MOFFATT & NICHOL
ENGINEERS

August 2, 2001

State of California
Coastal Conservancy
1330 Broadway, Suite 1100
Oakland, CA 94612-2530

Attn: Melanie Denninger, Project Manager

Subj: Letter Report, Bolsa Chica Project - Additional Modeling Services Related to Bird Use of the Bolsa Chica Wetland
M&N File: 4012-18

Dear Ms. Denninger:

This letter report presents findings of the additional numerical modeling of potential water quality impacts from bird use of Bolsa Chica wetlands to the tidal inlet and the ocean near the inlet. Numerical modeling of potential water quality impacts from bird use of Bolsa Chica wetland was conducted by Moffatt & Nichol Engineers (M&NE, July 18, 2001), to be referred in this report as the previous M&NE study. The previous modeling and analyses were based on assuming that only the Full Tidal Basin (FTB) is used by birds and significantly contributes bacteria to the ocean. A stakeholder group of reviewers recommended that the Future Full Tidal Basin (FFTB) and the Muted Tidal Basin (MTB) be added to the analysis for more comprehensive predictions. This supplemental modeling effort therefore includes the entire tidal area of future Bolsa Chica.

1.0 INTRODUCTION

A recent study done at Talbert Marsh by Dr. Stanley Grant, *Generation of Enterococci Bacteria in a Coastal Salt Marsh and Its Impact on Surf Zone Water Quality,* published in the Journal of Environmental Science and Technology in June of 2001, indicates that seagull feces are a contributor of enterococci bacteria to the marsh and ocean. The State Department of Parks and Recreation has expressed concern that restoration at Bolsa Chica may cause similar conditions, and has requested modeling to predict bacteria levels caused by bird feces relative to state criteria and the potential for beach closures.

The objectives of this study are similar to those of the previous M&NE study and are to:

- *Perform numerical modeling of potential water quality impacts at Bolsa Chica from bird excrement;*
- *Quantify the worst-case number of beach closures at Bolsa Chica State Beach Park that could occur during a representative period of time; and*
- *Determine whether modeling of Talbert Marsh, as suggested by the State Department of Parks and Recreation, is warranted.*

2.0 MODELING SCENARIOS

This work was performed for reasonable and worst-case scenarios. Assumptions for bird use and excretions, and ocean tides are the same as those used previously. For each scenario, the assumed bird use condition is early spring with gulls and terns on the flood bar during daylight hours (when excretions occur).

Scenario 1 predicts impacts from a reasonable worst case of tides and bird use at the wetland. A typical ocean tide condition of alternating spring and neap tides that occur over a 14-day period was assumed, as shown in Figure 1.

Scenario 2 predicts conditions during narrow range neap tides that were recorded in March of 2001 to result in less dilution of contaminants. The tidal range was between 4.4 and 3.8 feet for seven days, as shown in Figure 2. Bird use throughout the entire wetland, and thus the number of bacteria contributed per acre, was assumed to be identical to Scenario 2 of the previous M&NE study.

3.0 MODEL DESCRIPTIONS, MODELING ASSUMPTIONS AND PROCEDURES

3.1 Model Descriptions

Two numerical models were used to perform the work. A one-dimensional Hydrodynamic Circulation Model (HCM) was used to compute the discharge from the wetlands at the two-dimensional model wetland boundary. A two-dimensional modeling suite (RMA2/RMA4) was used to disperse the contaminants from the wetlands to the nearshore ocean. All these models were calibrated specifically for the Bolsa Chica project, and the model descriptions and calibrations were detailed in the Preliminary Engineering Inlet Studies for Bolsa Chica Wetlands Restoration (M&NE, 2000).

3.2 Modeling Assumptions

As was assumed in the previous M&NE study, water quality modeling at Bolsa Chica is based primarily on parameters of tidal prism, bird concentrations, bird types and distribution. Bacteria generation by the wetland itself was not included due to its unknown magnitude and the possible ramifications on results. The lack of available data for this parameter precludes its effective use as a modeling assumption. Other assumptions used are listed below.

Bird Use of Marsh: Bird use in the FTB and FFTB was assumed to be the same as that measured at Batiquitos Lagoon (similar in size and habitat distributions as future Bolsa Chica) in mid-Spring of 1999. Bird use in the MTB will likely be similar to that occurring in the existing Inner Bolsa Bay (IBB). However, for this effort it was conservatively assumed to be similar to that in the full tidal basin. The seagull and tern densities on the flood bar just inside the lagoon from the inlet were assumed to be similar to those measured at Talbert Marsh in May of 2000. Therefore, the seagull concentration, enterococci concentration per excretion, excretion rate per seagull, and consequent number of enterococci per acre generated by birds are the same as those used in the previous M&NE study.

Modeling Area: The entire modeling area shown in Figure 3 was divided into two subareas: the ocean (nearshore ocean, tidal inlet and easternmost portion of the full tidal basin) and the wetland defined as the remaining area in the FTB together with the FFTB and MTB. The enterococci bacteria dropped by all birds were evenly distributed in the wetland and over time. The average enterococci concentration in the wetland calculated using the method mentioned above and was applied at the two-dimensional numerical modeling boundary shown in Figure 4. The enterococci bacteria were then modeled as moving with ebbing tides to the nearshore and offshore areas.

Bacteria Dilution and Tidal Flushing: For both scenarios, the enterococci concentration in the marsh was calculated assuming that the total number of enterococci dropped by shorebirds, wading birds, waterfowl, and aerial foragers in one tidal cycle would be diluted by the tidal prism of the wetland area. Also, all enterococci contributed by birds in one tidal cycle are assumed to be carried to the ocean within the same ebbing tidal period. Tidal flushing is complete every day with no extended residence time of seawater in the marsh.

During neap tides of Scenario 2, only a fraction of the tidal prism would dilute the enterococci dropped by gulls/terns on the flood bar located close to the inlet. Two conservative assumptions were made regarding bacteria dilution and dispersion: 1) it was conservatively estimated that one sixth of the tidal prism was used to dilute the enterococci contributed by gulls/terns at the flood bar; and 2) all enterococci contributed by gulls/terns during one tidal cycle were assumed to be carried to the ocean in the first hour of the ebbing tidal flow rather than being gradually released over the entire ebbing tide.

Flow Stratification: The shallow depth of flow in the inlet and the high flow rate will clearly lead to mixing through the water column. In the ocean, waves mix nearshore waters, and wave- and wind-driven currents generate further turbulence that creates a generally well-mixed environment. Therefore, stratification of flows in the inlet and ocean is negligible due to turbulence, and three-dimensional modeling considering the vertical stratification is not necessary for this study.

Bacteria Decay: No decay of the enterococci bacteria was assumed in the RMA4 water quality modeling for both scenarios. This assumption is not realistic, but was employed to generate the absolute worst-case predicted bacteria levels along the beach as an envelope to work within for analysis. Also, being conservative, wind and wave-driven longshore currents were not considered, so that maximum concentrations remain at the inlet mouth, rather than dispersing along the coast.

Ocean Background Bacteria Level: No background bacteria level was considered in the numerical modeling in order to isolate the enterococci bacteria contributed by the bird use of marsh. However, background levels of enterococci do exist in the ocean. Concentrations sampled at station 33N by the Orange County Sanitation District (OCSD) are plotted in Figure 5. Station 33N is the closest water quality sampling station near the proposed tidal inlet. Sampling data show that there eleven exceedences of the instantaneous state criterion have occurred since June 1, 1998 for existing conditions. However, there were no exceedences of the 30-day geometric mean criterion of 35 Most Probable Number (MPN)/100 ml during the same period, as shown in Figure 6. The average enterococcus concentration in the ocean at Bolsa Chica as

estimated from existing data from the Orange County Sanitation District is 14.9 MPN/100 ml. This suggests long-term water quality conditions are good, with episodic "spikes" of poor conditions.

The configuration of the FFTB: The FFTB is assumed to be the Expanded Future Full Tidal (EFTB) basin. The EFTB has a larger tidal prism than the FFTB, thus it leads to maximum tidal muting in the marsh and less dilution of contaminants.

3.3 Modeling Procedures

The modeling sequence for this study is described below.

A. Calculate the marsh area enterococci concentrations based on the bird use populations, bird types, bird weights, bird excretion patterns, and tidal prism.

B. Compute the tidal exchange flow rates between the marsh and the ocean at the two-dimensional model boundary shown in Figure 4 with the HCM model.

C. Predict the enterococci concentration distributions in the tidal inlet and the ocean near the inlet with the RMA2/RMA4 modeling suite.

4.0 MODELING OF SCENARIO 1 – REASONABLE WORST-CASE

4.1 Calculation of Marsh Area Enterococci Concentration

Table 1 shows the calculation of the enterococci concentration in the wetland area for Scenario 1. Column four in Table 1 shows the total number of enterococci in each tidal basin, as the product of the wetland area and the number of enterococci per acre as calculated from the previous M&NE study. The maximum bacteria concentration was estimated to be 0.25 MPN/100 milliliters (ml).

4.2 Computation of Tidal Discharge from the Wetland to the Ocean

The calibrated HCM model was used to calculate the tidal exchange between the wetland areas and the ocean. The model domain includes the FTB, FFTB and MTB as shown in Figure 3. Tides were based on a representative two-week spring and neap tide cycle called a Tidal Epoch Analysis (TEA) tide. This TEA tide is simply a statistical tide developed to represent the variations that occur over the two-week spring and neap tide cycles and longer-term tidal variations over 19 years. It provides the benefit of analyzing the full range of tide conditions over a shorter time period with less computation time than modeling of the full 19-year tidal record. It is fully described in the reference (M&NE, 2000). This statistical tide is used to drive the HCM model to compute a period of 45 calendar days of hydraulic exchange between the marsh and ocean. The computed tidal exchange flow rates over that period is shown in Figure 7.

4.3 Prediction of Enterococci Concentration in the Inlet and Ocean

The calibrated RMA2 hydrodynamic model was run to compute flow fields in the nearshore and offshore areas with the TEA tide applied at the offshore boundary as the driving tide and discharges computed from the HCM model applied at the wetland/ocean boundary. The model domain is shown in Figure 4.

The calibrated RMA4 water quality model was then run to predict the enterococci concentration in the nearshore and offshore area for a 45-day period with input of flow fields predicted by the RMA2 model.

4.4 Modeling Results

Figure 8 shows the highest enterococci concentration that the model predicted over the 45-day modeling period. Values at the beach and ocean varied, with the highest value occurring at ebbing tides. The peak enterococci concentrations are 0.25 MPN/100 ml in the wetland area, 0.24 MPN/100 ml in the inlet and 0.05 MPN/100 ml in the ocean 1,000 feet away from the tidal inlet. Because the predicted values were so low relative to the state criteria even without decay, no additional modeling was performed using a realistic decay rate. Any modeling results with a decay rate would yield bacteria values below those predicted with a rate of zero.

These results show very low levels of bacteria at the tidal inlet mouth from bird excretions, and suggest no beach postings would occur from this effect. The bacteria concentration is predicted to be much lower than the state standard of 35 MPN/100 ml for a 30-day geometric mean condition and 104 MPN/100 ml for an instantaneous reading, even when added to the baseline bacteria levels.

5.0 MODELING OF SCENARIO 2 – WORST CASE

In this study, bird use in the FTB, FFTB, MTB and flood bar is assumed to be identical to those assumed in Scenario 2 of the previous M&NE study.

5.1 Calculation of Wetland Area Enterococci Concentration

The total number of enterococci in the marsh shown in column four of Table 2 is simply the product of the total wetland area and the number of enterococci per acre calculated from the previous M&NE study. On the flood bar, the enterococci concentration is estimated from the number of enterococci per acre contributed by the birds being diluted by a smaller tidal prism from a muted tidal range of 2.69 feet instead of 2.8 feet used previously in the FTB. The smaller tidal range is due to tidal muting caused by connecting the FFTB and MTB to the FTB. The final concentration applied at the wetland boundary of the water quality modeling is shown in Figure 9. It shows a bacteria concentration of 2.30 MPN/100 ml.

5.2 Computation of Tidal Discharge from the Wetland to the Ocean

The calibrated one-dimensional HCM model was used to compute the tidal exchange between the wetland areas and the ocean. The model domain includes the FTB, FFTB and MTB as shown in Figure 3. To be conservative, a neap tide recorded at the tidal gage in the Outer

Harbor, Los Angeles, California from March 13, 2001 to March 19, 2001 was selected in the modeling in order to create a smaller dilution of enterococci bacteria compared to other tides. This is the closest tidal gage to the project site and the differences in the tidal elevation and phase between the tidal gage and project site are negligible. The tidal elevation data shown in Figure 2 was downloaded from the National Oceanic and Atmospheric Administration (NOAA) web page, and was used in driving the HCM model to predict the tidal exchange rates at the wetland/ocean boundary line. The computed flow rates at that boundary are shown in Figure 10.

5.3 Prediction of Enterococci Concentration in the Nearshore and Offshore Area

The RMA2 hydrodynamic model was used to predict flow fields in the model domain shown in Figure 4 with the neap tide applied at the offshore boundary as the driving tide and discharges computed from the HCM model at the wetland/ocean boundary. The calibrated RMA4 water quality model was then used to predict the enterococci concentration distribution in the nearshore and offshore area with input of the flow field generated by the RMA2 model. To be extremely conservative, no decay of the enterococci bacteria was assumed in the RMA4 enterococci transport modeling. This assumption is not realistic, but was employed to generate the absolute worst-case predicted bacteria levels along the beach as an envelope to work within for analysis.

5.4 Modeling Results

Figure 11 shows the highest enterococci concentration that the model predicted over the neap tide modeling period for the worst case. As shown in the Figure, the peak enterococci concentrations are 2.3 MPN/100 ml in the wetland area, 2.0 MPN/100 ml in the inlet area, and 0.5 MPN/100 ml at a radius of 1,000 feet from the tidal inlet. Figure 12 shows the enterococci concentration versus time at model input boundary, inlet and ocean 1,000 feet away from the inlet for the worst case. Values at the beach and ocean vary, with the highest value occurring at ebbing tides.

The predicted bacteria concentrations are less than the state standard of 35 MPN/100 ml for a 30-day geometric mean and 104 MPN/100 ml for an instantaneous reading. Conditions during a neap tide only extend for five to seven days, so the instantaneous standard may be more appropriate as a comparison.

6.0 ANALYSES OF RESULTS

The predicted values of bacteria concentrations are compared to state water quality criteria below. Either the instantaneous maximum criterion of 104 MPN/100 ml or the 30-day geometric mean value of 35 MPN/100 ml could be applied in the exercise, but the prediction falls well below either value.

For Scenario 1, the highest predicted enterococci bacteria concentration levels for the worst case condition in the wetland and nearshore area are two orders of magnitude lower than the applicable state criteria (the 30-day geometric mean). In order to reach an exceedance of the criteria, the concentration of bacteria would have to be increased 140 fold in the wetland. For Scenario 2, the highest predicted enterococci concentration levels for the worst case condition

in the wetland and nearshore area over the modeling period are at least one order of magnitude lower than the most stringent state criteria. In order to reach an exceedance of the criteria, the concentration of bacteria would have to be increased 15 fold in the marsh. No physical (decreased tidal prism) or biological conditions (increased bird use) are anticipated for this to occur with the proposed project. Therefore, beach postings or closures would not occur more frequently than existing conditions from bird use of the wetland under the assumptions used for this analysis.

The detection limit for enterococci bacteria is 10 MPN/100ml as shown in data obtained from the Orange County Health Care Agency, and 2 MPN/100ml as shown in data obtained from the OCSD. Using the OCSD detection limit, the enterococci concentrations predicted for Scenario 1 would not be detectable, and predictions for Scenario 2 would only be detected in the wetland and the tidal inlet, but not in the ocean. Under these assumptions and methods, the existing beach water quality condition should remain basically unaffected after project construction. There may be occasional beach postings or closures due to exceedences of the instantaneous criterion as presently occurs unrelated to the project, but the 30-day geometric mean should stay below the state criterion.

7.0 COMPARISON OF RESULTS WITH CONDITIONS AT OTHER WETLAND SITES

As a responsible agency, the California Department of Parks and Recreation retains a valid concern over potential increases in beach postings and closures at Bolsa Chica State Beach from this project, similar to conditions in 1999 along Huntington State Beach near Talbert Marsh and inlet channel. As such, Parks has requested modeling of Talbert Marsh to test the method employed herein for Bolsa Chica. The work performed for this present effort indicates that similar modeling of Talbert Marsh would likely not be prudent or productive when weighed against the very significant investment of time and effort required, while yielding results that may be only marginally applicable.

The purpose of this section is to place these modeling results into context with conditions at Talbert Marsh and IBB, which is considered to be a suitable reference site due to its similar bird use and water quality conditions to the future Bolsa Chica project. This is intended to provide sufficient information for decision-makers to understand the limitations of modeling Talbert Marsh.

The primary data to compare between wetlands is the estimated bacteria concentration in the wetland prior to its release to the sea. If the concentrations are vastly different between locations, the effort should then focus on causes for the dissimilarities to identify whether further comparative work is appropriate or the sites are so different in character as to render further comparison meaningless. With the assumptions and methods employed to date, this analysis has reached the point of concluding that Talbert Marsh and Bolsa Chica are sufficiently different to render further comparison meaningless. If the estimated bacteria concentrations in the wetlands were more similar, then further modeling and analysis to determine bacteria concentrations in the ocean from tidal flows would have been warranted and recommended.

7.1 Inner Bolsa Bay

Bird use at IBB is assumed to be the same as that in future Bolsa Chica to estimate the bacteria contribution to the wetland. Using a tidal prism of 6.2 million cubic feet, bacteria concentrations in the wetland are estimated to be 0.50 MPN/100 ml. To be consistent with estimates made for future Bolsa Chica and Talbert Marsh, no die-off rate is applied to the estimate.

Monthly water sample data collected by the Orange County Health Care Agency (OCHCA) from April 1999 to May 2001 were reviewed to characterize existing IBB and an adjacent flood control channel. As shown in Table 3, the data are limited by the detection limit of 10 MPN/100 ml, so no lower readings are available. Enterococcus levels in IBB were below detection, or below 10 MPN/100 ml, for 50% of the time. When above detection, enterococcus levels in IBB average 18.9 MPN/100 ml and the highest reading is 40 MPN/100 ml (OCHCA, 2001).

IBB is connected to the mouth of the East Garden Grove Wintersberg Flood Control (EGGW) Channel by culverts and therefore influenced by its water quality. As shown in Table 3, EGGW Channel waters are below detection, or 10 MPN/100 ml, 33.3% of the time. When above detection, enterococcus levels in the EGGW Channel average 2,222.7 MPN/100 ml with the highest reading being 24,192 MPN/100 ml (OCHCA, 2001). Bacteria levels are higher at the EGGW Channel than at IBB. On the infrequent occasions when bacteria levels are elevated at IBB, then generally are also elevated at the EGGW Channel, suggesting that the flood control channel may cause episodes of water quality criteria exceedances at IBB.

These estimates of bacteria concentration at IBB are higher than those for future Bolsa Chica due to the muted tidal range in the IBB. Episodes of water quality criteria exceedances that occur at IBB will likely not occur at future Bolsa Chica because it will not be connected to the flood control channel.

7.2 Talbert Marsh

Information in this section was also presented in the previous M&N study dated July 18, 2001. A first-order approximation of bacteria generation and concentrations from birds at Talbert Marsh is presented as calculated from data provided by UCI and analyzed in the recent journal article cited in reference 1. To be consistent with estimated made for future Bolsa Chica and IBB, no die-off rate is applied to the estimate.

The calculated bacteria concentration for Talbert Marsh under the conditions cited in the previous M&NE study is 8.7 MPN/100 ml as shown in Table 4. If the birds are assumed to be 50 percent western gulls and 50 percent elegant terns, the calculated bacteria concentration is 5.5 MPN/100 ml as shown in Table 5. For comparison, the estimate at future Bolsa Chica is 0.21 MPN/100 ml under typical bird use conditions and a maximum concentration of 2.2 MPN/100 ml assuming a bird population of five times that predicted (considered unrealistically high). The estimate for IBB is 0.5 MPN/100 ml, assuming bird use is the same as future Bolsa Chica. Levels of bacteria at Talbert Marsh are therefore from 26 to 41 times higher than those at future Bolsa Chica under reasonable bird use conditions, and 2.5 to 4.0 times higher than future Bolsa Chica under unrealistically high bird use conditions. Talbert Marsh bacteria levels are from 11.0 to 17.4 times higher than those at IBB under assumed bird use conditions.

Talbert Marsh is clearly an anomaly compared to IBB and future Bolsa Chica. Geometric means of enterococcus concentrations on ebbing tides recorded by UCI during the May 2000 study vary from 40 to 60 MPN/100 ml. This compares to a condition in which the long-term average condition in IBB is below 10 MPN/100 ml for 50% of the time, and when above detection it is 18.9 MPN/100 ml. Therefore, Talbert Marsh bacteria concentrations are measured to be between 2.1 to 3.2 times higher than those at IBB.

Other unknown sources contribute bacteria to Talbert Marsh at a magnitude of approximately 5- to 9-fold the quantity of bacteria assumed to be contributed by birds. These sources are obviously significant and should be determined if that system is to be understood. They may include the ocean, flood control channels and marsh environment as effected by outside sources.

The quality of ocean water and water contributed to Talbert Marsh from flood control channels is characterized from data provided by the Orange County Sanitation District (OCSD) for the nearshore ocean and for Talbert Flood Control (D2) Channel immediately upstream from the marsh. These data show that the average enterococcus concentration in the ocean near the inlet channel (1,200 feet to the south) is 27 MPN/100 ml and the average concentration in D2 channel is 48 MPN/100 ml. Thus, relatively high levels of bacteria exist on average in water sources adjacent to the marsh, possibly leading to an anomalously high bacteria condition in the marsh. It is also possible that the marsh reacts when receiving high concentrations of bacteria from outside sources over a prolonged period of time by incubating or storing bacteria that is released later in time.

This condition, combined with the higher than average measured bird use concentrations, lead to a poor water quality condition at Talbert Marsh that will not occur at Bolsa Chica. Bolsa Chica will not experience the same prolonged influence of poor water quality conditions and high bird use concentrations, and therefore should not present the same type of anomaly as Talbert Marsh. Bolsa Chica and Talbert Marsh are determined from this analysis to be sufficiently different in condition to preclude the need for additional numerical modeling, given the data, assumptions and methods applied to date.

8.0 RECOMMENDATIONS

If additional investigation of bacteria contributions from wetlands is warranted, several tasks can be performed to further verify predictions at Bolsa Chica compared to other wetlands. Additional soil bacteria data could be collected at Talbert Marsh over a specified time period for the express purpose of investigating the possibility that the marsh possesses anomalous sediment quality compared to Bolsa Chica, IBB or another representative site such as Batiquitos Lagoon. Similar data could be collected concurrently at other sites including IBB and Batiquitos Lagoon for comparison. These data would be analyzed to quantify existing bacteria levels in soils, and patterns in the marshes over space at the first order. The study purpose would be to quantify the bacteria concentration in soils at Talbert Marsh, IBB and Batiquitos Lagoon and assess anomalies. It is not recommended that modeling occur.

Additionally, water sampling in Batiquitos Lagoon may be useful in characterizing water quality at that site for comparison with Bolsa Chica and Talbert Marsh to confirm that Talbert Marsh is an anomaly.

9.0 REFERENCES

1. Grant, S.G., Generation Of Enterococci Bacteria In A Coastal Salt Marsh And Its Impact On Surf Zone Water Quality, Journal Of Environmental Science And Technology, June 2001.

2. Moffatt & Nichol Engineers, Preliminary Engineering Studies For Bolsa Chica Wetlands Restoration, Final Report, 2000.

3. Moffatt & Nichol Engineers, Final Letter Report, Numerical Modeling Of Potential Water Quality Impacts From Bird Use Of Bolsa Chica Wetland, July 18, 2001.

4. Orange County Health Care Agency, 2001, Bolsa Chica/East Garden Grove Wintersberg Channel Bacteriological Monitoring.

5. Orange County Sanitation District, 2001, Data Provided by Charles McGee and from the website: http://www.ocsd.com/Environment/ .

10.0 CLOSING

Thank you for the opportunity to be of continued service to the Conservancy and the subcommittee on this project. Please call Chris Webb or me with any questions or comments you may have.

Sincerely,

MOFFATT & NICHOL ENGINEERS

Michael J. McCarthy, P.E.
Vice President

MJM/CKW:pjs
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Enclosure

Table 1 Calculation of Enterococci Concentration in the Marsh for Scenario 1 (DayTime)

(Most Birds - Early Spring with Gulls and Terns on Flood Shoal)

Location/Basin .	Total Marsh Area (acre, MTL)	Mean Tidal Range (ft)	Total No. of ENT .	Mean Tidal Prism (acre-ft)	Mean Tidal Prism (m^3)
Full Tidal Basin	296	3.6	2,918,720,000	1,066	1,314,410
Future Full Tidal Basin	216	3.6	2,129,876,757	778	959,164
Muted Tidal Basin	119	1.24	1,173,404,324	148	182,014
Total	631		6,222,001,081	1,991	2,455,589

ENT Concentration in Marsh=Total No. of ENT/ Tidal Prism= 0.25 MPN/100ml

The bird populations and bird types in the FFTB and MTB are conservatively assumed the same as these in the FTB.

Therefore, total No. of ENT is the product of total marsh area and No.of ENT per acre in the FTB, the latter is calculated in the previous study.

Table 2 Calculation of Enterococci Concentration in the Marsh for Scenario 2 (DayTime)

(Most Birds - Early Spring Times Five with Gulls and Terns on Flood Shoal)

Location/Basin .	Total Marsh Area (acre, MTL)	Neap Tidal Range (ft)	Total No. of ENT [1] .	Mean Tidal Prism (acre-ft)	Neap Tidal Prism (m^3)
Ocean		2.84			
Full Tidal Basin	296	2.69	12,703,600,020	796	982,156
Future Full Tidal Basin	216	2.69	9,270,194,609	581	716,709
Muted Tidal Basin	119	0.91	5,107,190,549	108	133,575
Total	631		27,080,985,178	1,486	1,832,440

ENT Concentration Contributed by Birds in Marsh =Total No. of ENT/ Tidal Prism= 1.48 MPN/100ml

ENT Concentration Contributed by birds on Flood Bar= 0.82 MPN/100ml

Total Peak ENT Concentration= 2.30 MPN/100ml

[1.] The bird populations and bird types in the FFTB and MTB are conservatively assumed the same as these in the FTB. Therefore, total No. of ENT is the product of total marsh area and No.of ENT per acre in the FTB, the latter is calculated in the previous study.

Table 3 Measured Water Quality at Inner Bolsa Bay and EGGW Channel
(Enterococcus Most Probable Number per 100 ml Sample)

Date	BOLSA CHICA RESERVE AT PED BRIDGE	EGGWC ABOVE TIDE GATE
4/28/99	<10	31
5/19/99	20	<10
6/16/99	40	20
7/15/99	10	<10
8/18/99	<10	<10
10/20/99	<10	10
11/17/99	<10	<10
12/8/99	10	<10
1/12/00	10	10
3/7/00	<10	933
4/26/00	10	1334
5/24/00	20	20
8/23/00	<10	<10
9/27/00	<10	>24192
10/1/00		
11/1/00		
12/1/00		
1/1/01		
2/22/01	<10	52
3/12/01	<10	20
4/9/01	40	30
5/10/01	10	20

Source:
COUNTY OF ORANGE, HCA/ENVIRONMENTAL HEALTH DIVISION
Bolsa Chica/East Garden Grove Wintersburg Channel Bacteriological Monitoring

Table 4 **Calculation of ENT Concentration in the Talbert Marsh (Daytime)**

Name of Bird	No. of Birds	No. of Drops per bird/day time	Bird Weight (g)	No. of ENT/drop (1)	Total No. of ENT/Day Time
Western gull	1,180	4	1,000	1,000,000	4,720,000,000
				Total ------>>	4,720,000,000
Total	1,180				

(1) No. of ENT/drop calculated based on 1,000 ENT/dropping for each gram of bird weigh **Total No. of ENT ------>>** **4,720,000,000**

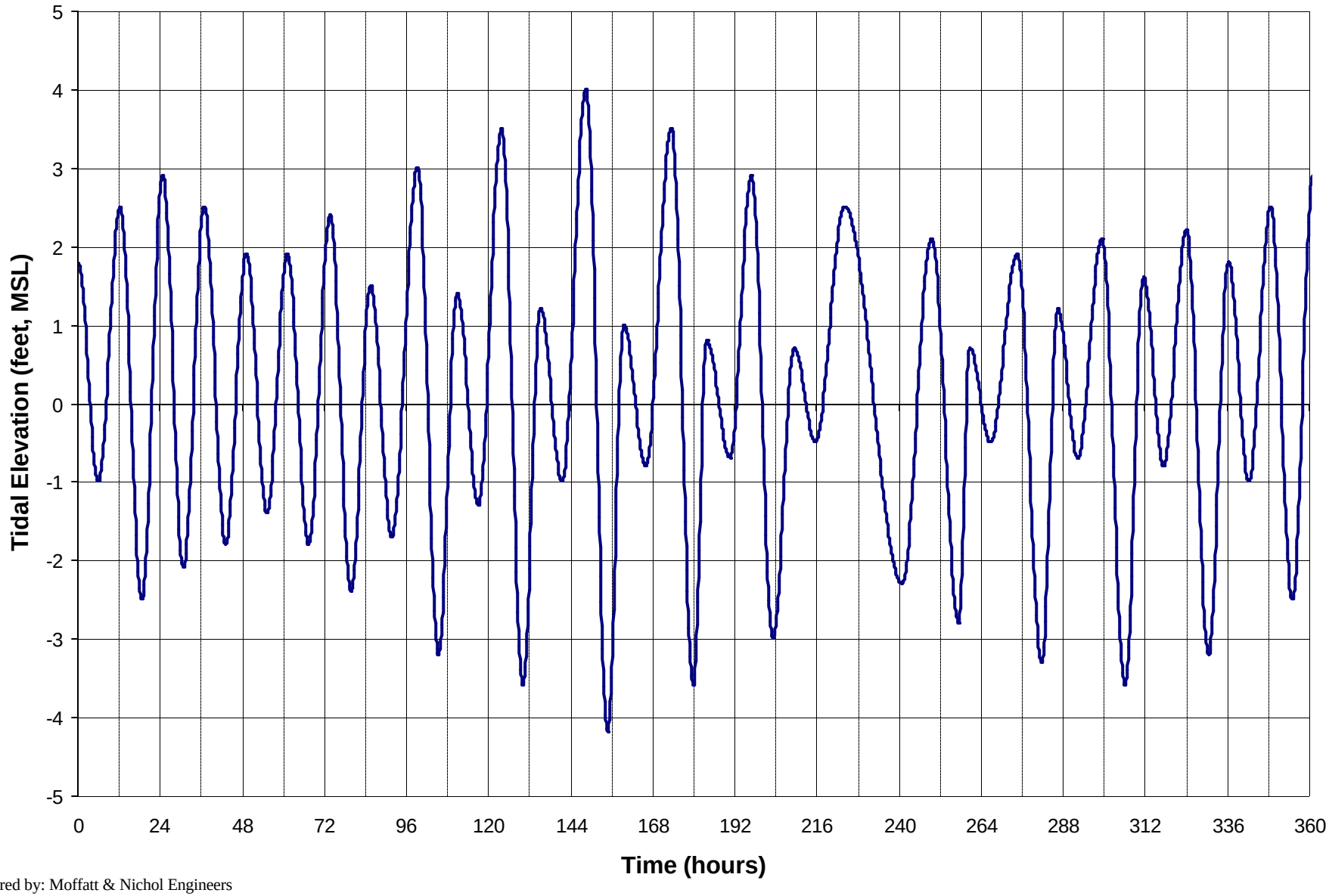
	Tidal Prism	**1912214**	**ft^3**
ENT Concentration =	**Total No. of ENT/ Tidal Prism**	**8.7**	**MPN/100ml**

Table 5 **Calculation of ENT Concentration in the Talbert Marsh (Daytime)**

Name of Bird	No. of Birds	No. of Drops per bird/day time	Bird Weight (g)	No. of ENT/drop (1)	Total No. of ENT/Day Time
Western gull	590	4	1,000	1,000,000	2,360,000,000
Elegant tern	590	4	260	260,000	613,600,000
				Total ------>>	2,973,600,000
Total	1,180				

(1) No. of ENT/drop calculated based on 1,000 ENT/dropping for each gram of bird weigh **Total No. of ENT ------>> 2,973,600,000**

	Tidal Prism	**1912214**	**ft^3**
ENT Concentration =	**Total No. of ENT/ Tidal Prism**	**5.5**	**MPN/100ml**



Prepared by: Moffatt & Nichol Engineers
August 2001
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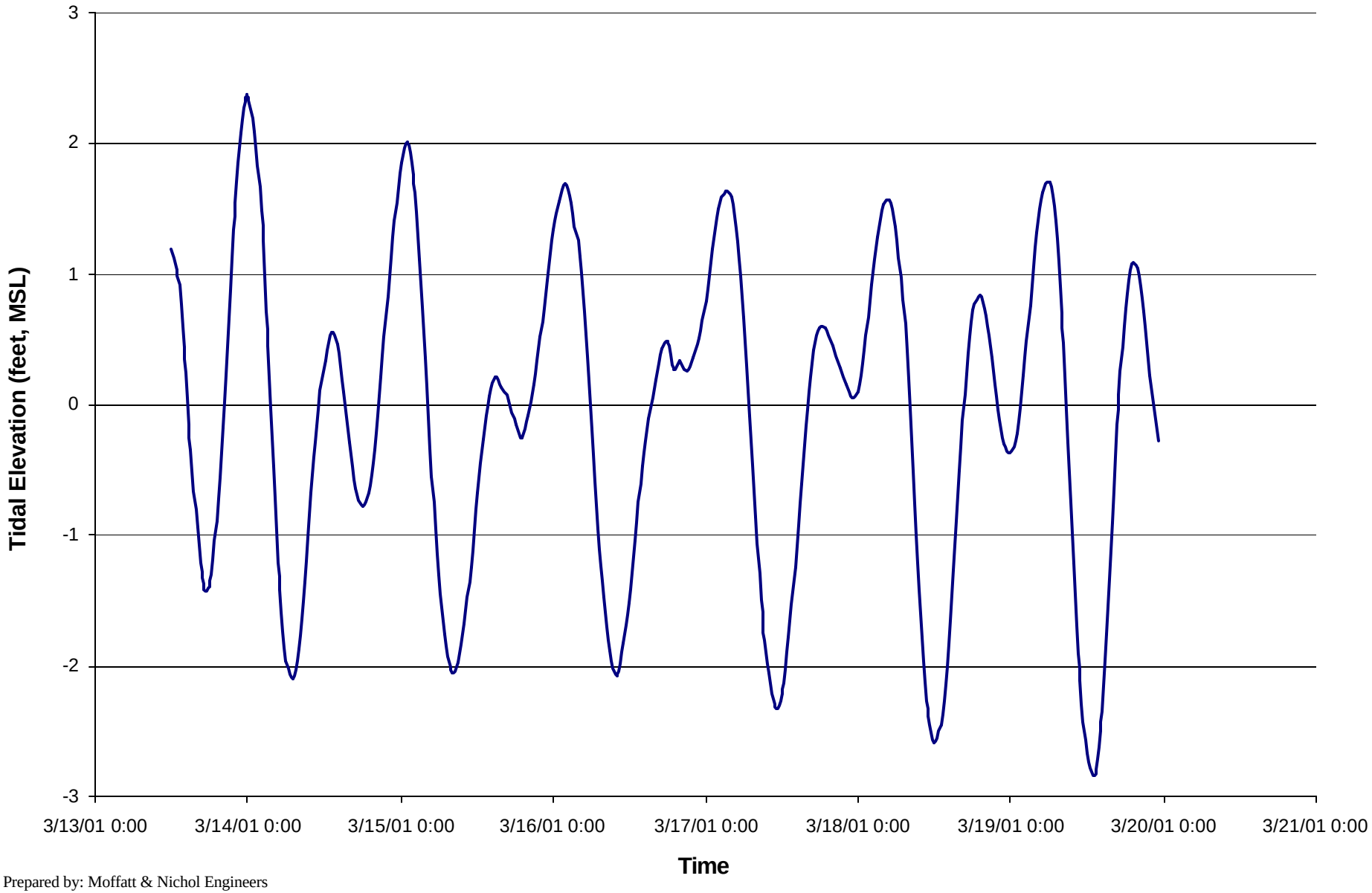
Bolsa Chica Engineering Studies	Tidal Epoch Analyses (Tea) Tidal Series for Scenario 1	**Figure 1**



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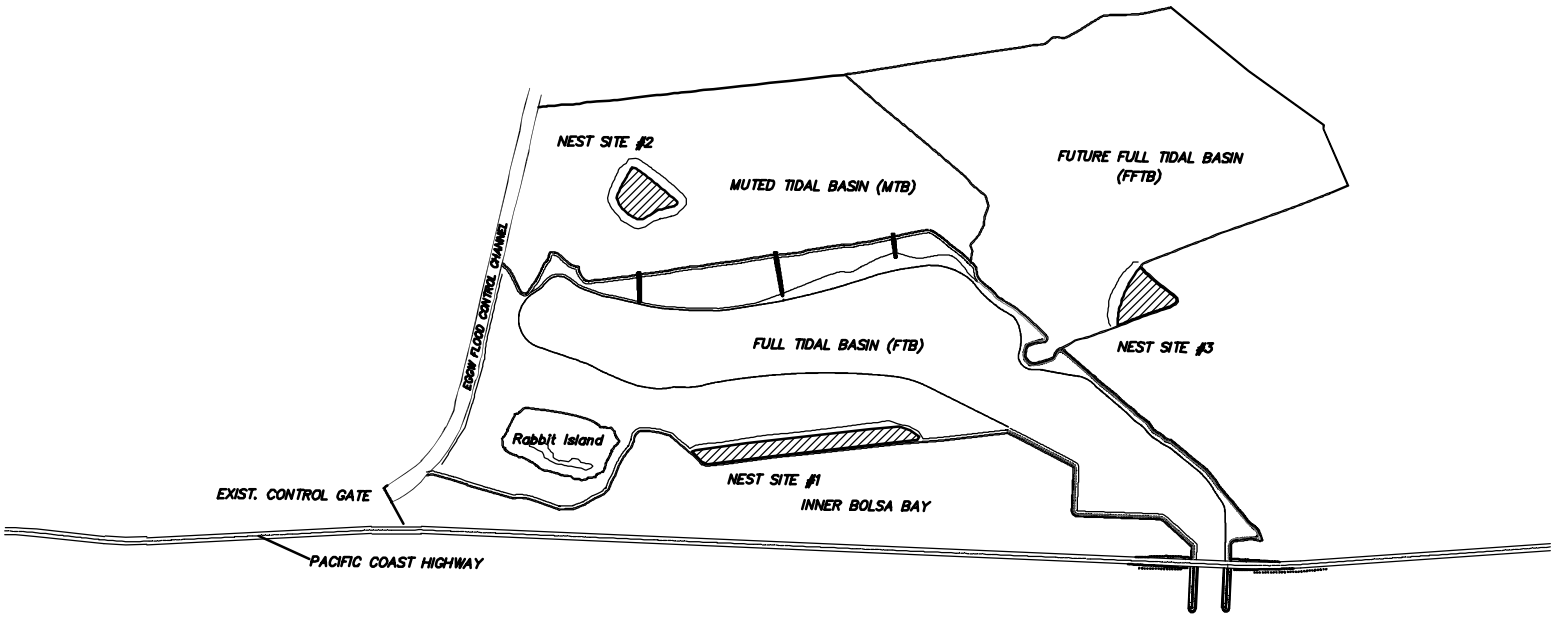
Bolsa Chica Engineering Studies	Neap Tidal Series for Scenario 2	**Figure 2**



PLAN SCALE: 1" = 2000
8/1/01

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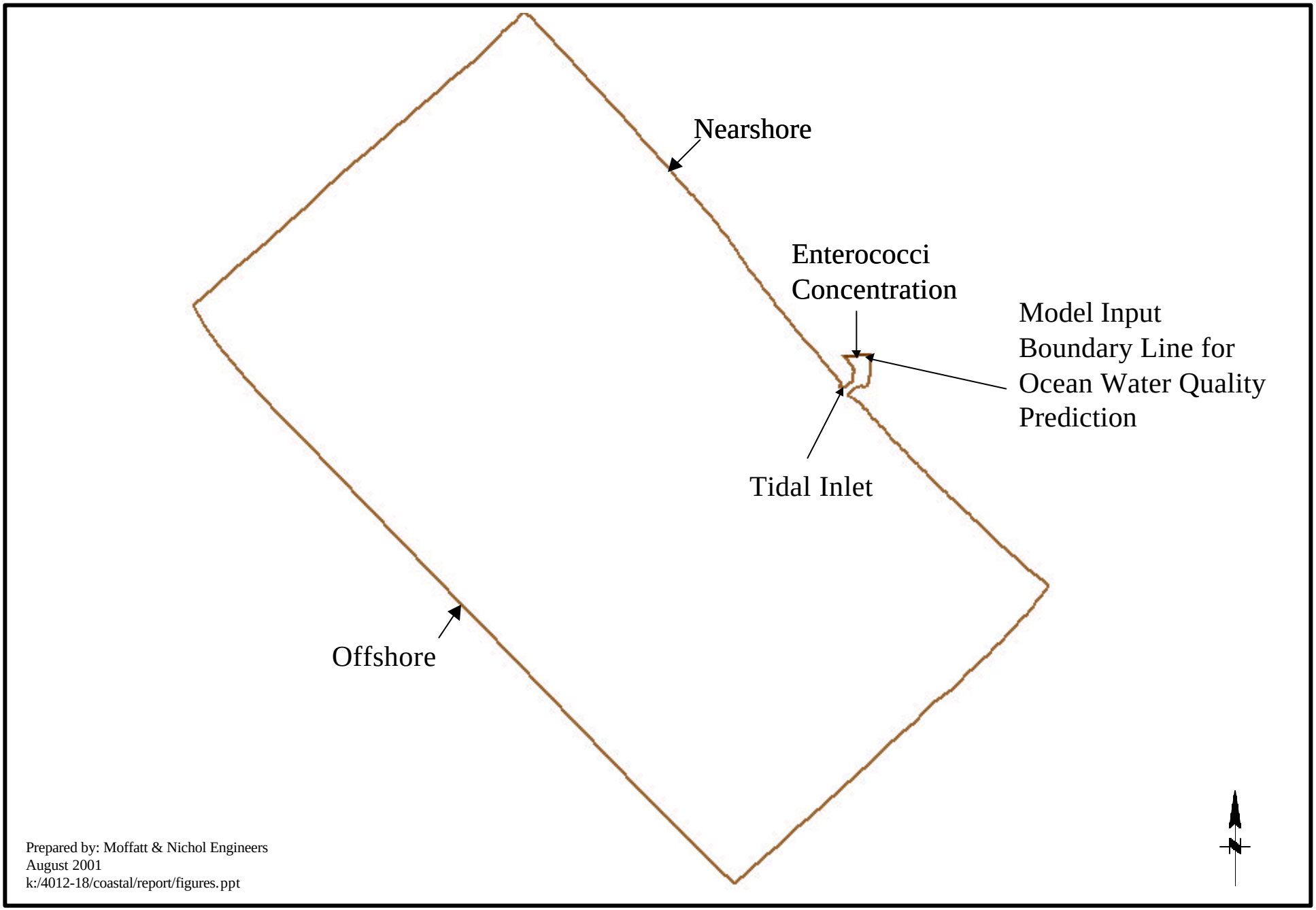
LONG BEACH, CALIFORNIA

* Area of Rabbit Island where the elevation is above +2.7' MSL: 16.3 acres.

Bolsa Chica Preliminary Engineering Studies	BACTERIA MODELING AREA	Figure 3

k: \4012-18\coastal\REPORT\Bacteria_model_area.dwg



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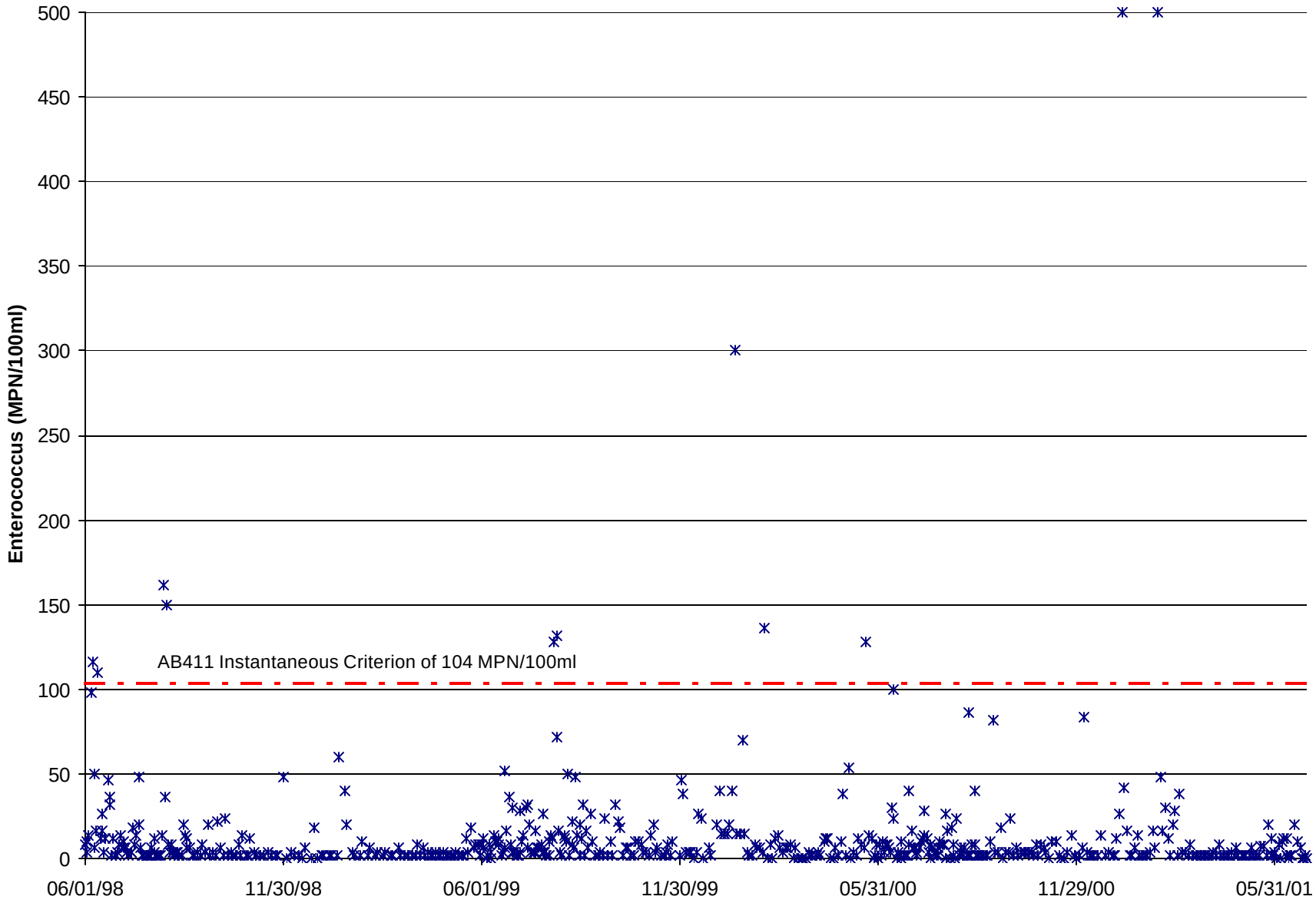
Bolsa Chica Engineering Studies	RMA2 and RMA4 Modeling Area - Both Scenarios	**Figure 4**



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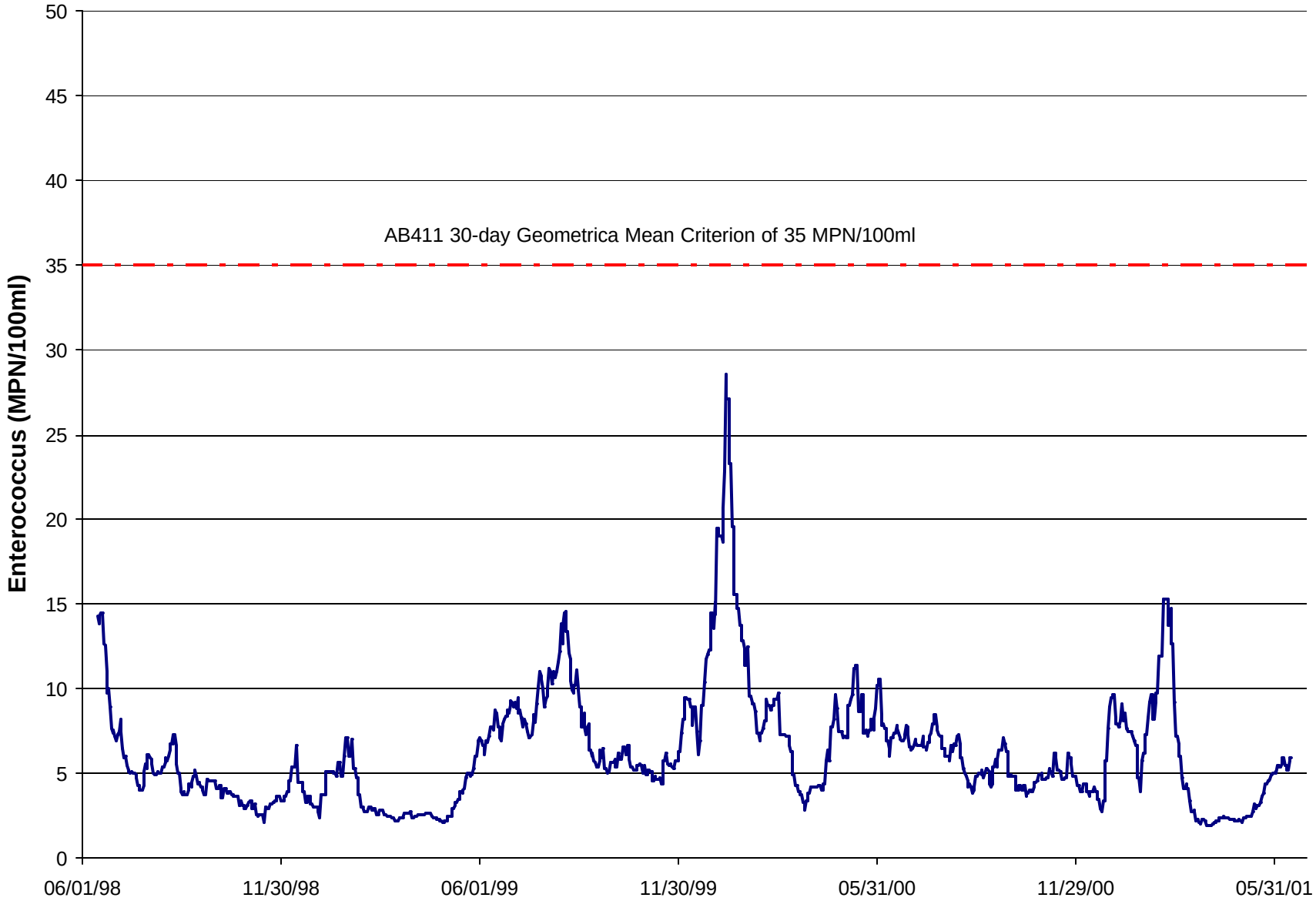
Bolsa Chica Engineering Studies	Instantaneous Enterococci Concentration Sampled at OCSD Station 33N (Downcoast End of Bolsa Chica State Beach)	**Figure 5**



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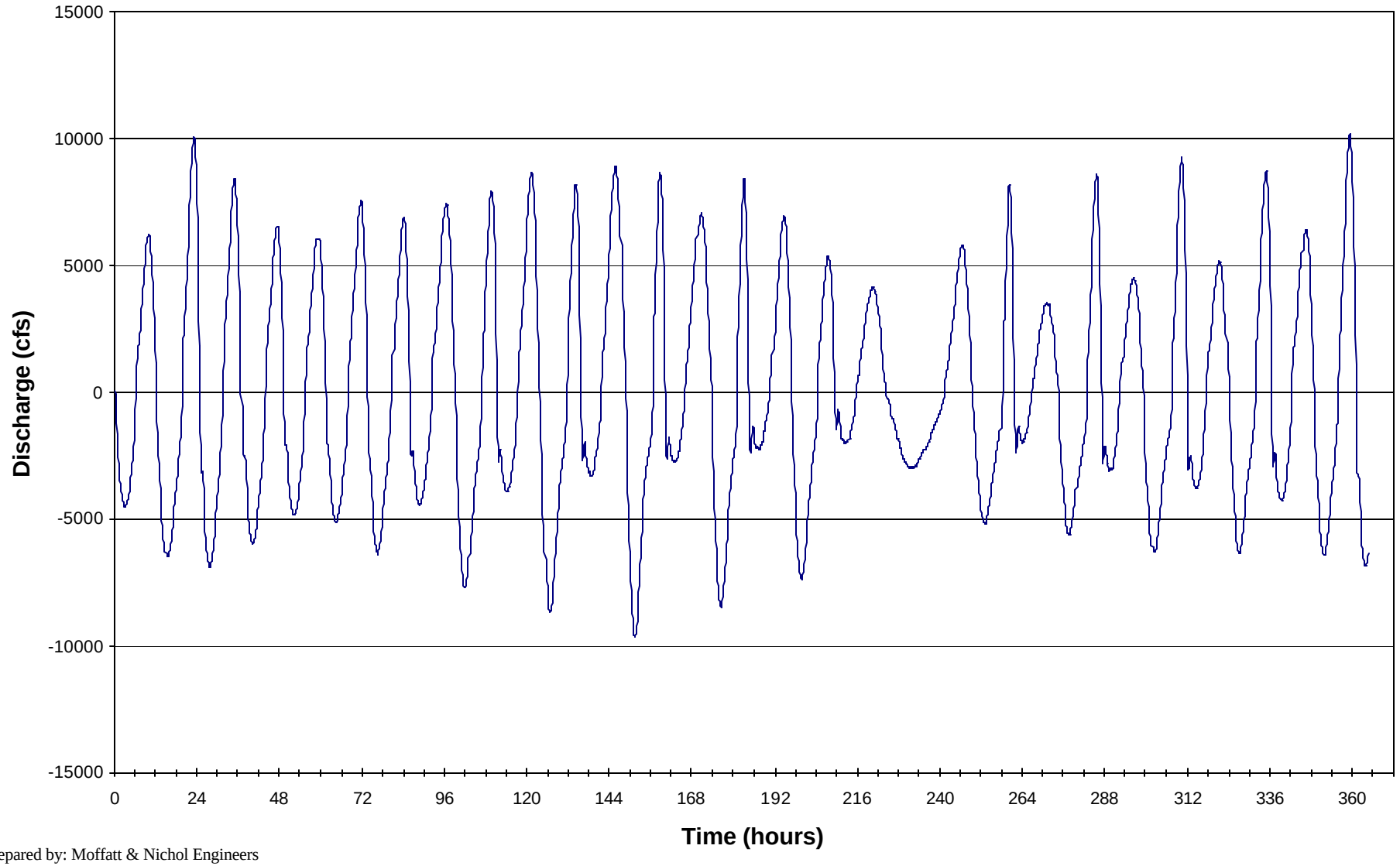
k:/4012-18/coastal/report/figures.ppt

Bolsa Chica Engineering Studies	30-day Geometrica Mean of Enterococci Concentration at OCSD Station 33N(Downcoast End of Bolsa Chica State Beach)	**Figure 6**



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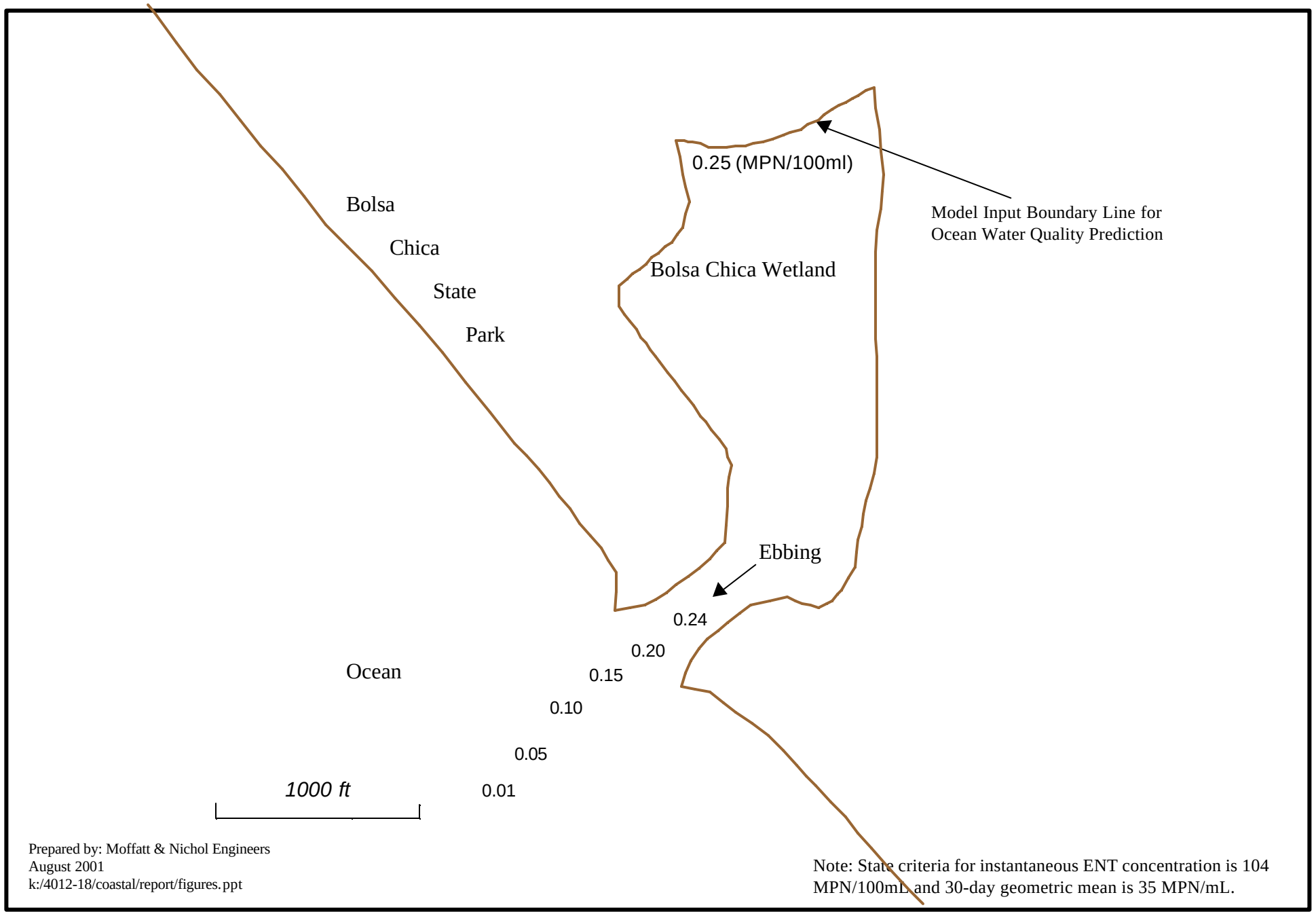
k:/4012-18/coastal/report/figures.ppt

Bolsa Chica Engineering Studies	Discharge from Marsh to Ocean for Scenario 1	**Figure 7**



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August 2001
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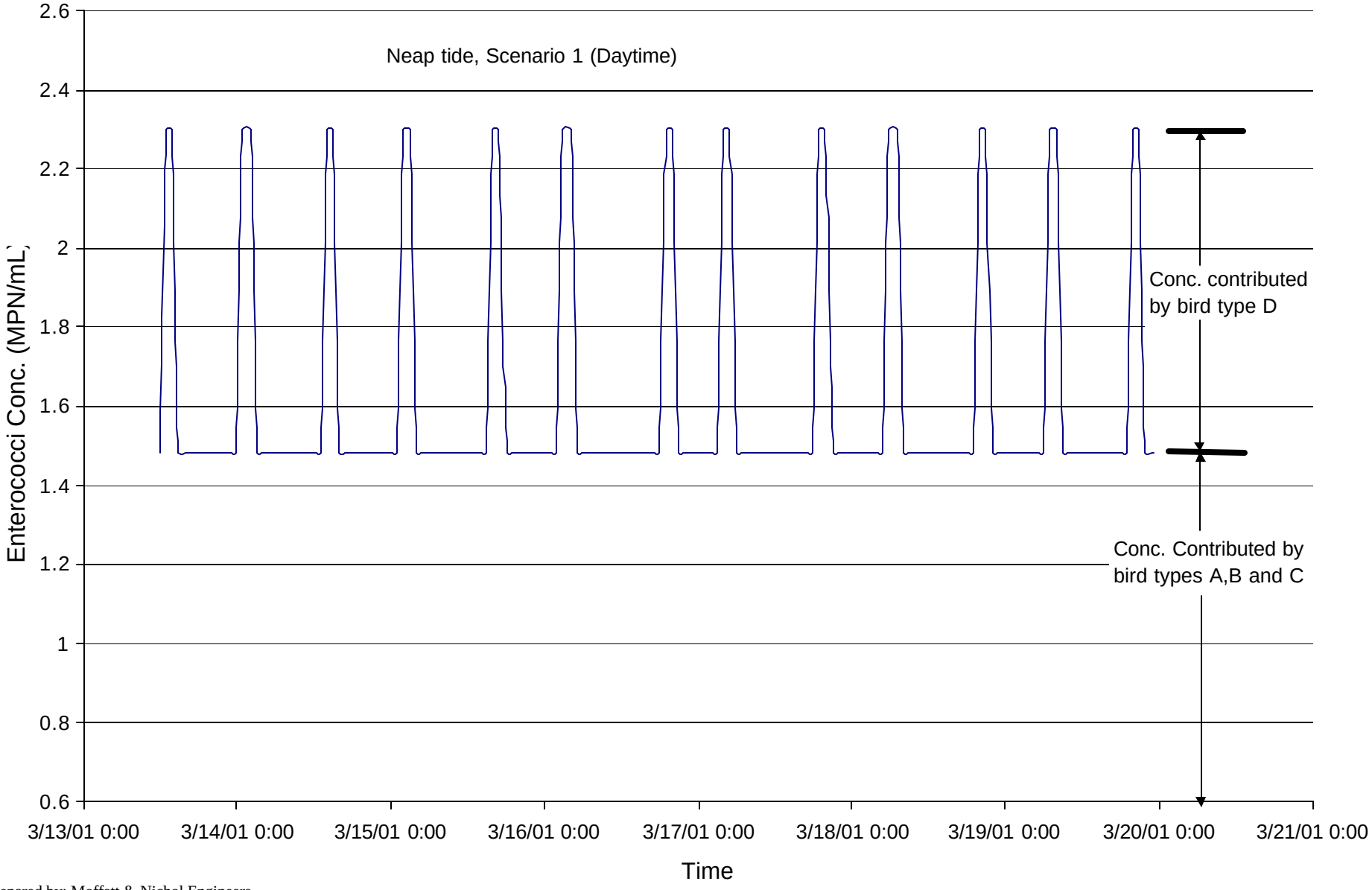
Note: State criteria for instantaneous ENT concentration is 104 MPN/100mL and 30-day geometric mean is 35 MPN/mL.

Bolsa Chica Engineering Studies

Scenario 1 - Predicted Enterococci Concentration with Modeling Area Covering FTB, FFTB and MTB

Figure 8



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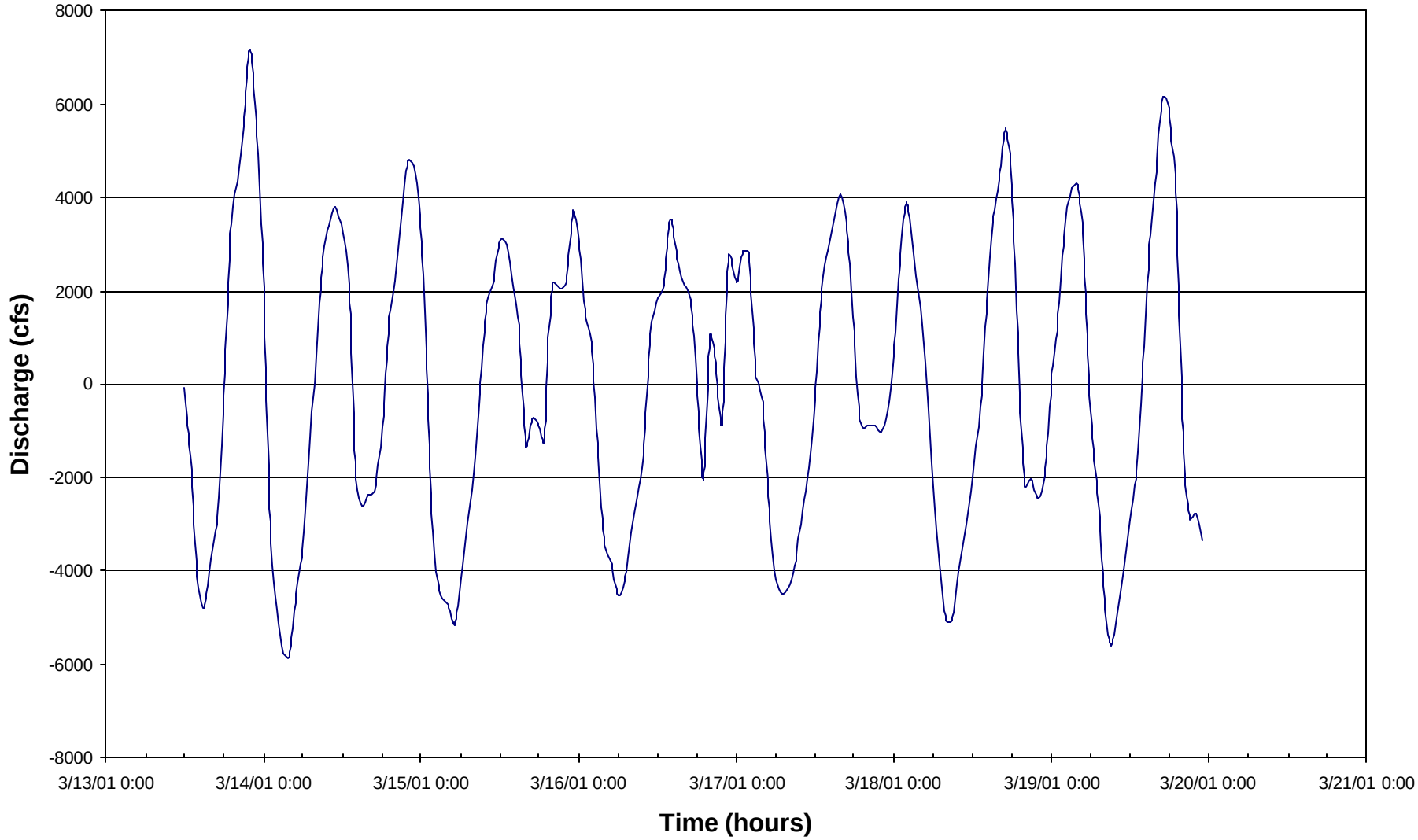
k:/4012-18/coastal/report/figures.ppt

Bolsa Chica Engineering Studies	Enterococci Concentration at Model Input Boundary for Scenario 2	**Figure 9**



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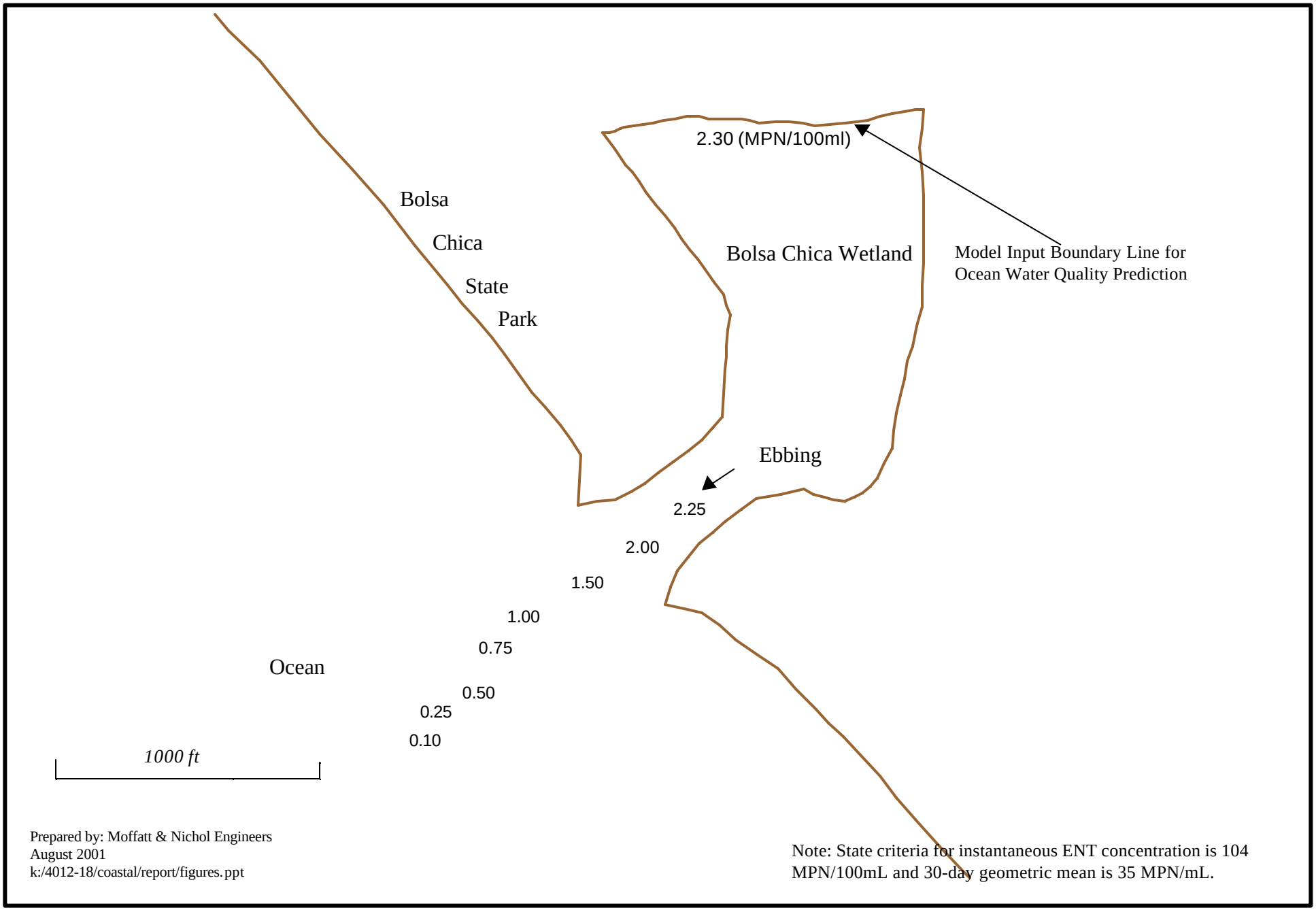
k:/4012-18/coastal/report/figures.ppt

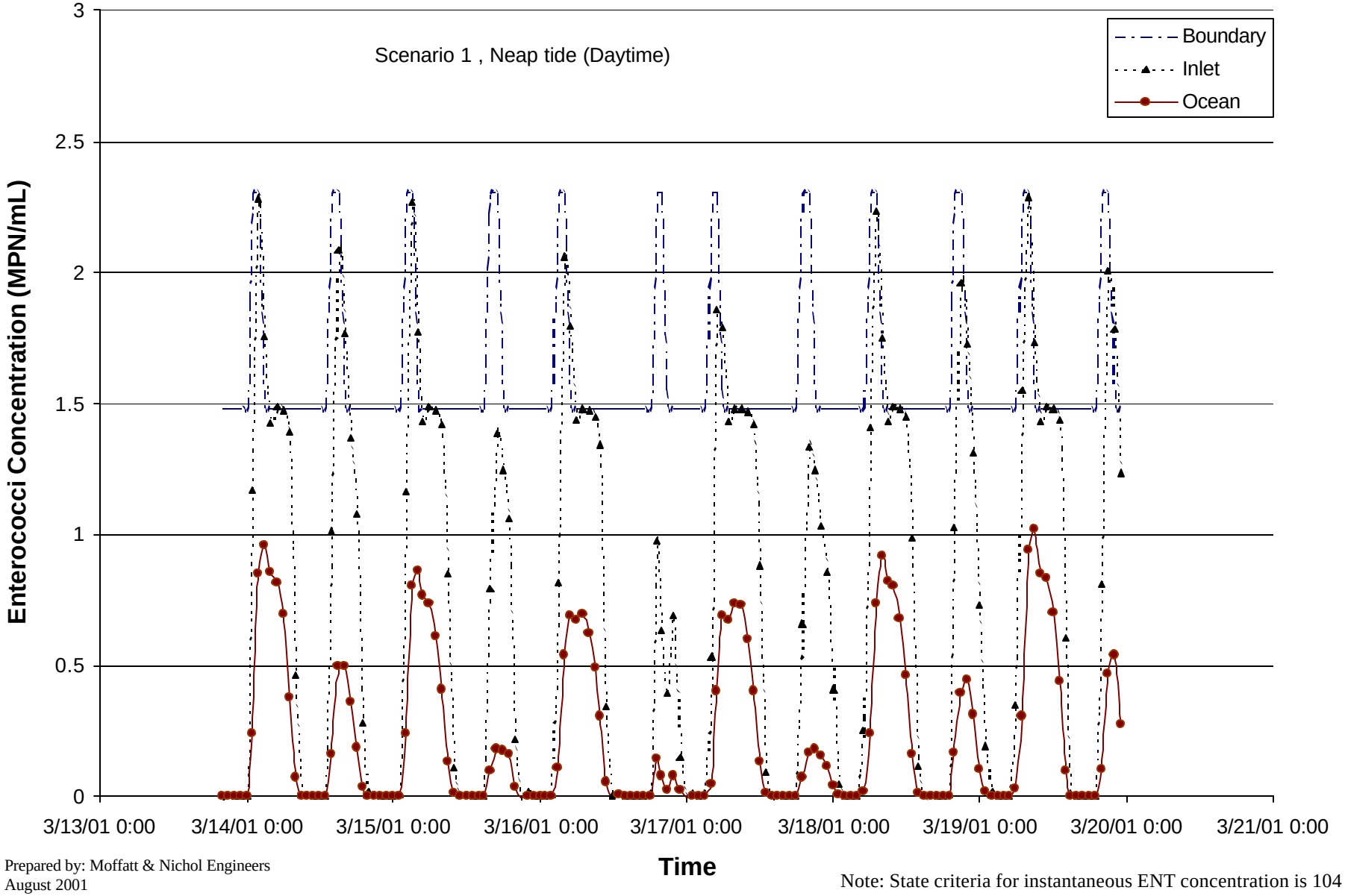
Bolsa Chica Engineering Studies	Discharge from Marsh to Ocean for Scenario 2	**Figure 10**



Prepared by: Moffatt & Nichol Engineers
August 2001
k:/4012-18/coastal/report/figures.ppt

Note: State criteria for instantaneous ENT concentration is 104 MPN/100mL and 30-day geometric mean is 35 MPN/mL.

Bolsa Chica Engineering Studies	Scenario 2 - Predicted Enterococci Concentration with Modeling Area Covering FTB, FFTB and MTB	**Figure 11**



Prepared by: Moffatt & Nichol Engineers
August 2001
k:/4012-18/coastal/report/figures.ppt

Note: State criteria for instantaneous ENT concentration is 104 MPN/100mL and 30-day geometric mean is 35 MPN/mL.

Bolsa Chica Engineering Studies	Predicted Enterococci Concentration Time Series Scenario 2	**Figure 12**