Los Angeles and Long Beach Harbors and San Pedro Bay Modeling

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Presentation Outline

- Background
- Greater Harbors Modeling Approach
- Observational Data
- Model Configuration
- Status of Hydrodynamic Model Calibration
- Schedule for Remaining Task
- Discussion

Background

- Modeling Tools Are Being Developed to Support TMDL Implementation in Los Angeles Harbor, Dominguez Channel, LA River, and San Gabriel River
- Multiple Model Applications to Different Regions by Different Groups
- Model Applications Integrated by Use of Same EFDC Modeling Software System and Coordinated Data Sharing

303D Listings

Management Area	Metals	Pesticides	PCBS	PAHs	Fecal Coliform
Ballona Creek	√	√	√		√
Ballona Creek Estuary	√	√	√	√	√
Cabrillo Beach		√	√		√
Dominguez Channel	√	√	√	√	√
Long Beach Harbor Main Channel		√	√	√	
Los Angeles Fish Harbor		√	√	√	
Consolidated Slip	√	√	√	√	
Los Angeles Inner Harbor		√	√	√	
Los Angeles Harbor Main Channel	√	√	√	√	
Los Angeles Harbor SW Slip		√	√		
Los Angeles River Estuary	√	√	√		
Los Angeles River [1]	√				√
Los Cerritos Channel	√	√			√
Marina del Rey Harbor	√	√	√		√

Integration of Multiple Modeling Studies

- Dominguez Channel and Estuary – Everest
- Los Angeles Harbor – Tetra Tech
- San Gabriel Rivers – SCCWP
- Everest and Tetra Models Cover All of LA and LB Harbors and Near Shore Region of San Pedro Bay

Integration of Multiple Modeling Studies

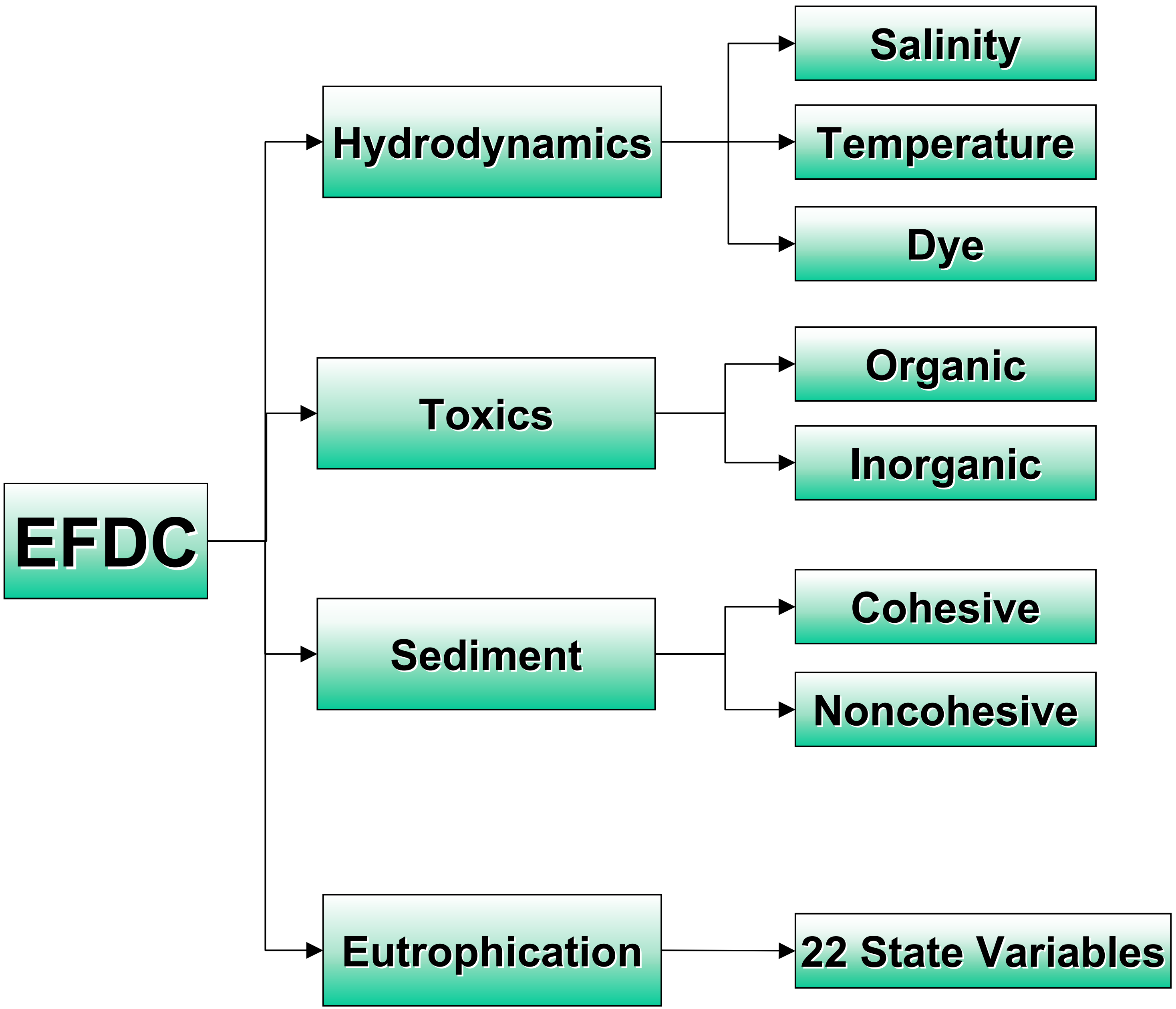
- Tetra Tech Model Will Receive Loadings from Everest Dominguez Channel Model
- Tetra Tech Model Can Provide Boundary Conditions for SCCWP River Model and Receive Loadings
- Since Models Are Based On Same Software System, They Can Be Collapsed Into Single Application if Required.

Greater Harbors Modeling Approach

- Multi-Component EFDC Modeling System
- Observational Data to Support Model Configuration and Calibration
- Model Configuration
- Model Calibration
- TMDL Scenario Simulations

Modeling System Components

- Watershed Model – Provides Non-Point Source Load to Water Body
- Hydrodynamics- Provides Physics to Describe the Movement of Contaminants
- Eutrophication Model – Describes the Carbon, Nitrogen and Phosphorous Cycles and the Impact of Nutrients
- Sediment Transport Model – Movement of Particulate Material Including Deposition and Resuspension
- Contaminant Transport and Fate Model – Describes Transport and Fate of Metals and Organic Compounds Having Tendency to Adsorb to Sediments


EFDC
Hydrodynamics
Toxics
Sediment
Eutrophication
Salinity
Temperature
Dye
Organic
Inorganic
Cohesive
Noncohesive
22 State Variables

EFDC Modeling System

- Public Domain, Open Source Code
- Maintained by Tetra Tech with Support from US EPA
- More than 100 Applications Worldwide
- 3-D Hydrodynamics with Coupled Salinity and Temperature Transport
- Directly Coupled Water Quality-Eutrophication Component
- Sediment-Contaminant Transport and Fate Components
- Extensive Pre and Post Processing

Observational Data to Support Model Configuration and Calibration

- Hydrodynamic Model
  - Inflows (WSM,LACDPW)
  - Open Boundary Conditions (NOAA, PV Shelf)
  - Atmospheric Forcing (NCDC, CIMS)
- Sediment Transport
  - Inflow Concentrations or Loads (WSM, Calibrate)
  - Physical Properties of Bed Sediment (Various)
  - Bed Initial Conditions
  - Erosion Potential (UCSB Study)

Observational Data to Support Model Configuration and Calibration

- Contaminant Transport Model
  - Contaminant Inflow Concentrations or Loads (WSM, Calibration)
  - Initial Contaminant Concentrations in Sediment Bed (Various)
  - Partition Coefficients (Lit, Observed)
  - Particulate and Dissolve Organic Carbon Concentrations in Bed and Water Column (Observations, Calibration)

Model Configuration and Calibration

- Sequential Configuration and Calibration
- Hydrodynamics
  - Configuration Completed
  - Calibration in Progress
- Sediment Transport
  - Sediment Properties and Erosion Potential Data Assembled and Analyzed
  - Configuration in Progress
- Contaminant Transport
  - Observational Data Assembled

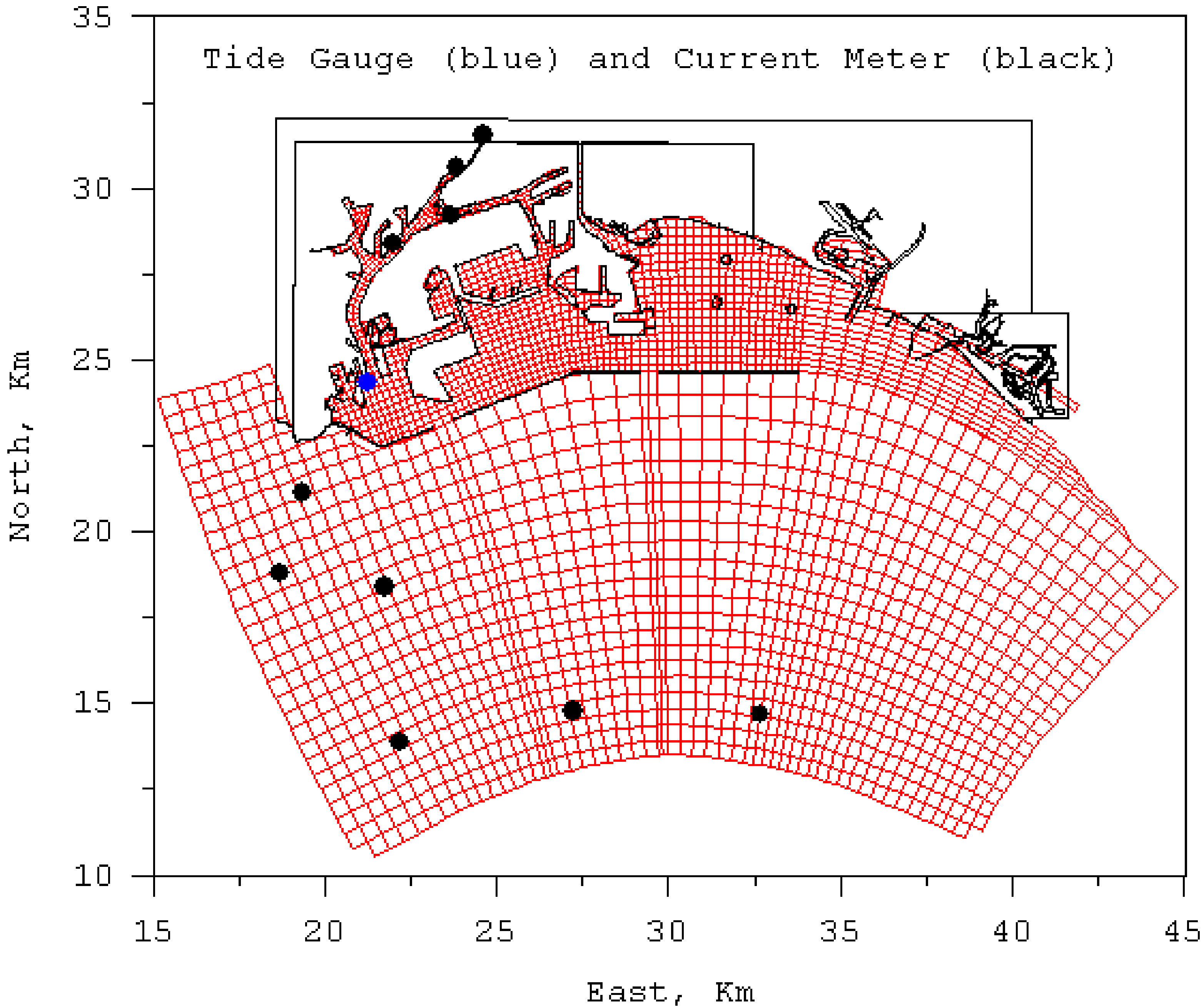
Hydrodynamic Model Status

- Model Spatial Coverage and Grid
- Calibration Data Coverage
- Calibration Approach
- Preliminary Results

Model Grid System

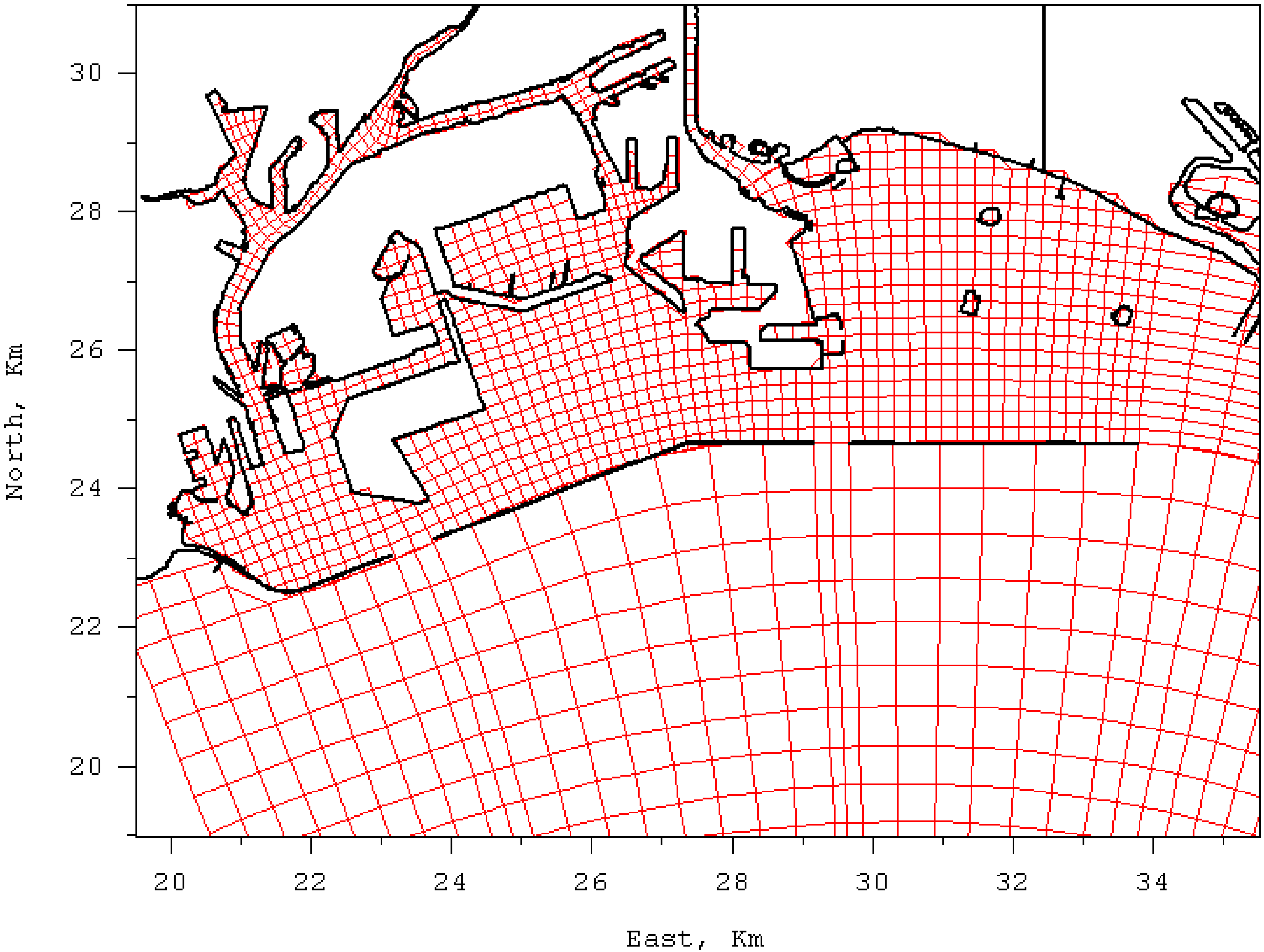
- Multi-Domain with Focused Resolution
- Allows Sub-Sets of Grid to Run Separately
- Expanded Since Jan 06 to Include 6 Current Meter Moorings in San Pedro Bay
- Base Configuration Has 2568 Horizontal Cells
- NOAA Coastal Relief and POLA Bathymetry

Model Grid System

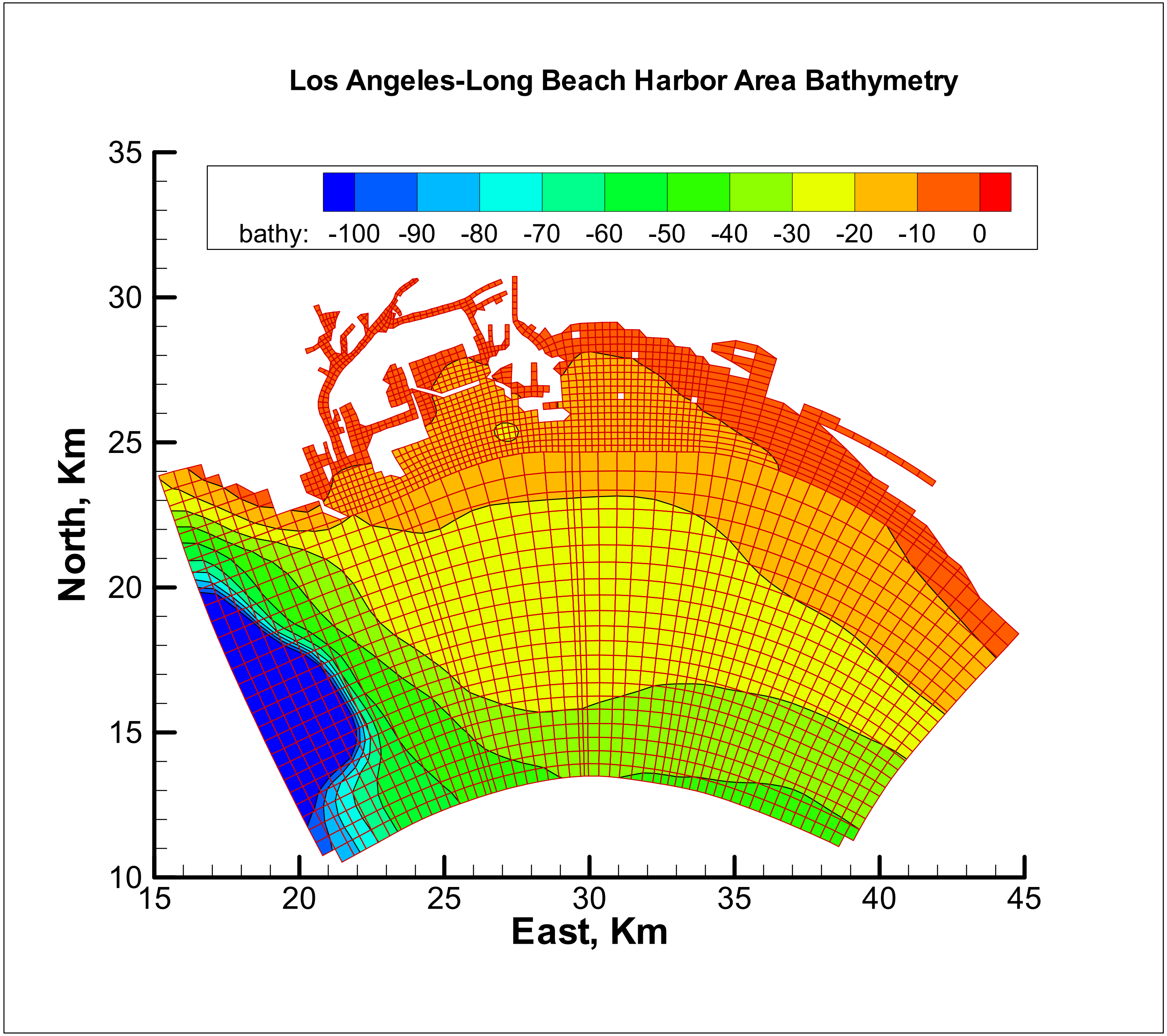


Model Grid Comments

- Large Region of San Pedro Bay Included to Reduce Concentration Boundary Condition Influence in Study Area
  - Consistent with Previous Corps of Engineers Modeling Studies
  - Tidal Boundary Conditions Become Complex and Must Be Determined by Sensitivity-Optimization Procedure (8-64 Model Runs Required)



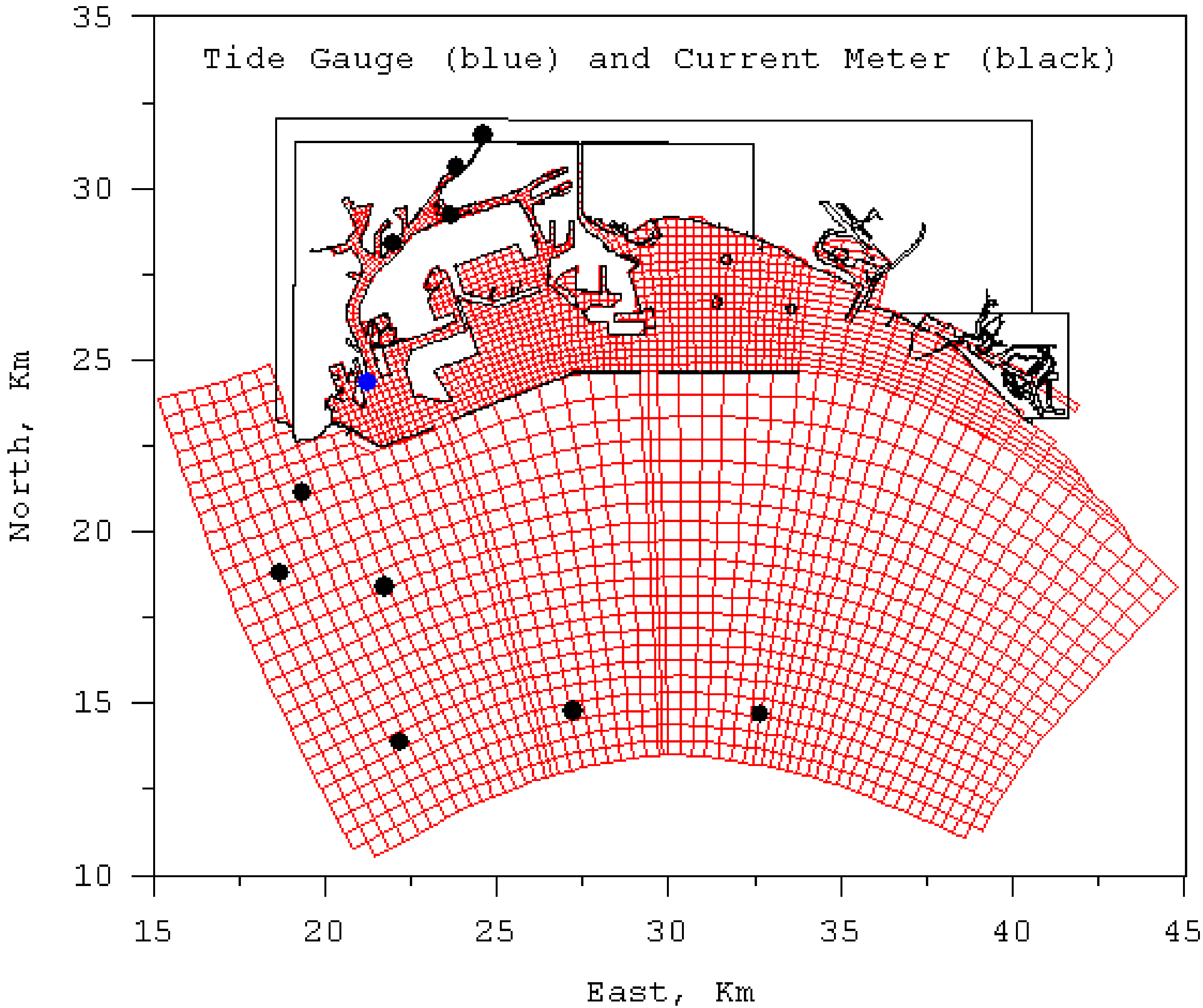
30
28
26
24
22
20
North, Km
20
22
24
26
28
30
32
34
East, Km


Los Angeles-Long Beach Harbor Area Bathymetry
bathy: -100 -90 -80 -70 -60 -50 -40 -30 -20 -10 0
North, Km
35
30
25
20
15
10
East, Km
15 20 25 30 35 40 45

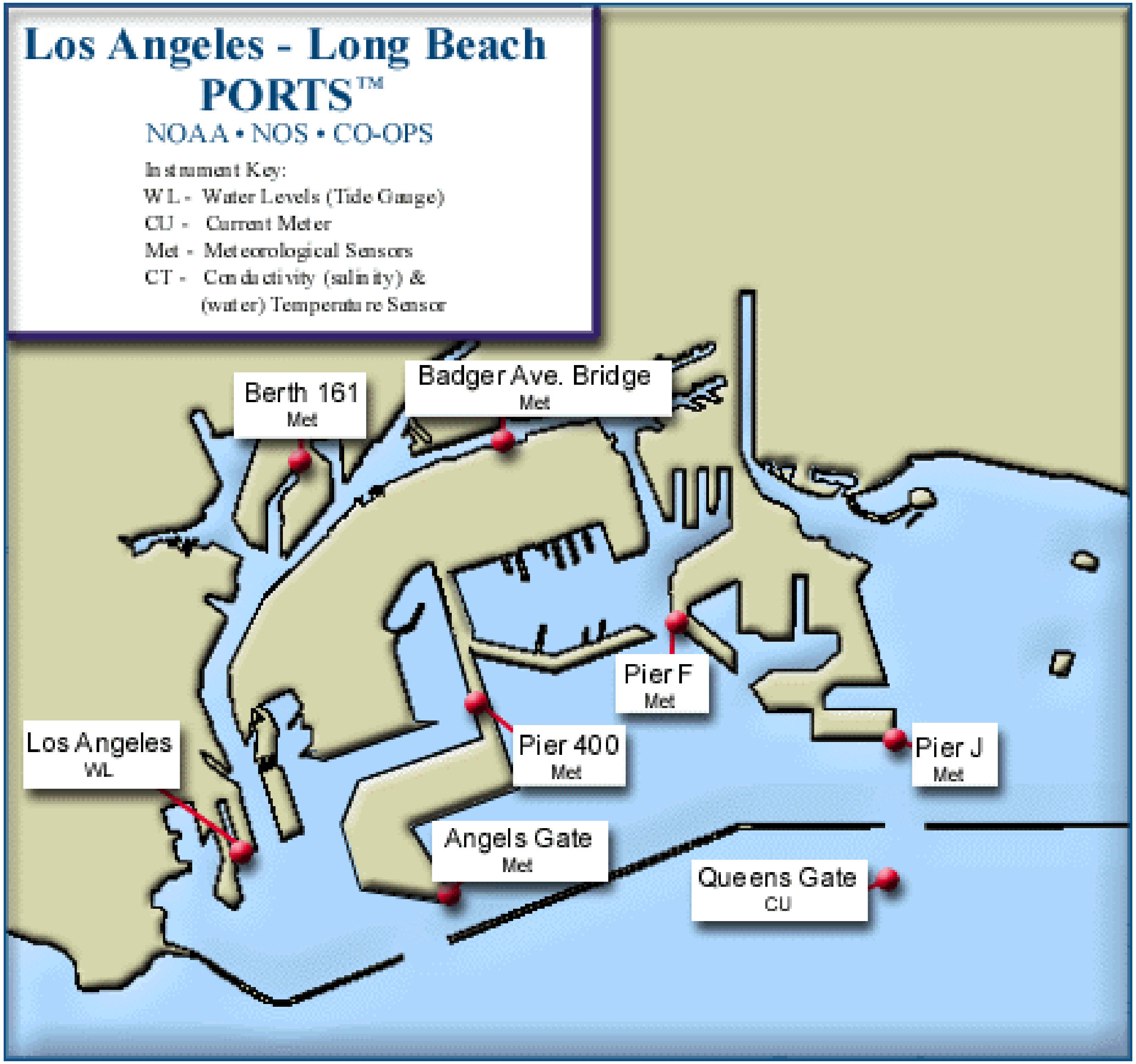
Hydrodynamic Data Coverage and Hydrodynamic Calibration

- Limited Direct Physical Data
  - Tide Gauges
  - Current Meters
- Salinity and Temperature Monitoring Data
- Calibration to
  - Tide Gauges and Current Meters
  - Salinity Observations After High Flow Events
- Preliminary Results

Model Grid System



NOAA Ports System Data Stations



Water Level, Current, Salinity and Temperature Calibration

- Tidal Frequency WL and Currents
  - Water Surface Elevation Harmonic Analysis
  - Tidal Current Ellipse Harmonic Analysis
- Sub-Tidal Frequency WL and Currents
  - Sub-Tidal Time Series Error Analysis
- Salinity and Temperature
  - Discrete, Lumped and Time Series Error Analysis

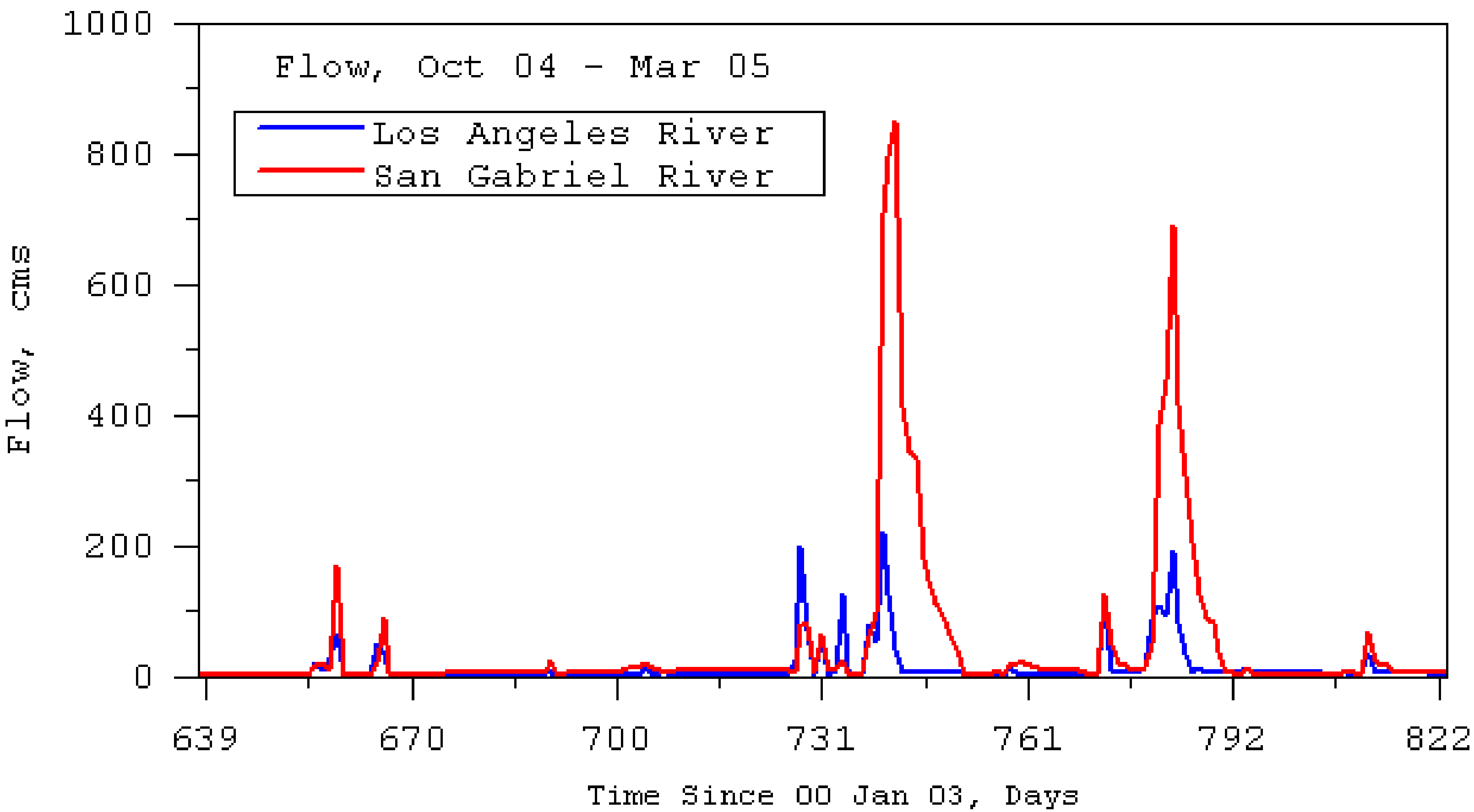
Tidal Harmonic Comparison
NOAA Gauge, LA Harbor

Tide Con	Obs Amp (m)	Mod Amp (m)	Amp Error	Obs Phs (s)	Mod Phs (s)	Phase Error (s)
M2	0.503	0.5	0.006	27434	27554	120
S2	0.203	0.203	0	31335	31457	122
N2	0.119	0.106	0.109	31824	32293	469
K1	0.371	0.374	0.008	19854	20624	770
O1	0.246	0.247	0.004	7829	8253	424
P1	0.107	0.106	0.009	22894	22868	16

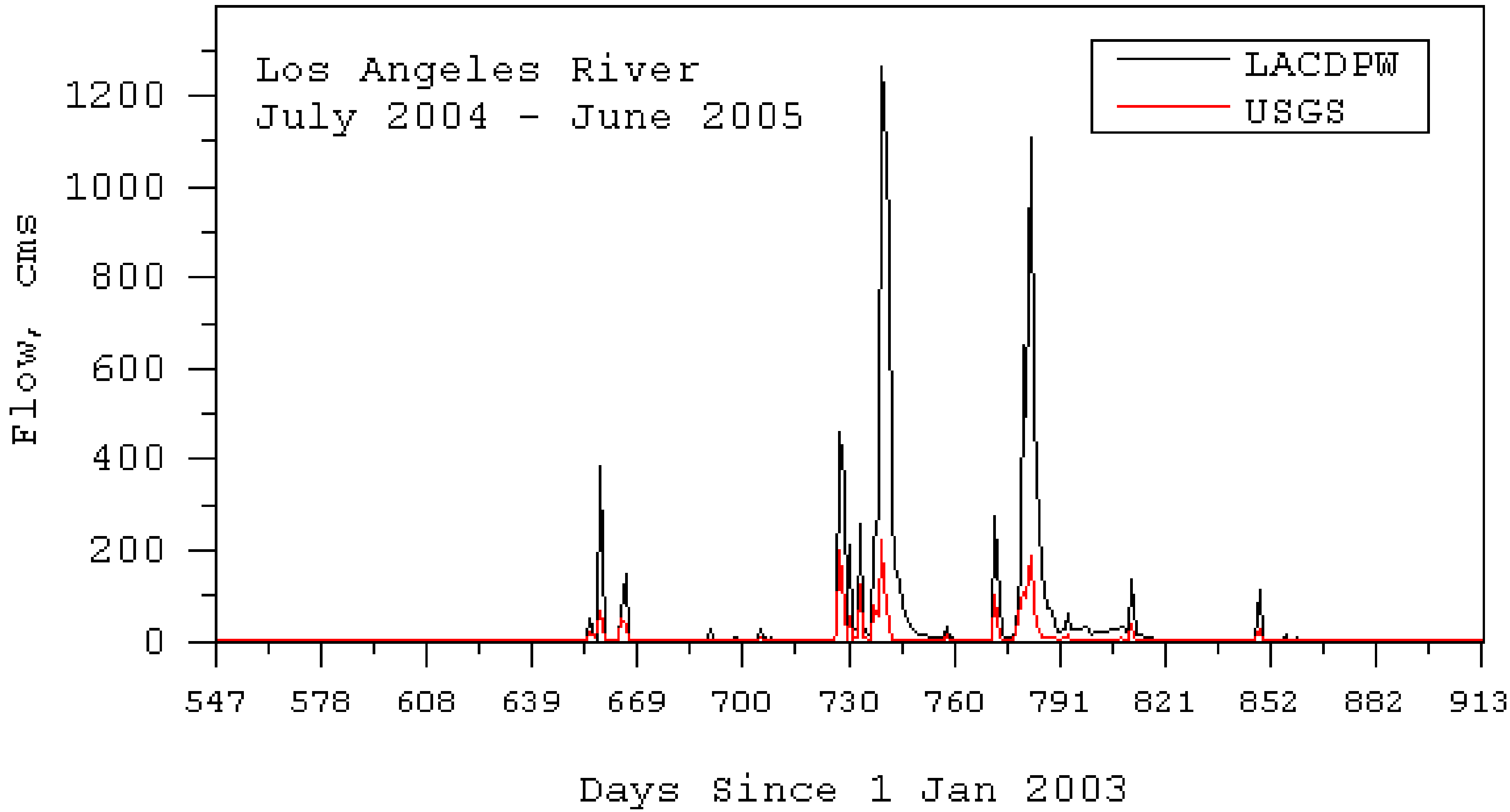
Salinity and Temperature Calibration

- Compare Model Predictions with Observational Data
- Significant Salinity Variability Associated with Inflow Events
- Temperature Simulation Activated to Account of Direct Rainfall and Evaporation to Improve Salinity Predictions

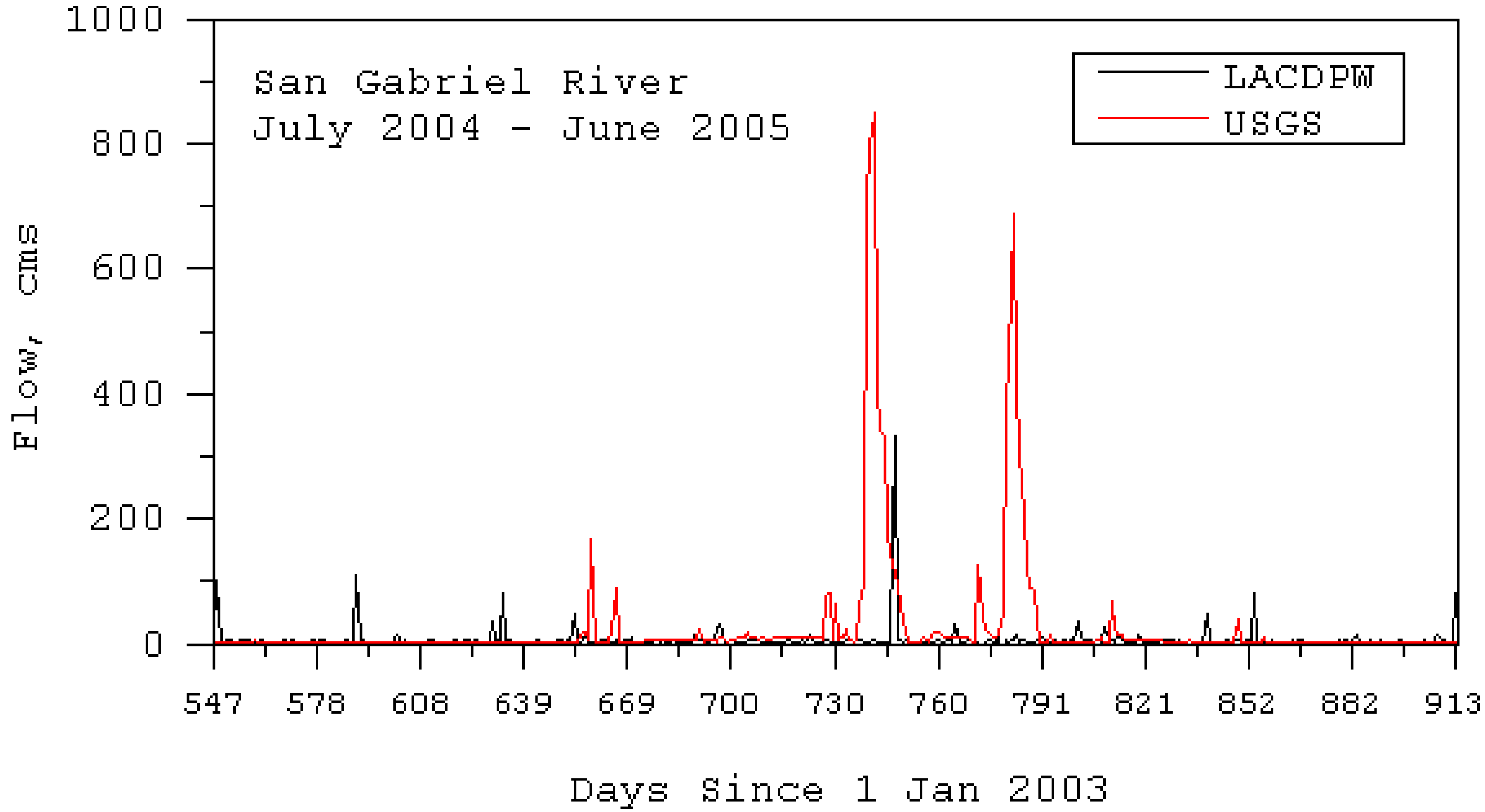
USGS Gauged River Flows During a Salinity Transport Calibration Period



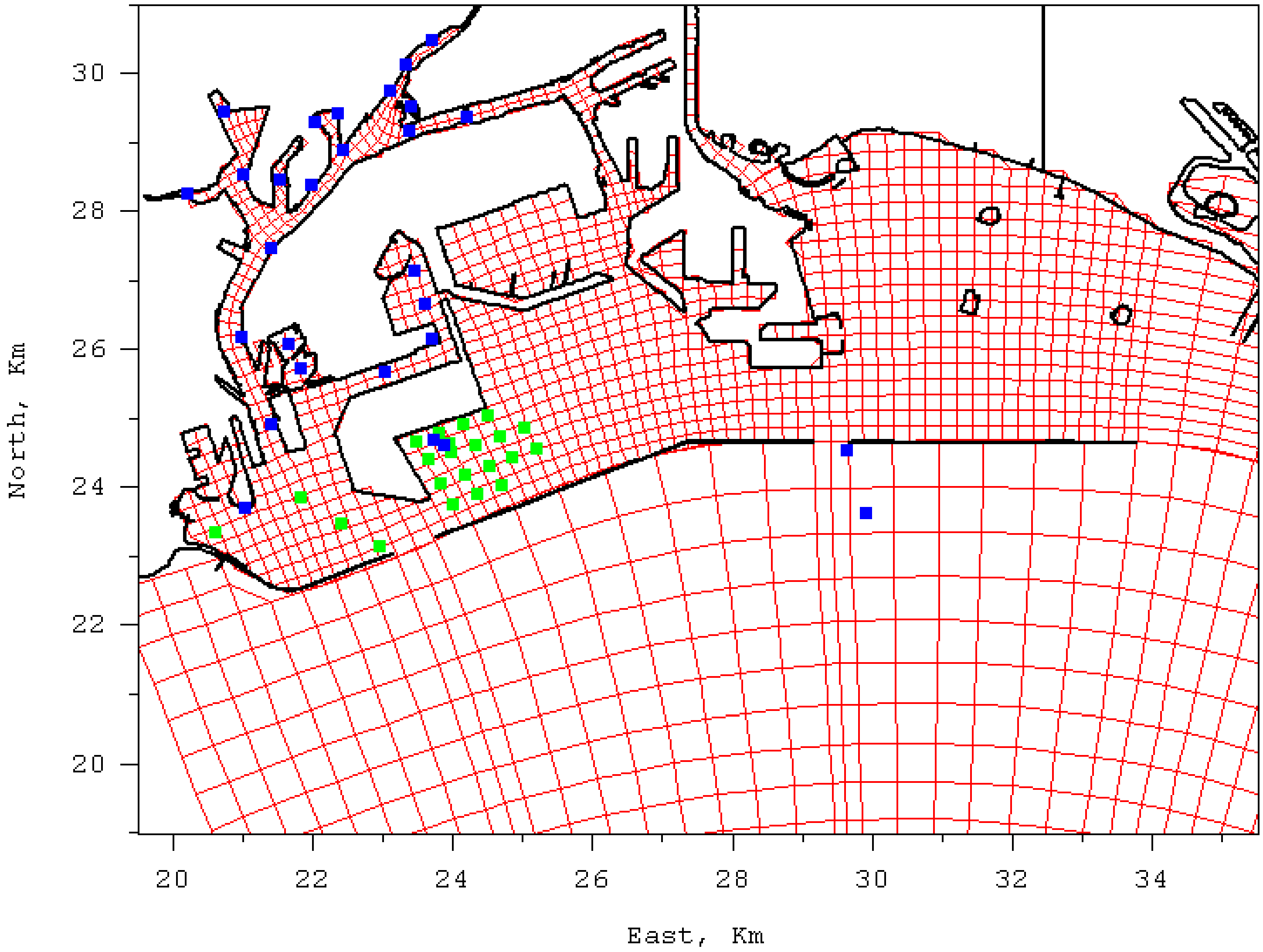
Los Angeles River Flow



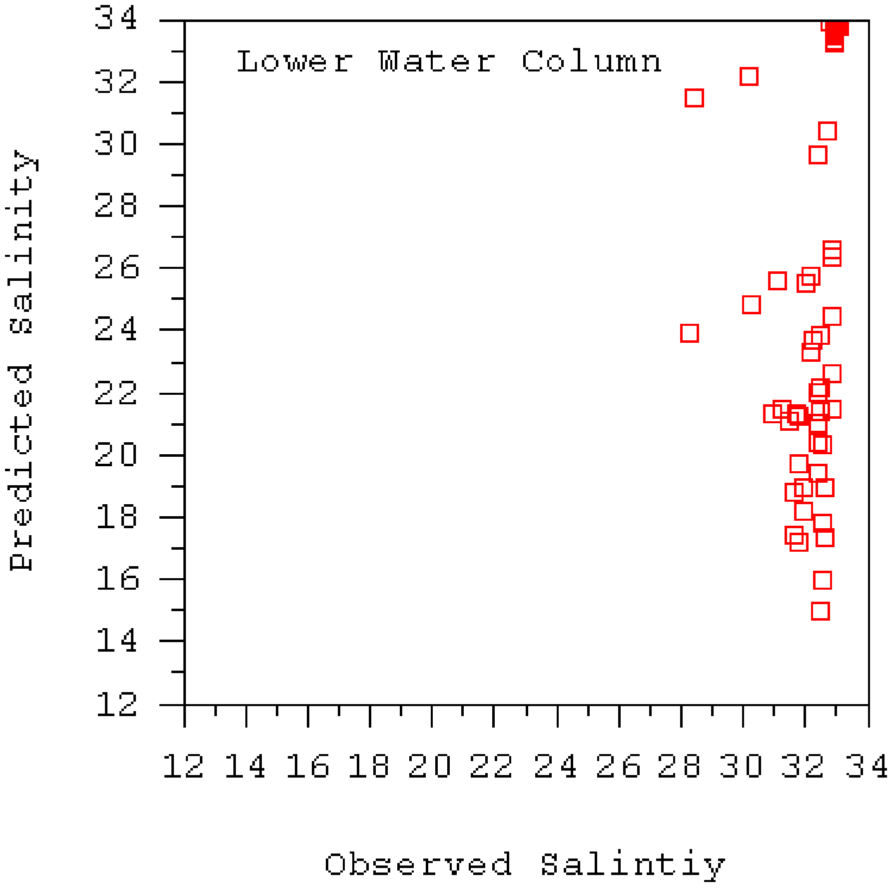
San Gabriel River Flow

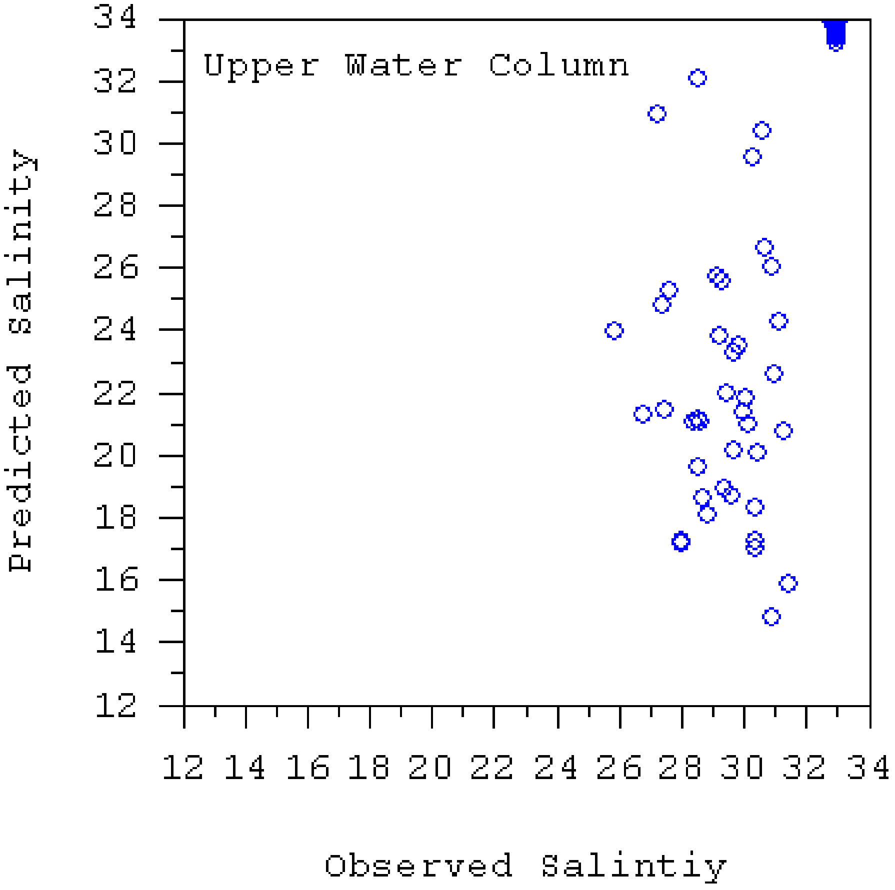


Salinity Monitoring Stations, LA Harbor



Salinity Comparison Outer LA Harbor





Improvement of Salinity Calibration

- Model Predicted Salinity too Low
- QA of River Inflow Data
- Incorporate Watershed Model Output for Rivers and Un-gauged Regions
- Calibrate Evaporation by Adjusting Overland Air Temperature to Over Water
- Incorporate Additional Event Focused Observational Data
- Higher Vertical Resolution

Schedule

- Hydrodynamic Model Currently Nearing Calibration
  - Complete by 30 June ‘06
- Sediment and Contaminant Transport and Fate Model
  - Preliminary Model Setup in Progress
  - Calibration Completed During Fall ‘06
  - Additional Field Studies Planned for Summer ‘06

Sediment Transport Modeling Approach

- Focus on Initialization of Bed Conditions
- Sediment Physical Properties Data Currently Being Used for Bed Initialization
  - Sediment Size and Type
  - Void Ratio or Water Content
  - Surface and Profile Data
- Erosion Potential
  - Site Specific Study to Parameterize Erosion
- Calibration to Water Column TSS

Physical Monitoring Locations

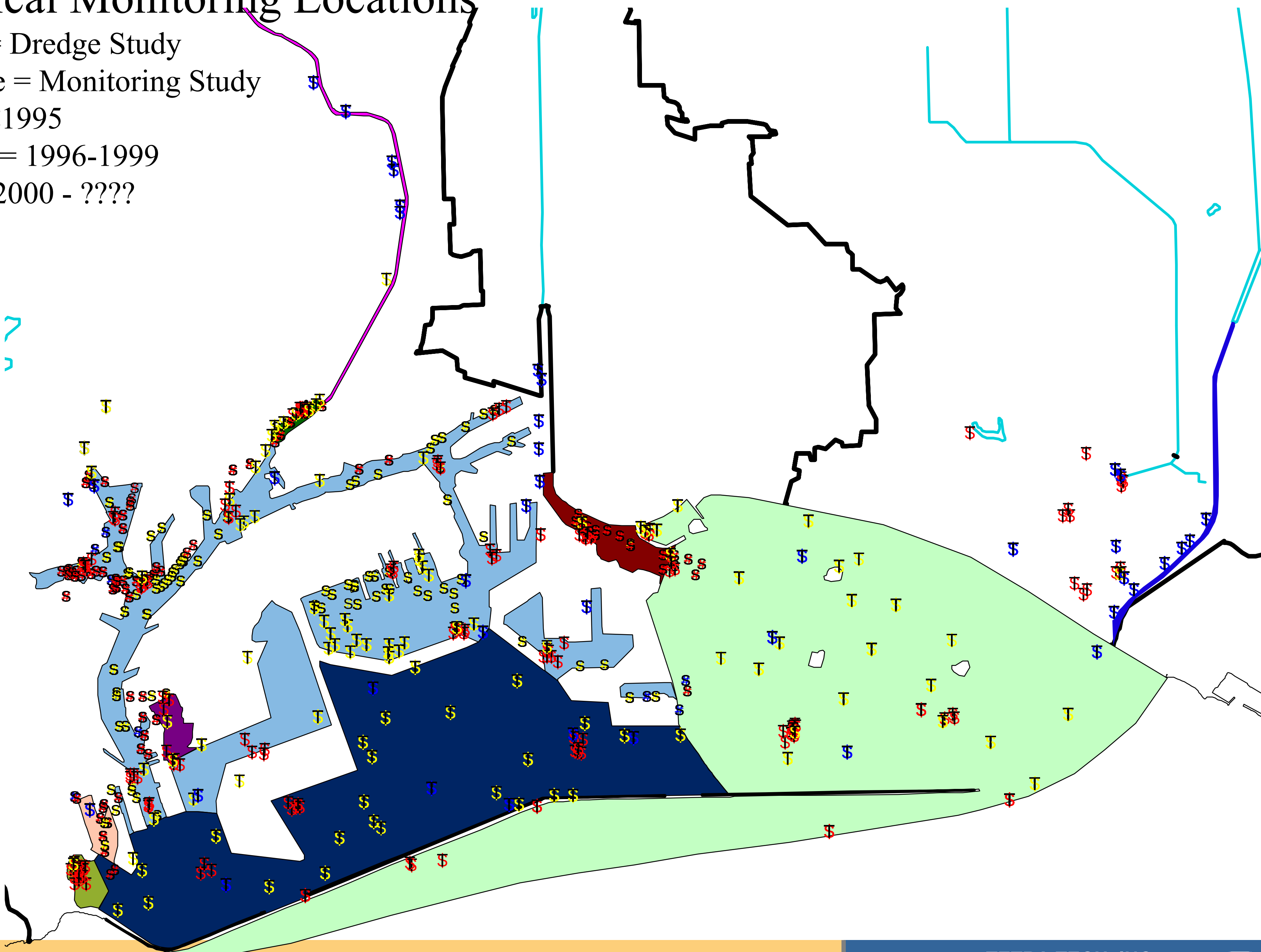
Circle = Dredge Study

Triangle = Monitoring Study

Red = <1995

Yellow = 1996-1999

Blue = 2000 - ????

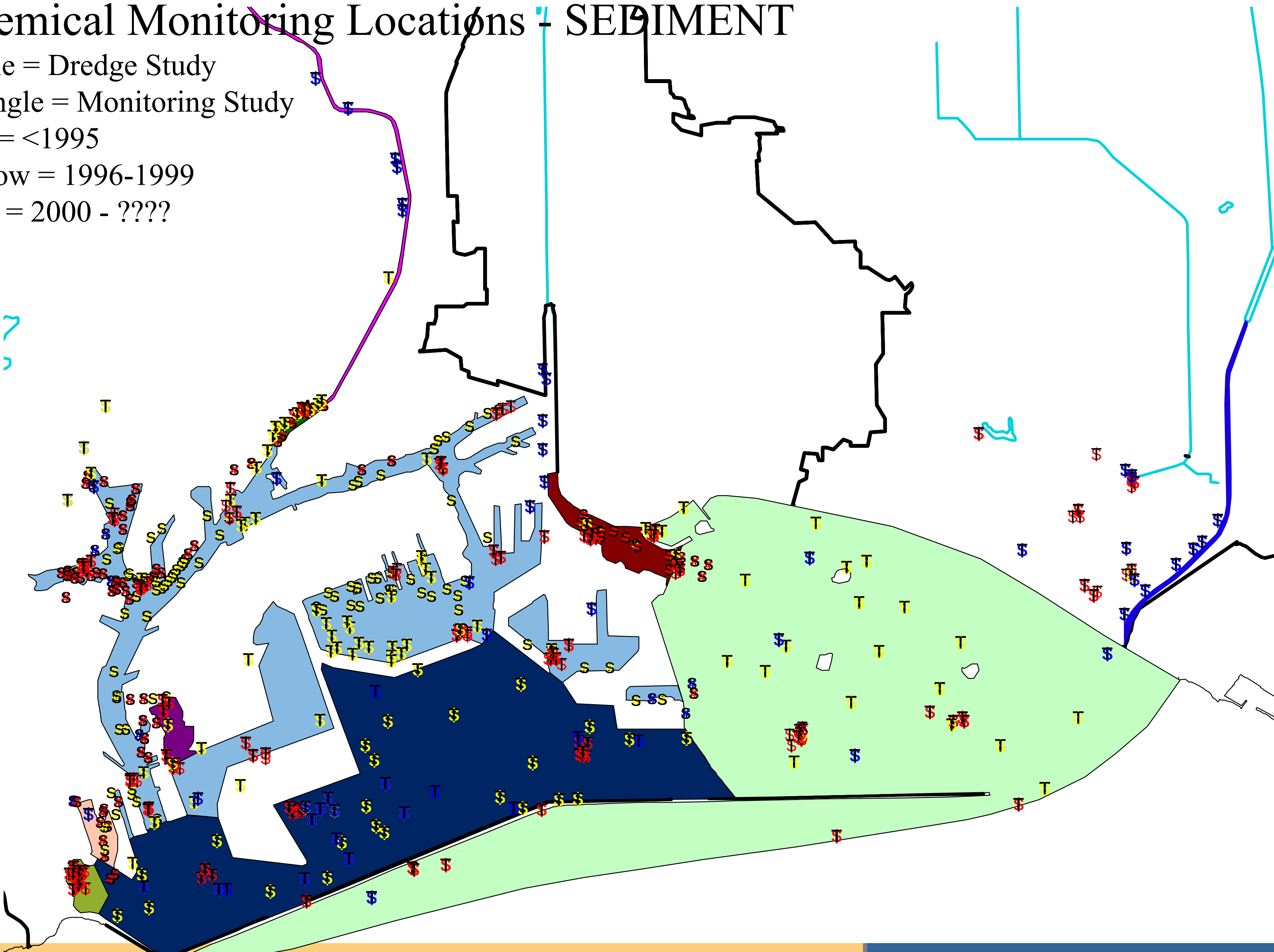


Contaminant Transport Modeling Approach

- Focus on Initialization of Contaminant Levels in Bed and Estimation of Partition Coefficients
  - Initial Contaminant Levels
  - Particulate and Dissolved Organic Carbon Levels Desirable with Respect to Hydrophobic Organics
  - Site Specific or Literature Values for Partition Coefficients
- Calibration to Contaminant Concentrations In Water Column

Chemical Monitoring Locations - SEDIMENT

Circle = Dredge Study
Triangle = Monitoring Study
Red = <1995
Yellow = 1996-1999
Blue = 2000 - ????



Erosion Rate As Function of Bed Stress and Bulk Density (UCSB Study)

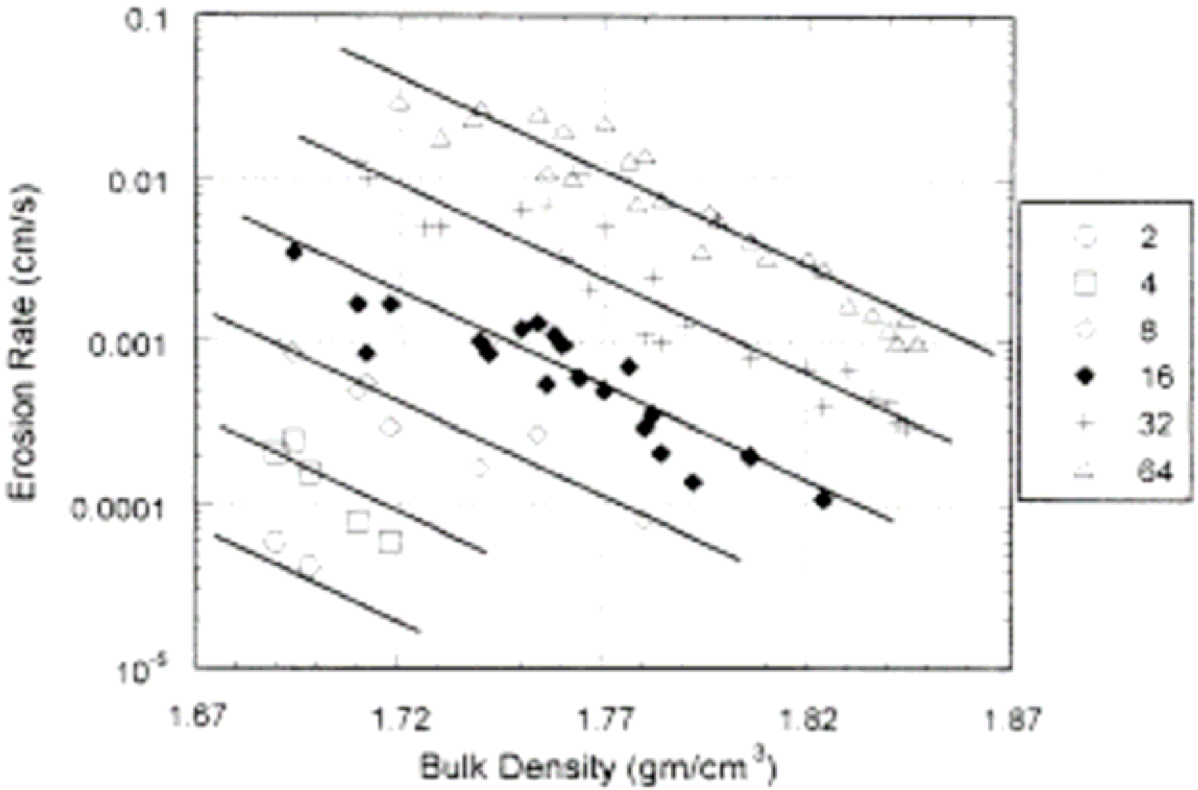


Figure 19. Erosion rates as a function of bulk density for the composited sediments. Erosion rates for shear stresses of 2, 4, 8, 16, 32, and 64 dynes/cm² are shown.

Bulk Density as Function of Depth in Sediment Bed (UCSB Study) (void ratios 0.95 to 1.35)

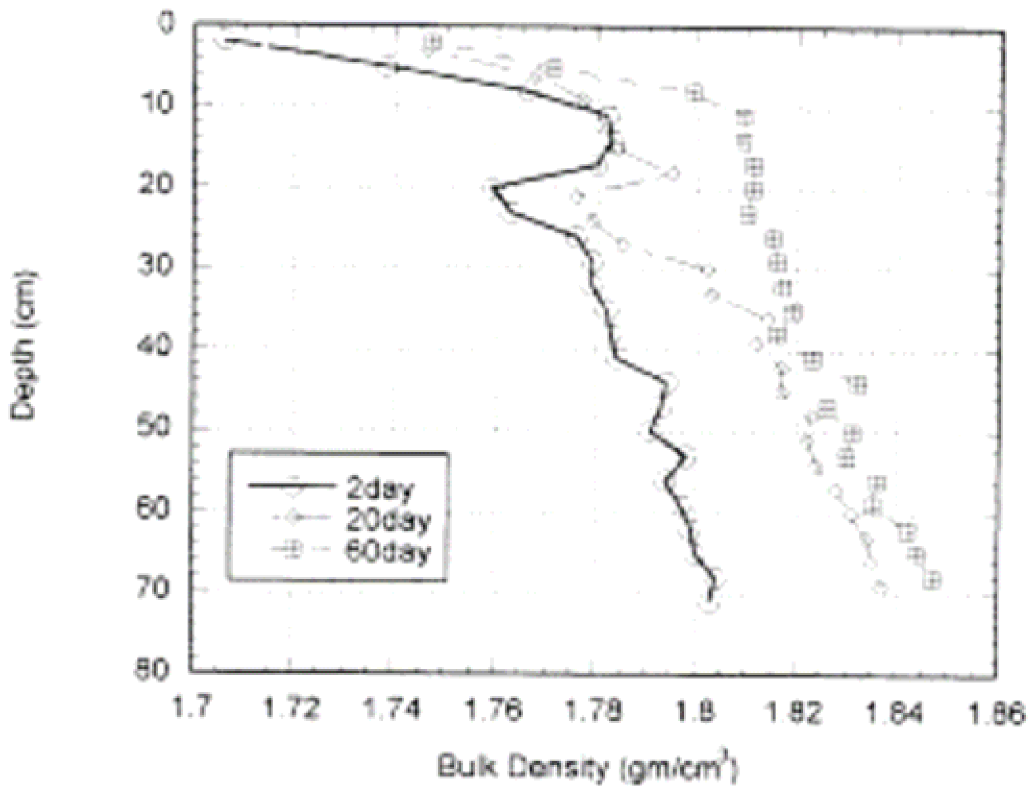


Figure 13. Bulk density as a function of depth for the 80 cm composited sediment cores at consolidation times of 2, 20, 60 days.

Contaminant Field Studies, Summer 2006

- Flux Measurements
  - Measured Flux Depends of Pore Water Concentration (DOC, Koc)
  - Gives Sediment to Water Exchange Coefficient (Diffusion, Biological Mixing)
  - Possible to Infer Pore Water Concentration
- Sediment Chemistry
  - Measure Total and Particulate Concentration
  - Measure DOC and POC in Sediment
  - Gives Partition Coefficient

Sediment to Water Diffusive Flux

$$F_d = \frac{D}{\delta}\left(C_{db} - C_{dw}\right)$$

$$D = diffusion\ coefficient, \quad \delta = diffusion\ length\ scale$$

$$C_{dbed} = \left(\frac{n + n \cdot DOC_{bed} \cdot K_{oc}}{n + n \cdot DOC_{bed} \cdot K_{oc} + f_{POCbed} \cdot S_{bed} \cdot K_{oc}} \right) = bed\ \ pore\ water\ conc$$

$$C_{dwat} = \left(\frac{1 + DOC_{wat} \cdot K_{oc}}{1 + DOC_{wat} \cdot K_{oc} + f_{POCwat} \cdot S_{wat} \cdot K_{oc}} \right) = water\ column\ dissolved\ conc$$

$$n = porosity$$

$$f_{poc} = fraction\ \ particulate\ organic\ carbon$$

$$K_{oc} = organic\ carbon\ to\ water\ \ partition\ coefficient$$

$$S = sediment\ concentration$$

Sediment to Water Particulate Flux

$$F_p = \max\left(w_e S_{bed}, 0\right)\left(\frac{f_{POCbed} \cdot K_{ow}}{n + n \cdot DOC_{bed} \cdot K_{oc} + f_{POCbed} \cdot S_{bed} \cdot K_{oc}}\right)$$

$$+ \min\left(w_s S_{wat}, 0\right)\left(\frac{f_{POCwat} \cdot K_{oc}}{1 + DOC_{wat} \cdot K_{oc} + f_{POCwat} \cdot S_{wat} \cdot K_{oc}}\right)$$

$$w_e = erosion\ velocity\ (function\ of\ \ sediment\ size\ \ fraction,\ void\ ratio, bed\ \ stress)$$

$$w_s = settling\ velocity\ (function\ of\ \ sediment\ size)$$

Questions and Discussion