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Water Resources ● Flood Control ● Water Rights

T E C H N I C A L M E M O R A N D U M

DATE: July 29, 2014

TO: North Delta Water Agency

FROM: Walter Bourez, Patrick Ho, and Gary Kienlen

SUBJECT: Technical Comments on Bay-Delta Conservation Plan Modeling

This technical memorandum is a summary of MBK Engineers' findings and opinions on the hydrodynamic modeling performed in support of the environmental document for the Bay-Delta Conservation Plan (BDCP) for North Delta Water Agency (NDWA). The results of that modeling are summarized in Appendix 5A to the Draft Environmental Impact Report/Environmental Impact Statement (EIR/EIS) for the BDCPs.

This review of the BDCP modeling focuses on water quality, stage, flow, and velocity at numerous locations within the NDWA. Although, this memorandum focuses on the following locations, data for other locations reviewed are contained in the Appendix:

- Sacramento River at Emmaton
- Sacramento River at Three Mile Slough
- Sacramento River at Rio Vista
- Steamboat Slough at Sutter Slough
- North Fork Mokelumne River
- Cache Slough at Ryer Island
- Barker Slough at North Bay Aqueduct (NBA)
- Shag Slough

No Action Alternative

Assumptions used in CalSim II water operations modeling and DSM2 Delta hydrodynamic modeling for the BDCP No Action Alternatives (NAA) are defined in the December 2013 BDCP[1] and associated EIR/EIS. Those assumptions include changes to hydrology cause by climate change.

[1] The detailed assumptions are stated in BDCP EIR/EIS Appendix 5A.

Climate Change

Analysis presented in the BDCP plan and EIR/EIS attempts to incorporate the effects of climate change at two future climate periods: Early Long Term (ELT) at approximately year 2025; and Late Long Term (LLT) at approximately year 2060. Although BDCP modeling includes both the ELT and LLT, the EIR/EIS relies on the LLT and only includes the ELT in Appendix 5. As described in the BDCP plan and EIR/EIS[2], other analytical tools were used to determine anticipated changes to precipitation and air temperature that is expected to occur under ELT and LLT conditions. Projected precipitation and temperature were then used to determine how much water is expected to flow into the upstream reservoirs. These time-series were then input to the CalSim II model to perform water operations modeling and determine Delta inflow, outflow, and exports.

A second aspect of climate change, the anticipated amount of sea level rise, is incorporated into the CalSim II model by modifying a subroutine that determines salinity within the Delta based on flows within Delta channels. Sea level rise is evaluated in greater detail through use of DSM2 using output from CalSim II. Effects of sea level rise will manifest as a need for additional outflow when Delta water quality is controlling operations to prevent seawater intrusion. In this technical memorandum, we do not critique the climate change assumptions themselves[3], we instead focus on effects of BDCP by comparing with project modeling to without project modeling.

There are three without Project ("baseline" or "no action") modeling scenarios used for the BDCP modeling analysis: No Action Alternative (NAA)[4], No Action Alternative at the Early Long Term (NAA-ELT), and No Action Alternative at the Late Long Term (NAA–LLT). Assumptions for NAA, NAA-ELT, and NAA-LLT are provided in the EIR/EIS's modeling appendix[5]. The only difference between these scenarios is the climate-related changes made for the ELT and LLT conditions (Table 1).

Table 1. Scenarios Used to Evaluate Climate Change

	Climate Change Assumptions	
Scenario	**Hydrology**	**Sea Level Rise**
No Action Alternative (NAA)	None	None
No Action Alternative at Early Long Term (NAA-ELT)	Modified reservoir inflows and runoff for expected conditions at 2025	15 cm
No Action Alternative at Early Long Term (NAA-LLT)	Modified reservoir inflows and runoff for expected conditions at 2060	45 cm

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[2] BDCP EIR/EIS Appendix 5A, Section A and BDCP HCP/NCCP plan Appendix 5.A.2.
[3] This should not be read to imply that climate change assumptions are reasonable or considered correct or incorrect; the limited review reflects the scope of this memorandum.
[4] NAA is also called the Existing Biological Conditions number 2 (EBC-2) in the Plan.
[5] BDCP EIR/EIS Appendix 5A, Section B, Table B-8.

Description of the BDCP Project

The BDCP contemplates a dual conveyance system that would move water through the Delta's interior or around the Delta through an isolated conveyance facility. The BDCP CalSim II files contain a set of studies evaluating the projected operation of a specific version of such a facility. Each Alternative was imposed on two baselines: the NAA-ELT scenario and the NAA-LLT scenario. The BDCP Preferred Alternative, Alternative 4, has four possible sets of operational criteria, termed the Decision Tree. Key components of Alternative 4 ELT and Alternative 4 LLT are as follows:

The same system demands and facilities as described in the NAA with the following primary changes:

- three proposed North Delta Diversion (NDD) intakes of 3,000 cfs each;
- NDD bypass flow requirements;
- additional positive Old and Middle River (OMR) flow requirements and elimination of the San Joaquin River I/E ratio and the export restrictions during Vernalis Adaptive Management Program;
- modification to the Fremont Weir to allow additional seasonal inundation and fish passage;
- modified Delta outflow requirements in the spring and/or fall (defined in the Decision Tree discussed below);
- relocation of the Emmaton salinity standard; redefinition of the E/I ratio;
- acquisition of 25,000 acres and 65,000 acres of in-Delta lands for ELT and LLT environments respectively for habitat restoration; and
- removal of current permit limitations for the south Delta export facilities.

The changes (benefits or impacts) of the operation due to Alternative 4 are highly dependent upon the assumed operation of not only the NDD and the changed regulatory requirements associated with those facilities, but also by the assumed integrated operation of existing CVP and SWP facilities. The modeling of the NAA scenarios introduces significant changes in operating protocols suggested primarily to react to climate change. The extent of the reaction does not necessarily represent a likely outcome, and thus, the reviewers have little confidence that the NAA baselines are a valid representation of a baseline from which to compare an action Alternative. However, a comparison review of the Alternative 4 to the NAA illuminates operational issues in the BDCP modeling and provides insight as to where benefits or impacts may occur.

BDCP Alternative 4 has four possible sets of operational criteria, termed the Decision Tree, that differ based on the "X2" standards that they contemplate:

- Low Outflow Scenario (LOS), otherwise known as operational scenario H1, assumes existing spring X2 standard and the removal of the existing fall X2 standard;
- High Outflow Scenario (HOS), otherwise known as H4, contemplates the existing fall X2 standard and providing additional outflow during the spring;
- Evaluated Starting Operations (ESO), otherwise known as H3, assumes continuation of the existing X2 spring and fall standards;
- Enhanced spring outflow only (not evaluated in the BDCP), scenario H2, assumes additional spring outflow and no fall X2 standards.

While it is not entirely clear how the Decision Tree would work in practice, the general concept is that, prior to operation of the NDD, implementing authorities would select the appropriate Decision Tree scenario (from amongst the four choices) based on their evaluation of targeted research and studies to be conducted during planning and construction of the facility.

Our review examined the ESO (or H3) scenario (labeled Alt 4-ELT or Alt 4-LLT) because it employs the same X2 standards which are implemented in NAA-ELT and NAA-LLT. This allowed the Reviewers to focus the analysis on the effects of the BDCP operations independent of the possible change in the X2 standard.

Method of Review

The first part of the review focused on effects of Delta hydrodynamics determined by DSM2 Models used in support of the EIR/EIS. During a separate review of the CalSim II modeling used in support of the EIR/EIS (Model), MBK Engineers and Dan Steiner found that the Model provided very limited useful information to understand the effects of BDCP. The Model contains erroneous assumptions, errors, and outdated tools, which result in impractical or unrealistic Central Valley Project (CVP) and State Water Project (SWP) operations. The unrealistic operations, in turn, do not accurately depict the effects of the BDCP. The Model used in support of the EIR/EIS analyzes NDD and habitat restoration as inseparable project components; therefore, it is not possible to distinguish whether the effects of the project are due to climate change, NDD operations or the proposed habitat restoration. Moreover, it is possible, if not probable, that NDD could be constructed and operating for an extended period of time without the proposed habitat in place. Habitat restoration requires time to establish its intended functionality and effects to Delta hydrodynamics and salinity from operating the NDD itself cannot be evaluated under the Model. To separate and understand the effects, the independent DSM2 modeling included two additional scenarios, an NAA with habitat scenario and an Alternative 4 NDD (Alt 4 NDD) without habitat scenario.

An independent CalSim II water operation modeling analysis was thus performed by MBK Engineers and a subsequent DSM2 Delta hydrodynamics modeling analysis was performed and provided by Contra Costa Water District. Assumptions used in the Independent CalSim II water operations modeling are described in a report prepared by MBK Engineers and Dan Steiner titled “Report on Review of Bay Delta Conservation Program Modeling” (MBK, 2014).

The DSM2 Independent Modeling provides two Alternative 4 scenarios: 1) Alt 4 NDD without climate change, sea level rise, and habitat restoration; and, 2) Alt 4 NDD without Climate Change and sea level rise, but includes 25,000 acres of habitat. For basis of comparison, a NAA without climate change, sea level rise, and habitat was provided.

Outputs were extracted from the DSM2 modeling and flows, stage, velocities, and salinity under the alternative were compared against the baseline, i.e. Alt 4 ELT is compared to NAA-ELT and Alt 4 LLT is compared to NAA-LLT. DSM2 simulates from October 1974 to September 1991 and produces output at 15-minute intervals. Daily maximums, minimums, and averages are then calculated from the 15-minute data. To provide meaning to the data, daily exceedance charts were produced. Percent exceedance describes the portion of the dataset, expressed in percentages, that exceeds a specific level. For example, a 90% flow exceedance of 200,000 cfs means that 90% of the daily flow during the simulated period, i.e. October 1974 to September 1991, is greater than 200,000 cfs. Exceedances provide an overall view of the entire dataset in an ordered manner. When alternatives are plotted together, differences between the alternatives are easily distinguishable and potential project effects can be identified.

Hydrodynamics and salinity were reviewed at various locations within NDWA. For the purposes of this review locations reviewed include the NDWA contract compliance points on the Sacramento River at Three Mile Slough, Rio Vista and Walnut Grove, Steamboat Slough at Sutter Slough, and the North Fork Mokelumne River at Walnut Grove. It is the reviewers' understanding that the majority of the habitat areas will be located within the lower Yolo Bypass area; therefore, the Cache Slough complex, which includes lower Cache Slough, Shag Slough, and Barker Slough and another area of interest to the NDWA and its landowners. In the inner Delta, changes in cross channel gate operations at Walnut Grove will control the hydrodynamics of the Mokelumne River; and therefore, effects of flow, stage, and velocities along the North Fork Mokelumne River were reviewed.

Summary of findings

BDCP Modeling

Figure 1 through Figure 16 illustrates hydrodynamics, and water quality under the NAA-ELT and the Existing Conditions from the EIR/EIS. Positive maximum values quantify daily outgoing, or ebb tides, while negative minimum values quantify daily incoming (reverse), or flood tides. Under the NAA-ELT, daily positive flows and daily reverse flows increase, while daily maximum, average, and minimum stage are increased throughout the system when compared to existing conditions. As shown in Figure 1, for the Sacramento River at Emmaton, daily outgoing flows increase by an average of 4,335 cfs, while daily average reverse flow increase by 3,614 cfs. As illustrated in Figure 2, daily maximum, average, and minimum stage on the Sacramento River at Emmaton increases by approximately 0.5 feet when compared to existing conditions. Similar effects are observed in velocities at Emmaton. Figure 3 illustrates increases in daily average outgoing and incoming velocity. Positive changes in daily maximum represent an increase in velocity on the outgoing tide, while negative changes in daily minimum velocity represent an increase in velocity on the incoming tide. Increased velocities have the potential to induce scouring along channels and undermine levee stability. Figure 6 illustrates the 14-day running average salinity, expressed as electrical conductivity in millimhos per centimeter, for the Sacramento River at Threemile Slough over the simulation period. The NDWA contract provision at Three Mile Slough is plotted to emphasize periods of contract compliance or non-compliance. Water quality is in compliance when the 14-day running average is less than the allowed salinity concentration. Likewise, water quality is non-compliant when the 14-day running average exceeds allowed salinity concentration. To summarize Figure 6, non-compliant days were counted for the simulation period and expressed as a percentage of non-compliant days in the simulation period, or 6,209 days. Figure 7 illustrates the percentage of 6,209 days that were non-compliant, and also quantifies the concentration in excess of contract compliance under the NAA-ELT and existing conditions. Overall, water quality in the Sacramento River at Three Mile Slough is worse under NAA-ELT when compared to existing conditions. Under the existing conditions, 472 days were non-compliant under NDWA contract provisions, while 736 days were non-compliant under the NAA-ELT. Similar effects to flows, stage, velocities, and water quality are observed in the Sacramento River at Three Mile Slough, the Sacramento River at Rio Vista, Steamboat Slough at Sutter Slough, Barker Slough at the NBA pumping plant, and Shag Slough, illustrated from Figure 6 through Figure 16.

Figures 17 through 32 illustrate percent exceedances of hydrodynamics and water quality under the NAA-ELT and Alt 4-ELT. In the Sacramento River at Emmaton and Rio Vista, under Alt 4-ELT, daily positive flows and daily reverse flows increase, while daily average flow decreases when compared to NAA-ELT. Moreover, daily maximum stage decreases, while daily minimum stage increases when compared to NAA-ELT. At Emmaton, daily average flow decreases by approximately 1,370 cfs, daily average positive flows increase by approximately 10,680 cfs, while daily average reverse flow increases by approximately 8,450 cfs as illustrated in Figure 17. Daily maximum stage decreases on an average of 0.32 feet, while daily minimum stage increases on average by approximately 0.37 feet as illustrated in Figure 18. Decreases in daily maximum stage and increases in daily minimum stage could be explained by the transport of flood and ebb tides into proposed habitat areas, which provides a dampening effect to hydrodynamics in the Delta system.

Although habitat areas are not clearly defined, the effects are observed at lower parts of the Delta system, such as the observations at Emmaton. Figure 23 and Figure 27 illustrates an improvement in water quality in the Sacramento River at Rio Vista and at Three Mile Slough under Alt 4-ELT when compared to NAA-ELT. In Steamboat Slough at Sutter Slough, daily maximum, average, and minimum flows decrease under ALT 4-ELT as illustrated in Figure 28. As would be expected with decreased flows, decreases in stage also were also observed in Steamboat Slough, where daily average stage decreased by approximately 0.25 feet and the maximum stage is reduced on average by approximately 0.53 feet under Alt 4-ELT when compared to NAA-ELT. At the NBA pumping plant on Barker Slough daily maximum stage is decreased on average by approximately 0.6 feet, while daily minimum stage is increased on average by approximately 0.77 feet as illustrated in Figure 31. At Shag Slough, daily maximum stage is reduced on average by 0.55 feet, while daily minimum stage is increased on average by approximately 0.57 feet as illustrated in Figure 32.

In summary, water quality is worsened under NAA-ELT when compared with existing conditions. At Three Mile Slough, the number of days not compliant with NDWA water quality contract provisions has increased by 264 days under NAA-ELT, compared to existing conditions. However, water quality improves under Alt 4 ELT when compared to NAA-ELT. An assumption under the ELT climate change environment is a 15 cm sea level rise. Sea level rise increases stage throughout the Delta system, which may result in increased seepage and flood risk to Delta Islands. However, under the project alternative (Alt 4), daily maximum stages are reduced, while daily minimum stage increases when compared to NAA-ELT.

Independent Modeling

Figures 33 through 52 illustrate hydrodynamics and water quality under the NAA without habitat and NAA with habitat. Under NAA with habitat, daily positive flows and daily reverse flows increase in the Sacramento River at Emmaton and at Rio Vista, while daily average flow decreases when compared to NAA without habitat. Moreover, daily maximum stage decreases, while daily minimum stage increases when compared to NAA with habitat. At Emmaton, daily average flow increases by approximately 170 cfs, daily average positive flows increase by approximately 9,590 cfs, while daily average reverse flow increase by approximately 5,125 cfs, as illustrated in Figure 33. Daily maximum stage decreases on an average of 0.31 feet, while daily minimum stage increases on average by approximately 0.36 feet, as illustrated in Figure 34. Figures 37 and 39 illustrate improvement in water quality in the Sacramento River at Emmaton and at Three Mile Slough under the NAA with habitat, when compared to NAA without habitat. For Steamboat Slough at Sutter Slough, daily maximum, average, and minimum flows decrease under NAA without habitat as illustrated in Figure 44. Corresponding changes in stage are also observed; the daily average stage is reduced by approximately 0.1 feet, daily maximum stage is reduced on average by approximately 0.42 feet, while daily minimum stage is increased on average by 0.2 feet under NAA with habitat compared to NAA without habitat.

In the interior Delta, daily positive flow in the North Fork Mokelumne River increase on average by 1,140 cfs, while daily reverse flow increase on by 2,755 cfs, as illustrated in Figure 47. Daily maximum stage decreases on average by approximately 0.72 feet while daily minimum stage increases on average by approximately 0.8 feet, as illustrated on Figure 48. In Cache Slough at Ryer Island, daily maximum stage decrease on average by approximately 0.5 feet, while daily minimum stage increases by an average of approximately 0.5 feet. In Barker Slough at the NBA pumping plant, daily maximum stage is reduced approximately 0.6 feet on average, while daily minimum stage is increased on average by approximately 0.76 feet, as illustrated in Figure 51. At Shag Slough, daily maximum stage is reduced on average by 0.52 feet, while daily minimum stage is increased an average of 0.56 feet, as illustrated in Figure 52.

Figures 53 through 72 compare the hydrodynamics and water quality under Alternative 4 with habitat and NAA without habitat. The effects are similar in pattern when compared to the models in support of the EIR/EIS. In the Sacramento River at Emmaton and at Rio Vista, under Alt 4 with habitat, daily positive flows and daily reverse flows increase, while the daily average flows decrease when compared to NAA without habitat. Moreover, daily maximum stage decreases, while daily minimum stage increases when compared to NAA without habitat. At Emmaton, daily average flow decreases by approximately 1,800 cfs, daily average positive flows increase by 8,600 cfs, while daily average reverse flow increase by 7,460 cfs, as illustrated in Figure 53. Daily maximum stage decreases by an average of 0.32 feet, while daily minimum stage increases by approximately 0.36 feet, as illustrated in Figure 54. Figure 57 and Figure 59 illustrate worsening water quality in the Sacramento River at Rio Vista and at Three Mile Slough under Alt 4 with habitat when compared to NAA without habitat. In Steamboat Slough at Sutter Slough, daily maximum, average, and minimum flows decrease under ALT 4 with habitat, as illustrated in Figure 64. Daily average stage is reduced by 0.29 feet, while daily maximum stage is reduced on average by 0.56 feet under Alt 4 with habitat when compared to NAA without habitat. In the interior Delta, daily positive flow in the North Fork Mokelumne River increase on average by 1,140 cfs, while daily reverse flow increases by 2,750 cfs, as illustrated in Figure 67. Daily maximum stage decreases on average by approximately 0.72 feet while daily minimum stage increases on average by 0.8 feet, as illustrated by Figure 68. In Cache Slough at Ryer Island, daily maximum stage decrease on average approximately by 0.53 feet, while daily minimum stage increase on average approximately by 0.5 feet. At the NBA pumping plant on Barker Slough, daily maximum stage is reduced on average approximately by 0.62 feet, while daily minimum stage is increased on average approximately by 0.75 feet, as illustrated in Figure 71. At Shag Slough, daily maximum stage is reduced on average approximately by 0.54 feet, while daily minimum stage is increased on average approximately by 0.55 feet, as illustrated in Figure 72.

Figures 73 through 92 compare hydrodynamics and water quality under Alternative 4 without habitat and NAA without habitat. On the Sacramento River at Emmaton and Rio Vista, under Alt 4 without habitat, daily positive flows, daily reverse flows, and daily average flows decrease when compared to NAA without habitat. Changes in daily maximum, minimum, and average stage is immeasurable when compared to NAA without habitat. At Emmaton, daily average flow decreases approximately by 2,260 cfs, daily average positive flows decrease approximately by 1,060 cfs, while daily average reverse flow increase approximately by 2,650 cfs, as illustrated in Figure 73. Figure 77 and Figure 79 illustrate worsening in water quality in the Sacramento River at Emmaton and at Three Mile Slough under Alt 4 without habitat when compared to NAA without habitat. In Steamboat Slough at Sutter Slough, daily maximum, average, and minimum flows decrease under ALT 4 with habitat, as illustrated in Figure 84. Daily average stage is reduced approximately by 0.21 feet and daily maximum stage is reduced on average approximately by 0.13 feet. Daily average stage is reduced by 0.21 feet under Alt 4 without habitat when compared to NAA without habitat. In the interior Delta, daily positive flow in the North Fork Mokelumne River decrease on average by 230 cfs, while daily reverse flow increase on by 300 cfs, as illustrated in Figure 87. Changes in stage are immeasurable under Alt 4 without habitat as illustrated in Figure 88. Daily maximum, minimum and average stage in Cache Slough at Ryer Island, at the NBA pumping plant on Barker Slough, and at Shag Slough decrease by 0.02 feet, as illustrated in Figures 90 through 92.

The EIR/EIS did not analyze the NDD without habitat restoration. Therefore, the impacts of the project cannot be adequately assessed if the NDD were to begin operating before habitat areas are acquired and established. Contrary to the Model in support of the EIREI/S, the independent analysis, without habitat, Alt 4 results worsening of water quality at Emmaton and Three Mile Slough when compared to NAA without habitat. Also, daily maximum, minimum, and average flow decrease at Emmaton and Rio Vista.

Conclusions and Recommendations

Based on the BDCP modeling, water quality under Alt 4 NAA-ELT worsens when compared with existing conditions. At Three Mile Slough, the number of days where water quality is not compliant with NDWA contract increases by 264 days under NAA-ELT, compared to existing conditions. Because the BDCP modeling includes assumptions regarding climate change and sea level rise, effects of Alt 4 water operations are not easily discernable. Additionally, the Modeling used in support of the EIR/EIS analyzes NDD and habitat restoration as inseparable project components; therefore, it is not possible to distinguish whether the effects indicated by the BDCP modeling are due to NDD operations or the proposed habitat restoration. Furthermore, it is possible, if not probable, that NDD could be constructed and operating for an extended period of time without the proposed habitat in place. Habitat restoration requires time to establish its intended functionality and effects to Delta hydrodynamics and salinity from operating the NDD itself cannot be evaluated under the BDCP Model.

In addition to water quality, the project's effects on river stage, flows, and velocities are of great interest to NDWA. Reductions in river stage to levels below historical elevations will result in impacts to both those who rely on gravity, and those who rely on pumped diversions. Siphons in the Delta were designed to operate within the historical tidal range. Reductions in river stage below historical low water elevations will impact the ability of some siphons to function at lower tides. For those who rely on pumped diversions, lower river stage will increased energy usage and pumping costs. Furthermore, increased river stage may result in increased seepage, requiring additional maintenance for drainage.

For the reasons stated above, it is recommended that the BDCP analyze effects of operating the NDD without the habitat restoration and without the effects of climate change to assess both short and long term impacts of the proposed project. Further, the analysis should utilize the updated CalSim II operations and DSM2 hydrodynamics models.

NO ACTION ALTERNATIVE ELT VS. EXISTING CONDITIONS (BDCP EIR/EIS MODELING)

No Action Alternative ELT vs. Existing Conditions (BDCP EIR/EIS Modeling)

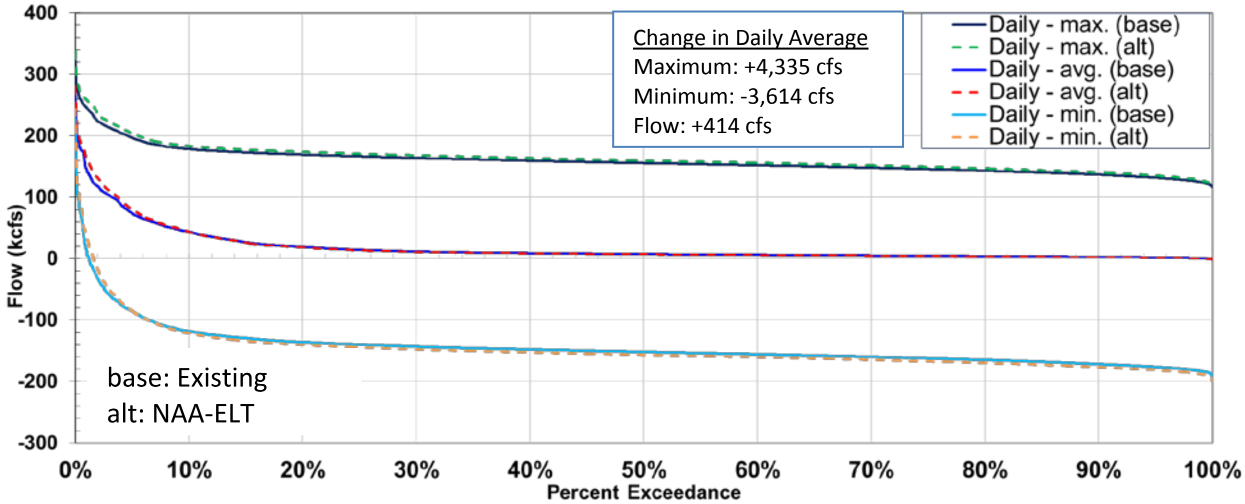

Figure 1. Daily Flow on the Sacramento River at Emmaton

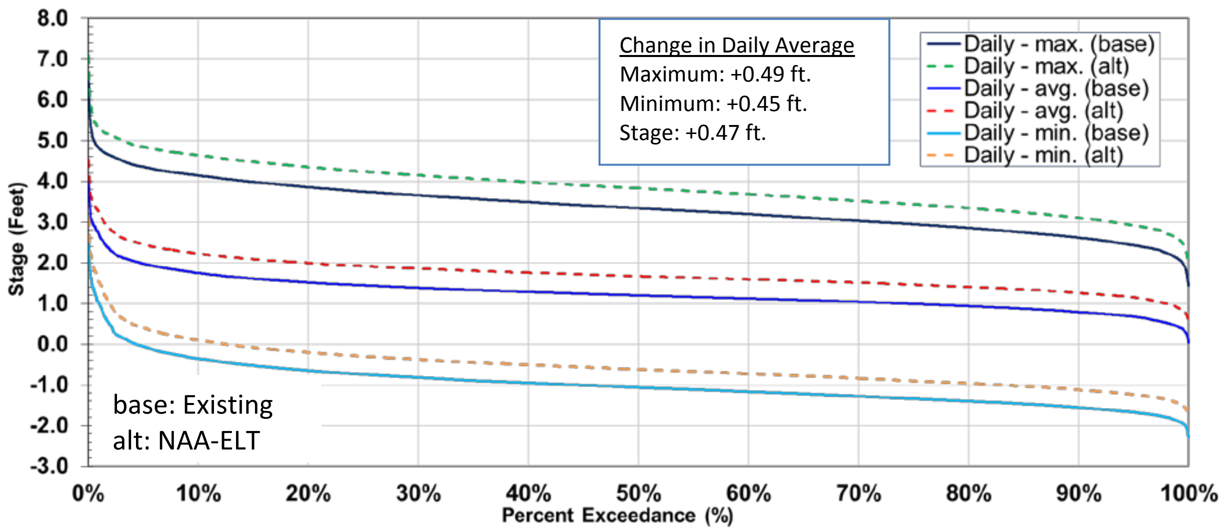

Figure 2. Daily Stage on the Sacramento River at Emmaton

No Action Alternative ELT vs. Existing Conditions (BDCP EIR/EIS Modeling) Continued

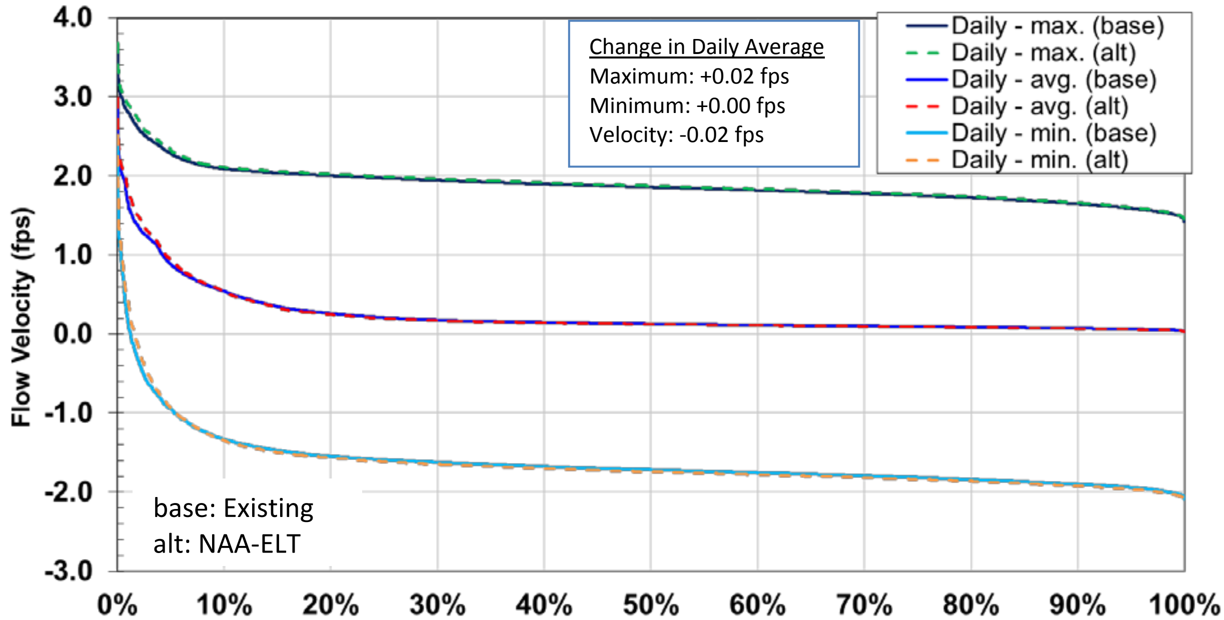

Figure 3. Daily Velocities on the Sacramento River at Emmaton

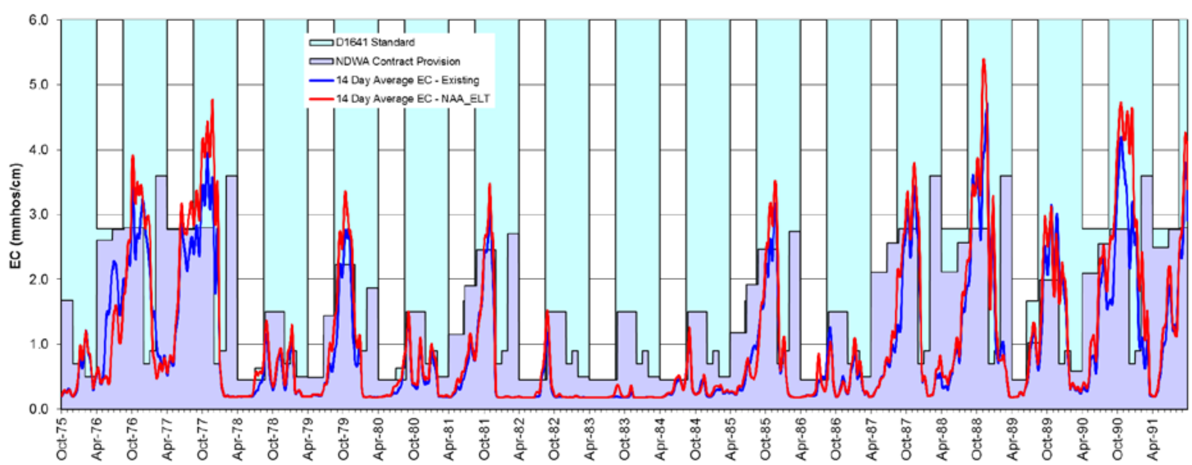

Figure 4. EC in the Sacramento River at Emmaton

No Action Alternative ELT vs. Existing Conditions (BDCP EIR/EIS Modeling) Continued

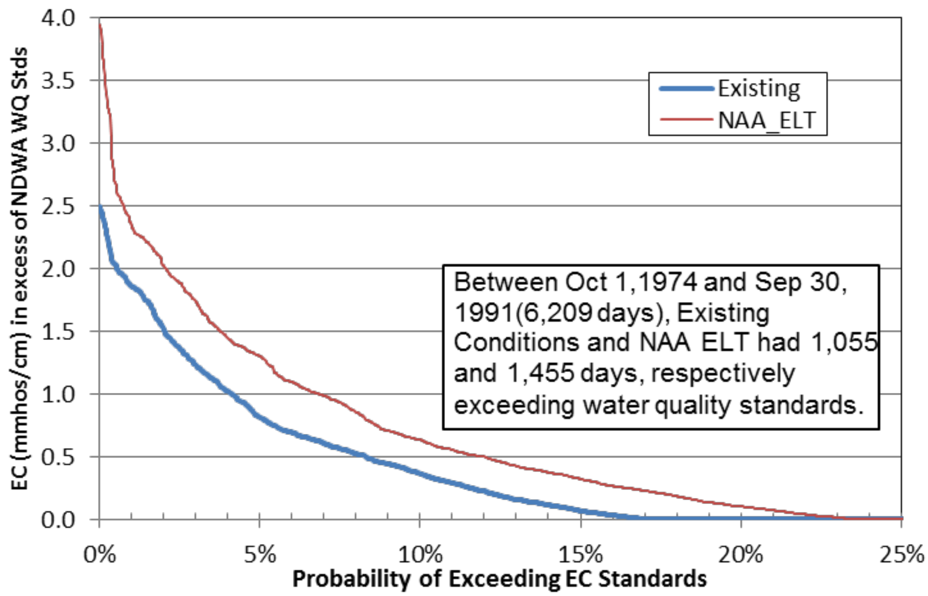

Figure 5. Probability of Exceeding EC Standards in the Sacramento River at Emmaton

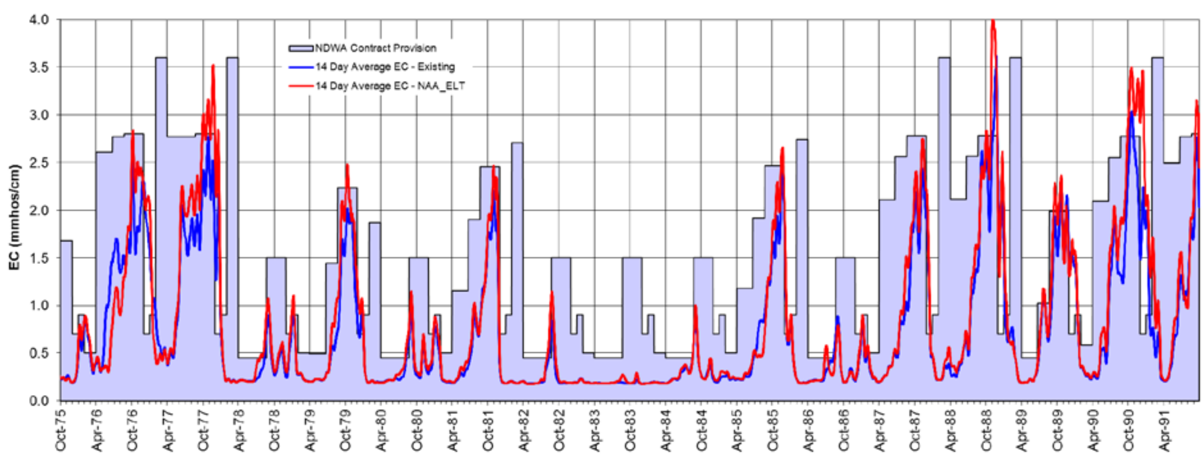

Figure 6. EC in the Sacramento River at Three Mile Slough

No Action Alternative ELT vs. Existing Conditions (BDCP EIR/EIS Modeling) Continued

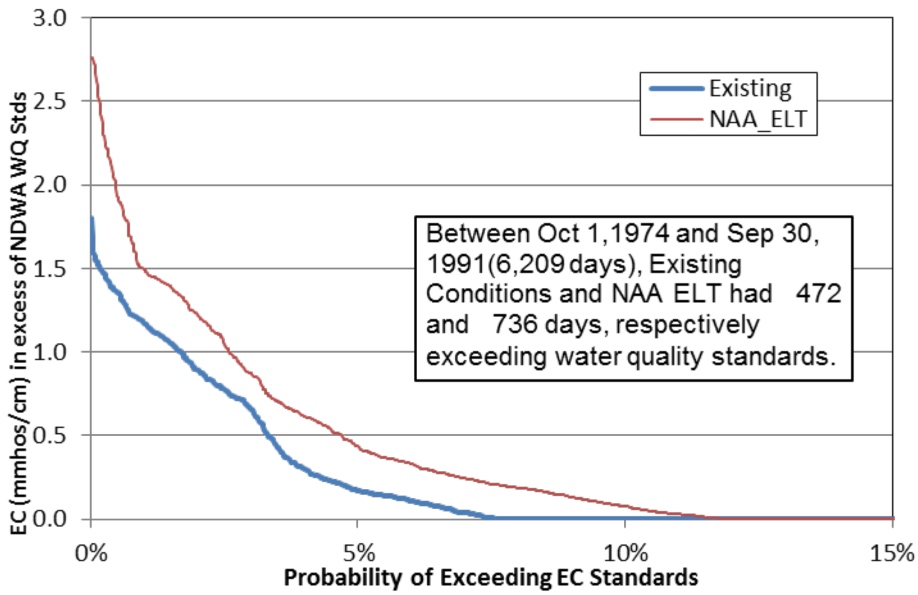

Figure 7. Probability of Exceeding EC Standards in the Sacramento River at Three Mile Slough

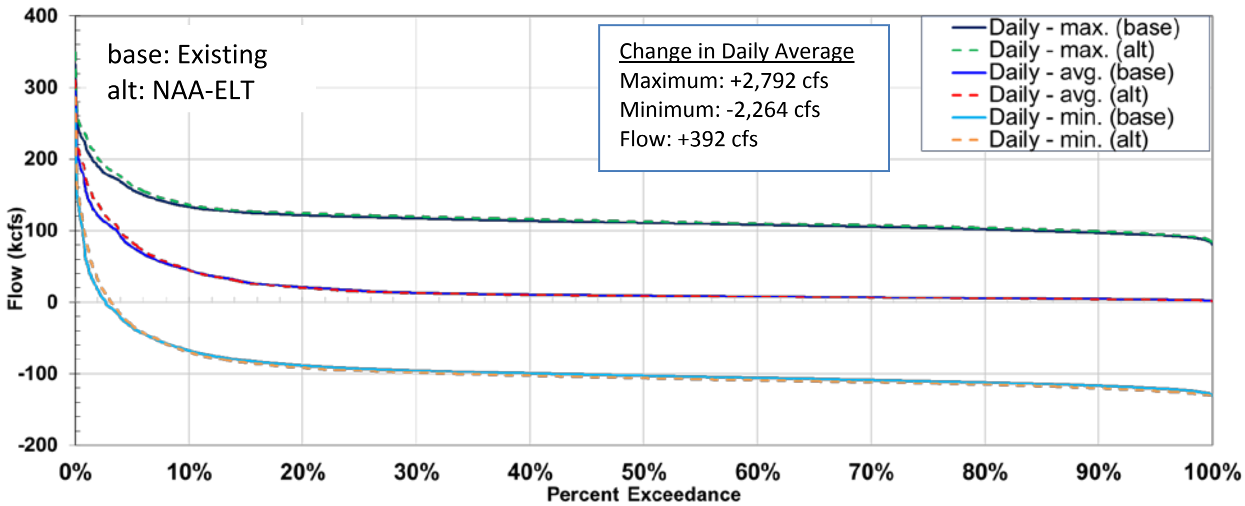

Figure 8. Daily Flow on the Sacramento River at Rio Vista

No Action Alternative ELT vs. Existing Conditions (BDCP EIR/EIS Modeling) Continued

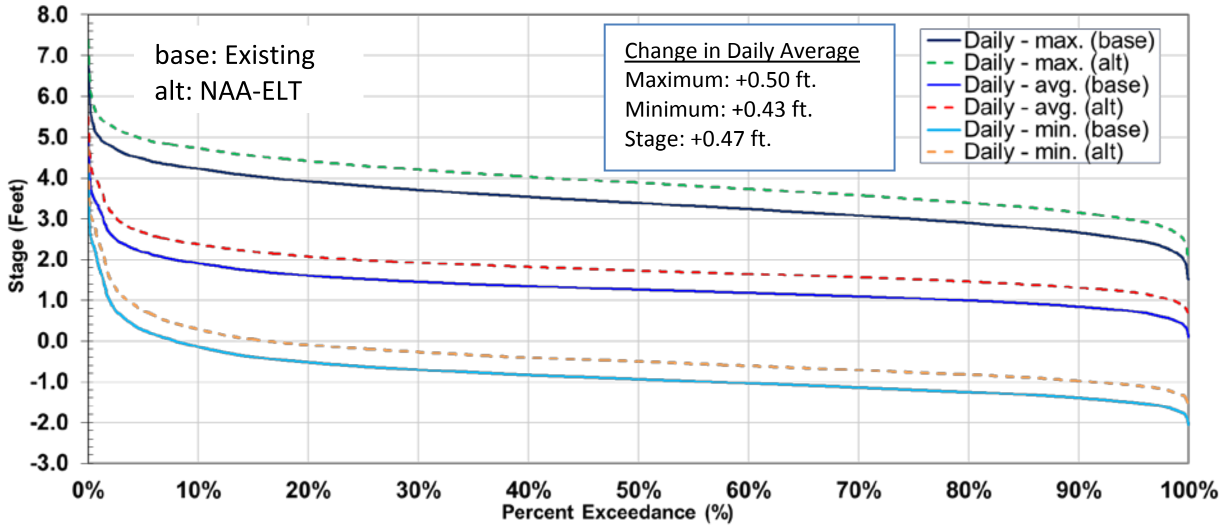

Figure 9. Daily Stage on the Sacramento River at Rio Vista

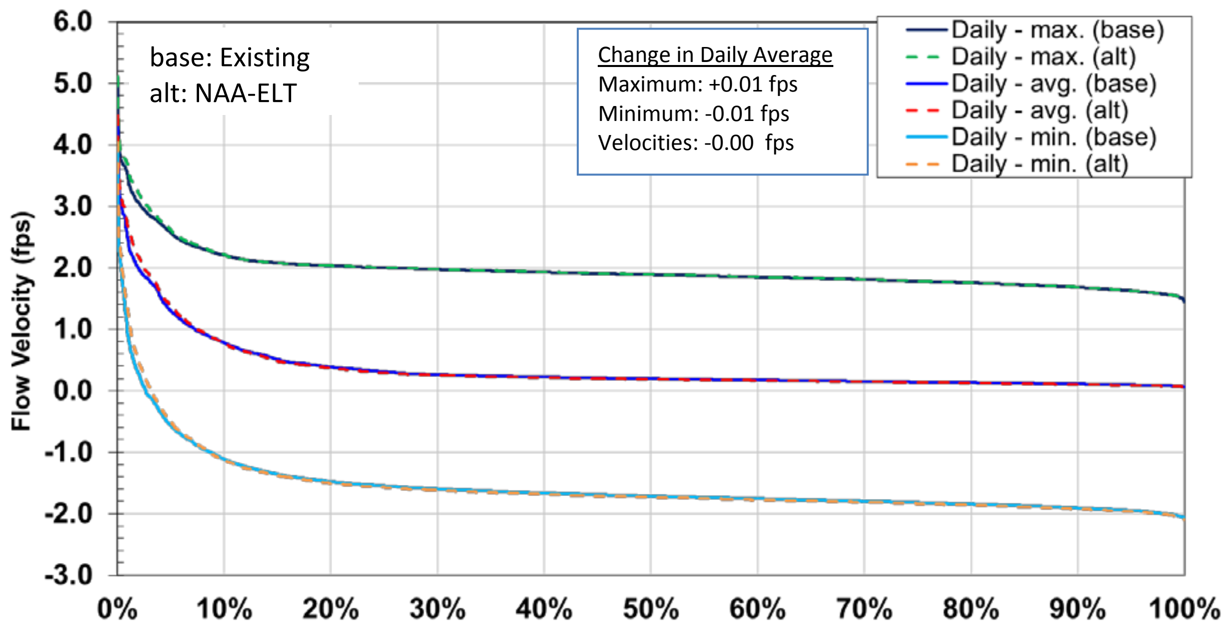

Figure 10. Daily Velocities on the Sacramento River at Rio Vista

No Action Alternative ELT vs. Existing Conditions (BDCP EIR/EIS Modeling) Continued

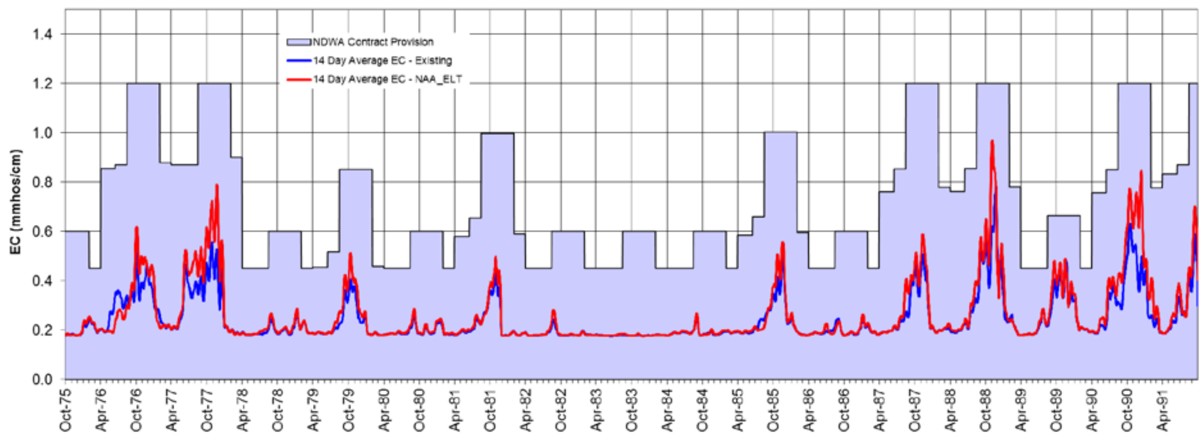

Figure 11. EC in the Sacramento River at Rio Vista

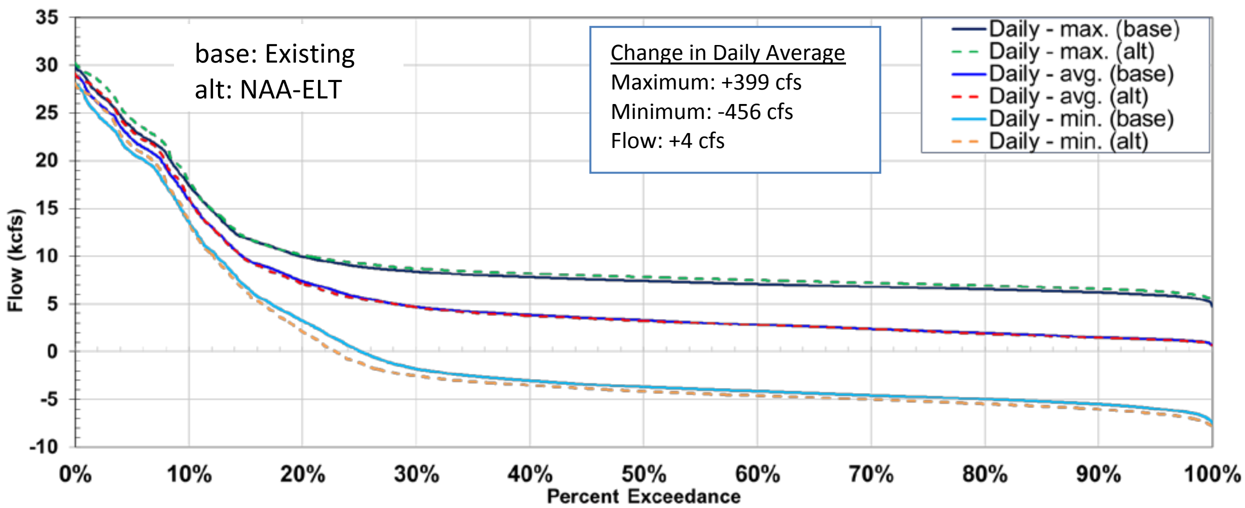

Figure 12. Daily Flow on Steamboat Slough at Sutter Slough

No Action Alternative ELT vs. Existing Conditions (BDCP EIR/EIS Modeling) Continued

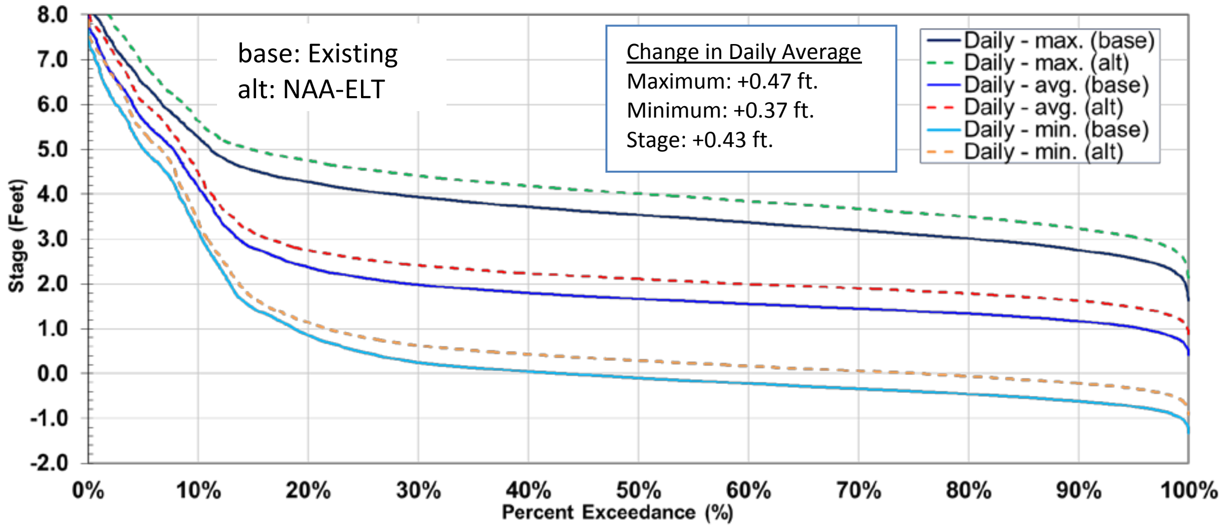

Figure 13. Daily Stage on Steamboat Slough at Sutter Slough

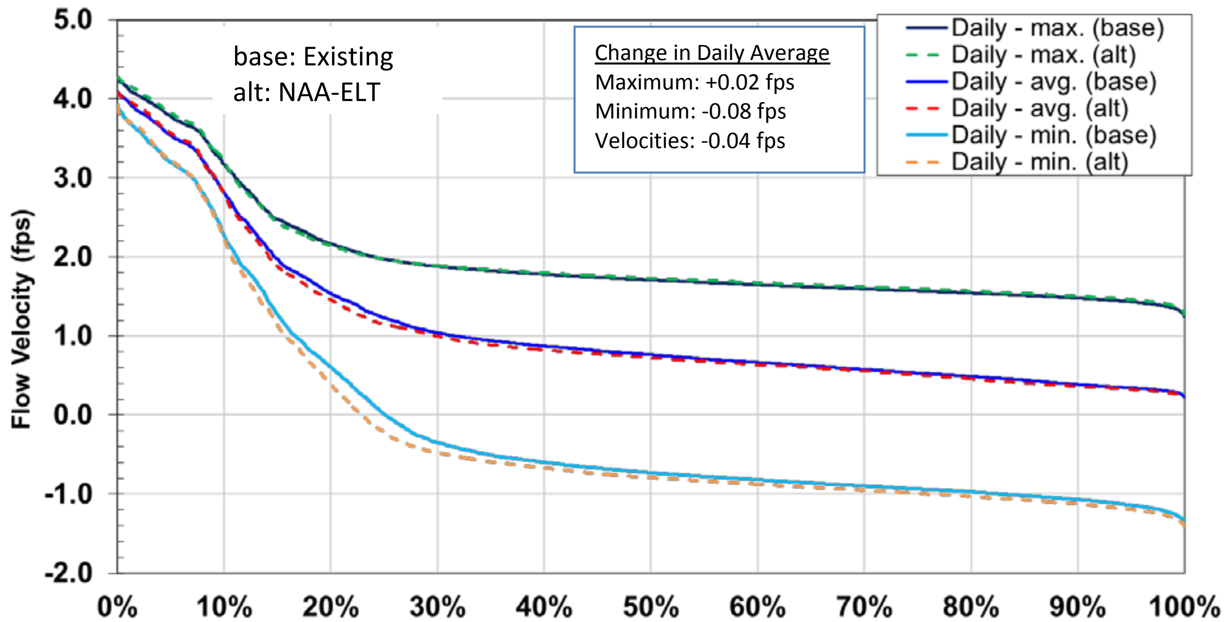

Figure 14. Daily Velocities on Steamboat Slough at Sutter Slough

No Action Alternative ELT vs. Existing Conditions (BDCP EIR/EIS Modeling) Continued

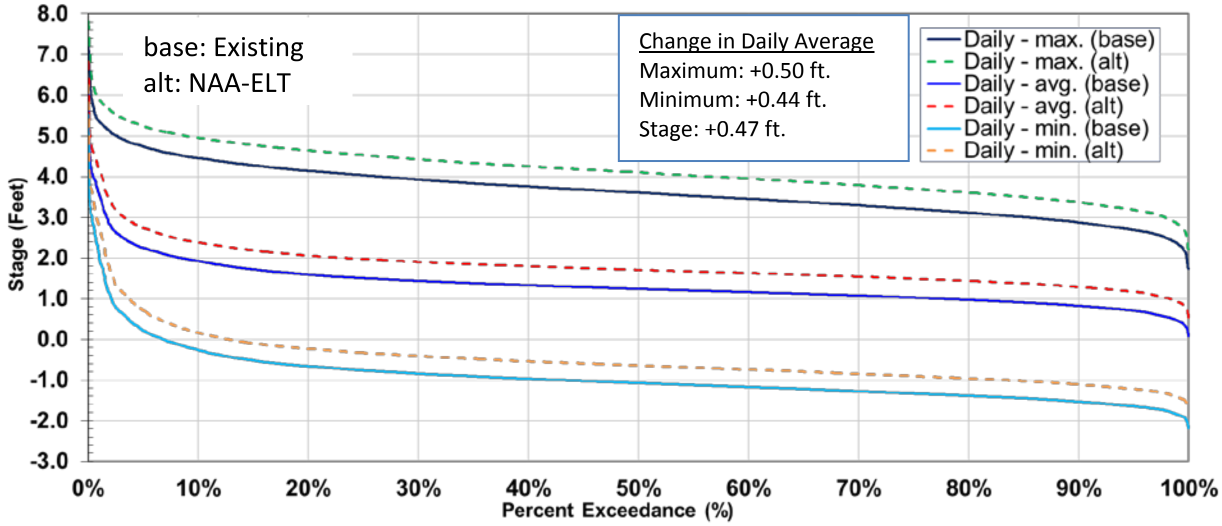

Figure 15. Daily Stage in Barker Slough at NBA Intakes

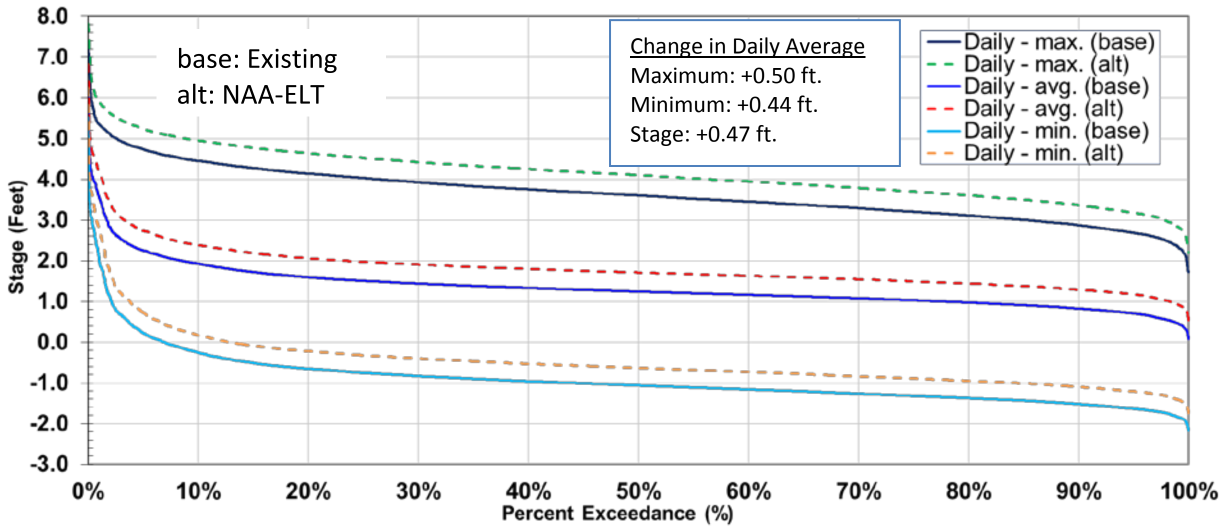

Figure 16. Daily Stage in Shag Slough

NO ACTION ALTERNATIVE ELT
VS. ALTERNATIVE 4 ELT
(BDCP EIR/EIS MODELING)

No Action Alternative ELT vs. Alternative 4 ELT (BDCP EIR/EIS Modeling)

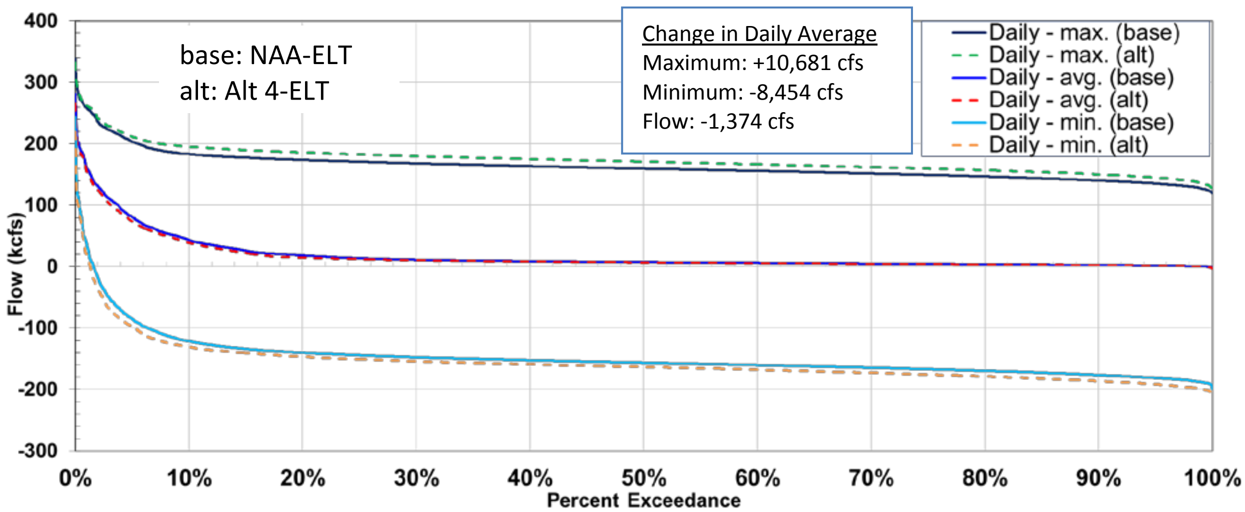

Figure 17. Daily Flow in the Sacramento River at Emmaton

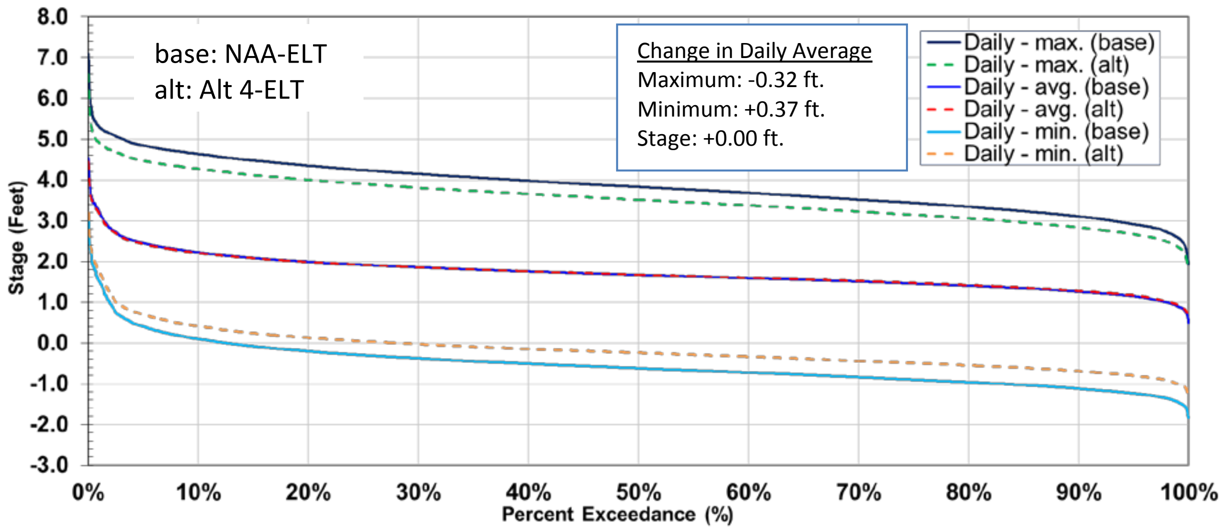

Figure 18. Daily Stage in the Sacramento River at Emmaton

No Action Alternative ELT vs. Alternative 4 ELT (BDCP EIR/EIS Modeling) Continued

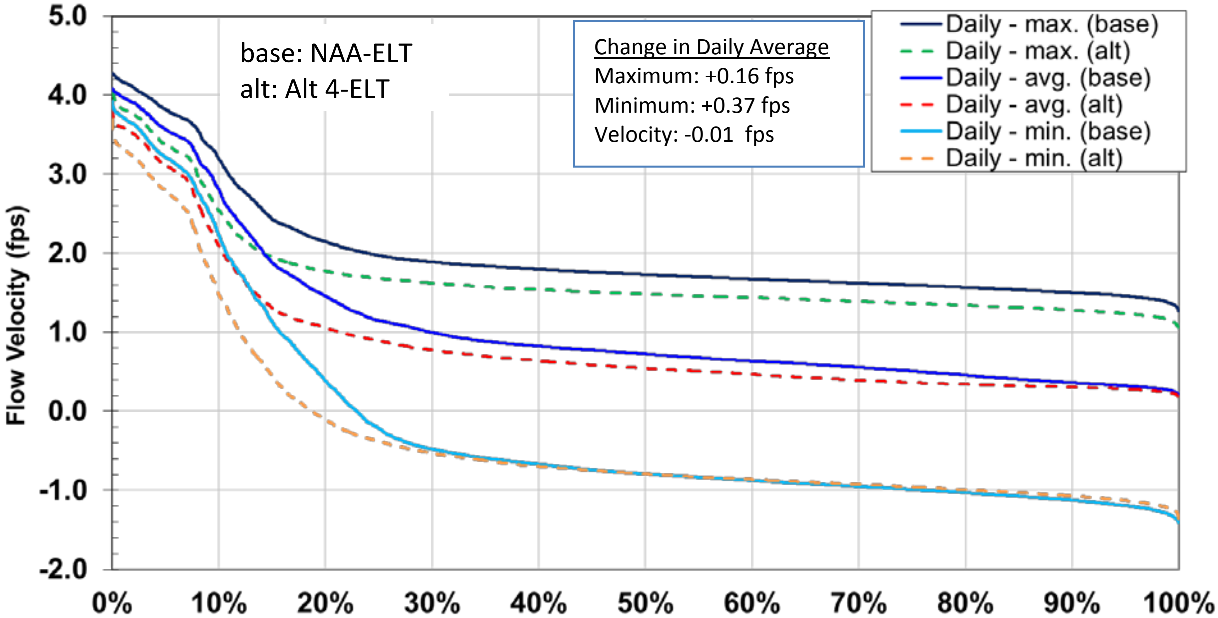

Figure 19. Daily Velocities in the Sacramento River at Emmaton

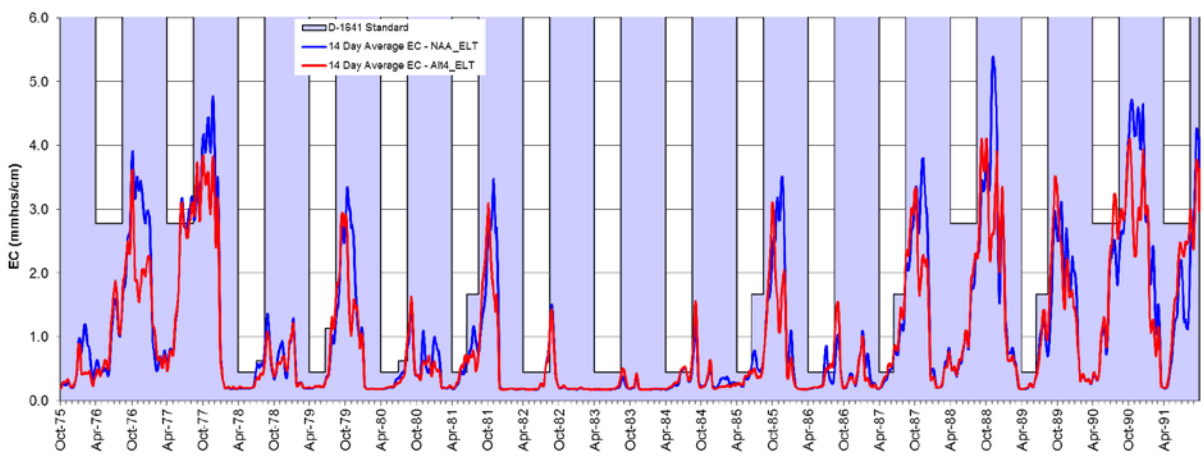

Figure 20. EC in the Sacramento River at Emmaton

No Action Alternative ELT vs. Alternative 4 ELT (BDCP EIR/EIS Modeling) Continued

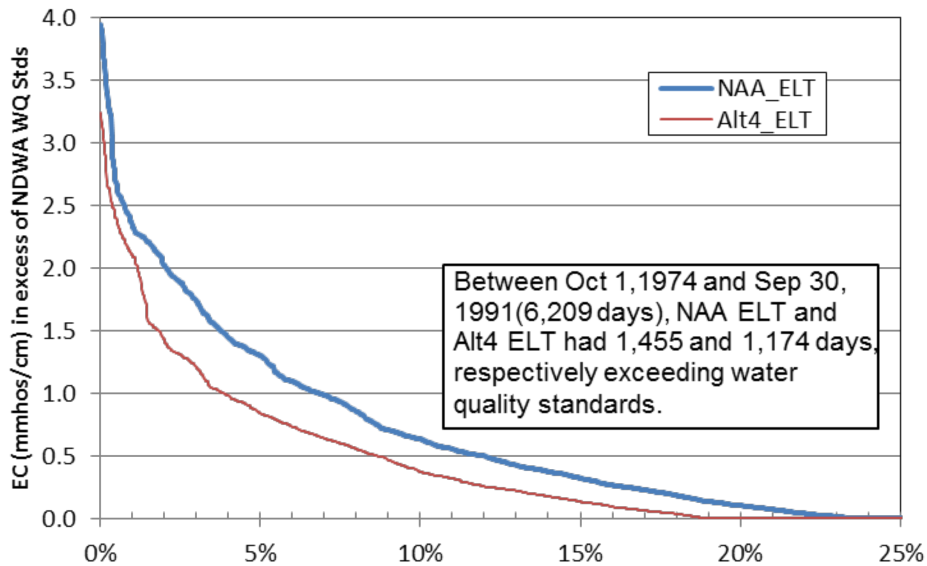

Figure 21. Probability of Exceeding EC Standards in the Sacramento River at Emmaton

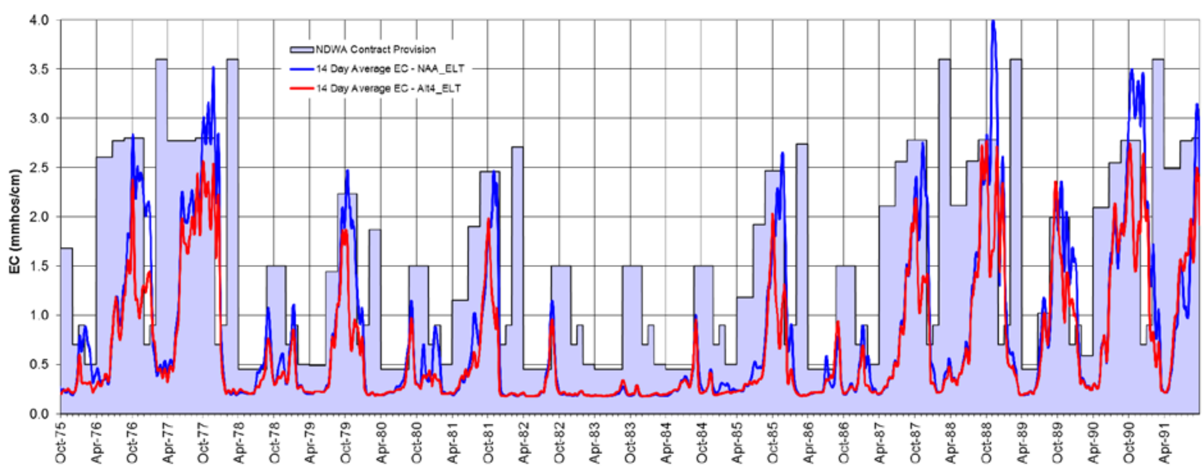

Figure 22. EC in the Sacramento River at Threemile Slough

No Action Alternative ELT vs. Alternative 4 ELT (BDCP EIR/EIS Modeling) Continued

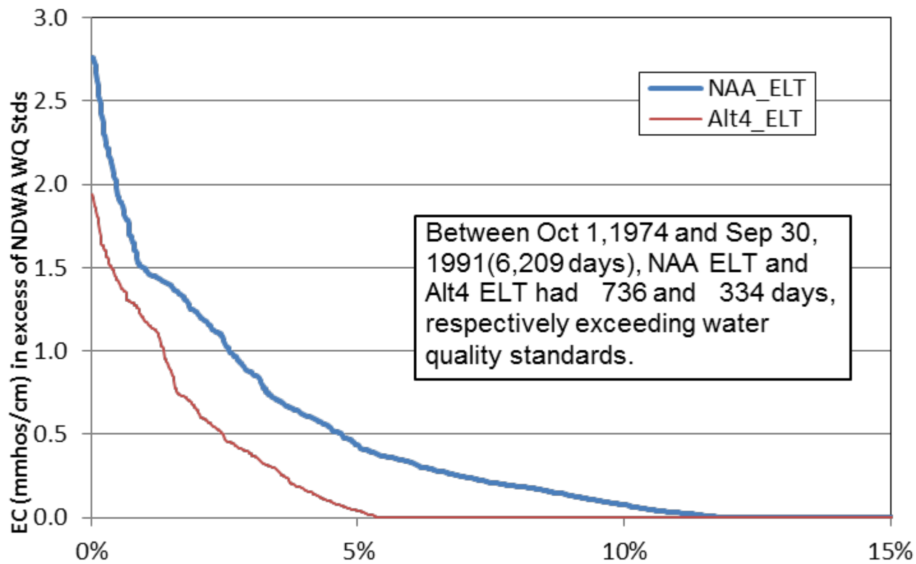

Figure 23. Probability of Exceeding EC Standards in the Sacramento River at Three Mile Slough

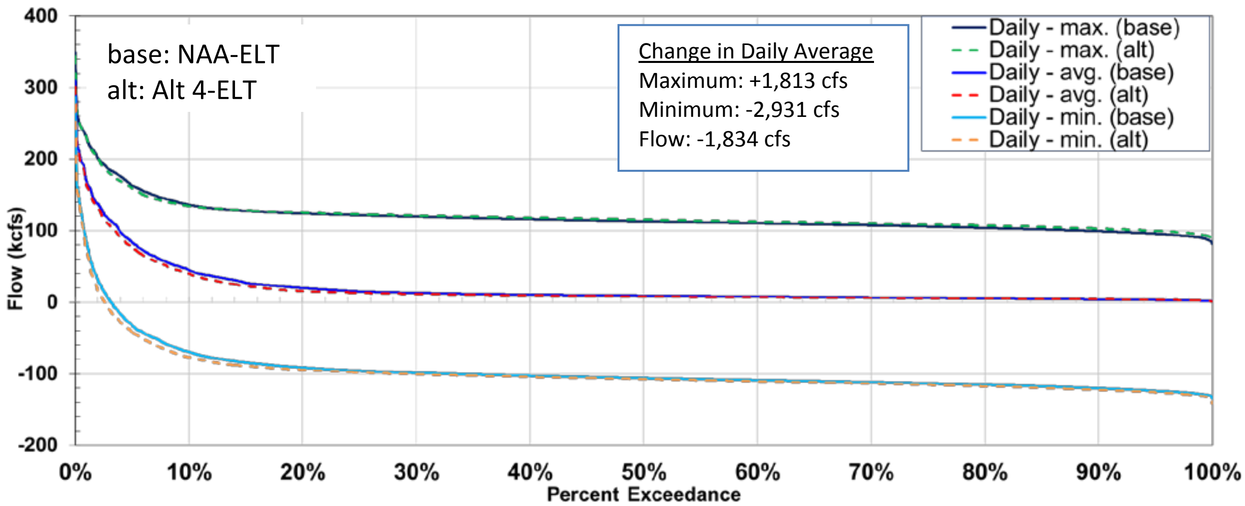

Figure 24. Daily Flow in the Sacramento River at Rio Vista

No Action Alternative ELT vs. Alternative 4 ELT (BDCP EIR/EIS Modeling) Continued

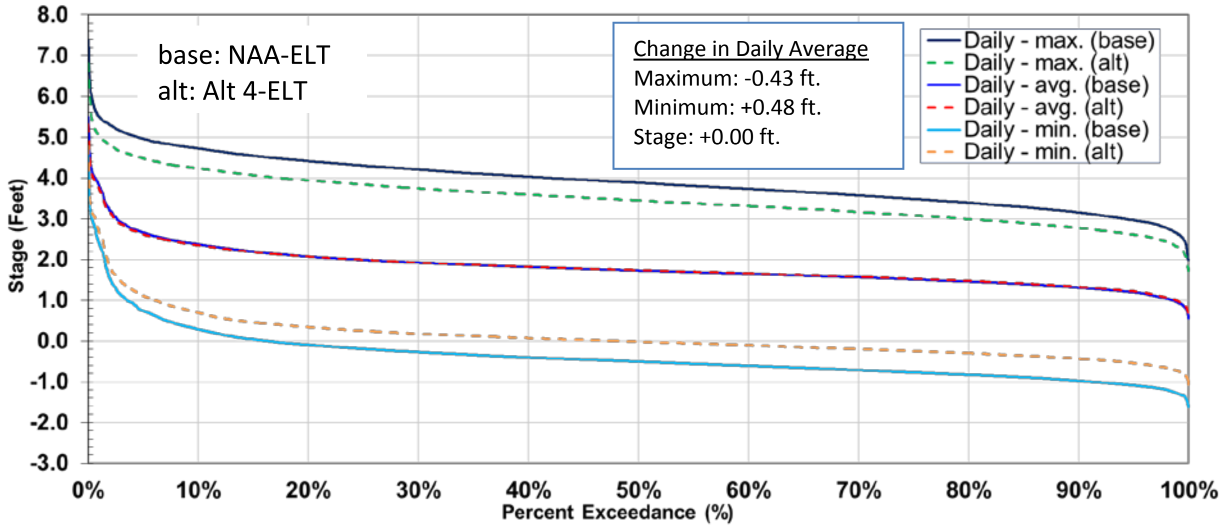

Figure 25. Daily Stage in the Sacramento River at Rio Vista

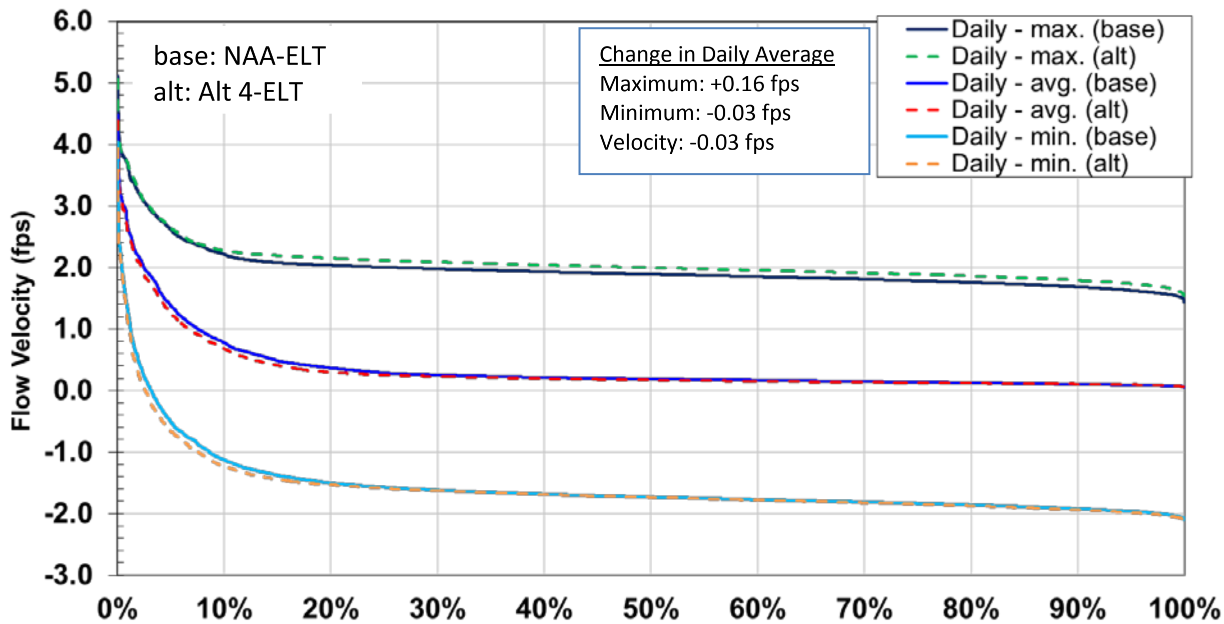

Figure 26. Daily Velocities in the Sacramento River at Rio Vista

No Action Alternative ELT vs. Alternative 4 ELT (BDCP EIR/EIS Modeling) Continued

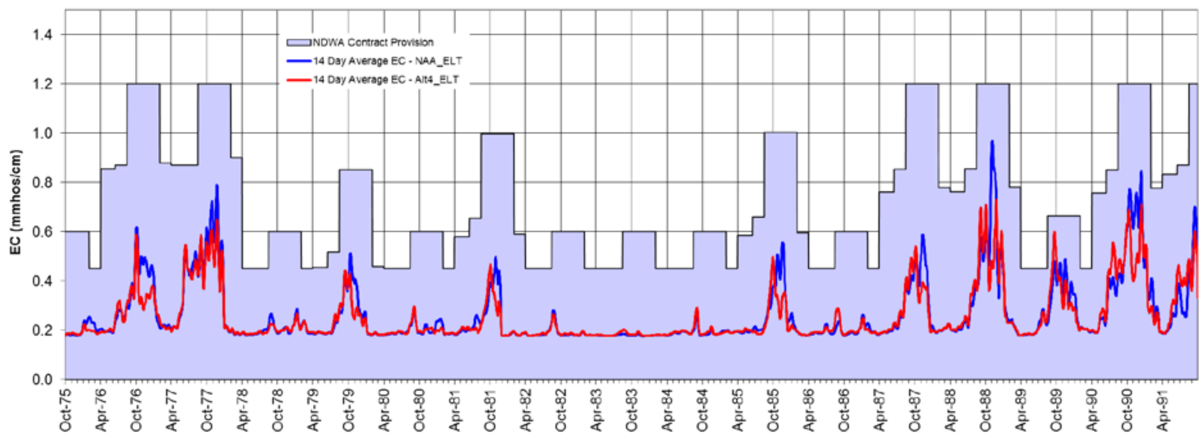

Figure 27. EC in the Sacramento River at Rio Vista

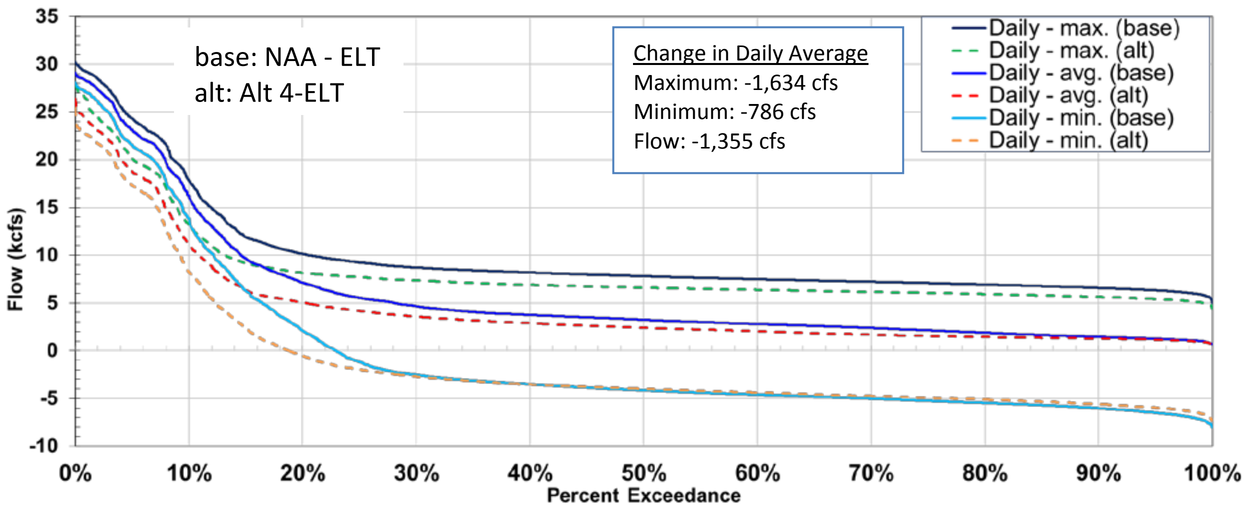

Figure 28. Daily Flow in Steamboat Slough at Sutter Slough

No Action Alternative ELT vs. Alternative 4 ELT (BDCP EIR/EIS Modeling) Continued

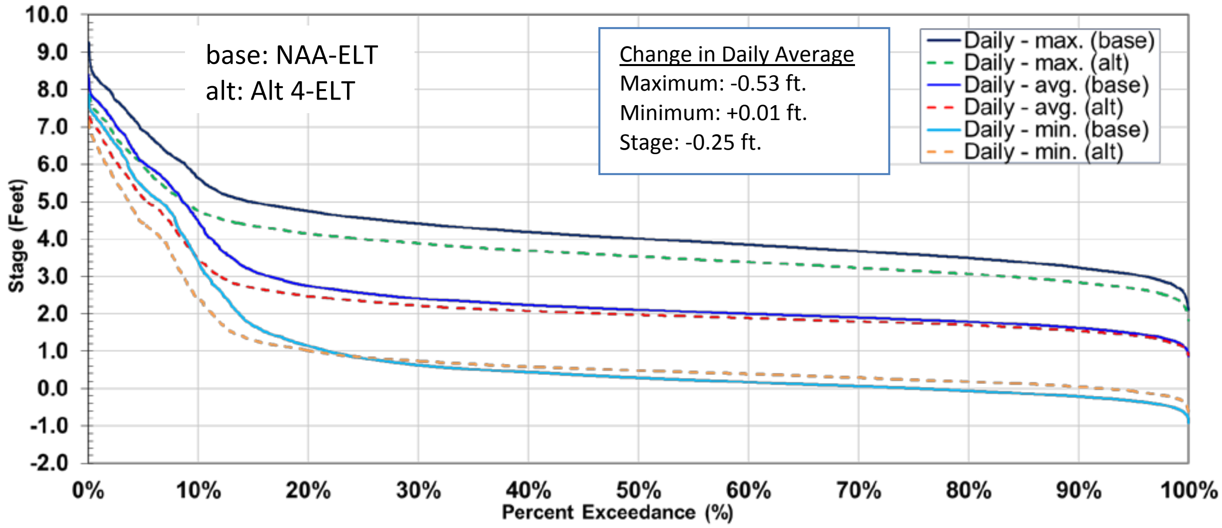

Figure 29. Daily Stage in Steamboat Slough at Sutter Slough

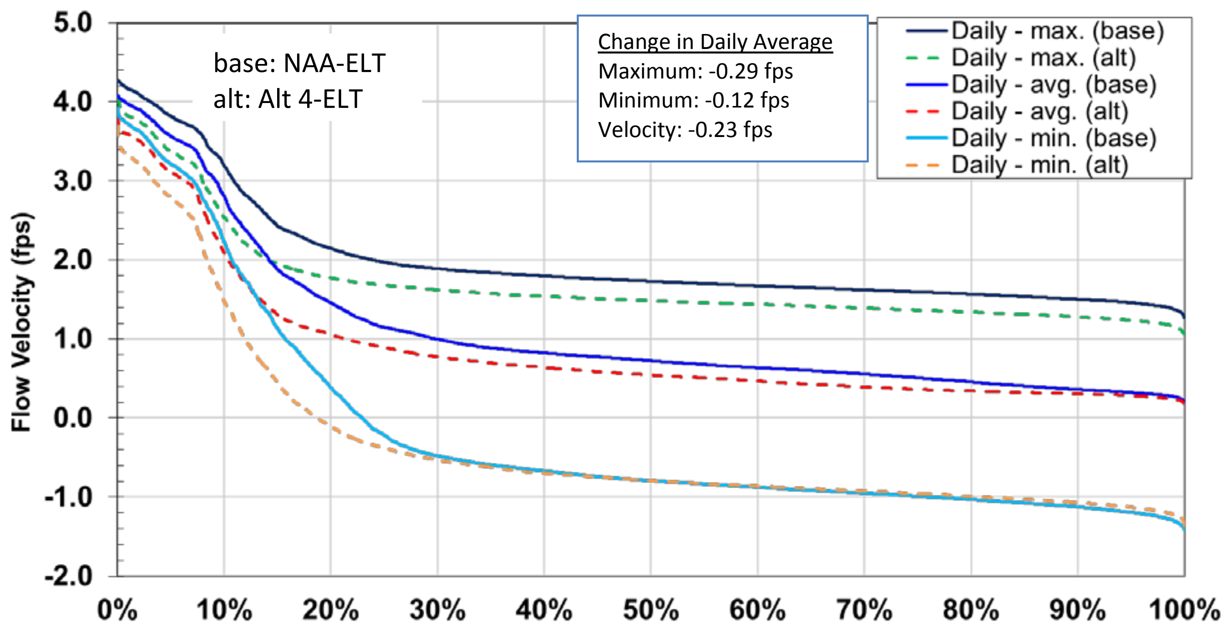

Figure 30. Daily Velocities in Steamboat Slough at Sutter Slough

No Action Alternative ELT vs. Alternative 4 ELT (BDCP EIR/EIS Modeling) Continued

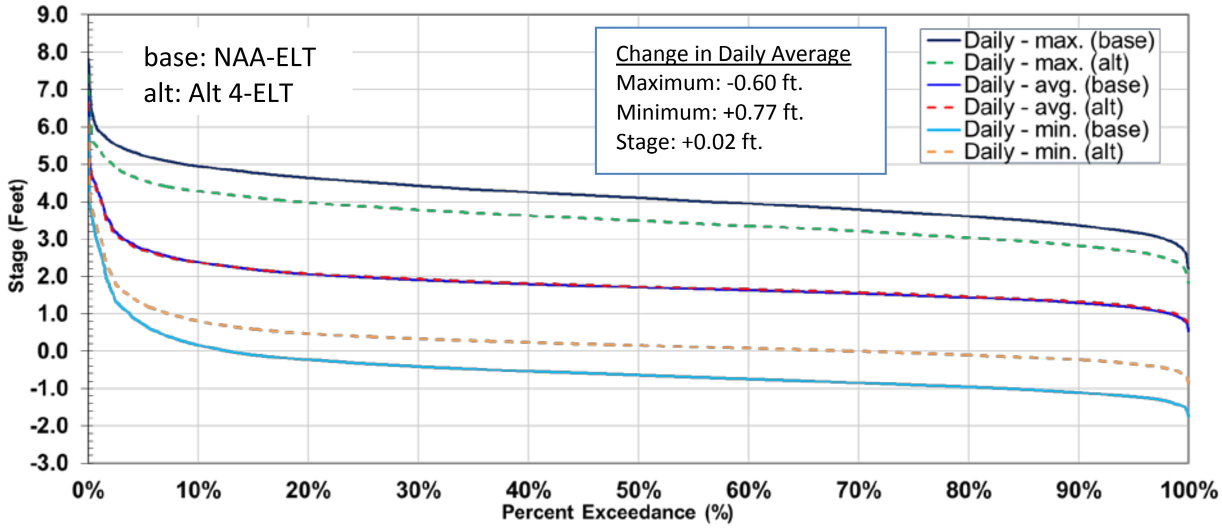

Figure 31. Daily Stage in Barker Slough at NBA Intakes

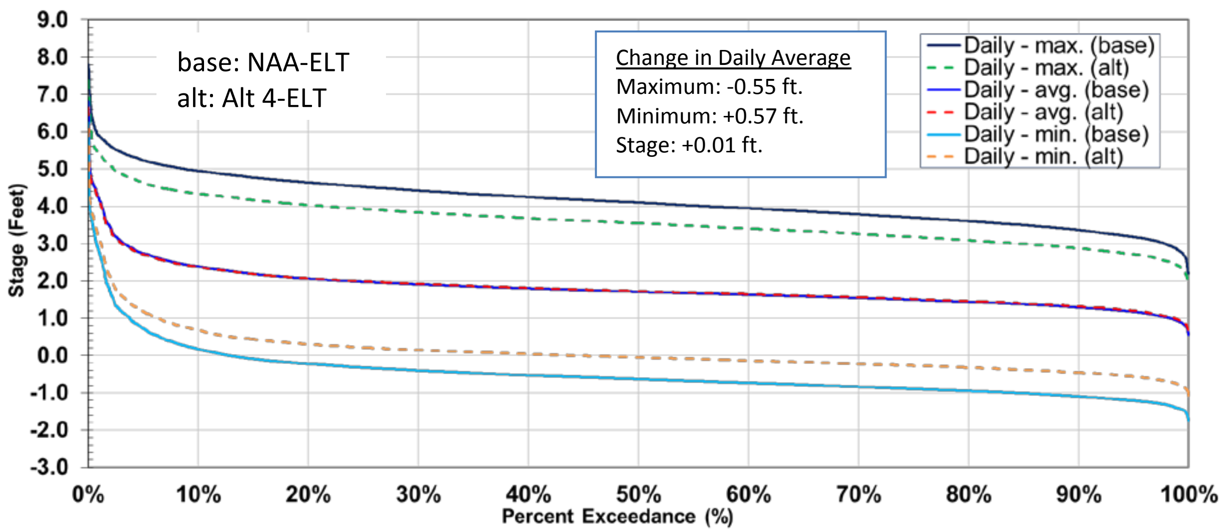

Figure 32. Daily Stage in Shag Slough

NO ACTION ALTERNATIVE WITH HABITAT VS. NO ACTION ALTERNATIVE WITHOUT HABITAT (INDEPENDENT MODELING)

No Action Alternative with Habitat vs. No Action Alternative without Habitat (Independent Modeling)

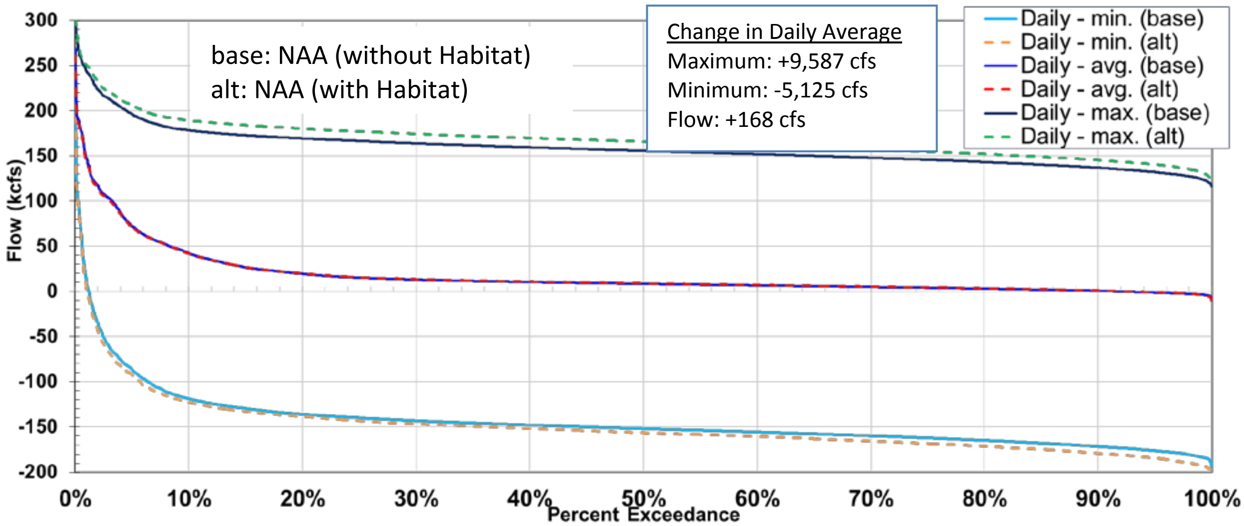

Figure 33. Daily Flow in Sacramento River at Emmaton

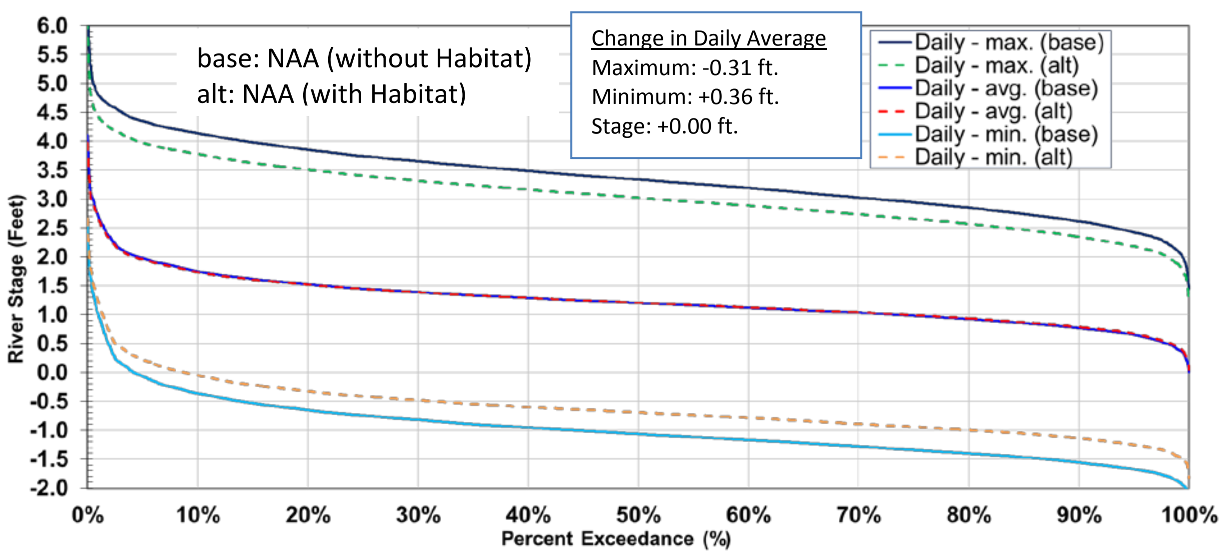

Figure 34. Daily Stage in Sacramento River at Emmaton

No Action Alternative with Habitat vs. No Action Alternative without Habitat (Independent Modeling) Continued

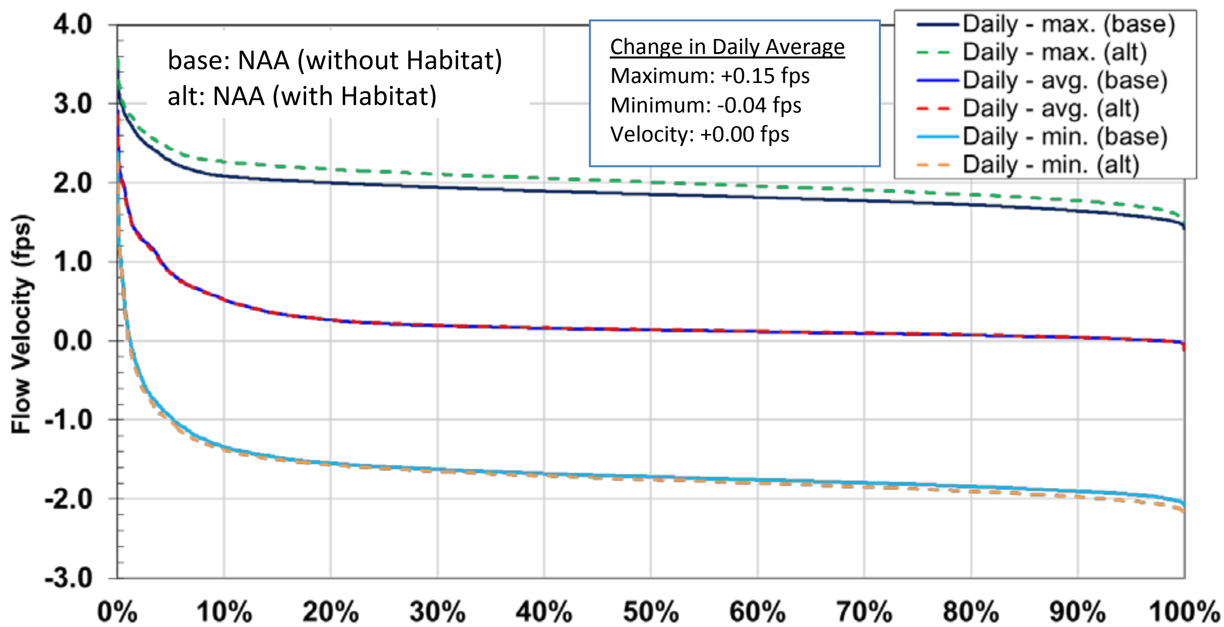

Figure 35. Daily Velocities in Sacramento River at Emmaton

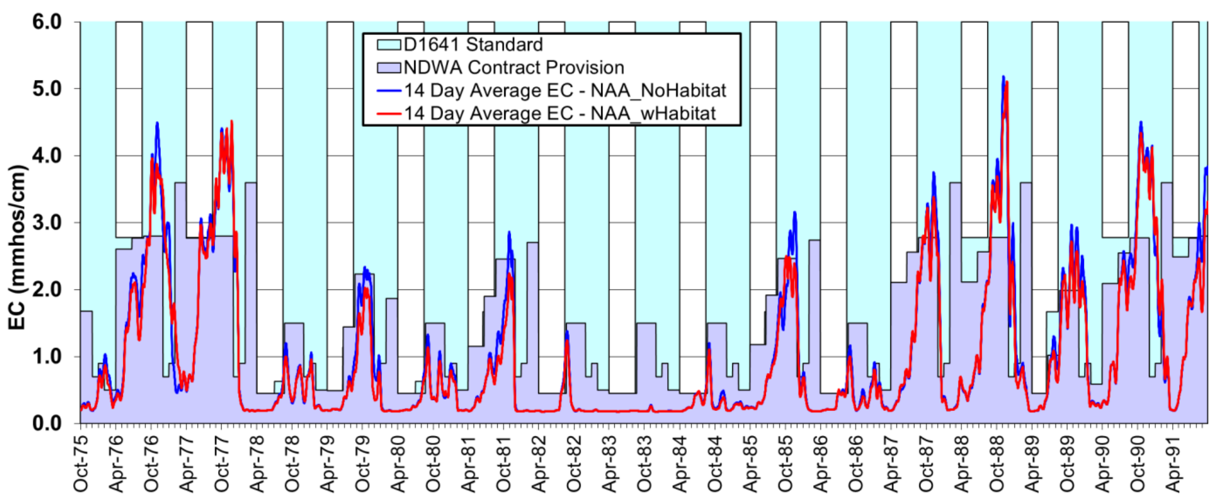

Figure 36. EC in the Sacramento River at Emmaton

No Action Alternative with Habitat vs. No Action Alternative without Habitat (Independent Modeling) Continued

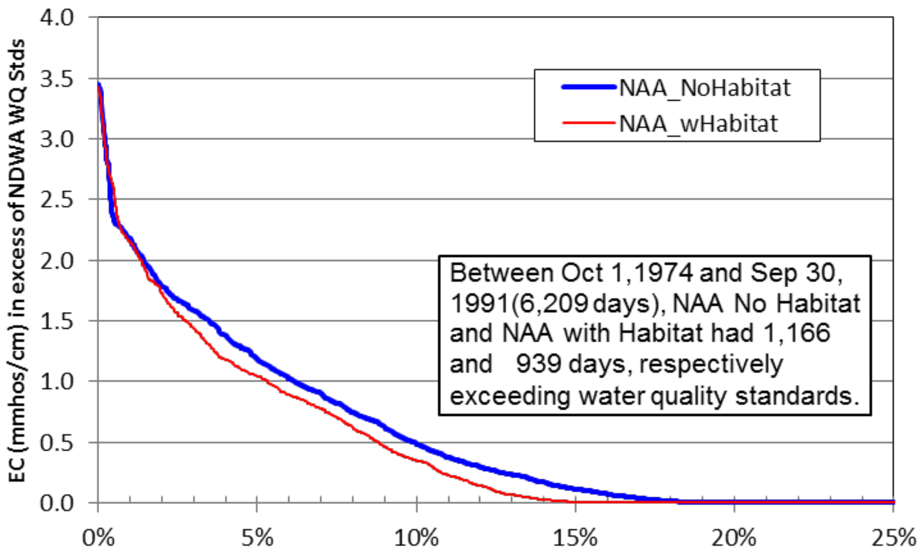

Figure 37. Probability of Exceeding EC Standards in the Sacramento River at Emmaton

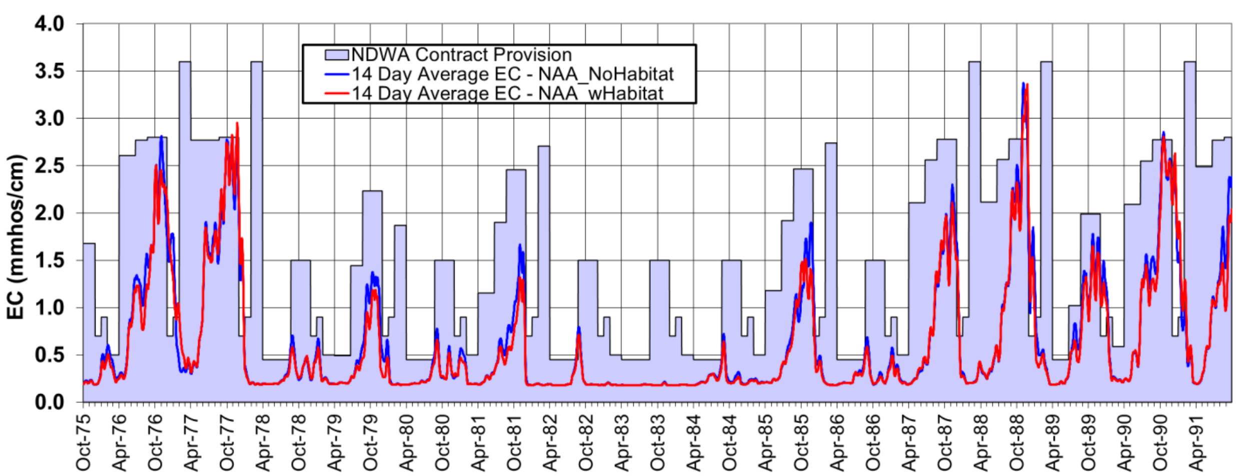

Figure 38. EC in the Sacramento River at Three Mile Slough

No Action Alternative with Habitat vs. No Action Alternative without Habitat (Independent Modeling) Continued

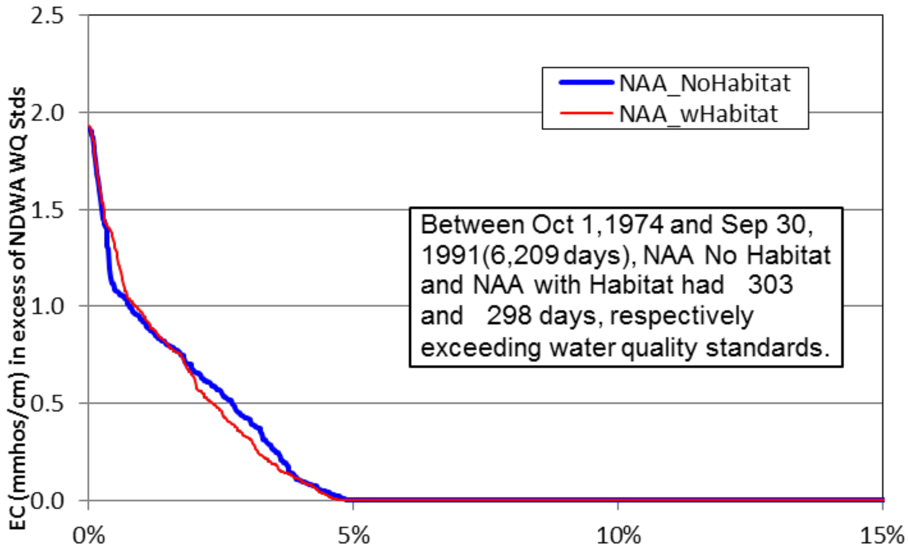

Figure 39. Probability of Exceeding EC Standards in the Sacramento River at Three Mile Slough

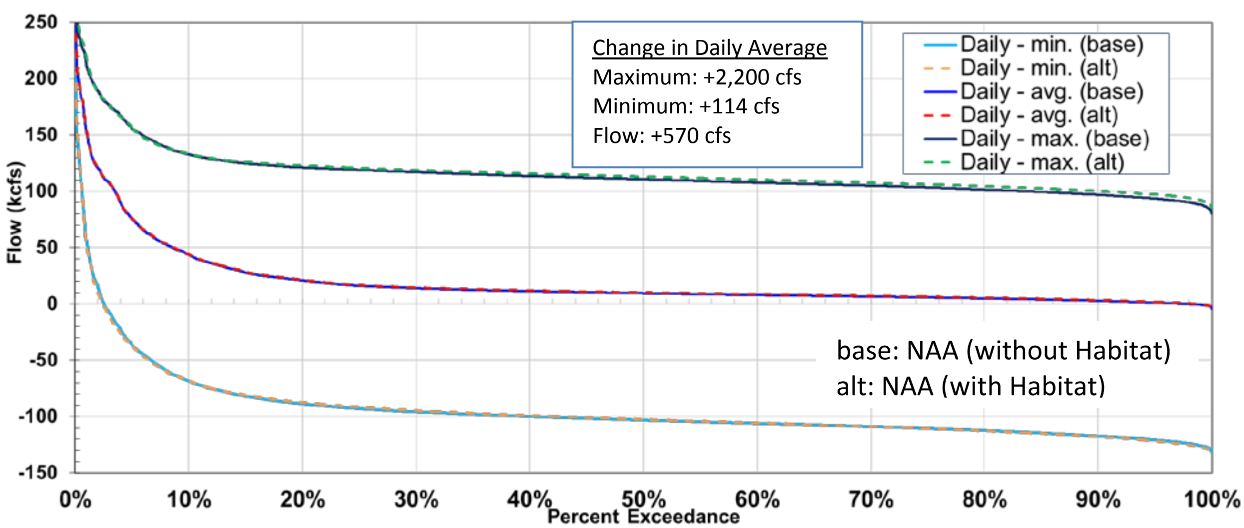

Figure 40. Daily Flow in Sacramento River at Rio Vista

No Action Alternative with Habitat vs. No Action Alternative without Habitat (Independent Modeling) Continued

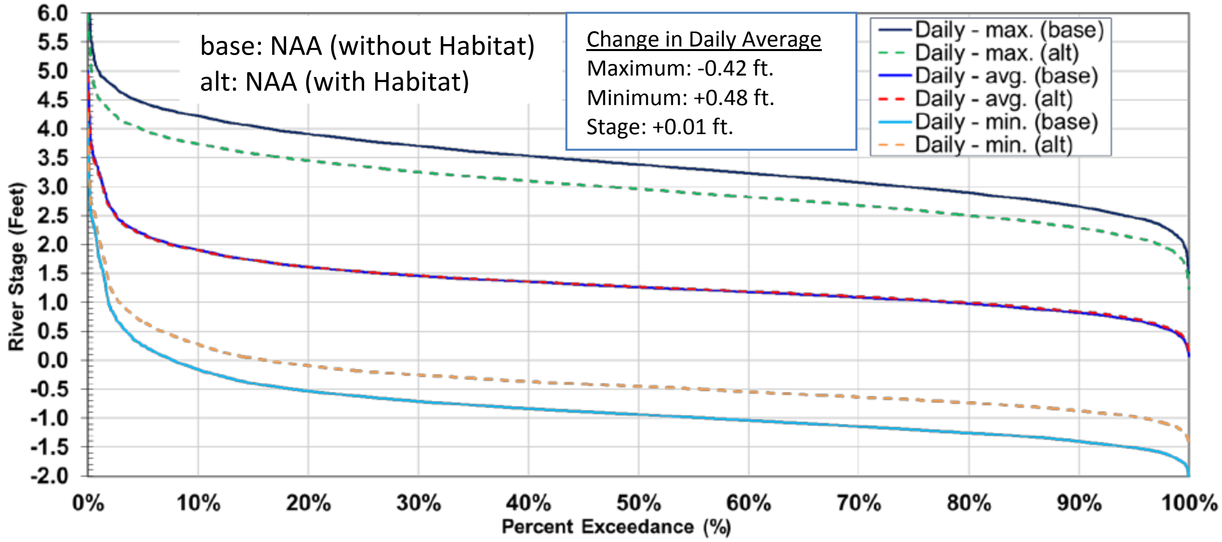

Figure 41. Daily Stage in Sacramento River at Rio Vista

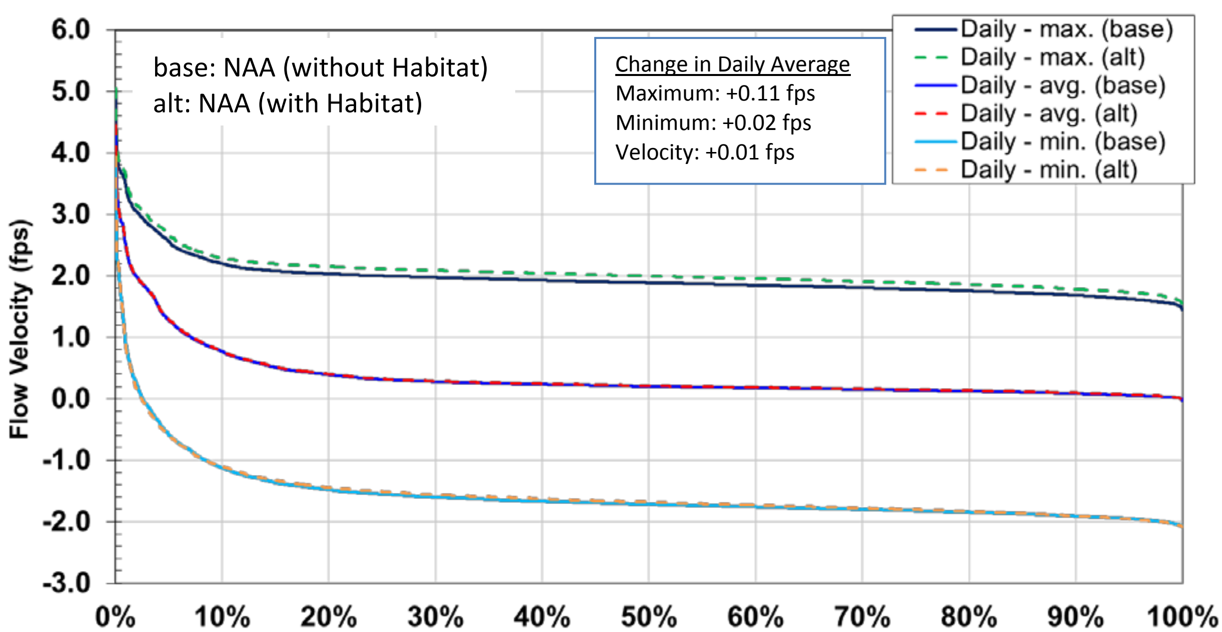

Figure 42. Daily Velocities in Sacramento River at Rio Vista

No Action Alternative with Habitat vs. No Action Alternative without Habitat (Independent Modeling) Continued

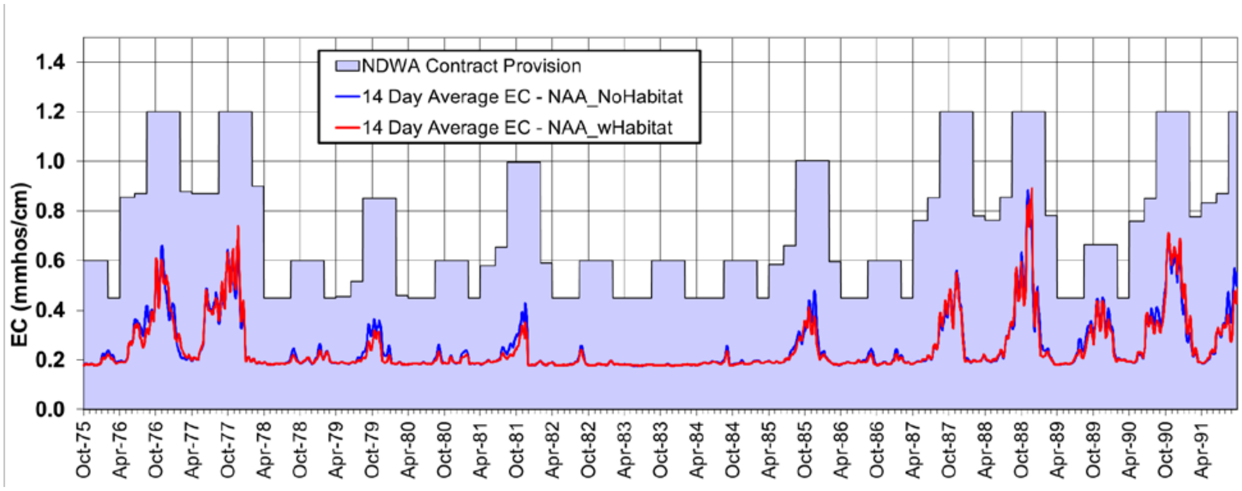

Figure 43. EC in the Sacramento River at Rio Vista

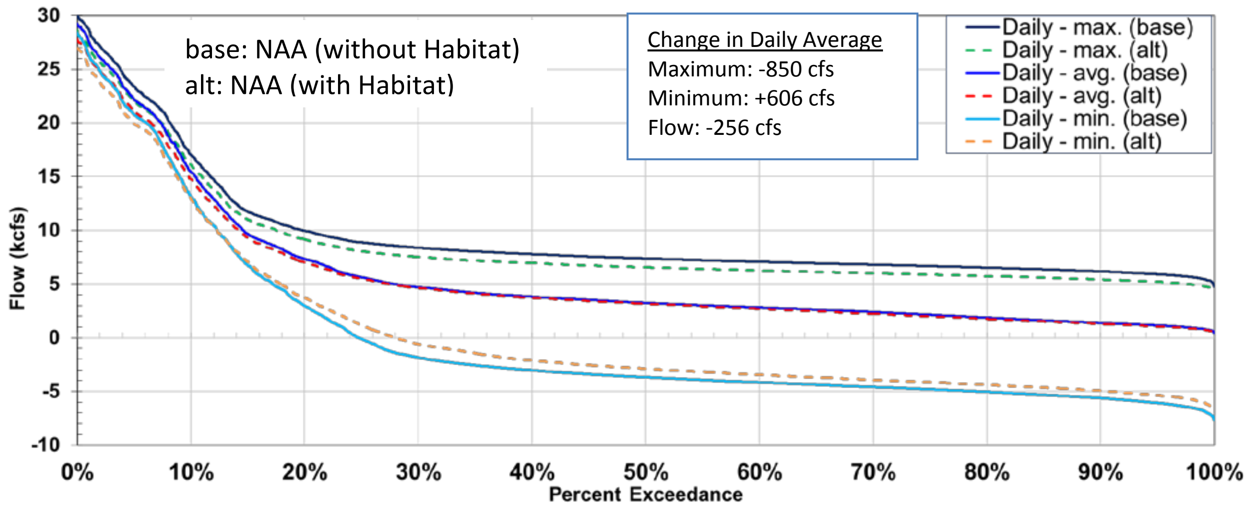

Figure 44. Daily Flow in Steamboat Slough at Sutter Slough

No Action Alternative with Habitat vs. No Action Alternative without Habitat (Independent Modeling) Continued

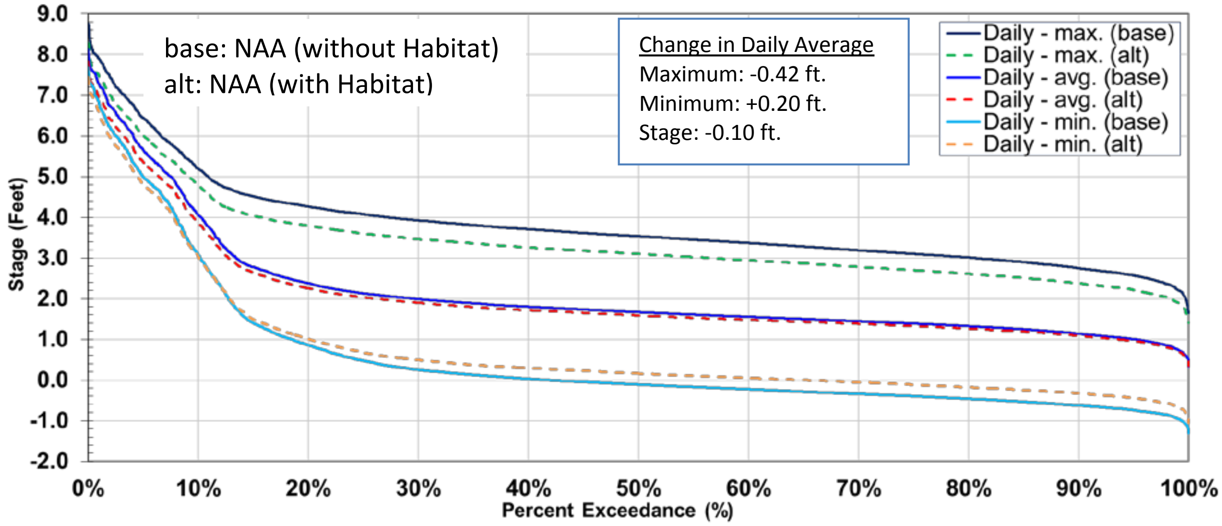

Figure 45. Daily Stage in Steamboat Slough at Sutter Slough

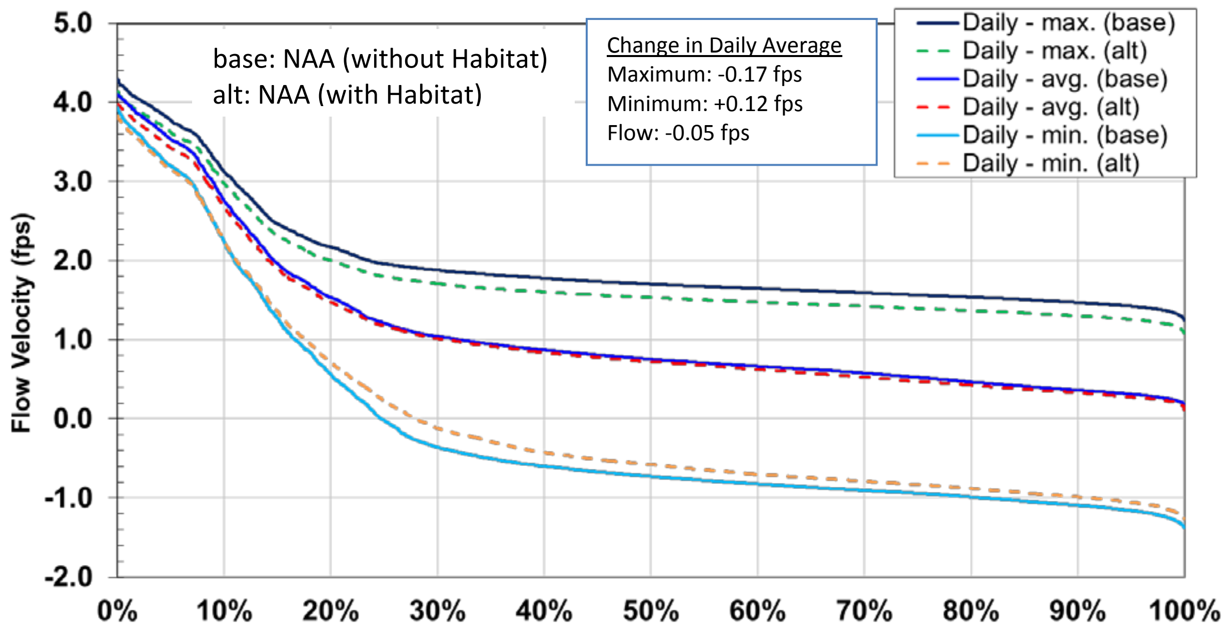

Figure 46. Daily Velocities in Steamboat Slough at Sutter Slough

No Action Alternative with Habitat vs. No Action Alternative without Habitat (Independent Modeling) Continued

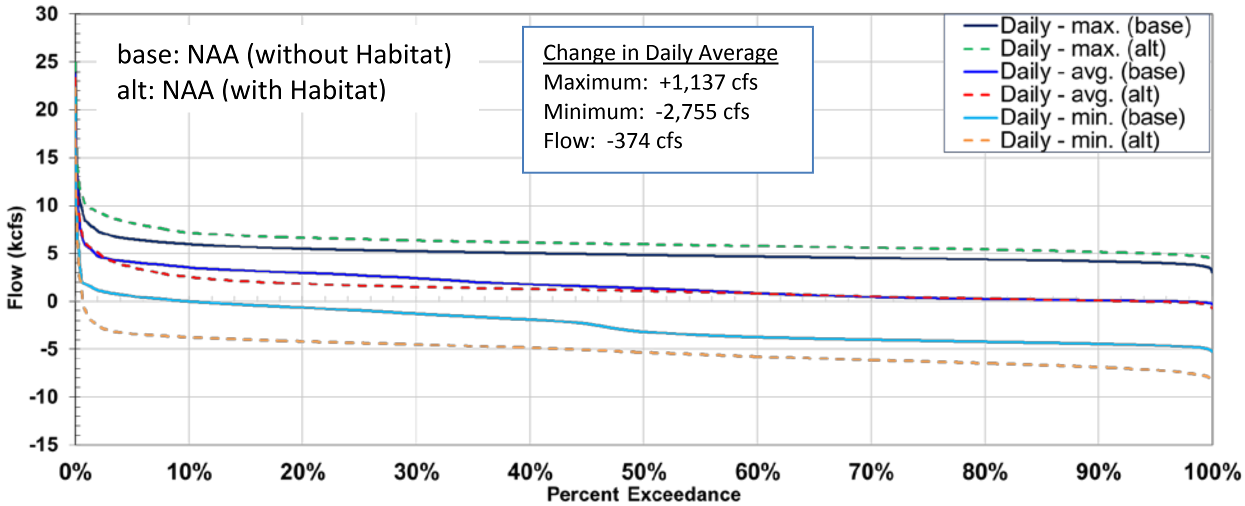

Figure 47. Daily Flow in North Fork Mokelumne River

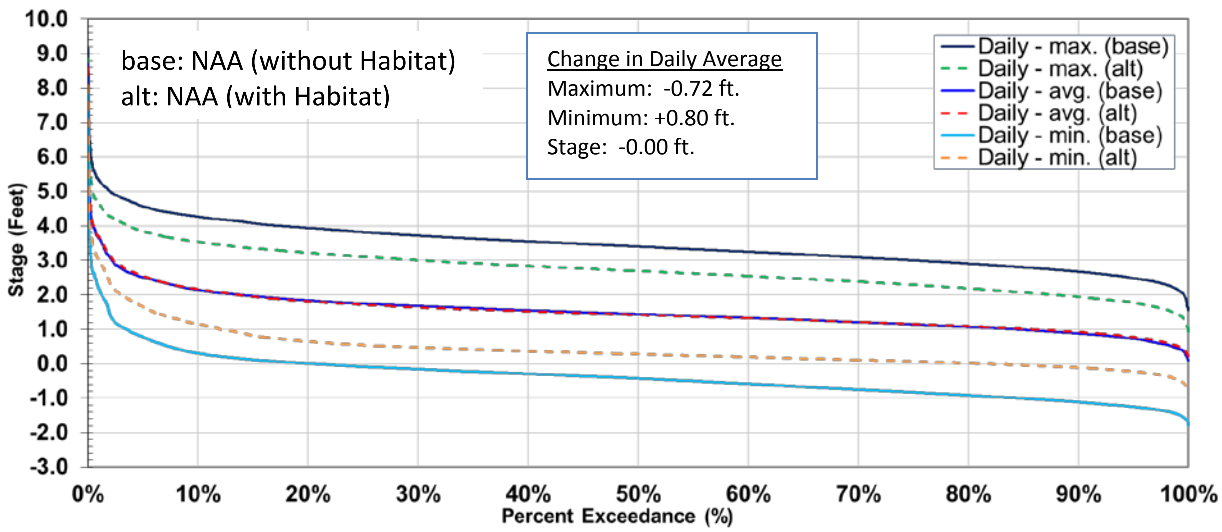

Figure 48. Daily Stage in North Fork Mokelumne River

No Action Alternative with Habitat vs. No Action Alternative without Habitat (Independent Modeling) Continued

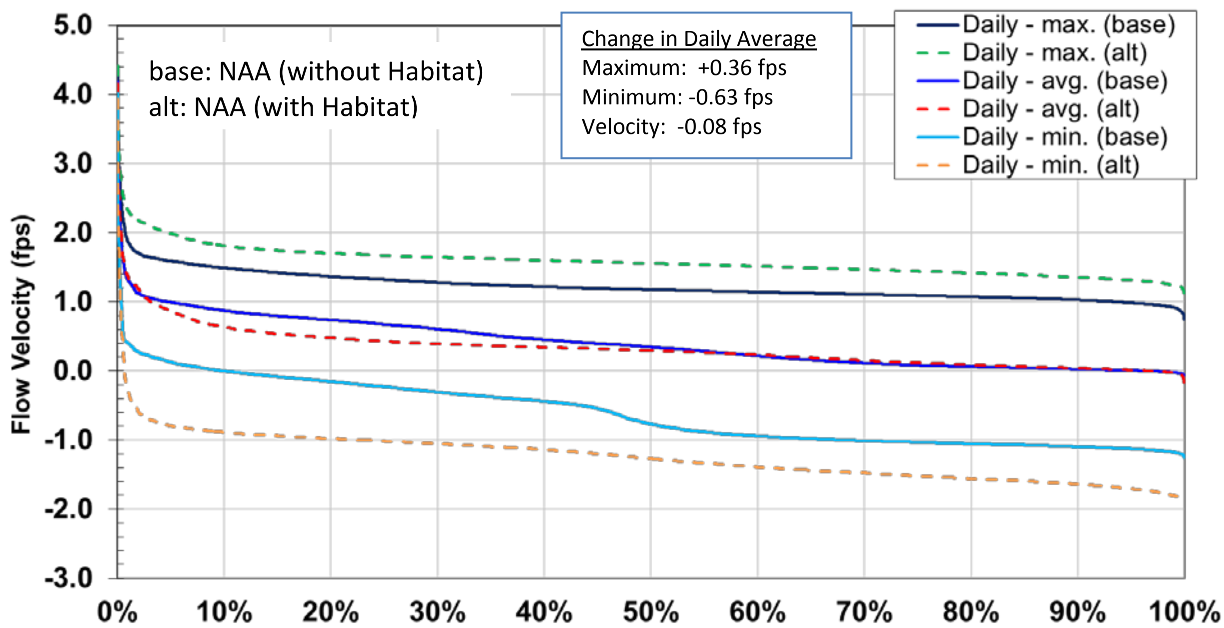

Figure 49. Daily Velocities in North Fork Mokelumne River

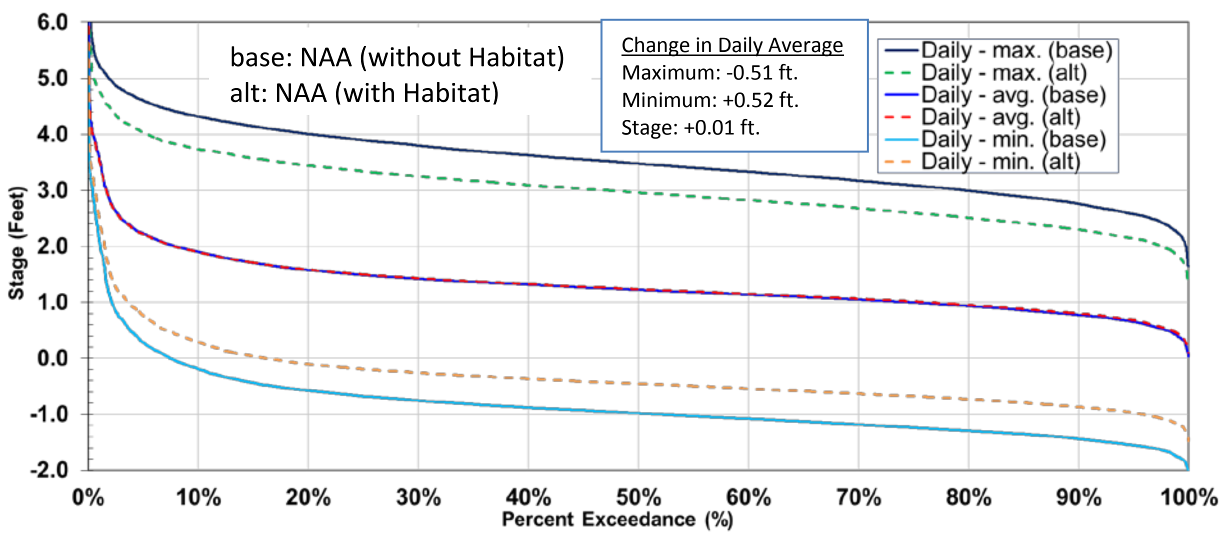

Figure 50. Daily Stage in Cache Slough at Ryer Island

No Action Alternative with Habitat vs. No Action Alternative without Habitat (Independent Modeling) Continued

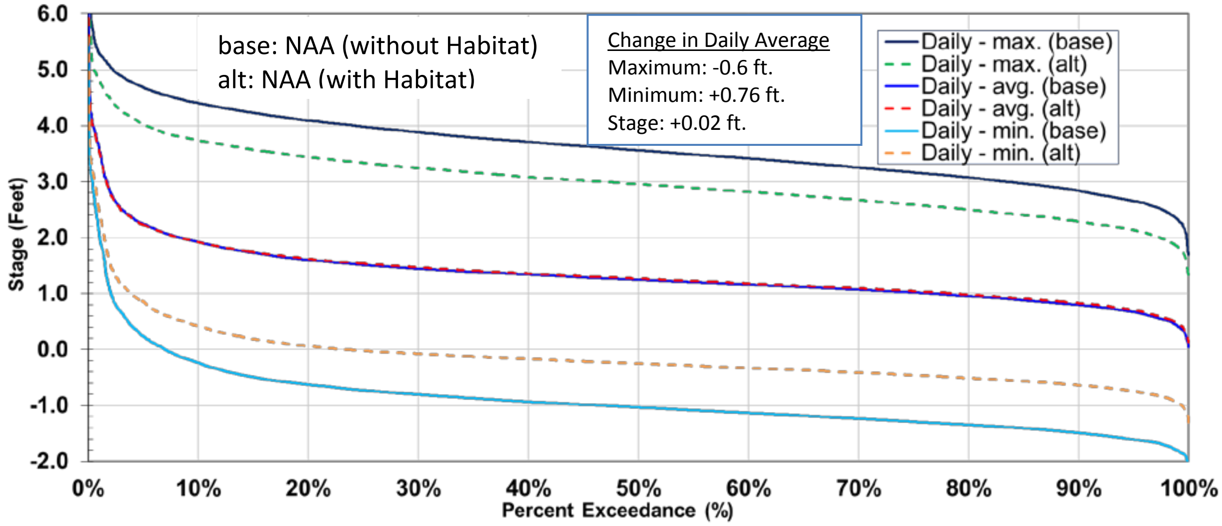

Figure 51. Daily Stage in Barker Slough at NBA Intakes

ALTERNATIVE 4 WITH HABITAT VS. NO ACTION ALTERNATIVE WITHOUT HABITAT (INDEPENDENT MODELING)

Alternative 4 with Habitat vs. No Action Alternative Without Habitat (Independent Modeling)

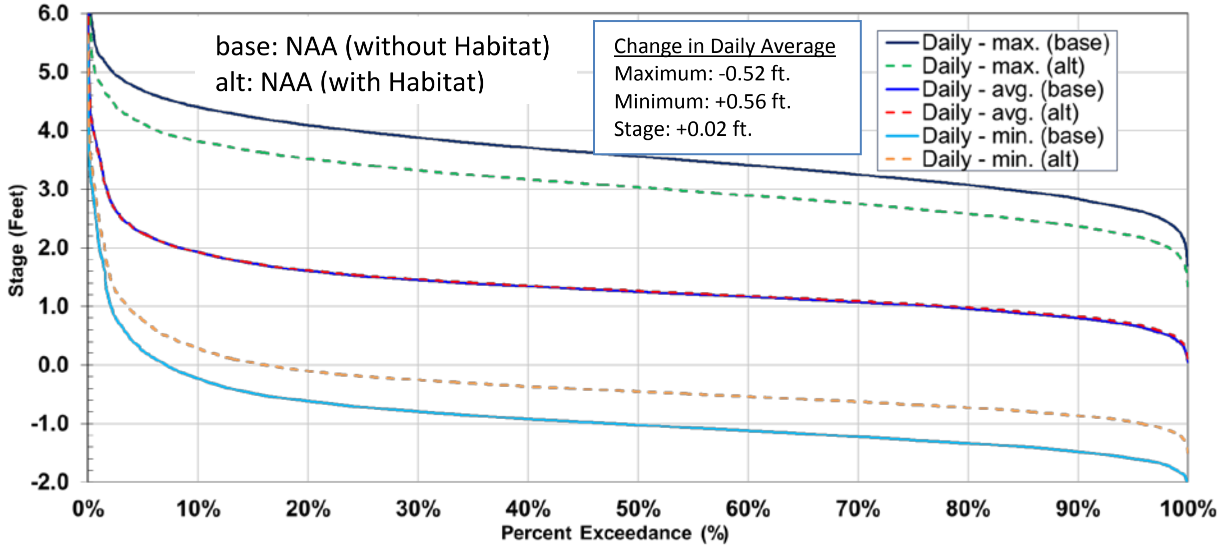

Figure 52. Daily Stage in Shag Slough Intakes

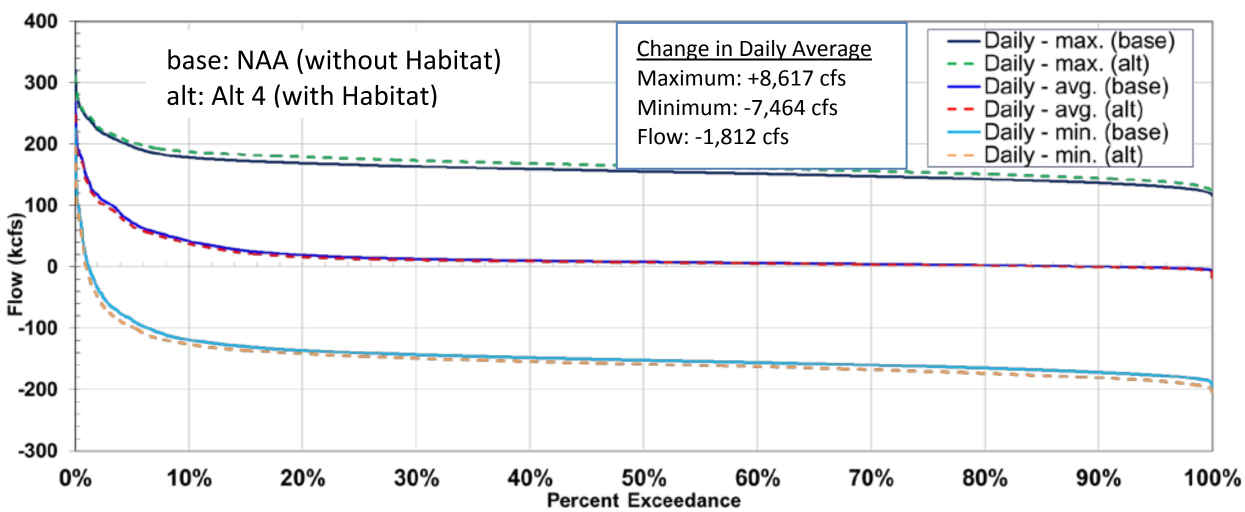

Figure 53. Daily Flow in Sacramento River at Emmaton

Alternative 4 with Habitat vs. No Action Alternative Without Habitat (Independent Modeling) Continued

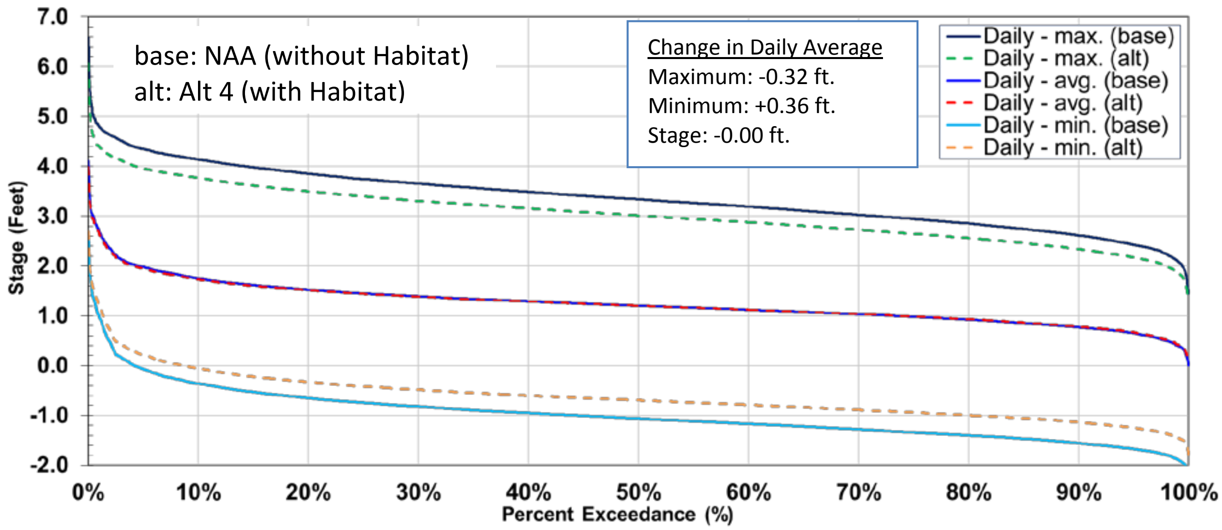

Figure 54. Daily Stage in Sacramento River at Emmaton

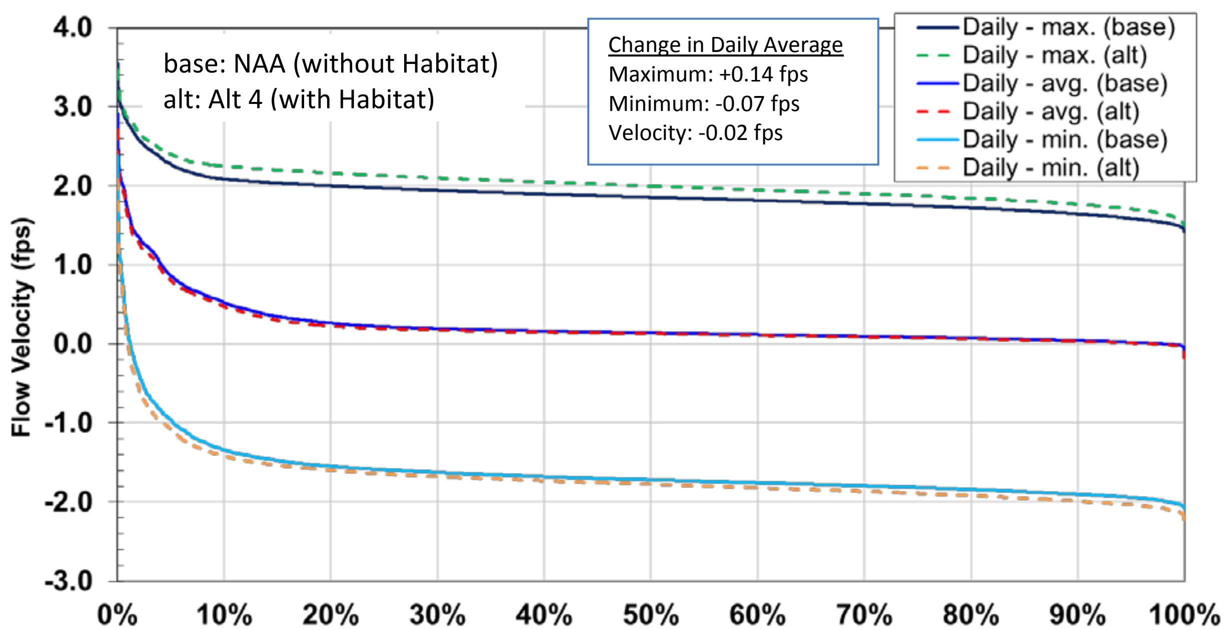

Figure 55. Daily Velocities in Sacramento River at Emmaton

Alternative 4 with Habitat vs. No Action Alternative Without Habitat (Independent Modeling) Continued

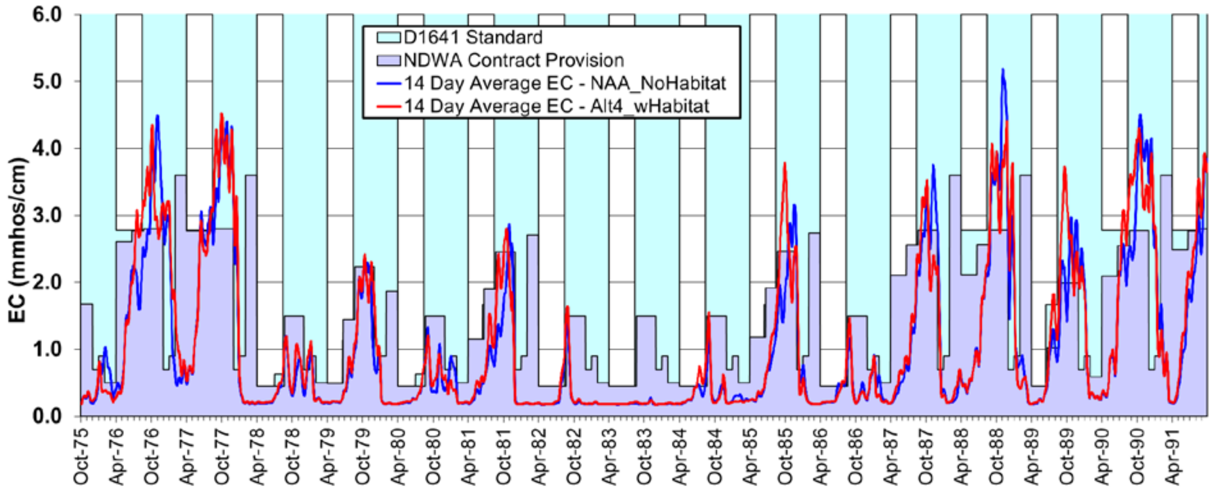

Figure 56. EC in the Sacramento River at Emmaton

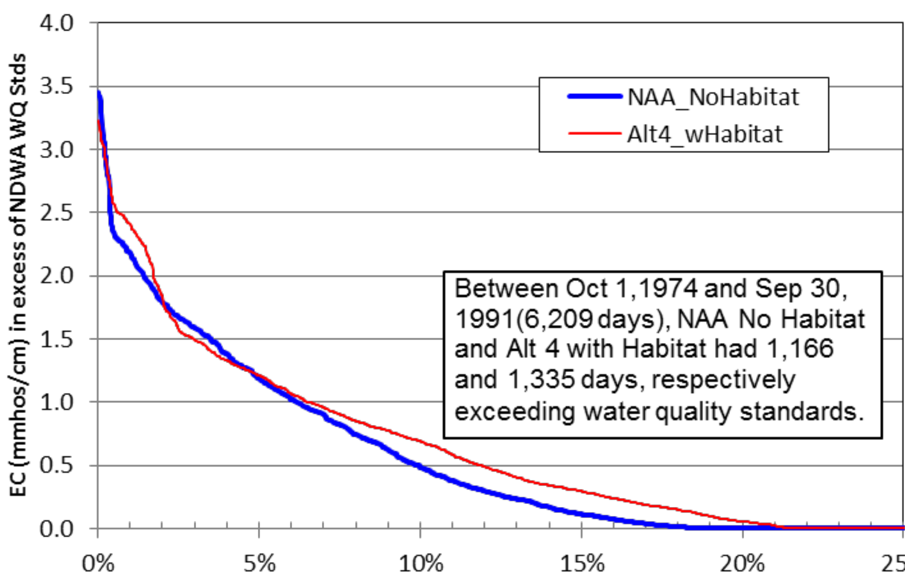

Figure 57. Probability of Exceeding EC Standards in the Sacramento River at Emmaton

Alternative 4 with Habitat vs. No Action Alternative Without Habitat (Independent Modeling) Continued

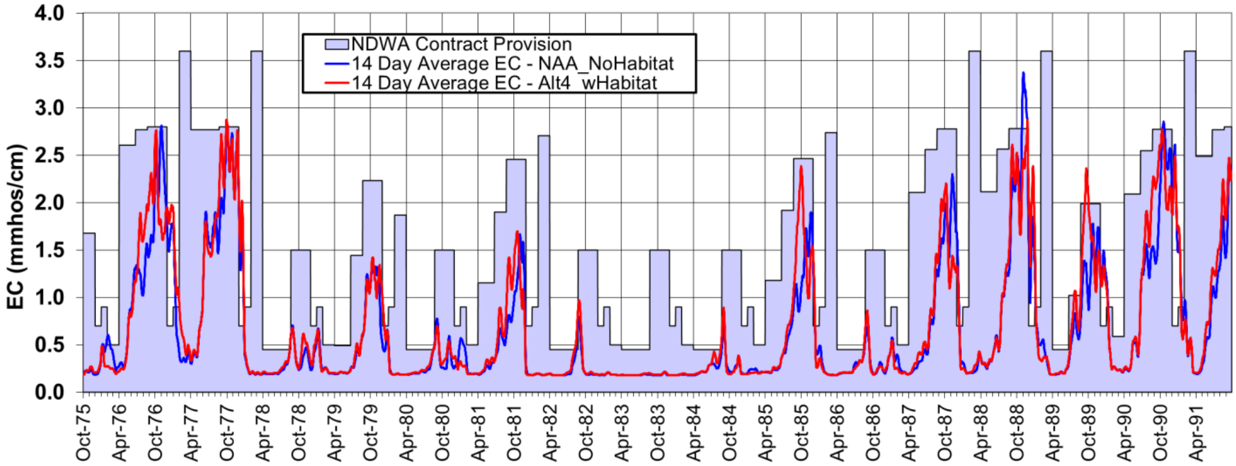

Figure 58. EC in the Sacramento River at Three Mile Slough

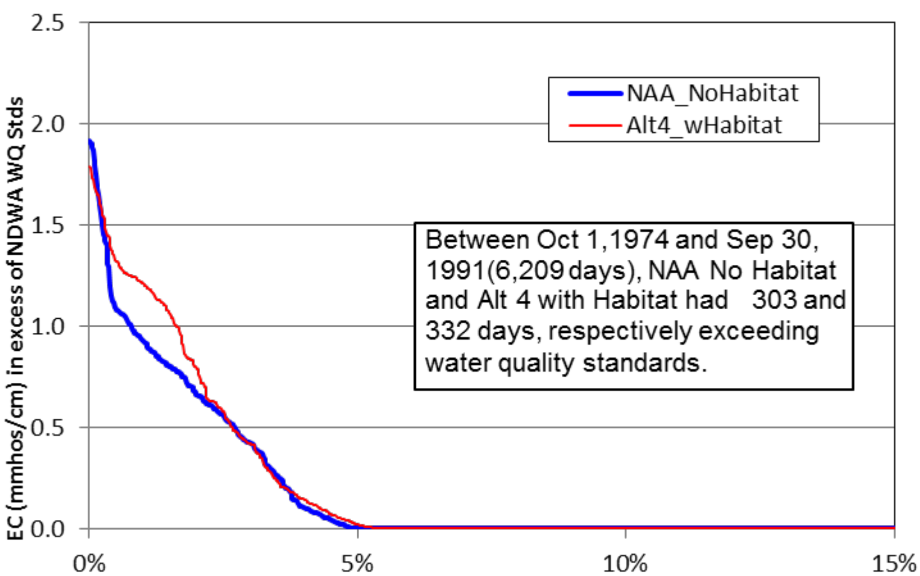

Figure 59. Probability of Exceeding EC Standards in the Sacramento River at Three Mile Slough

Alternative 4 with Habitat vs. No Action Alternative Without Habitat (Independent Modeling) Continued

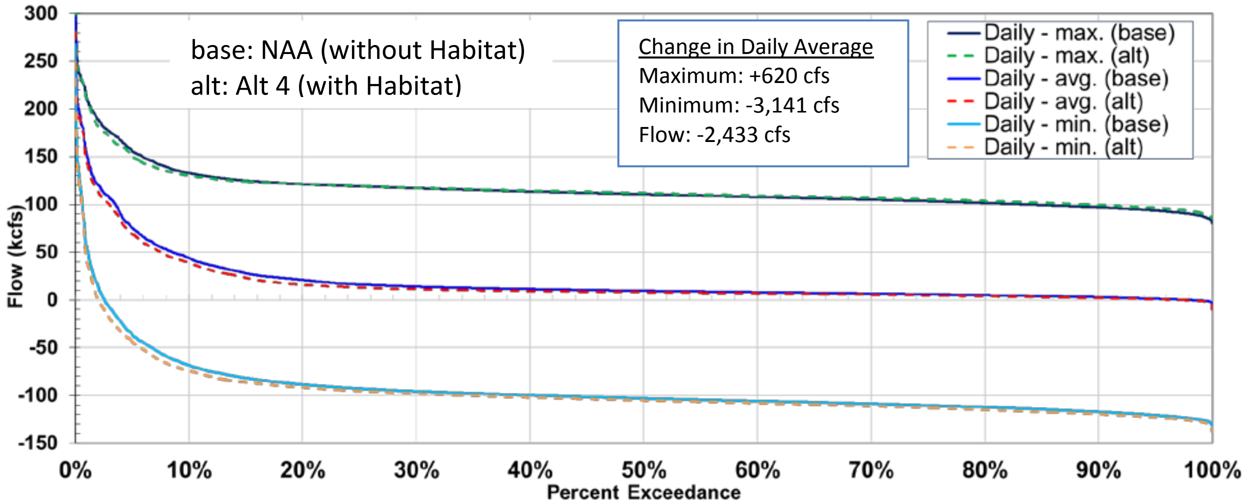

Figure 60. Daily Flow in Sacramento River at Rio Vista

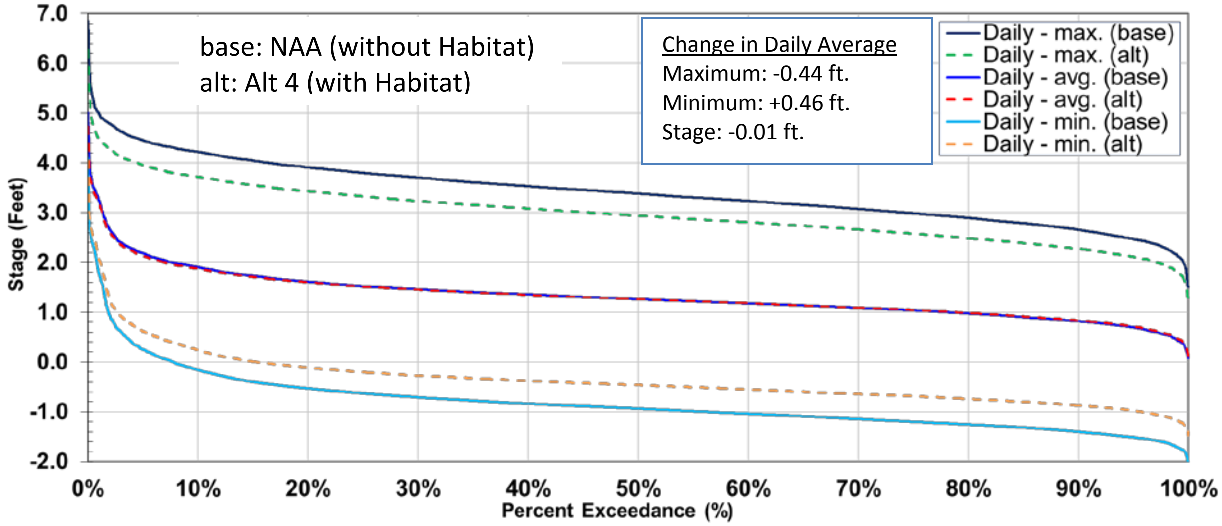

Figure 61. Daily Stage in Sacramento River at Rio Vista

Alternative 4 with Habitat vs. No Action Alternative Without Habitat (Independent Modeling) Continued

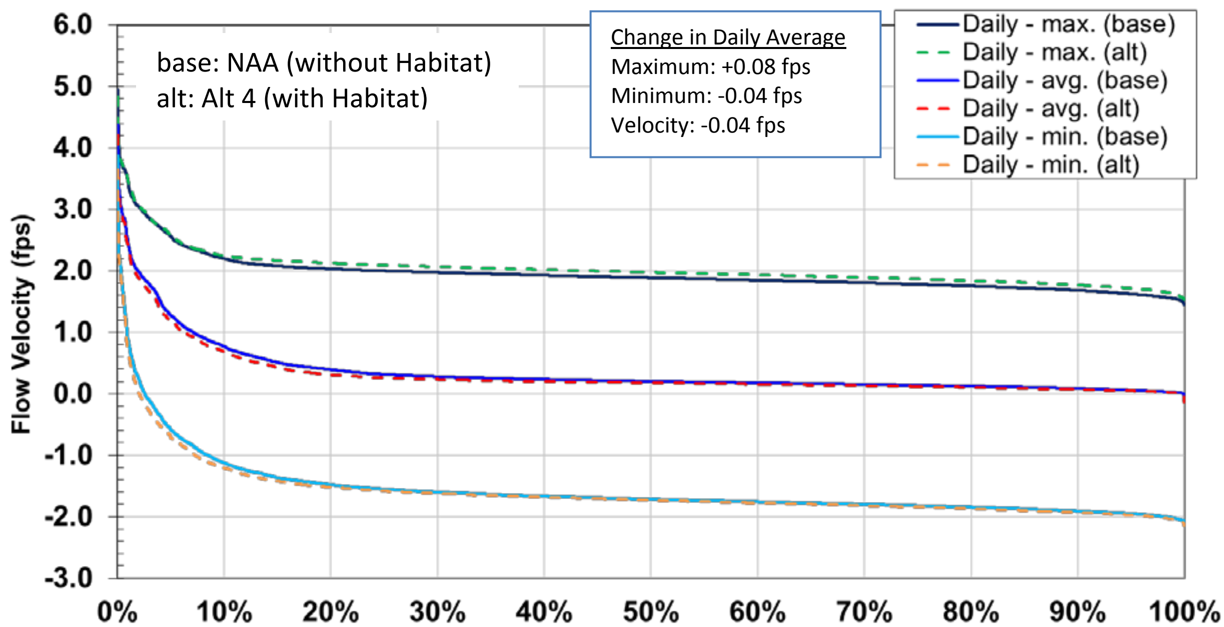

Figure 62. Daily Velocities in Sacramento River at Rio Vista

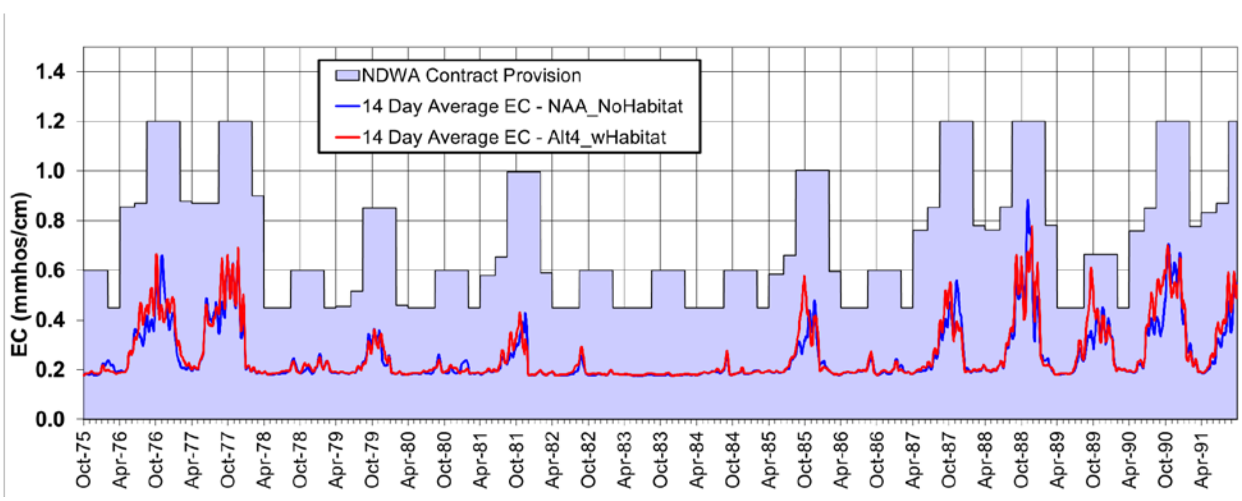

Figure 63. EC in the Sacramento River at Rio Vista

Alternative 4 with Habitat vs. No Action Alternative Without Habitat (Independent Modeling) Continued

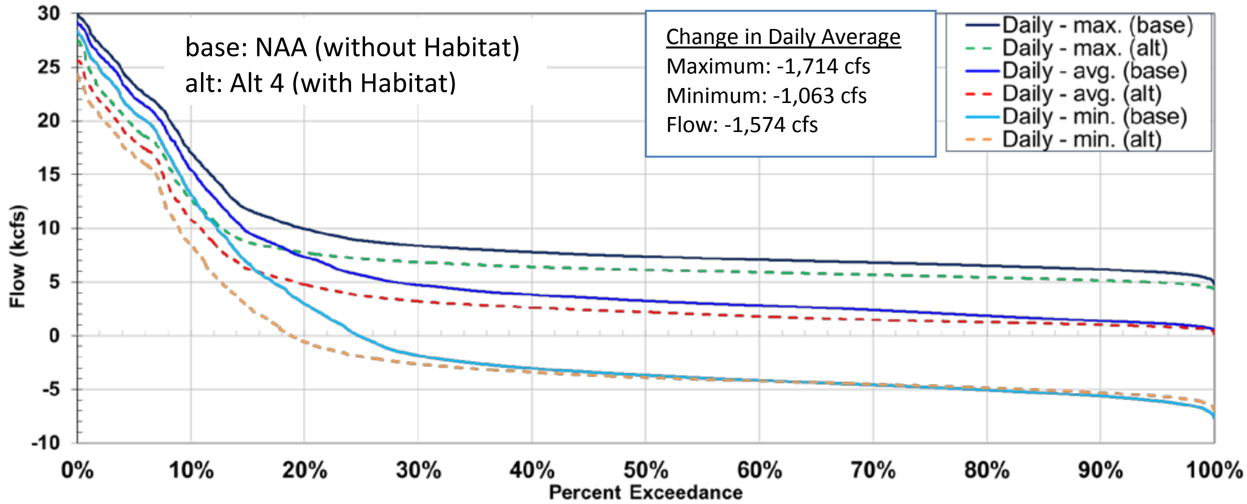

Figure 64. Daily Flow in Steamboat Slough at Sutter Slough

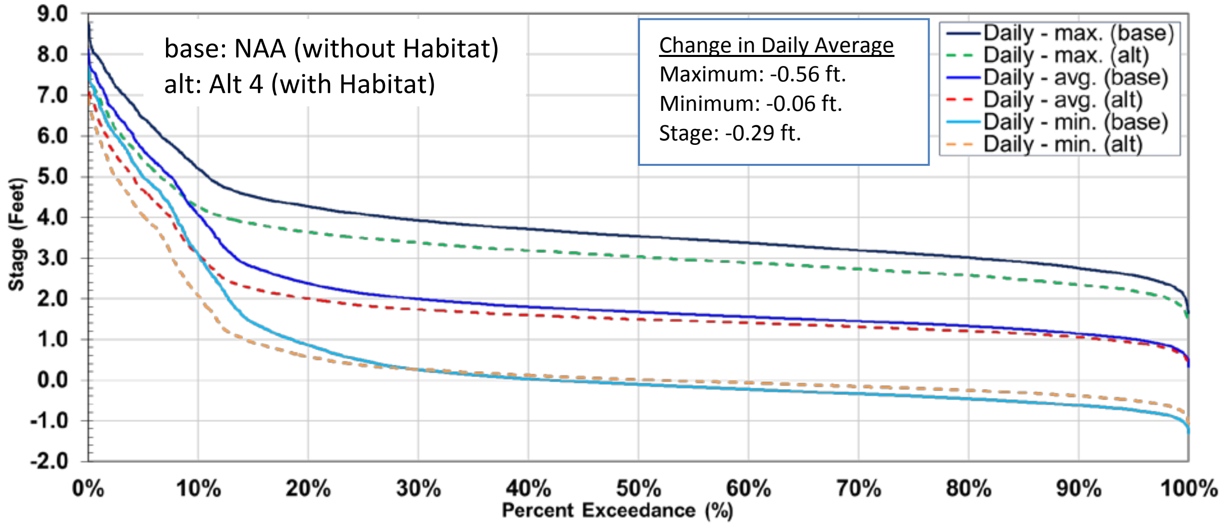

Figure 65. Daily Stage in Steamboat Slough at Sutter Slough

Alternative 4 with Habitat vs. No Action Alternative Without Habitat (Independent Modeling) Continued

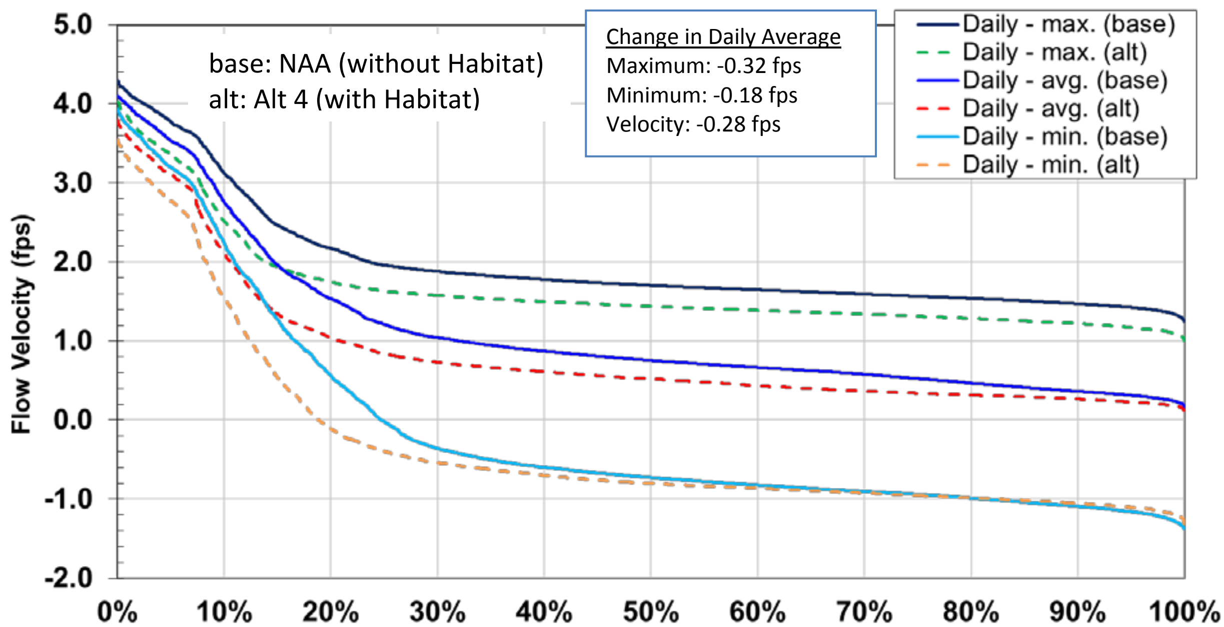

Figure 66. Daily Velocities in Steamboat Slough at Sutter Slough

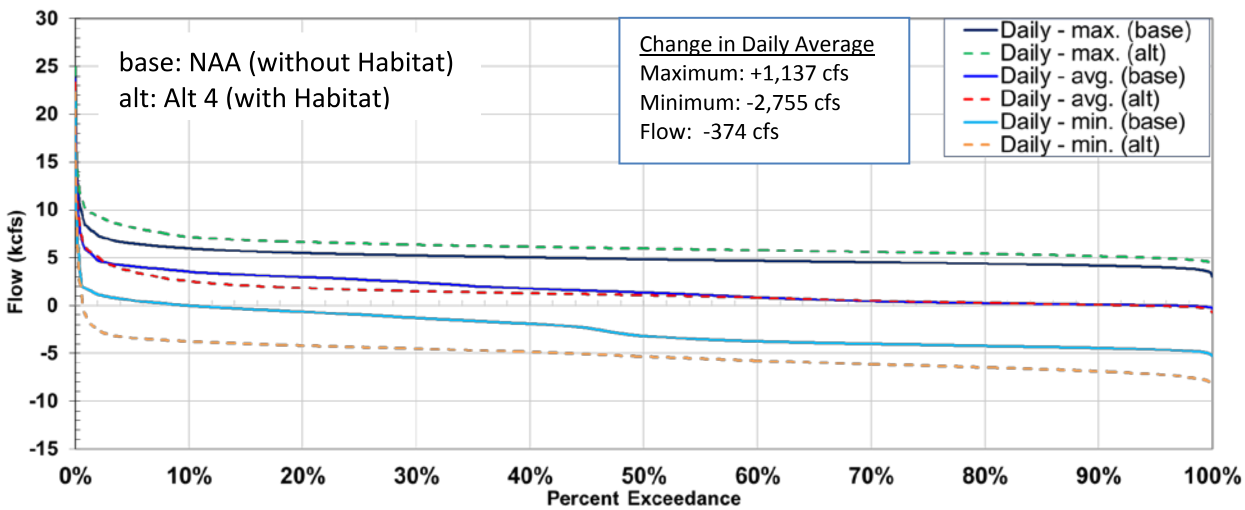

Figure 67. Daily Flow in North Fork Mokelumne River

Alternative 4 with Habitat vs. No Action Alternative Without Habitat (Independent Modeling) Continued

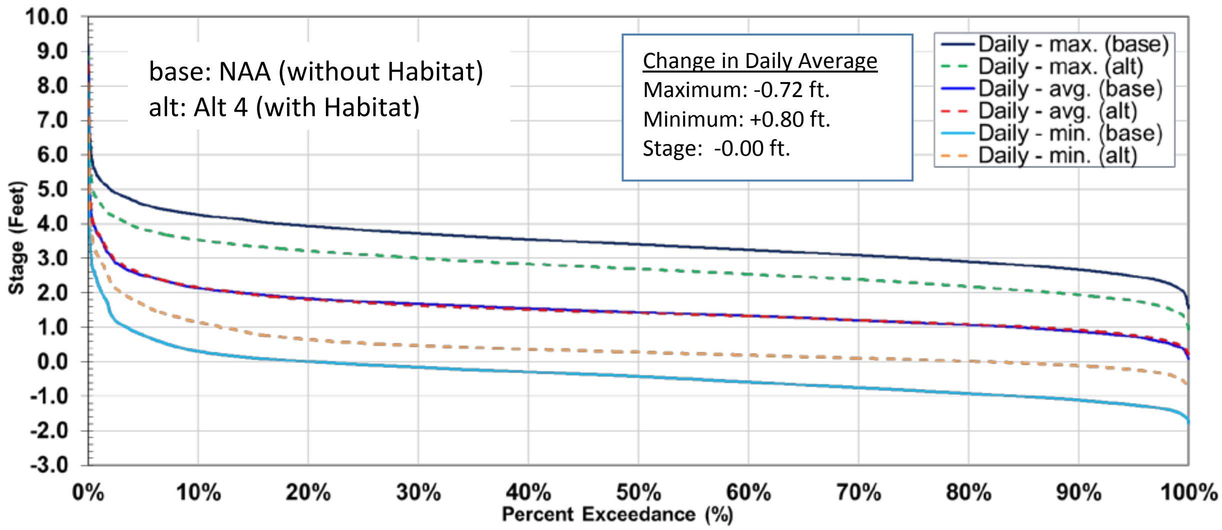

Figure 68. Daily Stage in North Fork Mokelumne River

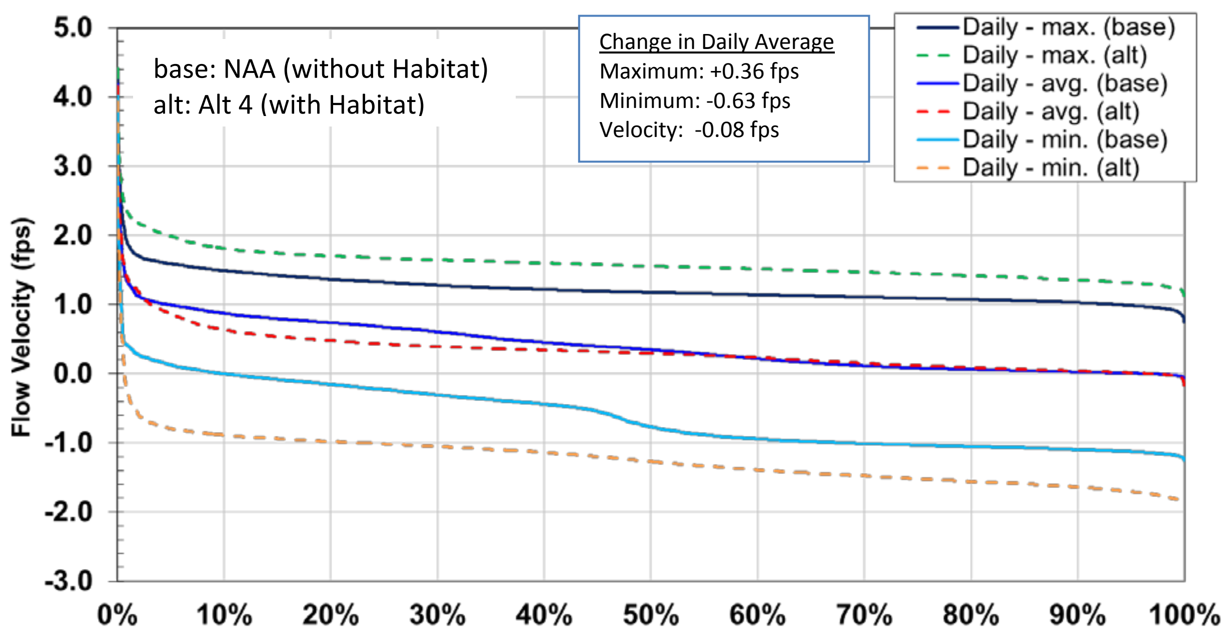

Figure 69. Daily Velocities in North Fork Mokelumne River

Alternative 4 with Habitat vs. No Action Alternative Without Habitat (Independent Modeling) Continued

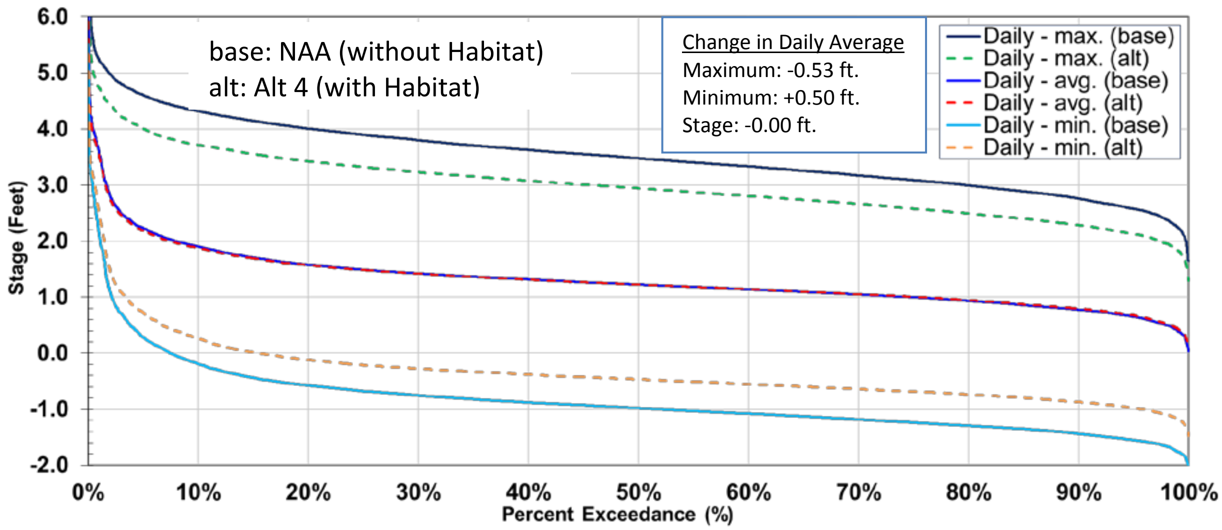

Figure 70. Daily Stage in Cache Slough at Ryer Island

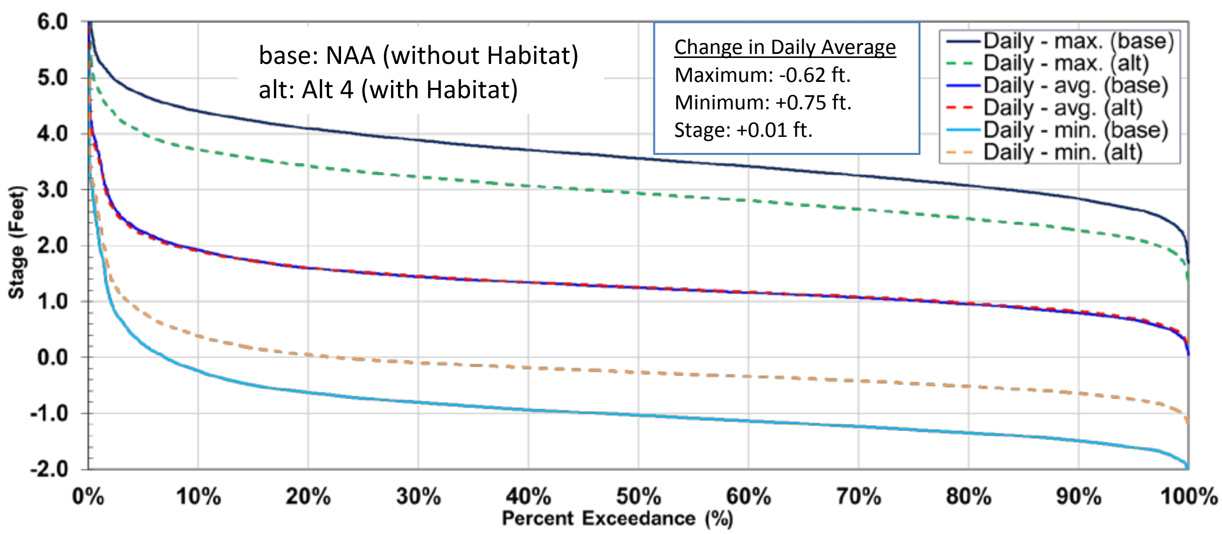

Figure 71. Daily Stage in Barker Slough at NBA Intakes

Alternative 4 with Habitat vs. No Action Alternative Without Habitat (Independent Modeling) Continued

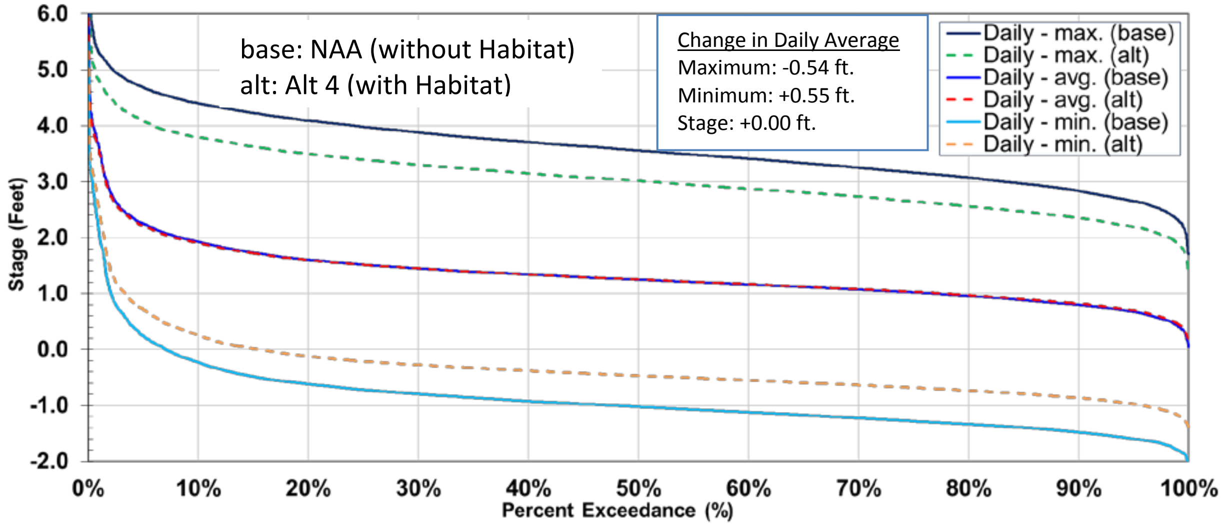

Figure 72. Daily Stage in Shag Slough Intakes

ALTERNATIVE 4 WITHOUT HABITAT VS. NO ACTION ALTERNATIVE WITHOUT HABITAT (INDEPENDENT MODELING)

Alternative 4 Without Habitat vs. No Action Alternative Without Habitat (Independent Modeling)

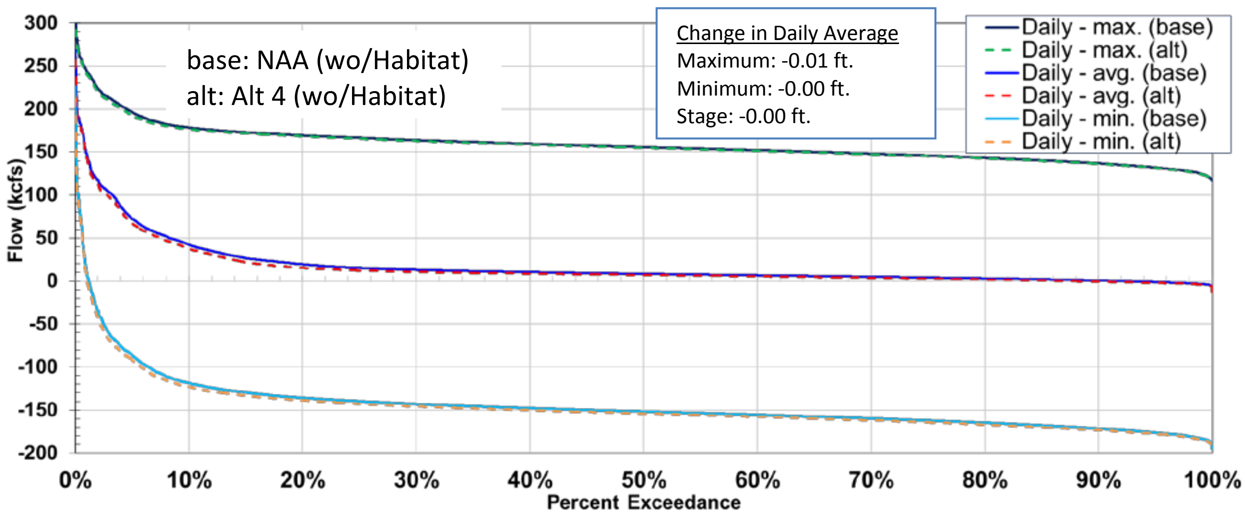

Figure 73. Daily Flow in Sacramento River at Emmaton

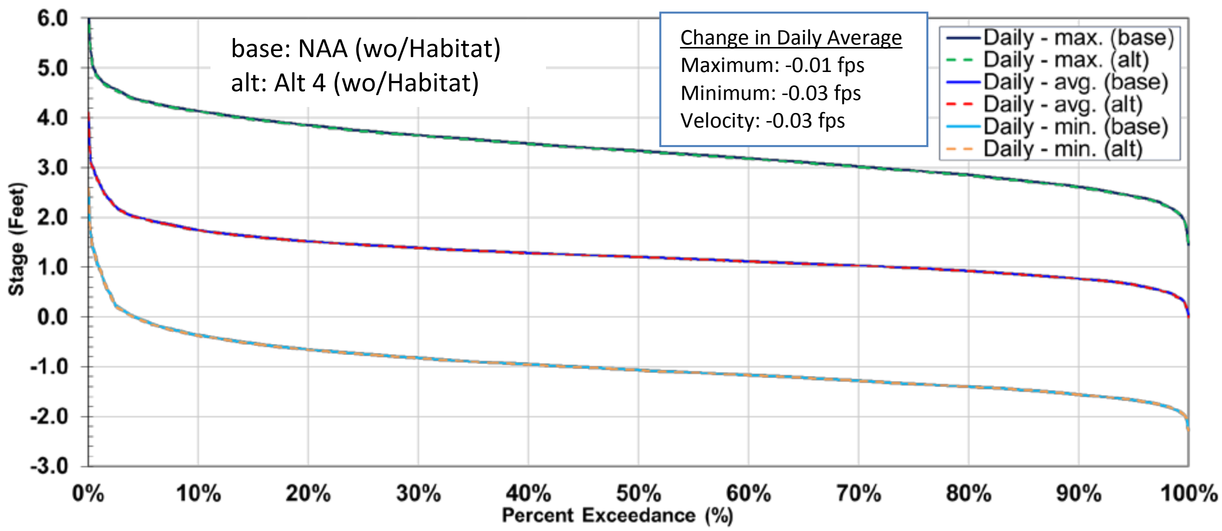

Figure 74. Daily Stage in Sacramento River at Emmaton

Alternative 4 Without Habitat vs. No Action Alternative Without Habitat (Independent Modeling) Continued

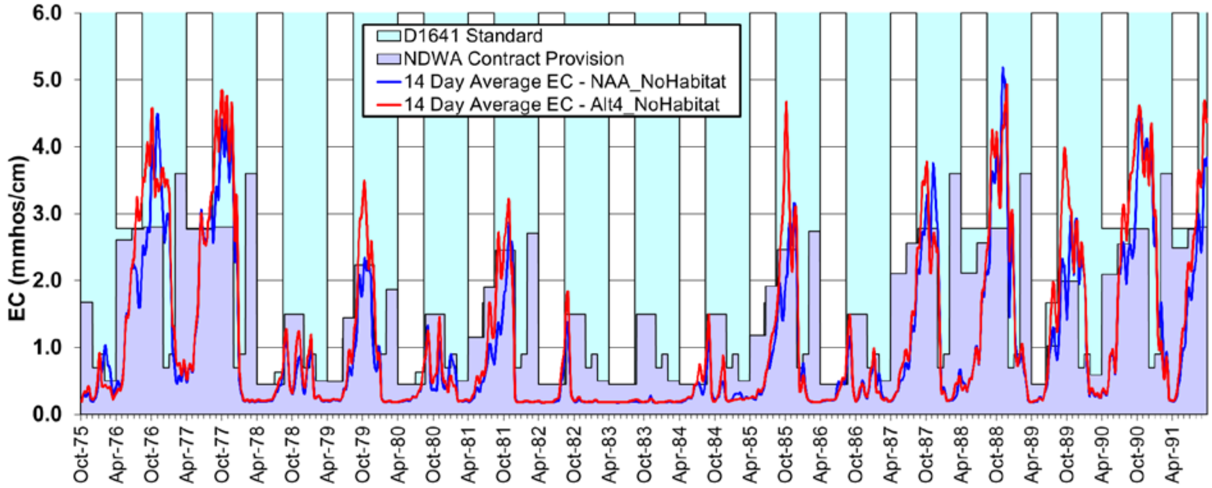

Figure 75. Daily Velocities in Sacramento River at Emmaton

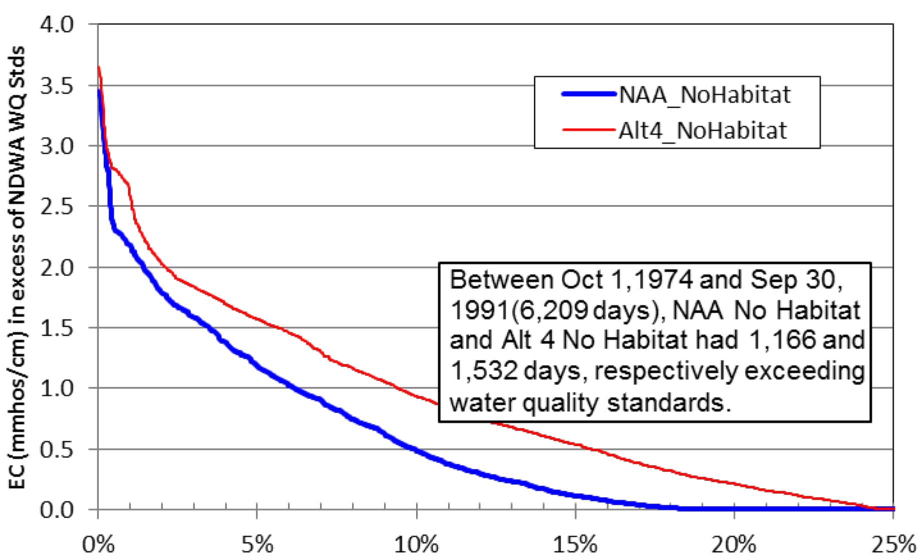

Figure 76. EC in the Sacramento River at Emmaton

Alternative 4 Without Habitat vs. No Action Alternative Without Habitat (Independent Modeling) Continued

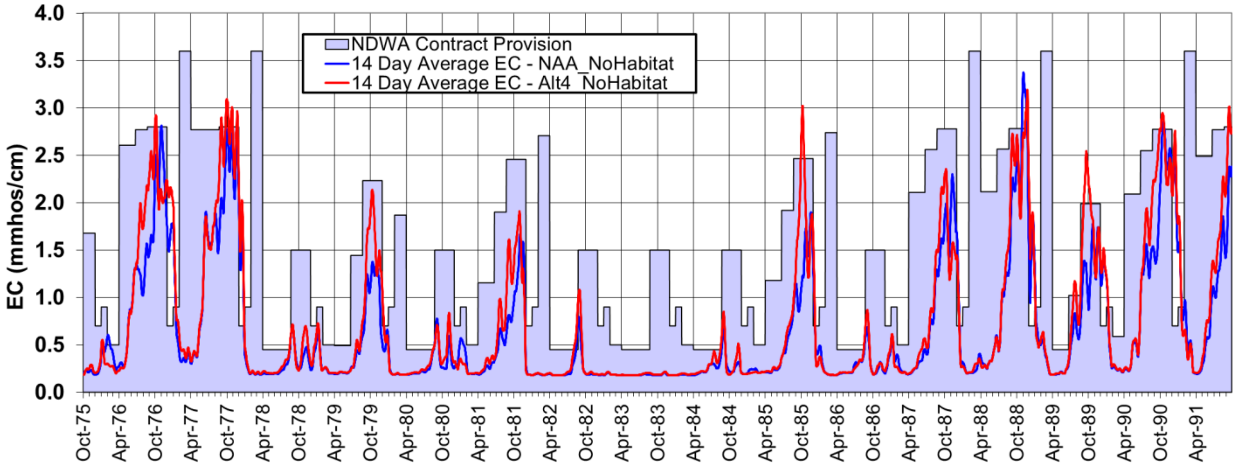

Figure 77. Probability of Exceeding EC Standards in the Sacramento River at Emmaton

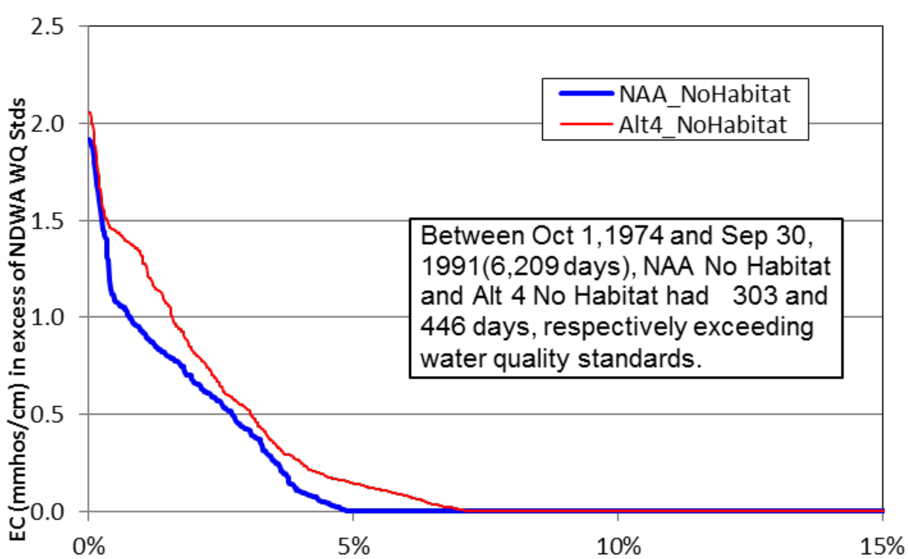

Figure 78. EC in the Sacramento River at Three Mile Slough

Alternative 4 Without Habitat vs. No Action Alternative Without Habitat (Independent Modeling) Continued

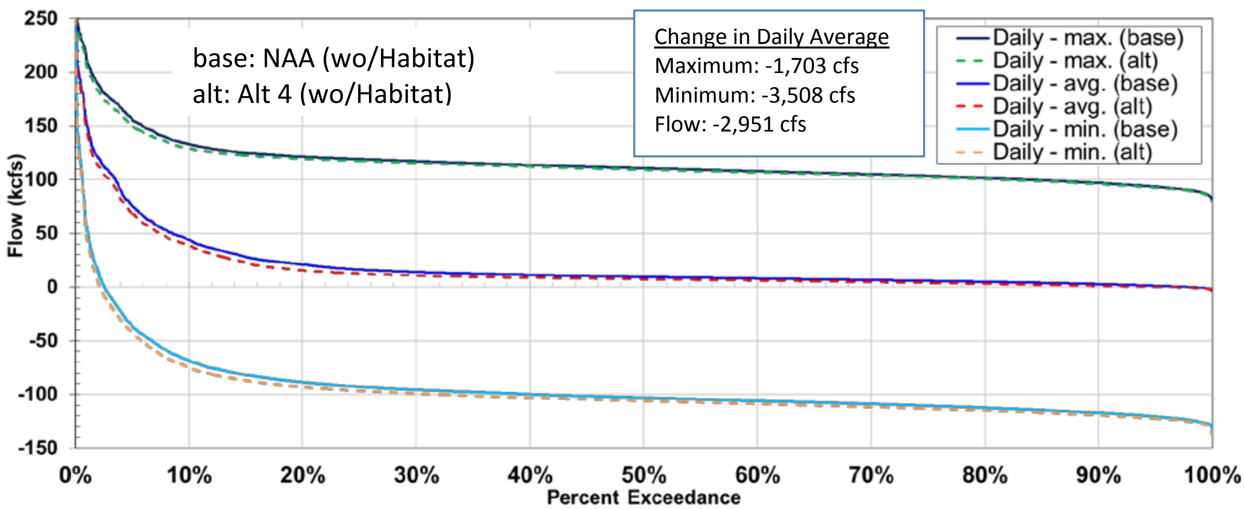

Figure 79. Probability of Exceeding EC Standards in the Sacramento River at Three Mile Slough

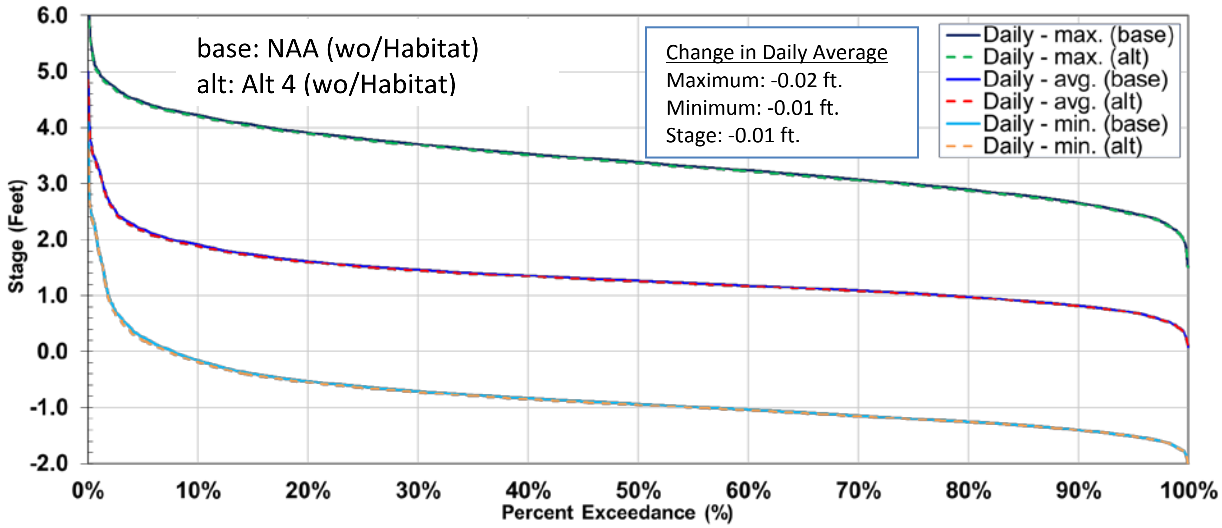

Figure 80. Daily Flow in Sacramento River at Rio Vista

Alternative 4 Without Habitat vs. No Action Alternative Without Habitat (Independent Modeling) Continued

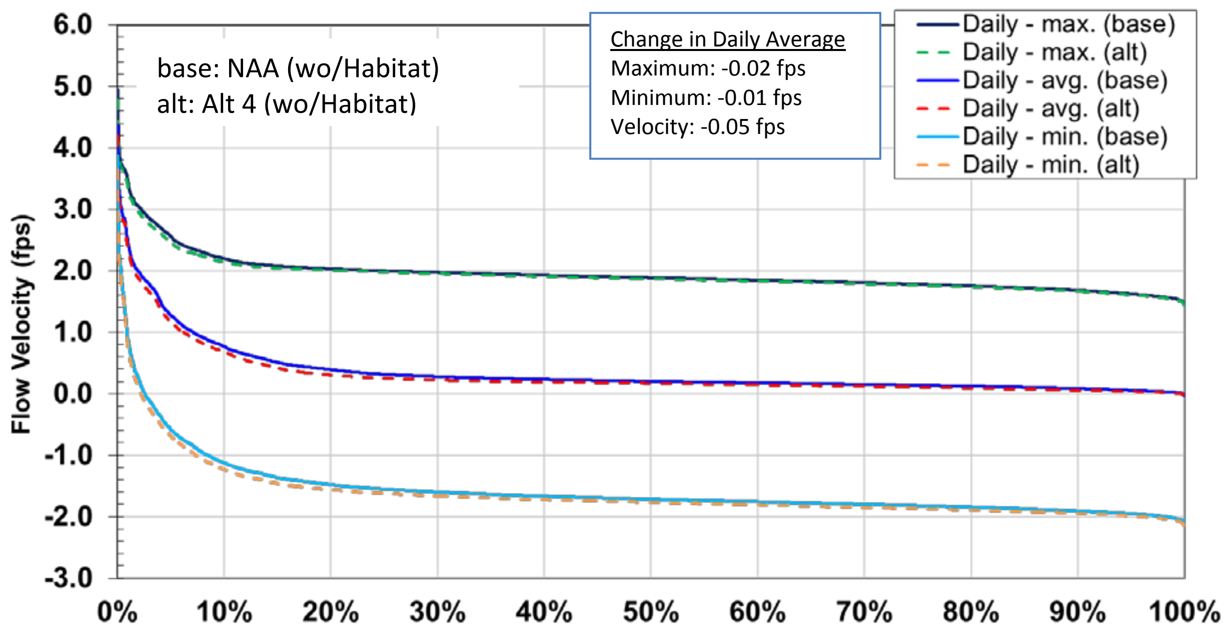

Figure 81. Daily Stage in Sacramento River at Rio Vista

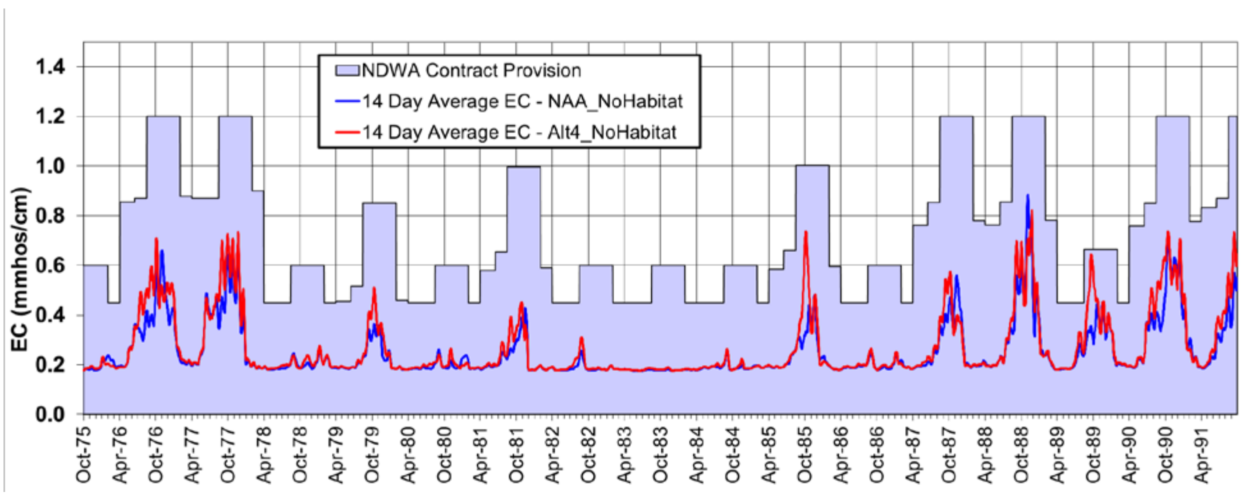

Figure 82. Daily Velocities in Sacramento River at Rio Vista

Alternative 4 Without Habitat vs. No Action Alternative Without Habitat (Independent Modeling) Continued

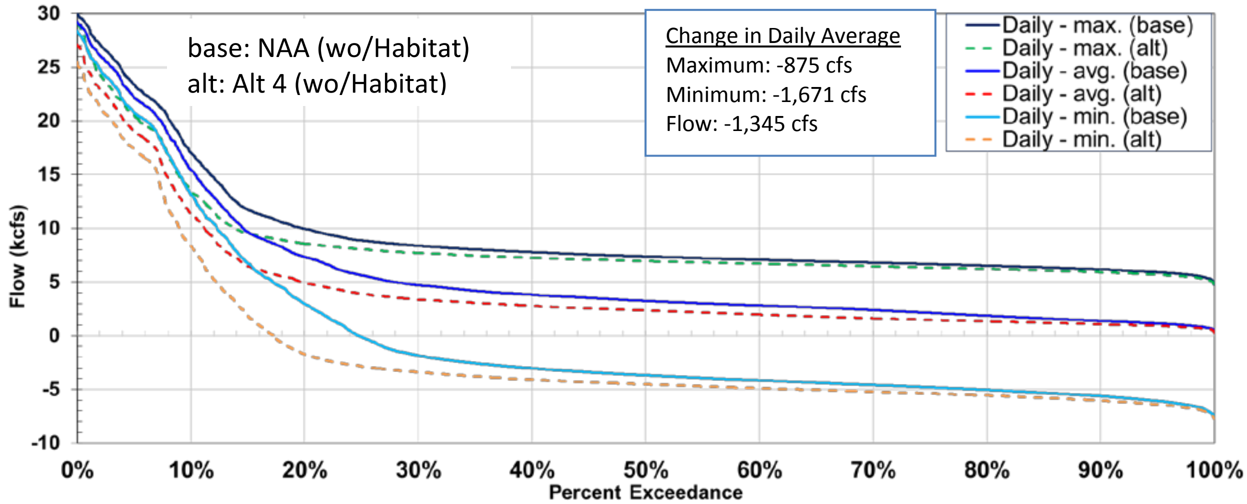

Figure 83. EC in the Sacramento River at Rio Vista

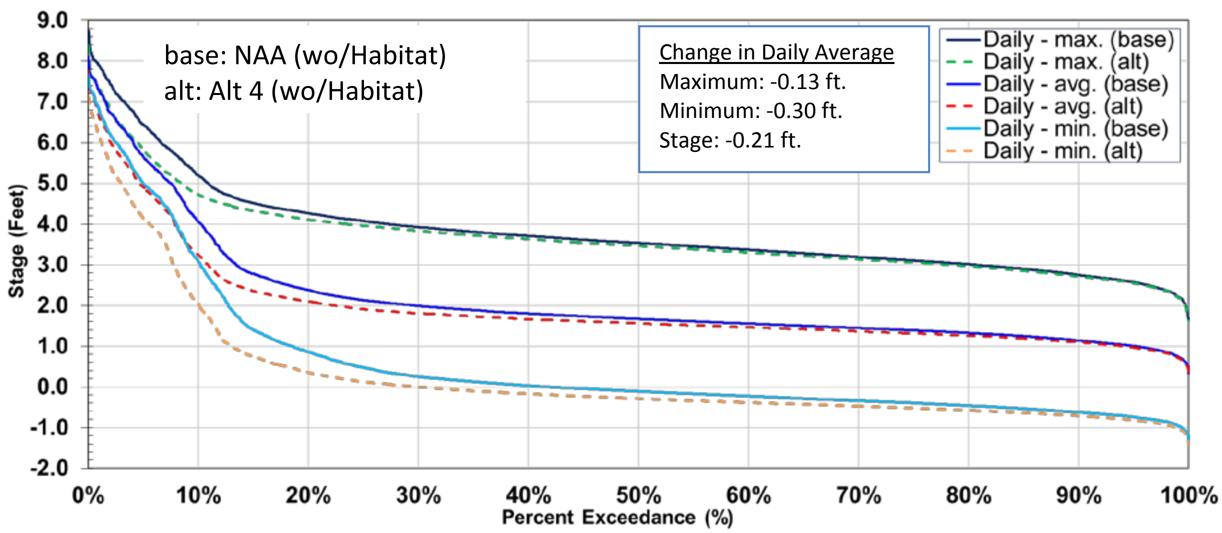

Figure 84. Daily Flow in Steamboat Slough at Sutter Slough

Alternative 4 Without Habitat vs. No Action Alternative Without Habitat (Independent Modeling) Continued

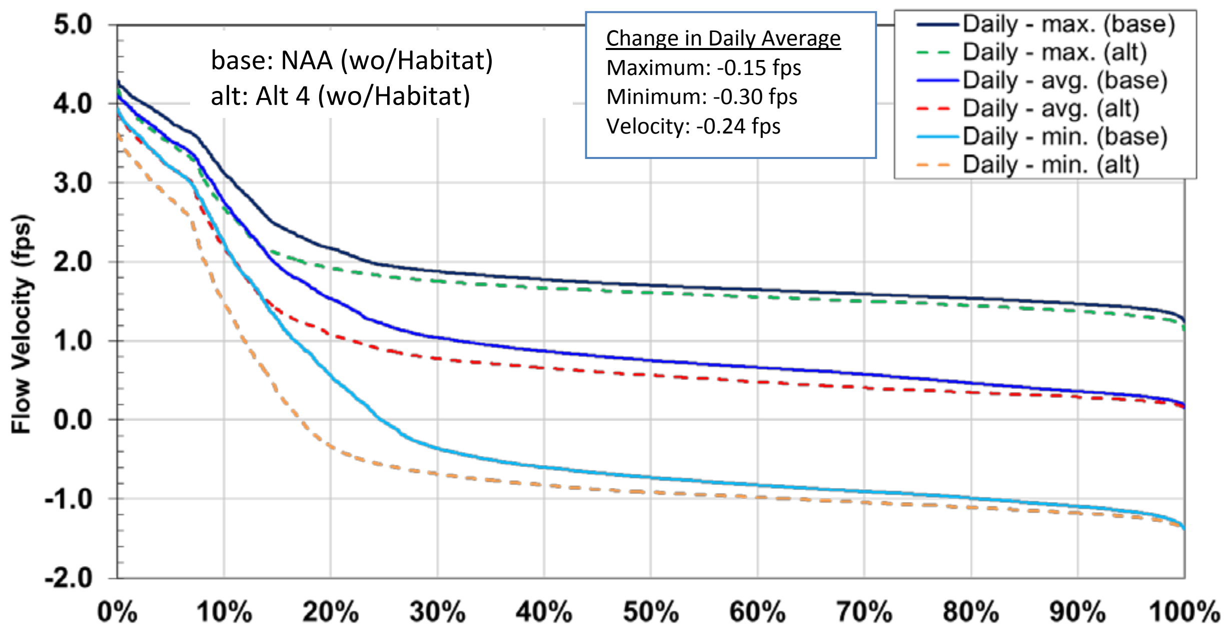

Figure 85. Daily Stage in Steamboat Slough at Sutter Slough

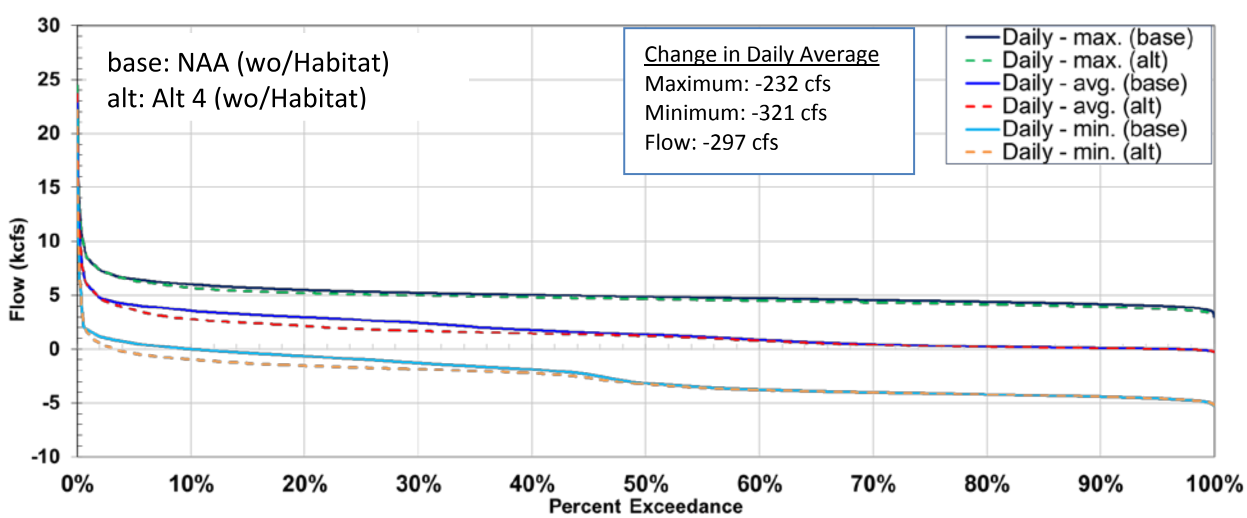

Figure 86. Daily Velocities in Steamboat Slough at Sutter Slough

Alternative 4 Without Habitat vs. No Action Alternative Without Habitat (Independent Modeling) Continued

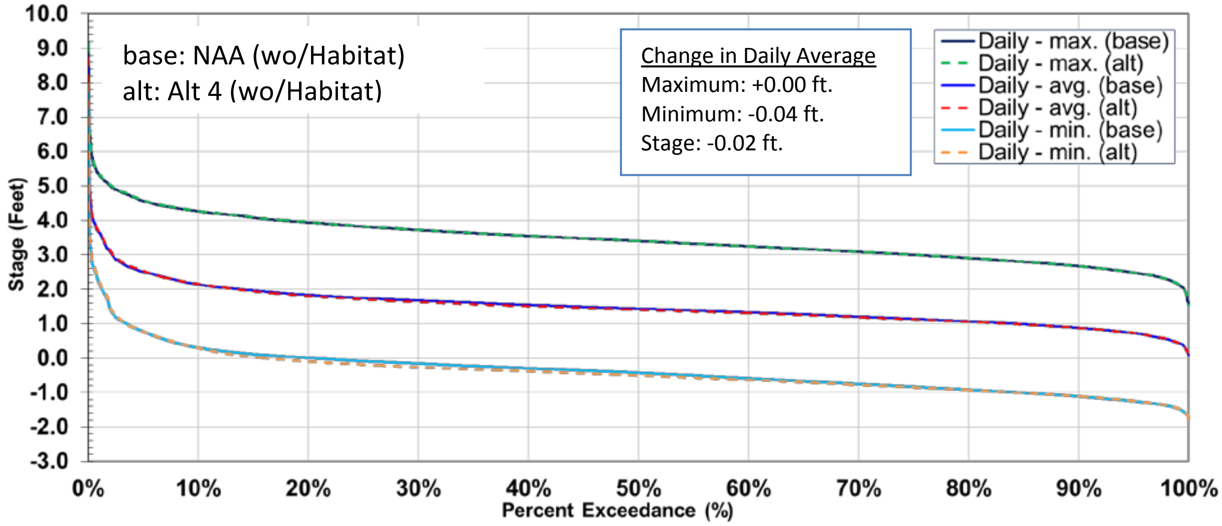

Figure 87. Daily Flow in North Fork Mokelumne River

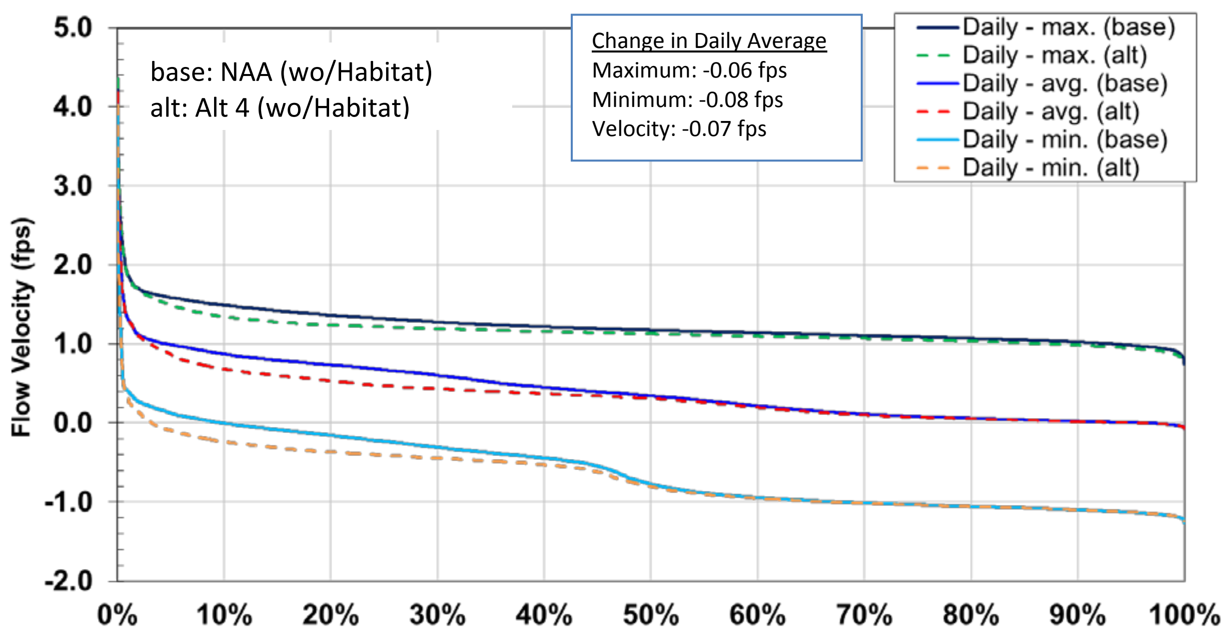

Figure 88. Daily Stage in North Fork Mokelumne River

Alternative 4 Without Habitat vs. No Action Alternative Without Habitat (Independent Modeling) Continued

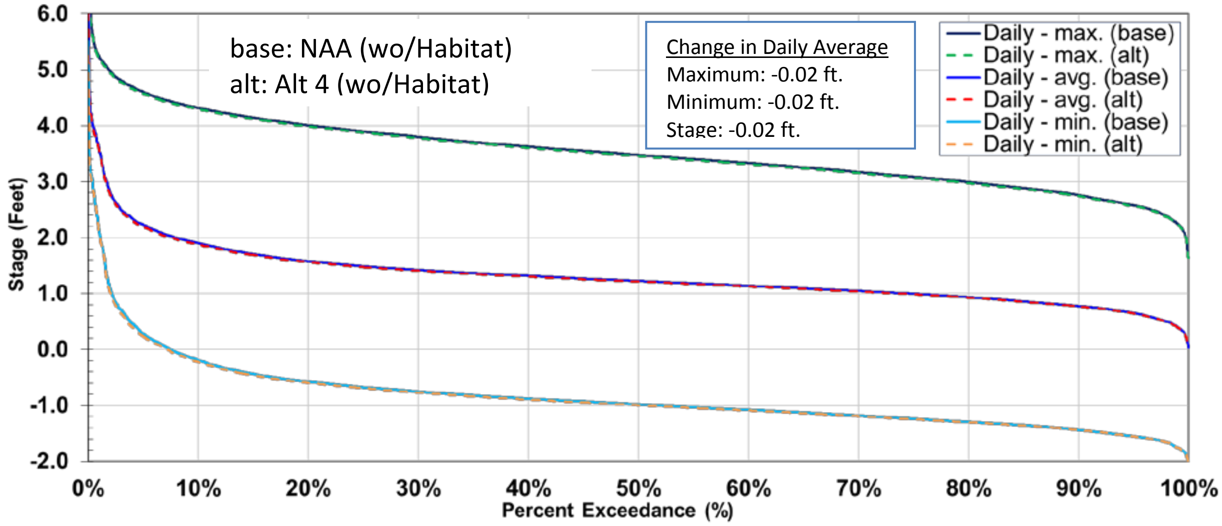

Figure 89. Daily Velocities in North Fork Mokelumne River

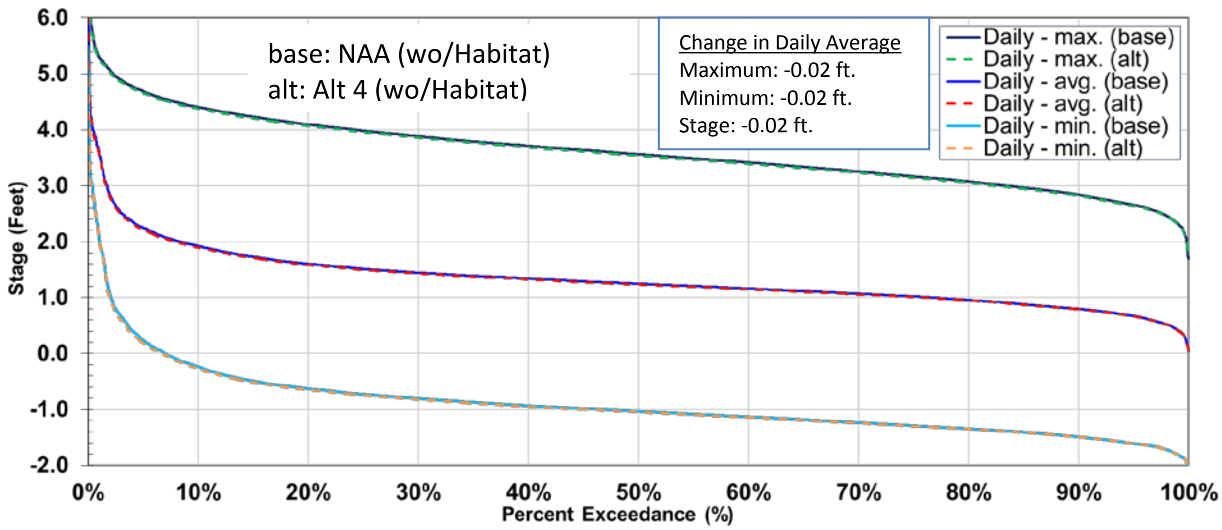

Figure 90. Daily Stage in Cache Slough at Ryer Island

Alternative 4 Without Habitat vs. No Action Alternative Without Habitat (Independent Modeling) Continued

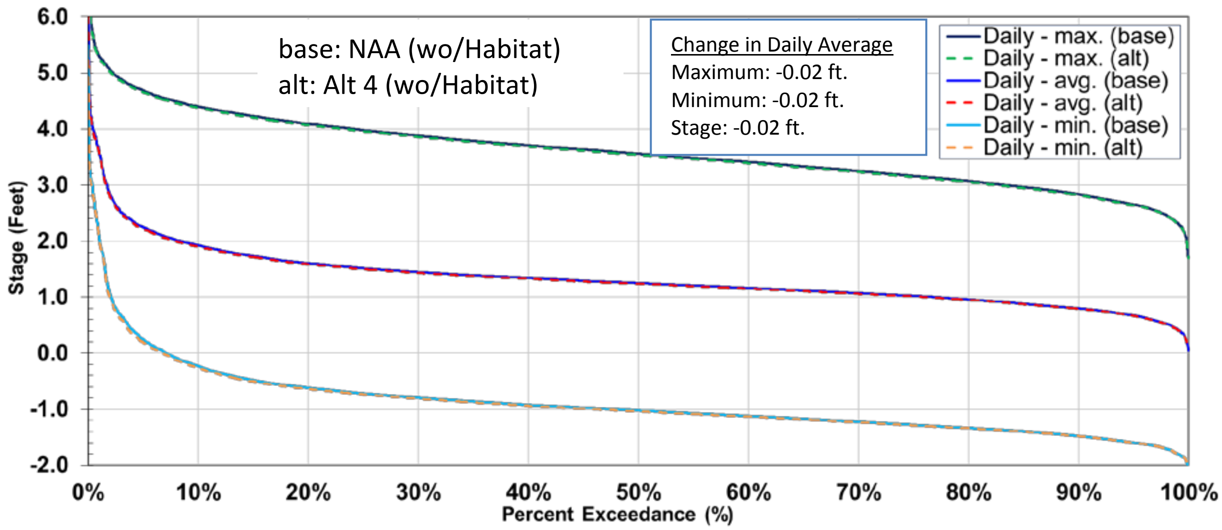

Figure 91. Daily Stage in Barker Slough at NBA Intakes

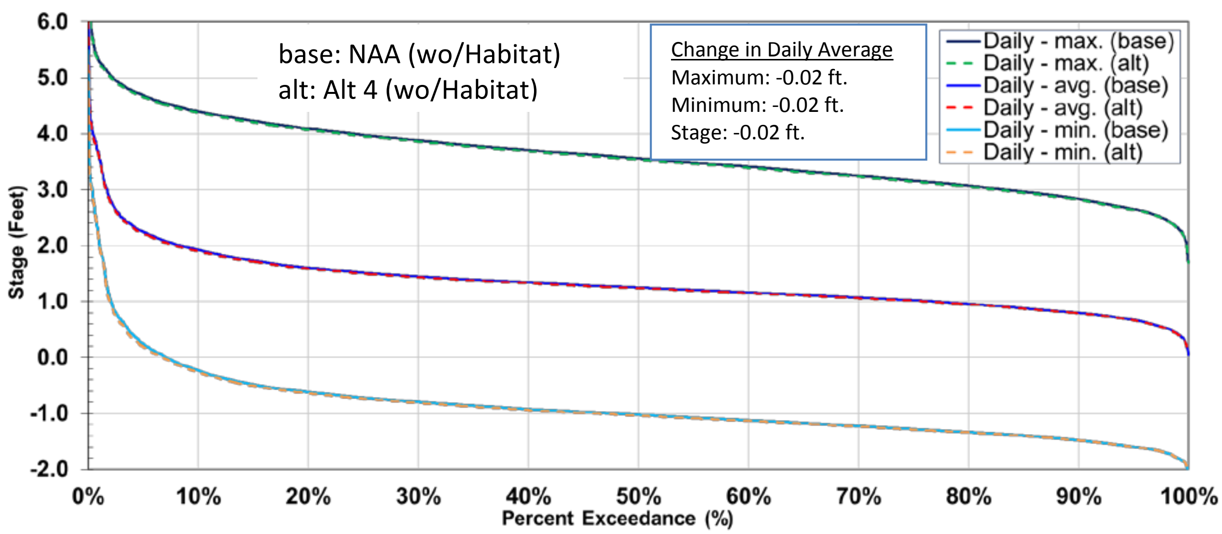

Figure 92. Daily Stage in Shag Slough Intakes