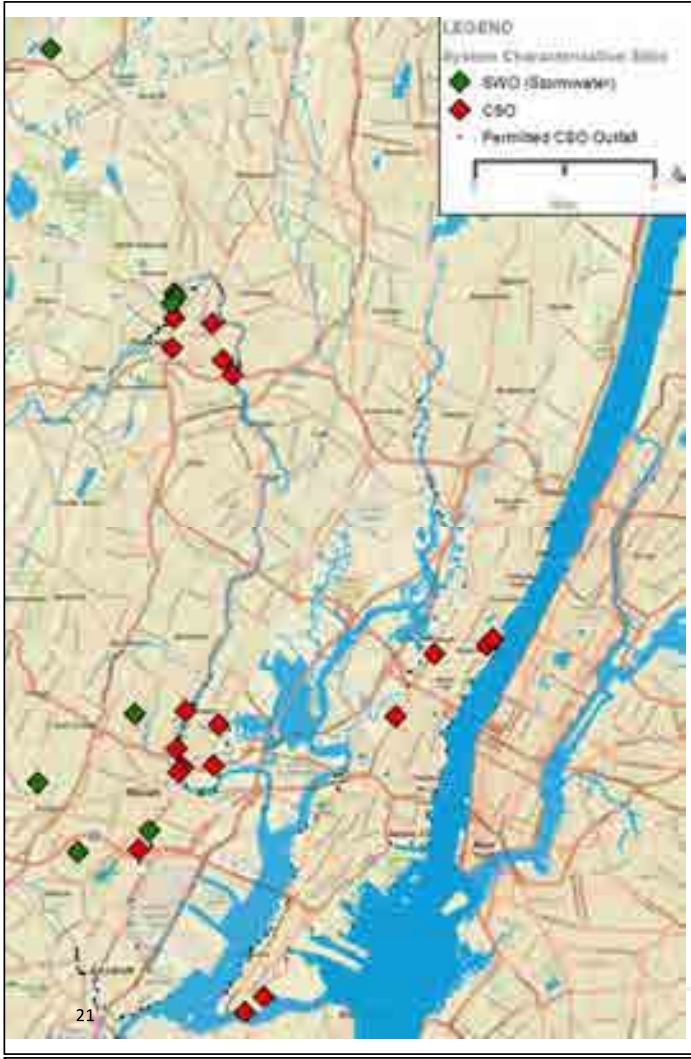
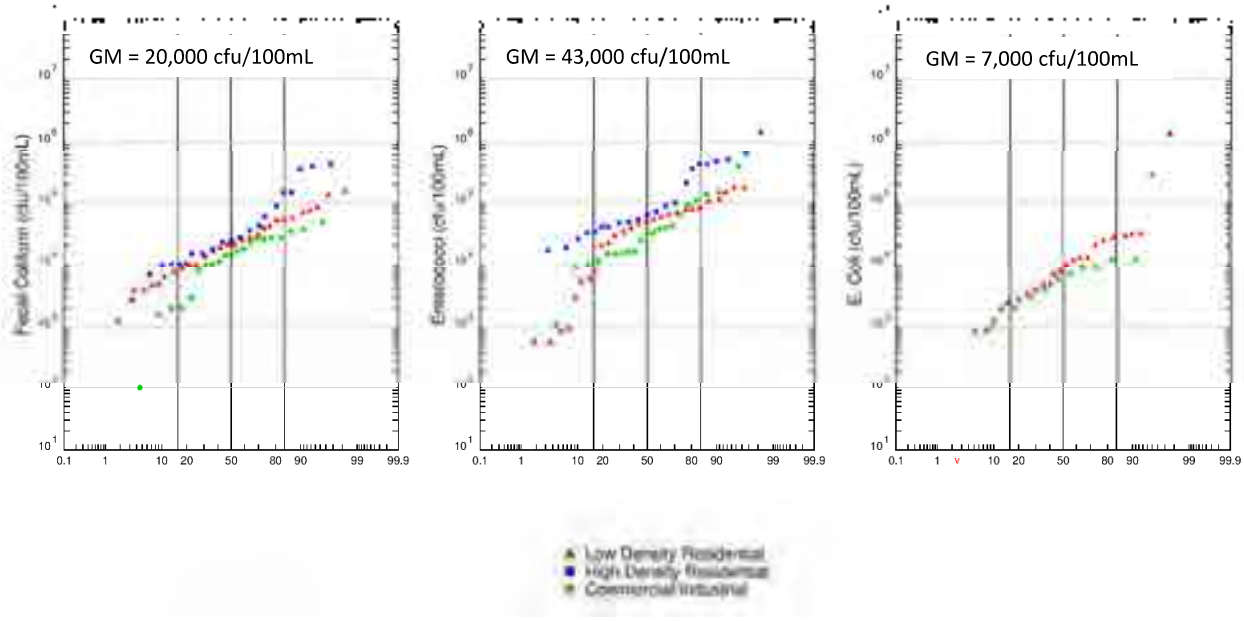
Landside Pathogen Concentration Stations



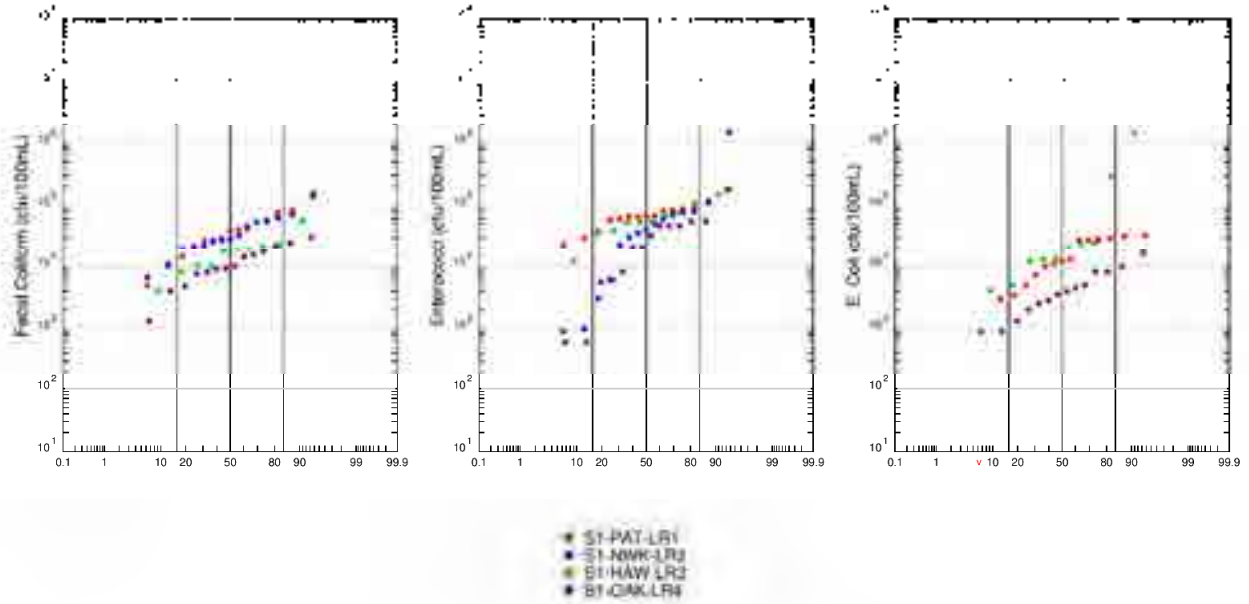
- Stormwater – 8 locations
  - Low Density Residential (4)
  - High Density Residential (2)
  - Commercial / Industrial (2)
- CSO – 18 Locations
  - Paterson (5)
  - Newark (4)
  - North Bergen (3)
  - Harrison (2)
  - Bayonne (2)
  - Guttenberg (1)
  - Kearny (1)

Probability Plot of Stormwater Pathogen Data
By Land Use
2016-2017



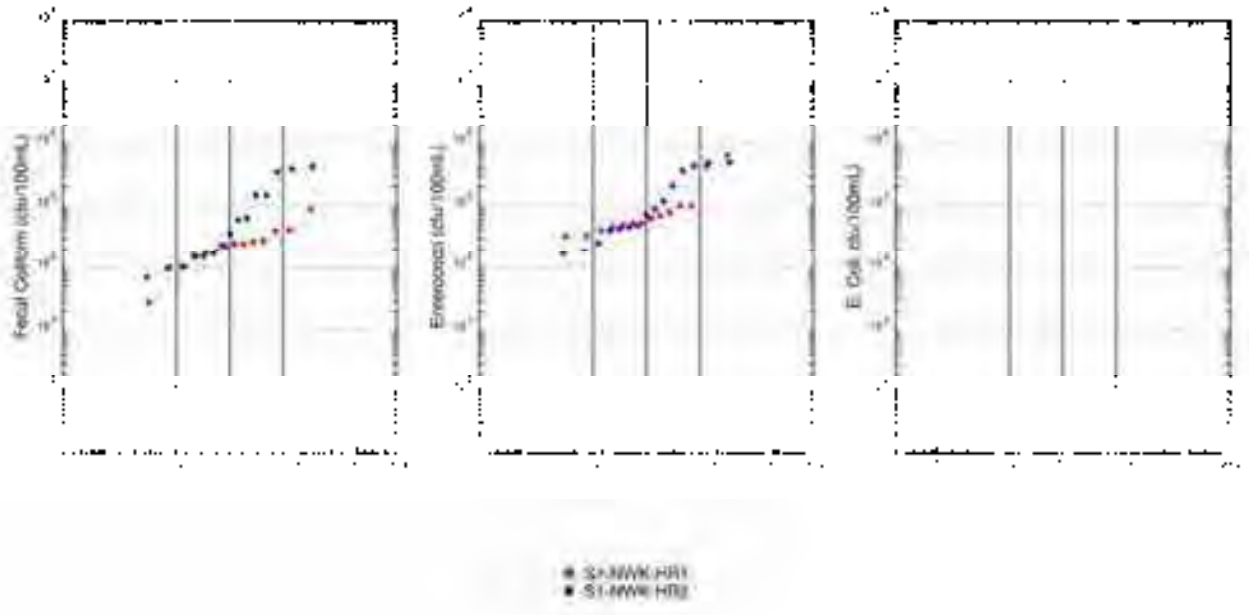
Probability Plot of Stormwater Pathogen Data
By Individual Location
2016-2017

Low Density Residential



Probability Plot of Stormwater Pathogen Data
By Individual Location
2016-2017

Non Density Residential



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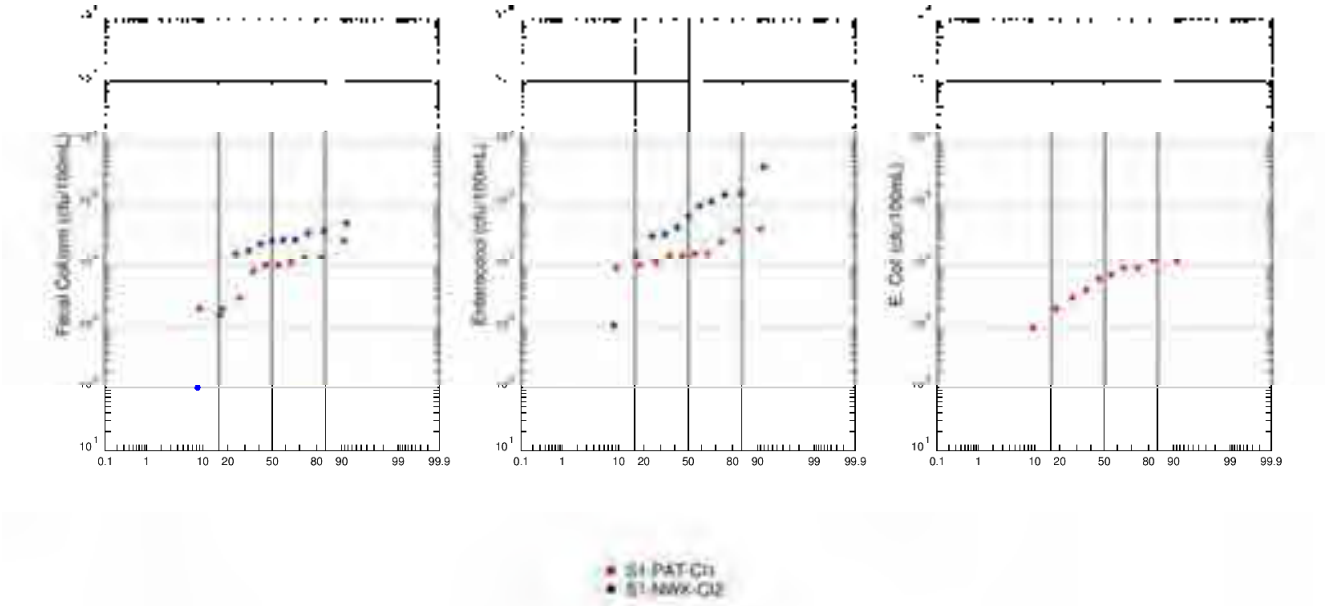
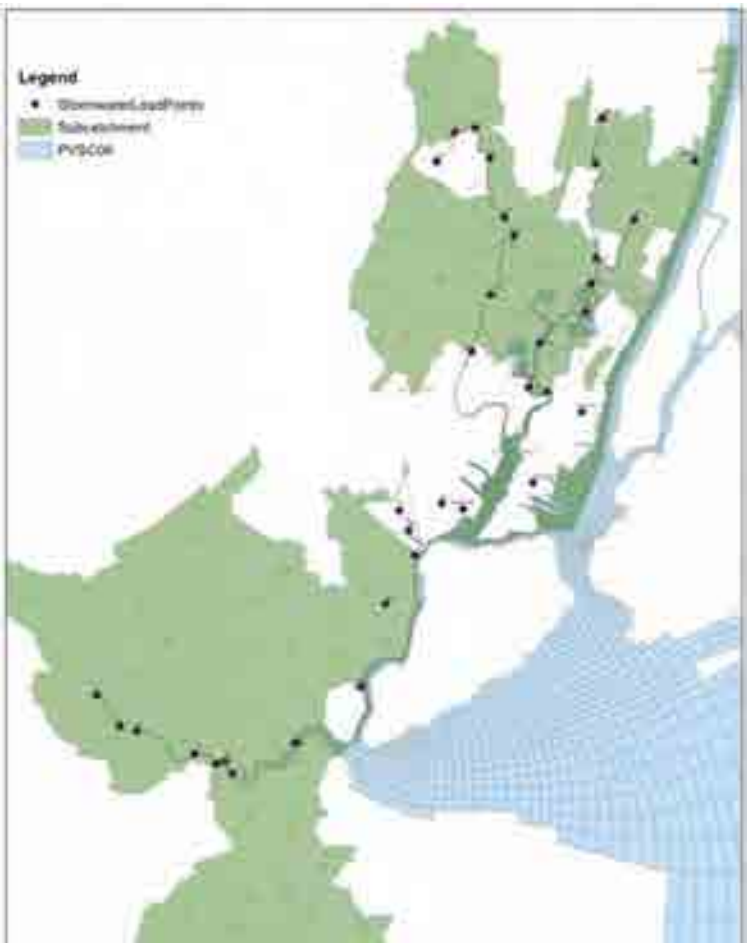
Probability Plot of Stormwater Pathogen Data
By Individual Local on
2010-2017

Commercial / Industrial



Stormwater Flows



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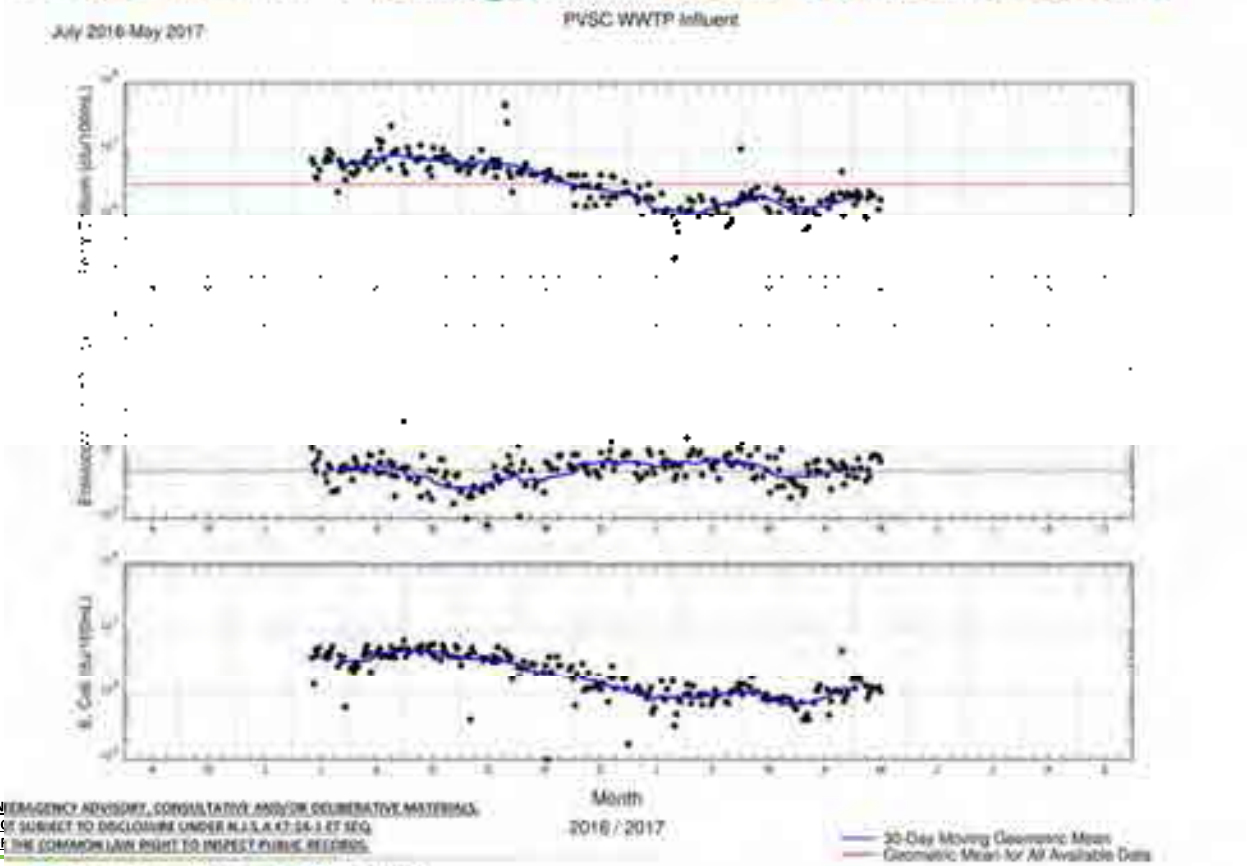
CSO Loading Calculations

- The Mass Balance approach will be used to assign loading to the CSOs
- The hydraulic models will provide flow and the sanitary/stormwater flow fractions.
  - The hydraulic models are still undergoing calibration
- CSO concentrations will be calculated using sanitary and stormwater concentrations.
- Estimated CSO concentrations will be compared to CSO concentration data.
  - Sampling program is behind schedule due to lower than normal precipitation.
- In some cases, the approach to calculating the CSO loads will need to be modified if the Mass Balance approach does not compare well to the data.

PVSC WWTP Pathogen Influent Concentrations



Measured CSO Concentrations

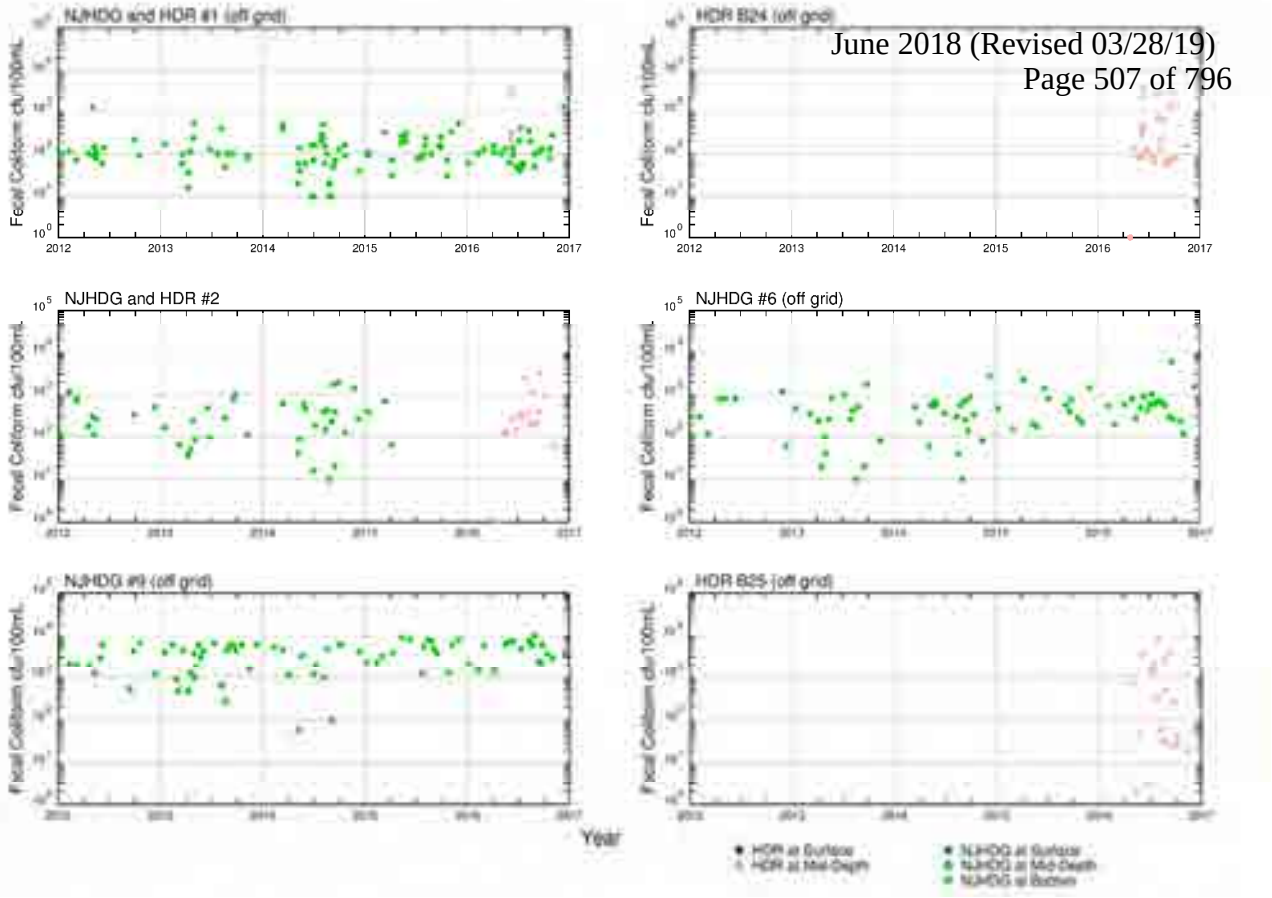
- 10 Locations have been sampled
- 17 events have been sampled

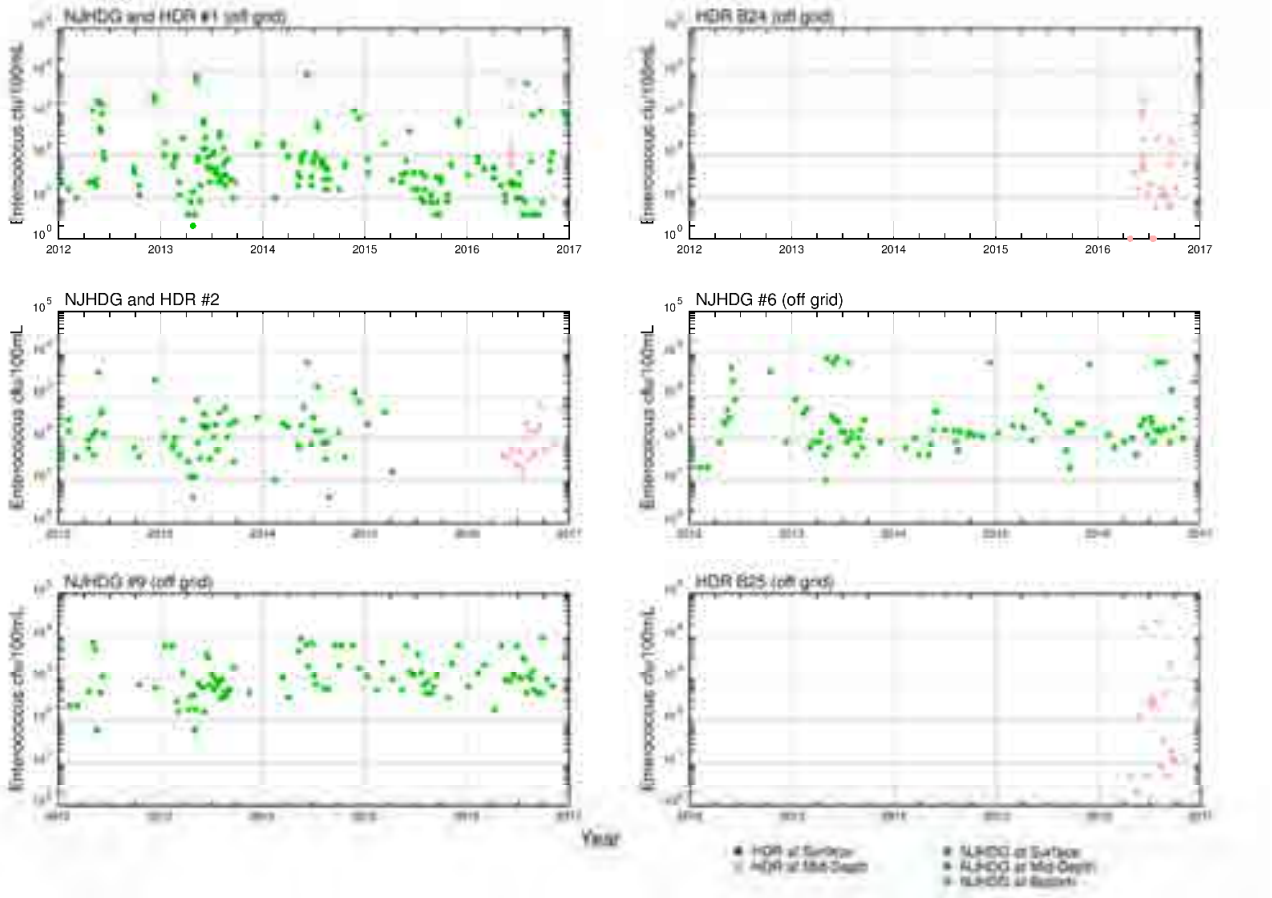
	CSO Bacteria Concentrations (cfu/100mL)	
	Fecal Coliform	Enterococci
Geometric Mean[1]	305,300	110,400
Average[2]	469,300	186,200
Range[3]	53,200 – 1,414,000	21,800-782,200
WWTP Sanitary	~3,000,000	~500,000
Event Sanitary	2,100,000	690,000

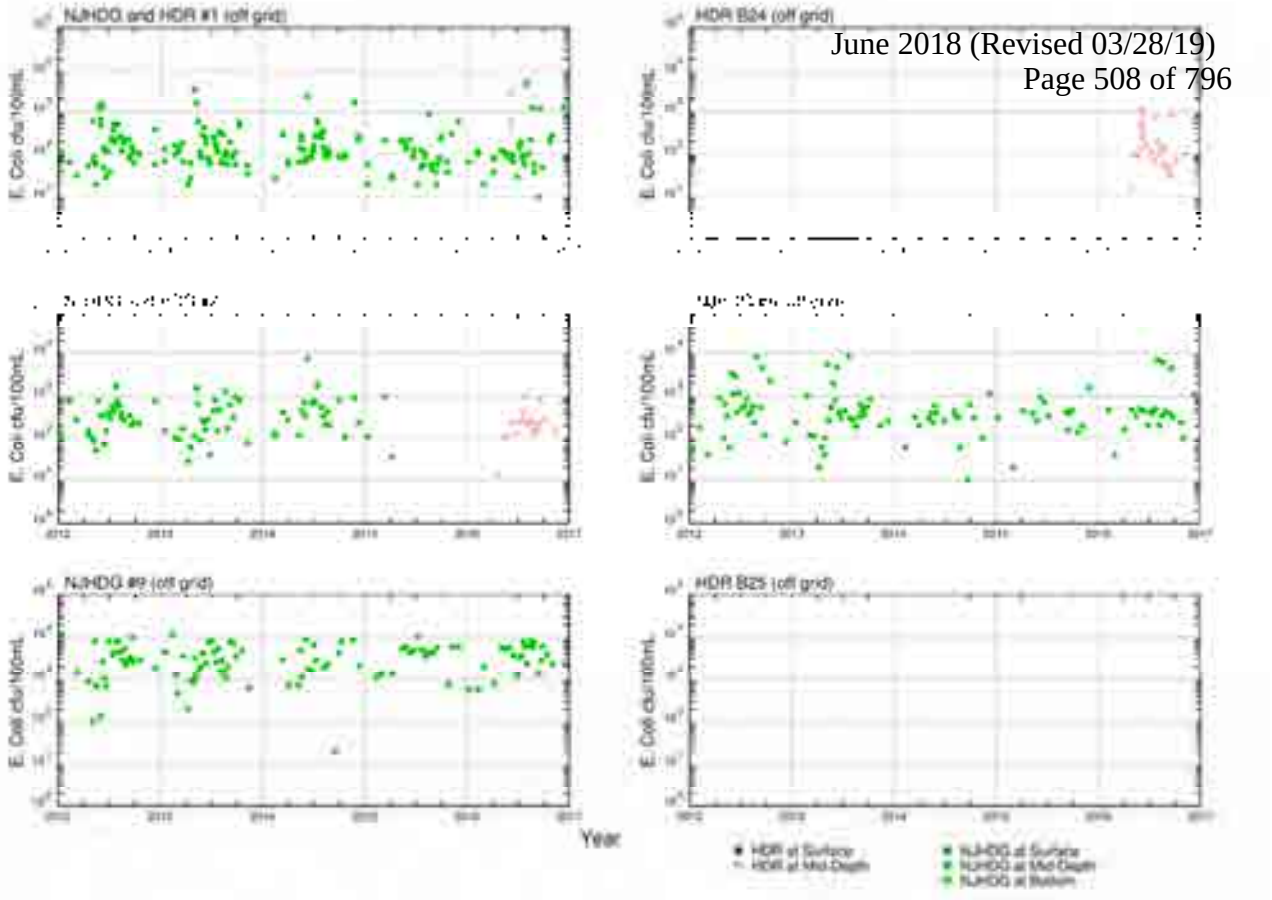
1 - GM of event GMs
2 - Average of event GMs
3 –Range of event GMs

River Loads

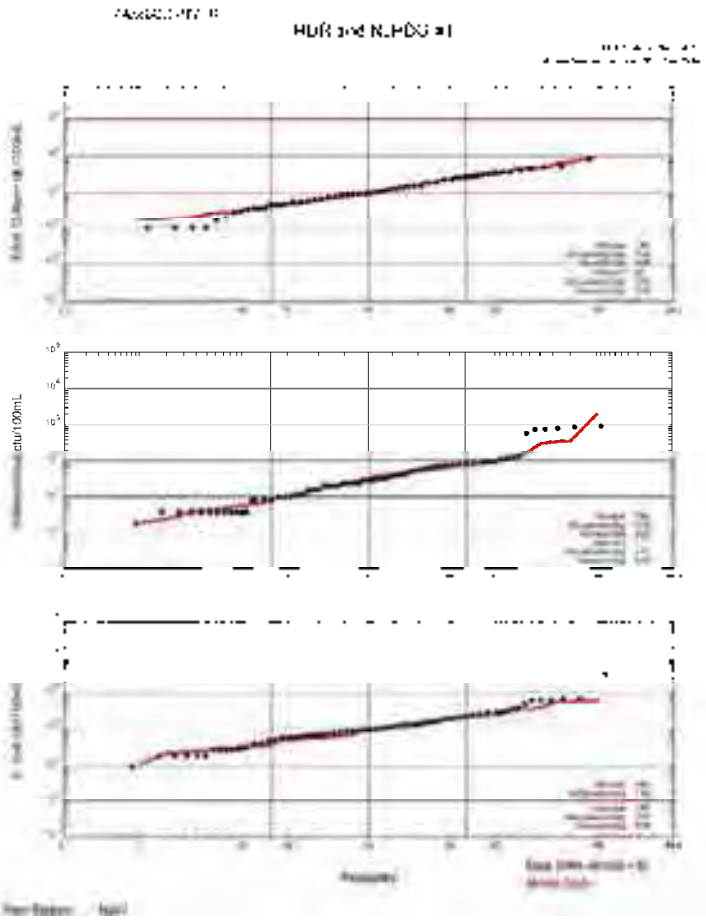
- Dry-weather
  - "Monte Carlo"
- Wet-weather
  - Concentration vs. 24-hr rainfall



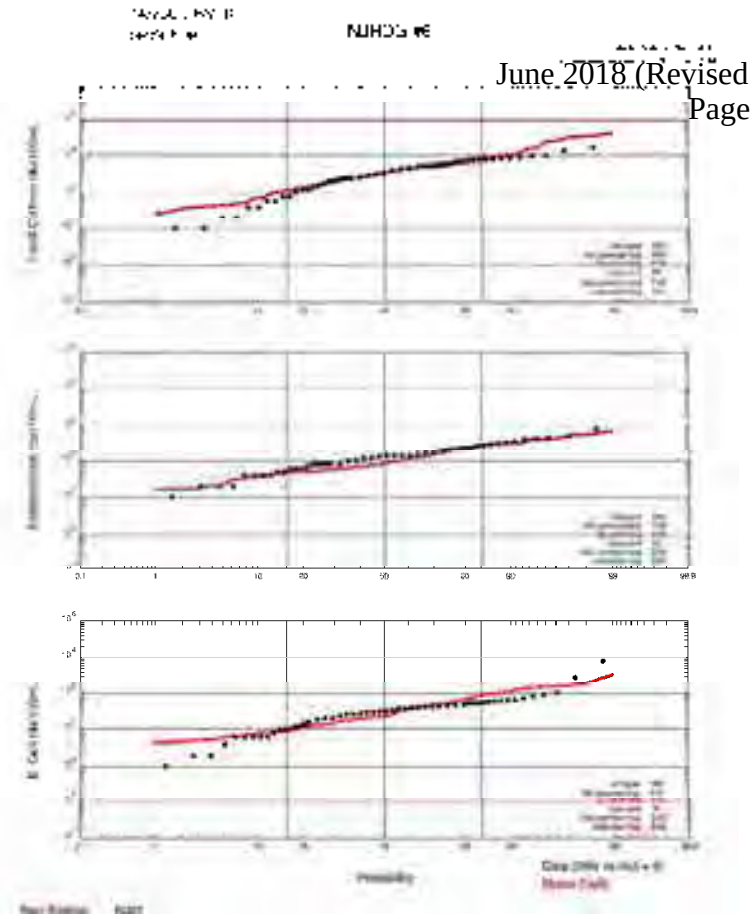




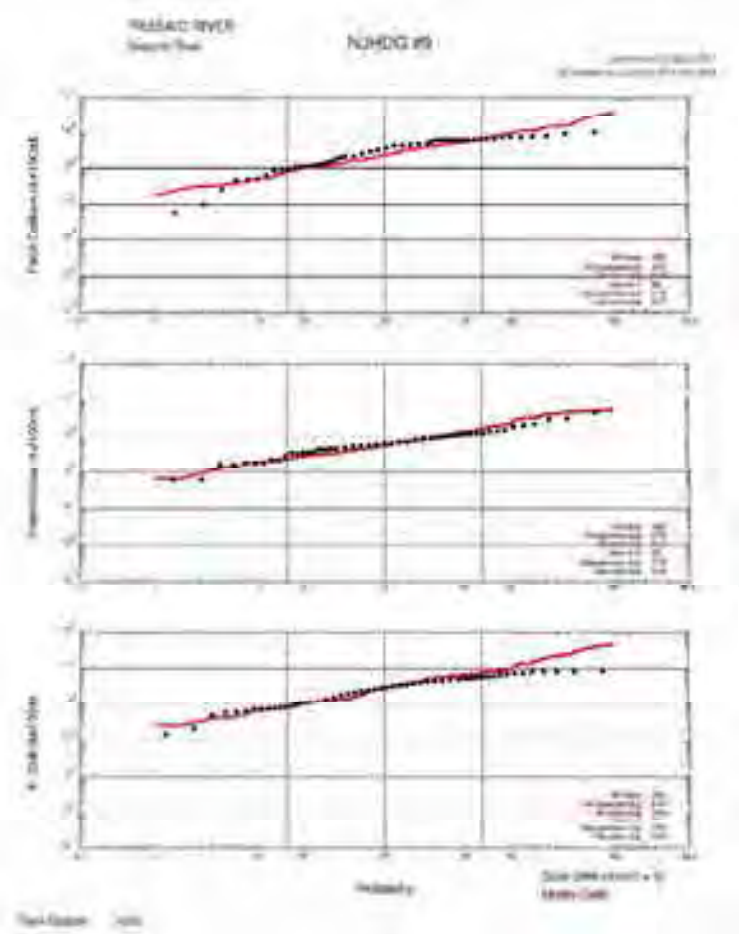
Dry-weather concentrations



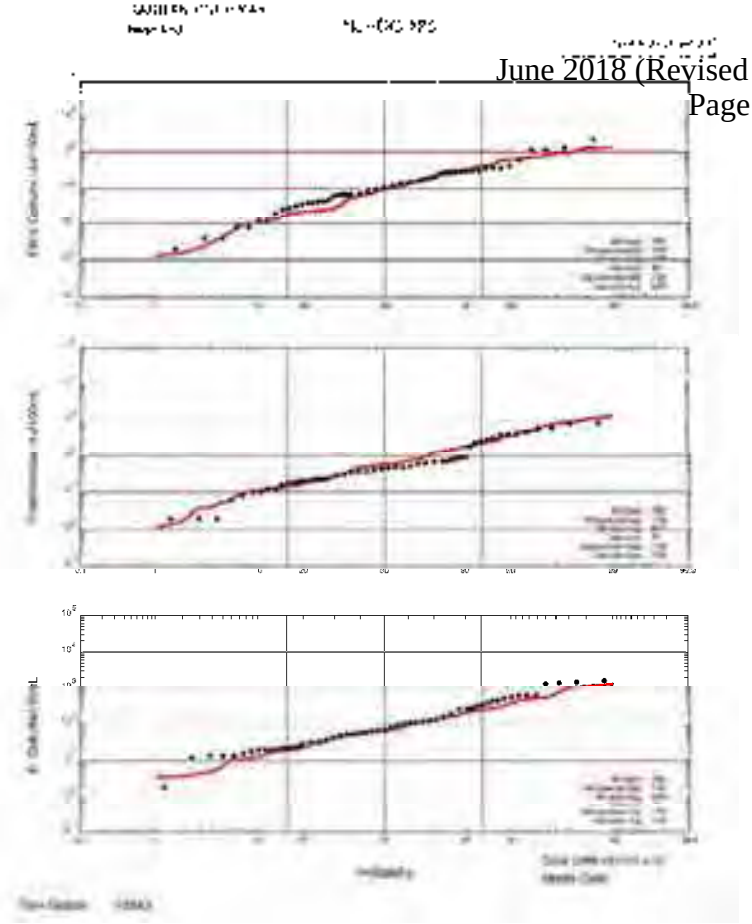
Dry-weather concentrations



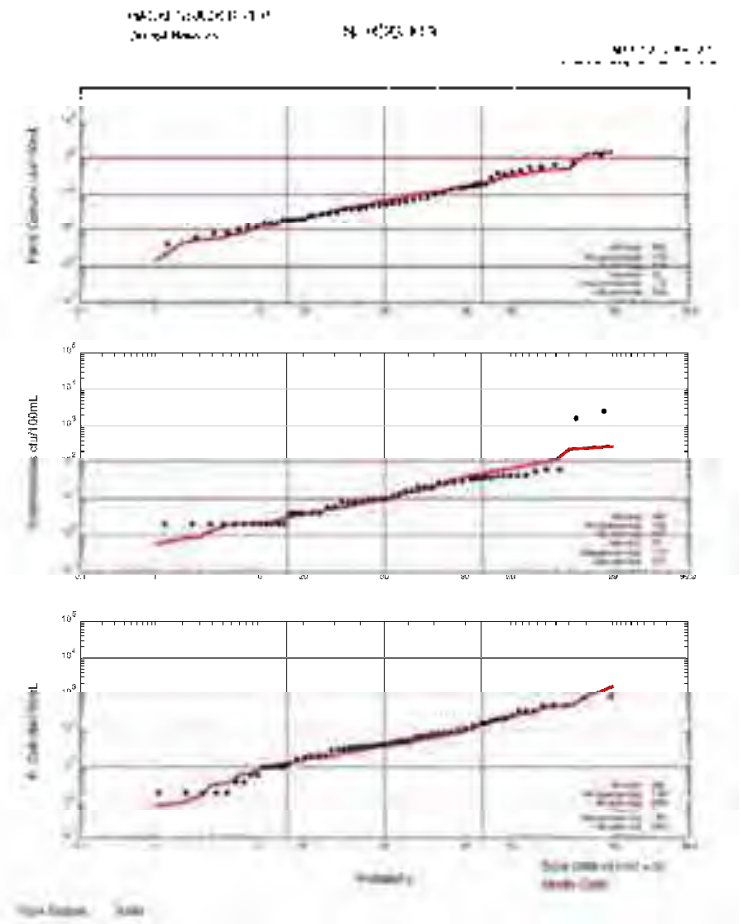
Dry-weather concentrations



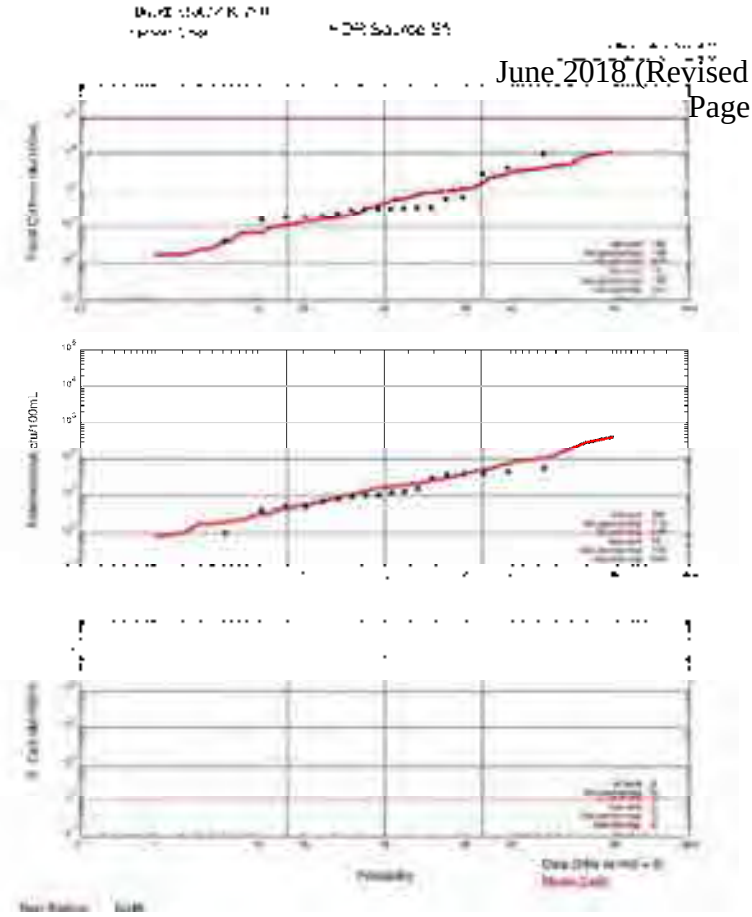
Dry-weather concentrations



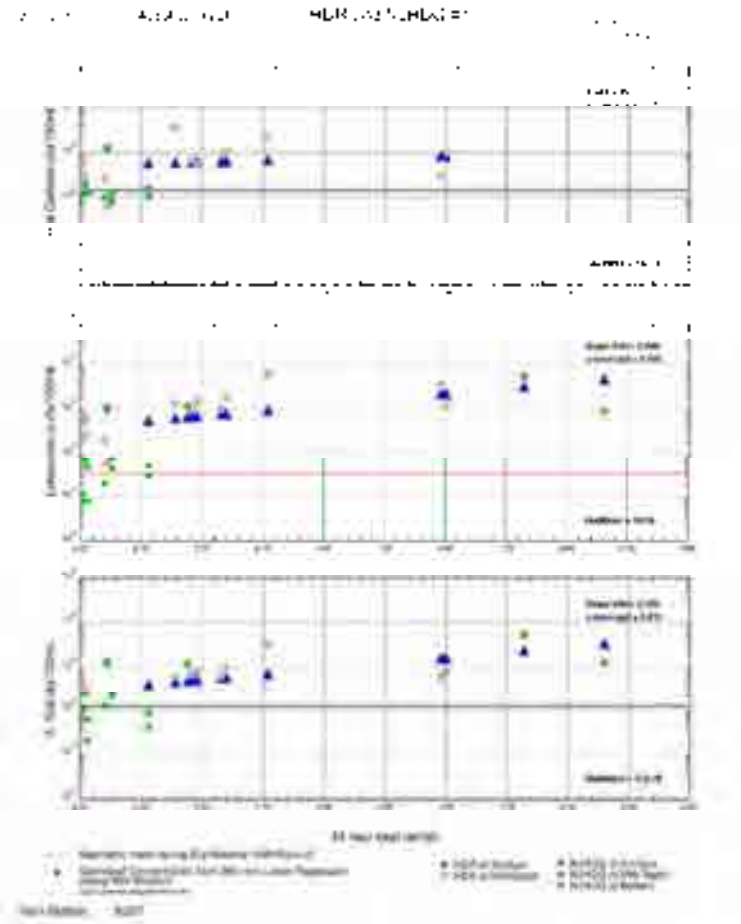
Dry-weather concentrations



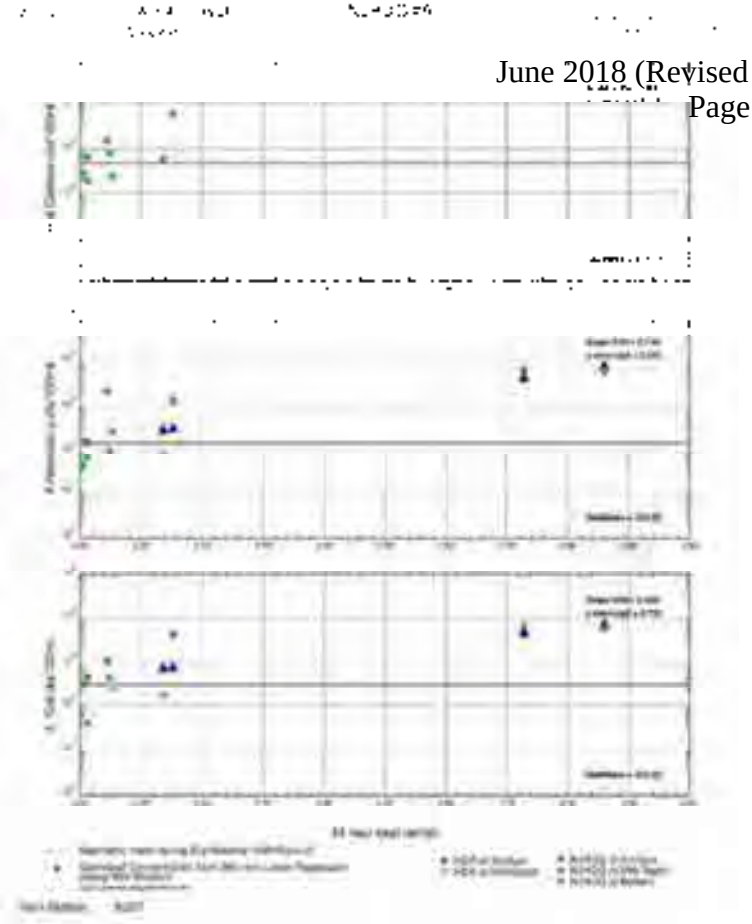
Dry-weather concentrations



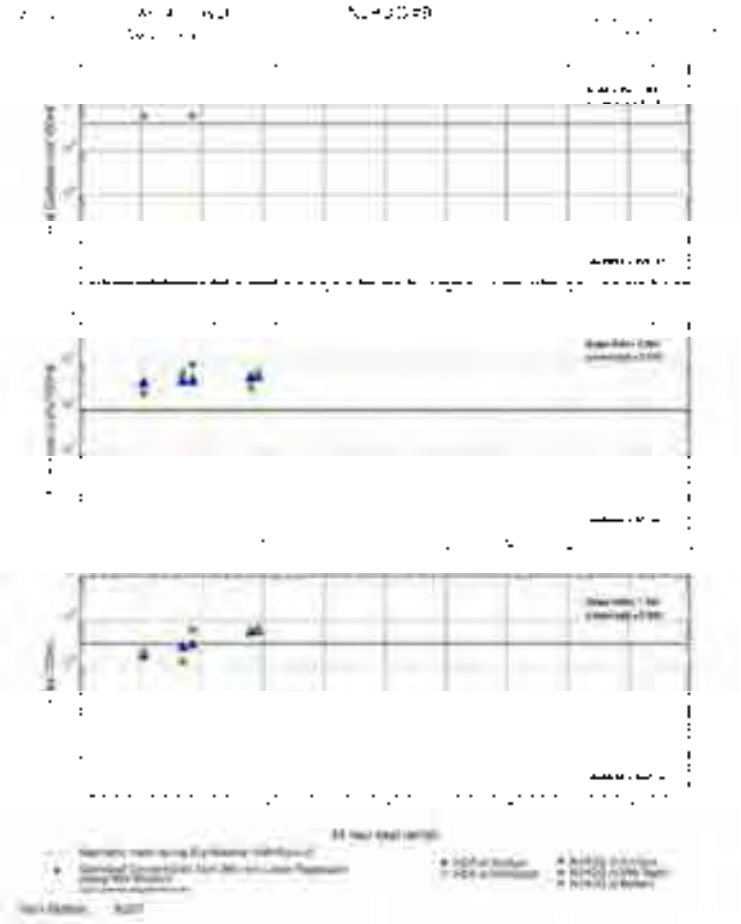
Wet-weather concentrations



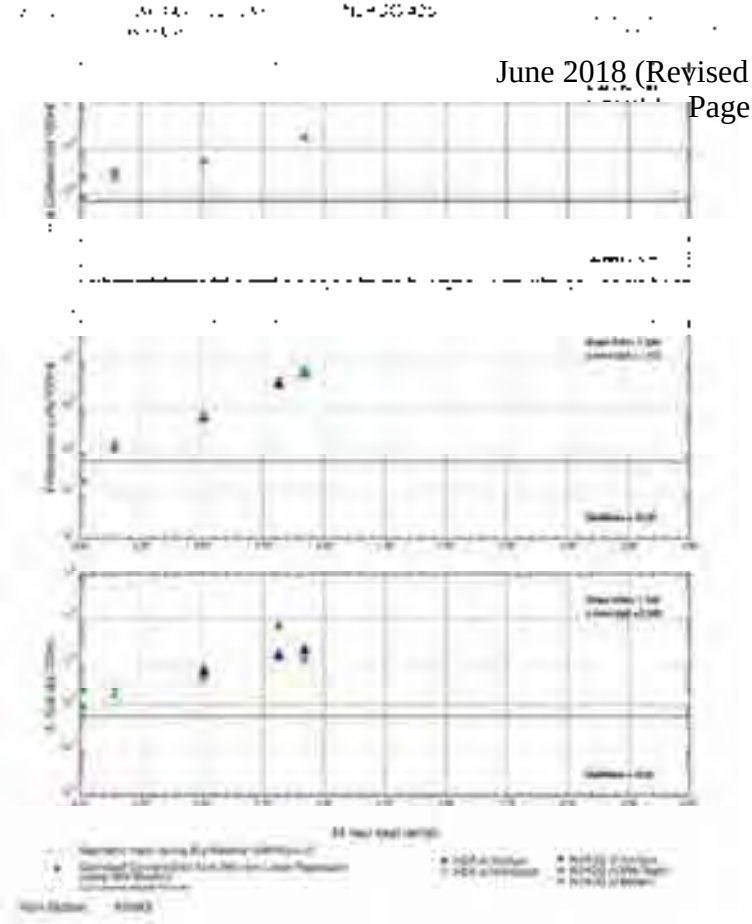
Wet-weather concentrations



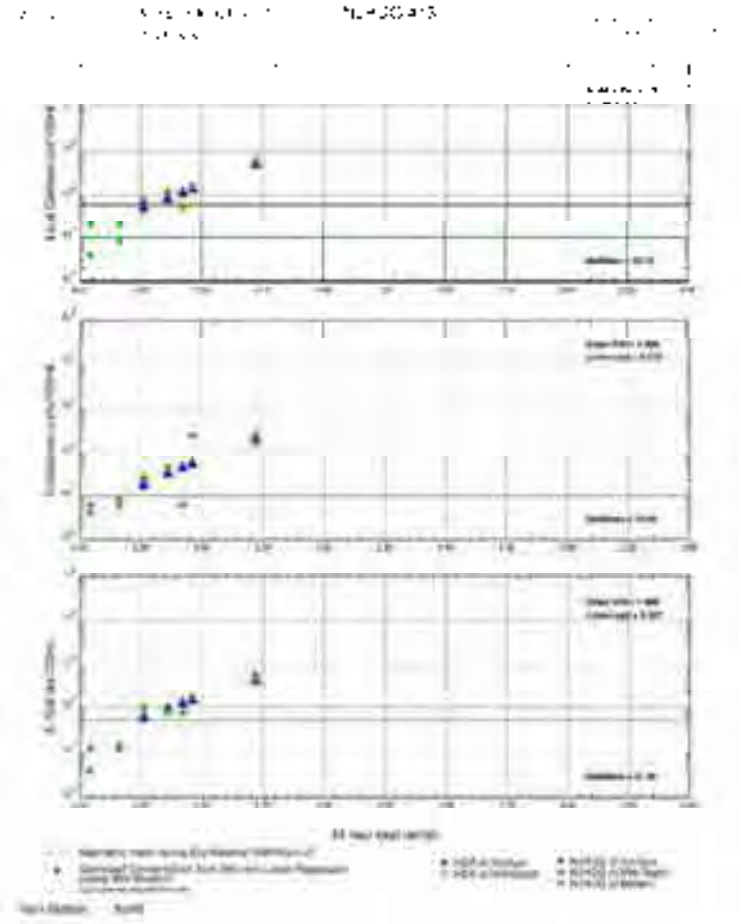
Wet-weather concentrations



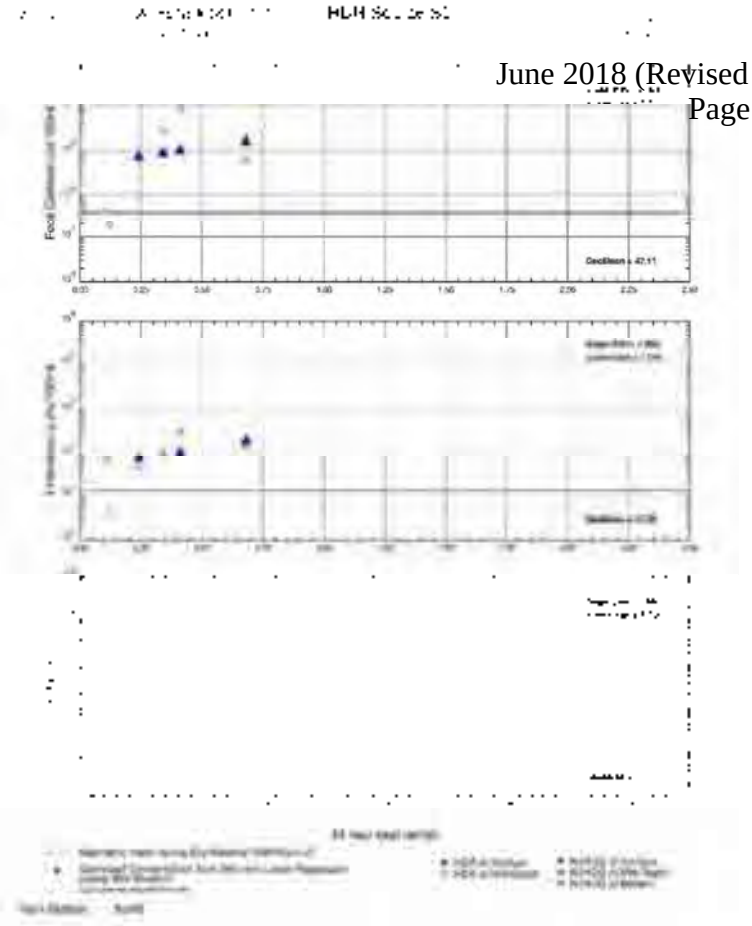
Wet-weather concentrations

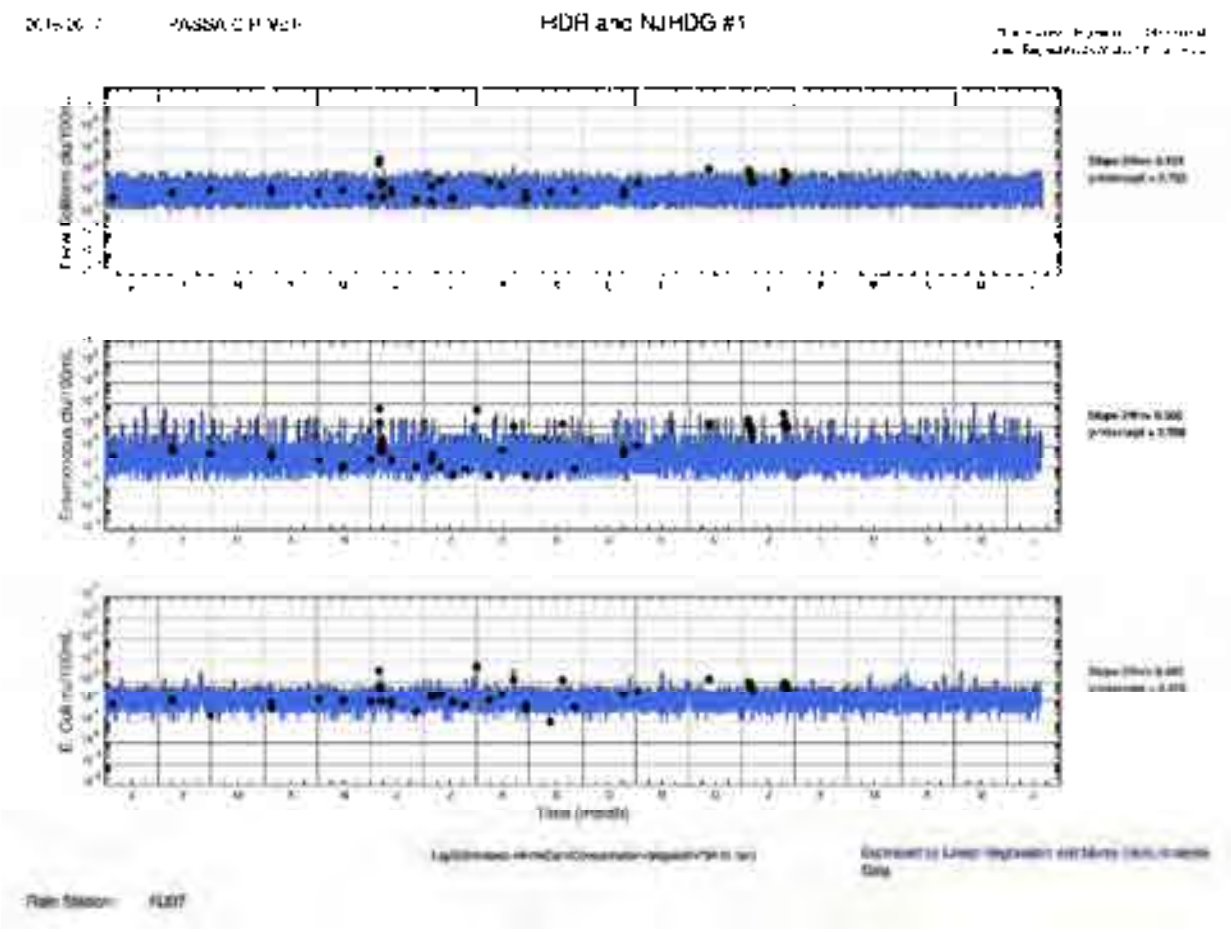


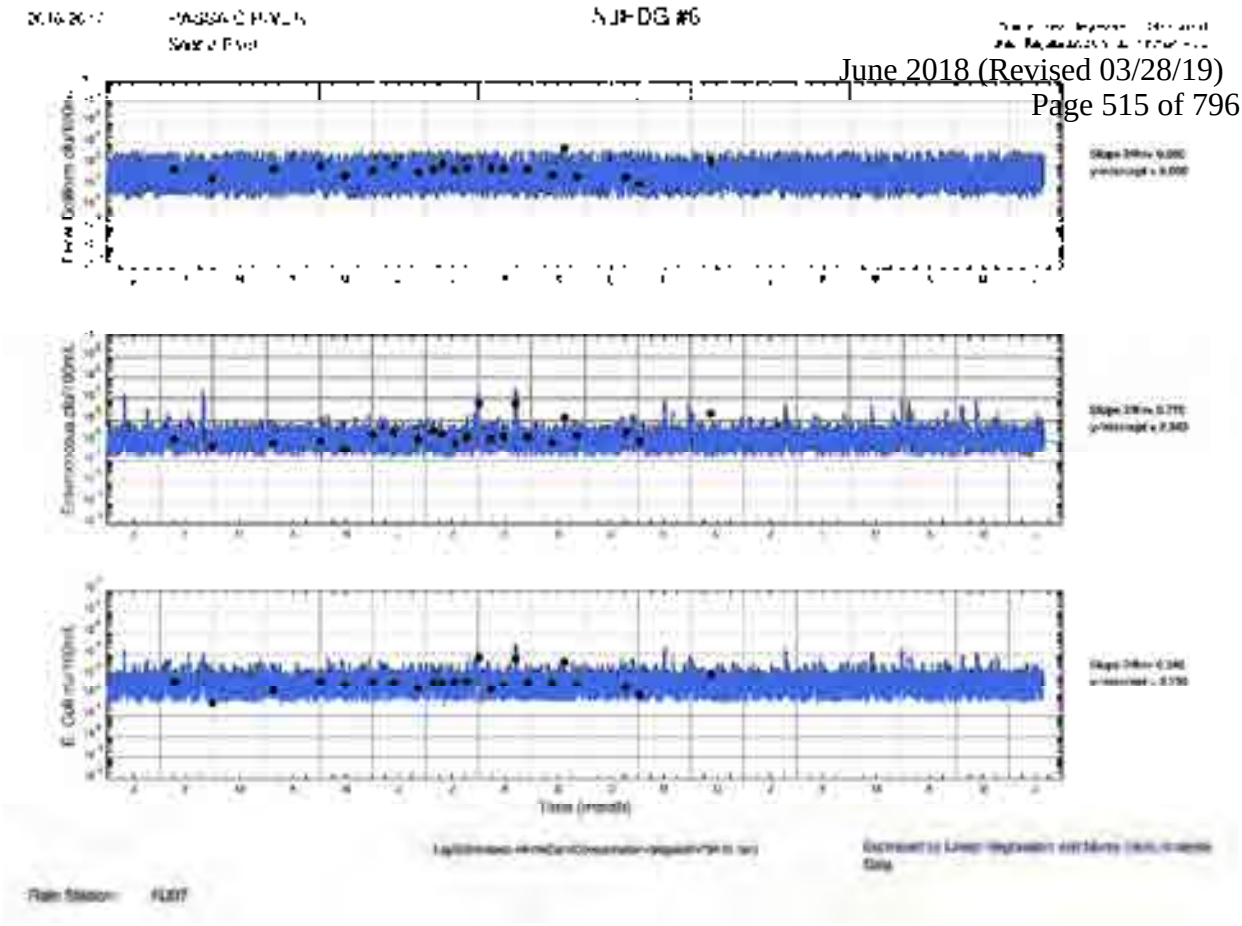
Wet-weather concentrations

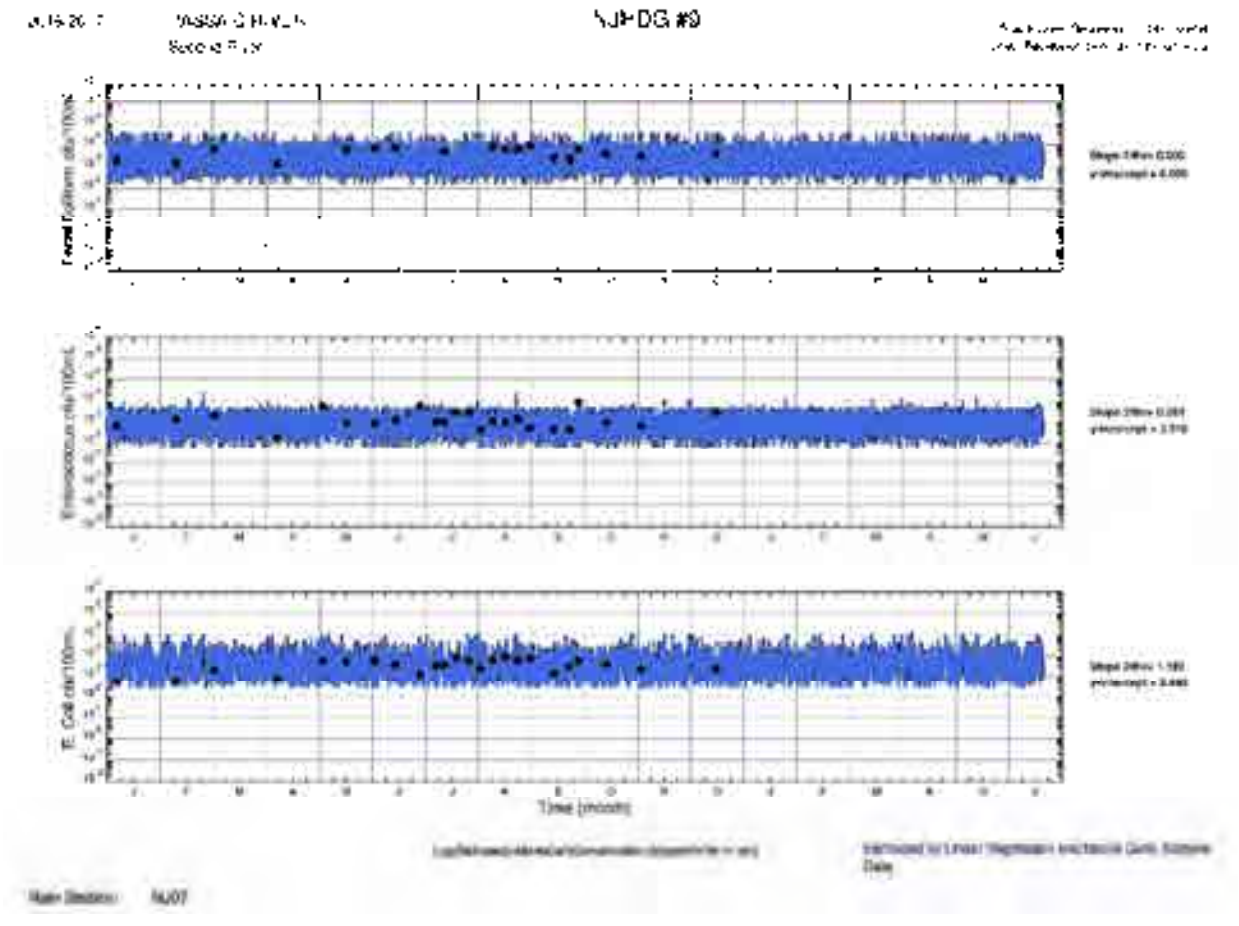


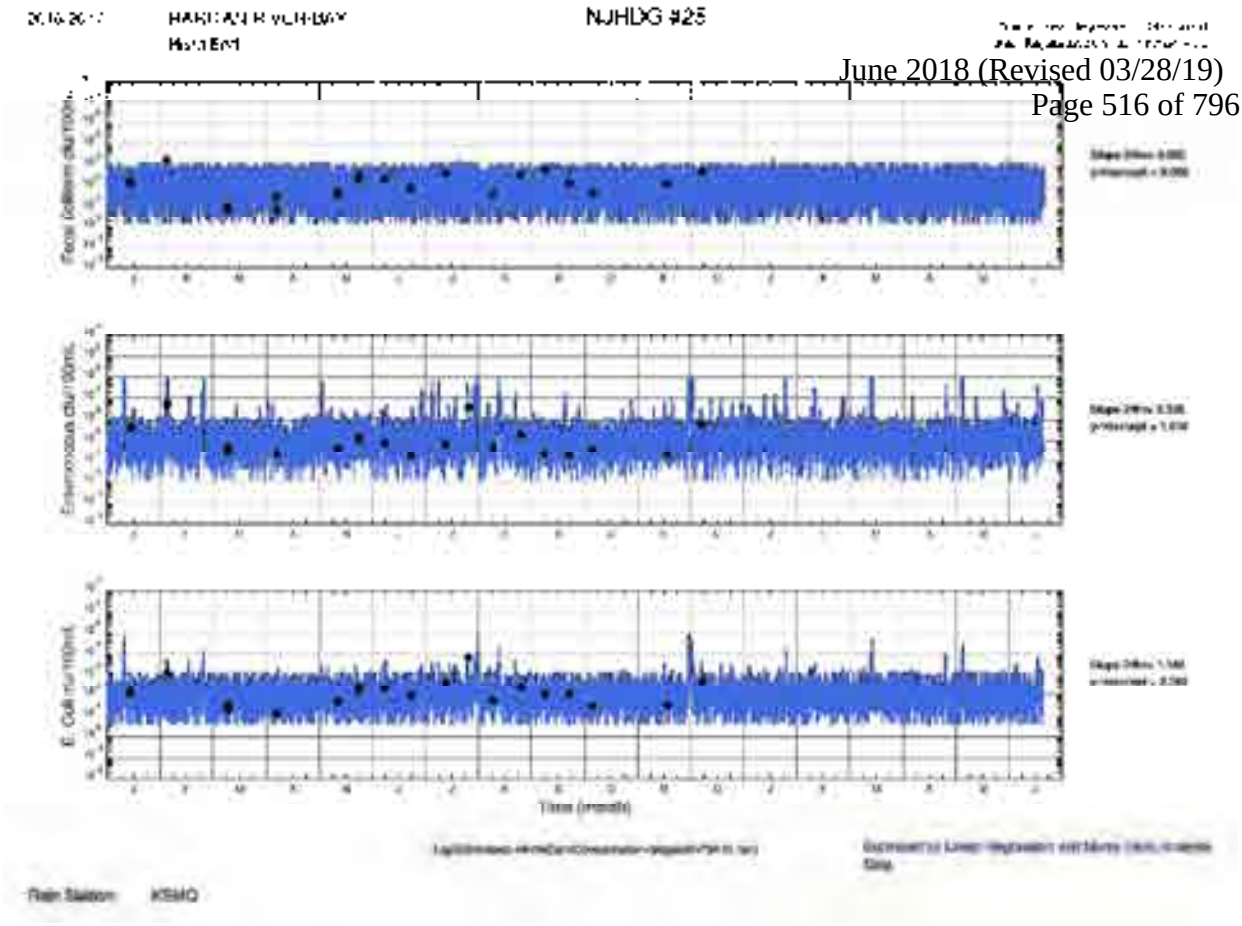
Wet-weather concentrations

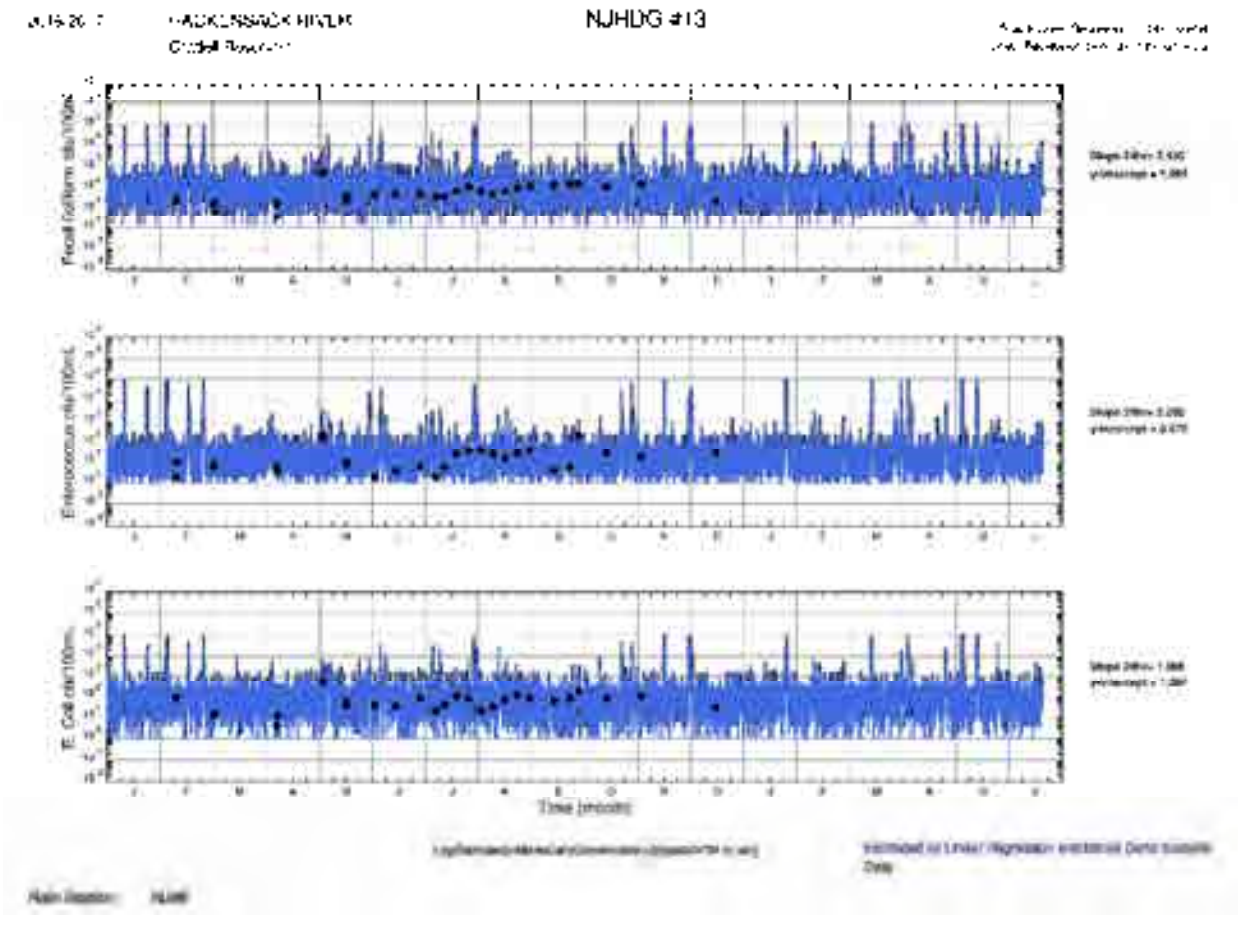


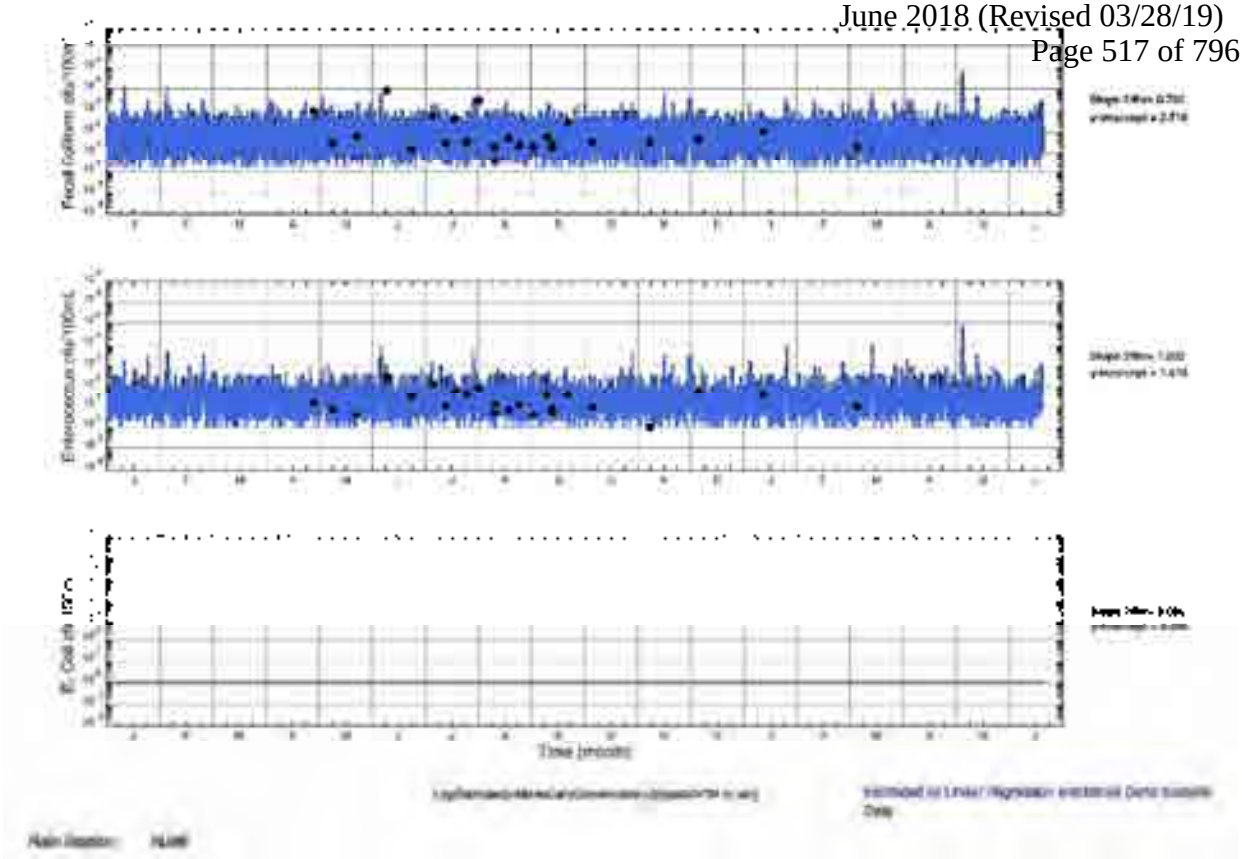












Other Loads

- Dry-weather sources
  - May be need for calibration during dry-weather
  - Projection conditions?
- Hudson River

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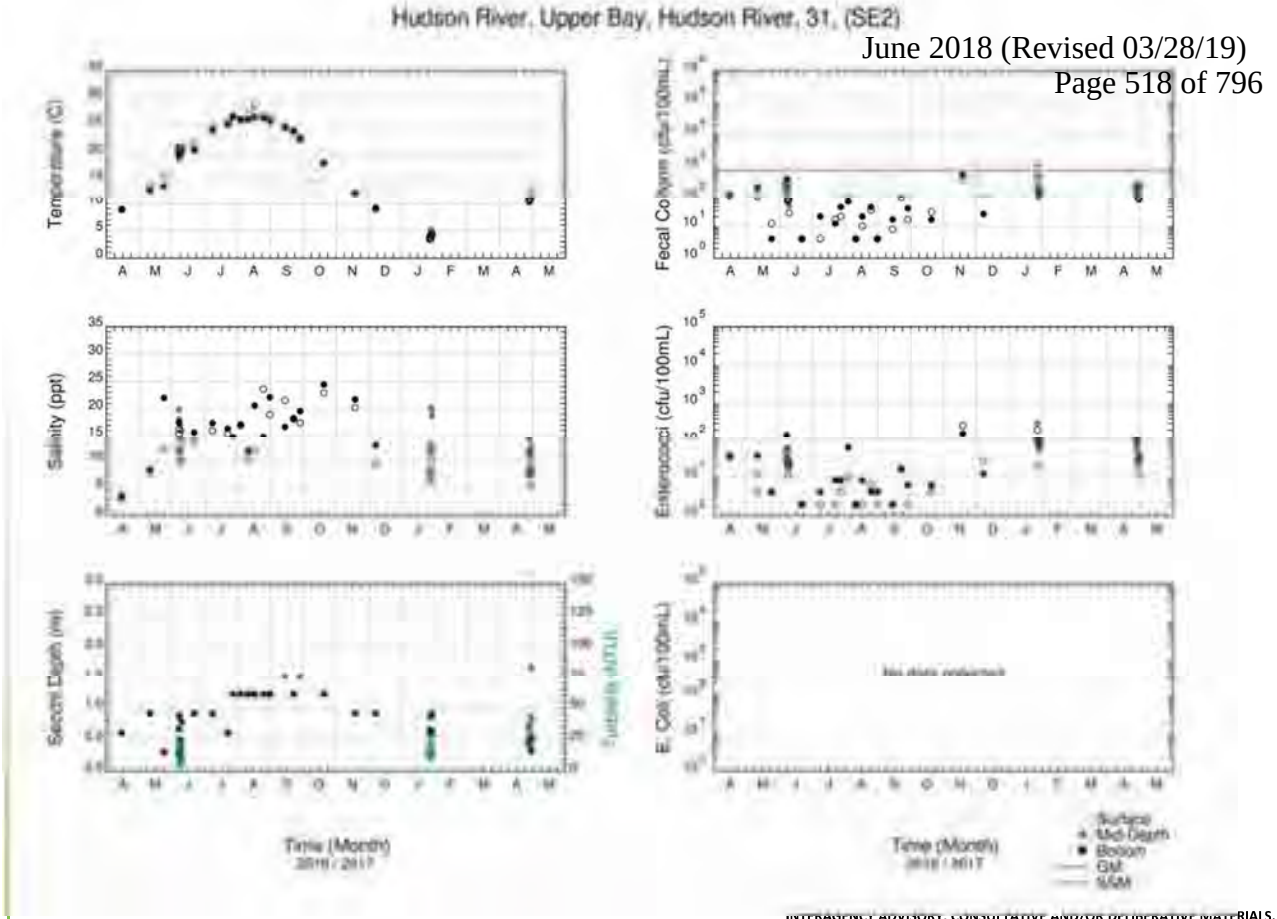


Pathogen Model Kinetics

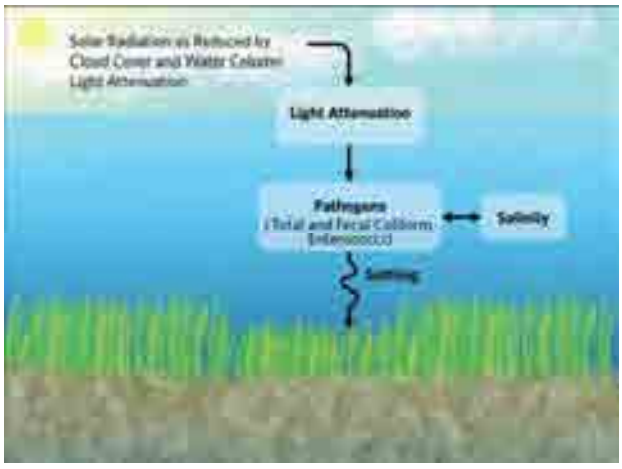
$$N = N_0 \exp(-KBt)$$

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

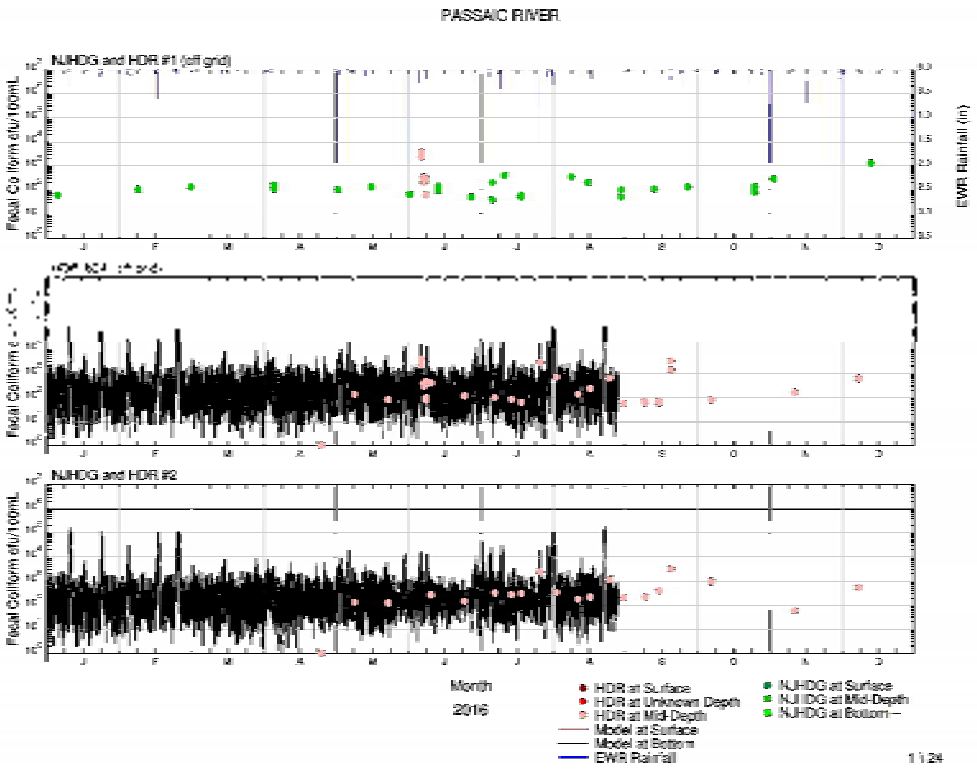
$+ \alpha I_0(t)/K_eH[1-\exp(-K_eH)]$

$+ V_s/H$ (Mancini, 1978)

N = Bacteria concentration
K_B = Bacteria loss rate
T = Temperature (°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)



Model Calibration



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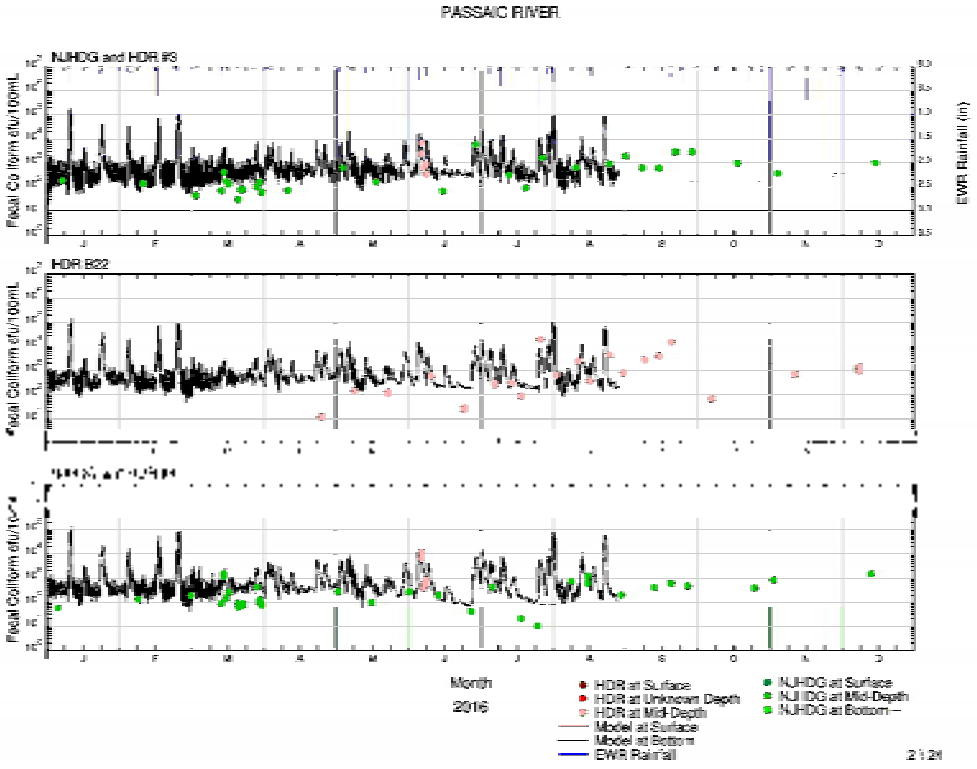

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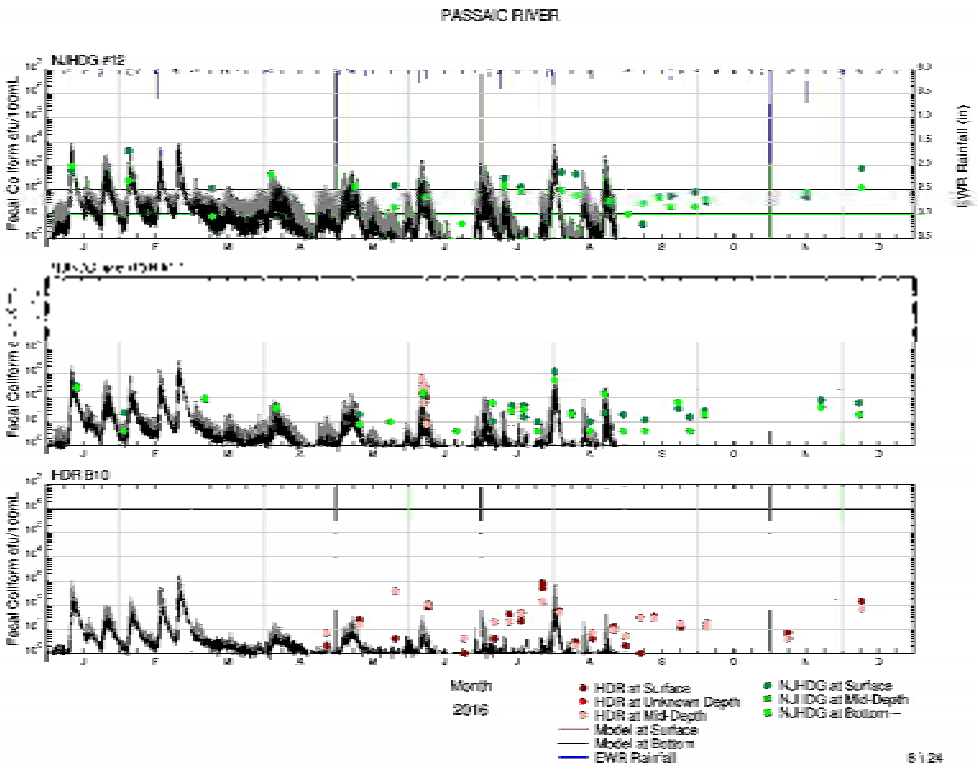

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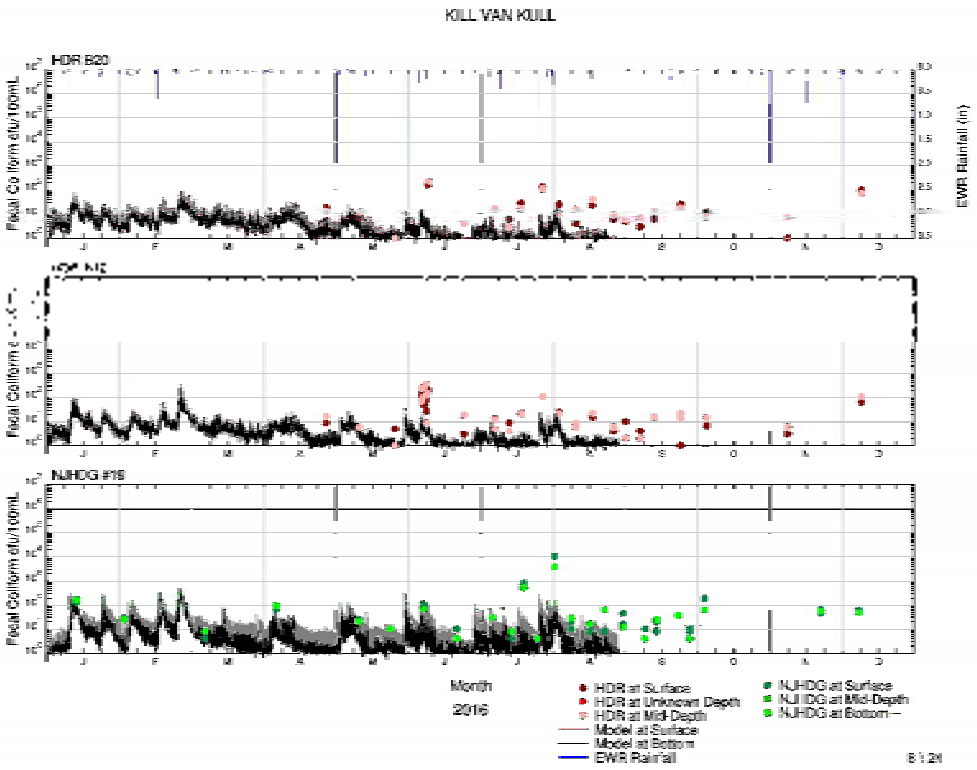

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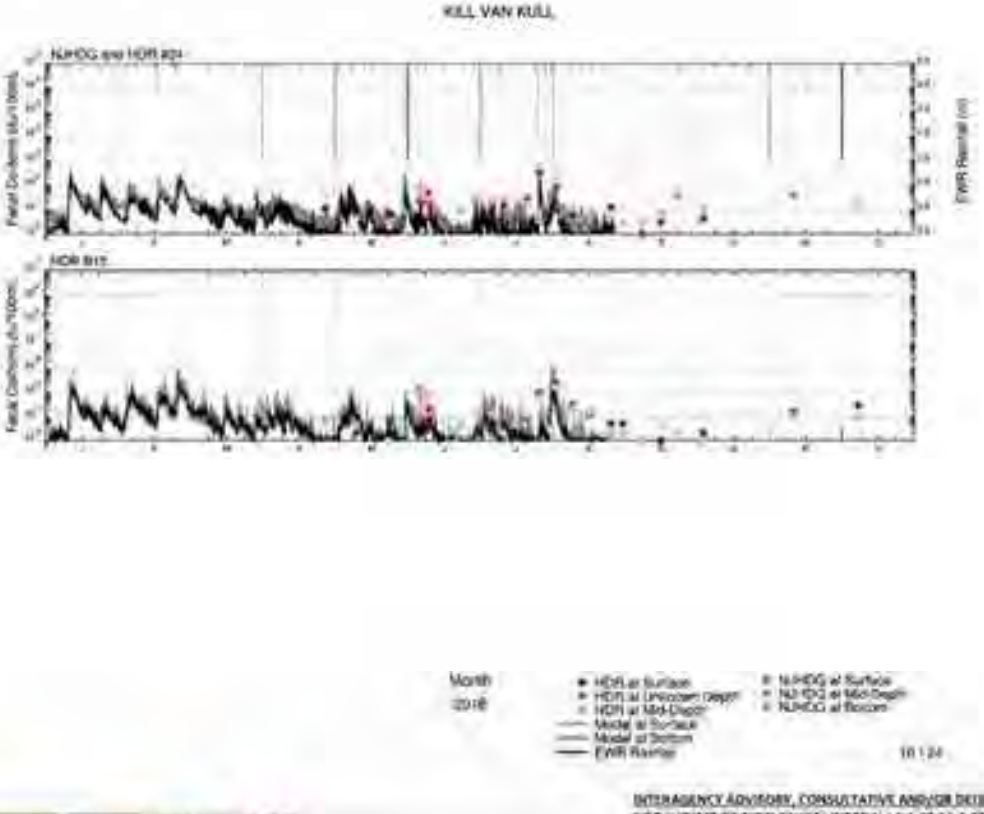

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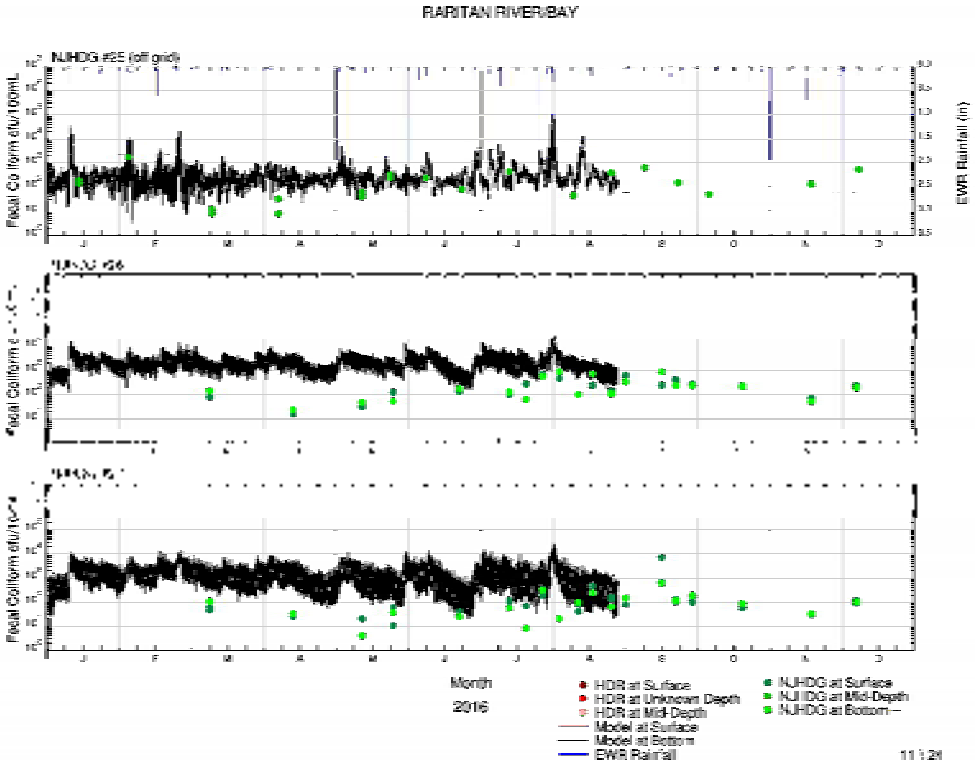

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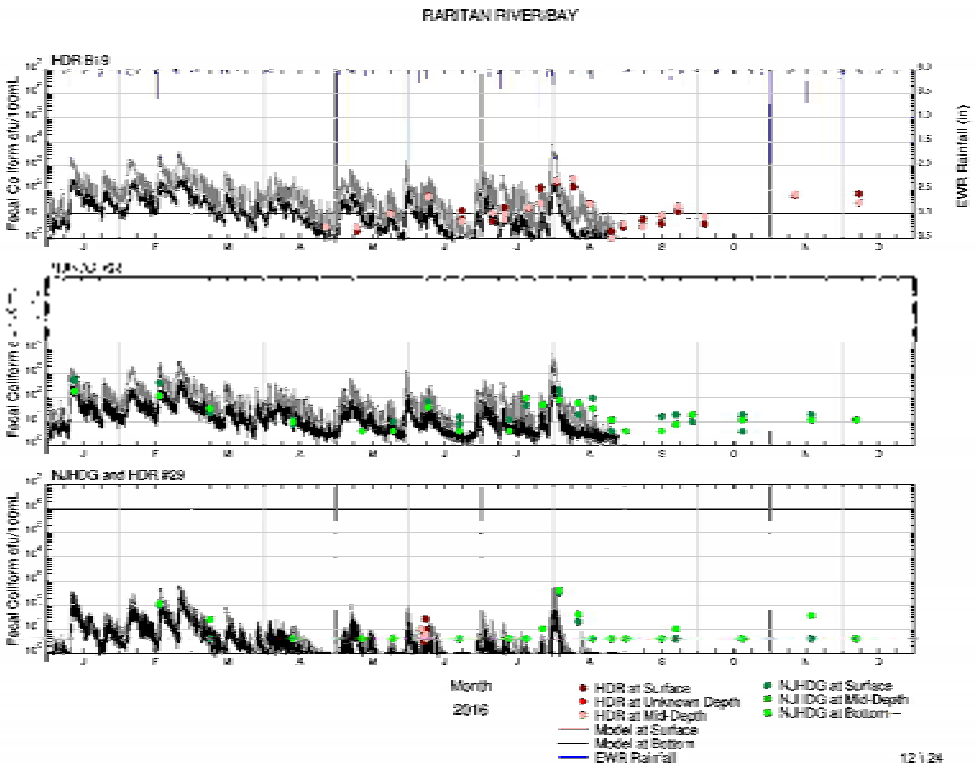
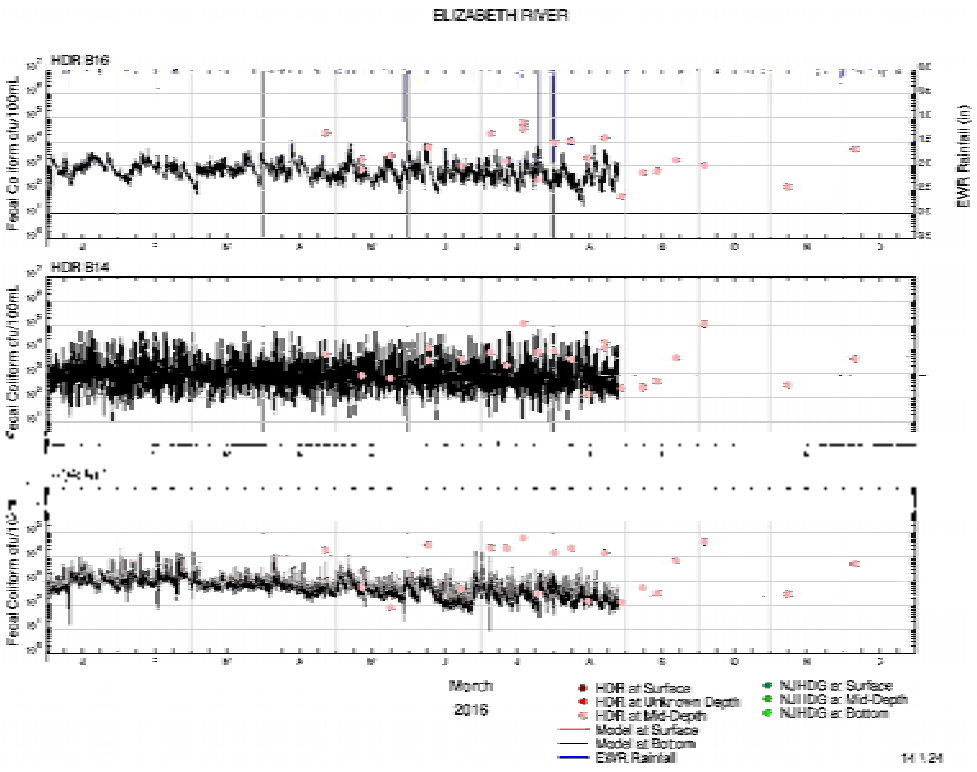


Model Calibration



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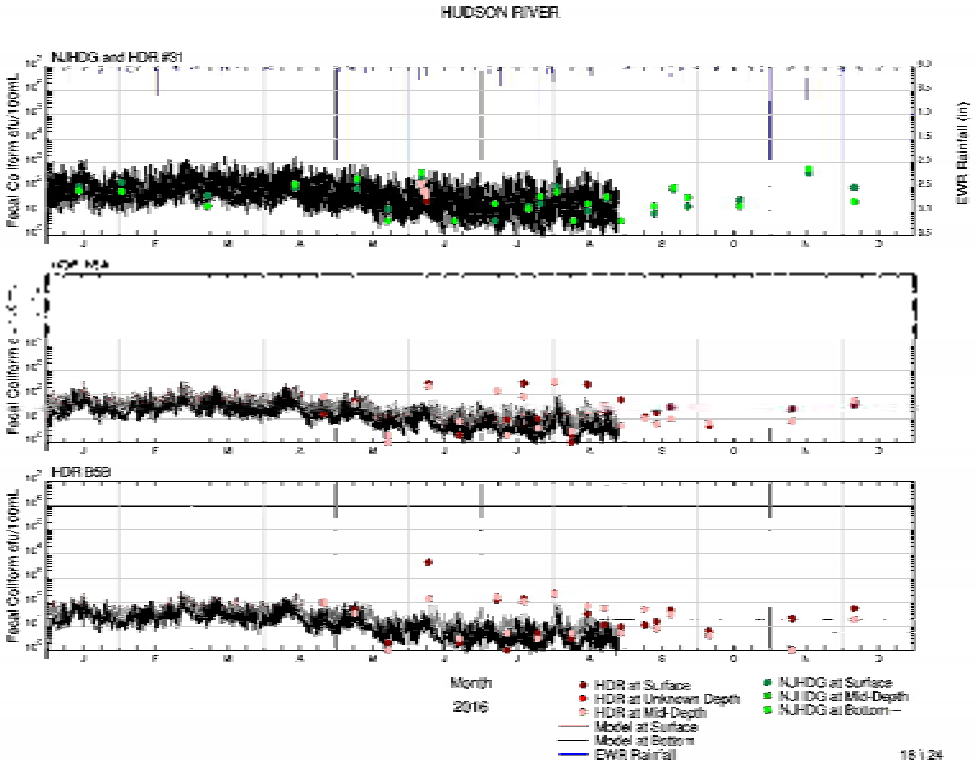

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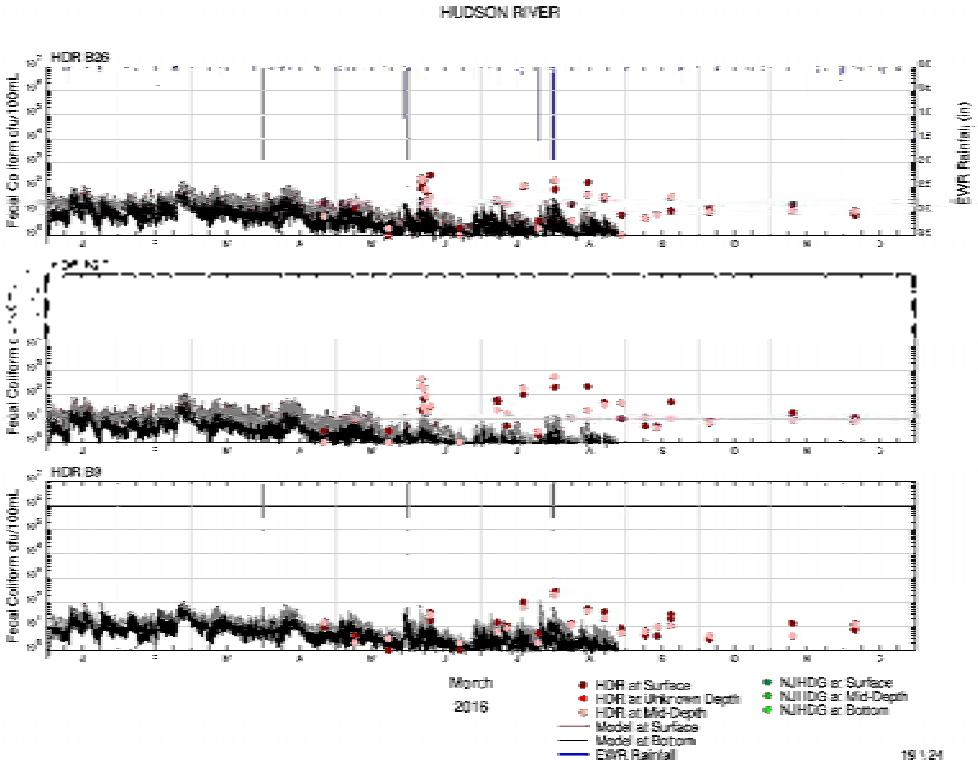

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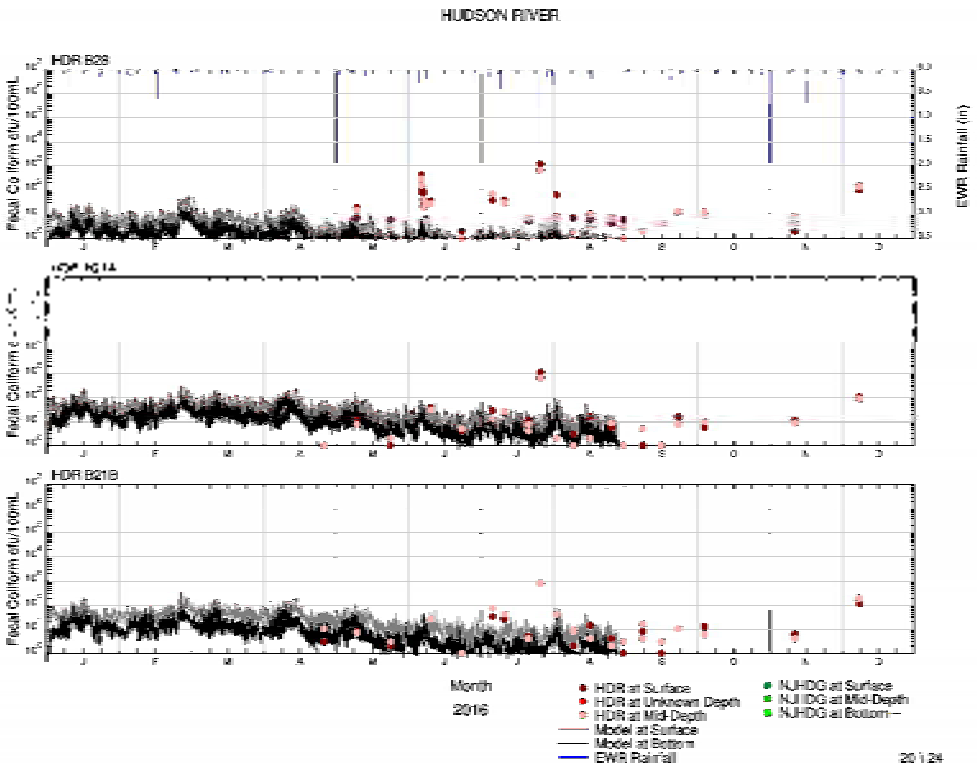

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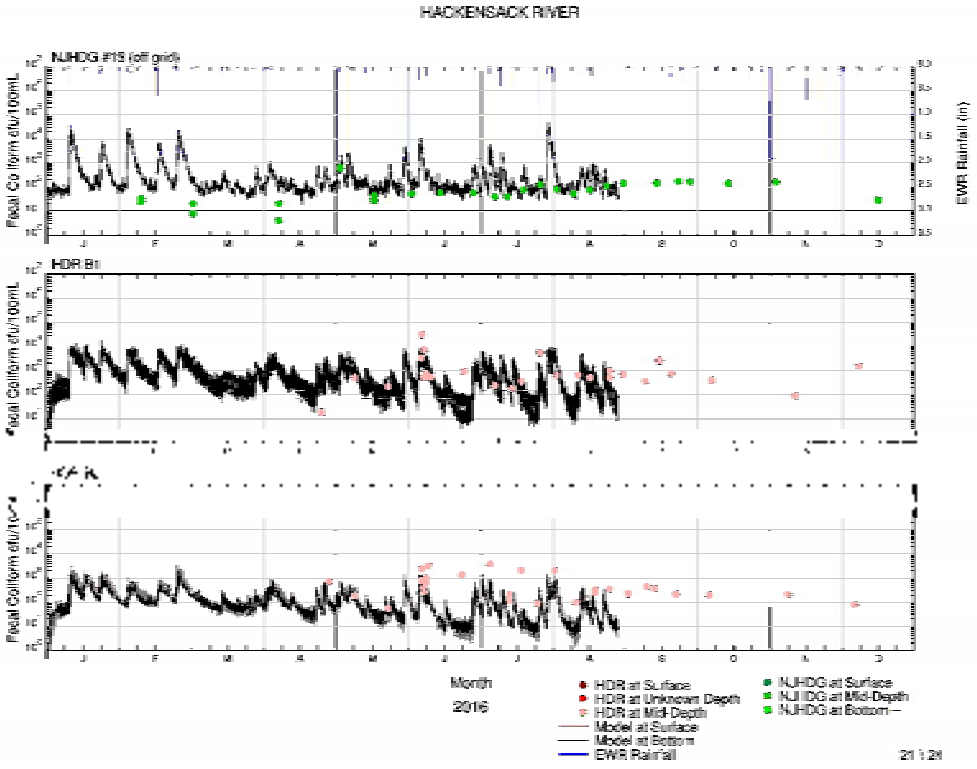

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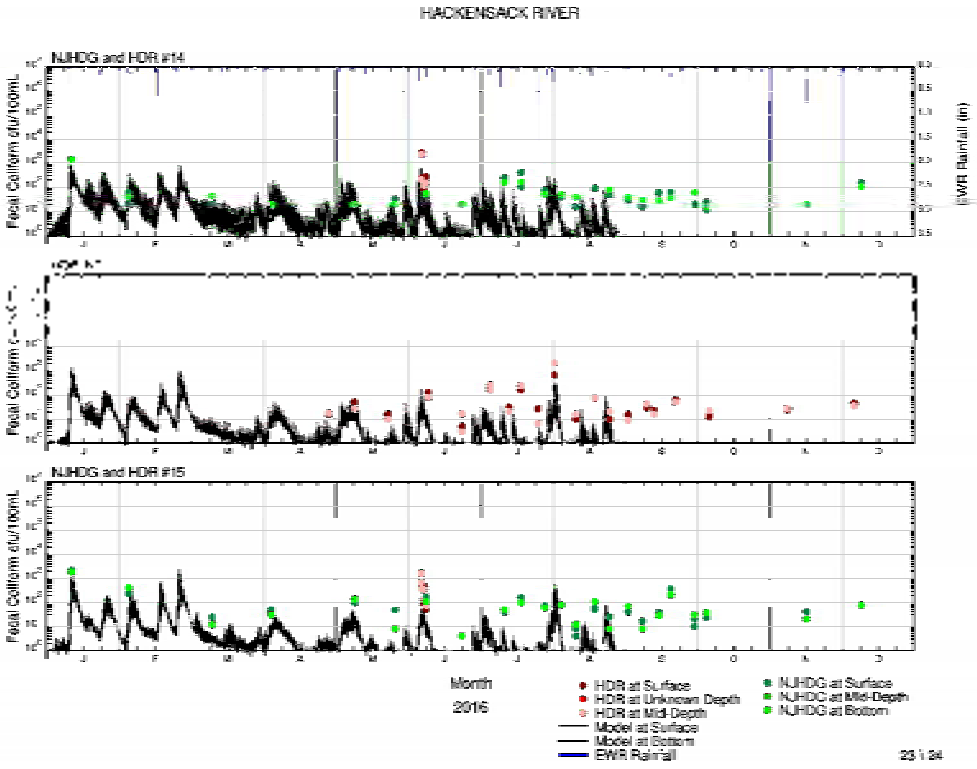


Next Steps

- CSO data
- Obtain CSO flow and load files from consultant teams
- Continue model calibration

PVSC – Long Term Control Plan
Modeling Evaluation Group – Session 4

Hydrologic and Hydraulic Model Overview

Greeley and Hansen LLC
December 5, 2018

Agenda

- Overview of PVSC H&H Model
  - Model Service Area and Network
  - Wet Weather Operating Rules
- H&H Model Calibration & Validation
- H&H Model Application

GREELEY AND HANSEN

PVSC H&H Model Overview

3

Sewer Systems

- Passaic Valley Sewerage Commission
  - 48 municipalities
    - 8 CSO municipalities (0.9 million residents)
  - 1.5 million residents
  - 147 mi² service area
  - 22 mile interceptor sewer
  - 330 mgd WPCF
- NBMUA Woodcliff WWTP
  - 2 CSO municipalities
  - 3 mgd Woodcliff WWTP
  - 477 acres (368 acres in North Bergen)

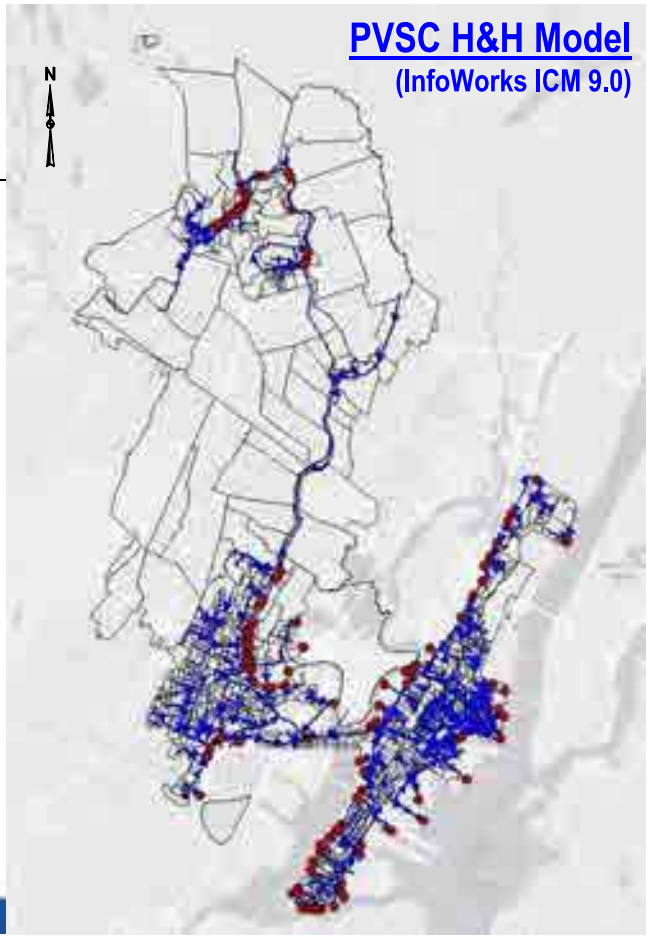
4 4

CSO Communities

Municipality	WWTP	Population	Area (mi²)	Sewerage (miles)	CSOs
Bayonne	PVSC WRRF	63,000	5.8	94	30
East Newark		2,400	0.1	2	1
Harrison		13,600	1.3	18	7
Jersey City		247,600	14.8	230	21
Kearny		40,700	6.5	52	5
Newark		277,100	22.3	579	18
North Bergen		52,600	4.5	59	7
Paterson		146,200	8.7	164	23
Guttenberg	NBMUA Woodcliff	11,200	0.2	5	1
North Bergen		8,200	0.7	8	1
Total		**862,600**	**84**	**1,211**	**114**

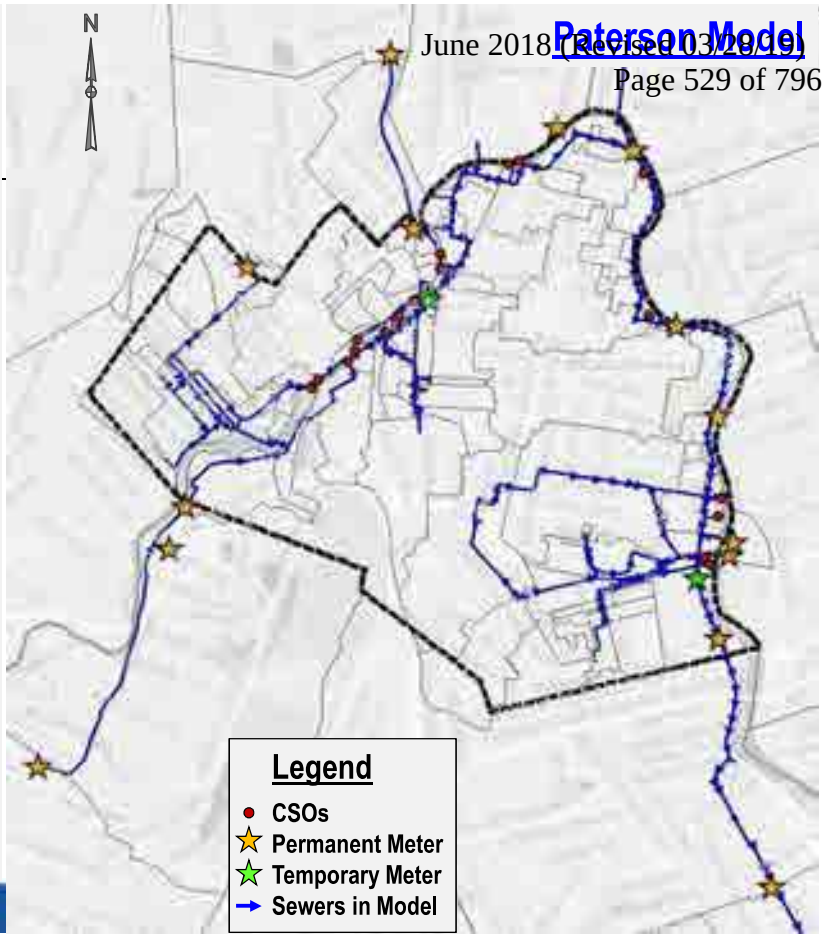
Entire PVSC H&H Model

- Subcatchment: 1121
- Nodes (4216)
  - Manhole: 4081
  - Outfall: 123
  - Storage: 12
- Link (4413)
  - Conduit: 4039
  - Flap Valve: 101
  - Orifice: 42
  - Pump: 16
  - Sluice: 95 (34 variable)
  - Weir: 120



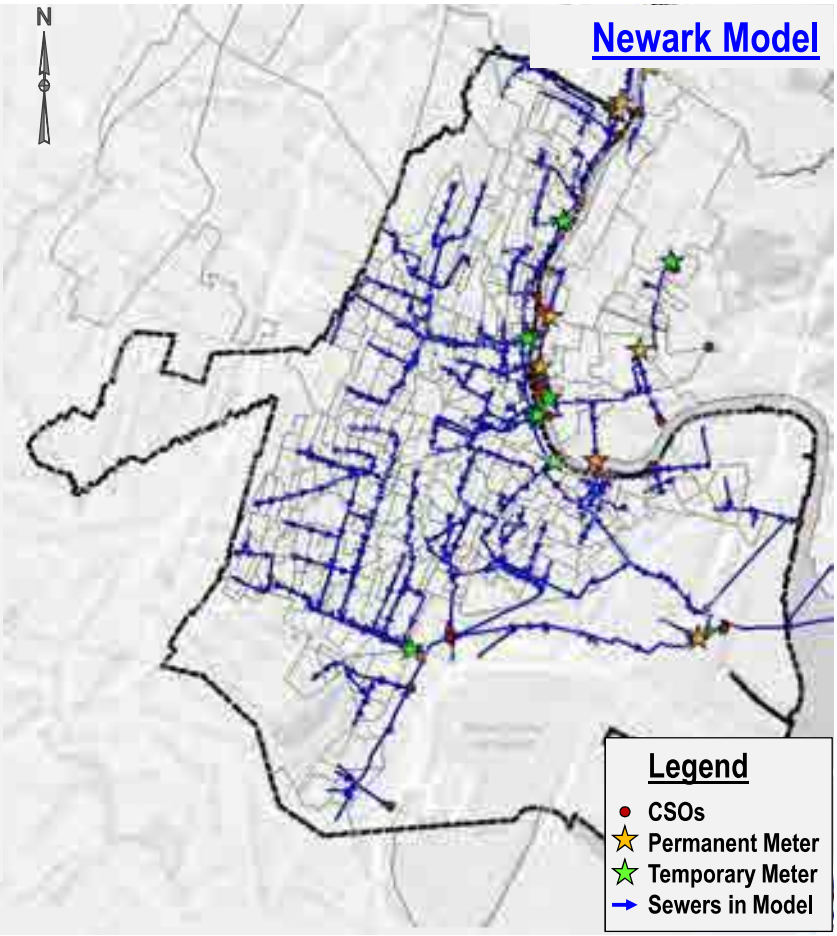
Paterson Model

- Subcatchment: 67
- Nodes (585)
  - Manhole: 562
  - Outfall: 23
  - Storage: 0
- Link (657)
  - Conduit: 503
  - Flap Valve: 82
  - Orifice: 14
  - Pump: 0
  - Sluice: 16 (2 variable)
  - Weir: 42



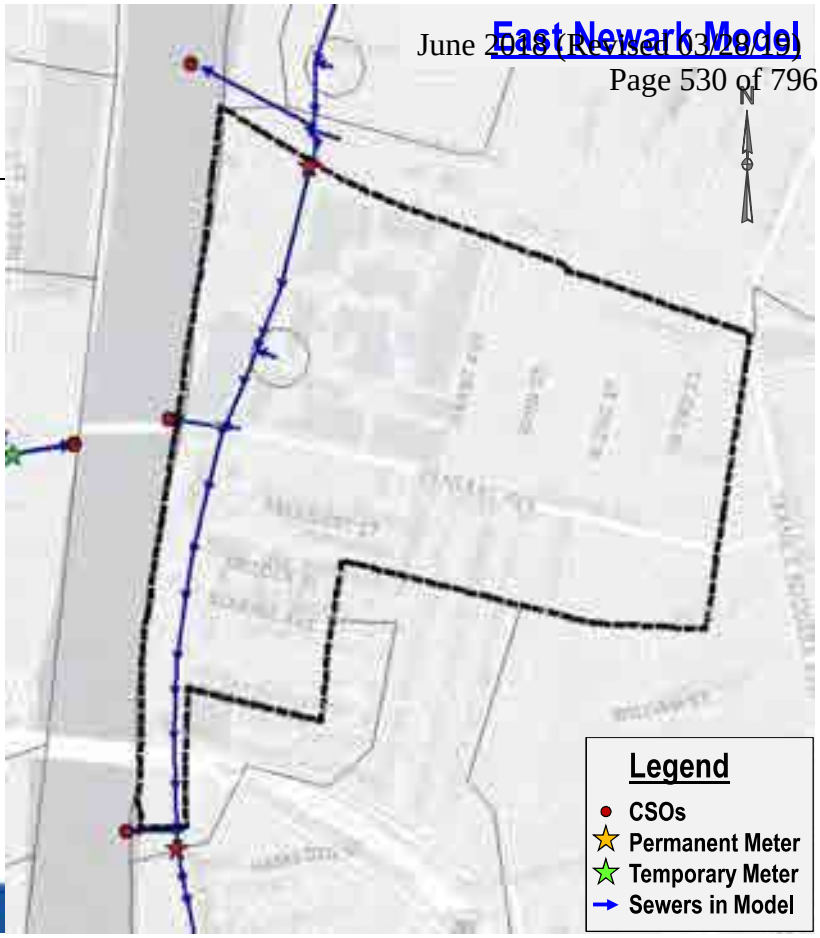
Newark Model

- Subcatchment: 310
- Nodes (758)
  - Manhole: 738
  - Outfall: 18
  - Storage: 2
- Link (819)
  - Conduit: 746
  - Flap Valve: 17
  - Orifice: 3
  - Pump: 3
  - Sluice: 27 (17 variable)
  - Weir: 23



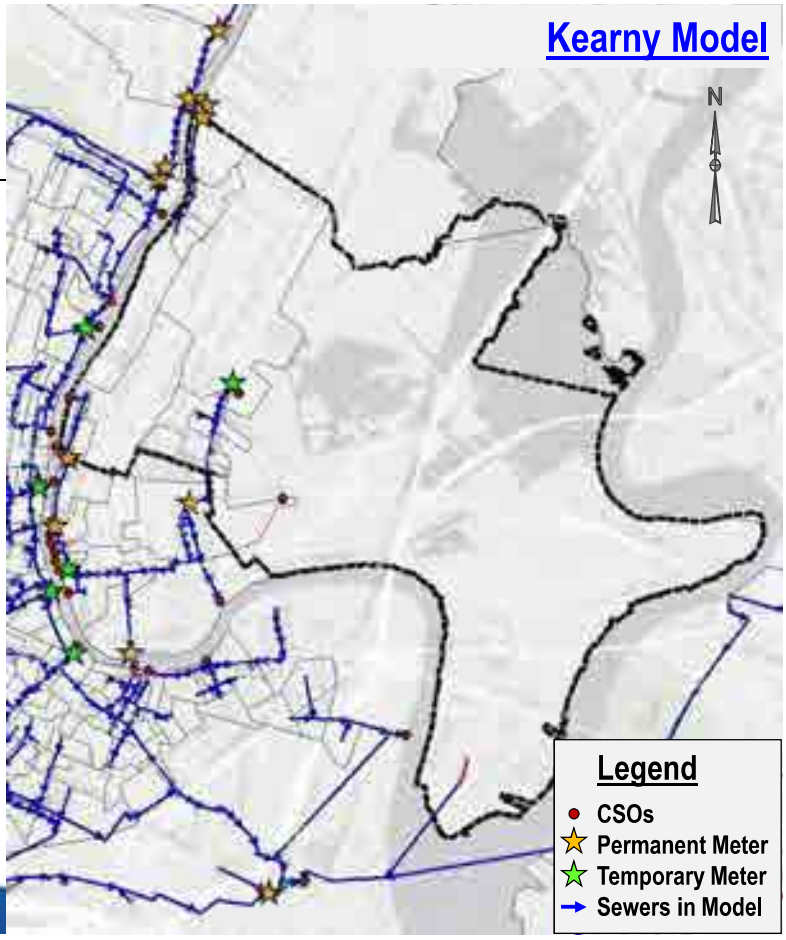
East Newark Model

- Subcatchment: 1
- Nodes (22)
  - Manhole: 21
  - Outfall: 1
  - Storage: 0
- Link (22)
  - Conduit: 19
  - Flap Valve: 1
  - Orifice: 1
  - Pump: 0
  - Sluice: 0
  - Weir: 1



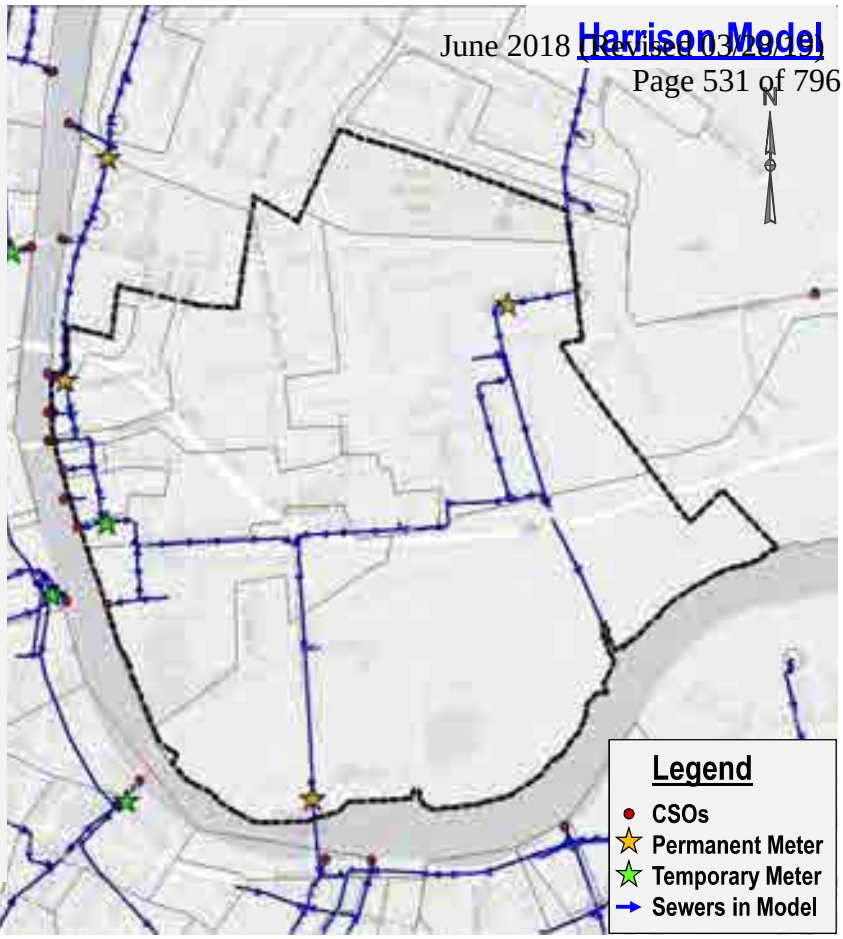
Kearny Model

- Subcatchment: 16
- Nodes (97)
  - Manhole: 91
  - Outfall: 5
  - Storage: 1
- Link (97)
  - Conduit: 78
  - Flap Valve: 5
  - Orifice: 7
  - Pump: 1
  - Sluice: 1
  - Weir: 5



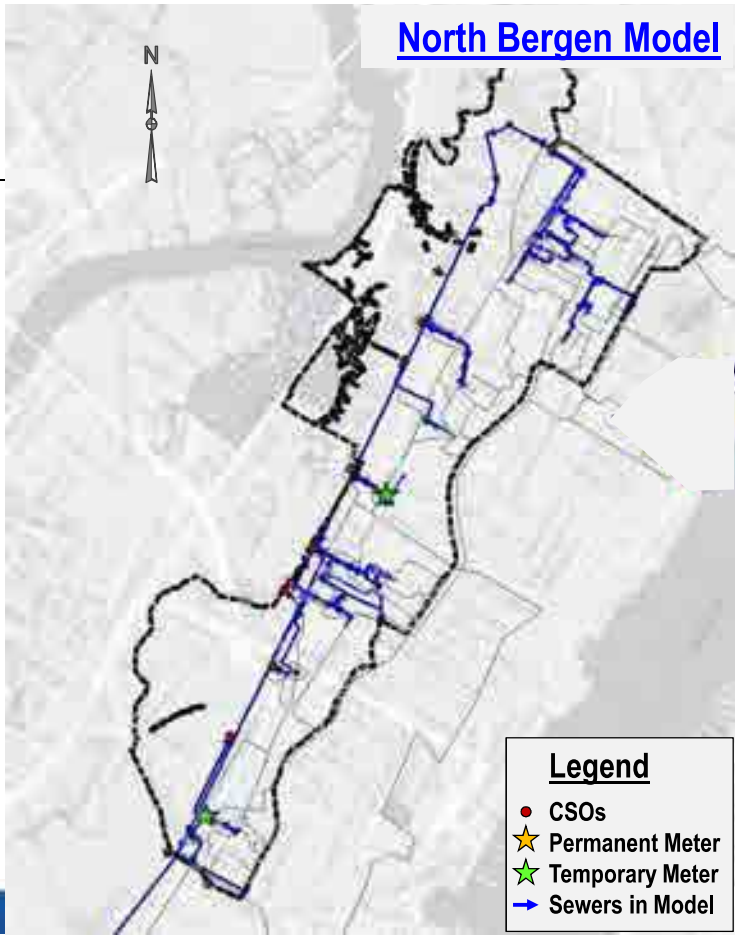
Harrison Model

- Subcatchment: 16
- Nodes (117)
  - Manhole: 110
  - Outfall: 7
  - Storage: 0
- Link (118)
  - Conduit: 97
  - Flap Valve: 7
  - Orifice: 7
  - Pump: 0
  - Sluice: 0
  - Weir: 7



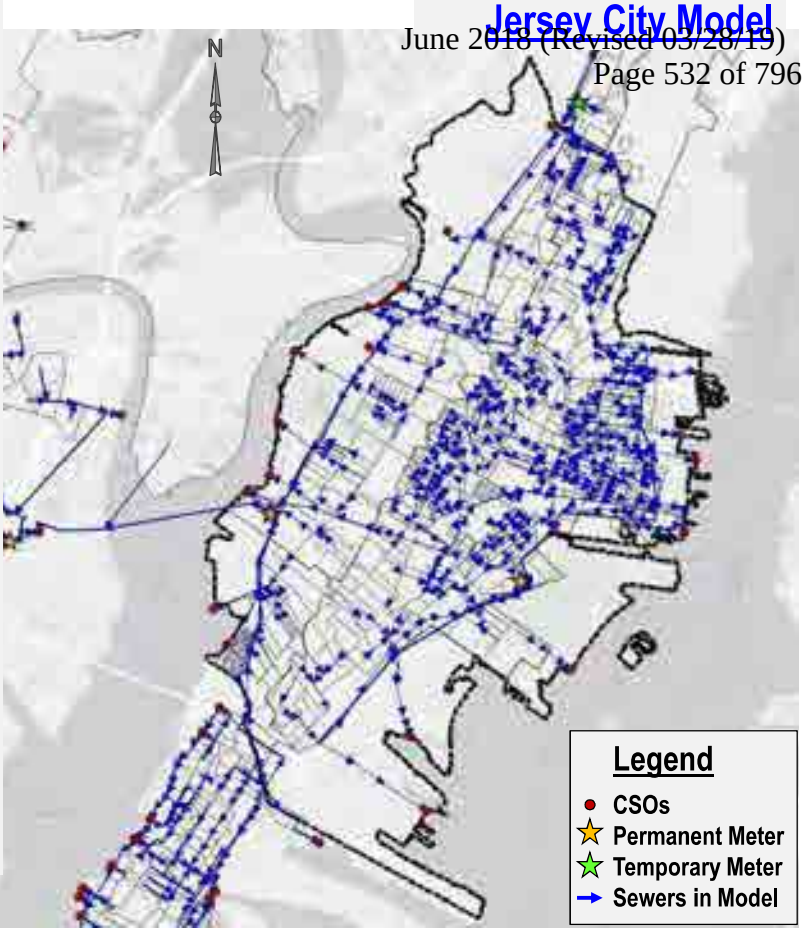
North Bergen Model

- Subcatchment: 41
- Nodes (178)
  - Manhole: 166
  - Outfall: 9
  - Storage: 3
- Link (199)
  - Conduit: 183
  - Flap Valve: 0
  - Orifice: 0
  - Pump: 3
  - Sluice: 5
  - Weir: 8



Jersey City Model

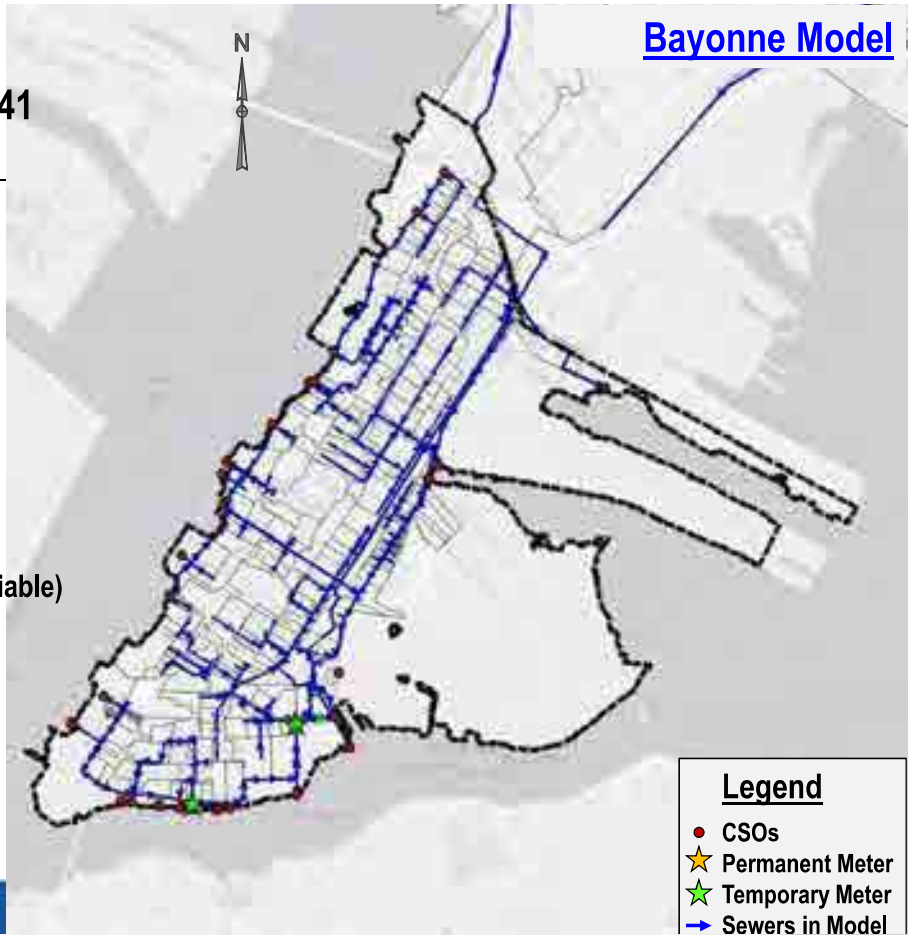
- Subcatchment: 393
- Nodes (1498)
  - Manhole: 1476
  - Outfall: 21
  - Storage: 1
- Link (1552)
  - Conduit: 1487
  - Flap Valve: 21
  - Orifice: 1
  - Pump: 3
  - Sluice: 27 (4 variable)
  - Weir: 13



13

Bayonne Model

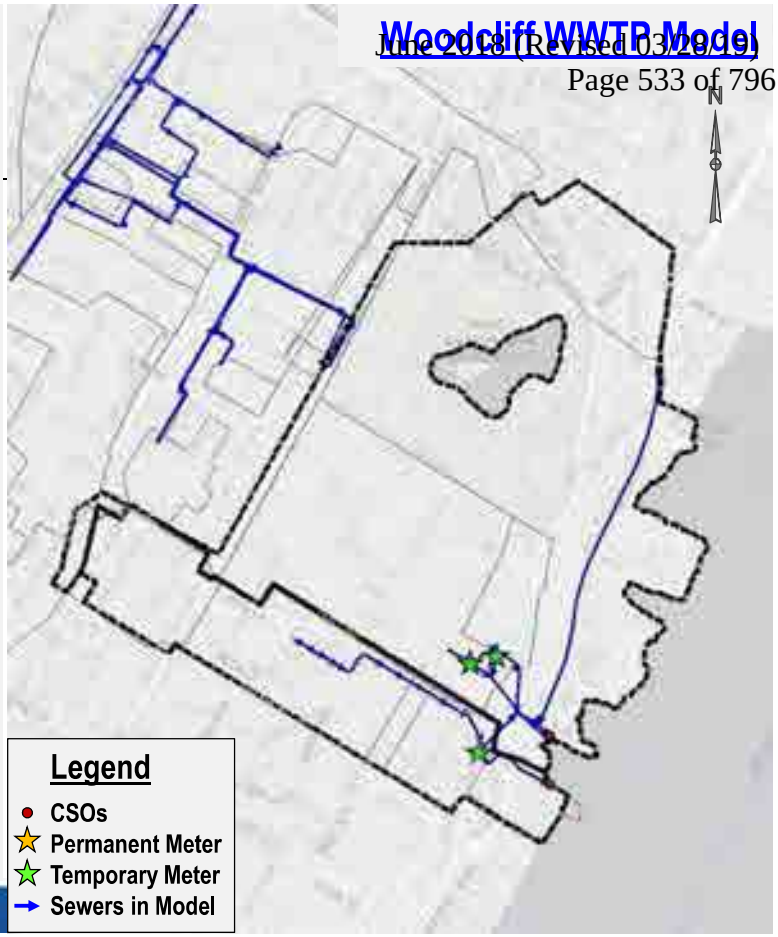
- Subcatchment: 41
- Nodes (685)
  - Manhole: 651
  - Outfall: 29
  - Storage: 5
- Link (712)
  - Conduit: 648
  - Flap Valve: 27
  - Orifice: 0
  - Pump: 5
  - Sluice: 20 (11 variable)
  - Weir: 12



14

Woodcliff WWTP Model

- Subcatchment: 5
- Nodes (38)
  - Manhole: 35
  - Outfall: 2
  - Storage: 1
- Link (39)
  - Conduit: 37
  - Flap Valve: 0
  - Orifice: 0
  - Pump: 0
  - Sluice: 1
  - Weir: 1

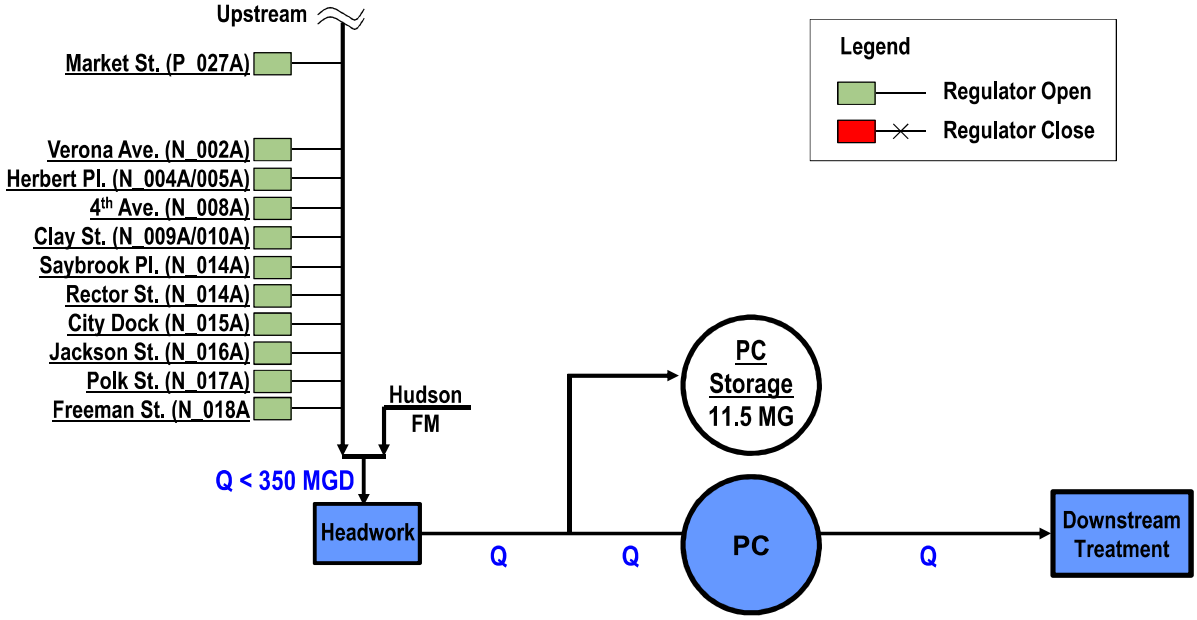


GREELEY AND HANSEN

Wet Weather Operating Rules

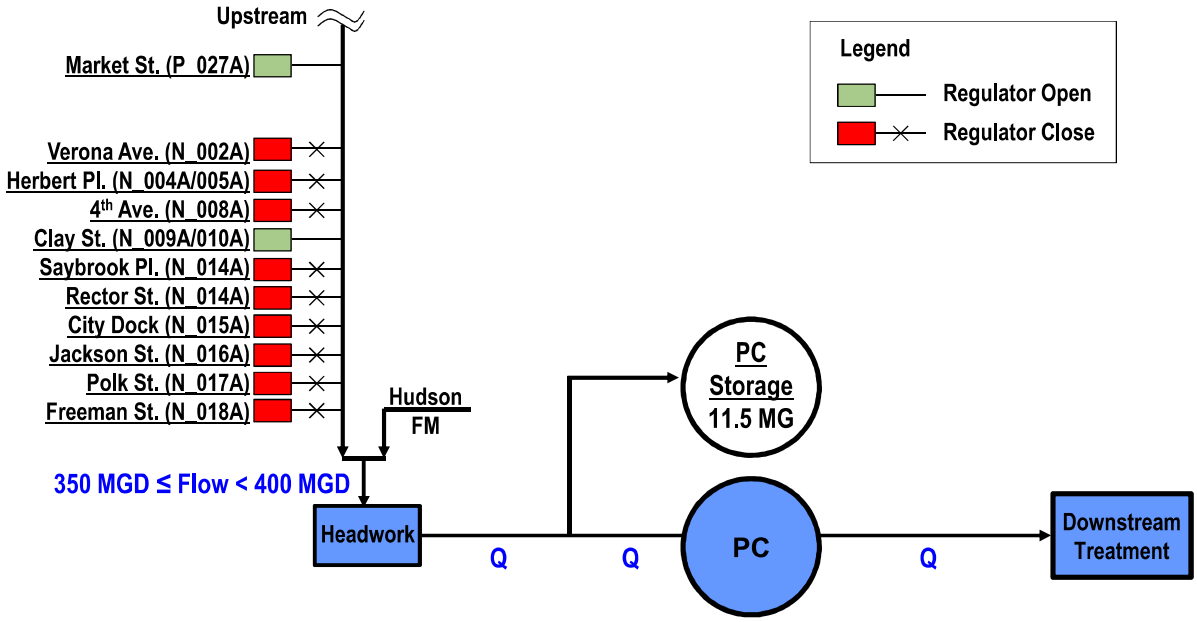
Wet Weather SOP

Flow < 350 MGD



Wet Weather SOP

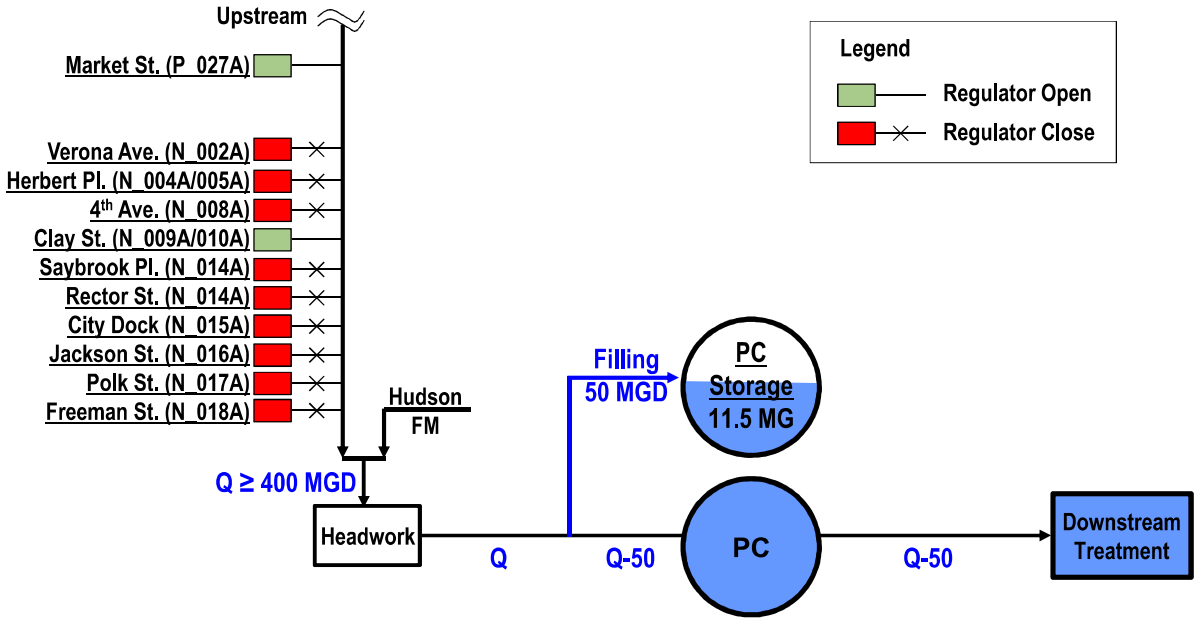
350 MGD ≤ Flow < 400 MGD



Note: During 10/7/15 to 7/7/16, CSOs were put in use at plant flow 400 MGD.

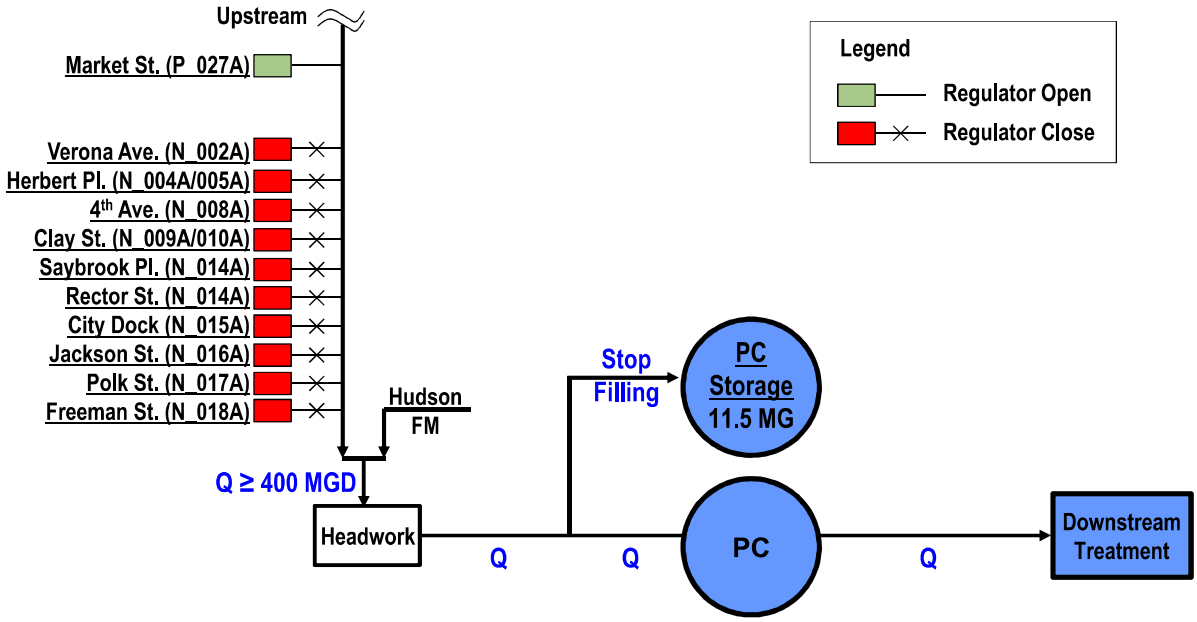
Wet Weather SOP

Flow ≥ 400 MGD



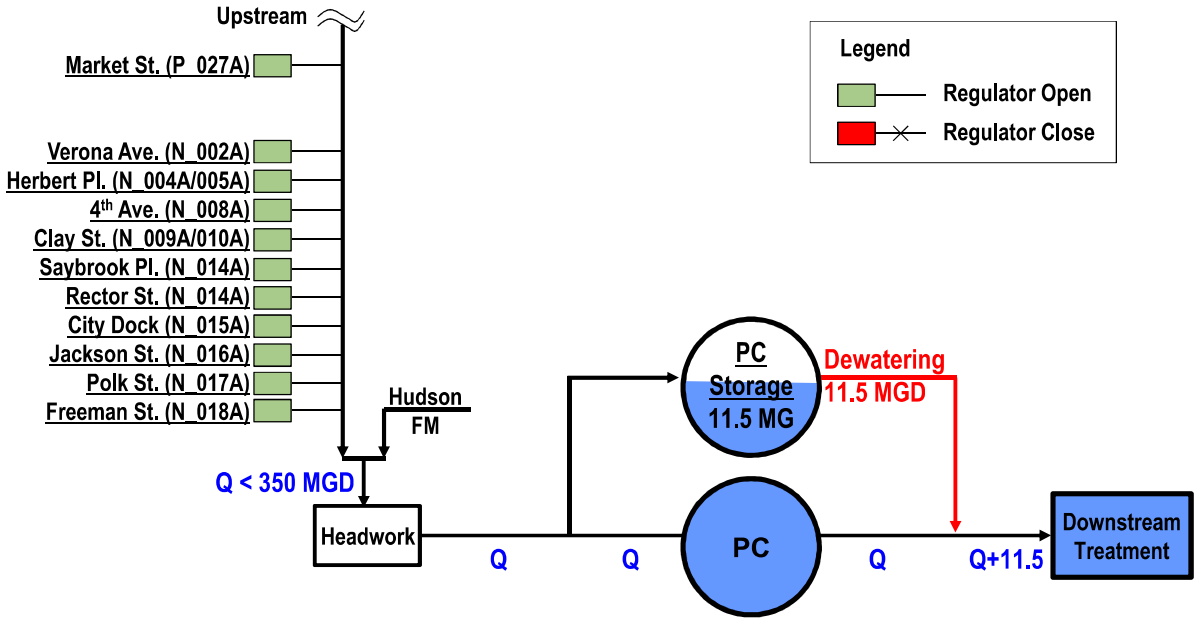
Wet Weather SOP

Flow ≥ 400 MGD, & Storage Full



Wet Weather SOP

Flow Drops to 350 MGD



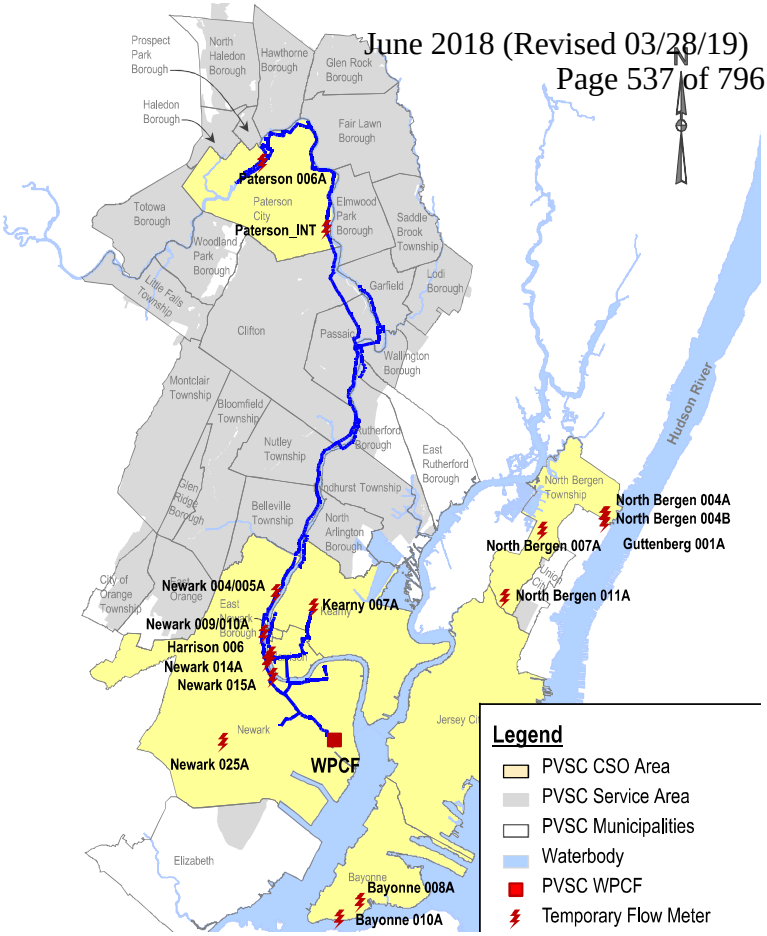
GREELEY AND HANSEN

PVSC H&H Model Calibration and Validation

Temporary Flow Meters (April to August 2016)

21 Flow Meters

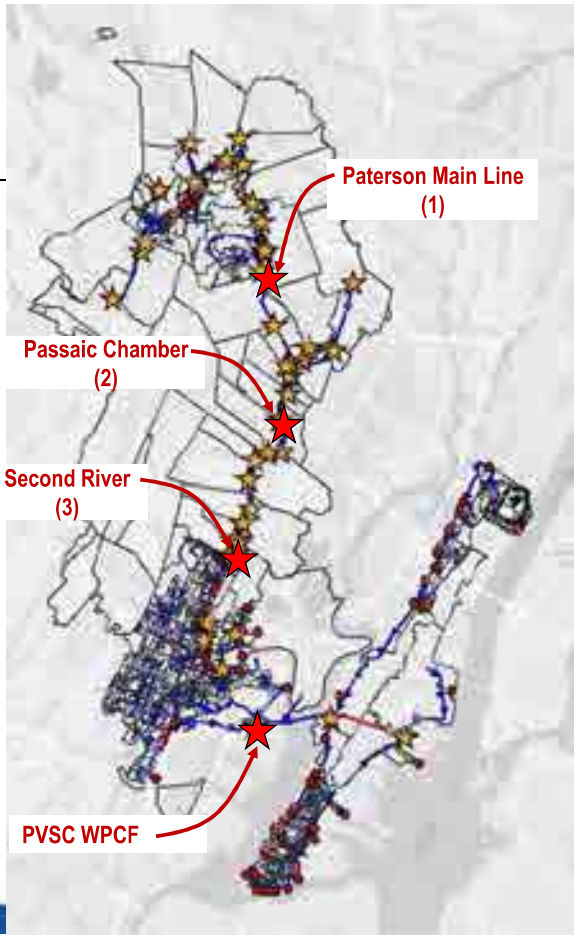
- 13 outfall pipe
- 5 regulator influent
- 2 regulator effluent
- 1 interceptor



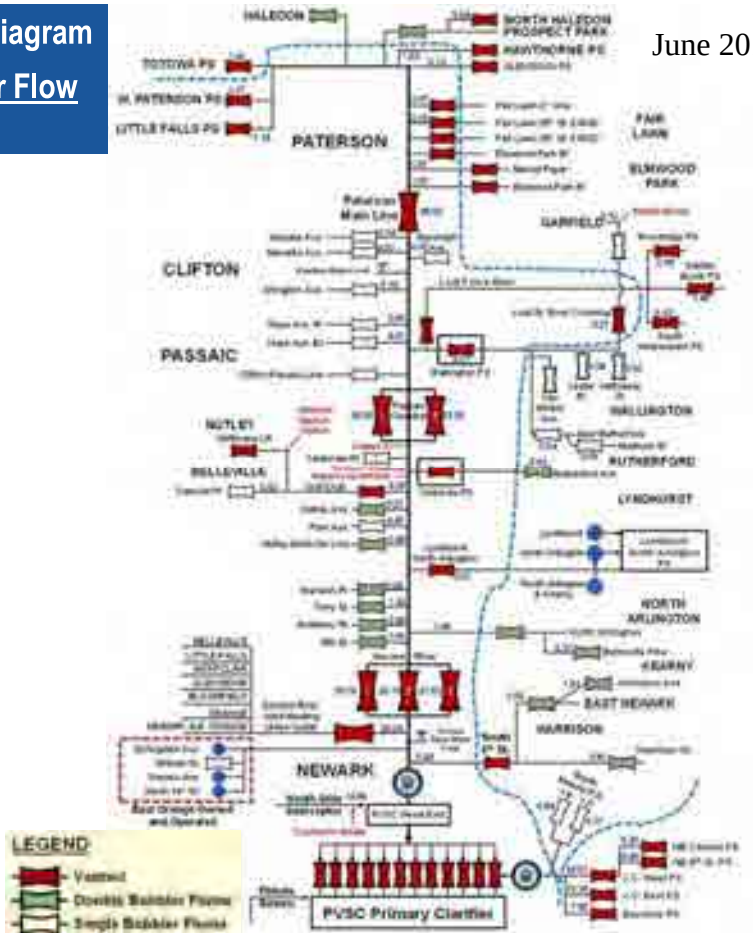
PVSC Permanent Flow Meters

Over 70 Flow Meters, 55 was analyzed for DWF and model calibration

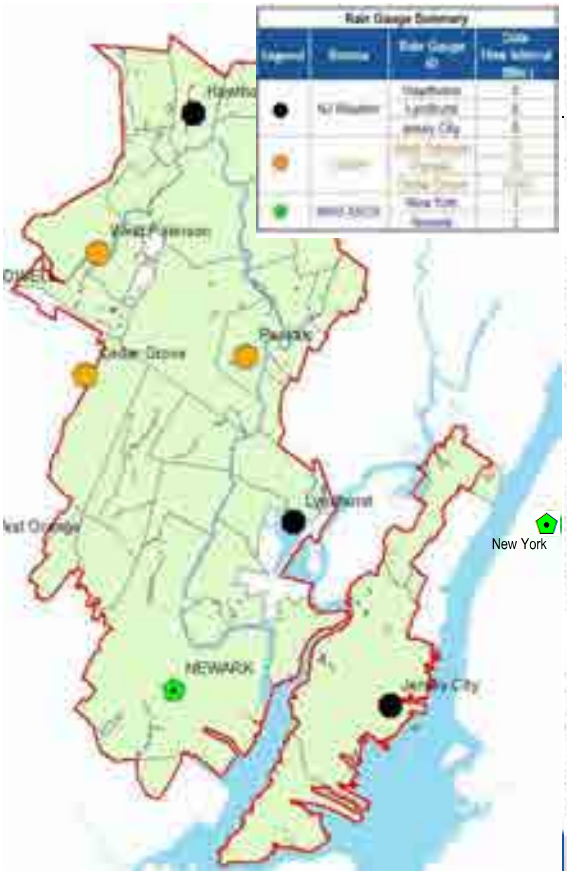
- PVSC Interceptor: 6
- Pump Station: 6
- Combined area: 5
- Separated Area: 38

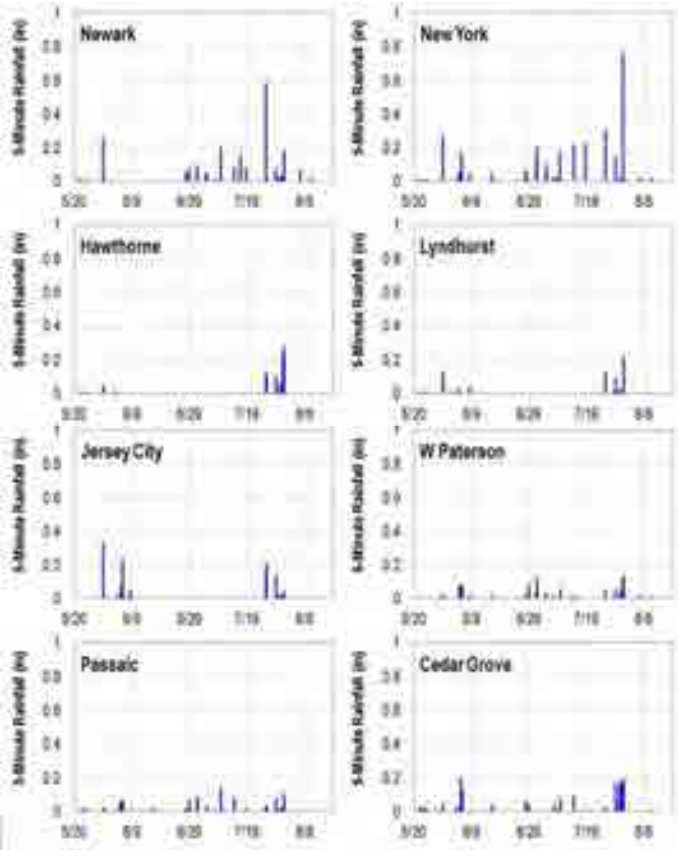


Flow Meter Diagram
Dry Weather Flow (MGD)

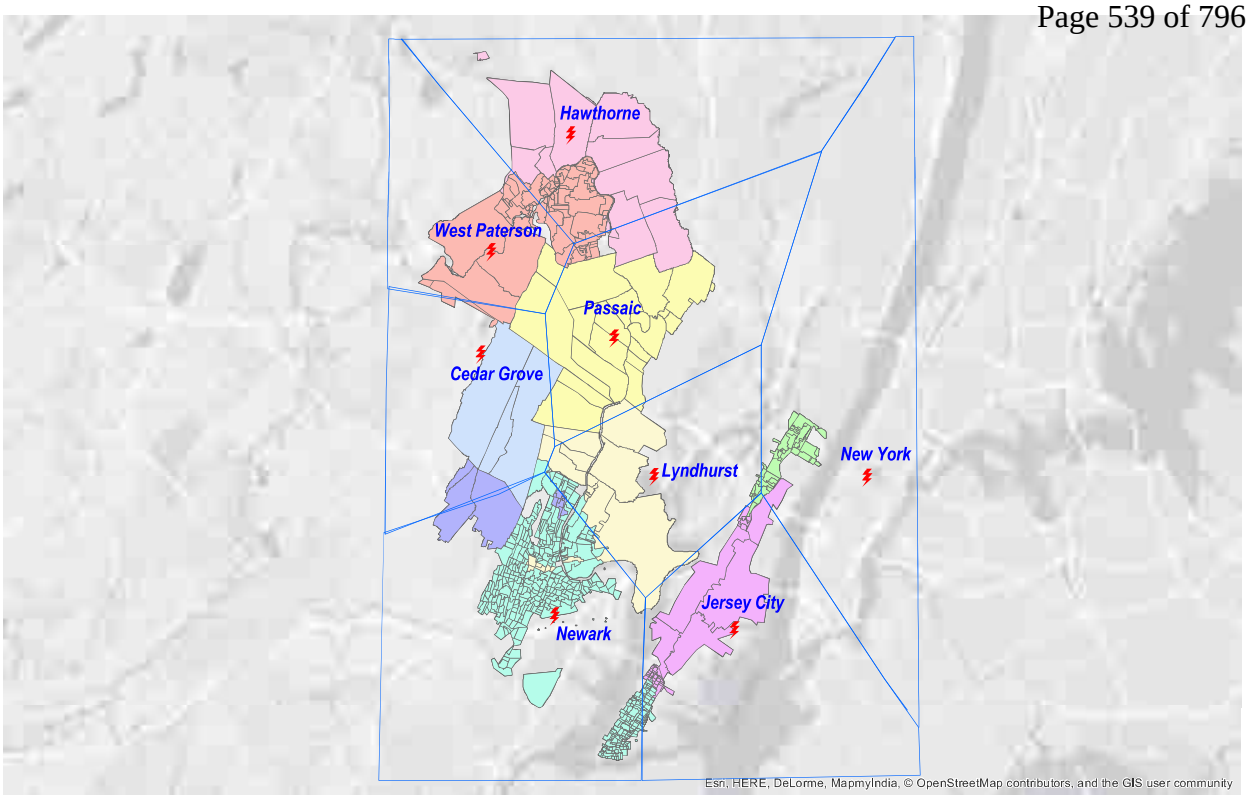


Rainfall Stations





Rainfall Station Assignment



Candidate Storm Events for Calibration

Rainfall Based on Newark

Rain Start	Rain End	Duration (hr)	Depth (in)	Max Intensity (in/hr)	Average Intensity (in/hr)
7/25/16 16:05	7/25/16 18:50	2.75	**1.81**	1.68	0.66
5/29/16 23:50	5/30/16 5:20	5.50	**1.6**	1.09	0.29
7/29/16 0:20	7/29/16 8:35	8.25	**0.85**	0.42	0.10
5/2/16 22:40	5/3/16 9:50	11.17	**0.7**	0.17	0.06
7/31/16 8:35	7/31/16 22:35	14.00	**0.69**	0.49	0.05
7/4/16 19:20	7/5/16 2:50	7.50	**0.63**	0.23	0.08
5/6/16 2:30	5/6/16 12:25	9.92	**0.6**	0.19	0.06
7/16/16 14:50	7/16/16 15:35	0.75	**0.56**	0.75	0.75
6/8/16 11:25	6/8/16 14:10	2.75	**0.49**	0.3	0.18
7/9/16 21:30	7/9/16 22:05	0.58	**0.48**	0.82	0.82
4/4/16 7:45	4/4/16 17:00	9.25	**0.43**	0.12	0.05

Model Calibration and Validation Goals

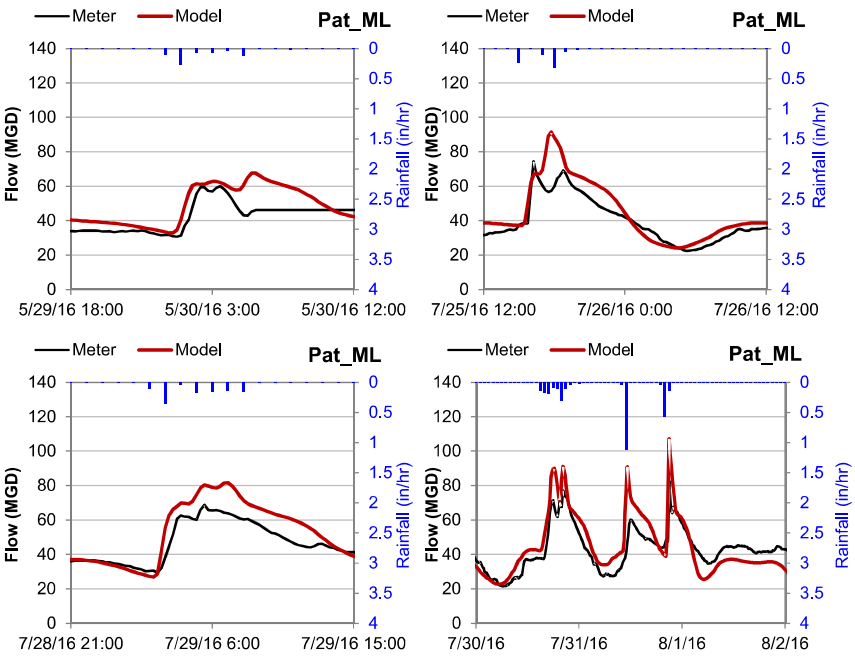
- Visual match
- +20/-10% volume and
- +25%/-15% peak

GREELEY AND HANSEN

Major Interceptor

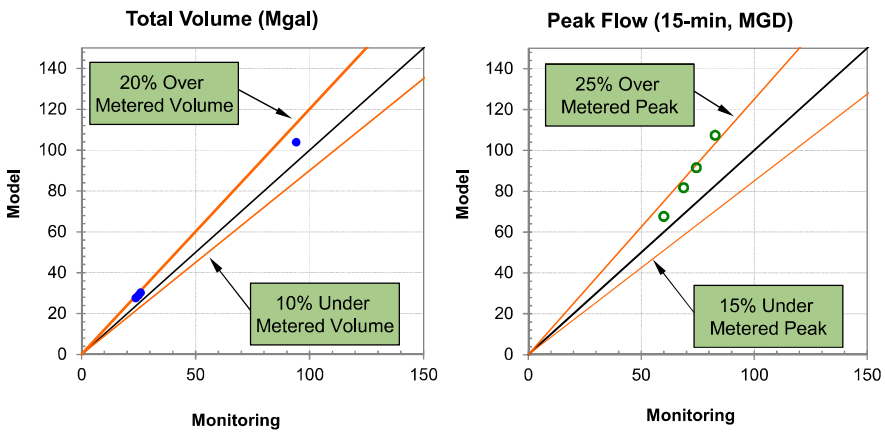
Calibration Results – Main Interceptor

Paterson Main Line



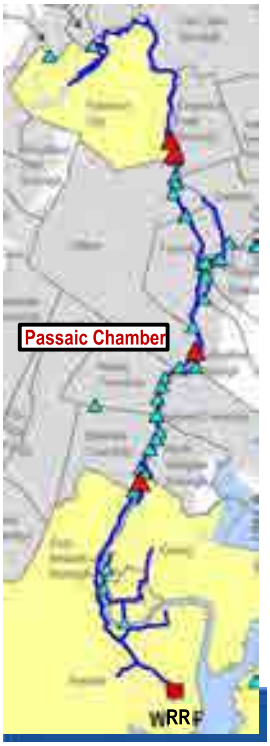
Calibration Results – Main Interceptor

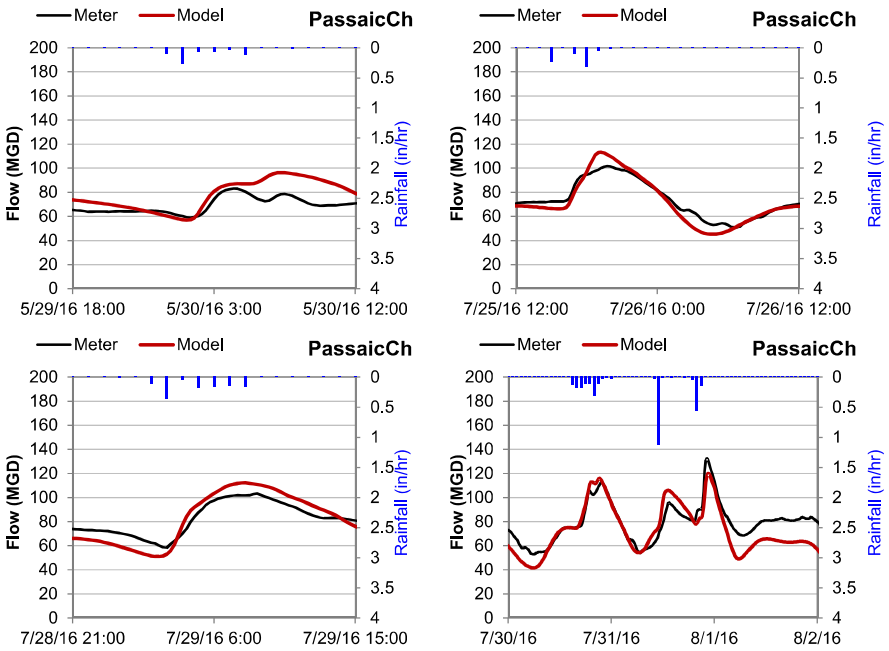
Paterson Main Line: Goodness-of-Fit



Calibration Results – Main Interceptor

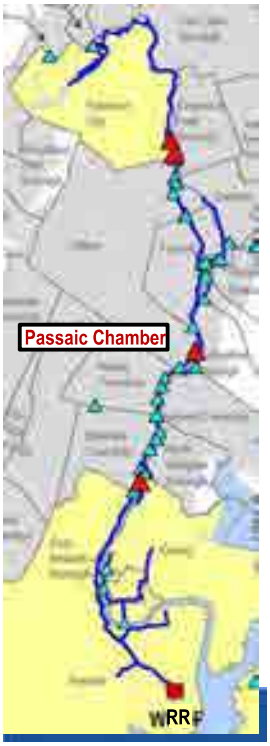
Passaic Chamber

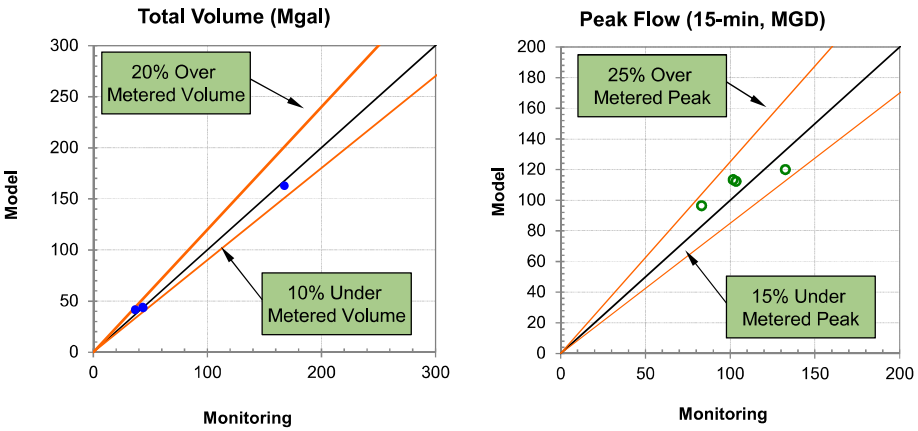




Calibration Results – Main Interceptor

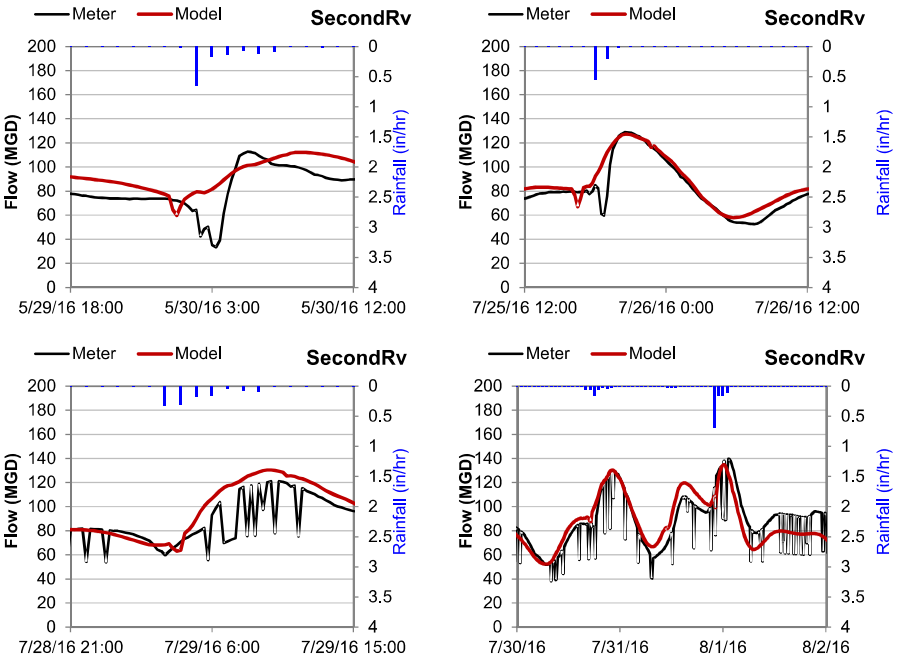
Passaic Chamber: Goodness-of-Fit





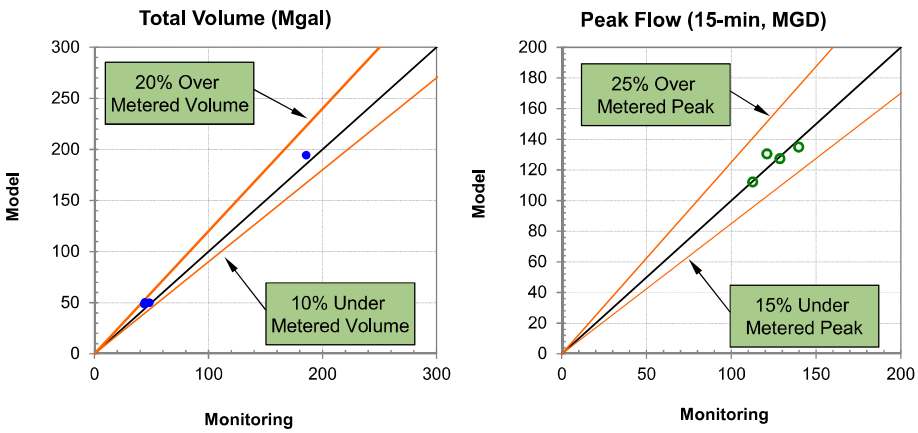
Calibration Results – Main Interceptor

Second River Crossing



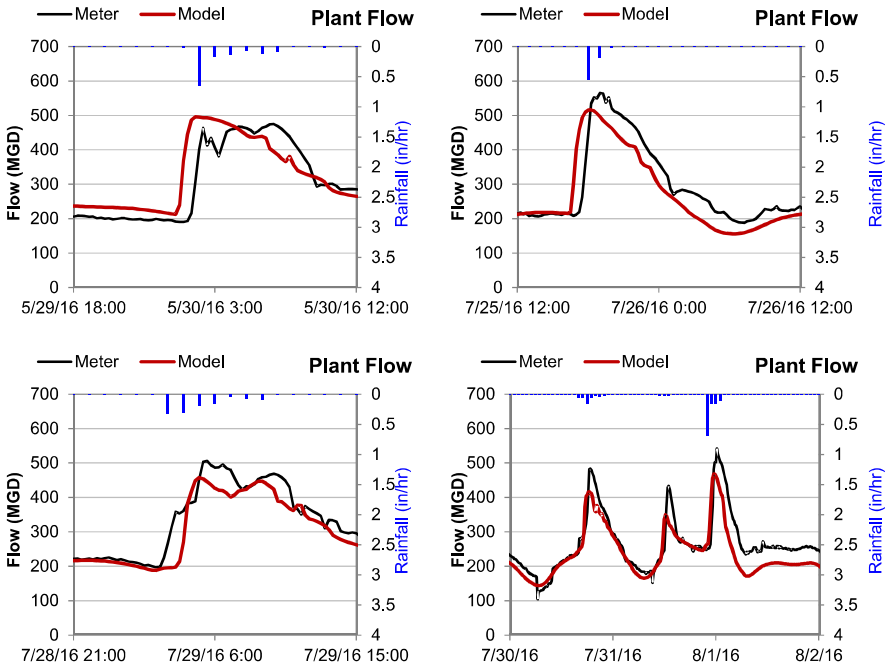
Calibration Results – Main Interceptor

Second River Crossing: Goodness-of-Fit



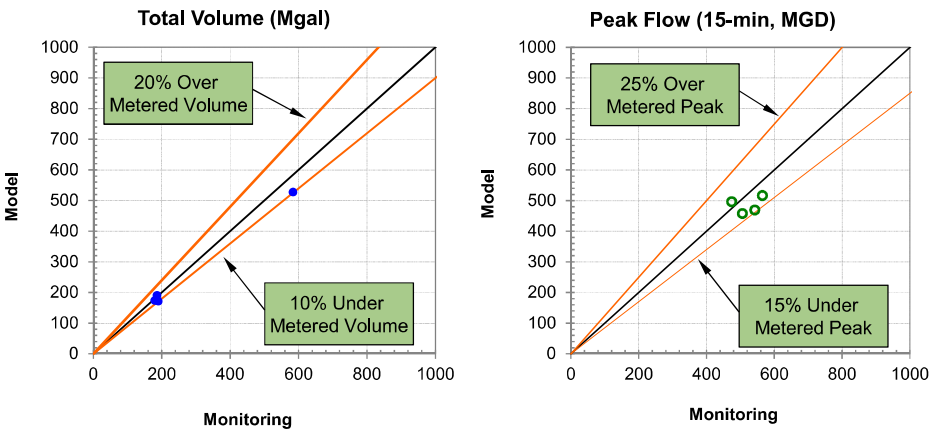
Calibration Results – Main Interceptor

PVSC WPCF



Calibration Results – Main Interceptor

PVSC WPCF: Goodness-of-Fit

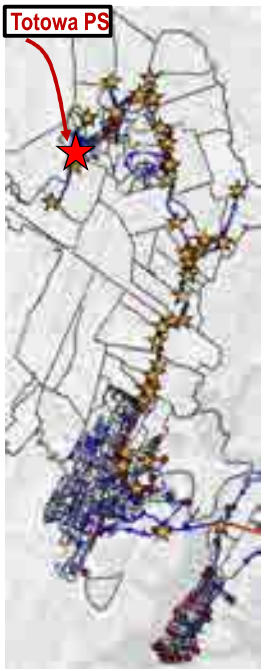


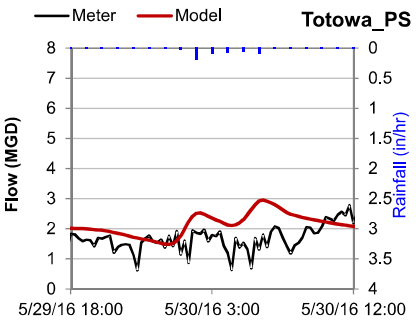
GREELEY AND HANSEN

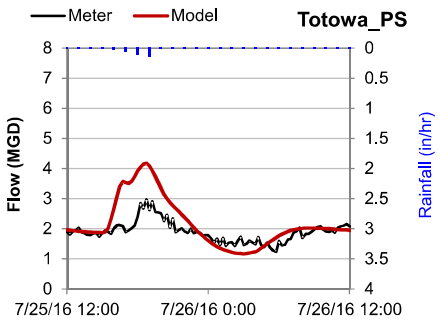
Separated Area

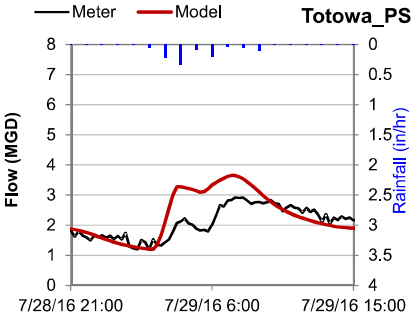
Calibration Results – Separated Area

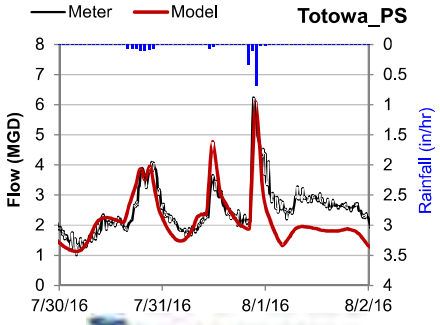
Totowa PS





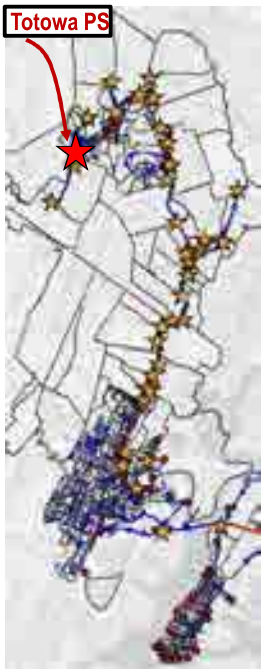


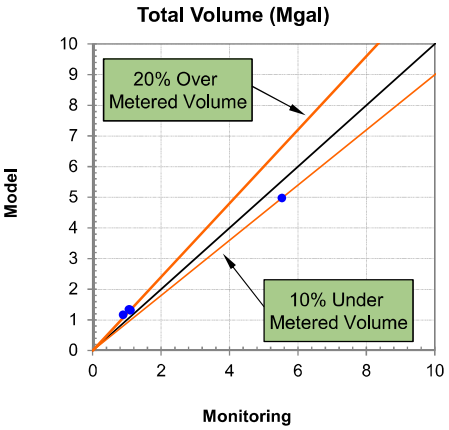


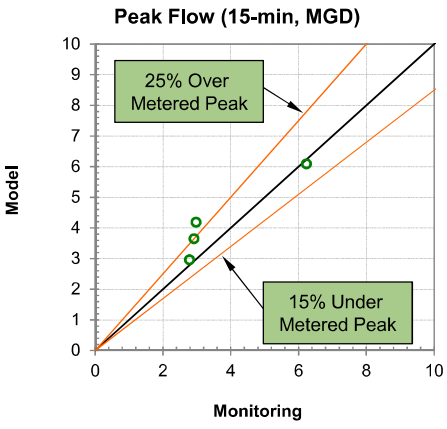


Calibration Results – Separated Area

Totowa PS: Goodness-of-Fit

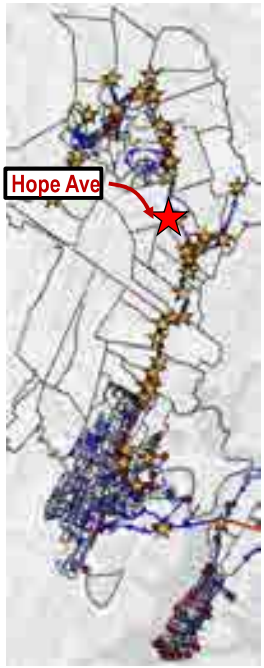


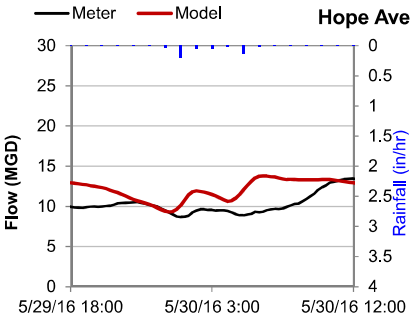


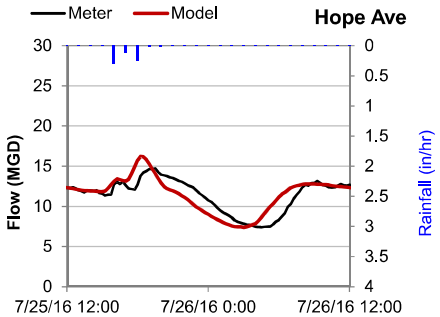


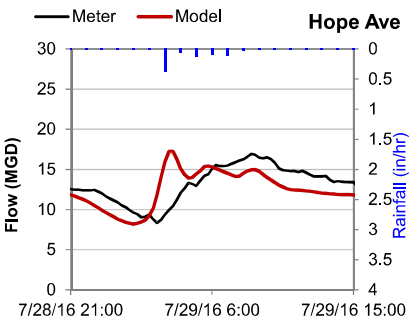
Calibration Results – Separated Area

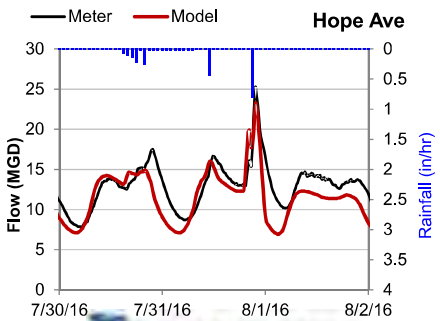
Hope Ave





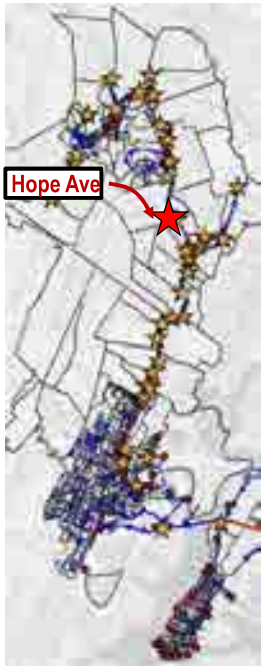


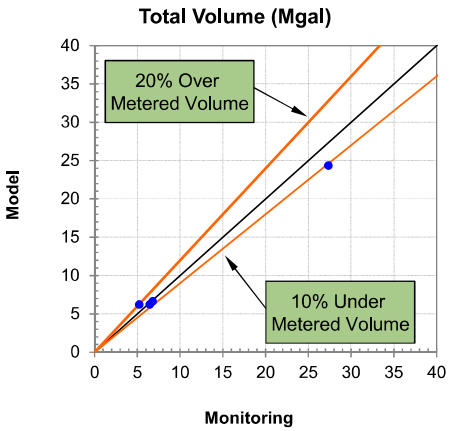


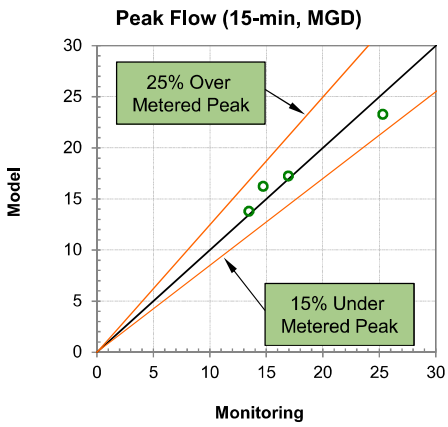


Calibration Results – Separated Area

Hope Ave: Goodness-of-Fit

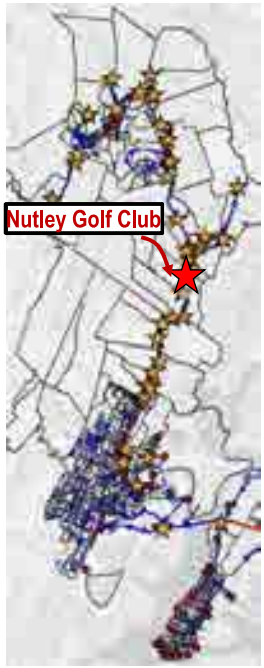


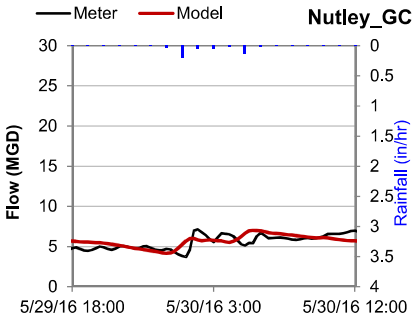


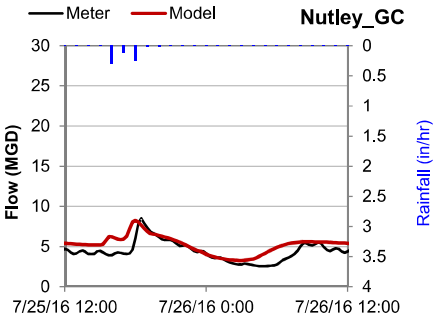


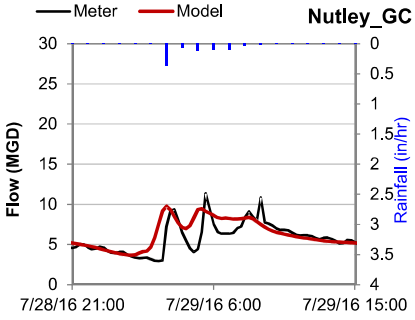
Calibration Results – Separated Area

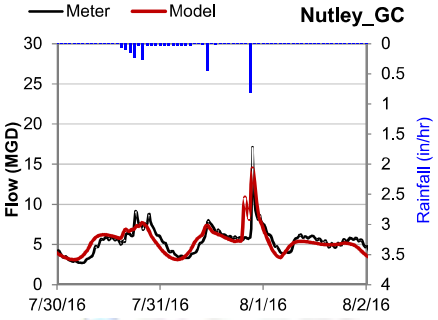
Nutley Golf Club





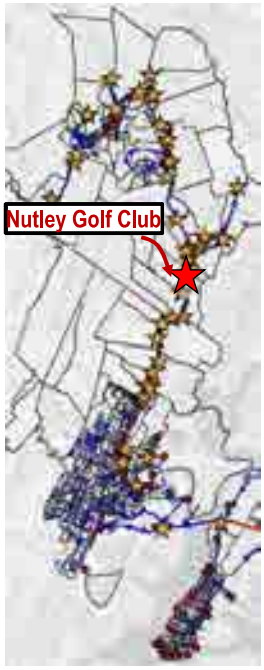


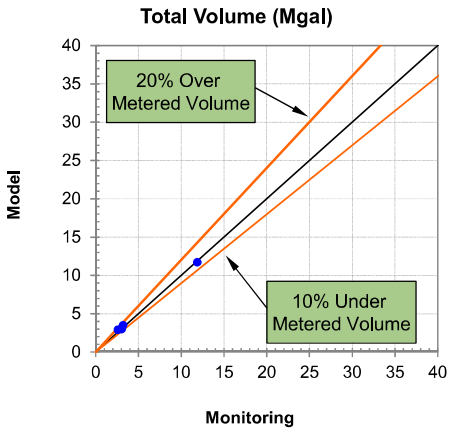


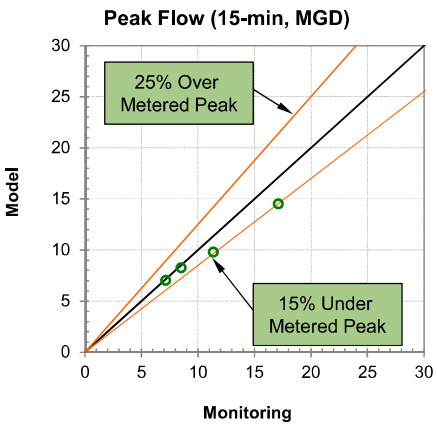


Calibration Results – Separated Area

Nutley Golf Club: Goodness-of-Fit

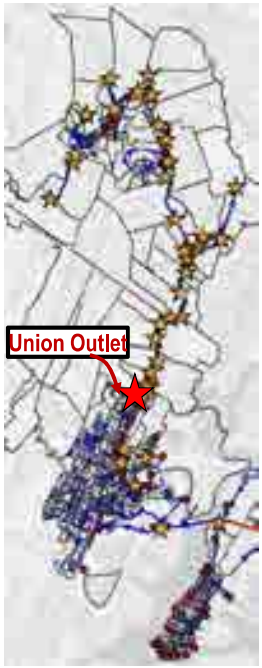


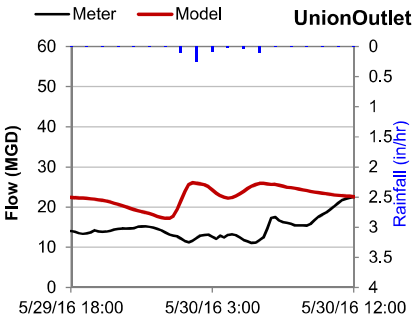


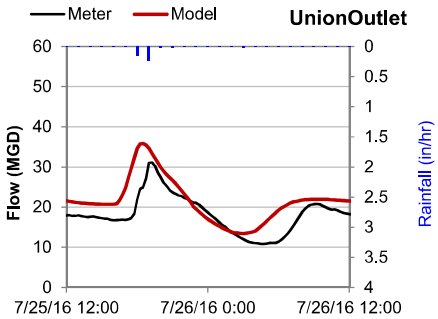


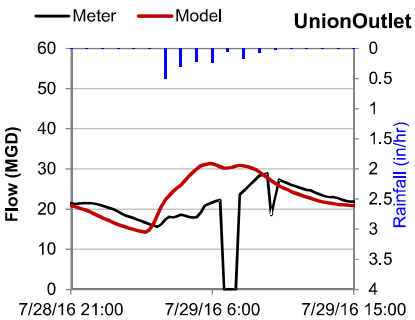
Calibration Results – Separated Area

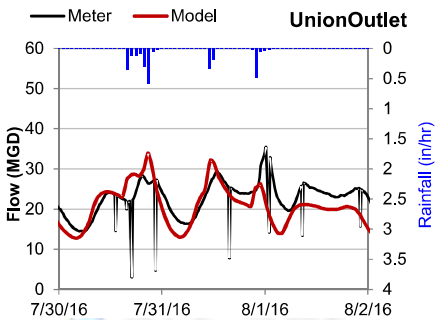
Union Outlet





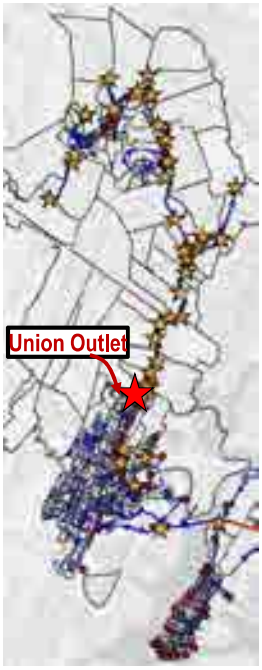


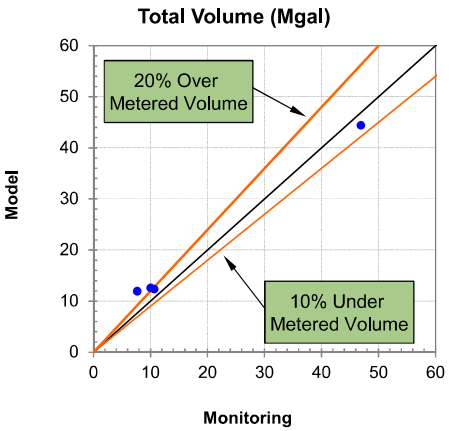


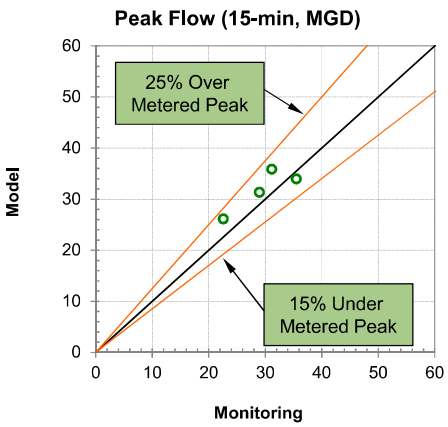


Calibration Results – Separated Area

Union Outlet







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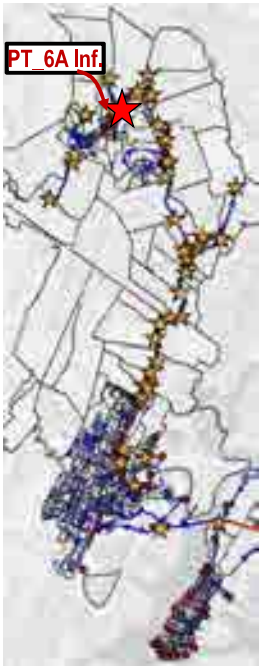
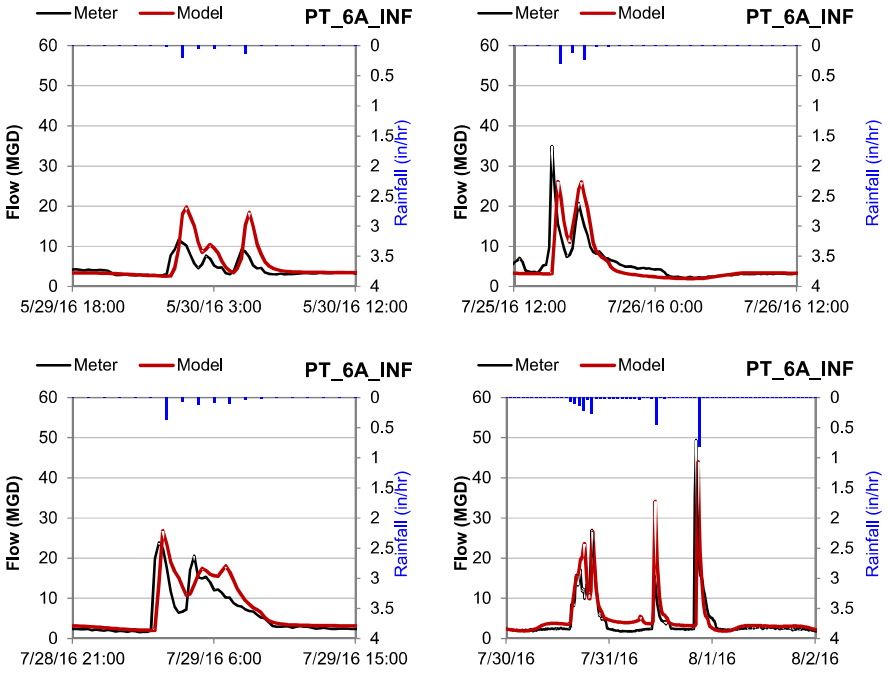
Combined Area

Calibration Results – Combined Area

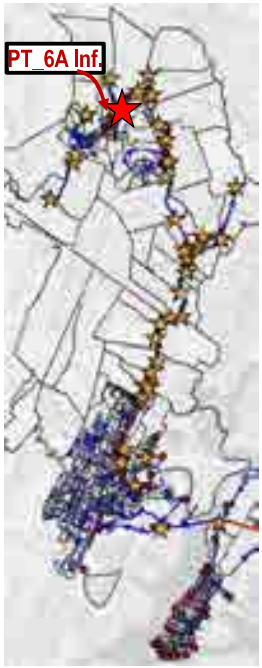
Paterson 6A Influent

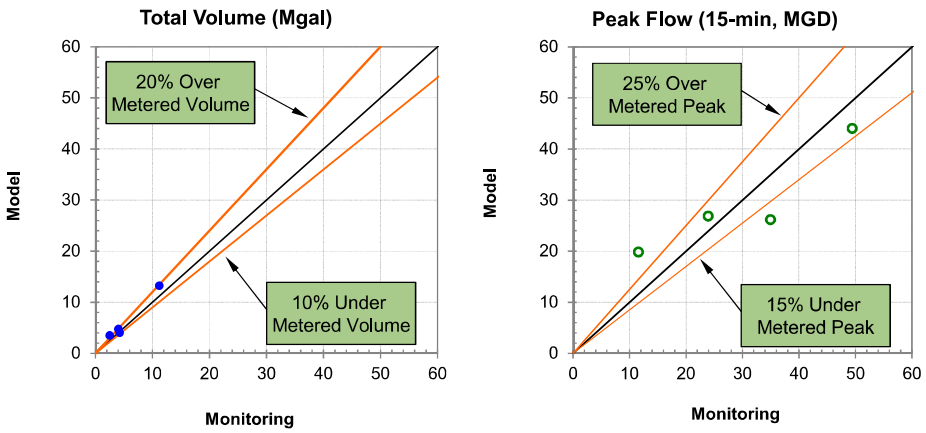




Calibration Results – Combined Area

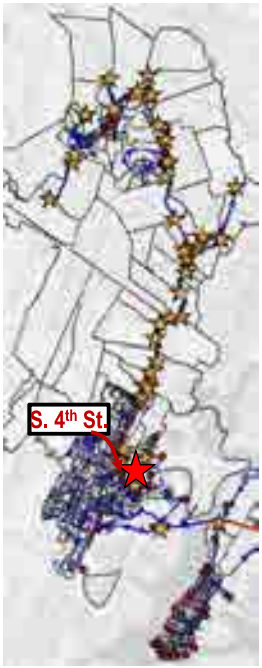
Paterson 6A Influent

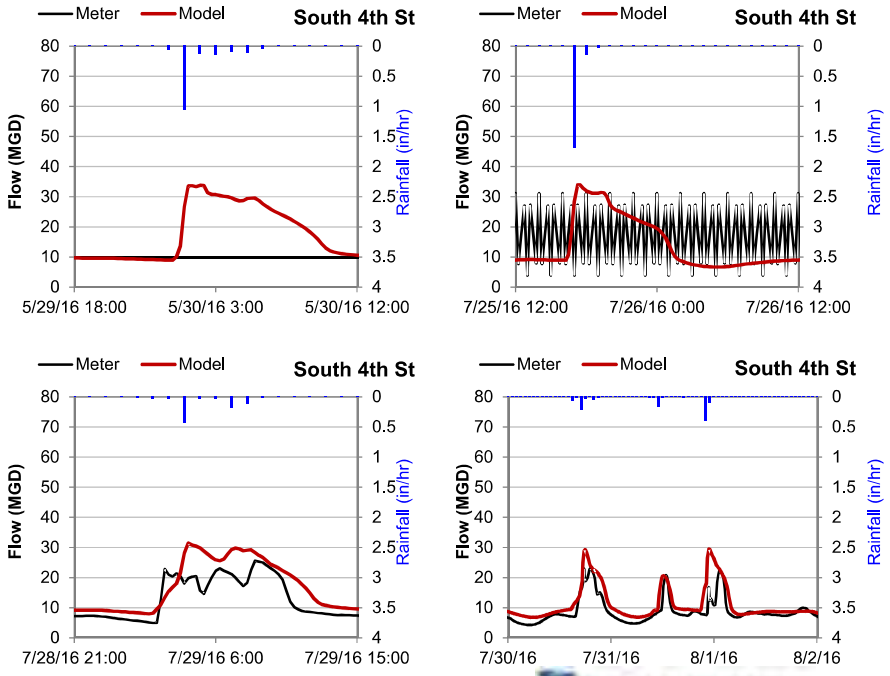




Calibration Results – Combined Area

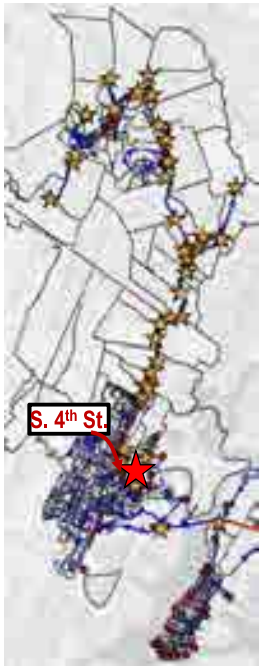
South 4th St.

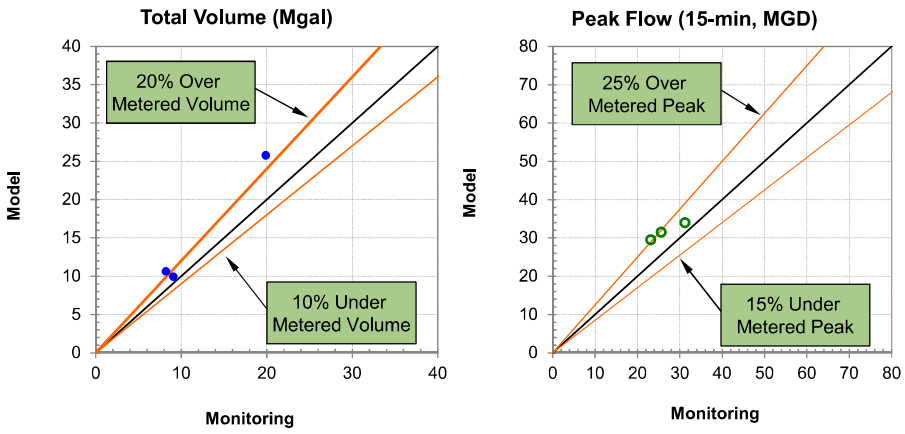




Calibration Results – Combined Area

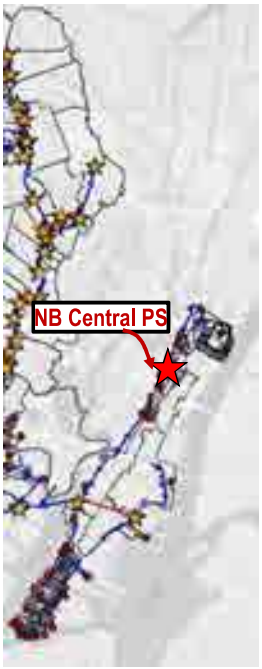
South 4th St.

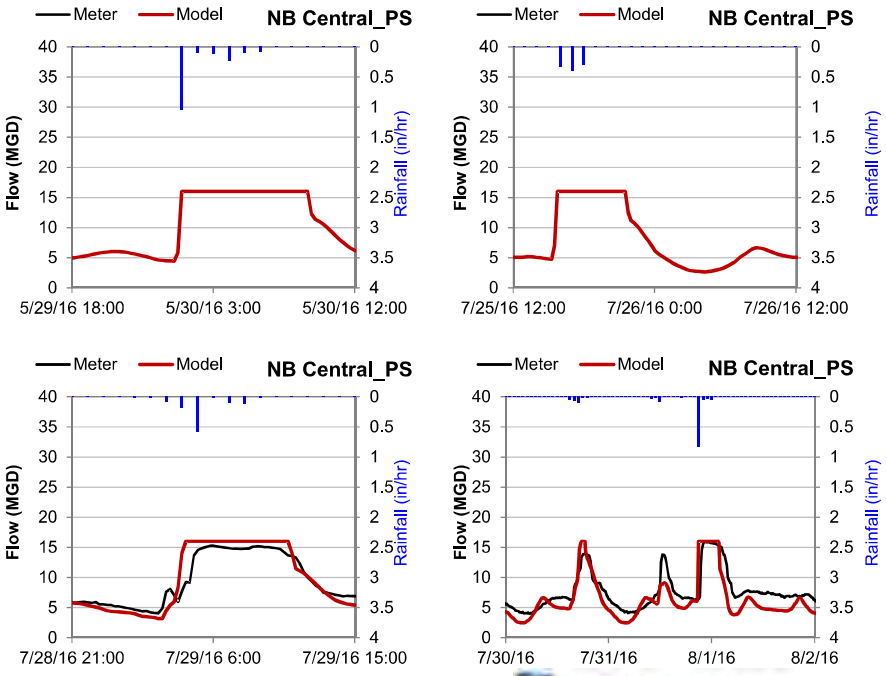




Calibration Results – Combined Area

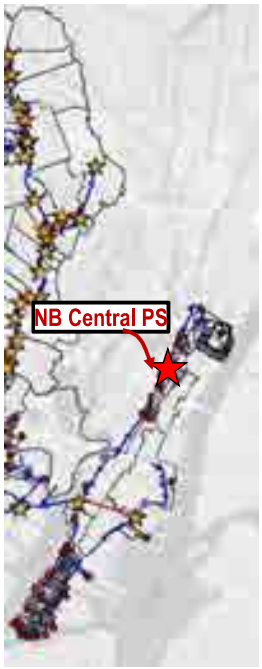
NB Central PS.

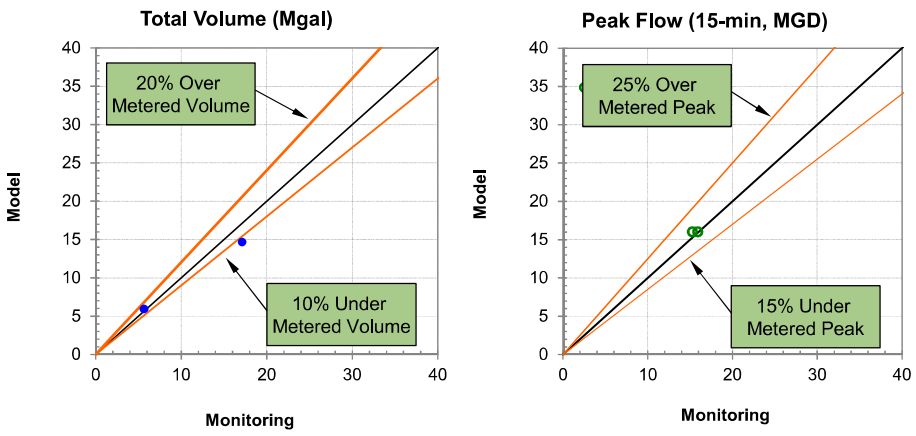




Calibration Results – Combined Area

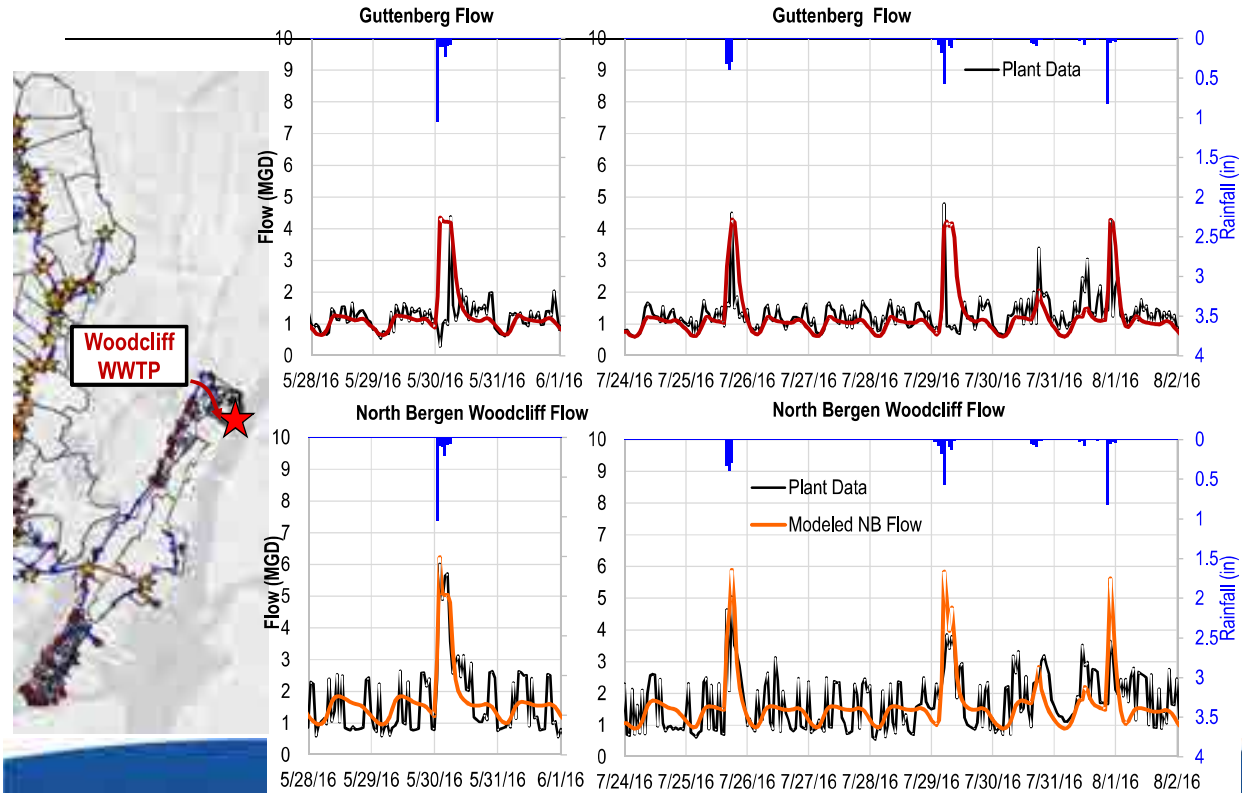
NB Central PS.





Calibration Results – Woodcliff WWTP

Influent Flows



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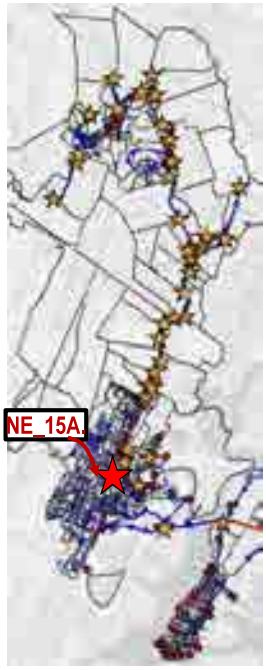
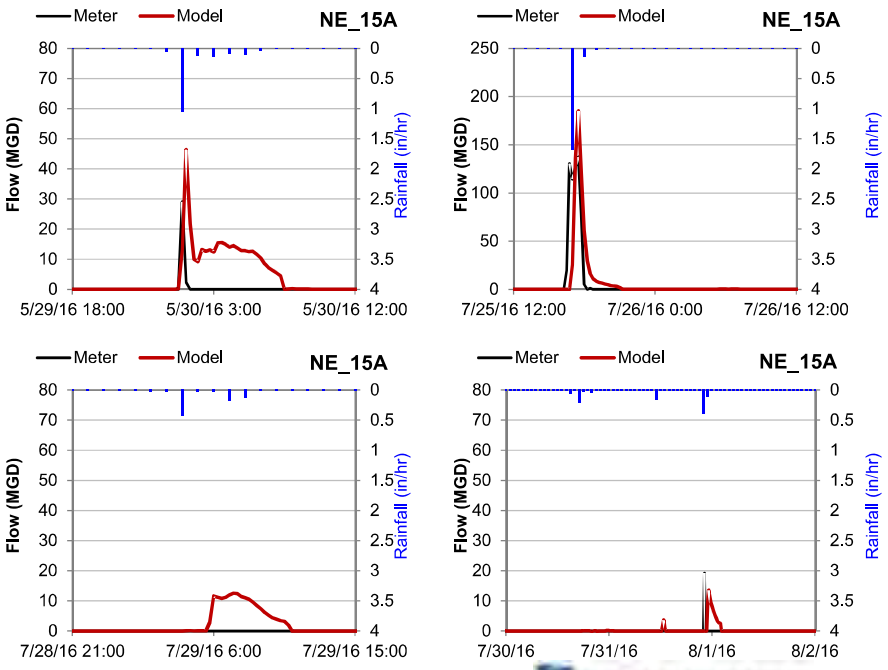
CSO Meters

Calibration Results – CSO Overflow

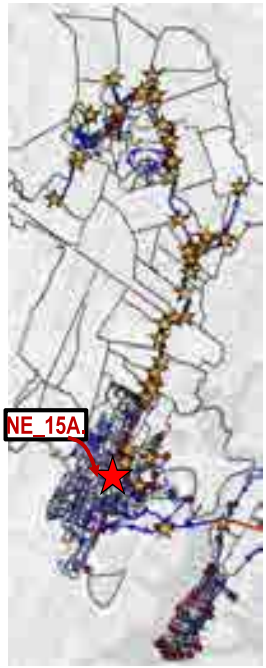
NE_15A

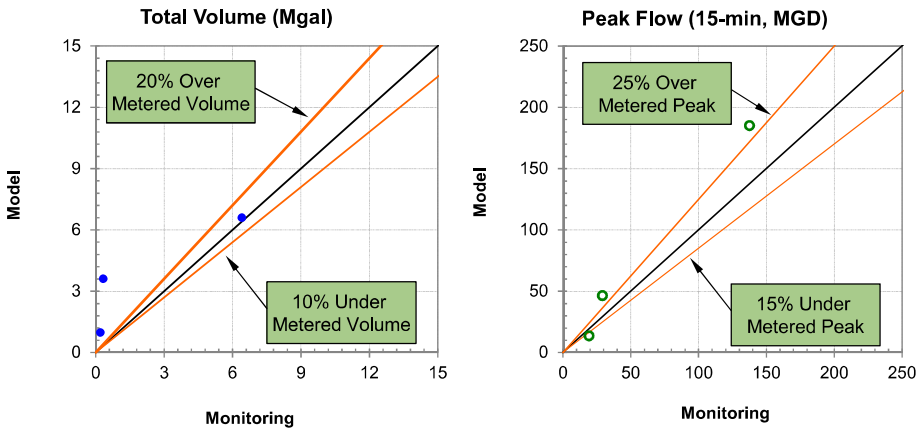




Calibration Results – CSO Overflow

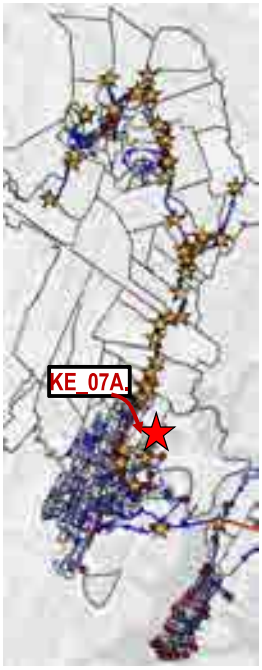
NE_15A

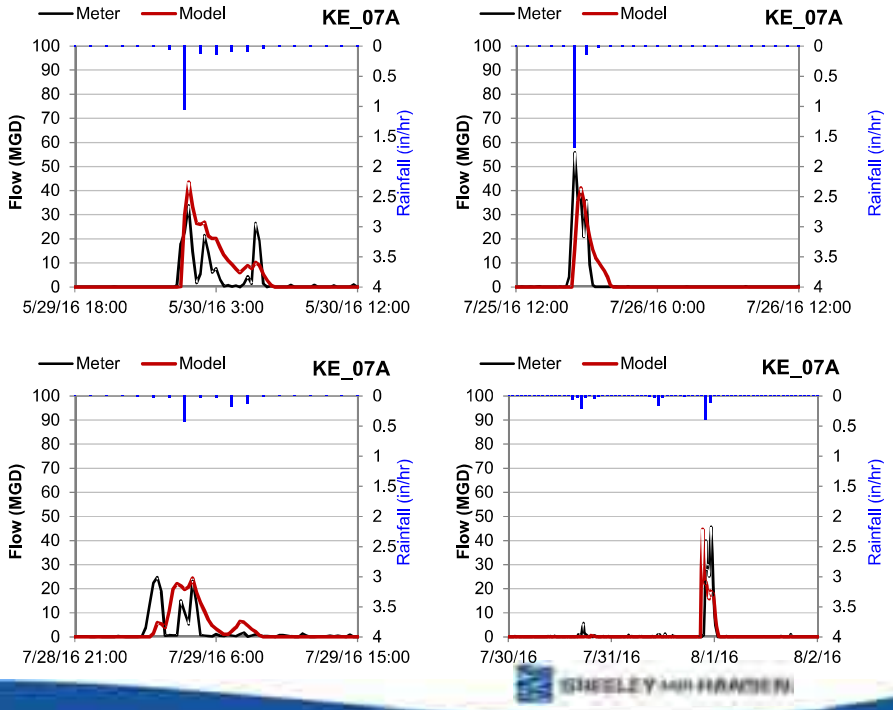




Calibration Results – CSO Overflow

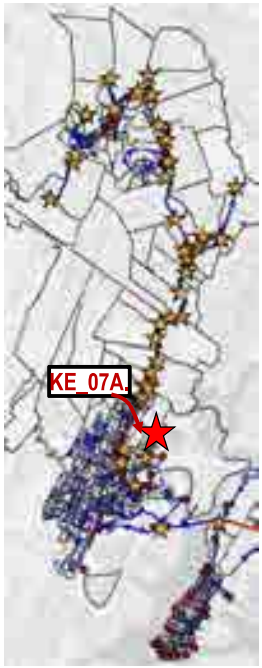
KE_07A

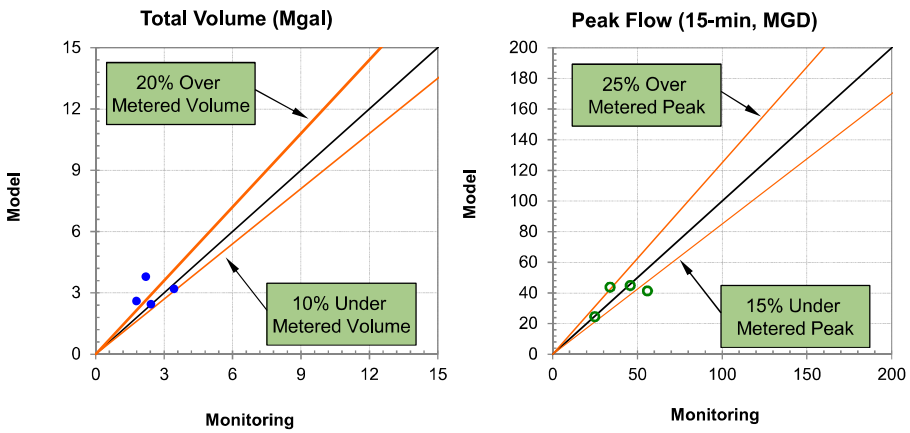




Calibration Results – CSO Overflow

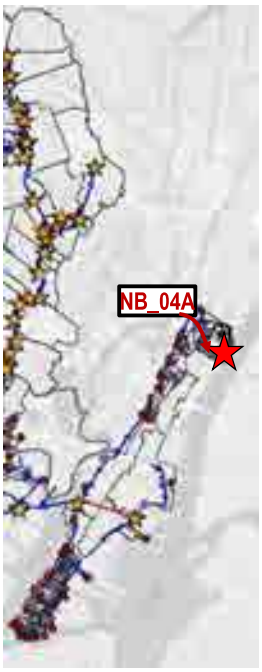
KE_07A

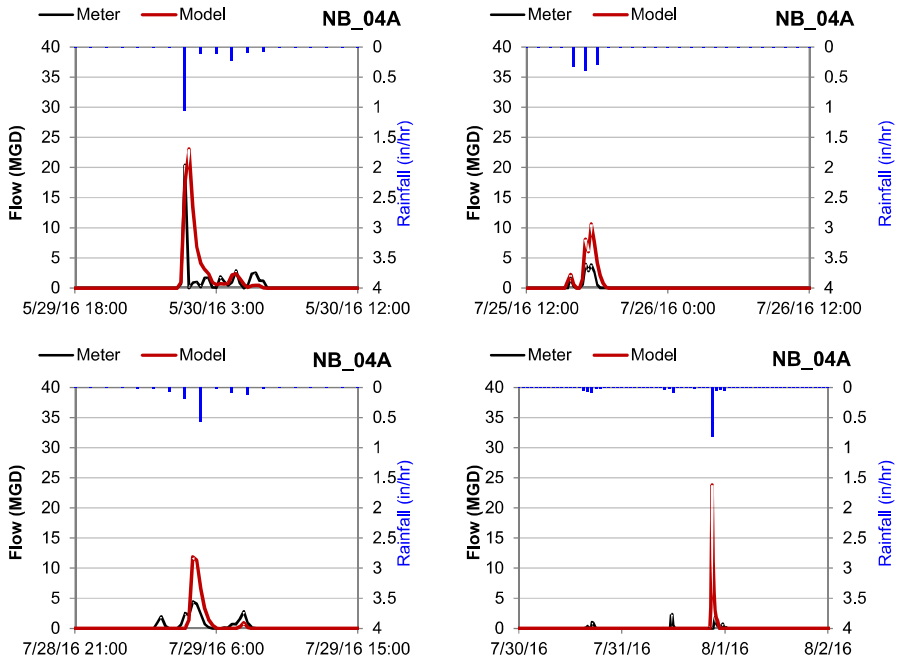




Calibration Results – CSO Overflow

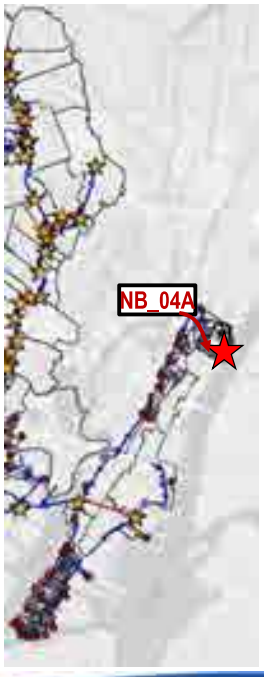
NB_04A

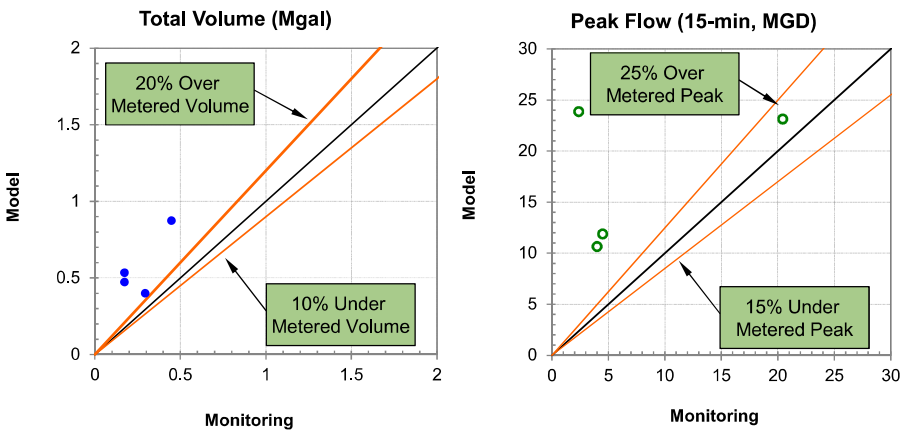




Calibration Results – CSO Overflow

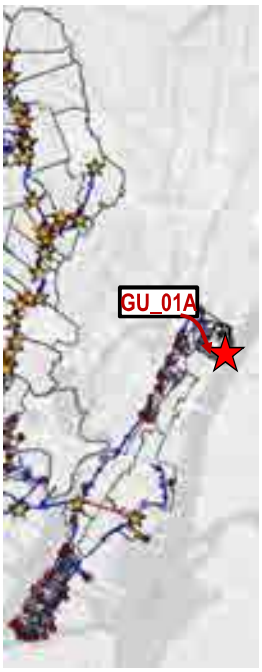
NB_04A

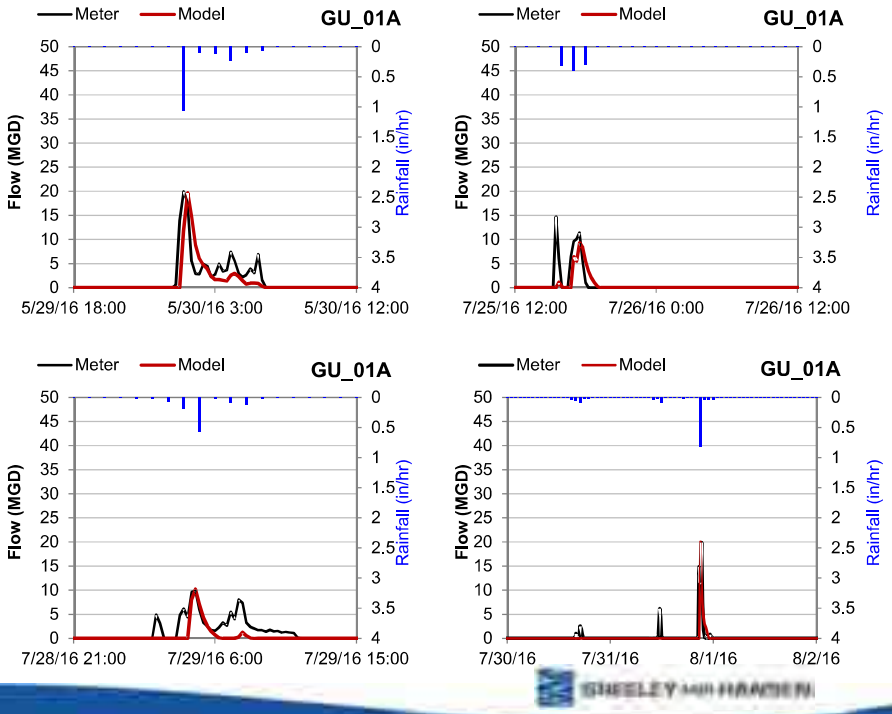




Calibration Results – CSO Overflow

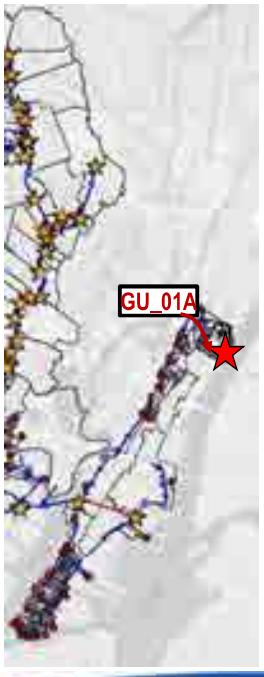
GU_01A

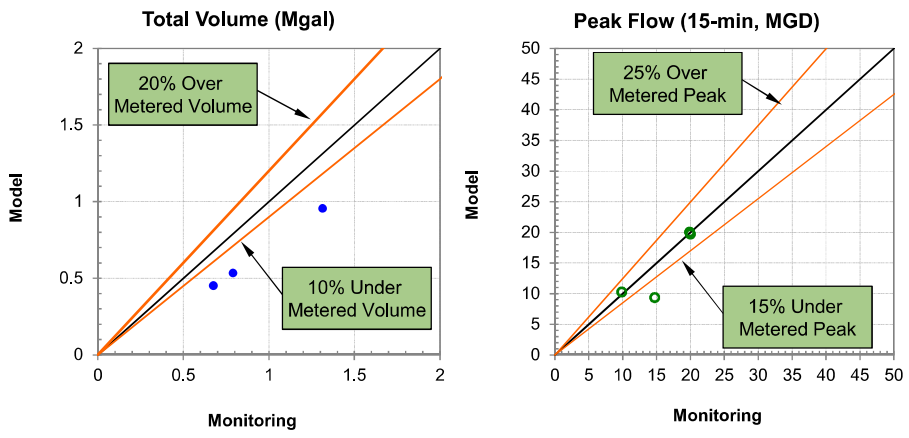




Calibration Results – CSO Overflow

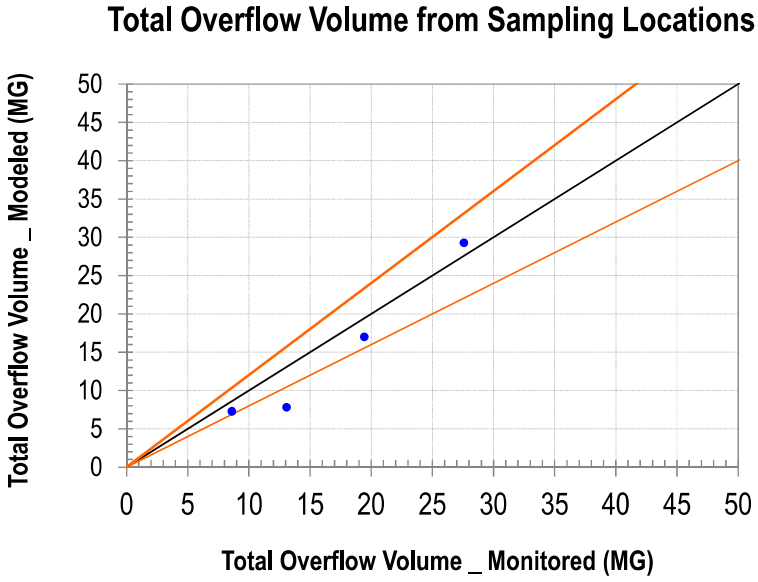
GU_01A





Total Overflow Volume

NE_04&05, NE_09&10, NE_14A , NE_15A , KE_07A , BA_08A , BA_10A ,NB_11A , NB_07A, NB_04A, NB_04B, GU_01A



Summary

- The updated PVSC H&H model includes
  - 48 municipalities served by the PVSC WPCF
  - 2 municipalities served by the NBMUA Woodcliff WWTP
  - Dry weather flow based on 2016 flow monitoring data
  - Wet weather flow simulated as runoff from the combined areas and RDII from the separated areas
  - Current PVSC WPCF wet weather operating rules
- The model is calibrated and validated to 2016 flow monitoring data

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PVSC H&H Model Application

PVSC H&H Model Application

- Typical Year Simulation
- CSO Control Alternative Simulation
- Generate CSO flows for WQ model

CSO ID	Overflow		
	Volume (MG)	# per Year	Duration (Hour)
PT001	24.9	38	162
PT003	1.8	20	27
PT005	6.5	27	77
PT006	76.6	38	161
PT007	42.8	37	155
PT010	9.7	26	68
PT013	11.4	29	71
PT014	0.1	5	3
PT015	0.5	18	11
PT016	12.3	30	55
PT017	8.7	33	106
PT021	5.0	30	112
PT022	17.4	33	141
PT023	3.0	17	25
PT024	8.3	31	52
PT025	87.9	56	120
PT026	0.5	15	7
PT027	41.0	46	83
PT028	10.0	28	48
PT029	92.4	48	178
PT030	4.5	4	3
PT031	9.5	27	39
PT032	30.2	32	122

CSO ID	Overflow		
	Volume (MG)	# per Year	Duration (Hour)
EN001	16.6	37	97
HR001	1.3	30	36
HR002	2.8	34	50
HR003	13.6	33	60
HR005	18.8	36	133
HR006	6.7	30	48
HR007	13.3	49	133
KE001	3.9	33	54
KE004	12.3	58	177
KE006	118.8	63	246
KE007	86.0	36	165
KE010	26.0	54	144
NE002	91.5	46	268
NE003	0.0	0	0
NE004	1.4	23	29
NE005	21.2	43	249
NE008	93.3	52	327
NE009	163.7	42	210
NE010	163.7	42	210
NE014	180.1	52	387
NE015	74.7	43	248
NE016	54.3	49	252
NE017	107.4	51	281
NE018	75.5	53	326
NE022	45.7	69	262
NE023	16.8	35	108
NE025	58.2	16	30
NE026	16.6	17	25
NE027	11.3	17	39
NE030	10.4	19	21

CSO ID	Overflow		
	Volume (MG)	# per Year	Duration (Hour)
NB003	171	51	286
NB005	30.1	55	255
NB006	0.0	0	0
NB007	6.6	32	98
NB008	15.1	30	82
NB009	25.6	45	175
NB010	1.2	25	41
NB011	5.1	37	121
NB014	0.5	7	6
BA001	373.3	71	533
BA002	8.7	9	14
BA003	11.2	34	108
BA004	0.0	3	1
BA006	16.0	37	138
BA007	72.1	37	125
BA008	10.0	34	88
BA009	4.2	33	58
BA010	17.3	52	178
BA011	5.9	34	71
BA012	14.0	57	142
BA013	0.8	33	35
BA014	12.7	43	127
BA015	46.6	54	231
BA016	6.5	48	130
BA017	54.2	62	350
BA018	14.6	58	232
BA019	38.8	35	112
BA020	10.1	33	65
BA021	62.9	54	212
BA022	0.0	0	0
BA024	0.1	3	2
BA026	1.3	9	4
BA028	0.0	0	0
BA029	6.8	24	41
BA030	1.5	16	10
BA034	0.1	7	4
BA037	0.9	8	8

PVSC H&H Model Typical Year CSO Overflow Volume, Frequency, & Duration

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The End

Hydrodynamic Modeling

Northern NJ CSO Long-Term Control Plan

December 5, 2018
Nicholas Kim, HDR

Agenda

- Calibration Period: 2016 – 2017
- Model Calibration
  - Temperature
  - Salinity
  - Note: Tidal elevation and current calibration results were presented in March 2017 MEG

Model Input

- Tidal Forcing:
  - Mid-Atlantic Bight: Global Tidal Prediction Program and observed low frequency variation
- Freshwater Sources:
  - Rivers: USGS gages (28)
  - CSOs: NJ and NYC
  - Stormwater : CDM Smith landside model
  - STP
- Meteorological Forcing: North America Regional Reanalyses (NARR) Model: 30km resolution; 3-hourly
  - Winds
  - Air temperature
  - Barometric pressure
  - Relative humidity
  - Shortwave solar radiation

- Landside Input
  - Stormwater
  - CSO
  - STP

Available Calibration Data

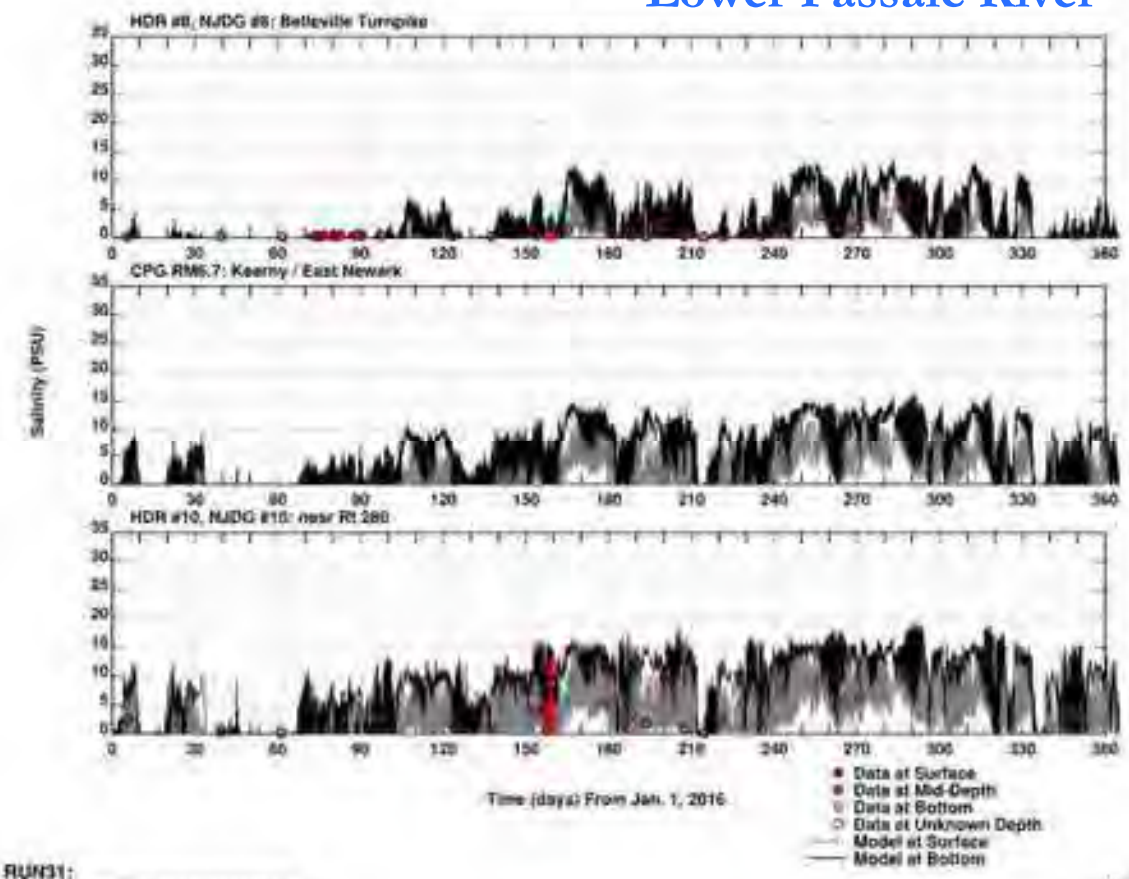
- NJ Harbor Dischargers Group: 2003-2017 (T/S)*
- NJ LTCP WQ Sampling Program: 2016 - 2017 (T/S)
- NYC DEP Harbor Survey Program: 1980's – 2017 (T/S)
- HRECOS *in-situ* monitoring data: T/S
- Meadowlands Environmental Research Institute (MERI): T/S (grab and moored): 2008 - present

* At times, the quality of NJ Harbor Discharge Group salinity data are questionable.

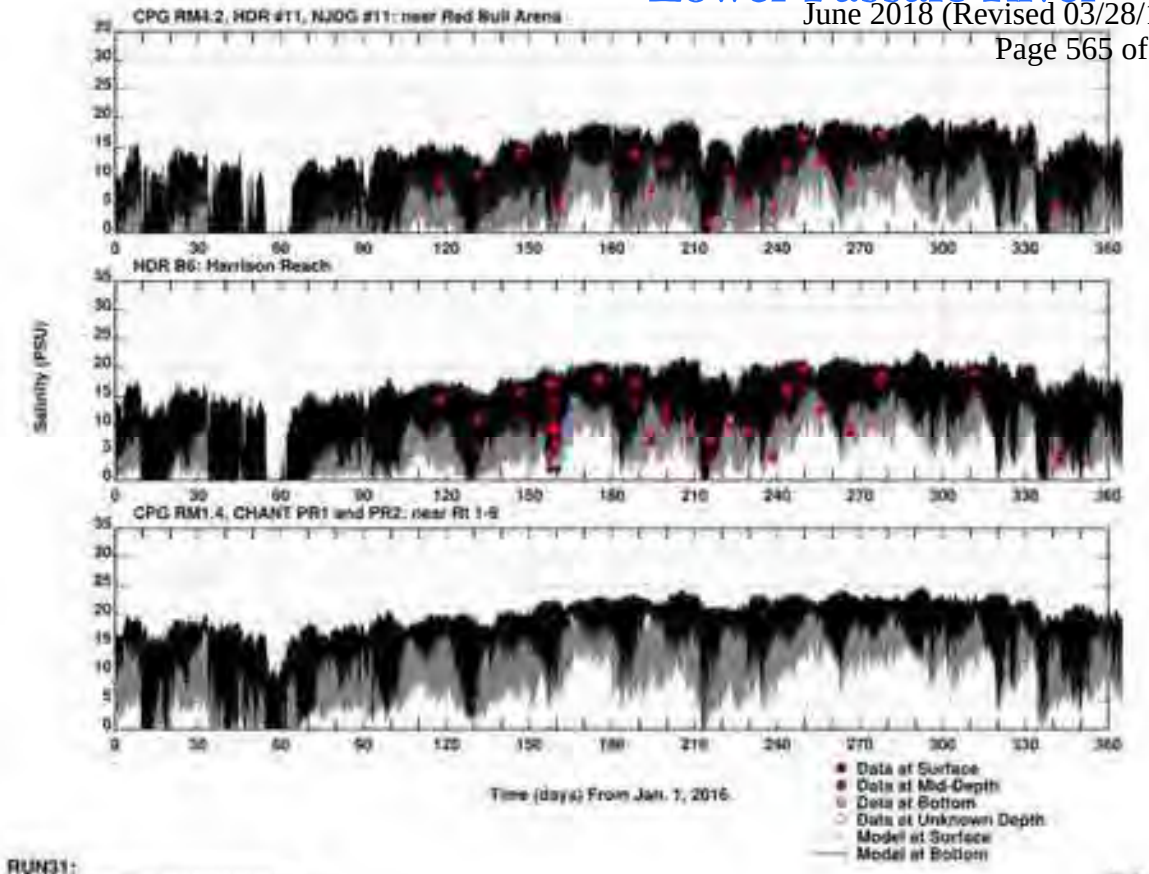
Salinity Results

- Lower Passaic River
- Hackensack River
- Newark Bay
- Kill van Kull
- Arthur Kill
- Raritan Bay
- Hudson River/Upper Bay

Lower Passaic River

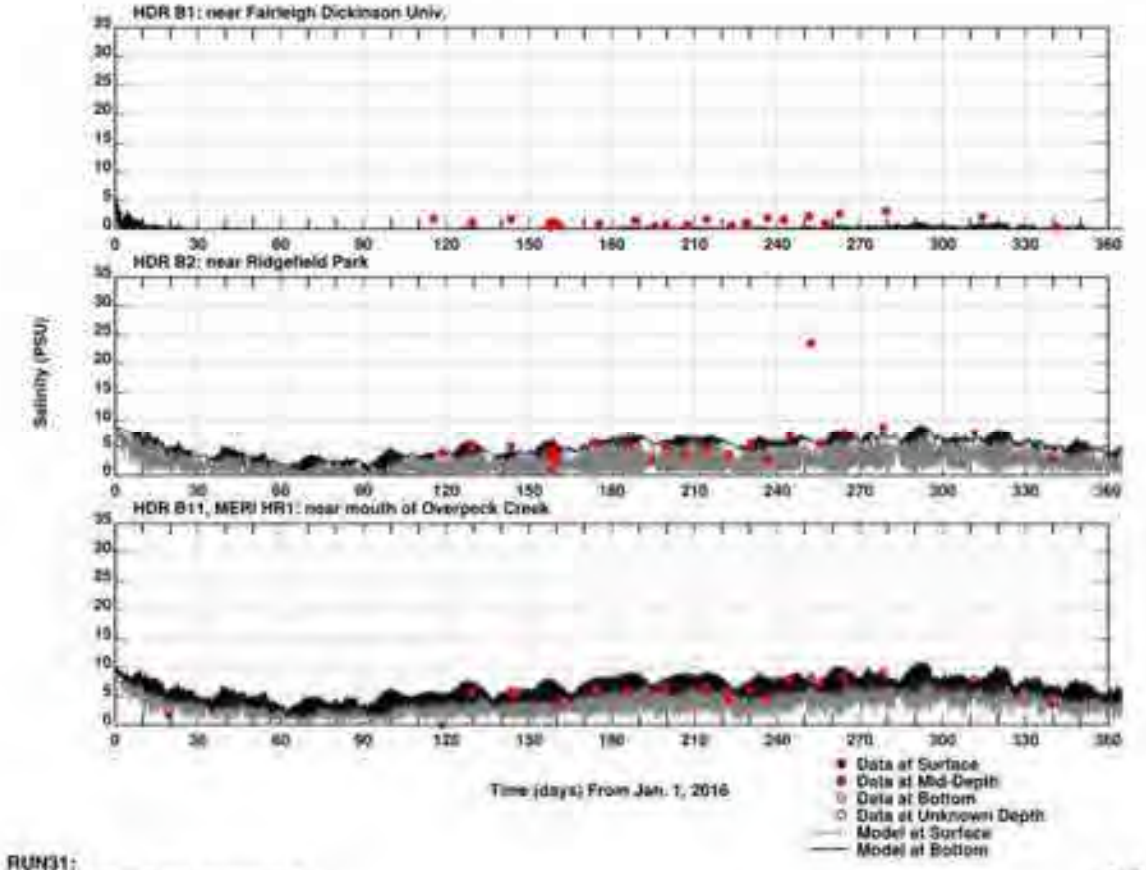


Lower Passaic River



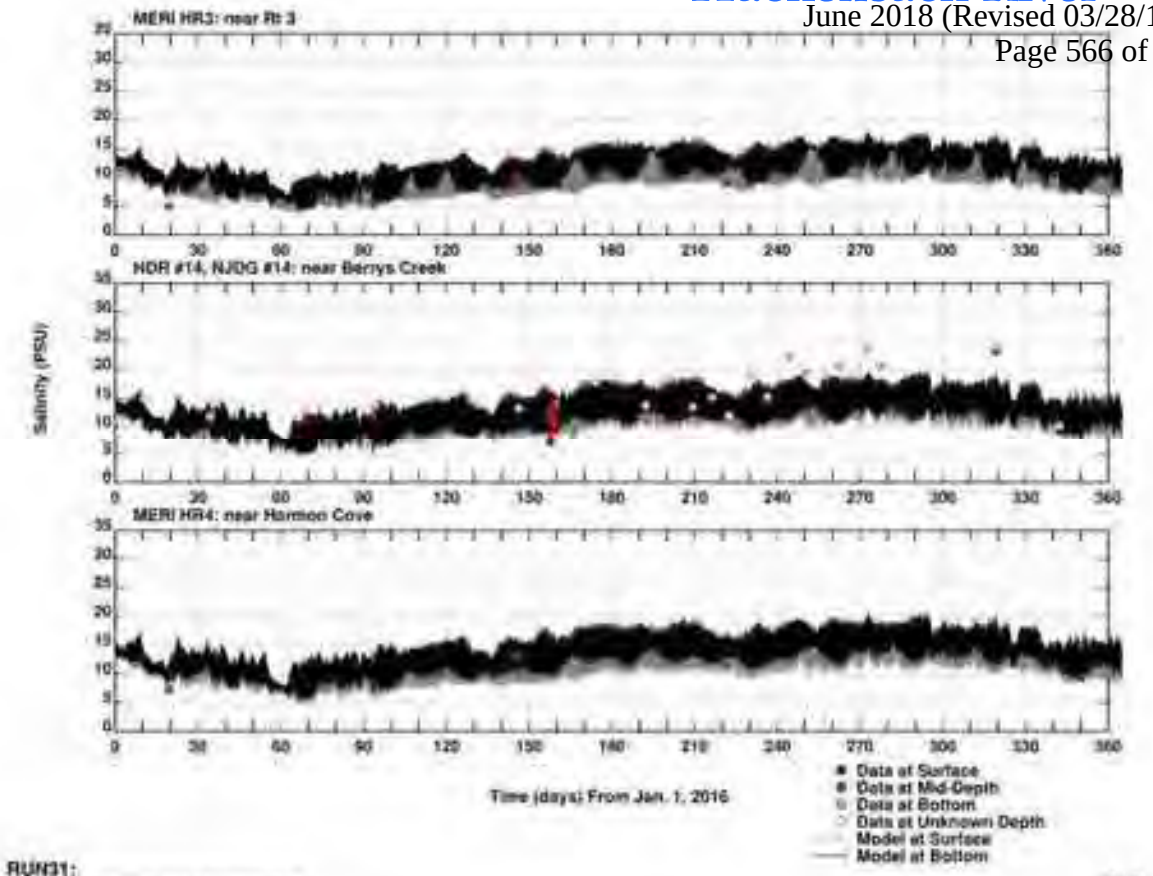
RUN31:

Hackensack River



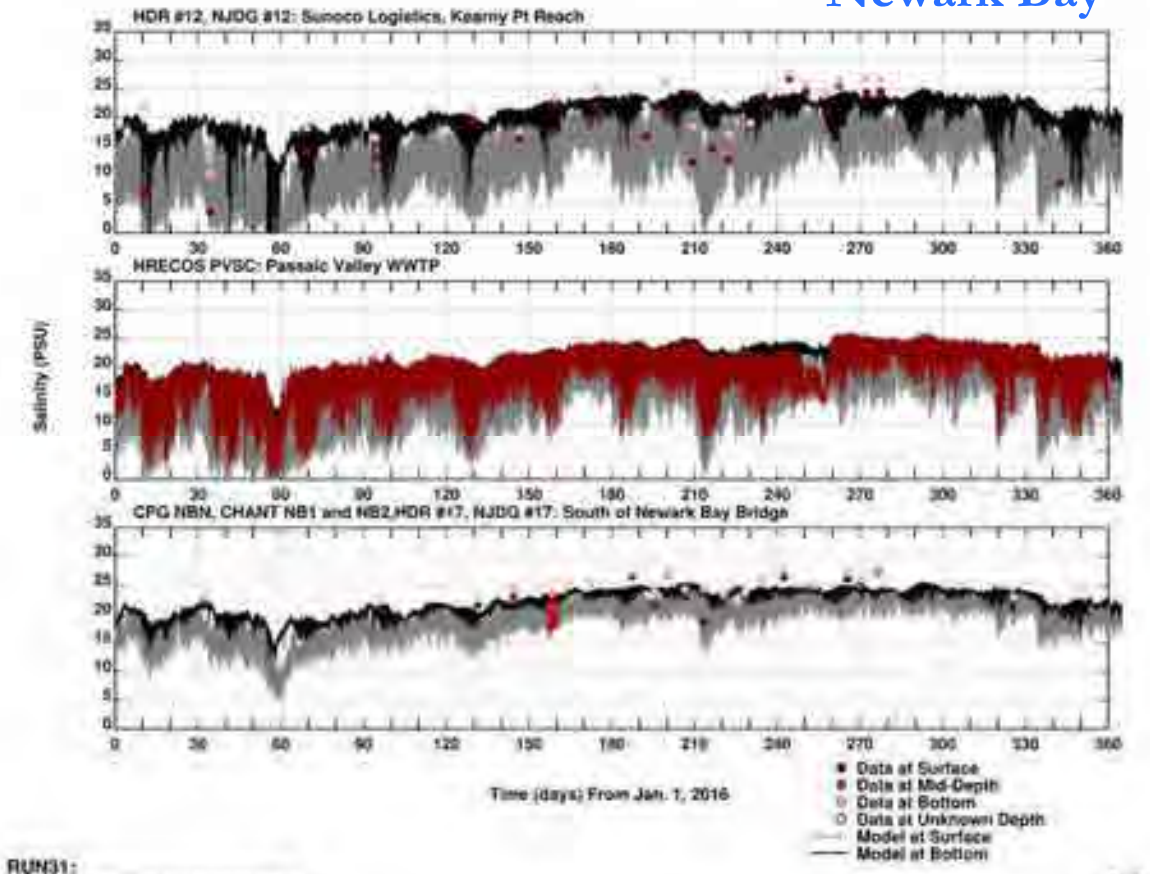
RUN31:

Hackensack River

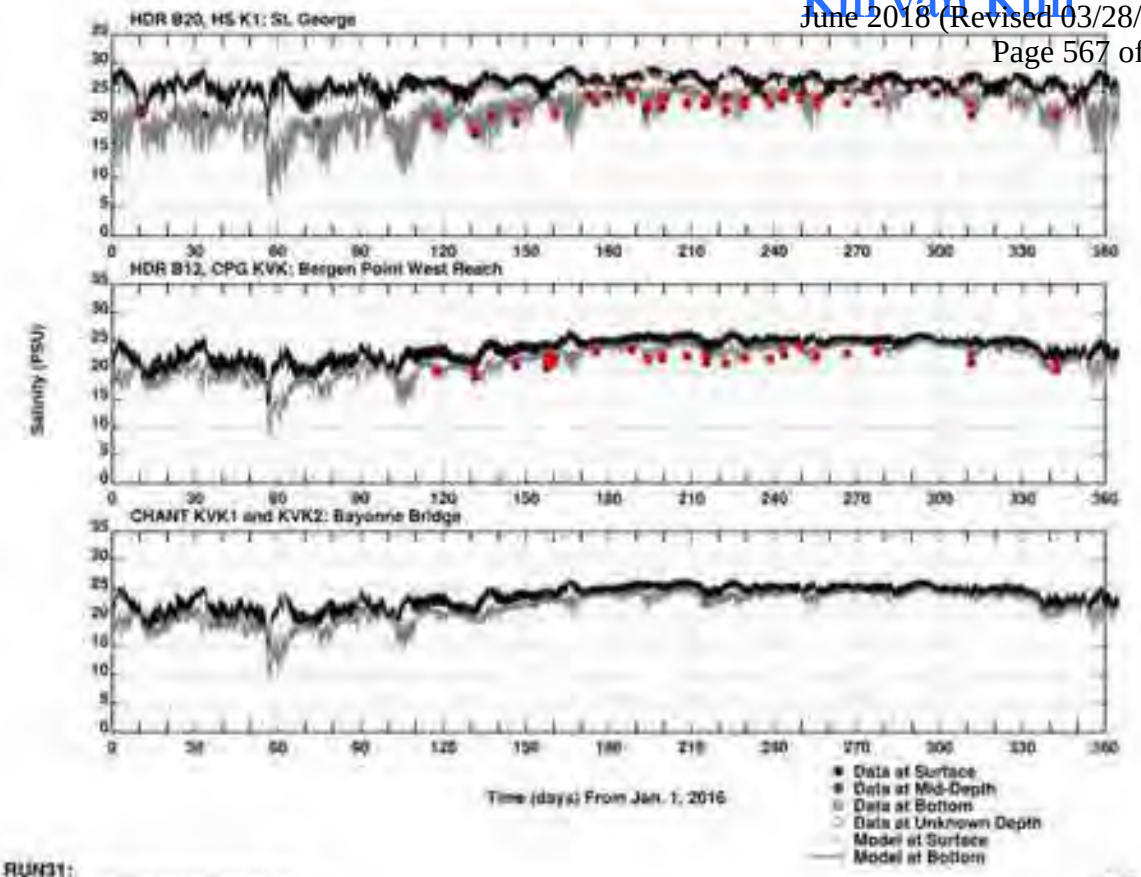


RUN31:

Newark Bay



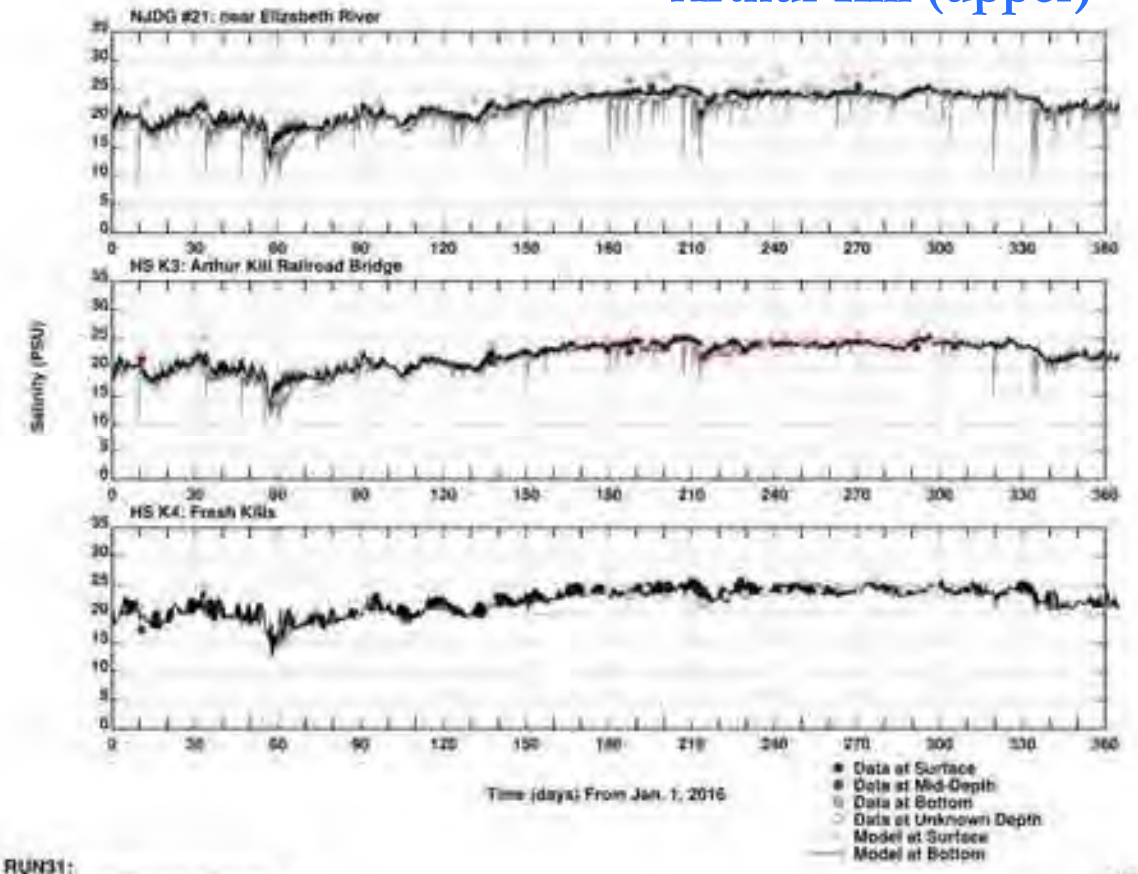
RUN31:



RUN31:

1 | 7

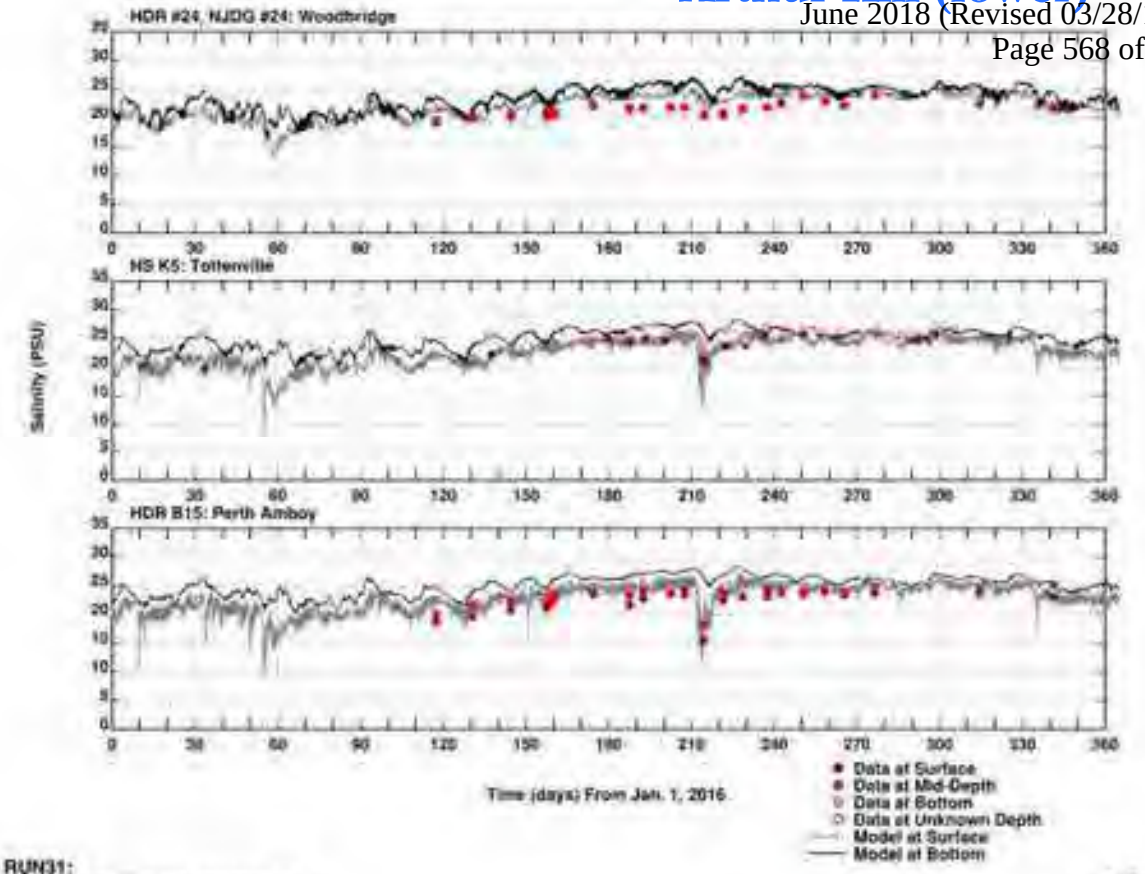
Arthur Kill (upper)



RUN31:

3 | 7

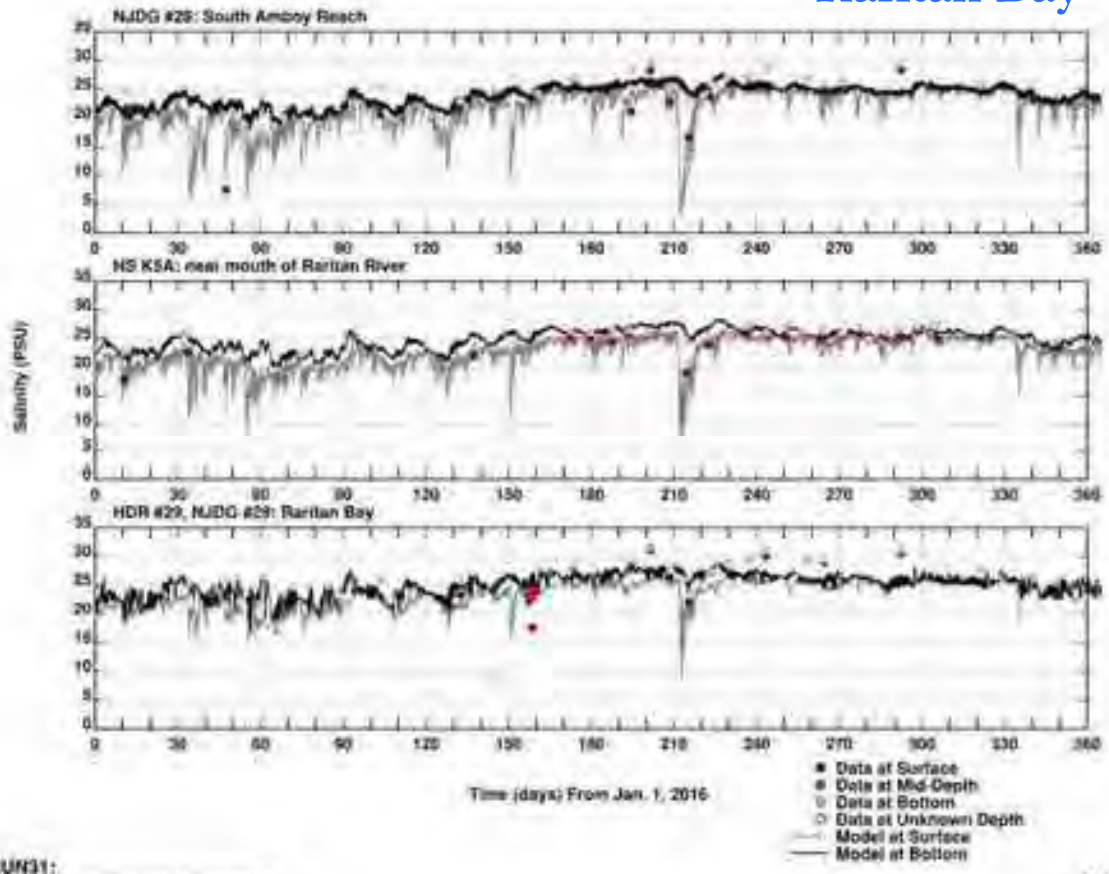
Arthur Kill (lower)



RUN31:

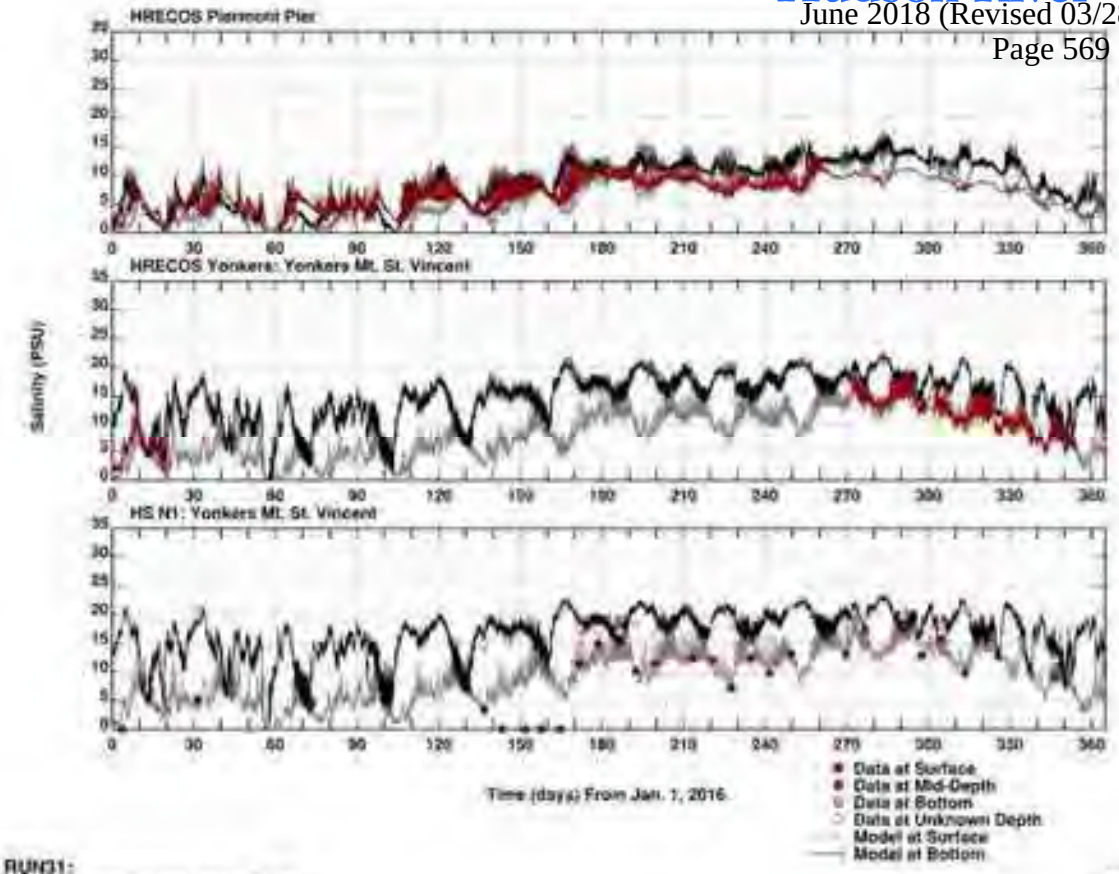
4 \ 7

Raritan Bay



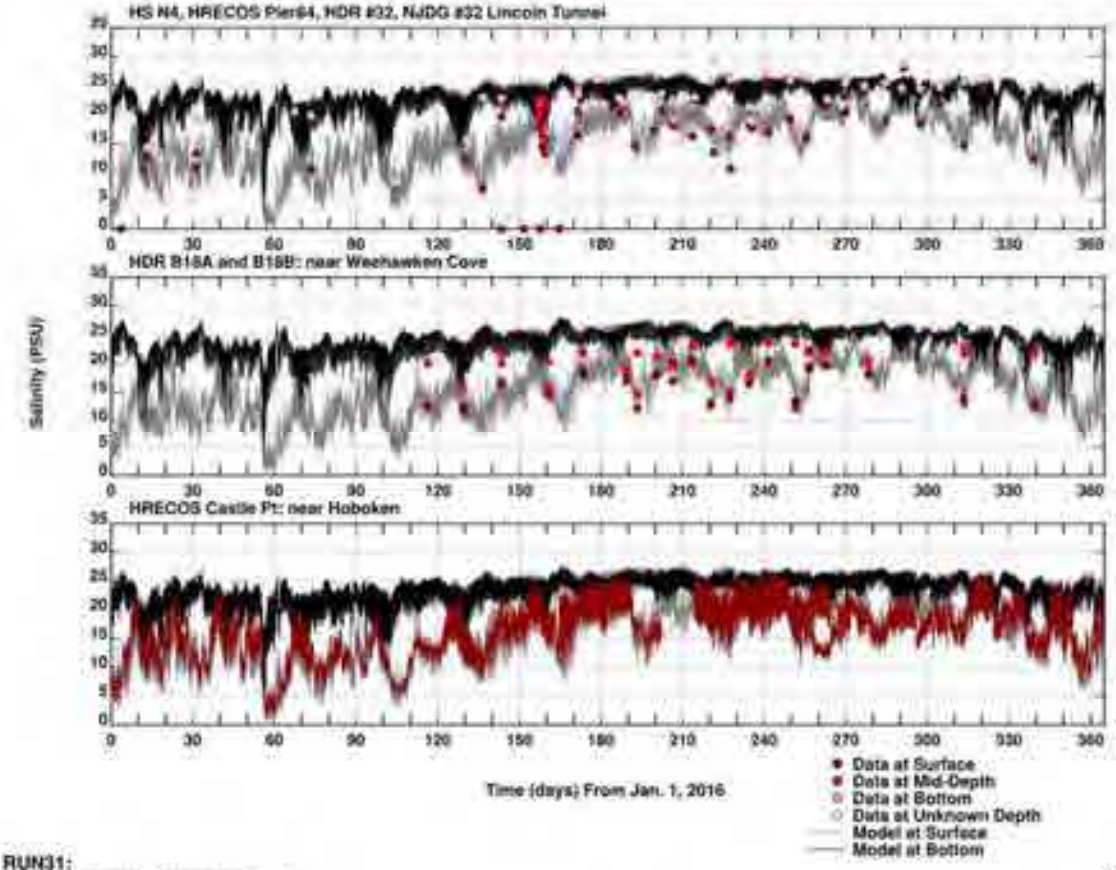
RUN31:

5 \ 7



RUN31:

Hudson River



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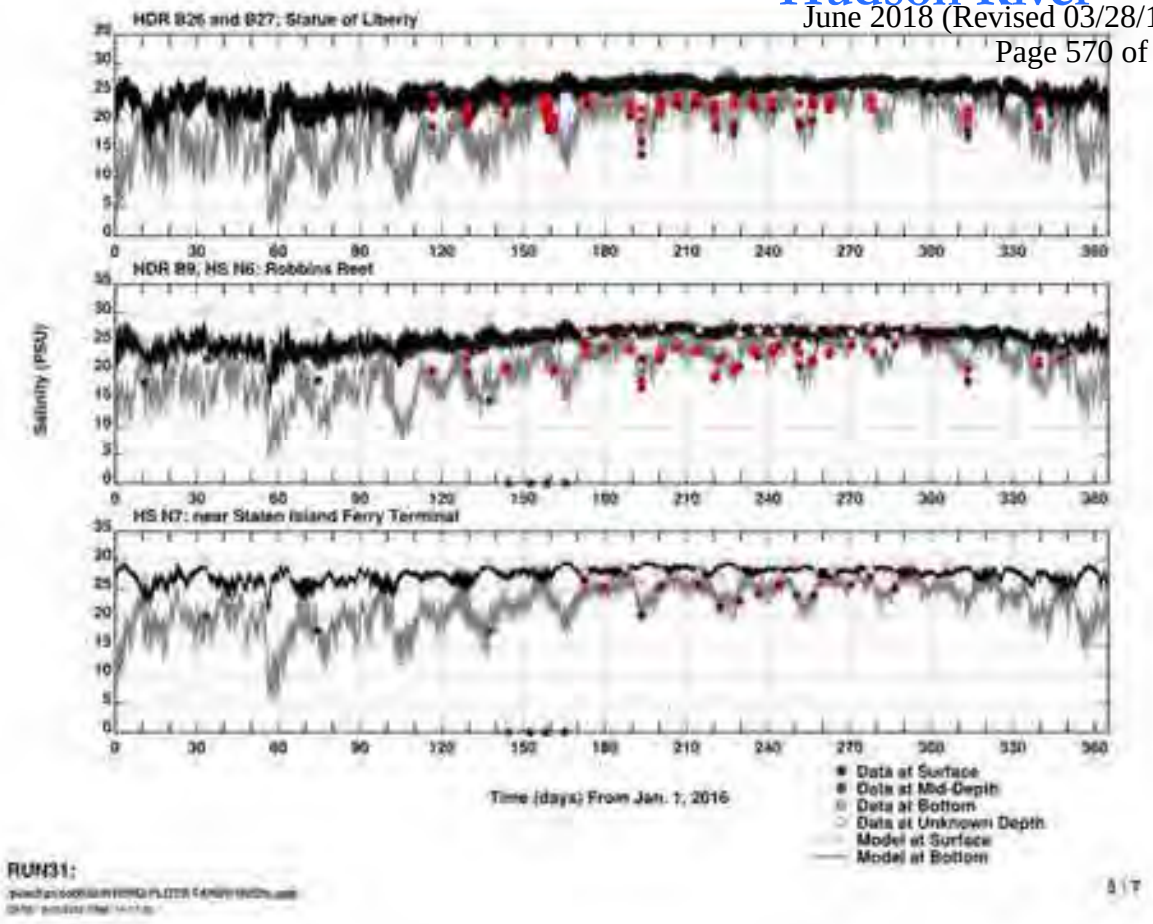
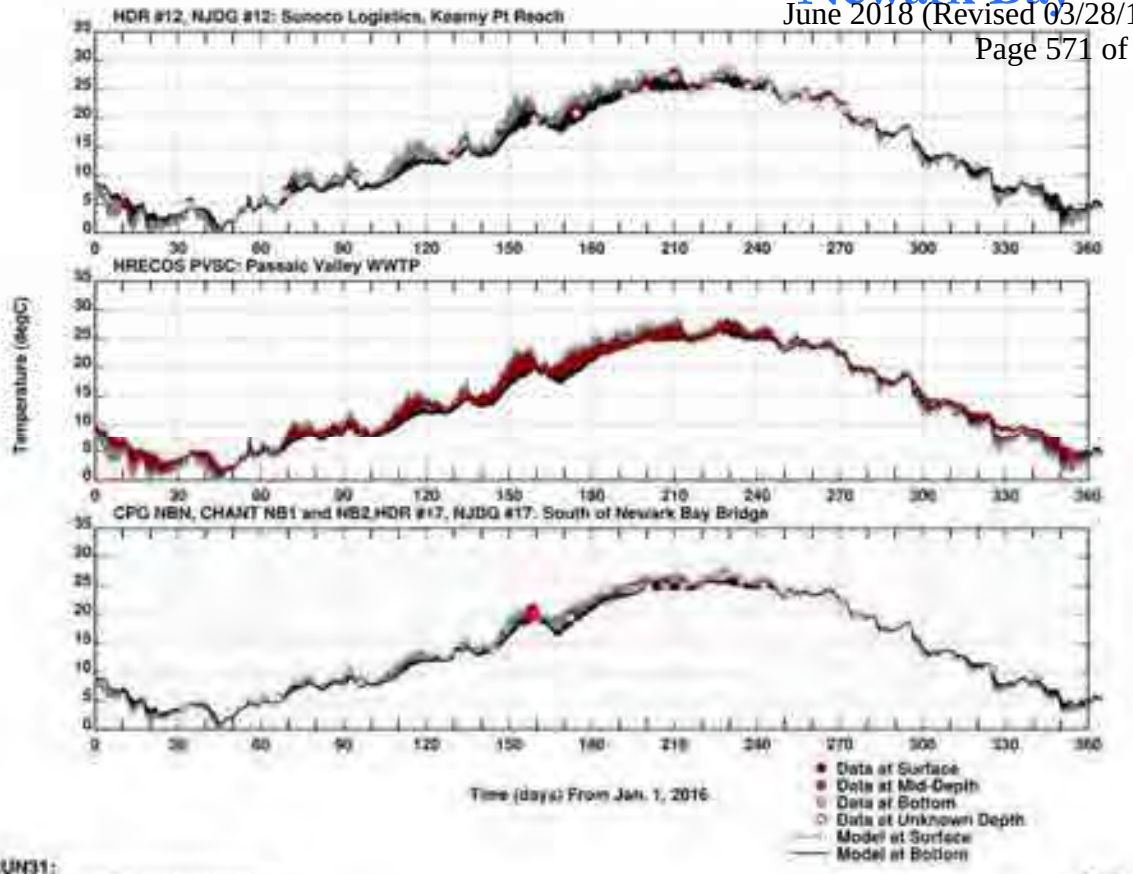


Temperature Results

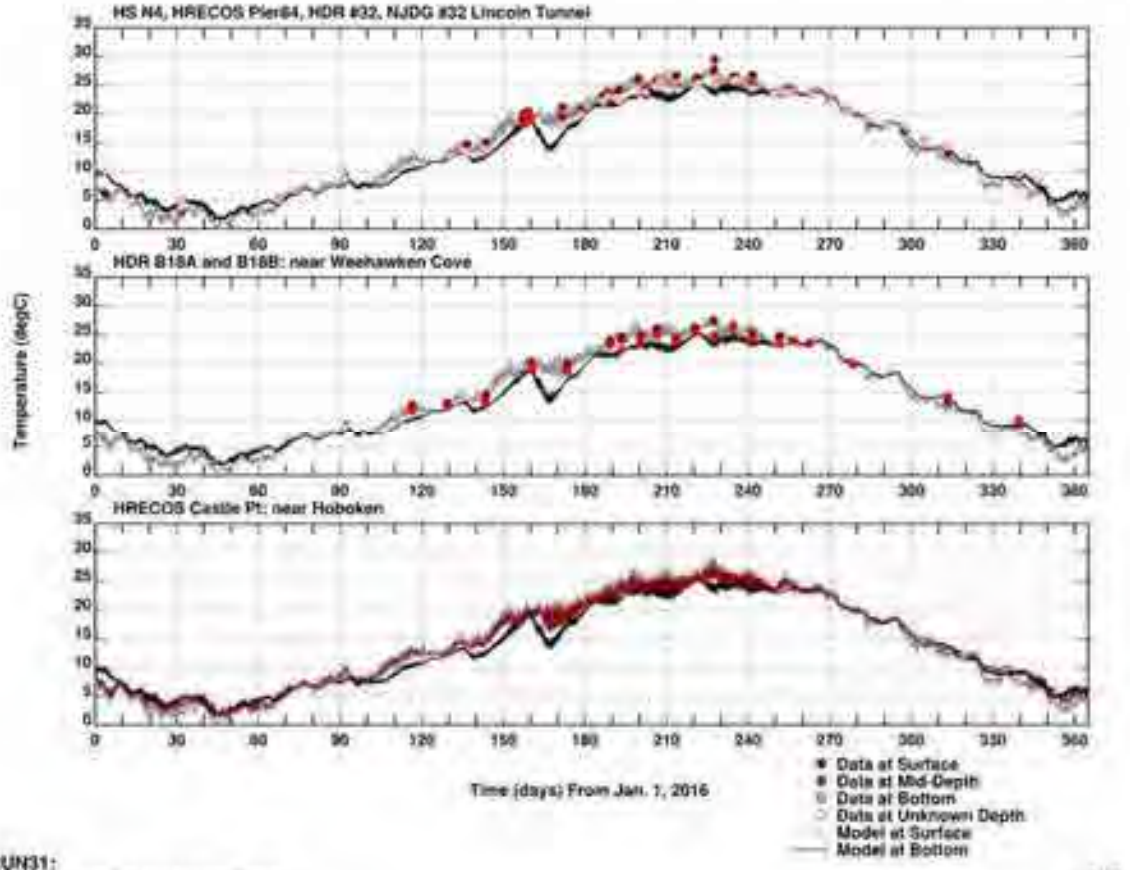
- Newark Bay
- Hudson River

Newark Bay



RUN31:

Hudson River



RUN31:

Summary of Hydrodynamic Model Calibration

- Model has been configured for 2016-2017 with comprehensive model input and compared with data from various sources
- Reasonable reproduction of hydrodynamics in the regions (i.e. water temperature, and salinity) during dry periods and wet events.
- Setup 2004 Projection Conditions

Water Quality Modeling Update

Model Evaluation Group – Session 4

Rich Isleib, HDR

December 5, 2018

Agenda

- Model Kinetics
- Model Inputs
  - Source Loading
    - Stormwater
    - CSO
    - Rivers
    - Other
    - Bacteria Ratios
  - Constants
- Model Calibration/Validation
  - Time Series
    - Annual
    - Events
  - Probability
- Baseline

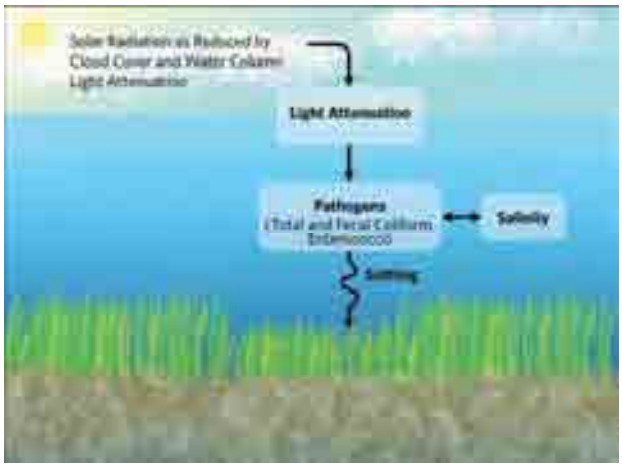
Pathogen Model Kinetics

$$N = N_0 \exp(-KBt)$$

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

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

$+ V_s/H$ (Mancini, 1978)



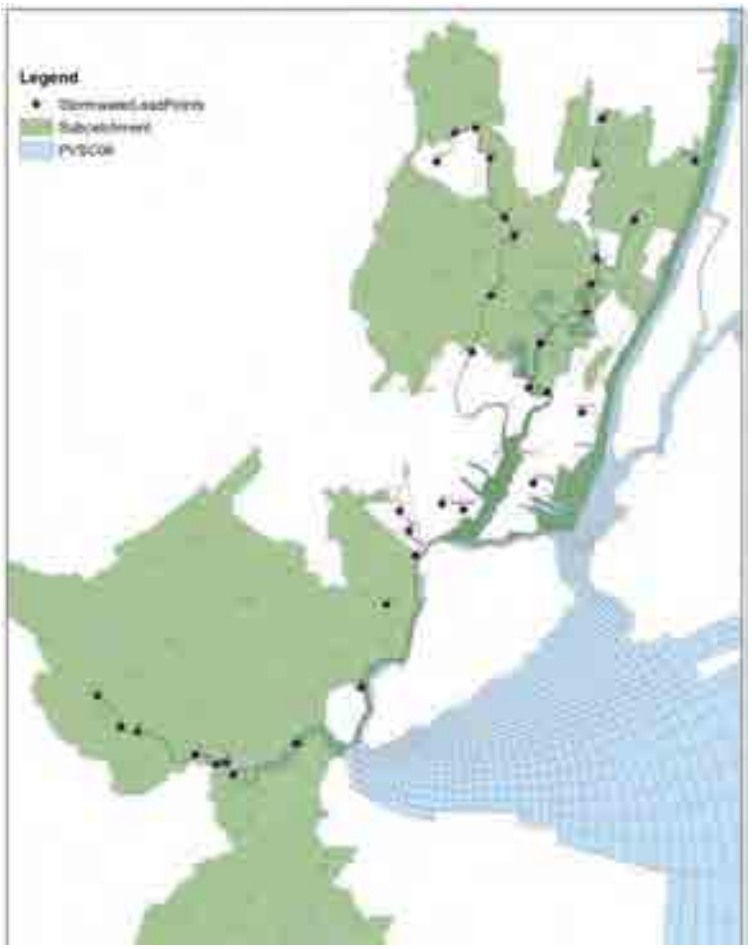
N = Bacteria concentration
K_B = Bacteria loss rate
T = Temperature (°C)
α = proportionality constant
I_0 = Surface solar radiation
t = time
K_e = Extinction coefficient (/m)
H = Depth (m)
V_s = Net settling rate (m/d)

Pathogen Sources

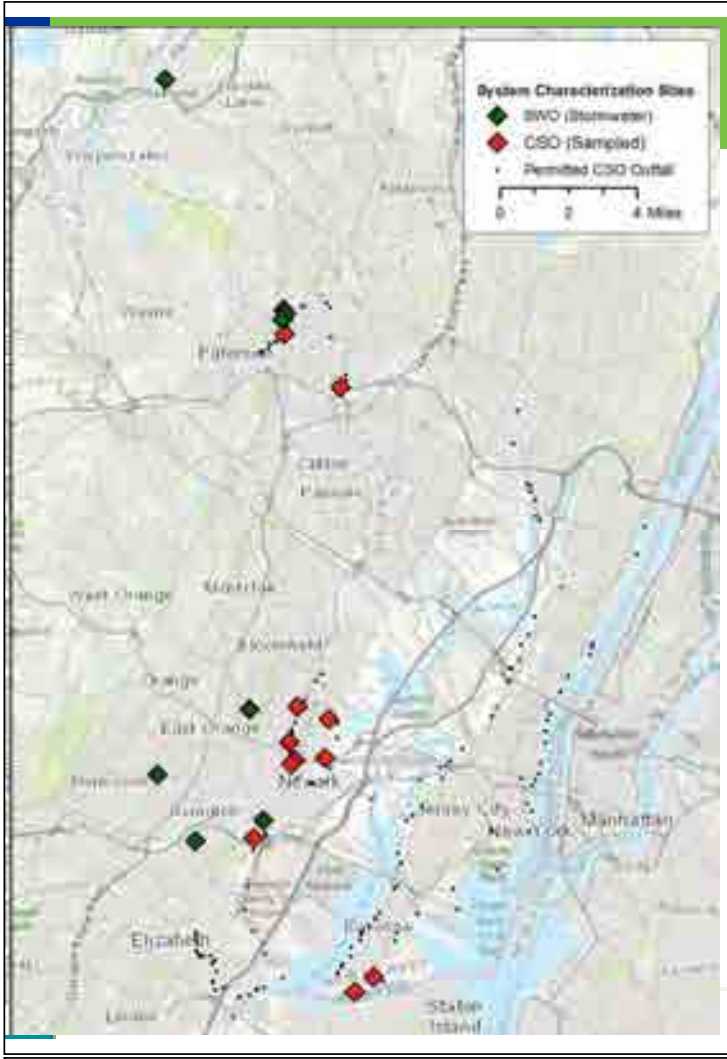
- Source Loading
  - Stormwater
  - CSO
  - Rivers
  - Other
  - Bacteria Ratios

Stormwater Flows

- Flows derived from an InfoWorks model
- Loads were based on constant concentrations

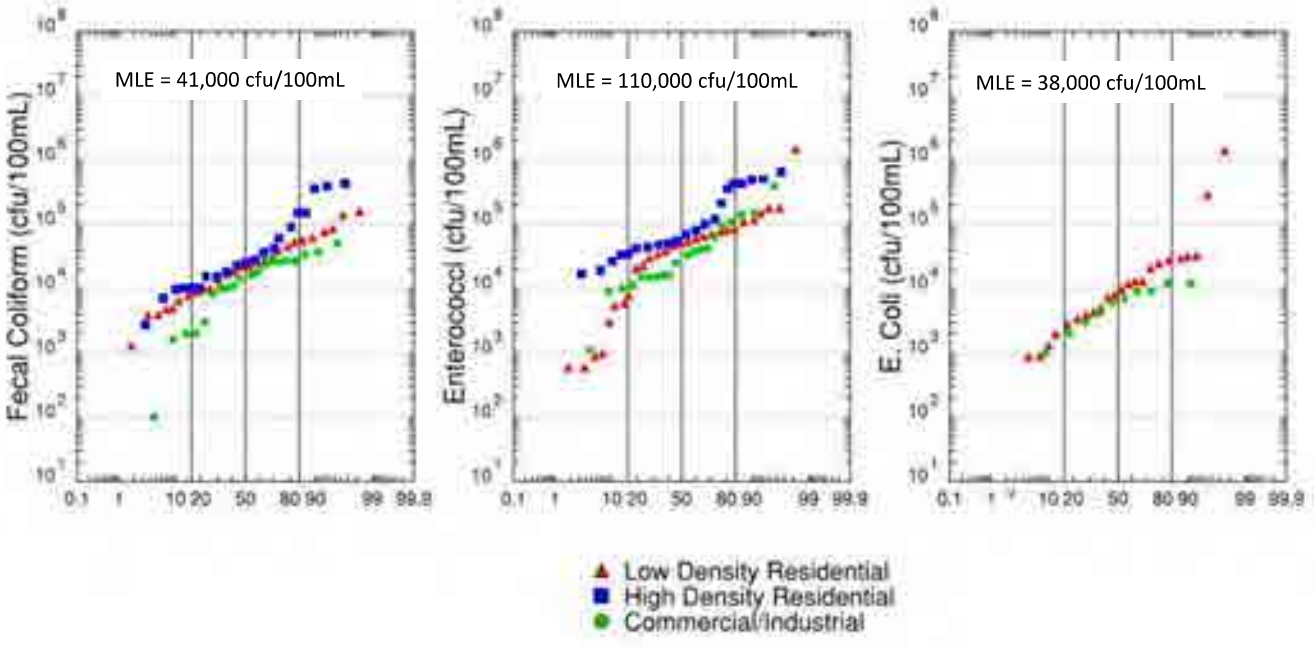


Landside Pathogen Concentration Stations



- Stormwater – 8 locations
  - Low Density Residential (4)
  - High Density Residential (2)
  - Commercial / Industrial (2)
- CSO – 11 Locations/(18 Planned)
  - Paterson (2)
  - Newark (4)
  - Harrison (2)
  - Kearny (1)
  - Bayonne (2)

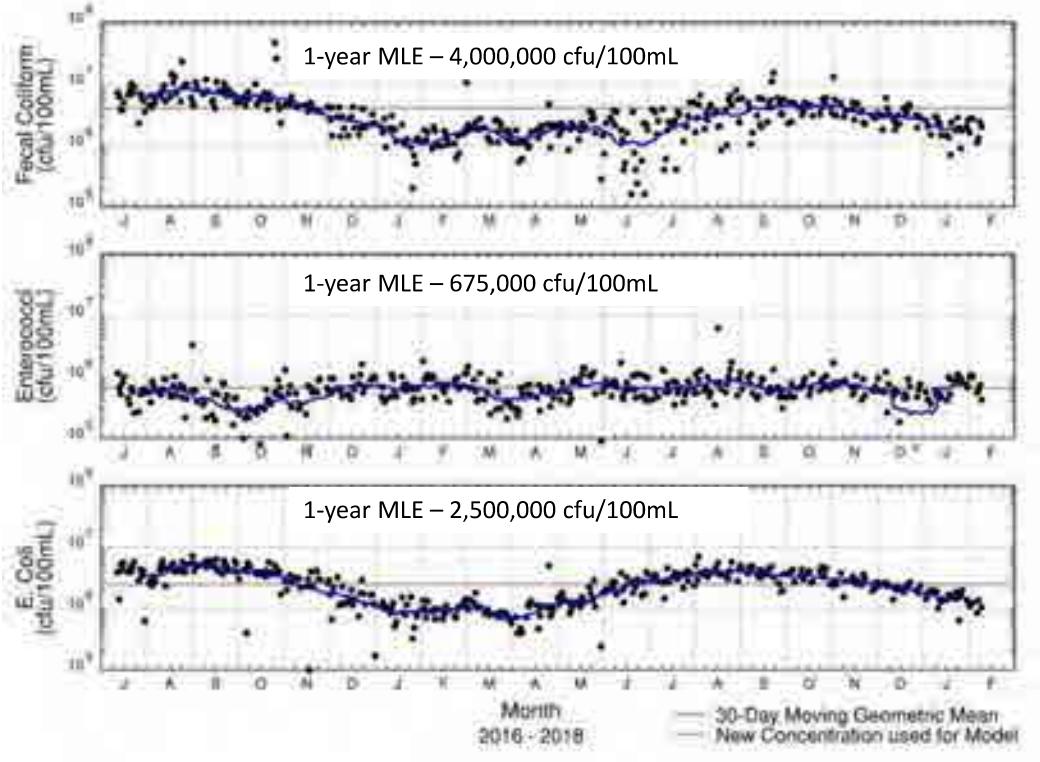
Stormwater Pathogen Concentrations



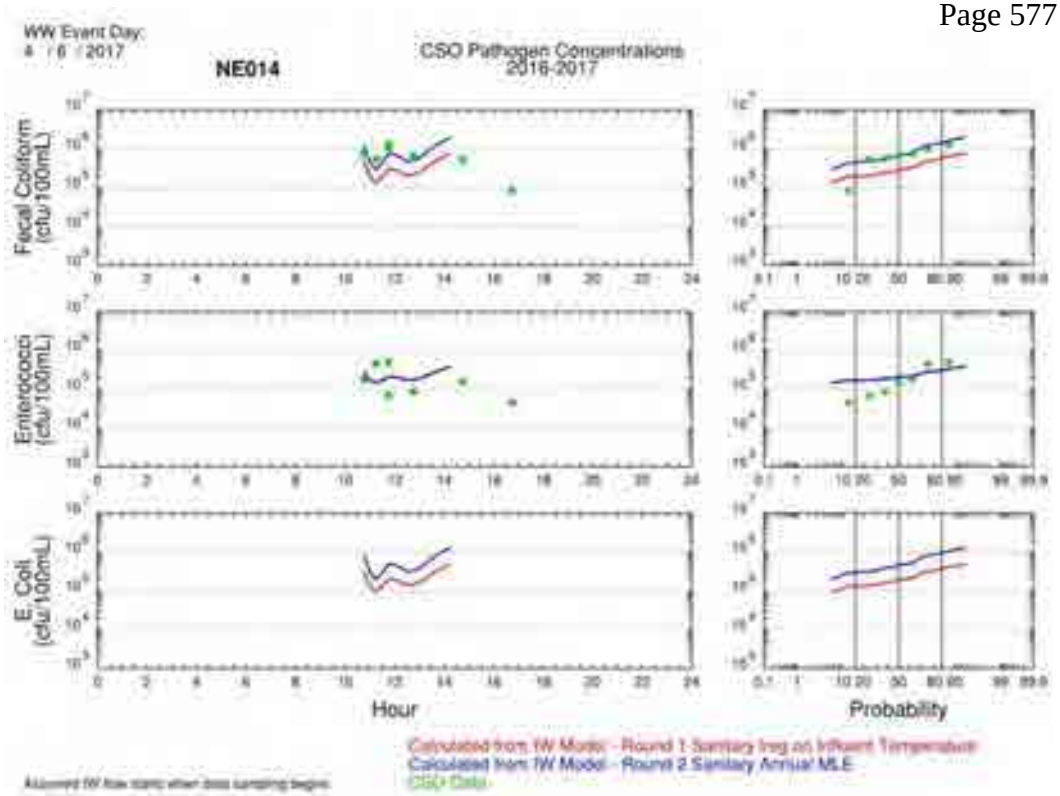
CSO Loading Calculations

- The Mass Balance approach was used to assign loading to the CSOs
- The hydraulic models provided flow and the sanitary/stormwater flow fractions.
- CSO concentrations were calculated using sanitary and stormwater concentrations.
- Estimated CSO concentrations were compared to CSO concentration data.

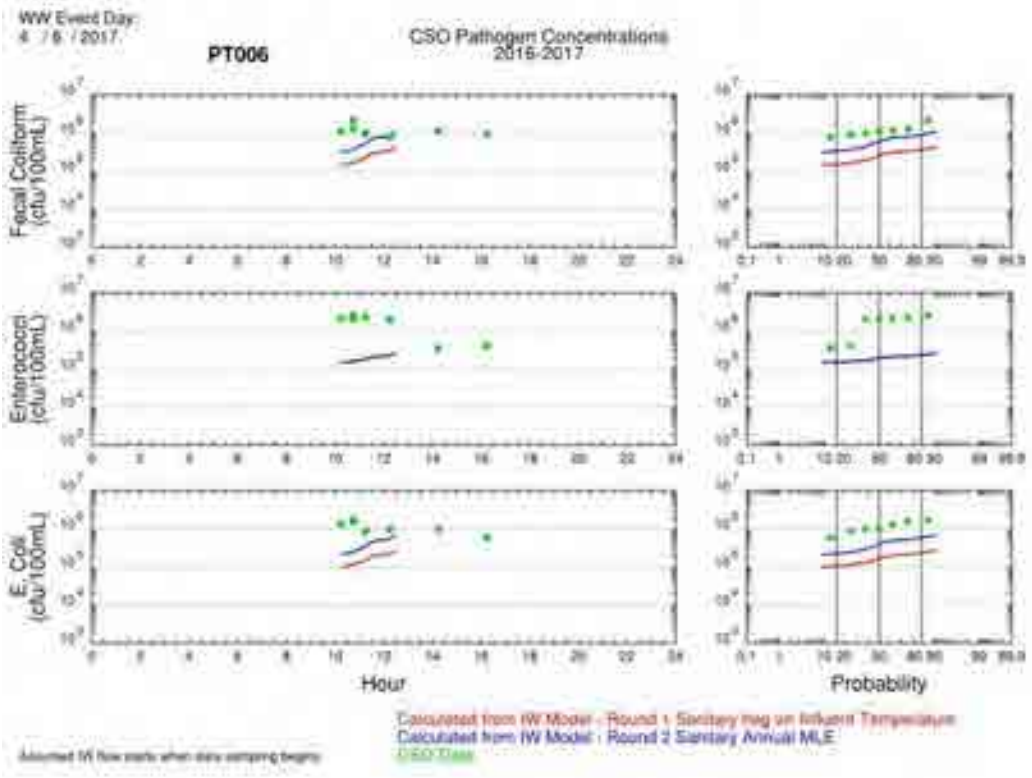
PVSC WWTP Pathogen Influent Concentrations



CSO Mass Balance Check



CSO Mass Balance Check



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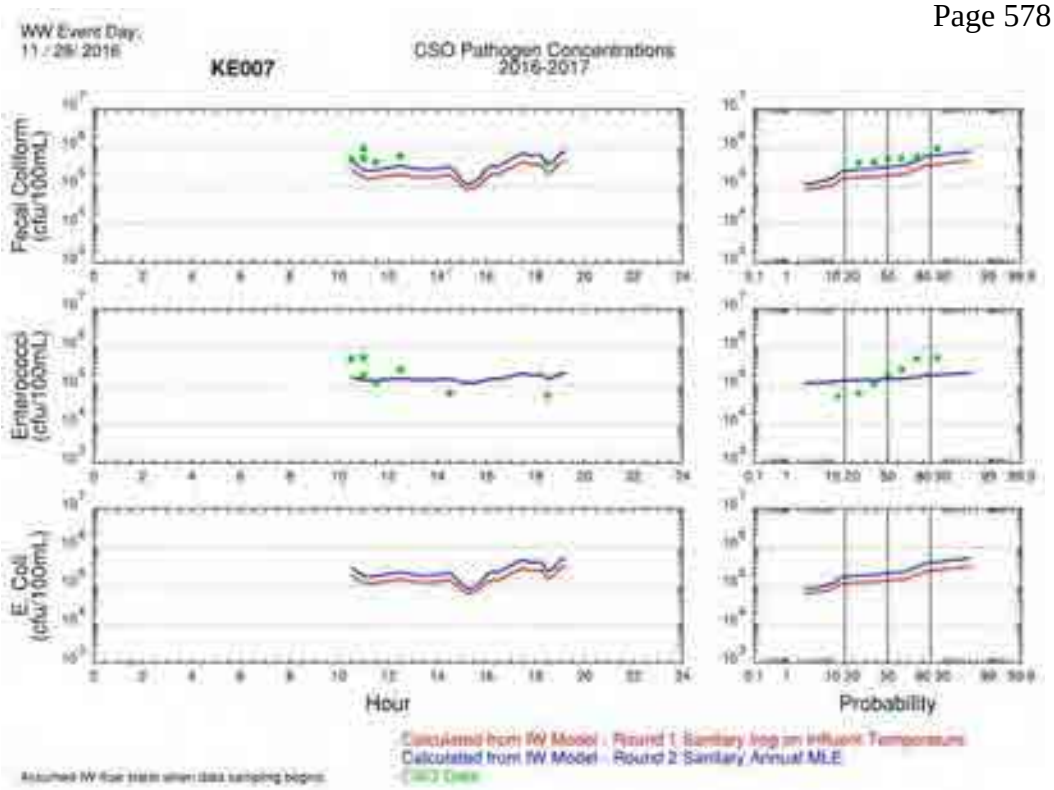
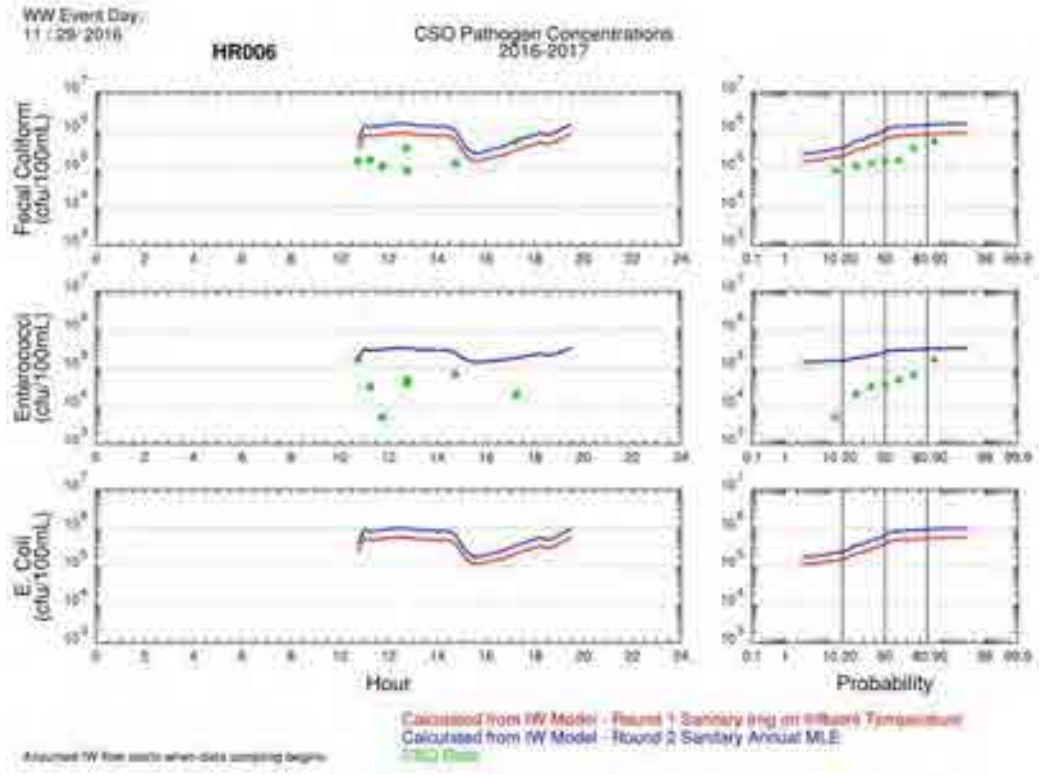
CSO Mass Balance Check



CSO Mass Balance Check



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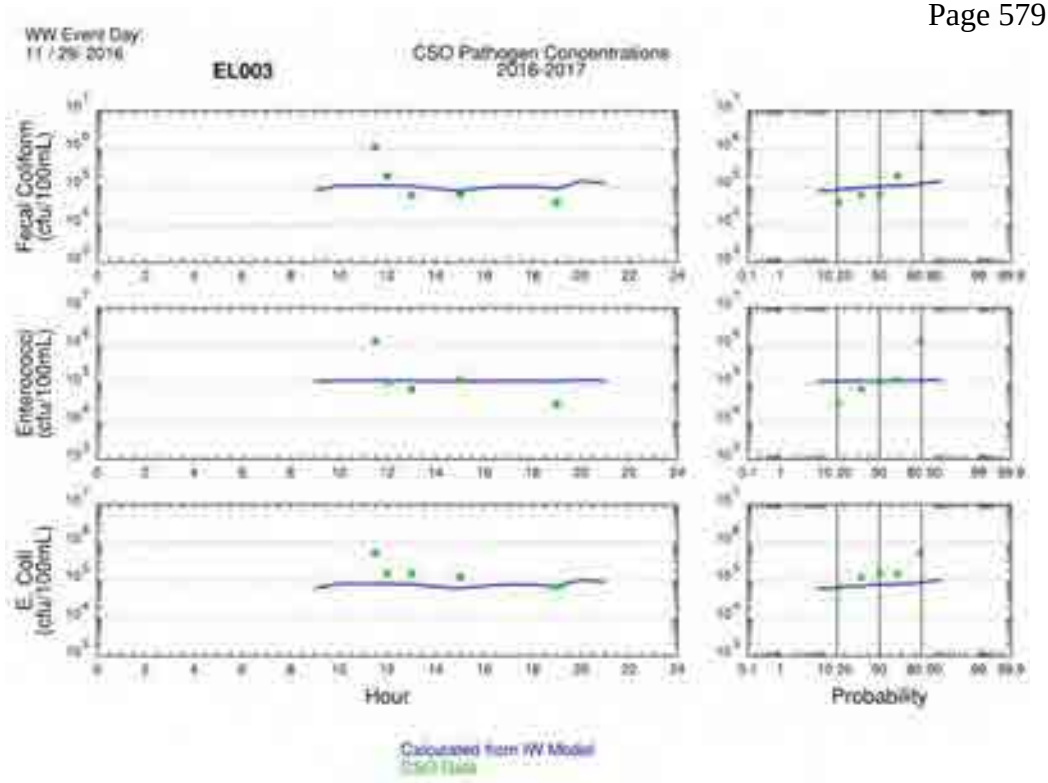

River Loads

- Dry-weather
  - "Monte Carlo" ✔
  - Data Interpolation
  - Data Average
- Wet-weather
  - MLE ✔
  - Concentration vs. Flow

River Boundaries, Stations used for Loading Calculations										
		2004			2016			2017		
Waterbody	Data Station	Data EC	Data FC	Data EN	Data EC	Data FC	Data EN	Data EC	Data FC	Data EN
Hudson River	31	N	Y	Y	N	Y	Y	N	Y	Y
Hackensack River	13	N	Y	Y	Y	Y	Y	Y	Y	Y
Passaic River	1	N	Y	Y	Y	Y	Y	Y	Y	Y
Saddle River	6	N	Y	Y	Y	Y	Y	Y	Y	Y
Raritan River	25	N	Y	Y	Y	Y	Y	Y	Y	Y

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Dry-weather Loads

- Clear need for dry-weather sources based on water quality data
- Assumed sanitary flow concentrations
- 150 gal/day-person

Waterbody	Equivalent People
Passaic River	405
Hackensack River	945
Newark Bay	765
Elizabeth River	105
Kill van Kull	300
Arthur Kill	360
Hudson River	405
Upper Bay	1,380

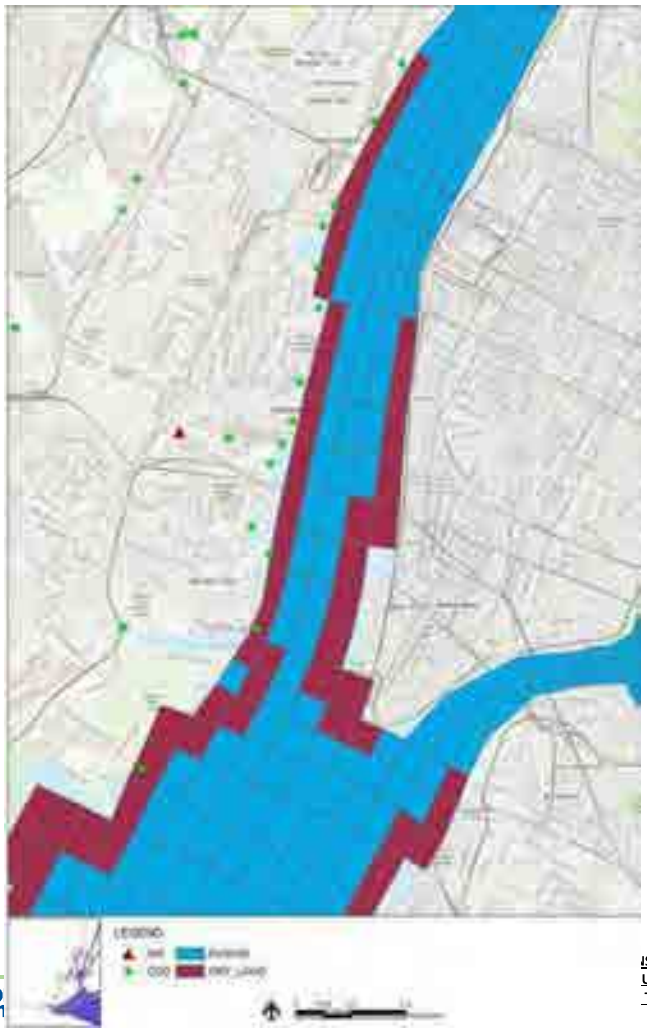
Dry-weather Loads – Passaic River

Dry-weather Loads – Hackensack River

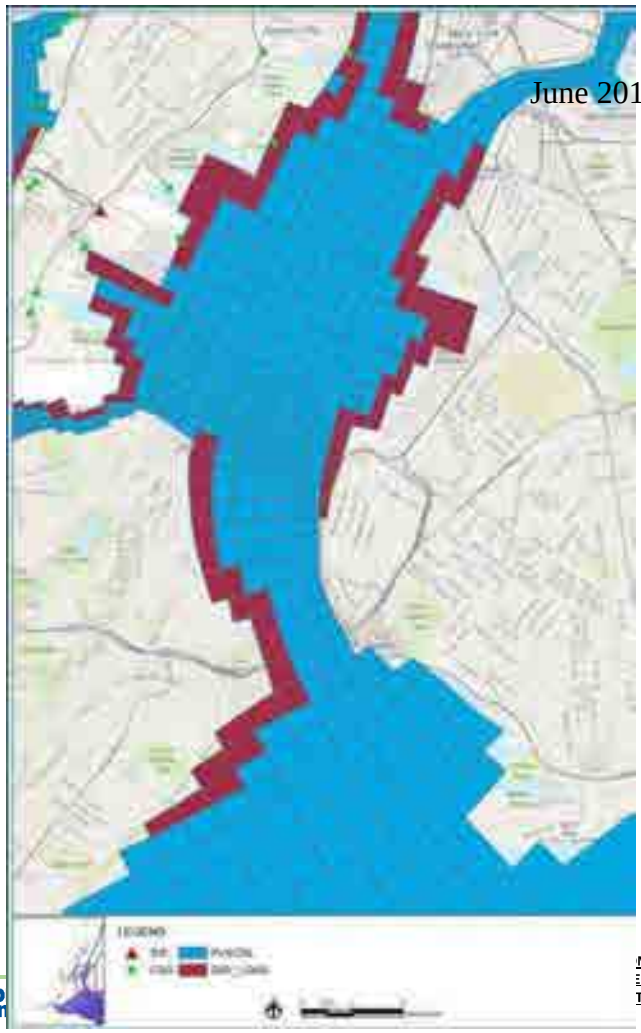
Dry-weather Loads – Newark Bay

Dry-weather Loads – Elizabeth River

Dry-weather Loads – Hudson River



Dry-weather Loads – Upper Bay



Other Loads

- WWTP
  - Fecal coliform = 200 cfu/100mL
  - E. Coli = 100 cfu/100mL
  - Enterococci = 100cfu/100mL
- Base flow from stormwater model
  - Fecal Coliform = 10 cfu/100mL
  - E. Coli = 5 cfu/100mL
  - Enterococci = 1 cfu/100mL
- Hudson River
  - Artificial load created near study area so that upstream loads did not have to be estimated

Pathogen Loading Ratios

Source	FC:ENT Ratio
Sanitary	5.9
Stormwater	0.4
CSO	0.4-4.6
Hudson River	2.7
Hackensack River	2.7
Passaic River	0.5
Raritan River	0.5

Calibration Constants and Parameters

Calibration Constants and Parameters

Constant	F. Coliform & E. Coli	Enterococci
Base Mortality Rate	0.2/day	0.68/day
Temperature Coefficient	1.07	1.07
Seawater Die-off Rate	0.01875/day	0.01875/day
Solar Radiation Die-off Rate	0.003/ly-day	0.00824/ly-day

Calibration Rates

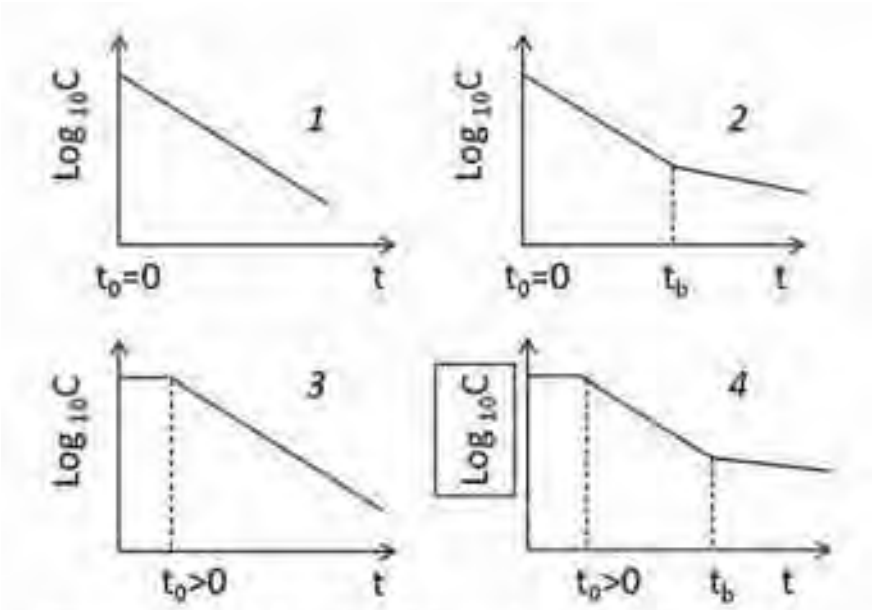
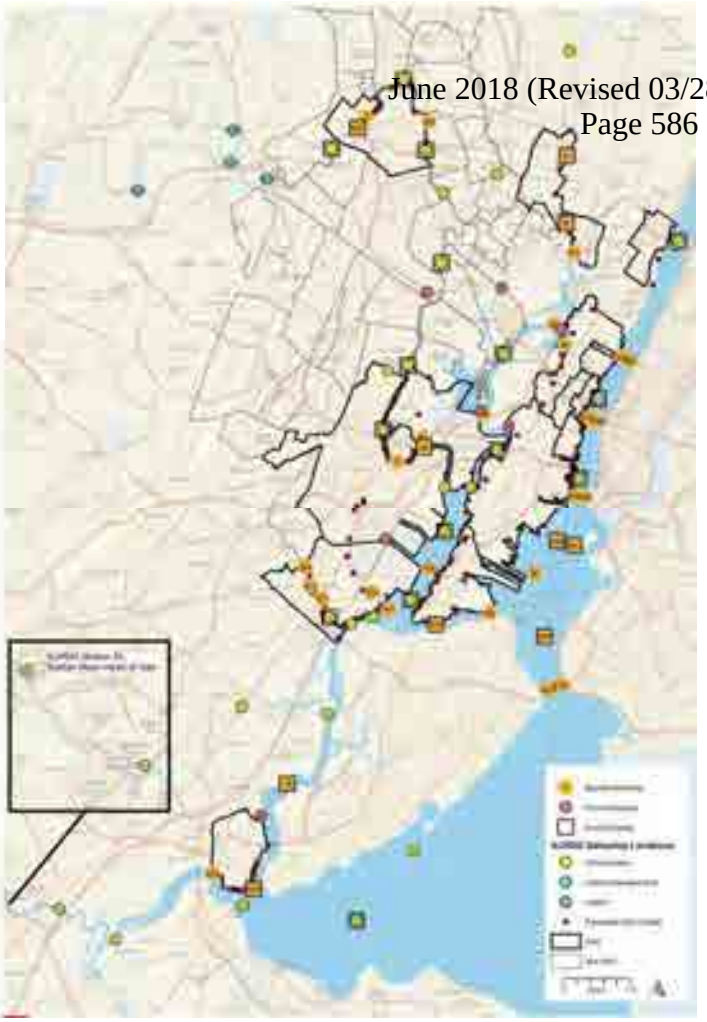


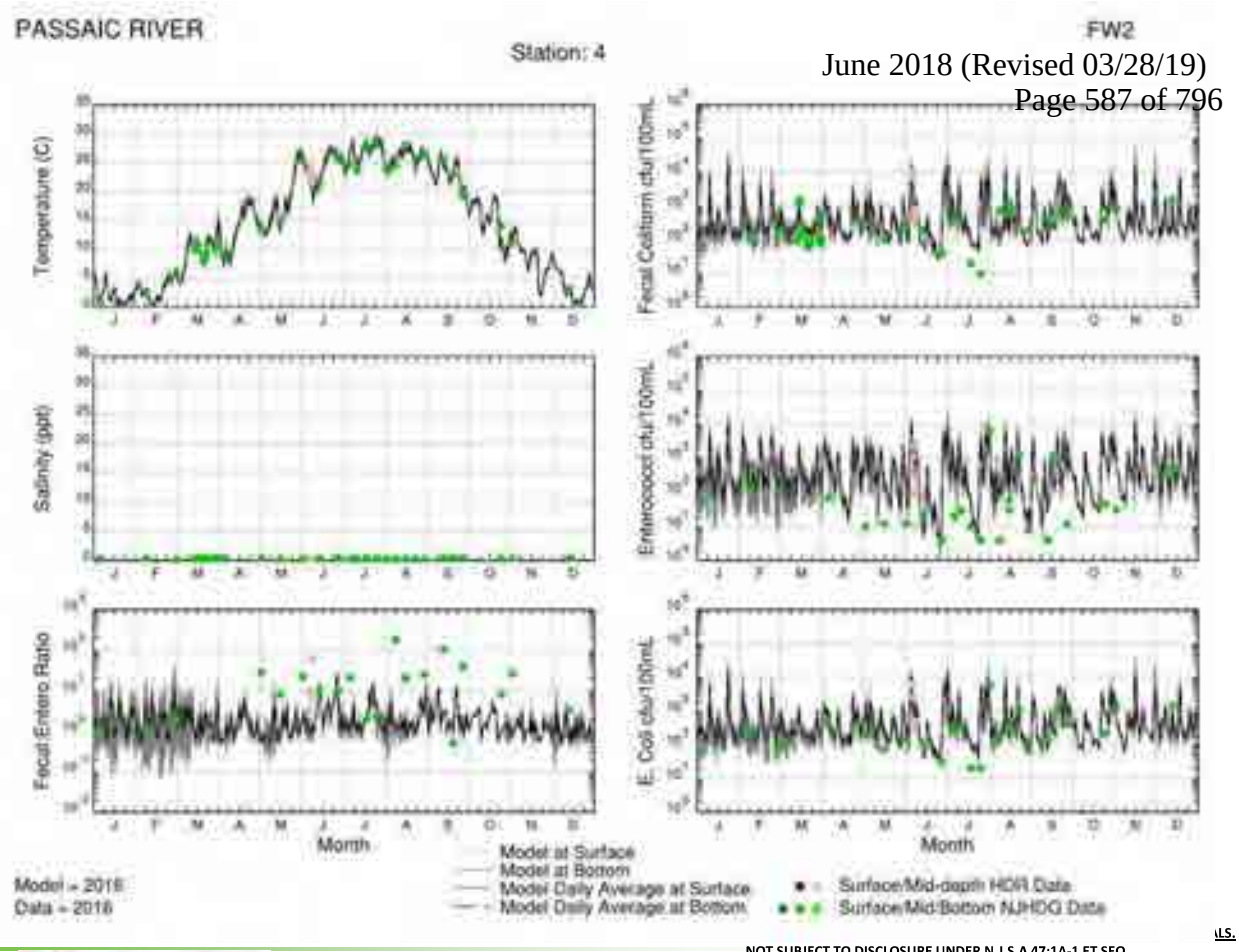
Fig. 1 – Patterns found in data on E. coli inactivation in waters.

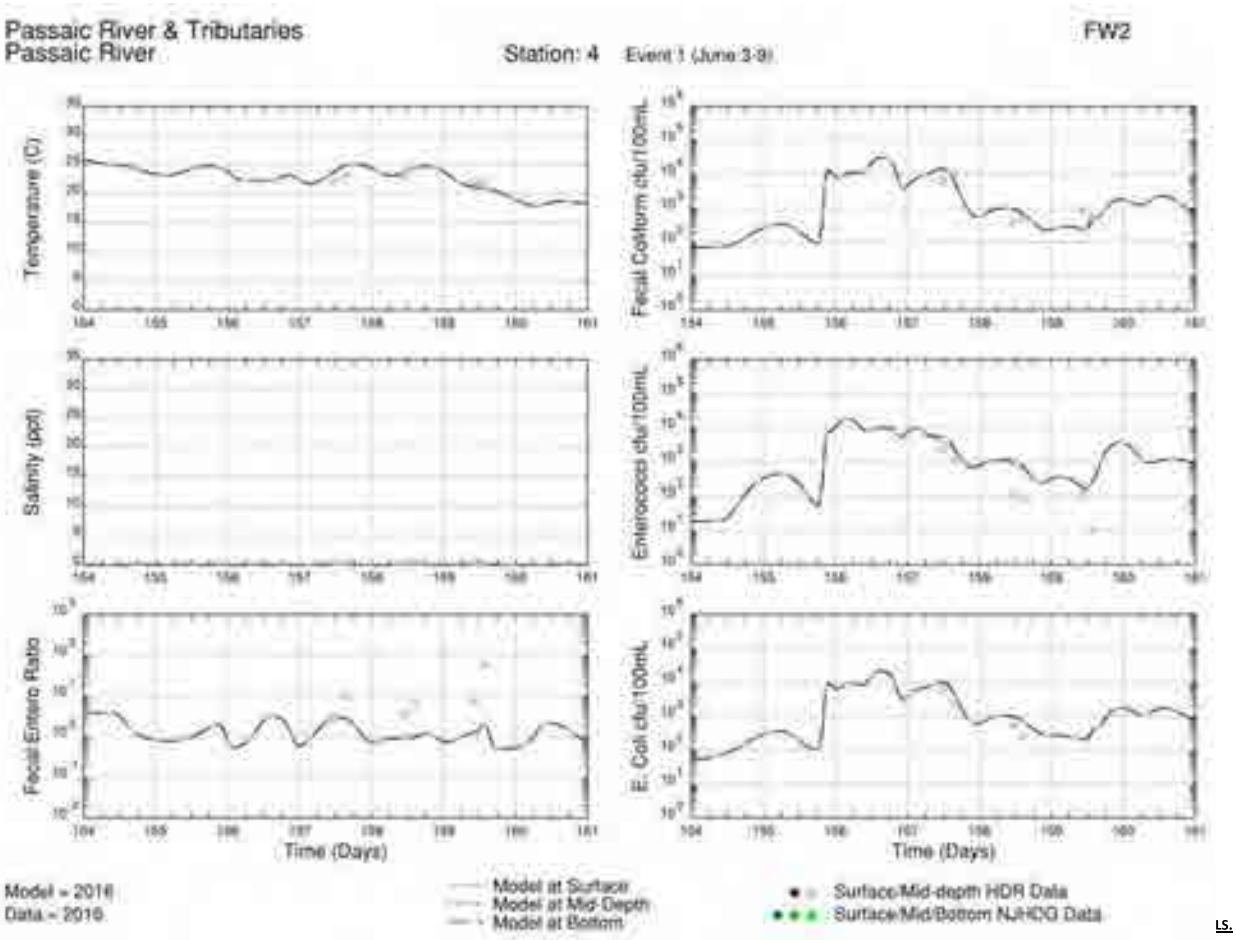
Blaustein et al., 2013

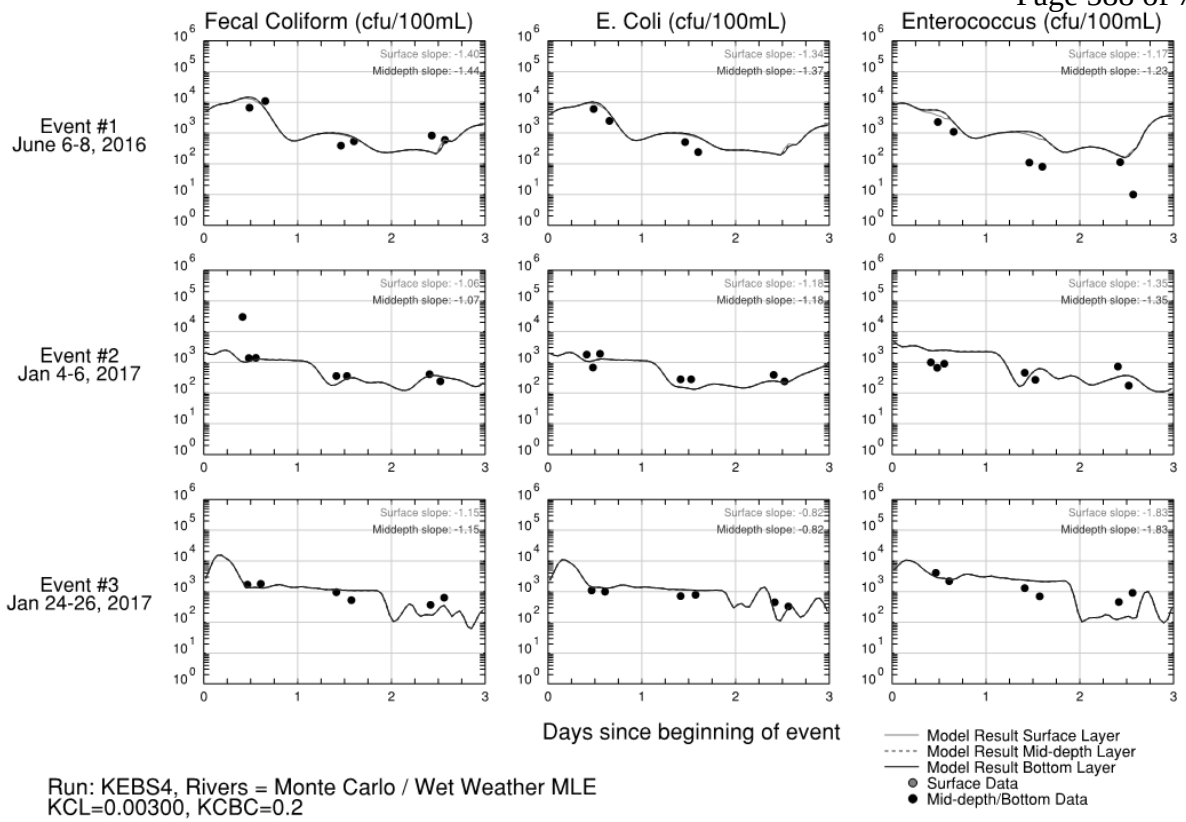
Receiving Water Sampling Locations



Model Calibration







Run: KEBS4, Rivers = Monte Carlo / Wet Weather MLE
KCL=0.00300, KCBC=0.2

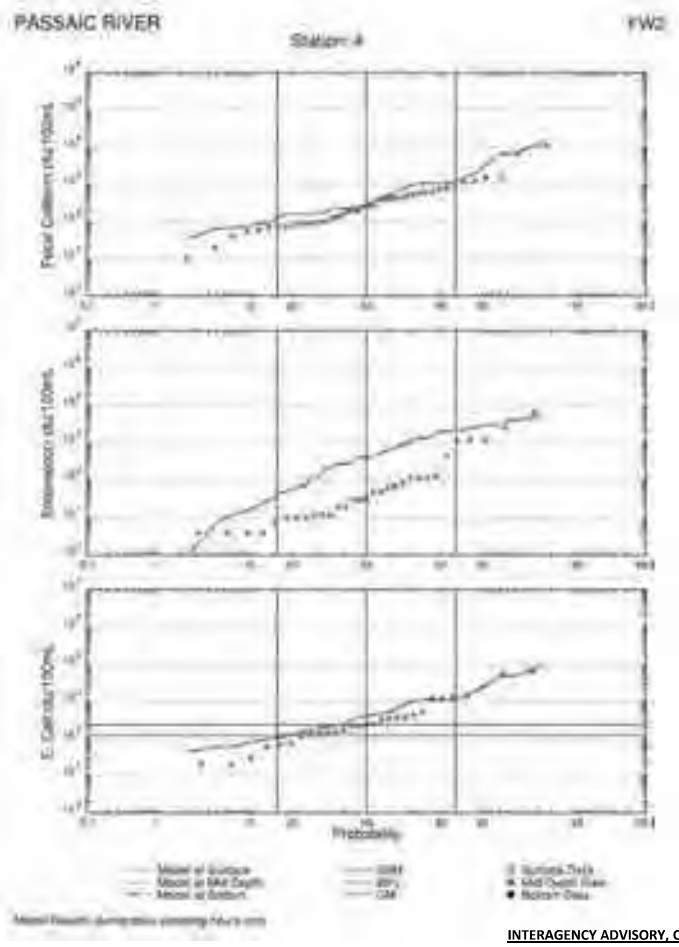
NJ Pathogen Criteria

- Primary Contact Recreation:
  - Enterococci levels shall not exceed a geometric mean of **35/100 ml**, or a single sample maximum of **104/100 ml**. (SE1 and SC)
    - Hackensack R. (upper), Hudson R. (north of Harlem R.), Raritan R., Raritan Bay
  - E. coli levels shall not exceed a geometric mean of **126/100 ml** or a single sample maximum of **235/100 ml**. (All FW2)
    - Elizabeth R., Passaic R., Raritan R.

- Secondary Contact Recreation:
  - Fecal coliform levels shall not exceed a geometric mean of **770/100 ml**. (SE2)
    - Arthur Kill (lower), Hackensack R. (mid), Hudson R., Passaic R. (mid), Rahway R.
  - Fecal coliform levels shall not exceed a geometric mean of **1500/100ml**. (SE3)
    - Arthur Kill (upper), Elizabeth R., Hackensack R. (lower), Kill Van Kull, Newark Bay, Passaic R. (lower)

NJ Pathogen Criteria

The Department shall **utilize a geometric mean to assess compliance** with the bacterial quality indicators at N.J.A.C.7:9B-1.14(d)1ii-iii. The geometric mean shall be calculated using a minimum of five samples collected over a thirty-day period. The **single sample maximum shall be used for beach notification** in accordance with N.J.A.C. 8:26 and to identify where additional ambient water quality sampling is needed to calculate a geometric mean.



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Assessment of Model's Ability to Calculate Attainment

- Passaic River – GM Criterion – Mid-depth
- Do Data and Model Exceed Criterion (Using imaginary 30-day period)?

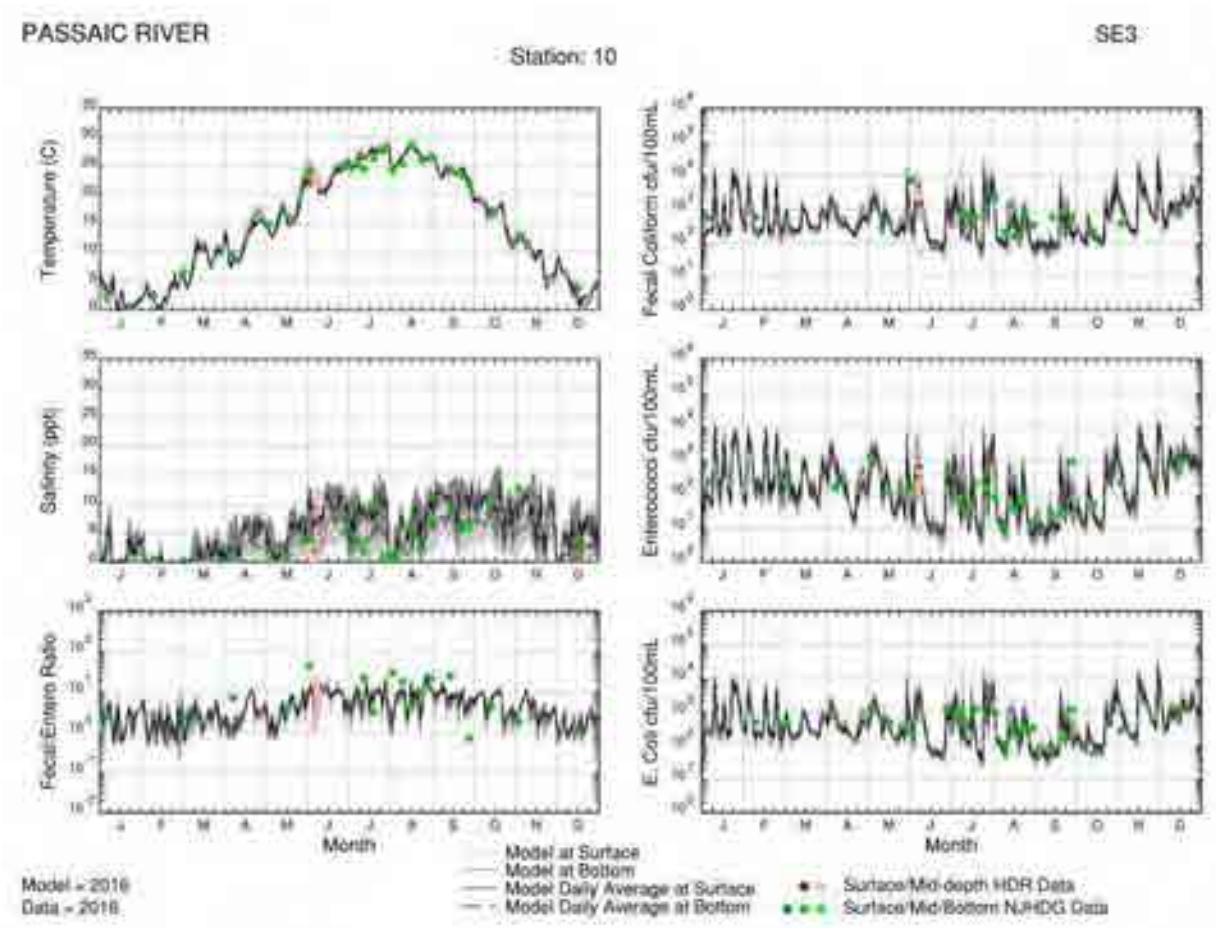
Station	Class	Criterion	2016 Data	2016 Model	2017 Data	2017 Model
B24	FW2	126	**Y**	**Y**	**Y**	**Y**
2	FW2	126	**Y**	**Y**	-	-
3	FW2	126	**Y**	**Y**	**Y**	**Y**
B22	FW2	126	**Y**	**Y**	-	-
4	FW2	126	**Y**	**Y**	**Y**	**Y**
5	FW2	126	**Y**	**Y**	**Y**	**Y**
7	FW2-SE2	126	**Y**	**Y**	**Y**	**Y**
8	FW2-SE2	126	**Y**	**Y**	**Y**	**Y**

Assessment of Model's Ability to Calculate Attainment

- Passaic River – SSM Criterion – Mid-depth
- Percent of Time Data and Model Exceed Criterion (Using imaginary 30-day period)

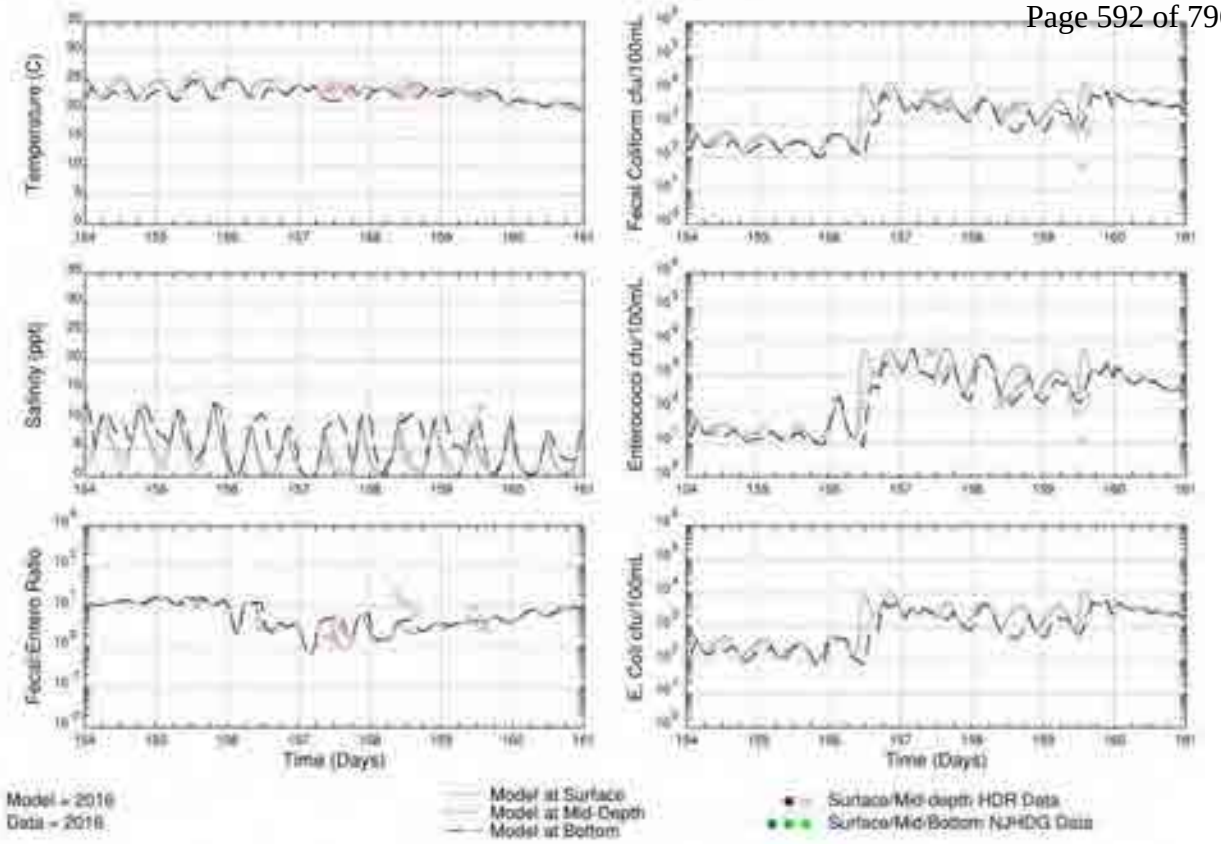
Station	Class	Criterion	2016 Data	2016 Model	**diff**	2017 Data	2017 Model	**diff**
B24	FW2	235	33.1	47.8	**14.7**	73.8	59.6	**14.2**
2	FW2	235	46.5	59.0	**12.5**	NA	NA	
3	FW2	235	70.4	37.7	**32.7**	67.8	56.1	**11.7**
B22	FW2	235	53.0	38.0	**15.0**	NA	NA	
4	FW2	235	50.6	60.7	**10.1**	61.9	42.1	**19.8**
5	FW2	235	44.0	49.7	**5.7**	46.8	30.5	**16.3**
7	FW2-SE2	235	80.5	75.0	**5.5**	88.1	55.1	**33.0**
8	FW2-SE2	235	77.1	79.2	**2.1**	91.9	62.5	**29.4**

Model Calibration



Passaic River & Tributaries
Passaic River

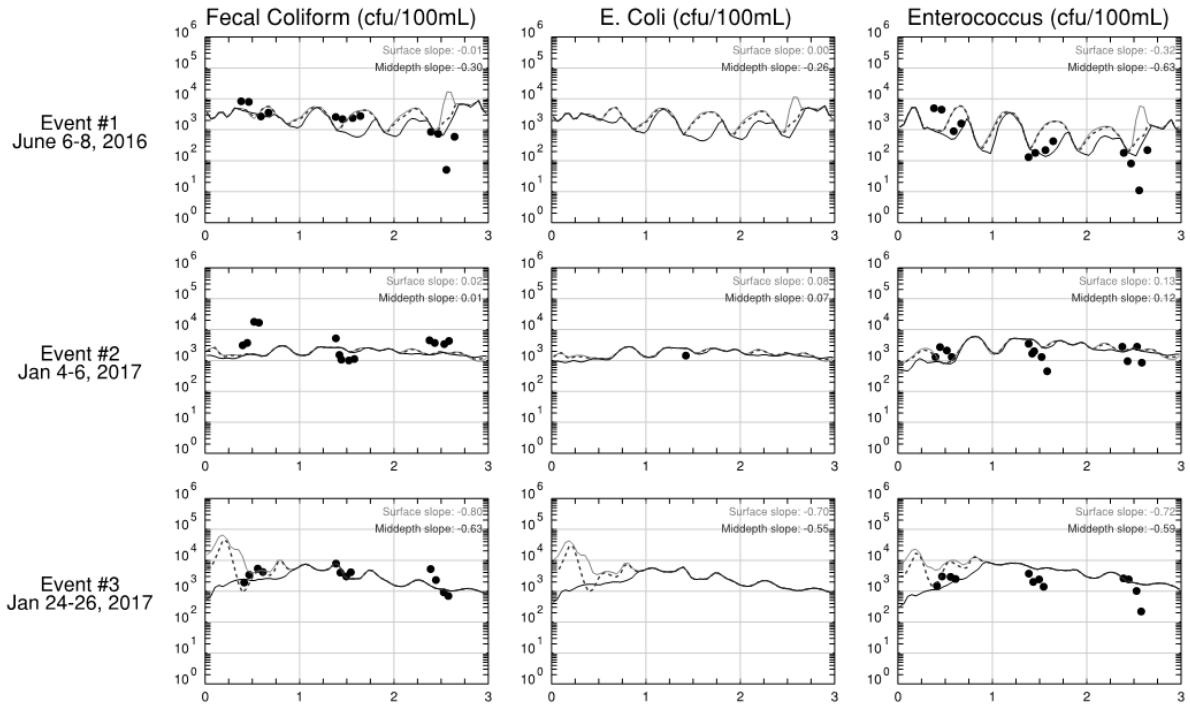
Station: 10 Event 1 (June 3-9)



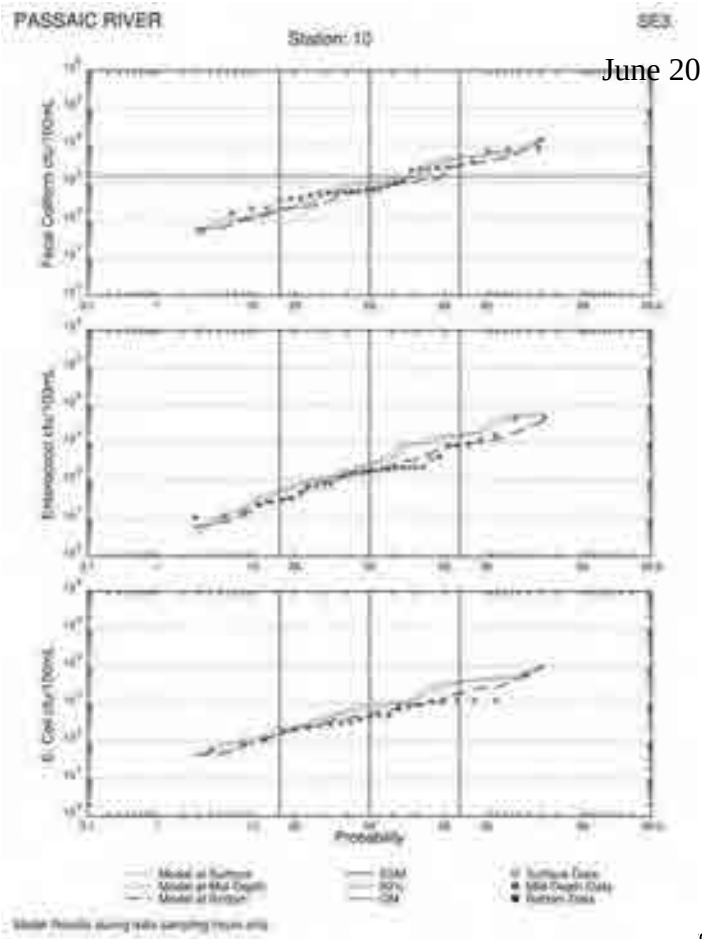
Passaic River & Tributaries
Passaic River

SE3

Station: 10



Run: KEBS4, Rivers = Monte Carlo / Wet Weather MLE
KCL=0.00300, KCBC=0.2

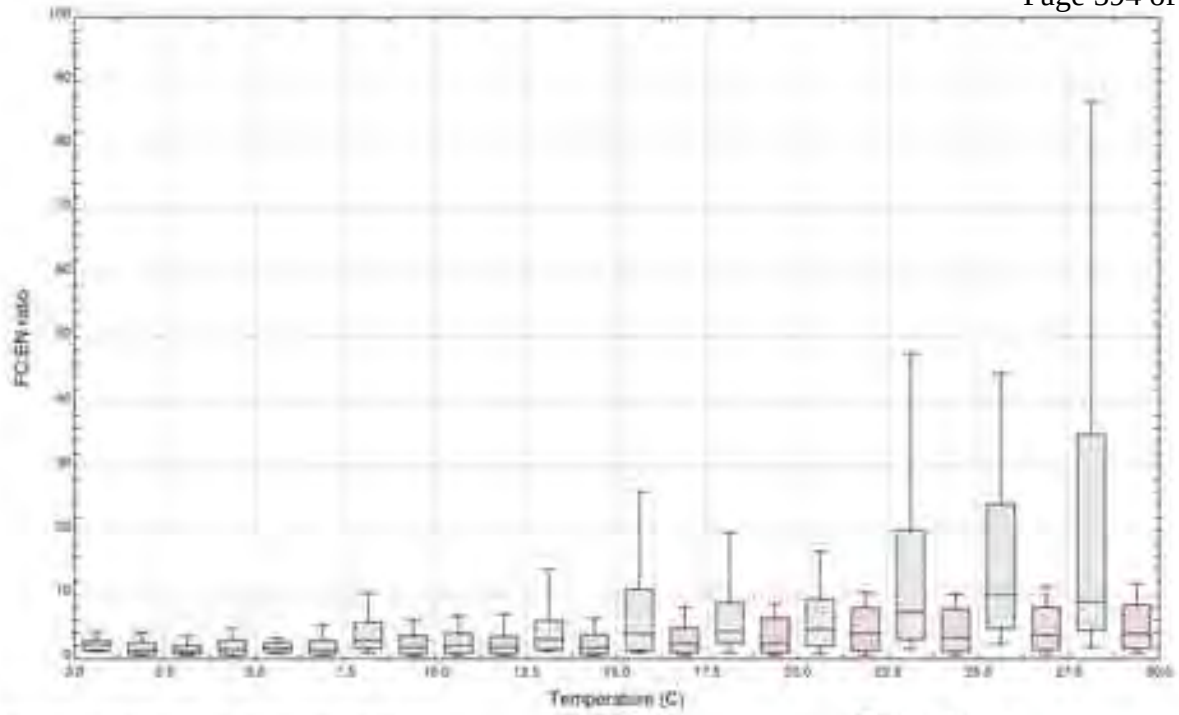


Assessment of Model's Ability to Calculate Attainment

- Passaic River – GM Criterion – Mid-depth
- Do Data and Model Exceed Criterion (Using imaginary 30-day period)?

Station	Class	Criterion	2016 Data	2016 Model	2017 Data	2017 Model
7	FW2-SE2	770	Y	N (49)	N	N
8	FW2-SE2	770	N	Y	Y	Y
10	SE3	1500	N	N	Y	N (49)
11	SE3	1500	N	N	-	-
B6	SE3	1500	N	N	Y	Y
12	SE3	1500	-	-	-	-

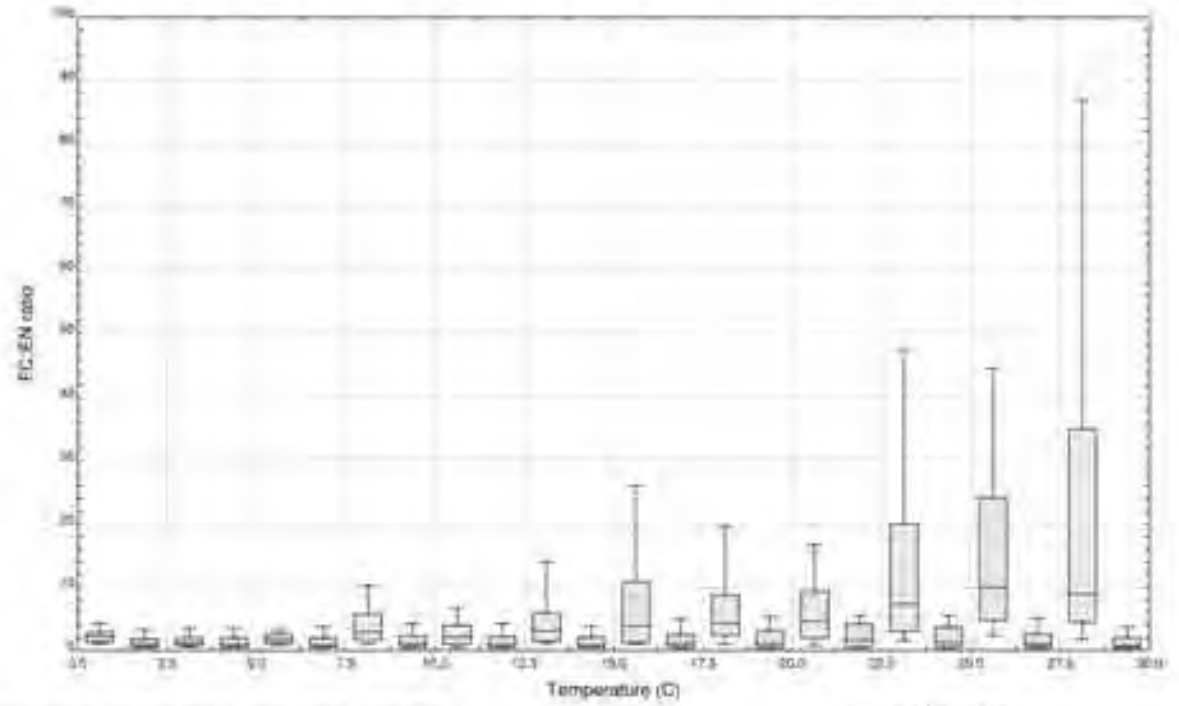
Passaic River & Tributaries
2016 / 2017



Run: KEBS4, Rivers + Monte Carlo / Wet Weather MLE
KCL=0.00300, KCBC=0.2

plots show 10, 25, 50, 75, 90 percentiles

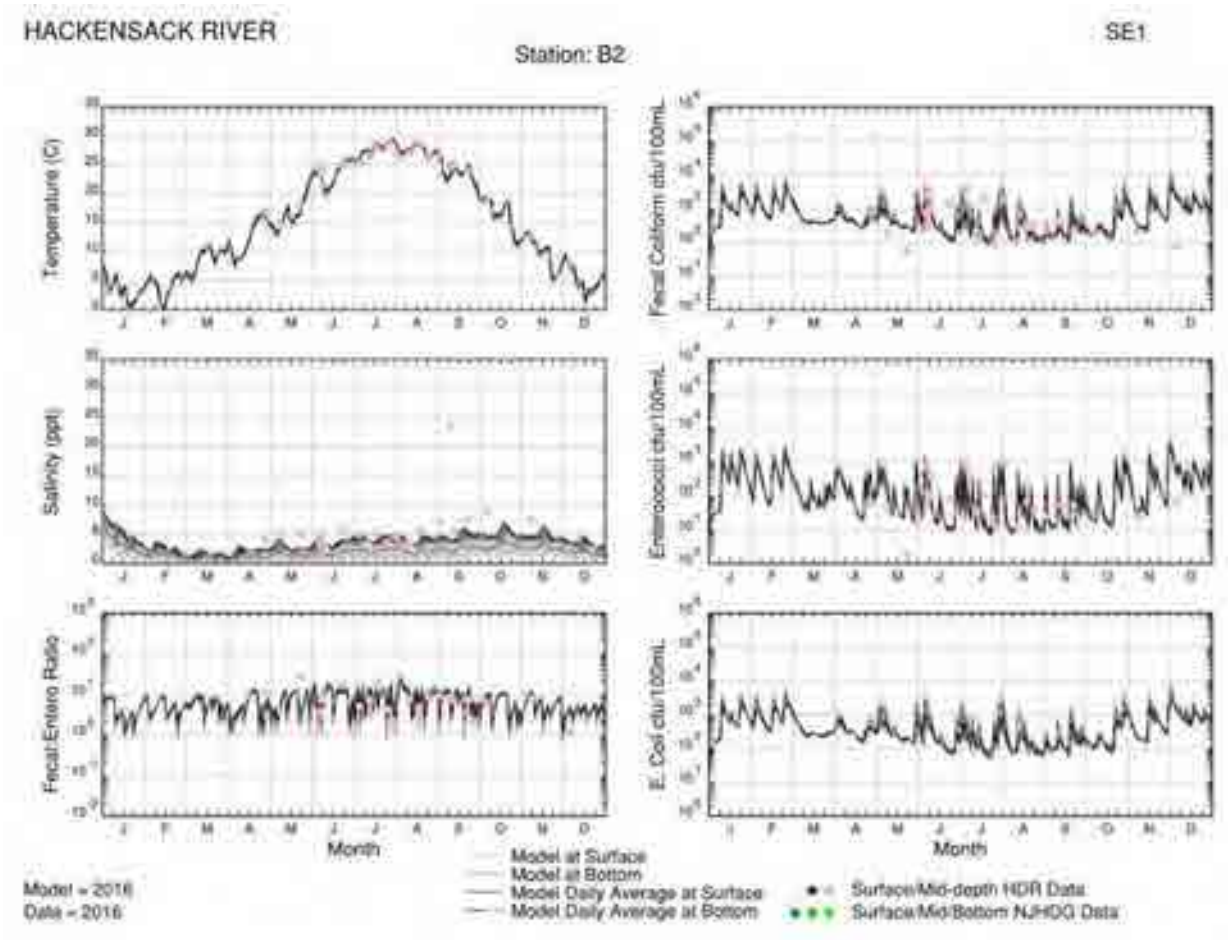
Passaic River & Tributaries
2016 / 2017



Run: KEBS4, Rivers + Monte Carlo / Wet Weather MLE
KCL=0.00824, KCBC=0.8

plots show 10, 25, 50, 75, 90 percentiles

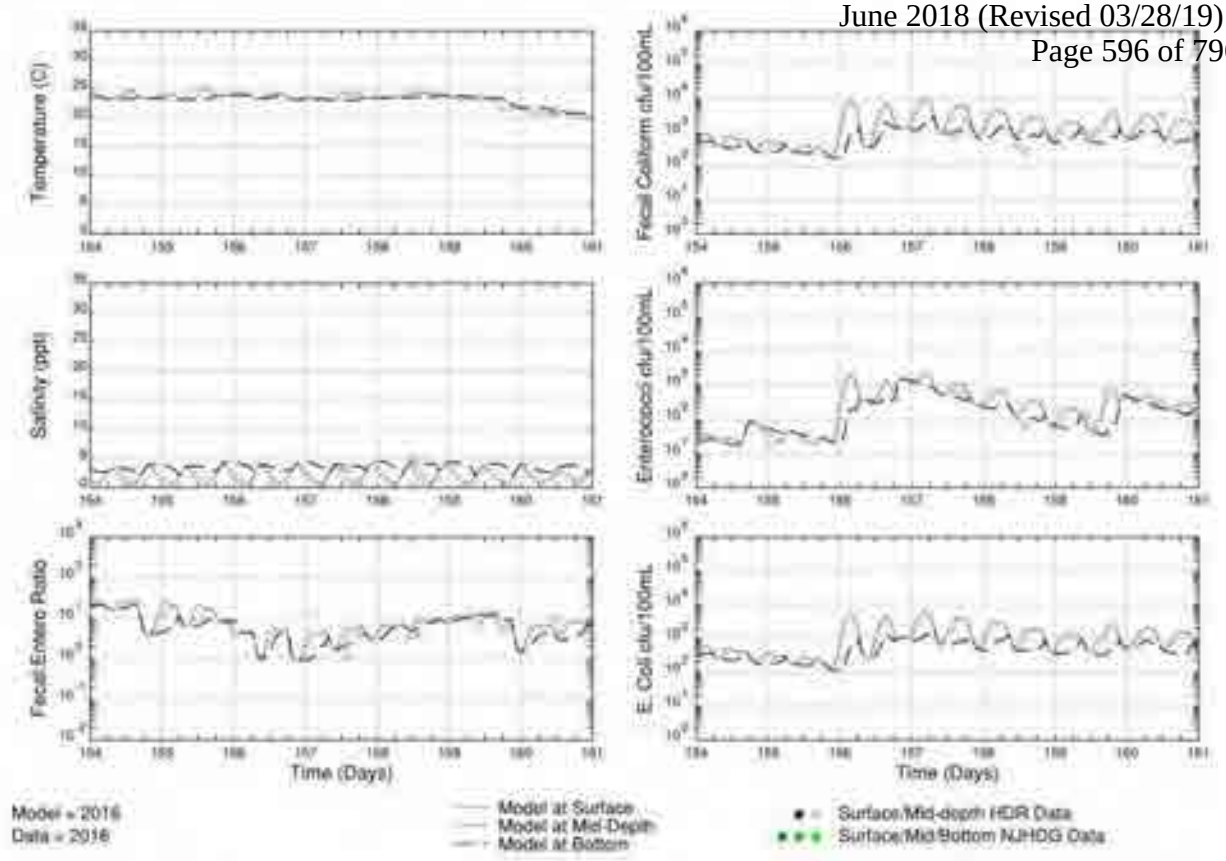
Model Calibration



Hackensack River & Tributaries
Hackensack River

Station: B2 Event 1 (June 3-9)

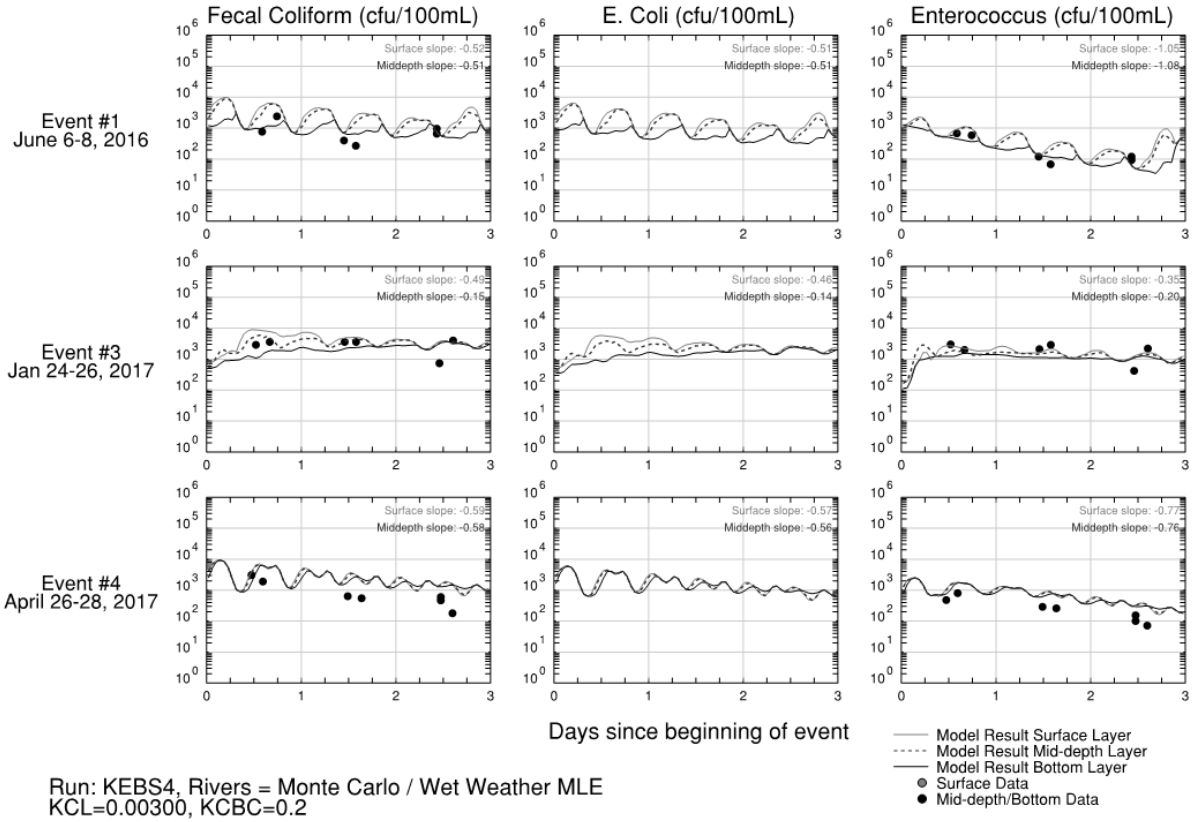
SE1



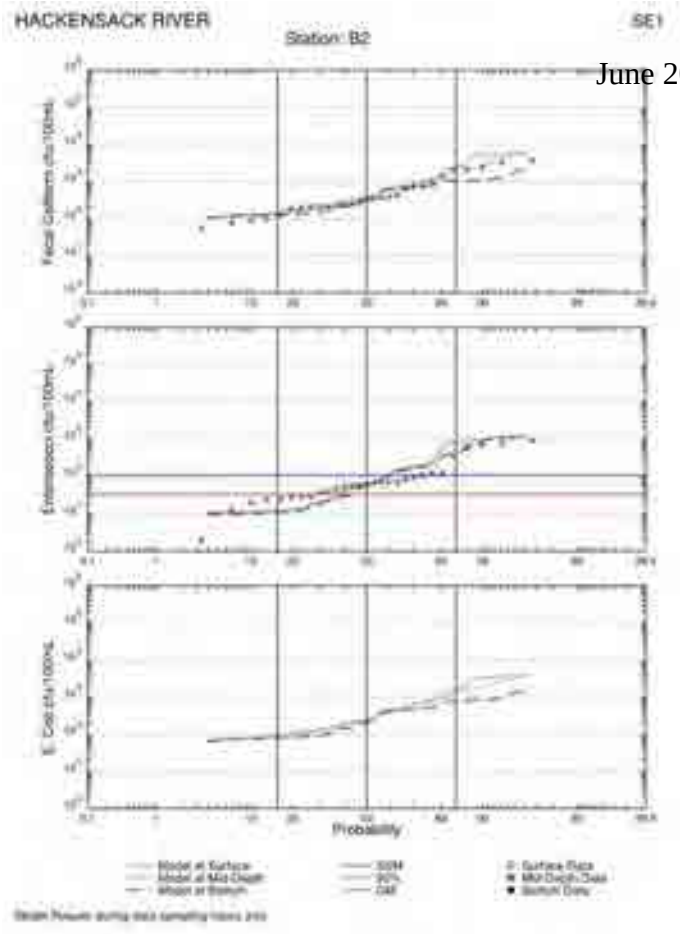
Hackensack River & Tributaries
Hackensack River

Station: B2

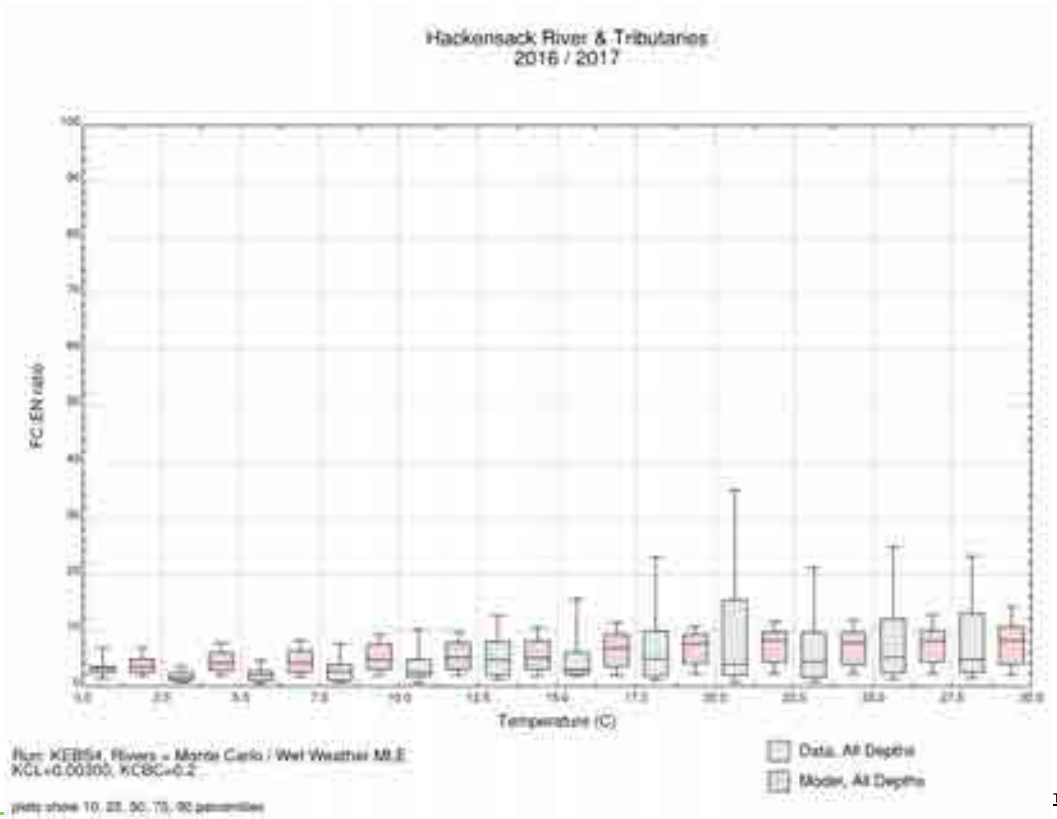
SE1



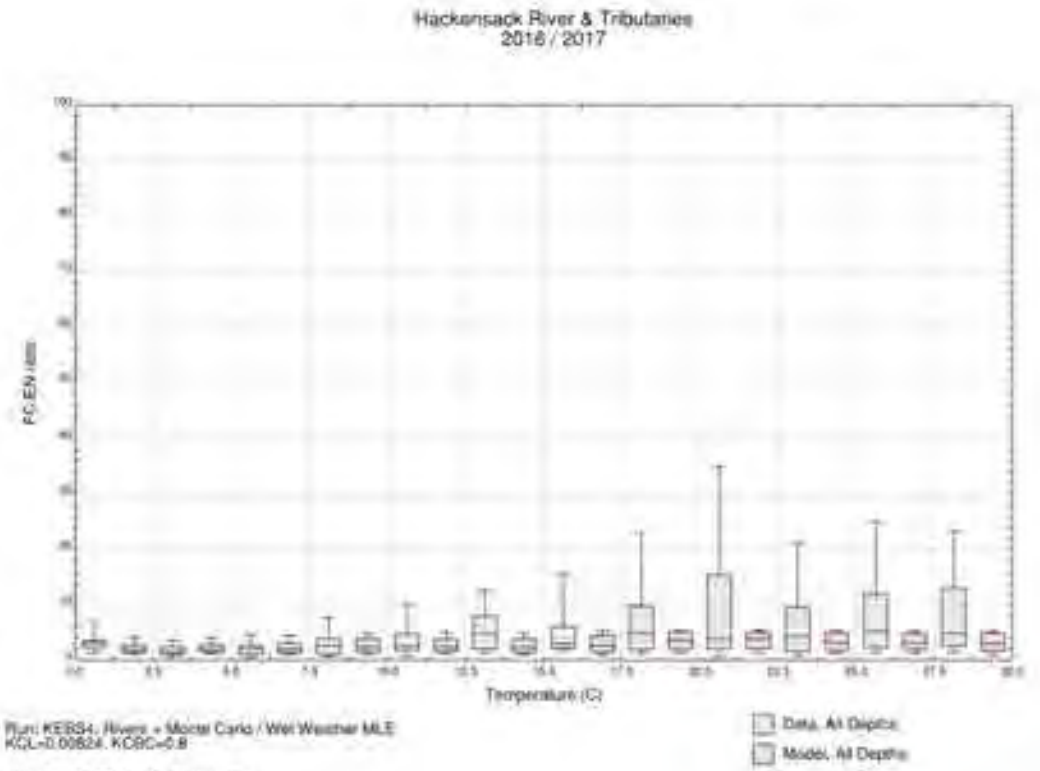
Run: KEBS4, Rivers = Monte Carlo / Wet Weather MLE
KCL=0.00300, KCBC=0.2



Model Calibration



Model Calibration

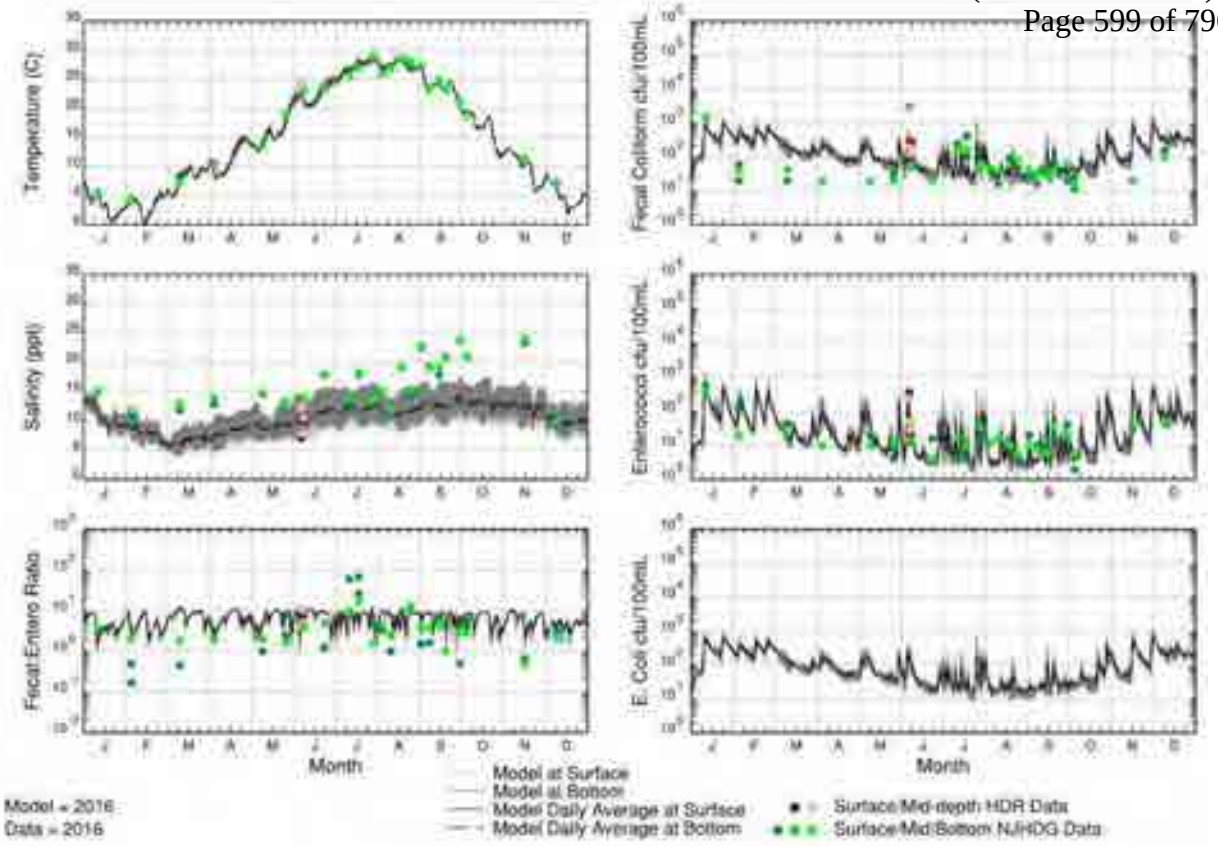


Model Calibration

HACKENSACK RIVER

SE2

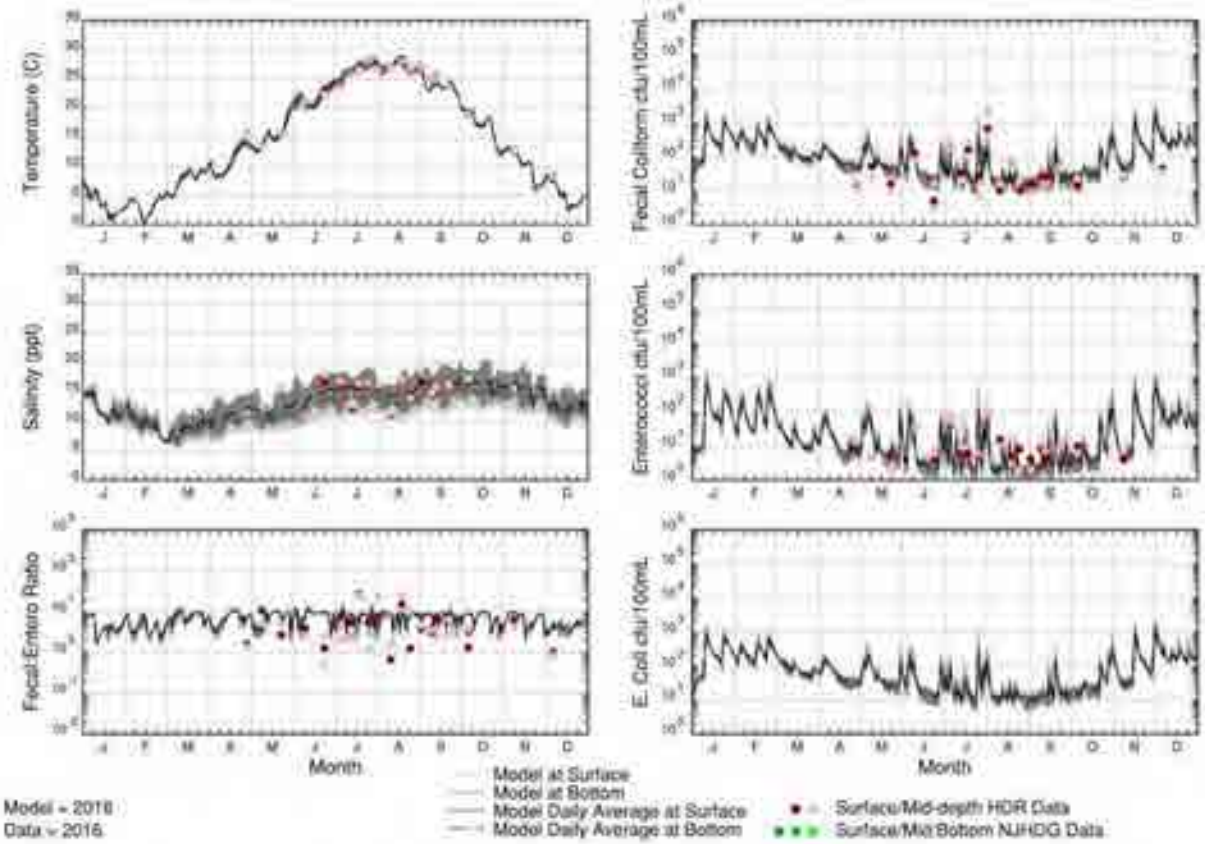
Station: 14



HACKENSACK RIVER

SE2

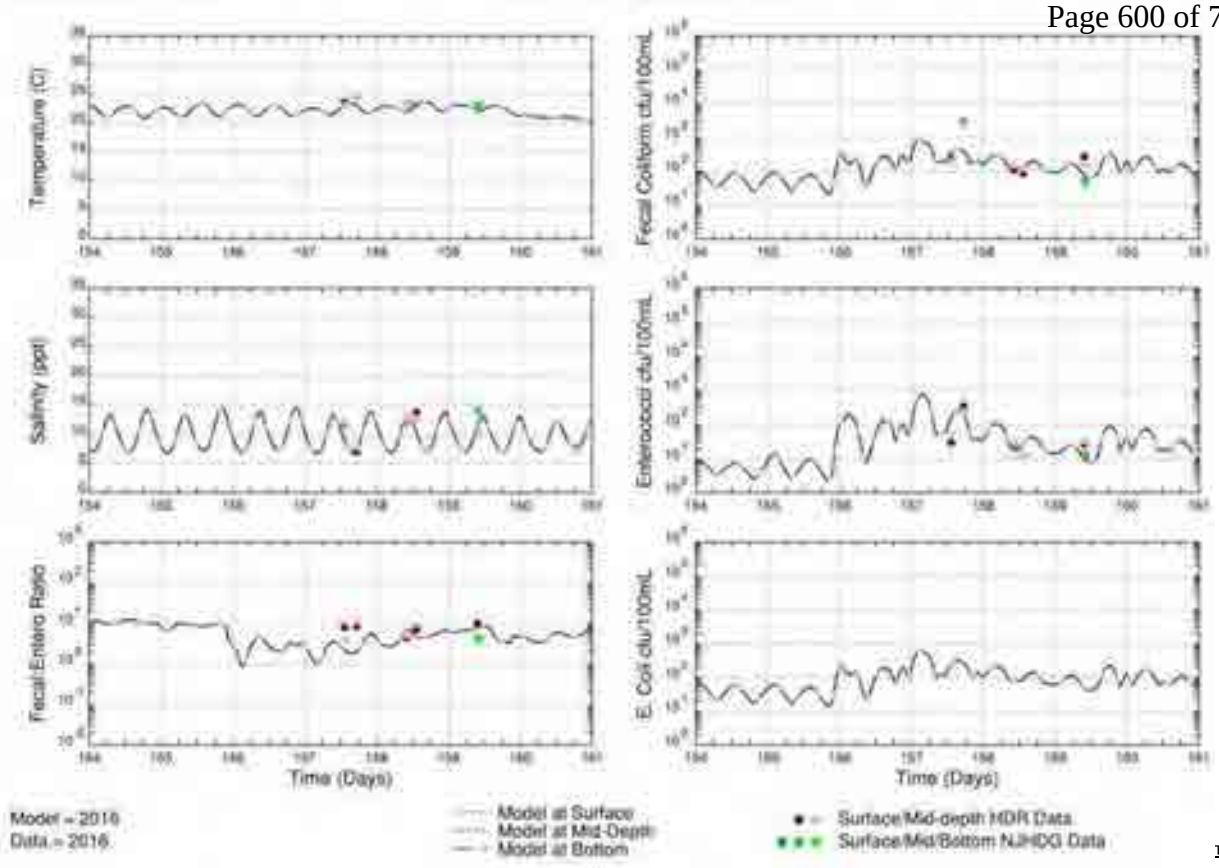
Station: B7



Hackensack River & Tributaries
Hackensack River

Station: 14 Event 1 (June 3-8)

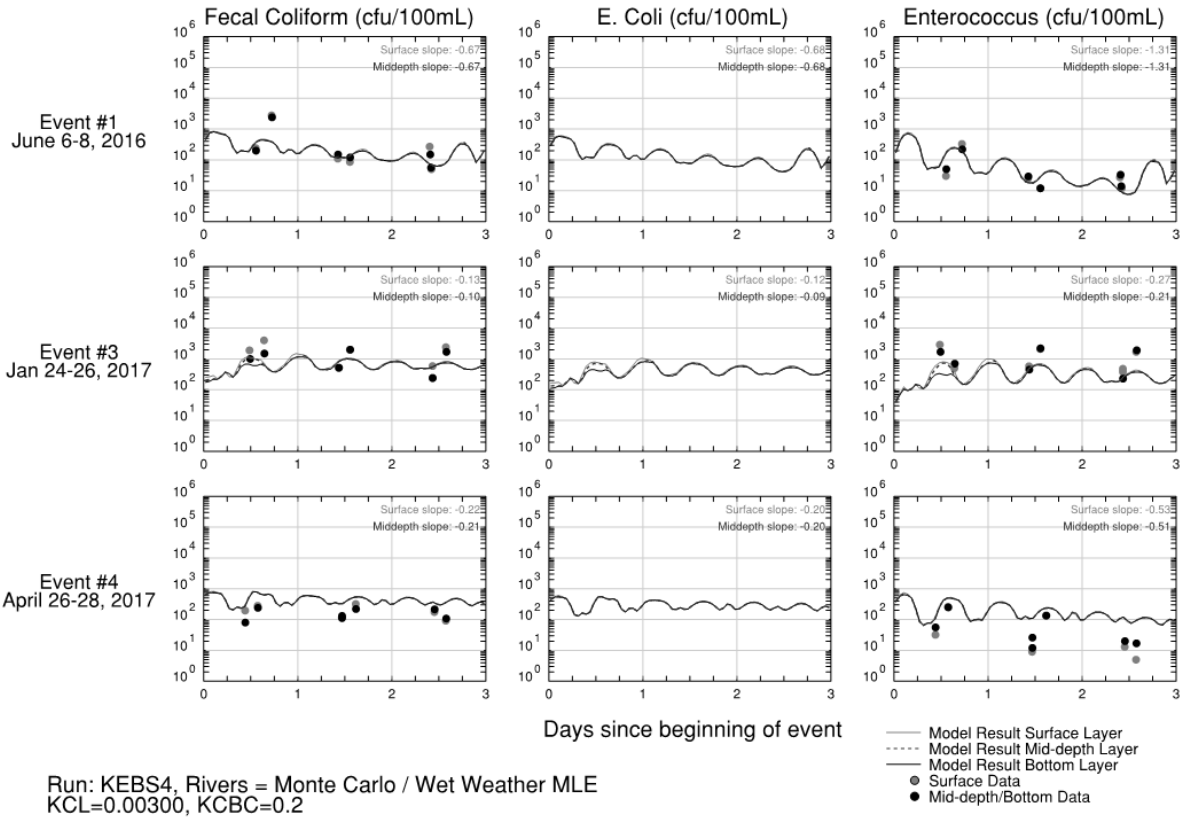
SE2



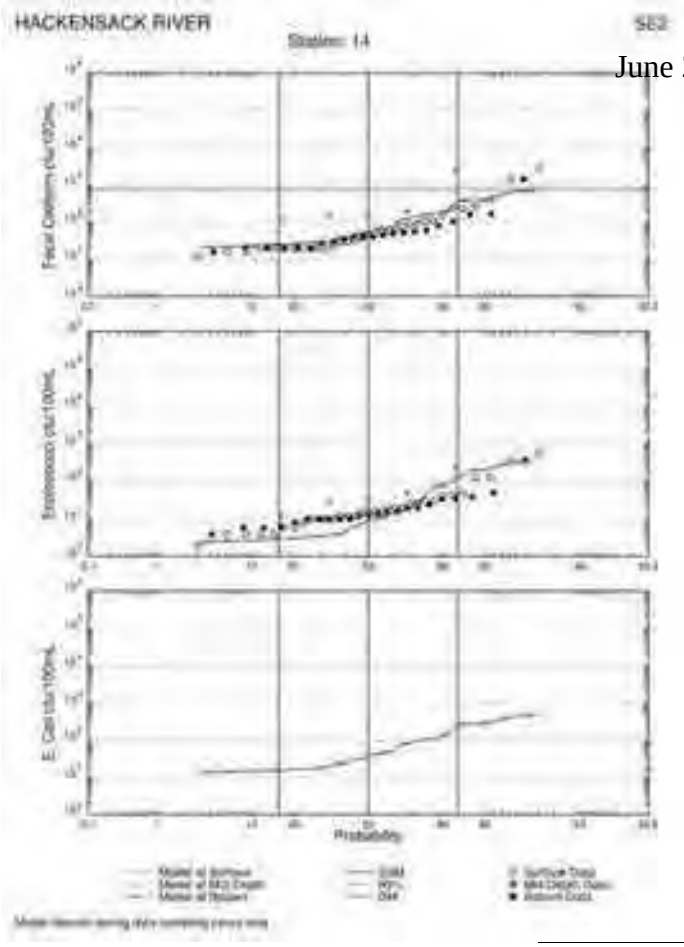
Hackensack River & Tributaries
Hackensack River

Station: 14

SE2



Run: KEBS4, Rivers = Monte Carlo / Wet Weather MLE
KCL=0.00300, KCBC=0.2

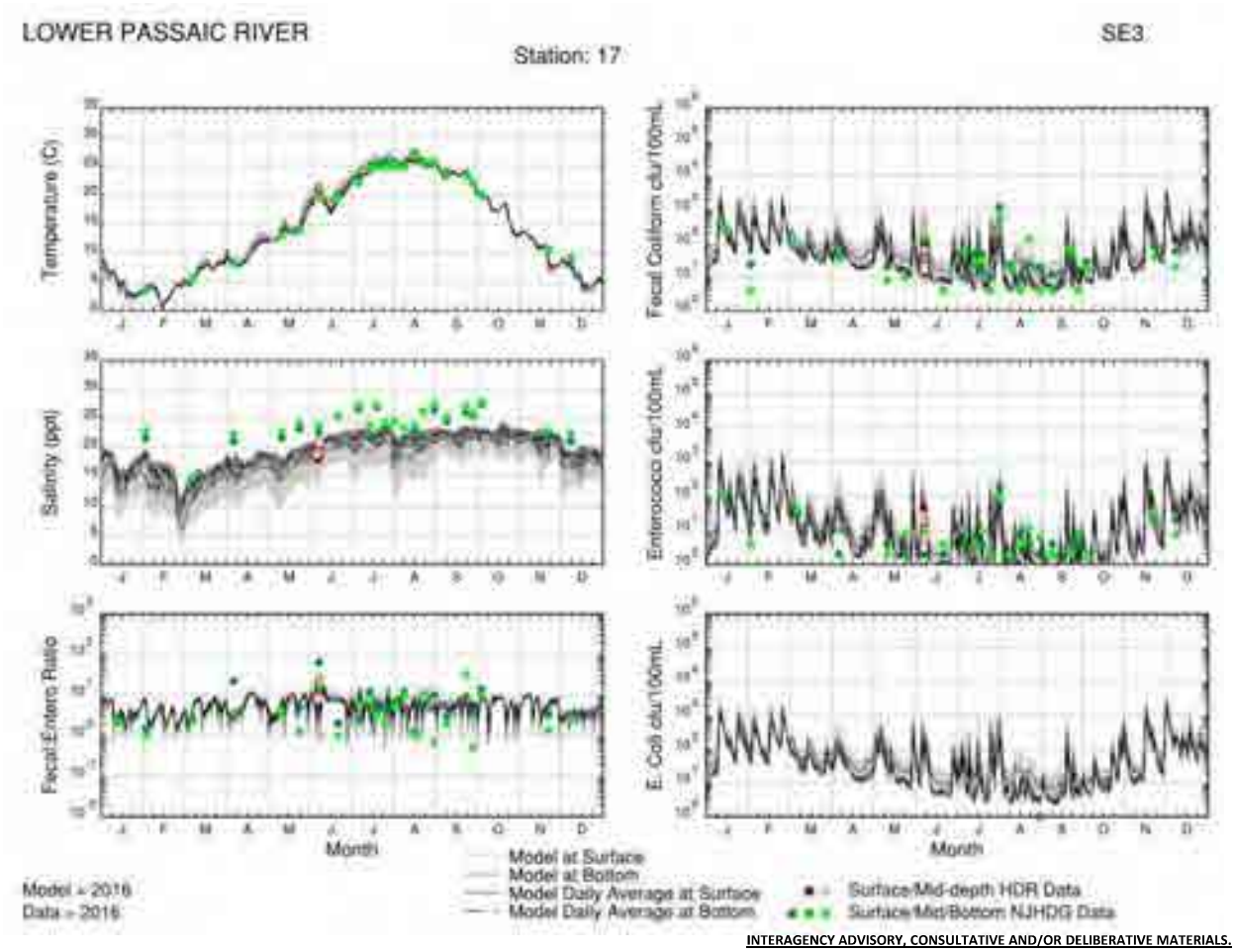


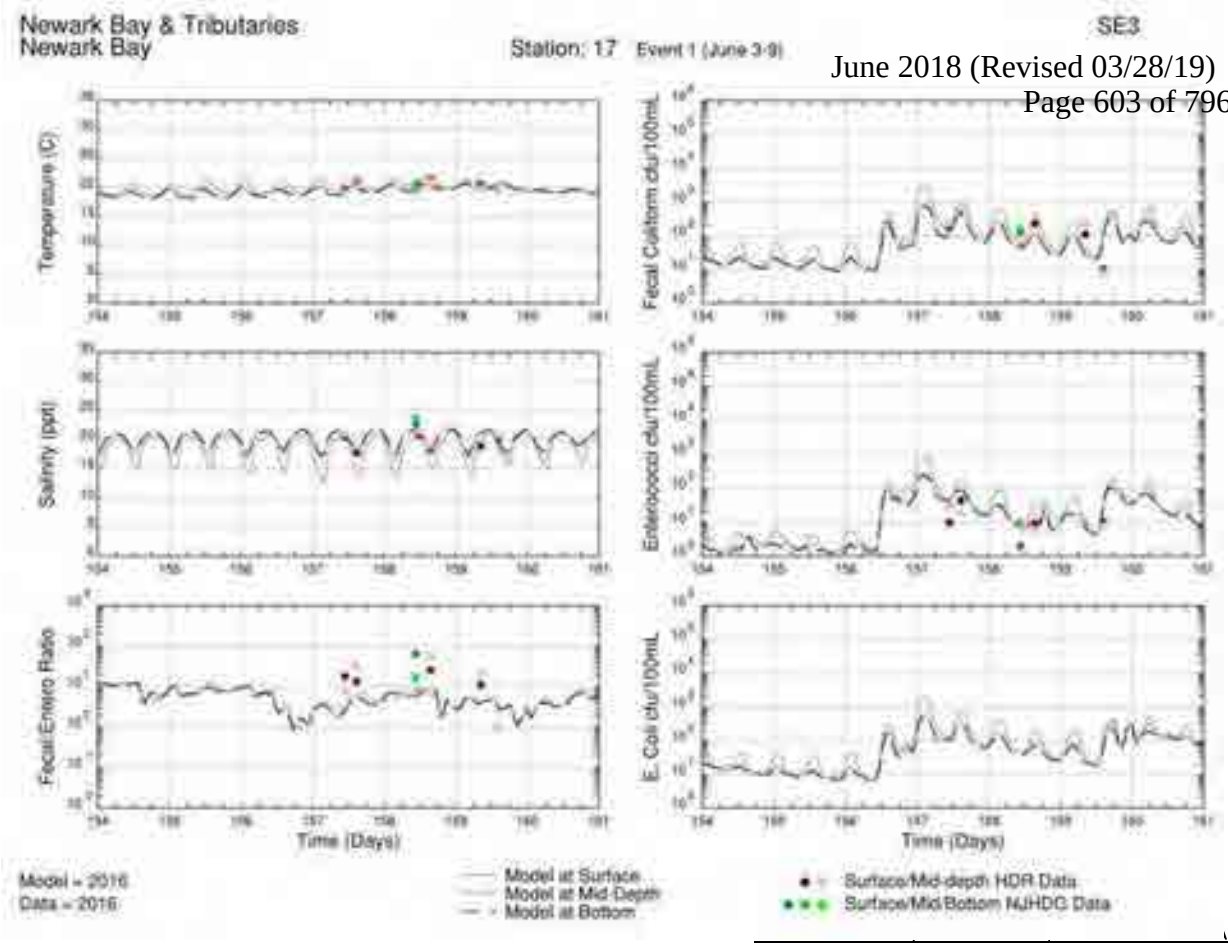
Assessment of Model's Ability to Calculate Attainment

- Hackensack River – GM Criterion – Mid-depth
- Do Data and Model Exceed Criterion (Using imaginary 30-day period)?

Station	Class	Criterion	2016 Data	2016 Model	2017 Data	2017 Model
13	SE1	35	N	N	N	N
B1	SE1	35	Y	Y	Y	Y
B2	SE1	35	Y	Y	Y	Y
B11	SE2	770	N	N	-	-
B3	SE2	770	N	N	-	-
B4	SE2	770	N	N	-	-
14	SE2	770	-	-	N	N
B7	SE2	770	N	N	-	-
15	SE2	770	N	N	N	N
16	SE3	1500	-	-	-	-

Model Calibration

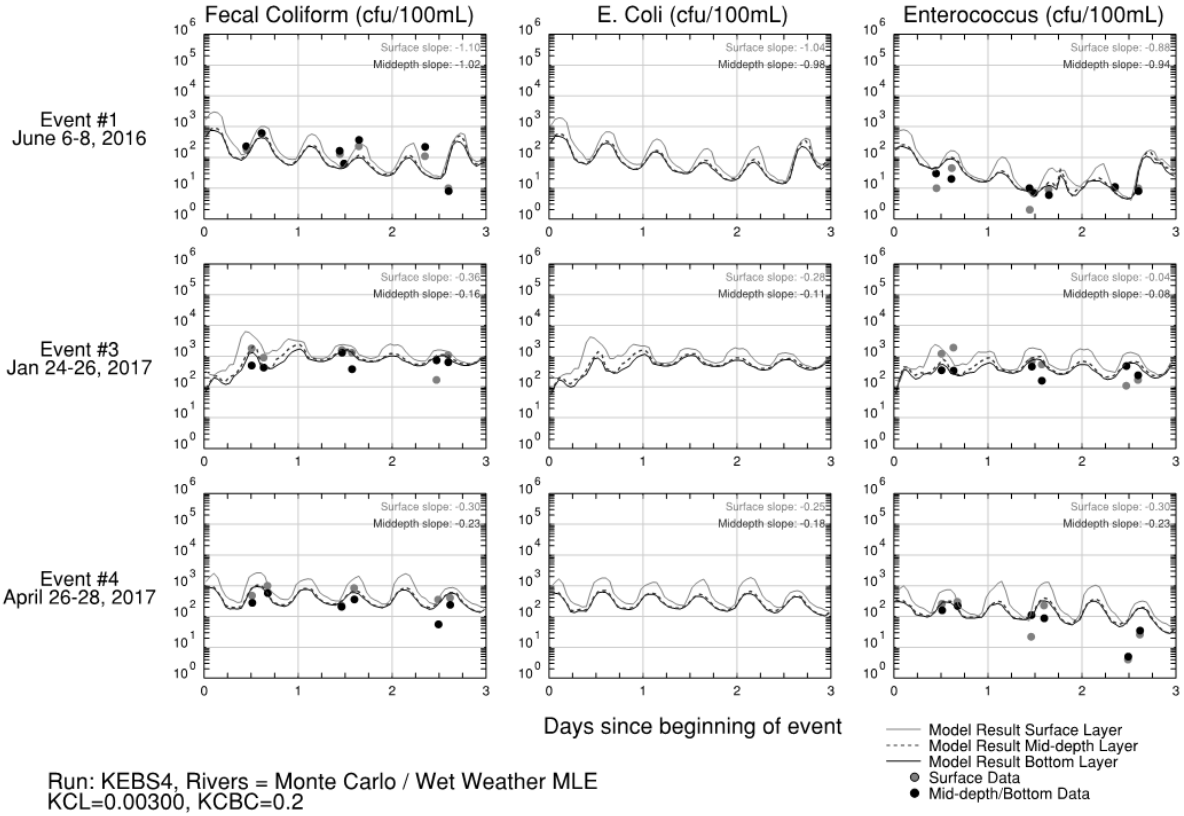




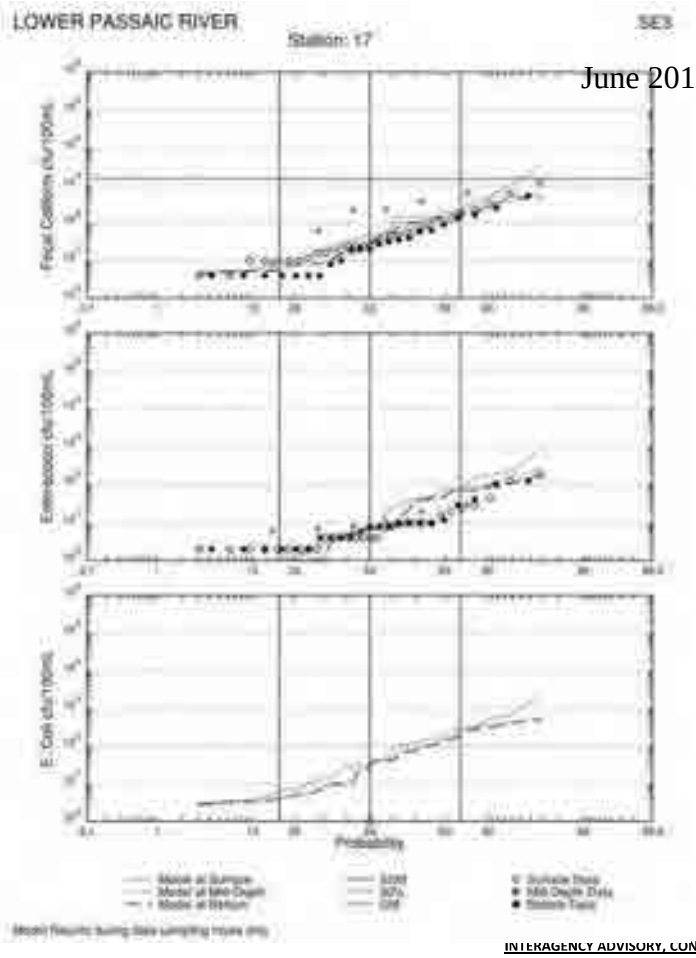
Newark Bay & Tributaries
Newark Bay

Station: 17

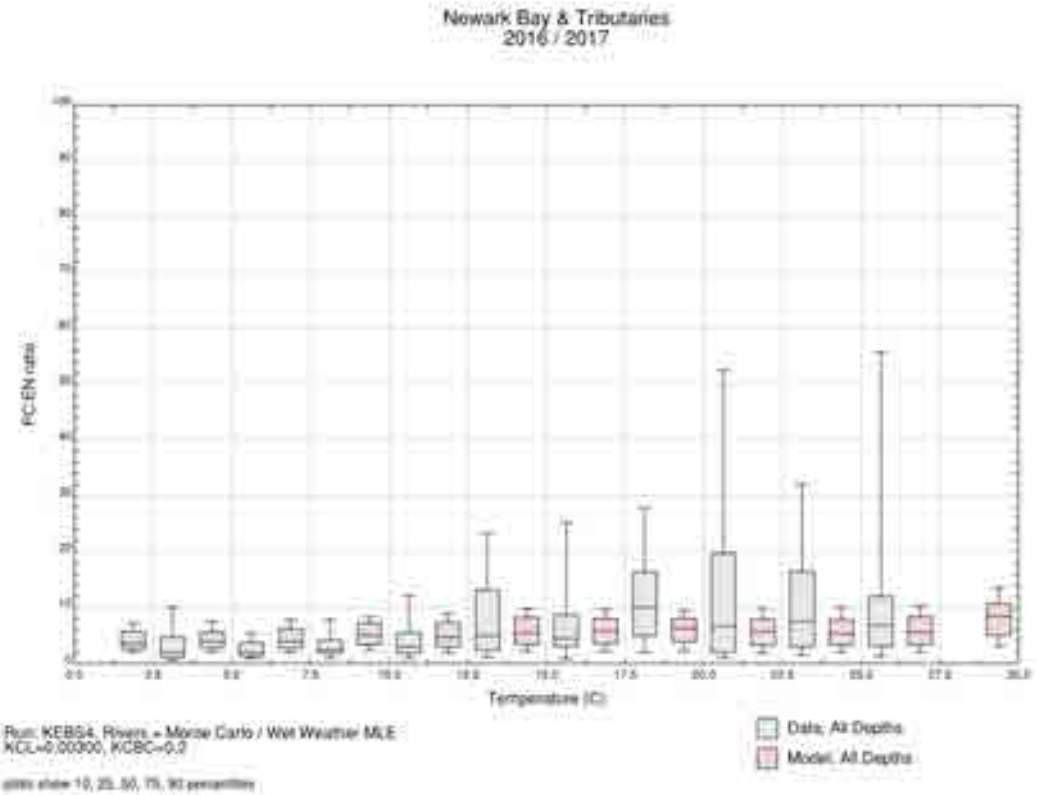
SE3



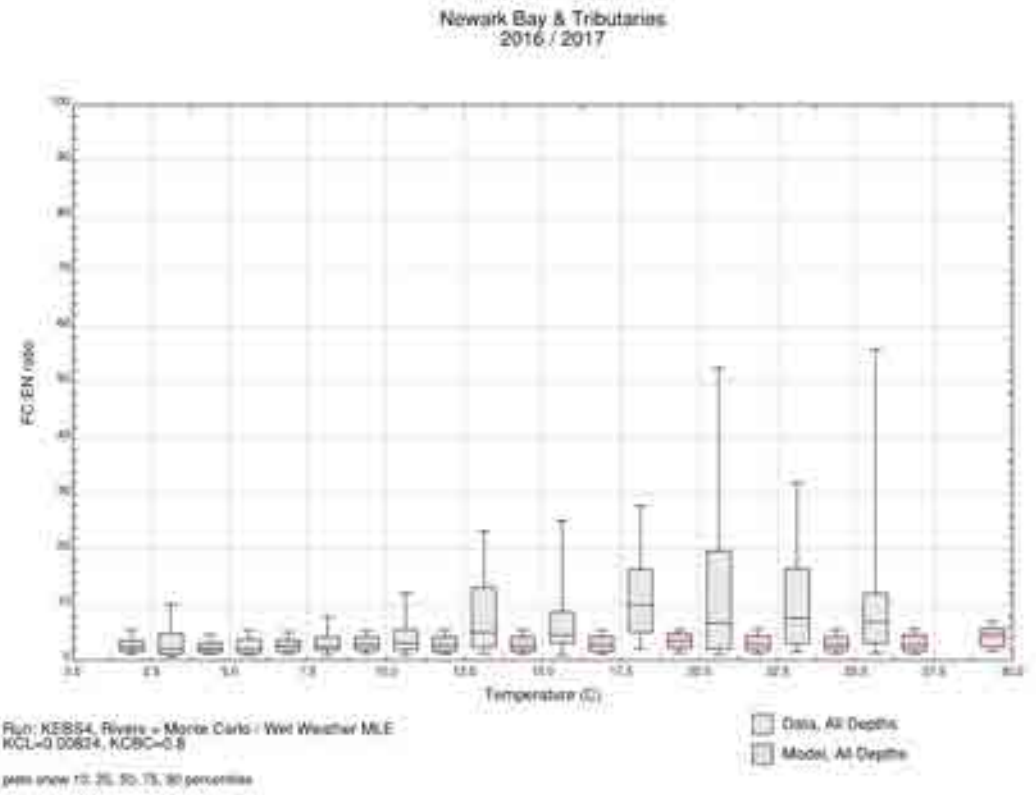
Run: KEBS4, Rivers = Monte Carlo / Wet Weather MLE
KCL=0.00300, KCBC=0.2



Model Calibration



Model Calibration

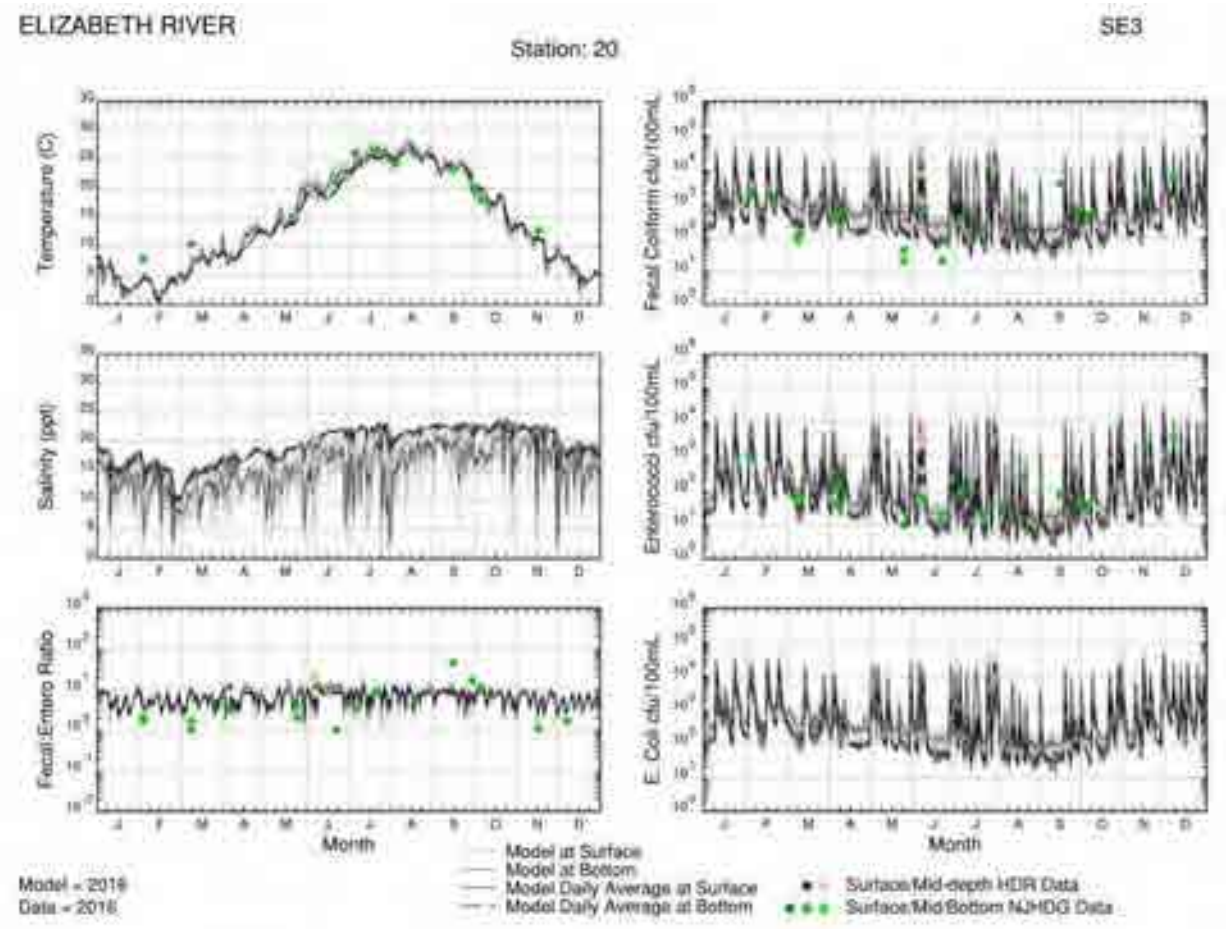


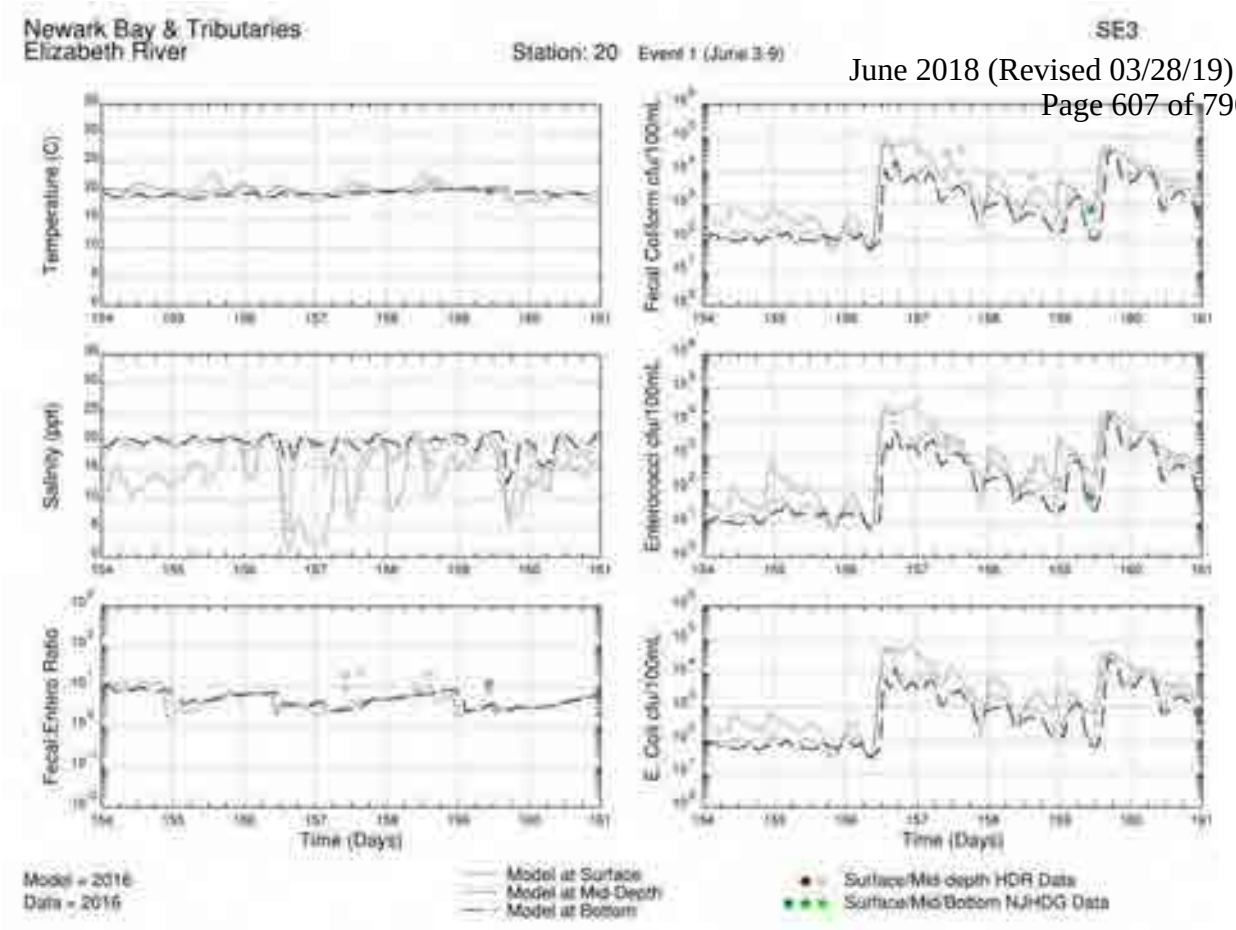
Assessment of Model's Ability to Calculate Attainment

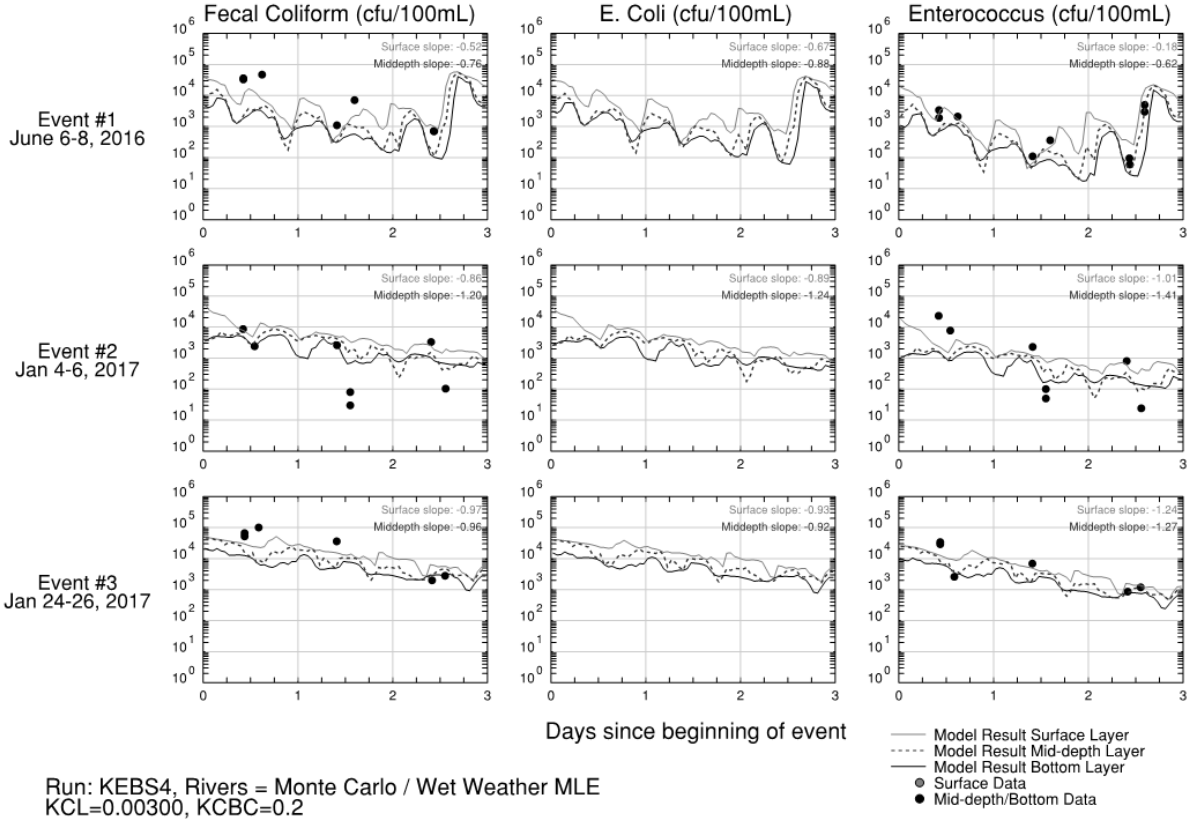
- Newark Bay – GM Criterion – Mid-depth
- Do Data and Model Exceed Criterion (Using imaginary 30-day period)?

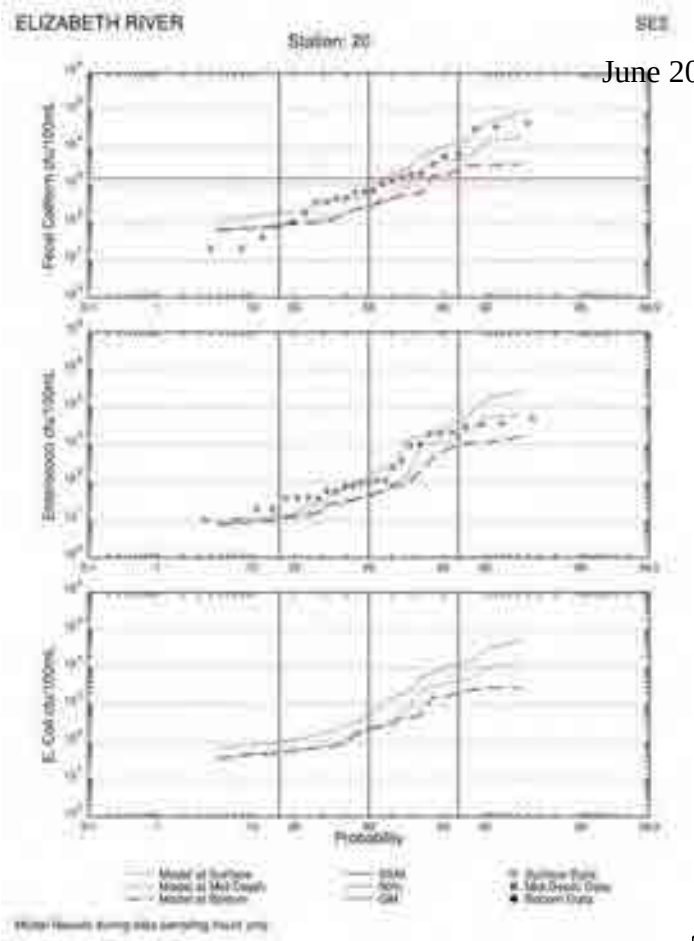
Station	Class	Criterion	2016 Data	2016 Model	2017 Data	2017 Model
17	SE3	1500	N	N	N	N
B10	SE3	1500	N	N	-	-
18	SE3	1500	N	N	N	N
B17	SE3	1500	-	-	-	-
19	SE3	1500	N	N	N	N

Model Calibration









Assessment of Model's Ability to Calculate Attainment

- Elizabeth River – GM Criterion – Mid-depth
- Do Data and Model Exceed Criterion (Using imaginary 30-day period)?

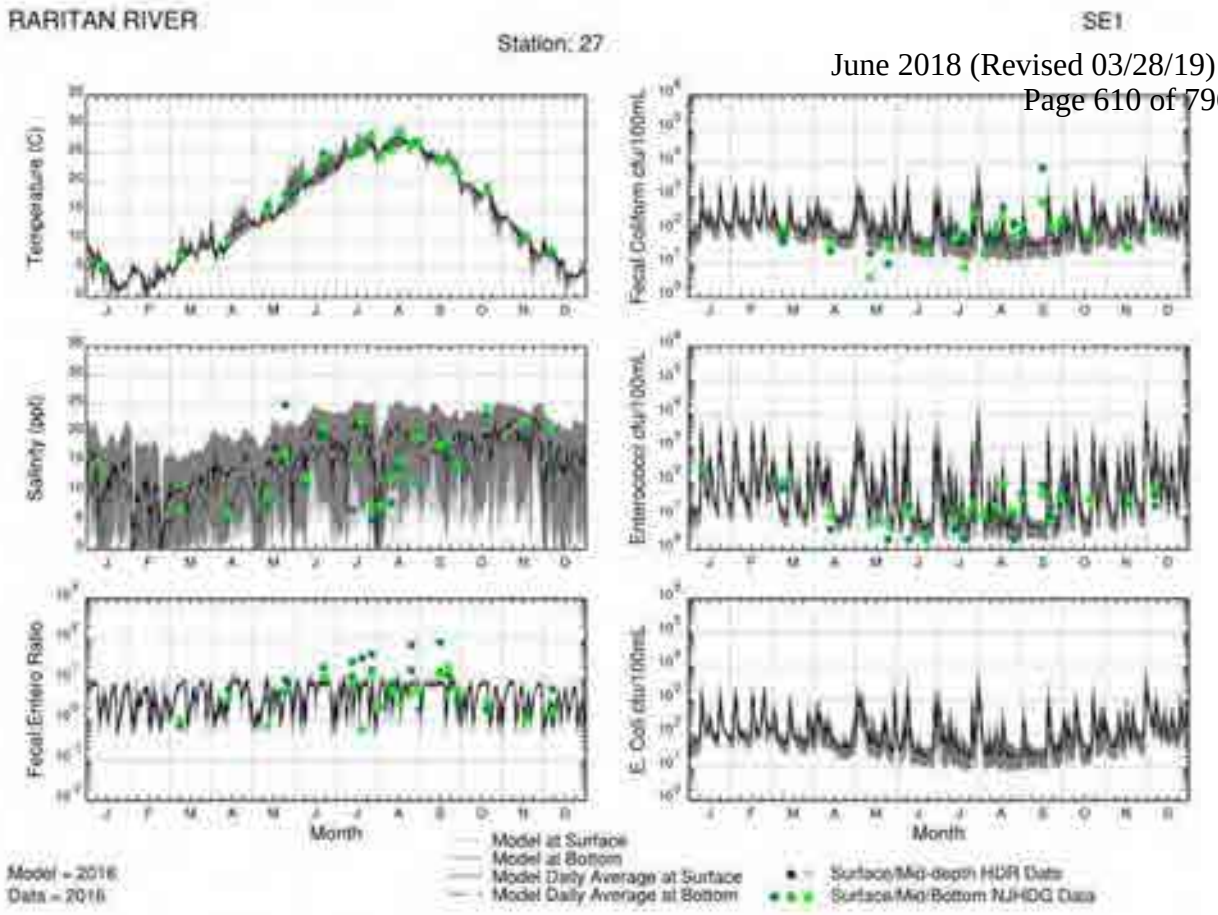
Station	Class	Criterion	2016 Data	2016 Model	2017 Data	2017 Model
B16	FW2	126	Y	Y	-	-
B14	FW2	126	Y	Y	-	-
B13	SE3	1500	Y	N	-	-
20	SE3	1500	N	N	Y	Y

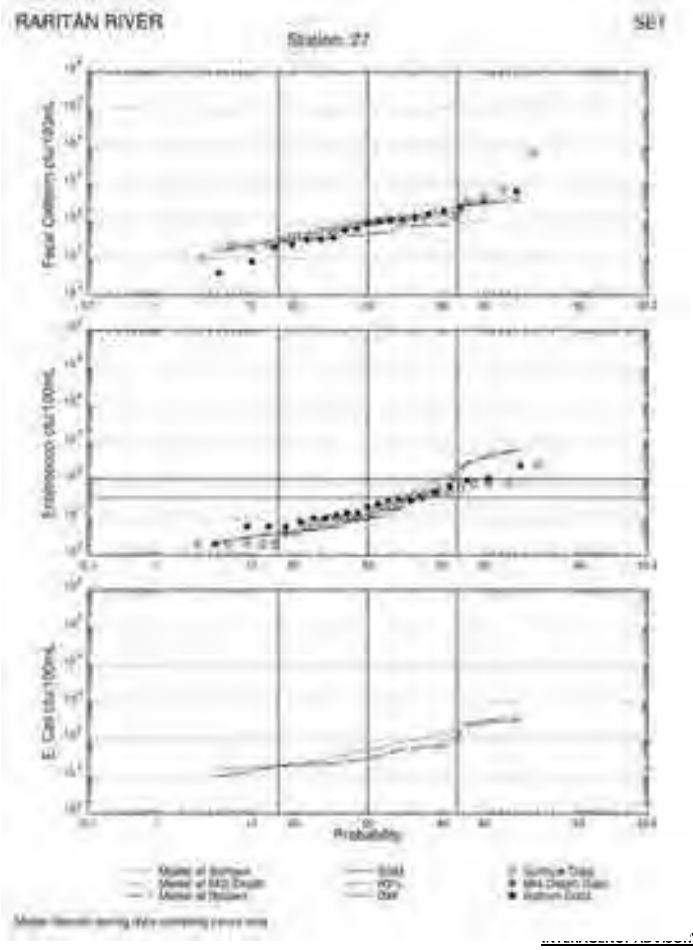
Assessment of Model's Ability to Calculate Attainment

- Elizabeth River – SSM Criterion – Mid-depth
- Percent of Time Data and Model Exceed Criterion (Using imaginary 30-day period)

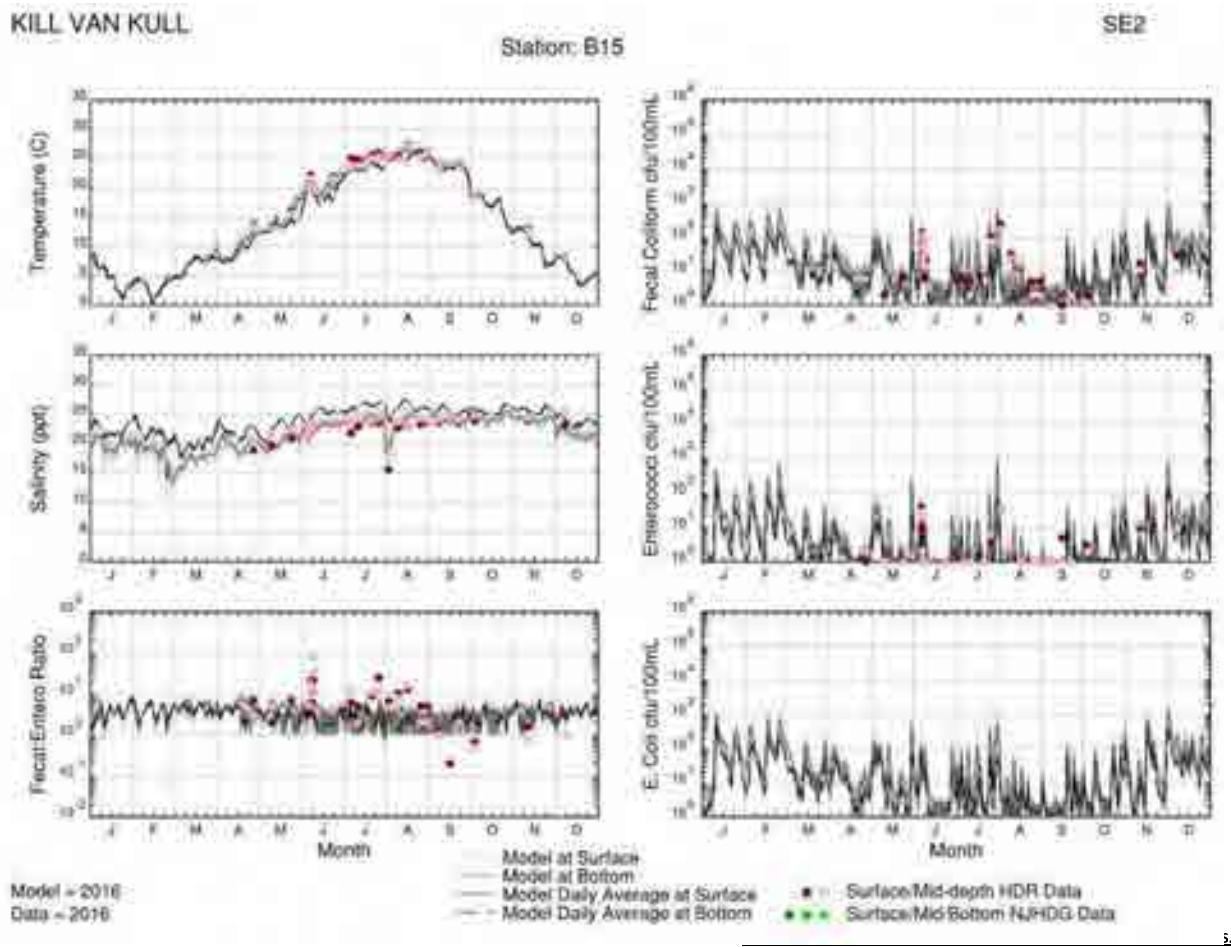
Station	Class	Criterion	2016 Data	2016 Model	diff
B16	FW2	235	91.1	80.8	**10.3**
B14	FW2	235	86.6	70.7	**15.9**

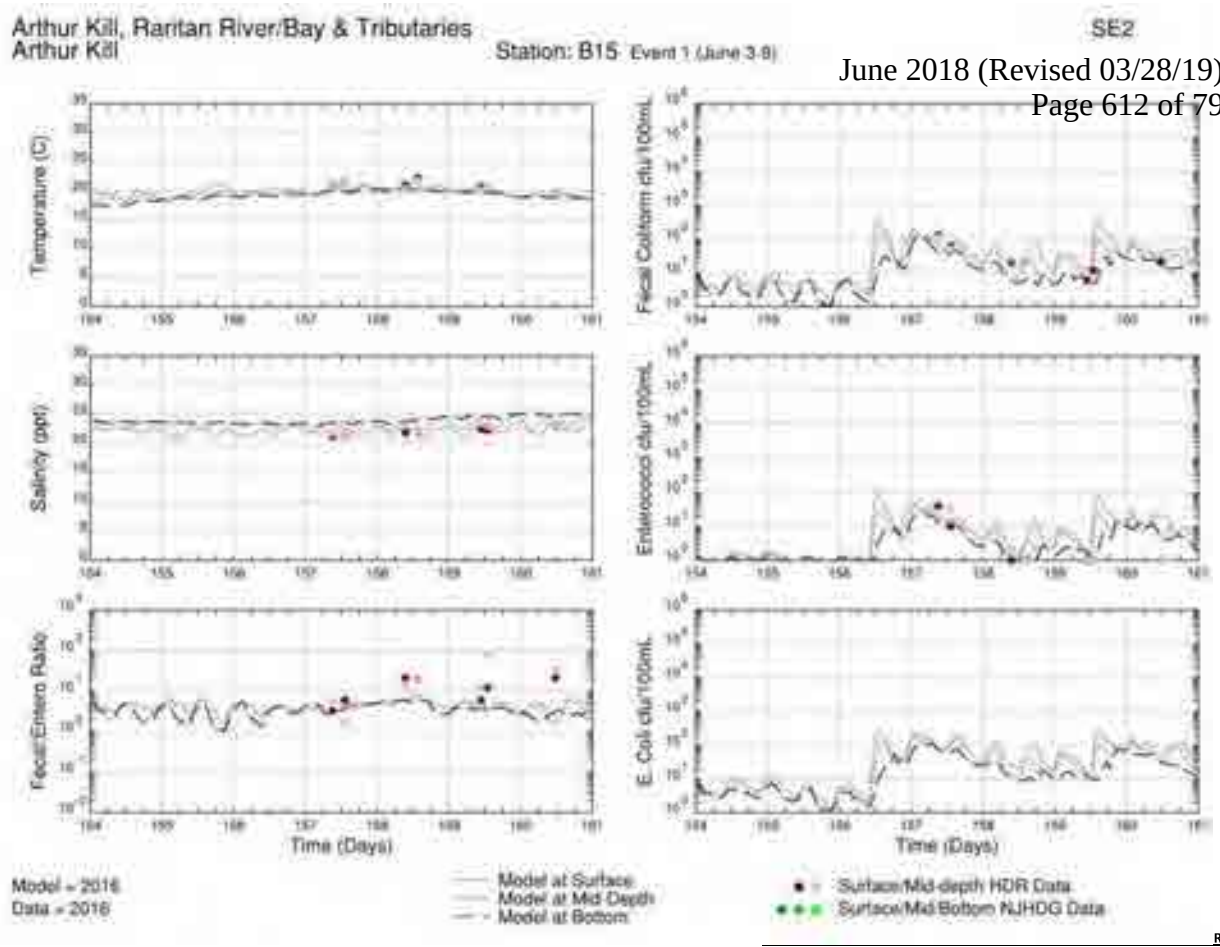
Model Calibration

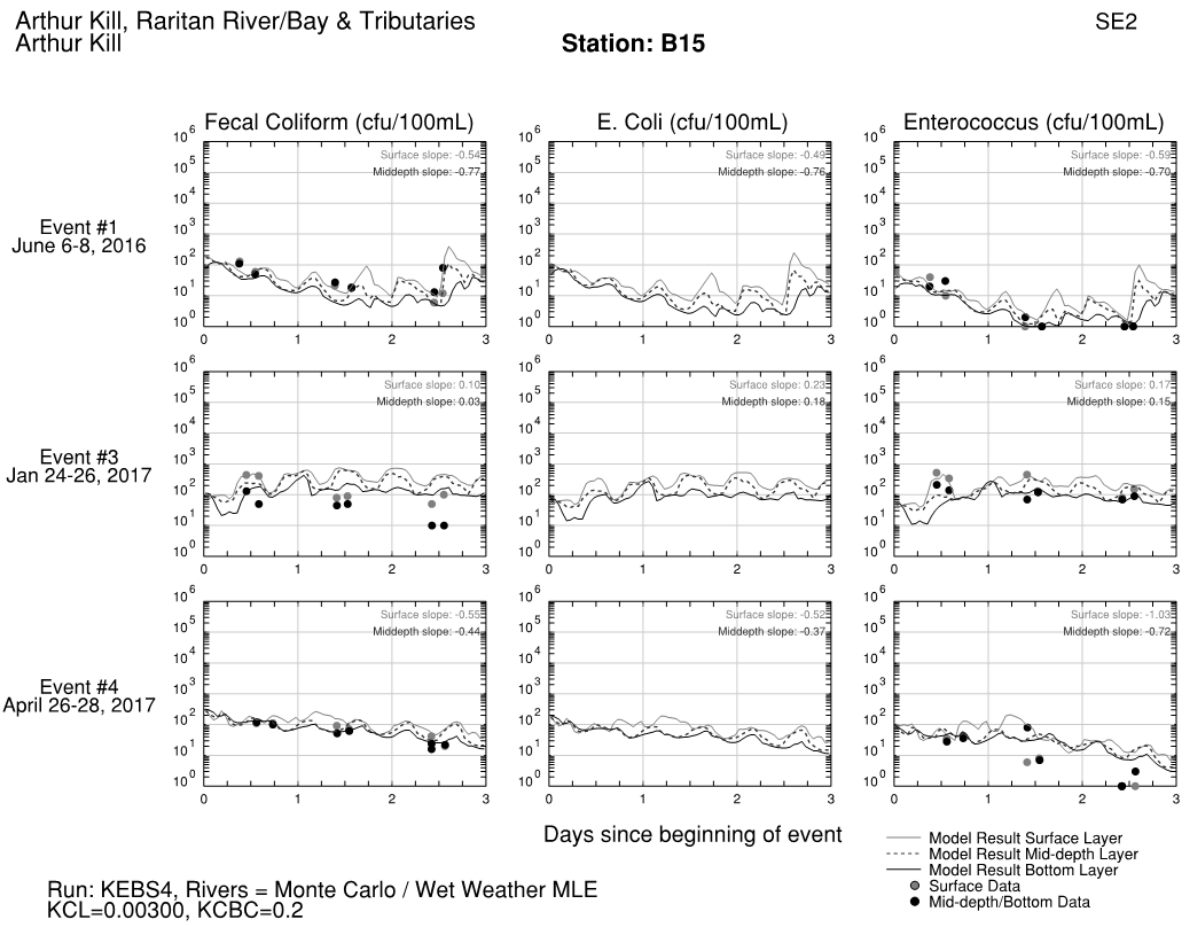


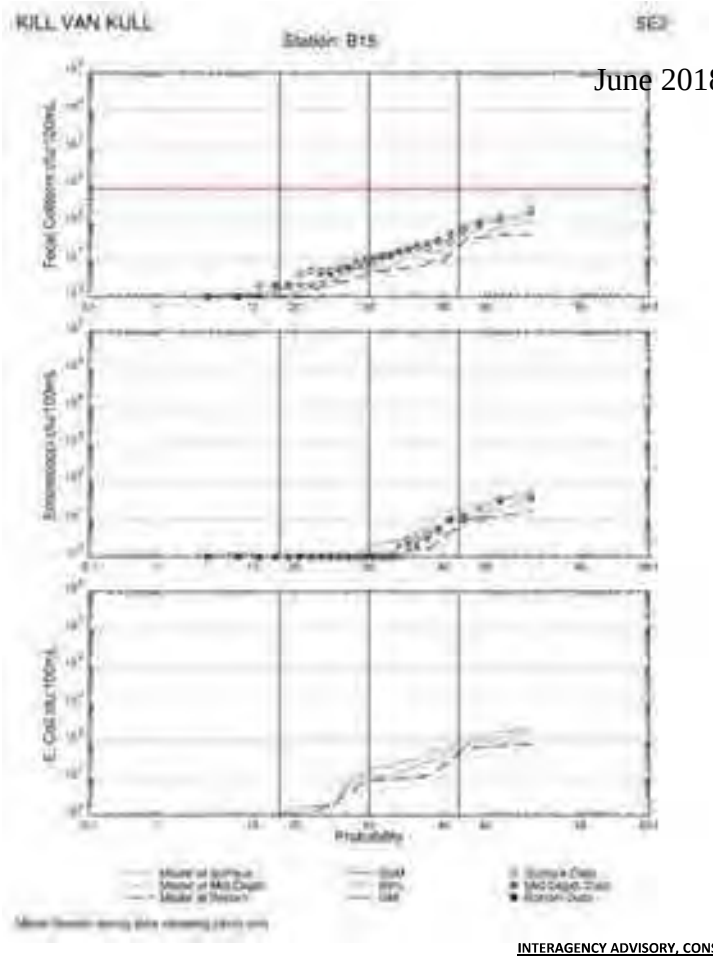


Model Calibration









Assessment of Model's Ability to Calculate Attainment

- Arthur Kill– GM Criterion – Surface
- Do Data and Model Exceed Criterion (Using imaginary 30-day period)?

Station	Class	Criterion	2016 Data	2016 Model	2017 Data	2017 Model
21	SE3	1500	N	N	N	N
23	SE3	1500	N	N	N	N
24	SE3	1500	N	N	N	N
B15	SE2	770	N	N	N	N

Assessment of Model's Ability to Calculate Attainment

- Raritan Bay – GM Criterion – Surface
- Do Data and Model Exceed Criterion (Using imaginary 30-day period)?

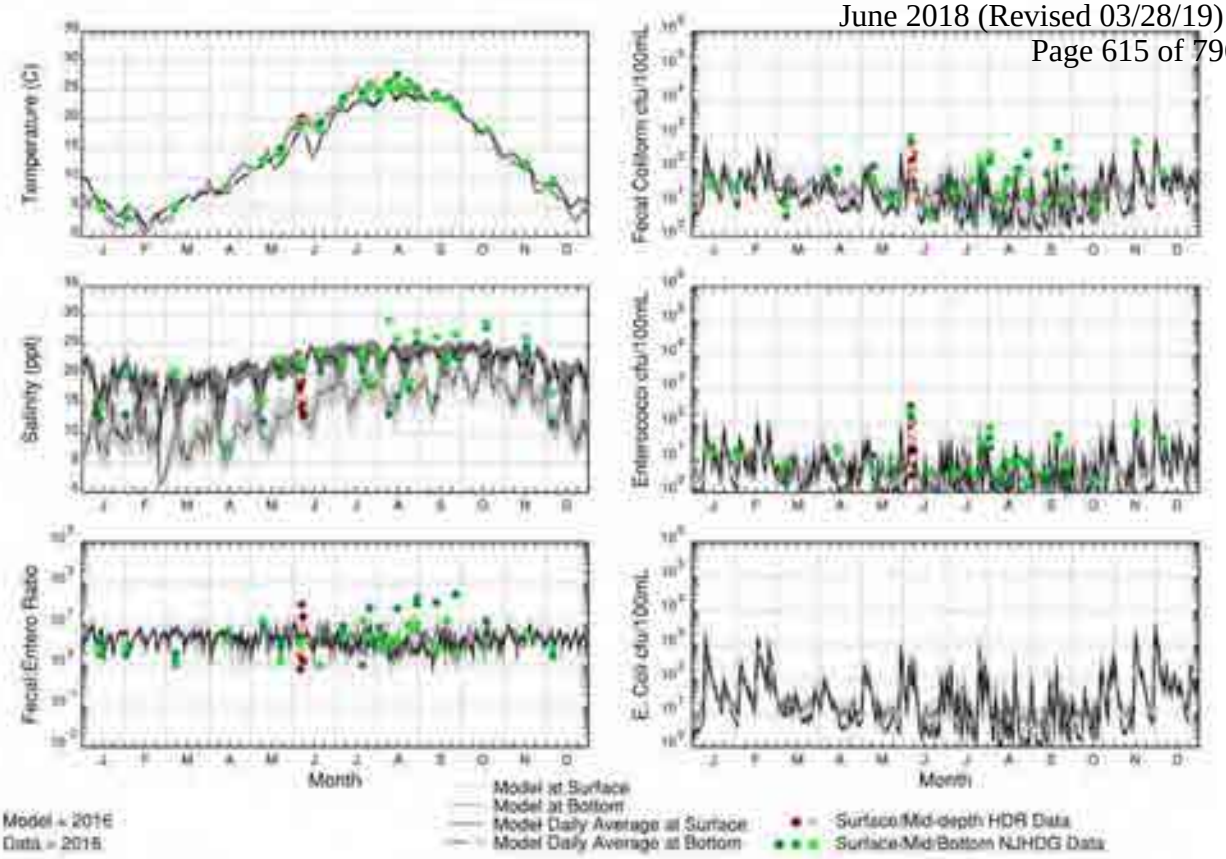
Station	Class	Criterion	2016 Data	2016 Model	2017 Data	2017 Model
28	Shellfish	35	N	N	N	N
29	Shellfish	35	N	N	N	N
30	Shellfish	35	N	N	N	N

Model Calibration

HUDSON RIVER

Station: 32

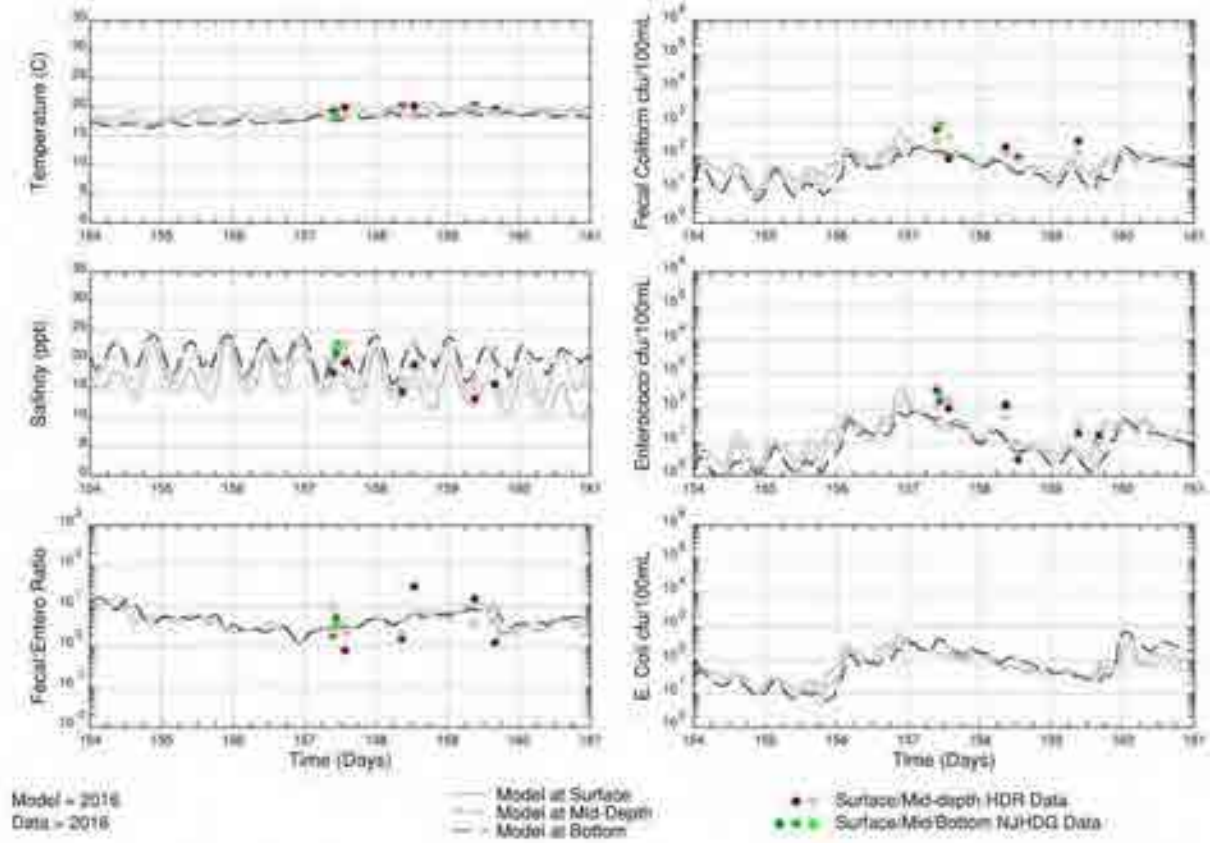
SE2

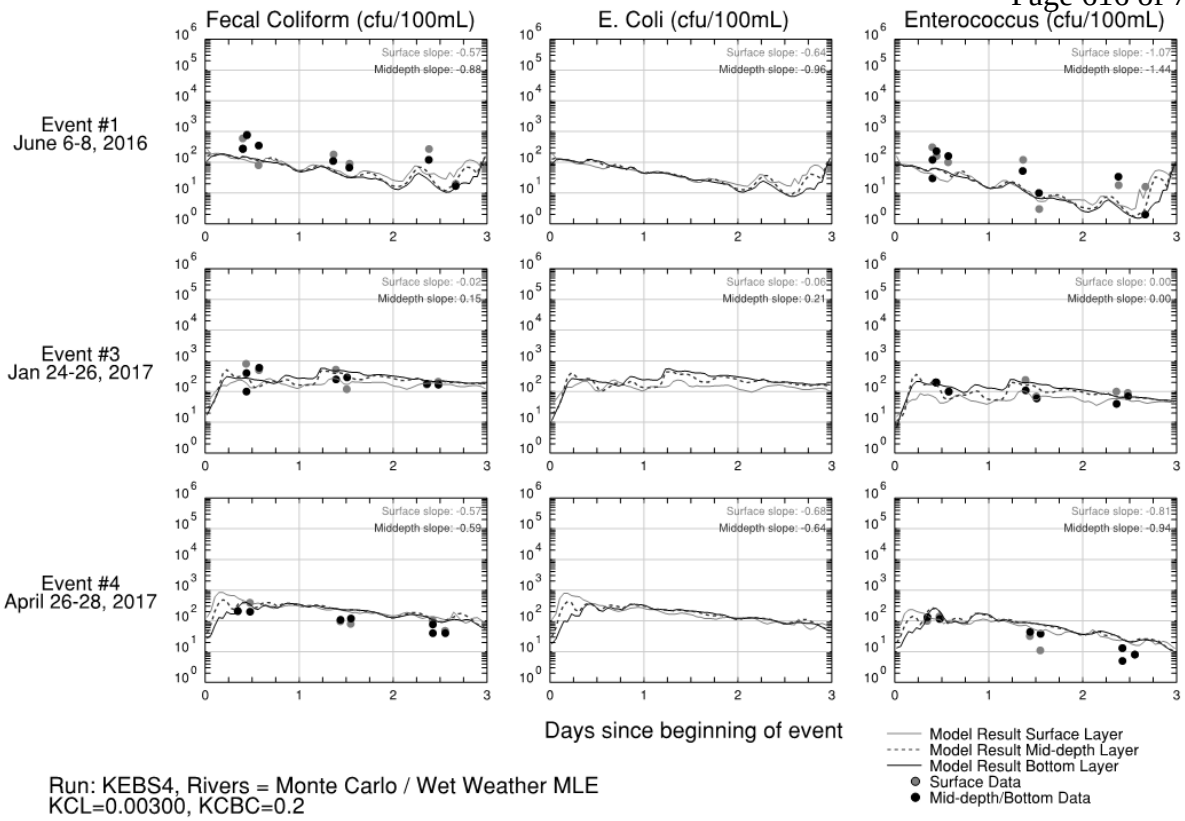


Hudson River, Upper Bay
Hudson River

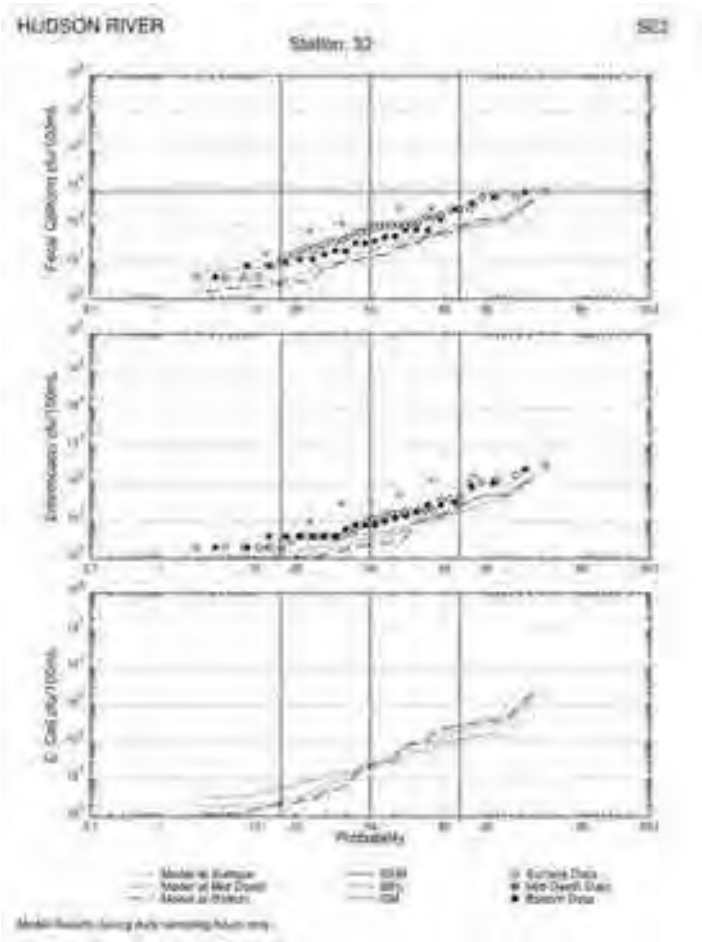
Station: 32 Event 1 (June 3-9)

SE2

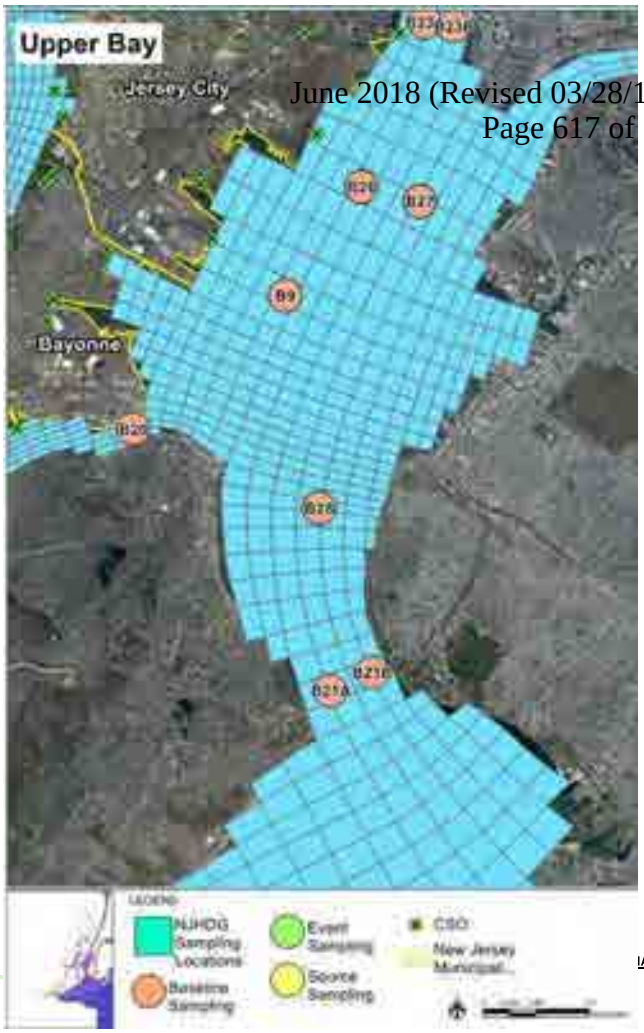


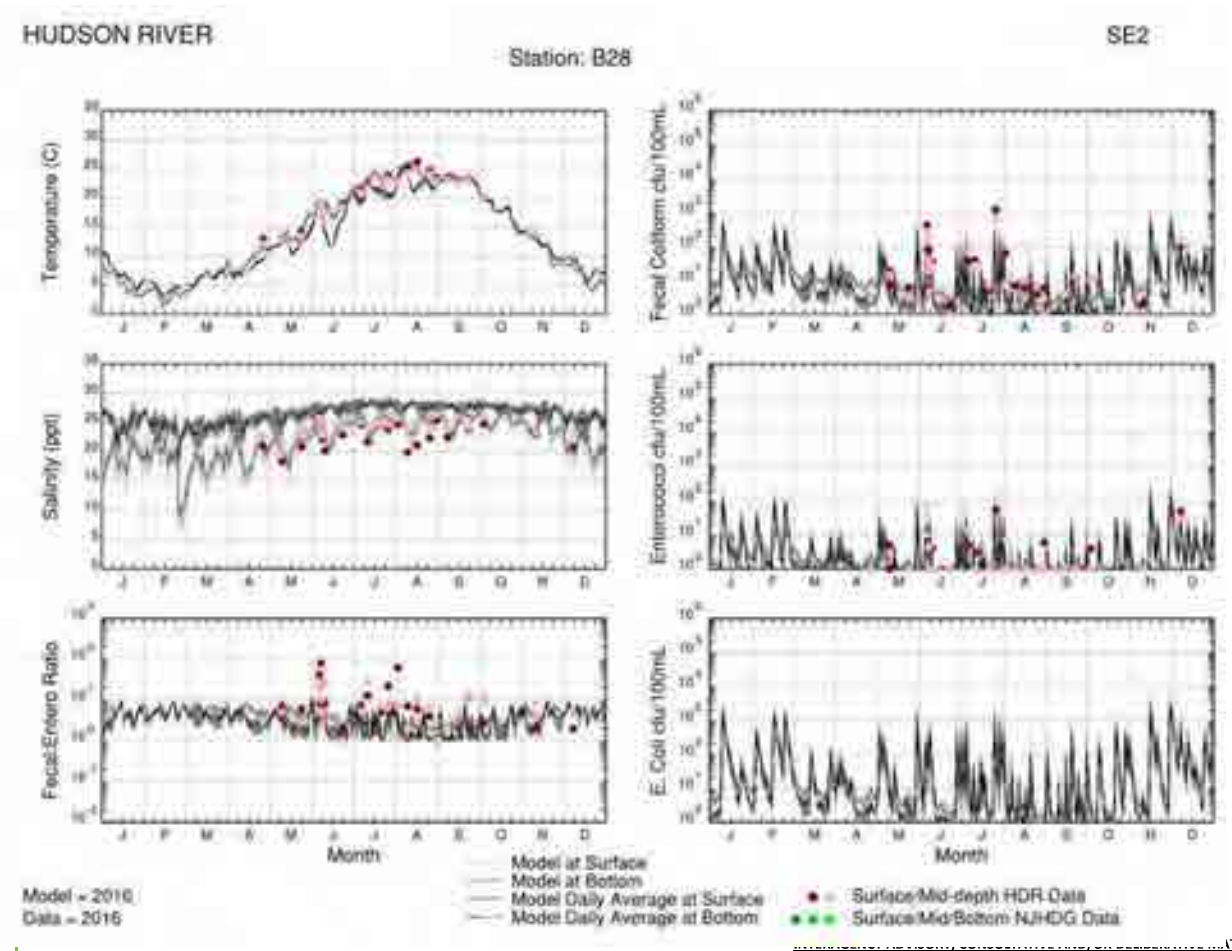


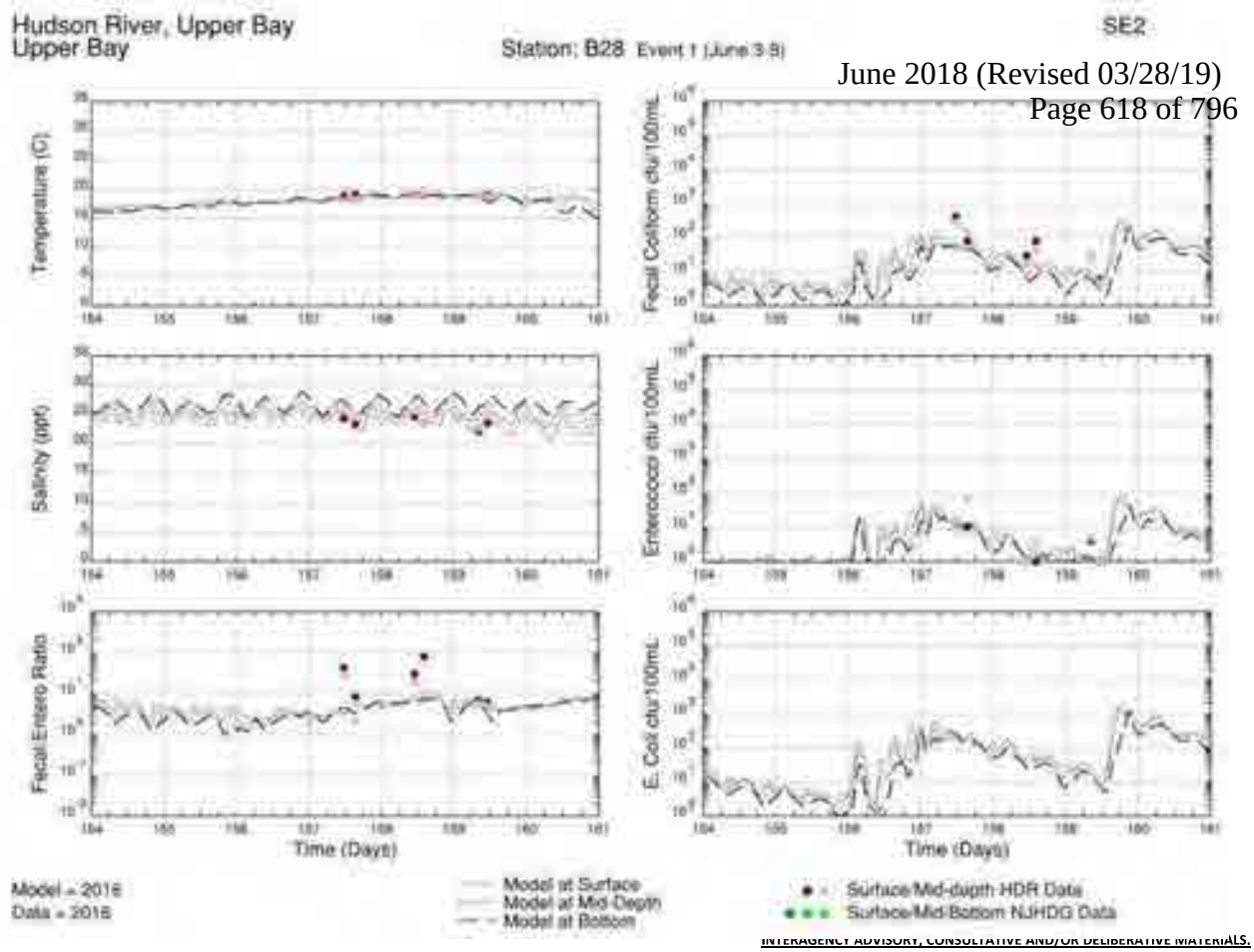
Run: KEBS4, Rivers = Monte Carlo / Wet Weather MLE
KCL=0.00300, KCBC=0.2

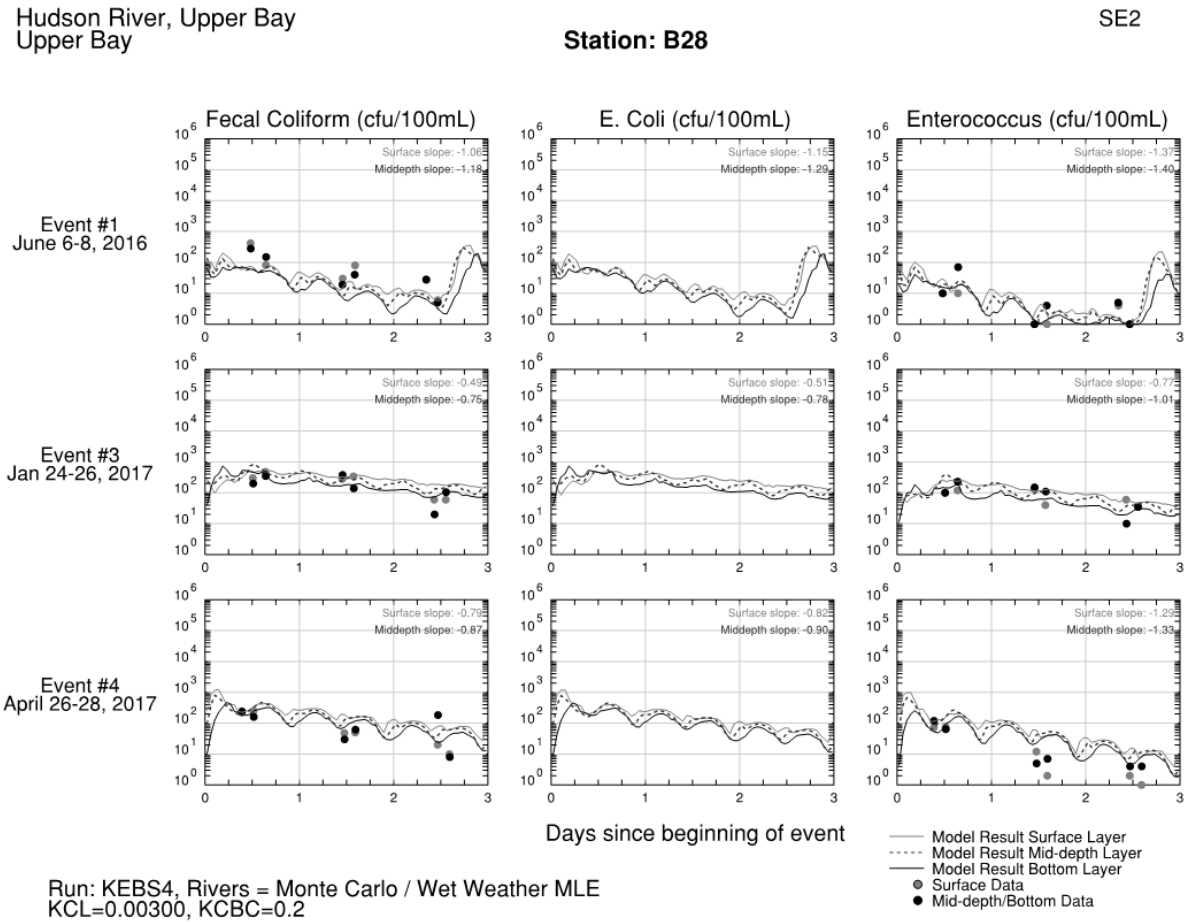


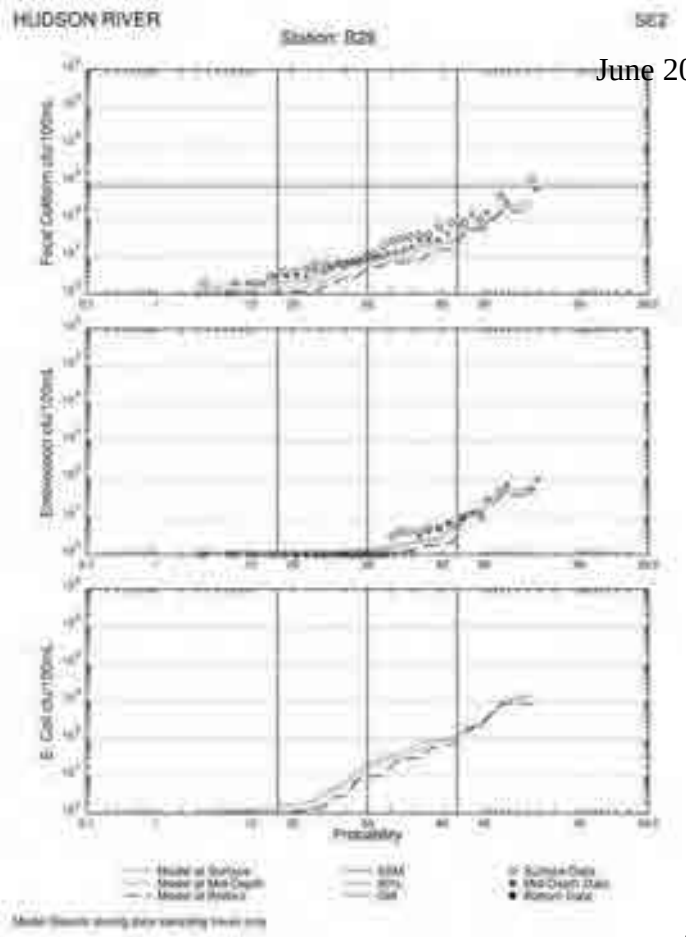
Model Calibration











Calibration/Validation Conclusions

- The hydrodynamic model successfully reproduces the observed temperature and salinity within the area of interest during the calibration/validation periods.
- The receiving water model generally reproduces the observed fecal coliform, enterococci and E. coli concentrations within the project area during the calibration/validation periods.
- The receiving water model, as developed, will be a useful tool for comparing water quality improvements associated with CSO control alternatives.
- The model can be used to assess attainment of water quality criteria, but is more suited to assess relative attainment of alternatives than absolute attainment.

INTERAGENCY ADVISORY, CONSULTATIVE AND/OR DELIBERATIVE MATERIALS.
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OR THE COMMON LAW RIGHT TO INSPECT PUBLIC RECORDS.

Projection Runs

- Baseline
- Gap Analysis (100% CSO Removal)
- Component Analysis
  - NYC Sources
  - NJ CSOs
  - NJ Non-CSOs
  - Upstream/Downstream Boundary Conditions
  - Dry-Weather Sources
- CSO Control Alternatives
  - Permittee Related (3)
  - Area-Wide
  - Final Selected Plan

Baseline Conditions

- 2004 Meteorological Conditions
- 2015 Infrastructure
- River Concentrations at Existing Conditions
- Dry-weather loading as is

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GREELEY and HANSEN CDM Smith HDR

Final Thoughts or Questions?

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