Intra-daily variation of fecal indicators and pathogens in wastewater

9.20.2016

A New Recreational Water Quality Criteria

Coliphage Criteria?

EPA has interest in coliphage criteria as an indicator of pathogens

FDA/ISSC

2015 National Shellfish Sanitation Program Guide

Preparation for Coliphage Criteria

- Understanding of fate and transport
- Hampton Roads specific data

HRSD Projects:

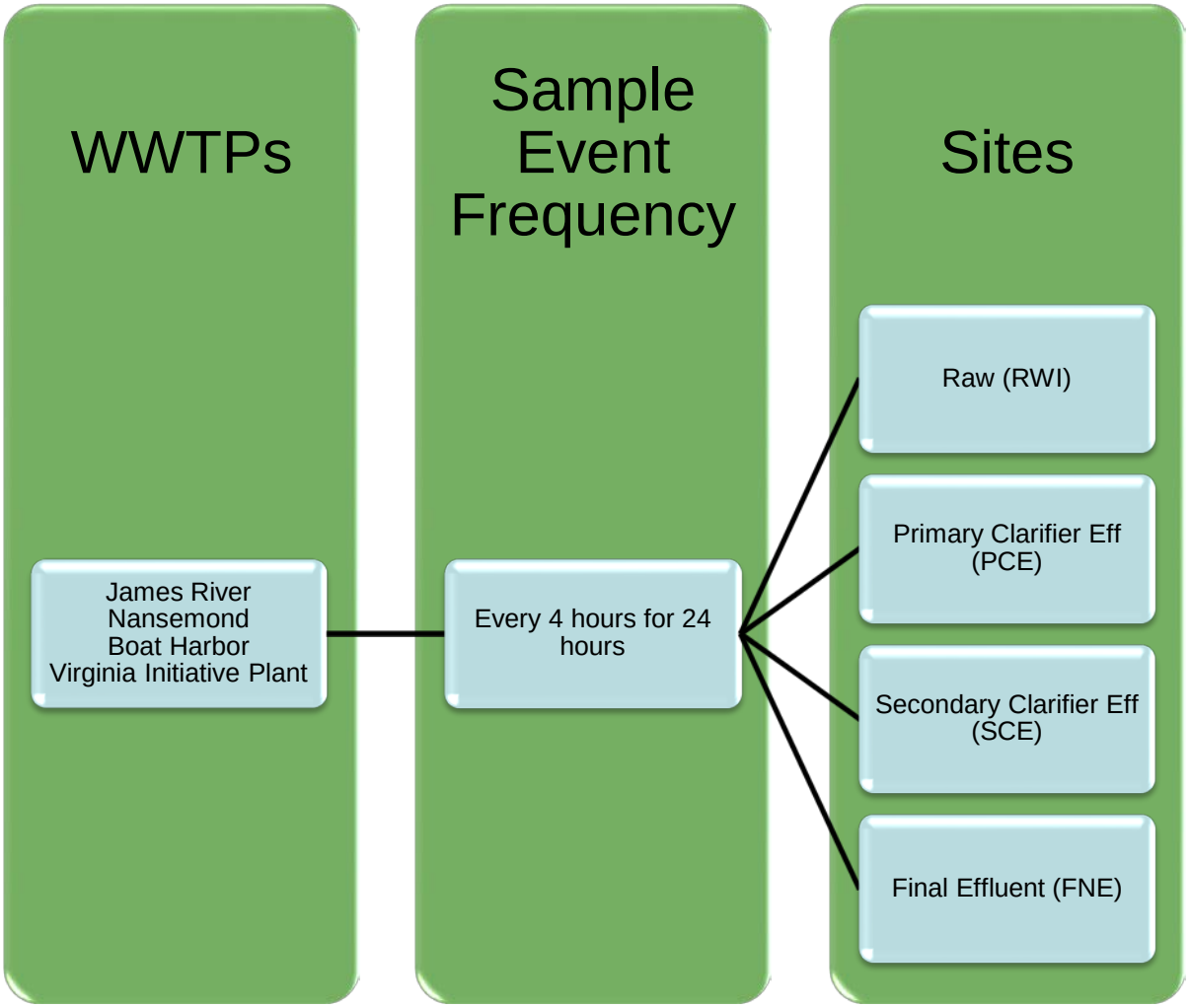
EPA Multi-Lab, Dilution, Baseline, Wet weather transport, Seasonal Variation, Treatability, Viability

Goal: Examine the diel variability of indicators and pathogens in 4 POTWs with differing biological treatment

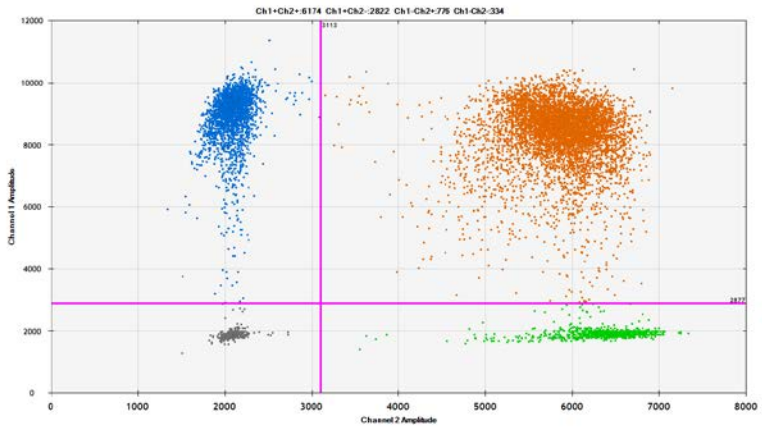
Objectives:

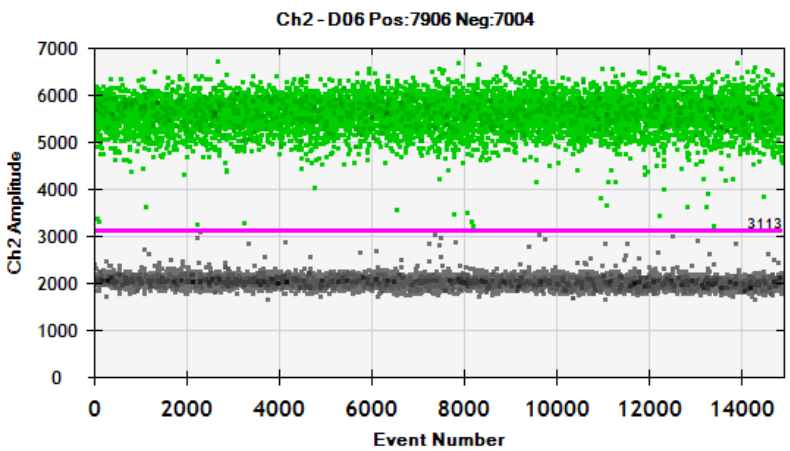
1. Determine if hydrologic retention time should be incorporated into sampling
2. Characterize the indicator-pathogen relationship within the POTWs

Sample Scheme



Measured Parameters





Indicators

Enterococci

E. coli

Male-Specific Coliphage

Enteric Pathogens

Adenovirus

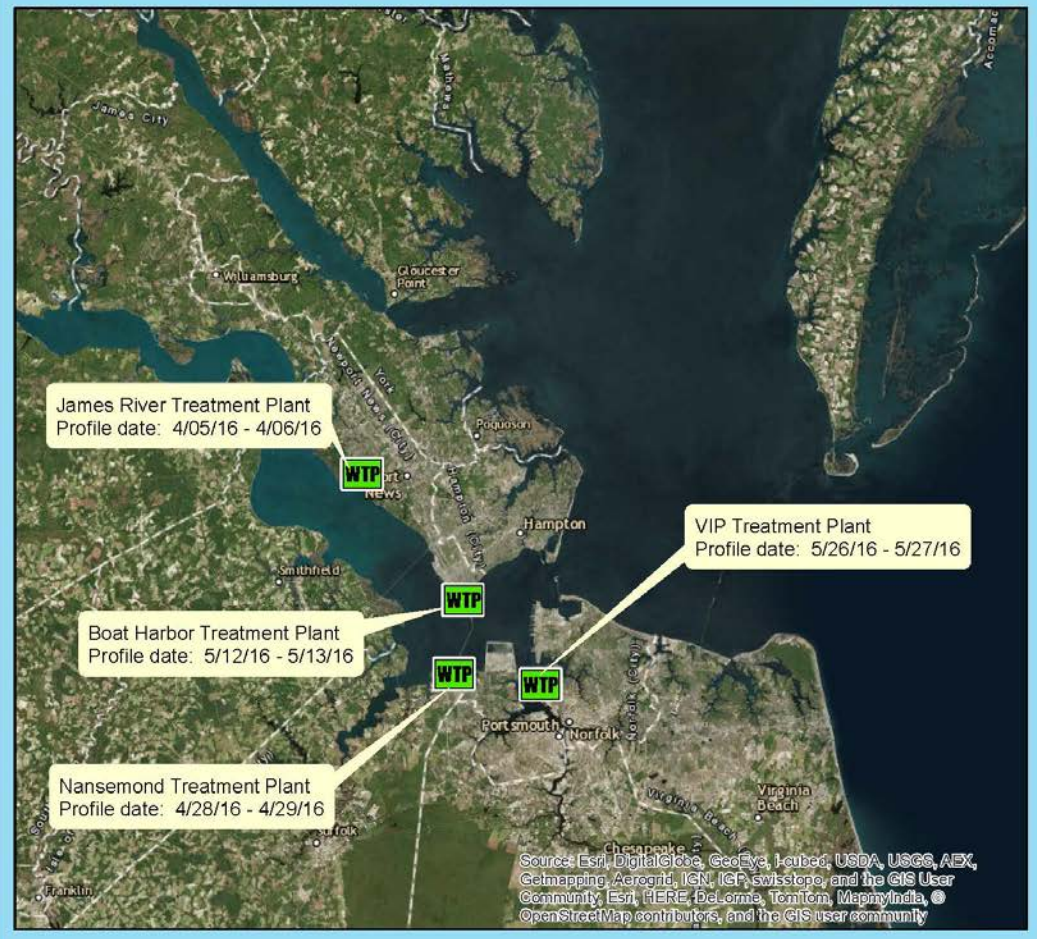
Norovirus GI

Enterovirus

Environmental

Ammonia, salinity, turbidity, temperature, dissolved oxygen, free chlorine, combined chlorine

HRSD Treatment Plant Locations
Coliphage Profile

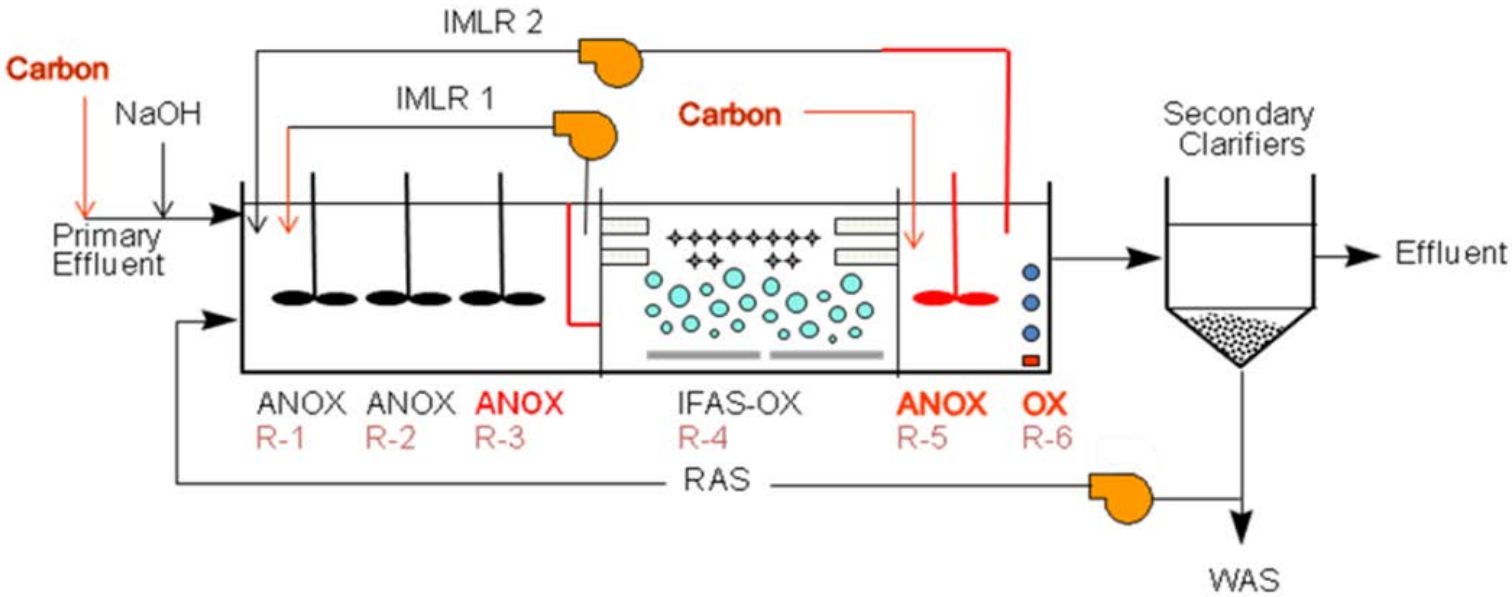


N

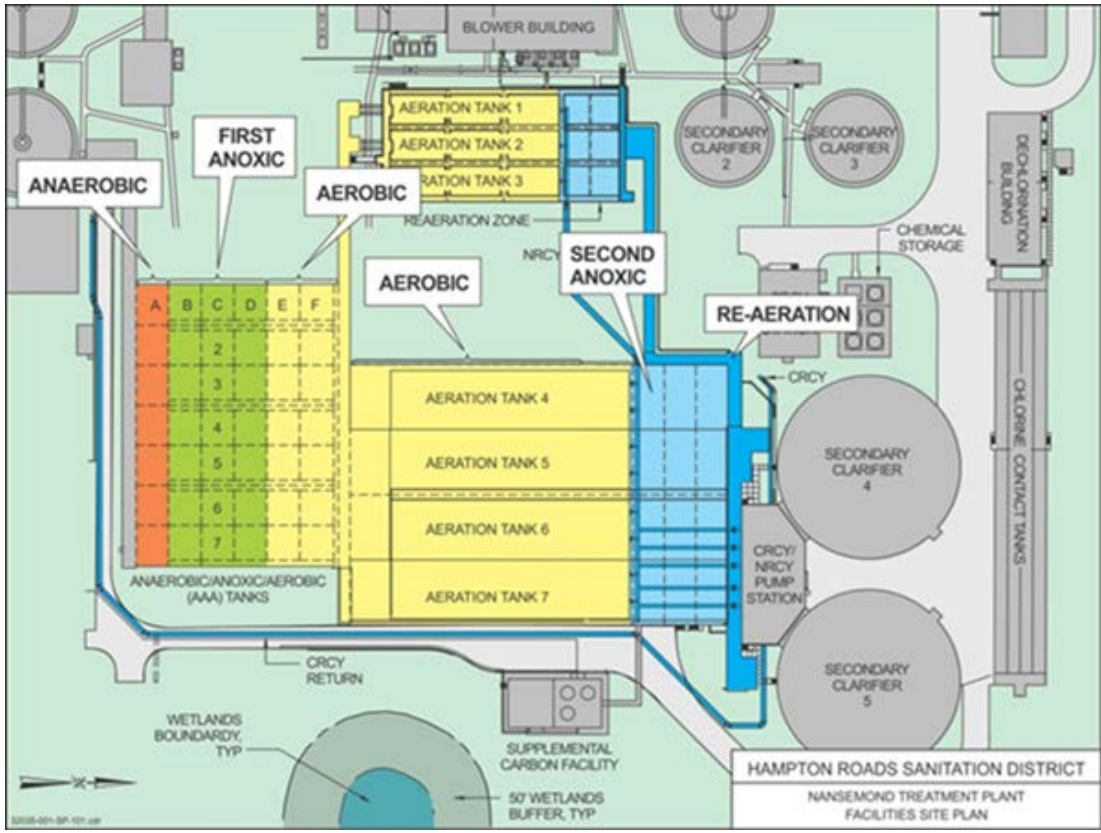
0 5 10 20 Miles

HRSD

James River	
Average daily design flow	20 MGD
Average flow during sampling	13.8 MGD
Primary treatment	Circular, peripheral feed, center weir
Secondary treatment	4 Stage MLE with 2 anoxic and 2 aeration regions. NRCY recycle to primary anoxic zone. IFAS media is used for fixed growth BNR
Sludge SRT	3.1 days
MLSS	2740 mg/L
Disinfection type	Sodium Hypochlorite
Avg. design disinfection contact time	37.15 minutes



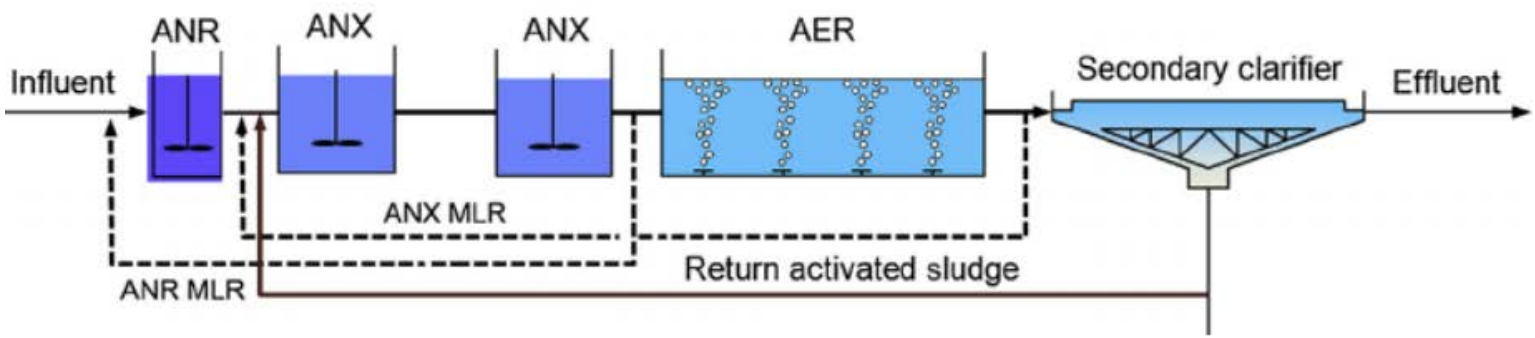
Nansemond	
Average daily design flow	30
Average flow during sampling	17.63
Primary treatment	Circular, center feed with peripheralweir & rectangular clarifiers
Secondary treatment	5 Stage Bardenpho for BNR and Phosphorus removal
Sludge SRT	15.1 days
MLSS	3080 mg/L
Disinfection type	Sodium Hypochlorite
Avg. design disinfection CT	38 minutes



Boat Harbor	
Average daily design flow	25
Average flow during sampling	14.7
Primary treatment	Rectangular clarifiers
Secondary treatment	Aeration tanks for carbonaceous BOD removal, BNR not a primary function
Sludge SRT	43.8 days
MLSS	2720 mg/L
Disinfection type	Sodium Hypochlorite
Avg. design disinfection contact time	59 minutes

HRSD

VIP	
Average daily design flow	40
Average flow during sampling	29.33
Primary treatment	Circular, center feed with peripherial weir & rectangular
Secondary treatment	Virginia initiative process for BNR and phosphorus removal
Sludge SRT	9.4 days
MLSS	2280 mg/L
Disinfection type	Sodium Hypochlorite
Avg. design disinfection contact time	32.3



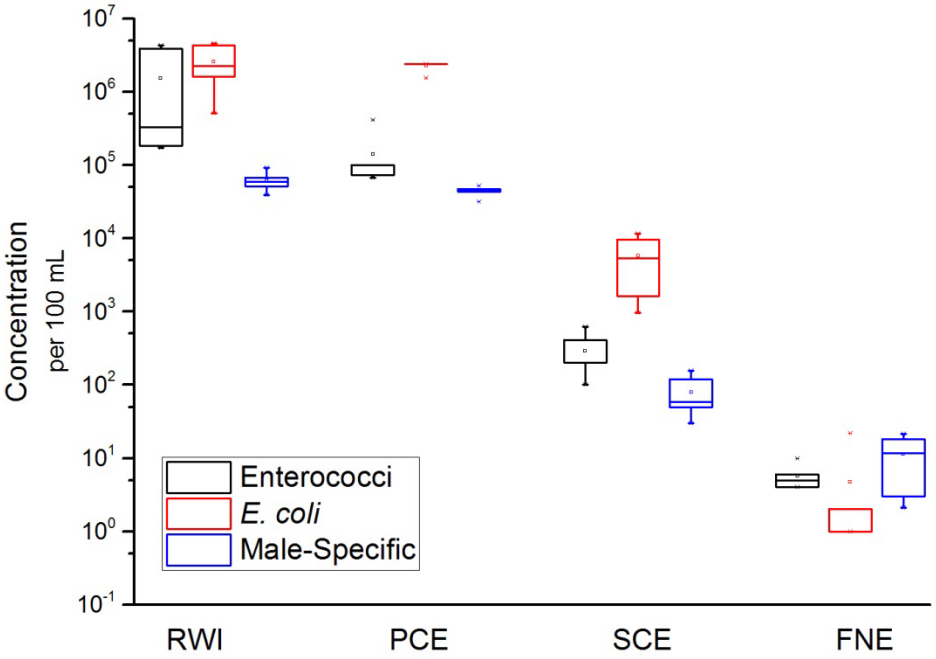
Results

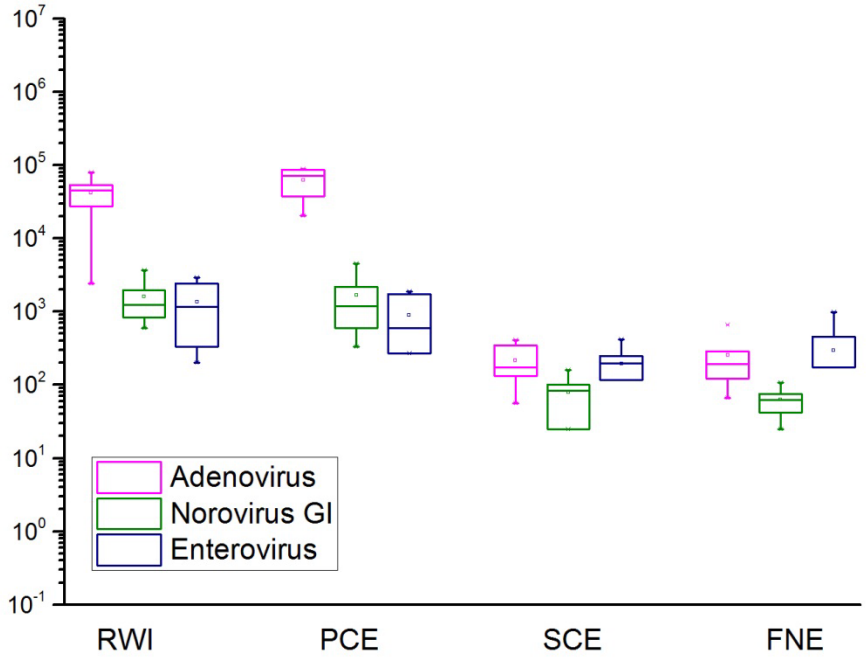
Environmental Parameters

Parameter During Sampling	POTW			
	James River	Nansemond	Boat Harbor	Virginia Initiative Plant
Combined Chlorine (mg/L)	0.0 - 0.01	0.0 - 0.03	0.01 - 0.18	0.0 - 0.42
Free Chlorine (mg/L)	0.0 - 0.02	0.0 - 0.02	0.0 - 0.07	0.0 - 0.05
Ammonia (mg/L)				
influent	25.9 - 33.0	34 - 40.4	19.7 - 28.7	20.7 - 25.4
effluent	0.24 - 1.36	0.78 - 1.55	20.9 - 23.2	0.092 - 0.124
DO (mg/L)				
influent	0.92 - 1.63	0.73 - 1.38	0.91 - 1.66	0.61 - 2.39
effluent	8.14 - 8.75	7.61 - 8.55	7.98 - 9.13	7.06 - 8.19
pH				
influent	6.7 - 6.79	6.96 - 7.47	6.82 - 6.98	6.02 - 6.88
effluent	6.9 - 7.18	6.93 - 7.15	7.26 - 7.39	6.34 - 6.78
Temp				
influent	14.09 - 17.06	18.19 - 19.29	19.77 - 20.68	20.95 - 26.80
effluent	16.25 - 17.66	19.72 - 20.62	21.37 - 22.818	22.07 - 26.81
Salinity				
influent	0.31 - 0.45	0.52 - 0.77	0.49 - 0.68	0.01 - 1.01
effluent	0.13 - 0.29	0.46 - 0.51	0.56 - 0.61	0.31 - 0.69
Turbidity				
influent	102 - 155	112 - 377	78.6 - 171	60.5 - 114
effluent	1.67 - 7.09	2.54 - 4.64	5.6 - 12.3	4.22 - 5.77

HRSD

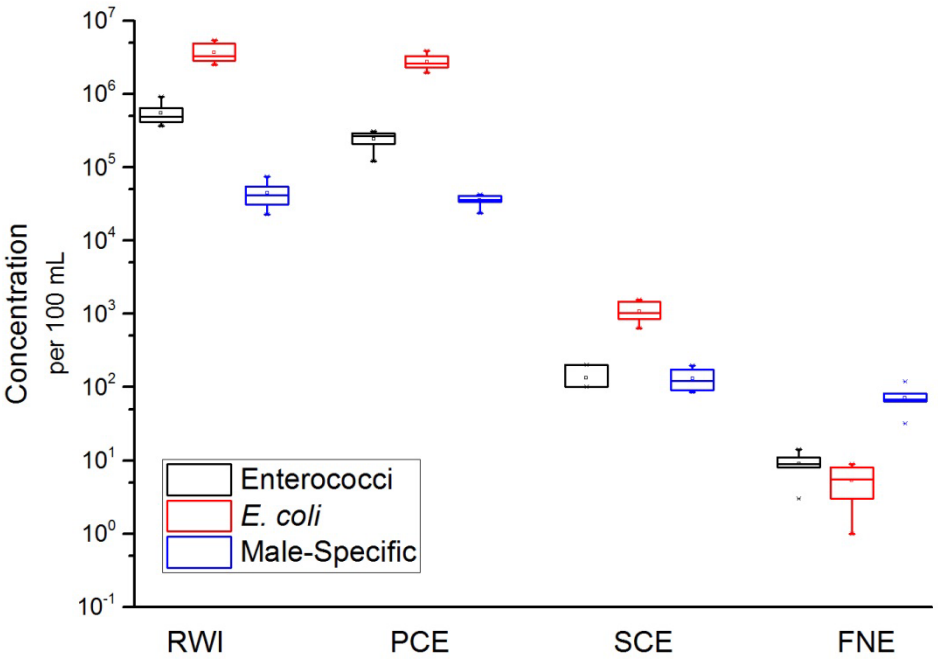
James River

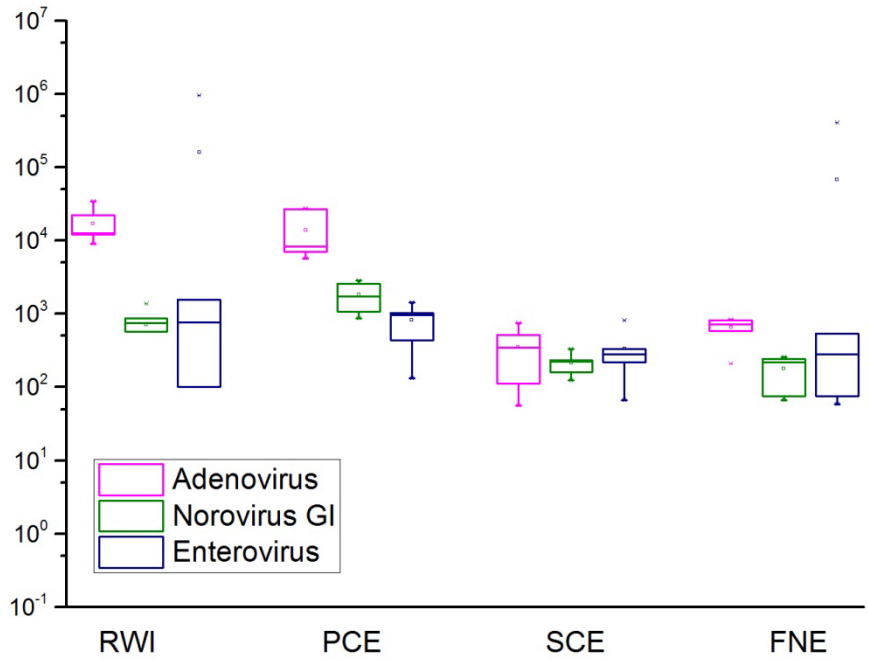




N=6 for each individual box and whisker plot

Nansemond





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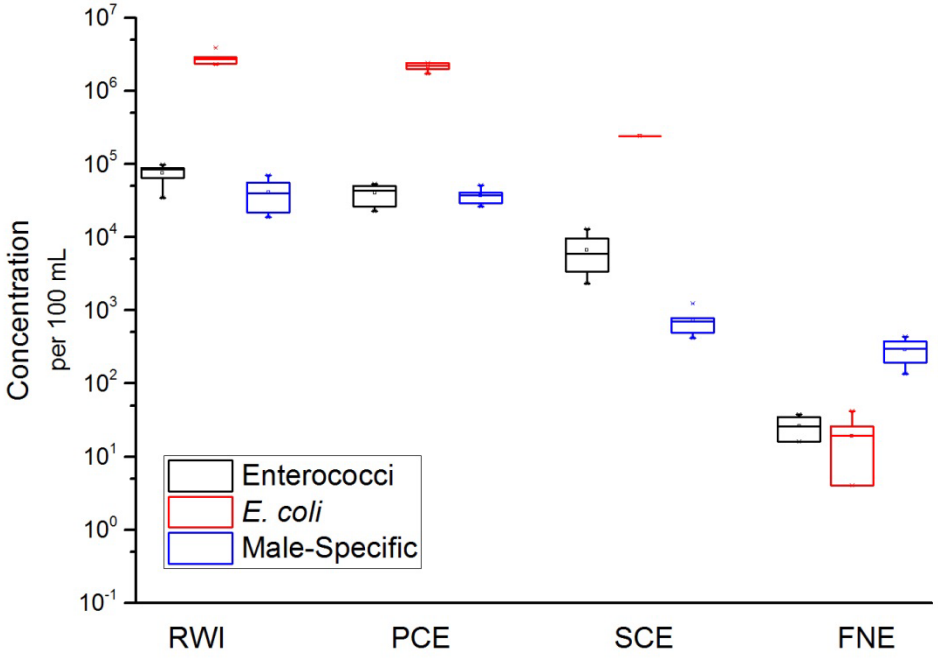
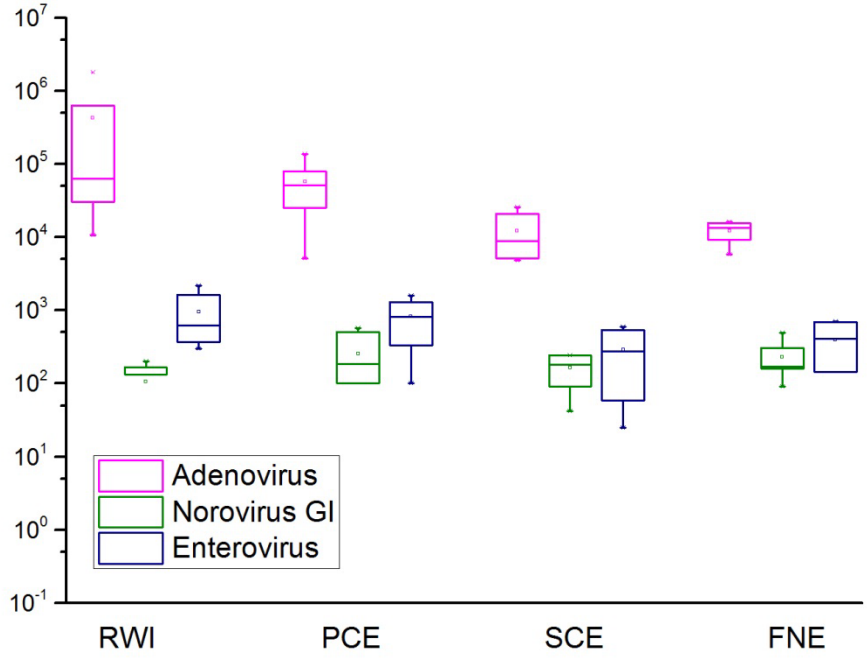
Boat Harbor





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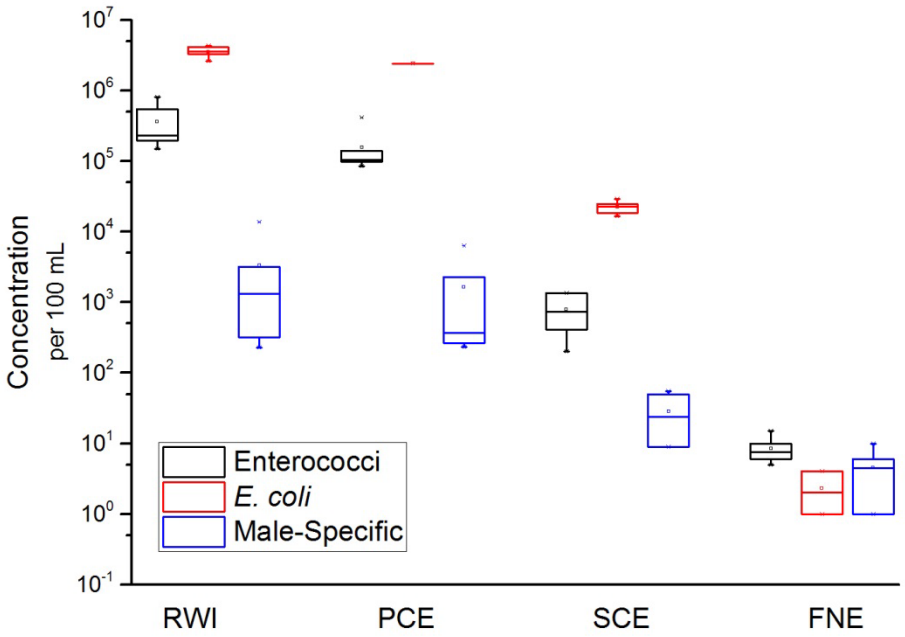
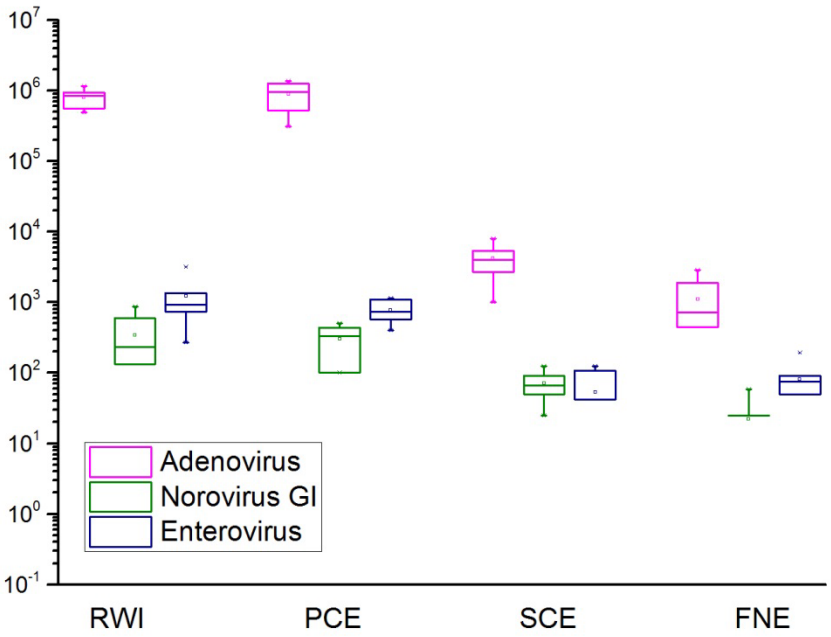
Virginia Initiative Plant





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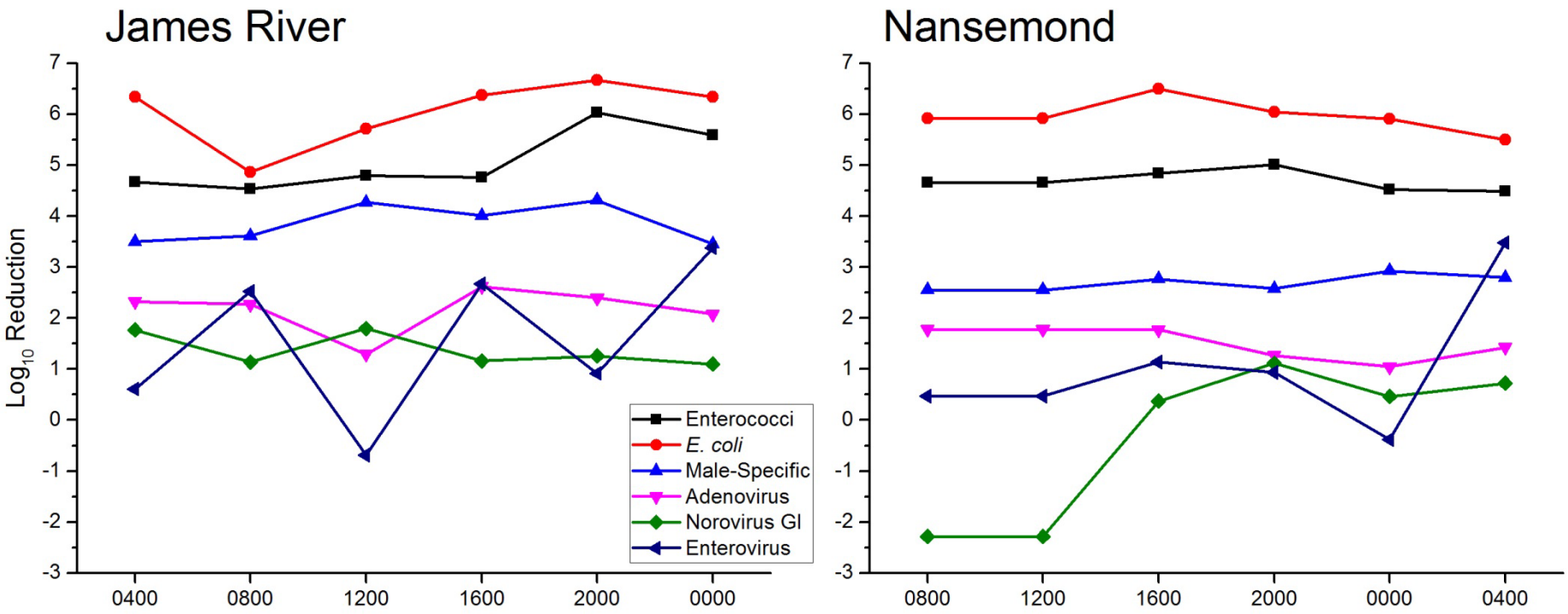
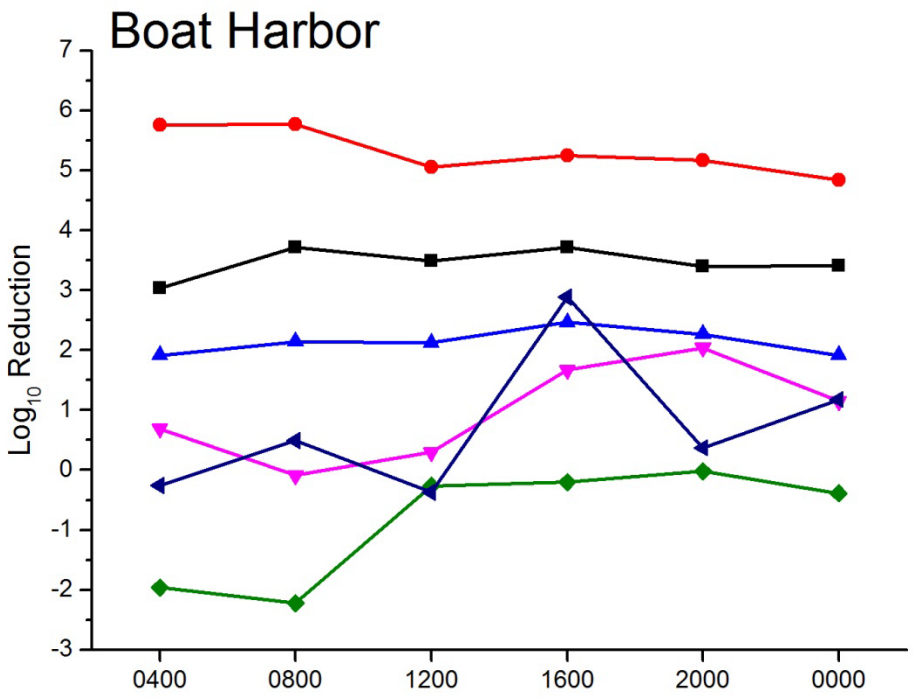
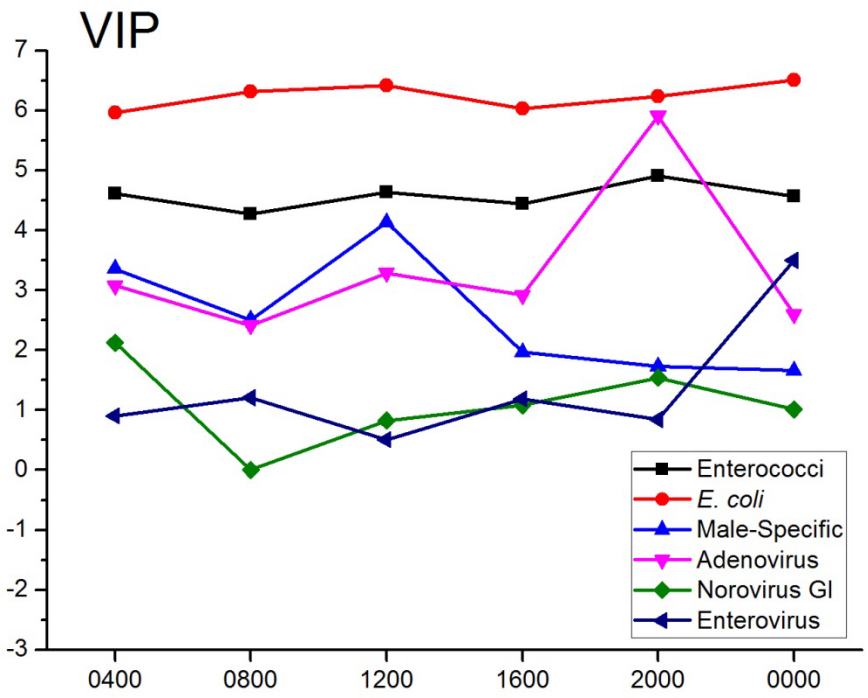
Log_{10} Reduction Variability



Log Reduction = $\log_{10}$(influent) – $\log_{10}$(effluent)

Log_{10} Reduction Variability





Log Reduction = $\log_{10}$(influent) – $\log_{10}$(effluent)

Indicators and Pathogens	Mean log_{10} reduction ± sd		
	Whole Process	Secondary Treatment	Chlorination
James River			
Enterococci	5.06 ± 0.79	2.67 ± 0.22	1.65 ± 0.24
E. coli	6.05 ± 1.25	2.74 ± 0.38	3.34 ± 0.87
Male-Specific Phage	3.86 ± 0.39	2.81 ± 0.23	0.91 ± 0.35
Adenovirus	2.16 ± 0.56	2.50 ± 0.17	-0.05 ± 0.3
Norovirus GI	1.37 ± 1.07	1.26 ± 0.32	0.05 ± 0.45
Enterovirus	1.57 ± 1.48	0.88 ± 0.84	0.58 ± 1.51
Nansemond			
Enterococci	4.70 ± 0.20	3.26 ± 0.18	1.19 ± 0.34
E. coli	5.96 ± 0.32	3.39 ± 0.17	2.38 ± 0.27
Male-Specific Phage	2.70 ± 0.16	2.46 ± 0.23	0.27 ± 0.15
Adenovirus	1.51 ± 0.31	1.69 ± 0.55	-0.37 ± 0.54
Norovirus GI	-0.32 ± 1.55	0.90 ± 0.13	0.12 ± 0.34
Enterovirus	1.02 ± 1.32	0.37 ± 0.36	-0.40 ± 1.44
Boat Harbor			
Enterococci	2.53 ± 0.25	0.82 ± 0.30	1.98 ± 0.15
E. coli	3.95 ± 0.38	0.95 ± 0.06	3.42 ± 0.43
Male-Specific Phage	1.60 ± 0.21	1.73 ± 0.12	0.66 ± 0.15
Adenovirus	0.61 ± 0.82	0.59 ± 0.37	0.17 ± 0.41
Norovirus GI	-0.50 ± 0.98	-0.15 ± 1.03	-0.07 ± 0.37
Enterovirus	0.52 ± 1.20	0.52 ± 0.22	0.33 ± 0.88
Virginia Initiative Plant			
Enterococci	4.57 ± 0.21	2.30 ± 0.25	1.92 ± 0.31
E. coli	6.25 ± 0.21	2.04 ± 0.09	4.04 ± 0.29
Male-Specific Phage	2.56 ± 1.00	1.49 ± 0.68	0.83 ± 0.59
Adenovirus	3.37 ± 1.29	2.36 ± 0.45	1.02 ± 1.45
Norovirus GI	1.10 ± 0.71	0.60 ± 0.32	0.81 ± 0.63
Enterovirus	1.36 ± 1.08	1.63 ± 1.09	-0.39 ± 0.77

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Correlations

	Enterococci	*E. coli*	Male-Specific	Adenovirus	Norovirus GI	Enterovirus
Enterococci	-	0.93	0.79	0.71	0.61	0.53
E. coli	0.93	-	0.77	0.76	0.51	0.55
Male-Specific	0.79	0.77	-	0.68	0.66	0.55
Adenovirus	0.71	0.76	0.68	-	0.44	0.55
Norovirus GI	0.61	0.51	0.66	0.44	-	0.42
Enterovirus	0.53	0.55	0.55	0.55	0.42	-

N=96

Take Home Messages

- Diel variability was minimal
  - HRT will not be incorporated into sampling scheme
- Indicator log reductions were greater than enteric pathogens, and consistent with literature values
- POTWs that performed BNR in 2° treatment had enhanced log removal

Questions?

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