APPENDIX M

Bacteria and Nutrient Modeling Report

Buena Vista Lagoon Enhancement Project

Bacteria and Nutrient Modeling

Final Report

Prepared for:

SANDAG

Prepared by:

Everest International Consultants, Inc.

In association with:

Dr. Martha Sutula, SCCWRP

Under contract to:

AECOM

April 2015

EVEREST

BUENA VISTA LAGOON ENHANCEMENT PROJECT

BACTERIA AND NUTRIENT MODELING

Final Report

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LIST OF ACRONYMS AND ABBREVIATIONS

#	number
µg	microgram
^{0}C	degree Celsius
3-D	three-dimensional
Alt	Alternative
BOD	biochemical oxygen demand
BVLEP	Buena Vista Lagoon Enhancement Project
Caltrans	California State Department of Transportation
CBOD	carbonaceous biochemical oxygen demand
CDFW	California Department of Fish and Wildlife
cfs	cubic feet per second
CFU	colony forming unit
CH	Coast Highway
Chl-a	chlorophyll a
CHU	Carlsbad Hydrologic Unit
CIMIS	California Irrigation Management Information System
COLD	Cold freshwater habitat
CORDC	Coastal Observing Research and Development Center
CVDT	Carlsbad Village Double Tracking
DO	dissolved oxygen
dw	dry weight
EFDC	Environmental Fluid Dynamic Code
EMC	event mean concentration
EPA	Environmental Protection Agency
et al.	and others
EUTRO	Eutrophication Program Module of WASP Program
FIB	fecal indicator bacteria

ft	foot; feet
FW	Freshwater
g	gram
HOV	high occupancy vehicle
Hwy	Highway
I-5	Interstate 5
L	liter
L^{-1}	per liter
m^2	square meter
m^3	cubic meter
m^{-3}	per cubic meter
MAR	marine habitat
Max	maximum
mg	milligram
MHHW	mean higher high water
MHW	mean high water
Min	minimum
mL	milliliter
MLLW	mean lower low water
MLW	mean low water
MPN	most probable number
MSL	mean sea level
N	nitrogen
NA	not available
NAVD	North American Vertical Datum
NCTD	North County Transit District
NFWF	National Fish and Wildlife Foundation
NGVD	National Geodetic Vertical Datum
NNE	nutrient numeric endpoint
NOAA	National Oceanic and Atmospheric Administration

NTDE	National Tidal Datum Epoch
O_2	oxygen
P	phosphorus
PSU	practical salinity unit
RR	Railroad
SANDAG	San Diego Association of Governments
SCCOOS	Southern California Coastal Ocean Observing System
SCCWRP	Southern California Coastal Water Research Project
SDRWQCB	San Diego Regional Water Quality Control Board
SIO	Scripps Institution of Oceanography
SOD	sediment oxygen demand
SRP	soluble reactive phosphorus
SW	Saltwater
SWRCB	State Water Resources Control Board
TDN	total dissolved nitrogen
TDP	total dissolved phosphorus
TMDL	total maximum daily load
TN	total nitrogen
TP	total phosphorus
USEPA	United States Environmental Protection Agency
WARM	warm freshwater habitat
WASP	Water Quality Analysis Simulation Program
WQO	Water Quality Objectives

1. INTRODUCTION

1.1 BACKGROUND

The Buena Vista Lagoon (Lagoon) is located on the border between the cities of Carlsbad and Oceanside in San Diego County, California. The Lagoon covers an area over 200 acres. Although the majority of the Lagoon is owned and managed by the California Department of Fish and Wildlife (CDFW), other public agencies and private parties own portions of the Lagoon. The portion of the Lagoon owned and managed by CDFW is designated a State Ecological Reserve.

Historically (e.g., pre-1940s), the Lagoon was in a dynamic equilibrium between a tidal-influenced Saltwater system during dry conditions and a river-influenced freshwater system during wet weather. Over time the Lagoon was converted to a fully freshwater system as a result of highway, roadway, and railroad construction as well as installation of a weir at the ocean outlet. The Lagoon has been progressively degrading in terms of benefits and value to biological communities, habitats, and human uses. Without restoration, it will most likely become a vegetated freshwater marsh or riparian woodland-meadow in the future. This degradation would reduce or eliminate wetland functions and values as well as result in increased vector concerns, water quality impairments, and aesthetic impacts.

The San Diego Association of Governments (SANDAG) is leading an effort to enhance the Lagoon. Several other federal, state, and local governmental agencies as well as several non-governmental organizations are working with SANDAG to develop and implement an enhancement project for the Lagoon. As envisioned, the Buena Vista Lagoon Enhancement Project (BVLEP) would restore over 200 acres of wetland habitat. Infrastructure modifications that may be considered for this project include changes to Coast Highway and the creation of a tidal inlet. Infrastructure improvements to existing Lagoon crossings that are currently being planned or designed under other projects would be considered in the analyses of the BVLEP. These improvements include the Interstate 5 (I-5) Bridge and the North County Transit District (NCTD) Railroad Bridge.

The California Department of Transportation (Caltrans) is currently working on the development of a project to improve I-5 throughout northern San Diego County. Caltrans is currently proposing to construct one additional HOV lane in each direction from Genesee Avenue to Del Mar Heights Road on I-5. In addition, Caltrans is proposing to add two HOV/managed lanes in each direction from Del Mar Heights Road to Vandergrift Boulevard and one general purpose lane in each direction from Del Mar Heights Road to State Route 78. Implementation of this project will entail construction work across and within the coastal salt marsh lagoons located throughout northern San Diego County, including the Lagoon. At this time, the type of work anticipated includes roadway and embankment widening as well as demolition of the existing I-5 Bridge and subsequent construction of a new I-5 Bridge.

NCTD is currently undertaking a railroad improvement project in northern San Diego County in the cities of Carlsbad and Oceanside. The project, which is known as the Carlsbad Village Double Tracking (CVDT) Project, will consist of adding one mile of new railroad track, straightening the existing curve of the track, and replacing the existing single track railroad bridge that crosses the Lagoon with a double track railroad bridge. On behalf of NCTD, SANDAG is leading the program management, environmental review, and engineering design of the CVDT Project.

To support the EIR for the BVLEP, Everest (2014a) conducted a water quality analysis for the proposed alternatives. In the analysis, change in residence time was used as a surrogate to compare the changes in water quality in the Buena Vista Lagoon basins with and without the proposed alternatives. For the same given pollutant source, a reduction in residence time would indicate improved water quality. In 2014, SANDAG accepted funding from the National Fish and Wildlife Foundation (NFWF) to conduct a more detailed evaluation of potential improvement of the water quality of the Buena Vista Lagoon with the BVLEP; specifically the potential reduction in bacteria and nutrient levels in the Lagoon basins with the proposed enhancement alternatives. Hence, SANDAG has retained Everest to develop a linked hydrodynamic model (EFDC) and water quality model (WASP) for the Buena Vista Lagoon, and to use the linked model for the evaluation of potential change in bacteria and nutrient levels in the Lagoon basins with the proposed enhancement alternatives. In this report, the development and validation of the linked EFDC-WASP model, the use of the linked model for simulating the changes in bacteria, nutrient and biomass, as well as the use of the model results for the evaluation of the proposed alternatives are provided.

For this study, Dr. Martha Sutula of the Southern California Coastal Water Research Project (SCCWRP) provided existing Lagoon data that was collected as part of a water quality monitoring and TMDL development process and this data was used for validation of the linked model. In addition, Dr. Sutula provided technical input and oversight in development and validation of the model, as well as interpretation of the water quality model results with respect to water quality objectives described in the San Diego Regional Water Quality Control Board (SDRWQCB) Basin Plan.

1.2 PURPOSE AND OBJECTIVES

The purpose of the bacteria and nutrient modeling summarized in this report is to assess the potential changes in bacteria, nutrient and biomass in each of the Buena Vista Lagoon basins associated with the proposed enhancement alternatives.

The following objectives are established to fulfill the purpose.

1. Develop a linked hydrodynamic and water quality model for the Buena Vista Lagoon.

2. Apply the linked model to provide quantitative estimates of bacteria and nutrient levels under existing and proposed conditions for the purpose of identifying project-induced changes.

3. Conduct an evaluation of the proposed alternatives with respect to water quality.

Since the primary purpose of this analysis is to compare the relative changes in bacteria and nutrient levels in the Lagoon under different proposed alternatives, the model developed for this analysis is not vigorously calibrated or validated with field data. The model is suitable for comparative purpose but not for regulatory compliance (e.g., TMDL compliance). Additional data and further calibration would likely be needed if the model is to be used for regulatory compliance.

1.3 EXISTING CONDITIONS

Under existing conditions, Buena Vista Lagoon is a freshwater lagoon. As shown in Figure 1.1, the Lagoon is bisected in three locations; by Interstate 5 (I-5), Carlsbad Boulevard (Coast Highway 101 in the City of Oceanside), and the NCTD Railroad Bridge. These crossings create four basins; the I-5 Basin, the Coast Highway (CH) Basin, the Railroad (RR) Basin, and the Weir Basin. Increased urbanization in the watershed led to increased amounts of nutrients, fecal indicator bacteria (FIB) and other contaminants to the Lagoon. Increased nutrient loads are known to fuel the productivity of algal communities in the Lagoon, in a process known as eutrophication. Eutrophication is defined as the increase in the rate of supply and/or in situ production of organic matter (from algae and aquatic plants) in a waterbody. While algae are important in estuarine nutrient cycling and food web dynamics (Fong 2008), their excessive abundance can reduce the habitat quality of a system. Increased primary production can lead to depletion of oxygen (O_2) from the water column causing hypoxia (low O_2) or anoxia (no O_2), Valiela et al. (1992) and reduced abundance and diversity of benthic invertebrates, leading to trophic level effects on birds and fish and disruption of biogeochemical cycling (Sfriso et al. 1987; Valiela et al. 1992, 1997; Raffaelli et al. 1989; Bolam et al. 2000). Excessive algal blooms are also unsightly and, during bloom die-off, can produce noxious odors.

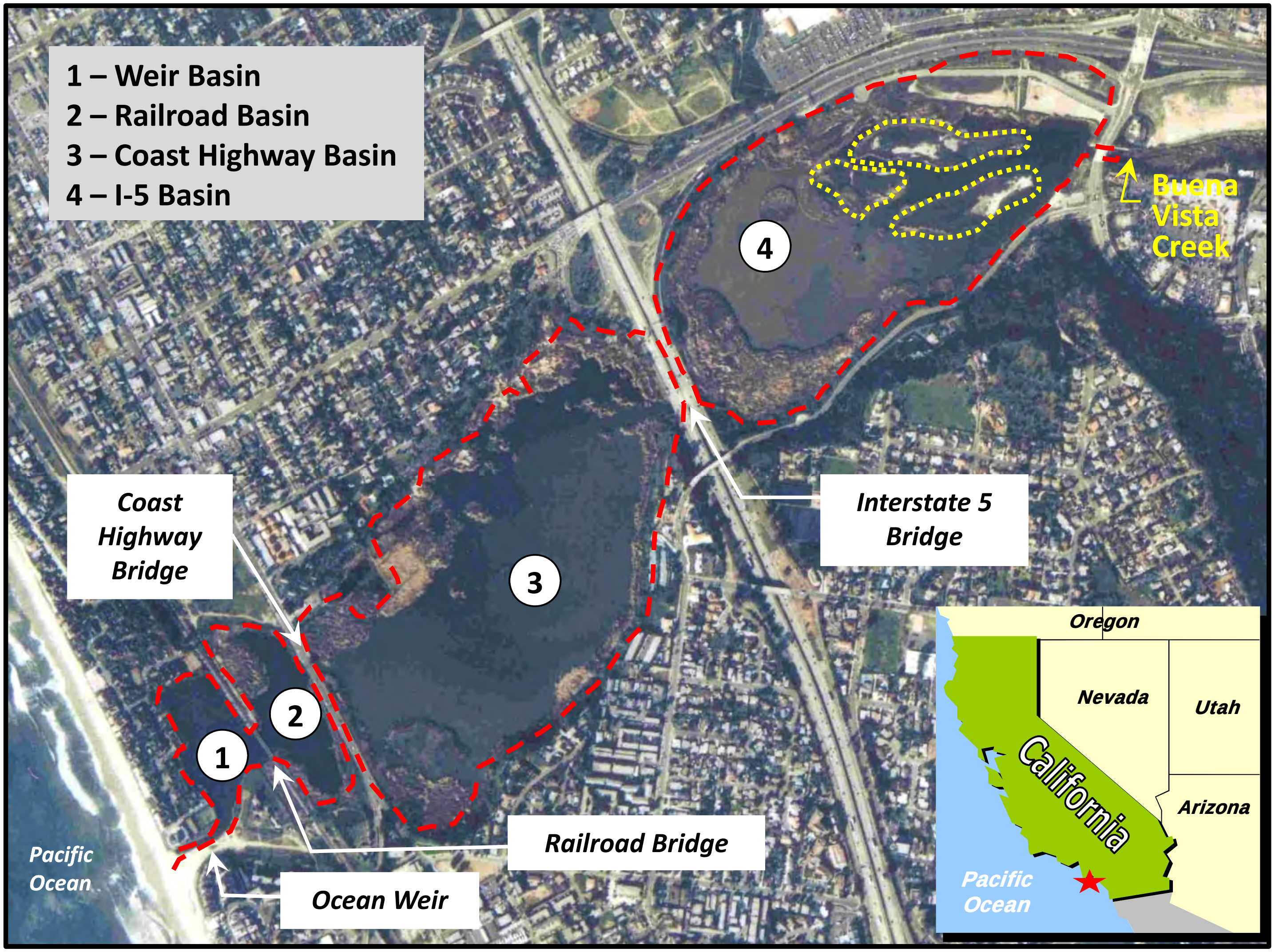


Figure 1.1 Buena Vista Lagoon

As a result of increased sedimentation, algal blooms and FIB loading to the Lagoon, the Buena Vista Lagoon was placed on the State Water Resources Control Board's (SWRCB) 303(d) list of impaired waterbodies. The 2010 303(d) listing for the Lagoon includes impairments for nutrients, indicator bacteria, and sedimentation/siltation (USEPA 2011). The original 303(d) listing for nutrients, bacteria, and sediment was largely observational and qualitative. Treated sewage discharged directly into the Lagoon until 1967 was a historical nutrient source. Periodic algae blooms were observed to cause localized fish kills and nutrient buildup in the sediments have promoted eutrophication in the Lagoon. The bacteria listing was based on occasional exceedances of water quality objectives from water quality sampling in the Lagoon. Sewage spills in 1991-1995 contributed to elevated bacteria levels, and storm water runoff may also contribute to the occasional exceedance of bacteria objectives. For sediment, the Lagoon receives runoff from agricultural land erosion, construction, and channel erosion. The weir structure reduces sediment transport through the Lagoon and out the Pacific Ocean, and results in retention of sediment within the Lagoon. Urbanization of the watershed that has increased runoff during storm events and encroachment upon the floodplain that eliminated most of the riparian and marsh land buffer are considered primary factors in sedimentation of the Lagoon, particularly in the late 70's and early 80's (SWRCB 2002).

2. ALTERNATIVES UNDER REVIEW

2.1 OVERVIEW

The enhancement alternatives were developed from past efforts in response to the need to improve and enhance the biologic and hydrologic functions of the Lagoon. Each of the alternatives evaluated within this document seeks to enhance existing lagoon functions and services through dredging and grading as well as control of freshwater and saltwater inputs and outputs. The range of alternatives developed reflects differing water regimes as well as resulting habitat distribution. Appropriate infrastructure improvements are also included in the enhancement alternatives, as necessary. A brief description of each alternative is provided below. More detail descriptions of the alternatives can be found in Everest (2014b).

2.2 FRESHWATER ALTERNATIVE

Under the Freshwater Alternative, the hydrologic regime of the Lagoon would remain a freshwater system influenced primarily by freshwater entering the Lagoon from the upstream watershed in the eastern portion of the system and along the boundary of the Lagoon. Prominent features of this alternative include: removal of existing exotic vegetation for the creation of open freshwater habitat in the Lagoon basins, as well as the replacement of the existing 50-ft wide weir with an 80-ft wide weir at the ocean outlet. A plan view of the Freshwater Alternative is shown in Figure 2.1.

2.3 SALTWATER ALTERNATIVE

Under the Saltwater Alternative, the hydrologic regime of the Lagoon would be changed from the existing freshwater system to a saltwater system influenced primarily by salt water entering the Lagoon from an open tidal inlet during flood tides, as well as freshwater entering the Lagoon from upstream and along the boundary of the Lagoon. Prominent features of this alternative include: removal of existing exotic vegetation for the creation of open saltwater habitat in the Lagoon basins, as well as the replacement of the existing 50-ft wide weir with a tidal inlet to provide continuous tidal exchange between the Lagoon and ocean. A plan view of the Saltwater Alternative is shown in Figure 2.2.

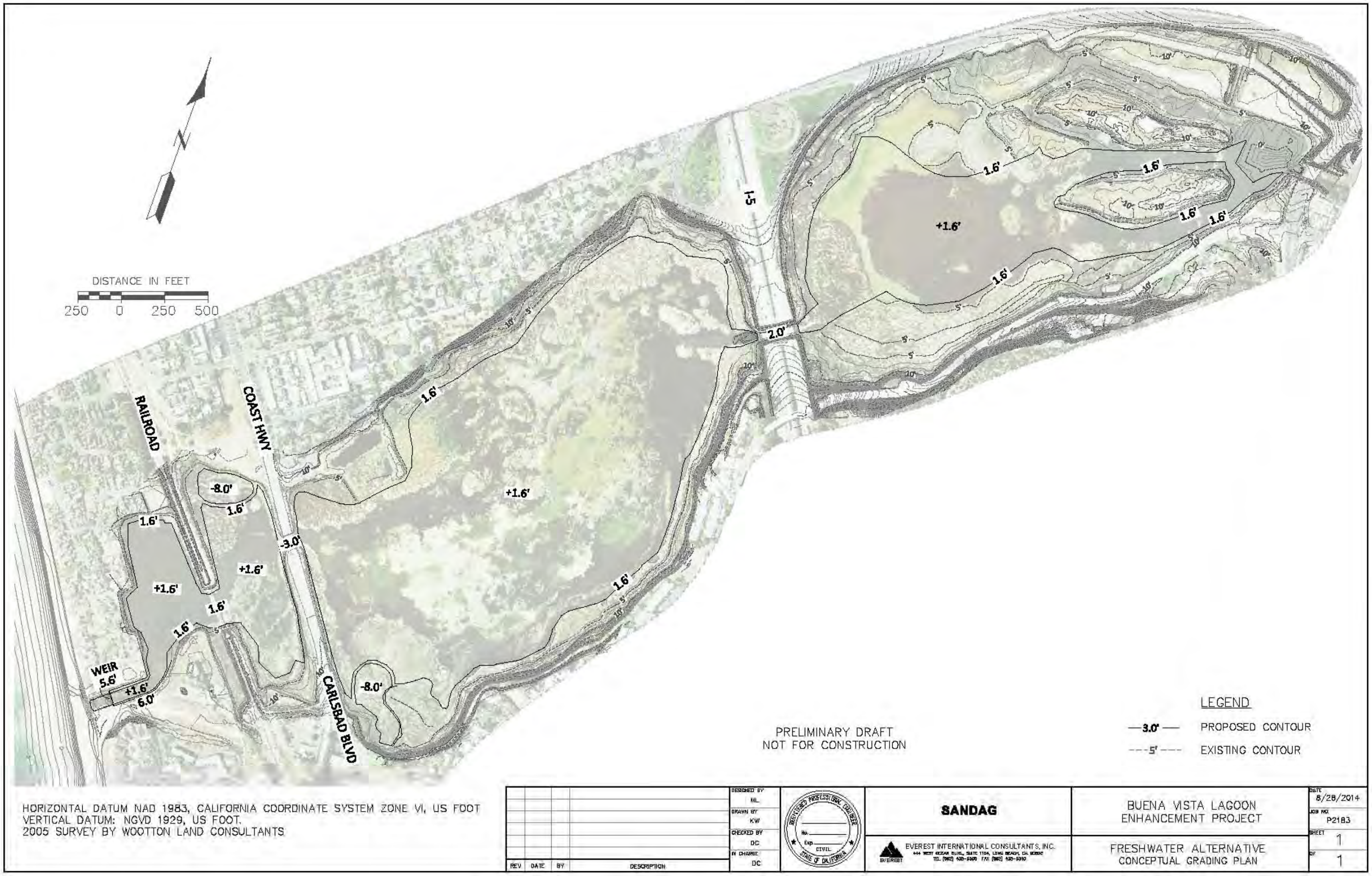


Figure 2.1 Freshwater Alternative Plan View

Figure 2.2 Saltwater Alternative Plan View

2.4 HYBRID ALTERNATIVE

Under the Hybrid Alternative, the hydrologic regime of the Lagoon would be changed from the existing freshwater system to a hybrid system influenced by both saltwater and freshwater, with a saltwater system created west of I-5 and a freshwater system maintained east of I-5. The hydrologic system west of I-5 would be influenced primarily by saltwater entering the system from an open tidal inlet during flood tides, as well as fresh water entering the Lagoon just downstream from I-5 and along the boundary of the Lagoon. Under the Hybrid Alternative, water would exit the Lagoon primarily during ebb tides. The hydrologic system east of I-5 would be controlled primarily by freshwater entering the system from upstream and along the boundary of the Lagoon, and outputs via overflow at the weir to be located under the I-5 Bridge.

For the Buena Vista Lagoon Enhancement Project, two design options under the Hybrid Alternative (Options A and B) differentiated by work within the Weir Basin were considered. Under Hybrid Alternative Option A, a channel would be constructed to connect the tidal inlet from the ocean area through the Weir Basin and into the Railroad Basin. Hybrid Alternative Option B would achieve tidal exchange in the same manner as the Saltwater Alternative with an open tidal inlet connecting the ocean to the Weir Basin. For this analysis, only Option B was evaluated as the Hybrid Alternative for comparison with the other Alternatives. Hybrid Option A with a proposed dike to create a perched brackish water basin within the Weir Basin is considered as a variation of the Hybrid Alternative and was not analyzed. It is expected that the water quality in the Lagoon basins between Option A and Option B will be similar except for the area behind the dike in the Weir Basin under Option A. A plan view of the Hybrid Alternative Option B is provided in Figure 2.3.

Figure 2.3 Hybrid Alternative Option B Plan View

3. Study Approach and Model Setup

3.1 Overview

A comprehensive study approach was developed to achieve the objectives identified in Chapter 1. The study approach involved the use of a linked hydrodynamic and water quality model for the evaluation of change in bacteria pollution and nutrient over-enrichment in the Buena Vista Lagoon (Lagoon) with and without the implementation of the proposed Lagoon enhancement alternatives. The Environmental Fluid Dynamic Code (EFDC) developed by the Environmental Protection Agency (EPA) was used to conduct the hydrodynamic modeling of the water surface elevation, flow, temperature, salinity, and bacteria concentrations. EFDC is a three-dimensional (3D) hydrodynamic and water quality model supported by EPA for TMDL development in river, lake, estuary, wetland, and coastal regions. EFDC is capable of simulating river inflows, control flow structures (e.g., weir), and wetting and drying of intertidal areas. The EFDC-simulated hydrodynamic conditions for the Lagoon were then linked to the WASP Model for the simulation of dissolved oxygen (DO), nutrients, and algal biomass in the Lagoon.

For this analysis, a one-year model simulation period between October 2007 and September 2008 was selected because of available data to define the flow, bacteria and nutrient loadings from upstream Buena Vista Creek to the Lagoon, as well as available data for water level, dissolved oxygen (DO), nutrient and biomass measurement for several dry and wet weather periods in the Lagoon that could be used for model validation. The 2007-2008 data are the latest and most comprehensive water quality data collected for the Lagoon. Details about the field data collection program are provided in Chapter 4.

Since the primary purpose of this analysis is to compare the relative changes in bacteria and nutrient pollution in the Lagoon under different proposed alternatives, the linked hydrodynamic and water quality model was not vigorously calibrated or validated with field data. It is beyond the scope of work for this study to develop a vigorously calibrated model for regulatory compliance (e.g. TMDL compliance). Additional data and further calibration would likely be needed if the model is to be used for regulatory purposes.

3.2 EFDC Model Setup

3.2.1 Model Grids

EFDC model grids for Existing Conditions and the proposed alternatives were previously developed for fluvial and tidal analyses (Everest, 2014b). Those model grids were developed for the evaluation of habitat distribution which needs the use of very fine resolution (i.e., small grid sizes) to capture the wetting and drying of the intertidal areas for the Saltwater and Hybrid Alternatives. The WASP model for water quality simulation does not allow any model grid cell to become dry; hence, the EFDC model grids developed for the earlier work were simplified to generate the EFDC/WASP model grid for this study. For water quality modeling (the simulation of bacteria, nutrient and biological response for this study), the most important process is the mixing of upstream flows and associated pollutant loadings with the flood and ebb tidal flows, there is no need to use very fine model grids if the simplified model grid still has sufficient resolution to capture the tidal exchange. In addition, the use of a simplified EFDC/WASP grid substantially reduces the simulation time, which makes it faster to conduct long-term simulations.

The simplified EFDC/WASP model grids has significantly less grid cells compared to the original EFDC model grids. In addition, each of the EFDC/WASP model grid cells has three water layers compared to five water layers that were used in the original EFDC grid. The EFDC/WASP grid and bathymetry for Existing Conditions is shown in Figure 3.1. The Lagoon bathymetry was based on a 2005 survey, which was the latest bathymetry data available for the Lagoon. In the Weir Basin, the Lagoon bottom is generally at 3 ft, NGVD (National Geodetic Vertical Datum of 1929), which corresponds to a water depth of 2.6 ft when water levels are at the weir elevation of +5.6 ft, NGVD. The Lagoon bottom ranges from 3 to 5 ft, NGVD in the Railroad and CH Basins, with corresponding water depths of 2.6 to 1.6 ft. In the I-5 Basin, the Lagoon bottom is at approximately 5 ft, NGVD, corresponding to a water depth of about 1.6 ft.

Under the Freshwater Alternative, the Lagoon would be deepened to 1.6 ft, NVGD, which corresponds to a water depth of 4 ft when water levels are at the weir elevation. The EFDC/WASP grid and bathymetry for the Freshwater Alternative is provided in Figure 3.2.

As mentioned earlier, the Saltwater Alternative contains both subtidal and intertidal areas that were incorporated into the previously developed EFDC grid. For this study, the EFDC grid was simplified to consist of only the subtidal portion of the Lagoon because for water quality modeling, all the model grid cells have to stay wet (a.k.a. with water) all the time. The EFDC grid for the previous study and the simplified EFDC/WASP grid for this study are shown in Figure 3.3. The top panel shows the detailed EFDC grid with subtidal and intertidal areas. The lower panel shows the simplified EFDC/WASP grid. The subtidal portion of the Lagoon would be continuously inundated, as illustrated by the blue shaded area. Under the Hybrid Alternative – Option B, tidal conditions occur in the Weir, Railroad, and CH Basins, while the I-5 Basin will stay as fresh water. The detailed and simplified grids for the Hybrid Alternative - Option B are shown in Figures 3.4.

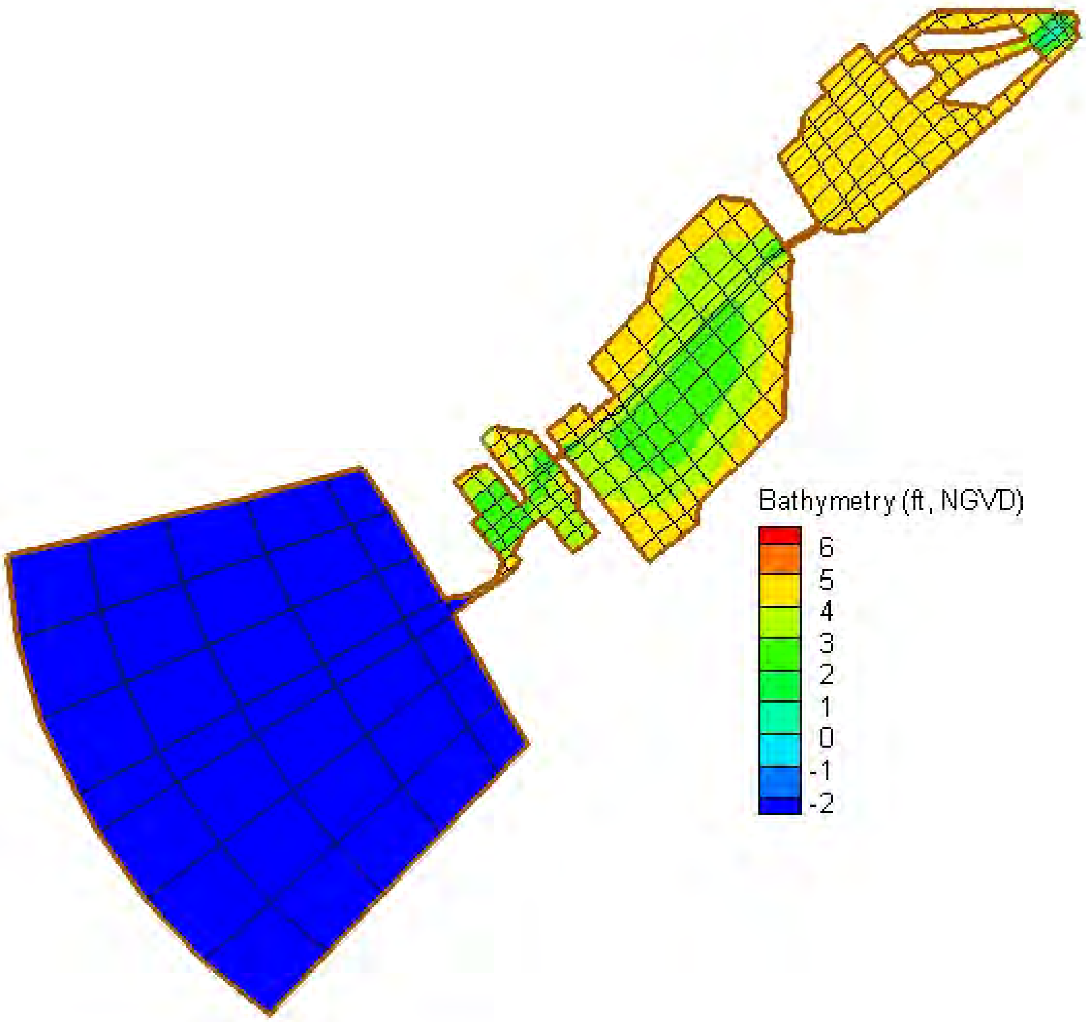


Figure 3.1 EFDC/WASP Model Grid and Bathymetry for Existing Conditions

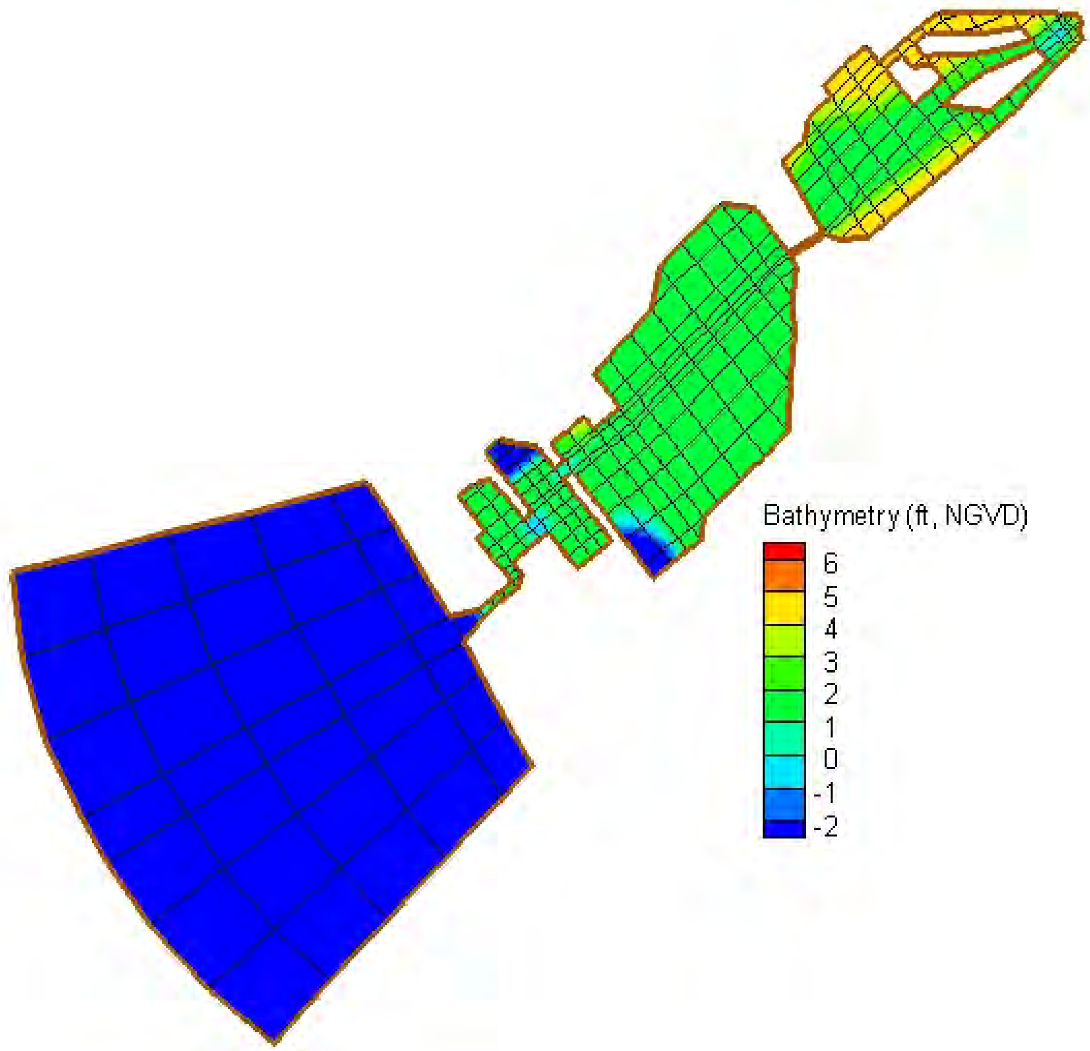
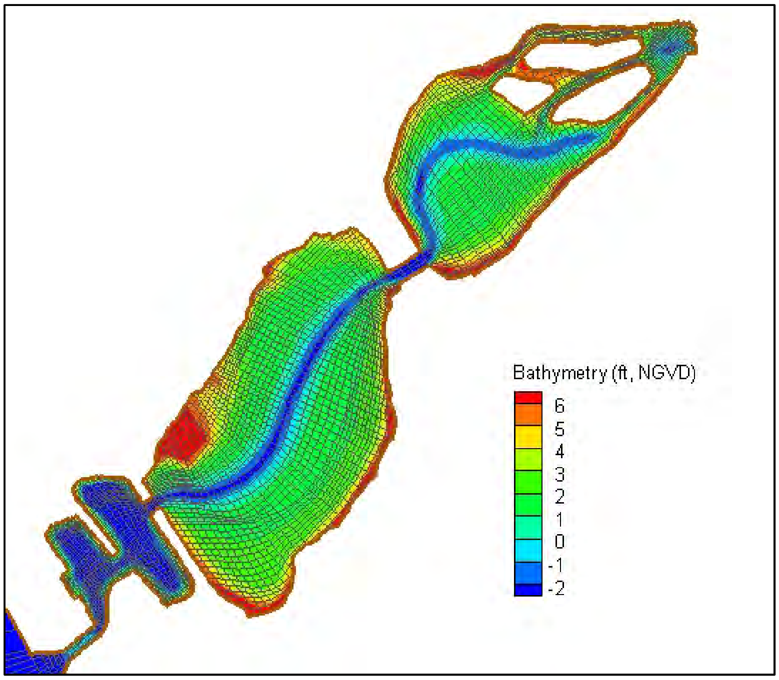
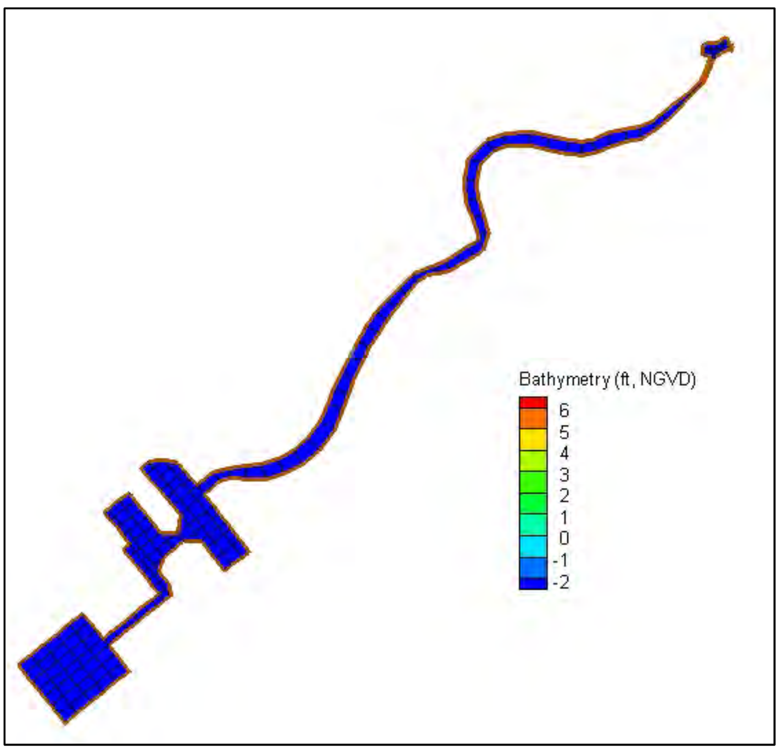


Figure 3.2 EFDC/WASP Model Grid and Bathymetry for Freshwater Alternative

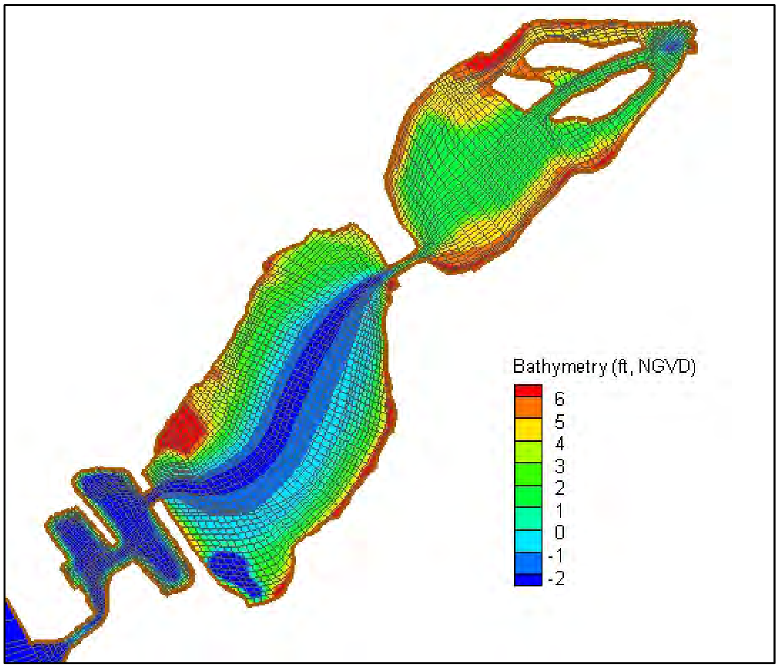


Detailed EFDC Grid with Subtidal and Intertidal Areas

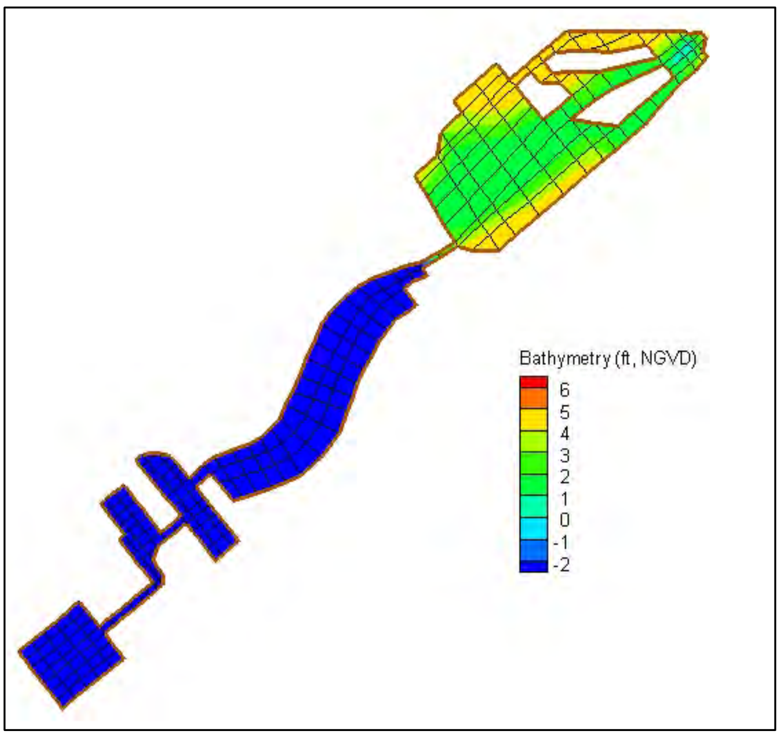


Simplified EFDC/WASP Grid with only Subtidal Areas

Figure 3.3 EFDC/WASP Model Grid and Bathymetry for Saltwater Alternative



Detailed EFDC Grid with Subtidal and Intertidal Areas



Simplified EFDC/WASP Grid with only Subtidal Areas

Figure 3.4 EFDC/WASP Model Grid and Bathymetry for Hybrid Alternative - Option B

The simplified EFDC/WASP grids for the Salt Water and Hybrid were developed in such a way that the tidal prism for the salt water basins are preserved; i.e. for each tidal cycle, the tidal flows going through the subtidal areas of the Lagoon represented by the simplified EFDC/WASP grid are approximately the same as the tidal flows going through both the intertidal and subtidal areas of the Lagoon represented by the detailed EFDC grid. Tidal flows (i.e., flow through the tidal inlet) through the Lagoon simulated based on the simplified EFDC/WASP model grid are compared with those simulated based on the detailed EFDC grid in Figure 3.5. In the figure, comparison of the tidal flows for the Saltwater Alternative is shown in the top panel, and similar comparison for the Hybrid Alternative – Option B is shown in the bottom panel. As illustrated in the figure, the simulated tidal flows using the simplified EFDC/WASP grids for both the Saltwater and Hybrid Alternatives are similar to the simulated tidal flows using the detailed EFDC grids; i.e. tidal prism for the salt water basins are preserved using the simplified grids. Since the use of the simplified EFDC/WASP model grids produce similar tidal flows as the use of the detailed EFDC grids, the simplified grids are suitable to be used for water quality modeling.

3.2.2 EFDC Hydrodynamic Model Boundary Conditions

Buena Vista Creek was monitored by MACTEC (2009) as part of a larger monitoring program to support the development of TMDLs in the Carlsbad Hydrologic Unit (CHU) by the San Diego Regional Water Quality Control Board (RWACB). Data collected from Buena Vista Creek included continuous measurements for flow, specific conductivity, and temperature (MACTEC 2009). The data collected between October 2007 and October 2008, as shown in Figure 3.6, were used to specify the upstream boundary conditions for Buena Vista Creek for the EFDC hydrodynamic model. In the figure, monitored flows are shown in the top panel, salinity in the middle panel, and water temperature in the lower panel. The salinity from Buena Vista Creek (shown in the middle panel) was derived from the measured specific conductivity and water temperature. As expected, as shown in Figure 3.7, there were higher flows during the winter months (from December 2007 through February 2008), resulting in corresponding lower salinity levels. There was also a small rain event on May 23-24 2008 during the summer months resulting in a small drop in the salinity levels during that period. Water temperatures also follow a seasonal trend with lower temperatures during the winter months and higher temperature in the summer months.

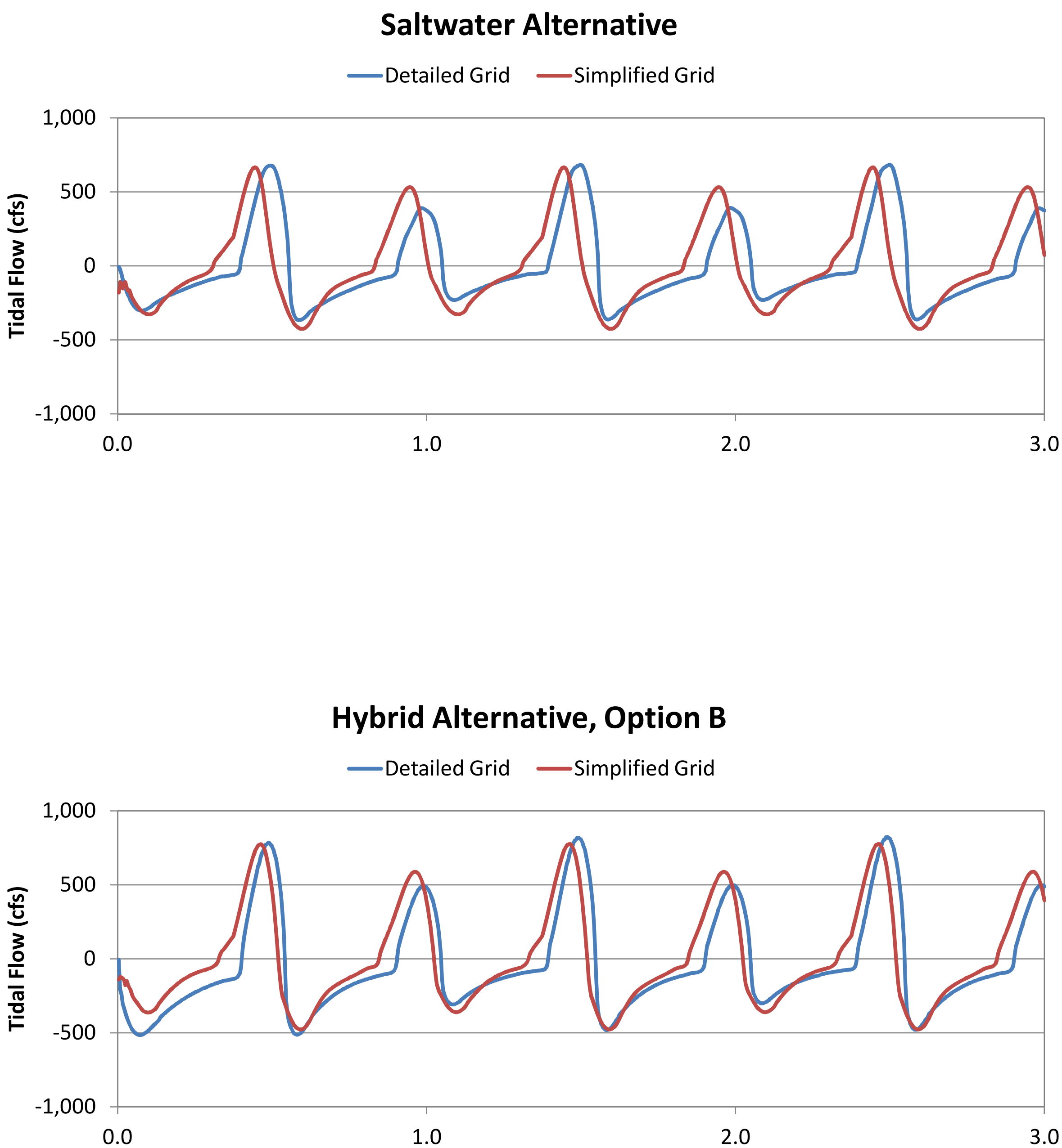


Figure 3.5 Tidal Flow Comparisons

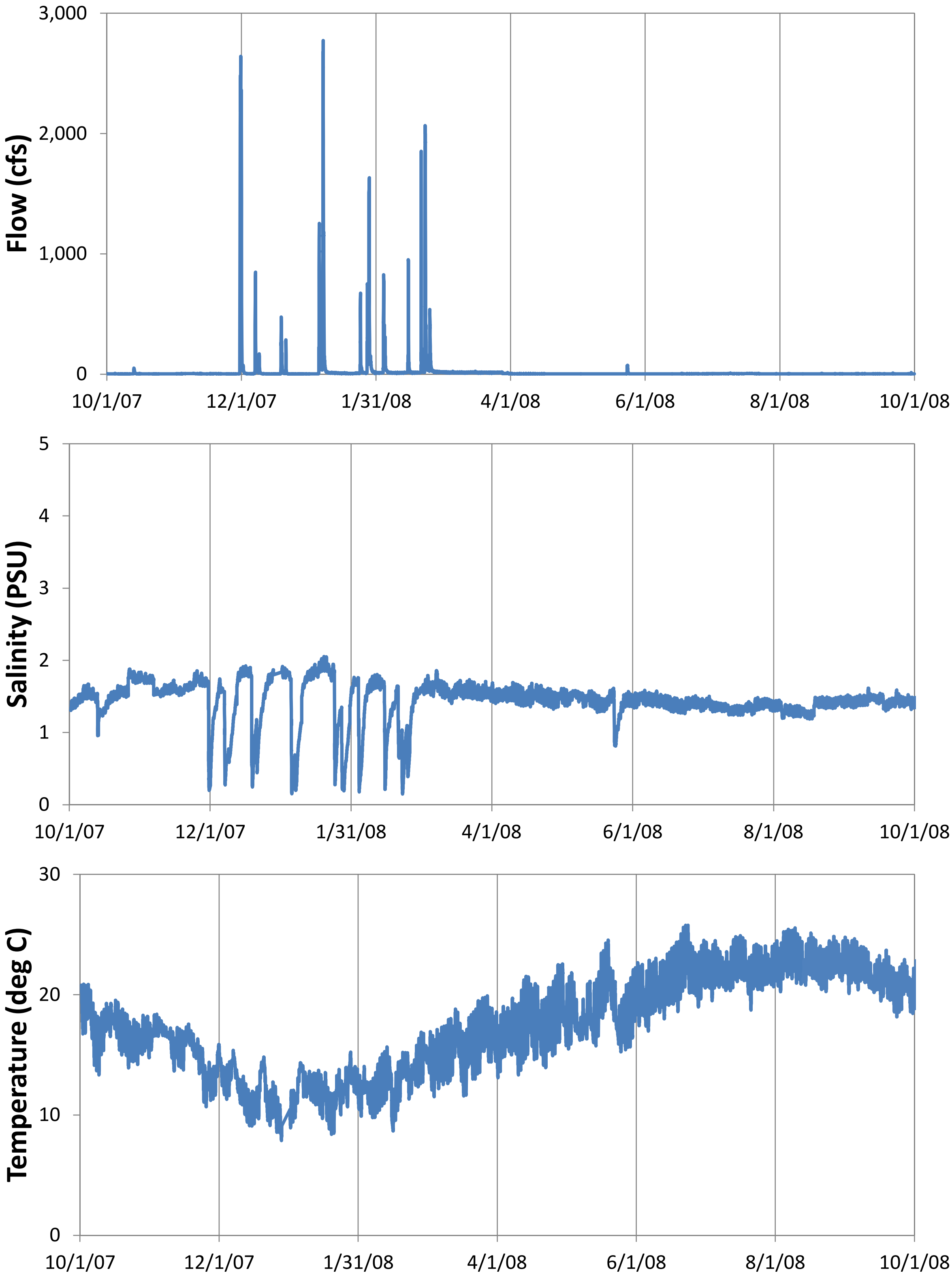


Figure 3.6 Buena Vista Creek Data

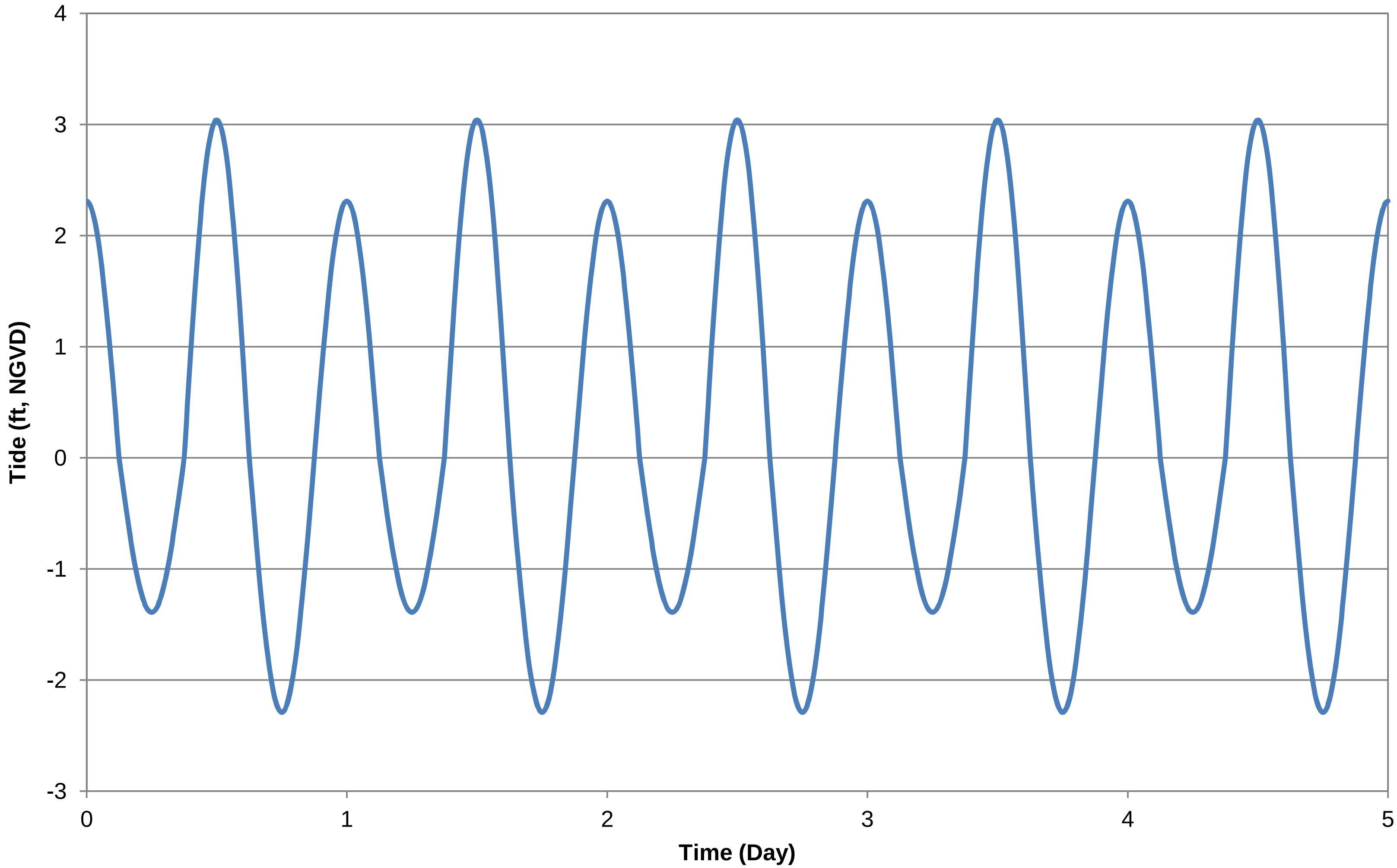


Figure 3.7 Mean Tide Applied at the Ocean Boundary of Model Grid

For the Saltwater and Hybrid Alternatives, ocean boundary conditions were specified based on monitored ocean conditions recorded at Scripps Pier (La Jolla), which adequately represents ocean conditions offshore of the Lagoon given the geographic proximity to the Lagoon. Tides off the coast of the Lagoon are mixed, semi-diurnal with two daily highs and lows. Tidal levels are monitored by the National Oceanic and Atmospheric Administration (NOAA) at Scripps Pier (Station 9410230). Tidal datums at this NOAA tide gage are provided in Table 3.1. These tidal datums represent long term average water levels for the latest National Tidal Datum Epoch (NTDE) from 1983 to 2001. For the EFDC hydrodynamic model, a mean tide representing average tidal conditions, as shown in Figure 3.7, was generated based on the Mean High Water (MHW), Mean Low Water (MLW0, Mean Higher High Water (MHHW), and Mean Lower Low Water (MLLW) datums, and applied at the ocean boundary of the model grids.

Table 3.1 NOAA Tidal Datums for Scripps Pier, La Jolla

TIDE	ELEVATION (FT, NGVD)
Highest Observed Water Level (11/13/97)	5.35
Mean Higher High Water (MHHW)	3.04
Mean High Water (MHW)	2.31
Mean Sea Level (MSL)	0.44
Mean Low Water (MLW)	-1.39
North American Vertical Datum – 1988 (NAVD88)	-2.11
Mean Lower Low Water (MLLW)	-2.29
Lowest Observed Water Level (12/17/33)	-5.16

Source: NOAA 2003

Ocean salinity and temperature boundary conditions were also specified from monitoring data at Scripps Pier. Continuous salinity and water temperature data were obtained from the Southern California Coastal Ocean Observing System (SCCOOS). The automated monitoring station is operated by the Coastal Observing Research and Development Center (CORDC) at Scripps Institution of Oceanography (SIO).

Weather boundary conditions were obtained from the California Irrigation Management Information System (CIMIS), which monitors weather conditions throughout California. Atmospheric and wind boundary conditions were specified based on data from the Torrey

Pines station. Atmospheric conditions included atmospheric pressure, air temperature, relative humidity, precipitation, evapotranspiration, solar radiation, and cloud cover. Wind conditions were specified based on hourly wind speed and direction.

3.2.3 Bacteria Modeling Boundary Conditions

The bacteria loadings at the upstream EFDC model boundary were specified based on data collected for Buena Vista Creek as part of the CHU Lagoon Monitoring Program (MACTEC 2009). As part of the monitoring program, water quality data from Buena Vista Creek were obtained during several wet and dry weather conditions. The dates and number of samples collected for each of the sampling events are summarized in Table 3.2. As shown in the table, two wet weather events in January 2008 were monitored. For the wet events, water quality samples were collected as flow-weighted composite samples, while bacteria samples were collected as grab samples. In the table, water quality and bacteria data were also shown for a third wet weather event that was collected for a different monitoring program conducted under the San Diego County Regional Monitoring Program.

Table 3.2 Buena Vista Creek Water Quality and Bacteria Sampling Summary

MONITORING EVENT	DATE IN 2008	WATER QUALITY SAMPLES	BACTERIA SAMPLES
Wet Event 1	1/5 – 1/7	8	6
Wet Event 2	1/23 – 1/24	9	6
Wet Event 3*	2/3	NA	NA
Index Period 1	1/14, 1/15, 1/16, 2/7, 2/8, 2/11	6	6
Index Period 2	3/31, 4/1, 4/7, 4/8, 4/9, 4/10	6	6
Index Period 3	7/14, 7/15, 7/16, 7/21, 7/22, 7/23	6	6
Index Period 4	9/15, 9/16, 9/17, 9/22, 9/23, 9/24	6	6

Source: MACTEC 2009
**Sampling conducted under San Diego County Regional Monitoring Program, Order No. 2007-01*
NA – Not Available

Dry weather water quality was monitored over four dry weather periods, referred to as index periods in the MACTEC (2009) report. For each index period, a single sample was obtained on six separate days resulting in six samples per index period. The timing of the index period sampling is illustrated in Figure 3.8. Sampling for Index Period 1 occurred between storm events in January and February. The remaining index period samplings occurred during extended dry weather conditions. For the dry weather sampling, each water quality sample was obtained as a time-weighted composite sample over a 30-min period, and the bacteria sample was collected as a grab sample.

Timing of the wet weather water quality and bacteria sampling for Buena Vista Creek is illustrated in Figure 3.9. For Wet Event 1, the creek monitoring was conducted over three days, as indicated by the pink shaded area. The first wet event included eight water samples, shown by the black circles, and six bacteria samples indicated by the black "x". Creek monitoring for Wet Event 2 occurred over a 16-hr storm event; nine water quality samples and six bacteria samples were collected. Details about the data collected for Wet Event 3 are not available; however, it was reported in the MACTEC (2009) report that for this event, sampling occurred over a portion of the storm event during which one composite sample was collected.

Fecal indicator bacteria (FIB) concentrations for the bacteria modeling were estimated using bacteria data collected from Buena Vista Creek. The bacteria concentrations based on the collected data for enterococcus, fecal coliform, and total coliform are summarized in Table 3.3. In the table, the median, minimum, and maximum bacteria concentration for each monitoring event (except Wet Event 3) are provided. Although each monitoring event (except Wet Event 3) consisted of six samples, results for individual samples were not reported, only the median, minimum, and maximum concentrations were available. For Wet Event 3 which was collected under a separate program, only the median concentrations were reported. In general, wet weather bacteria concentrations were one to two orders of magnitude higher than those for dry weather. The range in bacteria concentrations were also greater for the wet event as compared to the range observed for dry events.

Continuous time series of bacteria concentrations for the model simulation period between October 2007 and September 2008 were developed based on the median bacteria concentrations obtained from the seven creek monitoring events. For the monitored storm events, the median data were applied over the duration of the wet weather flow. Bacteria concentrations from Wet Event 3, which were the EMCs, were only used for the storm event on February 3. For unmonitored storms, the bacteria concentrations were specified from either Wet Event 1 or 2, depending on the peak flow. Unmonitored storms with larger peak flows were based on Wet Event 1, while smaller storms with peak flows up to 800 cfs were based on Wet Event 2. Bacteria concentrations during dry weather conditions were specified from the index periods. Index period 1 was used for dry weather bacteria concentrations from December 1, 2007 to March 30, 2008. Index period 2 was used from March 31 to June 30, 2008. The dry weather bacteria concentrations for July and August 2008 were based on Index Period 3, and Index Period 4 was used for the months of October 2007, November 2007, and September 2008.

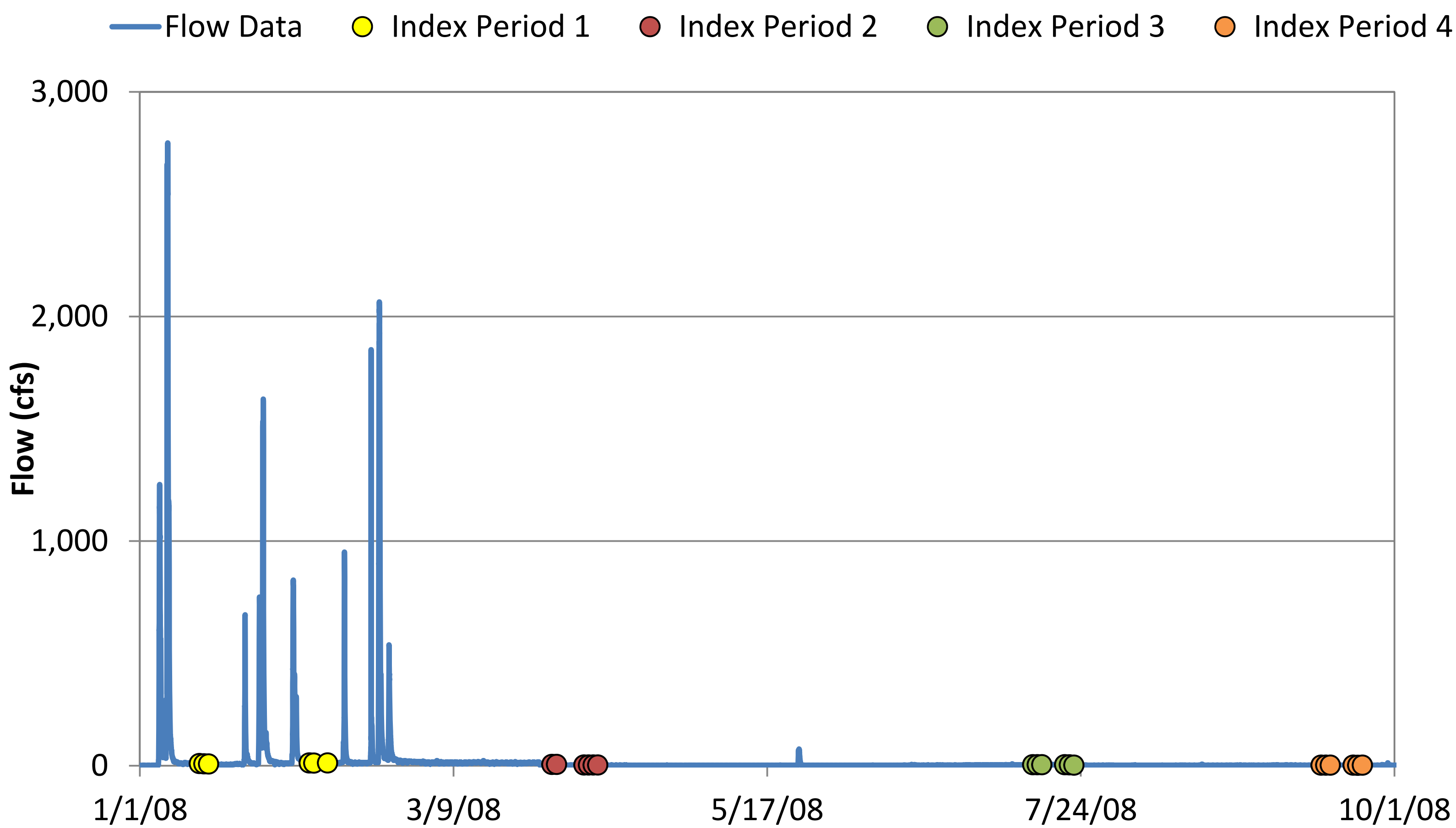


Figure 3.8 Index Period Sampling

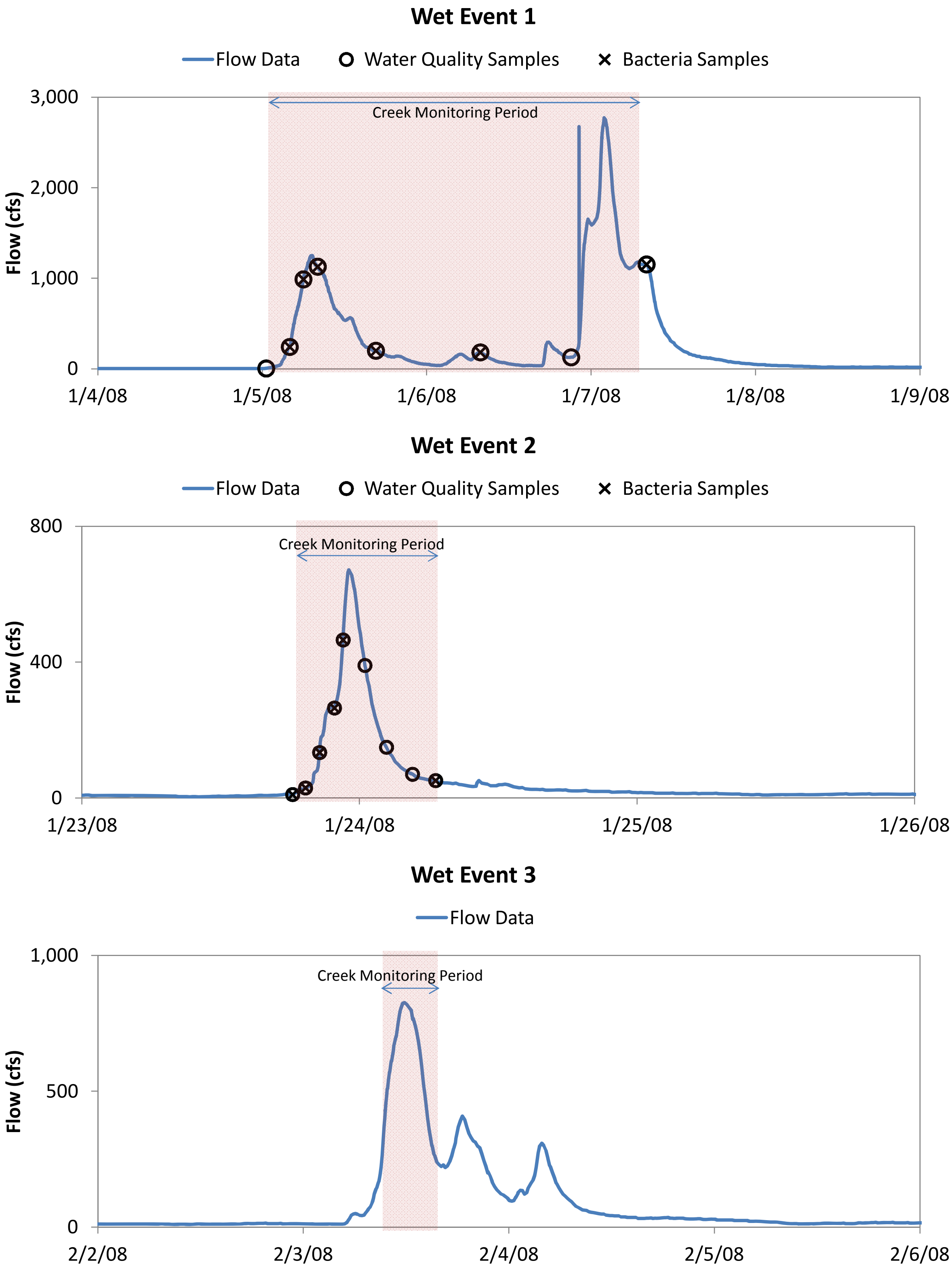


Figure 3.9 Timing of Buena Vista Creek Monitoring

Table 3.3 Buena Vista Creek Bacteria Data

Monitoring Event	Enterococcus (CFU/100 mL)			Fecal Coliform (MPN/100 mL)			Total Coliform (MPN/100 mL)		
	Median	Min	Max	Median	Min	Max	Median	Min	Max
Wet Event 1	13,750	6,800	38,000	6,500	3,000	14,000	60,000	9,000	160,000
Wet Event 2	12,000	240	17,000	8,000	200	90,000	17,500	2,400	90,000
Wet Event 3*	17,000**	NA	NA	5,000*	NA	NA	80,000*	NA	NA
Index Period 1	168	60	269	152	52	648	714	328	1,260
Index Period 2	58	22	102	101	56	370	450	370	650
Index Period 3	235	128	284	600	260	1,230	924	452	1,620
Index Period 4	152	92	288	465	140	610	940	580	1,120

Source: MACTEC 2009
**Sampling conducted under San Diego County Regional Monitoring Program, Order No. 2007-01*
***Bacteria data reported as Event Mean Concentrations (EMCs)*
NA – Not Available

The measured flows and corresponding bacteria concentrations used for modeling are shown in Figure 3.10. In the figure, the top panel show the measured flow (indicated by the blue line, with the scale on the left) and corresponding Enterococcus concentrations (indicated by the red line, with scale shown on the right). Similar plots for Fecal Coliform and Total Coliform are shown in the middle and bottom panels, respectively. Note that while the vertical scales for flows are the same in all three panels, the scales for bacteria concentrations shown in the right are different for each panel.

3.3 WASP MODEL SETUP

The USEPA Water Quality Analysis Simulation Program version 7 (WASP 7) was used to simulate water quality conditions within the Lagoon under existing and alternative conditions. WASP 7 is a Windows-based modeling tool that helps to interpret and predict water quality responses to natural phenomena and man-made pollution for various water quality management decisions. For this project, the EUTRO module of WASP 7 is used to simulate and compare nutrient levels of the Lagoon under existing and alternative enhancement conditions. The WASP 7 model grids for the existing and alternative enhancement conditions were imported from the EFDC hydrodynamics model grids, which also supplied the hydrodynamics results including flow rates, water depths and velocity time series that are dynamically coupled with salinity and temperature. As discussed in the previous sections, each of the model grids is a three-layered grid.

The simulation time period for BVLEP nutrient modeling was a complete year. Since WASP model simulations were based on data collected in 2008 and hydrodynamic data collected between October 2007 and September 2008, the selected simulation time period is from October 1, 2007 to September 30, 2008.

The following sections discuss the upstream and downstream boundary conditions, water quality parameters and constants, as well as benthic flux input for the WASP models. Validation of these parameters and input values were conducted to compare the simulated existing conditions with the field data (see Chapter 4). To maintain consistency for the purpose of comparison, the same set of validated values was then used in the simulation of existing conditions, as well as all the proposed alternatives under consideration for the BVLEP.

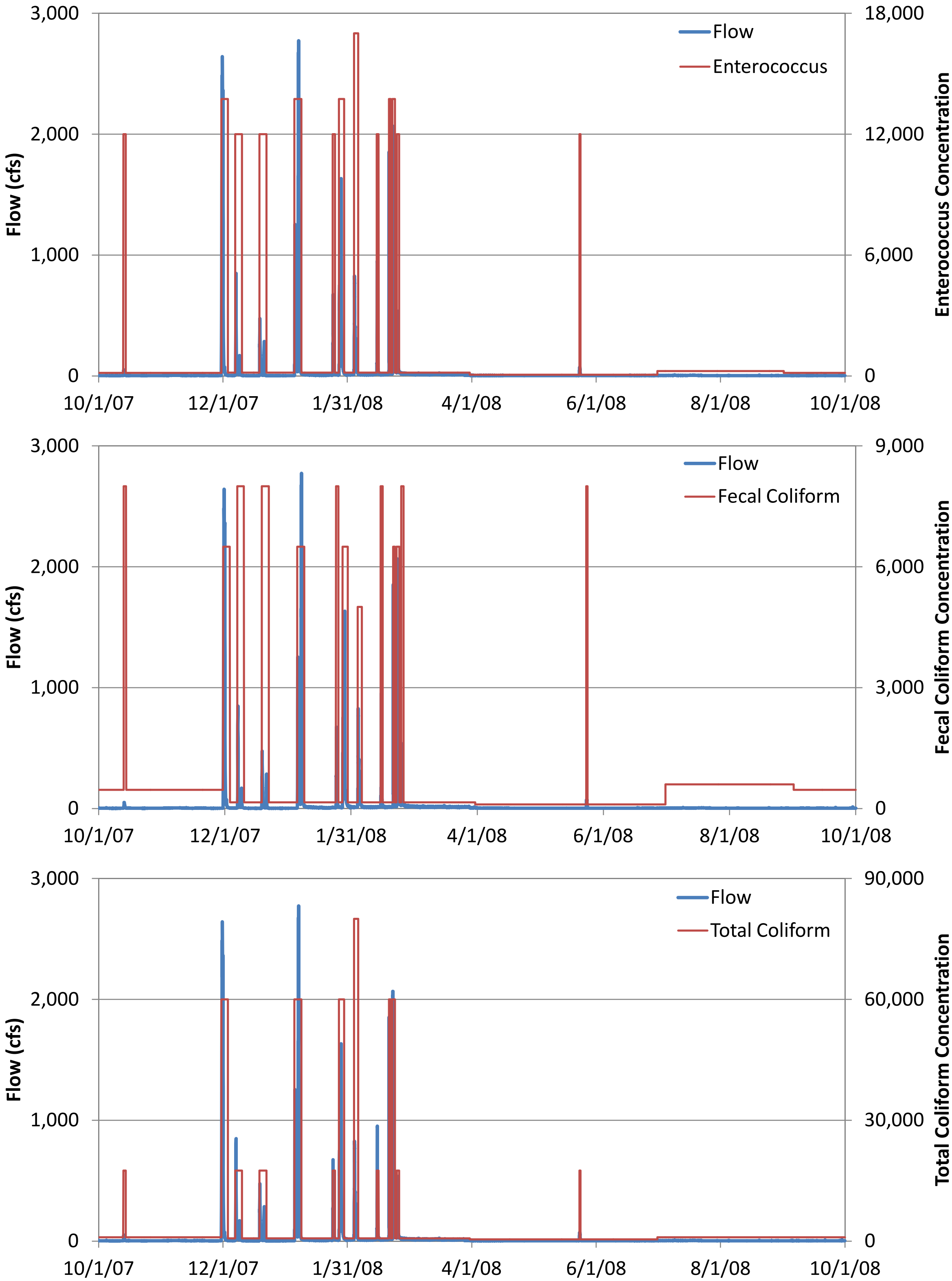


Figure 3.10 Measured Flow and Bacteria Concentrations for Buena Vista Creek

3.3.1 WASP Model Boundary Conditions

The upstream boundary conditions were based on field data for the Buena Vista Lagoon collected in the year 2008 by MACTEC at a mass emission monitoring station located in the Buena Vista Creek upstream of the Lagoon. These data provided values for the upstream boundary conditions. The downstream coastal boundary conditions were modeled using values taken from the Loma Alta Slough TMDL water quality modeling using the WASP model (Sutula et al. 2013). Since Loma Alta Slough is located in close proximity to the Buena Vista Lagoon (approximately one mile north of the Lagoon), the coastal conditions at the Buena Vista Lagoon is expected to be similar to that of the Loma Alta Slough. For the purpose of comparison, the same set of boundary conditions was applied to the Existing Conditions and all alternative enhancement conditions.

3.3.2 WASP Model Parameters and Constants

A set of input parameters were based largely on literature values and previous modeling studies (e.g. Loma Alta Slough, Sutula et al. 2013). During model validation, some adjustments were made so that the model results of the existing conditions are more comparable with the measured data. The set of parameters used in the BVLEP models are listed in Table 3.4.

Table 3.4 WASP Model Parameters

PARAMETERS	VALUE
Global Constants and Parameters	
Atmospheric Deposition of Nitrate (mg/m2-day)	0.09
Atmospheric Deposition of Ammonia (mg/m2-day)	0.0383
Atmospheric Deposition of Orthophosphate (mg/m2-day)	0.0821
Atmospheric Deposition of Organic Nitrogen (mg/m2-day)	0.0246
Ammonia	
Nitrification Rate Constant @20°C (per day)	0.15
Nitrification Temperature Coefficient	1.08
Half Saturation Constant for Nitrification Oxygen Limit (mg O/L)	1
Nitrate	
Denitrification Rate Constant @20 °C (per day)	0.09
Denitrification Temperature Coefficient	1.08
Half Saturation Constant for Denitrification Oxygen Limit (mg O/L)	0.1
Organic Nitrogen	
Dissolved Organic Nitrogen Mineralization Rate Constant @20°C (per day)	1
Dissolved Organic Nitrogen Mineralization Temperature Coefficient	1.02
Fraction of Phytoplankton Death Recycled to Organic Nitrogen	1

PARAMETERS	VALUE
Organic Phosphorus	
Mineralization Rate Constant for Dissolved Organic P @20°C (per day)	0.22
Dissolved Organic Phosphorus Mineralization Temperature Coefficient	1.02
Fraction of Phytoplankton Death Recycled to Organic Phosphorus	1
Phytoplankton	
Phytoplankton Maximum Growth Rate Constant @20°C (per day)	4.4
Phytoplankton Growth Temperature Coefficient	1.07
Phytoplankton Self Shading Extinction (Dick Smith Formulation)	0.017
Phytoplankton Carbon to Chlorophyll Ratio	30
Phytoplankton Half-Saturation Constant for Nitrogen Uptake (mg N/L)	0.05
Phytoplankton Half-Saturation Constant for Phosphorus Uptake (mg P/L)	0.025
Phytoplankton Endogenous Respiration Rate Constant @20°C (per day)	0.08
Phytoplankton Respiration Temperature Coefficient	1.07
Phytoplankton Death Rate Constant (Non-Zooplankton Predation) (per day)	0
Phytoplankton Phosphorus to Carbon Ratio	0.025
Phytoplankton Nitrogen to Carbon Ratio	0.1
Light	
Light Option (1 uses input light; 2 uses calculated diel light)	1
Phytoplankton Maximum Quantum Yield Constant	720
Phytoplankton Optimal Light Saturation	200
Dissolved Oxygen	
Waterbody Type Used for Wind Driven Reaeration Rate	0
Oxygen to Carbon Stoichiometric Ratio	2.67
CBOD 1	
BOD (1) Decay Rate Constant @20 °C (per day)	0.1
BOD (1) Decay Rate Temperature Correction Coefficient	1.047
BOD (1) Half Saturation Oxygen Limit (mg O/L)	1
CBOD2	
BOD (2) Decay Rate @20 °C (per day)	0.1
BOD (2) Half Saturation Oxygen Limit (mg O/L)	2.5
Fraction of Detritus Dissolution to BOD (2)	1.026
CBOD3	
BOD (3) Decay Rate Constant @20 °C (per day)	9
BOD (3) Decay Rate Temperature Correction Coefficient	1.3
BOD (3) Decay Rate Constant in Sediments (per day)	0.6
BOD (3) Decay Rate in Sediments Temperature Correction Coefficient	0.6
Fraction of Detritus Dissolution to BOD (3)	1.08
Fraction of BOD (3) Carbon Source for Denitrification	2
Detritus	
Detritus Dissolution Rate (1/day)	0.15
Temperature Correction for detritus dissolution	1.07

3.3.3 WASP Model Benthic Flux Input

The BVLEP nutrient modeling also includes the effect of sediment benthic activities in the Lagoon. The sediment benthic fluxes (exchange of nutrient across the sediment-water interface) for ammonia, phosphorus and sediment oxygen demand (SOD) were specified in the WASP models to simulate the nutrient interactions between the sediment and the water in the Lagoon. The three types of benthic fluxes were applied to the bottom layers of the grid cells in the three-layered WASP models. The benthic fluxes were based on field data collected during the four index periods in 2008. Data were collected in the I-5 Basin and in the CH Basin. I-5 Basin was designated as Segment 1 and the CH Basin as Segment 2 in the previous data sampling program. Benthic flux data are not available for the RR Basin and CH Basin. Based on field observation (McLaughlin et al, 2011), the biomasses in these two basins are similar to that at the CH Basin; hence, the RR Basin and Weir Basin were assumed to have the same benthic behavior as the CH Basin. Adjustment was made to the phosphorus flux in the three downstream basins (i.e. CH Basin, RR Basin and Weir Basin) during model validation. Table 3.5 summarizes the benthic flux input in the BVLEP WASP nutrient modeling. In the table, negative values designate fluxes from the water column into the sediment; vice versa, positive values designate fluxes from the sediment into the water column.

Table 3.5 Benthic Flux Input

INDEX PERIOD	SIMULATION PERIOD	AMMONIA (mg N/m^2/day)	PHOSPHORUS (mg P/m^2/day)	SOD (g O/m^2/day)
I-5 Basin (Segment 1)				
4	10/1/2007 – 11/30/2007	2.567	-3.426	0.6329
1	12/1/2007 – 2/29/2008	1.990	-22.496	-0.0553
2	3/1/2008 – 5/31/2008	8.599	-10.121	-0.6327
3	6/1/2008 – 8/31/2008	5.858	-4.032	-0.2176
4	9/1/2008 -9/30/2008	2.567	-3.426	0.6329
CH Basin / RR Basin / Weir Basin (Segment 2)				
4	10/1/2007 – 11/30/2007	68.906	12.856	-2.1019
1	12/1/2007 – 2/29/2008	0.723	13.939	-1.6262
2	3/1/2008 – 5/31/2008	-26.235	8.030	-1.9175
3	6/1/2008 – 8/31/2008	66.795	22.371	-3.6357
4	9/1/2008 -9/30/2008	68.906	12.856	-2.1019

Negative flux designates INTO the sediment (demand) while + designates efflux (out of the sediment).

4. MODEL VALIDATION

4.1 OVERVIEW

As part of the CHU Lagoon Monitoring Program, water levels and water quality data were monitored in Buena Vista Lagoon for the period between January 2008 and October 2008 (MACTEC 2009). These data were used to validate the linked EFDC and WASP model described in Chapter 3 under existing conditions. As mentioned in Section 1.2, the primary purpose of this study is compare the relative changes in bacteria and nutrient levels in the Lagoon under different proposed alternatives, thus model validation for this study is aiming at order of magnitude comparison between model-predicted and field measured concentrations for bacteria, nutrients, and biomasses.

A brief description and summary of the available field data for model validation are provided in Section 4.2, followed by the comparison of the model predicted results with the field data in Section 4.3.

4.2 LAGOON DATA

Monitoring data for the Buena Vista Lagoon were collected at I-5 Basin (referred to as Segment 1 in the MACTEC report) and CH Basin (Segment 2). Data collected in the Lagoon included: 1) continuous monitoring to establish baseline conditions, and 2) water quality sampling of wet and dry weather conditions. The locations for continuous monitoring are shown by the red circles in Figure 4.1, while the stars in the figure show the locations for water quality sampling.

4.2.1 Continuous Monitoring

Continuous monitoring of water levels, specific conductivity, water temperature, pH, dissolved oxygen, and turbidity were conducted from January to October 2008. The measured water levels and the corresponding flows from Buena Vista Creek are shown in Figure 4.2. In the figure, the top panel shows the measured Buena Vista Creek flow, the middle panel shows the water levels in the I-5 Basin (a.k.a. Lagoon Segment 1), and the bottom panels shows the water levels in the CH Basin (a.k.a. Lagoon Segment 2). The elevation for the existing weir at the downstream end of the Lagoon, which controls the water levels in the Lagoon, is shown in the figure as the black dashed line. There appears to be a problem with the initial water level measurements in I-5 Basin, as illustrated by the rapid oscillations in the measured water levels to below the weir elevation. Otherwise, the increase in water elevations at the two basins in general correspond to the wet weather flows

Figure 4.1 Buena Vista Lagoon Sampling Locations

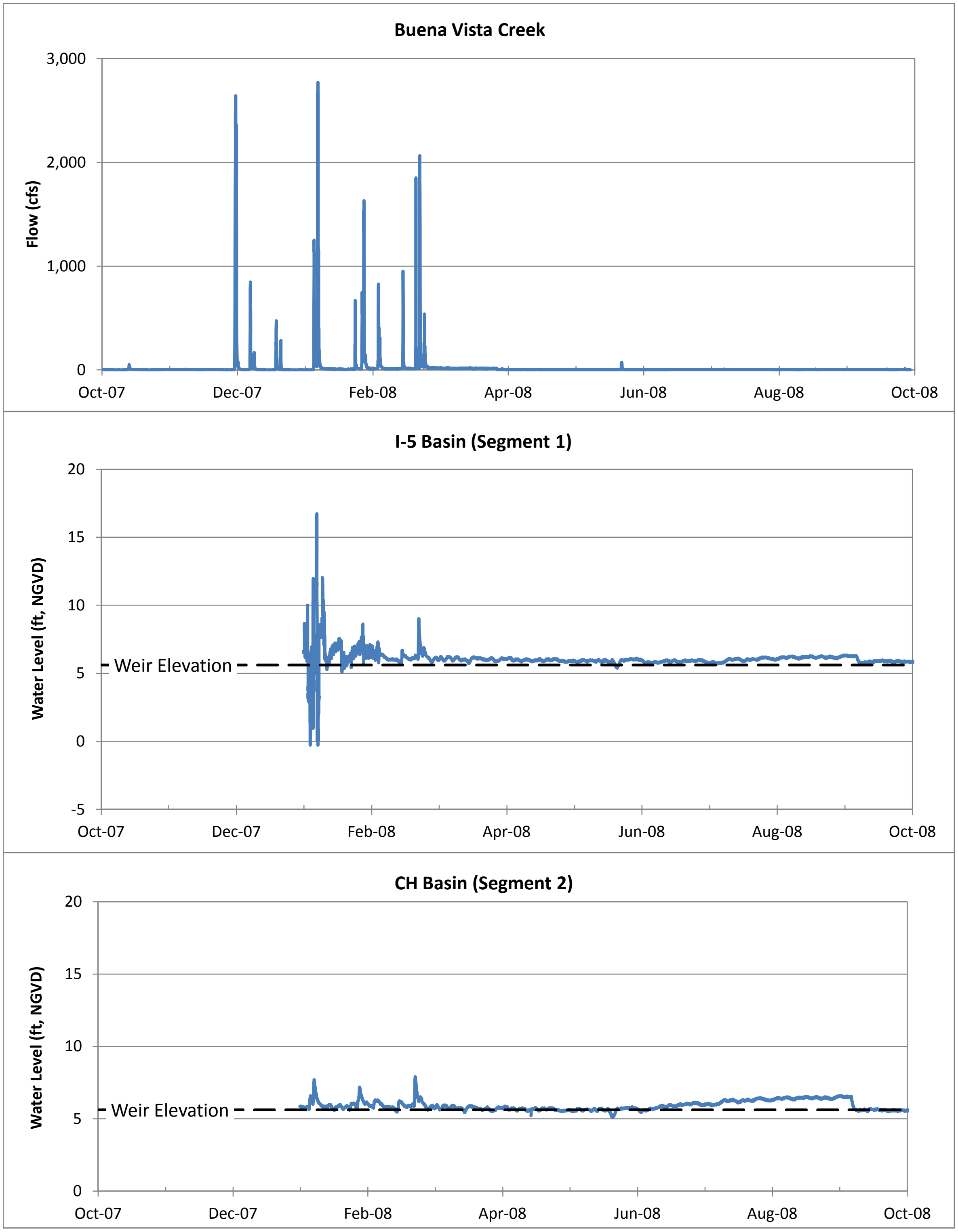


Figure 4.2 Buena Vista Lagoon Water Levels

from Buena Vista Creek. Measured water elevations in the CH Basin indicated that the water elevations remained rather constant at just above the weir elevation from March to May, followed by a steady increase from June to August and a sharp decline in early September. This could be caused by the accumulation of the sand berm in front of the weir, allowing for higher water levels in the Lagoon. Then removal of the sand berm, typically conducted in September by the City of Oceanside, results in water level returning to normal levels.

Salinity levels in the Lagoon, shown in Figure 4.3, were determined from the continuously measured specific conductivity and water temperature. In the figure, the top panel shows the salinity of the Buena Vista Creek flow entering the Lagoon, while salinity levels in the I-5 and CH Basins are shown in the middle and lower panels, respectively. In general, the salinity levels in the Lagoon are consistent with the salinity in the creek, which decrease during wet weather flows. However, there is an unexplained drop in salinity in the I-5 Basin that occurred in May 2008.

Measured water temperatures in the creek and Lagoon are provided in Figure 4.4. The top panel contains the measured water temperature from Buena Vista Creek which shows the seasonal variation with lower temperature during the winter months and higher temperature during the summer months. Lagoon water temperatures in the I-5 Basin and CH Basin are shown in the middle and lower panels, respectively. The Lagoon water temperature in general follows the same seasonal trend as the creek with lower temperatures in the winter months and higher temperatures in the summer months.

Monitored dissolved oxygen levels in the creek and Lagoon are provided in Figure 4.5. Dissolved oxygen levels at Buena Vista Creek are shown in the top panel, while dissolved oxygen levels at the Lagoon locations are shown in the middle and lower panels. In general, dissolved oxygen levels in the Lagoon are higher during wet weather conditions and lower during the summer months. However, there may be problem with the dissolved oxygen measurement because it shows extensive period of time that the dissolved oxygen levels in the Lagoon basins exceeds 20 mg/L while the observed algal biomass concentrations were high.

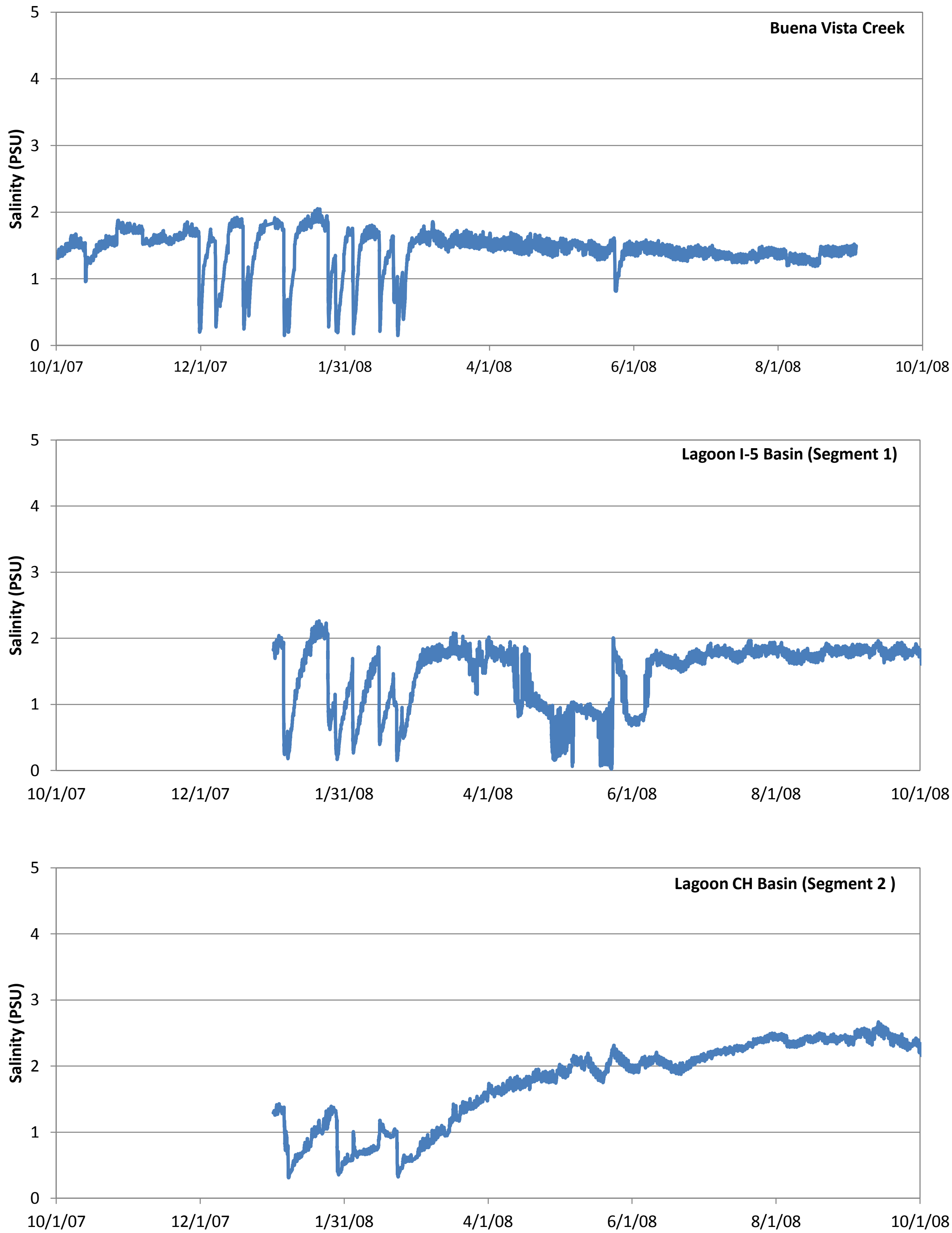


Figure 4.3 Buena Vista Lagoon Salinity

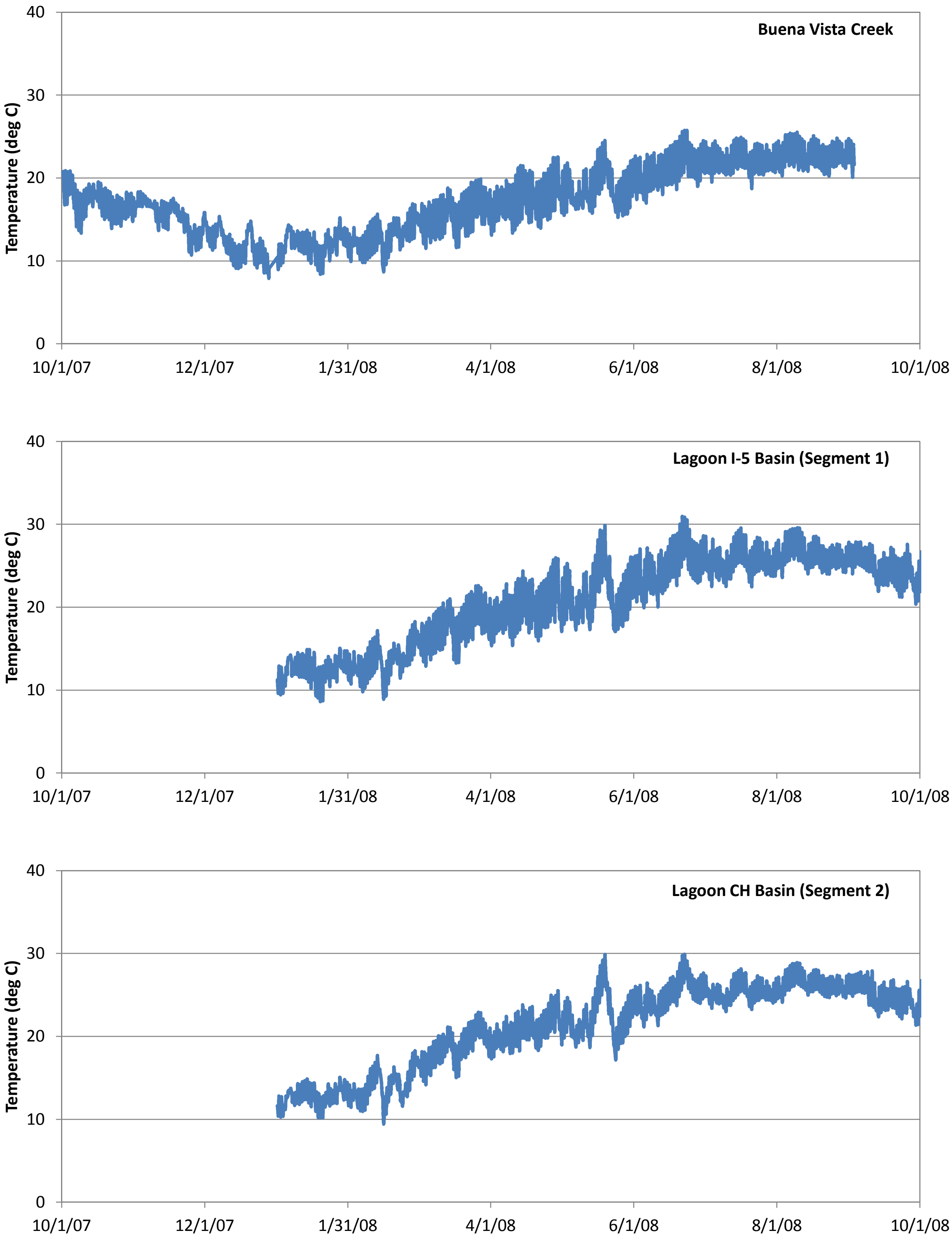


Figure 4.4 Buena Vista Lagoon Water Temperature

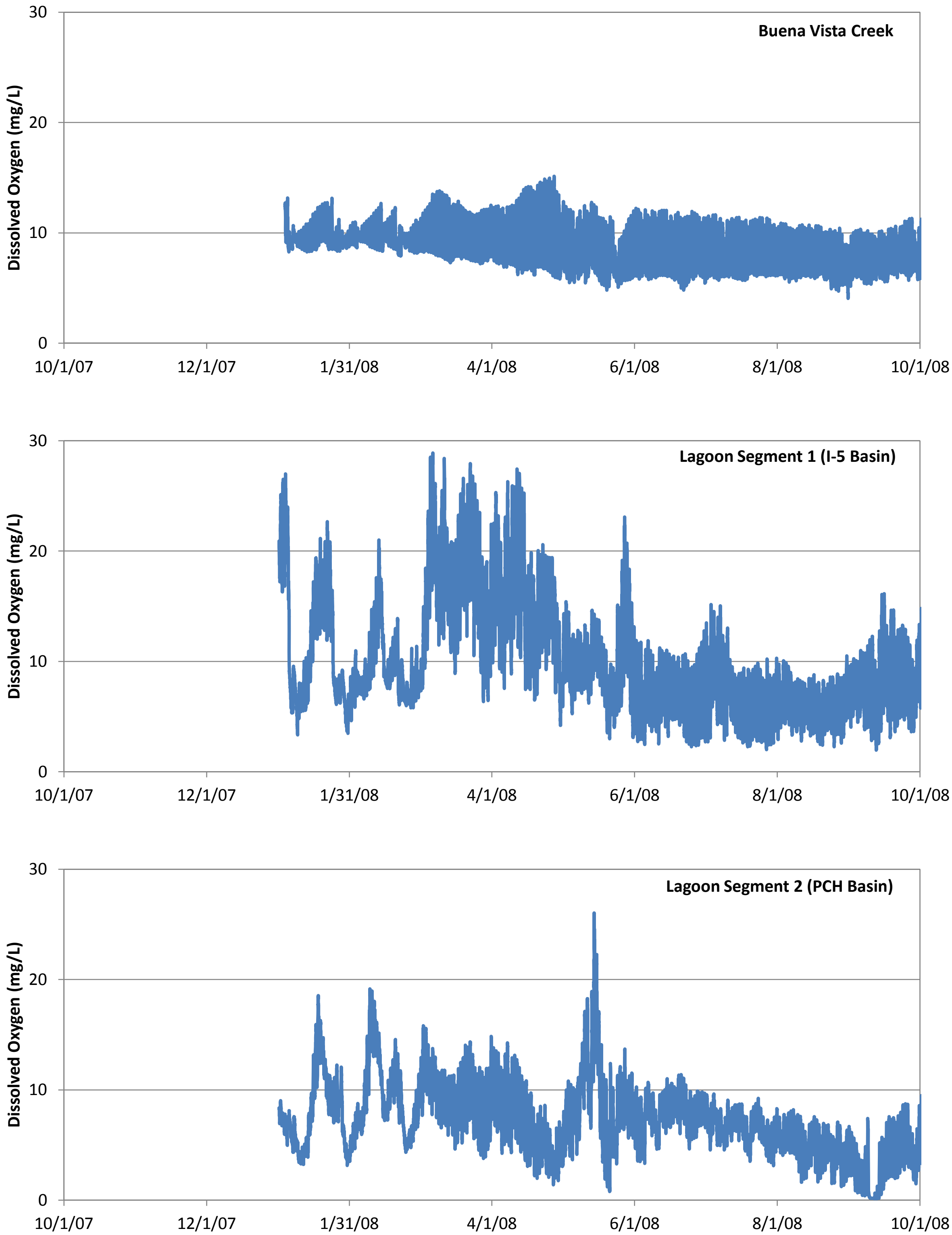


Figure 4.5 Buena Vista Lagoon Dissolved Oxygen

4.2.2 Lagoon Water Quality Sampling

Water quality sampling in the Lagoon was collected at two locations – at the edge of the I-5 Basin and near the Pacific Coast Highway Bridge in the CH Basin. Water quality constituents measured included bacteria (enterococcus, fecal coliform, and total coliform), TSS, ammonia as nitrogen, carbonaceous biochemical oxygen demand (CBOD), chlorophyll a, nitrate plus nitrite, soluble reactive phosphorus (SRP), total and dissolved nitrogen (TN and TDN), and total and dissolved phosphorus (TP and TDP).

The Lagoon sampling was conducted for three wet weather events and four index periods to characterize dry weather conditions as summarized in Table 4.1. Water quality samples were collected as time-weighted composite samples using automated sampling equipment. Bacteria grab samples were obtained concurrently with the composite samples.

For wet weather events, two samples were collected at each water quality monitoring location. The Lagoon sampling occurred once during high tide and once during low tide. Each composite sample was obtained as a time-weighted composite every 15 minutes over three hours. Although Buena Vista Lagoon is not tidally influenced, the same sampling schedule was maintained as other lagoons being monitored as part of the same program.

Table 4.1 Buena Vista Lagoon Water Quality and Bacteria Sampling Summary

MONITORING EVENT	DATE IN 2008	SAMPLES
Wet Event 1	1/5	2
Wet Event 2	1/23 – 1/24	2
Wet Event 3	2/3	2
Index Period 1	1/14, 1/15, 1/16, 2/7, 2/8, 2/11	6
Index Period 2	3/31, 4/1, 4/7, 4/8, 4/9, 4/10	6
Index Period 3	7/14, 7/15, 7/16, 7/21, 7/22, 7/23	6
Index Period 4	9/15, 9/16, 9/17, 9/22, 9/23, 9/24	6

For dry weather events, six samples were collected for each index period. The composite water quality sample was taken every 15 minutes over a 30-minute period. Bacteria samples were obtained as grab samples. The Lagoon index period sampling was conducted on the same days of the Buena Vista Creek index period sampling, which was shown previously in Figure 3.8. Index Period 1 represented dry weather conditions during the storm season. Three of the six samples were taken between Wet Events 1 and 2, while the other three samples were obtained following Wet Event 3. Index Period 2 occurred in March and April, representing post-storm and pre-algal bloom conditions. Index period 3 was collected in July during high algal bloom conditions. The fourth index period occurred in September for post-algal bloom and pre-storm conditions.

As mentioned previously, the Lagoon sampling was coordinated with monitoring of Buena Vista Creek in order to measure the response in the Lagoon to watershed inputs. The timing of the creek and Lagoon sampling for the wet weather events is illustrated in Figure 4.6. In each panel, the creek flow is shown by the blue line with the red dashed line indicating the duration of the creek sampling. Timing of the Lagoon water quality sampling is indicated by the gray shaded area in the figure. For Wet Event 1, the creek monitoring occurred over a three-day period with three consecutive storms. However, the Lagoon sampling was conducted on the first day. Due to the timing of the sampling, the Lagoon data for Wet Event 1 may not represent the response in the Lagoon. Wet Event 2 was a single storm event with the creek monitoring occurring over the duration of the wet weather flow. The Lagoon sampling for Wet Event 2 occurred after storm event as water levels in the Lagoon were subsiding from the wet weather flows. The creek monitoring for Wet Event 3 was part of a separate monitoring program and was conducted over only a portion of the storm event, as illustrated in the lower panel of Figure 4.6. The flows shown in the figure are from the creek monitoring, but these measured flows differed from the flows reported in MACTEC 2009. The Lagoon sampling for Wet Event 3 occurred following the storm event as water levels in the Lagoon were subsiding from the wet weather flows.

Comparisons of the creek and Lagoon bacteria data are provided in Tables 4.2, 4.3 and 4.4 for enterococcus, fecal coliform, and total coliform, respectively. The bacteria data are given for the median, minimum, and maximum bacteria concentrations. In general, bacteria concentrations were the highest at Buena Vista Creek. In the Lagoon, bacteria concentrations were typically higher in the I-5 Basin compared to the CH Basin. Also, wet weather bacteria concentrations were generally higher than the dry weather bacteria concentrations.

A number of nutrients were measured in the samples collected during the 2008 sampling program. The field data used for model validation included chlorophyll-a, total phosphorus, and total nitrogen.

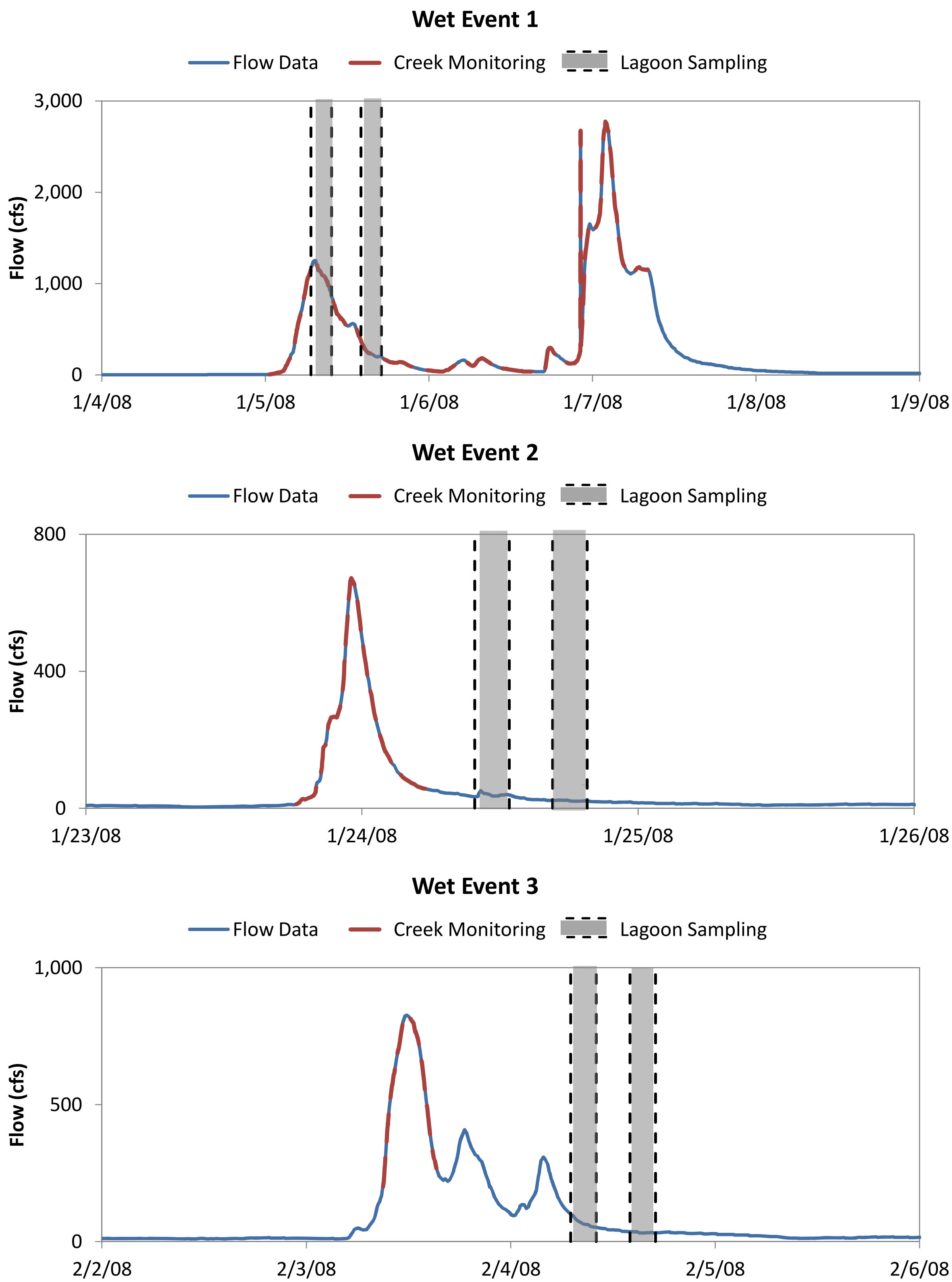


Figure 4.6 Timing of Buena Vista Creek and Lagoon Monitoring

Table 4.2 Buena Vista Creek and Lagoon Enterococcus Data

Monitoring Event	Buena Vista Creek			I-5 Basin (Segment 1)			CH Basin (Segment 2)		
	Median	Min	Max	Median	Min	Max	Median	Min	Max
Wet Event 1	13,750	6,800	38,000	11,100	9,200	13,000	1,485	370	2,600
Wet Event 2	12,000	240	17,000	6,270	540	12,000	25	20	30
Wet Event 3	17,000*	NA	NA	9,050	7,300	10,800	2,450	1,800	3,100
Index Period 1	168	60	269	67	16	228	17	10	32
Index Period 2	58	22	102	12	6	30	19	2	44
Index Period 3	235	128	284	62	16	134	15	2	38
Index Period 4	152	92	288	11	2	22	13	2	98

Source: MACTEC 2009
Units in CFU/100 mL
**Bacteria data reported as Event Mean Concentrations (EMCs)*
NA – Not Available

Table 4.3 Buena Vista Creek and Lagoon Fecal Coliform Data

Monitoring Event	Buena Vista Creek			I-5 Basin (Segment 1)			CH Basin (Segment 2)		
	Median	Min	Max	Median	Min	Max	Median	Min	Max
Wet Event 1	6,500	3,000	14,000	15,000	13,000	17,000	600	500	700
Wet Event 2	8,000	200	90,000	3,500	2,000	5,000	120	70	170
Wet Event 3	5,000*	NA	NA	2,350	1,700	3,000	1,050	800	1,300
Index Period 1	152	52	648	123	40	234	100	84	180
Index Period 2	101	56	370	136	36	250	48	34	70
Index Period 3	600	260	1,230	116	20	444	96	40	240
Index Period 4	465	140	610	146	48	344	88	36	140

Source: MACTEC 2009
Units in MPN/100 mL
**Bacteria data reported as Event Mean Concentrations (EMCs)*
NA – Not Available

Table 4.4 Buena Vista Creek and Lagoon Total Coliform Data

Monitoring Event	Buena Vista Creek			I-5 Basin (Segment 1)			CH Basin (Segment 2)		
	Median	Min	Max	Median	Min	Max	Median	Min	Max
Wet Event 1	60,000	9,000	160,000	150,000	80,000	220,000	2,600	2,200	3,000
Wet Event 2	17,500	2,400	90,000	93,000	26,000	160,000	1,500	800	2,200
Wet Event 3	80,000*	NA	NA	29,500	9,000	50,000	13,500	3,000	24,000
Index Period 1	714	328	1,260	442	80	2,200	356	228	520
Index Period 2	450	370	650	355	160	450	105	60	250
Index Period 3	924	452	1,620	265	72	500	159	80	210
Index Period 4	940	580	1,120	255	110	890	80	50	180

Source: MACTEC 2009
Units in MPN/100 mL
**Bacteria data reported as Event Mean Concentrations (EMCs)*
NA – Not Available

The seasonal trends in biomass for the Buena Vista Lagoon were assessed using the biomass of two primary producers: phytoplankton biomass (measured as suspended chlorophyll-a in mg chl–a/m^3)); and macroalgal biomass (measured in g dry weight/m^3). In the I-5 Basin (Segment 1 in the 2008 sampling program), where phytoplankton is the dominant producer of biomass, validation of I-5 Basin modeled algal biomass to field data was based on chlorophyll-a values, the field data for which is summarized in Table 4.5. For the CH Basin, RR Basin and Weir Basin basins, macroalgae (*Chara spp.*) is the dominant primary producer. Table 4.6 summarizes the field data for macroalgal biomass in the CH basin (Segment 2 in the 2008 sampling program).

Table 4.5 I-5 Basin (Segment 1) Chlorophyll-a Data (mg/m^3)

SAMPLING EVENT	I-5 BASIN (SEGMENT 1)
Wet Event 1	8.00
Wet Event 2	14.75
Wet Event 3	10.70
Index Period 1	21.18
Index Period 2	409.23
Index Period 3	36.00
Index Period 4	102.30

Source: MACTEC 2009

Table 4.6 CH Basin (Segment 2) Macroalgal Biomass Data (g dw/m^3)

SAMPLING EVENT	CH BASIN (SEGMENT 2)
Index Period 1	0
Index Period 2	123.06
Index Period 3	225.39
Index Period 4	128.25

Source: McLaughlin et al. 2011

The field data for total phosphorus and total nitrogen are listed in Tables 4.7 and 4.8, respectively.

Table 4.7 Buena Vista Lagoon Total Phosphorus Data (mg/L)

SAMPLING EVENT	I-5 BASIN (SEGMENT 1)	CH BASIN (SEGMENT 2)
Wet Event 1	0.25	0.14
Wet Event 2	0.17	0.18
Wet Event 3	0.26	0.26
Index Period 1	0.19	0.29
Index Period 2	0.26	0.23
Index Period 3	0.07	0.04
Index Period 4	0.06	0.04

Source: MACTEC 2009

Table 4.8 Buena Vista Lagoon Total Nitrogen Data (mg/L)

SAMPLING EVENT	I-5 BASIN (SEGMENT 1)	CH BASIN (SEGMENT 2)
Wet Event 1	1.75	0.94
Wet Event 2	1.80	0.98
Wet Event 3	1.99	1.90
Index Period 1	2.42	1.38
Index Period 2	2.43	1.60
Index Period 3	0.89	0.87
Index Period 4	0.82	0.96

Source: MACTEC 2009

4.3 COMPARISON OF MODEL RESULTS WITH FIELD DATA

To verify the EFDC and WASP Models for Existing Conditions, the two models were used to simulate conditions from October 2007 to October 2008 for subsequent compare to Lagoon data collected during the same period. EFDC was used to simulate hydrodynamic, salinity, temperature, and bacteria. WASP was used to simulate dissolved oxygen, nutrients, and biomass. As mentioned earlier, model validation for this study is aiming at order of magnitude comparison between model predicted values and measured data (i.e., Lagoon data). This is especially the case for bacteria which the limited data shows order of magnitude variations in the measured bacteria concentrations. For example, as shown in Table 4.2, for Wet Event 2, the data indicates that the Enterococcus concentration for Buena Vista Creek ranges from 240 to 17,000 CFU/100 mL, a variation of two orders of magnitude. Hence, the EFDC model predicted bacteria concentrations in the Lagoon, which are governed by the input from Buena Vista Creek, can be at best within two orders of magnitude.

4.3.1 Water Levels

Comparison of the Lagoon data and EFDC simulated water levels are provided in Figure 4.7. In the figure, the flow from Buena Vista Creek is shown in the top panel, and water levels in the I-5 Basin (Segment 1) and in the CH Basin (Segment 2) are shown in the middle and bottom panels, respectively. The measured water levels in the Lagoon are shown in blue, while the EFDC simulated water levels are shown in red. As mentioned earlier, there appears to have been a problem with the initial measurements of the water levels in I-5 Basin, which shows rapid oscillations of up to more than 16 ft, as well as drops below the weir elevation over a short time when there is no corresponding flow into the Lagoon from the Buena Vista Creek. Hence, the measured water levels for this initial period should not be used to compare with the model predictions. After this initial period, the measured water levels seem to follow the flow into the Lagoon from the Buena Vista Creek, with a rapid rise of water levels following a flood flow event from the creek. In general, the EFDC model shows the same trends as the measured water levels in the Lagoon, with sharp rise in water levels following each flow event. As expected, during the dry weather months, the EFDC modeled water level is close to the weir elevation at +5.6 ft, NGVD. However, the monitored data shows a continuous rise in water levels in the CH Basin from June to August 2008, which was probably caused by the buildup of a summer sand berm outside of the weir. The effect of the summer sand berm is not included in the EFDC model because there is no data on the gradual build up of the sand berm.

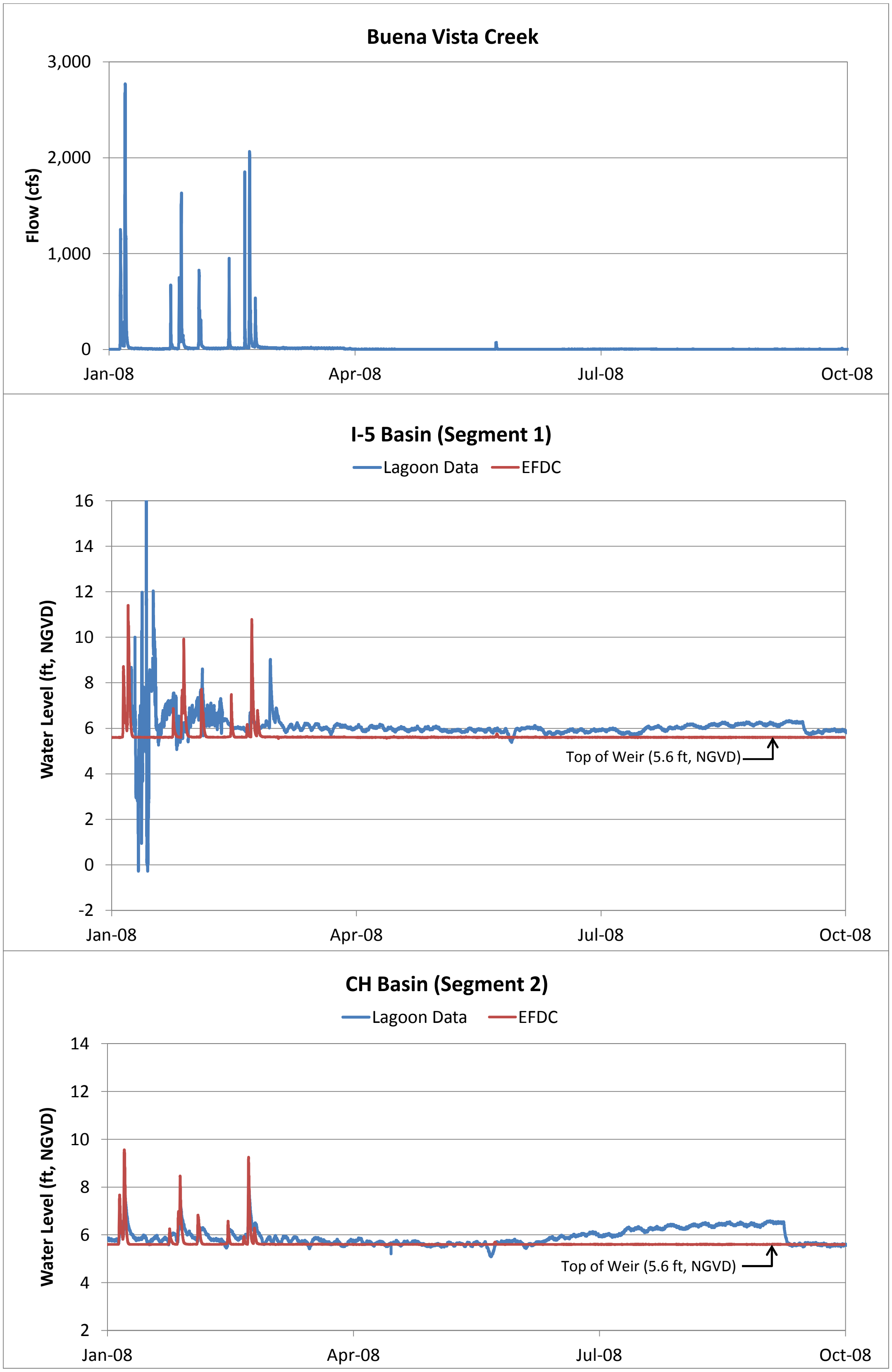


Figure 4.7 Lagoon Data and EFDC Water Levels

4.3.2 Salinity

The EFDC simulated salinity levels are compared with the measured salinity levels in the Lagoon in Figure 4.8. In the figure, the top panel shows the comparisons for the I-5 Basin (Segment 1) and the bottom panel shows the comparison for the CH Basin (Segment 2). In general, the EFDC predicted salinity matches well with the measured salinity, especially during the wet weather months. In the I-5 Basin, the model did not match the anomalous salinity decline shown in the measured data in May 2008. In the CH Basin, the EFDC results did not match the increase in salinity from June to August 2008. The increase in salinity may be attributed to the accumulation of a sand berm in front of the weir, which was not simulated in the EFDC model.

4.3.3 Temperature

The EFDC simulated water temperatures are compared with the measured water temperatures in Figure 4.9 for the I-5 Basin (Segment 1) and CH Basin (Segment 2). In general, the EFDC simulated temperature agrees well with the Lagoon data. The EFDC results also show the seasonal trend observed in the Lagoon data with the highest temperatures occurring during summer months.

4.3.4 Bacteria

Bacteria were simulated as a tracer using the EFDC model. Two simulations were conducted for the Existing Condition – one with a decay rate of zero to represent the condition of no bacteria die-off, and one with a decay rate of one per day (1/day) to represent typical bacteria die off condition, which typically range from 0.7 to 1.5/day (Schueler and Holland, 2000).

The EFDC model simulated wet weather bacteria concentrations for the wet weather months (January and February 2008) are compared to measured Lagoon bacteria concentrations in Figure 4.10. In the figure, the left panels show the comparisons in the I-5 Basin (Lagoon Segment 1), while the right panels show the comparisons in the Coast Highway Basin (Lagoon Segment 2). In each panel, the bacteria concentrations without die-off are indicated by the blue line and bacteria concentrations with die-off are indicated by the green line. The measured median bacteria concentrations in the Lagoon for the three monitored wet events are indicated by the red circles, with the minimum and maximum measured concentrations for the same event shown as the black lines above and below the red circles. The EFDC simulated bacteria concentrations in the I-5 Basin reflect the bacteria concentrations in Buena Vista Creek flow discharging into the basin. Since the bacteria loadings from the creek entering the Lagoon during the wet weather events were of very short duration, as indicated by the green lines, the bacteria die-off does not significantly affect the Lagoon bacteria concentrations during wet weather conditions.

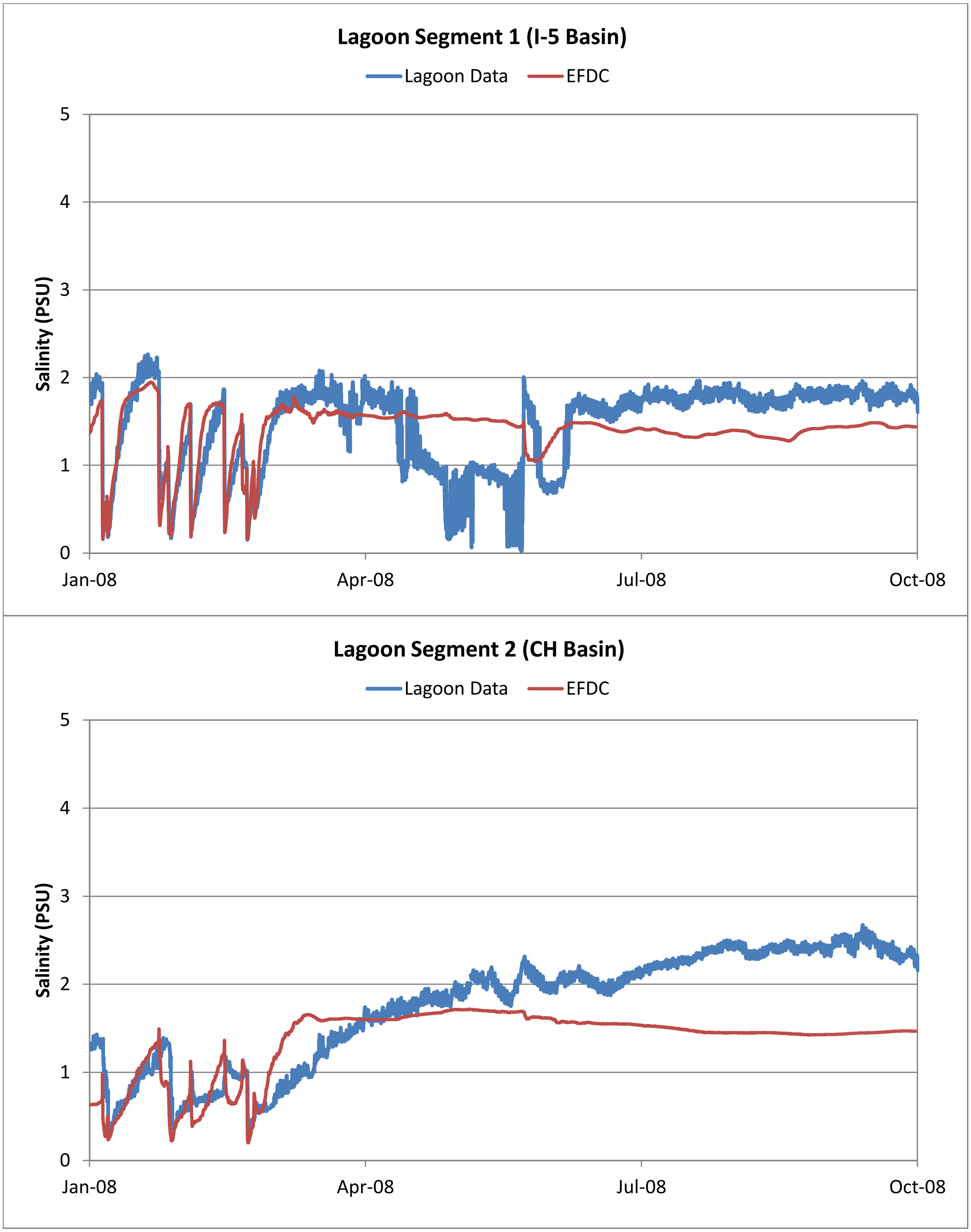


Figure 4.8 Lagoon Data and EFDC Salinity

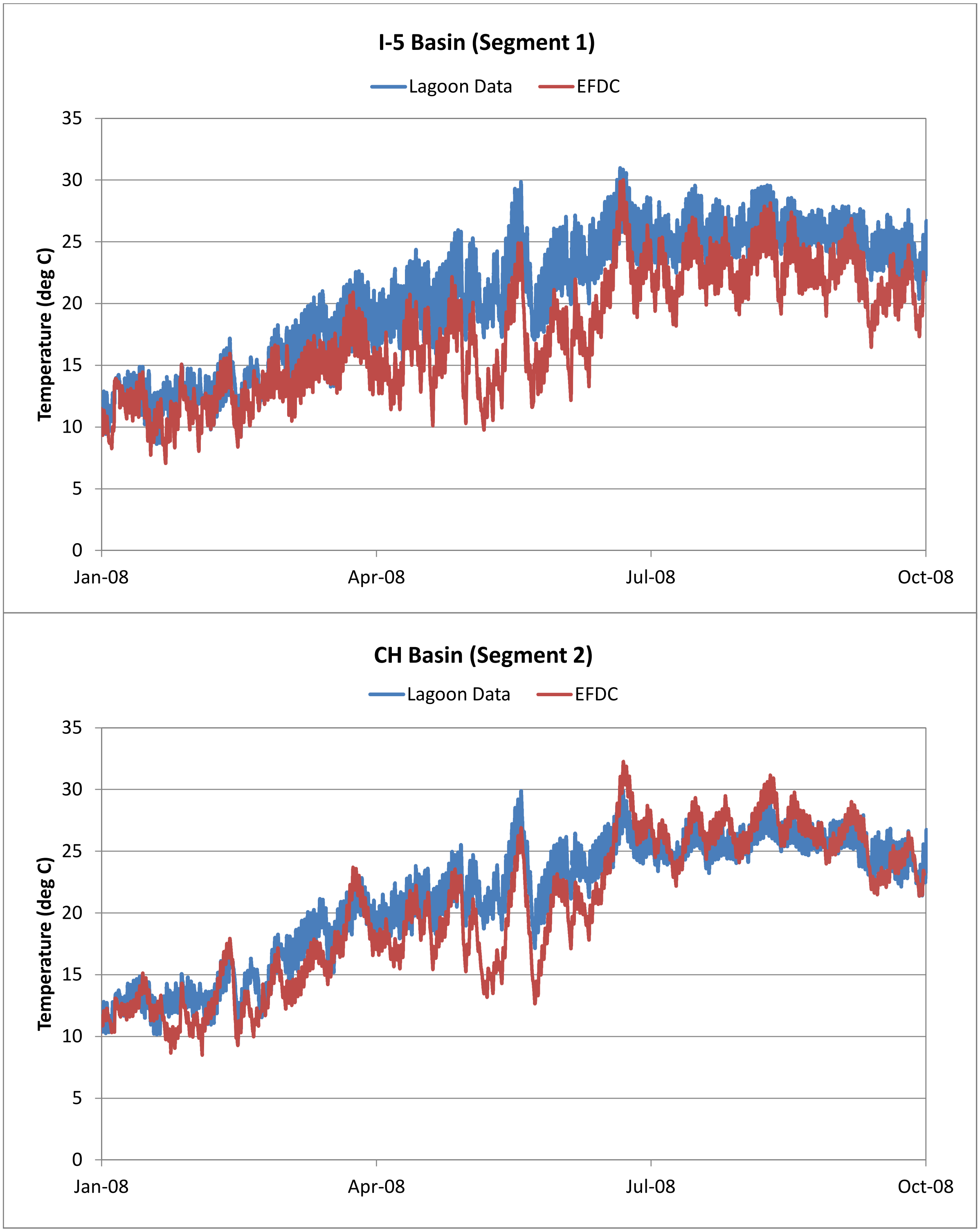


Figure 4.9 Lagoon Data and EFDC Temperature

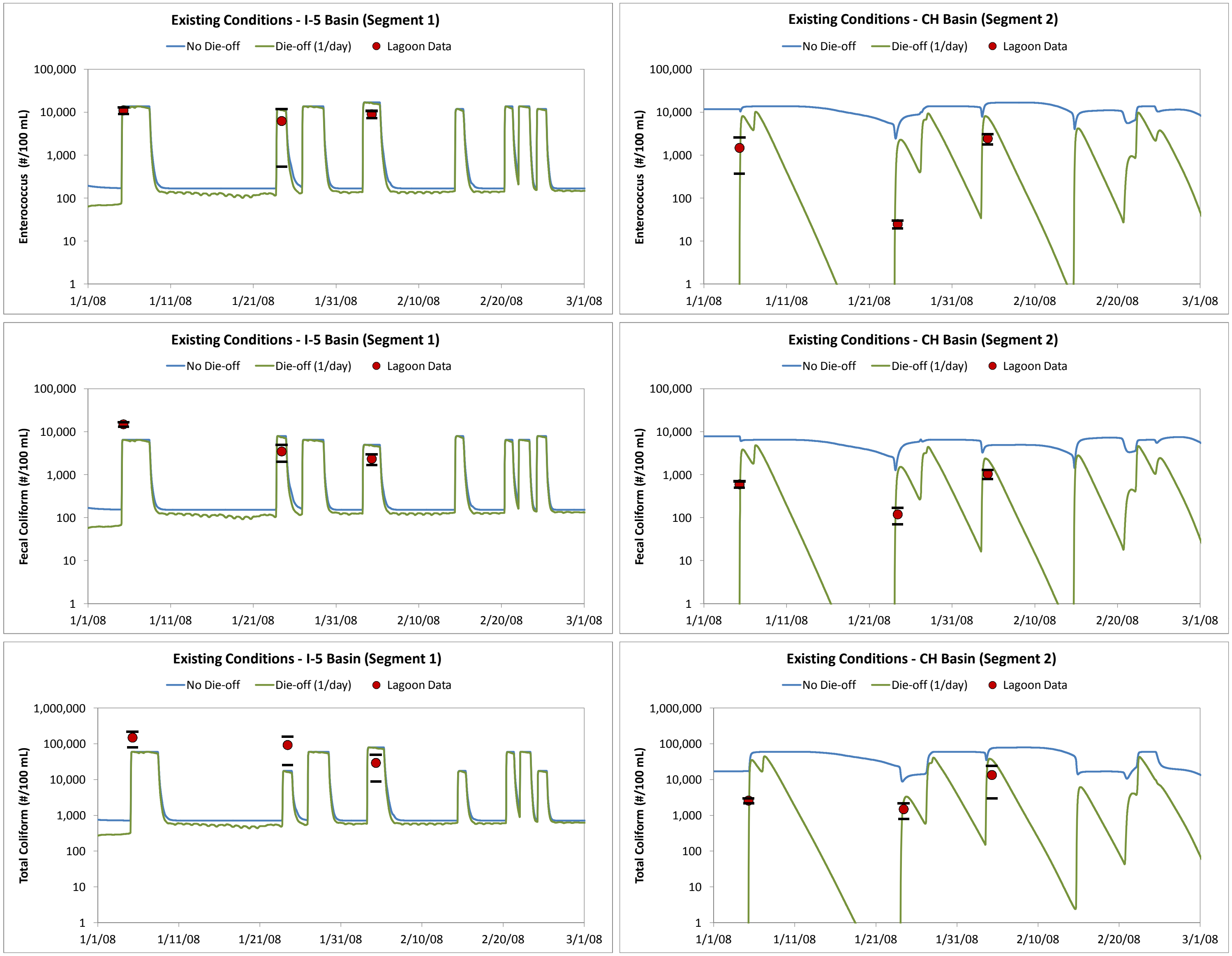


Figure 4.10 Wet Weather Bacteria Comparisons

The simulated bacteria concentrations in the CH Basin without die-off are somewhat lower than those in the I-5 Basin. However, the drop in bacteria concentrations in the CH Basin is much slower than those in the I-5 Basin since flows exiting the Lagoon essentially stop after the wet weather flows pass through the Lagoon due to the weir, and the bacteria loading passing from the I-5 Basin are left trapped in the basin and then slowly decrease as dry weather flows from Buena Vista Creek move through the Lagoon. In addition, bacteria die-off plays a much stronger role in reducing the bacteria concentrations in the CH Basin compared to the I-5 Basin.

In the CH Basin, the EFDC model-simulated bacteria concentrations with die-off near the sampling times are similar to the measured concentrations. In the I-5 Basin, the model simulated bacteria concentrations are in general within a factor of two to three as the measured concentrations. Note that as described in Section 4.2, the median bacteria concentrations are used to define the bacteria loading from Buena Vista Creek into the Lagoon. Since there is a wide range of measured bacteria concentrations in the Buena Vista Creek, the actual bacteria loadings from the creek into the Lagoon were likely more than a factor of two to three different from the median values being used in the model to define the creek loadings. To illustrate the natural variations of the bacteria concentration, the model simulated bacteria concentrations in the Lagoon were also compared with the measured bacteria concentrations in Tables 4.9, 4.10 and 4.11 for enterococcus, fecal coliform, and total coliform, respectively. In the tables, the ranges in the creek and Lagoon bacteria concentrations are provided to show the variability of the measured concentrations. In general, both the wet and dry weather simulated concentrations are within the range of the bacteria data. Based on the comparisons of the EFDC bacteria concentrations and Lagoon data, the model is suitable to simulate bacteria concentrations for relative comparison of the proposed Lagoon alternatives.

Table 4.9 Lagoon Data and EFDC Enterococcus Comparison

Monitoring Event	Creek	I-5 Basin (Segment 1)		CH Basin (Segment 2)	
		Data	EFDC	Data	EFDC
Wet Event 1	6,800 – 38,000	9,200 – 13,000	13,535 – 13,750	370 – 2,600	4,279 – 11,930
Wet Event 2	240 – 17,000	540 – 12,000	10,925 – 12,000	20 – 30	2,042 – 5,167
Wet Event 3*	17,000	7,300 – 10,800	15,915 – 17,000	1,800 – 3,100	6,909 – 16,225
Index Period 1	60 – 269	16 – 228	126 – 169	10 – 32	120 – 14,284
Index Period 2	22 – 102	6 – 30	34 – 64	2 – 44	0 – 183
Index Period 3	128 – 284	16 – 134	139 – 235	2 – 38	0 – 768
Index Period 4	92 - 288	2 – 22	74 – 152	2 – 98	0 – 255

Units in CFU/100 mL
**Bacteria data reported as Event Mean Concentrations (EMCs)*

Table 4.10 Lagoon Data and EFDC Fecal Coliform Comparison

Monitoring Event	Creek	I-5 Basin (Segment 1)		CH Basin (Segment 2)	
		Data	EFDC	Data	EFDC
Wet Event 1	3,000 – 14,000	13,000 – 17,000	6,399 – 6,500	500 – 700	2,023 – 6,790
Wet Event 2	200 – 90,000	2,000 – 5,000	7,283 – 8,000	70 – 170	1,362 – 3,286
Wet Event 3*	5,000	1,700 – 3,000	4,681 – 5,000	800 – 1,300	2,032 – 4,825
Index Period 1	52 – 648	40 – 234	114 – 152	84 – 180	36 – 5,302
Index Period 2	56 – 370	36 – 250	56 – 104	34 – 70	0 – 162
Index Period 3	260 – 1,230	20 – 444	354 – 600	40 – 240	0 – 614
Index Period 4	140 – 610	48 – 344	225 – 465	36 – 140	0 – 598

Units in MPN/100 mL
**Bacteria data reported as Event Mean Concentrations (EMCs)*

Table 4.11 Lagoon Data and EFDC Total Coliform Comparison

Monitoring Event	Creek	I-5 Basin (Segment 1)		CH Basin (Segment 2)	
		Data	EFDC	Data	EFDC
Wet Event 1	9,000 – 160,000	80,000 – 220,000	59,064 – 60,000	2,200 – 3,000	18,672 – 34,897
Wet Event 2	2,400 – 90,000	26,000 – 160,000	15,932 – 17,500	800 – 2,200	2,988 – 10,539
Wet Event 3*	80,000	9,000 – 50,000	74,892 – 80,000	3,000 – 24,000	32,512 – 76,252
Index Period 1	328 – 1,260	80 – 2,200	533 – 716	228 – 520	565 – 65,119
Index Period 2	370 – 650	160 – 450	250 – 464	60 – 250	0 – 743
Index Period 3	452 – 1,620	72 – 500	545 – 924	80 – 210	0 – 1,490
Index Period 4	580 – 1,120	110 – 890	456 – 940	50 – 180	0 – 948

Units in MPN/100 mL
**Bacteria data reported as Event Mean Concentrations (EMCs)*

4.3.5 Dissolved Oxygen

The simulated dissolved oxygen concentration from WASP for the existing conditions is compared with that of the field data. From the WASP output, an average daily concentration was calculated for each day of the 366 simulated days. These daily average value time series were plotted against the daily average values of the field measurements, which were calculated based on the field measurements (MACTEC 2009). Figure 4.11 shows the comparisons between field data and WASP output for dissolved oxygen concentration. It can be seen that in general, the simulated values are more similar to the measured data during the summer months. Of the two locations being validated, there is more agreement between measured and simulated values in the CH Basin.

4.3.6 Total Nitrogen

The simulated total nitrogen concentration from WASP for the existing conditions is compared with that of the field data. The total nitrogen field measurements only accounted for concentration in water, and did not include the portion of total nitrogen attributed to macroalgal biomass, which is dominant in Segment 2. The total nitrogen concentration output from WASP, on the other hand, accounts for all contributions, including that attributed to macroalgae. Therefore for the purpose of comparing total nitrogen concentration in the Lagoon water, the total nitrogen concentration from WASP output for Segment 2 (CH Basin) was post-processed to remove the portion attributed to the macroalgae biomass. From the adjusted WASP output, an average daily concentration was calculated for each day of the 366 simulated days. The daily average values for the entire simulated year were plotted together with the field measurements (MACTEC 2009). Figure 4.12 shows the comparisons between field data and WASP output for total nitrogen concentrations for the I-5 Basin and CH Basin. It can be seen that in general, the simulated values match reasonably well with the measured data (Lagoon data) for both basins.

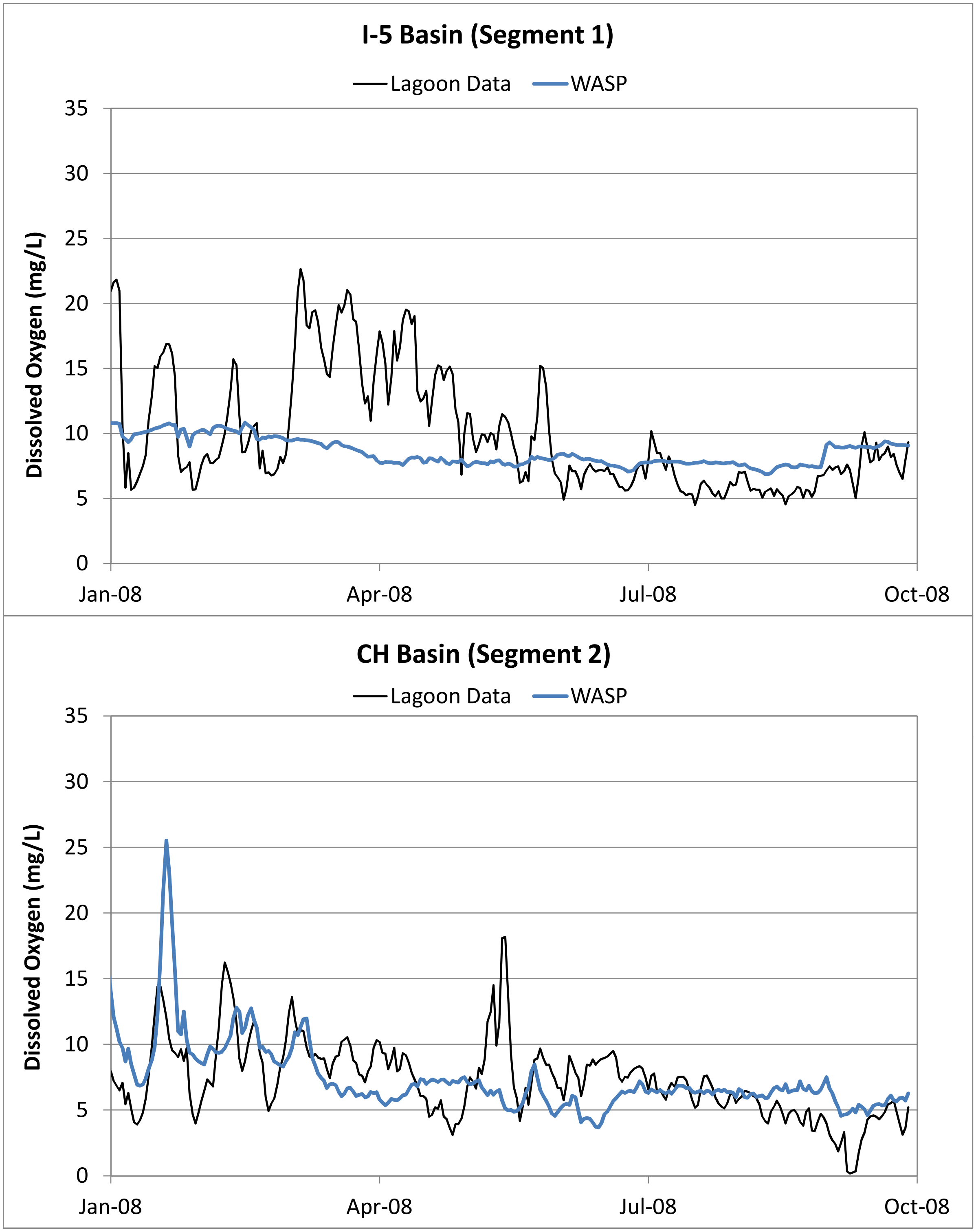


Figure 4.11 Lagoon Data and WASP Dissolved Oxygen Concentration Comparison

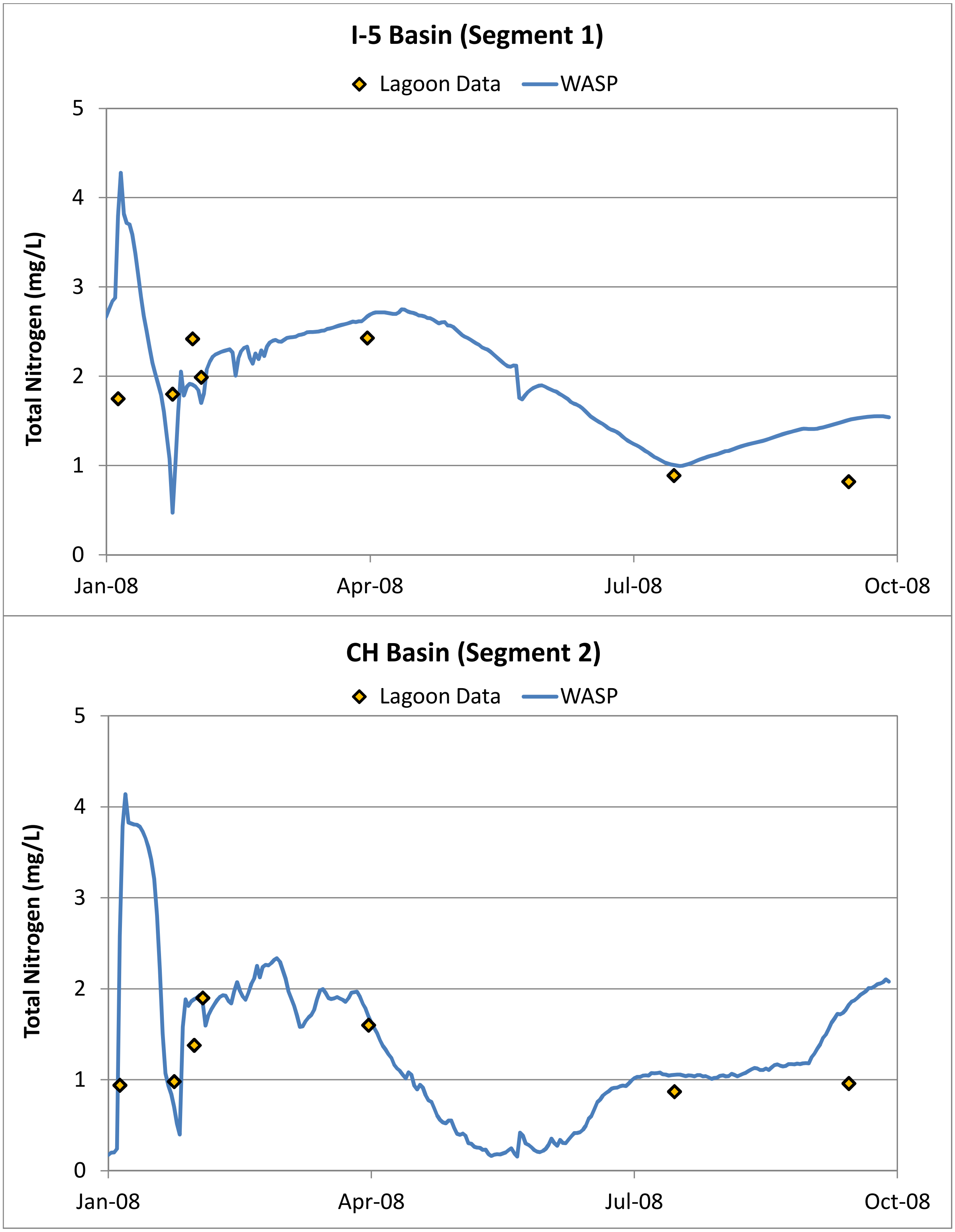


Figure 4.12 Lagoon Data and WASP Total Nitrogen Concentration Comparison

4.3.7 Total Phosphorus

The simulated total phosphorus concentration from WASP for the existing conditions is compared with that of the field data. Similar to the total nitrogen, the total phosphorus field measurements only accounted for concentration in water, and did not include the portion of total phosphorus attributed to macroalgal biomass, which is dominant in Segment 2. The total phosphorus concentration output from WASP, on the other hand, accounts for all contributions, including that attributed to macroalgae. Therefore for the purpose of comparing total phosphorus concentration in the Lagoon water, the total phosphorus concentration from WASP output for Segment 2 (CH Basin) was post-processed to remove the portion attributed to the macroalgae biomass. From the adjusted WASP output, an average daily concentration was calculated for each day of the 366 simulated days. The daily average values for the entire simulated year were plotted together with the field measurements (MACTEC 2009). Figure 4.13 shows the comparisons between field data and WASP output for total phosphorus concentrations for the I-5 Basin and CH Basin. It can be seen that in general, the simulated values match reasonably well with the measured data (Lagoon data) for both basins for the purpose of this project.

4.3.8 Phytoplankton and Macroalgae

Based on previous studies of the Lagoon (Sutula et. al, 2011), the biomass in the I-5 Basin is dominated by phytoplankton, and the biomass in the CH Basin is dominated by macroalgae. Because of this difference, the post-processing of output for these two basins are not the same. The biomass in the I-5 Basin was evaluated using the chlorophyll-a, while the biomass of the other three basins was evaluated using the macroalgae present per cubic meter of water. In both locations, the output from WASP is in the form of chlorophyll-a concentration. In the CH, Railroad, and Weir basins, the chlorophyll-a biomass are converted to macroalgae using a C: Chlorophyll-a ratio of 30:1 and the assumption that 22% of dry weight macroalgae is carbon (McLaughlin et al. 2011). After converting the WASP chlorophyll-a concentration for CH Basin into macroalgae biomass, an average daily concentration was calculated for each day of the 366 simulated days. The daily average values for the entire simulated year were plotted together with the field measurements. Figure 4.14 shows the comparisons between field data and WASP output for the biomass concentrations for the I-5 Basin and CH Basin. It can be seen that in general, the simulated values match reasonably well with the measured data (Lagoon data) for both basins for the purpose of this project.

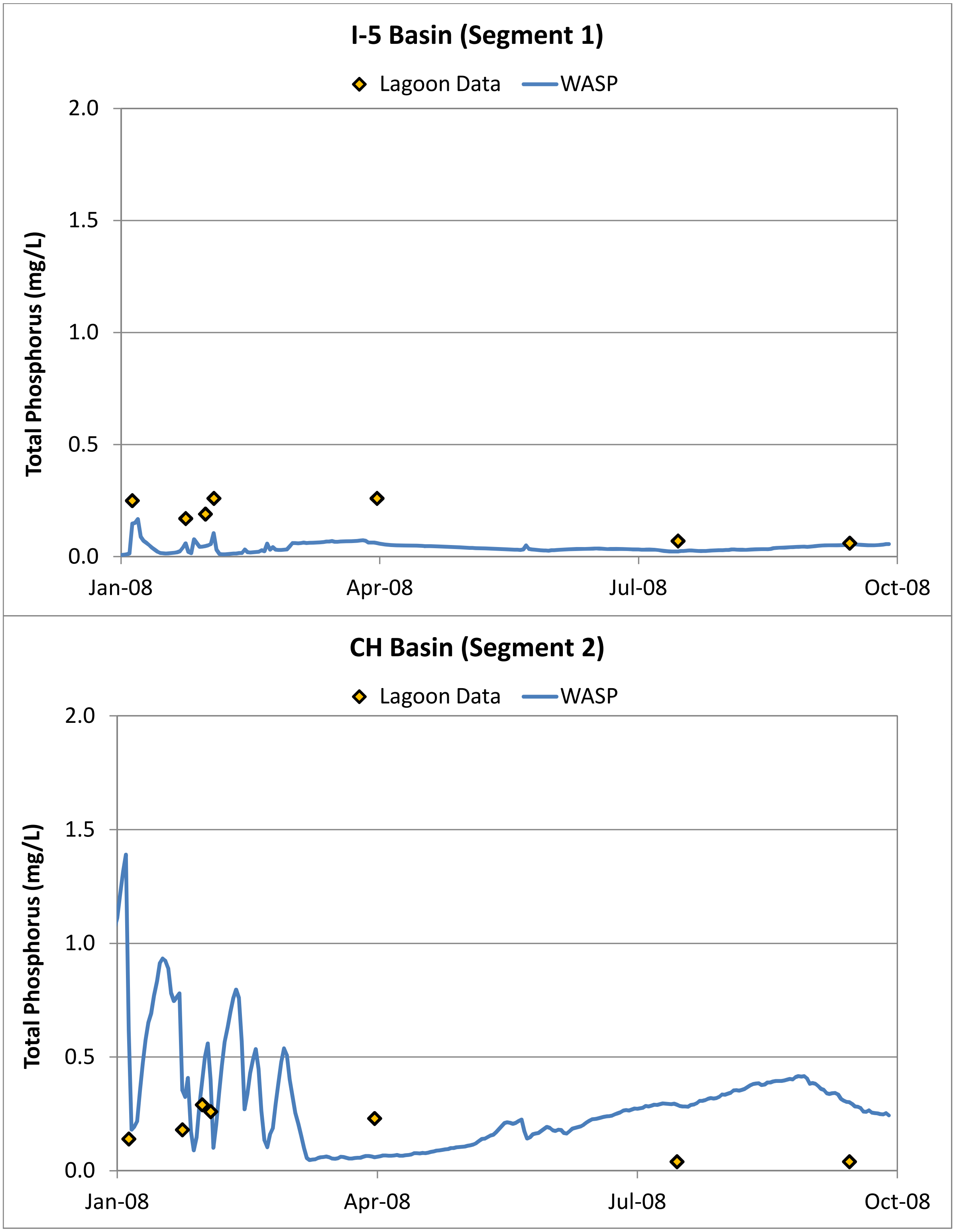
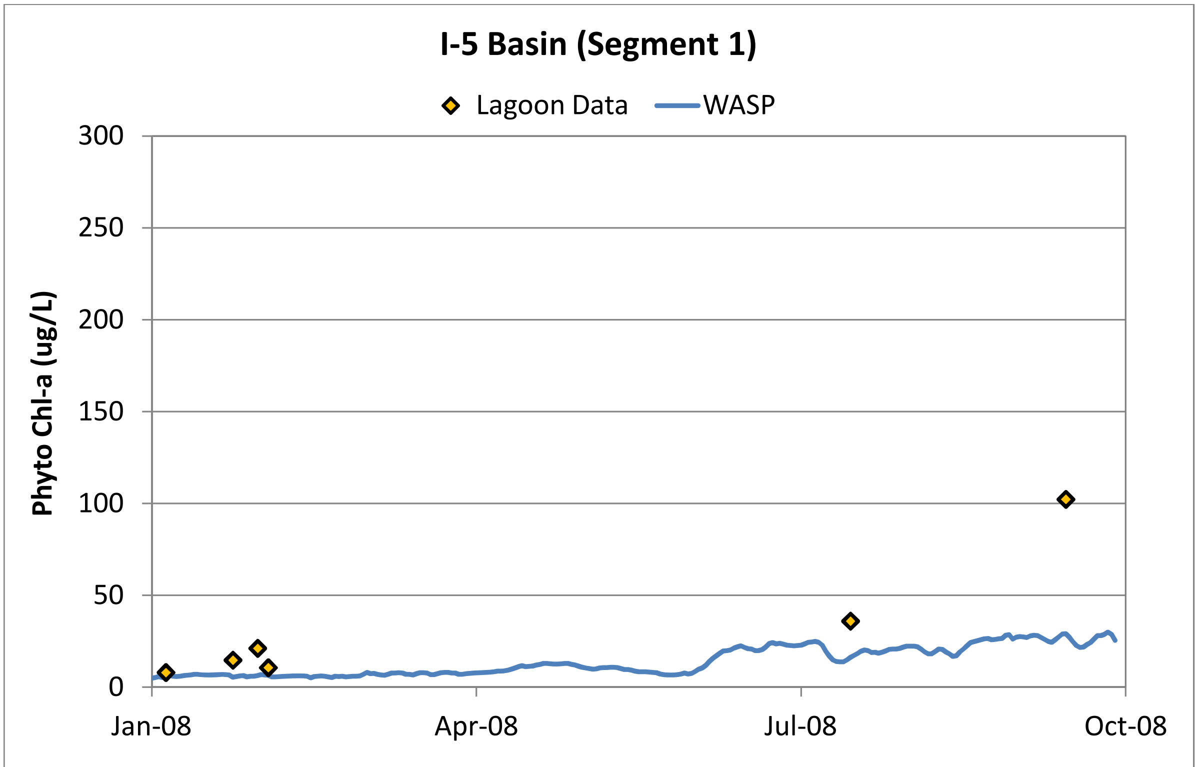


Figure 4.13 Lagoon Data and WASP Total Phosphorus Concentration Comparison



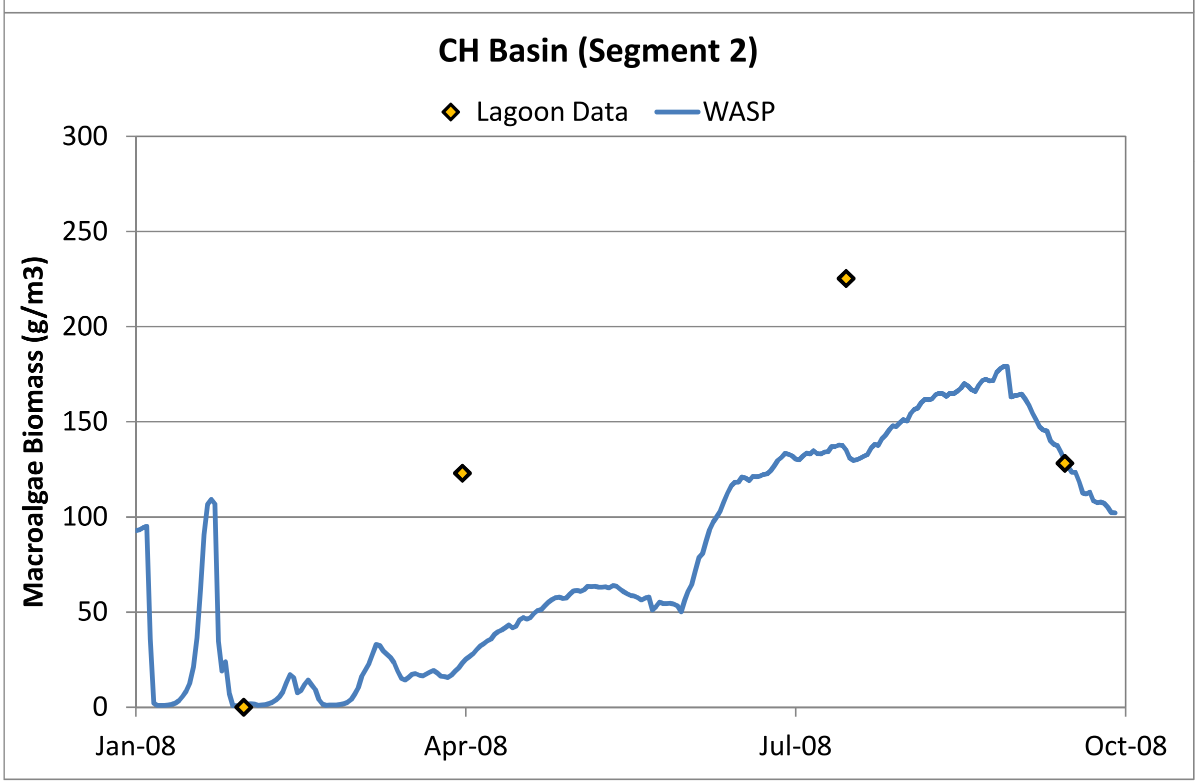


Figure 4.14 Lagoon Data and WASP Phytoplankton and Macroalgae Biomass Comparison

5. MODEL RESULTS AND ALTERNATIVE EVALUATIONS

5.1 OVERVIEW

The linked EFDC and WASP model was used to conduct a one year simulation (October 2007 to September 2008) of the hydrodynamics, salinity, bacterial, dissolved oxygen (DO), nutrient and biomass for the Buena Vista Lagoon under Existing Condition and proposed Alternatives. The results were used to evaluate potential changes and/or water quality improvements with the implementation of the proposed Alternatives.

The model predicted salinity, bacteria, DO, TN, TP and biomass for the Existing Condition and the proposed Alternatives are presented and compared in Section 5.2 below, and the evaluation of proposed Alternatives are evaluated with respect to water quality objectives in Section 5.3. As mentioned in Section 2.4, for the two options of the Hybrid Alternative, only Hybrid Option B with the entire Weir Basin being converted to a salt water basin was modeled and evaluated. Hybrid Option A with a proposed dike to create a perched brackish water basin within the Weir Basin is considered as a variation of the Hybrid Alternative and was not modeled. It is expected that the water quality in the Lagoon basins between Option A and Option B will be similar except for the area behind the dike in the Weir Basin under Option A.

5.2 COMPARISON OF MODEL RESULTS BETWEEN EXISTING CONDITION AND PROPOSED ALTERNATIVES

5.2.1 Salinity

Salinity levels under Existing Condition and proposed Alternatives are compared in Figure 5.1. In the figure, the daily average salinity at a location near the middle of each basin is shown in separate panels. As expected, salinity levels for Existing Conditions (grey dashed line) and Fresh Water Alternative (red line) are very similar, both with salinity ranging between 1 and 2 Practical Salinity Unit (PSU) during dry weather and below 1 PSU during wet weather. For the Saltwater Alternative (blue line), salinity levels in general are similar to those in the ocean during dry weather conditions, with periodic drops in salinity when there is a rain event. In the Weir, Railroad, and CH Basins, dry weather salinity is about 31-32 PSU. The I-5 Basin, which receives fresh water inputs from Buena Vista Creek, in general has lower salinity levels of about 28 PSU. During rain events, the salinity in the Lagoon can temporarily drop to below 5 PSU under the Salt Water Alternative. During the small rain event on May 23-24, the salinity can drop to about 15 PSU at the I-5 Basin and CH Basin, and about 25 PSU at the RR Basin and Weir Basin.

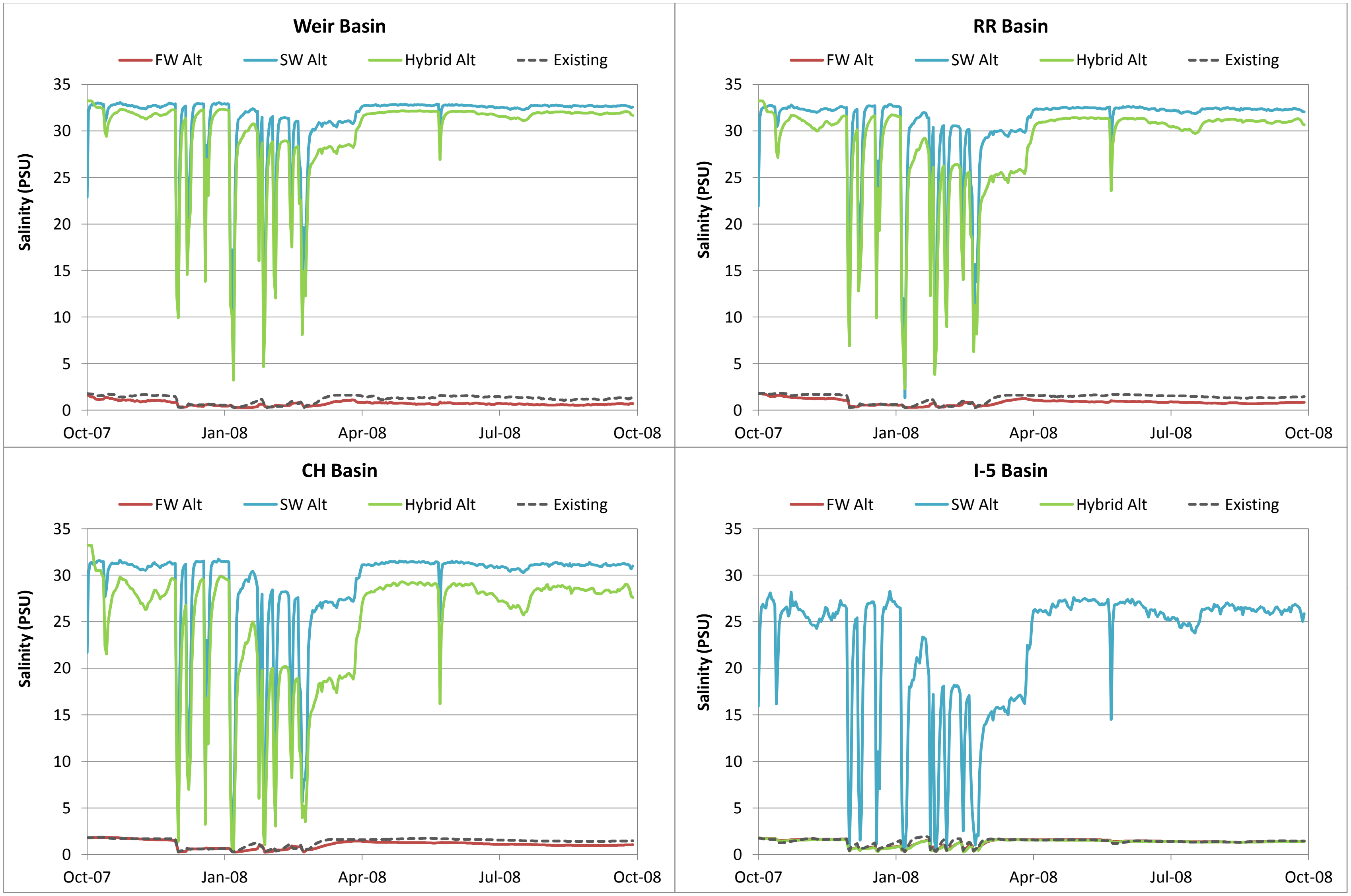


Figure 5.1 Salinity Concentration Comparison

Under the Hybrid Alternative, the I-5 Basin would have a fresh water hydrologic regime, while the other basins would have a salt water hydrologic regime. Hence, the salinity in the I-5 Basin would be similar to those for Existing Condition and Freshwater Alternative; while the salinities in the Weir, Railroad, and CH Basins would be similar to those for the Saltwater Alternative.

5.2.2 Bacteria

Bacteria modeling was conducted for Existing Condition and the proposed Alternatives. For comparative purposes, the bacteria were simulated as a conservative tracer (i.e., no die-off). Since the primary purpose for this study is to compare the change in bacteria levels in the Lagoon among different alternatives, it does not matter whether the effect of die-off is considered. Since freshwater and saltwater regimes in general would have different die-off rates, comparisons can be made between the fresh and salt water regimes without adjusting the die-off rate.

Daily averaged bacteria concentrations for each of the four Lagoon basins under Existing Condition and proposed alternatives are compared in Figures 5.2, 5.3, and 5.4 for enterococcus, fecal coliform, and total coliform, respectively. The bacteria concentrations under the Freshwater Alternative are almost the same as those under Existing Condition. In general, the bacteria concentrations follow the same pattern as the bacteria loading from Buena Vista Creek, with higher bacteria concentrations associated with wet weather flows and lower concentrations during dry weather conditions.

With tidal flushing, bacteria concentrations for the Saltwater Alternative are in general lower than those under Existing Condition. The decrease in bacteria levels in the Weir Basin and Railroad Basin are in general more significant because of strong tidal flushing for those two basins. Being farther away from the ocean tidal inlet (i.e., less tidal flushing), the drop in bacteria concentrations at the CH Basin and I-5 Basin are not as substantial as those in the Weir Basin and Railroad Basin. For the Hybrid Alternative, the bacteria concentrations for the salt water basins (Weir Basin, Railroad Basin and CH Basin) are similar to those for the Saltwater Alternatives, while the bacteria concentrations at the I-5 Basin are similar to those for Existing Condition and Freshwater Alternative.

Since bacteria die-off rates are in general much faster in marine and estuarine waters than freshwater (Thoman and Mueller, 1987), if the effect of bacteria die-off is considered, it is expected that there will be even higher decreases in bacteria concentrations in the salt water basins for the Saltwater Alternative and Hybrid Alternative compared to the Existing Condition.

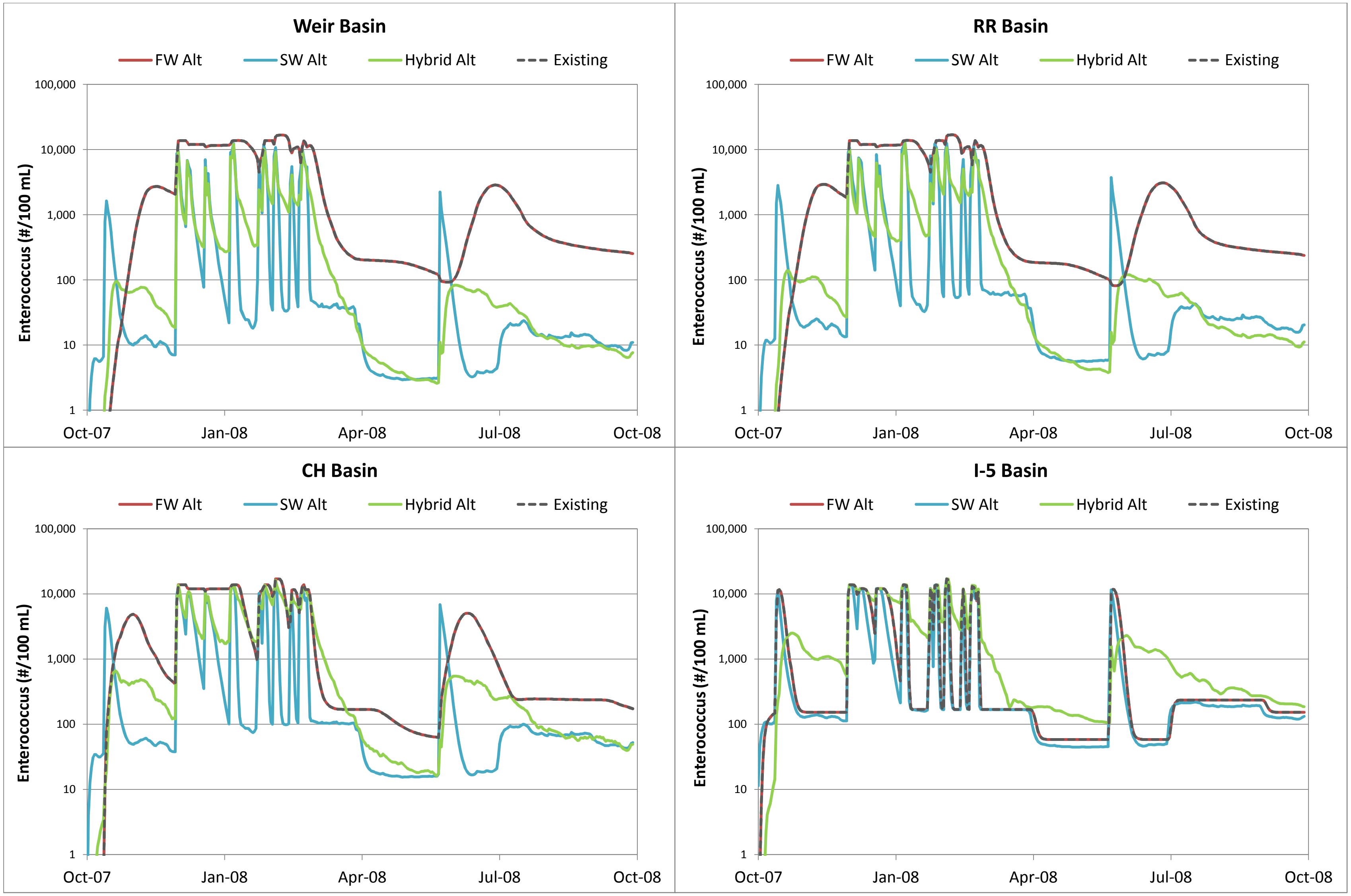


Figure 5.2 Enterococcus Bacteria Concentration Comparison

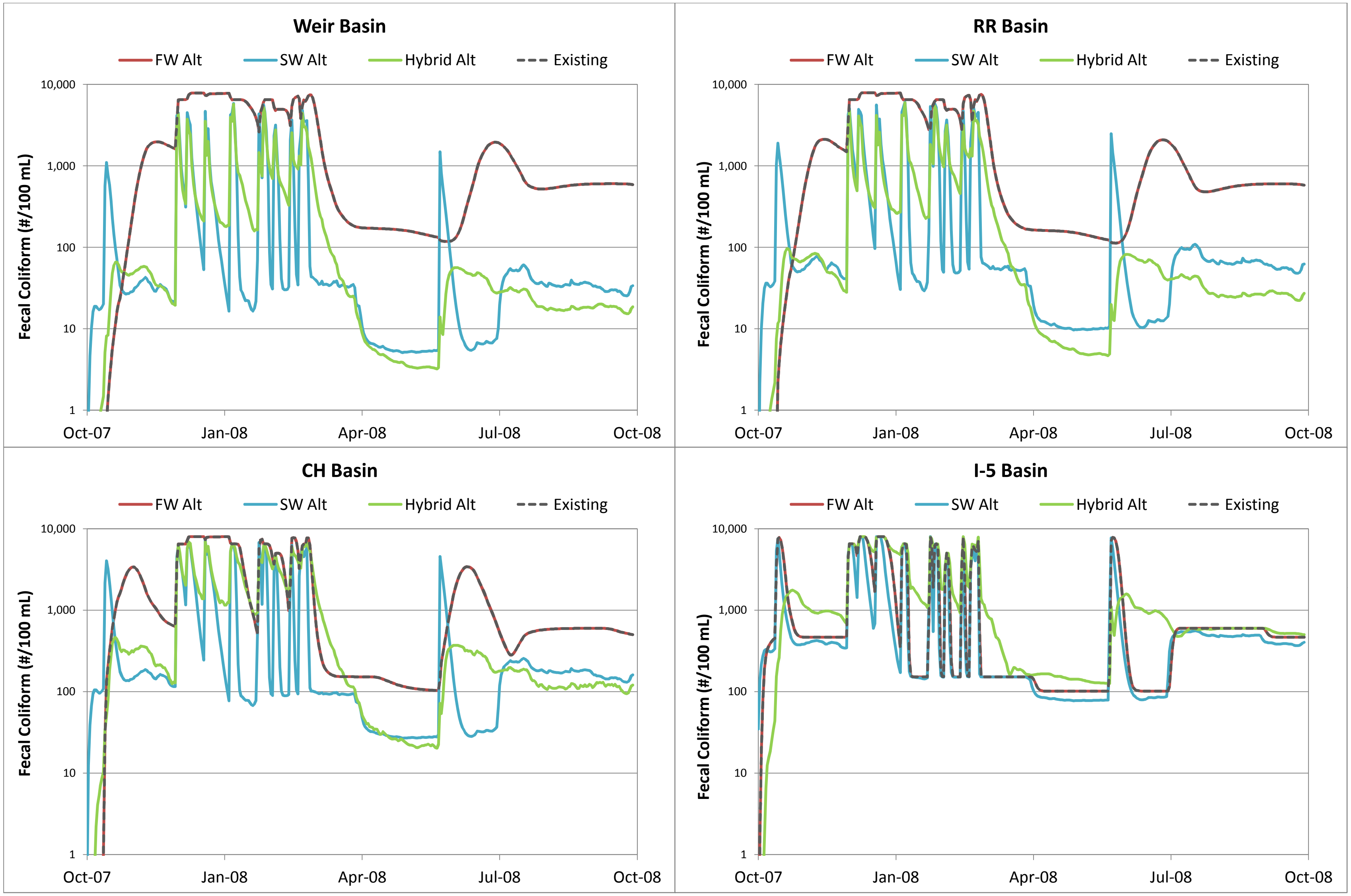


Figure 5.3 Fecal Coliform Bacteria Concentration Comparison

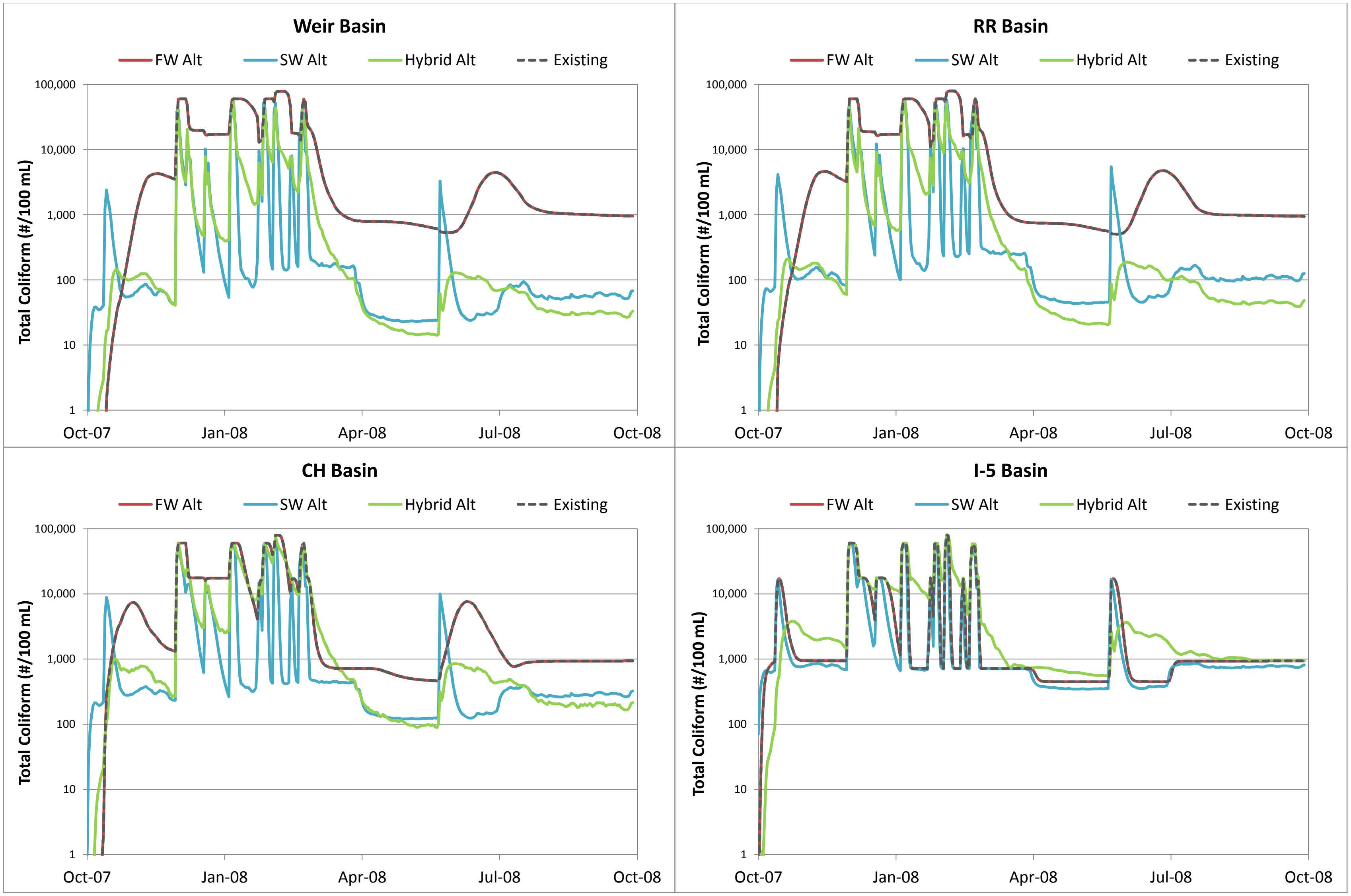


Figure 5.4 Total Coliform Bacteria Concentration Comparison

5.2.3 Dissolved Oxygen

The WASP simulated dissolved oxygen concentrations for the Existing Condition and the proposed Alternatives are presented in Figure 5.5. In this figure, the averaged daily values across each basin through the one-year simulation period are plotted.

The grey dashed lines in the figure represent the dissolved oxygen concentration for the Existing Condition. As shown in the figure, the dissolved oxygen concentration is higher during the wet season in the Weir Basin, RR Basin and CH Basin. The dissolved oxygen concentration in the I-5 Basin remains low throughout the year with a daily average of around 10 mg/L. The red lines in figure represent the dissolved oxygen concentration for the Freshwater Alternative. Similar to the Existing Condition, the dissolved oxygen concentration under the Freshwater Alternative is higher during the wet season in the Weir Basin, RR Basin and CH Basin, and lower in the I-5 Basin.

The blue lines in Figure 5.5 represent the dissolved oxygen concentration for the Saltwater Alternative. Since there would be tidal exchange in the Lagoon for the Saltwater Alternative, the dissolved oxygen concentration is much influenced by the ocean water, which was set at 7.9 mg/L in the WASP model. The green lines in Figure 5.5 represent the dissolved oxygen concentration for the Hybrid Alternative. Similar to the Salt Water Alternative, there would be tidal exchange in the Weir, RR and CH Basins for the Hybrid Alternative; hence, the dissolved oxygen concentration is also influenced by the ocean water. In the I-5 Basin, the dissolved oxygen concentration is below 5 mg/L in March and April.

5.2.4 Total Nitrogen

The WASP simulated total nitrogen concentrations for the existing conditions and the proposed alternatives are compared in Figure 5.6. In this figure, the averaged daily values across each basin for the one-year simulation period are plotted. The grey dashed lines in the figure represent the total nitrogen concentrations for the Existing Condition. As shown in the figure, the total nitrogen concentration is higher during the wet season in all the four basins. The highest daily averaged total nitrogen concentration occurs in January and is about 4 mg/L. The red lines in the figure represent the total nitrogen concentrations for the Freshwater Alternative. In general, the total nitrogen concentrations for the Freshwater Alternative are similar to those under Existing Condition.

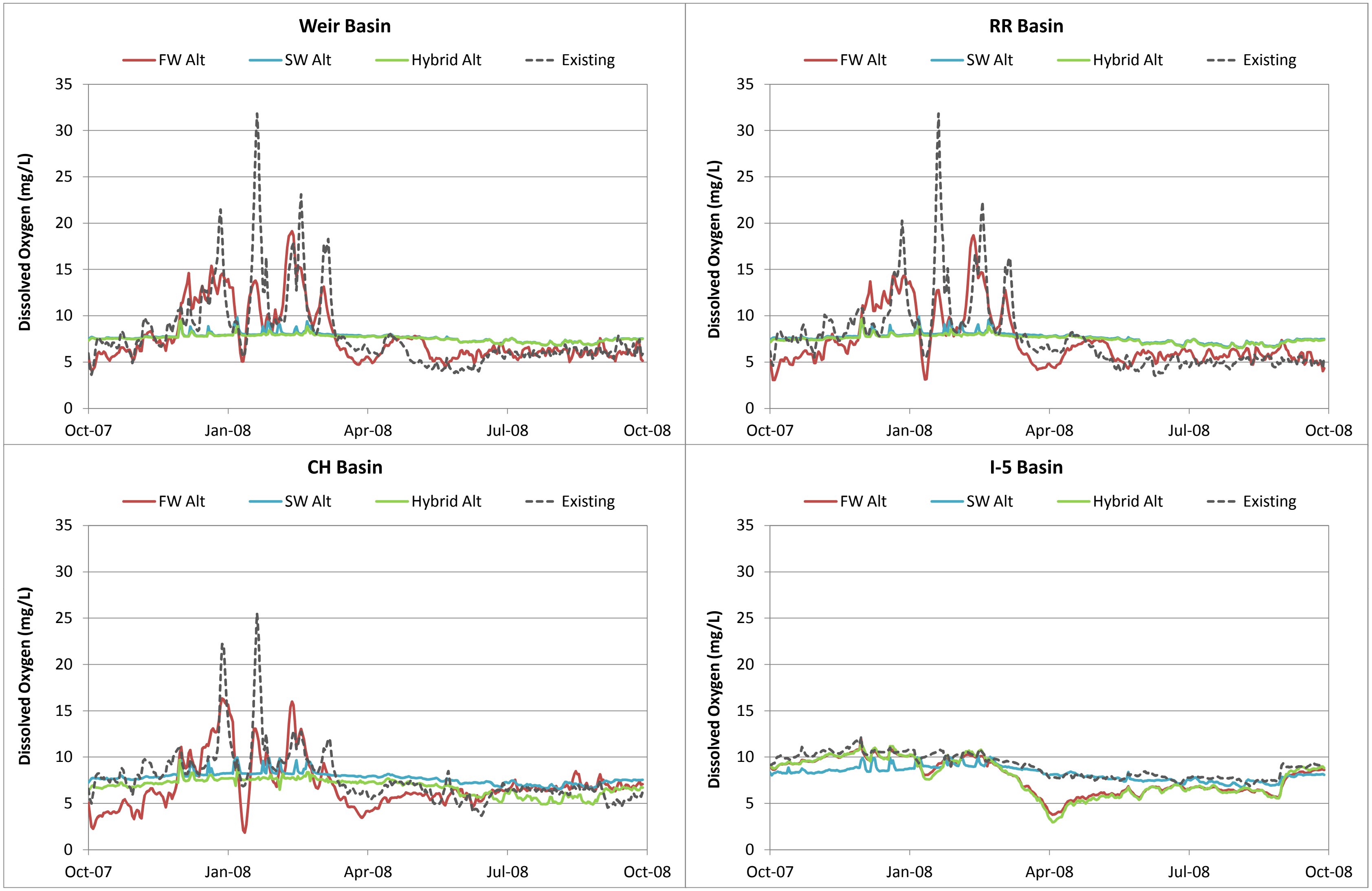


Figure 5.5 Dissolved Oxygen Concentration Comparison

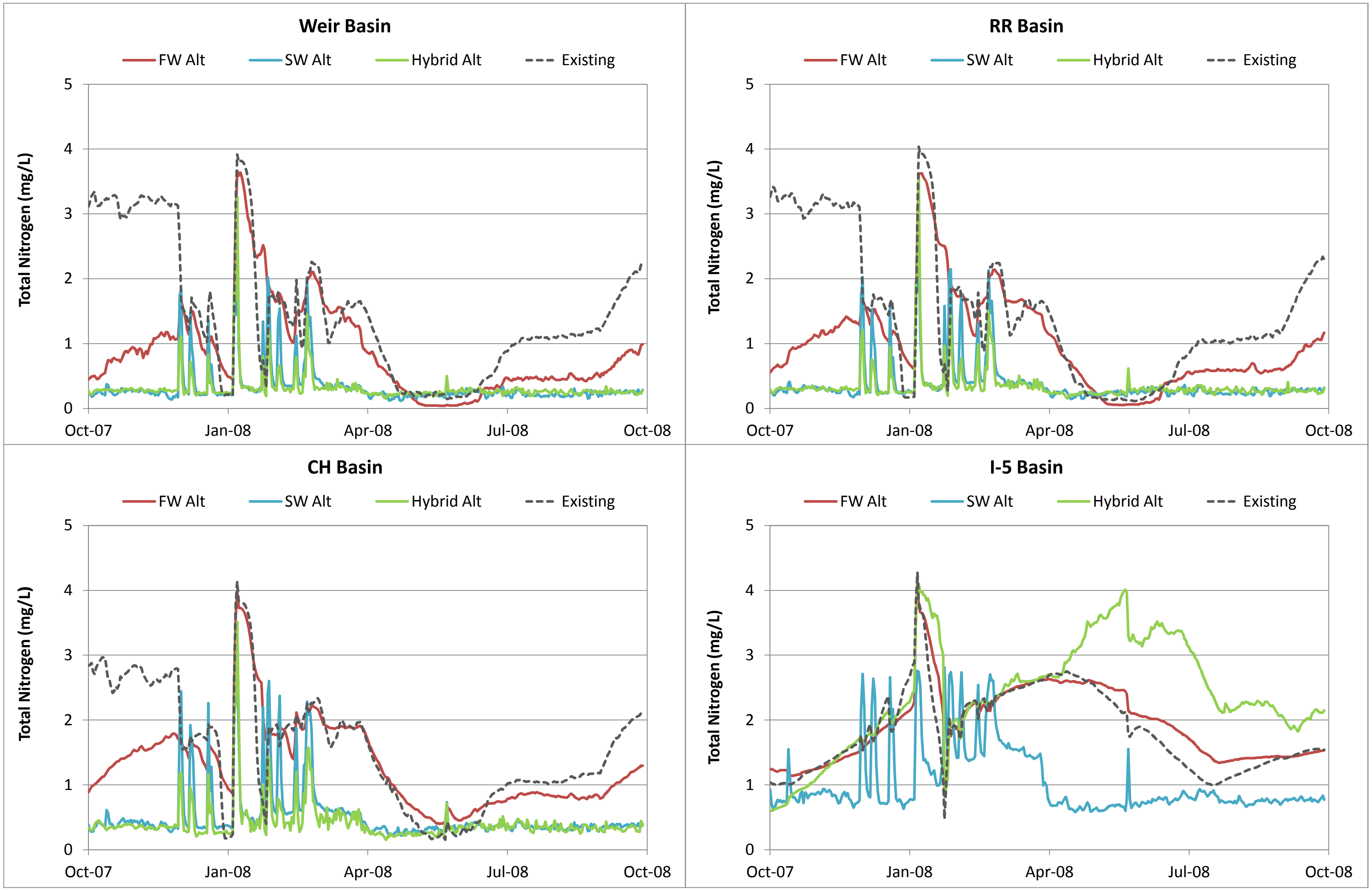


Figure 5.6 Total Nitrogen Concentration Comparison

The blue lines in Figure 5.6 represent the total nitrogen concentrations for the Saltwater Alternative. Since there would be tidal exchange in the Lagoon for the Saltwater Alternative, the total nitrogen concentration is much influenced by the ocean water, which was assumed to be zero in the WASP model based on the condition used for the Loma Alta Slough study (Sutula et al., 2013). The green lines in the figure represent the total nitrogen concentrations for the Hybrid Alternative. Since there would be tidal exchange in the Weir, RR and CH Basins for the Hybrid Alternative, the total nitrogen concentrations in those basins are similar to those under the Saltwater Alternative. In the I-5 Basin, the total nitrogen concentration is similar to the Existing Condition for the wet weather periods. However, with the presence of the weir at the I-5 Bridge limiting the flow from the I-5 Basin to the CH Basin, the total nitrogen concentration in the I-5 Basin under the Hybrid Alternative is higher compared to Existing Condition.

5.2.5 Total Phosphorus

The WASP simulated total phosphorus concentrations for the existing conditions and the proposed alternatives are compared in Figure 5.7. In this figure, the averaged daily values across each basin for the one-year simulation period are plotted. The grey dashed lines in the figure represent the total phosphorus concentrations for the Existing Conditions. As shown in the figure, the total phosphorus concentration is higher during the wet season in the three downstream basins, i.e. Weir Basin, RR Basin and CH Basin. The highest daily averaged total phosphorus concentration occurs in January and it ranges between 1.2 mg/L in the Weir Basin to 1.4 mg/L in the CH Basin. The total phosphorus concentration in the I-5 Basin is lower through the simulation period.

The red lines in Figure 5.7 represent the total phosphorus concentrations for the Freshwater Alternative. The total phosphorus concentration is less than 0.25 mg/L in most areas during the simulation period. The highest daily averaged total phosphorus concentration occurs in September and the concentration reaches 0.27 to 0.29 mg/L for several days. The total phosphorus concentration in the I-5 Basin is lower and exhibits less variation, the daily average value fluctuates around 0.04 mg/L.

The blue lines in Figure 5.7 represent the total phosphorus concentrations for the Saltwater Alternative. Since there would be tidal exchange in the Lagoon for the Saltwater Alternative, the total phosphorus concentration is much influenced by the ocean water, the concentration of which was set to zero in the WASP model based on the condition used for the Loma Alta Slough study (Sutula et al., 2013). The green lines in Figure 5.7 represent the total phosphorus concentrations for the Hybrid Alternative. Similar to the Saltwater Alternative, there would be tidal exchange in the Weir, RR and CH Basins for the Hybrid Alternative, the total phosphorus concentration is much influenced by the ocean water. In the I-5 Basin, the total phosphorus concentration is low and similar to the Existing Conditions and other alternatives.

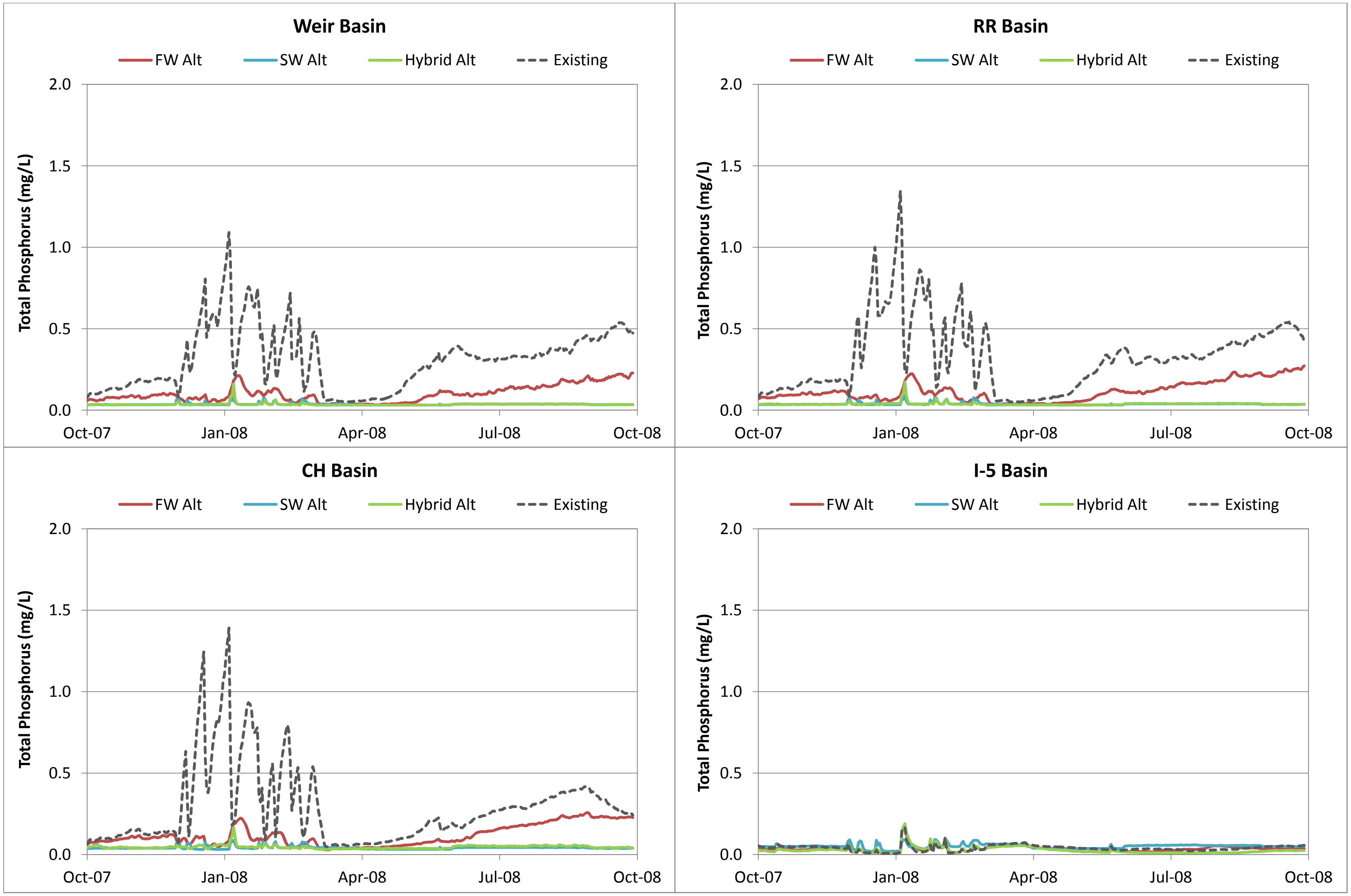


Figure 5.7 Total Phosphorus Concentration Comparison

5.2.6 Phytoplankton and Macroalgal Biomass

The biomass concentrations for the Existing Condition and the proposed Alternatives are compared in Figure 5.8. As discussed in Section 4.3.8, the I-5 Basin is currently dominated by phytoplankton (expressed as μg/L chlorophyll-a) while the other downstream basins are dominated by macroalgae (expressed as mg dry weight/m^3). The grey dashed lines in Figure 5.8 represent the macroalgal and phytoplankton biomass for the Existing Condition. As shown in the figure, the biomass is generally higher during the dry seasons in the three downstream basins (Weir Basin, RR Basin and CH Basin). The highest daily averaged biomass occurs in September 2008 and it ranges between 180 g/m^3 in the CH Basin to 220 g/m^3 in the Weir and RR Basins. In the I-5 Basin, the phytoplankton chlorophyll-a concentration is below 25 ug/L throughout the simulation period.

The red lines in Figure 5.8 represent the biomass concentrations for the Freshwater Alternative. The biomass concentration for the basins where macroalgae dominates is mostly below 90 g/m^3 dry weight. The highest daily averaged biomass concentration occurs in September when the concentration is higher than 90 g/m^3. The chlorophyll-a concentration in the I-5 Basin is mostly below 25 μg/L. However, there is a period during the summer when the concentration exceeds 25 μg/L.

The blue lines and green lines in Figure 5.8 represent the biomass concentrations for the Saltwater Alternative and Hybrid Alternative, respectively. The growths of phytoplankton and macroalgae appear to be minimal due to the flushing out of biomass with the in the tidally influenced Lagoon basins. In the I-5 Basin, the phytoplankton chlorophyll-a concentration for the Hybrid Alternative is also generally lower than those for Existing Condition.

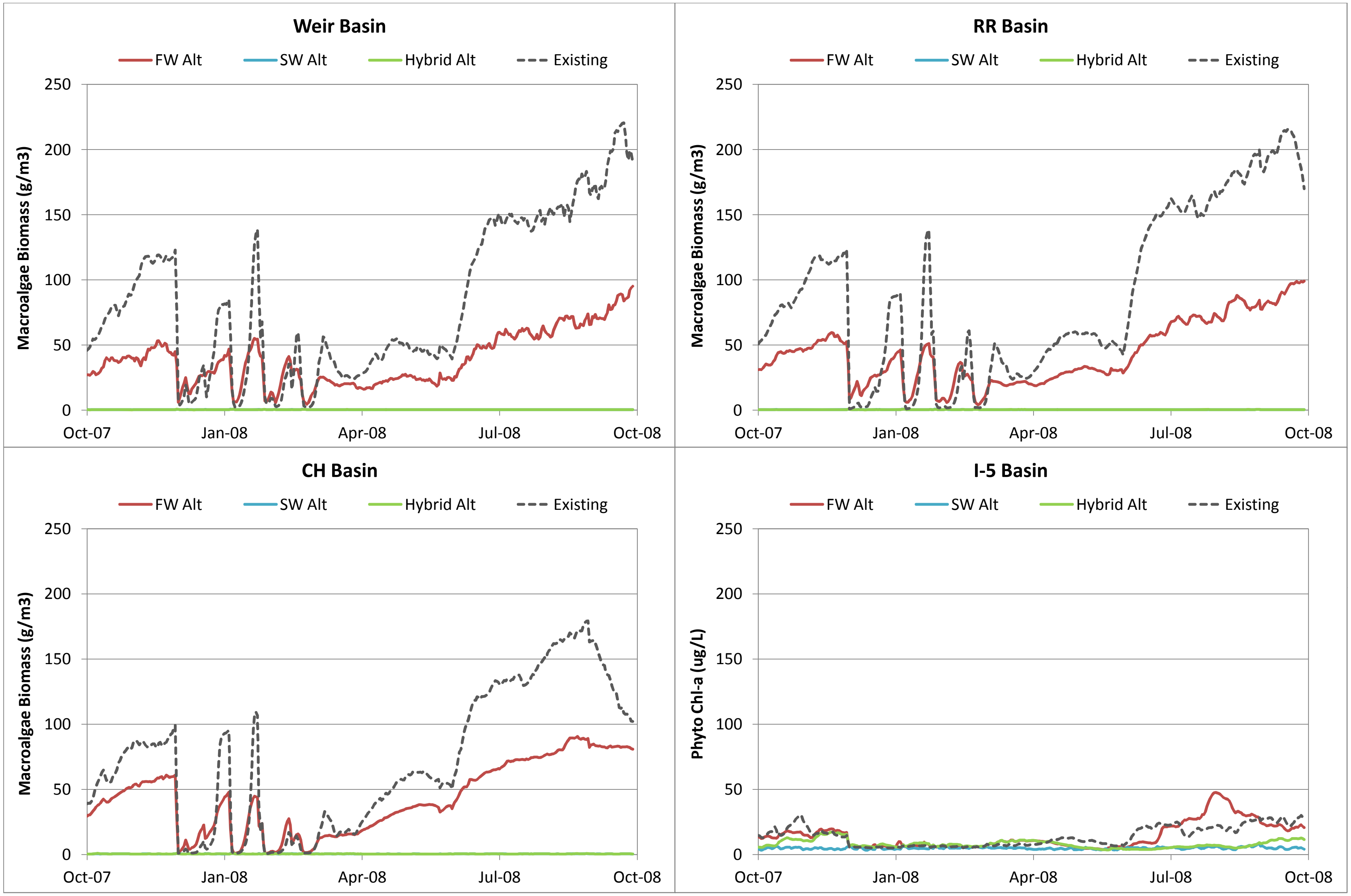


Figure 5.8 Macroalgae Biomass and Phytoplankton Comparison

5.3 EVALUATION OF ALTERNATIVES IN MEETING WATER QUALITY OBJECTIVES AND GUIDANCE

One lens from which to evaluate the Buena Vista Lagoon enhancement alternatives is to what extent each of the alternatives under consideration may alleviate water quality problems in the Lagoon. While it is unreasonable to expect that enhancement would address all water quality problems, some benefit may occur. The purpose of this analysis is to quantify the reduction in water quality problems that each enhancement alternative may provide using established regulatory objectives or guidance. In general, the evaluation of the alternatives will follow three set water quality objectives (WQOs) specified in the SDRWQCB Basin Plan with some modifications based on recent work in Loma Alta Slough by Sutula et al (2013). The three WQOs used to evaluate water quality improvements are: (1) FIB Objectives, 2) Biostimulatory Objectives (Nuisance Algae and Nutrients) and 3) Dissolved Oxygen objectives.

5.3.1 Bacteria

Approach

Fecal indicator bacteria (FIB) are used as surrogate indicators of waterborne pathogens that can cause illness in humans. Exposure can occur through recreational activities or consumption of filter-feeding shellfish. In 2010, the Revised TMDL for Indicator Bacteria, Project I – Twenty Beaches and Creeks in the San Diego Region (including Tecolote Creek), hereafter referred to as Revised Bacteria TMDLs Project I, was adopted and approved into the San Diego Basin Plan (effective April 4, 2011). In the Basin Plan, WQOs have been established for bacteria in the water of the Pacific Ocean shoreline, as summarized in Table 5.1.

Table 5.1 Water Quality Objectives for Bacteria

WATER QUALITY OBJECTIVE	ENTEROCOCCUS*	FECAL COLIFORM*	TOTAL COLIFORM*
Single Sample	104	400	10,000
30-day Geomean	35	200	1,000

Source: SDRWQCB 2010
**Units in Most Probable Number (MPN)/100 mL*

The Basin Plan states allowable exceedances of REC-1 WQOs due to bacteria loads from natural, uncontrollable sources. Allowable exceedances may be applied using a reference system or natural source exclusion approach (SDRWQCB 2010). Currently, interim numeric targets for the bacteria TMDLs specify a 22% exceedance allowance for wet weather and 0% exceedance for dry weather. This allowable exceedance was based on a reference system study conducted in the Los Angeles region.

The bacteria WQOs are applicable based on bacteria samples. For example, the geomean criteria are applicable based on a minimum of five samples for a 30-day period. However, the bacteria modeling are based on a one-year simulation period. Interpretation of the WQOs using modeling results has been previously utilized in the Loma Alta Slough Bacteria and Nutrient TMDL modeling study, which sets precedence for interpretation of these WQOs using bacteria modeling results (Sutula et.al 2013). Application of bacteria modeling results requires the following:

- Simulated bacteria concentrations need to be spatially averaged and daily averaged
- Compute running 30-day geometric mean for comparison with corresponding criteria
- Days of exceedance will be used to compare simulated bacteria concentrations with FIB criteria over a one-year period
- Wet weather is defined as a rain event greater than 0.1 inches for the day of the storm plus 72 hours (3 days)

In this analysis, evaluation of the bacteria modeling was conducted with the same approach used for the Loma Alta Slough Bacteria TMDL. The bacteria modeling were conducted for a one-year simulation period from October 2007 to September 2008. Daily average bacteria concentrations were determined for each Lagoon basin using the EFDC model-simulated bacteria concentrations presented previously in Section 5.2.2. The one-year model period contained a total of 366 days comprised of 58 wet days and 308 dry days. The bacteria concentrations for the wet weather days were compared to the single sample criteria to determine the number of wet weather exceedance days. The dry weather daily average concentrations were also compared to the single sample criteria. In addition, the 30-day geometric mean bacteria concentration were calculated and compared with the 30-day geomean criteria to determine the number of dry weather exceedance days. The percent exceedance was determined as the number of exceedance days divided by the number of wet or dry weather days. As mentioned previously, the bacteria modeling does not account for bacteria die-off to allow comparison between alternatives. Hence, the bacteria evaluation does not represent the actual exceedances expected under the analyzed alternatives.

Results

The model predicted wet weather percent exceedances are summarized in Table 5.2. In general, there was not much difference between Existing Condition and the enhancement alternatives in the ability to meet wet weather FIB WQO. The wet weather percent exceedances for both the Existing Condition and Fresh Water Alternative ranged from 72% to 100%. Among the three alternatives, the Saltwater Alternative resulted in the most decrease in the wet weather percent exceedances compared to Existing Condition, especially for the fecal and total coliform. For the Hybrid Alternative, the wet weather percent exceedances were similar to the Saltwater Alternative except for the I-5 Basin.

Table 5.2 Wet Weather Bacteria Exceedance (Percent of Days in a Year)

ALTERNATIVE	FIB	WEIR BASIN	RR BASIN	CH BASIN	I-5 BASIN
Existing Conditions	Enterococcus	93%	93%	97%	100%
	Fecal Coliform	93%	93%	93%	84%
	Total Coliform	93%	93%	90%	72%
Freshwater Alternative	Enterococcus	93%	93%	97%	100%
	Fecal Coliform	93%	93%	93%	84%
	Total Coliform	93%	93%	90%	72%
Saltwater Alternative	Enterococcus	83%	86%	90%	100%
	Fecal Coliform	81%	81%	83%	81%
	Total Coliform	34%	48%	53%	62%
Hybrid Alternative	Enterococcus	93%	93%	93%	100%
	Fecal Coliform	90%	90%	93%	95%
	Total Coliform	36%	45%	78%	83%

The simulated dry weather exceedances based on the single sample criteria and the 30-day geomean are shown in Table 5.3 and Table 5.4, respectively. As shown in these tables, dry weather simulations showed more distinction among the proposed Alternatives compared to the wet weather results. Under Existing Condition and Freshwater Alternative, the highest percent exceedance would occur for enterococcus, followed by fecal coliform and then total coliform. The percent exceedances are similar under the Freshwater Alternative and Existing Condition. In comparison with the Existing Condition and the Freshwater Alternative, the percent exceedances for the Saltwater would be generally an order of magnitude lower. For the Hybrid Alternative, the percent exceedances would be lower in the salt water regime basins and higher in the I-5 Basin compared to Existing Condition.

Table 5.3 Dry Weather Bacteria Single Sample Exceedance (Percent of Days in a Year)

ALTERNATIVE	FIB	WEIR BASIN	RR BASIN	CH BASIN	I-5 BASIN
Existing Conditions	Enterococcus	89%	89%	97%	73%
	Fecal Coliform	61%	62%	65%	53%
	Total Coliform	13%	13%	11%	5%
Freshwater Alternative	Enterococcus	89%	89%	97%	73%
	Fecal Coliform	61%	62%	65%	53%
	Total Coliform	13%	13%	11%	5%
Saltwater Alternative	Enterococcus	5%	6%	9%	72%
	Fecal Coliform	1%	4%	7%	35%
	Total Coliform	0%	0%	1%	1%
Hybrid Alternative	Enterococcus	14%	15%	37%	95%
	Fecal Coliform	4%	8%	17%	72%
	Total Coliform	0%	1%	5%	11%

Table 5.4 Dry Weather Bacteria 30-Day Geomean Exceedance (Percent of Days in a Year)

ALTERNATIVE	FIB	WEIR BASIN	RR BASIN	CH BASIN	I-5 BASIN
Existing Conditions	Enterococcus	87%	88%	90%	100%
	Fecal Coliform	65%	65%	67%	67%
	Total Coliform	55%	49%	44%	26%
Freshwater Alternative	Enterococcus	87%	88%	90%	100%
	Fecal Coliform	65%	65%	67%	67%
	Total Coliform	55%	49%	44%	26%
Saltwater Alternative	Enterococcus	16%	31%	79%	100%
	Fecal Coliform	0%	0%	13%	63%
	Total Coliform	0%	0%	0%	11%
Hybrid Alternative	Enterococcus	43%	48%	79%	96%
	Fecal Coliform	10%	13%	39%	73%
	Total Coliform	8%	11%	19%	61%

<ins>Summary</ins>

In summary, the Freshwater Alternative shows no change in bacteria exceedance compared to Existing Conditions. The Saltwater Alternative results in substantial reduction in bacteria exceedance due to the tidal flushing from the Lagoon. Under the Hybrid Alternative, there are reductions in bacteria exceedance in the Weir, Railroad, and Coast Highway Basin, but a slight increase in the I-5 Basin because the weir at the I-5 Bridge traps the flow and associated bacteria loading from Buena Vista Creek in the I-5 Basin for a longer time.

5.3.2 Nuisance Algae, Nutrients and Dissolved Oxygen

Approach

The San Diego RWQCB has existing dissolved oxygen objectives and biostimulatory objectives, the latter which establishes narrative guidance on nuisance algae and numeric guidance for nutrient concentrations for estuaries (Table 5.5). These objectives, along with numeric targets from the Loma Alta Slough TMDL, were used to evaluate the enhancement alternatives relative to Existing Condition.

Numeric Targets*:* For dissolved oxygen, the Basin Plan objective of 5 mg/L (for designated WARM beneficial uses) was used as the numeric target to evaluate the restoration alternatives (Table 5.5). This was based on the precedent established in the Loma Alta Slough TMDL (Sutula et al. 2013).

Numeric targets supporting the biostimulatory objective require additional explanation. The intent of the biostimulatory objective is that either nutrients or other human impacts (e.g. habitat and hydromodification) can cause algal overgrowth. Total nitrogen and phosphorus limits are provided by water body type to translate these narrative objectives. However, the science supporting the nutrient limits is dated. During the process of a TMDL, State Water Board Impaired Waters Guidance (SWRCB 2005) allows for the use of alternative targets in lieu of established basin plan objectives when there is adequate scientific evidence supporting an alternative. Alternative numeric targets were used to interpret the biostimulatory objective in the Loma Alta Slough TMDL (Sutula et al. 2013). Consideration of alternative targets included two types of algae: 1) Macroalgae and 2) phytoplankton (e.g. water column chlorophyll a) are the preferred indicators. The rationale for consideration of these two alternative numeric targets are given in greater detail in Sutula et al. (2013) and Tetra Tech (2006).

The SDRWQCB chose to use 90 g m^{-3} dry weight algae as the numeric target for Loma Alta Slough. This numeric target is appropriate for evaluation of the CH Basin, RR Basin and Weir Basin of Buena Vista Lagoon, where the biomass are dominated by macroalgae (McLaughlin et al, 2011). For the I-5 Basin, in which biomass is dominated by phytoplankton, a numeric target of 25 mg m^{-3} chlorophyll-a is used. This numeric target was proposed by Tetra Tech (2006) at which WARM beneficial uses become impaired, and has been used in previous TMDLs, including Los Angeles lakes (US EPA 2012).

These phytoplankton biomass (I-5 Basin) and macroalgal biomass (CH Basin, RR Basin, and Weir Basin) alternative numeric targets were used, in addition to existing total phosphorus and nitrogen guidance (0.025 mg P L-1 and 0.25 mg L-1 TN) in the Biostimulatory Objectives, to compare restoration alternatives. However, more emphasis is given to degree of compliance with algae numeric targets than to the total nutrient concentrations, consistent with the Loma Alta Slough TMDL (Sutula et al. 2013).

Table 5.5 SDRWQCB Basin Plan Objectives for Biostimulatory Substances and Dissolved Oxygen

INDICATOR	OBJECTIVES
Dissolved Oxygen	Dissolved oxygen levels shall not be less than 5.0 mg L^{-1} in inland surface waters with designated MAR or WARM beneficial uses or less than 6.0 mg L^{-1} in waters with designated COLD beneficial uses.
Bio-stimulatory Substances	Inland surface waters, bays and estuaries and coastal lagoon waters shall not contain biostimulatory substances in concentrations that promote aquatic growth to the extent that such growths cause nuisance or adversely affect beneficial uses. Threshold total phosphorus (P) concentrations shall not exceed 0.05 mg L^{-1} in any stream at the point where it enters any standing body of water, nor 0.025 mg L^{-1}in any standing body of water. A desired goal in order to prevent plant nuisance in streams and other flowing waters appears to be 0.1 mg L^{-1} total P. These values are not to be exceeded more than 10% of the time unless studies of the specific water body in question clearly show that water quality objective changes are permissible and changes are approved by the Regional Board. Analogous threshold values have not been set for nitrogen compounds; however, natural ratios of nitrogen to phosphorus are to be determined by surveillance and monitoring and upheld. If data are lacking, a ratio of N:P = 10:1, on a weight to weight basis shall be used. Note - Certain exceptions to the above water quality objectives are described in Section 4 in the subsections titled Discharges to Coastal Lagoons from Pilot Water Reclamation Projects and Discharges to Inland Surface Waters.

***Evaluation of Alternatives using Numeric Targets**:* As with bacteria, the San Diego RWQCB has established policies allowing for occasional non-compliance of dissolved oxygen (DO) and biostimulatory objectives. The San Diego RWQCB Basin plan generally allows for 10% of chemical values (e.g., nutrients and DO) to be out of compliance with established objectives. This same rate of non-compliance was also applied to nuisance algae in the Loma Alta Slough TMDL.

Application of this 10% rule to monitoring data or model output varies depending on whether the target should not be exceeded (as in nutrient concentrations and algal biomass) or should not fall below (as in DO). For nutrients and algal biomass, the 90th percentile (the value below which 90 percent of the nutrients or algal biomass model output values may be found) of monitoring or modeling data defines whether the waterbody is meeting objectives. For DO, the 10th percentile is used to determine compliance with the objective.

Thus the 10th percentile was applied nutrient and algal biomass daily averaged values and the 90th percentile applied to DO values to compare restoration alternatives' compliance with eutrophication WQOs. In addition, for each calendar day of the one year simulation, average biomass, TN and TP concentration were computed for each basin for the existing conditions and proposed alternatives. The percent of days in one year that the daily value exceeded the numeric targets [5 mg/L for DO; 25 mg m^{-3} chlorophyll-a (I-5 Basin) or 90 g m^{-3} dry weight mass (Coast Highway Basin, RR Basin and Weir Basin), 0.025 mg L^{-1} TP (all basins), 0.25 mg L^{-1} TN (all basins)] was computed and compared.

Results

Nuisance Algae*:* Under Existing Condition, the WASP model results show uniformly high concentrations of phytoplankton and macroalgal biomass that exceed numeric targets (Table 5.6); biomass in the I-5 Basin exceeds the numeric target 11% of the time, while the rate roughly triple that for the other basins (Table 5.7). The Freshwater Alternatives show similar exceedance rates for the I-5 Basin as Existing Conditions but substantially less exceedance for the other three basins (Table 5.7). With the implementation of the Saltwater or the Hybrid Alternatives, the WASP results show that all basins would fall below the numeric targets every day (Table 5.7), with algal biomass at one to two orders of magnitude lower than the Existing Condition or Freshwater Alternative (Table 5.6).

Table 5.6 Comparison of the 90th Percentile of Biomass (Chl-a or Macroalgae) Concentration among Lagoon Alternatives. The I-5 Basin results are compared relative to a numeric target of 25 mg Chlorophyll-a /m^3, while the remaining basins are compared relative to 90 g dry weight/m^3 macroalgae.

Lagoon Condition	I-5 Basin Phyto Chl-a (mg Chl-a/m^3)	CH Basin Macroalgae (g DW/m^3)	RR Basin Macroalgae (g DW/m^3)	Weir Basin Macroalgae (g DW/m^3)
Existing	25.3	150.7	183.6	164.9
Freshwater	28.9	82.5	81.9	70.2
Saltwater	6.0	0.6	0.5	0.5
Hybrid	12.0	0.6	0.5	0.5

Table 5.7 Percent of Days Exceeding Algal Biomass Numeric Target of 25 mg Chlorophyll-a /m^3 for I-5 Basin, 90 g dry weight /m^3 Macroalgae for Other Basins

Lagoon Condition	I-5 Basin	CH Basin	RR Basin	Weir Basin
Existing	11%	35%	42%	40%
Freshwater	14%	0%	4%	1%
Saltwater	0%	0%	0%	0%
Hybrid	0%	0%	0%	0%

Total Nutrient Concentrations*:* While not bringing the concentrations below the WQO (Tables 5.8 and 5.9), the Saltwater and Hybrid Alternatives reduce total phosphorus and nitrogen by roughly an order of magnitude relative to the Existing Condition in the CH, RR and Weir Basins (Tables 5.10 - 5.11). None of the alternatives appear to have a substantial effect on total nitrogen and phosphorus concentrations in the I-5 Basin. This is likely due to the fact that there is not sufficient dilution of Buena Vista Creek water, the major source of nutrients to the Lagoon.

Table 5.8 Percent of Days Exceeding for Total Phosphorus Concentration Numeric Target of 0.025 mg/L

LAGOON CONDITION	I-5 BASIN	CH BASIN	RR BASIN	WEIR BASIN
Existing	83%	100%	100%	100%
Freshwater	71%	100%	100%	100%
Saltwater	95%	100%	100%	100%
Hybrid	40%	100%	100%	100%

Table 5.9 Percent of Days Exceeding for Total Nitrogen Numeric Target of 0.25 mg/L

LAGOON CONDITION	I-5 BASIN	CH BASIN	RR BASIN	WEIR BASIN
Existing	100%	93%	86%	86%
Freshwater	100%	100%	88%	86%
Saltwater	100%	98%	66%	46%
Hybrid	100%	89%	79%	63%

Table 5.10 Comparison of the 90th Percentile of Total Phosphorus Concentration among Lagoon Alternatives Relative to a numeric target of 0.025 mg P/L

LAGOON CONDITION	I-5 BASIN	CH BASIN	RR BASIN	WEIR BASIN
Existing	0.060	0.609	0.606	0.535
Freshwater	0.054	0.227	0.213	0.183
Saltwater	0.064	0.045	0.040	0.038
Hybrid	0.051	0.056	0.042	0.039

Table 5.11 Comparison of the 90th Percentile of Total Nitrogen Concentration among Lagoon Alternatives Relative to a Numeric Target of 0.25 mg N/L

LAGOON CONDITION	I-5 BASIN	CH BASIN	RR BASIN	WEIR BASIN
Existing	2.65	2.78	3.17	3.20
Freshwater	2.60	1.91	1.73	1.69
Saltwater	1.66	0.70	0.49	0.45
Hybrid	3.51	0.58	0.41	0.35

Dissolved Oxygen: The percent of times the WASP model simulated DO in the Lagoon basins that would fall below the DO objective numeric target of 5 mg/L (a.k.a., non-compliance) are shown in Table 5.12. Under Existing Condition, except for the I-5 Basin, DO in the Lagoon would fall below the DO numeric target about 7 to 20% of the time. The frequency of non-compliance for the Freshwater Alternative would be similar to the Existing Condition (4 to 18%). The Saltwater Alternative would be in compliance for all the basins, while the Hybrid Alternative would have substantial reduction in frequency of non-compliance to 0 to 6%. The 10th percentile DO concentrations for CH Basin, RR Basin, and Weir Basin under the Saltwater Alternative and Hybrid Alternative are all higher than those under Existing Condition and the Freshwater Alternative (Table 5.13).

Table 5.12 Percent of Time below Dissolved Oxygen Objective of 5 mg/L

LAGOON CONDITION	I-5 BASIN	CH BASIN	RR BASIN	WEIR BASIN
Existing	0%	7%	20%	12%
Freshwater	4%	18%	16%	4%
Saltwater	0%	0%	0%	0%
Hybrid	6%	2%	0%	0%

Table 5.13 Comparison of the 10th Percentile of DO Concentration Among Lagoon Alternatives Relative to a Numeric Target of 5 mg/L

LAGOON CONDITION	I-5 BASIN	CH BASIN	RR BASIN	WEIR BASIN
Existing	7.6	5.4	4.6	4.7
Freshwater	5.7	4.2	4.8	5.3
Saltwater	7.2	6.9	6.9	7.1
Hybrid	5.4	5.5	6.8	7.1

Summary

Overall, modeling analyses show the Existing Condition to be out of compliance with the WQO related to eutrophication in Buena Vista Lagoon, consistent with the findings of the Lagoon baseline monitoring results (McLaughlin et al. 2011). The comparison of proposed enhancement alternatives using nuisance algae, dissolved oxygen and nutrient concentrations as multiple lines of evidence suggests that the Saltwater Alternative provides the greatest water quality improvement in the Weir, CH, and RR basins, with the Hybrid Alternative as a close second. These alternatives generally demonstrated an order of magnitude reduction in the concentrations of nutrients and algal biomass and substantial reduction in DO objective frequencies of non-compliance in the CH Basin, RR Basin and Weir Basin. The Freshwater Alternative was comparable to Existing Condition. For the I-5 Basin, the alternatives were generally comparable, with the exception of algal biomass, where the Saltwater Alternative provided the greatest water quality improvement.

6. SUMMARY OF FINDINGS

A linked hydrodynamic (EFDC) and water quality (WASP) model was developed for the Buena Vista Lagoon (Lagoon) and validated with water quality data collected between January 2008 and October 2008 at the I-5 Basin and Coast Highway Basin. The linked model was used for the evaluation of predicted change in bacteria pollution and nutrient over-enrichment in the Lagoon with and without the implementation of three proposed Lagoon enhancement alternatives; namely, Fresh Water Alternative, Saltwater Alternative, and Hybrid Alternative. These alternatives were developed under the Buena Vista Lagoon Enhancement Project (BVLEP) described in Everest (2014b). A one-year model simulation model period between October 2017 and September 2018 was selected for this study because of available data to define the flow, bacteria, and nutrient loadings from upstream Buena Vista Creek to the Lagoon.

For the evaluation, the model predicted bacteria, nutrient enrichment (TN, TP, biomass) and dissolved oxygen (DO) for the Existing Conditions and with the proposed alternatives are compared and evaluated with respect to three sets of water quality objectives specified in the SDRWQCB Basin Plan with some modifications based on recent work in Loma Alta Slough by Sutula et al (2013). The three WQOs used to evaluate water quality improvements are: (1) FIB Objectives, 2) Biostimulatory Objectives (Nuisance Algae and Nutrients) and 3) Dissolved Oxygen Objectives.

Major findings and evaluation results based on the linked model simulations for Existing Conditions and the enhancement alternatives are summarized below.

6.1 BACTERIA

In general, the model results show that predicted bacteria levels in the Lagoon for the Freshwater Alternative would be similar to those under Existing Conditions. With tidal flushing, bacteria concentrations for the Saltwater Alternative in general would be lower than those under Existing Condition. The decrease in bacteria levels in the Weir Basin and RR Basin are in general more significant because of strong tidal flushing for those two basins. Being farther away from the tidal inlet (i.e., less tidal flushing), the drop in bacteria concentrations at the CH Basin and I-5 Basin are not as substantial as those in the Weir Basin and RR Basin. For the Hybrid Alternative, the bacteria concentrations for the salt water basins (Weir Basin, RR Basin and CH Basin) would be similar to those for the Saltwater Alternative, while the bacteria concentrations at the I-5 Basin would be similar to those for Existing Condition and the Freshwater Alternative.

Predicted wet weather percent exceedances for the Freshwater Alternative were the same as Existing Conditions; while the Saltwater Alternative would result in a decrease in the wet weather percent exceedances compared to Existing Conditions, especially for total coliform. For the Hybrid Alternative, the wet weather percent exceedances would be similar to the Saltwater Alternative except for the I-5 Basin. For dry weather, the Freshwater Alternative shows no predicted change in bacteria exceedance compared to Existing Condition. The Saltwater Alternative would result in substantial reduction in bacteria exceedance due to the tidal flushing from the lagoon. Under the Hybrid Alternative, reductions in bacteria exceedance would occur in the Weir, RR, and CH Basins, but an increase would occur in the I-5 Basin because the weir at the I-5 Bridge would trap flow and associated bacteria loading from Buena Vista Creek in the I-5 Basin for a longer time.

6.2 NUISANCE ALGAE AND NUTRIENT

Under Existing Condition, the WASP model results show that the biomass in the I-5 Basin exceeds the numeric target 11% of the time, while the rate is roughly triple that for the other basins. The Freshwater Alternatives show similar exceedance rates for the I-5 Basin as Existing Condition but substantially less exceedance for the other three basins. With the implementation of the Saltwater or the Hybrid Alternatives, the WASP results predict that all basins would fall below the numeric targets every day, with algal biomass at an order of magnitude lower than the Existing Condition or Freshwater Alternative.

Under Existing Condition, Freshwater, and Saltwater Alternatives, the WASP model results show that the total phosphorus in the I-5 Basin exceeds the numeric target 83 to 95% of the time. Only the Hybrid Alternative shows a substantial reduction in total phosphorus concentrations. In the CH, RR and Weir Basins, the Existing Condition and enhancement alternatives would not be differentiated in their ability to meet the objectives - all remain at 100% exceedance. The results are similar for total nitrogen, though with higher exceedance rates in the I-5 Basin and lower rates in the western basins.

When comparing the 90th percentile of the total phosphorus and total nitrogen, the Saltwater Alternative reduces total phosphorus by an order of magnitude and total nitrogen concentrations by half relative to the Existing Condition and Freshwater Alternative in the CH, RR, and Weir Basins.

6.3 DISSOLVED OXYGEN

In general, the predicted DO levels in the Lagoon would be similar between the Fresh Water Alternative and Existing Condition, but higher with the implementation of the Saltwater Alternative or Hybrid Alternative. Under Existing Conditions, approximately 7 to 20% of time the DO in three of the four Lagoon basins would fall below the DO objective of 5 mg L^{-1}. For the Freshwater Alternative, the DO levels in the Lagoon would fall below 5 mg L^{-1} about 4 to

18% percent of time. With the implementation of the Saltwater Alternative, the Lagoon DO levels would be above the DO objective throughout the year. For the Hybrid Alternative, the DO at the RR Basin and Weir Basin would be above the DO objective for the entire year of simulation period, and would fall below the objective at the I-5 Basin and CH Basin 6% and 2% of the time, respectively.

6.4 OVERALL FINDINGS

- Overall, modeling analyses show the Existing Condition to be out of compliance with the WQO related to fecal indicator bacteria (FIB) and eutrophication in Buena Vista Lagoon, consistent with the findings of Lagoon baseline monitoring results (McLaughlin et al. 2011, MACTEC 2009).
- The comparison of enhancement alternatives using FIB, nuisance algae, dissolved oxygen, and nutrient concentrations as multiple lines of evidence suggests that the Saltwater Alternative and Hybrid Alternative would provide the greatest dry weather water quality improvement in the Weir, RR, and CH Basins. These alternatives generally would have an order of magnitude reduction in the concentrations of nutrients and algal biomass and substantial reduction in DO objective frequencies of non-compliance in the basins west of the I-5 Bridge. The primary reason for this improvement is dilution of land-based nutrient concentrations by ocean water due to tidal flushing, export of accrued of algal biomass to the ocean, and lower residence time of Lagoon waters.
- The Freshwater Alternative was comparable to the Existing Condition in that it provided little to no water quality improvement over the existing condition.
- For the I-5 Basin, the Hybrid Alternative generally performed comparable to or worse than the Existing Condition, due to increased residence times from the placement of the weir at the I-5 Bridge.

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