; this difference is significantly less than the offset of 0.7960 psu in Equation 7-14.

Figure 7.2-3 shows the predicted cross-section average salinity and tidally averaged cross-section average salinity at the Golden Gate for the Baseline and 45 cm SLR scenarios. The cross-correlation yields a best linear fit of

[Salinity 45 cm SLR] = 0.9640 x *[Salinity Baseline] + 1.2153* (7-15)

with an R^2 value of 1.000 and a phase lead of 1 minute. The slope of the salinity relationship at the Golden Gate for 45 cm SLR is 0.9640 which is not as close to 1.00 as for the stage relationship suggesting that the salinity difference is not accurately represented by a constant offset. This is also reflected by the difference between the annual mean salinity for the Baseline scenario and the annual mean salinity for the 15 cm SLR scenario which is 0.092 psu; this difference is significantly less than the offset of 1.2153 psu in Equation 7-15.

Figure 7.2-4 shows the predicted cross-section average salinity and tidally averaged cross-section average salinity at the Golden Gate for the Baseline and 60 cm SLR scenarios. The cross-correlation yields a best linear fit of

[Salinity 60 cm SLR] = 0.9519 x *[Salinity Baseline] + 1.6210* (7-16)

with an R^2 value of 0.999 and a phase lead of 1 minute. The slope of the salinity relationship at the Golden Gate for 60 cm SLR is 0.9519 which is not as close to 1.00 as for the stage relationship suggesting that the salinity difference is not accurately represented by a constant offset. This is also reflected by the difference between the annual mean salinity for the Baseline scenario and the annual mean salinity for the 60 cm SLR scenario which is 0.120 psu; this difference is significantly less than the offset of 1.6210 psu in Equation 7-16.

Figure 7.2-5 shows the predicted cross-section average salinity and tidally averaged cross-section average salinity at the Golden Gate for the Baseline and 140 cm SLR scenarios. The cross-correlation yields a best linear fit of

[Salinity 140 cm SLR] = 0.8871 x *[Salinity Baseline] + 3.7768* (7-17)

with an R^2 value of 0.998 and a phase lead of 6 minutes. The slope of the salinity relationship at the Golden Gate for 140 cm SLR is 0.0.8871 which is much less than 1.00, suggesting that the salinity difference is not accurately represented by a constant offset. This is also reflected by the difference between the annual mean salinity for the Baseline scenario and the annual mean salinity for the 140 cm SLR scenario which is 0.254 psu; this difference is significantly less than the offset of 3.7768 psu in Equation 7-17.

Figure 7.2-6 shows the predicted cross-section average salinity and tidally averaged cross-section average salinity at the Golden Gate for the Baseline and 140 cm SLR with 5% Amplification scenarios. The cross-correlation yields a best linear fit of

[Salinity 140 cm SLR with 5% Amplification] = 0.9037 x *[Salinity Baseline] + 3.2957* (7-18)

with an R^2 value of 0.997 and a phase lead of 4 minutes. The slope of the salinity relationship at the Golden Gate for 140 cm SLR with 5% Amplification is 0.9037 which is much less than 1.00, suggesting that the salinity difference is not accurately represented by a constant offset. This is also reflected by the difference between the annual mean salinity for the Baseline scenario and the annual mean salinity for the 140 cm SLR with 5% Amplification scenario which is 0.290 psu; this difference is significantly less than the offset of 3.2957 psu in Equation 7-18.

7.2.2 Salinity Relationships for Sea Level Rise at Martinez

Salinity relationships at Martinez were developed using both the predicted surface salinity at the location of the DWR Martinez surface salinity sensor (RSAC054), and for predicted cross-sectional average salinity at the location shown on Figure 3-1. The reason for these two different relationships are that observed surface salinity at Martinez is typically used for historical DSM2 simulations, whereas the predicted cross-section averaged salinity from the UnTRIM Bay-Delta model is more representative of the salinity at Martinez as represented by a 1-D model such as DSM2.

Figure 7.2-7 shows the predicted surface salinity and tidally averaged surface salinity at Martinez (RSAC054) for the Baseline and 15 cm SLR scenarios. The cross-correlation yields a best linear fit of

[Salinity 15 cm SLR] = 1.0001 x *[Salinity Baseline] + 0.2778* (7-19)

with an R^2 value of 0.999 and a phase lag of 1 minute. Because this relationship is linear with a slope very close to 1.000, this shows that the 15 cm stage offset applied at the ocean boundary is translating almost exactly to 0.2778 psu salinity increase at the Martinez surface salinity sensor. This is also reflected by the difference between the annual mean salinity for the Baseline scenario and the annual mean salinity for the 15 cm SLR scenario which is 0.279 psu. This suggests that a constant salinity offset between 0.278 and 0.279 psu would fairly accurately represent the salinity increase at Martinez for the 15 cm SLR scenario. The largest expected errors using this approach are likely to occur for low salinity values at Martinez, when salinity in the Delta is expected to be low.

Figure 7.2-8 shows the predicted cross-section average salinity and tidally averaged cross-section average salinity at Martinez (location shown on Figure 3-1) for the Baseline and 15 cm SLR scenarios. The cross-correlation yields a best linear fit of

[Salinity 15 cm SLR] = 0.9969 x *[Salinity Baseline] + 0.3416* (7-20)

with an R^2 value of 1.000 and no phase difference. Because this relationship is linear with a slope very close to 1.000, this shows that the 15 cm stage offset applied at the ocean boundary is translating to approximately a 0.3416 psu increase in cross-section average salinity at Martinez. This is also reflected by the difference between the annual mean salinity for the Baseline scenario and the annual mean salinity for the 15 cm SLR scenario which is 0.301 psu. This suggests that a constant salinity offset between 0.3010 and 0.3416 psu would fairly accurately represent the salinity increase at Martinez for the 15 cm SLR scenario. The relationship derived from the predicted cross-section averaged salinity suggests a larger increase than the relationship derived from the predicted surface salinity.

Figure 7.2-9 shows the predicted surface salinity and tidally averaged surface salinity at Martinez (RSAC054) for the Baseline and 30 cm SLR scenarios. The cross-correlation yields a best linear fit of

[Salinity 30 cm SLR] = 0.9968 x *[Salinity Baseline] + 0.5853* (7-21)

with an R^2 value of 0.998 and a phase lead of 3 minutes. Because this relationship is linear with a slope very close to 1.000, this shows that the 30 cm stage offset applied at the ocean boundary is translating almost exactly to 0.5853 psu salinity increase at the Martinez surface salinity sensor. This is also reflected by the difference between the annual mean salinity for the Baseline scenario and the annual mean salinity for the 30 cm SLR scenario which is 0.550 psu. This suggests that a constant salinity offset between 0.550 and 0.585 psu would fairly accurately represent the salinity increase at Martinez for the 30 cm SLR scenario. The largest expected errors using this approach are likely to occur for low salinity values at Martinez, when salinity in the Delta is expected to be low.

Figure 7.2-10 shows the predicted cross-section average salinity and tidally averaged cross-section average salinity at Martinez (location shown on Figure 3-1) for the Baseline and 30 cm SLR scenarios. The cross-correlation yields a best linear fit of

[Salinity 30 cm SLR] = 0.9912 x *[Salinity Baseline] + 0.7044* (7-22)

with an R^2 value of 1.000 and a phase lead of 1 minute. Because this relationship is linear with a slope very close to 1.000, this shows that the 30 cm stage offset applied at the ocean boundary is translating to approximately a 0.7044 psu increase in cross-section average salinity at Martinez. This is also reflected by the difference between the annual mean salinity for the Baseline scenario and the annual mean salinity for the 30 cm SLR scenario which is 0.602 psu. This suggests that a constant salinity offset between 0.602 and 0.7044 psu would fairly accurately represent the salinity increase at Martinez for the 30 cm SLR scenario. The relationship derived from the predicted cross-section averaged salinity suggests a larger increase than the relationship derived from the predicted surface salinity.

Figure 7.2-11 shows the predicted surface salinity and tidally averaged surface salinity at Martinez (RSAC054) for the Baseline and 45 cm SLR scenarios. The cross-correlation yields a best linear fit of

[Salinity 45 cm SLR] = 0.9919 x *[Salinity Baseline] + 0.9024* (7-23)

with an R^2 value of 0.997 and a phase lead of 4 minutes. Because this relationship is linear with a slope very close to 1.000, this shows that the 45 cm stage offset applied at the ocean boundary is translating to approximately a 0.9024 psu salinity increase at the Martinez surface salinity sensor. This is also reflected by the difference between the annual mean salinity for the Baseline scenario and the annual mean salinity for the 45 cm SLR scenario which is 0.814 psu. This suggests that a constant salinity offset between 0.814 and 0.9024 psu would fairly accurately represent the salinity increase at Martinez for the 45 cm SLR scenario. The largest expected errors using this approach are likely to occur for low salinity values at Martinez, when salinity in the Delta is expected to be low.

Figure 7.2-12 shows the predicted cross-section average salinity and tidally averaged cross-section average salinity at Martinez (location shown on Figure 3-1) for the Baseline and 45 cm SLR scenarios. The cross-correlation yields a best linear fit of

[Salinity 45 cm SLR] = 0.9842 x *[Salinity Baseline] + 1.0914* (7-24)

with an R^2 value of 0.999 and a phase lead of 2 minutes. The slope of the section averaged salinity relationship at Martinez for the 45 cm SLR is 0.9842 which is not as close to 1.00 as for the surface salinity relationship suggesting that the cross-section average salinity difference is not accurately represented by a constant offset. This is also reflected by the difference between the annual mean cross-section average salinity for the Baseline scenario and the annual mean salinity for the 45 cm SLR scenario which is 0.8890 psu; this difference is significantly less than the offset of 1.0914 psu in Equation 7-24. This suggests that with increasing sea level rise, applying a constant salinity offset is less appropriate than for the 15 cm SLR scenario, however the linear fit given by Equation 7-24 shows a high correlation.

Figure 7.2-13 shows the predicted surface salinity and tidally averaged surface salinity at Martinez (RSAC054) for the Baseline and 60 cm SLR scenarios. The cross-correlation yields a best linear fit of

[Salinity 60 cm SLR] = 0.9866 x *[Salinity Baseline] + 1.2019* (7-25)

with an R^2 value of 0.996 and a phase lead of 6 minutes. Because this relationship is linear with a slope relatively close to 1.000, this shows that the 60 cm stage offset applied at the ocean boundary is translating to approximately a 1.2019 psu salinity increase at the Martinez surface salinity sensor. However, the deviation of the slope from 1.000 suggests that the linear fit rather than a constant offset is more appropriate for higher levels of sea level rise. This is also reflected by the difference between the annual mean salinity for the Baseline scenario and the annual mean salinity for the 60 cm SLR scenario which is 1.056 psu; this difference is significantly less than the constant offset of 1.2019 psu in Equation 7-25.

Figure 7.2-14 shows the predicted cross-section average salinity and tidally averaged cross-section average salinity at Martinez (location shown on Figure 3-1) for the Baseline and 60 cm SLR scenarios. The cross-correlation yields a best linear fit of

[Salinity 60 cm SLR] = 0.9769 x *[Salinity Baseline] + 1.4848* (7-26)

with an R^2 value of 0.999 and a phase lead of 3 minutes. Because this relationship is linear with a slope relatively close to 1.000, this shows that the 60 cm stage offset applied at the ocean boundary is translating to approximately a 1.4848 psu increase in cross-section average salinity at Martinez. However, the deviation of the slope from 1.000 suggests that the linear fit rather than a constant offset is more appropriate for higher levels of sea level rise. This is also reflected by the difference between the annual mean salinity for the Baseline scenario and the annual mean salinity for the 60 cm SLR scenario which is 1.177 psu; this difference is significantly less than the constant offset of 1.4848 psu in Equation 7-26. The relationship derived from the predicted cross-section averaged salinity suggests a larger increase than the relationship derived from the predicted surface salinity.

Figure 7.2-15 shows the predicted surface salinity and tidally averaged surface salinity at Martinez (RSAC054) for the Baseline and 140 cm SLR scenarios. The cross-correlation yields a best linear fit of

[Salinity 140 cm SLR] = 0.9633 x *[Salinity Baseline] + 2.9195* (7-27)

with an R^2 value of 0.992 and a phase lead of 12 minutes. Because this relationship is linear with a slope somewhat less than 1.000, this shows that the 140 cm stage offset applied at the ocean boundary does not translate accurately to a constant salinity offset at the Martinez surface salinity sensor. The deviation of the slope from 1.000 suggests that the linear fit rather than a constant offset is more appropriate for higher levels of sea level rise. This is also reflected by the difference between the annual mean salinity for the Baseline scenario and the annual mean salinity for the 140 cm SLR scenario which is 2.520 psu; this difference is significantly less than the constant offset of 2.9195 psu in Equation 7-27.

Figure 7.2-16 shows the predicted cross-section average salinity and tidally averaged cross-section average salinity at Martinez (location shown on Figure 3-1) for the Baseline and 140 cm SLR scenarios. The cross-correlation yields a best linear fit of

[Salinity 140 cm SLR] = 0.9231 x *[Salinity Baseline] + 3.5618* (7-28)

with an R^2 value of 0.994 and a phase lead of 9 minutes. Because this relationship is linear with a slope somewhat less than 1.000, this shows that the 140 cm stage offset applied at the ocean boundary does not translate accurately to a constant salinity offset to cross-section average salinity at Martinez. The deviation of the slope from 1.000 suggests that the linear fit rather than a constant offset is more appropriate for higher levels of sea level rise. This is also reflected by the difference between the annual mean salinity for the Baseline scenario and the annual mean salinity for the 140 cm SLR scenario which is 2.579 psu, , which is significantly less than the constant offset of 3.5618 psu in Equation 7-28. The relationship derived from the predicted cross-section averaged salinity suggests a larger increase than the relationship derived from the predicted surface salinity.

Figure 7.2-17 shows the predicted surface salinity and tidally averaged surface salinity at Martinez (RSAC054) for the Baseline and 140 cm SLR with 5% Amplification scenarios. The cross-correlation yields a best linear fit of

[Salinity 140 cm SLR with 5% Amplification] = 0.9797 x *[Salinity Baseline] + 2.8654* (7-29)

with an R^2 value of 0.991 and a phase lead of 12 minutes. Because this relationship is linear with a slope relatively close to 1.000, this shows that the 140 cm stage offset with 5% amplification applied at the ocean boundary is translating to approximately a 2.8654 psu salinity increase at the Martinez surface salinity sensor. This is also reflected by the difference between the annual mean salinity for the Baseline scenario and the annual mean salinity for the 140 cm SLR with 5% Amplification scenario which is 2.645 psu; this difference is relatively similar to the offset of 2.8654 psu in Equation 7-29. However, it is likely that the linear fit would produce better results than a constant for higher levels of sea level rise.

Figure 7.2-18 shows the predicted cross-section average salinity and tidally averaged cross-section average salinity at Martinez (location shown on Figure 3-1) for the Baseline and 140 cm SLR with 5% Amplification scenarios. The cross-correlation yields a best linear fit of

[Salinity 140 cm SLR with 5% Amplification] = 0.9405 x *[Salinity Baseline] + 3.4103* (7-30)

with an R^2 value of 0.994 and no phase difference. Because this relationship is linear with a slope somewhat less than 1.000, this shows that the 140 cm stage offset with 5% amplification applied at the ocean boundary does not translate accurately to a constant salinity offset in cross-section average salinity at Martinez. This is also reflected by the difference between the annual mean salinity for the Baseline scenario and the annual mean salinity for the 140 cm SLR with 5% Amplification scenario which is 2.650 psu; this difference is significantly less than the constant offset of 3.4103 psu in Equation 7-30. The relationship derived from the predicted cross-section averaged salinity suggests a larger salinity increase than the relationship derived from the predicted surface salinity.

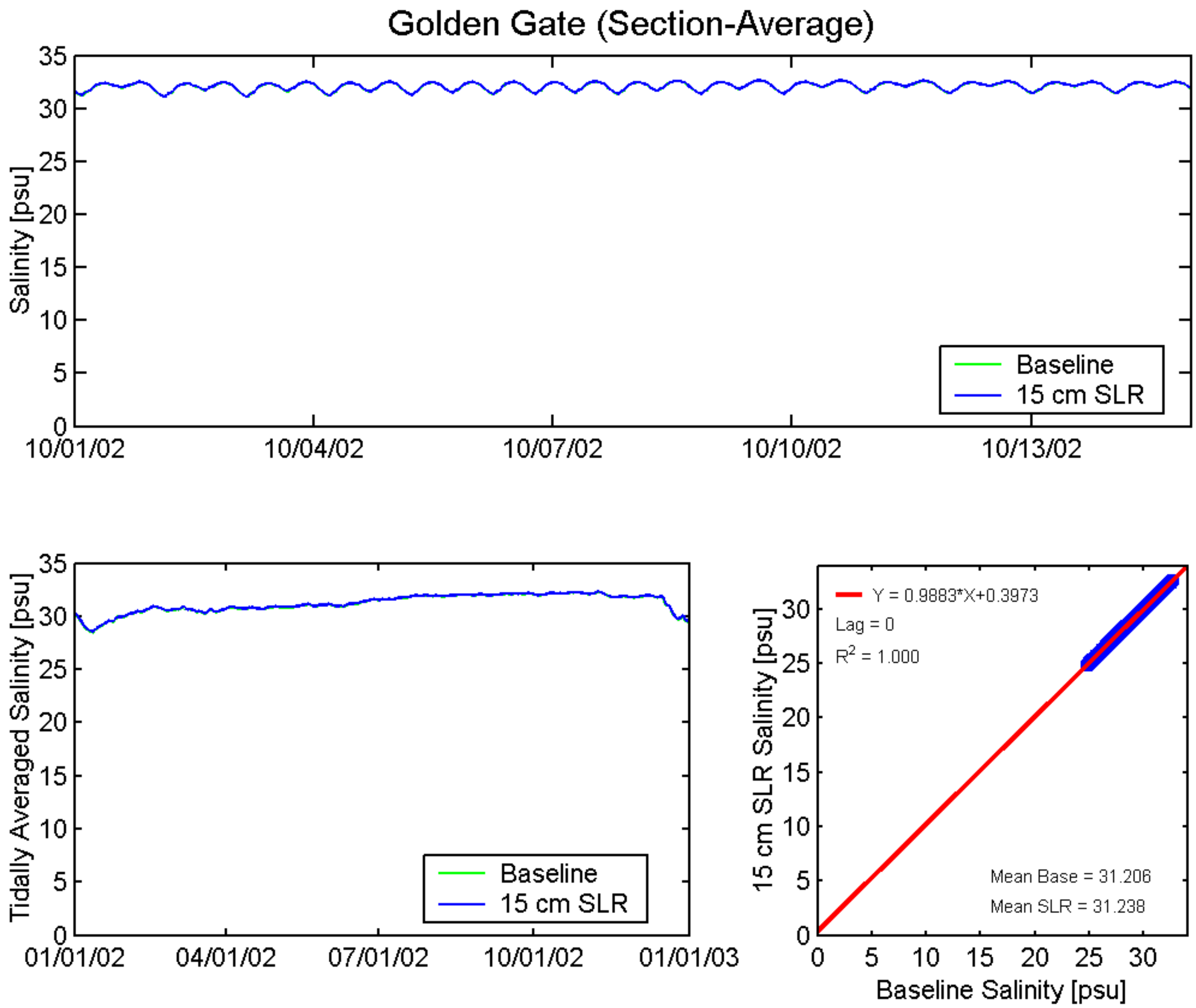


Figure 7.2-1 Predicted salinity (top) and tidally averaged salinity (lower left) at the Golden Gate for Baseline and 15 cm SLR scenarios. Regression (lower right) shows the best linear fit for the effect on salinity at the Golden Gate resulting from 15 cm of SLR at the Pacific Ocean boundary.

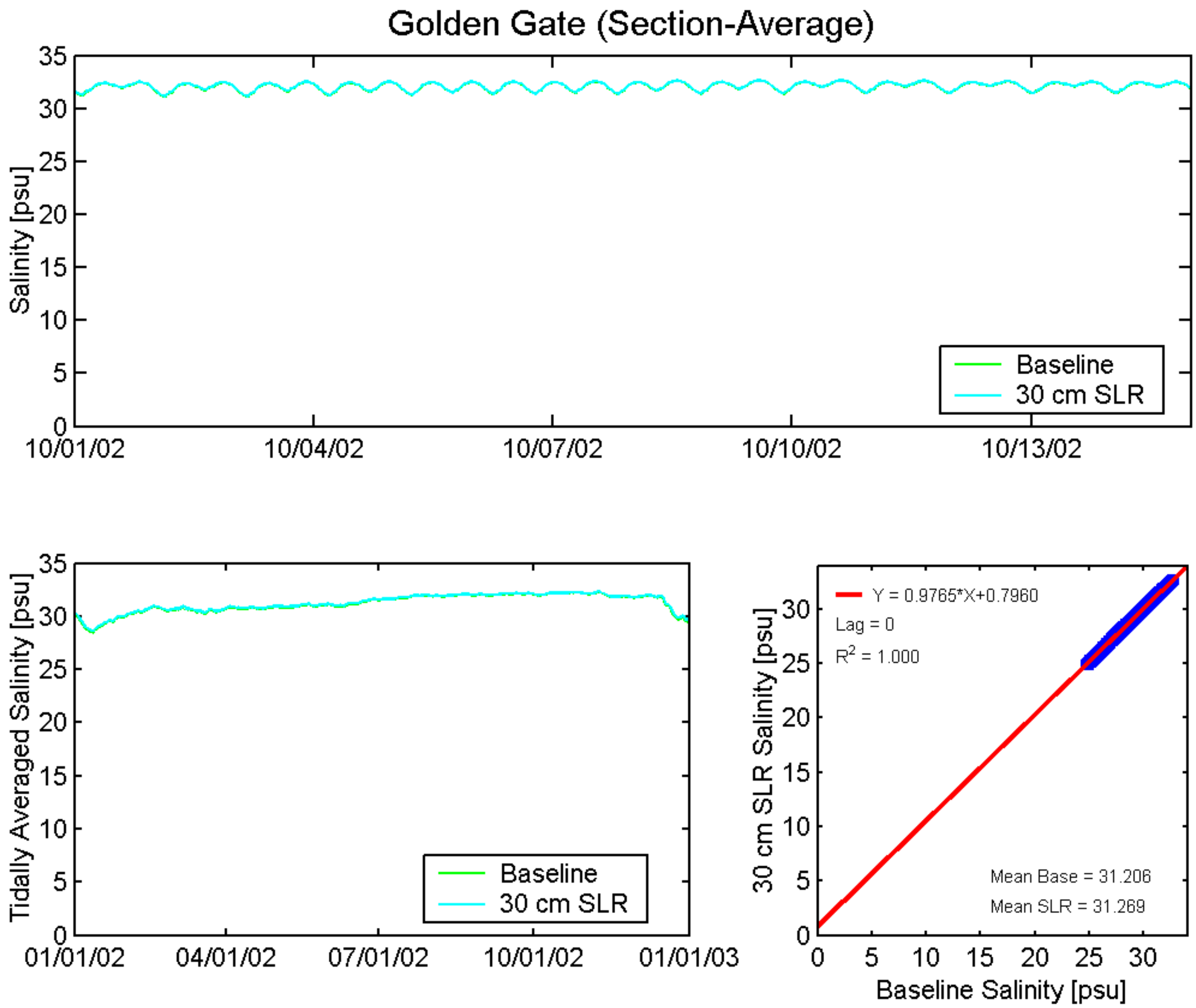


Figure 7.2-2 Predicted salinity (top) and tidally averaged salinity (lower left) at the Golden Gate for Baseline and 30 cm SLR scenarios. Regression (lower right) shows the best linear fit for the effect on salinity at the Golden Gate resulting from 30 cm of SLR at the Pacific Ocean boundary.

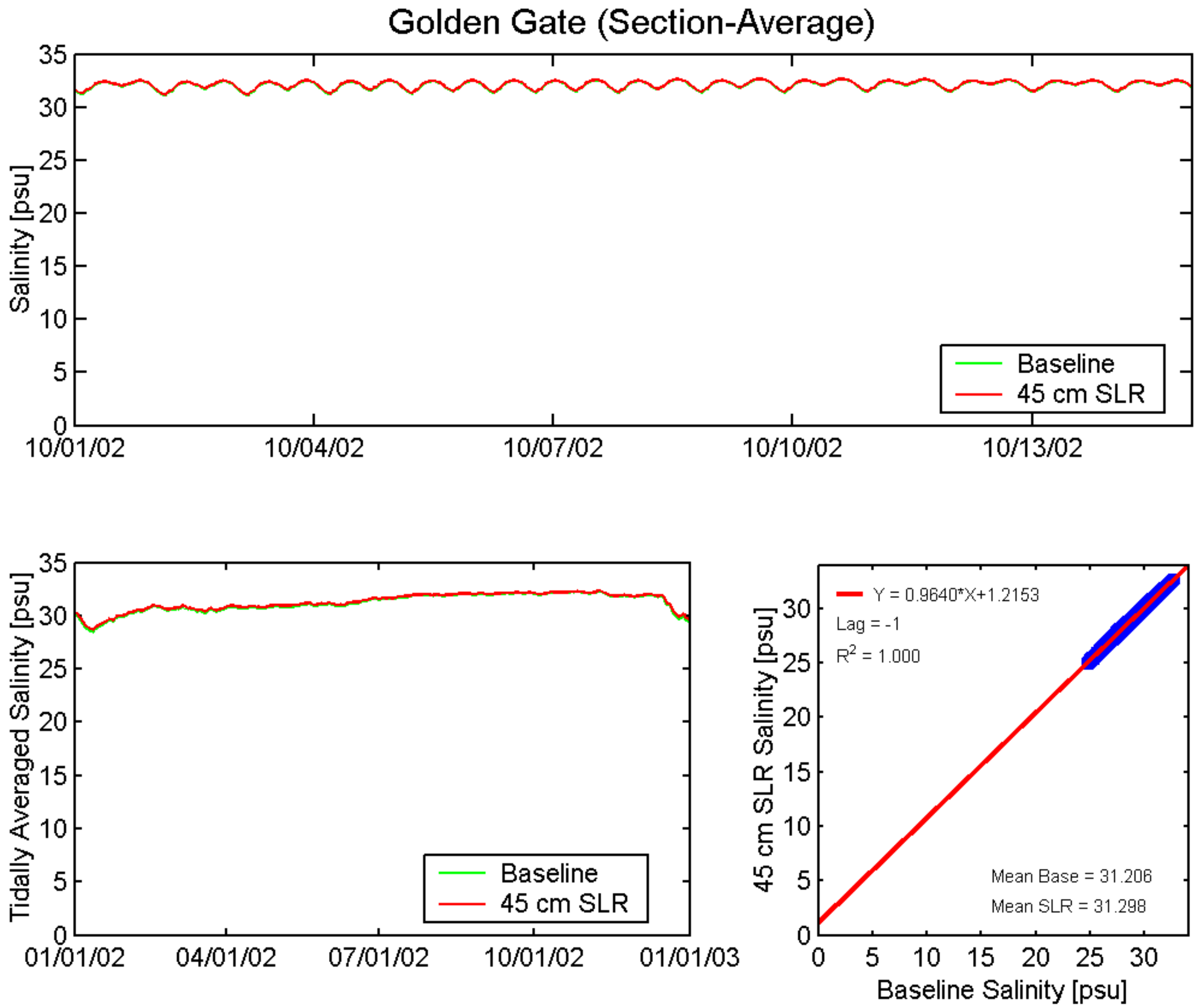


Figure 7.2-3 Predicted salinity (top) and tidally averaged salinity (lower left) at the Golden Gate for Baseline and 45 cm SLR scenarios. Regression (lower right) shows the best linear fit for the effect on salinity at the Golden Gate resulting from 45 cm of SLR at the Pacific Ocean boundary.

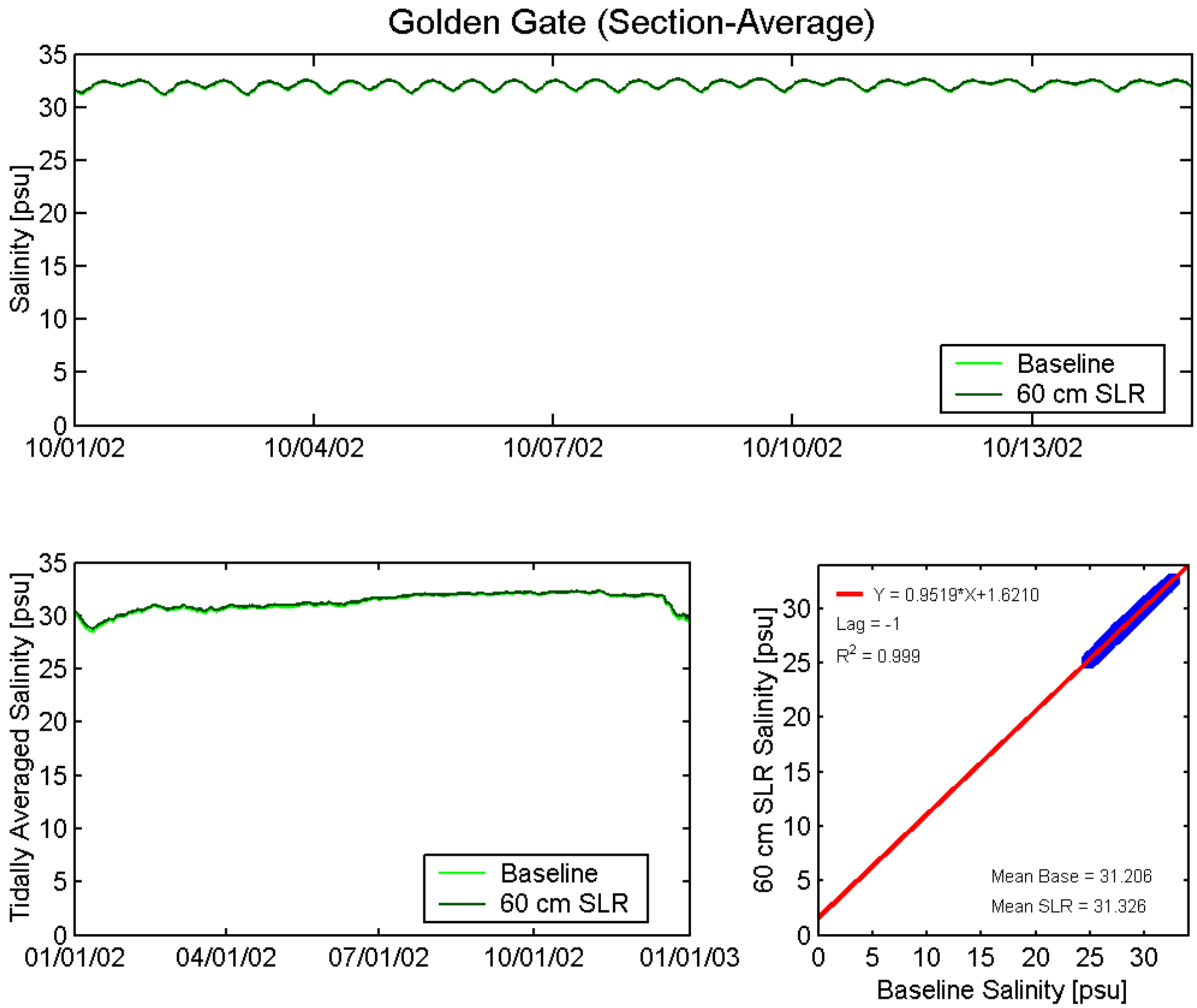


Figure 7.2-4 Predicted salinity (top) and tidally averaged salinity (lower left) at the Golden Gate for Baseline and 60 cm SLR scenarios. Regression (lower right) shows the best linear fit for the effect on salinity at the Golden Gate resulting from 60 cm of SLR at the Pacific Ocean boundary.

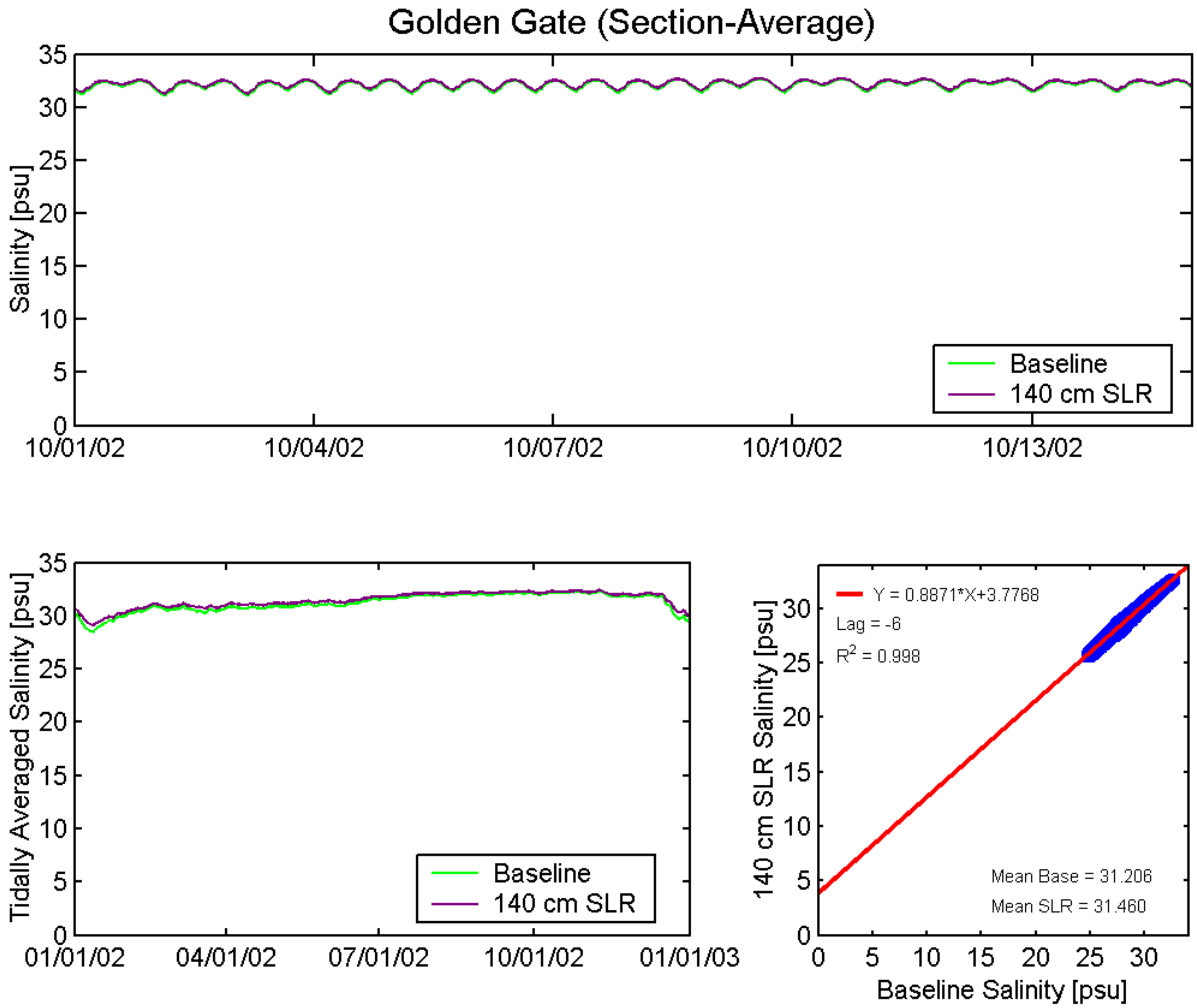


Figure 7.2-5 Predicted salinity (top) and tidally averaged salinity (lower left) at the Golden Gate for Baseline and 140 cm SLR scenarios. Regression (lower right) shows the best linear fit for the effect on salinity at the Golden Gate resulting from 140 cm of SLR at the Pacific Ocean boundary.

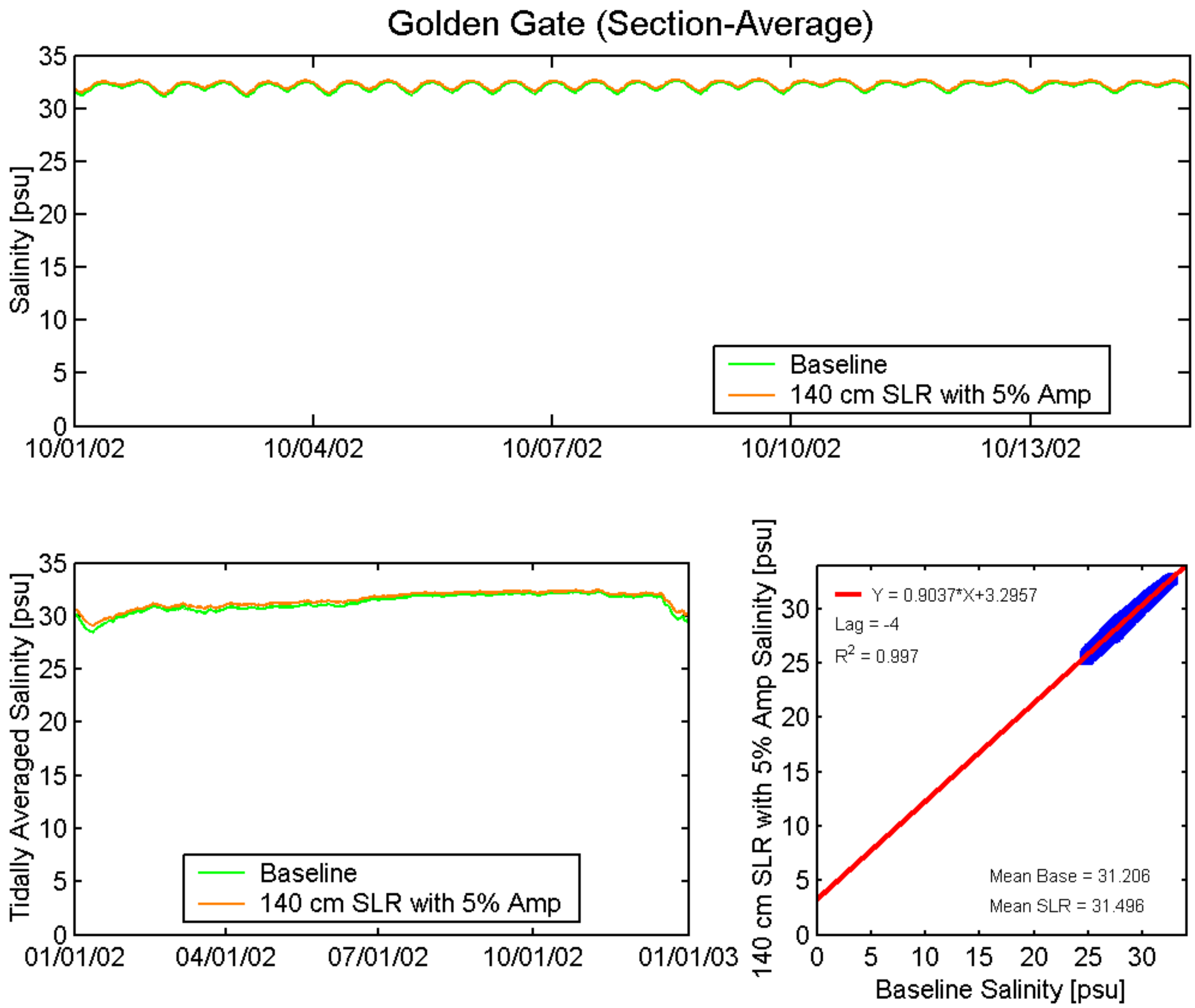


Figure 7.2-6 Predicted salinity (top) and tidally averaged salinity (lower left) at the Golden Gate for Baseline and 140 cm of SLR with 5% Amplification scenarios. Regression (lower right) shows the best linear fit for the effect on salinity at the Golden Gate resulting from 140 cm of SLR with 5% Amplification at the Pacific Ocean boundary.

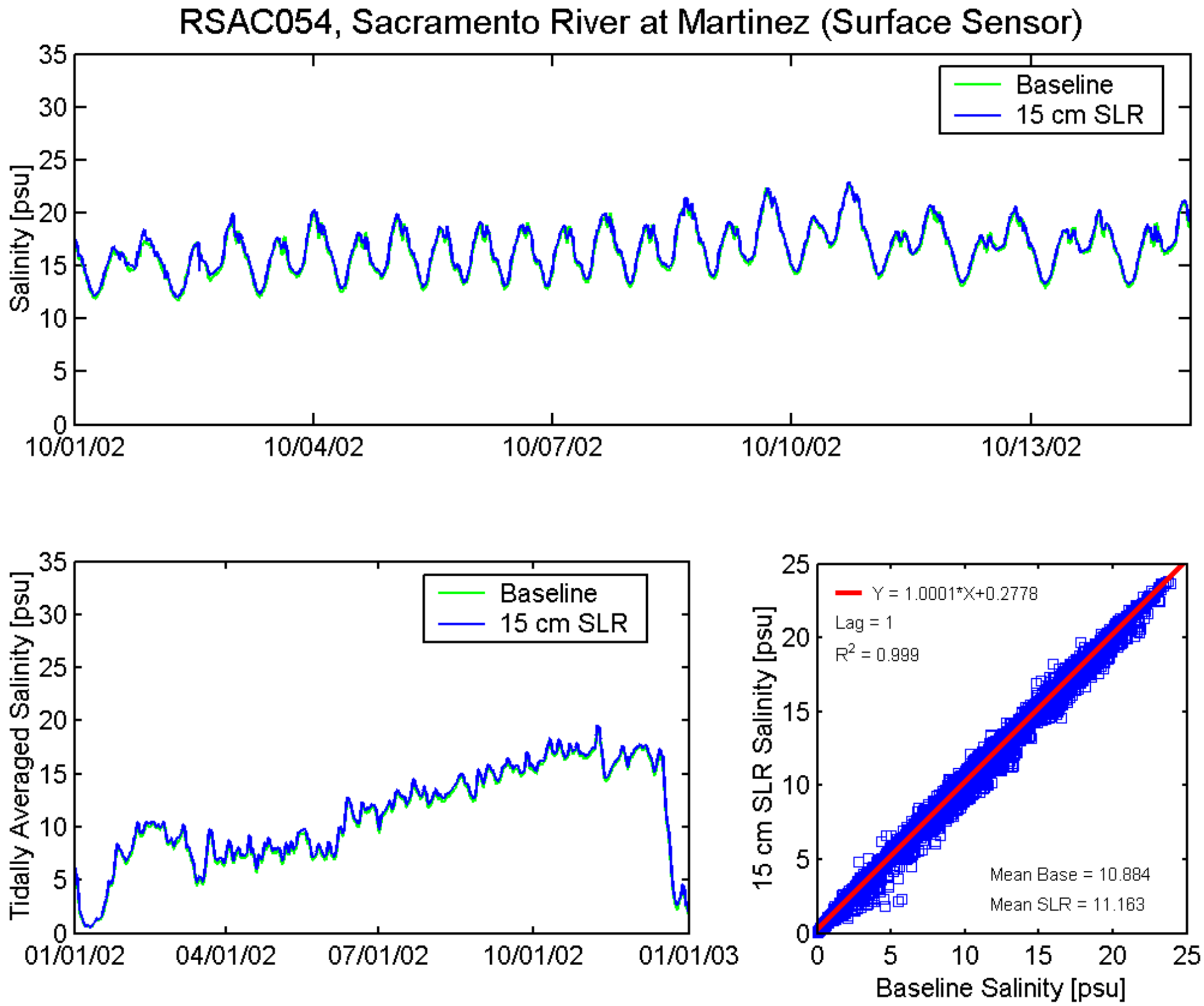


Figure 7.2-7 Predicted salinity (top) and tidally averaged salinity (lower left) at the Martinez surface salinity sensor (RSAC054) for Baseline and 15 cm SLR scenarios. Regression (lower right) shows the best linear fit for the effect on salinity at the Martinez surface salinity sensor resulting from 15 cm of SLR at the Pacific Ocean boundary.

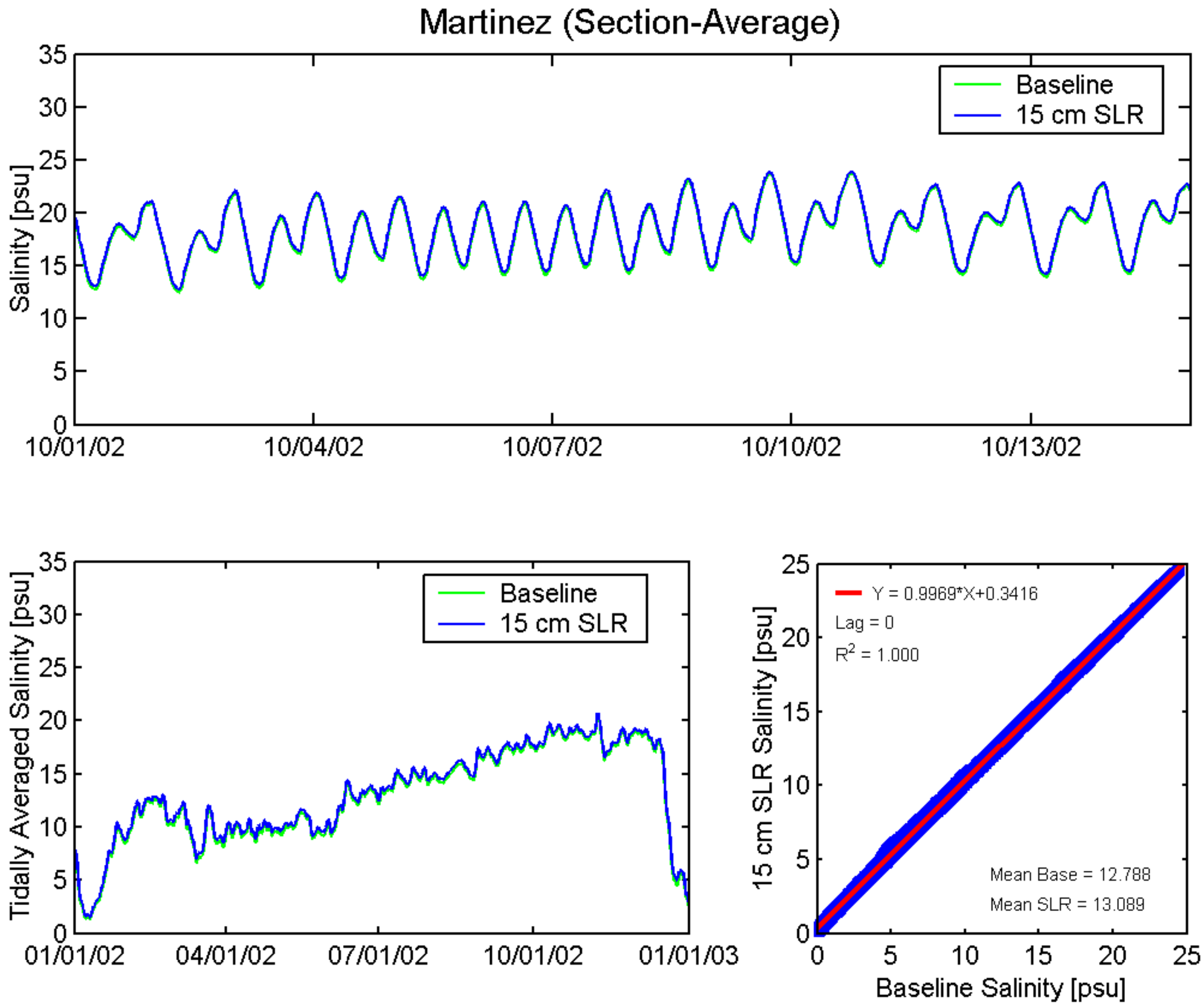


Figure 7.2-8 Predicted cross-section average salinity (top) and tidally averaged cross-section average salinity (lower left) at Martinez for Baseline and 15 cm SLR scenarios. Regression (lower right) shows the best linear fit for the effect on cross-section average salinity at Martinez resulting from 15 cm of SLR at the Pacific Ocean boundary.

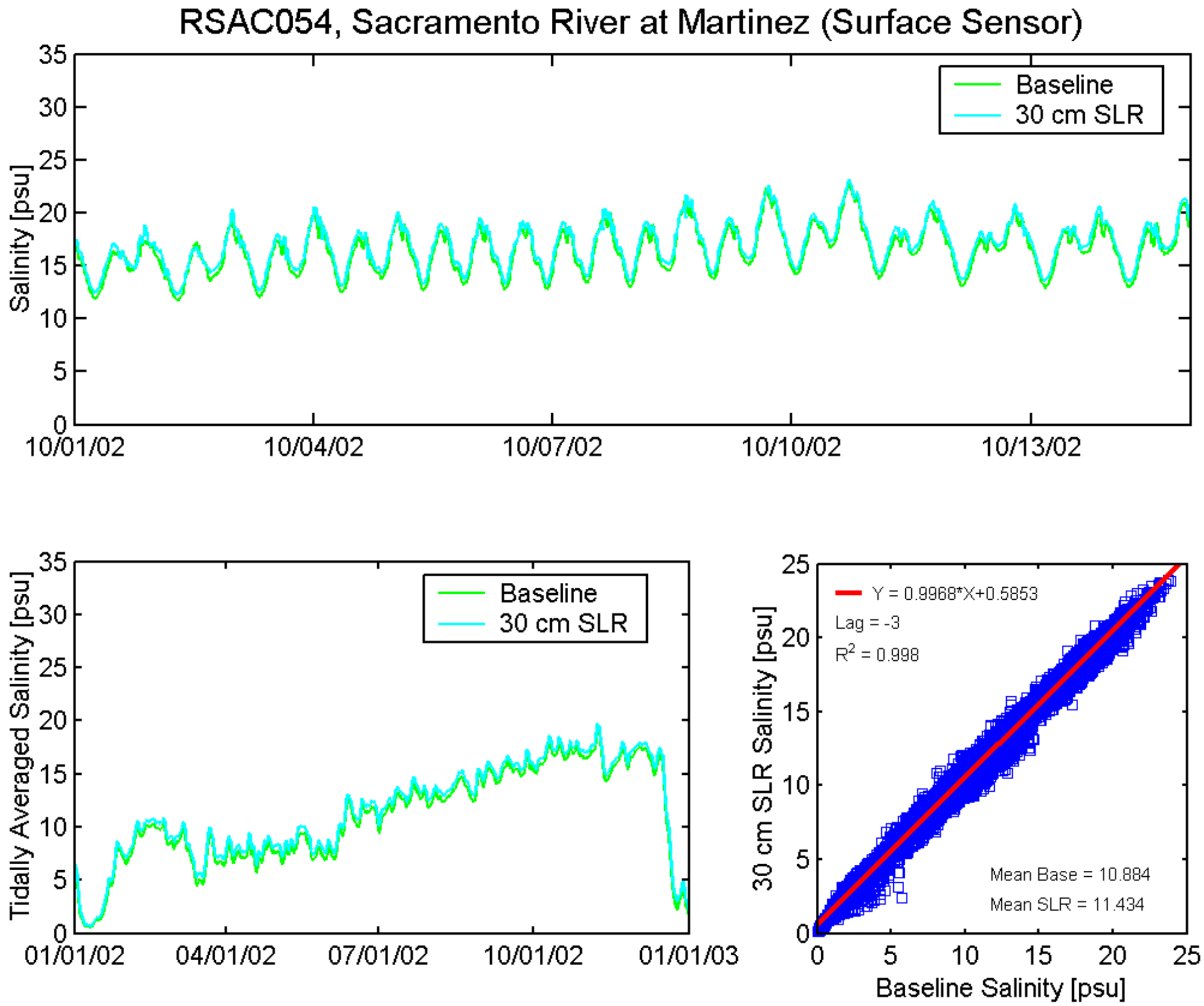


Figure 7.2-9 Predicted salinity (top) and tidally averaged salinity (lower left) at the Martinez surface salinity sensor (RSAC054) for Baseline and 30 cm SLR scenarios. Regression (lower right) shows the best linear fit for the effect on salinity at the Martinez surface salinity sensor resulting from 30 cm of SLR at the Pacific Ocean boundary.

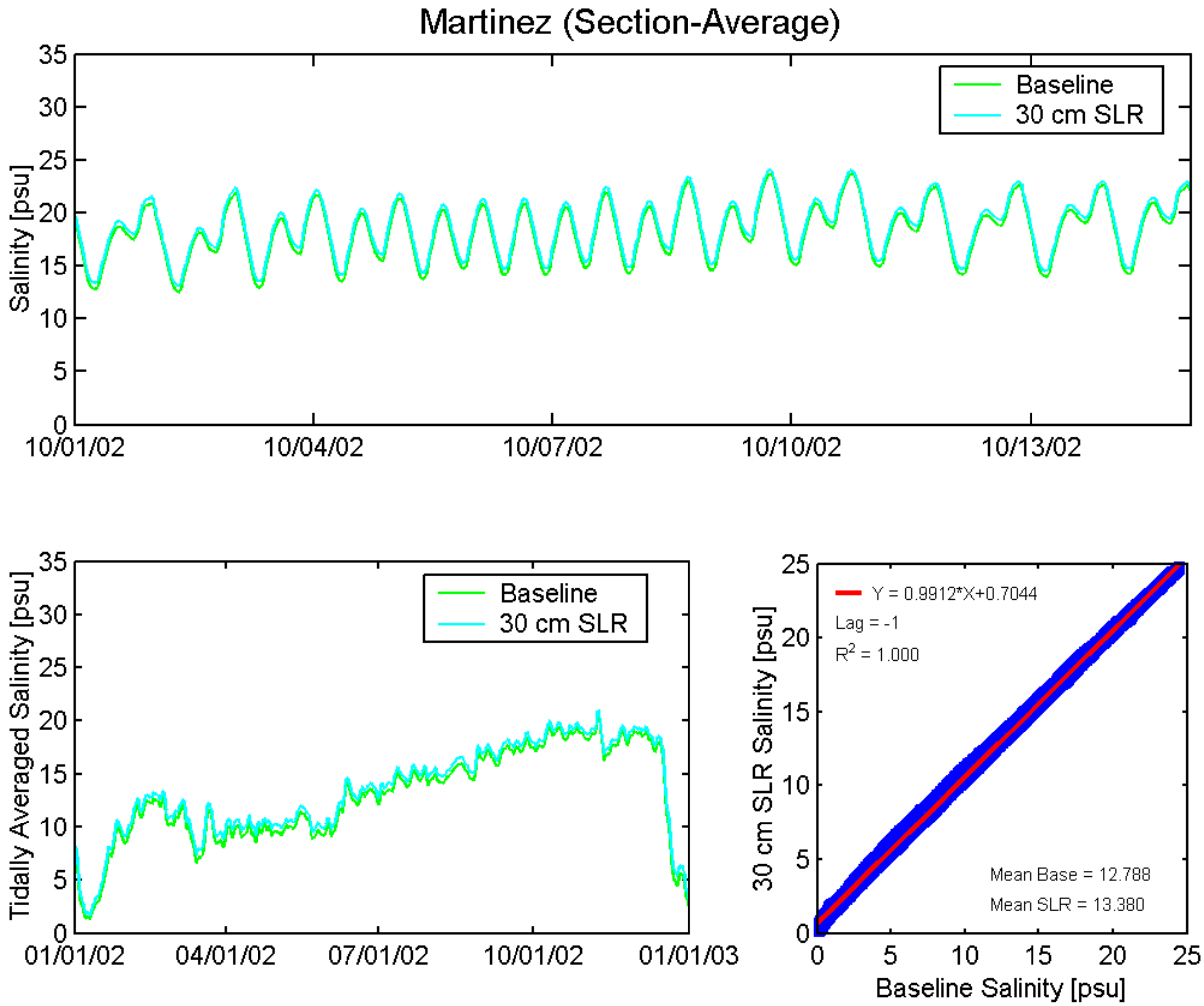


Figure 7.2-10 Predicted cross-section average salinity (top) and tidally averaged cross-section average salinity (lower left) at Martinez for Baseline and 30 cm SLR scenarios. Regression (lower right) shows the best linear fit for the effect on cross-section average salinity at Martinez resulting from 30 cm of SLR at the Pacific Ocean boundary.

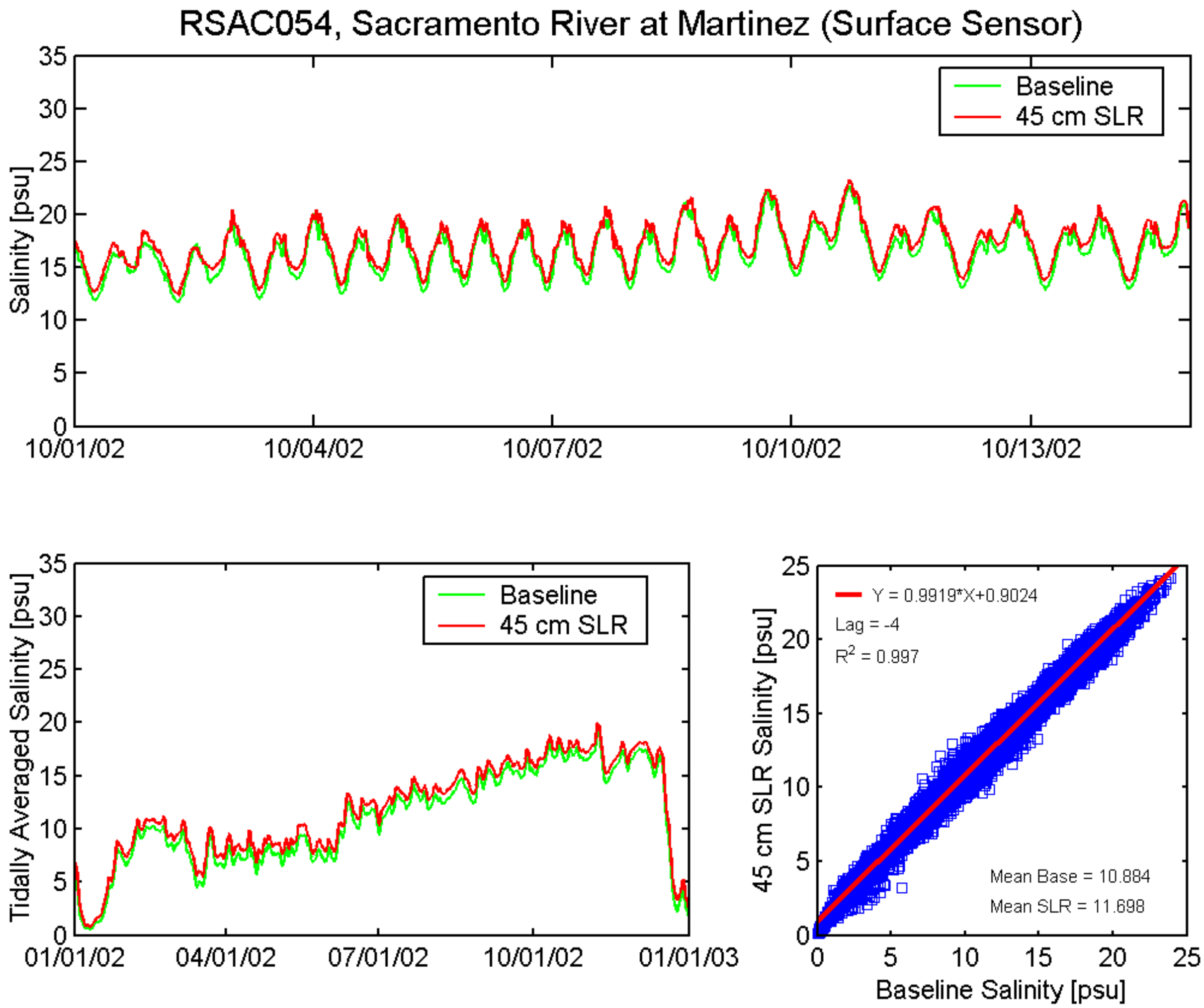


Figure 7.2-11 Predicted salinity (top) and tidally averaged salinity (lower left) at the Martinez surface salinity sensor (RSAC054) for Baseline and 45 cm SLR scenarios. Regression (lower right) shows the best linear fit for the effect on salinity at the Martinez surface salinity sensor resulting from 45 cm of SLR at the Pacific Ocean boundary.

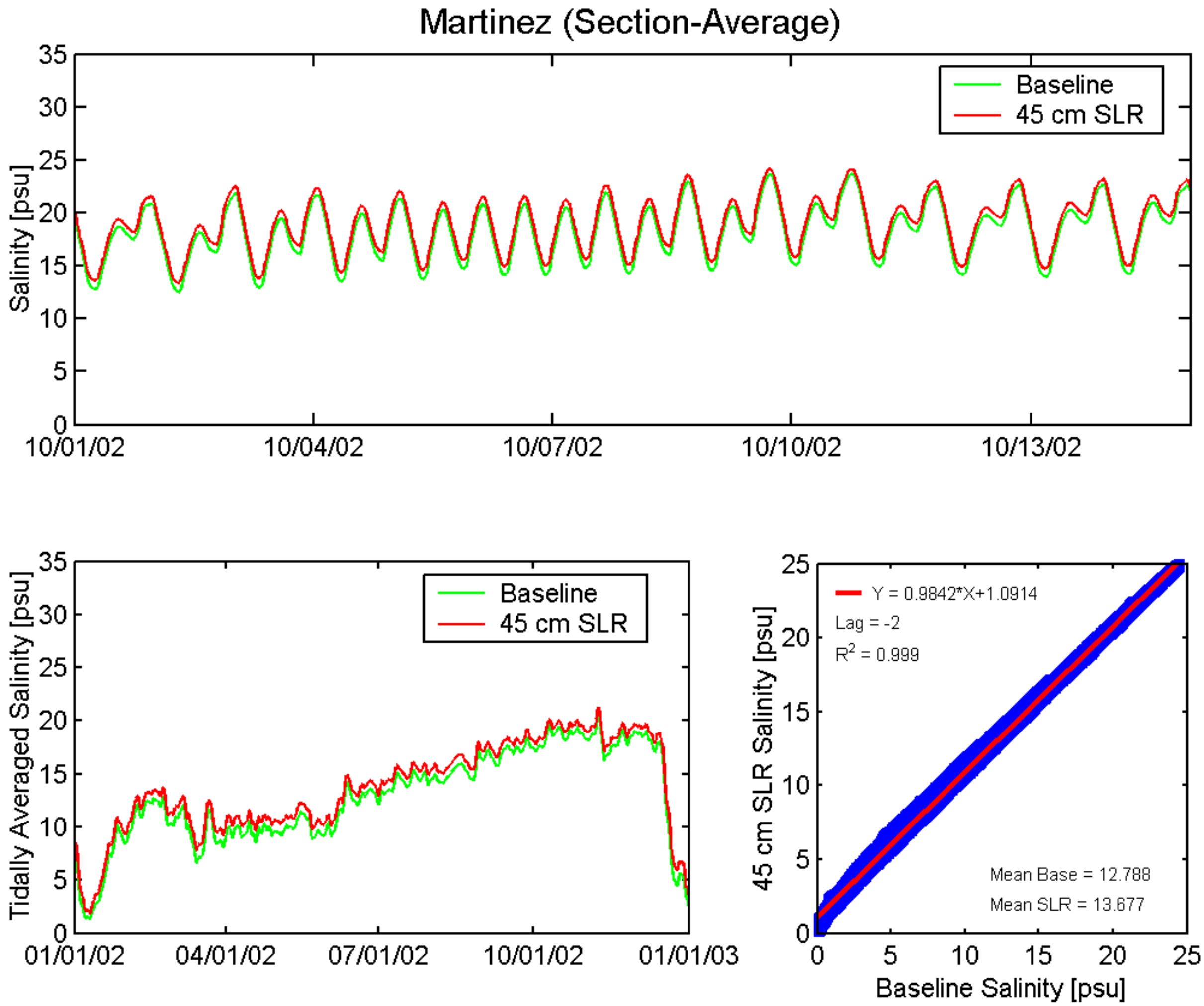


Figure 7.2-12 Predicted cross-section average salinity (top) and tidally averaged cross-section average salinity (lower left) at Martinez for Baseline and 45 cm SLR scenarios. Regression (lower right) shows the best linear fit for the effect on cross-section average salinity at Martinez resulting from 45 cm of SLR at the Pacific Ocean boundary.

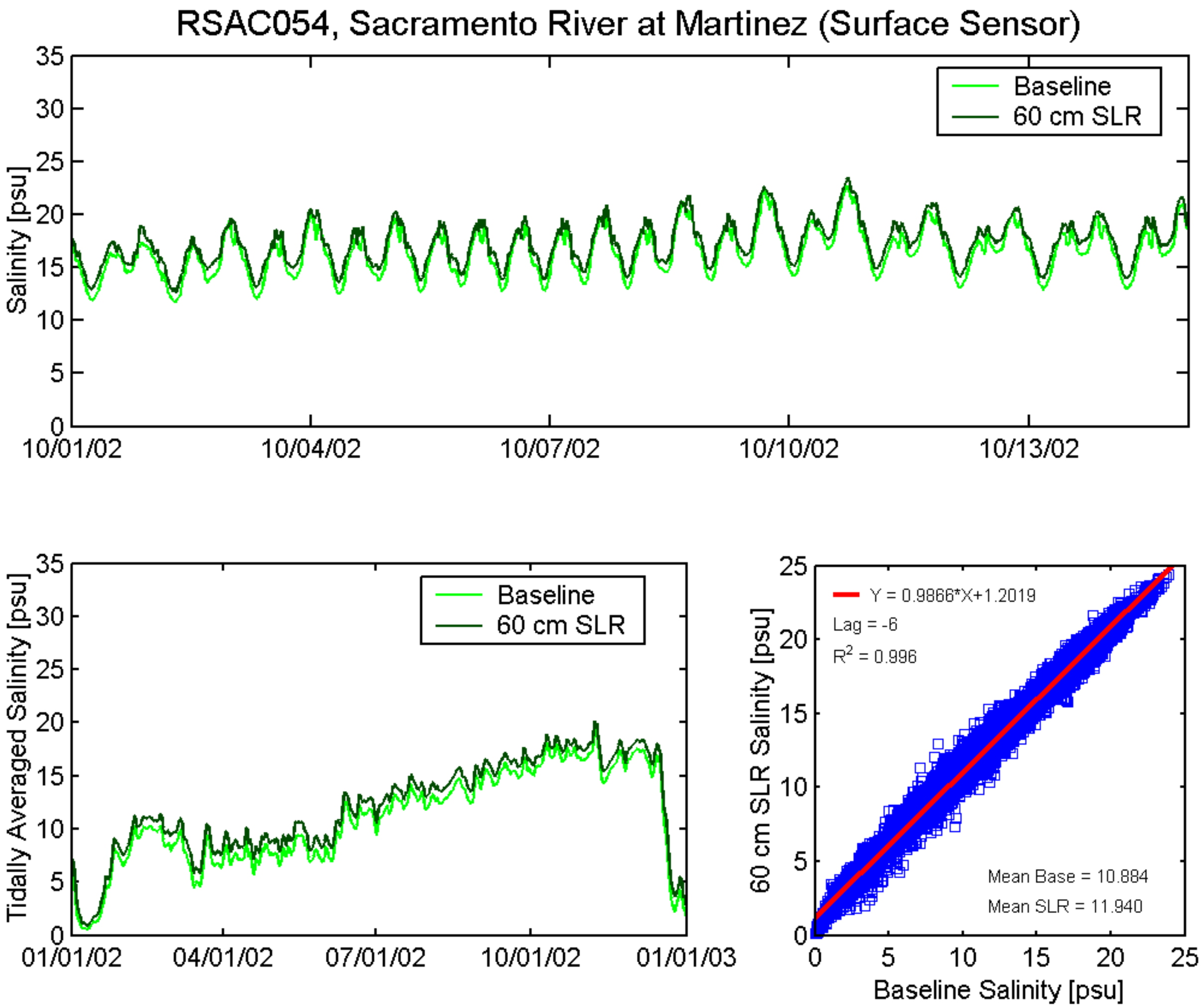


Figure 7.2-13 Predicted salinity (top) and tidally averaged salinity (lower left) at the Martinez surface salinity sensor (RSAC054) for Baseline and 60 cm SLR scenarios. Regression (lower right) shows the best linear fit for the effect on salinity at the Martinez surface salinity sensor resulting from 60 cm of SLR at the Pacific Ocean boundary.

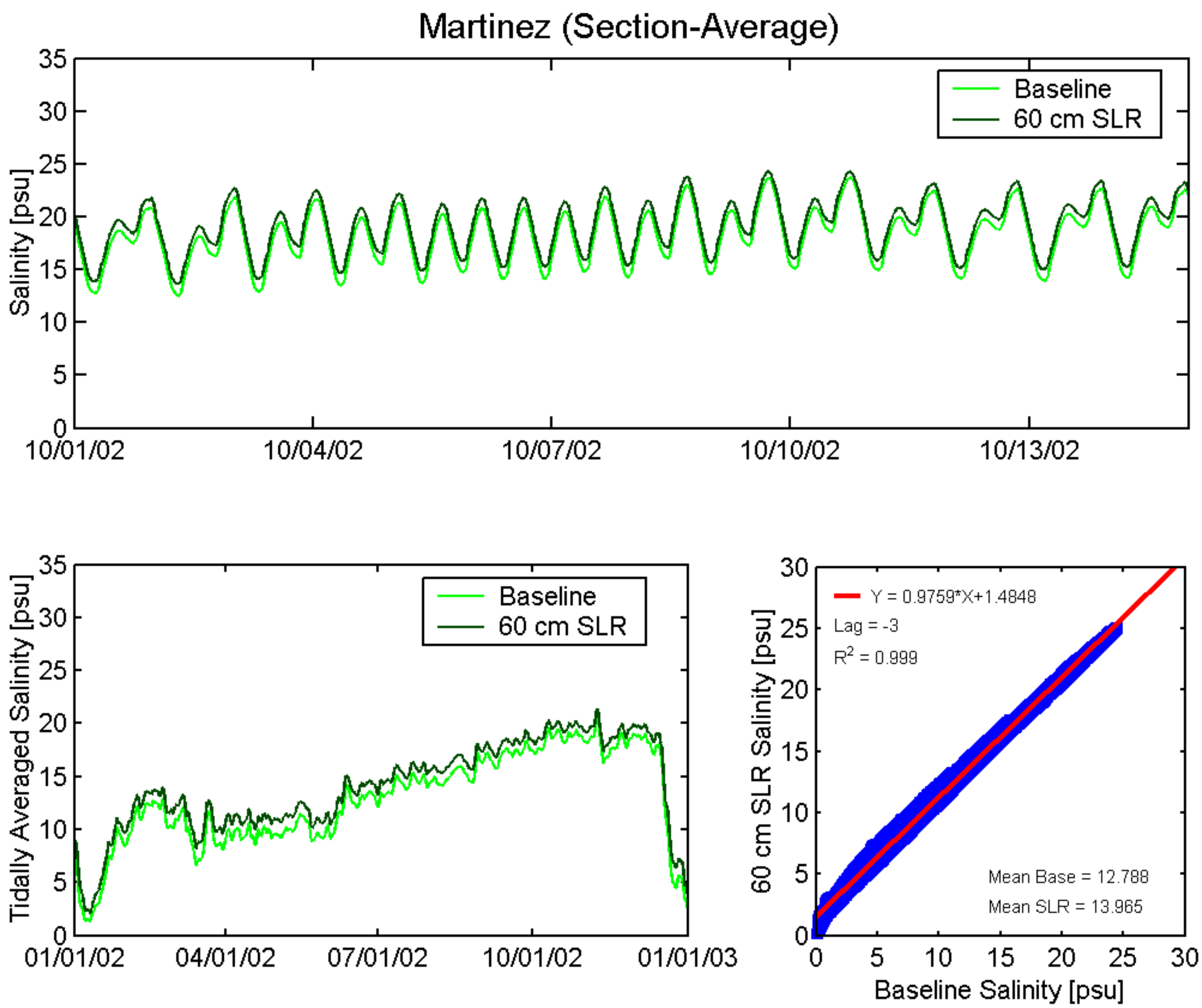


Figure 7.2-14 Predicted cross-section average salinity (top) and tidally averaged cross-section average salinity (lower left) at Martinez for Baseline and 60 cm SLR scenarios. Regression (lower right) shows the best linear fit for the effect on cross-section average salinity at Martinez resulting from 60 cm of SLR at the Pacific Ocean boundary.

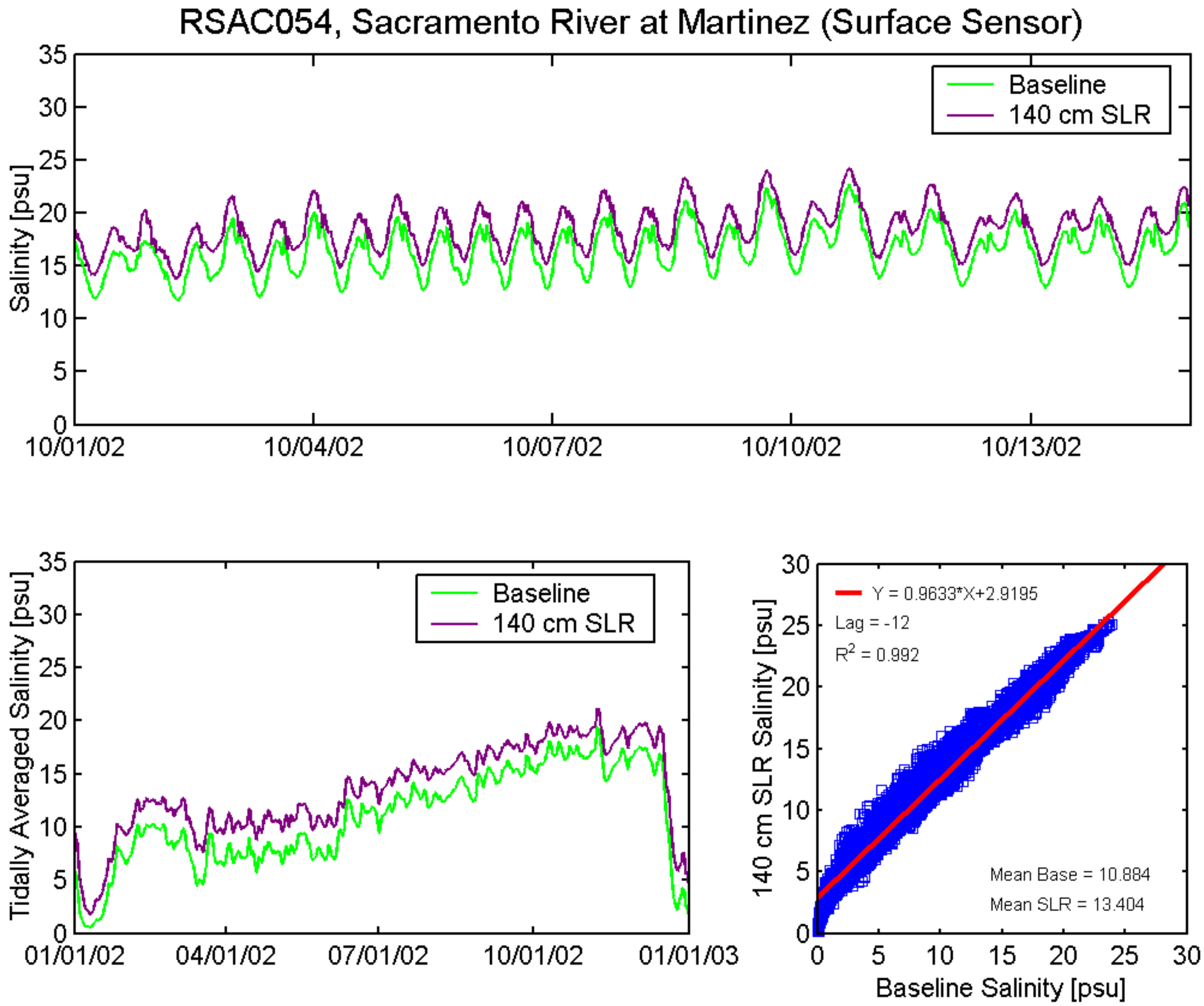


Figure 7.2-15 Predicted salinity (top) and tidally averaged salinity (lower left) at the Martinez surface salinity sensor (RSAC054) for Baseline and 140 cm SLR scenarios. Regression (lower right) shows the best linear fit for the effect on salinity at the Martinez surface salinity sensor resulting from 140 cm of SLR at the Pacific Ocean boundary.

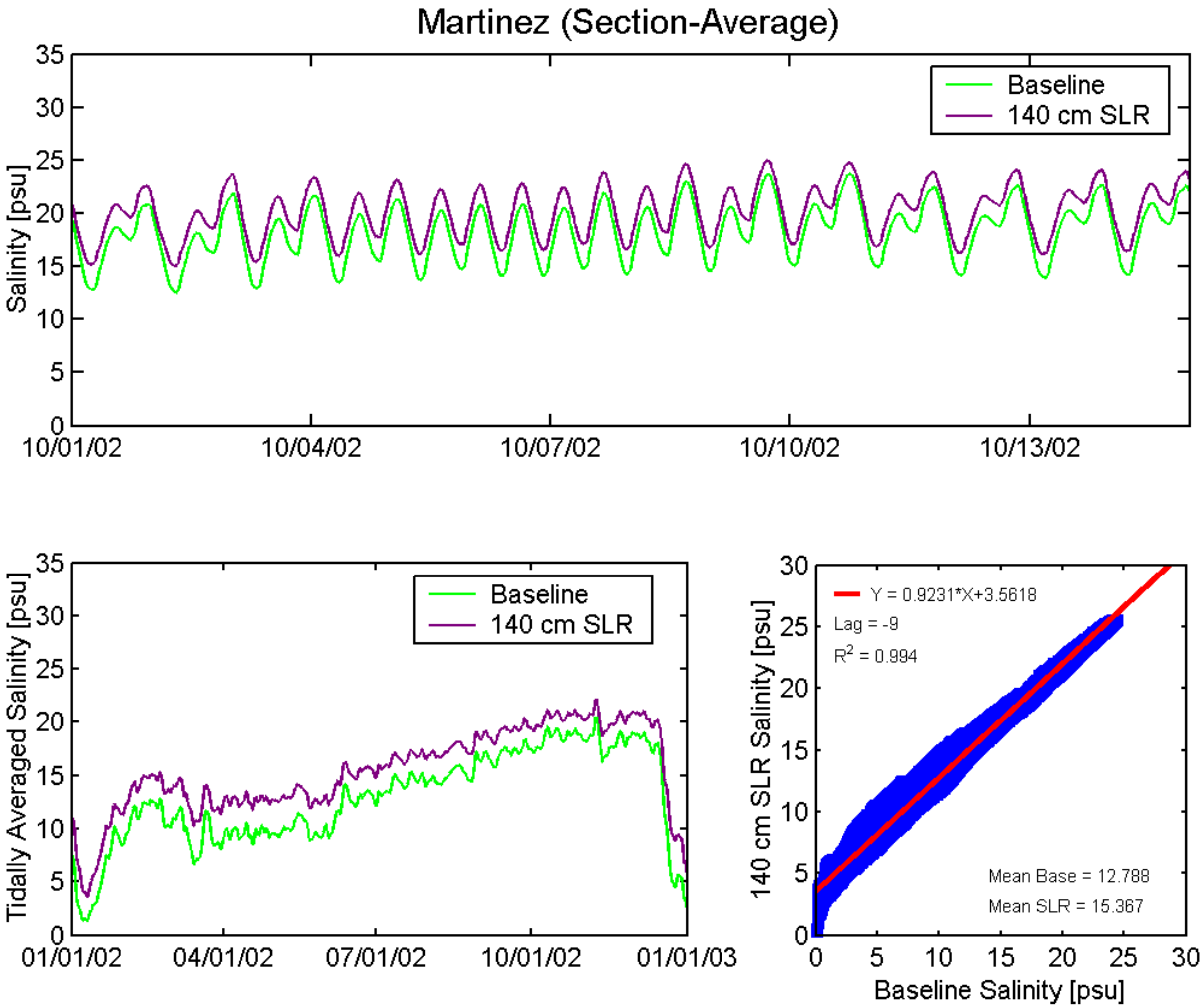


Figure 7.2-16 Predicted cross-section average salinity (top) and tidally averaged cross-section average salinity (lower left) at Martinez for Baseline and 140 cm SLR scenarios. Regression (lower right) shows the best linear fit for the effect on cross-section average salinity at Martinez resulting from 140 cm of SLR at the Pacific Ocean boundary.

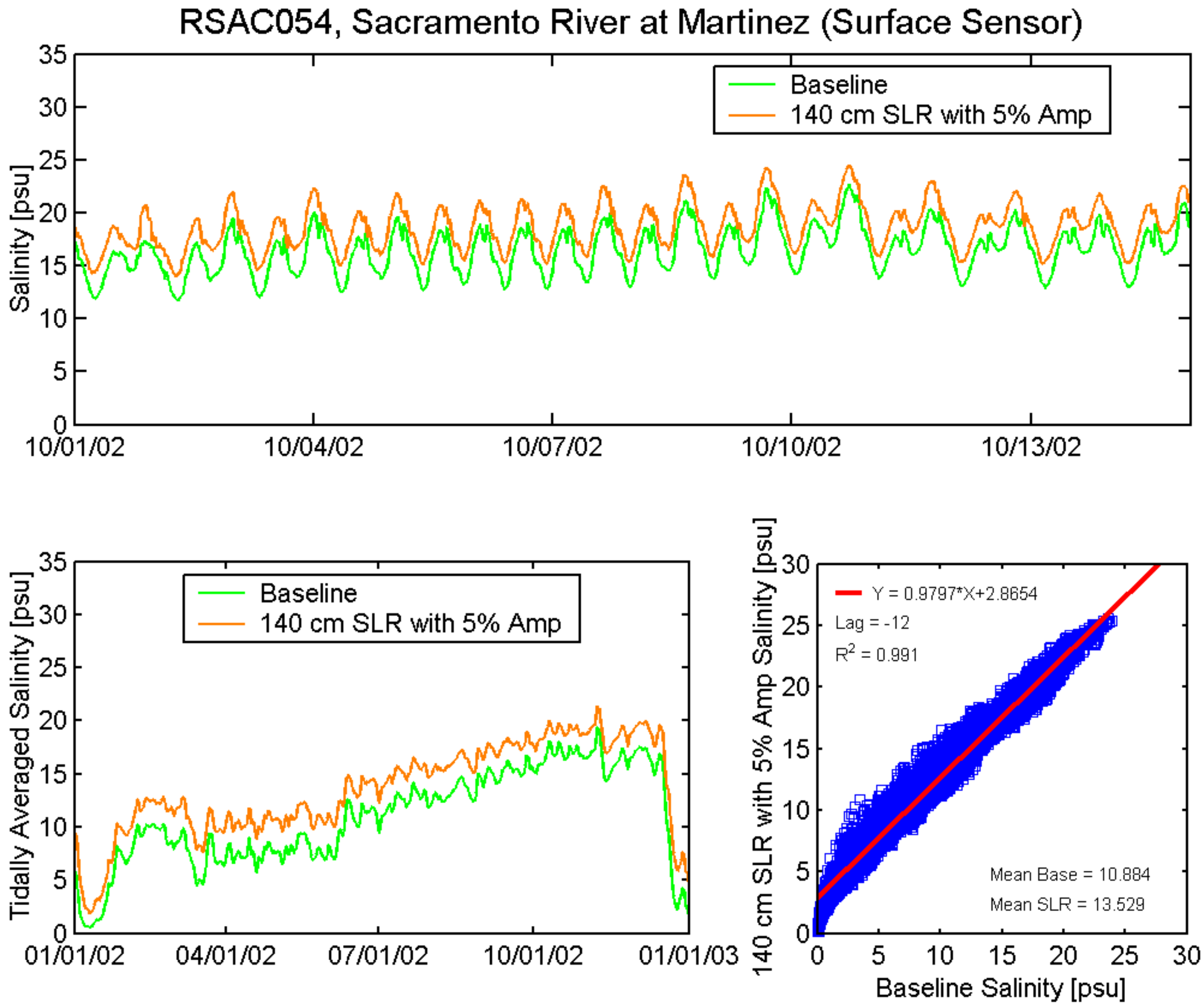


Figure 7.2-17 Predicted salinity (top) and tidally averaged salinity (lower left) at the Martinez surface salinity sensor (RSAC054) for Baseline and 140 cm of SLR with 5% Amplification scenarios. Regression (lower right) shows the best linear fit for the effect on salinity at the Martinez surface salinity sensor resulting from 140 cm of SLR with 5% Amplification at the Pacific Ocean boundary.

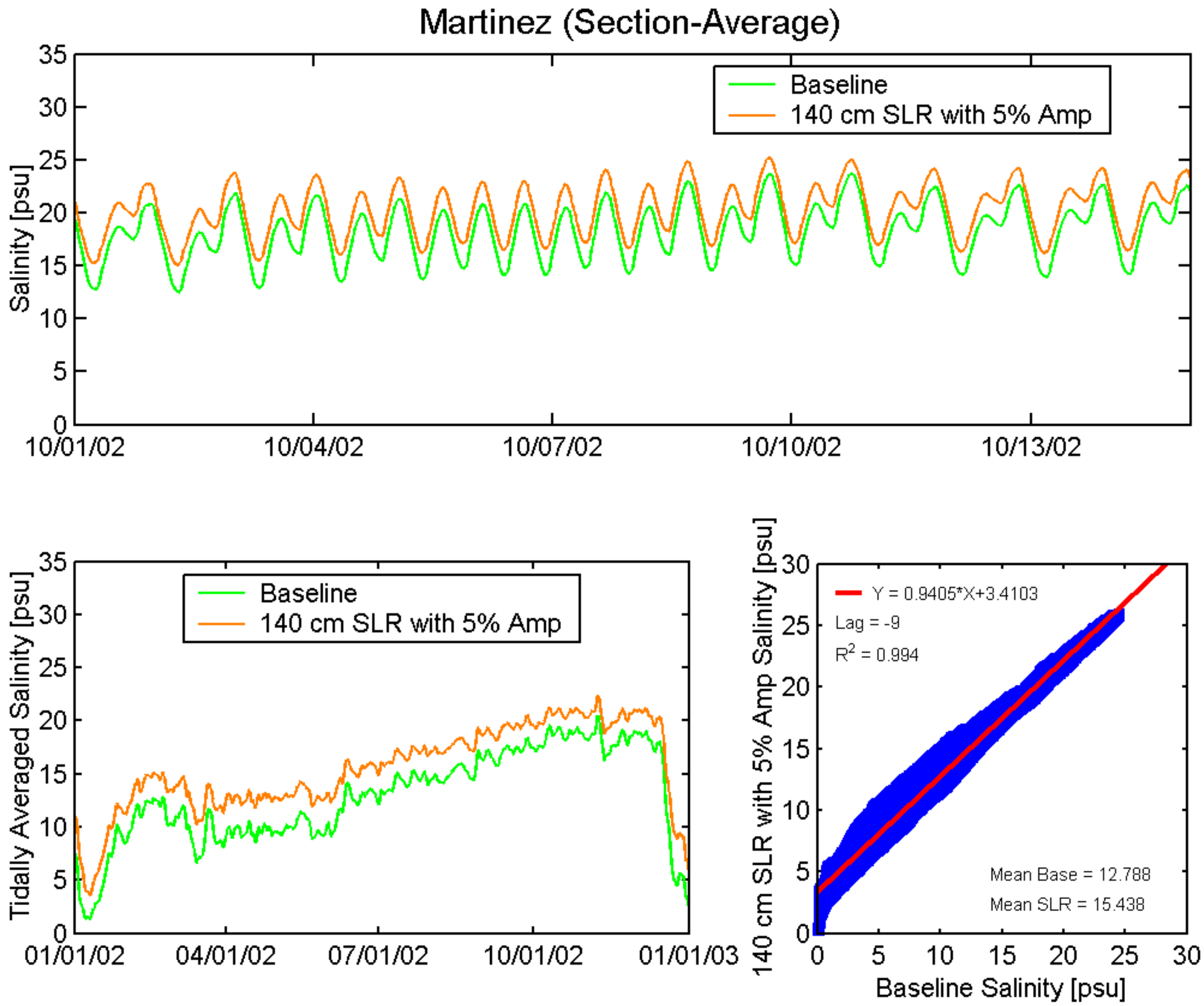


Figure 7.2-18 Predicted cross-section average salinity (top) and tidally averaged cross-section average salinity (lower left) at Martinez for Baseline and 140 cm of SLR with 5% Amplification scenarios. Regression (lower right) shows the best linear fit for the effect on cross-section average salinity at Martinez resulting from 140 cm of SLR with 5% Amplification at the Pacific Ocean boundary.

7.3 Summary of Stage and Salinity Relationships for SLR at Fort Point and Martinez

The linear relationships between stage and salinity for the Baseline scenario and each of the sea level rise scenarios at Fort Point and Martinez were developed to facilitate the development of appropriate sea level rise boundary conditions for models that use Martinez as the downstream boundary (such as DMS2 or the RMA2 Delta model) or the Golden Gate as the downstream boundary (such as the RMA2 San Francisco Bay model).

The stage relationships developed at Fort Point (Section 7.1.1) indicate that the sea level rise offset applied at the ocean boundary is translating almost exactly to a similar offset at Fort Point. This suggests that for a Golden Gate boundary a constant sea level rise offset is appropriate. The stage relationships developed at Martinez (Section 7.1.2) indicate that the predicted change in mean sea level at Martinez is slightly less than the offset applied at the ocean boundary. This difference increases with sea level rise. For the 60 cm and 140 cm SLR scenario, both phase and amplitude differences are evident in the stage correlations at Martinez, indicating the complexity of translating a sea level rise offset at the ocean boundary to Martinez when both changes to wave speed propagation with depth and changes to tidal prism in the Delta resulting from sea level rise are influencing stage at Martinez.

The salinity relationships developed at the Golden Gate (Section 7.2.1) show that a constant offset is not appropriate to account for the change in salinity at the Golden Gate as a result of sea level rise. The salinity relationships for 15 cm SLR and 30 cm SLR at Martinez have a slope of almost exactly 1.000 indicating that a constant salinity offset is appropriate at Martinez. however, for higher levels of sea level rise the slope of the best fit line is somewhat less than 1.000 indicating that a constant salinity offset is not appropriate at Martinez for higher levels of sea level rise.

Anderson and Miller (2005) used a similar approach to develop relationships to estimate electrical conductivity at Martinez for sea level rise conditions simulated using the RMA2 Bay-Delta model for 1 foot (30.48 cm) of SLR. The relationship they derived using the G-model for EC at Martinez for 1 foot of SLR is given by (Anderson and Miller, 2005)

$$[EC\ 1ft\ SLR] = 1.0022 \times [EC\ Baseline] + 840.87 \qquad (7\text{-}31)$$

The most similar relationship from this study is the relationship for surface salinity at Martinez for the 30 cm SLR scenario given by Equation 7-21 as

$$[Salinity\ 30\ cm\ SLR] = 0.9968 \times [Salinity\ Baseline] + 0.5853 \qquad (7\text{-}32)$$

The comparison between the difference of the annual mean and the offset from the best linear fit suggested that a constant salinity offset between 0.550 and 0.585 psu would fairly accurately represent the salinity increase at Martinez for the 30 cm SLR scenario. This corresponds approximately to an offset of between 1112.14 and 1180.53 [μmhos cm^{-1}]. When the Baseline salinity and the predicted salinity for the 30 cm SLR scenario were converted to EC and the cross-correlation was applied, the best fit relationship is given by

[EC 30 cm SLR] = 0.9924 x *[EC Baseline] + 1001.45* (7-33)

which suggests an offset of 1001.45 [µmhos cm-1]. While this type of comparison is somewhat problematic (as discussed below) due to the nonlinear relationship between EC and salinity, these comparisons show that the predicted EC increase at Martinez for 30 cm SLR is between 19% and 40% higher than the EC offset derived from the G-model for 30.48 cm (1 foot) of SLR.

The salinity relationships for the Golden Gate and Martinez were developed for salinity (psu). The salinity predicted by UnTRIM was converted to EC for some of the sea level rise scenarios and the same cross-correlation was applied (as in Equations 7-32 and 7-33). The resulting linear fit equations for EC were significantly different than the fit equations derived from converting the offset in Equations 7-13 through 7-30 from psu to EC, in part because the slope of the lines for the EC derived curves deviated from 1.000. Part of these differences arise because the relationship between salinity and EC is not linear, and also because EC is not a conservative quantity. As a result, the appropriate method to apply Equations 7-13 through 7-30 for EC boundary conditions would be to convert an EC boundary time series to salinity, apply the appropriate linear relationship to account for sea level rise on salinity, and then convert the resulting salinity back to EC to use for a boundary condition for a model simulating EC instead of salinity. However, as discussed in Section 3.4, there are significant disadvantages to simulating EC since EC is not a conservative quantity.

8. Analysis of Salt Flux Mechanisms

The salt flux analysis presented in this section quantitatively estimates the contributions of individual transport processes to predicted increased salt intrusion resulting from sea level rise. Distinguishing the relative contributions of individual processes responsible for salt intrusion will have several practical benefits. First, it will improve the conceptual model of how salinity is expected to change with different modifications to the Delta, including sea level rise. Second, this analysis may provide insight to the effectiveness of potential management actions to address salt intrusion. Third, this salt flux analysis will provide guidance to the representation of salt intrusion processes in one-dimensional and two-dimensional models for sea level rise scenarios.

As part of the Delta Risk Management Strategy (DRMS) project, the transport processes associated with salt flux were estimated for a Baseline scenario and 4 different sea level rise scenarios simulated with UnTRIM (Gross et al. 2007b). The goal of the study was to parameterize the effects of sea level rise on salt intrusion in a one-dimensional tidally averaged salinity model. The three-dimensional hydrodynamic model applied in the DRMS sea level rise analysis was the first generation of the UnTRIM Bay-Delta model (MacWilliams and Gross, 2007), which resolved only a limited portion of the Delta. The DRMS project scenarios used repeating tides and steady Delta outflow to simplify analysis and interpretation of results. The analysis was limited to a single period (e.g., single Delta outflow) for each SLR scenario. Another DRMS report documented a salt flux analysis for a large range of Delta outflow values to estimate dispersion coefficients as a function of Delta outflow (Gross et al., 2007a). The dispersion coefficients were found to vary strongly with Delta outflow. In particular, the gravitational circulation component increased strongly with increased Delta outflow.

The salt flux analysis presented here is distinct from the previous DRMS analysis and has several advantages. First of all, this analysis uses the UnTRIM Bay-Delta model that was applied to the BDCP scenarios, which uses an updated, more accurate computational method, a model domain covering all of San Francisco Bay and the entire Sacramento-San Joaquin Delta, and has been more thoroughly calibrated. Second, a more complex analysis is performed using real tides. In contrast, the DRMS study used idealized “average” tides that repeated the same pattern each day. Therefore, the salt flux analysis in the DRMS study assumed that the salt flux and dispersion associated with the idealized tides was similar to the average salt flux and dispersion over a spring-neap cycle. Third, more sea level rise scenarios are explored in this analysis. Fourth, the analysis discussed here is performed for two different periods for each scenario. Lastly, the salt flux analysis is discussed in a more accessible (less technical) manner in this report.

8.1 Overview of Dispersion Processes

Salinity in the San Francisco Estuary depends primarily on:

- freshwater input to the Delta;
- salinity in the coastal ocean and exchange between the ocean and the estuary;
- salt transport processes;
- pumping, consumptive use and operations in the Delta;

- salt input from agricultural drainage and other sources; and
- evaporation and precipitation.

Seasonal and yearly variations in salinity are driven primarily by variability in freshwater flow. Mixing of ocean water and salt into an estuary results “from a combination of small-scale turbulent diffusion and larger scale variation of … velocities” (Fischer et al. 1979) which are primarily forced by astronomical tides in the San Francisco Estuary (Walters et al. 1985). The combination of differential advection and turbulent mixing is referred to as dispersive transport. Dispersive transport in estuaries is a complex topic due to the large range of spatial and temporal scales associated with different physical processes.

One key transport process is gravitational circulation, also referred to as estuarine circulation. This process results from longitudinal density gradients and is a form of vertical exchange process. Gravitational circulation results in differential advection in which the more saline near-bed flow has a net landward (up-estuary) direction, while the near-surface flow has a net seaward (down-estuary) direction. Gravitational circulation can result in stratification and is strengthened by stratification, providing a form of positive feedback. Due to the increase in gravitational circulation with stratification, Monismith et al. (2002) predicted that dispersion from gravitational circulation can increase by several orders of magnitude from low Delta outflow to high Delta outflow. The salt flux analysis performed as part of the DRMS studies (Gross et al. 2007a) also showed this strong increase in gravitational circulation with increased Delta outflow. Another vertical exchange process is Strain Induced Periodic Stratification (SIPS), which results from ebb-flood asymmetries in velocity profiles (Simpson et al. 1990). These tidal-asymmetries are a result of different stratification and vertical shear during ebb and flood. Asymmetries occur because stratification decreases turbulent mixing leading to more vertical shear in velocity and stratification. Due to tidal straining, stratification is typically stronger on ebb tides than flood tides, and therefore the velocity profile is more strongly sheared during ebb tides. The effect of SIPS on salt transport is an exchange flow with net transport of salt landward near the bed and seaward near the surface, similar to the exchange flow associated with gravitational circulation. Stacey et al. (2001) found the SIPS process to be active in a Suisun Bay field study.

Another important dispersive transport process in the Estuary is tidal dispersion, including the processes of “tidal trapping” and “tidal pumping.” Tidal trapping is a term used by Fischer et al. (1979) to describe one simple process by which tidal dispersion can cause landward transport of salt. The classic case of tidal trapping occurs in an estuary with side embayments when some of the salt mass that enters the side embayments on the flood tide remains “trapped” in the subembayment for a large portion of the ebb tide. More generally, tidal dispersion occurs as a result of tidal flows over bathymetric features such as side embayments, junctions, mudflats and marshes. Tidal dispersion is typically significant when substantial variability in bathymetry and geometry is experienced over the distance of a tidal excursion.

8.2 Analysis of Dispersion Processes

The “salt balance” equation (Fischer et al. 1979) is a simplified but useful description of salt transport:

$$QS = -KA\frac{\partial S}{\partial x} \qquad (8\text{-}1)$$

where Q is the tidally averaged flow, S is tidally and cross-sectionally averaged salinity, K is the longitudinal dispersion coefficient, A is the cross-sectional area, and x is the longitudinal position. The salt balance equation applies to the longitudinal salinity distribution under tidally averaged steady state conditions. If these conditions are met, Equation 8-1 can be used to estimate dispersion coefficients.

Estimating the portion of the salt flux and dispersion coefficient associated with gravitational circulation and other individual processes requires detailed analysis of the simulation results. The salt flux associated with individual physical processes can be estimated at any cross-section by an analysis method described in Fischer et al. (1979). The longitudinal velocity (u) is decomposed into several components

$$u(x,y,z,t) = U_a(x) + U_c(x,t) + u_s(x,y,z) + u'(x,y,z,t) \qquad (8\text{-}2)$$

where x is the longitudinal position of a cross-section, y and z are the lateral and vertical distances within a cross-section, and t is time. The velocity components are the cross-sectional and tidally averaged velocity (U_a= Q/A), the deviation of the cross-sectional average from the cross-sectional and tidally averaged velocity (U_c), the deviation of the tidally averaged velocity from the cross-sectional and tidally averaged velocity (u_s) and the remaining variability (u’). The capital letters refer to depth-averaged quantities. The last two terms of Equation 8-2 are further decomposed into lateral and vertical variability

$$u_s(x, y, z) = U_t(x, y) + u_v(x, y, z) \qquad (8\text{-}3)$$

$$u'(x, y, z, t) = U'_t(x, y, t) + u'_v(x, y, z, t) \qquad (8\text{-}4)$$

The same decomposition approach is followed for salinity. The cross-sectional area is decomposed into a tidal cycle average and variation from this average,

$$A(x,t) = A_a(x) + A_c(x,t) \qquad (8\text{-}5)$$

The salt flux through a cross-section at any time is

$$Flux(x,t) = [u(x,y,z,t)\, s(x,y,z,t)]A(x,t) \qquad (8\text{-}6)$$

where A is the cross-sectional area and the square brackets represent a cross-sectional average. The average salt flux during a tidal cycle is determined by averaging over the tidal cycle:

$$Flux(x) = < Flux(x,t) > = < [u(x,y,z,t)\, s(x,y,z,t)]A(x,t) > \qquad (8\text{-}7)$$

where the angle brackets represent a tidal cycle average. This notation follows Fischer et al. (1979) closely except that the square brackets are used instead of an overbar to represent cross-sectional averages. The decomposed velocity, salinity and area are substituted into Equation 8-7 and the product expanded into individual terms. Many of the terms are zero or negligible (Dyer 1973). Retaining all terms that are expected to be significant in any part of the San Francisco Estuary yields

$$
\begin{aligned}
\text{Flux}(x) = {} & A_a\, U_a\, S_a + S_a < A_c\, U_c > + A_a < U_c\, S_c > + U_a < A_c\, S_c > + < A_c\, U_c S_c > \\
& + A_a\,[U_t\, S_t] + A_a\,[u_v\, u_v] + <[U'_t\, S'_t\,](A_a + A_c) > + <[u'_v\, s'_v\,](A_a + A_c) > \\
& + <[\, U_t\, S'_t\,](A_a + A_c) > + <[\, u_v\, s'_v\,](\, A_a + A_c) > \\
& + <[\, U'_t\, S_t](\, A_a + A_c) > + <[\, u'_v\, s_v](\, A_a + A_c) >
\end{aligned} \qquad (8\text{-}8)
$$

The sum of the first and second terms in this equation is advective transport associated with Delta outflow. All other terms are dispersive flux terms. The dispersive terms in this equation are associated with one or more physical processes. Some particularly important terms for the analysis of transport in the San Francisco Estuary are:

- $A_a\, U_a\, S_a + S_a < A_c\, U_c >$ – advective salt flux (QS in the salt balance equation)
- $A_a\,[u_v\, s_v]$ – steady vertical exchange, primarily associated with gravitational circulation
- $<[u'_v\, s'_v\,]\,(A_a + A_c) >$ – the primary term associated with unsteady vertical shear
- $A_a < U_c\, S_c >$ – the primary term associated with tidal dispersion

Both steady vertical exchange and unsteady vertical shear are vertical exchange processes related to stratification and velocity shear in the water column. The steady vertical exchange is primarily associated with gravitational circulation and therefore is referred to as the gravitational circulation term in this report and other estuarine literature. However, this term can also be substantially affected by wind which can also result in a persistent vertical exchange flow. The unsteady vertical shear term is primarily associated with Strain Induced Period Stratification (SIPS). The 11th and 13th terms in Equation 8-8, also represent vertical exchange processes, but are typically small in magnitude. The remaining terms are associated with tidal dispersion processes, such as “tidal trapping” and “tidal pumping” (Fischer et al., 1979). This grouping of salt flux terms and terminology is consistent with the analysis of fluxes at the Golden Gate by Fram et al. (2007) and somewhat simplified relative to the DRMS salt flux analysis (Gross et al. 2007b).

8.3 Analysis Locations and Periods

The cross-sections numbed 1 through 32 in Figure 8.3-1 are the locations at which salt fluxes and dispersion coefficients were estimated for each scenario. These locations were chosen to capture spatial variability in salt transport processes in the estuary.

Multiple criteria were used to select the salt intrusion flux analysis period. First, a period of relatively steady Delta outflow is preferred so that the flow value used in Equation 8-1 is not ambiguous. Second, the period should span at least one spring-neap cycle to cover a full range of tidal conditions. A 29 day analysis period was chosen to allow a full range of tidal conditions. This is the time period typically used by NOAA for analysis of tides. Third, a fairly good “flux balance” is desired, meaning that advective fluxes and dispersive fluxes should roughly balance during the simulation period.

The analysis periods chosen were July 15, 2002 through August 12, 2002 and October 13, 2002 through November 10, 2002. The analysis periods are identified as grey regions in Figure 8.3-2 which shows Sacramento River flow during 2002. Though the Sacramento River flow varies substantially between the two analysis periods, the average predicted flow past Chipps Island is similar. During the first analysis period the average predicted flow past Chipps Island is 170 $m^3 s^{-1}$ and during the second period the average predicted flow past Chipps Island is 167 $m^3 s^{-1}$ for the Baseline scenario. The predicted net flows were similar for the other scenarios. Because a fairly steady flow period is required for unambiguous estimates of dispersion coefficients, a high flow period could not be analyzed.

The observed water surface elevation through each 29 day simulation period is shown by the grey shaded regions in Figure 8.3-3. The 29 day period spans two spring-neap cycles and the first period exhibits more diurnal inequality (e.g. higher high water) on average than the second period.

As indicated by Figure 8.3-4 through Figure 8.3-17, the salinity conditions are somewhat different between the two analysis periods, with higher salinity in the October 13, 2002 through November 10, 2002 analysis period than the July 16, 2002 through August 12, 2002 analysis period. As discussed in Section 4, the predicted salinity increases with increased sea level rise.

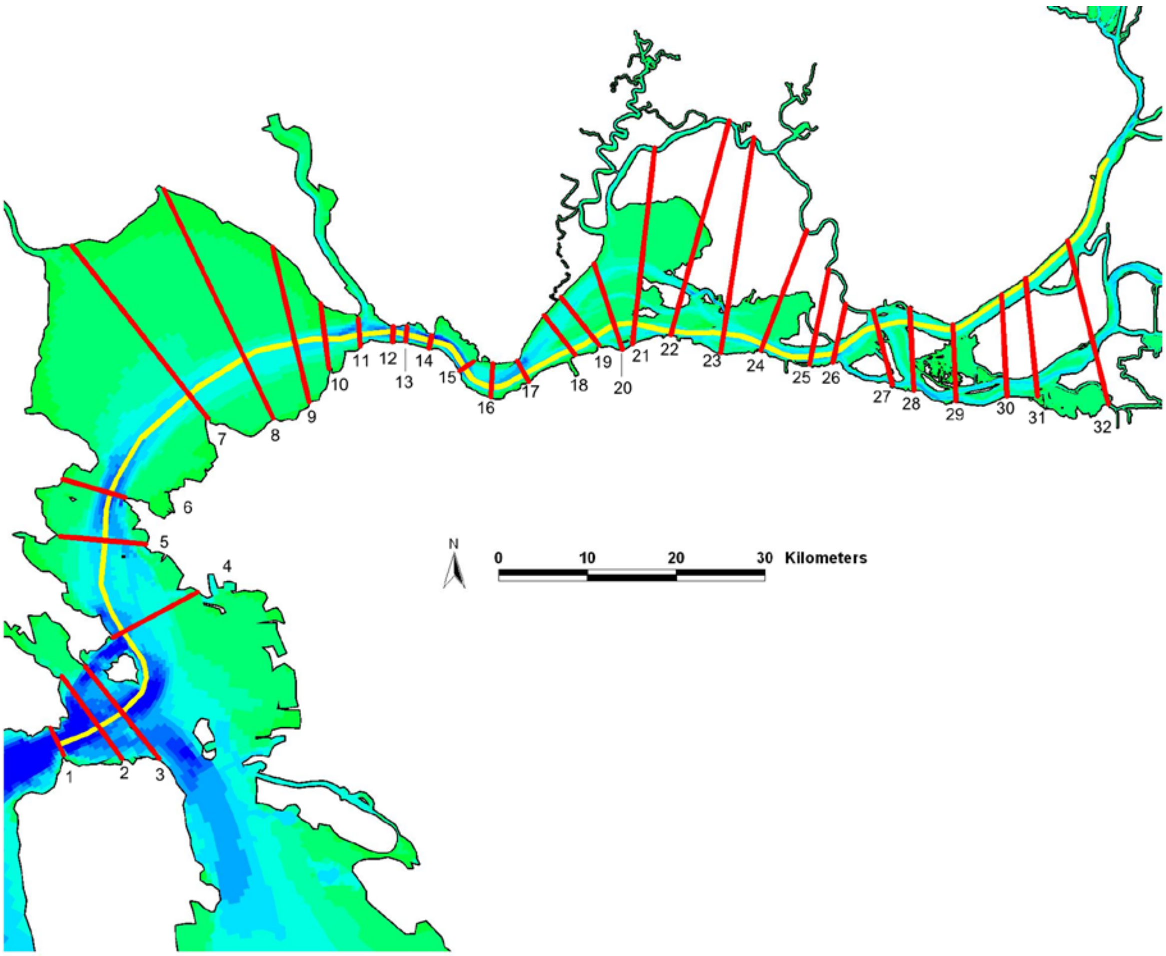


Figure 8.3-1 Locations of cross-sections and centerline transect for salt flux analysis.

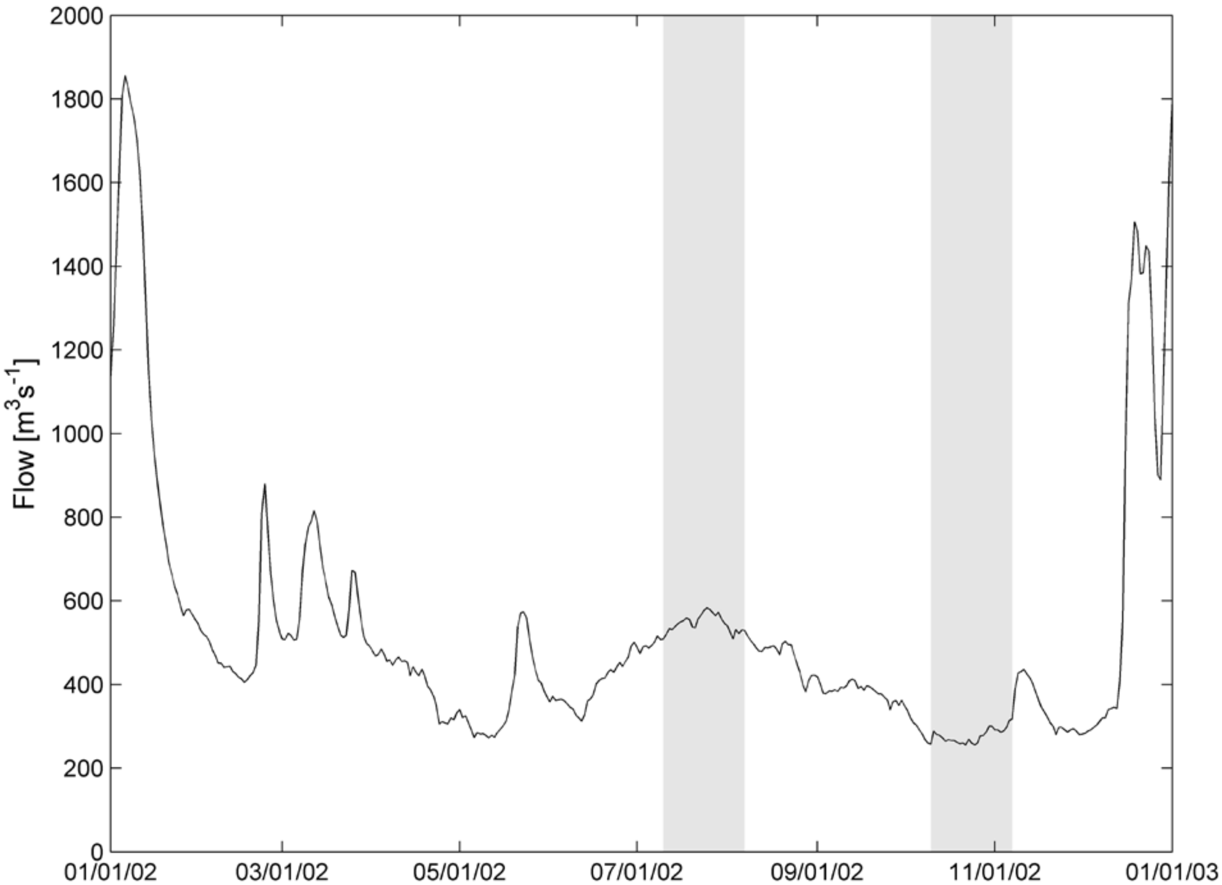


Figure 8.3-2 Observed Sacramento River flow at Freeport during 2002 with salt flux analysis periods identified with grey shading.

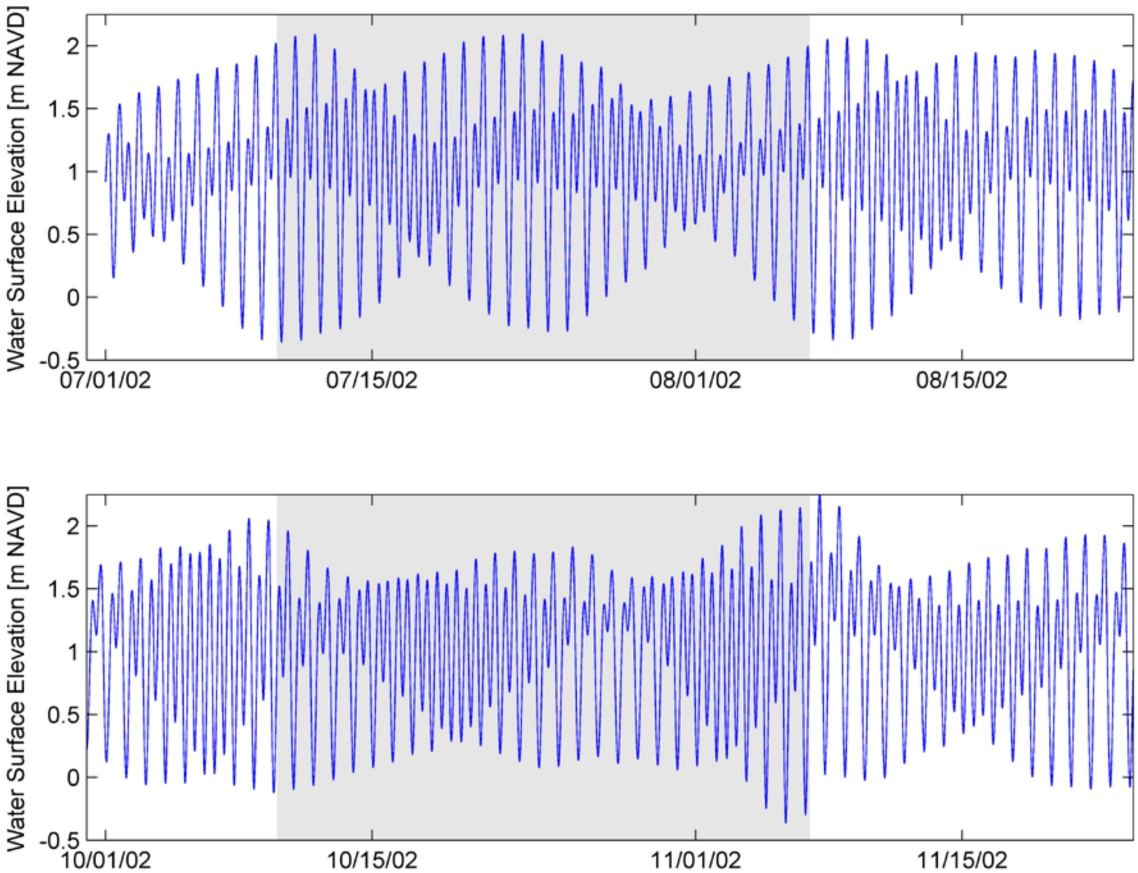


Figure 8.3-3 Observed water surface elevation at the San Francisco Fort Point NOAA station (9414290) during and surrounding the salt flux analysis periods, indicated with grey shading.

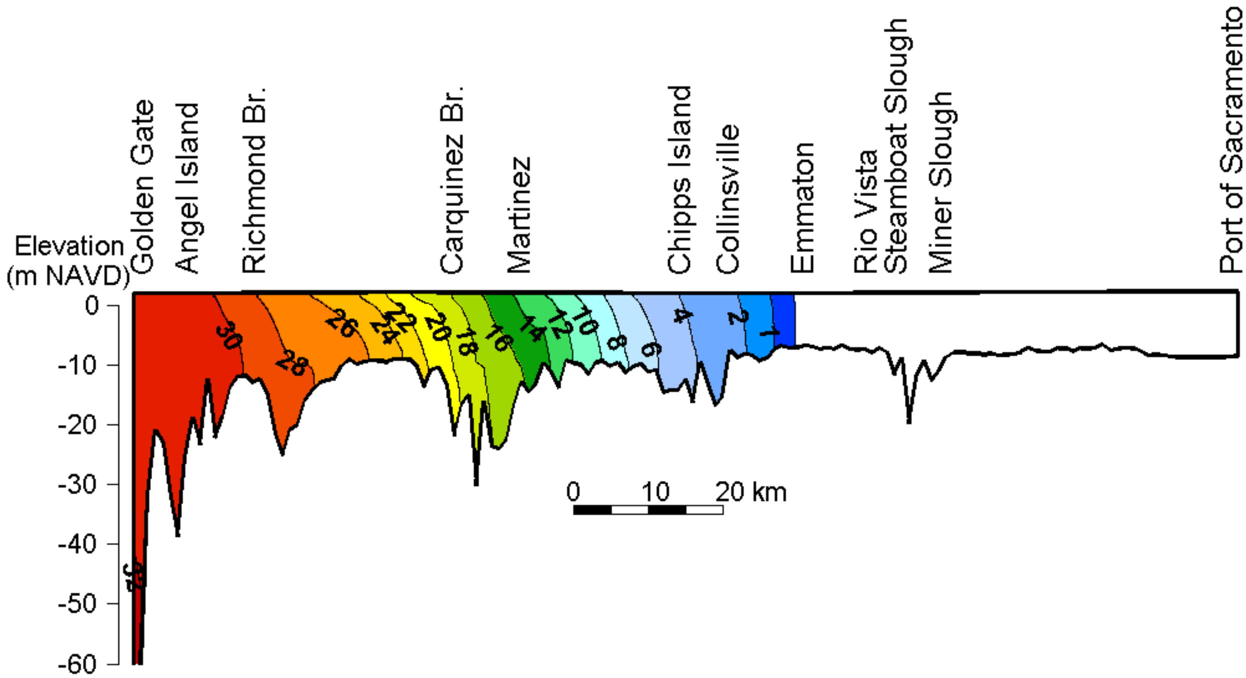


Figure 8.3-4 Period averaged salinity along the centerline transect from the Golden Gate to the Port of Sacramento for the Baseline scenario during the July 15, 2002 through August 12, 2002 analysis period.

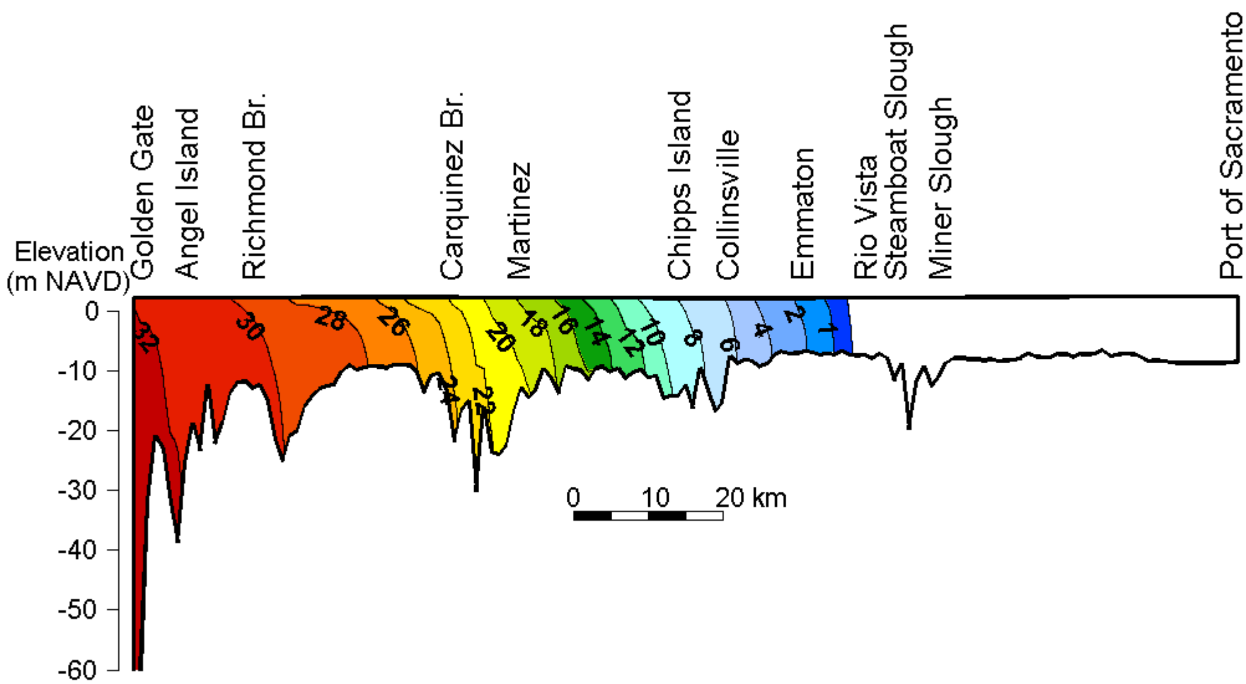


Figure 8.3-5 Period averaged salinity along the centerline transect from the Golden Gate to the Port of Sacramento for the Baseline scenario during the October 13, 2002 through November 10, 2002 analysis period.

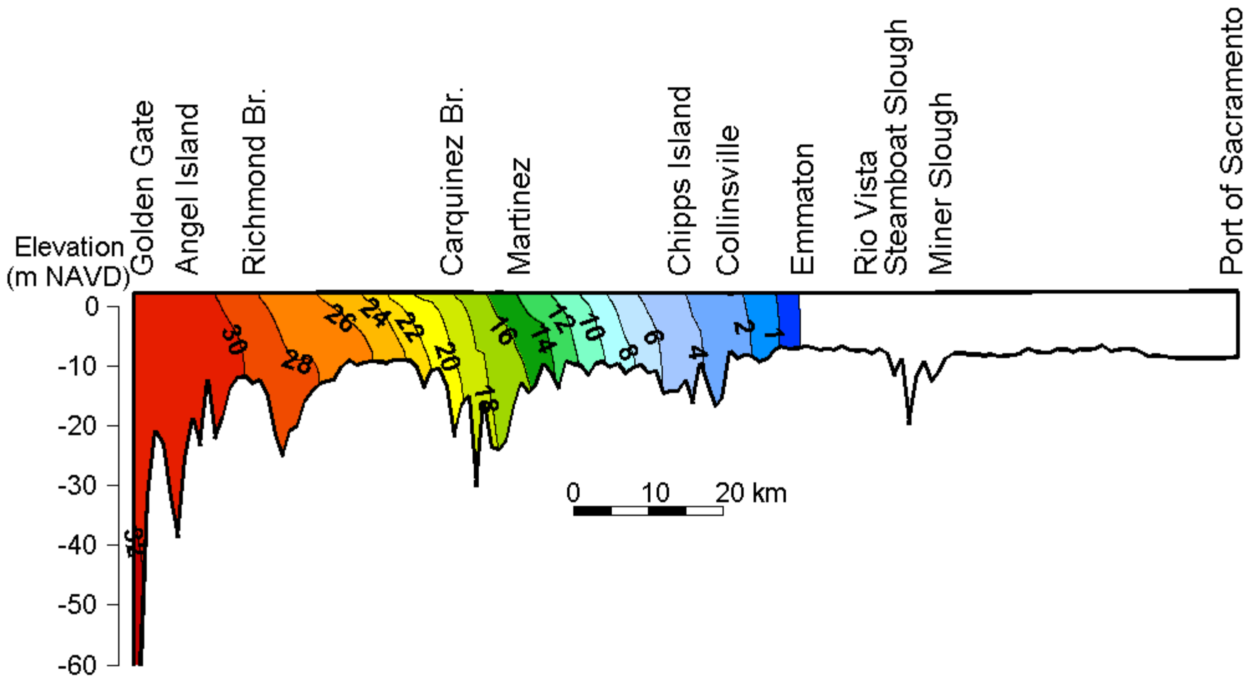


Figure 8.3-6 Period averaged salinity along the centerline transect from the Golden Gate to the Port of Sacramento for the 15 cm SLR scenario during the July 15, 2002 through August 12, 2002 analysis period.

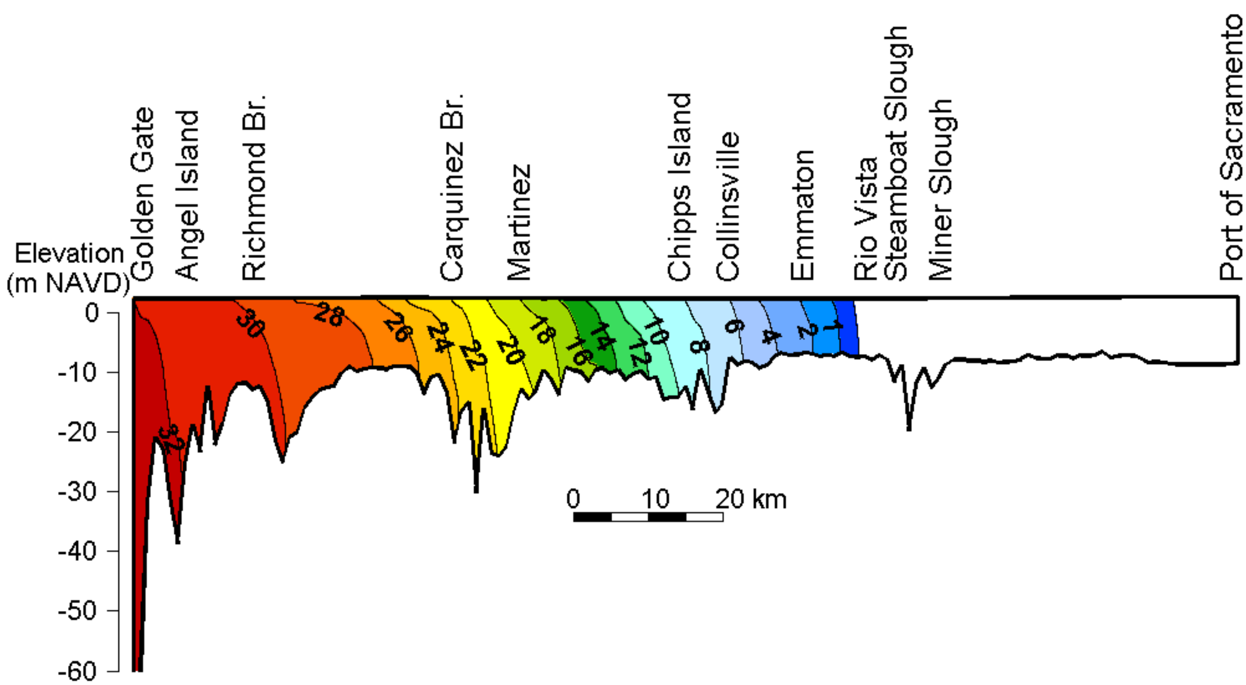


Figure 8.3-7 Period averaged salinity along the centerline transect from the Golden Gate to the Port of Sacramento for the 15 cm SLR scenario during the October 13, 2002 through November 10, 2002 analysis period.

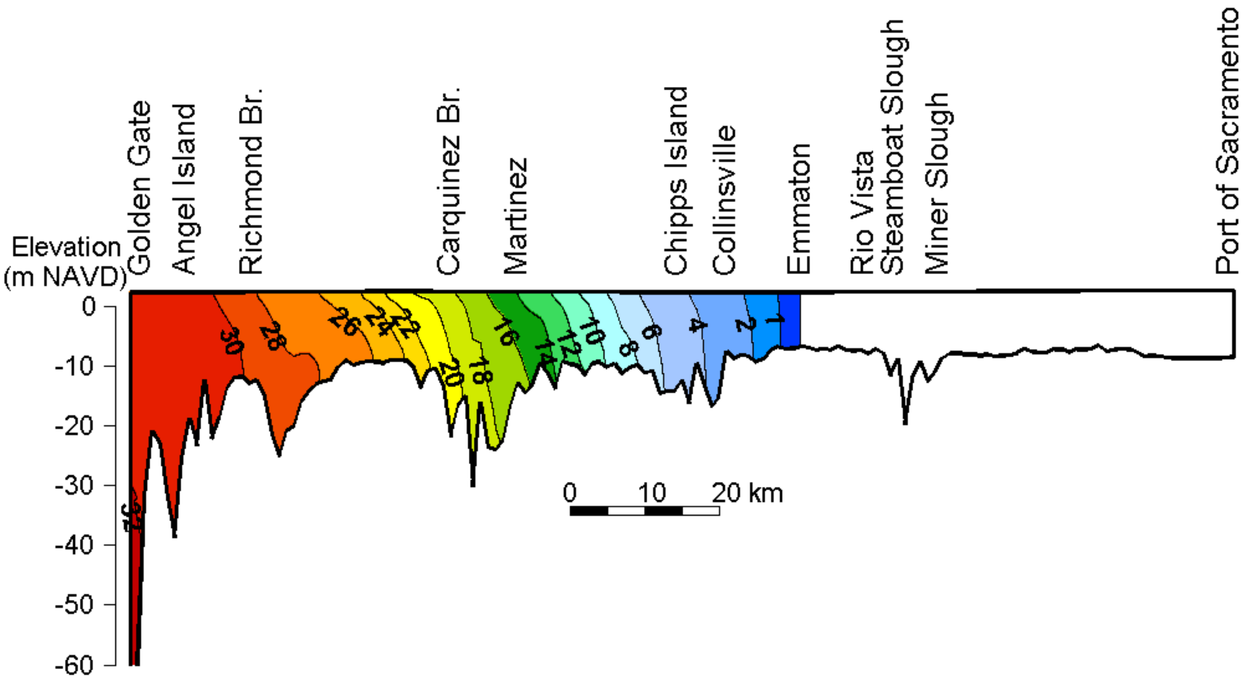


Figure 8.3-8 Period averaged salinity along the centerline transect from the Golden Gate to the Port of Sacramento for the 30 cm SLR scenario during the July 15, 2002 through August 12, 2002 analysis period.

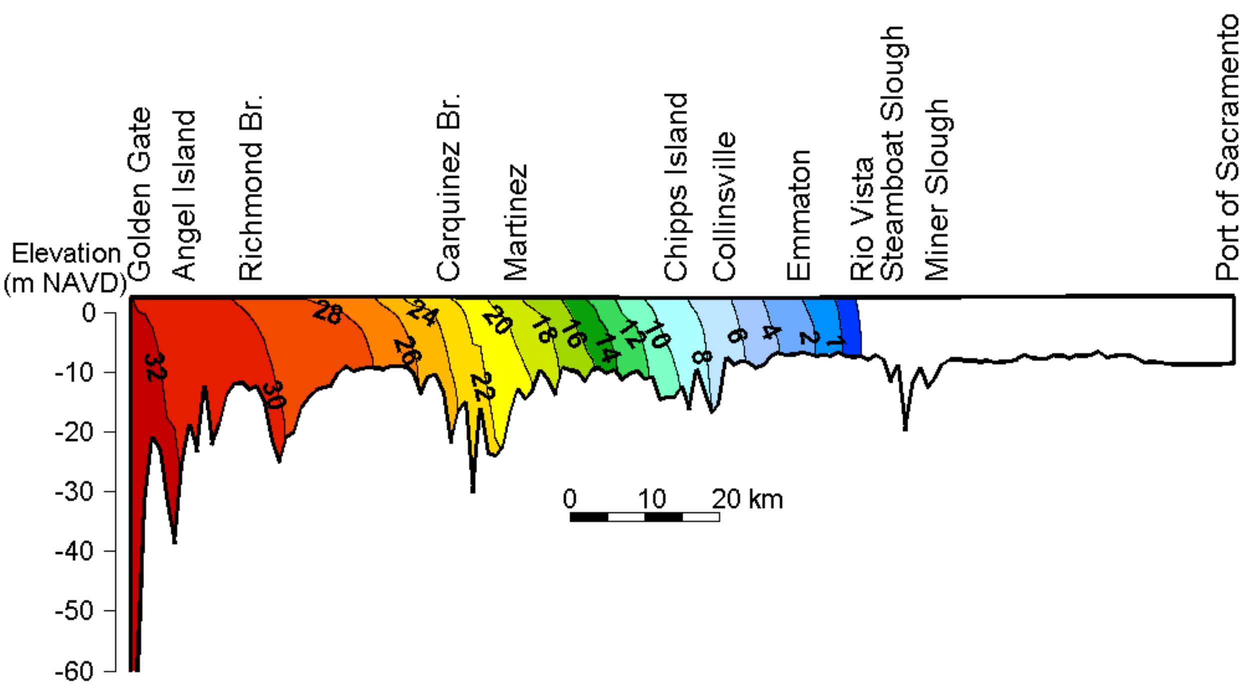


Figure 8.3-9 Period averaged salinity along the centerline transect from the Golden Gate to the Port of Sacramento for the 30 cm SLR scenario during the October 13, 2002 through November 10, 2002 analysis period.

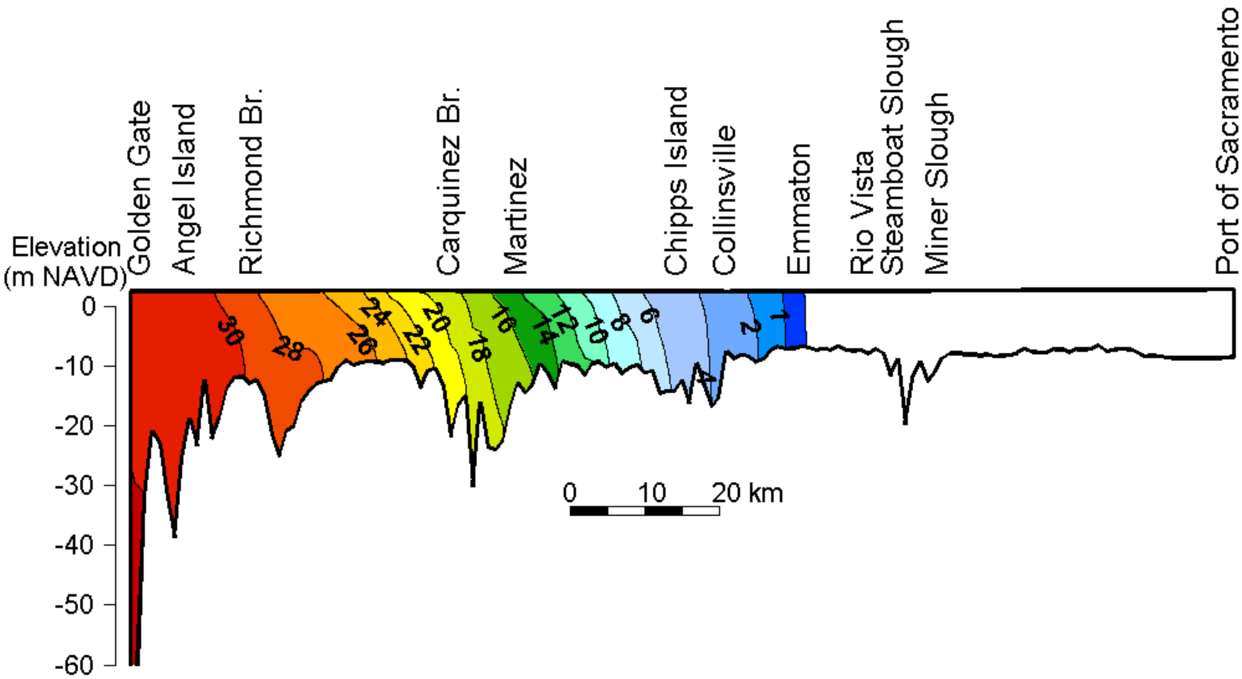


Figure 8.3-10 Period averaged salinity along the centerline transect from the Golden Gate to the Port of Sacramento for the 45 cm SLR scenario during the July 15, 2002 through August 12, 2002 analysis period.

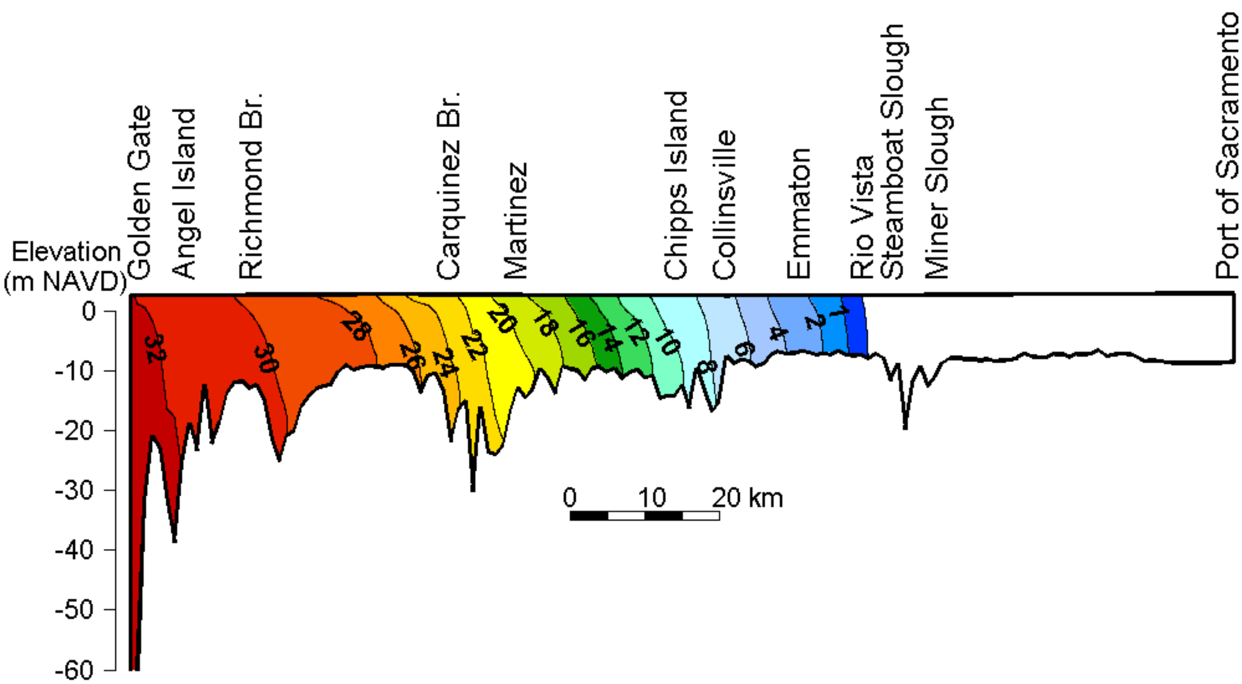


Figure 8.3-11 Period averaged salinity along the centerline transect from the Golden Gate to the Port of Sacramento for the 45 cm SLR scenario during the October 13, 2002 through November 10, 2002 analysis period.

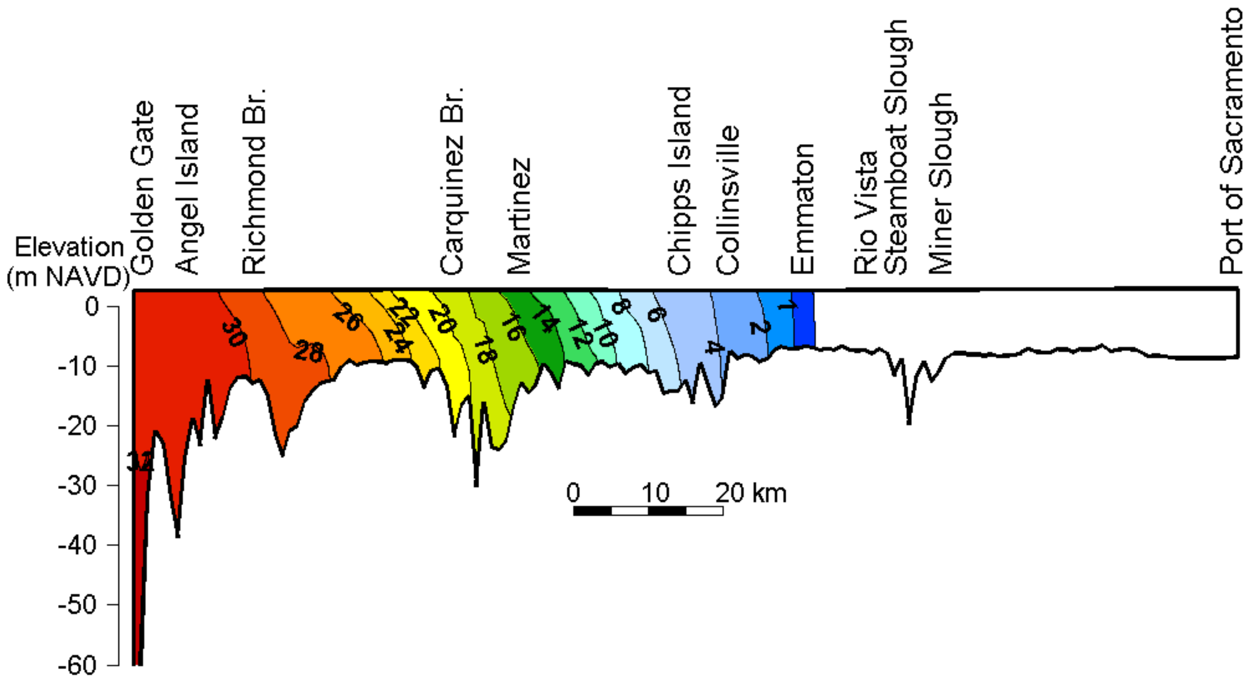


Figure 8.3-12 Period averaged salinity along the centerline transect from the Golden Gate to the Port of Sacramento for the 60 cm SLR scenario during the July 15, 2002 through August 12, 2002 analysis period.

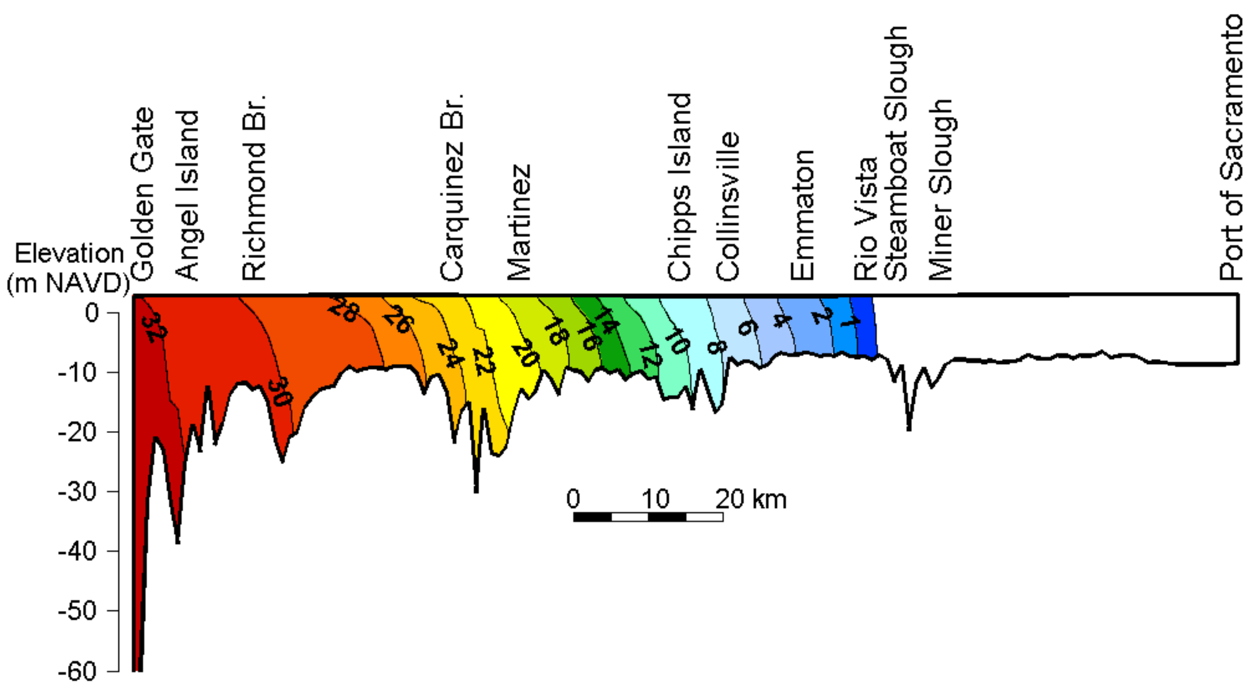


Figure 8.3-13 Period averaged salinity along the centerline transect from the Golden Gate to the Port of Sacramento for the 60 cm SLR scenario during the October 13, 2002 through November 10, 2002 analysis period.

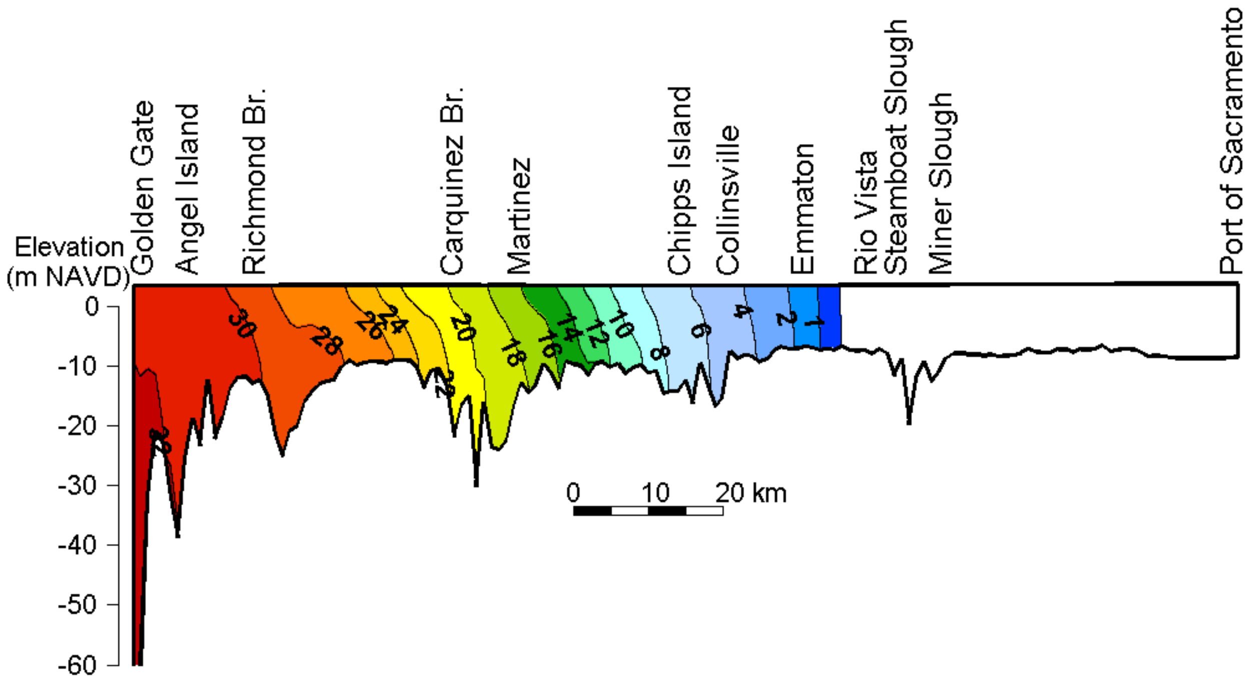


Figure 8.3-14 Period averaged salinity along the centerline transect from the Golden Gate to the Port of Sacramento for the 140 cm SLR scenario during the July 15, 2002 through August 12, 2002 analysis period.

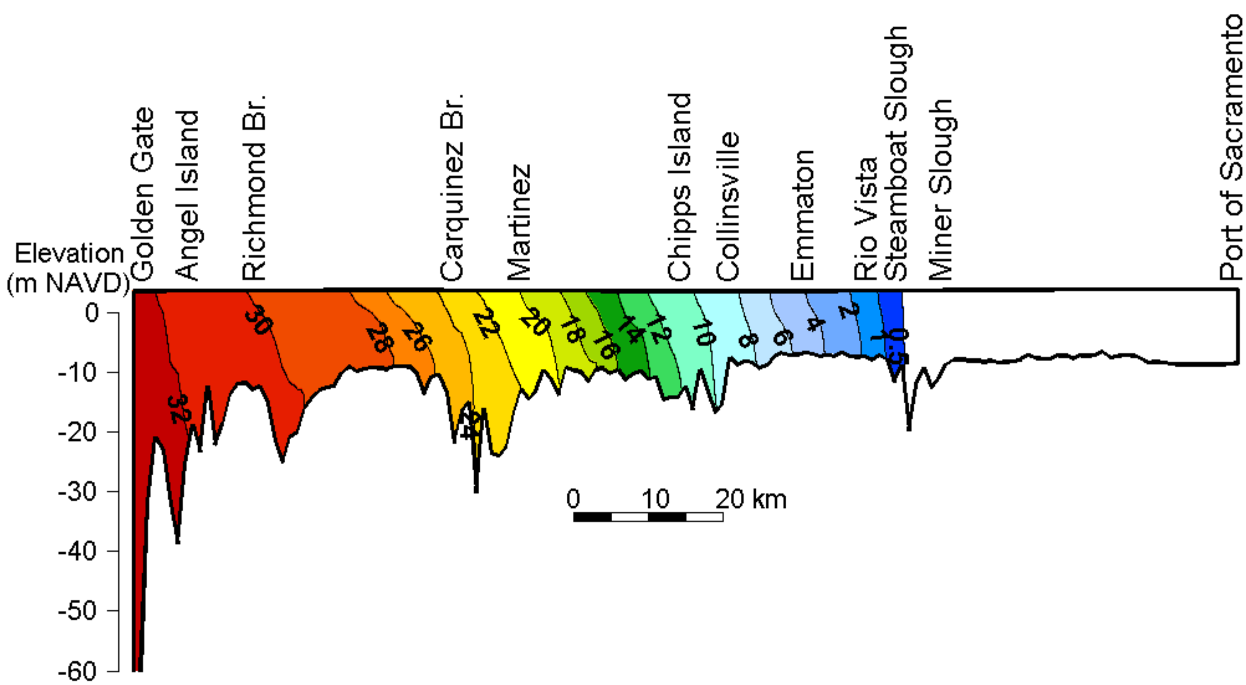


Figure 8.3-15 Period averaged salinity along the centerline transect from the Golden Gate to the Port of Sacramento for the 140 cm SLR scenario during the October 13, 2002 through November 10, 2002 analysis period.

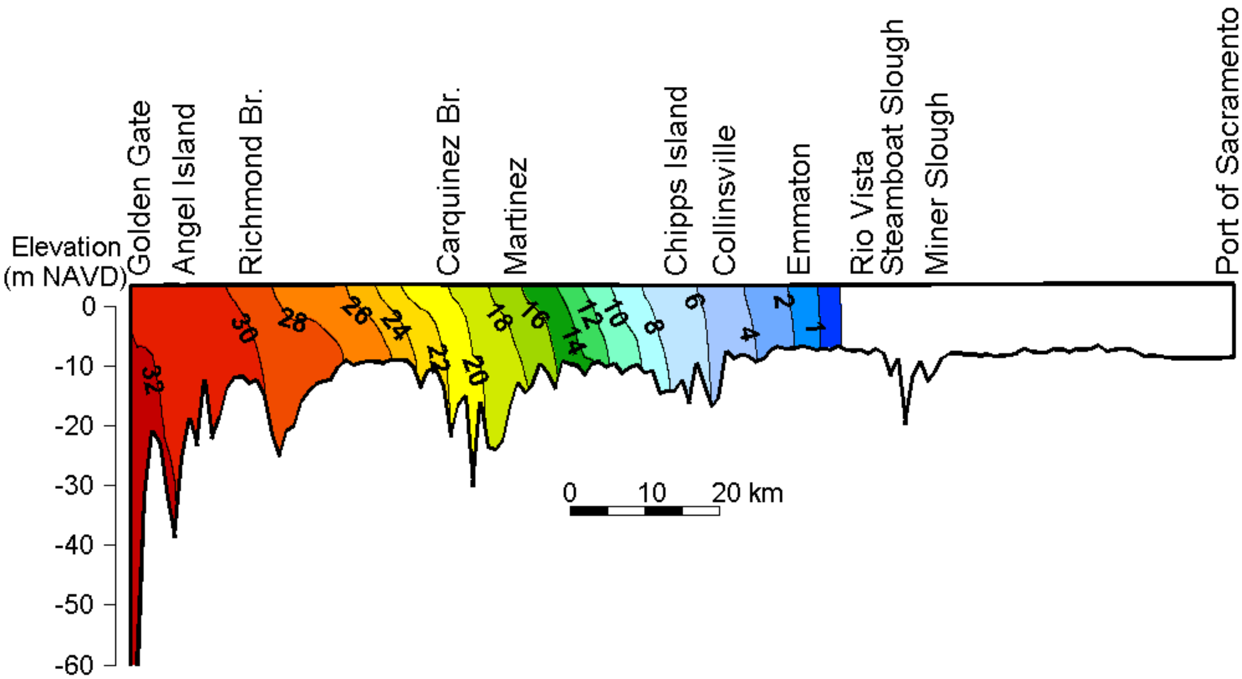


Figure 8.3-16 Period averaged salinity along the centerline transect from the Golden Gate to the Port of Sacramento for the 140 cm SLR with 5% Amplification scenario during the July 15, 2002 through August 12, 2002 analysis period.

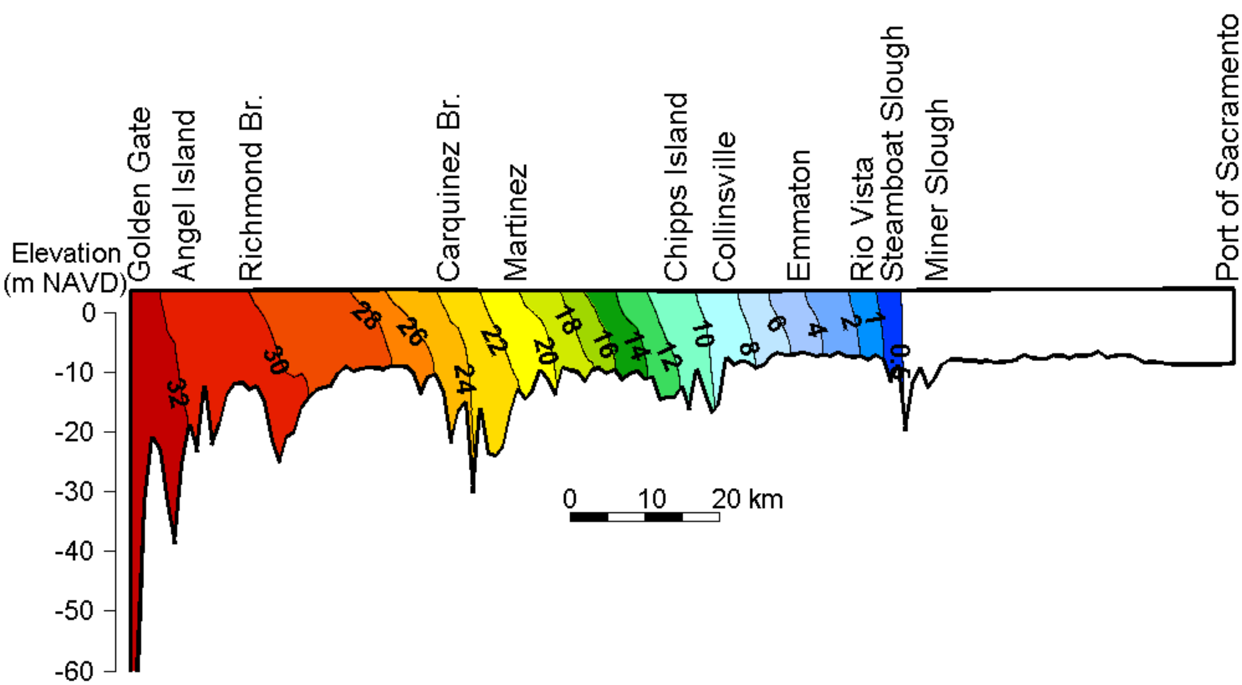


Figure 8.3-17 Period averaged salinity along the centerline transect from the Golden Gate to the Port of Sacramento for the 140 cm SLR with 5% Amplification scenario during the October 13, 2002 through November 10, 2002 analysis period.

8.4 Sea Level Rise Scenario Salt Flux Analysis Results

As discussed in Section 8.3, analysis periods were chosen in part as periods in which advective and dispersive fluxes balance closely. In other words, they are periods of moderate variability in salinity conditions. The total dispersive, advective and net fluxes during each period are shown for both analysis periods of each SLR scenario in Figure 8.4-1 through Figure 8.4-12. The distance shown on the x-axis corresponds to the distances labeled on the Golden Gate to Rio Vista transect in Figure 5.1-2. For each scenario and analysis period, the advective and dispersive fluxes were bigger than the net fluxes at all cross-sections, indicating limited net change in salt mass in the estuary during the analysis period. The net fluxes, indicated with a black x, are generally quite close to the sum of the advective and dispersive fluxes, indicated with a green +. Differences between net fluxes and the sum of the advective and dispersive fluxes are associated with flux terms that are neglected in the flux analysis and other sources of inaccuracies in the analysis but are typically very small.

In Figure 8.4-13 through Figure 8.4-20 the average tidal prism predicted during each analysis period is provided for several cross-sections. The tidal prism increases substantially at all locations with increased sea level rise, with the largest proportional increases with SLR at Chipps Island (cross-section 25). The increase in tidal prism with SLR is likely to explain several trends in the salt flux analysis. It should be noted that the SLR scenarios assume “hard shorelines.” As a result of this assumption, the tidal prism is likely to increase more substantially with sea level rise than predicted in this analysis due to inundation of low elevation regions bordering the estuary.

In order to calculate dispersion coefficient using Equation 8-1, the variables Q, S and A are averaged through the analysis period at the individual cross-sections. Salinity is also period averaged along the centerline transect shown in Figure 8.3-1, and is shown for each SLR scenario and analysis period in Figure 8.3-4 through Figure 8.3-15. In order to calculate the longitudinal salinity gradient (dS/dx) at each cross section, the period averaged salinity along the centerline transect is depth-averaged for each scenario to calculate the predicted depth-averaged and period averaged salinity along the centerline of the estuary from the Golden Gate to Rio Vista. The longitudinal salinity gradient at each point is determined by a linear fit of the variability of depth-averaged salinity with distance along the centerline. The longitudinal salinity gradients along the centerline of the estuary are shown in Figure 8.4-21 and Figure 8.4-22.

Salt fluxes and dispersion coefficients were calculated for each cross-section shown in Figure 8.3-1 for the Baseline scenario and for each SLR scenario. Increases in salt fluxes and dispersion coefficients with SLR indicate that increased Delta inflows will be required to meet salinity standards as a result of SLR. The estimated dispersion coefficients (K) are shown in Figure 8.4-23 for the July 15, 2002 through August 12, 2002 analysis period and in Figure 8.4-24 for the October 13, 2002 through November 10, 2002 analysis period. The dispersion coefficients for the two periods show similar trends, but the dispersion coefficients for the October 13, 2002 through November 10, 2002 analysis period are higher in Suisun Bay and the western Delta than the respective dispersion coefficients for the July 15, 2002 through August 12, 2002 analysis period. The calculated dispersion coefficients have limited variability with SLR at most cross-sections in Central Bay and San Pablo Bay. However, dispersion coefficients in Suisun Bay and the western Delta generally increase substantially with SLR, with more pronounced increases with SLR for the October 13, 2002 through November 10, 2002 analysis period.

The salt flux analysis described in Section 8.2 was used to divide each dispersion coefficient into three components: K_{gc}, $K_{uvs,}$ and K_{td}. K_{gc} represents the strength of gravitational circulation, K_{uvs} represents the strength of all unsteady vertical shear dispersion processes, and K_{td} represents the strength of all tidal dispersion processes. The mixing associated with gravitational circulation and unsteady vertical shear processes are not represented by depth-averaged models. In addition the mixing caused by tidal dispersion processes can be estimated to be quite different among models, particularly between depth-averaged and three-dimensional models.

The estimated dispersion coefficients associated with gravitational circulation (K_{gc}) are shown in Figure 8.4-25 for the July 15, 2002 through August 12, 2002 analysis period and in Figure 8.4-26 for the October 13, 2002 through November 10, 2002 analysis period. Note that this dispersion coefficient component is more variable with location than the overall dispersion coefficient. The dispersion coefficients associated with gravitational circulation drop substantially in Suisun Bay, relative to San Pablo Bay, starting at 55 km from the Golden Gate, near Benicia. These results are consistent with the findings of Burau et al. (1998) in the Entrapment Zone Study. The interpretation in that study is that the reduced depth at the Benicia Shoal reduced the strength of gravitational circulation. The dispersion coefficient components associated with gravitational circulation generally increase strongly with SLR in Suisun Bay and the western Delta, with more pronounced increases with SLR for the October 13, 2002 through November 10, 2002 analysis period than for the July 15, 2002 through August 12, 2002 analysis period. This is consistent with the higher salinity conditions in the October 13, 2002 through November 10, 2002 analysis period than the July 15, 2002 through August 12, 2002 analysis period.

The dispersion coefficients associated with unsteady vertical shear (K_{uvs}) are shown in Figure 8.4-27 for the July 15, 2002 through August 12, 2002 analysis period and in Figure 8.4-28 for the October 13, 2002 through November 10, 2002 analysis period. The unsteady vertical shear component is highly variable but often of similar magnitude as the gravitational circulation component. Some of the dispersion associated with unsteady vertical shear is associated with the SIPS mechanism which is known to be active in portions of Suisun Bay (Stacey et al. 2001). The dispersion associated with unsteady vertical shear varies with sea level rise in Carquinez Strait, Suisun Bay and the western Delta. However, the trend of change in this component with sea level rise varies from cross-section to cross-section. Dispersion coefficient components of less than 1 m^2 s^{-1} are off the y-axis scale and do not appear on the figure.

The dispersion coefficients associated with all tidal dispersion processes (K_{td}) are shown in Figure 8.4-29 for the July 15, 2002 through August 12, 2002 analysis period and in Figure 8.4-30 for the October 13, 2002 through November 10, 2002 analysis period. K_{td} is similar between the two analysis periods and varies over slightly more than one order of magnitude spatially. Since this component of the dispersion coefficient is not expected to have strong variation with stratification, the less pronounced spatial variability was expected. The dispersion coefficient component associated with tidal dispersion generally increases with increased SLR in Carquinez Strait, Suisun Bay and the western Delta. This increase is probably related to the increased tidal prism shown in Figure 8.4-13 through Figure 8.4-20.

In the following sections, the dispersion analysis results in each sub-embayment will be presented.

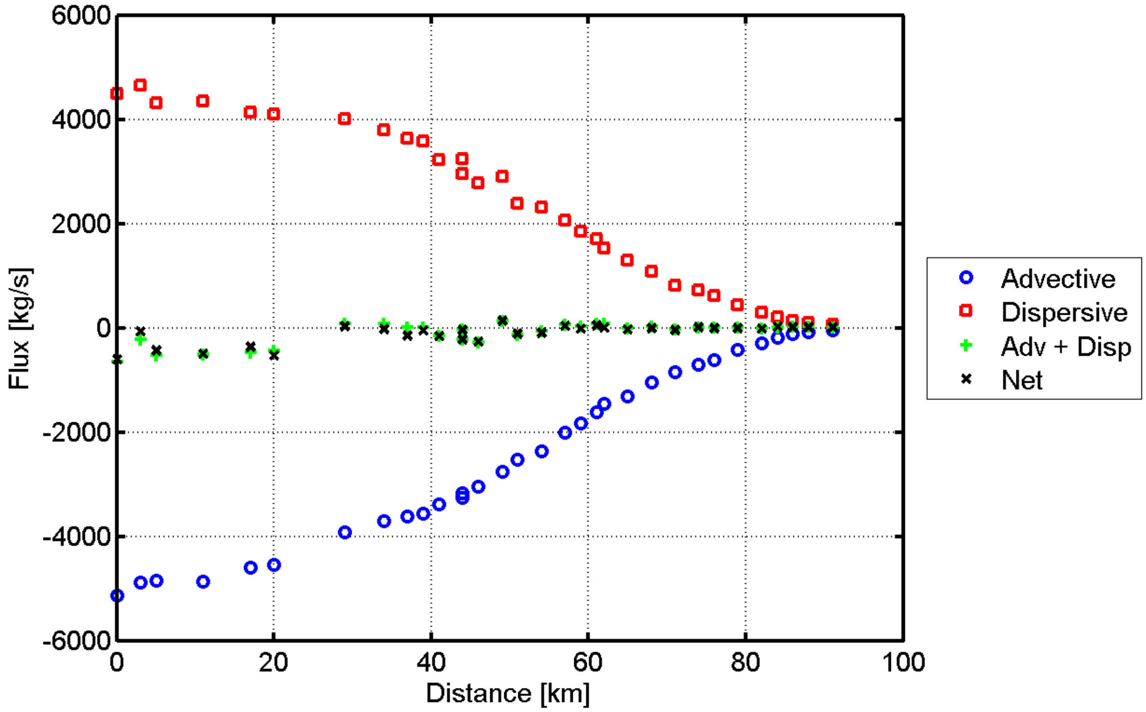


Figure 8.4-1 Predicted advective, dispersive and net salt fluxes for the Baseline scenario during the July 15, 2002 through August 12, 2002 analysis period.

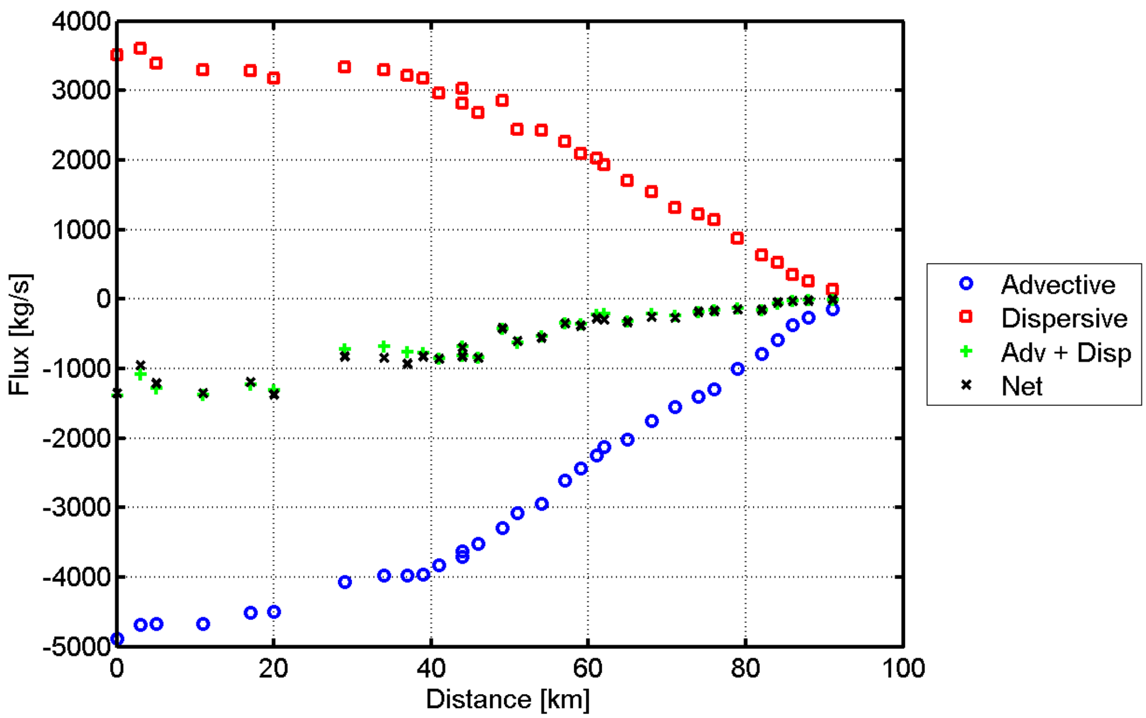


Figure 8.4-2 Predicted advective, dispersive and net salt fluxes for the Baseline scenario during the October 13, 2002 through November 10, 2002 analysis period.

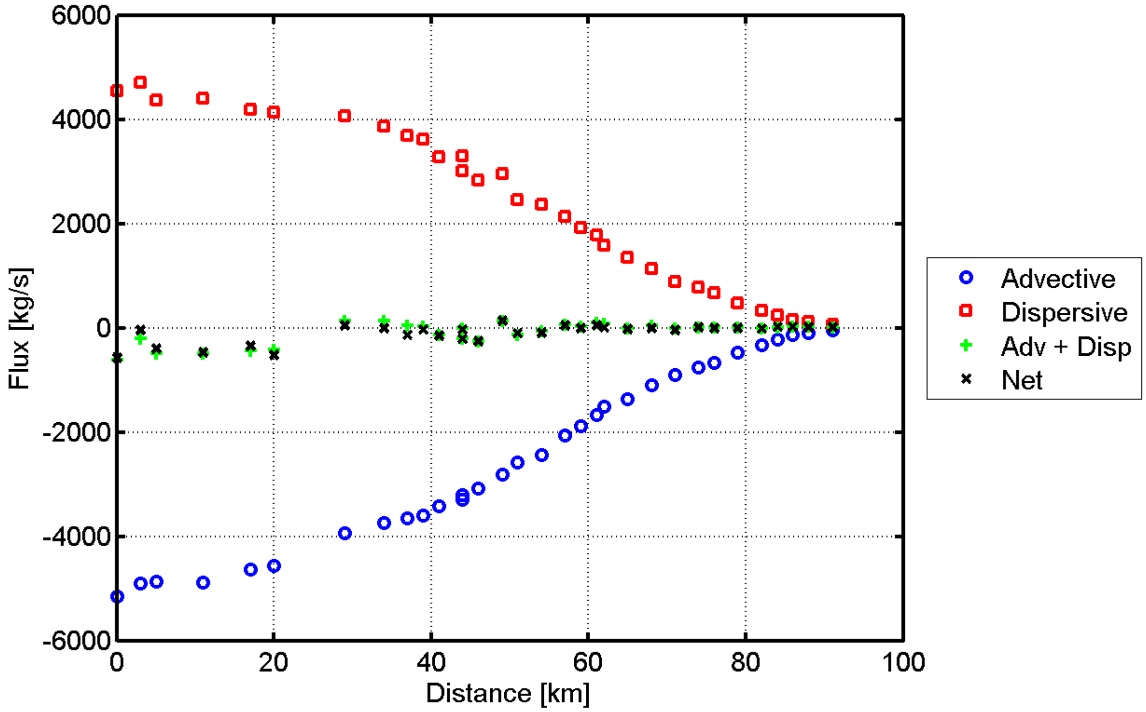


Figure 8.4-3 Predicted advective, dispersive and net salt fluxes for the 15 cm SLR scenario during the July 15, 2002 through August 12, 2002 analysis period.

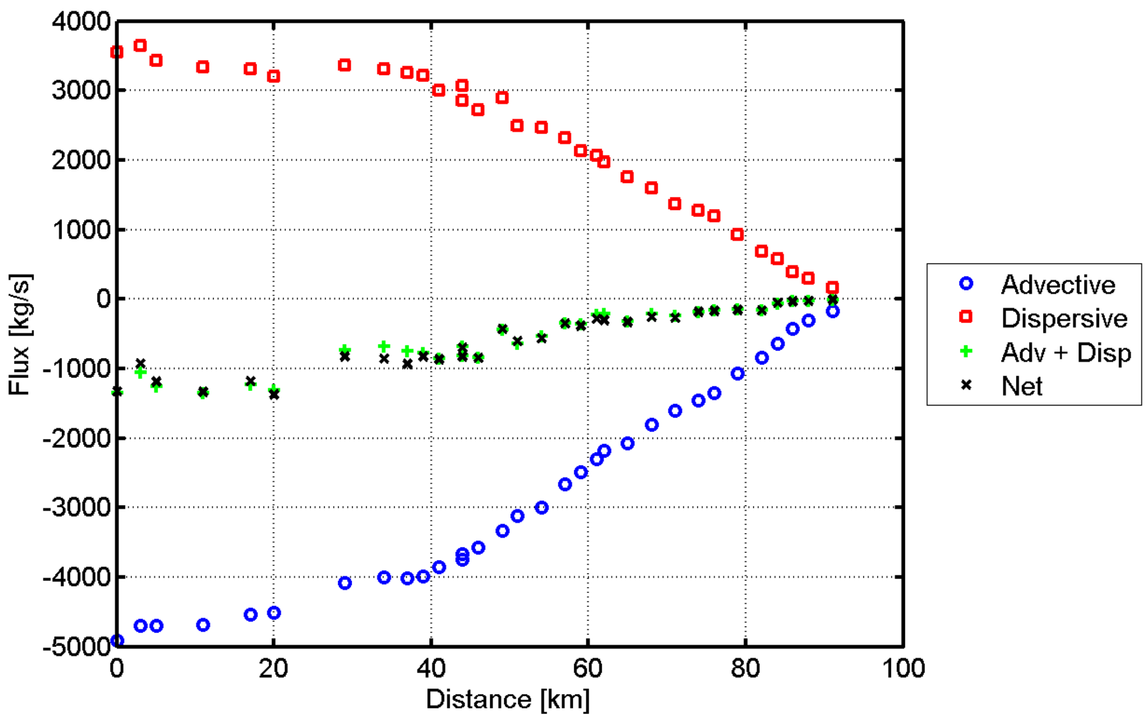


Figure 8.4-4 Predicted advective, dispersive and net salt fluxes for the 15 cm SLR scenario during the October 13, 2002 through November 10, 2002 analysis period.

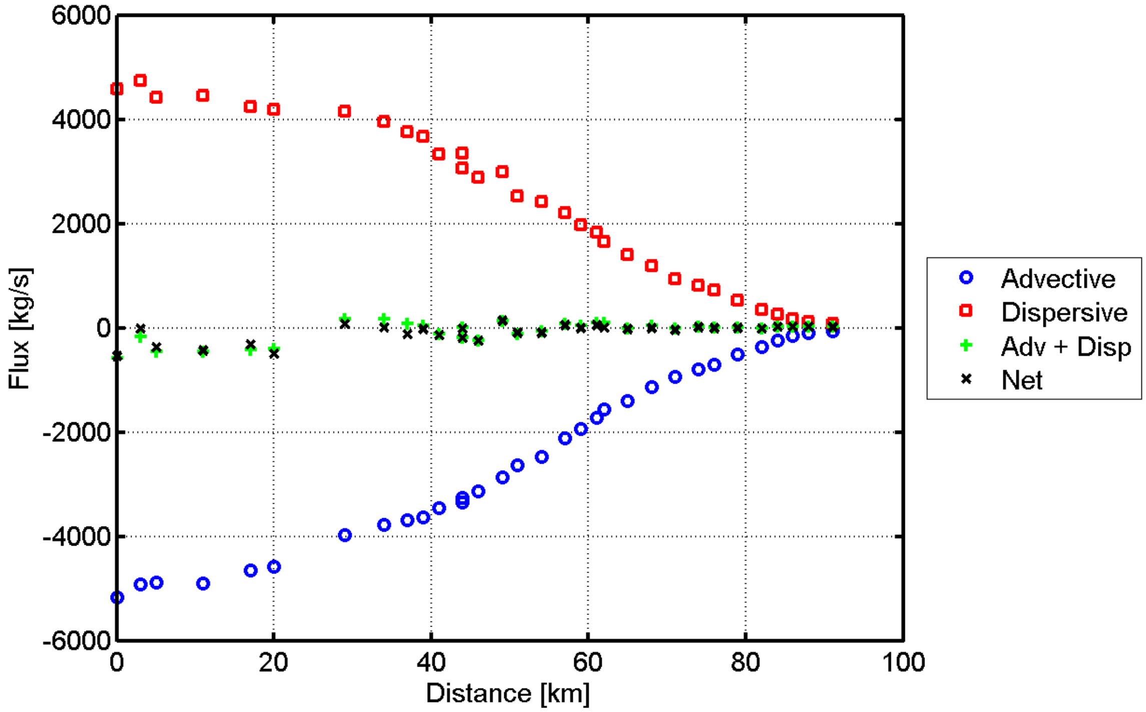


Figure 8.4-5 Predicted advective, dispersive and net salt fluxes for the 30 cm SLR scenario during the July 15, 2002 through August 12, 2002 analysis period.

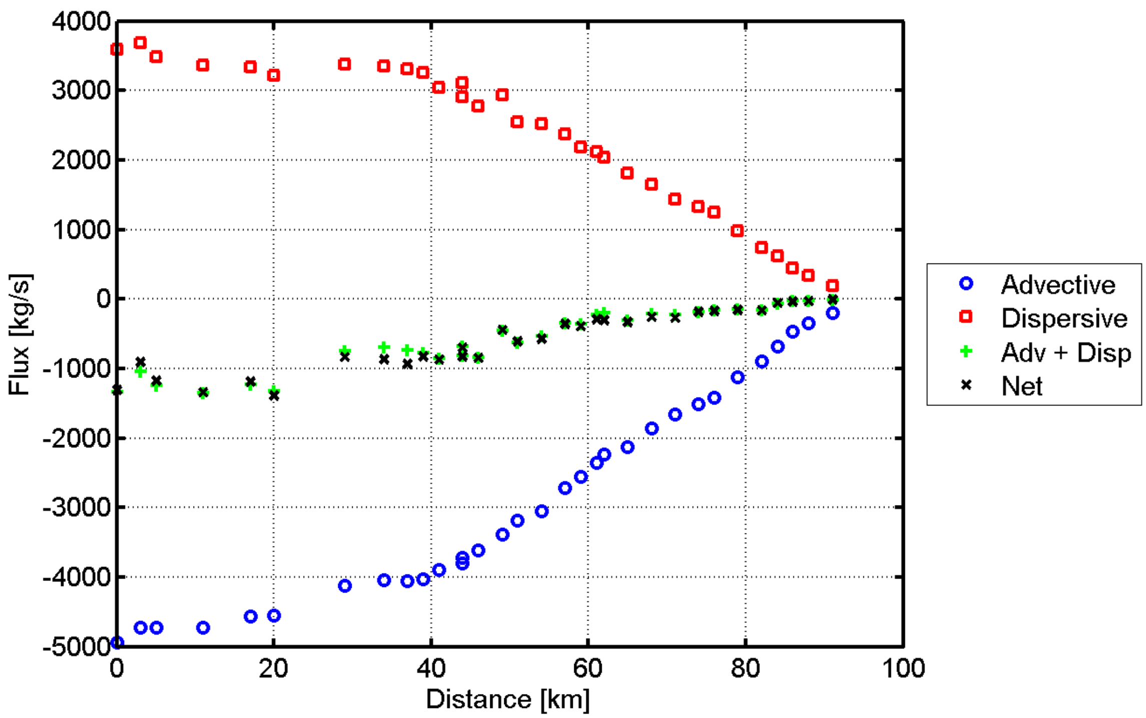


Figure 8.4-6 Predicted advective, dispersive and net salt fluxes for the 30 cm SLR scenario during the October 13, 2002 through November 10, 2002 analysis period.

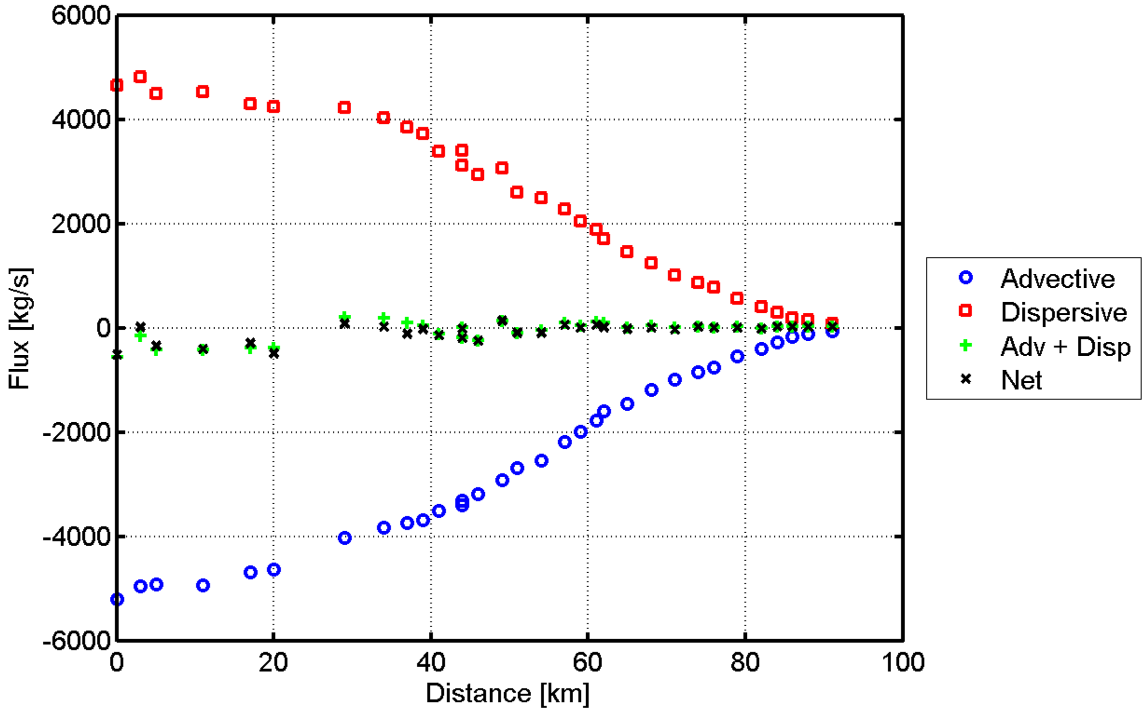


Figure 8.4-7 Predicted advective, dispersive and net salt fluxes for the 45 cm SLR scenario during the July 15, 2002 through August 12, 2002 analysis period.

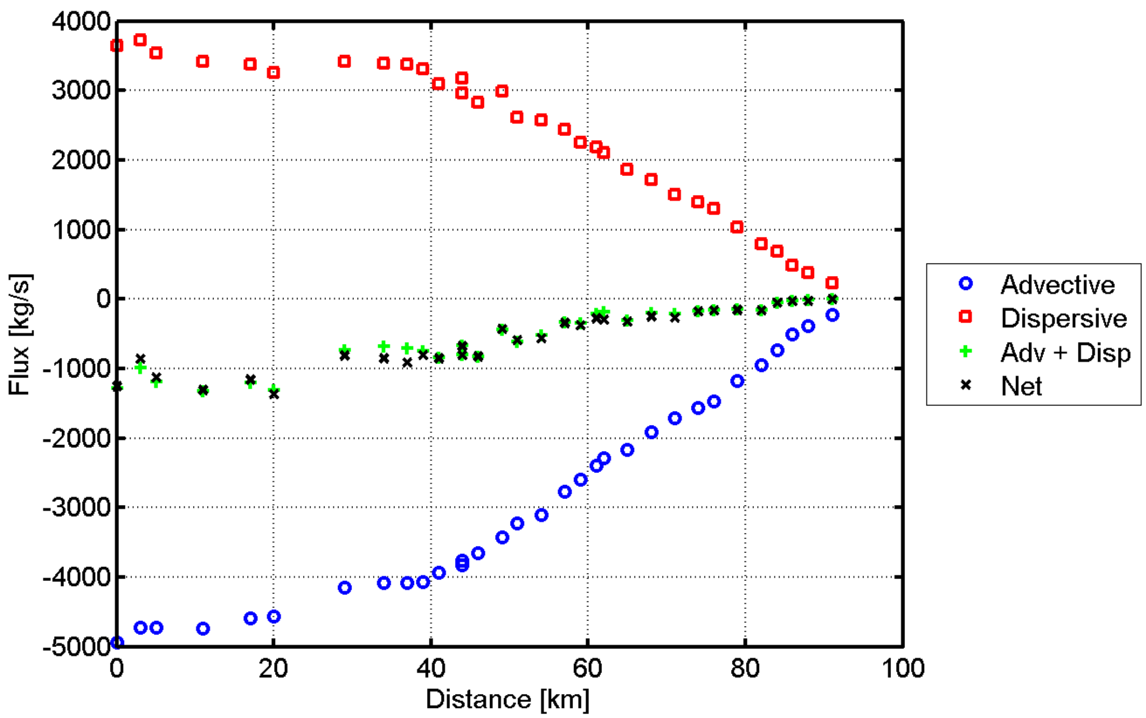


Figure 8.4-8 Predicted advective, dispersive and net salt fluxes for the 45 cm SLR scenario during the October 13, 2002 through November 10, 2002 analysis period.

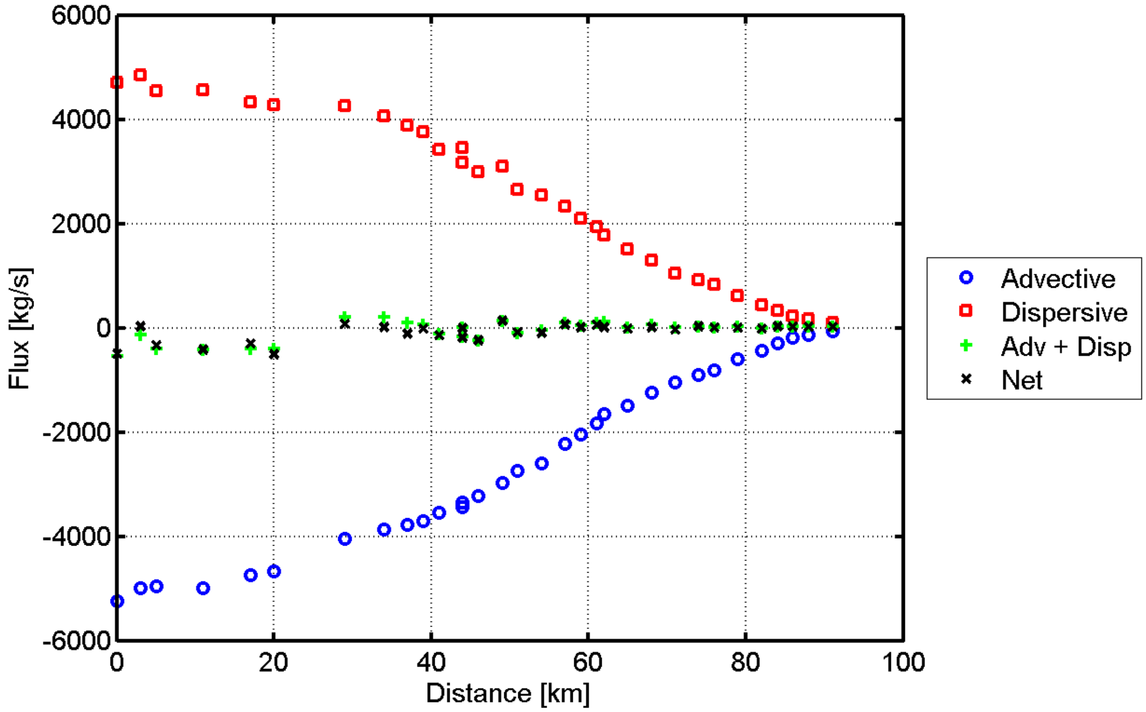


Figure 8.4-9 Predicted advective, dispersive and net salt fluxes for the 60 cm SLR scenario during the July 15, 2002 through August 12, 2002 analysis period.

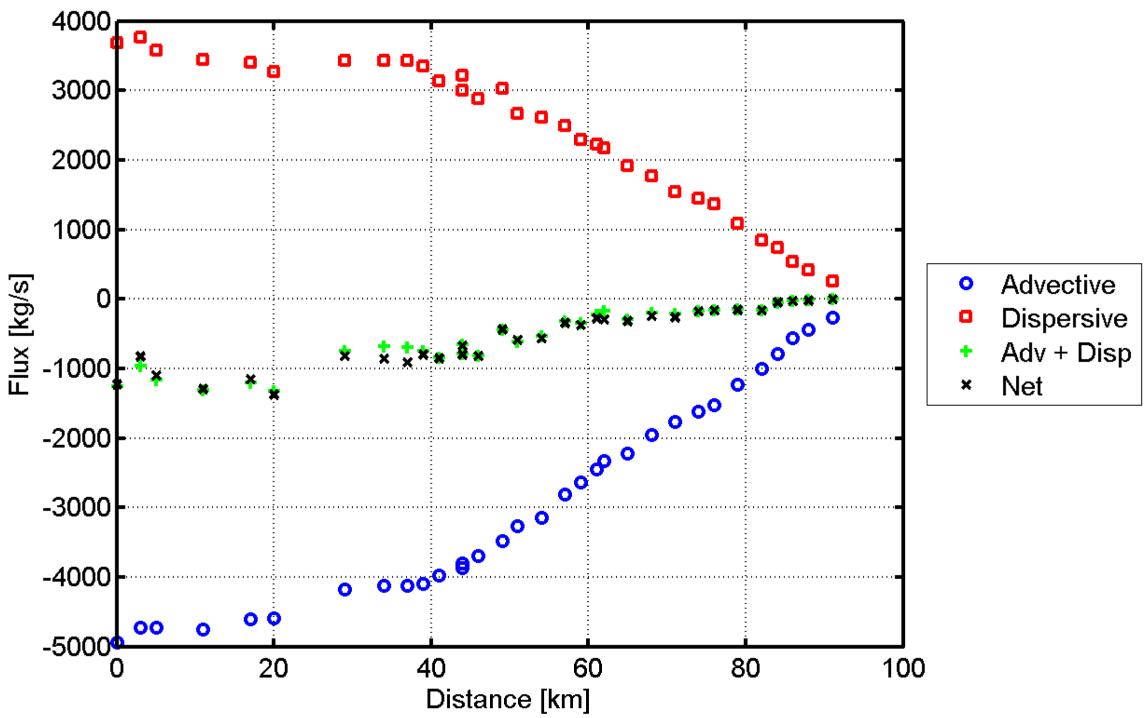


Figure 8.4-10 Predicted advective, dispersive and net salt fluxes for the 60 cm SLR scenario during the October 13, 2002 through November 10, 2002 analysis period.

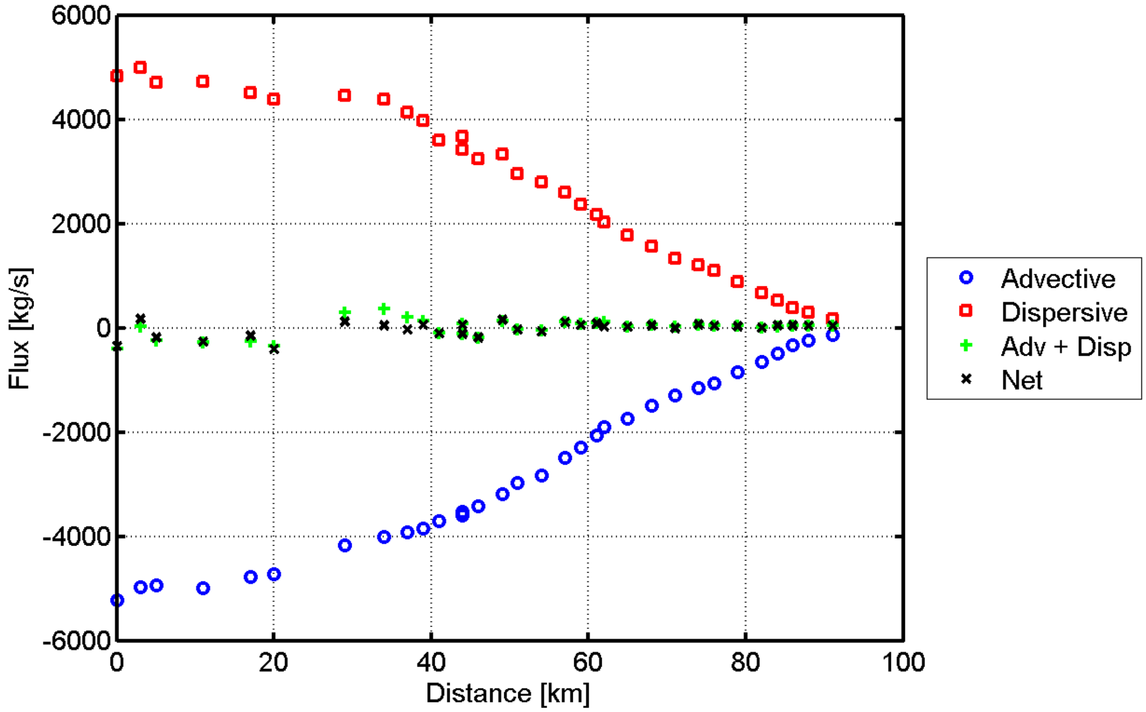


Figure 8.4-11 Predicted advective, dispersive and net salt fluxes for the 140 cm SLR scenario during the July 15, 2002 through August 12, 2002 analysis period.

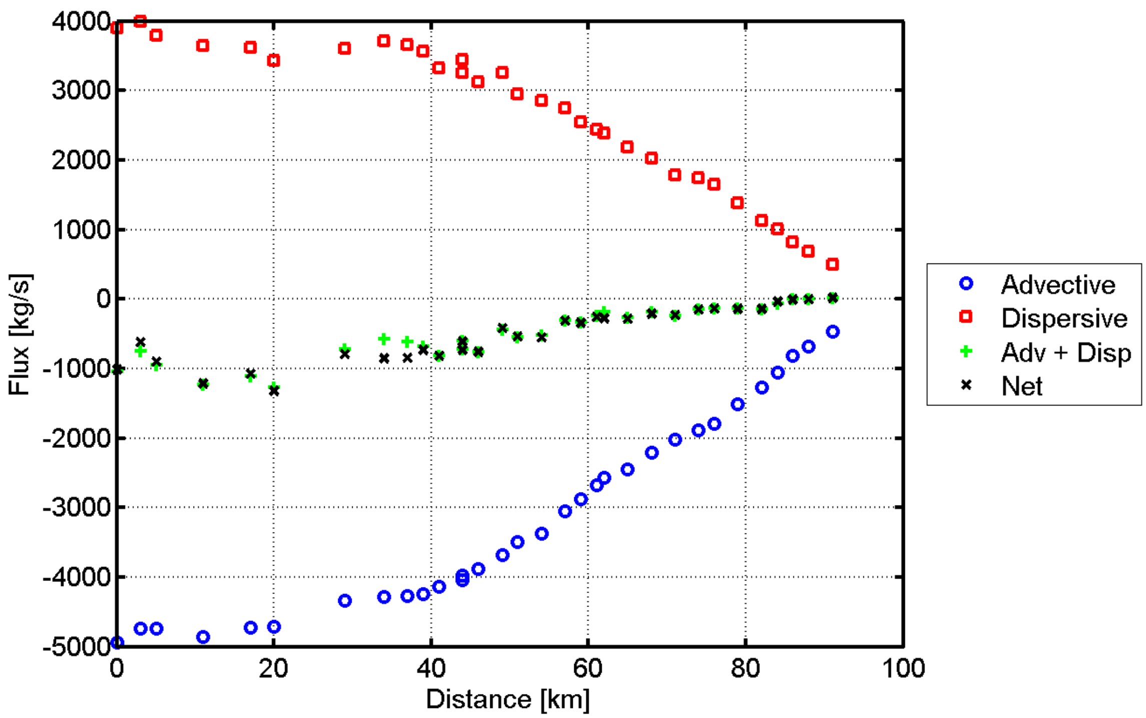


Figure 8.4-12 Predicted advective, dispersive and net salt fluxes for the 140 cm SLR scenario during the October 13, 2002 through November 10, 2002 analysis period.

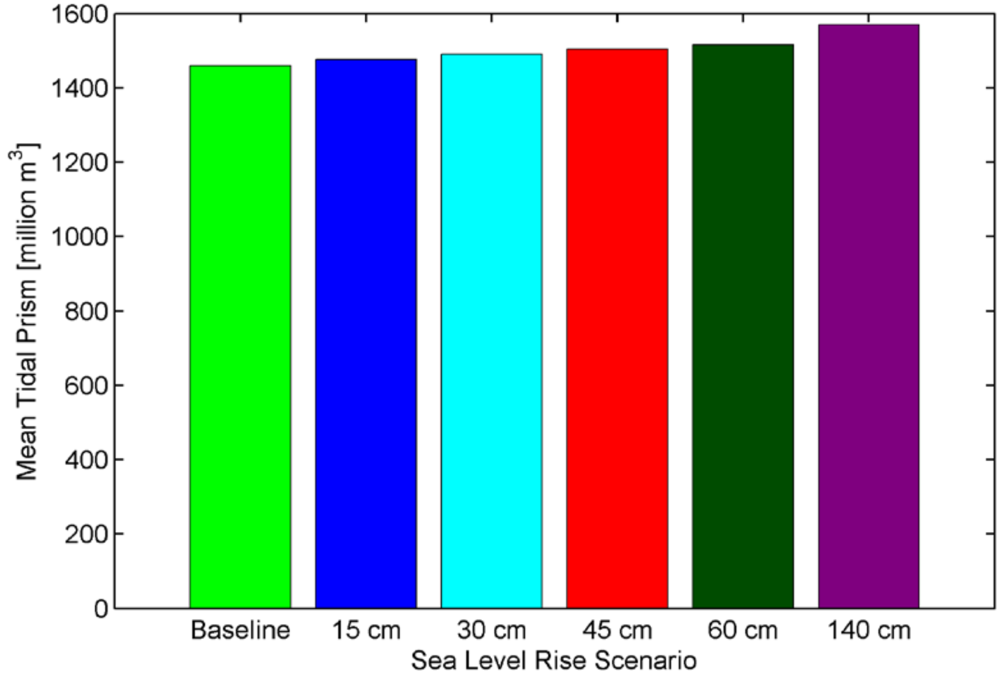


Figure 8.4-13 Average tidal prism at cross-section 1, located at the Golden Gate, for the Baseline and SLR scenarios during the July 15, 2002 through August 12, 2002 analysis period.

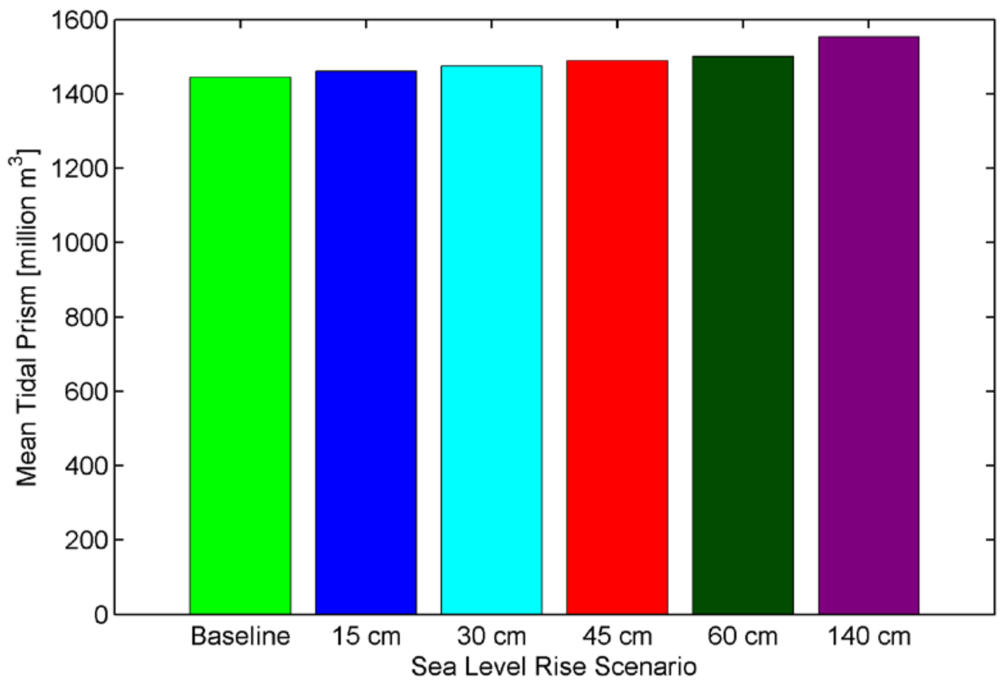


Figure 8.4-14 Average tidal prism at cross-section 1, located at the Golden Gate, for the Baseline and SLR scenarios during the October 13, 2002 through November 10, 2002 analysis period.

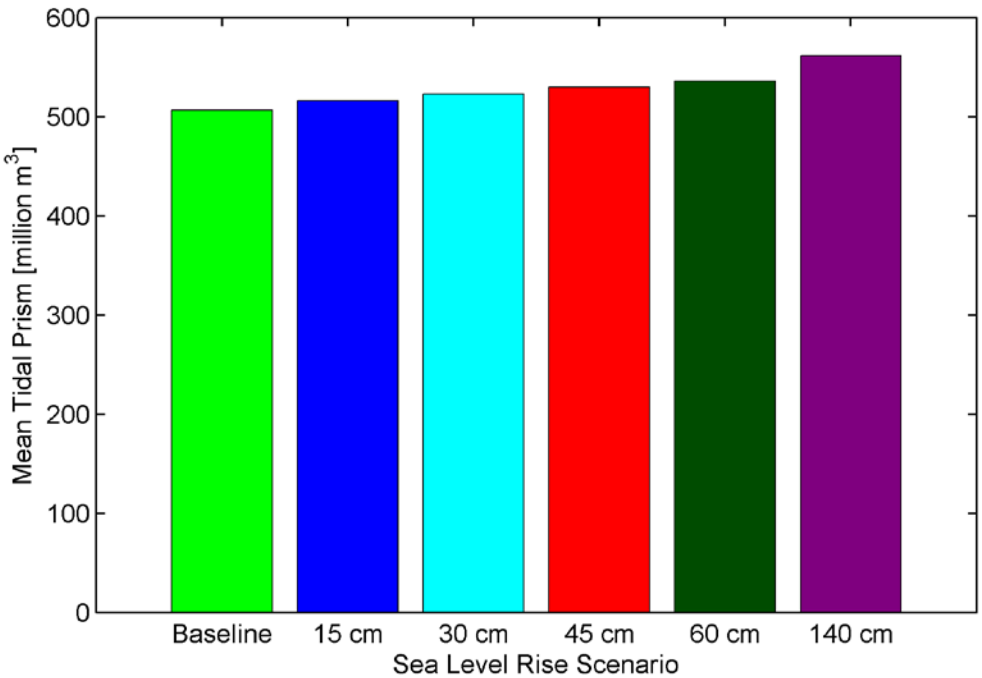


Figure 8.4-15 Average tidal prism at cross-section 5, located at the Richmond-San Rafael Bridge, for the Baseline and SLR scenarios during the July 15, 2002 through August 12, 2002 analysis period.

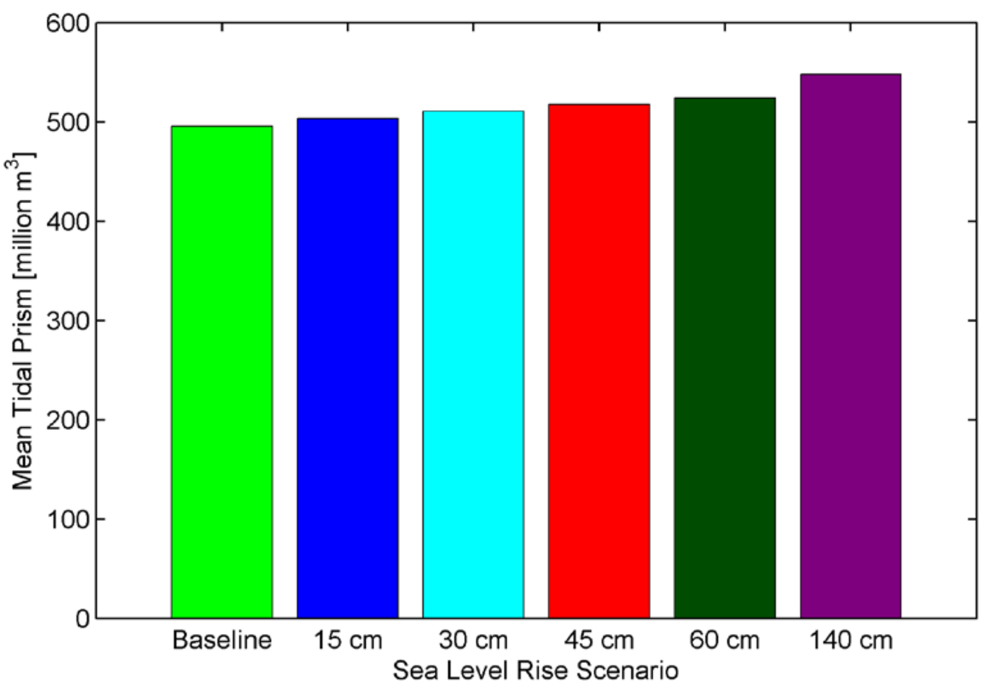


Figure 8.4-16 Average tidal prism at cross-section 5, located at the Richmond-San Rafael Bridge, for the Baseline and SLR scenarios during the October 13, 2002 through November 10, 2002 analysis period.

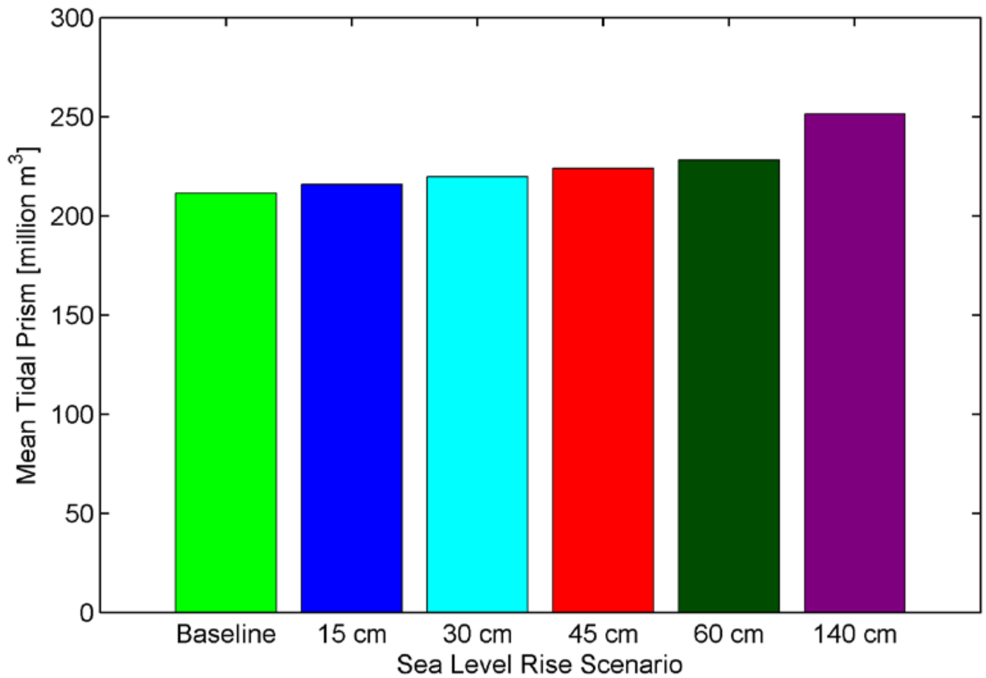


Figure 8.4-17 Average tidal prism at cross-section 12, located at the Carquinez Bridge, for the Baseline and SLR scenarios during the July 15, 2002 through August 12, 2002 analysis period.

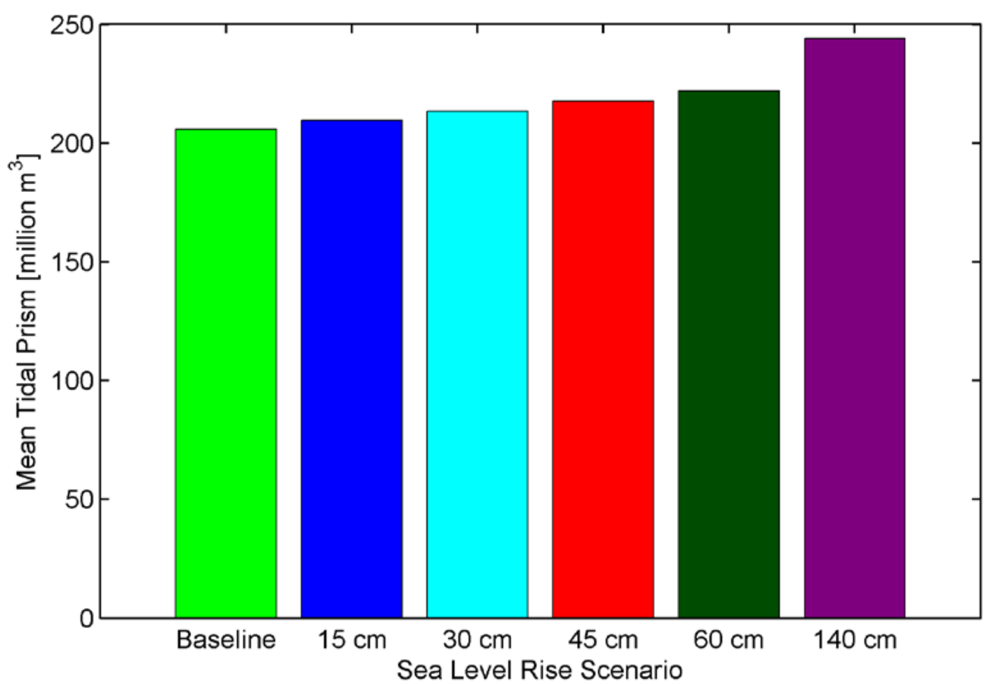


Figure 8.4-18 Average tidal prism at cross-section 12, located at the Carquinez Bridge, for the Baseline and SLR scenarios during the October 13, 2002 through November 10, 2002 analysis period.

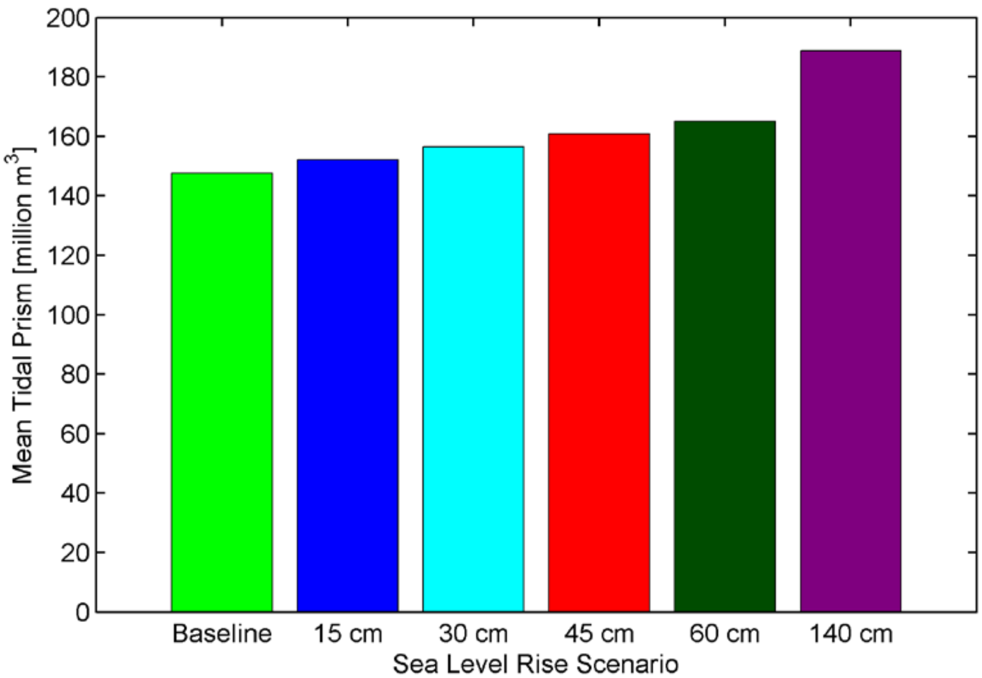


Figure 8.4-19 Average tidal prism at cross-section 25, located at Chipps Island, for the Baseline and SLR scenarios during the July 15, 2002 through August 12, 2002 analysis period.

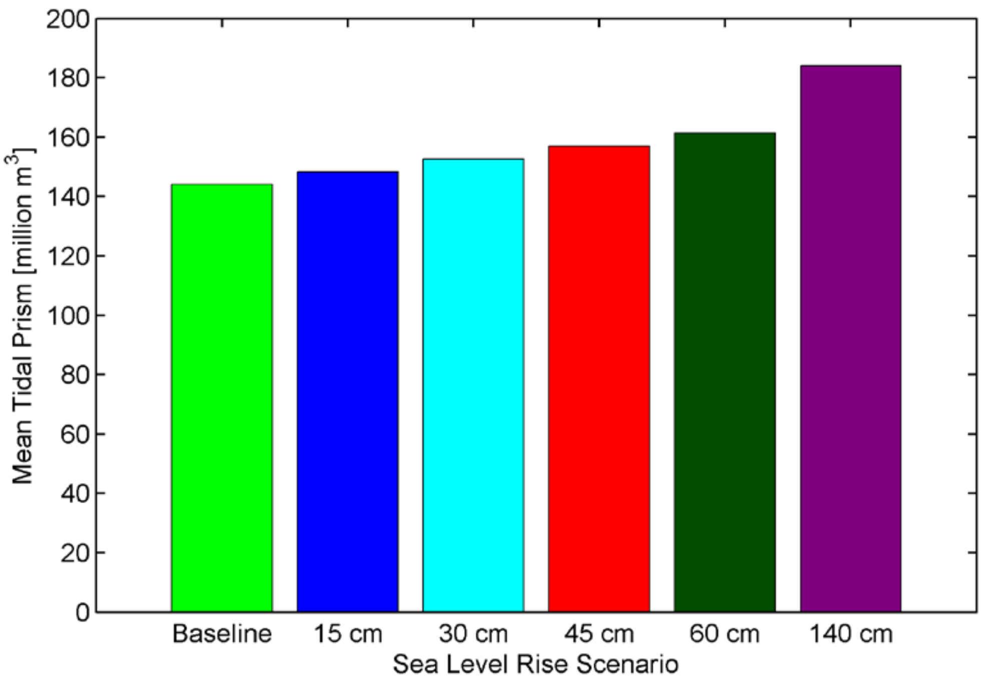


Figure 8.4-20 Average tidal prism at cross-section 25, located at Chipps Island, for the Baseline and SLR scenarios during the October 13, 2002 through November 10, 2002 analysis period.

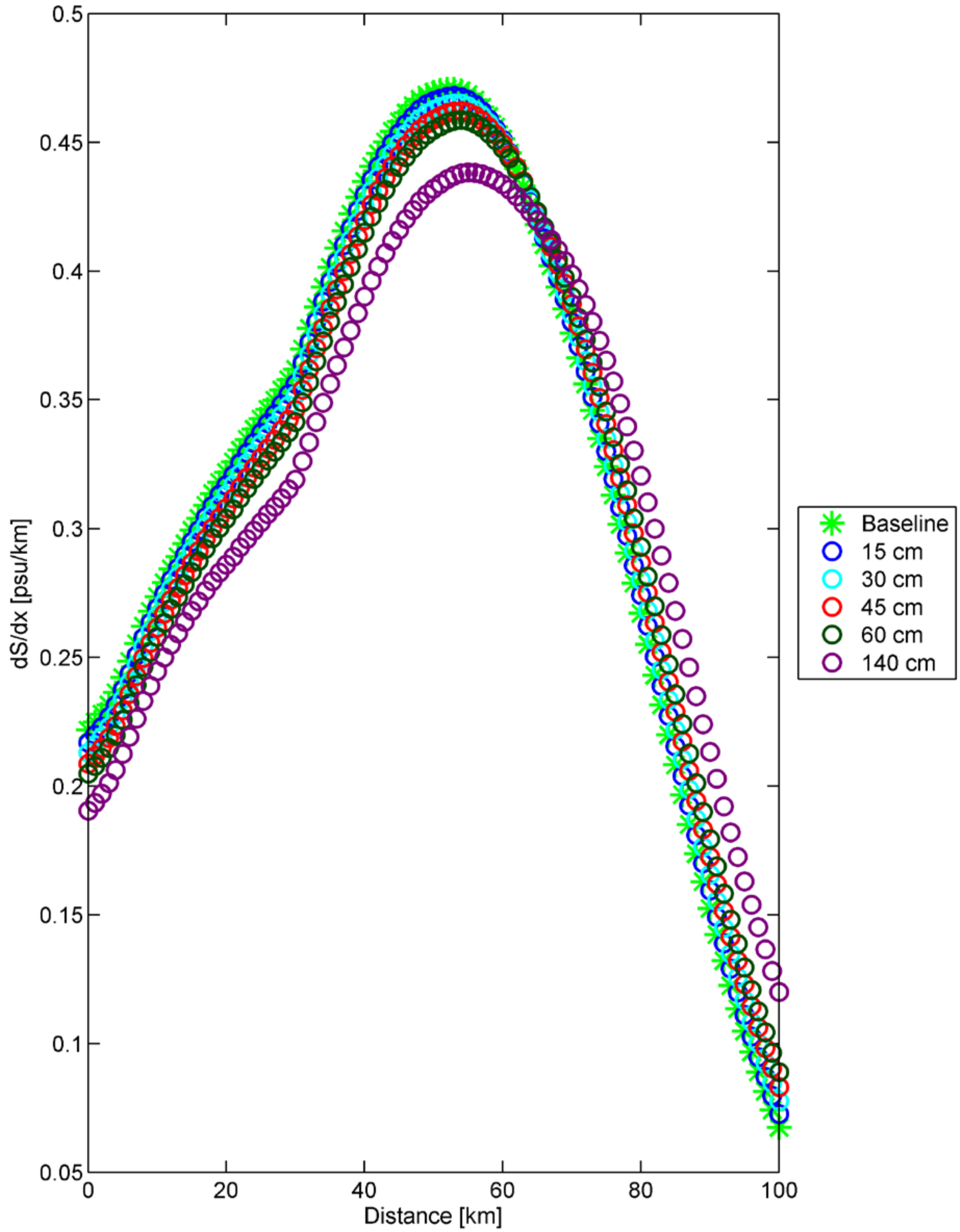


Figure 8.4-21 Estimated depth-averaged salinity gradient for the Baseline and SLR scenarios for the July 15, 2002 through August 12, 2002 analysis period. The horizontal scale is distance along the axis of the estuary from the Golden Gate.

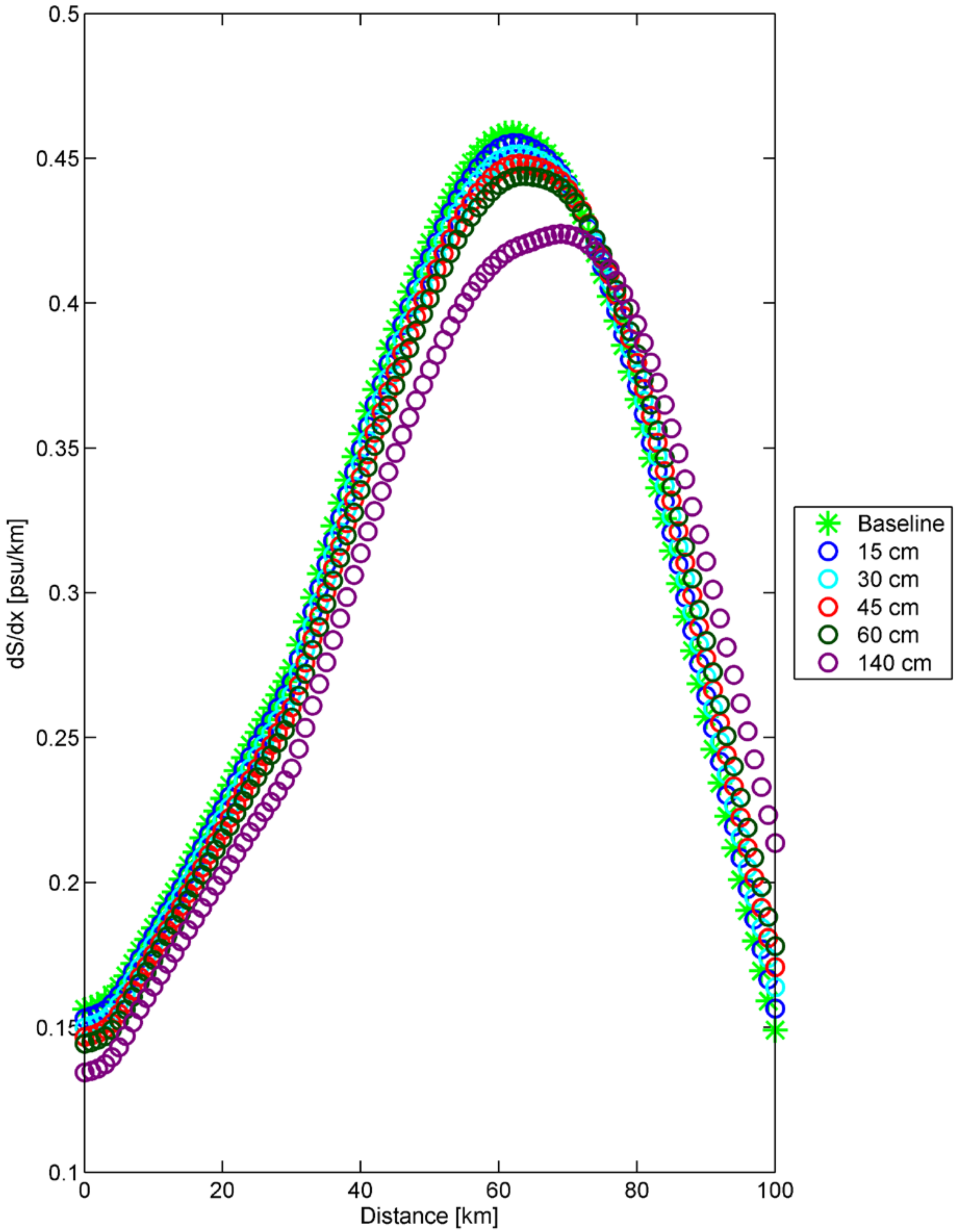


Figure 8.4-22 Estimated depth-averaged salinity gradient for the Baseline and SLR scenarios during the October 13, 2002 through November 10, 2002 analysis period. The horizontal scale is distance along the axis of the estuary from the Golden Gate.

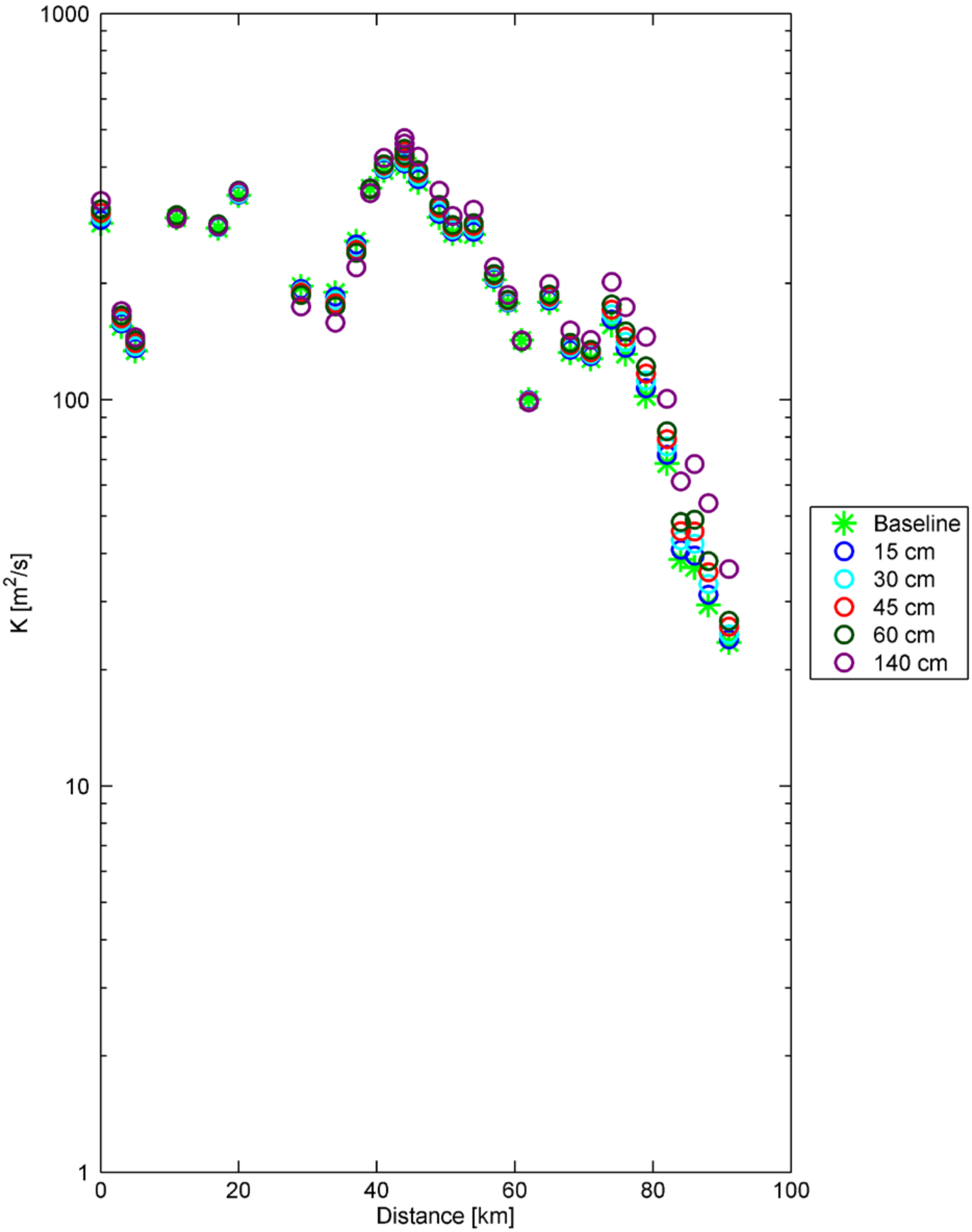


Figure 8.4-23 Estimated dispersion coefficient for the Baseline and SLR scenarios for the July 15, 2002 through August 12, 2002 analysis period. The horizontal scale is distance along the axis of the estuary from the Golden Gate.

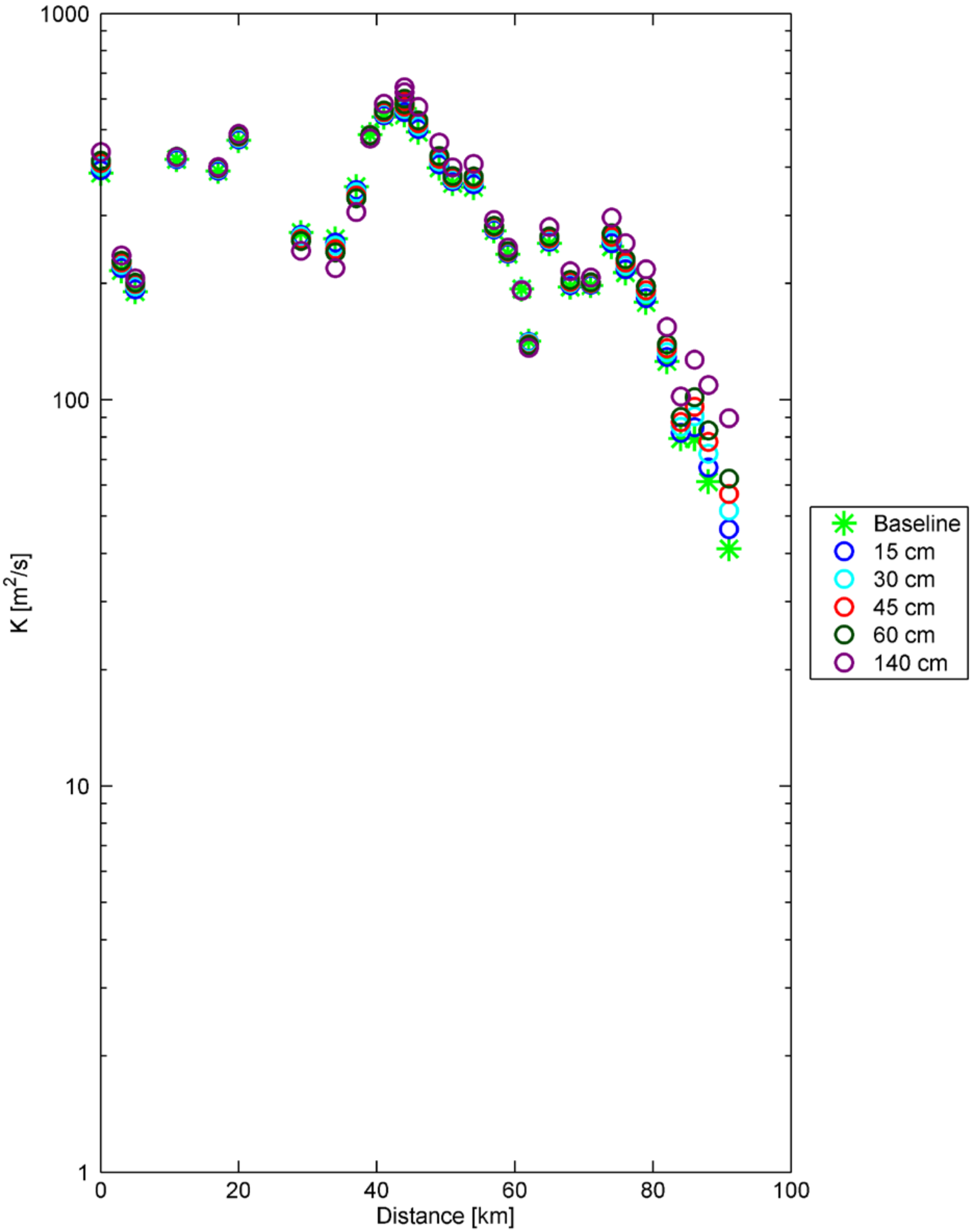


Figure 8.4-24 Estimated depth-averaged dispersion coefficient for the Baseline and SLR scenarios for the October 13, 2002 through November 10, 2002 analysis period. The horizontal scale is distance along the axis of the estuary from the Golden Gate.

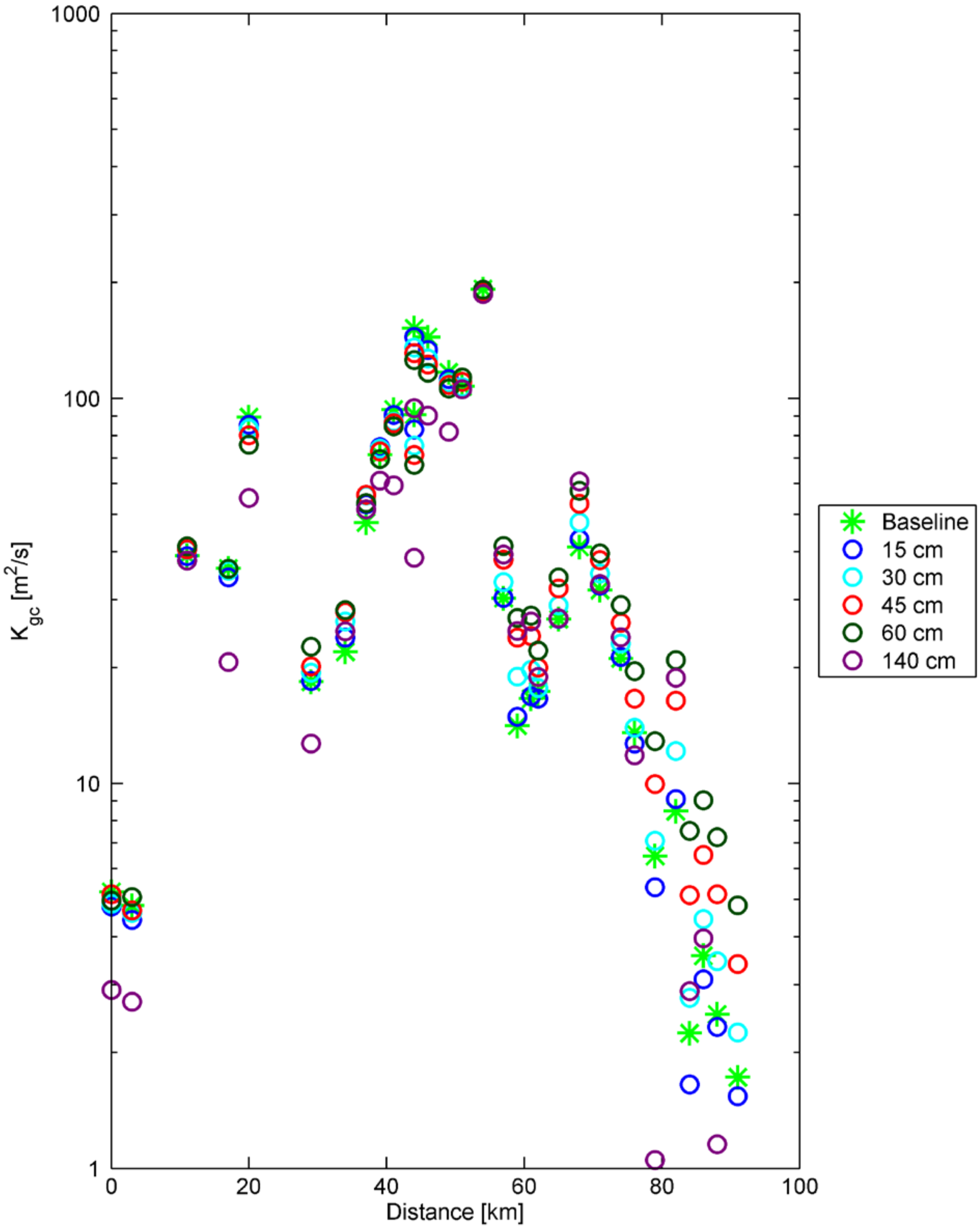


Figure 8.4-25 Estimated dispersion coefficient due to gravitational circulation for the Baseline and SLR scenarios for the July 15, 2002 through August 12, 2002 analysis period. The horizontal scale is distance along the axis of the estuary from the Golden Gate.

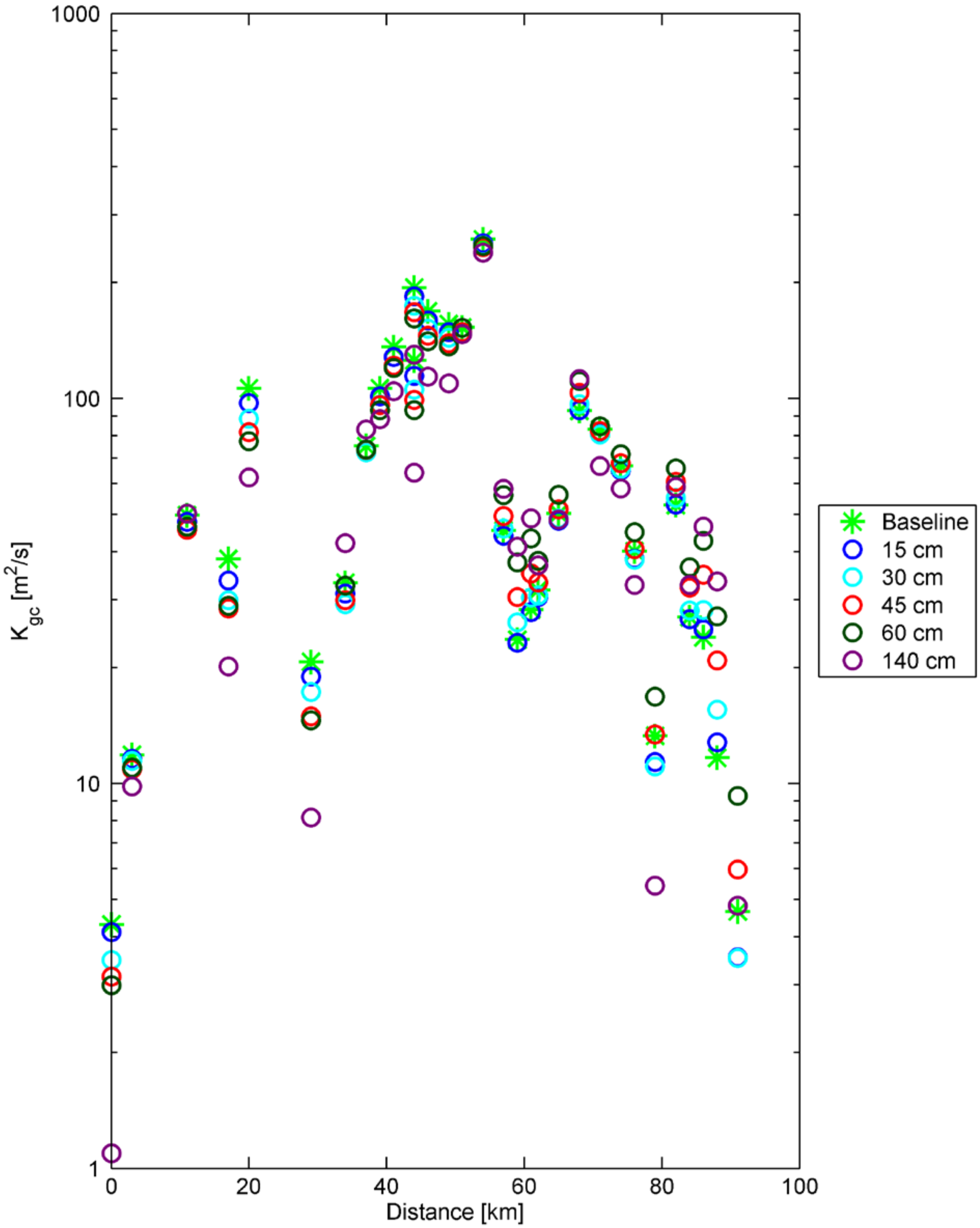


Figure 8.4-26 Estimated dispersion coefficient due to gravitational circulation for the Baseline and SLR scenarios for the October 13, 2002 through November 10, 2002 analysis period. The horizontal scale is distance along the axis of the estuary from the Golden Gate.

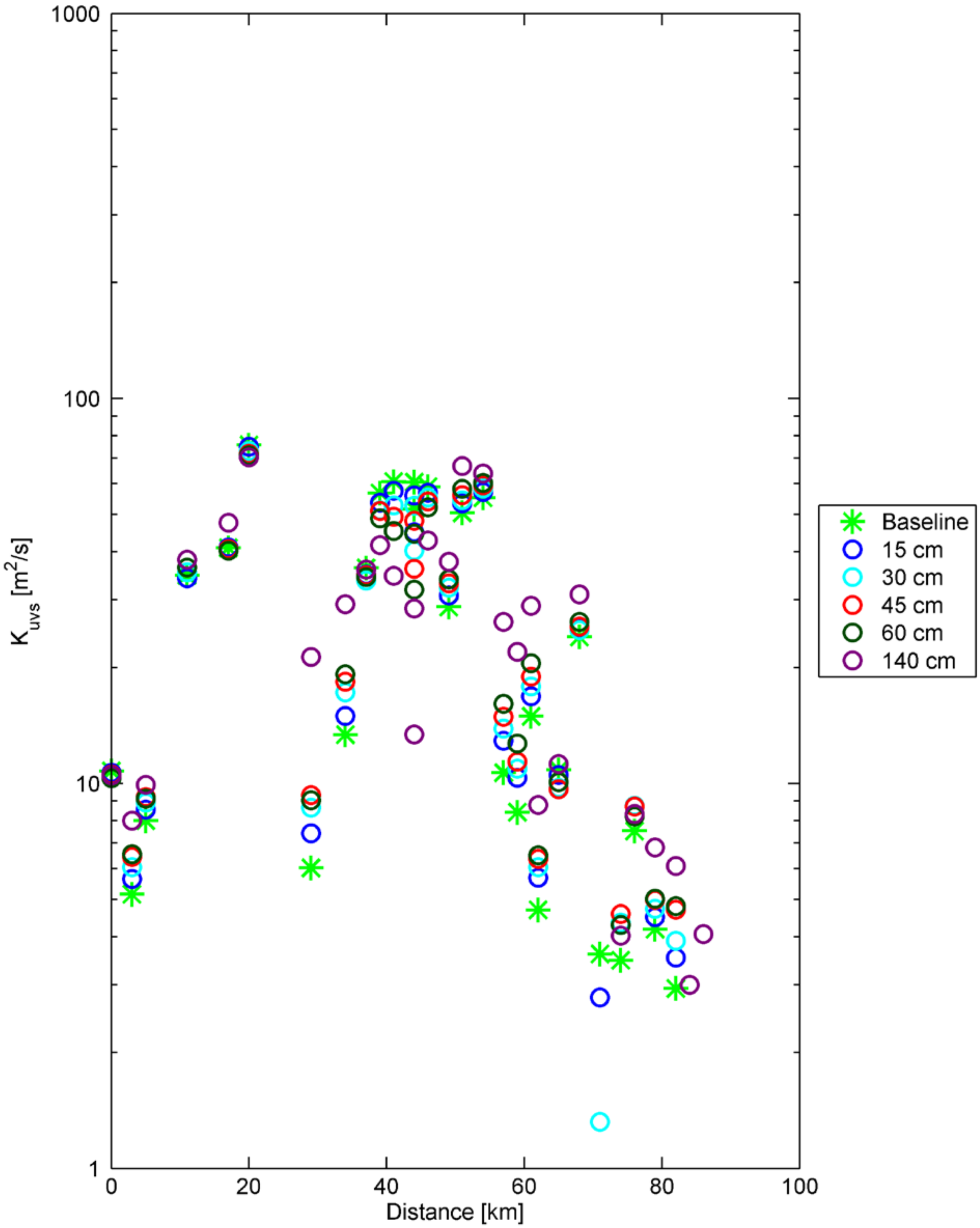


Figure 8.4-27 Estimated dispersion coefficient due to unsteady vertical shear for the Baseline and SLR scenarios for the July 15, 2002 through August 12, 2002 analysis period. The horizontal scale is distance along the axis of the estuary from the Golden Gate.

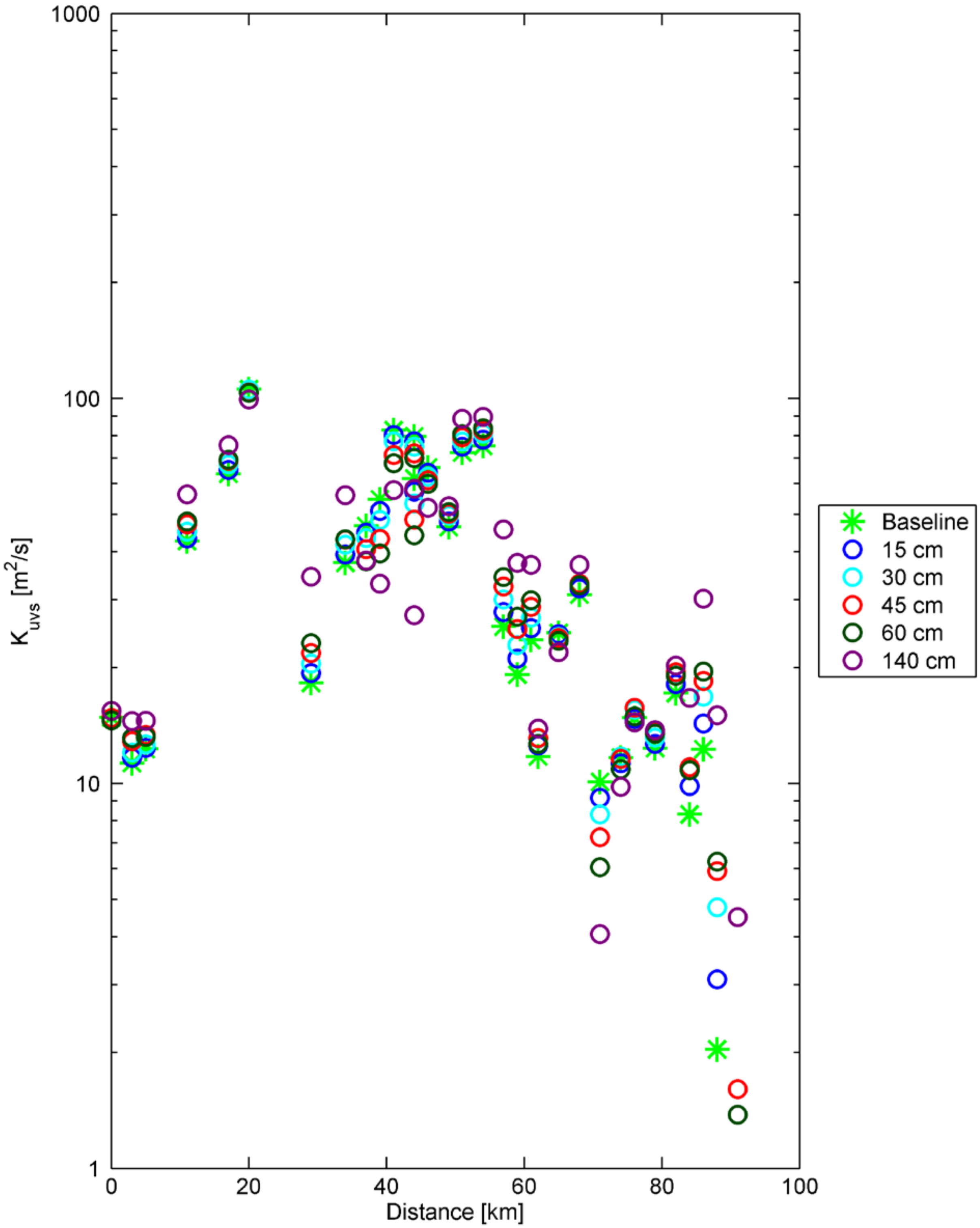


Figure 8.4-28 Estimated dispersion coefficient due to unsteady vertical shear for the Baseline and SLR scenarios for the October 13, 2002 through November 10, 2002 analysis period. The horizontal scale is distance along the axis of the estuary from the Golden Gate.

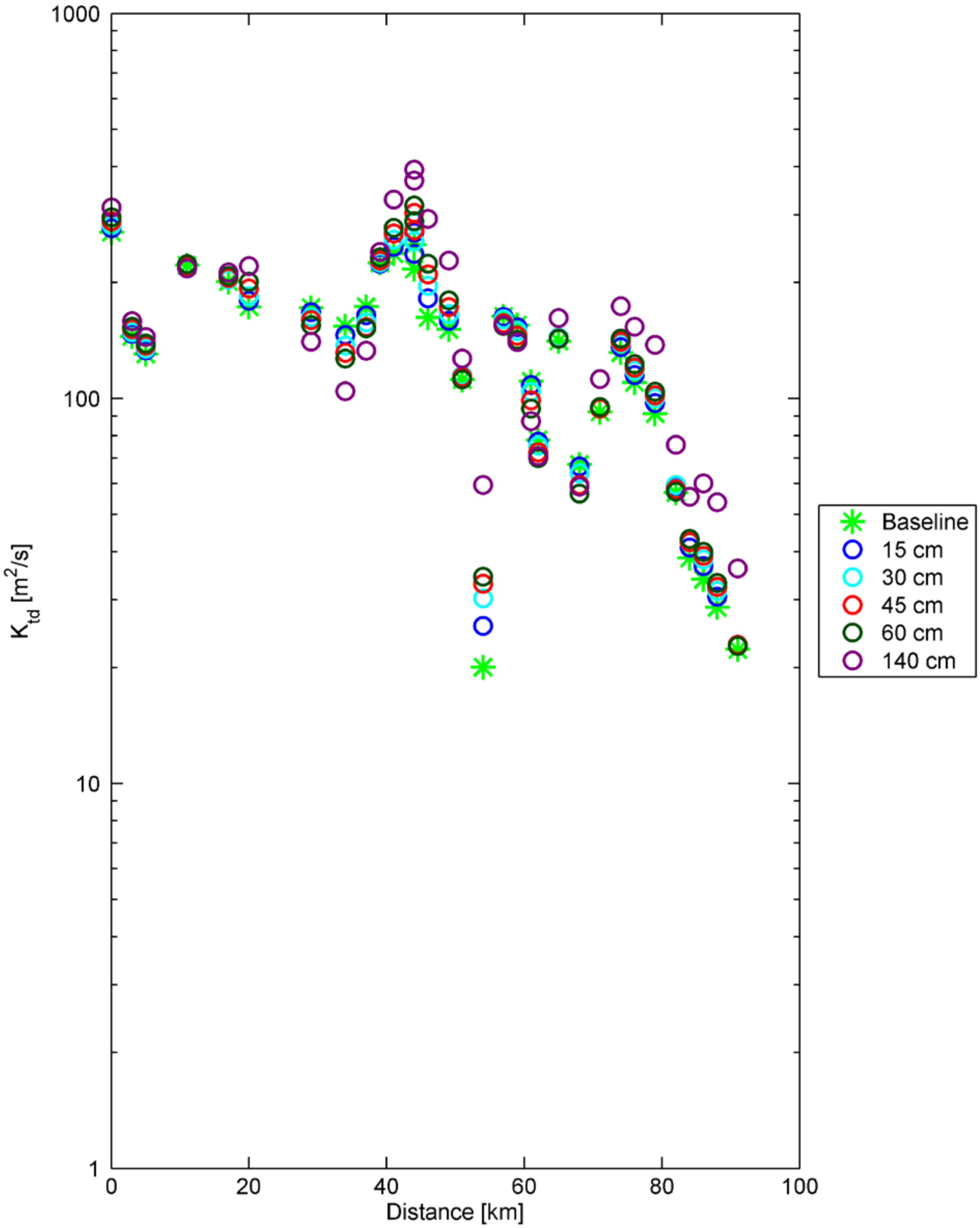


Figure 8.4-29 Estimated dispersion coefficient due to tidal dispersion for the Baseline and SLR scenarios for the July 15, 2002 through August 12, 2002 analysis period. The horizontal scale is distance along the axis of the estuary from the Golden Gate.

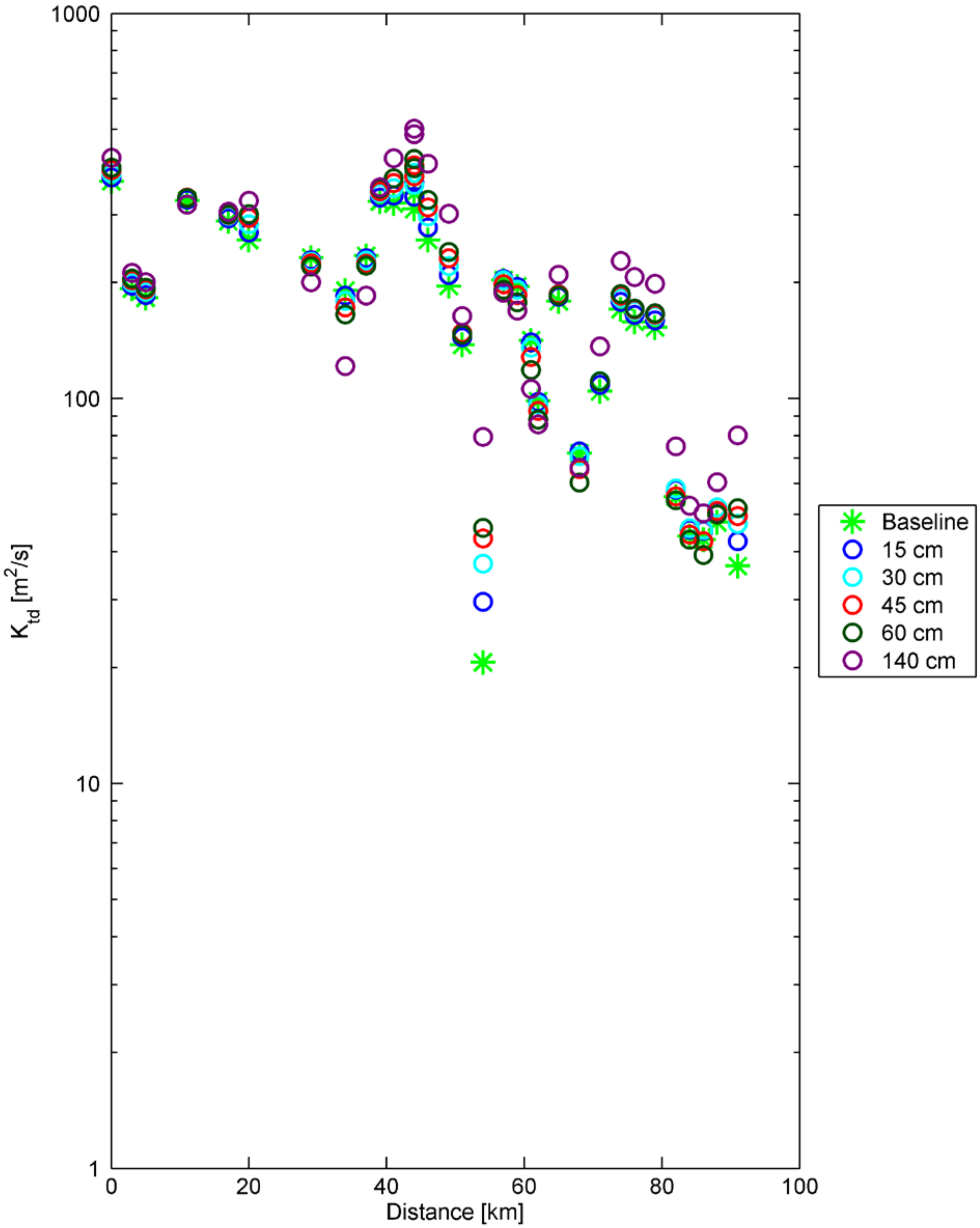


Figure 8.4-30 Estimated dispersion coefficient due to tidal dispersion for the Baseline and SLR scenarios for the October 13, 2002 through November 10, 2002 analysis period. The horizontal scale is distance along the axis of the estuary from the Golden Gate.

8.4.1 Central San Francisco Bay Cross-Sections

Dispersion coefficients and salt fluxes were estimated at the five cross-sections in Central Bay (cross-section 1 to cross-section 5) shown in Figure 8.3-1. In Figure 8.4-31 through **Error! Reference source not found.**, analysis results are provided for each cross-section that summarize the dispersion analysis at that location for a given analysis period. The top panel shows the contributions of individual processes to dispersive salt flux (advective salt flux is not shown) for each SLR scenario. The second type of figure shows the overall dispersion coefficient (K), the portion of the dispersion coefficient associated with gravitational circulation (K_{gc}), the portion of the dispersion coefficient associated with unsteady vertical shear dispersion processes (K_{uvs}), and the portion of the dispersion coefficient associated with tidal dispersion processes (K_{td}) for each SLR scenario. The bottom panel shows the period averaged velocity profile and salinity profile at the deepest point in the cross-section for each SLR scenario.

The dispersion coefficients are generally large in Central Bay. Tidal dispersion processes are the most important salt intrusion processes at all cross-sections in Central Bay for both analysis periods. The dispersion coefficients increase weakly with SLR in Central Bay due to increased tidal dispersion at most cross-sections. The increase in tidal dispersion is likely related to the increased tidal prism with SLR indicated by Figure 8.4-13 and Figure 8.4-14. The velocity profiles do not show clear evidence of gravitational circulation in Central Bay during either analysis period. In most sections the near surface layers are directed landward (up estuary), in the opposite direction expected for gravitational circulation, suggesting that wind forcing may be important and/or that the currents are likely to have strong lateral variability. The predicted stratification in Central Bay is weak during both analysis periods. As a result, the predicted fluxes from gravitational circulation and unsteady vertical shear are small at all sections for all scenarios. The salt flux term referred to as “gravitational circulation” in this report and other estuarine literature is more precisely referred to as “steady vertical exchange” (e.g. Fram et al. 2007). It can be substantially affected by wind. The negative fluxes associated with the steady vertical exchange term at some cross-sections in Central Bay suggest that wind effects are substantial in this region. Note that negative fluxes associated with the steady vertical exchange term result in negative dispersion coefficients that do not appear on the dispersion coefficient figures due to the use of a y-axis range from 1 to 1000 $m^2 s^{-1}$.

Salinity in Central Bay is higher in the October 13, 2002 through November 10, 2002 analysis period than the July 15, 2002 through August 12, 2002 analysis period. In addition, conditions are slightly more stratified during the October 13, 2002 through November 10, 2002 analysis period. This results in a slight increase in the predicted dispersion coefficient associated gravitational circulation during the October 13, 2002 through November 10, 2002 analysis period relative to the July 15, 2002 through August 12, 2002 analysis period.

The dispersive salt flux in the October 13, 2002 through November 10, 2002 analysis period is significantly lower than the dispersive salt flux in the July 15, 2002 through August 12, 2002 analysis period. This is surprising because the period averaged salinity is higher in the October 13, 2002 through November 10, 2002 analysis period is higher than period averaged salinity in the July 15, 2002 through August 12, 2002 analysis period and the Delta outflow is similar in the two periods. The lower dispersive salt fluxes are related to the higher unsteadiness in the October 13, 2002 through November 10, 2002 averaging period (Figure 8.4-2) relative to the July 15, 2002 through August 12, 2002 analysis period (Figure 8.4-1). The unsteadiness indicates that the total salt mass in the estuary decreased between October 13, 2002 and November 10, 2002. As seen in the salinity time series in Section 6, the salinity conditions are much more variable between October 13, 2002 and November 10, 2002 than between July 15, 2002 through August 12, 2002. It should be noted that the total dispersion coefficients are similar for the two periods indicating that the strength of mixing processes was similar for the two periods.

The results in Central Bay are generally consistent with the flux analysis of sea level rise scenarios performed as part of the DRMS studies (Gross et al., 2007b). However the DRMS scenarios were for higher Delta outflow and, therefore, showed a larger contribution of gravitational circulation and unsteady vertical shear. In addition, wind forcing was not included in the DRMS analysis of salt intrusion processes (Gross et al., 2007b) and negative fluxes were not estimated at any location for the steady vertical exchange term in that study. The flux analysis of various Delta outflows performed as part of the DRMS studies (Gross et al., 2007a) was consistent with these results for low Delta outflows and indicated that gravitational circulation becomes the dominant salt intrusion process at high Delta outflows.

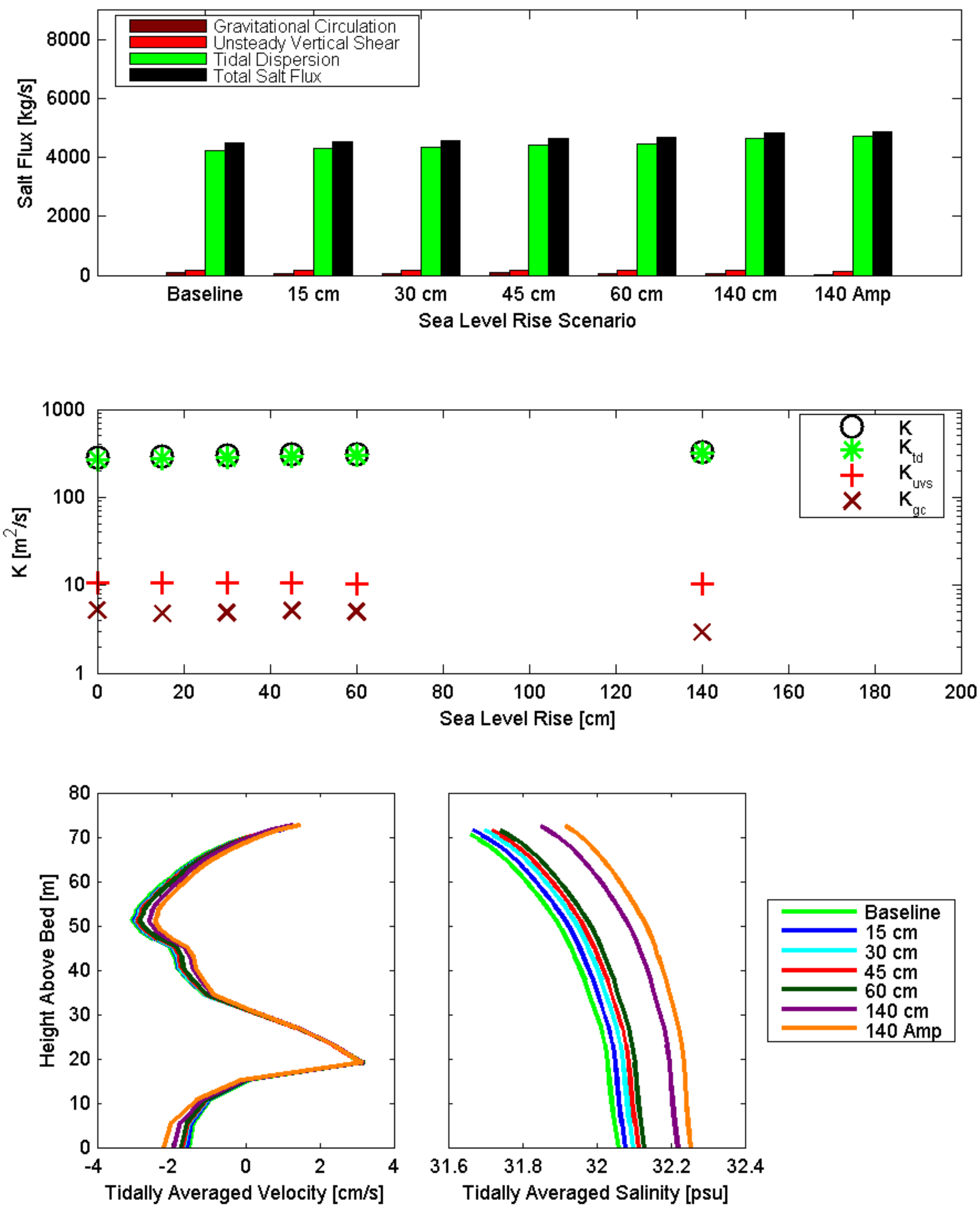


Figure 8.4-31 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each SLR scenario at cross-section 1, located at the Golden Gate, for the July 15, 2002 through August 12, 2002 analysis period.

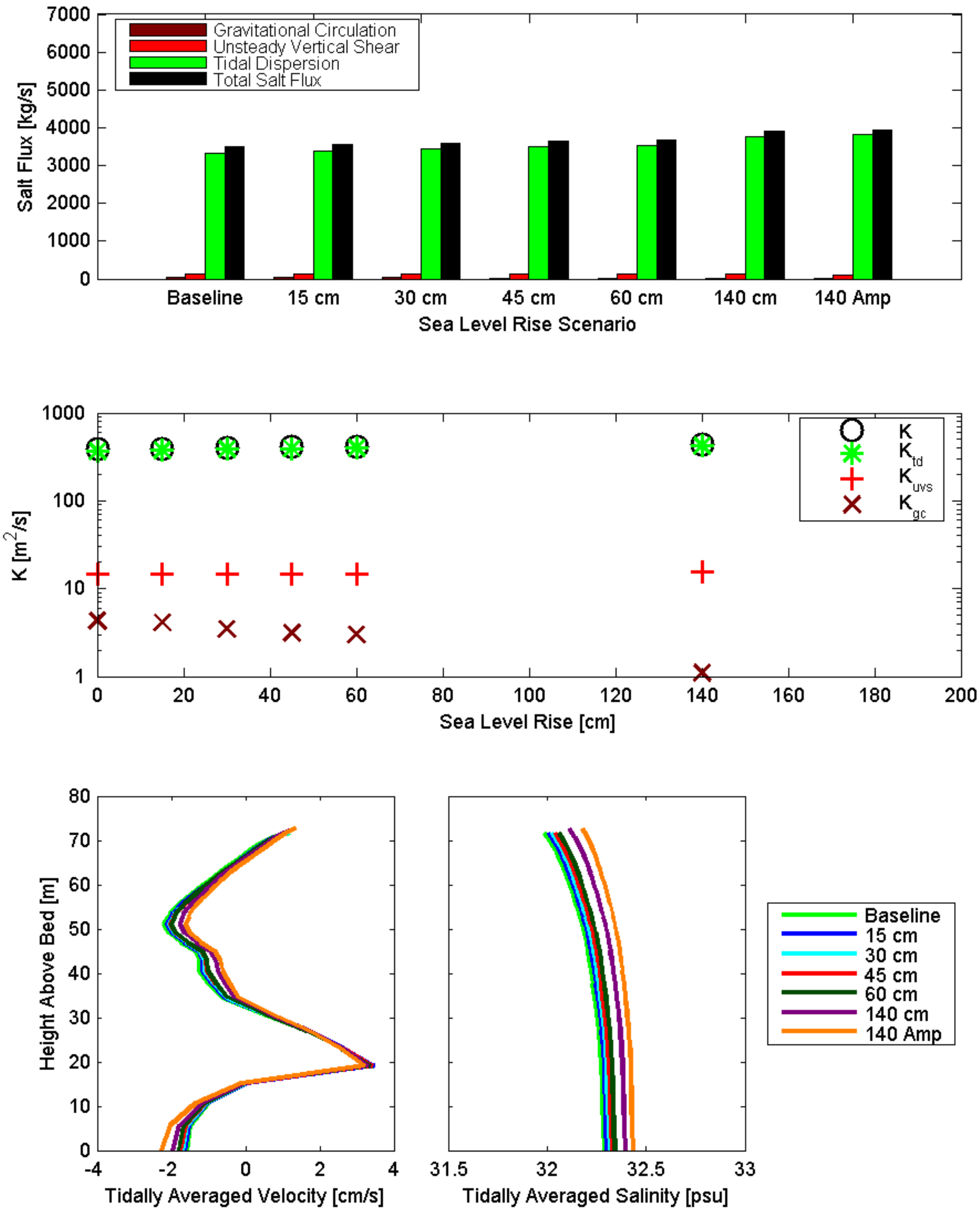


Figure 8.4-32 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 1, located at the Golden Gate, for the October 13, 2002 through November 10, 2002 analysis period.

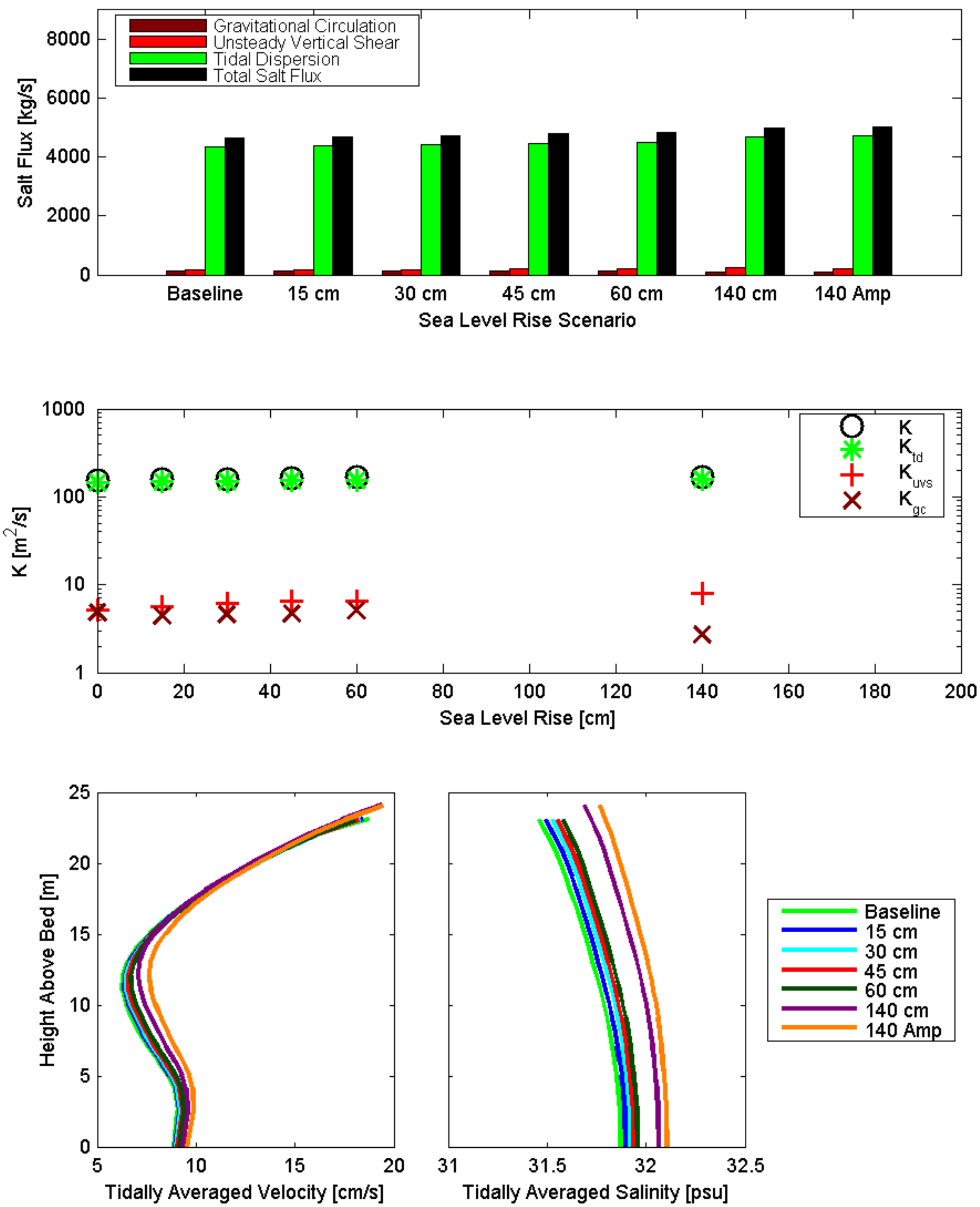


Figure 8.4-33 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 2, extending from North Point to Sausalito, for the July 15, 2002 through August 12, 2002 analysis period.

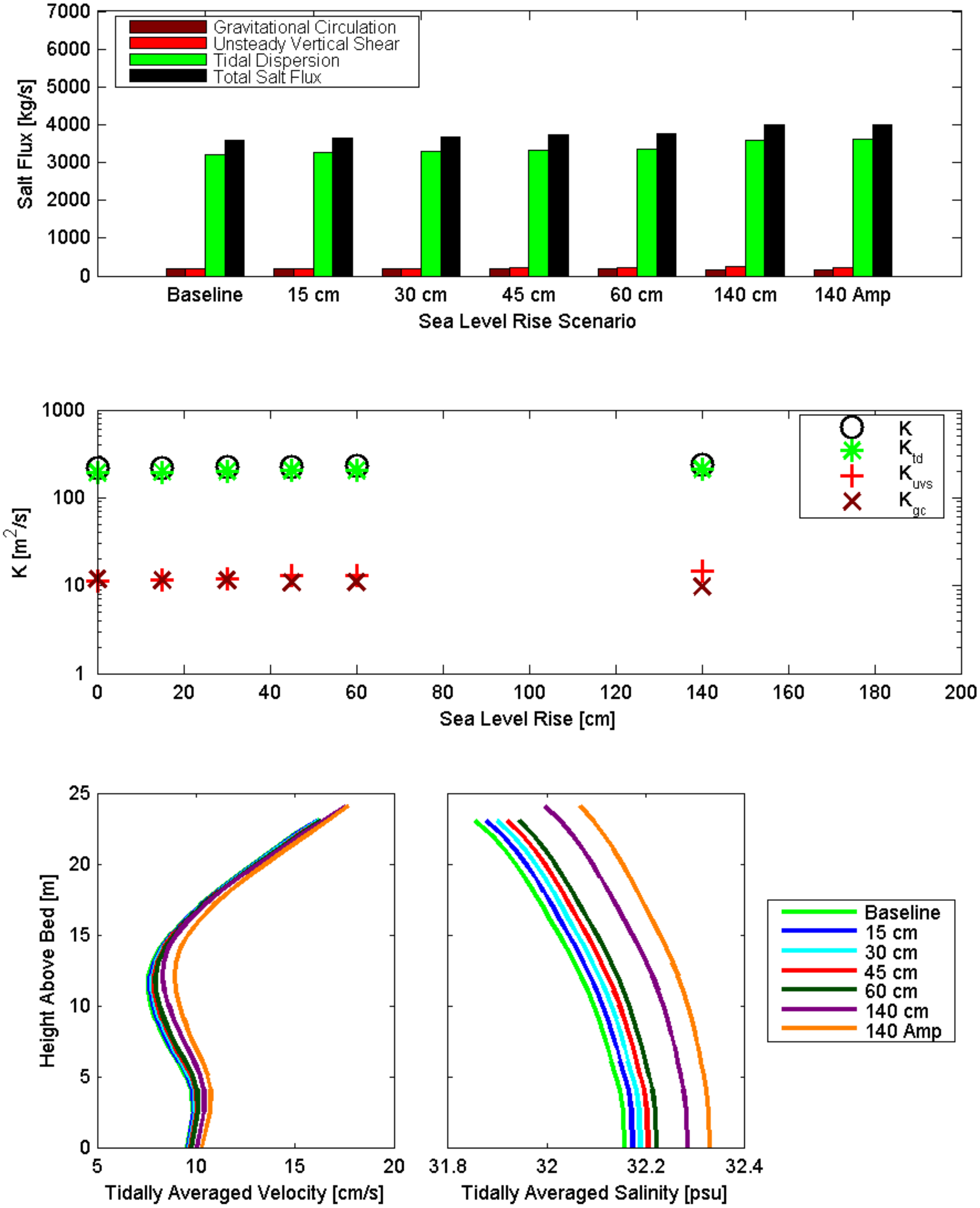


Figure 8.4-34 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 2, extending from North Point to Sausalito, for the October 13, 2002 through November 10, 2002 analysis period.

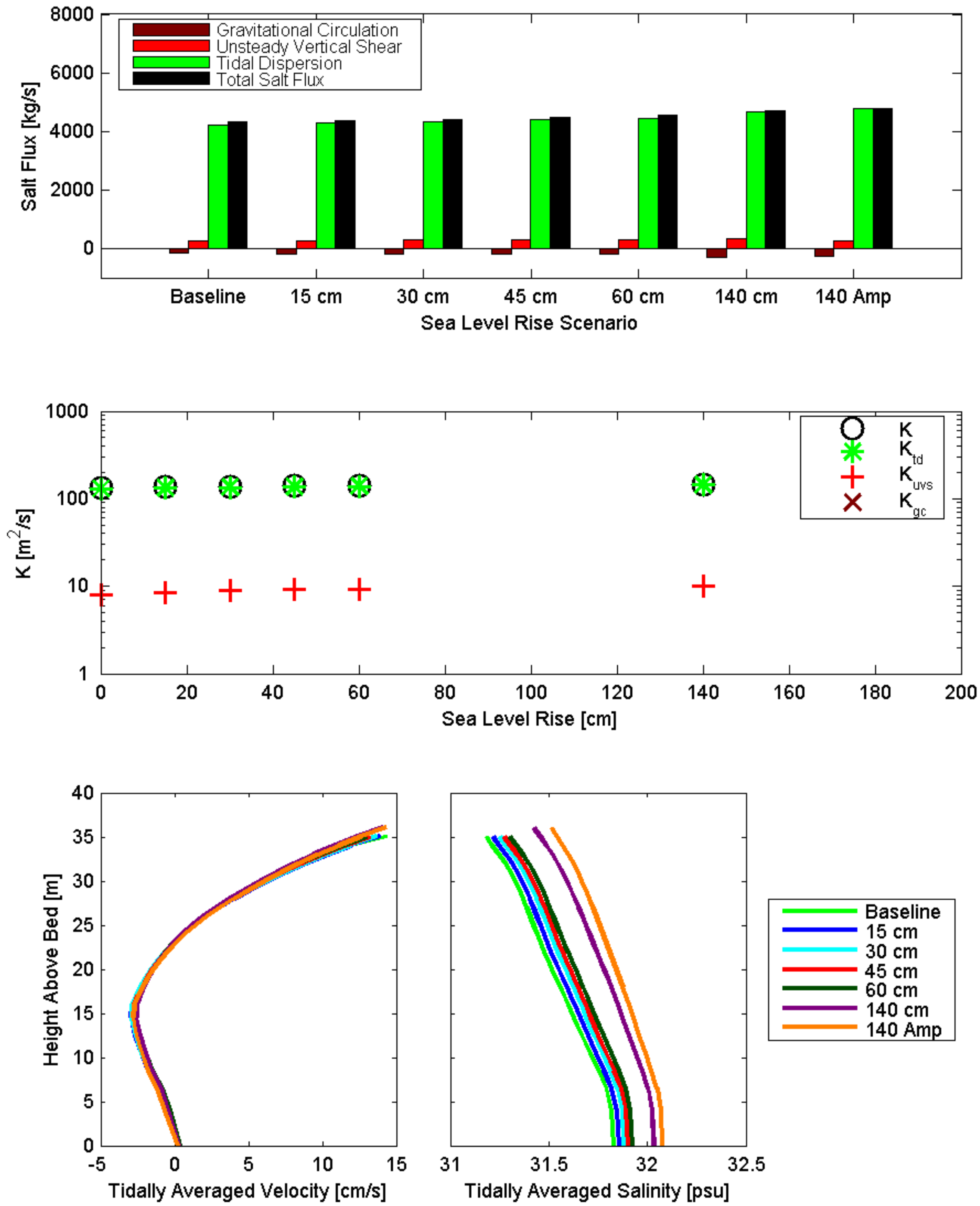


Figure 8.4-35 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 3, extending from San Francisco to Tiburon, for the July 15, 2002 through August 12, 2002 analysis period.

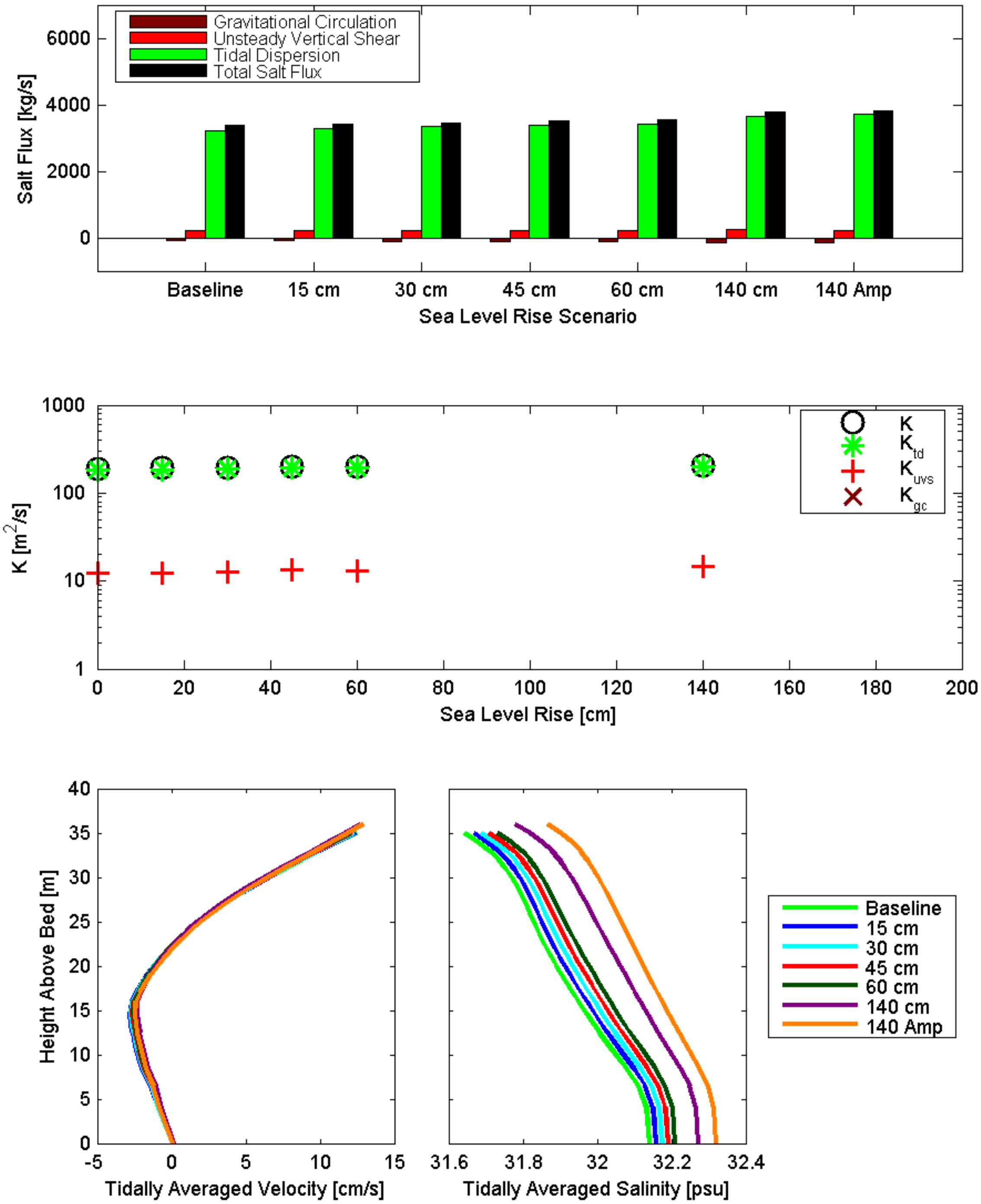


Figure 8.4-36 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 3, extending from San Francisco to Tiburon, for the October 13, 2002 through November 10, 2002 analysis period.

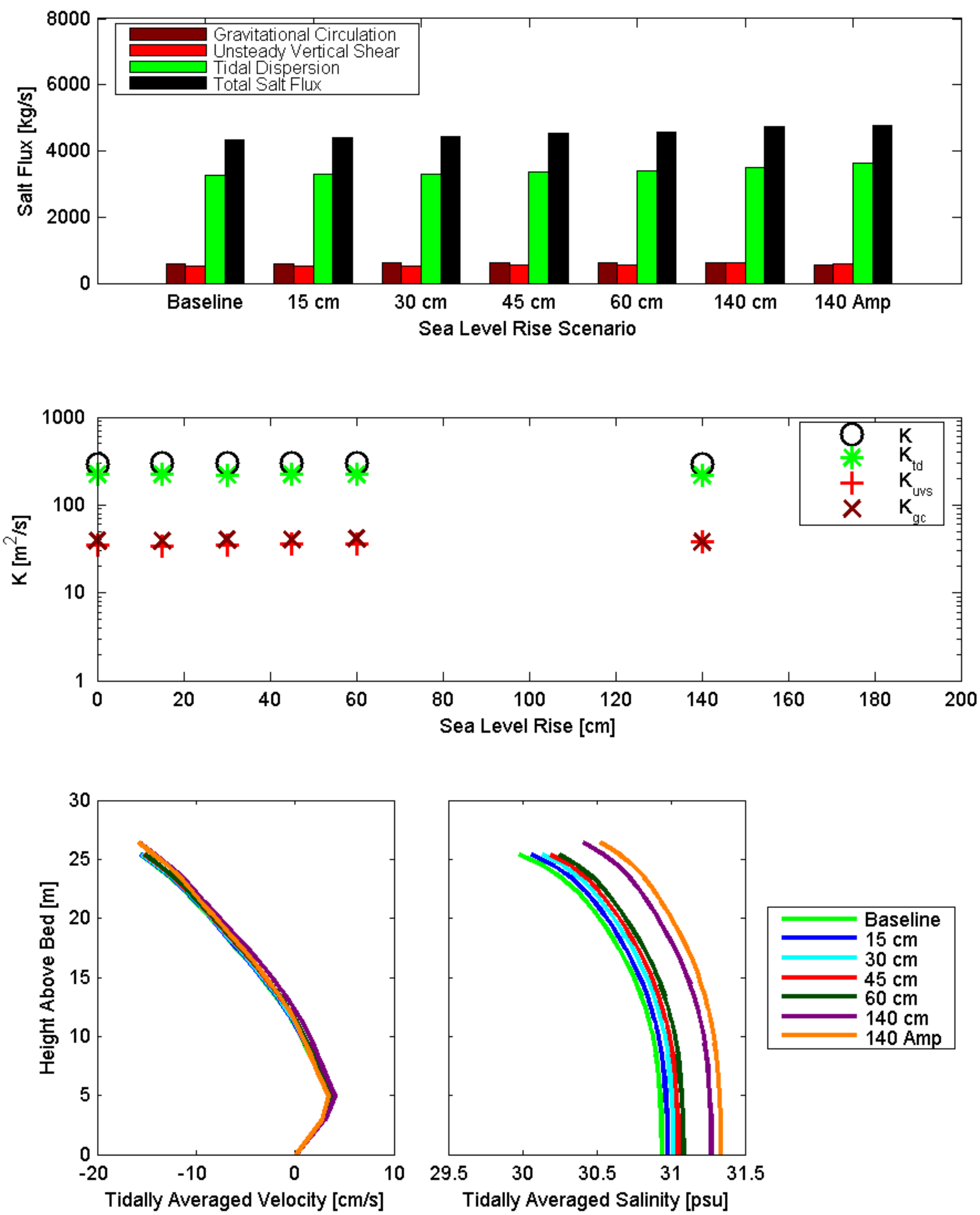


Figure 8.4-37 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 4, extending from Point Richmond to Bluff Point, for the July 15, 2002 through August 12, 2002 analysis period.

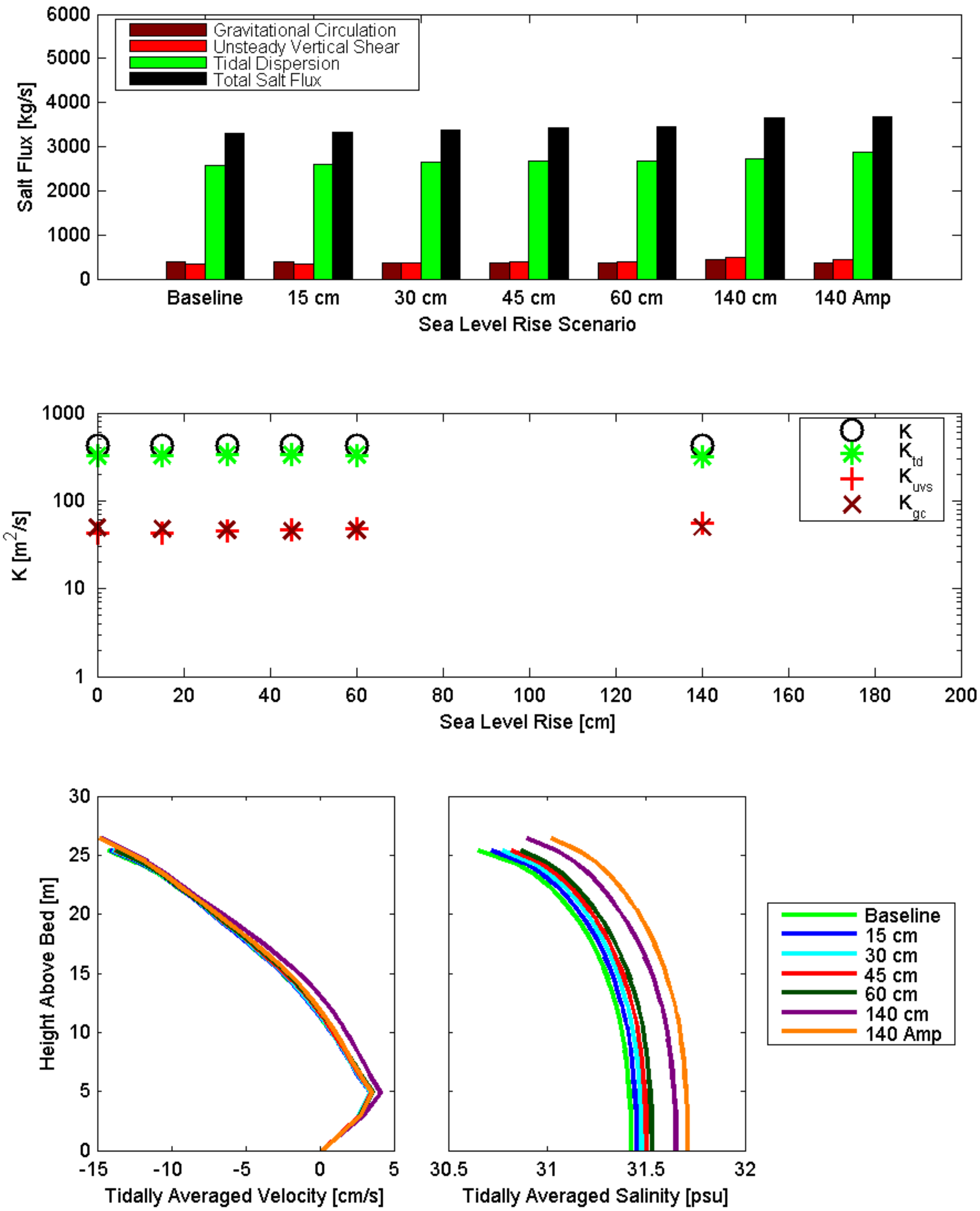
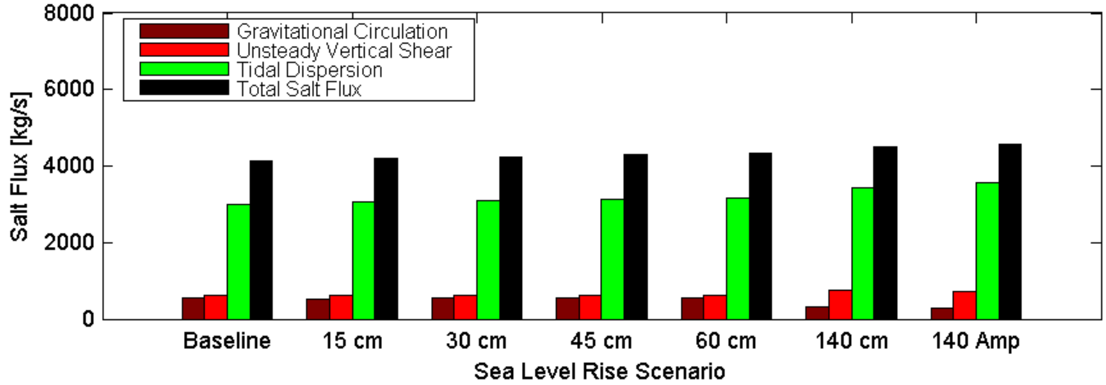
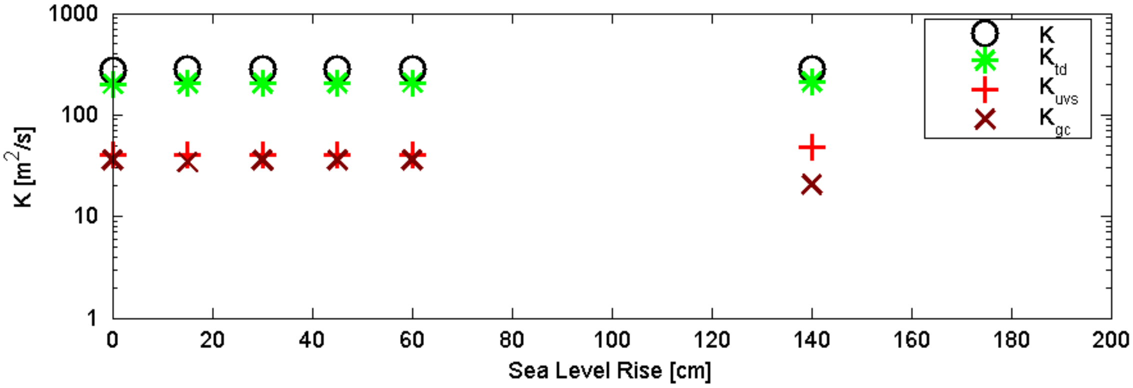


Figure 8.4-38 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 4, extending from Point Richmond to Bluff Point, for the October 13, 2002 through November 10, 2002 analysis period.





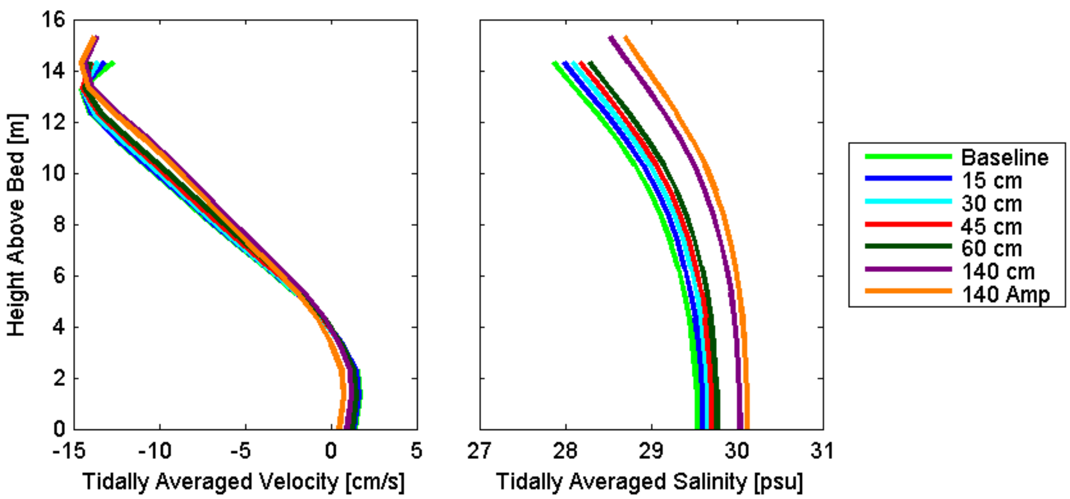


Figure 8.4-39 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 5, located at the Richmond-San Rafael Bridge, for the July 15, 2002 through August 13, 2002 analysis period.

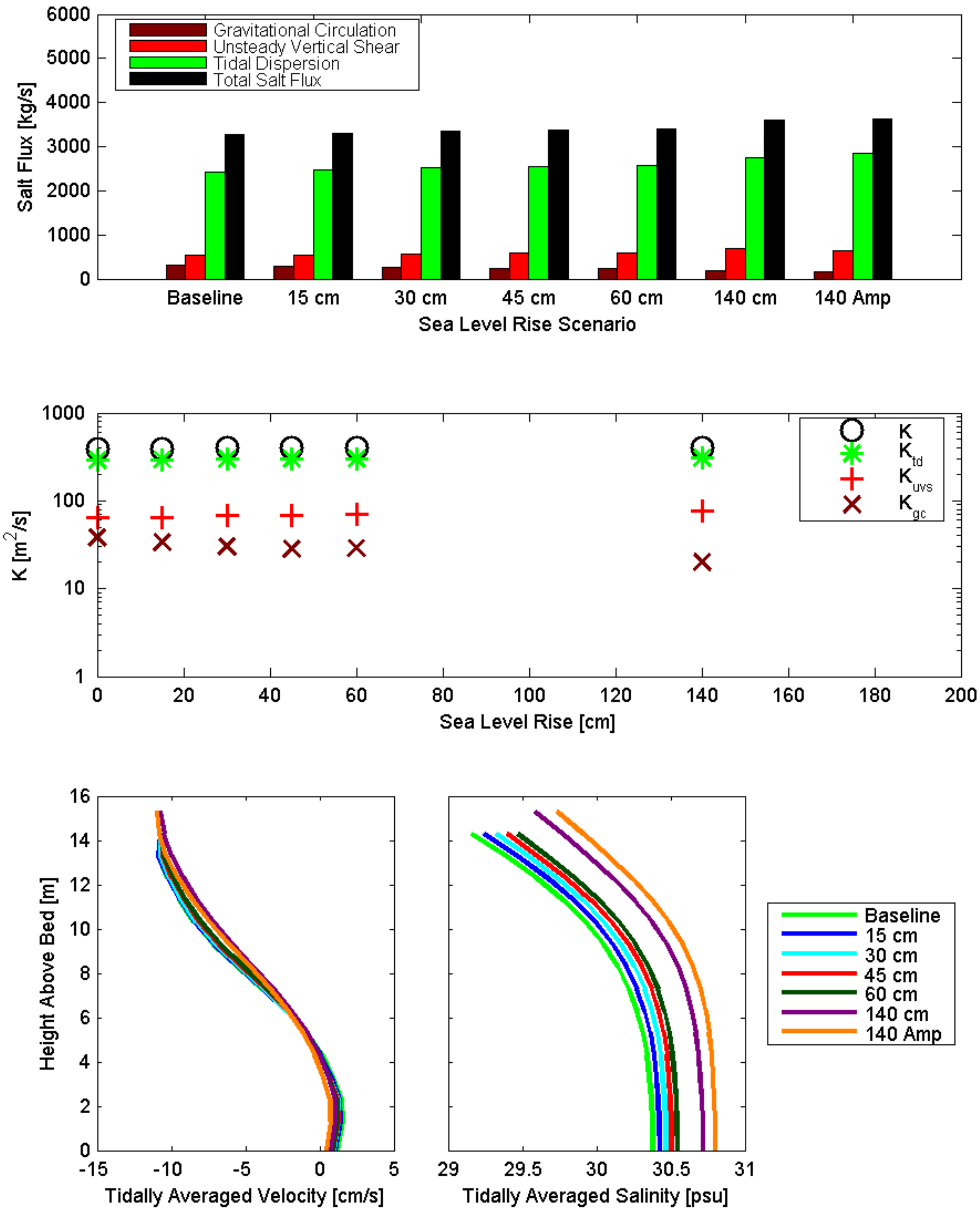


Figure 8.4-40 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 5, at the Richmond-San Rafael Bridge, for the October 13, 2002 through November 10, 2002 analysis period.

8.4.2 San Pablo Bay Cross-Sections

Dispersion coefficients and salt fluxes were estimated at the six cross-sections in San Pablo Bay (cross-section 6 to cross-section 11) shown in Figure 8.3-1. In Figure 8.4-41 through **Error! Reference source not found.**, analysis results are provided for each cross-section that summarize the dispersion analysis at that location for a given analysis period. The top panel shows the contributions of individual processes to dispersive salt flux (advective salt flux is not shown) for each SLR scenario. The second type of figure shows the overall dispersion coefficient (K), the portion of the dispersion coefficient associated with gravitational circulation (K_{gc}), the portion of the dispersion coefficient associated with unsteady vertical shear dispersion processes (K_{uvs}), and the portion of the dispersion coefficient associated with tidal dispersion processes (K_{td}) for each SLR scenario. The bottom panel shows the period averaged velocity profile and salinity profile at the deepest point in the cross-section for each SLR scenario.

The dispersion coefficients are generally large in San Pablo Bay. Tidal dispersion processes are the most important salt intrusion processes at all cross-sections in San Pablo Bay for both analysis periods. Gravitational circulation and unsteady vertical shear dispersion are both substantial at all locations in San Pablo Bay. The dispersive salt fluxes increase with sea level rise due to increased salinity in San Pablo Bay. However, the dispersion coefficients show little variability with SLR at most cross-sections indicating minimal changes in local mixing processes during low Delta outflow conditions. The velocity profiles show clear evidence of gravitational circulation in San Pablo Bay during both analysis periods but do not change substantially with sea level rise. The predicted stratification in San Pablo Bay is substantial during both analysis periods. Though salinity increases with sea level rise, the predicted stratification (e.g. difference between bottom and surface salinity) shows little variability with sea level rise.

The results in San Pablo Bay are generally consistent with the flux analysis of sea level rise scenarios performed as part of the DRMS studies (Gross et al., 2007b). However the DRMS scenarios were for higher Delta outflow and, therefore, showed a larger contribution of gravitational circulation and unsteady vertical shear. The flux analysis of various Delta outflows performed as part of the DRMS studies (Gross et al., 2007a) was consistent with these results for low Delta outflows and indicated that gravitational circulation becomes the dominant salt intrusion process at high Delta outflows.

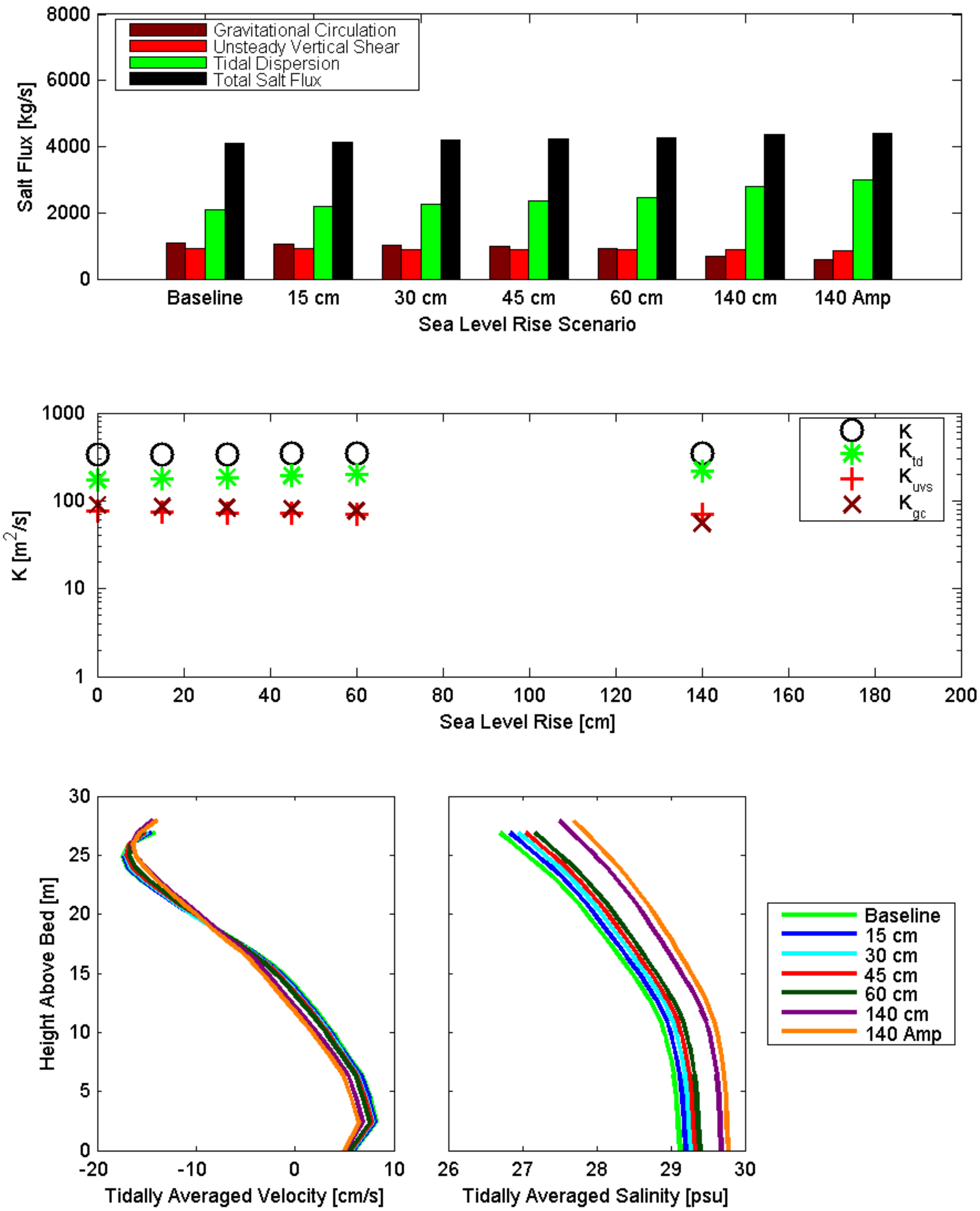


Figure 8.4-41 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 6, extending from Point San Pablo to Point San Pedro, for the July 15, 2002 through August 12, 2002 analysis period.

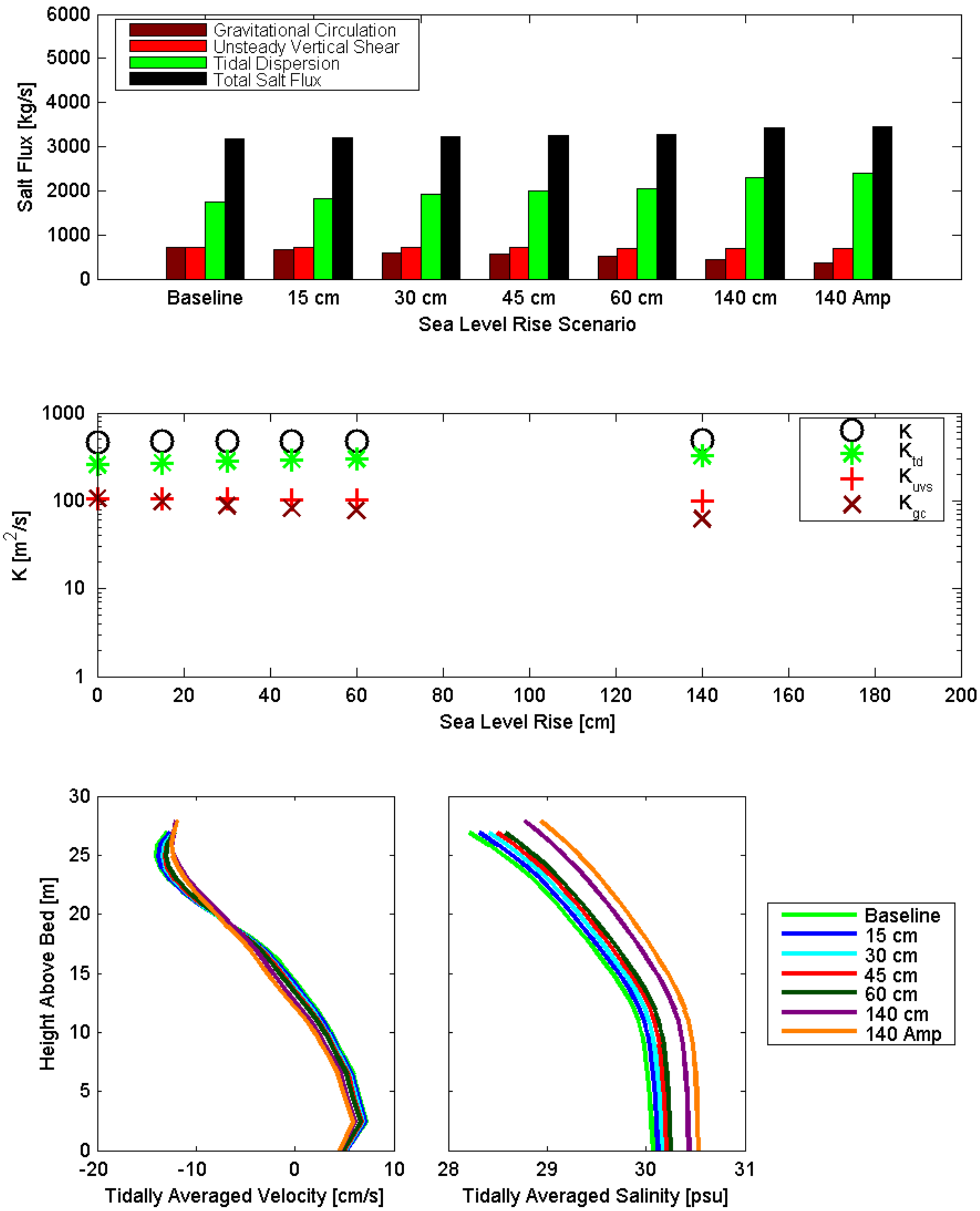


Figure 8.4-42 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 6, extending from Point San Pablo to Point San Pedro, for the October 13, 2002 through November 10, 2002 analysis period..

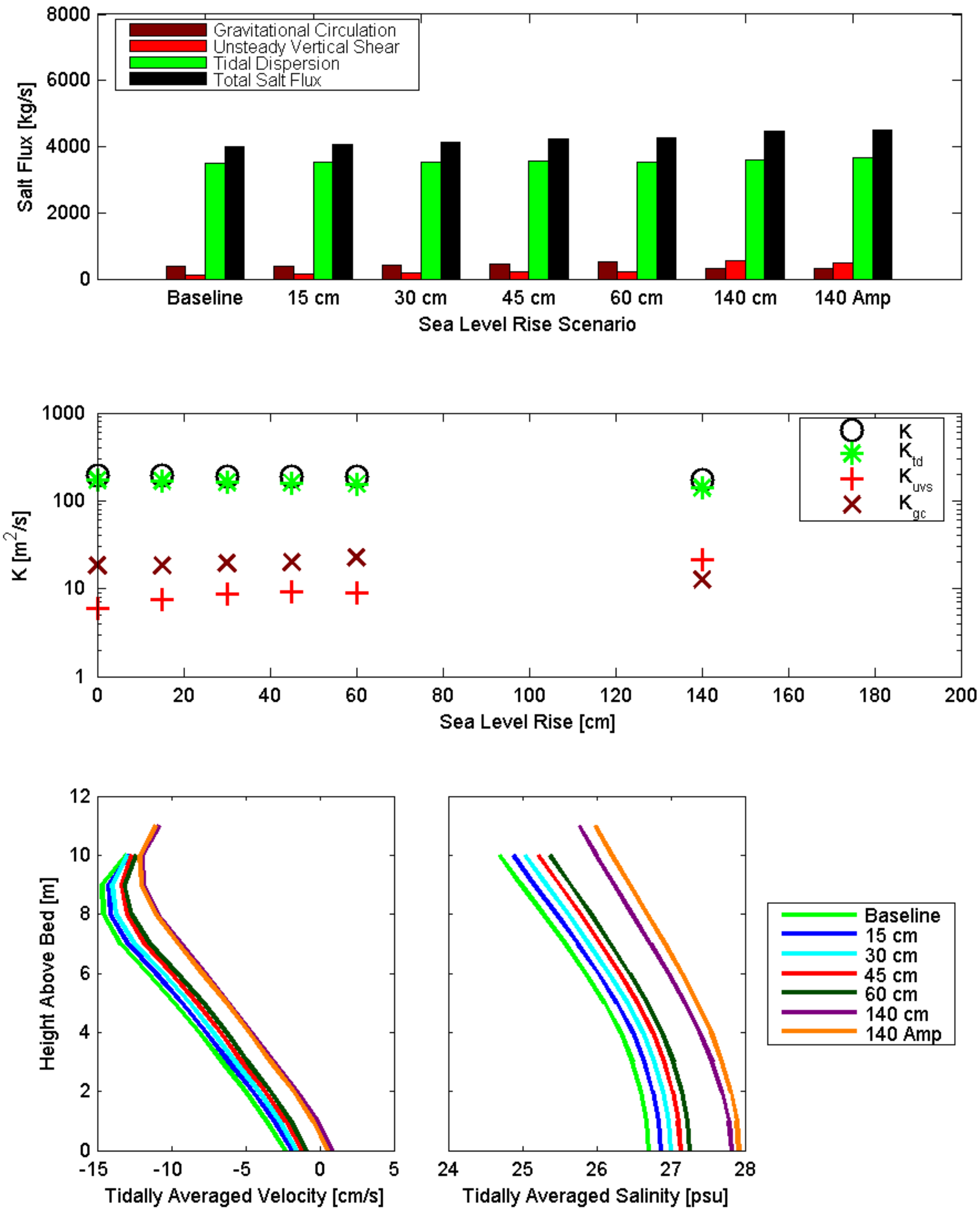


Figure 8.4-43 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 7, extending from Pinole Point to Tolay Creek, for the July 15, 2002 through August 12, 2002 analysis period.

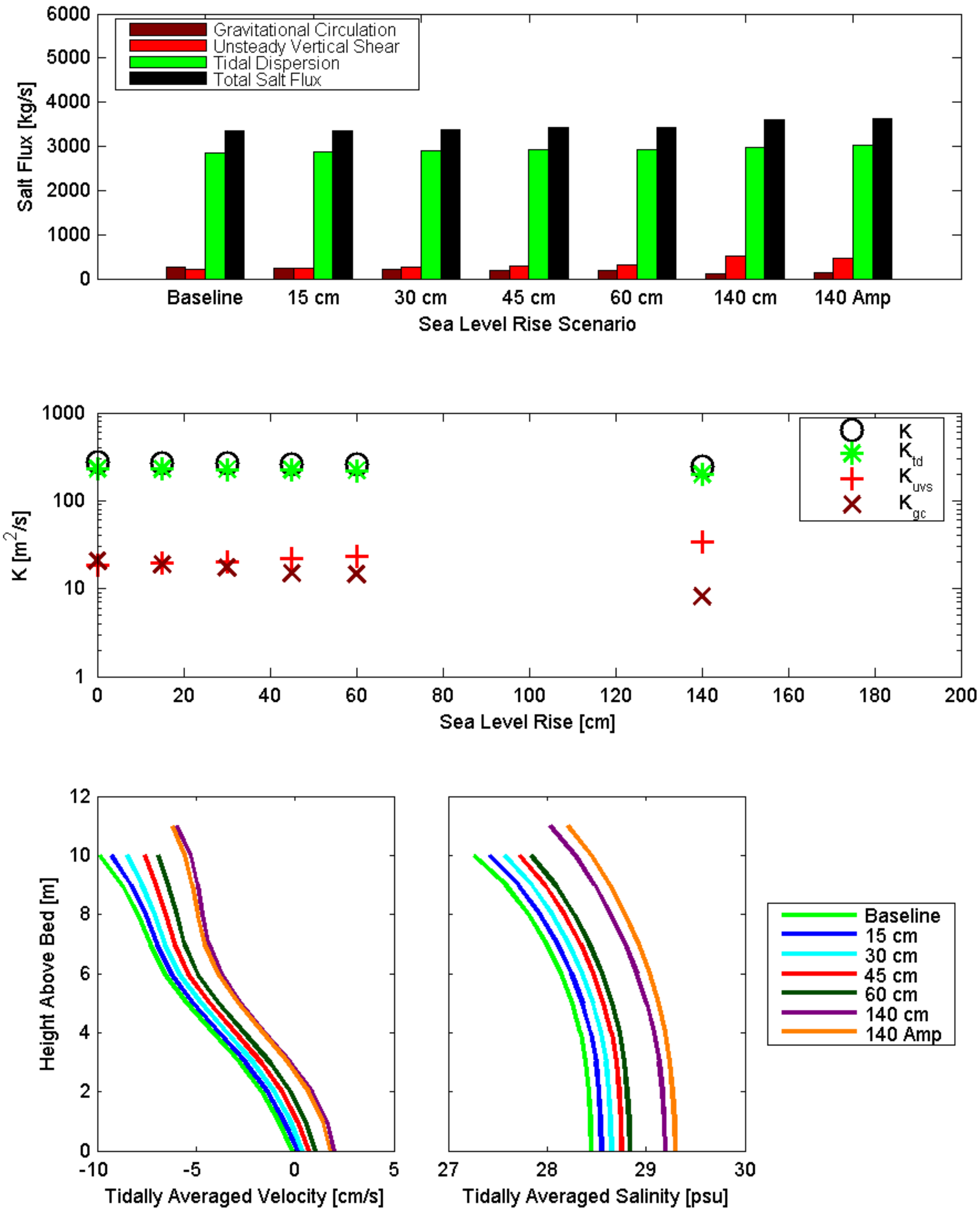


Figure 8.4-44 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 7, extending from Pinole Point to Tolay Creek, for the October 13, 2002 through November 10, 2002 analysis period.

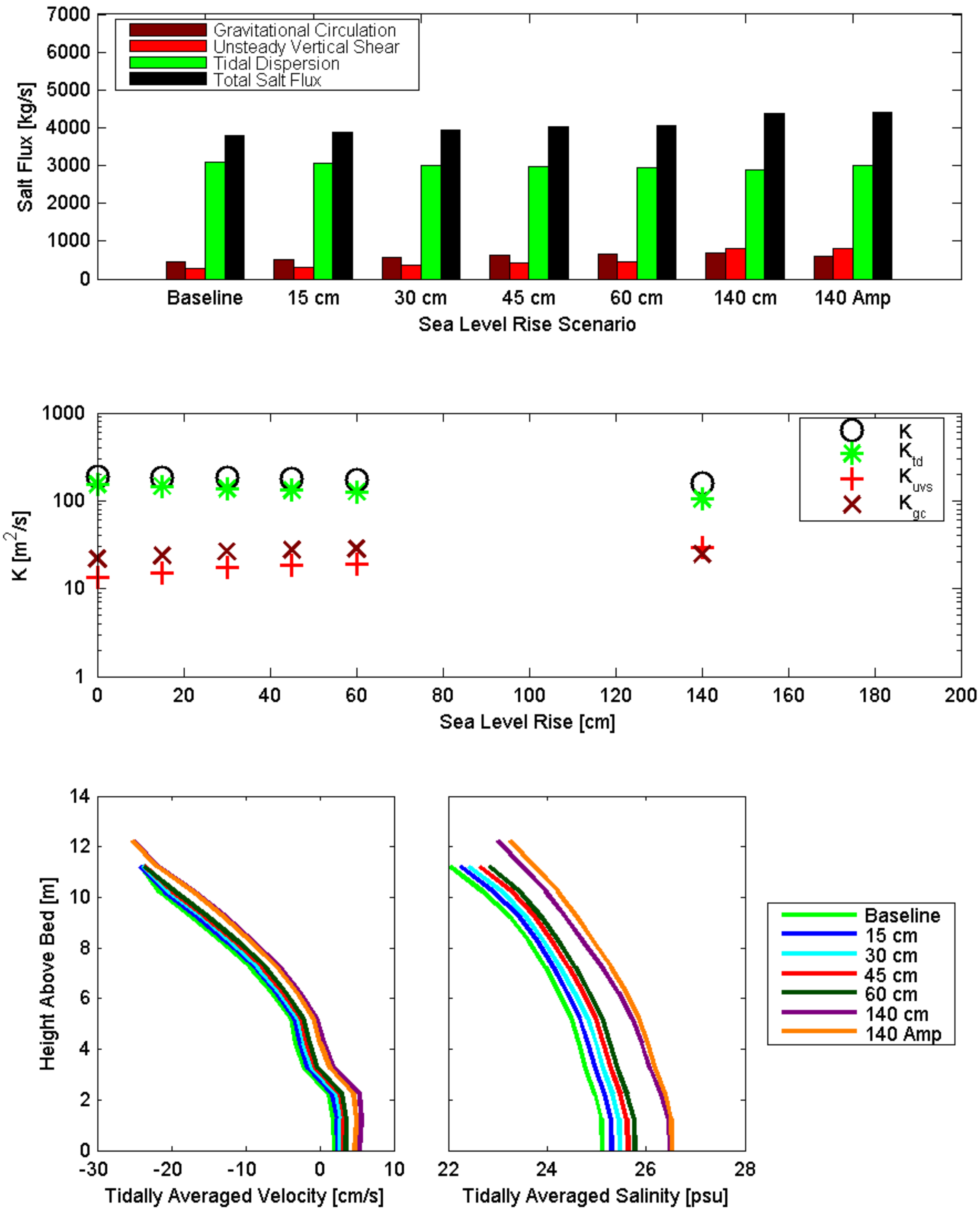


Figure 8.4-45 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 8, extending from Wilson Point to Sonoma Creek, for the July 15, 2002 through August 12, 2002 analysis period.

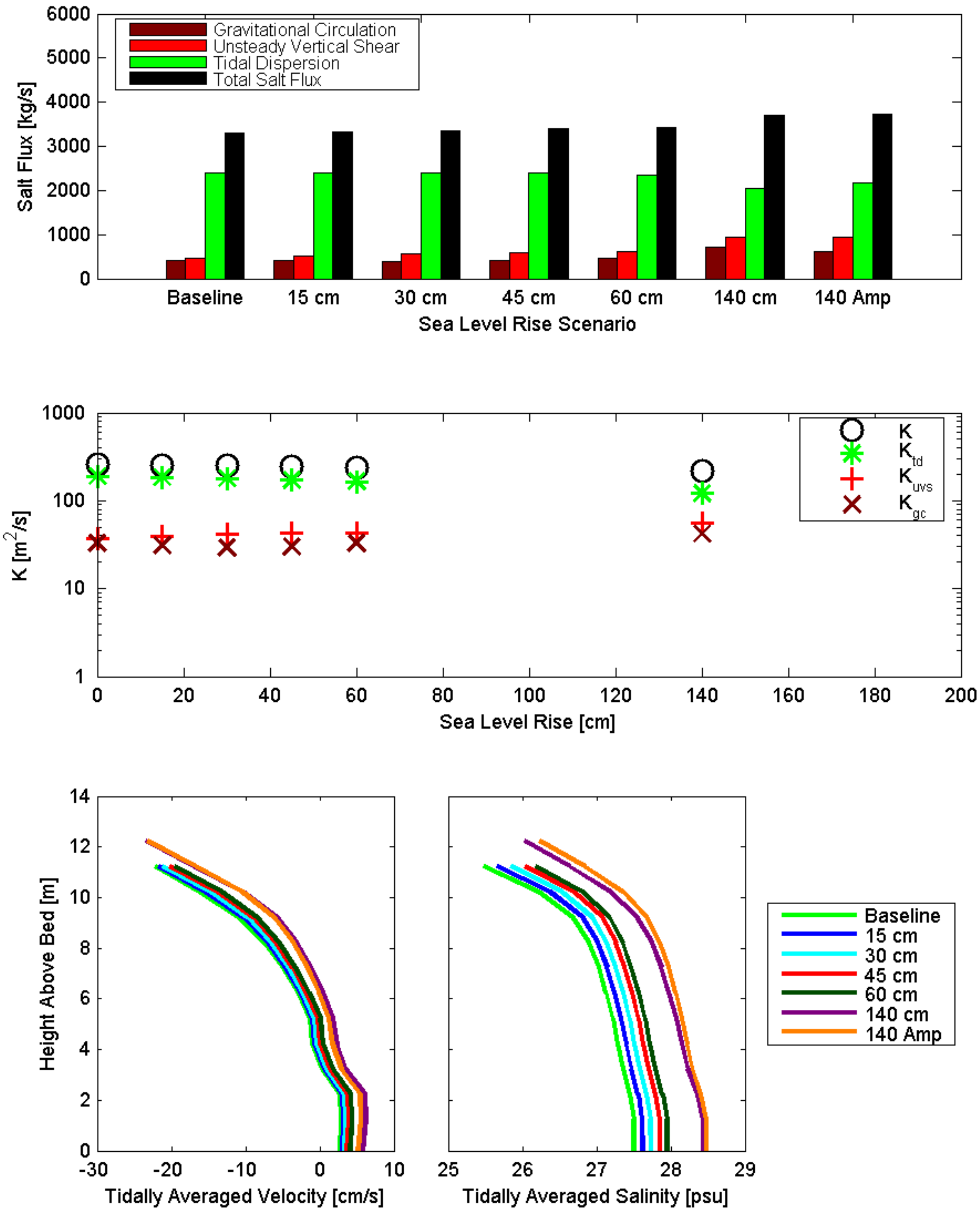


Figure 8.4-46 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 8, extending from Wilson Point to Sonoma Creek, for the October 13, 2002 through November 10, 2002 analysis period.

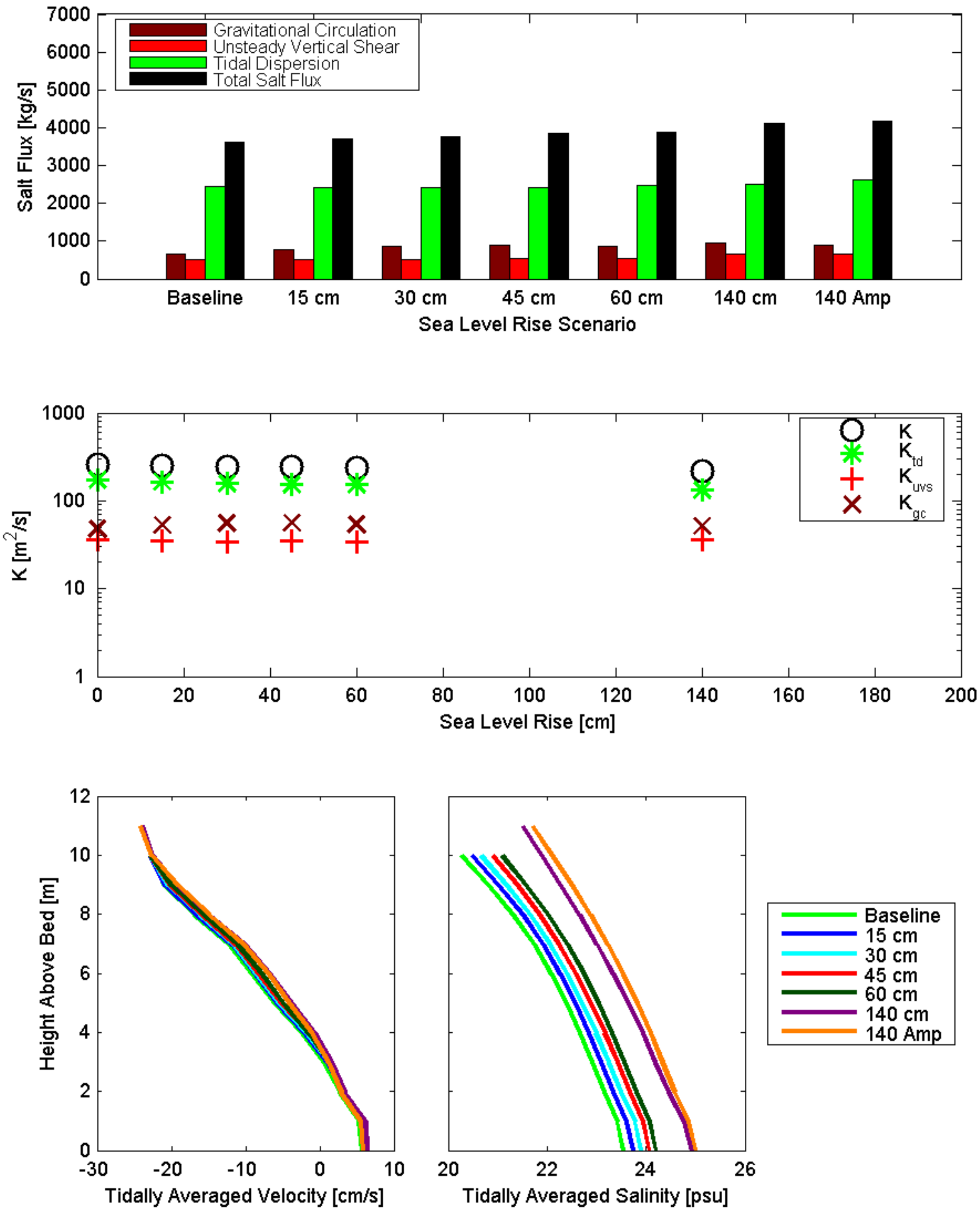


Figure 8.4-47 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 9, extending from Hercules to Mare Island for the July 15, 2002 through August 12, 2002 analysis period.

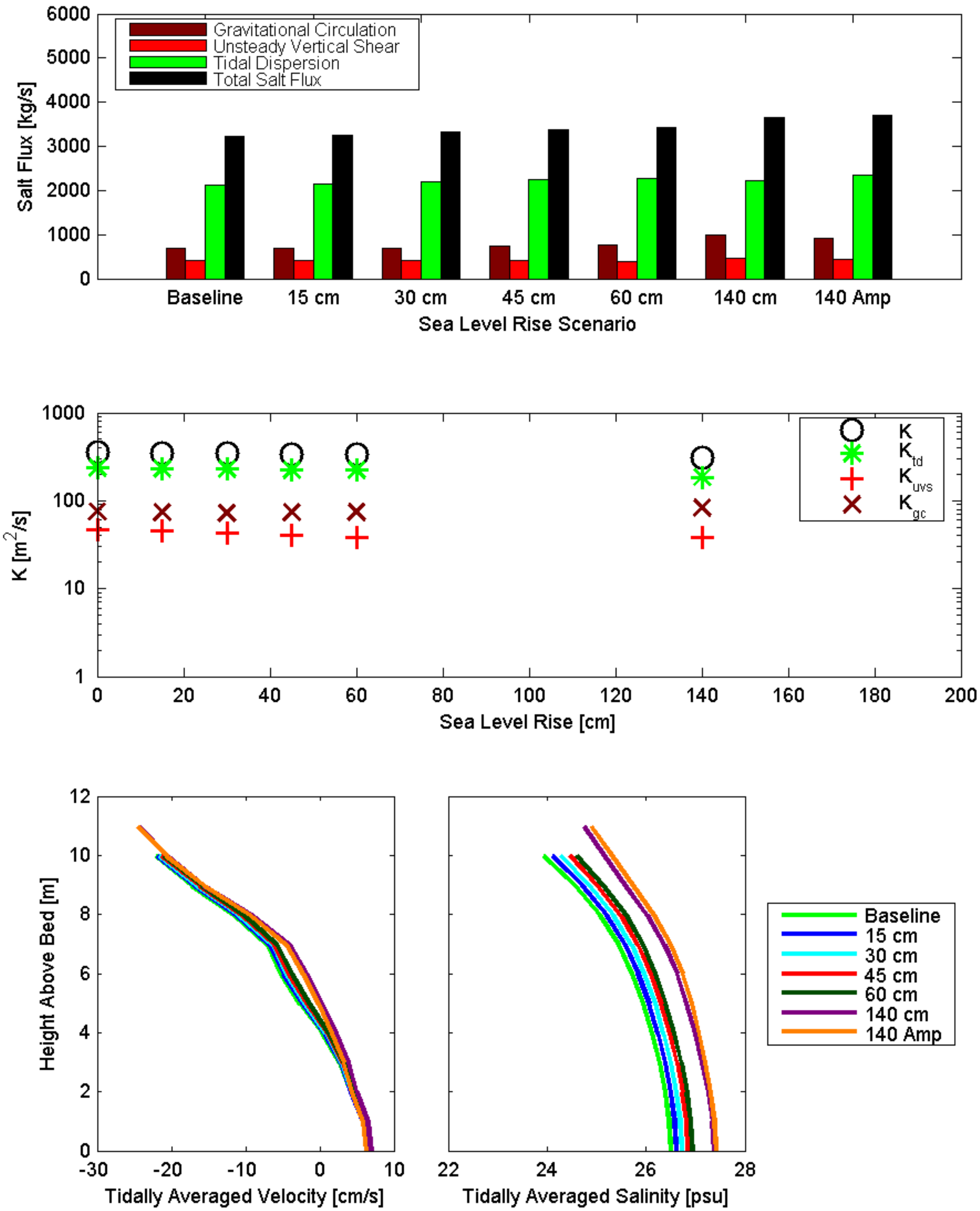


Figure 8.4-48 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 9, extending from Hercules to Mare Island, for the October 13, 2002 through November 10, 2002 analysis period.

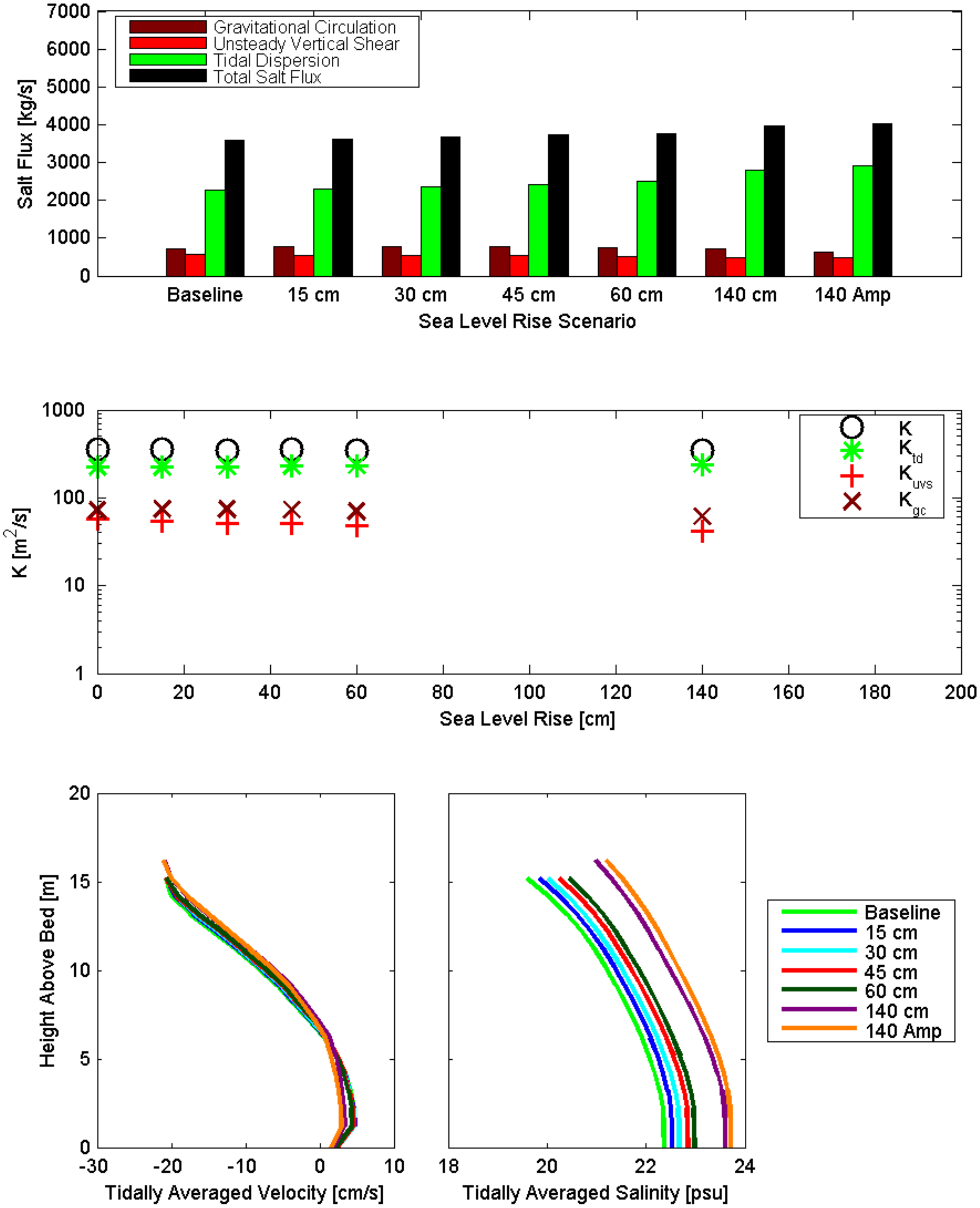


Figure 8.4-49 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 10, extending from Davis Point to Mare Island, for the July 15, 2002 through August 12, 2002 analysis period.

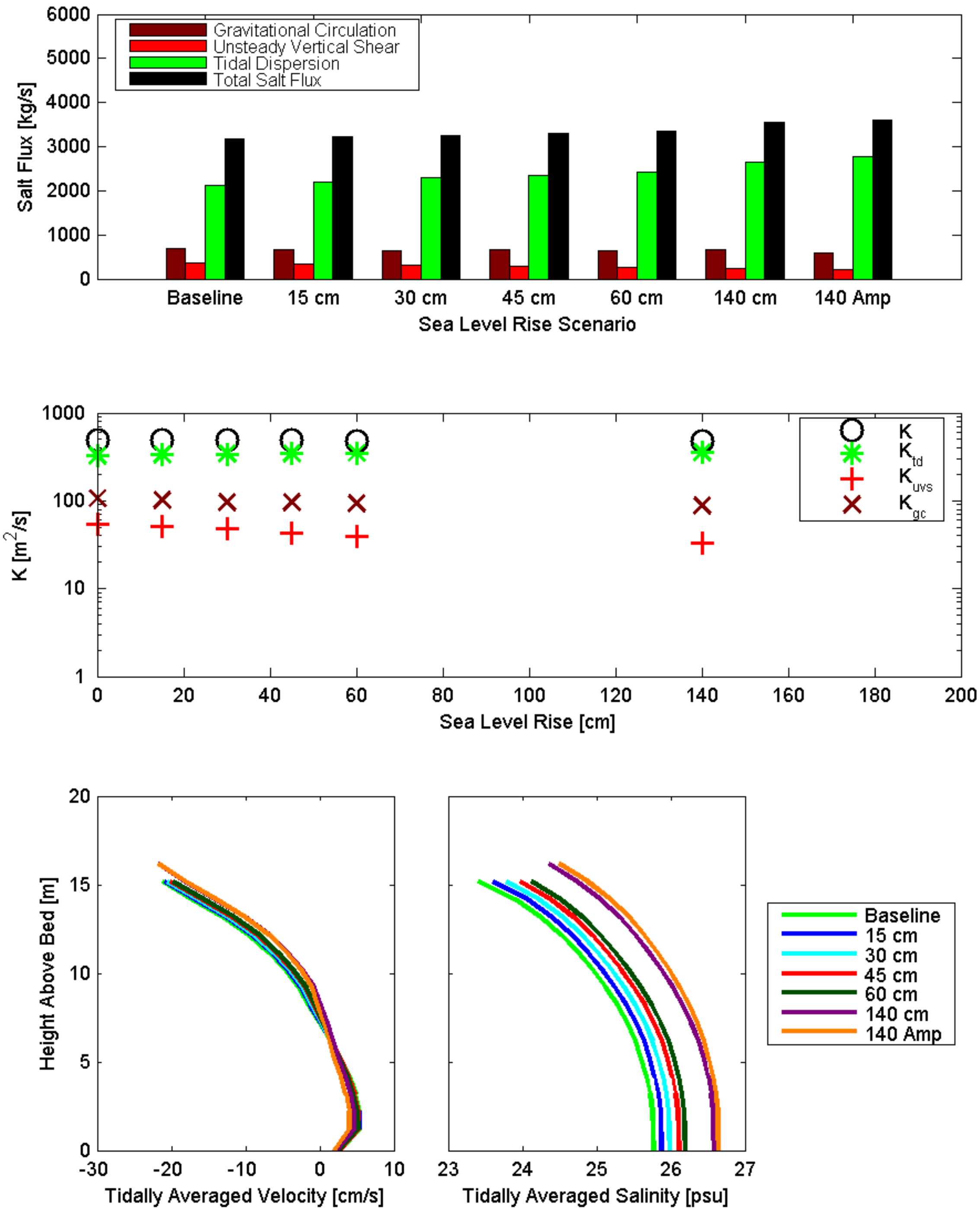


Figure 8.4-50 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 10, extending from Davis Point to Mare Island, for the October 13, 2002 through November 10, 2002 analysis period.

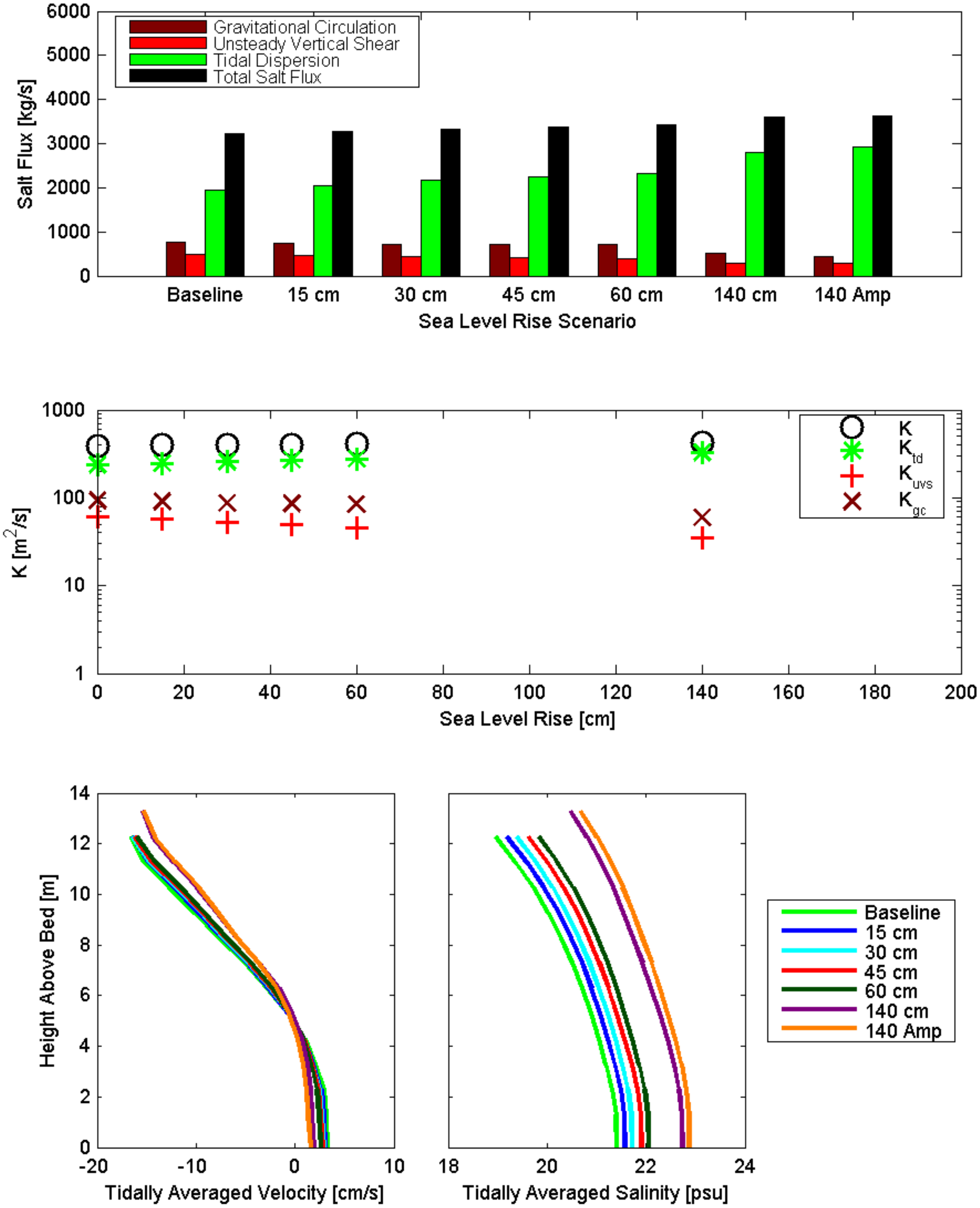


Figure 8.4-51 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 11, extending from Selby to Mare Island Strait, for the July 15, 2002 through August 12, 2002 analysis period.

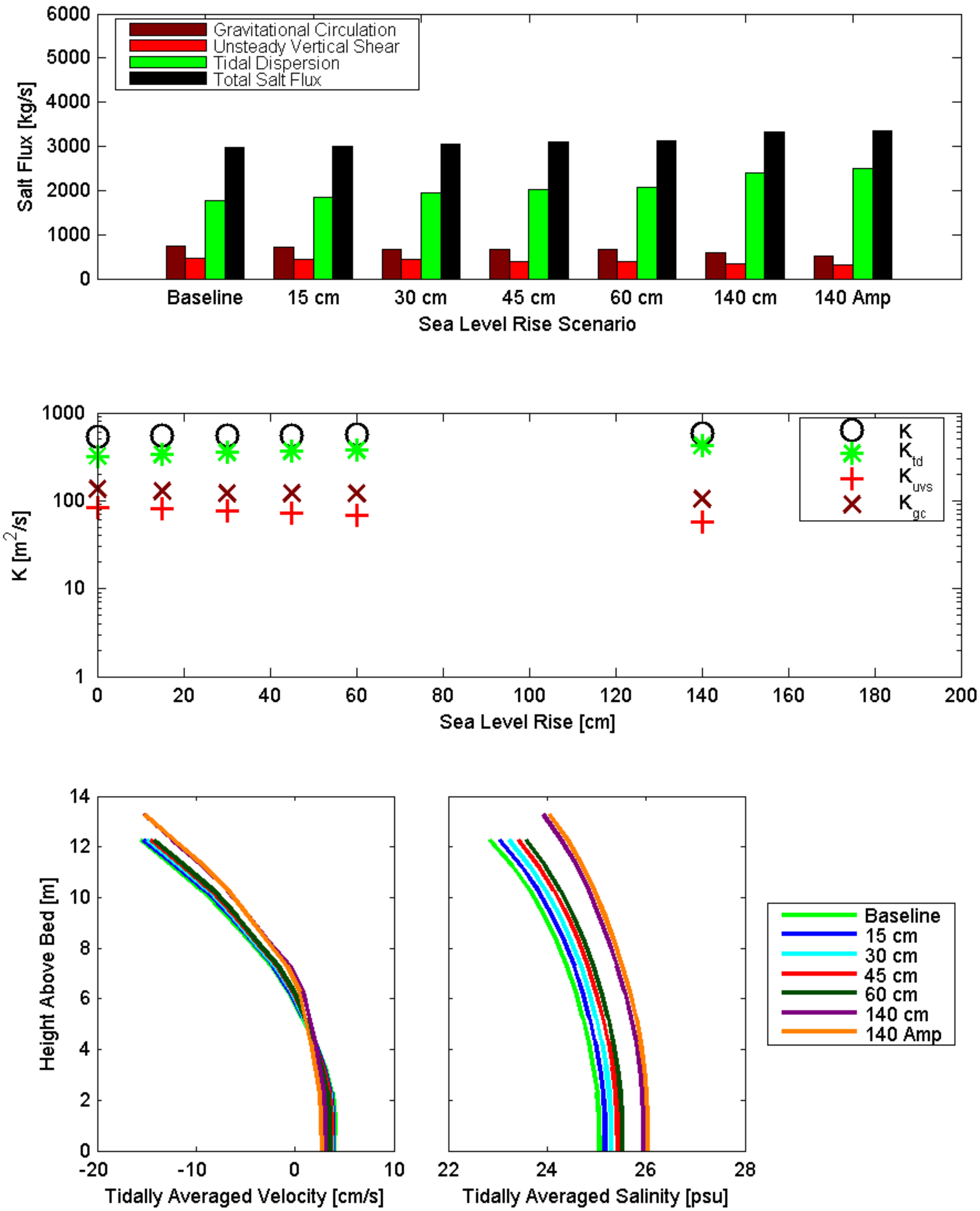


Figure 8.4-52 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 11, extending from Selby to Mare Island Strait, for the October 13, 2002 through November 10, 2002 analysis period.

8.4.3 Carquinez Strait Cross-Sections

Dispersion coefficients and salt fluxes were estimated at the five cross-sections in Carquinez Strait (cross-section 12 to cross-section 17) shown in Figure 8.3-1. In Figure 8.4-53 through Figure 8.4-64, analysis results are provided for each cross-section that summarize the dispersion analysis at that location for a given analysis period. The top panel shows the contributions of individual processes to dispersive salt flux (advective salt flux is not shown) for each SLR scenario. The second type of figure shows the overall dispersion coefficient (K), the portion of the dispersion coefficient associated with gravitational circulation (K_{gc}), the portion of the dispersion coefficient associated with unsteady vertical shear dispersion processes (K_{uvs}), and the portion of the dispersion coefficient associated with tidal dispersion processes (K_{td}) for each SLR scenario. The bottom panel shows the period averaged velocity profile and salinity profile at the deepest point in the cross-section for each SLR scenario.

The dispersion coefficients are generally large in Carquinez Strait. Tidal dispersion processes are the most important salt intrusion processes in cross-sections in the seaward (western) portion of Carquinez Strait for both analysis periods. Gravitational circulation and unsteady vertical shear dispersion are both substantial for all cross-sections in Carquinez Strait and increase with landward (up estuary) distance to become the dominant mechanisms at cross-section 17, located at the Benicia Bridge. The dispersive salt fluxes increase with sea level rise due to increased salinity in Carquinez Strait. However, the dispersion coefficients show little variability with SLR at most cross-sections indicating small changes in the strength of local mixing processes during low Delta outflow conditions. The relative contributions of individual salt flux mechanisms do change substantially with sea level rise. For example, at cross-section 12, located at the Carquinez Bridge, the importance of tidal dispersion increases with sea level rise and the importance of gravitational circulation and unsteady vertical shear decreases with sea level rise. It is likely that both trends are explained by the substantial predicted increases in tidal prism at this location (Figure 8.4-17 and Figure 8.4-18). Increased tidal prism can decrease the effect of gravitational circulation and unsteady vertical shear because vertical mixing increases with increased tidal current speed, resulting in less stratification and less vertical shear in tidally averaged velocity. Figure 8.4-53 and Figure 8.4-54 show that both stratification and tidally averaged vertical shear decrease with increased sea level rise at cross-section 12. In contrast to the results at cross-section 12, at cross-section 17, located at the Benicia Bridge, gravitational circulation and unsteady vertical shear are the dominant salt intrusion mechanisms for all of the scenarios (Figure 8.4-63 and Figure 8.4-64). Vertical shear in the tidally averaged velocity and stratification remain roughly constant with sea level rise.

The results in Carquinez Strait are generally consistent with the flux analysis of sea level rise scenarios performed as part of the DRMS studies (Gross et al., 2007b). However the DRMS scenarios were for higher Delta outflow and, therefore, showed a larger contribution of gravitational circulation and unsteady vertical shear. The flux analysis of various Delta outflows performed as part of the DRMS studies (Gross et al., 2007a) was consistent with these results for low Delta outflows and indicated that gravitational circulation becomes the dominant salt intrusion process at moderate to high Delta outflows.

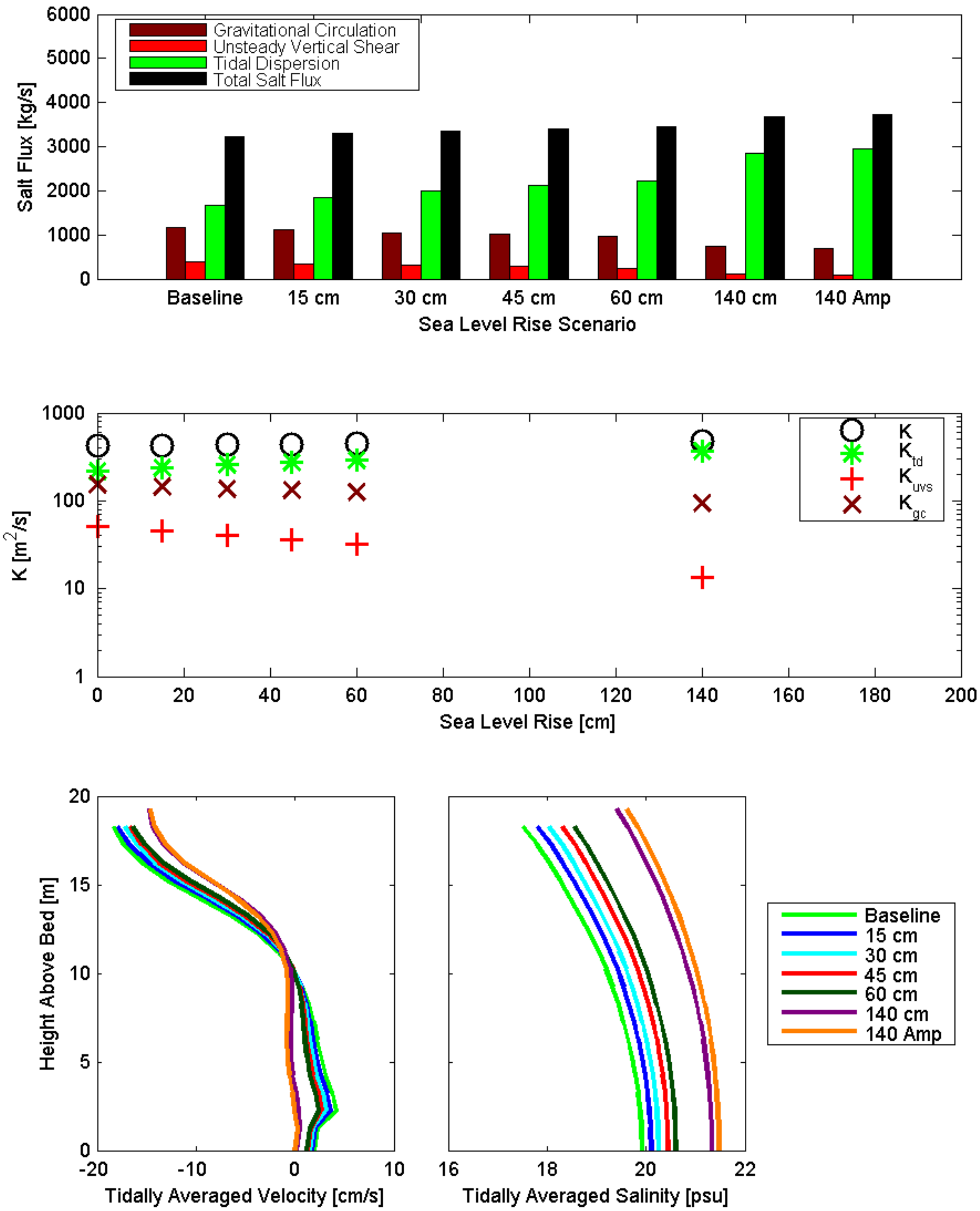


Figure 8.4-53 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 12, located at the Carquinez Bridge, for the July 15, 2002 through August 12, 2002 analysis period.

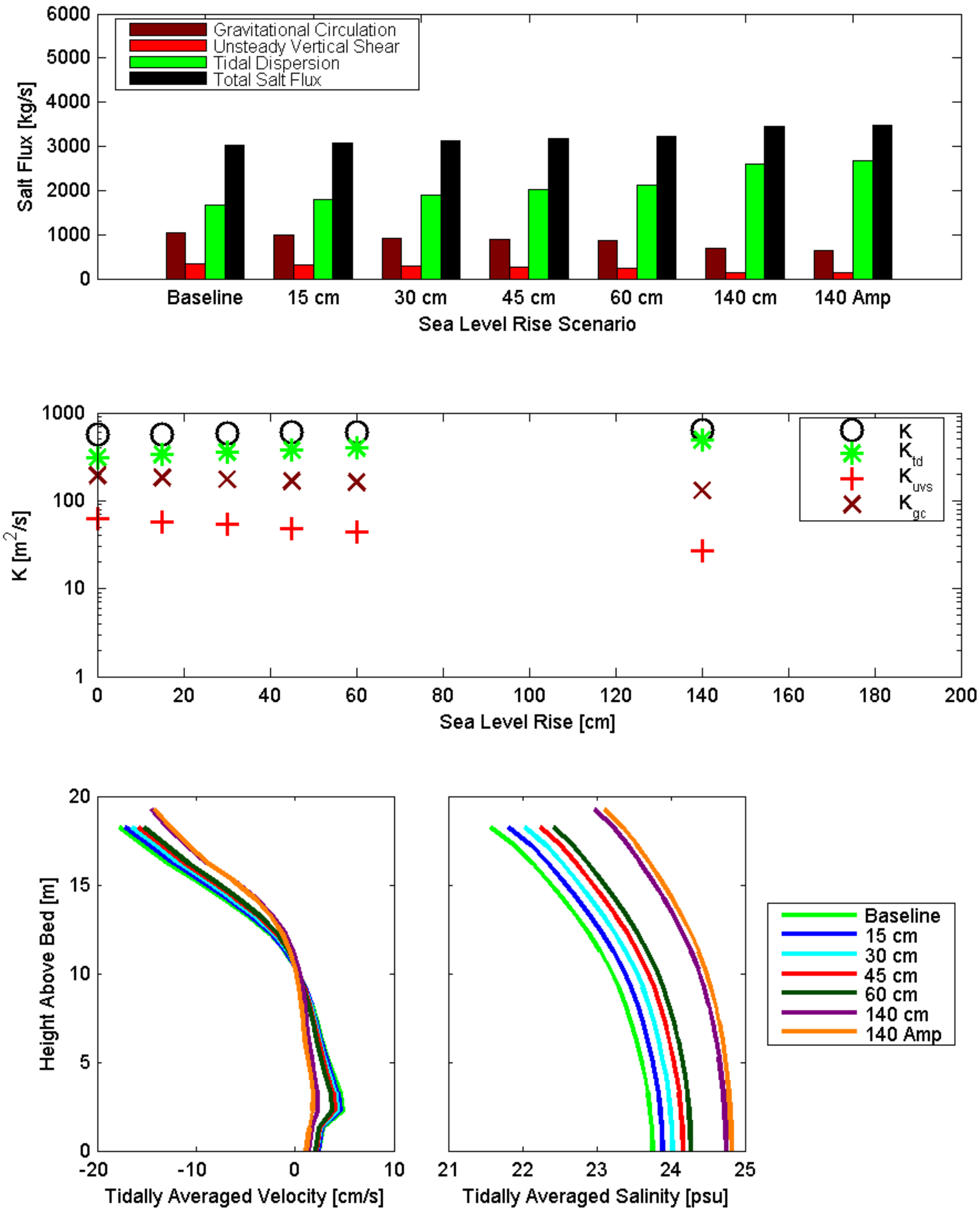


Figure 8.4-54 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 12, located at the Carquinez Bridge, for the October 13, 2002 through November 10, 2002 analysis period.

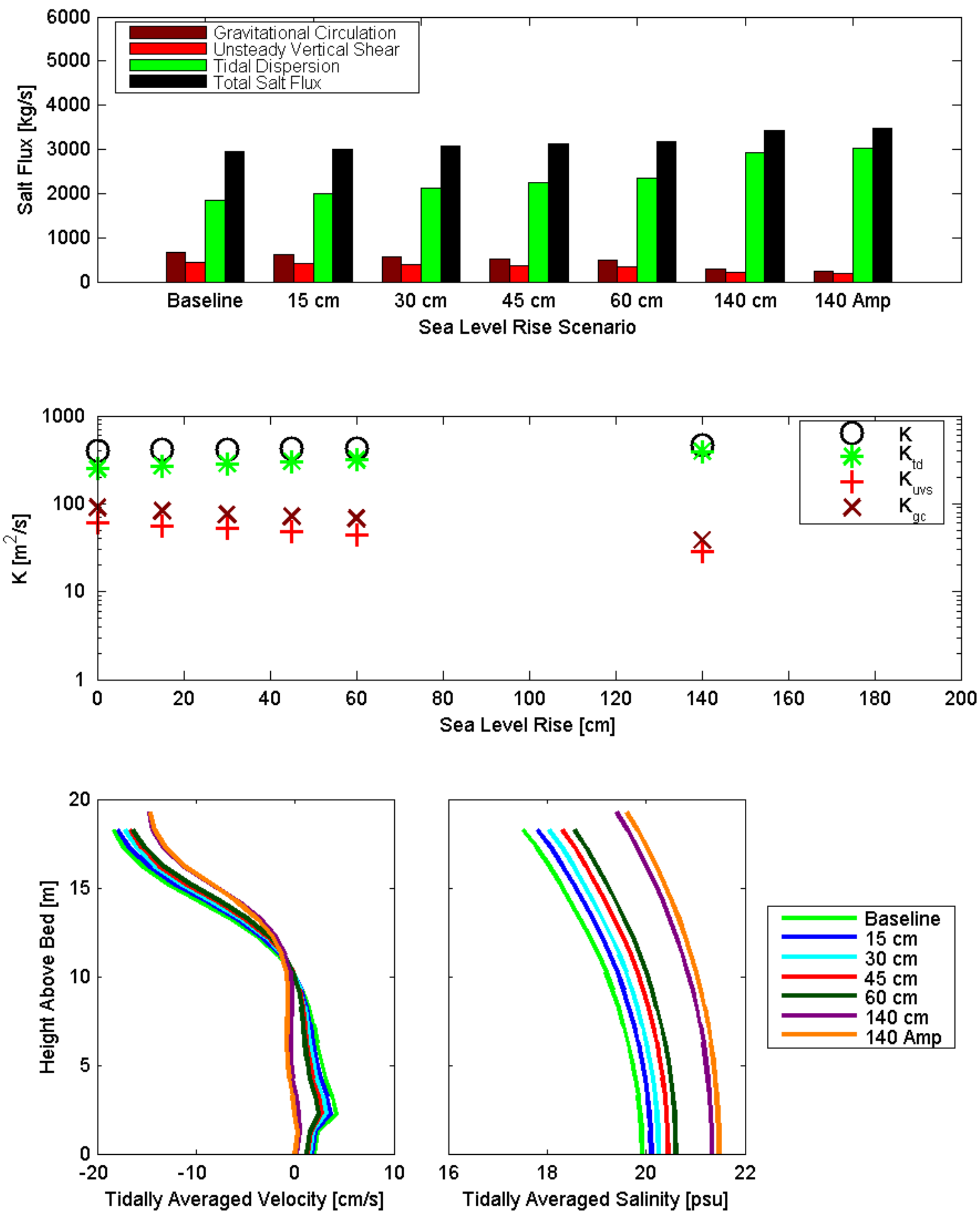


Figure 8.4-55 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 13, extending from Crockett to Elliot Cove, for the July 15, 2002 through August 12, 2002 analysis period.

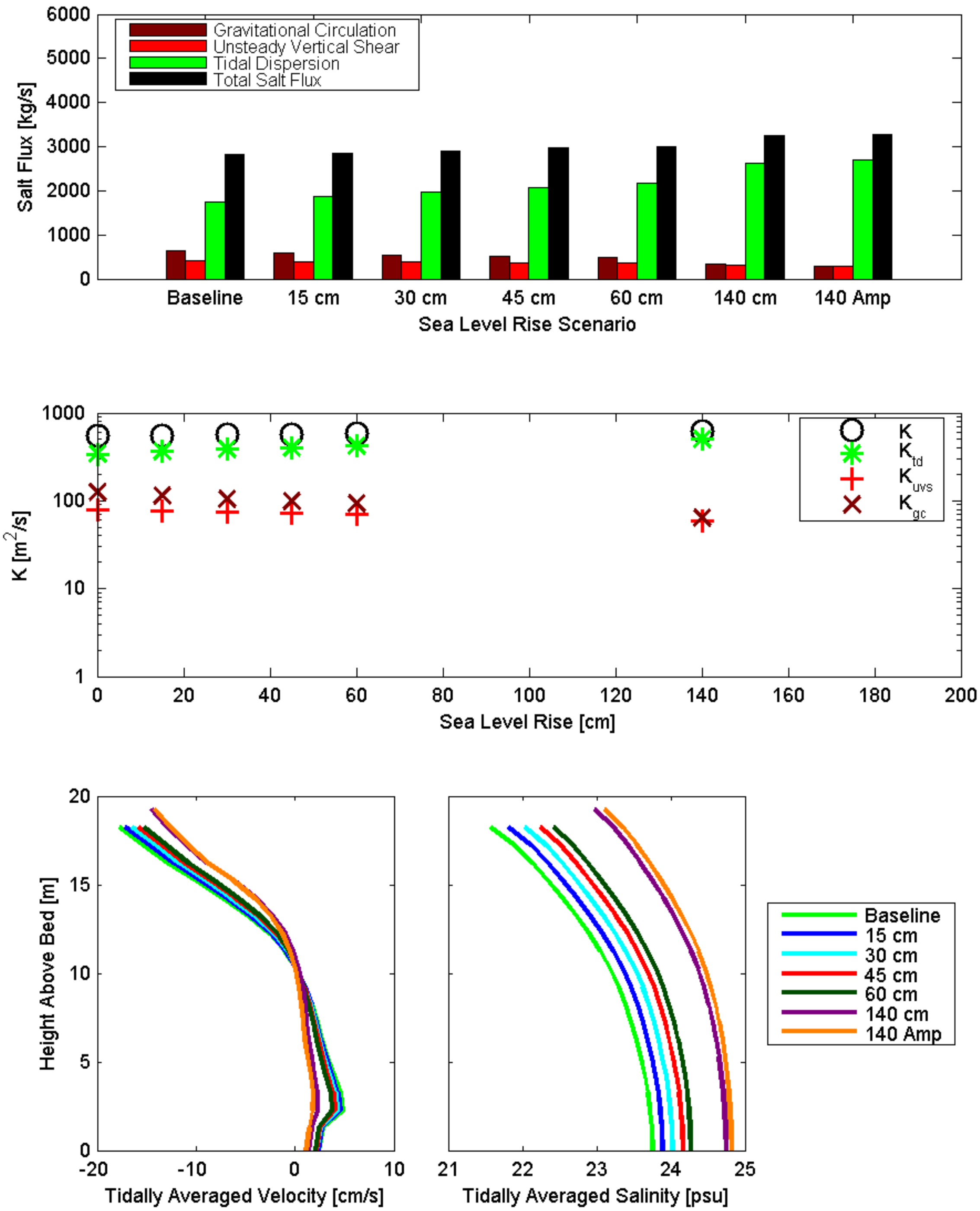


Figure 8.4-56 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 13, extending from Crockett to Elliot Cove, for the October 13, 2002 through November 10, 2002 analysis period.

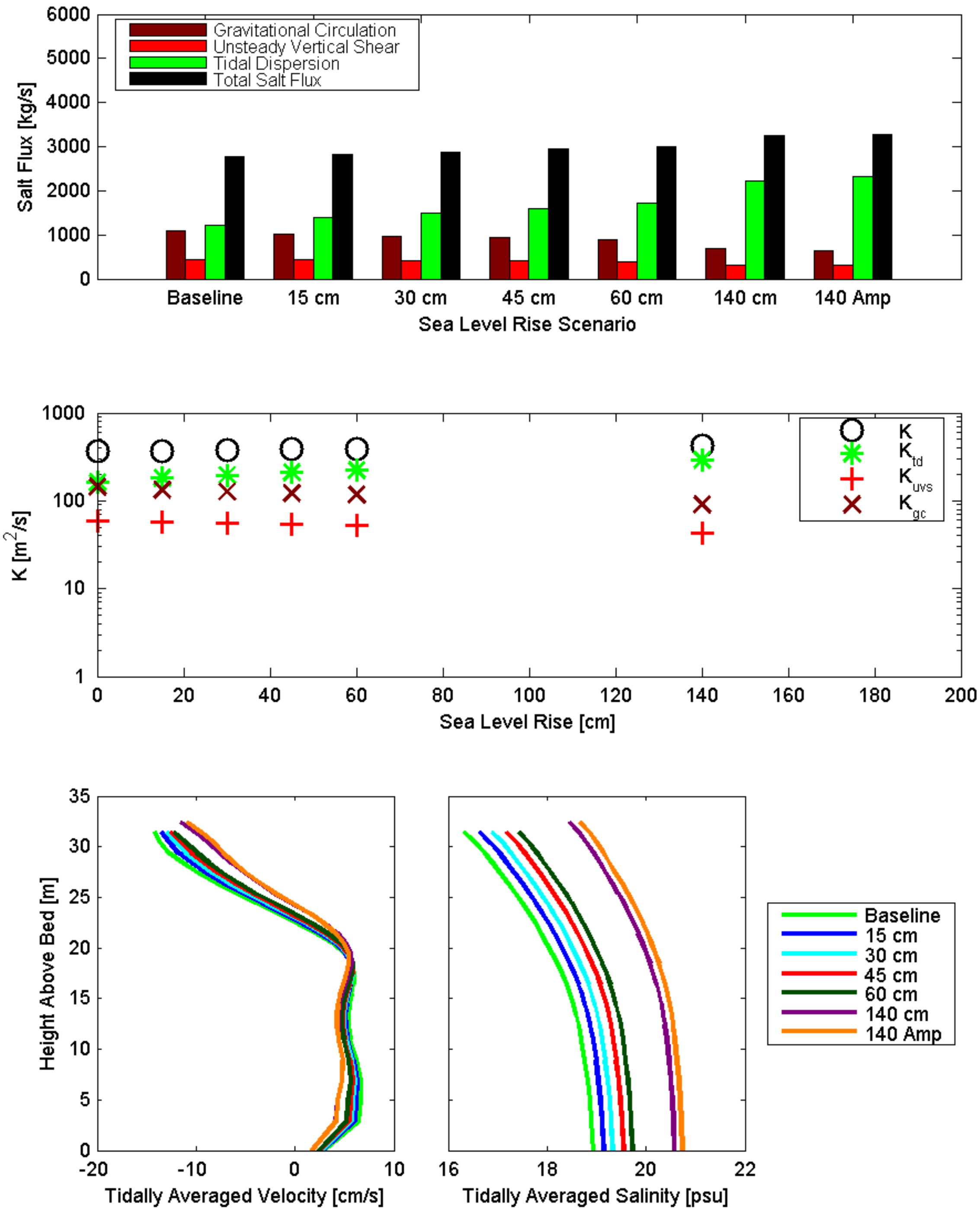


Figure 8.4-57 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 14, extending from Crockett to Dillon Point, for the July 15, 2002 through August 12, 2002 analysis period.

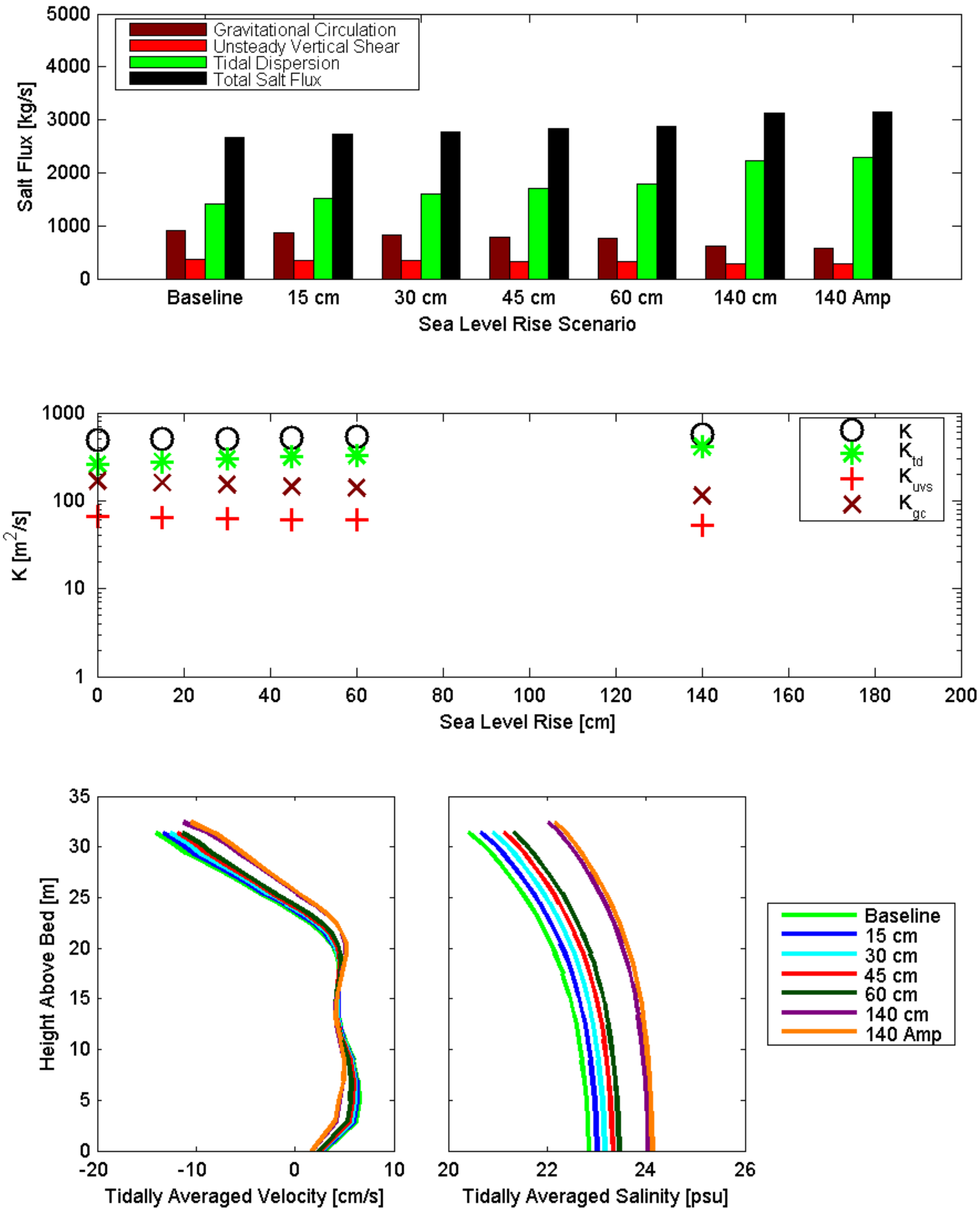


Figure 8.4-58 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 14, extending from Crockett to Dillon Point, for the October 13, 2002 through November 10, 2002 analysis period.

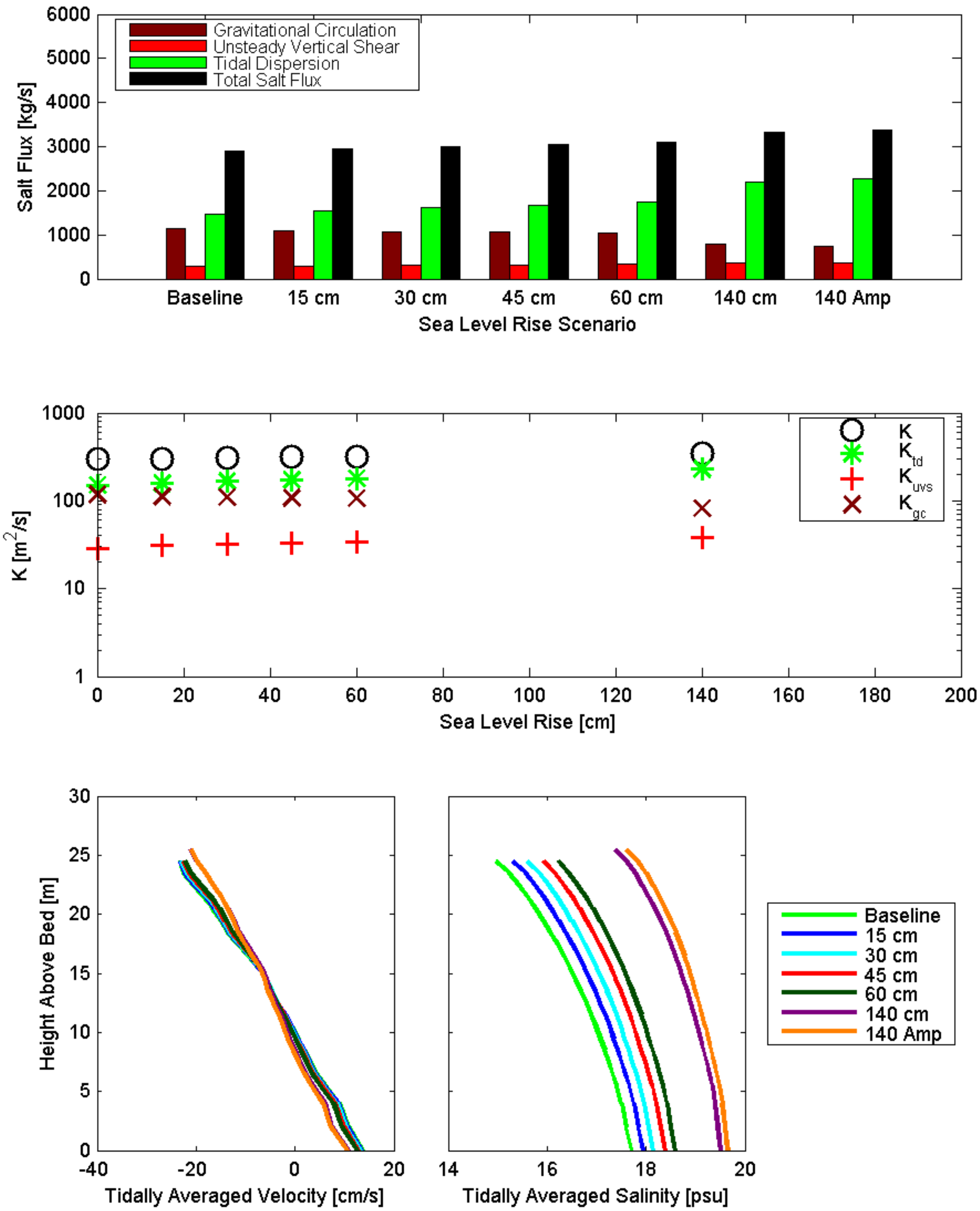


Figure 8.4-59 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 15, extending from Ozol to Benicia Point, for the July 15, 2002 through August 12, 2002 analysis period.

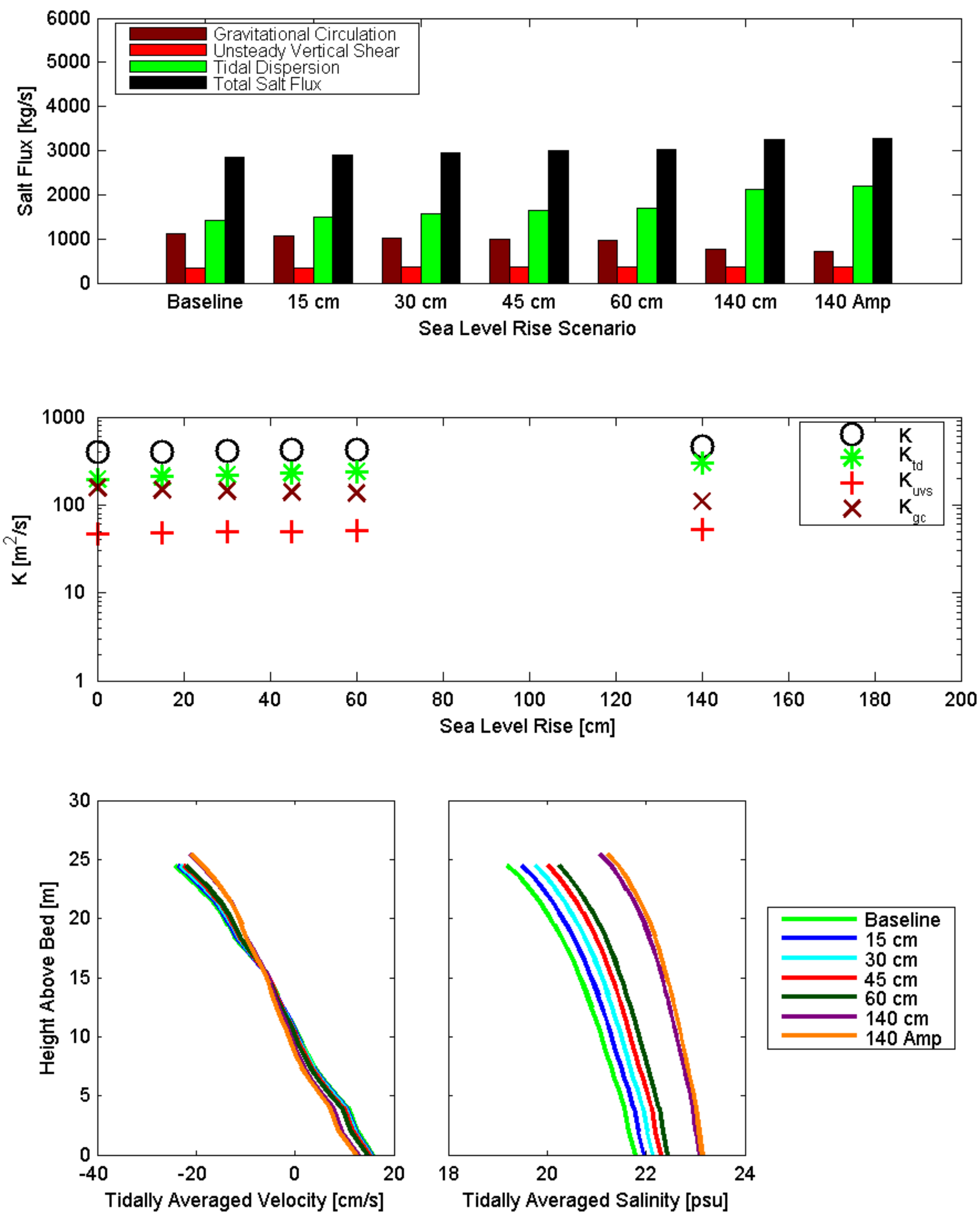


Figure 8.4-60 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 15, extending from Ozol to Benicia Point, for the October 13, 2002 through November 10 2002 analysis period.

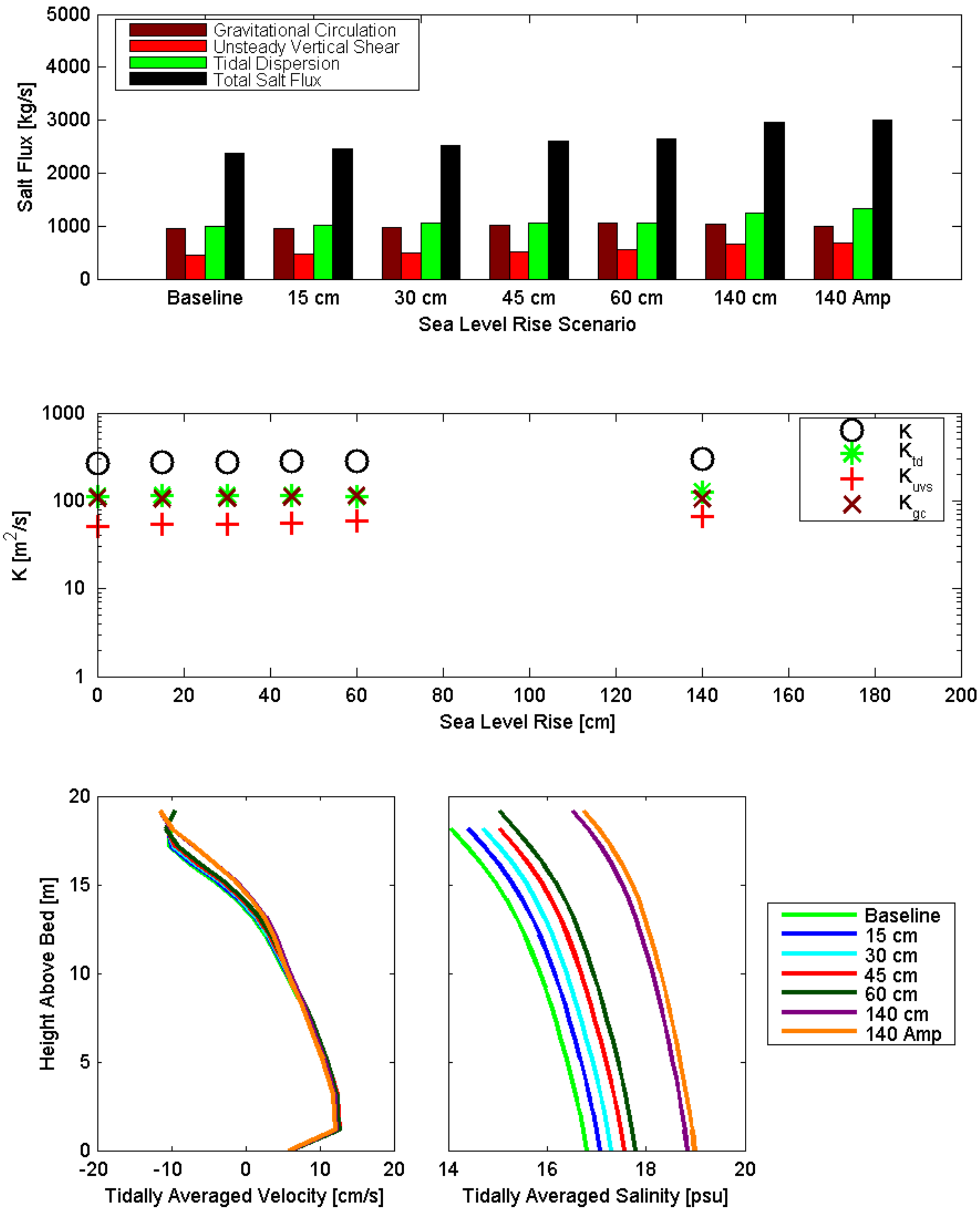


Figure 8.4-61 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 16, extending from Martinez to Benicia, for the July 15, 2002 through August 12, 2002 analysis period.

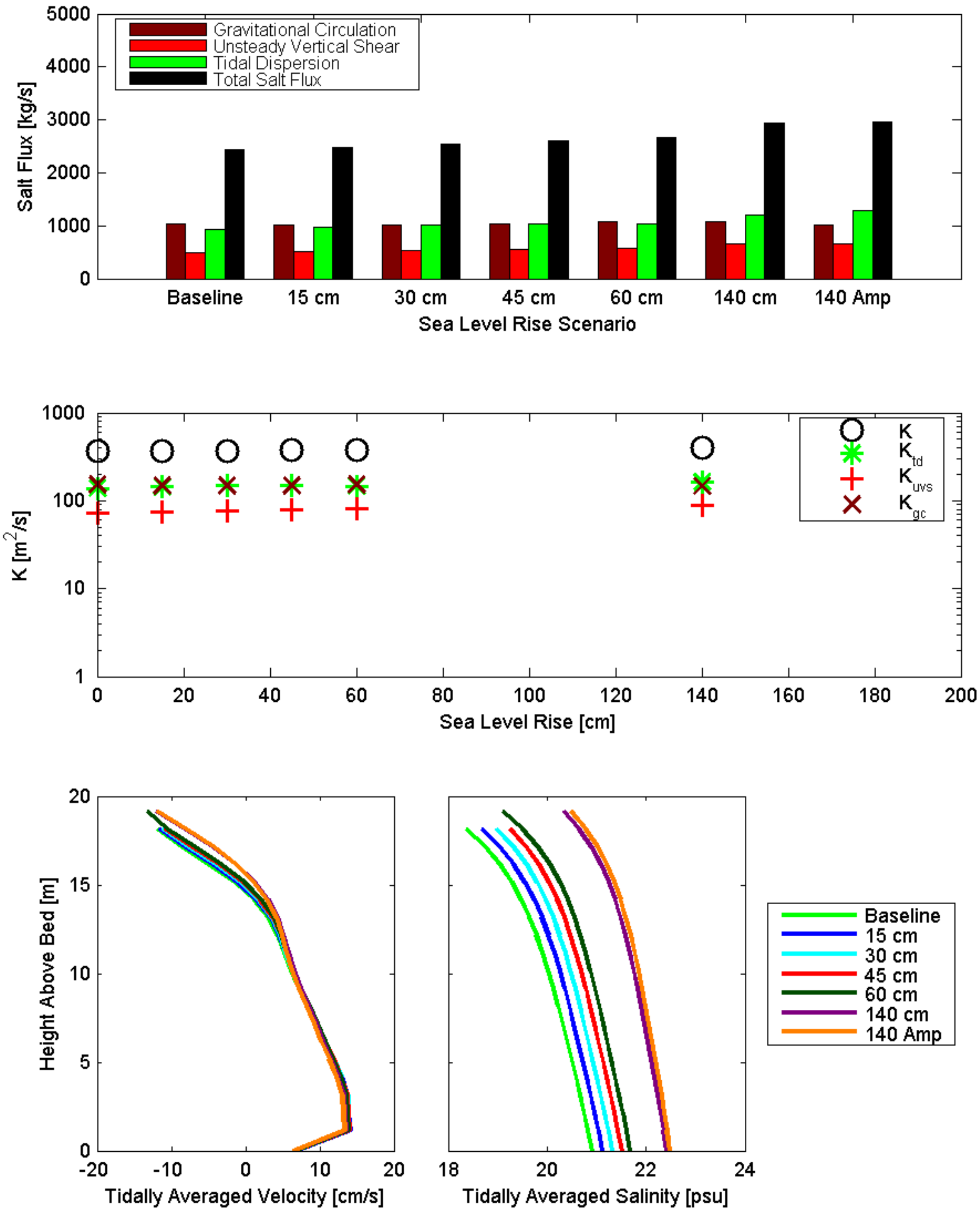


Figure 8.4-62 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 16, extending from Martinez to Benicia, for the October 13, 2002 through November 10, 2002 analysis period.

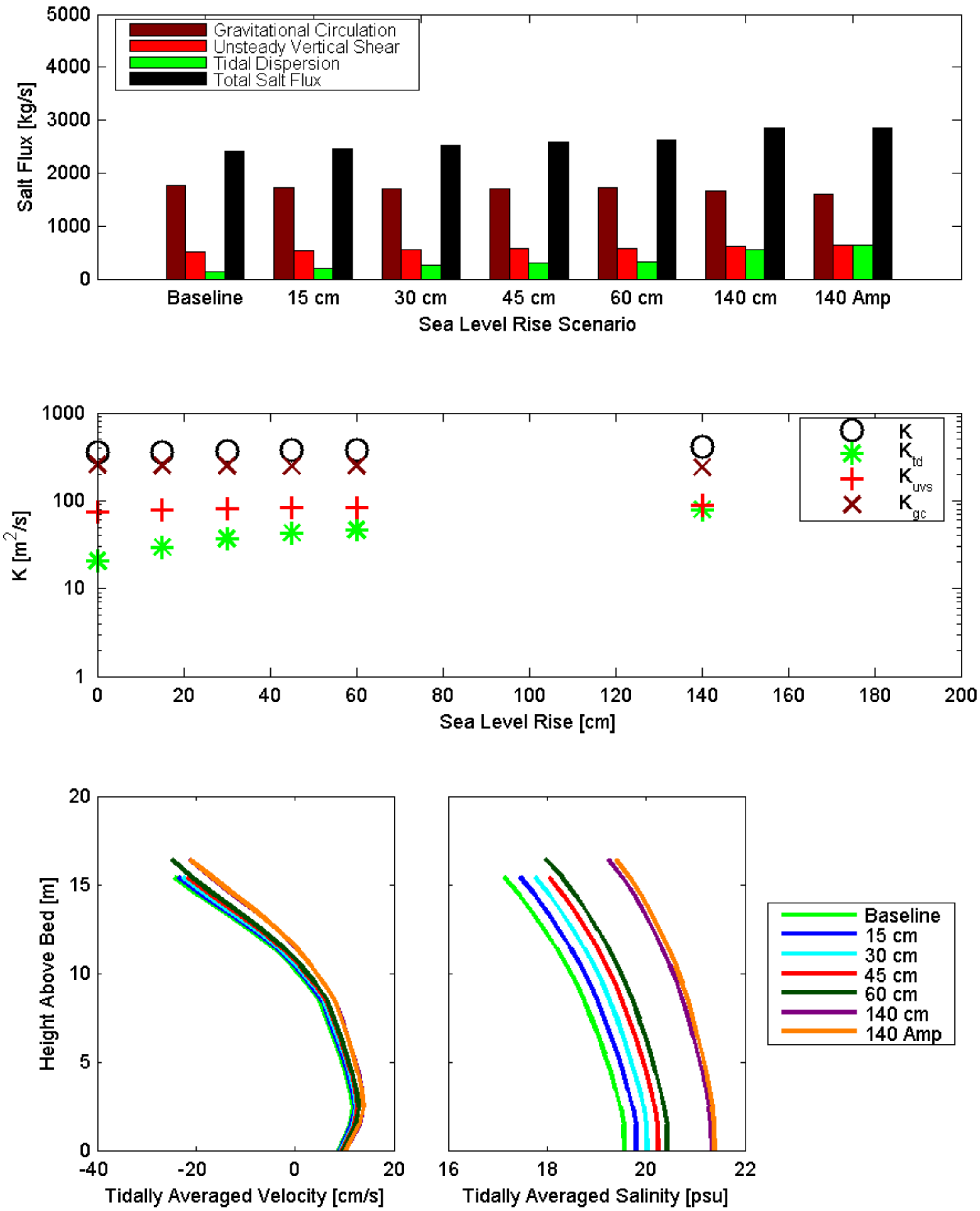


Figure 8.4-63 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 17, located at the Benicia Bridge, for the July 15, 2002 through August 12, 2002 analysis period.

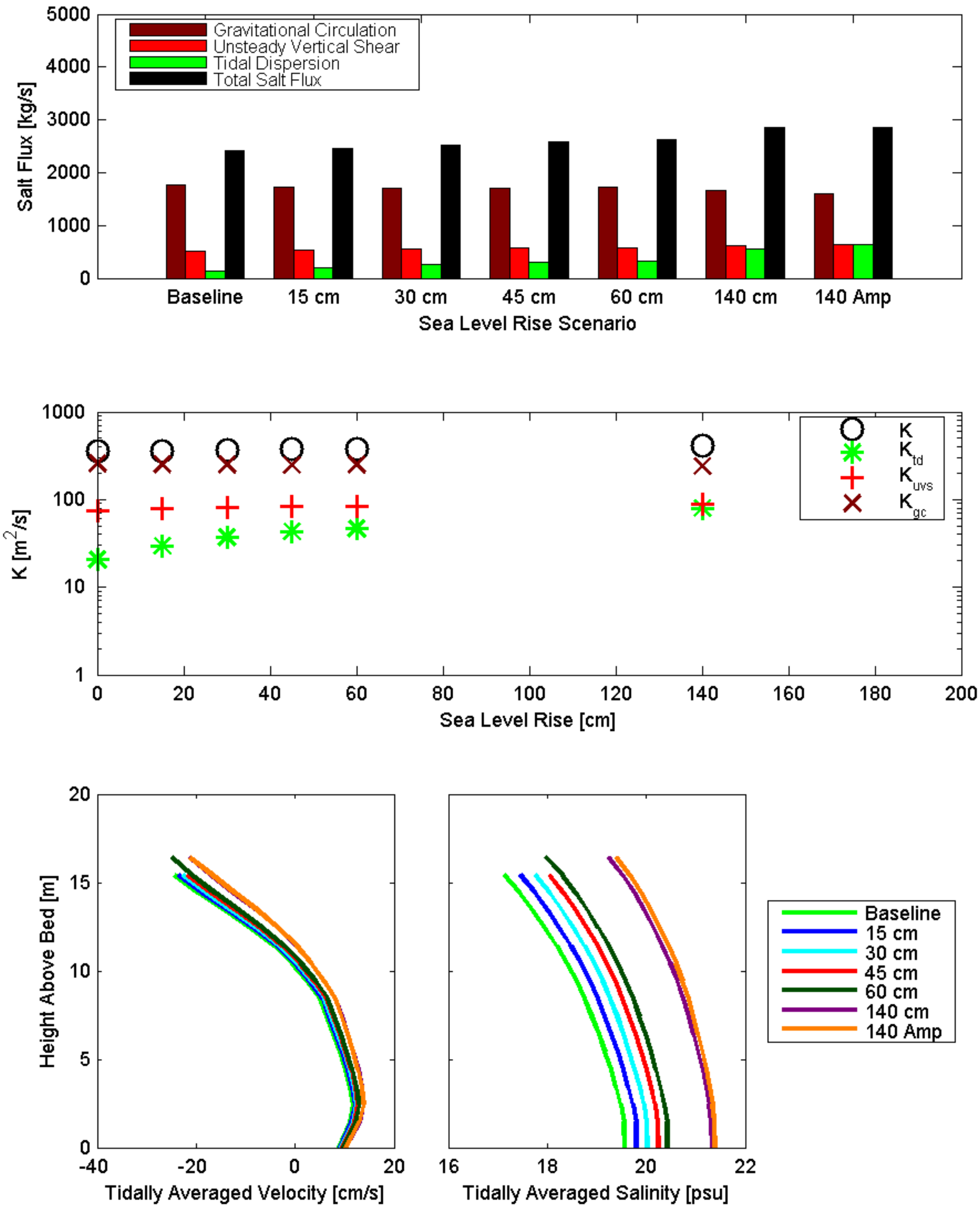


Figure 8.4-64 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and October 13, 2002 through November 10, 2002 analysis period tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 17, located at the Benicia Bridge, for the October 13, 2002 to November 10, 2002 analysis period.

8.4.4 Suisun Bay Cross-Sections

Dispersion coefficients and salt fluxes were estimated at the eight cross-sections in Suisun Bay (cross-section 18 to cross-section 25) shown in Figure 8.3-1. In Figure 8.4-65 through Figure 8.4-80, analysis results are provided for each cross-section that summarize the dispersion analysis at that location for a given analysis period. The top panel shows the contributions of individual processes to dispersive salt flux (advective salt flux is not shown) for each SLR scenario. The second type of figure shows the overall dispersion coefficient (K), the portion of the dispersion coefficient associated with gravitational circulation (K_{gc}), the portion of the dispersion coefficient associated with unsteady vertical shear dispersion processes (K_{uvs}), and the portion of the dispersion coefficient associated with tidal dispersion processes (K_{td}) for each SLR scenario. The bottom panel shows the period averaged velocity profile and salinity profile at the deepest point in the cross-section for each SLR scenario.

The dispersion coefficients are smaller on average in Suisun Bay than in Central Bay and San Pablo Bay. Tidal dispersion processes are the most important salt intrusion processes in most cross-sections for both analysis periods. Gravitational circulation and unsteady vertical shear dispersion are both substantial for all cross-sections in Suisun Bay and gravitational circulation is the strongest salt intrusion process at cross-section 23, extending from Concord to Montezuma Slough, during the October 13, 2002 through November 10, 2002 analysis period (Figure 8.4-76). The dispersive salt fluxes increase with sea level rise due to increased salinity in Suisun Bay. The dispersion coefficients also increase with SLR at most cross-sections primarily due to increases in tidal dispersion. It is likely that this predicted increase results from substantial increases in tidal prism (Figure 8.4-19 and Figure 8.4-20). At most cross-sections in Suisun Bay vertical shear and stratification do not vary greatly with sea level rise.

The results in Suisun Bay are generally consistent with the flux analysis of sea level rise scenarios performed as part of the DRMS studies (Gross et al., 2007b). For example, the DRMS study also showed strong local importance of gravitational circulation in Suisun Bay near Concord. However the DRMS scenarios were for higher Delta outflow and, therefore, showed a larger contribution of gravitational circulation and unsteady vertical shear. The flux analysis of various Delta outflows performed as part of the DRMS studies (Gross et al., 2007a) was consistent with these results for low Delta outflows and indicated that gravitational circulation increases in the seaward (western) portion of Suisun Bay at moderate outflows. At higher Delta outflows, salt is almost entirely flushed out of Suisun Bay.

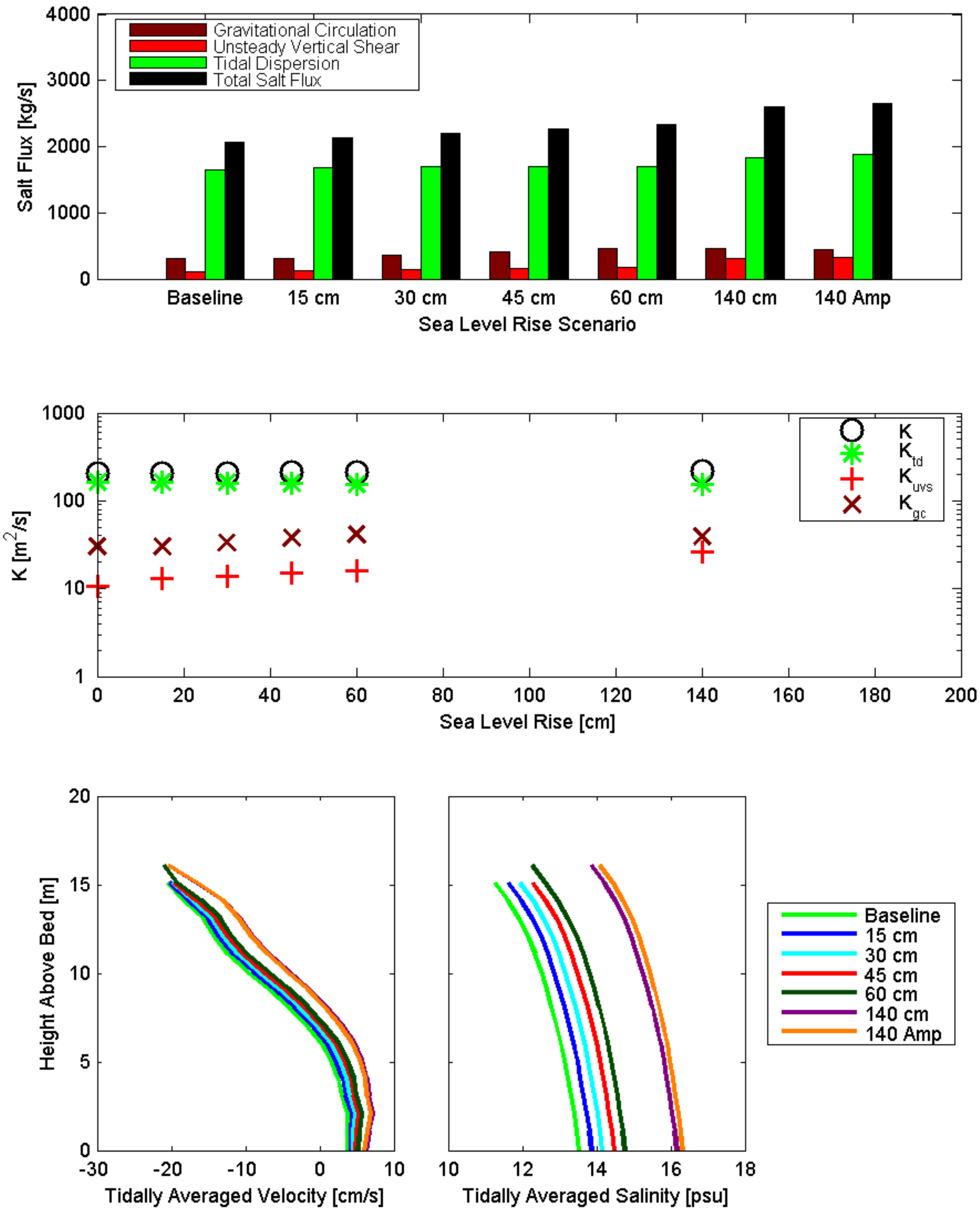


Figure 8.4-65 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 18, located east of the Mothball Fleet, for the July 15, 2002 through August 12, 2002 analysis period.

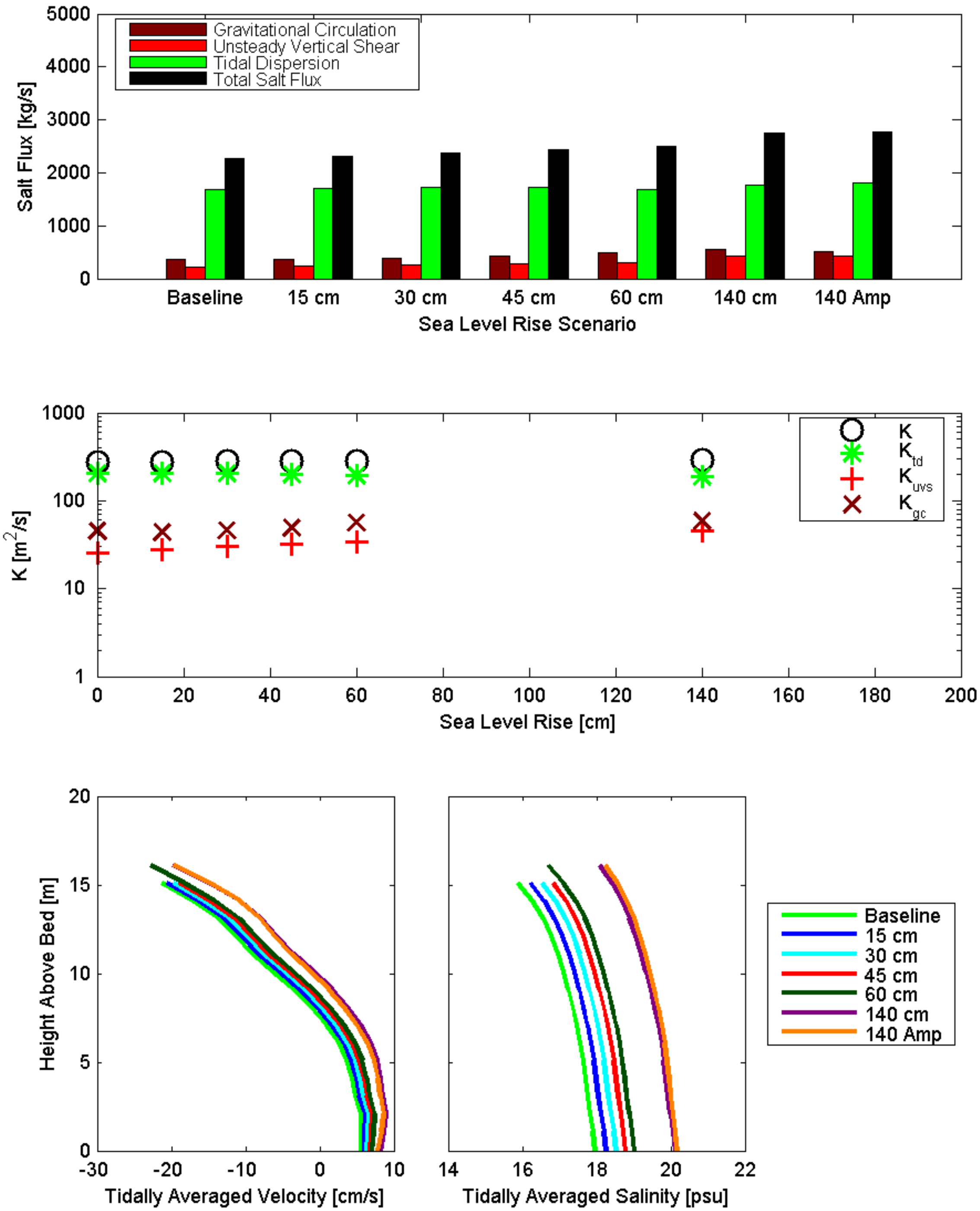


Figure 8.4-66 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 18, located east of the Mothball Fleet, for the October 13, 2002 through November 10, 2002 analysis period.

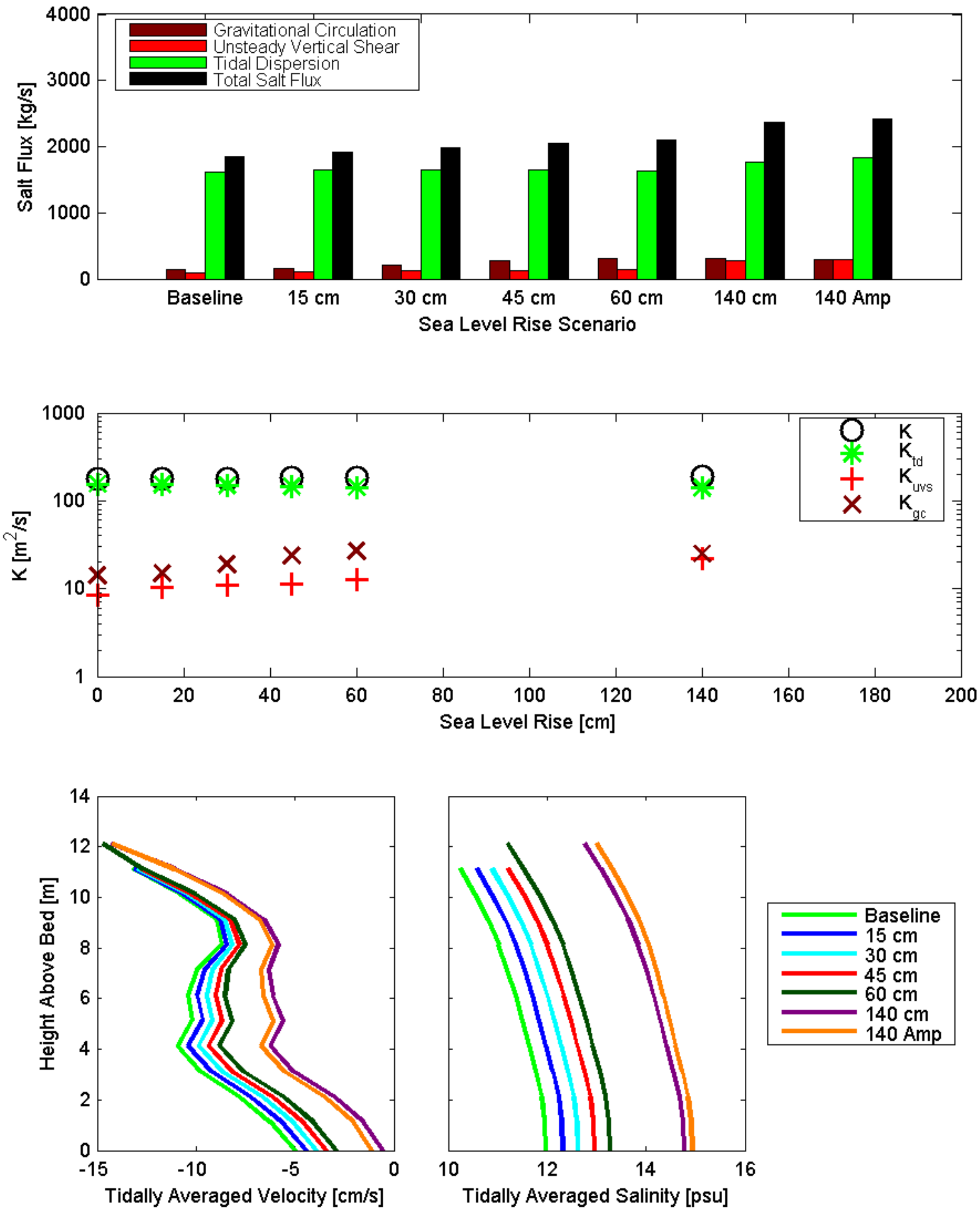


Figure 8.4-67 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 19, extending from Edith Point to Bahia, for the July 15, 2002 through August 12, 2002 analysis period.

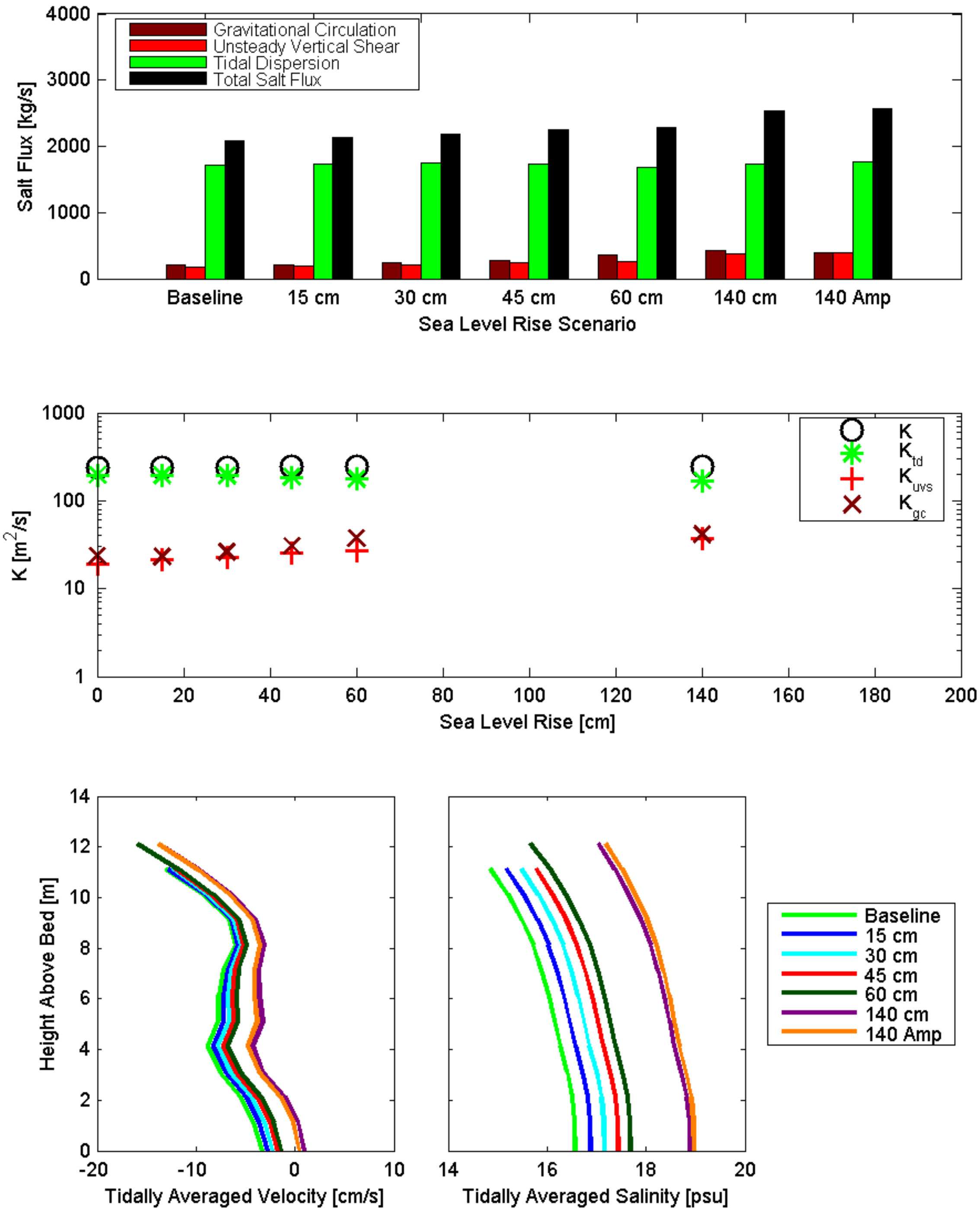


Figure 8.4-68 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 19, extending from Edith Point to Bahia, for the October 13, 2002 through November 10, 2002 analysis period.

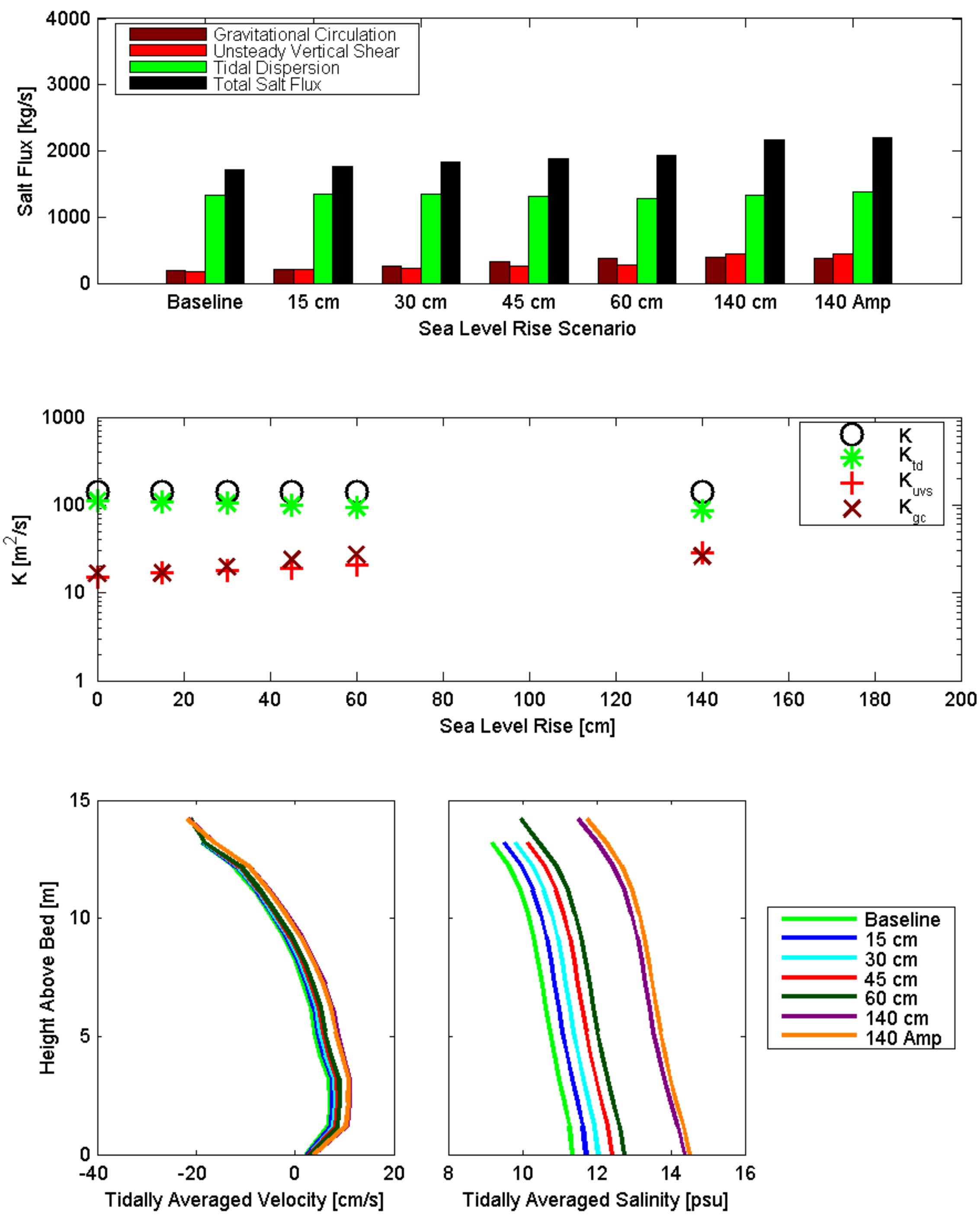


Figure 8.4-69 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 20, extending from Point Edith to Suisun Slough, for the July 15, 2002 through August 12, 2002 analysis period.

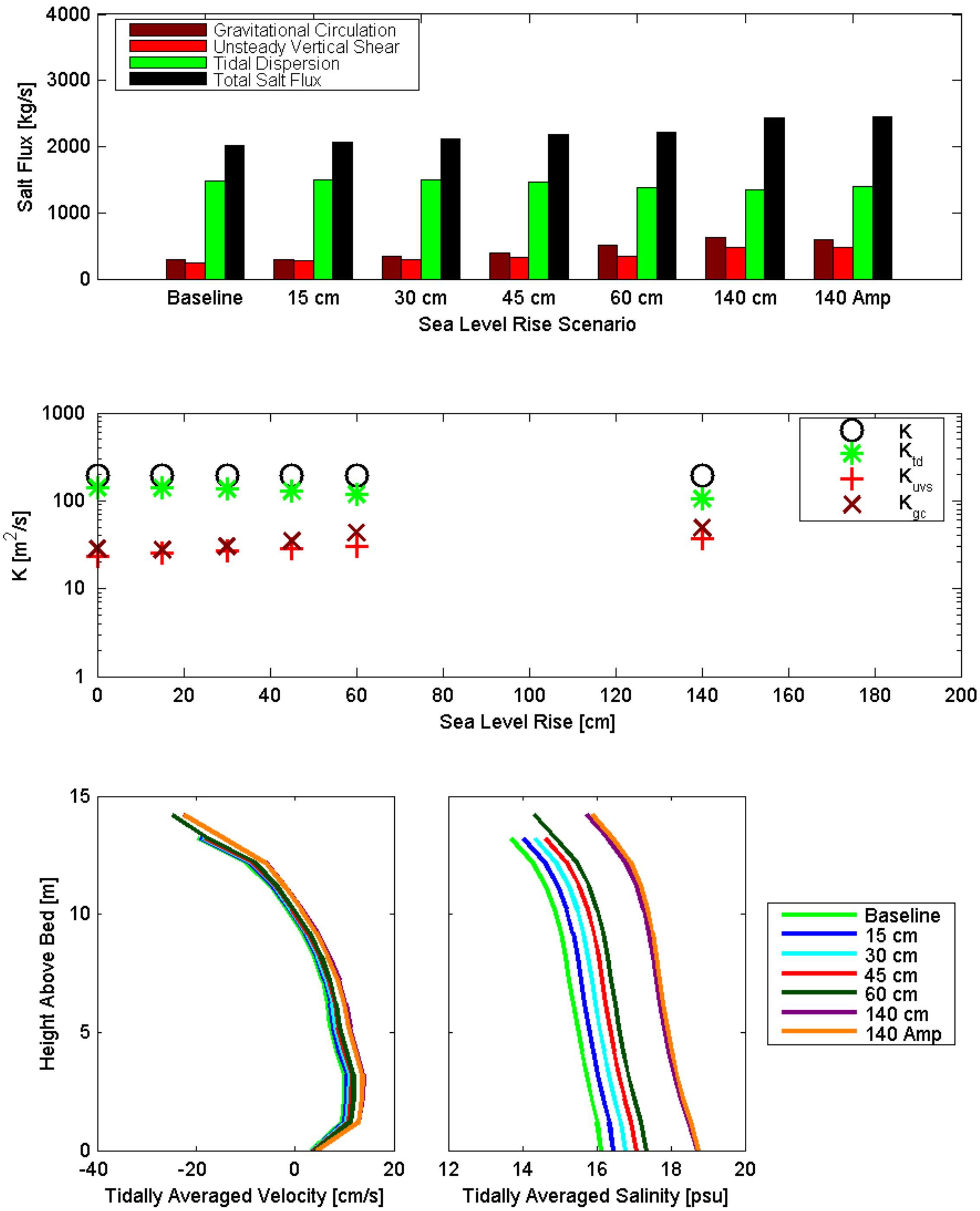


Figure 8.4-70 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 20, extending from Point Edith to Suisun Slough, for the October 13, 2002 through November 10, 2002 analysis period.

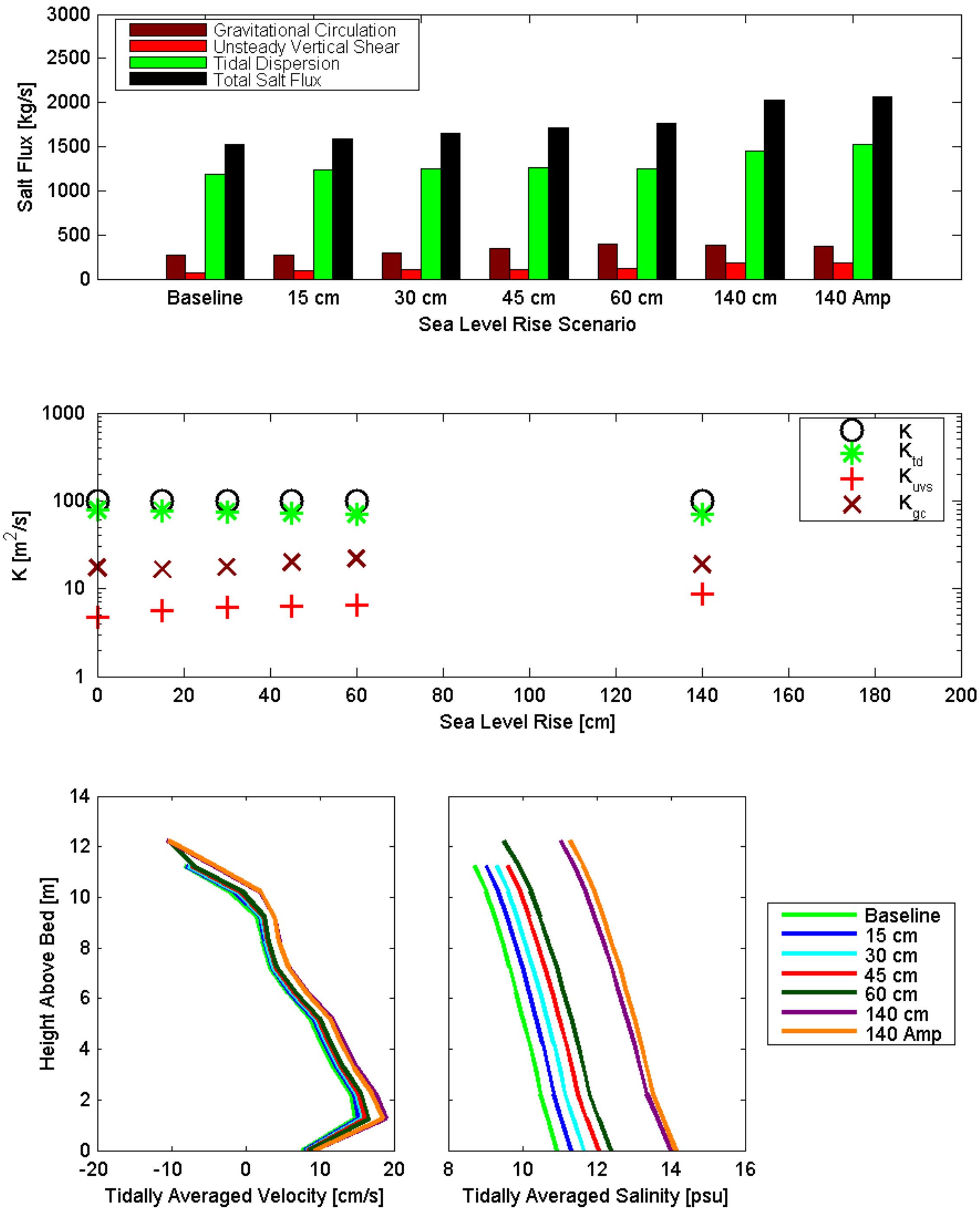


Figure 8.4-71 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 21, extending from Hastings Slough to Montezuma Slough, for the July 15, 2002 through August 12, 2002 analysis period.

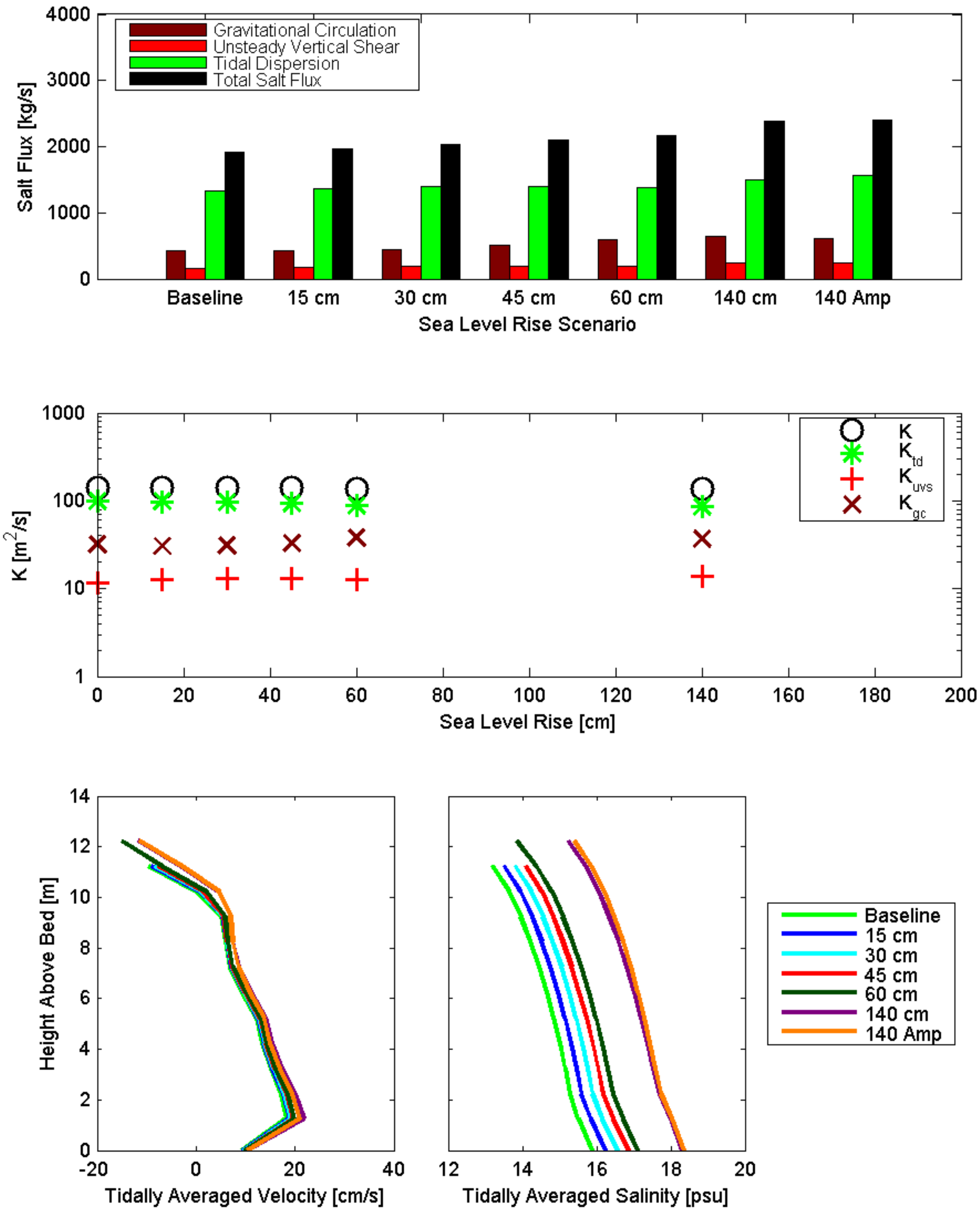


Figure 8.4-72 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 21, extending from Hastings Slough to Montezuma Slough, for the October 13, 2002 through November 10, 2002 analysis period.

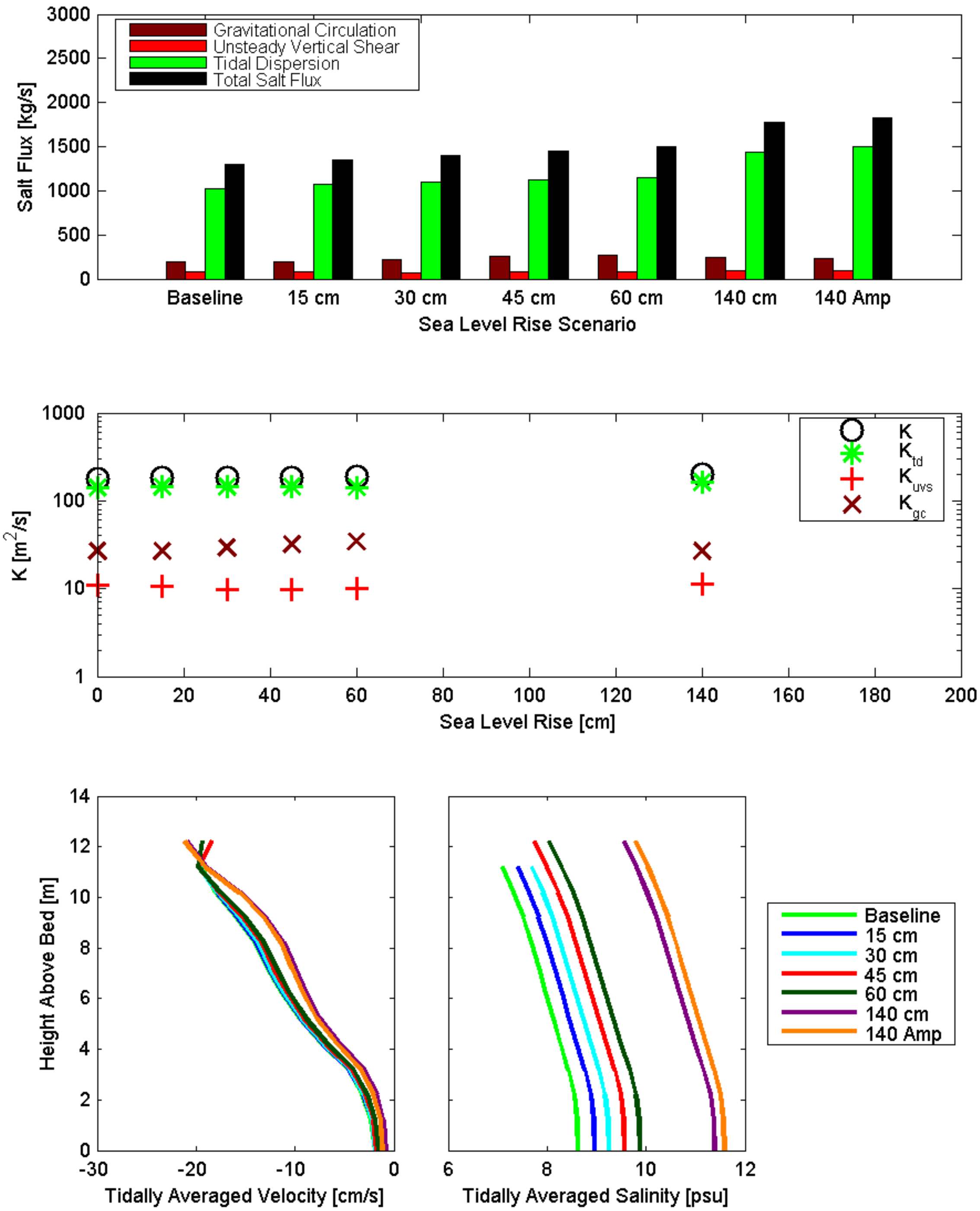


Figure 8.4-73 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 22, extending from Port Chicago to Montezuma Slough, for the July 15, 2002 through August 12, 2002 analysis period.

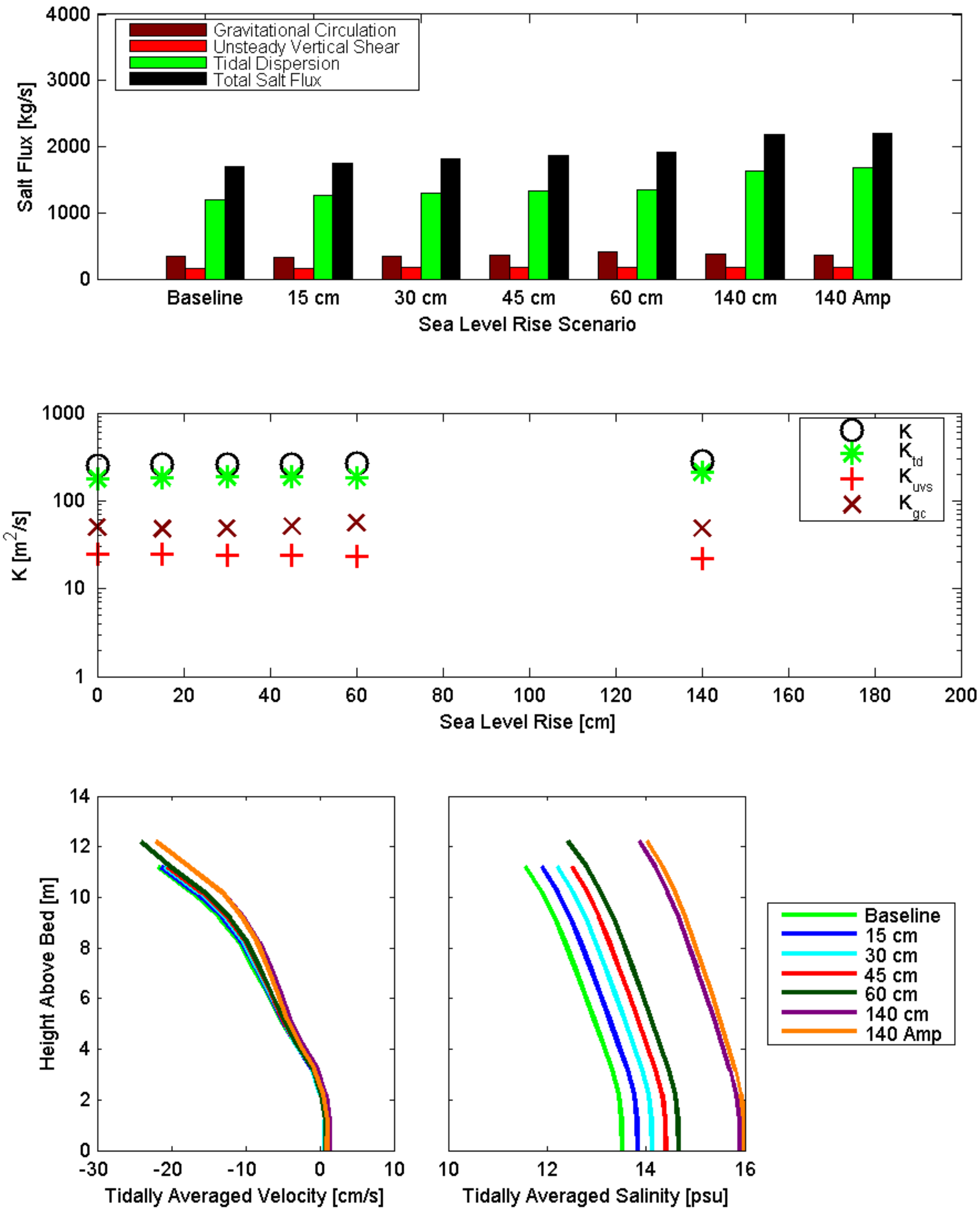


Figure 8.4-74 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 22, extending from Point Chicago to Montezuma Slough, for the October 13, 2002 through November 10, 2002 analysis period.

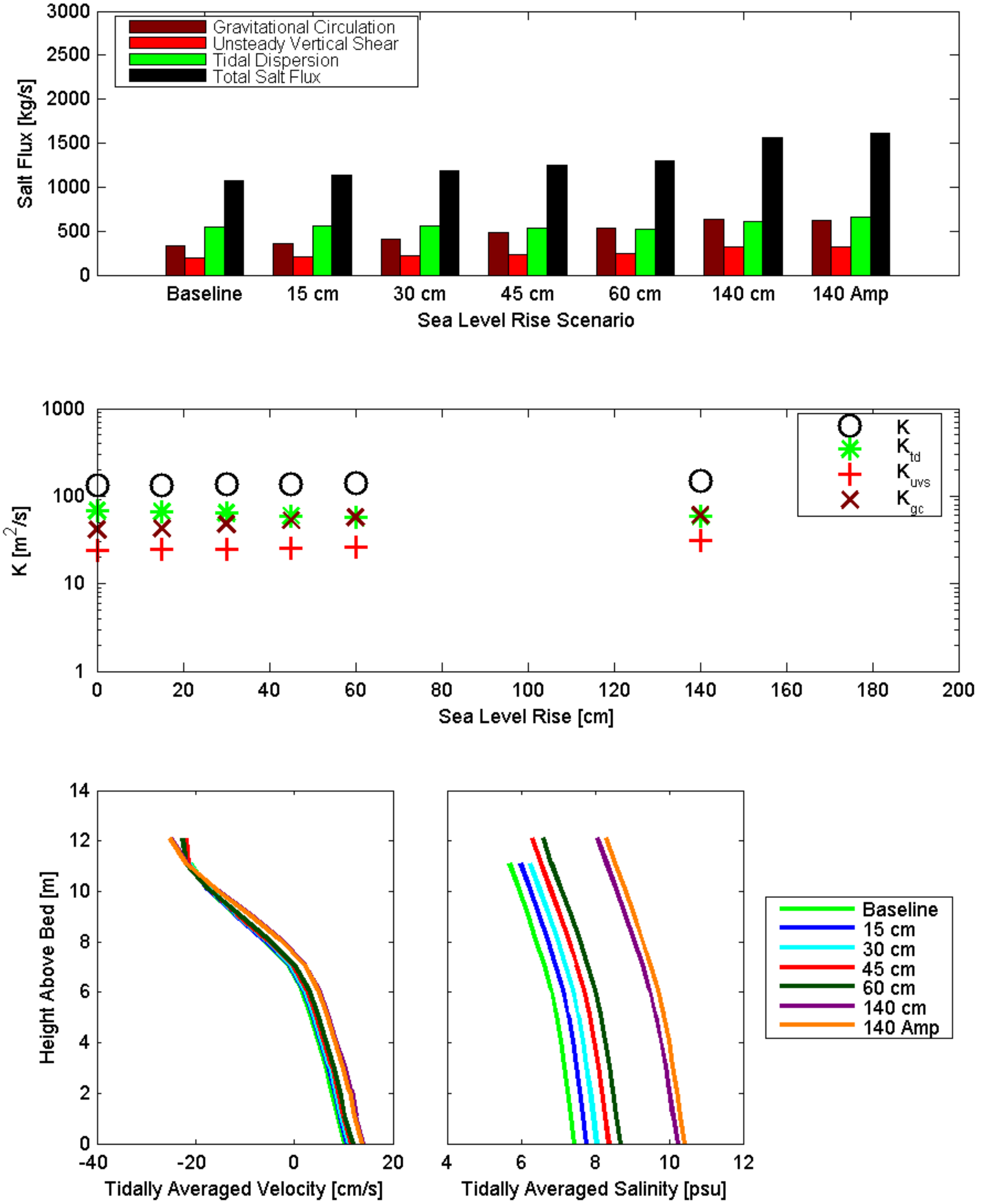


Figure 8.4-75 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 23, extending from Concord to Montezuma Slough for the July 15, 2002 through August 12, 2002 analysis period.

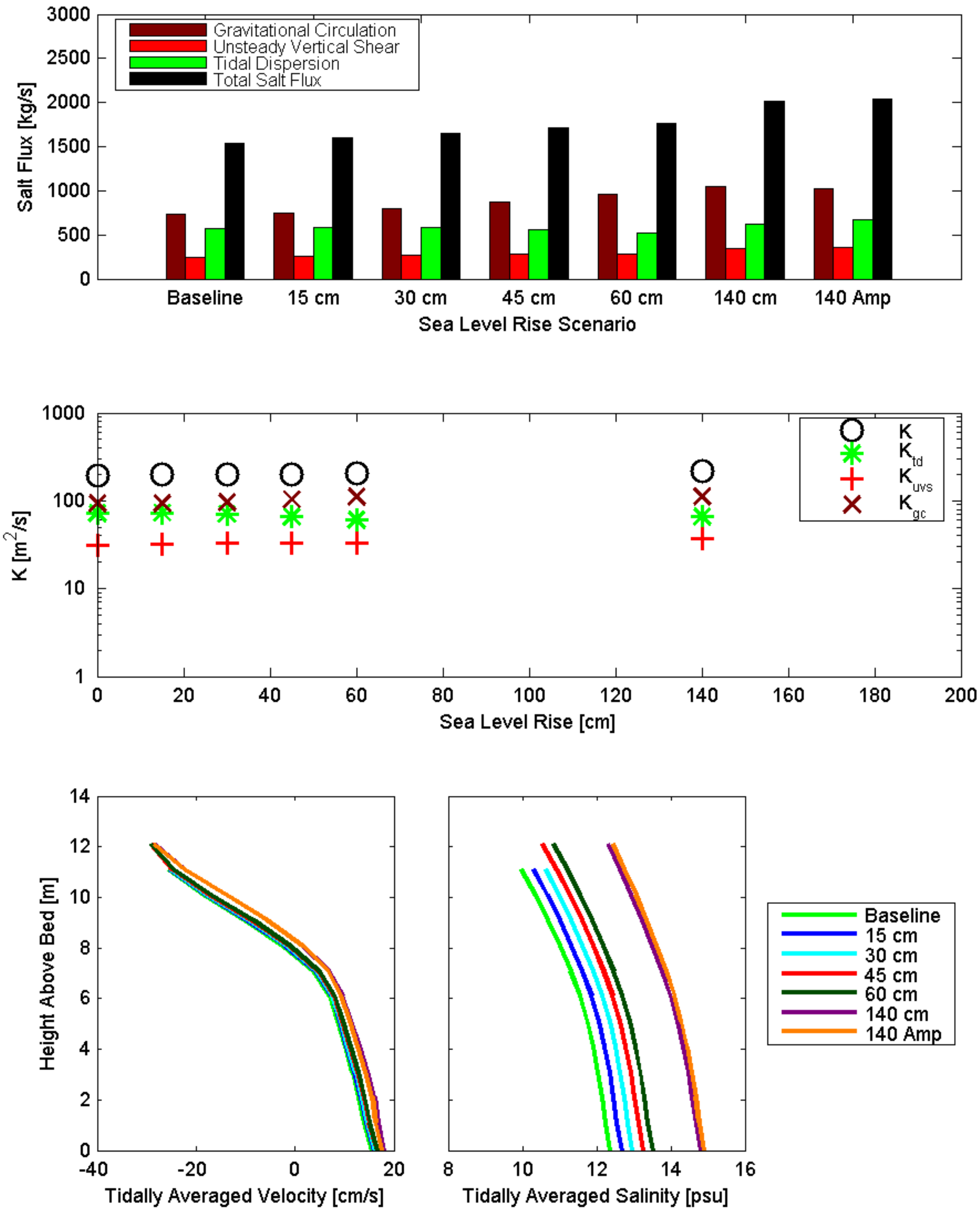


Figure 8.4-76 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 23, extending from Concord to Montezuma Slough, for the October 13, 2002 through November 10, 2002 analysis period.

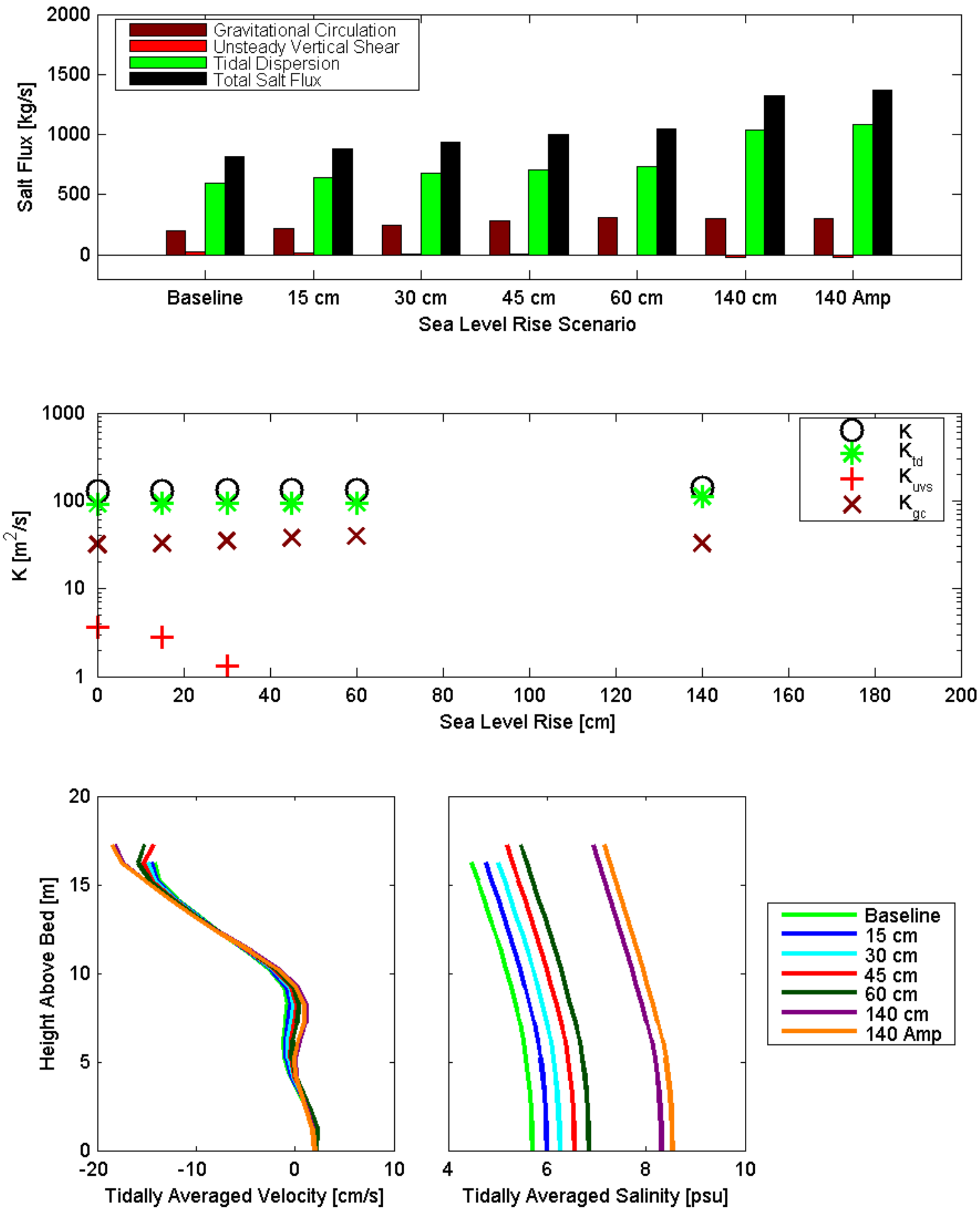


Figure 8.4-77 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 24, extending from Stake Point to Montezuma Slough, for the July 15, 2002 through August 12, 2002 analysis period.

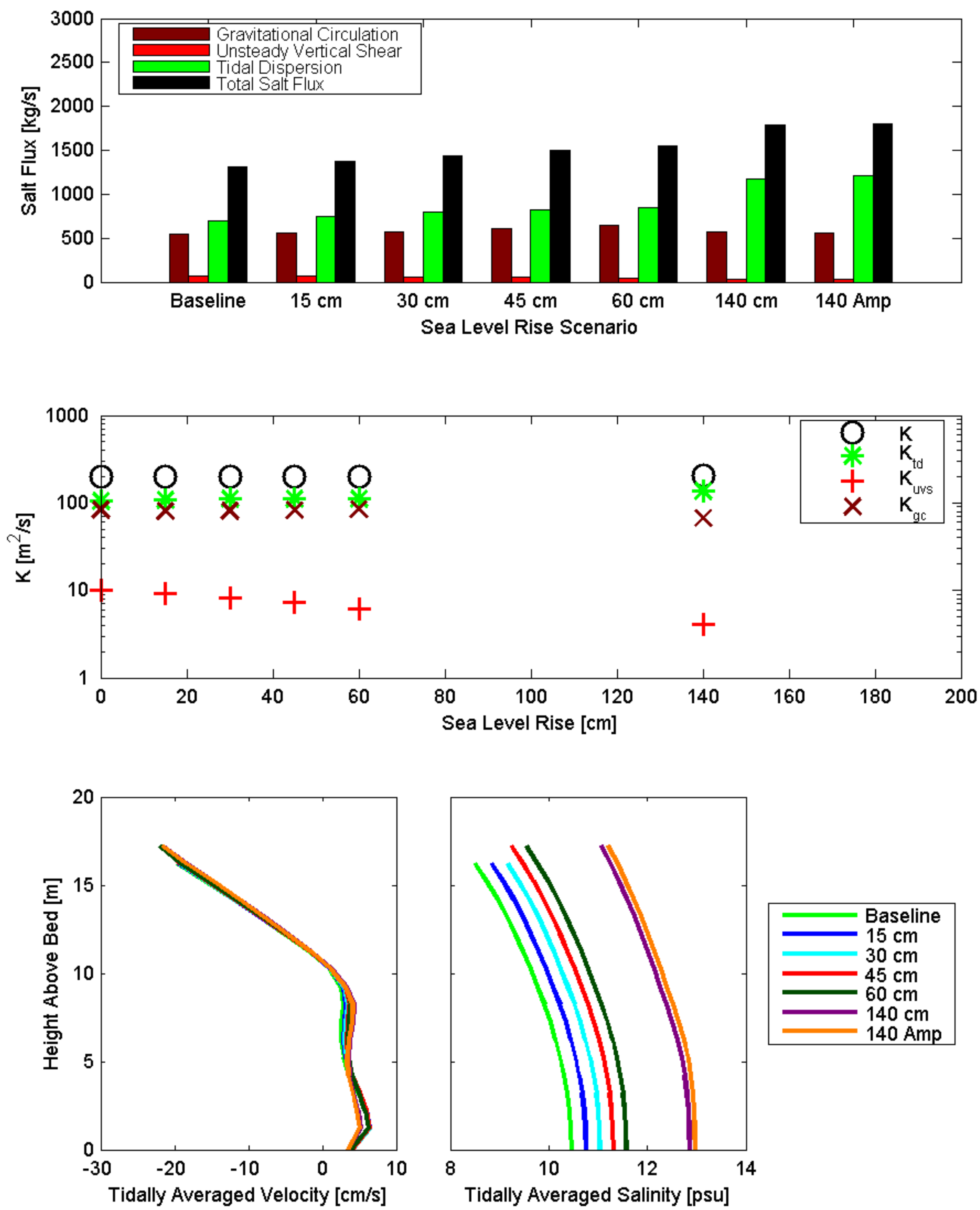


Figure 8.4-78 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 24, extending from Stake Point to Montezuma Slough, for the October 13, 2002 through November 10, 2002 analysis period.

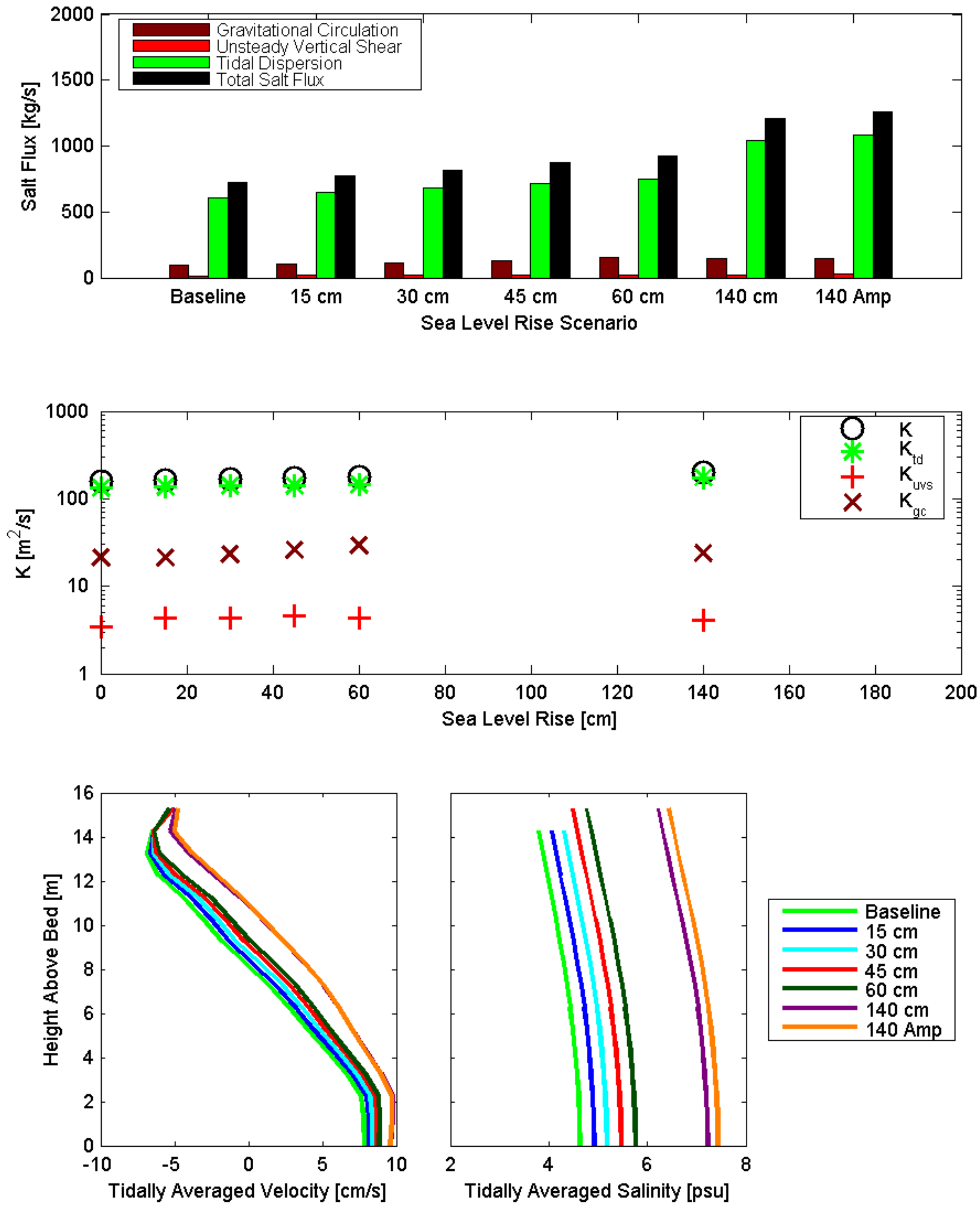


Figure 8.4-79 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 25, extending from Mallard Island to Montezuma Slough, for the July 15, 2002 through August 12, 2002 analysis period.

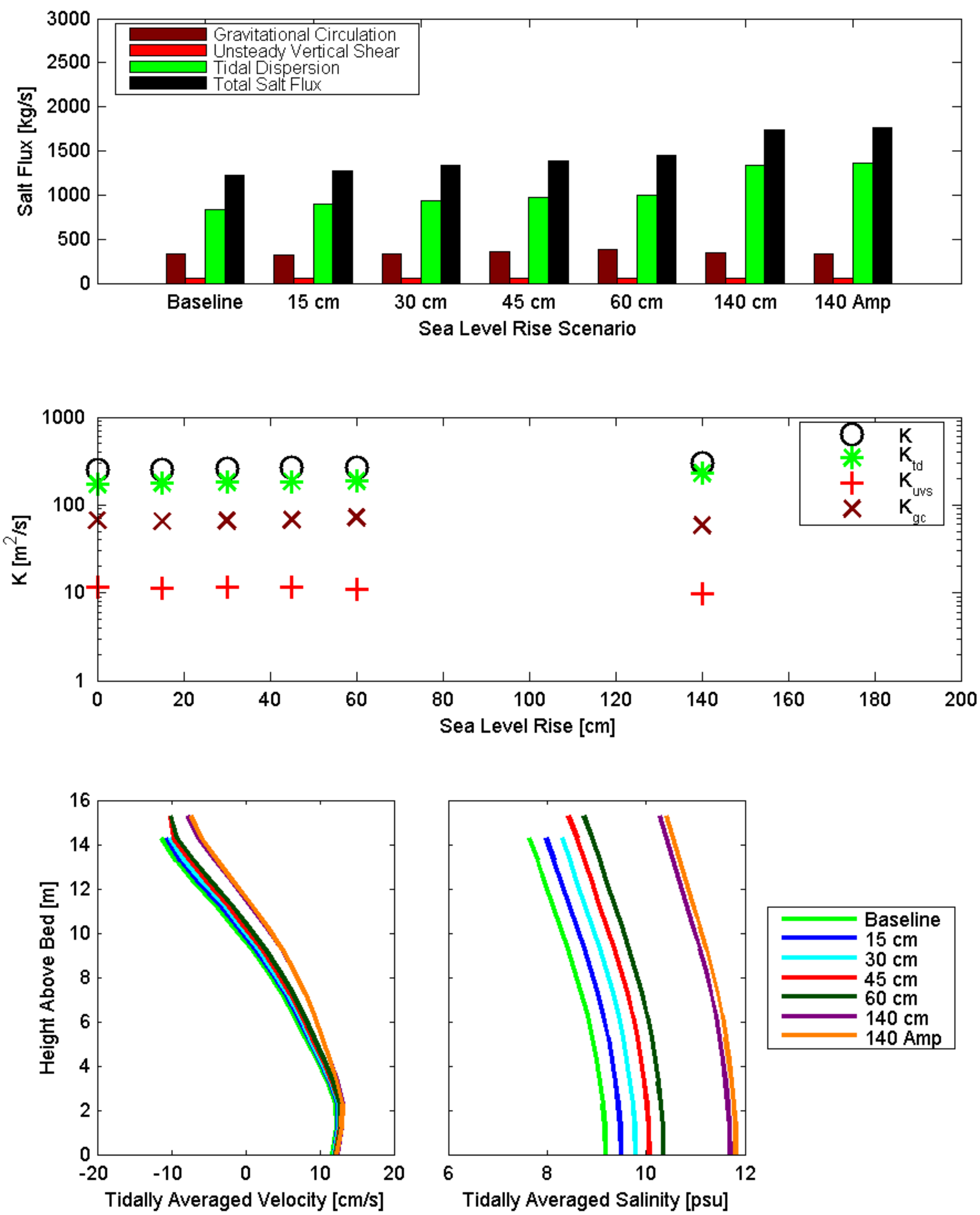


Figure 8.4-80 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 25, extending from Mallard Island to Montezuma Slough, for the October 13, 2002 through November 10, 2002 analysis period.

8.4.5 Western Delta Cross-Sections

Dispersion coefficients and salt fluxes were estimated at the seven cross-sections in the western Delta (cross-section 26 to cross-section 32) shown in Figure 8.3-1. In Figure 8.4-81 through Figure 8.4-94, analysis results are provided for each cross-section that summarize the dispersion analysis at that location for a given analysis period. The top panel shows the contributions of individual processes to dispersive salt flux (advective salt flux is not shown) for each SLR scenario. The second type of figure shows the overall dispersion coefficient (K), the portion of the dispersion coefficient associated with gravitational circulation (K_{gc}), the portion of the dispersion coefficient associated with unsteady vertical shear dispersion processes (K_{uvs}), and the portion of the dispersion coefficient associated with tidal dispersion processes (K_{td}) for each SLR scenario. The bottom panel shows the period averaged velocity profile and salinity profile at the deepest point in the cross-section for each SLR scenario.

The dispersion coefficients are smaller on average in the western Delta than in San Francisco Bay. Tidal dispersion processes are the most important salt intrusion processes in most cross-sections for both analysis periods. Gravitational circulation and unsteady vertical shear dispersion are both substantial for all cross-sections in the western Delta and gravitational circulation is the strongest salt intrusion process for some scenarios at cross-section 28, extending from Antioch to Montezuma Landing, during the October 13, 2002 through November 10, 2002 analysis period (Figure 8.4-86). Gravitational circulation is more pronounced in the October 13, 2002 through November 10, 2002 analysis period than the July 15, 2002 through August 12, 2002 analysis period, because salt has intruded further into the Delta by the time of the October 13, 2002 through November 10, 2002 analysis period, thereby allowing stratification to develop. In both analysis periods, the dispersive salt fluxes increase with sea level rise due to increased salinity in the western Delta. The dispersion coefficients also increase significantly with SLR at most cross-sections, primarily due to increases in tidal dispersion. It is likely that these predicted increases result from substantial increases in tidal prism (Figure 8.4-19 and Figure 8.4-20). At several cross-sections, the strength of gravitational circulation also increases with sea level rise, probably due to increased depth (Monismith et al., 2002). At most cross-sections in the western Delta, the predicted vertical shear and stratification increase with sea level rise, particularly during the July 15, 2002 through August 12, 2002 analysis period.

The results in the western Delta are generally consistent with the flux analysis of sea level rise scenarios performed as part of the DRMS studies (Gross et al., 2007b). One substantial difference in this analysis is that all cross-sections extend across the Delta, while in the salt flux analysis for DRMS (Gross et al., 2007b), some cross-sections extended only across the Sacramento River. The flux analysis of various Delta outflows performed as part of the DRMS studies (Gross et al., 2007a) was consistent with these results for low Delta outflows. At higher Delta outflows, the ocean derived salt is flushed out of the western Delta and the flux analysis could not be performed.

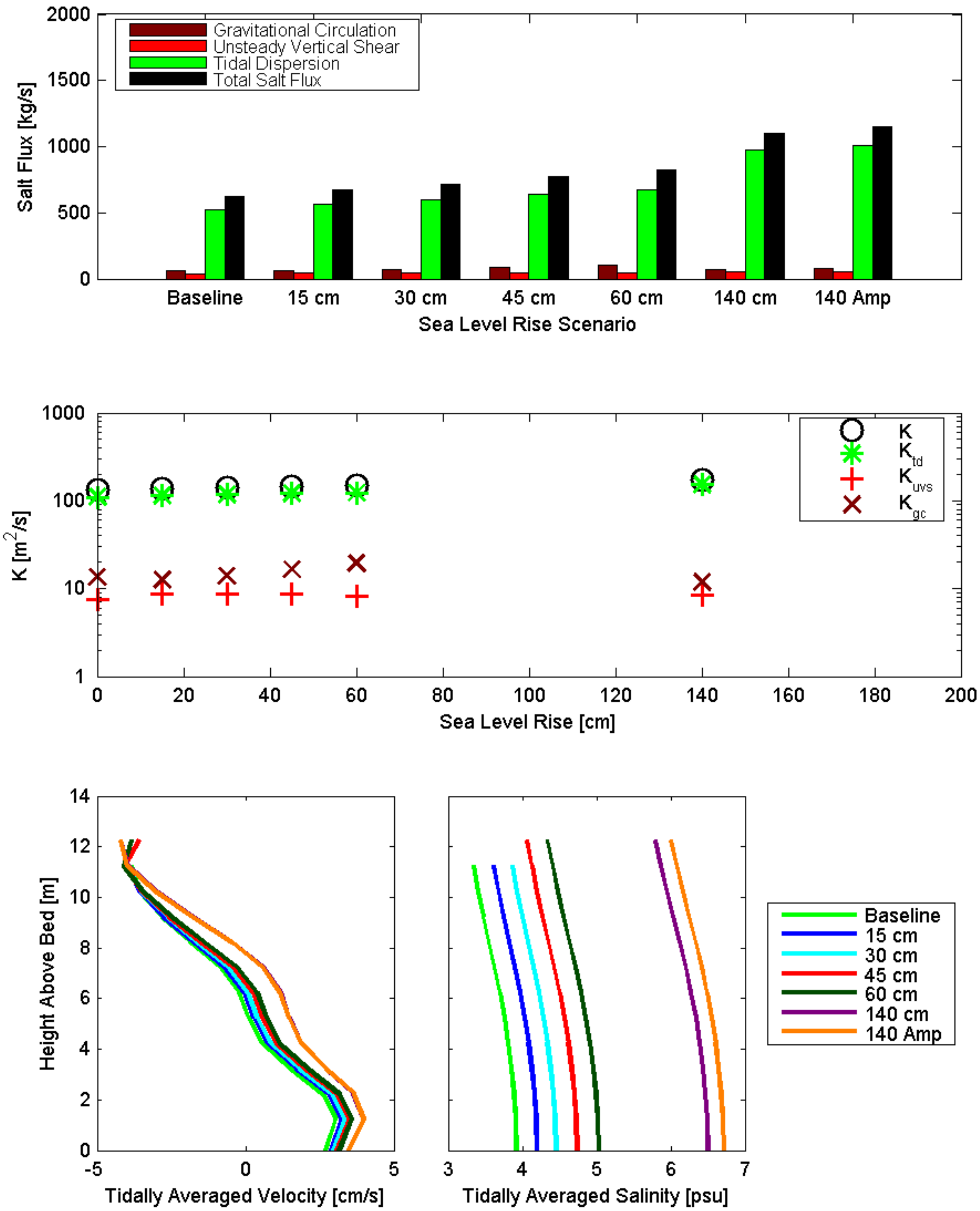


Figure 8.4-81 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 26, extending from Pittsburg to Montezuma Slough, for the July 15, 2002 through August 12, 2002 analysis period.

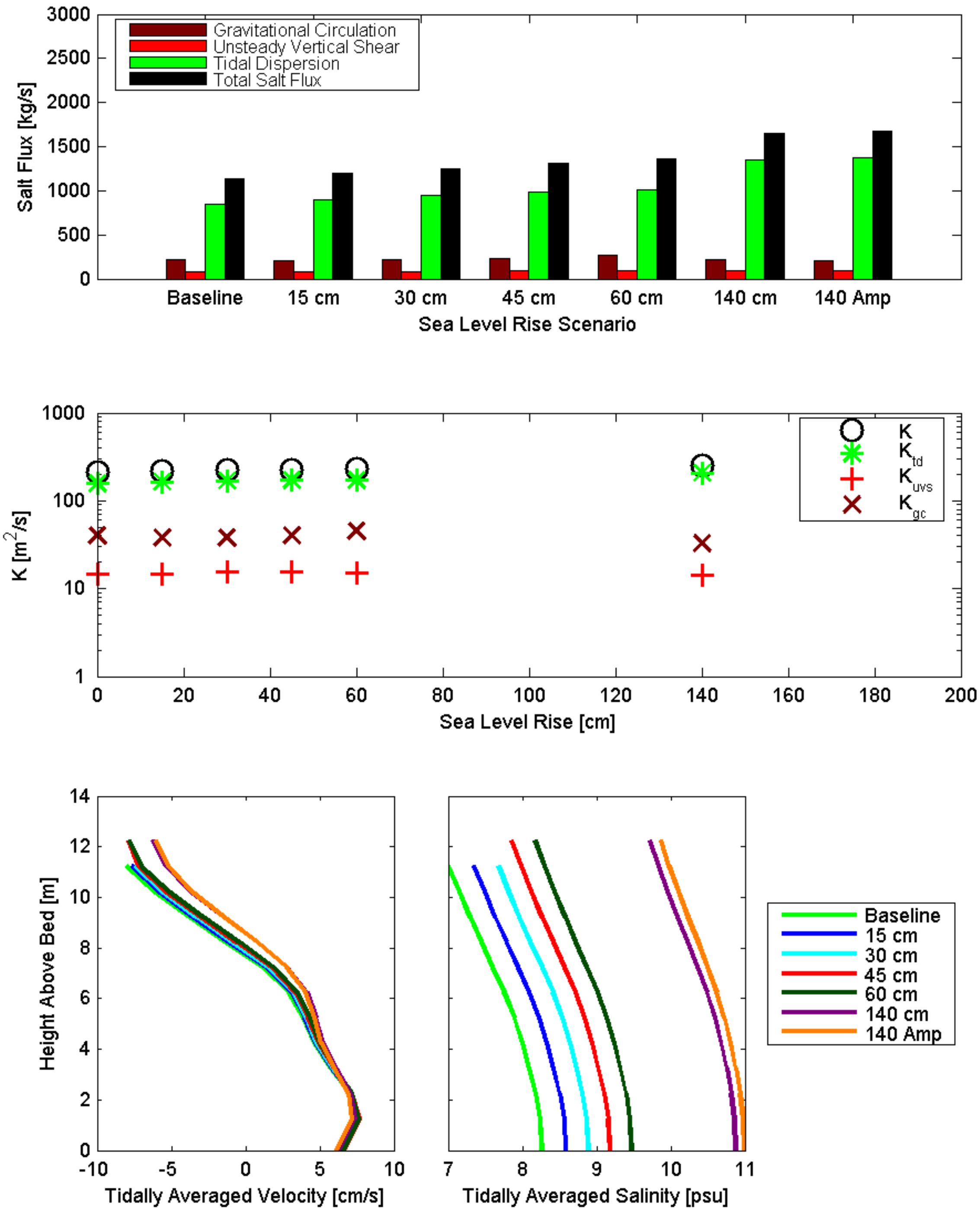


Figure 8.4-82 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 26, extending from Pittsburg to Montezuma Slough, for the October 13, 2002 through November 10, 2002 analysis period.

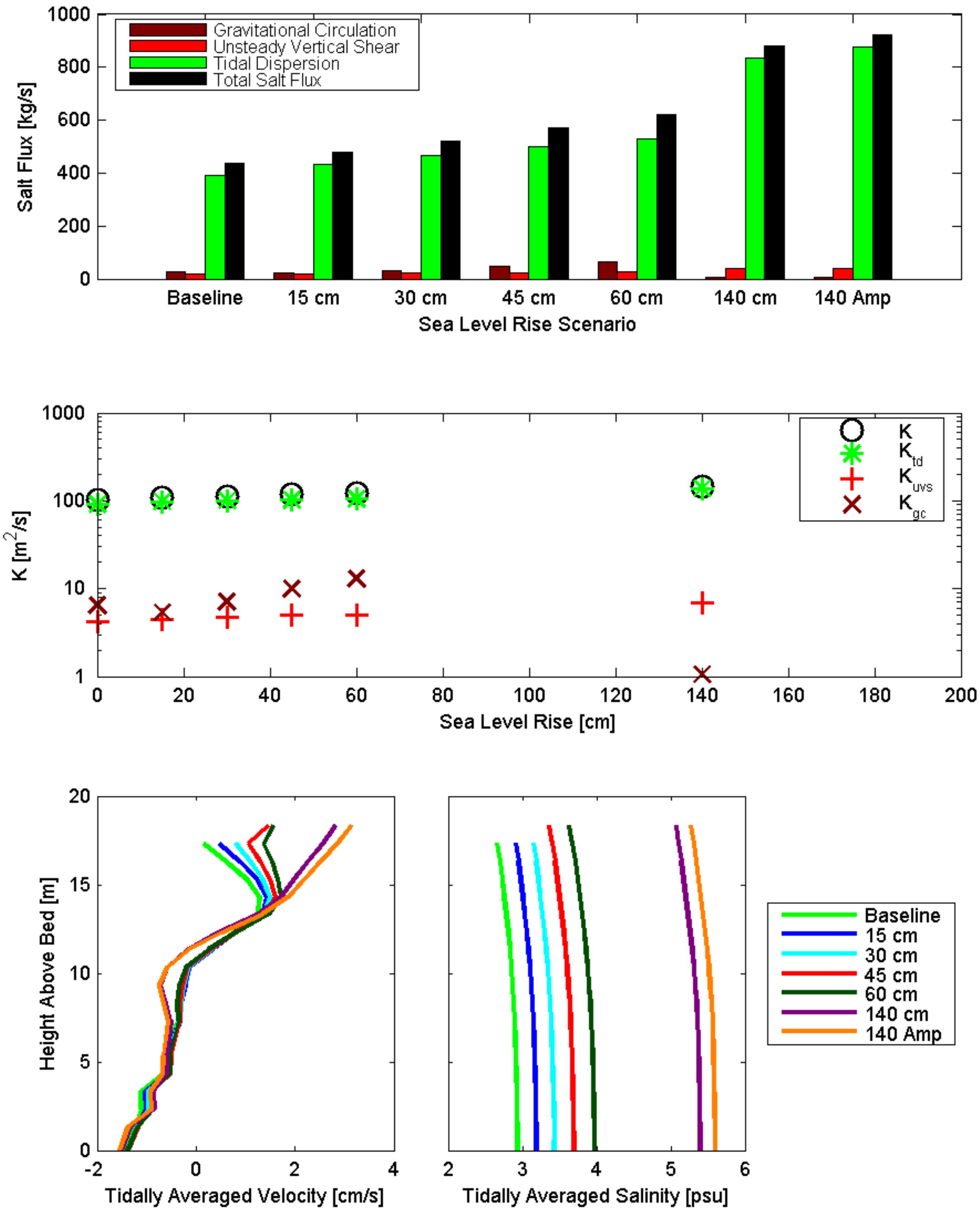


Figure 8.4-83 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 27, extending from Pittsburg to Collinsville. for the July 15, 2002 through August 12, 2002 analysis period.

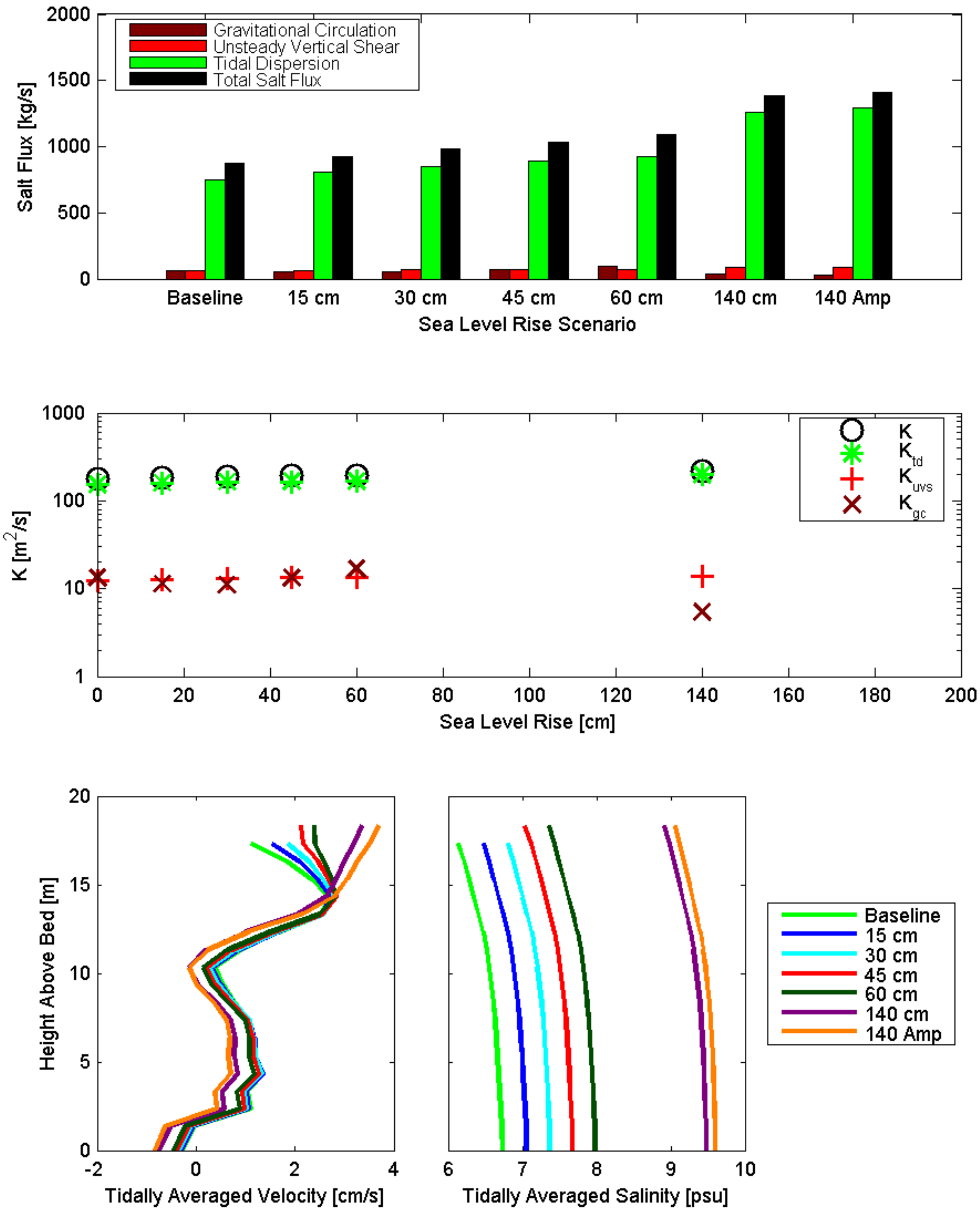


Figure 8.4-84 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 27, extending from Pittsburg to Collinsville, for the October 13, 2002 through November 10, 2002 analysis period.

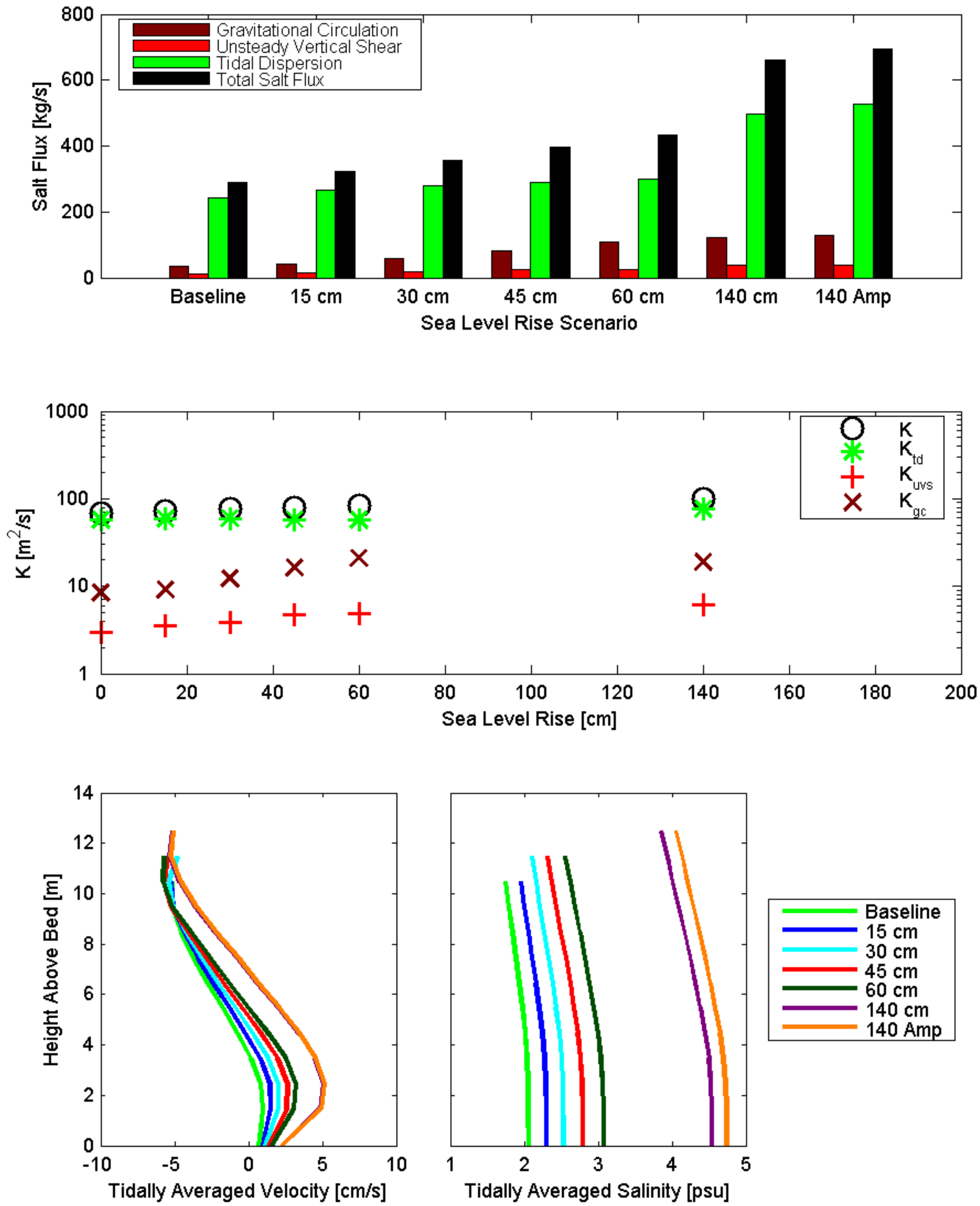


Figure 8.4-85 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 28, extending from Antioch to Montezuma Landing, for the July 15, 2002 through August 12, 2002 analysis period.

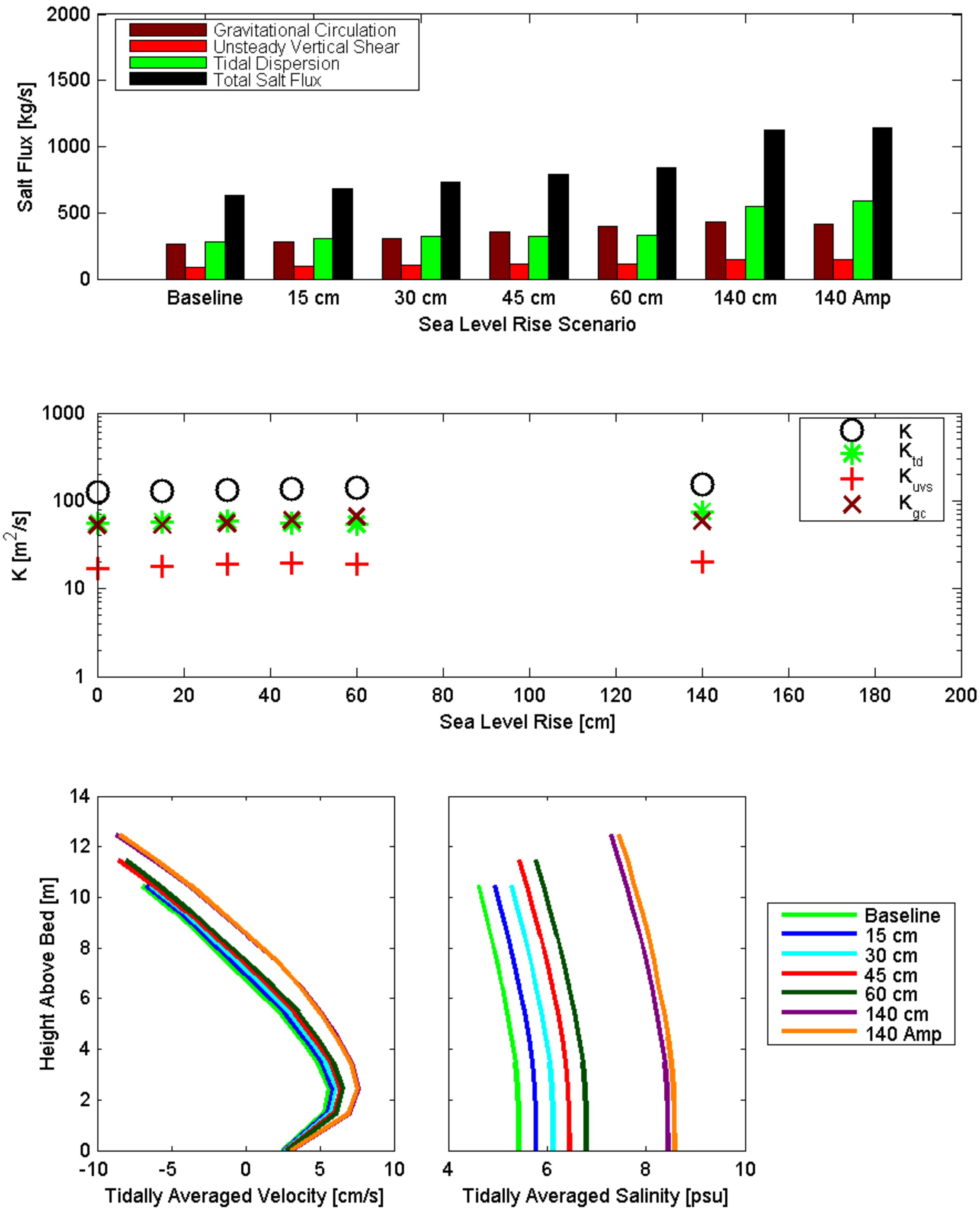


Figure 8.4-86 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 28, extending from Antioch to Montezuma Landing, for the October 13, 2002 through November 10, 2002 analysis period.

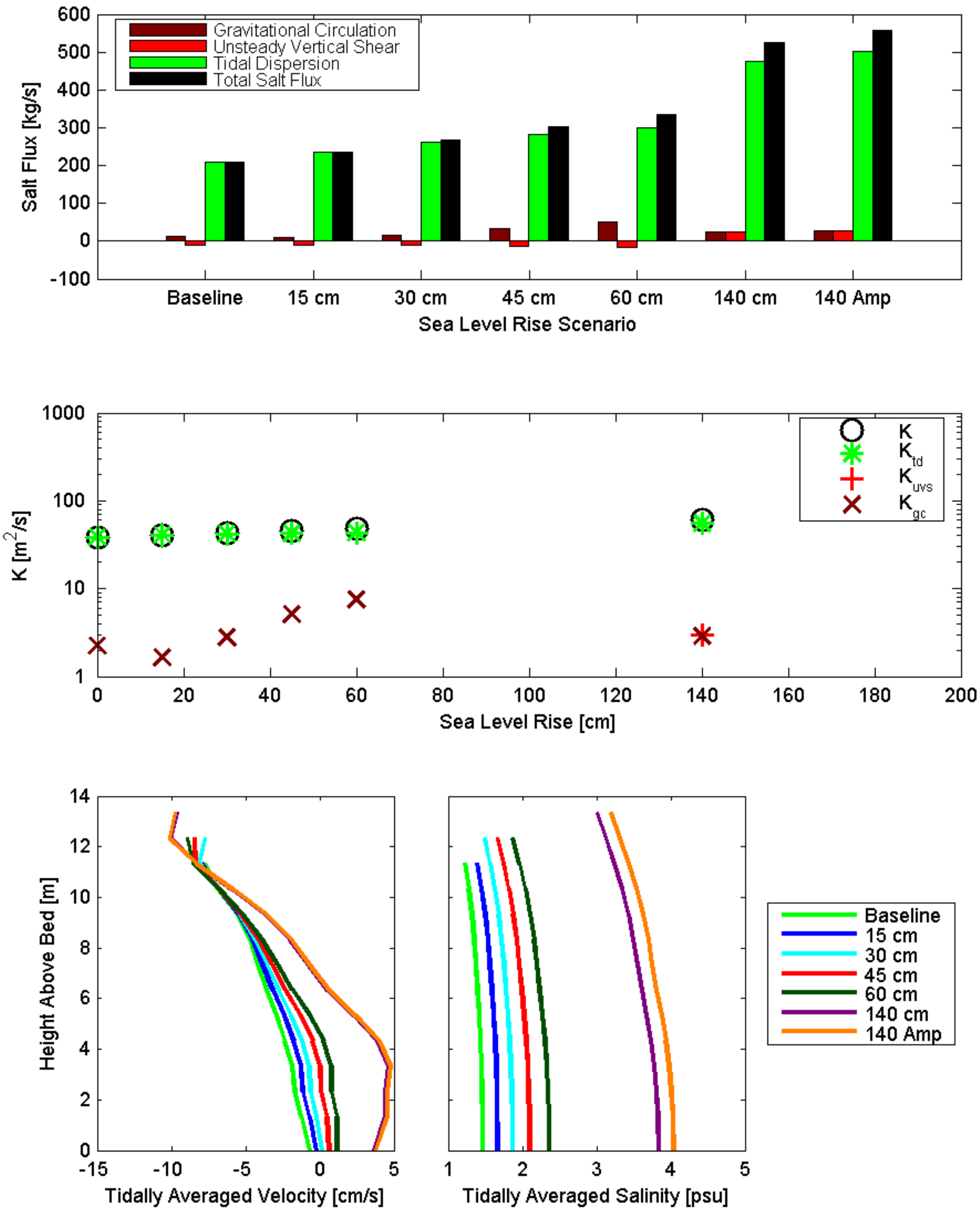


Figure 8.4-87 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 29, extending through Sherman Lake, for the July 15, 2002 through August 12, 2002 analysis period.

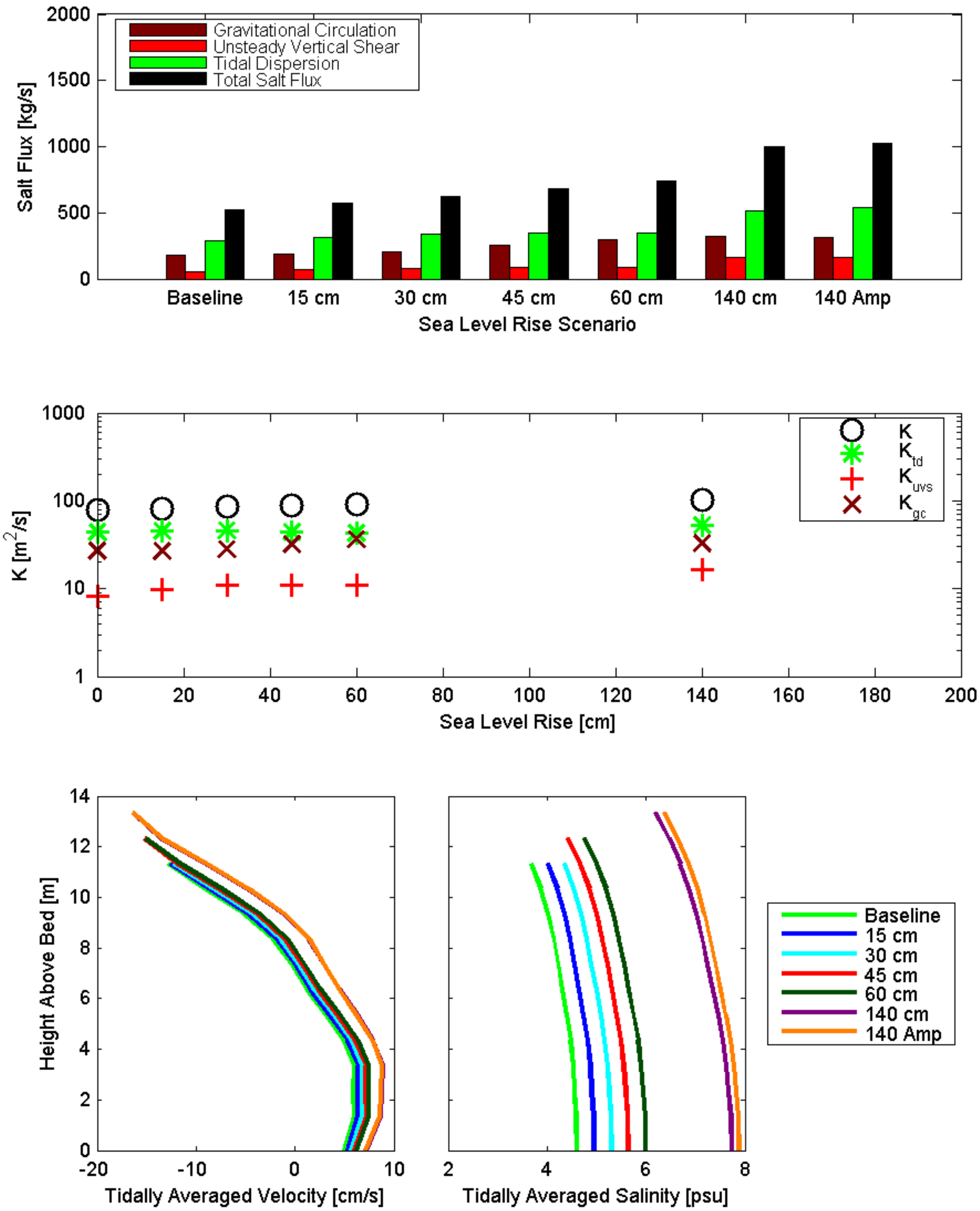


Figure 8.4-88 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 29, extending through Sherman Lake, for the October 13, 2002 through November 10, 2002 analysis period.

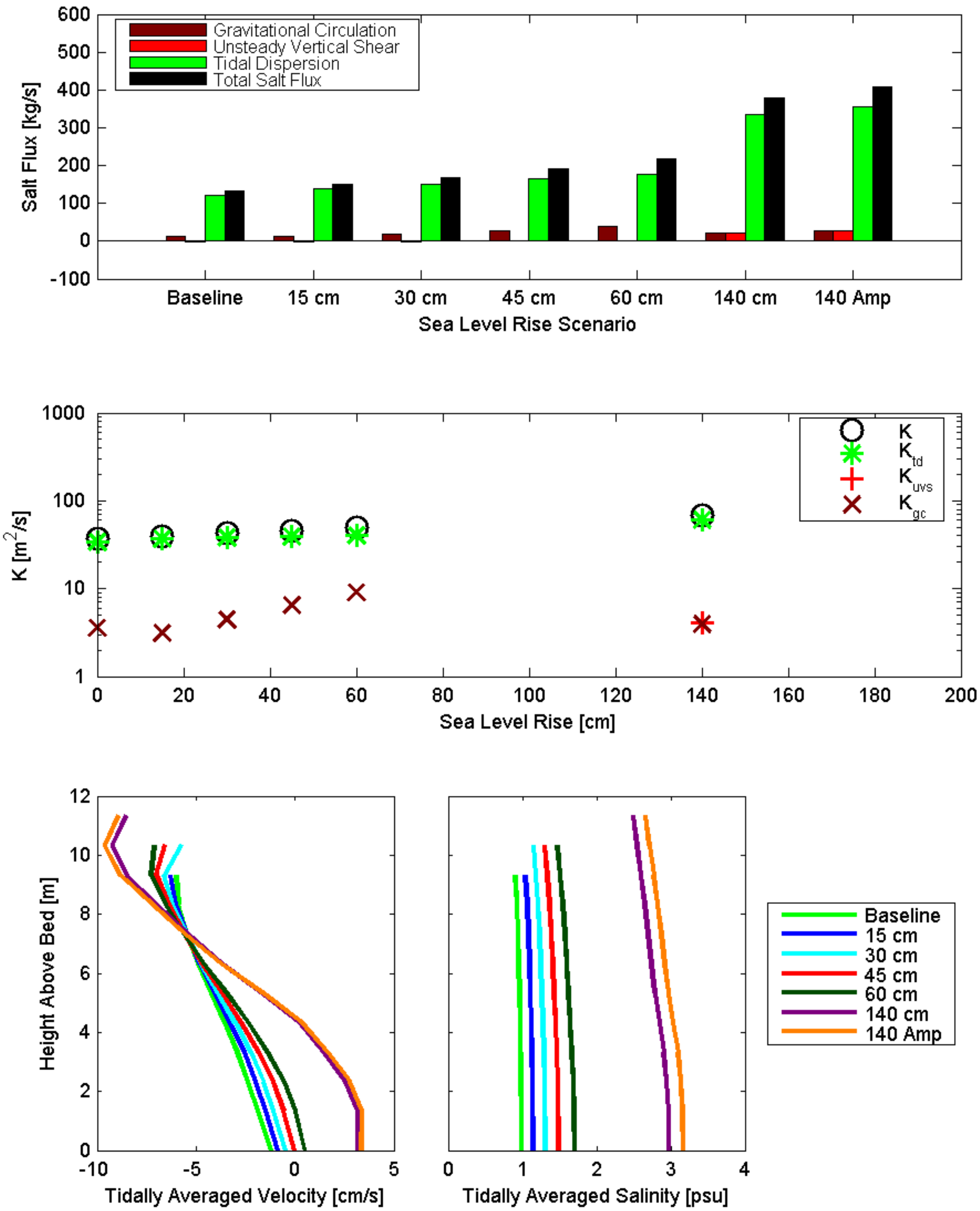


Figure 8.4-89 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 30, located near State Highway 160, for the July 15, 2002 through August 12, 2002 analysis period.

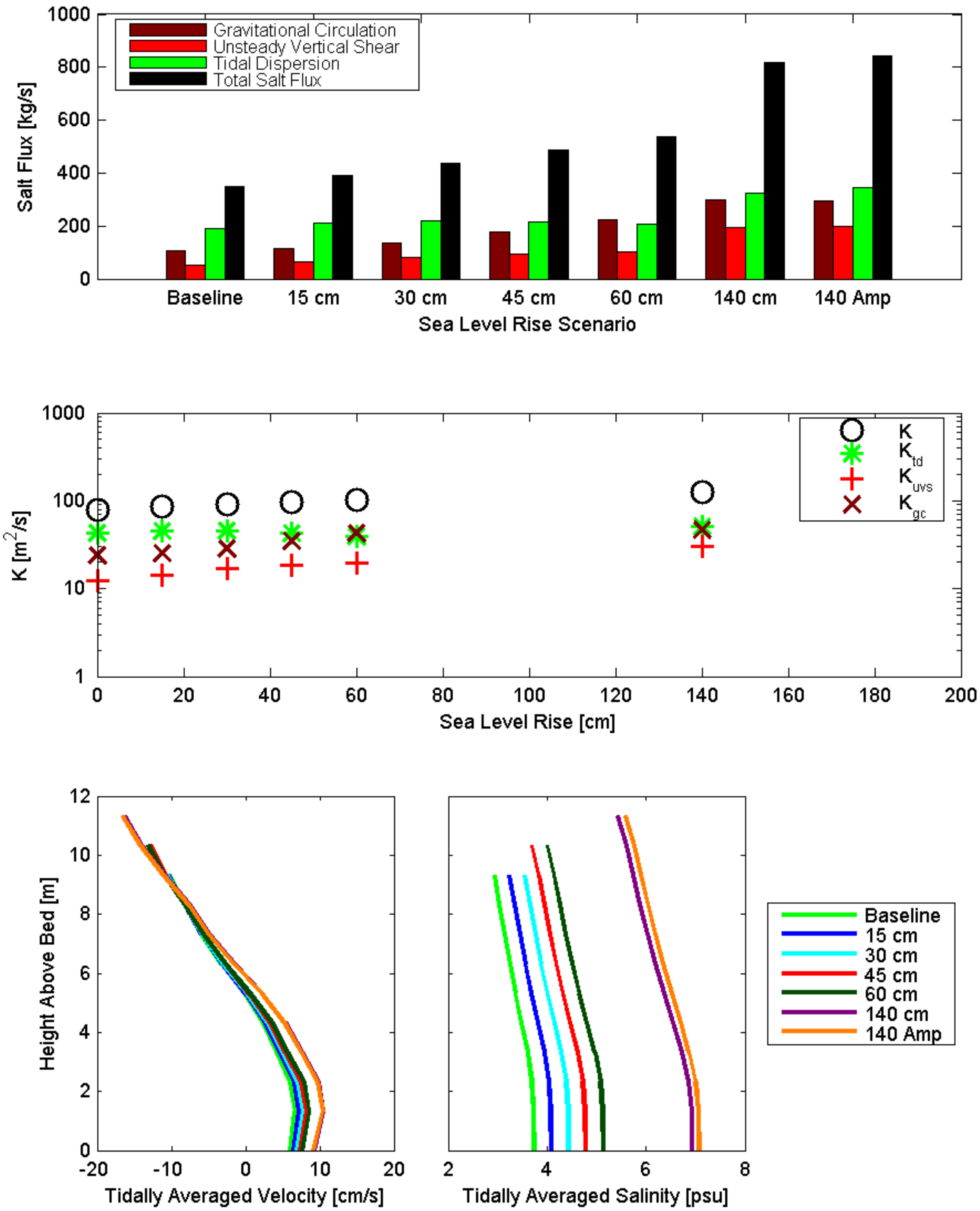


Figure 8.4-90 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 30, located near State Highway 160, for the October 13, 2002 through November 10, 2002 analysis period.

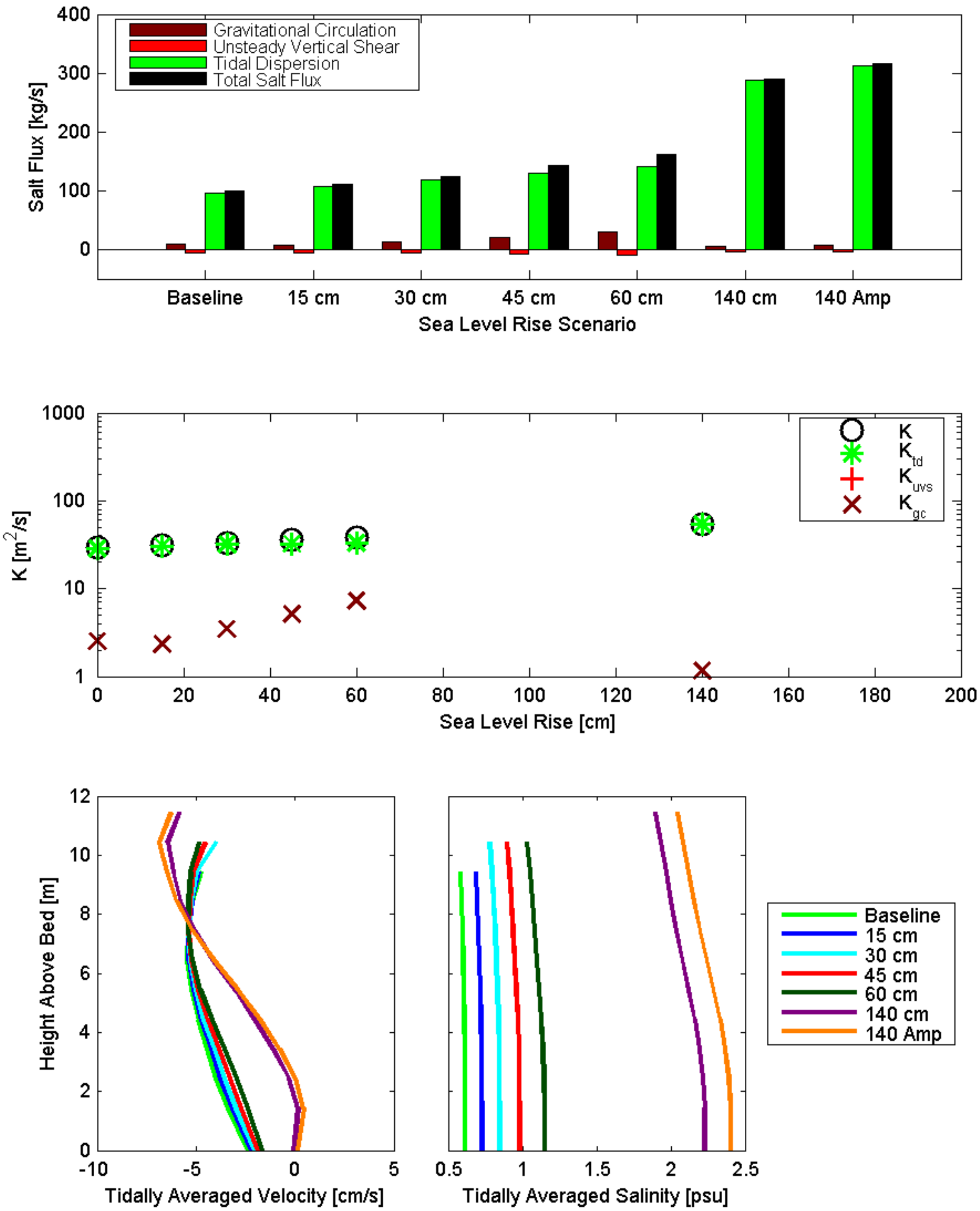


Figure 8.4-91 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 31, extending from Big Break to Toland Landing, for the July 15, 2002 through August 12, 2002 analysis period.

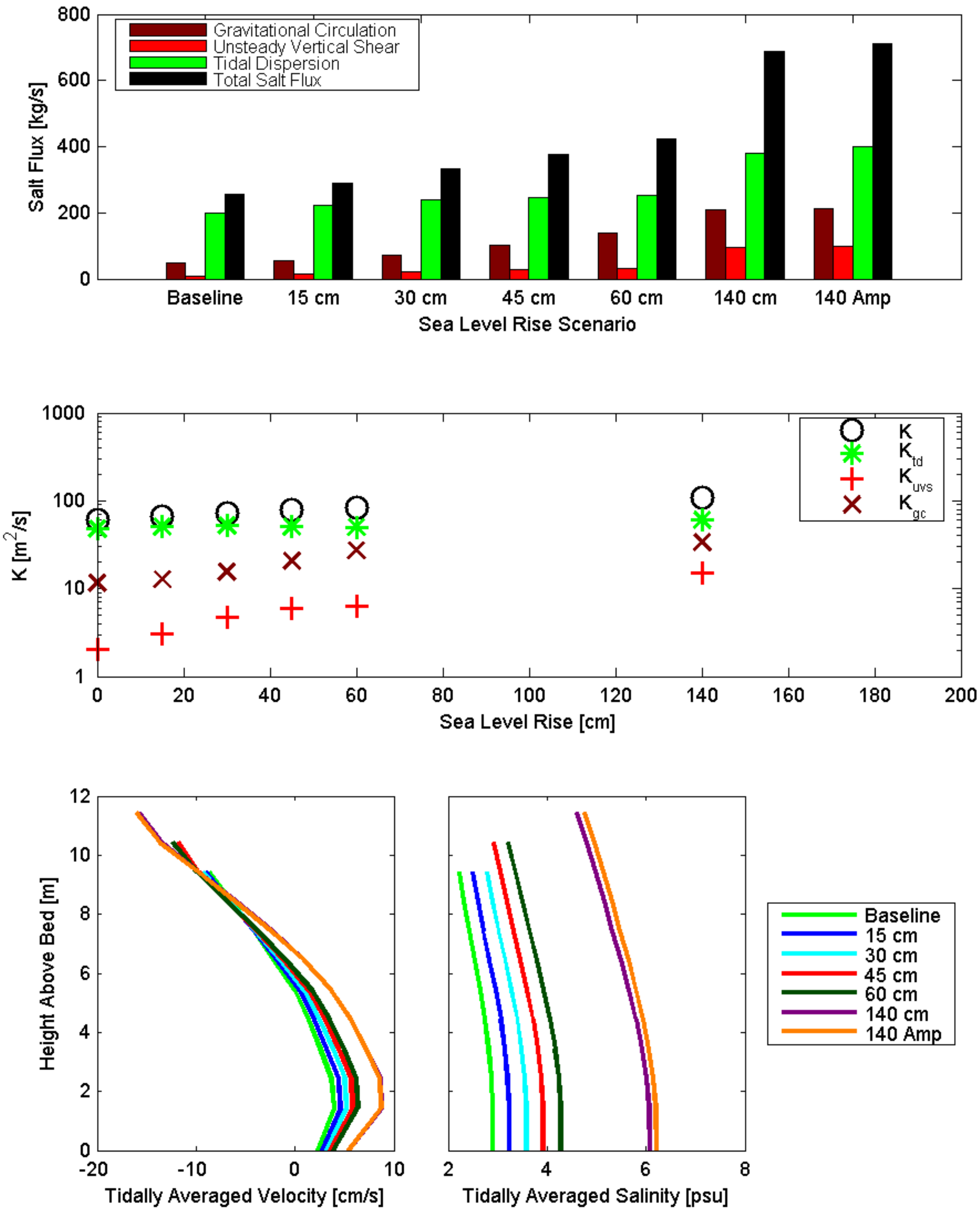


Figure 8.4-92 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 31, extending from Big Break to Toland Landing, for the October 13, 2002 through November 10, 2002 analysis period.

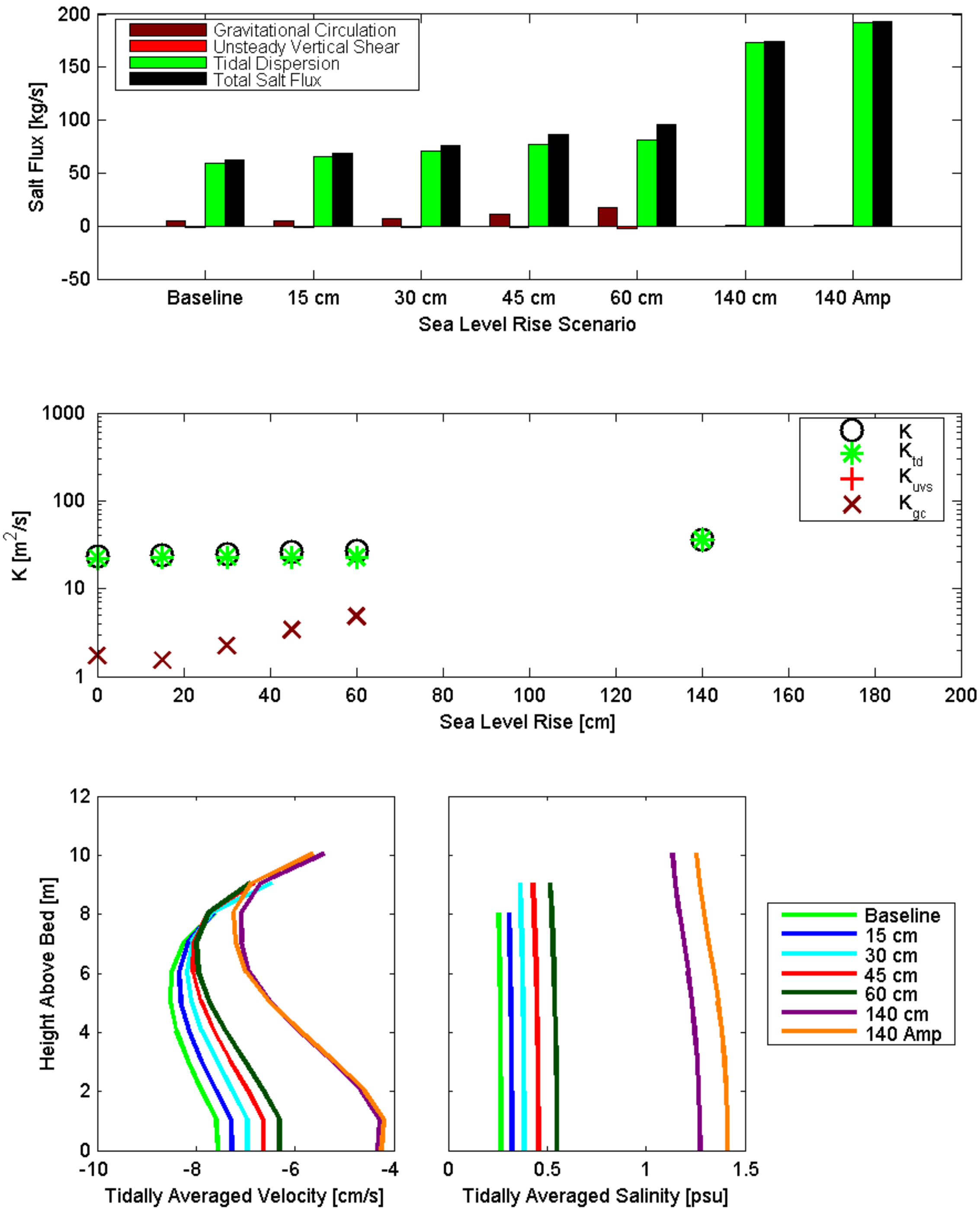


Figure 8.4-93 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 32, extending from Dutch Slough to Chinese Cut, for the July 15, 2002 through August 12, 2002 analysis period.

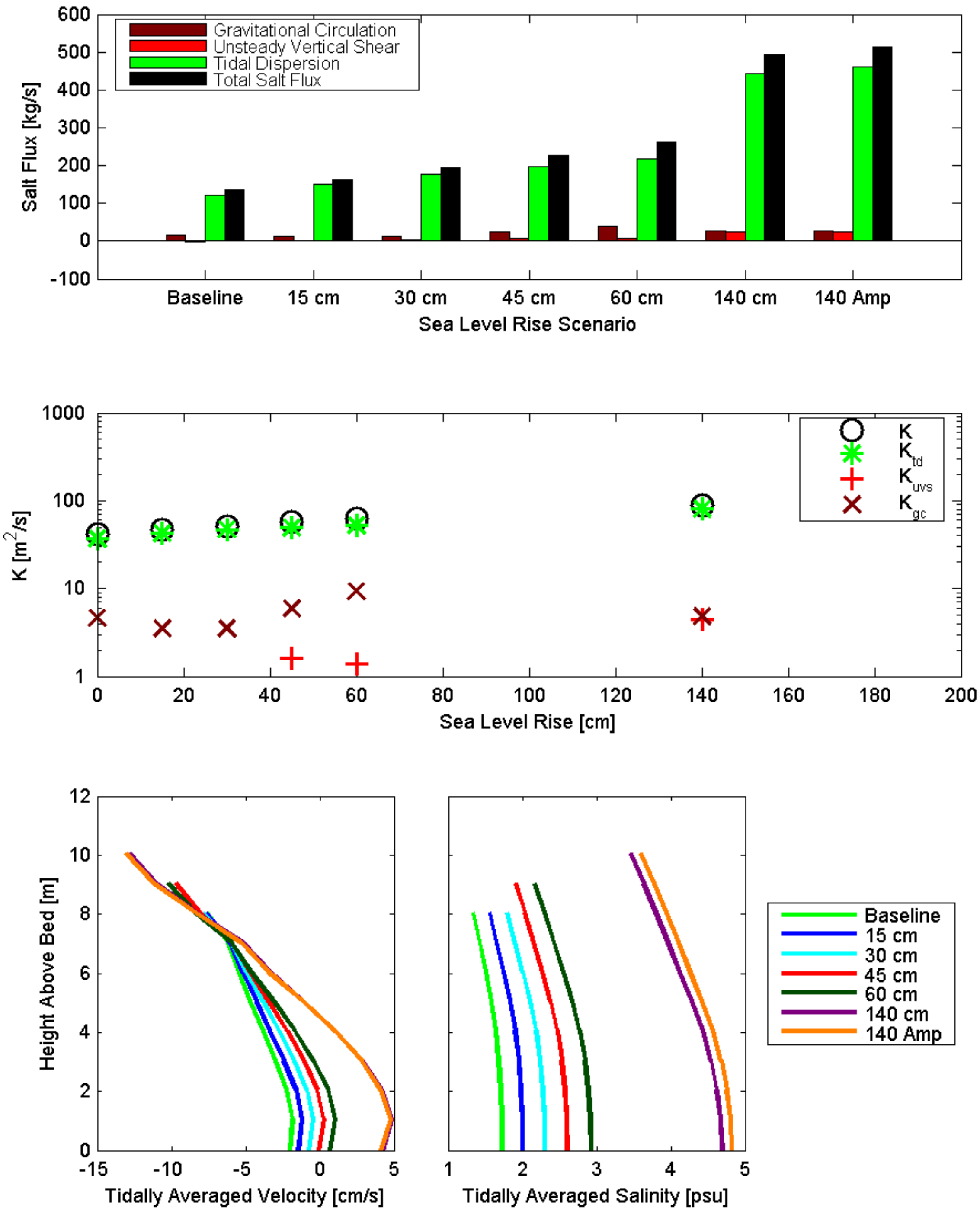


Figure 8.4-94 Dispersive salt flux (top), dispersion coefficients and dispersion coefficient components (middle) and tidally averaged velocity (bottom left) and tidally averaged salinity (bottom right) calculated for each scenario at cross-section 32, extending from Dutch Slough to Chinese Cut, for the October 13, 2002 through November 10, 2002 analysis period.

8.5 Tidal Amplification Scenario Salt Flux Analysis Results

This section evaluates the effect of the amplification of tidal range on salt flux through the comparison of the salt flux analysis for the 140 cm SLR scenario and the 140 cm SLR with 5% Amplification scenario.

As discussed in Section 8.3, analysis periods were chosen in part as periods in which advective and dispersive fluxes balance closely. In other words, the periods selected for the salt analysis have low to moderate variability in salinity conditions. The total dispersive, advective and net fluxes during each period are shown for both analysis periods of the 140 cm SLR scenario and the 140 cm SLR with 5% Amplification scenario in Figure 8.5-1 through Figure 8.5-4. The distance shown on the x-axis corresponds to the distances labeled on the Golden Gate to Rio Vista transect in Figure 5.1-2. For each scenario and analysis period, the advective and dispersive fluxes were bigger than the net fluxes at most or all cross-sections, indicating limited net change in salt mass in the estuary during the analysis period. The net fluxes, indicated with a black x, are generally quite close to the sum of the advective and dispersive fluxes, indicated with a green +. Differences between net fluxes and the sum of the advective and dispersive fluxes are associated with flux terms that are neglected in the flux analysis and other sources of inaccuracies in the analysis but are typically very small.

In Figure 8.5-5 through Figure 8.5-12, the average tidal prism predicted during each analysis period is provided for several cross-sections. The tidal prism increases significantly at all locations with 5% amplification of tidal amplitude. The increase in tidal prism with tidal range amplification is likely to explain several trends in the salt flux analysis. It should be noted that the scenarios assume “hard shorelines.” As a result of this assumption, the tidal prism is likely to increase more substantially with amplification of tides than is predicted in this analysis due to more frequent inundation of low elevation regions bordering the estuary.

In order to calculate dispersion coefficient using Equation 8-1, the variables Q, S and A are averaged through the analysis period at the individual cross-sections. Salinity is also period averaged along the centerline transect shown in Figure 8.3-1, and is shown the 140 cm SLR scenario and the 140 cm SLR with 5% Amplification scenario for both analysis periods in Figure 8.3-14 through Figure 8.3-17. In order to calculate the longitudinal salinity gradient (dS/dx) at each cross section, the period averaged salinity along the centerline transect is depth-averaged for each scenario, to calculate the predicted depth-averaged and period averaged salinity along the centerline of the estuary from the Golden Gate to Rio Vista. The longitudinal salinity gradient at each point is determined by a linear fit of the variability of depth-averaged salinity with distance along the centerline. The longitudinal salinity gradients along the centerline of the estuary for the 140 cm SLR scenario and the 140 cm SLR with 5% Amplification scenario are shown in Figure 8.5-13 and Figure 8.5-14, respectively.

Salt fluxes and dispersion coefficients were calculated for each cross-section shown in Figure 8.3-1 and for the 140 cm SLR scenario and the 140 cm SLR with 5% Amplification scenario. Increases in salt fluxes and dispersion coefficients with amplification indicate that increased Delta inflows will be required to meet salinity standards as a result of amplification of tidal range. The estimated dispersion coefficients (K) are shown in Figure 8.5-15 for the July 15, 2002 through August 12, 2002 analysis period and in Figure 8.5-16 for the October 13, 2002 through November 10, 2002 analysis period. The dispersion coefficients for the two periods show similar trends, but the dispersion coefficients for the October 13, 2002 through November 10, 2002 analysis period are higher in Suisun Bay and the western Delta than the respective dispersion coefficients for the July 15, 2002 through August 12, 2002 analysis period. The calculated dispersion coefficients have limited variability with amplification at most cross-sections in Central Bay and San Pablo Bay. However, dispersion coefficients in Suisun Bay and the western Delta generally increase significantly with amplification.

The salt flux analysis described in Section 8.2 was used to divide each dispersion coefficient into three components: K_{gc}, $K_{uvs,}$ and K_{td}. K_{gc} represents the strength of gravitational circulation, K_{uvs} represents the strength of all unsteady vertical shear dispersion processes and K_{td} represents the strength of all tidal dispersion processes.

The estimated dispersion coefficients associated with gravitational circulation (K_{gc}) for the 140 cm SLR scenario and the 140 cm SLR with 5% Amplification scenario are shown in Figure 8.5-17 for the July 15, 2002 through August 12, 2002 analysis period and in Figure 8.5-18 for the October 13, 2002 through November 10, 2002 analysis period. Note that the dispersion coefficient component associated with gravitational circulation is more variable with location than the overall dispersion coefficient. The dispersion coefficient components associated with gravitational circulation decrease with amplification at most locations. This was expected because tidal range amplification results in higher tidal currents and, therefore, stronger vertical mixing and less stratification.

The dispersion coefficients associated with unsteady vertical shear (K_{uvs}) for the 140 cm SLR scenario and the 140 cm SLR with 5% Amplification scenario are shown in Figure 8.5-19 for the July 15, 2002 through August 12, 2002 analysis period and in Figure 8.5-20Figure 8.4-28 for the October 13, 2002 through November 10, 2002 analysis period. The unsteady vertical shear component is highly variable but often of similar magnitude as the gravitational circulation component. Some of the dispersion associated with unsteady vertical shear is associated with the SIPS mechanism which is known to be active in portions of Suisun Bay (Stacey et al. 2001). The dispersion associated with unsteady vertical shear varies significantly with amplification. However, the sign and magnitude of change in this component with amplification varies from cross-section to cross-section.

The dispersion coefficients associated with all tidal dispersion processes (K_{td}) for the 140 cm SLR scenario and the 140 cm SLR with 5% Amplification scenario are shown in Figure 8.5-21 for the July 15, 2002 through August 12, 2002 analysis period and in Figure 8.5-22 for the October 13, 2002 through November 10, 2002 analysis period. K_{td} is similar between the two analysis periods and varies over slightly more than one order of magnitude spatially. Since this component of the dispersion coefficient is not expected to have strong variation with stratification, the less pronounced spatial variability was expected. The dispersion coefficient component associated with tidal dispersion generally increases with amplification. This increase is probably related to the increased tidal prism shown in Figure 8.5-6 through Figure 8.5-12.

The effects of amplification were shown individually at each cross-section in Section 8.4.

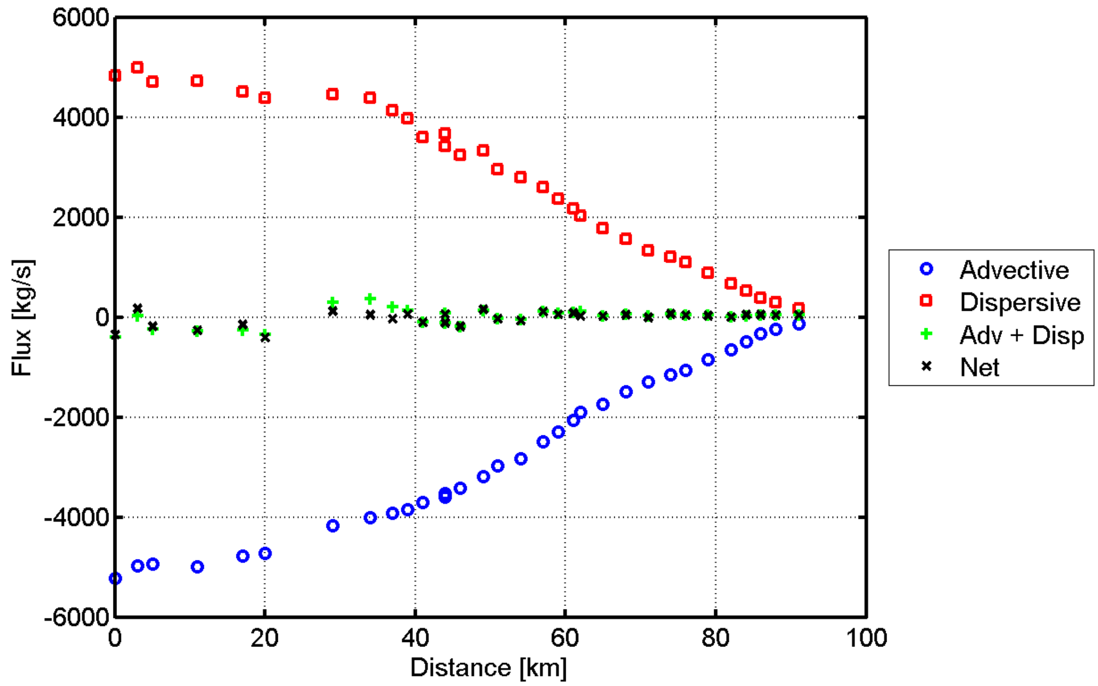


Figure 8.5-1 Predicted advective, dispersive and net salt fluxes for the 140 cm SLR scenario during the July 15, 2002 through August 12, 2002 analysis period.

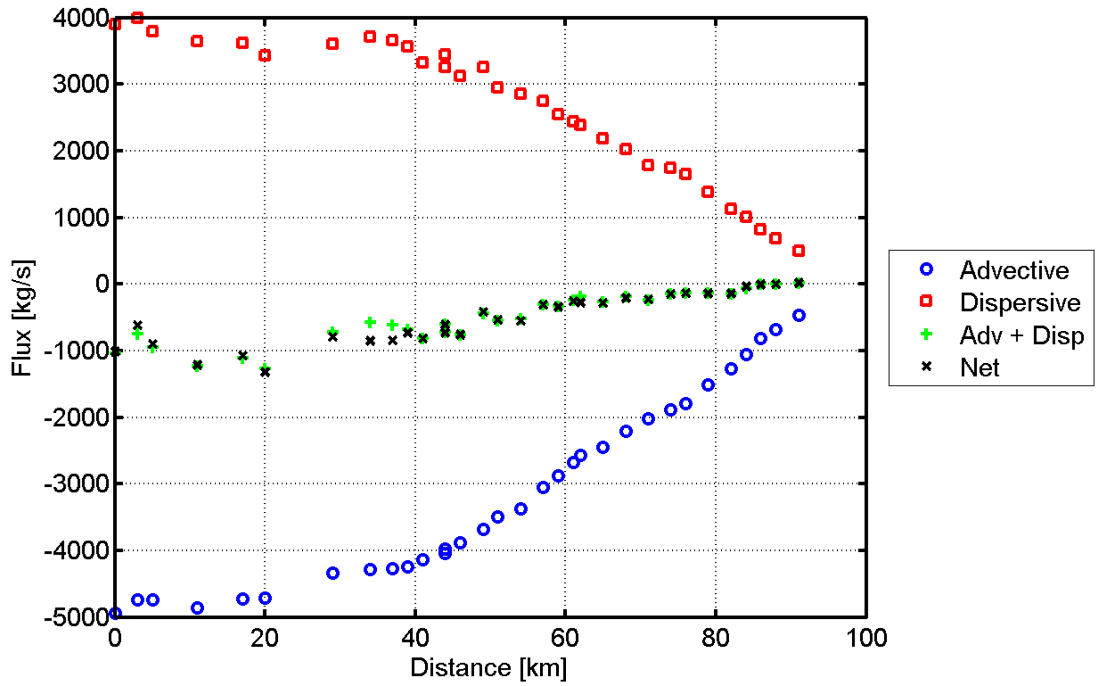


Figure 8.5-2 Predicted advective, dispersive and net salt fluxes for the 140 cm SLR scenario during the October 13, 2002 through November 10, 2002 analysis period.

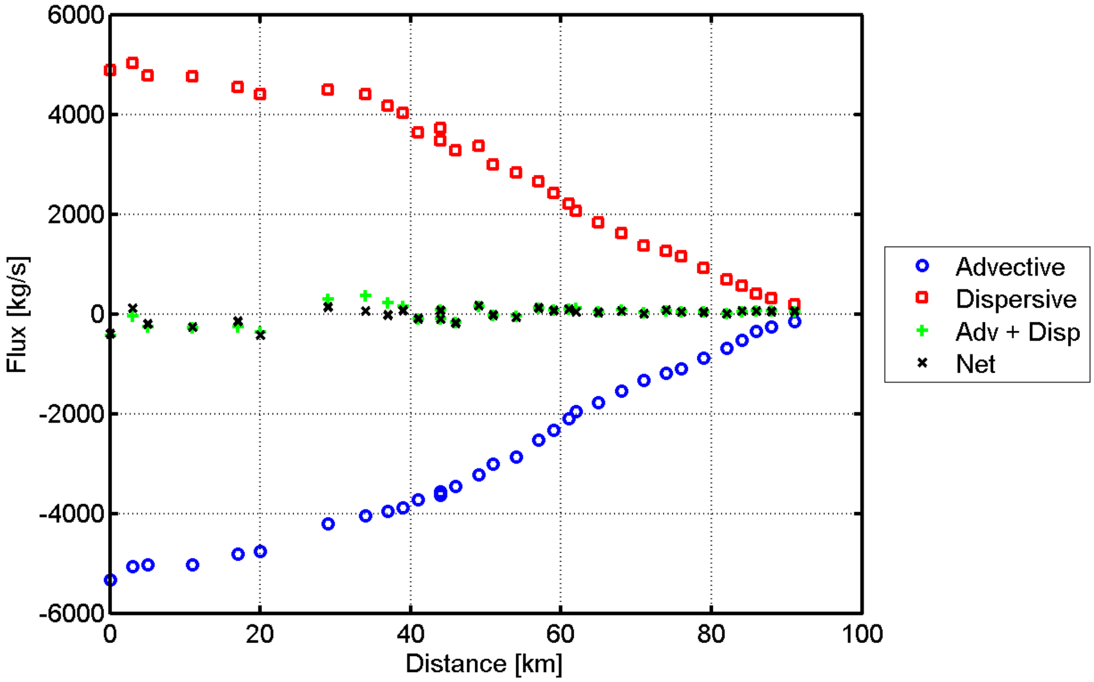


Figure 8.5-3 Predicted advective, dispersive and net salt fluxes for the 140 cm SLR with 5% Amplification scenario during the July 15, 2002 through August 12, 2002 analysis period.

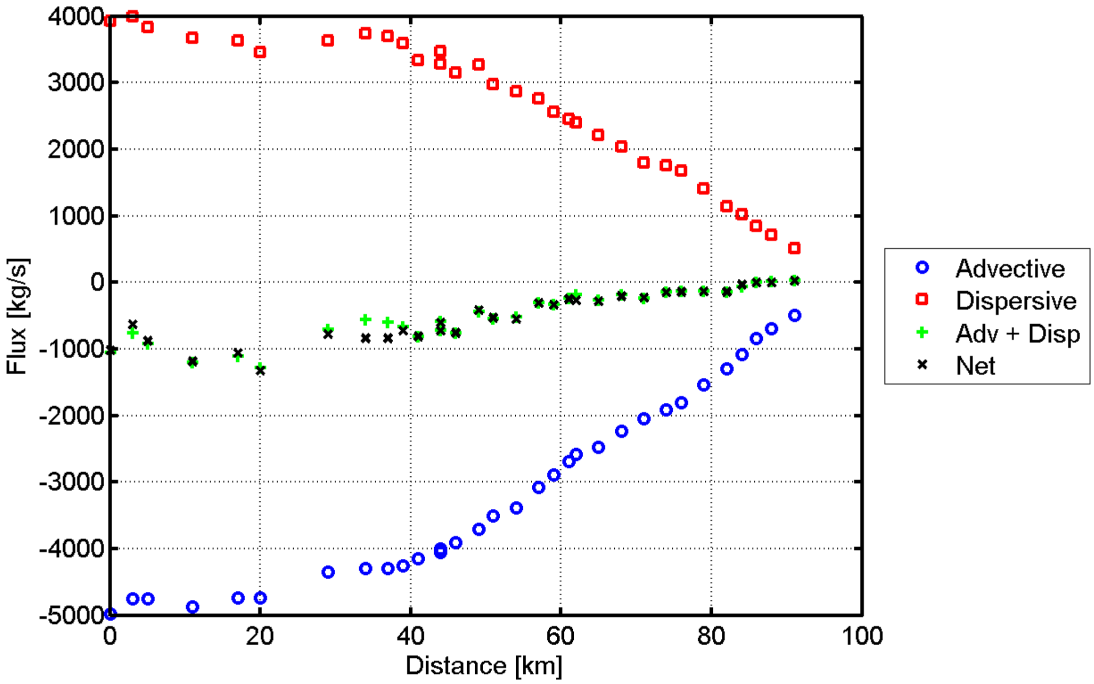


Figure 8.5-4 Predicted advective, dispersive and net salt fluxes for the 140 cm SLR with 5% Amplification scenario during the October 13, 2002 through November 10, 2002 analysis period.

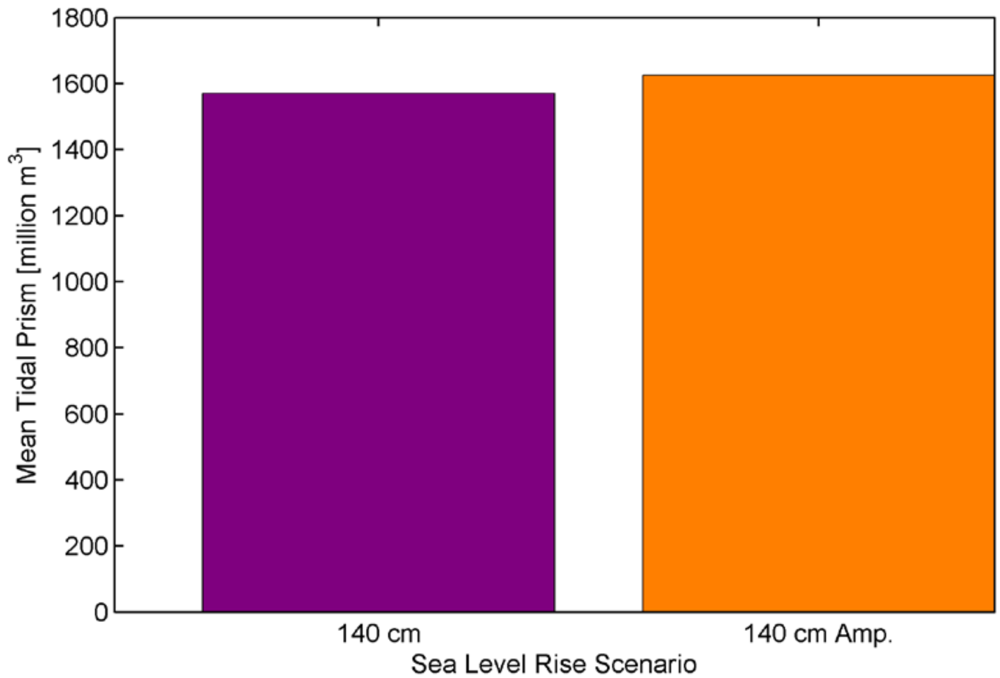


Figure 8.5-5 Average tidal prism at cross-section 1, located at the Golden Gate, for the 140 cm SLR and 140 cm SLR with 5% Amplification scenarios during the July 15, 2002 through August 12, 2002 analysis period.

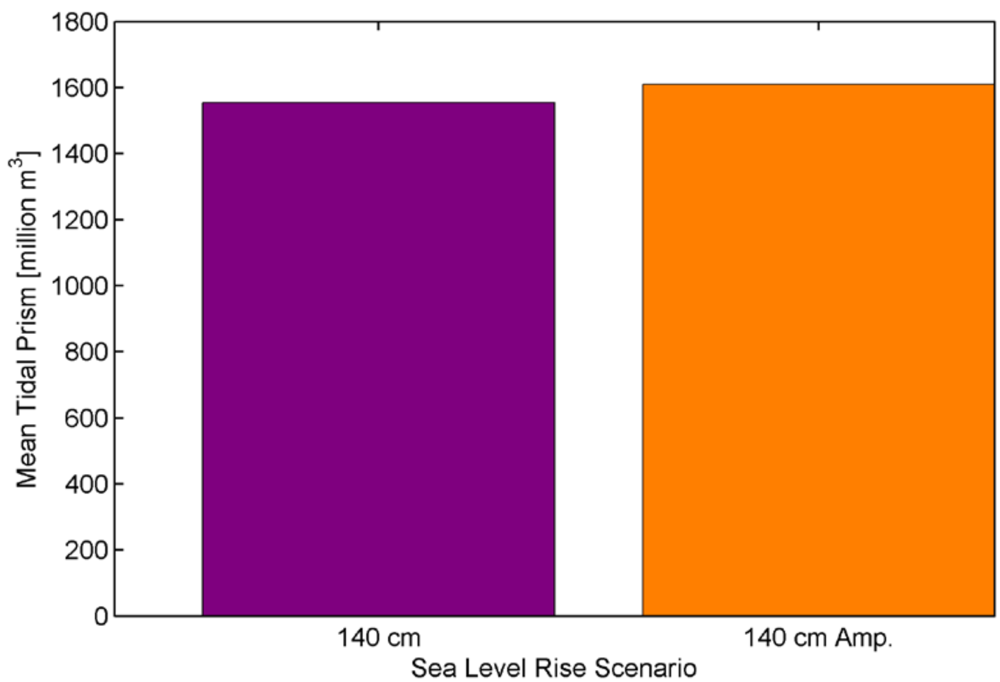


Figure 8.5-6 Average tidal prism at cross-section 1, located at the Golden Gate, for the 140 cm SLR and 140 cm SLR with 5% Amplification scenarios during the October 13, 2002 through November 10, 2002 analysis period.

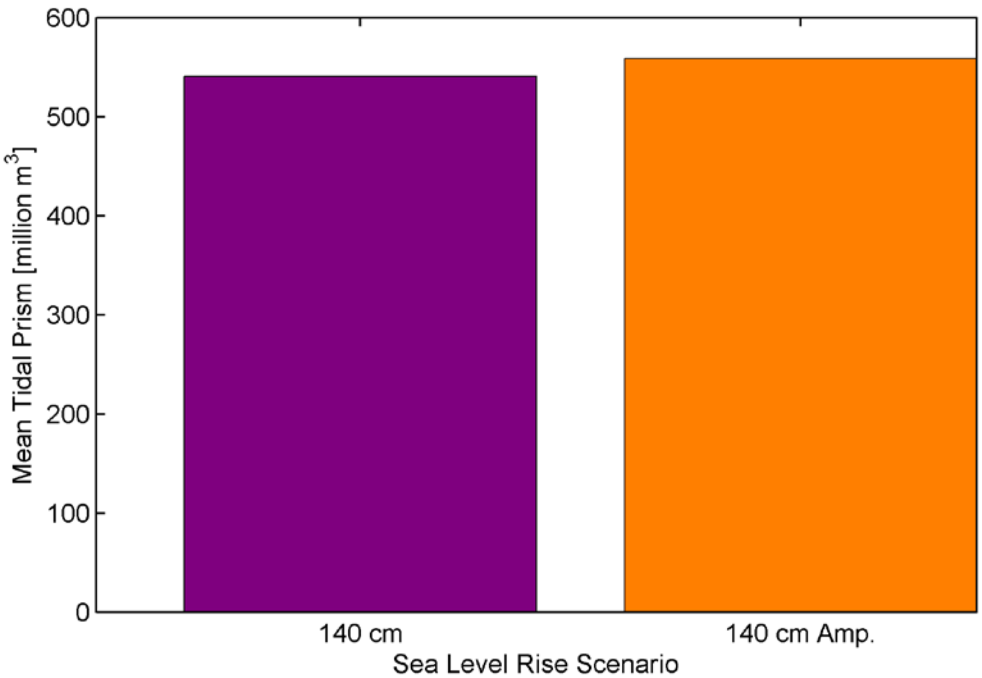


Figure 8.5-7 Average tidal prism at cross-section 5, located at the Richmond-San Rafael Bridge, for the 140 cm SLR and 140 cm SLR with 5% Amplification scenarios during the July 15, 2002 through August 12, 2002 analysis period.

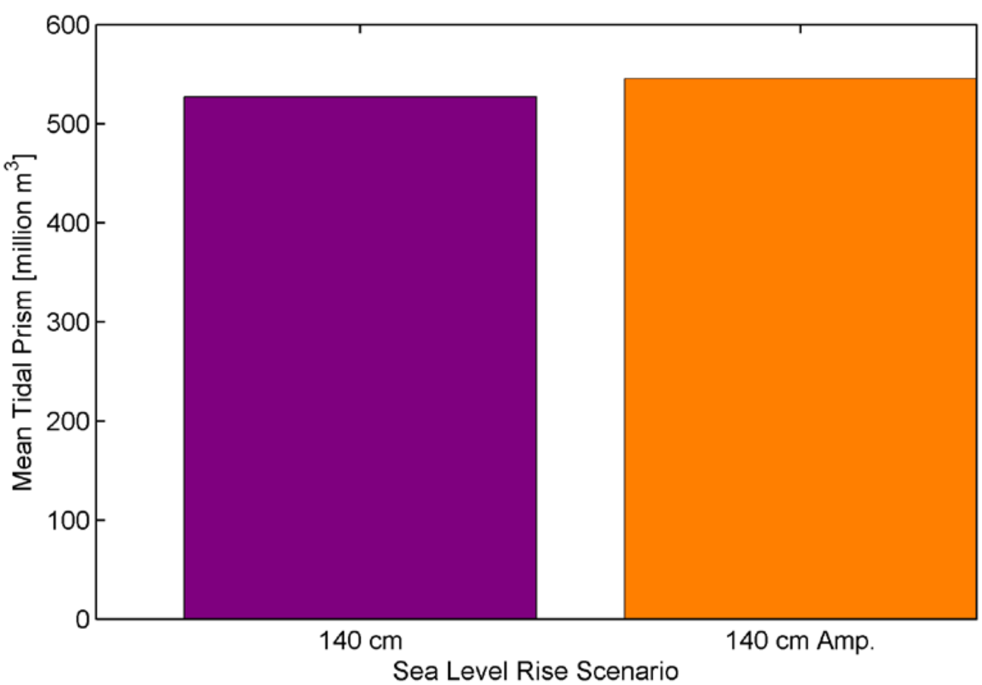


Figure 8.5-8 Average tidal prism at cross-section 5, located at the Richmond-San Rafael Bridge, for the 140 cm SLR and 140 cm SLR with 5% Amplification scenarios during the October 13, 2002 through November 10, 2002 analysis period.

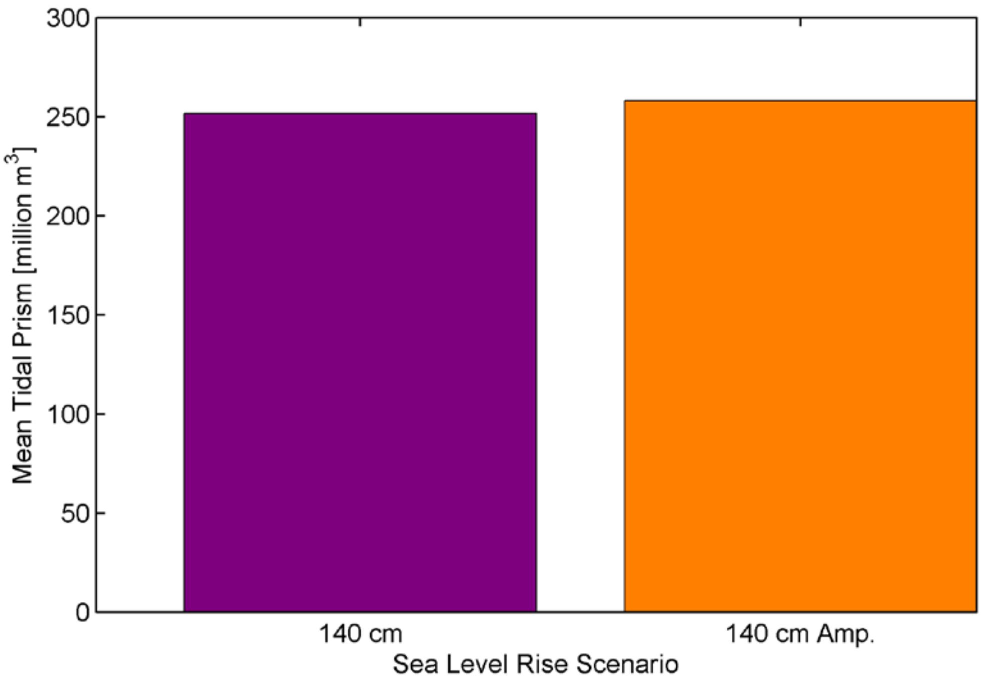


Figure 8.5-9 Average tidal prism at cross-section 12, located at the Carquinez Bridge, for the 140 cm SLR and140 cm SLR with 5% Amplification scenarios during the July 15, 2002 through August 12, 2002 analysis period.

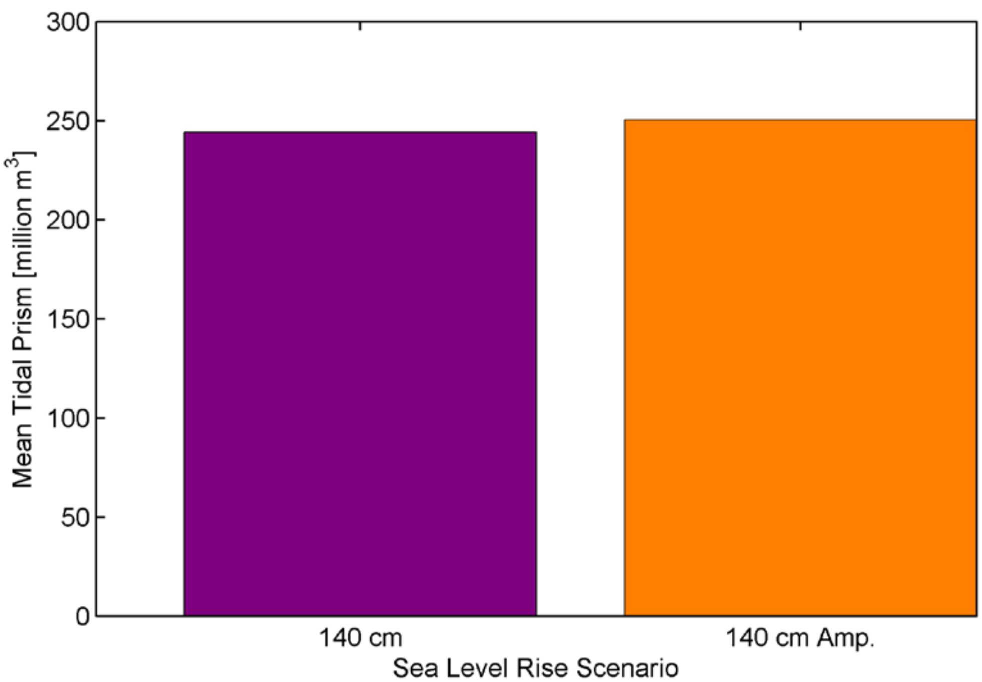


Figure 8.5-10 Average tidal prism at cross-section 12, located at the Carquinez Bridge, for the 140 cm SLR and 140 cm SLR with 5% Amplification scenarios during the October 13, 2002 through November 10, 2002 analysis period.

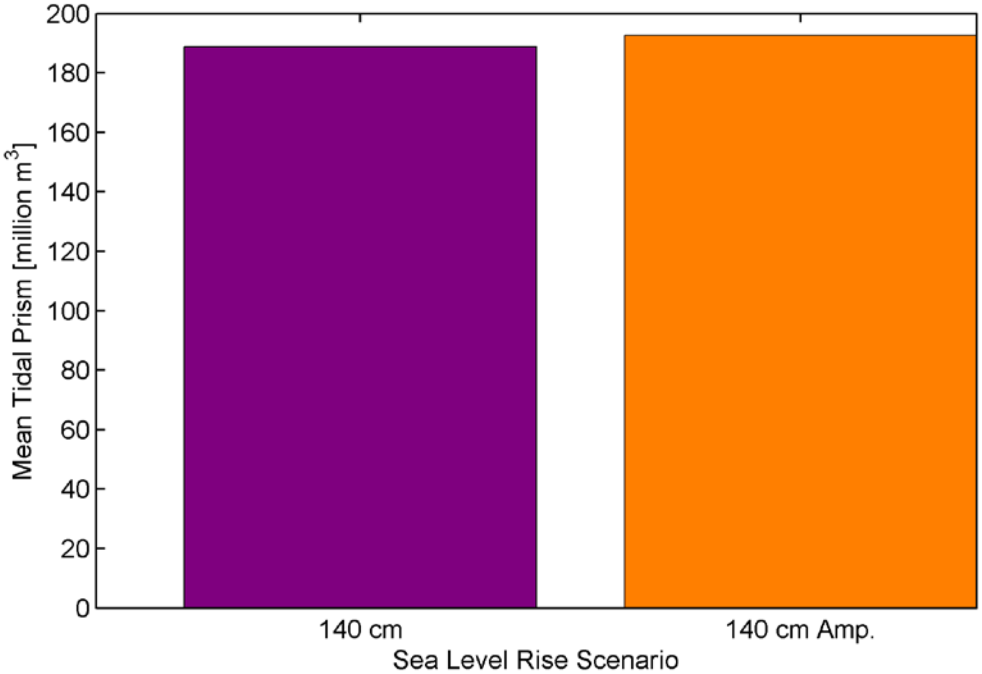


Figure 8.5-11 Average tidal prism at cross-section 25, located at Chipps Island, for the 140 cm SLR and 140 cm SLR with 5% Amplification scenarios during the July 15, 2002 through August 12, 2002 analysis period.

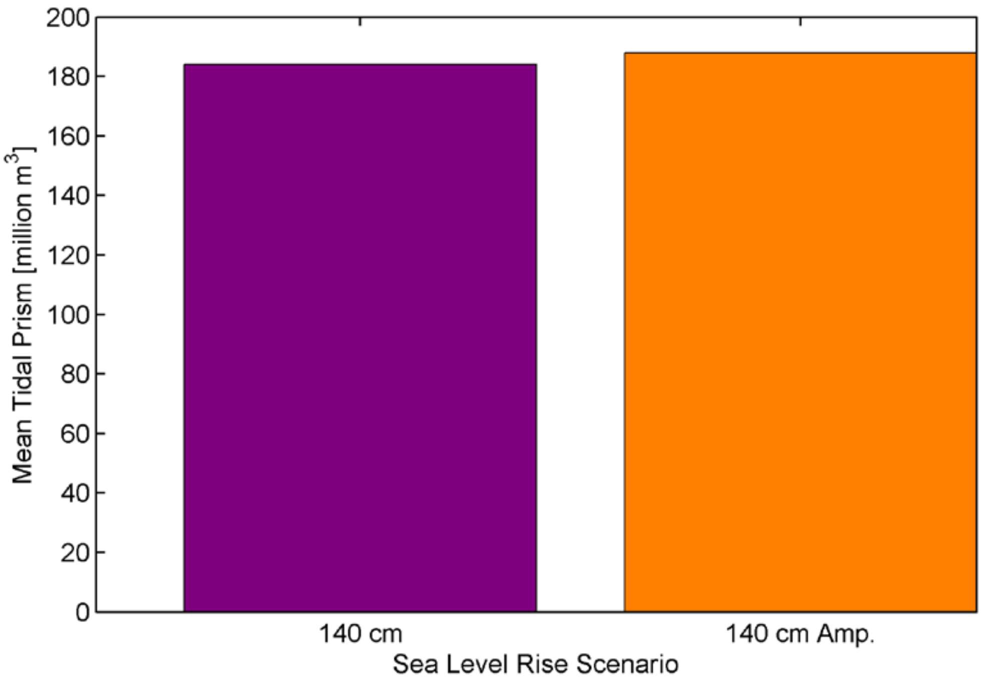


Figure 8.5-12 Average tidal prism at cross-section 25, located at Chipps Island, for the 140 cm SLR and 140 cm SLR with 5% Amplification scenarios during the October 13, 2002 through November 10, 2002 analysis period.

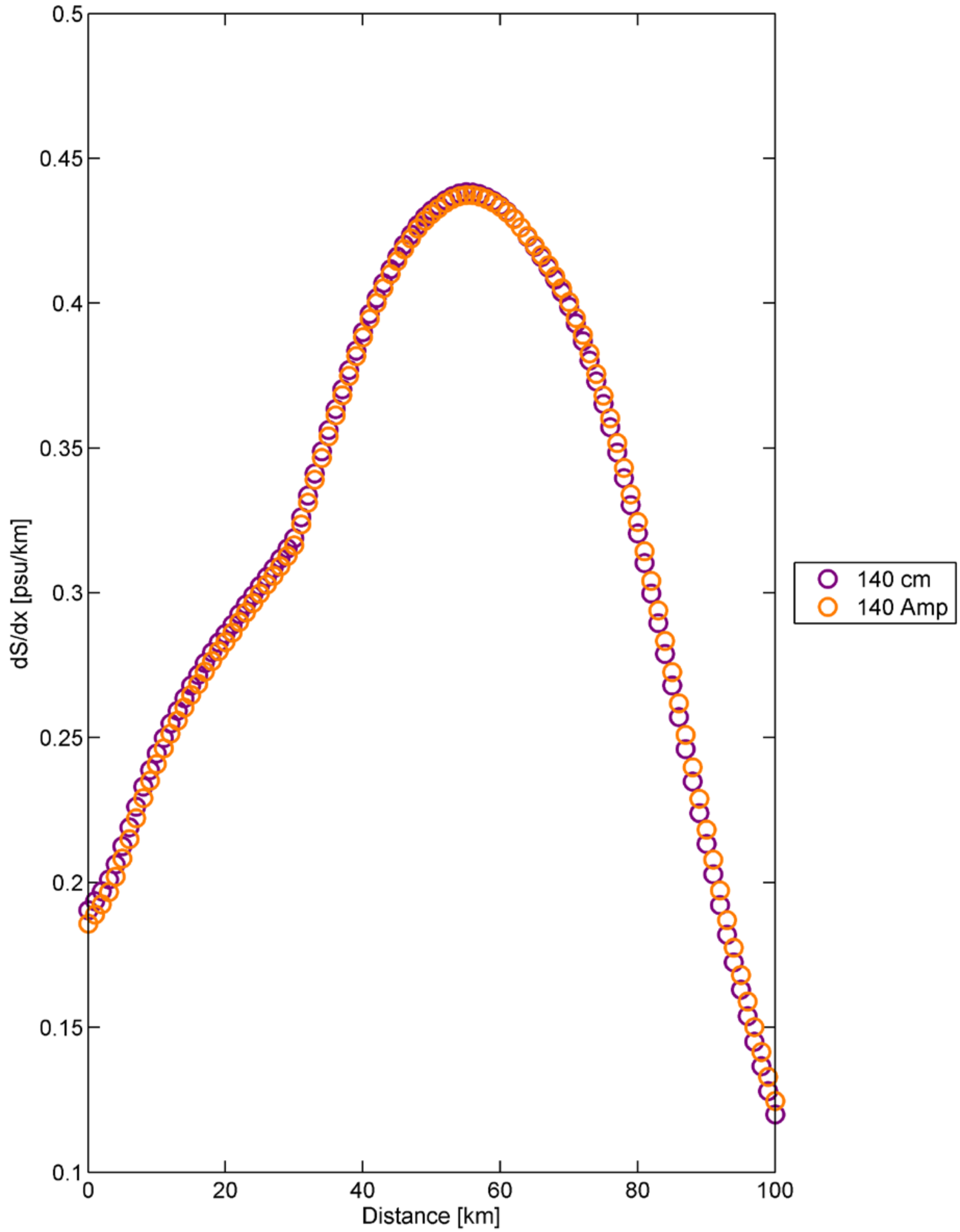


Figure 8.5-13 Estimated depth-averaged salinity gradient for the 140 cm SLR and 140 cm SLR with 5% Amplification scenarios for the July 15, 2002 through August 12, 2002 analysis period. The horizontal scale is distance along the axis of the estuary from the Golden Gate.

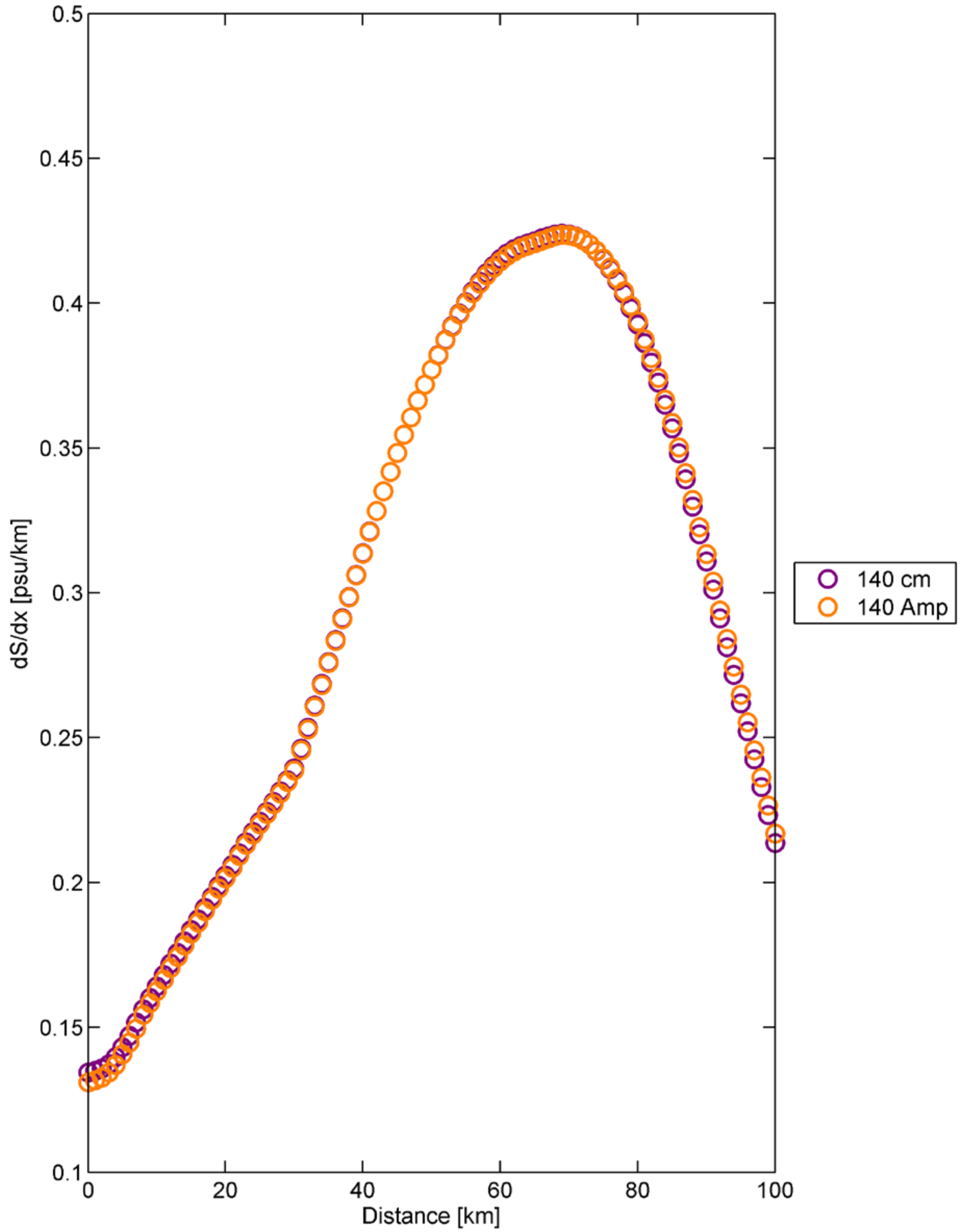


Figure 8.5-14 Estimated depth-averaged salinity gradient for the 140 cm SLR and 140 cm SLR with 5% Amplification scenarios for the October 13, 2002 through November 10, 2002 analysis period. The horizontal scale is distance along the axis of the estuary from the Golden Gate.

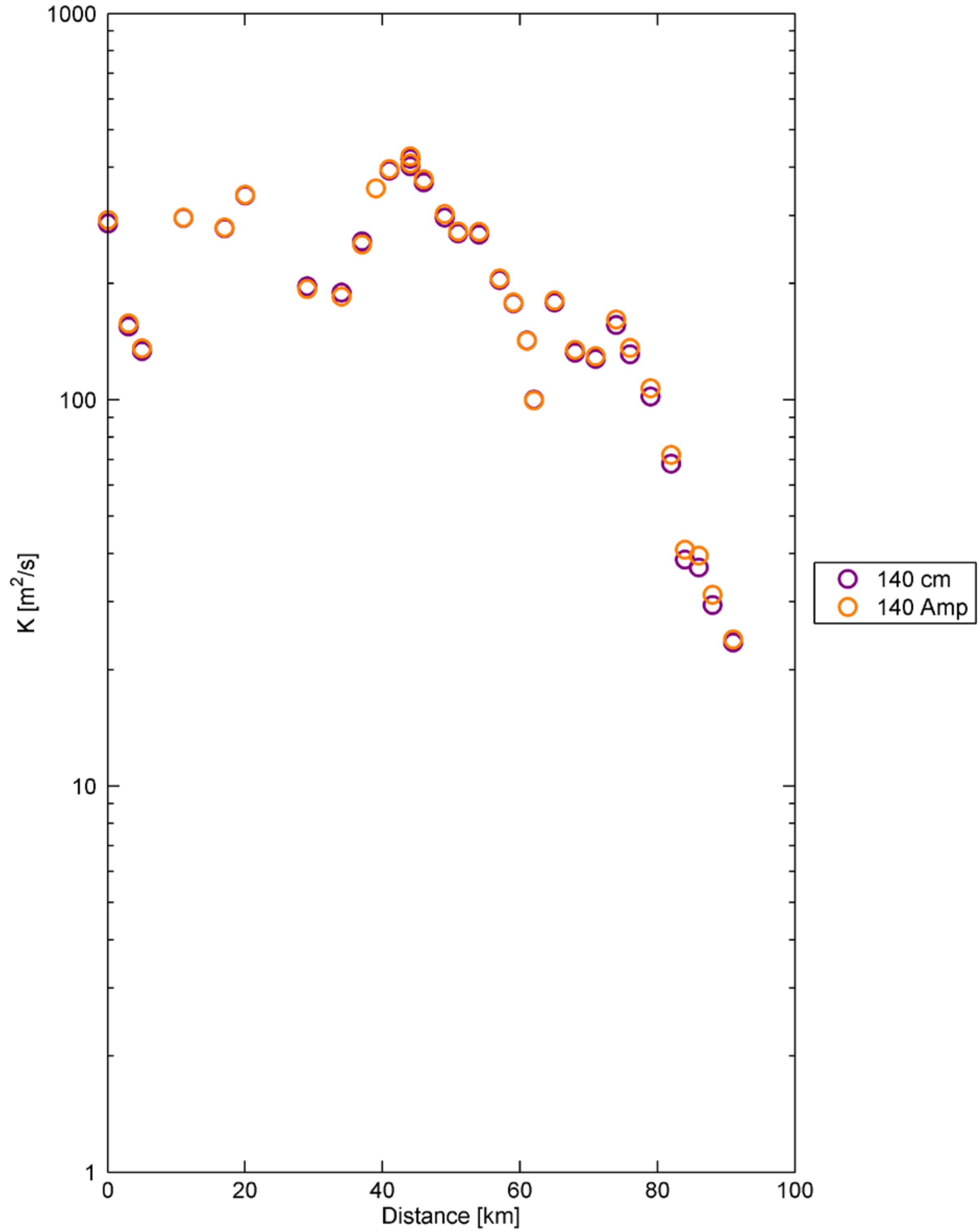


Figure 8.5-15 Estimated dispersion coefficient for the 140 cm SLR and 140 cm SLR with 5% Amplification scenarios for the July 15, 2002 through August 12, 2002 analysis period. The horizontal scale is distance along the axis of the estuary from the Golden Gate.

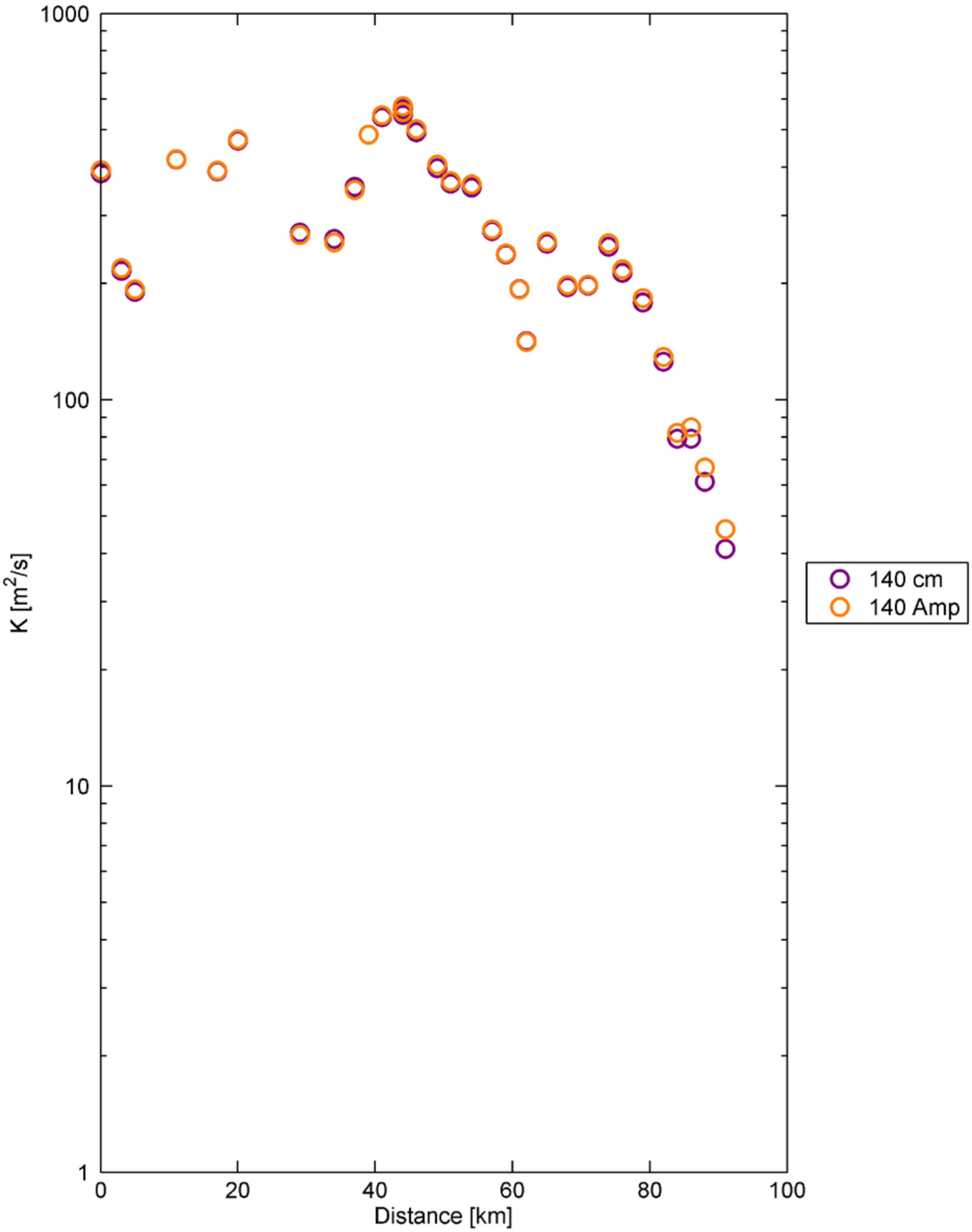


Figure 8.5-16 Estimated dispersion coefficient for the 140 cm SLR and 140 cm SLR with 5% Amplification scenarios for the October 13, 2002 through November 10, 2002 analysis period. The horizontal scale is distance along the axis of the estuary from the Golden Gate.

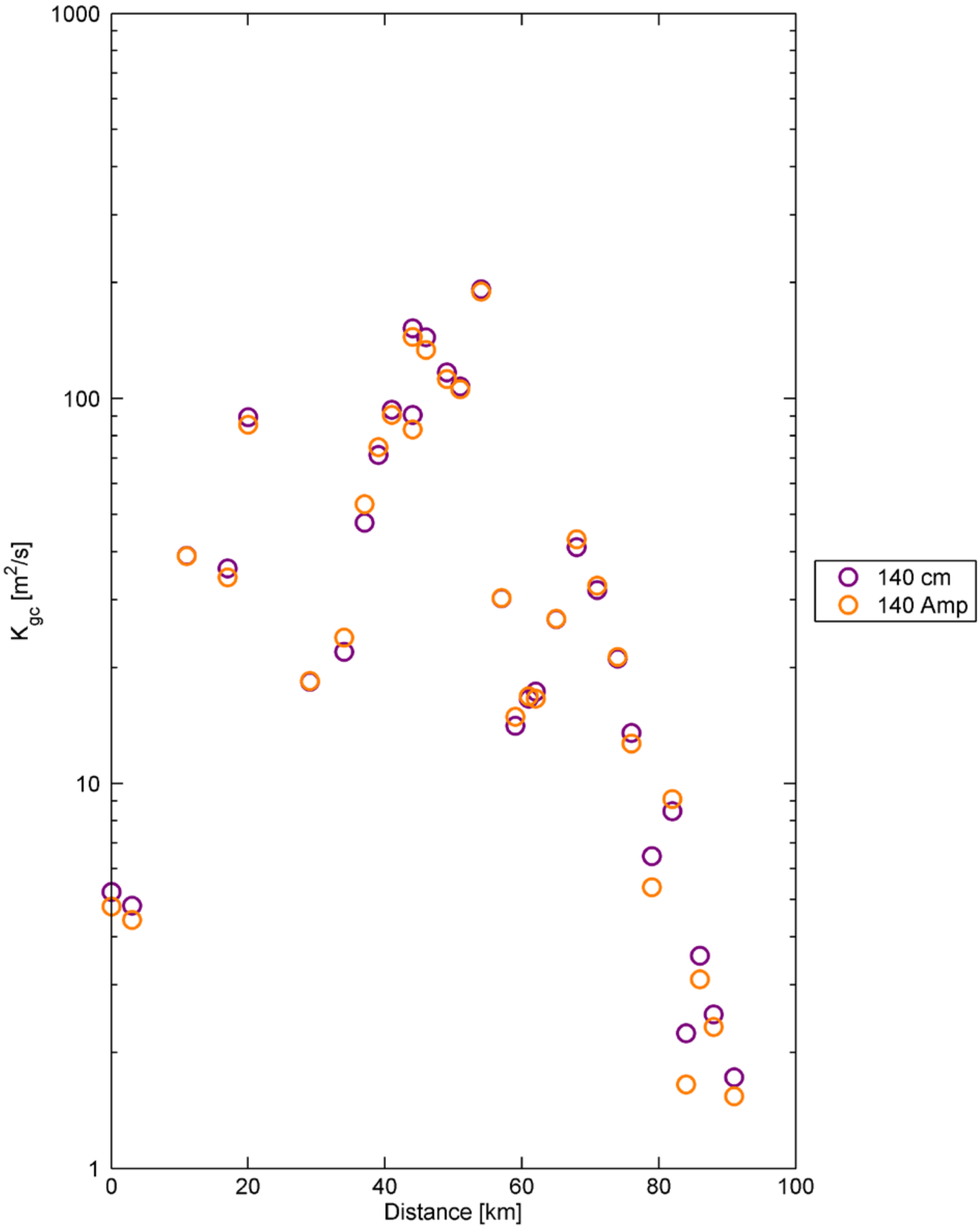


Figure 8.5-17 Estimated dispersion coefficient due to gravitational circulation for the 140 cm SLR and 140 cm SLR with 5% Amplification scenarios for the July 15, 2002 through August 12, 2002 analysis period. The horizontal scale is distance along the axis of the estuary from the Golden Gate.

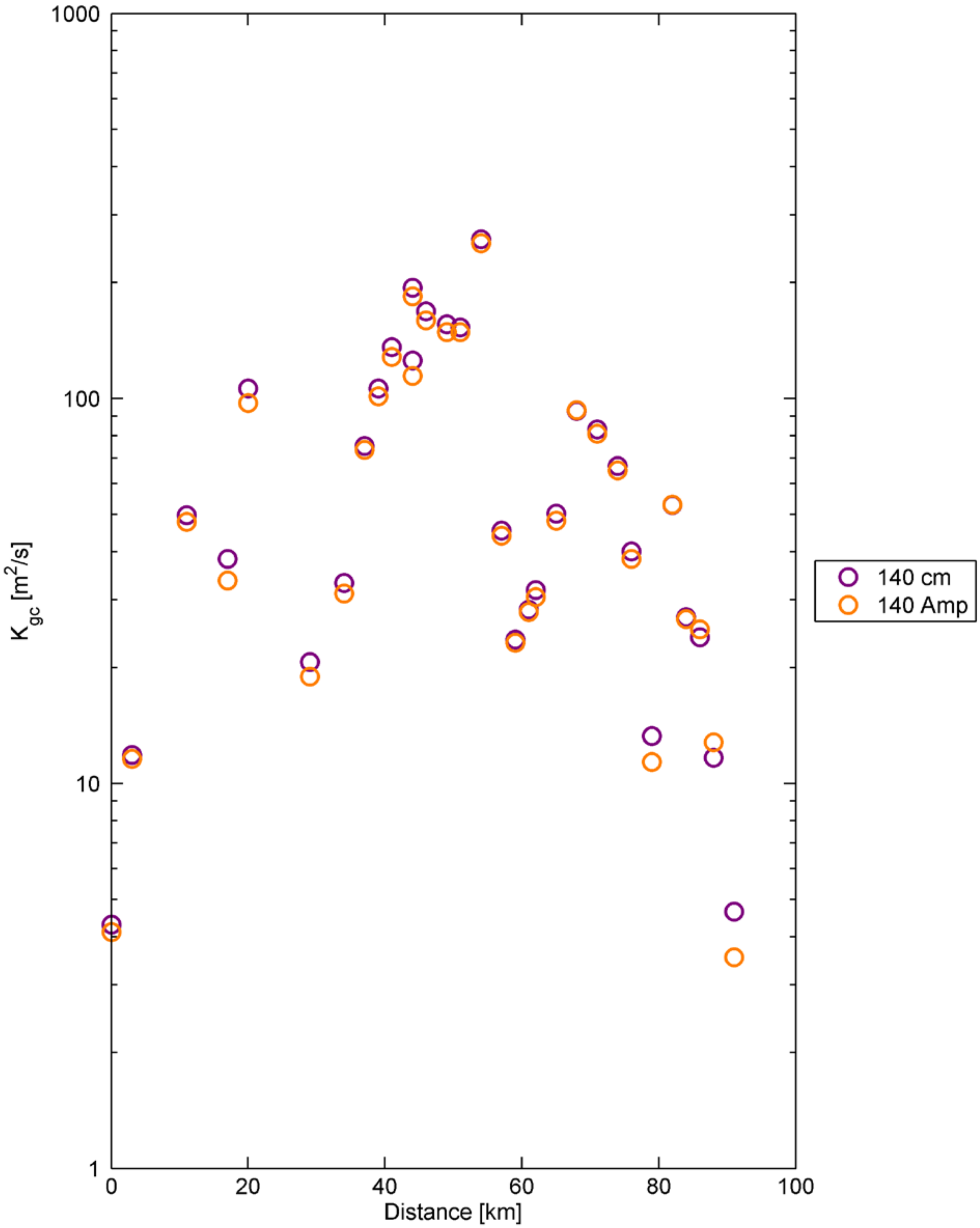


Figure 8.5-18 Estimated dispersion coefficient due to gravitational circulation for the 140 cm SLR and 140 cm SLR with 5% Amplification scenarios for the October 13, 2002 through November 10, 2002 analysis period. The horizontal scale is distance along the axis of the estuary from the Golden Gate.

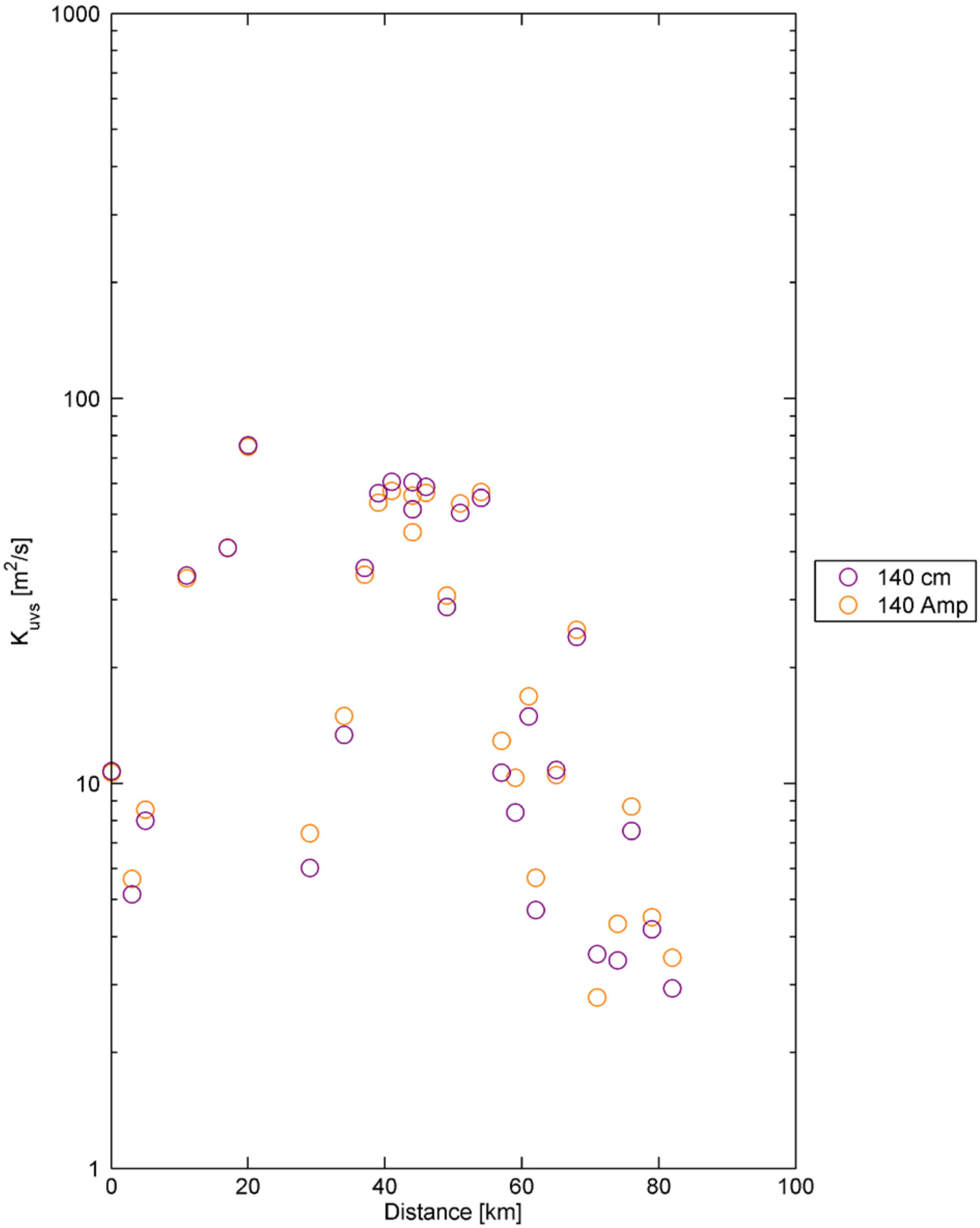


Figure 8.5-19 Estimated dispersion coefficient due to unsteady vertical shear for the 140 cm SLR and 140 cm SLR with 5% Amplification scenarios for the July 15, 2002 through August 12, 2002 analysis period. The horizontal scale is distance along the axis of the estuary from the Golden Gate.

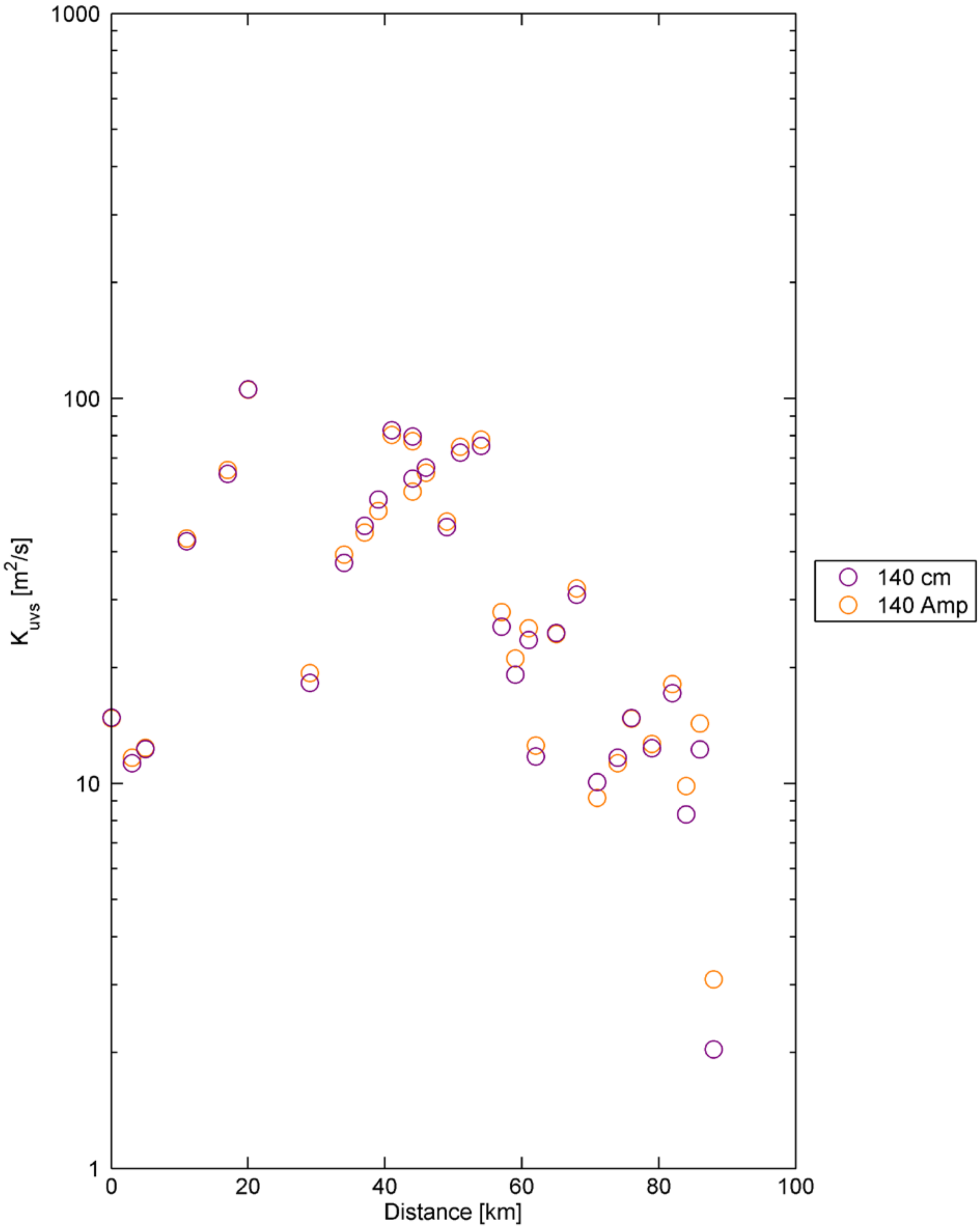


Figure 8.5-20 Estimated dispersion coefficient due to unsteady vertical shear for the 140 cm SLR and 140 cm SLR with 5% Amplification scenarios for the October 13, 2002 through November 10, 2002 analysis period. The horizontal scale is distance along the axis of the estuary from the Golden Gate.

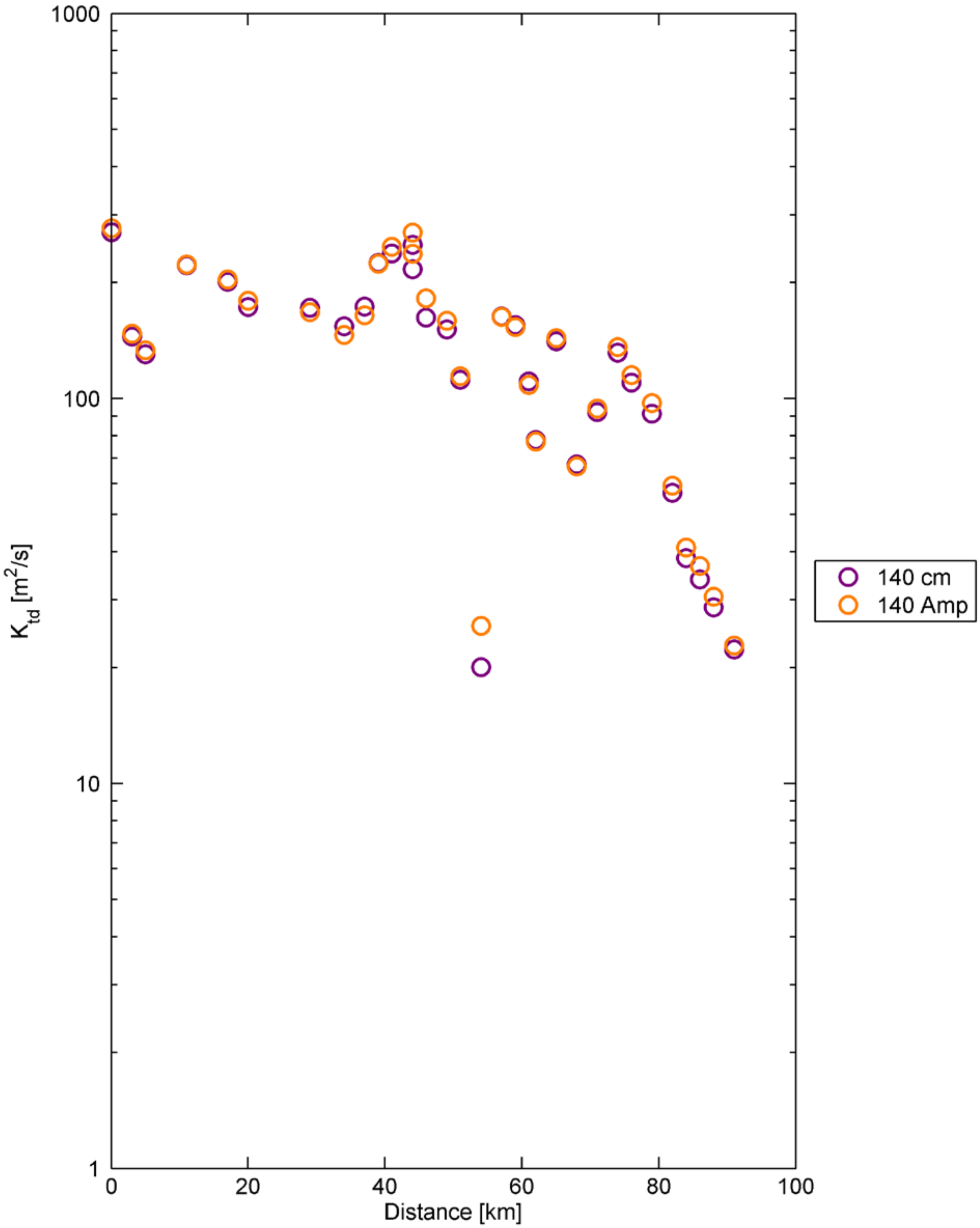


Figure 8.5-21 Estimated dispersion coefficient due to tidal dispersion for the 140 cm SLR and 140 cm SLR with 5% Amplification scenarios for the July 15, 2002 through August 12, 2002 analysis period. The horizontal scale is distance along the axis of the estuary from the Golden Gate.

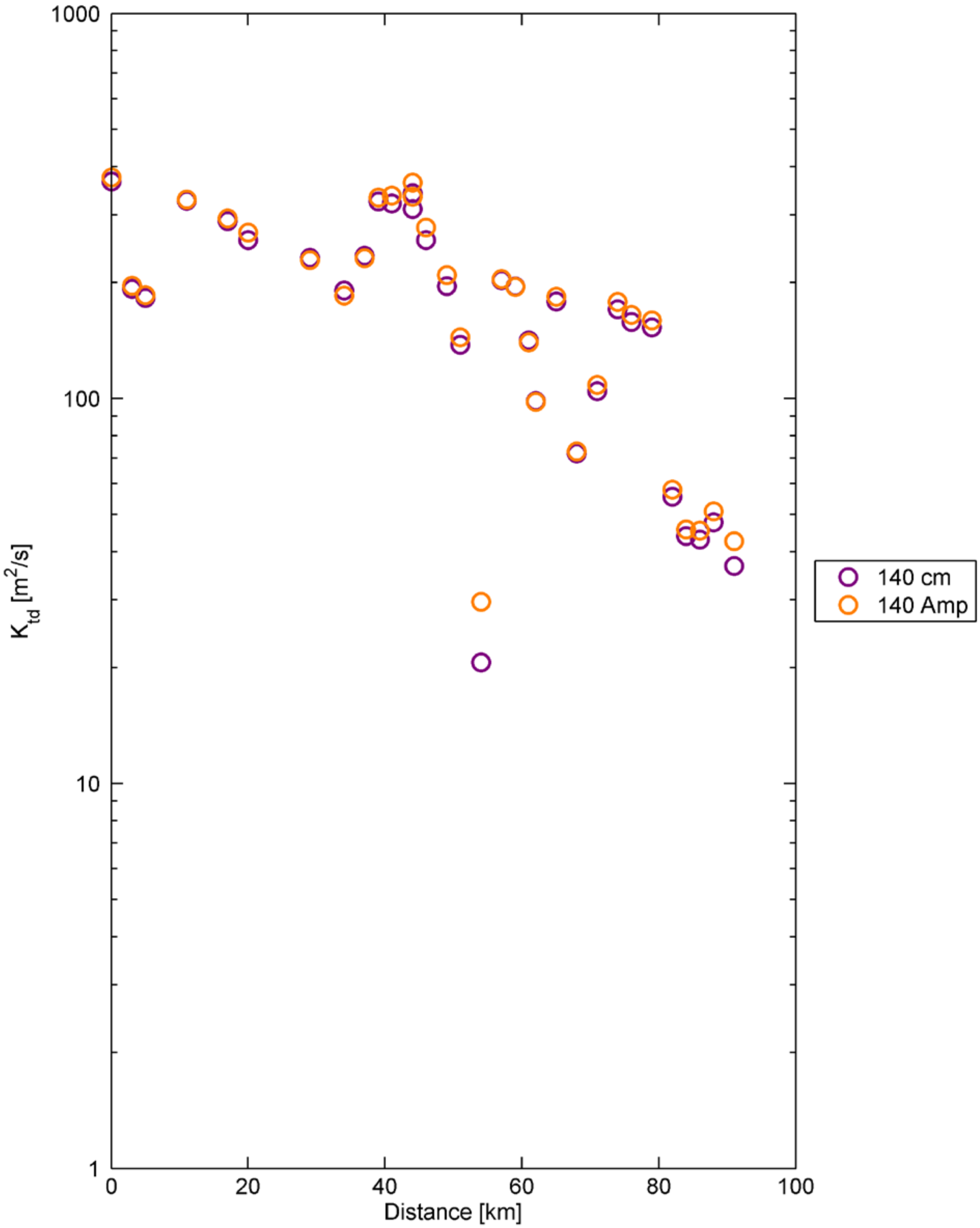


Figure 8.5-22 Estimated dispersion coefficient due to tidal dispersion for the 140 cm SLR and 140 cm SLR with 5% Amplification scenarios for the October 13, 2002 through November 10, 2002 analysis period. The horizontal scale is distance along the axis of the estuary from the Golden Gate.

8.6 Uncertainty of Salt Flux and Dispersion Analysis

The UnTRIM Bay-Delta model was calibrated for historical conditions and predicts salinity accurately during the calibration period. This calibration provides confidence that physical processes responsible for salt transport are represented adequately. The method used for the calculation of dispersion coefficients and the method used to distinguish fluxes from different physical processes are well-established (e.g. Fischer et al. 1979).

The results of the analysis for the Baseline (0 cm SLR) scenario are consistent with the conceptual model of transport developed through many field studies (e.g. Burau et al., 1998). The conceptual model is that gravitational circulation is a key transport mechanism in San Pablo Bay and Carquinez Strait and that the importance of gravitational circulation decreases sharply at the Benicia shoal due to limited depth. The DRMS analysis of dispersion coefficients at varying Net Delta Outflow (Gross et al. 2007a) indicated that the strength of gravitational circulation increased strongly with flow so that at higher flow rates it became the dominant mechanism in San Pablo Bay and Carquinez Strait, as expected. The salt flux and dispersion analysis conclusions from this analysis apply only to low flow rates similar to those during the two periods used in the analysis presented in this section. In Suisun Bay, due to complex bathymetry as well as less pronounced gravitational circulation, tidal dispersion processes are the dominant transport processes (e.g. Burau et al., 1998).

Though the accuracy of the estimated salt fluxes and dispersion coefficients is likely to be adequate, several limitations and uncertainties limit confidence in the estimated salt fluxes and dispersion coefficients. Some of this uncertainty is associated with the three-dimensional model predictions while additional uncertainty is associated with the analysis method. The three-dimensional model applied in this analysis provides a more detailed description of fluid motion in the San Francisco Estuary than depth-averaged or one-dimensional models. The model has been well-calibrated to water levels, tidal and tidally averaged flows and salinity. Comparison of model results to observed tidally averaged velocity profiles was not included in the calibration effort. Such a comparison would improve confidence in the model's ability to accurately predict gravitational circulation. Any future improvements to model calibration would result in some changes to calculated salt fluxes and dispersion coefficients.

Substantial uncertainty is associated with the analysis technique. Sources of uncertainty include:

- The model cross-sections are not perfectly aligned normal to tidal or tidally averaged flows.
- Only an approximate balance between advective fluxes and dispersive fluxes is achieved during the averaging period. Some of the imbalance is likely to occur due to varying Delta outflow during the analysis periods. Some of the imbalance is likely due to net tidal advection because the averaging period does not encompass an integer number of all tidal constituents (M2, K1, etc.). However, the imbalance could also affect the dispersive flux analysis to some extent.
- The salinity gradient in Equation 8-1 is the longitudinal gradient of cross-sectionally averaged and tidally averaged salinity. This salinity gradient was estimated based on centerline ("thalweg") salinity, not cross-sectionally averaged salinity, in our analysis.

- The order of spatial averaging can affect the flux decomposition. In an analysis of flux at the Golden Gate, Fram et al. (2007) report that changing from averaging laterally first to averaging vertically first changed individual flux components by approximately 10%.
- Some cross-sections are placed in branching channels. The locations where the cross-section crosses each individual channel were somewhat subjective. Adopting a different convention for orienting the cross-sections across branching channels could affect the flux decomposition.

8.7 Summary and Conclusions

The salt flux analysis presented in this section quantitatively estimated the contributions of individual transport processes to predicted increased salt intrusion resulting from sea level rise and tidal amplification. Salt fluxes and dispersion coefficients were estimated at 32 different cross-sections for seven different scenarios: Baseline, 15 cm SLR, 30cm SLR, 45 cm SLR, 60 cm SLR, 140 cm SLR, and 140 cm SLR with 5% Amplification. Two different periods, each spanning 29 days of historic tides and variable Delta outflows were analyzed for each scenario. Periods of fairly steady flows were chosen to simplify interpretation of the analysis results. For this reason, both periods were low flow periods, but the second analysis period, October 13, 2002 through November 10, 2002, had more variable flows and substantially higher salinity conditions than the first analysis period, July 16, 2002 through August 12, 2002. Therefore the two sets of results can be viewed two different realizations of flux analysis for fairly similar Delta outflows.

The salt flux analysis had not previously been applied in the San Francisco Estuary to simulations using historical tides. This analysis was successfully conducted, as evidenced by the close balance between computed dispersive flux and advective flux in the July 16, 2002 through August 12, 2002 analysis period and fairly good balance between computed dispersive flux and advective flux in the October 13, 2002 through November 10, 2002 analysis period. The second period was more challenging due to more variable Delta outflow and salinity.

The predicted salinity and salt fluxes increase at all locations with sea level rise. The estimated dispersion coefficients show little variability with sea level rise in Central Bay and San Pablo Bay and increase with sea level rise in Carquinez Strait, Suisun Bay and the Western Delta. Much of the predicted increase is attributed to increases in tidal dispersion associated with increased tidal prism for sea level rise scenarios and the tidal amplification scenario. Gravitational circulation was predicted to increase slightly with sea level rise at most cross-sections in Suisun Bay and the Western Delta but show little variation in other locations. At some locations in Central Bay, Suisun Bay and the western Delta, the salt flux and dispersion coefficient associated with gravitational circulation was negligible, so the predicted variability with sea level rise was not meaningful. The salt flux and dispersion coefficients for the unsteady vertical shear term varied substantially with sea level rise but did not show consistent trends from cross-section to cross-section as a result of sea level rise. The dispersion coefficient associated with unsteady vertical shear increased in many cross sections but also decreased significantly in some locations.

Amplification of tides increased salt intrusion at all locations. The 5% amplification of tidal range resulted in increased tidal prism at all locations and increased tidal dispersion at nearly all cross-sections. In contrast, the 5% amplification of tidal range resulted in decreased gravitational at most cross-sections. There was no consistent trend of change in the magnitude of unsteady vertical shear with amplification of tidal range.

The salt flux results were generally consistent with previous analyses conducted as part of the DRMS studies (Gross et al., 2007a; Gross et al., 2007b). Since the Delta outflow conditions were higher for the SLR analysis conducted for DRMS (Gross et al., 2007a), gravitational circulation was estimated to be more substantial for those higher flow conditions. However, the spatial variability of dispersion components and variability with sea level rise predicted in the DRMS studies (Gross et al., 2007a) were generally similar to those predicted in this report. In this report, additional supporting analysis has been conducted showing variability in tidal prism, vertical shear in tidally averaged velocity and stratification between scenarios. These analyses help to explain predicted changes in salt flux processes and dispersion coefficients.

It should be emphasized that the results in this report apply only to low flow conditions typical of summer and fall when salt intrusion is most pronounced. Under higher flow conditions, gravitational circulation becomes dominant throughout most of the estuary (Gross et al., 2007a). Increases in gravitational circulation could result from the deepening associated with sea level rise. Those increases would result in less efficient flushing of salt during peak flow periods, as noted in Section 4.

Some of the results of the salt flux analysis in this report and the DRMS studies (Gross et al., 2007a) may be surprising to San Francisco Bay scientists. First, tidal prism increases significantly with sea level rise. Second, at least partially as a consequence of increases in tidal prism, tidal dispersion increases as a result of sea level rise. Third, in many locations, gravitational circulation is estimated to decrease with sea level rise. Increased depth, as an isolated factor, can be expected to cause increased gravitational circulation (e.g. Monismith et al., 2002). However, increases in tidal prism with sea level rise causes increased vertical mixing and less stratification, resulting in less gravitational circulation.

These salt flux analysis results have some important ramifications for simulation of salt intrusion in San Francisco Bay and the Delta. First, since dispersion coefficients at many locations change significantly with sea level rise, one-dimensional models should be "recalibrated" to account for this change in dispersion with sea level rise. Second, since dispersion coefficients change with tidal amplitude, it is reasonable to assume that they will change with tidal restoration, flooding of islands, inundation of low lying regions as sea level rises, or other changes to the Delta geometry that are likely to affect tidal range and/or tidal prism. Therefore, dispersion coefficients applied in a one-dimensional model for an existing geometry of the Delta may not be accurate for simulation of an altered geometry. Lastly, the gravitational circulation component of dispersion also changes with tidal prism, as clearly evidenced in the 140 cm SLR with 5% Amplification scenario. Therefore, this component of dispersion should also be expected to change as a result to changes in Delta geometry. For this reason, unless adjusted to account for changes to dispersion processes, the dispersion coefficients of both one-dimensional and two-dimensional models could lead to significant inaccuracies in simulations of salt intrusion for substantially altered Delta geometry. In order to assure appropriate representation of changes to salt intrusion processes for scenarios of substantially altered Delta geometry, three-dimensional simulations are preferable.

The salt flux analysis results also inform expectations of effects of restoration scenarios on salt intrusion. They suggest that increases in tidal prism associated with restoration are likely to result in increased salt intrusion during low Delta outflow conditions.

9. Summary and Conclusions

As part of the Bay Delta Conservation Plan (BDCP), future conditions simulations are planned which will need to incorporate the potential effects of sea level rise on salinity intrusion in the Sacramento-San Joaquin Delta. In support of this effort, three-dimensional hydrodynamic and salinity simulations using the UnTRIM Bay-Delta model were made to provide a reference condition for re-calibration of appropriate dispersion factors for the 1-D and 2-D models which are the primary tools being used in the BDCP planning process. The 3-D UnTRIM Bay-Delta model provides an already established and well-documented hydrodynamic model which is suitable for a detailed assessment of the potential salinity impacts of Sea Level Rise (SLR) in San Francisco Bay and the Sacramento-San Joaquin Delta.

This report presents the results of the sea level rise impacts on salinity in San Francisco Bay and the Sacramento-San Joaquin Delta that were predicted using the UnTRIM Bay-Delta model. A full set of hydrodynamic and salinity model results were also provided to CH2M Hill for use in recalibration of the DSM2 and RMA2 models to incorporate the effects of SLR into the lower dimensional models being used as part of the BDCP technical studies.

The UnTRIM Bay-Delta model used for this project builds on previous applications (e.g., MacWilliams et al., 2007; MacWilliams et al., 2008; MacWilliams et al., 2009), and was further refined as part of this study to increase the model grid resolution in Suisun Marsh. The UnTRIM Bay-Delta model was used to simulate hydrodynamics and salinity under Baseline conditions and for two levels of SLR. The Baseline simulation period spans from October 15, 2001 through January 1, 2003. The analysis of sea level rise impacts spans a one-year period from January 1, 2002 through January 1, 2003.

The sea level rise simulation results and salt flux analysis demonstrate that multiple different processes result in salinity impacts due to sea level rise. These processes include increased tidal dispersion, increased gravitational circulation in some regions, and decreased efficiency of flushing flows at pushing salt out of the Delta. In the south Delta, more frequent flow over agricultural barrier weirs with increasing SLR also results in some salinity differences. Additionally, increased water volume with SLR results in a slower response in the south Delta to inflow salinity increases, which results in decreases in salinity with SLR in some regions, particularly in the San Joaquin River near Stockton, during periods of increasing tributary inflow salinity.

The simulations with increased tidal amplitude suggest that increased tidal prism results in increased salt intrusion. These results are consistent with the salt flux analysis in indicating the importance of tidal dispersion processes in causing salt intrusion during low Delta outflow periods and suggest that tidal marsh restoration, flooding of Delta islands and any other actions which increase tidal prism in the Delta could increase salt intrusion.

The sea level rise simulations presented in this report assume a “hard shoreline,” which means that the current shoreline as represented by the edges of the UnTRIM Bay-Delta model grid is assumed to stay constant with SLR. Since additional areas—including in-channel islands, high marsh areas, and other regions that are expected to flood with increasing sea level or due to levee failures—are expected to flood with increasing sea level rise, it is likely that the hard shoreline assumption results in an under prediction of salinity impact due to SLR. The effect of this under prediction is likely to increase with the level of SLR simulated. Furthermore, the salt flux analysis suggests that the dispersion coefficients used to represent unresolved salt transport processes in one-dimensional models may be inappropriate for future scenarios with substantially different tidal prism than current conditions.

The SLR simulations presented in this report assumed no operational response to the increased salinity intrusion. Incorporation of operational response into SLR simulations requires the incorporation of the predicted salinity impacts due to SLR into DSM2 and CALSIM II. The predicted salinity impacts from the UnTRIM Bay-Delta model simulations presented in this report are being used to incorporate the increases in salinity resulting from SLR into the DSM2 and CALSIM II models in order to allow for the simulation of operational response to predicted salinity impacts due to SLR in CALSIM II. This will allow for future SLR simulations that incorporate operational response, using either UnTRIM, RMA2, or DSM2.

Acknowledgments

The authors would like to acknowledge Armin Munevar (CH2M Hill) for project management and technical oversight. Additional technical expertise—particularly with regards to coordination of boundary conditions between UnTRIM, RMA2, and DSM2—was provided by Kyle Winslow (CH2M Hill), Chandra Chilmakuri (CH2M Hill), Richard Rachiele (RMA), Stacie Grinbergs (RMA), and John DeGeorge (RMA). Observation data were provided by Nick Leach (USGS) and Cathy Ruhl (USGS). Additional data and information was provided by Min Yu (DWR). The authors would like to acknowledge Sandy Chang and Rusty Holleman for their assistance with the analysis and figure preparation for the salt flux analysis. The UnTRIM code was developed by Professor Vincenzo Casulli (University of Trento, Italy). The authors would especially like to thank Richard Rachiele (RMA) and John DeGeorge (RMA) for sharing their vast experience and knowledge of modeling the Sacramento-San Joaquin Delta and providing guidance on the application of UnTRIM to the Bay-Delta. Additional technical input and expertise in the development of the UnTRIM Bay-Delta model was provided by Ralph Cheng (USGS, retired), Pete Smith (USGS, retired), and Jon Burau (USGS).

References

Anderson, J. and A. Miller, 2005. Estimation of Electrical Conductivity at Martinez for Sea Level Rise Conditions, Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh, 26th Annual Progress Report, Chapter 5.

Casulli, V. 1990. Semi-implicit finite difference methods for the two-dimensional shallow water equations. Journal of Computational Physics. 86, 56-74.

Burau, J.R., Gartner, J.W., and Stacey, M., 1998. Results for the hydrodynamic element of the 1994 Entrapment Zone Study in Suisun Bay. In Report of the 1994 Entrapment Zone Study, edited by Wim Kimmerer, 13-53. Interagency Ecological Program for the San Francisco Bay/Delta Estuary.

Casulli, V., 1999. A semi-implicit numerical method for non-hydrostatic free-surface flows on unstructured grid, in Numerical Modelling of Hydrodynamic Systems, ESF Workshop, pp. 175-193, Zaragoza, Spain.

Casulli, V. and R.A. Walters, 2000. An unstructured, three-dimensional model based on the shallow water equations, International Journal for Numerical Methods in Fluids 2000, 32: 331 - 348.

Casulli, V. and Zanolli, P., 2002. Semi-Implicit Numerical Modelling of Non-Hydrostatic Free-Surface Flows for Environmental Problems, Mathematical and Computer Modelling, 36: 1131 - 1149.

Casulli, V. and Zanolli, P., 2005. High Resolution Methods for Multidimensional Advection-Diffusion Problems in Free-Surface Hydrodynamics, Ocean Modelling, 2005, v. 10, 1-2, p. 137-151.

[CDWR] California Department of Water Resources, 1986. DAYFLOW program documentation and data summary user's guide. California Department of Water Resources, Sacramento.

CH2M Hill, 2009. DSM2 Recalibration, prepared for California Department of Water Resources, October.

Department of Water Resources, 2009. Chronological Reconstructed Sacramento and San Joaquin Valley Water Year Hydrologic Classification Indices, http://cdec.water.ca.gov/cgi-progs/iodir/wsihist

Dyer K.R., 1973. Estuaries: A Physical Introduction. Wiley-Interscience, New York and London.

Fischer, H.B., List, E.J., Koh, R.C.Y., Imberger, J., and N.H. Brooks, 1979. Mixing in Inland and Coastal Waters. New York: Academic Press.

Fram, J.P., Martin. M.A., and M.T. Stacey. 2007. Dispersive Fluxes between the Coastal Ocean and a Semienclosed Estuarine Basin, Journal of Physical Oceanography, 37: 1645-1660.

Gross, E.S., Nidzieko, N., and M.L. MacWilliams, 2007a. Parameterization of mixing using a three-dimensional hydrodynamic model, Delta Risk Management Study, prepared for CA Department of Water Resources, March 2007.

Gross, E.S., MacWilliams M.L., and N. Nidzieko, N. 2007b. Three-dimensional salinity simulations of sea level rise scenarios, Delta Risk Management Study, prepared for CA Department of Water Resources, March 2007.

Hill, K. D., T. M. Dauphinee, and D. J. Woods, 1986. The extension of the Practical Salinity Scale 1978 to low salinities. IEEE J. Oceanic Eng. OE-11: 109–112.

[IEP] Interagency Ecological Program, 2008. DSS database, http://iep.water.ca.gov/data.html

[IEP] Interagency Ecological Program, 2009. Dayflow Documentation, http://iep.water.ca.gov/dayflow/

Jassby, A.D., W.J. Kimmerer, S.G. Monismith, C. Armor, J.E. Cloern, T.M. Powell, J. R. Schubel, and T.J. Vendlinski,1995. Isohaline position as a habitat indicator for estuarine populations. Ecological Applications 5:272-289.

MacWilliams, M.L., and E.S. Gross, 2007. UnTRIM San Francisco Bay-Delta Model Calibration Report, Delta Risk Management Study, prepared for CA Department of Water Resources, March 2007.

MacWilliams, M.L., E.S. Gross, J.F. DeGeorge, and R.R. Rachiele, 2007. Three-dimensional hydrodynamic modeling of the San Francisco Estuary on an unstructured grid, IAHR, 32nd Congress, Venice Italy, July 1-6, 2007.

MacWilliams, M.L., Salcedo, F.G., and E.S. Gross, 2008. San Francisco Bay-Delta UnTRIM Model Calibration Report, POD 3-D Particle Tracking Modeling Study, Prepared for California Department of Water Resources, December 19, 2008, 344 p.

MacWilliams, M.L., Salcedo, F.G., and E.S. Gross, 2009 (in review). San Francisco Bay-Delta UnTRIM Model Calibration Report, Sacramento and Stockton Deep Water Ship Channel 3-D Hydrodynamic and Salinity Modeling Study, Prepared for US. Army Corps of Engineers, San Francisco District, July 14, 2009, 574 p.

Monismith, S.G., Kimmerer, W., Burau, J.B., and M.T. Stacey. 2002. Structure and flow-induced variability of the subtidal salinity field in Northern San Francisco Bay, *Journal of Physical Oceanography*, 32, 3,003-3,019.

[NOAA] National Oceanic & Atmospheric Administration, 2008. NOAA Tides & Currents http://tidesandcurrents.noaa.gov/

[RMA] Resource Management Associates, 2005. Flooded Islands Pre-Feasibility Study: RMA Delta Model Calibration Report, prepared for CA Department of Water Resources for submittal to California Bay-Delta Authority, June 30.

Schoellhamer, D, and P. Buchanan, 2010. Continuous Monitoring in the San Francisco Bay and Delta, Data Collection Methods and Procedures, http://sfbay.wr.usgs.gov/sediment/cont_monitoring/methods.html

Simpson, J.H., Brown, J., Matthews, J. and G. Allen. 1990. Tidal straining, density currents and stirring in the control of estuarine stratification, Estuaries, 13, 125-131.

Sommer T, Armor C, Baxter R, Breuer R, Brown L, Chotkowski M, Culberson S, Feyrer F, Gingras M, Herbold B, Kimmerer W, Mueller-Solger A, Nobriga M, Souza K. 2007. The collapse of pelagic fishes in the upper San Francisco Estuary. Fisheries 32:270-277.

Stacey, M.T., Burau, J.R, and S.G. Monismith, 2001. The creation of residual flows in a partially stratified estuary, Journal of Geophysical Research, 106(C8), 17,013-17,038.

[SWRCB] State Water Resources Control Board, California Environmental Protection Agency, 2000. Revised Water Right Decision 1641, In the Matter of: Implementation of Water Quality Objectives for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary; A Petition to Change Points of Diversion of the Central Valley Project and the State Water Project in the Southern Delta; and A Petition to Change places of Use of the Central Valley Project, December 29, 1999; Revised in Accordance with Order WR 2000-02, March 15, 2000.

UNESCO, 1985. The International System of Units (SI) in Oceanography. Tech. Pap. Mar. Sci., 45: 124 pp.

USGS, 2009, USGS Water Quality of SF Bay, http://sfbay.wr.usgs.gov/access/wqdata

Walters, R.A., Cheng, R.T. and Conomos, T.J., 1985. Time scales of circulation and mixing processes of San Francisco Bay waters, *Hydrobiologia*, 129, 13-36.

Appendix A. Model Validation Figures for 2002 Simulation Period

The calibration of UnTRIM Bay-Delta model for flow, stage, and salinity has been thoroughly documented in previous studies (i.e., MacWilliams et al., 2008; MacWilliams et al., 2009). As a result, no additional calibration was conducted as part of this study. In this context, comparison of predicted water levels, flows, and salinity with observations during this simulation provides an additional validation of the previous calibration and validation studies.

Some aspects of the boundary conditions used in this application of the UnTRIM Bay-Delta model differ from the commonly used boundary conditions described by MacWilliams et al. (2008; 2009). In general, these modifications were made so that the boundary conditions used in this application of the UnTRIM Bay-Delta model were as close to identical as possible to the boundary conditions used in DSM2 for the DSM2 recalibration (CH2M Hill, 2009). The most significant change was that the flow though the radial gates into Clifton Court Forebay were applied using the exact flows calculated by DSM2. This modification results in a much lower level of agreement between observed and predicted water levels inside Clifton Court Forebay, than in previous applications of the UnTRIM Bay-Delta model (e.g., MacWilliams et al., 2009). In addition, the agreement between observed and predicted tidal time scale flows in Old River is decreased relative to the three periods simulated by MacWilliams et al. (2008) or the three periods simulated by MacWilliams et al. (2009). This largely results because the gate equations used in DSM2 are not nearly as accurate at determining the instantaneous flow through the radial gates as the historical SWP flow values which are based in part the daily change in volume inside Clifton Court Forebay. Additionally, the time interpolation of inflow boundaries was modified to reflect the stepwise application of these boundaries in DSM2. The effect of this change is evident in the stage comparisons at Verona and Vernalis, and some of the predicted phase differences in the calibration, but this change is not expected to have a significant impact on the overall model results. Lastly, additional inflows were applied in Suisun Marsh to be consistent with the flows used in the RMA2 model.

The hydrodynamic model validation presented in this section gives a measure of the ability of the UnTRIM Bay-Delta model to accurately predict water levels (stage), flows, and salinity in San Francisco Bay and the Sacramento-San Joaquin Delta. Accurate prediction of water levels in San Francisco Bay demonstrates that tides are accurately propagating through the Bay and into the Delta. Comparison of predicted flows to observations in the Delta demonstrate the degree that the model captures the instantaneous, tidally averaged, and net flows in specific channels within the Delta. Accurate prediction of salinity in San Francisco Bay and the western Delta demonstrate the degree to which the model is accurately predicting salinity intrusion due to gravitational circulation and other processes. Within the Sacramento-San Joaquin Delta, prediction of salinity is strongly dependent on consumptive use and the out flow salinity from agricultural diversions, both of which introduce a significant level of uncertainty.

This section presents the method used to assess the model validation, and provides an extensive set of comparisons between observed and predicted water levels, flows, and salinity at observation stations in San Francisco Bay and in the Delta for the model simulation period in 2002.

A.1 Model Assessment Method

The calibration dataset included water level observations collected by NOAA, USGS, and DWR, flow measurements made by USGS and DWR, salinity data from continuous monitoring sites operated by the USGS, United States Bureau of Reclamation (USBR), and the DWR, and synoptic salinity observations by the USGS, consisting of vertical profiles of salinity at 1 meter vertical resolution at 38 sampling locations along the axis of the San Francisco Estuary (USGS, 2009).

Predicted stage, flow, and salinity were compared to observation data at stations where data were collected by NOAA, USGS, and DWR. Data from NOAA were downloaded from the Tides and Currents webpage (NOAA, 2008) and are identified using the seven digit NOAA station identification number. USGS data were provided by Cathy Ruhl and Nick Leach from the USGS Sacramento office and are identified using the three letter USGS identifier. The DWR data were obtained both from the IEP DSS database (IEP, 2008) and from the California Data Exchange Center (CDEC) online database. Data extracted from the IEP DSS database are identified using the DSS B value field which consists of a string of letters and numbers, while data downloaded from CDEC are identified by the three letter CDEC identifier, which in some cases differs from the USGS three letter identifier for the same station.

The quality of fit between predicted model results and observed stage, flow, and salinity time series data are assessed following a cross-correlation procedure similar to that used by RMA (2005). This approach has also been used by MacWilliams and Gross (2007) and MacWilliams et al. (2008; 2009), and provides a thorough description of the differences between time series records through a quantitative measure of differences in terms of phase, mean, amplitude, and constant offsets. Statistics are derived to quantify the differences between predicted and observed time series data. Four types of statistics are presented in this report, following the approach used by RMA (2005):

- Mean – Comparison of simple mean values of the predicted and observed time series.

- Phase Shift – The average shift in time between the predicted and observed time series.

- Amplitude Ratio – Comparison of the time series range, which ideally would equal 1. This value is estimated after removing the phase shift between predicted and observed time series.

- Scatter – The remaining difference between predicted and observed time series after phase and amplitude errors are removed. One measure of the scatter is the goodness of fit parameter, R^2, from a linear regression performed on the observed and predicted time series with phase error removed. Note that this R^2 is a measure of the scatter around a best-fit line, not a 1:1 line, on the scatter plots.

For each stage, flow, and salinity time series comparison, a total of three different types of figures are shown. The top figure shows the tidal time scale variability for a period of approximately fifteen days. On the bottom left, a tidally averaged plot is shown for the full analysis period to evaluate spring-neap and longer time scale variability, as well as non-tidal forcing such as storm surge. Tidal averages are computed by filtering twice using a 24.75 hour running average filter. On the lower right, the scatter plot shows a comparison between the observed and predicted data over the analysis period. The scatter plot is produced by first running a cross-correlation between the observed data and model predictions to find the average phase lag over the entire record. The cross-correlation was performed following the procedure outlined by RMA (2005). The process entails repeatedly shifting the predicted time series record at one minute increments relative to the observed time series and computing the correlation coefficient at each time shift. The correlation has a maximum value when the shifted model time series best matches the observed time series. The time shift when the maximum correlation occurs represents the phase difference in minutes between the predicted and observed data, with positive values indicating that the predicted time series lags the observed time series. The linear regression is then performed between the time shifted model results and observed data record to yield the amplitude ratio, best-fit line, and correlation coefficient. In some cases, the cross-correlation procedure does not identify a local maximum correlation coefficient within a four hour analysis window (two hours forward and two hours backward). This can occur for water level comparisons when the data does not having a strong tidal time-scale signal (at upstream stations such as Verona on the Sacramento River or Vernalis on the San Joaquin River), or for upstream salinity stations where the inflow salinity is constant or nearly constant. For these stations, the phase lag is shown as “n/a”, and the linear regression is performed with no phase correction. In summary, the statistics reported on each scatter plot include the following:

- Mean Obs – Average value of observed time series for analysis period
- Mean Pred – Average value of predicted time series for analysis period
- Lag – Phase difference in minutes between observed and predicted; a positive value indicates that the predicted time series lags behind the observed time series.
- Y = slope*X + offset – Best linear fit, where Y is predicted, X is observed. The slope value is used as the amplitude ratio.
- R^2 – Linear regression goodness of fit parameter.

The observed and predicted means, phase lag, amplitude ratio, and R^2 value are also summarized in tables for each simulation period and comparison type.

A.2 Description of 2002 Simulation Period

The 2002 simulation period, which spans from January 1, 2002 to January 1, 2003, was used as the primary analysis period in this study. This period was selected to provide the opportunity for comparison to the corroboration results from the RMA2 and DSM2 models which was completed as part of the BDCP study. A subset of this period was used for flow and stage model calibration of the UnTRIM Bay-Delta model as part of the POD project (MacWilliams, et al., 2008). No previous salinity calibration or validation of the UnTRIM Bay-Delta model has been conducted for this simulation period.

The 2002 simulation period spans from water year 2002 to water year 2003. Water year 2002 (from October 1, 2001 through September 30, 2002) was classified as a "dry" year on both the Sacramento River and the San Joaquin River. Water Year 2003 (from October 1, 2002 through September 30, 2003) was classified as an "above normal" year on the Sacramento River and as a "below normal" year on the San Joaquin River (DWR, 2009).

A.3 Water Level Comparison Figures

Observed and predicted water levels were compared at seven stations in San Francisco Bay and at fifty-six stations in the Sacramento-San Joaquin Delta during the 2002 simulation period. At each station, observed and predicted water levels were plotted over a fifteen day period to show the water level agreement over tidal time scales. In addition, the observed and predicted stage are tidally averaged, to assess the accuracy of the model in predicting water level variability on spring-neap time scales, as well as non-tidal forcing such as storms. Lastly, the cross-correlation (as described in Section A.1) was used to determine the mean observed and predicted water level, the amplitude ratio, the phase lag, and the correlation coefficient squared (R^2). For each of the water level stations, these values are compiled in Table A-1.

A.3.1 San Francisco Bay

Water level comparisons were made at five NOAA and two DWR continuous observation stations in the San Francisco Estuary, at the locations shown in Figure A.3-1. Water level comparisons at these stations are shown in Figures A.3-2 through A.3-8.

A.3.2 Northern Sacramento-San Joaquin Delta

Water level comparisons were made at ten continuous water level observation stations in the northern portion of the Sacramento-San Joaquin Delta, at the locations shown in Figure A.3-9. Water level comparisons at these stations are shown in Figures A.3-10 through A.3-19.

A.3.3 Central Sacramento-San Joaquin Delta

Water level comparisons were made at nineteen continuous water level observation stations in the central portion of the Sacramento-San Joaquin Delta, at the locations shown in Figure A.3-20. Water level comparisons at these stations are shown in Figures A.3-21 through A.3-39.

A.3.4 Southern Sacramento-San Joaquin Delta

Water level comparisons were made at twenty continuous water level observation stations in the southern portion of the Sacramento-San Joaquin Delta, at the locations shown in Figure A.3-40. Water level comparisons at these stations are shown in Figures A.3-41 through A.3-60.

Table A-1 Predicted and observed stage and cross-correlation statistics for stage monitoring stations in San Francisco Bay and the Sacramento-San Joaquin Delta during the 2002 simulation period.

Location	Data Source	Figure Number	Mean Water Level		Cross Correlation		R^2
			Observed (m)	Predicted (m)	Amp Ratio	Lag (min)	
2002 San Francisco Bay Stage Stations (Figure A.3-1)							
San Francisco	NOAA	A.3-2	0.96	0.95	0.999	-1	0.999
Alameda	NOAA	A.3-3	0.96	0.99	1.003	13	0.998
Redwood City	NOAA	A.3-4	0.97	1.00	0.988	6	0.998
Richmond	NOAA	A.3-5	0.97	0.99	0.991	7	0.998
Sacramento River at Martinez	DWR	A.3-6	1.11	1.10	0.973	13	0.988
Port Chicago	NOAA	A.3-7	1.14	1.14	0.973	10	0.996
Sacramento River near Mallard Island	DWR	A.3-8	1.12	1.14	0.950	8	0.995
2002 North Delta Stage Stations (Figure A.3-9)							
Sacramento River South of Georgiana Slough	USGS	A.3-10	1.54	1.46	0.980	-6	0.985
Georgiana Slough near Sacramento River	USGS	A.3-11	1.45*	1.45	0.952	9	0.978
Delta Cross Channel	USGS	A.3-12	1.24	1.36	1.016	8	0.928
Sacramento River North of Delta Cross Channel	USGS	A.3-13	1.56	1.47	0.945	7	0.979
Mokelumne River near Thornton	DWR	A.3-14	1.35	1.33	0.884	-33	0.843
South Fork Mokelumne River at New Hope Bridge	DWR	A.3-15	1.34	1.30	1.097	7	0.986
Steamboat Slough between Sacramento River and Sutter Sl.	USGS	A.3-16	1.39	1.39	1.157	2	0.985
Sacramento River at Freeport	USGS	A.3-17	1.78*	1.78	0.789	-25	0.982
Sacramento River at I Street	DWR	A.3-18	2.27*	2.27	0.824	-4	0.994
Sacramento River at Verona	DWR	A.3-19	3.82	3.84	0.642	117	0.995
2002 Central Delta Stage Stations (Figure A.3-20)							
San Joaquin River at Antioch	DWR	A.3-21	1.19*	1.19	0.942	1	0.976
Sacramento River at Rio Vista	USGS	A.3-22	1.25	1.22	1.029	11	0.993
Threemile Slough at San Joaquin River	USGS	A.3-23	1.19*	1.19	1.082	1	0.989
San Joaquin River at Jersey Point	USGS	A.3-24	1.21	1.20	1.019	13	0.982
Dutch Slough at Jersey Island	USGS	A.3-25	1.20	1.20	1.015	13	0.990
False River	USGS	A.3-26	1.15	1.18	1.067	20	0.994
Taylor Slough	USGS	A.3-27	1.15	1.19	1.073	17	0.993
Sand Mound Slough	USGS	A.3-28	1.15	1.20	1.048	23	0.987
San Joaquin River at San Andreas Landing	DWR	A.3-29	1.29	1.22	1.043	10	0.982
Old River at San Joaquin River	USGS	A.3-30	1.16	1.22	1.068	23	0.994
Mokelumne River near San	USGS	A.3-31	1.21	1.21	1.028	11	0.987

Joaquin River							
North Fork of Mokelumne River at Georgiana Slough	DWR	A.3-32	1.32	1.24	1.055	3	0.990
San Joaquin River at Venice Island	DWR	A.3-33	1.23*	1.23	1.034	11	0.991
Franks Tract East	USGS	A.3-34	1.14	1.21	1.059	23	0.993
Franks Tract West	USGS	A.3-35	1.16	1.20	0.983	24	0.967
Old River at Mandeville Island	USGS	A.3-36	1.15	1.21	1.072	23	0.994
Holland Cut	USGS	A.3-37	1.18	1.20	1.011	23	0.974
San Joaquin River at Rindge Pump	DWR	A.3-38	1.23*	1.23	1.022	13	0.990
Middle River south of Columbia Cut	USGS	A.3-39	1.22*	1.22	1.038	-22	0.990
2002 South Delta Stage Stations (Figure A.3-40)							
Old River at Bacon Island	USGS	A.3-41	1.18	1.21	1.015	9	0.984
Middle River at Middle River	USGS	A.3-42	1.16	1.16	1.024	6	0.991
Middle River at Borden Highway	DWR	A.3-43	1.19	1.15	1.030	-1	0.986
Middle River at Tracy Blvd	DWR	A.3-44	1.21	1.20	1.006	-7	0.977
Middle River at Howard Road Bridge	DWR	A.3-45	1.23*	1.23	0.944	5	0.947
Middle River at Mowry Bridge	DWR	A.3-46	1.25	1.25	0.971	1	0.959
Old River near Byron	DWR	A.3-47	1.18	1.15	1.039	-15	0.986
Clifton Court Forebay Radial Gates	DWR	A.3-48	0.58	0.16	0.566	-99	0.499
Old River at Clifton Court Ferry	DWR	A.3-49	1.05	1.09	1.020	-17	0.979
Grant Line Canal at Tracy Blvd	USGS	A.3-50	1.12	1.15	0.911	19	0.960
Doughty Cut above Grant Line Canal	DWR	A.3-51	1.24	1.24	0.843	-4	0.901
Old River near Delta Mendota Canal (NW of Barrier)	DWR	A.3-52	1.04	1.08	1.018	-13	0.976
Old River near Delta Mendota Canal (SE of Barrier)	USGS	A.3-53	1.21	1.20	0.932	-22	0.944
Old River at Tracy Blvd	DWR	A.3-54	1.18	1.21	0.894	-6	0.944
Stockton Ship Channel at Burns Cutoff	DWR	A.3-55	1.29	1.23	1.005	10	0.983
San Joaquin River at Stockton	USGS	A.3-56	1.24	1.24	1.037	10	0.989
San Joaquin River below Old River near Lathrop	DWR	A.3-57	1.42*	1.42	1.066	11	0.937
Old River at Head	DWR	A.3-58	1.35	1.35	1.018	-11	0.917
San Joaquin River at Mossdale	DWR	A.3-59	1.57	1.57	1.423	-7	0.863
San Joaquin River at Vernallis	DWR	A.3-60	4.28*	4.28	0.756	23	0.994

* Observed data are measured relative to arbitrary vertical datum. Observed data are offset to match predicted mean water level for comparison plots.

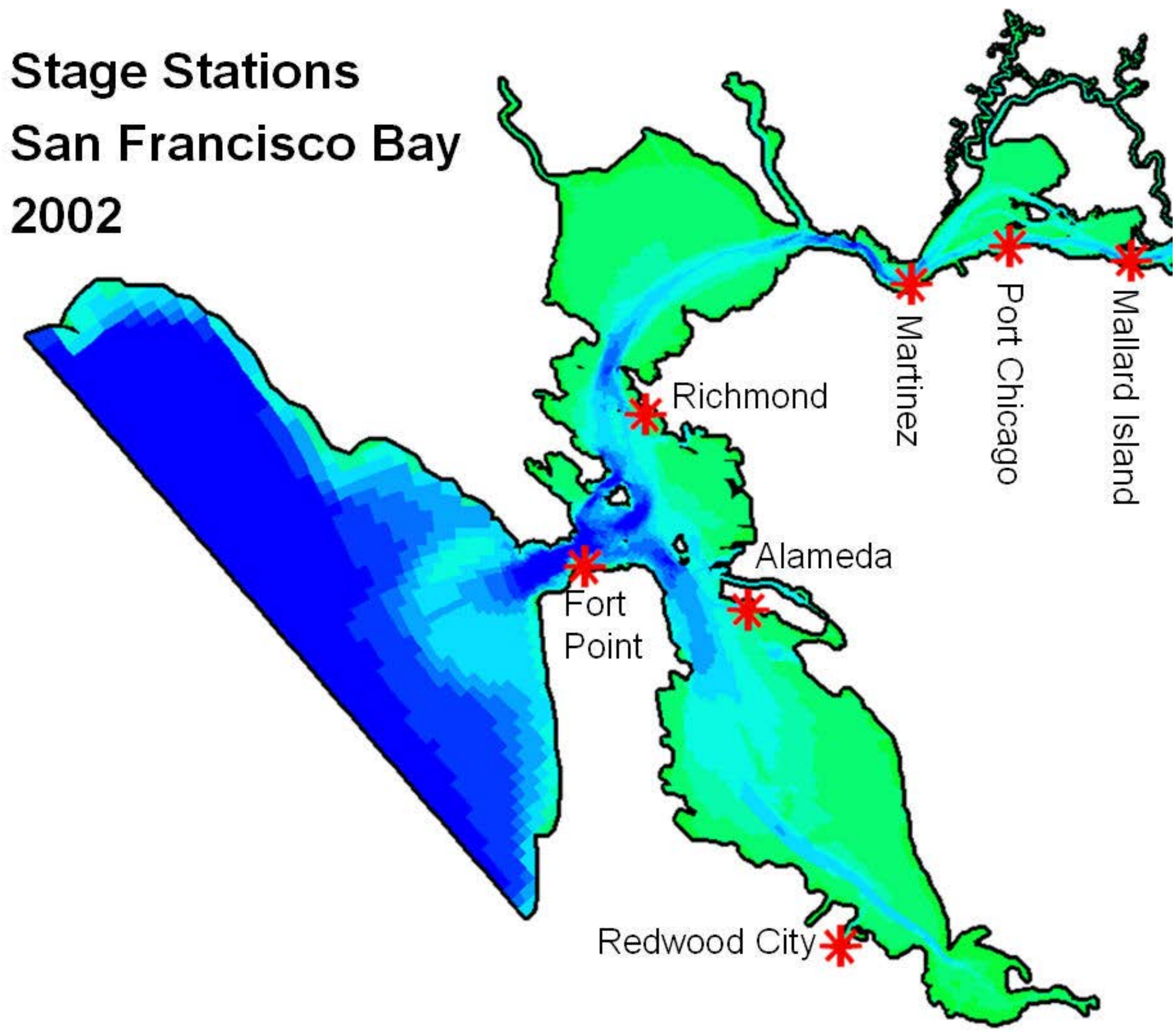


Figure A.3-1 Location of NOAA and DWR water level monitoring stations in San Francisco Bay used for 2002 water level comparisons.

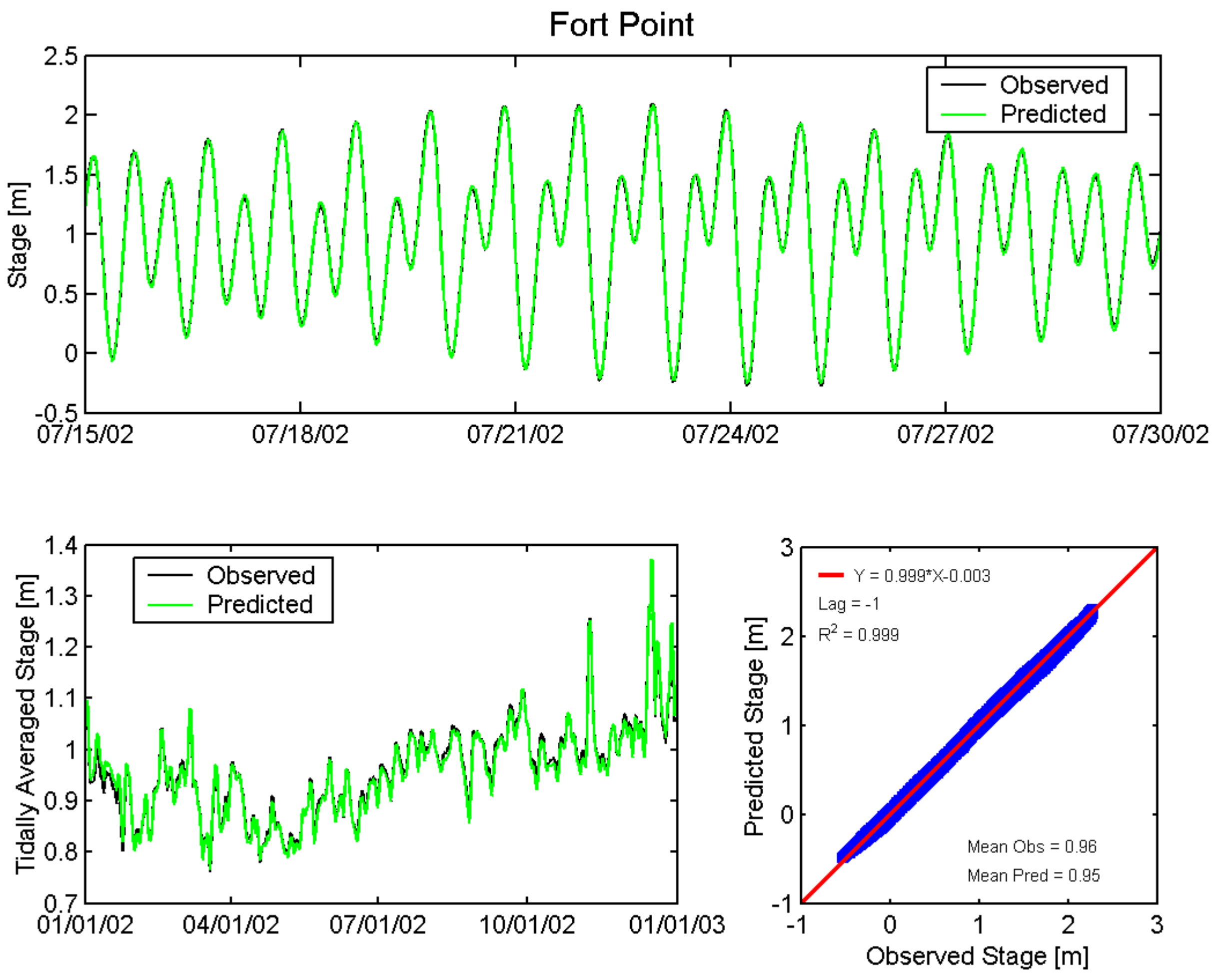


Figure A.3-2 Observed and predicted stage at San Francisco Fort Point NOAA station (9414290) during the 2002 simulation period.

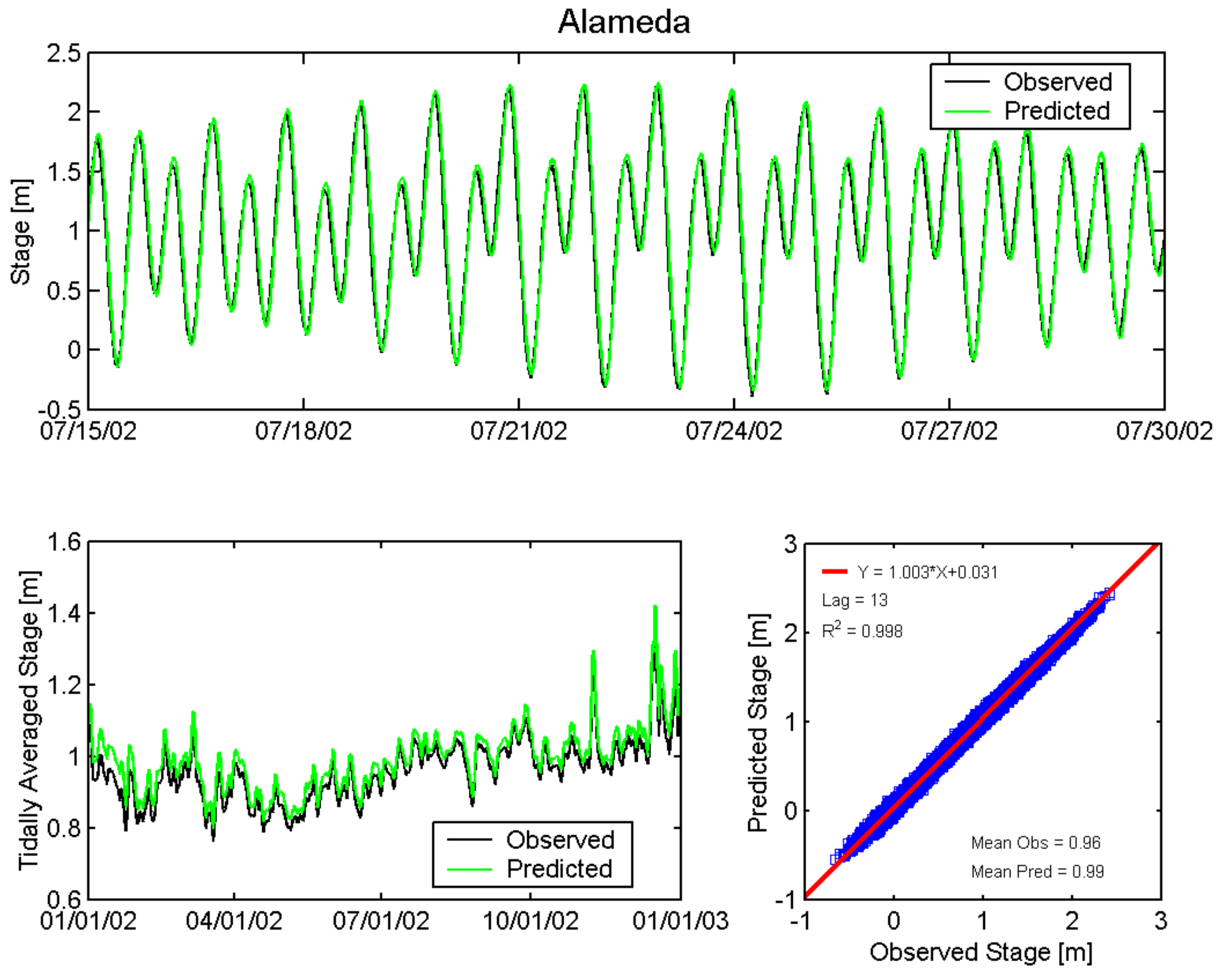


Figure A.3-3 Observed and predicted stage at Alameda NOAA station (9414750) during the 2002 simulation period.

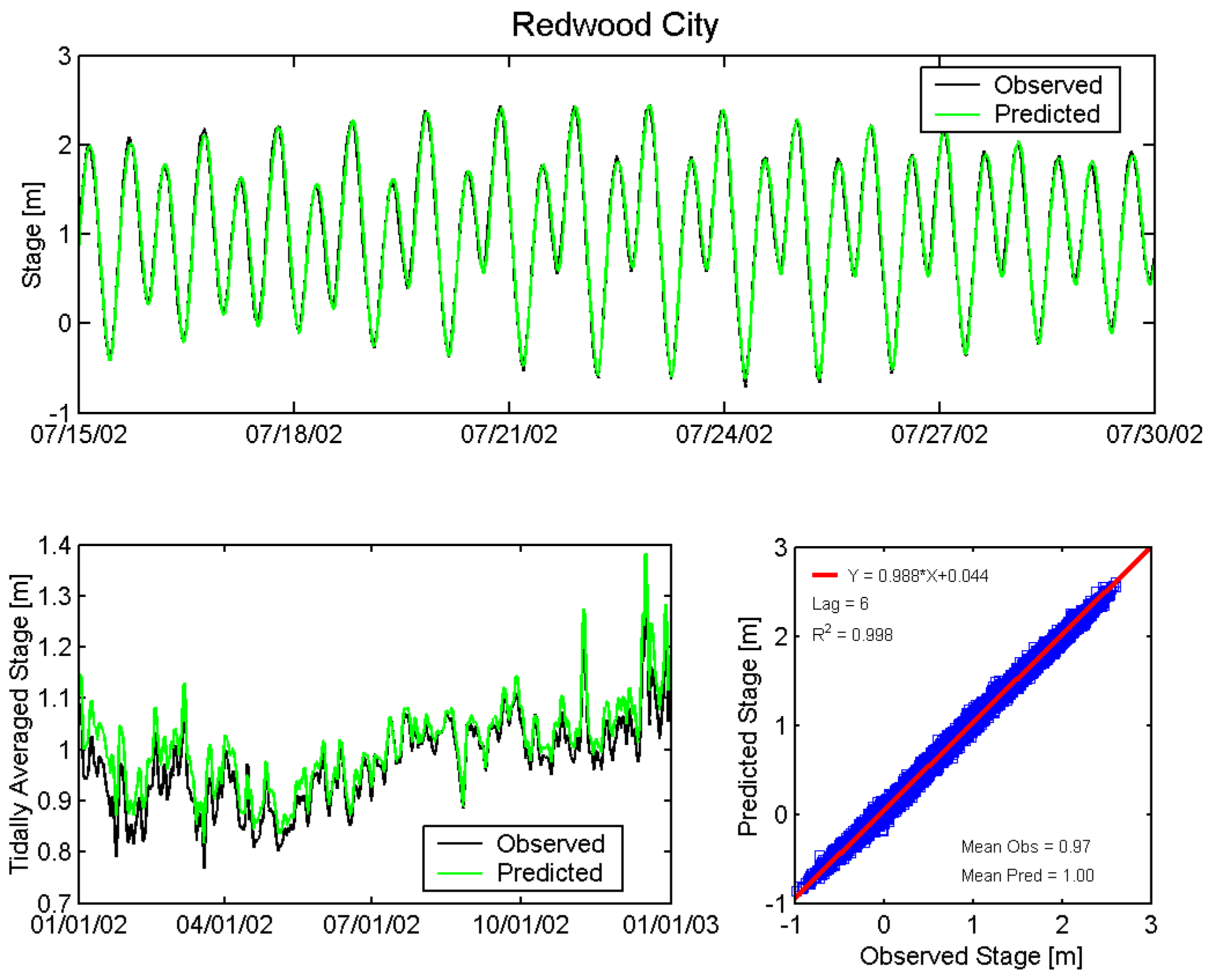


Figure A.3-4 Observed and predicted stage at Redwood City NOAA station (9414523) during the 2002 simulation period.

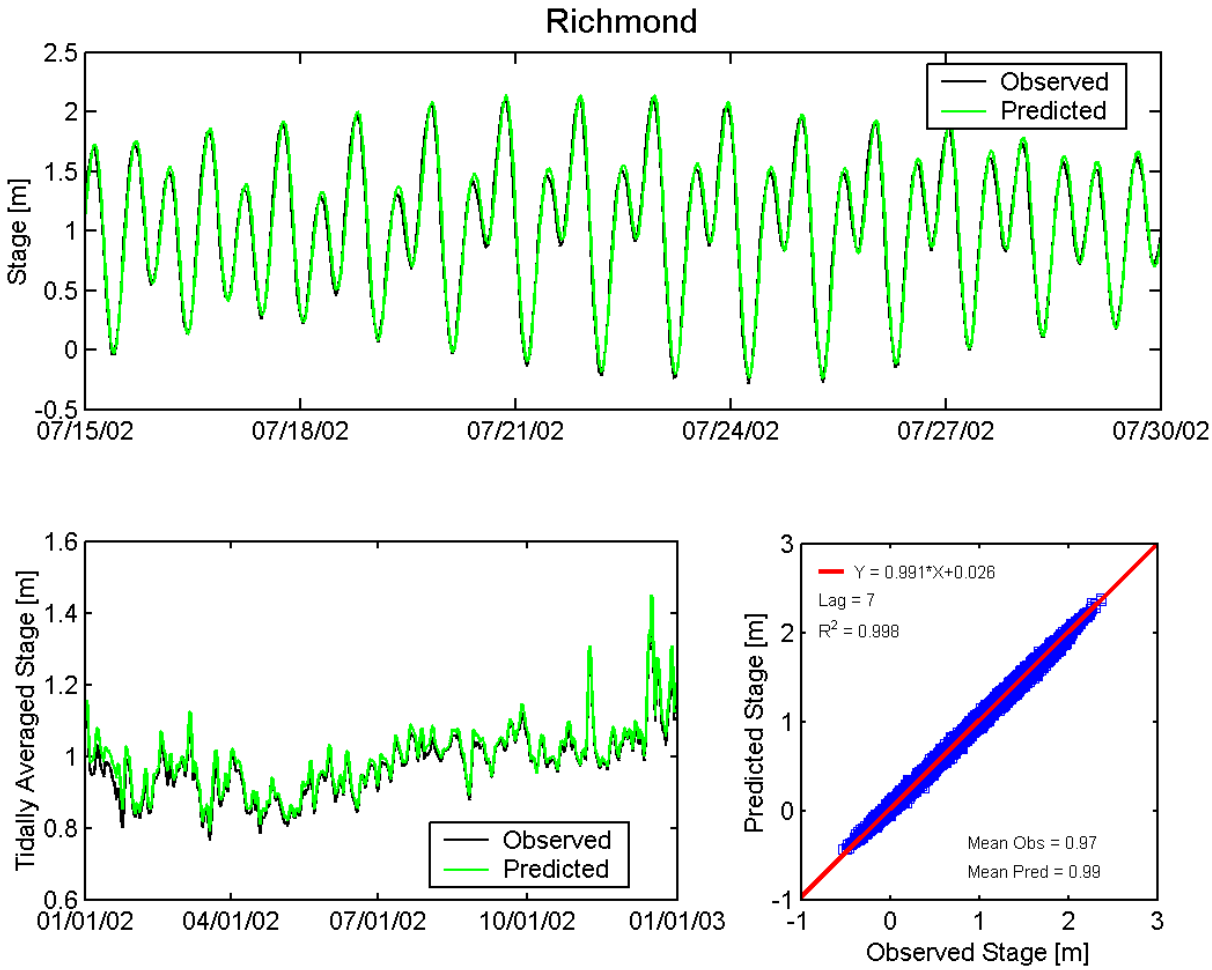


Figure A.3-5 Observed and predicted stage at Richmond NOAA station (9414863) during the 2002 simulation period.

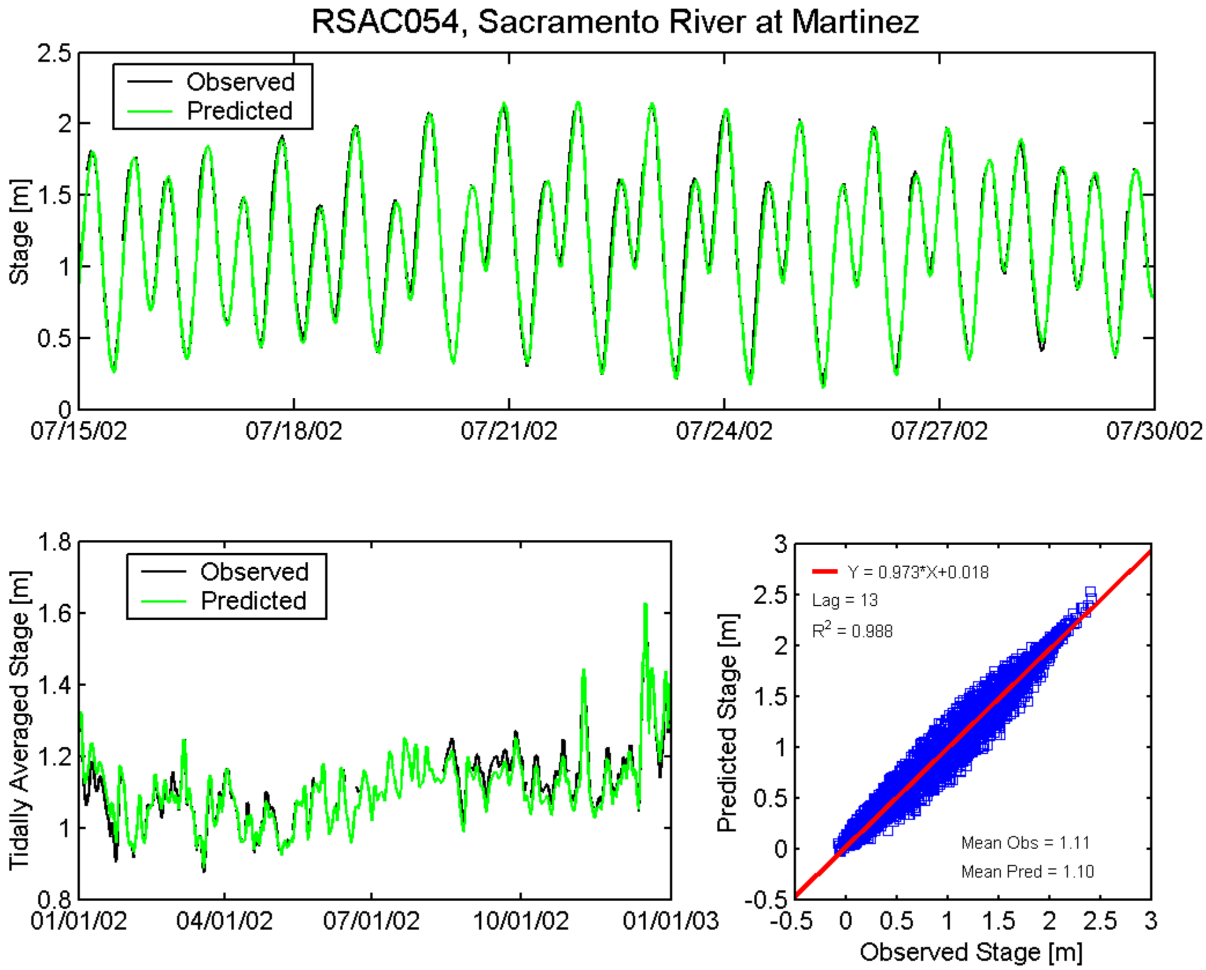


Figure A.3-6 Observed and predicted stage at Sacramento River at Martinez DWR station (RSAC054) during the 2002 simulation period.

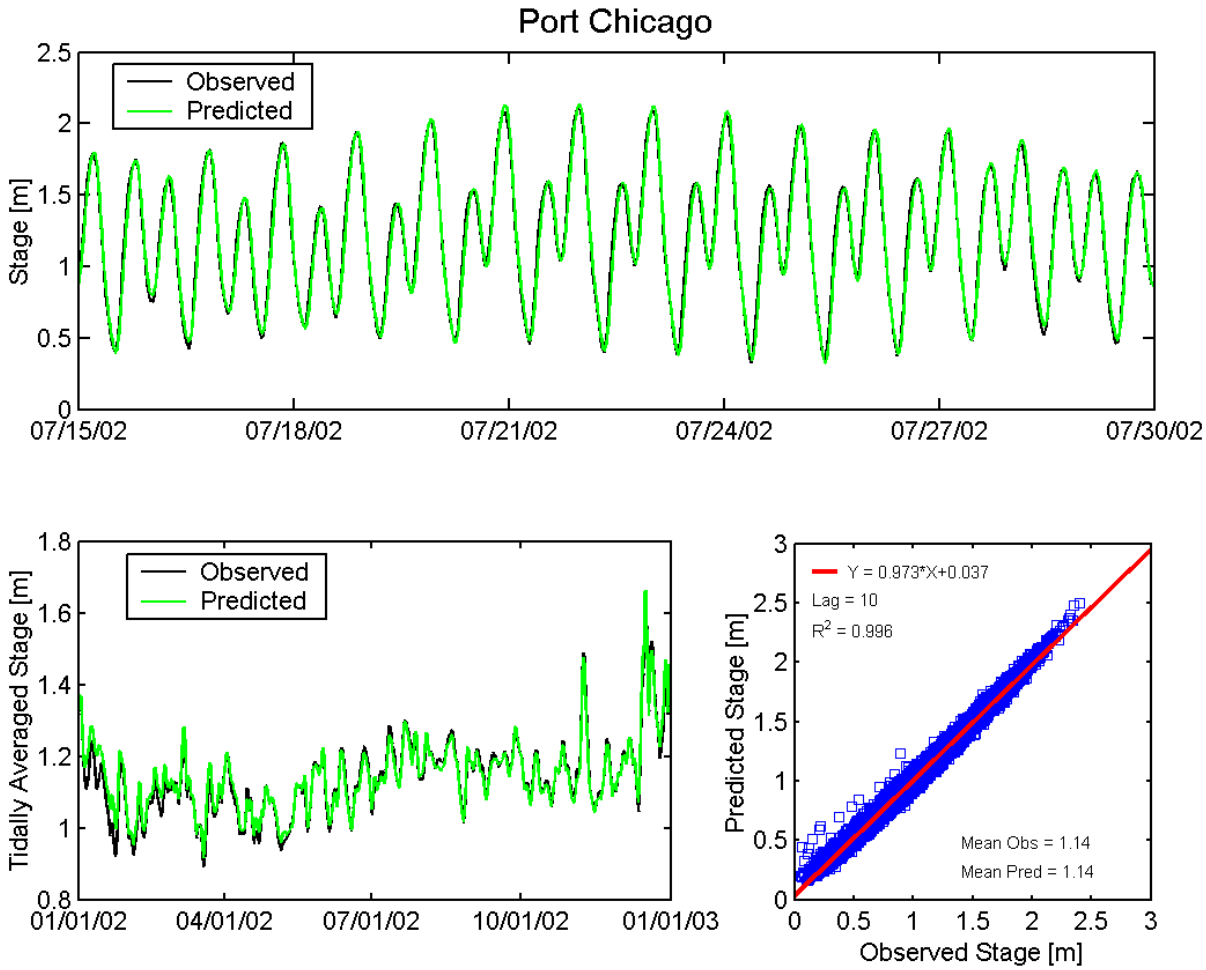


Figure A.3-7 Observed and predicted stage at Port Chicago NOAA station (9415144) during the 2002 simulation period.

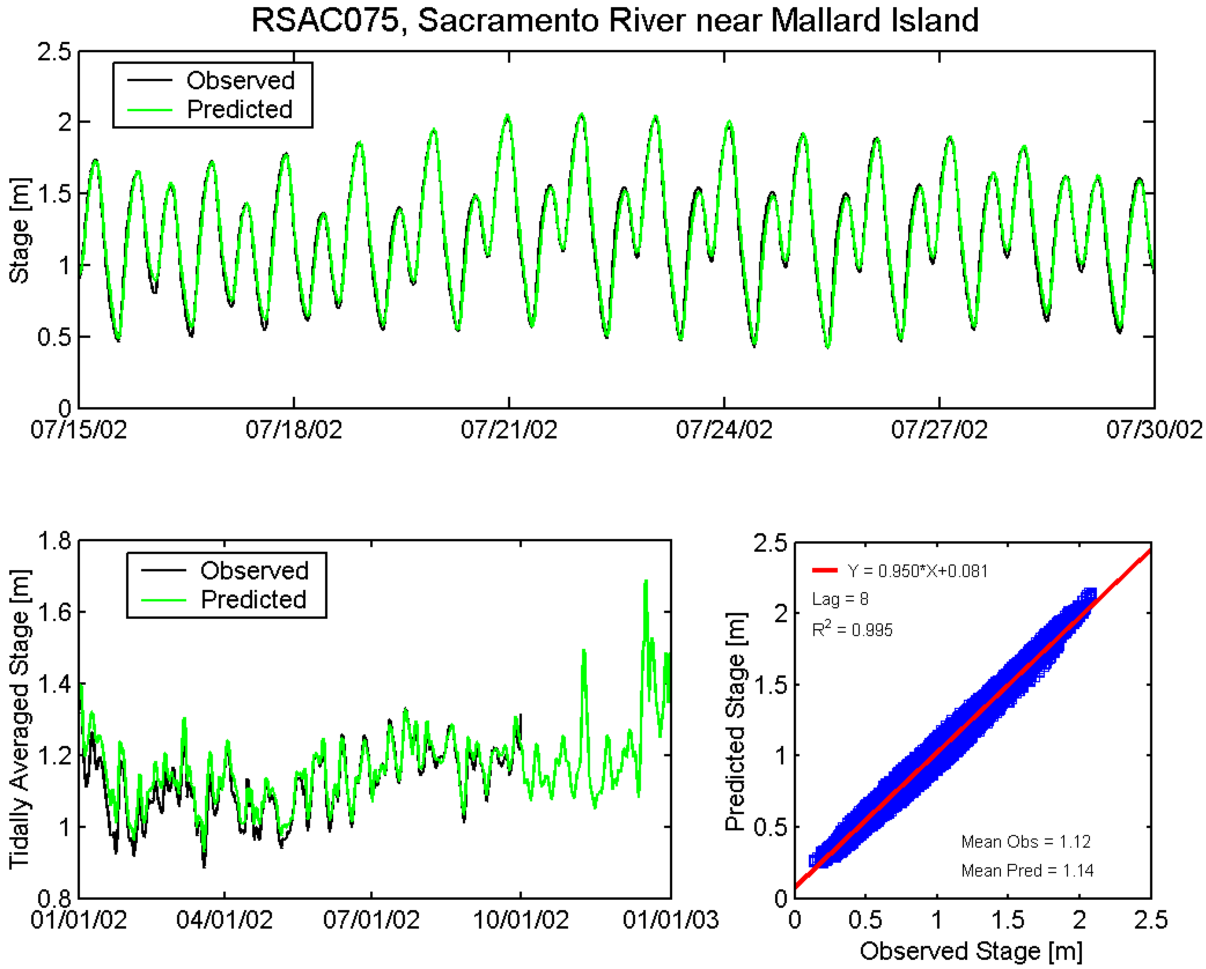
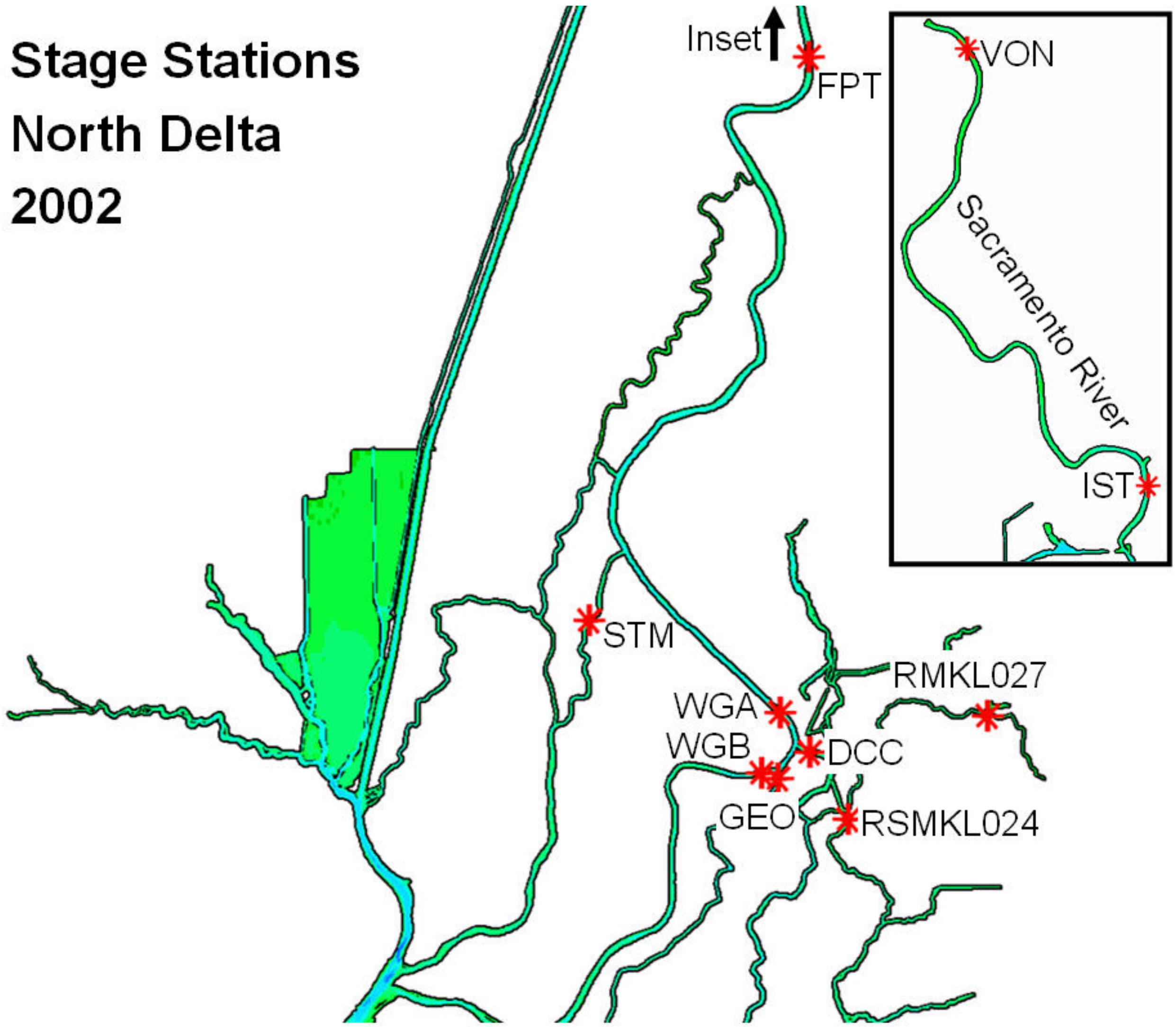


Figure A.3-8 Observed and predicted stage at Sacramento River near Mallard Island DWR station (RSAC075) during the 2002 simulation period.



Station Names

WGB, Sacramento River South of Georgiana Slough

GEO, Georgiana Slough near Sacramento River

DCC, Delta Cross Channel

WGA, Sacramento River North of Delta Cross Channel

RMKL027, Mokelumne River near Thornton (Benson's Ferry)

RSMKL024, South Fork Mokelumne River at New Hope Bridge

STM, Steamboat Slough between Sacramento River and Sutter Sl.

FPT, Sacramento River at Freeport

IST, Sacramento River at I Street

VON, Sacramento River at Verona

Figure A.3-9 Location of water level monitoring stations in the northern portion of the Sacramento-San Joaquin Delta used for 2002 water level comparisons.

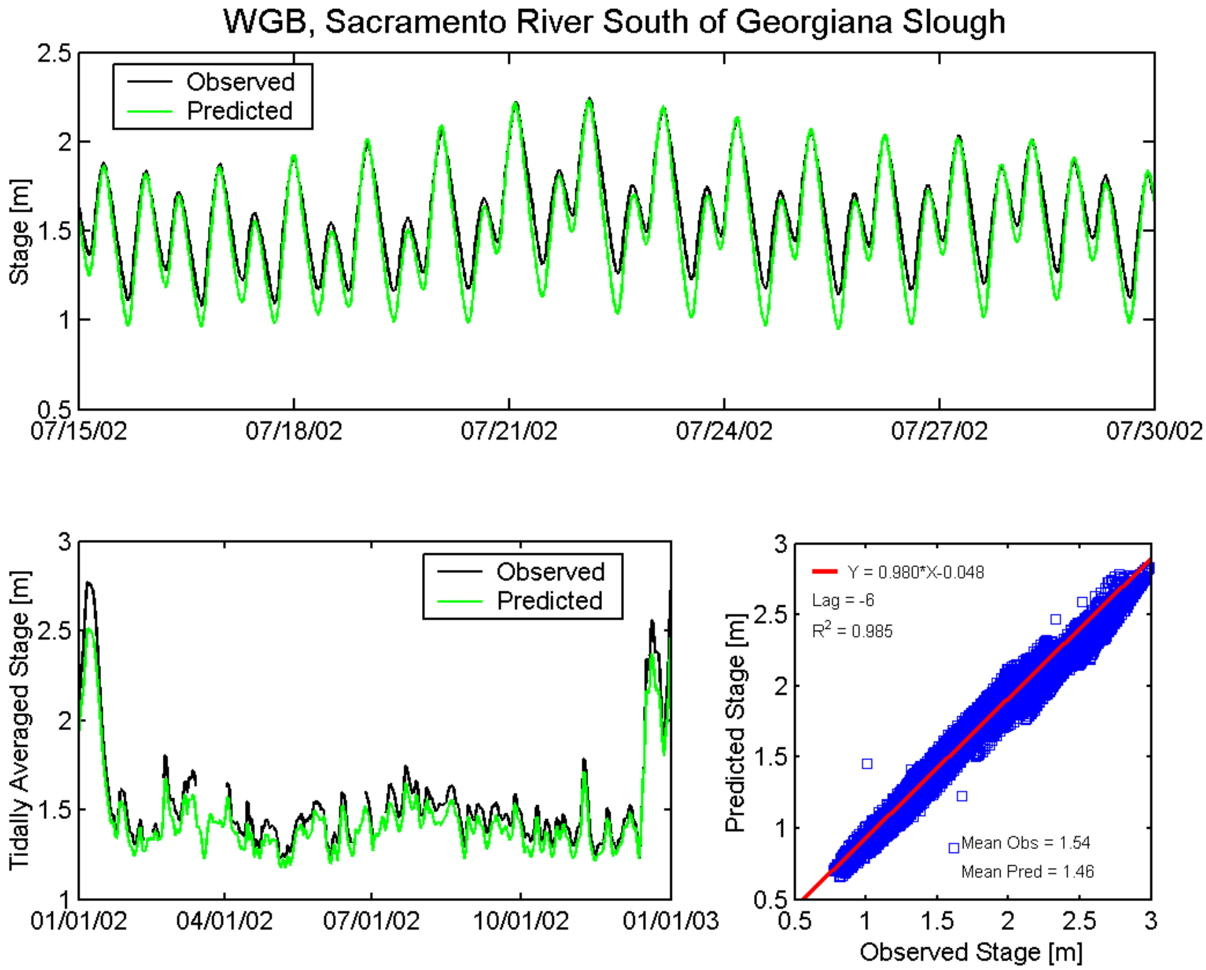


Figure A.3-10 Observed and predicted stage at Sacramento River South of Georgiana Slough USGS station (WGB) during the 2002 simulation period.

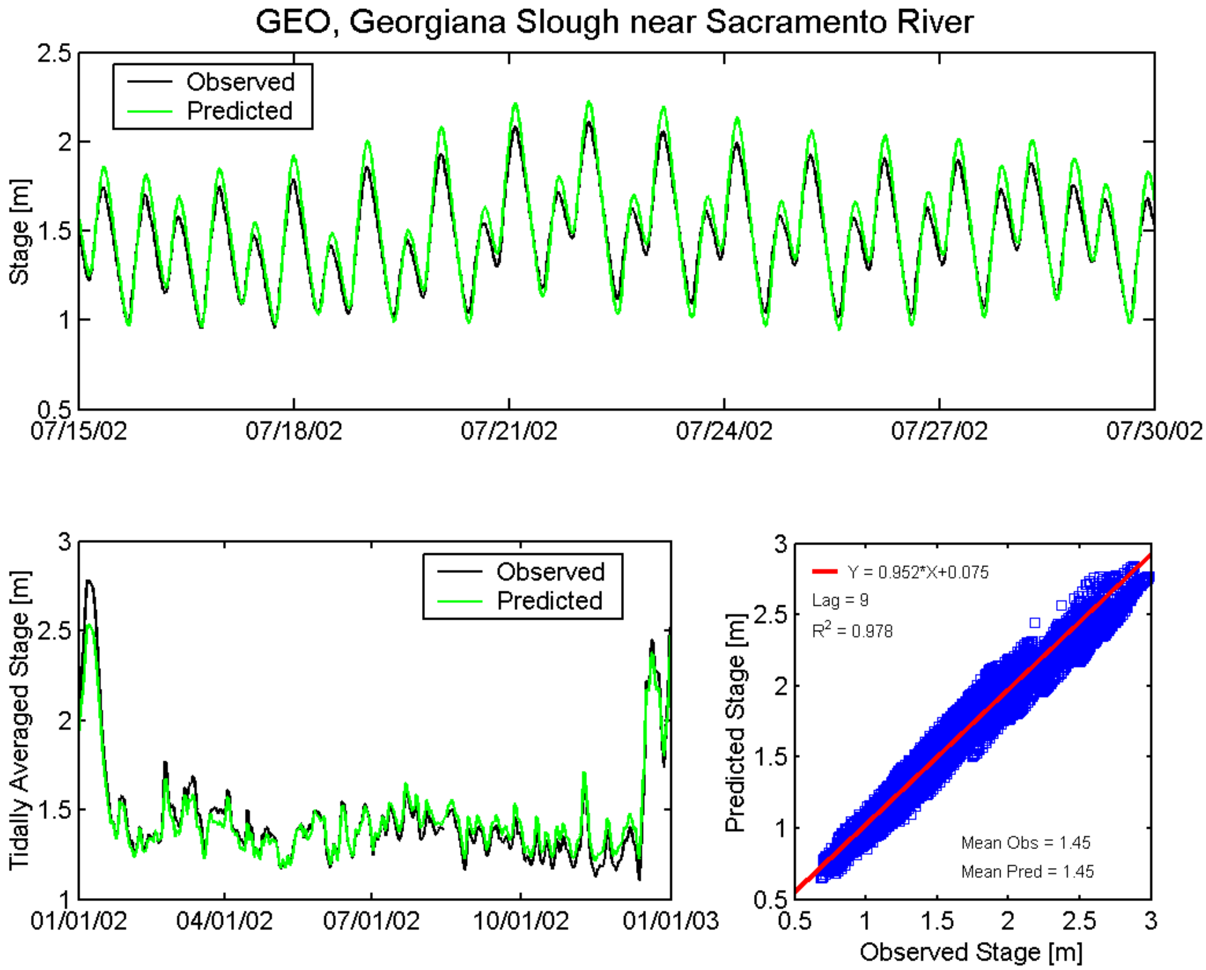


Figure A.3-11 Observed and predicted stage at Georgiana Slough near Sacramento River USGS station (GEO) during the 2002 simulation period.

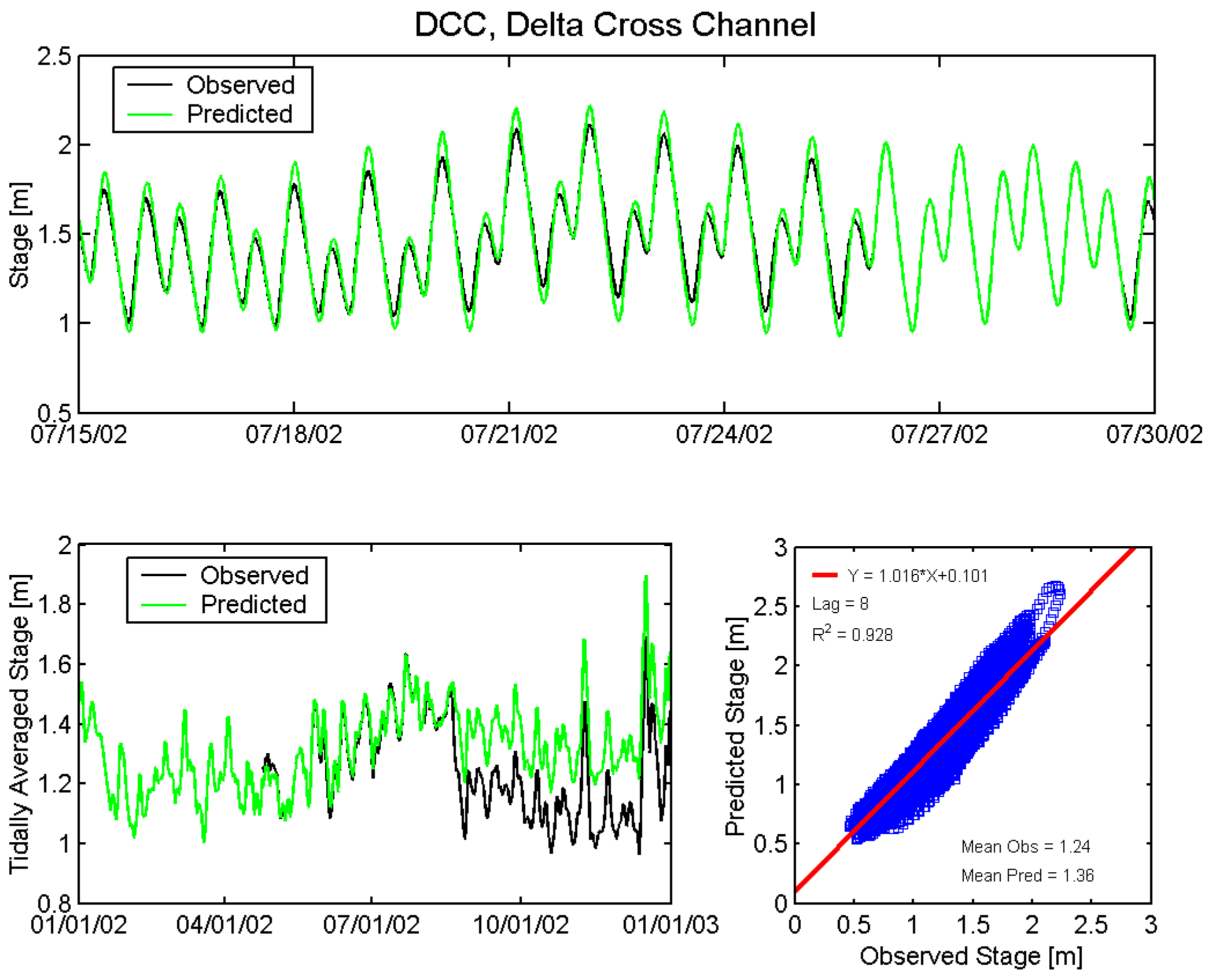


Figure A.3-12 Observed and predicted stage at Delta Cross Channel USGS station (DCC) during the 2002 simulation period.

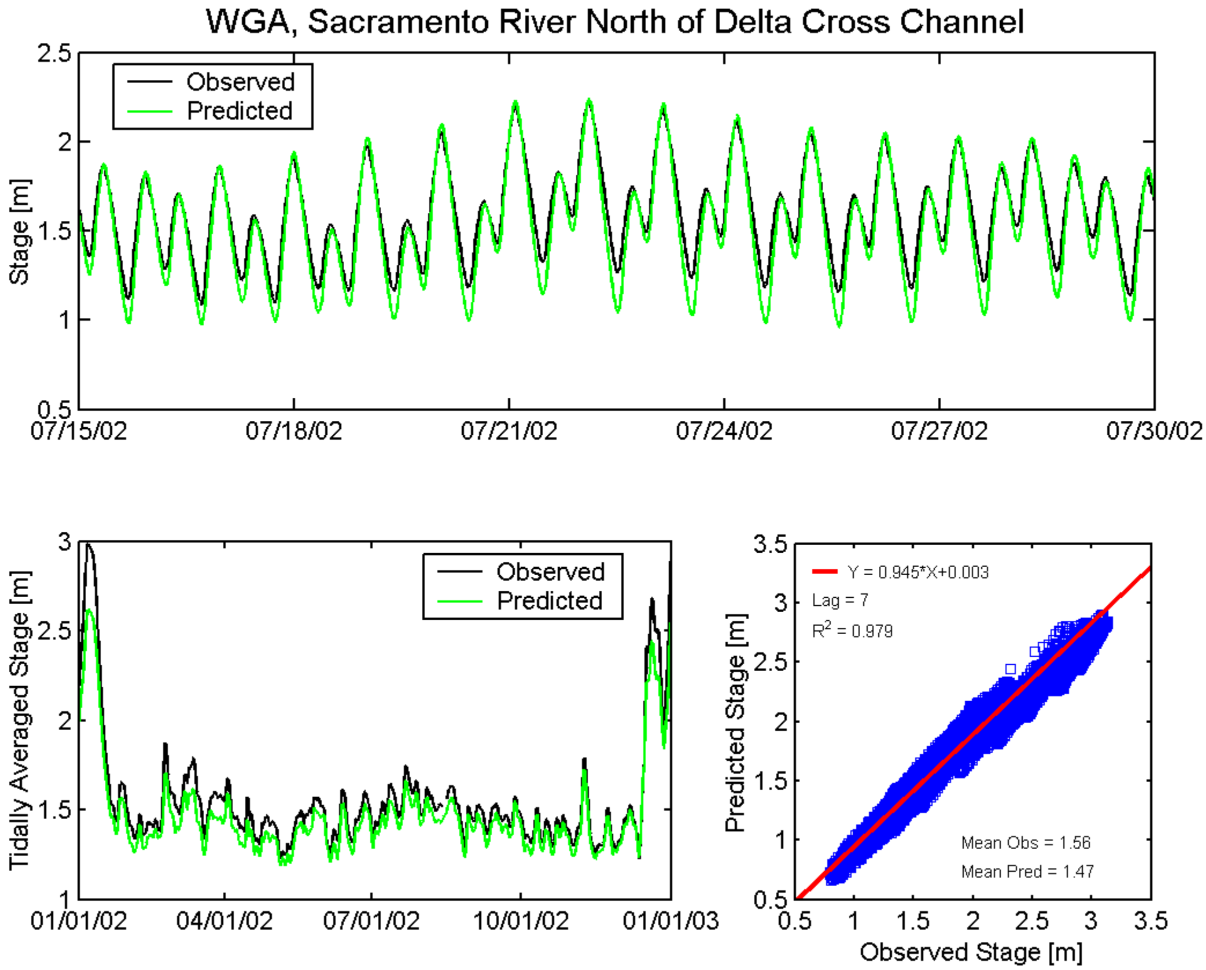


Figure A.3-13 Observed and predicted stage at Sacramento River North of Delta Cross Channel USGS station (WGA) during the 2002 simulation period.

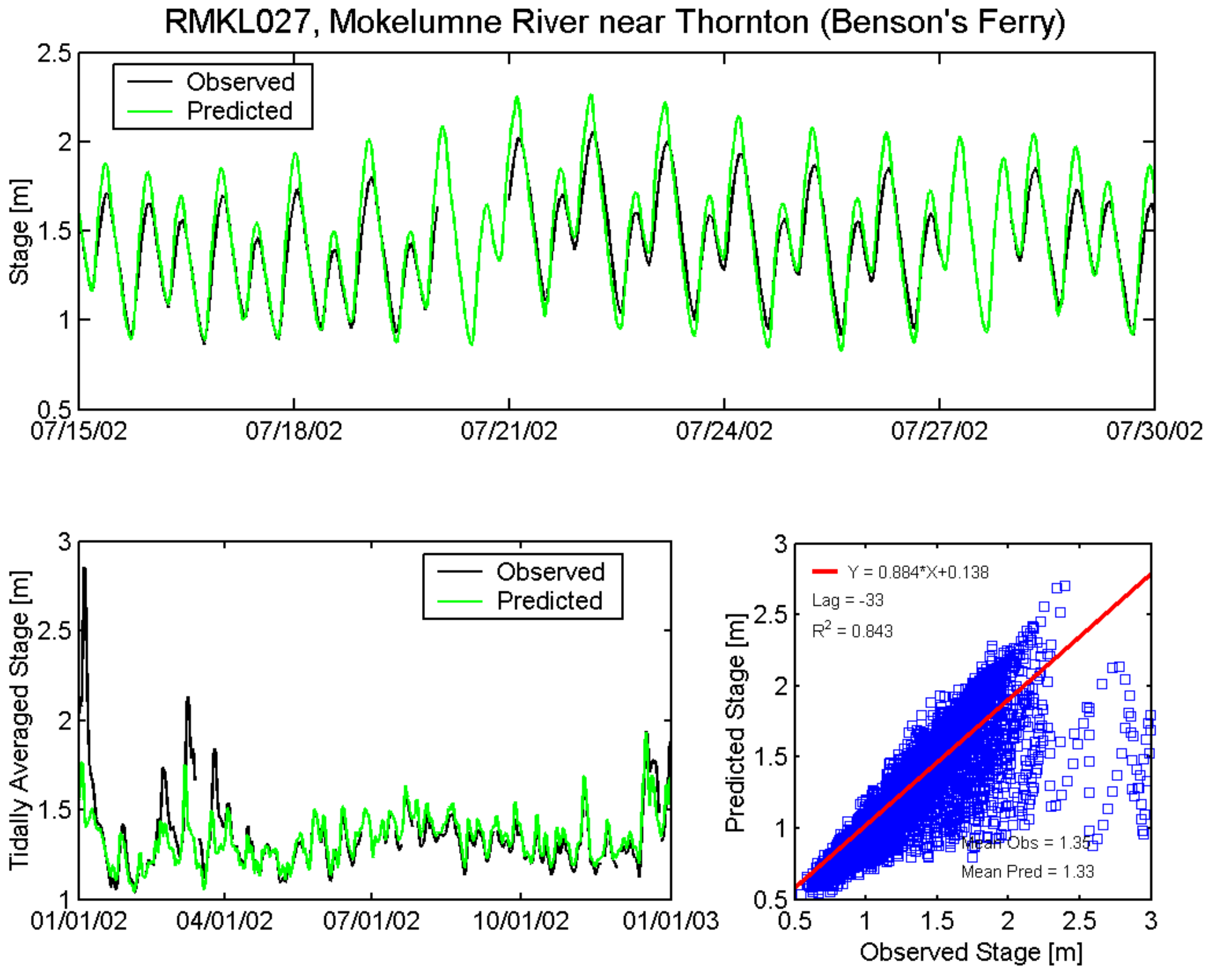


Figure A.3-14 Observed and predicted stage at Mokelumne River near Thornton (Benson's Ferry) DWR station (RMKL027) during the 2002 simulation period.

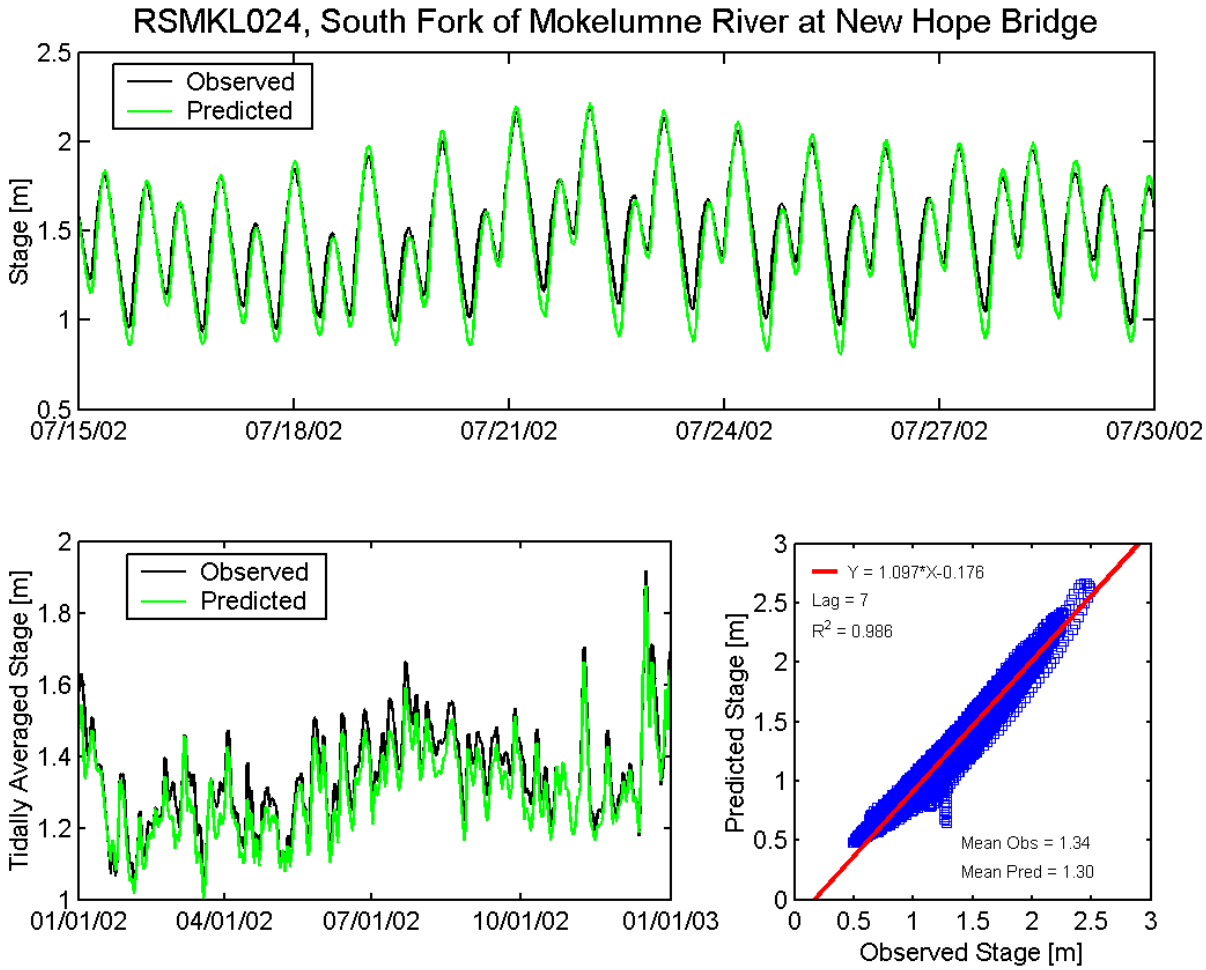


Figure A.3-15 Observed and predicted stage at Mokelumne River at New Hope Bridge DWR station (RSMKL024) during the 2002 simulation period.

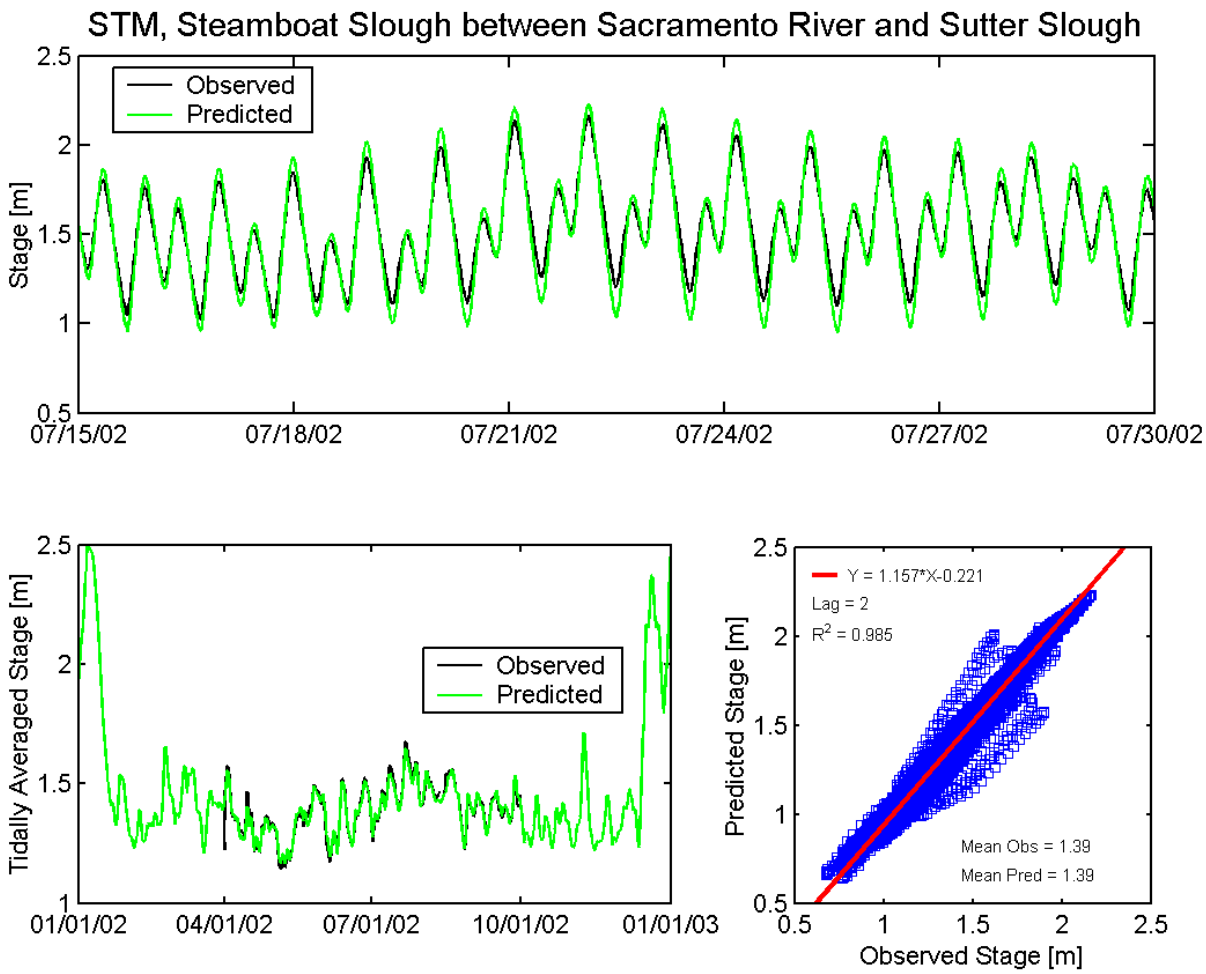


Figure A.3-16 Observed and predicted stage at Steamboat Slough between Sacramento River and Sutter Slough USGS station (STM) during the 2002 simulation period.

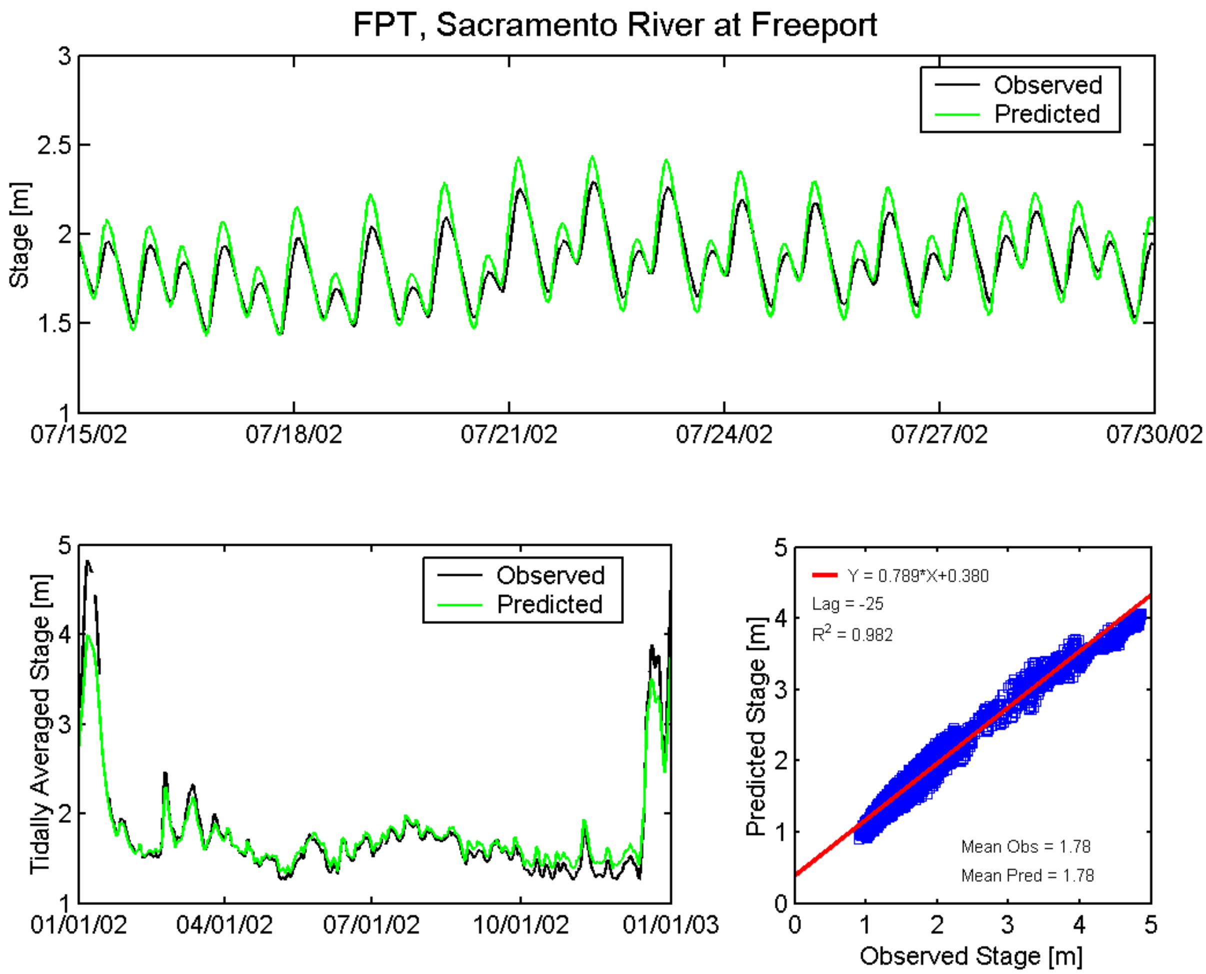


Figure A.3-17 Observed and predicted stage at Sacramento River at Freeport USGS station (FPT) during the 2002 simulation period.

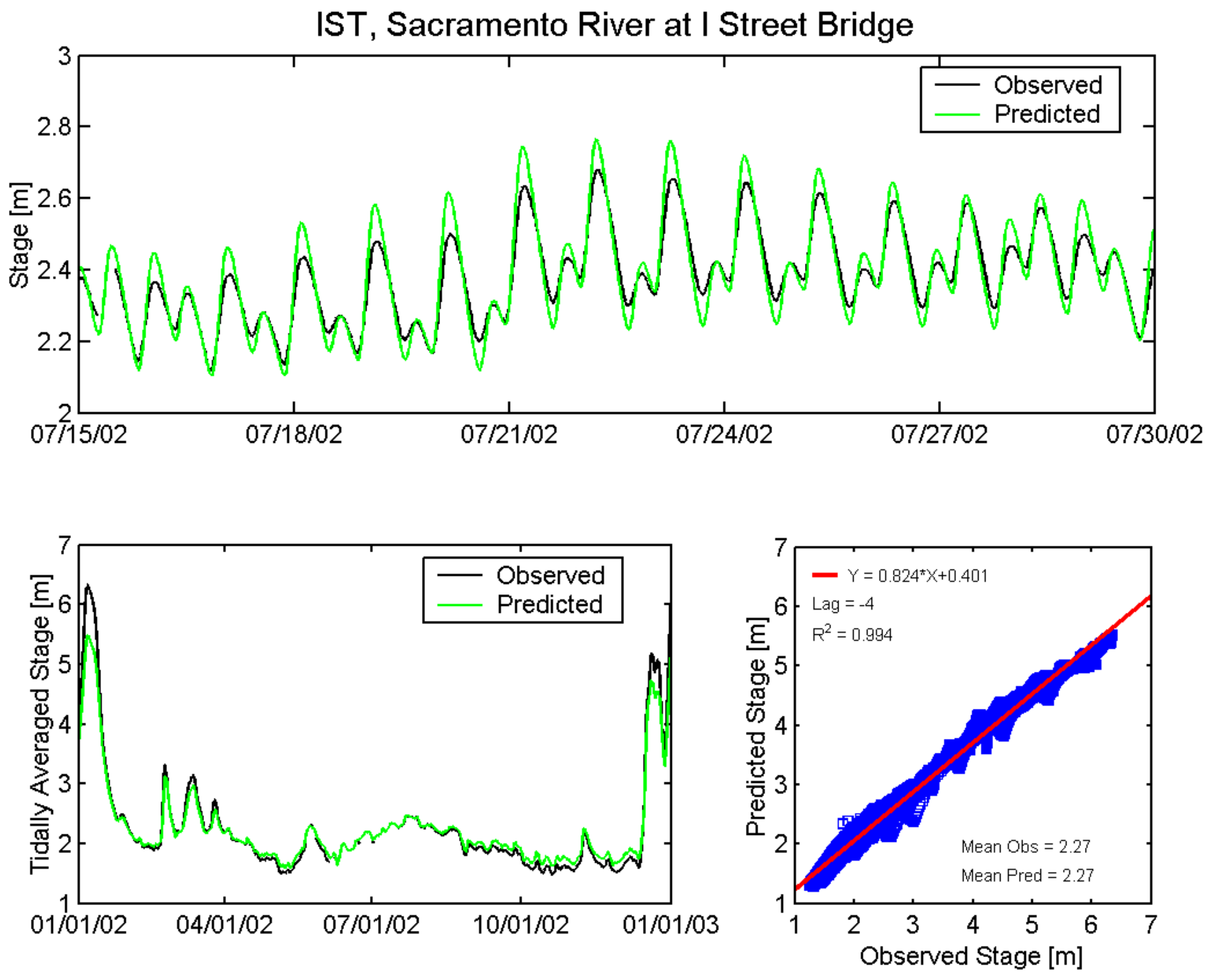


Figure A.3-18 Observed and predicted stage at Sacramento River at I Street Bridge DWR station (CDEC IST) during the 2002 simulation period.

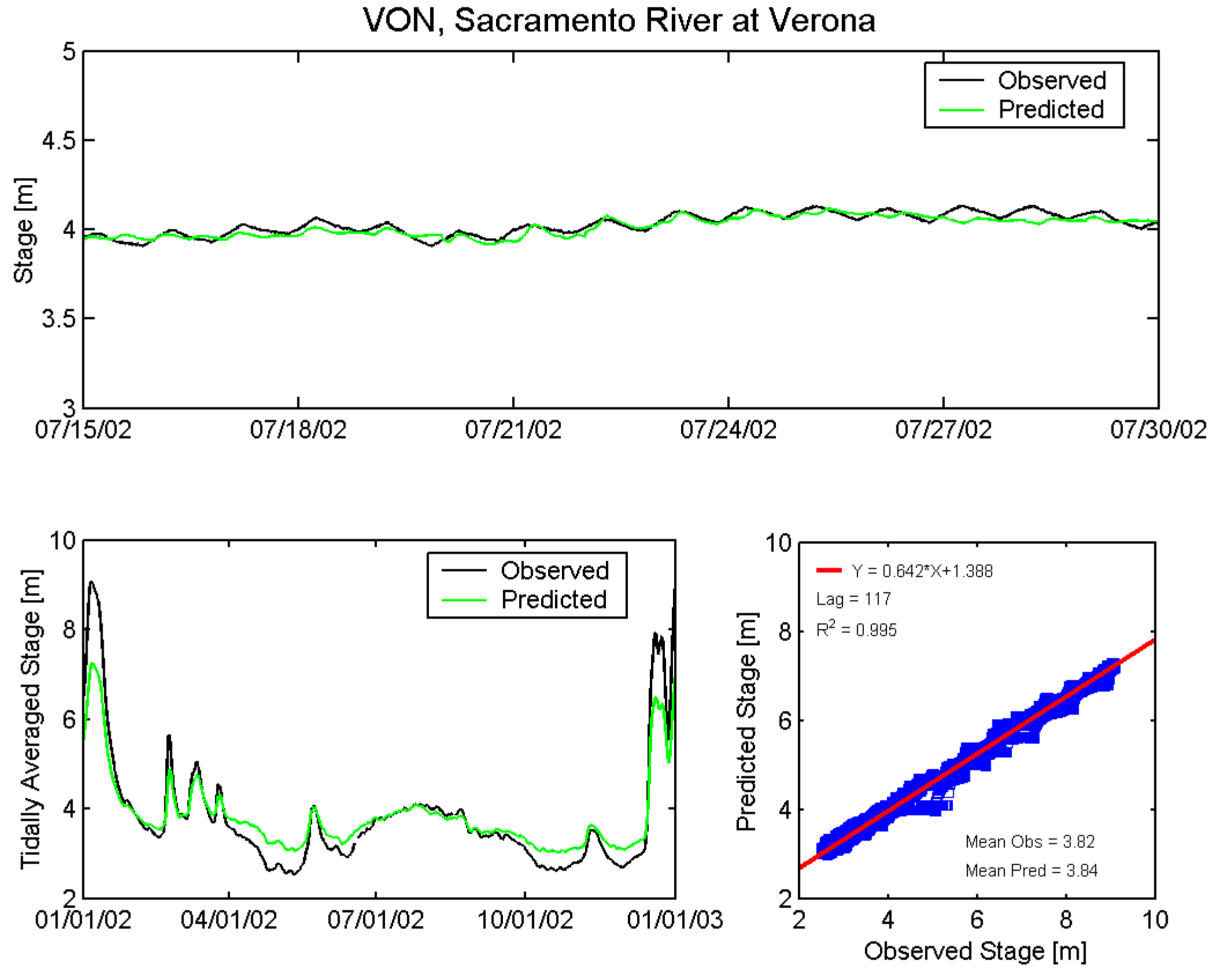
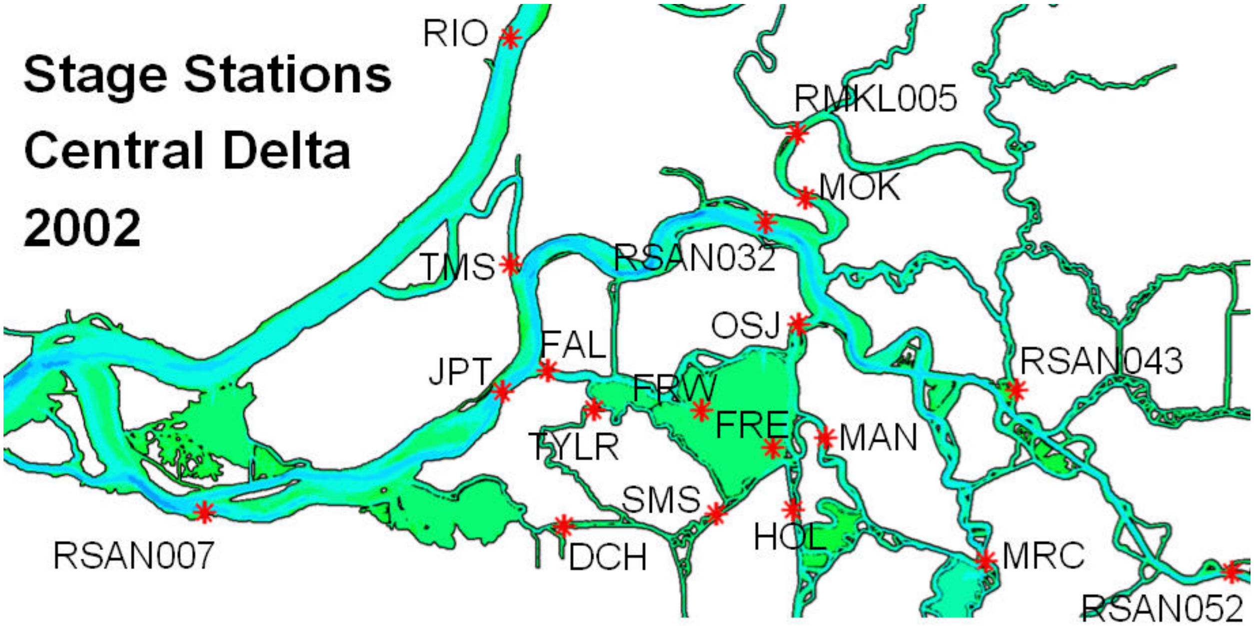


Figure A.3-19 Observed and predicted stage at Sacramento River at Verona DWR station (CDEC VON) during the 2002 simulation period.



Station Names

RSAN007, San Joaquin River at Antioch

RIO, Sacramento River at Rio Vista

TMS, Threemile Slough at San Joaquin River

JPT, San Joaquin River at Jersey Point

DCH, Dutch Slough at Jersey Island

FAL, False River

TYLR, Taylor Slough

SMS, Sand Mound Slough

RSAN032, San Joaquin River at San Andreas Landing

OSJ, Old River at San Joaquin River

MOK, Mokelumne River near San Joaquin River

RMKL005, North Fork of Mokelumne River at Georgiana Slough

FRE, Franks Tract East

FRW, Franks Tract West

MAN, Old River at Mandeville Island

HOL, Holland Cut

RSAN043, San Joaquin River at Venice Island

RSAN052, San Joaquin River at Rindge Pump

MRC, Middle River South of Columbia Cut

Figure A.3-20 Location of water level monitoring stations in the central portion of the Sacramento-San Joaquin Delta used for 2002 water level comparisons.

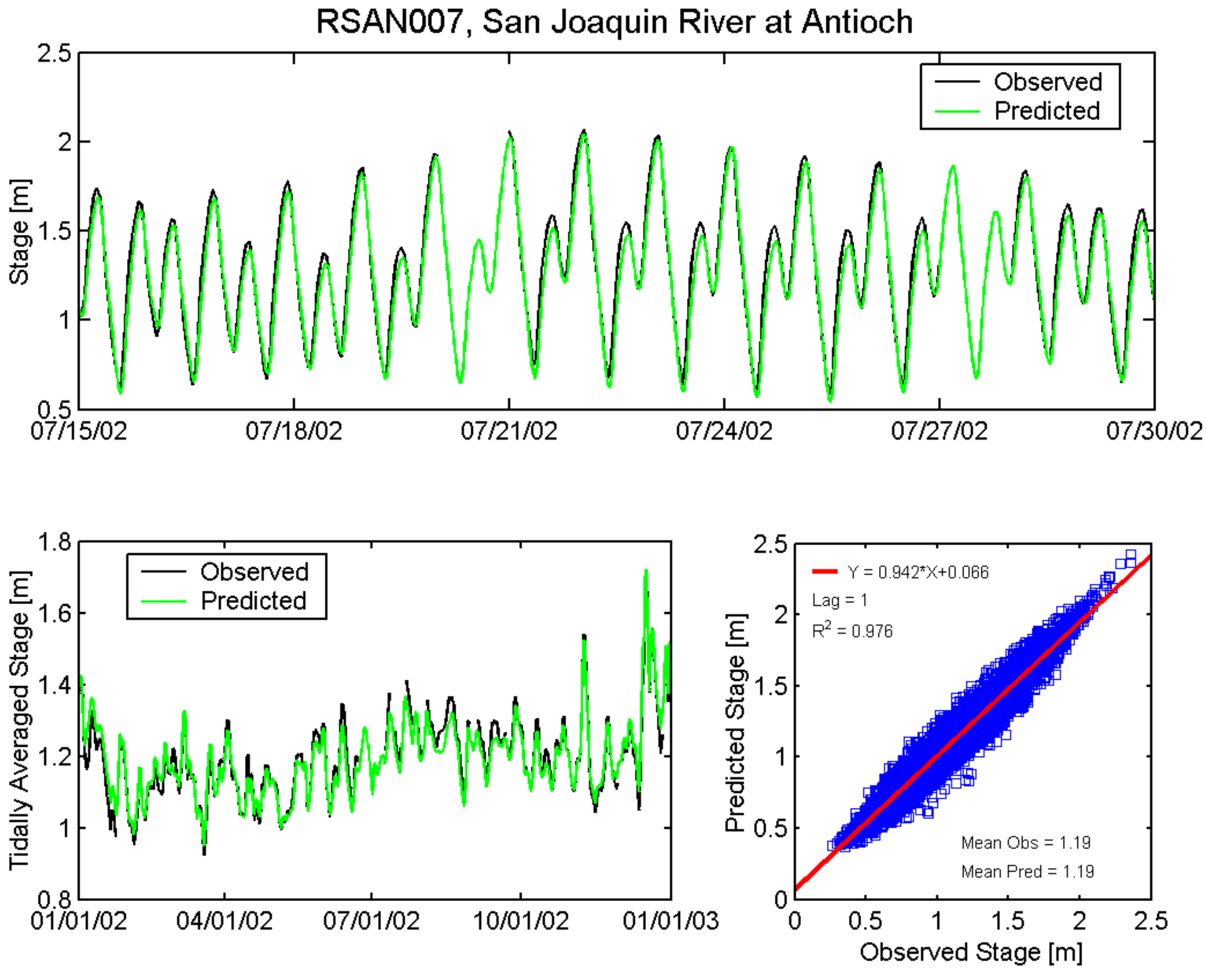


Figure A.3-21 Observed and predicted stage at San Joaquin River at Antioch DWR station (RSAN007) during the 2002 simulation period.

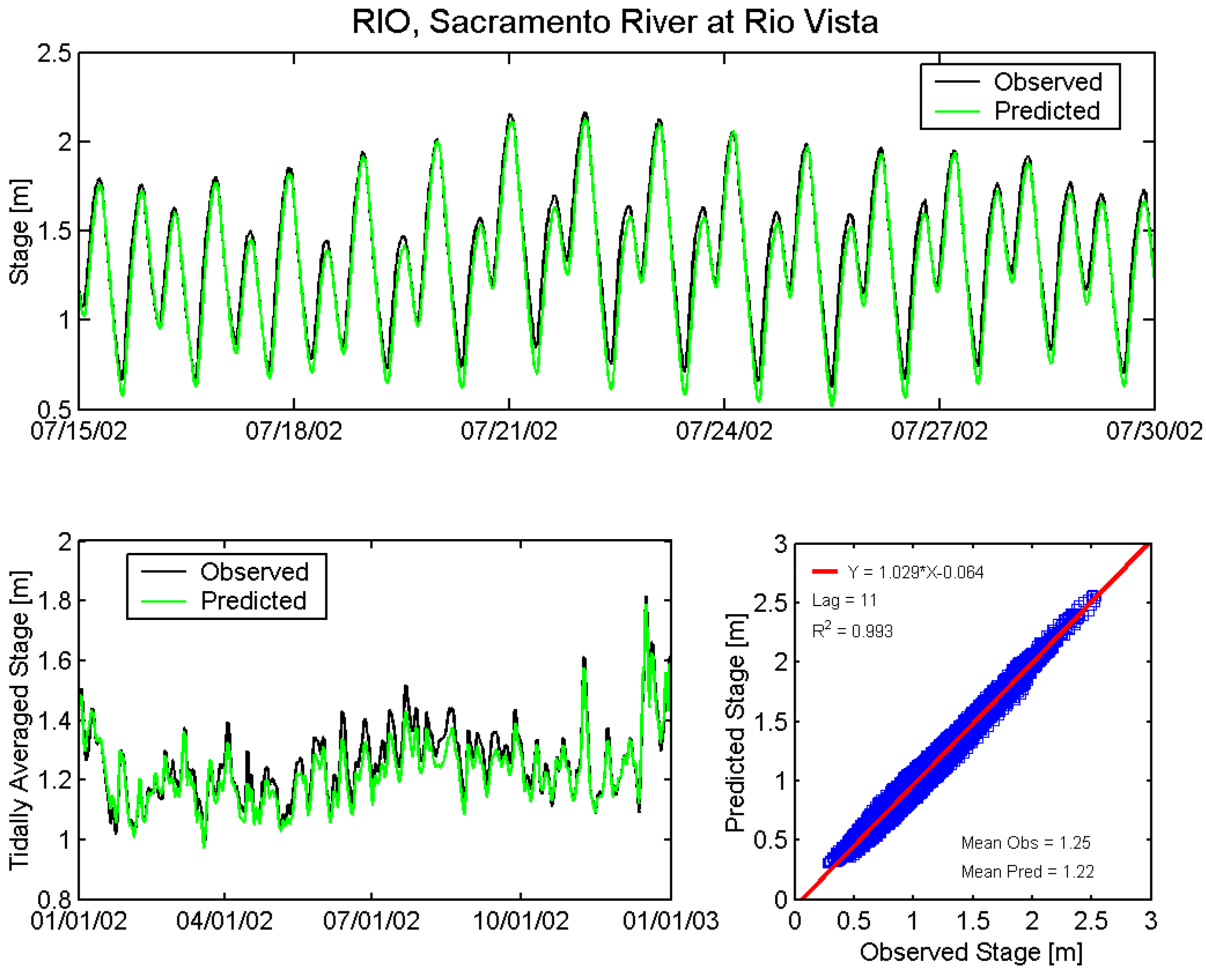


Figure A.3-22 Observed and predicted stage at Sacramento River at Rio Vista USGS station (RIO) during the 2002 simulation period.

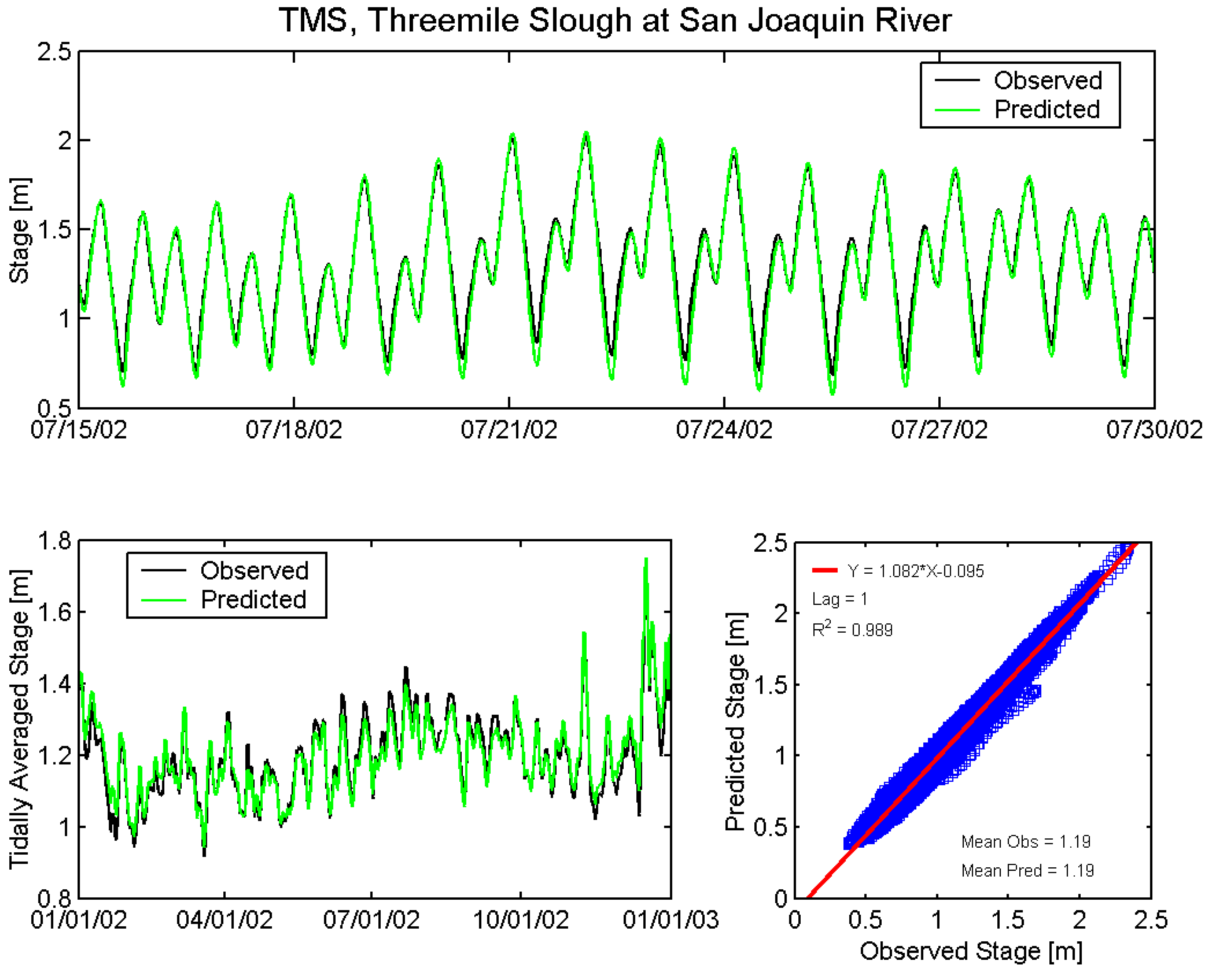


Figure A.3-23 Observed and predicted stage at Threemile Slough at San Joaquin River USGS station (TMS) during the 2002 simulation period.

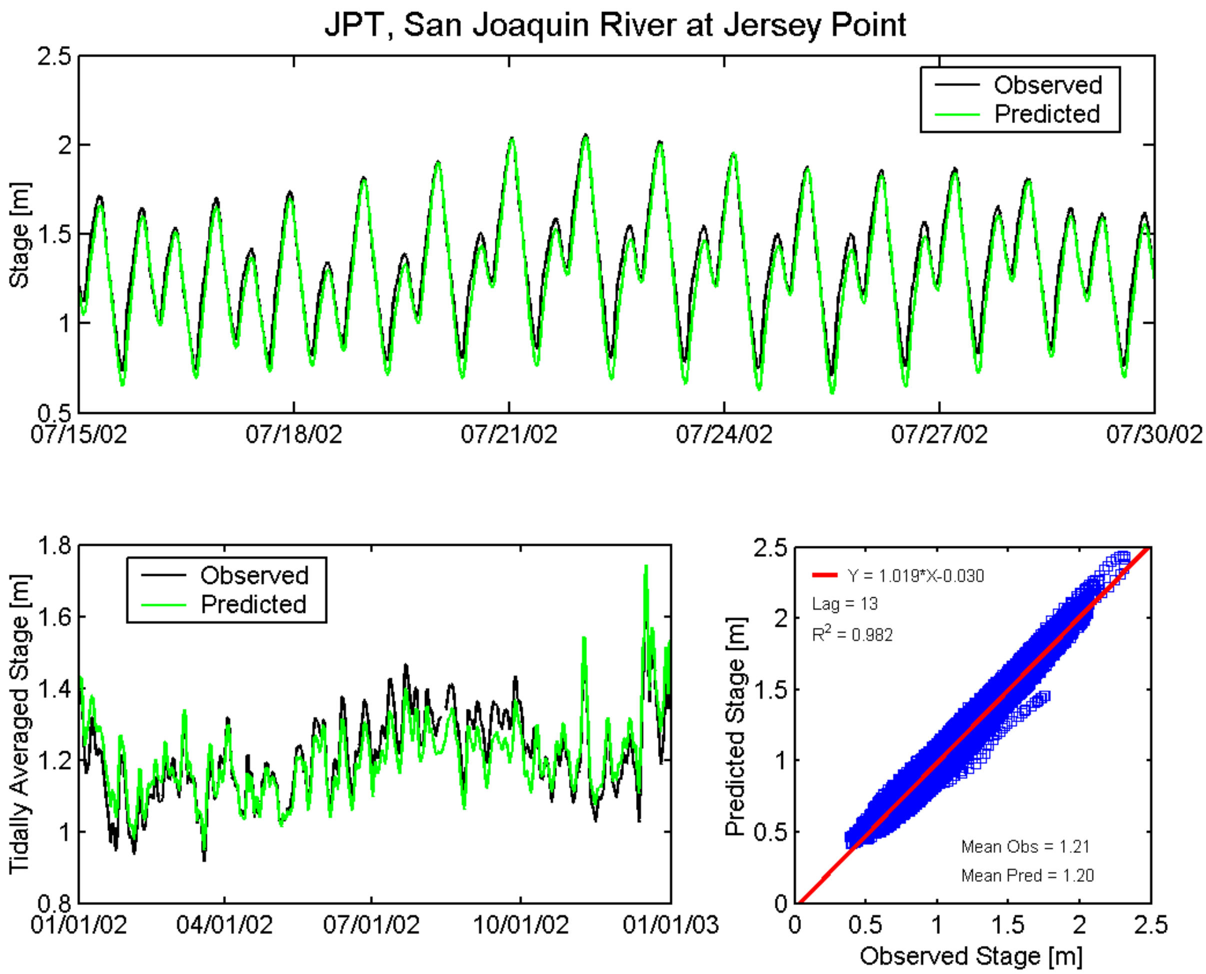


Figure A.3-24 Observed and predicted stage at San Joaquin River at Jersey Point USGS station (JPT) during the 2002 simulation period.

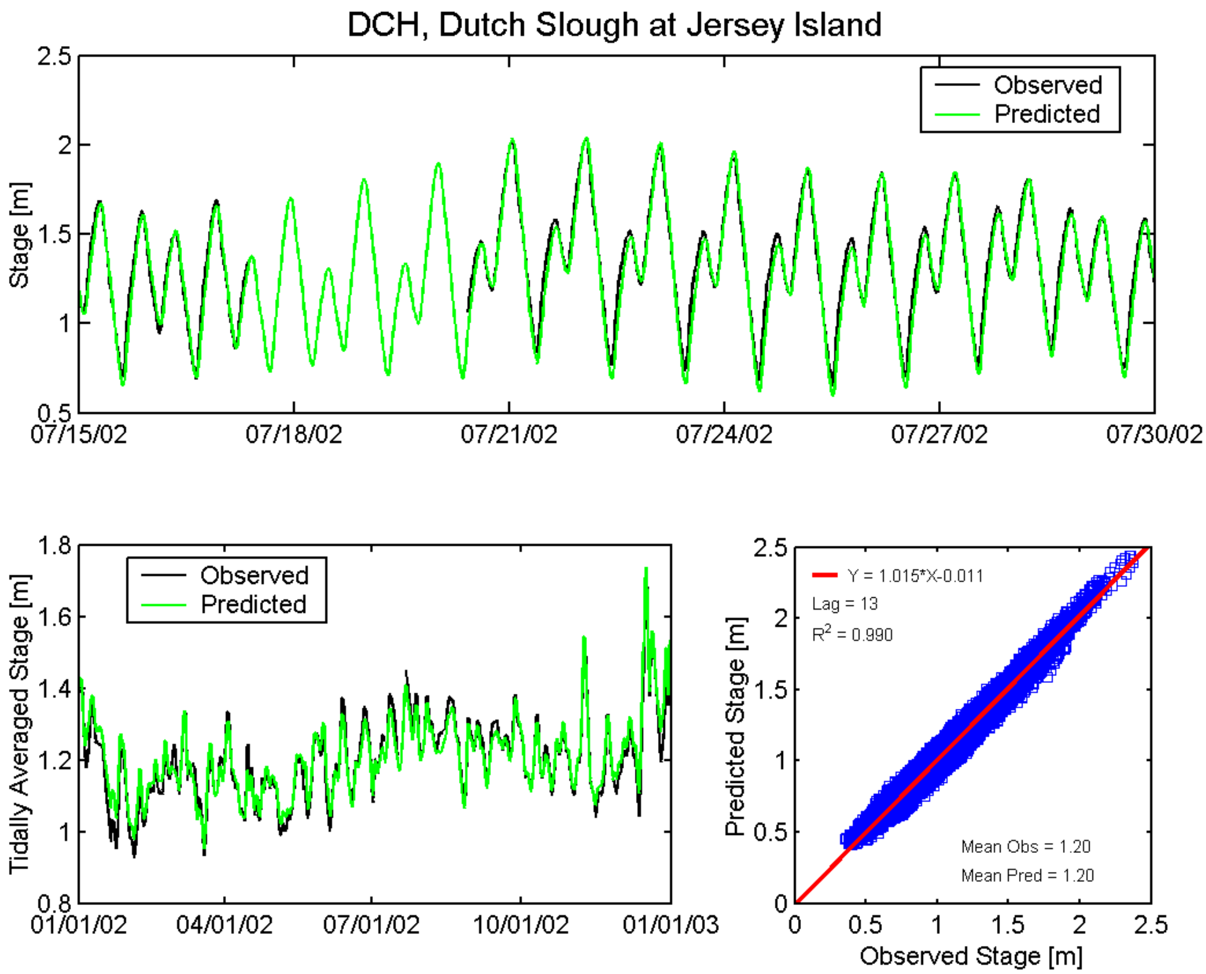


Figure A.3-25 Observed and predicted stage at Dutch Slough at Jersey Island USGS station (DCH) during the 2002 simulation period.

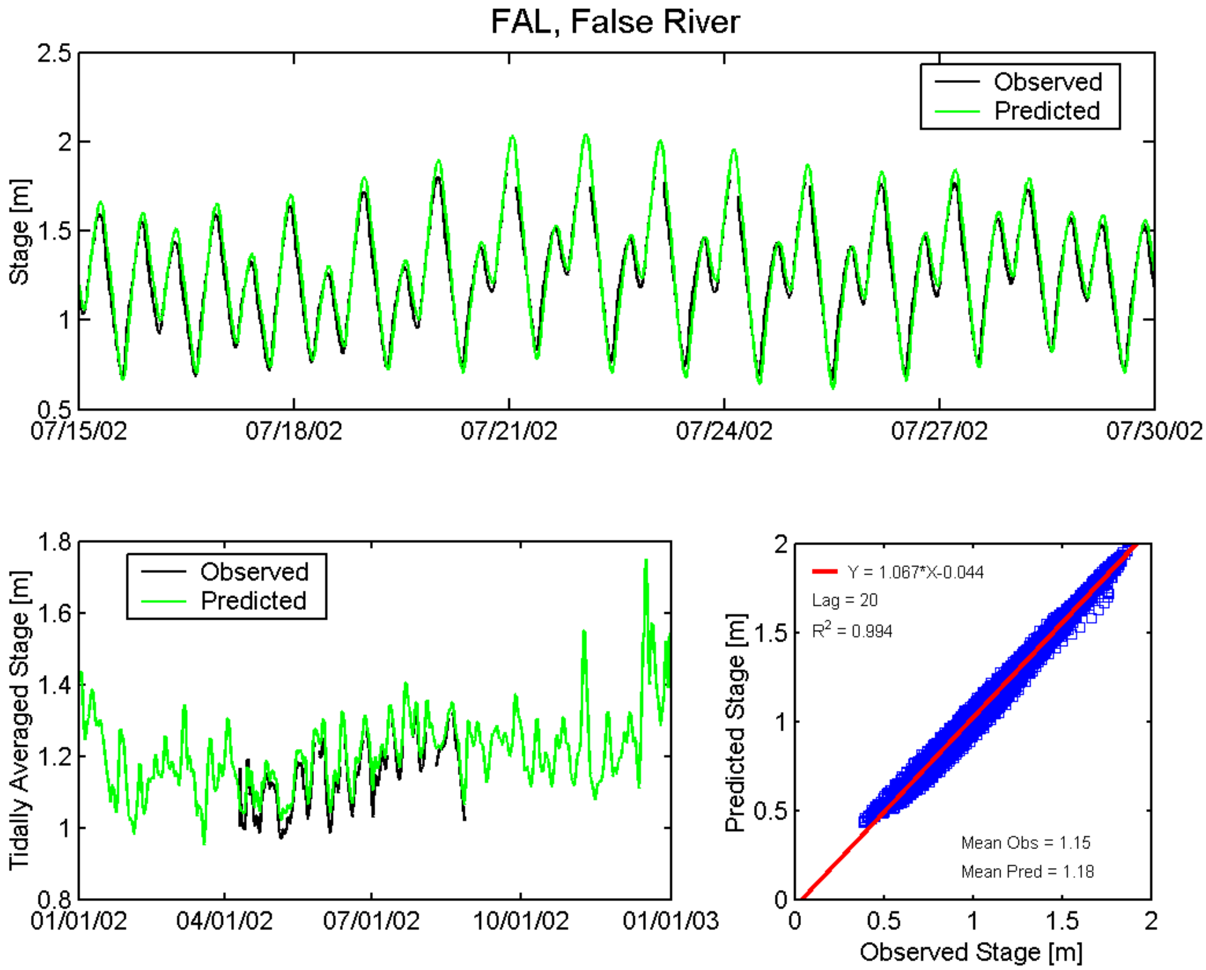


Figure A.3-26 Observed and predicted stage at False River USGS station (FAL) during the 2002 simulation period.

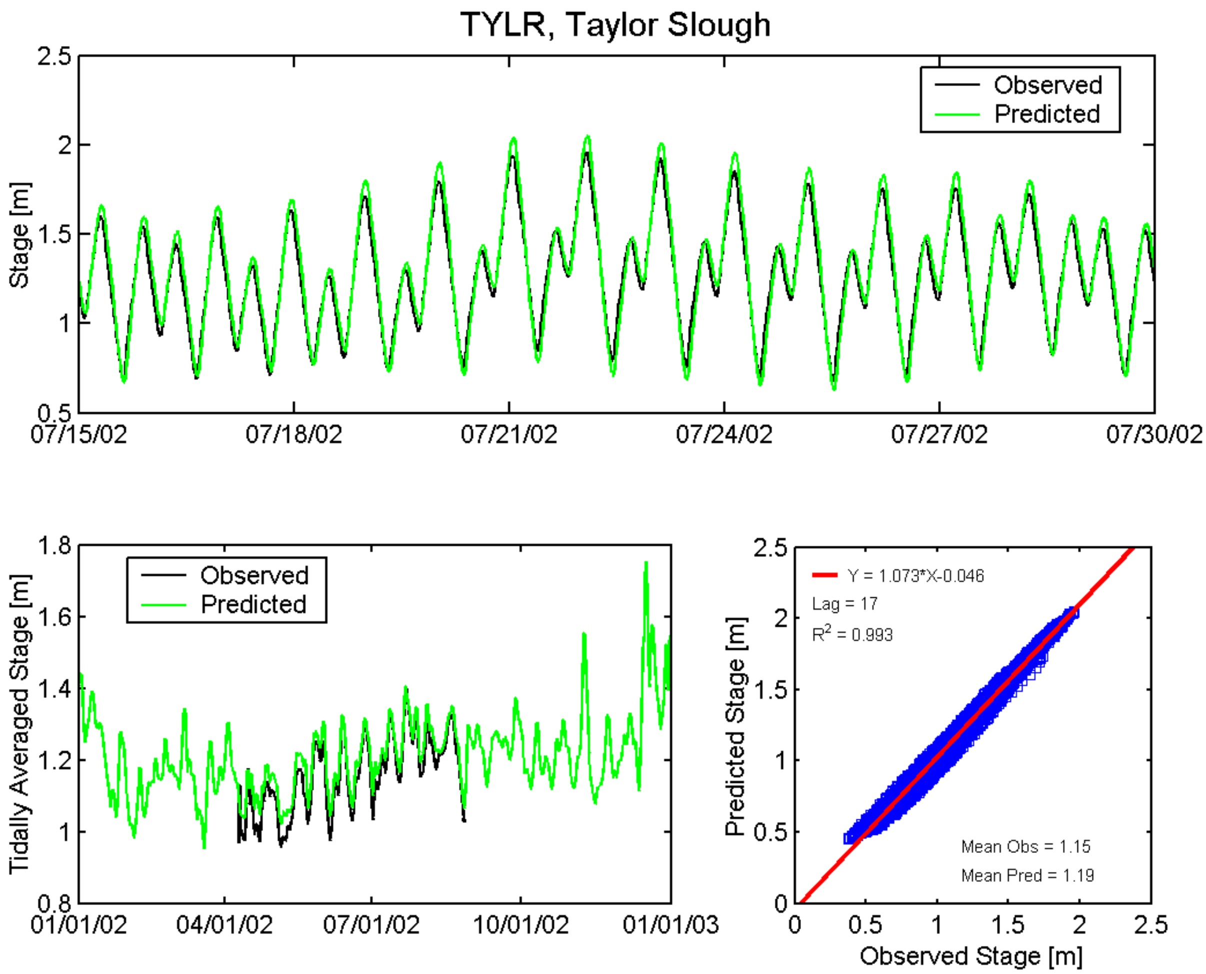


Figure A.3-27 Observed and predicted stage at Taylor Slough USGS station (TYLR) during the 2002 simulation period.

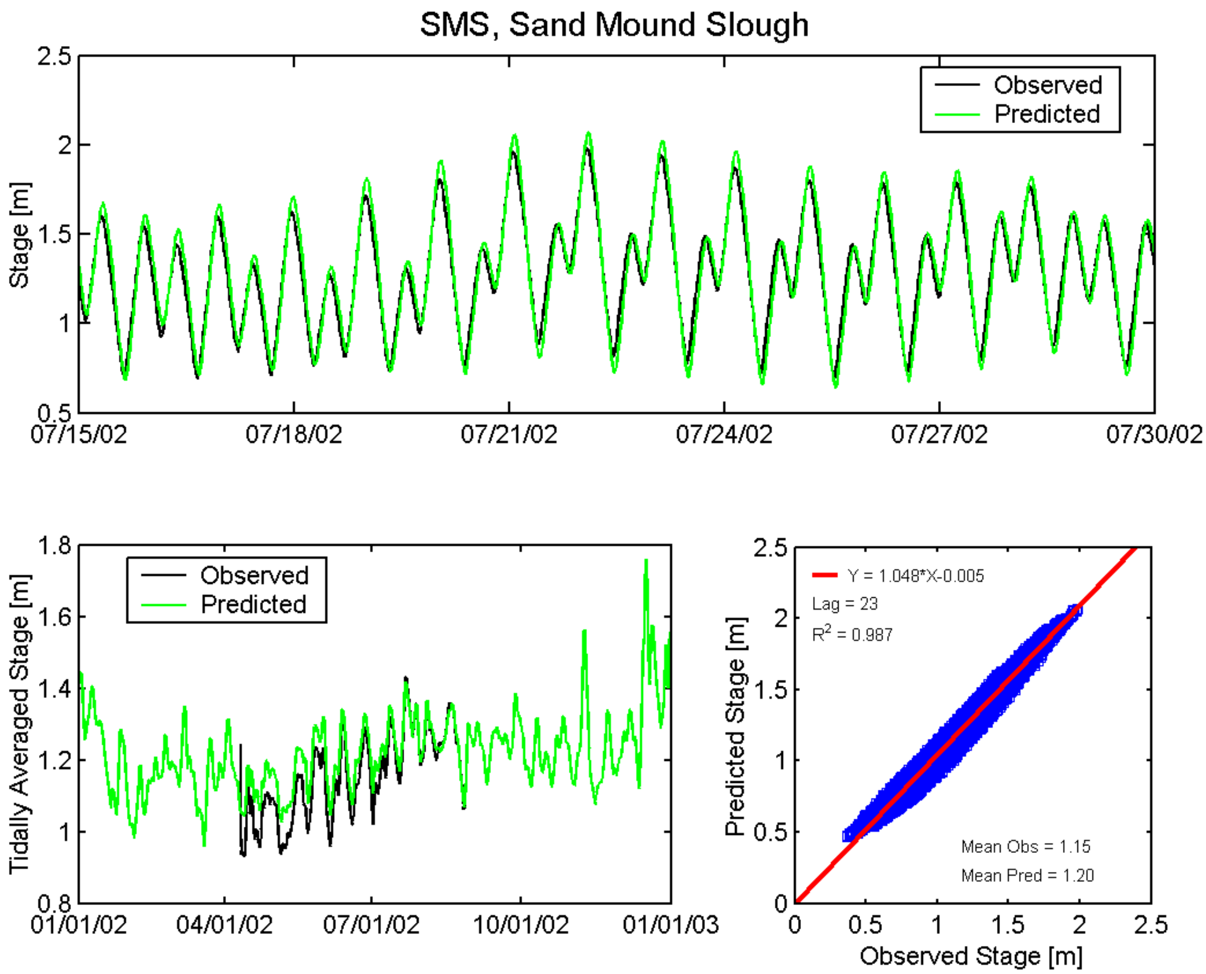


Figure A.3-28 Observed and predicted stage at Sand Mound Slough USGS station (SMS) during the 2002 simulation period.

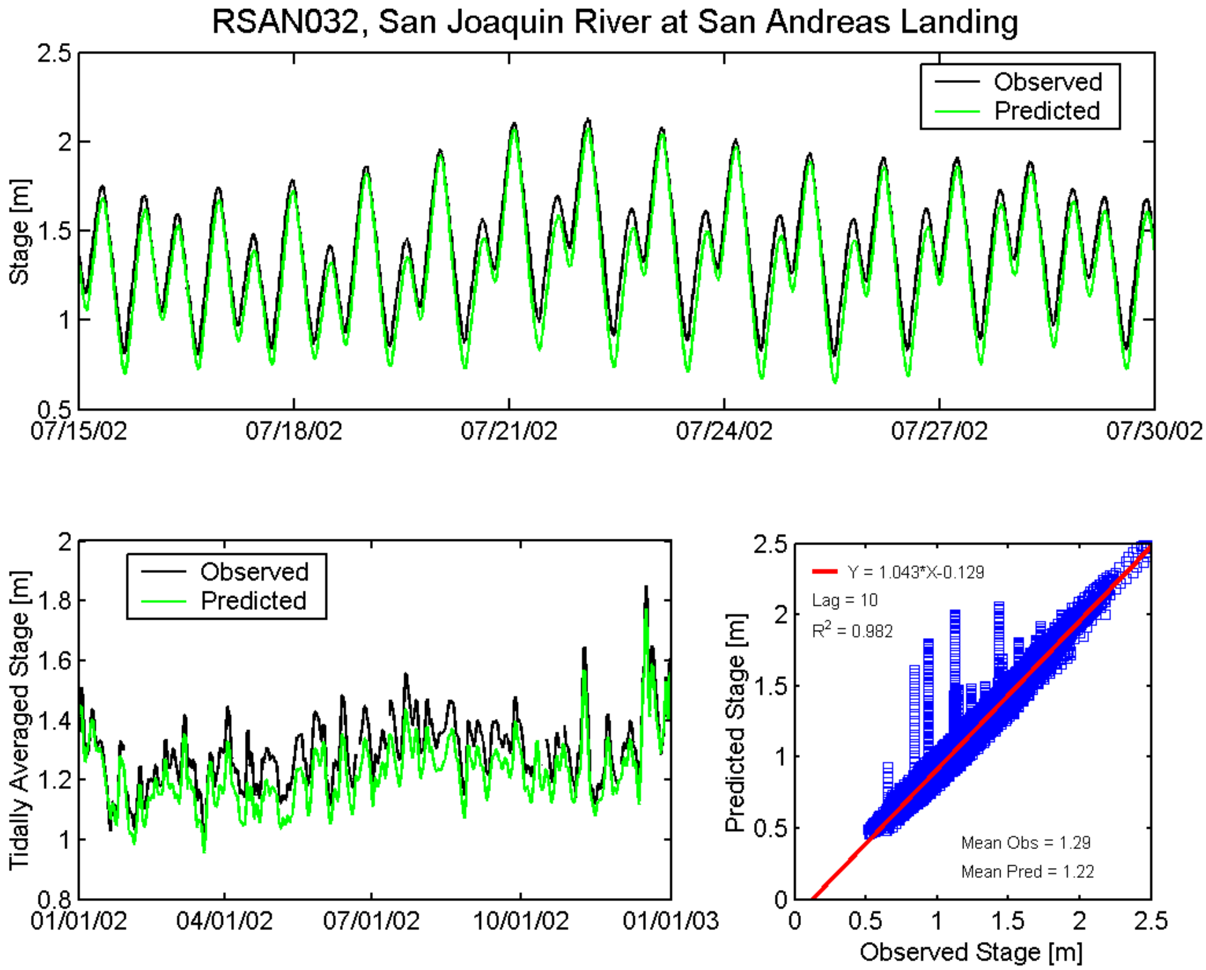


Figure A.3-29 Observed and predicted stage at San Joaquin River at San Andreas Landing DWR station (RSAN032) during the 2002 simulation period.

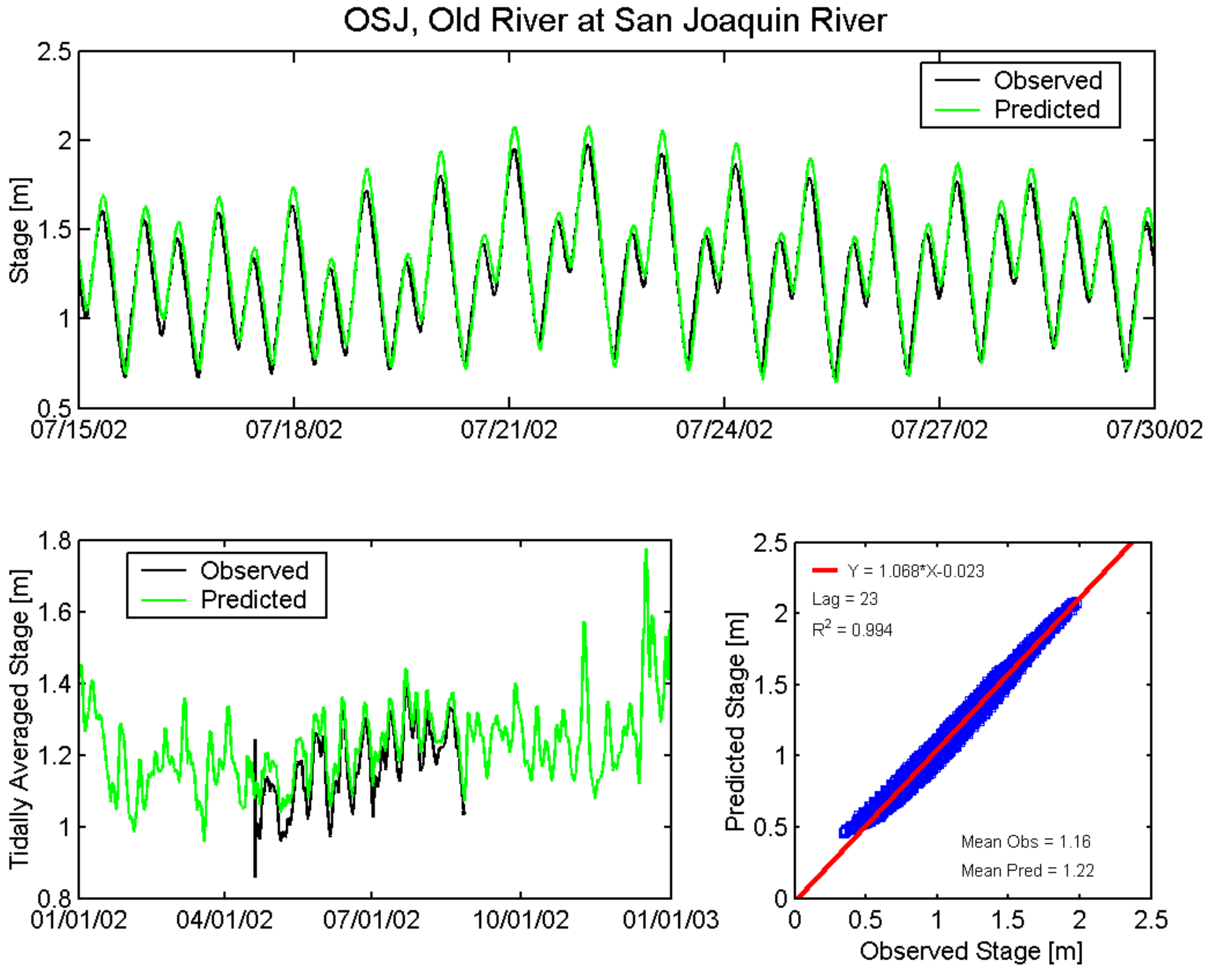


Figure A.3-30 Observed and predicted stage at Old River at San Joaquin River USGS station (OSJ) during the 2002 simulation period.

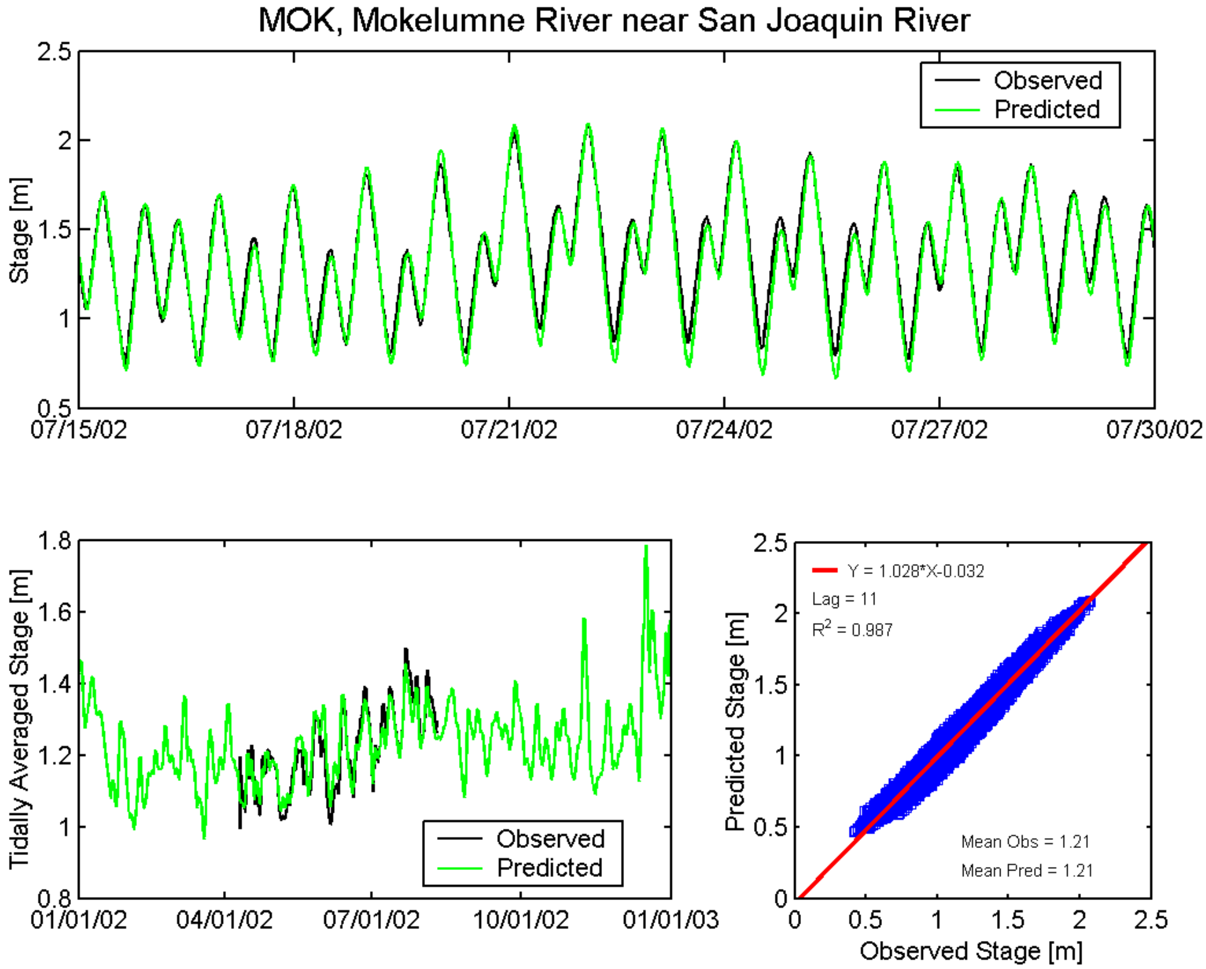


Figure A.3-31 Observed and predicted stage at Mokelumne River near San Joaquin River USGS station (MOK) during the 2002 simulation period.

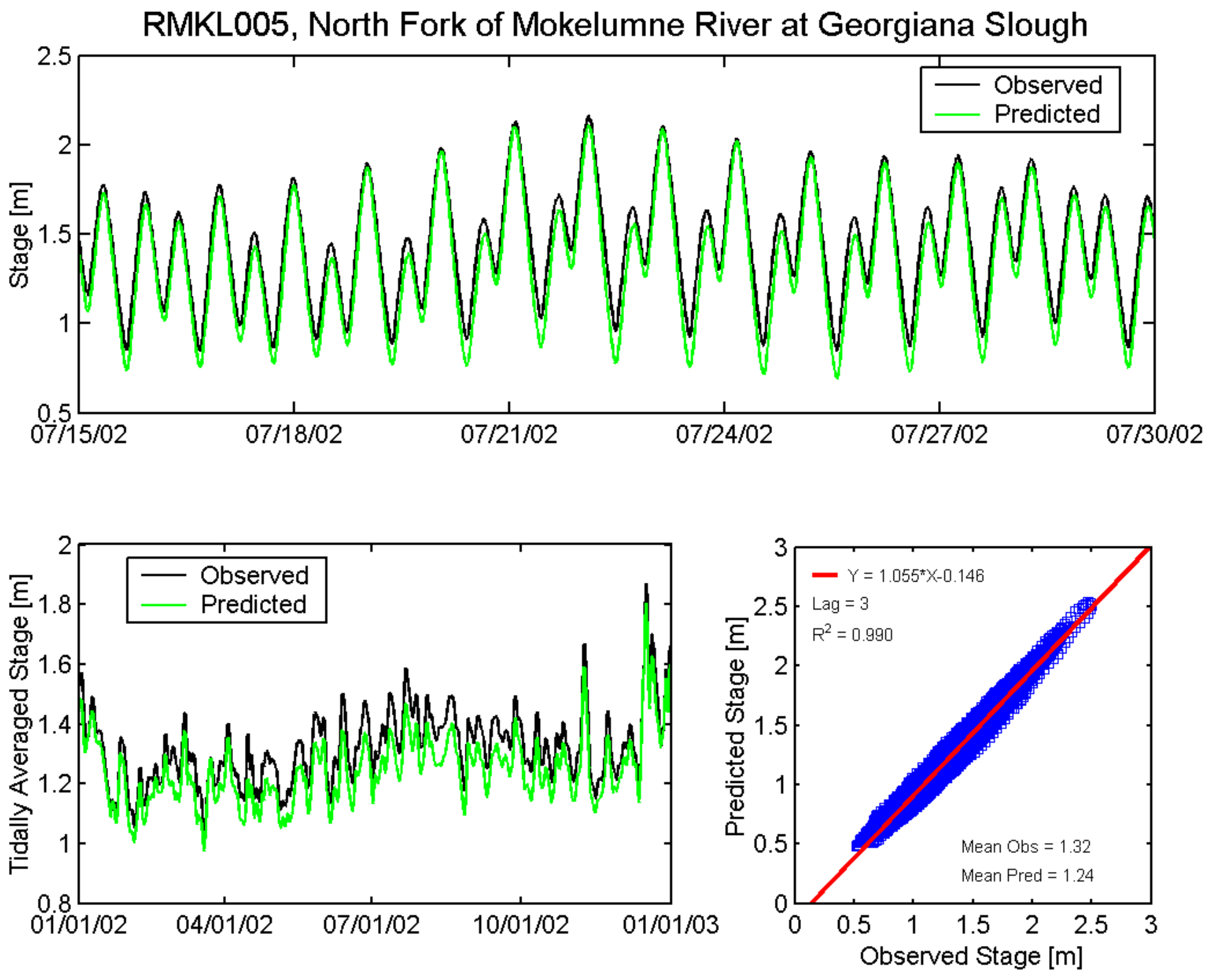


Figure A.3-32 Observed and predicted stage at North Fork of Mokelumne River at Georgiana Slough DWR station (RMKL005) during the 2002 simulation period.

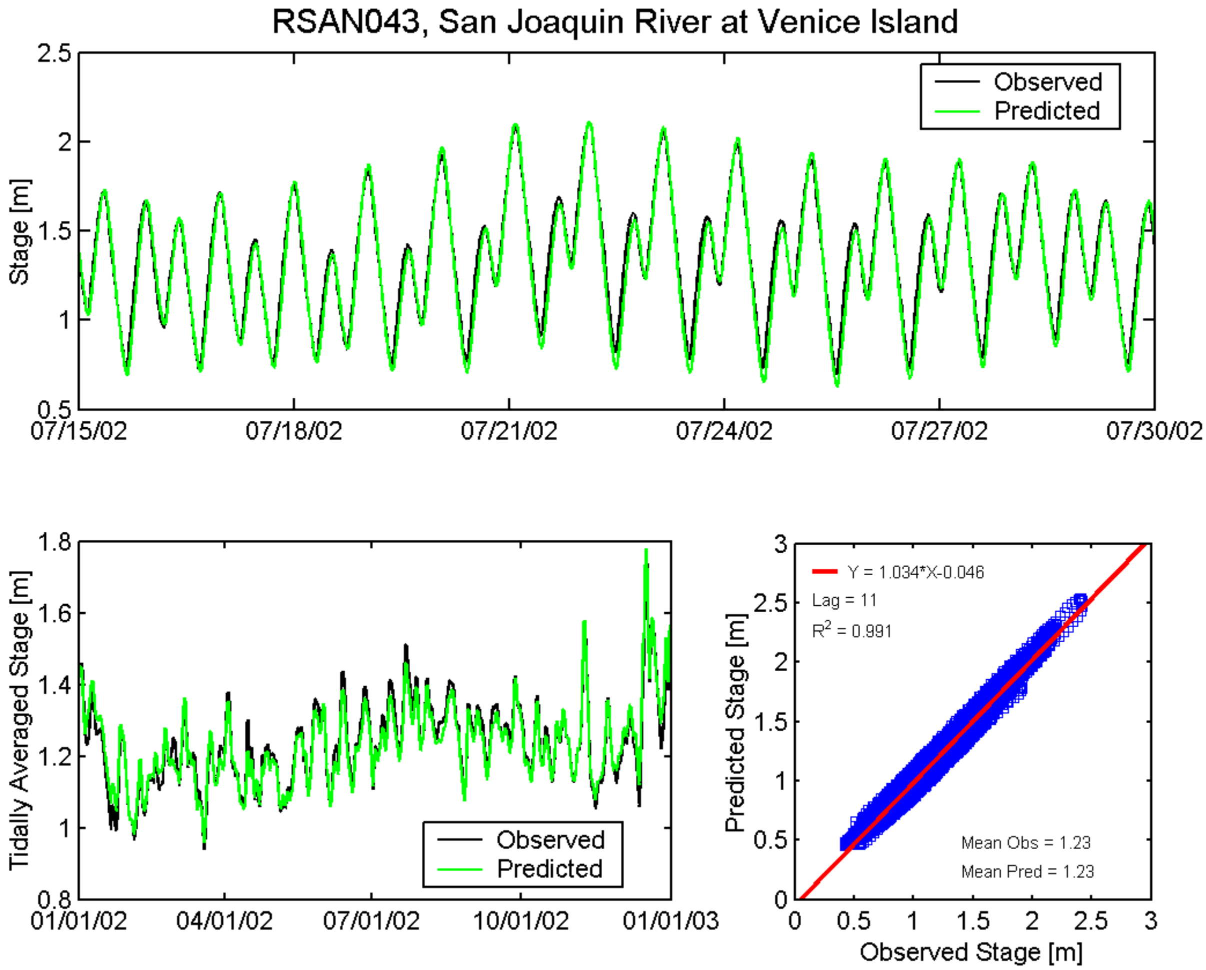


Figure A.3-33 Observed and predicted stage at San Joaquin River at Venice Island DWR station (RSAN043) during the 2002 simulation period.

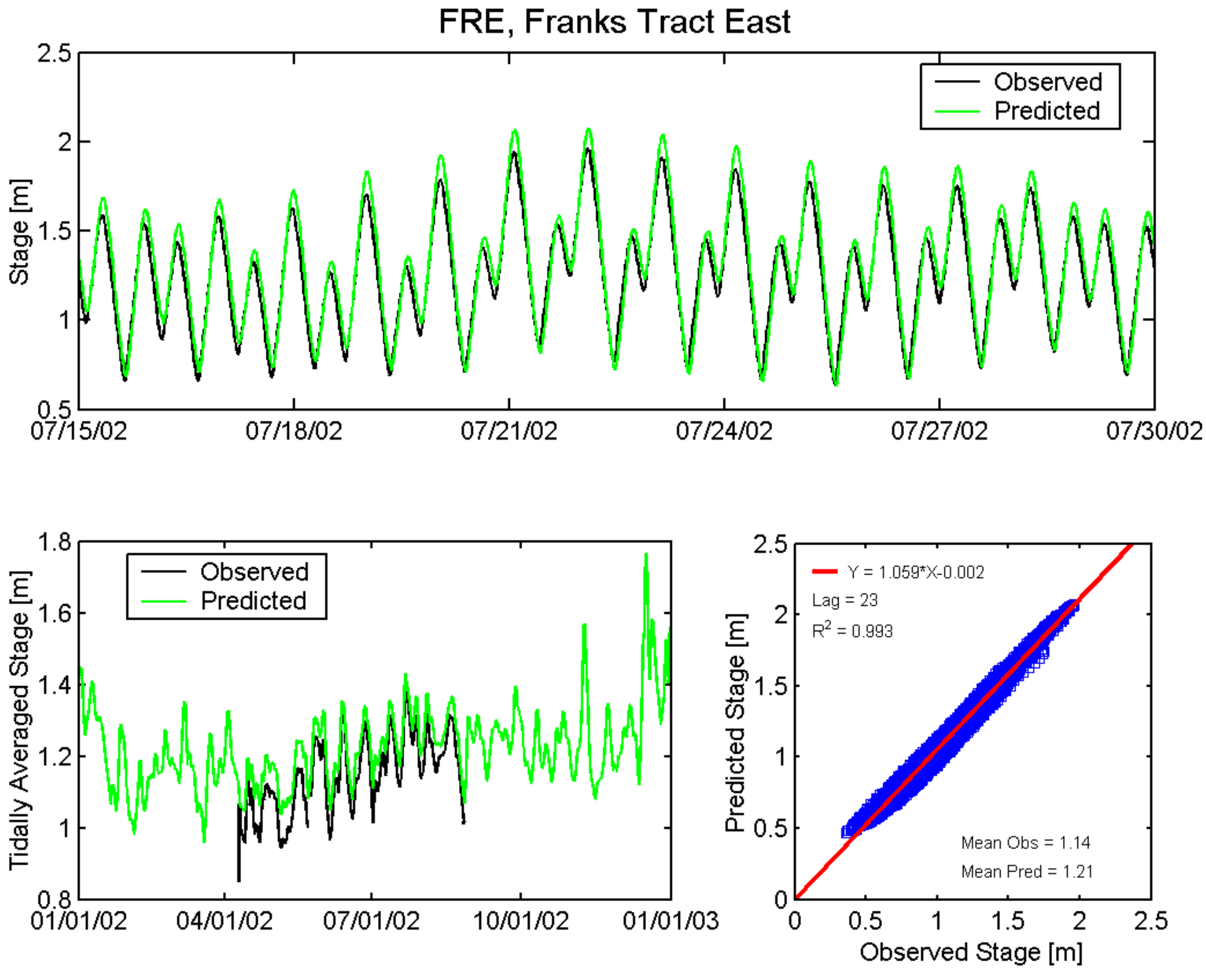


Figure A.3-34 Observed and predicted stage at Franks Tract East USGS station (FRE) during the 2002 simulation period.

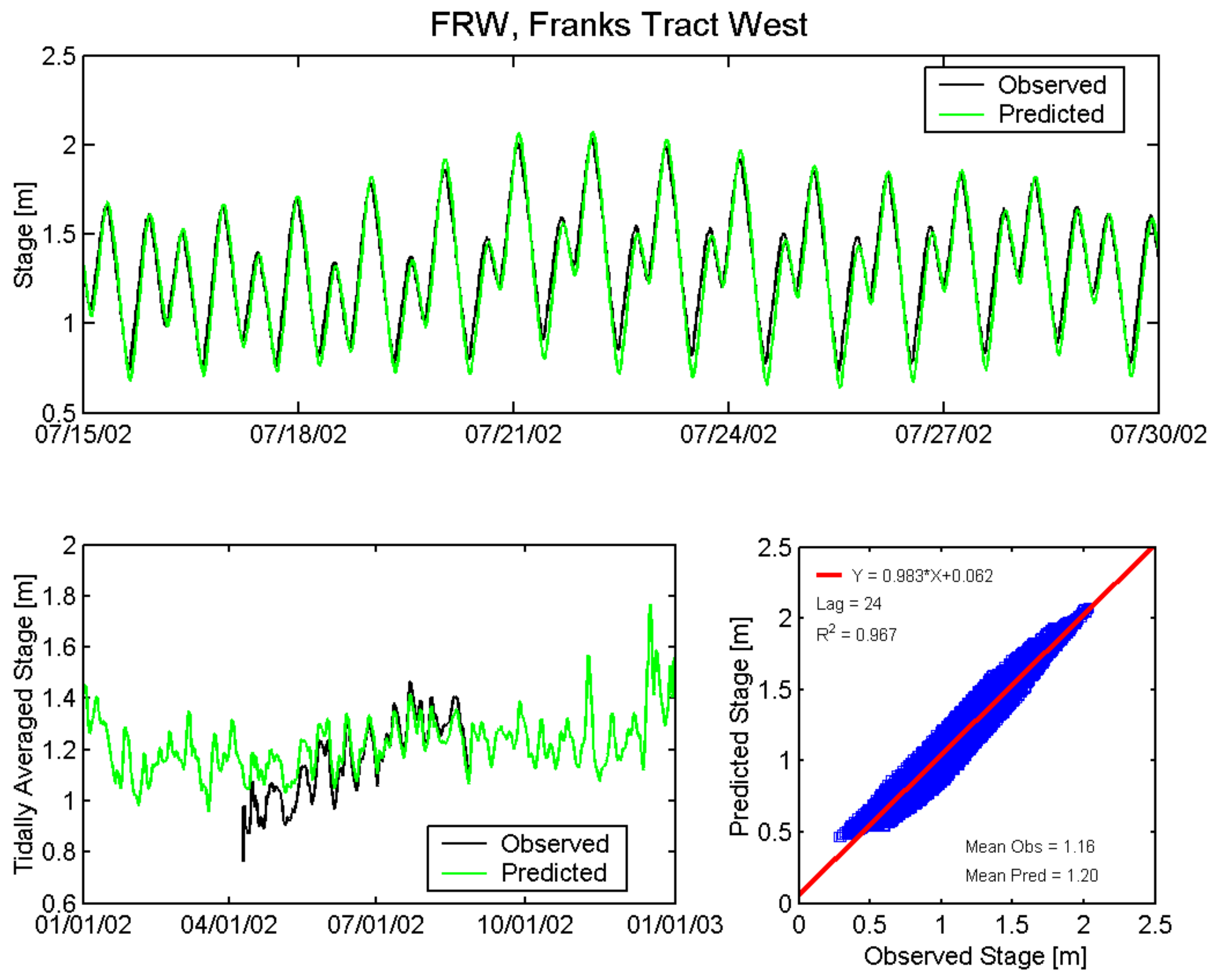


Figure A.3-35 Observed and predicted stage at Franks Tract West USGS station (FRW) during the 2002 simulation period.

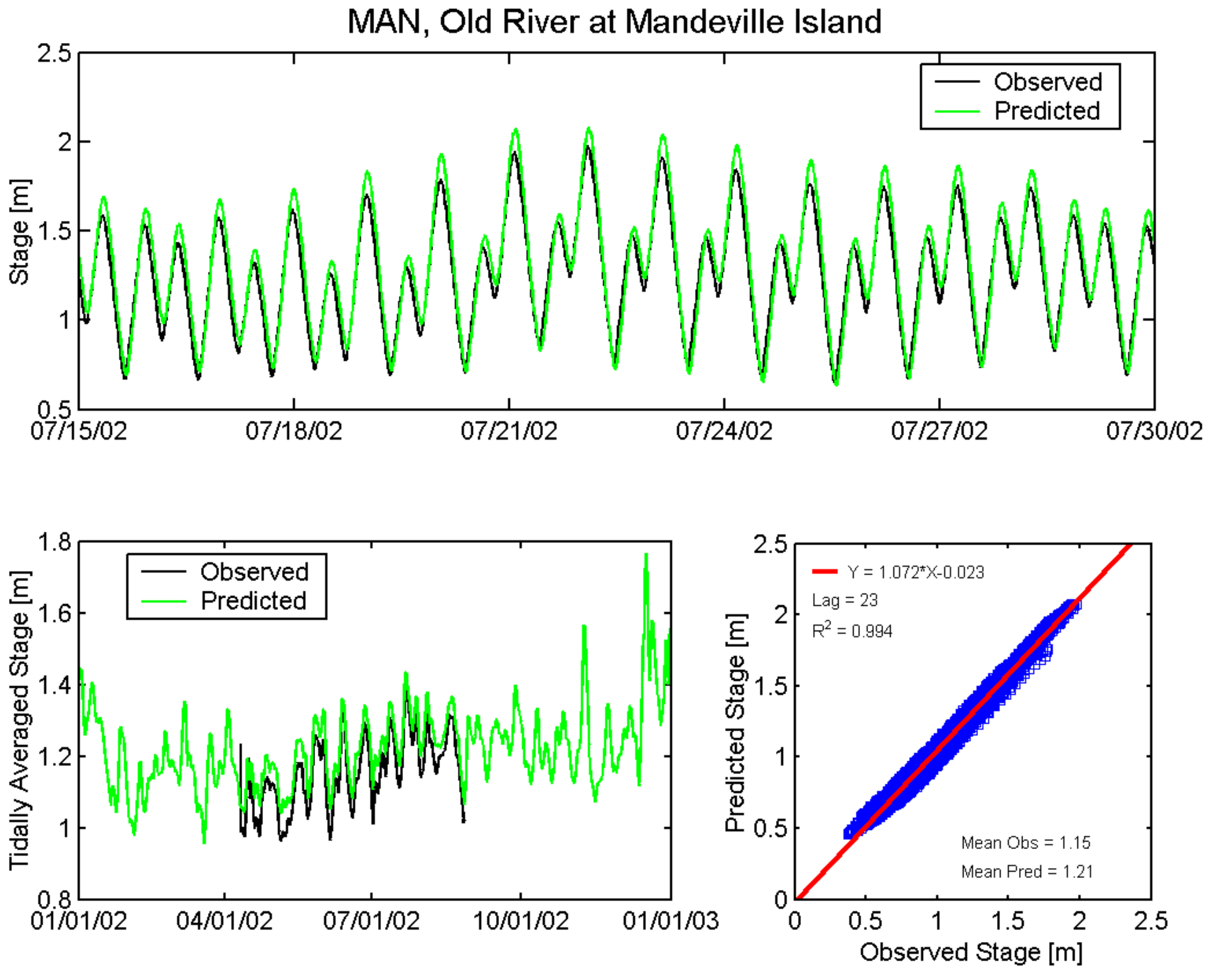


Figure A.3-36 Observed and predicted stage at Old River at Mandeville Island USGS station (MAN) during the 2002 simulation period.

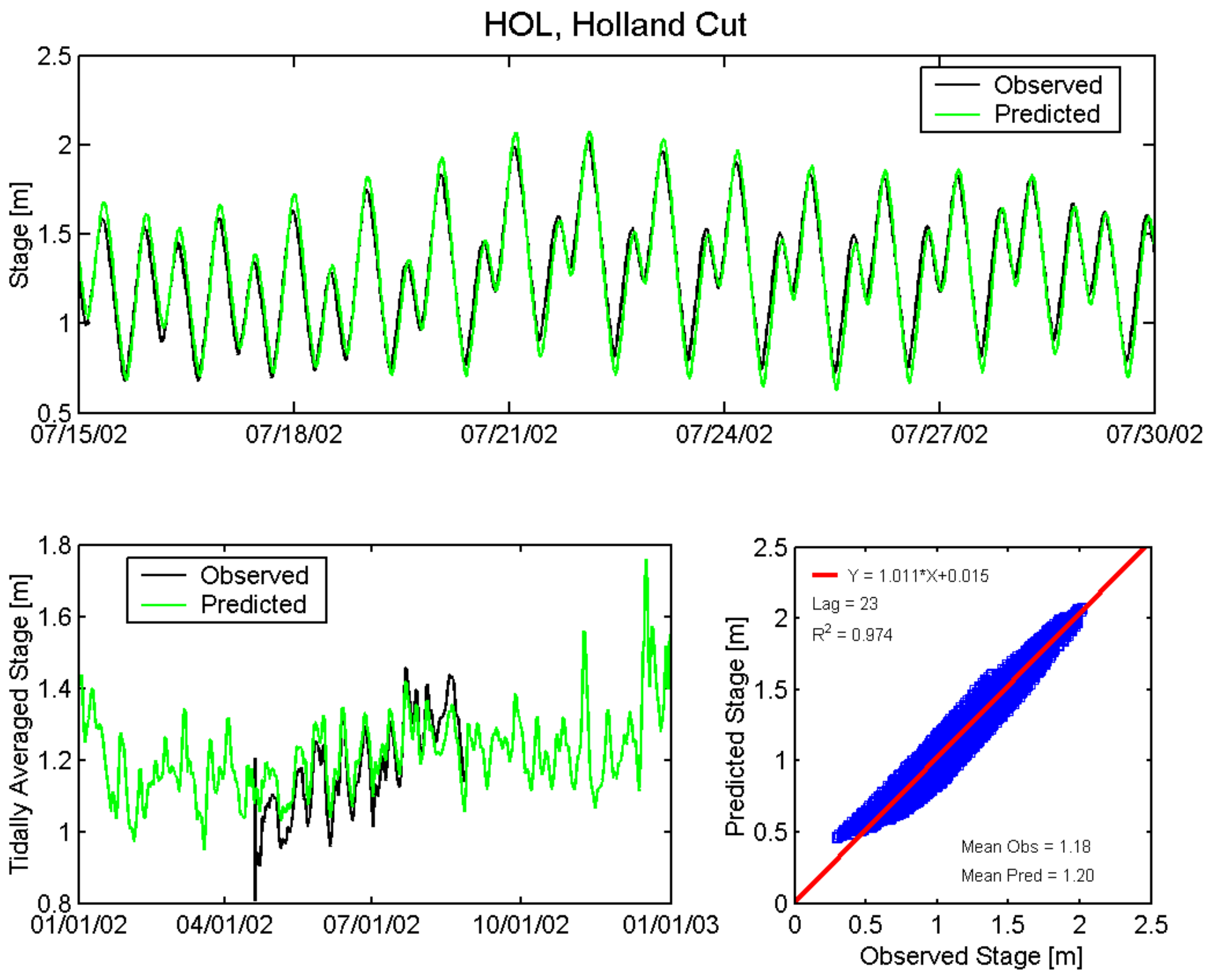


Figure A.3-37 Observed and predicted stage at Holland Cut USGS station (HOL) during the 2002 simulation period.

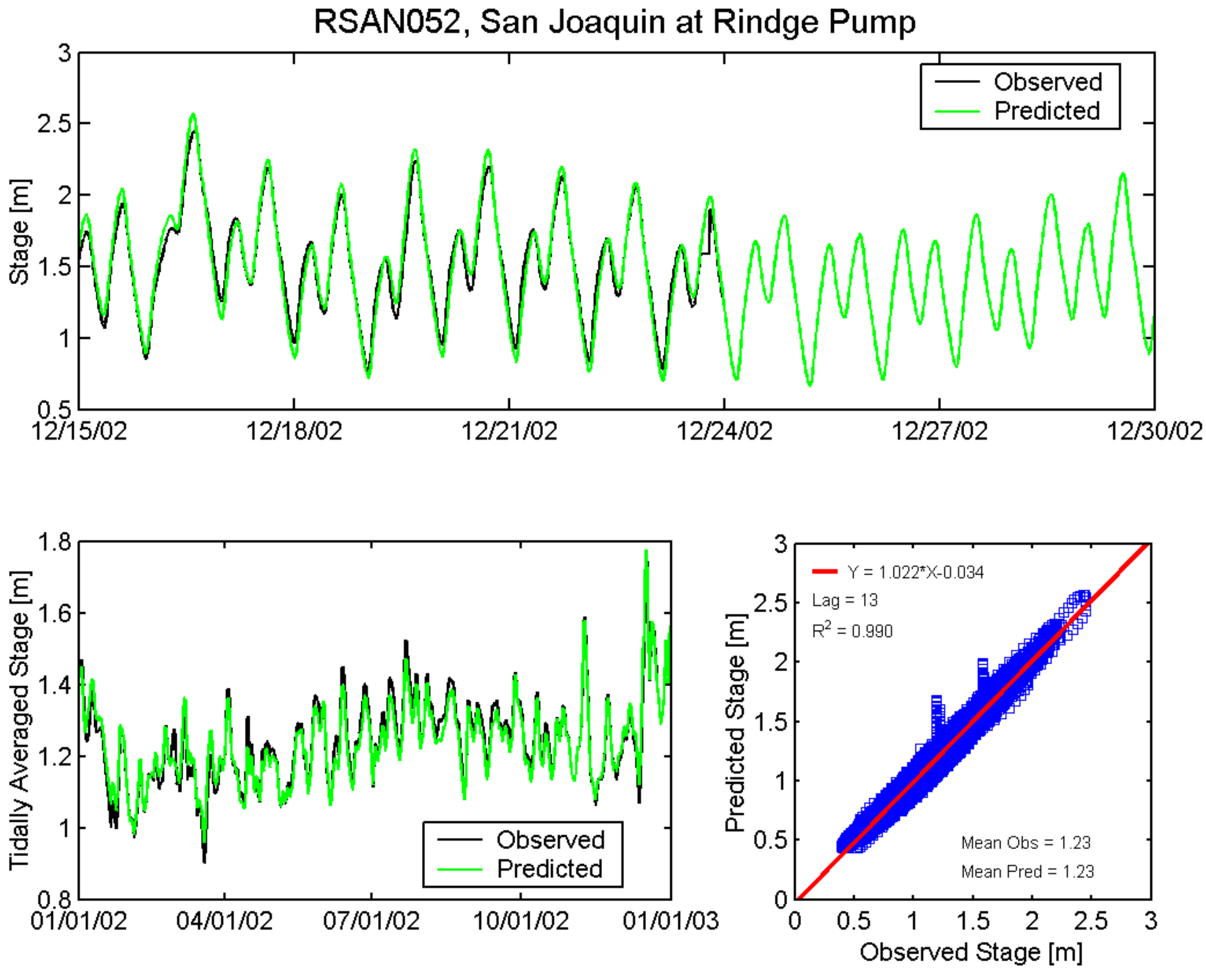


Figure A.3-38 Observed and predicted stage at San Joaquin River at Rindge Pump DWR station (RSAN052) during the 2002 simulation period.

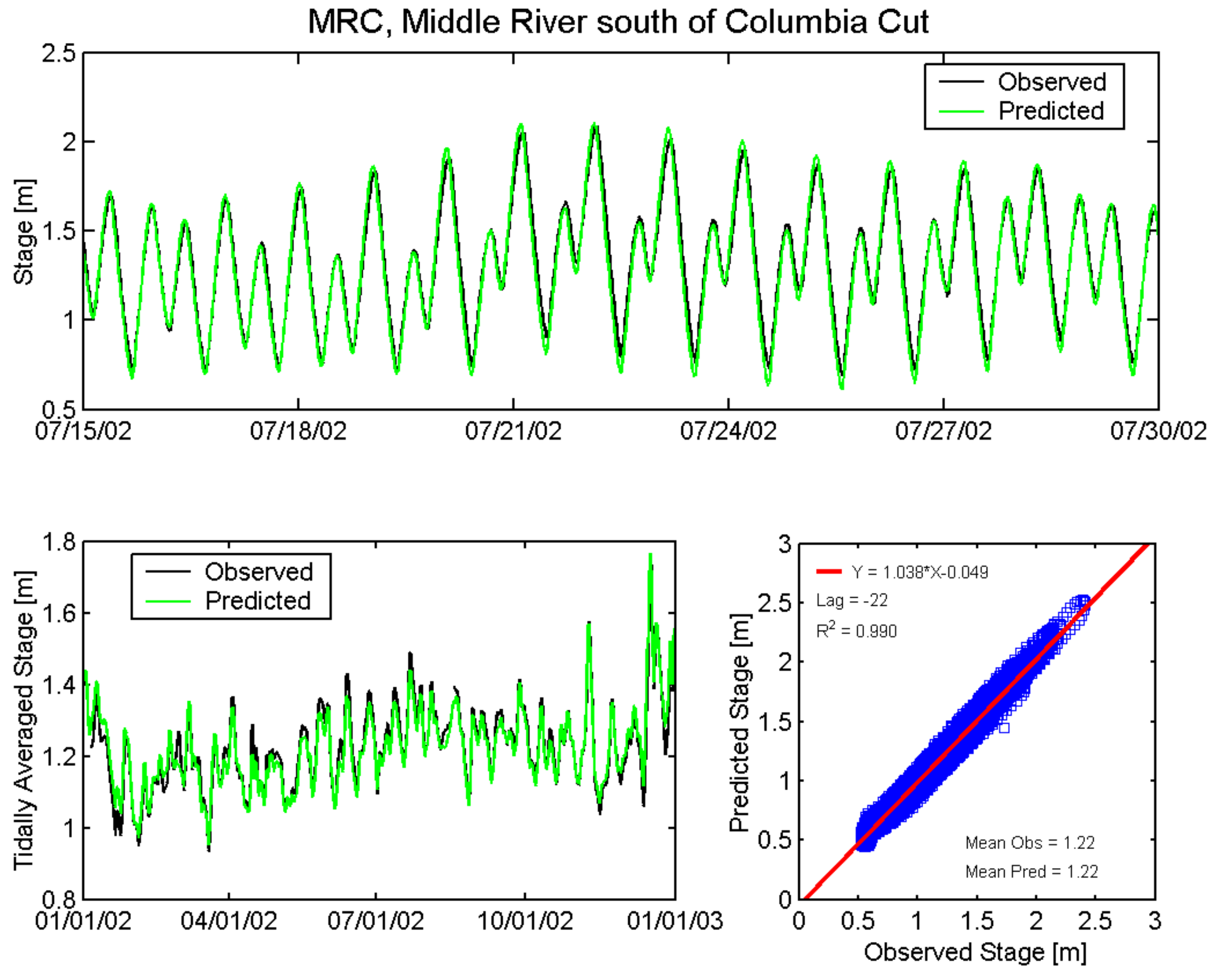


Figure A.3-39 Observed and predicted stage at Middle River south of Columbia Cut USGS station (MRC) during the 2002 simulation period.

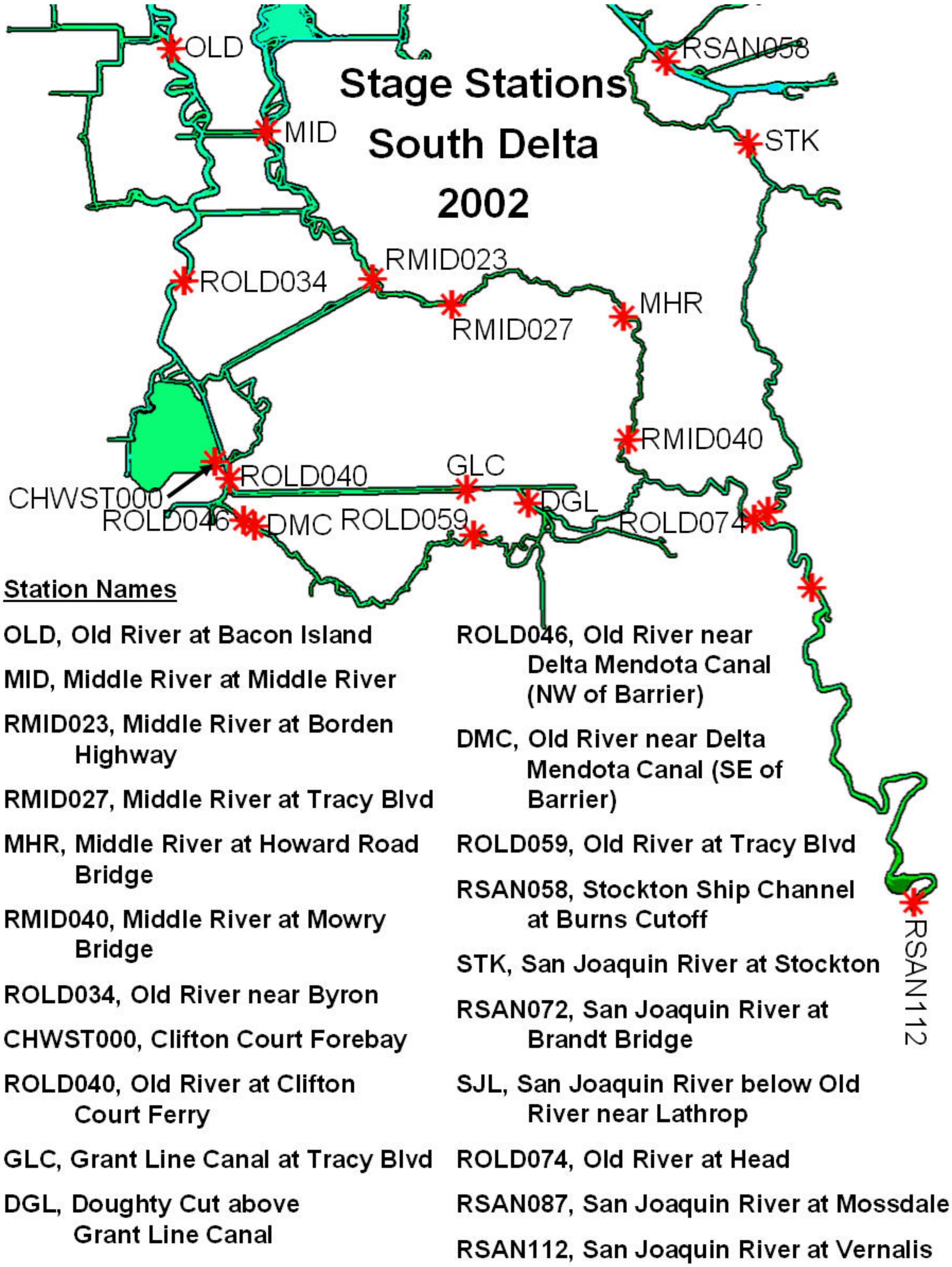


Figure A.3-40 Location of water level monitoring stations in the southern portion of the Sacramento-San Joaquin Delta used for 2002 water level comparisons.

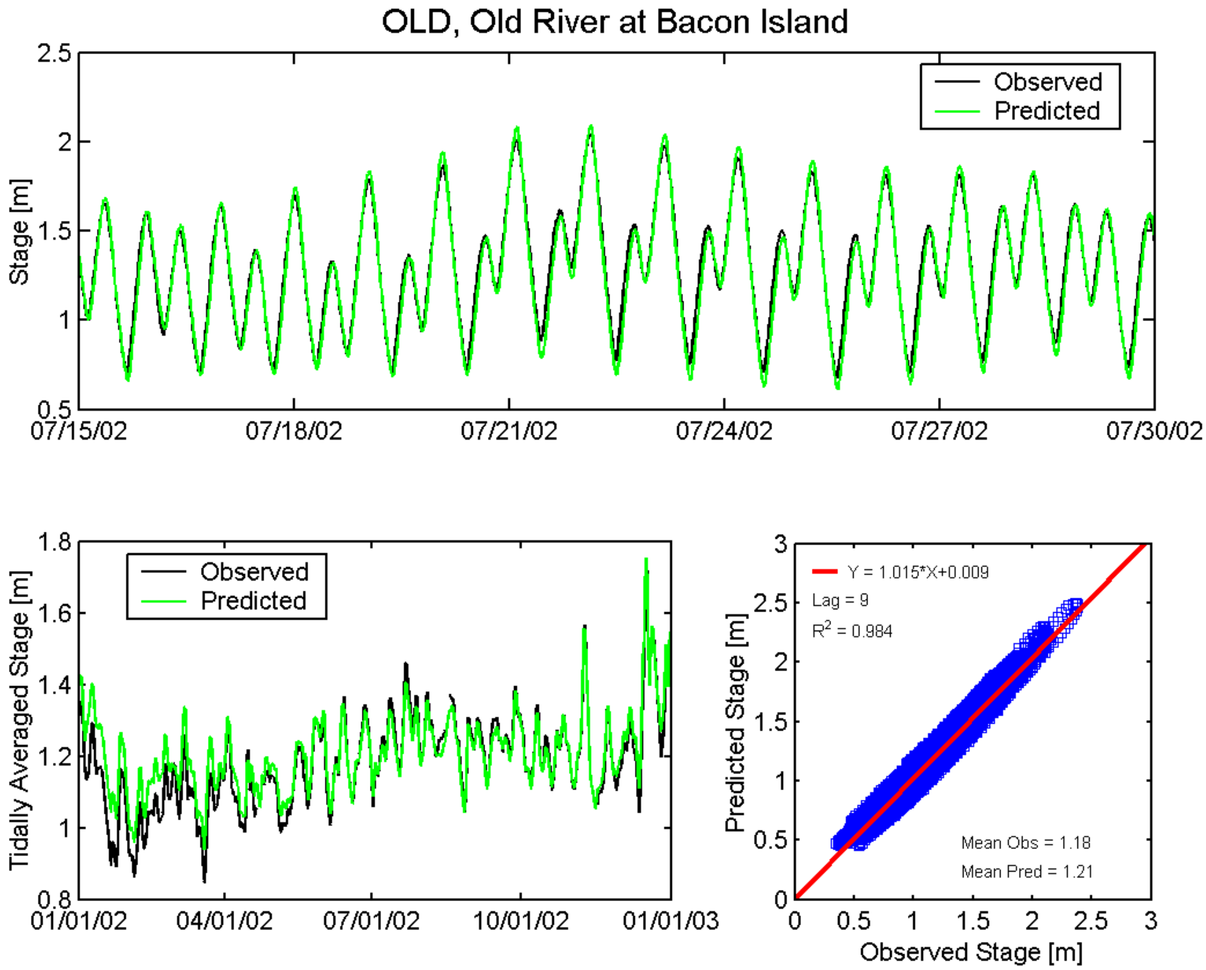


Figure A.3-41 Observed and predicted stage at Old River at Bacon Island USGS station (OLD) during the 2002 simulation period.

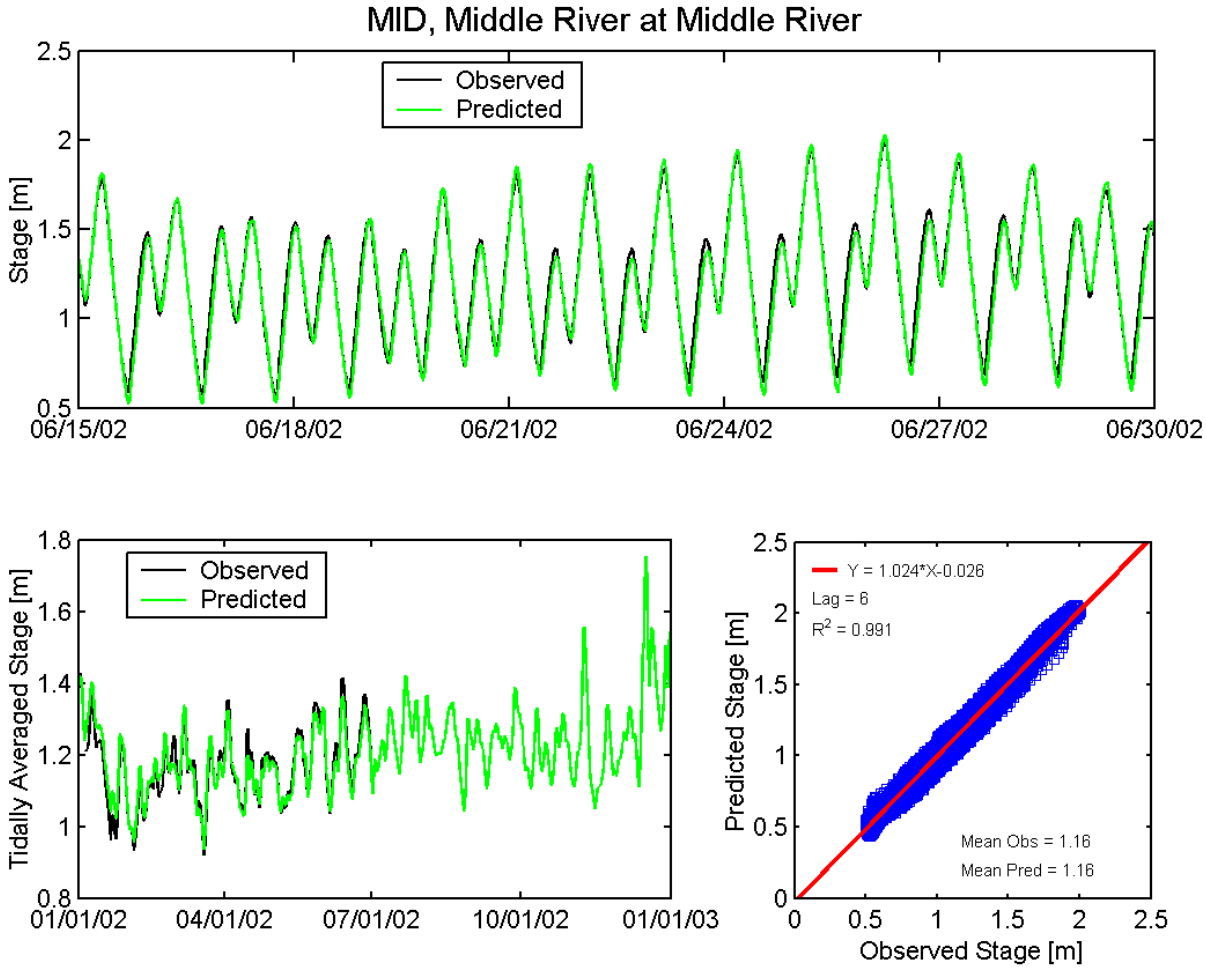


Figure A.3-42 Observed and predicted stage at Middle River at Middle River USGS station (MID) during the 2002 simulation period.

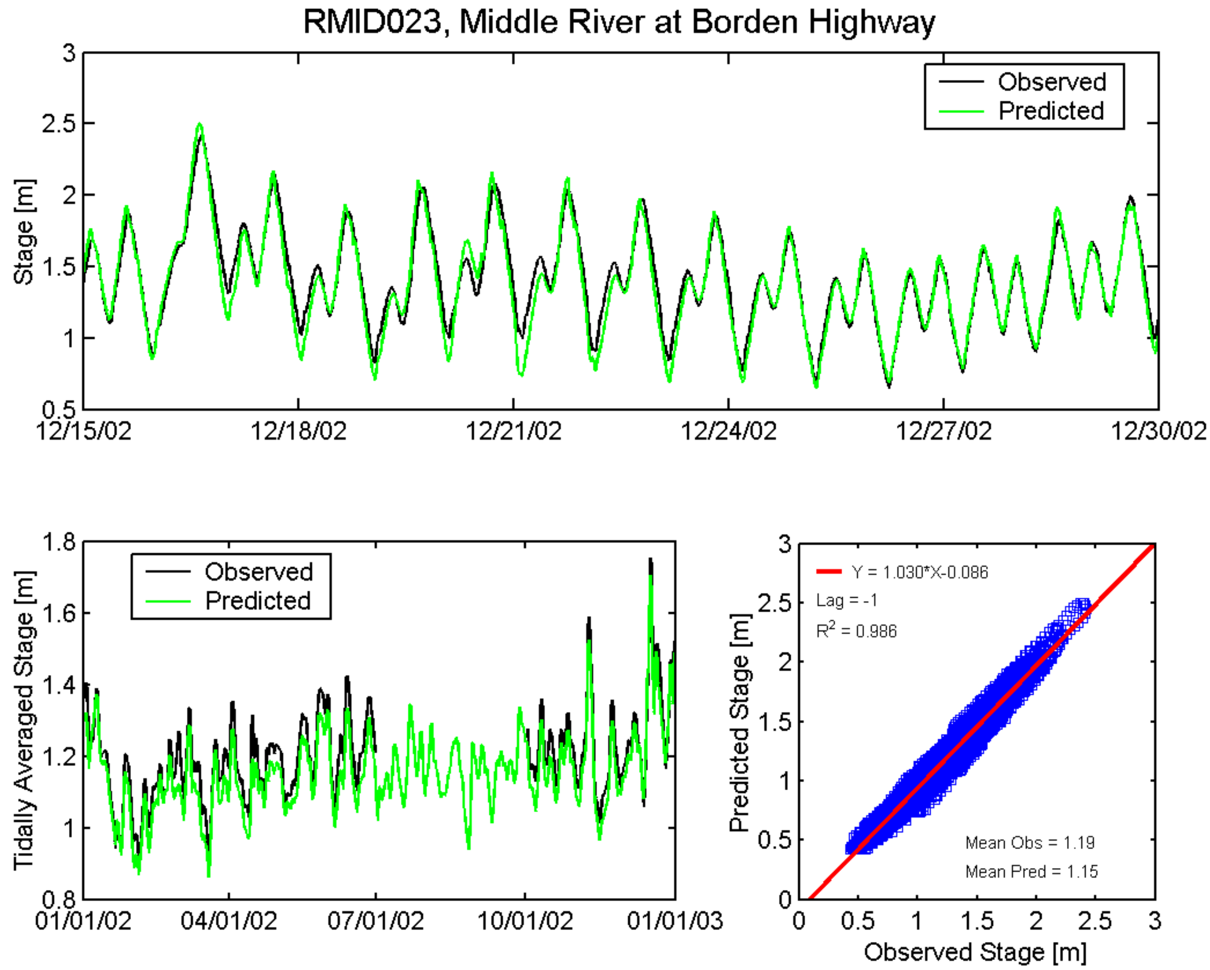


Figure A.3-43 Observed and predicted stage at Middle River at Borden Highway DWR station (RMID023) during the 2002 simulation period.

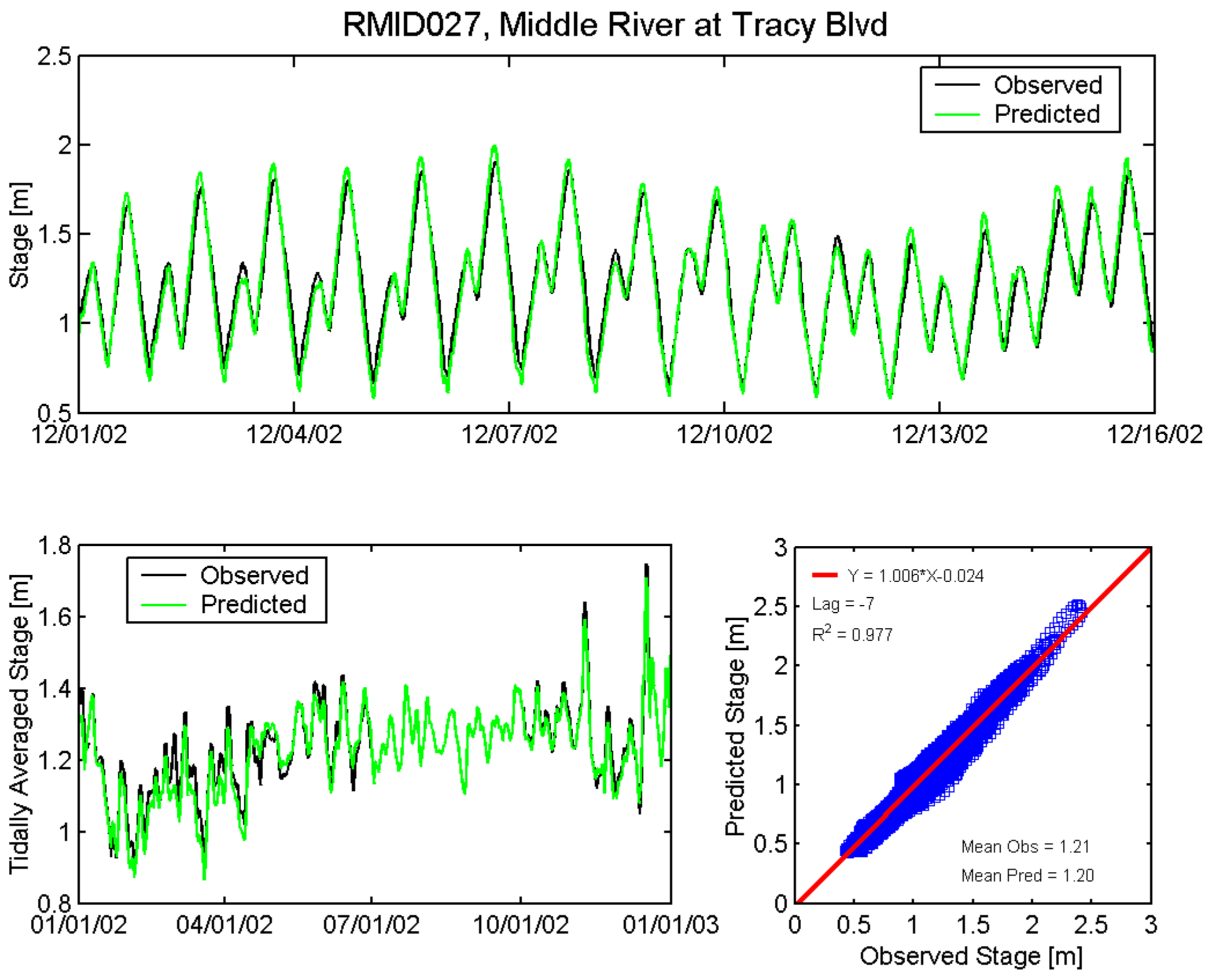


Figure A.3-44 Observed and predicted stage at Middle River at Tracy Boulevard DWR station (RMID027) during the 2002 simulation period.

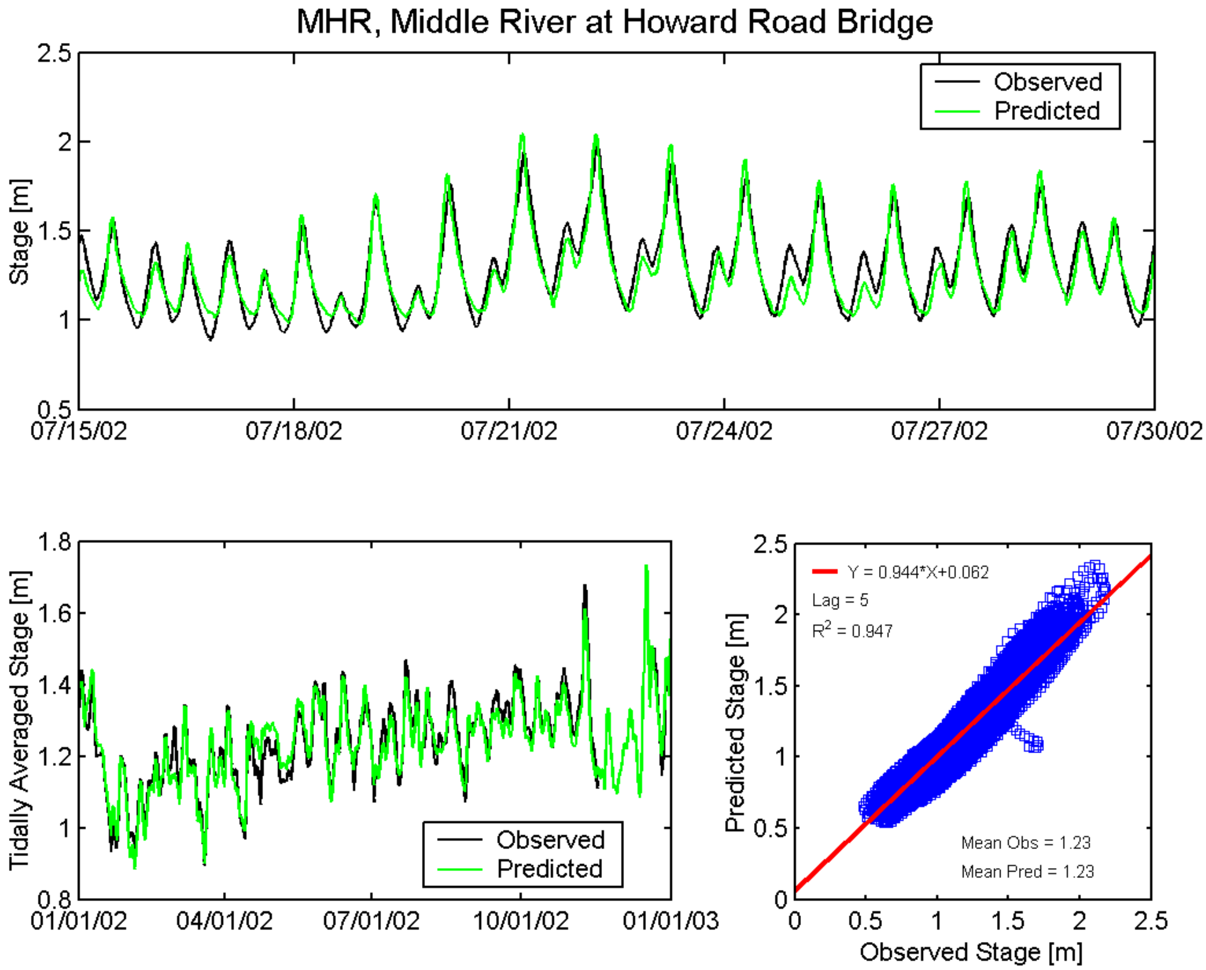


Figure A.3-45 Observed and predicted stage at Middle River at Howard Road Bridge DWR station (CDEC MHR) during the 2002 simulation period.

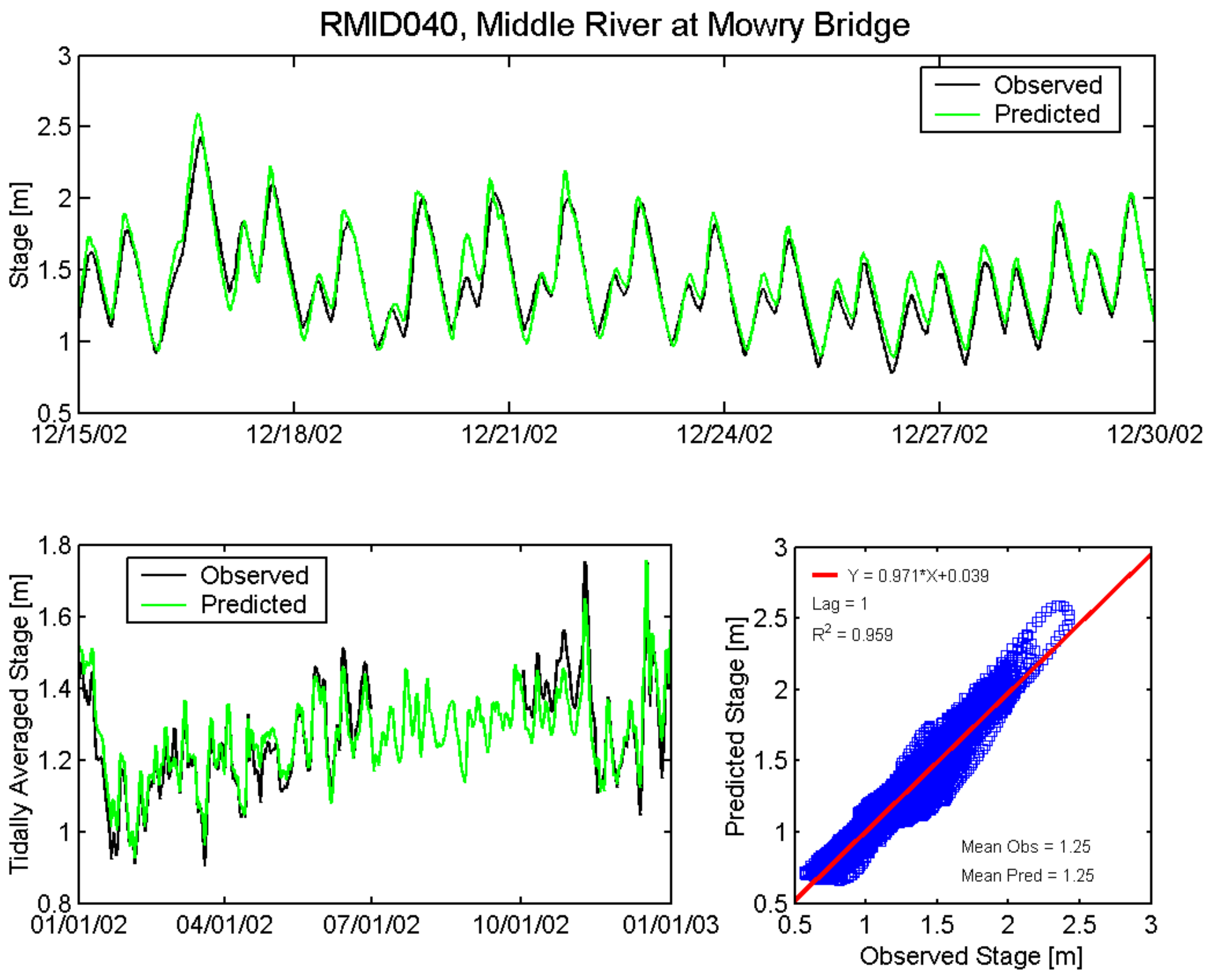


Figure A.3-46 Observed and predicted stage at Middle River at Mowry Bridge DWR station (RMID040) during the 2002 simulation period.

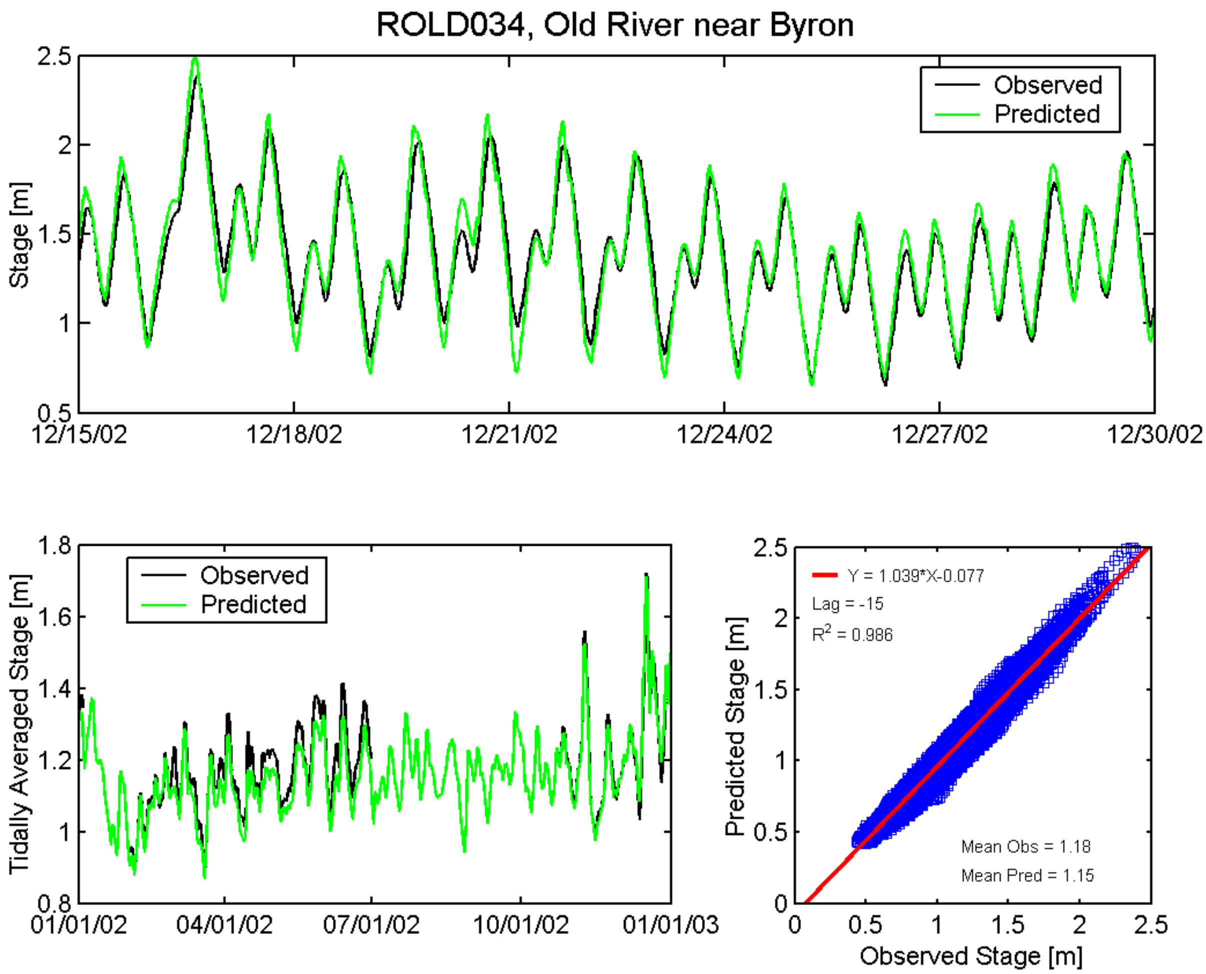


Figure A.3-47 Observed and predicted stage at Old River near Byron DWR station (ROLD034) during the 2002 simulation period.

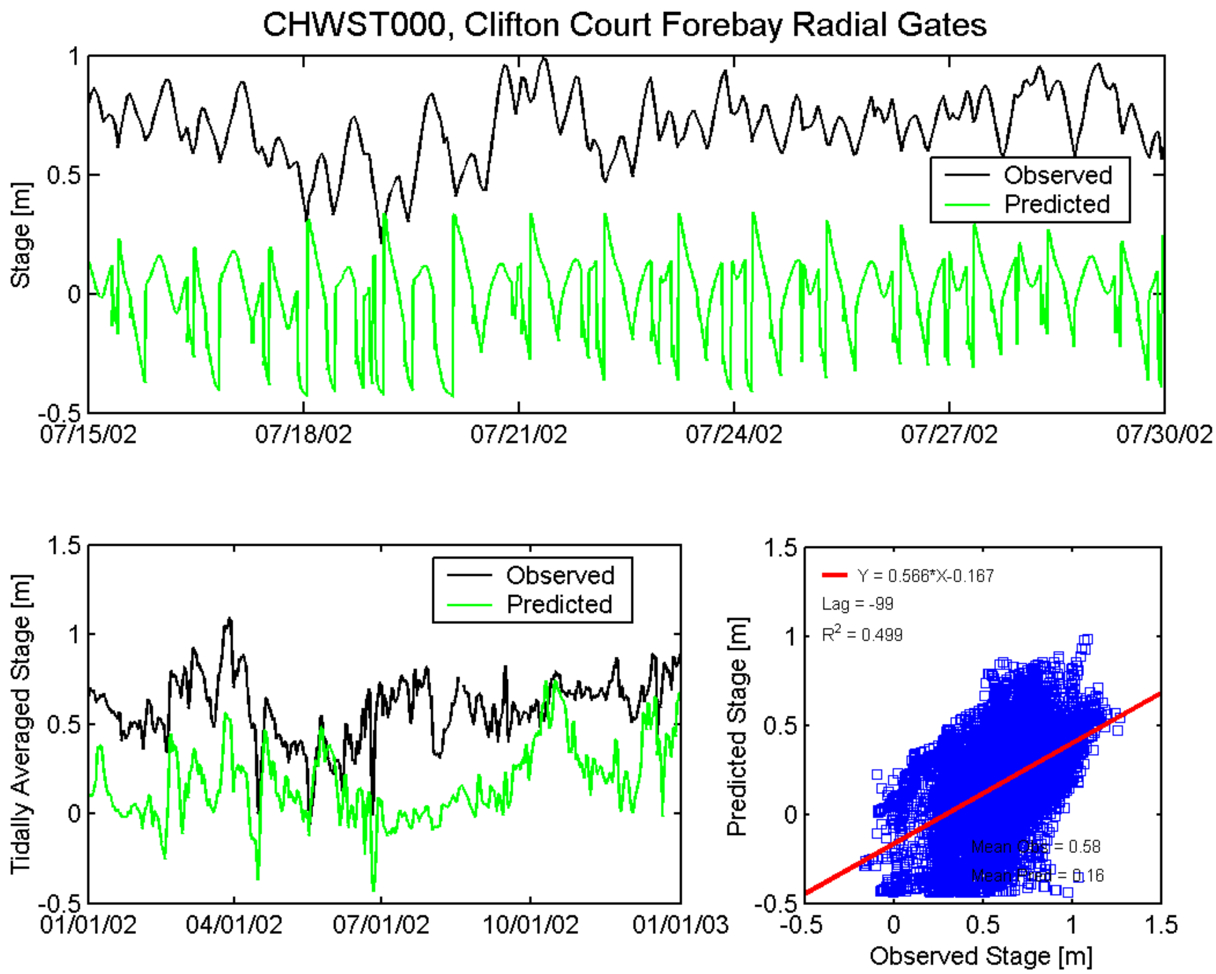


Figure A.3-48 Observed and predicted stage at Clifton Court Forebay Radial Gates DWR station (CHWST000) during the 2002 simulation period.

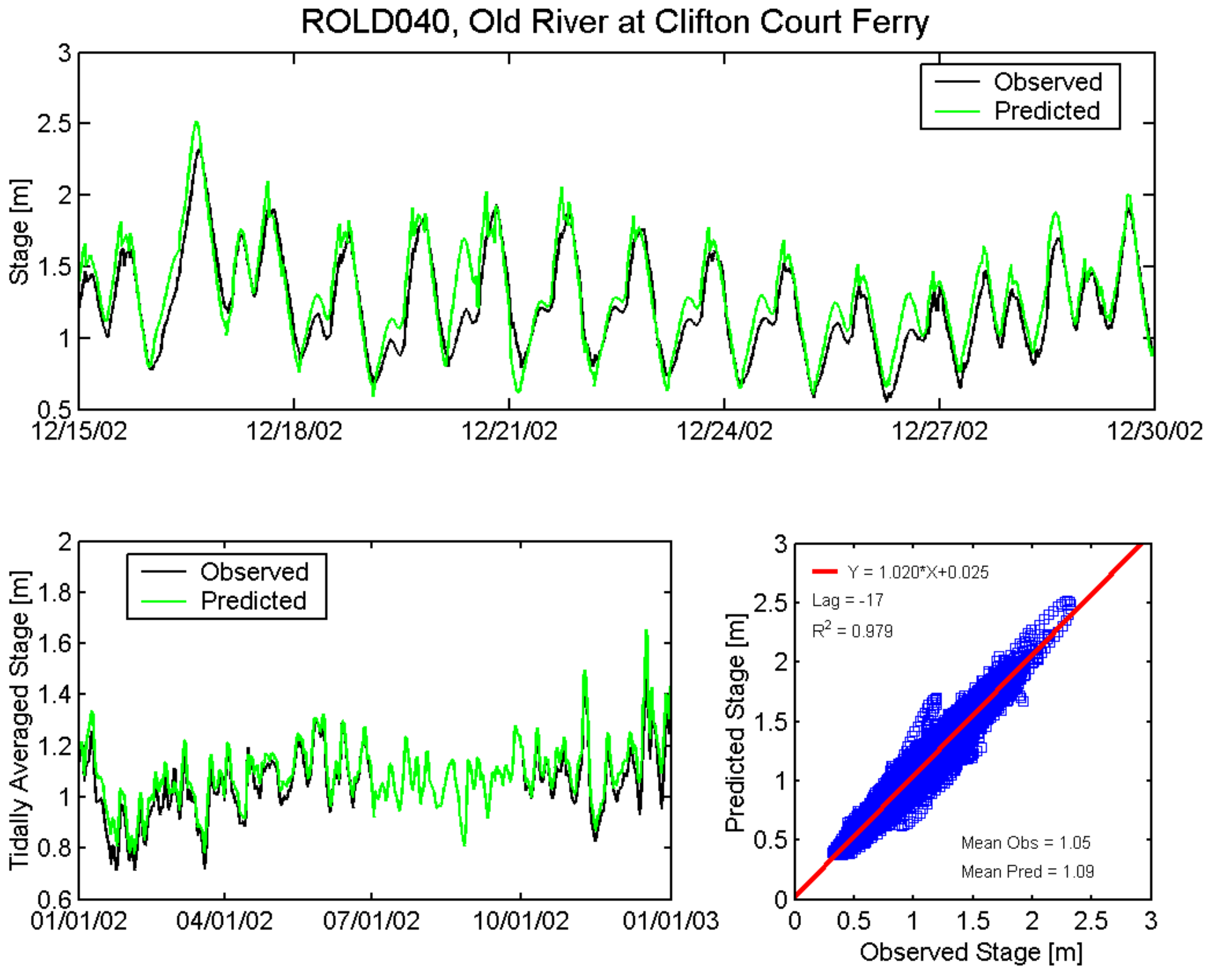


Figure A.3-49 Observed and predicted stage at Old River at Clifton Court Ferry DWR station (ROLD040) during the 2002 simulation period.

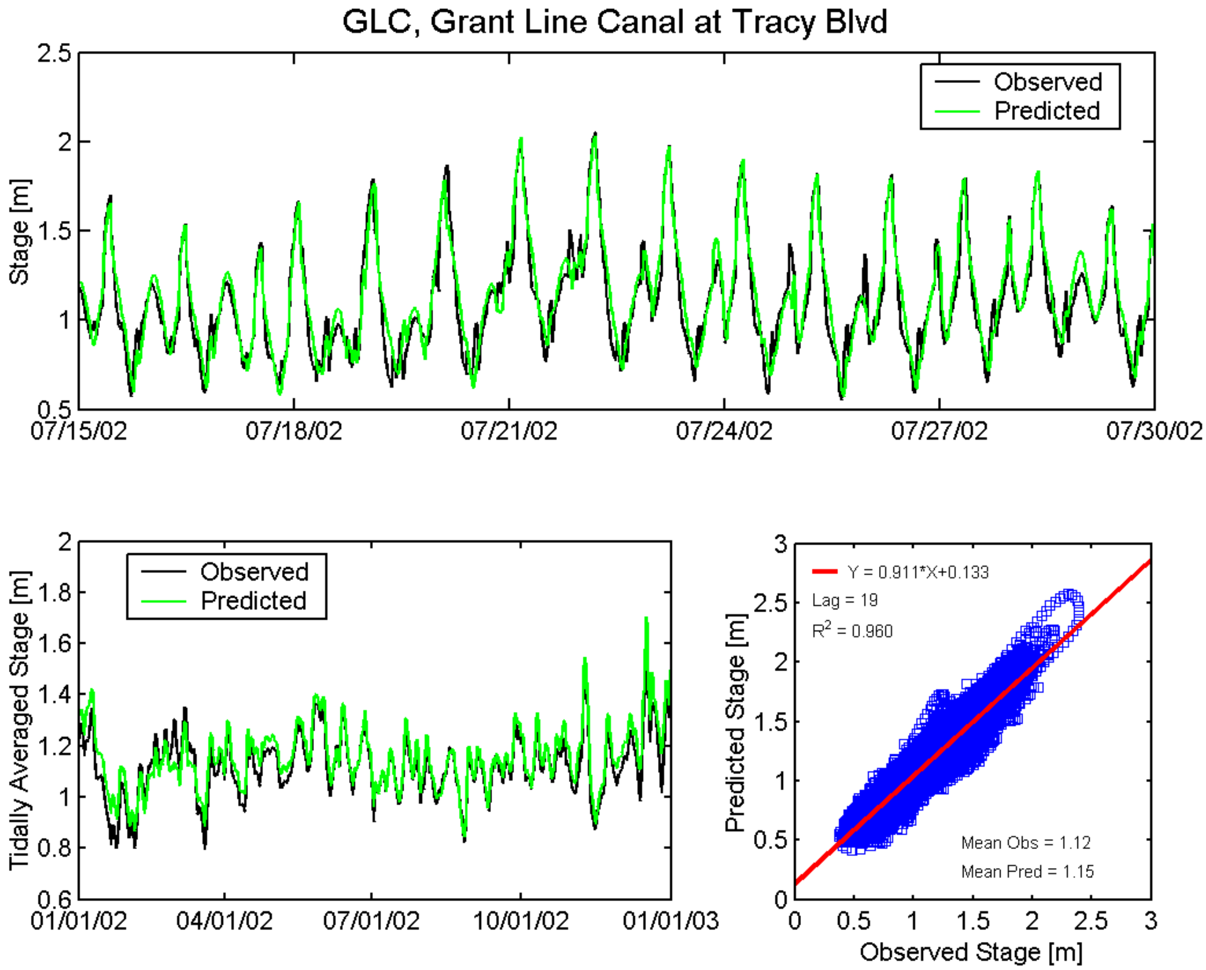


Figure A.3-50 Observed and predicted stage at Grant Line Canal at Tracy Boulevard USGS station (GLC) during the 2002 simulation period.

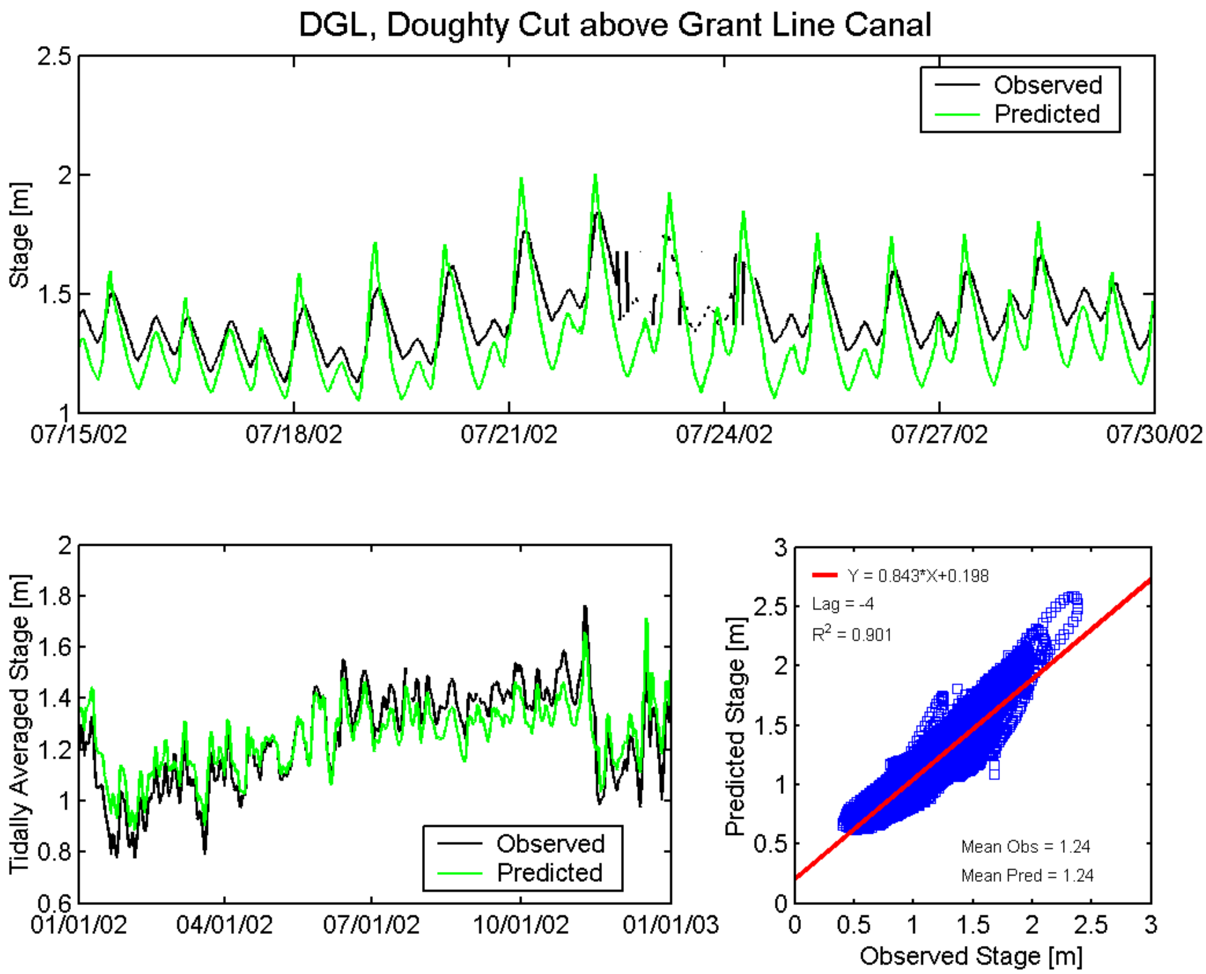


Figure A.3-51 Observed and predicted stage at Doughty Cut above Grant Line Canal DWR station (CDEC DGL) during the 2002 simulation period.

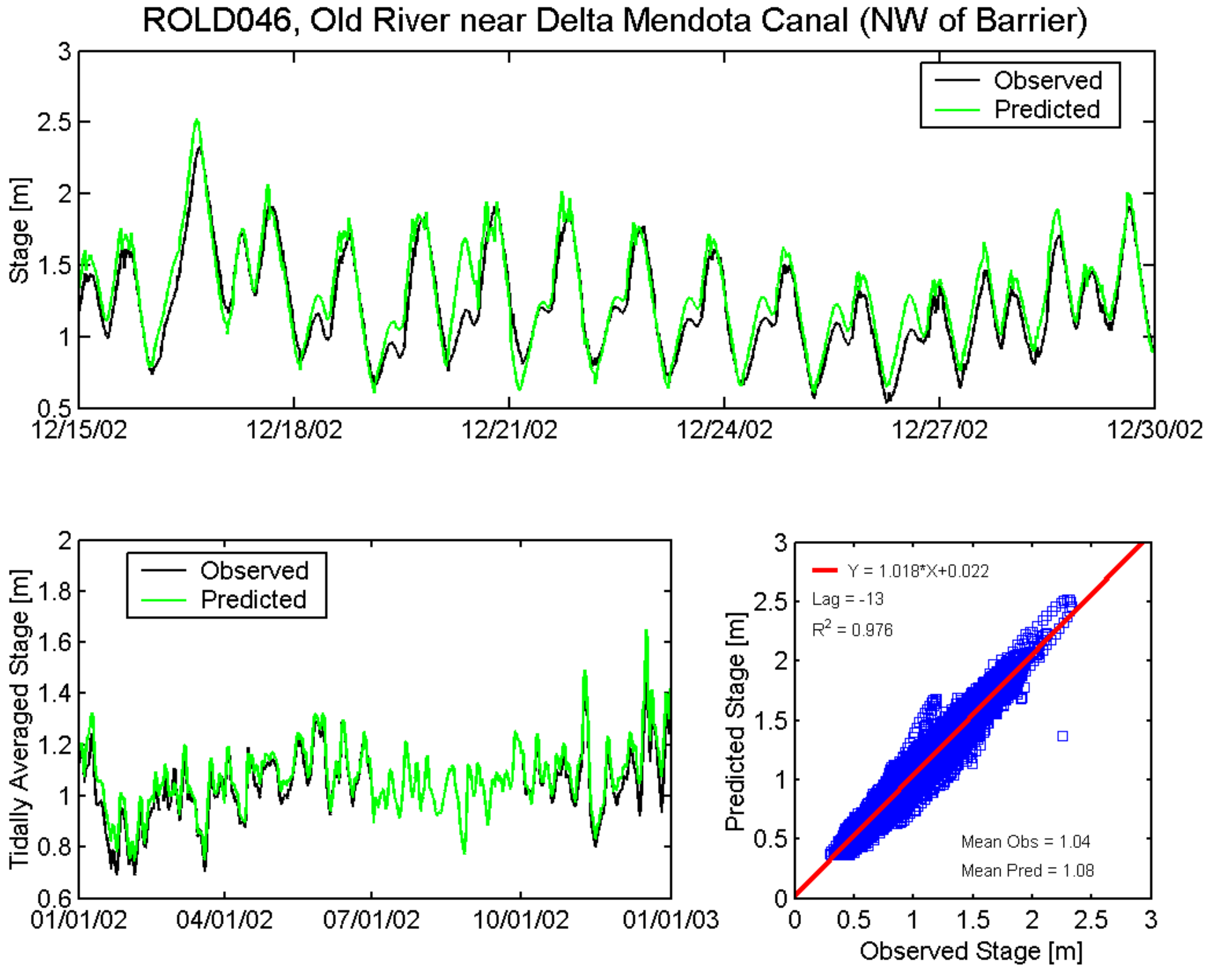


Figure A.3-52 Observed and predicted stage at Old River near Delta Mendota Canal NW of Barrier DWR station (ROLD046) during the 2002 simulation period.

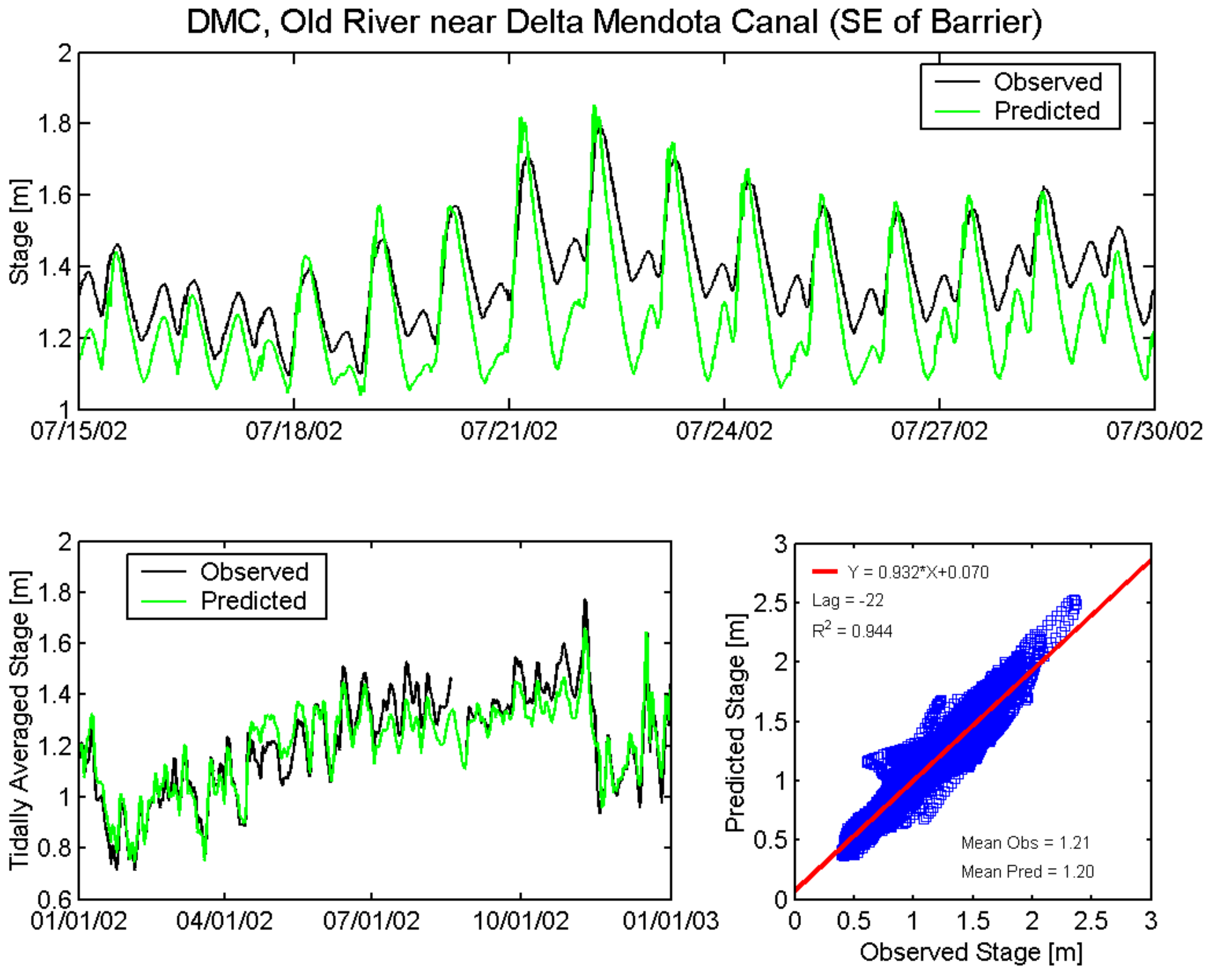


Figure A.3-53 Observed and predicted stage at Old River near Delta Mendota Canal SE of Barrier USGS station (DMC) during the 2002 simulation period.

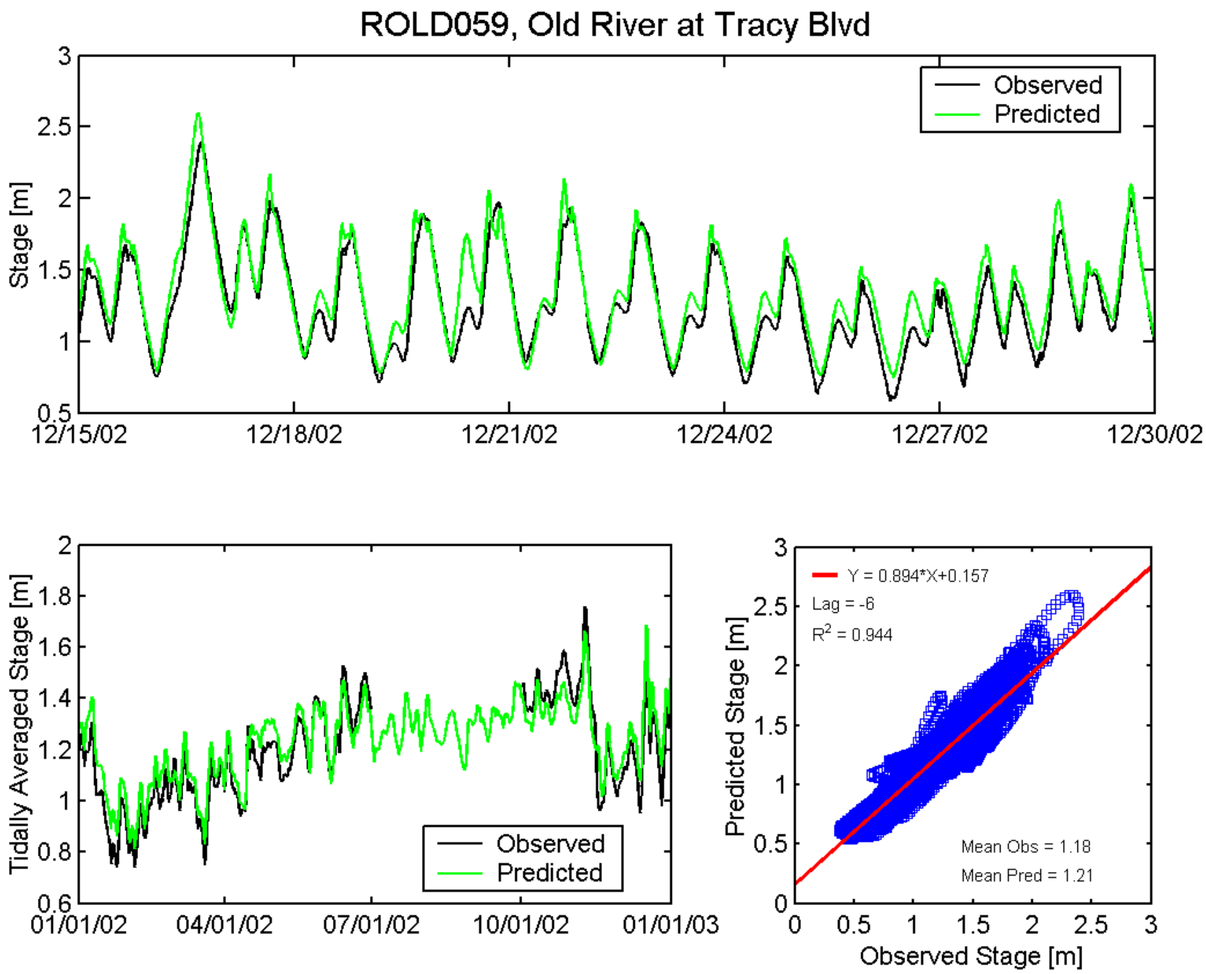


Figure A.3-54 Observed and predicted stage at Old River at Tracy Boulevard DWR station (ROLD059) during the 2002 simulation period.

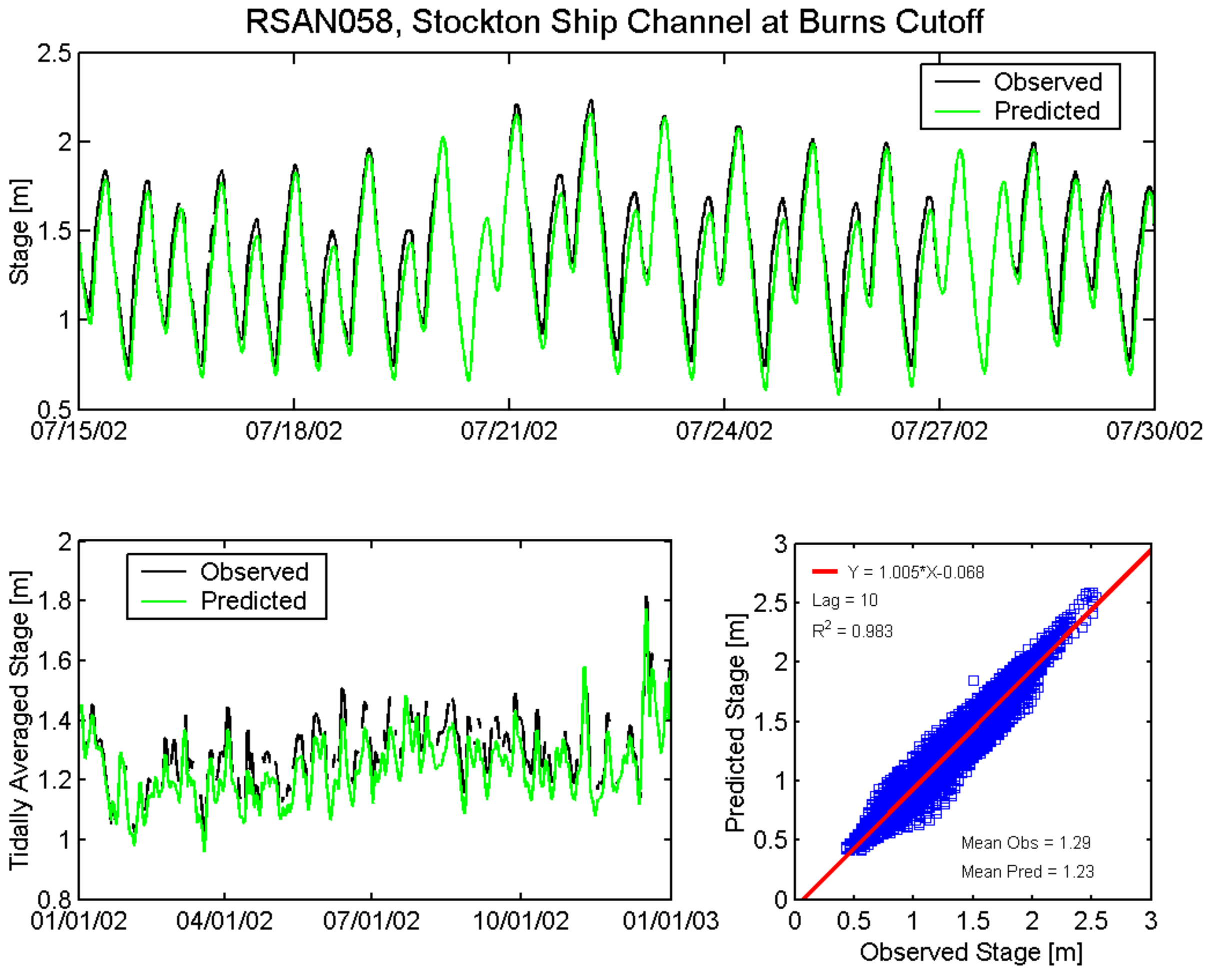


Figure A.3-55 Observed and predicted stage at Stockton Ship Channel at Burns Cutoff DWR station (RSAN058) during the 2002 simulation period.

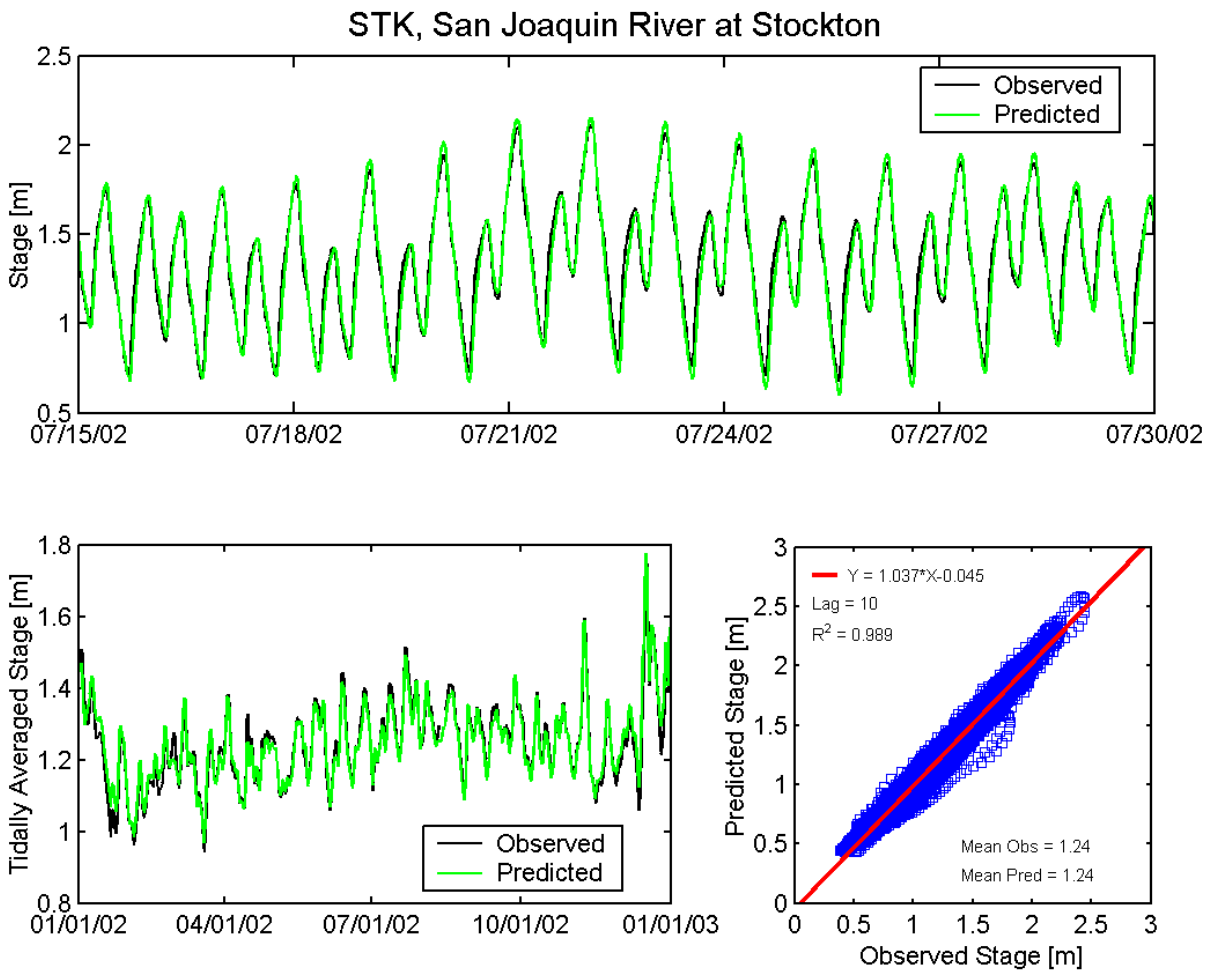


Figure A.3-56 Observed and predicted stage at San Joaquin River at Stockton USGS station (STK) during the 2002 simulation period.

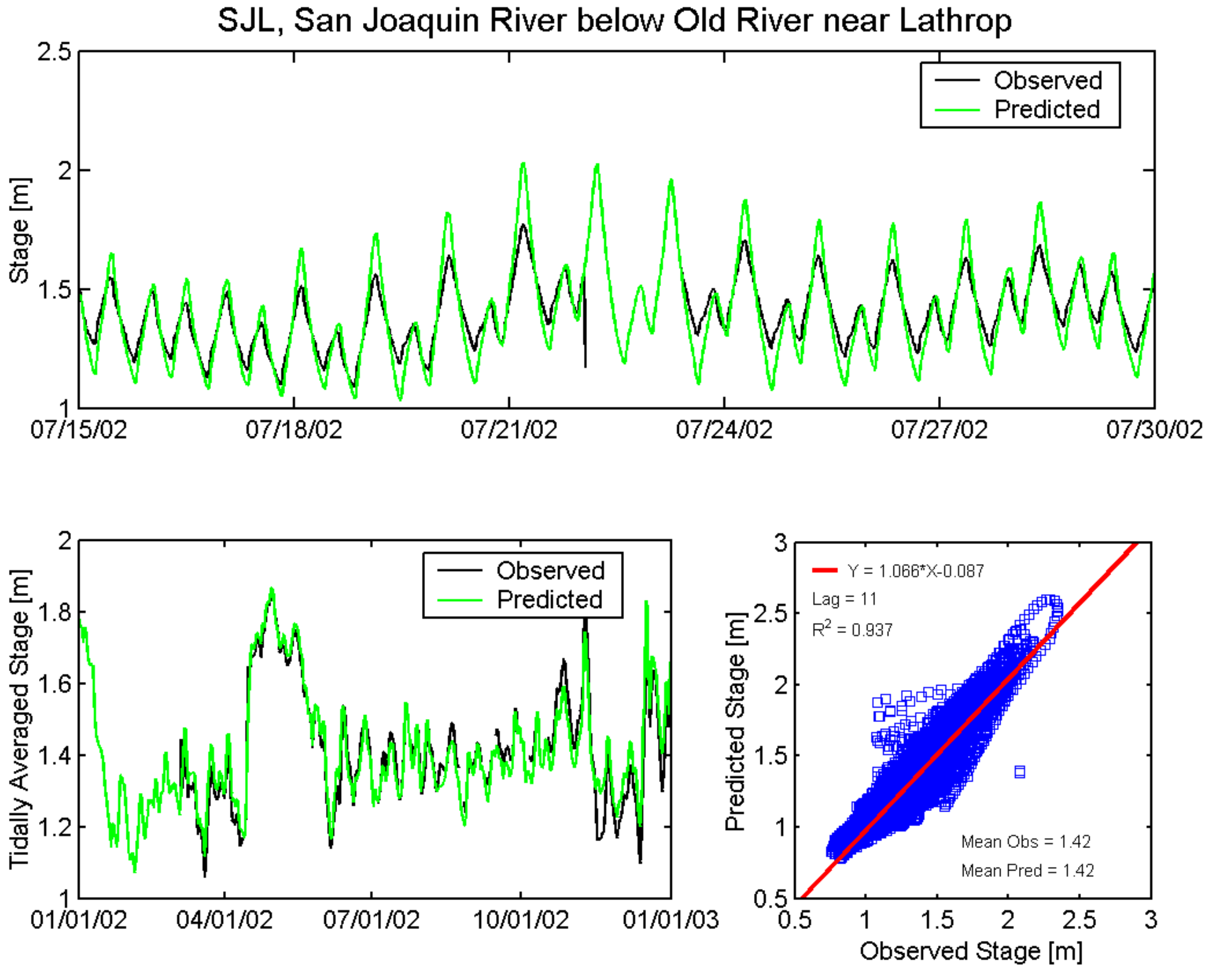


Figure A.3-57 Observed and predicted stage at San Joaquin River below Old River near Lathrop DWR station (CDEC SJL) during the 2002 simulation period.

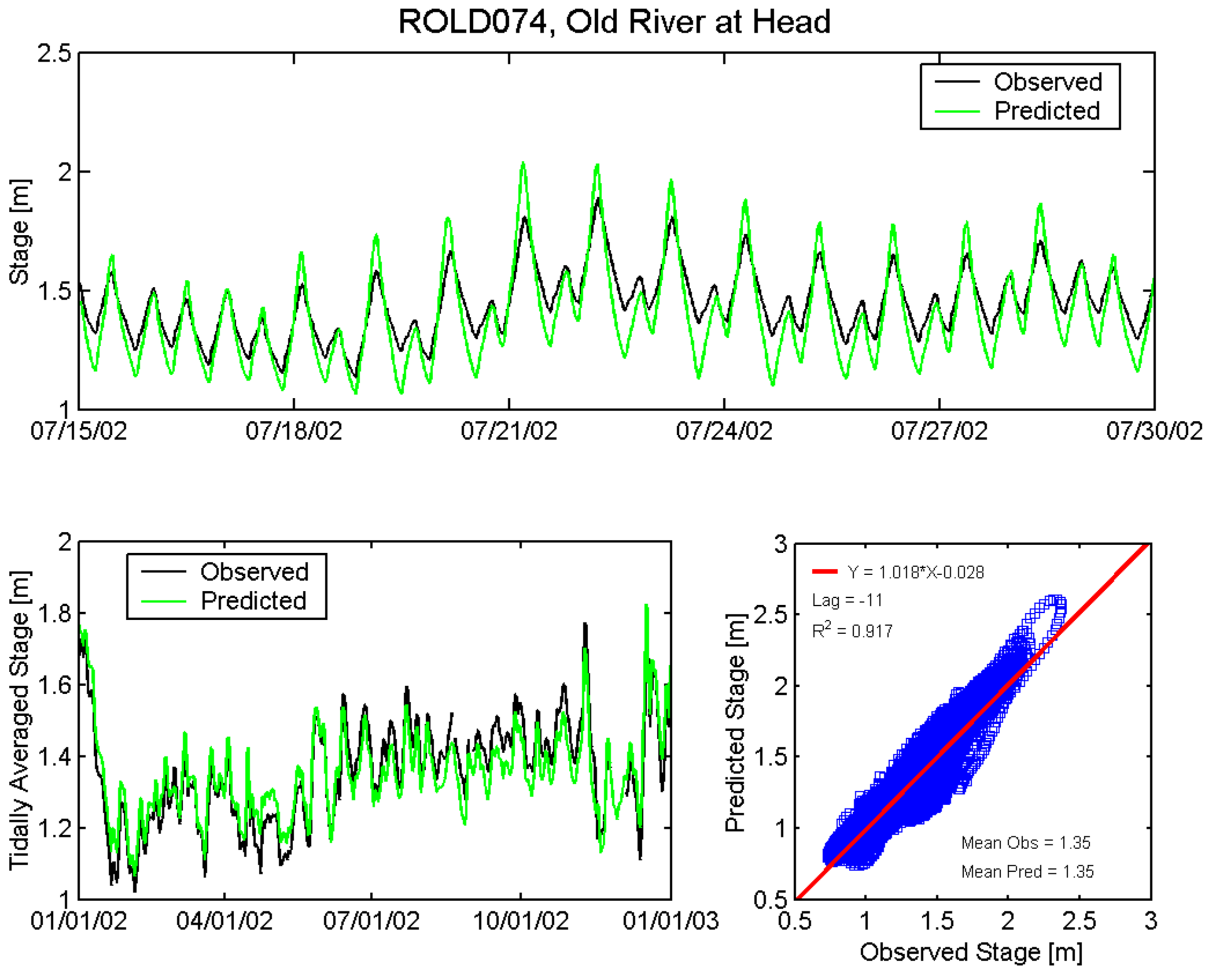


Figure A.3-58 Observed and predicted stage at Old River at Head DWR station (ROLD074) during the 2002 simulation period.

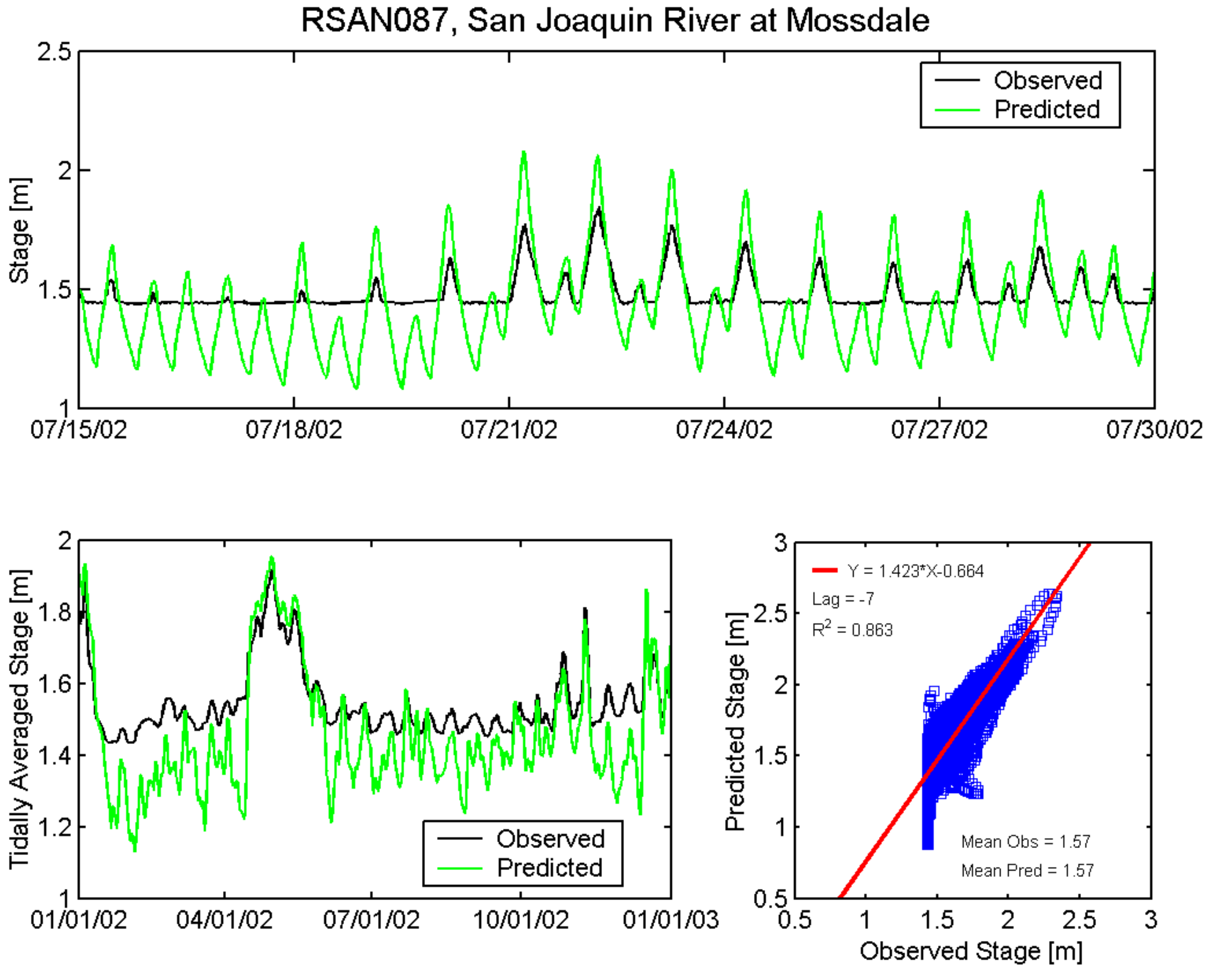


Figure A.3-59 Observed and predicted stage at San Joaquin River at Mossdale DWR station (RSAN087) during the 2002 simulation period.

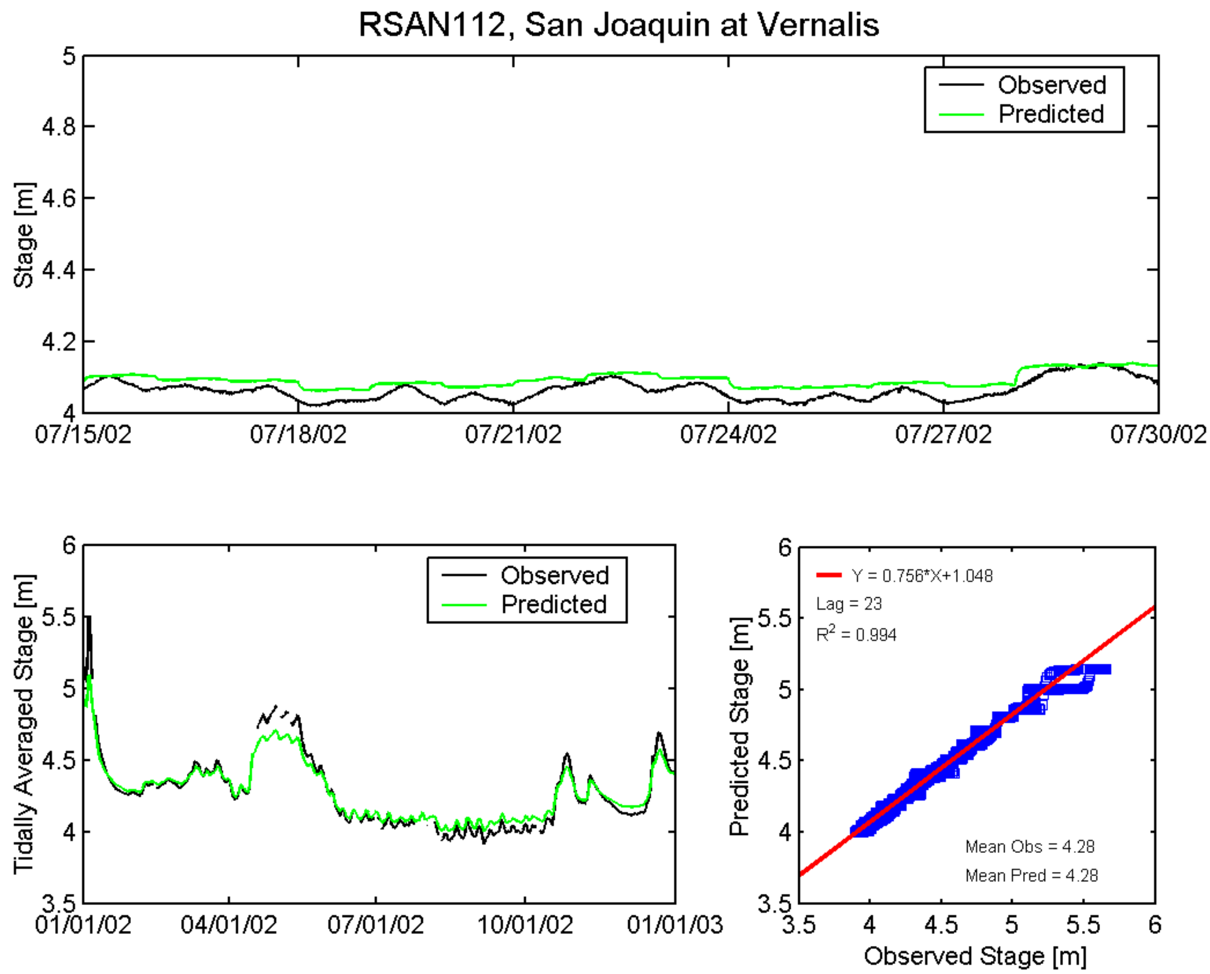


Figure A.3-60 Observed and predicted stage at San Joaquin River at Vernalis DWR station (RSAN112) during the 2002 simulation period.

A.4 Delta Flow Comparison Figures

During the 2002 simulation period, flow measurements are available at a total of twenty-five flow monitoring stations in the Sacramento-San Joaquin Delta. For each station, the mean observed and predicted net flow was calculated over the full simulation period, and the same cross-correlation procedure used in the water level analysis was applied to flow. Table A-2 gives the predicted and observed mean flow at each station as well as the corresponding amplitude ratio, phase lag, and R^2 for each station.

A.4.1 Northern Sacramento-San Joaquin Delta

Flow comparisons were made at six continuous flow monitoring stations in the northern portion of the Sacramento-San Joaquin Delta, at the locations shown in Figure A.4-1. Flow comparisons at these stations are shown in Figures A.4-2 through A.4-7.

A.4.2 Central Sacramento-San Joaquin Delta

Flow comparisons were made at twelve continuous flow monitoring stations in the central portion of the Sacramento-San Joaquin Delta, at the locations shown in Figure A.4-8. Flow comparisons at these stations are shown in Figures A.4-9 through A.4-20.

A.4.3 Southern Sacramento-San Joaquin Delta

Flow comparisons were made at seven continuous flow monitoring stations in the southern portion of the Sacramento-San Joaquin Delta, at the locations shown in Figure A.4-21. Flow comparisons at these stations are shown in Figures A.4-22 through A.4-28.

Table A-2 Predicted and observed stage and cross-correlation statistics for flow monitoring stations in the Sacramento-San Joaquin Delta during the 2002 simulation period.

Location	Data Source	Figure Number	Mean Flow		Cross Correlation		R^2
			Observed (m^3/s)	Predicted (m^3/s)	Amp Ratio	Lag (min)	
2002 North Delta Flow Stations (Figure A.4-1)							
Sacramento River South of Georgiana Slough	USGS	A.4-2	168	157	1.033	-11	0.992
Georgiana Slough near Sacramento River	USGS	A.4-3	98.3	102	0.974	33	0.989
Delta Cross Channel	USGS	A.4-4	87.9	84.1	0.936	-8	0.962
Sacramento River North of Delta Cross Channel	USGS	A.4-5	319	316	1.018	0	0.992
Sacramento River at Freeport	USGS	A.4-6	518	517	1.017	-15	0.992
Steamboat Slough between	USGS	A.4-7	61.2	61.9	1.290	2	0.983

Sacramento River and Sutter Sl.							
2002 Central Delta Flow Stations (Figure A.4-8)							
Sacramento River at Rio Vista	USGS	A.4-9	414	372	1.019	-2	0.995
Threemile Slough at San Joaquin River	USGS	A.4-10	-21.6	-76.0	1.031	7	0.994
San Joaquin River at Jersey Point	USGS	A.4-11	67.7	76.9	0.945	1	0.994
Dutch Slough at Jersey Island	USGS	A.4-12	0.26	-11.6	0.849	-1	0.993
False River	USGS	A.4-13	-4.64	-36.6	0.925	-37	0.982
Taylor Slough	USGS	A.4-14	-0.28	-7.21	0.672	-34	0.739
Fisherman's Cut	USGS	A.4-15	-21.2	-18.4	0.842	n/a*	0.439
Old River at San Joaquin River	USGS	A.4-16	-33.2	-2.96	0.965	-68	0.966
Mokelumne River near San Joaquin River	USGS	A.4-17	82.9	108	1.021	-35	0.973
Old River at Mandeville Island	USGS	A.4-18	-46.9	-34.6	0.820	-43	0.980
Holland Cut	USGS	A.4-19	-40.7	-40.9	0.901	-35	0.975
Middle River south of Columbia Cut	USGS	A.4-20	-117	-70.5	1.138	-58	0.978
2002 South Delta Flow Stations (Figure A.4-21)							
Middle River at Middle River	USGS	A.4-22	-93.8	-88.3	0.728	-2	0.974
Old River at Bacon Island	USGS	A.4-23	-81.5	-67.0	0.734	-1	0.984
Old River near Byron	USGS	A.4-24	-114	-122	0.960	-4	0.963
Old River near Delta Mendota Canal (SE of Barrier)	USGS	A.4-25	12.9	6.13	0.832	-14	0.938
Grant Line Canal at Tracy Blvd	USGS	A.4-26	39.6	41.6	0.801	-20	0.933
San Joaquin River at Stockton	USGS	A.4-27	21.5	14.8	1.089	-2	0.974
Old River at Head	DWR	A.4-28	15.6	33.1	1.119	-4	0.842

* n/a indicates that the cross-correlation procedure did not identify a local maximum correlation coefficient within the four hour analysis window. This can be indicative of the data not having a strong tidal time-scale signal.

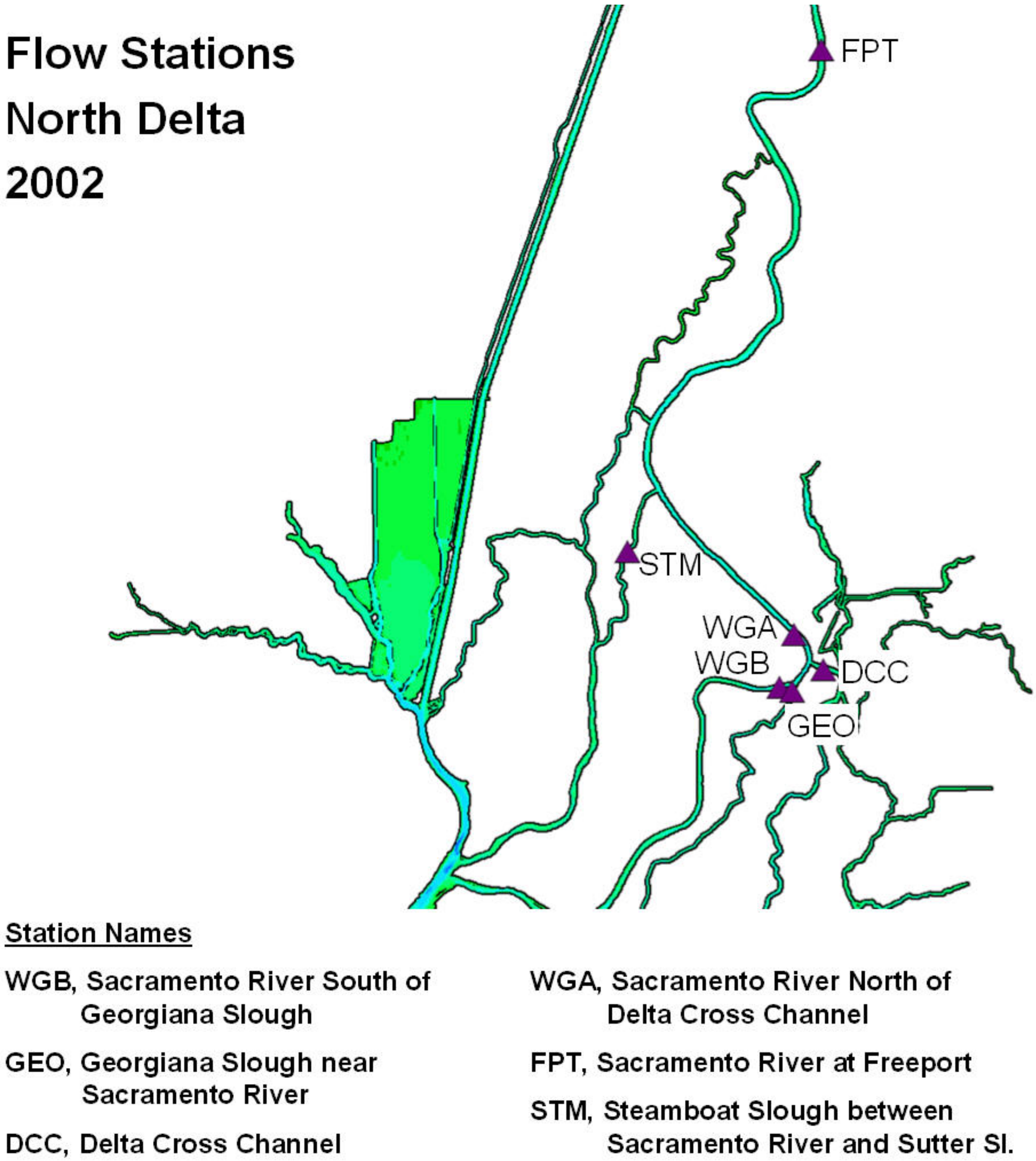


Figure A.4-1 Location of flow monitoring stations in the northern portion of the Sacramento-San Joaquin Delta used for 2002 flow comparisons.

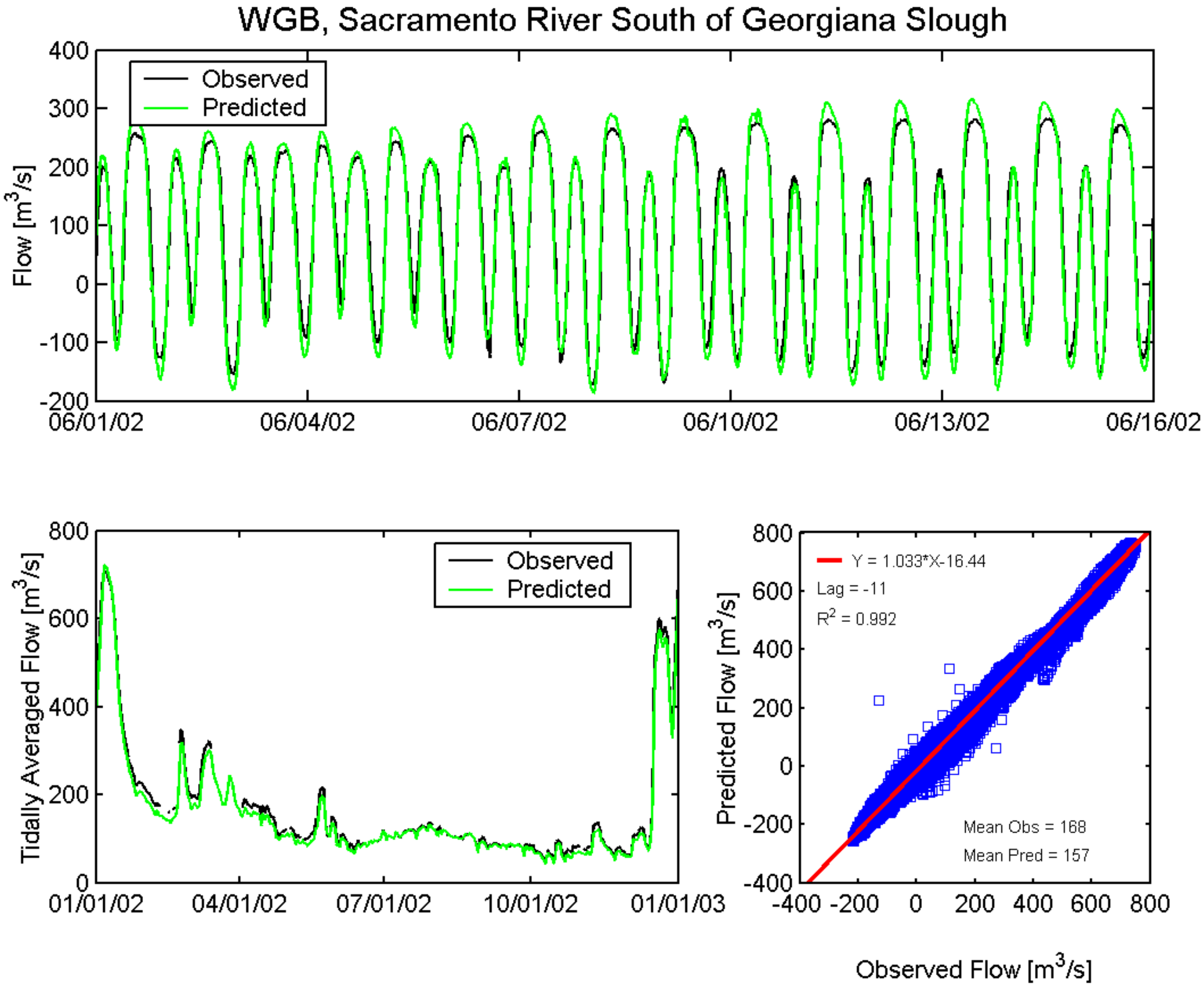


Figure A.4-2 Observed and predicted flow at Sacramento River South of Georgiana Slough USGS station (WGB) during the 2002 simulation period.

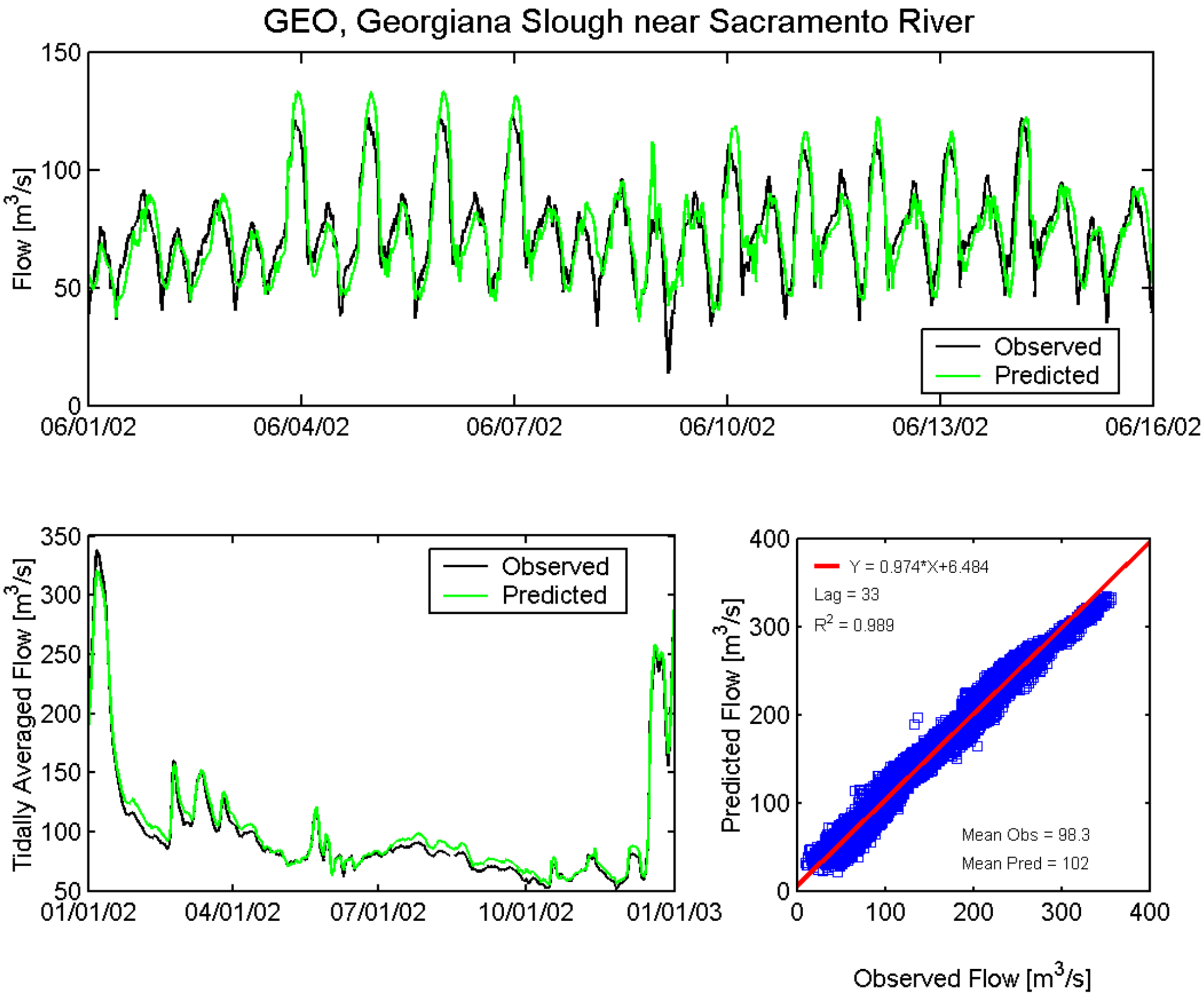


Figure A.4-3 Observed and predicted flow at Georgiana Slough near Sacramento River USGS station (GEO) during the 2002 simulation period.

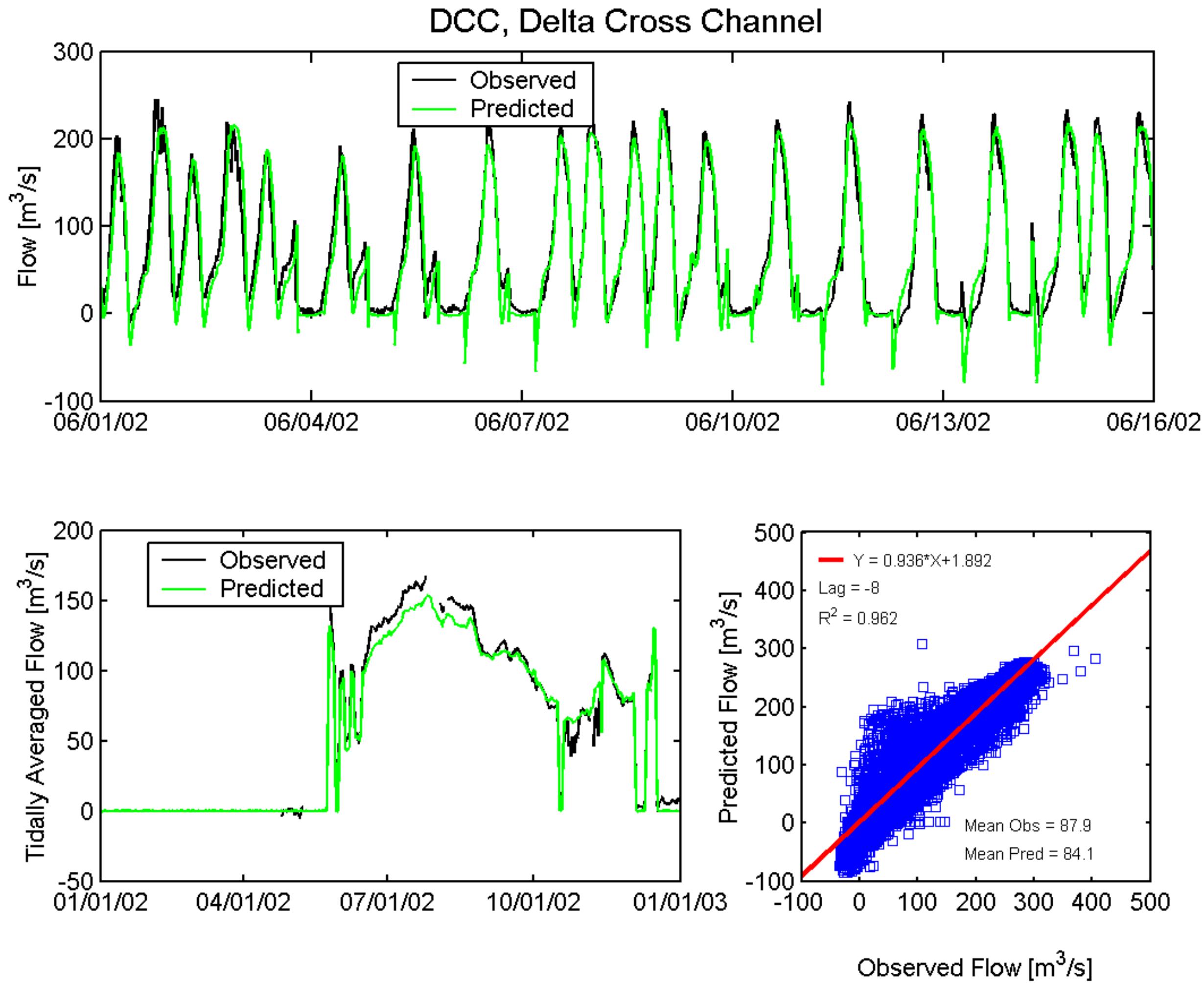


Figure A.4-4 Observed and predicted flow at Delta Cross Channel USGS station (DCC) during the 2002 simulation period.

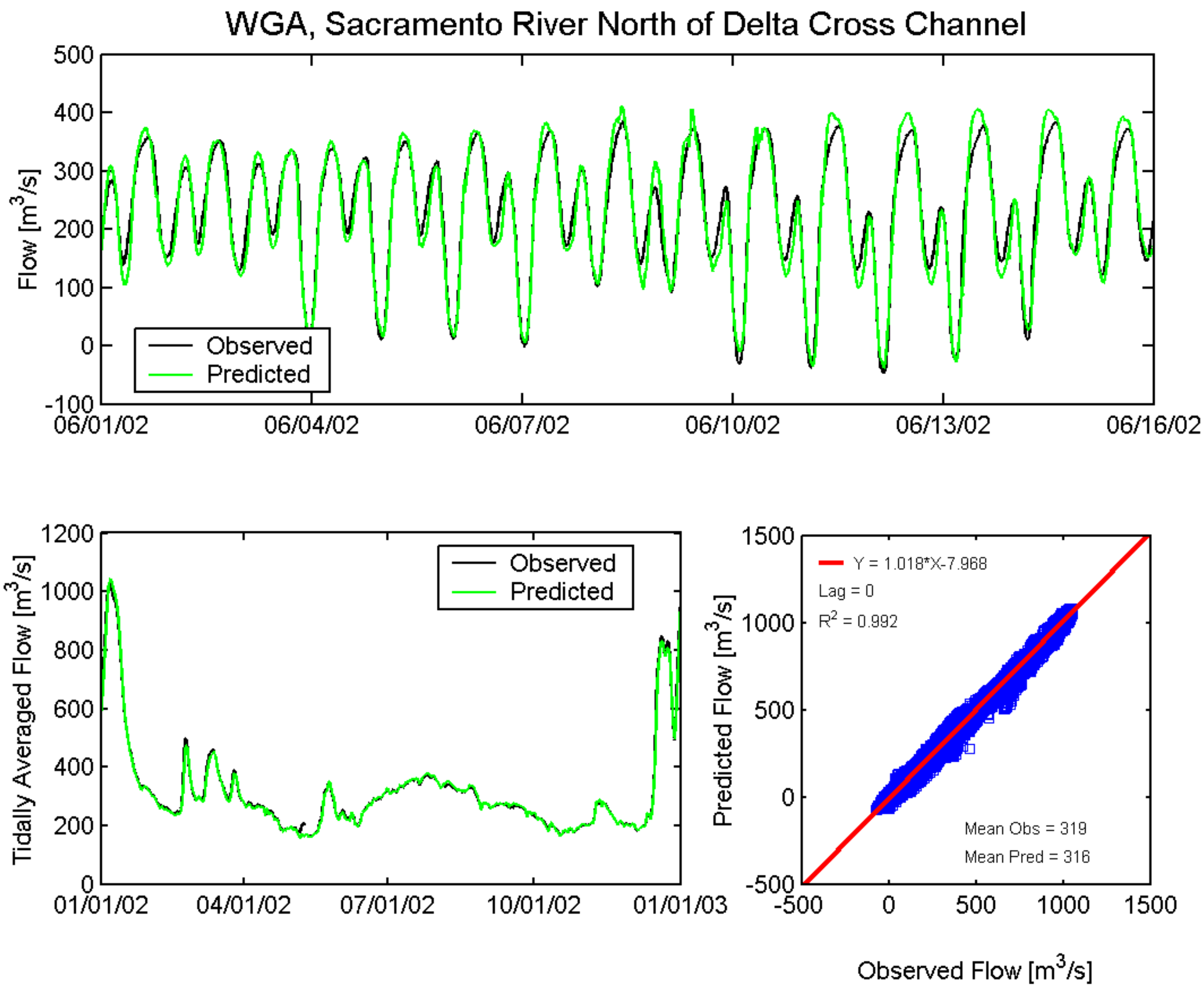


Figure A.4-5 Observed and predicted flow at Sacramento River North of Delta Cross Channel USGS station (WGA) during the 2002 simulation period.

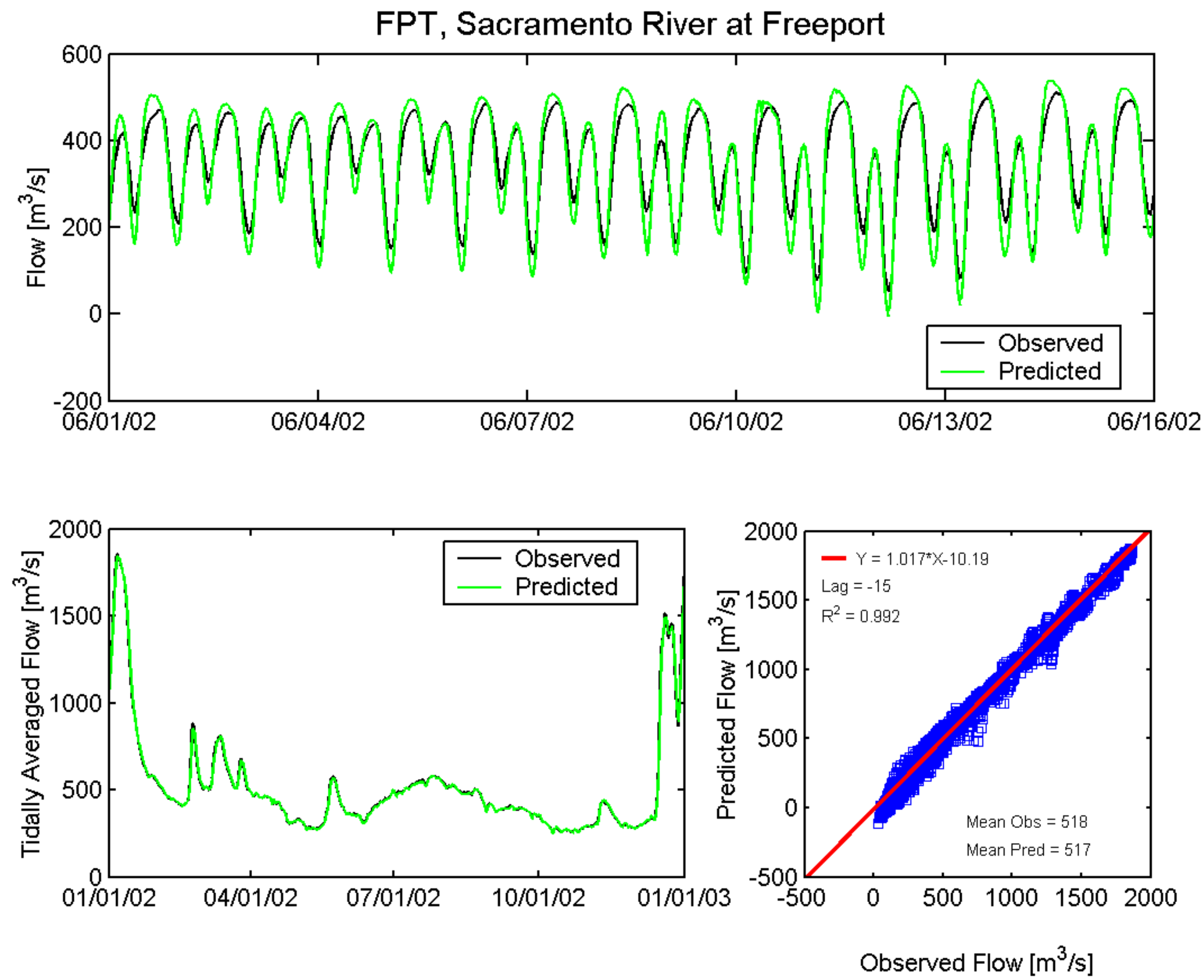


Figure A.4-6 Observed and predicted flow at Sacramento River at Freeport USGS station (FPT) during the 2002 simulation period.

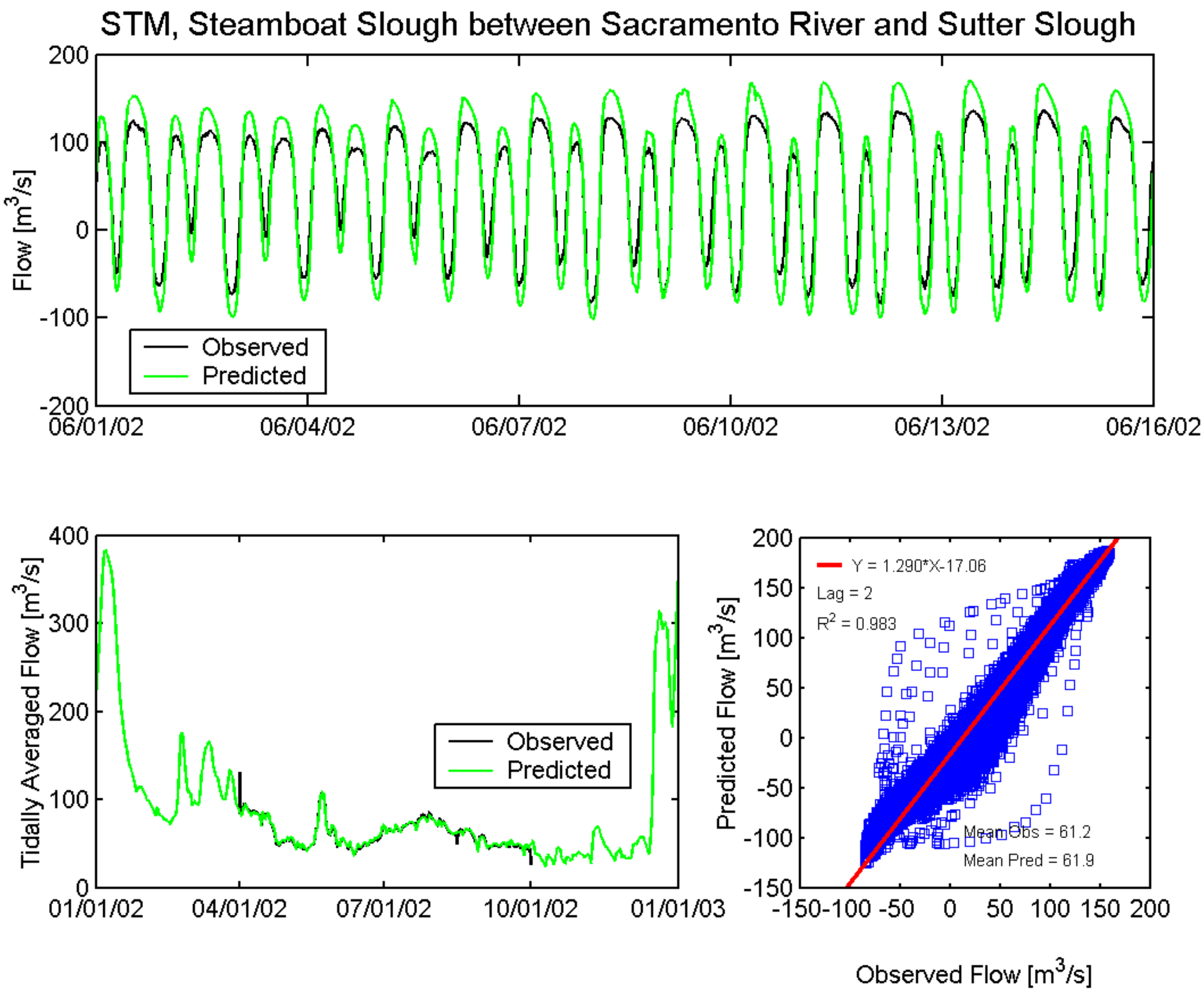
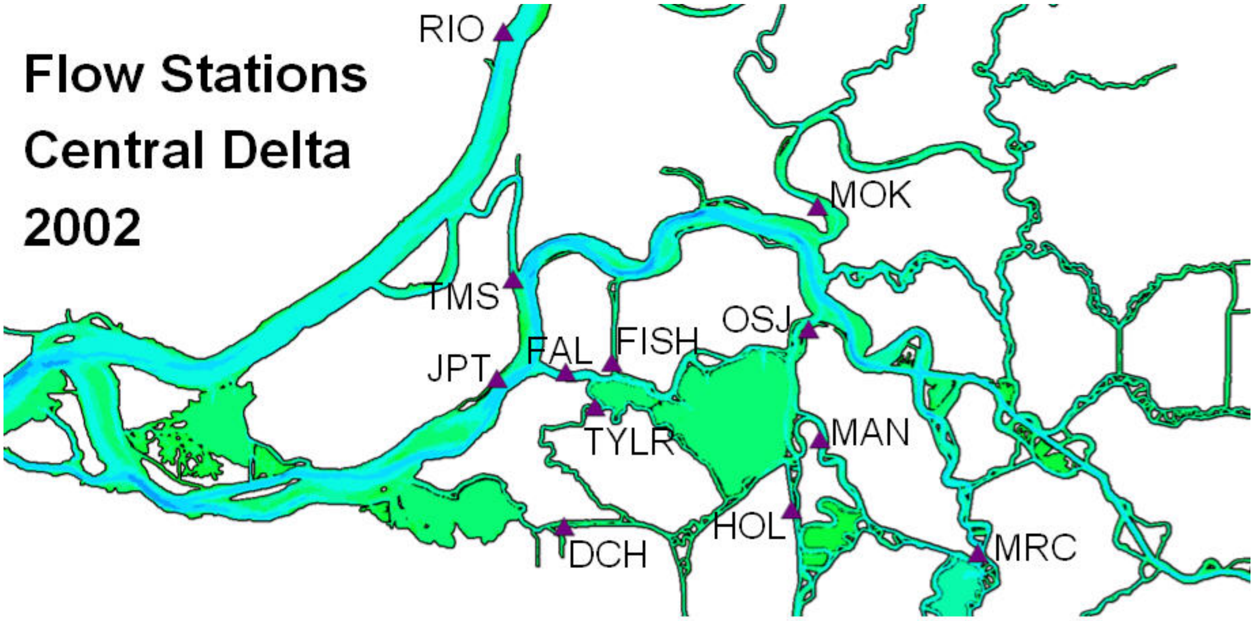


Figure A.4-7 Observed and predicted flow at Steamboat Slough between Sacramento River and Sutter Slough USGS station (STM) during the 2002 simulation period.



Station Names

RIO, Sacramento River at Rio Vista

TMS, Threemile Slough at San Joaquin River

JPT, San Joaquin River at Jersey Point

DCH, Dutch Slough at Jersey Island

FAL, False River

TYLR, Taylor Slough

FISH, Fisherman's Cut

OSJ, Old River at San Joaquin River

MOK, Mokelumne River near San Joaquin River

MAN, Old River at Mandeville Island

HOL, Holland Cut

MRC, Middle River South of Columbia Cut

Figure A.4-8 Location of flow monitoring stations in the central portion of the Sacramento-San Joaquin Delta used for 2002 flow comparisons.

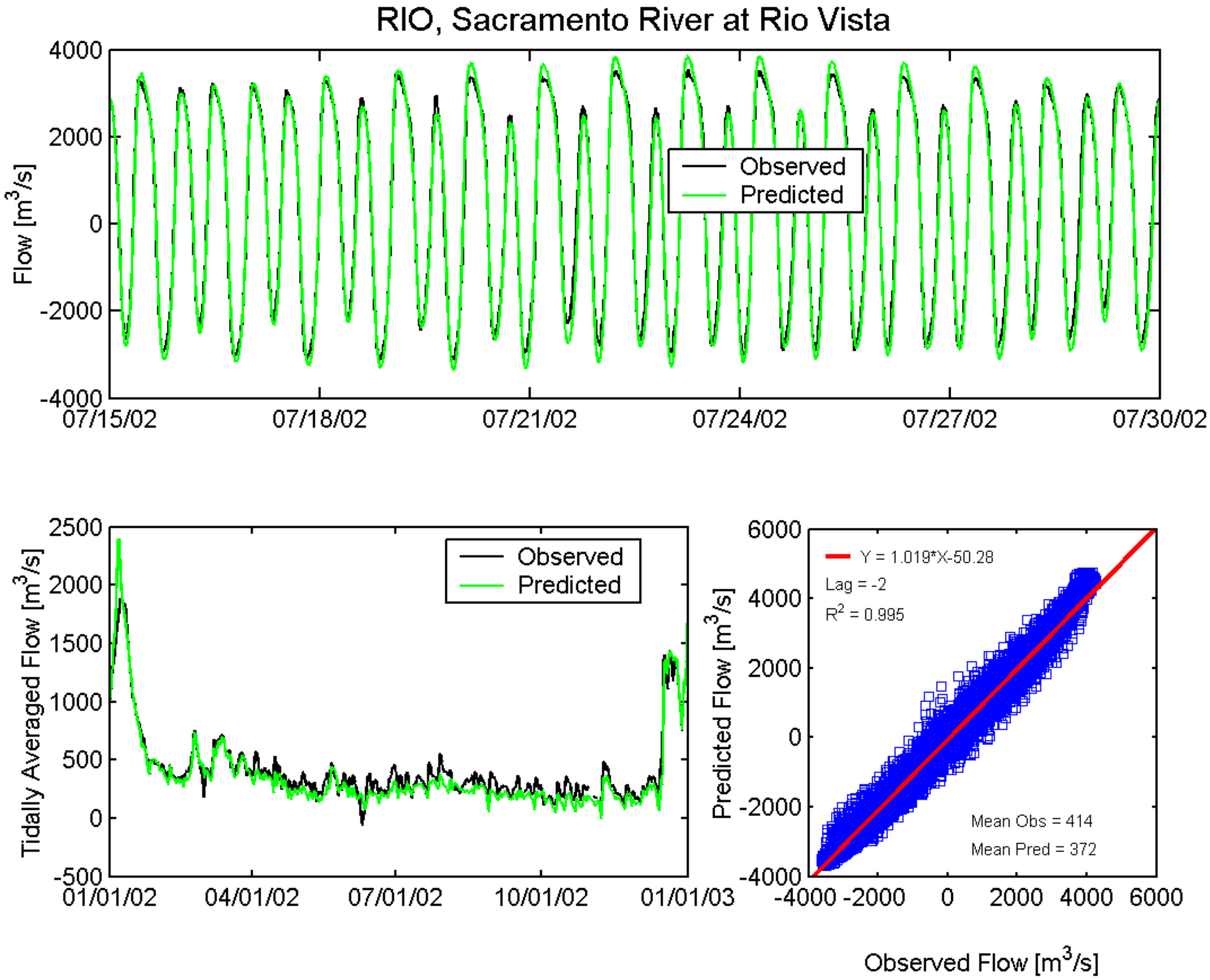


Figure A.4-9 Observed and predicted flow at Sacramento River at Rio Vista USGS station (RIO) during the 2002 simulation period.

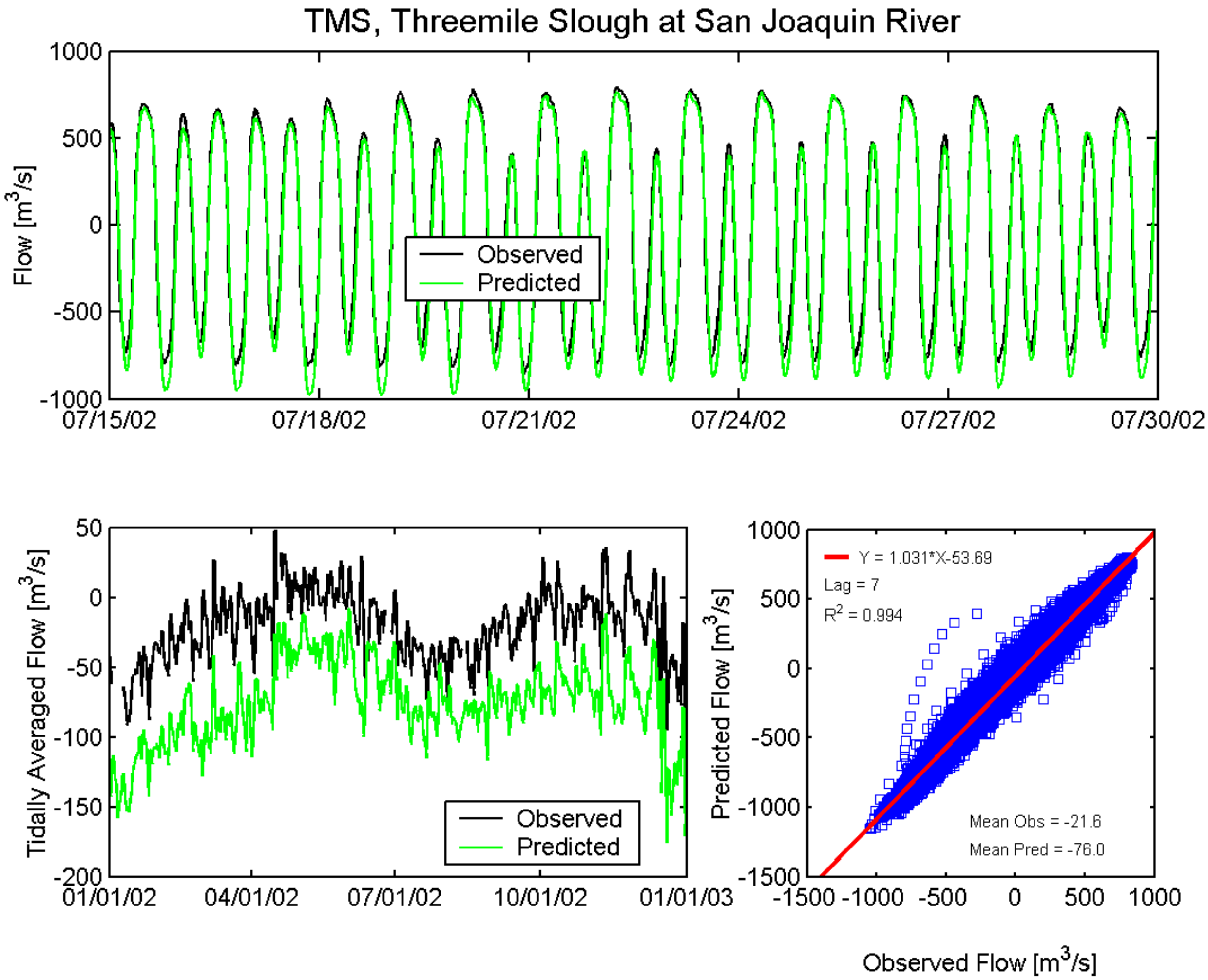


Figure A.4-10 Observed and predicted flow at Threemile Slough at San Joaquin River USGS station (TMS) during the 2002 simulation period.

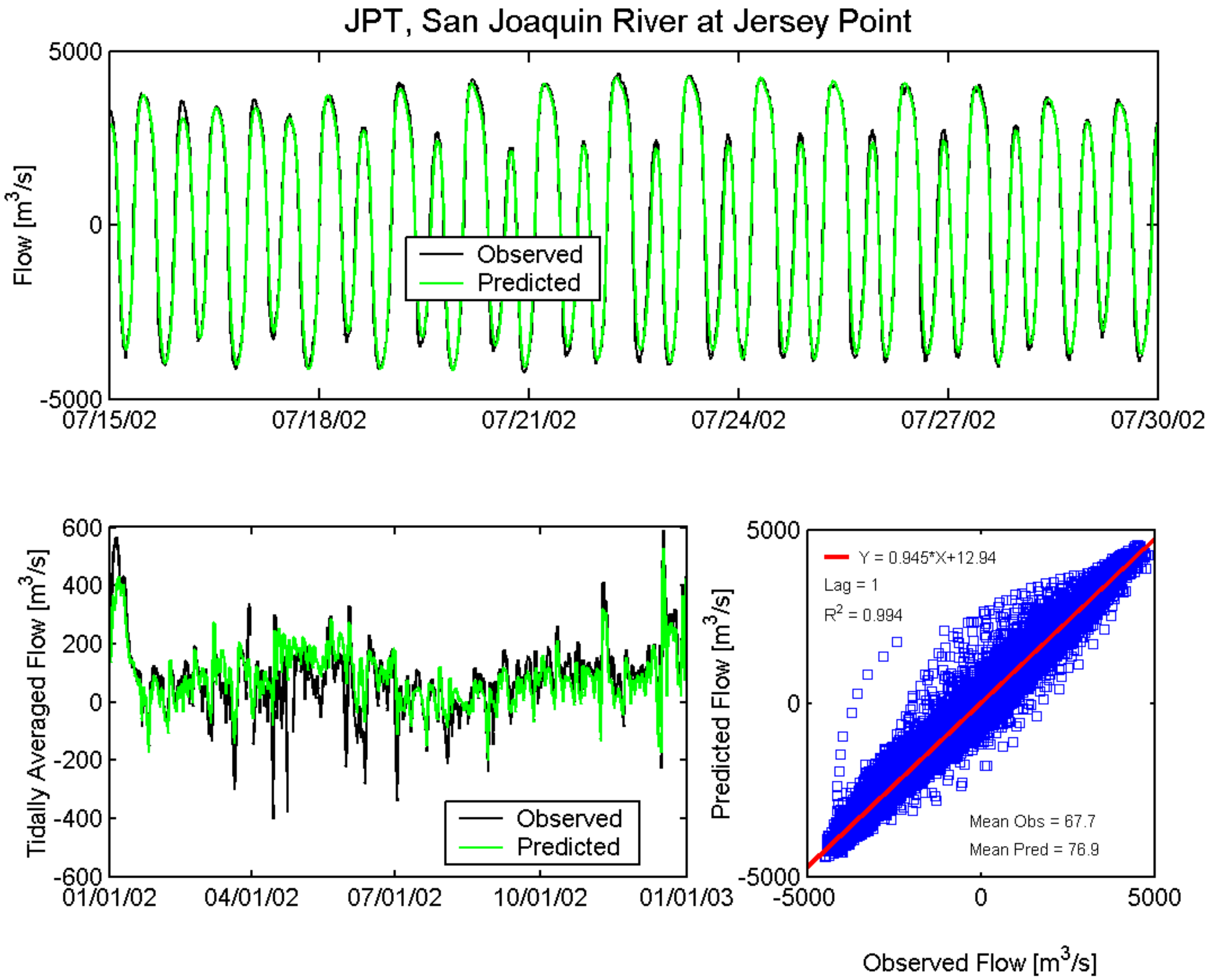


Figure A.4-11 Observed and predicted flow at San Joaquin River at Jersey Point USGS station (JPT) during the 2002 simulation period.

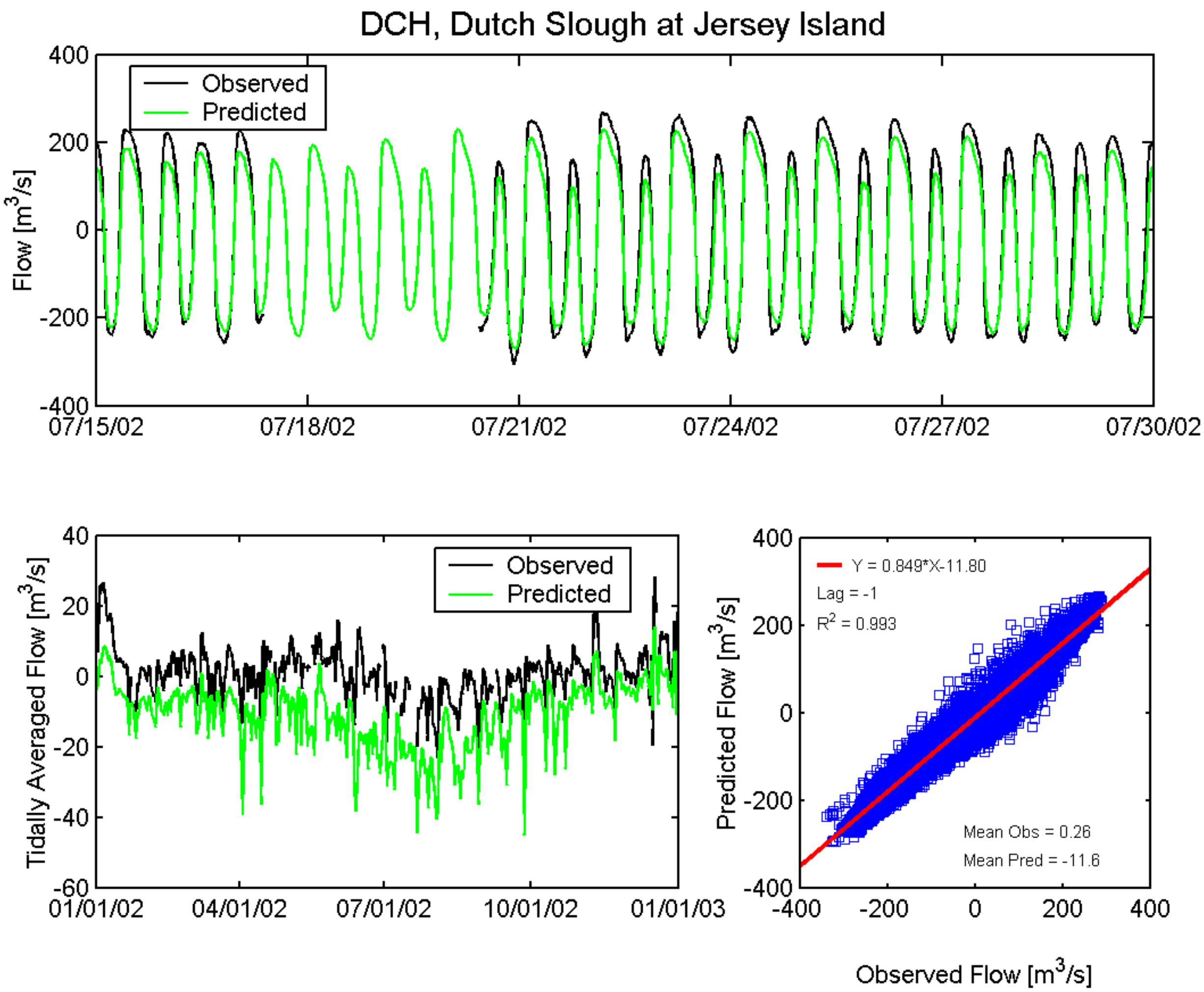


Figure A.4-12 Observed and predicted flow at Dutch Slough at Jersey Island USGS station (DCH) during the 2002 simulation period.

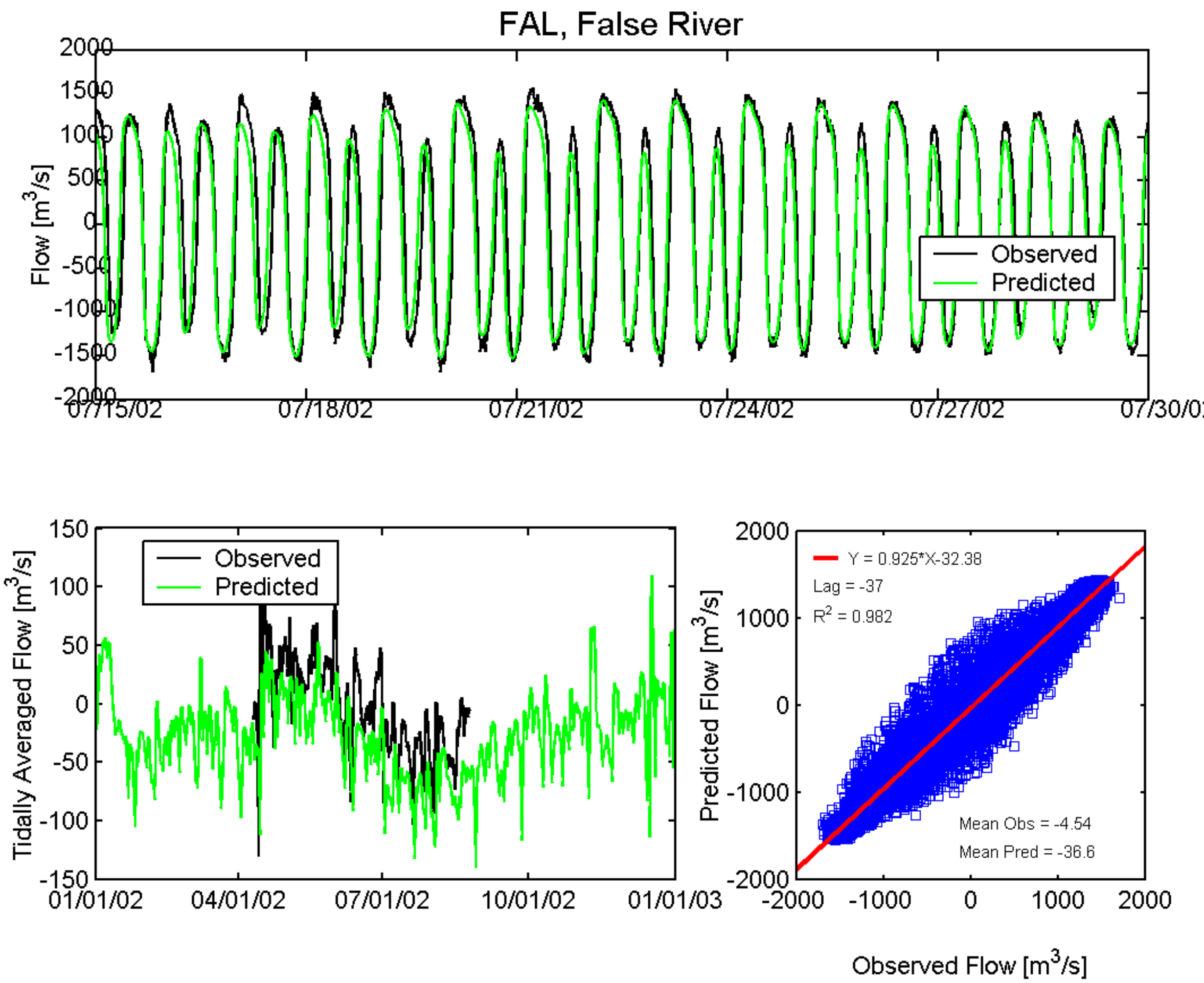


Figure A.4-13 Observed and predicted flow at False River USGS station (FAL) during the 2002 simulation period.

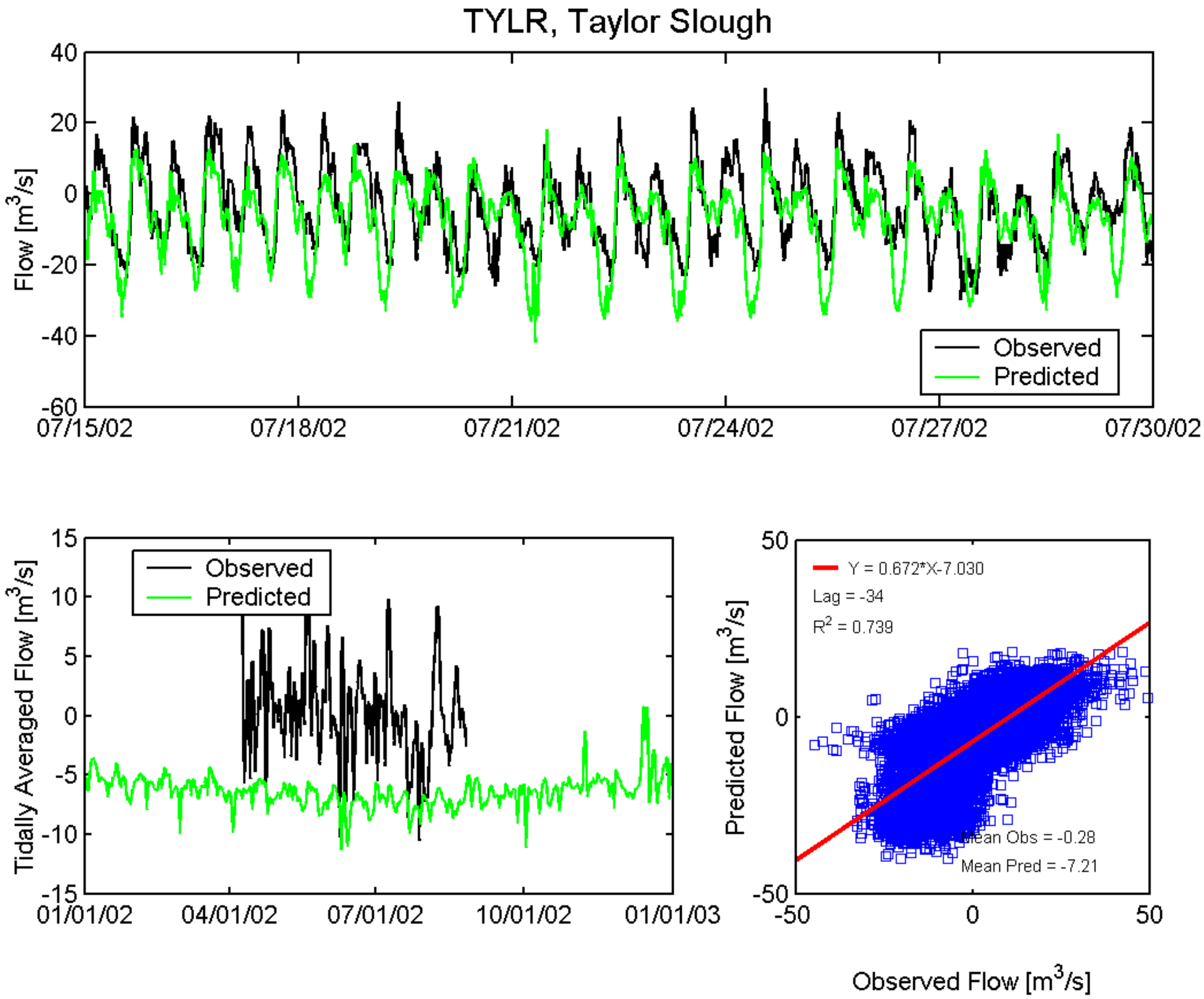


Figure A.4-14 Observed and predicted flow at Taylor Slough USGS station (TYLR) during the 2002 simulation period.

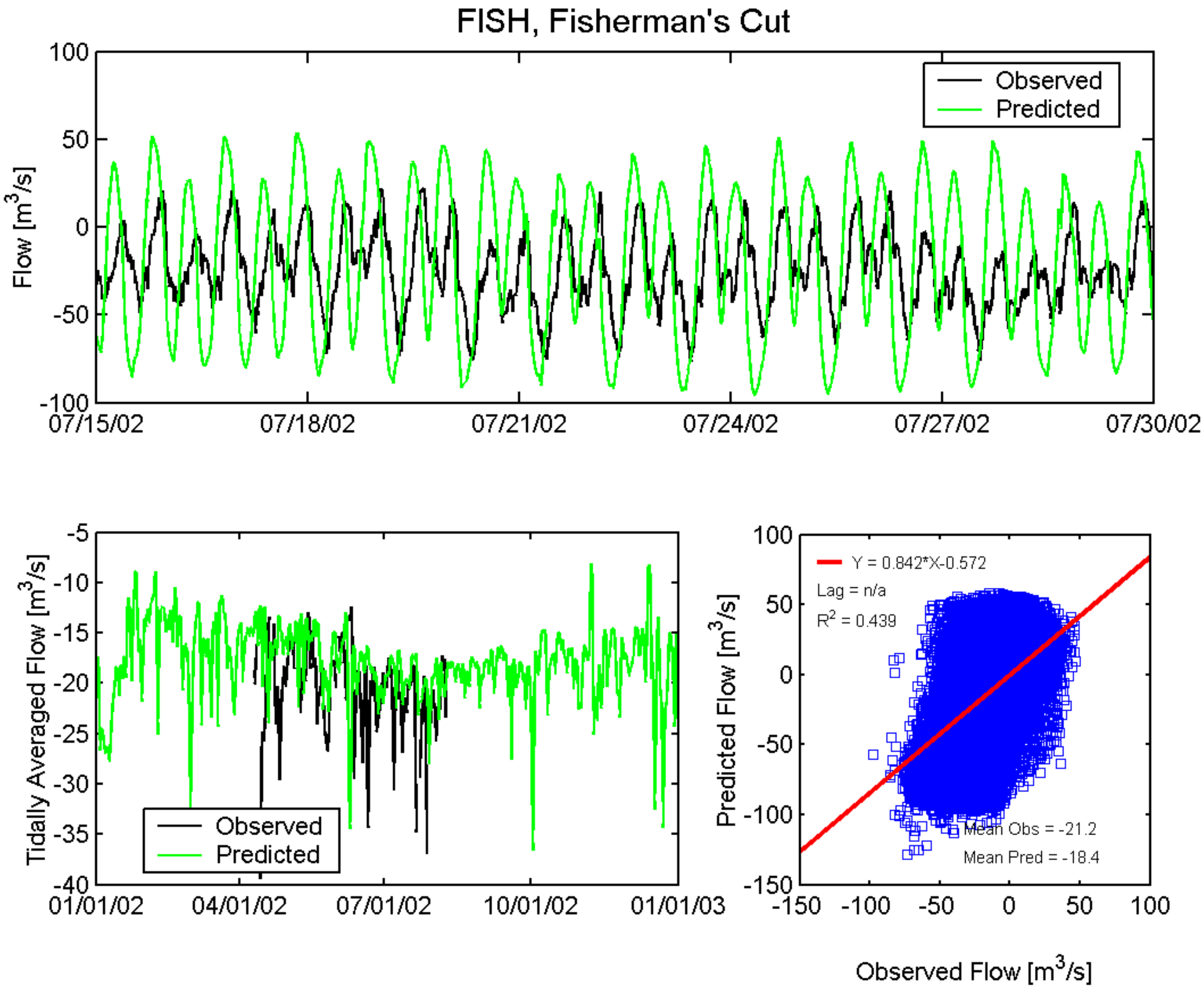


Figure A.4-15 Observed and predicted flow at Fisherman's Cut USGS station (FISH) during the 2002 simulation period.

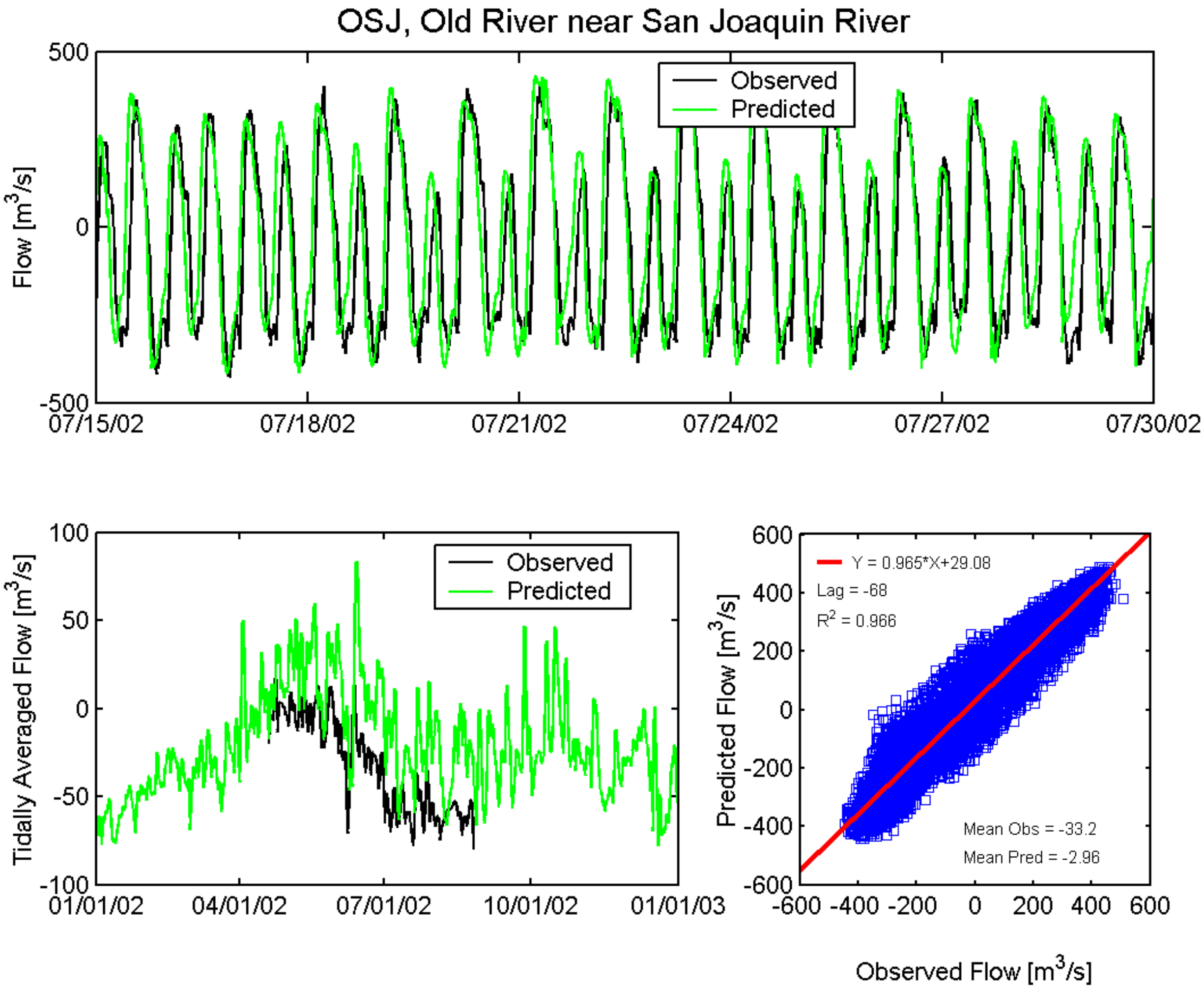


Figure A.4-16 Observed and predicted flow at Old River near San Joaquin River USGS station (OSJ) during the 2002 simulation period.

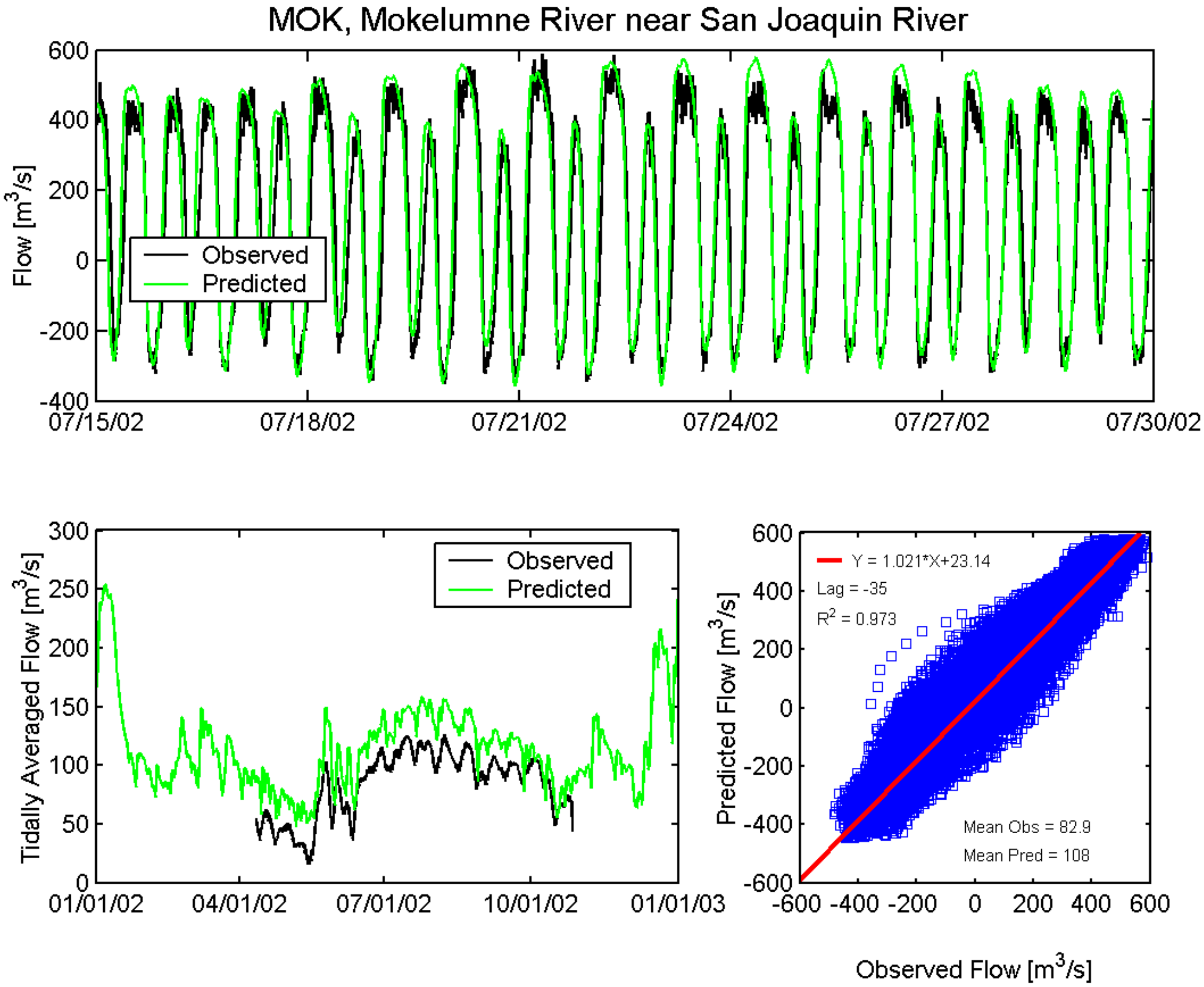


Figure A.4-17 Observed and predicted flow at Mokelumne River near San Joaquin River USGS station (MOK) during the 2002 simulation period.

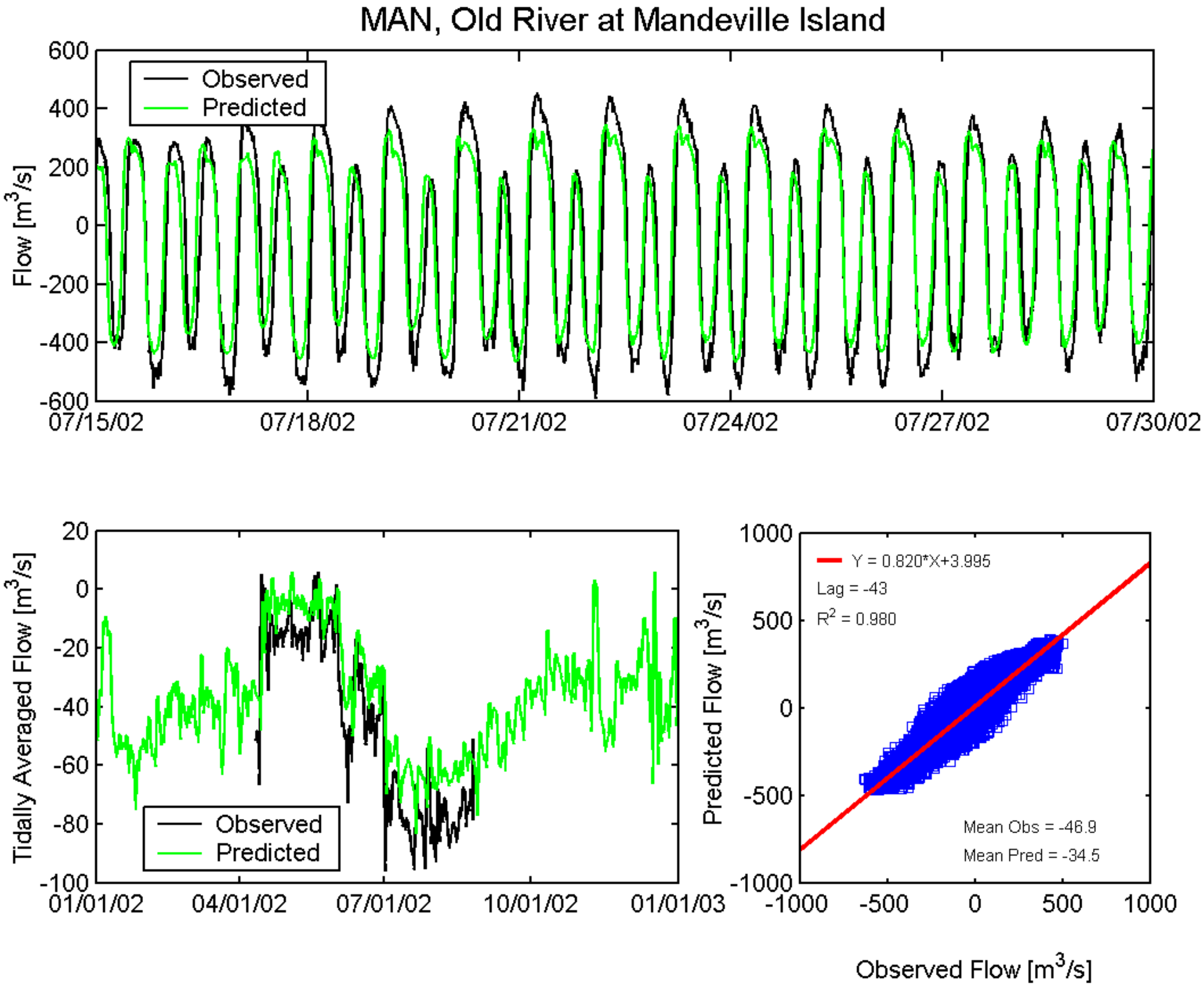


Figure A.4-18 Observed and predicted flow at Old River at Mandeville Island USGS station (MAN) during the 2002 simulation period.

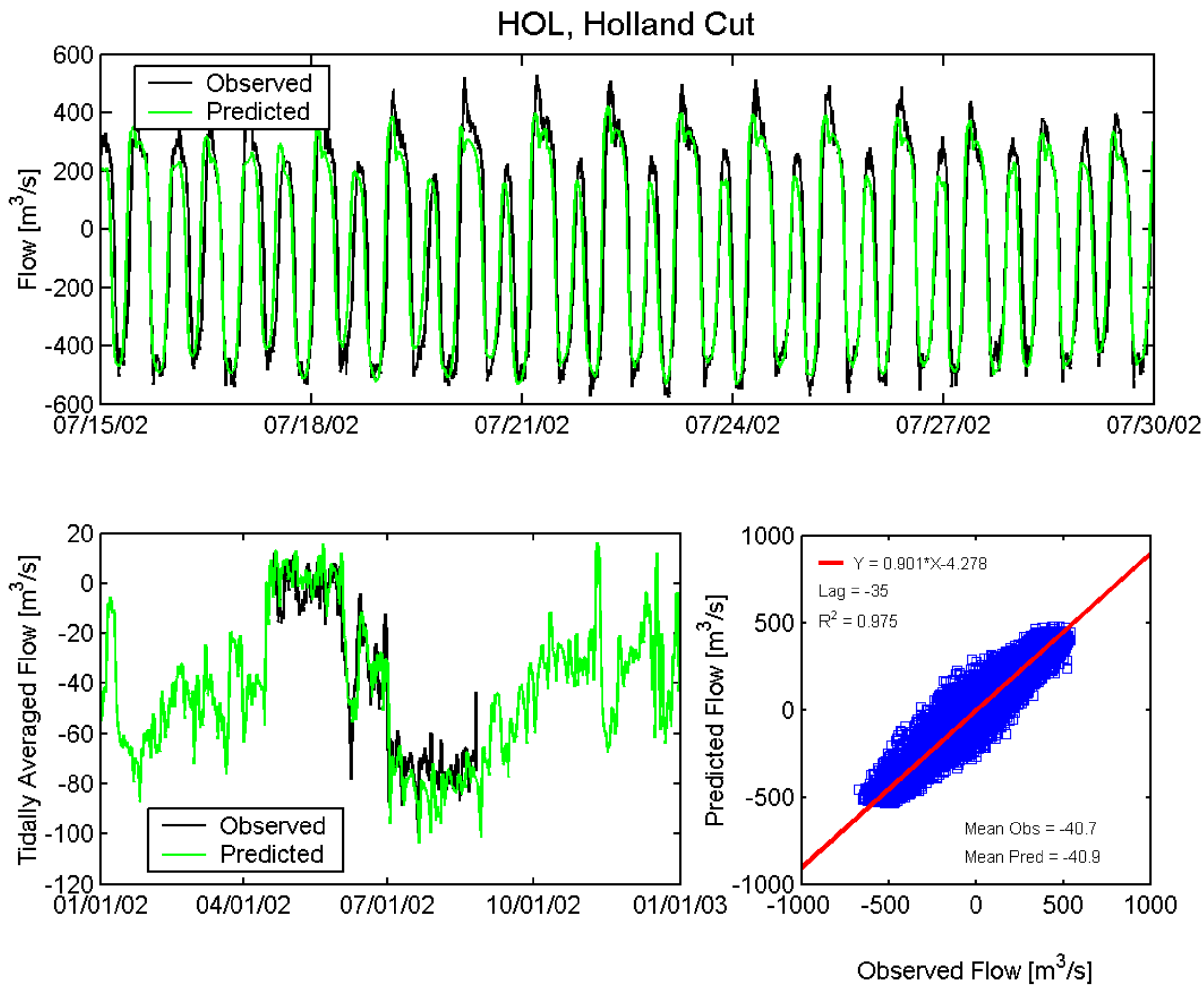


Figure A.4-19 Observed and predicted flow at Holland Cut USGS station (HOL) during the 2002 simulation period.

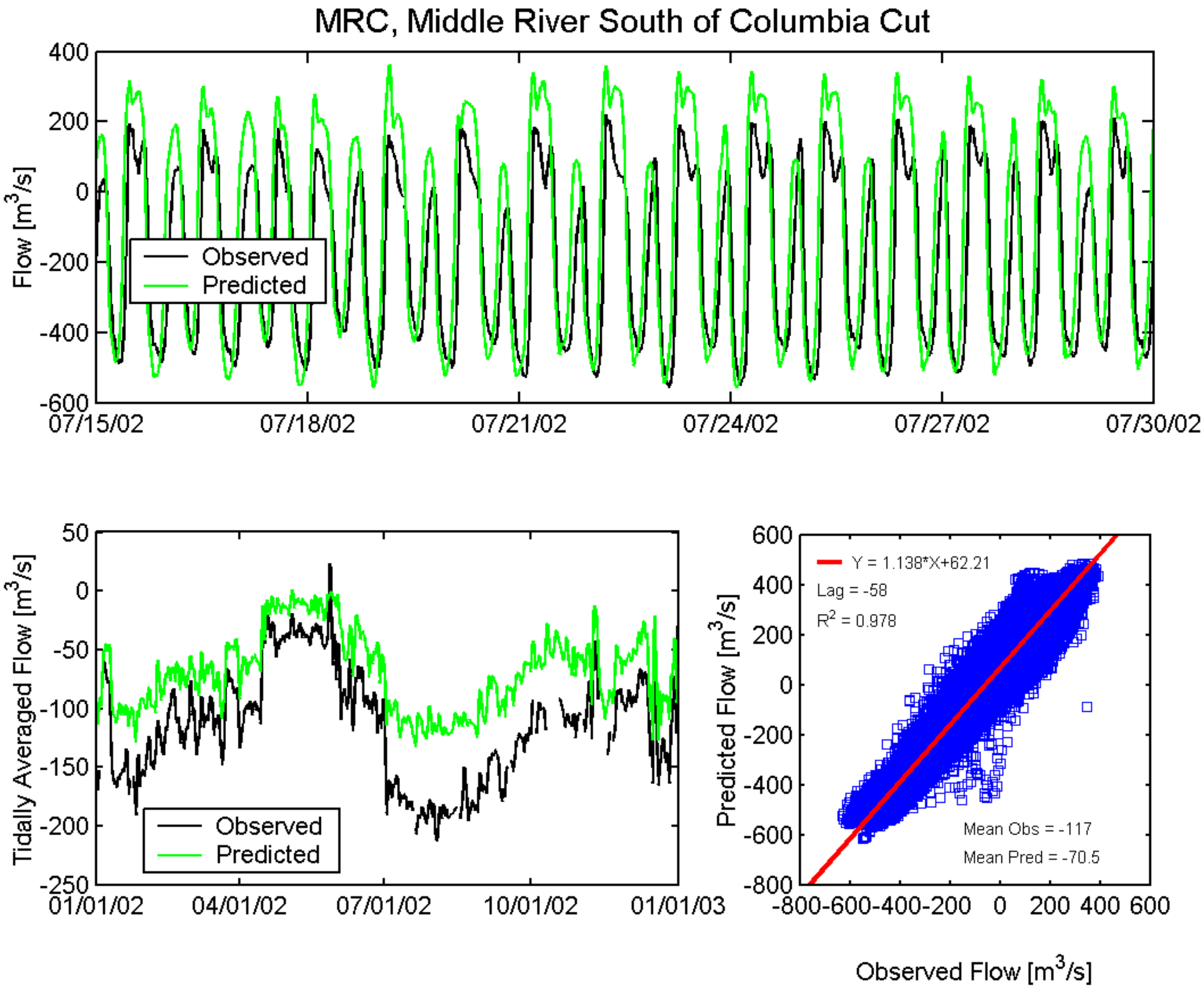


Figure A.4-20 Observed and predicted flow at Middle River South of Columbia Cut USGS station (MRC) during the 2002 simulation period.

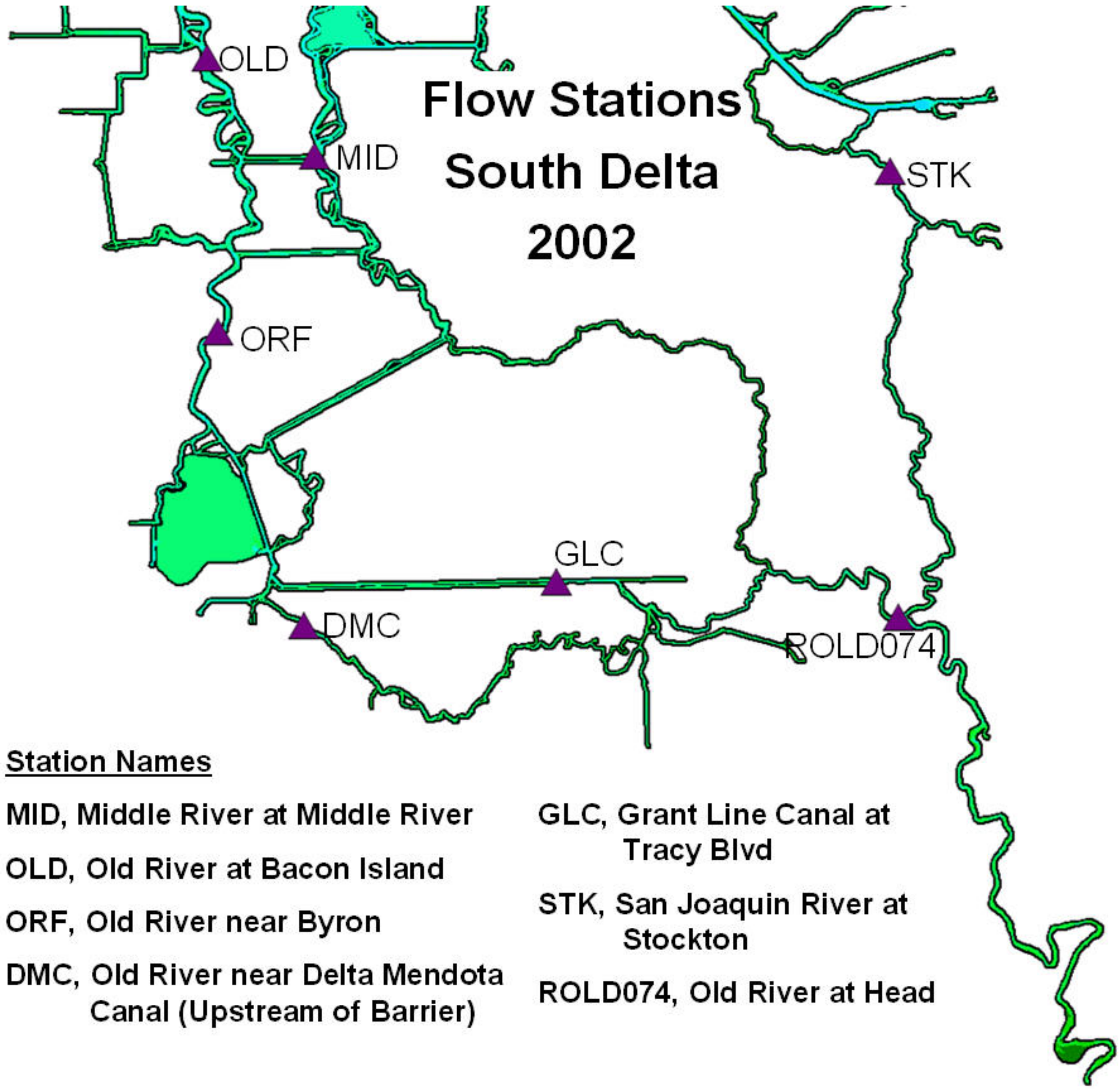


Figure A.4-21 Location of flow monitoring stations in the southern portion of the Sacramento-San Joaquin Delta used for 2002 flow comparisons.

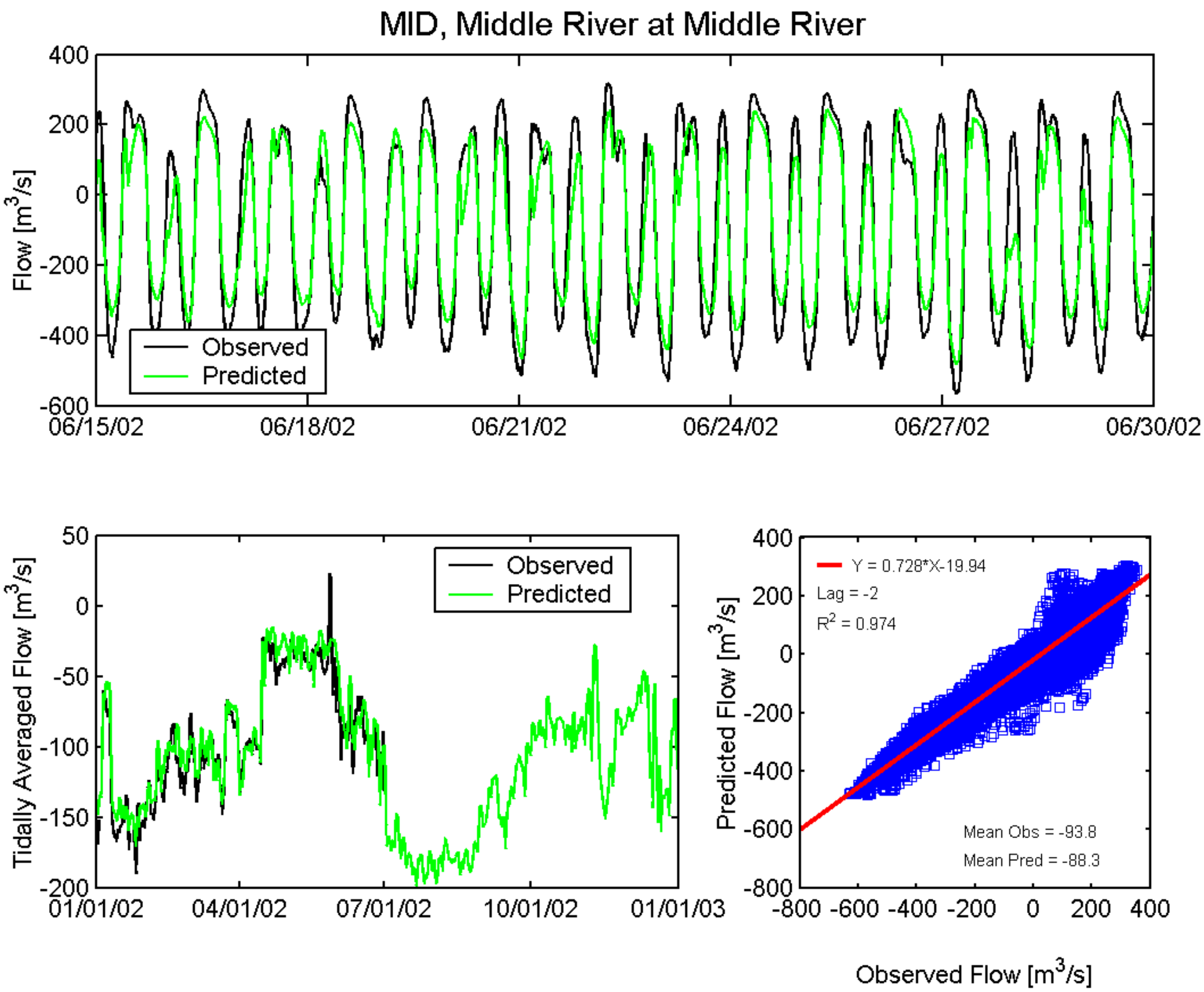


Figure A.4-22 Observed and predicted flow at Middle River at Middle River USGS station (MID) during the 2002 simulation period.

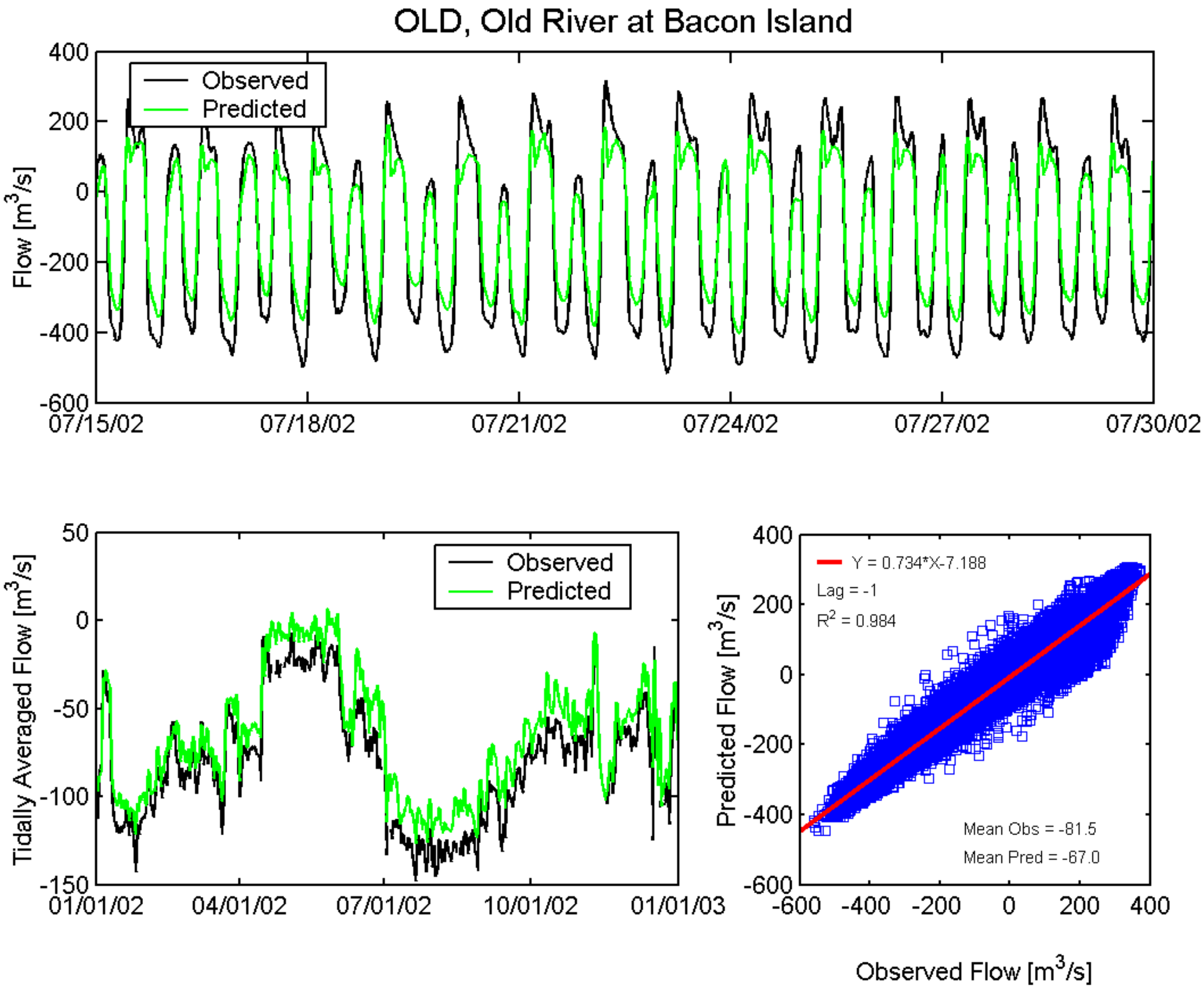


Figure A.4-23 Observed and predicted flow at Old River at Bacon Island USGS station (OLD) during the 2002 simulation period.

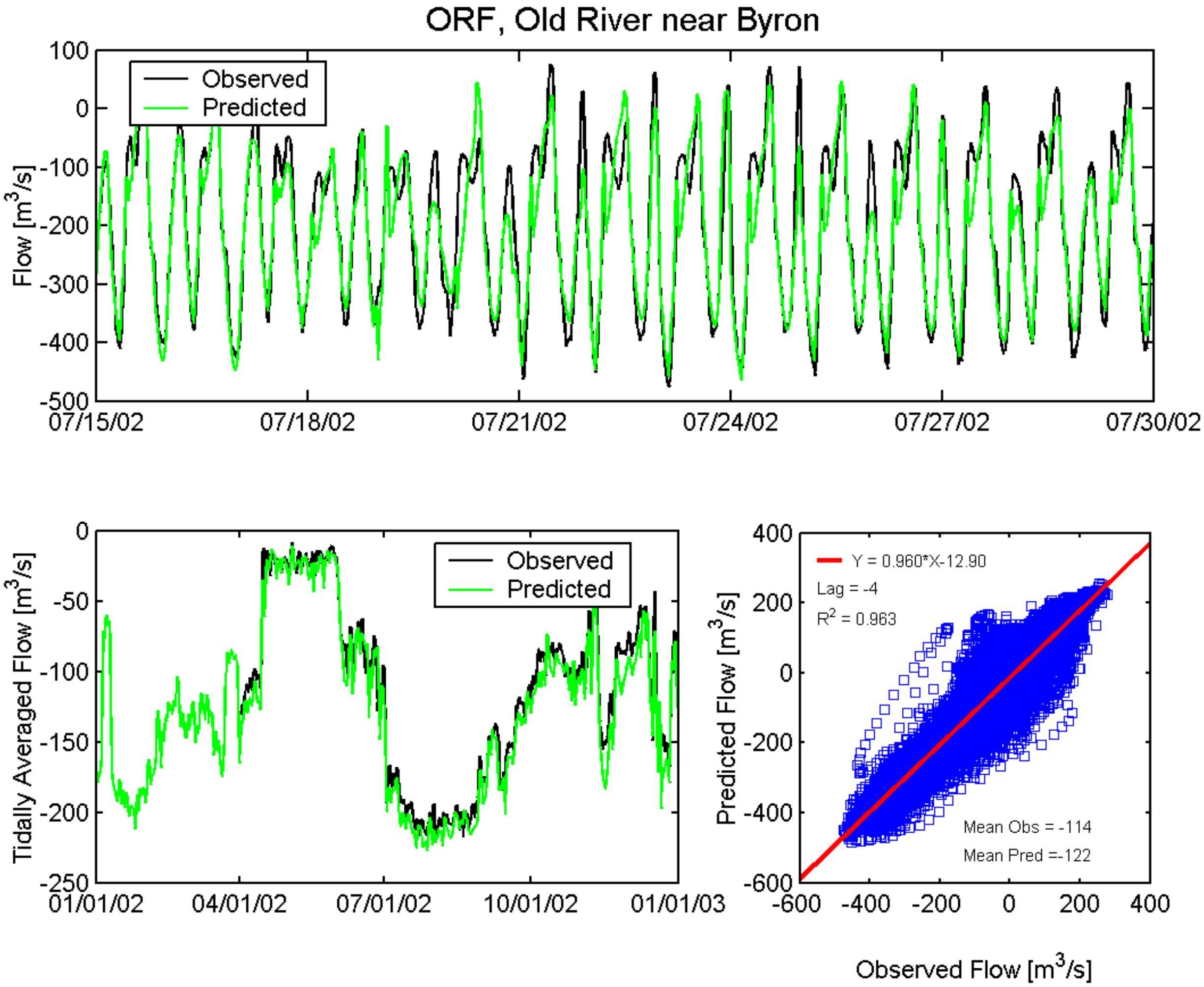


Figure A.4-24 Observed and predicted flow at Old River near Byron USGS station (ORF) during the 2002 simulation period.

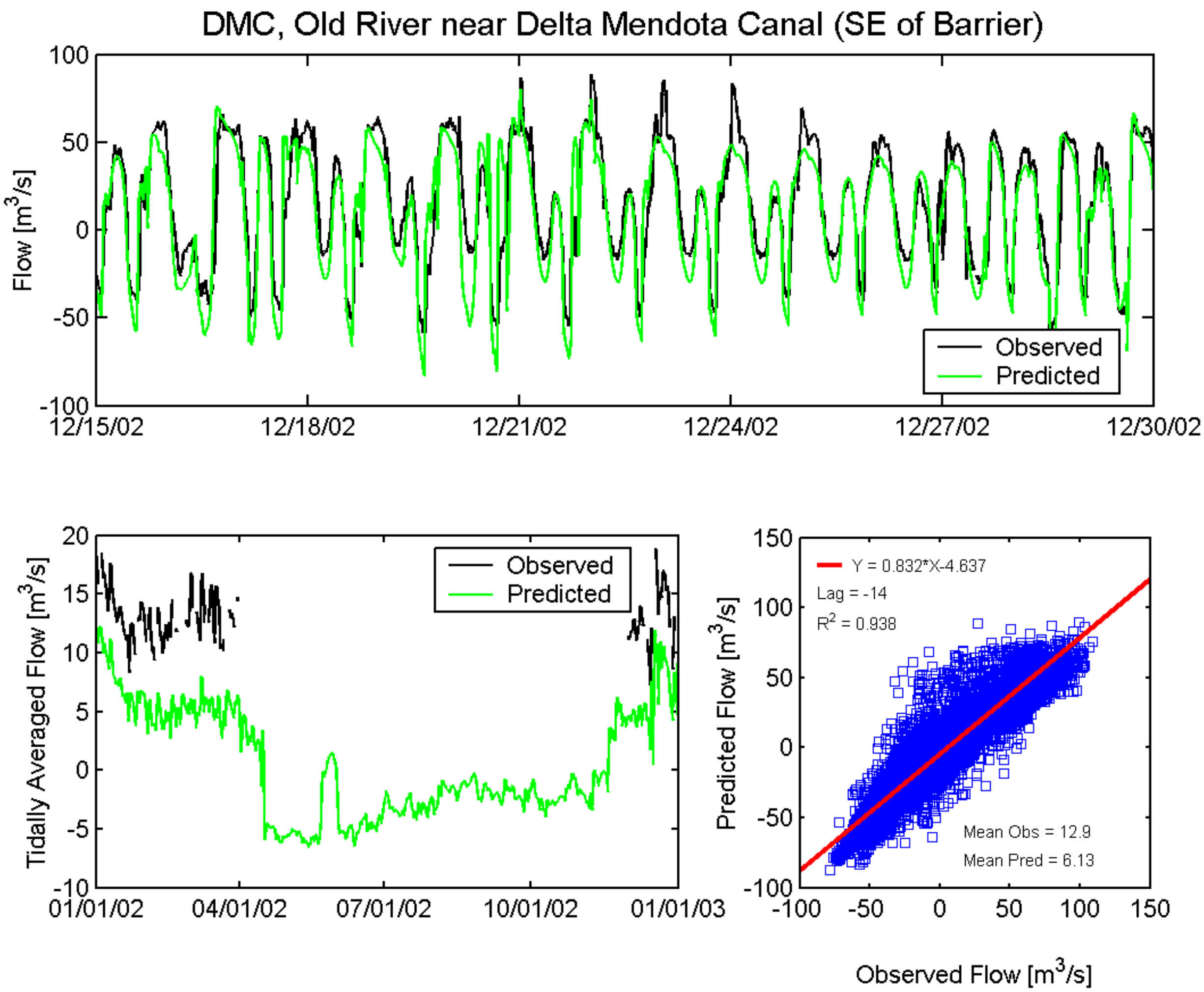


Figure A.4-25 Observed and predicted flow at Old River near Delta Mendota Canal SE of Barrier USGS station (DMC) during the 2002 simulation period.

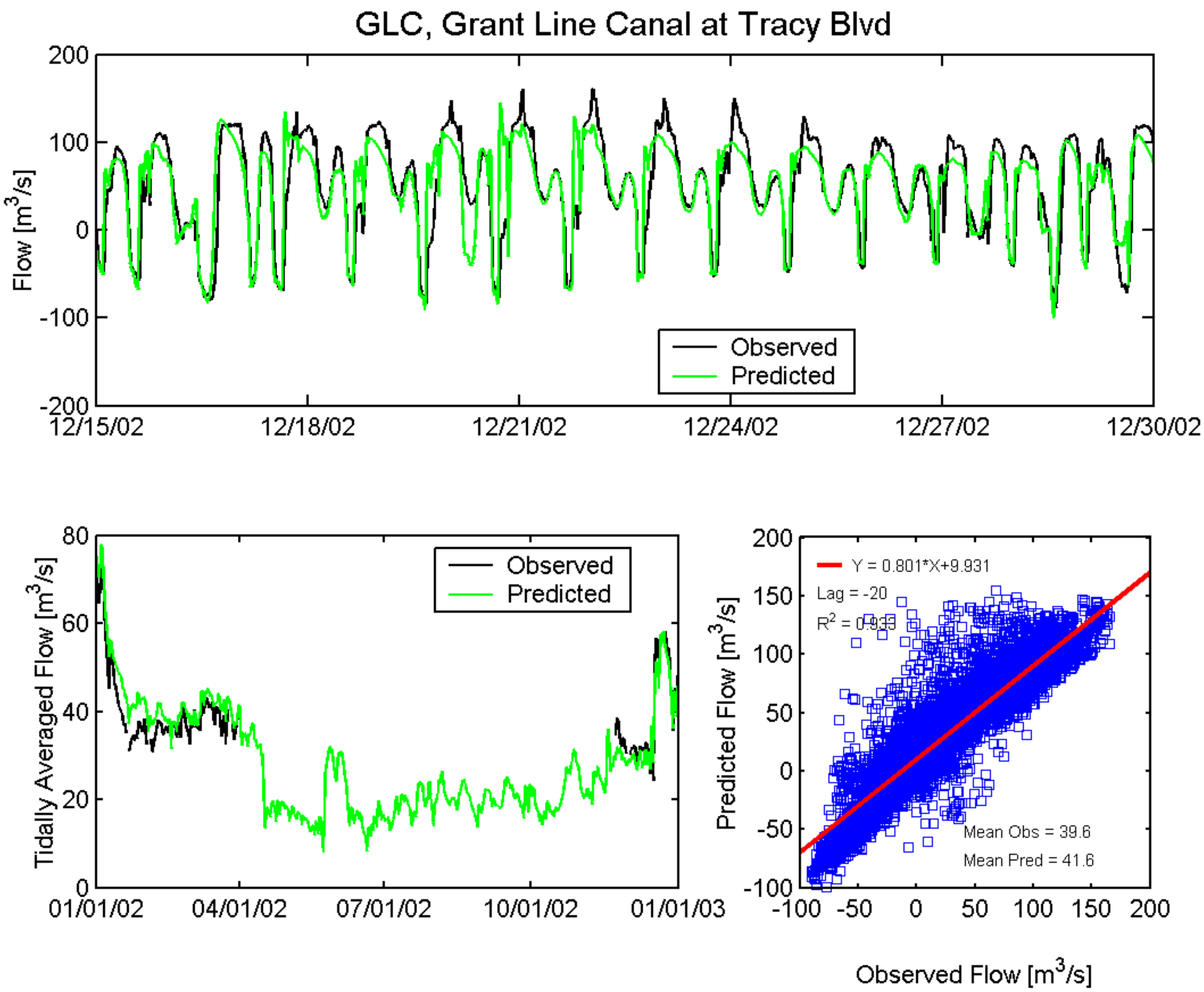


Figure A.4-26 Observed and predicted flow at Grant Line Canal at Tracy Boulevard USGS station (GLC) during the 2002 simulation period.

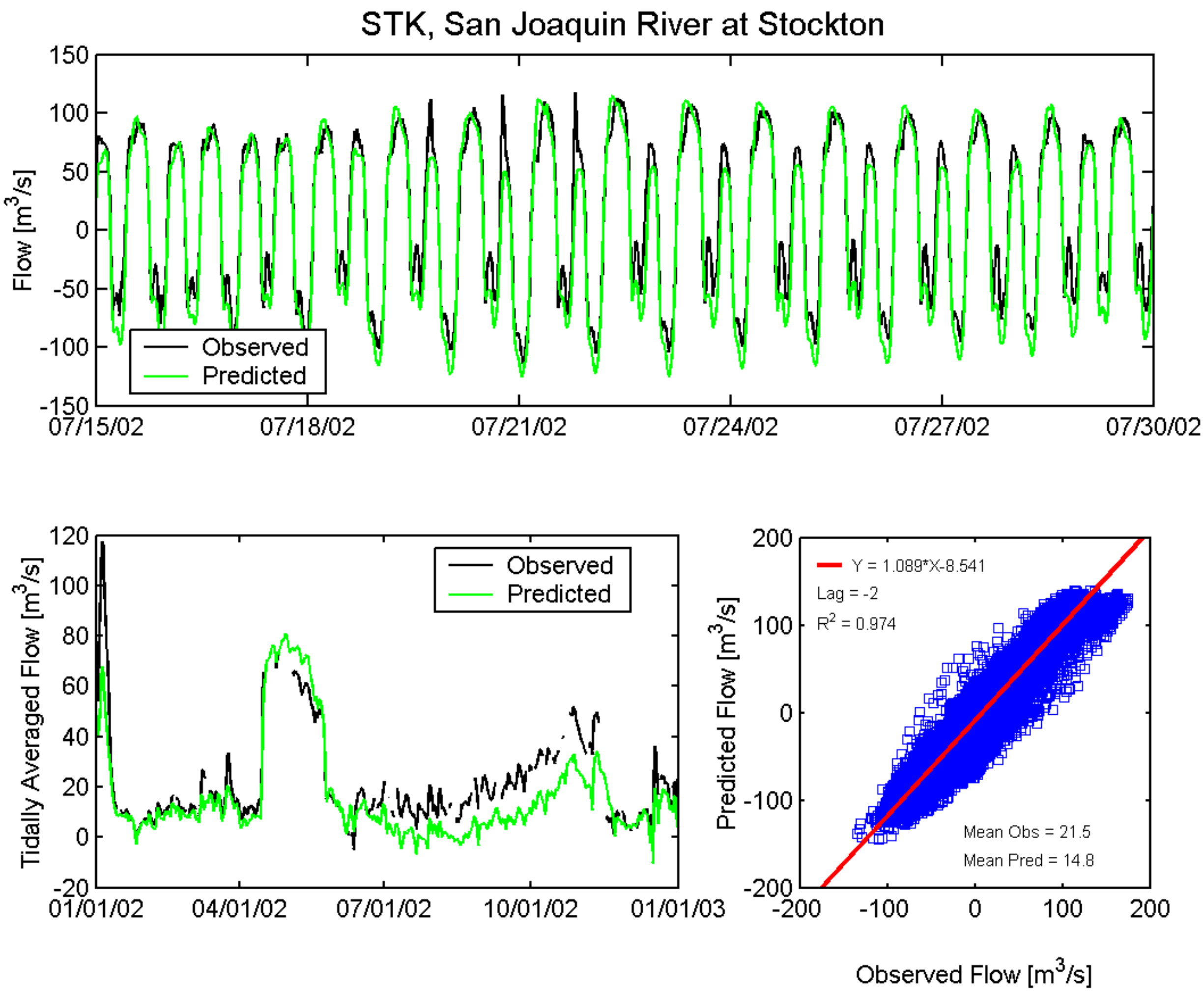


Figure A.4-27 Observed and predicted flow at San Joaquin River at Stockton USGS station (STK) during the 2002 simulation period.

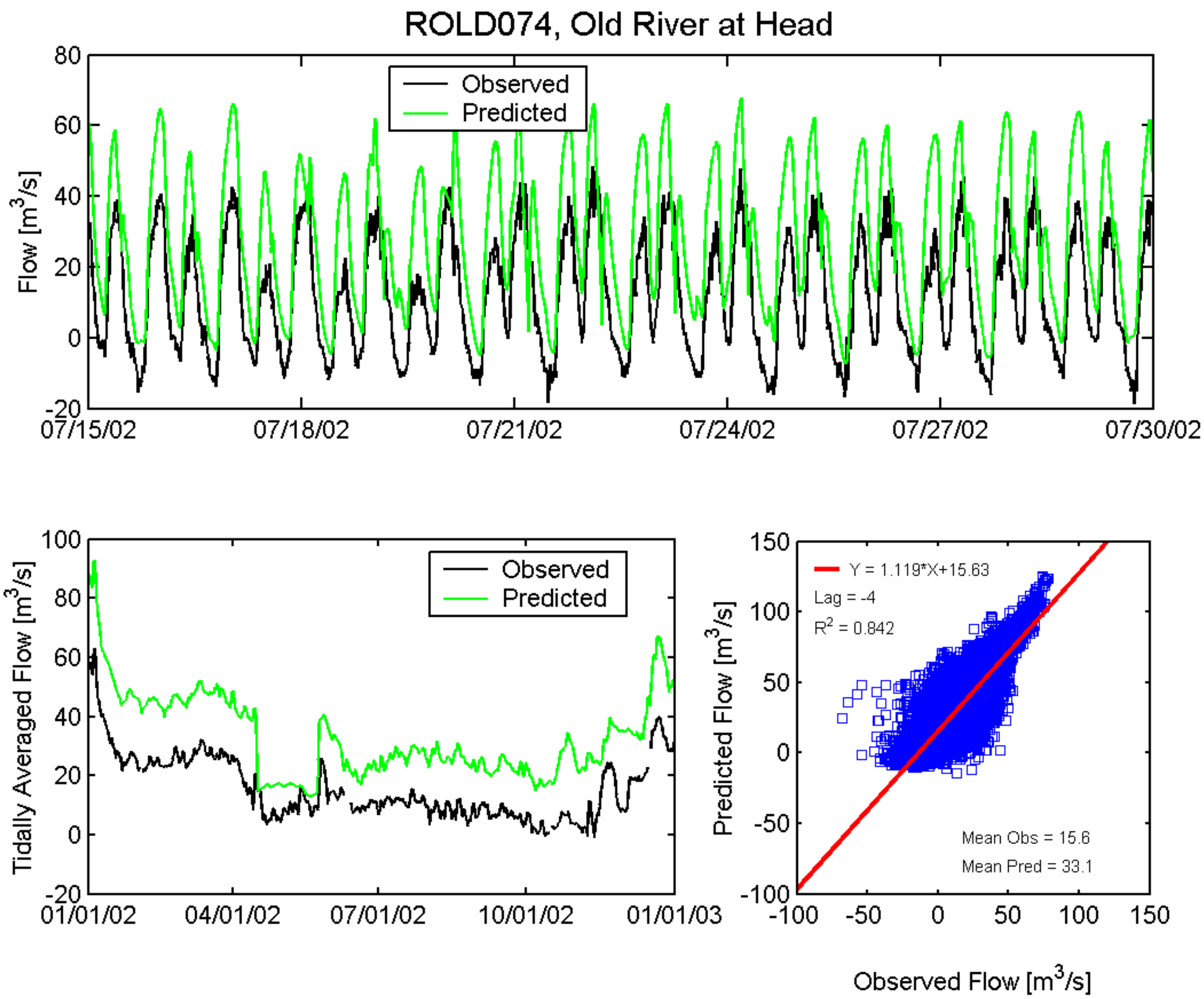


Figure A.4-28 Observed and predicted flow at Old River at Head DWR station (ROLD074) during the 2002 simulation period.

A.5 Synoptic Salinity Validation

The USGS maintains a program of research and observation in San Francisco Bay that includes regular measurements of water quality along a 145 kilometer transect spanning the length of the entire estuarine system (USGS, 2009). These data include synoptic salinity observations, consisting of vertical profiles of salinity at 1 meter vertical resolution at 38 sampling locations, along the axis of the San Francisco Estuary (USGS, 2009; Figure A.5-1). The synoptic salinity data are typically collected over a period of 10 to 12 hours, as the USGS research vessel travels along the channel of San Francisco Bay from the South Bay to the western Delta. The location of the synoptic monitoring stations are shown on Figure A.5-1.

A.6.1 USGS San Francisco Bay Synoptic Salinity Transects

The predicted salinity along the axis of the San Francisco Estuary was compared with USGS synoptic sampling observations (USGS, 2009) during all San Francisco Bay cruises between January 1, 2002 and January 1, 2002, except cruises that were limited to South San Francisco Bay. An additional comparison was made on November 27, 2001 (Figure A.5-2) during the model spin-up period.

Salinity was predicted accurately along the axis of the estuary by the UnTRIM Bay-Delta model on most dates (Figures A.5-2 through A.5-9), and the average errors and standard errors are small relative to the large range of salinity conditions that occurred during the calibration period (Table A-3).

Table A-3 Average error and standard error for each synoptic sampling cruise covering the axis of the San Francisco Estuary during the 2002 simulation period.

Date	Figure Number	Average Error (psu)	Standard Error (psu)	R^2
11/27/2001	A.5-2	0.54	0.87	0.99
05/13/2002	A.5-3	-0.11	0.57	0.79
07/16/2002	A.5-4	-1.40	1.11	0.97
08/20/2002	A.5-5	-1.01	0.91	0.98
09/10/2002	A.5-6	-0.79	1.15	0.98
10/08/2002	A.5-7	0.20	1.62	0.97
11/13/2002	A.5-8	0.30	0.98	0.99
12/10/2002	A.5-9	0.16	0.56	1.00

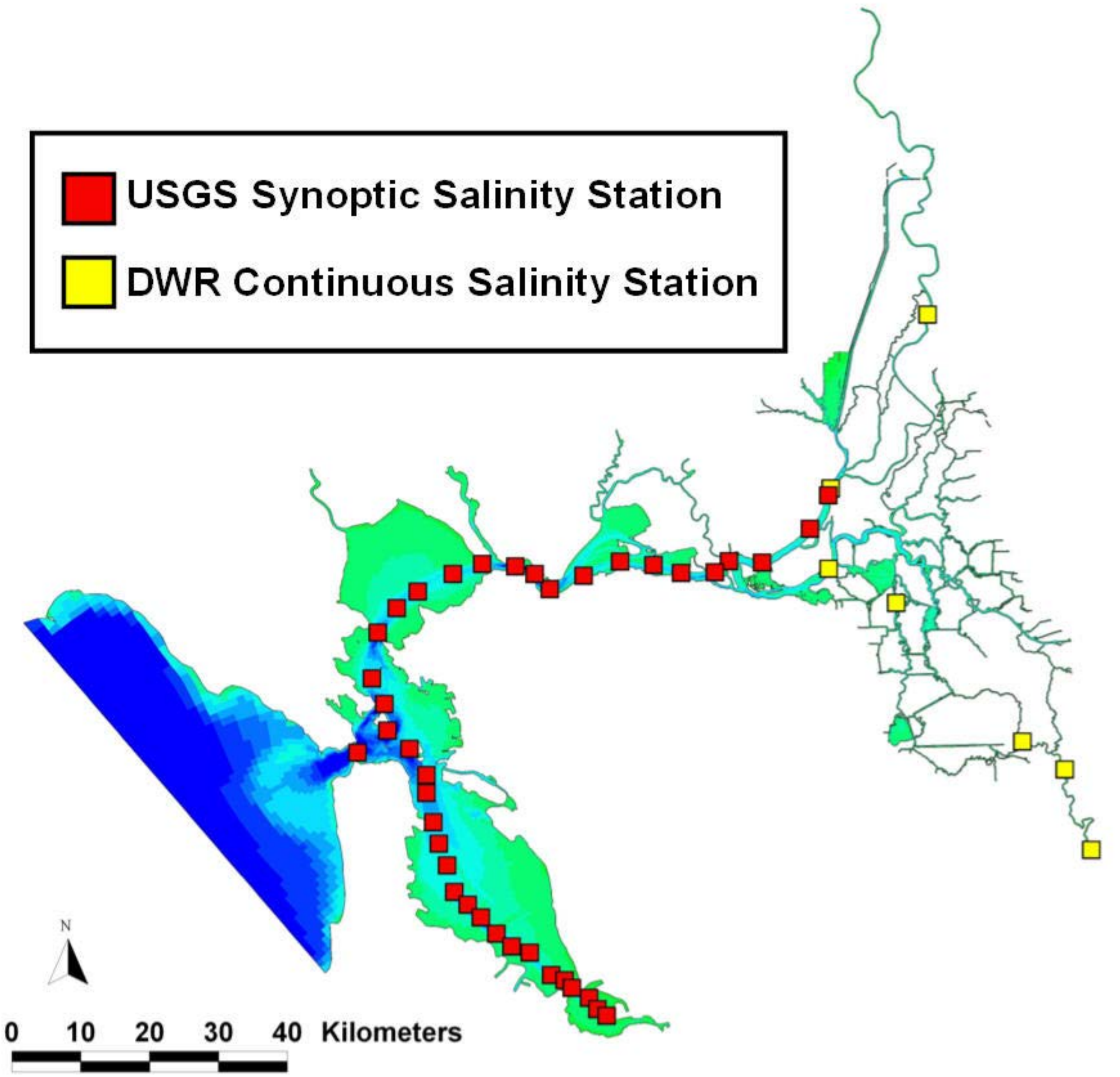


Figure A.5-1 Location of USGS synoptic monitoring stations along the axis of the San Francisco Estuary.

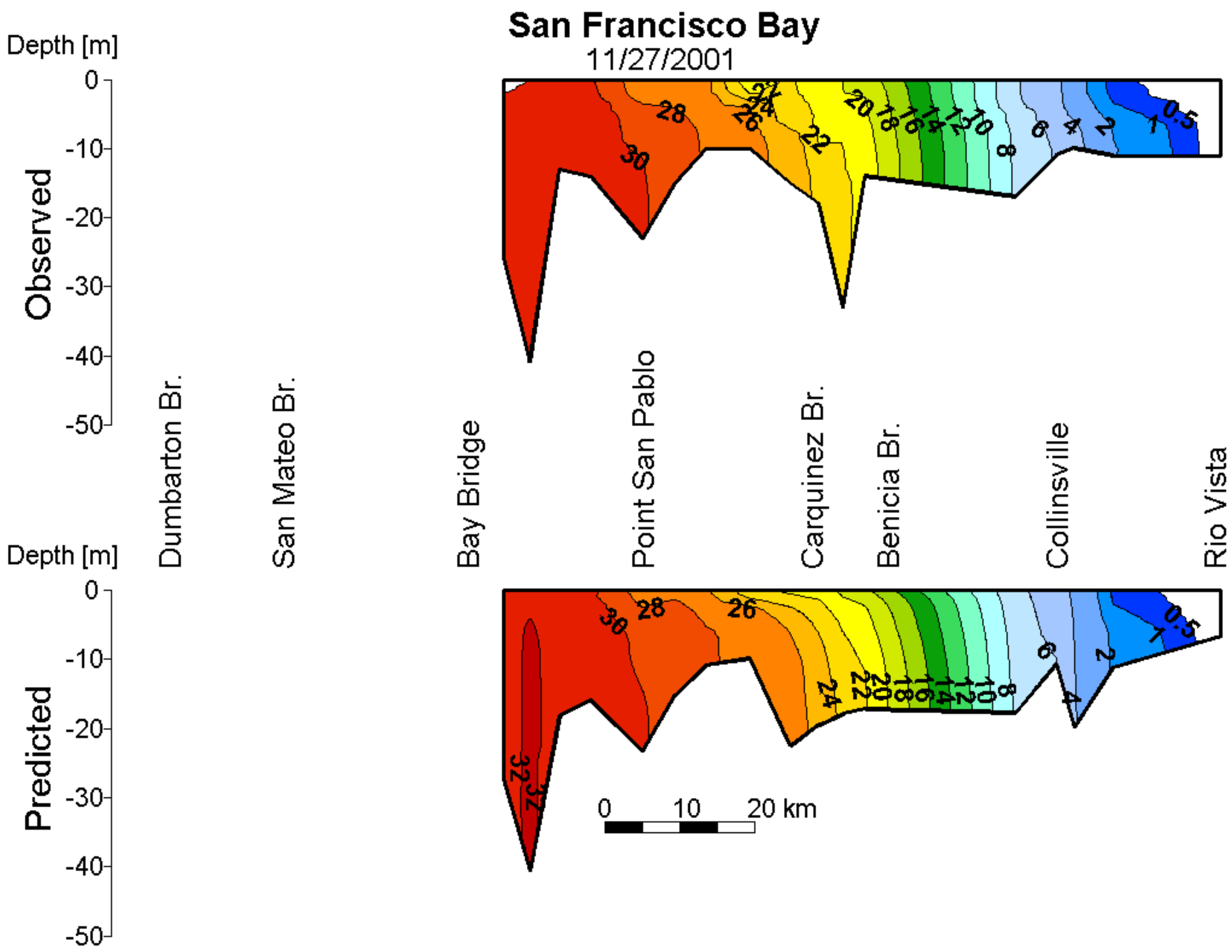


Figure A.5-2 Observed and predicted salinity profiles at synoptic sampling stations, interpolated along the axis of the San Francisco Estuary on November 27, 2001 during the model spin-up period.

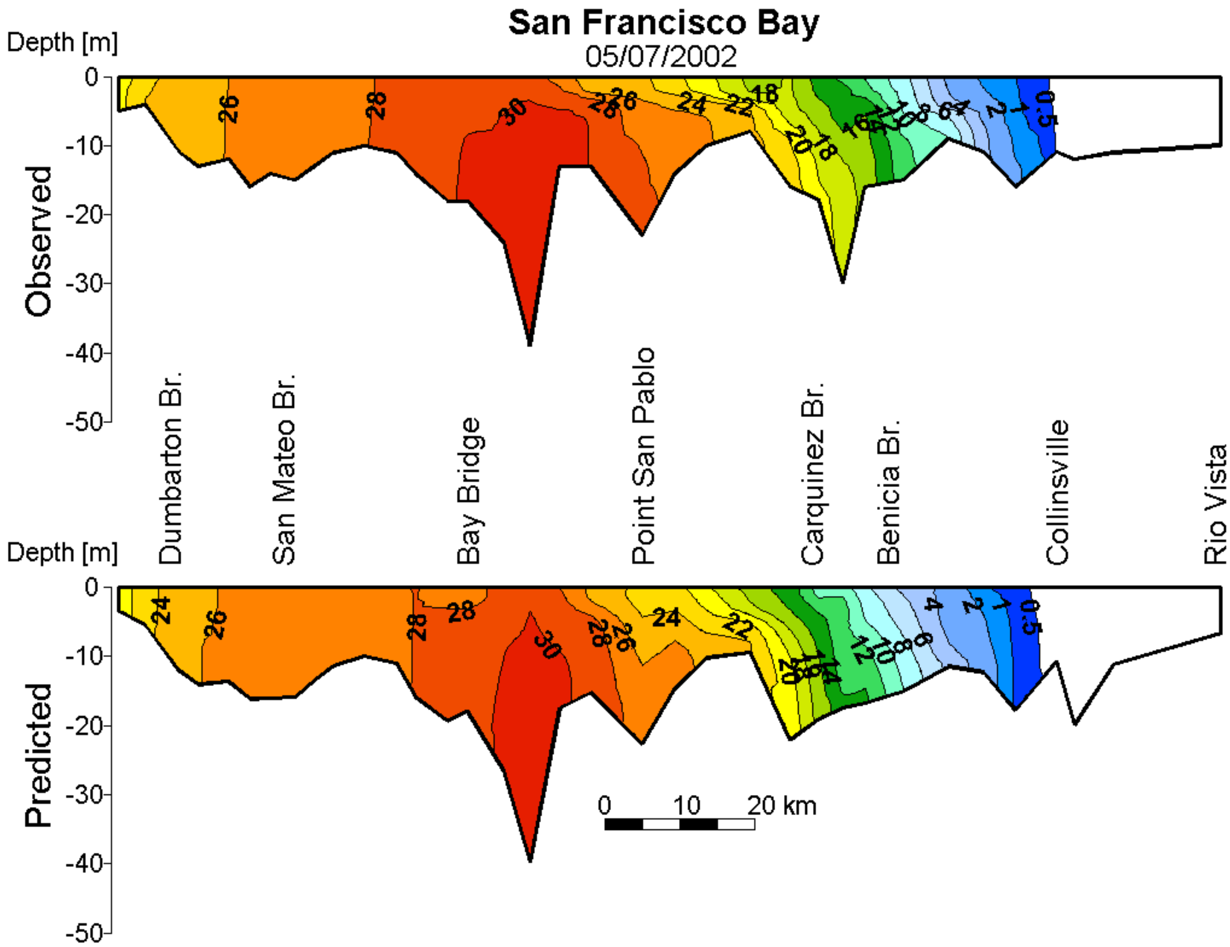


Figure A.5-3 Observed and predicted salinity profiles at synoptic sampling stations, interpolated along the axis of the San Francisco Estuary on May 7, 2002.

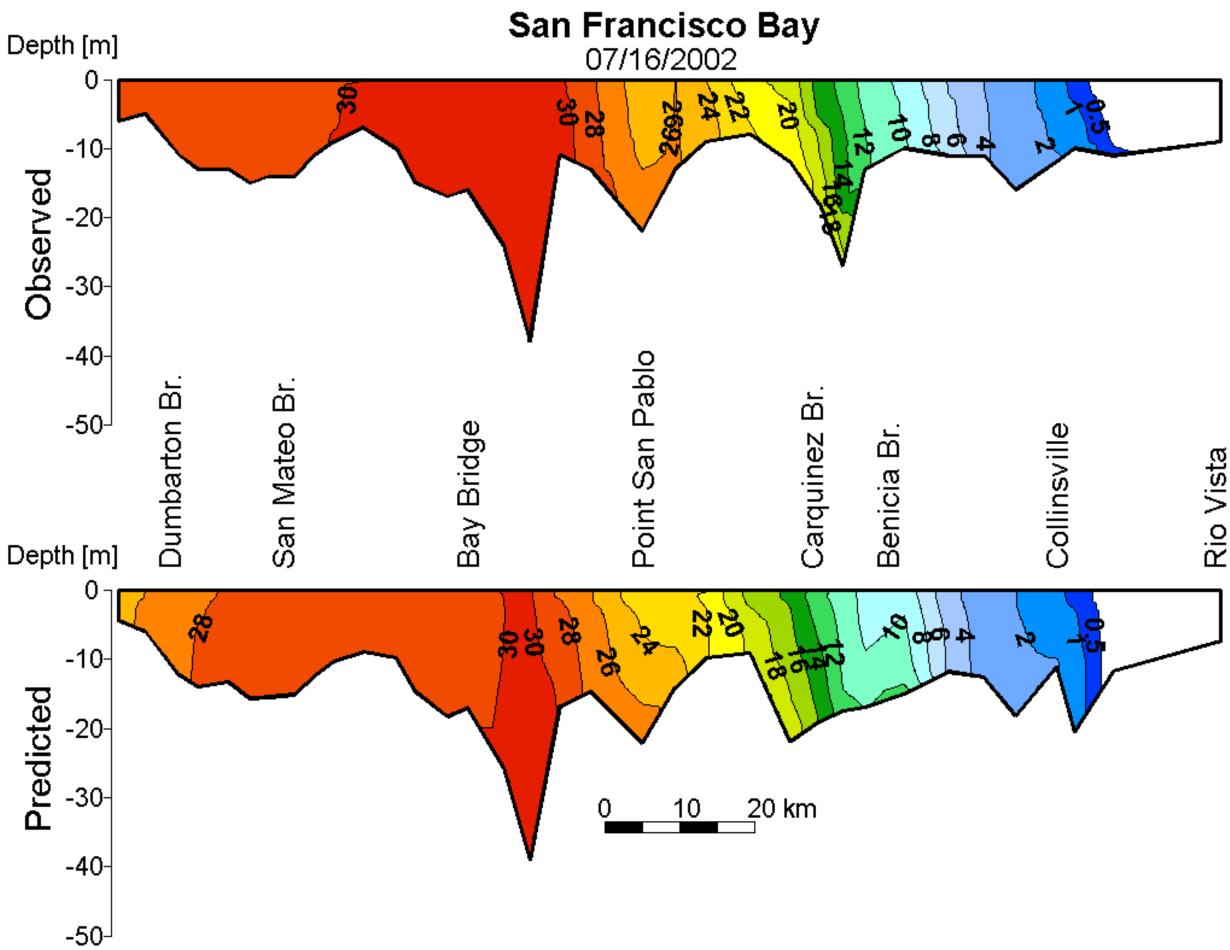


Figure A.5-4 Observed and predicted salinity profiles at synoptic sampling stations, interpolated along the axis of the San Francisco Estuary on July 16, 2002.

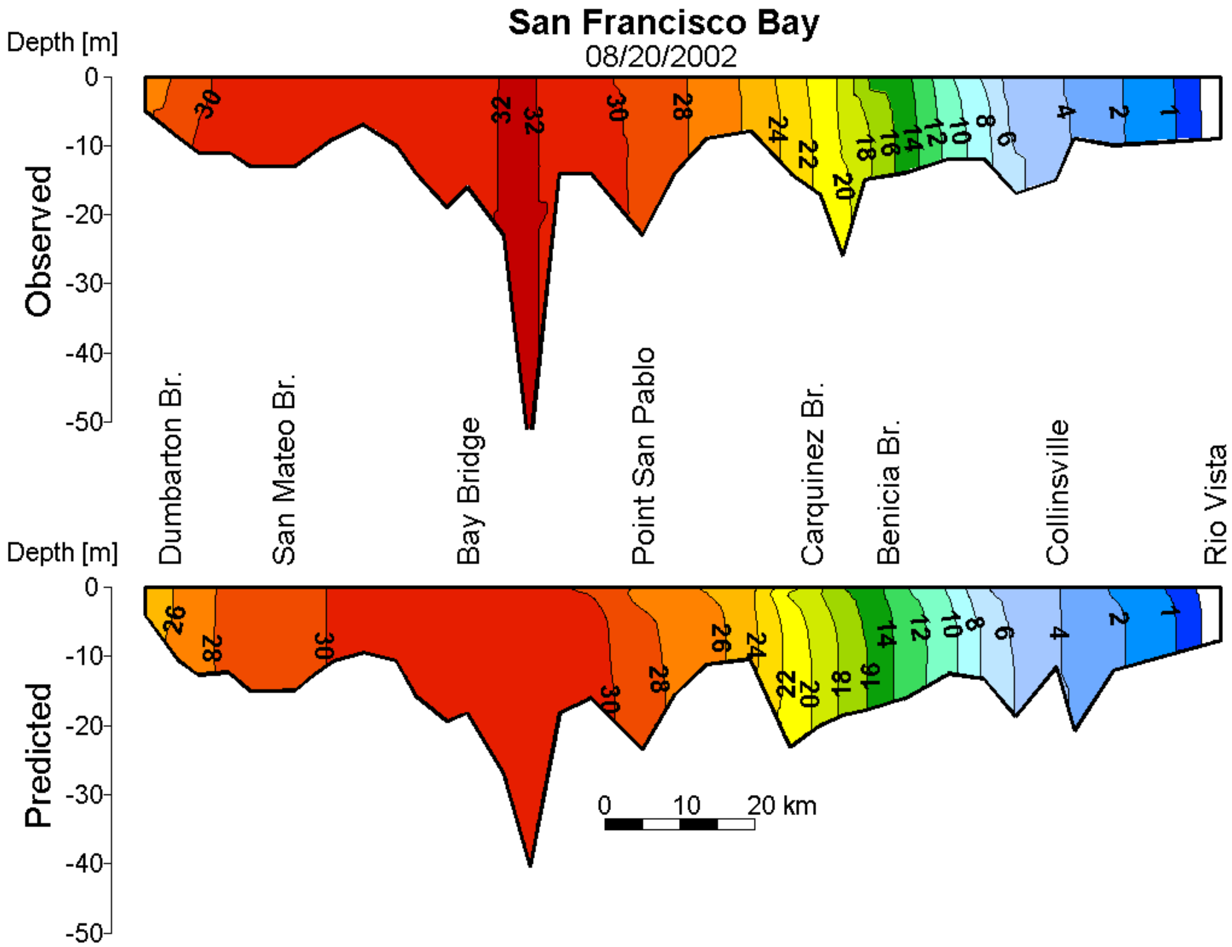


Figure A.5-5 Observed and predicted salinity profiles at synoptic sampling stations, interpolated along the axis of the San Francisco Estuary on August 20, 2002.

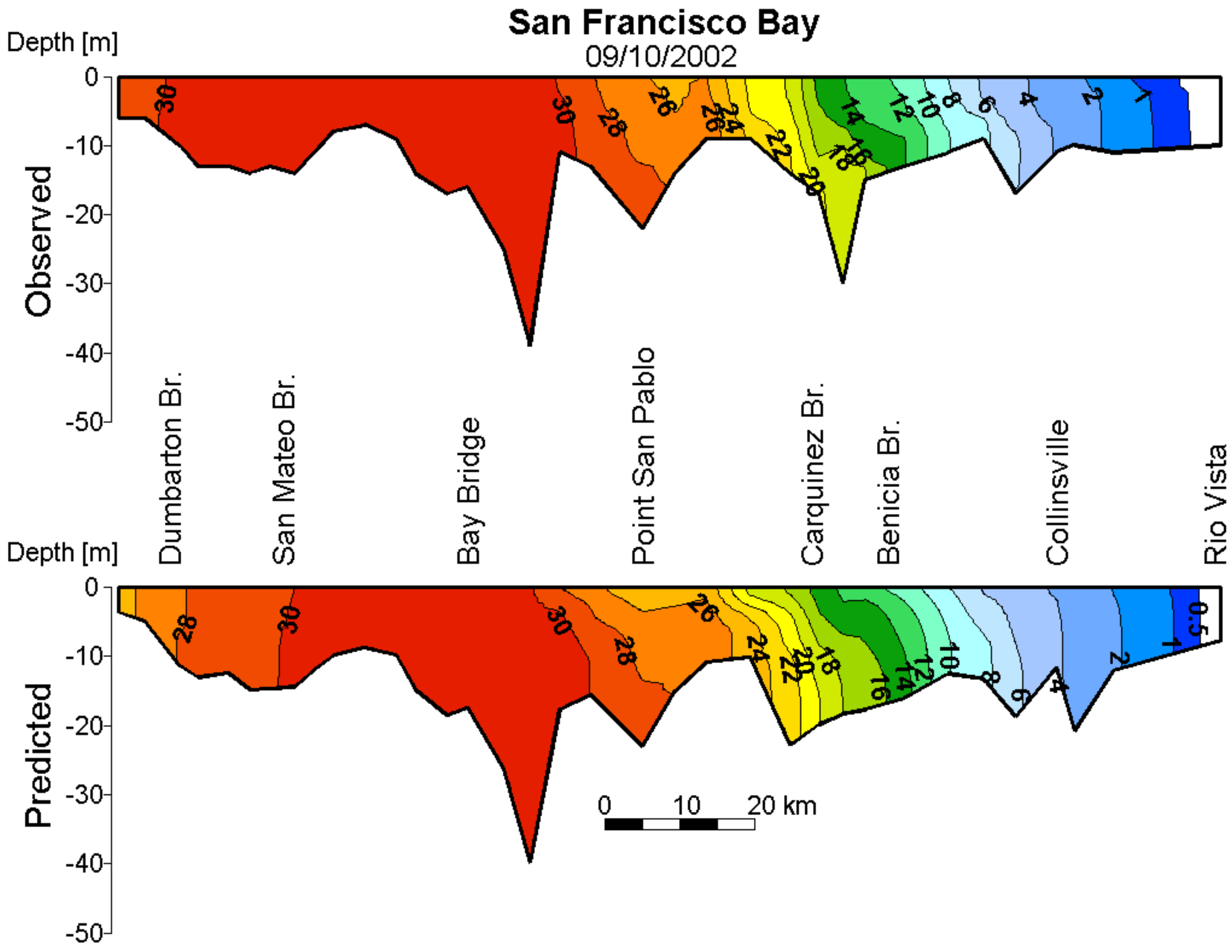


Figure A.5-6 Observed and predicted salinity profiles at synoptic sampling stations, interpolated along the axis of the San Francisco Estuary on September 10, 2002.

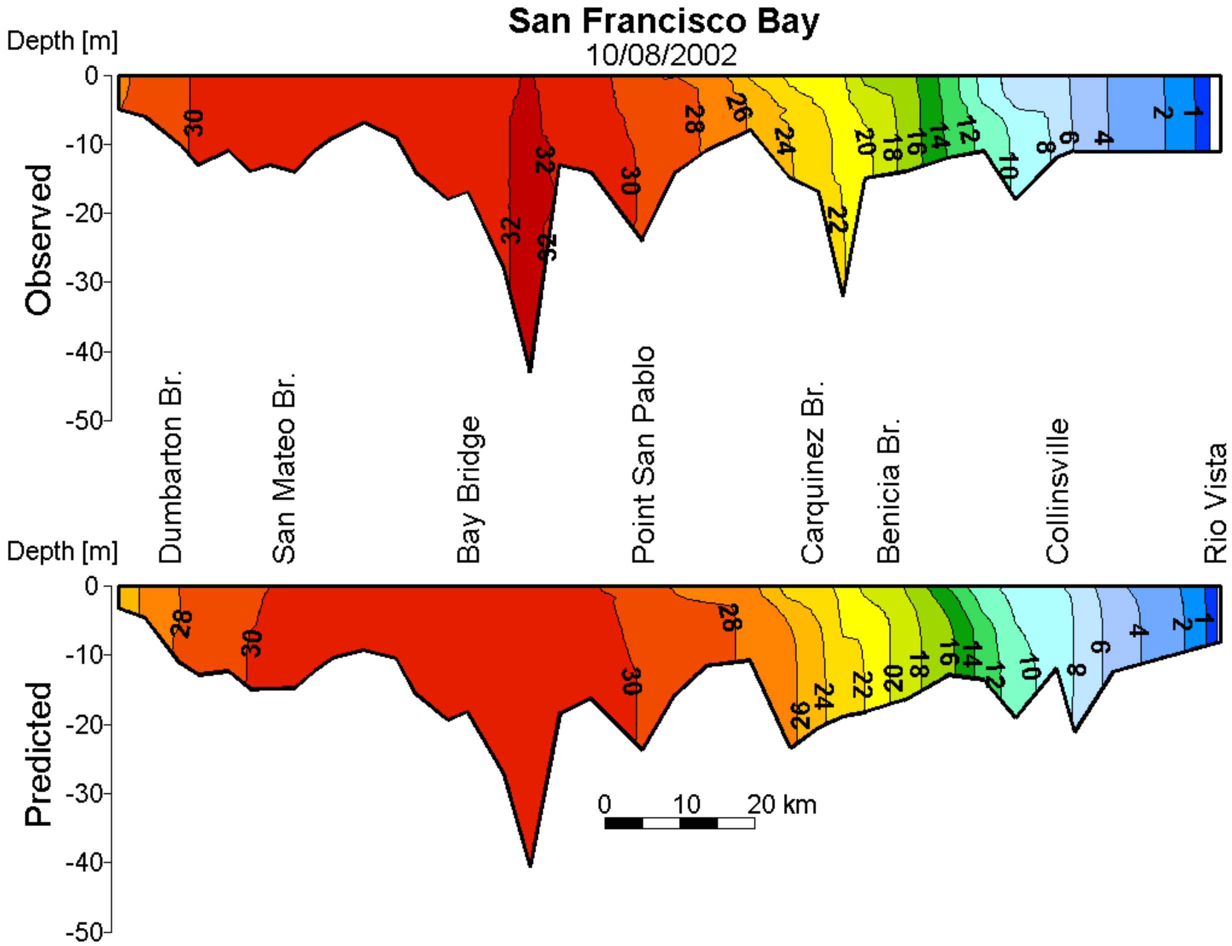


Figure A.5-7 Observed and predicted salinity profiles at synoptic sampling stations, interpolated along the axis of the San Francisco Estuary on October 8, 2002.

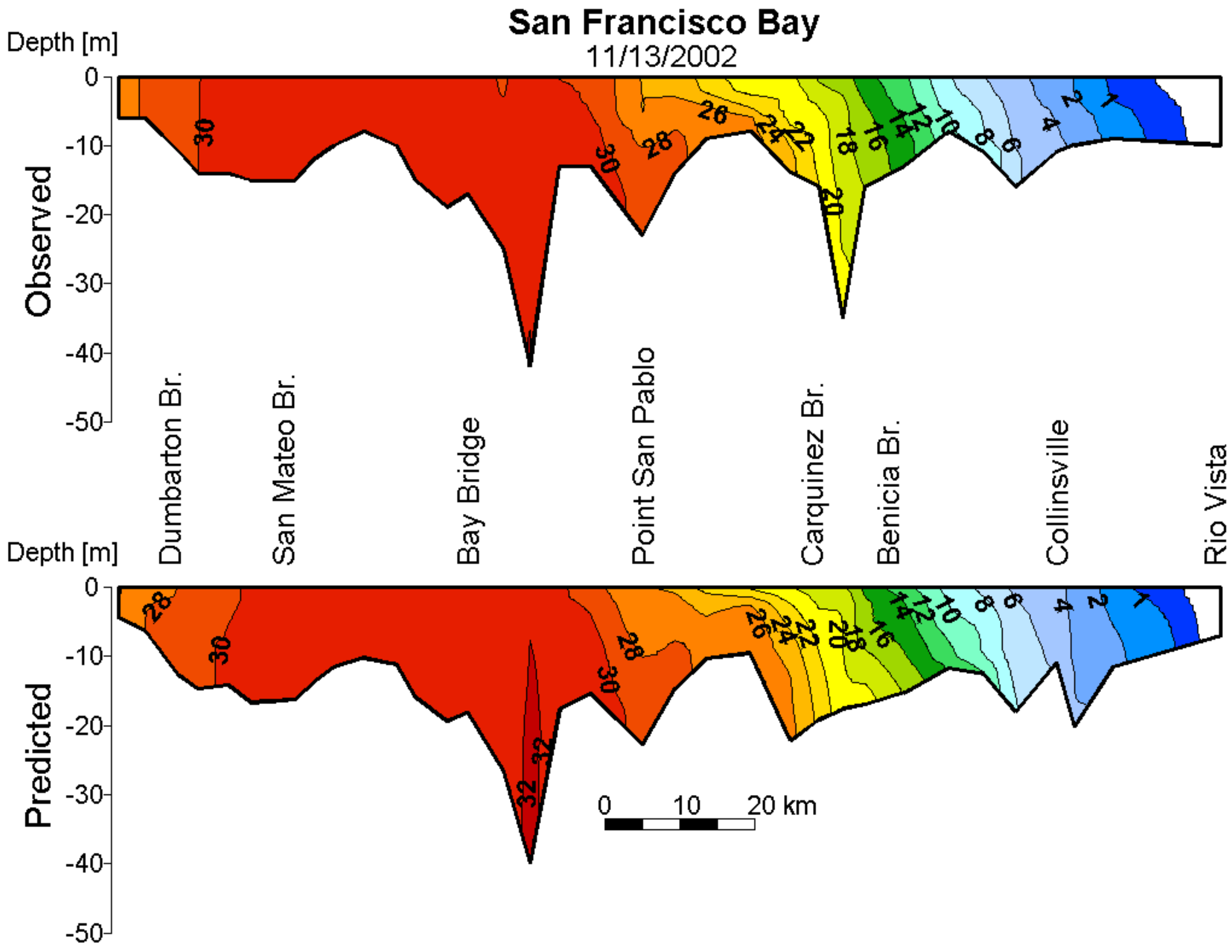


Figure A.5-8 Observed and predicted salinity profiles at synoptic sampling stations, interpolated along the axis of the San Francisco Estuary on November 13, 2002.

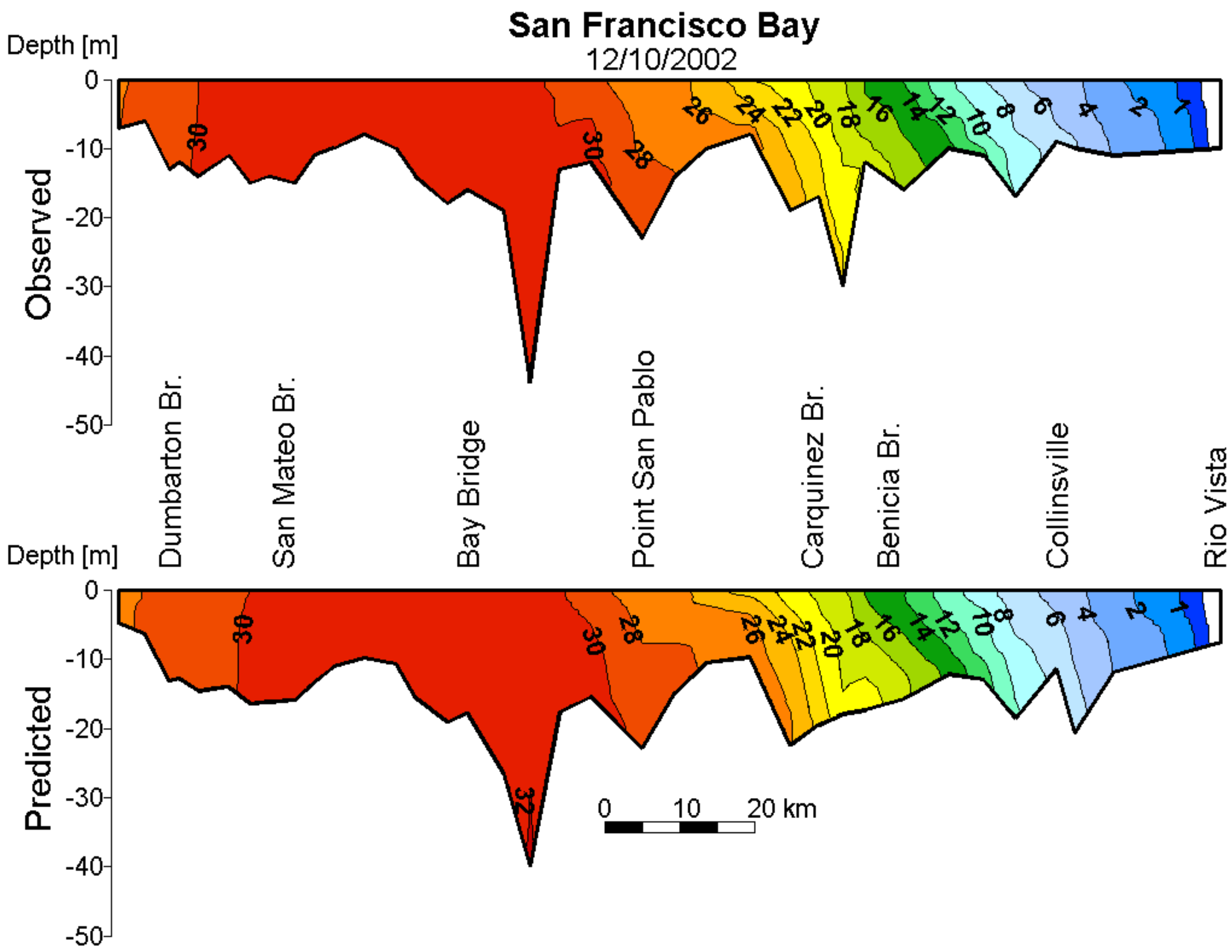


Figure A.5-9 Observed and predicted salinity profiles at synoptic sampling stations, interpolated along the axis of the San Francisco Estuary on December 10, 2002.

A.6 Salinity Comparison Figures

Observed and predicted salinity were compared at twenty-two locations in San Francisco Bay and at thirty-seven stations in the Sacramento-San Joaquin Delta during the 2002 simulation period. At each station (and at multiple depths at some stations), observed and predicted salinity were plotted over a fifteen day period to show the water level agreement over tidal time scales. In addition, the observed and predicted salinity are tidally averaged, to assess the accuracy of the model in predicting water level variability on spring-neap time scales, as well as during non-tidal forcing such as storms. Lastly, the cross-correlation (as described in Section A.1) was used to determine the mean observed and predicted salinity, the amplitude ratio, the phase lag, and the correlation coefficient squared (R^2). For each of the salinity monitoring stations, these values are compiled in Table A-4.

A.6.1 San Francisco Bay

Salinity comparisons were made at twenty-two continuous monitoring stations in the San Francisco Estuary, at the locations shown in Figure A.6-1. Salinity comparisons at these stations are shown in Figures A.6-2 through A.6-23.

A.6.2 Northern Sacramento-San Joaquin Delta

Salinity comparisons were made at three continuous monitoring stations in the northern portion of the Sacramento-San Joaquin Delta, at the locations shown in Figure A.6-24. Salinity comparisons at these stations are shown in Figures A.6-25 through A.6-27.

A.6.3 Central Sacramento-San Joaquin Delta

Salinity comparisons were made at twenty-three continuous monitoring stations in the central portion of the Sacramento-San Joaquin Delta, at the locations shown in Figure A.6-28. Salinity at these stations are shown in Figures A.6-29 through A.6-51.

A.6.4 Southern Sacramento-San Joaquin Delta

Salinity comparisons were made at eleven continuous monitoring stations in the southern portion of the Sacramento-San Joaquin Delta, at the locations shown in Figure A.6-52. Salinity comparisons at these stations are shown in Figures A.6-53 through A.6-63.

Table A-4 Predicted and observed salinity and cross-correlation statistics for salinity monitoring stations in San Francisco Bay and the Sacramento-San Joaquin Delta during the 2002 simulation period.

Location	Data Source	Figure Number	Mean Salinity		Cross Correlation		R^2
			Observed (psu)	Predicted (psu)	Amp Ratio	Lag (min)	

2002 San Francisco Bay Salinity Stations (Figure A.6-1)							
Presidio	USGS	A.6-2	30.6	30.6	0.667	-36	0.892
Pier 24 (Lower Sensor)	USGS	A.6-3	26.9	27.9	0.762	9	0.780
Pier 24 (Upper Sensor)	USGS	A.6-4	26.3	27.2	0.749	5	0.817
San Mateo Bridge (Lower Sensor)	USGS	A.6-5	27.5	28.1	0.750	17	0.983
San Mateo Bridge (Upper Sensor)	USGS	A.6-6	26.6	27.4	0.767	6	0.971
Point San Pablo (Lower Sensor)	USGS	A.6-7	25.3	25.6	0.781	14	0.925
Point San Pablo (Upper Sensor)	USGS	A.6-8	25.2	25.0	0.839	12	0.924
Channel Marker 9	USGS	A.6-9	18.5	18.7	0.856	12	0.932
Mare Island Causeway (Lower Sensor)	USGS	A.6-10	16.0	13.6	1.065	44	0.881
Mare Island Causeway (Upper Sensor)	USGS	A.6-11	14.9	13.5	1.047	35	0.944
Carquinez Bridge (Lower Sensor)	USGS	A.6-12	17.8	18.3	0.794	25	0.880
Carquinez Bridge (Upper Sensor)	USGS	A.6-13	17.3	18.6	0.893	-8	0.917
Sacramento River at Martinez (Bottom Sensor)	DWR	A.6-14	13.8	13.9	0.930	33	0.950
Sacramento River at Martinez (Surface Sensor)	DWR	A.6-15	11.4	10.8	0.961	-25	0.937
Benicia Bridge (Lower Sensor)	USGS	A.6-16	14.0	14.6	0.720	52	0.877
Benicia Bridge (Upper Sensor)	USGS	A.6-17	12.6	12.5	0.988	6	0.953
Sacramento River at Port Chicago (Bottom Sensor)	USBR	A.6-18	7.59	7.63	0.972	-54	0.962
Sacramento River at Port Chicago (Surface Sensor)	USBR	A.6-19	6.79	5.99	0.895	-71	0.941
Sacramento River near Mallard Island (Bottom Sensor)	DWR	A.6-20	3.65	4.03	1.118	24	0.974
Sacramento River near Mallard Island (Surface Sensor)	DWR	A.6-21	3.35	3.42	1.043	34	0.975
Sacramento River at Pittsburgh (Bottom Sensor)	USBR	A.6-22	2.86	3.01	0.966	-23	0.907
Sacramento River at Pittsburgh (Surface Sensor)	USBR	A.6-23	2.84	2.90	1.064	-12	0.960
2002 North Delta Salinity Stations (Figure A.6-24)							
Mokelumne River below Snodgrass Slough	DWR	A.6-25	0.08	0.08	0.139	-26	0.179
Sacramento River at Green's Landing	USBR	A.6-26	0.07	0.07	0.887	n/a*	0.905
Sacramento River at Hood	DWR	A.6-27	0.08	0.07	0.812	n/a*	0.914
2002 Central Delta Salinity Stations (Figure A.6-28)							
Sacramento River at Collinsville	USBR	A.6-29	1.88	2.03	0.955	-20	0.898

Sacramento River at Emmaton (Bottom Sensor)	USBR	A.6-30	0.33	0.33	1.170	1	0.964
Sacramento River at Emmaton (Surface Sensor)	USBR	A.6-31	0.40	0.46	1.282	-7	0.942
Sacramento River at Rio Vista	USBR	A.6-32	0.10	0.10	1.684	-7	0.760
Threemile Slough at San Joaquin River	DWR	A.6-33	0.24	0.21	0.940	-4	0.852

San Joaquin River at Antioch (Bottom Sensor)	DWR	A.6-34	0.82	0.66	0.875	8	0.987
San Joaquin River at Antioch (Surface Sensor)	DWR	A.6-35	0.73	0.63	0.882	-38	0.989
San Joaquin River at Jersey Point	USBR	A.6-36	0.40	0.30	0.807	-24	0.948
Dutch Slough at Jersey Island	USBR	A.6-37	0.33	0.29	0.752	-54	0.950
False River	USGS	A.6-38	0.25	0.17	0.573	28	0.961
Taylor Slough	USGS	A.6-39	0.22	0.18	0.704	38	0.966
Sand Mound Slough	USGS	A.6-40	0.20	0.19	0.905	-67	0.944
Piper Slough at Bethel	DWR	A.6-41	0.25	0.16	0.489	-20	0.960
San Joaquin River at San Andreas Landing	USBR	A.6-42	0.12	0.10	0.500	4	0.774
Old River at San Joaquin River	USGS	A.6-43	0.13	0.10	0.118	n/a*	0.125
San Joaquin River before Prisoner's Point	DWR	A.6-44	0.11	0.10	0.910	-99	0.942
Mokelumne River near San Joaquin River	USGS	A.6-45	0.07	0.07	0.819	-5	0.874
Mokelumne River (South Fork) at Staten Island	USBR	A.6-46	0.07	0.08	0.356	n/a*	0.534
Franks Tract West	USGS	A.6-47	0.20	0.14	0.423	37	0.954
Franks Tract East	USGS	A.6-48	0.19	0.14	0.425	117	0.930
Holland Cut	USGS	A.6-49	0.18	0.15	0.547	113	0.950
Old River near Mandeville Island	USGS	A.6-50	0.16	0.13	0.400	35	0.895
Old River and Holland Cut at Mandeville Island	USBR	A.6-51	0.22	0.16	0.522	n/a*	0.907
2001 South Delta Salinity Stations (Figure A.6-52)							
Old River at Bacon Island	USGS	A.6-53	0.16	0.15	0.657	68	0.844
Middle River at Borden Highway	DWR	A.6-54	0.21	0.16	0.242	-3	0.188
Middle River at Tracy Blvd	DWR	A.6-55	0.33	0.23	0.467	-110	0.463
Clifton Court Forebay Radial Gates	DWR	A.6-56	0.23	0.17	0.367	-8	0.637
Grant Line Canal at Tracy Blvd	DWR	A.6-57	0.39	0.33	1.083	6	0.926
Old River near Delta Mendota Canal (NW of Barrier)	DWR	A.6-58	0.35	0.24	0.182	-15	0.322
Old River near Delta Mendota Canal (SE of Barrier)	DWR	A.6-59	0.50	0.24	-0.445	-105	-0.294
Old River at Tracy Blvd	DWR	A.6-60	0.45	0.34	0.634	-110	0.733
Middle River near Old River	USBR	A.6-61	0.35	0.33	0.797	119	0.898
Stockton Ship Channel at Burns Cutoff	DWR	A.6-62	0.33	0.26	0.743	118	0.641
San Joaquin River at Mossdale	DWR	A.6-63	0.36	0.32	0.930	n/a*	0.966

* n/a indicates that the cross-correlation procedure did not identify a local maximum correlation coefficient within the four hour analysis window. This can be indicative of the data not having a strong tidal time-scale signal.

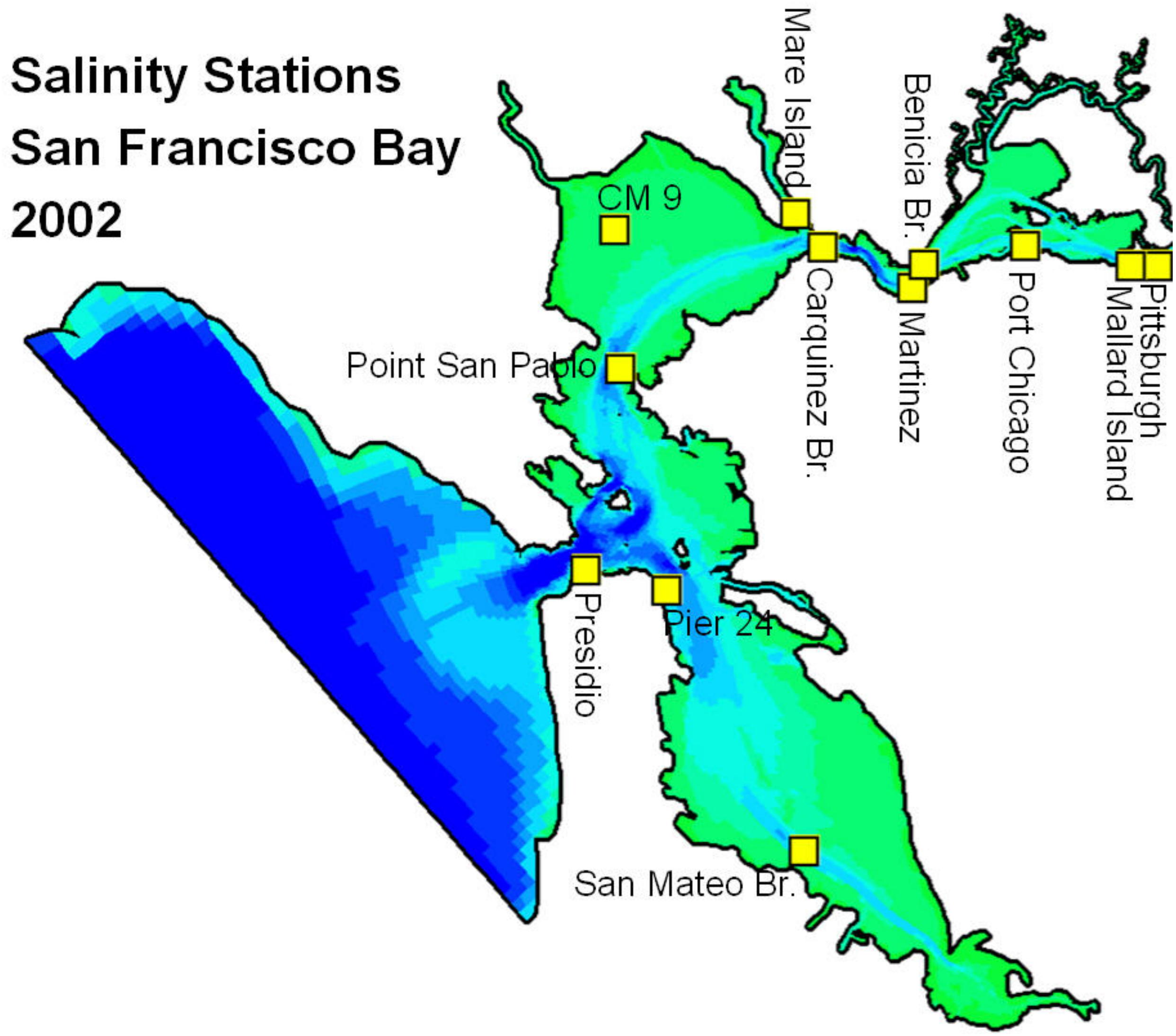


Figure A.6-1 Location of salinity monitoring stations in San Francisco Bay used for 2002 salinity comparisons.

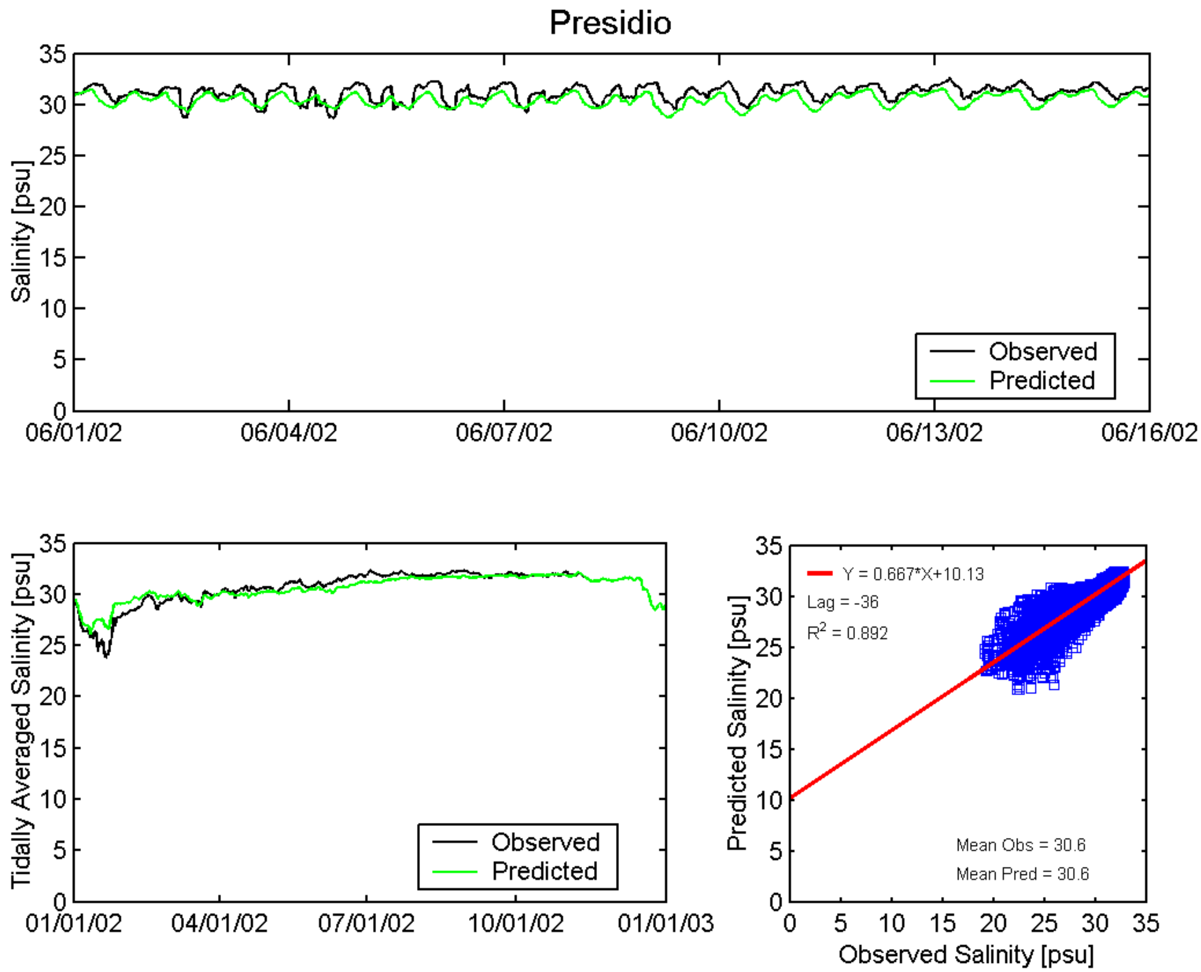


Figure A.6-2 Observed and predicted salinity at Presidio USGS station during the 2002 simulation period.

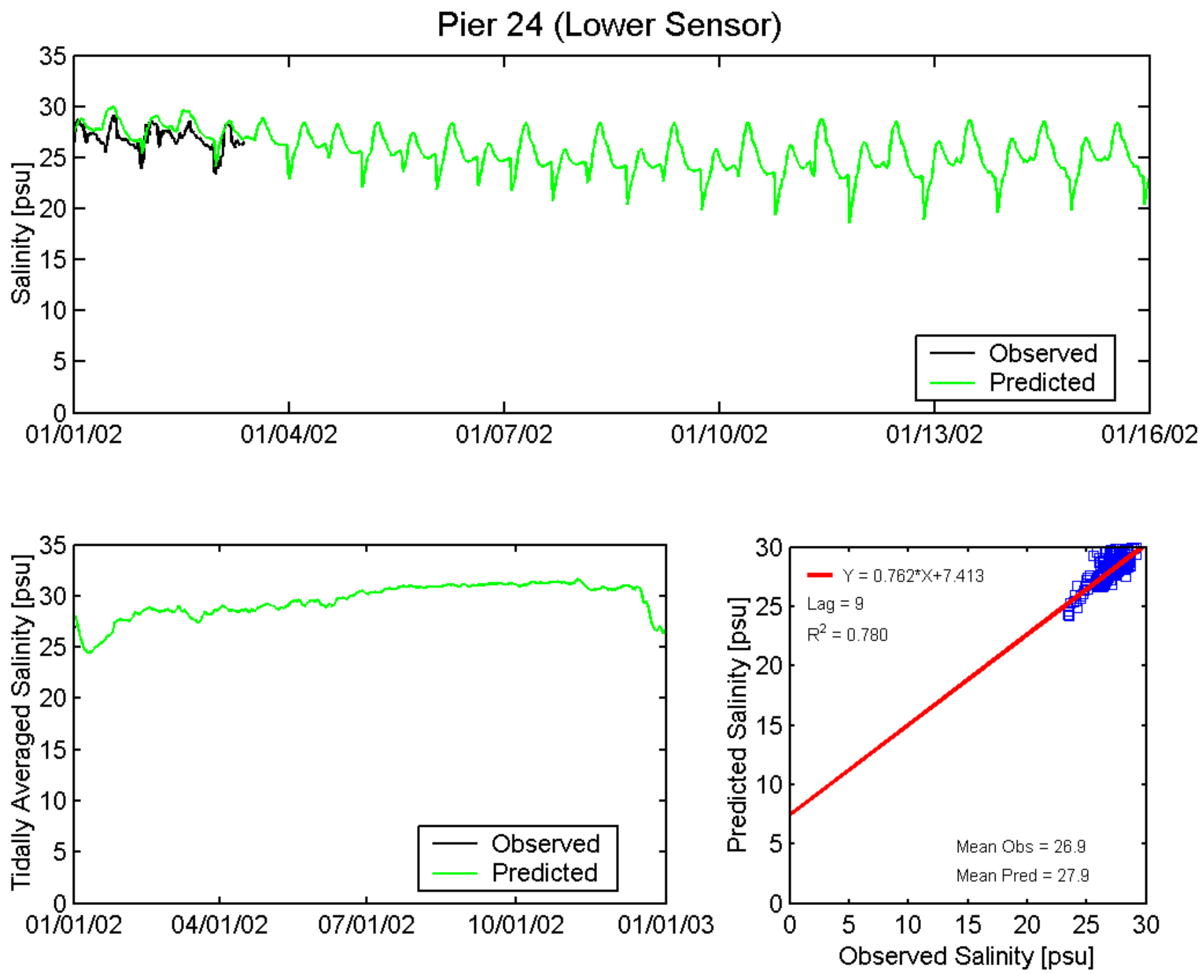


Figure A.6-3 Observed and predicted salinity at Pier 24 USGS station (Lower Sensor) during the 2002 simulation period.

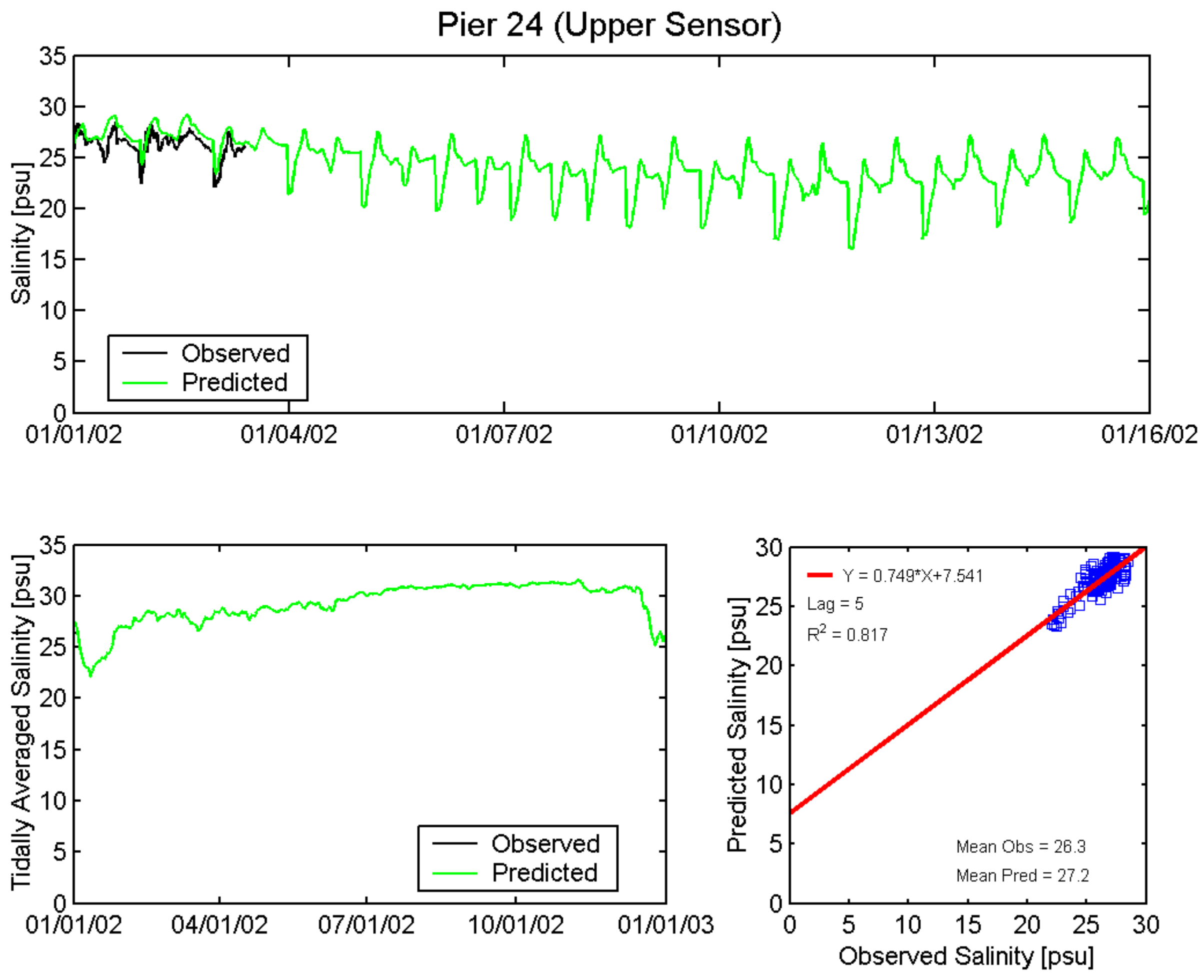


Figure A.6-4 Observed and predicted salinity at Pier 24 USGS station (Upper Sensor) during the 2002 simulation period.

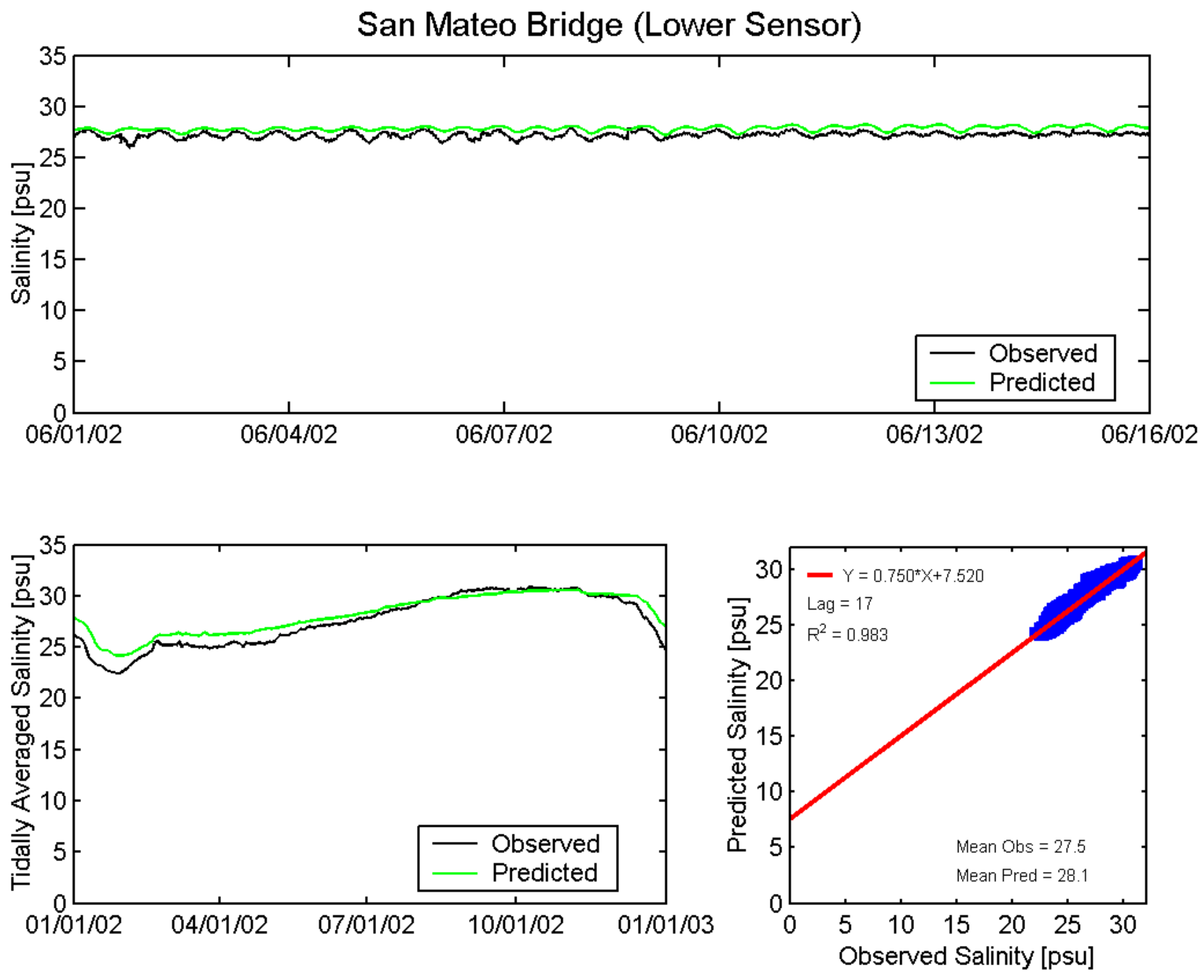


Figure A.6-5 Observed and predicted salinity at San Mateo Bridge USGS station (Lower Sensor) during the 2002 simulation period.

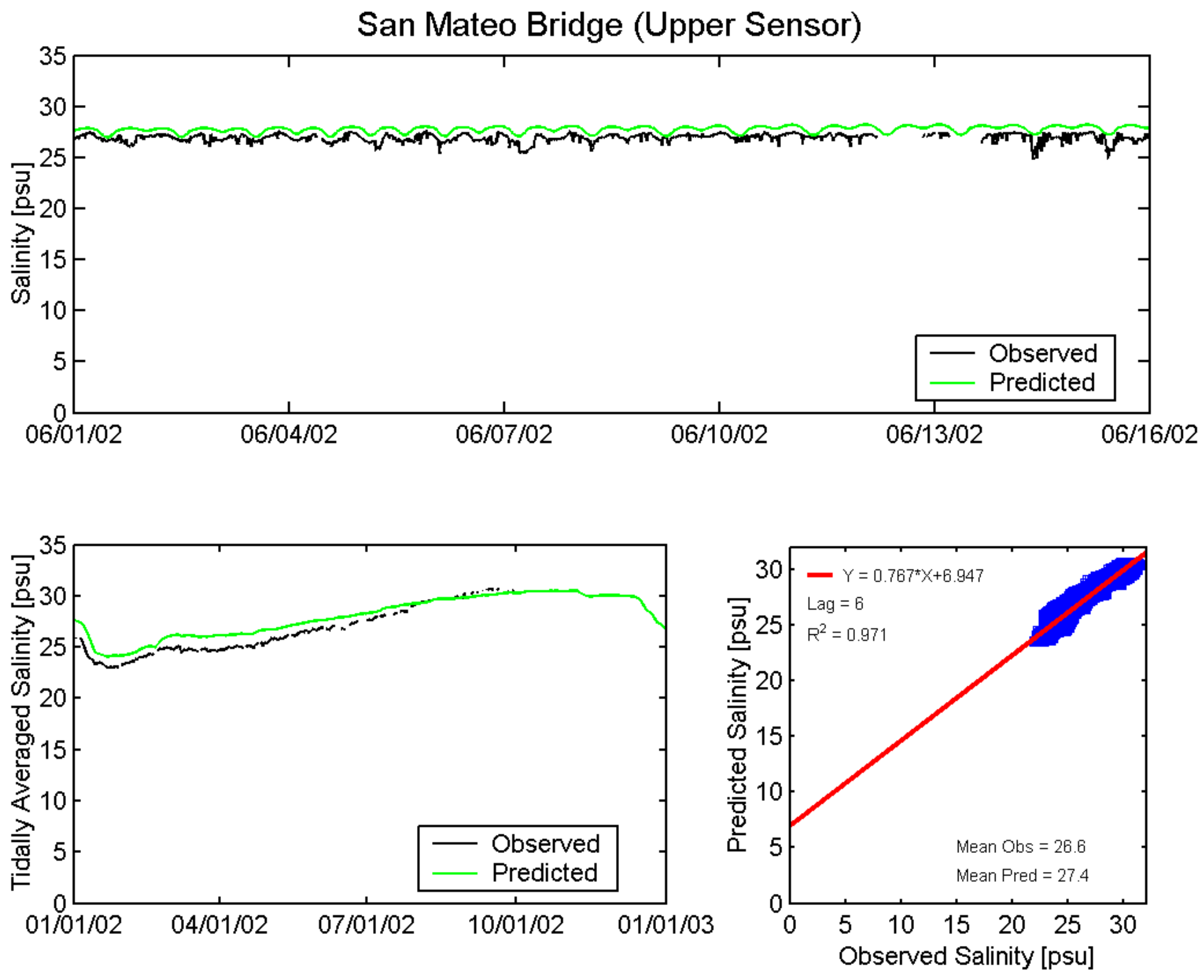


Figure A.6-6 Observed and predicted salinity at San Mateo Bridge USGS station (Upper Sensor) during the 2002 simulation period.

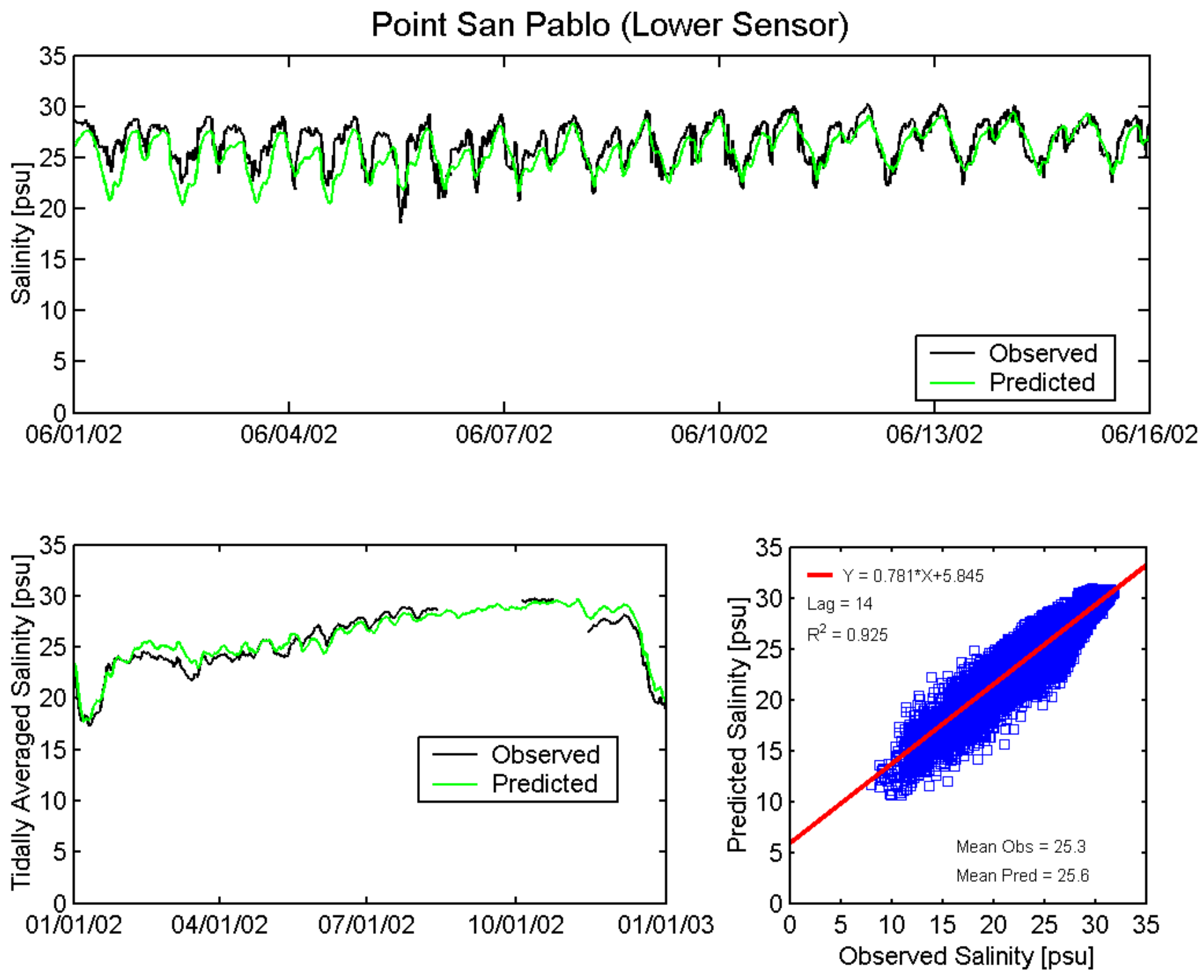


Figure A.6-7 Observed and predicted salinity at Point San Pablo USGS station (Lower Sensor) during the 2002 simulation period.

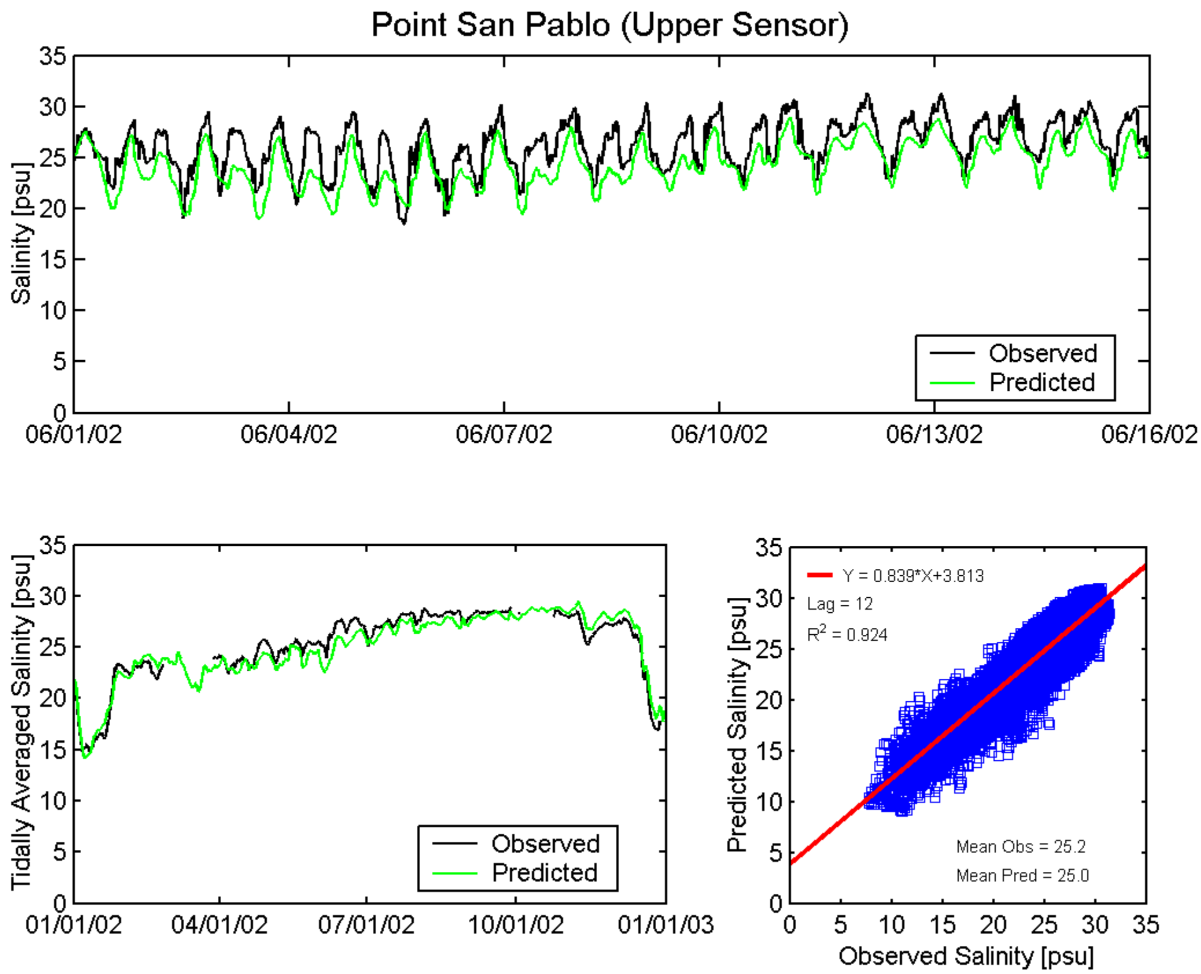


Figure A.6-8 Observed and predicted salinity at Point San Pablo USGS station (Upper Sensor) during the 2002 simulation period.

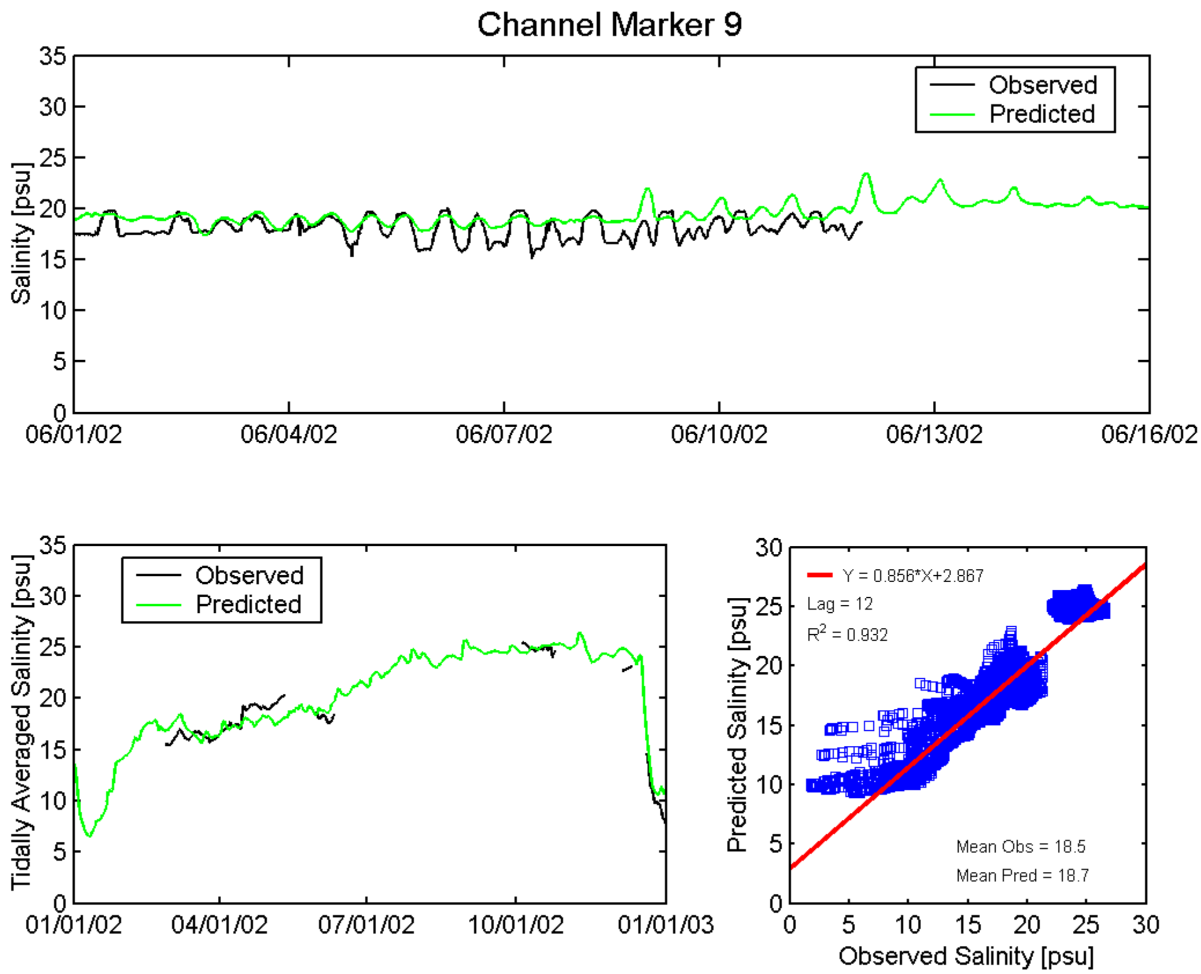


Figure A.6-9 Observed and predicted salinity at Channel Marker 9 USGS station during the 2002 simulation period.

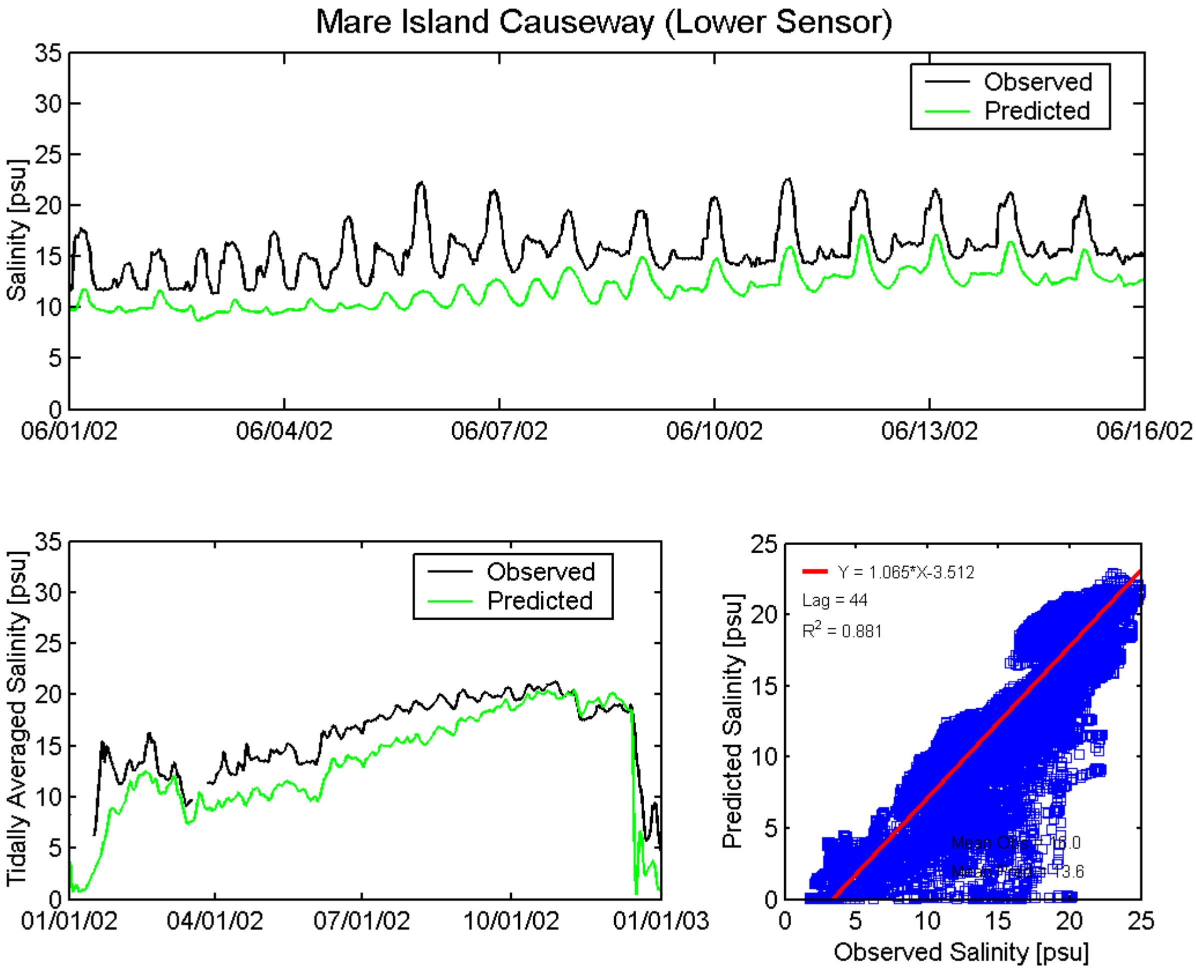


Figure A.6-10 Observed and predicted salinity at Mare Island Causeway USGS station (Lower Sensor) during the 2002 simulation period.

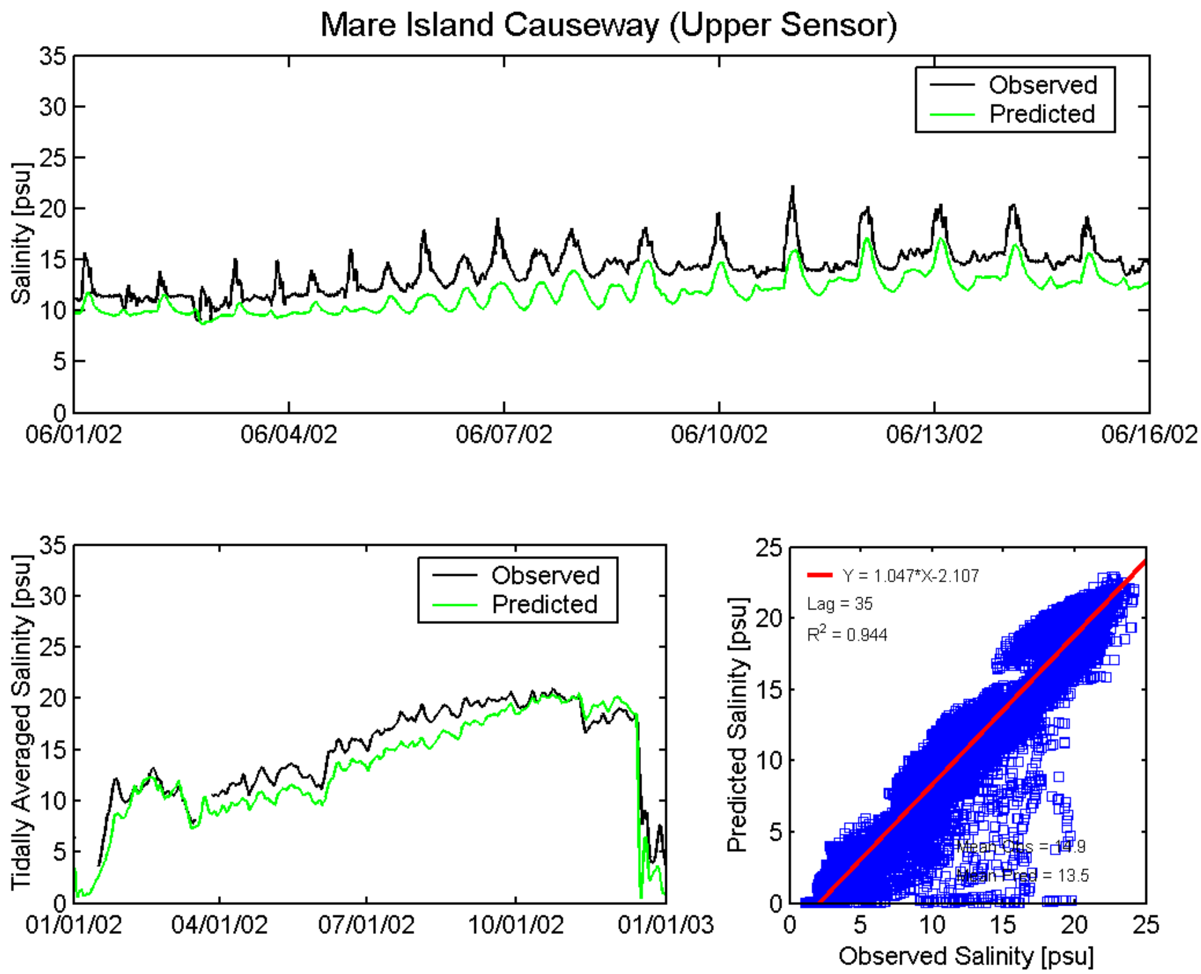


Figure A.6-11 Observed and predicted salinity at Mare Island Causeway USGS station (Upper Sensor) during the 2002 simulation period.

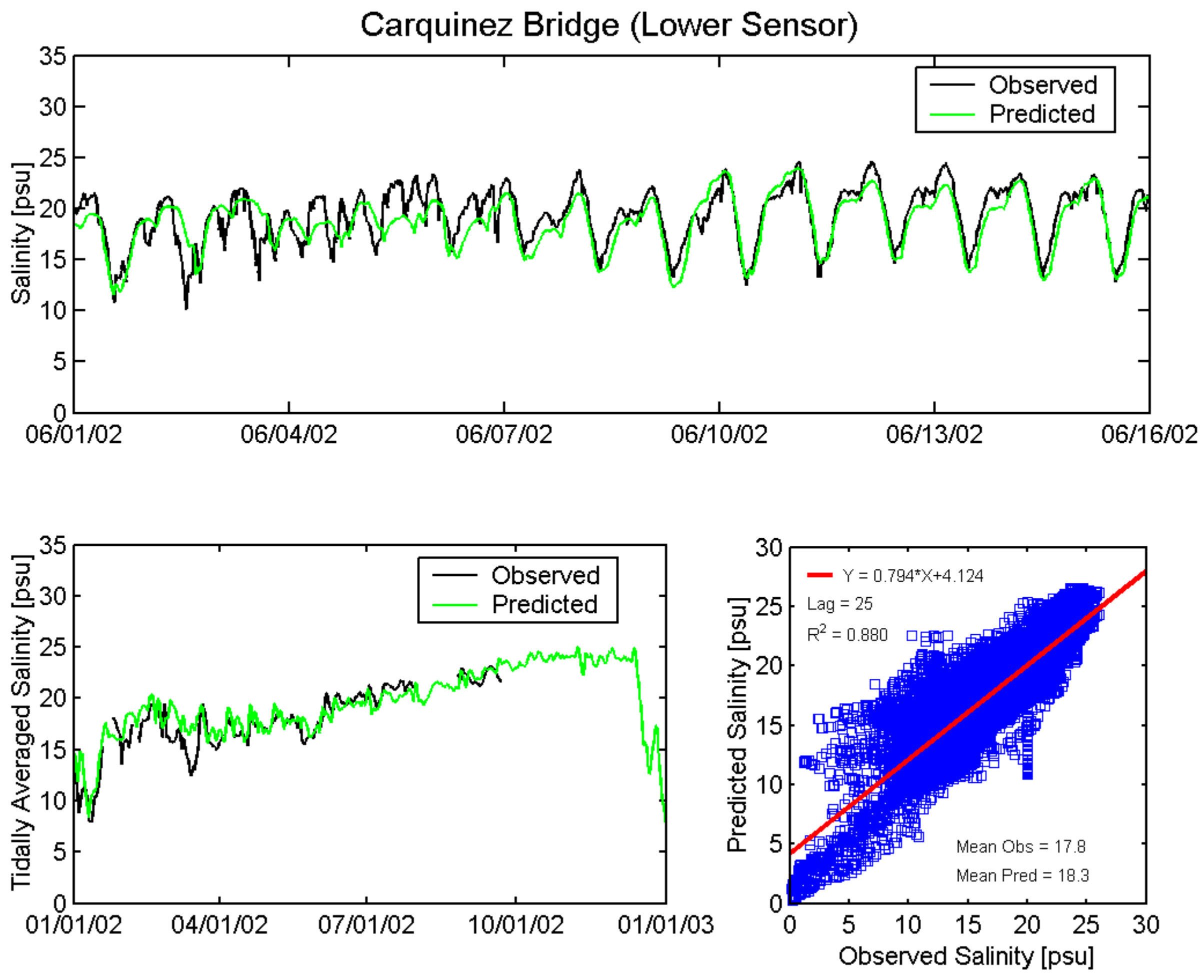


Figure A.6-12 Observed and predicted salinity at Carquinez Bridge USGS station (Lower Sensor) during the 2002 simulation period.

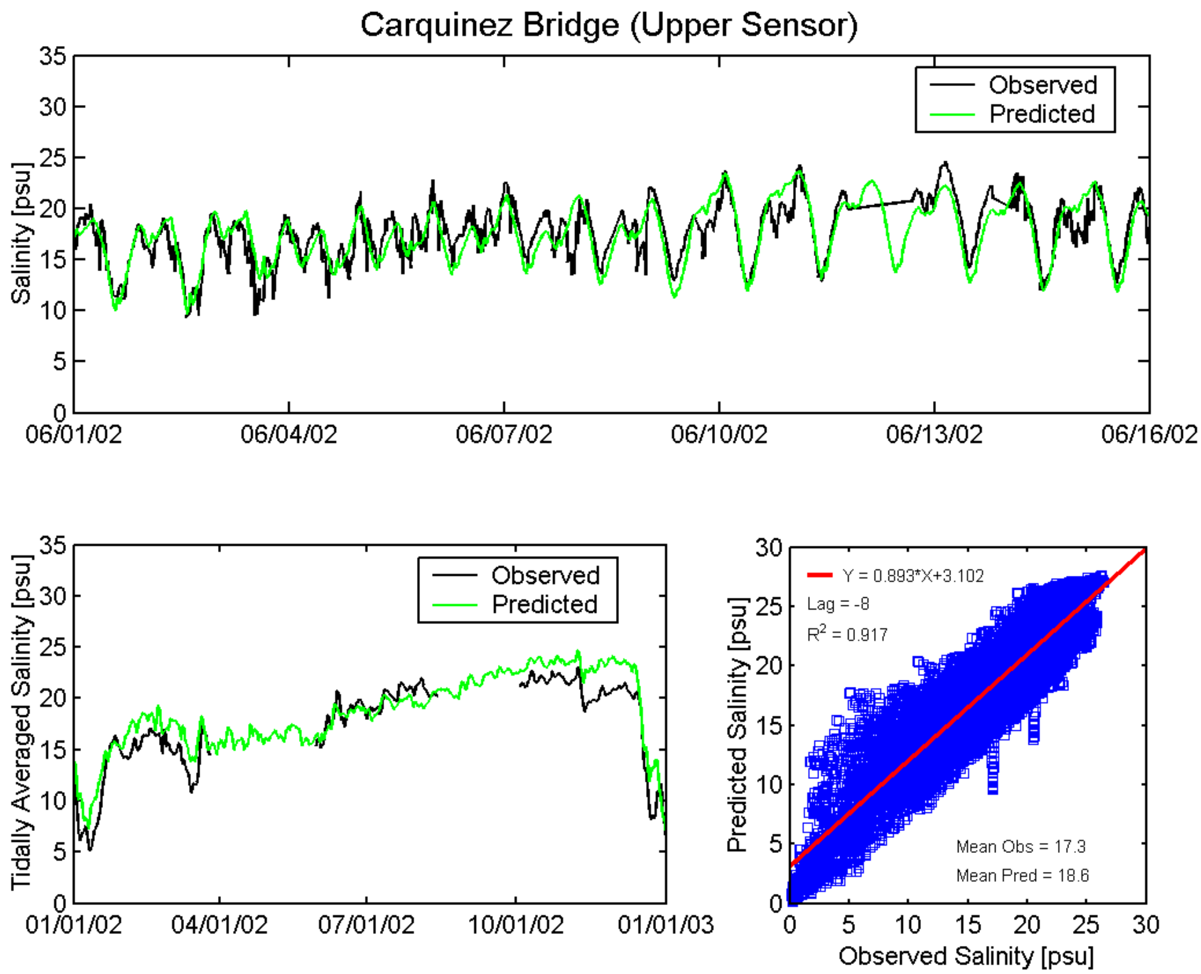


Figure A.6-13 Observed and predicted salinity at Carquinez Bridge USGS station (Upper Sensor) during the 2002 simulation period.

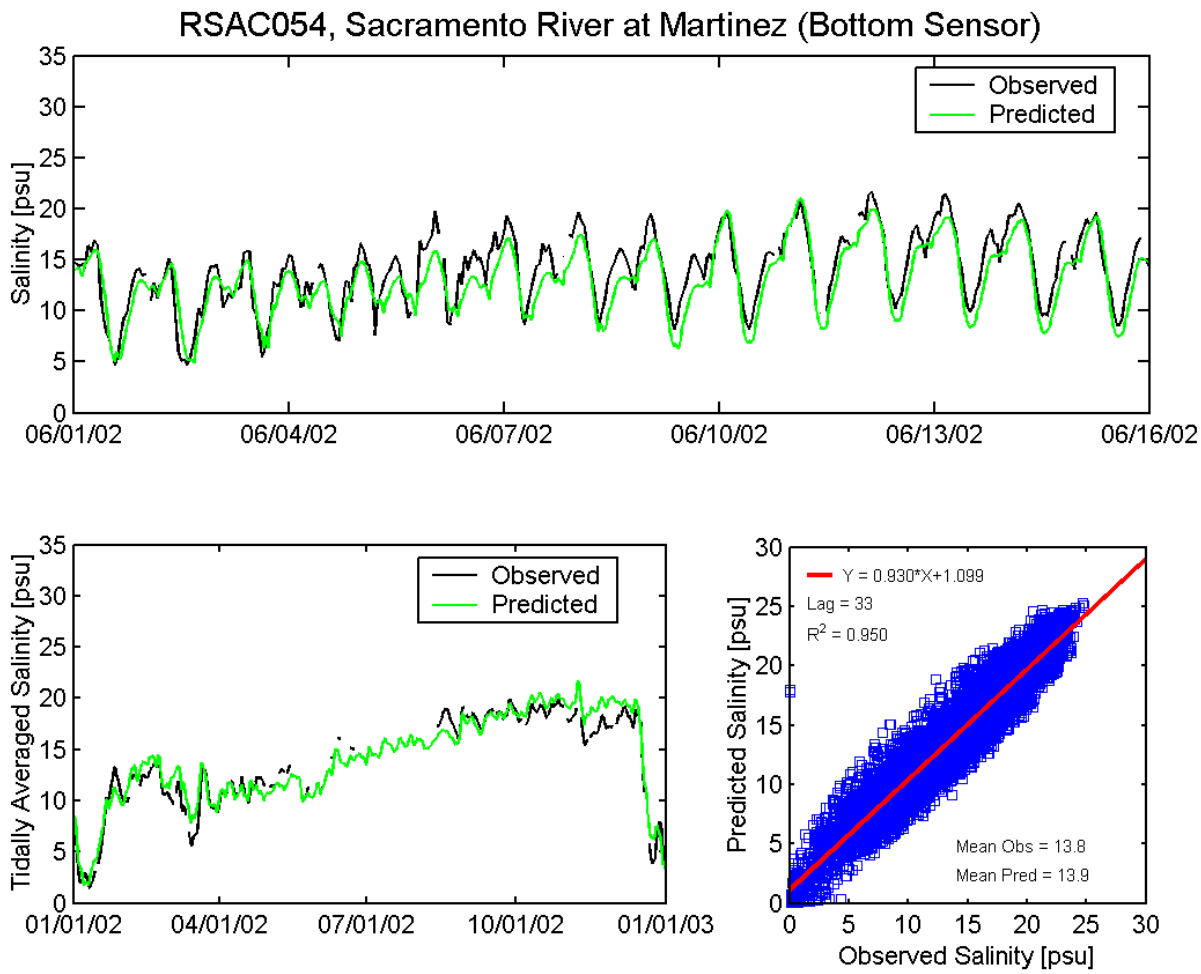


Figure A.6-14 Observed and predicted salinity at Sacramento River at Martinez (Bottom Sensor) DWR station (RSAC054) during the 2002 simulation period.

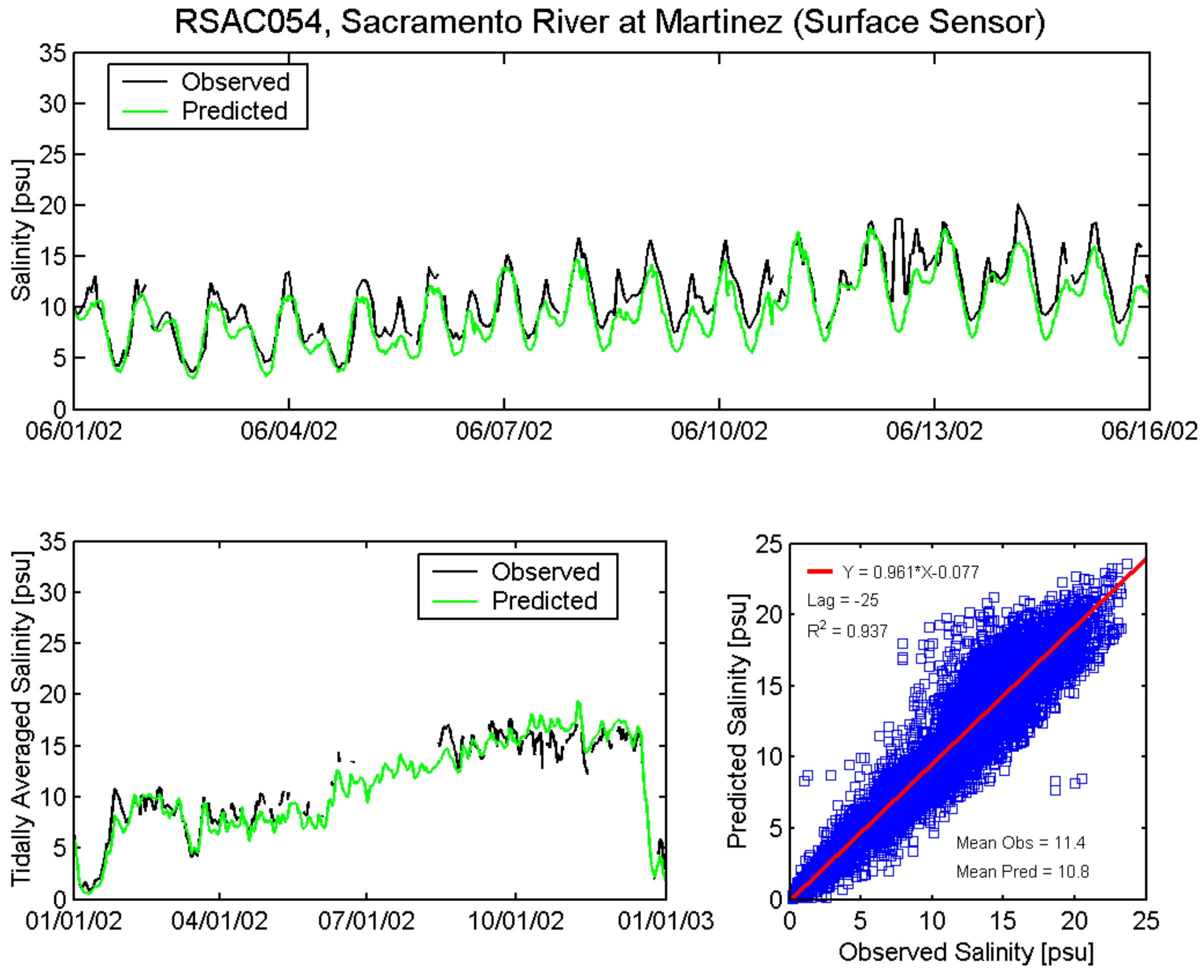


Figure A.6-15 Observed and predicted salinity at Sacramento River at Martinez (Surface Sensor) DWR station (RSAC054) during the 2002 simulation period.

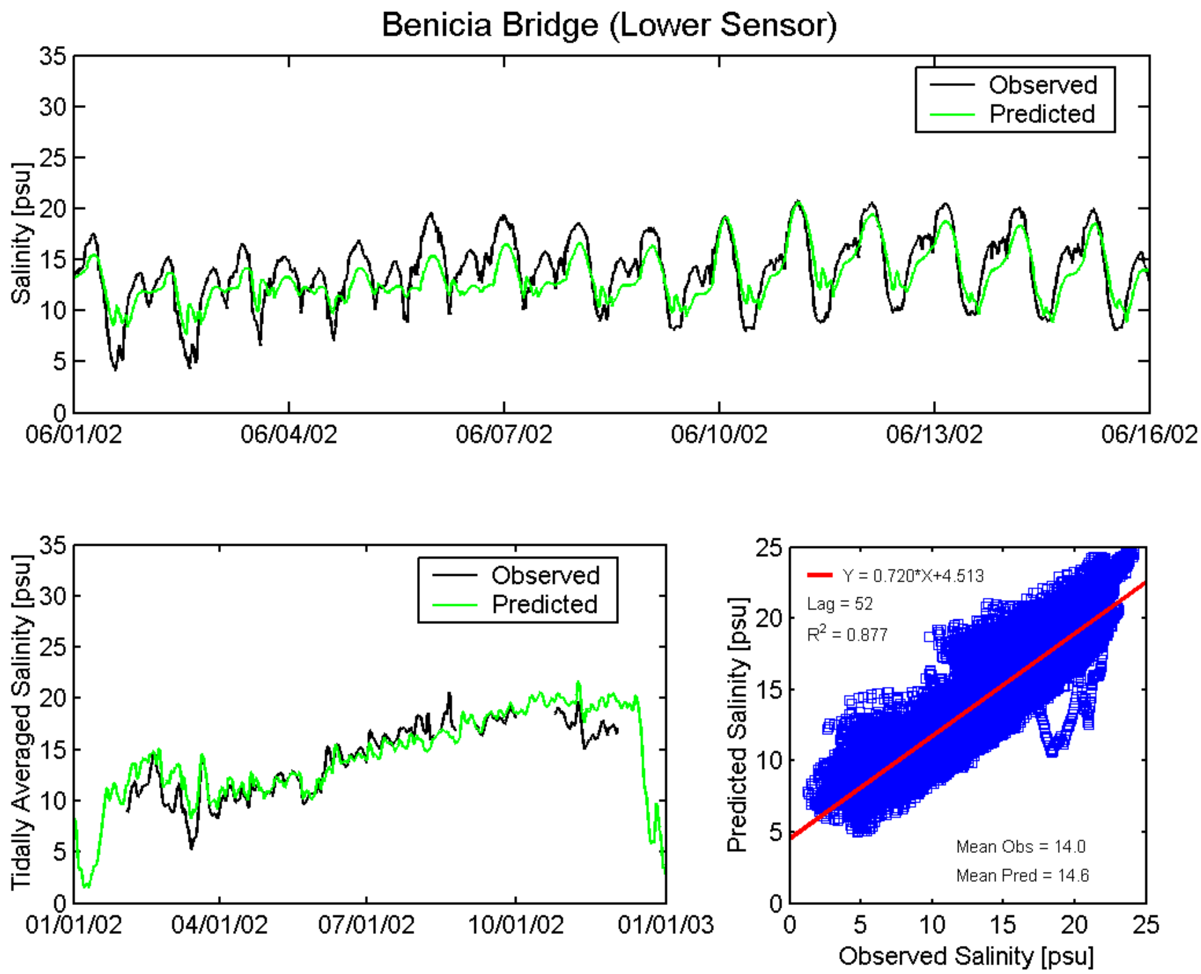


Figure A.6-16 Observed and predicted salinity at Benicia Bridge (Lower Sensor) USGS station during the 2002 simulation period.

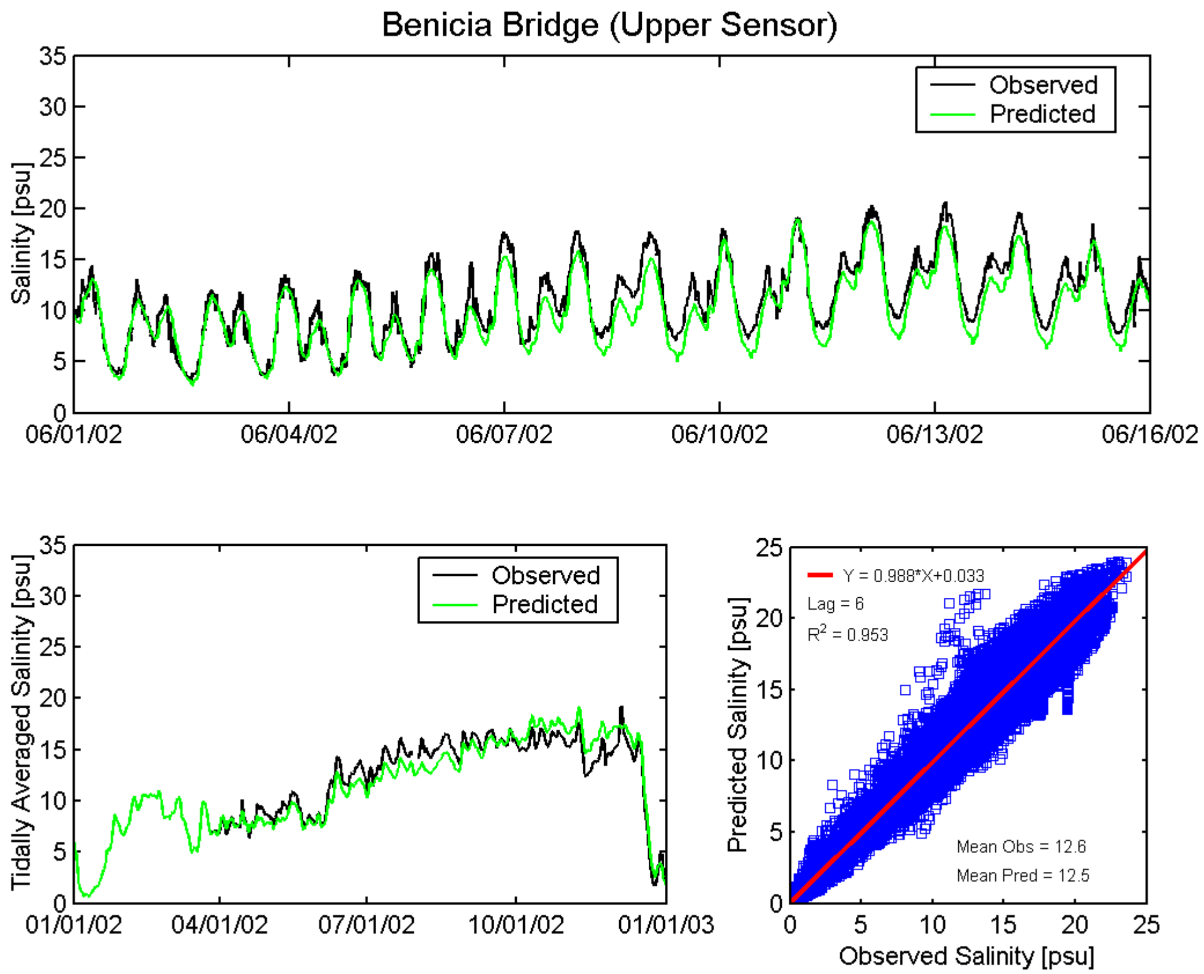


Figure A.6-17 Observed and predicted salinity at Benicia Bridge (Upper Sensor) USGS station during the 2002 simulation period.

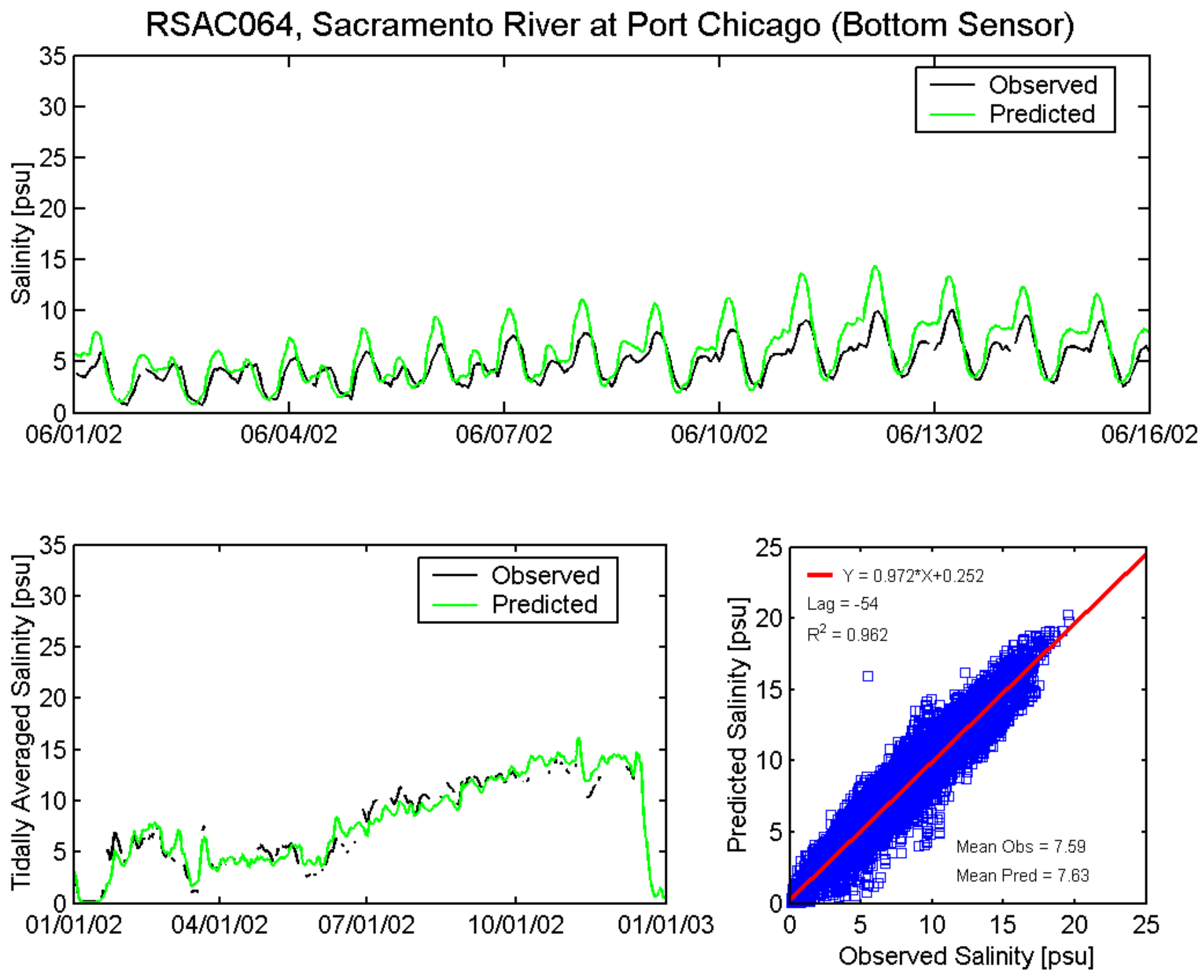


Figure A.6-18 Observed and predicted salinity at Sacramento River at Port Chicago (Bottom Sensor) DWR station (RSAC064) during the 2002 simulation period.

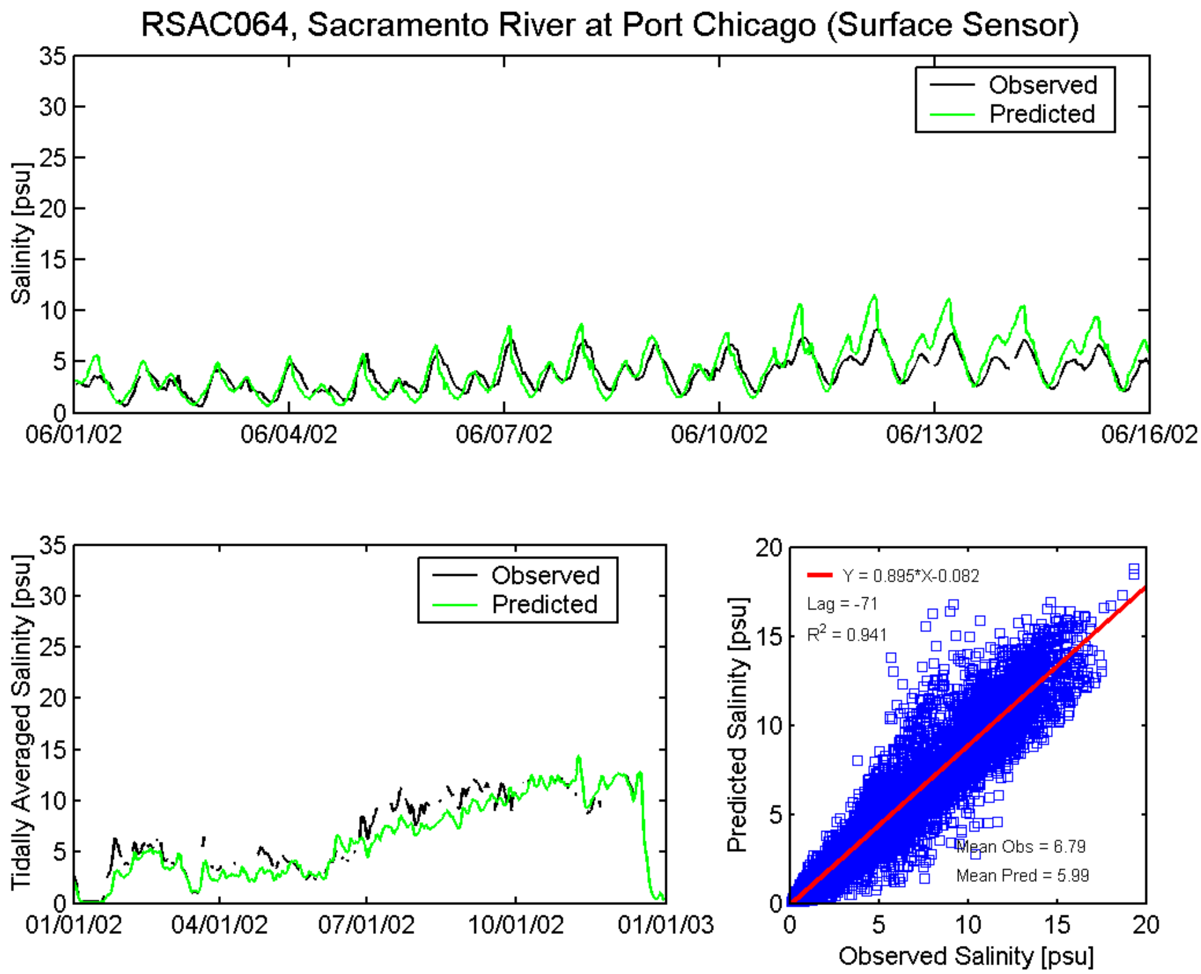


Figure A.6-19 Observed and predicted salinity at Sacramento River at Port Chicago (Surface Sensor) DWR station (RSAC064) during the 2002 simulation period.

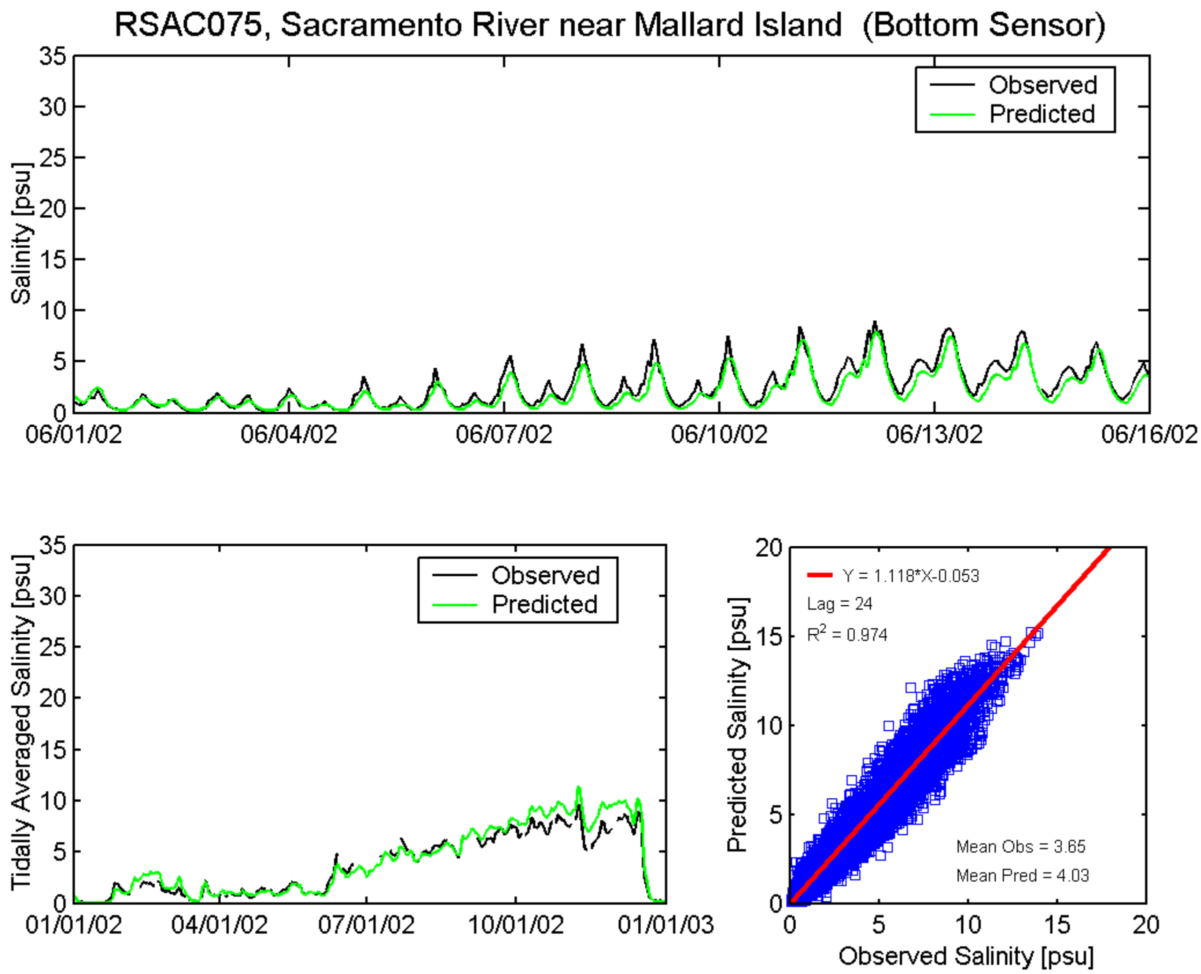


Figure A.6-20 Observed and predicted salinity at Sacramento River near Mallard Island (Bottom Sensor) DWR station (RSAC075) during the 2002 simulation period.

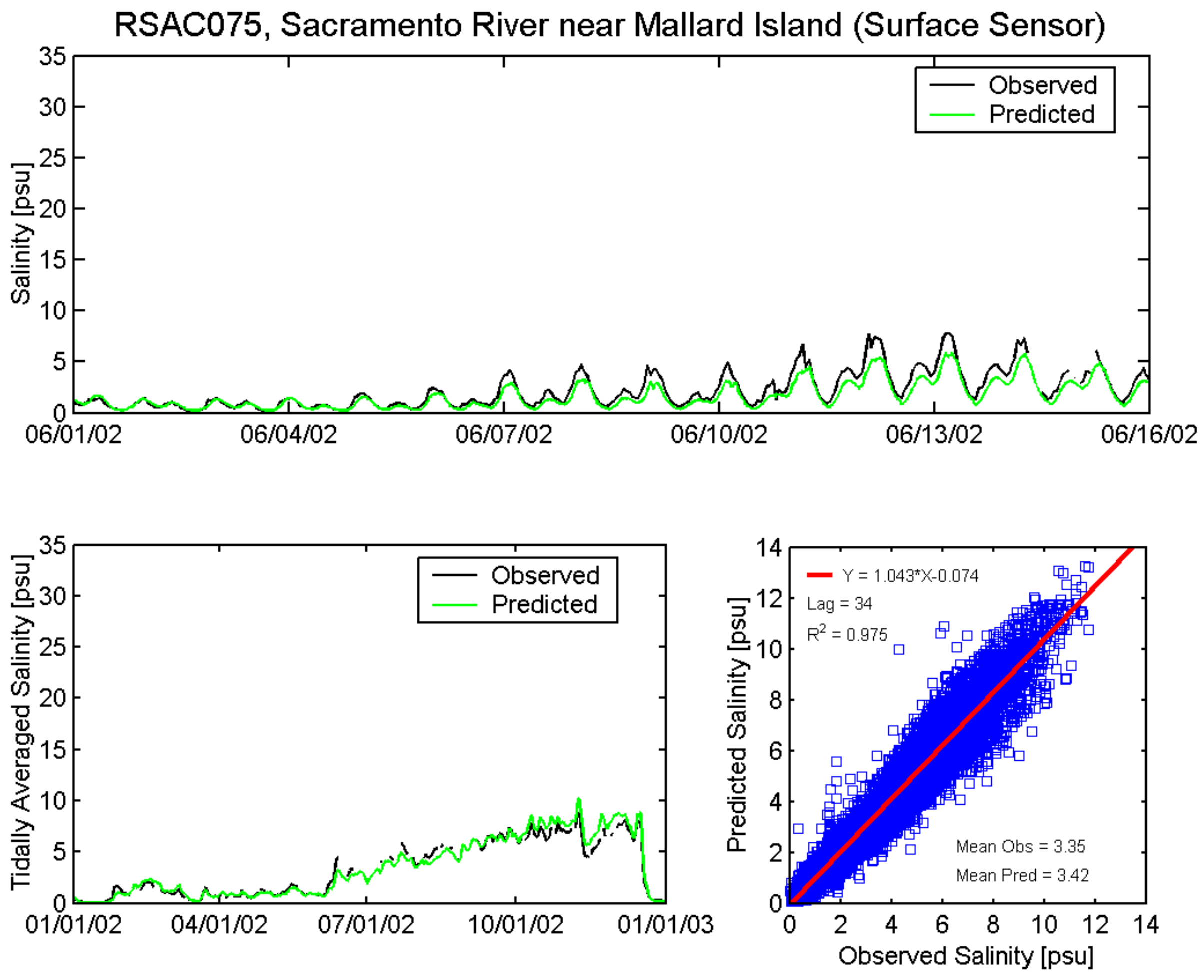


Figure A.6-21 Observed and predicted salinity at Sacramento River near Mallard Island (Surface Sensor) DWR station (RSAC075) during the 2002 simulation period.

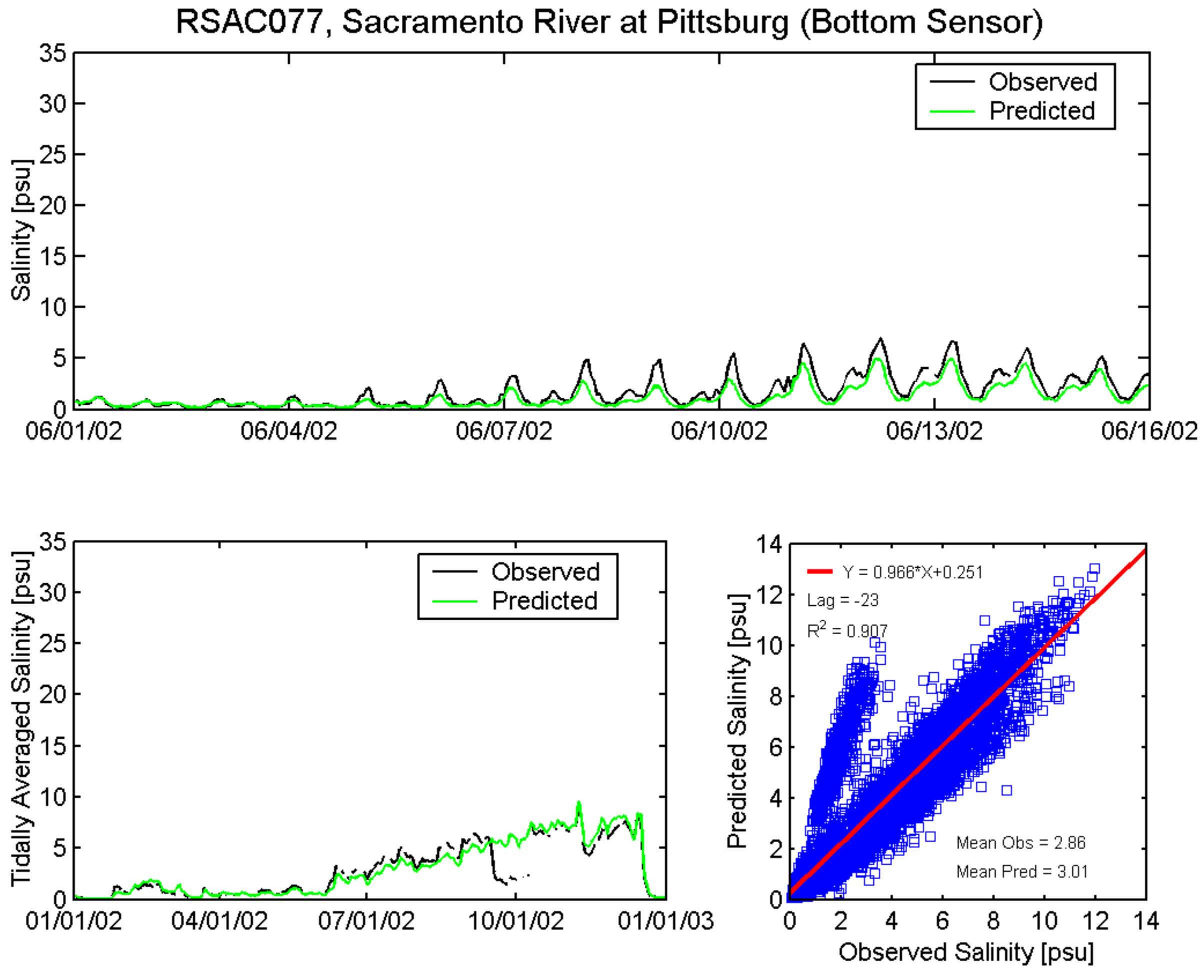


Figure A.6-22 Observed and predicted salinity at Sacramento River at Pittsburgh (Bottom Sensor) DWR station (RSAC077) during the 2002 simulation period.

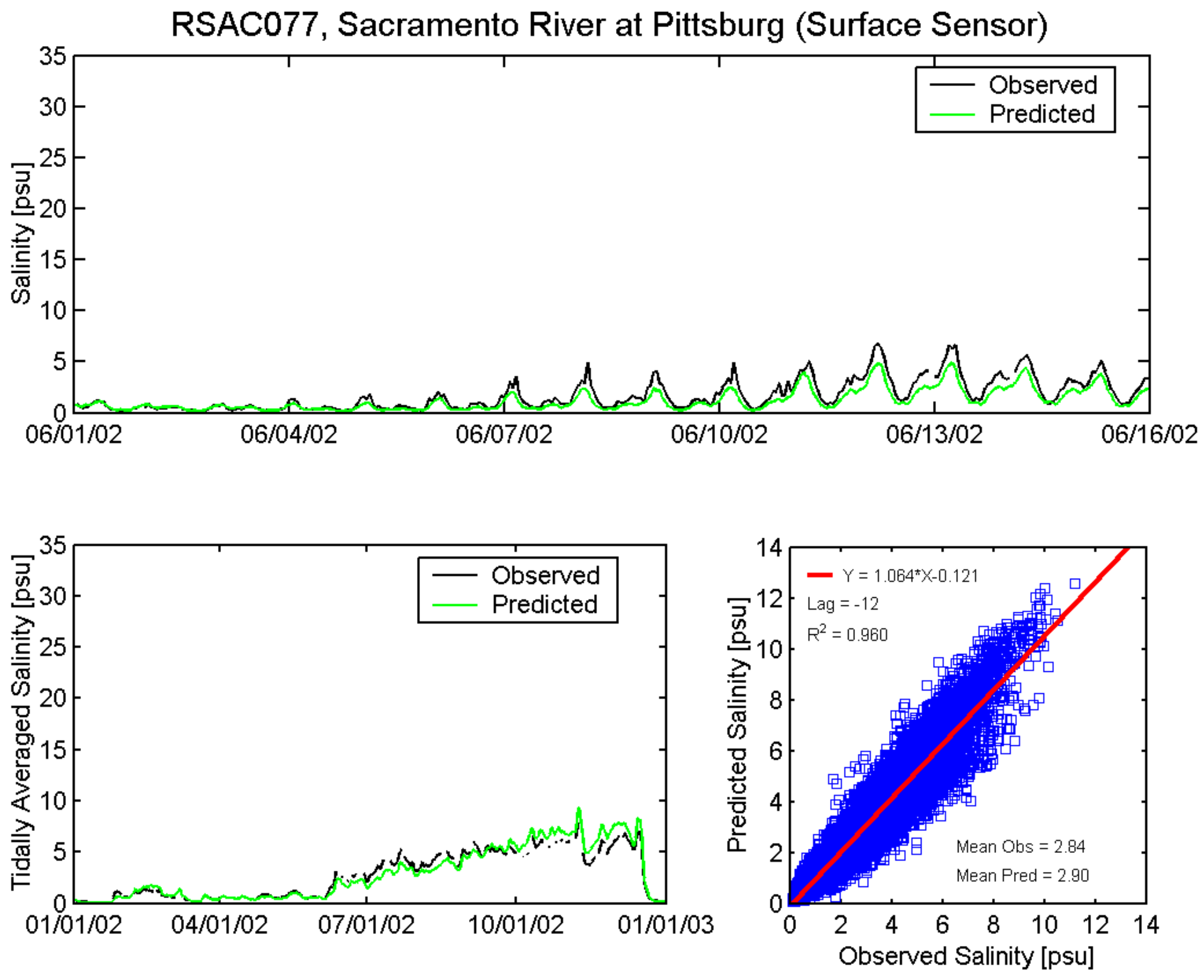


Figure A.6-23 Observed and predicted salinity at Sacramento River at Pittsburgh (Surface Sensor) DWR station (RSAC077) during the 2002 simulation period.

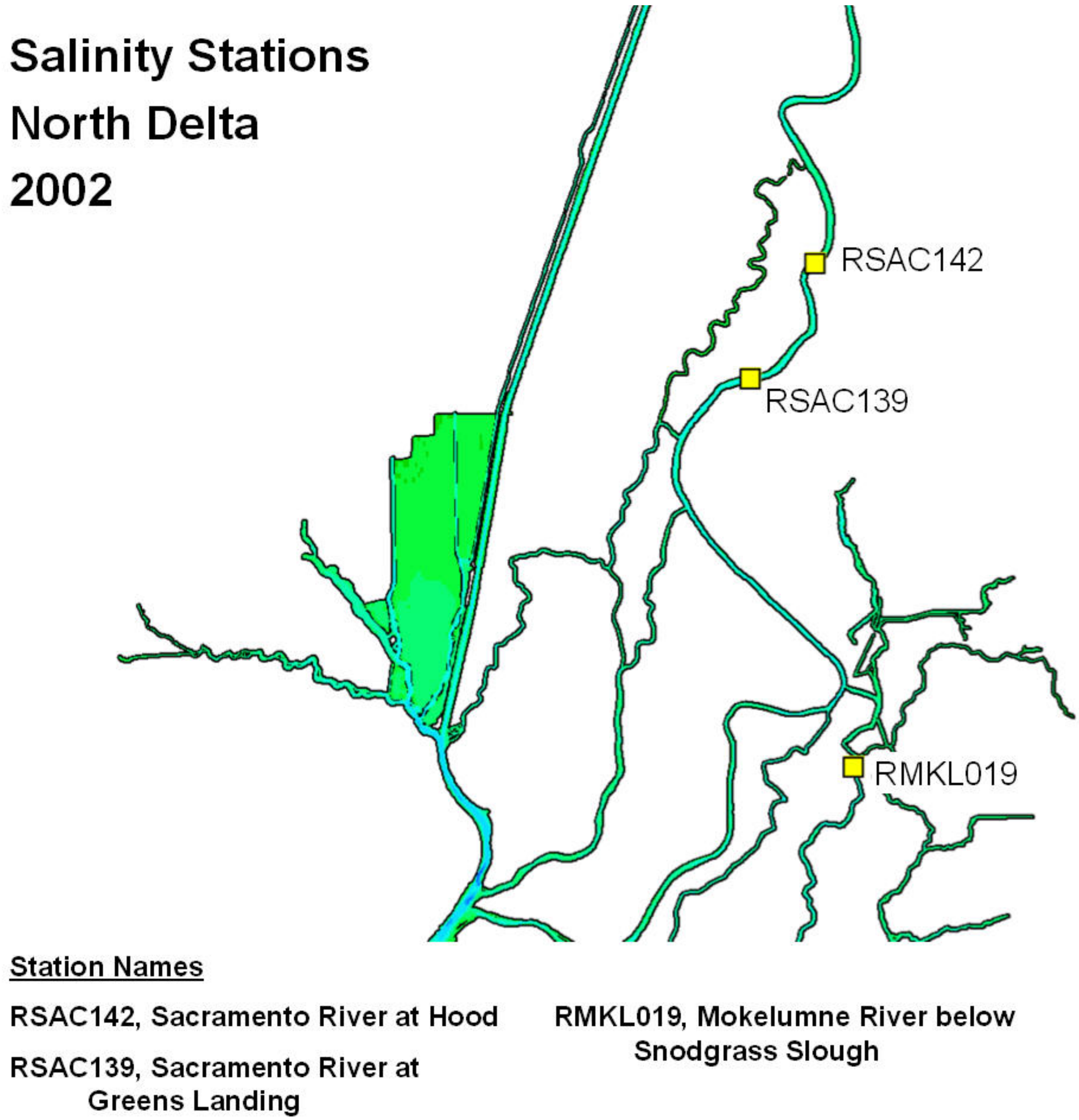


Figure A.6-24 Location of salinity monitoring stations in the northern portion of the Sacramento-San Joaquin Delta used for 2002 salinity comparisons.

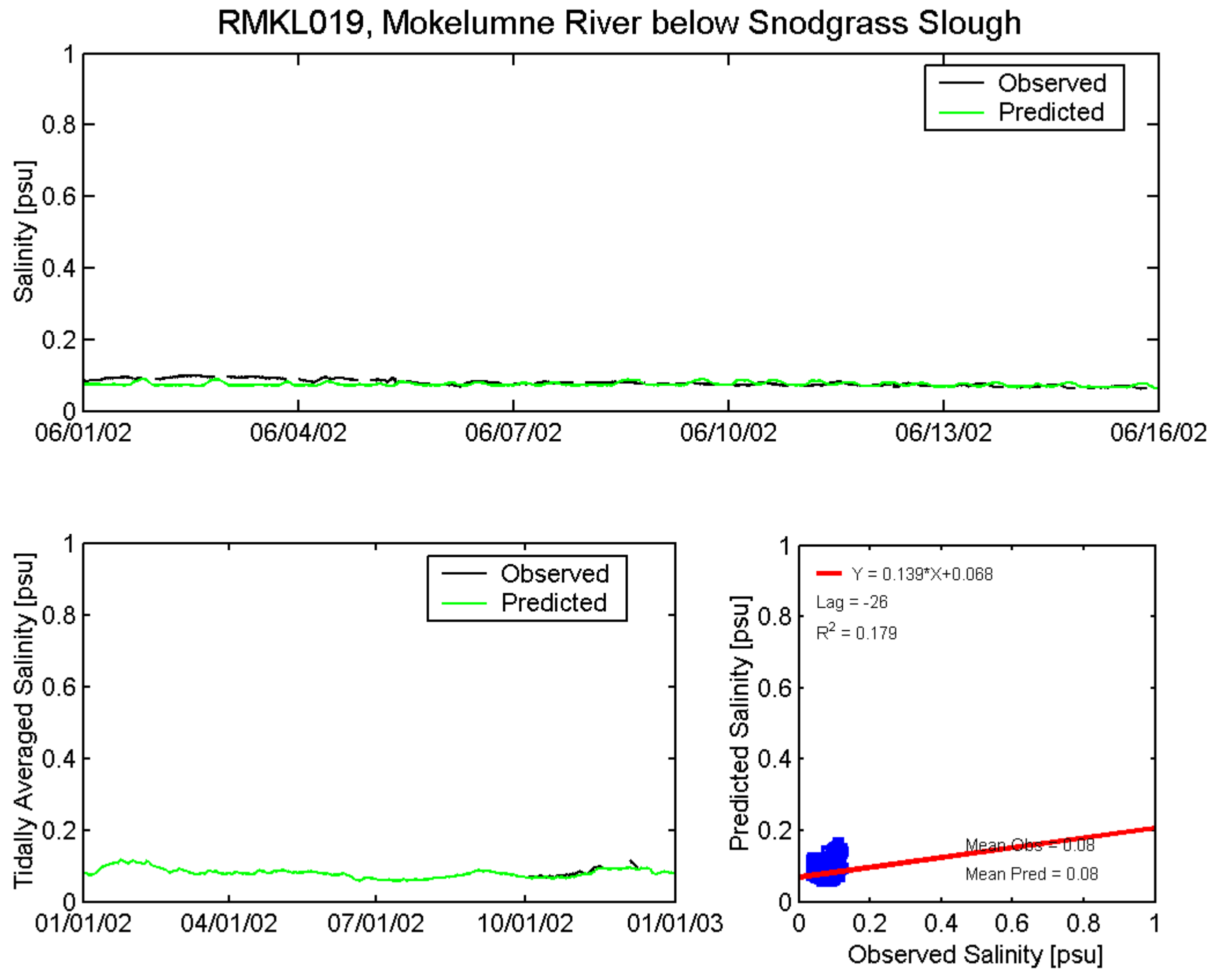


Figure A.6-25 Observed and predicted salinity at Mokelumne River below Snodgrass Slough DWR station (RMKL019) during the 2002 simulation period.

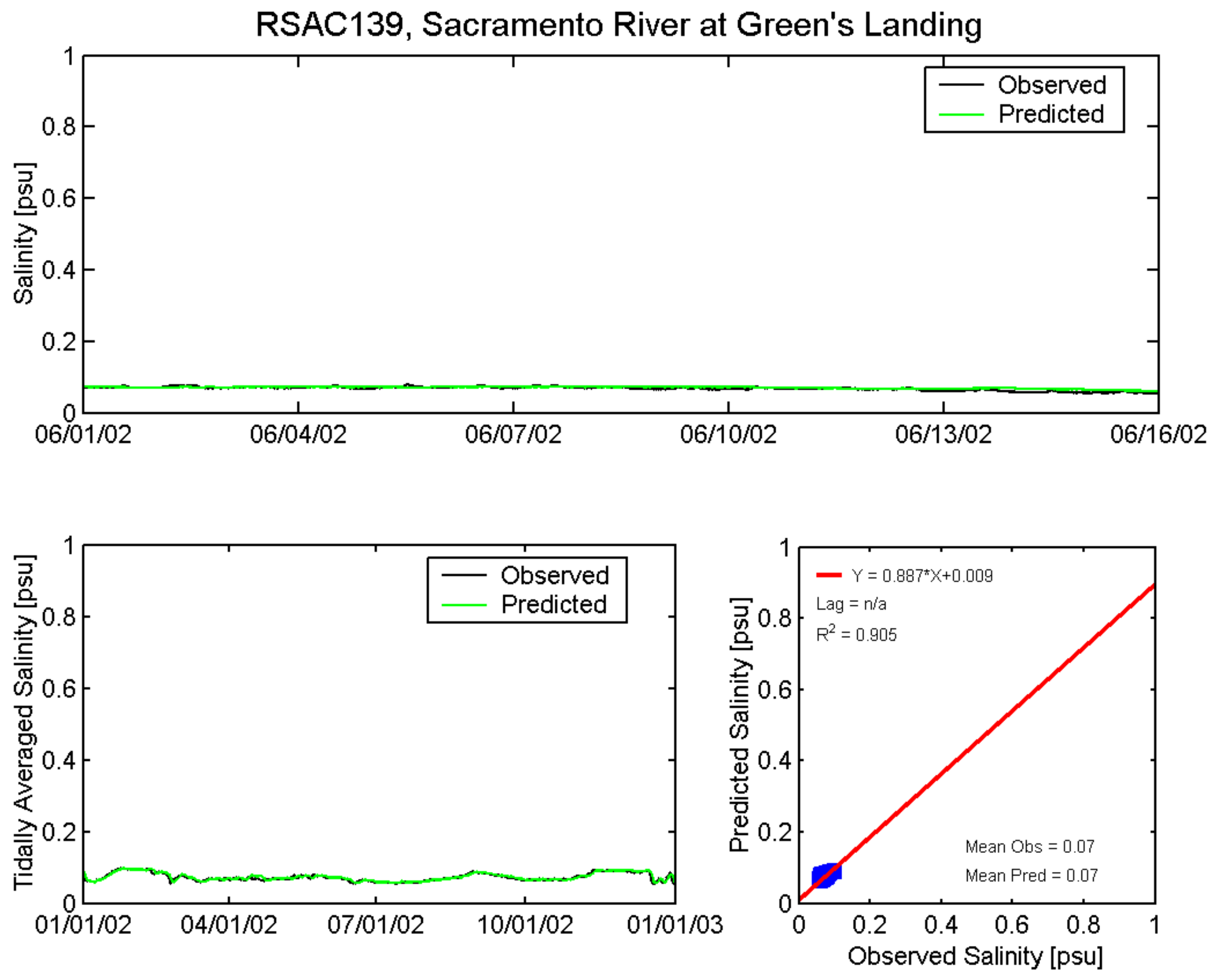


Figure A.6-26 Observed and predicted salinity at Sacramento River at Green's Landing DWR station (RSAC139) during the 2002 simulation period.

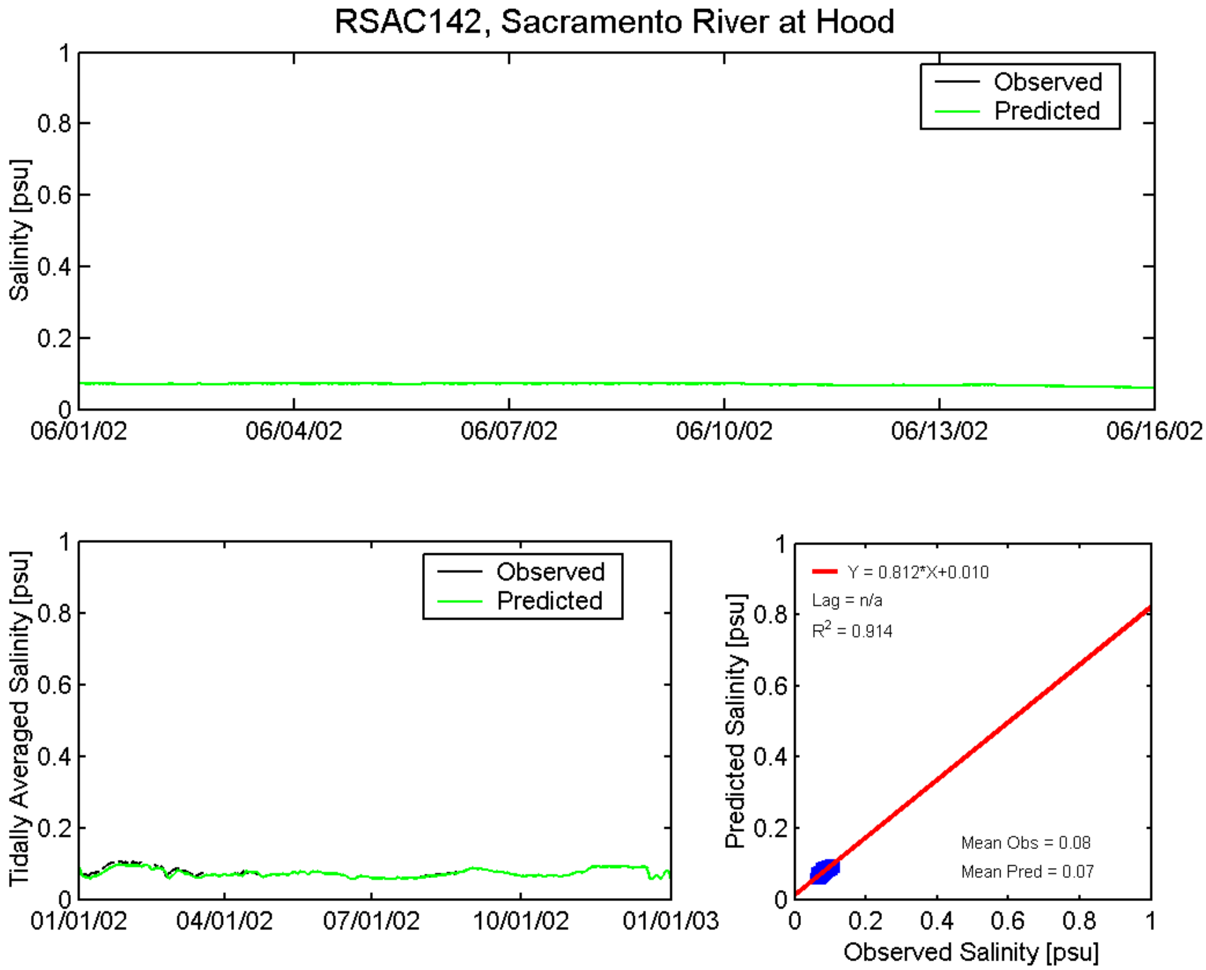
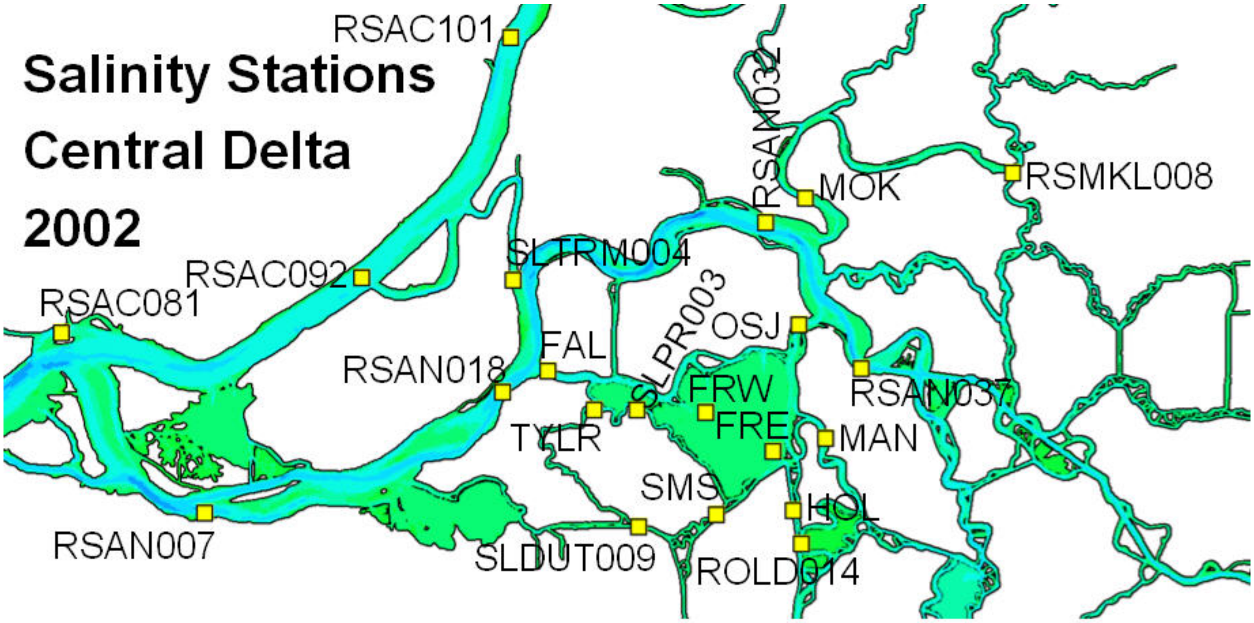


Figure A.6-27 Observed and predicted salinity at Sacramento River at Hood DWR station (RSAC142) during the 2002 simulation period.



Station Names

RSAC081, Sacramento River at Collinsville

RSAC092, Sacramento River at Emmaton

RSAC101, Sacramento River at Rio Vista

SLTRM004, Threemile Slough at San Joaquin River

RSAN007, San Joaquin River at Antioch

RSAN018, San Joaquin River at Jersey Point

SLDUT009, Dutch Slough at Jersey Island

FAL, False River

TYLR, Taylor Slough

SMS, Sand Mound Slough

SLPR003, Piper Slough at Bethel

RSAN032, San Joaquin River at San Andreas Landing

OSJ, Old River at San Joaquin River

RSAN037, San Joaquin River before Prisoners Point

MOK, Mokelumne River near San Joaquin River

RSMKL008, South Fork Mokelumne River at Staten Island

FRE, Franks Tract East

FRW, Franks Tract West

MAN, Old River at Mandeville Island

HOL, Holland Cut

ROLD014, Old River and Holland Cut at Mandeville Island

Figure A.6-28 Location of salinity monitoring stations in the central portion of the Sacramento-San Joaquin Delta used for 2002 salinity comparisons.

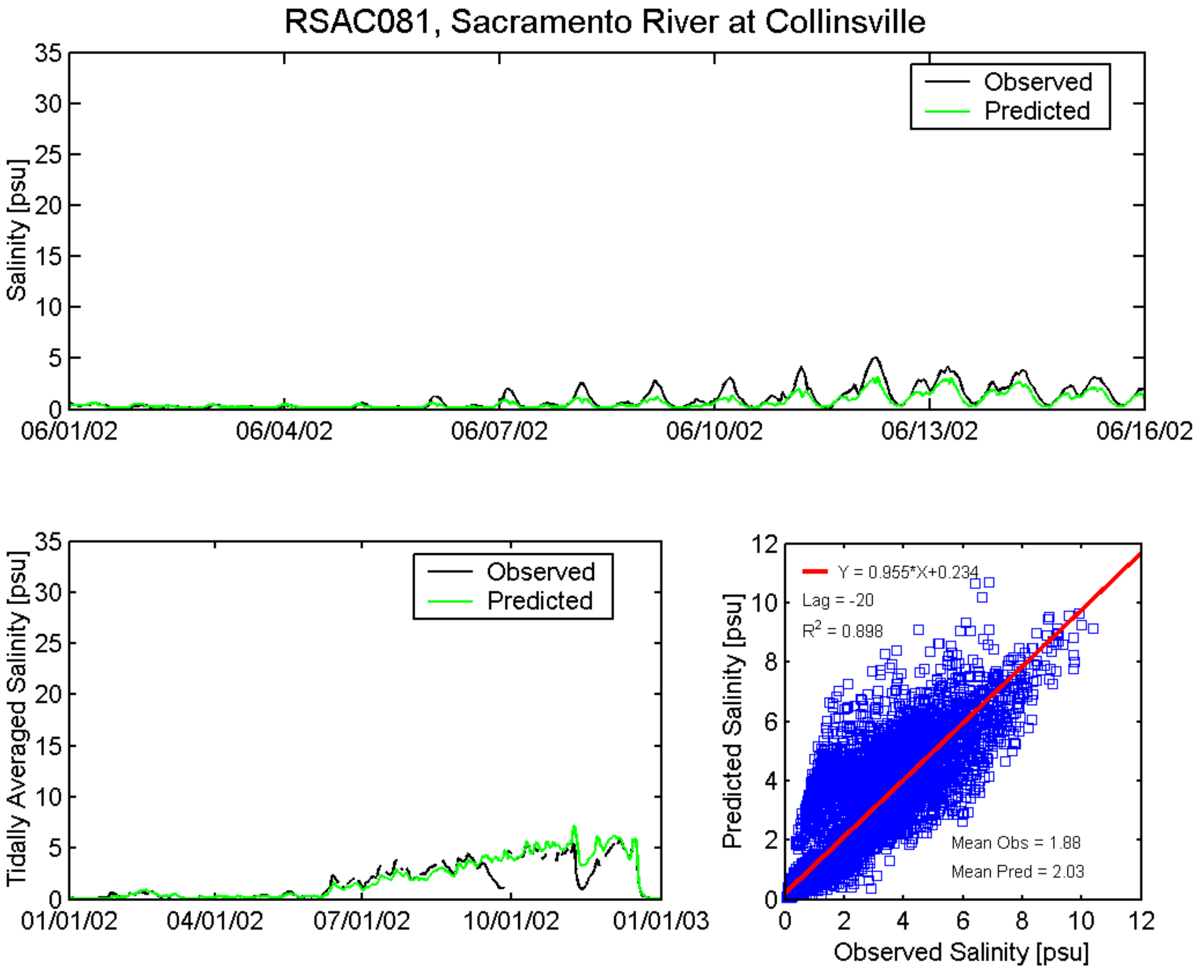


Figure A.6-29 Observed and predicted salinity at Sacramento River at Collinsville DWR station (RSAC081) during the 2002 simulation period.

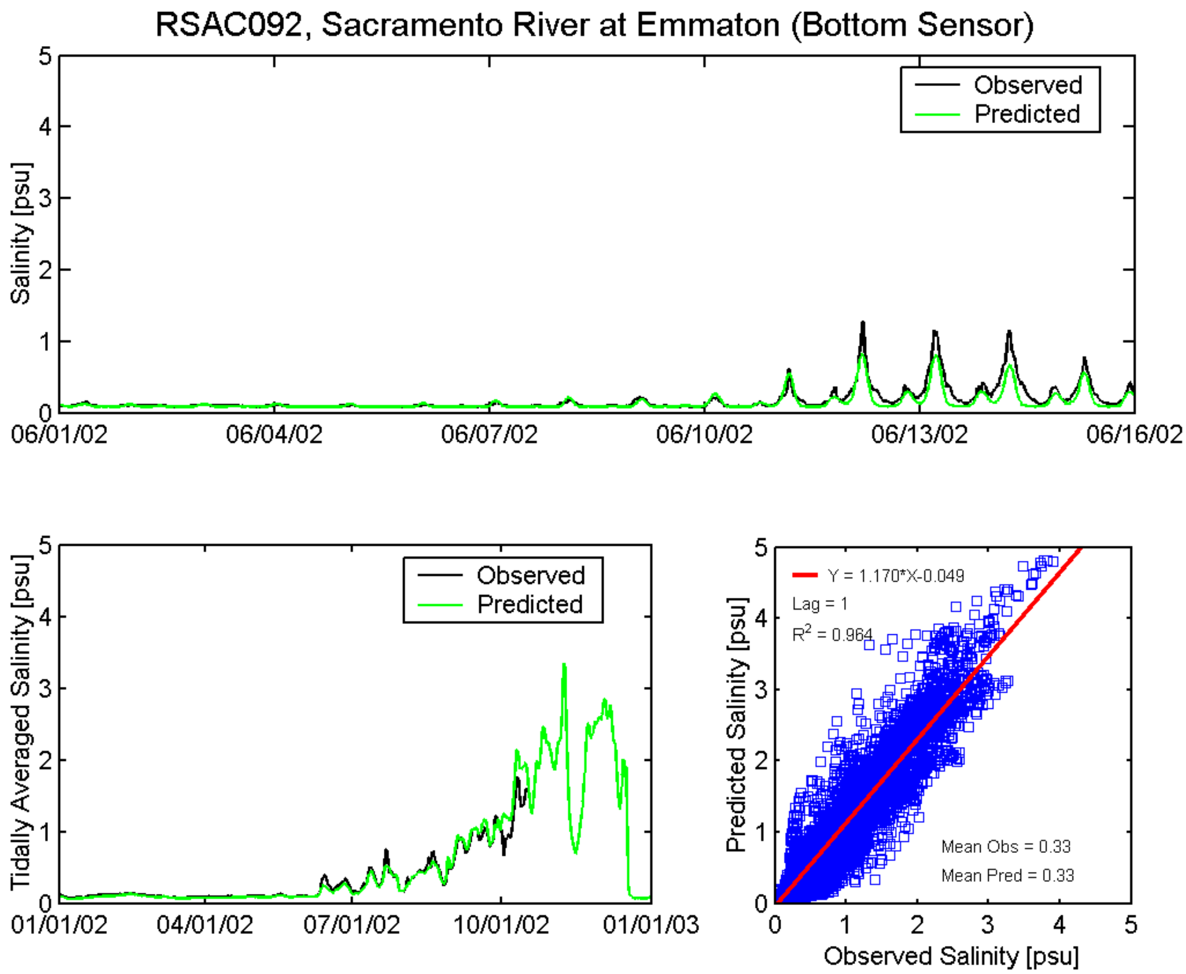


Figure A.6-30 Observed and predicted salinity at Sacramento River at Emmaton (Bottom Sensor) DWR station (RSAC092) during the 2002 simulation period.

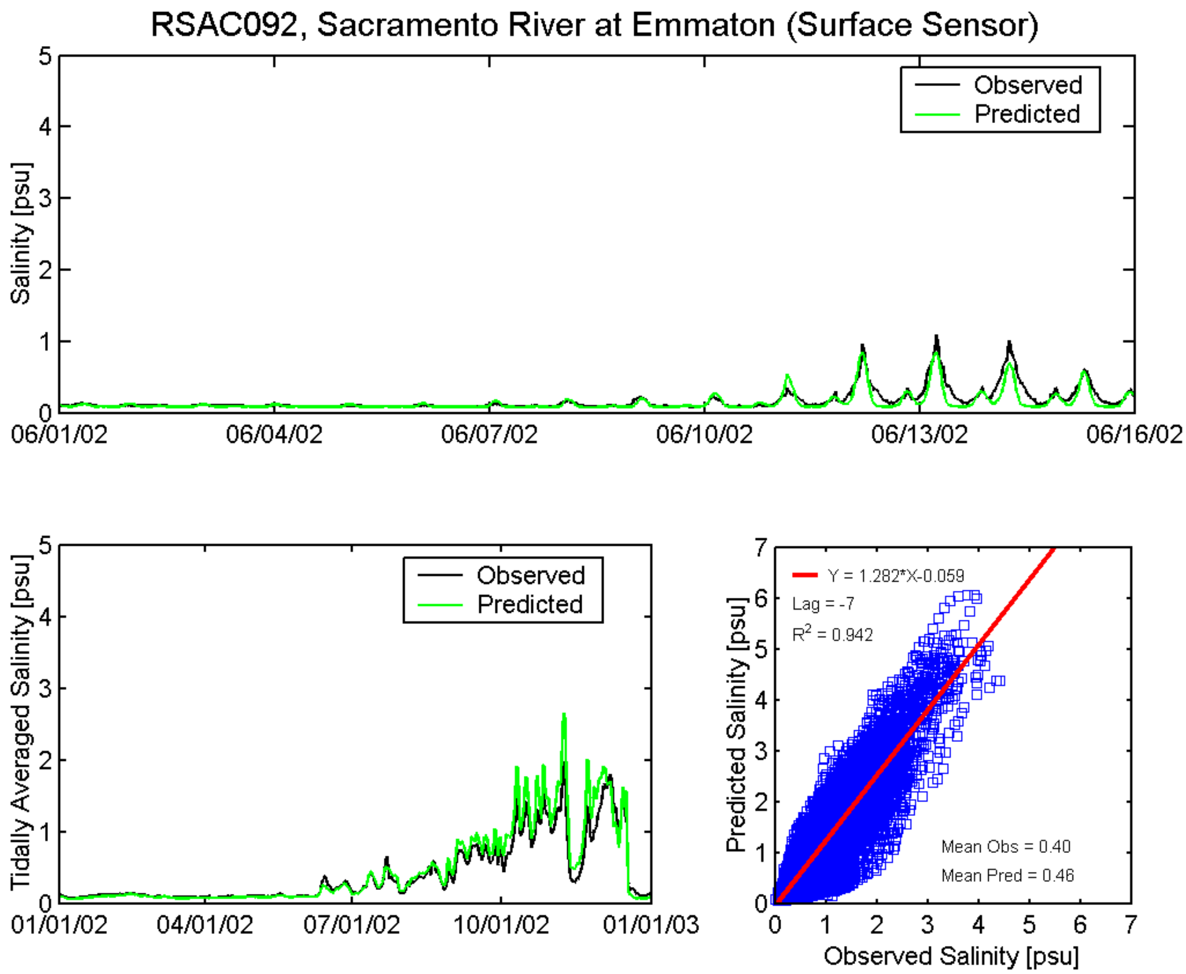


Figure A.6-31 Observed and predicted salinity at Sacramento River at Emmaton (Surface Sensor) DWR station (RSAC092) during the 2002 simulation period.

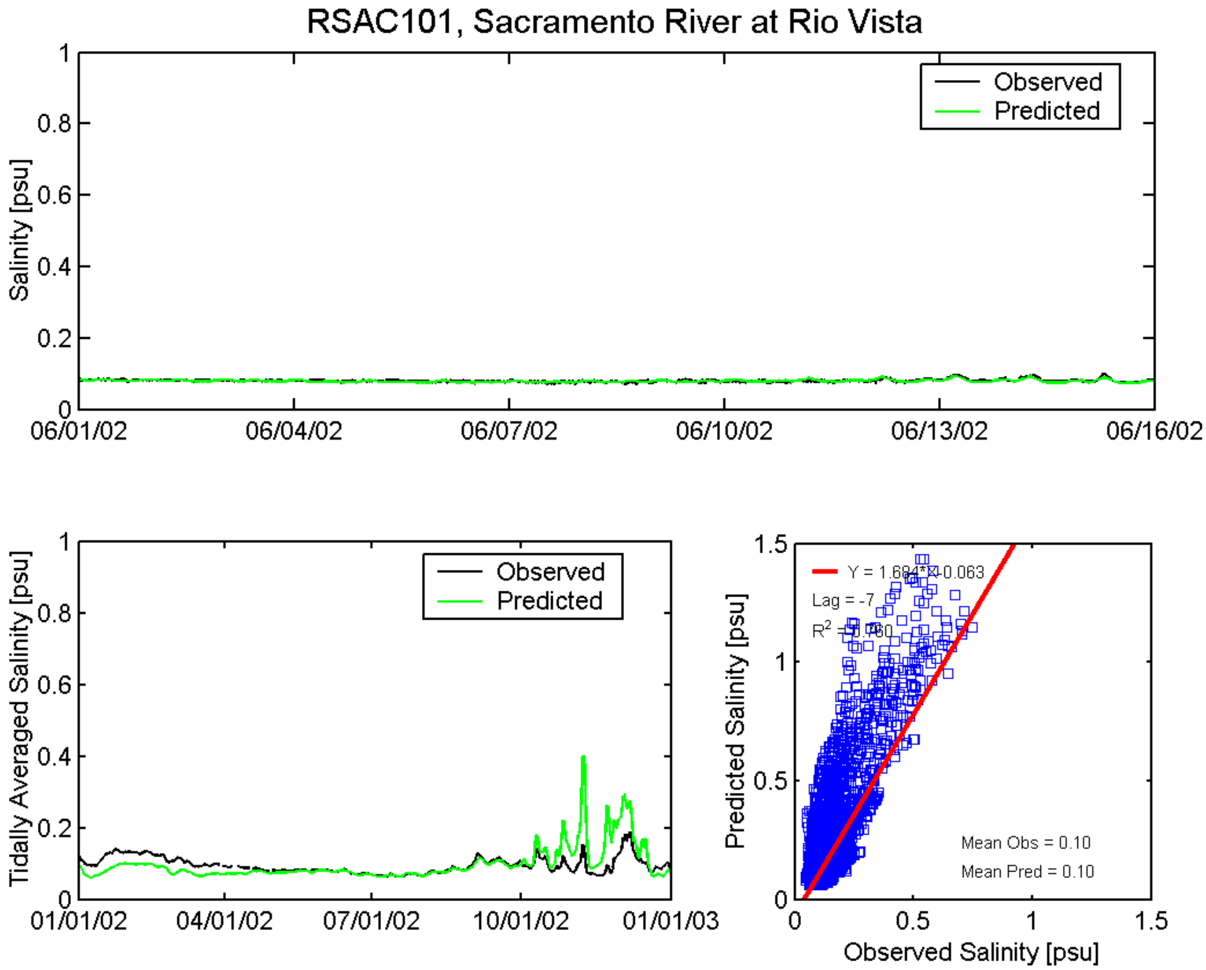


Figure A.6-32 Observed and predicted salinity at Sacramento River at Rio Vista DWR station (RSAC101) during the 2002 simulation period.

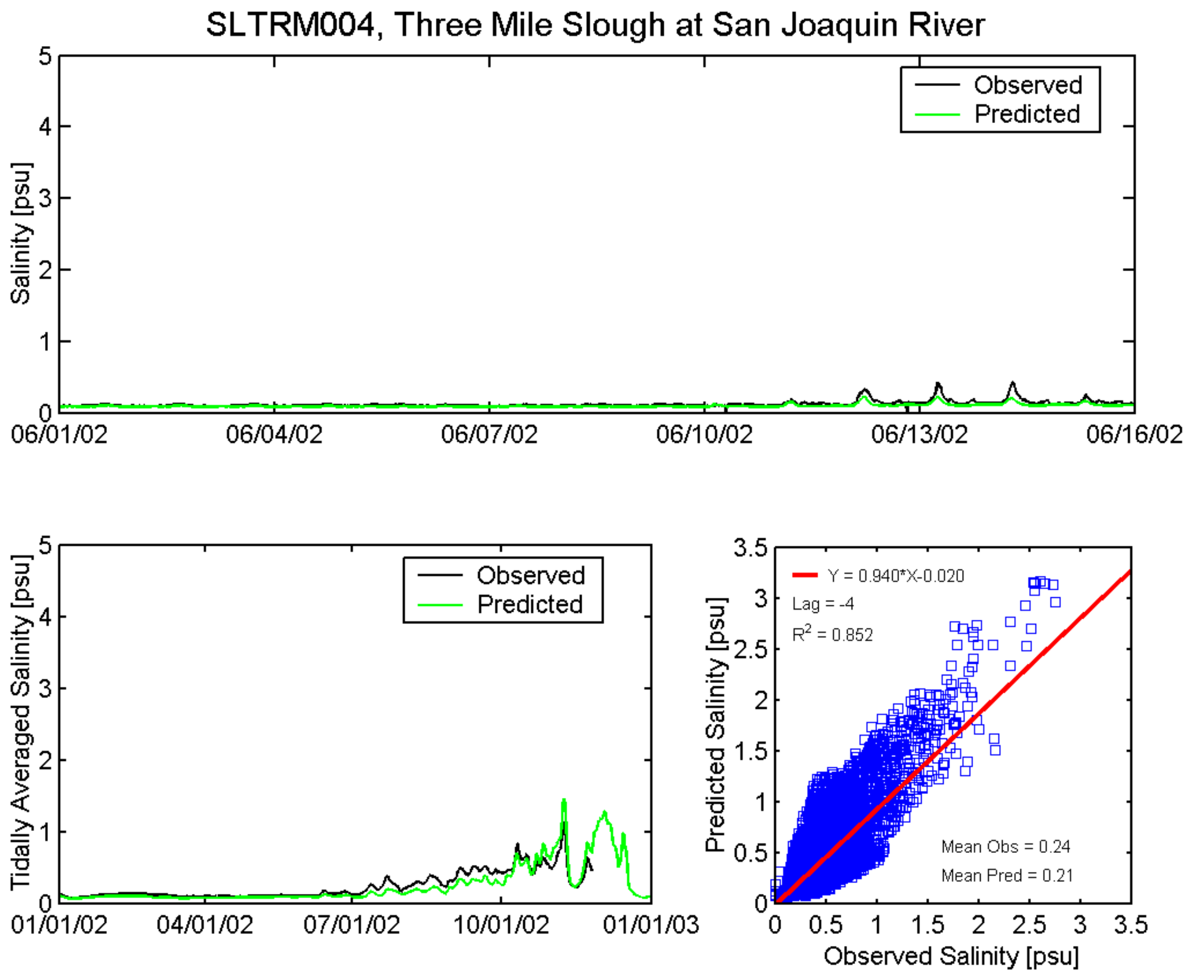


Figure A.6-33 Observed and predicted salinity at Threemile Slough at San Joaquin River DWR station (SLTRM004) during the 2002 simulation period.

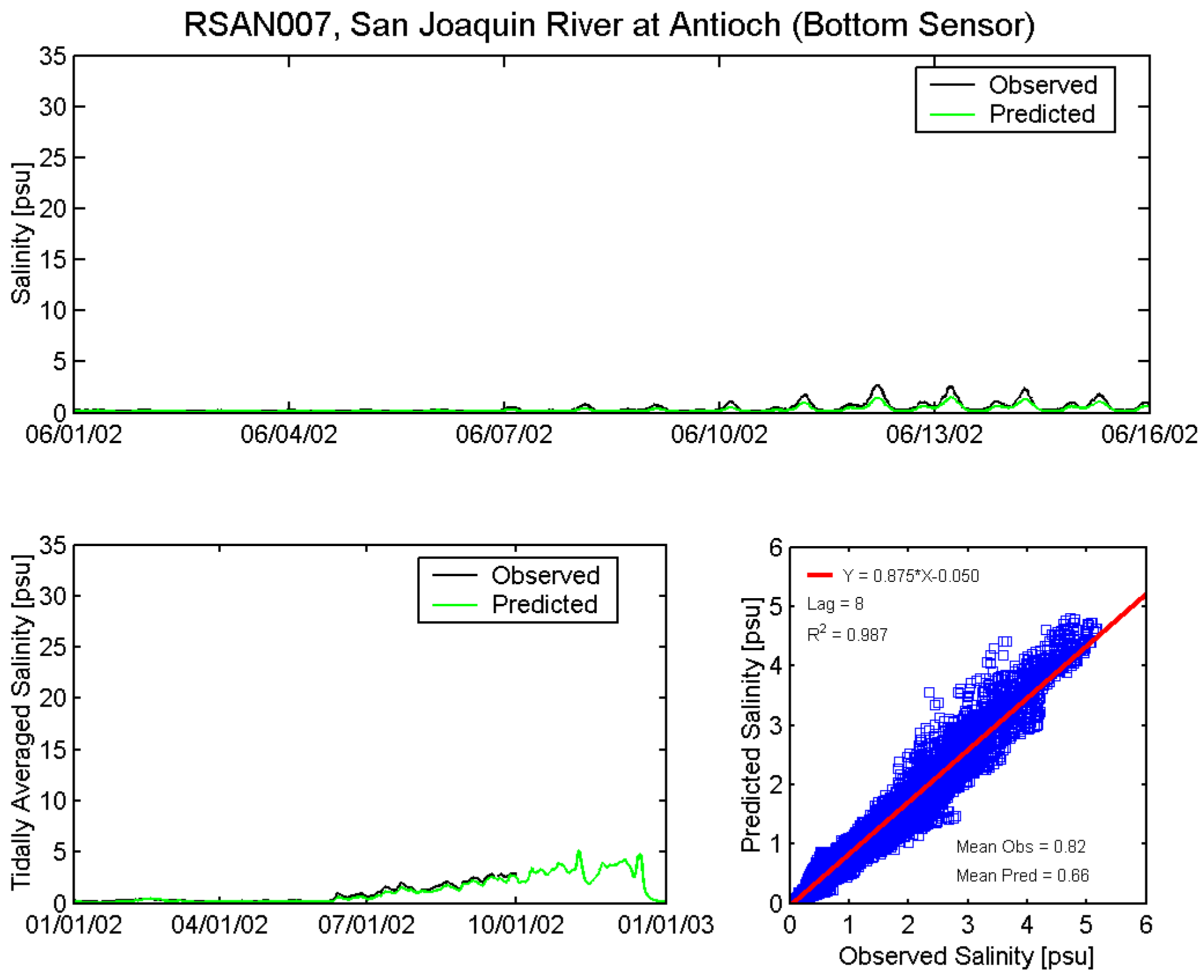


Figure A.6-34 Observed and predicted salinity at Antioch (Bottom Sensor) DWR station (RSAN007) during the 2002 simulation period.

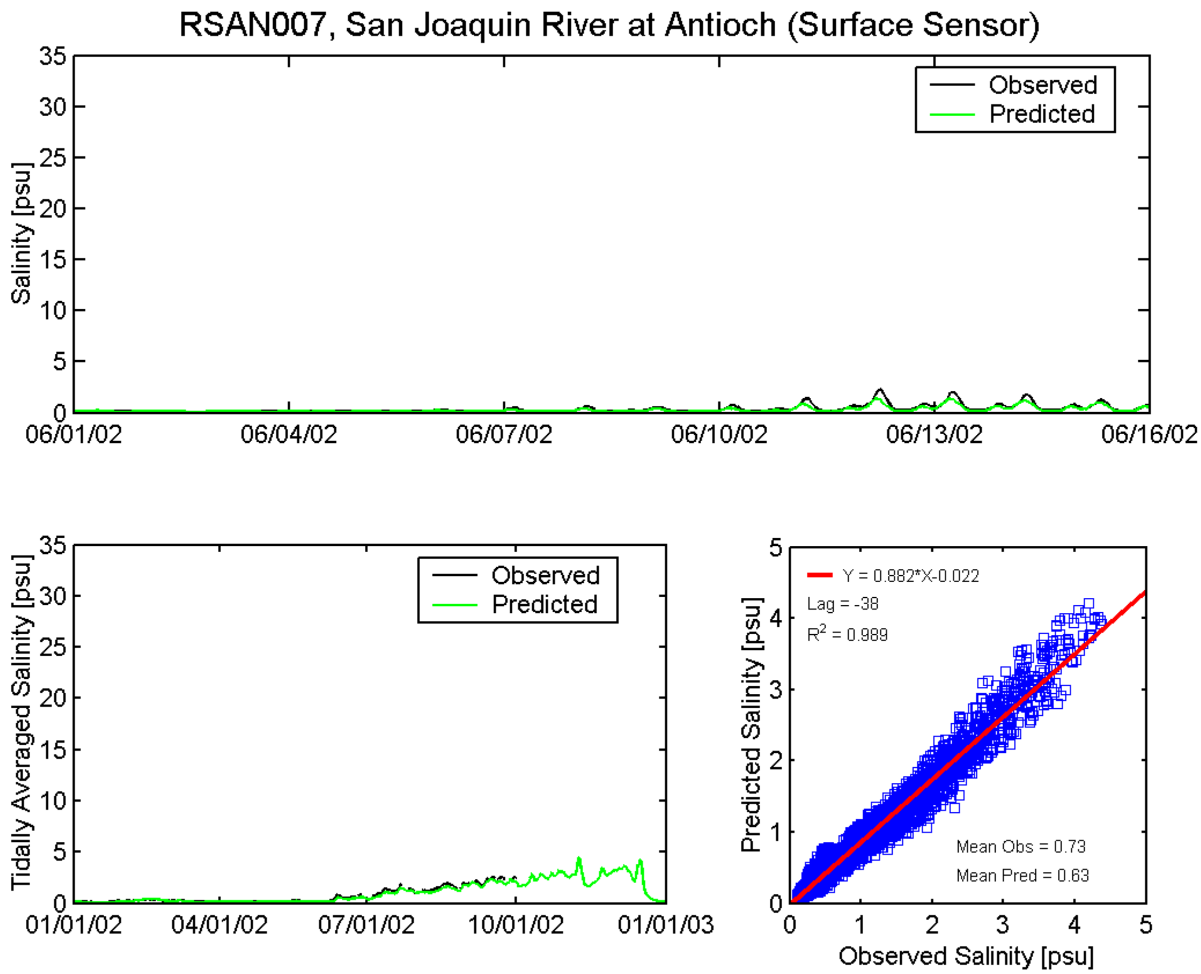


Figure A.6-35 Observed and predicted salinity at Antioch (Surface Sensor) DWR station (RSAN007) during the 2002 simulation period.

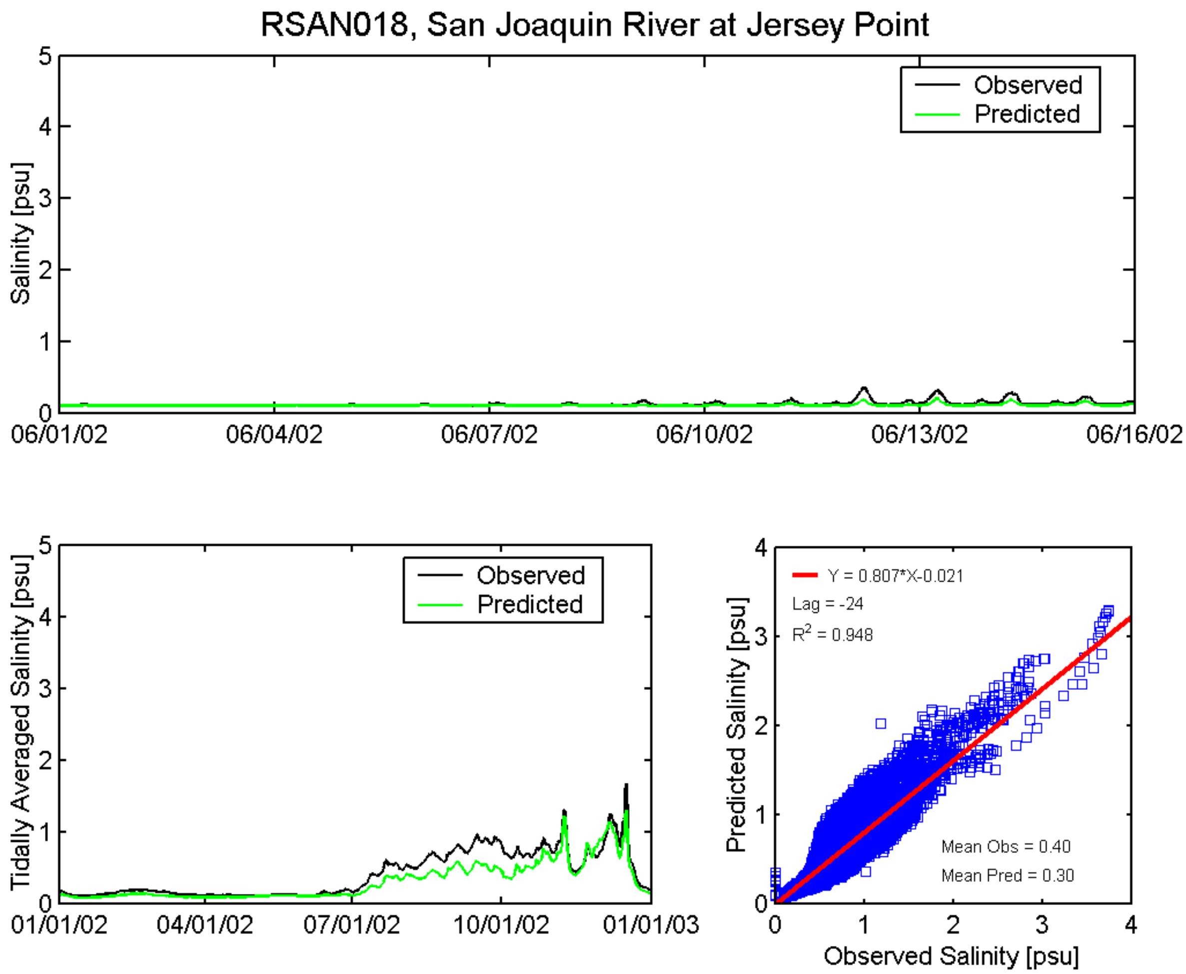


Figure A.6-36 Observed and predicted salinity at San Joaquin River at Jersey Point DWR station (RSAN018) during the 2002 simulation period.

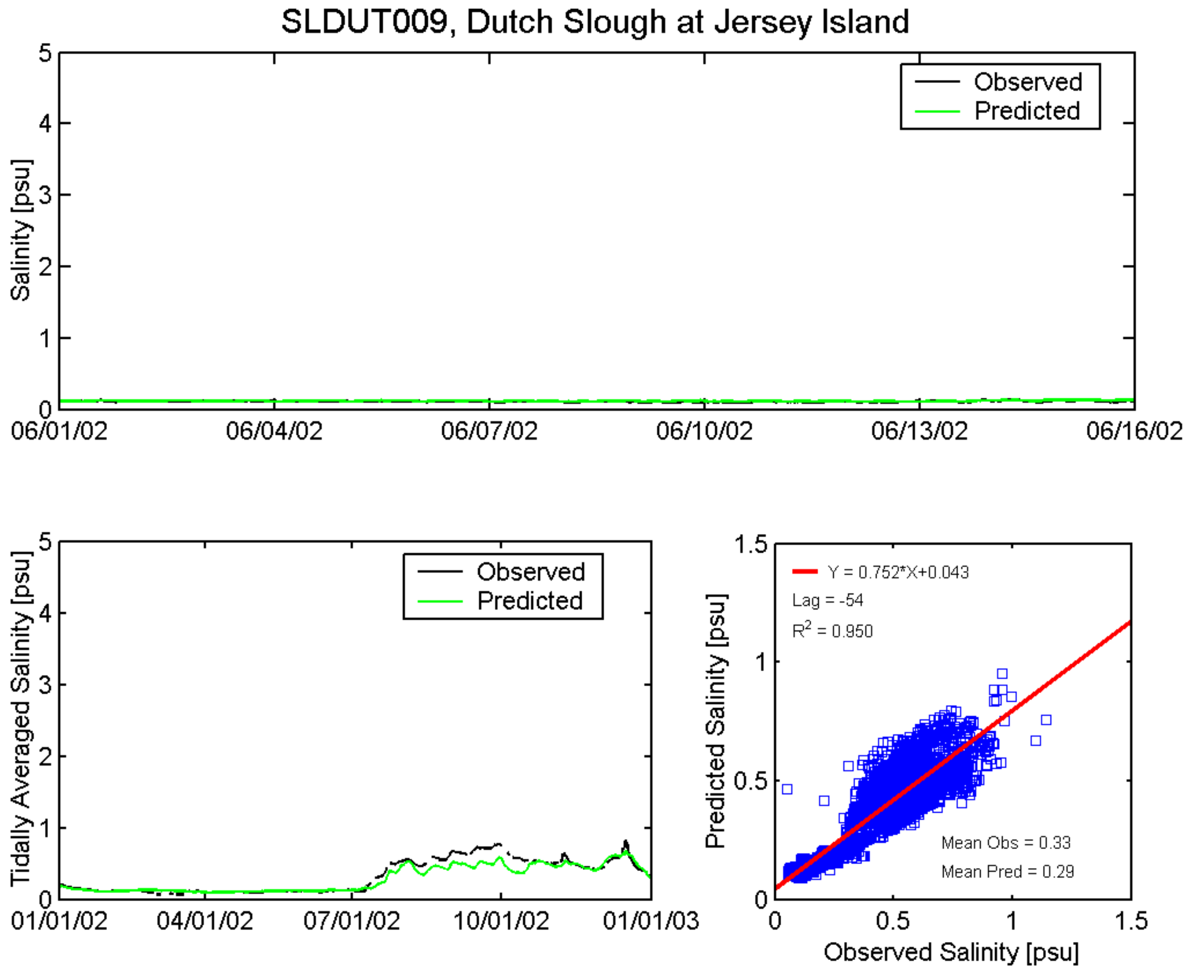


Figure A.6-37 Observed and predicted salinity at Dutch Slough at Jersey Island DWR station (SLDUT009) during the 2002 simulation period.

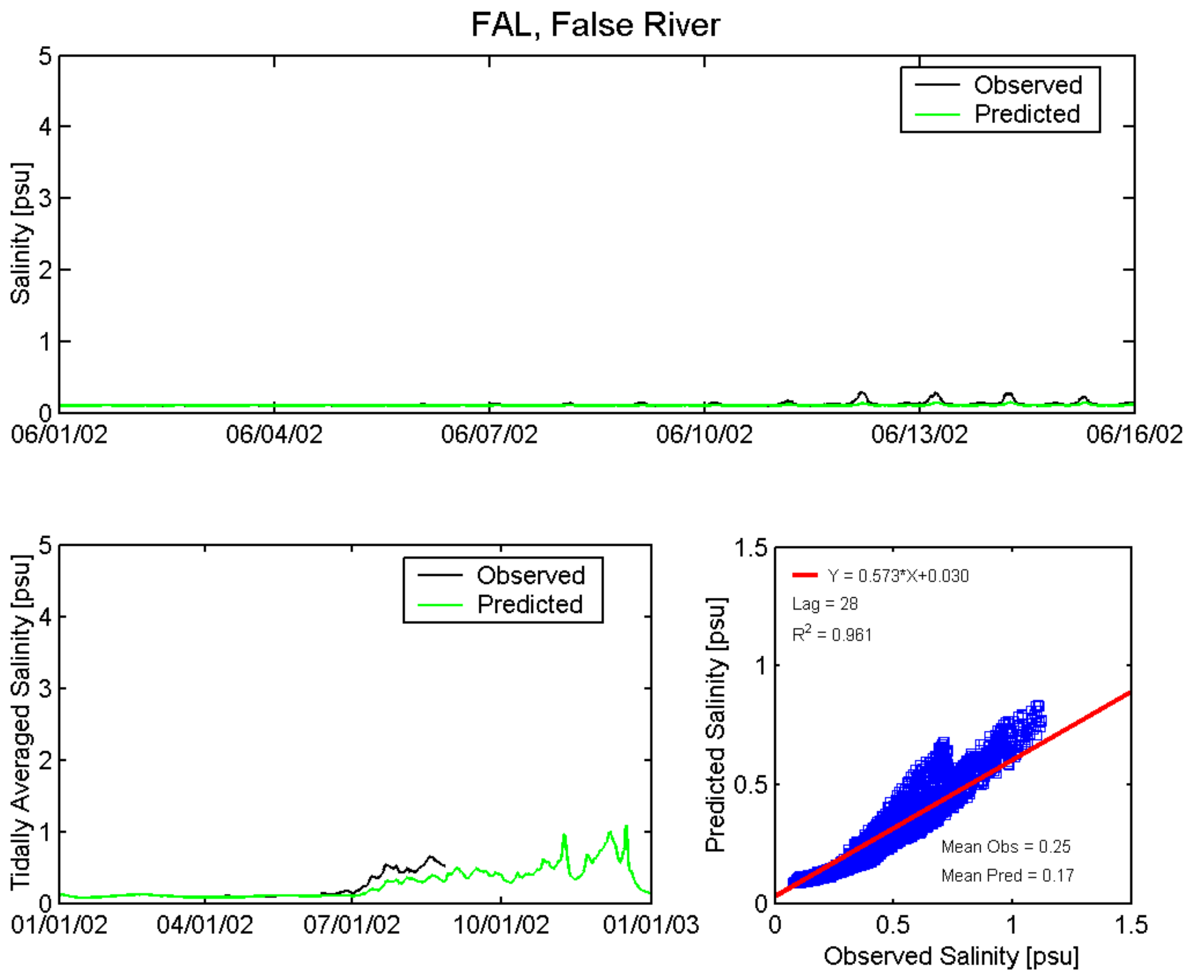


Figure A.6-38 Observed and predicted salinity at False River USGS station (FAL) during the 2002 simulation period.

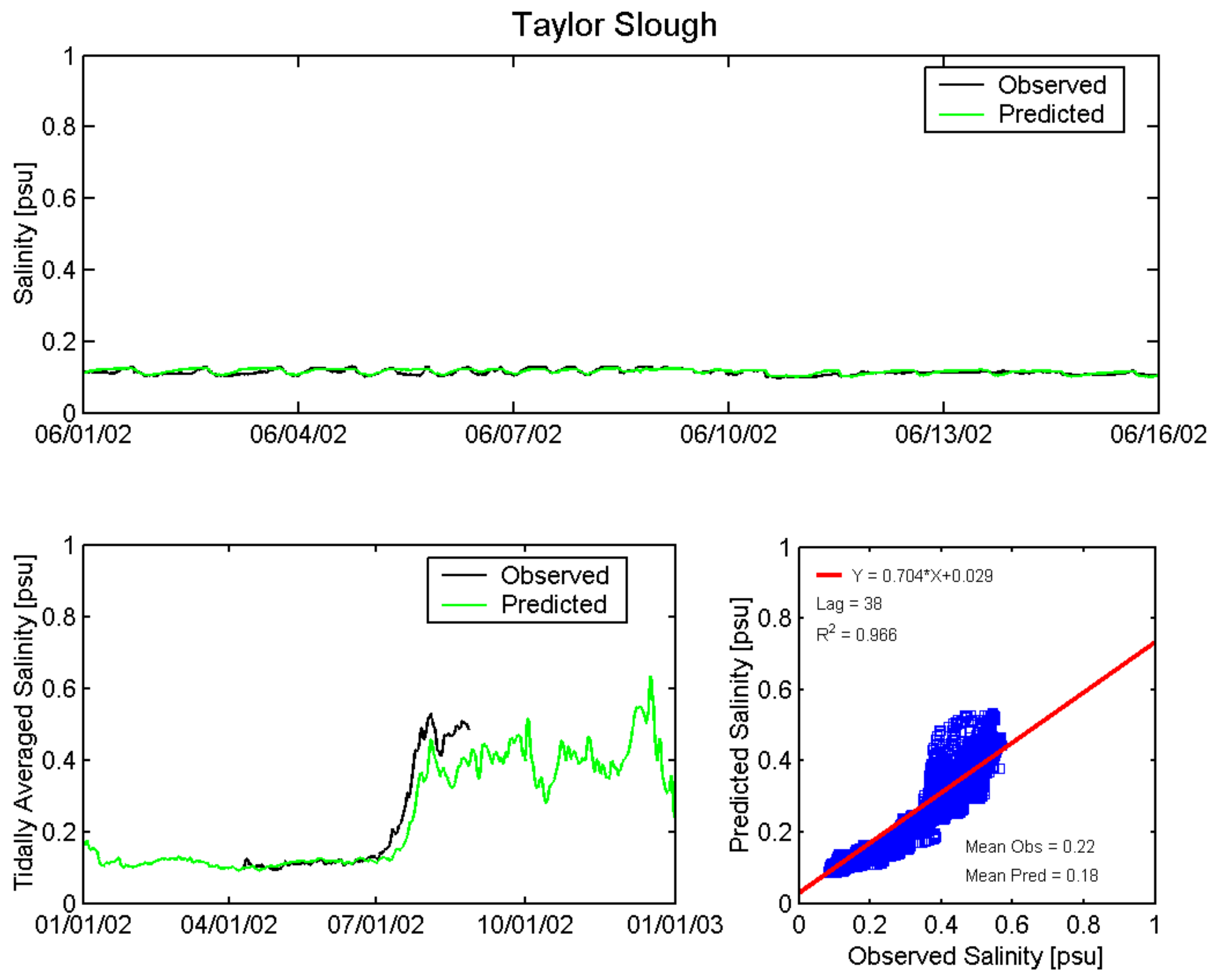


Figure A.6-39 Observed and predicted salinity at Taylor Slough USGS station (TYLR) during the 2002 simulation period.

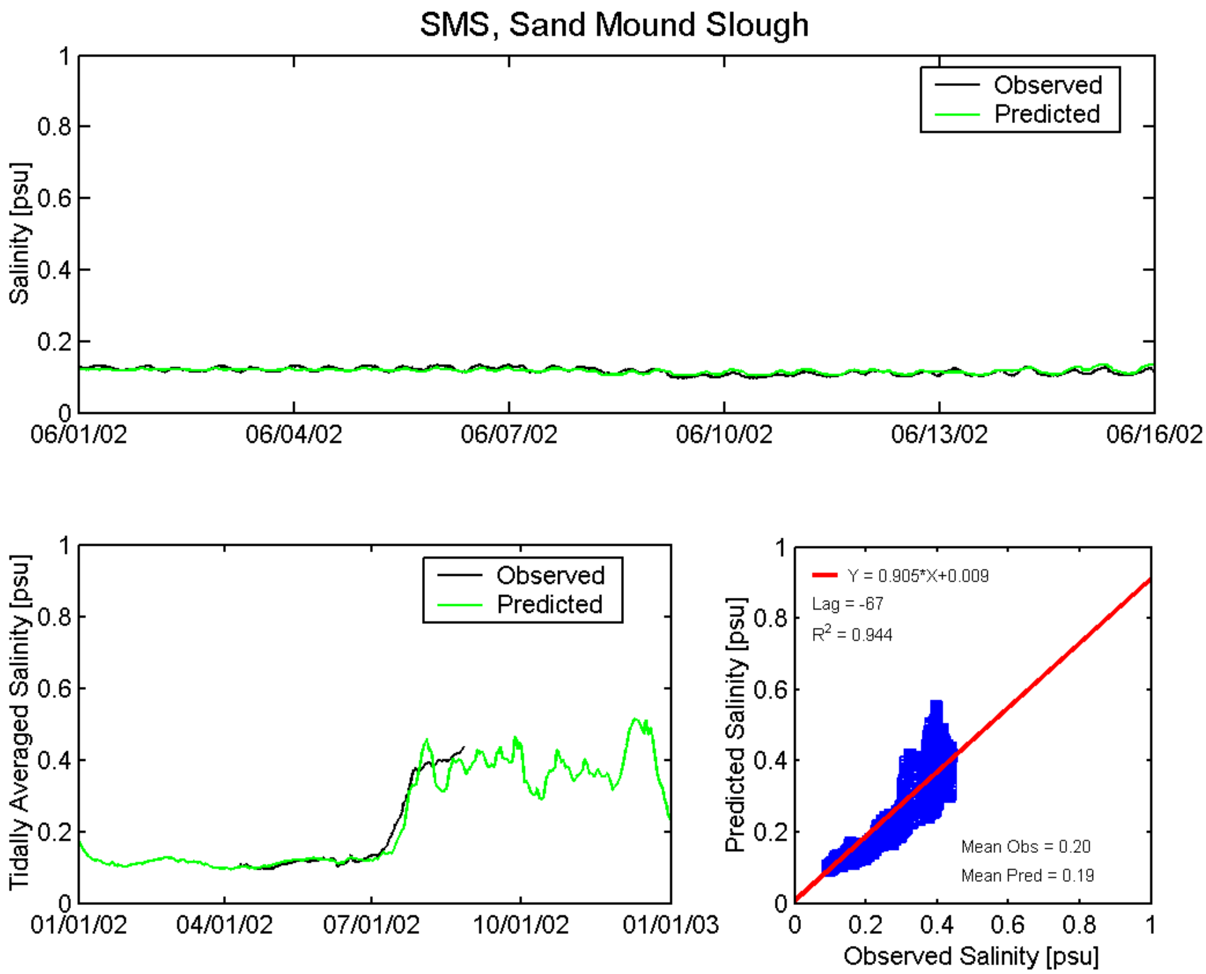


Figure A.6-40 Observed and predicted salinity at Sand Mound Slough USGS station (SMS) during the 2002 simulation period.

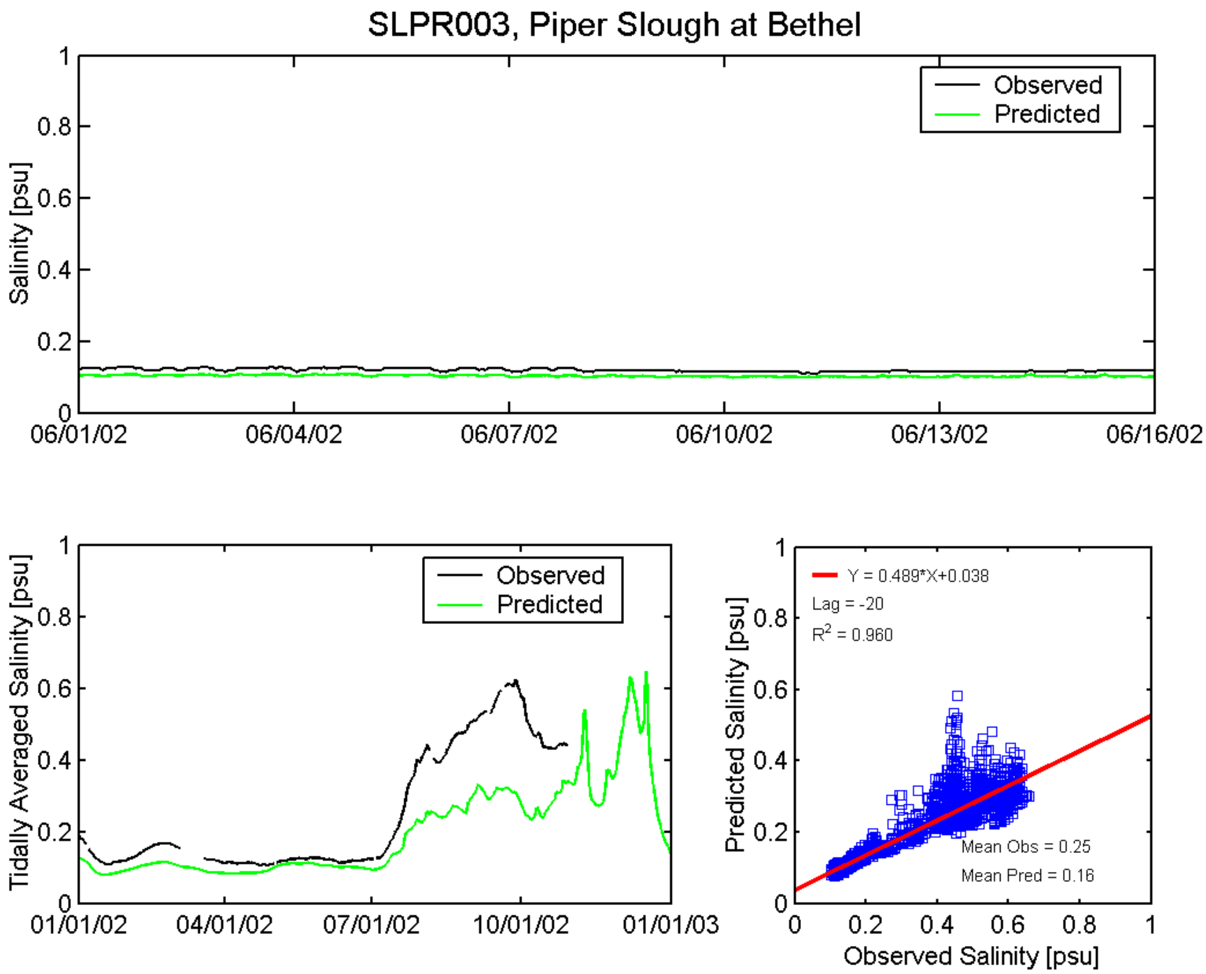


Figure A.6-41 Observed and predicted salinity at Piper Slough at Bethel Tract DWR station (SLPR003) during the 2002 simulation period.

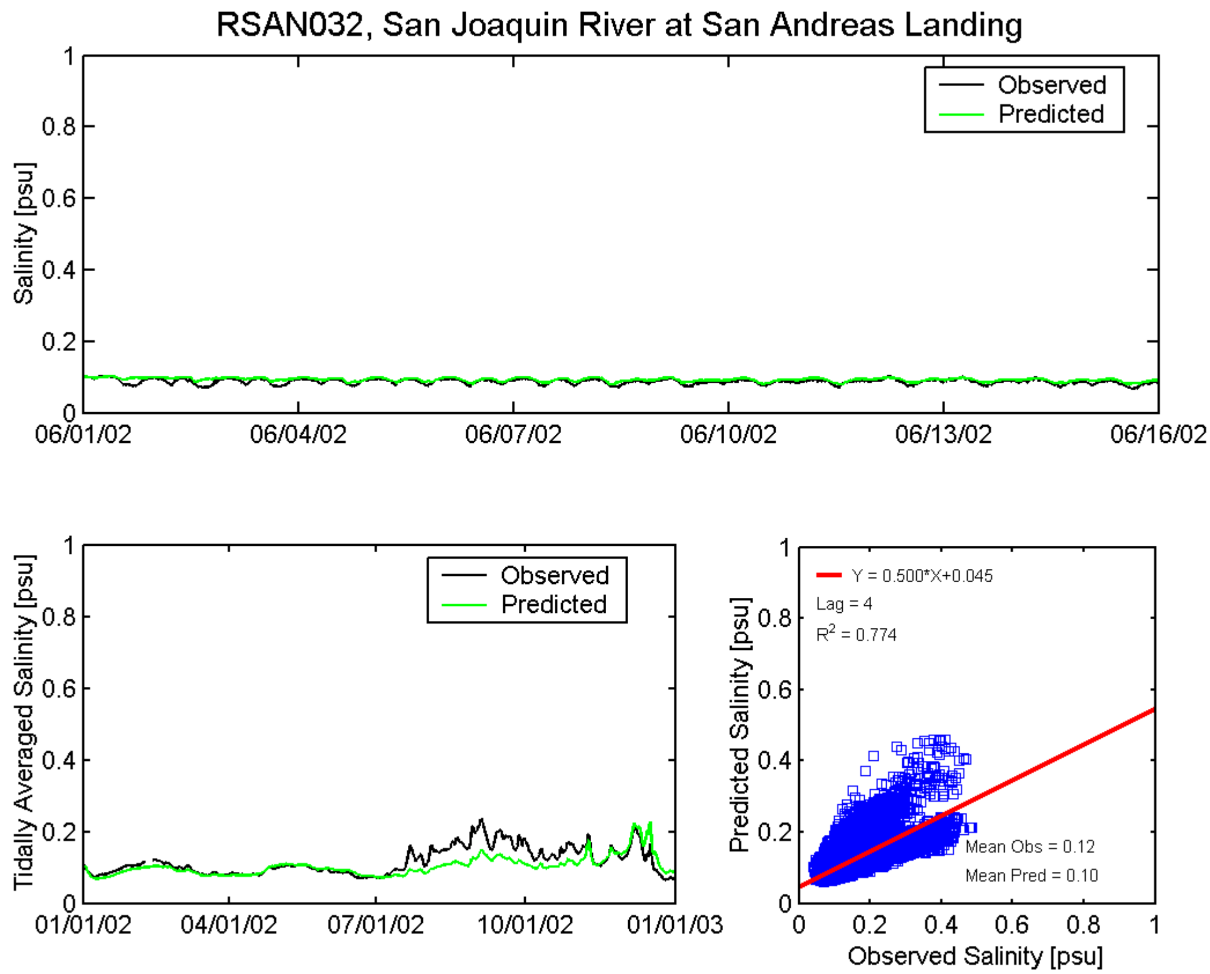


Figure A.6-42 Observed and predicted salinity at San Joaquin River at San Andreas Landing USBR station (RSAN032) during the 2002 simulation period.

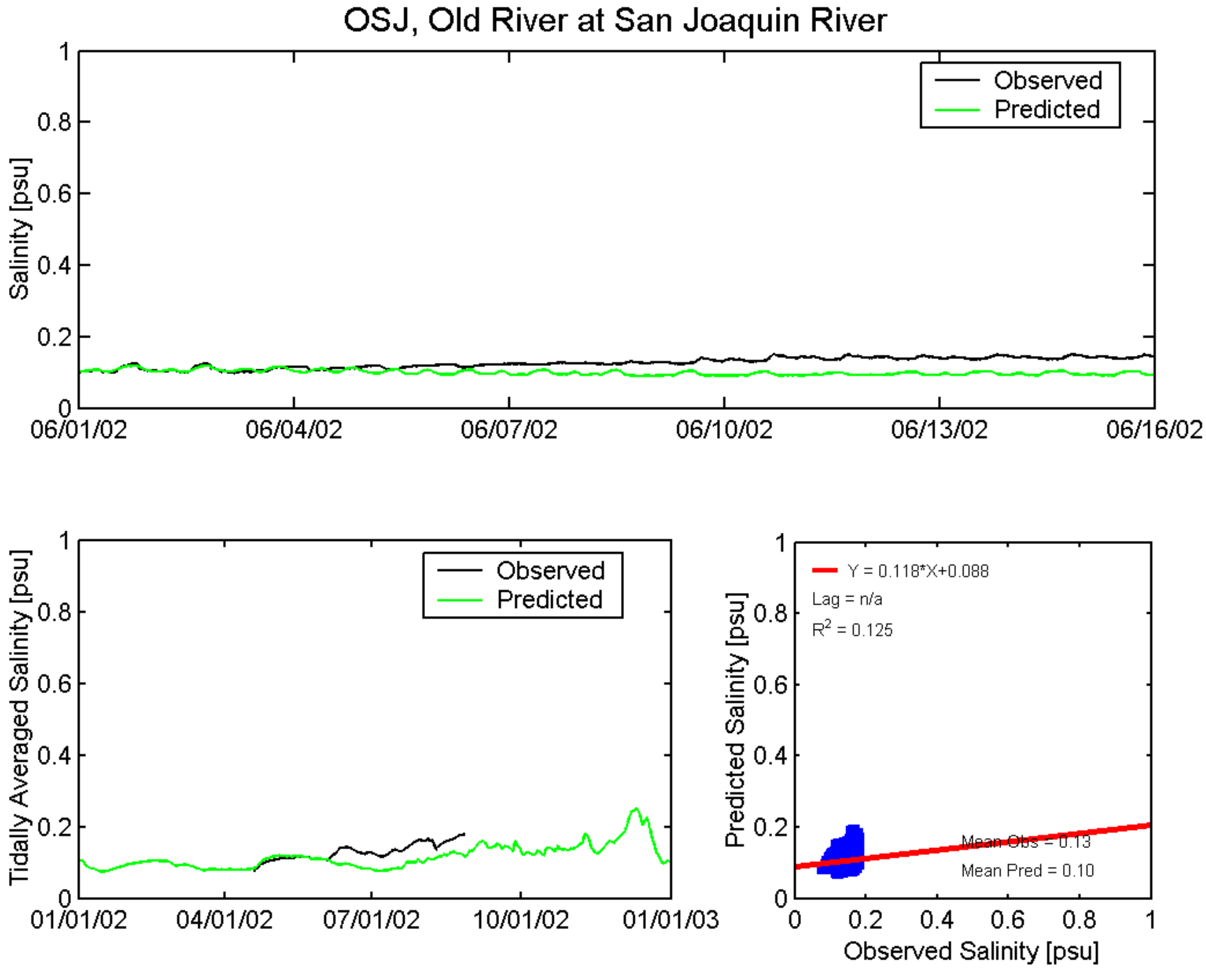


Figure A.6-43 Observed and predicted salinity at Old River at San Joaquin River USGS station (OSJ) during the 2002 simulation period.

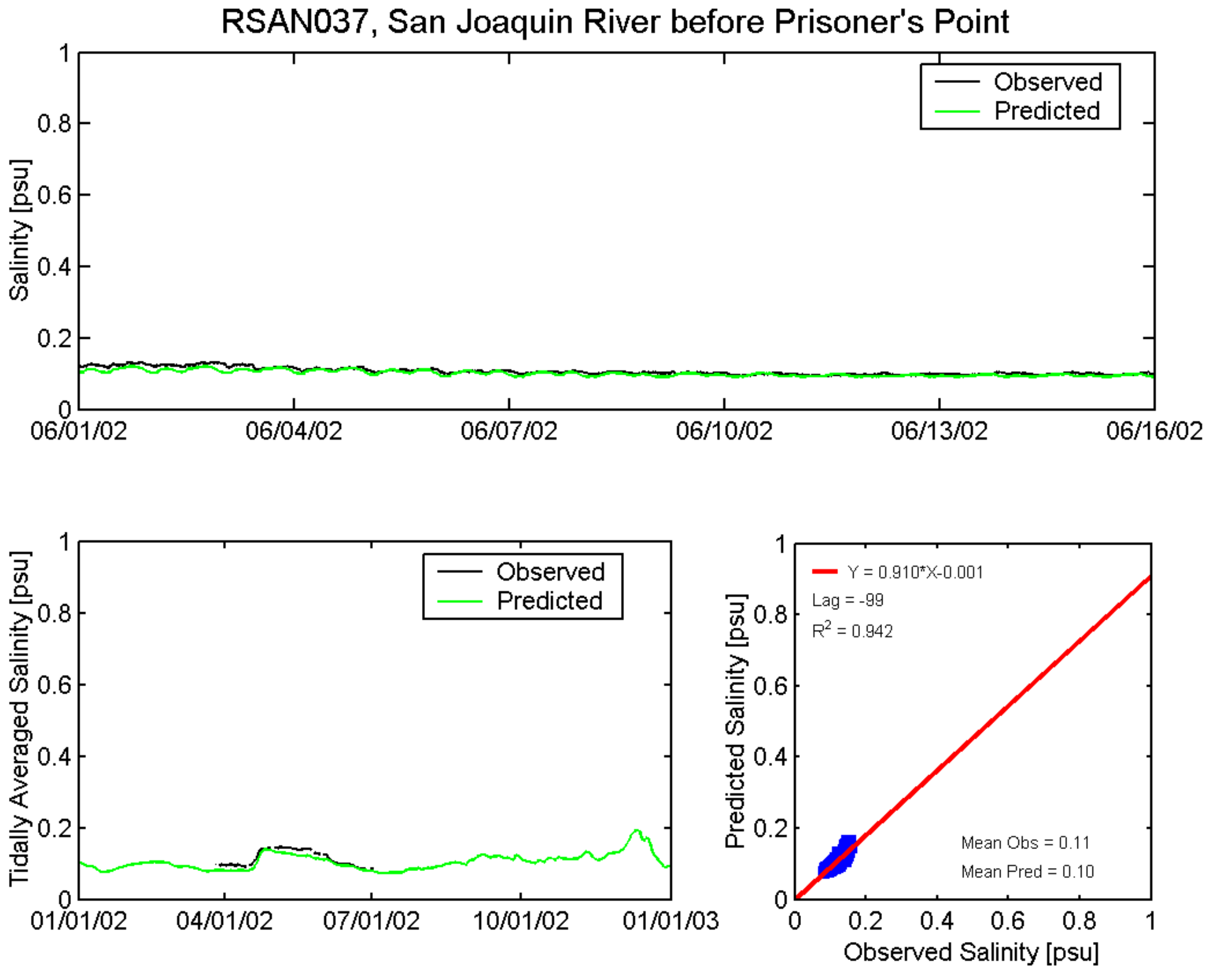


Figure A.6-44 Observed and predicted salinity at San Joaquin River before Prisoner's Point DWR station (RSAN037) during the 2002 simulation period.

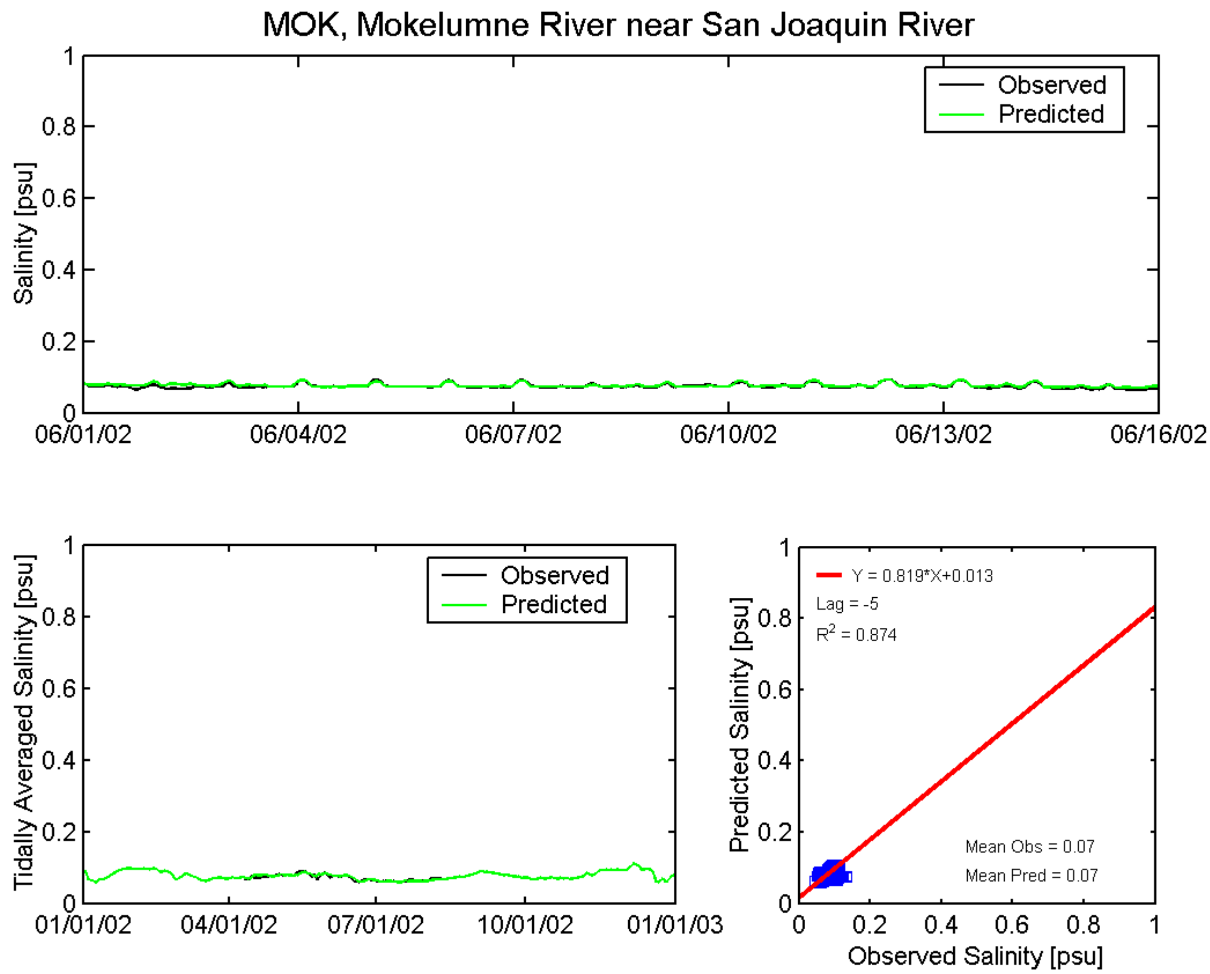


Figure A.6-45 Observed and predicted salinity at Mokelumne River near San Joaquin River USGS station (MOK) during the 2002 simulation period.

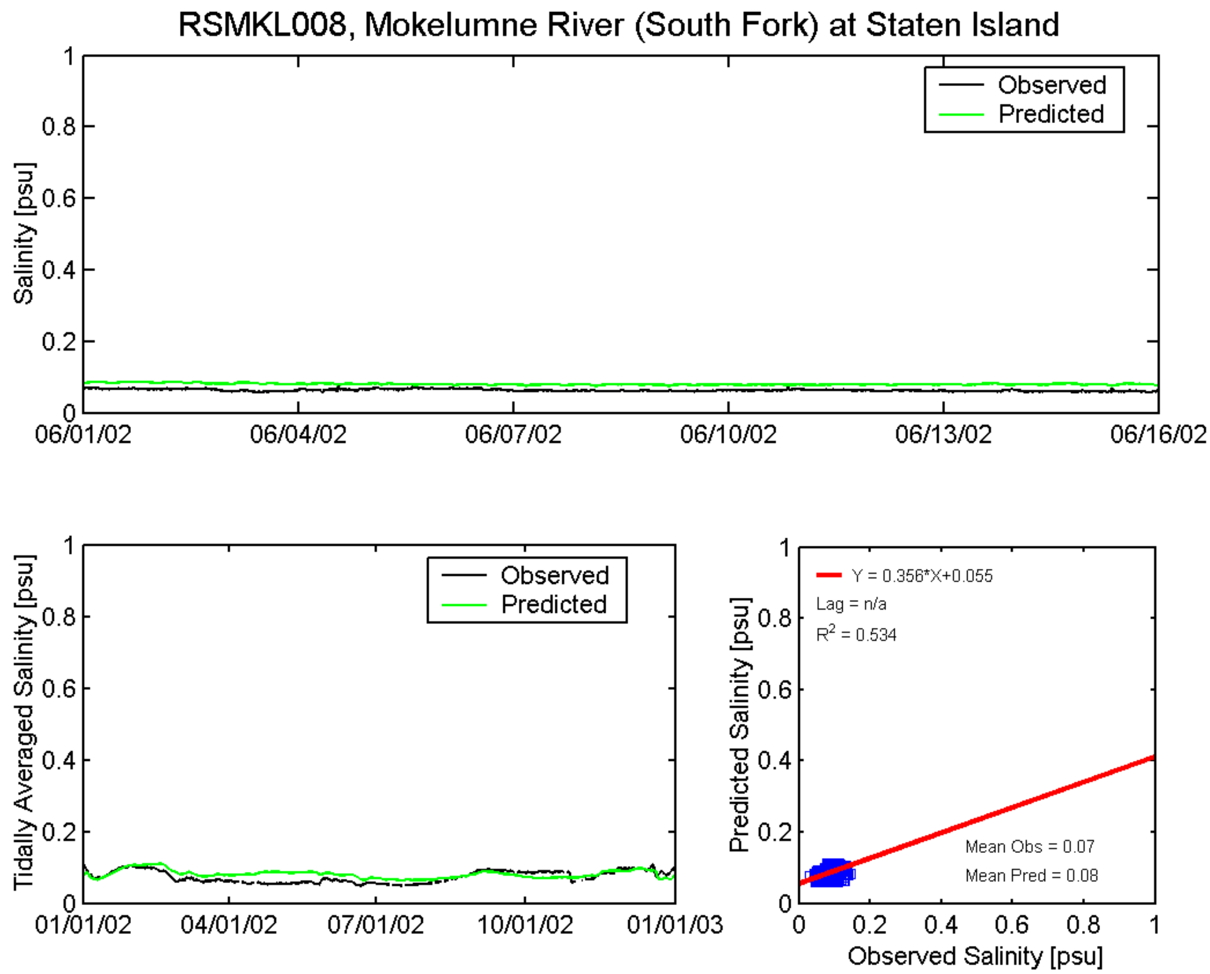


Figure A.6-46 Observed and predicted salinity at Mokelumne River (South Fork) at Staten Island DWR station (RSMKL008) during the 2002 simulation period.

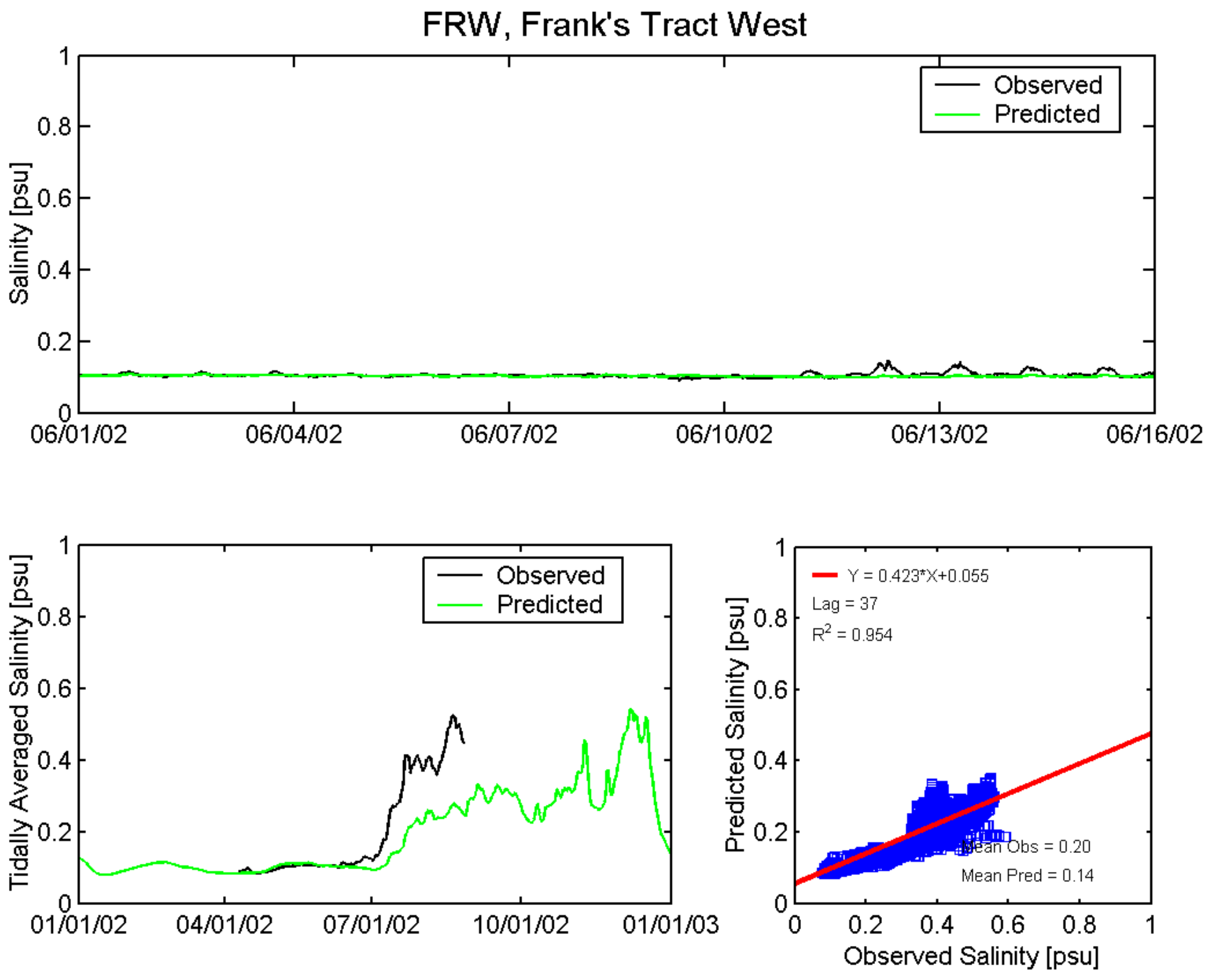


Figure A.6-47 Observed and predicted salinity at Franks Tract West USGS station (FRW) during the 2002 simulation period.

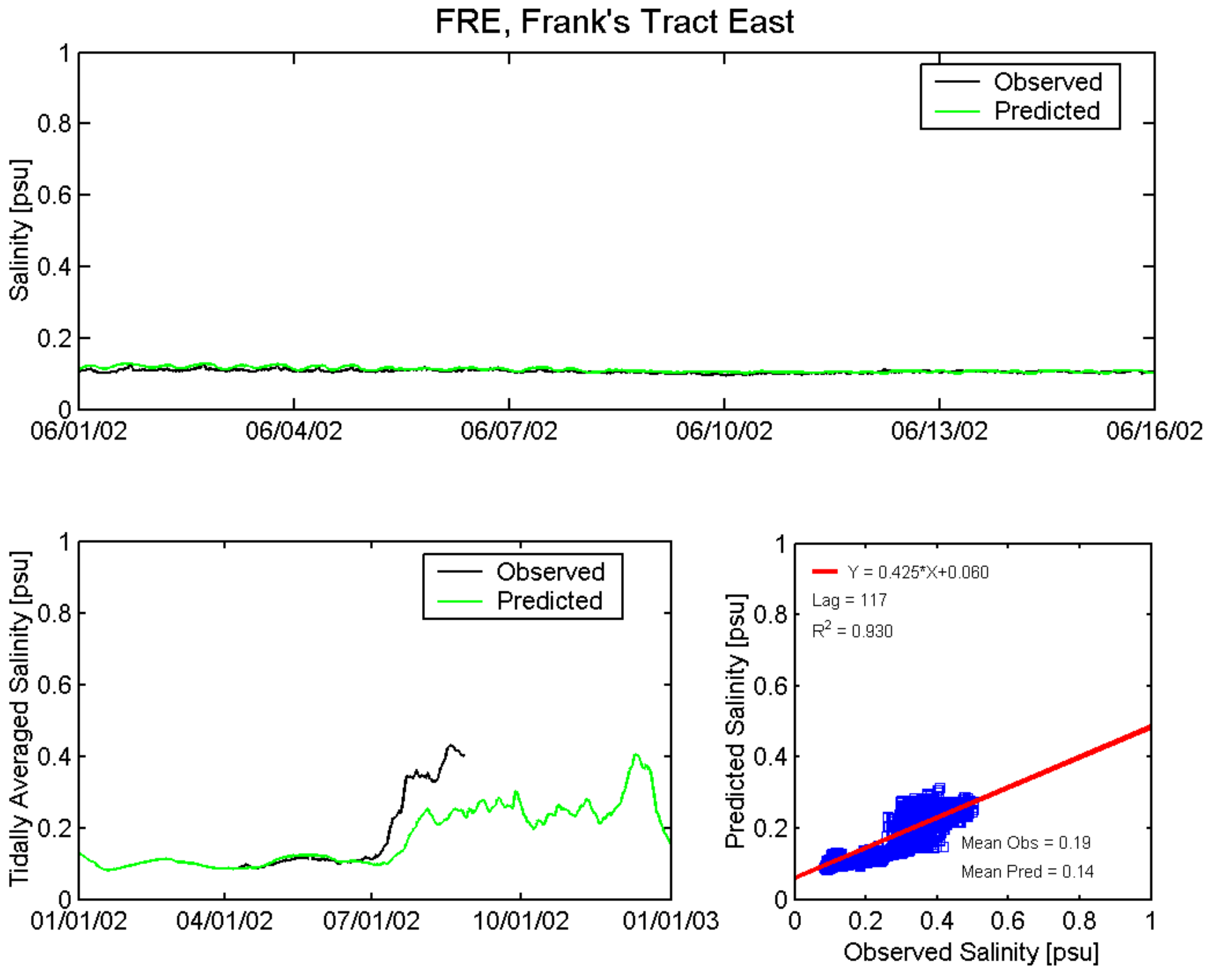


Figure A.6-48 Observed and predicted salinity at Franks Tract East USGS station (FRE) during the 2002 simulation period.

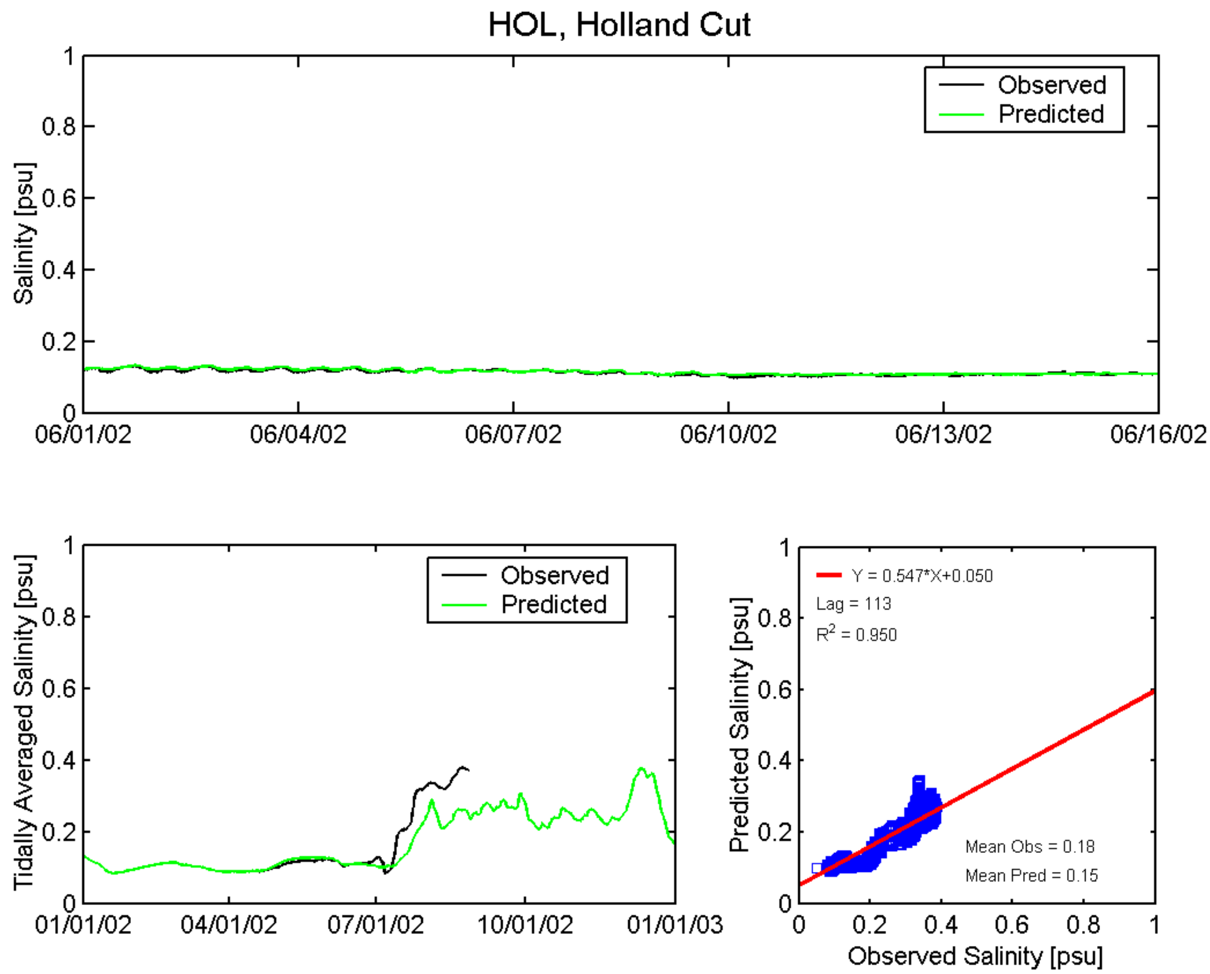


Figure A.6-49 Observed and predicted salinity at Holland Cut USGS station (HOL) during the 2002 simulation period.

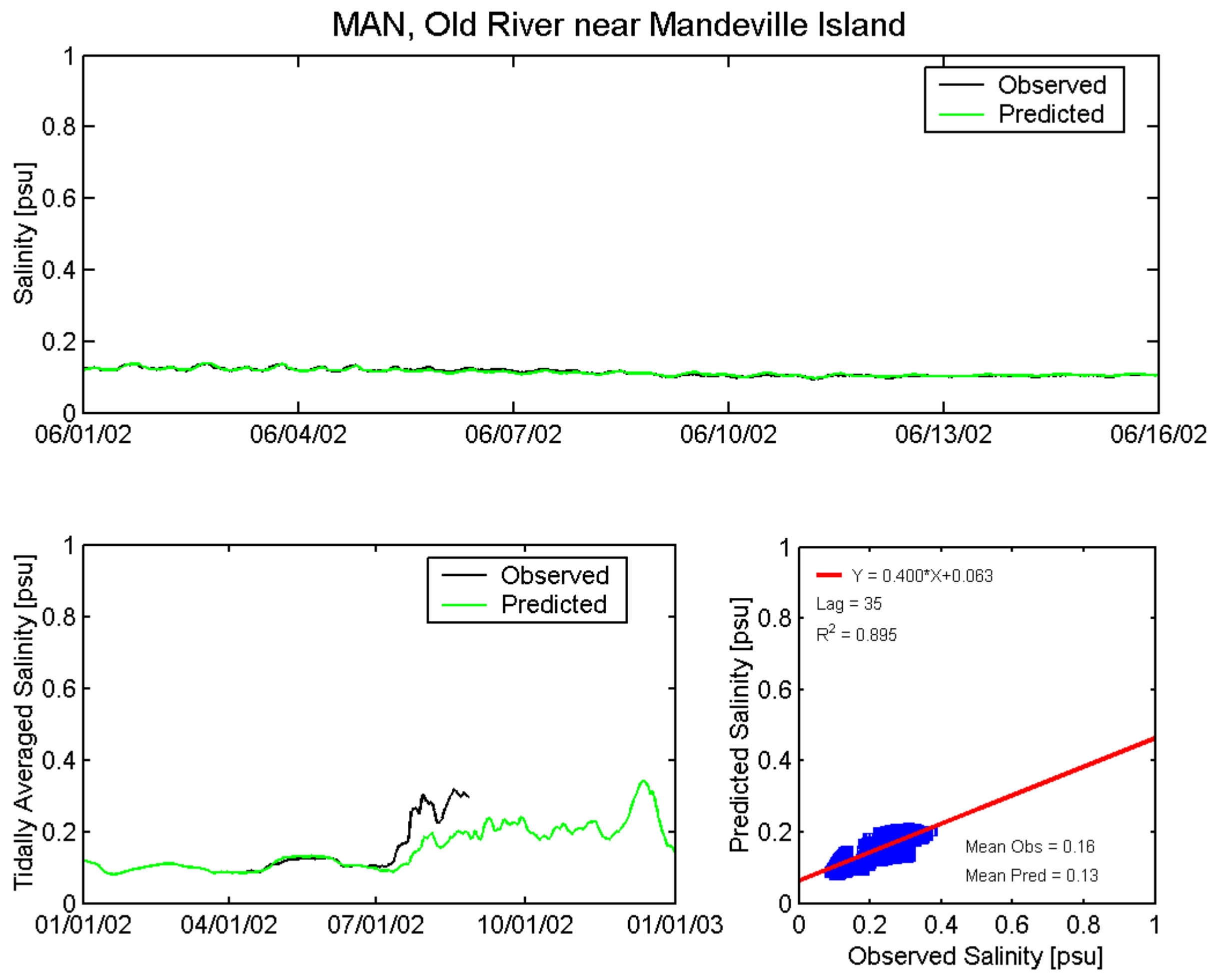


Figure A.6-50 Observed and predicted salinity at Old River near Mandeville Island USGS station (MAN) during the 2002 simulation period.

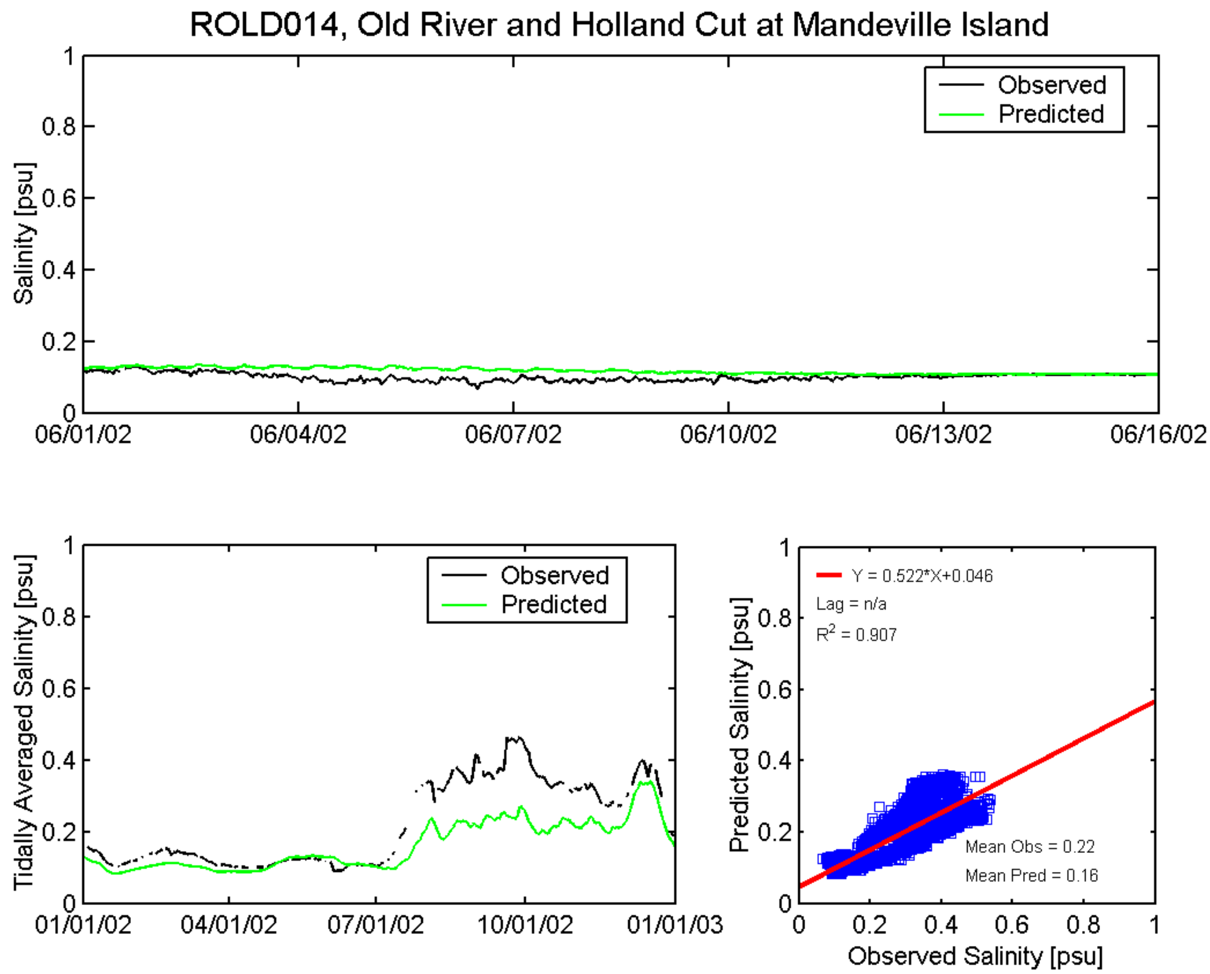


Figure A.6-51 Observed and predicted salinity at Old River and Holland Cut at Mandeville Island USBR station (ROLD014) during the 2002 simulation period.

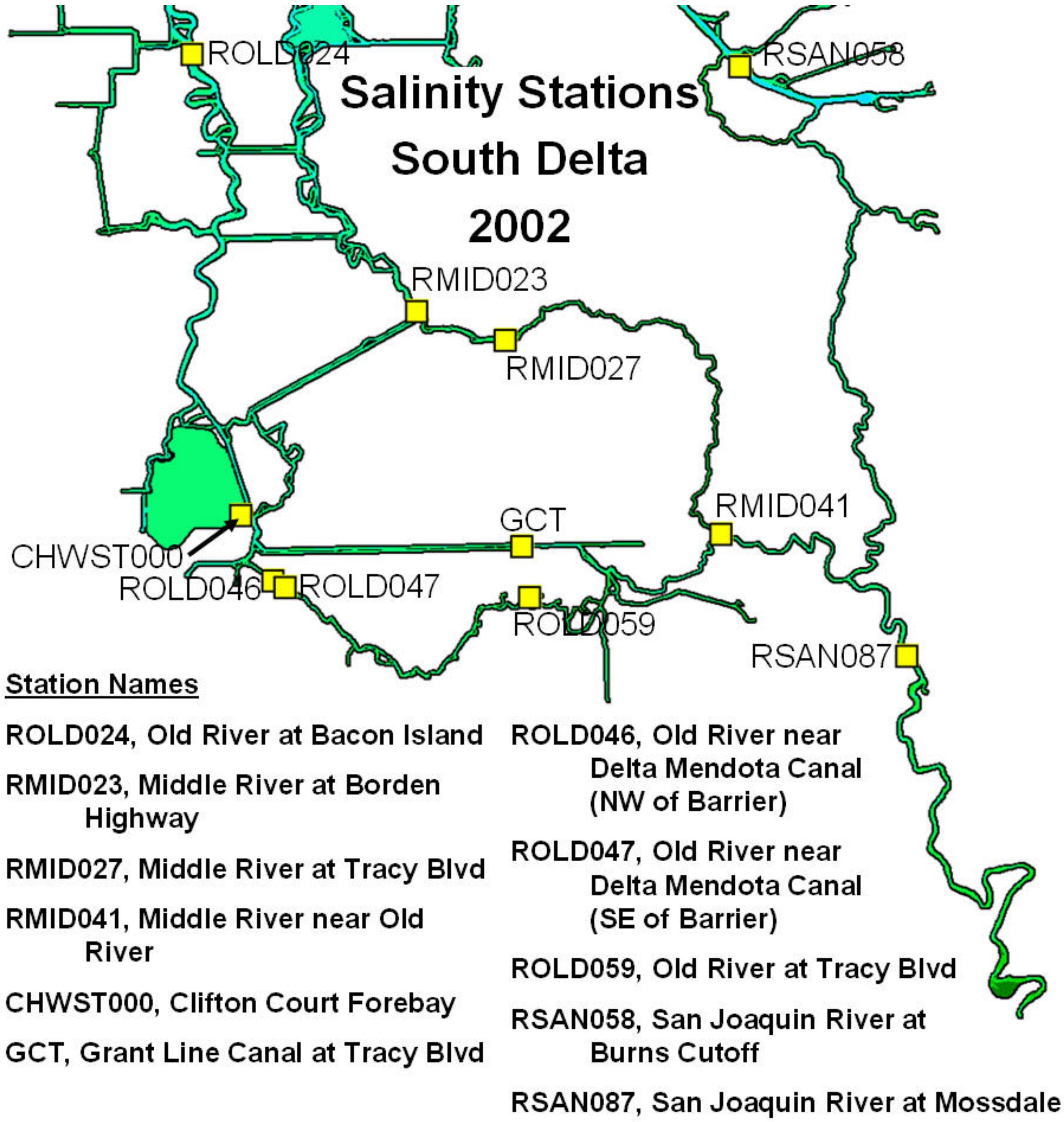


Figure A.6-52 Location of salinity monitoring stations in the southern portion of the Sacramento-San Joaquin Delta used for 2002 salinity comparisons.

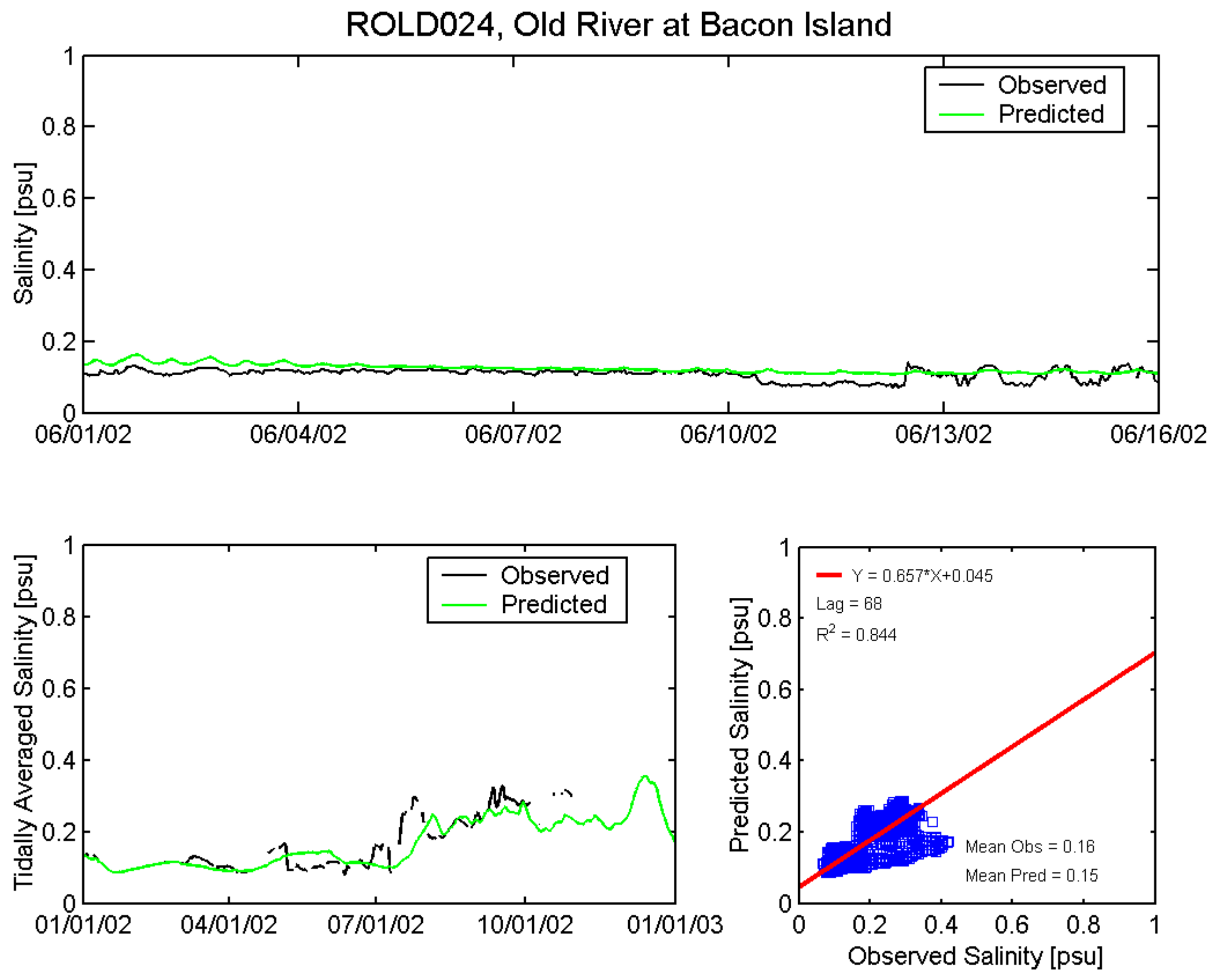


Figure A.6-53 Observed and predicted salinity at Old River at Bacon Island DWR station (ROLD024) during the 2002 simulation period.

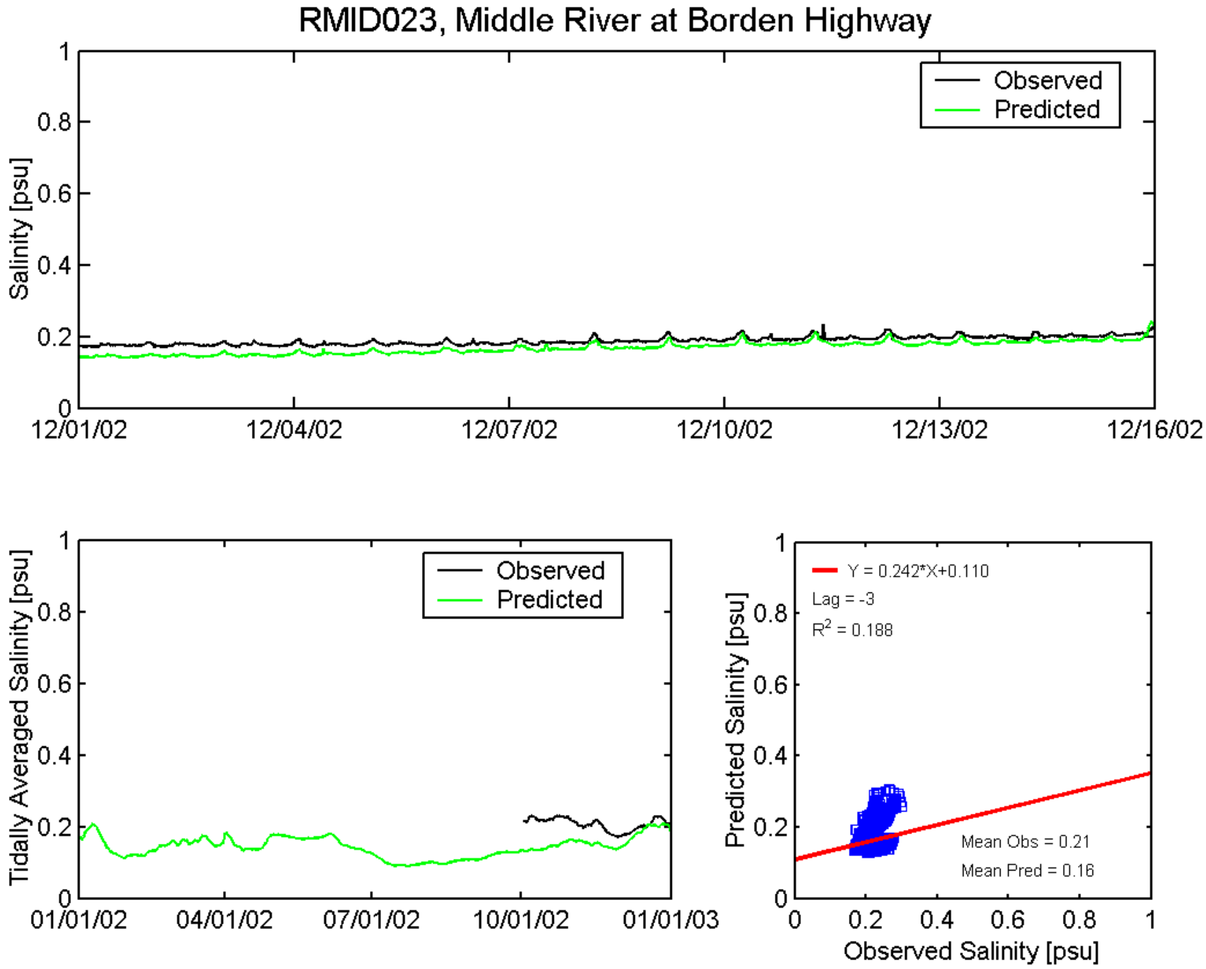


Figure A.6-54 Observed and predicted salinity at Middle River at Borden Highway DWR station (RMID023) during the 2002 simulation period.

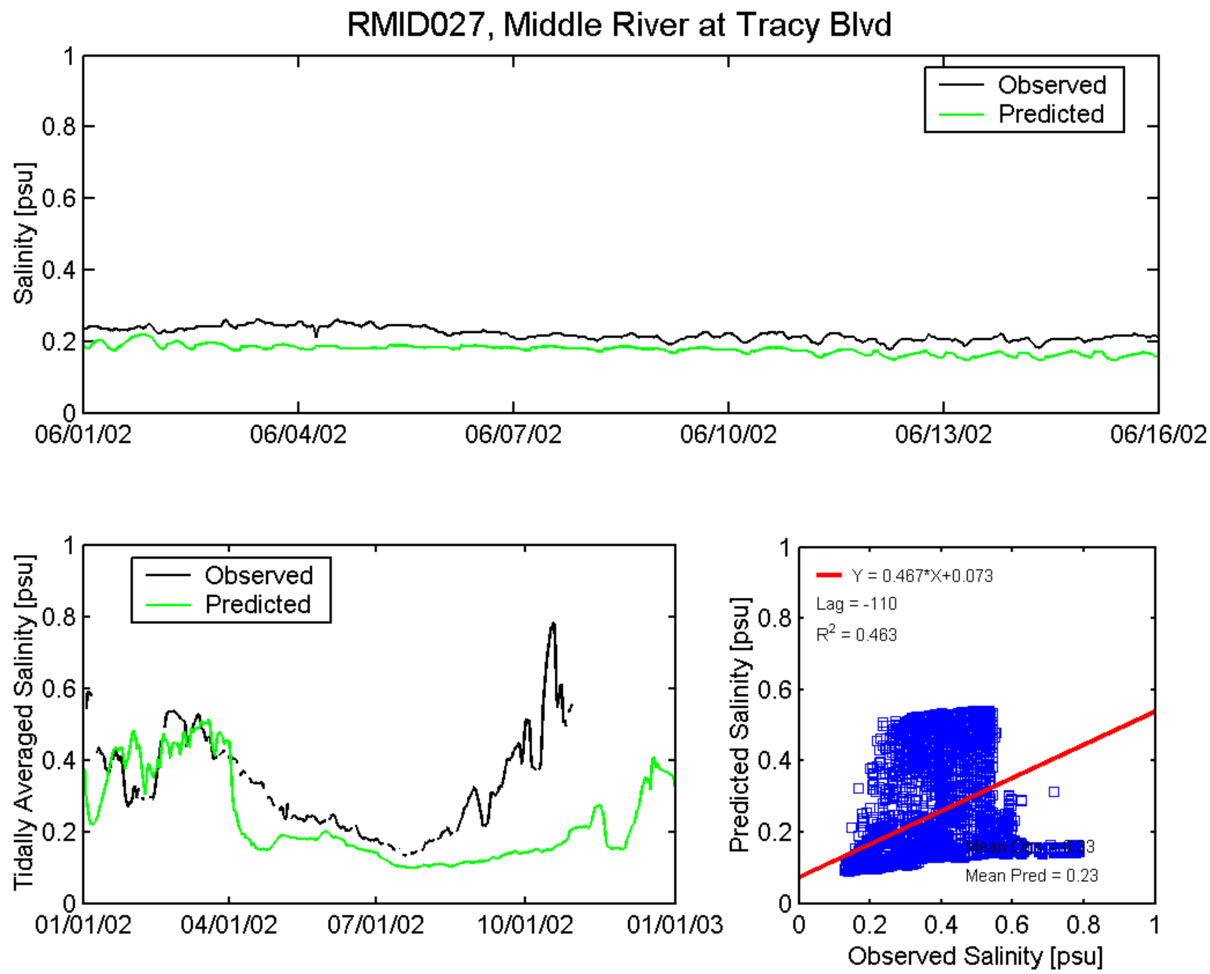


Figure A.6-55 Observed and predicted salinity at Middle River at Tracy Boulevard DWR station (RMID027) during the 2002 simulation period.

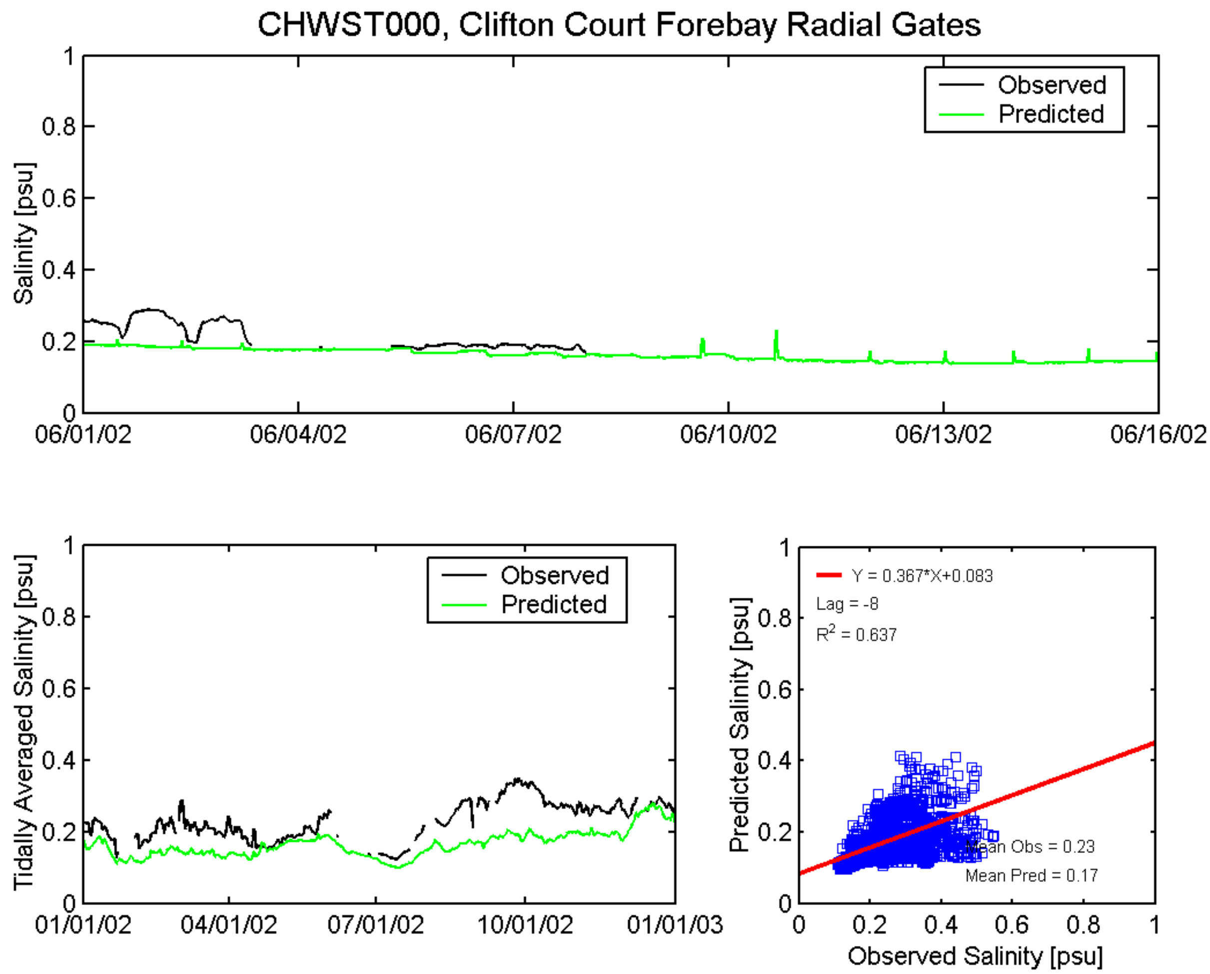


Figure A.6-56 Observed and predicted salinity at Clifton Court Forebay Radial Gates DWR station (CHWST000) during the 2002 simulation period.

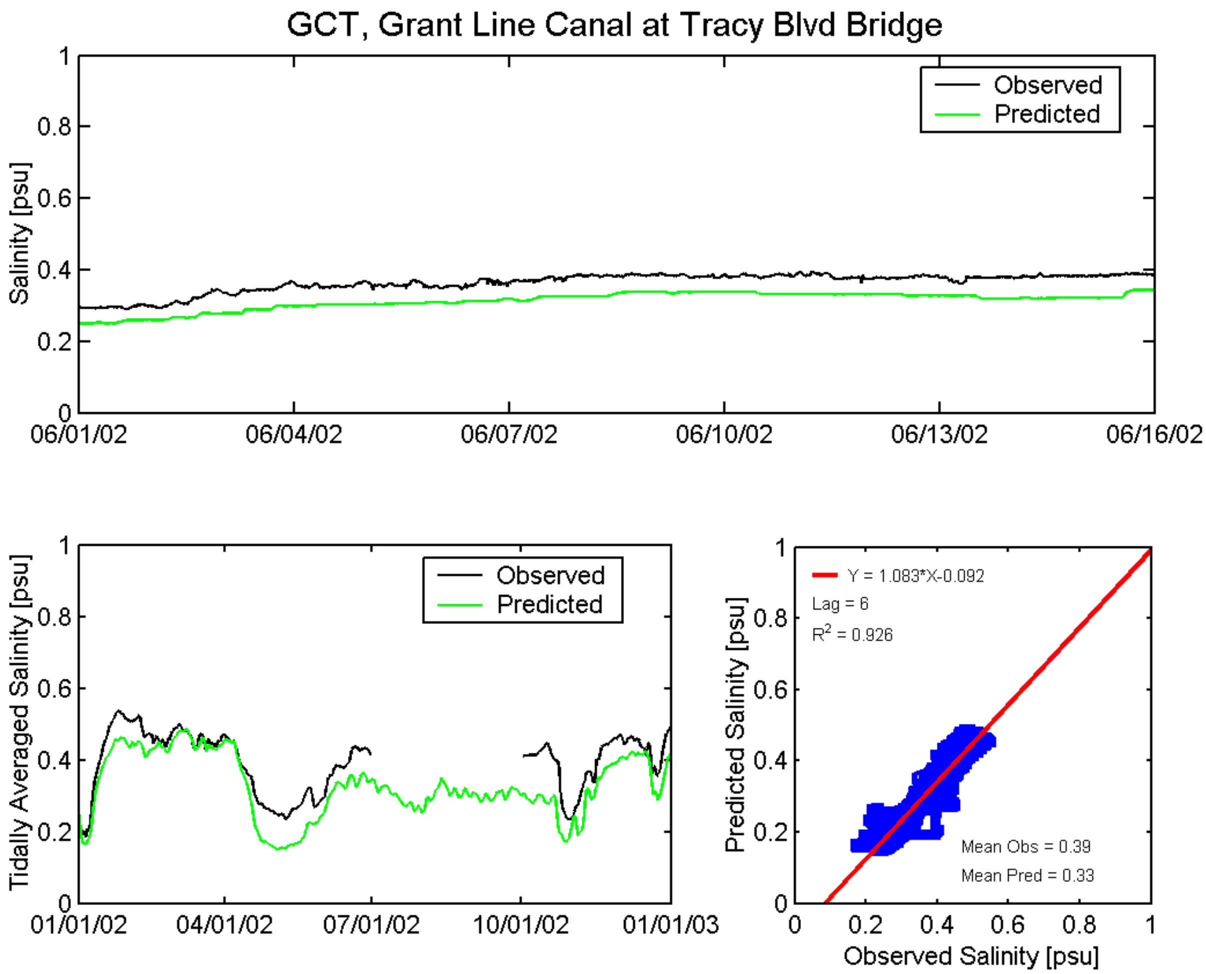


Figure A.6-57 Observed and predicted salinity at Grant Line Canal at Tracy Boulevard DWR station (CDEC GCT) during the 2002 simulation period.

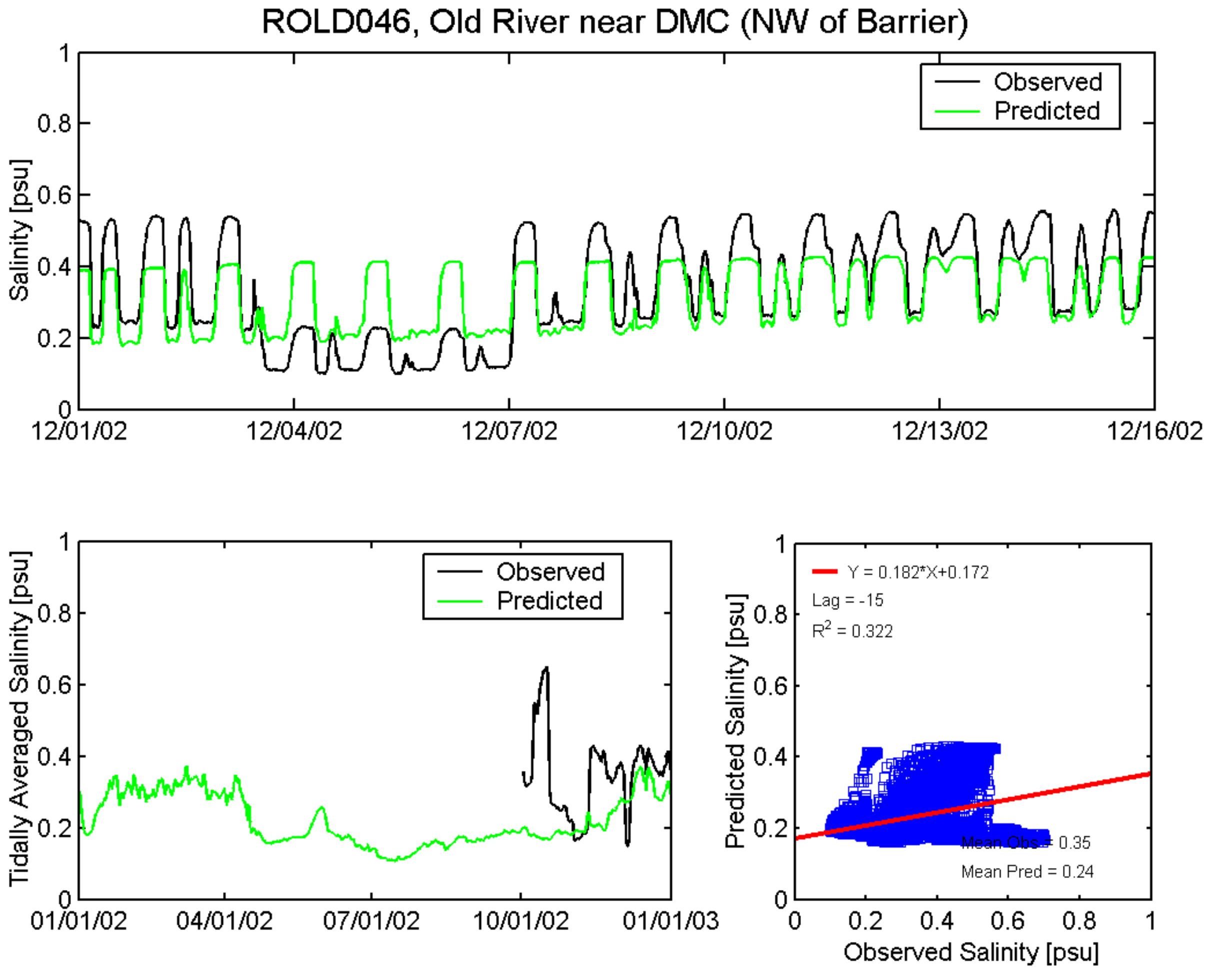


Figure A.6-58 Observed and predicted salinity at Old River near Delta Mendota Canal NW of Barrier DWR station (ROLD046) during the 2002 simulation period.

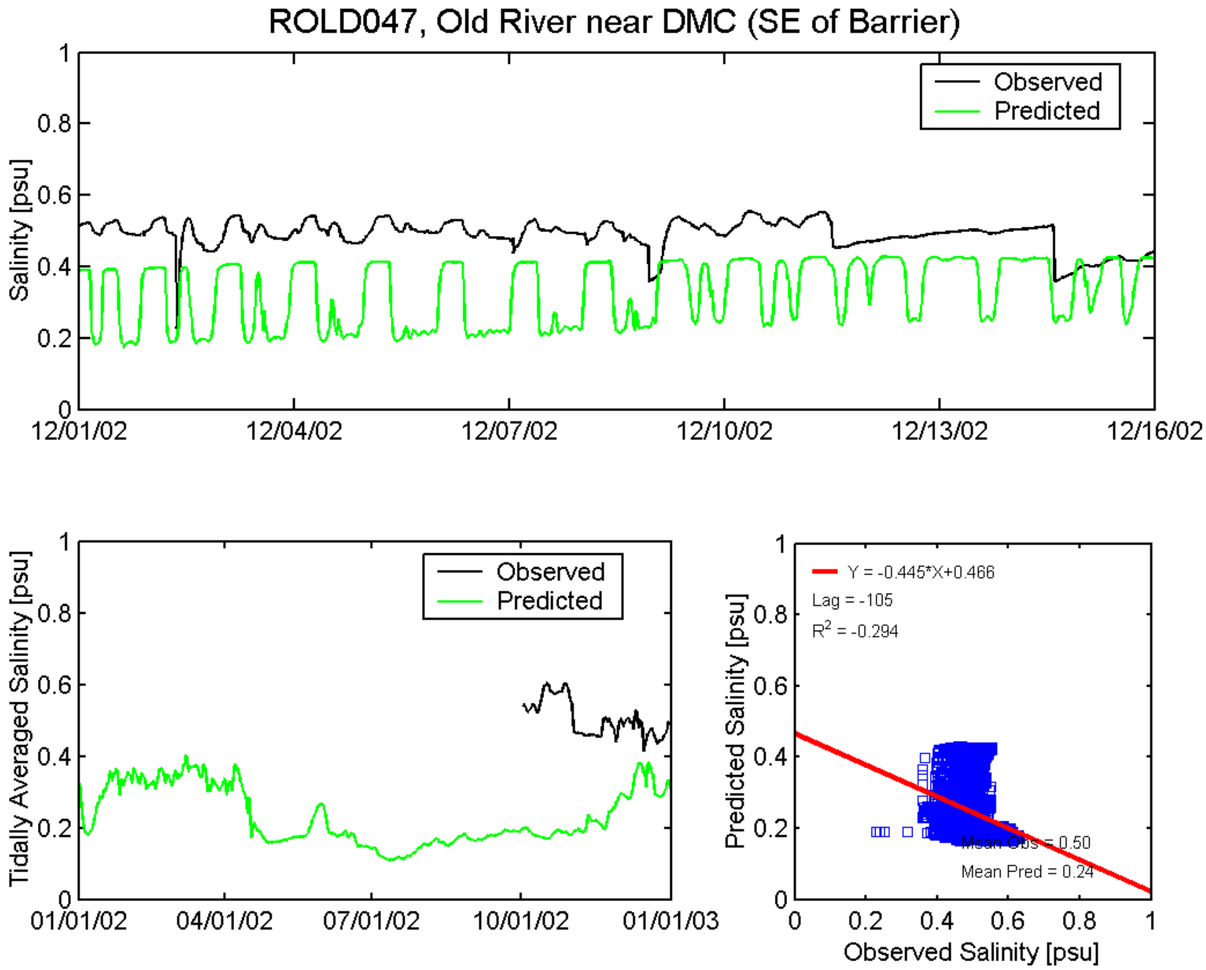


Figure A.6-59 Observed and predicted salinity at Delta Mendota Canal SE of Barrier DWR station (ROLD047) during the 2002 simulation period.

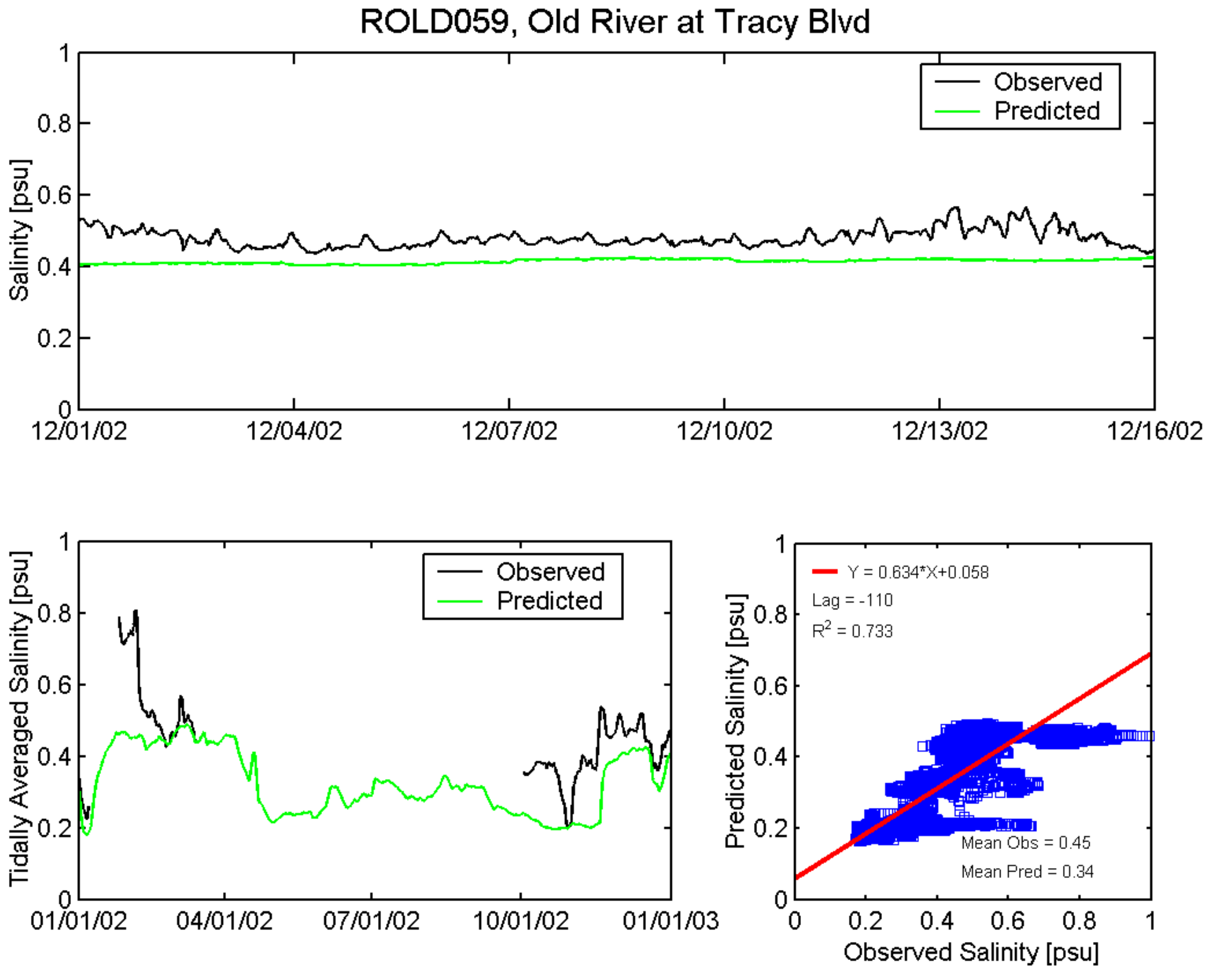


Figure A.6-60 Observed and predicted salinity at Old River at Tracy Boulevard DWR station (ROLD059) during the 2002 simulation period.

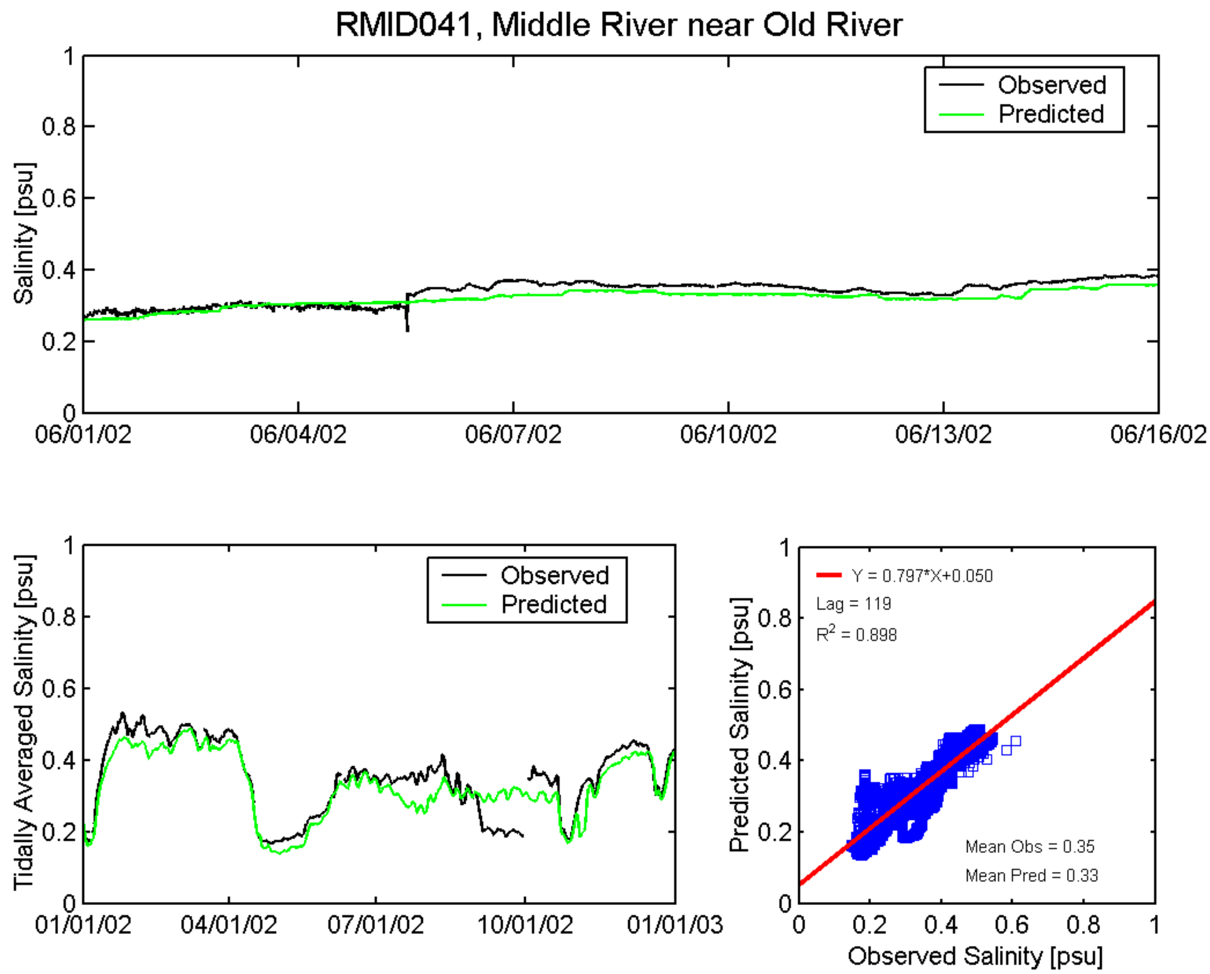


Figure A.6-61 Observed and predicted salinity at Middle River near Old River DWR station (RMID041) during the 2002 simulation period.

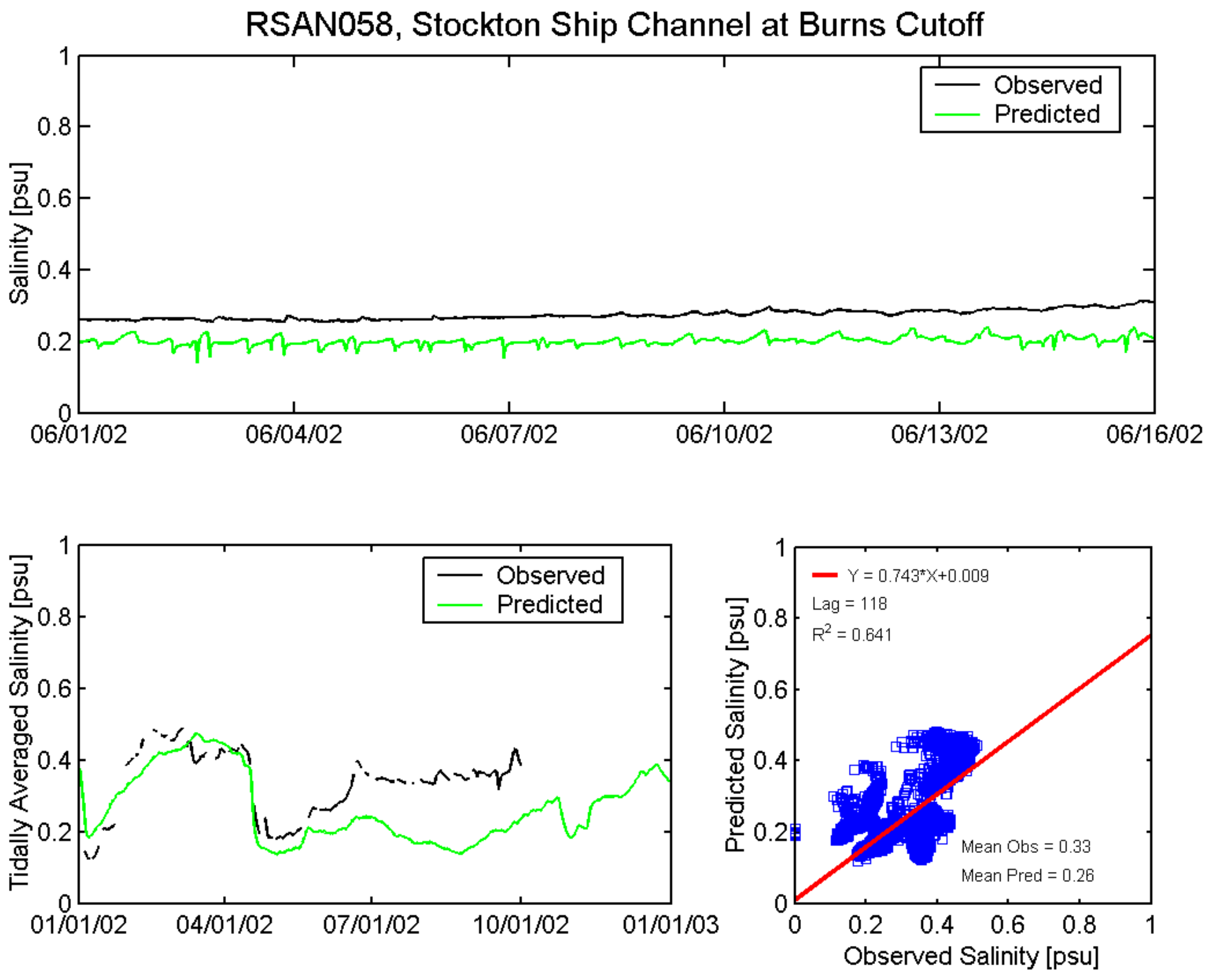


Figure A.6-62 Observed and predicted salinity at Stockton Ship Channel at Burns Cutoff DWR station (RSAN058) during the 2002 simulation period.

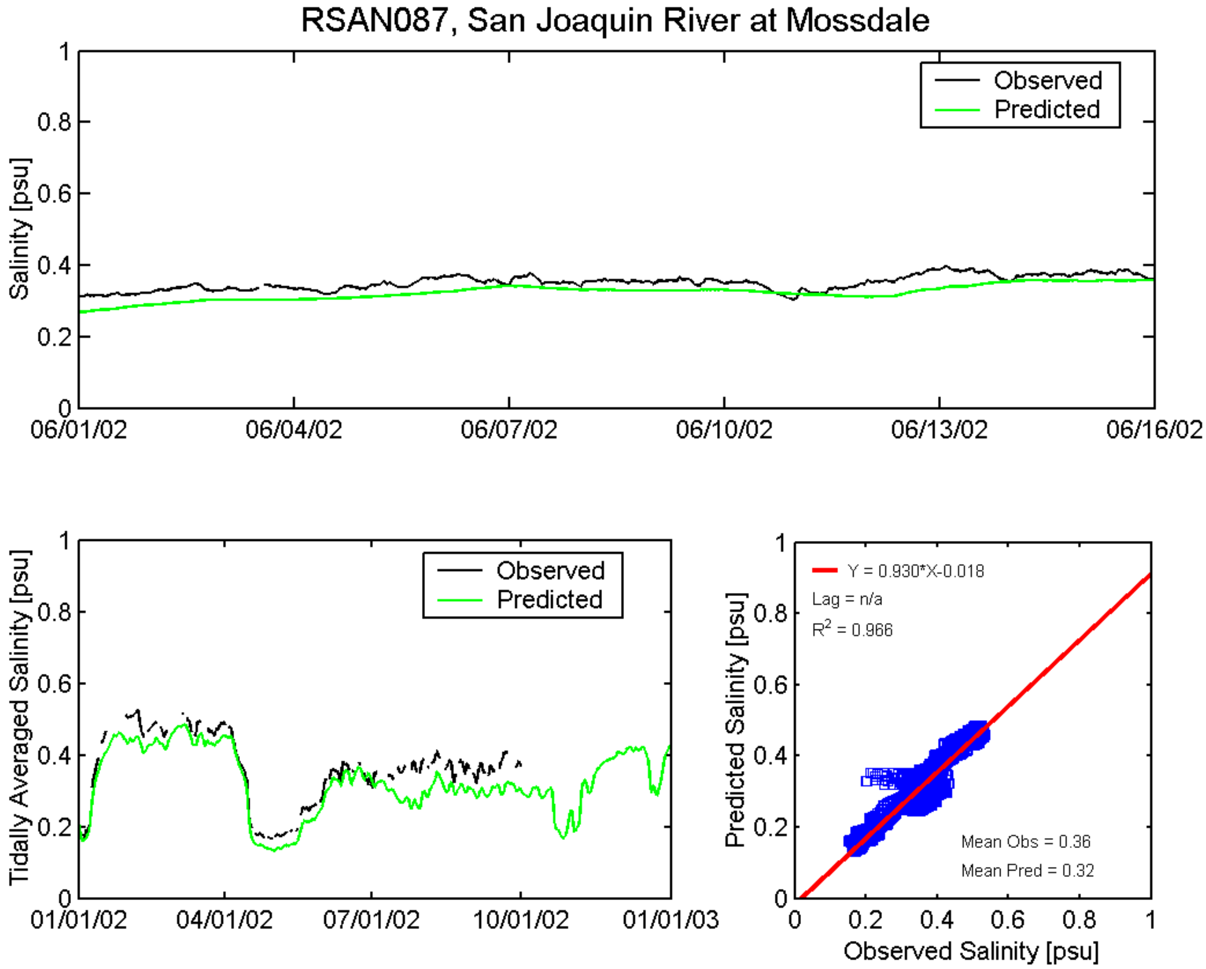


Figure A.6-63 Observed and predicted salinity at San Joaquin River at Mossdale DWR station (RSAN087) during the 2002 simulation period.

5.B.A.3 Appendix 5B - Attachment 3: DSM2 Sea Level Rise Corroboration

5.B.A.3.1 Introduction

In the analysis of the CWF Proposed Action (PA), sea level rise is an integral part of the physical modeling to capture the effects. In the process of preparing Delta Simulation Model (DSM2) for evaluating the CWF alternatives, the simulation of sea level rise in DSM2 is corroborated using the modeling results from higher dimensional models of the California Bay-Delta. This memorandum provides a brief description of the purpose, methodology and the results of this process.

5.B.A.3.2 Purpose of Corroboration

CWF NAA and PA scenarios evaluation requires long-term analysis of hydrodynamics and water quality in the Delta resulting from the proposed physical and operational changes. DSM2 is an appropriate model for this type of analysis. It has been successfully used in analyzing several projects in the Delta. However, DSM2 has a limited ability to simulate three-dimensional processes such as gravitational circulation which is known to increase with sea level rise in the estuaries. Therefore, it is imperative that DSM2 be recalibrated or corroborated based on a dataset that accurately represents the conditions in the Delta under sea level rise. Since the proposed conditions are hypothetical, the best available approach to estimate the Delta hydrodynamics would be to simulate higher dimensional models which can resolve the three-dimensional processes well. These models would generate the data sets needed to corroborate or recalibrate DSM2 under the proposed conditions so that it can simulate the hydrodynamics and salinity transport with reasonable accuracy.

5.B.A.3.3 Modeling Tools

5.B.A.3.3.1 DSM2

DSM2 is a one-dimensional hydrodynamics, water quality and particle tracking simulation model used to simulate hydrodynamics, water quality, and particle tracking in the Sacramento-San Joaquin Delta (DWR, 2002). DSM2 represents the best available planning model for Delta tidal hydraulics and salinity modeling. It is appropriate for describing the existing conditions in the Delta, as well as performing simulations for the assessment of incremental environmental impacts caused by facilities and operations. The DSM2 model has three separate components: HYDRO, QUAL, and PTM. HYDRO simulates one-dimensional hydrodynamics including flows, velocities, depth, and water surface elevations. The HYDRO module is a one-dimensional, implicit, unsteady, open channel flow model that DWR developed from FOURPT, a four-point finite difference model originally developed by the USGS in Reston, Virginia. HYDRO provides the flow input for QUAL and PTM. The QUAL module is a one-dimensional water quality transport model that DWR adapted from the Branched Lagrangian Transport Model originally developed by the USGS in Reston, Virginia. QUAL simulates fate and transport of conservative and non-conservative water quality constituents by solving the one-dimensional advection-dispersion equation in which non-conservative constituent relationships are considered to be governed, in general, by first order rates. Tidal boundary (stage in feet) is applied at Martinez. Flow boundaries are specified at Sacramento, Vernalis, Yolo bypass and

East side streams. Other boundaries include gates and other control structures, diversions, exports and Delta Island Consumptive Use (DICU). QUAL uses EC boundary specified at Martinez and other boundary inflow locations mentioned above.

5.B.A.3.3.2 UnTRIM-3D

Sea level rise is known to alter the transport processes in the estuaries. Processes such as the gravitational circulation are affected by the resulting changes in the density gradients under the sea level rise. DSM2 does not explicitly simulate these transport processes unlike the other higher order models, such as UnTRIM-3D. Therefore, results from the UnTRIM-3D were used to corroborate and fine tune the transport processes in DSM2 under the sea level rise conditions.

UnTRIM Bay-Delta Model, a three-dimensional hydrodynamics and water quality model was used to simulate the sea level rise effects on hydrodynamics and salinity transport under the historical operations in the Delta. The results from the UnTRIM model were used to corroborate RMA and DSM2 models so that they simulate the effect of sea level rise accurately.

A complete description of the UnTRIM Bay-Delta model can be found in MacWilliams et al. (2009). The UnTRIM model solves the three-dimensional Navier-Stokes equations on an unstructured grid in the horizontal plane. The boundaries between vertical layers are at fixed elevations, and cell heights can be varied vertically to provide increased resolution near the surface or other vertical locations. Volume conservation is satisfied by a volume integration of the incompressible continuity equation, and the free-surface is calculated by integrating the continuity equation over the depth, and using a kinematic condition at the free-surface as described in Casulli (1990). The numerical method allows full wetting and drying of cells in the vertical and horizontal directions. The governing equations are discretized using a finite difference – finite volume algorithm.

The UnTRIM San Francisco Bay-Delta model (UnTRIM Bay-Delta model) is a three-dimensional hydrodynamic model of San Francisco Bay and the Sacramento-San Joaquin Delta, which has been developed using the UnTRIM hydrodynamic model (MacWilliams et al., 2007; MacWilliams et al., 2008; MacWilliams et al., 2009). The UnTRIM Bay-Delta model extends from the Pacific Ocean through the entire Sacramento-San Joaquin Delta (Figure 2-1). The UnTRIM Bay-Delta model takes advantage of the grid flexibility allowed in an unstructured mesh by gradually varying grid cell sizes, beginning with large grid cells in the Pacific Ocean and gradually transitioning to finer grid resolution in the smaller channels of the Sacramento-San Joaquin Delta. The model calibration and validation results (MacWilliams et al., 2008; MacWilliams et al. 2009) demonstrate that the UnTRIM Bay-Delta model is accurately predicting flow, stage, and salinity in San Francisco Bay and the Sacramento-San Joaquin Delta under a wide range of hydrologic conditions and is suitable for evaluating the potential salinity impacts resulting from sea level rise.

5.B.A.3.4 CWF Corroboration Scenario

The evaluation of CWF is performed at year 2030. A sea level rise of 15cm was assumed at year 2030 for the CWF BA. DSM2 was corroborated for a 15cm sea level rise scenario using results from UnTRIM model simulation, which assumed 15 cm increase in the mean sea level without any change in the amplitude at the ocean end.

5.B.A.3.5 Corroboration Methodology

Maintaining consistent grid and boundary conditions between the higher dimensional model and DSM2 model for each scenario is critical for successful corroboration. The methodology includes building the physical changes into the DSM2 grid and ensuring the boundary conditions for stage, inflow, diversion and gate operations are consistent between DSM2 and the higher dimensional model. Once ensuring the consistency between the two model setups, the results from the higher dimensional model are used to fine tune the DSM2 results.

5.B.A.3.5.1 Corroboration Baseline

DSM2 model from the 2009 mini-calibration is used as the baseline in the corroboration process. The historical boundary conditions are updated to be same as that UnTRIM baseline model. DSM2 stage and EC boundary at Martinez are set equal to the output at Martinez from the UnTRIM baseline model. Figure 2 shows the north Delta portion of the DSM2 grid used for the corroboration baseline.

5.B.A.3.5.2 Physical Changes in DSM2

The DSM2 bathymetry remains unchanged and sea level rise is the only modification.

5.B.A.3.5.3 Boundary Conditions

In order to achieve DSM2 results consistent with the higher dimensional model, the number of differences between the two models in terms of the grid, bathymetry and boundary conditions have to be minimized. Therefore, the historical flow and EC boundaries at all the rim stations and in-Delta locations were set equal to those used in the higher dimensional model. Further, the stage and EC boundary conditions at Martinez used in the DSM2 model were set equal to the simulated outputs at Martinez from higher dimensional model used in the corroboration process.

5.B.A.3.5.4 Information from Higher Dimensional Models

In the corroboration scenario, correlations capturing the changes in stage and EC at Martinez were provided from the UnTRIM model. In addition, to verify the DSM2 results, timeseries of breach flows at all the proposed breach locations, timeseries of tidal flows at key channel locations and timeseries of EC at key channel locations in the Delta were provided based on the UnTRIM results.

5.B.A.3.5.5 Simulation Period for Corroboration

In general the corroboration was performed over a portion of the water years 2002 and 2003.

5.B.A.3.5.6 Corroboration Metrics

During the process of corroboration, changes to the DSM2 parameters were made based on computed statistics such that the incremental changes predicted by DSM2 between the baseline and corroboration scenario were similar to those predicted by higher dimensional model. The metrics used to assess the quality of flow corroboration included incremental change of instantaneous flows in the corroboration model from baseline model at key locations, incremental change of tidally averaged daily flows in the corroboration model from baseline model at key locations, instantaneous flows and tidally averaged net daily flows at key channel locations in the Delta and at breaches. The metrics used to assess the quality of EC corroboration included incremental change of tidally-averaged daily EC from the current conditions model to the corroboration model at key locations in the Delta and the tidally averaged daily EC at key locations in the Delta.

- Incremental change of instantaneous flows from baseline model at key locations
- Incremental change of tidally averaged daily flows from baseline model at key locations
- Tidally averaged daily EC at key locations
- Incremental change of tidally averaged daily EC at key locations

5.B.A.3.6 Corroboration of Scenario with 15 cm Sea Level Rise

This section describes the specifics related to the corroboration of DSM2 for the 15 cm sea level rise scenario. UnTRIM model was used in this corroboration process. In this corroboration process, the DSM2 baseline model stayed the same, except the stage and EC boundary conditions at Martinez were from the UnTRIM baseline outputs.

For the sea level rise corroboration, there were no physical changes to the baseline grid. Once again, for the baseline and the sea level rise corroboration run, the boundary conditions and the model setup were ensured to be consistent between DSM2 and UnTRIM models.

5.B.A.3.6.1 Boundary Conditions

The boundary conditions under DSM2 baseline model were consistent with the UnTRIM baseline model. The stage and EC boundary conditions at Martinez used in the DSM2 model were set equal to the simulated outputs at Martinez from the corresponding UnTRIM model. Table 1 summarizes the list of boundary conditions that are used in the DSM2 model for the sea level rise corroboration runs.

5.B.A.3.6.2 Simulation Period for Sea Level Rise Corroboration Scenarios

The UnTRIM runs were simulated from October 2001 to Dec 2002 period. The period of corroboration was from January 2002 through December 2002, although the simulations were initiated in October 2001. For this period, the UnTRIM model was run with the assumed changes in the mean sea level at the ocean boundary under the 15 cm scenario. The flow and EC results from the UnTRIM model were used to corroborate DSM2 with full boundary condition changes incorporated. During the process of corroboration, changes to the DSM2 parameters were performed based on computed statistics such that the incremental changes predicted by DSM2 between the baseline and sea level rise scenarios were similar to those predicted by UnTRIM.

5.B.A.3.6.3 Parameters Adjusted for the Corroboration

The consistency in the boundary conditions between the two models ensured that DSM2 HYDRO runs for the sea level rise scenarios resulted in a good match with UnTRIM in terms of the incremental changes in the flow without any changes to the model parameters. Based on the initial QUAL results, dispersion factors were modified for a few channels between Sherman Lake and Rio Vista on the Sacramento River in DSM2 to match the incremental change in salinity in the UnTRIM results. Since DSM2 does not capture the increased gravitational circulation caused by the sea level rise as in UnTRIM, increasing the dispersion factors in DSM2 compensates for the higher tidal dispersion caused by the sea level rise. Table 2 shows the DSM2 channels with the modified dispersion factors for sea level rise scenarios along with the values under the baseline.

5.B.A.3.6.4 Corroboration Results

The DSM2 results from the final sea level rise corroboration runs were compared with the UnTRIM results. Figure 1 compares the average incremental change in tidally-averaged EC at several key locations in the Delta for 15 cm sea level rise scenario simulated in DSM2 and UnTRIM models. The results show that DSM2 matches UnTRIM reasonably well in terms of the direction and magnitude of the average change at most locations.

Figures 2, 3, 4 and 5 show the timeseries of incremental change in EC between DSM2 and UnTRIM at Collinsville, Emmaton, Jersey Point and Old River at Rock Slough locations for the 15 cm sea level rise scenario, respectively. In general, the incremental change in DSM2 matches well with UnTRIM. Even though the incremental change in EC from DSM2 is slightly lower at Collinsville, it matches well at Emmaton. At Jersey Point and Old River at Rock Slough DSM2 shows higher incremental change than UnTRIM. Comparing the DSM2 and UnTRIM baseline models with the observed data it was found that UnTRIM was under-predicting the salinity in the central and south Delta. It was found that UnTRIM salinity result at Jersey Point was about 20% below the observed values and DSM2 was about 20% higher than the observed values. South Delta salinities simulated in DSM2 matched well with the observed data. For this reason, the UnTRIM results in this region of the Delta were mainly used to capture the trends and not necessarily to match the magnitude of the change while corroborating DSM2 sea level rise scenarios. Figures 6 through 15 compare incremental changes in EC from DSM2 to the incremental changes in UnTRIM at other key locations in the Delta.

Table 1. Summary of DSM2 Boundary Conditions for the Corroboration Baseline

Boundary Location	DSM2 Node/ Reservoir	Boundary Type
Calaveras	21	flow/EC
Cosumnes	446	flow/EC
Mokelumne	447	flow/EC
North Bay	273	Diversion
Yolo	316	flow/EC
Sacramento	330	flow/EC
Vernalis	17	flow/EC
Martinez	361	Stage/EC
CVP	181	Diversion
Green Valley Creek	369	flow/EC
Suisun Creek	396	flow/EC
Ledgewood Creek	392	flow/EC
Laurel Creek	368	flow/EC
Fairfield WWTP	400	flow/EC
Roaring River Duck Club	418	flow/EC
Morrow Island Duck Club	384	Diversion
Montezuma Sl West Duck Club	428	flow/EC
Montezuma Sl East Duck Club	420	flow/EC
Montezuma Sl Middle Duck Club	422	flow/EC
Nurse Sl Duck Club	406	flow/EC
Suisun Sl Duck Club	375	flow/EC
Boynton Sl Tidal Marsh	400	Precipitation/EC
Peytonia Sl Tidal Marsh	371	Precipitation/EC
Hill Sl Tidal Marsh	395	Precipitation/EC
First Mallard Sl Tidal Marsh	373	Precipitation/EC
Cutoff Sl Tidal Marsh	399	Precipitation/EC
Beldons Landing Tidal Marsh	425	Precipitation/EC

Table 2. Modified DSM2 Channel Dispersion Factors to Compensate for the Increased Tidal Dispersion under 15 cm Sea Level Rise Scenario

	Channel Dispersion Factors	
DSM2 Channel	**Baseline**	**15cm Sea Level Rise**
431	0.05	0.08
432	0.20	0.20
433	0.20	0.25
434	0.50	0.55

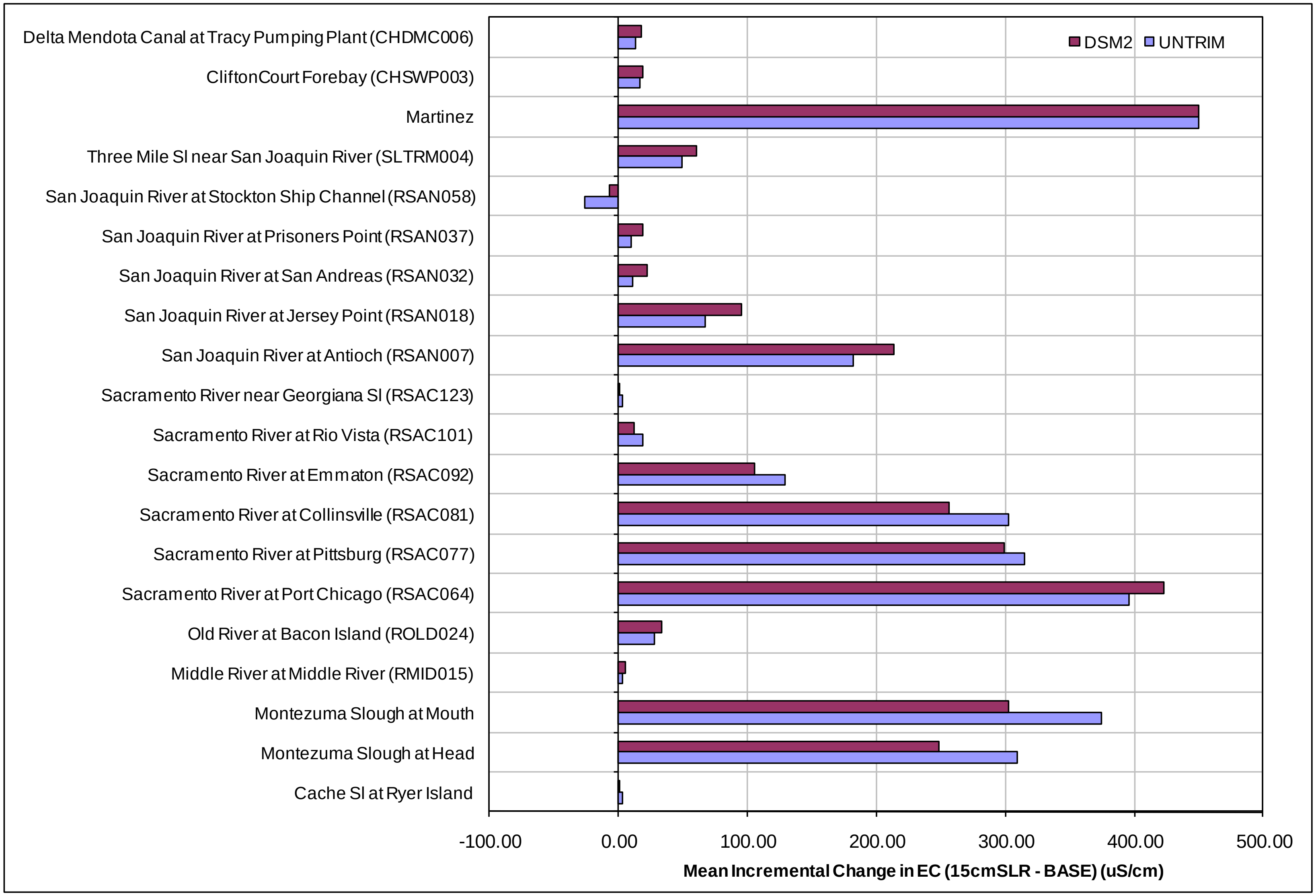


Figure 1: Comparison of average incremental change in tidally averaged EC in 15cm SLR scenario from the baseline between DSM2 and UNTRIM

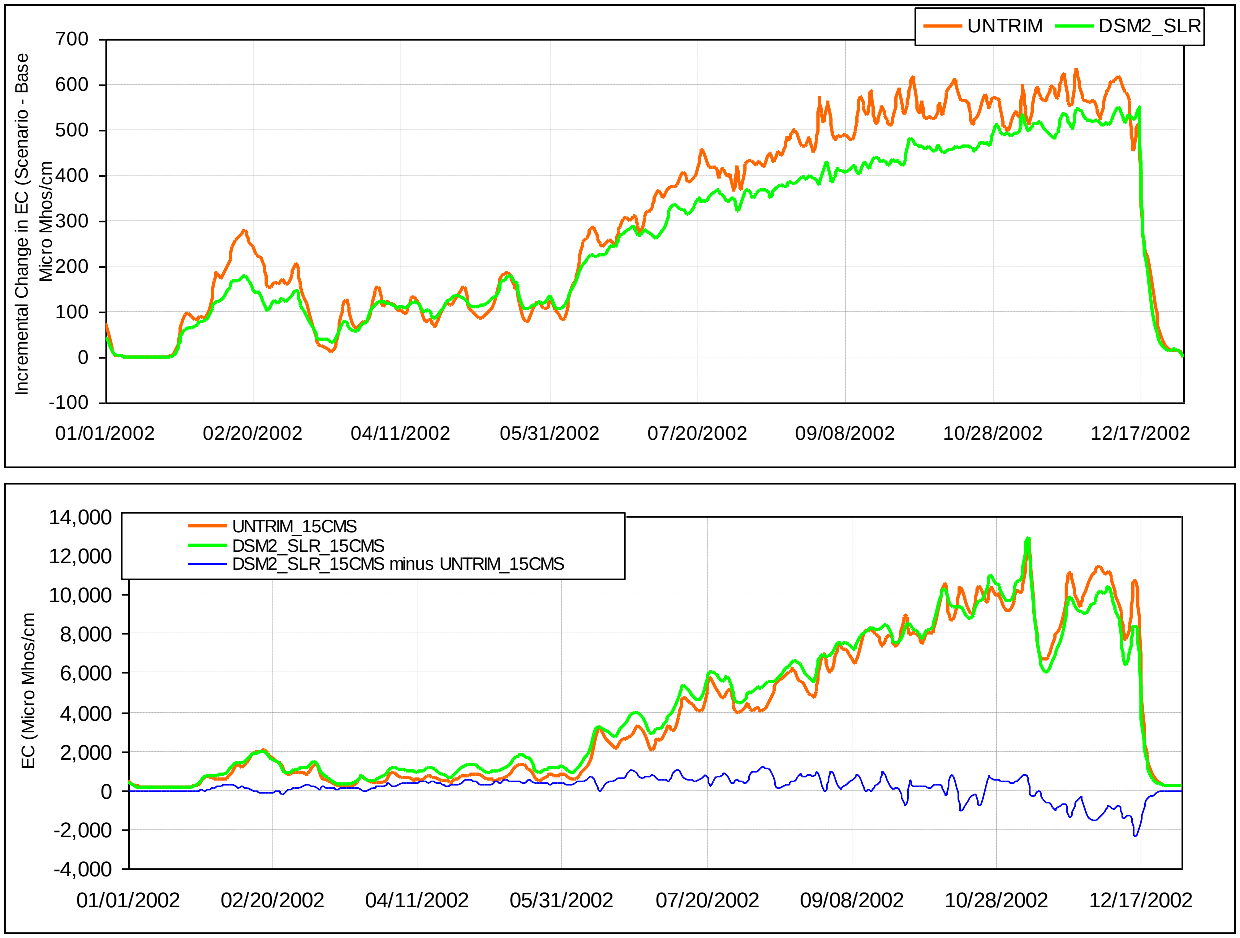


Figure 2: Comparison of Tidally-Averaged Daily EC and the Incremental Change in the Daily EC between the 15 cm Sea Level Rise and the Current Conditions Scenario from UnTRIM Model and DSM2 Model for Sacramento River at Collinsville Location

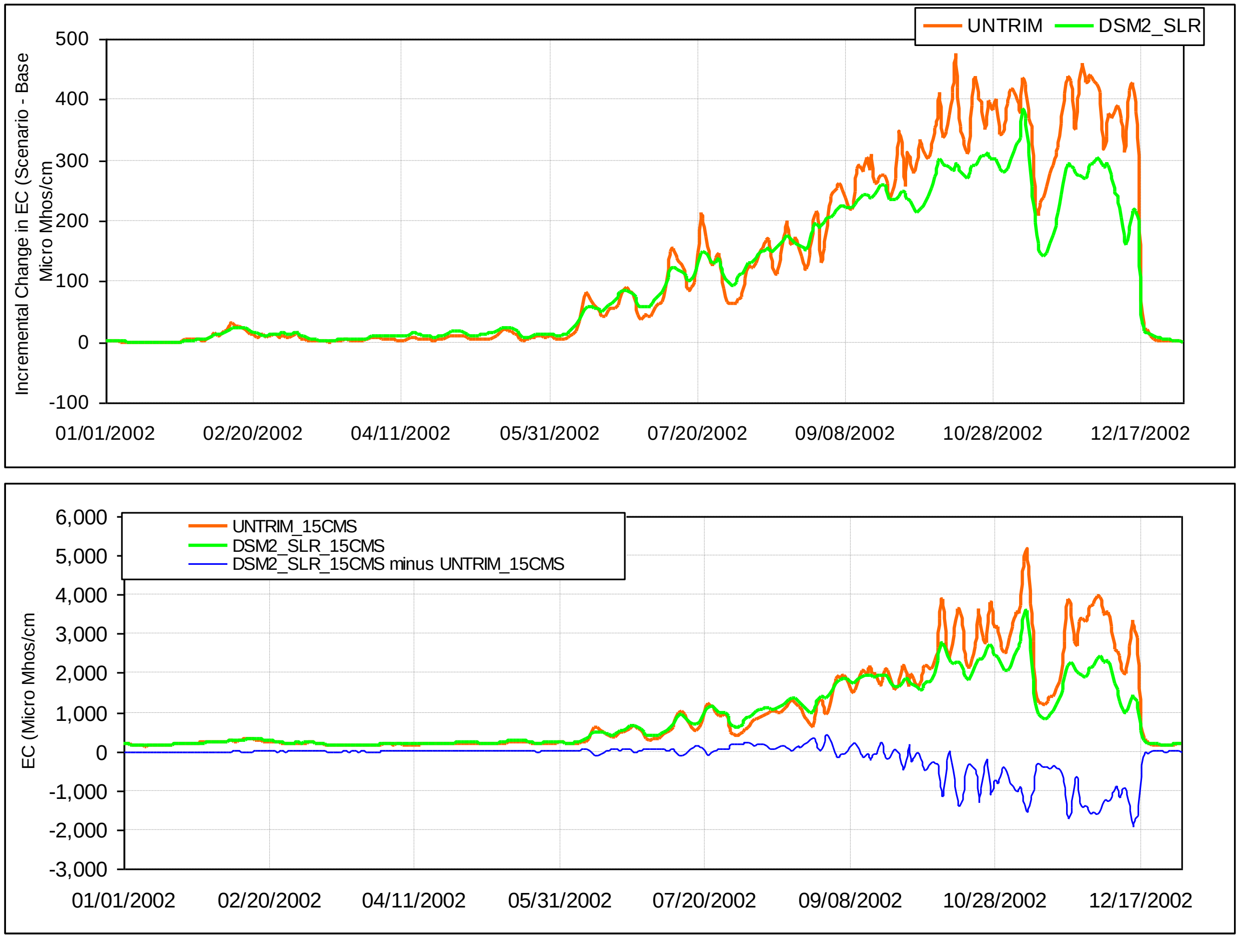
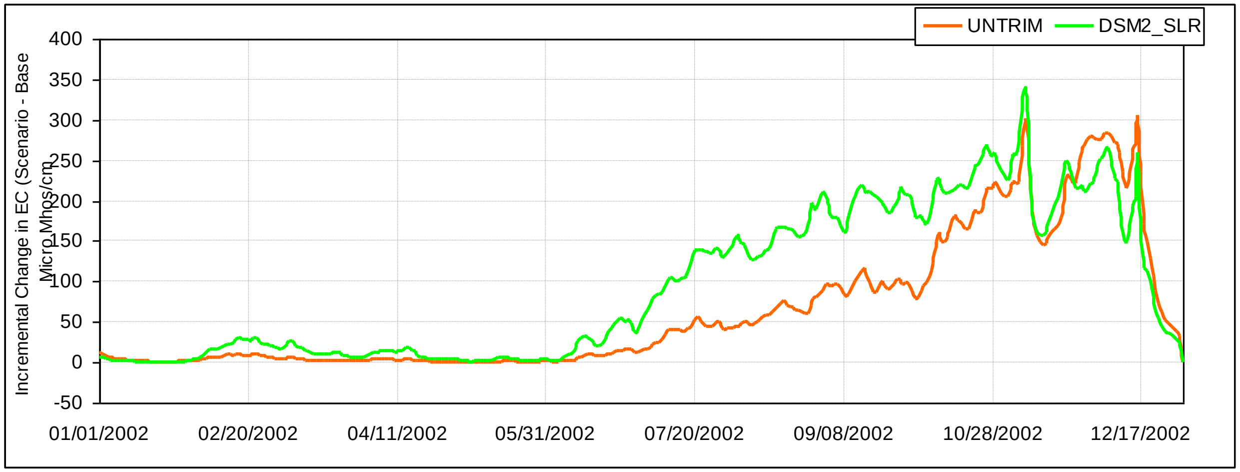


Figure 3: Comparison of Tidally-Averaged Daily EC and the Incremental Change in the Daily EC between the 15 cm Sea Level Rise and the Current Conditions Scenario from UnTRIM Model and DSM2 Model for Sacramento River at Emmaton Location



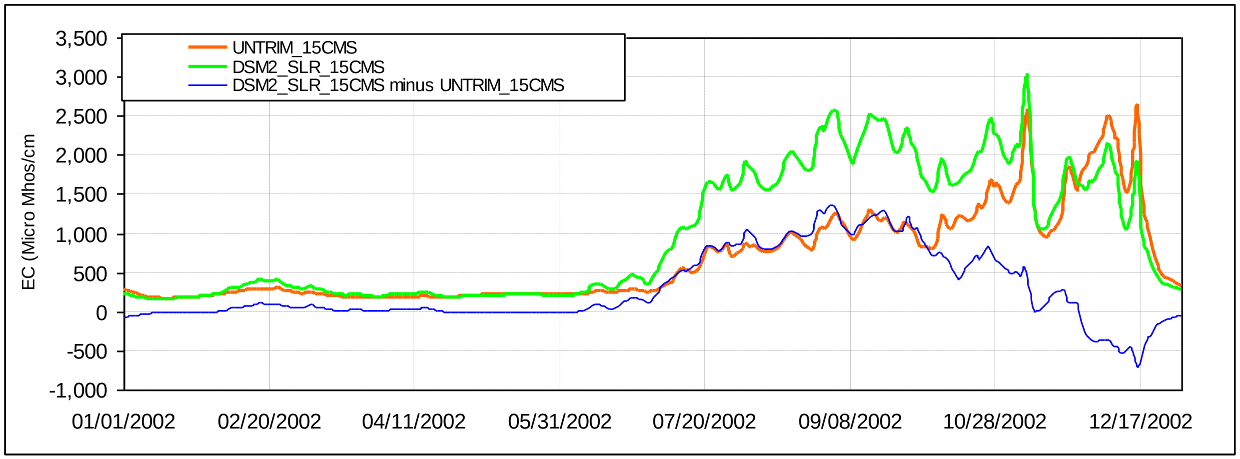
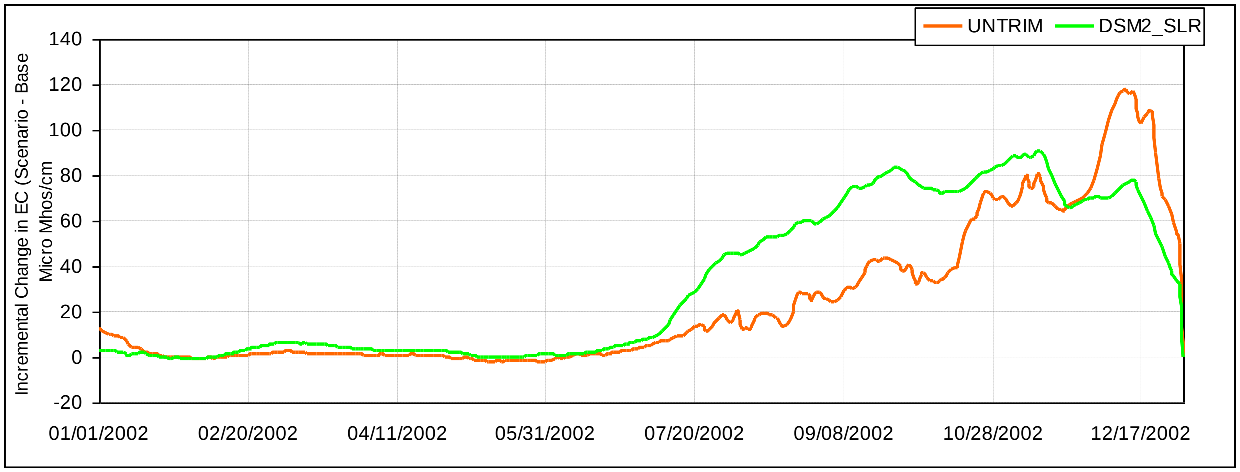


Figure 4: Comparison of Tidally-Averaged Daily EC and the Incremental Change in the Daily EC between the 15 cm Sea Level Rise and the Current Conditions Scenario from UnTRIM Model and DSM2 Model for San Joaquin River at Jersey Point Location



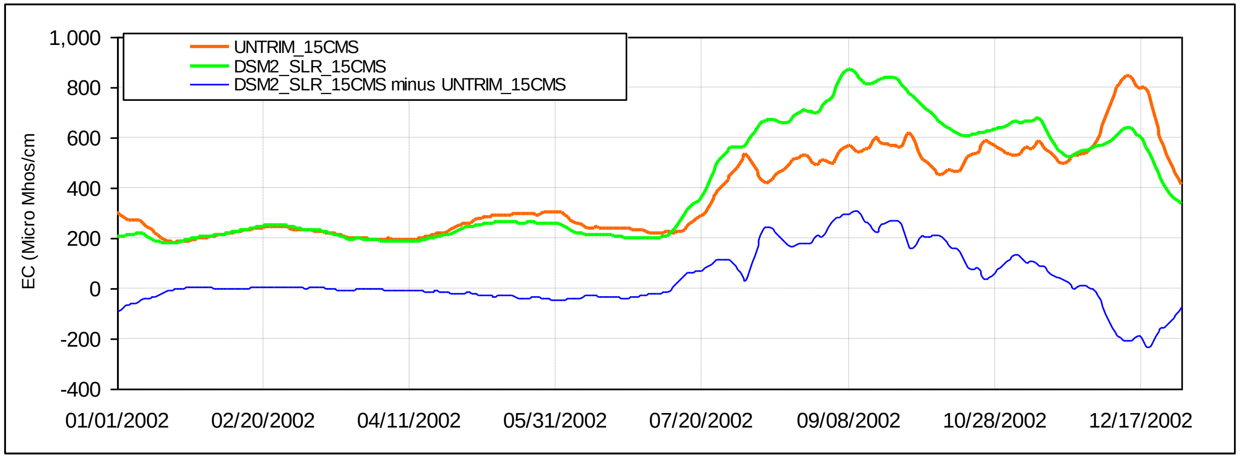


Figure 5: Comparison of Tidally-Averaged Daily EC and the Incremental Change in the Daily EC between the 15 cm Sea Level Rise and the Current Conditions Scenario from UnTRIM Model and DSM2 Model for Old River at Rock Slough Location

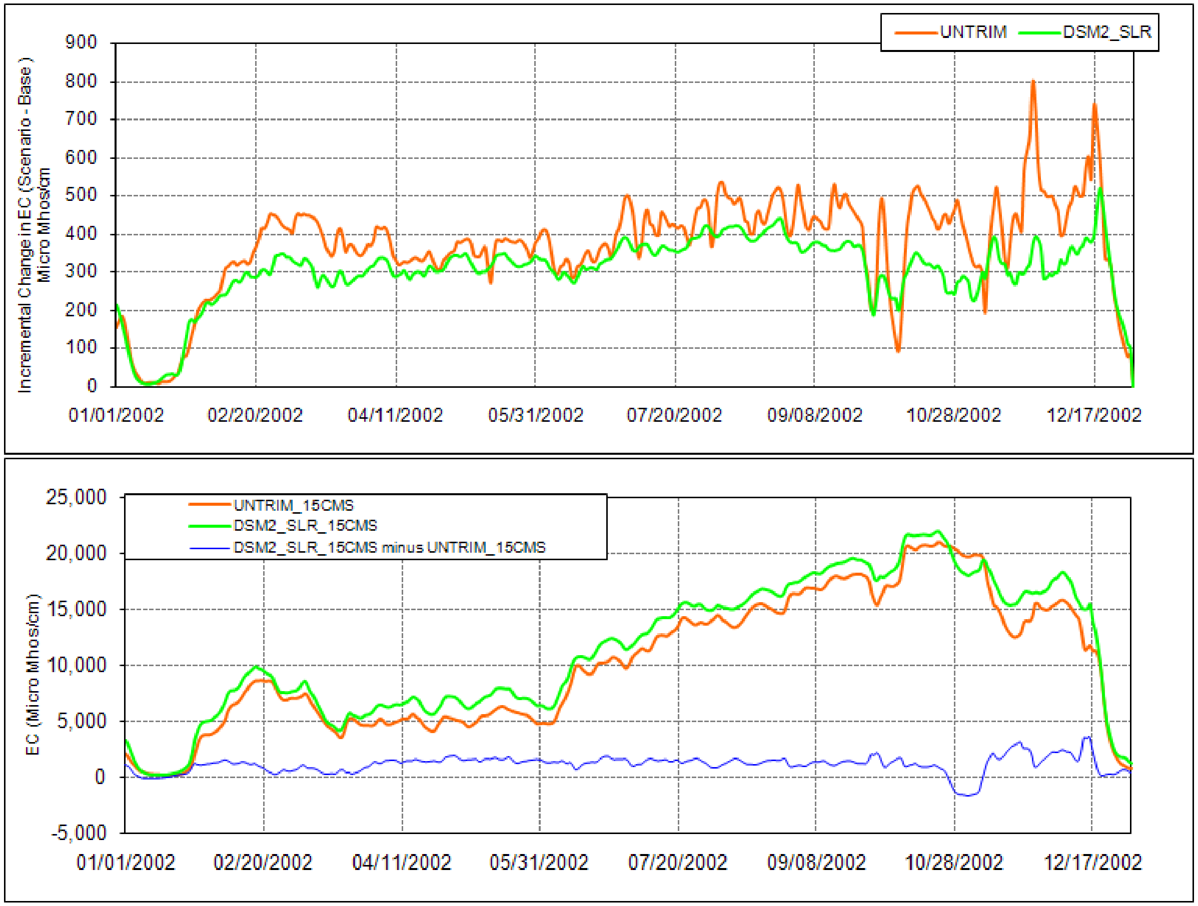


Figure 6: Comparison of Tidally-Averaged Daily EC and the Incremental Change in the Daily EC between the 15cm SLR Scenario and the Current Conditions Scenario from UNTRIM Model and DSM2 Model for Montezuma Slough at Mouth Location.

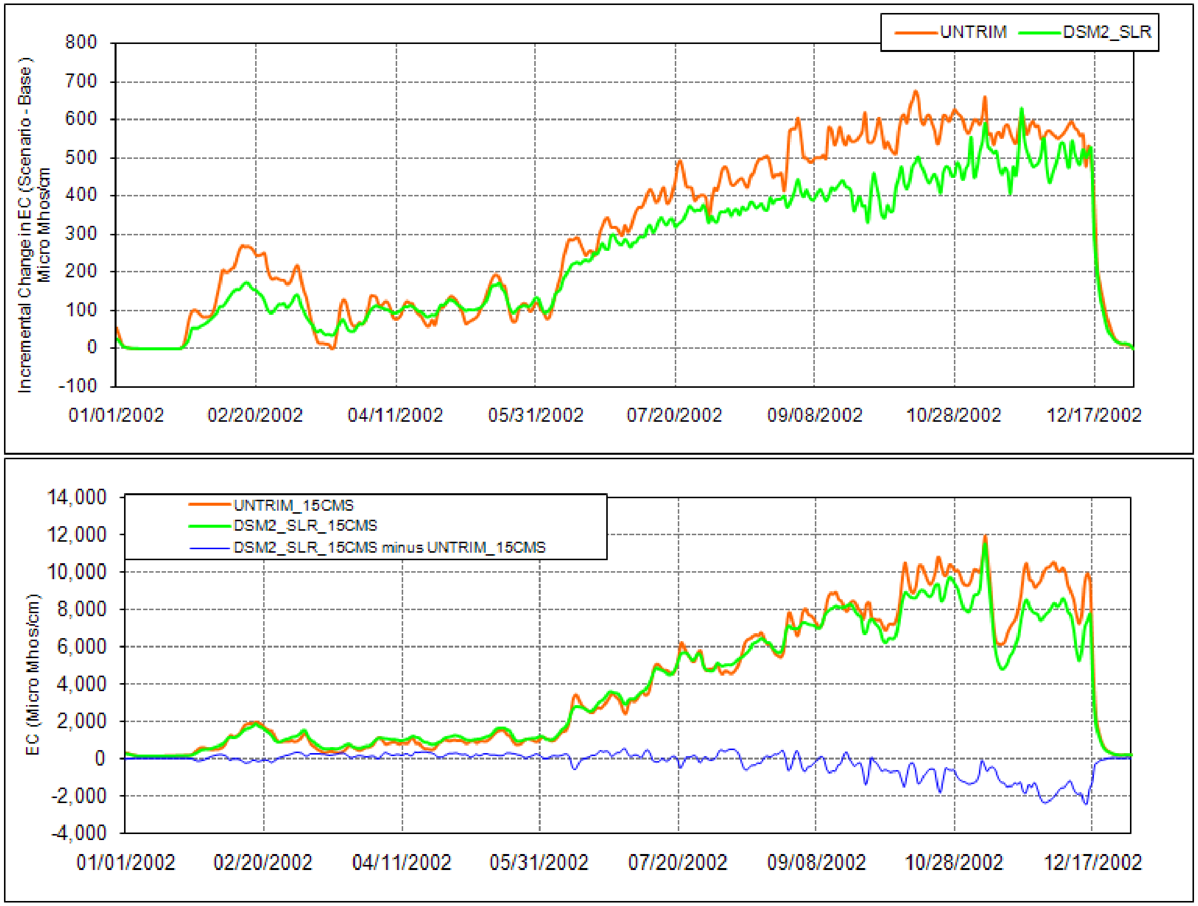


Figure **7**: Comparison of Tidally-Averaged Daily EC and the Incremental Change in the Daily EC between the 15cm SLR Scenario and the Current Conditions Scenario from UNTRIM Model and DSM2 Model for Montezuma Slough at Head Location.

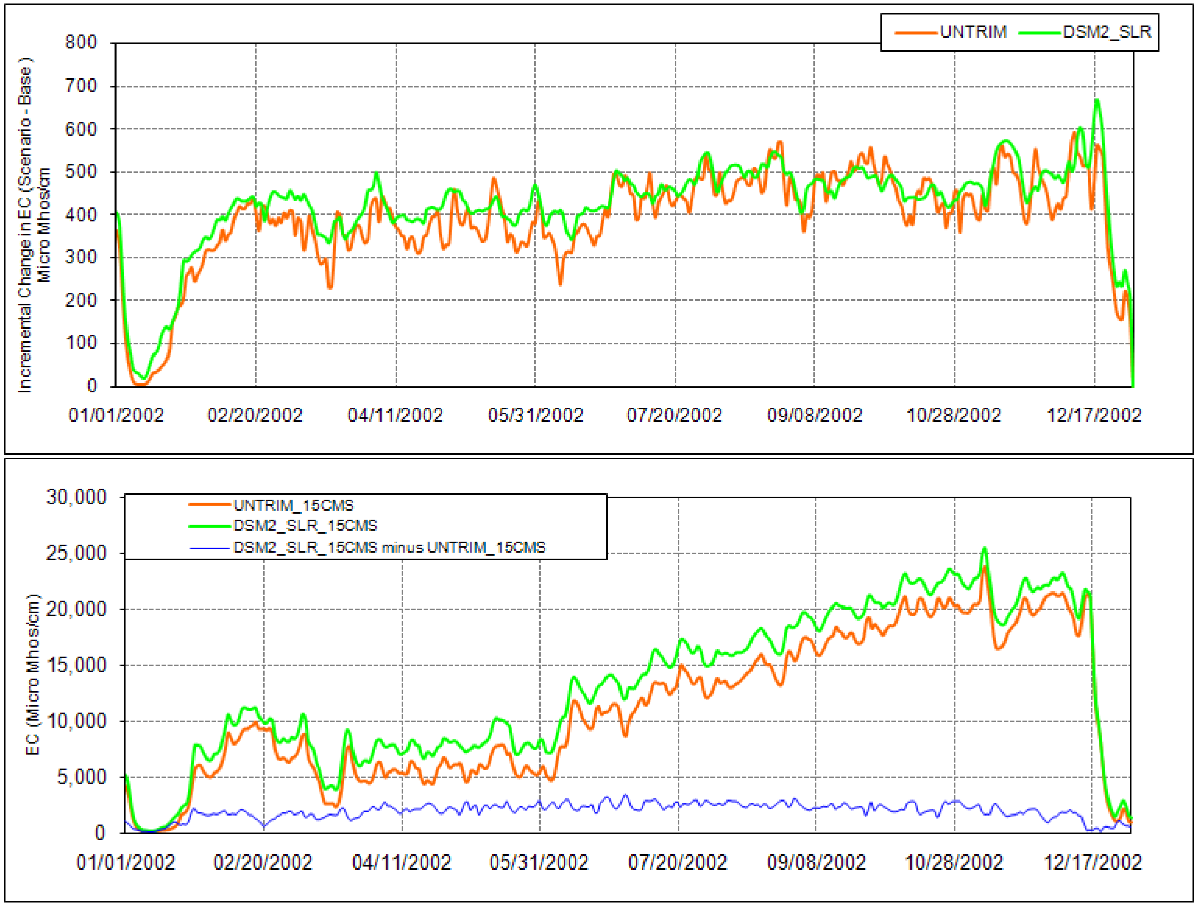


Figure **8:** Comparison of Tidally-Averaged Daily EC and the Incremental Change in the Daily EC between the 15cm SLR Scenario and the Current Conditions Scenario from UNTRIM Model and DSM2 Model for Sacramento River at Port Chicago Location.

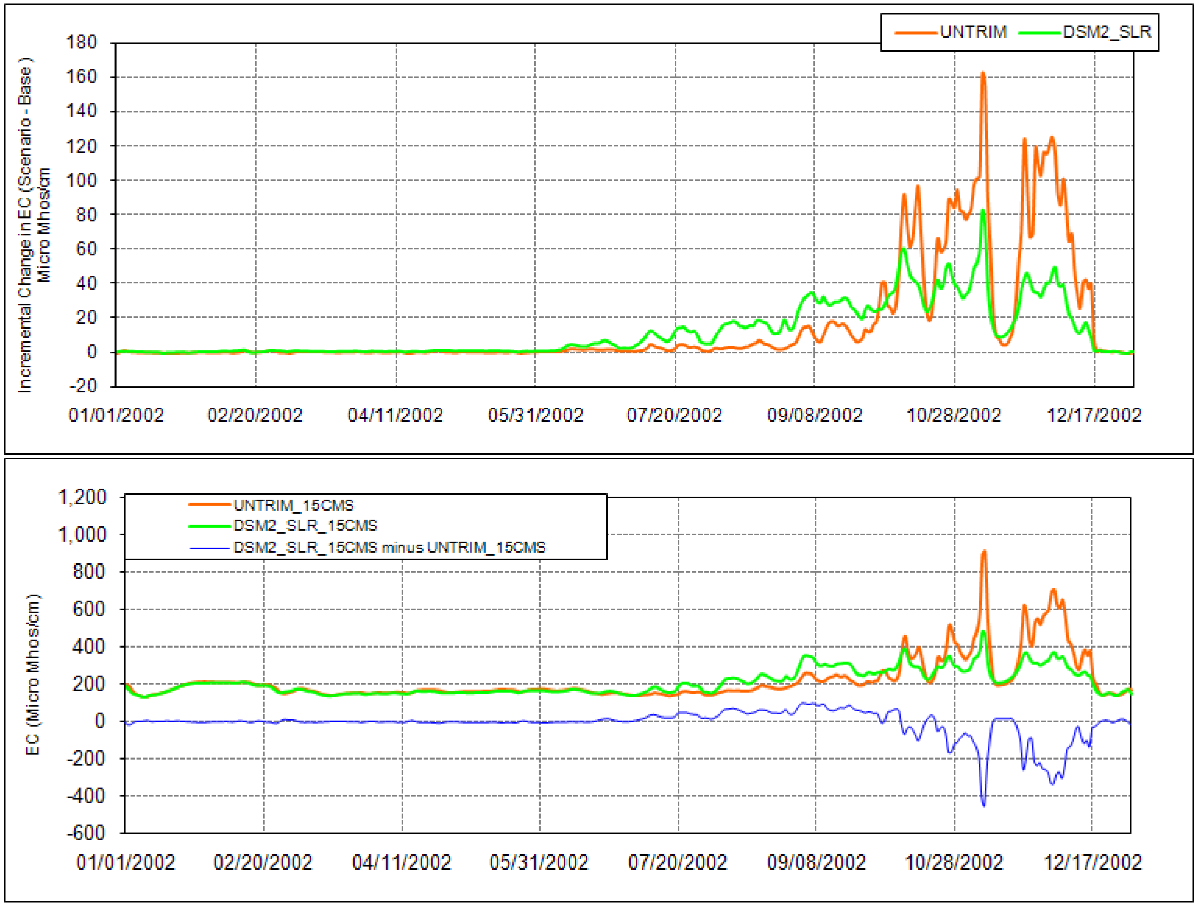


Figure 9: Comparison of Tidally-Averaged Daily EC and the Incremental Change in the Daily EC between the 15cm SLR Scenario and the Current Conditions Scenario from UNTRIM Model and DSM2 Model for Sacramento River at Rio Vista Location.

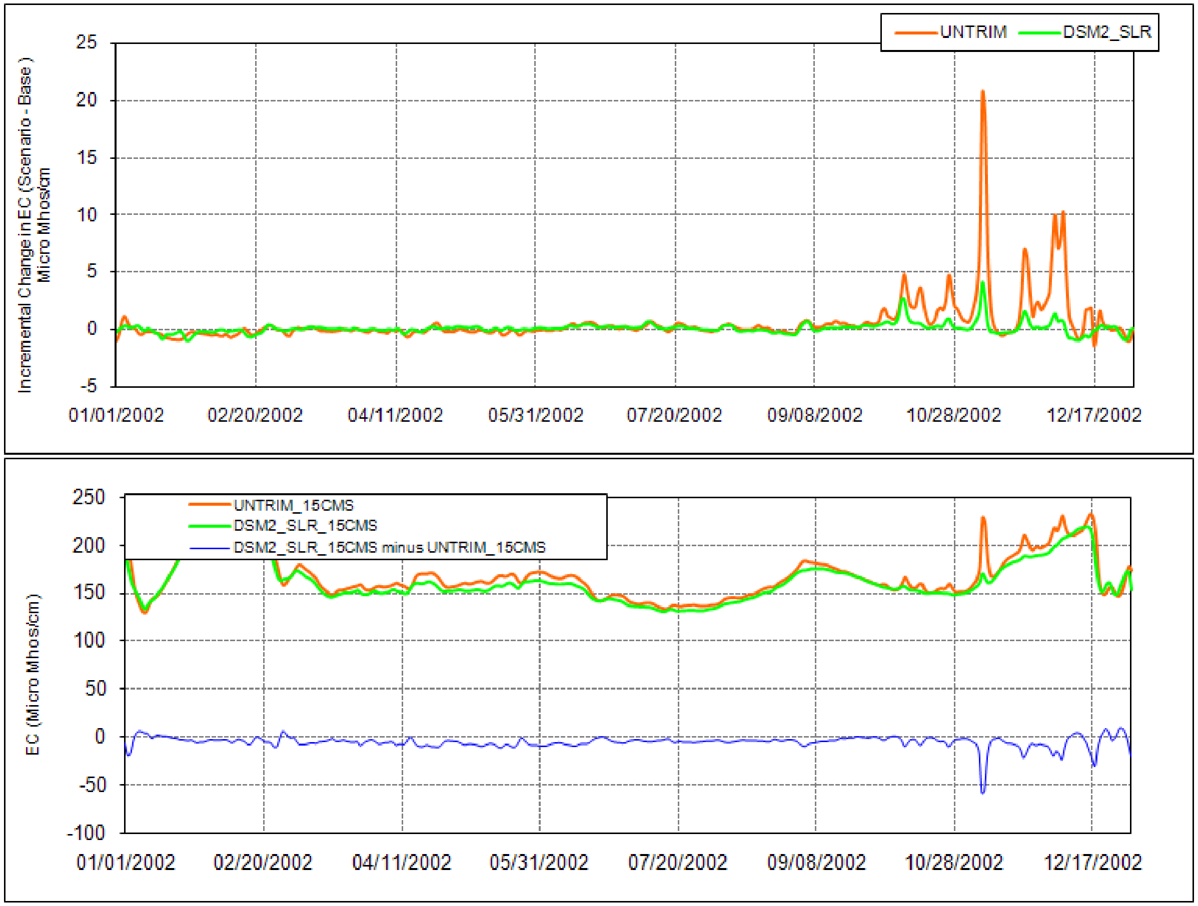


Figure 10: Comparison of Tidally-Averaged Daily EC and the Incremental Change in the Daily EC between the 15cm SLR Scenario and the Current Conditions Scenario from UNTRIM Model and DSM2 Model for Cache Slough at Ryer Island Location.

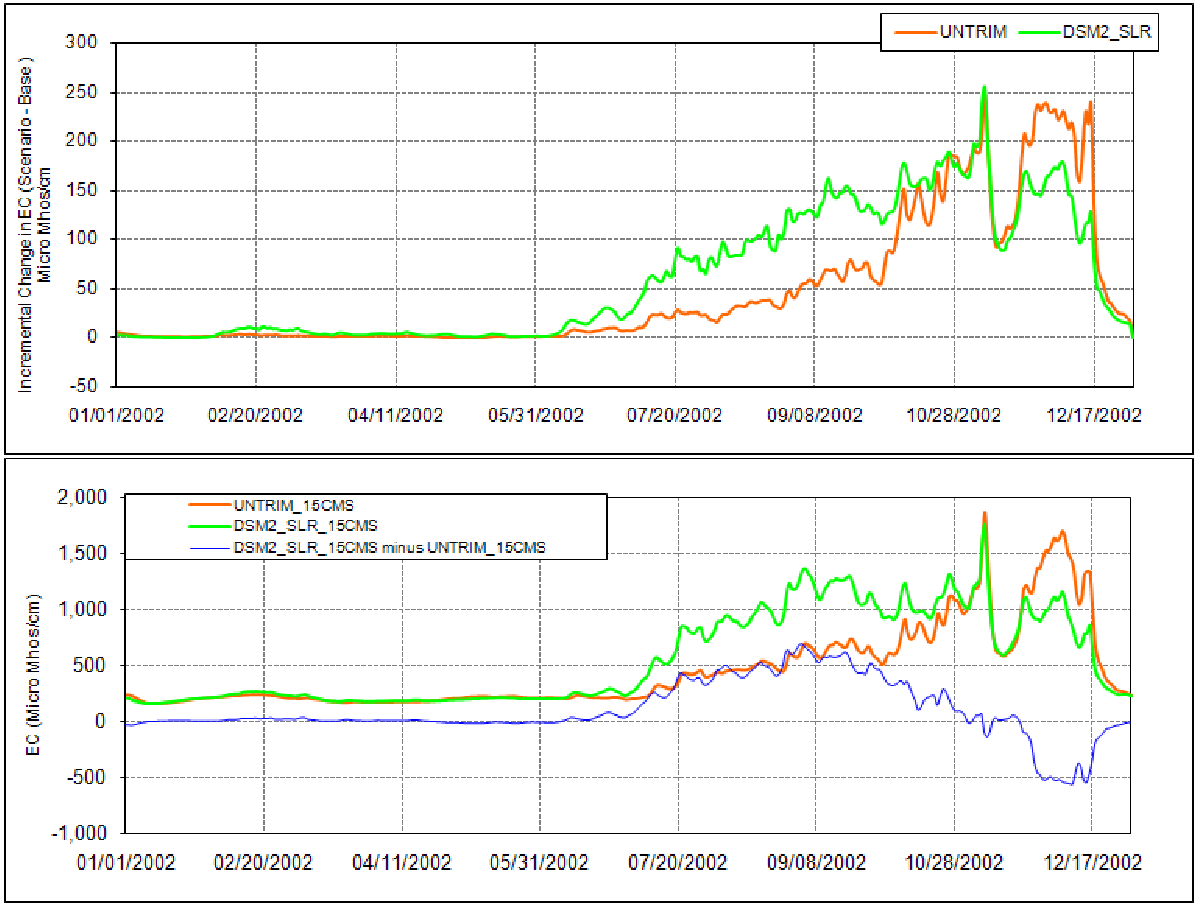


Figure 11: Comparison of Tidally-Averaged Daily EC and the Incremental Change in the Daily EC between the 15cm SLR Scenario and the Current Conditions Scenario from UNTRIM Model and DSM2 Model for Three Mile Slough at San Joaquin River Location.

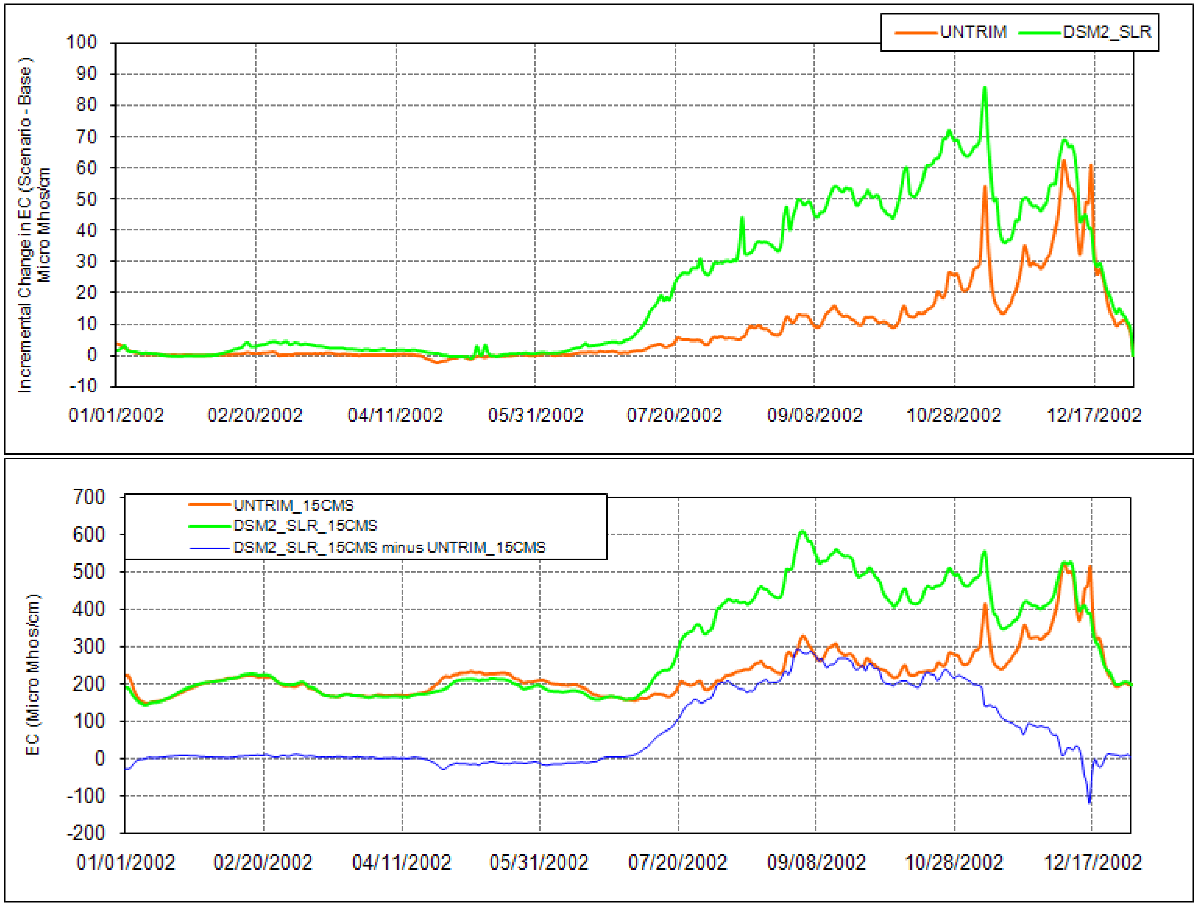


Figure 12**:** Comparison of Tidally-Averaged Daily EC and the Incremental Change in the Daily EC between the 15cm SLR Scenario and the Current Conditions Scenario from UNTRIM Model and DSM2 Model for San Joaquin River at San Andreas Location.

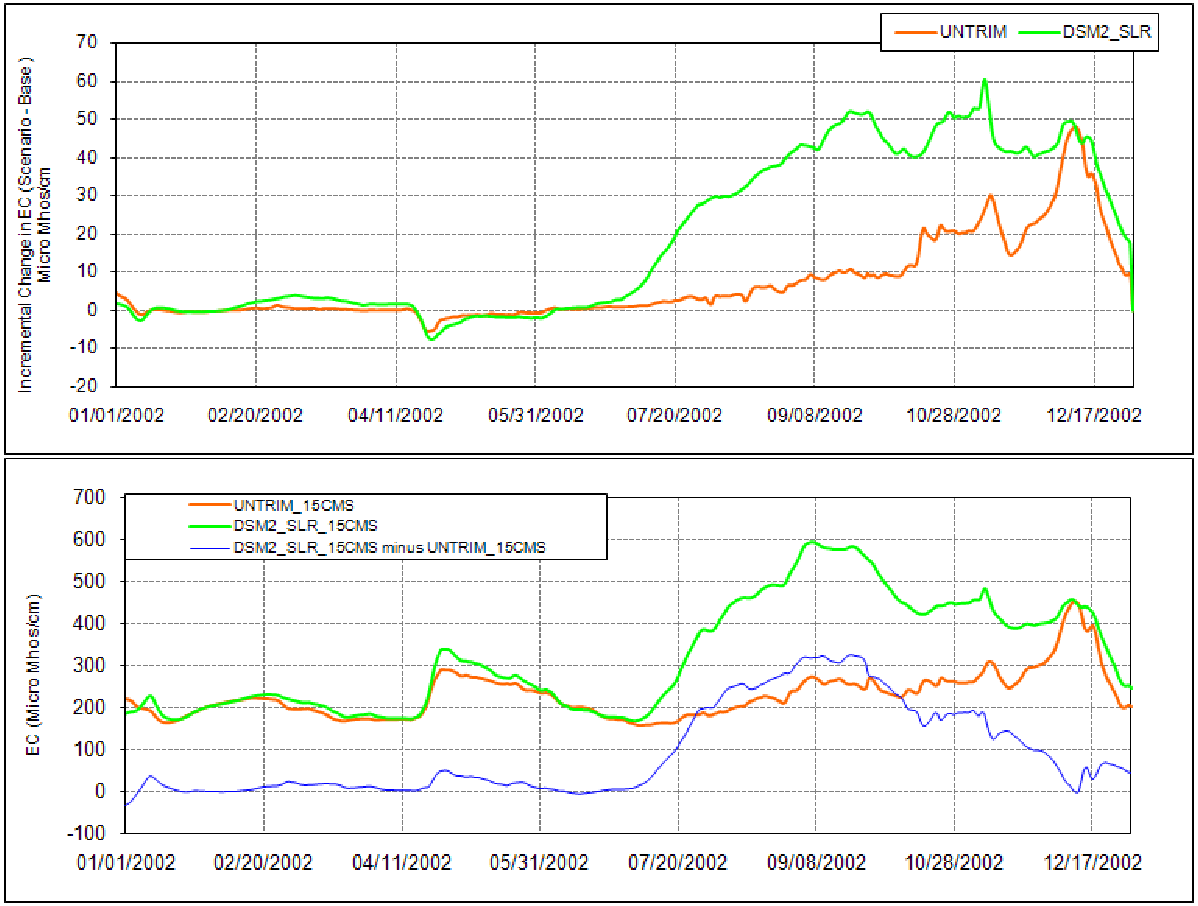


Figure 13: Comparison of Tidally-Averaged Daily EC and the Incremental Change in the Daily EC between the 15cm SLR Scenario and the Current Conditions Scenario from UNTRIM Model and DSM2 Model for San Joaquin River at Prisoners Point Location.

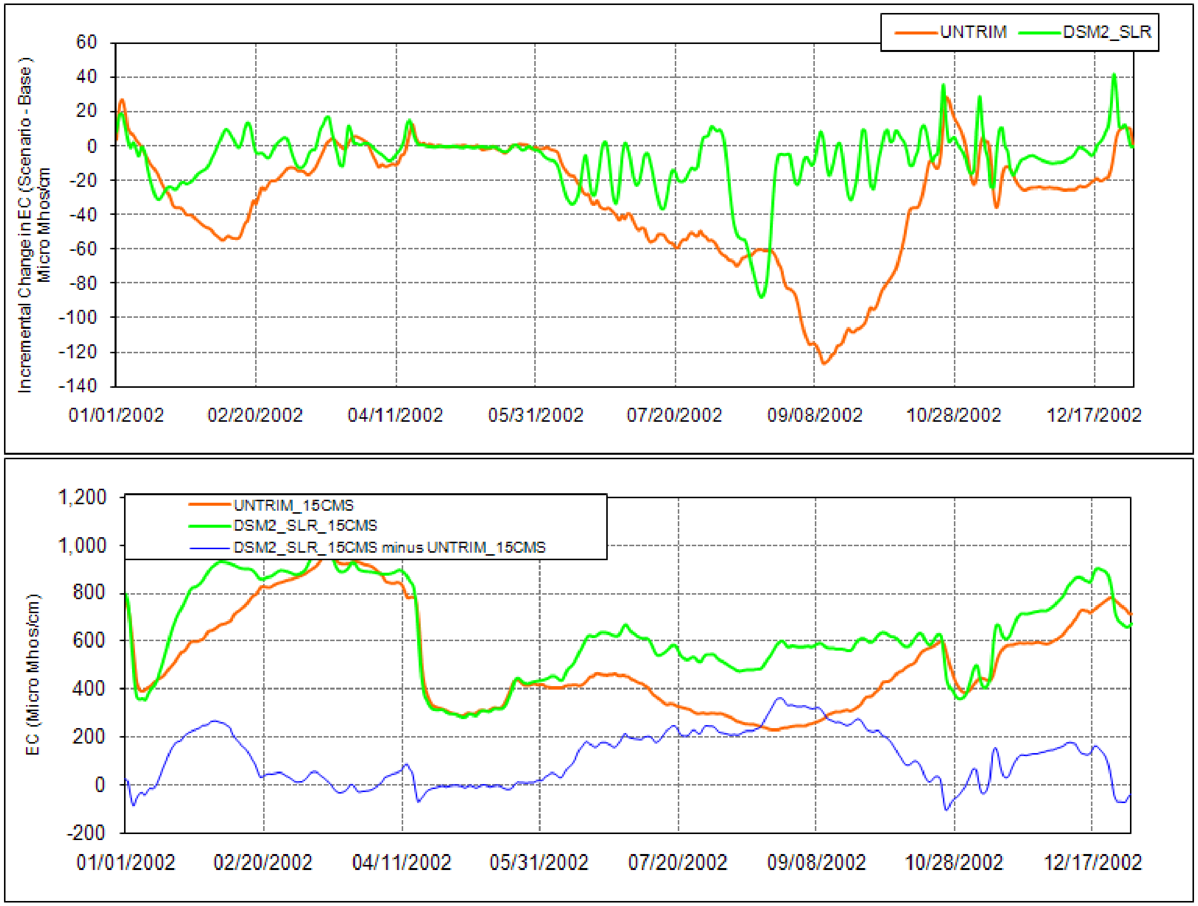


Figure 14**:** Comparison of Tidally-Averaged Daily EC and the Incremental Change in the Daily EC between the 15cm SLR Scenario and the Current Conditions Scenario from UNTRIM Model and DSM2 Model for San Joaquin River at Stockton Location.

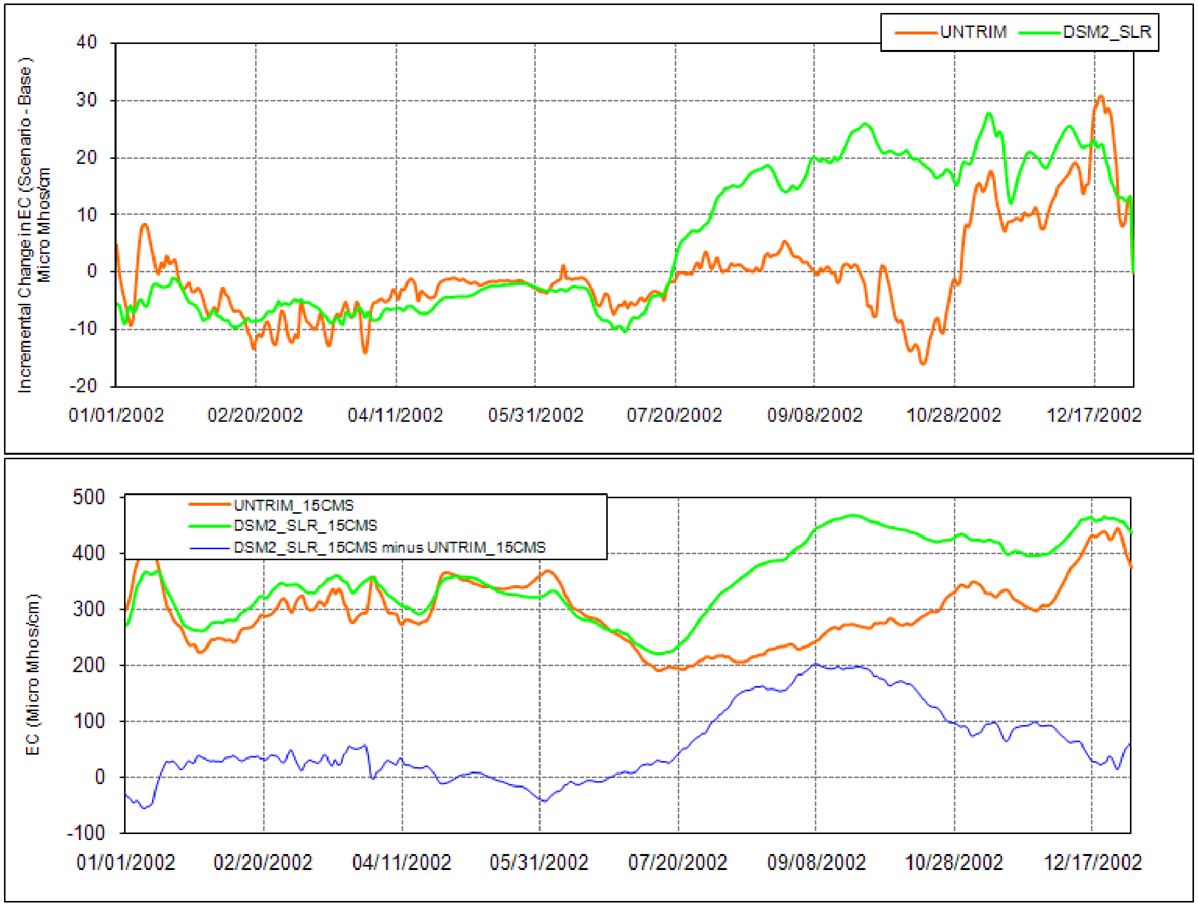


Figure 15**:** Comparison of Tidally-Averaged Daily EC and the Incremental Change in the Daily EC between the 15cm SLR Scenario and the Current Conditions Scenario from UNTRIM Model and DSM2 Model for Middle River at Middle River Location.

5.B.A.4 DSM2 Temperature Modeling

5.B.A.4.1 Executive Summary

The work discussed in this report covers the application of a calibrated QUAL water temperature model, V8.1.2, to the two California WaterFix scenario simulations as well as additional data and explanatory background to assist in the interpretation of the model results. Additional documentation on the calibration and residual analysis of the water temperature model is found in the enclosed Appendix.

DSM2 is a suite of one-dimensional numerical models developed at the Department of Water Resources (DWR) of the State of California. DSM2-HYDRO calculates the hydrodynamics of the Sacramento-San Joaquin Delta region, while the dynamics of water temperature are conceptualized in the DSM2-QUAL mass transport model. The models are run consecutively, with QUAL using previously calculated HYDRO model output in its calculations for the transport of water temperature.

All of the DSM2 simulations represent hypothetical modeled water years 1921 – 2003, with California WaterFix scenarios representing proposed or predicted changes to: Delta operations such as exports and the volume and timing of reservoir releases; meteorological conditions due to climate change; and, stage at Martinez due to sea level rise. Changes to modeled Delta bathymetry associated with the largescale tidal marsh restoration included in previous Bay Delta Conservation Plan (BDCP) model scenarios are NOT included in the CWF scenarios discussed herein.

Differences in model output reflect differences between the California WaterFix Proposed Action (PA) scenario and the No Action Alternative (NAA) at year 2030 under assumed climate changes and sea level rise conditions as well as changes in export volumes, location and timing. Changes in water temperature at the inflow boundaries due to upstream effects from climate change, changes in runoff, changes in reservoir usage, changes in effluent volume or water temperature due to population changes, or other potentially influential parameters were not considered. However, as described below, the inflow temperatures are adjusted based on the projected temperature changes in the vicinity of the Delta as a result of the climate change assumed. A set of representative model output locations was selected and monthly averaged to represent an average result for each month at each location.

Input files for DSM2 HYDRO simulations were supplied to RMA, and then modified to represent hypothetical conditions for the calculation of water temperature. Changes to the HYDRO model input for this purpose consist of the addition of effluent inflow at twelve locations within the DSM2 model domain. Boundary conditions for water temperature were synthesized for the QUAL water temperature model from data as described below.

A single set of effluent boundary conditions for effluent inflow and water temperature, inflow water temperature and meteorology were synthesized from existing effluent data and applied to all of the scenarios. In the HYDRO model runs, effluent inflow representing current-day (2000 – 2005) conditions of wastewater treatment plants discharges into the Delta were included in all scenarios, but otherwise the hydrodynamic conditions and all other inputs to HYDRO used in the California WaterFix simulations were implemented without alteration.

Meteorological and water temperature boundary conditions were synthesized from time series of projected daily average temperatures supplied to RMA that represent a future climate change condition for the 2030 time frame. These time series were then used as a basis for formulating the hourly meteorological boundary conditions used in the QUAL nutrient model. The synthetic hourly meteorological time series was developed by first matching average air temperature under this climate change condition with historical air temperature used in DSM2 at approximately the same annual date (+/- 2 days), creating a correspondence between these historical dates and the model dates. Existing hourly meteorological data used in the calibration of the QUAL nutrient model from the historical dates was then used to build the model time series for meteorological and water temperature boundary conditions. This set of matched daily air temperature dates was also used to develop time series of daily water temperature at three model boundaries – Sacramento, Vernalis and Martinez – that were then used as water temperature boundary conditions at the model inflow boundaries.

Boundary conditions for effluent inflow and water temperature were synthesized on an annual year basis (January – December) using existing data for each modeled year (1976 – 1991), creating a correspondence between one model year and one historical year. Using the aforementioned year-correspondence, Sacramento Regional Wastewater Treatment Plant (SRWTP) effluent flows were scaled to maintain the percentage of effluent flow in Sacramento R. inflow at or below the historical 2000 - 2005 daily maximum (approximately 4.5%). All other effluent flows were applied without scaling using the same annual year selection.

The DSM2/QUAL temperature model was calibrated for the time span 1990 - 2008 (Guerin, 2010). Model calibration was followed by a validation step. Data availability and the spatial and temporal resolution of calibration data dictated the quality of the calibration. Details on the temperature model calibration are documented in (Guerin, 2010), and discussed briefly in the Appendix of this document.

Figures representing the model bias in the historical simulation of water temperature are included in the Appendix as a guide to the interpretation of model results for each of seven analysis regions specified in previous BDCP analyses in the DSM2 model domain. For example, modeled water temperature in the South Delta and the upstream section of the San Joaquin R. was biased by several Celsius degrees cooler than indicated by data in the summer. This bias in model calculations is mainly due to the limitation in QUAL to a single meteorological region – previous results indicated that a minimum of two meteorological regions are required for modeling water temperature over the entire Delta (Guerin, 2010). However, since the boundary condition data, including meteorology, applied in the California WaterFix scenarios is based on historical data used in the calibrated model, the average monthly bias in the historical model can be applied to the California WaterFix model as a regional correction to model output on a monthly-average basis..

5.B.A.4.2 Background

5.B.A.4.2.1 Objectives

The main objectives of the work discussed in this document are to: (1) document model parameterization, boundary conditions and results of California WaterFix DSM2 water temperature simulations; and, (2) provide information on regional model bias as an aid to the appropriate interpretation of the DSM2 scenario water temperature results.

5.B.A.4.2.2 DSM2 Simulations for California WaterFix

The Delta Simulation Model-2,[1] or DSM2, is a suite of one-dimensional models that were used in this project to model the hydrodynamics and water temperature dynamics in the Delta due to changes in Delta operations, sea level rise and climate change as conceptualized in the California WaterFix scenarios.

The DSM2 suite of models was developed by California's Department of Water Resources (DWR). The hydrodynamic and water quality modules, HYDRO and QUAL, respectively, have been developed by DWR to simulate historical conditions in the Delta – this implementation is called the "Historical Model" herein. DSM2 is also frequently used to model hypothetical scenarios, as it was in this project for the California WaterFix. The scenario simulations were run using sets of hypothetical conditions over the water years[2] 1922 – 2003. The conditions modeled in this time frame do not represent conditions that actually occurred during these years – however, inflow boundary conditions are based loosely on the natural flow conditions occurring in California watersheds during this time frame as described in Appendix B, Section 5.B.2.3.2.

5.B.A.4.3 DSM2 Model Description

5.B.A.4.3.1 DSM2 – General information

DSM2 is a suite of one-dimensional hydrodynamic and water quality simulation models used to represent conditions in the Sacramento-San Joaquin Delta. DSM2 was developed by the Department of Water Resources (DWR) and is frequently used to model impacts associated with projects in the Delta, such as changes in exports, diversions, or channel geometries associated with dredging in Delta channels. It is considered the official Delta model for many purposes.

The simplification of the Delta to a one-dimensional model domain means that DSM2 can simulate the entire Delta region rapidly in comparison with higher dimensional models. Although many channels in the Delta are modeled well in one dimension, the loss of spatial detail in areas that are naturally multi-dimensional, such as Suisun Bay, limit DSM2's accuracy in those areas. In addition, the DSM2 grid conceptualizes several open water areas, for example Franks Tract and Mildred Island, as zero-dimensional "reservoir" volumes. For the transport of QUAL constituents, reservoirs is assumed to be a fully-mixed volume.

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[1] http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/models/dsm2/dsm2.cfm

[2] A water year runs from the first of October the previous year through the end of September in the given year.

DSM2 contains three separate models, a hydrodynamic model (HYDRO), a water quality model (QUAL), and a particle tracking model (PTM). HYDRO was developed from the USGS FOURPT model (USGS, 1997). DWR adapted the FOURPT model to the Delta, accounting for such features as operable gates, open water areas, and export pumps. The water quality model, QUAL, is based on the Branched Lagrangian Transport Model (Jobson, 1997), also developed by the USGS. QUAL uses the hydrodynamics simulated in HYDRO as the basis for its transport calculations. The capability to simulate nutrient dynamics and water temperature in QUAL was developed by Rajbhandari (1995a, 1995b). The third model in the DSM2 suite is PTM, which simulates the fate and transport of neutrally buoyant particles. PTM also uses hydrodynamic results from HYDRO to track the fate of particles released at user-defined points in space and in time.

Detailed descriptions of the mathematical formulation implemented in HYDRO and for constituents in QUAL, required data, and past applications of the DSM2 Historical Model are documented in a series of reports available at:

http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/annualreports.cfm.

Documentation on the calibration and validation of the HYDRO model and the QUAL model for salinity used in the current and prior versions of DSM2 is available at that website. The calibration of DSM2 has generally focused on hydrodynamics and the transport of salinity, modeled as electrical conductivity (EC), and of dissolved organic carbon (DOC). The calibration of HYDRO in DSM2 Version 8 for hydrodynamics used in this project is assumed to be sufficient for our purposes.

Recently (Guerin, 2010), the water temperature and nutrient modules in QUAL Version 6 were calibrated in the Delta for the years 1990 through 2008 to model the transport of nutrients and water temperature as an extension of the base Historical Model implementation. In QUAL, water temperature can be modeled independently of the nutrients. The Version 6 calibration (Guerin, 2010) required the collection and synthesis of a large quantity of data needed to set the model boundary conditions over the modeled time span (1990 – 2008) and to calibrate and validate the model calculations. The description of the data used for the initial calibration, in particular the results of the water temperature calibration, is covered in detail in (Guerin, 2010). Subsequently, the temperature and nutrient models were recalibrated as improved versions of QUAL were made available (Guerin, 2011).

With the introduction of a new bathymetry in the DSM2 model grid of the Delta to incorporate the flooding of Liberty Island in the Cache Slough area due to levee breaks in the late 1990's, a recalibration of the hydrodynamics in HYDRO was undertaken for this bathymetry change by CH2M HILL (2009), and a new version for the DSM2 suite of models, Version 8[3], was introduced. The hydrodynamic simulations discussed in this report were run using the executable HYDRO Verison-8.0.6 (the version used in previous BDCP DSM2 modeling), while the water temperature models were run using QUAL Version-8.1.2 (the most recent version in 2014).

[3] http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/models/dsm2/dsm2.cfm

QUAL Version-8.1.2 corrects and improves QUAL's computational accuracy. The computational results from the HYDRO version (8.0.6) used are somewhat different from those calculated in the most recent version (8.1.2), so the former version (8.0.6) of HYDRO was used as the hydrodynamic basis for the water temperature simulations for consistency with CWF BA NAA and PA hydrodynamic results.

5.B.A.4.3.2 California WaterFix Model Bathymetry

Figure 5.B-1 shows the changes to the network of the DSM2 model (CH2M HILL 2009) used for the scenario simulations used in this study. The major changes are the inclusion of the Liberty Island open water area - this is modeled as a zero-dimensional "reservoir" in DSM2 terminology - and an extension and refinement in the grid at the northern boundary of the model. Figure 5.B-2 shows the earlier DSM2 Version 6 grid with channels, nodes and general location of open water areas other than Liberty Island.

5.B.A.4.4 Description of the DSM2 HYDRO and QUAL models

The implementation of the DSM2 modules HYDRO and QUAL discussed in this report extends the standard configuration of the DSM2 "Historical Model" by including effluent inflow from most of the wastewater treatment plants (WWTPs) with outfalls within DSM2's model domain in the Delta.

5.B.A.4.4.1 HYDRO flow and stage boundaries

Boundaries that define the movement of water into and out of the Delta consist of inflow boundaries, outflow boundaries and a stage boundary set at Martinez. In Figure 5.B-3, the main inflow boundaries are denoted by blue stars. These boundaries are found at the each of the major rivers (Sacramento, San Joaquin, Calaveras, Mokelumne and Cosumnes), and at the Yolo Bypass and the Lisbon Toe Drain (in the Yolo region). The Yolo boundary only has inflow during periods of high Sacramento River inflow which generally occurs late fall through early spring. Flows at the Lisbon Toe Drain near Liberty Island on the north western edge of the Delta, used in the Version 6 implementation of the nutrient model and the Version 8 calibration discussed herein, are incorporated in the Yolo flow boundary for the two California WaterFix scenarios discussed in this document.

Figure 5.B-4 shows the approximate location of effluent inflow boundaries used in California WaterFix scenarios discussed in this report – two effluent locations supplying inflow to the Delta at Woodland and Davis are not included at boundary conditions. The combined volume of effluent water is generally small in comparison with other inflow contributions except in periods of very low inflow. The effects of evaporation, precipitation, and channel depletions and additions ascribed to agricultural influences are modeled using the Delta Island Consumptive Use (DICU) model[4]. This model is used to set boundary conditions at 258 locations throughout the Delta – these locations are subdivided into 142 regions. DICU flow boundary conditions vary monthly by region and are set by Water Year Type.

[4] http://www.iep.ca.gov/dsm2pwt/reports/DSM2FinalReport_v07-19-02.pdf, http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/models/dicu/DICU_Dec2000.pdf

5.B.A.4.4.2 QUAL's Conceptual Model for Water Temperature

The conceptual model for portraying the transport of water temperature in DSM2-QUAL is based on equations adopted from QUAL-2E (Brown and Barnwell, 1987). DSM2 is limited to a single set of meteorological boundary conditions for the entire model domain. This constitutes a major simplification for the Delta as the conditions can vary substantially regionally – for example, wind speed can vary by a factor of two at different meteorological observation stations within the Delta. DICU inflow water temperature is specified as a single monthly time series that is repeated annually. Effluent inflow water temperature was developed from wastewater treatment plant data. Details on the development of scenario boundary conditions for QUAL are discussed in the Appendix.

5.B.A.4.5 California WaterFix Water Temperature Simulation Comparisons

DSM2 hydrodynamic and water temperature models were run and subject to QA/QC for the following California WaterFix scenarios:

NAA_Q5_ ELT

PA_Q5_ELT

The hydrodynamic models were run using the executable for HYDRO Verison-8.0.6, the version used in previous BDCP DSM2 modeling, while the water temperature models were run using the QUAL executable Version-8.1.2 (the most recent version as of 2014). The two versions are fully compatible.

5.B.A.4.5.1 Analysis Period

The analysis period was October 1921– September 2003. The months February - September 1921 were modeled as a spin-up period (mainly for the water temperature simulations).

5.B.A.4.5.2 Boundary Conditions for the Scenarios

5.B.A.4.5.2.1 Hydrodynamic boundary conditions

Hydrodynamic boundary conditions for all simulations were provided to RMA by CH2M Hill for DSM2 model input. Effluent inflow boundaries were added to the HYDRO for the water temperature modeling – this aspect is covered below in the section on setting effluent boundary conditions. With the exception of effluent inflow, the hydrodynamic boundary conditions for each of the California WaterFix model scenarios were used without alteration from the original. Identical effluent inflow conditions were used for all scenarios.

5.B.A.4.5.2.2 Water temperature boundary conditions

Boundary conditions must be specified for water temperature at inflow boundaries and at the tidal boundary at Martinez, as specified in Figure 5.B-3, and for effluent locations as specified in Figure 5.B-4. Water temperature must also be specified at each DICU inflow location. For the California WaterFix scenarios documented in this report, DICU inflow water temperature is given as a monthly average that repeats annually – the values are shown in Figure 5.B-5. For comparison, the DICU temperature used in the California WaterFix scenarios (purple line, adapted from (DWR, 1995)) is shown in comparison to a Delta-wide average of agricultural drain data (blue line) from DWR's Municipal Water Quality Investigations (MWQI) branch database, 1997 through 2004. Note that although DICU inflows and outflows are also specified as monthly averages, the flows vary by year type so do not repeat annually.

The boundary conditions for meteorological parameters required for QUAL water temperature simulations were developed for the year 2030 - the details are covered later in this section.

All computations for the meteorological and water temperature boundary condition development were performed using Matlab scripts. Compilation of the output was performed in either Matlab or EXCEL. The assembly and calculation of effluent boundary conditions was done in EXCEL.

5.B.A.4.5.2.3 Synthesis of meteorological and temperature boundary conditions

Meteorological and water temperature boundary conditions were developed separately from the effluent boundary conditions. A single set of synthetic meteorology was generated using historical data, for the future climate change conditions for year 2030. Meteorological boundary conditions for QUAL include air temperature (dry bulb), wet bulb temperature, atmospheric pressure, wind speed and cloud cover.

Projected daily average temperatures for the 2030 climate change condition were used as a basis for meteorological boundary condition development by closely matching the average air temperature specified for each time frame with historical air temperature at approximately the same annual date (+/- 2 days) using the meteorological data[5] from the calibrated QUAL water temperature model. For a given model day for one of the climactic conditions, the projected average daily temperature is compared with daily average temperatures within +/-two days for all available historical years from the calibrated model (i.e., 1990 – 2008). The closest temperature is chosen from the list, the selected day and year is recorded, and the set of hourly meteorological conditions from the chosen historical day and year is then used for that model day. The final day in February in leap years was developed separately using a similar protocol Figure 5.B-7 and Figure 5.B-8 document the monthly averages of the meteorological parameters used as California WaterFix boundary conditions in the 2030 time frame.

A single set of boundary conditions for water temperature were also generated using historical data by using the same dates used in matching the projected and historical air temperatures. The historical water temperatures used in the calibrated QUAL model at the Sacramento R., Martinez and the San Joaquin R. boundaries from that day is then mapped into the California WaterFix scenario boundary conditions for water temperature. There are the only three time series used in setting all boundary water temperatures. Figure 5.B-9 illustrates the monthly averaged time series for water temperature and the document the boundaries used in each. Note that that the inflow water temperatures for these boundary condition time series show less variability among the three time frames than that shown by the meteorological boundary conditions.

[5] This methodology was adapted from a method developed by Don Smith (president of RMA) for creating meteorological boundary conditions from historical data.

5.B.A.4.5.2.4 Effluent boundary conditions

Effluent boundary conditions were set in two ways – for the previous California WaterFix models, the period 1975 – 1992, effluent was set using historical data from the years 2000 through 2005 - boundary conditions from a historical year were selected to represent each modeled year. The historical year to use for boundary condition during a given model year, 1975 – 1991, was selected using a similar water year type on the Sacramento River as a general guide.

Table 5.B-1 shows the annual correspondence established between the historical year (Column 3) and the modeled year (Column 1). Sacramento Regional Wastewater Treatment Plant (SRWTP) effluent flows were scaled, using this year-correspondence, to ensure the daily percentage of effluent flow in Sacramento R. inflow remained below the historical 2000 -2005 maximum (approximately 4.5%, see Figure 5.B-6). All other effluent flows were applied without scaling using the annual year selection shown in Table 5.B-1. Values for effluent inflow water temperature were not changed from the values recorded in the historical time series for any of the effluent locations.

For the remainder of the modeled years for these two scenarios, historical years 2000 – 2004 were used. For leap years, either 2000 or 2004 was used, and for the other model years, historical years 2001, 2002 and 2003 were used the correspondence and the scaling for SRWTP inflows are shown in Table 5.B-2 for the years 1921 – 1974 and Table 5.B-3 for the years 1992 -2003.

5.B.A.4.6 Discussion

The regular bias in the historical QUAL modeled water temperature calculations quantified in the Appendix can be used to improve the accuracy in interpreting the California WaterFix scenario model results in the seven California WaterFix subregions. Because the meteorology and water temperature boundary conditions for the California WaterFix scenarios was developed based on those of the calibrated Historical Model, the calculated average bias also applies to the regions identified in the California WaterFix scenarios. Note that since the meteorology and inflow water temperatures for 2030 time frame scenarios were developed using meteorology and inflow water temperatures from the present day Historical Model, the maximum values for boundary condition temperatures for the 2030 scenarios are bounded by present-day maximums.

As noted in previous discussions, the open water areas in DSM2 are conceptualized as zero-dimensional fully mixed volumes. The consequence of this simplification is that the water temperature in the open water areas is an average temperature for the volume, and as such water exiting the open water areas may be muted (i.e., the overall range may be diminished) depending on the timing and location. However, this observation is a general one and has not been specifically tested in reviewing the California WaterFix results in comparison with a higher dimensional model (as this would require additional model development not practical at this juncture).

Due to the simplifications used in the conceptualizations of California WaterFix scenarios for DSM2 HYDRO and QUAL-water temperature, it seems reasonable to use the model results from QUAL as monthly averages along with application of the calculated average regional bias in water temperature from the historical simulation results.

5.B.A.4.7 References

Brown, Linfield C., Thomas O. Barnwell, 1987. The Enhanced Stream Water Quality Models QUAL2E and QUAL2E_UNCAS: Documentation and User Manual, USEPA Environmental Prot3ction Laboratory, May, 1987.

DWR (Department of Water Resources), 1995. Modeling Support Branch, Representative Delta Island Return Flow Quality for Use in DSM2: Memorandum Report May 1995, Division of Planning, Department of Water Resources. 1995.

Jobson,1997 (USGS).

http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/models/misc/BLTMenhancementsUSGSWRI97_4050.pdf

Guerin, M., Modeling the Fate and Transport of Ammonia Using DSM2-QUAL: Calibration/Validation Report, Prepared for: Metropolitan Water District, 2010.

Guerin, M., Modeling the Fate and Transport of Nutrients Using DSM2: Calibration/Validation Report, Prepared for: Metropolitan Water District, November, 2011.

Rajbhandari, H. Dynamic simulation of water quality in surface water sytems utilizing a Langrangian reference frame. Ph.D. Dissertation. University of California, Davis. 1995a.

Rajbhandari, H., DWR 1995 Annual Progress Report, Chap 3: Water Quality. 1995b.

USGS,1997. http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/models/misc/FourPointUSGSWRI97_4016.pdf

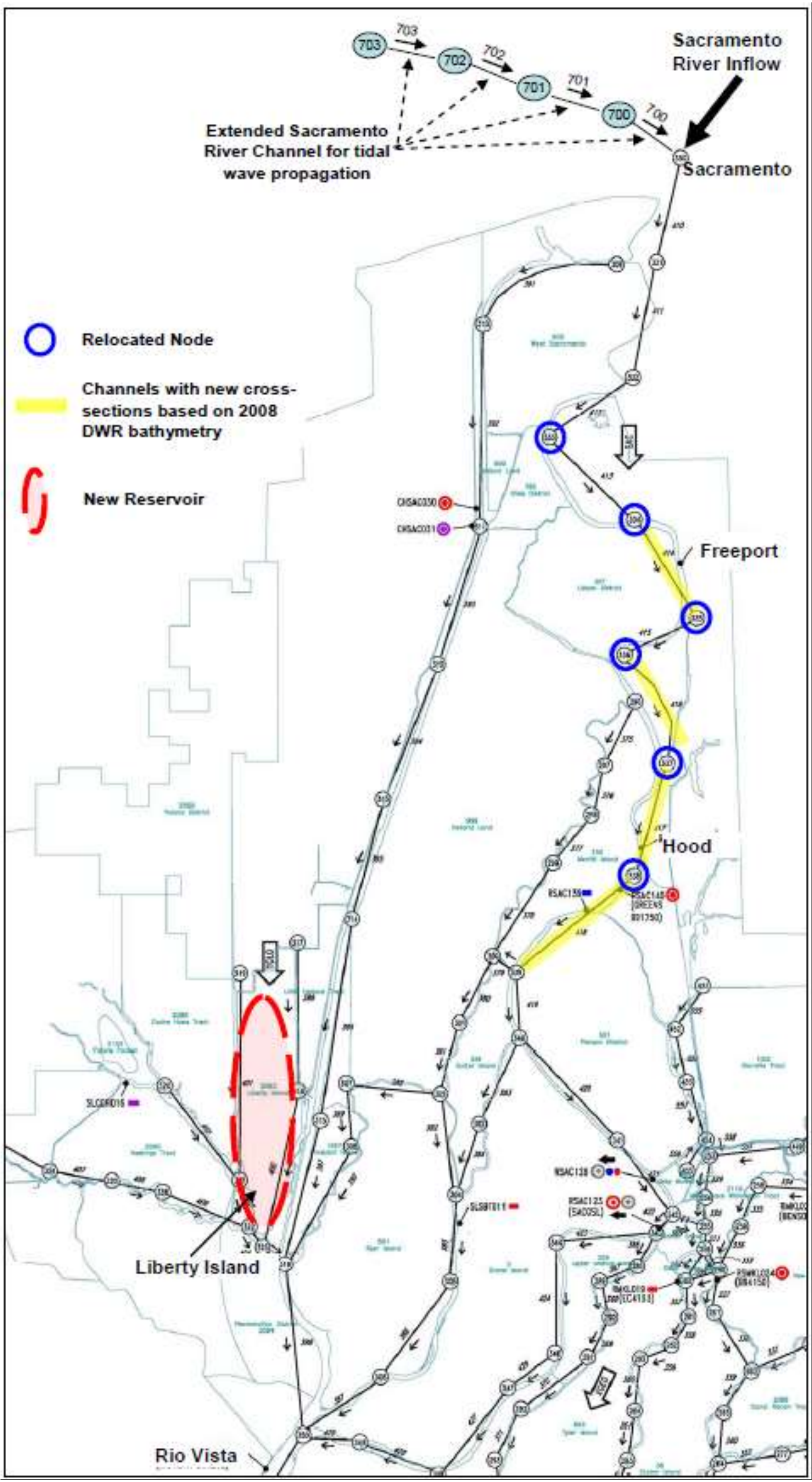


Figure 5.B-1 Changes implemented in the DSM2 V.8 model grid showing the new Liberty Island "reservoir" location, and changes to the grid and modes along the upstream portion of the Sacramento River.

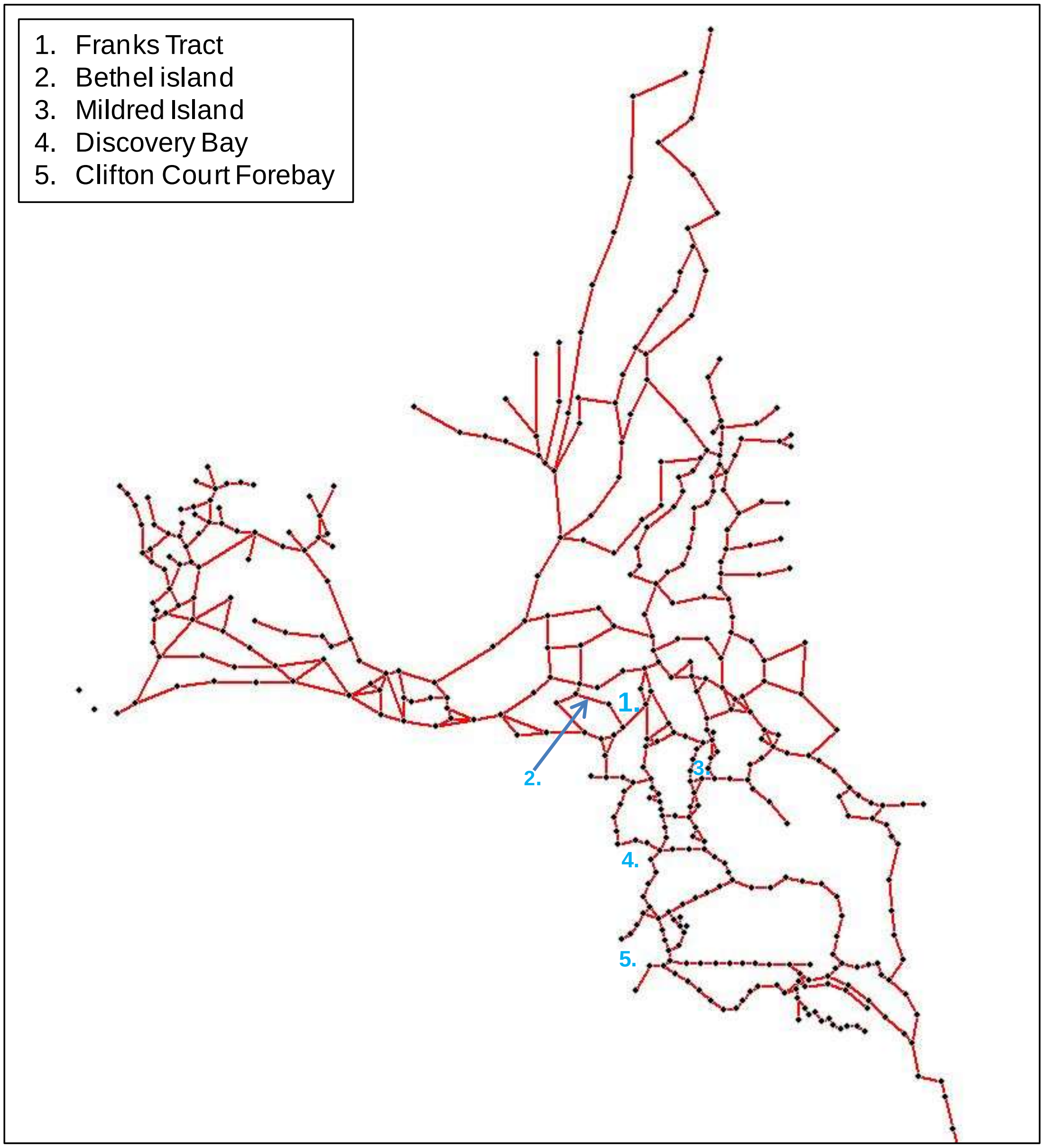


Figure 5.B-2 DSM2 Version 6 model grid showing channels (red), the approximate location of reservoirs (blue numbers), and nodes (black) between channels or at model boundaries.

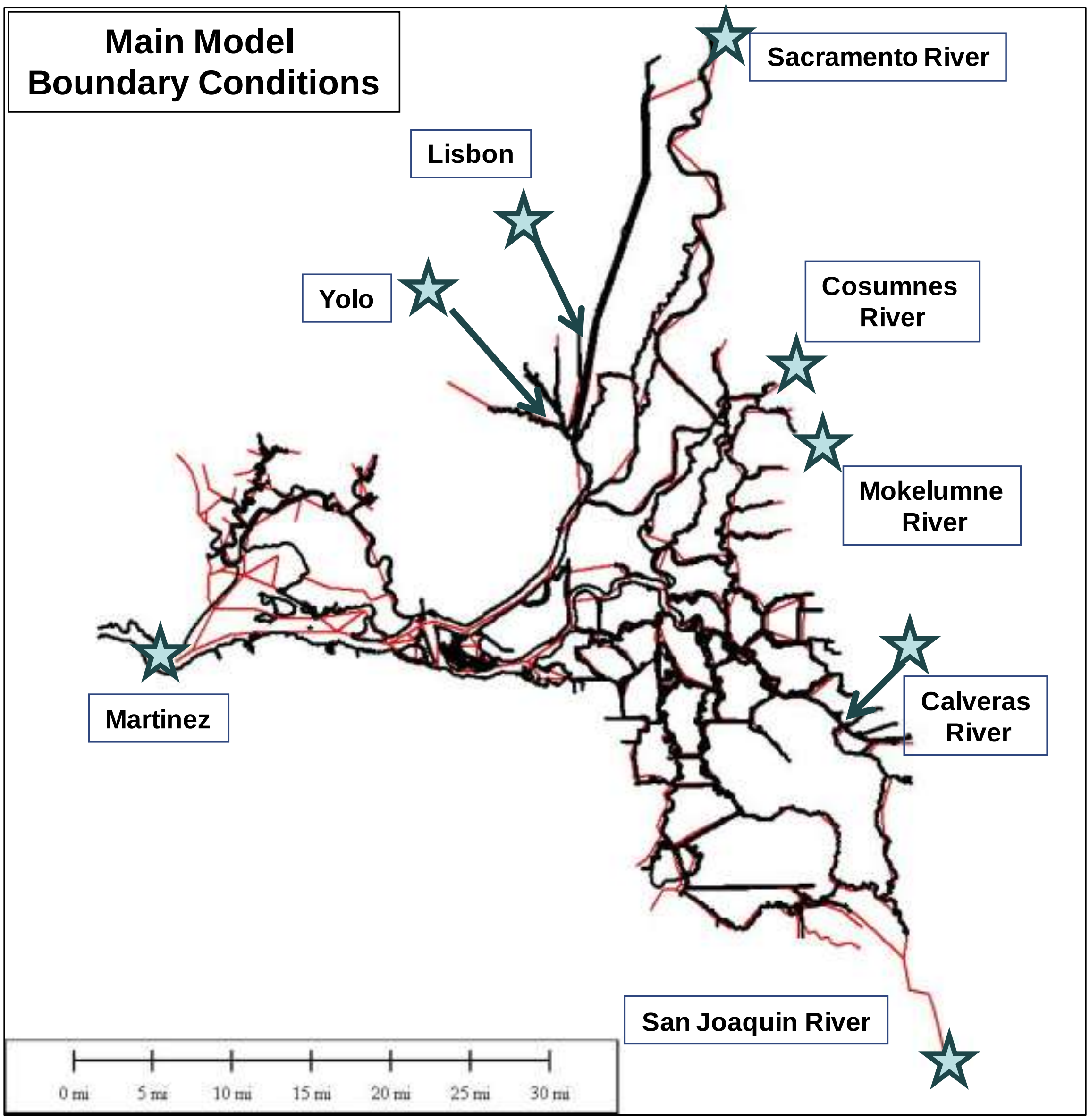


Figure 5.B-3 Approximate location of the model inflow (or outflow) boundaries (blue stars). The stage boundary is at Martinez.

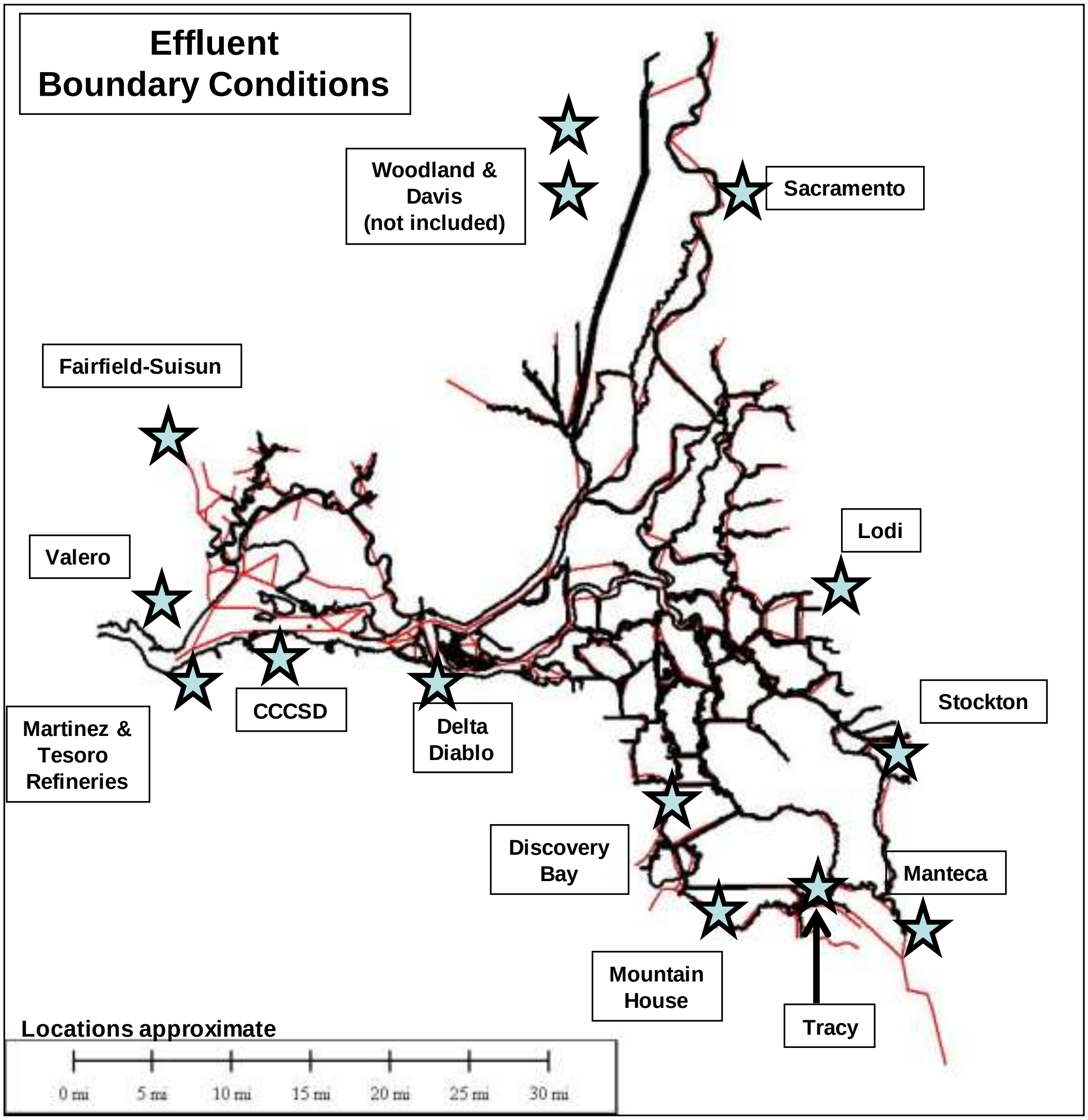


Figure 5.B-4 Approximate location of effluent boundary conditions for waste water treatment plants considered in this report.

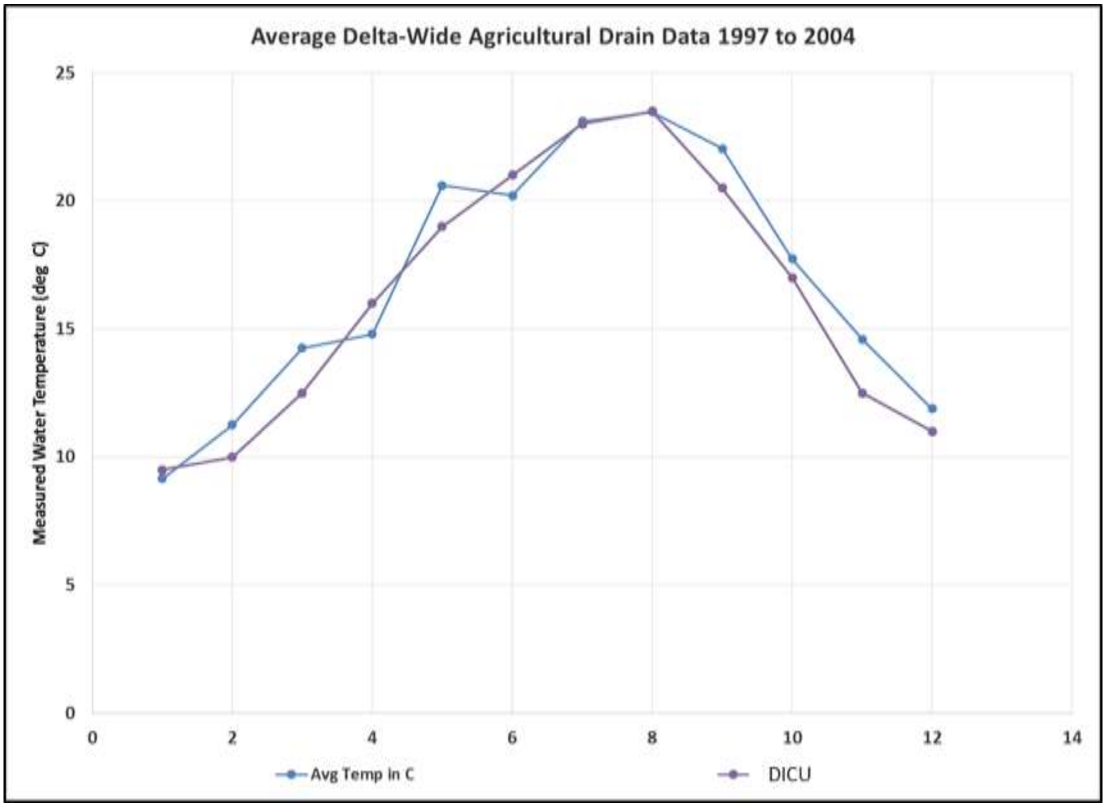


Figure 5.B-5 Comparison of DICU inflow water temperature (purple line) and a Delta-wide average of agricultural drain data (blue line) from the MWQI database.

Table 5.B-1 Correspondence between the former BDCP scenario model years (Column 1) and the Historical Model year (Column 3) used to apply all effluent BC, and the factor used to scale SRWTP effluent inflow (Column 4).

Model year	Sac WY Type	Historical BC Year	Factor*SRWTP Flow
1975	*W*	2000	1.0
1976	*C*	2004	1/1.4
1977	*C*	2002	1/1.6
1978	*AN*	2000	1.15
1979	*BN*	2004	1.0
1980	*AN*	2000	1.0
1981	*D*	2001	1.0
1982	*W*	2000	1.7
1983	*W*	2001	1.5
1984	*W*	2002	1.2
1985	*D*	2001	1.0
1986	*W*	2000	1.0
1987	*D*	2001	1/1.1
1988	*C*	2002	1/1.5
1989	*D*	2004	1/1.25
1990	***C***	2001	1/2.1
1991	***C***	2000	1/2

Table 5.B-2 Correspondence between the BDCP scenario years 1921 - 1974 and Historical years used to apply effluent BC, and the factor used to scale SRWTP effluent inflow).

Scenario Year	Sac WY Type	Historical BC Year	Factor*SRWTP Flow
1921	AN	2003	1
1922	AN	2003	1
1923	BN	2001	1/1.1
1924	C	2004	1/1.2
1925	D	2001	1
1926	D	2001	1
1927	W	2003	1
1928	AN	2000	1/1.4
1929	C	2001	1/1.1
1930	D	2001	1/1.3
1931	C	2001	1/1.3
1932	D	2004	1/1.2
1933	C	2001	1/1.1
1934	C	2001	1/2.5
1935	BN	2001	1/2.2
1936	BN	2004	1/1.1
1937	BN	2001	1
1938	W	2001	1
1939	D	2002	1/2.0
1940	AN	2000	1
1941	W	2003	1
1942	W	2003	1/1.4
1943	W	2003	1
1944	D	2000	1
1945	BN	2001	1
1946	BN	2001	1
1947	D	2001	1
1948	BN	2004	1/1.8
1949	D	2002	1/1.2
1950	BN	2002	1
1951	AN	2003	1
1952	W	2004	1
1953	W	2003	1
1954	AN	2003	1
1955	D	2001	1/1.3
1956	W	2000	1
1957	AN	2003	1
1958	W	2003	1
1959	BN	2001	1/1.3
1960	D	2004	1/1.1
1961	D	2001	1/1.2
1962	BN	2001	1
1963	W	2003	1
1964	D	2004	1/1.1
1965	W	2003	1
1966	BN	2001	1
1967	W	2003	1
1968	BN	2004	1
1969	W	2003	1
1970	W	2003	1
1971	W	2003	1
1972	BN	2004	1
1973	AN	2003	1
1974	W	2003	1

Table 5.B-3 Correspondence between the BDCP scenario years 1992 - 2003 and Historical years used to apply effluent BC, and the factor used to scale SRWTP effluent inflow).

Scenario Year	Sac WY Type	Historical BC Year	Factor*SRWTP Flow
1992	C	2004	1/1.5
1993	AN	2003	1
1994	C	2001	1/1.1
1995	W	2003	1
1996	W	2000	1
1997	W	2003	1
1998	W	2003	1
1999	W	2003	1
2000	AN	2000	1
2001	D	2001	1
2002	D	2002	1
2003	AN	2003	1

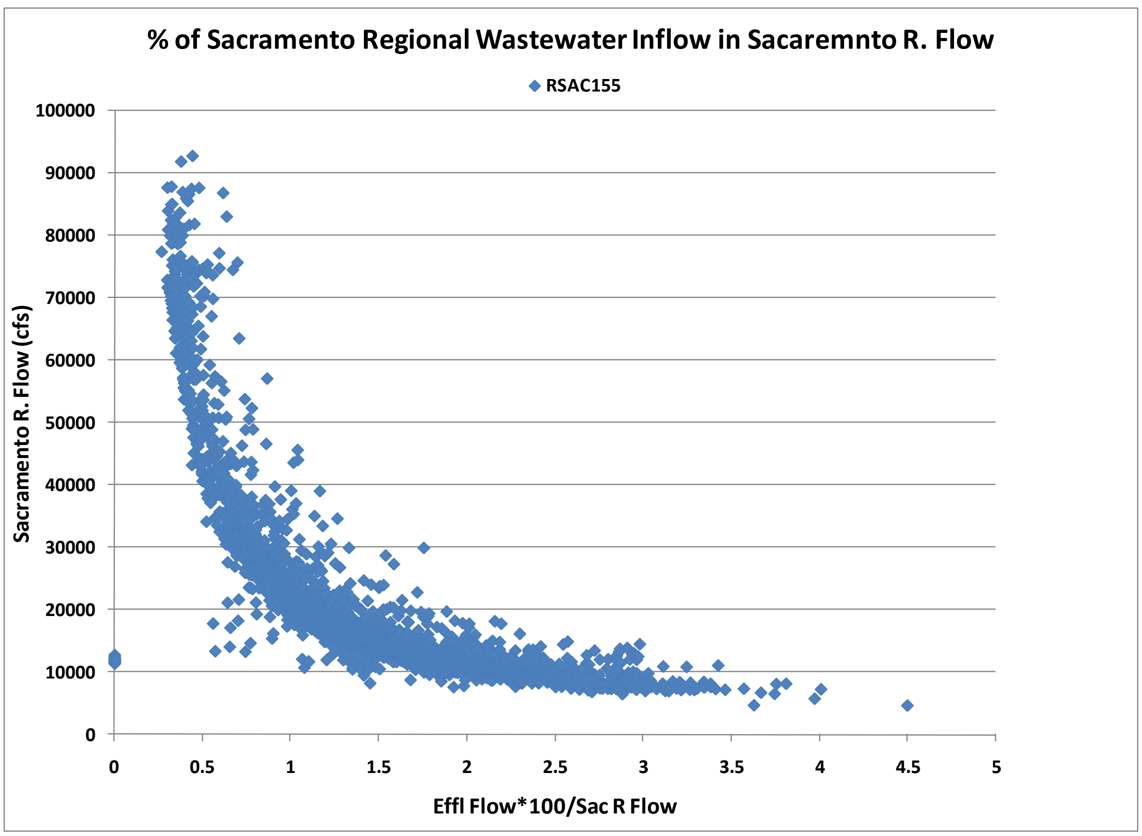


Figure 5.B-6 Maximum percentage of Sacramento Regional Wastewater inflow in Sacramento R. inflow was generally less than 4 %.

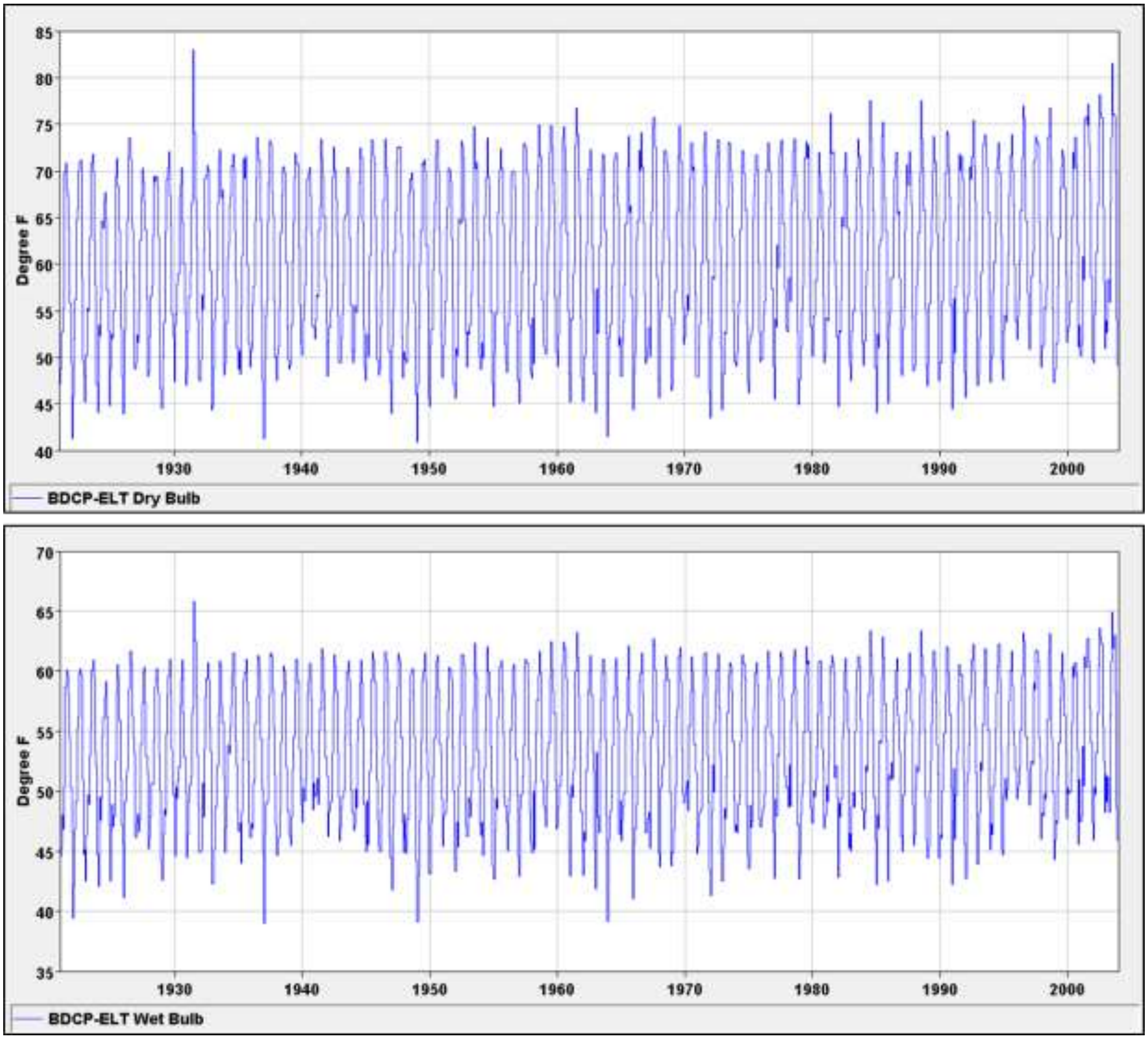
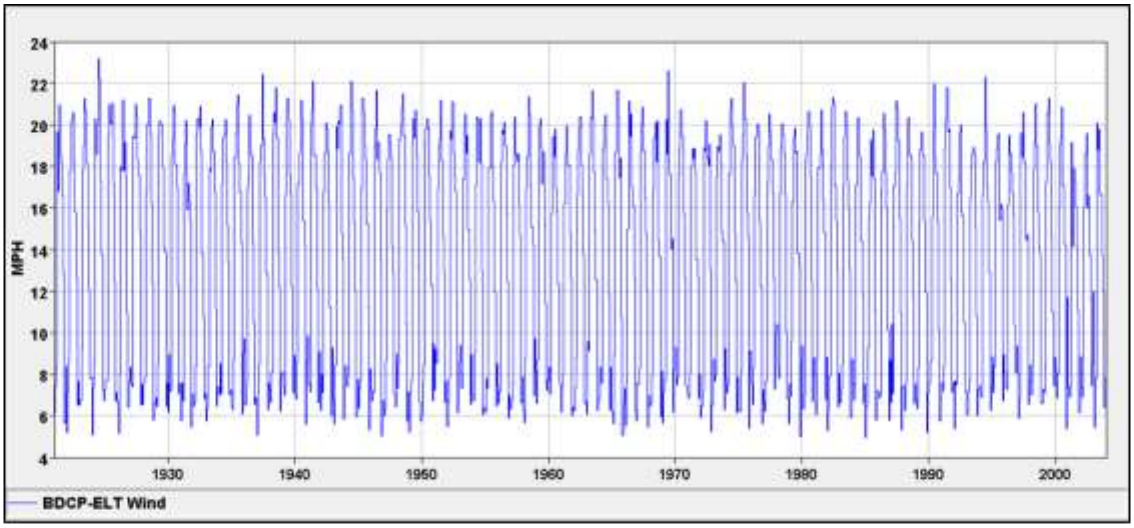


Figure 5.B-7 Monthly average air temperature (upper) and wet bulb temperature (lower) for the year 2030 time frame.



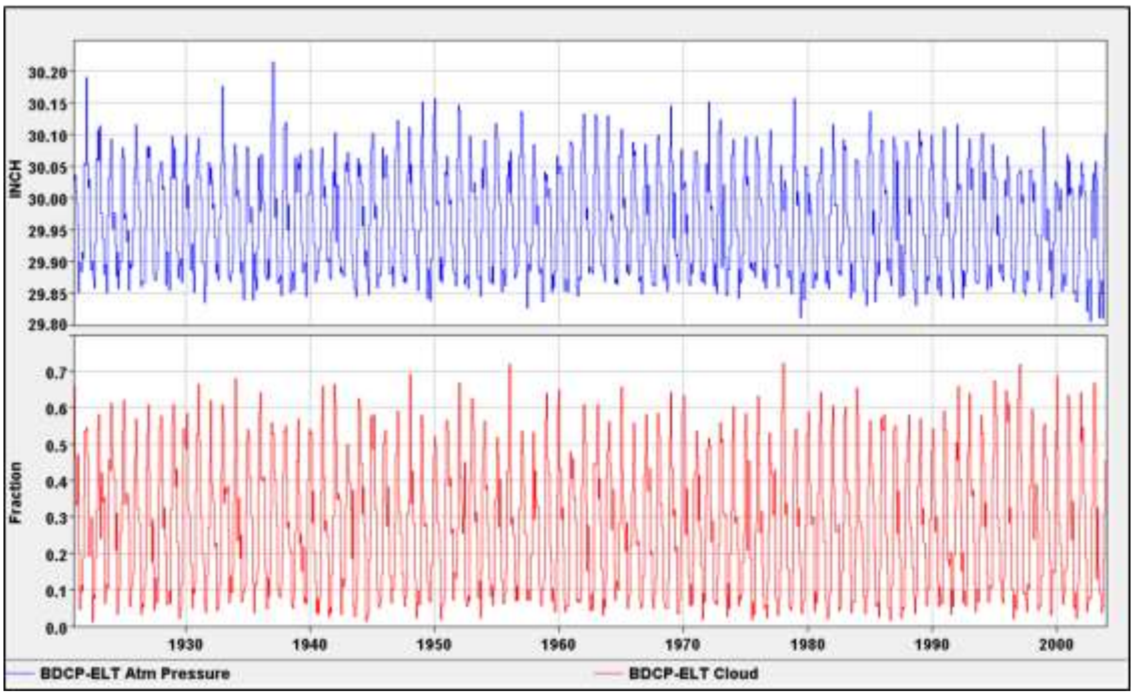


Figure 5.B-8 Monthly average wind speed (upper), fraction cloud cover and atmospheric pressure (lower) for the year 2030 scenario time frame.

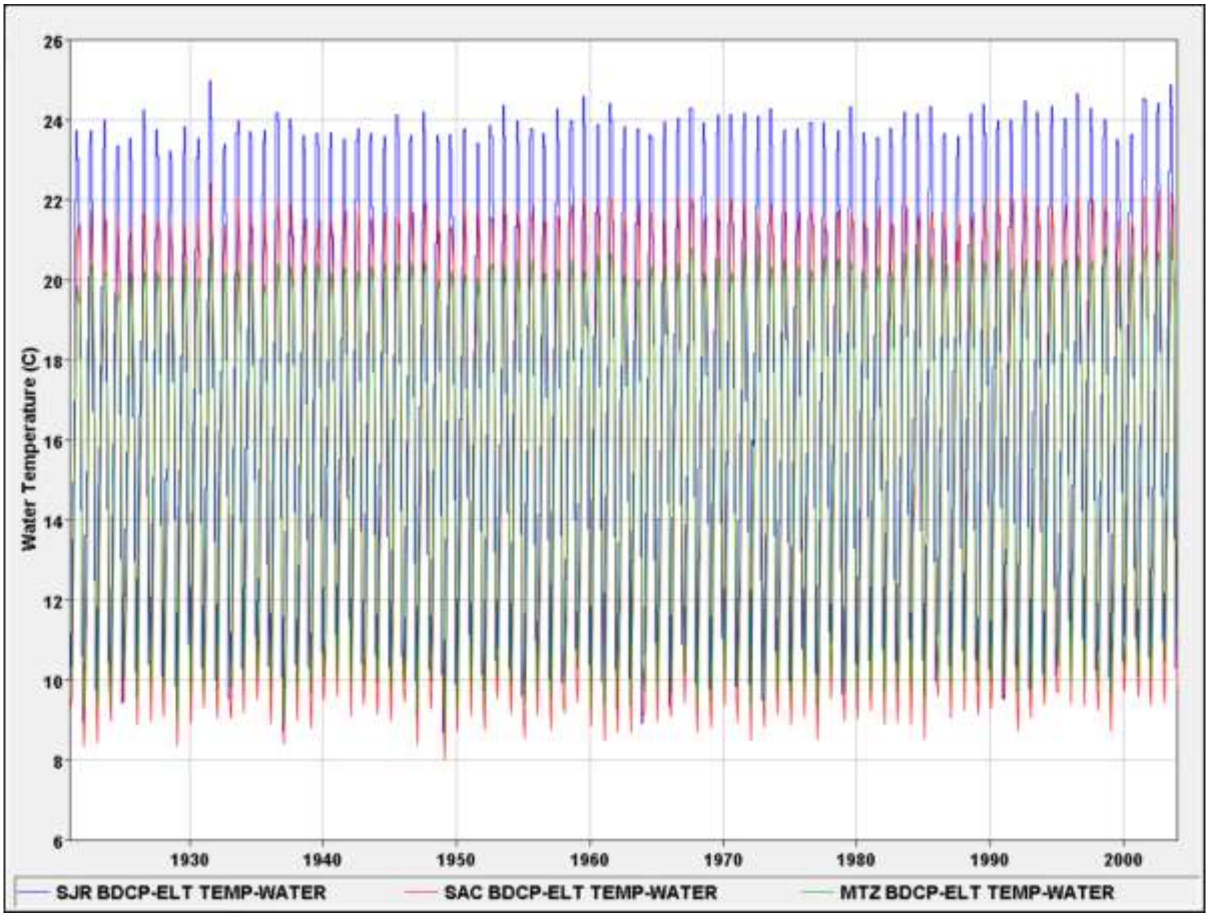


Figure 5.B-9 Inflow water temperature for the Sacramento and San Joaquin Rivers and the Martinez stage boundary for the year 2030 time frame. The San Joaquin River boundary is also applied to the Calaveras River. The Sacramento River boundary is applied to all remaining inflow boundaries.

5.B.A.4.8 Appendix

5.B.A.4.8.1 Water Temperature Model Calibration/validation

Data acquisition locations used to support the water temperature model calibration are shown in Figure 5.B-10. Discussion on the sources and quality of this data is covered in great detail in (Guerin, 2010) and in (Guerin, 2011). Both graphical and statistical model evaluation techniques were used in the analysis of calibration and validation results. Water temperature calibration and validation statistics were calculated on an annual basis by Wet or Dry Water Year Type at each available location. Residuals for water temperature were calculated as the difference (data – model) between the measured data and the modeled result on the same time scale, hourly or daily averages.

Selected plots documenting the quality of the water temperature model calibration are shown in Figure 5.B-11 through Figure 5.B-15. As discussed in (Guerin, 2010), the temperature model calibration results are generally Very Good. The main draw-back in the DSM2/QUAL temperature model is that meteorological boundary conditions are applied globally over the model domain, but model results indicate that a minimum of two temperature regions are required to improve results. The current model results are very good along the Sacramento River corridor where the calibration was focused. In the Central and South Delta, modeled water temperatures in the summer months can be several degrees Celsius cooler than indicated by the data, as illustrated at ROLD024 (Figure 5.B-15). However, the model temperature trends and diurnal variations are reasonable.

A more extensive analysis of the modeling of water temperature was undertaken to help define potential pitfalls with the conceptualization of Liberty Island as a fully mixed reservoir in DSM2. This analysis is documented in (RMA, 2015).

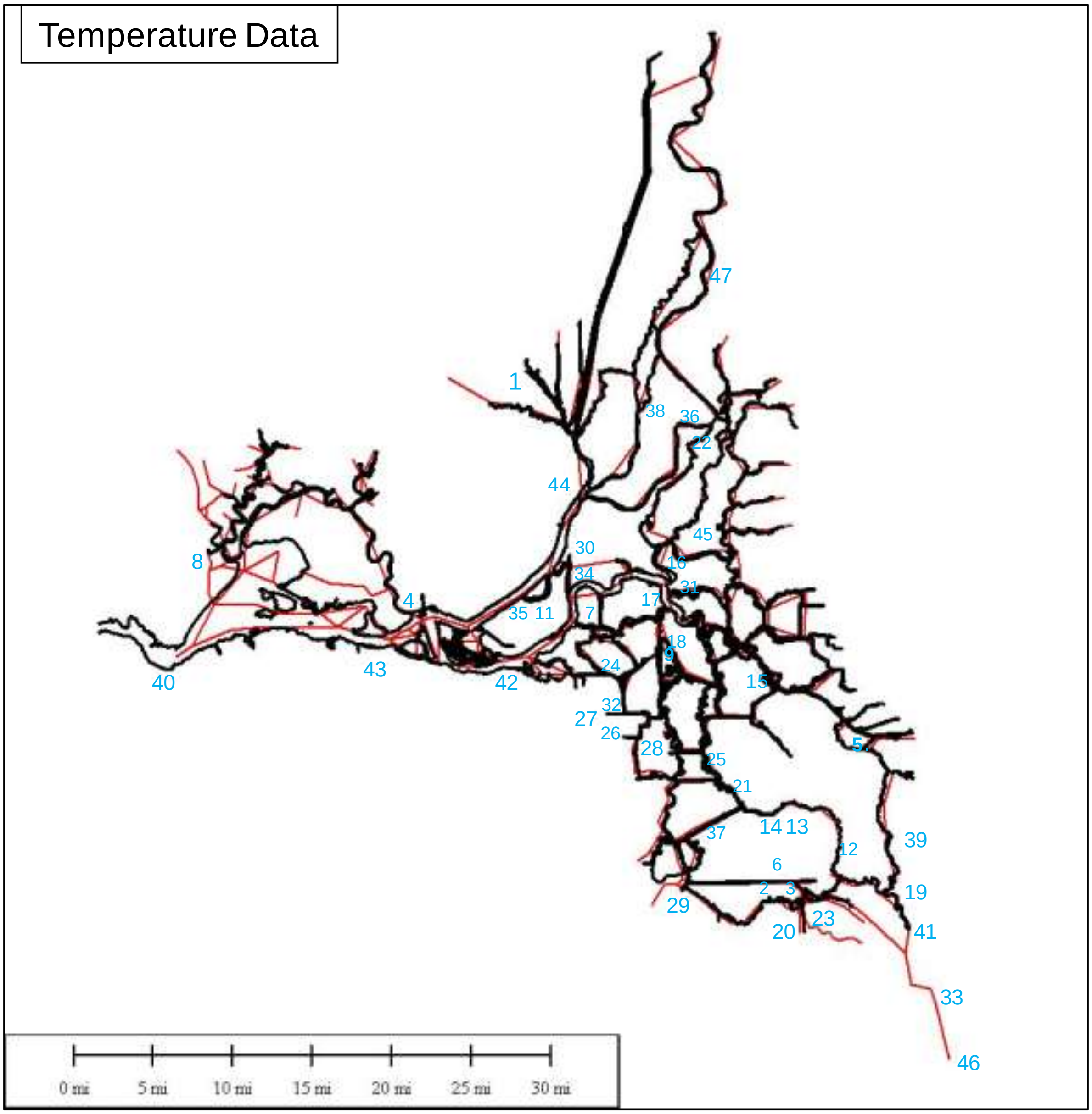


Figure 5.B-10 Locations of temperature data regular time series. Data quality and length of record was variable.

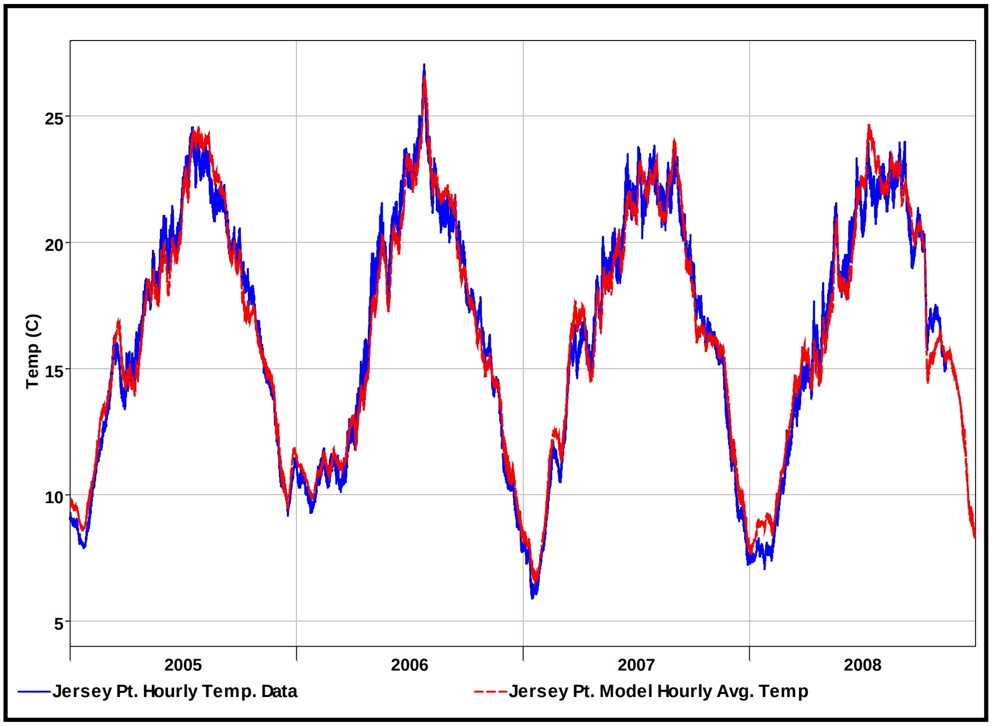


Figure 5.B-11 Hourly calibration results for water temperature at Jersey Point. Blue line is hourly data, red line is the modeled hourly result averaged from 15-minute model output.

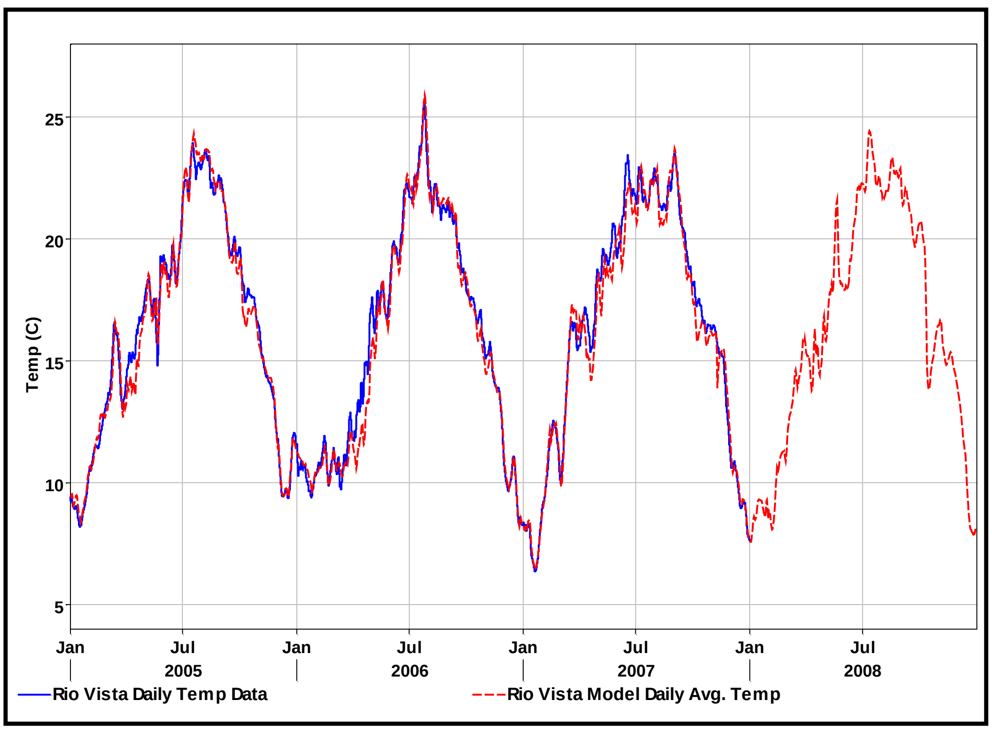


Figure 5.B-12 Daily calibration results for water temperature at Rio Vista. Blue line is daily data, red line is the modeled daily result averaged from 15-minute model output.

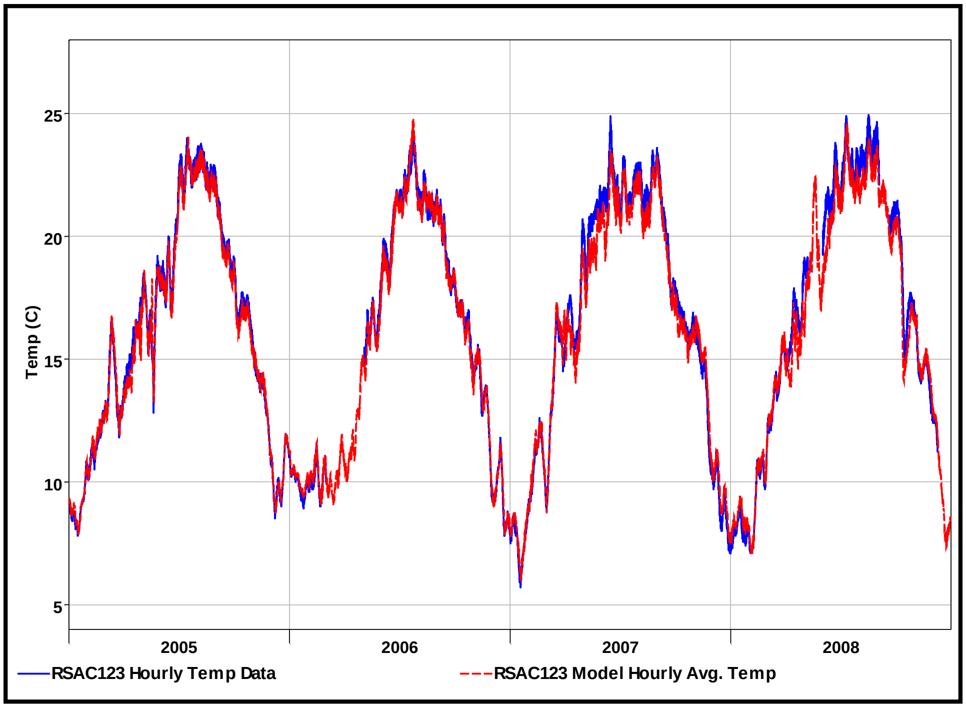


Figure 5.B-13 Hourly calibration results for water temperature at RSAC123. Blue line is hourly data, red line is the modeled hourly result averaged from 15-minute model output.

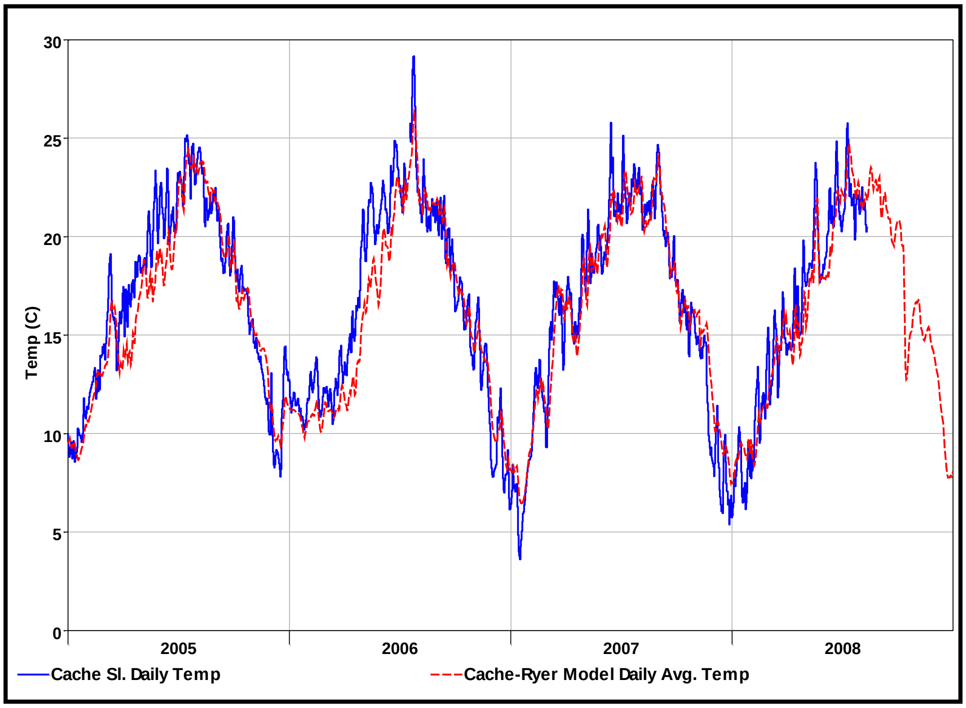


Figure 5.B-14 Hourly calibration results for water temperature at locations in the Cache Slough area. Blue line is daily data, red line is the modeled daily result averaged from 15-minute model output.

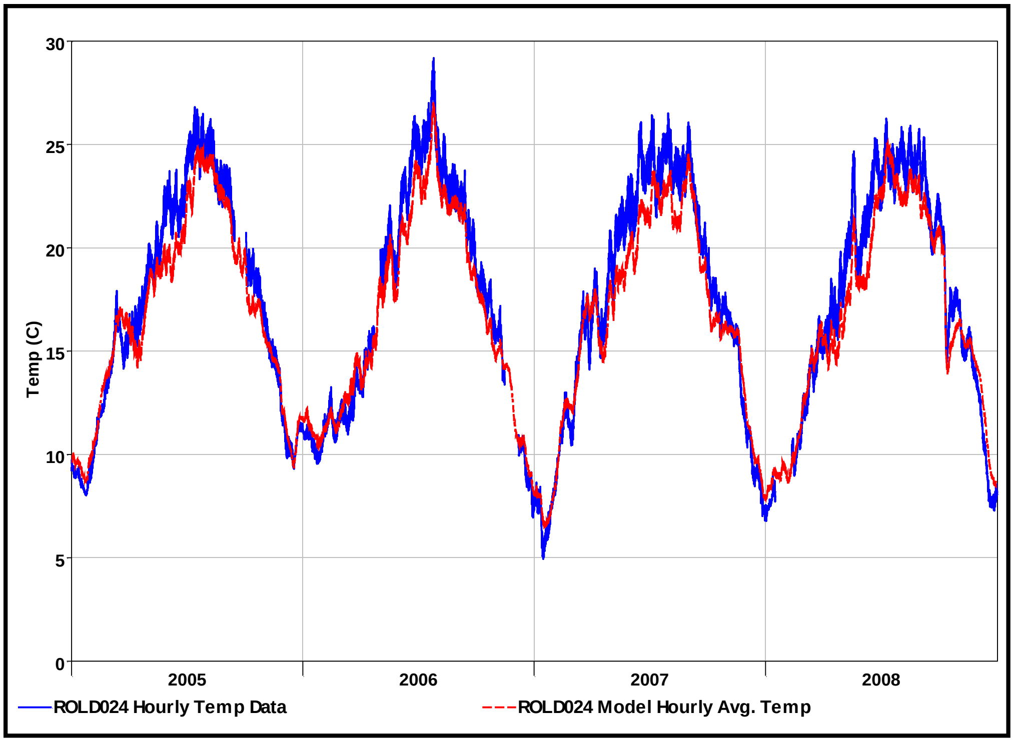


Figure 5.B-15 Hourly calibration results for water temperature at ROLD024. Blue line is hourly data, red line is the modeled hourly result averaged from 15-minute model output.

5.B.A.4.8.2 Residual analysis using recent data

The DSM2 Historical model was used to calculate estimates of bias in water temperature modeling at a monthly time step using model residuals (*i.e.*, model – data). The Historical water temperature model was run with boundary conditions relevant to the type of conditions used in the BDCP analyses. The following process was used to create estimates of QUAL model bias in water temperature using the seven regions identified in the BDCP scenarios (see **Error! Reference source not found.**):

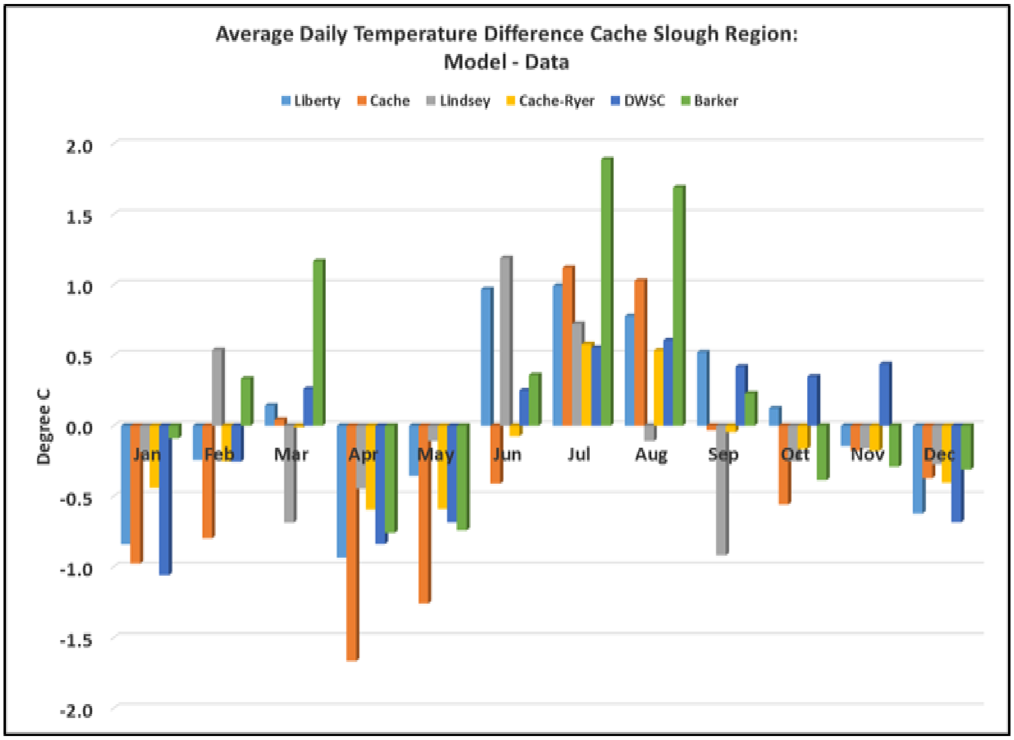
- Process Step 1: CDEC data was downloaded at each location where there was water temperature data in the Delta, with a focus on data from 12/2007 to 03/2012
- The data was examined and spurious data points were deleted – for most locations the gaps were then filled with a linear approximation.
- The data was then daily-averaged
- Process Step 2: The DSM2 Historical model output (15-min output) at each available CDEC data location was daily averaged.
- The difference (model-data) was calculated, sorted by month, and an overall average was calculated for each month at every data location.
- The individual location results were categorized by the BDCP region as individual bar charts, and then collated as a BDCP-regional bar chart and also in a tabular format.

The results in the individual and regional bar charts and tables give an estimate of the bias in the BDCP water temperature results, and the bias is generally regular, i.e., it the direction of the bias is consistent over the locations in a given region. For example, in the South Delta Region, the regional bar chart (Figure 5.B-22) shows that regional water temperature calculated by Historical DSM2 is too cold by 1- 2 °C from April to October annually. The estimates of bias found in the Tables as regional averages can be used in the interpretation of BDCP regional water temperature results.

Special notes:

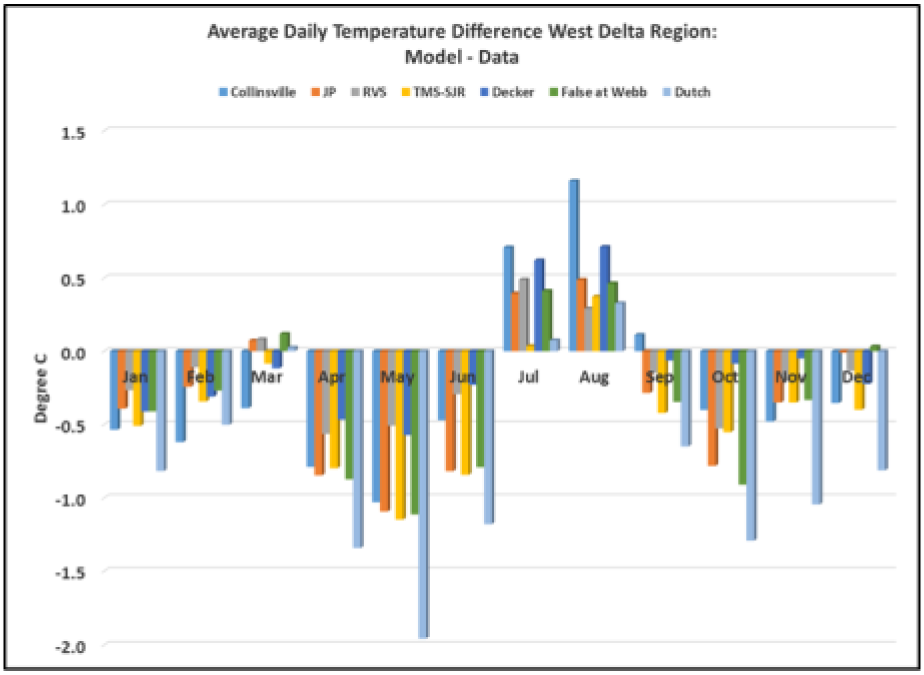
- Some locations had data that was harder to identify as spurious – those locations are noted in text near the individual bar chart
- At some locations, e.g. Dutch Slough in the West Delta Region, the results are quite different from the other locations, indicating that the influences on that location are complicated – possibly more of a mixture of the hydrodynamic influences on nearby regions and/or that DSM2 model results do not accurately reflect the data.

The water temperature and meteorological boundary conditions used in DSM2-CWF models were developed based on historical data, so it is expected that the magnitude of the regional (model – data) bias calculations documented herein are applicable to CWF models as a regional monthly bias in water temperature. The reason that the bias occurs in the DSM2 water temperature model is that DSM2 only allows a single meteorological region as a boundary condition when in fact the meteorological conditions influencing the Delta would more realistically require a minimum of two regions. When the bias is regular as it is in the South Delta, for example, this legitimately allows for correction in the interpretation of the CWF model results.



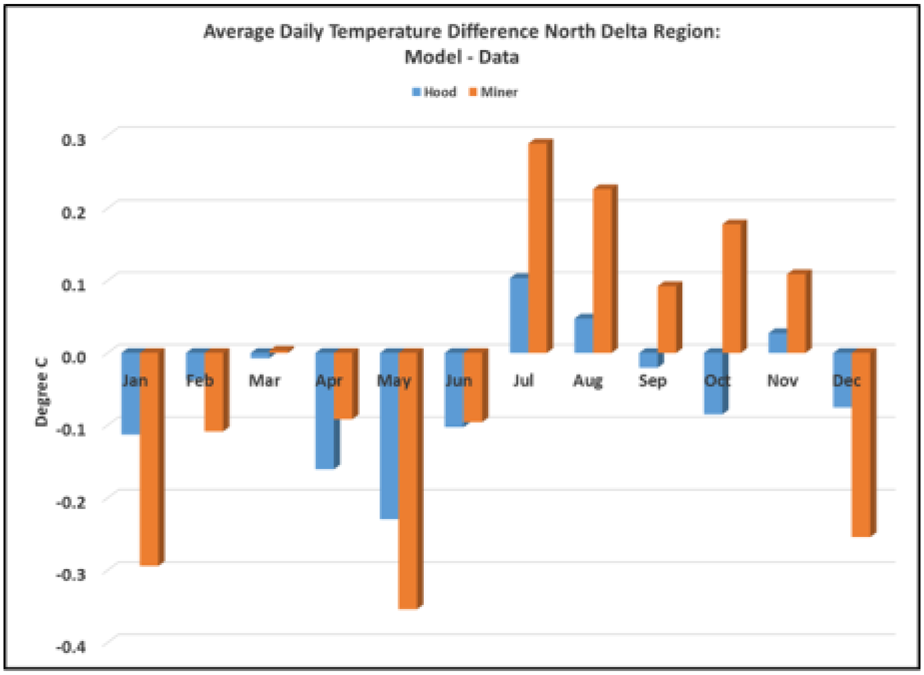
Cache Region: Average Monthly Temperature Difference From Daily Average Data (Deg C)							
	Liberty	Cache	Lindsey	Cache-Ryer	DWSC	Barker	Average
Jan	-0.8	-1.0	-0.2	-0.4	-1.1	-0.1	-0.6
Feb	-0.2	-0.8	0.5	-0.3	-0.3	0.3	-0.1
Mar	0.1	0.0	-0.7	0.0	0.3	1.2	0.2
Apr	-0.9	-1.7	-0.4	-0.6	-0.8	-0.8	-0.9
May	-0.4	-1.3	-0.1	-0.6	-0.7	-0.7	-0.6
Jun	1.0	-0.4	1.2	-0.1	0.3	0.4	0.4
Jul	1.0	1.1	0.7	0.6	0.6	1.9	1.0
Aug	0.8	1.0	-0.1	0.5	0.6	1.7	0.8
Sep	0.5	0.0	-0.9	0.0	0.4	0.2	0.0
Oct	0.1	-0.6	-0.3	-0.2	0.3	-0.4	-0.1
Nov	-0.1	-0.2	-0.2	-0.2	0.4	-0.3	-0.1
Dec	-0.6	-0.4	-0.3	-0.4	-0.7	-0.3	-0.4

Figure 5.B-16 QUAL water temperature bias calculation for the Cache Slough region.



West Delta: Average Monthly Temperature Difference From Daily Average Data (Deg C)								
	Collinsville	JP	RVS	TMS-SJR	Decker	False at Webb	Dutch	Average
Jan	-0.5	-0.4	-0.3	-0.5	-0.4	-0.4	-0.8	-0.5
Feb	-0.6	-0.2	-0.1	-0.3	-0.3	-0.3	-0.5	-0.3
Mar	-0.4	0.1	0.1	-0.1	-0.1	0.1	0.0	0.0
Apr	-0.8	-0.8	-0.6	-0.8	-0.5	-0.9	-1.3	-0.8
May	-1.0	-1.1	-0.5	-1.1	-0.6	-1.1	-2.0	-1.1
Jun	-0.5	-0.8	-0.3	-0.8	-0.2	-0.8	-1.2	-0.7
Jul	0.7	0.4	0.5	0.0	0.6	0.4	0.1	0.4
Aug	1.2	0.5	0.3	0.4	0.7	0.5	0.3	0.5
Sep	0.1	-0.3	-0.1	-0.4	-0.1	-0.3	-0.6	-0.3
Oct	-0.4	-0.8	-0.5	-0.6	-0.1	-0.9	-1.3	-0.6
Nov	-0.5	-0.3	-0.2	-0.3	0.0	-0.3	-1.0	-0.4
Dec	-0.4	0.0	-0.1	-0.4	-0.2	0.0	-0.8	-0.3

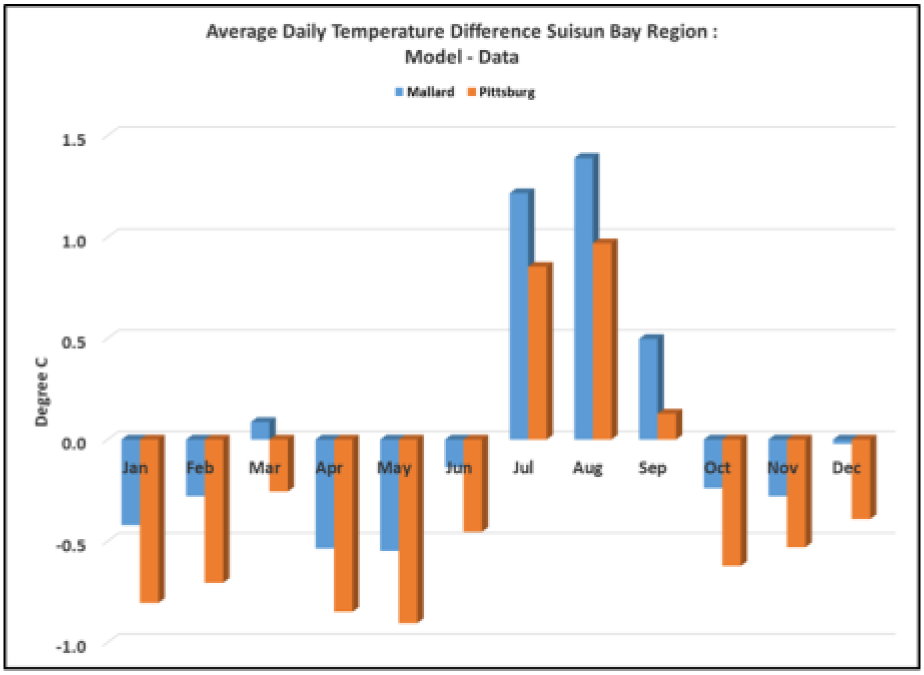
Figure 5.B-17 QUAL water temperature bias calculation for the West Delta region.



North Delta: Average Monthly Temperature Difference From Daily Average Data (Deg C)

	Hood	Miner	Average
Jan	-0.1	-0.3	-0.2
Feb	0.0	-0.1	-0.1
Mar	0.0	0.0	0.0
Apr	-0.2	-0.1	-0.1
May	-0.2	-0.4	-0.3
Jun	-0.1	-0.1	-0.1
Jul	0.1	0.3	0.2
Aug	0.0	0.2	0.1
Sep	0.0	0.1	0.0
Oct	-0.1	0.2	0.0
Nov	0.0	0.1	0.1
Dec	-0.1	-0.3	-0.2

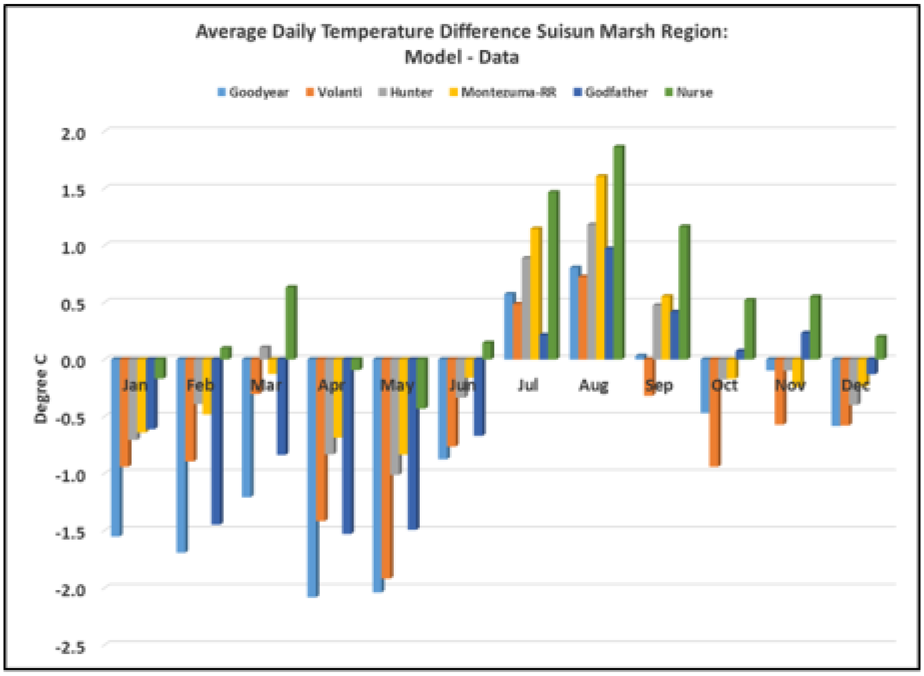
Figure 5.B-18 QUAL water temperature bias calculation for the North Delta region.



Suisun Bay: Average Monthly Temperature Difference From Daily Average Data (Deg C)

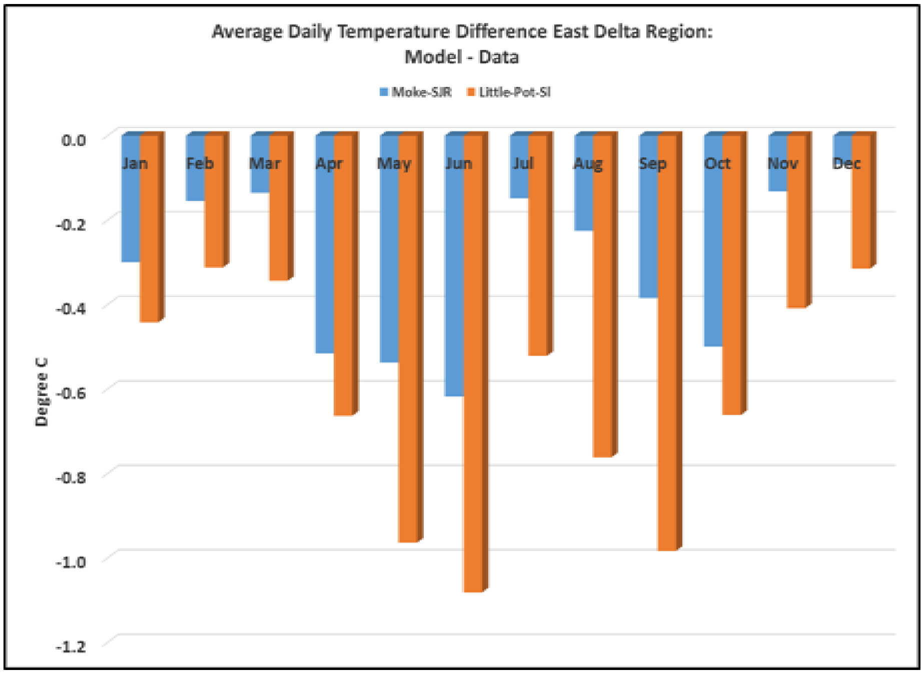
	Mallard	Pittsburg	Average
Jan	-0.4	-0.8	-0.6
Feb	-0.3	-0.7	-0.5
Mar	0.1	-0.3	-0.1
Apr	-0.5	-0.8	-0.7
May	-0.5	-0.9	-0.7
Jun	-0.1	-0.5	-0.3
Jul	1.2	0.9	1.0
Aug	1.4	1.0	1.2
Sep	0.5	0.1	0.3
Oct	-0.2	-0.6	-0.4
Nov	-0.3	-0.5	-0.4
Dec	0.0	-0.4	-0.2

Figure 5.B-19 QUAL water temperature bias calculation for the Suisun Bay region.



Suisun Marsh: Average Monthly Temperature Difference From Daily Average Data (Deg C)							
	Goodyear	Volanti	Hunter	Montezuma-RR	Godfather	Nurse	Average
Jan	-1.6	-0.9	-0.7	-0.6	-0.6	-0.2	-0.8
Feb	-1.7	-0.9	-0.4	-0.5	-1.4	0.1	-0.8
Mar	-1.2	-0.3	0.1	-0.1	-0.8	0.6	-0.3
Apr	-2.1	-1.4	-0.8	-0.7	-1.5	-0.1	-1.1
May	-2.0	-1.9	-1.0	-0.8	-1.5	-0.4	-1.3
Jun	-0.9	-0.8	-0.3	-0.2	-0.7	0.1	-0.4
Jul	0.6	0.5	0.9	1.1	0.2	1.5	0.8
Aug	0.8	0.7	1.2	1.6	1.0	1.9	1.2
Sep	0.0	-0.3	0.5	0.6	0.4	1.2	0.4
Oct	-0.5	-0.9	-0.2	-0.2	0.1	0.5	-0.2
Nov	-0.1	-0.6	-0.1	-0.2	0.2	0.6	0.0
Dec	-0.6	-0.6	-0.4	-0.2	-0.1	0.2	-0.3

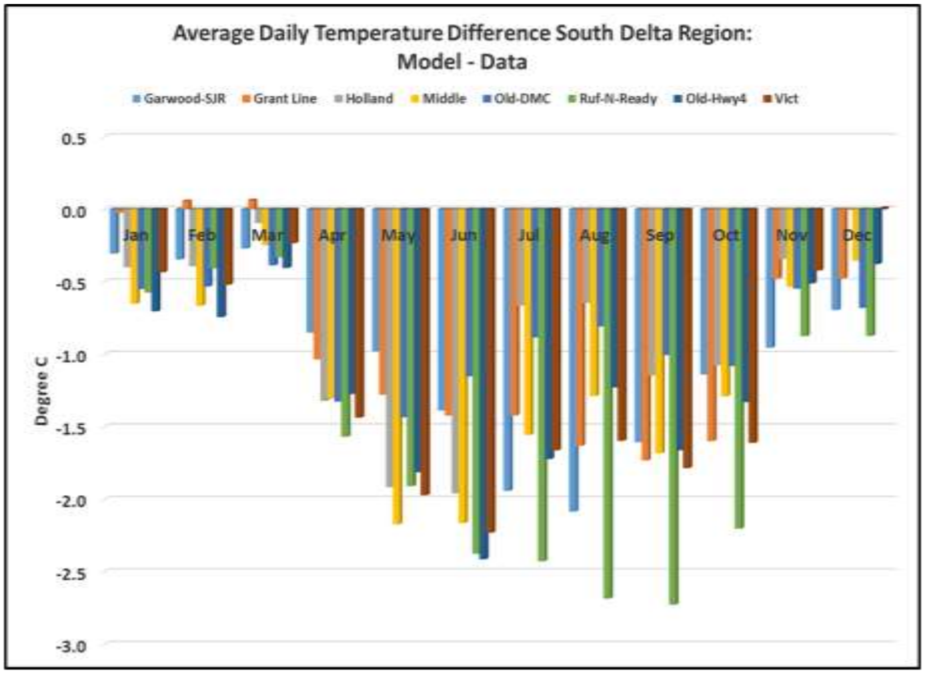
Figure 5.B-20 QUAL water temperature bias calculation for the Suisun Marsh region.



East Delta: Average Monthly Temperature Difference From Daily Average Data (Deg C)

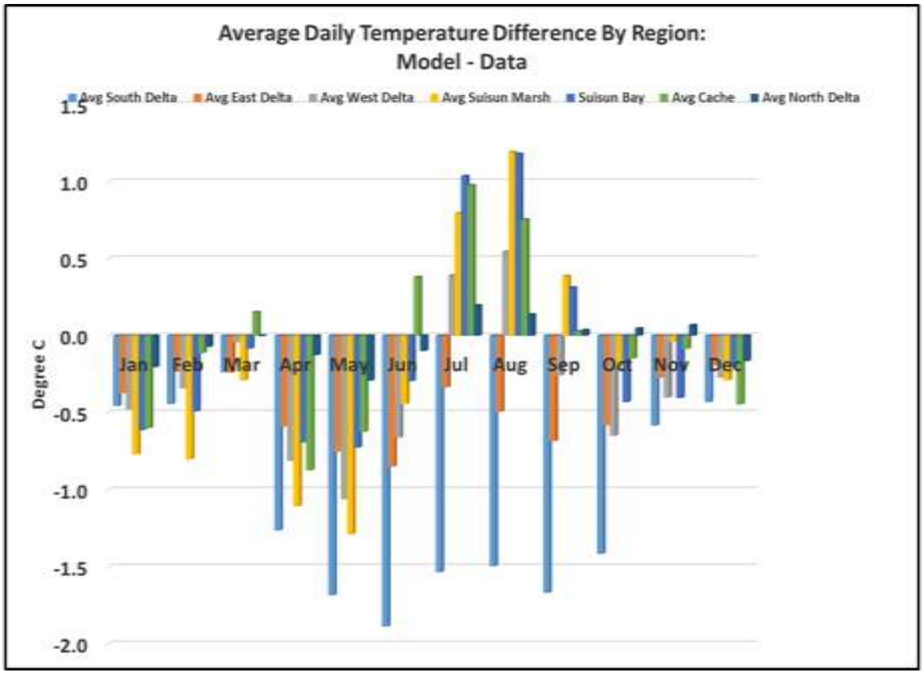
	Moke-SJR	Little-Pot-Sl	Average
Jan	-0.3	-0.4	-0.4
Feb	-0.2	-0.3	-0.2
Mar	-0.1	-0.3	-0.2
Apr	-0.5	-0.7	-0.6
May	-0.5	-1.0	-0.8
Jun	-0.6	-1.1	-0.8
Jul	-0.1	-0.5	-0.3
Aug	-0.2	-0.8	-0.5
Sep	-0.4	-1.0	-0.7
Oct	-0.5	-0.7	-0.6
Nov	-0.1	-0.4	-0.3
Dec	-0.1	-0.3	-0.2

Figure 5.B-21 QUAL water temperature bias calculation for the East Delta region.



South Delta: Average Monthly Temperature Difference From Daily Average Data (Deg C)										
	Garwood-SJR	Grant Line	Holland	Middle	Old-DMC	Ruf-N-Ready	Old-Hwy4	Vict	Middle-Holt	Average
Jan	-0.3	0.0	-0.4	-0.7	-0.5	-0.6	-0.7	-0.4	-0.5	-0.5
Feb	-0.3	0.1	-0.4	-0.7	-0.5	-0.4	-0.7	-0.5	-0.4	-0.4
Mar	-0.3	0.1	-0.1	-0.2	-0.4	-0.3	-0.4	-0.2	0.0	-0.2
Apr	-0.9	-1.0	-1.3	-1.3	-1.3	-1.6	-1.3	-1.4	-1.3	-1.3
May	-1.0	-1.3	-1.9	-2.2	-1.4	-1.9	-1.8	-2.0	-1.9	-1.7
Jun	-1.4	-1.4	-2.0	-2.2	-1.2	-2.4	-2.4	-2.2	-1.8	-1.9
Jul	-1.9	-1.4	-0.7	-1.6	-0.9	-2.4	-1.7	-1.7	-0.8	-1.5
Aug	-2.1	-1.6	-0.6	-1.3	-0.8	-2.7	-1.2	-1.6	-0.8	-1.5
Sep	-1.6	-1.7	-1.1	-1.7	-1.0	-2.7	-1.7	-1.8	-1.2	-1.7
Oct	-1.1	-1.6	-1.1	-1.3	-1.1	-2.2	-1.3	-1.6	-1.2	-1.4
Nov	-1.0	-0.5	-0.3	-0.5	-0.5	-0.9	-0.5	-0.4	-0.4	-0.6
Dec	-0.7	-0.5	0.0	-0.4	-0.7	-0.9	-0.4	0.0	-0.1	-0.4

Figure 5.B-22 QUAL water temperature bias calculation for the South Delta region.



Regional Averages Compiled: Average Monthly Temperature Difference From Daily Average Data (Deg C)

	Avg South Delta	Avg East Delta	Avg West Delta	Avg Suisun Marsh	Suisun Bay	Avg Cache	Avg North Delta
Jan	-0.5	-0.4	-0.5	-0.8	-0.6	-0.6	-0.2
Feb	-0.4	-0.2	-0.3	-0.8	-0.5	-0.1	-0.1
Mar	-0.2	-0.2	0.0	-0.3	-0.1	0.2	0.0
Apr	-1.3	-0.6	-0.8	-1.1	-0.7	-0.9	-0.1
May	-1.7	-0.8	-1.1	-1.3	-0.7	-0.6	-0.3
Jun	-1.9	-0.8	-0.7	-0.4	-0.3	0.4	-0.1
Jul	-1.5	-0.3	0.4	0.8	1.0	1.0	0.2
Aug	-1.5	-0.5	0.5	1.2	1.2	0.8	0.1
Sep	-1.7	-0.7	-0.3	0.4	0.3	0.0	0.0
Oct	-1.4	-0.6	-0.6	-0.2	-0.4	-0.1	0.0
Nov	-0.6	-0.3	-0.4	0.0	-0.4	-0.1	0.1
Dec	-0.4	-0.2	-0.3	-0.3	-0.2	-0.4	-0.2

Figure 5.B-23 Compilation of the QUAL water temperature bias calculation for seven regions used in previous BDCP simulations.

5.B.A.5 Incorporation of Daily Variability in the CalSim II and DSM2 Modeling

5.B.A.5.1 Introduction

In reality, daily operations in the overall CVP-SWP system that affect Delta flows depend on daily decisions under unique conditions, occasionally through consultation between several agencies. As the spatial extent of the system increases, the permutations of possible daily outcomes increase so much that it is difficult to assume rules to implement such decisions in a long-term planning model such as CalSim II. For the CWF BA modeling, updates were implemented for new CWF facilities that are sensitive to daily river flow pattern. Monthly river flows were downscaled to represent daily variability using historical data. The daily downscaling did not require any operational decisions. Daily modeling for Delta would require several assumptions on daily operations that cannot be modeled, and therefore, was not attempted. Most of the current Delta standards are 14-day average or monthly. Sub-monthly requirements have been attempted to be addressed conservatively at a monthly time step in CalSim II.

This technical memorandum summarizes the approach used to incorporate daily variability into CalSim II and DSM2 modeling performed for CWF BA. CalSim II results are based on operational decisions on a monthly timestep. It is important to note that this daily mapping approach does not in any way represent the flows resulting from operational responses on a daily time step. It is simply a technique to incorporate representative daily variability into the flows resulting from CalSim II's monthly operational decisions.

5.B.A.5.2 Sacramento River Daily Variability in CalSim II

The operation of the modified Fremont Weir under the CWF NAA and PA scenarios, and the bypass rules associated with the proposed North Delta intakes under the PA are sensitive to the daily variability of flows. Short duration, highly variable storms are likely to cause Fremont Weir spills. However, if flows are averaged for the month, as is done in a monthly model, it is possible to not identify any spill. Similarly, the operating criteria for the north delta intakes include variable bypass flows and pulse protection criteria. Storms as described above may permit significant diversion but only for a short period of time. Initial comparisons of monthly versus daily operations at these facilities indicated that weir spills were likely underestimated and diversion potential was likely overstated using a monthly time step.

Figure 1 shows a comparison of observed monthly averaged Sacramento River flow at Freeport and corresponding daily flow as an example. The figure shows that the daily flow exhibits significant variability around the monthly mean in the winter and spring period while remaining fairly constant in summer and fall months. Figure 2 shows the daily historical patterns by water year type. It shows that daily variability is significant in the winter-spring while the summer flows are holding fairly constant in the most water year types. The winter-spring daily variability is deemed important to species of concern.

In an effort to better represent the sub-monthly flow variability, particularly in early winter, a monthly-to-daily flow mapping technique is applied directly in CalSim II for the Fremont Weir, Sacramento Weir, and the North Delta intakes. The technique applies historical daily patterns, based on the hydrology of the year, to transform the monthly volumes into daily flows. Daily patterns are "borrowed" from the observed DAYFLOW period of 1956-2008. In all cases, the monthly volumes are preserved between the daily and monthly flows. It is important to note that this daily mapping approach does not in any way represent the flows resulting from operational responses on a daily time step. It is simply a technique to incorporate representative daily variability into the flows resulting from CalSim II's monthly operational decisions.

5.B.A.5.2.1 Observed Daily Patterns

CalSim II hydrology is derived from historical monthly gauged flows for 1922-2003. This is the source data for monthly flow variability. DAYFLOW provides a database of daily historical Delta inflows from WY 1956 to present. This database is aligned with the current Delta infrastructure setting. Despite including the historical operational responses to various regulatory regimes existed over this period, in most winter and spring periods the reservoir operations and releases are governed by the inflows to the reservoirs. It is likely that the unimpaired daily patterns are preserved in these seasons in most years.

Daily patterns from DAYFLOW used directly for mapping CalSim II flows for water years 1956 to 2003. For water years 1922 to 1955 with missing daily flows, daily patterns are selected from water years 1956 to 2003 based on similar total annual unimpaired Delta inflow. The daily pattern for the water year with missing daily flows is assumed to be the same as the daily pattern of the identified water year. Correlation among the various hydrologic basins is preserved by selecting same pattern year for all rivers flowing into the Delta, for a given year in the 1922-1955 period. Table 1 lists the selected pattern years for the water years 1922 to 1955 along with the total unimpaired annual Delta inflow.

Thus, for each month in the 82-year CalSim II simulation period, the monthly flow is mapped onto a daily pattern for computation of spills over the Fremont Weir and Sacramento Weir and for computing water available for diversions through the North Delta intakes. A preprocessed timeseries of daily volume fractions, based on Sacramento River at Freeport observed flows, is input into CalSim II. The monthly volume as determined dynamically from CalSim II then is multiplied by the fractions to arrive at a daily flow sequence. The calculation of daily spills and daily diversions are thus obtained. In the subsequent cycle (but still the same month), adjustments are made to the daily river flow upstream of the Sacramento Weir and the North Delta intakes to account for differences between the monthly flows assumed in the first cycle and the daily flows calculated in subsequent cycles. For example, if no spill over Fremont was simulated using a monthly flow, but when applying a daily pattern spill does occur, then the River flow at the Sacramento Weir is reduced by this amount. In this fashion, daily balance and monthly balance is preserved while adding more realism to the operation of these facilities.

5.B.A.5.2.2 North Delta Diversion Operations

CWF PA includes three new intakes on Sacramento River upstream of Sutter Slough, in the north Delta. Each intake is proposed to have 3,000 cfs maximum pumping capacity. It is also proposed that the intakes will be screened using positive barrier fish screens to eliminate entrainment at the pumps. Water diverted at the intakes is conveyed to a new forebay in the south Delta via tunnels. The CWF proposes bypass (in-river) rules, which govern the amount of water required to remain in the river before any diversion can occur. Bypass rules are designed to avoid increased upstream tidal transport from downstream channels, to support salmonid and pelagic species transport to regions of suitable habitat, to preserve shape of the natural hydrograph which may act as cue to important biological functions, to lower potential for increased tidal reversals that may occur because of the reduced net flow in the River and to provide flows to minimize predation effects downstream. The bypass rules include three important components:

- a constant low level pumping of up to 300 cfs at each intake depending on the flow in the Sacramento River,
- an initial pulse protection, and
- a post-pulse operations that permit a percentage of river flow above a certain threshold to be diverted (and transitioning from Level I to Level II to Level III).

The bypass rules are simulated in CalSim II using daily mapped Sacramento River flows as described above to determine the maximum potential diversion that can occur in the north Delta for each day. The simulation identifies which of the three criteria is governing, based on antecedent daily flows and season. An example of the north delta flows and diversion is illustrated in Figure 3. As can be seen in this figure, bypass rules begin at Level I in October until the Sacramento River pulse flow develops. During the pulse flow, the constant low level pumping (Level 0) is permitted, but is limited to a certain percentage of river flow. After longer periods of high bypass flows, the bypass flow requirements moves to Level II and eventually Level III which permit greater potential diversion. CalSim II uses the monthly average of this daily potential diversion as one of the constraints in determining the final monthly north Delta diversion.

5.B.A.5.3 Daily Hydrologic Inputs in DSM2

DSM2 is simulated on a 15-minute time step to address the changing tidal dynamics of the Delta system. However, the boundary flows are typically provided from monthly CalSim II results. In all previous planning-level evaluations, the DSM2 boundary flow inputs were applied on a daily time step but used constant flows equivalent to the monthly average CalSim II flows except at month transitions. In an effort to better represent the sub-monthly flow variability, particularly in early winter, a monthly-to-daily flow mapping technique is applied to the boundary flow inputs to DSM2.

The daily mapping also helps in refining the monthly CalSim II operations by providing a better estimate of the Fremont and Sacramento weir spills which are sensitive to the daily flow patterns. It also allows in providing the upper bound of the available North Delta Diversion in the PA. The daily mapping approach used in CalSim II and DSM2 are consistent.

It is important to note that this daily mapping approach does not in any way represent the flows resulting from operational responses on a daily time step. It is simply a technique to incorporate representative daily variability into the flows resulting from CalSim II’s monthly operational decisions.

5.B.A.5.3.1 Observed Daily Patterns

CalSim II hydrology is derived from historical monthly gaged flows 1922-2003. Main Delta inflows are Sacramento River, San Joaquin River, Yolo Bypass, Mokelumne River, Cosumnes River and Calaveras River. All the monthly river inflows to Delta resulting from CalSim II are mapped according to "borrowed" observed daily patterns in this approach.

DAYFLOW provides a database of daily historical Delta inflows from WY 1956 to present. This database is aligned with the current Delta infrastructure setting. Even though it includes the historical operational responses to various regulatory regimes existed over this period, in most winter and spring periods the reservoir operations and releases are governed by the inflows to the reservoirs. It is likely that the unimpaired daily patterns are preserved in these seasons in most years.

Daily patterns from DAYFLOW used directly for mapping CalSim II flows for water years 1956 to 2003. For water years 1922 to 1955 with missing daily flows, daily patterns are selected from water years 1956 to 2003 based on similar total annual unimpaired Delta inflow. The daily pattern for the water year with missing daily flows is assumed to be the same as the daily pattern of the identified water year. Correlation among the various hydrologic basins is preserved by selecting same pattern year for all rivers flowing into the Delta, for a given year in the 1922-1955 period. Table 1 lists the identified pattern years for the water years 1922 to 1955 along with the total unimpaired annual Delta inflow.

5.B.A.5.3.2 Daily Patterning of Delta River Inflows

Based on the pattern years identified for WY 1922-1955 and the DAYFLOW data for WY 1956-2003, daily flow timeseries are prepared for all the observed Delta inflows for the 82-year period. Based on the 82-year daily timeseries, monthly average timeseries are computed for all the observed Delta inflows over the 82-year period. When preparing the 82-year daily and monthly observed database, adjustments may be needed for February months. If a water year is a leap year and the corresponding selected pattern water year is not, then March 1st flow in the selected pattern year is used to compute the monthly average flow for February and to pattern the flow on the 29th day of February. Converse to that if the selected pattern year is a leap year and the water year is not, then the February average for the selected pattern year is computed from the first 28 days in February. Table 2 shows the years with adjustments made to February monthly averages.

The 82-year observed daily flows are scaled based on the ratio of simulated to observed monthly flows.

i. Adjustment factor is calculated based on monthly average flows:

$$f_{adj} = Q_{monthly\ simulated} / Q_{monthly\ observed}$$

ii. Simulate daily flows are estimated by scaling the observed daily flows using the adjustment factor:

$$q_{simulated} = f_{adj} * q_{observed}$$

Under some extreme observed flow conditions that are not present in the simulated flows, the patterning produces unrealistic swings in daily flows and corrections to constant patterns were implemented. In order to reduce this effect, a set of criteria was introduced for each boundary flow. The criteria allow daily mapping only when the simulated monthly flow is greater than a minimum flow target and the adjustment factor is falling within a certain range reducing the risk of introducing unrealistic variability into daily mapped flows. If either criterion is not met the mapping is not performed and constant monthly average flow is assigned to all the days in the month. The observed daily river flow record used for mapping each simulated monthly Delta inflow is listed in the Table 3 below along with the criteria for the daily mapping. As with CalSim II, in all cases the monthly flows and diversions are maintained as the daily mapping is implemented.

5.B.A.5.3.2.1 Sacramento River

Daily mapping of Sacramento River flow is performed in CalSim II using the approach described above. The daily Sacramento River flow simulated in CalSim II is used to map the monthly C169 output from CalSim II for use in DSM2. The Freeport Regional Water Project (FRWP) diversions from CalSim II (D168B and D168C) are added to the daily mapped C169 as FRWP diversion is explicitly simulated in DSM2.

5.B.A.5.3.2.2 Yolo Bypass

Yolo Bypass receives water from the Sacramento River via Fremont Weir and Sacramento Weir spills and other local flows such as Knight's Landing Ridge Cut, Cache Creek, Willow Slough and Putah Creek. The daily flow values for Fremont Weir and Sacramento Weir spills are simulated directly in CalSim II based on the daily mapped Sacramento River flows. The Yolo Bypass flow from local sources, computed from monthly CalSim II results by subtracting spills (D160 and D166A) from Yolo Bypass flow into Delta (C157), are mapped using the daily residuals computed from QYOLO and observed Fremont and Sacramento Weir spills. For observed Fremont weir spill CDEC FRE gage data is used for 1984 – 2003 period. The missing values were filled based on a flow correlation with Sacramento at Verona (USGS 11425500, 1929-2009) using 2006 weir rating curve. For observed Sacramento Weir spill USGS 11426000 gage data is used.

Finally, the simulated daily Fremont Weir and Sacramento Weir spills from CalSim II are added to the daily mapped Yolo Bypass local flows to estimate the daily inflow for Yolo Bypass into the Delta.

5.B.A.5.3.2.3 San Joaquin River

Monthly San Joaquin River flow at Vernalis simulated in CalSim II (C639) is mapped using QSJR daily flow pattern from DAYFLOW. The daily mapping is not performed if C639 is less than 2,000 cfs or if the adjustment factor is not within 0.25 and 7.0 for all months except April and May. The minimum flow target for April and May months is dependent on the 60-20-20 Water Year Type for San Joaquin River Valley. Table 4 shows the long-term minimum flow target to be used for daily mapping of San Joaquin River flow at Vernalis in April and May. The higher minimum flow targets are used to ensure that the daily flows do not fall below the values shown in the Table 4.

The daily mapped C639 flows are then added to R644 return flow from CalSim II to estimate the daily inflow for San Joaquin River at Vernalis boundary.

5.B.A.5.3.2.4 Eastside Streams

Monthly Mokelumne River inflow (C603) to Delta from CalSim II is estimated by subtracting Cosumnes River flow (C601) from C604 flow. It is mapped using the 82-year daily flow pattern prepared from QMOKE data from DAYFLOW. Monthly Cosumnes River (C601) is mapped using the daily flow pattern based on the CSMR data from DAYFLOW.

Monthly Calaveras River flow from CalSim II (C508) is mapped based on the daily pattern of QMISC data from DAYFLOW. The daily pattern for Calaveras inflow from WY 1956-1960 was based on the CALR daily flow data from the 1930-1960 DAYFLOW dataset and based on QMISC daily flow data from the current DAYFLOW dataset for WY 1960 - 2003. The reason for this is that the current DAYFLOW QMISC data set records reports monthly averages for WY 1956 – 1960 as shown in the Figure 4. The daily patterned C508 data is added to the R514 return flow from CalSim II to estimate the daily inflow for Calaveras River into the Delta.

5.B.A.5.3.2.5 Daily Patterning of North Delta Diversion

Daily mapping of the Sacramento River flow in CalSim II allows to accurately implementing the bypass rules proposed in the CWF so that a refined estimate of potential north Delta diversion can be estimated. Daily north Delta diversion flows used in DSM2 are estimated by patterning the actual monthly north Delta diversion (D400) from CalSim II based on the potential daily north Delta diversion from CalSim II operations. Adjustment factors are computed as the ratio of simulated north Delta diversion in CalSim II (D400) and the monthly average of potential daily north Delta diversion from CalSim II. The daily CalSim II outputs for potential north Delta diversion are then scaled using the adjustment factor to compute the initial estimate of the daily north Delta diversion boundary condition for DSM2.

The final north Delta diversion is computed by adjusting its initial estimate using the daily south Delta exports and constraining the total daily pumping (combined north and south) to the available maximum total pumping capacity of 9,000 cfs. The north Delta diversion is adjusted by reallocating the amount of total daily pumping in excess of 9,000 cfs to the days when the total pumping is less than 9,000 cfs within each month while making sure that daily Sacramento River flow if at least 5,000 cfs. The monthly averages of the final daily north Delta diversion are checked against the CalSim II (D400) results to ensure the mass balance.

5.B.A.5.3.2.6 Daily Patterning of South Delta Exports

The initial estimate of the daily south Delta exports at Jones Pumping Plant and Banks Pumping Plant is simply setting all the days in a month equal to the constant monthly average values from CalSim II (D418_TD and D419_TD). The initial estimates are then adjusted by constraining combined north and south Delta pumping at Jones to 4,600 cfs (maximum pumping capacity at Jones Pumping Plant) and by constraining combined north and south Delta pumping at Banks to

10,300 cfs (maximum pumping capacity at Banks Pumping Plant). The daily Jones and Banks components in the north Delta are computed from initial estimate of the daily north Delta diversion using the monthly fractional volumes from CalSim II (D418_IF and D419_IF).

The initial daily south Delta export at Jones is adjusted by reallocating the amount of daily combined Jones pumping in excess of 4,600 cfs to the days when total Jones pumping is less than 4,600 cfs within each month. Similarly, the initial south Delta export at Banks is adjusted by reallocating the amount of daily combined Banks pumping in excess of 10,300 cfs to the days when total Banks pumping is less than 10,300 cfs within each month. The monthly averages of the final south Delta exports at Jones and Banks Pumping Plants are checked against the CalSim II (D418_TD and D419_TD) results to ensure the mass balance. It is important to note that in the absence of the north Delta diversion as in the case of No Action scenario this approach results in constant monthly south Delta exports across all the days in the month similar to the traditional method.

5.B.A.5.3.2.7 Daily Patterning of DCC Gate Operations

DCC gate operations are determined based on the CalSim II output "//DXC/GATE-DAYS-OPEN//1MON//", which provides the number of days DCC gates are open for each month in the 82-year period. For the months where GATE-DAYS-OPEN is zero, the gate operation is set to close on all the days in the month. For the months where GATE-DAYS-OPEN is greater than zero, the gate operation is determined based on daily Sacramento River flow upstream of the Delta Cross Channel estimated from daily mapped Sacramento inflow and subtracting the north Delta diversion from it. From beginning of the month, the gates are set to open on the days if Sacramento River flow upstream of the Delta Cross Channel is less than 25,000 cfs, otherwise the gates are assumed to be closed. The cumulative sum of the number of days with the gates open is tracked. If the number of the days specified by CalSim II is met in a month, then the gates are closed for the rest of the month.

The monthly total number of days with DCC gates open is computed from the final daily timeseries and compared to the CalSim II result. This approach could result in discrepancy with CalSim II result if daily Sacramento River flow is greater than 25,000 cfs while the monthly average in CalSim II was not. The discrepancy was not corrected since the daily approach is more realistic.

5.B.A.5.3.2.8 End-of-month Smoothing

The daily mapped Delta inflows are smoothed at the month transition to avoid abrupt change in flow. The smoothing approach used computes 4-day forward moving average and 4-day backward moving average and averages the two moving averages in the last 5 days of a month and the first 5 days of the next month. Once the smoothing is performed the resulting daily timeseries is scaled to conserve the monthly average of the inflow.

Smoothing is performed on all the main Delta River inflows. Sacramento River is an exception since the daily pattern needs to be consistent with the daily mapping of Sacramento River flow in CalSim II as the north Delta diversion is mapped based on the daily potential estimated in

CalSim II. There is a chance that with smoothing the daily Sacramento flow could change from the CalSim II pattern and may not be sufficient to meet the daily north Delta diversion.

Table 1. Identified "Pattern" Water Year for the Water Years 1922 to 1955 with Missing Daily Historical Flows

Water Year	Total Annual Unimpaired Delta Inflow (TAF)	Selected "Pattern" Water Year	Total Annual Unimpaired Delta Inflow (TAF)
1922	32,975	1975	31,884
1923	23,799	2002	23,760
1924	8,174	1977	6,801
1925	26,893	1962	25,211
1926	18,534	1959	17,967
1927	38,636	1984	38,188
1928	26,363	1962	25,211
1929	12,899	1994	12,456
1930	20,326	1972	19,863
1931	8,734	1977	6,801
1932	24,179	2002	23,760
1933	14,126	1988	14,019
1934	12,895	1994	12,456
1935	28,486	2003	28,228
1936	30,698	2003	28,228
1937	25,448	1962	25,211
1938	56,949	1998	56,482
1939	12,743	1994	12,456
1940	37,185	1963	36,724
1941	46,746	1986	46,602
1942	42,301	1980	41,246
1943	36,870	1963	36,724
1944	17,158	1981	17,131
1945	26,757	1962	25,211
1946	28,823	2003	28,228
1947	16,206	2001	15,460
1948	23,741	1979	22,973
1949	19,176	1960	19,143

Table 1. Identified "Pattern" Water Year for the Water Years 1922 to 1955 with Missing Daily Historical Flows

Water Year	Total Annual Unimpaired Delta Inflow (TAF)	Selected "Pattern" Water Year	Total Annual Unimpaired Delta Inflow (TAF)
1950	23,272	1979	22,973
1951	39,110	1984	38,188
1952	49,270	1986	46,602
1953	30,155	2003	28,228
1954	26,563	1962	25,211
1955	17,235	1981	17,131

Table 2. Adjustment in Number of Days to Calculate February Monthly Average in the Selected Pattern Years

Water Year	Selected Pattern Water Year	Water Year Days in February	Pattern Year Days in February	Adjustment (days)
1922	1975	28	28	0
1923	2002	28	28	0
1924	1977	29	28	1
1925	1962	28	28	0
1926	1959	28	28	0
1927	1984	28	29	-1
1928	1962	29	28	1
1929	1994	28	28	0
1930	1972	28	29	-1
1931	1977	28	28	0
1932	2002	29	28	1
1933	1988	28	29	-1
1934	1994	28	28	0
1935	2003	28	28	0
1936	2003	29	28	1
1937	1962	28	28	0
1938	1998	28	28	0
1939	1994	28	28	0
1940	1963	29	28	1

Table 2. Adjustment in Number of Days to Calculate February Monthly Average in the Selected Pattern Years

Water Year	Selected Pattern Water Year	Water Year Days in February	Pattern Year Days in February	Adjustment (days)
1941	1986	28	28	0
1942	1980	28	29	-1
1943	1963	28	28	0
1944	1981	29	28	1
1945	1962	28	28	0
1946	2003	28	28	0
1947	2001	28	28	0
1948	1979	29	28	1
1949	1960	28	29	-1
1950	1979	28	28	0
1951	1984	28	29	-1
1952	1986	29	28	1
1953	2003	28	28	0
1954	1962	28	28	0
1955	1981	28	28	0

Table 3. DSM2 Boundary Flow, CalSim II Output Used, Observed DAYFLOW Record Used for Daily Mapping and Applicable Constraints

DSM2 Boundary Flow	CALSIM Output	Observed DAYFLOW Records	Constraints [2]
Sacramento River at Freeport	C169	QSAC	None
Yolo bypass flow not including Fremont and Sacramento Weir Spills	(C157 – D160 – D166A)	QYOLO minus Historic Fremont and Sacramento Weir Spills	Allowed range for adjustment factor is 0.25 to 7.0
Cosumnes River	C501	CSMR	Allowed range for adjustment factor is 0.25 to 7.0
Mokelumne River	(C504 – C501)	QMOKE	Allowed range for adjustment factor is 0.25 to 7.0
Calaveras River at Stockton	C508	QMISC	Allowed range for adjustment factor is 0.25 to 7.0
San Joaquin River at Vernalis	C639	QSJR	Allowed range for adjustment factor is 0.25 to 7.0; Minimum flow target for simulated

Table 3. DSM2 Boundary Flow, CalSim II Output Used, Observed DAYFLOW Record Used for Daily Mapping and Applicable Constraints

DSM2 Boundary Flow	CALSIM Output	Observed DAYFLOW Records	Constraints [2]
			monthly flow is 2,000 cfs in most months [1]

Notes:

[1] In April and May months the minimum target flow to allow daily mapping for San Joaquin River is determined based on San Joaquin River 60-20-20 Water Year Type. Minimum target flow for Wet and Above Normal Years 7,000 cfs, Below Normal Years 5,500 cfs, Dry Years 4,000 cfs and Critical Years 2,500 cfs.

[2] Daily mapping is not performed and constant monthly average flow is assigned to all the days in the month if the listed criteria is not met

TABLE 4. San Joaquin River at Vernalis Minimum Flow Target in April and May for Daily Mapping

San Joaquin River Index (60-20-20)	Long-term Flow Target at Vernalis (cfs)
1	7,000
2	7,000
3	5,500
4	4,000
5	2,500

Notes: 2,000 cfs is used as the minimum flow target for other months

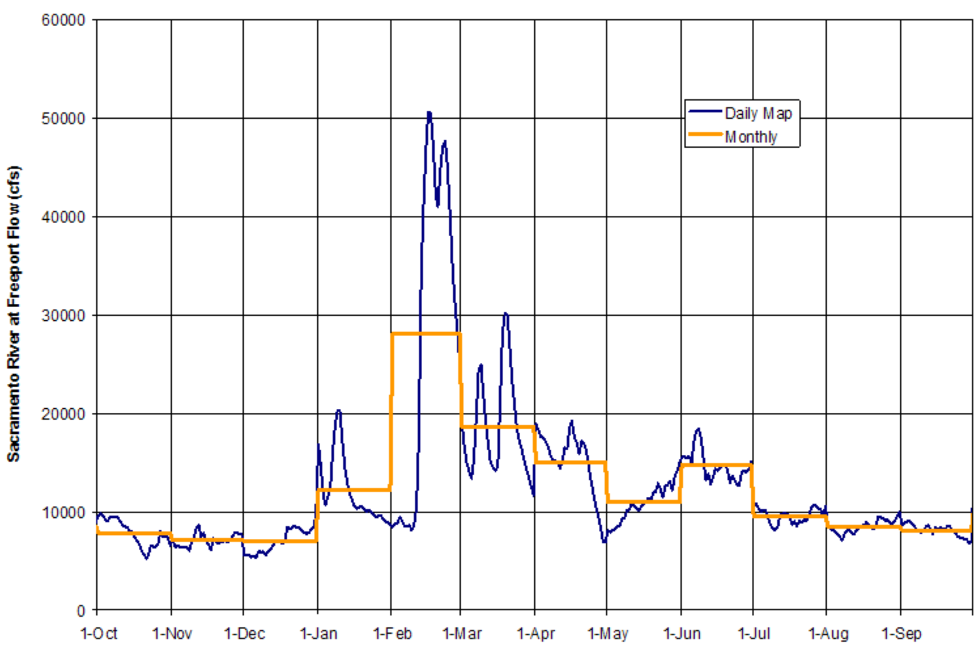


Figure 1: Example monthly-averaged and daily-averaged flow for Sacramento River at Freeport

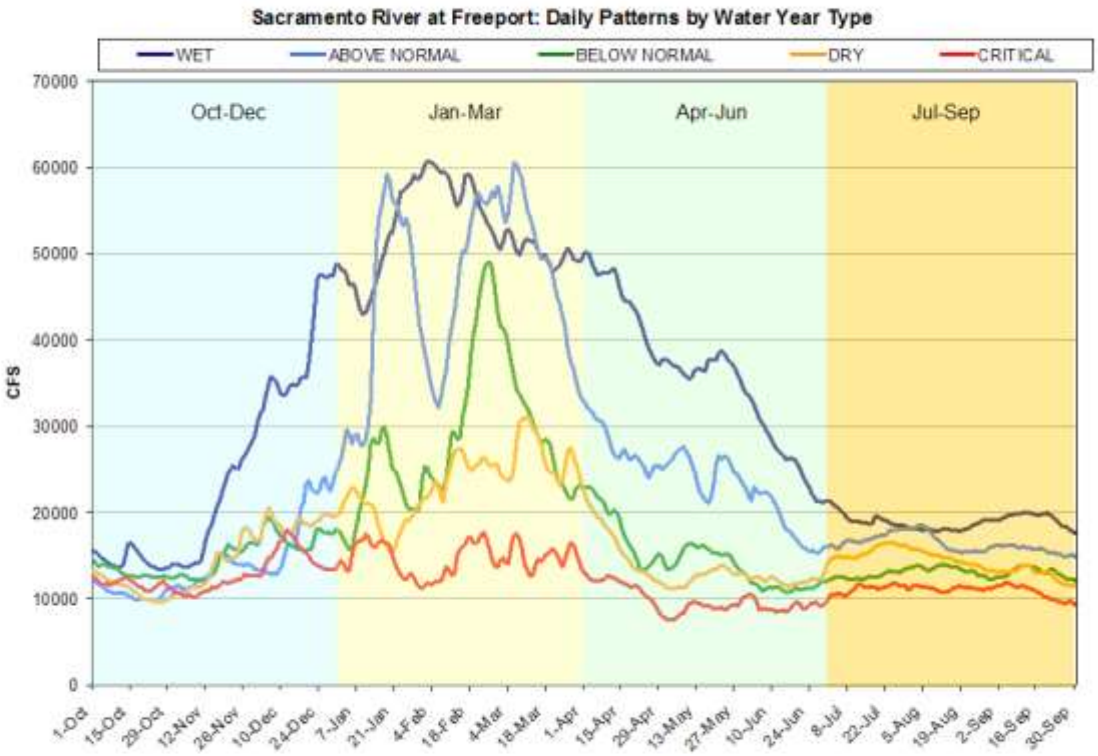


Figure 2: Mean daily flows by Water Year Type for Sacramento River at Freeport

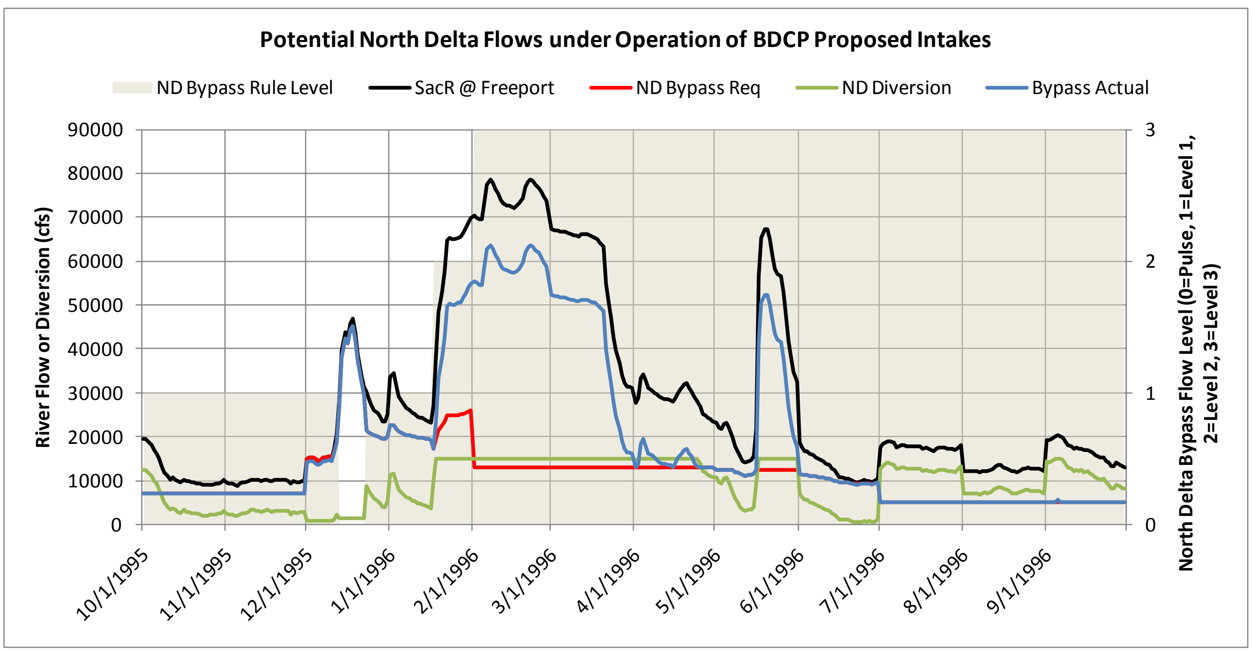


Figure 3: Example year daily patterns and operation of the North Delta intakes. Note: the grey shading indicates the active bypass rule (0=pulse/low level pumping, 1=level I, 2=level II, and 3=level III).

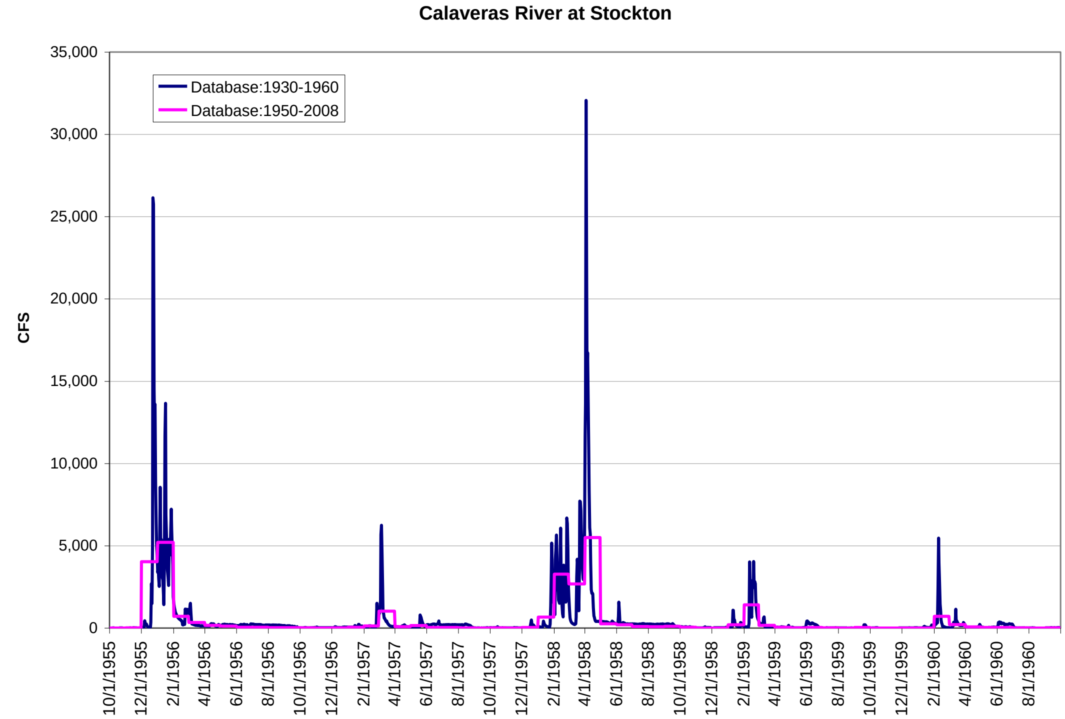


Figure 4: Calaveras River flow from 1930-1960 DAYFLOW and QMISC daily flow from the Current DAYFLOW Datasets