



Assessing the Water Quality Impacts in a Tidal Embayment from the Closure of Proposed Tidal Barriers

June 5, 2017



Richard R. Isleib, PE, HDR
James Fitzpatrick, HDR
Nicholas Kim, HDR
Nataliya Kogan, HDR



1

Background

2

Models

3

Modeling Conditions

4

Results

5

Lessons

0

Background

1

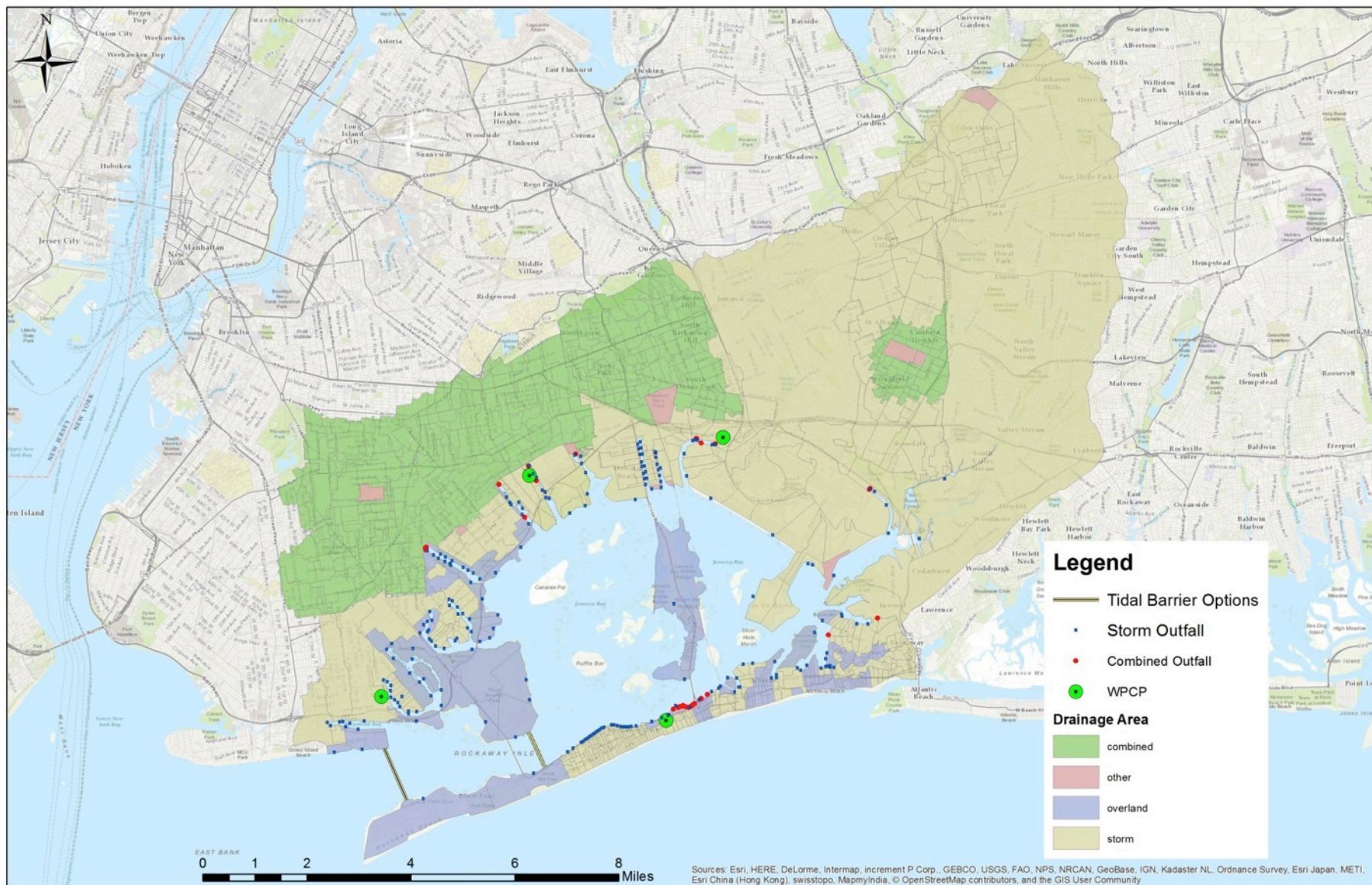
Background

- Jamaica Bay is located on the southwestern portion of Long Island within New York City
- Superstorm Sandy caused significant flooding in the communities in and around the Bay
- To prevent future flooding the USACE is considering the construction of a tidal barrier across the entrance of the Bay, Rockaway Inlet
- A modeling study was conducted using an existing model of Jamaica Bay to assess the impacts of the tidal barrier on Bay water quality during periods both when the barrier was open and closed.

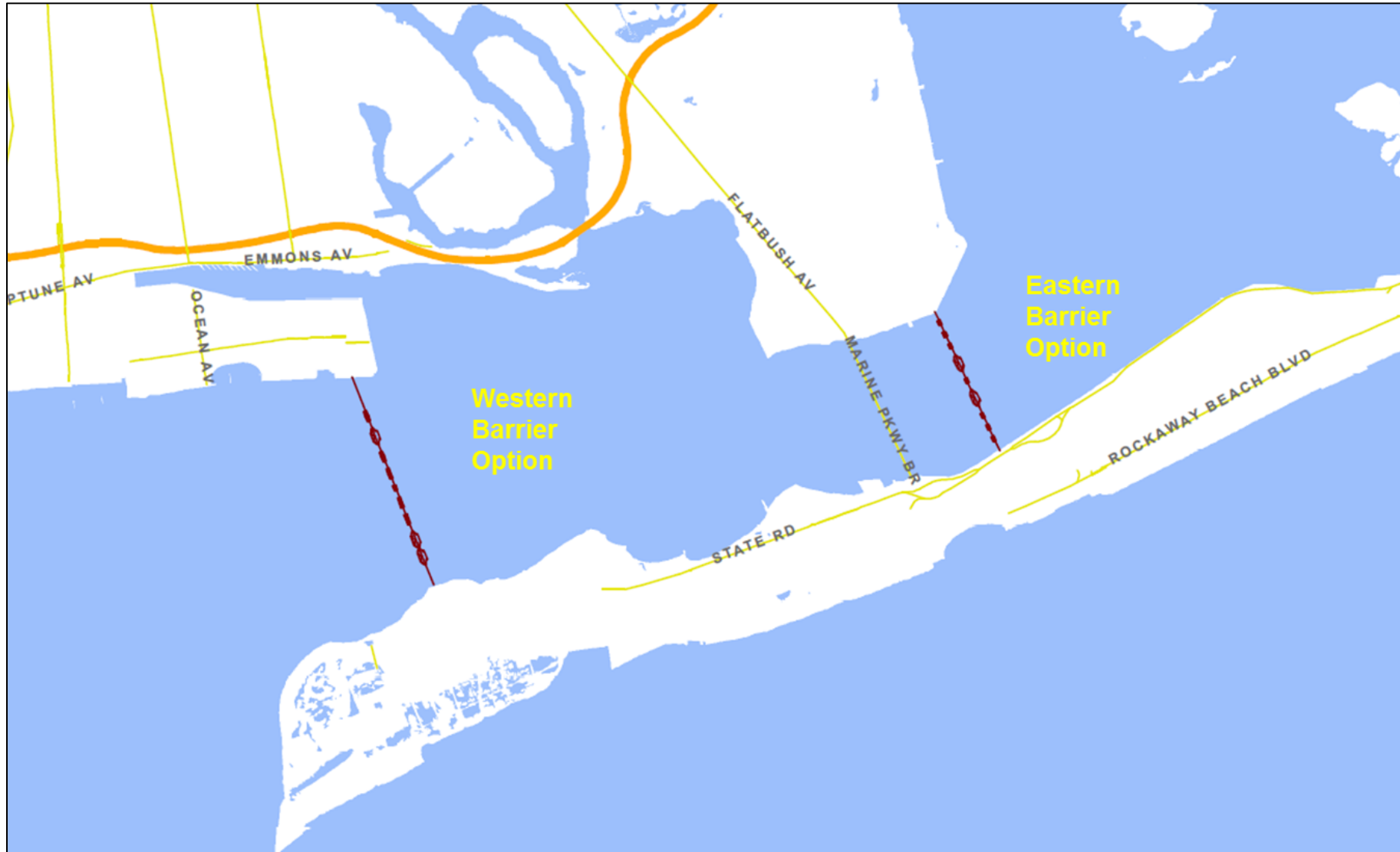
Study Area



Sewershed



Potential Barrier Locations

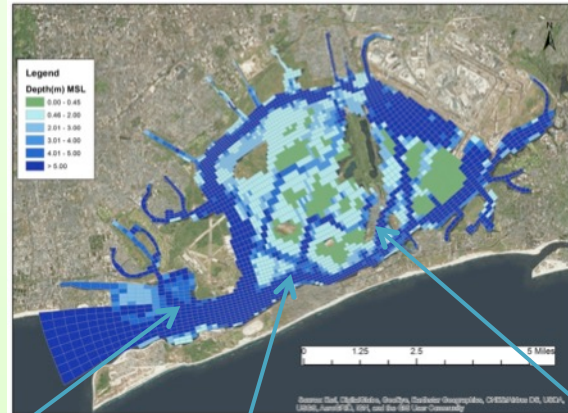


0

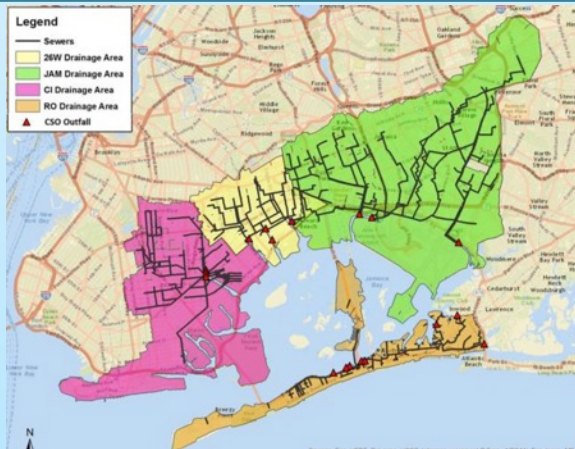
Models

2

Jamaica Bay - Integrated Modeling Framework

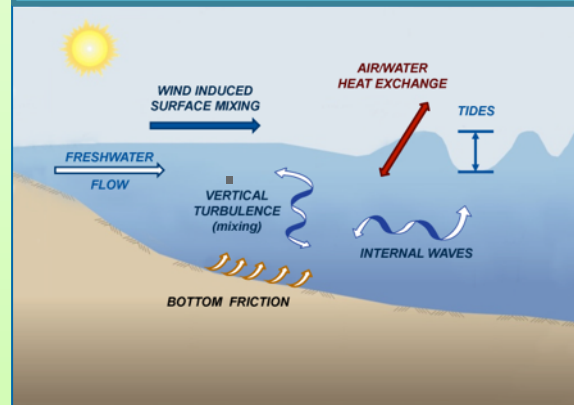


FRESHWATER INFLOW & POLLUTANT LOADS



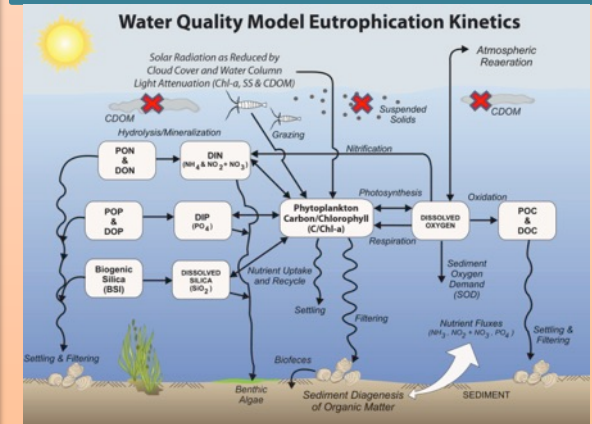
WATERSHED MODEL

CIRCULATION & TRANSPORT



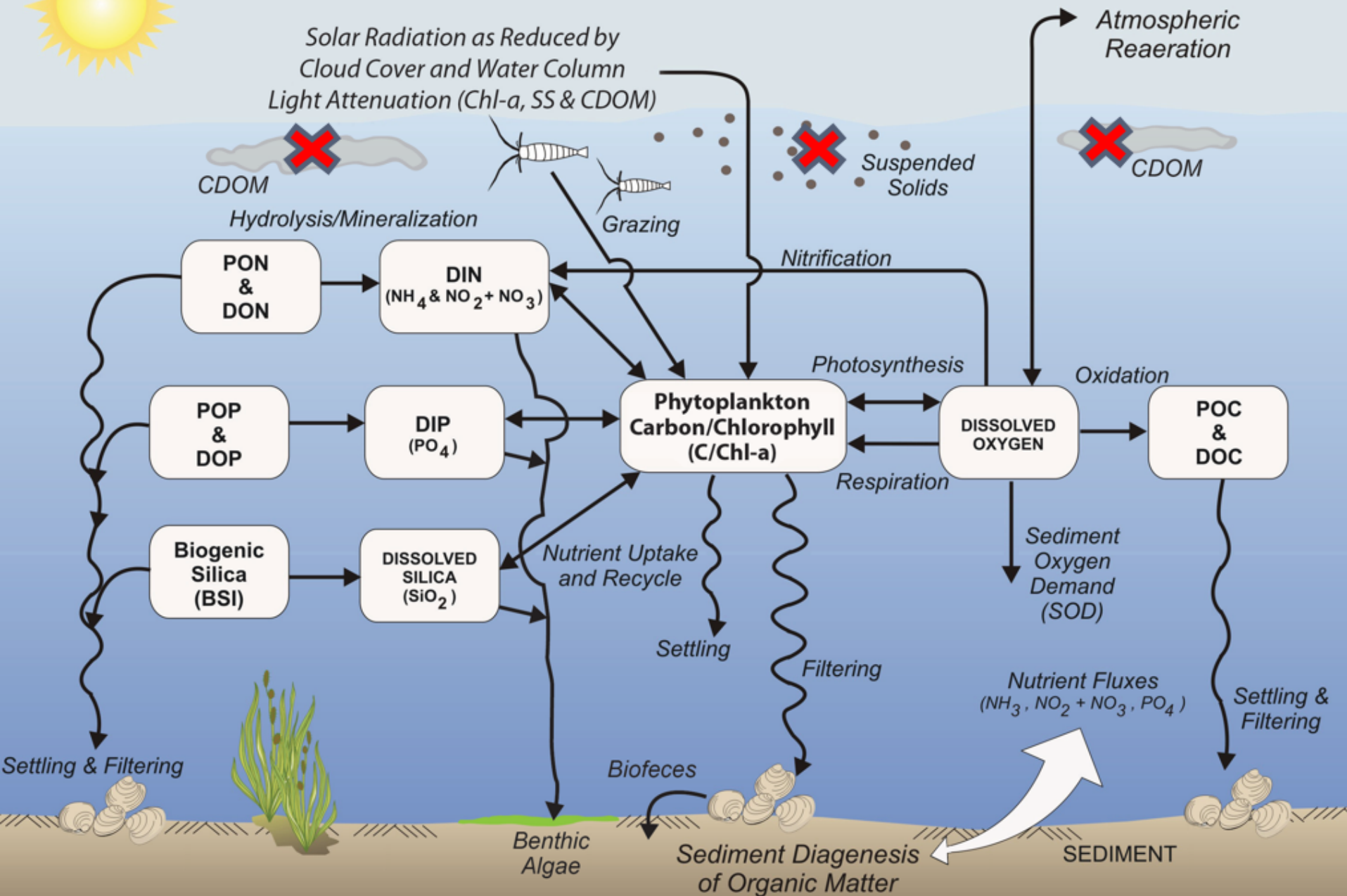
HYDRODYNAMIC MODEL

CHEMICAL & BIOLOGICAL REACTIONS



WATER QUALITY MODEL

Water Quality Model Eutrophication Kinetics



Bacteria Model Kinetics

$$N = N_0 \exp(-K_B t)$$

$$K_B = [0.8 + 0.006(\% \text{seawater})] 1.07^{(T-20)}$$

$$+ \alpha I_0(t) / K_e H [1 - \exp(-K_e H)]$$

$$+ V_s / H \quad (\text{Mancini, 1978})$$

N = Bacteria concentration

K_B = Bacteria loss rate

T = Temperature ($^{\circ}\text{C}$)

α = proportionality constant

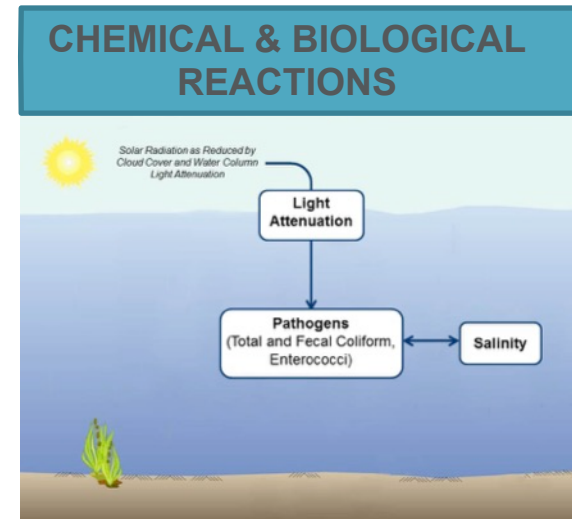
I_0 = Surface solar radiation

t = time

K_e = Extinction coefficient (/m)

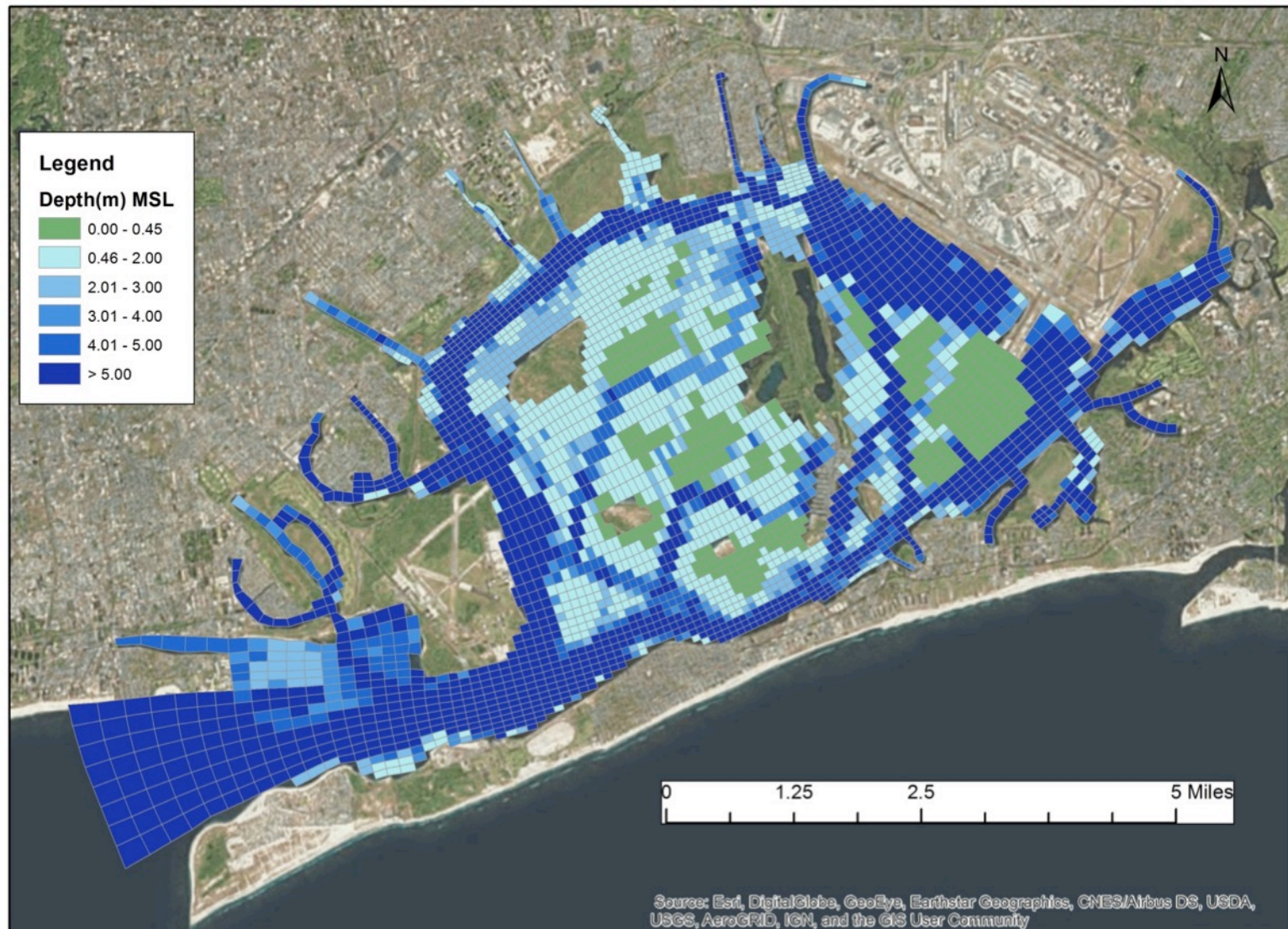
H = Depth (m)

V_s = Net settling rate (m/d)



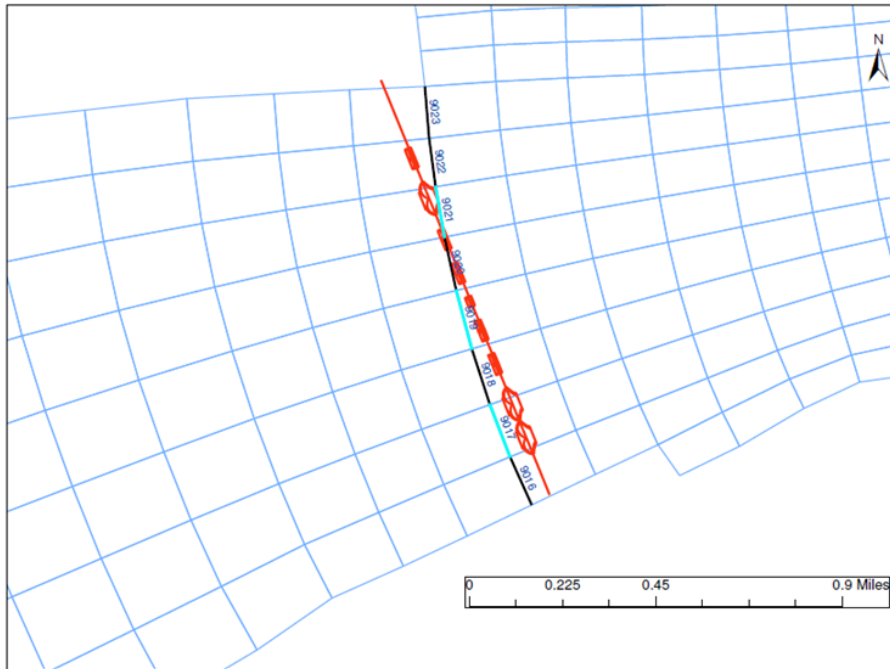
WATER QUALITY MODEL

Jamaica Bay Water Quality Model Grid

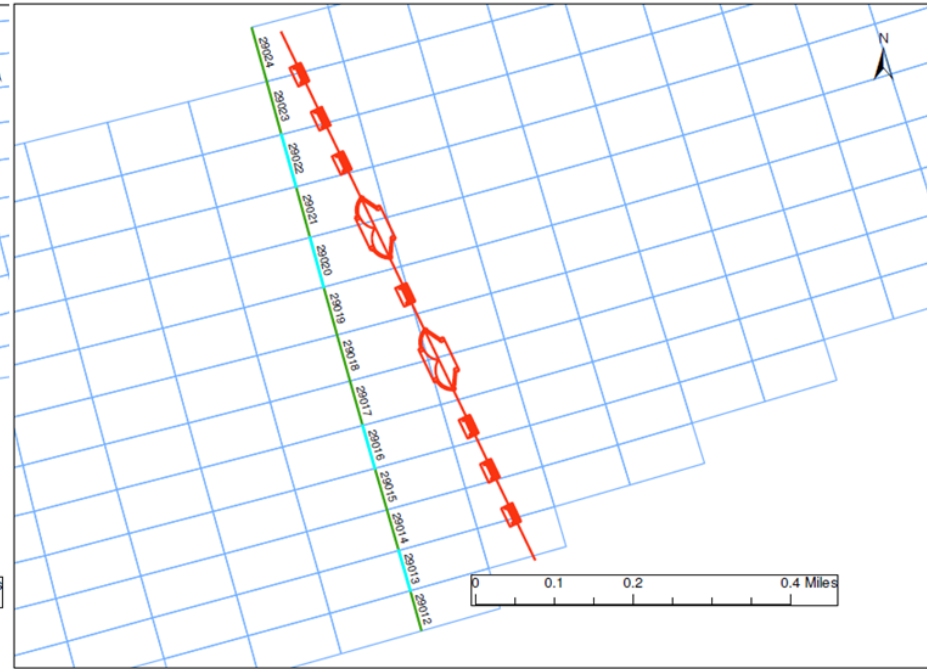


Model Representation of Potential Barrier Locations

Western Barrier



Eastern Barrier



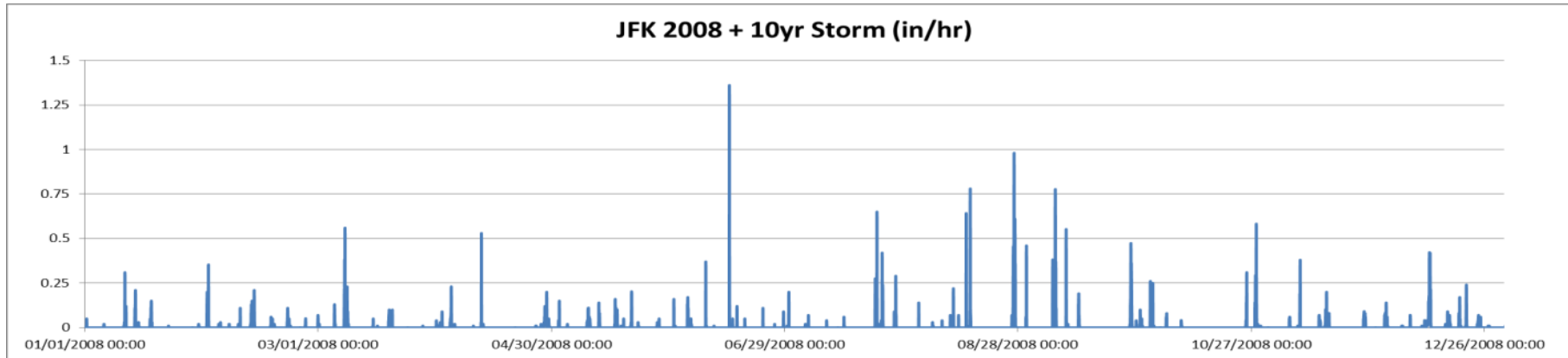
0

Modeling Conditions

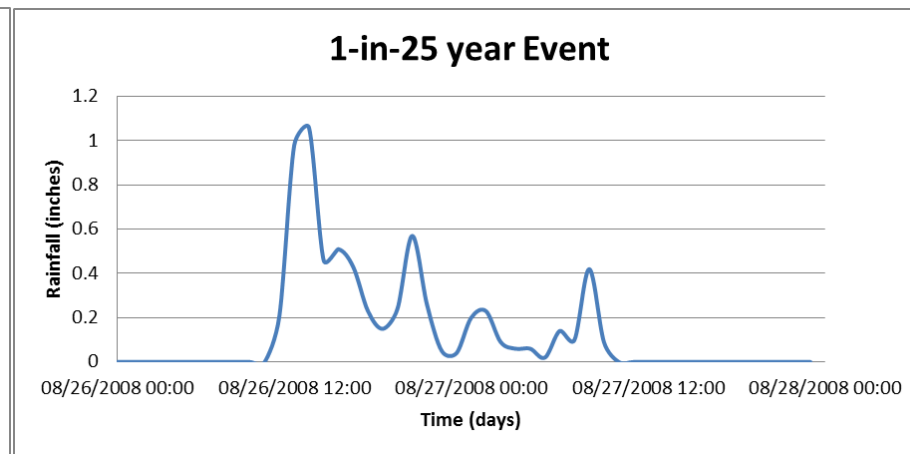
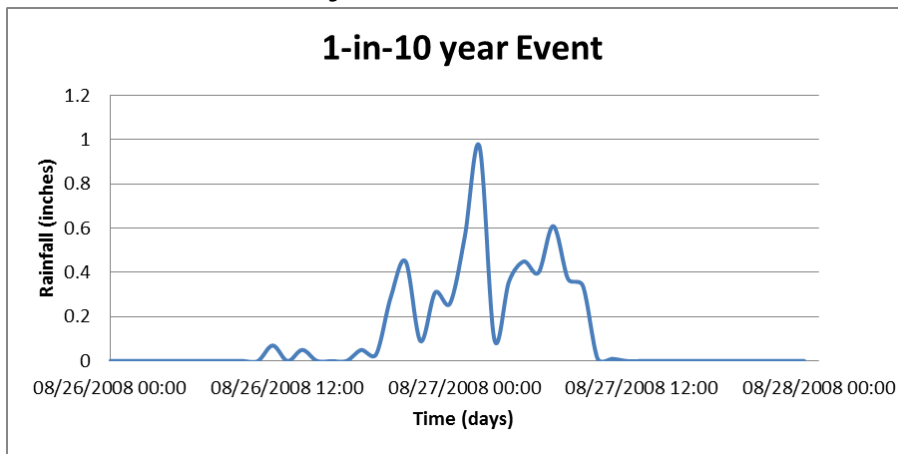
2

Rainfall Conditions

- 2008 chosen selected as average year rainfall and then storm events added during the critical summer period



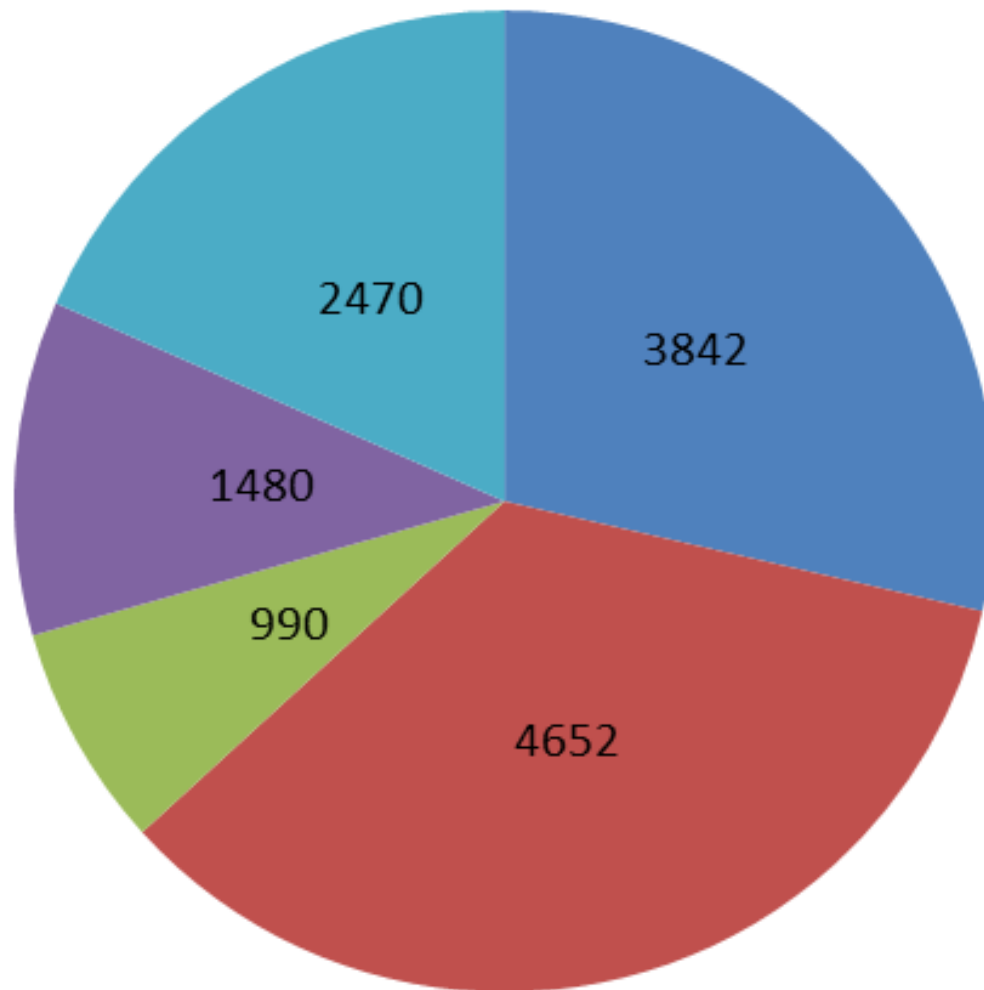
- 1-in-10 year event: 5.78 inches over 24 hours
- 1-in-25 year event: 6.60 inches over 24 hours



Modeling Scenarios

Modeling Scenarios		
No Barrier	Eastern Barrier	Western Barrier
1-in-10 year storm	Always open – 1-in-10	Always open – 1-in-10
1-in-25 year storm	48-hr closure – 1-in-10	48-hr closure – 1-in-10
	96-hr closure – 1-in-10	96-hr closure – 1-in-10
	Always open – 1-in-25	Always open – 1-in-25
	48-hr closure – 1-in-25	48-hr closure – 1-in-25
	96-hr closure – 1-in-25	96-hr closure – 1-in-25

Freshwater Sources



**Volume (MG) entering
Bay from various sources
for 1-in-25 year storm
Eastern Barrier
96 hr closure**

- CSOs
- Storm Water
- Direct Runoff
- WWTPs
- Direct Precipitation

0

Results

4

Variables Evaluated

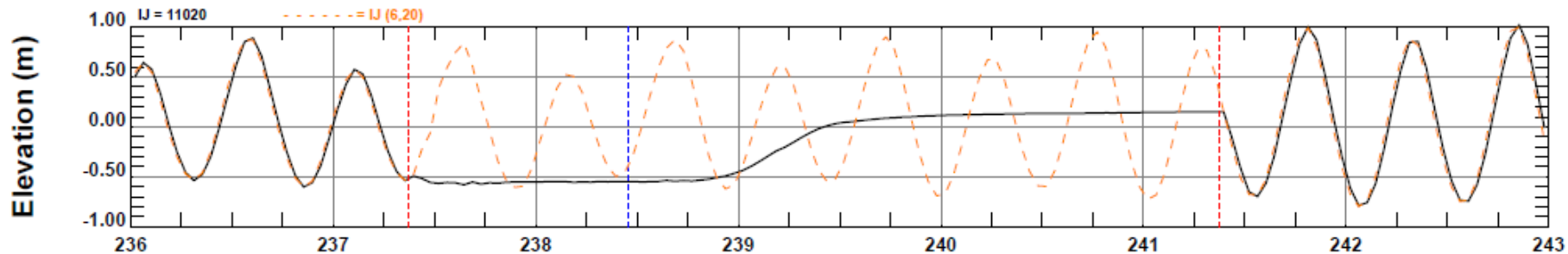
- Water Elevation
- Salinity
- Nutrients
- Chlorophyll-a
- DO
- Pathogens

Long-Term Results – Barrier Open

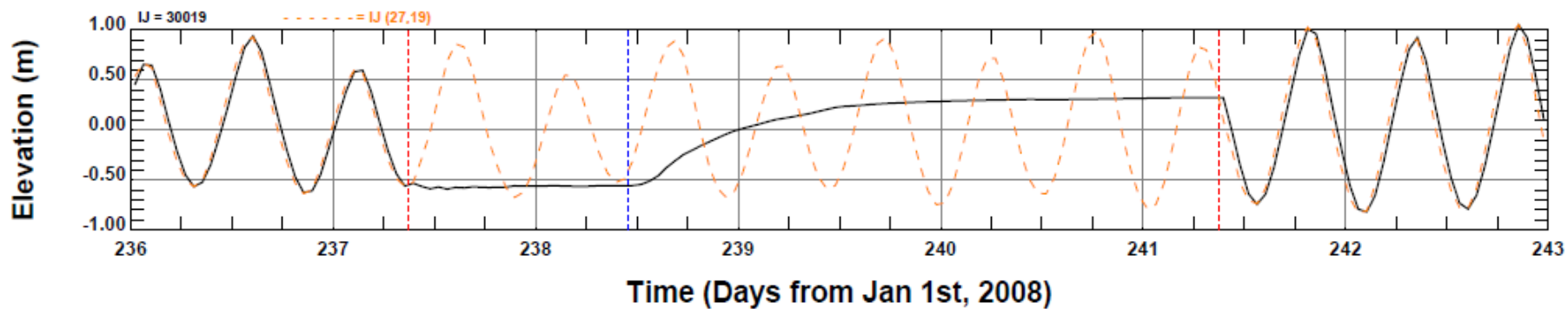
- Minor impacts on a long-term average
 - Elevation (+/- 6 cm)
 - Salinity (+/- 0.2 psu)
 - Nutrients (+/- < 1 μg TN/L)
 - Chlorophyll-a (+/- 0.2 μg /L)
 - DO (+/- 0.01 mg/L)
 - Pathogens (+/- 0.1 cfu/100mL [GM])

Short-Term Results (Barrier Closed) - Water Elevation

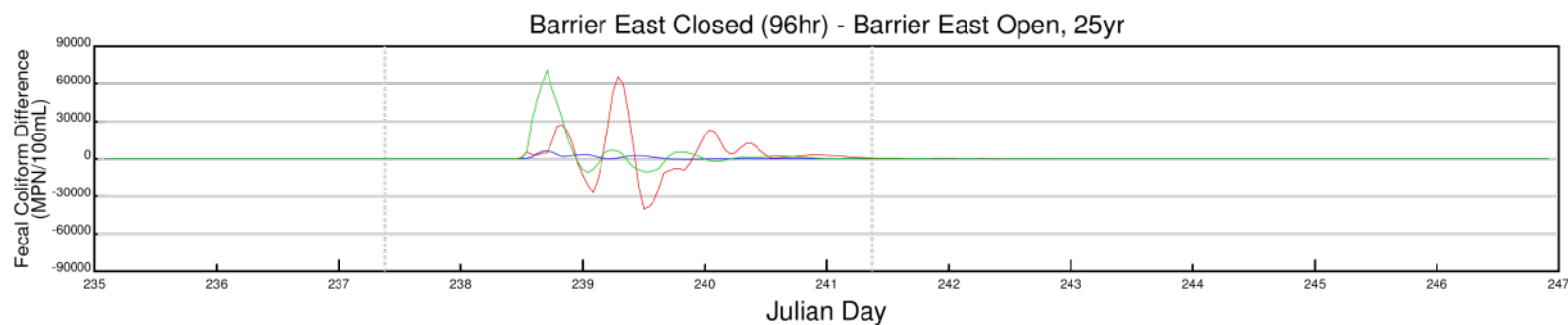
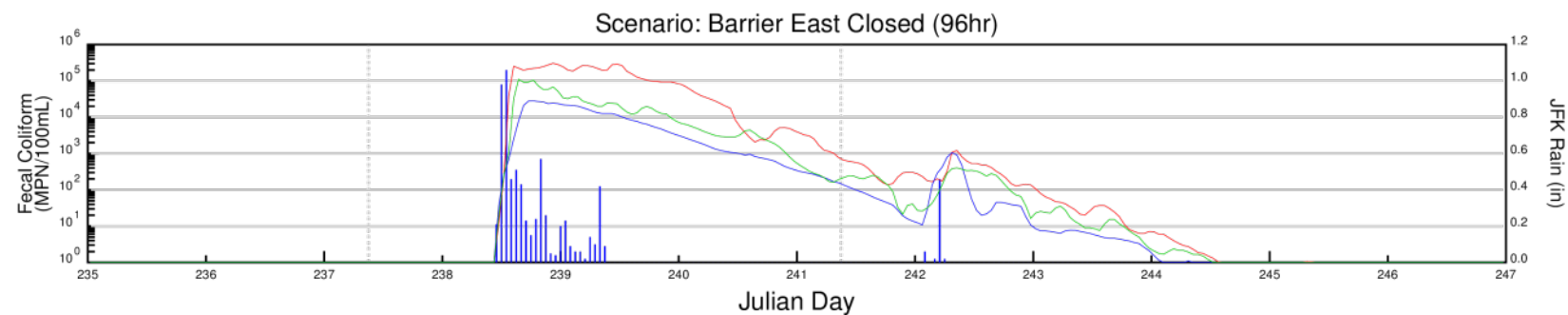
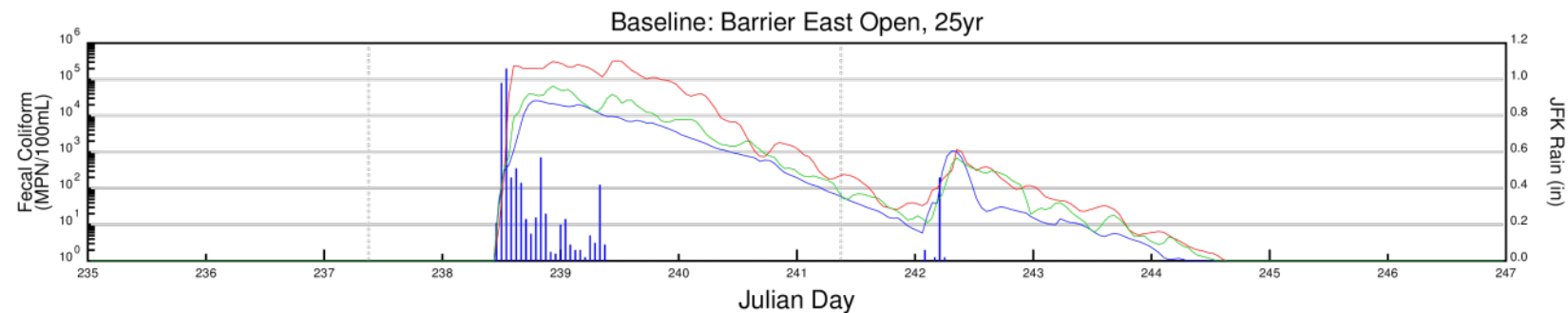
Western Barrier – 1-in-10 Year Storm



Eastern Barrier – 1-in-25 Year Storm



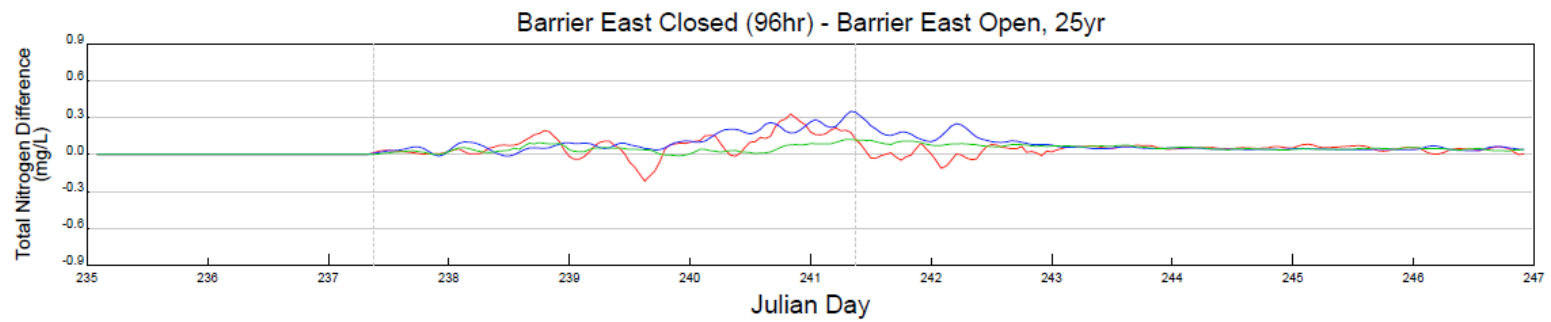
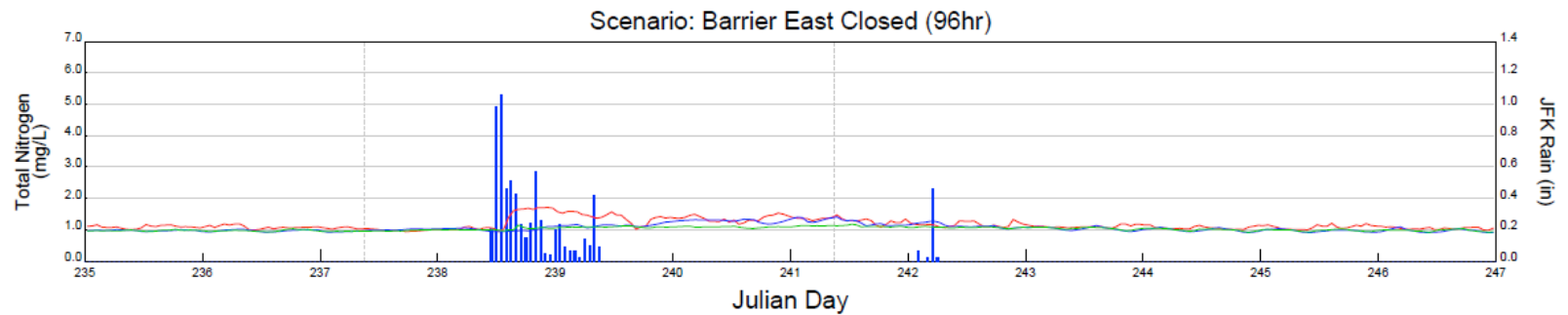
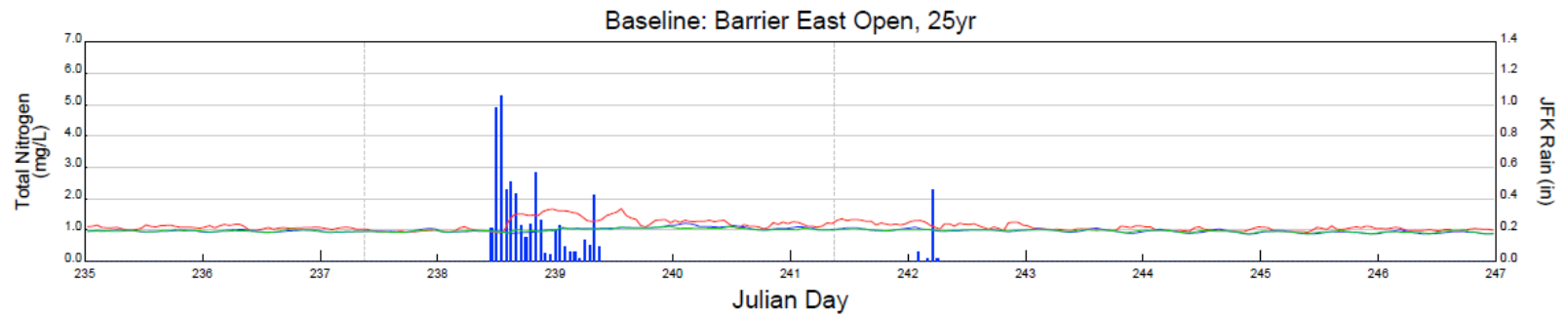
Short-term Results - Pathogens



Station PB2, Paerdegat Basin, Middle
Jamaica Bay, 2008

— Model Surface
— Model Middle
— Model Bottom
— Gates closed/opened

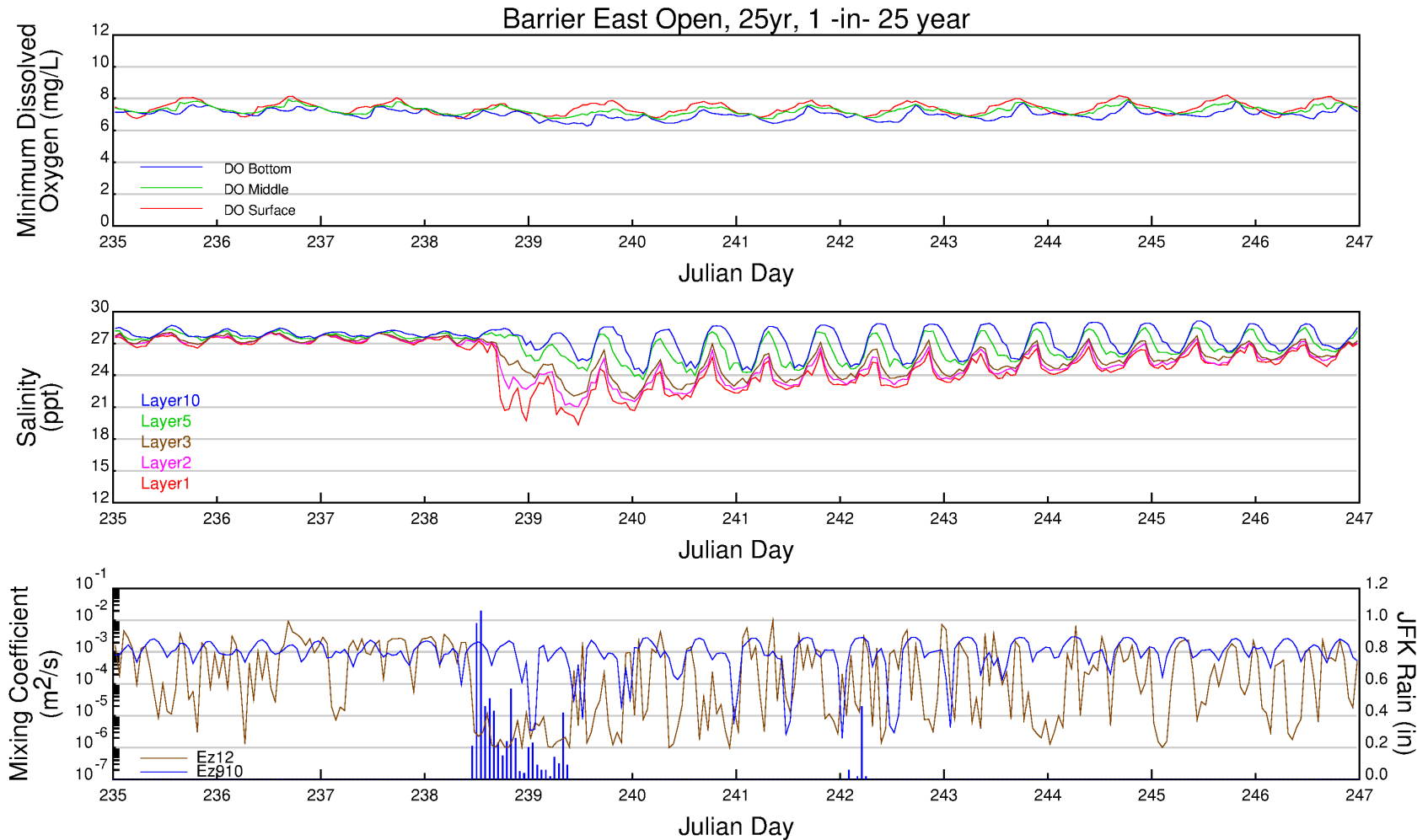
Short-term Results - Nitrogen



Station J7, Bergen Basin
Jamaica Bay, 2008

- Model Surface
- Model Middle
- Model Bottom
- Gates closed/opened

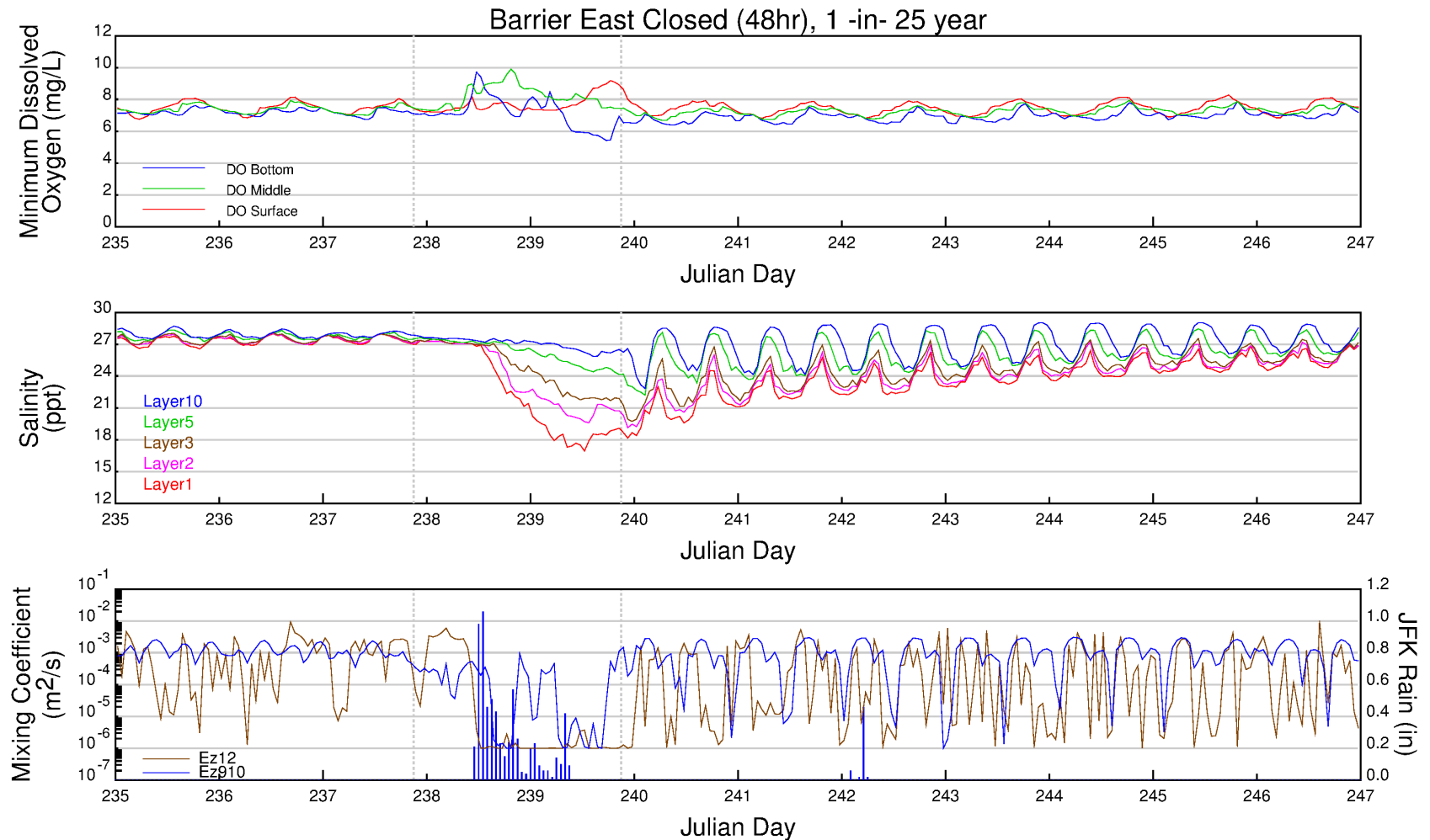
Short-term Results - Dissolved Oxygen



Station IC, Island Channel-west of Ruffle Bar
Jamaica Bay, 2008

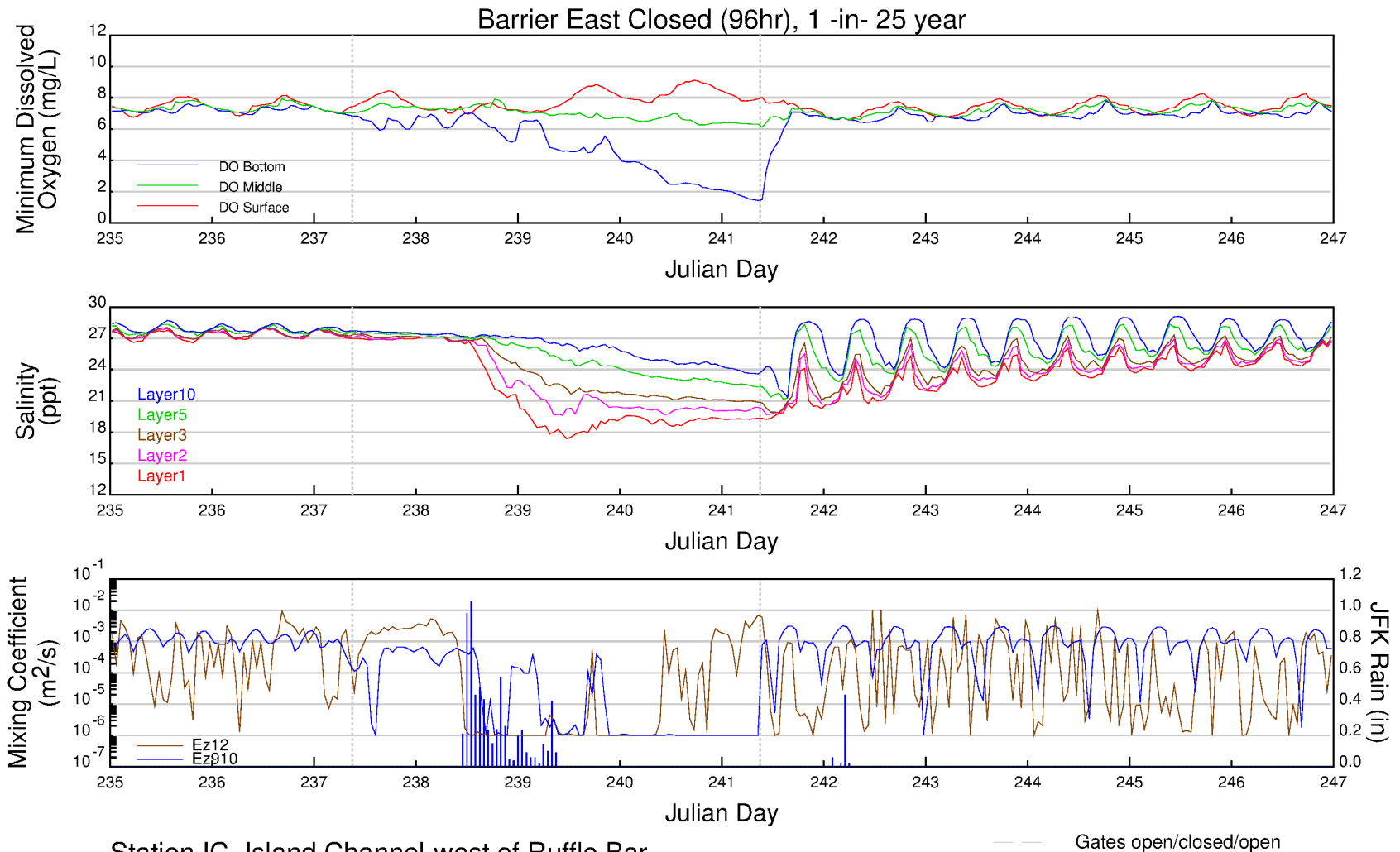
— Gates open/closed/open

Short-term Results - Dissolved Oxygen



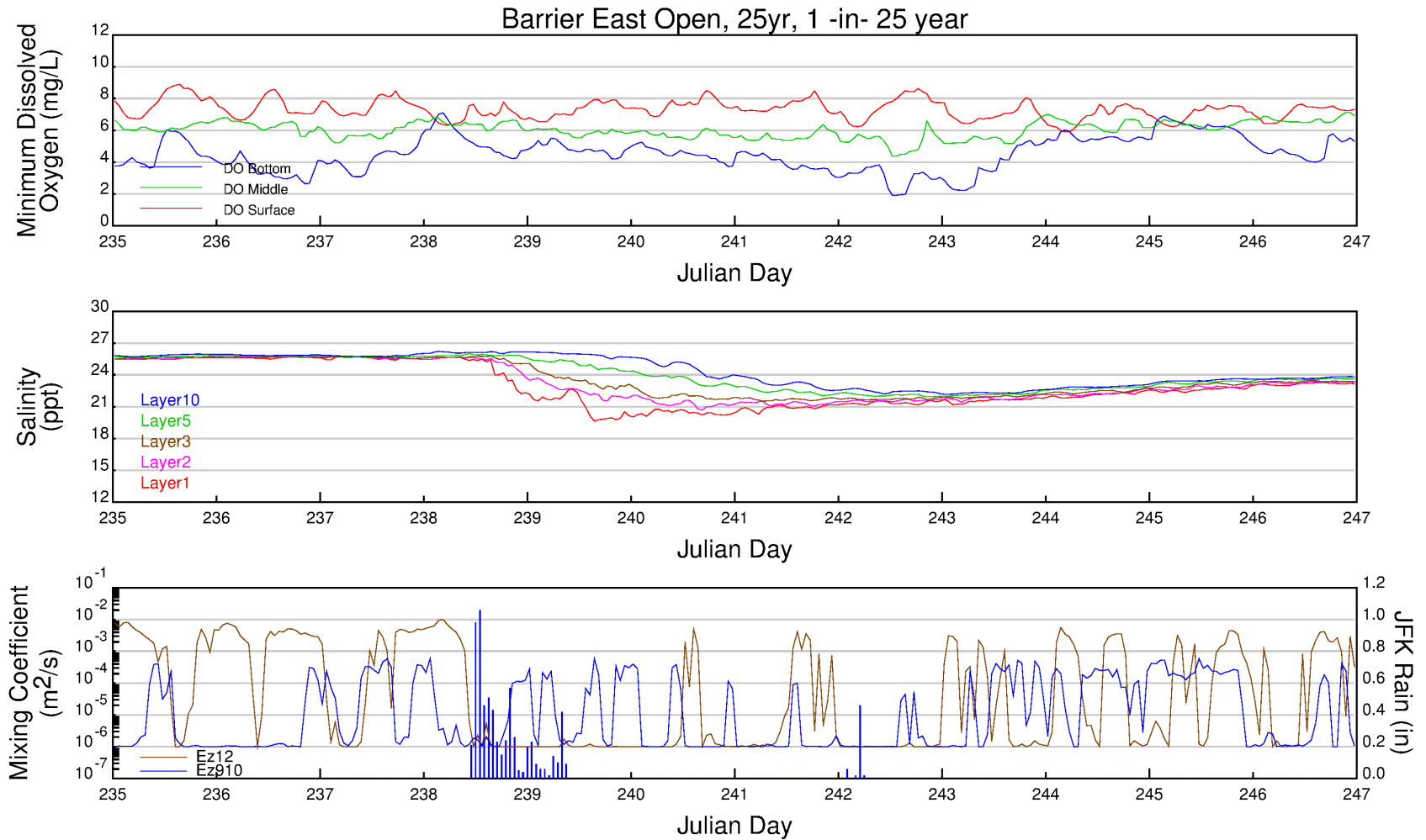
Station IC, Island Channel-west of Ruffle Bar
Jamaica Bay, 2008

Short-term Results - Dissolved Oxygen



Station IC, Island Channel-west of Ruffle Bar
Jamaica Bay, 2008

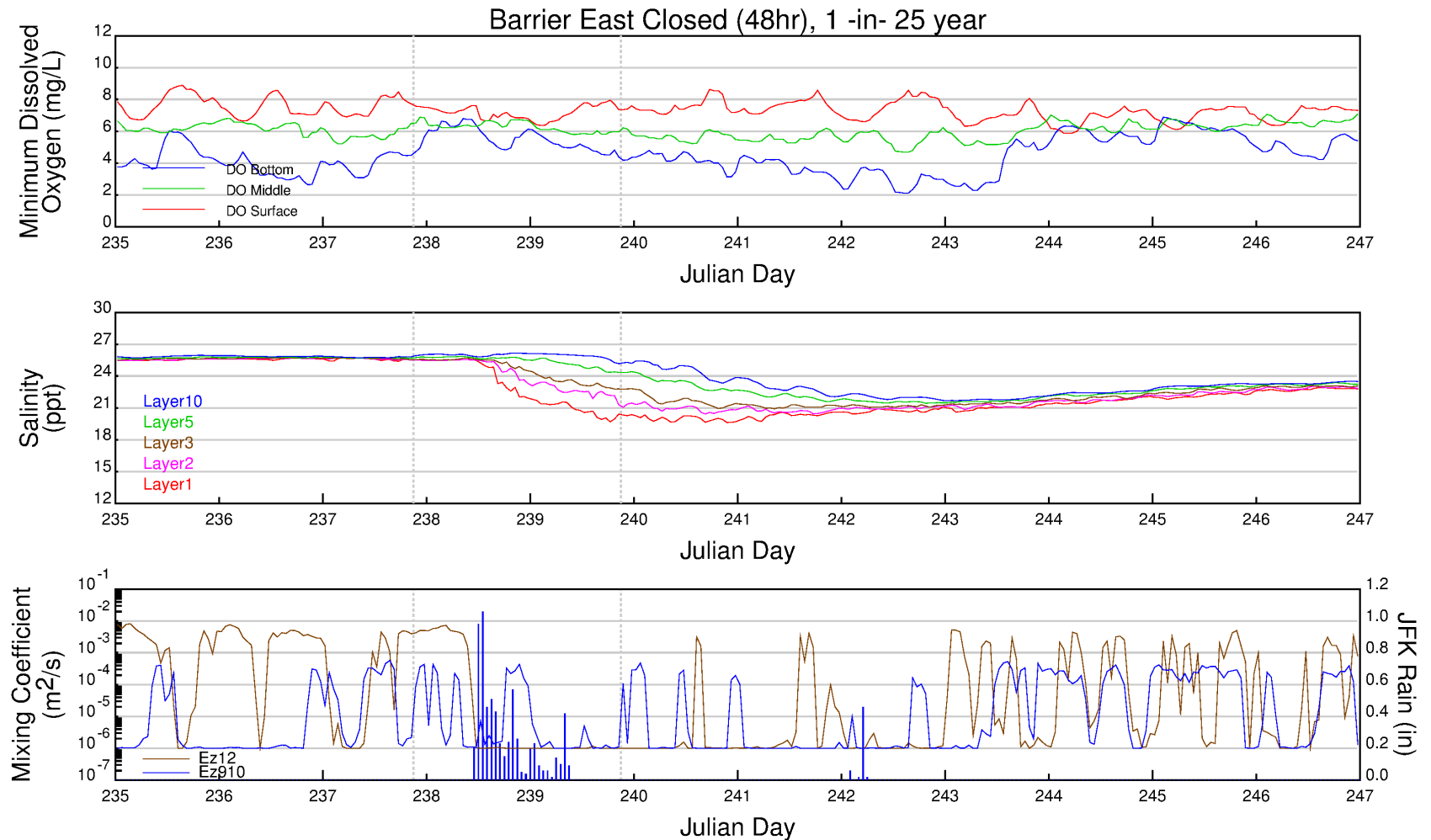
Short-term Results - Dissolved Oxygen



Station J12, Grassy Bay
Jamaica Bay, 2008

— — Gates open/closed/open

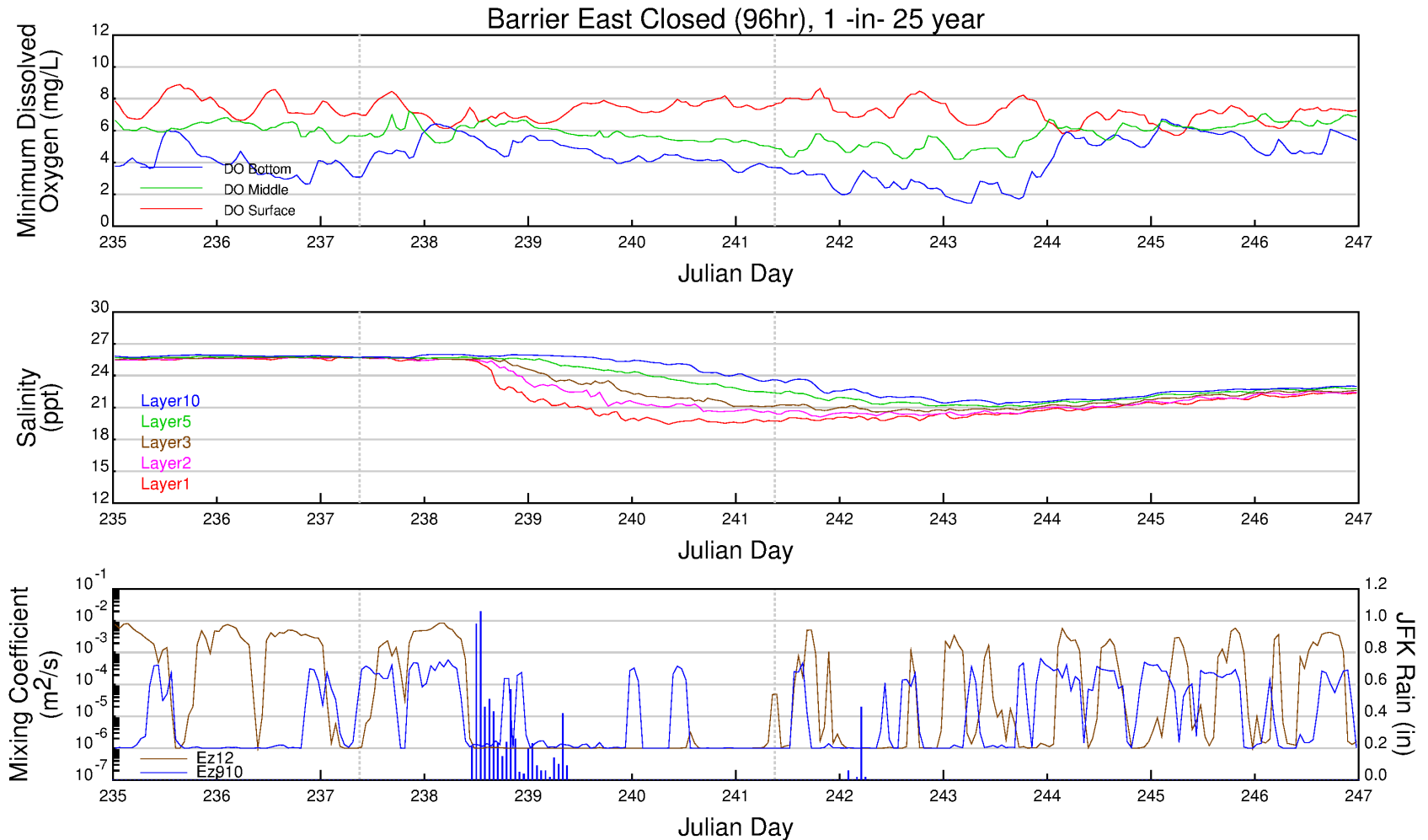
Short-term Results - Dissolved Oxygen



Station J12, Grassy Bay
Jamaica Bay, 2008

— Gates open/closed/open

Short-term Results - Dissolved Oxygen



Station J12, Grassy Bay
Jamaica Bay, 2008

— — — Gates open/closed/open

0

Lessons

7

Observations

- Closing the tidal barrier at low tide provides more storage volume
- The ratio of the drainage area to the surface area of the water body is an important consideration for siting a tidal barrier
- In this case, the tidal barrier design did not have a long term impact on water quality
- During periods when the barrier is closed, reduced horizontal and vertical mixing can have a significant impact on DO concentrations
- Minimizing the time of closure reduces the impact on DO levels.

As seas rise, city mulls a massive sea barrier across Boston Harbor



LEE CELANO/AFP/GETTY IMAGES/FILE

After Hurricane Katrina, the federal government built a 1.8-mile barrier along Lake Borgne, a lagoon of the Gulf of Mexico.

By [David Abel](#) | GLOBE STAFF FEBRUARY 18, 2017

Massachusetts Water Quality Criteria

- DO shall not be less than 5.0 mg/l
- Waters designated for shellfishing shall not exceed a fecal coliform median or geometric mean MPN of 88 organisms per 100 ml, nor shall more than 10% of the samples exceed an MPN of 260 per 100 ml
- at bathing beaches ..., no single enterococci sample taken during the bathing season shall exceed 104 colonies per 100 ml and the geometric mean of the five most recent samples taken within the same bathing season shall not exceed 35 enterococci colonies per 100 ml.

Jamaica Bay - Boston Harbor Comparison

Parameter	Jamaica Bay	Boston Harbor
Surface Area	~20 mi ²	~50 mi ²
Drainage Area	~80 mi ²	~600 mi ²
Area Ratio	4	12
Tide Range	~ 5 ft	~9 ft
Avg FW Flow	~250 cfs	~600 cfs

Conclusions

- The ratio of the drainage area to the surface area of the water body is an important consideration for siting a tidal barrier
- During periods when the barrier is closed, reduced horizontal and vertical mixing can have a significant impact on DO concentrations
- Minimizing the time of closure reduces the impact on DO levels.
- Other considerations need to be made (e.g. nutrients, bacteria, etc.) depending on local water quality criteria.

Questions

- Richard Isleib (HDR)
- Richard.Isleib@hdrinc.com



“We do things right to make great things possible.”