

# Understanding the Role of Human Bacteroides Analysis in IDDE Investigations

**NEWEA Annual Conference**

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**January 24, 2023**



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# Bacteria as a Water Quality Indicator

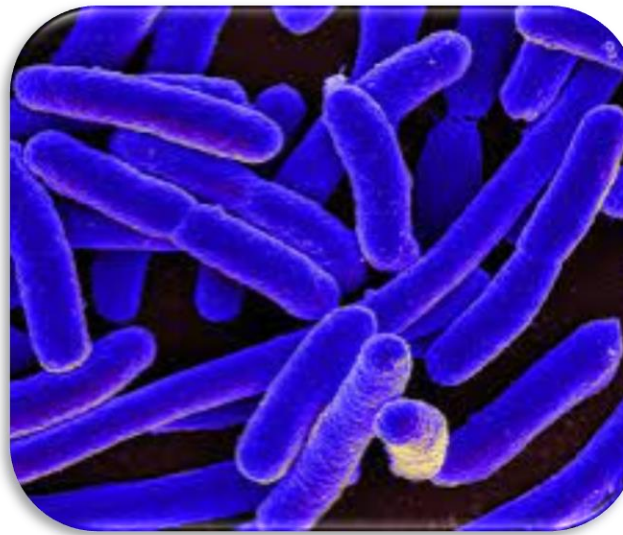
# Common Water Quality Investigation Parameters

**MS4 General Permit Parameters:** "Likely sewer indicators": bacteria ammonia, surfactants, and chlorine



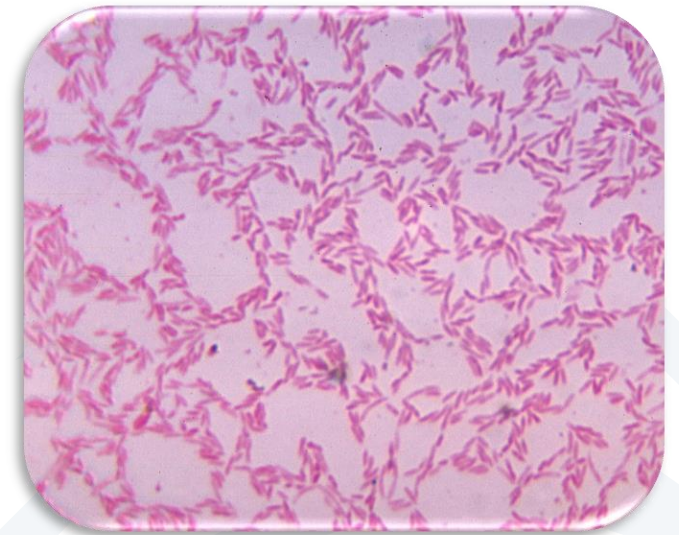
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**E. coli/Enterococci:** Indicator of the presence of fecal material in water, does not differentiate between sources



<https://www.niaid.nih.gov/diseases-conditions/e-coli>

**Bacteroides:** Indicator of the source of fecal material in water; i.e., human versus other sources



<https://en.wikipedia.org/wiki/Bacteroides>

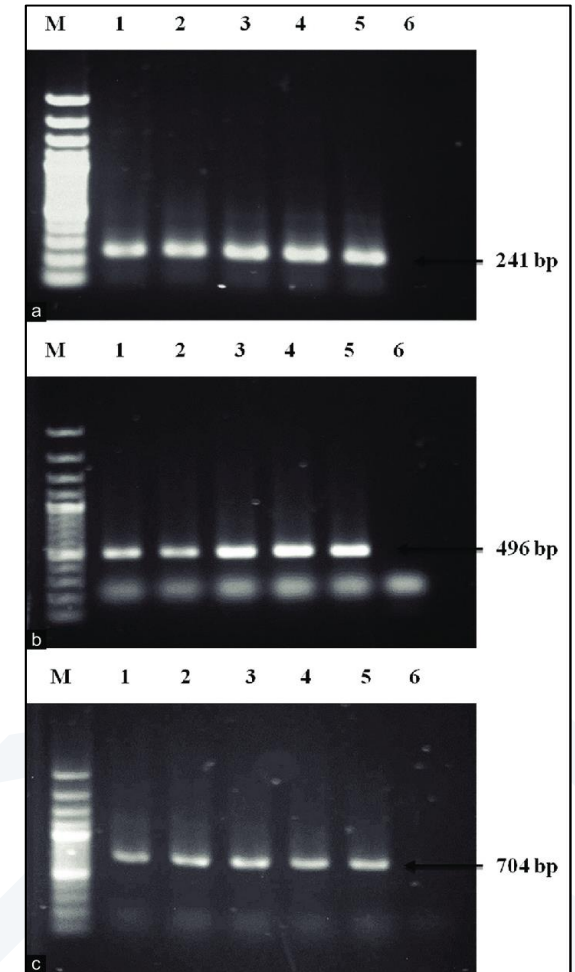
# Bacteroides: Bacterial Source Indicator

Specific marker for fecal contamination from some warm-blooded vertebrates

- Found in gastrointestinal tracts of many "hosts", reflecting differences in the digestive system of the host animal
- Examples: Humans, dogs, avian, cows, deer

Identified using laboratory analysis by qPCR to identify the host-specific DNA genetic marker without culturing the bacteria

- Total versus Human concentrations provide reliable indicators of human specific fecal contamination



[https://www.researchgate.net/figure/Figure-1-Polymerase-chain-reaction-PCR-amplification-of-16S-rRNA-of-Staphylococcus\\_fig1\\_339210094](https://www.researchgate.net/figure/Figure-1-Polymerase-chain-reaction-PCR-amplification-of-16S-rRNA-of-Staphylococcus_fig1_339210094)

# Bacteroides: Linking Detected Concentrations to Risk Based Thresholds

- ▶ EPA's 2012 Recreational Water Quality Criteria – estimated illness rate based on 32 illnesses per 1,000 primary contact recreators

Criteria Source	Enterococci (cfu/100 mL)	E. coli (cfu/100 mL)
EPA 2012 Recreational Water Quality Criteria	130	410
Massachusetts Surface Water Quality Standards (314 CMR 4.00)	130	410
Massachusetts Minimum Standards for Bathing Beaches (105 CMR 445.000)	104	235

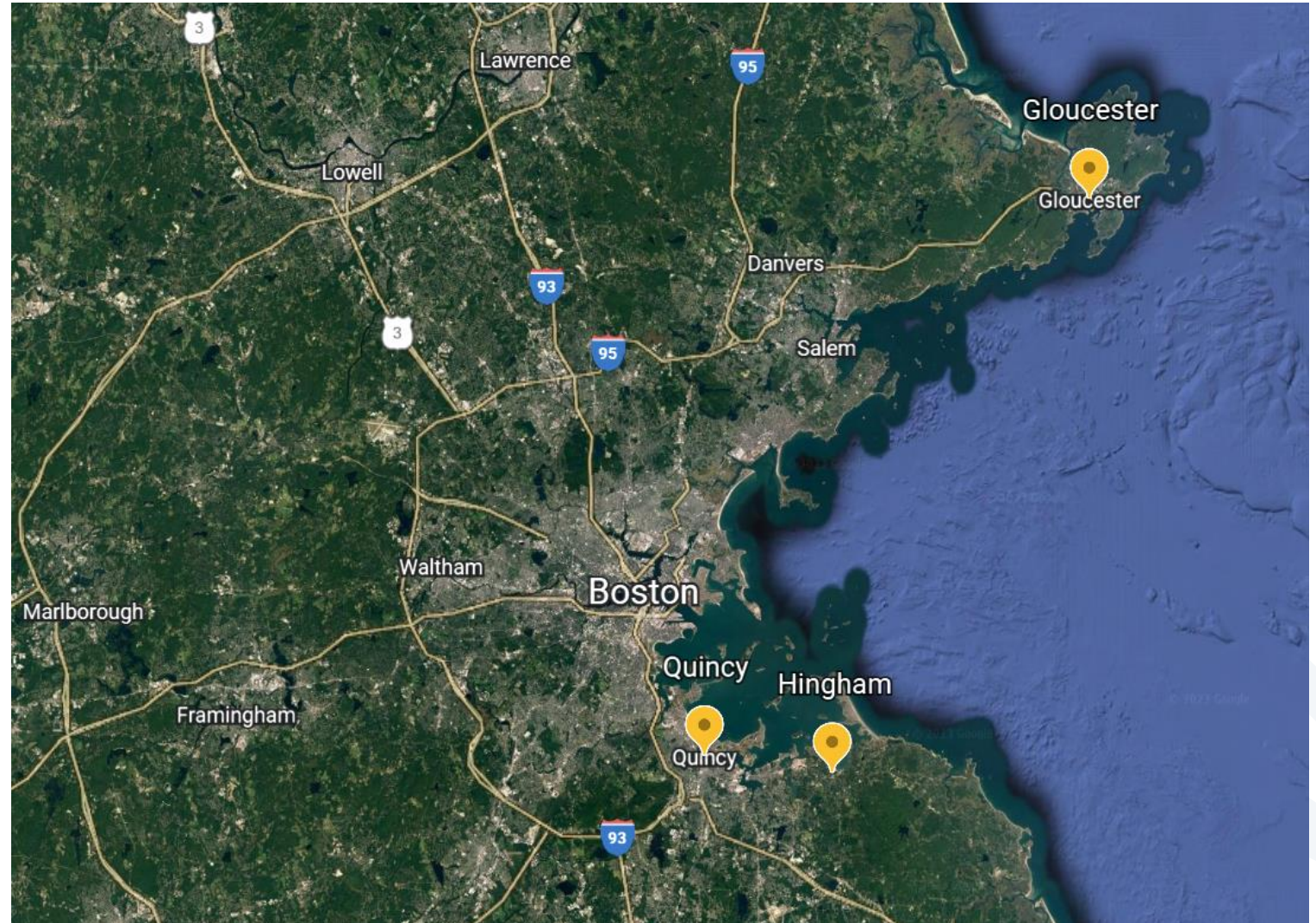
- ▶ Academic literature poses 500 – 1,000 copies of HF183/100 mL as analogous to EPA's 2012 Recreational Water Quality Criteria

# Massachusetts Coastal Communities: Three Case Studies



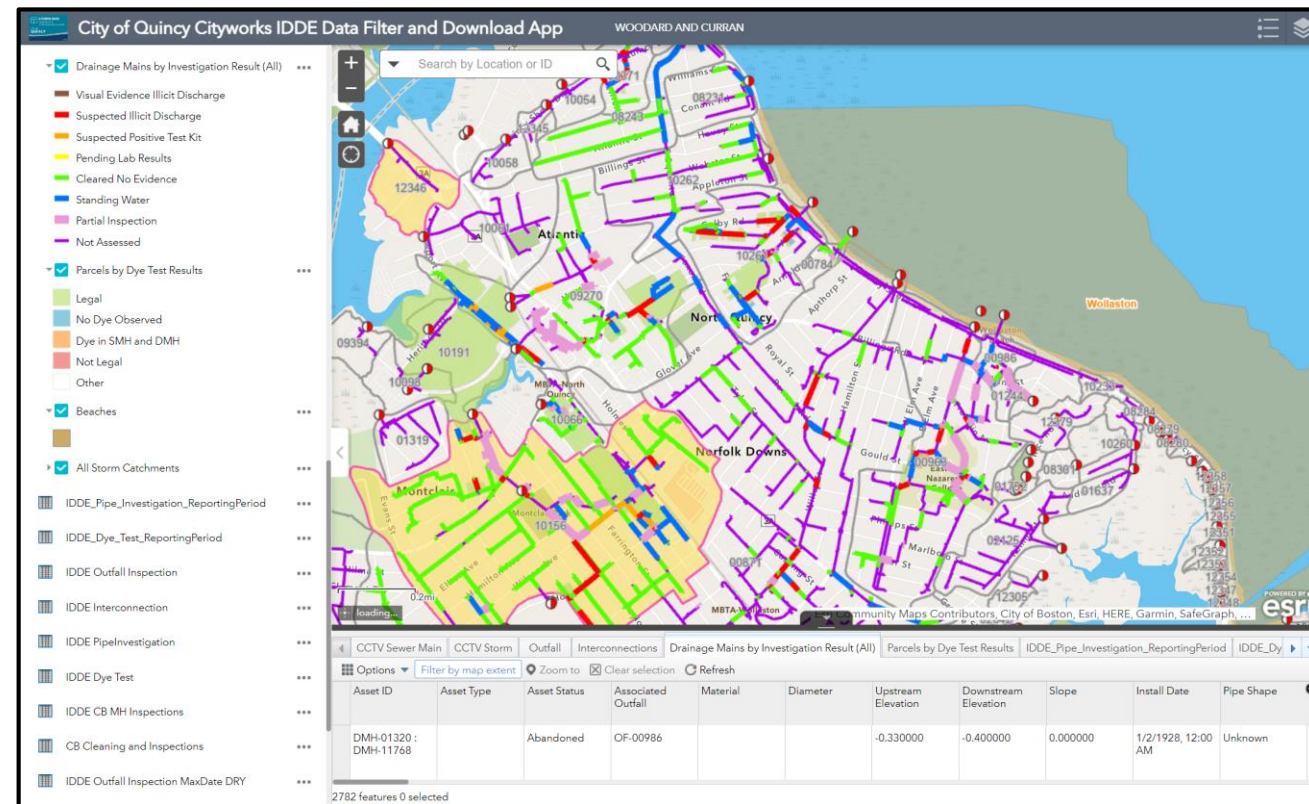
# Massachusetts Coastal Communities: Geographic Setting

- ▶ Quincy: 101,636 pop.
- ▶ Hingham: 24,284 pop.
- ▶ Gloucester: 29,729 pop.



# Quincy, MA: IDDE Driven by EPA Consent Decree

- ▶ Consent Decree Effective June 9, 2021:
  - Aggressive schedule – 1<sup>st</sup> 18 months
    - Dry and wet weather outfall inspections and sampling
    - Catchment investigations
    - Abatement of illicit discharges
  - Stringent criteria for potential illicit discharges
  - Focus on water quality sampling and beaches
  - MS4 data integration with sewer inspection and rehabilitation





# Quincy, MA: MS4 and Beach Considerations

- ▶ 14 City, State, and Private Beaches
  - Very few beach closures in recent years
  - Potential illicit discharges at a few outfalls

Beach Name	MS4 Outfall(s) Nearby
Avalon Beach	OF-05520
Baker (Broady) Beach	OF-04029
Chickatabot Beach - Private	OF-08549 and OF-10028
Edgewater Drive Beach	OF-11021 and OF-03400
Fire Station (Doane) Beach	OF-10164
Front (Heron) Beach	OF-02829
Merrymount (Shore Ave) Beach – Private	OF-02600
Mound Beach	N/A
Nickerson Beach	OF-00014, OF-00031 and OF-00097
Norton Beach – Public/Private	OF-08573
Orchard Beach	OF-00214, OF-00176 and OF-00147
Parkhurst (Perry) Beach	OF-01677 and OF-01578
Rhoda Beach	OF-10039 (200' North)
Wollaston Beach	OF-00784, OF-00871, OF-00963, OF-00986, OF-08231, OF-08243, OF-10261, and OF-10262

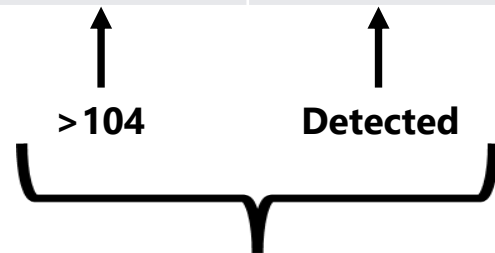


**“No Swimming Near Outfall – Contaminated Stormwater”  
Signage Required for Potential Illicit Discharges**

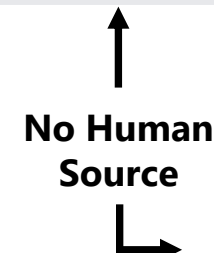
# Quincy, MA: Interpreting Results

- ▶ Example Monitoring Results (dry weather)
  - Potential illicit discharge in catchment to Wollaston Beach
  - Bacteroides data used to determine next steps

Location	Date	Enterococci (MPN/100mL)	Ammonia (mg/L)	Total Bacteroides (CE/100mL)	Human Bacteroides (CE/100mL)	Chlorine (mg/L)	Surfactants (mg/L)	Salinity (ppt)
OF-00986	7/20/2022	31	0.20	2,794	112	<0.02	1.0	>10
CB-19632	9/15/2022	<b>170</b>	<b>0.20</b>	12,015	<b>ND</b>	<0.02	1.0	2.3



**Exceeds Consent Decree  
Criteria for Potential  
Illicit Discharge**



- No further investigation activities
- No signage at beach
- Follow-up outfall monitoring only
- Low priority catchment

# Hingham, MA: Investigating Surface Water Quality and MS4 Permit Requirements

## ▶ Town Questions:

- What is driving MS4 Permit requirements for coastal outfalls?
- What is the status of coastal water quality?
- Could Town activities be contributing to water quality improvements?
  - Sewer rehabilitation in downtown and near public beaches
  - Harbor management – boat vessel discharge with sewer pump outs

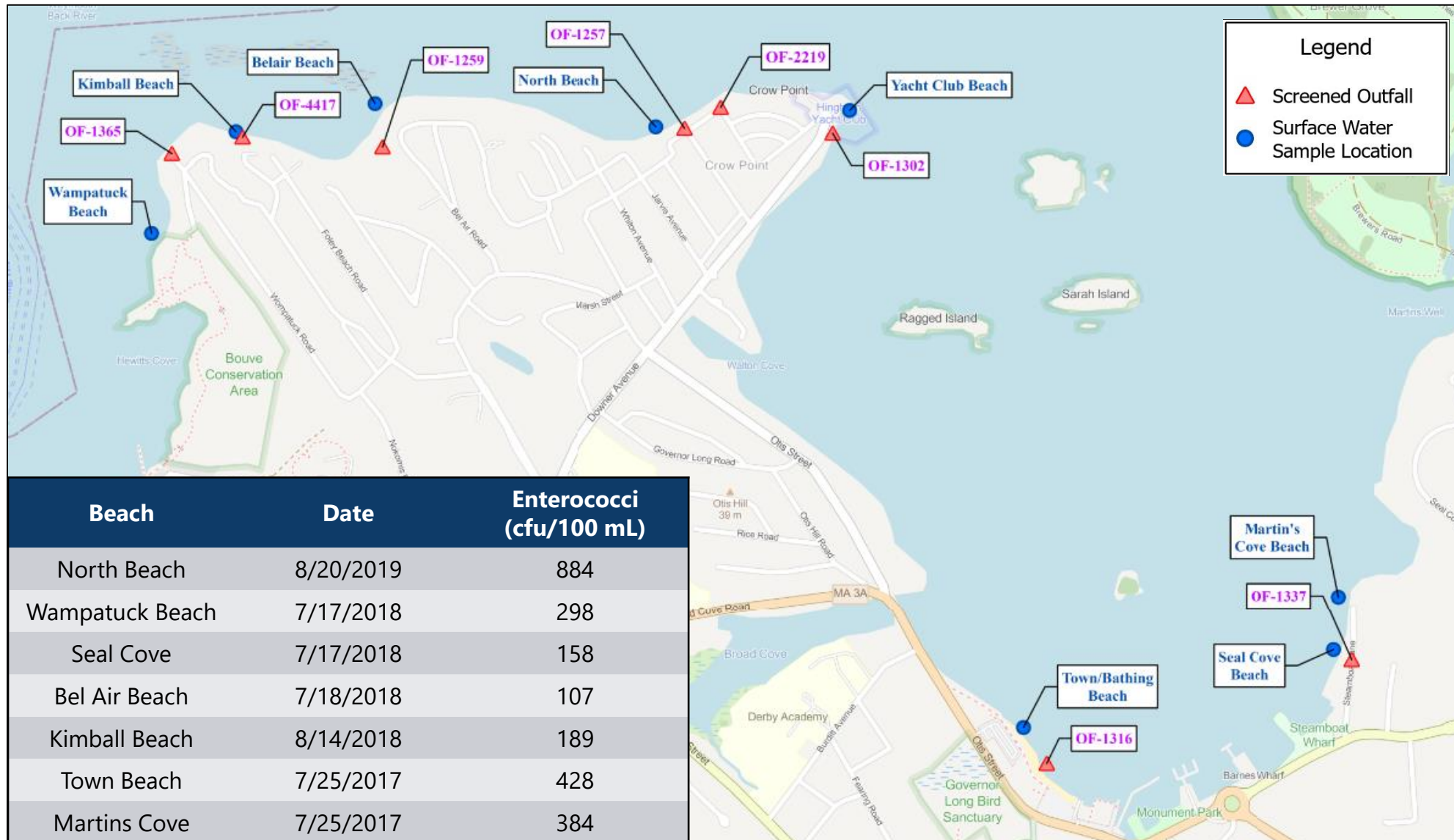
## ▶ Background and Understanding:

- Bacteria impairments in Hingham Harbor and Hingham Bay
- Some historic public beach closures
- Very few potential illicit discharges detected at outfalls

## ▶ Goals of Preliminary Investigation:

- Screen outfalls to determine whether human sources of bacteria are present
- Evaluate potential relationship between outfall discharges and water quality near beaches
- Evaluate surface water quality during the beach off-season

# Hingham, MA: Beaches and Outfalls





# Hingham, MA: Preliminary Investigation Results (April 2022)

Outfall ID	Corresponding Beach Location	Outfall Monitoring						Surface Water Monitoring		
			Flow Intensity	Surfactants (mg/L)	Ammonia (mg/L)	Chlorine (mg/L)	Enterococci (MPN/100mL)	Enterococci (MPN/100mL)	Total Bacteroides (CE/100mL)	Human Bacteroides (CE/100mL)
OF-1257	North Beach	Yes	Moderate	<0.05	<0.125	<0.02	50	<b>145</b>	5,935	ND
OF-2219		No	N/A	--	--	--	--			
OF-1259	Belair Beach	No	N/A	--	--	--	ND	<b>153</b>	ND	ND
OF-1316	Town Beach/Bathing Beach	Yes	Heavy	3	<0.125	<0.02	<b>250</b>	<b>397</b>	ND	ND
OF-1337	Seal Cove	Yes	Trickling	0.08	<0.125	0.02	30	<b>190</b>	ND	ND
	Martin's Cove							<b>291</b>	ND	ND
OF-1365	Wampatuck Beach	No	N/A	--	--	--	--	<b>126</b>	ND	ND
OF-4417	Kimball Beach	No	N/A	--	--	--	--	<b>107</b>	ND	ND
OF-1302	Yacht Club Beach	--	--	--	--	--	--	<b>115</b>	6,129	ND

- 1) Massachusetts Surface Water Quality Standards for Enterococci: 130 cfu/100 mL
- 2) Massachusetts Minimum Standards for Bathing Beaches : 104 cfu/100 mL
- 3) Surfactants, ammonia, and chlorine analyzed by test kit
- 4) Precipitation on 4/19/2022 = 0.56"
- 5) Outfall and surface water samples collected on 4/22/2022

↑  
**No Human Source**

# Gloucester, MA: Beach Water Quality Issues



# Gloucester, MA: Preliminary Investigation Implementation Overview



## Surface Water Sampling

Collection of surface water samples from Good Harbor Creek



## Drainage Infrastructure Investigations

Dry weather investigations of drainage infrastructure discharging to Good Harbor Creek

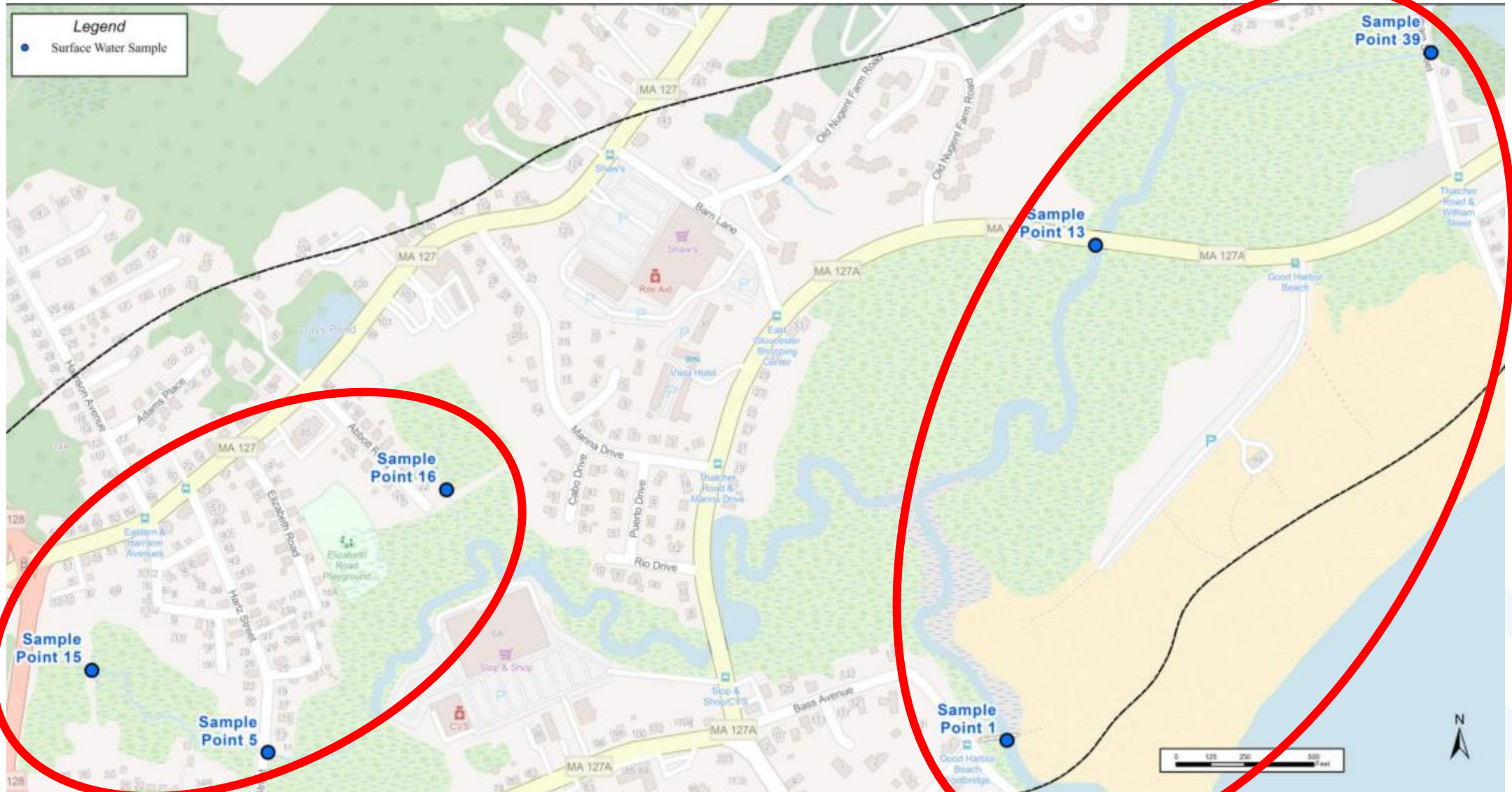


## Sewer CCTV Investigations

Camera investigations of sewer pipes extending across Good Harbor Creek



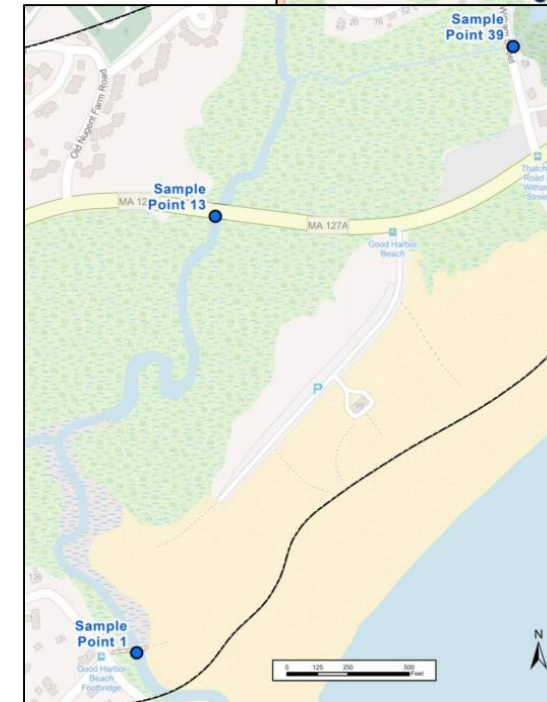
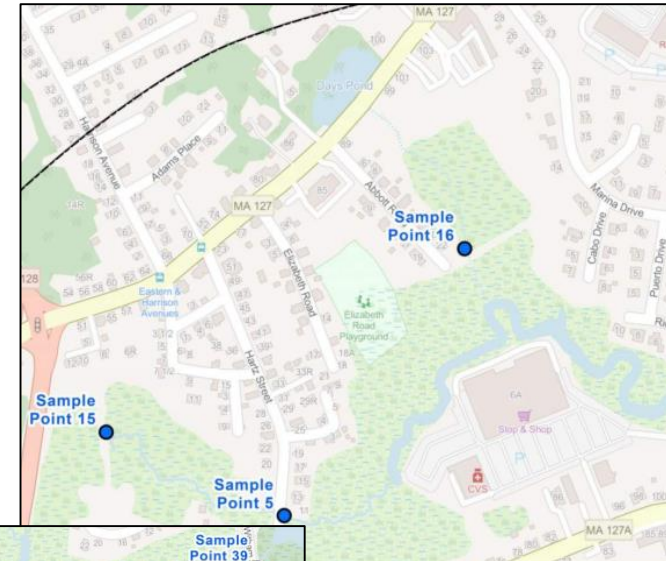
# Gloucester, MA: Surface Water Sample Locations





# Gloucester, MA: Dry Weather Surface Water Sampling Results

Sample ID	West Creek			East Creek	
	#5	#15	#16	#13	#39
Enterococci (MPN/100mL)	11	2	<b>884</b>	<b>556</b>	<b>301</b>
Total Bacteroides (CE/100mL)	19,409	2,296	119,821	2,506	90,655
Human Bacteroides (CE/100mL)	450	421	ND	ND	ND
	Sewer Main			Sewer Main	







# Gloucester, MA: Preliminary Investigation Results Summary

- ▶ No MS4 related bacterial contributions to Good Harbor Creek identified
- ▶ Investigated sewer infrastructure appears to be contributing bacteria to the western segment of Good Harbor Creek during specific precipitation events
- ▶ Non-human sources (potentially birds) are contributing most of the detected bacteria to the eastern segment of Good Harbor Creek, but a sewer force main may be also be a bacteria source





# Conclusions



# Bacteroides: Adding Value to Bacterial Source Investigations

- ▶ Additional supporting data/part of a more robust dataset
- ▶ Higher confidence in results
- ▶ Low-cost value to determining bacteria source (~\$90/sample)
  - No preservation or holding requirements – can be used as part of an iterative source investigation approach
- ▶ Driver toward focusing investigation efforts/making efficient and cost-effective decisions
- ▶ Evaluation of human health risks based on human vs non-human sources
- ▶ Mitigation strategies for human vs bird/dog bacterial contributions
  - Targeted infrastructure investigations
  - Waterfowl management
  - Enhanced education for pet waste management

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