Appendix 8B
Sacramento River Ecological Flows

Line items and numbers identified or noted as “No Action Alternative” represent the “Existing Conditions/No Project/No Action Condition” (described in Chapter 2 Alternatives Analysis). Table numbering may not be consecutive for all appendixes.

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NODOS Analysis
Corrected Literature Cited

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Analysis of the North-of-the-Delta Offstream Storage Investigation

Prepared for

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1. Introduction

Report Purpose

This report is intended to provide technical information to inform the evaluation of the North-of-the-Delta Offstream Storage (NODOS) Investigation (hereafter, the Investigation). Alternatives will be evaluated in detail in the NODOS EIS/EIR and Feasibility Report. The intended audience of this report is the set of resource specialists and decision makers associated with the Investigation that are evaluating the environmental effects and feasibility of alternatives. More specifically, this report presents detailed modeling results on how a set of focal species associated with the Sacramento River may be impacted (negatively and positively) by the Investigation's alternatives. Consistent with the design intent of the Sacramento River Ecological Flows Tool (SacEFT), this report will also inform interested stakeholders, decision makers, and the public of environmental trade-offs associated with the alternatives. Analyses included in this report are not strictly limited to the Investigation's alternatives. The Nature Conservancy has also reported on scenarios that include measures (rip rap removal and gravel augmentation) that are not included in the NODOS alternatives. These scenario features are intended to be informative and are not specific features of the Investigation's alternatives.

SacEFT Background

Between 2004 and 2008 the Sacramento River Ecological Flows Study team developed a decision analysis tool that incorporates physical models of the Sacramento River with biophysical habitat models for six Sacramento River species (see: www.dfg.ca.gov/ERP/signature_sacriverecoflows.asp). The Ecological Flows Study treats flow as the "master" variable regulating the form and function of riverine habitats. The Study included development of a decision-analysis tool, the "Sacramento River Ecological Flows Tool" (SacEFT) to evaluate the ecological consequences of management-related changes in flow regime and channel restoration activities (*e.g*., gravel augmentation and selected removal of bank armoring) (ESSA 2011). The SacEFT decision support tool emphasizes the clear communication of trade-offs for key ecosystem targets associated with alternative conveyance, water operations, and climate futures in the Sacramento River ecoregion.

In SacEFT, we chose representative performance measures for multiple focal species. SacEFT includes flow and habitat relationships for six different focal species/habitats (Chinook salmon, steelhead, green sturgeon, bank swallows, channel erosion/migration (large woody debris and western pond turtle), and Fremont cottonwood). Standardized visualization interfaces allow cross-walking of ecological consequences over different water operation and channel management alternatives.

Scientifically, SacEFT takes a bottom-up, process-based approach to the relationship between flow and related aquatic habitat variables and looks at how these variables are tied to key species life-stages and ecosystem functions. Our work and the input of many expert contributors develops a more complete understanding of the flow regime and its relation to natural processes and species' requirements so as to identify the critical attributes of the flow regime necessary to maintain ecosystem function. The multi-species, multi-performance measure paradigm provides a "portfolio" approach for assessing how different flow and habitat restoration combinations suit the different life stages of desired species. In so doing, SacEFT transparently relates additional attributes of the flow regime to multiple species' life-history needs in an overall effort at careful organization of *representative* functional flow needs. This provides a robust scientific framework to focus the definition of ecological flow guidelines and contributes to the understanding of water operation effects on focal species and their habitats.

The performance measures and functional relationships built into SacEFT were vetted through multi-disciplinary workshops and numerous design document reviews. The recommendations of these technical design workshops and subsequent peer reviews provide the basis for the performance measures and models that have been developed. Specific details on SacEFT submodels and performance measures are beyond the scope of this document. Readers are referred to ESSA (2011) for detailed descriptions of submodels, performance measures and related rules and assumptions. Collectively, the constituent focal species "submodels" provide twelve (12) performance measures (Table 2-A). Multi-year roll-ups of annual performance allow users to quickly zoom in on the much smaller set of performance measures which differ significantly across management scenarios.

A design principle of SacEFT is to leverage existing systems and data sources such as CALSIM II, USRWQM, USRDOM, historical gauging station records, Meander Migration Model outputs of bank erosion, and sediment-grain size specific sediment transport models. By leveraging many of the same physical planning models used in existing environmental, socioeconomic, and water resources planning evaluations in California, SacEFT provides an "eco plug-in" for water operation studies based on use of these physical hydrologic/water balance models.

As shown in this report, model outputs include an annual summary view for each water year and a multiple year "roll-up" view which summarizes results across all years. Both views incorporate a good-fair-poor performance measure ranking system shown with green, yellow and red colors. Daily site-specific data that produce the annual roll-up rankings are recorded in database output tables, and can be used for further analyses. Additionally, more detailed daily and site-specific data are also available for the different focal species performance measures through Excel output reports in the form of raw data, tables and graphs. SacEFT's output interface and reports for trade-off analyses make it clear how actions implemented for the benefit of one area or focal species may affect (both positively and negatively) another area or focal species. For example, we can show how altering Sacramento River flows to meet export pumping schedules in the Delta affects focal species' performance measures in the Upper and Middle Sacramento River.

1.1 Complementary Modeling Paradigms

Many agencies and organizations (*e.g.,* The Nature Conservancy (TNC), Bureau of Reclamation (USBR), Department of Water Resources (DWR), the US Geological Survey (USGS,) and the US Army Corps of Engineers (USACE)) have all developed flow modeling tools in response to a need to understand how flow and riparian land-use changes impact ecosystems. The modeling of ecosystem relationships is often used to assess ecosystem health or in the case of flow regime assessments, determine trade-offs between human water uses and ecological needs (Rapport *et al.* 1998).

Unlike physical modeling, attempting to build detailed ecological models that make accurate predictions of ecosystem behavior is challenging and usually not possible in complex, open natural systems (Oreskes *et al.* 1994). Because of the high uncertainty and incomplete understanding surrounding the complex interactions of communities of species with their physical environments (*e.g.*, time-lagged compensatory density-dependent survival mechanisms) modeling tools like SacEFT emphasize a specific set of species and life-stage linkages with physical habitat variables. The SacEFT approach does not consider detailed life-cycle modeling of a single species in an effort to predict precise numbers of emigrating smolts or returning adult spawners. As with the other modeling tools used in the Investigation, the focus of SacEFT is determining comparative effects on specific performance indicators. The assumption implicit in SacEFT is that flows and habitat conditions that generate better outcomes for discrete life-stage performance measures should – all else being equal – enable the species to support higher adult abundances. SacEFT also embeds a preferential emphasis on freshwater flow management where resource managers have more influence over conditions, than is practical in the case of marine conditions and processes (which usually exert a strong influence on adult abundance in salmonids).

In the case of fish species it is recognized that due to compensatory dynamics that can drive population level responses, that more high-quality habitat at a particular (usually freshwater juvenile) life-stage does not always translate to a higher abundance of adults. For this reason other modeling efforts pursue full life-cycle population representations that aim to evaluate the space-time abundance of a particular species (*e.g.*, Winter-Run Chinook Life Cycle Model (WRCLCM), also known as Winter-run Chinook IOS/DPM Model or SALMOD). By tracking the abundance and survival of salmon through successive life-stages, cumulative effects on specific run-types of Chinook salmon populations are simulated.

Given the accepted challenges of "validating" ecological models (Oreskes *et al.* 1994) many modeling practitioners favor a weight of evidence approach whereby directional trends in model predictions are compared across alternative (independently developed) models. Where multiple models determine the same rank-order results and trends, the strength of the evidence, or degree of belief in those evaluations increases. Hence, the relative trends in evaluations from life-cycle models provide an important and complementary line of evidence to SacEFT (and *vice versa*) in the assessment of flow management effects. For example, target flows identified by SacEFT could be simulated with IOS/DPM to determine the expected increase (if any) in total outmigrating winter-run Chinook smolts leaving the Sacramento River.

1.1.1 Classes of eFlow Assessment Tools

The Winter-run Chinook IOS/DPM, SALMOD and SacEFT all represent tools that fall in the **process-based** causal linkage category (Figure 1.1). Process-based models simulate linkages between flow, in-channel and riparian habitat changes through to a specific change in the survival or productivity of a particular focal species and life-stage (*e.g.*, success index of Fremont cottonwood (*Populus fremontii*) seedling initiation, Chinook salmon (*Oncorhynchus tshawytscha*) redd de-watering risk). In process-based models mathematical algorithms are used to describe the time-varying amount and relative suitability of habitat by drawing empirical relationships between species and environmental variables. These bio-physical relationships can for example be used to produce a habitat suitability index. Such indices can then be used to rank flow management alternatives or in the case of the Investigation, make comparisons with a baseline scenario.

A more widespread class of ecological flow assessment tools emphasizes generalized hydrologic indices and targets (Figure 1.1). These generalized hydrologic models analyze the changes in flow metrics themselves and leave it up to the user, outside of the tool, to infer the resultant habitat suitability changes or otherwise interpret how changes in the hydrologic index might potentially influence a particular species of concern. Both approaches for assessing and/or prescribing ecological flows are based on the idea that biological responses are adapted to and shaped by a river basin's natural hydrologic flow regime (inter- and intra-annual variability of flow levels and sequences of events) of a river (Poff *et al.* 1997). Early work in this area led to a definition of a collection of simple statistical metrics to quantify change in flow regime, typically after flow regulation (Richter *et al.* 1996). In an effort to assess how much a flow regime has been altered, indices of a natural (pre-regulation historical) regime can be compared with the indices of an altered flow regime. Further research proposed the idea that such statistical indices naturally have a range of variability, which led to the Range of Variability Analysis (RVA) approach, which can be used to compare different flow regimes. For these generalized hydrologic models – while there is a great deal of technical judgment required to interpret the biological significance of performance measure changes – they provide the advantage of offering simple/readily available input data. Thus, these methods can be more readily applied in other river basins with lower cost.

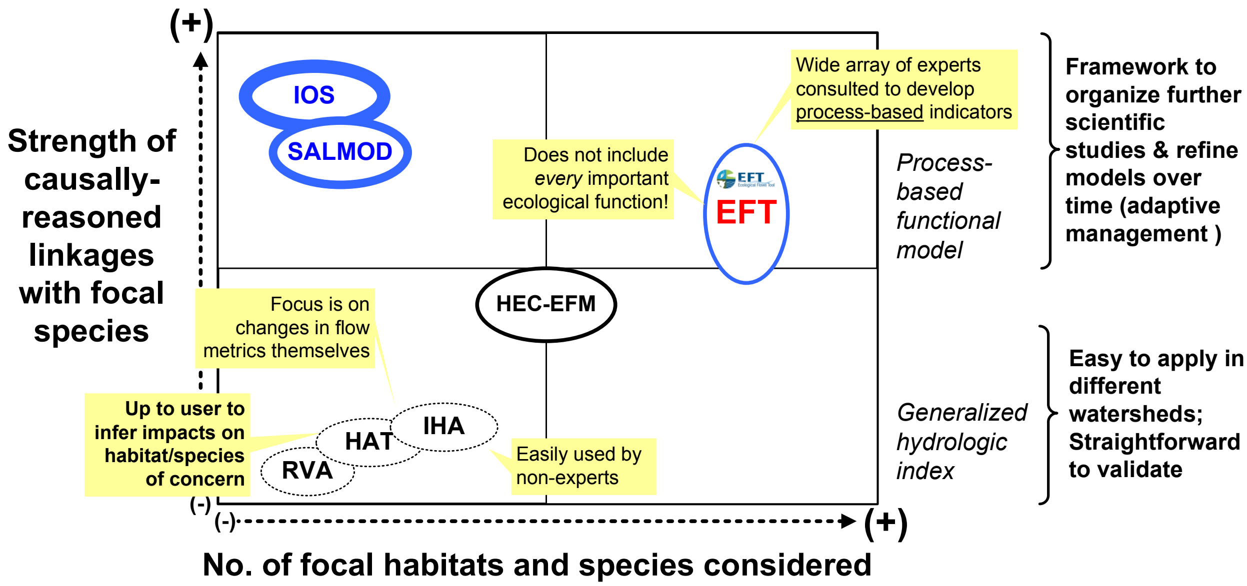


Figure 1.1: Attributes of alternative ecological flow assessment tools showing placement of the Sacramento River Ecological Flows Tool (SacEFT; ESSA (2011)). IHA = Indicators of Hydrologic Alteration (Mathews and Richter 2007). HAT = Hydrologic Assessment Tool (Kennen *et al.* 2009). RVA = Range of Variability Analysis (Mathews and Richter 2007). HEC-EFM = Hydrologic Engineering Center Ecosystem Functions Model (USACE 2002). IOS = Winter-run Chinook IOS/DPM. SALMOD = Salmonid Population Model (Bartholow *et al.* 2002).

1.2 North-of-the-Delta Offstream Storage Investigation

(a)

(b)

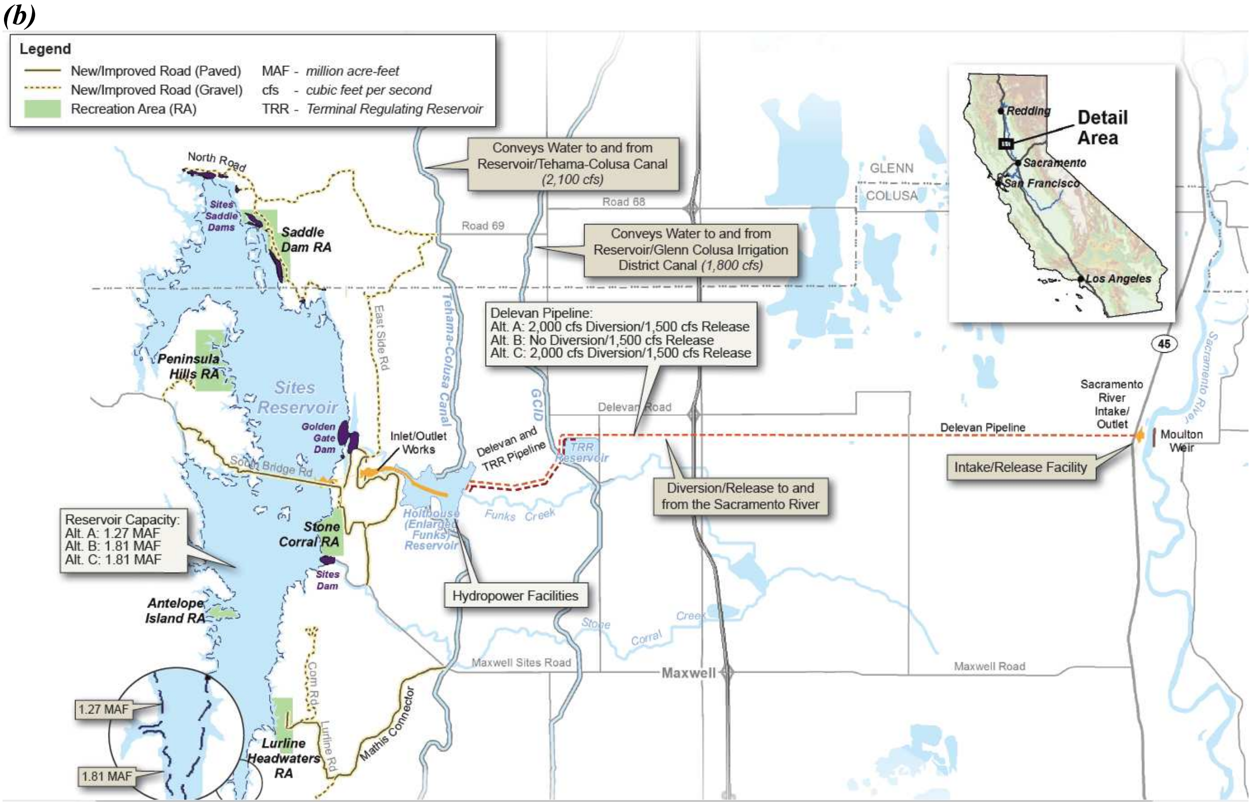


Figure 1.2: Artist's rendition of Sites Reservoir (a) and its location relative to the Sacramento River (b). Note: bottom panel (b) is for illustration purposes only, and is not intended to represent the final or preferred Plan Alternative. NODOS alternatives all include three conveyance facilities: TC Canal, GCID Canal and Delevan pipeline.

The North-of-the-Delta Offstream Storage (NODOS) Investigation is evaluating potential offstream surface water storage by constructing Sites Reservoir (pictured above) near the Sacramento River, downstream from Shasta Dam and west of Maxwell. The high-level project objectives are to:

- Improve water supply reliability for agricultural, urban, and environmental uses;
- Improve drinking, agricultural and environmental water quality in the Delta;
- Provide flexible hydropower generation to support integration of renewable energy sources; and
- Increase survival of anadromous and endemic fish populations.

The alternatives considered in this document are summarized in an October 1, 2010 memorandum, "Assumptions for Existing and Future No Action Alternative Conditions CALSIM II and DSM2 Models." The assumptions for the NODOS Alternatives are summarized in a January 5, 2011 document, "Definition of Proposed Alternatives for Evaluation in the North-of-the-Delta Offstream Storage Administrative Draft Environmental Impact Report and Statement." High level summaries of major alternatives are provided in Table 1-A.

Table 1-A: Interim Plan Formulation Alternatives – NODOS Investigation. Details subject to change. Information provided by the NODOS investigation planning team, DWR (August 2011).

Alternative	A	B	C
Storage Capacity			
Sites Reservoir	1.27 MAF	1.81 MAF	1.81 MAF
Conveyance Capacities *(to Sites Reservoir)*[1]			
Tehama-Colusa Canal	2,100 cfs	2,100 cfs	2,100 cfs
Glenn Colusa Irrigation District Canal	1,800 cfs	1,800 cfs	1,800 cfs
New Delevan Pipeline[2]			
Diversion	2,000 cfs	0 cfs [3]	2,000 cfs
Release	1,500 cfs	1,500 cfs	1,500 cfs
Operations Priorities *(Primary Planning Objectives)*			
Long Term *(all years)*	EESA[4] Power[5]	EESA[4] Power[5]	EESA[4] Power[5]
Driest Periods *(drought years)*	M&I	M&I	M&I
Average to Wet Periods *(non-drought years)*	Water Quality Level 4 Refuge Agricultural	Water Quality Level 4 Refuge Agricultural	Water Quality Level 4 Refuge Agricultural

Notes:

1. Diversions through the TC Canal, GCID Canal, and Delevan Pipeline are allowed in any month of the year.
2. New Delevan Pipeline can be operated June through March (April and May are reserved for maintenance).
3. A pump station, intake, and fish screens are not included for the Delevan Pipeline for Alternative B. For Alternative B, the Delevan Pipeline will be operated for releases only from Sites Reservoir to the Sacramento River year round.
4. Ecosystem Enhancement Storage Account (EESA) related operations are a function of specific conditions, and operating criteria that are defined uniquely for each action.
5. Includes dedicated pump/generation facilities with an additional dedicated after-bay/fore-bay (enlarged Funks Reservoir) used for managing conveyance of water between Sites Reservoir and river diversion locations.

Key:

cfs = cubic feet per second
CVP = Central Valley Project
EESA = ecosystem enhancement storage account
MAF = million acre-feet
M&I = municipal and industrial
SWP = State Water Project
TAF = thousand acre-feet

1.2.1 Ecosystem Enhancement Actions

The proposed NODOS alternatives include the following Ecosystem Enhancement Actions (EEAs):

Action 1. Improve the reliability of coldwater pool storage in Shasta Lake to increase the US Bureau of Reclamation's operational flexibility to provide suitable water temperatures in the Sacramento River (see Action 2 below). This action would operationally translate into the increase of Shasta Lake May storage levels, and increased coldwater pool in storage, with particular emphasis on Below Normal, Dry and Critical water year types.

Action 2. Provide releases from Shasta Dam of appropriate water temperatures, and subsequently from Keswick Dam, to maintain mean daily water temperatures year-round at levels suitable for all species and life-stages of anadromous salmonids in the Sacramento River between Keswick Dam and Red Bluff Diversion Dam, with particular emphasis on the months of highest potential water temperature-related impacts (*i.e.*, July through November) during Below Normal, Dry and Critical water year types.

Action 3. Increase the availability of coldwater pool storage in Folsom Reservoir, by increasing May storage and coldwater pool storage, to allow the U.S. Bureau of Reclamation additional operational flexibility to provide suitable water temperatures in the lower American River. This action would utilize additional coldwater pool storage by providing releases from Folsom Dam (and subsequently from Nimbus Dam) to maintain mean daily water temperatures at levels suitable for juvenile steelhead over-summer rearing and fall-run Chinook salmon spawning in the lower American River from May through November during all water year types (not explicitly modeled in CALSIM II).

Action 4. Provide supplemental Delta outflow during summer and fall months (*i.e.*, May through December) to improve X2 (if possible, west of Collinsville, 81 km) and increase estuarine habitat, reduce entrainment, and improve food availability for anadromous fishes and other estuarine-dependent species (*e.g.*, delta smelt, longfin smelt, Sacramento splittail, starry flounder, and the shrimp *Crangon franciscorum*).

Action 5. Improve the reliability of coldwater pool storage in Lake Oroville to improve water temperature suitability for juvenile steelhead and spring-run Chinook salmon over-summer rearing and fall-run Chinook salmon spawning in the lower Feather River from May through November during all water year types. Provide releases from Oroville Dam to maintain mean daily water temperatures at levels suitable for juvenile steelhead and spring-run Chinook salmon over-summer rearing, and fall-run Chinook salmon spawning in the lower Feather River. Stabilize flows in the lower Feather River to minimize redd dewatering, juvenile stranding and isolation of anadromous salmonids.

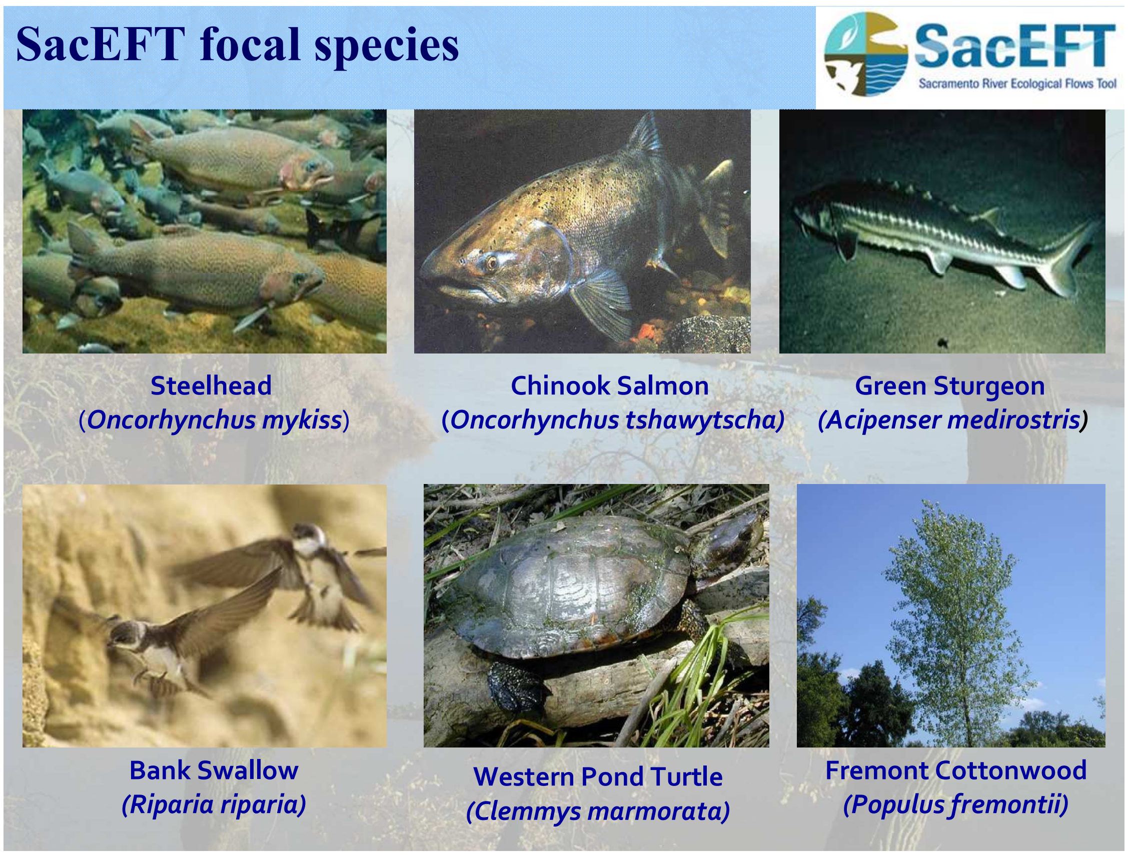
Action 6. Stabilize flows in the Sacramento River between Keswick Dam and the Red Bluff Diversion Dam to minimize dewatering of fall-run Chinook salmon redds (for the spawning and embryo incubation life-stage periods extending from October through March), particularly during fall months.

Action 7. Provide increased flows from spring through fall in the lower Sacramento River by reducing diversions at Red Bluff Diversion Dam (into the Tehama-Colusa Canal) and at Hamilton City (into the Glenn-Colusa Irrigation District Canal), and by providing supplemental flows (at Delevan). This action will provide multiple benefits to riverine and estuarine habitats, and to anadromous fishes and estuarine-dependent species (*e.g.*, delta smelt, splittail, longfin smelt, Sacramento splittail, starry flounder, and the shrimp *Crangon franciscorum*) by reducing entrainment, providing or augmenting transport flows, increasing habitat availability, increasing productivity, and improving nutrient transport and food availability.

2. Methodology and Assumptions

Details on SacEFT performance measure algorithms and their science foundation are beyond the scope of this document. Please refer to the SacEFT Record of Design for a complete description of model performance measures and assumptions (ESSA 2011).

2.1 SacEFT's Focal Species and Performance Measures



SacEFT's focal species and performance measures – discussed in detail in ESSA (2011) – are listed in Table 2-A. The sections that follow below provide a brief summary of SacEFT's focal species and performance measures.

Table 2-A: SacEFT focal species, ecological objectives, and performance measures.

Focal Species	Ecological Objectives	Performance Measures
Fremont cottonwood (FC)	Maximize areas available for riparian initiation, and rates of initiation success at individual index sites.	FC1 – Successful Fremont cottonwood initiation (incidence of cottonwoods initiated along a given cross section, at end of seed dispersal period) FC2 – Cottonwood seedling scour. Following years that have fair to good initiation success, evaluate the risk of seedling scour during the first year following successful initiation.
Bank swallow (BASW)	Maximize availability of suitable nesting habitats	BASW1 – Habitat potential/suitability. BASW2 – Risk of nest inundation and bank sloughing during nesting
Western pond turtle (WPT)	Maximize availability of habitats for foraging, basking, and predator avoidance	LWD1 – Index of old vegetation recruited to the Sacramento River mainstem.
Green sturgeon (GS)	Maximize quality of habitats for egg incubation	GS1 – Egg-to-larvae survival
Chinook salmon, Steelhead trout (CS)	Maximize quality of habitats for adult spawning	CS1 – Area of suitable spawning habitat (ft^2)
	Maximize quality of habitats for egg incubation	CS3 – Egg-to-fry survival (proportion) CS5 – Redd scour (Red/Yellow/Green hazard zones) CS6 – Redd dewatering (proportion)
	Maximize availability and quality of habitats for juvenile rearing	CS2 – Area of suitable rearing habitat (ft^2) CS4 – Juvenile stranding (index)

In addition to the SacEFT v.2 Record of Design (ESSA 2011), the Sacramento River Ecological Flows Study Final Report[1] (TNC *et al.* 2008) provides further background on hypotheses and linkages between riverine processes and biological responses for these species in SacEFT.

2.1.1 Aquatic Species and Performance Measures

Green Sturgeon Egg Survival (GS1)

Green sturgeon (*Acipenser medirostris*) eggs are susceptible to overheating during the April-July spawning and larval development period. Warm water temperatures during egg incubation increase the number of embryos that develop abnormally and reduce hatching success. Specifically, water temperatures above 17°C reduce egg survival and are lethal above 20°C. SacEFT uses daily water temperature at spawning index locations to simulate the proportion of survival for the larval young of year. Performance measure details and science foundation references are provided in the SacEFT v.2 Record of Design (ESSA 2011).

Chinook & Steelhead Spawning Habitat (ST1 / CH1)

Salmonids (4 seasonal run-types of Chinook (*Oncorhynchus tshawytscha*) plus steelhead trout (*Oncorhynchus mykiss*)) prefer to spawn in streams with a specific combination of water depth, velocity and gravel composition. SacEFT incorporates these preferences based on the River2D model and combines them with daily flow during the spawning period to calculate and report the weighted available habitat area for spawning, at up to 5 index sections of the Upper Sacramento River. The performance

[1] Available here: www.dfg.ca.gov/ERP/signature_sacriverecoflows.asp.

measure is weighted by the relative density of adult spawners present throughout the species and run-specific spawning period. Performance measure details and science foundation references are provided in the SacEFT v.2 Record of Design (ESSA 2011).

There is a common misperception that habitat potential is equivalent to spawning abundance. This is not the case. In SacEFT, spawning habitat quality (ST1 / CH1) is indexed by Weighted Usable Area (WUA); which is derived from the River2D simulation model, fitted to data obtained and parameterized by Mark Gard (USFWS) (USFWS 2005a). River2D's calculations depend on spatially explicit measurements of velocity, depth and gravel size; laboriously measured over survey grids located on 5 index reaches of the Sacramento River. WUA is therefore a quantitative measure that incorporates location-specific quality (*e.g.*, preferred depth, velocity, gravel). Although River2D uses velocity and depth internally, both of those variables are parameterized so that only flow is required as input.

None of the Chinook or Steelhead performance measures in SacEFT include explicit treatment of spawning populations: they are measures of habitat potential only (not how many actual spawning Chinook/steelhead make use of this potential habitat). Further, although there are several linkages between some performance measures, there is no linkage between redd dewatering and spawning WUA: they are completely independent in their calculation. It is up to biologists to interpret the relative effects on overall smolt production associated with directional changes in the different spawning/egg/fry performance measures available in SacEFT. The idea being that "more good" is always better than "more bad" when integrated over multiple simulation years and performance measures. SacEFT allows users to pull out what attributes of the flow regime specifically generate "more good" (or "more bad") and then feedback those flow regime attributes as new/revised constraints to CalSim/USRDOM modellers for inclusion in the upfront hydrosystem models. We are able to do this for multiple focal species, fish and riparian performance measures.

Chinook & Steelhead Egg-to-Fry Survival (ST3 / CH3)

The developing eggs of salmonids (4 seasonal run-types of Chinook (*Oncorhynchus tshawytscha*) plus steelhead trout (*Oncorhynchus mykiss*)) have specific water temperature requirements to successfully mature. SacEFT uses relationships from the SALMOD model, along with daily water temperature at up to 5 index sections to simulate the maturation and proportional survival of developing eggs. The performance measure is weighted by the relative density of eggs present in spawning redds. Performance measure details and science foundation references are provided in the SacEFT v.2 Record of Design (ESSA 2011).

Chinook & Steelhead Redd Dewatering (ST6 / CH6)

Spawning redds contain the developing eggs of salmonids (4 seasonal run-types of Chinook (*Oncorhynchus tshawytscha*) plus steelhead trout (*Oncorhynchus mykiss*)) and are susceptible to declining flows that expose and desiccate the redds. SacEFT incorporates empirical relationships developed from GIS models to calculate the proportion of redd habitat exposed during periods of declining flows. Performance measure details and science foundation references are provided in the SacEFT v.2 Record of Design (ESSA 2011).

Chinook & Steelhead Redd Scour (ST5 / CH5)

Spawning redds contain the developing eggs of the 4 season run-types of Chinook (*Oncorhynchus tshawytscha*) in SacEFT plus steelhead (*Oncorhynchus mykiss*) and are susceptible to extremely high flow events that mobilize the gravel of the redd, killing portions of the developing eggs/embryos. SacEFT combines these high flow events with the species and run-type specific spawning and egg development calendar to calculate and report the frequency of high flow events at times and locations when the developing embryos are most sensitive. Performance measure details and science foundation references are provided in the SacEFT v.2 Record of Design (ESSA 2011).

Chinook & Steelhead Juvenile Stranding (ST4 / CH4)

Free swimming juvenile salmonids (4 seasonal run-types of Chinook (*Oncorhynchus tshawytscha*) plus steelhead trout (*Oncorhynchus mykiss*)) typically reside in their natal stream for 3 to 12 months after emerging from the gravel. During this period they are susceptible to declining flows that may strand them in side channels exposing them to high water temperatures, desiccation and other factors heightening rates of mortality. SacEFT incorporates empirical relationships developed from GIS bathymetric models to calculate an index at up to 5 sections of the Sacramento River of the proportion of juveniles exposed to stranding during periods of declining flow. The performance measure is weighted by the relative density of juvenile fish present during the species and run-specific rearing period. Performance measure details and science foundation references are provided in the SacEFT v.2 Record of Design (ESSA 2011).

Chinook & Steelhead Juvenile Rearing Habitat (ST2 / CH2)

Juvenile salmonids (4 seasonal run-types of Chinook (*Oncorhynchus tshawytscha*) plus steelhead trout (*Oncorhynchus mykiss*)) prefer to rear in streams with a specific combination of water depth and velocity. SacEFT incorporates these preferences from the River2D model and combines them with daily flow during the rearing period to calculate and report the weighted available habitat area for rearing, at up to 5 index sections of the Upper Sacramento River. The performance measure is weighted by the relative density of juvenile fish present during the species and run-specific rearing period. Performance measure details and science foundation references are provided in the SacEFT v.2 Record of Design (ESSA 2011).

2.1.2 Riparian Species and Performance Measures

Fremont Cottonwood Initiation (FC1)

Fremont cottonwood (*Populus fremontii*) establishes in riparian areas where young seedlings require a continuous supply of groundwater to their growing tap root in order to survive during their first spring and summer (seedling initiation). Groundwater moisture is driven by the water table of the adjacent river, and successful initiation depends on a stage recession rate that matches the seedling's ability to grow a tap root. Historically, good initiation years happen about once or twice in every ten years, and SacEFT records and reports the number of successful initiation events at selected index cross sections along the Sacramento River. Performance measure details and science foundation references are provided in the SacEFT v.2 Record of Design (ESSA 2011).

Fremont Cottonwood Scour (FC2)

Newly initiated (but not yet "established") Fremont cottonwoods (*Populus fremontii*) seedlings are susceptible to high flow events that inundate the seedlings and mobilize the gravel and sand containing their root system. In SacEFT, scour risk is quantified by determining whether flow thresholds are exceeded in the first following fair or good initiation (FC1) years. Performance measure details and science foundation references are provided in the SacEFT v.2 Record of Design (ESSA 2011).

Bank Swallow Habitat Potential (BASW1)

Bank swallows (*Riparia riparia*) nest and rear their young in burrows along the river banks and prefer soils with particular characteristics, burrowing depth, and burrow age. Burrows remain habitable for about 3 years and are abandoned after that, due to ectoparasites and other factors which degrade the quality of burrows over time). The meandering of (unrocked) rivers occurs naturally during high flow events, which renews old and creates new bank swallow burrowing/nesting areas. Coupled to a river Meander Migration model, SacEFT simulates and reports the length of suitable bank habitat areas produced annually, at a number of representative index locations. Performance measure details and science foundation references are provided in the SacEFT v.2 Record of Design (ESSA 2011).

Bank Swallow Nest Inundation (BASW2)

During their spring and early summer nesting period, bank swallows (*Riparia riparia*) and their young are susceptible to extremely high flows that can inundate their nesting burrows drowning the nestlings. SacEFT tracks high flow events known to be associated with dangerously high river stage elevations. During the nesting period these flows and water levels, while potentially creating future nesting sites, will induce high mortality for the current year's cohort of nesting bank swallows. Performance measure details and science foundation references are provided in the SacEFT v.2 Record of Design (ESSA 2011).

Large Woody Debris Recruitment (LWD1)

Large woody debris is an important habitat requirement for western pond turtles (*Actinemys marmorata*) and is used as a proxy measurement for potential habitat quality in the mainstem Sacramento River. While western pond turtles utilize oxbow habitats and sloughs, they are also capable of utilizing the mainstem Sacramento River under appropriate conditions. To calculate the amount of Large Woody Debris recruited to the mainstem Sacramento River, SacEFT incorporates results from its spatially explicit bank erosion model combined with GIS mapping of mature forest vegetation, to provide a calculation of the amount of older vegetation added to the river each year. As with the BASW1 performance measure, bank erosion calculations are driven by the Meander Migration model. Performance measure details and science foundation references are provided in the SacEFT v.2 Record of Design (ESSA 2011).

2.2 Ecological Flows Tool – Core Concepts

Scientifically, SacEFT takes a bottom-up, process-based approach to the relationship between flow and related aquatic habitat variables, and looks at how these variables are tied to key species life-stages and ecosystem functions. SacEFT focal species and performance measures were selected using a rigorous vetting model combined with expert workshops and reviews (ESSA 2011). Each focal species has a defined conceptual model, within which specific biophysical linkages (performance measure algorithms) were selected for inclusion in SacEFT (ESSA 2011). This provides a multi-species, multi-performance measure approach for assessing how different flow and habitat restoration combinations suit the different life stages of desired species. In so doing, SacEFT transparently relates additional attributes of the flow regime to multiple species' life-history needs in an overall effort at careful organization of *representative* functional flow needs.

Most of SacEFT's 12 performance measures are calculated on a daily time-step at several index locations/river segments. Naturally, these daily calculations come in many different units appropriate to the performance measure (*e.g.*, square feet of suitable habitat, survival rates, counts of surviving cottonwood seedlings, *etc*.). The daily calculations for most aquatic performance measures (see above) are weighted by the appropriate life-history distribution as well as differences in habitat quantity/quality amongst the modeled index sites. For example, if a sudden dramatic low flow event occurs at the very beginning or very end of the egg incubation period for a particular run of Chinook, the weighted effect on the overall cumulative redd dewatering performance measure (ST6/CH6) will be negligible.

The SacEFT model is intended to be applied in multi-decadal simulations. For all 12 performance measures, annual cumulative weighted performance measure values are calculated for historic (observed) flows and water temperatures from WY1938–2003. These "annual roll-up" values for each performance measure are then assigned a "good" (green), "fair" (yellow), or "poor" (red) performance measure rating (*e.g.*, Figure 2.1).

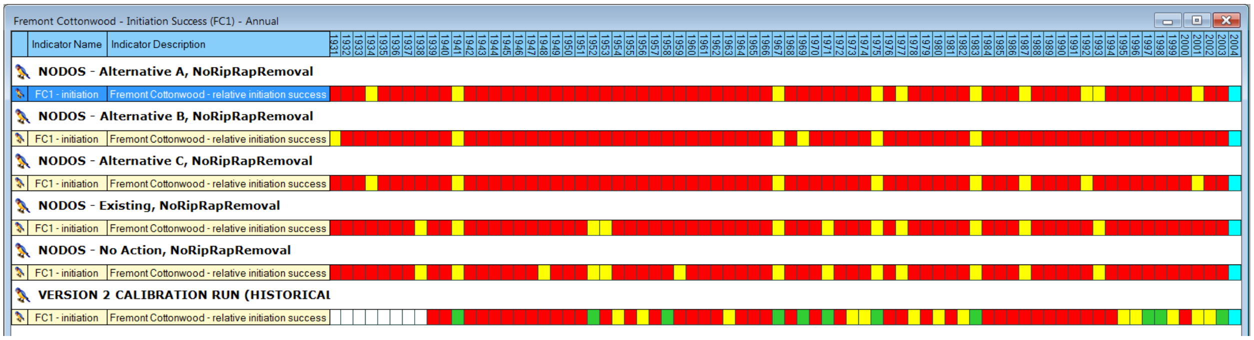


Figure 2.1: Typical SacEFT output showing annual roll-up results for the Fremont cottonwood initiation (FC1) performance measure. Analogous plots are available for all of the tools' focal species and performance measures.

These annual performance measure ratings are based on thresholds[1] defined by sorting cumulative annual results produced by SacEFT for historic observed flows and water temperatures between WY1938 and 2003 (*e.g.*, Figure 2.2). The "units" of these plots vary with the performance measure (see ESSA 2011). In this way, historic observed flows/temperatures provide the de facto "calibration scenario" for SacEFT's 12 focal species performance measures.

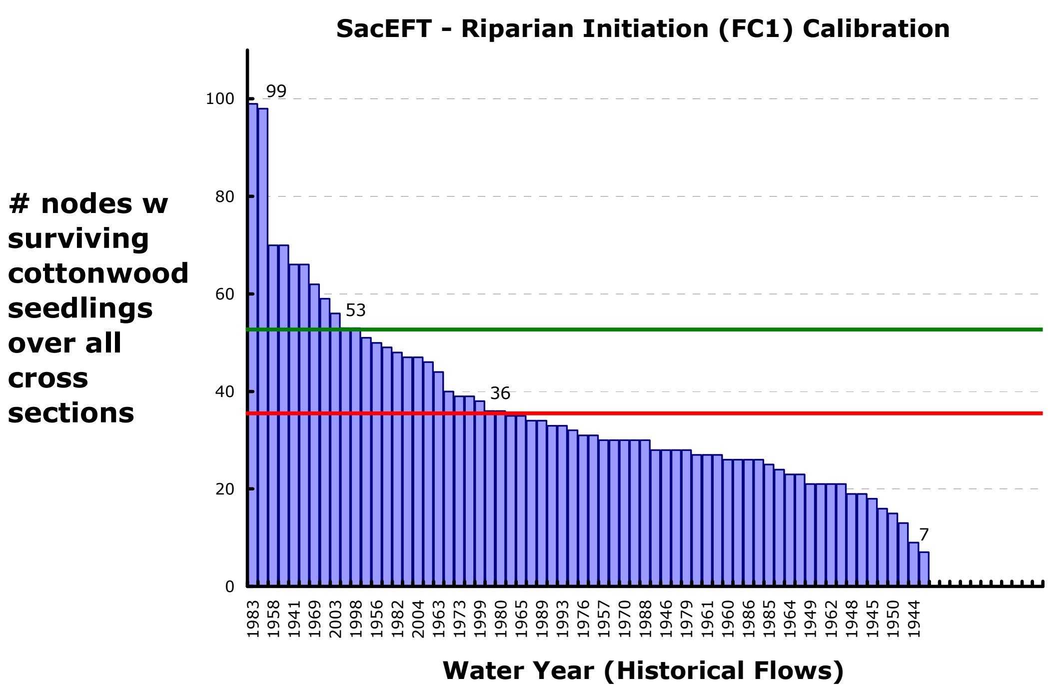


Figure 2.2: Annual roll-up results for the SacEFT Fremont cottonwood initiation (FC1) performance measure run using historic observed flows (WY1938–2003). This calibration also takes into consideration comparisons with aerial photographs of historically strong Cottonwood recruitment at study sites *vs.* model results.

[1] Indicator thresholds in SacEFT are fully configurable via settings found in the SacEFT relational database.

Our concept of indicator threshold calibration in SacEFT focuses on historical data. From an ecological standpoint, aquatic and riparian species are adapted to a historical range and frequency of variations in their habitats. Taken to the extreme, historical conditions would ideally include pre-settlement (natural) flows/water temperatures that represented 'typical' conditions experienced over evolutionarily significant windows of time. The closest flow/temperature time series that we have available to this evolutionarily representative condition is the range of variation in historical observed flows/temperatures (approximately 66 years). It is recognized that during WY1938–2003 the Sacramento River experienced a number of waves of human and structural development and operational changes to the hydrosystem. Nevertheless, these flows and temperatures, derived from measurements, actually occurred in recent history and encompass repeat episodes of multiple water year types. Calibrating SacEFT indicator thresholds to a future no action or 'existing' scenario that includes a fixed set of hydrosystem features, constraints, operating regulations and assumed human demands would create a "self-fulfilling prophecy" inconsistent with SacEFT's underlying natural flow regime science foundation. In general, all of the models used in the NODOS Investigation are calibrated based on historical information.

The preferred method for calibrating the indicator thresholds is to identify historical years for each performance measure that were known (in nature) to have experienced 'good' or 'poor' performance. Unfortunately, our *repeat* survey efforts of fisheries experts (*e.g.*, Mark Gard, USFWS, *pers. comm.*2011; Matt Brown, USFWS, *pers. comm.* 2011 amongst many others) and a questionnaire sent to fisheries biologists prior to the 2008 SacEFT v.1 review workshop revealed there are no known synoptic studies of this kind for many of the indicators in SacEFT. Because of this gap and the hesitancy of experts to reveal their opinions, we instead defaulted to the distribution of sorted weighted annual results and selected tercile break-points (the lower-, middle- and upper thirds of the sorted distribution) to categorize results into "Good" (Green), "Fair" (Yellow) or "Poor" (Red) categories. While this method provides a fully internally consistent method of comparing scenario results (*i.e.*, will always provide an accurate picture of which water management scenarios are "better" than another), it does not *necessarily* provide a concrete inference about the biological significance of being a "Poor" (Red) or "Good" (Green) category. For example, it is possible that a year that ranks as "Good" (Green) with this method may still be biologically suboptimal. Conversely, a year that ranks as "Poor" (Red) may be biologically insignificant (*i.e.*, not biologically unacceptable).

The challenge of identifying "acceptable" and "unacceptable" changes in habitat conditions or focal species performance measures confronts all biological effects analysis methods. SacEFT makes these inherent value judgments explicit in the model's summary outputs. Future analyses using SacEFT look forward to ecological effects analysis experts themselves providing clearer guidance on the (readily configurable) thresholds in the SacEFT modeling system. Readers interested in further details on SacEFT indicator thresholds are directed to Appendix B.

We note that none of the NODOS Investigation alternative modelling results are compared against the historical calibration due to the focus of CEQA/NEPA which emphasizes isolating project alternative effects as compared to a no action reference or existing condition comparison. Comparisons that include historical data reveal different information in a different context that does not address a specific project effect relative to the no action alternative or existing condition reference case. Comparisons that include historic calibration data identify the ecological effects of the future system operations and constraints relative to historic conditions. In fully considering ecological flow needs, the magnitude of departure from these historic conditions may reveal important information on how future constraints, climate and/or hydrosystem operational modifications are influencing preferred ecological flow targets.

The highest level synthesis concept in SacEFT is that of a "multi-year roll-up". This is the percentage of years in the simulation having favorable (green), fair (yellow), and poor (red) conditions (*e.g.*, Figure 2.3).


Fremont Cottonwood - Initiation Success (FC1) - Roll-Up

ScenarioID	Indicator Name	Indicator Description	Create Report	Multi-Year Rollup	% Poor	% Worris...	% Good
NODOS - Alternative A, NoRipRapRemoval							
136	FC1 - initiation	Fremont Cottonwood - relative initiation success			85	15	0
NODOS - Alternative B, NoRipRapRemoval							
139	FC1 - initiation	Fremont Cottonwood - relative initiation success			91	9	0
NODOS - Alternative C, NoRipRapRemoval							
140	FC1 - initiation	Fremont Cottonwood - relative initiation success			88	12	0
NODOS - Existing, NoRipRapRemoval							
132	FC1 - initiation	Fremont Cottonwood - relative initiation success			87	13	0
NODOS - No Action, NoRipRapRemoval							
134	FC1 - initiation	Fremont Cottonwood - relative initiation success			83	17	0
VERSION 2 CALIBRATION RUN (HISTORICAL)							
118	FC1 - initiation	Fremont Cottonwood - relative initiation success			63	20	17

Figure 2.3: Typical SacEFT output showing multi-year roll-up results for the Fremont cottonwood initiation (FC1) performance measure. Analogous plots are available for all of the tools' focal species and performance measures.

SacEFT also provides daily results within individual years at the specific index locations for the majority of its performance measures (*e.g.*, Figure 2.4). A variety of other forms of detailed daily results are contained in SacEFT's relational database tables.

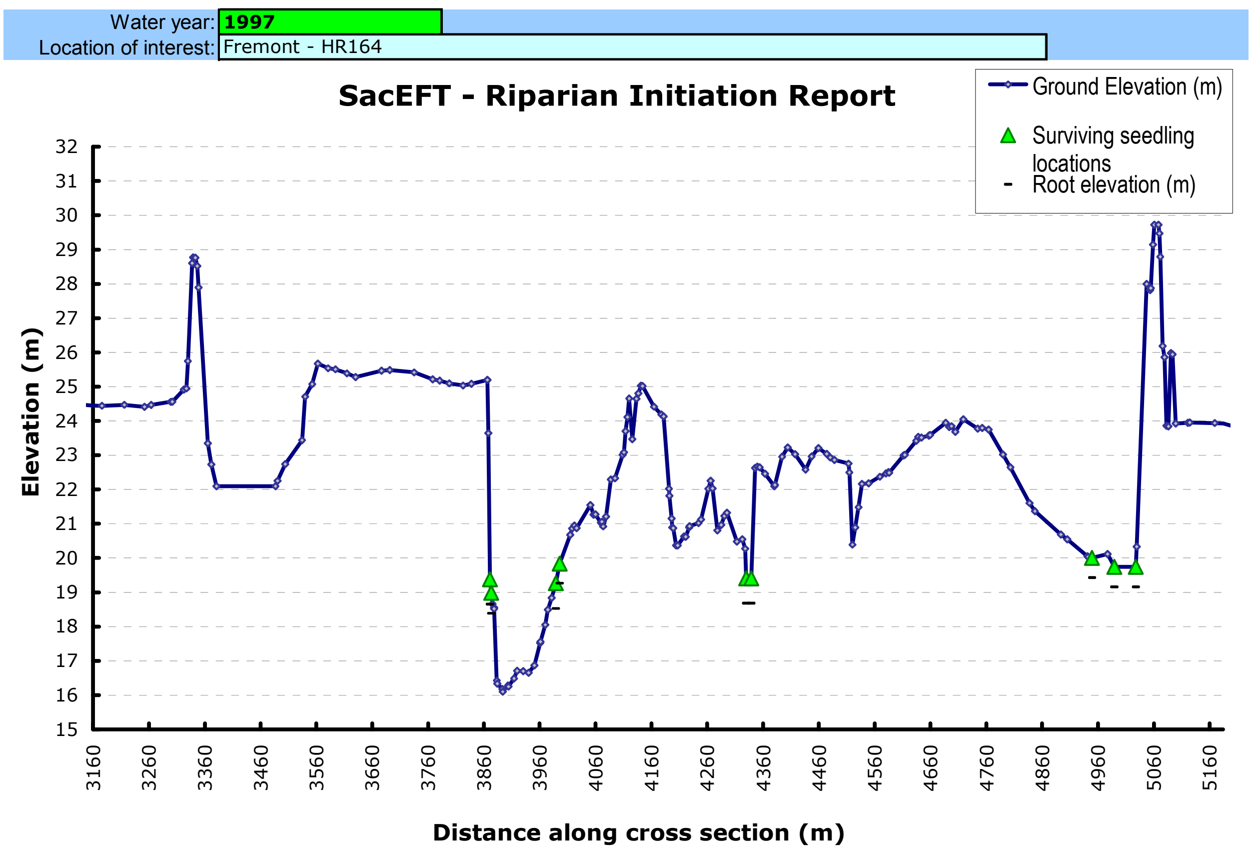


Figure 2.4: Example SacEFT output report showing results for the Fremont cottonwood initiation (FC1) performance measure at a specific cross-section at the conclusion of the seed dispersal period in WY1997.

2.3 Locations of Interest and Life-History Timing Assumptions

The spatial extent of SacEFT includes the mainstem Sacramento River at RM 301 (Keswick) downstream to RM 143 (Colusa) (Figure 2.5). Specific locations identified in SacEFT are chosen based on three factors:

1. their biological importance (*e.g.*, what is the current or historic range for a focal species?);
2. the areas where we have reliable *biological* relationships (focal species models); and
3. the feasibility of obtaining or producing the *physical* variables required for focal species submodels at these biologically relevant sites (*e.g.*, where have stage-discharge relations and channel cross-section profiles been developed?).

The overlap between these three considerations determines the spatial extent of performance measures throughout SacEFT's 158 mile study area.

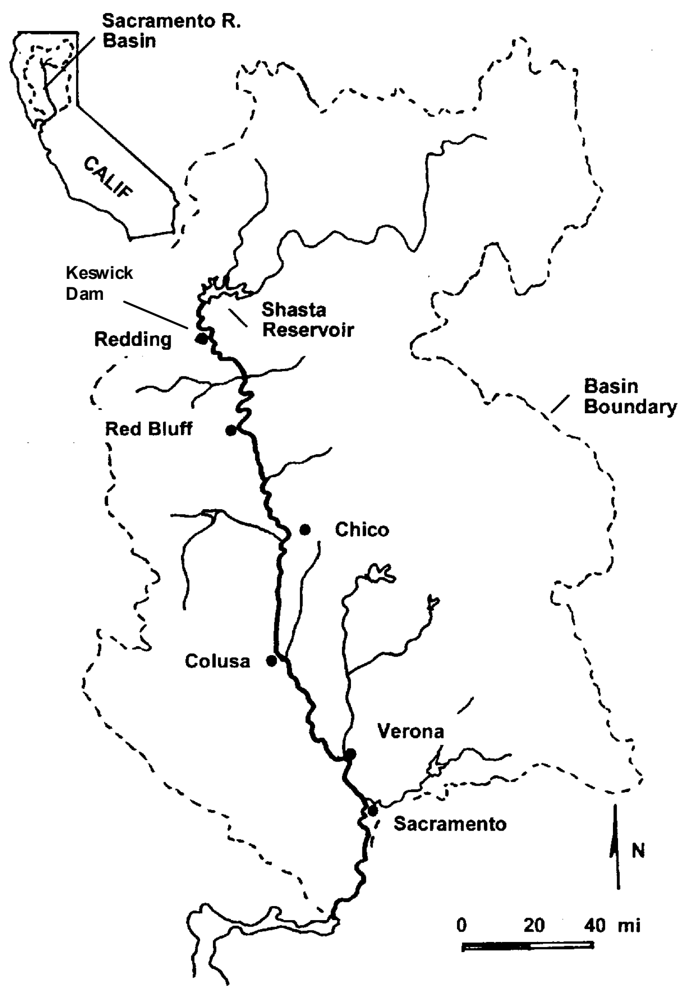


Figure 2.5: Map of the Sacramento River watershed and study area over which the SacEFT will be applied, from Keswick Dam (RM 301) to Colusa (RM 143) (CALFED Bay-Delta Program 2000).

Table 2-B provides a summary of the spatial locations for non-salmonid performance measures and the extent of linked physical datasets and external models. Performance measures for the species are summarized in Table 2-A. The analogous summary for salmonid performance measures is provided in

Table 2-C. Performance measure location details are provided in the SacEFT v.2 Record of Design (ESSA 2011).

The temporal resolution of SacEFT varies by submodel, ranging from specific events occurring at daily resolution (*e.g.*, changes in flow and stage) to performance measures that obtain their meaning when viewed over annual and longer time scales. Typical SacEFT simulations run between 65 and 82 years.

Table 2-E summarizes the life-history timing that is relevant to the various focal species performance measures. In the case of Chinook and steelhead spawning time, closely follows the timing and spread used by Bartholow and Heasley (2006) for the SALMOD model; a distribution which is in turn based on Vogel and Marine (1991). Performance measure timing details are provided in the SacEFT v.2 Record of Design (ESSA 2011).

Table 2-B: Spatial location and extent of physical datasets, linked models and performance measures for the non-salmonid focal species. Performance measures (PMs) for the species are summarized in Table 2-A. Vertical bars denote PMs that are simulated for river segments; dots denote those that are simulated (measured in the case of gauges) at points along the river. Q = river discharge. T = water temperature. Annotation details are listed in Table 2-D.

		Physical Driving Variables						Linked Models				Biological Models							
		Historical [1]		NODOS [2]		BDCP Analysis [6]		TUGS [3]		Meander Migration		Fremont Cottonwood	Bank Swallow			Large Woody Debris		Green Sturgeon	
RM	Name	Q	T	Q	T	Q	T	(a)	(b)	(a)	(b)		1 (a)	1 (b)	2	(a)	(b)		RM
301	Keswick	•	•	•	•	•	•		|										301
298	ACID Dam		•						|										298
293	ACID Intake			•					|						•				292
289	Clear Creek		•	•	•	•	•		|										289
281	Stillwater Creek			•	•														281
280	Cow Creek		•	•	•	•	•	|											280
278	Bear Creek			•	•			|											278
277	Ball's Ferry		•		•	•	•	|											277
275	Anderson Creek		•		•			|											275
273	Cottonwood Creek		•	•	•	•	•	|											273
272	Battle Creek		•	•	•			|	|										272
267	Jelly's Ferry		•		•	•	•		|										267
260	Bend Bridge A	•	•	•	•				|									•	260
258	Bend Bridge B								|										258
252									|										252
243	Red Bluff	•			•	•	•													243
243	Red Bluff DD				•	•	•		|										243
230	Mill Creek			•	•				|										230
218	Vina	•		•	•				|	|			|			|			218
208										|		•	|			|			208
207	GCID Pump									|		•	|			|			207
201										|	|		|	|		|	|		201
199	Hamilton City	•		•	•	•	•				|	•		|			|	•	199
197											|			|	•		|		197
196												•		|			|		196
192											|	•		|			|		192
190	Stony Creek										|			|			|		190
185										|	|	•	|	|		|	|		185
183										|		•	|			|			183
182										|			|			|			182
172										|		•	|			|			172
170										|			|			|			170
168	Butte City	•		•	•										•				168
165												•							165
164												•							164
159	Moulton Weir			•	•							•							159
143	Colusa	•		•	•														143

Table 2-C: Spatial location and extent of physical datasets, linked models and performance measures for the salmonid focal species. Performance measures (PMs) for the species are summarized in Table 2-A. Vertical bars denote PMs that are simulated for river segments; dots denote those that are simulated (measured in the case of gauges) at points along the river. Q = river discharge. T = water temperature. Annotation details are listed in Table 2-D.

		Physical Driving Variables						Linked Models				Biological Models																			
												Chinook & Steelhead Spawning & Egg Stage PMs[4]										Chinook Steelhead Juvenile Rearing Stage PMs									
		Historical[1]		NODOS[2]		BDCP Analysis[5]		TUGS[3]		Meander Migration		Spring		Fall		Late Fall		Winter		Steelhead		Spring		Fall		Late Fall		Winter		Steelhead	
RM	Name	Q	T	Q	T	Q	T	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
301	Keswick	●	●	●	●	●	●		█					█		█		█		█				█		█		█		█	
298	ACID Dam		●						█				▒	█	█	█	█	█	█	█	█		▒	█	█	█	█	█	█	█	█
293	ACID Intake			●					█				▒		█		█		█		█		▒		█		█		█		█
289	Clear Creek		●	●	●	●	●		█				▒		█		█		█		█		▒		█		█		█		█
281	Stillwater Creek			●	●								▒		█		█		█		█		▒		█		█		█		█
280	Cow Creek		●	●	●	●	●	▒				▒	▒	█	█	█	█	█	█	█	█	▒	▒	█	█	█	█	█	█	█	█
278	Bear Creek			●	●			▒				▒		█		█		█		█		▒		█		█		█		█	
277	Ball's Ferry		●		●	●	●	▒				▒		█		█		█		█		▒		█		█		█		█	
275	Anderson Creek		●		●			▒				▒		█		█		█		█		▒		█		█		█		█	
273	Cottonwood Creek		●	●	●	●	●	▒				▒		█		█		█		█		▒		█		█		█		█	
272	Battle Creek		●	●	●			▒	▒			▒		█	▒	█		█		█		▒	▒	█	▒	█	▒	█	▒	█	
267	Jelly's Ferry		●		●	●	●		▒						▒								▒		▒		▒		▒		
260	Bend Bridge A	●	●	●	●				▒						▒								▒		▒		▒		▒		
258	Bend Bridge B								▒						▒								▒		▒		▒		▒		
252									▒						▒								▒		▒		▒		▒		
243	Red Bluff	●			●	●	●																								
243	Red Bluff DD				●	●	●		▒						▒								▒		▒		▒		▒		
230	Mill Creek			●	●				▒						▒								▒		▒		▒		▒		
218	Vina	●		●	●				▒	█					▒								▒		▒		▒		▒		
207	GCID Pump									█																					
201										█	█																				
199	Hamilton City	●		●	●	●	●				█																				
197											█																				
192											█																				
190	Stony Creek										█																				
185										█	█																				
183										█																					
182										█																					
172										█																					
170										█																					
168	Butte City	●		●	●																										
165																															
164																															
159	Moulton Weir			●	●																										
143	Colusa	●		●	●																										

Table 2-D: Annotations for Table 2-B and Table 2-C.

[1] The common time span of Historic discharge (Q) data is 1-Oct-1938 to 30-Sep-2004. The common time span of Historic temperature (T) data is 1-Jan-1970 to 31-Dec-2001.

[2] The common time span of the NODOS scenario analyses performed in April 2011 include discharge (Q) and temperature (T) data between 1-Oct-1921 to 30-Sep-2003.

[3] TUGS simulations (Cui 2007) shown in red actually comprise 5 distinct reaches between RM 301 and RM 289. TUGS results are not available downstream from Cow Creek but are necessary for linkage to Chinook and Steelhead spawning Weighted Usable Area (WUA) (CS1). TUGS relationships for these downstream segments (pink) are mapped from the nearest upstream location, as described in ESSA (2011).

[4] Chinook and Steelhead *spawning* WUA relationships shown in pale blue are mapped from the closest downstream segment, as described in ESSA (2011). Spring Chinook habitat preferences are assumed to follow those of fall Chinook. Chinook *rearing* WUA relationships shown in pale blue are mapped from the closest upstream section, as describe in ESSA (2011).

[5] The BDCP analysis performed in June of 2010 included a subset of PMs: Chinook, Steelhead and green sturgeon in the region from Keswick to Hamilton City only.

The Meander Migration model is based on empirical river centerlines measured in 2004. For the meander (and bank erosion) simulations, WY1922 NODOS flows were applied starting with the 2004 river centerlines and this centerline run forwards for 82 years. Note that the first year of the simulation results (WY1922) was not included in SacEFT due to numerical instability of the meander migration results prior to burn-in. As a result, SacEFT results for NODOS are displayed beginning in WY1923. For the historical case, results are run forward for 65 years beginning in WY1939.

Table 2-E: Summary of the life-history timing information relevant to the SacEFT focal species. Only those performance measures requiring information on life history timing are included here. Abbreviations of performance measures (PMs) are described in Table 2-A. Time intervals marked with heavy color denote periods of greater importance to focal species. In the case of the spawning PMs (CS-1), heavily shaded regions denote for each salmonid run-type/species the period between the 25th and 75th percentile, when half the spawning takes place. In the case of the other salmonid PMs, the heavily shaded regions denote the period between the 25th and 75th percentile of the population are present. Specific timing of CS-2, 3, 4, 5, 6 depends on ambient water temperature and varies with discharge scenario and year. Juvenile residency is defined by a fixed 90 day period following emergence for Chinook and a 365 day period for steelhead. This table is based on SALMOD (Bartholow and Heasley 2006, ultimately Vogel and Marine 1991). Salmonid timing values shown here are typical and may shift by as much as five days earlier or later, depending on year and reach. Timing values for green sturgeon, cottonwood and bank swallow are based on workshop discussions, and all values are under user control.

Performance Measure & Timing Relevance		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CS - 1	**Spring Chinook** Spawning												
CS - 3,5,6	Egg Development Period												
CS - 2,4	Juvenile Period												
CS - 1	**Fall Chinook** Spawning												
CS - 3,5,6	Egg Development Period												
CS - 2,4	Juvenile Period												
CS - 1	**Late fall Chinook** Spawning												
CS - 3,5,6	Egg Development Period												
CS - 2,4	Juvenile Period												
CS - 1	**Winter Chinook** Spawning												
CS - 3,5,6	Egg Development Period												
CS - 2,4	Juvenile Period												
CS - 1	**Steelhead** Spawning												
CS - 3,5,6	Egg Development Period												
CS - 2,4	Juvenile Period												
GS1	**Green Sturgeon Spawning**												
FC1	**Fremont Cottonwood**												
	Seedling initiation												
BASW1	**Bank Swallow** Habitat												
BASW2	Ramping Rates												

2.4 Special Conditions and Limitations

Although the NODOS Investigation alternatives provide daily flow and temperature data for the WY1922–2003 period, most of the salmonid results from SacEFT in this analysis are unavailable prior to WY1939. This gap is a consequence of the required linkage between the calculation of spawning habitat and streambed gravel grain size-distribution. SacEFT requires annual estimates of the gravel grain size-distribution at each of 5 river segments in order to calculate the weighted useable area available for spawning (ST1/CH1). This habitat estimate is then used as one of the inputs to calculate subsequent performance measures for egg maturation, survival, and juvenile rearing. In the absence of gravel data, no calculations are possible for these linked components. For previous model analyses using SacEFT, colleagues at Stillwater Sciences calibrated and ran The Unified Gravel & Sand (TUGS) model (Cui 2007) over the WY1939-2004 period and provided this information for input to a number of SacEFT scenarios that all used this common time-frame. TUGS simulates changes in grain size of the river by accounting for how its sediment flux interacts with sediment in both the surface and subsurface of the channel bed. Time constraints for the current investigation prevented this level of engagement with Stillwater Sciences, and we were therefore required to re-use the "default historical gravel" scenario data (Stillwater Sciences 2007). This data was applied starting in WY1939 in the NODOS alternatives to ensure that the time series lengths matched. This is a known limitation of the results for the ST1/CH1 performance measures in this analysis, but does not have a significant bearing on the other 5 ST/CH performance measures.

2.5 Focal Comparisons

DWR and the US Bureau of Reclamation NODOS Investigation team have defined the storage and conveyance alternatives for evaluation in the North-of-the-Delta Offstream Storage Draft Environmental Impact Report and Statement (DEIR/EIS). These alternatives are described in section 1.2. Results of the SacEFT ecological effects analysis are organized by species for the following eight comparisons:

Comparison	NODOS Alternative (SacEFT ID)	Compared to (SacEFT ID)
1	No Action Alternative (134)	Existing Conditions (132)
2	A (136)	Existing Conditions (132)
3	A (136)	No Action Alternative (134)
4	B (139)	Existing Conditions (132)
5	B (139)	No Action Alternative (134)
6	C (140)	Existing Conditions (132)
7	C (140)	No Action Alternative (134)
8*	No Action Alternative (134)	Historic conditions (118)

*This is not a recognized EIS/EIR comparison. CEQA/NEPA which emphasize isolating project alternative effects as compared to a No Action reference or Existing condition comparison.

Comparison 8 is not used in our report to assess NODOS effects. Instead, it provides an essential reference case illustrating how SacEFT's various performance measures have performed under historic flows and water temperatures from WY1938–2003. Relative to future hydrosystem operations, these flows represent more natural patterns of variation in flow and water temperature that have occurred historically.

2.5.1 SacEFT Gravel Augmentation and Bank Protection Alternatives

In addition to analyzing the NODOS alternative flow and water temperature regimes, SacEFT enables comparisons of gravel augmentation and rock removal restoration actions. The NODOS alternatives, including the No Action Alternative, do not include gravel augmentation or bank protection modifications. SacEFT scenarios shown in this report that involve these modifications are for demonstration purposes only and will not be considered in the EIS/EIR or Feasibility Report.

For the current SacEFT NODOS effects analysis, we used the "No Gravel" TUGS dataset developed using historical flow data at Keswick (RM 301) to define how substrate composition changes in the simulations. This scenario involves modest historical gravel injections and assumptions about the initial sediment storage (Stillwater Sciences 2007)[1]. The TUGS dataset for the historical gravel injection case then evolves according to the inherent grain-size specific sediment transport calculations contained in the TUGS model (Cui 2007).

Likewise, for the present SacEFT NODOS study, bank erosion modeling repeated both (a) the existing channel armoring (Figure 2.6 to Figure 2.8) and (b) the selected rip-rap removal alternative defined during the Flows Study project (Larsen 2007). Five sites (2-6) that fall within the SacEFT study area were identified as good candidates for revetment removal. Again, the NODOS alternatives, including the No Action Alternative, do not include rip rap removal and are shown for demonstration purposes only and will not be considered in the EIS/EIR or Feasibility Report. Table 2-F includes descriptions of the criteria used to choose the sites, relevant studies related to the sites. These conditions have a direct bearing on riparian model performance measures (bank swallow and LWD recruitment). Conversely, these assumptions do not influence SacEFT's aquatic performance measure results. SacEFT results including the label "NoRipRapRemoval" refer to the existing 2004 channel and existing 2004 revetment (no change to bank protection) while scenarios with the label "RipRapRemoval" refer to selected removal of rock at specific locations (Larsen 2007).

[1] See Gravel Study Final Report (available at www.dfg.ca.gov/ERP/signature_sacriverecoflows.asp), Sections 2.5 and 3.5 for details.

Table 2-F: Potential revetment removal sites on the middle Sacramento River. Sites 2-6 define the "rip rap removal" scenario in SacEFT. For details see Larsen (2007).

POTENTIAL REVETMENT REMOVAL SITES ON THE MIDDLE SACRAMENTO RIVER

Site No.	Site Name	River Mile	Length (meters +/-)	Adjoining Landowner	Revetment Material	Description / Notes	Relevant Meander Analysis	Data Number on Google Earth File
1	La Barranca	240.5R	550	USFWS - La Barranca Unit, Sacramento River NWR	Medium rock	Lower 1/3 of a larger revetment area is adjacent to La Barranca Unit, removal would also take pressure of rock at 240L	A	Reach 2 - 981
2	Kopta Slough	220-222R	1775	State Controller's Trust (TNC is lessee)	Medium rock	Area is being converted to habitat, removal would help redirect erosion from State Recreation Area and County bridge, substantial planning work has occurred	A, B	Reach 2 - 5819
3	Rio Vista	216-217L	1425	USFWS - Rio Vista Unit, Sacramento River NWR	Large rock, privately installed	Rock was installed to protect agriculture, the area is now converted to habitat	A	Reach 2 - 1069, 1183, 4674
4	Brayton	197-198R	600	CDPR, Bidwell-Sac River St Park, Brayton property	Large rubble, privately installed	Rock was installed to protect agriculture, the area is planned to be converted to habitat, consider effect on the road to the east but geologic control should limit meander	A, C	Reach 2 - 2007
5	Phelan island	191-192R	1410	USFWS, Phelan Island Unit and Sac & San Joaquin Drainage Dist.	Medium rock, USACE installed in 1988	Area has been converted to habitat, consider possible Murphy's Slough cutoff / flood relief structure concerns	A, C, E	Reach 3 - 4626
6	Llano Seco Riparian Sanctuary	179R	1300	USFWS, Phelan Island Unit and Sac & San Joaquin Drainage District and small area of private property	Medium rock, USACE installed in 1985 & 87	Rock removal potential identified as part of Lano Seco Riparian Sanctuary planning project as part of a solution to fish screen concerns at Princeton, Codora/ Provident pumping plant at RM 178R	D	Reach 3 - 2805, 1422

Initial screening and review included staff from DWR Northern District, Sacramento River Conservation Area Forum and The Nature Conservancy

Criteria for Revetment Removal Identification

1. Revetment is adjacent to public or conservation ownership land
2. Revetment is not protecting important public infrastructure
3. Revetment removal does not create an obvious flood hazard
4. Revetment is currently limiting meander on lands in the historic meander belt
5. Revetment removal could result in ecosystem benefit: land reworking/creation of riparian habitat, creation of new bank swallow habitat, recruitment of spawning gravel, new shaded riverine aquatic habitat, etc.
5. Revetment removal could help direct meander to protect public infrastructure (if applicable)

Relevant Meander Analysis References

A. Department of Water Resources, Northern District, 1991, 25 and 50-year erosion projections for the Sacramento River.
B. Larsen, Eric, 2002. Modeling Channel Management Impacts on River Migration: A Case Study of Woodson Bridge state Recreation Area, Sacramento River, USA. University of California, Davis, Davis, California.
C. Larsen, Eric, 2002. The Control and Evolution of Channel Morphology of the Sacramento River: A Case Study of River Miles 201-185. University of California, Davis, Davis, California.
D. Larsen, Eric, 2004. Meander Bend Migration near River Mile 178 of the Sacramento River. University of California, Davis, Davis, California.
E. Larsen, Eric, 2005. Future Meander Bend Migration and Floodplain Development Patterns near River Miles 200 to 191 of the Sacramento River. University of California, Davis, Davis, California.

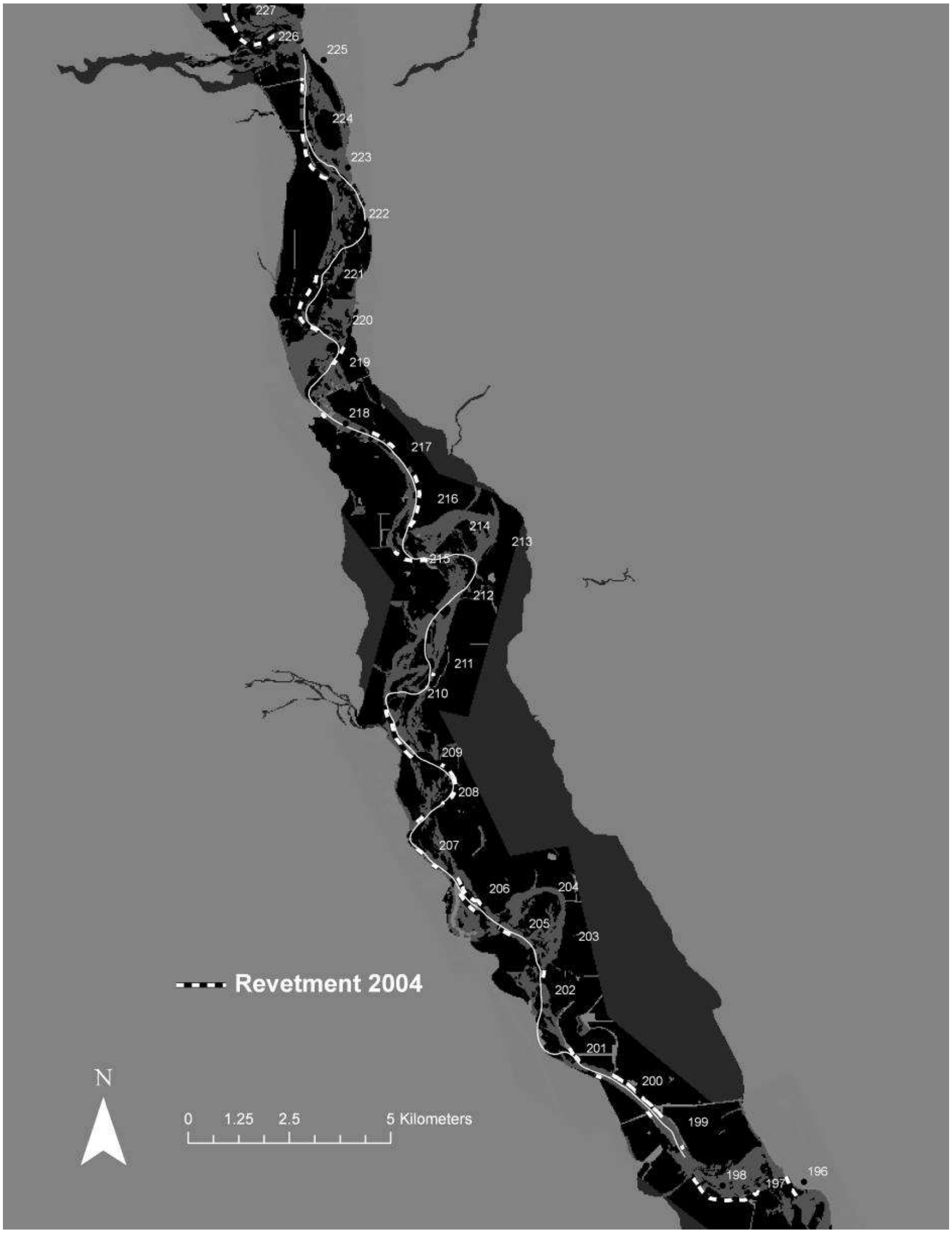


Figure 2.6: Meander Migration/Bank Erosion Model, Woodson Bridge segment showing 2004 revetment coverage (= SacEFT "no rip rap removal").

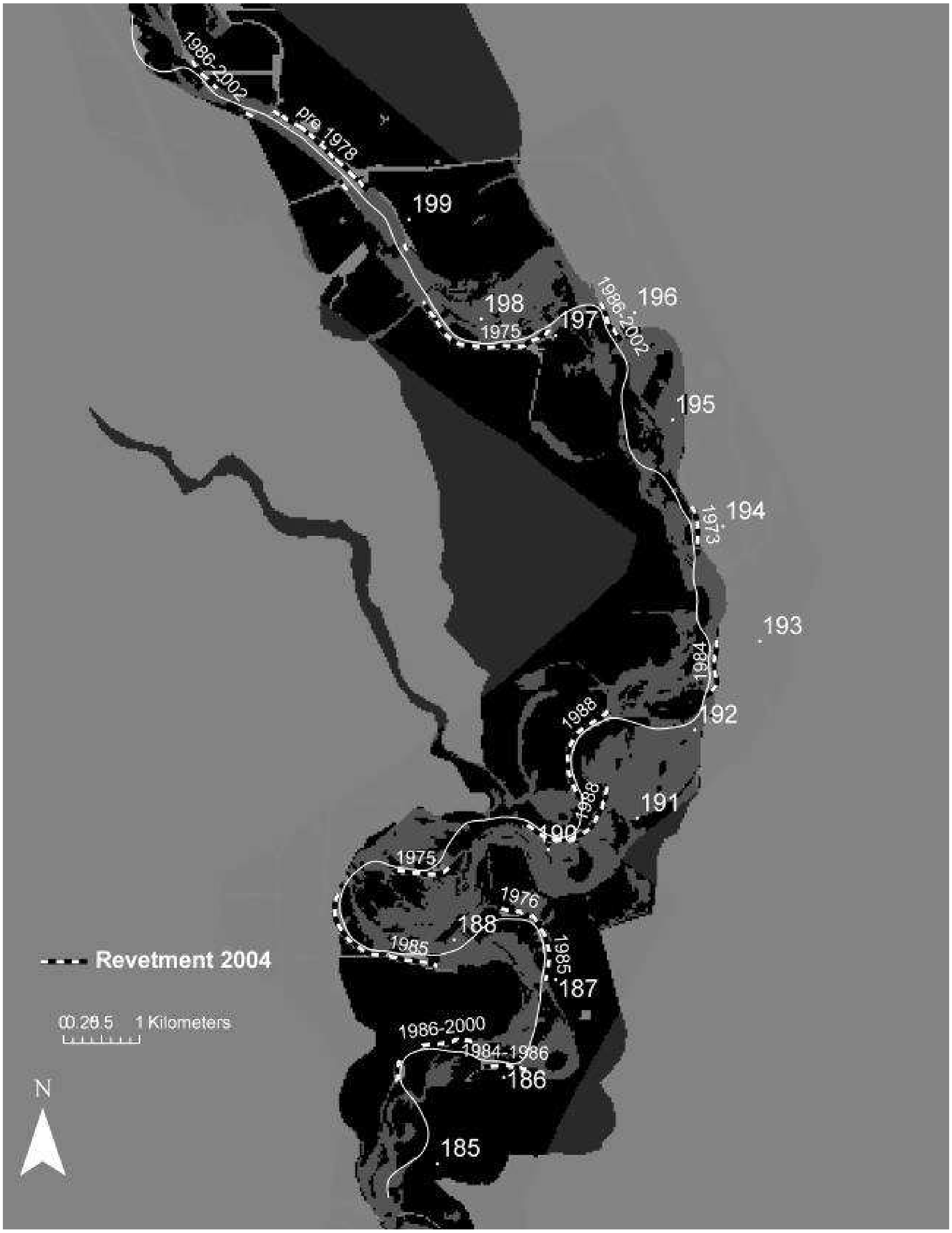


Figure 2.7: Meander Migration/Bank Erosion Model; Hamilton City segment showing 2004 revetment coverage (= SacEFT "no rip rap removal").

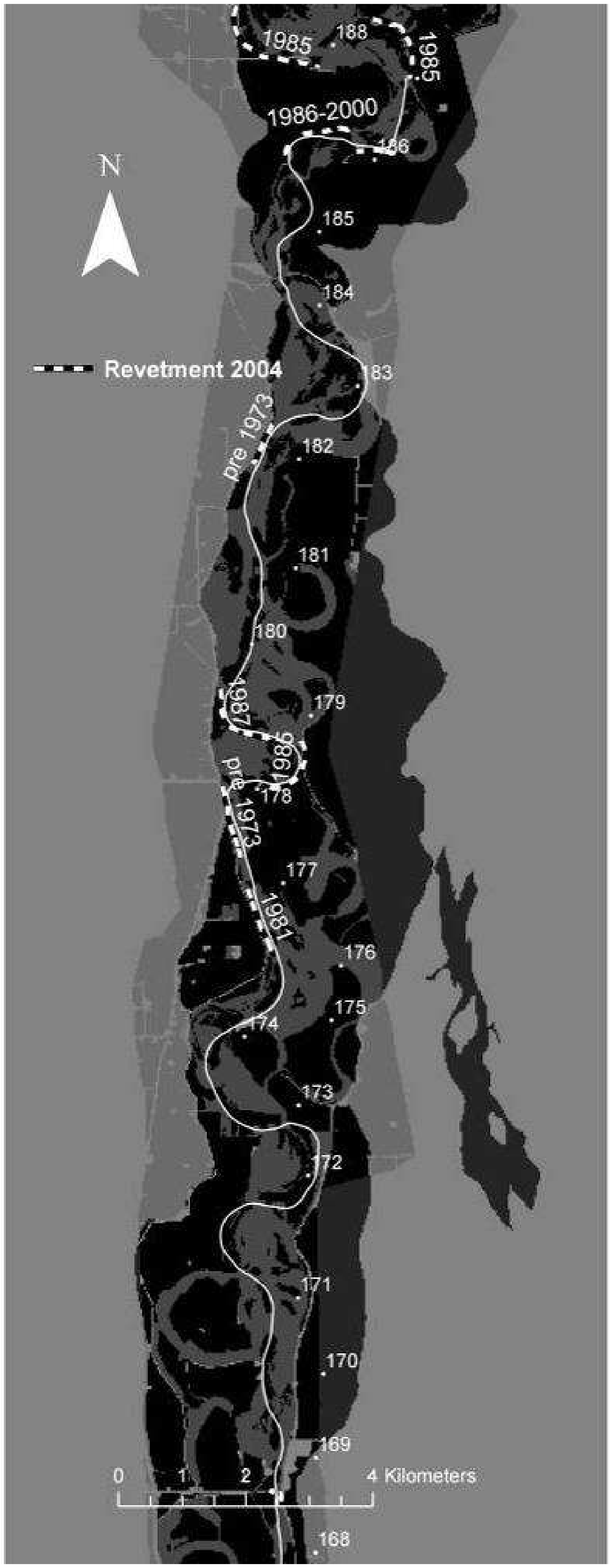


Figure 2.8: Meander Migration/Bank Erosion Model; Ord Ferry segment showing 2004 revetment coverage (= SacEFT "no rip rap removal").

3. Results and Discussion

3.1 Study Flows and Water Temperatures

The purpose of the EIS/EIR feasibility documents is to describe differences between No Action / Existing Conditions and the Action Alternatives which all reflect 2030 conditions, constraints, and operations. Figure 3.1 to Figure 3.4 provide flow exceedance probability summaries at selected river miles measured over the full water year for each of the 5 major NODOS alternatives plus historical flows. These plots illustrate relatively minor differences in flow exceedance probabilities at these locations between the NODOS alternatives.

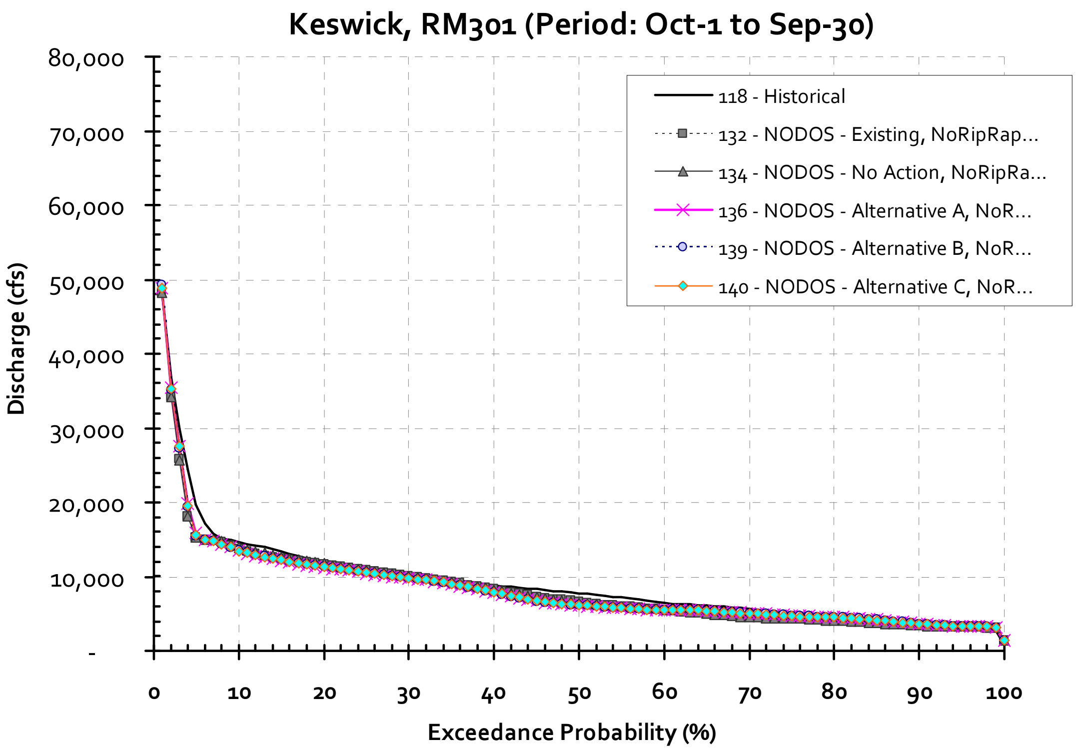


Figure 3.1: Flow exceedance plots at Keswick, RM301 (Oct-1 to Sep-30) for NODOS alternatives relative to historical flows.

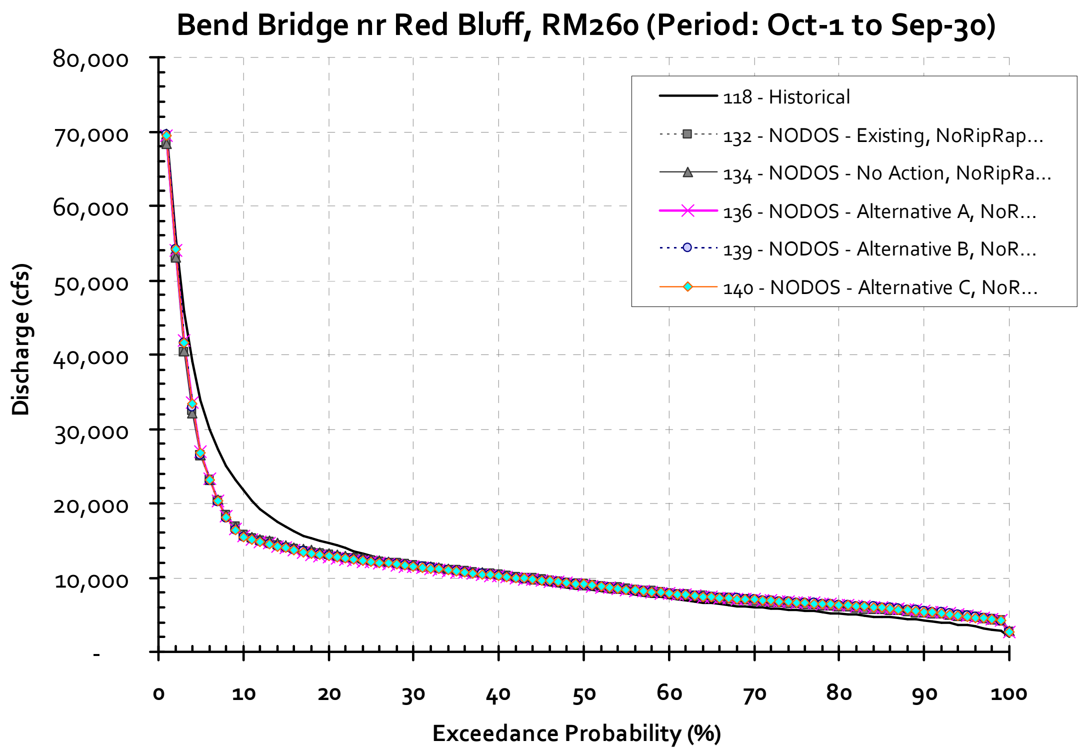


Figure 3.2: Flow exceedance plots at Bend Bridge near Red Bluff, RM260 (Oct-1 to Sep-30) for NODOS alternatives relative to historical flows.

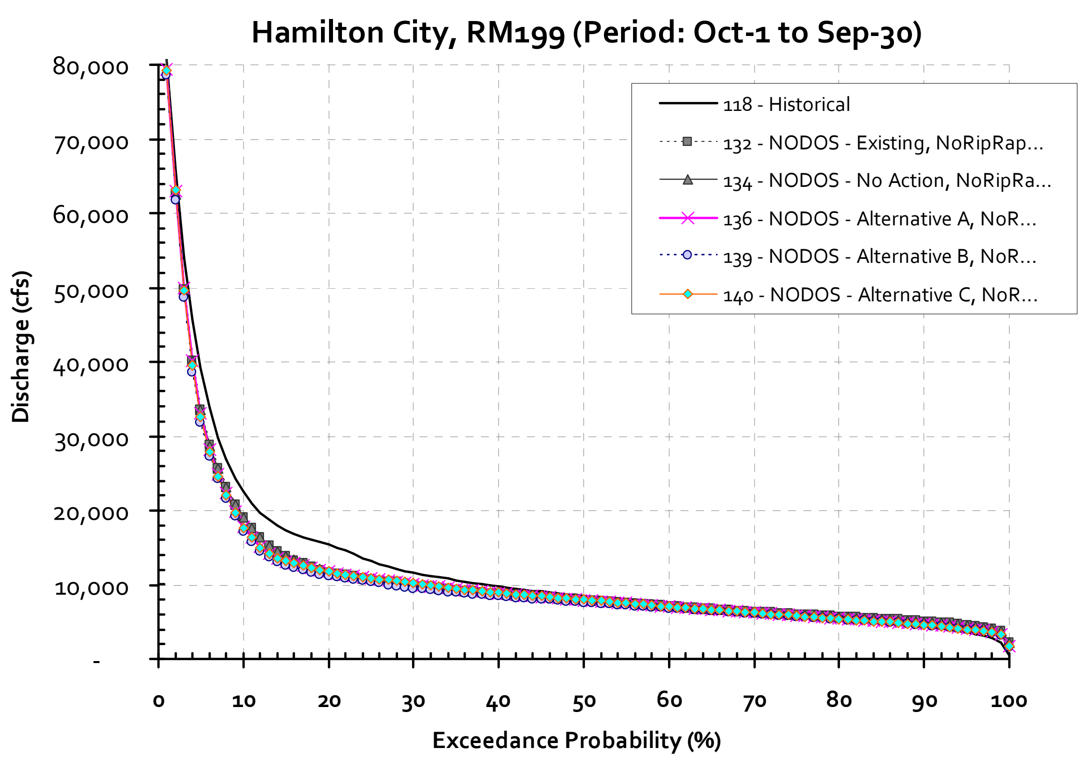


Figure 3.3: Flow exceedance plots near Hamilton City, RM199 (Oct-1 to Sep-30) for NODOS alternatives relative to historical flows.

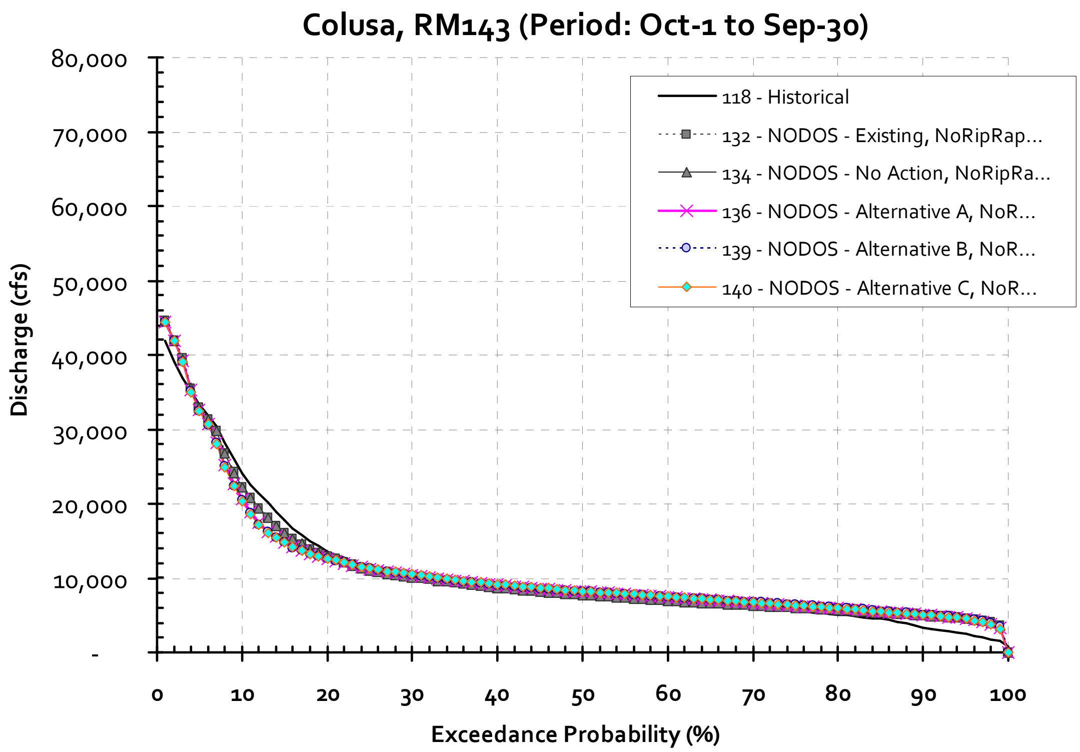


Figure 3.4: Flow exceedance plots near Colusa, RM143 (Oct-1 to Sep-30) for NODOS alternatives relative to historical flows.

Figure 3.5 to Figure 3.8 provide water temperature exceedance probability summaries at selected river miles measured over the full water year for each of the 5 major NODOS alternatives plus historical temperatures. These plots illustrate relatively minor differences in exceedance probabilities at these locations between the NODOS alternatives. Consistent with Ecosystem Enhancement Action #2, NODOS water temperatures in the upper Sacrament River are cooler than historical water temperatures.

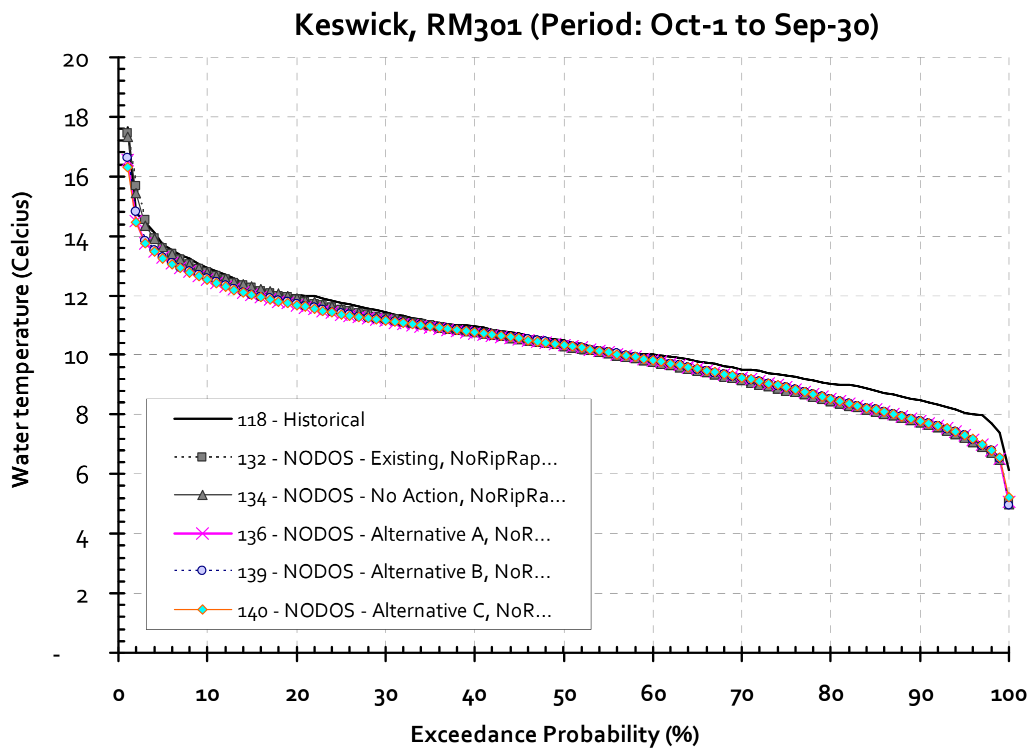


Figure 3.5: Water temperature exceedance plots at Keswick, RM301 (Oct-1 to Sep-30) for NODOS alternatives relative to historical temperatures.

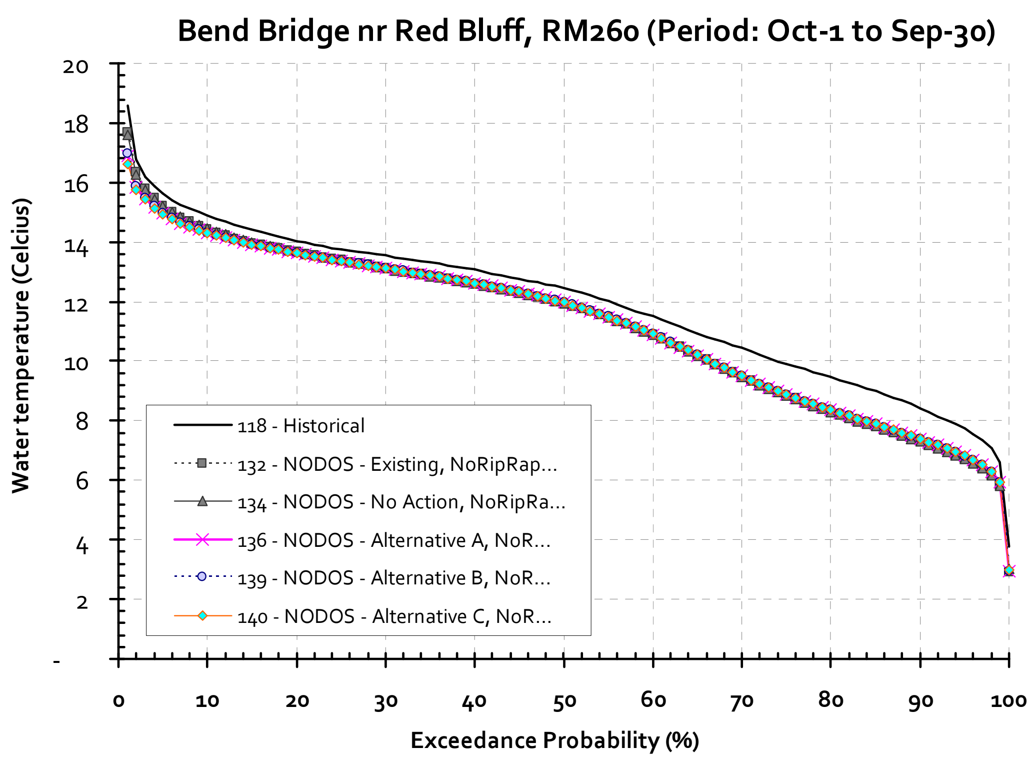


Figure 3.6: Water temperature exceedance plots at Bend Bridge near Red Bluff, RM260 (Oct-1 to Sep-30) for NODOS alternatives relative to historical temperatures.

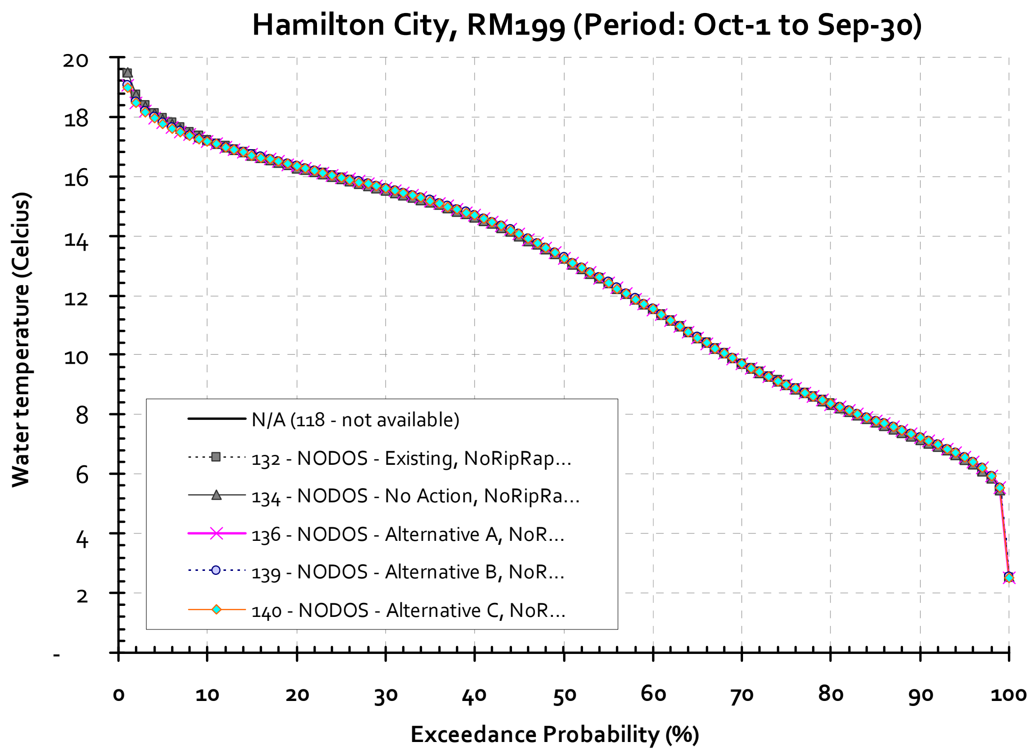


Figure 3.7: Water temperature exceedance plots near Hamilton City, RM199 (Oct-1 to Sep-30) for NODOS alternatives.

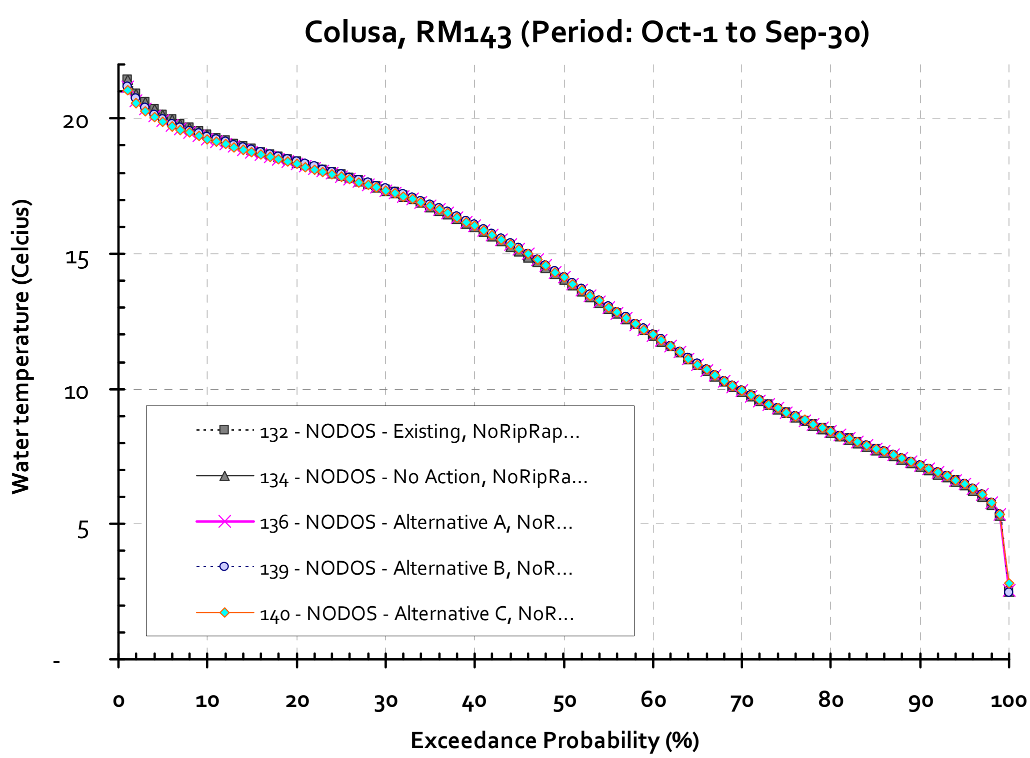


Figure 3.8: Water temperature exceedance plots near Colusa, RM143 (Oct-1 to Sep-30) for NODOS alternatives.

3.2 Performance of Alternatives: Overall Synthesis

Relative to the NODOS existing conditions alternative, study comparisons #1, #2, #4 and #6 reveal mixed results depending on the species and performance measure (Table 3-B). Species specific findings are provided in later sections. In all cases, performance measures relating to thermally modulated egg mortality (GS1, ST3, CH4) show either no appreciable impact owing to any of the NODOS Investigation alternatives (A, B, C) or a small beneficial impact. Relative to steelhead and Chinook salmon, green sturgeon eggs (GS1) received the largest benefits in terms of thermal egg mortality reduction (Table 3-B).

Overall, Steelhead appears to be most favored by NODOS Alternative B (Table 3-B). NODOS Alternative A favors fall Chinook, followed closely by NODOS Alternative B. Late-fall Chinook are least impacted by NODOS Alternative B. Spring Chinook clearly encounter a higher proportion of favorable conditions under NODOS Alternative B. Acknowledging the downward performance of rearing WUA (CH2), winter-run Chinook experience the highest proportion of favorable conditions under NODOS alternative C. NODOS alternative A is the next most favorable for winter-run Chinook.

Overall, riparian focal species performance measures (FC1, FC2, BASW2 and BASW1) appear to be most favored by NODOS Alternative C, followed by NODOS Alternative A (Table 3-B).

For Steelhead and winter-run Chinook, juvenile stranding changes (ST4/CH4) were inversely related relative to rearing WUA (ST2/CH2) (Table 3-B). These effects are partially offsetting, but the exact outcome depends on the response of Steelhead and winter-run Chinook to stage recession events (worse during day than at night) and on the survival benefits attributable to better rearing habitat conditions (see Appendix A for a deeper exploration of this inverse correlation).

Overall, the rank order preferred NODOS action alternative (*i.e.*, highest proportion of favored conditions / least impact across all performance measures) by focal species group is provided in Table 3-A. Table 3-A also illustrates that as currently defined; **no single NODOS alternative favors all SacEFT focal species**.

Table 3-A: Rank order of preferred NODOS alternative by focal species or group based on synthesis results in Table 3-B.

Focal Species (group)	Most favorable NODOS alternative	Next most favorable NODOS alternative
Riparian focal species	NODOS Alternative C	NODOS Alternative A
Green Sturgeon	No significant difference in performance amongst NODOS A, B or C	
Steelhead	NODOS Alternative B	n/a
Fall Chinook	NODOS Alternative A	n/a
Late Fall Chinook	NODOS Alternative B	n/a
Spring Chinook	NODOS Alternative B	
Winter Chinook	NODOS Alternative C	NODOS Alternative A

Table 3-B: High-level summary of the relative direction of change in performance measures between existing conditions and the different alternatives. Numbers in brackets refer to the increased percentage of simulation years having a favorable rating. **Results of these meander/erosion model dependent performance measures are for the Sacramento River channel with existing revetment (no revetment removal).

Focal species	Performance measure	Action Alternatives vs. Existing Conditions			
		NAA (comparison 1)	Alt A (comparison 2)	Alt B (comparison 4)	Alt C (comparison 6)
Fremont Cottonwood	Initiation success (FC1)	ni (+/-0)	ni (+/-0)	ni (+/-0)	ni (+/-0)
	Post-initiation scour risk (FC2)	+ (+9)	++ (+20)	ni (+2)	++ (+25)
Bank Swallows	Habitat potential/suitability (BASW1)**	ni (+/-0)	- (-4)	- (-5)	ni (- 3)
	Peak flow during nesting period (BASW2)	ni (+/-0)	ni (+/-0)	ni (+/-0)	ni (+/-0)
Western Pond Turtles	Large Woody Debris Recruitment (LWD)**	ni (-3)	ni (-3)	ni (-3)	ni (-3)
Green Sturgeon	Egg temperature preferences (GS1)	ni (+1)	+ (+6)	+ (+8)	+ (+8)
Steelhead	Spawning WUA (ST1)	ni (+/- 0)	ni (+2)	ni (+2)	ni (+2)
	Thermal egg mortality (ST3)	ni (+/-0)	ni (+/-0)	ni (+/-0)	ni (+/-0)
	Redd Dewatering (ST6)	ni (+/-0)	+ (+5)	+ (+6)	+ (+5)
	Redd Scour (ST5)	ni (+/-0)	ni (+/-0)	ni (+/-0)	ni (+/-0)
	Juvenile Stranding (ST4)	ni (+/-0)	- (-6)	- (-4)	- (-7)
	Rearing WUA (ST2)	ni (-3)	+ (+5)	+ (+5)	+ (+5)
Fall Chinook	Spawning WUA (CH1)	ni (+2)	ni (-2)	ni (-2)	- (-5)
	Thermal egg mortality (CH3)	ni (+1)	ni (+3)	ni (+1)	ni (+3)
	Redd Dewatering (CH6)	ni (+/-0)	+ (+4)	ni (+2)	+ (+4)
	Redd Scour (CH5)	ni (+/-0)	ni (+/-0)	ni (-1)	ni (-1)
	Juvenile Stranding (CH4)	ni (+/-0)	ni (-3)	- (-4)	- (-4)
	Rearing WUA (CH2)	ni (+/-0)	+(+7)	+ (+7)	+ (+7)
Late Fall Chinook	Spawning WUA (CH1)	ni (+/-0)	ni (-3)	ni (-3)	ni (-3)
	Thermal egg mortality CH3)	ni (+/-0)	ni (+/-0)	ni (+/-0)	ni (+/-0)
	Redd Dewatering (CH6)	ni (+/-0)	ni (+2)	ni (+3)	ni (+2)
	Redd Scour (CH5)	ni (+/-0)	ni (+2)	ni (+/-0)	ni (+/-0)
	Juvenile Stranding (CH4)	ni (-3)	- (-9)	- (-6)	- (-9)
	Rearing WUA (CH2)	ni (-1)	ni (+3)	+ (+5)	ni (+2)
Spring Chinook	Spawning WUA (CH1)	ni (+/-0)	ni (+3)	ni (+3)	ni (+2)
	Thermal egg mortality (CH3)	ni (-2)	ni (+3)	+ (+4)	ni (+3)
	Redd Dewatering (CH6)	ni (-1)	++ (+11)	++ (+12)	+ (+9)

Focal species	Performance measure	Action Alternatives vs. Existing Conditions			
		NAA (comparison 1)	Alt A (comparison 2)	Alt B (comparison 4)	Alt C (comparison 6)
	Redd Scour (CH5)	ni (+2)	ni (+/-0)	ni (+/-0)	ni (+/-0)
	Juvenile Stranding (CH4)	ni (-1)	ni (+2)	ni (+2)	ni (+2)
	Rearing WUA (CH2)	ni (+1)	**-** (-8)	**-** (-8)	**-** (-8)
Winter Chinook	Spawning WUA (CH1)	**-** (-5)	**++** (+10)	**+** (+9)	**++** (+10)
	Thermal egg mortality (CH3)	ni (+/-0)	ni (+/-0)	ni (+/-0)	ni (+2)
	Redd Dewatering (CH6)	ni (-1)	**+** (+4)	**+** (+4)	+ (+4)
	Redd Scour (CH5)	ni (+/-0)	ni (+/-0)	ni (+/-0)	ni (+/-0)
	Juvenile Stranding (CH4)	**+** (+4)	ni (+3)	ni (+3)	**+** (+8)
	Rearing WUA (CH2)	**-** (-8)	**-** (-4)	**-** (-8)	**-** (-5)

Legend

++	strong beneficial impact owing to project alternative
+	small beneficial impact owing to project alternative
ni	negligible detected impact owing to project alternative
-	small negative impact owing to project alternative
--	strong negative impact owing to project alternative

Table 3-C: High-level summary of the relative direction of change in performance measures between the No Action Alternative and the different alternatives. Numbers in brackets refer to the increased percentage of simulation years having a favorable rating. **Results of these meander/erosion model dependent performance measures are for the Sacramento River channel with existing revetment (no revetment removal).

Focal species	Performance measure	Action Alternatives vs. No Action Alternative			
		Existing (comparison 1)	Alt A (comparison 3)	Alt B (comparison 5)	Alt C (comparison 7)
Fremont Cottonwood	Initiation success (FC1)	ni (+/-0)	ni (+/-0)	ni (+/-0)	ni (+/-0)
	Post-initiation scour risk (FC2)	- (-9)	++ (+11)	- (-7)	++ (+16)
Bank Swallows	Habitat potential/suitability (BASW1)**	ni (+/-0)	- (-4)	- (-5)	ni (-3)
	Peak flow during nesting period (BASW2)	ni (+/-0)	ni (+/-0)	ni (+/-0)	ni (+/-0)
Western Pond Turtles	Large Woody Debris Recruitment (LWD)**	ni (+3)	ni (+/-0)	ni (+/-0)	ni (+/-0)
Green Sturgeon	Egg temperature preferences (GS1)	ni (-1)	+ (+5)	+ (+7)	+ (+7)
Steelhead	Spawning WUA (ST1)	ni (+/- 0)	ni (+2)	ni (+2)	ni (+2)
	Thermal egg mortality (ST3)	ni (+/-0)	ni (+/-0)	ni (+/-0)	ni (+/-0)
	Redd Dewatering (ST6)	ni (+/-0)	+ (+5)	+ (+6)	+ (+5)
	Redd Scour (ST5)	ni (+/-0)	ni (+/-0)	ni (+/-0)	ni (+/-0)
	Juvenile Stranding (ST4)	ni (+/-0)	- (-6)	- (-4)	- (-7)
	Rearing WUA (ST2)	ni (+3)	+ (+8)	+ (+8)	+ (+8)
Fall Chinook	Spawning WUA (CH1)	ni (-2)	- (-4)	- (-4)	- (-7)
	Thermal egg mortality (CH3)	ni (-1)	ni (+2)	ni (+/-0)	ni (+2)
	Redd Dewatering (CH6)	ni (+/-0)	+ (+4)	ni (+2)	+ (+4)
	Redd Scour (CH5)	ni (+/-0)	ni (+/-0)	ni (-1)	ni (-1)
	Juvenile Stranding (CH4)	ni (+/-0)	ni (-3)	- (-4)	- (-4)
	Rearing WUA (CH2)	ni (+/-0)	+ (+7)	+ (+7)	+ (+7)
Late Fall Chinook	Spawning WUA (CH1)	ni (+/-0)	ni (-3)	ni (-3)	ni (-3)
	Thermal egg mortality (CH3)	ni (+/-0)	ni (+/-0)	ni (+/-0)	ni (+/-0)
	Redd Dewatering (CH6)	ni (+/-0)	ni (+2)	ni (+3)	ni (+2)
	Redd Scour (CH5)	ni (+/-0)	ni (+2)	ni (+/-0)	ni (+/-0)
	Juvenile Stranding (CH4)	ni (+3)	- (-6)	ni (-3)	- (-6)
	Rearing WUA (CH2)	ni (+1)	+ (+4)	+ (+6)	ni (+3)
Spring Chinook	Spawning WUA (CH1)	ni (+/-0)	ni (+3)	ni (+3)	ni (+2)
	Thermal egg mortality (CH3)	ni (+2)	+ (+5)	+ (+6)	+ (+5)
	Redd Dewatering (CH6)	ni (+1)	++ (+12)	++ (+13)	++ (+10)
	Redd Scour (CH5)	ni (-2)	ni (-2)	ni (-2)	ni (-2)
	Juvenile Stranding (CH4)	ni (+1)	ni (+3)	ni (+3)	ni (+3)
	Rearing WUA (CH2)	ni (-1)	- (-9)	- (-9)	- (-9)

Focal species	Performance measure	Action Alternatives vs. No Action Alternative			
		Existing (comparison 1)	Alt A (comparison 3)	Alt B (comparison 5)	Alt C (comparison 7)
Winter Chinook	Spawning WUA (CH1)	**+** (+5)	**++** (+15)	**++** (+14)	**++** (+15)
	Thermal egg mortality (CH3)	ni (+/-0)	ni (+/-0)	ni (+/-0)	ni (+2)
	Redd Dewatering (CH6)	ni (-1)	**+** (+5)	**+** (+5)	**+** (+5)
	Redd Scour (CH5)	ni (+/-0)	ni (+/-0)	ni (+/-0)	ni (+/-0)
	Juvenile Stranding (CH4)	**-** (-4)	ni (-1)	ni (-1)	**+** (+4)
	Rearing WUA (CH2)	**+** (+8)	**+** (+4)	ni (+/-0)	ni (+3)

Legend		
	++	strong beneficial impact owing to project alternative
	+	small beneficial impact owing to project alternative
	ni	negligible detected impact owing to project alternative
	-	small negative impact owing to project alternative
	--	strong negative impact owing to project alternative

Table 3-D: High-level summary of the relative direction of change in performance measures between the No Action Alternative (which reflects 2030 conditions, constraints and operations) and historical flows. Numbers in brackets refer to the increased percentage of simulation years having a favorable rating. **Results of these meander/erosion model dependent performance measures are for the Sacramento River channel with existing revetment (no revetment removal).

Focal species	Performance measure	NAA vs. Historic Conditions (Comparison 8)
Fremont Cottonwood	Initiation success (FC1)	- - (-17)
	Post-initiation scour risk (FC2)	++ (+10)
Bank Swallows	Habitat potential/suitability (BASW1)**	ni (+1)
	Peak flow during nesting period (BASW2)	+ (+4)
Western Pond Turtles	Large Woody Debris Recruitment (LWD)**	- - (-29)
Green Sturgeon	Egg temperature preferences (GS1)	n/a
Steelhead	Spawning WUA (ST1)	++ (+14)
	Thermal egg mortality (ST3)	ni (+/-0)
	Redd Dewatering (ST6)	+ (+9)
	Redd Scour (ST5)	- - (-16)
	Juvenile Stranding (ST4)	- - (-24)
	Rearing WUA (ST2)	++ (+13)
Fall Chinook	Spawning WUA (CH1)	- - (-15)
	Thermal egg mortality (CH3)	+ (+8)
	Redd Dewatering (CH6)	+ (+4)
	Redd Scour (CH5)	- (-5)
	Juvenile Stranding (CH4)	- - (-25)
	Rearing WUA (CH2)	ni (+1)
Late Fall Chinook	Spawning WUA (CH1)	++ (+11)
	Thermal egg mortality (CH3)	ni (+/-0)
	Redd Dewatering (CH6)	+ (+6)
	Redd Scour (CH5)	- - (-13)
	Juvenile Stranding (CH4)	- - (-11)
	Rearing WUA (CH2)	++ (+20)
Spring Chinook	Spawning WUA (CH1)	ni (-2)
	Thermal egg mortality (CH3)	+ (+8)
	Redd Dewatering (CH6)	++ (+35)
	Redd Scour (CH5)	ni (+/-0)
	Juvenile Stranding (CH4)	- - (-29)
	Rearing WUA (CH2)	- - (-13)
Winter Chinook	Spawning WUA (CH1)	- - (-12)
	Thermal egg mortality (CH3)	ni (+1)
	Redd Dewatering (CH6)	ni (-3)
	Redd Scour (CH5)	- (-5)

Focal species	Performance measure	NAA vs. Historic Conditions (Comparison 8)
	Juvenile Stranding (CH4)	+ (+7)
	Rearing WUA (CH2)	ni (+/-0)

Legend		
	++	strong beneficial impact owing to project alternative
	+	small beneficial impact owing to project alternative
	ni	negligible detected impact owing to project alternative
	-	small negative impact owing to project alternative
	--	strong negative impact owing to project alternative

The purpose of the environmental and feasibility documents is to describe the difference between No Action / Existing Conditions and the Action Alternatives which all reflect 2030 conditions, constraints and operations. Typically, none of the NODOS Investigation alternative modelling results are compared against the historical calibration due to the focus of CEQA/NEPA which emphasizes isolating project alternative effects as compared to a no action reference or existing condition comparison.

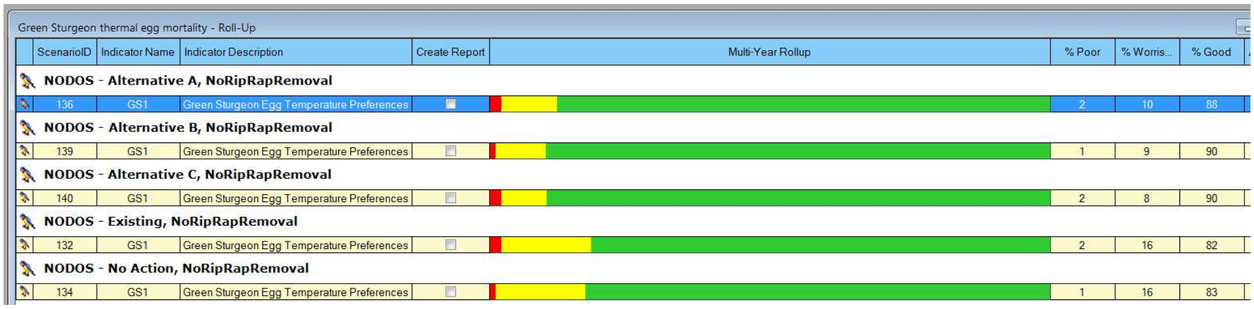
Comparison #8 (see Section 2.5; The NAA, relative to Actual Historic Conditions) is **not** used in our report to assess NODOS effects. Instead, it provides an essential reference case illustrating how SacEFT's various performance measures have performed under historic flows and water temperatures from 1938 – 2003 relative to the future 2030 conditions, constraints and hydrosystem operations in the NAA. Historic flows represent less constrained, more natural patterns of variation in flow and water temperature that have occurred in the past. Comparisons that include historical data reveal different information in a different context that does not address a specific project effect relative to the no action alternative or existing condition reference case. These comparisons identify the ecological effects of the future system operations and constraints relative to historic conditions. In fully considering ecological flow needs, the magnitude of departure from these historic conditions may reveal important information on how future constraints, climate and/or hydrosystem operational modifications are influencing preferred ecological flow targets. Historic flows represent less constrained, more natural patterns of variation in flow and water temperature that have occurred in the past.

Table 3-D shows that relative to historic flows and water temperatures, conditions associated with the NAA (comparison 8) generate a strong negative effect on Fremont Cottonwood initiation success (FC1), Large Woody Debris recruitment (LWD) and Steelhead/fall Chinook/late fall Chinook/spring Chinook juvenile stranding risk (ST4/CH4). For case #8, fall Chinook spawning WUA (CH1) performance declined, as it did for winter-run Chinook. Likewise, redd scour risk is increased for Steelhead (ST5) and late fall Chinook (CH5). Rearing WUA (CH2) habitat conditions were also lower in the case of spring run Chinook

The following performance measures showed a strong positive effect owing to the NAA relative to actual historic conditions: Steelhead and late fall Chinook spawning WUA (ST1 and CH1). Also improved were rearing WUA for late fall Chinook (CH2). Notably, as with NODOS alternatives A, B and C, spring Chinook redd dewatering risk (CH6) was markedly reduced by conditions present in the NAA vs. actual historic.

3.3 Aquatic Species and Performance Measures

3.3.1 Green Sturgeon



Green Sturgeon thermal egg mortality - Roll-Up

ScenarioID	Indicator Name	Indicator Description	Create Report	Multi-Year Rollup	% Poor	% Worris..	% Good
NODOS - Alternative A, NoRipRapRemoval							
136	GS1	Green Sturgeon Egg Temperature Preferences			2	10	88
NODOS - Alternative B, NoRipRapRemoval							
139	GS1	Green Sturgeon Egg Temperature Preferences			1	9	90
NODOS - Alternative C, NoRipRapRemoval							
140	GS1	Green Sturgeon Egg Temperature Preferences			2	8	90
NODOS - Existing, NoRipRapRemoval							
132	GS1	Green Sturgeon Egg Temperature Preferences			2	16	82
NODOS - No Action, NoRipRapRemoval							
134	GS1	Green Sturgeon Egg Temperature Preferences			1	16	83

Figure 3.9: Multi-year roll-up results for green sturgeon thermal egg mortality (GS1).

Figure 3.9 and Figure 3.10 show the percentage of years in each NODOS simulation having favorable (green) conditions for green sturgeon thermal egg mortality (GS1). SacEFT predicts that green sturgeon eggs (GS1) would receive benefits (+5% to +8% of years with better conditions) from all three of the NODOS Investigation alternatives in terms of reduction of thermal egg mortality (GS1) (Figure 3.10).

Figure 3.11 shows the number of days in each simulation that water temperatures are above the 20°C lethal threshold for green sturgeon egg development. Consistent with SacEFT preferred condition roll-up results, the NODOS Investigation alternatives all reduce the number of days green sturgeon eggs are exposed to lethal water temperatures.

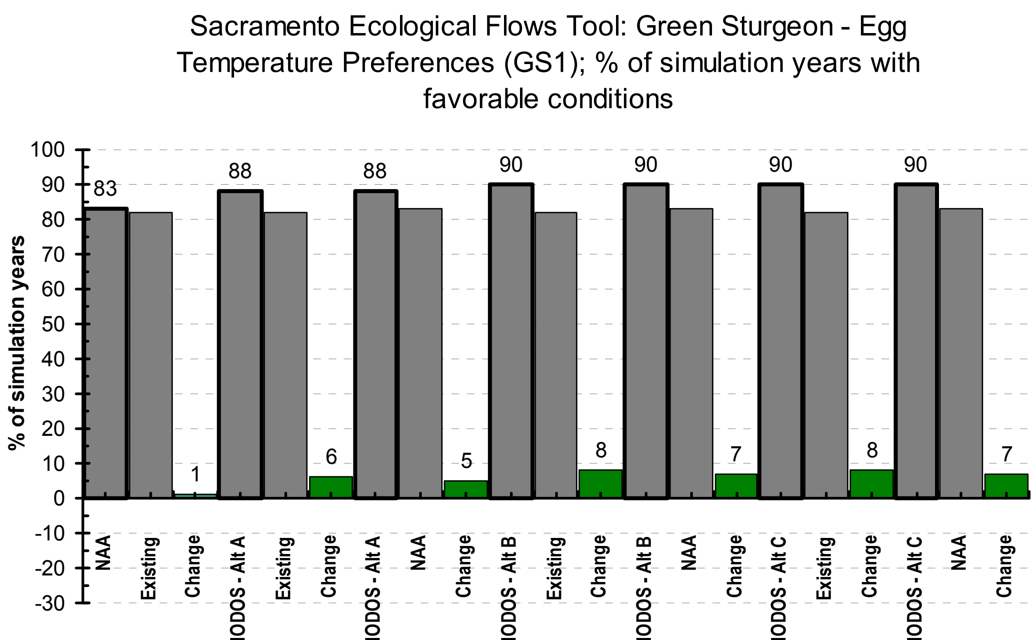


Figure 3.10: The percentage of years in each NODOS simulation having favorable (green) conditions for green sturgeon thermal egg mortality (GS1). Bars labeled with "Change" refer to the % change between the simulated alternative and the reference condition (either Existing conditions or the No Action Alternative (NAA)).

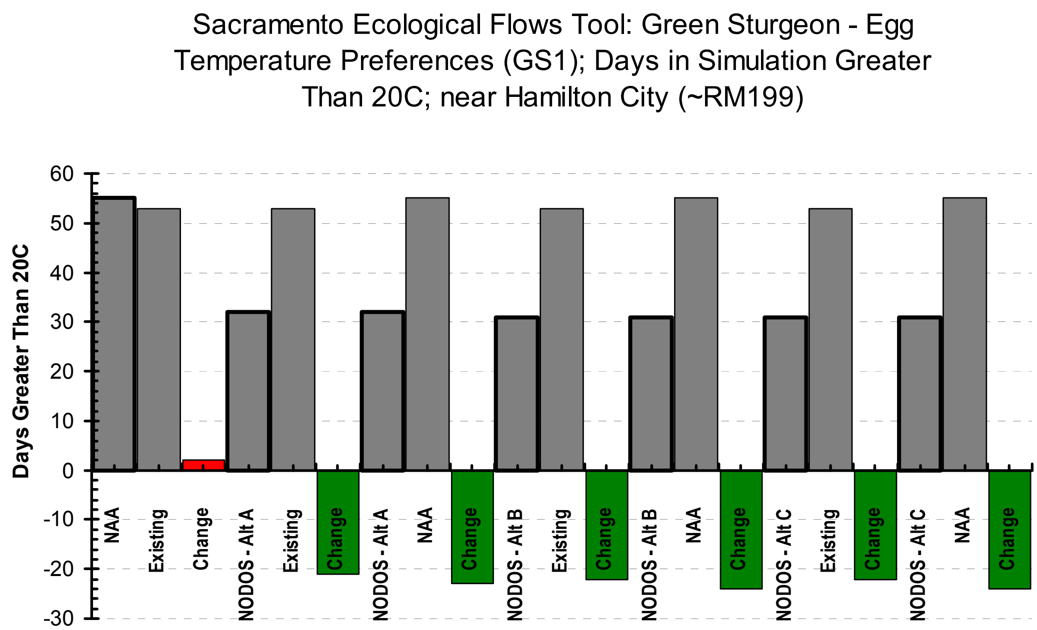


Figure 3.11: Number of days in each simulation where water temperatures near Hamilton City (RM199) are greater than 20°C. Bars labeled with "Change" refer to the change in number of days greater than 20°C between the simulated alternative and the reference condition (either Existing conditions or the No Action Alternative (NAA)).

SacEFT Target and Avoidance Flows for Green Sturgeon Egg Development

Figure 3.12 shows the SacEFT target/favorable water temperature profiles and the median target water temperature at the Sacramento River near Red Bluff (RM260) and Hamilton City (RM199) during the critical period for green sturgeon egg development.

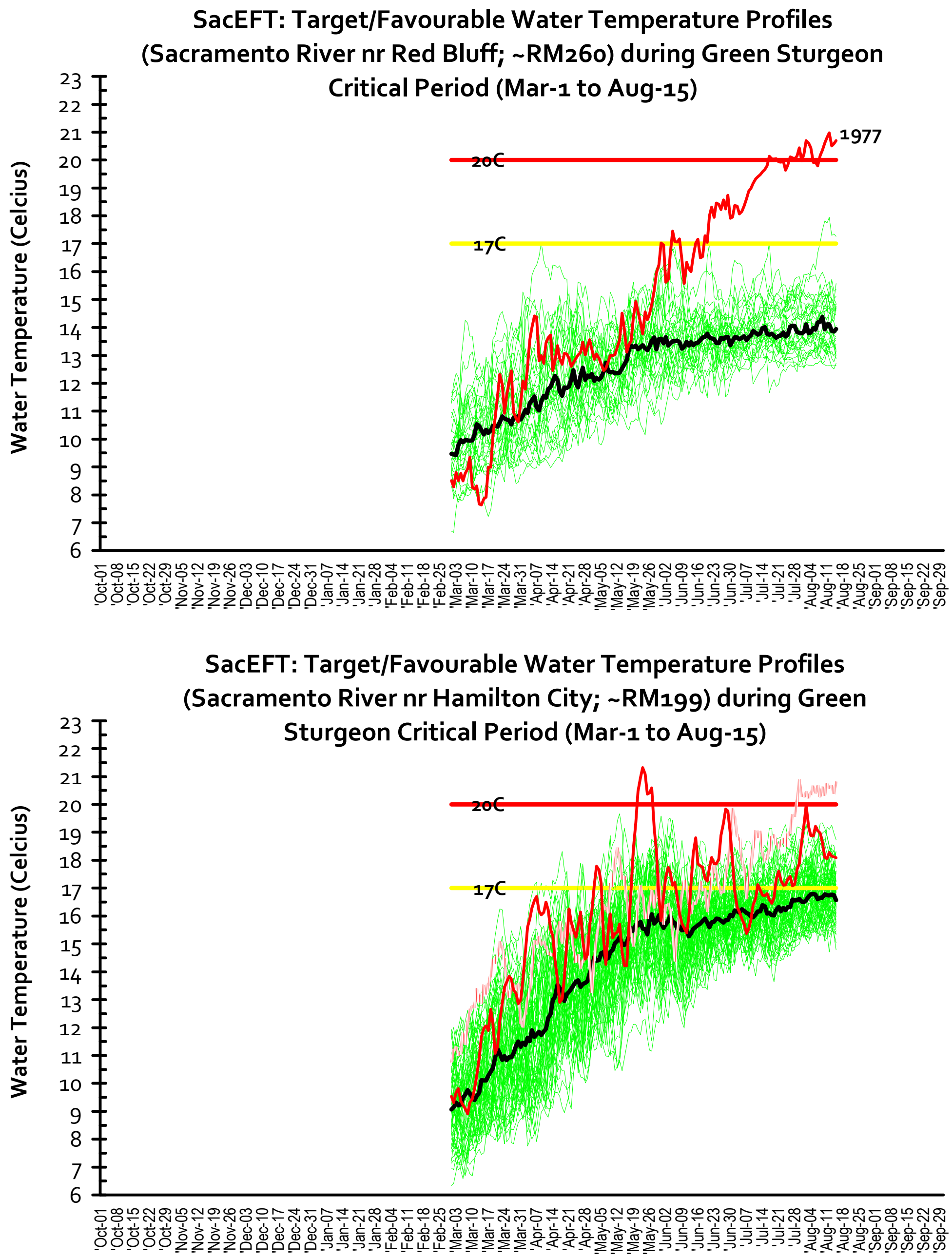


Figure 3.12: Target/favorable water temperature profiles (green) for minimizing green sturgeon thermal egg mortality (GS1) at two index locations (RM260 and RM199). Water temperature profiles in green refer to years where SacEFT's annual performance measure rating was assessed as good/favorable. The heavy black line provides the median of the all year favorable water temperature profiles. Lines in red show example years rated as poor by SacEFT (*i.e.*, highest category of egg mortality). Horizontal lines at 17°C and 20°C are important thresholds that affect green sturgeon egg development (GS1). [Note: this figure is designed for color printing].

Figure 3.13 provides an example of detailed daily output available from SacEFT for a poor year like 1977.

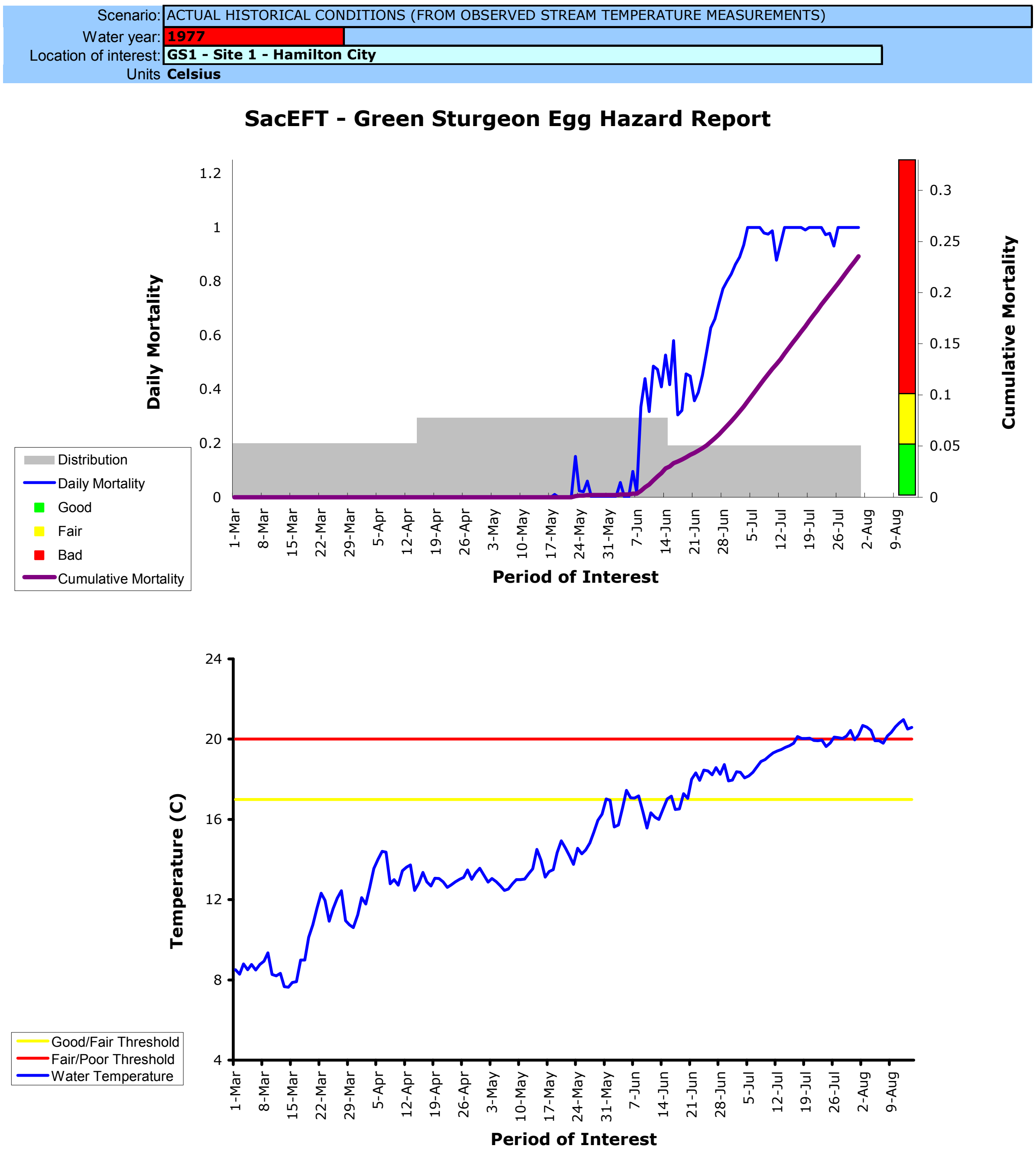


Figure 3.13: SacEFT detailed output report for a specific water year (1977) showing daily results for green sturgeon thermal egg mortality (GS1) at a specific index location (Hamilton City).

3.3.2 Steelhead Trout

Figure 3.14 to Figure 3.18 show the percentage of years in each NODOS simulation having favorable (green) conditions for the six independent Steelhead trout performance measure in SacEFT (ST3 omitted as SacEFT rates all scenarios as 100% favorable). SacEFT predicts that Steelhead would receive benefits in terms of reduced redd dewatering (ST6) (+5% to +6% of years with better conditions) from all three of the NODOS Investigation alternatives (Figure 3.15) as well as improvements to rearing conditions (ST2) (+5% to +8% of years with more favorable conditions) (Figure 3.18). Conversely the NODOS

Investigation alternatives increase juvenile stranding risks (ST4) over both existing conditions and NAA (approx. –4% to –7% reduction in years with favorable conditions) (Figure 3.17). Stranding risk increases (ST4) are particularly apparent when compared to rates of stranding found with historical flows (Figure 3.17). Likewise, redd scour risks are higher in all NODOS alternatives relative to historic conditions (Figure 3.16).

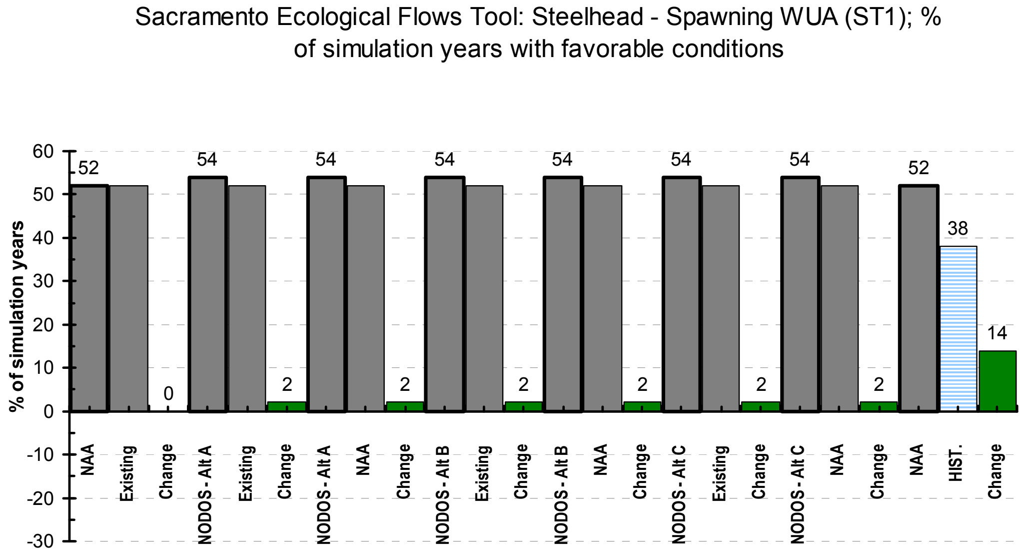


Figure 3.14: The percentage of years in each NODOS simulation having favorable (green) conditions for Steelhead spawning WUA (ST1). Bars labeled with "Change" refer to the % change between the simulated alternative and the reference condition (either Existing conditions or the No Action Alternative (NAA)).

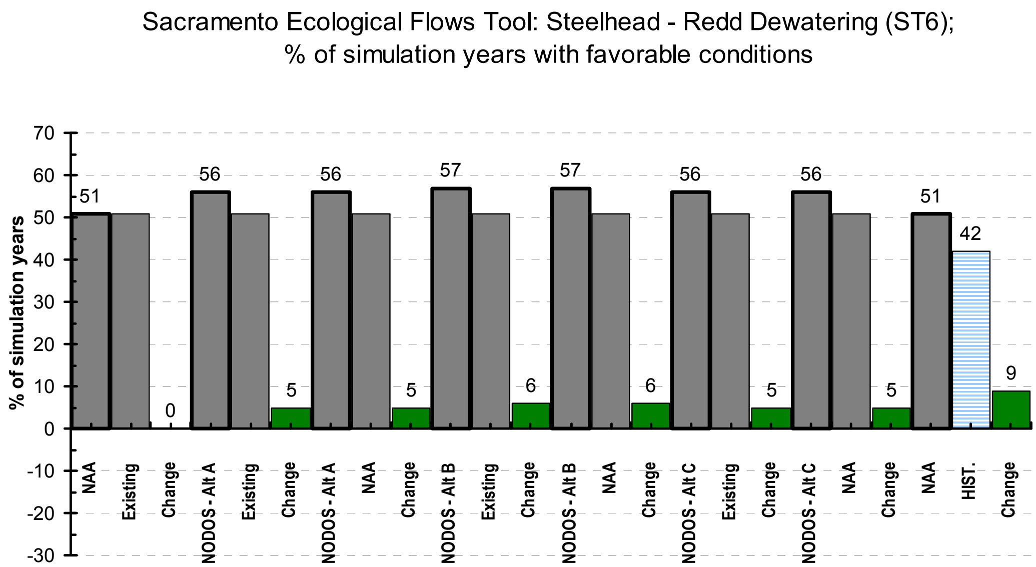


Figure 3.15: The percentage of years in each NODOS simulation having favorable (green) conditions for Steelhead redd dewatering (ST6). Bars labeled with "Change" refer to the % change between the simulated alternative and the reference condition (either Existing conditions or the No Action Alternative (NAA)).

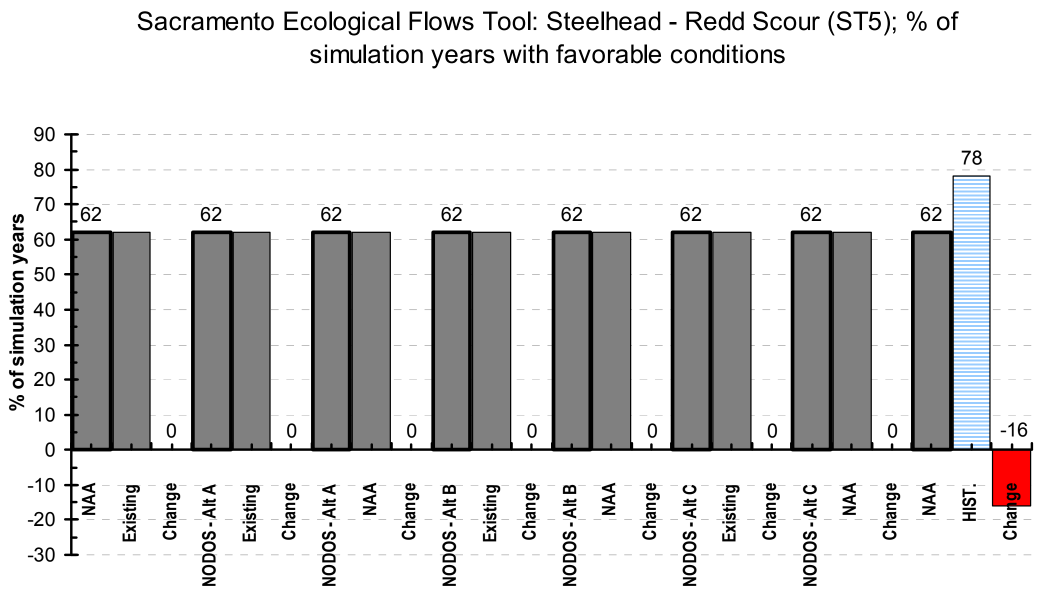


Figure 3.16: The percentage of years in each NODOS simulation having favorable (green) conditions for Steelhead redd scour (ST5). Bars labeled with "Change" refer to the % change between the simulated alternative and the reference condition (either Existing conditions or the No Action Alternative (NAA)).

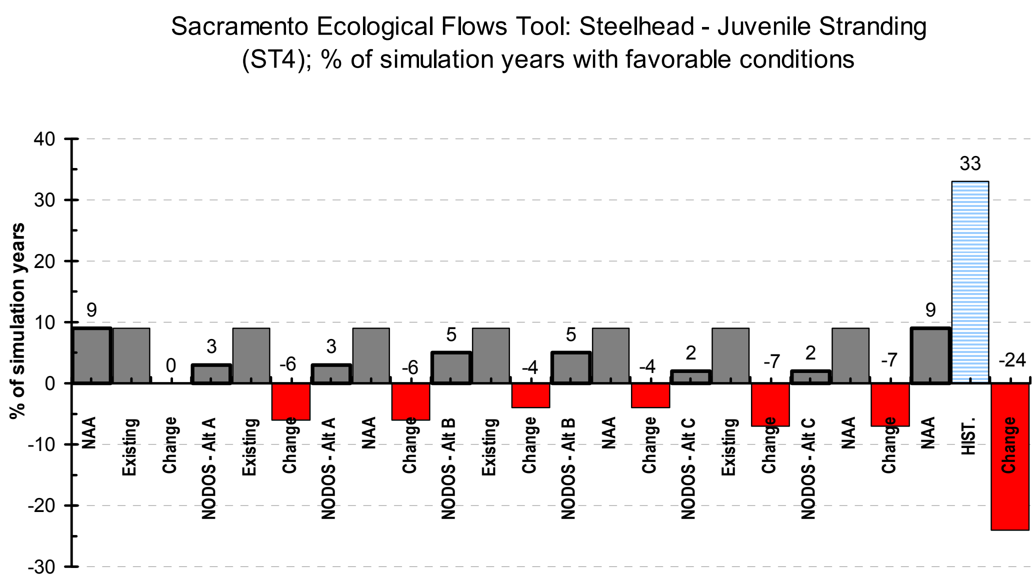


Figure 3.17: The percentage of years in each NODOS simulation having favorable (green) conditions for Steelhead juvenile stranding (ST4). Bars labeled with "Change" refer to the % change between the simulated alternative and the reference condition (either Existing conditions or the No Action Alternative (NAA)).

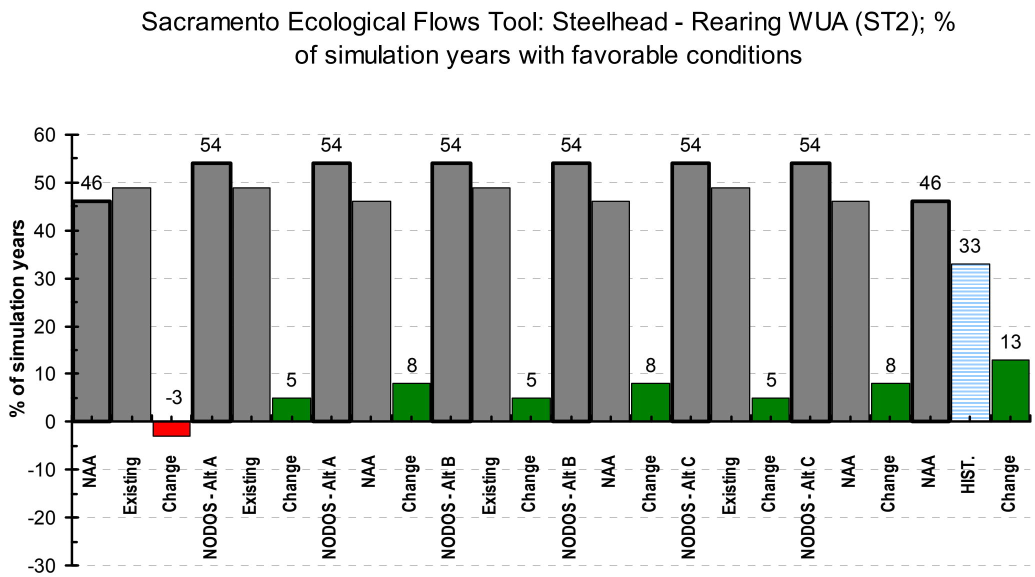


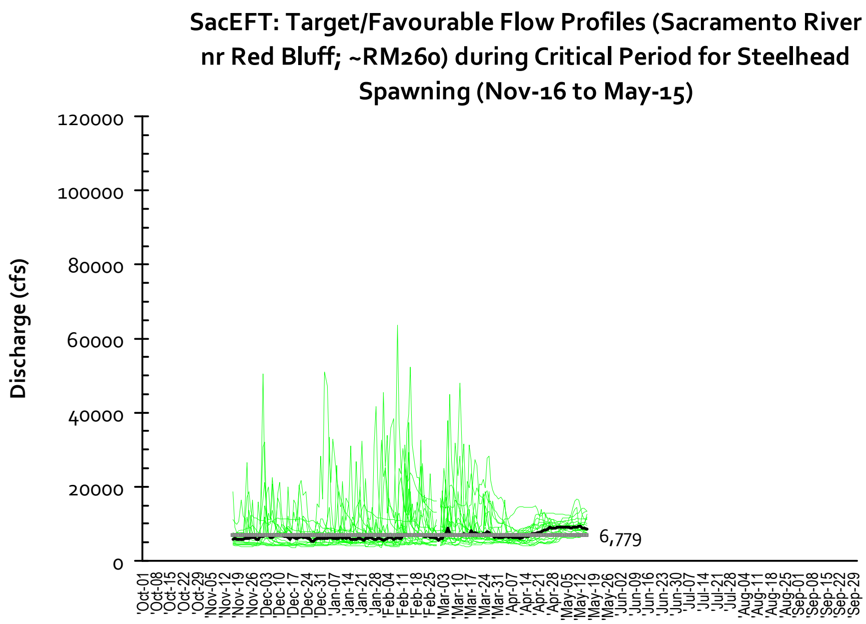
Figure 3.18: The percentage of years in each NODOS simulation having favorable (green) conditions for Steelhead rearing WUA (ST2). Bars labeled with "Change" refer to the % change between the simulated alternative and the reference condition (either Existing conditions or the No Action Alternative (NAA)).

Readers are referred to Appendix C for raw data for the results presented above, as well as all relevant SacEFT multi-year roll-up screen shot images.

SacEFT Target and Avoidance Flows and Water Temperatures for Steelhead Trout

Figure 3.19 shows the SacEFT target/favorable flow profiles and the median target flow at the Sacramento River near Red Bluff (RM260) during the critical period for Steelhead trout spawning as found using the spawning WUA performance measure (ST1).

(a)



(b)

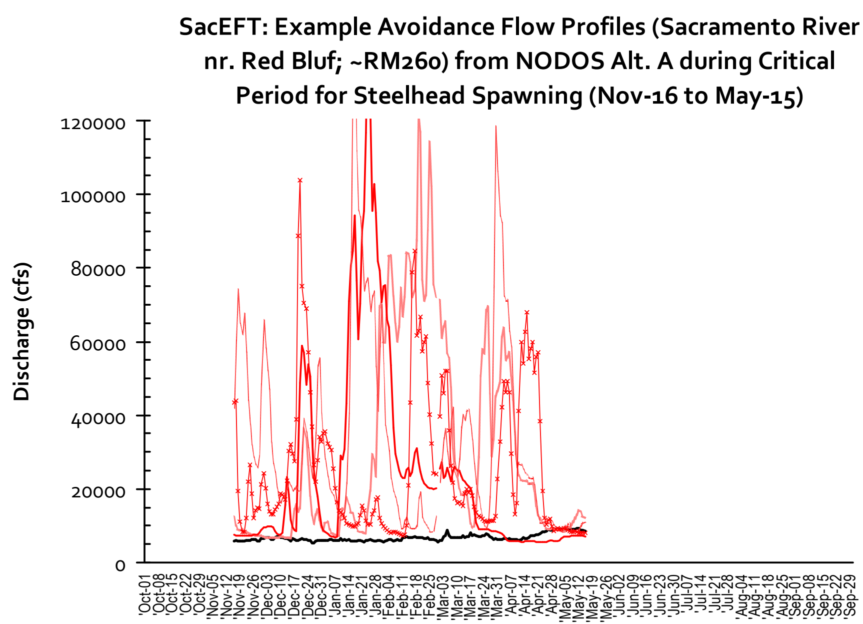
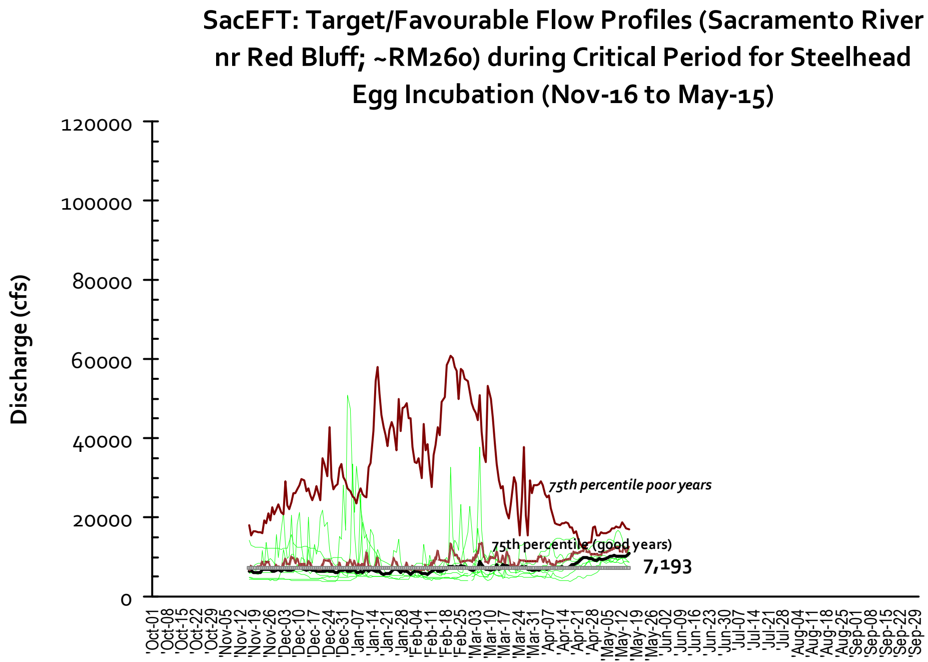


Figure 3.19: Target/favorable flow profiles (green) for steelhead spawning WUA (ST1) at Sacramento River near Red Bluff (RM260). Flow profiles in green refer to years where SacEFT's annual performance measure rating was assessed as good/favorable. The heavy black line provides the median of the all year favorable flow profiles. The grey horizontal line (panel a) is the average of the median target flow. Flow traces in red (panel b) are examples of typical years rated poor by SacEFT (*i.e.*, least cumulative spawning habitat potential). [Note: this figure is designed for color printing].

Figure 3.20 shows the SacEFT target/favorable flow profiles and the median target flow at the Sacramento River near Red Bluff (RM260) during the critical period for Steelhead trout egg incubation as found using the redd dewatering performance measure (ST6).

(a)



(b)

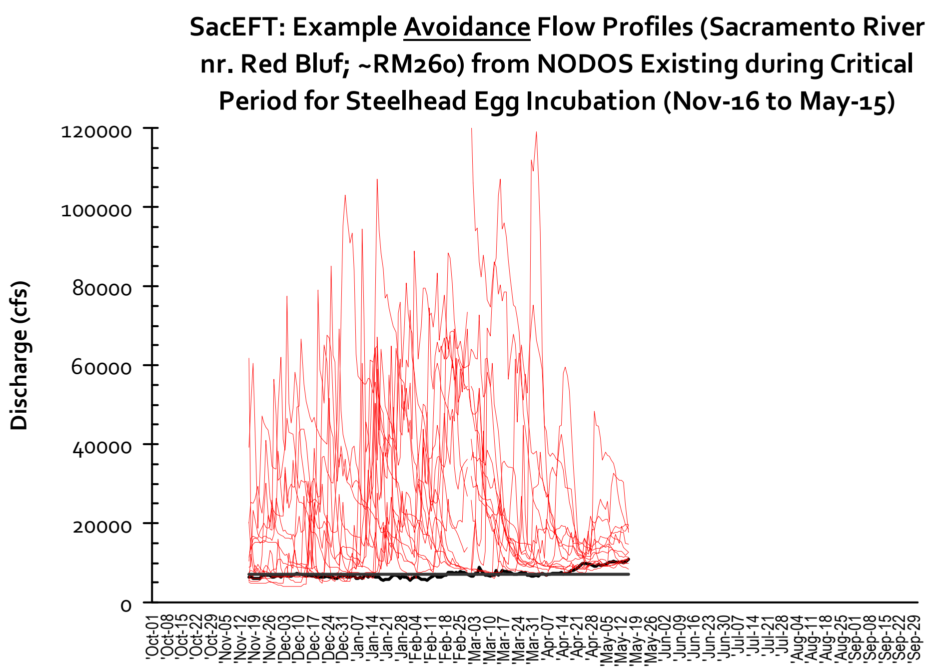


Figure 3.20: Example target/favorable flow profiles (green) for steelhead redd dewatering (ST6) at Sacramento River near Red Bluff (RM260) (panel a). Flow profiles in green refer to years where SacEFT's annual performance measure rating was assessed as good/favorable. Example flow traces in red (panel b) are examples of typical years rated poor by SacEFT (*i.e.*, highest values of redd dewatering).

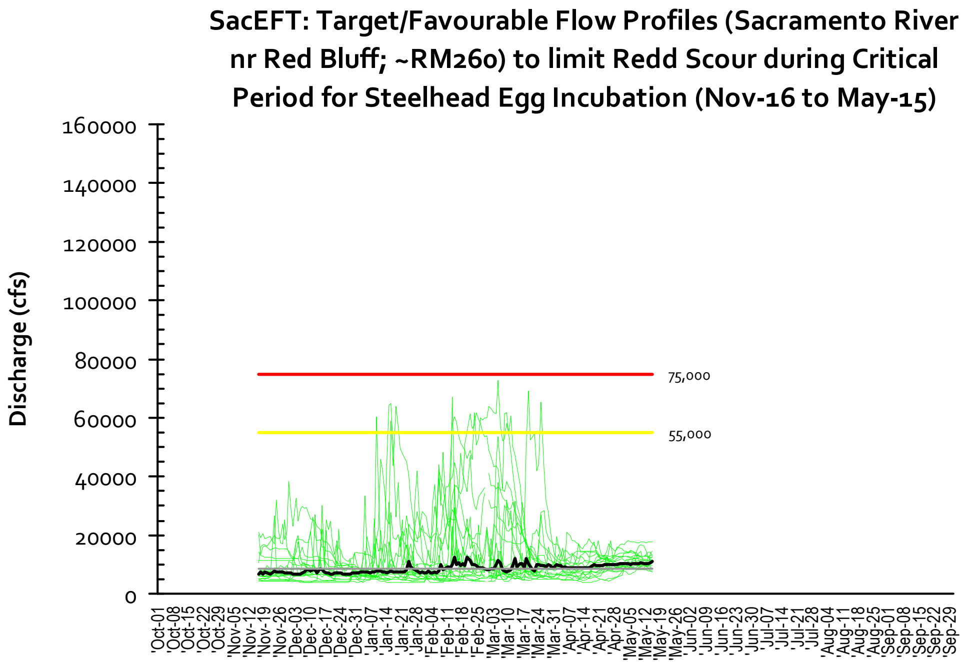
Steelheed redd de-watering risk is driven primarily by the presence of high flows during spawning, which contributes to a higher percentage of redds being spawned at higher elevations. This is apparent when comparing the 75th percentile flows between low de-watering years and high de-watering years in panel a of Figure 3.20. Hence, the de-watering threshold is dynamic, *and will be higher the higher average flows during the steelhead spawning period*.

Figure 3.21 shows the SacEFT target/favorable flow profiles and the median target flow at the Sacramento River near Red Bluff (RM260) during the critical period for Steelhead trout egg incubation as found using the redd scour performance measure (ST5).

Figure 3.22 shows the SacEFT target/favorable flow profiles and the median target flow at the Sacramento River near Red Bluff (RM260) during the critical period for Steelhead trout juvenile rearing as found using the juvenile stranding performance measure (ST4).

Figure 3.23 shows the SacEFT target/favorable flow profiles and the median target flow at the Sacramento River near Red Bluff (RM260) during the critical period for Steelhead trout juvenile rearing as found using the juvenile rearing WUA performance measure (ST2).

(a)



(b)

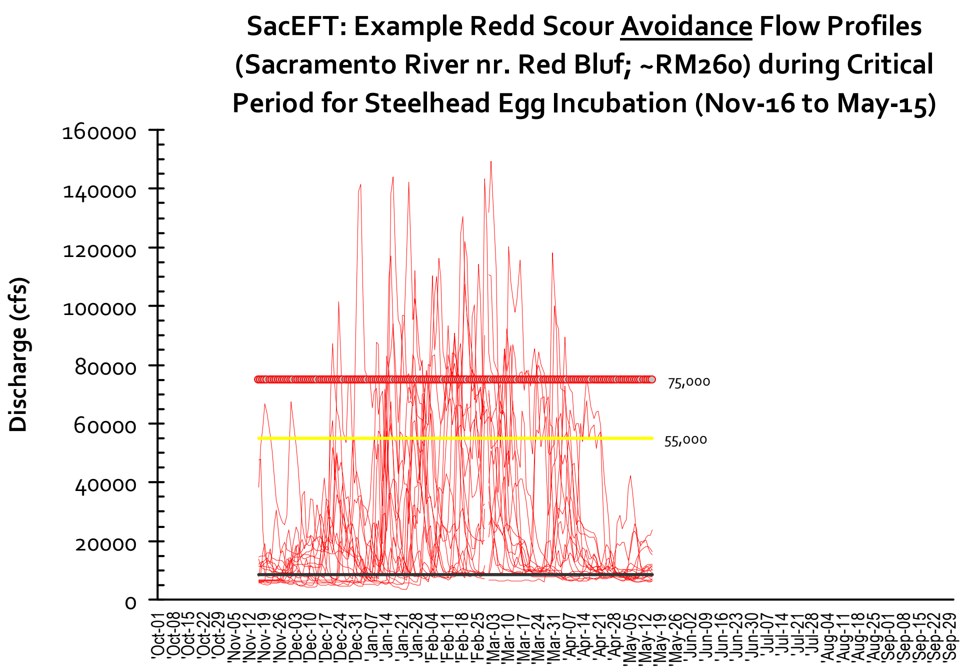
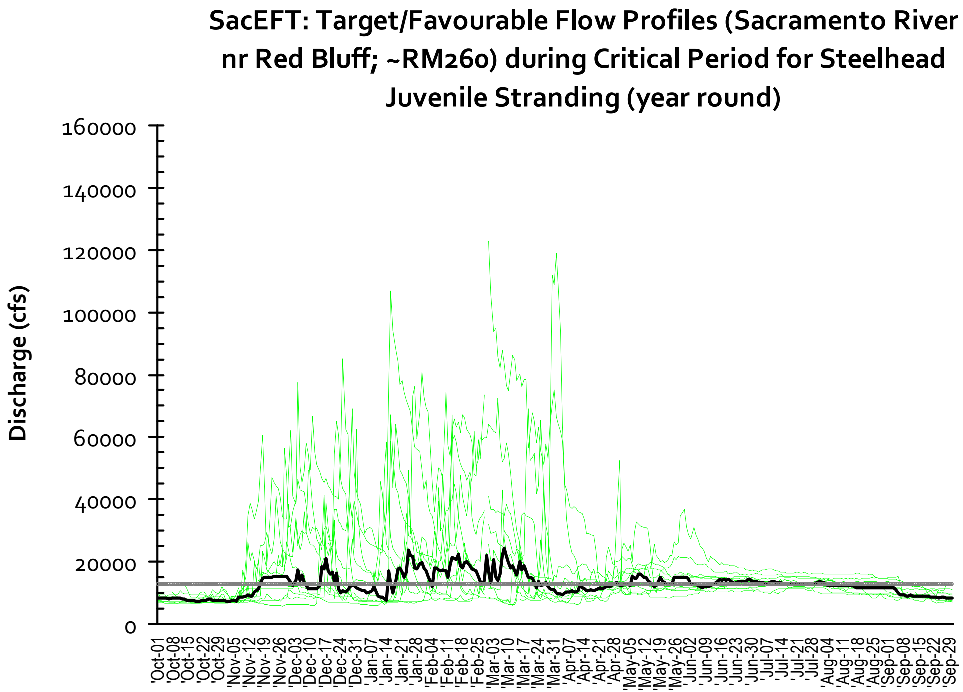


Figure 3.21: Target/favorable flow profiles (green) for minimizing steelhead egg scour mortality (ST5) at Sacramento River near Red Bluff (RM260) (panel a). Flow profiles in green refer to years where SacEFT's annual performance measure rating was assessed as good/favorable. The heavy black line (panel a) provides the median of the all year favorable flow profiles. Example flow traces in red (panel b) are examples of typical years rated poor by SacEFT (*i.e.*, highest values of redd scour). Horizontal lines at 55,000 cfs and 75,000 cfs are important thresholds that affect steelhead egg scour mortality rates (ST5).

(a)



(b)

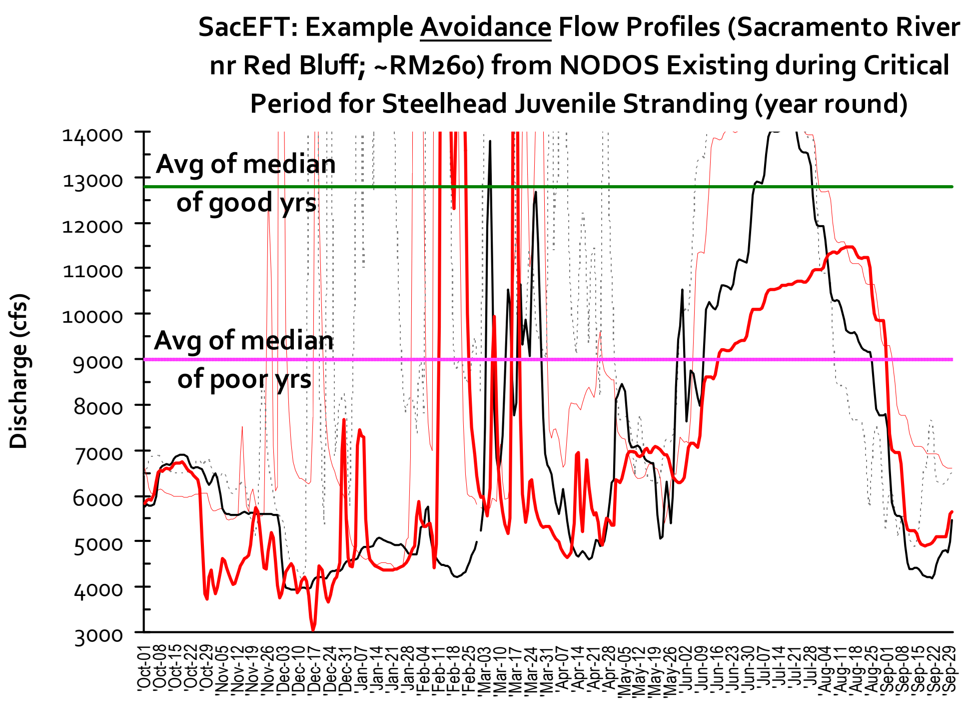
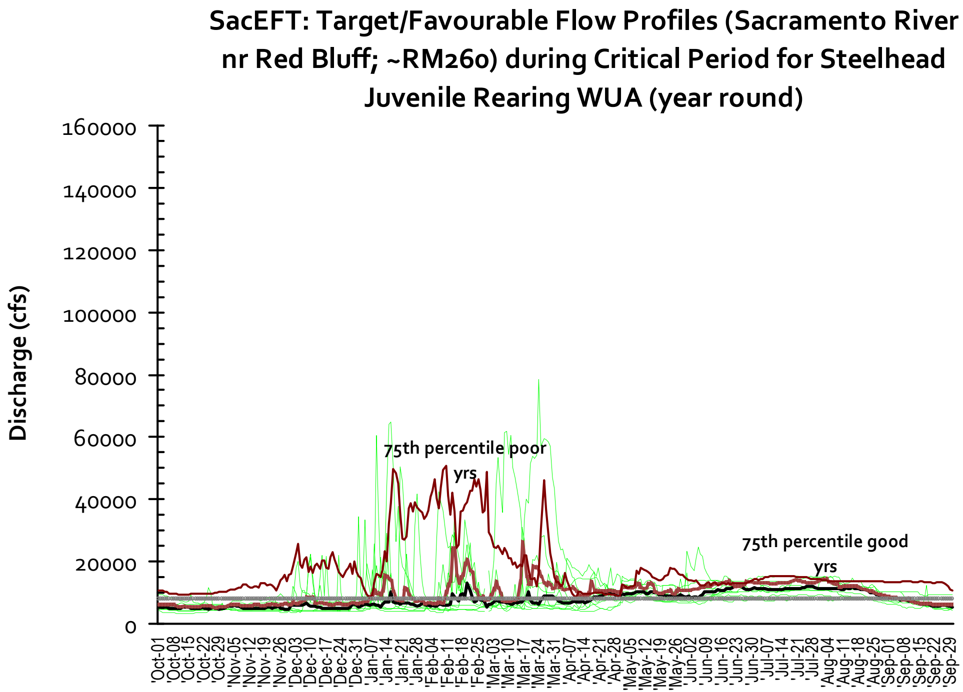


Figure 3.22: Target/favorable flow profiles (green) for minimizing juvenile steelhead stranding mortality (ST4) at Sacramento River near Red Bluff (RM260) (panel a). Flow profiles in green refer to years where SacEFT's annual performance measure rating was assessed as good/favorable. The heavy black line (panel a) provides the median of the all year favorable flow profiles. Example flow traces in red (panel b) are examples of typical years rated poor by SacEFT (*i.e.*, highest values of juvenile stranding). [Note: this figure is designed for color printing].

(a)



(b)

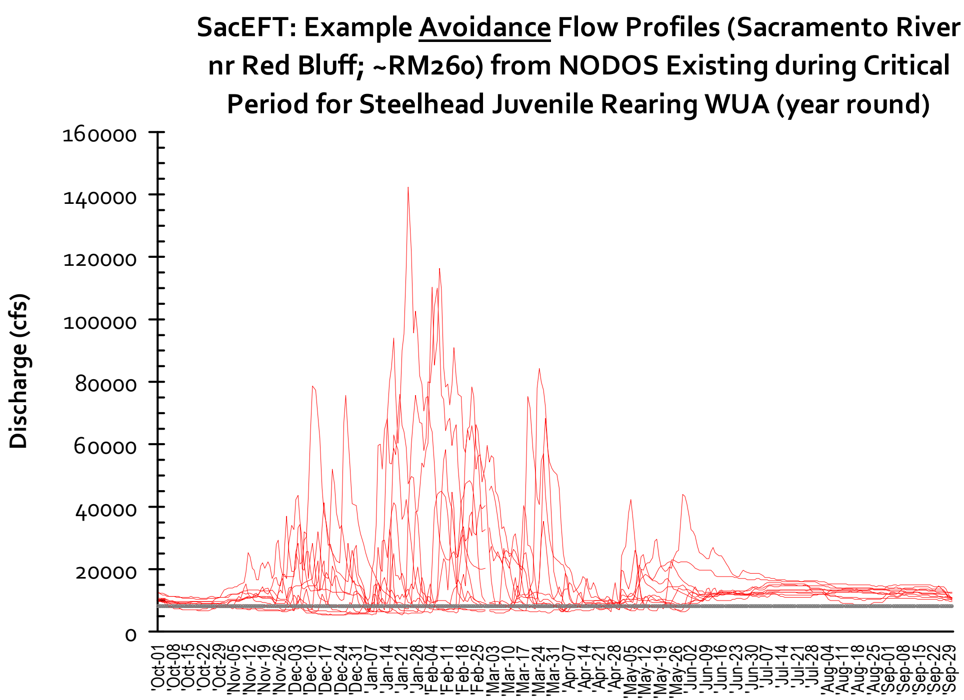


Figure 3.23: Target/favorable flow profiles (green) for maximizing juvenile steelhead rearing WUA (ST2) at Sacramento River near Red Bluff (RM260) (panel a). Flow profiles in green refer to years where SacEFT's annual performance measure rating was assessed as good/favorable. The heavy black line (panel a) provides the median of the all year favorable flow profiles. Example flow traces in red (panel b) are examples of typical years rated poor by SacEFT (*i.e.*, poorest values for juvenile rearing WUA). [Note: this figure is designed for color printing].

3.3.3 Fall Chinook

Readers are referred to Appendix C (FALL Chinook worksheet) for fall Chinook results for the six independent salmonid performance measures in SacEFT (CH1, CH3, CH6, CH5, CH4, CH2).

Section 3.2 summarizes the performance of the NODOS alternatives for fall Chinook (Table 3-B).

Using the same methods applied to Steelhead trout, it is possible to use SacEFT to quantify target and avoidance flows at index locations for fall Chinook critical periods.

3.3.4 Late Fall Chinook

Readers are referred to Appendix C (LFALL Chinook worksheet) for late fall Chinook results for the six independent salmonid performance measures in SacEFT (CH1, CH3, CH6, CH5, CH4, CH2).

Section 3.2 summarizes the performance of the NODOS alternatives for late fall Chinook (Table 3-B).

Using the same methods applied to Steelhead trout, it is possible to use SacEFT to quantify target and avoidance flows at index locations for late-fall Chinook critical periods.

3.3.5 Spring Chinook

Readers are referred to Appendix C (SPRING Chinook worksheet) for late fall Chinook results for the six independent salmonid performance measures in SacEFT (CH1, CH3, CH6, CH5, CH4, CH2).

Section 3.2 summarizes the performance of the NODOS alternatives for spring Chinook (Table 3-B).

Using the same methods applied to Steelhead trout, it is possible to use SacEFT to quantify target and avoidance flows at index locations for spring Chinook critical periods.

3.3.6 Winter Chinook

Readers are referred to Appendix C (WINTER Chinook worksheet) for winter-run Chinook results for the six independent salmonid performance measures in SacEFT (CH1, CH3, CH6, CH5, CH4, CH2).

Section 3.2 summarizes the performance of the NODOS alternatives for winter-run Chinook (Table 3-B).

Using the same methods applied to Steelhead trout, it is possible to use SacEFT to quantify target and avoidance flows at index locations for winter-run Chinook critical periods.

3.4 Riparian Species and Performance measures

3.4.1 Fremont Cottonwood Initiation


Fremont Cottonwood - Initiation Success (FC1) - Roll-Up

ScenarioID	Indicator Name	Indicator Description	Create Report	Multi-Year Rollup	% Poor	% Worris...	% Good
NODOS - Alternative A, NoRipRapRemoval							
136	FC1 - initiation	Fremont Cottonwood - relative initiation success			85	15	0
NODOS - Alternative B, NoRipRapRemoval							
139	FC1 - initiation	Fremont Cottonwood - relative initiation success			91	9	0
NODOS - Alternative C, NoRipRapRemoval							
140	FC1 - initiation	Fremont Cottonwood - relative initiation success			88	12	0
NODOS - Existing, NoRipRapRemoval							
132	FC1 - initiation	Fremont Cottonwood - relative initiation success			87	13	0
NODOS - No Action, NoRipRapRemoval							
134	FC1 - initiation	Fremont Cottonwood - relative initiation success			83	17	0
VERSION 2 CALIBRATION RUN (HISTORICAL)							
118	FC1 - initiation	Fremont Cottonwood - relative initiation success			63	20	17

Figure 3.24: Multi-year roll-up results for Fremont cottonwood seedling initiation success (FC1).

Figure 3.24 and Figure 3.25 show the percentage of years in each NODOS simulation having favorable (green) conditions for Fremont cottonwood seedling initiation (FC1). SacEFT predicts that Fremont cottonwood initiation (FC1) would not be impacted by any of the NODOS Investigation alternatives when compared with the existing conditions or NAA (Figure 3.25). However, results indicate that all of the NODOS alternatives are expected to generate unfavorable Cottonwood initiation conditions.

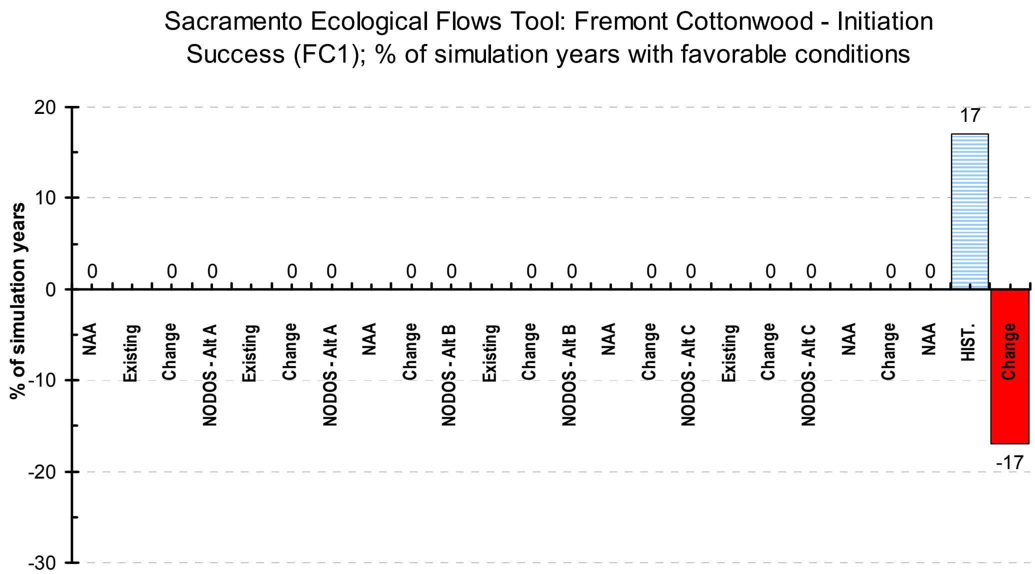


Figure 3.25: The percentage of years in each NODOS simulation having favorable (green) conditions for Fremont cottonwood seedling initiation (FC1). Bars labeled with "Change" refer to the % change between the simulated alternative and the reference condition (either Existing conditions or the No Action Alternative (NAA)).

It is noted that scour risk (FC2) is reduced under the NODOS alternatives, especially alternative C and A (Figure 3.26). However, this reduction in scour risk is in part due to the reduction in number of years with successful initiation (FC1). The FC2 performance measure in SacEFT is only relevant/calculated in years with successful Fremont cottonwood initiation (FC1).

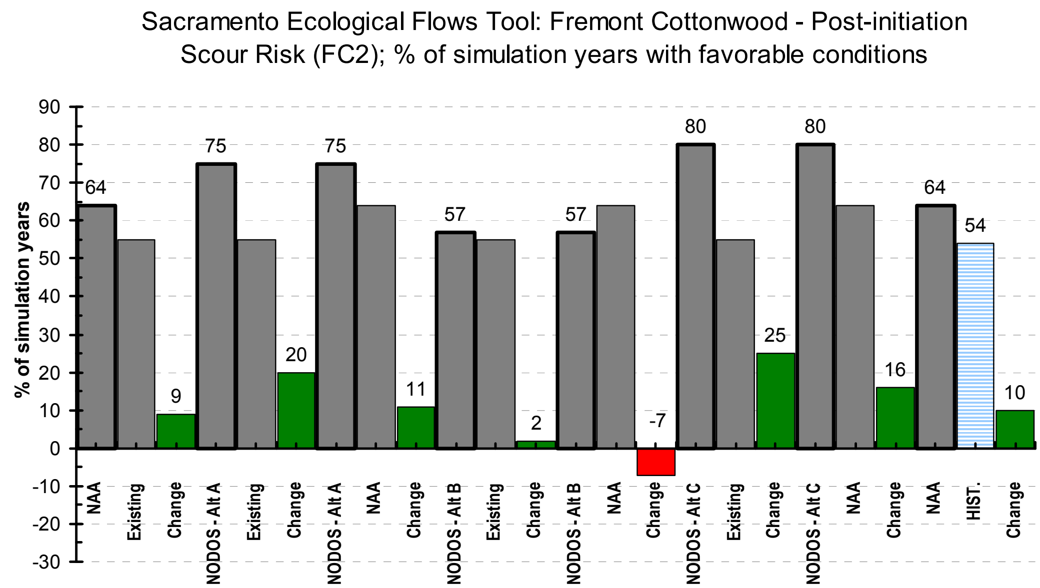


Figure 3.26: The percentage of years in each NODOS simulation having favorable (green) conditions for Fremont cottonwood seedling scour (FC2). Bars labeled with "Change" refer to the % change between the simulated alternative and the reference condition (either Existing conditions or the No Action Alternative (NAA)). Note: The FC2 performance measure in SacEFT is only relevant/calculated in years with successful Fremont cottonwood initiation (FC1).

In terms of Fremont cottonwood initiation, all NODOS alternative flows eliminate strong initiation events (see Figure 3.27).

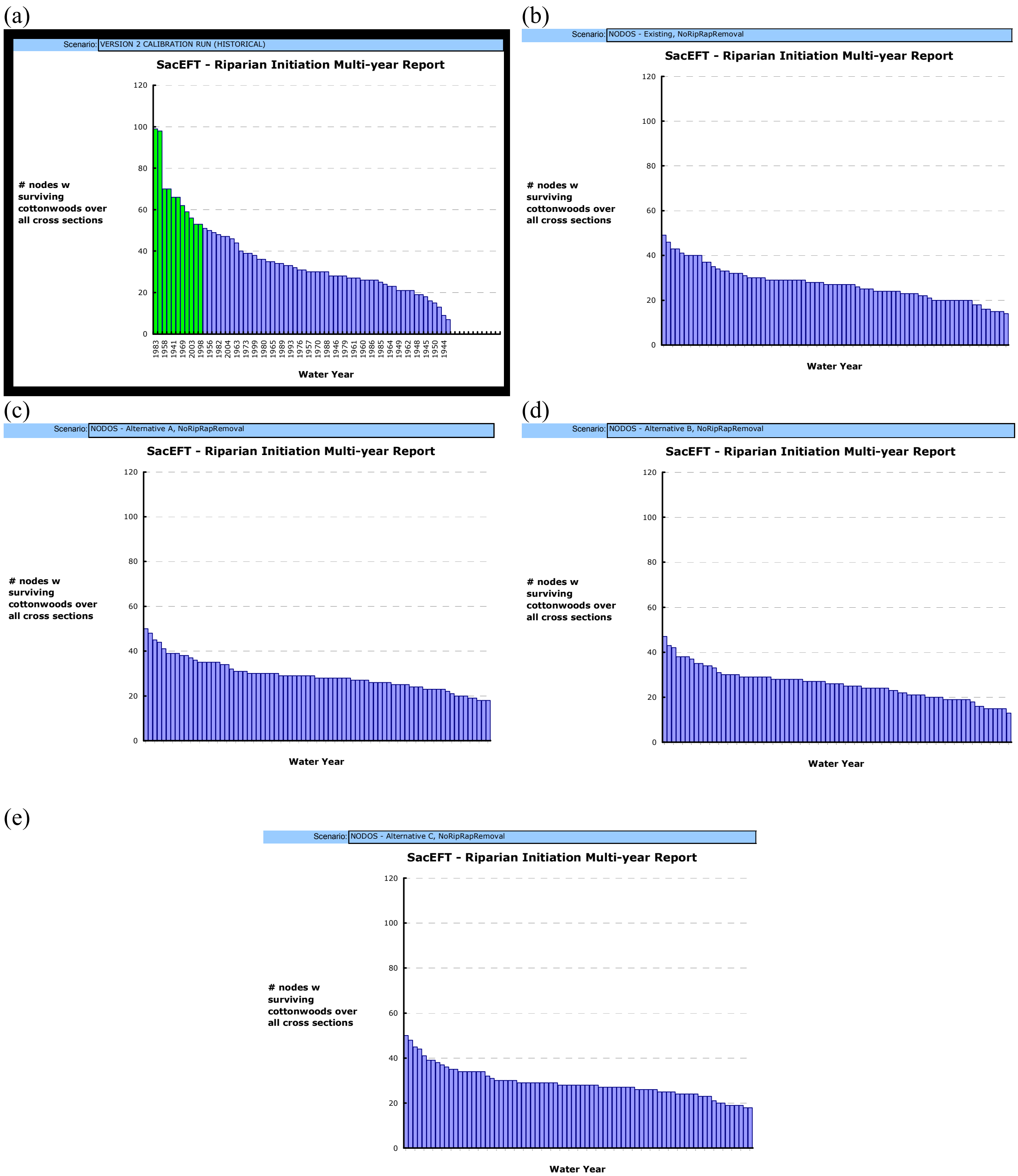


Figure 3.27: Annual index of total number of SacEFT cross-section nodes (entire study area) with successfully initiating Fremont cottonwood seedlings (FC1). These annual results are sorted in descending order. Panel (a) shows results for historical flows from 1938 to 2004. Green shaded bars refer to initiation totals that if met or exceeded, receive a favorable (green) rating in SacEFT. Panel (b) is for the NODOS existing conditions alternative. Panel (c) gives results for NODOS Investigation alternative A. Panel (d) shows results for NODOS Investigation alternative B. Finally, panel (e) shows results for NODOS Investigation alternative C.

Figure 3.28, Figure 3.29 and Figure 3.30 show the SacEFT target/favorable flow profiles and target flow recession rate at several index locations along the Sacramento River during the critical period for Fremont cottonwood seedling initiation (FC1).

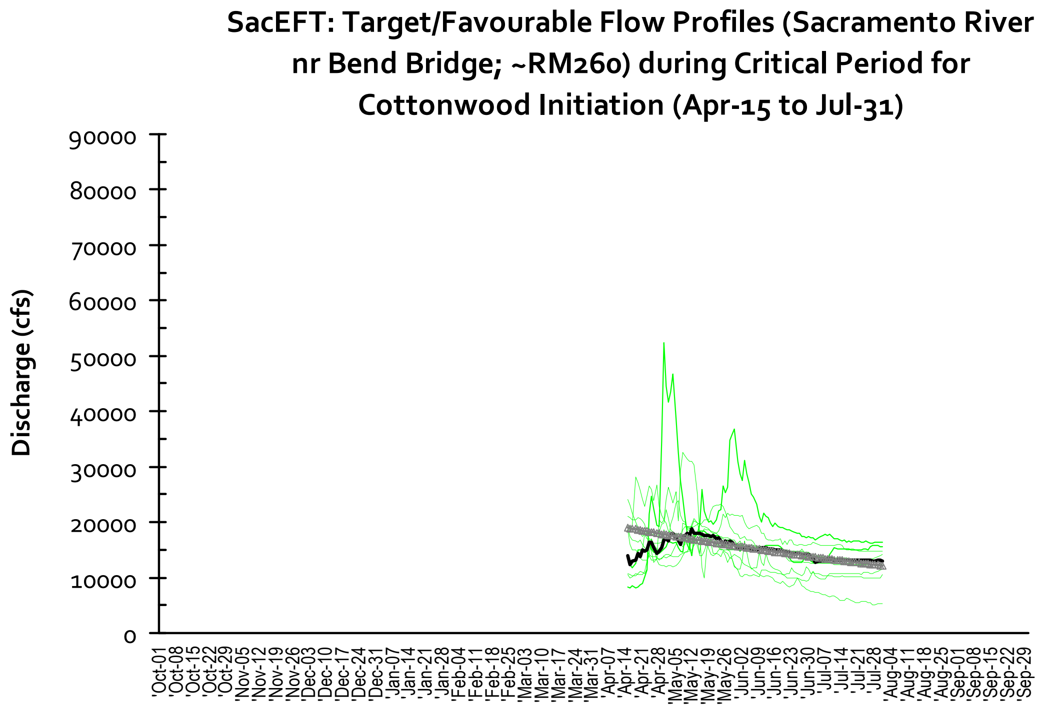


Figure 3.28: Target/favorable flow profiles (green) needed to deliver downstream successful Fremont cottonwood initiation (FC1) as measured at Sacramento River near Red Bluff (RM260). Flow profiles in green refer to years where SacEFT's annual performance measure rating was assessed as good/favorable. [Note: this figure is designed for color printing].

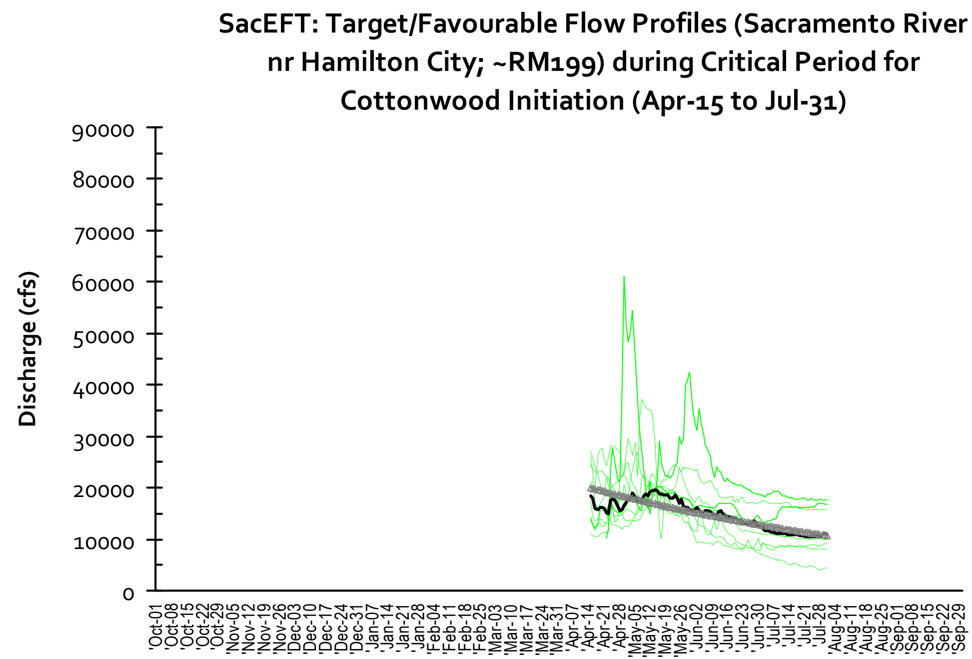


Figure 3.29: Target/favorable flow profiles (green) for successful Fremont cottonwood initiation (FC1) at Sacramento River near Hamilton City (RM199). Flow profiles in green refer to years where SacEFT's annual performance measure rating was assessed as good/favorable. [Note: this figure is designed for color printing].

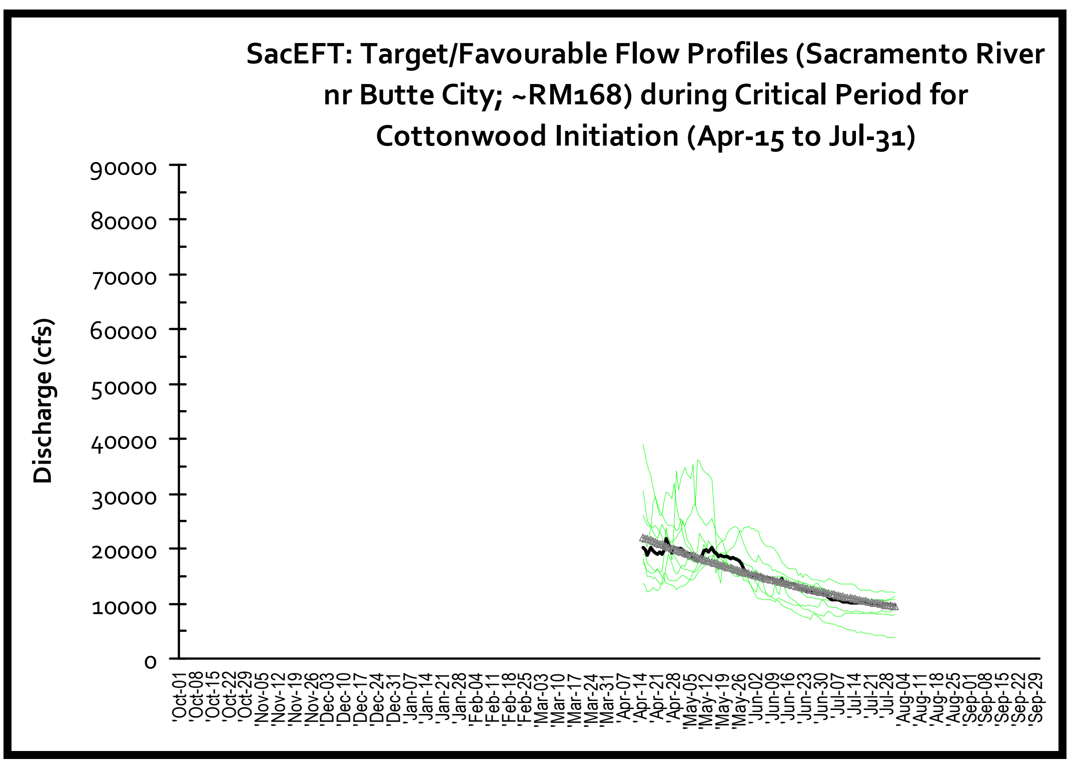


Figure 3.30: Target/favorable flow profiles (green) for successful Fremont cottonwood initiation (FC1) at Sacramento River near Butte City (RM168). Flow profiles in green refer to years where SacEFT's annual performance measure rating was assessed as good/favorable. [Note: this figure is designed for color printing].

The frequency and pattern in which favorable Fremont cottonwood initiation flows are missed along the Sacramento River near Butte City is clearly shown in Figure 3.32.

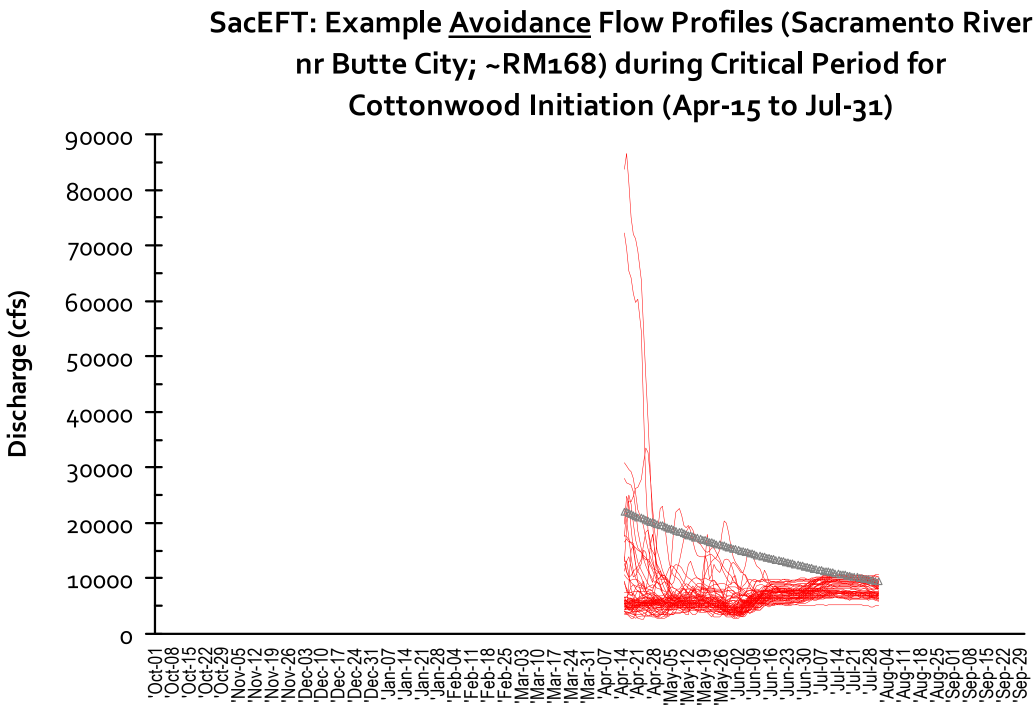


Figure 3.31: Avoidance flow profiles (red) for failed Fremont cottonwood initiation (FC1) at Sacramento River near Butte City (RM168) relative to the target flow and recession rate. [Note: this figure is designed for color printing].

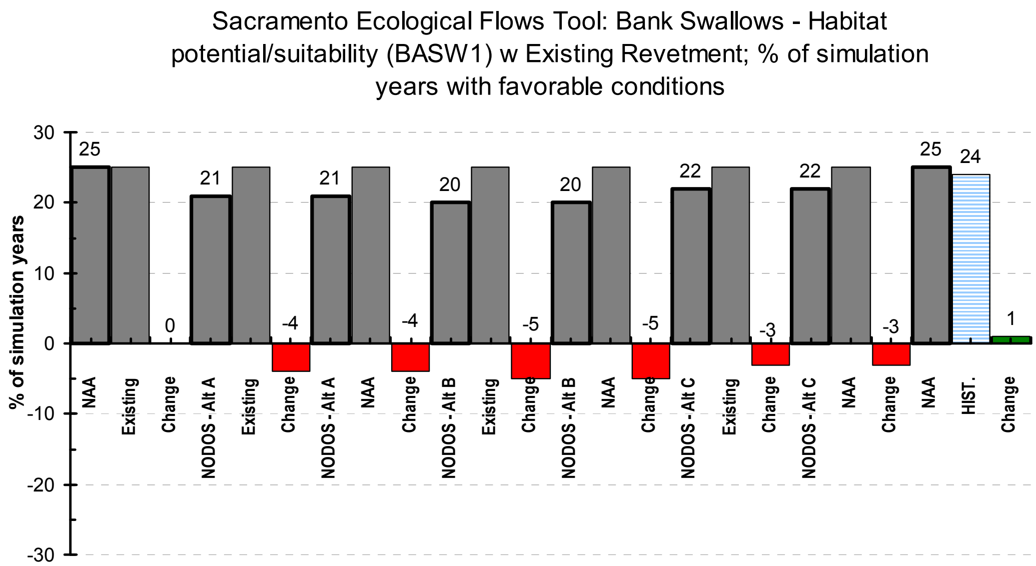
3.4.2 Bank Swallow Habitat Potential and Nest Inundation

Figure 3.32: Multi-year roll-up results for Bank swallow habitat potential (BASW1). The top panel shows results for all NODOS alternatives under existing revetment. The bottom panel shows results with select rock removal (as defined in section 2.5.1).

Figure 3.32 and Figure 3.33 show the percentage of years in each NODOS simulation having favorable (green) conditions for Bank swallow habitat potential/suitability (BASW1). SacEFT predicts that Bank swallow habitat suitability (BASW1) would not be appreciably impacted by any of the NODOS Investigation alternatives when compared with the existing conditions or NAA (Figure 3.33). Results point to the stronger, more important effect of **rock removal** for improving habitat suitability and potential for Bank swallow nesting habitat.

Bank swallow nest inundation is not appreciably different amongst any of the NODOS alternatives (Figure 3.34).

(a)



(b)

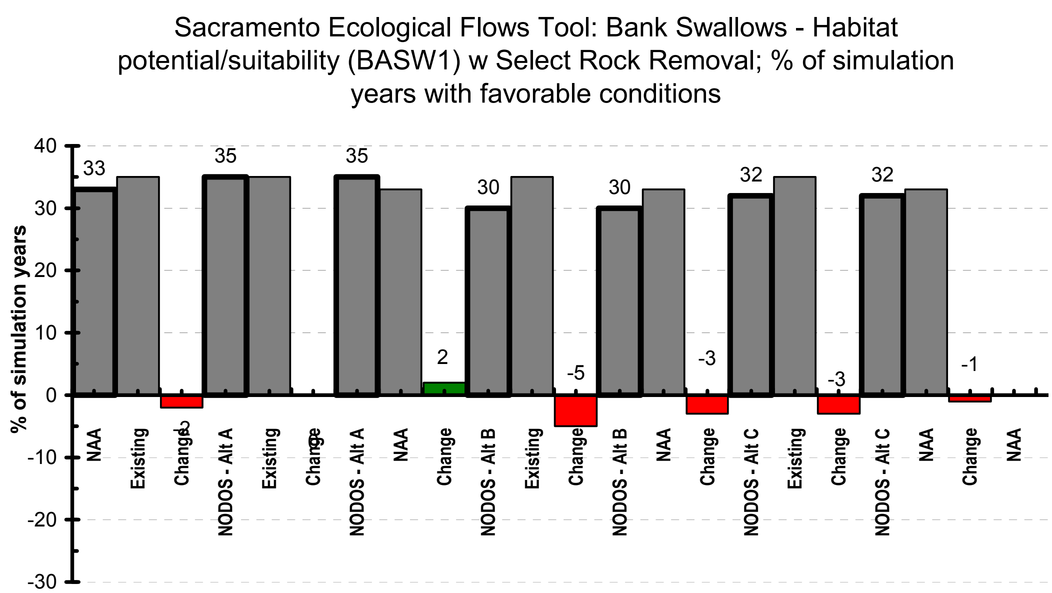


Figure 3.33: The percentage of years in each NODOS simulation having favorable (green) conditions for Bank swallow habitat potential/suitability (BASW1). Panel (a) provides results under existing revetment. Panel (b) shows results with selected rock removal (as defined in section 2.5.1). Bars labeled with "Change" refer to the % change between the simulated alternative and the reference condition (either Existing conditions or the No Action Alternative (NAA)).

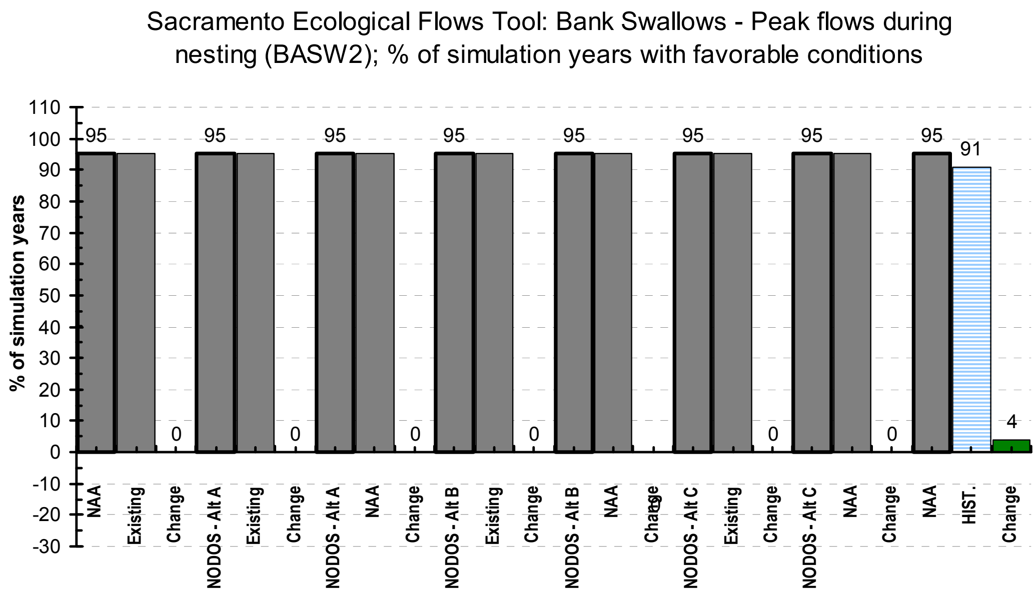


Figure 3.34: The percentage of years in each NODOS simulation having favorable (green) conditions for Bank swallow nest inundation (BASW1). Bars labeled with "Change" refer to the % change between the simulated alternative and the reference condition (either Existing conditions or the No Action Alternative (NAA)).

3.4.3 Large Woody Debris Recruitment

Large Woody Debris Recruitment - Existing revetment (LWD) - Roll-Up

ScenarioID	Indicator Name	Indicator Description	Create Report	Multi-Year Rollup	% Poor	% Worris...	% Good
NODOS - Alternative A, NoRipRapRemoval							
136	LWD	Large Woody Debris Recruitment			77	21	2
NODOS - Alternative B, NoRipRapRemoval							
139	LWD	Large Woody Debris Recruitment			77	21	2
NODOS - Alternative C, NoRipRapRemoval							
140	LWD	Large Woody Debris Recruitment			77	21	2
NODOS - Existing, NoRipRapRemoval							
132	LWD	Large Woody Debris Recruitment			72	23	5
NODOS - No Action, NoRipRapRemoval							
134	LWD	Large Woody Debris Recruitment			74	24	2
VERSION 2 CALIBRATION RUN (HISTORICAL)							
118	LWD	Large Woody Debris Recruitment			35	34	31

Large Woody Debris Recruitment - w Rock Removal (LWD) - Roll-Up

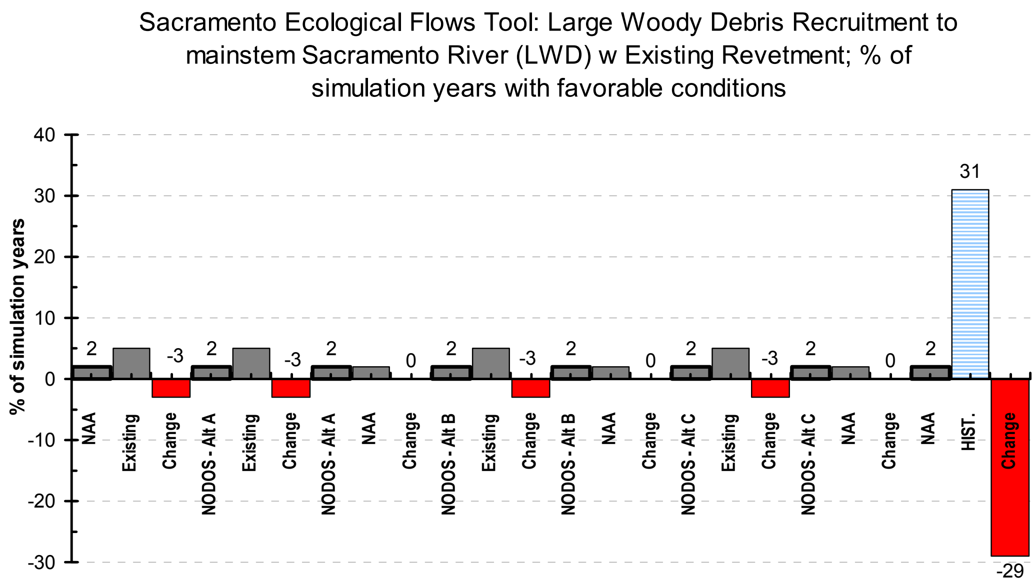
ScenarioID	Indicator Name	Indicator Description	Create Report	Multi-Year Rollup	% Poor	% Worris...	% Good
NODOS - Alternative A, RipRapRemoval							
128	LWD	Large Woody Debris Recruitment			59	32	9
NODOS - Alternative B, RipRapRemoval							
129	LWD	Large Woody Debris Recruitment			60	31	9
NODOS - Alternative C, RipRapRemoval							
130	LWD	Large Woody Debris Recruitment			59	32	9
NODOS - Existing, RipRapRemoval							
124	LWD	Large Woody Debris Recruitment			62	29	9
NODOS - No Action, RipRapRemoval							
127	LWD	Large Woody Debris Recruitment			58	33	9

Figure 3.35: Multi-year roll-up results for Large Wood Debris recruitment (LWD) to the mainstem Sacramento River. The top panel shows results for all NODOS alternatives under existing revetment. The bottom panel shows results with select rock removal (as defined in section 2.5.1).

Figure 3.35 and Figure 3.36 show the percentage of years in each NODOS simulation having favorable (green) conditions for Large Wood Debris recruitment (LWD) to the mainstem Sacramento River. Amongst NODOS alternatives, SacEFT predicts LWD would not be appreciably impacted by any of the

Investigation alternatives when compared with the existing conditions or NAA (Figure 3.36). Notably, LWD recruitment was significantly improved by conditions present in actual historic flows. Lastly, as with Bank Swallows, results point the important effect of rock removal for improving natural stream bank erosion and channel migration.

(a)



(b)

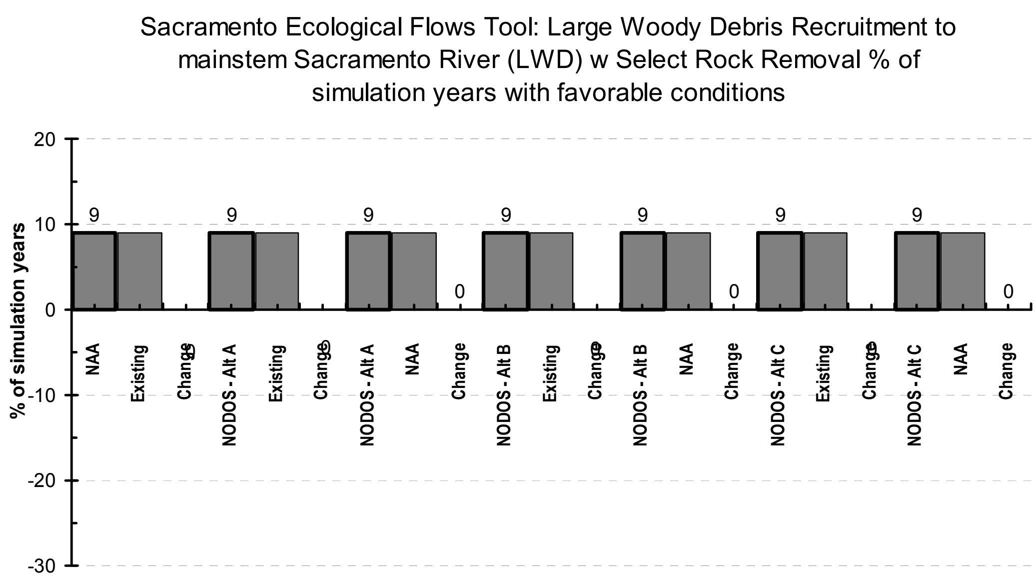


Figure 3.36: The percentage of years in each NODOS simulation having favorable (green) conditions for Large Woody Debris recruitment (LWD) to the mainstem Sacramento River. Panel (a) provides results under existing revetment. Panel (b) shows results with selected rock removal (as defined in section 2.5.1). Bars labeled with “Change” refer to the % change between the simulated alternative and the reference condition (either Existing conditions or the No Action Alternative (NAA)).

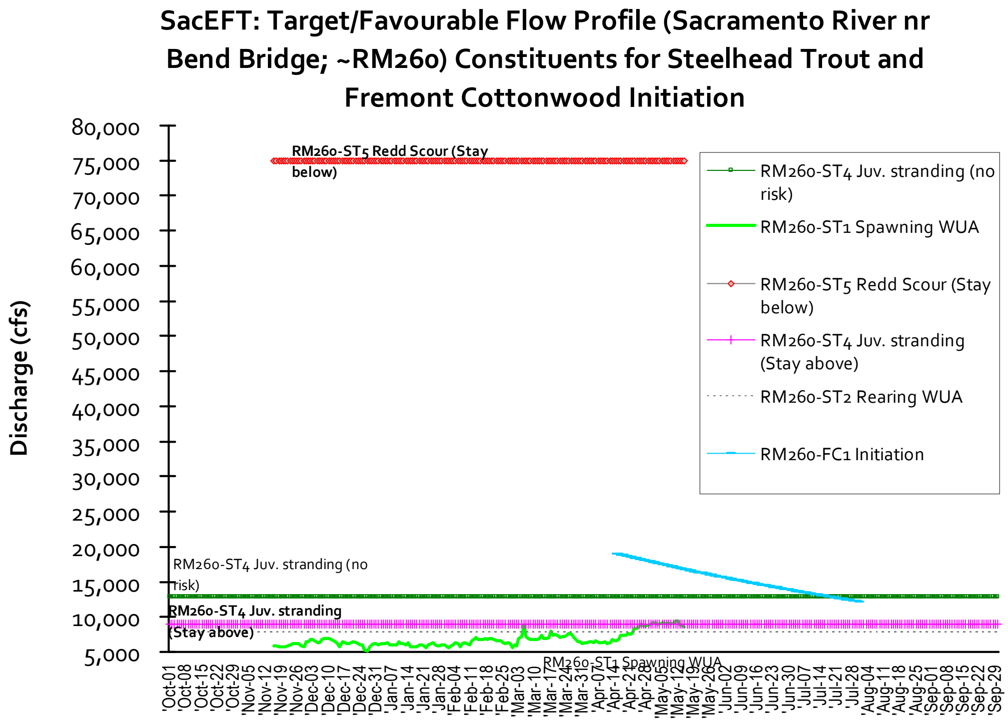
3.5 Integrated SacEFT Target and Avoidance Flows

One of the unique features of SacEFT is the ability to quantify varied functional flow needs. This can be done on the basis of focal species, performance measure by performance measure. Combining *representative* ecological functional flow needs across species and performance measures is the next level of target and avoidance flow synthesis sought in SacEFT studies. As a starting point, Figure 3.37 shows the integrated SacEFT target and avoidance flows for Fremont Cottonwood initiation and Steelhead trout. Using SacEFT, it is possible to add additional functional flow targets for other species and performance measures to this type of graph.

When interpreting SacEFT target and avoidance flow plots such as Figure 3.37, it is important to recognize that short-term deviations below the low- and above the high-flow targets are acceptable. Previous examples of flow traces reveal that cumulative weighted performance measures may be viewed favorably over the course of a year despite modest variations above and below these targets. In practical terms, an integrated evaluation would consider the number of days in the simulation that a given water management alternative generated flows (or water temperatures) outside these targets (Figure 3.38).

Lastly, while some do, not all functional flow needs are required to be met every year. Certain functional flow characteristics are required on a periodic basis and not every single year. Fremont cottonwood initiation (FC1) flow requirements are perhaps the best example, and most ecologists would consider strong recruitment cohorts two to three times in 10 years to be adequate.

(a)



(b)

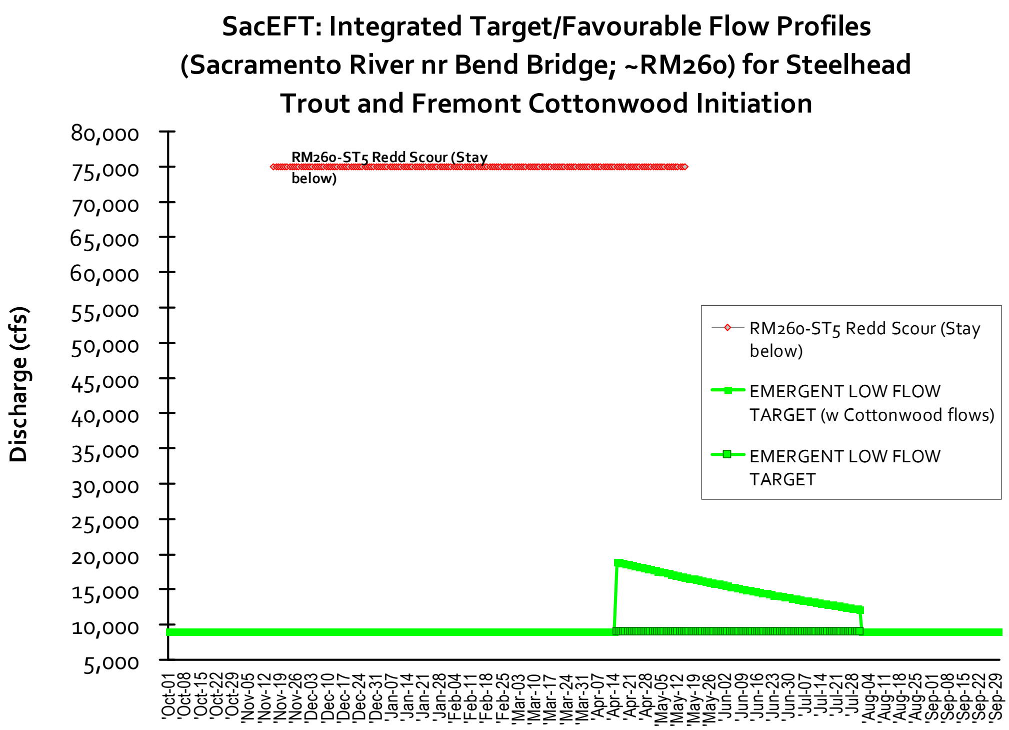


Figure 3.37: Constituent functional flow targets (panel (a)) used to derive integrated target flows (panel (b)) for Steelhead trout and Fremont cottonwood initiation referenced to flows at Sacramento River near Red Bluff (RM260). Using SacEFT, it is possible to add additional functional flow targets for other species and performance measures to this type of graph. [Note: this figure is designed for color printing].

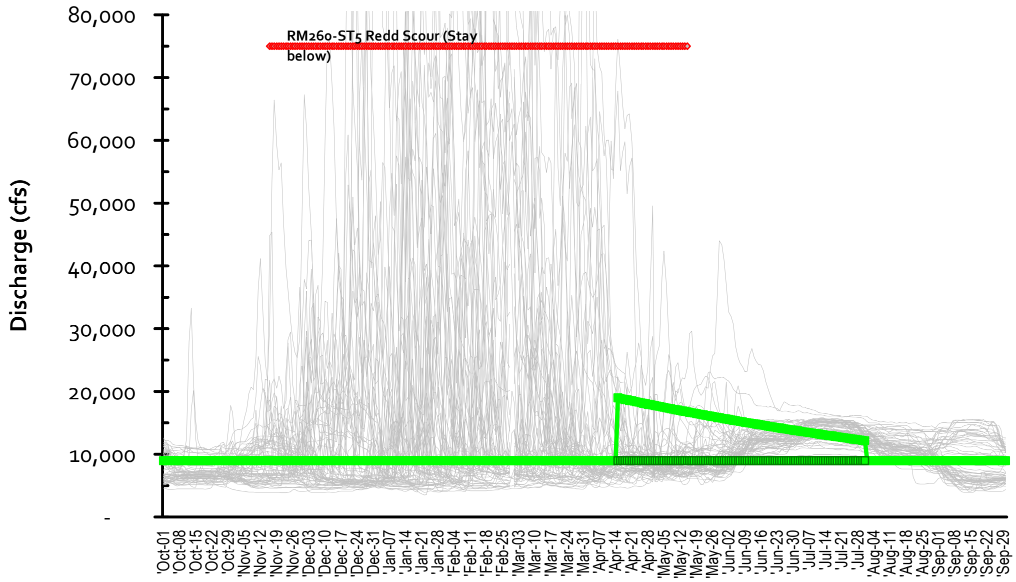


Figure 3.38: Flow traces for the NAA vs. SacEFT target flows for Steelhead trout and Fremont Cottonwood initiation as indexed at the Sacramento River near Red Bluff (RM260). Using SacEFT, it is possible to add additional functional flow targets for other species and performance measures to this type of graph.

4. Conclusions

Our analyses of the ecosystem consequences of the proposed NODOS alternatives demonstrate that no one alternative is beneficial for all focal species considered in SacEFT. This is not surprising, given that different species, and even different life stages of a given species, are responsive to different conditions and habitat attributes.

With respect to fisheries resources, we recommend that the detailed results presented in this report, and summarized in Table 3-B and Table 3-C (pp. 34-36), be considered in conjunction with the results from other modeling exercises (*e.g.*, IOS, SALMOD).

For terrestrial species, which are being given less consideration outside of our analyses, we are concerned with Alternative B which, according to our analyses, has the most negative impacts as compared to Alternatives A and C. Alternative B, which does not include the construction of a pumping station and the Delevan Pipeline, is expected to adversely impact Bank Swallows and not yield the benefits to Cottonwood that are found in Alternatives A and C.

These results suggest that from an ecosystem management standpoint, it is favorable to include a diversion point that is far downstream of the GCID diversion. Doing so would allow water to be routed through a relatively longer reach of the Middle Sacramento River before being withdrawn for the new storage facility. Allowing water to remain in the river as long as possible before diverting it to the storage facility would enhance geomorphic processes such as bank erosion and sediment deposition, both of which are important for creating nesting cutbanks for swallows and appropriate recruitment sites for cottonwoods.

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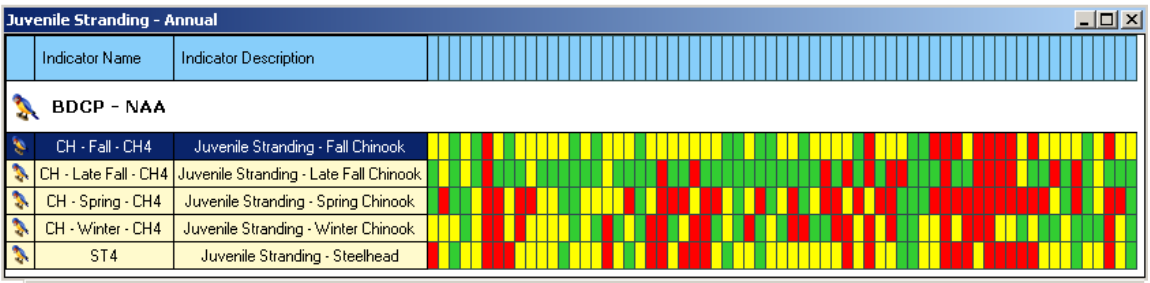
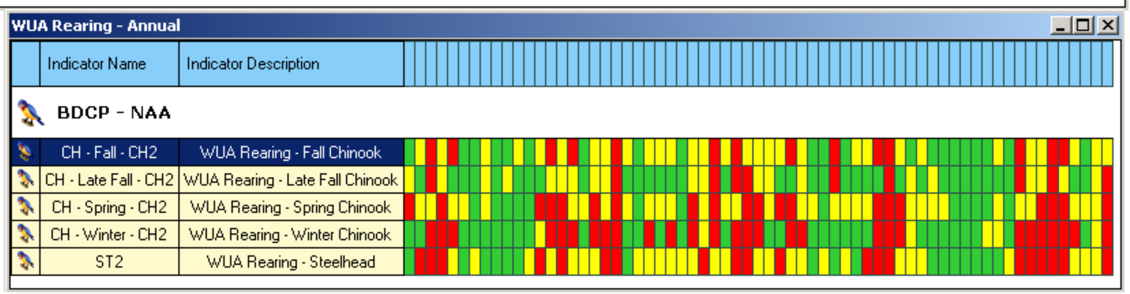
Appendix A – Inverse Correlation between Juvenile Stranding and Juvenile Rearing in SacEFT

SacEFT has six performance measures (PMs) related to the early life history of Chinook salmon and Steelhead trout. Positive and negative correlations between some of the PMs can often be seen. The example below compares juvenile Stranding (top panel) for all 5 run-types and WUA Rearing (bottom panel) for the run types. Each individual coloured cell represents the aggregated annual value beginning in Water Year (WY) 1939 and continuing until WY 2003. Separate rows show the different run types.



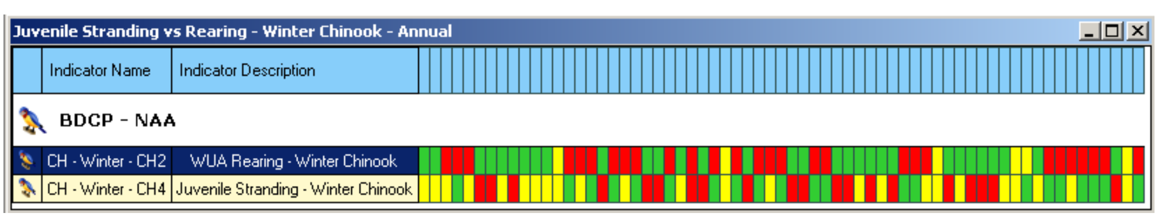


These high level summaries use the default SacEFT traffic light performance measure rating approach described earlier in the main body of this report.

One relationship that is particularly evident and appears to be counter-intuitive is the **negative** correlation between:

- juvenile rearing habitat ("WUA Rearing") and
- the index of juvenile stranding.

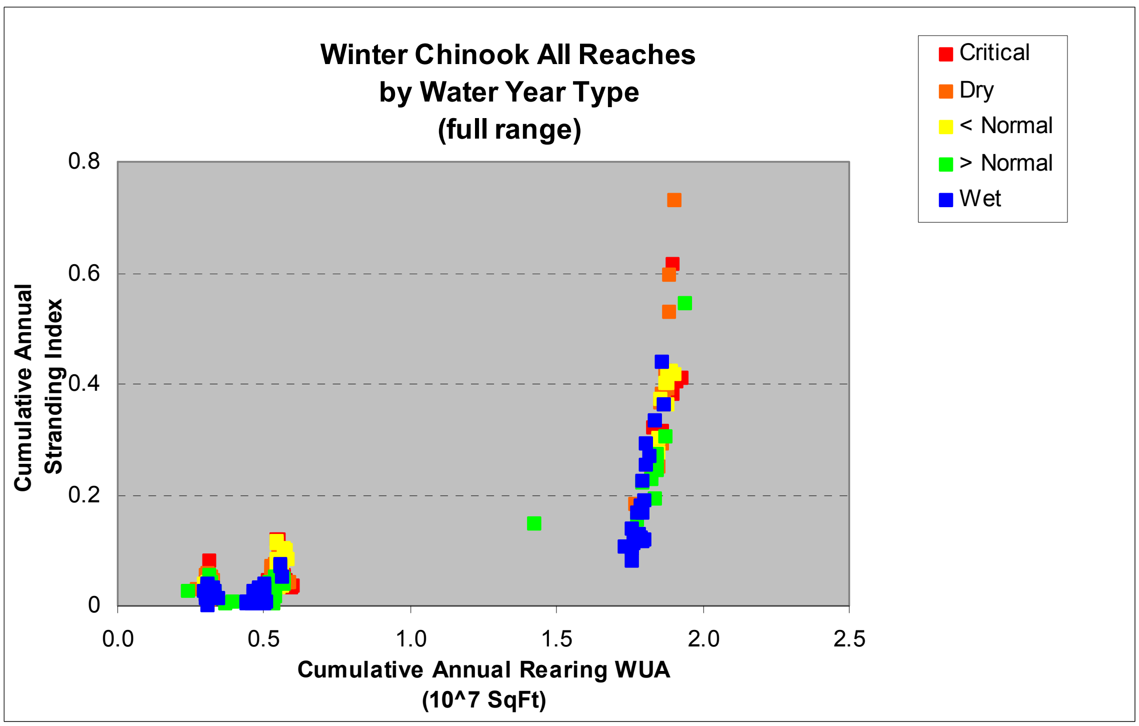
The figure below shows this for winter-run Chinook and gives a clear impression that good years (green) for WUA Rearing (ST2/CH2) are matched by fair (yellow) or poor (red) years for juvenile stranding (ST4/CH4) and *vice versa*.

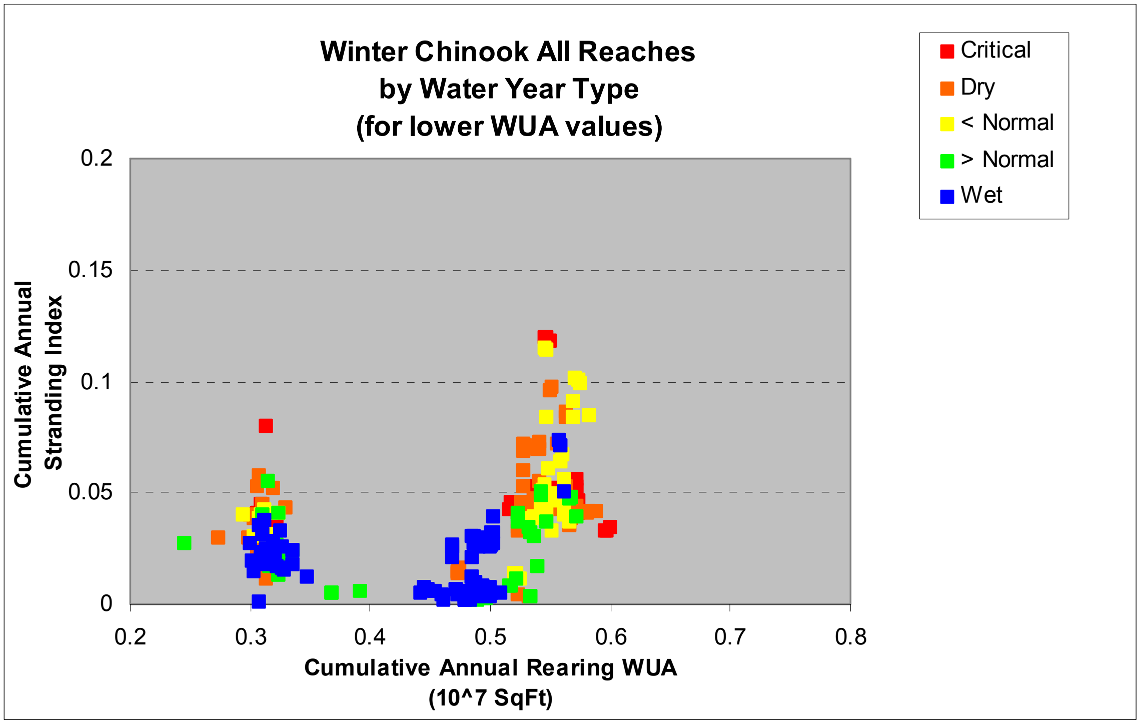


To explore this result in more depth, we examined this run type using a draft BDCP-NAA scenario provided in the spring of 2010. The assumptions embedded in this scenario are immaterial to the current exploration of the inverse relationship between WUA rearing and juvenile stranding.

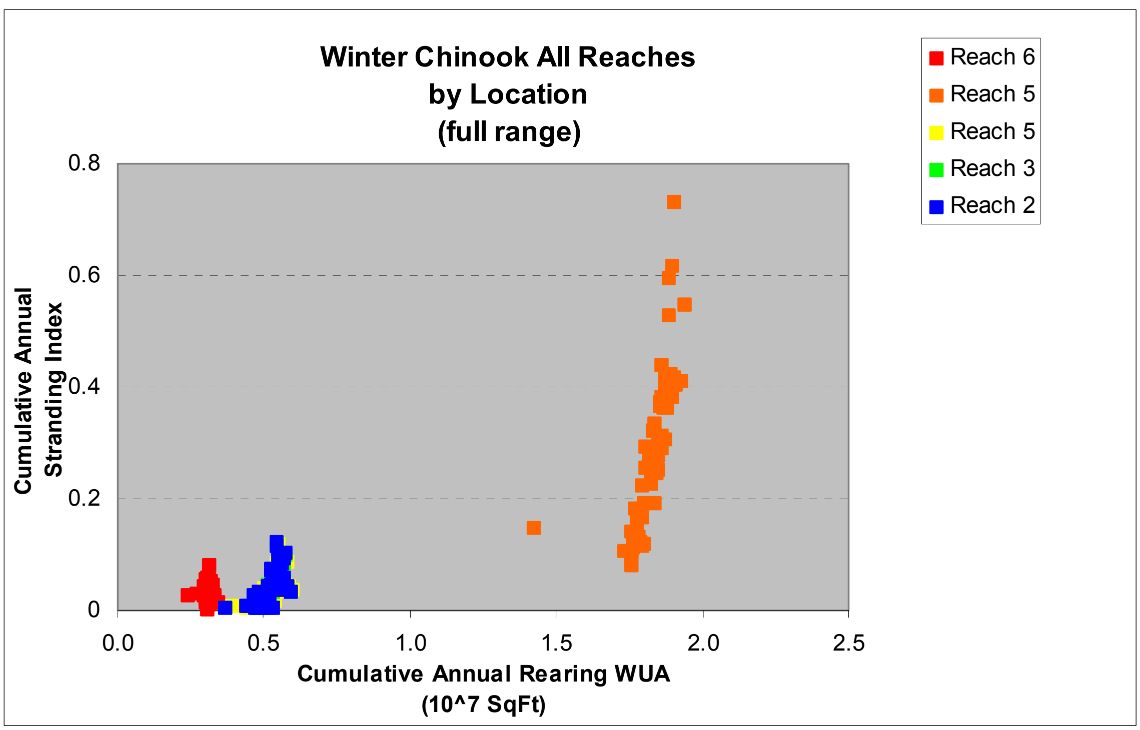
We plotted the annual summary data for WUA rearing against juvenile stranding, colouring each water year using the customary 5-level assignment used for the Sacramento River. Winter-run Chinook spawn from March 1 to August 15 with egg development typically continuing until early November. The Juvenile period begins in mid-June when the first-spawned eggs emerge and extends to early March of the following year. In SacEFT, all reports for year-cohorts are presented in the originating year of the cohort, even if the life stage continues into the next water year.

A plot of the full range of results is shown below, with water year strata coloured from very dry (red) to wet (blue). The upper panel shows the full range of the WUA rearing (ST2/CH2) and the juvenile stranding (ST4/CH4) index, and the lower panel expands the lower left corner of the upper panel to improve visibility of data points in that corner. It is very clear that the observations from all kinds of water years fall into three groups or clusters. There is also a trend for wet years (blue) to have lower rearing WUA and a lower stranding index.

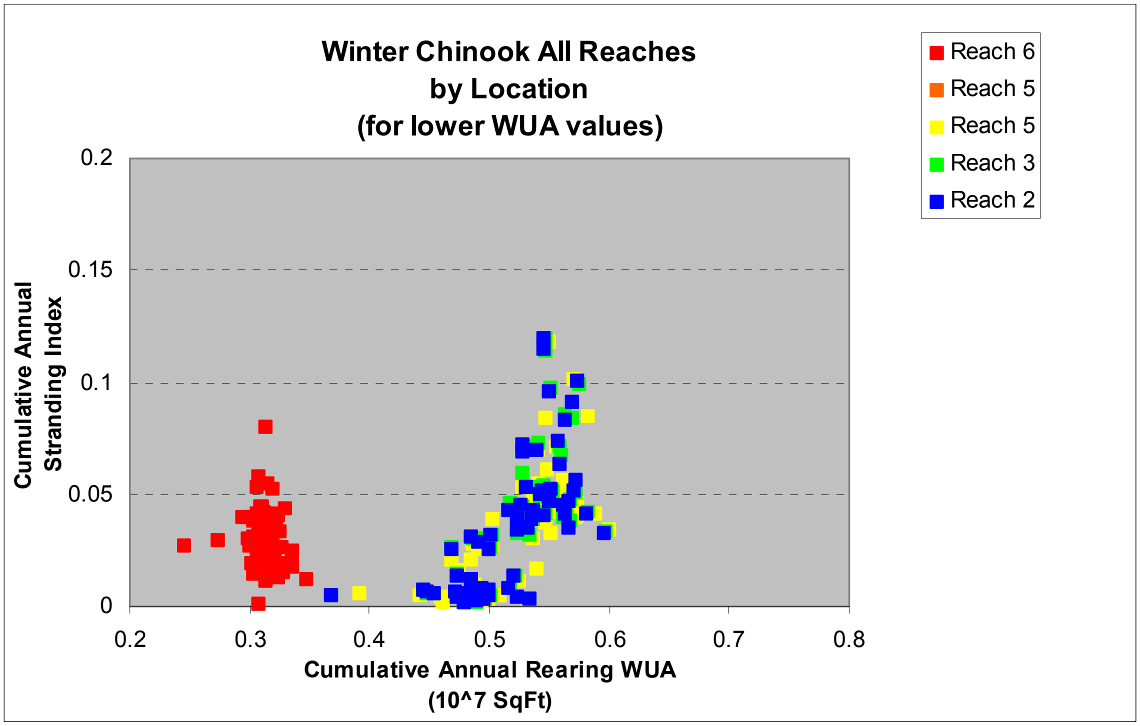




The different data cluster groups correspond to very different amounts of rearing WUA (x-axis) and to a lesser extent stranding index (y-axis) in the 5 reaches which are modelled by SacEFT's steelhead and Chinook submodels. This is made clear in the results stratified by location, plotted below.



Reach 5 (which begins downstream from Battle Creek and is coloured orange in the upper panel) has more than three times the potential rearing habit of the other reaches. The upper boundary of Reach 6 is at Keswick and the lower boundary of Reach 2 is at Vina.



The consistent and steep positive relationship between Rearing WUA and Stranding Index is clear for most of the reaches: **more rearing WUA produces more potential stranding.** The relationship also gives the impression of being slightly curved.

The relationship stems from the fact that the amount of potential rearing habitat is used as an input to weight the impact of juvenile stranding, making it inevitable that as more habitat is created (regardless of the details of the daily flow regime and the exact nature of the flow-stage recession relationship) it exposes proportionally more juveniles to stage-flow recession events when they inevitably occur. Since increased rearing WUA area results in a Good/Green performance measure rating while an increased stranding index results in a Poor/Red performance measure rating, the two measures become negatively correlated.

At the suggestion of Dr. David Swank (Fisheries Biologist, NMFS, Sacramento) we reviewed three articles relating to behavioral responses to stage recession and stranding.[1] These papers all conclude that fish will migrate in response to recession, given sufficient time. SacEFT operates at a daily timescale, while the real-world biological response to stage recession risk (in the context of these papers) is hourly. In general, trout and salmon are less likely to move during daylight hours, presumably to avoid predation. There are also species and seasonal differences in behavior. I could see no indication that juveniles will not use wetted habitat when it is present.

[1] **Halleraker, J.H., Saltveit, S.J., Harby, A., Arnekliev, J.V., Fjeldstad, H.-P. And B. Kohler.** 2003. Factors influencing stranding of wild juvenile Brown trout (*Salmo trutta*) during rapid and frequent flow decreases in an artificial stream. River Research and Applications 19:589-603.

Scruton, D.A., Ollerhead, L.M.N., Clarke, K.D., Pennell, C., Alfredsen, K., Harby, A. and D. Kelley. 2003. The behavioral response of juvenile Atlantic salmon (*Salmo salar*) and Brook trout (*Salvelinus fontinalis*) to experimental hydropeaking on a Newfoundland (Canada) river. River Research and Applications 19:577-587.

Bradford, M.J., Taylor, G.C., Allan, J.A. and P.S. Higgins. 1995. An experimental study of the stranding of juvenile Coho salmon and Rainbow trout during rapid flow decreases in winter conditions. North American Journal of Fisheries Management 15:473-479.

Dr. Swank suggested that we might find some gauges with hourly (or shorter) stage measurements and see how the high-resolution values are distributed, then compare that distribution to our daily resolution data, creating a relationship between daily recession and the distribution of hourly recession. It might then be possible to link the probability of a high-resolution rapid recession rate (*e.g.*, exceeding 10cm hr^{-1} as a threshold for “high risk”) derived from the literature with our daily recession. This could be a fairly involved analysis, and our modelers do not believe it would fundamentally remove the inverse correlation since the (potentially more accurate) hourly risk would still be weighted by rearing WUA in our model.

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Appendix B – Indicator Thresholds and Rating System[1]

The SacEFT output interface makes extensive use of a "traffic light" paradigm that juxtaposes performance measure (PM) results and scenarios to provide an intuitive overview of whether a given year's PMs are experiencing favorable conditions (Green), are performing only fairly (Yellow), or are experiencing unfavorable conditions (Red). For all twelve (12) performance measures, annual cumulative weighted performance measure values are calculated for our default historical water operation scenario based on the 66-year historical time series of observed flows and water temperatures from 1938 to 2003. These "annual roll-up" values for each performance measure (*e.g.*, average over days and locations with applicable biological distributions) are then assigned a "good" (Green), "fair" (Yellow) or "poor" (Red) performance measure rating (*e.g.*, Figure B.1). The *default* threshold boundaries between Yellow/Green and Red/Yellow are based on tercile break points determined by sorting the annual weighted performance measure values from the default historical water operation scenario.

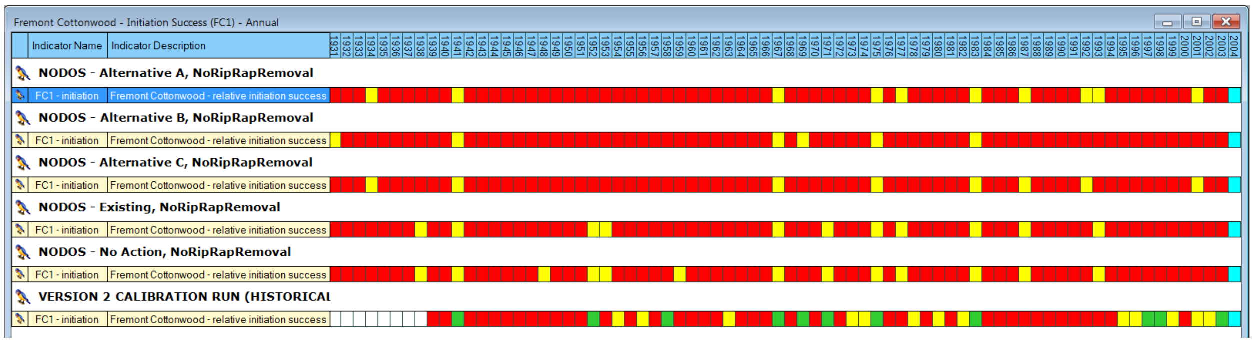

Figure B.1: Typical SacEFT output showing annual roll-up results for the Fremont cottonwood initiation (FC1) performance measure. Analogous plots are available for all of the tools' focal species and performance measures.

These annual performance measure ratings are based on thresholds[2] defined by sorting cumulative annual results produced by SacEFT for historic observed flows and water temperatures between calendar years 1938 and 2003 (*e.g.*, Figure B.2). The "units" of these plots vary with the performance measure. In this way, historic observed flows/temperatures provide the de facto "calibration scenario" for SacEFT's twelve (12) focal species performance measures.

[1] This introduction is drawn *verbatim* from Section 3.1.2 of:

ESSA Technologies Ltd. 2011. Sacramento River Ecological Flows Tool (SacEFT): Record of Design (v.2.00). Prepared by ESSA Technologies Ltd., Vancouver, BC for The Nature Conservancy, Chico, CA. 111 p. + appendices.

[2] Indicator thresholds in SacEFT are fully configurable via settings found in the SacEFT relational database.

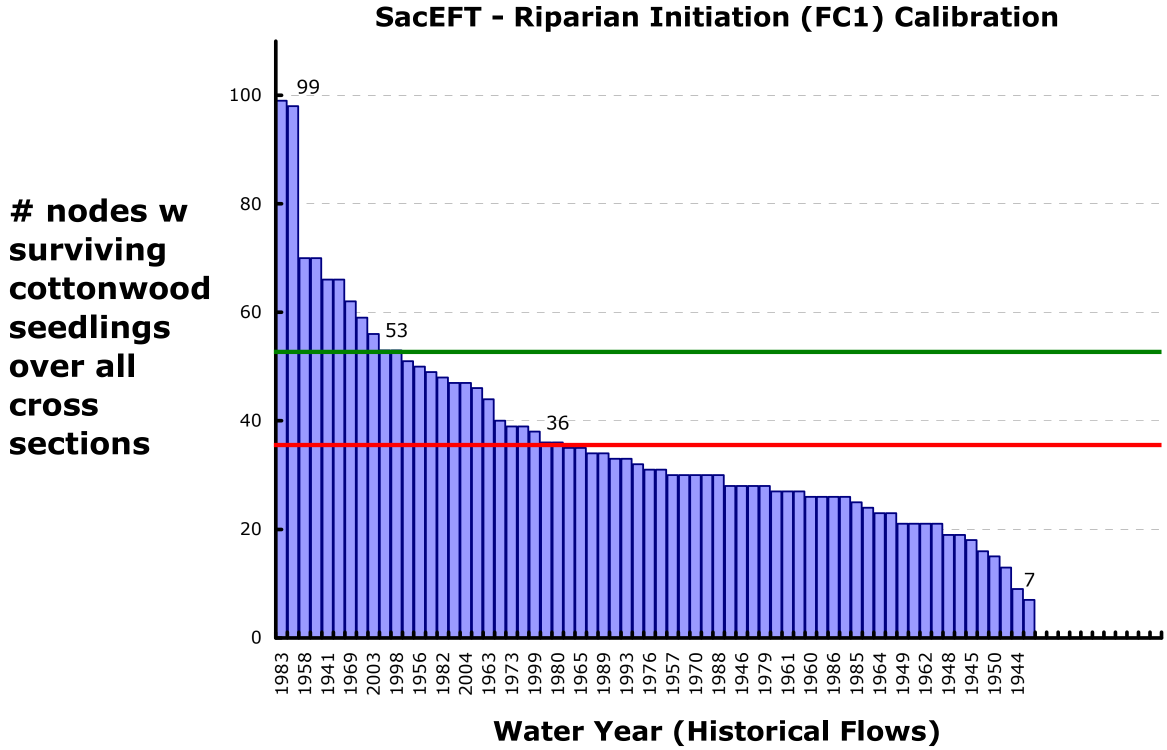

Figure B.2: Annual roll-up results for the SacEFT Fremont cottonwood initiation (FC1) performance measure run using historic observed flows (1938–2003). This calibration also takes into consideration comparisons with aerial photographs of historically strong Cottonwood recruitment at study sites vs. model results.

Our concept of indicator threshold calibration in SacEFT focuses on historical data. From an ecological standpoint, aquatic and riparian species are adapted to a historical range and frequency of variations in their habitats. Taken to the extreme, historical conditions would ideally include pre-settlement (natural) flows/water temperatures that represented ‘typical’ conditions experienced over evolutionarily significant windows of time. The closest flow/temperature time series that we have available to this evolutionarily representative condition is the range of variation in historical observed flows/temperatures (approximately 66 years). It is recognized that during 1938–2003 the Sacramento River experienced a number of waves of human and structural development and operational changes to the hydrosystem. Nevertheless, these flows and temperatures, derived from measurements, actually occurred in recent history and encompass repeat episodes of multiple water year types. Calibrating SacEFT indicator thresholds to a future no action or ‘existing’ scenario that includes a fixed set of hydrosystem features, constraints, operating regulations and assumed human demands would create a “self-fulfilling prophecy” inconsistent with SacEFT’s underlying natural flow regime science foundation. In general, all of the models used in the NODOS investigation are calibrated based upon historical information.

Typically, none of the NODOS investigation project alternative modelling results are compared against the historical calibration due to the focus of CEQA/NEPA which emphasizes isolating project alternative effects as compared to a no action reference or existing condition comparison. Comparisons that include historical data reveal different information in a different context that does not address a specific project effect relative to the no action alternative or existing condition reference case. Comparisons that include historic calibration data identify the ecological effects of the future system operations and constraints relative to historic conditions. In fully considering ecological flow needs, the magnitude of departure from these historic conditions may reveal important information on how future constraints, climate and/or hydrosystem operational modifications are influencing preferred ecological flow targets.

The highest level synthesis concept in SacEFT is that of a "multi-year roll-up". This is the percentage of years in the simulation having favorable (Green), fair (Yellow), and poor (Red) conditions (*e.g.*, Figure 2.3).

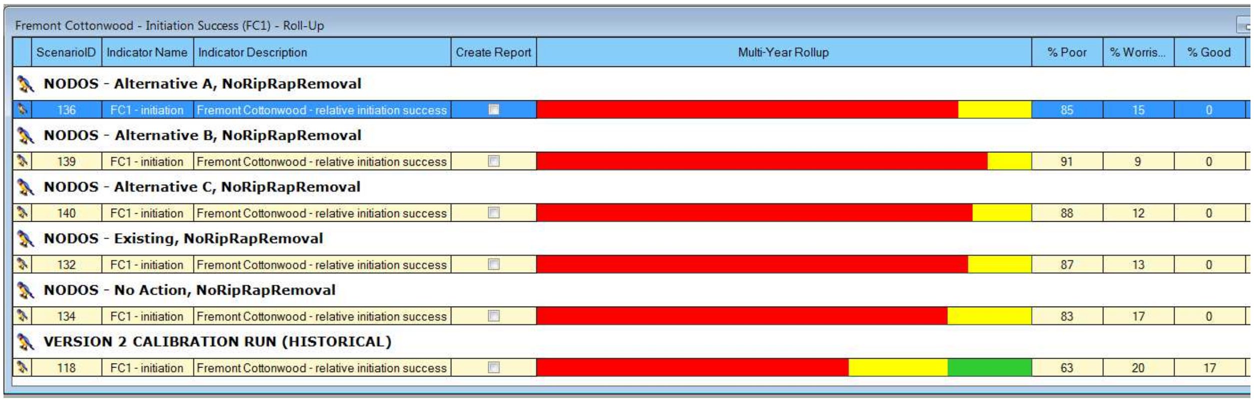

Figure B.3: Typical SacEFT output showing multi-year roll-up results for the Fremont cottonwood initiation (FC1) performance measure. Analogous plots are available for all of the tools' focal species and performance measures.

The preferred method for calibrating the indicator thresholds is to identify historical years for each performance measure that were known (in nature) to have experienced 'good' or 'poor' performance. Unfortunately, our *repeat* survey efforts of fisheries experts (*e.g.*, Mark Gard, USFWS, *pers. comm.*2011; Matt Brown, USFWS, *pers. comm.* 2011 amongst many others) and a questionnaire sent to fisheries biologists prior to the 2008 SacEFT v.1 review workshop revealed there are no known synoptic studies of this kind for many of the indicators in SacEFT. Because of this gap and the hesitancy of experts to reveal their opinions, we instead defaulted to the distribution of sorted weighted annual results and selected tercile break-points (the lower-, middle- and upper thirds of the sorted distribution) to categorize results into "Good" (Green), "Fair" (Yellow) or "Poor" (Red) categories. **While this method provides a fully internally consistent method of comparing scenario results (*i.e.*, will always provide an accurate picture of which water management scenarios are "better" than another), it does not *necessarily* provide a concrete inference about the biological significance** of being a "Poor" (Red) or "Good" (Green) category. For example, it is possible that a year that ranks as "Good" (Green) with this method may still be biologically suboptimal. Conversely, a year that ranks as "Poor" (Red) *may* be biologically insignificant (*i.e.*, *not* biologically 'unacceptable').

The challenge of identifying "acceptable" and "unacceptable" changes in habitat conditions or focal species performance measures confronts all biological effects analysis methods. SacEFT makes these inherent value judgments explicit in the model's summary outputs. Future analyses using SacEFT look forward to ecological effects analysis experts themselves providing clearer guidance on the (readily configurable) thresholds in the SacEFT modeling system.

On the following pages, Table B.1 provides all indicator rating threshold values for the Daily and Annual Rollup indicators. These are drawn from indicator threshold calibration descriptions in ESSA Technologies (2011). In Table B.1, we flag cases where there are major gradients in performance indicator thresholds. For detailed information on these thresholds, readers should refer to ESSA Technologies (2011).

Table B.1: Indicator rating threshold breakpoints for the 12 Performance Measures found in SacEFT Version 2. For detailed information on these thresholds, readers should refer to ESSA Technologies (2011).

Chinook/Steelhead 1 – Spawning WUA					
	Daily		**Rollup**		**Notes**
	Good-Fair	**Fair-Poor**	**Good-Fair**	**Fair-Poor**	
Winter-run Chinook	430060	195486	2880	2475	• Criteria: statistical distribution, terciles, "more" is better • Units: square feet • Flow, spawning period, habitat preferences, affect distribution
Spring-run Chinook	607975	217913	5825	4775	
Fall-run Chinook	1006472	29967	8470	5500	
Late-fall-run Chinook	520424	280581	4250	2760	
Steelhead	18692	13447	135	106	

Chinook/Steelhead 2 – Rearing WUA					
	Daily		**Rollup**		**Notes**
	Good-Fair	**Fair-Poor**	**Good-Fair**	**Fair-Poor**	
Winter-run Chinook	39675	10987	10250137	9997544	• Criteria: statistical distribution, terciles, "more" is better • Daily units: square feet • Rollup units: cumulative square feet • Flow, number of reaches affect distribution
Spring-run Chinook	109294	33678	24800719	19200148	
Fall-run Chinook	51872	20539	18341766	14048587	
Late-fall-run Chinook	47481	18283	13306025	11936239	
Steelhead	49501	14292	18160595	16361215	

Chinook/Steelhead 3 – Egg-to-Fry Thermal Mortality					
	Daily		**Rollup**		**Notes**
	Good-Fair	**Fair-Poor**	**Good-Fair**	**Fair-Poor**	
Winter-run Chinook	5	10	5	10	• Criteria: absolute values, "less" is better • Units: % mortality • Common threshold for all run-types
Spring-run Chinook	5	10	5	10	
Fall-run Chinook	5	10	5	10	
Late-fall-run Chinook	5	10	5	10	
Steelhead	5	10	5	10	

Chinook/Steelhead 4 – Juvenile Stranding Risk					
	Daily		Rollup		Notes
	Good-Fair	Fair-Poor	Good-Fair	Fair-Poor	
Winter-run Chinook	4.517E-05	3.528E-04	0.0804	0.1622	• Criteria: statistical distribution, terciles, "less" is better • Daily units: index • Rollup units: cumulative index • Flow, number of reaches affect distribution • *Late-fall-run may be more sensitive-responsive*
Spring-run Chinook	1.483E-04	8.852E-04	0.1472	0.2738	
Fall-run Chinook	1.083E-04	5.476E-04	0.1299	0.2161	
Late-fall-run Chinook	6.330E-05	2.249E-04	0.0654	0.0814	
Steelhead	9.964E-05	1.202E-03	0.1255	0.1845	

Chinook/Steelhead 5 – Redd Scour Risk					
	Daily		Rollup		Notes
	Good-Fair	Fair-Poor	Good-Fair	Fair-Poor	
Winter-run Chinook	N/A	N/A	5000	10000	• Criteria: calibrated to 80% Good years, "less" is better • Units: index flow (cfs) • No daily estimate • Common physical threshold for all run-types • *Very low risk for spring- , winter-runs*
Spring-run Chinook	N/A	N/A	5000	10000	
Fall-run Chinook	N/A	N/A	5000	10000	
Late-fall-run Chinook	N/A	N/A	5000	10000	
Steelhead	N/A	N/A	5000	10000	

Chinook/Steelhead 6 – Redd Dewatering Risk					
	Daily		Rollup		Notes
	Good-Fair	Fair-Poor	Good-Fair	Fair-Poor	
Winter-run Chinook	3.976E-06	4.042E-05	0.02	0.03	• Criteria: statistical distribution, terciles, "less" is better • Daily units: proportion stranded • Rollup units: cumulative proportion stranded • Flow, spawning period, habitat preferences, affect distribution • *Very low risk for winter-run* • *Higher sensitivity/risk for Late-fall run Chinook.*
Spring-run Chinook	6.184E-05	7.333E-04	0.07	0.13	
Fall-run Chinook	1.597E-05	1.910E-04	0.05	0.09	
Late-fall-run Chinook	1.336E-05	1.846E-04	0.12	0.22	
Steelhead	1.181E-05	1.428E-04	0.10	0.17	

Green Sturgeon 1 – Thermal Egg Mortality					
	Daily		**Rollup**		**Notes**
	Good-Fair	**Fair-Poor**	**Good-Fair**	**Fair-Poor**	
Thermal Egg Mortality	5	10	5	10	• Criteria: absolute values, , "less" is better • Units: % mortality

Bank Swallow 1 – Habitat Potential/Suitability					
	Daily		**Rollup**		**Notes**
	Good-Fair	**Fair-Poor**	**Good-Fair**	**Fair-Poor**	
Habitat potential	N/A	N/A	42200	29500	• Criteria: statistical distribution using discontinuities, "more" is better • Units: meters suitable habitat • No daily estimate

Bank Swallow 2 – Peak Flow During Nesting Period					
	Daily		**Rollup**		**Notes**
	Good-Fair	**Fair-Poor**	**Good-Fair**	**Fair-Poor**	
Nesting Peak Flow	47000	49700	≥ 2	< 1 (zero)	• Criteria: flow thresholds based on expert opinion, "less" is better • Daily units: flow (cfs) • Rollup units: count of locations assigned Good rating within a year.

Fremont Cottonwood 1 – Riparian Initiation					
	Daily		**Rollup**		**Notes**
	Good-Fair	**Fair-Poor**	**Good-Fair**	**Fair-Poor**	
Riparian Initiation Success	N/A	N/A	53	36	• Criteria: thresholds based on expert opinion and observation of Good initiation years, "more" is better • Units: count of cross section nodes with surviving stems or seedlings. • No daily estimate

Fremont Cottonwood 2 – Riparian Scour					
	Daily		**Rollup**		**Notes**
	Good-Fair	**Fair-Poor**	**Good-Fair**	**Fair-Poor**	
Riparian Scour Risk	N/A	N/A	80000	90000	• Criteria: thresholds based on expert opinion of scour events, "less" is better • Units: flow (cfs) • No daily estimate

Large Woody Debris 1 – Large Woody Debris Recruitment					
	Daily		**Rollup**		**Notes**
	Good-Fair	**Fair-Poor**	**Good-Fair**	**Fair-Poor**	
Large Woody Debris recruitment	N/A	N/A	120000	20000	• Criteria: statistical distribution, terciles, "more" is better • Units: square meters riparian forest eroded to mainstem Sacramento River having forests taller than 34 ft (height class 4 or higher). • No daily estimate

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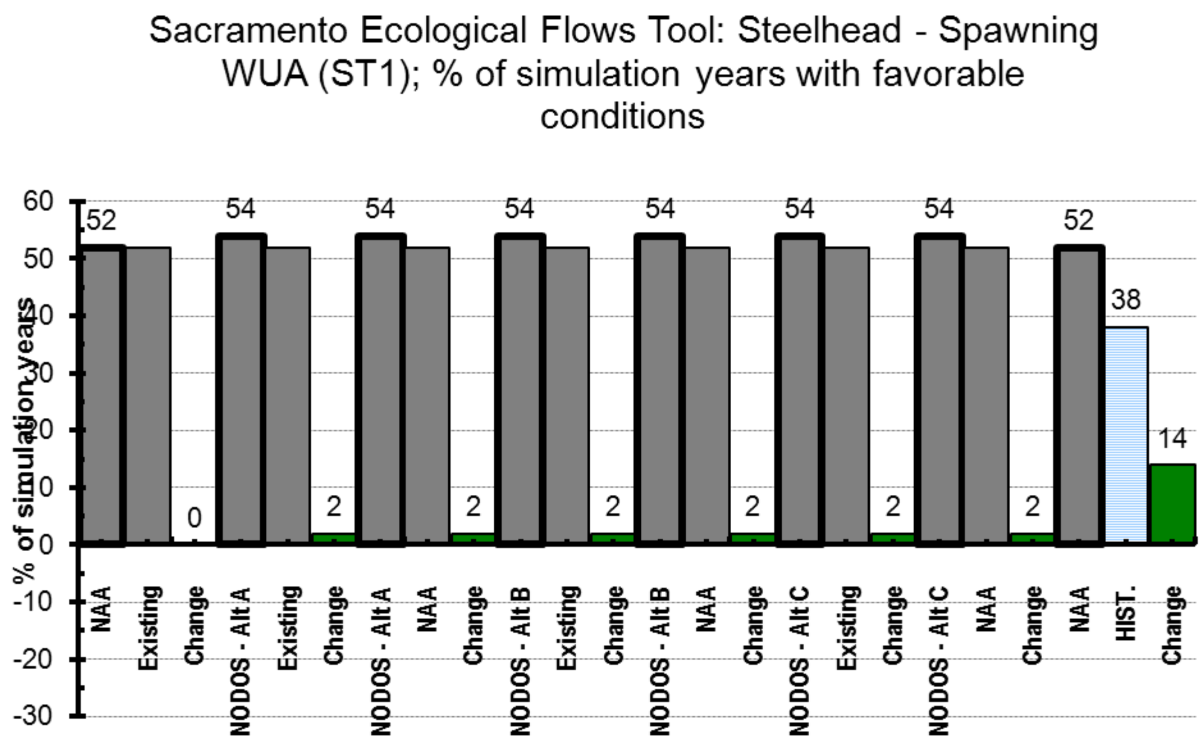
Appendix C – Additional Chinook Reports

C.1 Steelhead

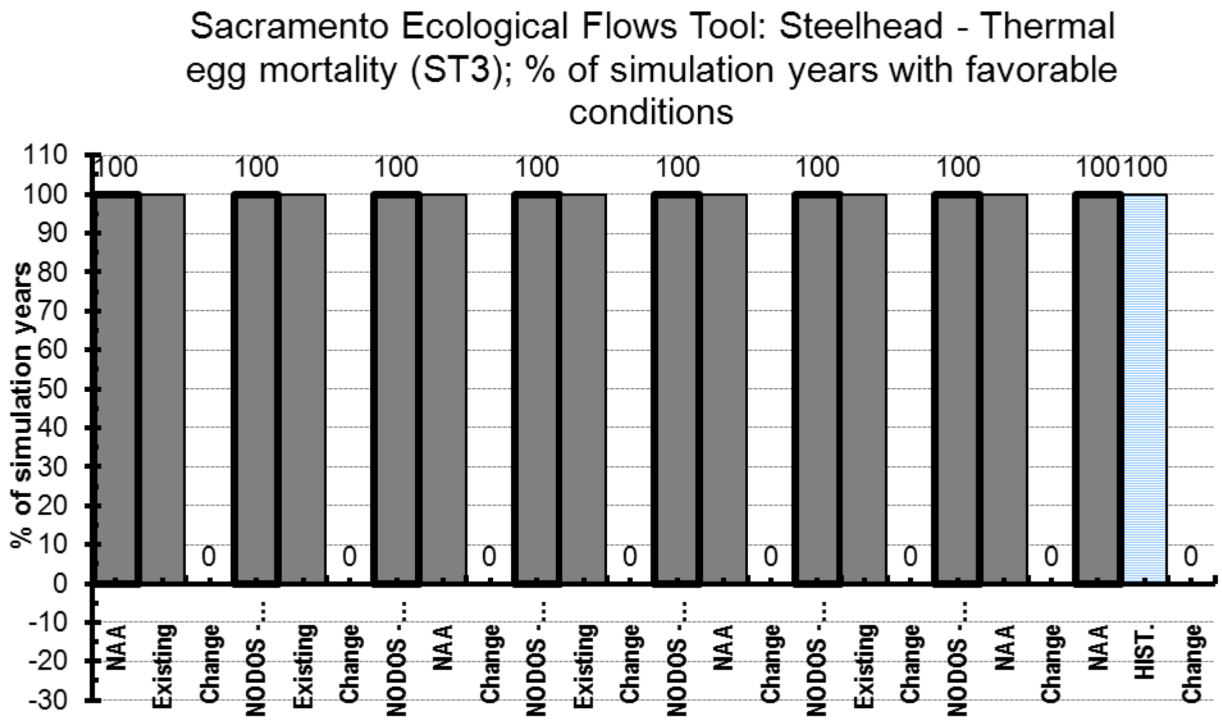
	Steelhead											
	Comparison 1			*Comparison 2*			*Comparison 3*			*Comparison 4*		
ScenarioID	134	132		136	132		136	134		139	132	
Scenario Name	NAA	Existing	Change	NODOS - Alt A	Existing	Change	NODOS - Alt A	NAA	Change	NODOS - Alt B	Existing	Change
	No Action Alternative	Existing conditions		NODOS - Alt A	Existing conditions		NODOS - Alt A	No Action Alternative		NODOS - Alt B	Existing conditions	
Spawning WUA (ST1)	52	52	0	54	52	2	54	52	2	54	52	2
Thermal Egg Mortality (ST3)	100	100	0	100	100	0	100	100	0	100	100	0
Redd Dewatering (ST6)	51	51	0	56	51	5	56	51	5	57	51	6
Redd Scour (ST5)	62	62	0	62	62	0	62	62	0	62	62	0
Juvenile Stranding (ST4)	9	9	0	3	9	-6	3	9	-6	5	9	-4
Rearing WUA (ST2)	46	49	-3	54	49	5	54	46	8	54	49	5

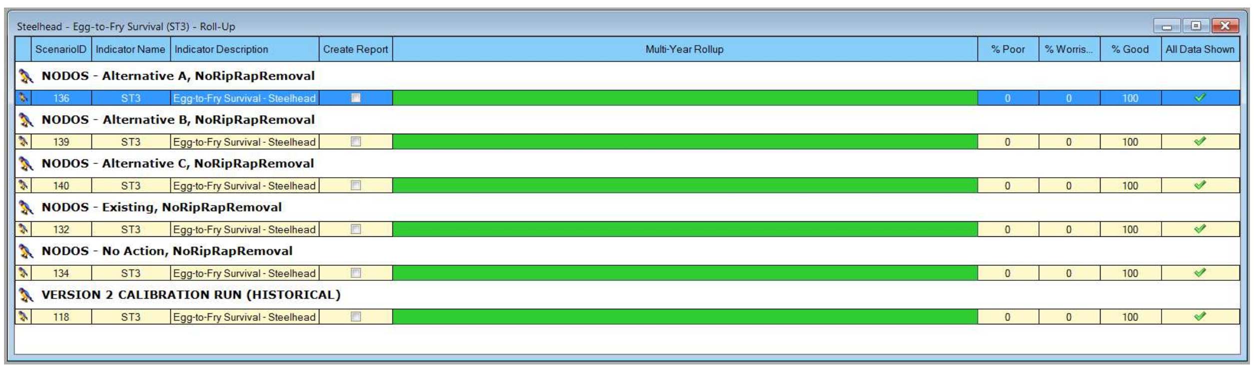
	Comparison 5			*Comparison 6*			*Comparison 7*			*Comparison 8*		
ScenarioID	139	134		140	132		140	134		134	118	
Scenario Name	NODOS - Alt B	NAA	Change	NODOS - Alt C	Existing	Change	NODOS - Alt C	NAA	Change	NAA	HIST.	Change
	NODOS - Alt B	No Action Alternative		NODOS - Alt C	Existing conditions		NODOS - Alt C	No Action Alternative		No Action Alternative	ACTUAL HISTORIC CONDITIONS	
Spawning WUA (ST1)	54	52	2	54	52	2	54	52	2	52	38	14
Thermal Egg Mortality (ST3)	100	100	0	100	100	0	100	100	0	100	100	0
Redd Dewatering (ST6)	57	51	6	56	51	5	56	51	5	51	42	9
Redd Scour (ST5)	62	62	0	62	62	0	62	62	0	62	78	-16
Juvenile Stranding (ST4)	5	9	-4	2	9	-7	2	9	-7	9	33	-24
Rearing WUA (ST2)	54	46	8	54	49	5	54	46	8	46	33	13



Steelhead - Spawning Weighted Useable Area - Roll-Up

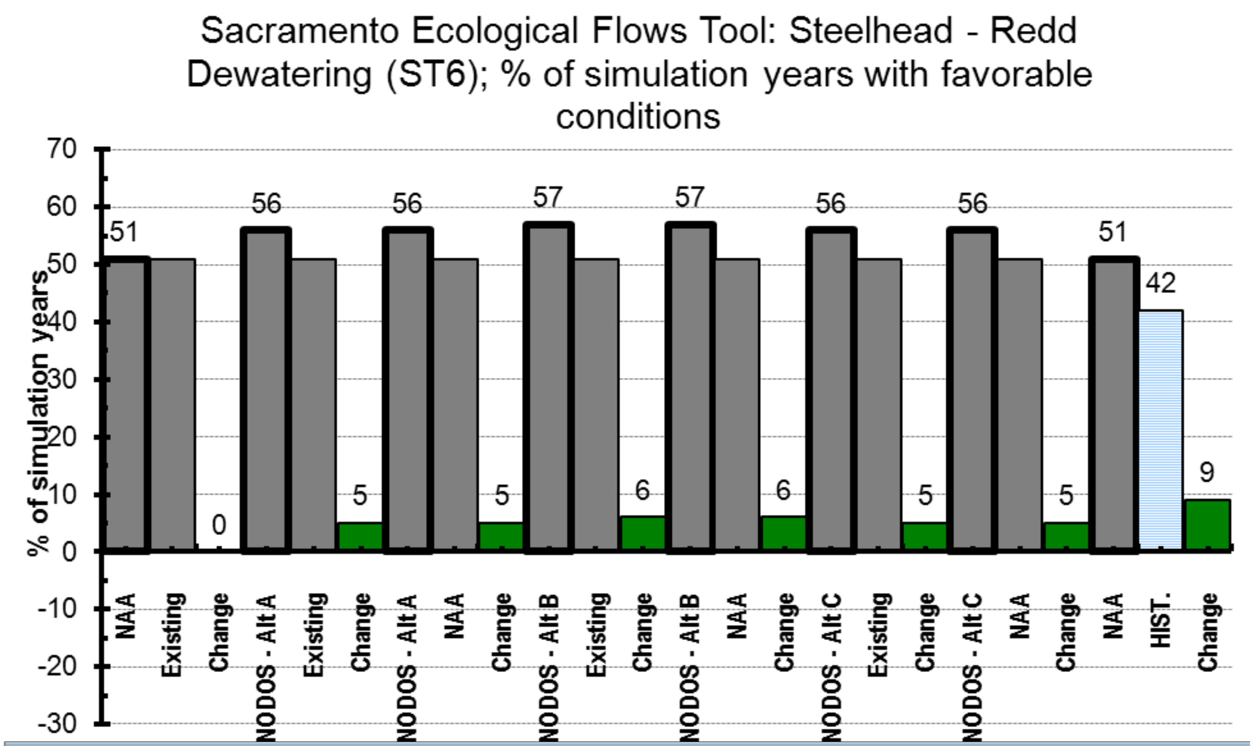
ScenarioID	Indicator Name	Indicator Description	Create Report	Multi-Year Rollup	% Poor	% Worris...	% Good
NODOS - Alternative A, NoRipRapRemoval							
136	ST1	WUA Spawning - Steelhead			8	38	54
NODOS - Alternative B, NoRipRapRemoval							
139	ST1	WUA Spawning - Steelhead			8	38	54
NODOS - Alternative C, NoRipRapRemoval							
140	ST1	WUA Spawning - Steelhead			8	38	54
NODOS - Existing, NoRipRapRemoval							
132	ST1	WUA Spawning - Steelhead			11	37	52
NODOS - No Action, NoRipRapRemoval							
134	ST1	WUA Spawning - Steelhead			11	37	52
VERSION 2 CALIBRATION RUN (HISTORICAL)							
118	ST1	WUA Spawning - Steelhead			22	40	38





Steelhead - Egg-to-Fry Survival (ST3) - Roll-Up

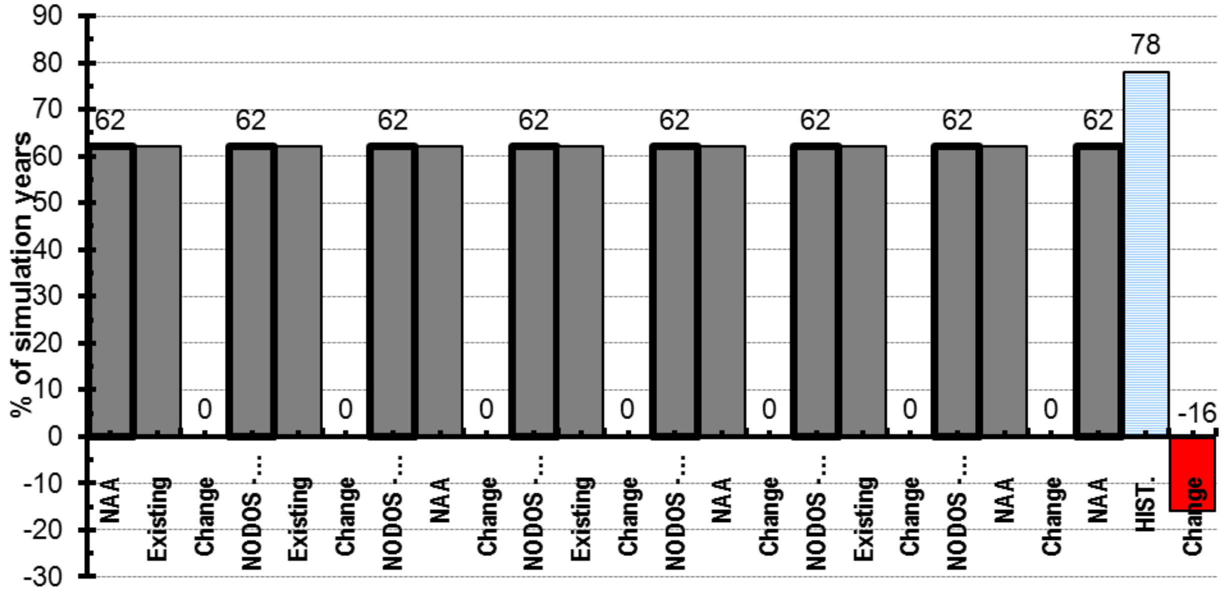
ScenarioID	Indicator Name	Indicator Description	Create Report	Multi-Year Rollup	% Poor	% Worris...	% Good	All Data Shown
NODOS - Alternative A, NoRipRapRemoval								
136	ST3	Egg-to-Fry Survival - Steelhead			0	0	100	✓
NODOS - Alternative B, NoRipRapRemoval								
139	ST3	Egg-to-Fry Survival - Steelhead			0	0	100	✓
NODOS - Alternative C, NoRipRapRemoval								
140	ST3	Egg-to-Fry Survival - Steelhead			0	0	100	✓
NODOS - Existing, NoRipRapRemoval								
132	ST3	Egg-to-Fry Survival - Steelhead			0	0	100	✓
NODOS - No Action, NoRipRapRemoval								
134	ST3	Egg-to-Fry Survival - Steelhead			0	0	100	✓
VERSION 2 CALIBRATION RUN (HISTORICAL)								
118	ST3	Egg-to-Fry Survival - Steelhead			0	0	100	✓



Steelhead - Redd Dewatering (ST6) - Roll-Up

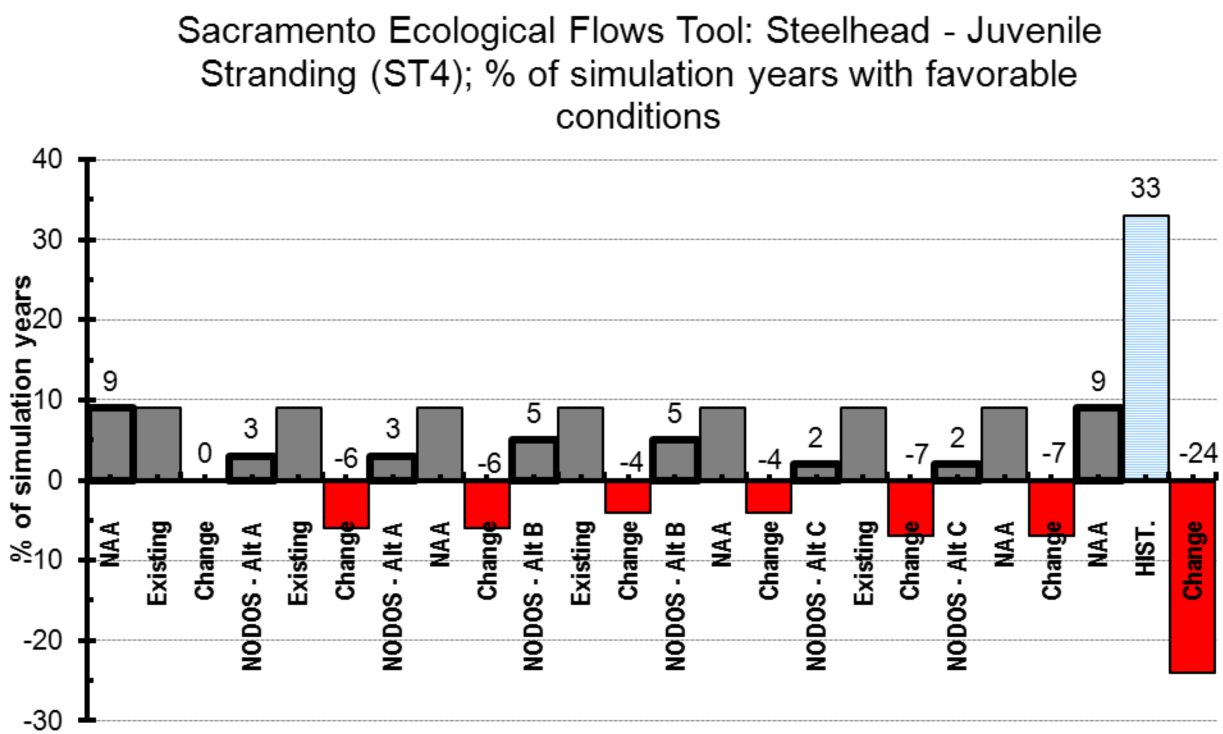
ScenarioID	Indicator Name	Indicator Description	Create Report	Multi-Year Rollup	% Poor	% Worris...	% Good
NODOS - Alternative A, NoRipRapRemoval							
136	ST6	Redd Dewatering - Steelhead			26	18	56
NODOS - Alternative B, NoRipRapRemoval							
139	ST6	Redd Dewatering - Steelhead			24	19	57
NODOS - Alternative C, NoRipRapRemoval							
140	ST6	Redd Dewatering - Steelhead			26	18	56
NODOS - Existing, NoRipRapRemoval							
132	ST6	Redd Dewatering - Steelhead			30	19	51
NODOS - No Action, NoRipRapRemoval							
134	ST6	Redd Dewatering - Steelhead			29	20	51
VERSION 2 CALIBRATION RUN (HISTORICAL)							
118	ST6	Redd Dewatering - Steelhead			42	16	42

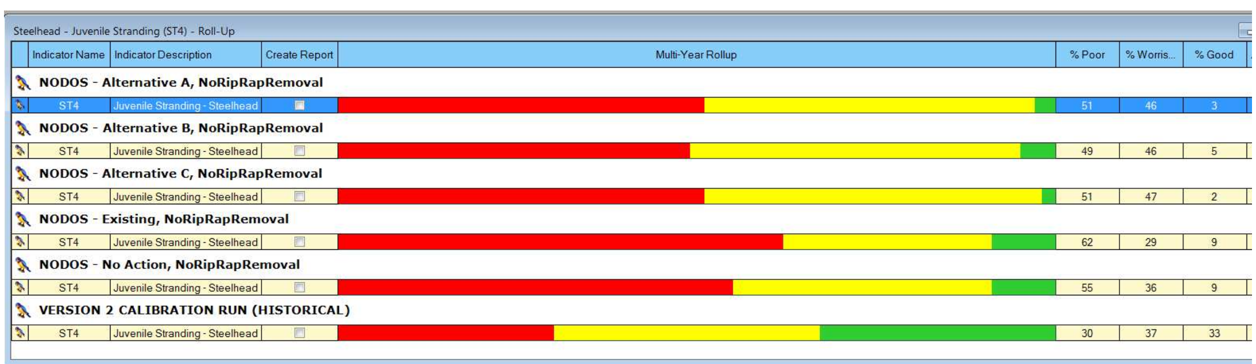
Sacramento Ecological Flows Tool: Steelhead - Redd Scour (ST5); % of simulation years with favorable conditions



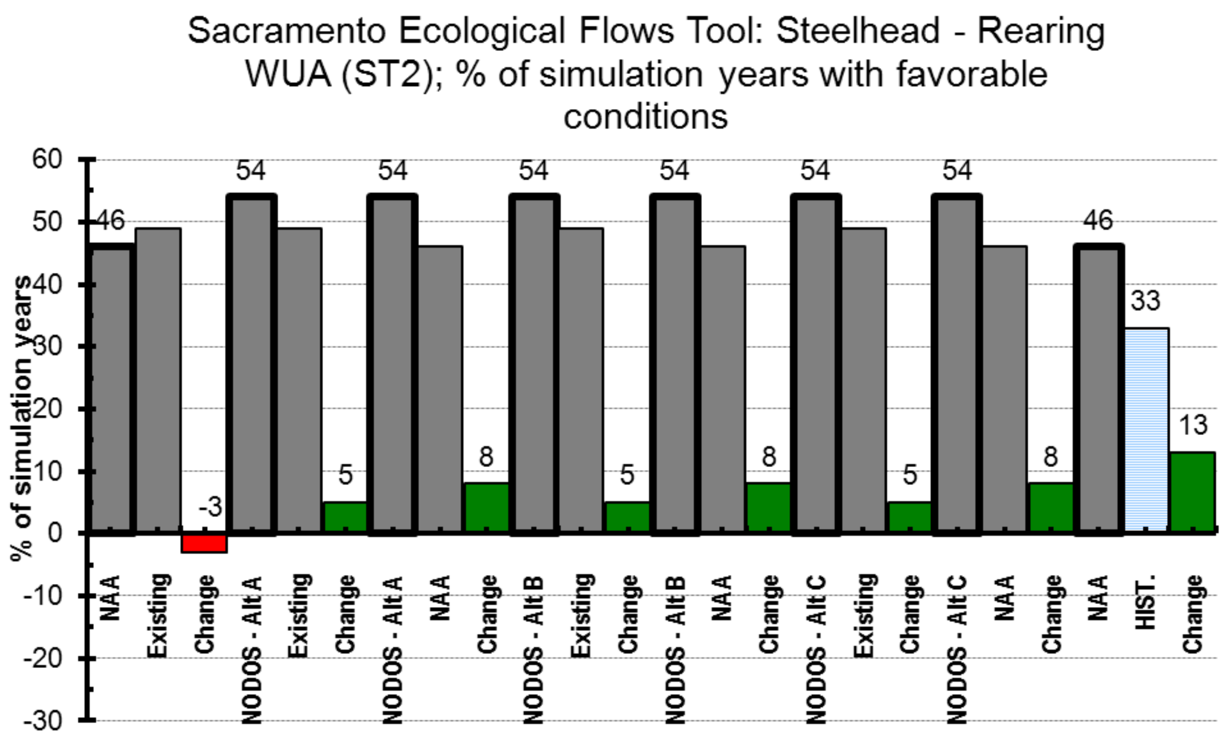
Steelhead - Redd Scour (ST5) - Roll-Up

Indicator Name	Indicator Description	Create Report	Multi-Year Rollup	% Poor	% Worris...	% Good
NODOS - Alternative A, NoRipRapRemoval						
ST5	Redd Scour - Steelhead			31	7	62
NODOS - Alternative B, NoRipRapRemoval						
ST5	Redd Scour - Steelhead			31	7	62
NODOS - Alternative C, NoRipRapRemoval						
ST5	Redd Scour - Steelhead			31	7	62
NODOS - Existing, NoRipRapRemoval						
ST5	Redd Scour - Steelhead			28	10	62
NODOS - No Action, NoRipRapRemoval						
ST5	Redd Scour - Steelhead			28	10	62
VERSION 2 CALIBRATION RUN (HISTORICAL)						
ST5	Redd Scour - Steelhead			22	0	78




Steelhead - Juvenile Stranding (ST4) - Roll-Up

Indicator Name	Indicator Description	Create Report	Multi-Year Rollup	% Poor	% Worris..	% Good
NODOS - Alternative A, NoRipRapRemoval						
ST4	Juvenile Stranding - Steelhead			51	46	3
NODOS - Alternative B, NoRipRapRemoval						
ST4	Juvenile Stranding - Steelhead			49	46	5
NODOS - Alternative C, NoRipRapRemoval						
ST4	Juvenile Stranding - Steelhead			51	47	2
NODOS - Existing, NoRipRapRemoval						
ST4	Juvenile Stranding - Steelhead			62	29	9
NODOS - No Action, NoRipRapRemoval						
ST4	Juvenile Stranding - Steelhead			55	36	9
VERSION 2 CALIBRATION RUN (HISTORICAL)						
ST4	Juvenile Stranding - Steelhead			30	37	33

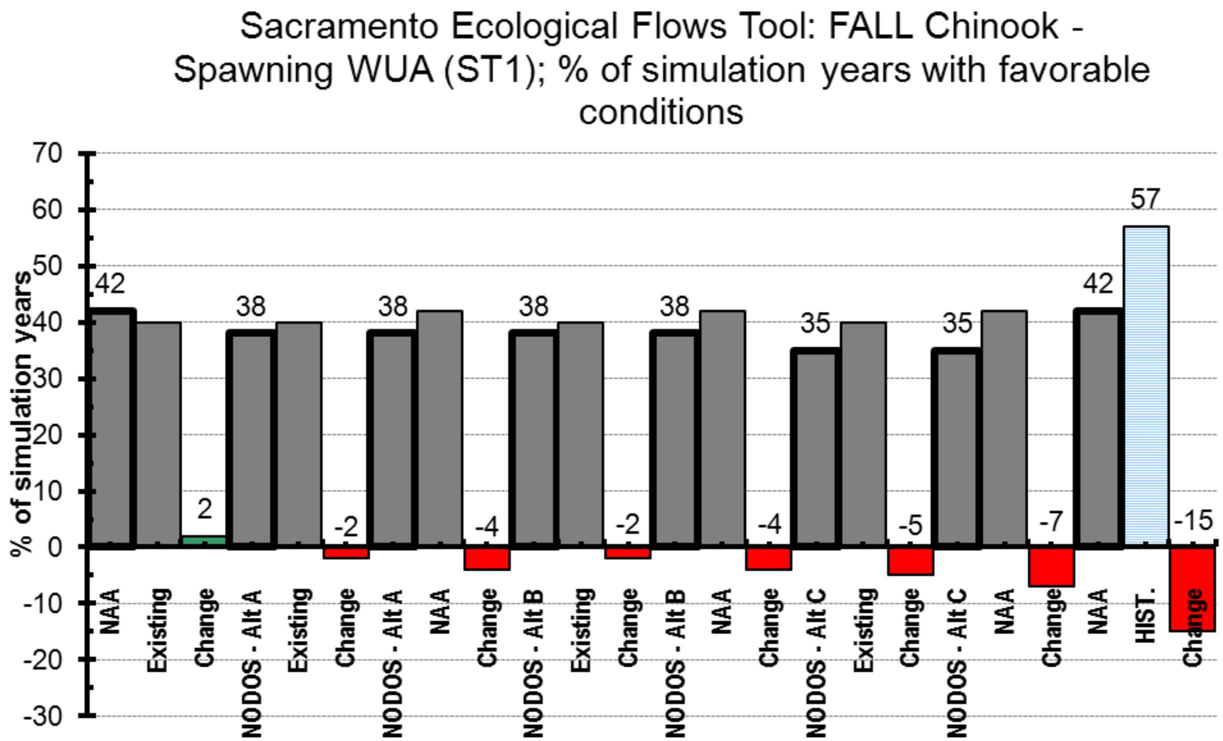


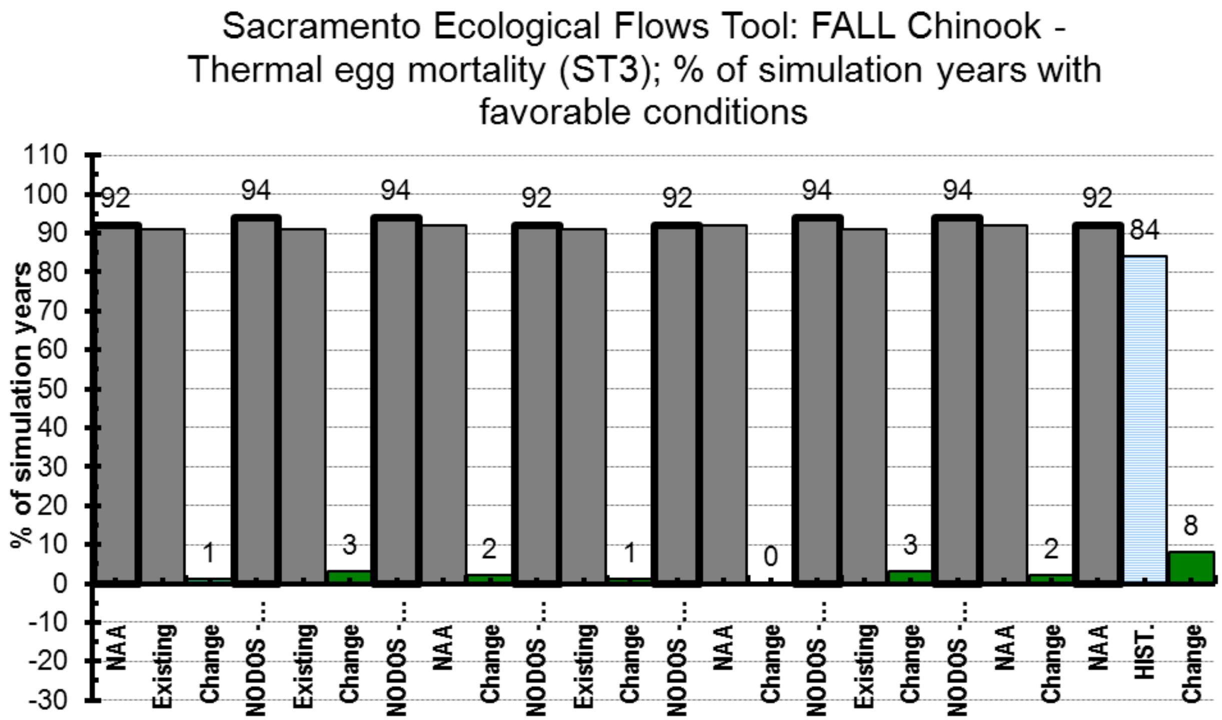
Steelhead - Juvenile Rearing (ST2) - Roll-Up

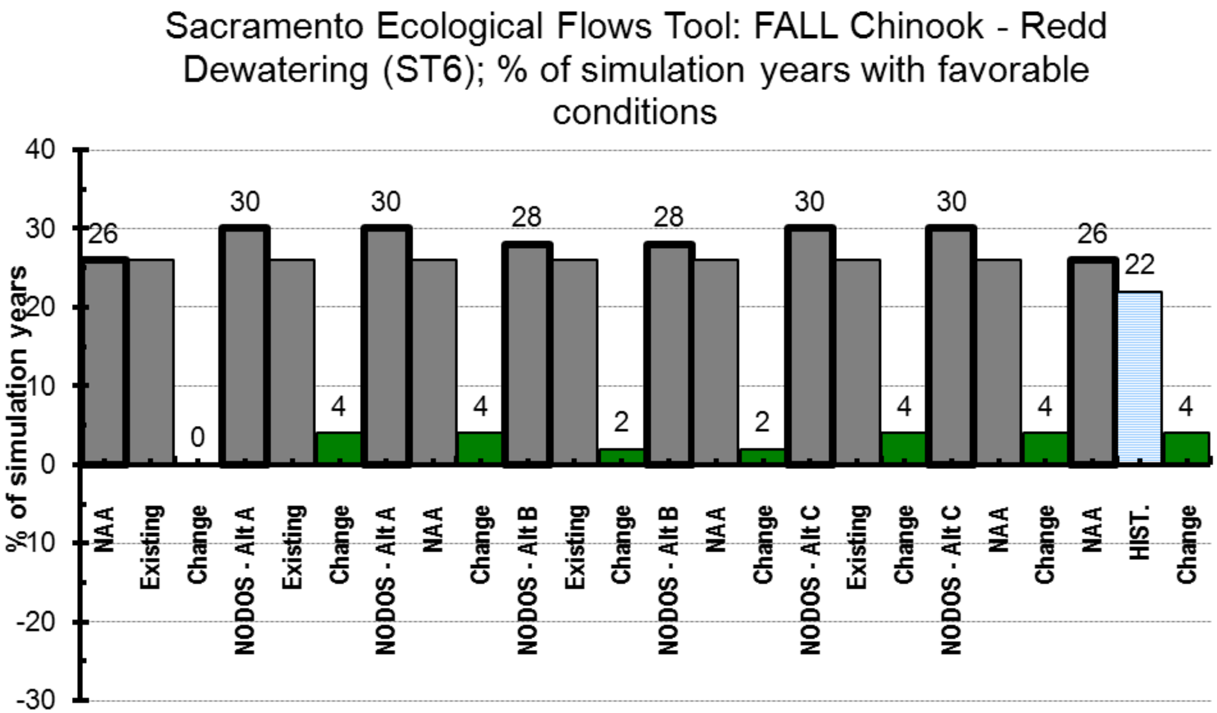
Indicator Name	Indicator Description	Create Report	Multi-Year Rollup	% Poor	% Worris...	% Good
NODOS - Alternative A, NoRipRapRemoval						
ST2	WUA Rearing - Steelhead			15	31	54
NODOS - Alternative B, NoRipRapRemoval						
ST2	WUA Rearing - Steelhead			14	32	54
NODOS - Alternative C, NoRipRapRemoval						
ST2	WUA Rearing - Steelhead			15	31	54
NODOS - Existing, NoRipRapRemoval						
ST2	WUA Rearing - Steelhead			17	34	49
NODOS - No Action, NoRipRapRemoval						
ST2	WUA Rearing - Steelhead			17	37	46
VERSION 2 CALIBRATION RUN (HISTORICAL)						
ST2	WUA Rearing - Steelhead			33	34	33

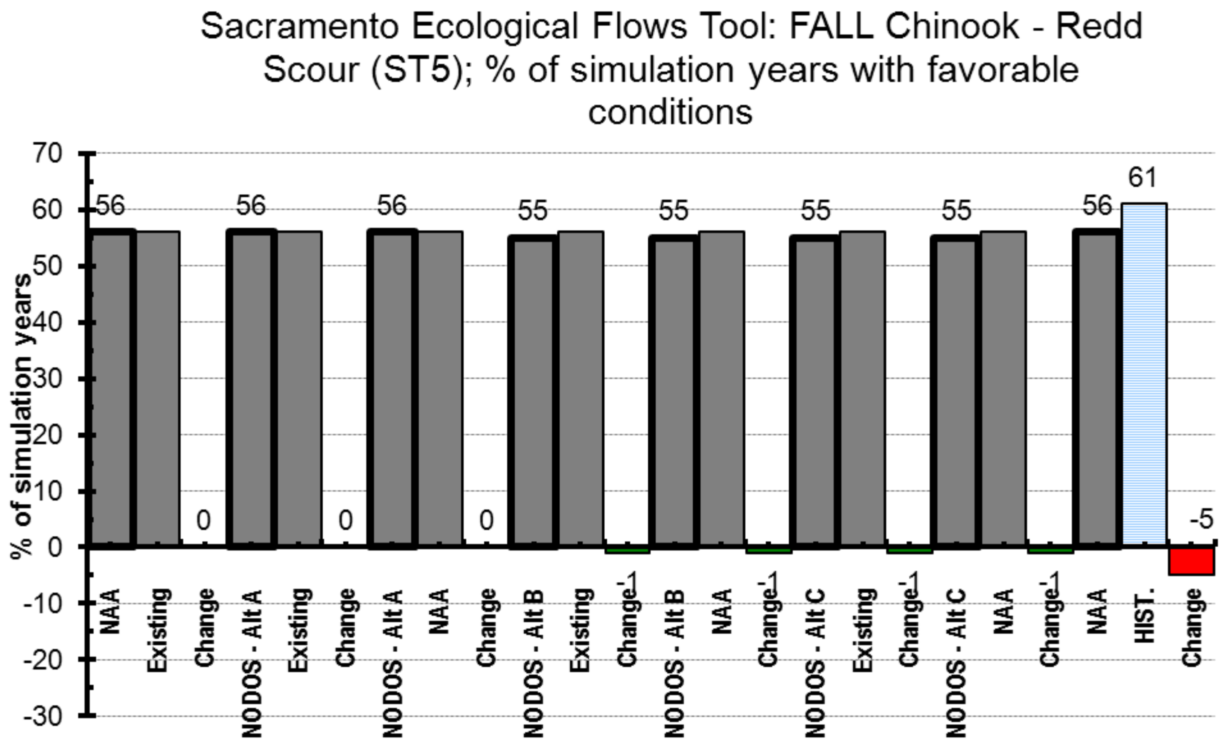
C.2 Fall Chinook

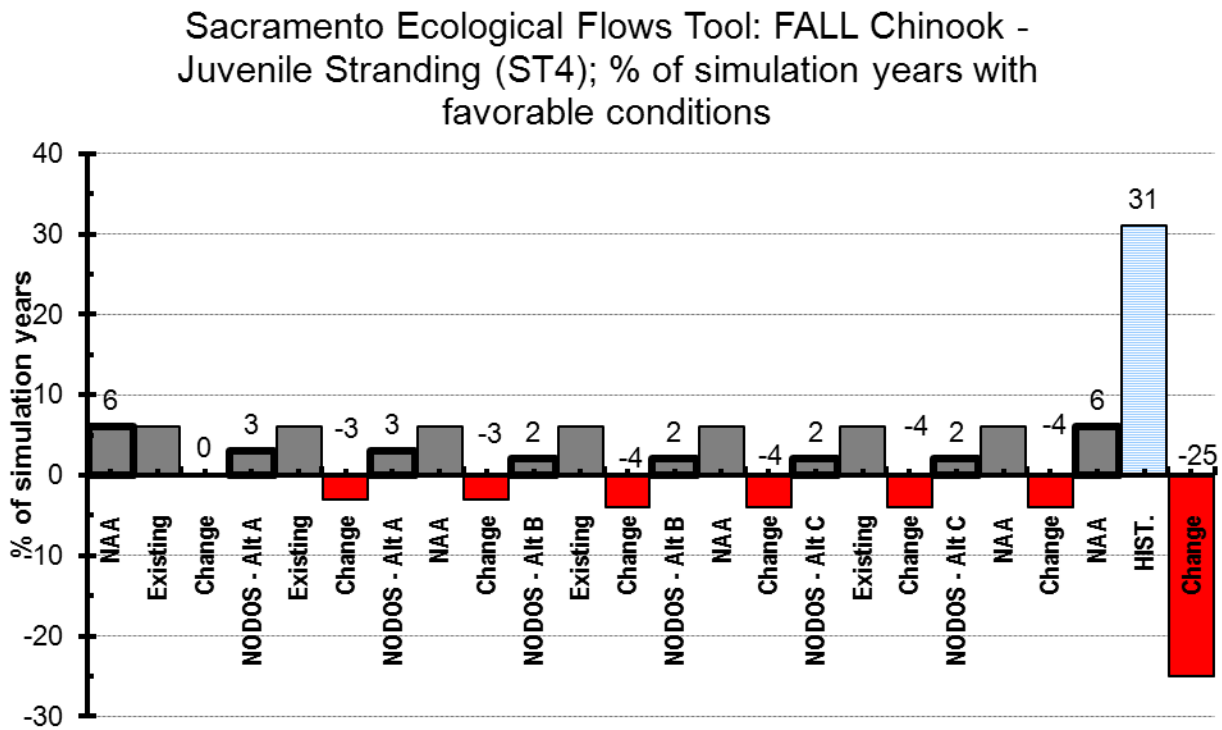
FALL CHINOOK																								
				Comparison 2			*Comparison 3*			*Comparison 4*			*Comparison 5*			*Comparison 6*			*Comparison 7*			*Comparison 8*		
ScenarioID	134	132		136	132		136	134		139	132		139	134		140	132		140	134		134	118	
Scenario Name	NAA	**Existing**	Change	NODOS - Alt A	**Existing**	Change	NODOS - Alt A	NAA	Change	NODOS - Alt B	**Existing**	Change	NODOS - Alt B	NAA	Change	NODOS - Alt C	**Existing**	Change	NODOS - Alt C	NAA	Change	NAA	**HIST.**	Change
	No Action Alternative	Existing conditions		NODOS - Alt A	Existing conditions		NODOS - Alt A	No Action Alternative		NODOS - Alt B	Existing conditions		NODOS - Alt B	No Action Alternative		NODOS - Alt C	Existing conditions		NODOS - Alt C	No Action Alternative		No Action Alternative	ACTUAL HISTORIC CONDITIONS	
Spawning WUA (CH1)	42	40	2	38	40	-2	38	42	-4	38	40	-2	38	42	-4	35	40	-5	35	42	-7	42	57	-15
Thermal Egg Mortality (CH3)	92	91	1	94	91	3	94	92	2	92	91	1	92	92	0	94	91	3	94	92	2	92	84	8
Redd Dewatering (CH6)	26	26	0	30	26	4	30	26	4	28	26	2	28	26	2	30	26	4	30	26	4	26	22	4
Redd Scour (CH5)	56	56	0	56	56	0	56	56	0	55	56	-1	55	56	-1	55	56	-1	55	56	-1	56	61	-5
Juvenile Stranding (CH4)	6	6	0	3	6	-3	3	6	-3	2	6	-4	2	6	-4	2	6	-4	2	6	-4	6	31	-25
Rearing WUA (CH2)	35	35	0	42	35	7	42	35	7	42	35	7	42	35	7	42	35	7	42	35	7	35	34	1

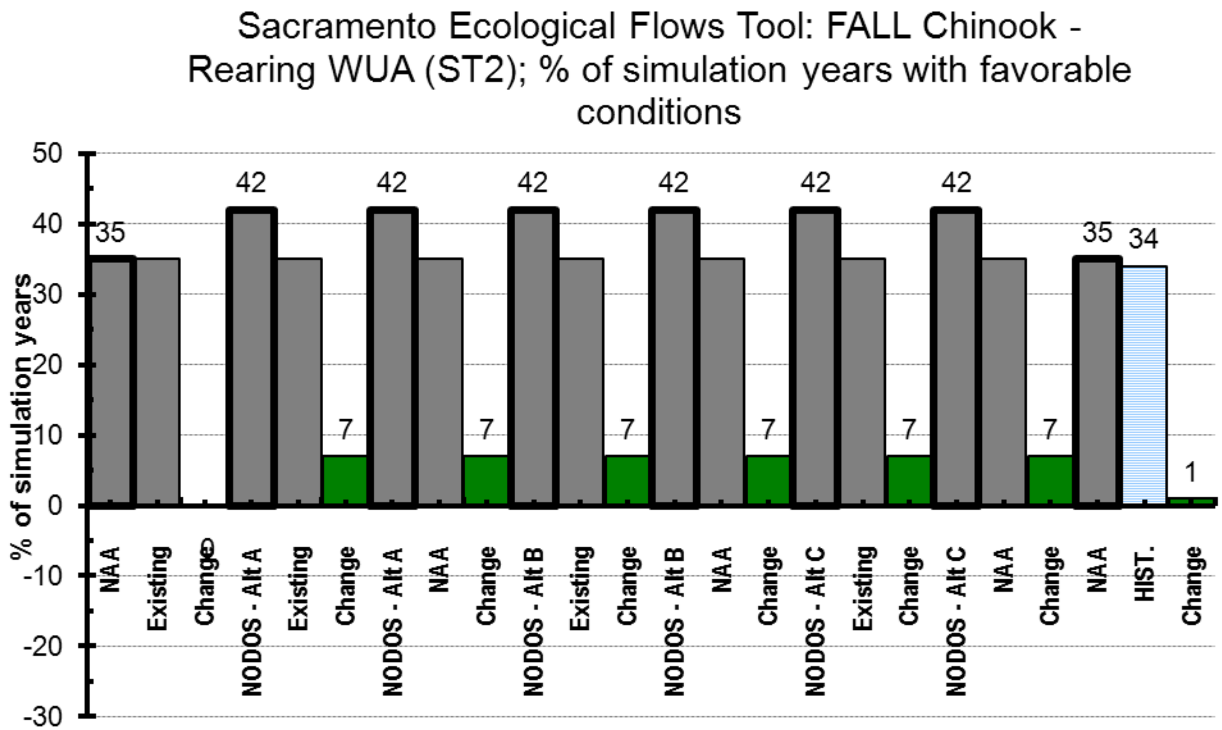

Sacramento Ecological Flows Tool: FALL Chinook - Spawning WUA (ST1); % of simulation years with favorable conditions
% of simulation years
70
60
50
40
30
20
10
0
-10
-20
-30
42
38
38
38
38
35
35
42
57
2
-2
-4
-2
-4
-5
-7
-15
NAA
Existing
Change
NODOS - Alt A
Existing
Change
NODOS - Alt A
NAA
Change
NODOS - Alt B
Existing
Change
NODOS - Alt B
NAA
Change
NODOS - Alt C
Existing
Change
NODOS - Alt C
NAA
Change
NAA
HIST.
Change


Sacramento Ecological Flows Tool: FALL Chinook - Thermal egg mortality (ST3); % of simulation years with favorable conditions
% of simulation years
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
92
94
94
92
92
94
94
92
84
1
3
2
1
0
3
2
8
NAA
Existing
Change
NODOS - ...
Existing
Change
NODOS - ...
NAA
Change
NODOS - ...
Existing
Change
NODOS - ...
NAA
Change
NODOS - ...
Existing
Change
NODOS - ...
NAA
Change
NAA
HIST.
Change


Sacramento Ecological Flows Tool: FALL Chinook - Redd Dewatering (ST6); % of simulation years with favorable conditions
% of simulation years
40
30
20
10
0
-10
-20
-30
26
0
30
4
30
4
28
2
28
2
30
4
30
4
26
22
4
NAA
Existing
Change
NODOS - Alt A
Existing
Change
NODOS - Alt A
NAA
Change
NODOS - Alt B
Existing
Change
NODOS - Alt B
NAA
Change
NODOS - Alt C
Existing
Change
NODOS - Alt C
NAA
Change
NAA
HIST.
Change

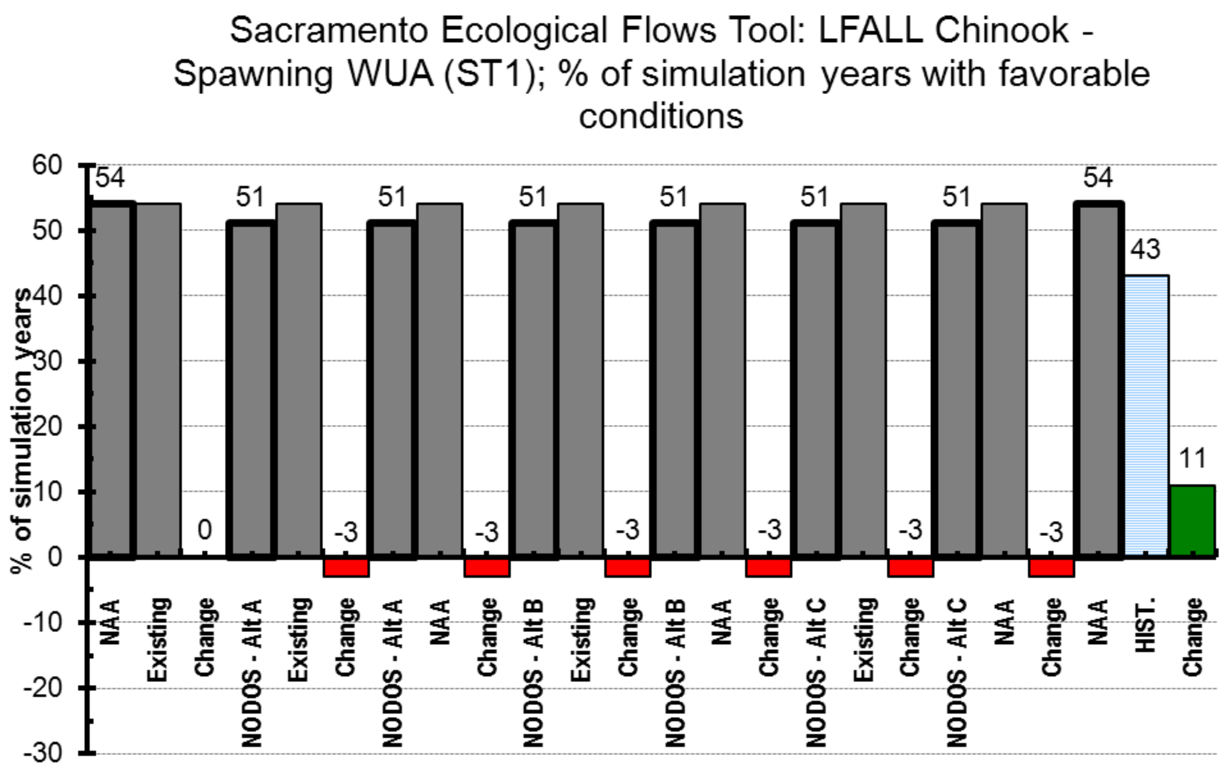

Sacramento Ecological Flows Tool: FALL Chinook - Redd Scour (ST5); % of simulation years with favorable conditions
% of simulation years
70
60
50
40
30
20
10
0
-10
-20
-30
56
56
56
55
55
55
55
56
61
0
0
0
-1
-1
-1
-1
-5
NAA
Existing
Change
NODOS - Alt A
Existing
Change
NODOS - Alt A
NAA
Change
NODOS - Alt B
Existing
Change
NODOS - Alt B
NAA
Change
NODOS - Alt C
Existing
Change
NODOS - Alt C
NAA
Change
NAA
HIST.
Change


Sacramento Ecological Flows Tool: FALL Chinook - Juvenile Stranding (ST4); % of simulation years with favorable conditions
% of simulation years
40
30
20
10
0
-10
-20
-30
6
0
3
-3
3
-3
2
-4
2
-4
2
-4
2
-4
6
31
-25
NAA
Existing
Change
NODOS - Alt A
Existing
Change
NODOS - Alt A
NAA
Change
NODOS - Alt B
Existing
Change
NODOS - Alt B
NAA
Change
NODOS - Alt C
Existing
Change
NODOS - Alt C
NAA
Change
NAA
HIST.
Change

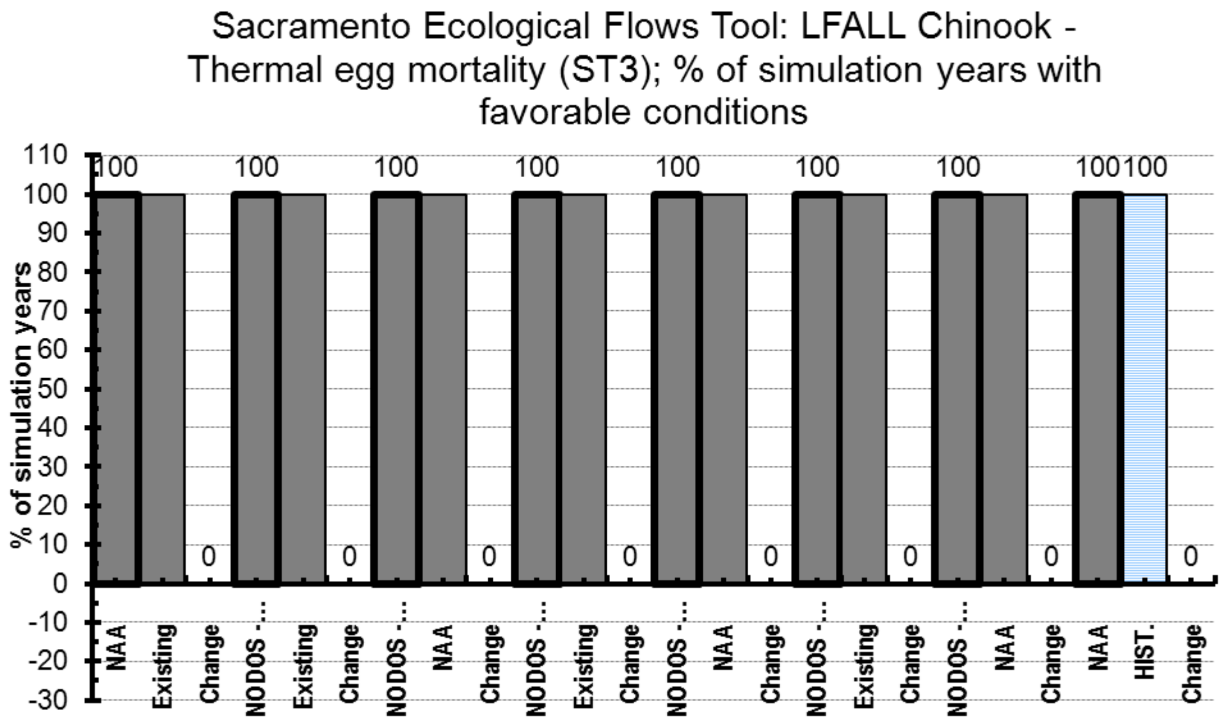

Sacramento Ecological Flows Tool: FALL Chinook - Rearing WUA (ST2); % of simulation years with favorable conditions
% of simulation years
50
40
30
20
10
0
-10
-20
-30
35
42
42
42
42
42
42
35
34
7
7
7
7
7
7
0
1
NAA
Existing
Change
NODOS - Alt A
Existing
Change
NODOS - Alt A
NAA
Change
NODOS - Alt B
Existing
Change
NODOS - Alt B
NAA
Change
NODOS - Alt C
Existing
Change
NODOS - Alt C
NAA
Change
NAA
HIST.
Change

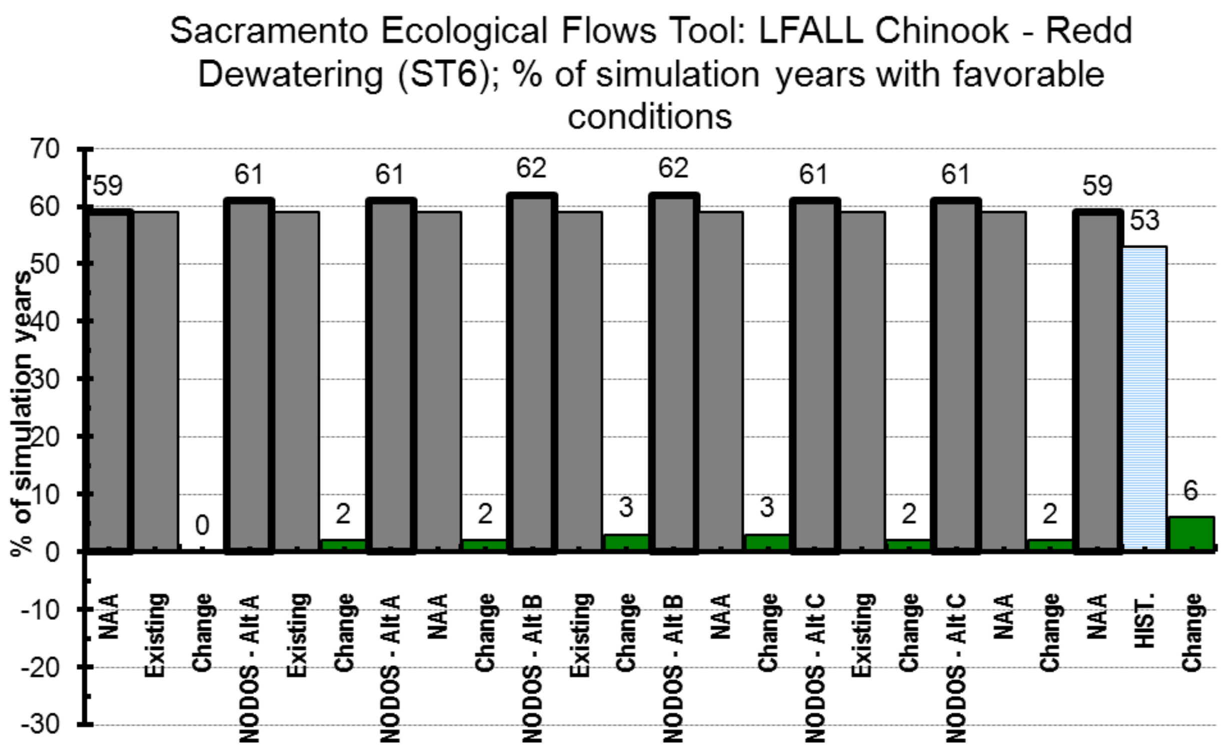
C.3 Late Fall Chinook

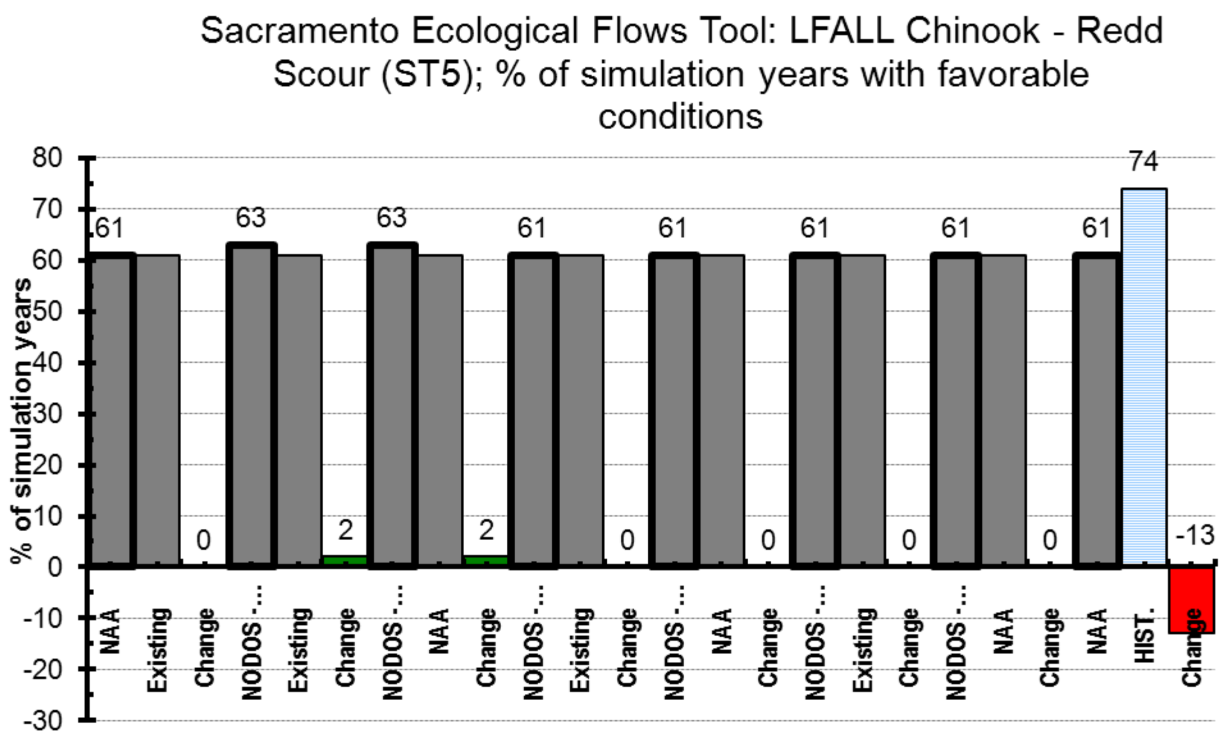
	LATE FALL CHINOOK																							
				Comparison 2			*Comparison 3*			*Comparison 4*			*Comparison 5*			*Comparison 6*			*Comparison 7*			*Comparison 8*		
ScenarioID	134	132		136	132		136	134		139	132		139	134		140	132		140	134		134	118	
Scenario Name	NAA	**Existing**	Change	NODOS - Alt A	**Existing**	Change	NODOS - Alt A	NAA	Change	NODOS - Alt B	**Existing**	Change	NODOS - Alt B	NAA	Change	NODOS - Alt C	**Existing**	Change	NODOS - Alt C	NAA	Change	NAA	**HIST.**	Change
	No Action Alternative	Existing conditions		NODOS - Alt A	Existing conditions		NODOS - Alt A	No Action Alternative		NODOS - Alt B	Existing conditions		NODOS - Alt B	No Action Alternative		NODOS - Alt C	Existing conditions		NODOS - Alt C	No Action Alternative		No Action Alternative	ACTUAL HISTORIC CONDITIONS	
Spawning WUA (CH1)	54	54	0	51	54	-3	51	54	-3	51	54	-3	51	54	-3	51	54	-3	51	54	-3	54	43	11
Thermal Egg Mortality (CH3)	100	100	0	100	100	0	100	100	0	100	100	0	100	100	0	100	100	0	100	100	0	100	100	0
Redd Dewatering (CH6)	59	59	0	61	59	2	61	59	2	62	59	3	62	59	3	61	59	2	61	59	2	59	53	6
Redd Scour (CH5)	61	61	0	63	61	2	63	61	2	61	61	0	61	61	0	61	61	0	61	61	0	61	74	-13
Juvenile Stranding (CH4)	23	26	-3	17	26	-9	17	23	-6	20	26	-6	20	23	-3	17	26	-9	17	23	-6	23	34	-11
Rearing WUA (CH2)	54	55	-1	58	55	3	58	54	4	60	55	5	60	54	6	57	55	2	57	54	3	54	34	20

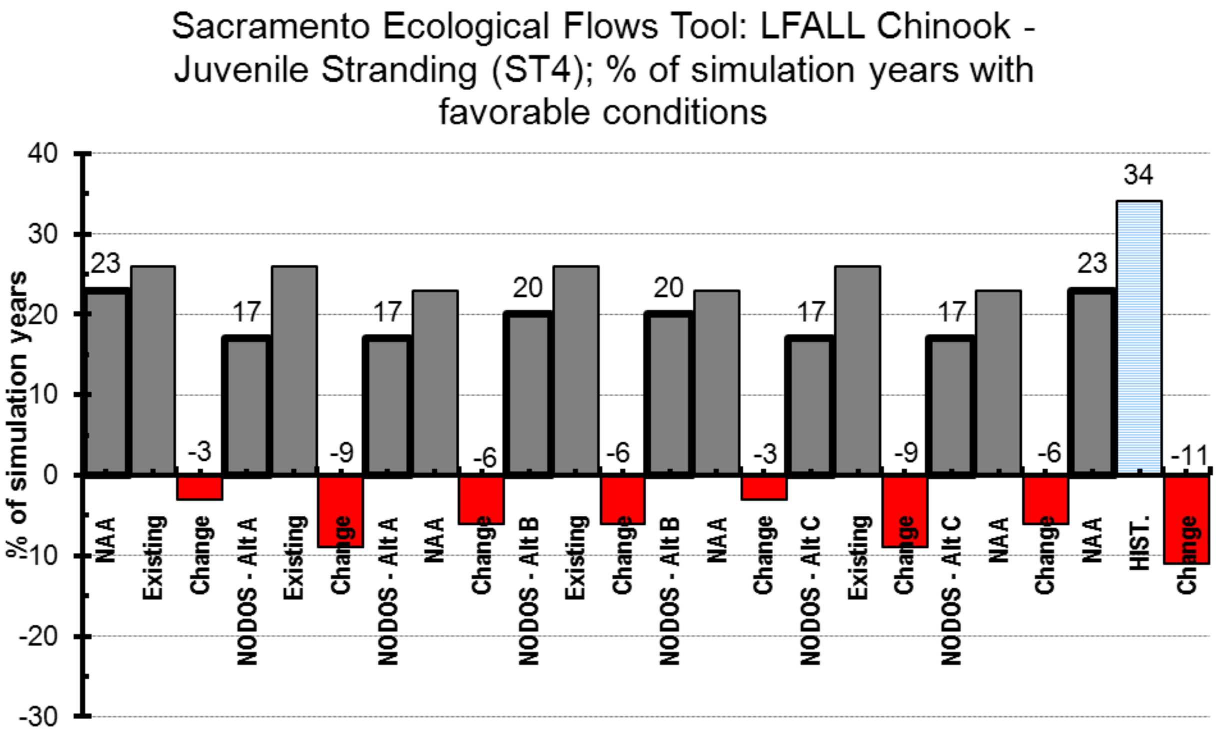


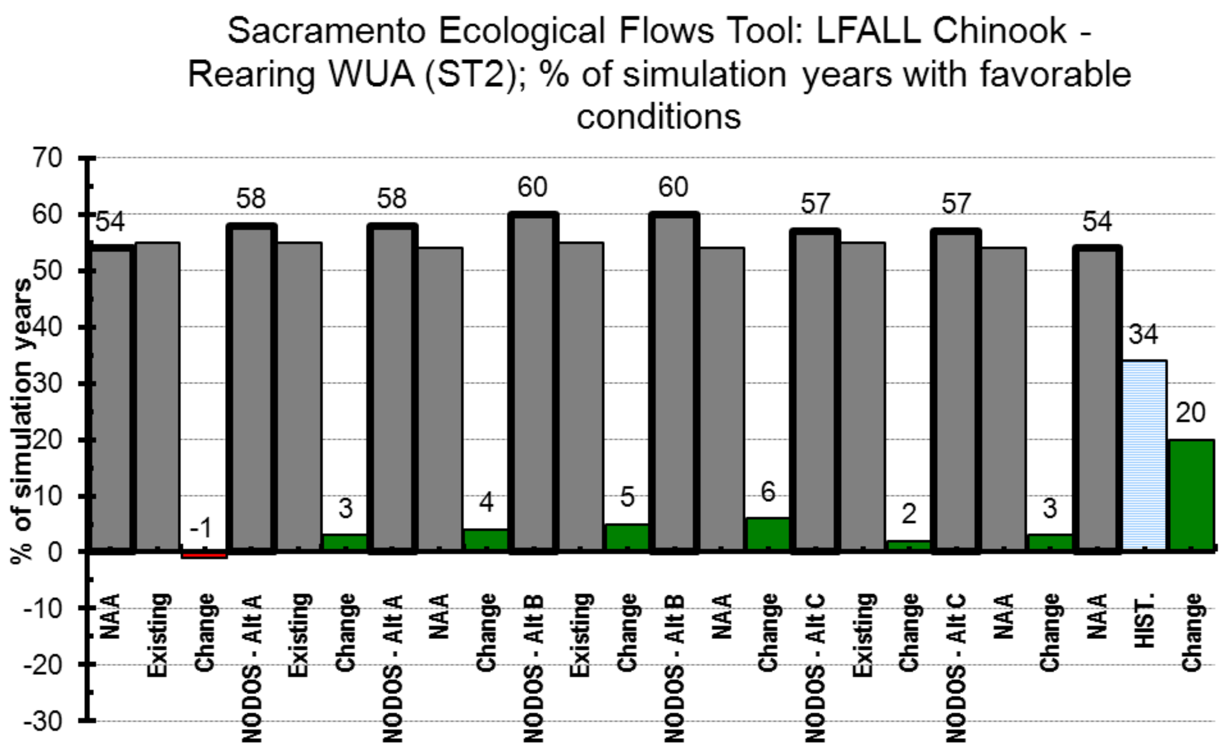
Sacramento Ecological Flows Tool: LFALL Chinook - Spawning WUA (ST1); % of simulation years with favorable conditions
% of simulation years
60
50
40
30
20
10
0
-10
-20
-30
54
0
51
-3
51
-3
51
-3
51
-3
51
-3
51
-3
54
43
11
NAA
Existing
Change
NODOS - Alt A
Existing
Change
NODOS - Alt A
NAA
Change
NODOS - Alt B
Existing
Change
NODOS - Alt B
NAA
Change
NODOS - Alt C
Existing
Change
NODOS - Alt C
NAA
Change
NAA
HIST.
Change


Sacramento Ecological Flows Tool: LFALL Chinook - Thermal egg mortality (ST3); % of simulation years with favorable conditions
% of simulation years
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
100
100
100
100
100
100
100
100
100
0
0
0
0
0
0
0
0
NAA
Existing
Change
NODOS - ...
Existing
Change
NODOS - ...
NAA
Change
NODOS - ...
Existing
Change
NODOS - ...
NAA
Change
NODOS - ...
Existing
Change
NODOS - ...
NAA
Change
NAA
HIST.
Change


Sacramento Ecological Flows Tool: LFALL Chinook - Redd Dewatering (ST6); % of simulation years with favorable conditions
% of simulation years
70
60
50
40
30
20
10
0
-10
-20
-30
59
0
61
2
61
2
62
3
62
3
61
2
61
2
59
53
6
NAA
Existing
Change
NODOS - Alt A
Existing
Change
NODOS - Alt A
NAA
Change
NODOS - Alt B
Existing
Change
NODOS - Alt B
NAA
Change
NODOS - Alt C
Existing
Change
NODOS - Alt C
NAA
Change
NAA
HIST.
Change

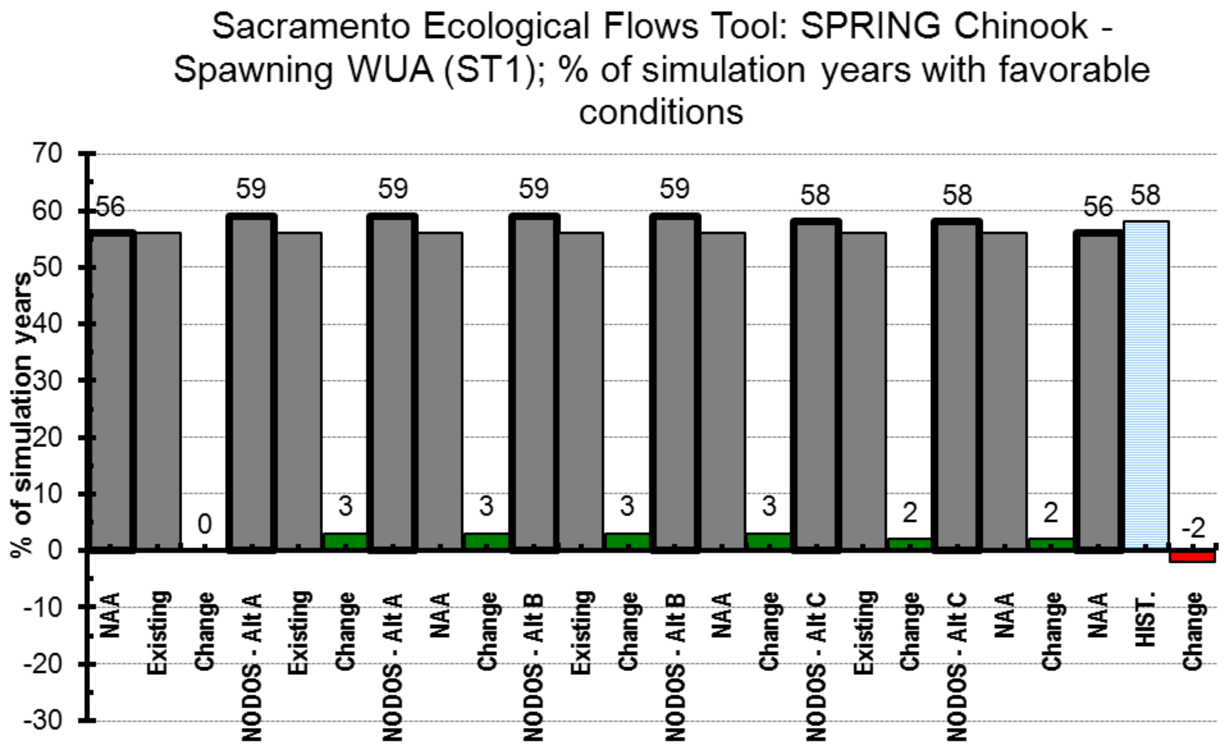

Sacramento Ecological Flows Tool: LFALL Chinook - Redd Scour (ST5); % of simulation years with favorable conditions
% of simulation years
80
70
60
50
40
30
20
10
0
-10
-20
-30
61
63
63
61
61
61
61
61
74
0
2
2
0
0
0
0
-13
NAA
Existing
Change
NODOS ...
Existing
Change
NODOS ...
NAA
Change
NODOS ...
Existing
Change
NODOS ...
NAA
Change
NODOS ...
Existing
Change
NODOS ...
NAA
Change
NAA
HIST.
Change

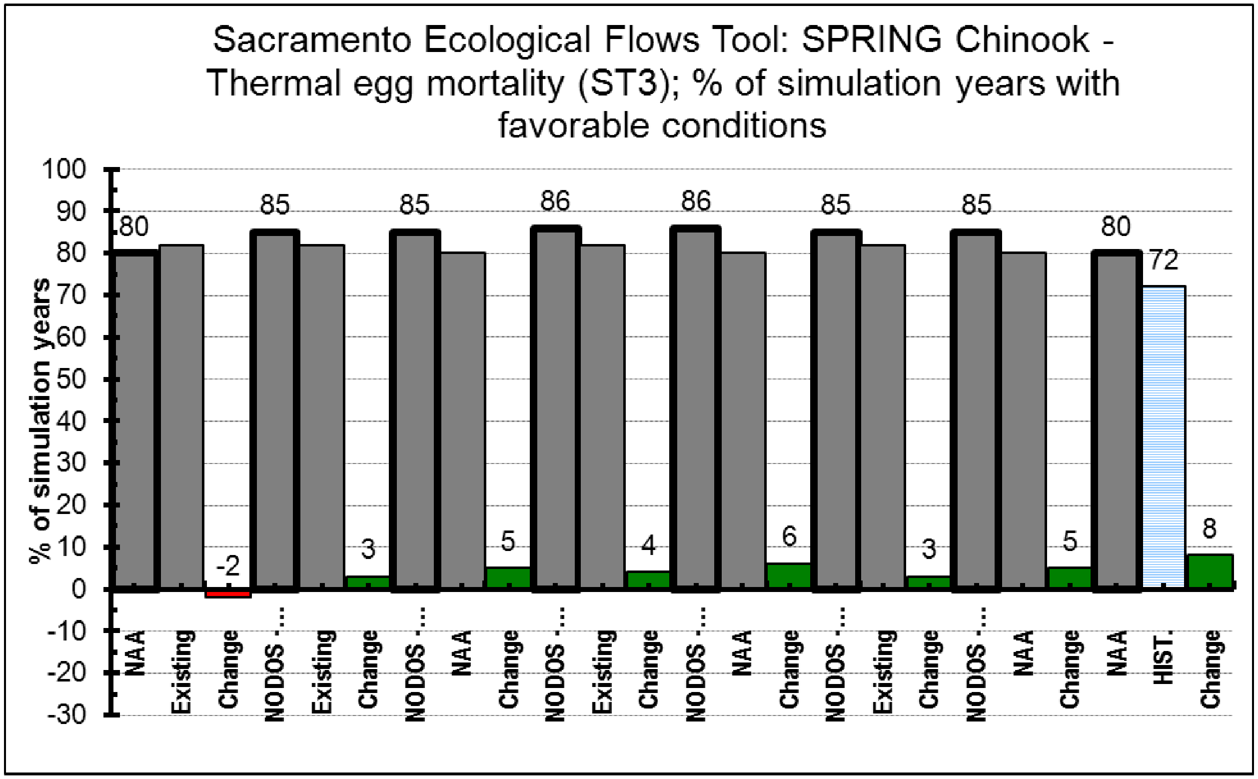

Sacramento Ecological Flows Tool: LFALL Chinook - Juvenile Stranding (ST4); % of simulation years with favorable conditions
% of simulation years
40
30
20
10
0
-10
-20
-30
23
-3
17
-9
17
-6
20
-6
20
-3
17
-9
17
-6
23
34
-11
NAA
Existing
Change
NODOS - Alt A
Existing
Change
NODOS - Alt A
NAA
Change
NODOS - Alt B
Existing
Change
NODOS - Alt B
NAA
Change
NODOS - Alt C
Existing
Change
NODOS - Alt C
NAA
Change
NAA
HIST.
Change

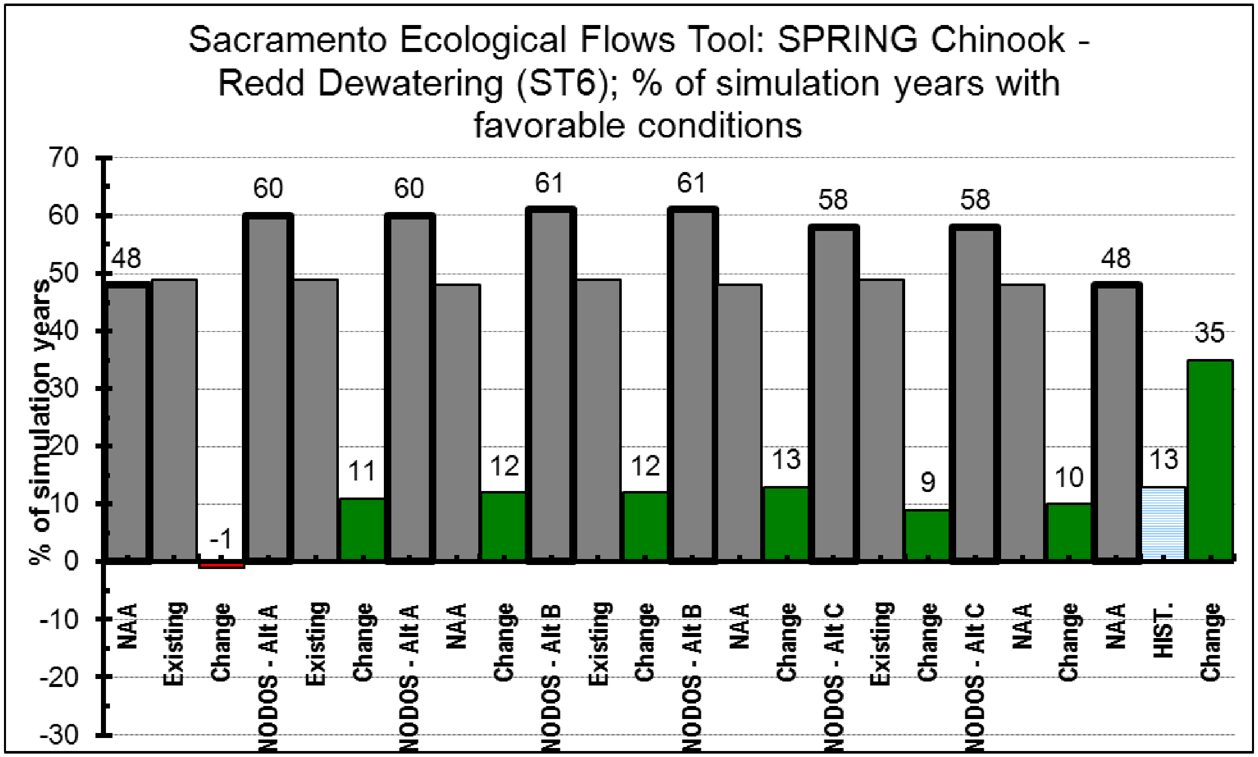

Sacramento Ecological Flows Tool: LFALL Chinook - Rearing WUA (ST2); % of simulation years with favorable conditions
% of simulation years
70
60
50
40
30
20
10
0
-10
-20
-30
54
-1
58
3
58
4
60
5
60
6
57
2
57
3
54
34
20
NAA
Existing
Change
NODOS - Alt A
Existing
Change
NODOS - Alt A
NAA
Change
NODOS - Alt B
Existing
Change
NODOS - Alt B
NAA
Change
NODOS - Alt C
Existing
Change
NODOS - Alt C
NAA
Change
NAA
HIST.
Change

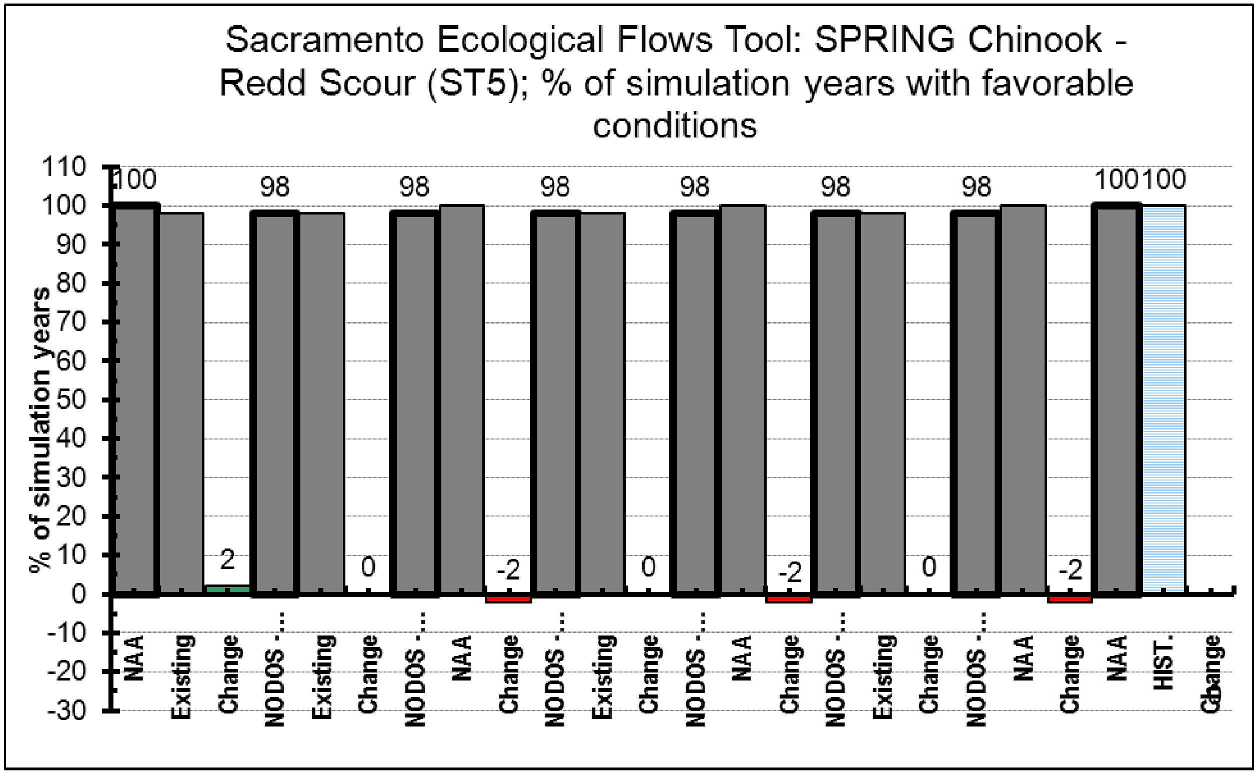
C.4 Spring Chinook

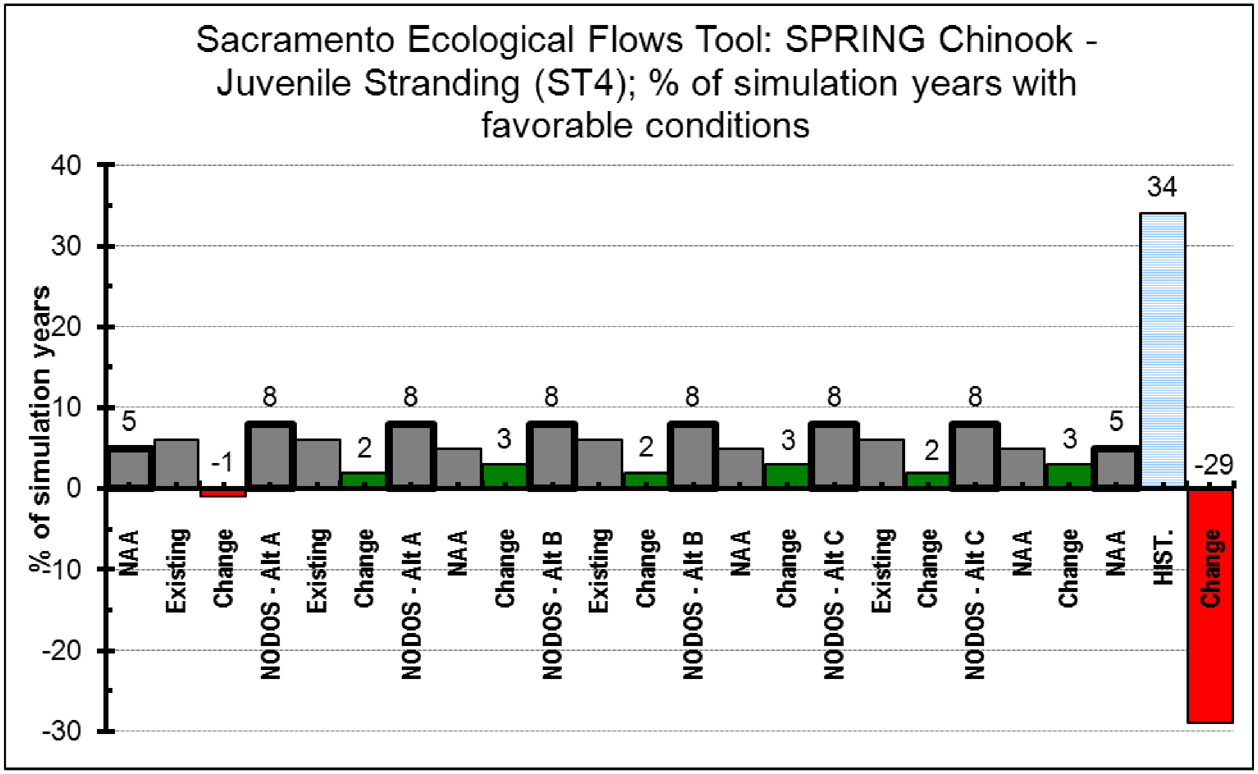
	SPRING CHINOOK																							
				Comparison 2			*Comparison 3*			*Comparison 4*			*Comparison 5*			*Comparison 6*			*Comparison 7*			*Comparison 8*		
ScenarioID	134	132		136	132		136	134		139	132		139	134		140	132		140	134		134	118	
Scenario Name	NAA	Existing	Change	NODOS - Alt A	Existing	Change	NODOS - Alt A	NAA	Change	NODOS - Alt B	Existing	Change	NODOS - Alt B	NAA	Change	NODOS - Alt C	Existing	Change	NODOS - Alt C	NAA	Change	NAA	HIST.	Change
	No Action Alternative	Existing conditions		NODOS - Alt A	Existing conditions		NODOS - Alt A	No Action Alternative		NODOS - Alt B	Existing conditions		NODOS - Alt B	No Action Alternative		NODOS - Alt C	Existing conditions		NODOS - Alt C	No Action Alternative		No Action Alternative	ACTUAL HISTORIC CONDITIONS	
Spawning WUA (CH1)	56	56	0	59	56	3	59	56	3	59	56	3	59	56	3	58	56	2	58	56	2	56	58	-2
Thermal Egg Mortality (CH3)	80	82	-2	85	82	3	85	80	5	86	82	4	86	80	6	85	82	3	85	80	5	80	72	8
Redd Dewatering (CH6)	48	49	-1	60	49	11	60	48	12	61	49	12	61	48	13	58	49	9	58	48	10	48	13	35
Redd Scour (CH5)	100	98	2	98	98	0	98	100	-2	98	98	0	98	100	-2	98	98	0	98	100	-2	100	100	0
Juvenile Stranding (CH4)	5	6	-1	8	6	2	8	5	3	8	6	2	8	5	3	8	6	2	8	5	3	5	34	-29
Rearing WUA (CH2)	18	17	1	9	17	-8	9	18	-9	9	17	-8	9	18	-9	9	17	-8	9	18	-9	18	31	-13

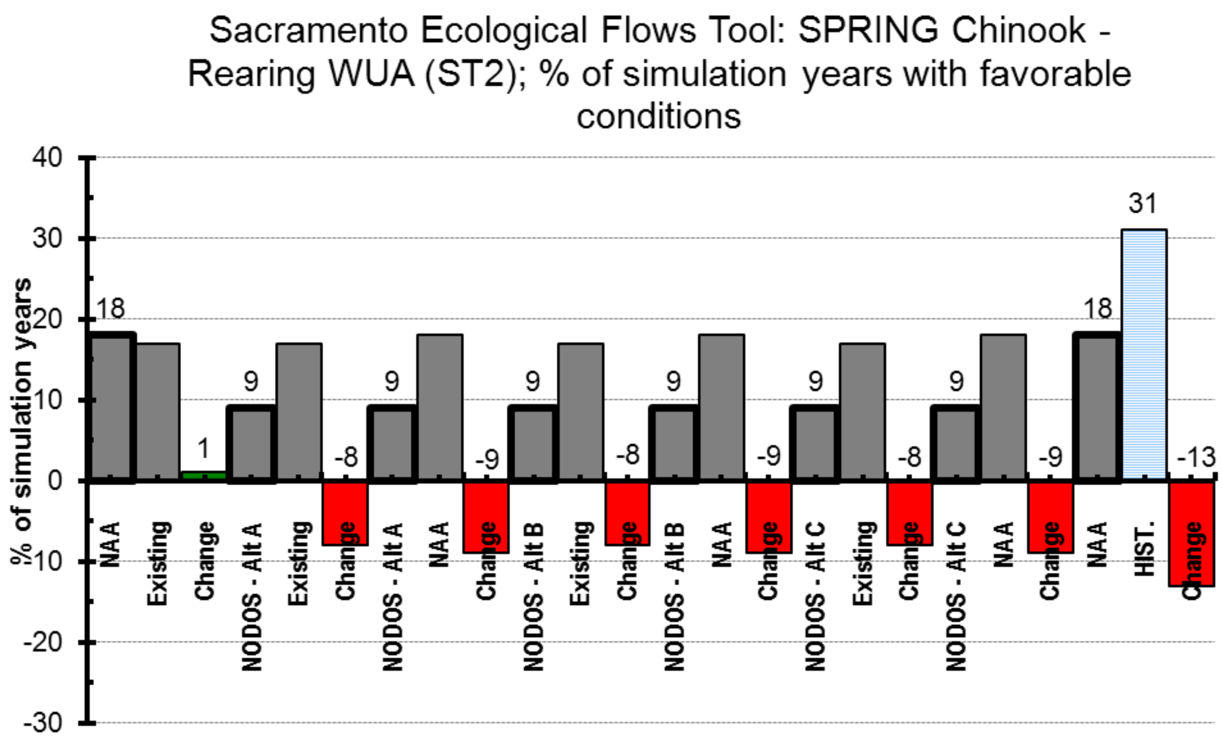

Sacramento Ecological Flows Tool: SPRING Chinook - Spawning WUA (ST1); % of simulation years with favorable conditions
% of simulation years
70
60
50
40
30
20
10
0
-10
-20
-30
56
0
59
3
59
3
59
3
59
3
58
2
58
2
56
58
-2
NAA
Existing
Change
NODOS - Alt A
Existing
Change
NODOS - Alt A
NAA
Change
NODOS - Alt B
Existing
Change
NODOS - Alt B
NAA
Change
NODOS - Alt C
Existing
Change
NODOS - Alt C
NAA
Change
NAA
HIST.
Change


Sacramento Ecological Flows Tool: SPRING Chinook - Thermal egg mortality (ST3); % of simulation years with favorable conditions
% of simulation years
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
80
-2
85
3
85
5
86
4
86
6
85
3
85
5
80
72
8
NAA
Existing
Change
NODOS ...
Existing
Change
NODOS ...
NAA
Change
NODOS ...
Existing
Change
NODOS ...
NAA
Change
NODOS ...
Existing
Change
NODOS ...
NAA
Change
NAA
HIST.
Change


Sacramento Ecological Flows Tool: SPRING Chinook - Redd Dewatering (ST6); % of simulation years with favorable conditions
% of simulation years
70
60
50
40
30
20
10
0
-10
-20
-30
48
-1
60
11
60
12
61
12
61
13
58
9
58
10
48
13
35
NAA
Existing
Change
NODOS - Alt A
Existing
Change
NODOS - Alt A
NAA
Change
NODOS - Alt B
Existing
Change
NODOS - Alt B
NAA
Change
NODOS - Alt C
Existing
Change
NODOS - Alt C
NAA
Change
NAA
HIST.
Change

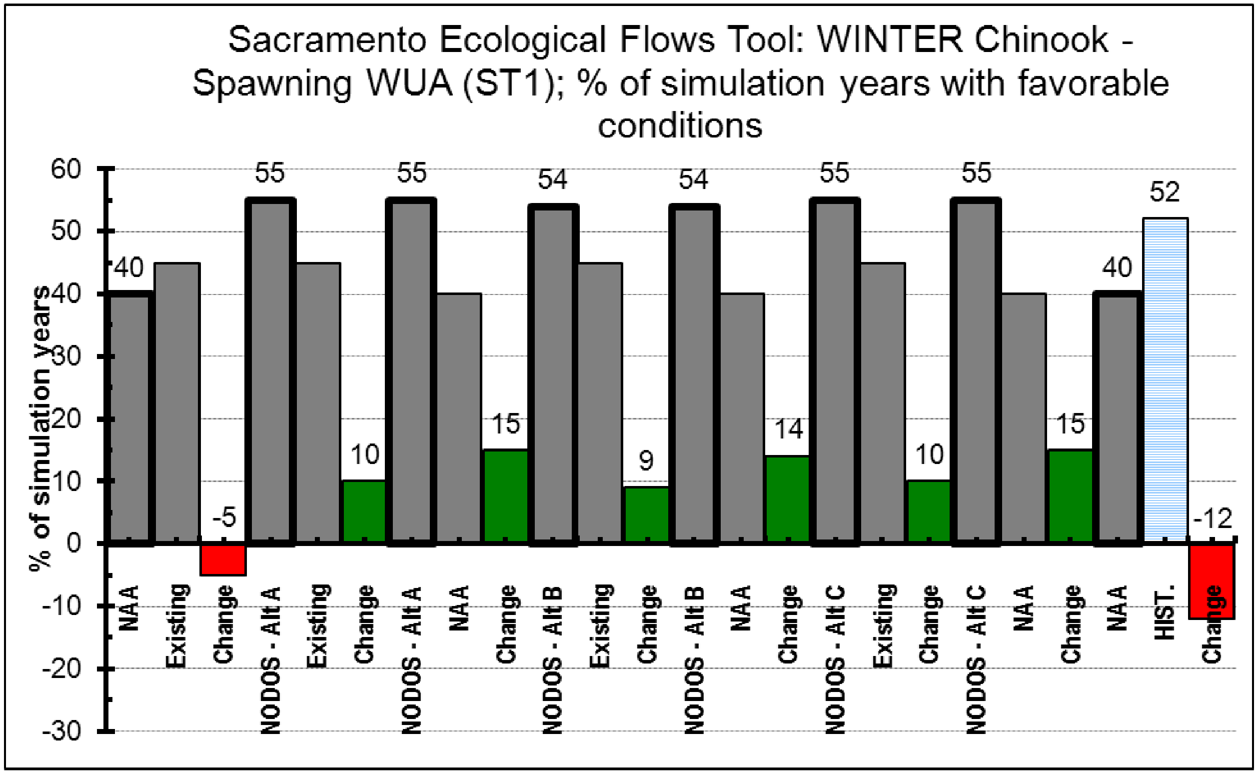

Sacramento Ecological Flows Tool: SPRING Chinook - Redd Scour (ST5); % of simulation years with favorable conditions
% of simulation years
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
100
98
98
98
98
98
98
100
100
2
0
-2
0
-2
0
-2
NAA
Existing
Change
NODOS - ...
Existing
Change
NODOS - ...
NAA
Change
NODOS - ...
Existing
Change
NODOS - ...
NAA
Change
NODOS - ...
Existing
Change
NODOS - ...
NAA
Change
NAA
HIST.
Change

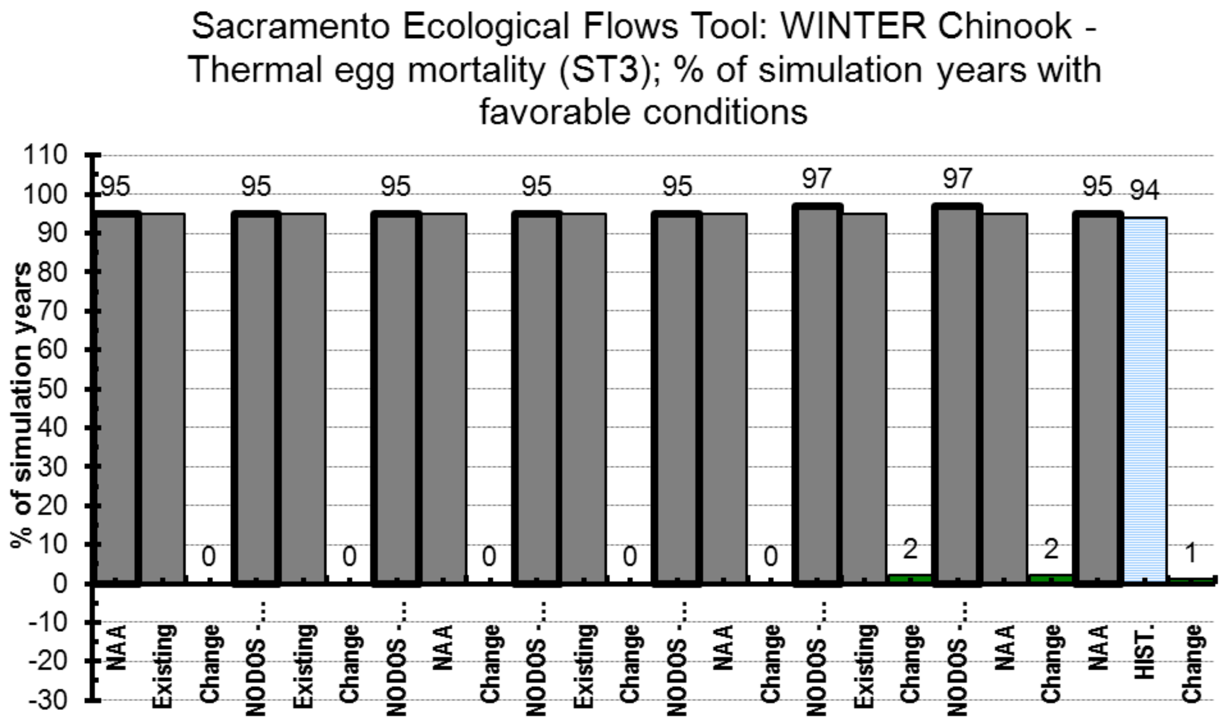

Sacramento Ecological Flows Tool: SPRING Chinook - Juvenile Stranding (ST4); % of simulation years with favorable conditions
% of simulation years
40
30
20
10
0
-10
-20
-30
5
-1
8
2
8
3
8
2
8
3
8
2
8
3
5
34
-29
NAA
Existing
Change
NODOS - Alt A
Existing
Change
NODOS - Alt A
NAA
Change
NODOS - Alt B
Existing
Change
NODOS - Alt B
NAA
Change
NODOS - Alt C
Existing
Change
NODOS - Alt C
NAA
Change
NAA
HIST.
Change


Sacramento Ecological Flows Tool: SPRING Chinook - Rearing WUA (ST2); % of simulation years with favorable conditions
% of simulation years
40
30
20
10
0
-10
-20
-30
18
1
9
-8
9
-9
9
-8
9
-9
9
-8
9
-9
18
31
-13
NAA
Existing
Change
NODOS - Alt A
Existing
Change
NODOS - Alt A
NAA
Change
NODOS - Alt B
Existing
Change
NODOS - Alt B
NAA
Change
NODOS - Alt C
Existing
Change
NODOS - Alt C
NAA
Change
NAA
HIST.
Change

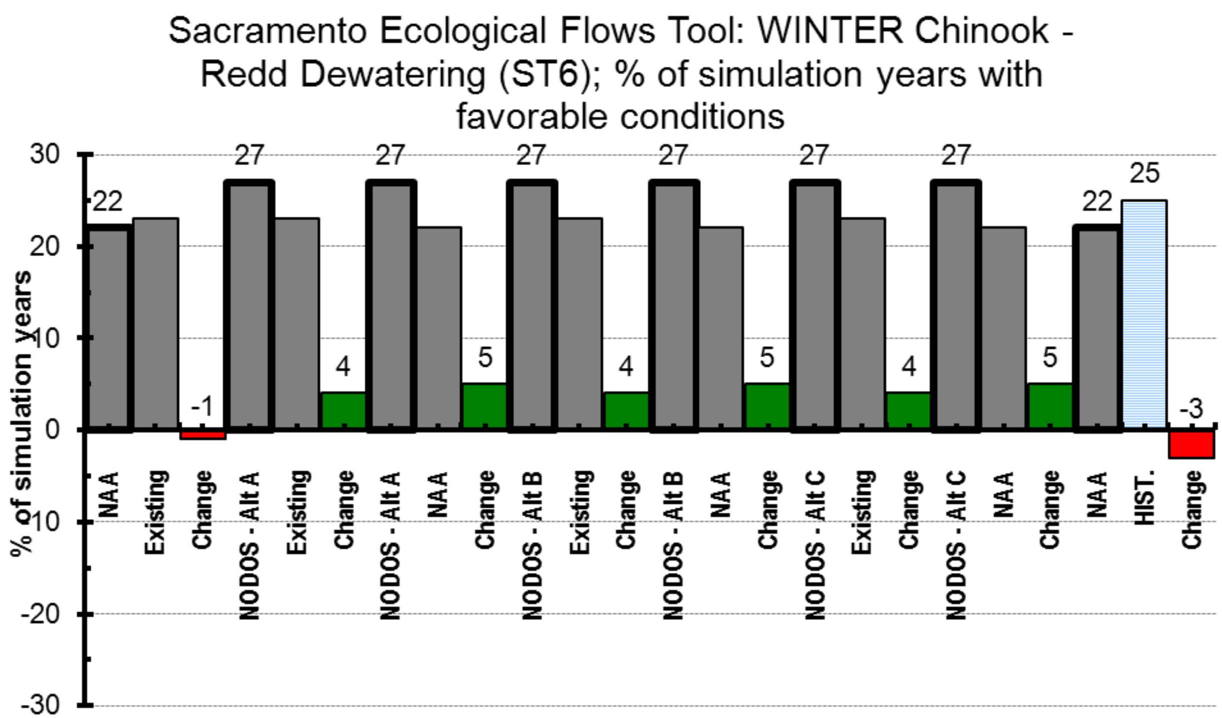
C.5 Winter Chinook

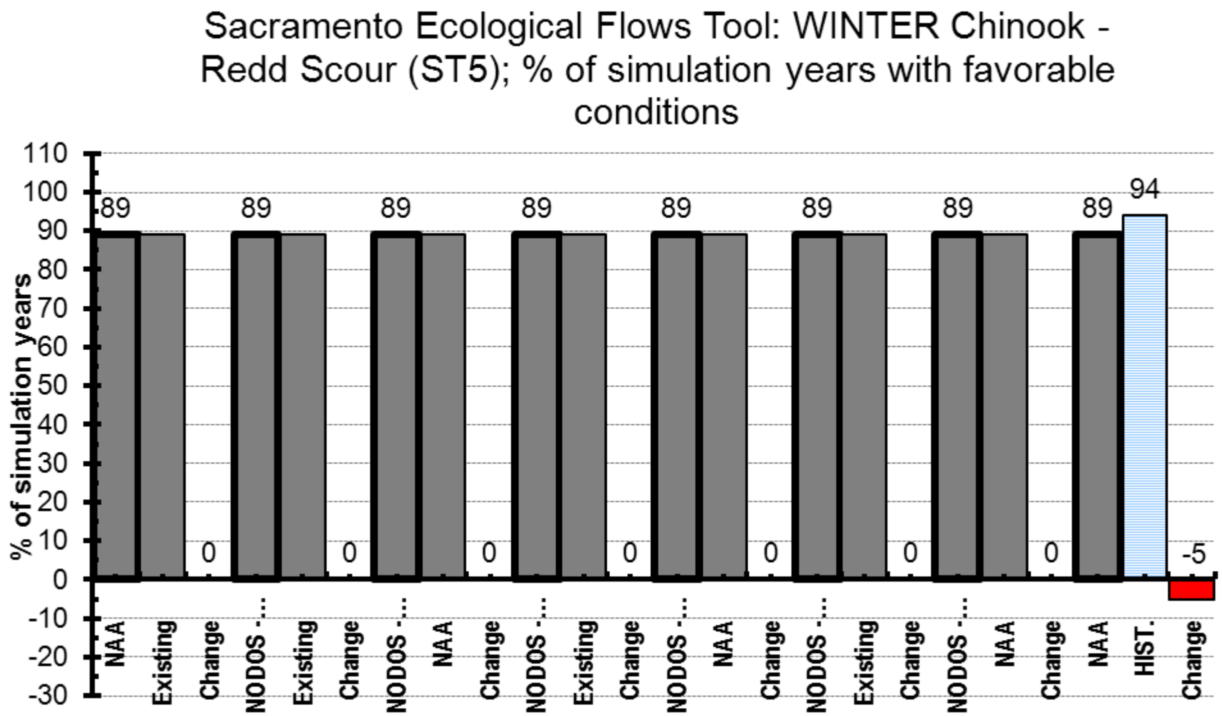
	WINTER CHINOOK																							
				Comparison 2			*Comparison 3*			*Comparison 4*			*Comparison 5*			*Comparison 6*			*Comparison 7*			*Comparison 8*		
ScenarioID	134	132		136	132		136	134		139	132		139	134		140	132		140	134		134	118	
Scenario Name	NAA	**Existing**	Change	NODOS - Alt A	**Existing**	Change	NODOS - Alt A	NAA	Change	NODOS - Alt B	**Existing**	Change	NODOS - Alt B	NAA	Change	NODOS - Alt C	**Existing**	Change	NODOS - Alt C	NAA	Change	NAA	**HIST.**	Change
	No Action Alternative	Existing conditions		NODOS - Alt A	Existing conditions		NODOS - Alt A	No Action Alternative		NODOS - Alt B	Existing conditions		NODOS - Alt B	No Action Alternative		NODOS - Alt C	Existing conditions		NODOS - Alt C	No Action Alternative		No Action Alternative	ACTUAL HISTORIC CONDITIONS	
Spawning WUA (CH1)	40	45	-5	55	45	10	55	40	15	54	45	9	54	40	14	55	45	10	55	40	15	40	52	-12
Thermal Egg Mortality (CH3)	95	95	0	95	95	0	95	95	0	95	95	0	95	95	0	97	95	2	97	95	2	95	94	1
Redd Dewatering (CH6)	22	23	-1	27	23	4	27	22	5	27	23	4	27	22	5	27	23	4	27	22	5	22	25	-3
Redd Scour (CH5)	89	89	0	89	89	0	89	89	0	89	89	0	89	89	0	89	89	0	89	89	0	89	94	-5
Juvenile Stranding (CH4)	38	34	4	37	34	3	37	38	-1	37	34	3	37	38	-1	42	34	8	42	38	4	38	31	7
Rearing WUA (CH2)	34	42	-8	38	42	-4	38	34	4	34	42	-8	34	34	0	37	42	-5	37	34	3	34	34	0

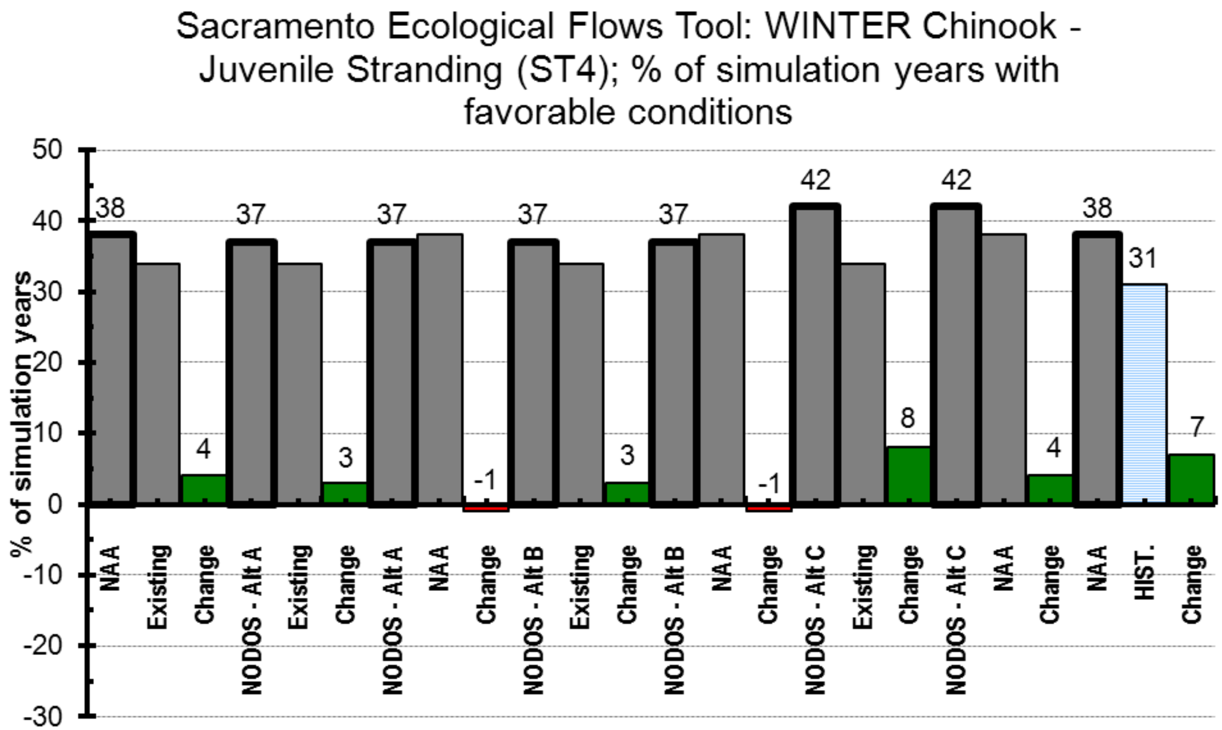

Sacramento Ecological Flows Tool: WINTER Chinook - Spawning WUA (ST1); % of simulation years with favorable conditions
% of simulation years
60
50
40
30
20
10
0
-10
-20
-30
40
55
55
54
54
55
55
52
40
-5
10
15
9
14
10
15
-12
NAA
Existing
Change
NODOS - Alt A
Existing
Change
NODOS - Alt A
NAA
Change
NODOS - Alt B
Existing
Change
NODOS - Alt B
NAA
Change
NODOS - Alt C
Existing
Change
NODOS - Alt C
NAA
Change
NAA
HIST.
Change

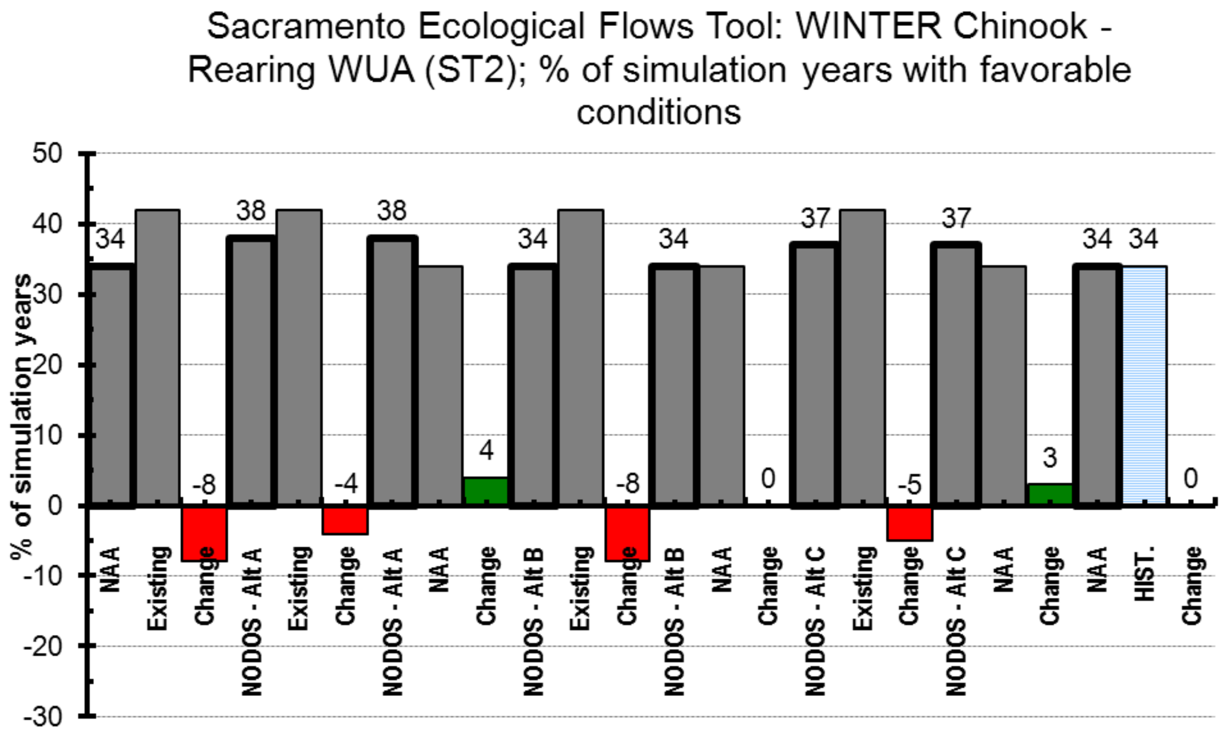


Sacramento Ecological Flows Tool: WINTER Chinook - Thermal egg mortality (ST3); % of simulation years with favorable conditions
% of simulation years
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
95
95
95
95
95
97
97
95
94
0
0
0
0
0
2
2
1
NAA
Existing
Change
NODOS - ...
Existing
Change
NODOS - ...
NAA
Change
NODOS - ...
Existing
Change
NODOS - ...
NAA
Change
NODOS - ...
Existing
Change
NODOS - ...
NAA
Change
NAA
HIST.
Change


Sacramento Ecological Flows Tool: WINTER Chinook - Redd Dewatering (ST6); % of simulation years with favorable conditions
% of simulation years
30
20
10
0
-10
-20
-30
22
-1
27
4
27
5
27
4
27
5
27
4
27
5
22
25
-3
NAA
Existing
Change
NODOS - Alt A
Existing
Change
NODOS - Alt A
NAA
Change
NODOS - Alt B
Existing
Change
NODOS - Alt B
NAA
Change
NODOS - Alt C
Existing
Change
NODOS - Alt C
NAA
Change
NAA
HIST.
Change


Sacramento Ecological Flows Tool: WINTER Chinook - Redd Scour (ST5); % of simulation years with favorable conditions
% of simulation years
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
89
89
89
89
89
89
89
89
94
0
0
0
0
0
0
0
-5
NAA
Existing
Change
NODOS -...
Existing
Change
NODOS -...
NAA
Change
NODOS -...
Existing
Change
NODOS -...
NAA
Change
NODOS -...
Existing
Change
NODOS -...
NAA
Change
NAA
HIST.
Change


Sacramento Ecological Flows Tool: WINTER Chinook - Juvenile Stranding (ST4); % of simulation years with favorable conditions
% of simulation years
50
40
30
20
10
0
-10
-20
-30
38
37
37
37
37
42
42
38
31
4
3
-1
3
-1
8
4
7
NAA
Existing
Change
NODOS - Alt A
Existing
Change
NODOS - Alt A
NAA
Change
NODOS - Alt B
Existing
Change
NODOS - Alt B
NAA
Change
NODOS - Alt C
Existing
Change
NODOS - Alt C
NAA
Change
NAA
HIST.
Change


Sacramento Ecological Flows Tool: WINTER Chinook - Rearing WUA (ST2); % of simulation years with favorable conditions
% of simulation years
50
40
30
20
10
0
-10
-20
-30
34
38
38
34
34
37
37
34 34
-8
-4
4
-8
0
-5
3
0
NAA
Existing
Change
NODOS - Alt A
Existing
Change
NODOS - Alt A
NAA
Change
NODOS - Alt B
Existing
Change
NODOS - Alt B
NAA
Change
NODOS - Alt C
Existing
Change
NODOS - Alt C
NAA
Change
NAA
HIST.
Change

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