October 14, 2025

BACWA Permits Committee

Dilution Study Requirements in SF Bay NPDES Permits

Mixing zone/Dilution Credit 101

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October 14, 2025

Overview

- What is dilution modeling
- Need for dilution modeling
- Technical references
- Shallow vs Deep discharges
- Model considerations
- Typical scenarios
- When to update dilution
- AWPF and ROC discharge
- Dilution report key information
- Questions

What is Dilution Modeling

Physical world

- Discharge mixes in the receiving water

Dilution credit

- Regulatory decision
  - Acute, Chronic, Chronic Toxicity, Human Health
- Specific discharge conditions
  - Discharge geometry, flowrate, density
- Specific receiving water conditions
  - Depth, density stratification
- Determine distance, travel time, area
- Real mixing is better than regulatory dilution credit

Need for Dilution Modeling

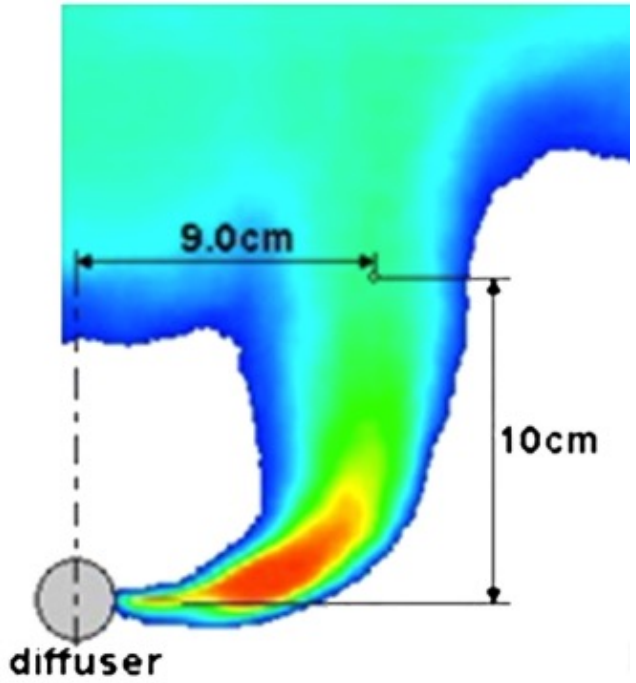
Modeling for reasonable “worst case” conditions

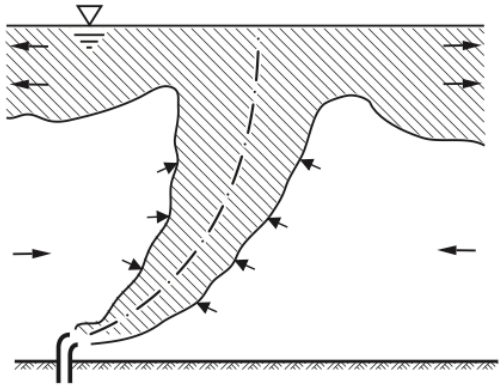
Regulator request

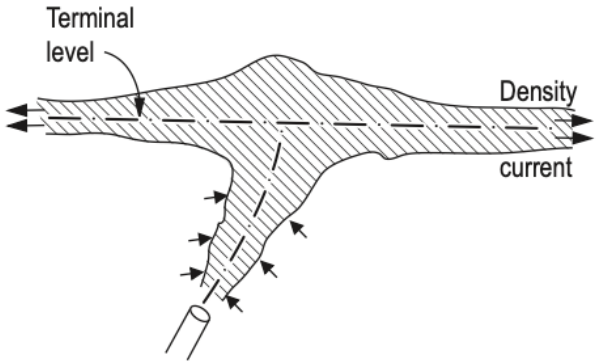
- New water quality objectives
- Basin Plan changes

Substantive change

- Increased or decreased discharge (i.e., new flows, increased recycling)
- Some ports plugged/unplugged
- Increased industrial discharge
  - High temperature
  - High density
- Adding ROC discharge or other waste stream







Dilution Definition

Different definition depending on application (mindset)

Modeling

$$C_d = \frac{Q_u C_u + Q_{eff} C_{eff}}{Q_u + Q_{eff}}$$

$$S = \frac{Q_u + Q_{eff}}{Q_{eff}}$$

$$C_d = C_u + \frac{1}{S}(C_{eff} - C_u)$$

Effluent Limitation

$$C_d = \frac{Q_u C_u + Q_{eff} C_{eff}}{Q_u + Q_{eff}}$$

$$D = \frac{Q_u}{Q_{eff}} = (S - 1)$$

$$C_{eff} = C_d + D(C_d - C_u)$$

$$ECA = C + D(C - B)$$

$$IWC = \frac{1}{D + 1} \cdot 100\%$$

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Dilution Definition

Modeling

$$S = \frac{Q_u + Q_{eff}}{Q_{eff}}$$

Effluent Limitation

$$D = \frac{Q_u}{Q_{eff}} = (S - 1)$$

$$IWC = \frac{1}{D + 1} \cdot 100\%$$

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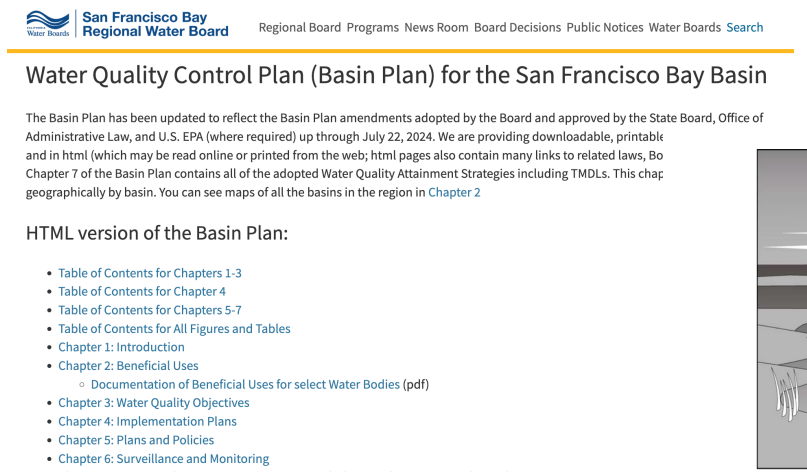
Technical References

Required

- Basin Plan
- SIP

Guidance

- USEPA TSD (1991)
- EPA Water Quality Standards Handbook
- Mixing Model user manuals


San Francisco Bay Regional Water Board

Regional Board Programs News Room Board Decisions Public Notices Water Boards Search

Water Quality Control Plan (Basin Plan) for the San Francisco Bay Basin

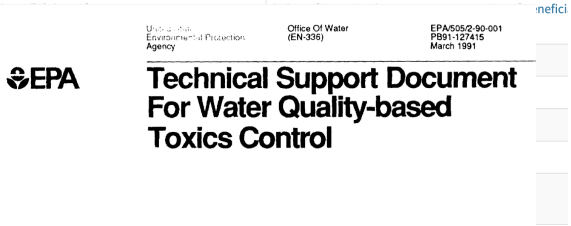
The Basin Plan has been updated to reflect the Basin Plan amendments adopted by the Board and approved by the State Board, Office of Administrative Law, and U.S. EPA (where required) up through July 22, 2024. We are providing downloadable, printable and in html (which may be read online or printed from the web; html pages also contain many links to related laws, Bo Chapter 7 of the Basin Plan contains all of the adopted Water Quality Attainment Strategies including TMDLs. This chap geographically by basin. You can see maps of all the basins in the region in Chapter 2

HTML version of the Basin Plan:

- Table of Contents for Chapters 1-3
- Table of Contents for Chapter 4
- Table of Contents for Chapters 5-7
- Table of Contents for All Figures and Tables
- Chapter 1: Introduction
- Chapter 2: Beneficial Uses
  - Documentation of Beneficial Uses for select Water Bodies (pdf)
- Chapter 3: Water Quality Objectives
- Chapter 4: Implementation Plans
- Chapter 5: Plans and Policies
- Chapter 6: Surveillance and Monitoring
- Chapter 7: Water Quality Attainment Strategies Including Total Maximum Daily Loads
- **NEW!** Chapters 1 through 7 combined in printer-friendly format

PDF files available for viewing and download

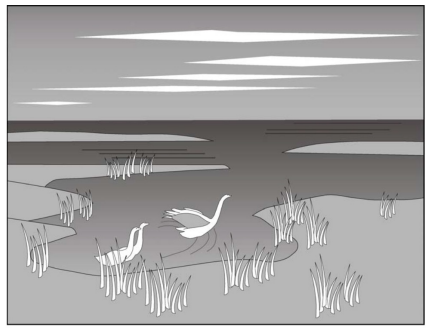
Chapter 1 (introduction)	see map of San Francisco Bay Region
Chapter 2 (	
Chapter 3 (	
Chapter 4 (	
Chapter 5 (	
Chapter 6 (	
Chapter 7 (including T	


Office Of Water (EN-336)

EPA/505/2-90-001 PB91-127415 March 1991

EPA

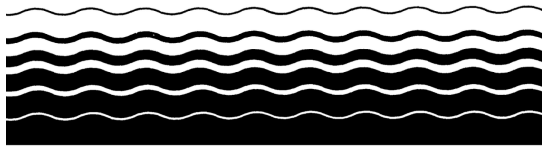
Technical Support Document For Water Quality-based Toxics Control



Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California

2005

STATE WATER RESOURCES CONTROL BOARD
California Environmental Protection Agency



Shallow vs Deep Water Discharges (Region 2 Basin Plan)

Deep Discharge

- Discharge via outfall with diffuser
- Minimum initial dilution of 10:1 (generally much greater)

Shallow Discharge

- Everything else
- Dilution credits granted on a pollutant-by-pollutant basis

Shallow Discharges

Discharger-by-discharger, pollutant-by-pollutant, and consistent with Antidegradation

- Source ID study
- Develop and implement source reduction
- Commit resources to fully implement source control/reduction plan

Workplan Required

- Approval by EO

Compliance in accordance with the SIP

- Demonstration of meeting WQO (including Chronic Tox)
- Based on ambient salinity and hardness (and meeting marine where water meets 5 ppt)
- Evaluation of worst-case conditions (tidal cycle, currents, or instream flows, as appropriate)
    - Account for averaging period of the objective
- Evaluation of mass loading and accumulation in aquatic life
    - Protect wildlife and human health

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Shallow Discharges SIP Requirements

A mixing zone shall not:

- Compromise integrity of the entire waterbody
- Cause acutely toxic conditions to aquatic life passing through the mixing zone
- Restrict the passage of aquatic life
- Adversely impact biologically sensitive or critical habitats
- Produce undesirable or nuisance aquatic life
- Result in floating debris, oil, or scum
- Produce objectionable color, odor, taste, or turbidity
- Cause objectionable bottom deposits
- Cause nuisance
- Dominate the receiving waterbody or overlap mixing zone from different outfall
- Be allowed near any drinking water intake

Deep Discharges in SF Bay

Generally limited to 10:1 dilution based on complex estuarine system of SF Bay

- Cumulative mass loadings
- Toxicity has been detected in Bay system
- Bioaccumulation is of concern to wildlife and human health
- Difficult to measure or model actual dilution in whole Bay
- Direction of waste transport varies over tidal cycle
- USEPA dilution models do not account for tidal transport

Will consider greater than 10:1 dilution

- Significant water reclamation or water reuse
- No increase in mass loading
- Rapid pollutant degradation in water column (e.g., chlorine, ammonia)
- Chronic toxicity

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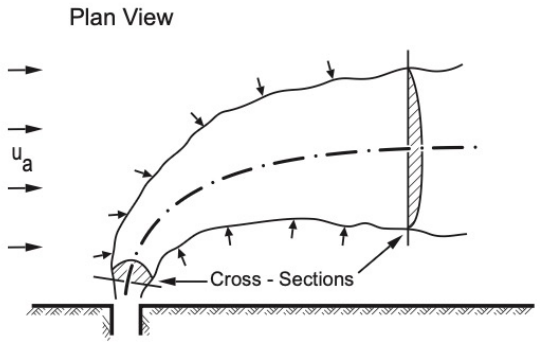
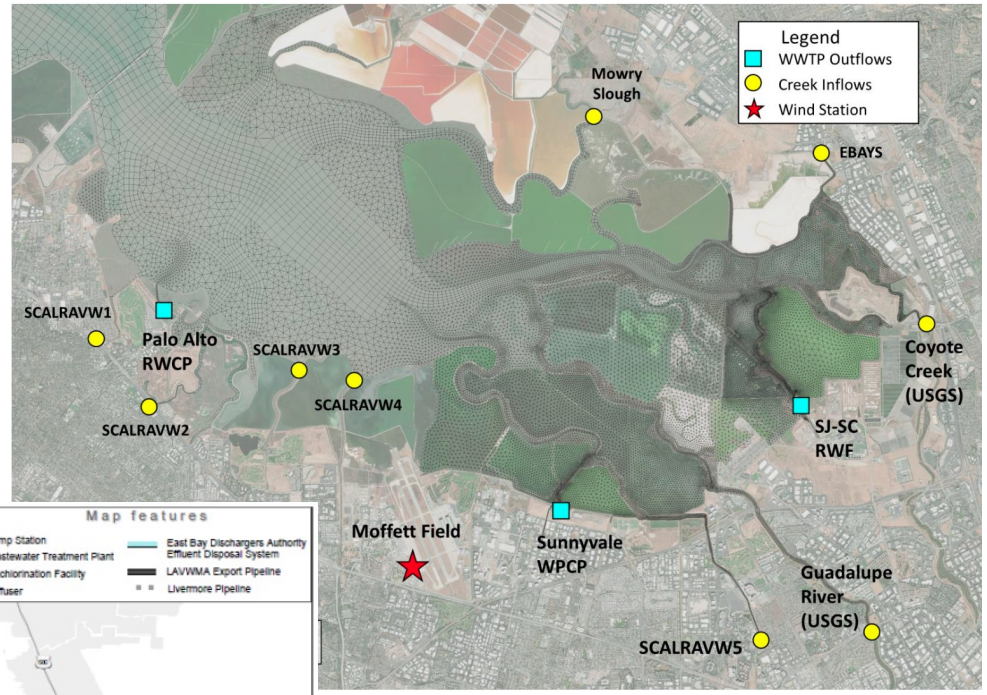
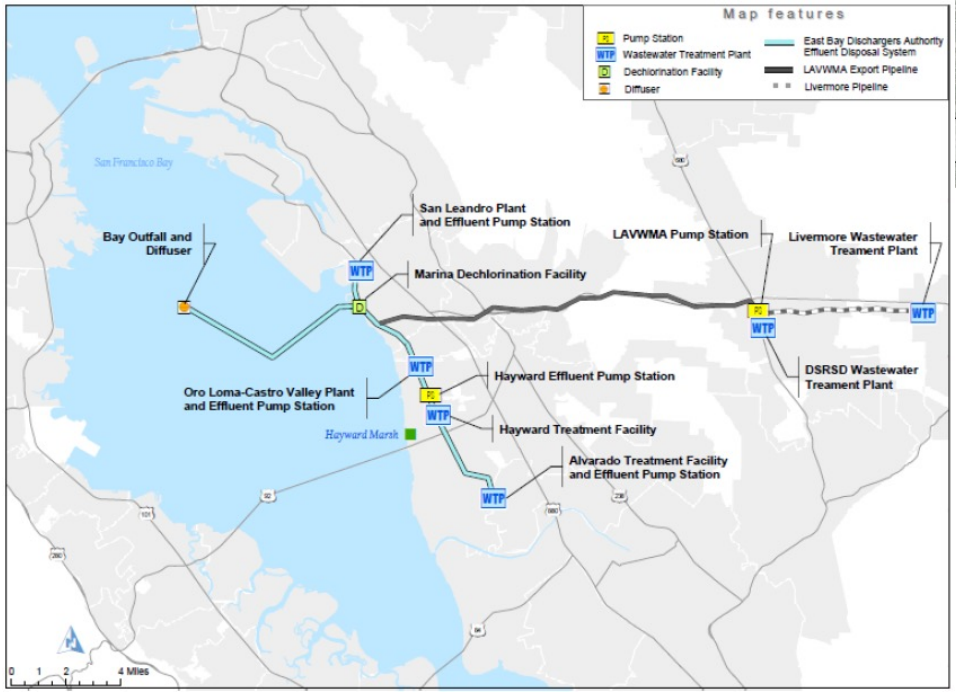
Model Selection

Where is discharge occurring?

- Above tidal influence
- Shallow tidal influence
- Deep discharge







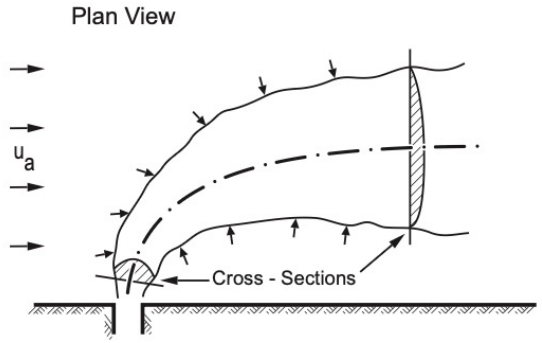
Model Selection
Above Tidal Influence

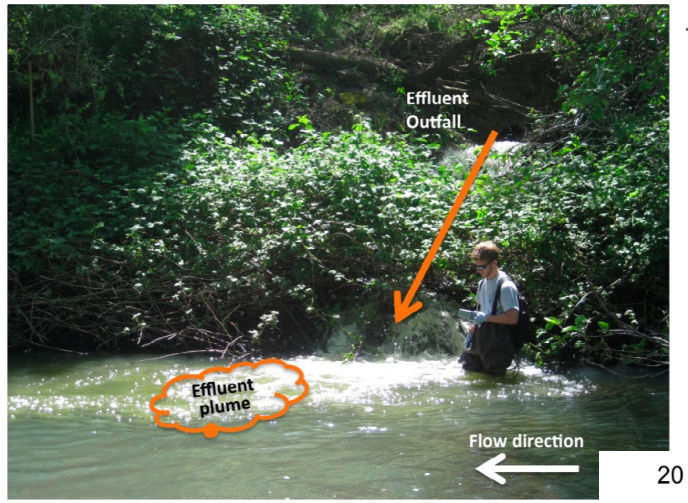
USEPA mixing zone models

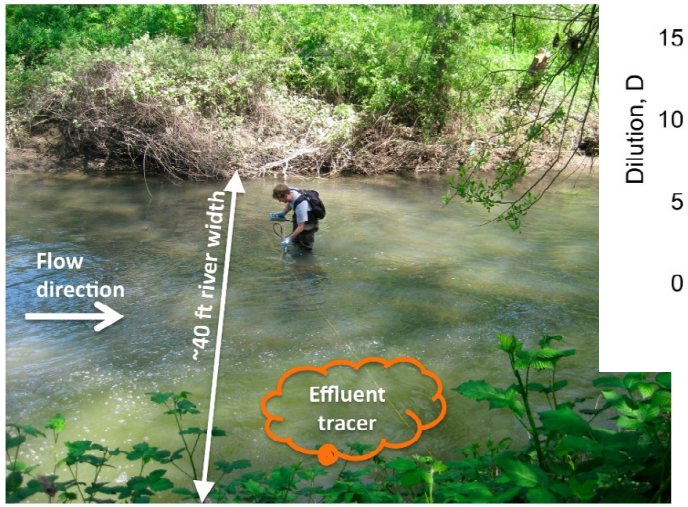
- CORMIX
- Visual Plumes

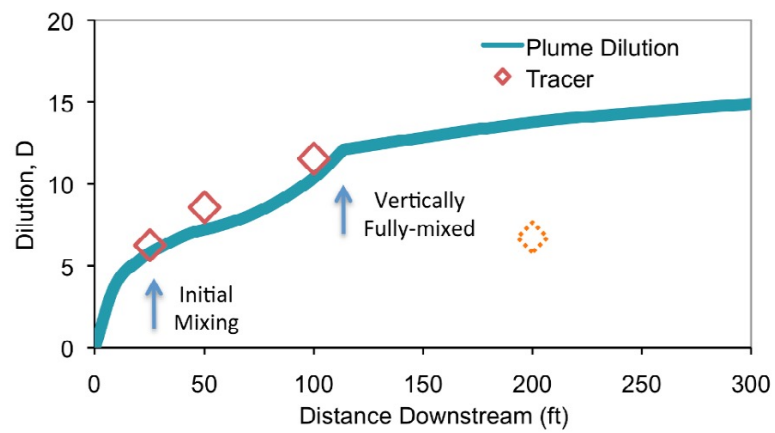
Exact CORMIX use case

- Constant ambient flow & characteristics
- Fixed channel geometry
- Constant effluent flow & characteristics
- Fixed effluent geometry









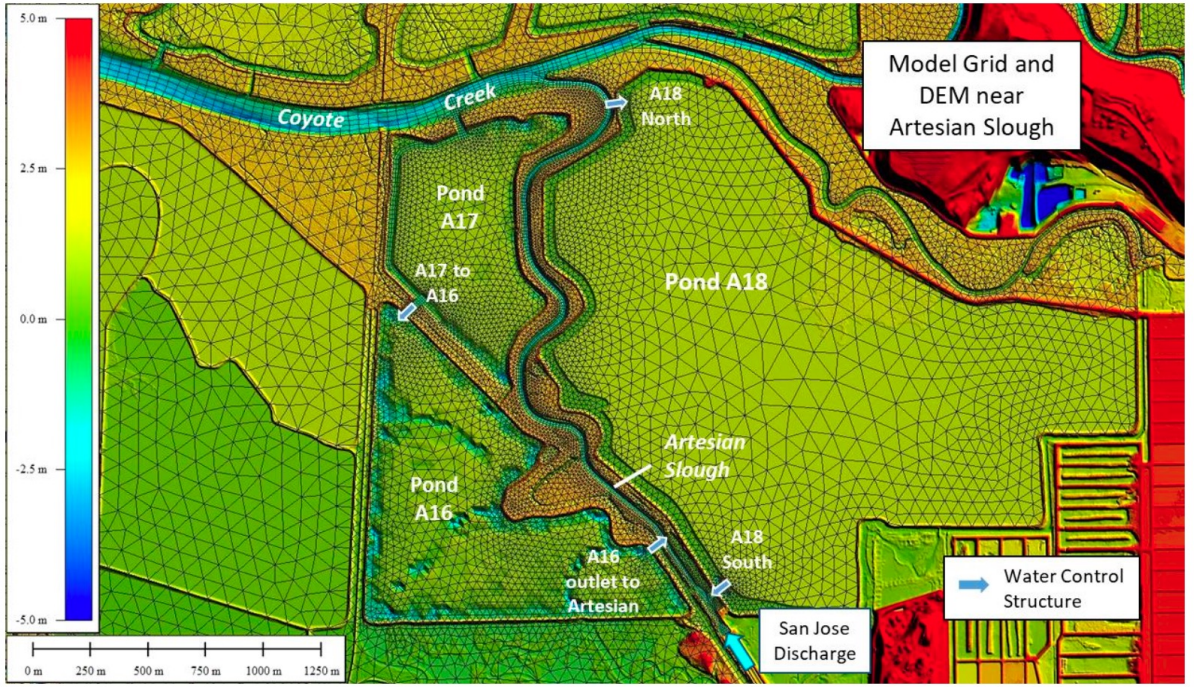
Model Selection
Shallow Tidal Influence

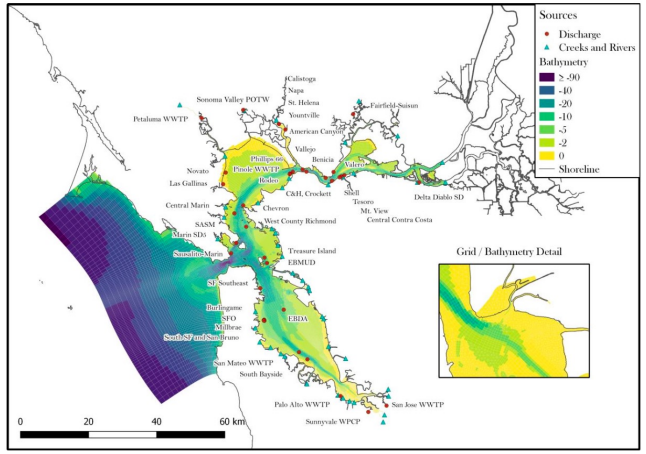
Bay Model

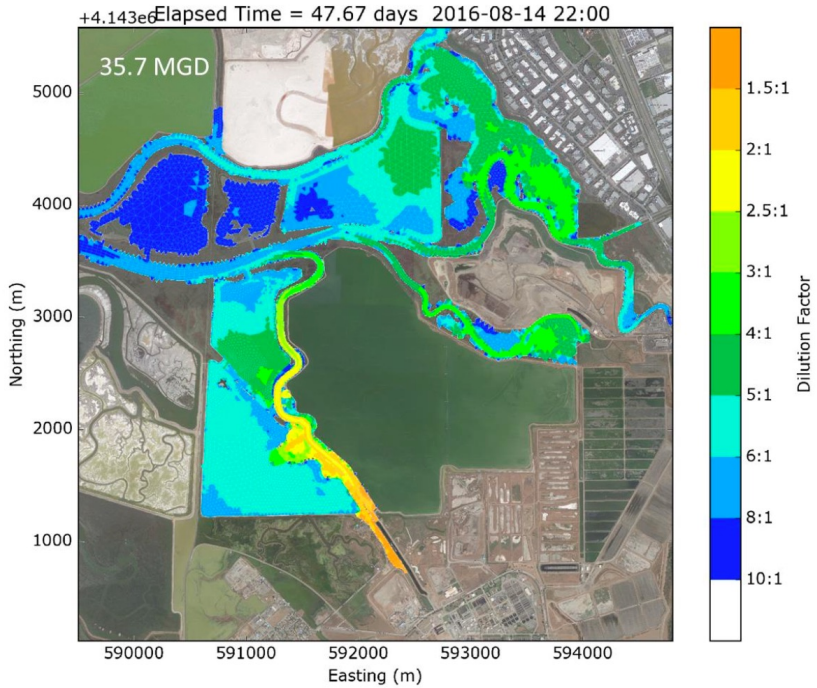
- Mike21
- RMA2
- SFEI-DFM

Exact use case

- Tidal exchange provides dilution
- Sloughs and near shore are well represented by mesh



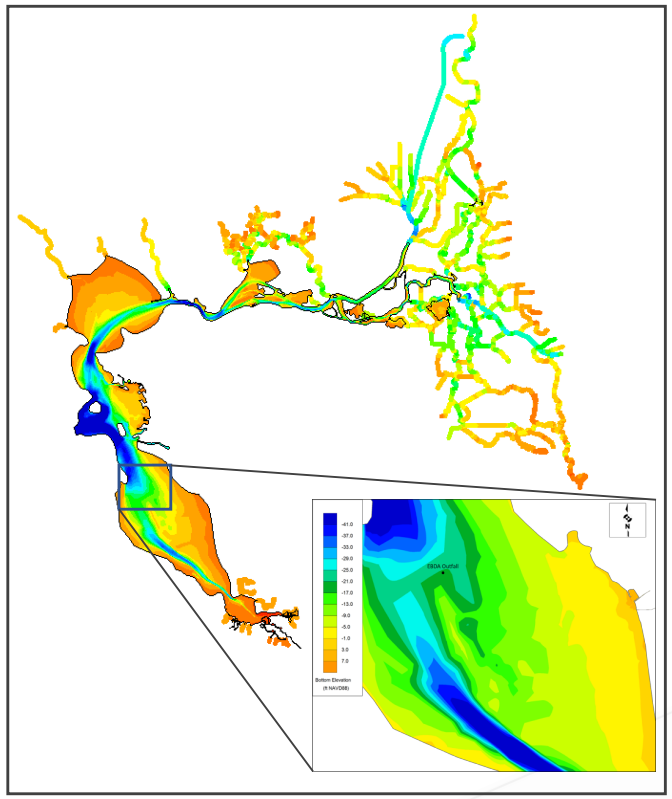


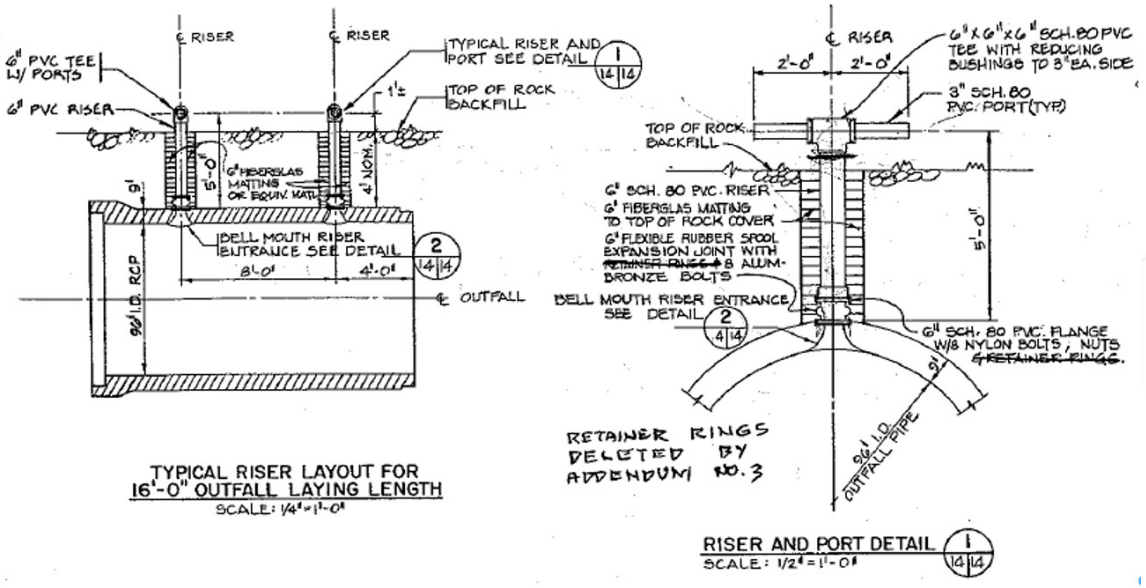


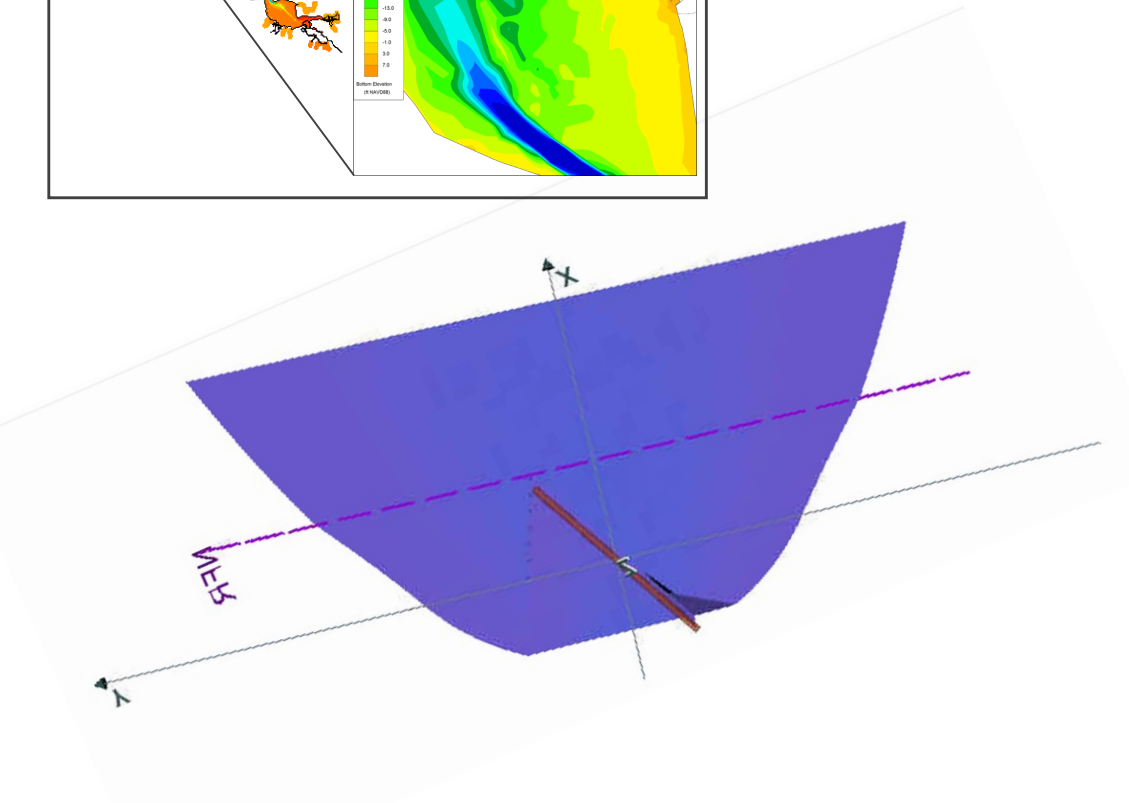
Model Selection
Deep Discharge

Leverage strength of both models

- Tidal exchange drives currents over diffuser – 2D or 3D Bay Model
- Momentum and buoyancy drive initial dilution – Mixing Zone Model







Scenarios

Acute Criteria (ammonia)

- 1-hour total exposure

Chronic Criteria (ammonia)

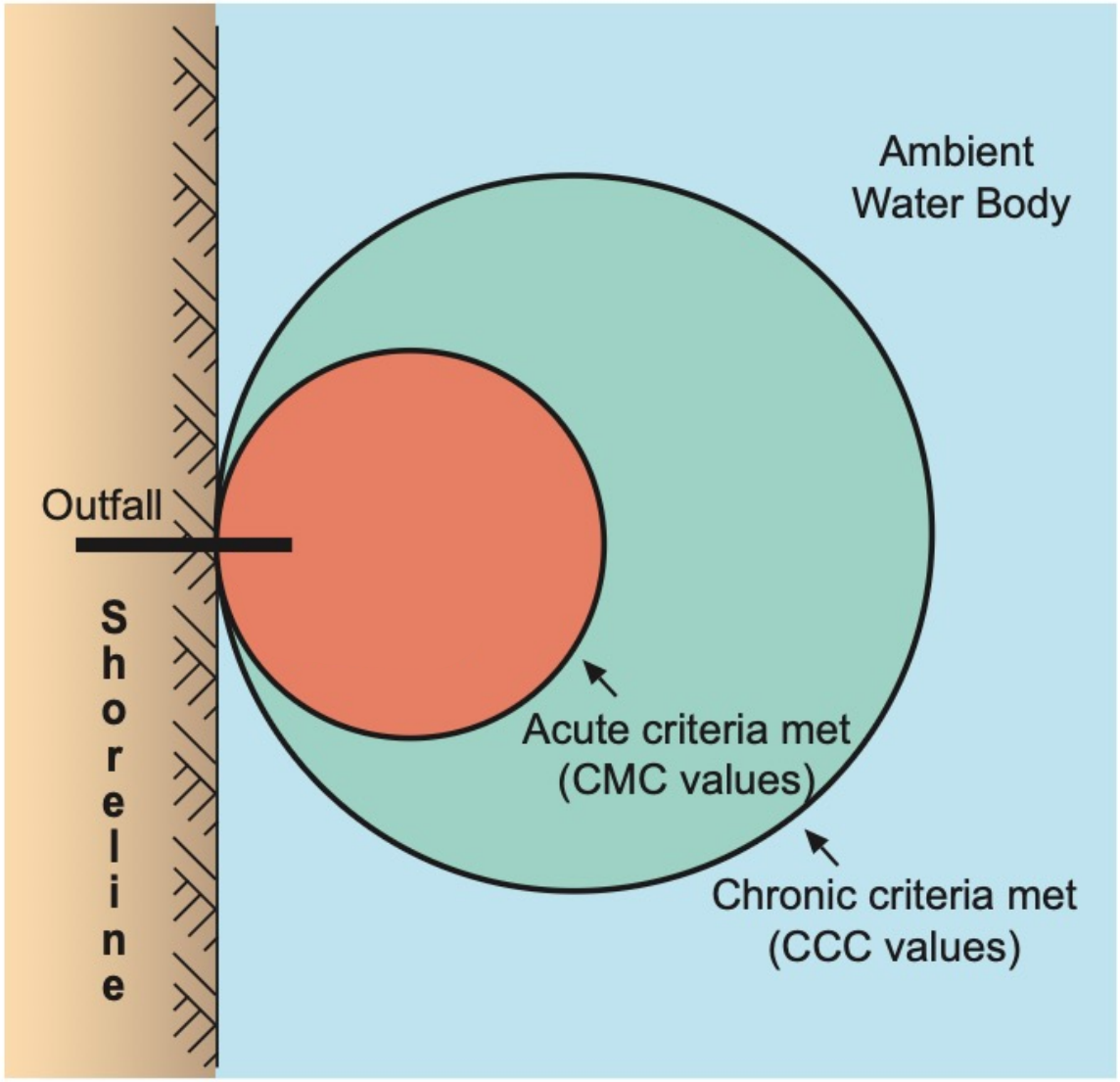
- 30-day average

Chronic Toxicity (or 4-day based CCC)

- 4-day average

Human Health Criteria

- Long-term exposure



Scenarios
Above Tidal Influence

Basin Plan requires SIP evaluation

Table 3. Effluent and Receiving Water Flows for Calculating Dilution Ratios

In calculating a dilution ratio for:	**Use the critical receiving water flow[1] of:**	**Use the discharged effluent flow of:**
Acute aquatic life criteria/objectives	*1Q10	*maximum daily flow during period of discharge
Chronic aquatic life criteria/objectives Chronic toxicity objective for aquatic life[2]	*7Q10	*four-day average of daily maximum flows during period of discharge
Human health criteria/objectives	*harmonic mean	*long-term arithmetic mean flow during period of discharge

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Scenarios
Tidal Influence

No specific guidance in Basin Plan

Shallow discharge

- Site appropriate critical conditions
- To be approved by EO

Deep discharge

- Default 10:1
- Acute
    - Max daily effluent flow, average ambient velocity 30 minutes before and after slack tide
- Chronic Ammonia (30-day objective)
    - Average daily effluent flow, median ambient velocity
- Chronic Toxicity (4-day objectives)
    - Max 4-day average effluent flow, minimum 4-day average ambient velocity

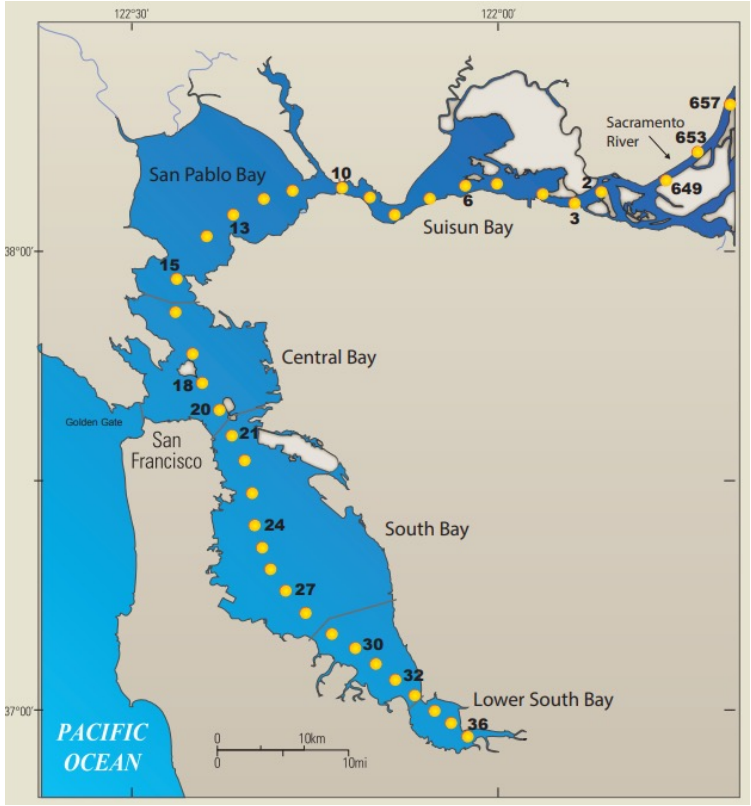
Scenarios
Additional Considerations

Effluent Density

- Temperature (for domestic wastewater effluent)
- Add EC or TDS if significant RO concentrate or industrial brine

Ambient Density Profile

- Seasonality to match discharge condition
- Use closest USGS monitoring station



Timing for Dilution Study Modeling and Reporting

Previous study is available with no substantive changes

- 2 – 4 months before submittal

No available previous study or substantive changes

- 3 – 12 months before submittal

Modification of treatment / addition of AWPF or brine

- Incorporate dilution/water quality assessment in planning
- 6 – 12+ months before submittal

Considerations for Reverse Osmosis Treatment Systems

RO Concentrate (ROC) Production

- What fraction of effluent would be treated?
  - ~20% of treated flow
  - ~5 times effluent concentrations
  - ~3-4 kg/m^3 increase in density

Receiving Water

- Freshwater
  - ROC potentially more dense than ambient
  - May become neutrally buoyant if sufficient dilution exits
  - May significantly reduce dilution
- SF Bay (or Ocean)
  - ROC buoyant
  - Minor reduction in dilution

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Dilution Modeling Report

State purpose of update

State model(s) used

Describe scenarios and representative conditions modeled

Present results for S, D, and IWC

Present plume size and travel time

Table 8. Available Dilution at the Outfall under Various Conditions

Condition	Effluent Flow (MGD)	Current Speed[a] (ft/s)	Dilution (S)	Dilution Credit (D)	Instream Waste Concentration[e] (IWC)
Acute Ammonia	304[b]	0.39	32	31	---
Chronic Ammonia	47.3[c]	1.04	124	123	---
Chronic Toxicity	184.5[d]	0.77	104	103	0.96%

[a] The tides are the primary mixing mechanism in the outfall area.
[b] Maximum hourly effluent flowrate discharged from the outfall over the past five years
[c] Average mean daily flowrate over three consecutive dry months (July through September) during the last 5 years adjusted to account for a 1% annual growth rate for the next 5 years
[d] Maximum 4-day running average flowrate (January 1, 2015 through February 29, 2020).
[e] Instream waste concentration only applicable to chronic toxicity dilution

Table 9. Plume Metrics for the Various Discharge Conditions

Condition	Plume Width (m)	Plume Area (acres)	Travel Time (seconds)	Dilution Credit (D)
Acute Ammonia	247	13.1	821	31
Chronic Ammonia	311	16.5	446	123
Chronic Toxicity	335	17.7	538	103

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Thank You

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