Town of Orleans Massachusetts

The History of Wastewater Planning and Implementation in Orleans, MA

August 19, 2020

(Revised December 12, 2022; May 30, 2023; June 1, 2023)

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Topics

- Regulatory Documents
- 208 Planning Project
- Orleans: 1970 – 2018
- Tri-Town Septage Receiving Facility
- Comprehensive Wastewater Management Plan (CWMP)
- Landfill
- Downtown Area Collection System, Pumping Stations, WWTF and Effluent Disposal
- Meetinghouse Pond Area Collection System and Pumping Station
- Future Wastewater Expansion Areas
- Aquifer Recharge (Effluent Disposal)
- Low-Pressure Sewerage Pump Systems
- Non-Traditional Technologies
  - Aquaculture
  - Nitrogen Removing Biofilters (NRBs)
  - Permeable Reactive Barriers (PRBs)
- Financial Model
- Revenue Sources
- Other Activities
- Nauset Regional Middle School and High School Educational Series
- Action Items

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)

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

Town of Orleans Massachusetts

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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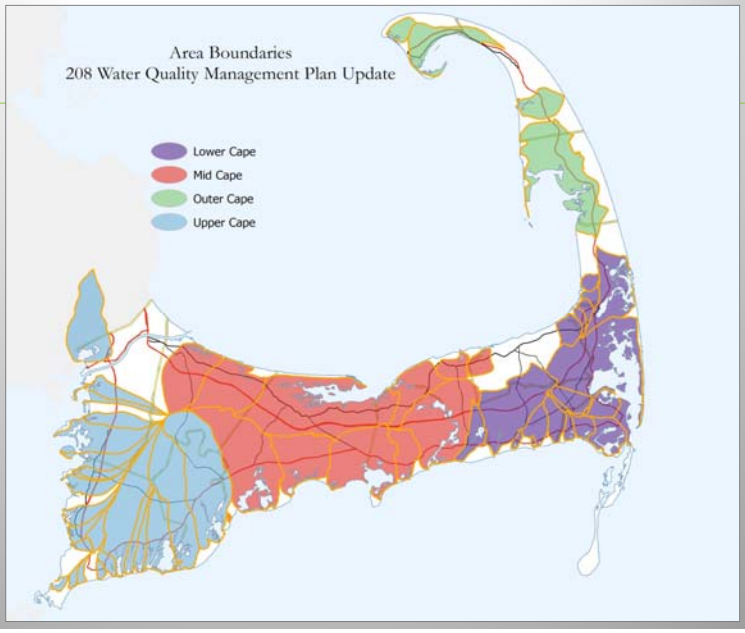
WATERSHED SUBGROUPS



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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

Technology Matrix (cont.) Traditional Technologies

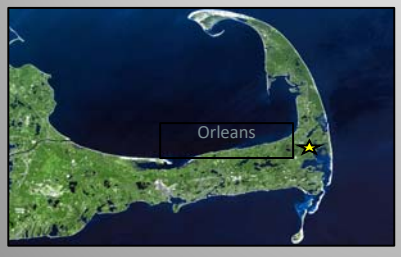
- Collection System
  - Gravity Sewers
  - Low Pressure Sewers
  - Septic Tank Effluent Pumping
  - Septic Tank Effluent Gravity
  - Vacuum Sewers
  - Hybrid
- Effluent Disposal
  - Open Basins
  - Subsurface
  - Drip
  - Wick Wells
- Treatment
  - Conventional Activated Sludge
  - Sequencing Batch Reactor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

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

Cape Cod's Nitrogen Problem

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

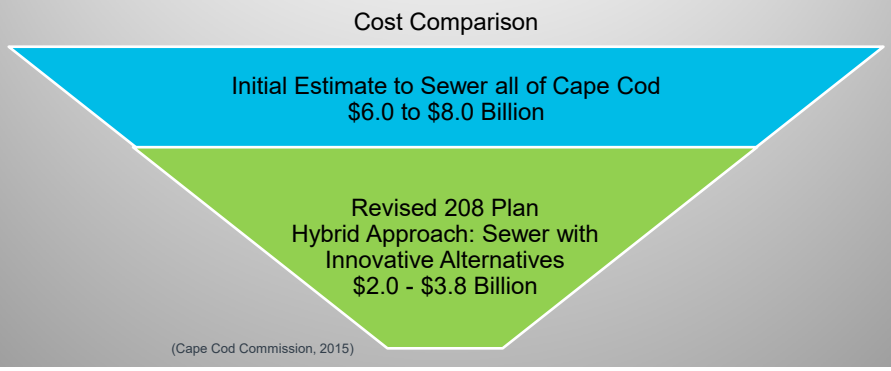



(Boston Globe, 2011)

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

Cape Cod's Solution

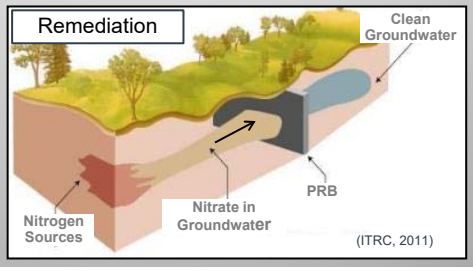
- Updated Regional Cape Cod 208 Water Quality Plan
  - Watershed-based Approach to Restore Embayments
  - Framework/Tools to Achieve Water Quality in Compliance with the Clean Water Act



(Cape Cod Commission, 2015)

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



(ITRC, 2011)

Town of Orleans Massachusetts

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

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

Town of Orleans Massachusetts

Tri-Town Septage Receiving Facility

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Tri-Town Septage Receiving Facility

- Orleans-Brewster-Eastham Groundwater Protection District (Tri-Town 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

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Tri-Town Septage Receiving Facility

- Schedule
  - Decommissioning – June 2016 thru August 2016
  - Contract Documents – June 2016 thru November 2016
  - Bidding – December 2016 thru February 2017
  - Town Meeting Appropriations (Brewster, Eastham & Orleans)
    - May 2017
    - October and November 2018
  - Demolition – September 2017 thru May 2020

Tri-Town Septage Receiving Facility

- **Major Process Components**
  - Septage Receiving Facilities
  - Filtrate Holding Tank
  - Primary Clarifiers
  - Rotating Biological Contactors
  - Secondary Clarifiers
  - Disinfection
  - Plate and Frame Presses
  - Chemical Storage and Feed Systems
  - Odor Control
- **Effluent Disposal**
  - 29 Overland Way
  - Open Recharge (Infiltration) Beds
- **Permit Design Data**
  - Average Daily Flow: 45,000 GPD
  - BOD_5: 30 mg/L
  - TSS: 30 mg/L
  - Total Nitrogen: 50 mg/L
  - Oil and Grease: 15 mg/L
  - Fecal Coliform: 200/100 ml
  - pH: 6.5 to 8.5






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Tri-Town Septage Receiving Facility Summary

Description	Tri-Town Septage Receiving Facility
Construction Duration	July 2017 – May 2020
As-Bid Cost	$1,803,060.00
Final Cost	$3,312,819.07 *
Contractor	S&R Corporation

* Includes differing site conditions - Removal and legal dispose of ACM Waste at Septage Treatment Facility and Compost Site at a total of $1,303,543.66

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Town of Orleans Massachusetts

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 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 Pipelines
  - 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

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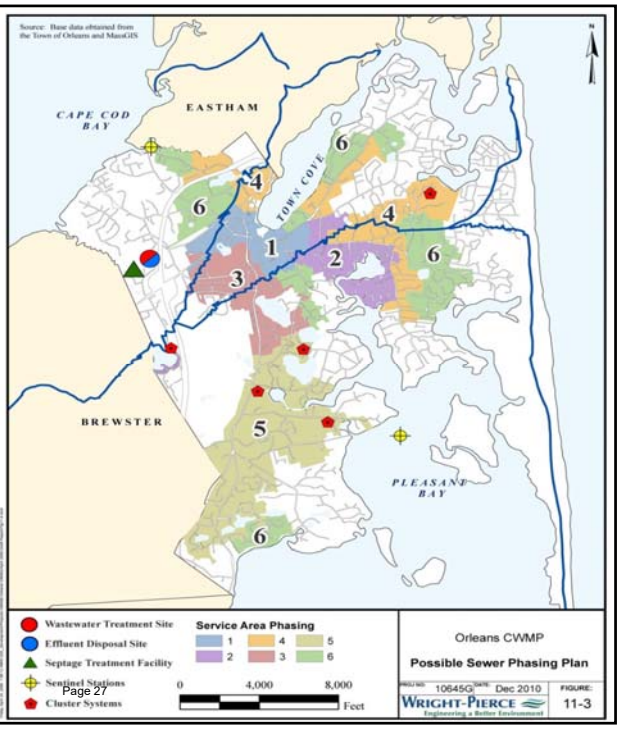
CWMP (cont.)

- 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

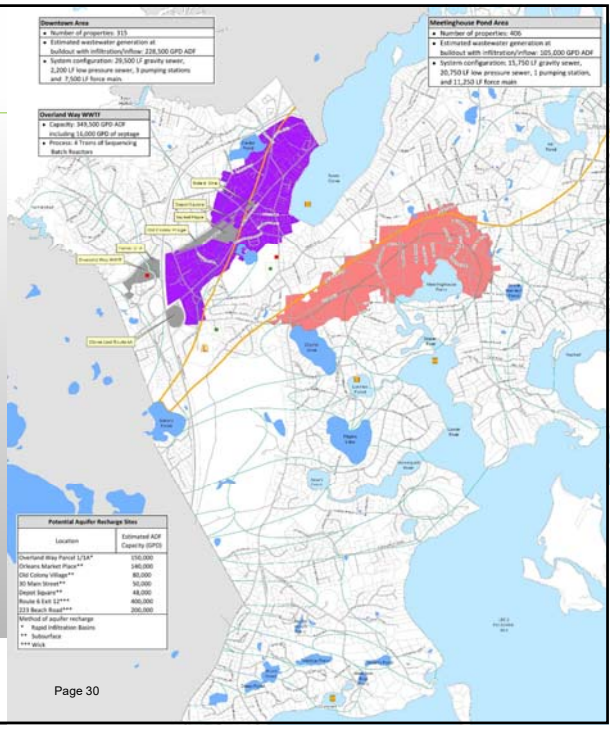
- Downtown Planning
- Working Groups
  - Aquaculture
  - Floating Contracted Wetlands
  - Permeable Reactive Barriers
  - WWTF and Collection System
- Effluent Disposal
- Septage Receiving/Processing
- Financial Model
- Landfill
- Town's Web Page
- Tri-Town Septage Facility Transition
- Delivery Options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

CWMP (cont.)

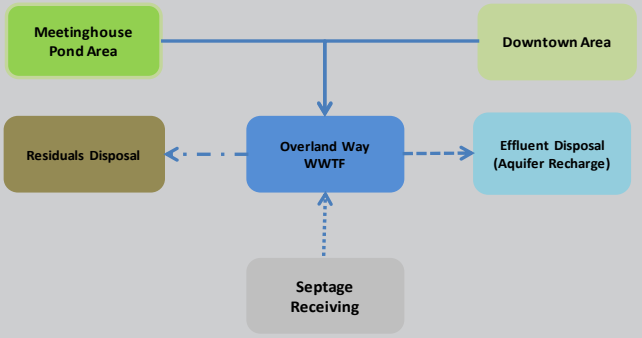
- Conceptual and Preliminary Design to Update the CWMP (2011) and To Reflect the Consensus Plan (2015)
- Goal: Minimize Proposed Sewered footprint to the Greatest Extent Possible
- Maximize Use of Non-traditional Technologies
- Notice of Project Change Certificates
  - Effluent Discharge
  - Non-Traditional 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

Orleans Water Quality Advisory Panel

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



Orleans Water Quality Advisory Panel (cont.)

Traditional Infrastructure	Non-Traditional Infrastructure
	Coastal Habitat Restoration
	Aquaculture
	Floating Constructed Wetlands
	Permeable Reactive Barriers
	Nitrogen Removing Biofilters

Reduces Project Costs from About $205 M to About $130 M

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 <= 30 mg/l
    - TN <= 10 mg/l
    - Designing for Lower Limits

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

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)

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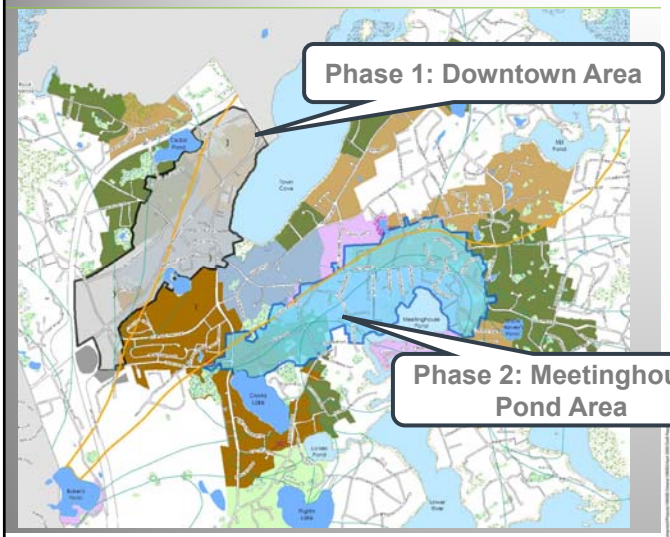
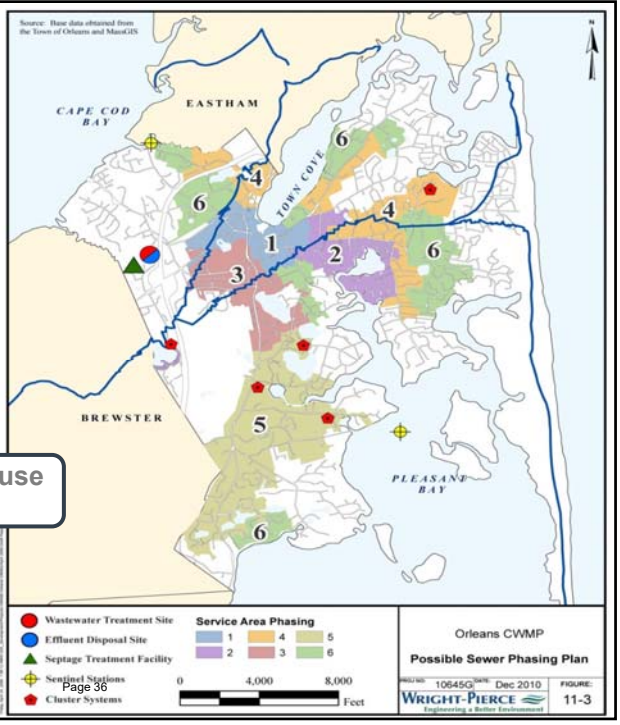
Service Area Overview





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Key CWMP Appropriations

Fiscal Year	Reference / Article	Amount	Remarks
2015	ATM / 44	$1,045,000	Planning
2016	ATM / 5	$1,000,000	Planning
2017	ATM / 9	$691,500	Planning
2017	STM / 2	$3,228,200	Planning and Downtown Area Design
2018	ATM / 13	$2,963,560	Planning
2018	STM / 1	$3,680,000	Main Street Area Construction
2019	ATM / 14	$4,223,600	Planning and Downtown Area Design

Fiscal Year	Reference / Article	Amount	Remarks
2020	ATM / 6	$47,382,800	Downtown Construction
2021	ATM / 42	$12,218,000	Downtown Construction
2021	ATM / 42	$1,700,500	Meetinghouse Pond Design
2022	ATM / 19	$658,300	Meetinghouse Pond Design
2022	ATM / 19	$32,906,000	Meetinghouse Pond Construction
2023	ATM / 16	$2,437,700	Lakes and Pond Design
2023	ATM / 17	$275,000	Downtown Construction

Town of Orleans Massachusetts

Landfill

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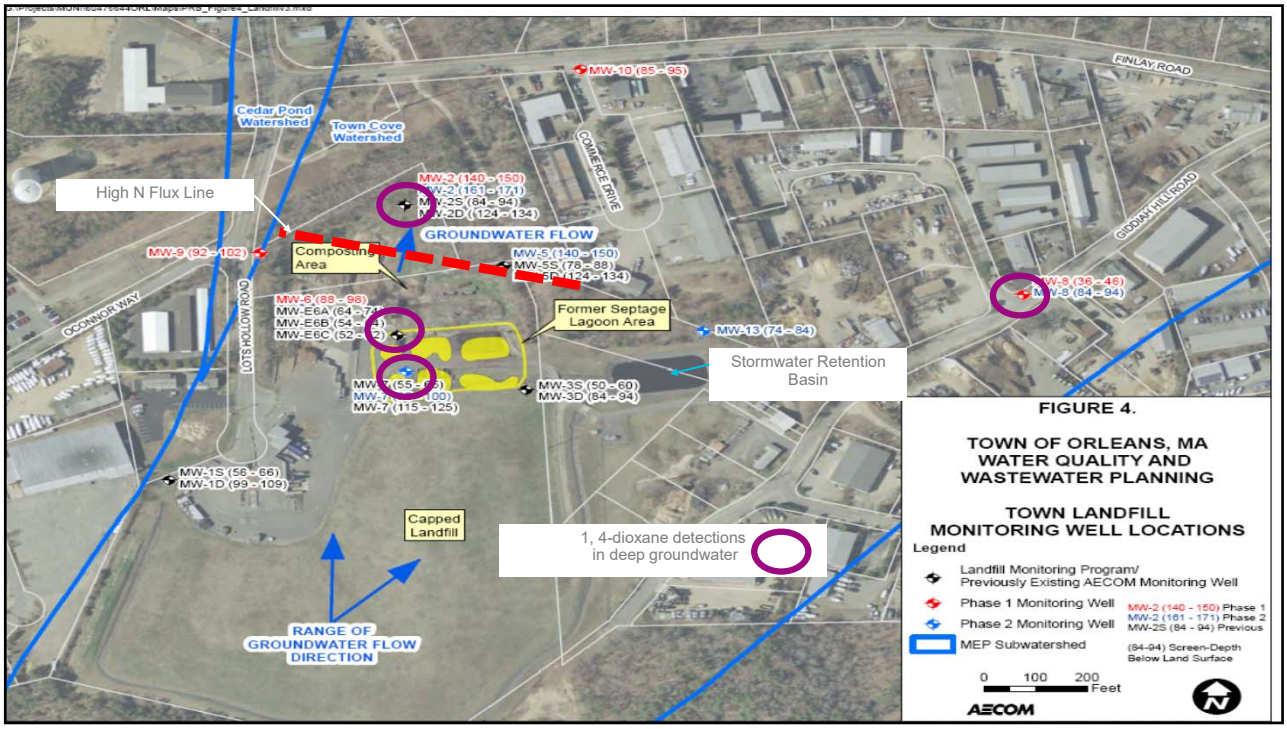
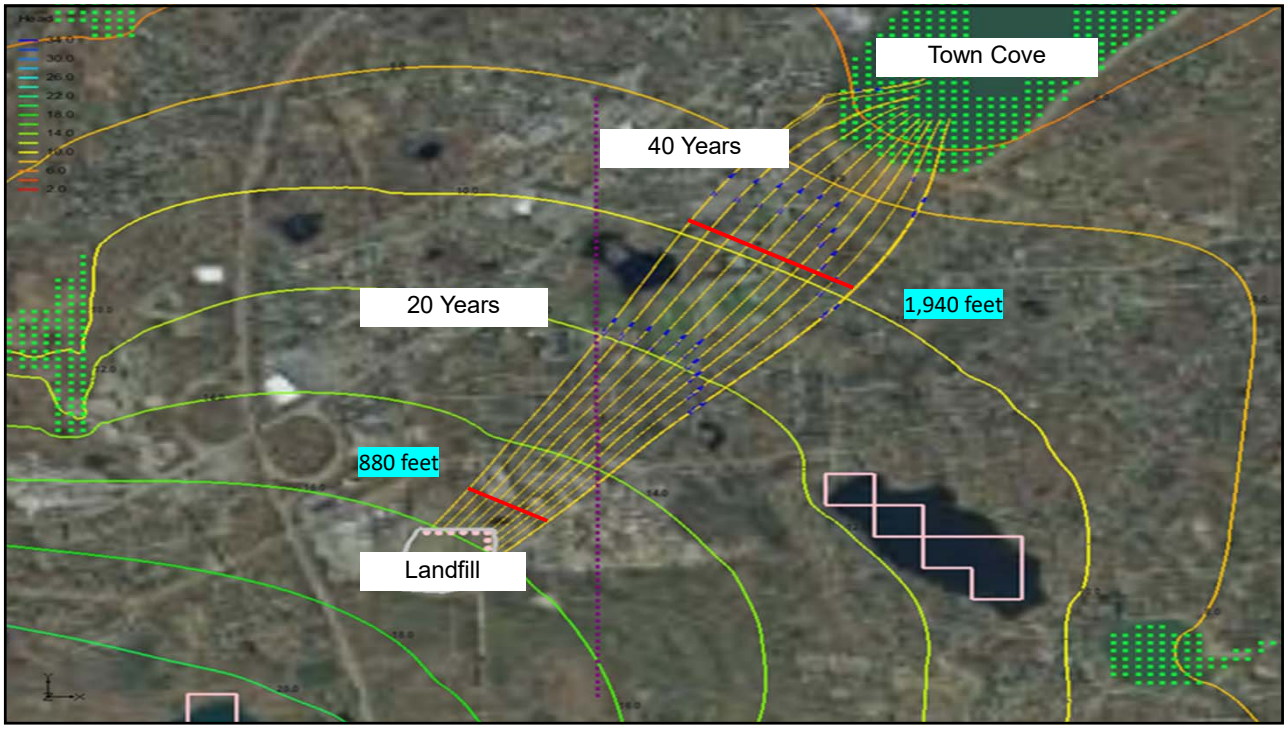
Landfill

- 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




Town Cove
40 Years
20 Years
1,940 feet
880 feet
Landfill

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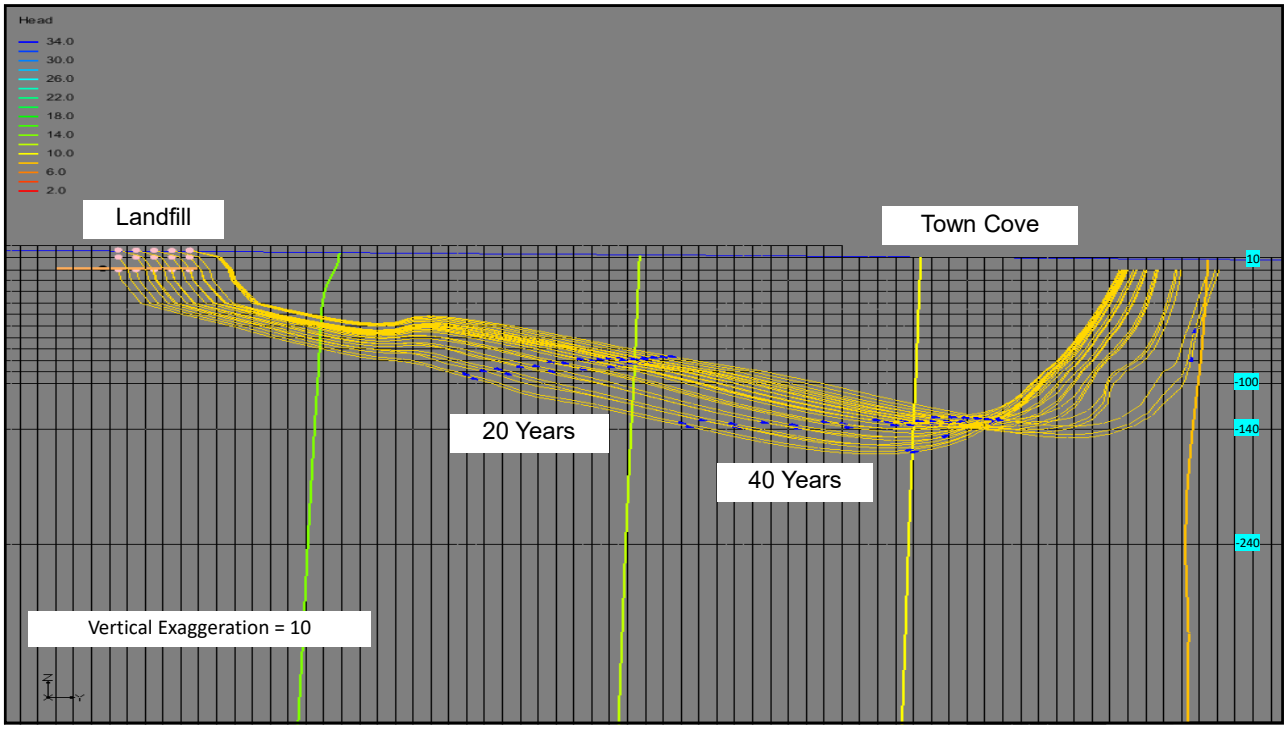
Head
34.0
30.0
26.0
22.0
18.0
14.0
10.0
6.0
2.0
Landfill
Town Cove
10
-100
-140
-240
20 Years
40 Years
Vertical Exaggeration = 10

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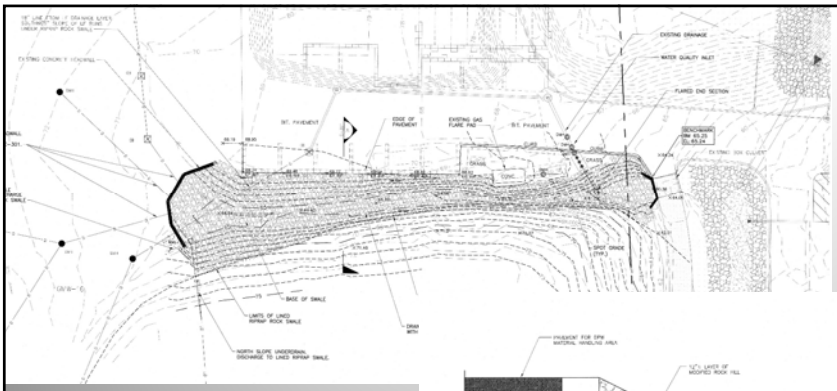
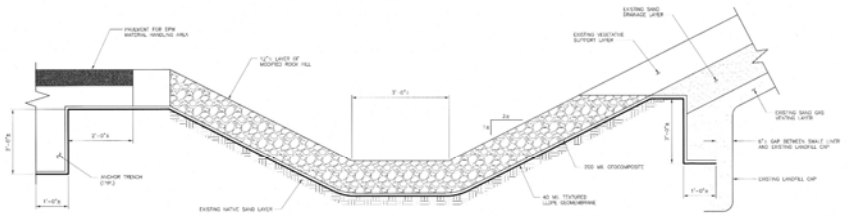


Constructed an Impervious Swale over the Septage Lagoons

Completed March 2018



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Town of Orleans Massachusetts

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

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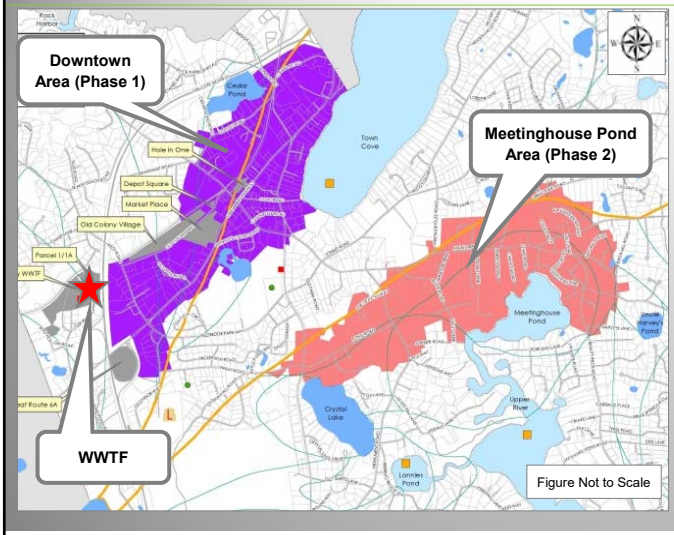
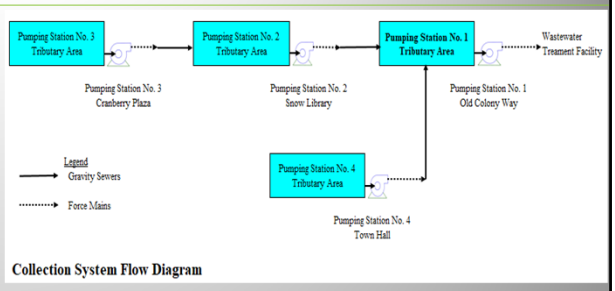
Phase 1 and Phase 2 Sewer Service Areas





Collection System Flow Diagram

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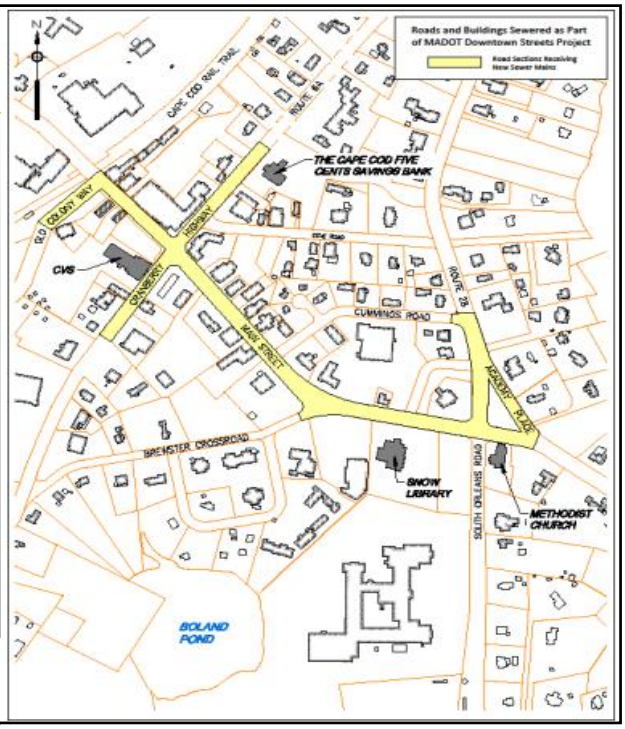
Main Street - Sewer Service Area

Collection System Parameters	Main Street
No. Users	39
8-inch to 10-inch Gravity Sewer	4,007 lf
6-inch Force Main	1,950 lf



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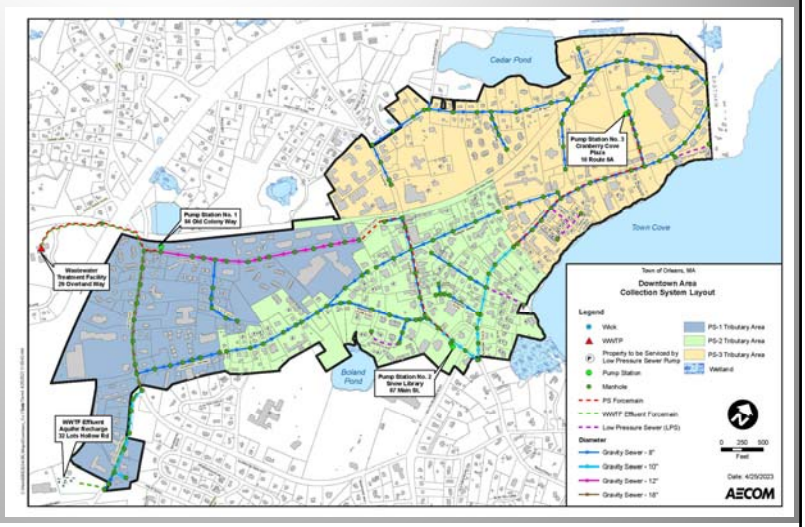
Phase 1 Downtown Area - Sewer Service Area

Collection System Parameters	Downtown Area
No. Users	1,071
8-inch to 18-inch Gravity Sewer	30,690 lf
6-inch to 8-inch Force Main	9,270 lf
2-inch Low Pressure Sewer	2,030 lf
No. of Submersible Pumping Stations	3
No. of Private Property Grinder Pumps	57
Route 6 Crossing	8-inch FM 8-inch Effluent FM 8-inch Future FM Two 4-inch Electrical Conduits



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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

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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

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

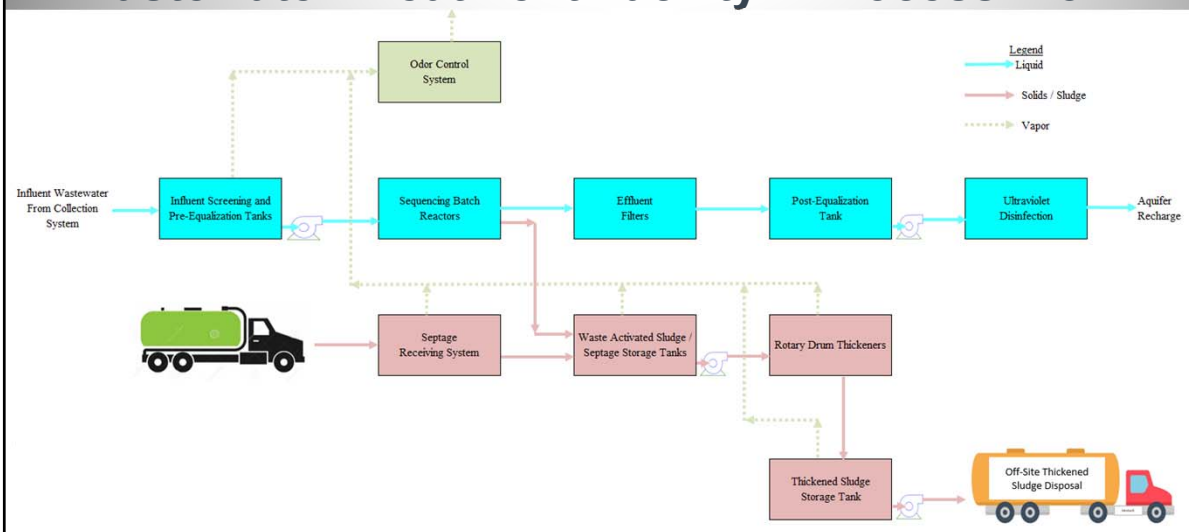
Downtown Area Wastewater Treatment Facility and Effluent Disposal

- **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
  - BOD_5: 30 mg/L
  - TSS: 30 mg/L
  - Total Nitrogen: 10 mg/L
  - Fecal Coliform: 200/100 ml
  - pH: 6.5 to 8.5

Wastewater Treatment Facility

Wastewater Treatment Facility Layout
1. Administration / Operations Building
2. Sequencing Batch Reactors
3. Equipment Storage Facility
4. Septage Receiving Bay
5. Thickened Sludge Loading Area
6. Generator
7. Future Expansion Area

Wastewater Treatment Facility – Process Flow



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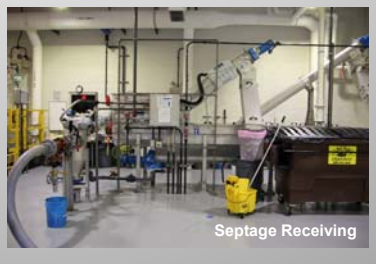
Wastewater Treatment Facility


Sequencing Batch Reactor


Disk Filters


UV Disinfection


Rotary Drum Thickeners


Septage Receiving

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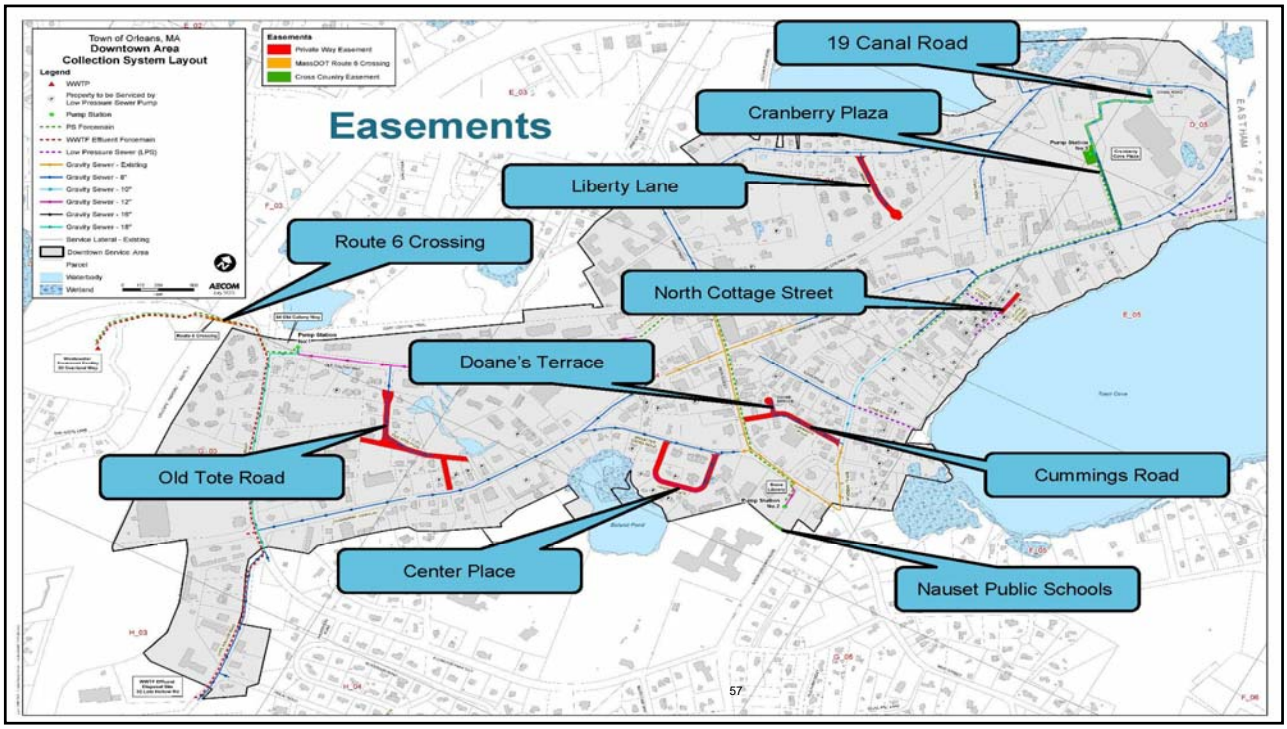
Utility Easements

- Design Layout
  - Maximize Use of Existing Roadways
  - Minimize Cross County Routes
- Permitting Requirements / Constraints
- Funding Authorization
- State Revolving Fund Schedule
- Process
  - Town Meeting Authorization
  - Select Board Adopts Order of Taking for Necessary Easements in Private Ways
  - Recording of Order of Taking at Registry of Deeds
  - Notice of Order of Taking to All Affected Property Owners

Utility 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 (Power Supply)



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Phase 1 Construction Summary

Description	Main Street Area Collection	Downtown Area WWTF	Downtown Area Collection
Construction Duration	February 2018 – May 2019	August 2020 – February 2023	August 2020 – March 2023
As-Bid Cost	$2,279,606.06	$32,786,000.00	$17,946,302.50
Final Cost	$2,695,185.99	$34,307,750 (Estimated)	$18,076,700 (Estimated)
Contractor	Revoli Construction Co., Inc.	Danial O'Connell's Sons	Robert B. Our, Co., Inc.

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Town of Orleans Massachusetts

Meetinghouse Pond Area Collection System and Pumping Station

August 19, 2020

(Revised December 12, 2022; May 30, 2023; June 1, 2023)

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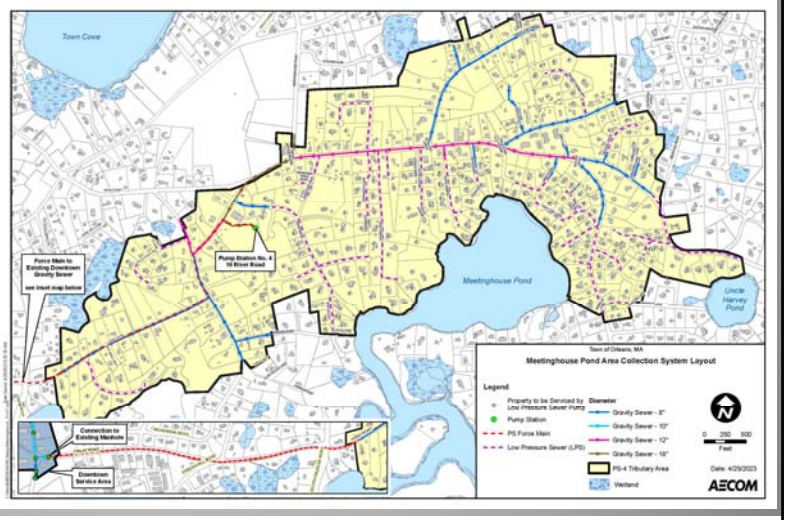
Phase 2 Meetinghouse Pond Area - Sewer Service Area

Collection System Parameters	Meetinghouse Pond Area
No. Users	480
8-inch to 18-inch Gravity Sewer	18,750 lf
8-inch Force Main	7,500 lf
2-inch Low Pressure Sewer	20,750 lf
No. of Submersible Pumping Stations	1
No. of Private Property Grinder Pumps	197



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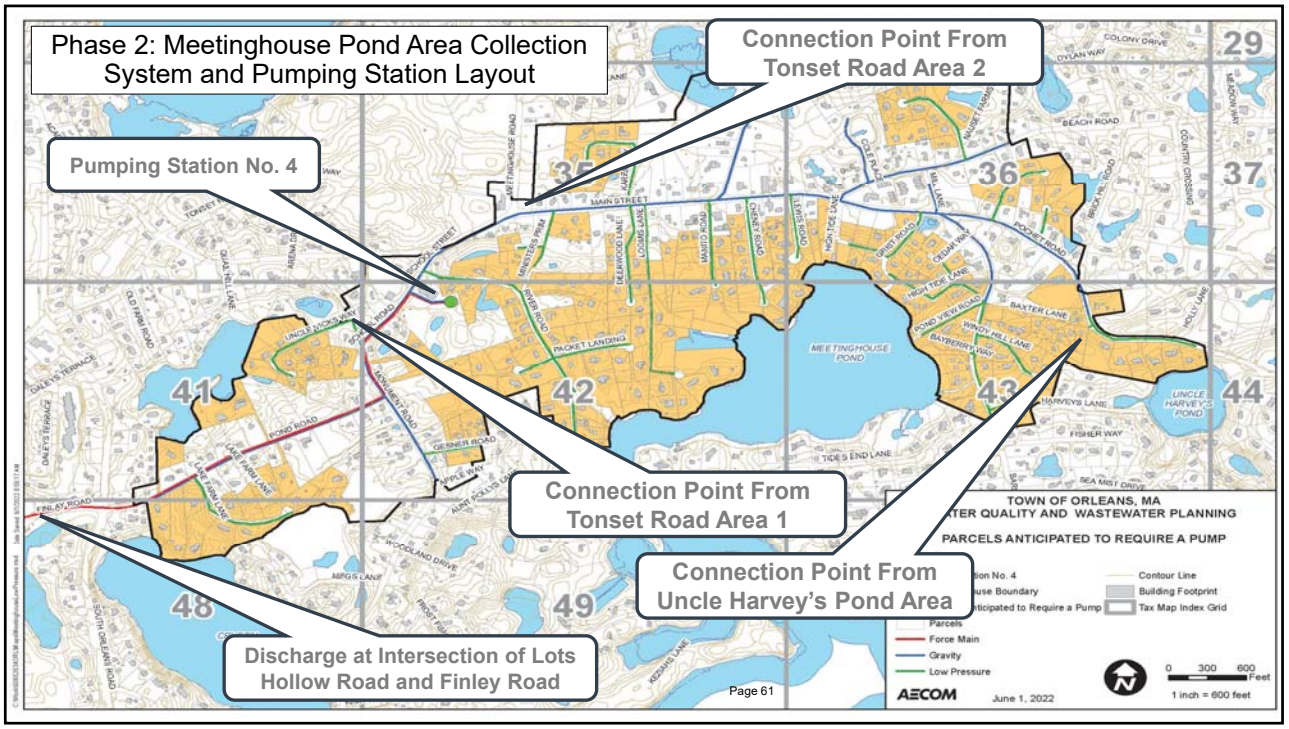

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Utility Easements

- Design Layout
  - Maximize Use of Existing Roadways
  - Minimize Cross County Routes
- Permitting Requirements / Constraints
- Funding Authorization
- State Revolving Fund Schedule
- Process
  - Town Meeting Authorization
  - Select Board Adopts Order of Taking for Necessary Easements in Private Ways
  - Recording of Order of Taking at Registry of Deeds
  - Notice of Order of Taking to All Affected Property Owners

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Utility Easements (cont.)
Locations

- Baxter Lane
- Bayberry Way
- Cheney Road
- Cole Place
- Gesner Road
- Grist Road
- High Tide Lane
- Lake Farm Road
- Lewis Road
- Linden Lane
- Loomis Lane
- Larboard Lane
- Lucy's Lane
- Manito Road
- Ministers Prim Road
- Natural Drive
- Nauset Farms Way
- Packet Landing
- Pond View Road
- Reverend Treat Road
- River Road
- Uncle Vicks Way
- Windy Hill Lane

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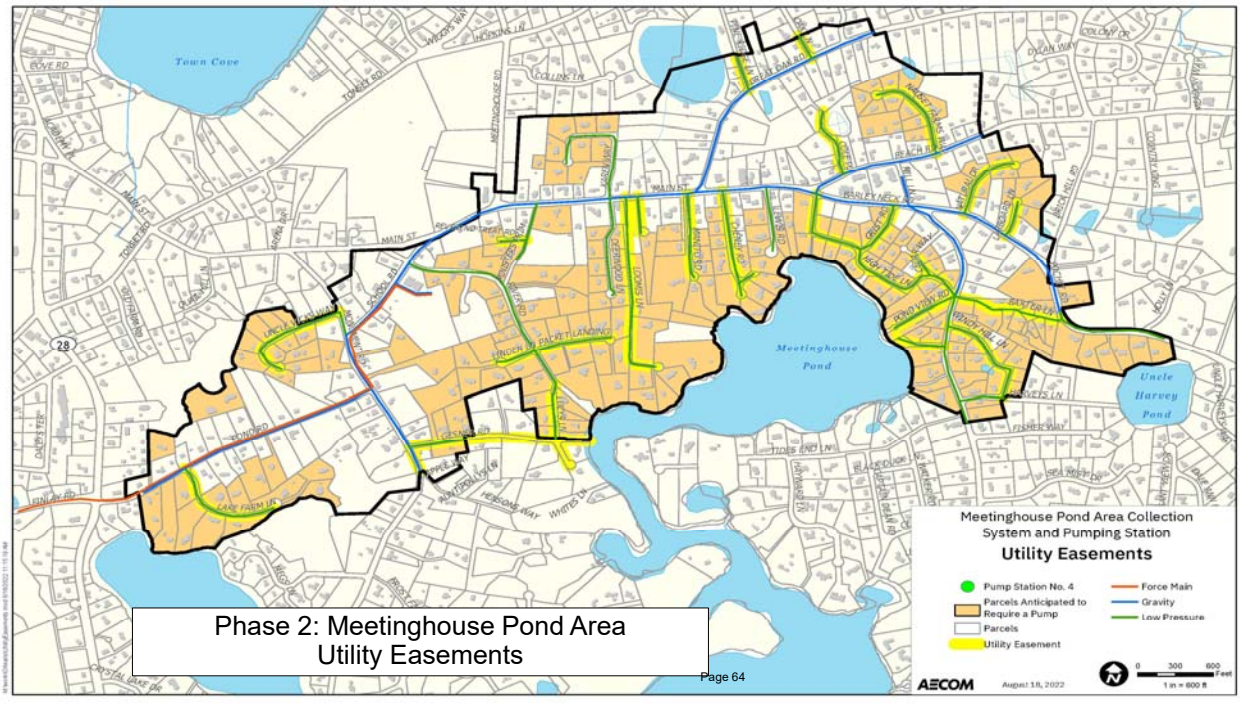

Phase 2: Meetinghouse Pond Area Utility Easements

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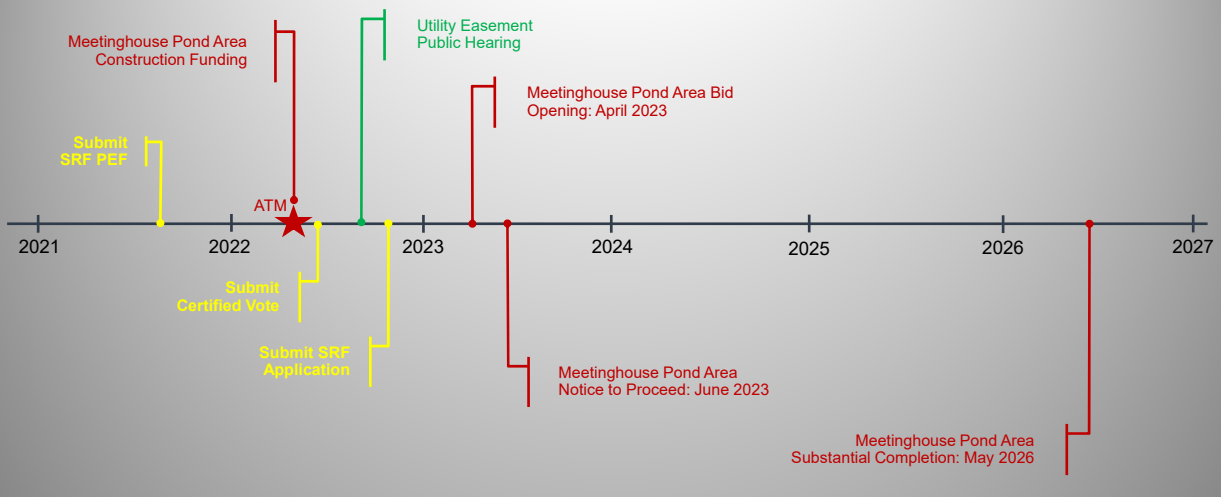
Project Schedule



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Meetinghouse Pond Area Collection System and Pumping Station - Contract No. 2022-01

- Probability of Project Cost: $24,955,000
- Bidding Phase
  - Bids Opened April 28, 2023
  - Four Bids Received
    - C.C. Construction, Inc.
    - Robert B Our, Inc.
    - RJV Construction Corporation
    - Revoli Construction, Co., Inc.
  - Proposals Ranged from $20.8M to $27.0M
  - C.C. Construction, Inc.
  - Bid Items
    - Construction of Wastewater Infrastructure: $19,946,752.71
    - Replacement of Water Services: $315,348.29
    - Replacement of Baxter Lane and Lucy's Lane Water Main: $288,490.65
    - Water Quality Improvements: $216,457.50
  - Total: $20,767,049.15

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Town of Orleans Massachusetts

Future Wastewater Expansion Areas

August 19, 2020

(Revised December 12, 2022; May 30, 2023; June 1, 2023)

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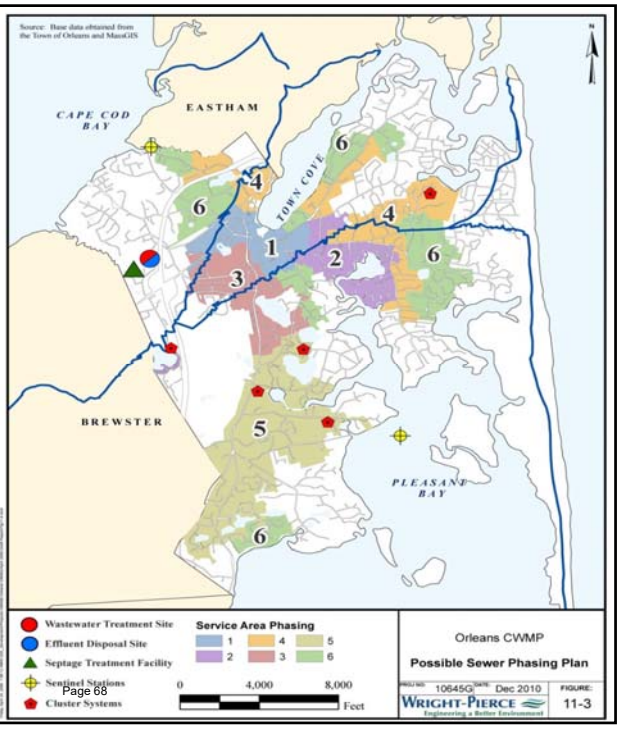
Master Planning

- Continued Coordination with Wastewater Advisory Committee
  - Phasing
  - Schedule
- Development / Update of CWMP Sewer Phasing Plan
- Impact Analysis on Existing Wastewater Infrastructure



The History of Wastewater Planning and Implementation in Orleans, MA

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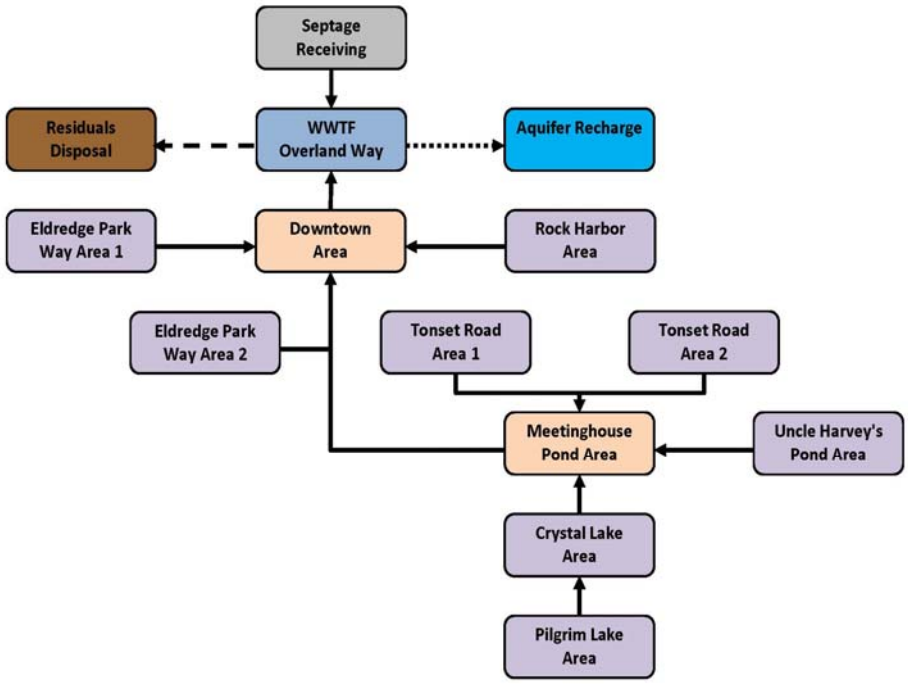
Master Planning - Wastewater Infrastructure Schematic



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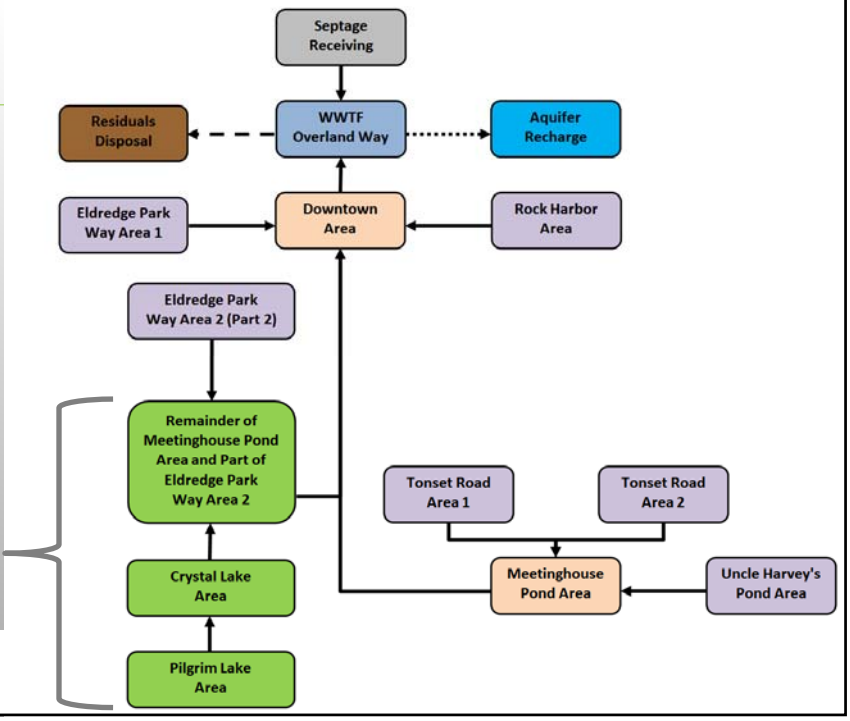
Master Planning - Updated Wastewater Infrastructure Schematic with Phase 3 - Lakes and Ponds Area

Phase 3



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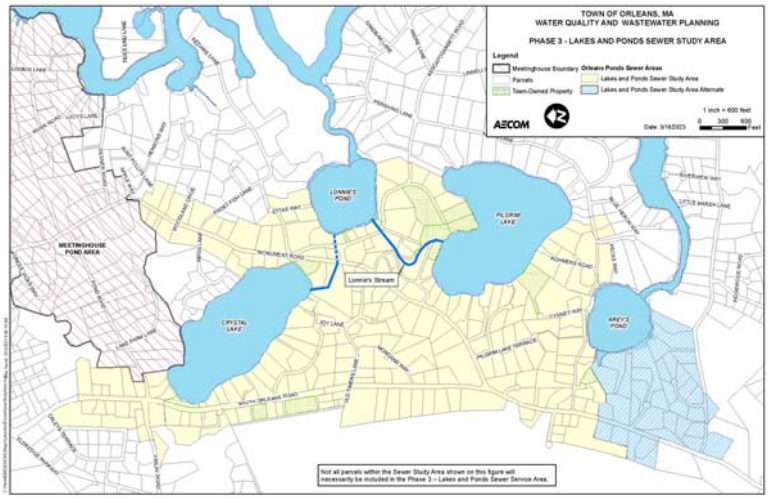
Phase 3 Lakes and Ponds - Sewer Service Area

Collection System Parameters	Lakes and Ponds Area
No. Users	175
8-inch to 12-inch Gravity Sewer	6,400 lf
8-inch Force Main	500 lf
2-inch Low Pressure Sewer	13,500 lf
No. of Submersible Pumping Stations	1
No. of Private Property Grinder Pumps	197



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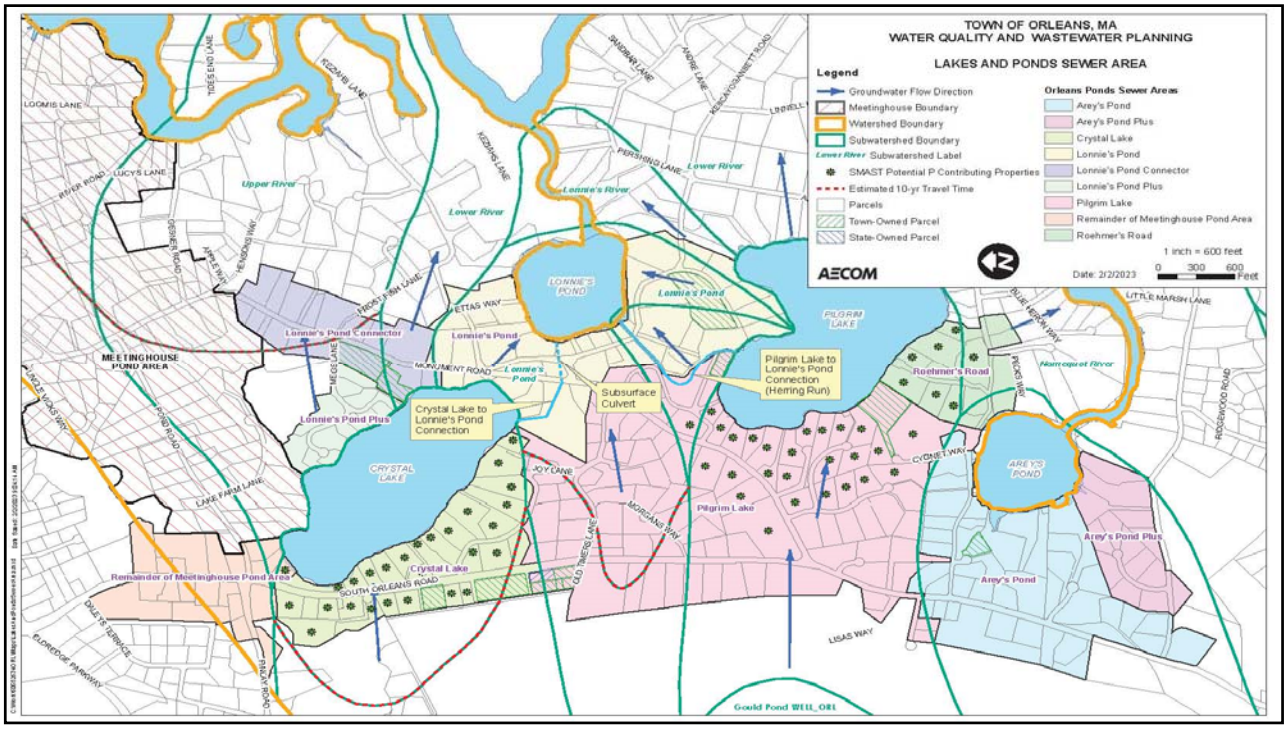

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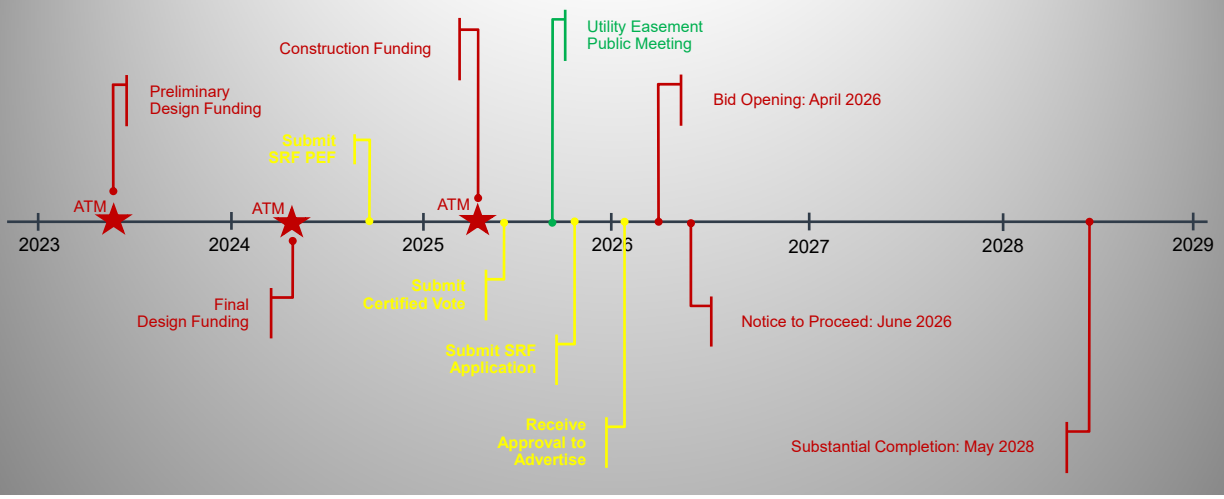
Phase 3 Collection System and Pumping Station Project Schedule



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Next Steps – Preliminary Design Engineering

- Conduct Aerial and Ground Survey
- Perform Subsurface Investigations
- Prepare a Cultural Resource Evaluation
- Identify Locations of Land Takings and/or Easements
- Identify Regulatory Permits Required
- Perform a Gravity Sewer Capacity Analysis
- Develop 25 Percent Plans and Profiles
- Develop an Opinion of Project Cost
- Prepare for, attend and present at Meetings, Workshops and Updates
- Prepare and file SRF Project Evaluation Form

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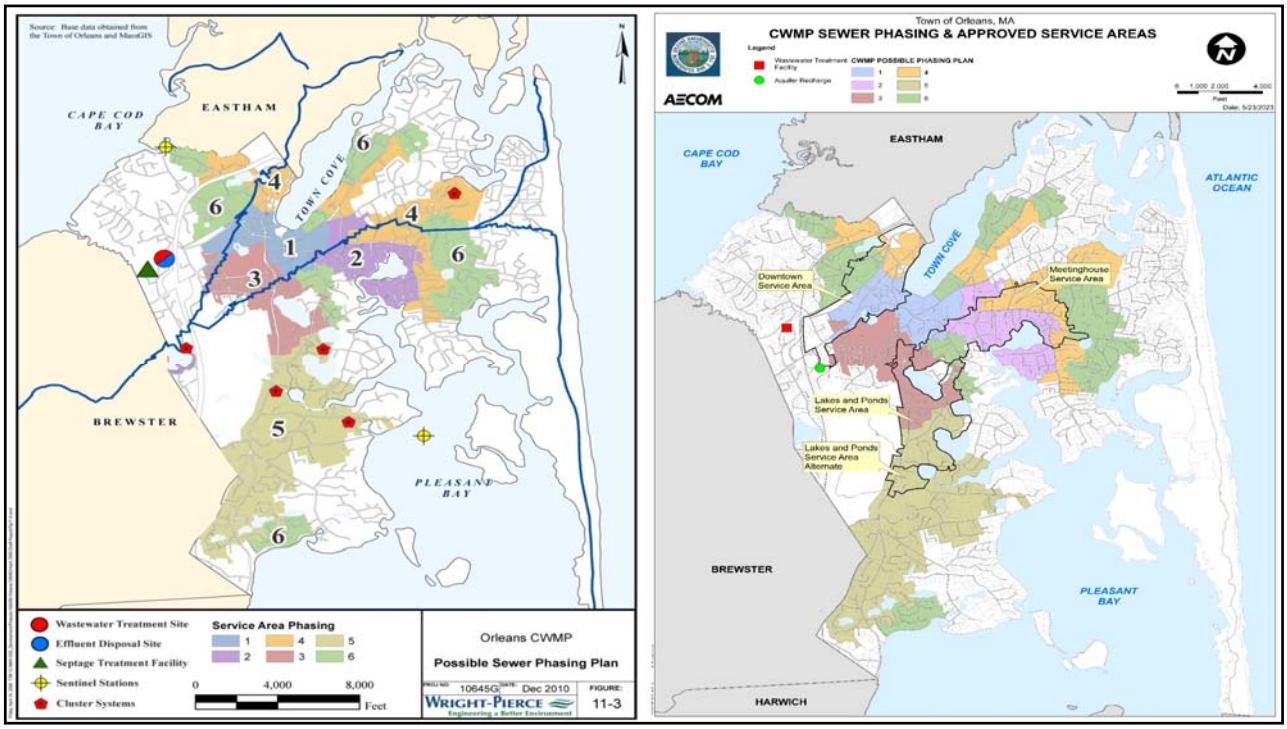

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Previous Future Sewer Service Areas

Collection System Parameters	Eldredge Park Way - 1	Eldredge Park Way - 2	Rock Harbor	Tonset - 1	Tonset - 2
Number of Parcels (Developed + Developable)	45 + 2	213 + 10	113 + 2	84 + 9	248 + 10
Gravity Sewer and Low-Pressure Sewer (l.f.)	7,500	17,950	10,000	7,750	20,500
No. of Submersible Pumping Stations	---	---	1	---	---
Estimate WW Flow, ADF - gpd) (Not Including I/I)	5,400	16,400	12,400	10,300	35,000
Probability of Project Cost (2023 Dollars)	$7.1M	$21.9M	$13.8M	$7.6M	$20.5M

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East Orleans – Future Sewer Service Areas

Collection System Parameters	Meetinghouse Pond - Addition	Meetinghouse Pond - North	Meetinghouse Pond - South
Number of Parcels (Developed + Developable)	33 + 2	198 + 6	276 + 10
Gravity Sewer and Low-Pressure Sewer (l.f.)	3,900	20,200	29,200
No. of Submersible Pumping Stations	---	1	1
Estimate Flow (ADF - gpd)	4,500	24,900	44,300
Probability of Project Cost (2023 Dollars)	$1.4M	$25.9M	$37.4M

South Orleans – Future Sewer Service Areas

Collection System Parameters	South Orleans - A	South Orleans - B	South Orleans - C	South Orleans - D	South Orleans - E	South Orleans - F
Number of Parcels (Developed + Developable)	139 + 3	112 + 3	71 + 6	50	136 + 2	78 + 2
Gravity Sewer and Low-Pressure Sewer (l.f.)	18,200	12,800	8,900	5,500	15,900	11,200
No. of Submersible Pumping Stations	1	1	1	1	1	1
Estimate Flow (ADF - gpd)	14,600	16,900	11,100	5,700	21,400	15,600
Probability of Project Cost (2023 Dollars)	$23.3M	$16.4M	$11.4M	$7.0M	$20.4M	$14.4M

DRAFT

Estimated Nitrogen Load Removals by Sewer Service Area

Loads in kg/yr

Loads Based on 4.5 kg/yr per Developed Parcel

Sewer Service Area	Nauset	Rock Harbor	Pleasant Bay	Little Namskaket
Phase 1 – Downtown	1,679	2,178		927
Phase 2 - Meetinghouse Pond	176		1,980	
Phase 3 – Lakes and Ponds	32		1,116	
Non-Traditional	161		67	
Downtown - North		284		5
Meetinghouse Pond - 2			149	
Phase 3 - Lakes and Ponds - Alternate			180	
Meetinghouse Pond - North	657		234	
Meetinghouse Pond - South			1,242	
Rock Harbor		509		
Eldredge Park Way - 1	86	117		
Eldredge Park Way - 2	702	5	252	
South Orleans - A			626	
South Orleans - B			504	
South Orleans - C			320	
South Orleans - D			225	
South Orleans - E			612	
South Orleans - F			351	
Tonset - 1	378			
Tonset -2	1,116			
Totals	**4,987**	**3,093**	**7,858**	**932**
Removal Requirement	**5,000**	**1,500**	**6,980**	**0**
Difference	**13**	**(1,593)**	**(878)**	**(932)**

The History of Wastewater Planning and Implementation in Orleans, MA

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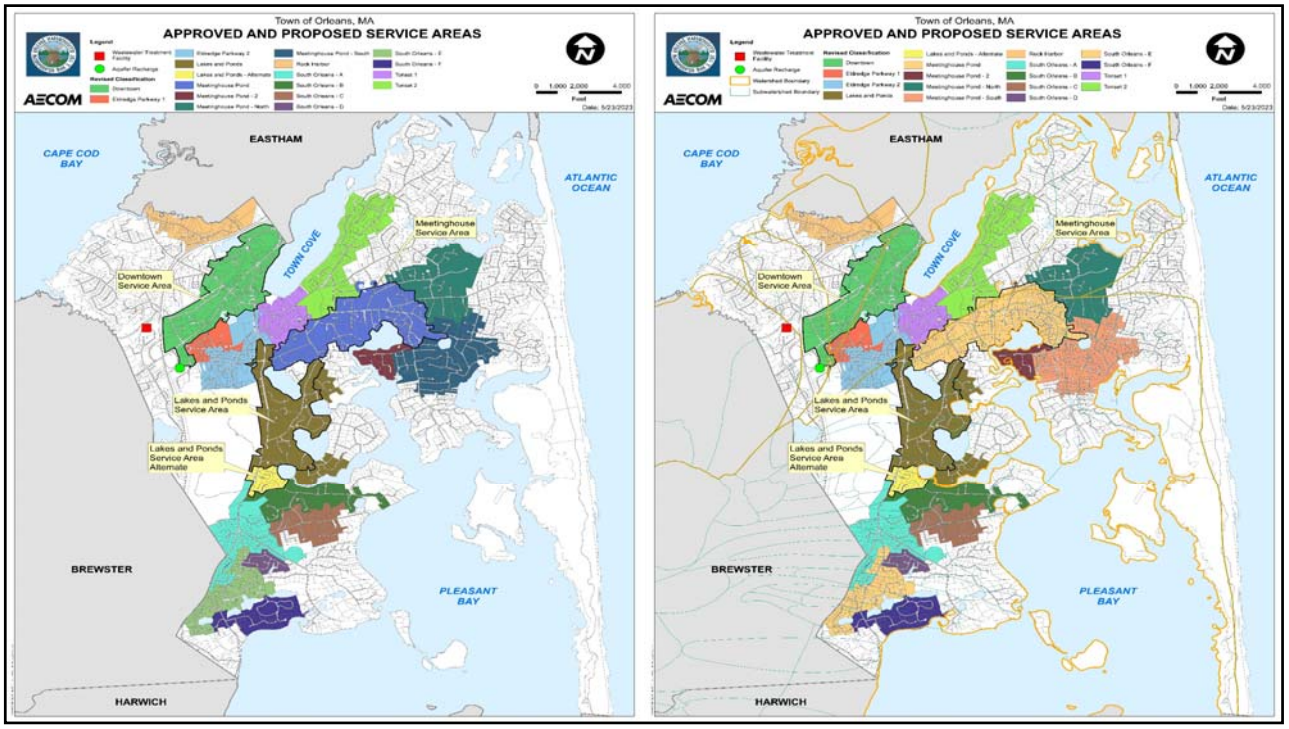

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Town of Orleans Massachusetts

Aquifer Recharge (Effluent Disposal)

August 19, 2020

(Revised December 12, 2022; May 30, 2023; June 1, 2023)

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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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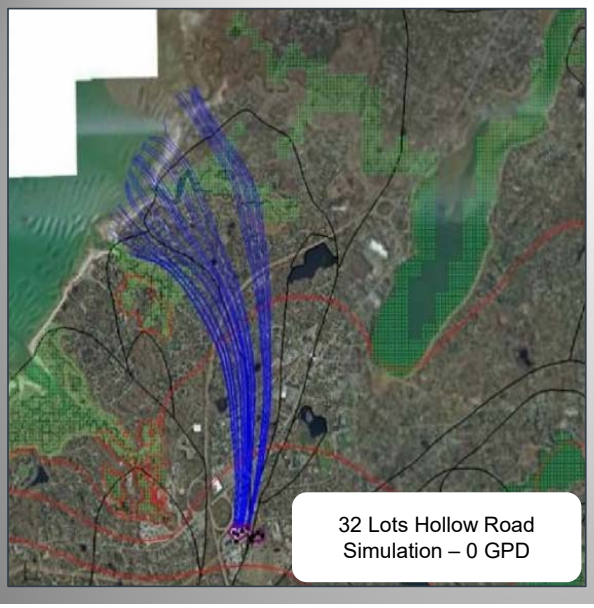
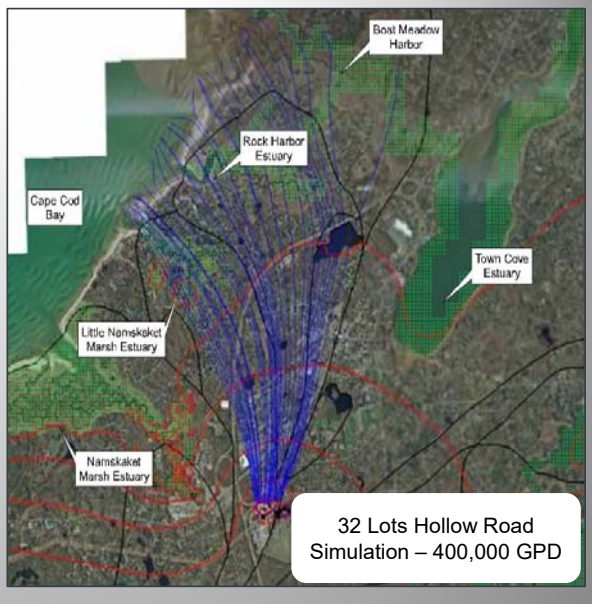
Effluent Disposal Sites

- 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 *

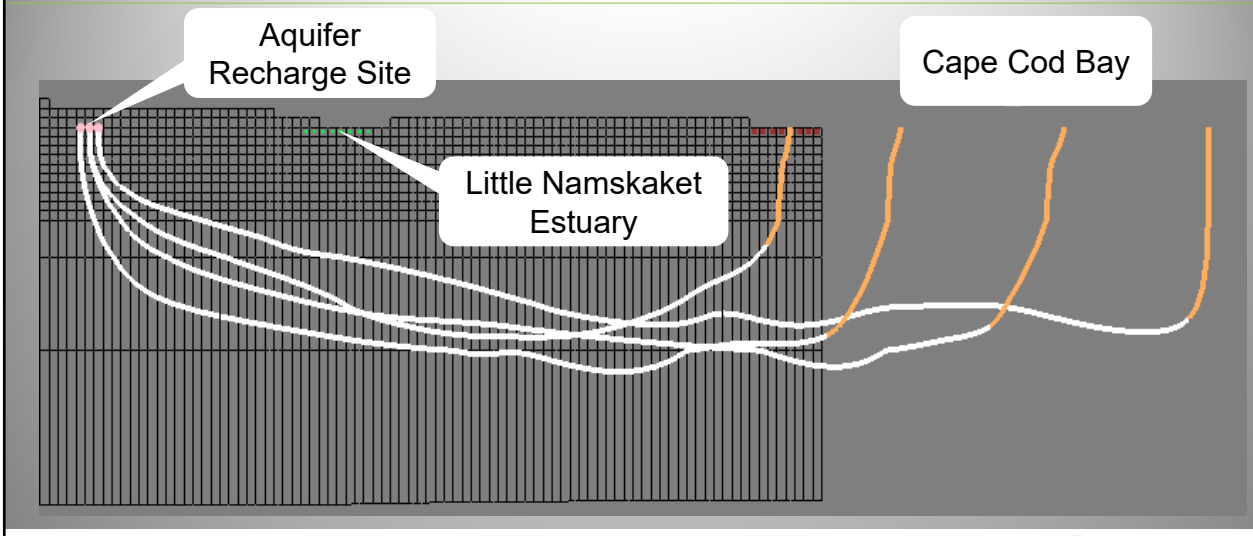
* MassDEP Approved Hydrogeology Evaluations

- Primary Aquifer Recharge Site
  - 32 Lots Hollow Road
- Backup Aquifer Recharge Sites
  - 43 Lots Hollow Road
  - Route 6, Exit 89 (fka Exit 12) Lobe
  - 223 Beach Road
- MassDEP Groundwater Discharge Permit Issued (March 2020 and Modification September 2021)
  - 32 Lots Hollow Road
  - 43 Lots Hollow Road





32 Lots Hollow Road - Cross Section



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Town of Orleans Massachusetts

Low-Pressure Sewerage Pump System Preselection

August 19, 2020

(Revised December 12, 2022; May 30, 2023; June 1, 2023)

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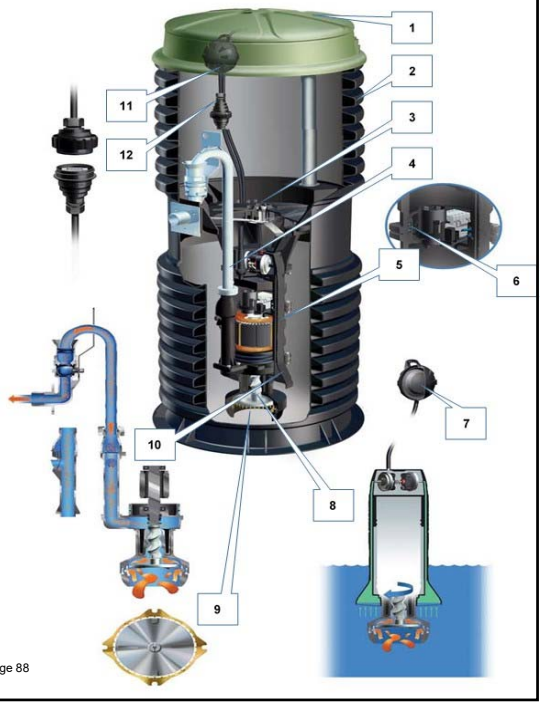
Low-Pressure Sewerage Pump System Preselection

- 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.

LPS System Components



LPS System Proposal Costs – February 2020

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

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LPS System Costs – May 2023		
Item	Description	Amount
1	Low-Pressure Sewerage Pump System	
	Type A (DH071-93 - Exterior, Simplex, 700 GPD and Wetwell Capacity of 70 Gallons)	$5,620.00
	Type B (DH151-93 - Exterior, Simplex, 1,500 GPD and Wetwell Capacity of 150 Gallons)	$6,145.00
	Type C (DH-152-93 - Exterior, Duplex, 3,000 GPD and Wetwell Capacity of 150 Gallons)	$11,890.00
	Type D (IH091- Interior, Simplex, 700 GPD and Wetwell Capacity of 90 Gallons)	$4,812.00
	Type E (DH272-92 - Exterior, Duplex, 5,000 GPD and Wetwell Capacity of 275 Gallons)	$25,460.00
2	5 Year Warranty is Now Standard	N/A
3	Engineered Stainless-Steel Service Lateral Component	$270.88.00
4	Pump Monitoring System	$528.10
5	Anti-Buoyancy Device	$359.00
6	Pump Core Replacement	$2,490.00
7	High Flood Configuration for Type A	$260.90
8	High Flood Configuration for Type B and Type C	$260.90
9	Insulation Disc for Freeze Protection	$75.00
10	Remote Sentry – Alarm Unit in House Mounting	$250.00

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Town of Orleans Massachusetts

Non-Traditional Technologies Aquaculture

August 19, 2020

(Revised December 12, 2022; May 30, 2023; June 1, 2023)

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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

July 13, 2016 **December 22, 2016**

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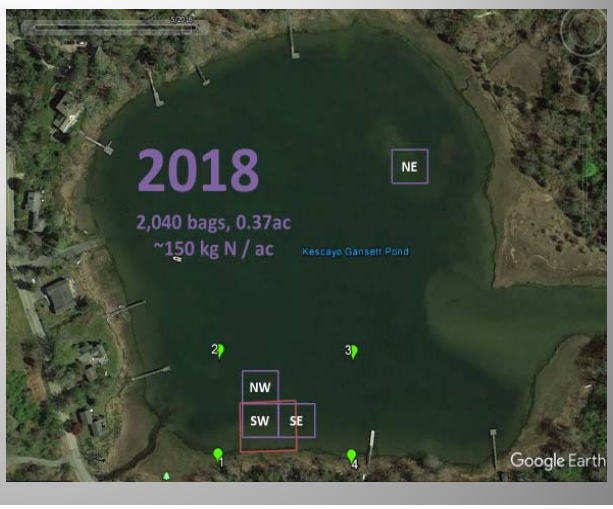
Aquaculture
Comparison of Demonstration Years

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.			

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
- Third Year of Private Operation
  - Oversight by Shellfish and Harbormaster Department
  - Monitoring by SMAST



Aquaculture

- Status
  - Third Year of Private Operation
    - Oversight by Shellfish and Harbormaster Department
    - Monitoring by SMAST
  - Nitrogen Application
    - Lonnie's Pond Oyster Aquaculture Demonstration Project
    - Submitted to MassDEP on June 28, 2022
    - Application Has Not Been Reviewed by MassDEP as of June 1, 2023
- Next Steps
  - Future Expansion?

Town of Orleans Massachusetts

Non-Traditional Technologies Nitrogen Reducing Barriers (NRBs)

August 19, 2020

(Revised December 12, 2022; May 30, 2023; June 1, 2023)

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

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

Town of Orleans Massachusetts

Non-Traditional Technologies
Permeable Reactive Barriers (PRBs)

August 19, 2020

(Revised December 12, 2022; May 30, 2023; June 1, 2023)

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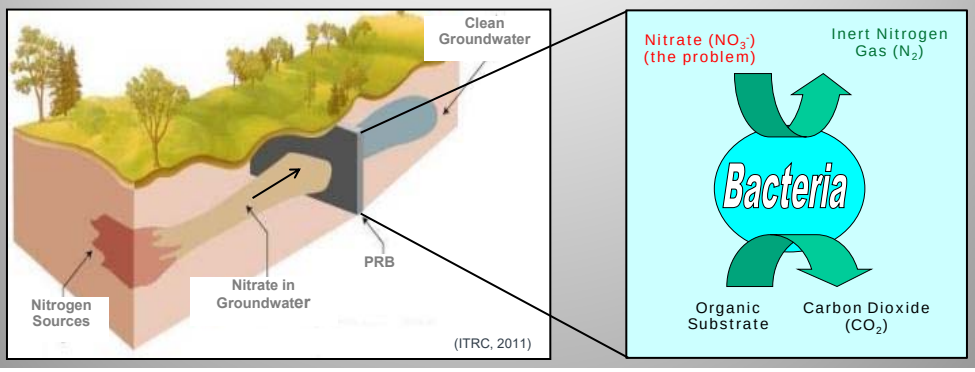
Permeable Reactive Barriers (PRBs)

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



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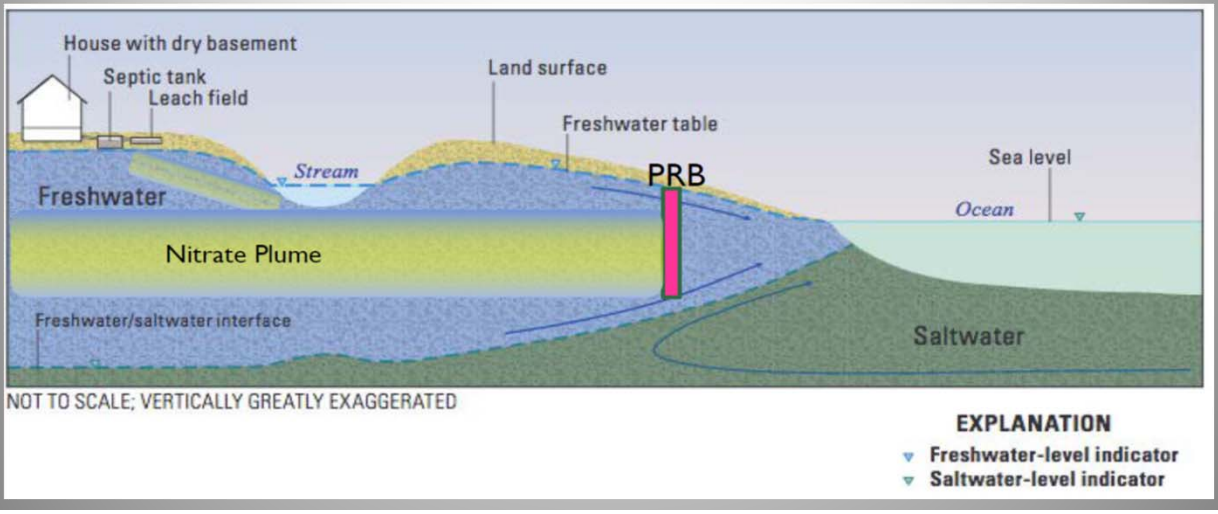
Concept: Intercept and Remove Nitrate From Groundwater

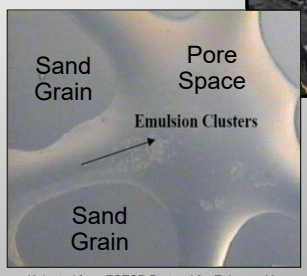


Why PRBs?

- 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

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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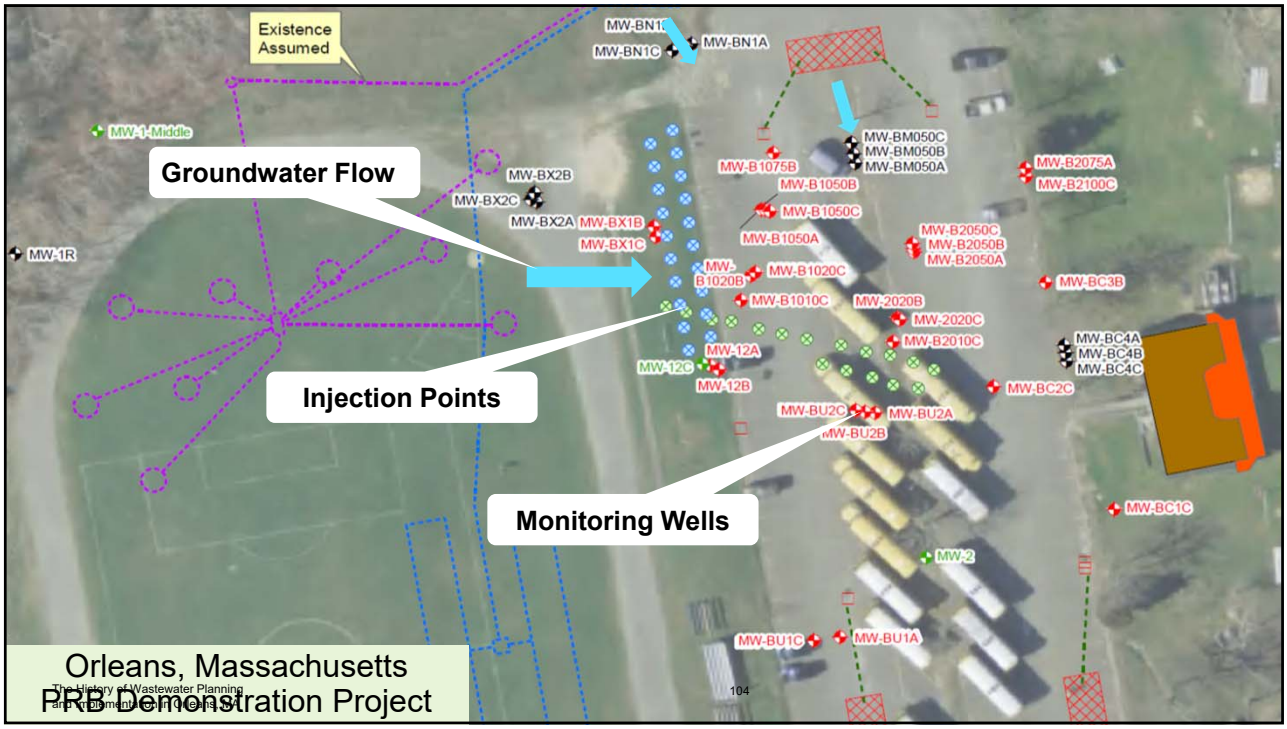

Orleans, Massachusetts
PRB Demonstration Project

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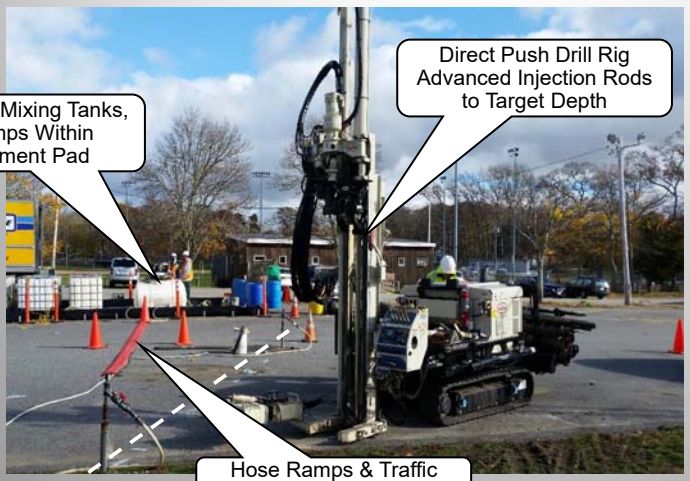
PRB Demonstration Test



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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 2023

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 CaCO3 (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)

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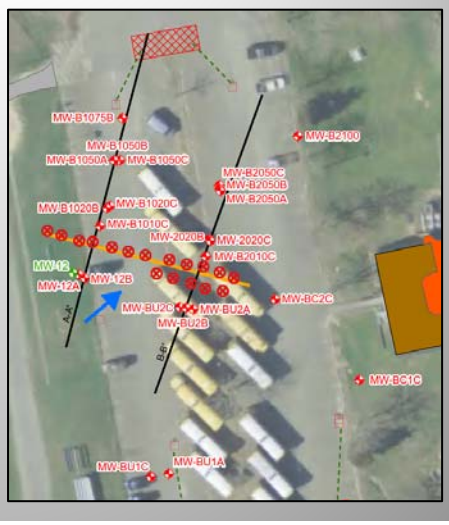
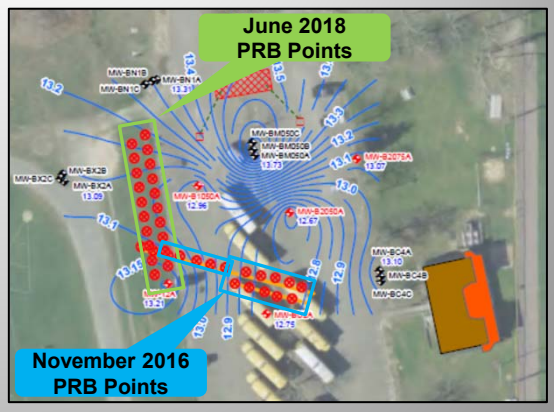
Initial Injections (Round 1) November 2016

- 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



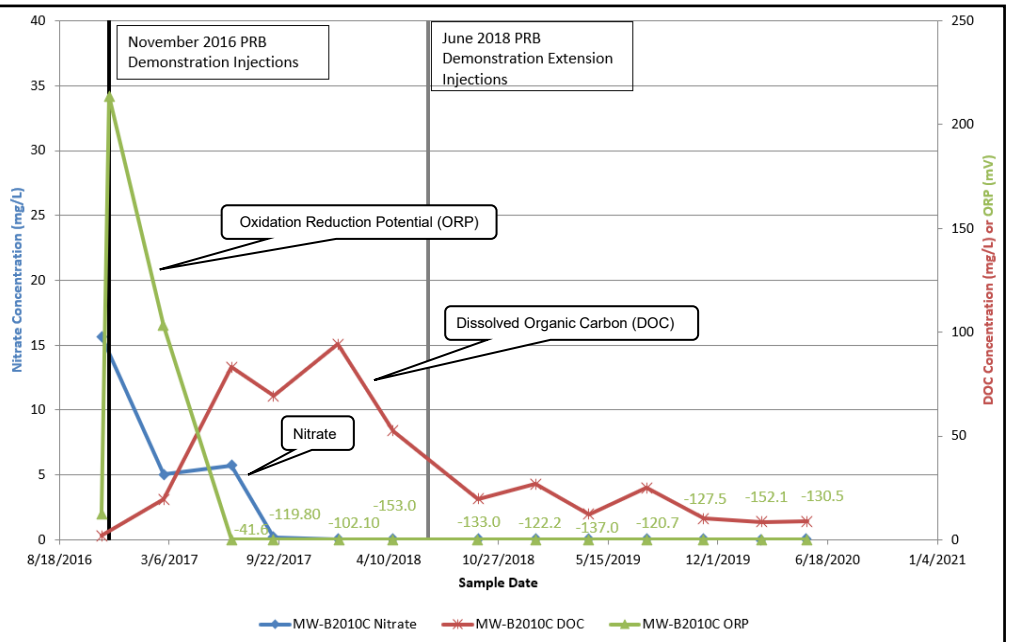
PRB Extension (Round 2) June 2018

- 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



Denitrification Results Shallow Well (MW-B2010C)

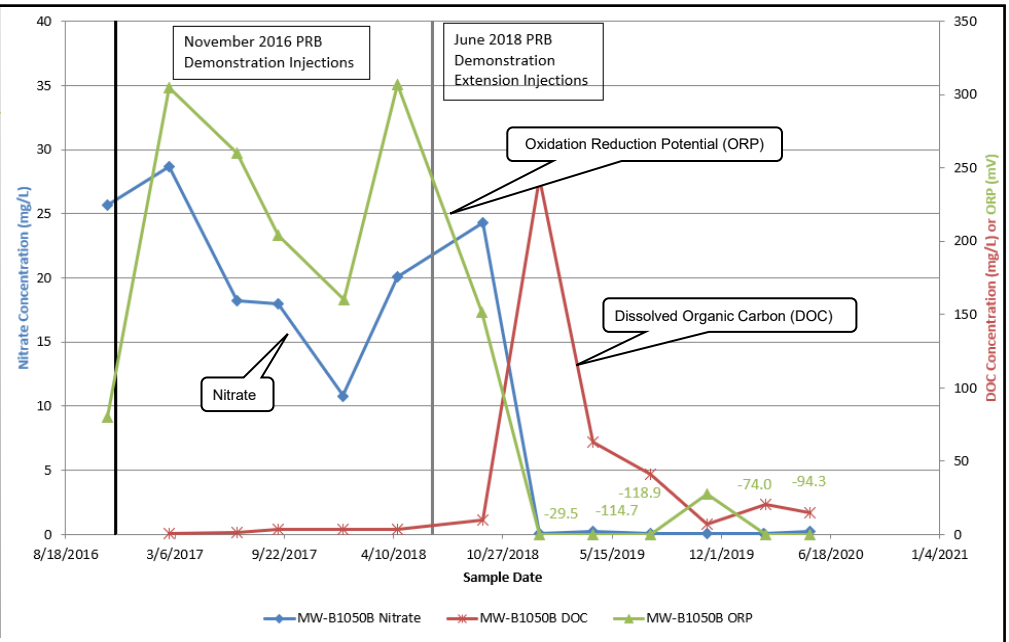
10 Feet Downgradient of 1st Injection



109

Denitrification Results Intermediate Well (MW-1050B)

50 Feet Downgradient of 2nd Injection



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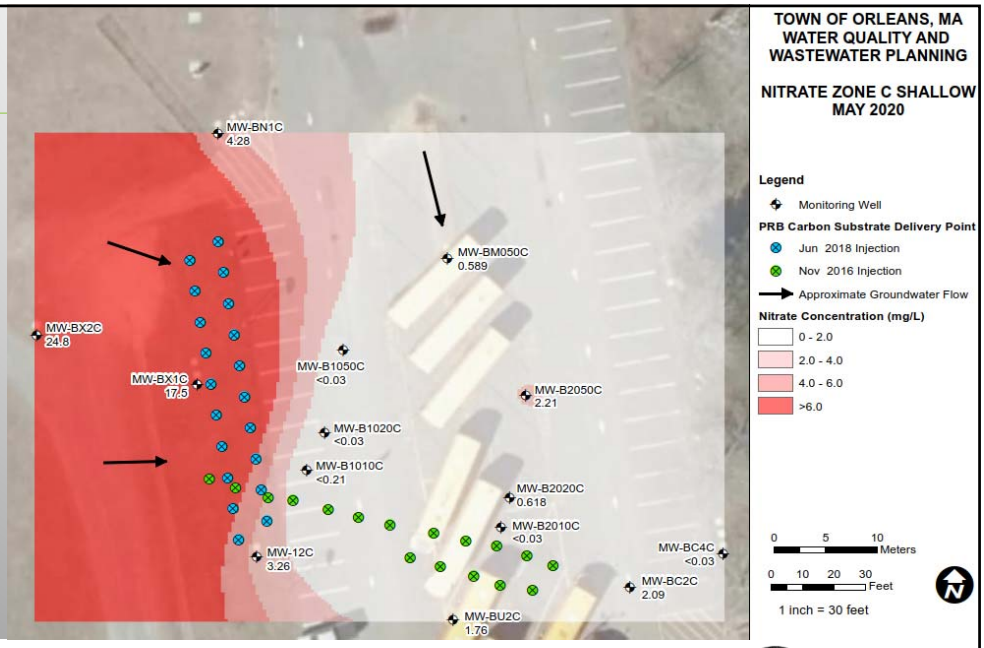
Denitrification Results Shallow Zone



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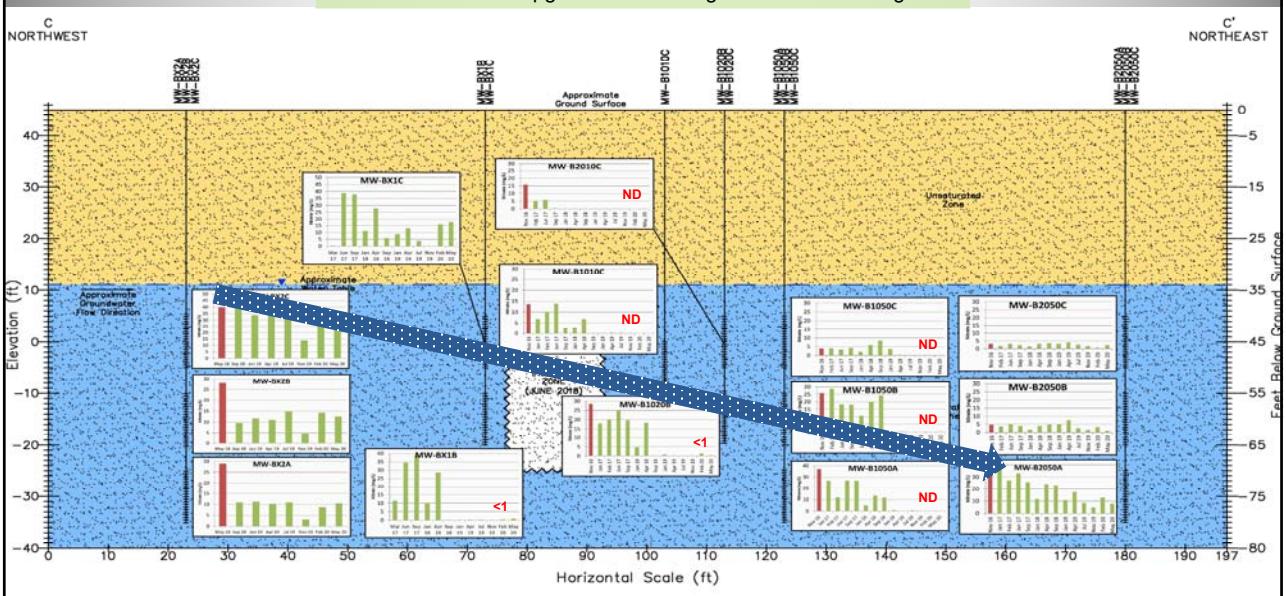
Cross Section Upgradient to Downgradient – Nitrate mg/L



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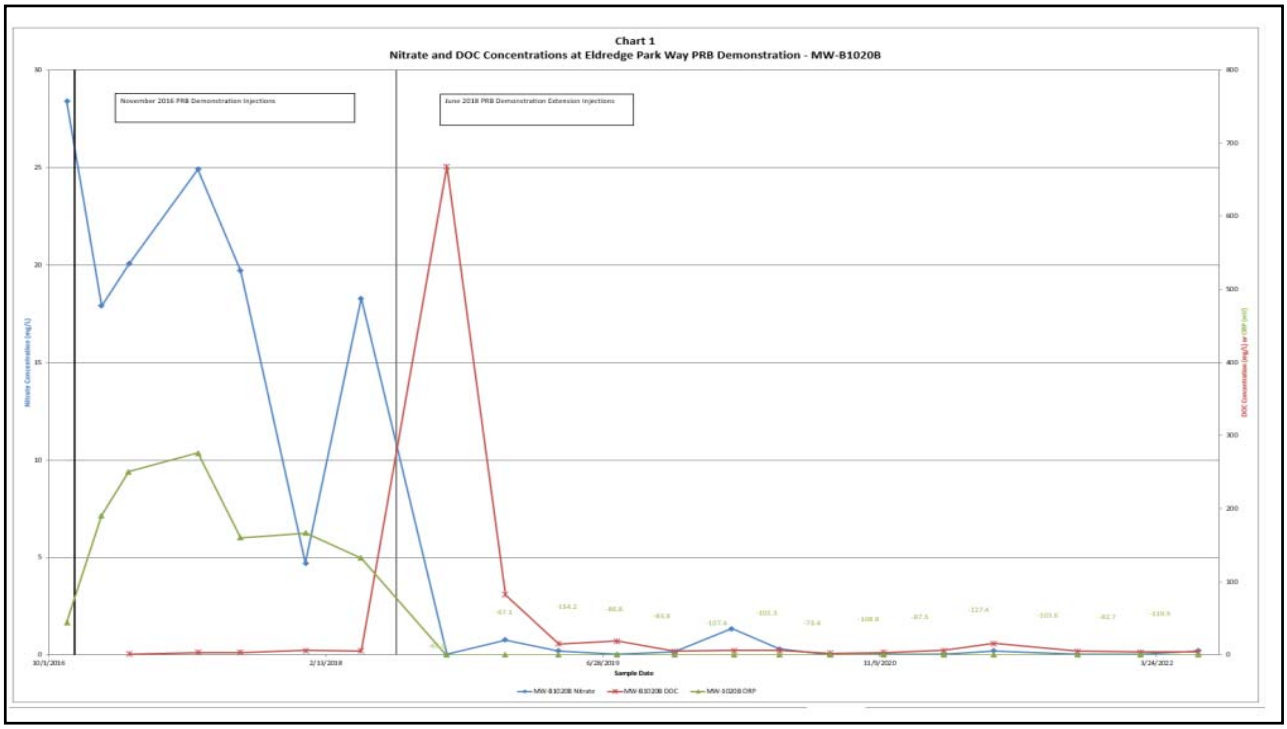

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Conclusions to Date

- 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

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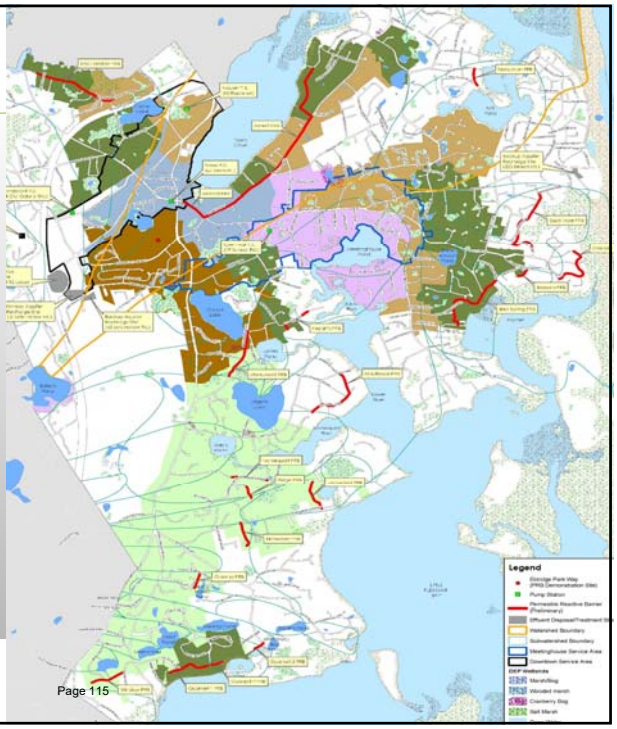
Potential Full Scale PRBs

- Total of ~34,000 Linear Feet in 3 Major Watersheds
  - Pleasant Bay Estuary
  - Nauset Estuary
  - Rock Harbor Estuary



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.

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

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

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	

Implementation and Monitoring Recommendation

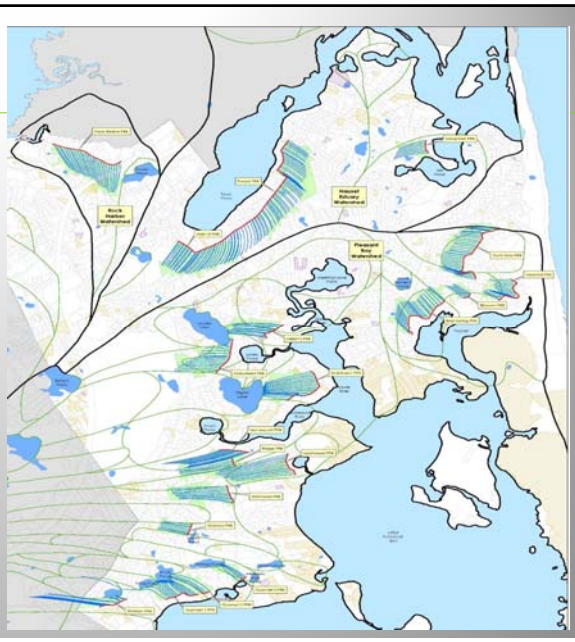
- Implementation
  - Phased Schedule with Most Cost-Effective/Favorable Locations First
  - Monitoring Wells per 400 LF of PRB
    - Upgradient - 2
    - Downgradient - 4
  - PRBs Located Within Right-of-Ways
  - Utilize Adaptive Management for Adjustments to Implementation Recommendations
- Sampling 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

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

Next Steps

- Ongoing
  - Conduct Field Investigations
  - Modify Assumptions Based on Information Obtained During Investigations
  - Modify Recommended PRB Locations
- Future
  - Run Scenarios through Updated MEP Model
  - CWMP Notice of Project Change



Planning Outcomes

- Pleasant Bay
  - 14 Potentially Viable PRBs - *3 Recommended for Further Field Assessment*
  - Nitrogen Removal of 2,115 kg/yr vs. Target of 4,996 kg/yr
- Nauset Estuary
  - 3 Potentially Viable PRBs - *2 Recommended for Further Field Assessment*
  - Nitrogen Removal of 866 kg/yr vs Target of 566 kg/yr
- Rock Harbor
  - 1 Potentially Viable PRB - *Not recommended for further field assessment*
  - Nitrogen Removal of 305 kg/yr vs. Target 634 kg/yr

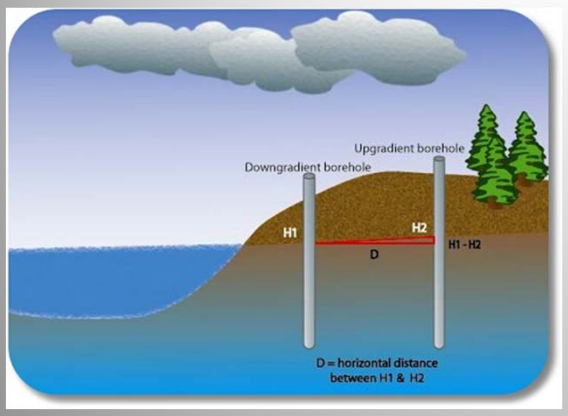
Investigation

- Collected Information
  - Depth to Groundwater at Each Location
  - Direction and Velocity of Groundwater Flow
  - Soil Stratigraphy and Hydraulic Conductivity in the Potential Vertical Extent of PRB
  - Maximum Feasible Depth of Direct Push Injection
  - Groundwater Chemistry and Nitrate Concentration
- Evaluated to Inform PRB Design and Estimate the Potential Nitrogen Load Reduction in Kilograms of Nitrogen Removed per Year

Summary of Field Investigations

- Installed 46 Monitoring Wells at 17 Locations
- Completed Elevation and Location survey
- Completed 2 Rounds of Monitoring
  - Water Level
  - Field Parameter
  - Water Quality Sampling and Analysis

Monitoring Well Network



Assessed Groundwater Gradient
(Flow Direction and Velocity)

- Duck Hole PRB: 6 Monitoring Well Locations - 3 Elevations Screened at Each Location
- Briar Spring PRB: 6 Monitoring Well Locations - 3 Elevations Screened at Each Location
- Namequoit PRB: 2 Monitoring Well Locations - One with 2 Screens, One with 3 Screens
- Ridge PRB: 3 Monitoring Well Locations - One with 1 Screen, Two with 2 Screens

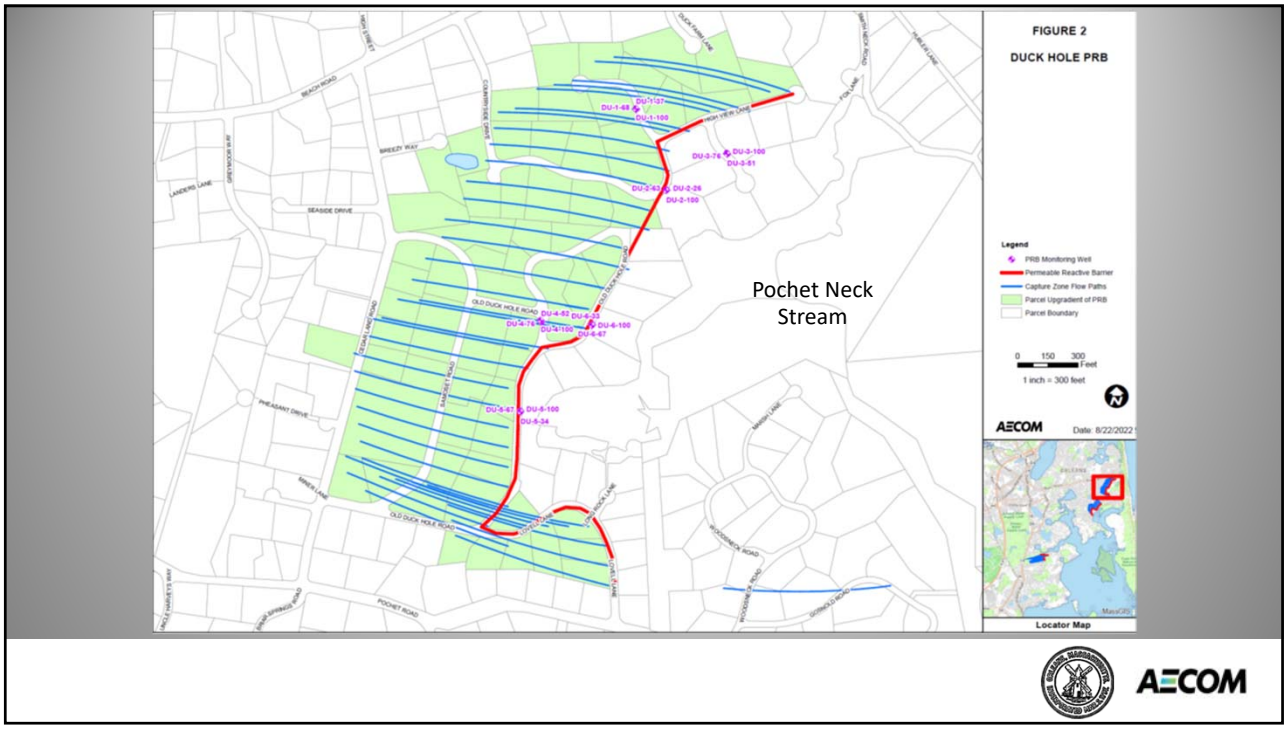


FIGURE 2
DUCK HOLE PRB
Pochet Neck Stream
Legend
PRB Monitoring Well
Permeable Reactive Barrier
Capture Zone Flow Paths
Parcel Upgradient of PRB
Parcel Boundary
0 150 300 Feet
1 inch = 300 feet
AECOM
Locator Map

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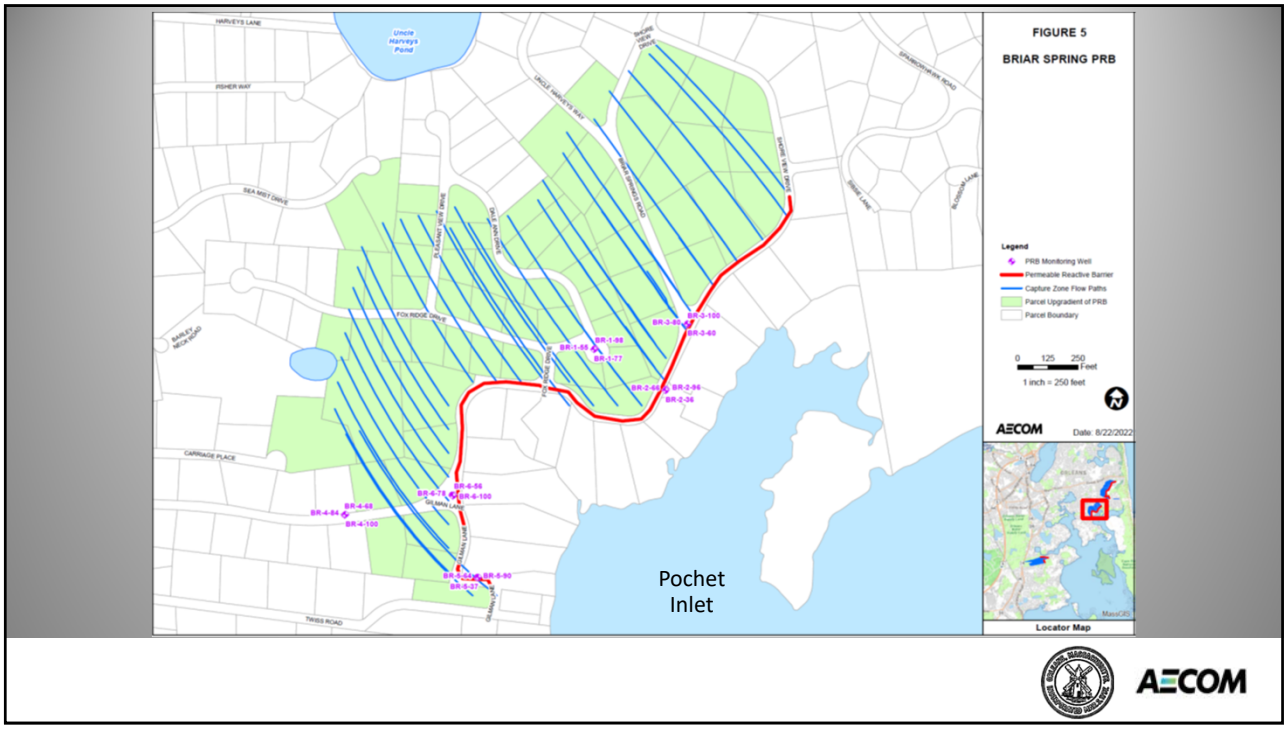
FIGURE 5
BRIAR SPRING PRB
Pochet Inlet
Legend
PRB Monitoring Well
Permeable Reactive Barrier
Capture Zone Flow Paths
Parcel Upgradient of PRB
Parcel Boundary
0 125 250 Feet
1 inch = 250 feet
AECOM
Locator Map

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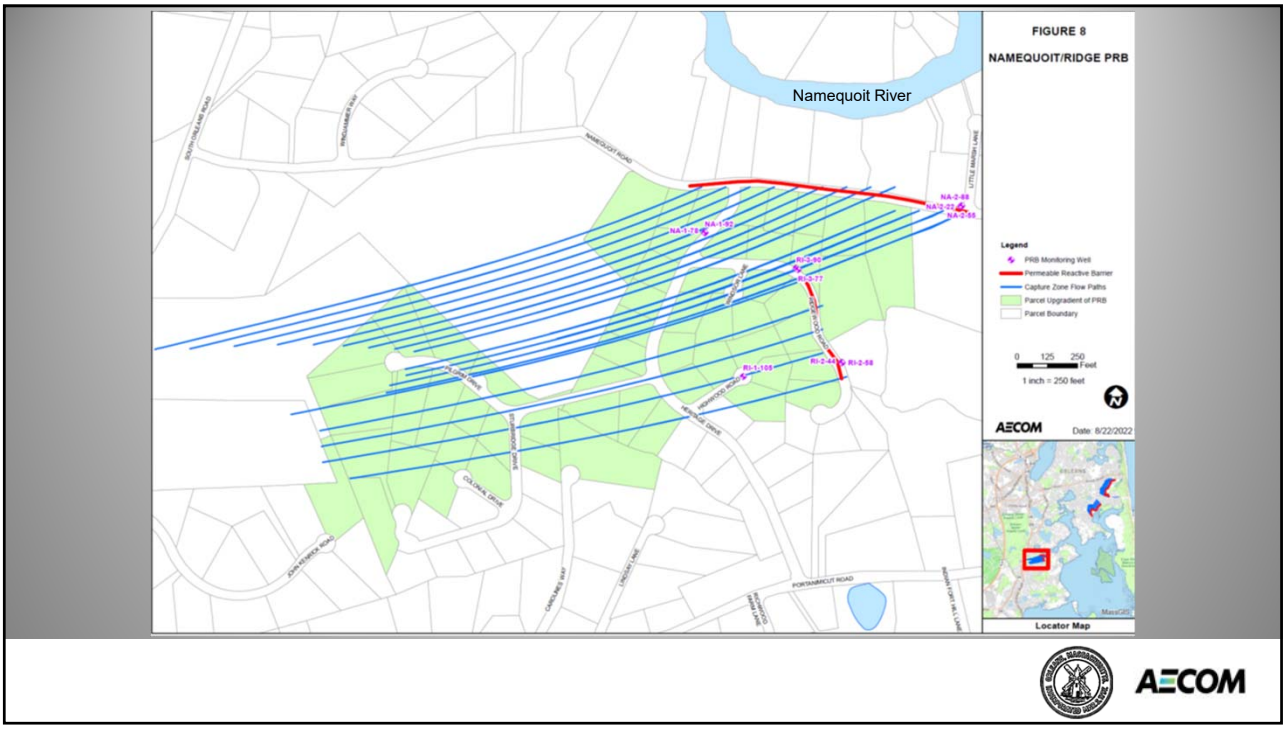

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Data Collection

- Measurement of Field Groundwater Parameters
  - pH (SU)
  - Temperature (°C)
  - Dissolved Oxygen (DO, mg/L)
  - Redox Potential (ORP; mV)
  - Specific Conductivity (µS/cm)
  - Turbidity (NTU)
- Sample Collection for Laboratory Analyses
  - Nitrate as N (mg/L)
  - Nitrite as N (mg/L)
  - Total Kjeldahl Nitrogen (TKN) (mg/L)
  - Total Nitrogen (mg/L)
  - Dissolved Organic Carbon (DOC)(mg/L)
  - Dissolved Iron (mg/L)
  - Dissolved Manganese (mg/L)

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Findings

- Groundwater Flow Directions and Velocity Were as Expected
  - V=0.5 feet/day
- Geologic Conditions Varied Between Locations
  - Mostly Permeable Fine to Medium Sand
  - Low Permeability Lenses Were Encountered
- Groundwater Chemistry and Nitrate Concentrations Varied
  - Both Anoxic and Aerobic Conditions were Encountered
  - Nitrate Concentrations Were Lower Than Expected at Some Locations
  - Nitrate Vertical Profile Shows Generally Lower Concentrations or Non-detectable Nitrate at Depth Related to Anoxic Conditions

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Duck Hole North Section

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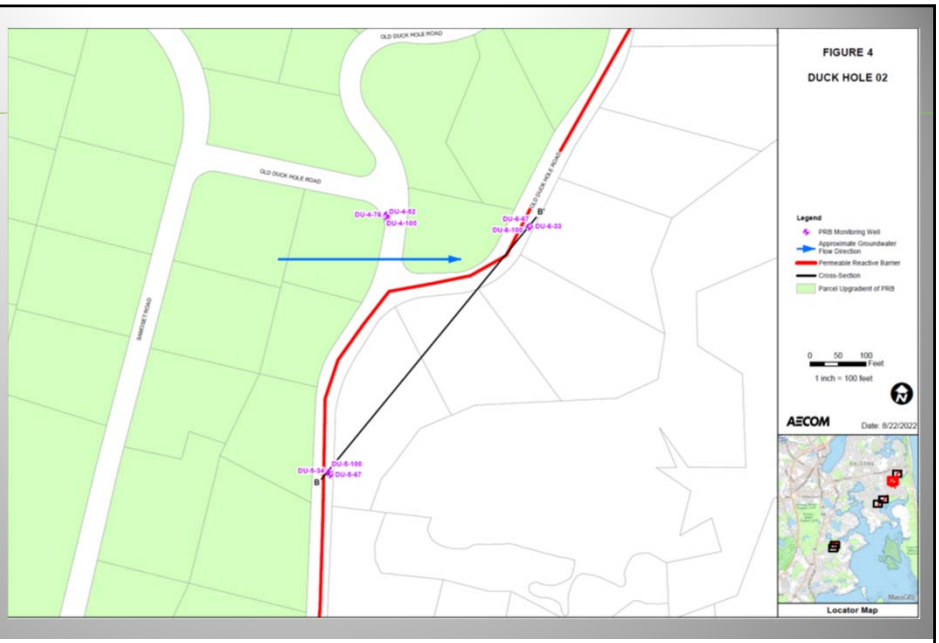
Duck Hole South Section



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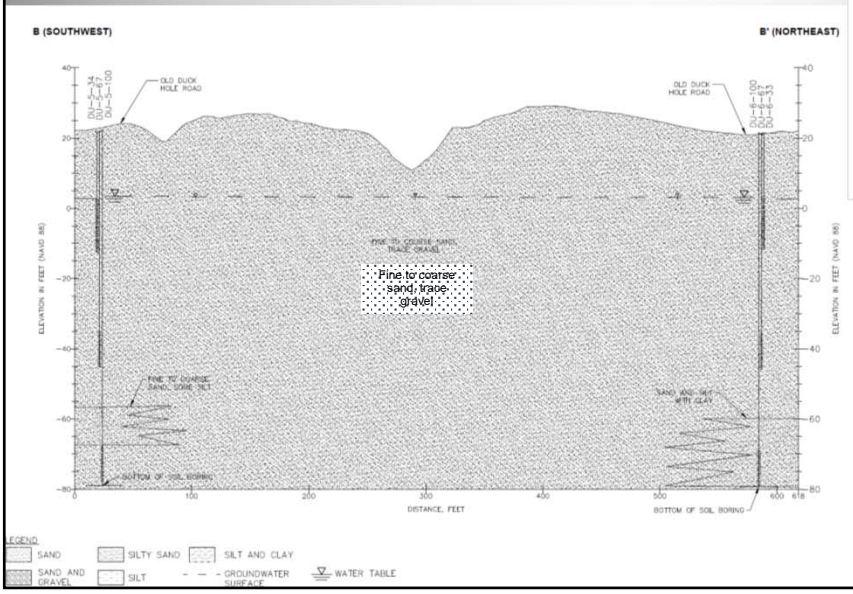
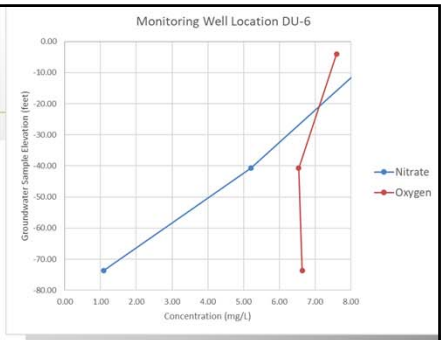
Duck Hole PRB Cross Section B-B'





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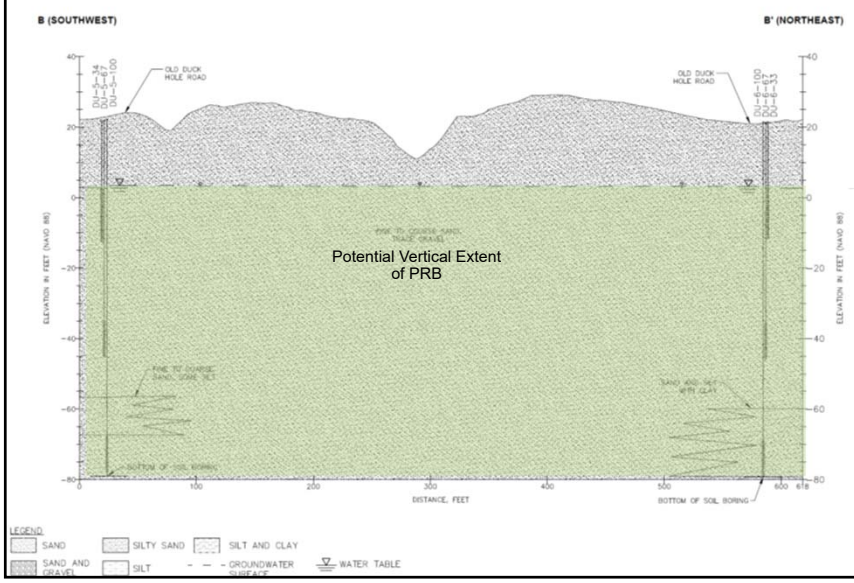
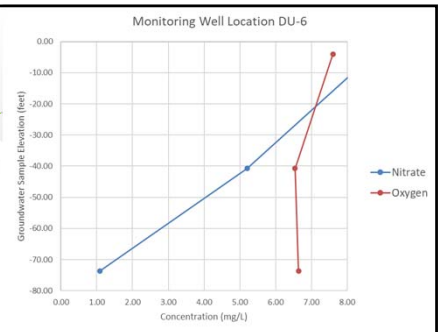
Duck Hole PRB Cross Section B-B'





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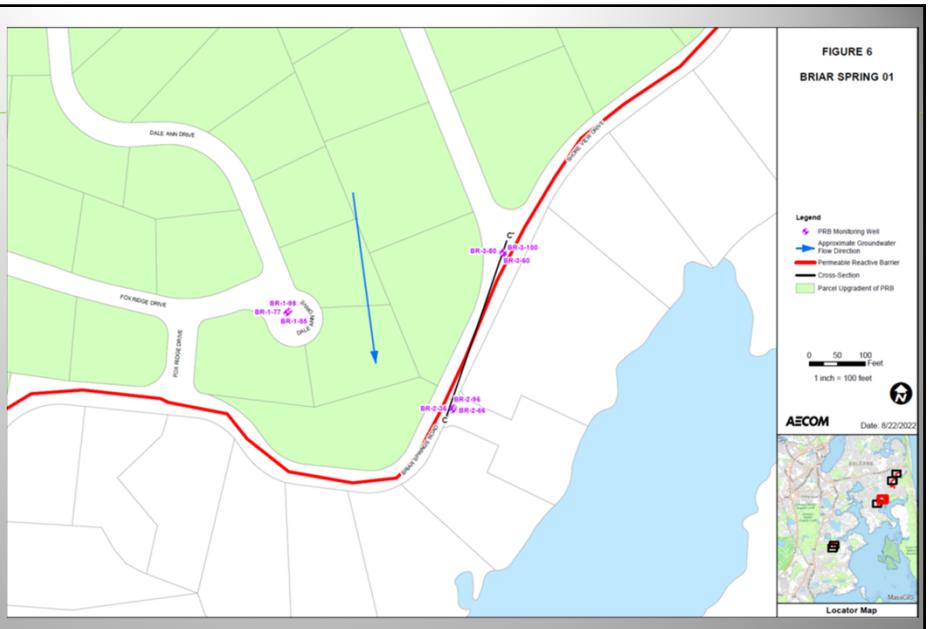
Briar Spring North Section



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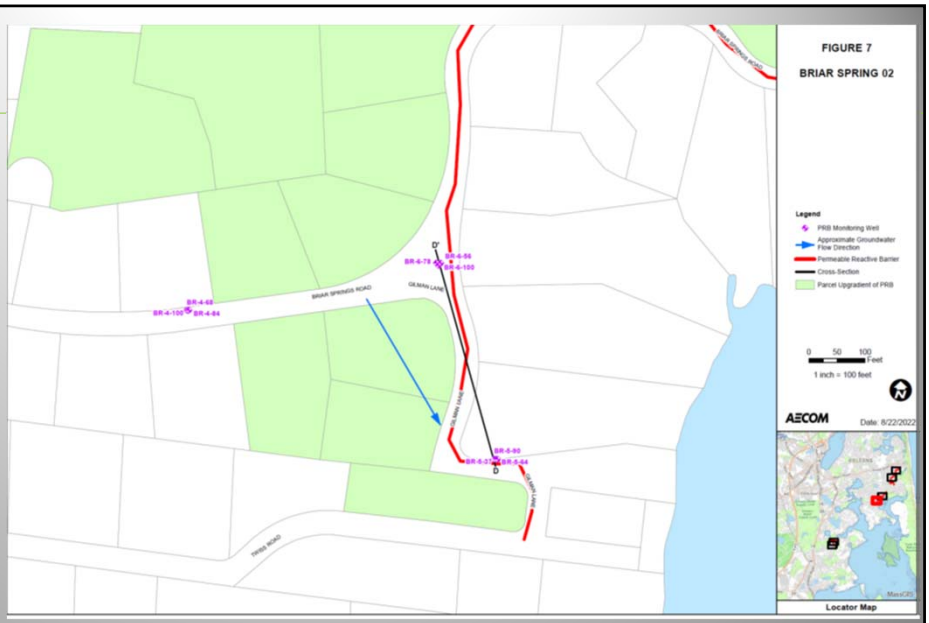
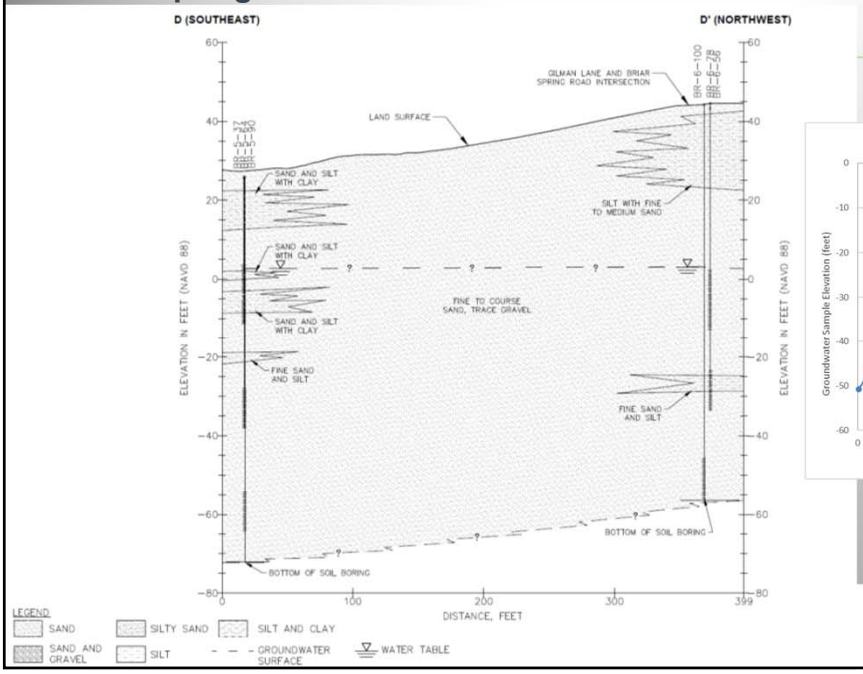
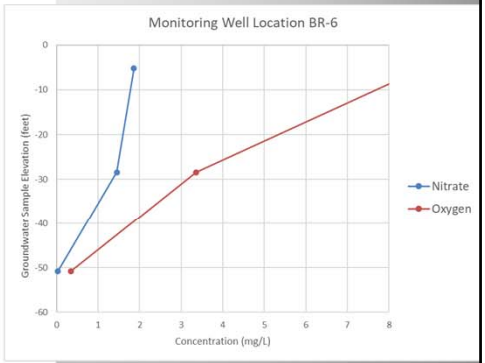
Briar Spring South Section



139

Briar Spring Cross Section D-D'





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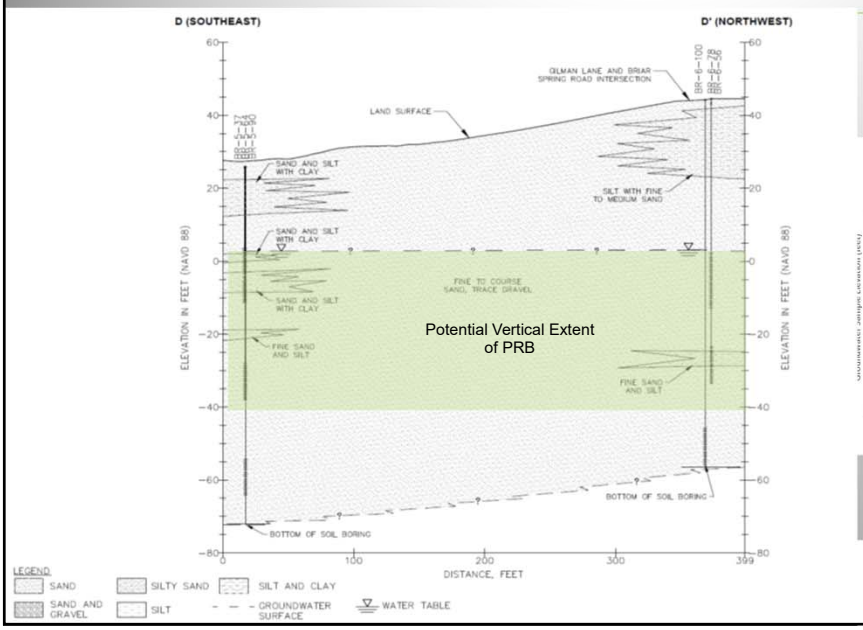
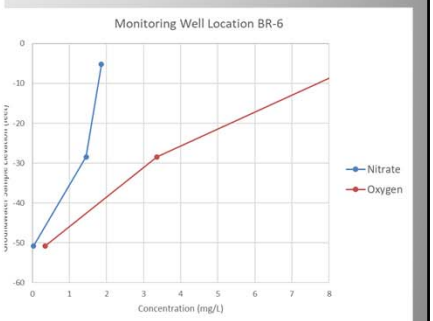
Briar Spring Cross Section D-D'





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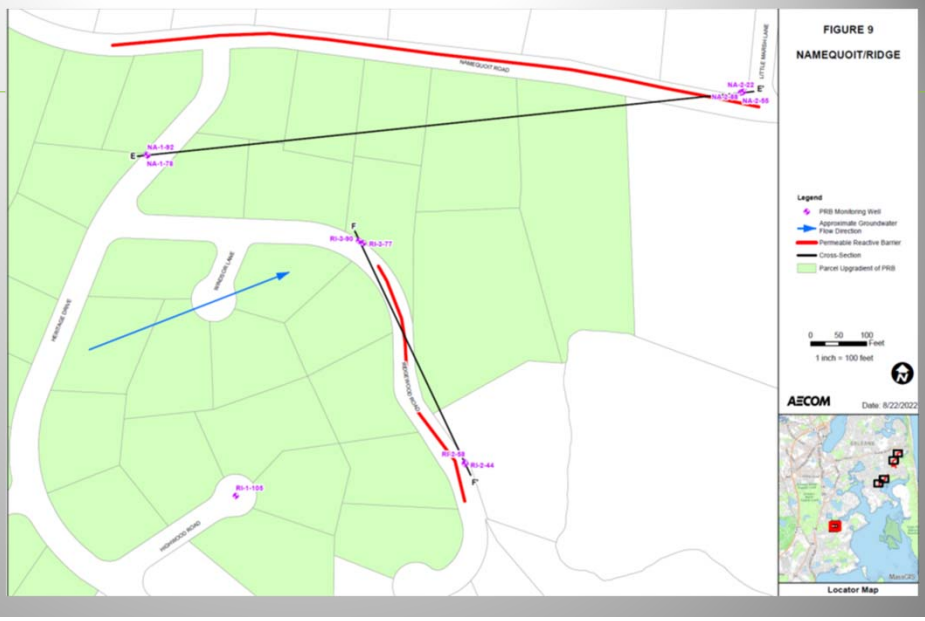
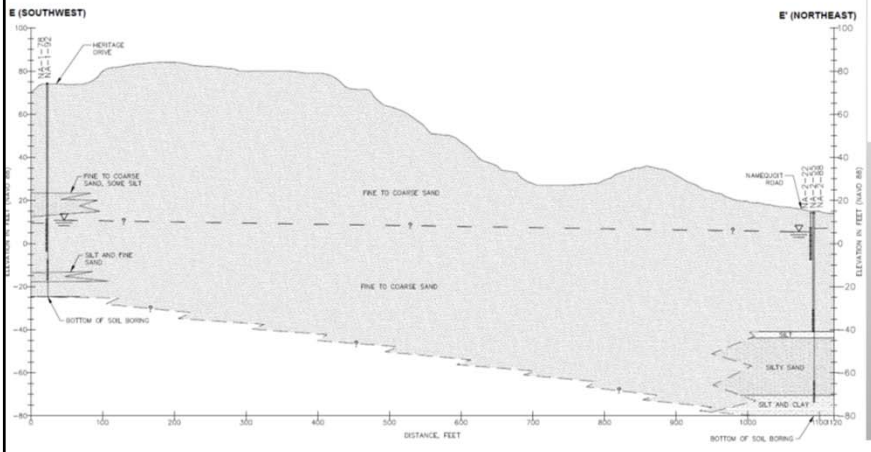
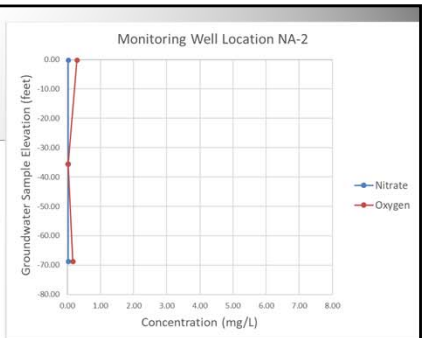
Namequoit and Ridge PRBs



142

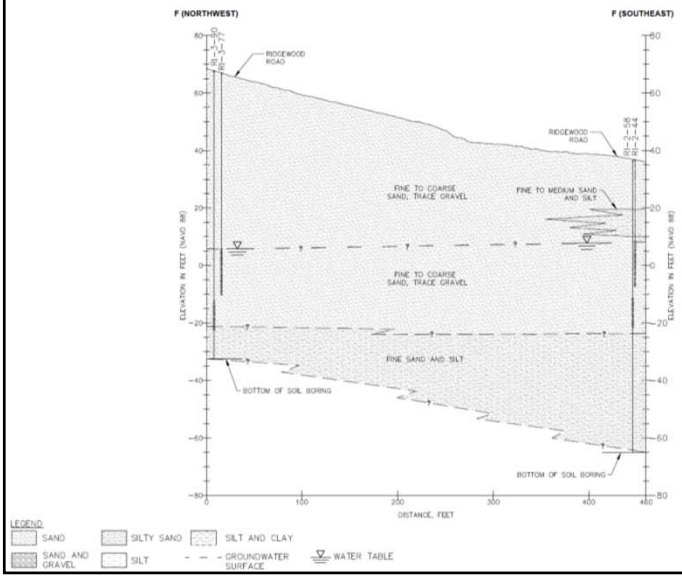
Namequoit Cross Section E to E'

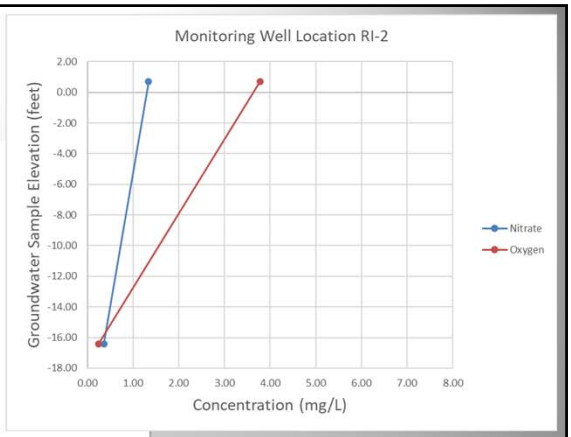




143

Ridge Cross Section F to F'





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Observations

- Groundwater Chemistry and Redox Conditions Varied Between Sampling Locations
  - Anoxic Conditions at 11 of the 46 Monitoring Wells
  - Anoxic Conditions Most Prevalent at Deep Monitoring Wells
- All Monitoring Wells with Anoxic Conditions had Nitrate Concentrations Less Than 1 mg/L
  - Suggests that Denitrification May be Occurring Naturally Under Anoxic Conditions

Duck Hole PRB Estimated vs. Observed Flux

Duck Hole Flux Range (30-foot vertical PRB)		
	Nitrate (mg/L)	**Nitrate Flux (kg/yr.)**
Low Concentration	0.80	178
High Concentration	3.62	805
Estimated sewer load based on source strength		370

- The estimated nitrogen load based on wastewater source strength falls within the range of observed vertically averaged nitrate concentration.

Feasible Implementation
Duck Hole PRB Dimensions

- Duck Hole Lithologic Conditions and Groundwater Chemistry Suitable for PRB Installation From the Water Table (Elevation +3 feet) Down to Elevation -80 feet (83 feet total)
  - With a PRB Length of 4,100 feet and a Vertical Extent of 83 feet the Potential Range of Nitrogen Flux is From 492 kg/yr to 2,228 kg/yr
  - Assuming an 80% Reduction in Nitrate Flux Based on PRB Performance, Nitrate Load Removal Would be Between 394 kg/yr and 1,782 kg/yr
- Duck Hole Location is Recommended for Further Consideration of Full-scale PRB Installation

Briar Spring PRB Estimated vs. Observed Flux

Briar Spring Flux Range (30-foot vertical PRB)		
	Nitrate (mg/L)	Nitrate Flux (kg/yr.)
Low Concentration	0.42	66
High Concentration	1.37	216
Estimated sewer load based on source strength		321

- The estimated nitrogen load based on wastewater source strength is approximately 50% higher than the load at the high end of the observed nitrate concentration range.

Feasible Implementation
Briar Spring PRB Dimensions

- Briar Spring Lithologic Conditions and Groundwater Chemistry Suitable for PRB From the Water Table (Elevation +2 feet) Down to Elevation -40 feet (42 feet total)
  - With a Length of 2,900 feet and a Vertical Extent of 42 feet Provides and Potential Range of Nitrogen Flux From 93 kg/yr to 302 kg/yr
  - With an 80% Reduction in Nitrate Flux Based on PRB Performance, Nitrate Load Removal Would be Between 74 kg/yr and 242 kg/yr
- Briar Spring Location is Recommended for Further Consideration of Full-scale PRB Installation

Namequoit and Ridge PRBs Estimated vs. Observed Flux

Combined Namequoit/Ridge Flux Range (30-Foot vertical PRB)		
	Nitrate (mg/L)	Nitrate Flux (kg/yr.)
Low Concentration	0.03	2
High Concentration	1.21	96
Estimated Sewer Load Namequoit		147
Estimated Sewer Load Ridge		158
Total Estimated Sewer Load		305

- The total estimated nitrogen load based on wastewater source strength is 220% higher than the load at the high end of the range based on observed nitrate concentration.

Namequoit and Ridge PRBs Not Considered Feasible

- Namequoit and Ridge Lithologic Conditions and Groundwater Chemistry are Not Suitable for PRB Installation
  - Anoxic and Low Nitrate Conditions are Prevalent
  - Geologic Conditions and Depth to Groundwater Limit PRB Construction
- Namequoit and Ridge Locations are Not Recommended for Further Consideration of Full-scale PRB Installation

Next Steps

- Develop Full-Scale Monitoring System and Design for Duck Hole and Briar Spring PRBs
- Confirm Selection, Permit and Implement Duck Hole and Briar Spring PRBs
- Gain Access to Private Road Locations to Facilitate Additional PRB Investigations
- Develop Streamlined Investigation Plan for Additional PRB Investigations

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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Town of Orleans Massachusetts

Financial Model

August 19, 2020

(Revised December 12, 2022; May 30, 2023; June 1, 2023)

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Funding and Financing Approach Elements

- Financial Model
- Wastewater Stabilization Fund
- Creative and Multiple Funding Sources
  - State Revolving Fund
  - Hotel/Motel Tax
  - Short-term Rental Tax
  - Cape Cod & Islands Water Protection Fund
  - Betterments
  - Property Tax

Financial Model

Background

- Evaluate Scenarios and Predict User Costs
- Designed to:
  - Inform the Town's Decisions Regarding Current and Future Planning
  - Estimate Annual Wastewater Costs for Rate Payers Based on Water Use
  - Account for Capital and Operation and Maintenance Costs
  - Produce Realistic Financial Assessments and Planning Values

Base Assumptions

- Betterments: Capital Costs for the Collection System and Pumping Stations
- Taxes: Capital Costs for Wastewater Infrastructure
- User Fees: Operation and Maintenance Costs
- Connection Costs: Individual Property Owner

Subsequent Evaluations Modified the Base Assumptions

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 %	Same for Residential, and Non-Residential/ Mixed Use Properties	Special Assessment %	Property Taxes %	Property Taxes %	Design/Build Savings %	Project Complete "All in Year 1" – Average Property Costs
Number of WWTFs	Term (Years)	Property Tax Assessment	Residential %	Property Tax Assessment			Additional Local Tax Options %	Program Phased over 40-Years – Average Property Costs
Folder for Saving Files	Interest Rate		Non-Residential/ Mixed Use %				Design/Build/ Operate Savings %	Program Phased over 40-Years – Per Property Costs
							Annual Septage Revenue	
Financial Model Inputs and Outputs							Grant(s) %	

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Financial Model Betterment Example - August 2020

Land Use Classification	Number of Sewer Units	Estimated Annual Betterment
Commercial Condo	20.28	$5,949
Shopping Center	9.10	$2,669
General Office Building	1.32	$387
Single Family	1.78	$521
Restaurant	16.21	$4,754
Commercial Developable Land	1.00	$293
Restaurant	15.50	$4,547
Residential Condo	1.00	$293

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Town of Orleans Massachusetts

Revenue Sources

August 19, 2020

(Revised December 12, 2022; May 30, 2023; June 1, 2023)

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Wastewater Stabilization Fund

- Fund Approved at the Annual Town Meeting
- Utility-specific Mechanism to Receive Revenue and Fund Wastewater Budgets
- Expenditures from Fund Requires a 2/3rds Vote from Town Meeting
- Without this Mechanism, Revenue from Multiple Streams Would be Subject to Competition from Other Town Priorities

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State Revolving Fund

Background

- Standard SRF Low Interest Loan
  - Interest Rate of 2%
  - 20 Year Term
- Eligibility
  - × Town Not Eligible for SRF Principal Forgiveness Since it Exceeds the State-wide Median Household Income
  - ✓ Town Eligible for a Reduced Interest Rate of 1.5% Since it is Part of the Housing Choice Initiative
  - ✓ Town Qualifies for 0% Interest Rate With a 30 Year Term

Requirements For 0% Interest

- Part 1 - Comprehensive Wastewater Management Plan
- Part 2 - Project Purpose to Reduce Nutrient Loads
- Part 3 - Flow Neutral Land Controls
- Part 4 – Consistency with Regional Planning
- Part 5 – No Enforcement Order

0% Loan Results in a Savings of Over $15,500,000

Innovative Funding and Financing

Increase the Hotel / Motel Tax

- Tax Increased from 4% to 6%
  - All 6% Allocated to Wastewater Stabilization Fund
- Over $350,000 Generated Annually, ~$1.0M since July 2019

Short-term Rental Tax

- Rentals Taxed at 6% for Orleans
- Town Allocated all Revenue to Wastewater Stabilization Fund
- Over $3,362,000 Generated since July 2019, Exceeding Town Expectations

Innovative Funding and Financing (cont.)

Cape Cod & Islands Water Protection Fund

- Hotel/Motels and Short-Term Rentals Taxed at 2.75% on Cape Cod
- Up to a 25% Subsidy
- Award Based on Funding Available
- Project is Required to be on the SRF IUP List to Obtain Subsidy

Phase	Total Construction Phase Costs	Funding Received (25% of Total Construction Phase Costs)
Phase 1	$59,409,200	$14,852,300
Phase 2	$32,906,000	$8,226,500
Totals	**$92,315,200**	**$23,078,800**

Orleans Wastewater Treatment Facility
Construction Progress Photo
June 2022, Orleans, MA

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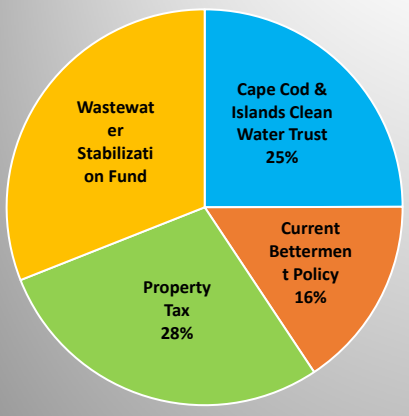
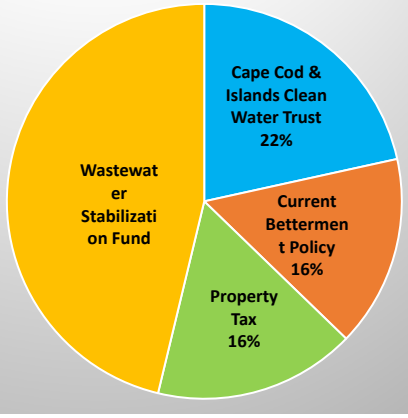
Summary of Wastewater System Funding Sources



May 2021
Summary of Funding Sources
for Phase 1 Project Cost



July 2022
Summary of Funding Sources
for Phase 1 and Phase 2 Project Cost

Subsidies and Tourism-related Revenue Streams Reduce the Estimated Property Tax Burden By About $32,000,000

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Project Costs vs Revenue Sources - July 2022

Description	Cost with Innovative Sources and SRF 0% Financing	Tax Burden Impact	
		Without Innovative Sources	Without SRF 0% Financing
Project Costs			
SRF Eligible	$92,315,200	$92,315,200	$92,315,200
SRF Interest	$0	$0	$15,500,000
SRF Ineligible	$14,739,145	$14,739,145	$14,739,145
Totals	**$107,054,345**	**$107,054,345**	**$122,554,345**
Revenue Sources			
Cape Cod & Islands Clean Water Trust	$23,078,800	$0	$23,078,800
Betterments	$16,795,109	$16,795,109	$16,795,109
Property Taxes	$17,680,436	$90,259,236	$33,180,436
Wastewater Stabilization Fund	$49,500,000	$0	$49,500,000
Totals	**$107,054,345**	**$107,054,345**	**$122,554,345**

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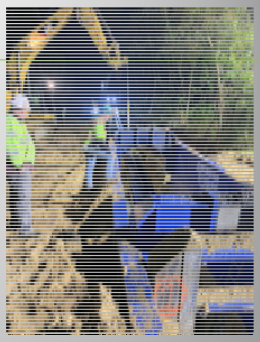
Conclusions

- Created a Fiscally Sound Funding and Financing Plan
- Flexibility to Adjust to Changing Conditions
- Developed Fair and Equitable Allocation of Costs
- Property Tax Revenue Offsets
  - $23M in Subsidies
  - $15.5M in Interest Savings on Phase 1 SRF Loan
  - $49.5M in Direct Taxes from Tourism Over 30 Year Term (Projected)
- Successful Fiscal Approach is Leading to Clean Water!

Downtown Area Collection System
Construction Progress Photos, Orleans, MA



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Town of Orleans Massachusetts

Other Activities

August 19, 2020

(Revised December 12, 2022; May 30, 2023; June 1, 2023)

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Other Activities

- Namskaket Salt Marsh Vegetation Monitoring
  - Plan Submitted to MassDEP on June 27, 2022
  - Conducted Monitoring Week of July 18, 2022
  - Submittal to MassDEP on December 23, 2022
- CWMP
  - Scope of Work
    - Notice of Project Change
    - Update of Completed and Ongoing Activities
  - Proposed Submittal to MassDEP by August 31, 2023 (Acceptable per by MassDEP on October 24, 2022)

Town of Orleans Massachusetts

Nauset Regional Middle School and High School Educational Series

August 19, 2020

(Revised December 12, 2022; May 30, 2023; June 1, 2023)

AECOM

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Nauset Regional Middle School and High School Educational Series

- Classroom and Field Observation and 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)

Town of Orleans Massachusetts

Action Items

August 19, 2020

(Revised December 12, 2022; May 30, 2023; June 1, 2023)

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Action Items

- MassDEP Groundwater Discharge Permit
  - Every Five Years
- Contract Operations
  - Veolia NA
  - Annual Cost Adjustment
  - Five Year Agreement with Up to Three Five Year Terms
- MassDOT Memorandum of Understanding Renewal
  - Route 6, Exit 89 (fka Exit 12) Lobe for Aquifer Recharge
  - 20-Year Agreement

AECOM

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It Takes a Village

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

Thank you!

Questions?