



Town of

Orleans
Massachusetts

The History of Wastewater Planning in Orleans, MA

Board of Water and Sewer Commissioners Meeting
August 19, 2020



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Topics

- ❖ Regulatory Documents
- ❖ 208 Planning Project
- ❖ Orleans: 1970 – 2018
- ❖ Comprehensive Wastewater Management Plan (CWMP)
- ❖ Landfill
- ❖ Effluent Disposal
- ❖ Downtown Area Collection System, Pumping Stations, WWTF and Effluent Disposal
- ❖ Downtown Area Easements
- ❖ Low-Pressure Sewerage Pump Systems
- ❖ Non-Traditional Technologies
 - Aquaculture
 - Nitrogen Removing Biofilters (NRBs)
 - Permeable Reactive Barriers (PRBs)
- ❖ Meetinghouse Pond Area Collection System and Pumping Station
- ❖ Financial Model
- ❖ Nauset Regional Middle School and High School Educational Series



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Regulatory Documents

- ❖ “TR16, Guides for the Design of Wastewater Treatment Works” by New England Interstate Water Pollution Control Commission
- ❖ “Wastewater Engineering: Treatment, Disposal, and Reuse” by AECOM (Metcalf & Eddy)
- ❖ “Water Reuse: issues, Technologies, and Applications” by AECOM (Metcalf & Eddy)
- ❖ “Biological Wastewater Treatment” by Grady, Daigger, & Lim
- ❖ “Wastewater Treatment Plant Design: Manual of Practice (MOP 8)” by Water Environment Federation
- ❖ “Process Design Manual: Land Treatment of Municipal Wastewater – Supplement on Rapid Infiltration and Overland Flow” by United States EPA (EPA 625/1-81-013a)



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Regulatory Documents (cont.)

- ❖ “Process Design Manual: Land Treatment of Municipal Wastewater” by United States EPA (EPA 625/1-81-013)
- ❖ “Northeast Guide for Estimating Staffing at Publicly and Privately Owned Wastewater Treatment Plants” by the New England Interstate Water Pollution Control Commission
- ❖ “310 CMR 15.00: The State Environmental Code Regulating Septic Systems (Title 5)” by MassDEP
- ❖ “Guidelines for the Design, Construction, Operation, and Maintenance of Small Wastewater Treatment Facilities with Land Disposal” by MassDEP

Words such as “should” and “recommended” used in the Documents are interpreted by MassDEP as “required” during their Review and approval of Contract Documents



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208 Planning Project

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Cape Cod's Background and Problem

Background

- ❖ 105 Watersheds
- ❖ 53 Embayment Watersheds
- ❖ 994 Ponds
- ❖ Sole Source Aquifer
- ❖ Development over Time
- ❖ Increased Nutrient Loads
- ❖ MEP Studies and TMDLs
- ❖ Section 208 Update

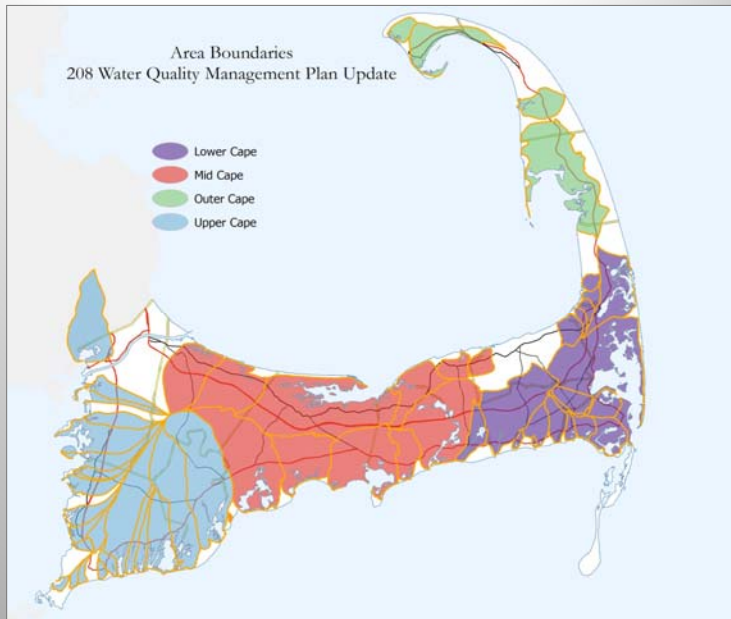
Problem

- ❖ Estuaries Nitrogen Sensitive
- ❖ Ponds Phosphorus Sensitive
- ❖ Eutrophication
- ❖ Economic Impacts (Tourism)
- ❖ Cost of Nutrient Removal



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WATERSHED SUBGROUPS



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Technology Matrix

- ❖ Technology / Strategy
- ❖ Description
- ❖ Influent Source and Concentration
- ❖ Pollutant Treated / Reason for Use
- ❖ Potential Permitting Agencies
- ❖ Siting Requirements
- ❖ Flow and Nutrient Influent Load
- ❖ Nutrient Reduction
- ❖ Impact on Surface Water Quality
- ❖ Nutrient Removed per Year
- ❖ Unit Metric
- ❖ Reduction per Planning Period
- ❖ Construction, Project and O&M Costs
- ❖ System Considerations
- ❖ Average Life Cycle Cost
- ❖ Cost per Kg of Nutrient Reduction
- ❖ Advantages / Disadvantages
- ❖ Eco Services: Habitat, Green Space, Energy Savings
- ❖ Monitoring
- ❖ References



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Technology Matrix (cont.) Traditional Technologies

- ❖ Collection System
 - Gravity Sewers
 - Low Pressure Sewers
 - Septic Tank Effluent Pumping
 - Septic Tank Effluent Gravity
 - Vacuum Sewers
 - Hybrid
- ❖ Effluent Disposal
 - Open Basins
 - Subsurface
 - Drip
 - Wick Wells
- ❖ Treatment
 - Conventional Activated Sludge
 - Sequencing Batch Reactor
 - Integrated Fixed Film Activated Sludge
 - Membrane Bioreactor
 - Rotating Biological Contractor



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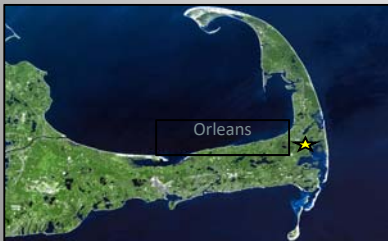
Technology Matrix (cont.) Non-Traditional Technologies

- ❖ Constructed Wetlands
- ❖ Hydroponic Treatment
- ❖ Phyto-irrigation
- ❖ Stormwater BMP
- ❖ Fertilizer Management
- ❖ Aquaculture
- ❖ Permeable Reactive Barriers
- ❖ Fertigation Wells
- ❖ Toilets: Composting, Urine Diverting and Incinerating
- ❖ Development: Remediation, Compact and Open Space, Transfer of Development Rights
- ❖ Inlet / Culvert Widening, Dredging
- ❖ Coastal Habitat Restoration
- ❖ Floating Constructed Wetlands
- ❖ Pond and Estuary Circulators
Chemical Treatment, and Dredging

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Cape Cod's Nitrogen Problem

- ❖ Widely Dispersed Development with 85% Reliance on Septic Systems
- ❖ Groundwater System Carries Nitrogen (mainly nitrate) to Numerous Coastal Embayments



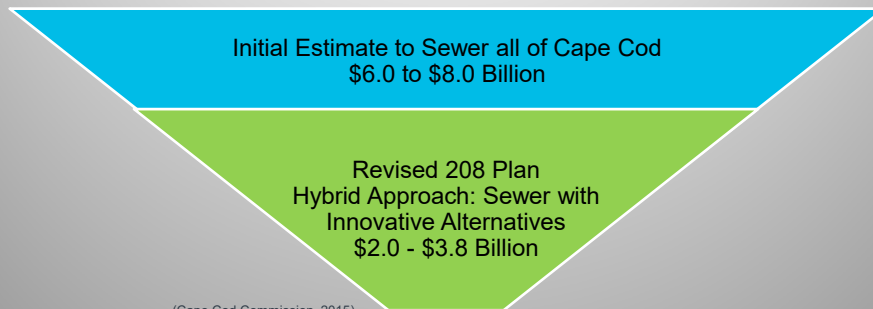
- ❖ Eutrophication – Poor Water Quality, Loss of Habitat, Aesthetic and Economic Impacts

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Cape Cod's Solution

- ❖ Updated Regional Cape Cod 208 Water Quality Plan
 - Watershed-based Approach to Restore Embayments
 - Framework/Tools to Achieve Water Quality in Compliance with the Clean Water Act

Cost Comparison

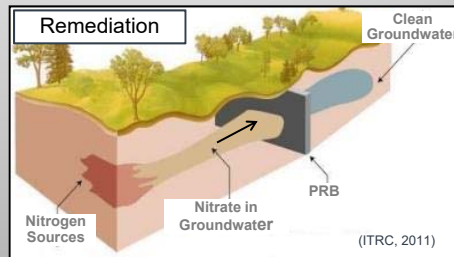


(Cape Cod Commission, 2015)

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Cape Cod's Solution (cont.)

- ❖ Combines Traditional Wastewater (sewer) and Non-traditional Treatments
 - Sewer Infrastructure in High Density Areas
 - Utilize Non-Traditional Technologies (Groundwater Treatment with PRBs, Shellfish Aquaculture Operations, etc.)
 - Monitoring to Assure Achievement of TMDLs
 - Adaptive Management for Course Correction



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Orleans: 1970 - 2018

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Orleans: 1970 - 2018

❖ Key Regulations

- 1972: Clean water Act Approved
- 1974: Title 5 Implemented
- 1994: Title 5 Amended
- 2008: State Approves Checkerboard Sewering
- 2016: Title 5 Updated

❖ Area of Critical Environmental Concerns

- 1987: Pleasant Bay
- 1985: Inner Cape Cod Bay

❖ Pleasant Bay

- 1998: Pleasant Bay Resource Management Plan Adopted
- 2003: Pleasant Bay Resource Management Plan Updated
- 2008: Pleasant Bay Resource Management Plan Updated
- 2013: Pleasant Bay Resource Management Plan Updated



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Orleans: 1970 - 2018 (cont.)

❖ Key Town Actions

- 1982: Orleans Conservation Trust Acquires Namskaket Marsh Acreage
- 1986: Orleans Water Quality Task Force Approved at Town Meeting
- 2000: Wastewater Management Steering Committee Established
- 2000: Orleans Starts Pond and Lake Stewarts (PALS) Monitoring Program
- 2008: Board of Health Develops Nutrient Management Regulations
- 2008: Board of Water and Sewer Commissioners Established
- 2008: Town Establishes a Wastewater Financing Plan
- 2009: Wastewater Regionalization Study Between Orleans-Brewster-Eastham
- 2009: Wastewater Management Validation Subcommittee Report
- 2009: Acceptance of MGL Chapter 83 Section 1A - Authorization to Install Sewer Mains
- 2013: Cedar Pond Study



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Orleans: 1970 - 2018 (cont.)

- ❖ Orleans-Brewster-Eastham Groundwater Protection District
 - 1978: Tri-Town Septage Treatment Facility Planning Begins
 - 1988: District Created
 - 2005: Facility Evaluation
 - 2013: Selectmen Vote to Discontinue the Use of the Facility
 - 2013: Intermunicipal Agreement Extended until 2016
 - Septage Receipts Ceased - June 1, 2016
- ❖ 2016: Decommissioning Standard Operating Procedures
- ❖ 2016: Phase 1 Environmental Site Assessment
- ❖ 2016: Demolition Contract Documents Completed
- ❖ 2017: Bid Opening
- ❖ 2018: Demolition Substantially Completed



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Orleans: 1970 - 2018 (cont.)

- ❖ Massachusetts Estuaries Project
 - 2001: Cape Cod Bay and Nauset Estuaries Monitoring Begins
 - 2006: Pleasant Bay Report Issued
 - 2008: Rock Harbor Report Issued
 - 2008: Namskaket Creek Report Issued
 - 2008: Little Namskaket Creek Report Issued
 - 2009: Pleasant Bay Report Independent Review and Validation
 - 2010: Rock Harbor, Namskaket Creek and Little Namskaket Creek – Report Citizens Peer Review
 - 2011: Scientific Peer Review Panel Finds MEP Data Adequate
 - 2012: Nauset Marsh Report Issued
 - 2012: Nauset Marsh Report ASA Review



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Comprehensive Wastewater Management Plan (CWMP)

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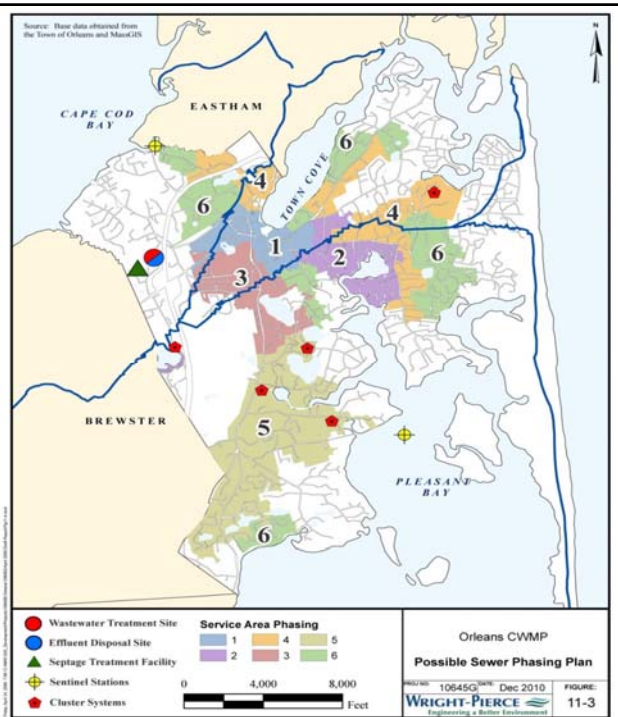
CWMP

- ❖ 2005: Data Review and Scoping
- ❖ 2007: Needs Assessment
- ❖ 2007: Development of Screening and Alternatives
- ❖ 2008: Detailed Evaluation of Evaluation of Alternatives, Regulatory Findings and Development of Recommended Plan
- ❖ 2008: Town Meeting Endorses CWMP Recommended Plan
 - 2,800 Properties
- Hybrid System
 - Gravity Sewer
 - Low-Pressure Sewer
 - 390,000 l.f. of Pipe Lines
- WWTF / Disposal at Overland Way
- ❖ 2009: Draft Environmental Impact Report Issued
- ❖ 2009: Citizens Petition Requesting Examination of Alternatives
- ❖ 2010: Independent Review
- ❖ 2010: Final Environmental Impact Report Issued



CWMP (cont.)

- ❖ 2011: MEPA Certificate Issued
- ❖ 2011: Cape Cod Commission Issues Development of Regional Impact (DRI)
- ❖ 2012: Weston and Sampson Technical Review and Cost Analysis
- ❖ 2013: Phase 1A Cost Estimate
- ❖ 2013: Annual Town Meeting Fails to Reach 2/3rds
- ❖ 2013: Special Town Meeting Fails to Reach 2/3rds



Orleans Water Quality Advisory Panel

- ❖ Downtown Planning
- ❖ Working Groups
 - Aquaculture
 - Floating Contracted Wetlands
 - Permeable Reactive Barriers
 - WWTF and Collection System
- ❖ Effluent Disposal
- ❖ Septage Receiving/Processing
- ❖ Financial Model
- ❖ Landfill
- ❖ Town's Web Page
- ❖ Tri-Town Septage Facility Transition
- ❖ Delivery Options
 - Design-Bid-Build with Contract Operations
 - Design-Build with Contract Operations
 - Design-Build-Operate
 - Public-Private Partnership

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CWMP (cont.)

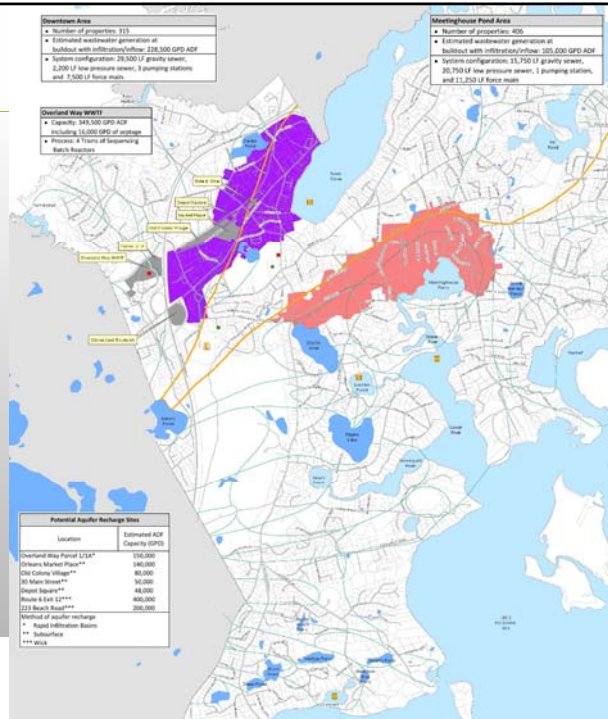
- ❖ Conceptual and Preliminary Design to Update the CWMP (2011) and To Reflect the Consensus Plan (2015)
- ❖ Goal: Minimize Proposed Sewered footprint to the Greatest Extent Possible
- ❖ Maximize Use of Non-traditional Technologies
- ❖ Notice of Project Change Certificates
 - Effluent Discharge
 - Non-Traditional Technologies
- ❖ First Project on Cape Cod to Implement a Hybrid Approach
- ❖ Combines Traditional and Non-traditional Wastewater Treatments
 - Sewer Infrastructure in High Density Areas
 - In-situ Groundwater Treatment with Permeable Reactive Barriers (PRBs)
 - Increase Shellfish Aquaculture Operations
 - On-Site System Enhancements
 - Adaptive Management for Course Correction

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Orleans Water Quality Advisory Panel

❖ Meetings

- Select Board
- Finance Committee
- Shell Fish Committee
- Businesses
- Orleans Can
- Lt. Governor's Office
- MEPA
- MassDOT
- MassDEP
- Nauset Regional School District
- Others

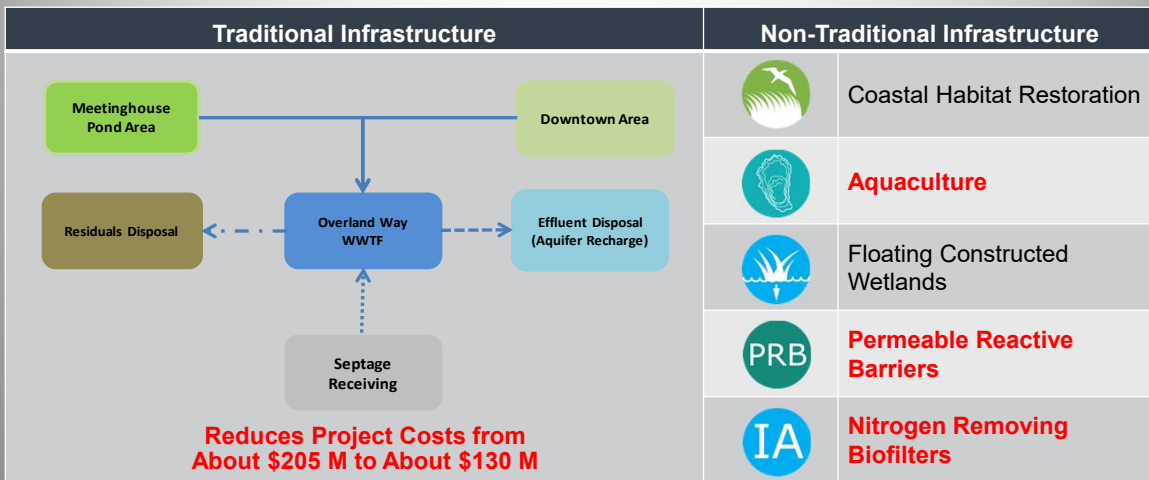


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Orleans Water Quality Advisory Panel (cont.)



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Orleans Water Quality Advisory Panel (cont.) Wastewater Treatment Facility

- ❖ WWTF Process Selection
 - Designed for Sewage and Septage Receiving/Treatment
 - Two Top Candidates Identified in Concept Design Phase Were Further Explored (SBR and MBR)
 - Design to Include Biosolids Thickening but Not Dewatering
- ❖ Design Data
 - Flows Derived from Collection System Evaluation
 - Sewage Strength (Assumed medium to strong) - Provincetown and Chatham Used as a Reference
 - Tri-town Septage Treatment Facility Data Used for Septage Characteristics
 - Anticipated Effluent Requirements
 - BOD & TSS \leq 30 mg/l
 - TN \leq 10 mg/l
 - Designing for Lower Limits



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Orleans Water Quality Advisory Panel (cont.) Wastewater Collection System

Collection System

- ❖ Gravity Sewers (GS)
- ❖ Low Pressure Sewers (LPS)
- ❖ Septic Tank Effluent Pumping (STEP)
- ❖ Septic Tank Effluent Gravity (STEG)
- ❖ Vacuum Sewers (VS)
- ❖ Hybrid

Cost Evaluation

- ❖ Prepared Preliminary System Layouts
 - Downtown Area
 - Meetinghouse Pond Area
- ❖ Developed Quantities
- ❖ Developed Unit Prices
 - Project (Capital)
 - Operation and Maintenance
 - Replacement
 - Monitoring
- ❖ Prepared Life-Cycle Cost Analysis



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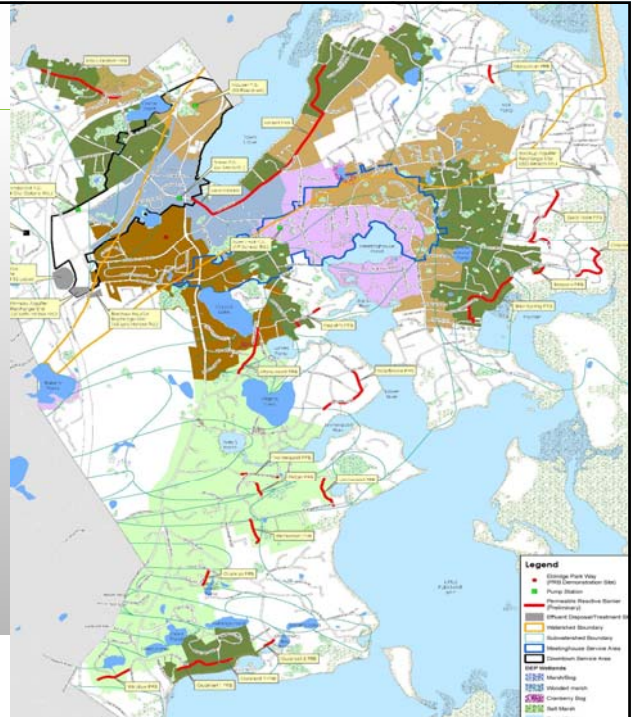
Orleans Water Quality Advisory Panel (cont.) Wastewater Collection System

- ❖ Sizing of a Wastewater Collection System (Initial, Design and Future)
 - Minimum and Maximum Daily Flows
 - Maximum Hourly Flows
 - Seasonal Flows
 - Required Peaking Factors
- ❖ Design Considerations
 - Type of Flow
 - Expansion
 - Change in Use / Zoning Changes
 - Utilities
 - Environmental
 - Historical
- ❖ Impacts of Improperly Designed Collection System
 - Odors
 - Sewer Overflows
 - Excessive Operating Costs
 - Short Equipment Life and Excess Energy Costs Due to Equipment Operating Outside of their Normal Operating Range
 - Lack of Flexibility for Future Conditions



Orleans Water Quality Advisory Panel (cont.)

- ❖ 2011 CWMP – Possible Sewer Phasing Plan
- ❖ Downtown Service Area
- ❖ Meetinghouse Pond Service Area (Preliminary)
- ❖ Future Permeable Reactive Barriers Locations (Preliminary)





Landfill

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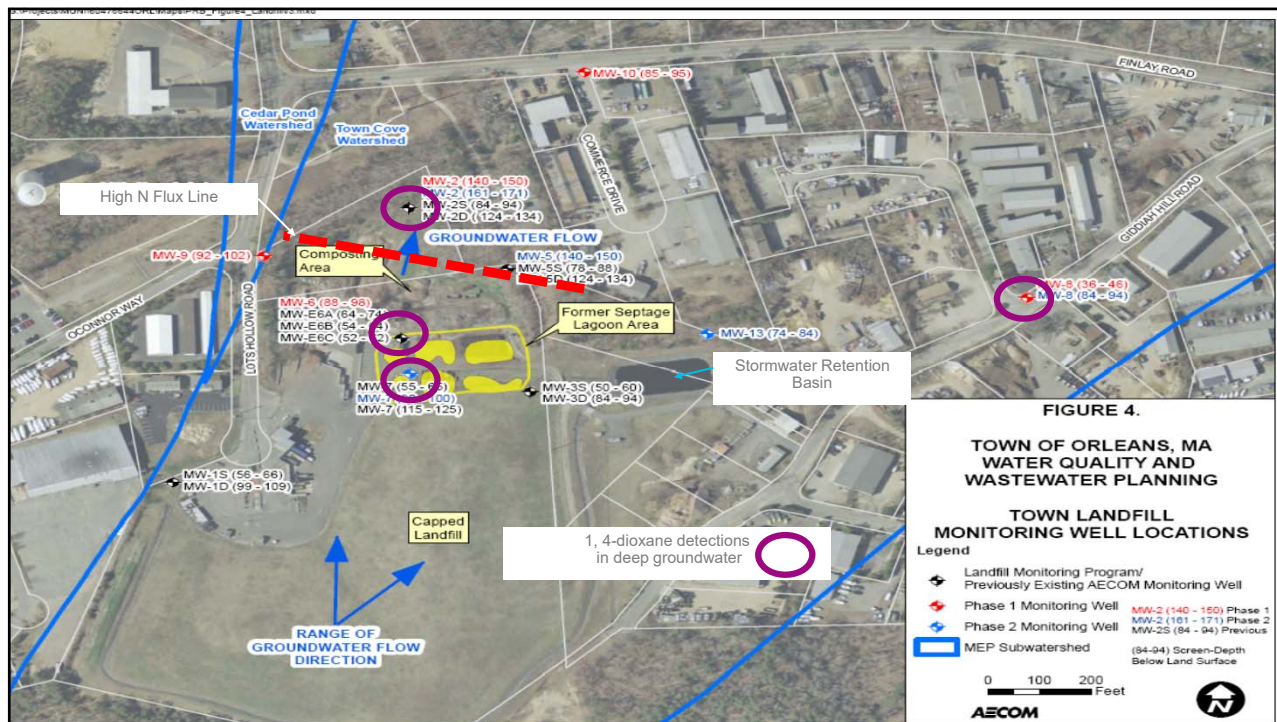
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Landfill

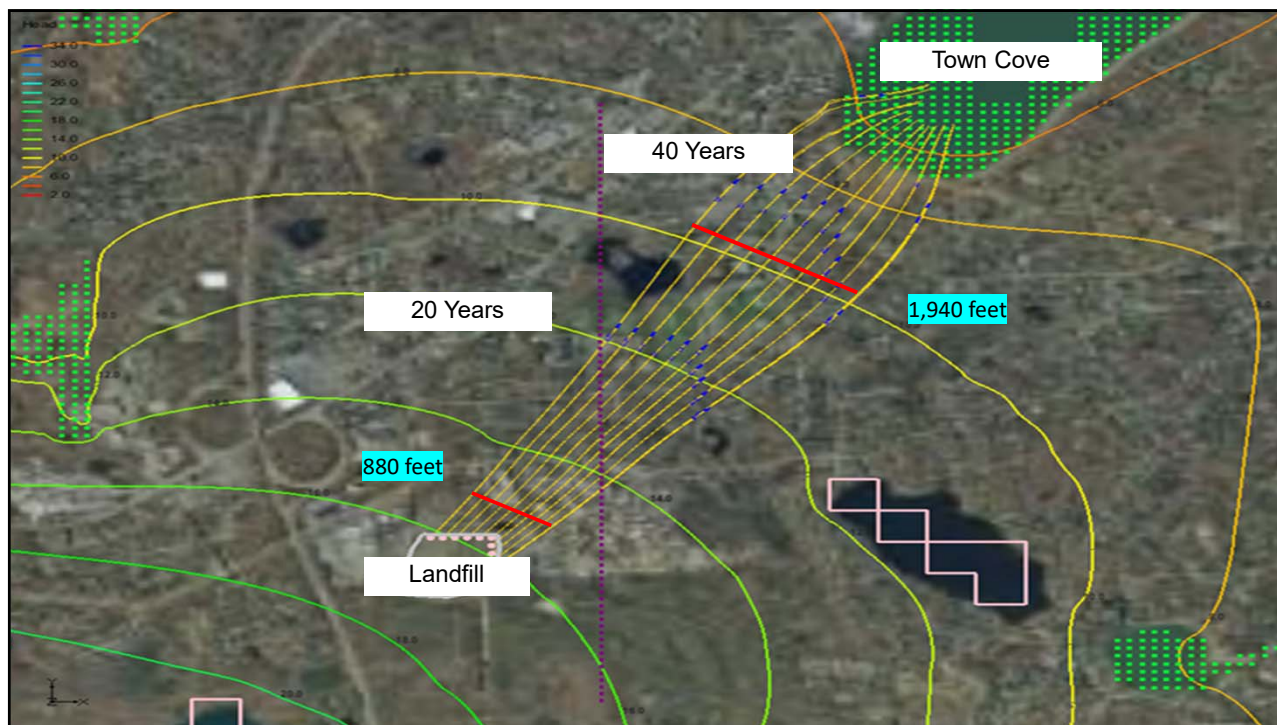
- ❖ Groundwater Impacted by a Two Layer Plume
 - Nitrate Nitrogen – Water Table to ~20-feet Below Water Table
 - Ammonia Nitrogen and 1,4-dioxane ~20-feet Below Water Table to ~100-feet Below the Water Table
- ❖ Sources Identified
 - 1,4-dioxane (Solid Waste in Landfill)
 - Nitrogen (Solid Waste, Septage Lagoons, Surface Runoff, Composting)
- ❖ Nitrogen Flux Highest in Area West of the Stormwater Retention Basin
- ❖ 1,4-dioxane detected in deep groundwater monitoring wells > 0.0003 mg/L standard across watershed area immediately downgradient of landfill



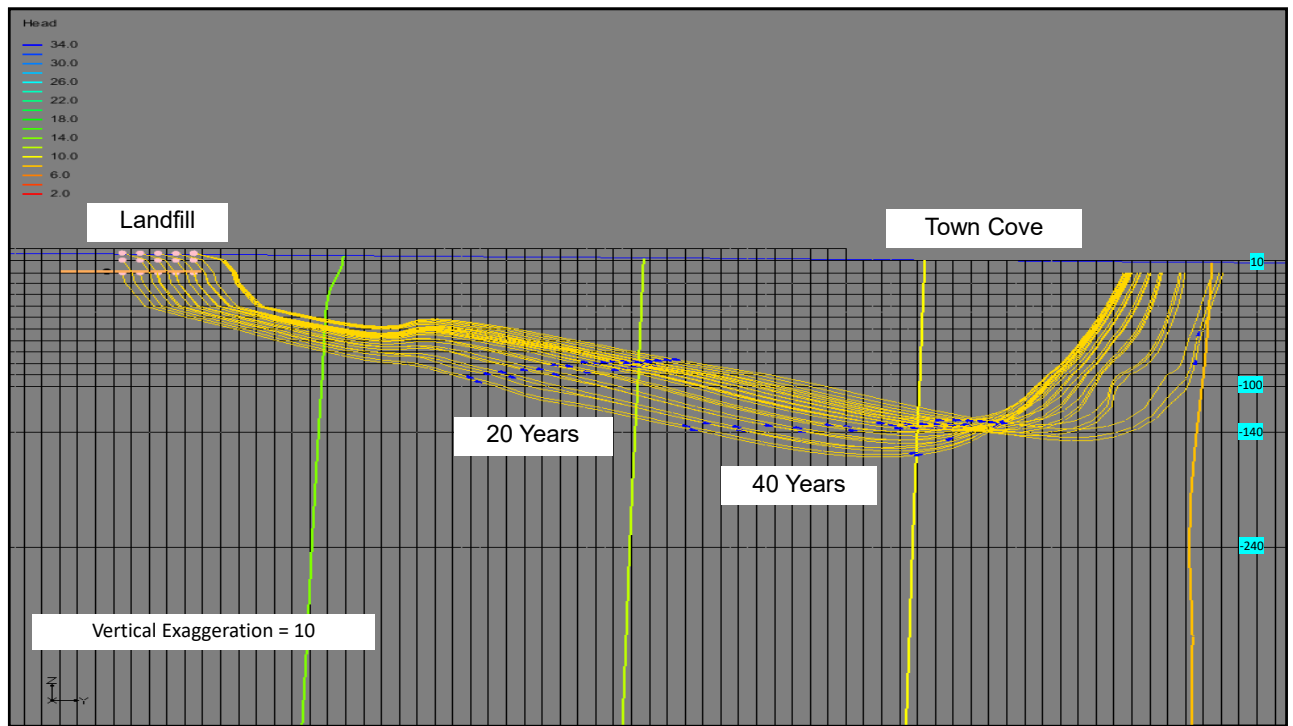
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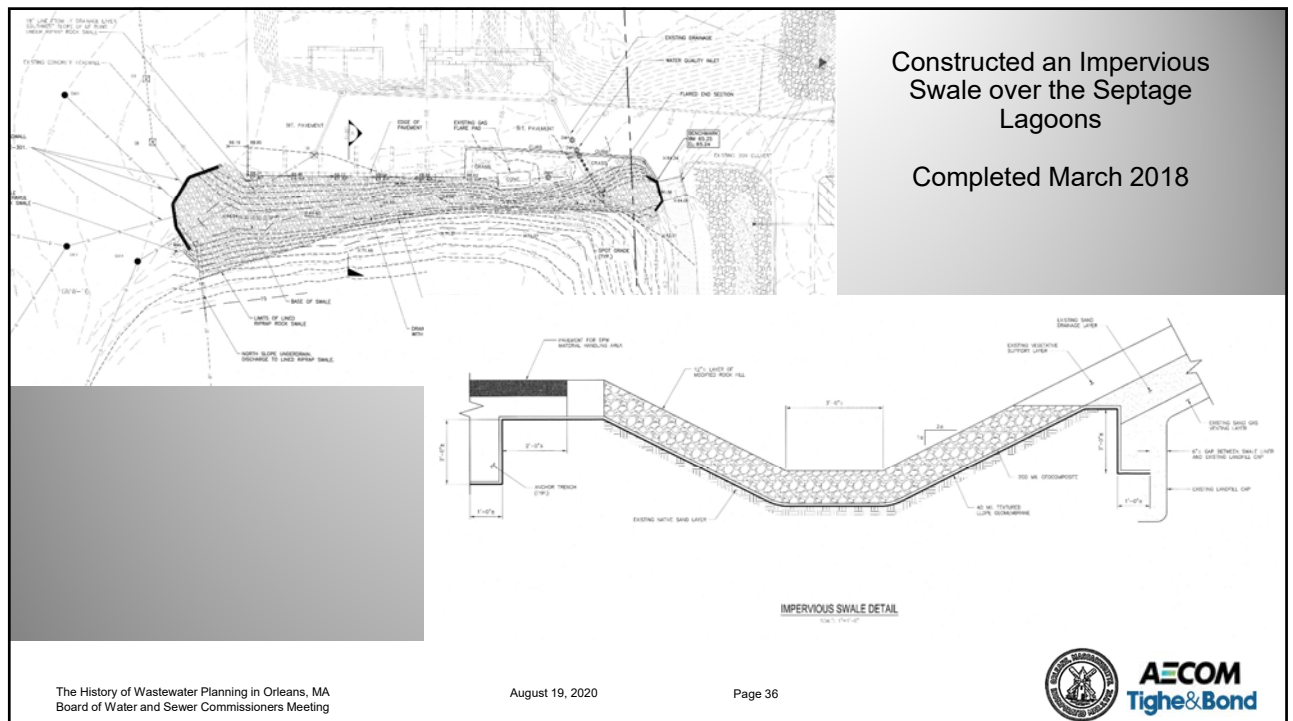
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Effluent Disposal

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Effluent Disposal Evaluation

- ❖ Preliminary Evaluation
 - Site Visit
 - Board of Health Records
 - USGS Data
 - Cape Cod Commission Data
- ❖ Detailed Evaluation
 - Field Investigation Requirements
 - Hydrogeologic Evaluation Proposal
 - Drilling Investigations
 - Loading Test on Test Wick
 - Groundwater Modeling
 - Wick Testing Evaluation and Report
 - Hydrogeologic Evaluation Report



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Effluent Disposal Sites

❖ Sites Evaluated

- 223 Beach Road *
- 32 Lots Hollow Road *
- 43 Lots Hollow Road *
- Depot Square
- Hole in One
- Market Place
- Old Colony Village
- Orleans Market Place *
- Route 6, Exit 12 Lobe *
- Tri-Town Septage Treatment Facility *

* MassDEP Approved Hydrogeology Evaluations

❖ Primary Aquifer Recharge Site

- 32 Lots Hollow Road

❖ Backup Aquifer Recharge Sites

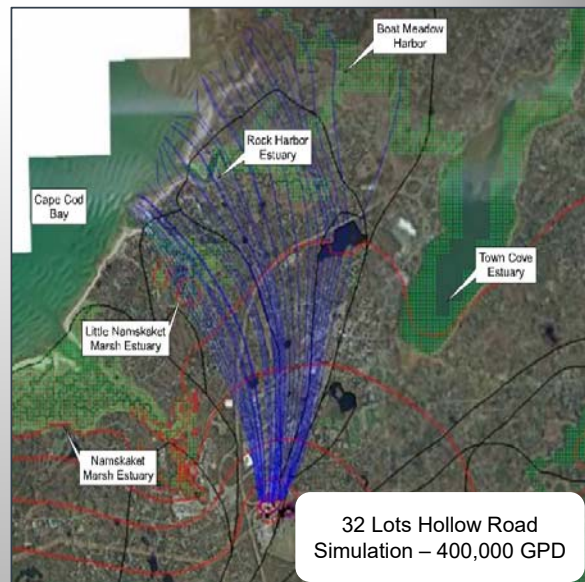
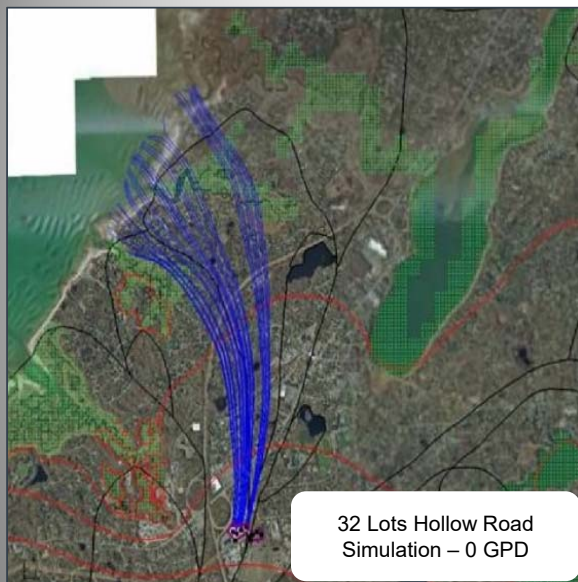
- 43 Lots Hollow Road
- Route 6, Exit 12 Lobe
- 223 Beach Road

❖ Submitted Groundwater Discharge Permit (July 2019)

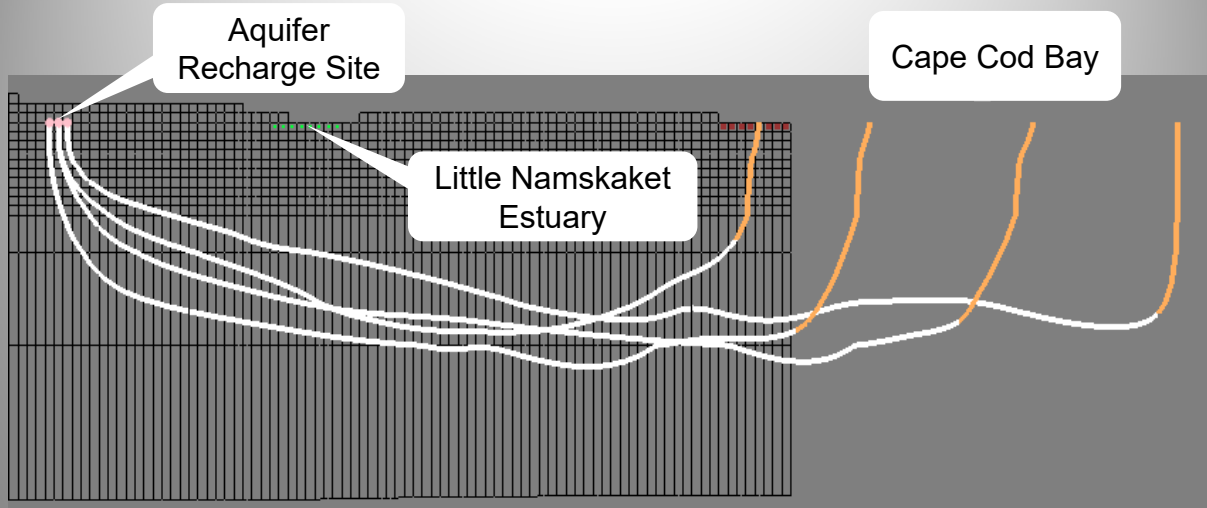
- 32 Lots Hollow Road
- 43 Lots Hollow Road

❖ MassDEP Groundwater Discharge Permit Issued (March 2020)

- 32 Lots Hollow Road
- 43 Lots Hollow Road



32 Lots Hollow Road - Cross Section



Downtown Area Collection System, Pumping Stations, WWTF and Effluent Disposal

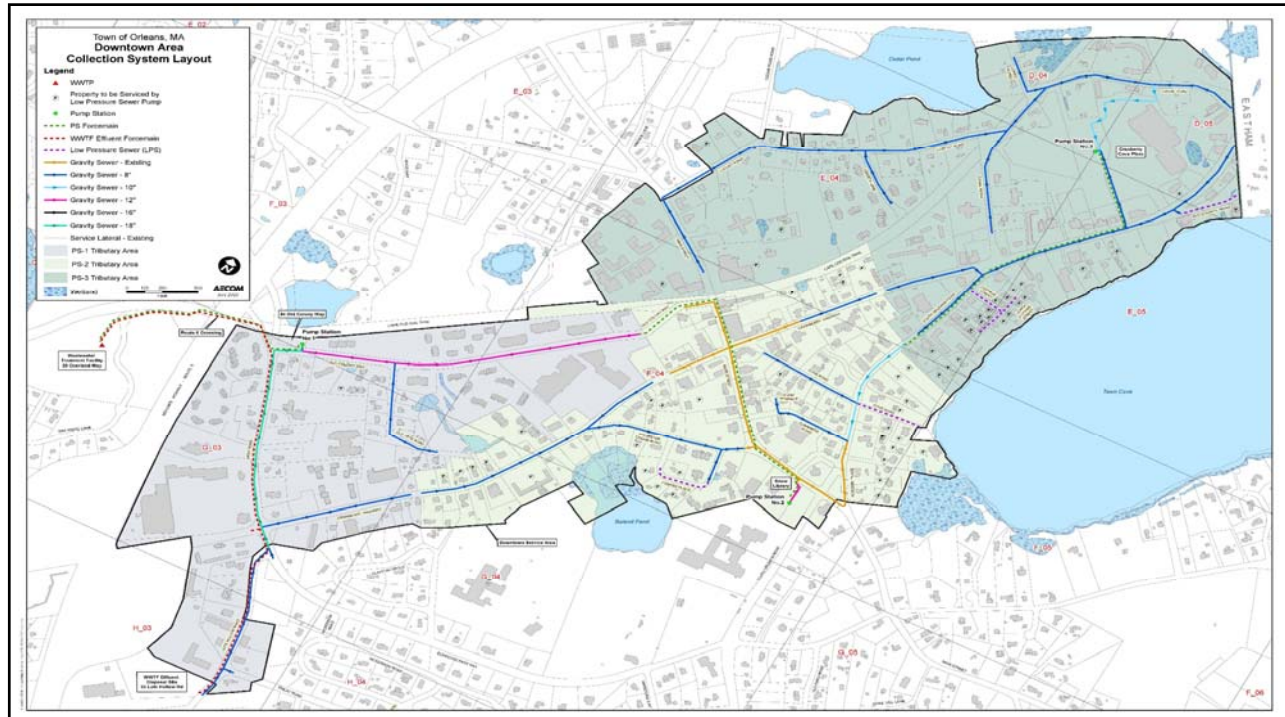
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Downtown Area Collection System and Pumping Stations

- ❖ About 32,200 Linear Feet of 8-inch through 18-inch PVC Gravity Sewer
- ❖ About 11,400 Linear Feet of 6-inch and 8-inch PVC and HDPE Force Main
- ❖ About 2,100 Linear Feet of 2-inch Low Pressure Sewer
- ❖ Piping Systems Connected Under Route 6
- ❖ 3 Submersible Pumping Stations
- ❖ Route 6 Crossing via Horizontal Directional Drilling
 - 8-inch Force Main (PS No. 1 to WWTF)
 - 8-inch Effluent Force Main (WWTF to the 32 Lots Hollow Road)
 - Two 4-inch Electrical Conduits
 - Additional 8-inch Force Main for Future Build-out Conditions
- ❖ Estimated 1,090 Users
- ❖ About 57 Privately Owned and Maintained Low-Pressure Sewerage Pump System

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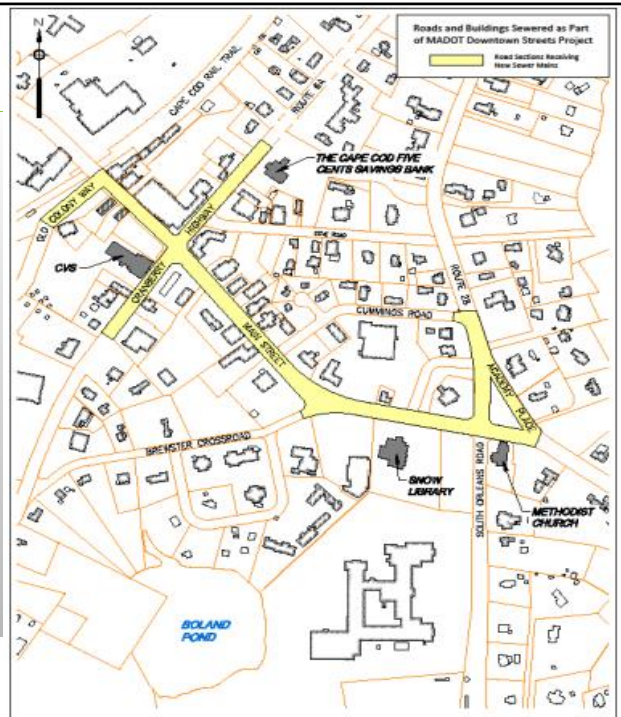
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Main Street Project Spring 2018

- ❖ Revoli Construction Co., Inc.
- ❖ Components
 - 4,007 Linear Feet of 8-inch and 10-inch PVC and DI Gravity Sewer
 - 1,950 Linear Feet of 6-inch HDPE Force Main
 - 1,142 Linear Feet of 6-inch Service Connections
- ❖ Cost
 - Construction (Final): \$2,695,187
 - Completed Under Budget by About \$500,000

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Downtown Area Collection System and Pumping Stations - SRF Ineligible Items

- ❖ Brewster Cross Road and Locust Road Water Quality Projects
 - Cost
 - Bid: \$27,000
 - Location
 - Brewster Cross Road
 - Locust Road
 - Reduce Nutrient Loading into Boland's Pond and Cedar Pond
- ❖ Replacement of Water Services in Sewer Area
 - Cost
 - Bid: \$105,720
 - Paid From the Water Special Revenue Fund
 - Location
 - 60 Locations Throughout the Downtown Area Collection System
 - Replace 57-year-old Water Services

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Downtown Area Collection System and Pumping Stations - SRF Ineligible Items

- ❖ Replacement of Canal Road Water Main
 - Cost
 - Bid: \$271,924
 - Paid From the Water Special Revenue Fund
 - Canal Road from Jones Road to Eastham Town Line
 - Replace the Original 1963 Water Main on Canal Road
 - Water Asset Management Plan Report Recommendation to Improve Fire Flows in the Area



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Downtown Area Wastewater Treatment Facility and Effluent Disposal

- ❖ Major Process Components
 - Influent Screening
 - Septage Receiving Station
 - Pre and Post Equalization Tanks
 - Sequencing Batch Reactors (SBR)
 - Effluent Disk Filters
 - Effluent Pumps
 - Ultraviolet Disinfection Equipment
 - Dual Rotary Drum Thickener
 - Chemical Storage and Feed Systems
 - Odor Control
- ❖ Effluent Disposal
 - Lots Hollow Road
 - Wicks (Aquifer Recharge)
- ❖ Permit Design Data
 - Average Daily Flow: 350,000 GPD
 - BOD₅: 30 mg/L
 - TSS: 30 mg/L
 - Total Nitrogen: 10 mg/L
 - Fecal Coliform: 200/100 ml
 - pH: 6.5 to 8.5



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Downtown Area Wastewater Treatment Facility



Downtown Area Collection System, Pumping Stations, WWTF and Effluent Disposal

- ❖ Contract No. 2019-01
 - Daniel O'Connell's & Sons, Inc.
 - Base Bid at \$31,141,400
 - Alternatives
 - No. 1 - Equipment Storage Facility: \$1,560,000
 - No. 2 - Fiber Optic Conduits, Handholes and Fiber Optic Cable: \$80,000
 - No. 3 - Tracer Wire: \$4,600
 - Total: \$32,786,000
- ❖ Contract No. 2019-02
 - Robert B. Our Co., Inc.
 - Base Bid: \$8,989,312.40
 - Alternatives
 - No. 1 - Pavement Restoration: \$1,019,430.00
 - No. 2 - PS No. 3 Tributary Area: \$7,309,506.10
 - No. 3 - Fiber Optic Conduits and Handholes: \$139,110
 - No. 4 - Tracer Wire: \$84,300
 - Total: \$17,541,658 *


* Does not include SRF Ineligible Items

Downtown Area Collection System, Pumping Stations, WWTF and Effluent Disposal

Item No.	Description	SRF Eligible Cost	SRF Ineligible Cost	Contract Executed
1	Downtown Area WWTF and Effluent Disposal	\$32,786,000	\$0	Yes – 08/05/20
2	Downtown Area Collection System and Pumping Stations	\$17,541,658	\$404,644	Yes – 08/05/20
3	Contingency	\$2,619,542	\$35,356	N/A
4	Construction Services			
	Tighe & Bond – OPM	\$612,000	\$0	No
	AECOM	\$4,850,000	\$0	Yes – 10/11/19 and 07/29/20
5	Other Costs			
	Police - Traffic Details	\$1,000,000	\$30,000	N/A
	Town Administration	\$85,000	\$0	N/A
	Total	\$59,494,200	\$470,000	



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Downtown Area Easements

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Easements

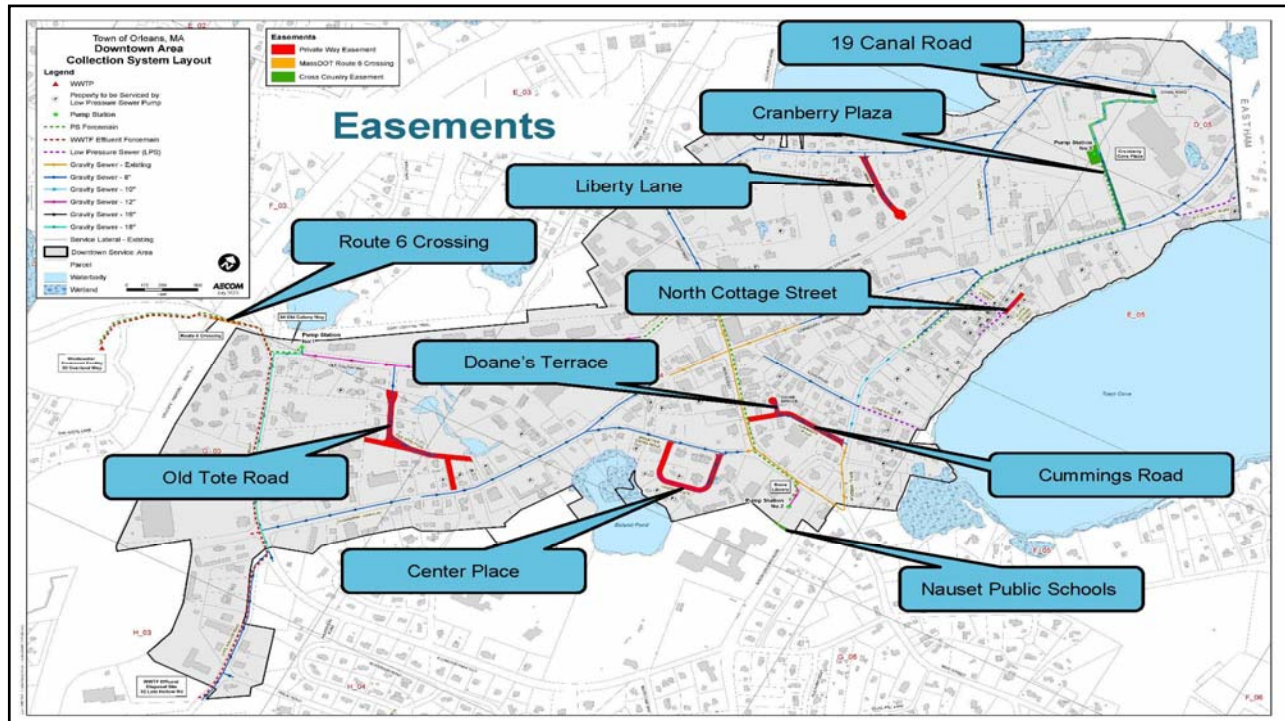
- ❖ Process
 - Design Layout
 - Maximize Use of Existing Roadways
 - Minimize Cross County Routes
- ❖ Permitting Requirements / Constraints
- ❖ Funding Authorization
- ❖ State Revolving Fund Schedule

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Easements (cont.) Locations

- ❖ Doane's Terrace
- ❖ Center Place
- ❖ Cummings Road
- ❖ Liberty Lane
- ❖ North Cottage Street
- ❖ Old Tote Road (portion)
- ❖ 19 Canal Road
- ❖ Cranberry Plaza
 - Permanent Easement (PS)
 - Permanent Easement (20' Wide)
 - Temporary Easement (10' Wide)
- ❖ MassDOT - Route 6 Crossing
- ❖ Nauset Public Schools

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Low-Pressure Sewerage Pump System Preselection

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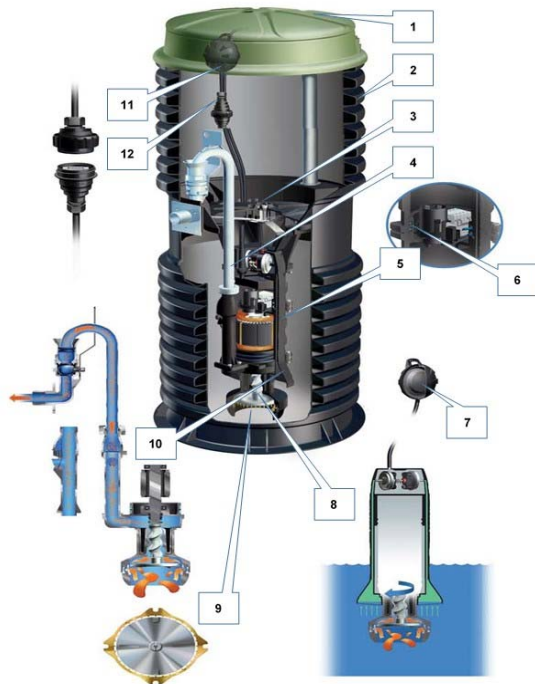
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Low-Pressure Sewerage Pump System Preselection

- ❖ Request for Proposals
 - Advertised December 2019
 - Received February 2020
- ❖ Standardize on the Pumping System to be Purchased, Installed and Operated and Maintained by Private Property Owners
- ❖ Incorporate Selected Manufacturer into the Sewer Use Rules and Regulations
- ❖ Evaluation
 - Technical
 - Life Cycle Cost Analysis
- ❖ Recommendation (February 2020) and Award (August 2020)
 - F.R. Mahoney & Associates, Rockland, MA
 - Exclusive New England Distributor for Environmental One Corp.

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LPS System Components



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LPS System Proposal Costs

Item	Description	Amount
1	Low-Pressure Sewerage Pump System	
	Type A (Exterior, Simplex, System Capacity at 700 GPD and Wetwell Capacity of 70 Gallons)	\$4,304.00
	Type B (Exterior, Simplex, System Capacity at 1,500 GPD and Wetwell Capacity of 150 Gallons)	\$4,814.00
	Type C (Exterior, Duplex, System Capacity at 5,000 GPD and Wetwell Capacity of 500 Gallons)	\$36,925.00
	Type D (Interior, Simplex, System Capacity at 700 GPD and Wetwell Capacity of 91 Gallons)	\$3,726.00
2	Extend the 2 Year Warranty to 5 Years	\$1.00
3	Engineered Stainless-Steel Service Lateral Component	\$238.00
4	Pump Monitoring System	\$551.00
5	Anti-Buoyancy Device	\$310.00
6	Pump Core Replacement	\$1,900.00





Town of
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Non-Traditional Technologies Aquaculture

Board of Water and Sewer Commissioners Meeting
August 19, 2020



AECOM
Tighe & Bond

Aquaculture

- ❖ Enhanced Aquaculture in Pleasant Bay and Town Cove
 - Build on Previous Experience with Growers to Enhance Shellfish Production Through Private aquaculture in Pleasant Bay
 - Assess the Feasibility of Increasing Private Aquaculture in Town Cove
- ❖ Lonnie's Pond
 - Plan, Design and Implement
 - Assess the Feasibility of Aquaculture
 - Determine Biomass and Optimal Starting Size
- ❖ Final Report – February 15, 2020



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Aquaculture Comparison of Demonstration Years

Parameter	2016	2017	2018
Field Area, ft ² (acres)	9,600 (0.22)	8,160 (0.19)	16,200 (0.37)
Number of Bags	800	1,020	2,040
Estimated Number of Oysters			
First Year	71,700	480,000	2,185,000
Second Year	127,000	127,000	392,000
Third Year	198,700	607,000	2,577,000
Total N Uptake, kg	25.9	28.1	60.0
Projection: Ability to remove 200 kg N per acre.			

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Aquaculture

- ❖ Request for Qualifications (November 2018)
 - Grow Oysters in Lonnie's Pond as Part of the Town's Non-Traditional Approach to Removing Nitrogen in the Pleasant Bay Watershed
 - Grow Oysters from Seed and Remove Them on an Annual Basis
- ❖ Second Year of Private Operation
 - Oversight by Shellfish and Harbormaster Department
 - Monitoring by SMAST
- ❖ Future Expansion?



Town of
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Non-Traditional Technologies Nitrogen Reducing Barriers (NRBs)

Board of Water and Sewer Commissioners Meeting
August 19, 2020



Nitrogen Reducing Biofilters (NRBs)

- ❖ Research and Review of Published Data
- ❖ Barnstable County Test Center
 - Site Visits - Joint Base Cape Cod
 - Meetings with George Heufelder of the Barnstable County Health Department Relative to Demonstration System Design, Permitting, Construction and Performance
- ❖ Orleans Health Department
 - Meetings and Coordination
 - Review Candidate Sites with Existing Applications
 - Onsite Sewage Disposal System Upgrades and New Construction
- ❖ Property Owners Candidate Sites
 - Plan Reviews
 - Site Visits
 - Onsite Meetings

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Nitrogen Reducing Biofilters (NRBs) (cont.)

- ❖ Identification of Sites
 - Identified Over 50 Sites
 - Evaluation Identified 20 Sites
 - Evaluation and 2nd Meeting Identified About 10 Sites
- ❖ No Suitable Demonstration Sites were Identified Due to the Following:
 - Property Owners Not Having the Time Available to Permit the System with State and Local Agencies
 - Insufficient Area Available
 - Unsuitable Soil Conditions
 - Unsuitable Site Topography
 - High Groundwater Elevations
 - Proximity of Wetlands
 - Limited to Residential Properties

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Non-Traditional Technologies Permeable Reactive Barriers (PRBs)

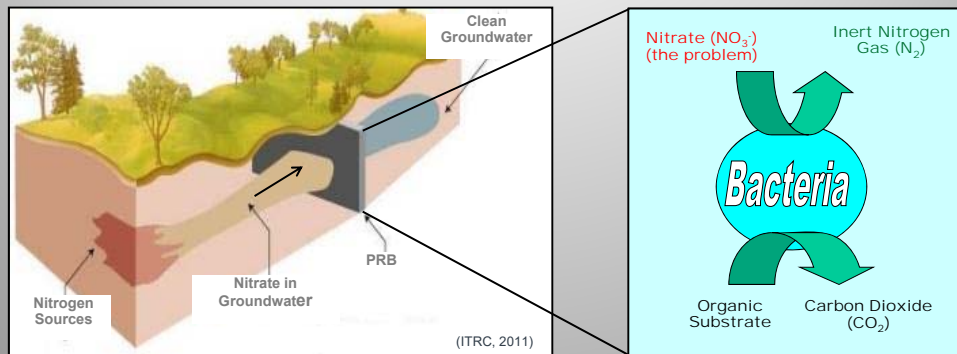
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Permeable Reactive Barriers (PRBs)

- ❖ Permeable - Groundwater Flows Through (passive)
- ❖ Reactive - Promotes Biological Denitrification
- ❖ Barrier - Prevents Nitrate Migration to Coastal Embayments



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Why PRBs?

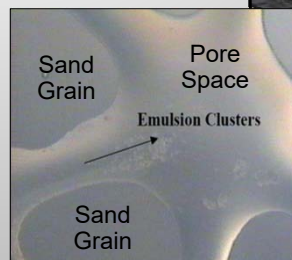
- ❖ Mature Groundwater Treatment Technology
- ❖ Applicable to Nitrate Treatment
 - Denitrifying Bacteria are Naturally Occurring
 - Converts Nitrate to Inert Nitrogen Gas (N₂)
- ❖ Sustainable Technology
 - Groundwater Flow Carries the Contaminant to the Barrier for Removal (natural pump)
- ❖ Bio-stimulation is Feasible
 - Supply a Carbon (food) Source
 - Shallow - Wood Chips
 - Deep - Injected Substrate



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Emulsified Vegetable Oil (EVO) Organic Substrate

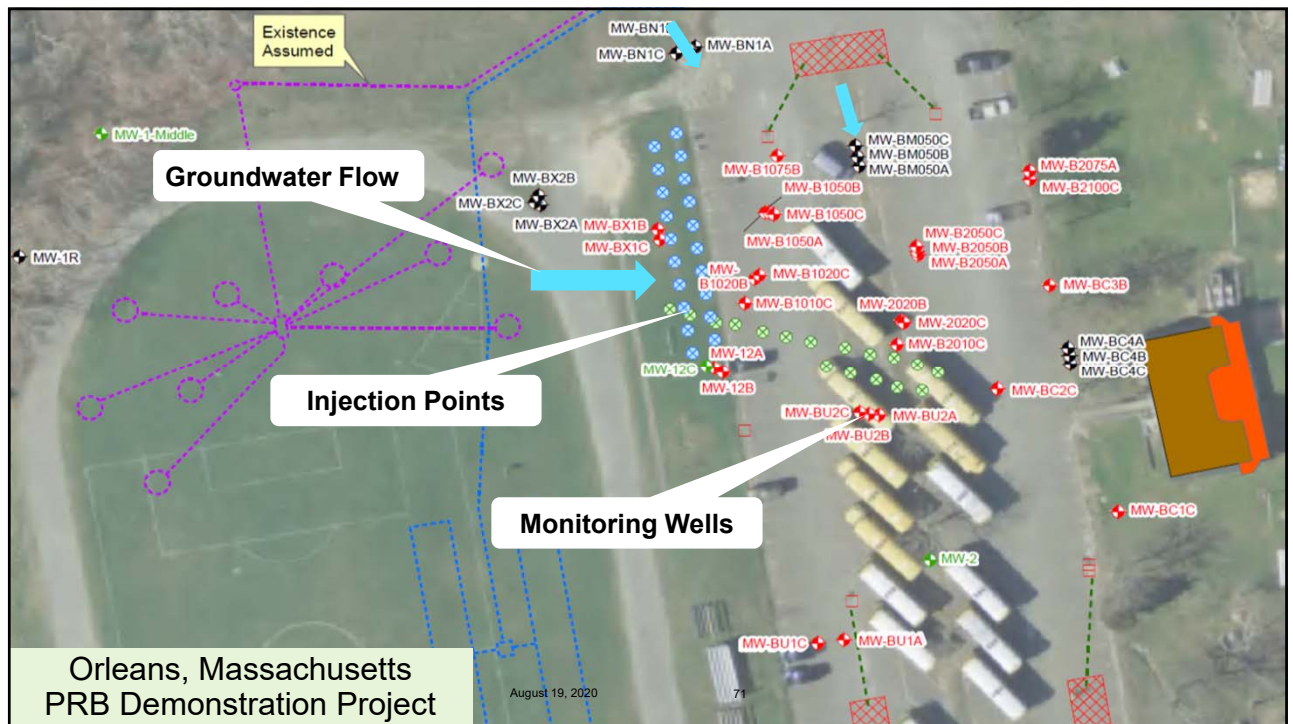
- ❖ Made with Soybean Oil
 - Oil-in Water Emulsion
 - Food-grade
 - Sustainable Technology
- ❖ Adheres to Soil Grains and Slowly Releases Dissolved Organic Carbon
 - Long-term Food Source
 - Immobile After Injection
- ❖ Commonly Used for Groundwater Treatment



(Adapted from ESTCP Protocol for Enhanced In Situ Bioremediation Using Emulsified Edible Oil prepared by Solutions-IES May 2006)



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PRB Demonstration Test

EVO Totes, Mixing Tanks, and Pumps Within Containment Pad

Direct Push Drill Rig Advanced Injection Rods to Target Depth

Hose Ramps & Traffic Delineators

Injection Screen Slot

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Demonstration Groundwater Monitoring

- ❖ Prior to Injection – Baseline Sampling
- ❖ During Injection to Monitor Distribution
- ❖ Initial Post-injection Sampling in Early January 2017
- ❖ Quarterly Sampling - February 2017 thru June 2021

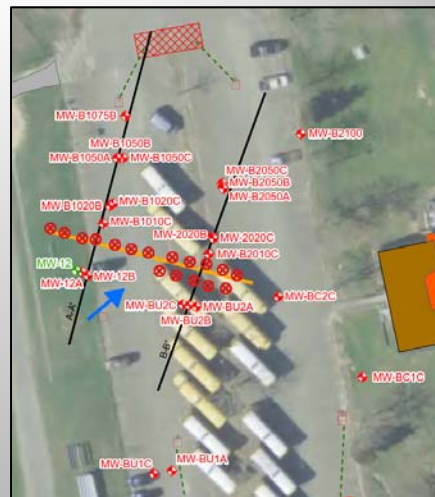


Field Measurements
Dissolved Oxygen (DO, mg/L)
pH (SU)
Redox Potential (ORP; mV)
Specific Conductivity (µS/cm)
Temperature (°C)
Turbidity (NTU)

Laboratory Analysis
Alkalinity as CaCO ₃ (mg/L)
Ammonia (mg/L)
Arsenic (µg/L)
Boron (mg/L)
Chloride (mg/L)
Dissolved Iron (mg/L)
Dissolved Manganese (mg/L)
Dissolved Organic Carbon (mg/L)
Methane (µg/L)
Nitrate as N (mg/L)
Nitrite as N (mg/L)
Nitrogen (mg/L)
Sulfate (mg/L)
Total Kjeldahl Nitrogen (mg/L)
Total Nitrogen (mg/L)

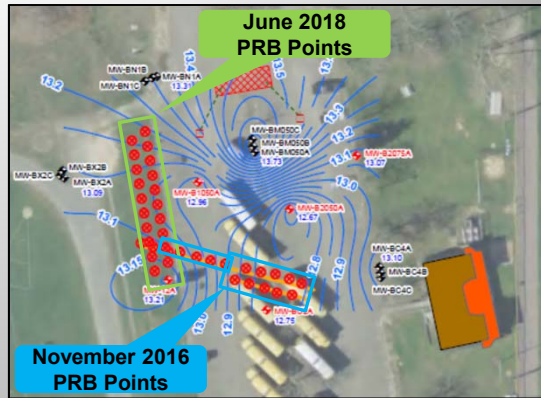
Initial Injections (Round 1) November 2016

- ❖ 110-Foot Long PRB
 - 17 Injection Points
 - Compared 1 and 2 Rows of Injection Points
 - 10-foot Grid Spacing
 - 36 to 68-feet Below Ground Surface
 - 32-foot Vertical PRB
- ❖ 14 Percent Pore Volume Target
- ❖ Injected 2,600 Gallons EVO Diluted to 10,800 Gallons
- ❖ Monitoring Well Network
 - Upgradient and Downgradient

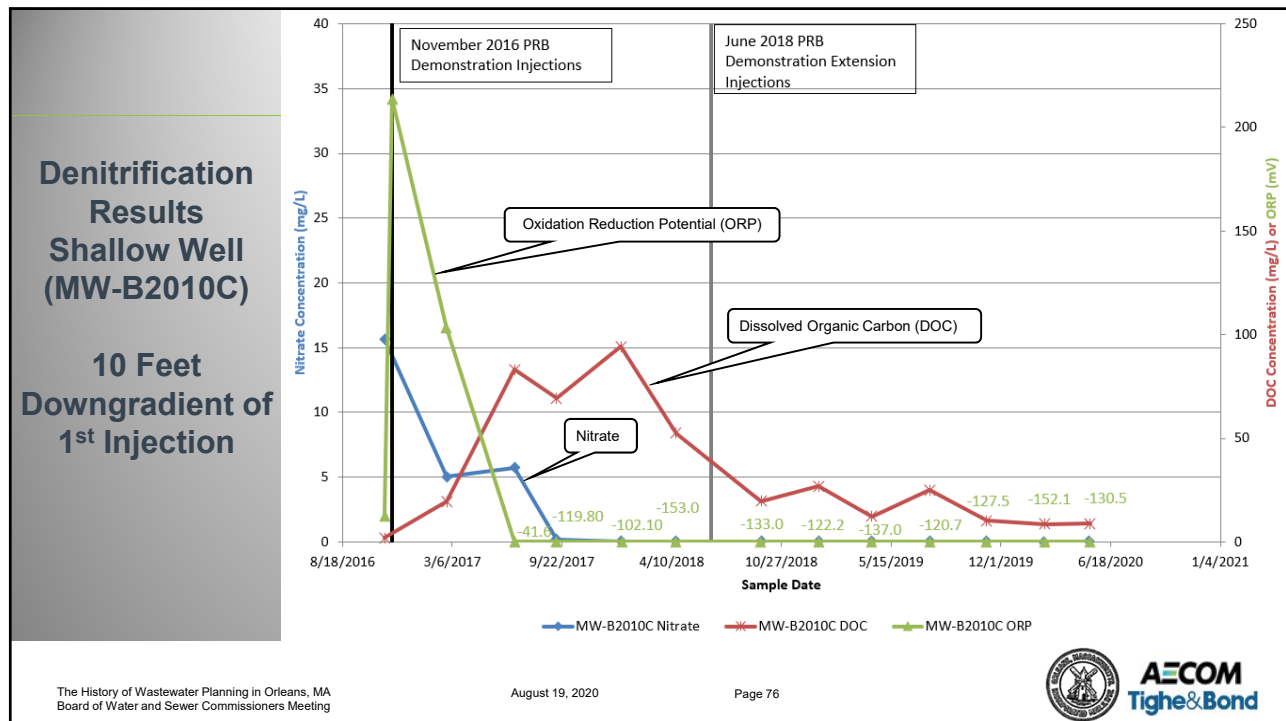


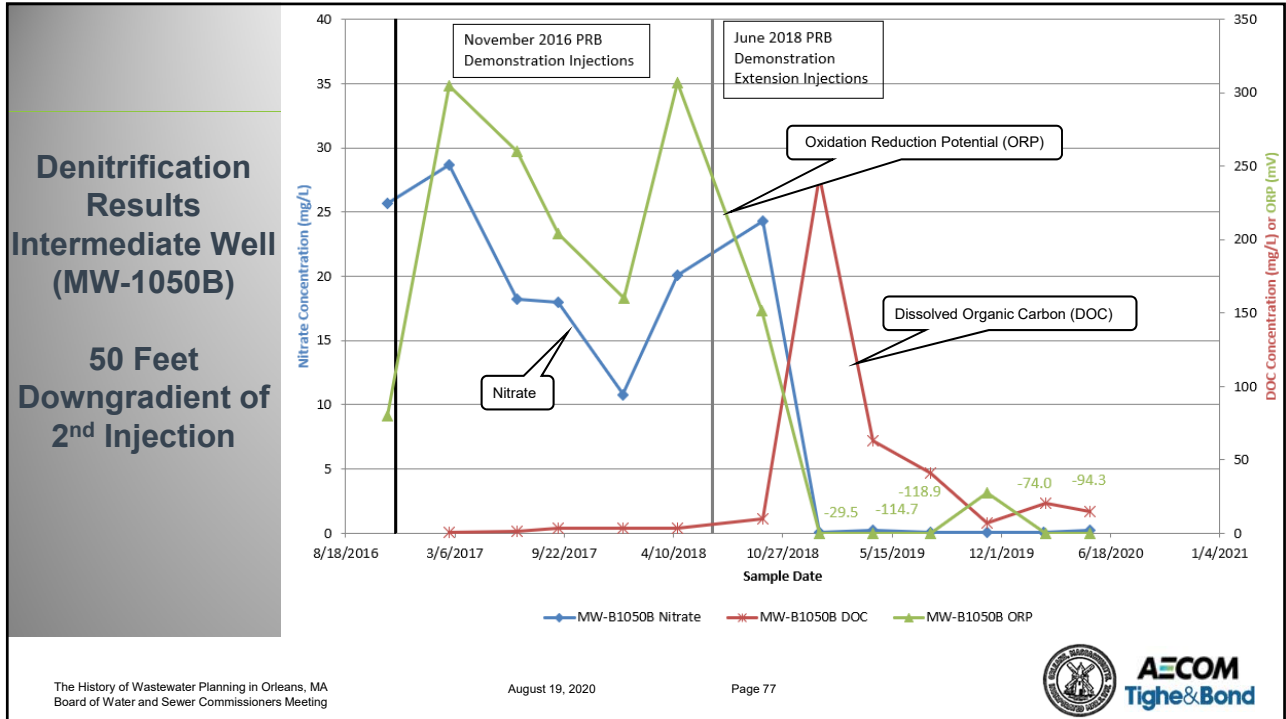
PRB Extension (Round 2) June 2018

- ❖ Groundwater Flow Complex
 - Stormwater Recharge Basins
 - Wastewater Discharge at Multiple Locations
 - Localized Mounding
- ❖ Extended PRB to the north
 - Intercept Groundwater From the West
 - 110-feet with 20 Injection Points
 - Injected 3,700 gallons EVO Diluted to 14,800 Gallons
 - Sodium Lactate Added as Quick Release Substrate

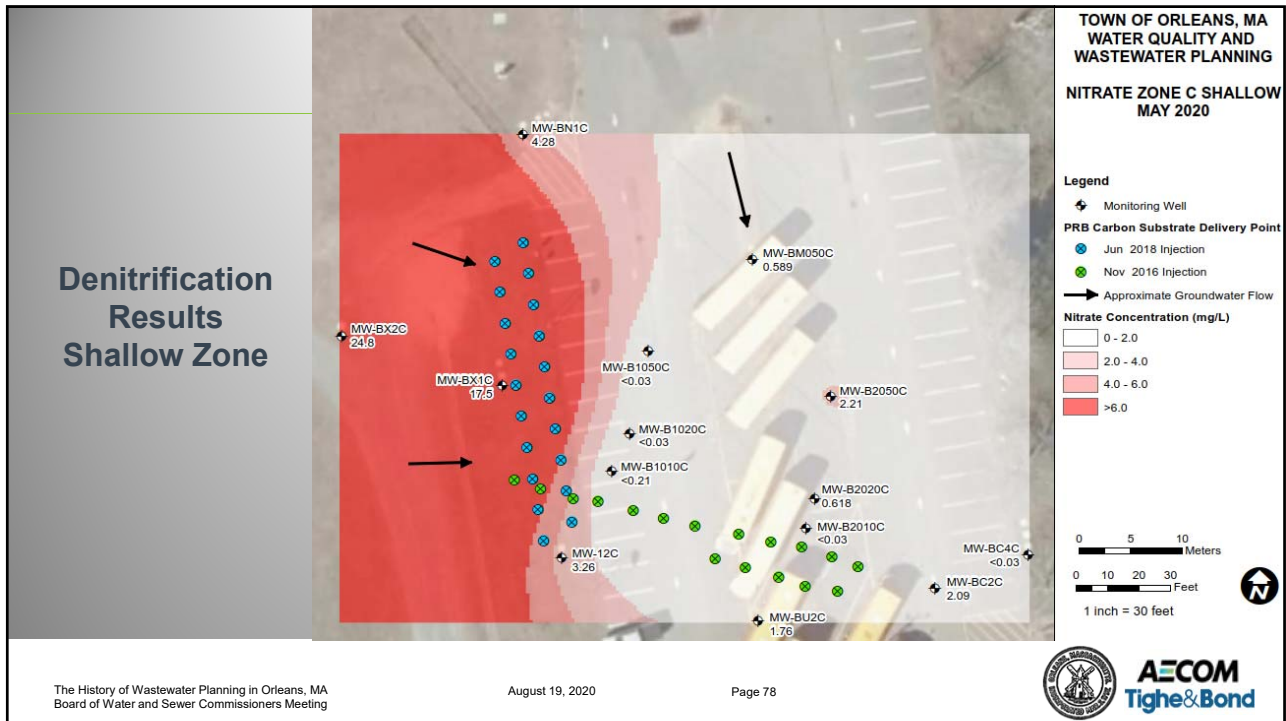


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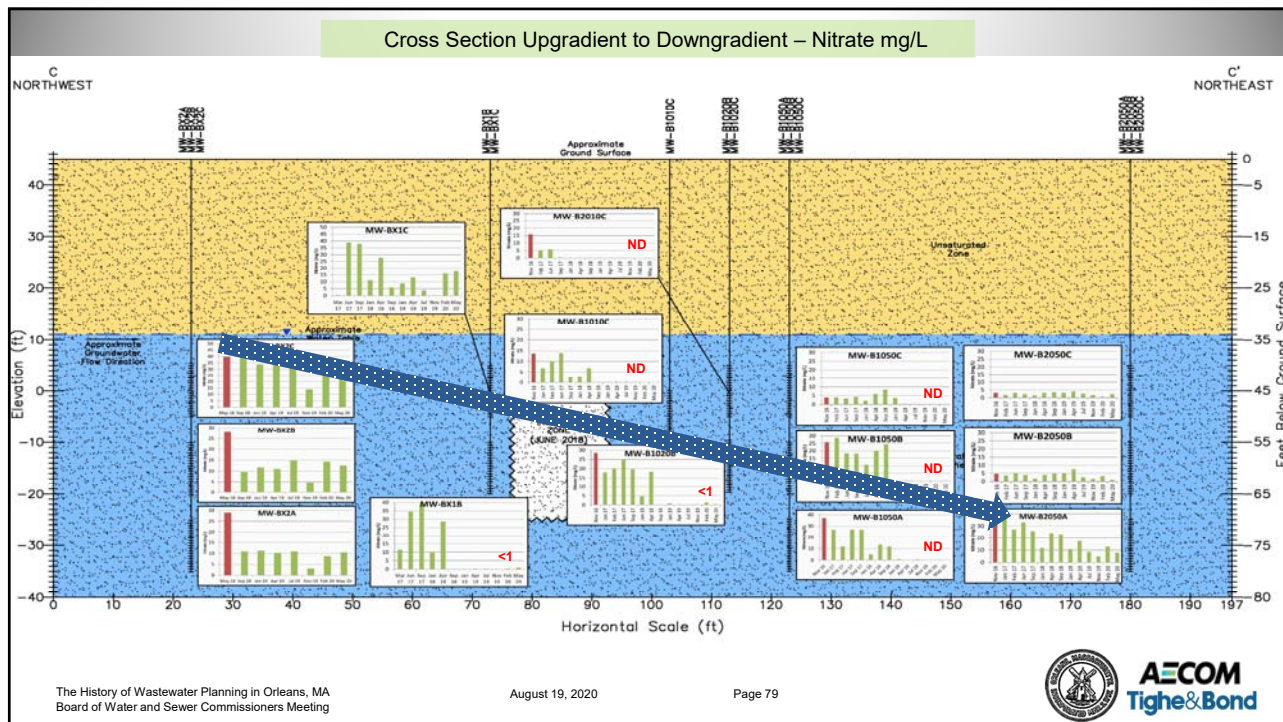




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Conclusions to Date

- ❖ PRB Demonstrates Denitrification in a High Permeability Sandy Aquifer
- ❖ Continues to Effectively Reduce Nitrate Flux 3 Years After Initial Injection
- ❖ Multiple Lines of Evidence
 - Decrease in Oxidation-reduction Potential
 - Increase in Dissolved Organic Carbon
 - Decrease in Nitrate Concentrations
- ❖ Understanding of Groundwater Flow Direction and Velocity Critical
- ❖ Use Closest Downgradient Wells For PRB Assessment

The History of Wastewater Planning in Orleans, MA
Board of Water and Sewer Commissioners Meeting

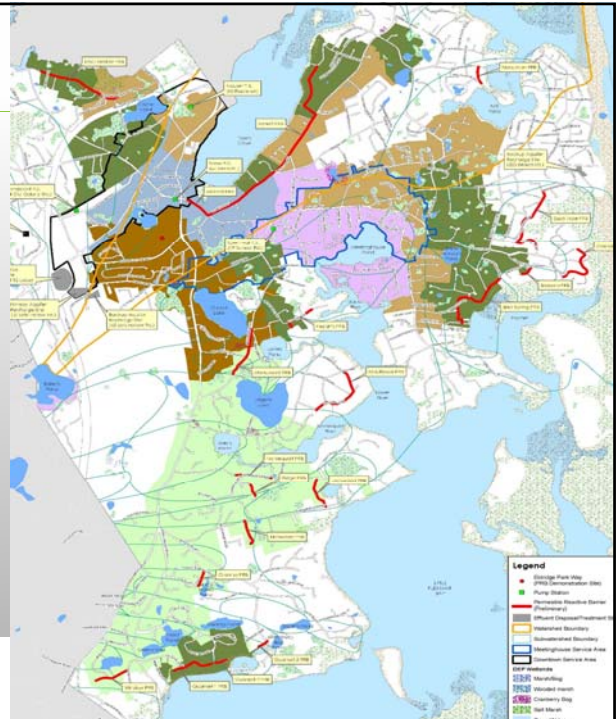
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Potential Full Scale PRBs

- ❖ Total of ~34,000 Linear Feet in 3 Major Watersheds
 - Pleasant Bay Estuary
 - Nauset Estuary
 - Rock Harbor Estuary
- ❖ 2011 CWMP – Possible Sewer Phasing Plan
- ❖ Downtown Service Area
- ❖ Meetinghouse Pond Service Area (Preliminary)
- ❖ Future Permeable Reactive Barriers Locations (Preliminary)



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Permeable Reactive Barrier Unit Costs

Description	Unit Cost
Implementation Cost (\$/LF)	\$ 1,230
Replacement Cost ¹ (\$/LF Annual basis)	\$ 63
Monitoring Cost ² (\$/LF)	\$ 17

Notes:

1. Replacement costs will occur every 15 years for PRB reinjection.
2. Monitoring costs represent an average on \$/LF basis. This may vary by location due to reporting efforts and costs.



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Traditional System - Unit Costs

Collection System and Pumping Stations	
Description	Unit Cost
Gravity Sewer (lf)	\$ 425
Low-Pressure Sewer (lf)	\$ 200
Pumping Station (each)	\$ 1,500,000
Force Main (lf)	\$ 200
Highway Crossing (l.s.)	\$ 500,000
O&M Cost (\$/gal)	\$ 1.75
Notes:	
1. Based on the Average of Bids Received on May 6, 2020 for Contract 2019-02 - Downtown Area Collection System and Pumping Stations	
2. O&M Cost Based on Estimated O&M Cost for Contract 2019-02 - Downtown Area Collection System and Pumping Stations	

WWTF and Effluent Disposal	
Description	Unit Cost
WWTF (\$/gal)	\$ 100
Force Main (lf)	\$ 200
Effluent Disposal (\$/gal)	\$ 10
O&M Cost (\$/gal)	\$ 3.25
Notes:	
1. Based on the Average of Bids Received on May 13, 2020 for Contract 2019-01 - Downtown Area WWTF and Effluent Disposal	
2. O&M Cost Based on Estimated O&M Cost for Contract 2019-01 - Downtown Area WWTF and Effluent Disposal	



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Additional Life Cycle Cost Analysis (LCCA) and N Removal

❖ LCCA Assumptions

- Term
 - 30 Years (SRF Loan Length)
 - 60 Years
 - 100 Years
- Interest Rate at 1.5%
- Inflation at 3.0%

❖ N Removal Assumptions

- PRBs - 80% Removal from Watershed
- Traditional System - 100% Removal from Watershed

Note: Utilized 26.25 mg/l per MEP Studies



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PRBs vs Traditional System LCCA Summary

PRB Description	LCCA at 30 Years		LCCA at 60 Years		LCCA at 100 Years	
	PRBs	Traditional System	PRBs	Traditional System	PRBs	Traditional System
Pleasant Bay Estuary						
Blossom	X		X		X	
Briar Spring	X			X		X
Duck Hole	X			X		X
Gosnold		X		X		X
Granny's	X		X		X	
Keziah's	X			X		X
Mayflower	X		X			X
Monument	X			X		X
Namequoit, Ridge & Lockwood	X		X			X

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PRBs vs Traditional System LCCA Summary (cont.)

PRB Description	LCCA at 30 Years		LCCA at 60 Years		LCCA at 100 Years	
	PRBs	Traditional System	PRBs	Traditional System	PRBs	Traditional System
Pleasant Bay Estuary (cont.)						
Quonset 1, 2, & 3	X		X			X
Richwood	X		X			X
Winslow		X		X		X
Nauset Estuary						
Norseman	X		X		X	
Tonset Road and Main Street	X			X		X
Rock Harbor Estuary						
Rock Harbor		X		X		X
Totals	12	3	7	8	3	12

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Pleasant Bay Composite N Management Analysis

Municipality	N Removal Requirement	
	kg/yr	Percent
Brewster	2,262	13
Chatham	4,076	23
Harwich	4,399	25
Orleans	6,980	39
Total	17,717	100

Town of Orleans, MA				
Description	Previous		Current	
	kg/yr	Percent of Total	kg/yr	Percent of Total
Source Control				
Sewering	2,014	29	1,876	27
Residential Fertilizer Reduction	241	3	241	3
Golf Course Fertilizer Reduction	0	0	0	0
On-Site Denitrifying Systems, Additional Sewering, etc.	2,024	29	2,665	38
Remediation				
Permeable Reactive Barriers	0	0	1,892	27
Fertigation at Golf Courses	0	0	0	0
Shellfish Propagation	2,695	39	300	5
Totals	6,974		6,974	

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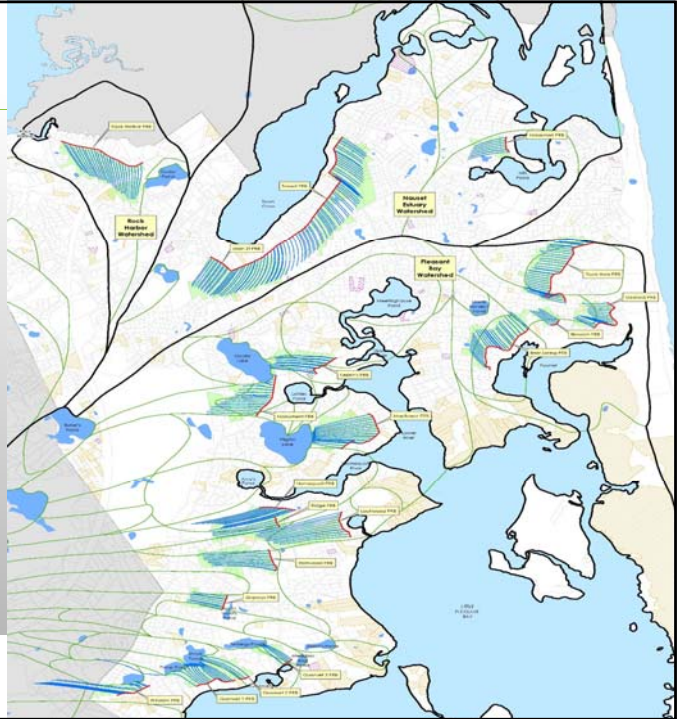
Implementation and Monitoring Recommendation

- ❖ Implementation
 - Phased Schedule with Most Cost-Effective/Favorable Locations First
 - Monitoring Wells per 400 LF of PRB
 - Upgradient - 2
 - Downgradient - 4
 - PRBs Located Within Right-of-Ways
 - Utilize Adaptive Management for Adjustments to Implementation Recommendations
- ❖ Sampling and Analysis
 - Baseline - Prior to Injection
 - During Injection - Monitor Distribution
 - Post Injection
 - Quarterly in Year 1
 - Annually Thereafter
 - Run Results through Updated MEP Model After Two Years

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Next Steps

- ❖ Finalize Technical Memorandum
- ❖ Next Phase
 - Conduct Field Investigations
 - Modify Assumptions Based on Information Obtained During Investigations
 - Modify Recommended PRB Locations
 - Run Scenarios through Updated MEP Model
 - CWMP Notice of Project Change



Next Steps (cont.)

- ❖ Next Phase (cont.)
 - Obtain Regulatory Approvals
 - Develop Implementation Technical Memorandum
 - Scope of Work
 - Schedule
 - Costs
- ❖ Future Phases over 10 Years
 - Preliminary Design
 - Final Design
 - Implementation

MassDEP Regulatory Meeting – June 30, 2020 Attendance and Summary

- ❖ Attendance
 - MassDEP
 - Town of Orleans, MA
 - Tighe & Bond
 - MT Environmental Restoration
 - AECOM
- ❖ Summary
 - Did Not See Any Issues With Approach, Analysis and Evaluation
 - Agreement with Implementation and Monitoring Recommendations
 - Approvals Will Be Based On Site Specific Submittals
 - Does Not See Any Reason Why PRBs Would Not Be SRF Eligible
 - Nitrogen Credit
 - Based on Site Specific Sampling and Analysis
 - Subject to Adaptive Management
 - Considerable Public Education and Involvement
 - Other Potential Applications
 - On-Site Wastewater Disposal Systems
 - WWTF Groundwater Discharge Site vs Upgrades at WWTF



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Moving Forward PRBs vs Traditional System Considerations

- ❖ Watershed Compliance (N Reduction)
- ❖ Life Cycle Cost Analysis (PRBs vs Traditional System)
- ❖ Environmental Response (Short Term vs. Long Term)
- ❖ Secondary Water Impacts (Public and Private Water Supplies: Existing and Future)
- ❖ Implementation Costs (Capital Improvement Plan)
- ❖ Location of PRBs vs. Wastewater Service Areas



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Meetinghouse Pond Area Collection System and Pumping Station

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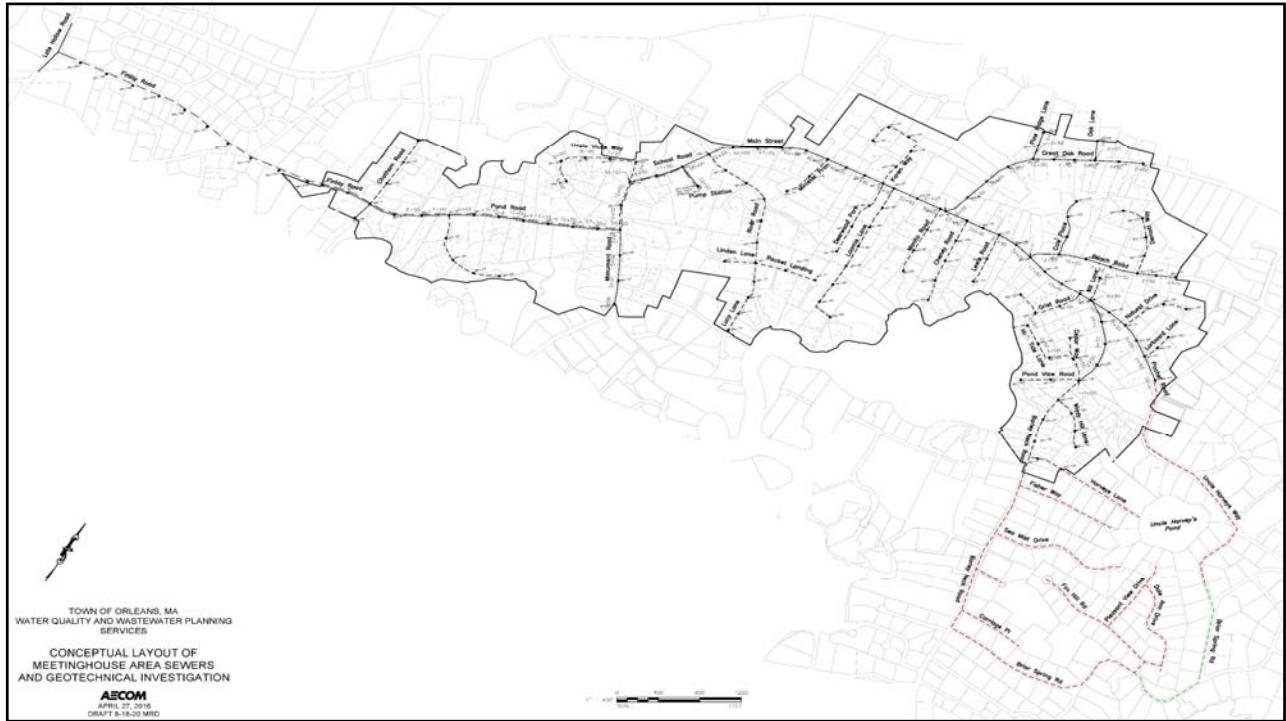
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Meetinghouse Pond Area Collection System and Pumping Station

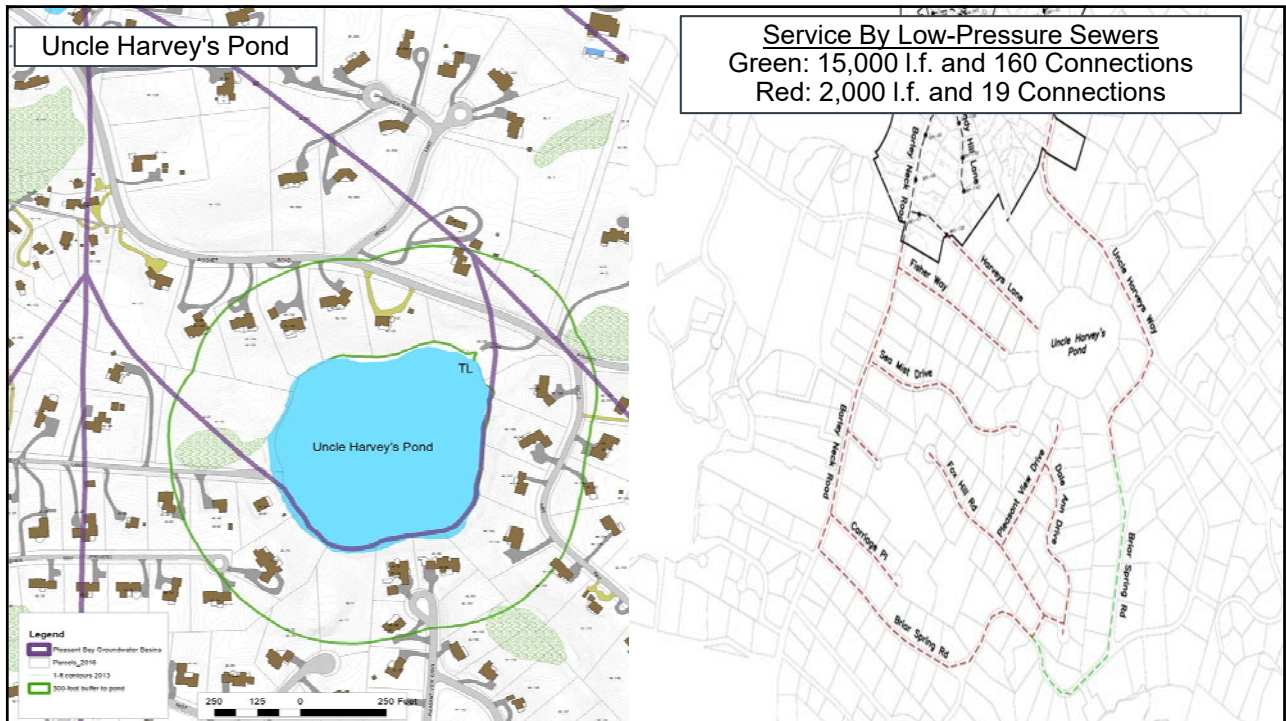
- ❖ About 15,750 Linear Feet of 8-inch through 12-inch PVC Gravity Sewer
- ❖ About 20,750 Linear Feet of 2-inch Low Pressure Sewer
- ❖ 1 Submersible Pumping Station
- ❖ About 7,500 Linear Feet of 8-inch PVC Force Main
- ❖ Estimated 474 Users
- ❖ About one-half of Users will have Privately Owned and Maintained Low-Pressure Sewerage Pump System
- ❖ Area Expansion
 - Uncle Harvey's Pond
 - Crystal Lake and Pilgrim Lake
 - Impacts – Sewering vs. PRBs



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Meetinghouse Pond Area Collection System and Pumping Station

- ❖ Design Phase - Field Investigations
 - Identify Location of On-site Disposal Systems and Utilities
 - Topographic Survey
 - Subsurface Explorations
 - Cultural Resource Evaluation
 - Project Cost Estimate
- ❖ Future Phases
 - Design Phase – Final
 - May 2021 through December 2021
 - Bidding Phase
 - February 2022 through April 2022
 - Construction Phase
 - June 2022 through October 2024
- ❖ SRF Funding
 - Project Evaluation Form - August 2021
 - SRF Application - October 2022

Town of *Orleans*
Massachusetts

Financial Model

Board of Water and Sewer Commissioners Meeting
August 19, 2020



Financial Model


- ❖ Established to Run Scenarios and Predict User Costs for Components of Program
 - Downtown Area
 - Meetinghouse Pond Area
 - Non-traditional Technologies
- ❖ Predicts Costs to User Groups Based on Number of Users
- ❖ Accounts for Both Capital and Operation and Maintenance
- ❖ Predicts Costs by Parcel/Owner Based on Water Use
- ❖ Objectives
 - Develop Functional Financial Model to Allow Inputs and Inform Town Decisions
 - Allow Rate Payers to See Annual Wastewater Costs for Their Property
 - Provide “Built-in Flexibility” to Allow Changes to Cost Allocations to User Groups to Produce Fair Financial Plan
 - Provide Tool that Town Can Continue to Use in the Future

Financial Model

- ❖ Collection System Capital Costs - 100% Betterments
- ❖ WWTF, Effluent Disposal and Non-Traditional Capital Costs - 100% Tax Rate
- ❖ Operation and Maintenance Costs - 100% User Fees Allocated to Respective User Groups
- ❖ Collection System: Does Not Include the Cost to Purchase, Operate and Maintain Private Property Components
- ❖ Non-traditional and Septic Only: Does Not Include Individual Owner Costs to Pump and Maintain On-site Septic Systems
- ❖ Financing
 - 30-year 0% SRF
 - Grant/Principal Forgiveness
 - Short Term Rental Tax
 - Septage Revenue
 - Additional Local Tax Options
 - Contingency for Capital/Replacement Costs

Input Selections								
Cost Estimate Sheets	Financing	Downtown Area	Downtown Area Special Assessment Breakdown	Meetinghouse Pond Area	Non-Traditional Technology Area	Septic System Only Area	Discounts, Offsets, and Additional Funds	Financial Model Outputs
Upload Files	Type (SRF or Conventional)	Special Assessment Percentage	Same for Residential, and Non-Residential/Mixed Use Properties	Special Assessment Percentage	Property Taxes Percentage	Property Taxes Percentage	Grant(s) Percentage	Project Complete "All in Year 1" – Average Property Costs
Number of WWTFs	Term (Years)	Property Tax Assessment	Residential Percentage	Property Tax Assessment			Design/Build Savings Percentage	Program Phased over 40-Years – Average Property Costs
Folder for Saving Files	Interest Rate		Non-Residential/Mixed Use Percentage				Design/Build/Operate Savings Percentage	Program Phased over 40-Years – Per Property Costs
							Local Tax Options Percentage	
							Annual Septage Revenue	

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Town of


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Massachusetts

Nauset Regional Middle School and High School Educational Series

Board of Water and Sewer Commissioners Meeting

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Nauset Regional Middle School and High School Educational Series

- ❖ Class Room and Field Observation / Participation
- ❖ Introduction and Overview of Problem
 - Present at the Beginning of Each Lesson
- ❖ Draft Lesson Plans
 - Lesson Plan 1 – Traditional Technologies (Engineering Students)
 - Lesson Plan 2 – Permeable Reactive Barrier (Chemistry Students)
 - Lesson Plan 3 – Aquaculture (Biology, Environmental Science, Ocean Science Students)
 - Lesson Plan 4 – Nitrate Reduction Options (General Science or Environmental Science Students)



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It Takes a Village

- ❖ Town of Orleans, MA
- ❖ Regulatory Agencies
- ❖ Special Interest Groups
- ❖ Tighe & Bond
- ❖ AECOM Technical Services, Inc.
- ❖ AECOM Subconsultants/Subcontractors

Thank you!

Questions?



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