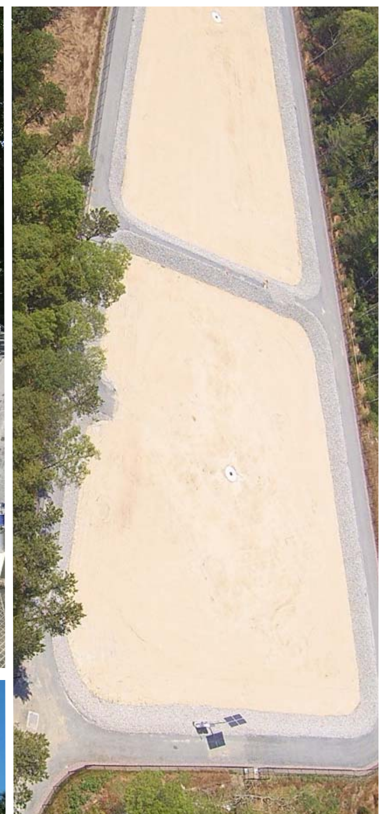
South Coast Embayments and West Falmouth Harbor

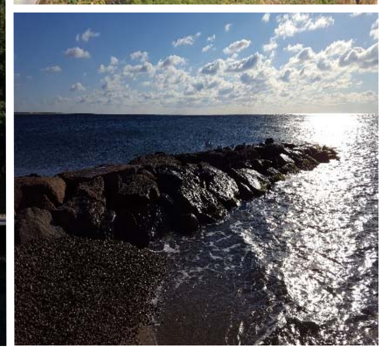
CWMP/TWMP Notice of Project Change Update

December 2019

Falmouth Water Quality Management Committee
GHD Inc.
Science Wares, Inc.



Town of Falmouth, MA



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Appendices are numbered according to the Chapter and Section in which they are discussed.

TOWN OF FALMOUTH

Office of the Town Manager & Selectmen

59 Town Hall Square, Falmouth, Massachusetts 02540
Telephone (508) 495-7320
Fax (508) 457-2573

November 22, 2019

Ms. Kathleen A. Theoharides, Secretary
Executive Office of Energy & Environmental Affairs
MEPA Office
100 Cambridge Street – Suite 900
Boston, MA 02114

Subject: Notice of Project Change Update Report
South Coast Embayments CWMP/TWMP
Town of Falmouth, MA EEA# 14154

Dear Ms. Theoharides,

Attached for your review is the South Coast Embayments CWMP/TWMP Notice of Project Change Update Report for Little Pond, Great Pond, Green Pond, Bournes Pond, Eel Pond and Waquoit Bay Watersheds and the West Falmouth Harbor Watershed.

The Town of Falmouth has worked diligently during the last five years, from the time that the initial Secretary's Certificate was issued, to develop and evaluate various demonstration/pilot projects as discussed in the approved CWMP/TWMP. This document provides an update of the findings of that work and next steps in the development of the next Targeted Watershed Management Plan for Great Pond as requested in the Secretary's Certificate. This is a continuation of the implementation of the approved plan and its adaptive management approach that is fundamental to our environmental and economic sustainability of Falmouth. This document also addresses the various issues raised in the Secretary's Certificate regarding the filing of subsequent NPC's related to the CWMP/TWMP process. We have consulted with the MEPA Office, the Massachusetts Department of Environmental Protection, the Cape Cod Commission and many other stakeholders on this document and on our overall planning process, and have responded to their input.

The important next step in this ongoing process has been affirmed by vote of the Falmouth Board of Selectmen in approving this Wastewater Management Plan at their regular business meeting of Monday, November 18. We look forward to the MEPA review of this document so that we can proceed to the next step of planning and implementation. If you have any questions, please contact Amy Lowell, Falmouth Wastewater Superintendent at (508) 457-2543 (amy.lowell@falmouthma.gov) or J. Jefferson Gregg, P.E., GHD Senior Project Manager at (774) 470-1640 (jeff.gregg@ghd.com). Thank you.

Sincerely,

Julian M. Suso
Falmouth Town Manager

Cc Falmouth Board of Selectmen
Ray Jack
Amy Lowell
Eric Turkington
Virginia Valiela
Frank Duffy
J. Jefferson Gregg

Commonwealth of Massachusetts

Executive Office of Energy and Environmental Affairs ■ MEPA Office

For Office Use Only
Executive Office of Environmental Affairs
MEPA Analyst:
Phone: 617-626-

Notice of Project Change

The information requested on this form must be completed to begin MEPA Review of a NPC in accordance with the provisions of the Massachusetts Environmental Policy Act and its implementing regulations (see 301 CMR 11.10(1)).

EEA # 14154			
Project Name: Falmouth Comprehensive Wastewater Management Plan			
Street Address: 59 Town Hall Square			
Municipality: Falmouth, MA	Watershed: Cape Cod		
Universal Transverse Mercator Coordinates:	Latitude: 41.55137 Longitude: -70.618299		
Estimated commencement date: 2009	Estimated completion date: 2040		
Project Type: CWMP/TWMP	Status of project design: 10 %complete		
Proponent: Town of Falmouth, MA			
Street Address: 59 Town Hall Square			
Municipality: Falmouth	State: MA	Zip Code: 02540	
Name of Contact Person: J. Jefferson Gregg, P.E., BCEE			
Firm/Agency: GHD Inc.	Street Address: 1545 Iyannough Road		
Municipality: Hyannis	State: MA	Zip Code: 02601	
Phone: 774-470-1640	Fax: 774-470-1631	E-mail: jeff.gregg@ghd.com	

With this Notice of Project Change, are you requesting:

a Single EIR? (see 301 CMR 11.06(8))	☐Yes	☑No
a Special Review Procedure? (see 301CMR 11.09)	☐Yes	☑No
a Waiver of mandatory EIR? (see 301 CMR 11.11)	☐Yes	☑No
a Phase I Waiver? (see 301 CMR 11.11)	☐Yes	☑No

Which MEPA review threshold(s) does the project meet or exceed (see 301 CMR 11.03)?

Implementation may exceed the following: Land alteration, wastewater facilities/collection systems, new discharge, ACEC, wetlands, waterways and tidelands.

Which State Agency Permits will the project require?

As applicable to various implementation of projects the following may be required: MassDEP GWDP, 401 Water Quality, Chapter 91 License, Mass Historical Review, NHESP Review, CZM Fed. Consistency review, MassDOT road opening.

Identify any financial assistance or land transfer from an Agency of the Commonwealth, including the Agency name and the amount of funding or land area in acres: N/A

PROJECT INFORMATION

In 25 words or less, what is the project change? The project change involves . . . an update to the approved CWMP/TWMP as called for in the January 10, 2014 Secretary's Certificate, EEA NO. 14154. See full project change description beginning on page 3.

Date of publication of availability of the ENF in the Environmental Monitor: (Date:)

Was an EIR required? ☑Yes ☐No; if yes,
was a Draft EIR filed? ☑Yes (Date: 6/30/19) ☐No
was a Final EIR filed? ☑Yes (Date: 9/16/13) ☐No
was a Single EIR filed? ☐Yes (Date:) ☑No

Have other NPCs been filed? ☑Yes (Date(s): 3/11/16) ☐No

If this is a NPC solely for lapse of time (see 301 CMR 11.10(2)) proceed directly to **ATTACHMENTS & SIGNATURES**.

PERMITS / FINANCIAL ASSISTANCE / LAND TRANSFER

List or describe all new or modified state permits, financial assistance, or land transfers not previously reviewed: **dd w/ list of State Agency Actions (e.g., Agency Project, Financial Assistance, Land Transfer, List of Permits)**

Several new permits were issued as part of the Bournes Pond NPC, including: MassDEP 401WQ and Chapter 91; MassDEP NOI, US Coast Guard US ACE 404

Are you requesting a finding that this project change is insignificant? A change in a Project is ordinarily insignificant if it results solely in an increase in square footage, linear footage, height, depth or other relevant measures of the physical dimensions of the Project of less than 10% over estimates previously reviewed, provided the increase does not meet or exceed any review thresholds. A change in a Project is also ordinarily insignificant if it results solely in an increase in impacts of less than 25% of the level specified in any review threshold, provided that cumulative impacts of the Project do not meet or exceed any review thresholds that were not previously met or exceeded. (see 301 CMR 11.10(6)) ☐**Yes** ☑**No; if yes, provide an explanation of this request in the Project Change Description below.**

FOR PROJECTS SUBJECT TO AN EIR

If the project requires the submission of an EIR, are you requesting that a Scope in a previously issued Certificate be rescinded?
☐**Yes** ☑**No; if yes, provide an explanation of this request______________.**

If the project requires the submission of an EIR, are you requesting a change to a Scope in a previously issued Certificate?
☐**Yes** ☑**No; if yes, provide an explanation of this request______________.**

SUMMARY OF PROJECT CHANGE PARAMETERS AND IMPACTS (NOTE: comprehensive planning, all values are estimates.)

Summary of Project Size & Environmental Impacts	Previously reviewed	Net Change	Currently Proposed
LAND			
Total site acreage	27,251 (in planning area)	no change	same
Acres of land altered	>30	no change	same
Acres of impervious area	>0.5	no change	same
Square feet of bordering vegetated wetlands alteration	>100	no change	same
Square feet of other wetland alteration	>100	no change	same
Acres of non-water dependent use of tidelands or waterways	>0.5	no change	same
STRUCTURES			
Gross square footage	>20,000	no change	same
Number of housing units	0	no change	same
Maximum height (in feet)	>20	no change	same
TRANSPORTATION			
Vehicle trips per day	>20	no change	same
Parking spaces	>10	no change	same
WATER/WASTEWATER			
Gallons/day (GPD) of water use	>500	no change	same
GPD water withdrawal	0	no change	same
GPD wastewater generation/ treatment	3,200,000	no change	same
Length of water/sewer mains (in miles)	>50	no change	same

Does the project change involve any new or modified:

1. conversion of public parkland or other Article 97 public natural resources to any purpose not in accordance with Article 97? ☐**Yes** ☑**No**

2. release of any conservation restriction, preservation restriction, agricultural preservation restriction, or watershed preservation restriction? ☐**Yes** ☑**No**

3. impacts on Rare Species? ☐**Yes** ☑**No**

4. demolition of all or part of any structure, site or district listed in the State Register of Historic Place or the inventory of Historic and Archaeological Assets of the Commonwealth? ☐**Yes** ☑**No**

5. impact upon an Area of Critical Environmental Concern? ☐**Yes** ☑**No**

If you answered 'Yes' to any of these 5 questions, explain below:

PROJECT CHANGE DESCRIPTION (attach additional pages as necessary). The project change description should include:

(a) a brief description of the project as most recently reviewed

(b) a description of material changes to the project as previously reviewed,

(c) if applicable, the significance of the proposed changes, with specific reference to the factors listed 301 CMR 11.10(6), and

(d) measures that the project is taking to avoid damage to the environment or to minimize and mitigate unavoidable environmental impacts. If the change will involve modification of any previously issued Section 61 Finding, include a draft of the modified Section 61 Finding (or it will be required in a Supplemental EIR).

Please refer to the attached "South Coast Embayments: CWMP/TWMP Notice of Project Change Update" Report Dated: December 2019; prepared for the Town of Falmouth, MA. This document is being prepared per the requirements stated in the EEA Secretary's Certificate Dated January 10, 2014.

- Chapter 11 Titled "CWMP/TWMP Notice of Project Change Summary and Next Steps" summarizes those items covered in Chapters 1 through 10 regarding the requirements as requested in the above referenced Certificate.

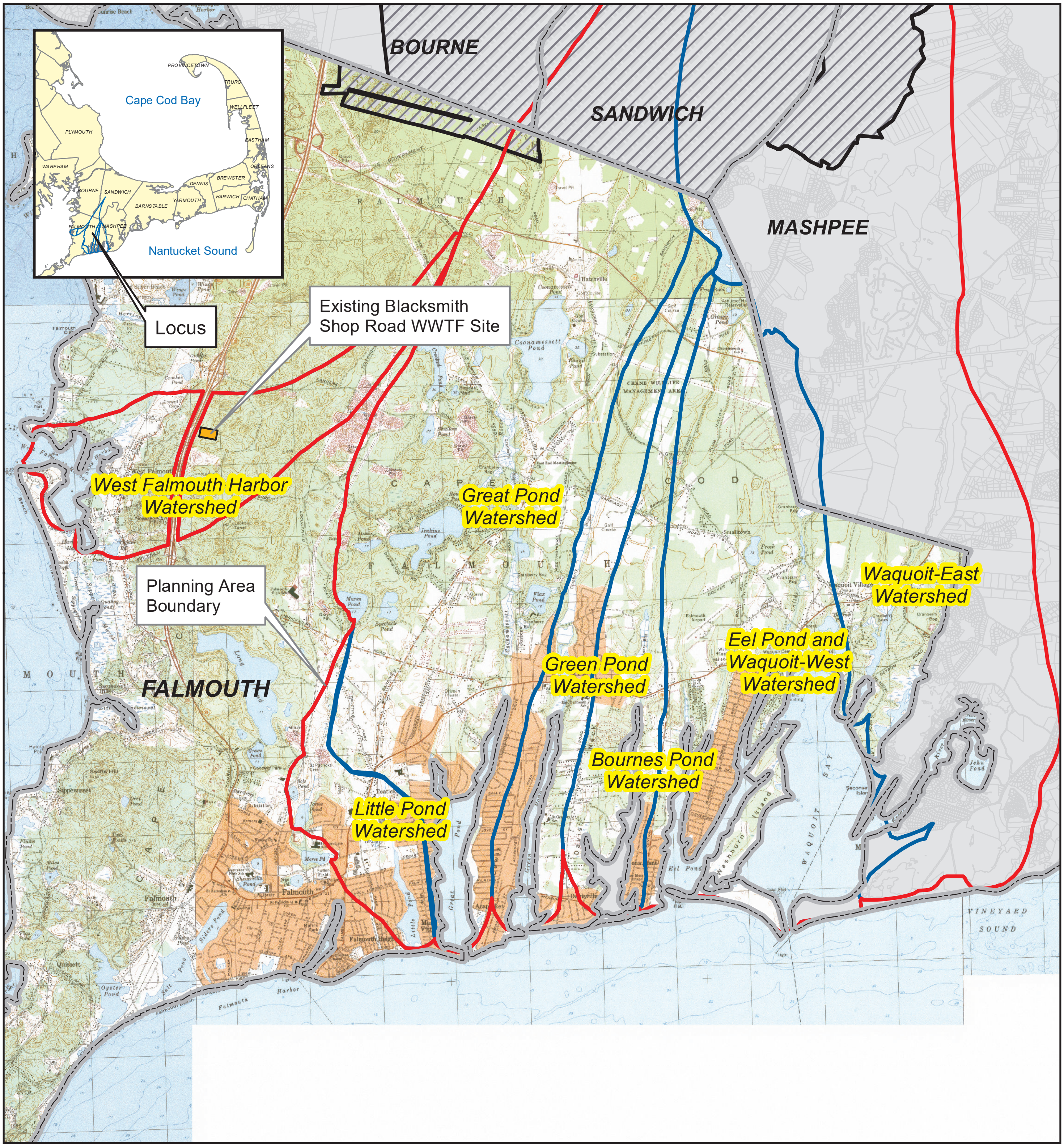
ATTACHMENTS & SIGNATURES

Attachments:

1. Secretary's most recent Certificate on this project (Refer to Appendix 1.1)
2. Plan showing most recent previously-reviewed proposed build condition (Refer to Chapter 1, Figure 1.1.)
3. Plan showing currently proposed build condition (Refer to Chapter 1, Figure 1.1)
4. Original U.S.G.S. map or good quality color copy (8-1/2 x 11 inches or larger) indicating the project location and boundaries (See Attached Figure NPC-1)
5. List of all agencies and persons to whom the proponent circulated the NPC, in accordance with 301 CMR 11.10(7) (See Report "Distribution List")

Signatures:

11/22/19 [signature]	11/22/19 [signature]
Date Signature of Responsible Officer or Proponent	Date Signature of person preparing NPC (if different from above)
Julian M. Suso, Town Manager	J. Jefferson Gregg, P.E., BCEE
Name (print or type)	Name (print or type)
Town of Falmouth, MA	GHD Inc.
Firm/Agency	Firm/Agency
59 Town Hall Square	1545 Iyannough Road
Street	Street
Falmouth, MA 02540	Hyannis, MA, 02601
Municipality/State/Zip	Municipality/State/Zip
(508) 495-7320	(774)470-1640
Phone	Phone



LEGEND

Planning Area/MEP Watershed Boundary

MEP Watershed Boundary

Town Boundary

Paper Size ANSI A

0 0.5 1 2 Miles

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1927
Grid: NAD 1927 StatePlane Massachusetts Mainland FIPS 2001

N

GHD

TOWN OF FALMOUTH, MA
CWMP UPDATE

NOTICE OF PROJECT CHANGE
LOCATION MAP

Job Number	86-12163
Revision	-
Date	25 Jul 2019

Figure NPC-1

1545 Iyannough Road, Hyannis Massachusetts 02601 USA T 1 508 362 5680 F 1 508 362 5684 E hyamail@ghd.com W www.ghd.com

G:\86\12163\GIS\71045 Falmouth\Figures\June 2012 Final Report Figures\JULY 2019 REV\Figure NPC-1.mxd

Distribution List

Notice of Project Change (NPC) Document
to
Final Comprehensive Wastewater Management Plan (CWMP) and
Final Environmental Impact Report (FEIR) and
Targeted Watershed Management Plan (TWMP)
EEA #14154

A copy of the NPC Document will be sent to the following:

Secretary of Energy and Environmental Affairs
Executive Office of Energy and Environmental Affairs (EEA)
Attn: MEPA Office
100 Cambridge Street, Suite 900
Boston, MA 02114
(1 Hard Copy and 1 CD)

Cape Cod Commission
3225 Main Street
Barnstable, MA 02630
(CD)

Massachusetts Department of Environmental Protection
One Winter Street
Boston, MA 02108
(Hard Copy)

Gary Moran, Deputy Commissioner
MassDEP
One Winter Street
Boston, MA 02108
(Hard Copy)

DEP/Southeastern Regional Office
20 Riverside Drive
Lakeville, MA 02347
Attn: MEPA Unit
(Hard Copy)

Brian Dudley
MassDEP
20 Riverside Drive
Lakeville, MA 02347
(Hard Copy)

Department of Energy Resources
100 Cambridge Street, Suite 1020
Boston, MA 02114
Attn: John Ballam, MEPA Liaison
(CD)

Massachusetts Historical Commission
Archives Building
220 Morrissey Boulevard
Boston, MA 02125
(Hard Copy)

Buzzards Bay Coalition
114 Front Street
New Bedford, MA 02740
(CD)

Commonwealth of Massachusetts
Military Division Joint Base Cape Cod (JBCC)
Office of the JBCC Executive Director, Building 1204
West Inner Road
Camp Edwards, MA 02542
(Hard Copy)

Massachusetts Division of Fisheries & Wildlife
Natural Heritage & Endangered Species Program
One Rabbit Hill Road
Westborough, MA 01581
Attn: Thomas W. French, Ph.D.
(Hard Copy)

Massachusetts Department of Transportation, Highway Division
District #5
1000 County Street
Taunton, MA 02780
Attn: MEPA Coordinator
(Hard Copy)

US Army Corps of Engineers
N.E. District
696 Virginia Road
Concord, MA 01742-2751
(Hard Copy)

Coastal Zone Management
251 Causeway Street, Suite 800
Boston, MA 02202
Attn: MEPA Coordinator
(Hard Copy)

Coastal Zone Management
3195 Main Street, Route 6A
PO Box 220
Barnstable, MA 02630
Attn: Steve McKenna
(Hard Copy)

Division of Marine Fisheries
1213 Purchase Street
New Bedford, MA 02740
Attn: MEPA Coordinator
(Hard Copy)

Town of Mashpee Public Library
64 Steeple Street
PO Box 657
Mashpee, MA 02649
Attn: Library Director
(Hard Copy)

Town of Mashpee
16 Great Neck Road North
Mashpee, MA 02649
Attn: Rodney C. Collins, Town Manager and Board of Selectmen
(Hard Copy)

Jonathan Bourne Public Library
19 Sandwich Road
Bourne, MA 02532
Attn: Library Director
(Hard Copy)

Town of Bourne
24 Perry Avenue
Buzzards Bay, MA 02532
Attn: Anthony Schiavi, Town Administrator and Board of Selectmen
(Hard Copy)

Town of Sandwich
130 Main Street
Sandwich, MA 02563
Attn: George H. Dunham, Town Manager and Board of Selectmen
(Hard Copy)

Sandwich Public Library
142 Main Street
Sandwich, MA 02563
Attn: Library Director
(Hard Copy)

Town of Falmouth DPW
59 Town Hall Square
Falmouth, MA 02540
Attn: Amy Lowell, Wastewater Superintendent
29 hard copies with distribution to:

- Town Manager/BOS Office (6)
- Health Agent/BOH Office (2)
- Conservation Agent/Cons. Comm. Office (2)
- DPW 9 hard copies and 1 CD
- Falmouth Libraries (2)
- Planning Board (1)
- Waterways Committee 1CD
- Coastal Resiliency Action Committee 1 CD
- WQMC 7 hard copies and 1 CD
- Beach Committee 1 CD
- Marine and Environmental Services 1 CD

Applied Coastal Research and Engineering
766 Falmouth Road, Suite A-1
Mashpee, MA 02649
(Hard Copy)

School for Marine Science & Technology
UMass Dartmouth
706 S. Rodney French Blvd.
New Bedford, MA 02744-1221
Attn: Brian Howes
(CD)

Sen. Viriato M. DeMacedo
10 Cordage Park Circle, Room 229
Plymouth MA 02360 (CD)

Rep. Dylan Fernandes
354 Gifford St., Unit 4
Falmouth MA 02540 (CD)

Rep. David T. Vieira
354 Gifford St., Unit 3
Falmouth MA 02540 (CD)

Commenters list: (All Receive CDs)

The Association for Crocker Pond
Andrew Bunker
11 Westmoreland Drive
Falmouth, MA 02540

Hilde Maingay and Earl Barnhart
28 Common Way
East Falmouth, MA 02536

Cape Cod & Islands Group – Sierra Club
David Dow
18 Treetop Lane
Falmouth, MA 02540

Preface

P.1 Introduction

Ten years ago, Stearns & Wheler, the engineering firm hired by the Town of Falmouth to study the deteriorating water quality in West Falmouth Harbor, Little Pond, Great Pond, Bournes Pond, Green Pond, Eel River, and Waquoit Bay (Figure P.1) made an expected finding: yes, these estuaries were impaired, and yes, nitrogen from residential septic systems was the main cause. But it was their recommendation for addressing the problem that got everyone's attention.

Sewering, they said, was the only answer. Sewer Falmouth Heights, Maravista, Teaticket, Acapesket, Davisville, Menauhant, and Seacoast Shores, everything south of Route 28 in East Falmouth, and then north of Route 28. The price tag: $600 million dollars.

Once Falmouth got over the shock of that number, the Town quickly decided there had to be a better way. A review committee was appointed, and two years later the Water Quality Management Committee was created by Town Meeting and appointed by the Selectmen.

The committee's assigned mission: to explore every practical alternative means of improving the water quality in the Town's estuaries, and to come up with an implementation plan that used cost-effective alternatives where practical, and sewers only where they were the most cost-effective solution.

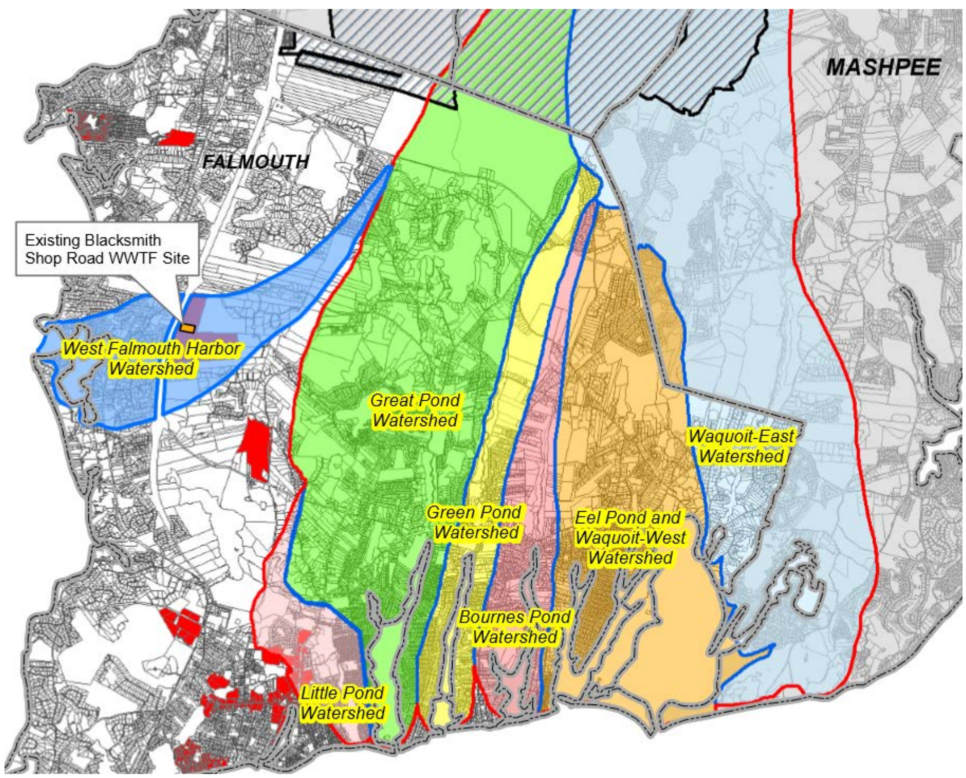


Figure P.1 Impaired Estuaries in the 2019 CWMP Update

This is that plan. This document, titled “South Coastal Embayments CWMP/TWMP Notice of Project Change (NPC) Update Report,” is a report to the Massachusetts Department of Environmental Protection (DEP) and the Massachusetts Environmental Policy Act office (MEPA).

But more importantly, it is a report to the people of Falmouth, telling them what has been done, with their support, over the past 10 years; and what we are recommending the Town should do in the next five years and beyond.

We have had many partners in these 10 years: The Board of Selectmen, the Department of Public Works, the Shellfish Advisory Committee, the Department of Marine and Environmental Services (MES), the Town GIS coordinator, the Planning Board, Buzzards Bay Coalition, Cape Cod Commission, George Heufelder and Barnstable County Alternative Septic System Test Center, UMASS Dartmouth School of Marine Science and Technology (SMAST), Woods Hole Oceanographic Institution (WHOI), Marine Biological Laboratory (MBL), Woods Hole Research Center, US Geological Survey (USGS), US Environmental Protection Agency (EPA), MassDEP, US Department of Agriculture, Cape Cod Water Protection Collaborative, Cape Cod Economic Development Commission, the Town of Mashpee, Citizens for the Protection of Waquoit Bay, and the Mashpee Environmental Coalition, consultants GHD and Wright-Pierce, the Woods Hole Group, Applied Coastal Research & Engineering Inc (ACRE), BETA, CDM Smith, MT Environmental Restoration, the Commonwealth of Massachusetts, and Science Wares.

With their help, the Town has accomplished a great deal. A brief summary:

P.2 Progress Summary Since 2014

Fertilizer Reduction: Too much lawn fertilizer, a significant source of nitrogen, ends up in our estuaries. So Falmouth passed the toughest fertilizer control bylaw in the Commonwealth—among other things, it bans all fertilizer application within 100 feet of an estuary. The Town DMES follows it up every year with a letter to affected property owners and also posts the letter at stores selling fertilizer.

Shellfish Aquaculture: Shellfish consume the microalgae that thrive on nitrogen. Falmouth demonstrated that we could grow millions of oysters from seed in an impaired estuary, overwinter them, and successfully transplant them for harvest. The Town is now identifying the best growing areas in each estuary and partnering with local aquaculture growers to reduce the nitrogen via aquaculture.

Inlet Widening in Bournes Pond: SMAST estimated that widening the inlet 40 feet would increase flushing enough to achieve approximately one-half of the nitrogen removal needed to restore Bournes Pond to a healthy state. Falmouth voters provided funding to widen the inlet and also replace the current 35-year-old bridge with a newer one. All environmental permits are now in place for this project to proceed.

Innovative/Alternative Septic Systems (I/As): For neighborhoods where sewering is not the most practical alternative and expected to be more costly, the Town is testing I/As that can be added onto existing home septic systems in order to remove nitrogen. Falmouth, with its partner the Buzzards Bay Coalition, worked with willing homeowners in the West Falmouth Harbor area to install 25 such systems. We are now measuring how well they work, and their short and long-term capital and operating costs.

This concept is being studied on a larger scale in the Oyster Pond watershed, where the Town has developed a plan for 187 homes to reduce their nitrogen effluent using I/As, along with a parallel alternative plan using sewers. Economic costs, environmental gains, and impact on homeowners of the two options will all be analyzed and compared.

West Falmouth Harbor: This is the first estuary on Cape Cod projected to meet the reduction target for nitrogen set by the Massachusetts Estuaries Project (MEP). The largest source of nitrogen to West Falmouth Harbor is the Town's wastewater treatment plant. This estuary is projected to meet its nitrogen reduction goal without sewering, thus saving the Town an estimated $24 million by:

- reducing the permitted volume of tertiary treated effluent discharged into the harbor watershed;
- reducing the nitrogen concentration in the treated effluent to the limit of technology for nitrogen removal; and
- taking into account further reductions due to the 25 I/As installed, fertilizer reduction, and stormwater improvement credits.

In addition, other projects include a shellfish reef and the transplantation of thousands of oysters to improve habitat quality.

Sewering Little Pond: To deal with the Town's most impacted estuary whose watershed has a high density of development, Falmouth voted to sewer approximately 1,350 parcels in the Little Pond lower watershed. Special legislation approved by the Town enabled the annual betterment charge to the affected homeowners to be reduced from $1,220 per year to $435, and the Town also provided low pressure pumps, at no cost, to homeowners who needed them to connect to the sewer. Our partners at USGS and MBL are measuring the nitrogen in groundwater entering the pond before and after sewering to provide a true test case of the environmental benefits of sewers.

Those are the highlights of Falmouth's progress in the past 10 years. We hope, in this document, to provide a road map for continued progress that addresses the Town's goal of restoring its coastal estuaries in a way that the Town can afford.

P.3 Vision for Next Five Years

Here is what we are recommending for the next five years and beyond (Table ES.1).

Upgrading the Wastewater Treatment Plant: To accommodate any additional sewering, or even to accommodate expected growth in the existing sewered areas, the Town's treatment plant will need some new and updated infrastructure in the next five years.

Connecting to the Plant: The existing force mains connecting currently sewered areas' collection systems to the plant do not have enough capacity to accommodate wastewater flow from any large new areas. A new force main from Teaticket along Brick Kiln Road to the plant will be needed to carry the additional wastewater flows being proposed from Teaticket and Acapesket in the next five years.

A New Discharge Site: The existing sites for discharge of the tertiary treated wastewater from the Town's treatment plant are at or approaching permitted capacity. Over the next five years the Town will need to identify and construct a new discharge site outside the West Falmouth Harbor watershed for the additional flow that any new sewered areas would bring to the plant.

Three potential sites are currently being studied: an ocean outfall into Buzzards Bay; recharge beds at the Town-owned “Allen Parcel” on Carriage Shop Road in East Falmouth; and expanded recharge beds at the Town-owned “swap parcel” (existing recharge beds 14 and 15) near Thomas Landers Road in West Falmouth. In addition, there is a regional evaluation being conducted on wastewater discharge options on Joint Base Cape Cod.

Sewering Great Pond Watershed: The next estuary where the high levels of nitrogen and the density of development indicate sewering is going to be required as part of the solution is Great Pond. To keep within the financial guidelines set by the Town, this would need to be done in two phases, with phase one being done in the next five years.

Phase One would encompass northern Maravista, Perch Pond, Teaticket Path, Falmouthport, and northern Shorewood Drive, and would be presented to voters in 2024 and constructed in 2025. Phase Two would include most of the rest of the Acapesket peninsula down to Emerson Road and would be presented to voters when the next Town debt drop-off occurs that would allow the project to be funded without raising the property tax rate.

Not Sewering Davisville and Menauhant Peninsulas: Because a substantial part of the recommended sewered area on the Acapesket peninsula is in the Green Pond watershed, and because inlet widening will produce major nitrogen reduction for Bournes Pond, and because expanded aquaculture is an option for both estuaries, we have concluded that these measures combined with the fertilizer and stormwater credits will be sufficient to improve the health of these estuaries and are therefore projecting that these areas will not need to be sewered, except possibly some small portions near Route 28.

Waquoit Bay Intermunicipal Agreement: With 48 sub-watersheds and shared by Falmouth, Mashpee, and Sandwich, the Waquoit Bay watershed is far and away the most complicated system to address.

The first question to answer is – for what amount of nitrogen reduction is each town responsible? Falmouth, Mashpee, and Sandwich have collaborated to fund and move forward with a study to answer that question and are awaiting the other towns’ responses. But given what we already know about this watershed, we feel confident in projecting that sewering is likely to be recommended in the future for the Seacoast Shores peninsula, as well as possibly Antler Shores and the Seapit peninsula.

Mashpee has also approved a plan to manage their nitrogen load to this watershed and the Town of Sandwich has also developed their Comprehensive Water Resources Management Plan regarding management of nitrogen within this watershed as well.

Executive Summary

ES.1 Introduction

This Notice of Project Change to the Comprehensive Wastewater Management Plan and Final Environmental Impact Report and Targeted Watershed Management Plan (CWMP/FEIR/TWMP) Document provides an update to several of the Town's CWMP implementation efforts and pilot projects as called for in the January 10, 2014 Executive Office of Energy and Environmental Affairs (EOEEA) Secretary Certificate.

These pilot projects and other initiatives have been primarily funded by Article 17 of Spring 2011 Town Meeting and a ballot vote in May 2011 and are underway. Their progress to date is summarized in this document.

This update has been prepared by GHD, the Falmouth Water Quality Management Committee (WQMC), and its contractor Science Wares, and has been approved by the Falmouth Board of Selectmen. It is a summary of the efforts and studies to date that support the Compliance Plan Approaches developed for each watershed.

ES.2 Water Quality Monitoring and Data Summary

The University of Massachusetts Dartmouth School of Marine Science and Technology (SMAST) facilitates two water quality monitoring programs in Falmouth's south-facing estuaries. The Pond Watch Monitoring Program has been collecting water quality data every two weeks during the critical impairment months (July and August) in Little, Great, Green, and Bournes Ponds since 1989. In Waquoit Bay, which is shared with the Town of Mashpee, there has been bi-weekly monitoring of the 19 established stations since 2001 during the critical impairment months. Measured parameters for each sampling event include total nitrogen, salinity, and chlorophyll as well as total depth, temperature, Secchi depth, nitrate + nitrite, ammonium, dissolved organic nitrogen, particulate organic nitrogen, phosphate, and dissolved oxygen.

All five of these estuaries remain nitrogen-impaired, as demonstrated by SMAST data. Historical trends from each of the estuaries do not indicate any significant change in the level of impairment in each of the estuaries. These results indicate that the conditions have remained relatively constant in the four Pond Watch estuaries (Little, Great, Green, and Bournes Pond) since 2004 and in Waquoit Bay since 2010.

Overall, the SMAST data show that the total nitrogen levels remain highest in the upper reaches of the estuaries [Station 1] and are lowest near the mouth of the estuary [Station 5]. The total nitrogen concentrations at the sentinel stations are still in excess of their target thresholds (see red line in Figures ES.1 and ES.2). For example, G4 is the sentinel station for Green Pond. Chlorophyll measurements also indicate nutrient enrichment in these estuaries.

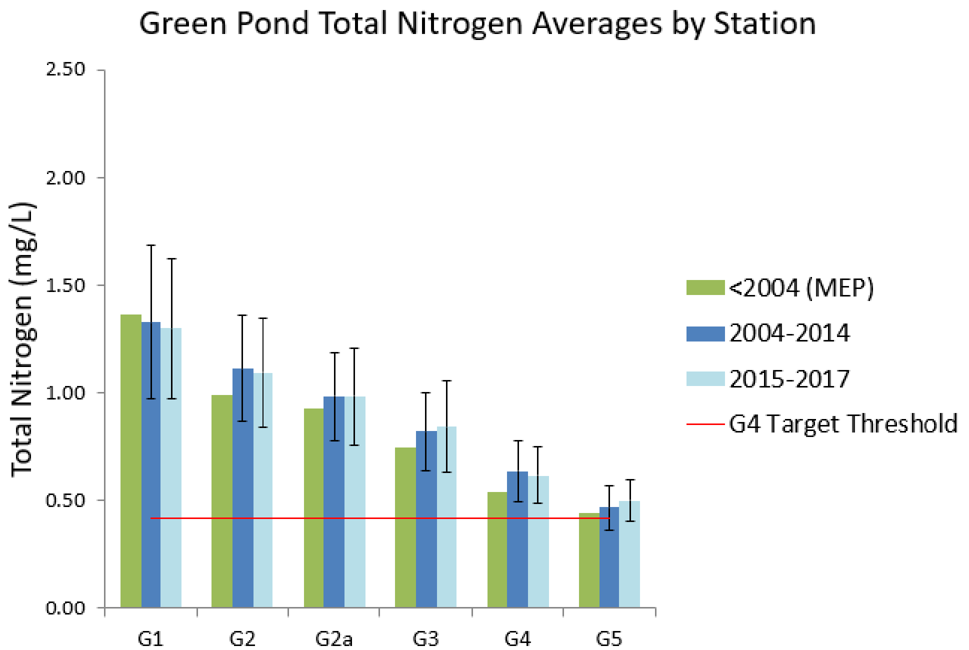


Figure ES.1 Example of the General Trend of Average Annual Total Nitrogen Concentration by Monitoring Period in the South-Facing Estuaries

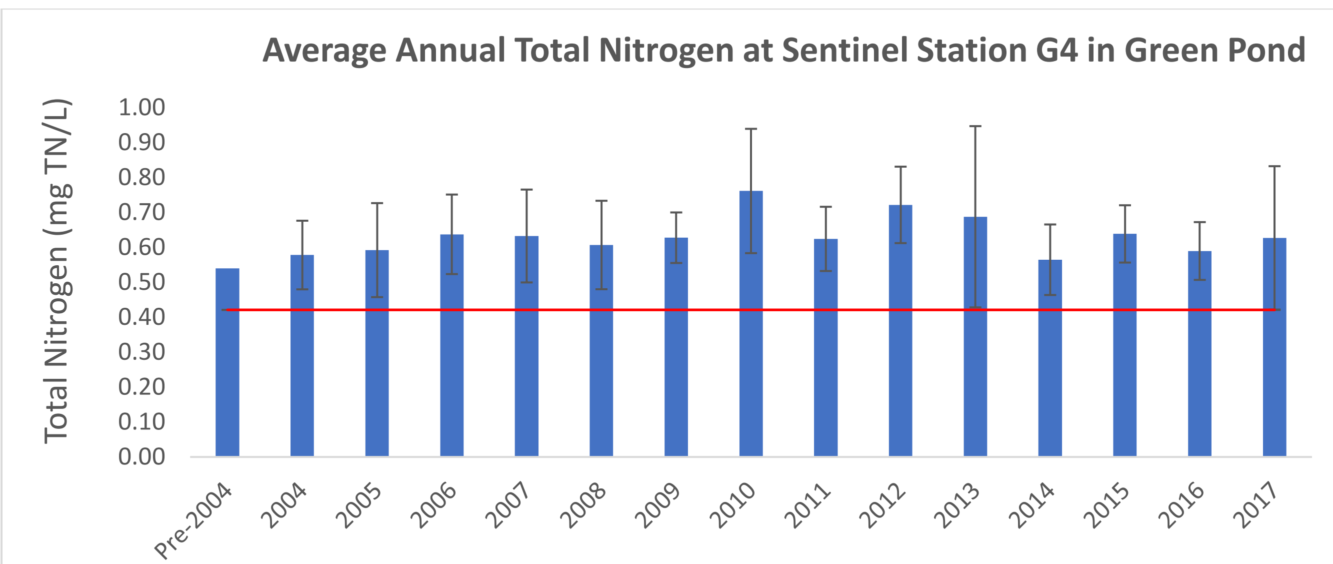


Figure ES.2 Example of the General Trend of Average Annual Total Nitrogen Concentration for the Sentinel Stations in the South-Facing Estuaries

The SMAST data for total nitrogen for Green Pond between 2004 and 2017 present a fairly constant level of impairment. Data from the other south-coast estuaries including Waquoit Bay show a similar pattern. Falmouth and Mashpee will continue to contract with SMAST to monitor these estuaries during July and August each year.

ES.3 Summary of Pilot Projects

At the 2011 Falmouth Spring Town Meeting, Town Meeting Members voiced their strong support for finding ways, in addition to sewering, to control nitrogen and improve the health of the estuaries. To fund the effort, a $2.77 million bond issue was voted and subsequently approved by the voters in a town-wide ballot. Since then, the WQMC and various Town departments have initiated a wide range of pilot/demonstration projects to provide a comprehensive analysis of non-traditional options for nutrient management in the impaired watersheds. Completed projects include a demonstration project on eco-toilets and a nitrogen control bylaw for fertilizer. The Town continues to actively conduct project initiatives on shellfish aquaculture, innovative and alternative septic systems (I/As), permeable reactive barriers (PRBs), stormwater management, and inlet widening.

ES.3.1 Eco-Toilets

The first of the Town's demonstration projects to have been completed focused on eco-toilets. The Town initiated an Eco-Toilet Incentive Program to encourage homeowners to install either composting or urine-diverting fixtures in their homes to gauge the effectiveness of the eco-toilets and general public response. To encourage participation, the Town offered three different financial incentives. Numerous outreach efforts were made to increase public awareness of the program, including a mailing to every household in town; about 170 homeowners responded.

Of the 170 homeowners, only 50 had site visits conducted. At the final stage of the program, only nine fixtures were installed. The performance of these systems was monitored by the Barnstable County Department of Health and Environment. Of those homeowners who initially showed interest in the program and chose not to participate, the reasons given were concerns over resale value of their home and the commitment to the ongoing operation and maintenance required for the systems.

The monitoring data results from the installed fixtures indicated a 48% to 86% nitrogen removal depending on the system. However, while the performance of the fixtures was effective in nitrogen reduction, the general findings from the program indicated that a large-scale initiative in Falmouth would likely not be embraced by the community. At present, the Town has no plans to pursue any further eco-toilet initiatives.

ES.3.2 Town Bylaw for Fertilizer

The second of the Town's demonstration projects to be completed was an effort to regulate fertilizer use in the immediate vicinity of the coastal estuaries and within the entire Town. The Town adopted a Nitrogen Control Bylaw that restricts fertilizer application timing, location, and application rate, and bans its application entirely within 100 feet of coastal estuaries. In efforts to regularly educate the public and encourage adherence to the bylaw, there is an annual mailing to all homeowners of properties within 100-feet of coastal estuaries. The bylaw and outreach efforts are expected to result in a 25% reduction in the attenuated fertilizer load to the estuaries.

ES.3.3 Shellfish Aquaculture

The Town initiated a significant oyster aquaculture project in Little Pond beginning in 2013. This demonstration project was funded by the Town, the Cape Cod Economic Development Council, and the Cape Cod Water Protection Collaborative. It was a three-year project to verify nitrogen uptake by oysters and to culture enough oysters to yield a detectable change in water quality at the site. SMAST was contracted for the three-year monitoring effort for the project. Results from SMAST show that the deployment of oysters in Little Pond produced small-scale, localized water quality improvements including total nitrogen concentration. The primary mechanism for these water quality improvements appears to be the uptake of phytoplankton.

During the course of the three-year program in Little Pond several overwintering techniques were evaluated. The project saw the highest survival when first-year oysters were removed from the water and placed in insulated cold-storage containers, resulting in < 1% mortality.

Based on the success of the pilot project, municipal aquaculture efforts are still ongoing in Little Pond. In 2017 the municipal propagation program assessed the comparative growth rates of different oyster seed stock and began exploring methods for optimizing propagation in impaired estuaries for shellfish other than oysters, such as quahogs and scallops (Figure ES.3).

Figure ES.3 2017 Little Pond Farm <2 Acre Deployment

Additional shellfish aquaculture pilot programs have occurred in West Falmouth Harbor, Waquoit Bay, and Bournes Pond. In West Falmouth Harbor, the project established an oyster reef and studied its ability to self-sustain. In Bournes Pond and Waquoit Bay, the projects examined the effects of various culture techniques on oyster growth rates, nitrogen sequestration by these oysters, and the potential for denitrification rates of oysters grown in the high-density floating bag system similar to those used in Little Pond (Figure ES.3).

Using the findings from the shellfish aquaculture demonstration projects in Little Pond, Waquoit Bay, and Bournes Pond, the Town has been able to progressively optimize its oyster growing strategies for nitrogen removal. The Town now has the experience and ability to grow large numbers of oysters in a high-density floating bag system and successfully overwinter the animals with minimal mortality. In addition, the Town used quantitative analyses to estimate the amount of nitrogen sequestered by oysters in the high-density floating gear using initial season weights and harvest weights for the total area occupied by gear and analyzing a subset of about 25 oysters for the percent nitrogen content in the shell and the tissue. Using these measures, the Town is able to accurately determine the total nitrogen removal on a kilogram per acre basis and produce measurable improvements in the surrounding water quality.

In 2017 the Town developed a plan that would promote increased aquaculture activities as a nitrogen removal strategy in impaired estuaries. The plan identified areas suitable for shellfish aquaculture activities based on a number of parameters (e.g. presence of eelgrass and/or harvestable shellfish, navigation channels, mooring fields, anadromous fish runs, etc.). The plan recommended involving commercial growers in the municipal efforts. As such, the Town is currently pursuing a pilot program in Eel River to contract with commercial growers to grow on Town-owned aquaculture sites following Town growing protocols including a target nitrogen removal condition (Figure ES.4). A request for proposals for the Eel River sites has been distributed and applicants have been evaluated.

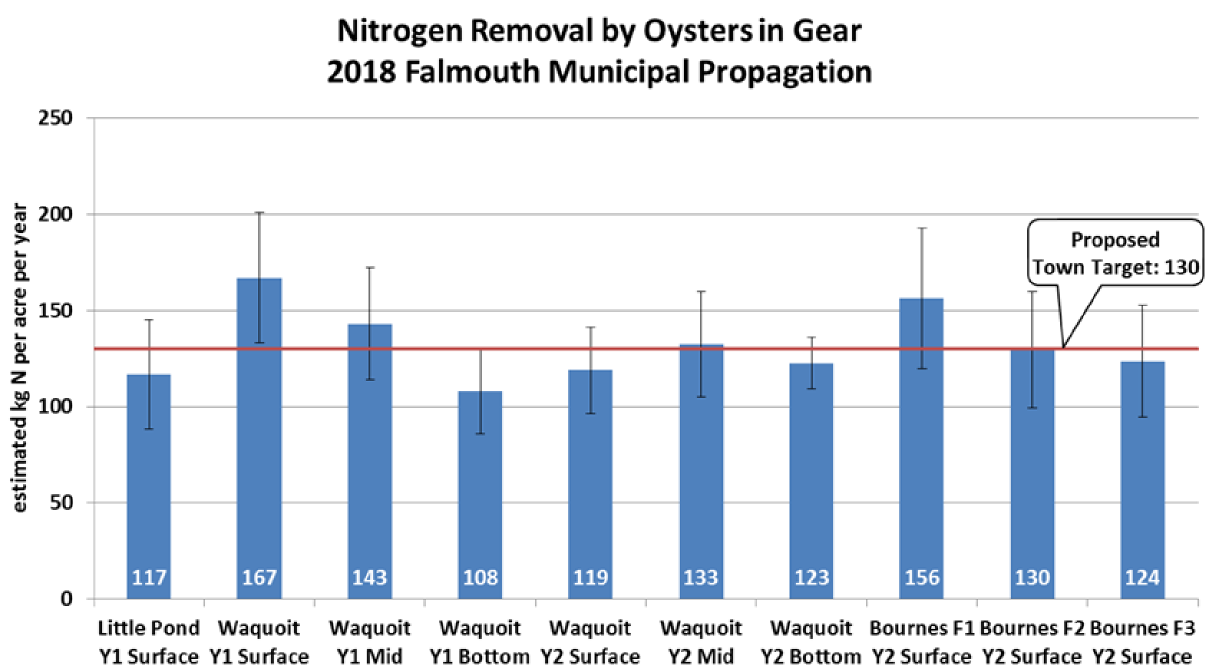


Figure ES.4 Summary of Nitrogen Removal Measurements in 2018

ES.3.4 Innovative and Alternative Septic Systems

In partnership with the Buzzards Bay Coalition, the Town received all equipment for and has completed the first phase of the West Falmouth Harbor Shoreline Septic System Remediation Project (WHFSSSRP) using advanced I/A septic systems. For the first phase of the project, 20 systems were installed and monitored. The range of installation costs for each system varied and were primarily driven by site constraints for installment and the costs to restore the landscaping.

The Town considers the MassDEP standard of 19 mg N/L to be too high to effectively improve the health of the estuary and therefore set a performance goal of 12 mg N/L for each system in this project. The monitoring results showed a wide range of performance from the various installed systems. Through the course of the project it was determined that to be the most effective for achieving Falmouth's Total Maximum Daily Loads (TMDL) goals, there needs to be options for I/A systems that achieve 10 mg N/L, or 75% total nitrogen reduction approved by MassDEP. The installation and monitoring costs are among the primary concerns in using I/A systems. The conclusion from the pilot project is that for the cost of I/As to be similar to sewers, loans for I/A systems would ideally be available that provide financing comparable to Falmouth's previous betterments.

Phase II of the WFHSSSRP is currently in progress with an additional five systems installed to date and another five systems planned. The groundwater monitoring for all of the systems installed is performed by the Barnstable County Department of Health and Environment. The Coalition for Buzzards Bay published an initial report of the project in 2018 and expects to make a final report at the end of the project.

ES.3.5 Permeable Reactive Barriers

The Town has actively explored and evaluated several potential sites in Great, Green, and Bournes Pond watersheds suitable for the installation of a permeable reactive barrier (PRB). Several potential sites suitable for a PRB were initially identified by a mapping exercise and funds were obtained through the Cape Cod Water Protection Collaborative and the EPA to install monitoring wells to characterize the groundwater hydrology, the soils, and the chemistry of dissolved substances.

Two candidate sites have been identified as a result of these efforts: 0 Shorewood Drive in the Great Pond watershed and Sailfish Drive in the Bournes Pond watershed. Both have a high groundwater velocity rate, high groundwater nitrate concentrations, and shallow depth to the water table. The Town has pursued various funding opportunities to aid in the installation costs to initiate a PRB demonstration project and expects to hear soon from the latest grant application to the Southeastern New England Program for a PRB installation at 0 Shorewood Drive. The US Geological Survey has also assisted in this project by installing a multi-port sampler at an upstream location on Shorewood Drive and sharing the data.

ES.3.6 Stormwater Management

The Town has worked to identify several candidate locations to implement stormwater Best Management Practices (BMP) for nitrogen removal. An initial review of the storm drain system in Great Pond was conducted to determine the nitrogen load from the two most prominent catchment areas in the watershed. Based on subsequent field investigations of the two catchment areas and the necessary steps to implement the BMP, the Town has decided to further review the effectiveness of emerging technologies such as media boxes prior to carrying out any specific stormwater management projects. The Falmouth Department of Public Works continues to employ Best Management Practices in all of its road improvement projects.

ES.3.7 Inlet Widening

In 2016, the Town filed a Notice of Project Change to advance the Bournes Pond Inlet Widening program. The objective of the project is to widen the existing inlet to increase water exchange within Bournes Pond. Historic information indicates the inlet width has naturally varied from 88-feet wide up to 400-feet wide from 1844 to 1984. Its current restrained opening of 50-feet wide occurred in 1985 with the construction of the bridge. The planned widening will open the inlet to approximately 90-feet which is on the lower end of the historical stable inlet widths observed at the Bournes Pond entrance. Modeling scenarios done by SMAST and ACRE indicate that inlet widening to 90-feet should achieve approximately 50% of the total nitrogen removal requirement in Bournes Pond. To date all of the required permits for the construction phase have been obtained and construction could begin as early as 2020.

ES.4 Little Pond Targeted Watershed Management Plan Update

As part of the approach for meeting the TMDL in Little Pond, the Little Pond Sewer Service Area (LPSSA) was designed to connect approximately 1,350 developed properties to the Town sewer system. Approximately 19% of these properties are within the boundaries of the Great Pond watershed.

The Town has partnered with the USGS and EPA on a project to monitor the groundwater beneath the Maravista Peninsula through a series of 18 monitoring wells. The objectives of the study are to assess groundwater levels and water quality beneath a densely developed coastal neighborhood undergoing a conversion from septic systems and cesspools to municipal sewers, and develop an understanding of water-quality conditions before and after installation of the sewers. It is estimated that it will take approximately seven years for the existing nitrogen load from the traditional septic systems to move through the groundwater and soils before the full benefit of sewering the LPSSA can be evaluated.

Construction of the new collection system for the LPSSA began in 2015. Groundwater sampling by the USGS began in June of 2016 and has continued to date. Data from the USGS efforts will show the timing of the impacts of sewering on the groundwater in Maravista while the continued monitoring data from the Pond Watch Monitoring Program (see Section ES.2) will indicate when the effects of sewering have reached Little Pond. The USGS groundwater monitoring data are publicly available through the USGS data repository.

To date, over 95% of the properties in the LPSSA have connected to the sewer system, and it is anticipated that the remaining properties will be connected by the fall of 2019. It is estimated that the sewering of the LPSSA will accomplish a minimum of an 83% reduction of the total nitrogen removal required to meet the TMDL goal.

The Town anticipates that the fertilizer bylaw and stormwater management practices will receive the State-approved nitrogen reduction credit of 25% reduction of the total attenuated load from these sources. Additionally, there are municipal aquaculture efforts in Little Pond that will further aid in meeting the TMDL goal.

Falmouth has taken significant steps to reduce the nitrogen load into Little Pond. As part of the adaptive management approach adopted by the Town, monitoring of the LPSSA will continue to assess the impacts from sewering. If the current efforts have not fully met the nitrogen removal requirements, use of I/A systems in the upper watershed or the expansion of the LPSSA northward would be the “back-up plan” to achieve TMDL compliance in the Little Pond watershed.

ES.5 West Falmouth Harbor Targeted Management Plan Update

The largest source of controllable nitrogen in the West Falmouth Harbor watershed is the effluent plume from the original lagoon wastewater treatment facility (WWTF) constructed in the 1980s. Since the plant came on line in 1986, significant upgrades to the plant have reduced nutrient concentrations in the effluent discharged into the West Falmouth Harbor watershed. In 2005, the WWTF was upgraded to a tertiary treatment facility. As a result of an evaluation on nitrogen removal optimization done as part of the design process for the LPSSA (see Section ES.4), several recommendations for additional upgrades to the WWTF were made and completed by 2016. In 2019, a new evaluation was conducted to assess additional requirements for the WWTF to process additional load from the proposed Teaticket/Acapesket Study Area (see Section ES.6). This evaluation recommended adding a third sequencing batch reactor (SBR) to the plant and constructing additional effluent discharge capacity outside of the West Falmouth Harbor watershed. The Town has requested capital funds to complete the recommended upgrades to accommodate additional flow and load from future sewer extensions.

Currently the plant is operating under the most recent Modified Groundwater Discharge Permit (December 2015); this permit limits discharge to 450,000 gpd within the West Falmouth Harbor watershed and to 260,000 gpd outside the watershed.

One of the requirements of the current discharge permit is quarterly groundwater monitoring for nitrogen and phosphorus. There is an existing network of monitoring wells upgradient and downgradient of the various recharge beds within and outside of the West Falmouth Harbor watershed. Monitoring wells downgradient from Recharge Beds 1 – 13 in the West Falmouth Harbor watershed have shown a significant decrease in groundwater total nitrogen concentration since the WWTF upgrade to a tertiary treatment plant was completed in 2005. All the monitoring wells except one, the furthest downgradient from the WWTF, have contained total nitrogen concentrations less than 2 mg/L for more than a year. The monitoring well most distant from the plant still contains a total nitrogen concentration greater than 4 mg/L, though that is expected to drop over time as well as the plume from the original lagoon WWTF washes out. Data from wells downgradient of Recharge Beds 1 - 13 also indicate that there has been no increase in phosphorus concentration in groundwater over the background levels, despite over 30 years of WWTF discharge.

In 2016, SMAST conducted additional modeling scenarios for West Falmouth Harbor to meet TMDL compliance. Using build-out scenarios and the current discharge permit restrictions, the modeling results indicated that if the plant effluent averages an annual concentration at or below 3 mg TN/L the system should meet the West Falmouth Harbor TMDL once the plume from the original lagoon WWTF has flushed out. As shown in Figure ES.5, effluent total nitrogen concentration from the original lagoon WWTF averaged 23.3 mg/L from 1994 to 2005; upgrades completed in 2005 resulted in effluent total nitrogen concentrations averaging 4.7 mg/L from 2006 to May 2016, and additional upgrades completed in 2016 resulted in effluent total nitrogen concentrations averaging 2.7 mg/L from June 2016 to December 2018. The WWTF did have a mechanical problem resulting in reduced performance in 2019. However, the performance from 2016 through 2018 demonstrates the capacity of the WWTF to average 3 mg/L over extended periods. Additional WWTF upgrades including the third SBR and upgrades to the WWTFs sludge processing system are envisioned as part of the next phase of wastewater system expansion to accommodate additional flow from additional service areas and to further improve the consistency of WWTF performance.

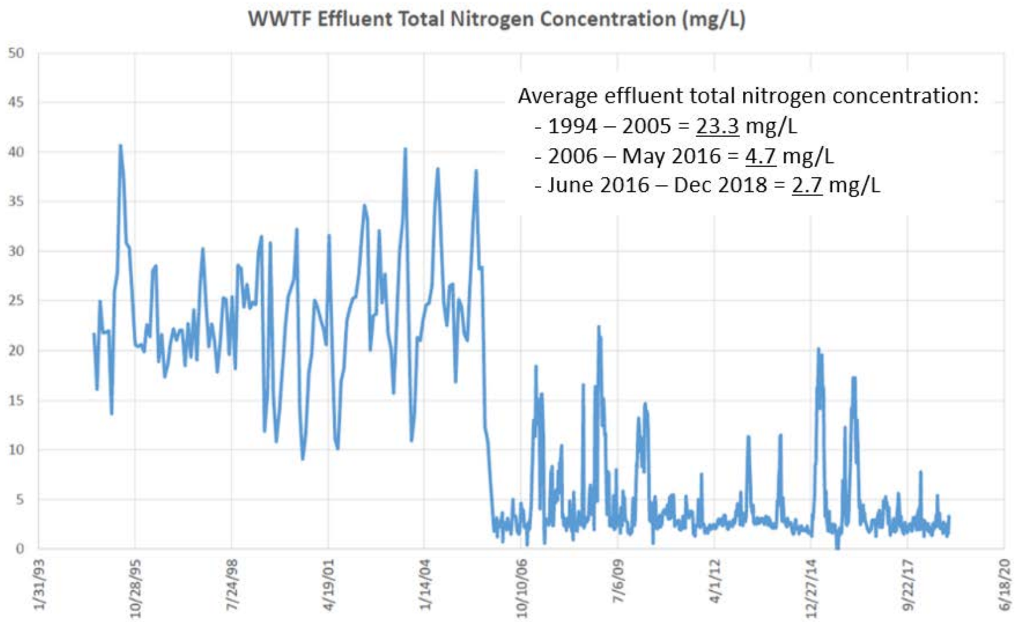


Figure ES.5 Historical Wastewater Treatment Facility Effluent Total Nitrogen Concentrations

To provide a suitable discharge site for treated effluent from the LPSSA, the Town built Recharge Beds 14 and 15 north of the WWTF and outside of the West Falmouth Harbor watershed. Data from the monitoring network for these beds show that total nitrogen has increased slightly in some downgradient wells since discharge began in 2016. It is noted that the upgradient background monitoring well contains slightly elevated total nitrogen concentrations, as well, indicating the potential influence of upgradient sources. Total phosphorus concentrations in the monitoring wells have not increased in any monitoring wells except for the two wells located only 20 feet horizontally from the recharge beds. These two adjacent wells, one screened at the top of the groundwater table and the other screened just below the first, were installed in this manner within 20 feet of the recharge beds in order to confirm phosphorus attenuation in aquifer soils over a short distance, as indeed demonstrated to date.

Crocker Pond lies generally downstream from Recharge Beds 14 and 15 and has been monitored in July, August, and September since 2016. The current data is considered baseline data and will be compared to future data to assess potential nutrient impacts to the pond from discharge to Beds 14 and 15.

The Town has made several additional efforts to augment the nitrogen removal in the West Falmouth Harbor watershed. The Town expects that the fertilizer bylaw and stormwater management practices will receive the State-approved nitrogen reduction credit of 25% reduction of the total attenuated load from these sources. Additionally, the West Falmouth Harbor Shoreline Septic System Remediation Project with the Buzzards Bay Coalition (See Section ES.3) has removed a small portion of the nitrogen load through the installation of approximately 25 I/A systems to date; five more I/A systems are in the planning stage.

Based on the SMAST modeling, the Town expects to be able to meet the nitrogen TMDL goal for West Falmouth Harbor with the WWTF improvements alone. However, the Town will also continue with the other nutrient mitigation strategies (fertilizer management, I/A system demonstrations, etc.) in order to provide the greatest flexibility to manage nitrogen within the watershed.

ES.6 Great Pond Watershed Planning Scenario

The largest source of controllable nitrogen in Great Pond is wastewater from on-site septic systems. Due to the large nitrogen reduction requirements (about 12,000 kg/yr) and density of development adjacent to the pond, sewering is being considered in order to meet the nitrogen TMDL goal for Great Pond.

The Town contracted GHD to develop a conceptual sewer plan and to provide an evaluation of the nitrogen load per parcel in the Great Pond watershed. GHD's conceptual design is for a phased sewering project in the Teaticket/Acapesket Study Area. In total this project proposes to sewer approximately 1,791 developed properties, 1,289 of which are located in the Great Pond watershed and 502 in the Green Pond watershed (Figure ES.6). The first phase of the project would be on the Teaticket Peninsula and contains approximately 811 dwelling units including 210 condominiums in Falmouthport. The mid-point of construction for the first phase of the sewering project is anticipated to be in 2026. It is estimated that the sewering of the Teaticket/Acapesket Study Area combined with the sewered parcels from the LPSSA (see Section ES.4) in Great Pond will remove a minimum of 59% of the nitrogen needed to meet the TMDL goal for Great Pond.

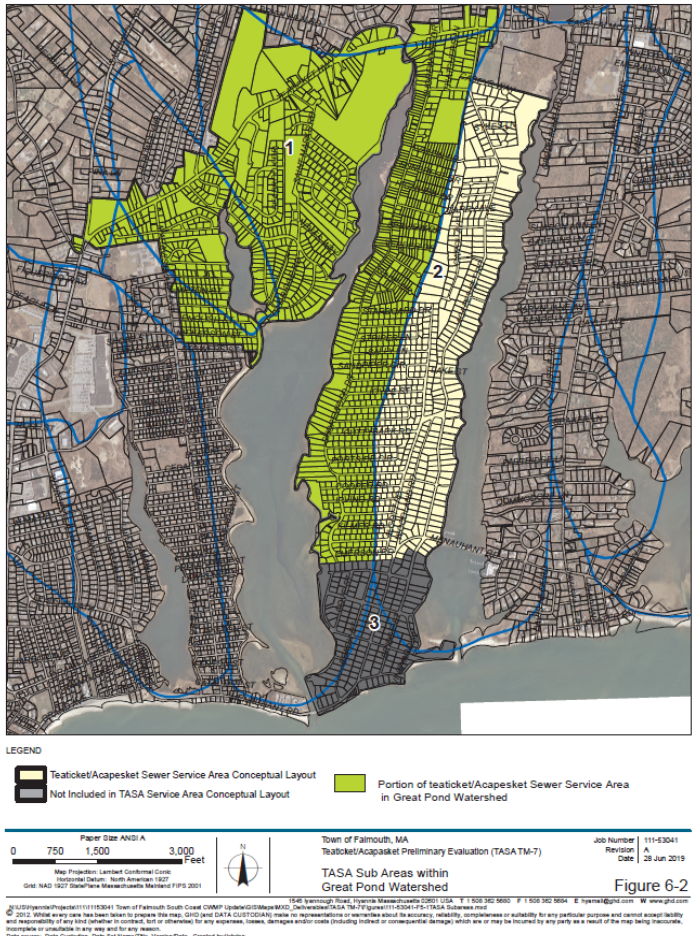


Figure ES.6 Teaticket/Acapesket Study Area Collection System Conceptual Layout of Parcels within the Great and Green Pond Watersheds

Part of GHD's evaluation of the Teaticket/Acapesket Study Area includes an assessment of effluent recharge technologies and disposal sites available to Falmouth. The flow from future development in existing sewered areas in Falmouth is also a consideration. The discharge options considered include: several sites for open sand beds or sub-surface leaching facilities in Falmouth or at Joint Base Cape Cod; and an ocean outfall into Buzzards Bay or Vineyard Sound and evaluations for capacity, community support, and cost.

Another main source of controllable nitrogen comes from the Coonamessett River which discharges into the head of Great Pond. It is estimated that 50% of the unattenuated nitrogen load entering Great Pond enters via the Coonamessett River. In 2014, the Falmouth Conservation Commission along with nearly two dozen project partners began to plan the conversion of 45 acres of retired cranberry bogs along the river into wetlands. To monitor the effects of the restoration efforts, the Town contracted the Woods Hole Research Center to quantify the nitrogen dynamics and physical characteristics of the river for a period of three years (2018 – 2020). Physical restoration of Lower Bog was completed only recently in 2018, and so the monitoring data has yet to show the anticipated nitrogen reduction impacts. Physical restoration of Middle and Reservoir Bogs is in design and permitting stages and will likely take place in 2020.

To meet the remaining nitrogen removal requirements to achieve the TMDL, the Town's plan expects that the fertilizer bylaw and stormwater management practices will receive the State-approved nitrogen reduction credit of 25% reduction of the total attenuated load from these sources. Additionally, the Town is currently evaluating potential acreage for significant shellfish aquaculture activities in Great Pond. At the head of the estuary, the Town is actively pursuing funding opportunities to install a 300-foot PRB at the Shorewood Drive parcel. It is estimated that the nitrogen reduction from the sewering, State-approved credits, shellfish aquaculture, and PRB will meet the TMDL. However, if these efforts do not fully meet the nitrogen removal requirements, the Town can consider I/A systems, sewer extensions north of Route 28, and exploring sites for an additional PRB north of Route 28 to achieve TMDL compliance in the Great Pond watershed.

ES.7 Green Pond Watershed Planning Scenario

The largest source of controllable nitrogen in Green Pond is from wastewater from on-site septic systems. In order to meet the nitrogen removal TMDL goal for Green Pond, the Town is considering various alternative options directly in the estuary and upstream in Mill Pond in addition to sewer extensions (Figure ES.7).

Figure ES.7 Green Pond Watershed

As part of the compliance approach for Great Pond (see Section ES.6) the Town's engineers have prepared a conceptual design for the Teaticket/Acapesket Study Area which proposes to sewer approximately 1,791 developed properties, 502 of which are located in the Green Pond watershed (Figure ES.7). It is estimated that the sewering of these properties on the Acapesket Peninsula will remove approximately half of the total requirement for nitrogen removal to meet the TMDL goal in Green Pond.

Another main source of controllable nitrogen comes from Mill Pond which discharges directly into the head of Green Pond. From 2015 to 2017 SMAST conducted an assessment on nutrient cycling in Mill Pond and determined that Mill Pond attenuates approximately 60% of the upstream nitrogen load and that the pond itself is phosphorus(P)-limited, not nitrogen-limited. The final report from SMAST made several recommendations for nutrient management in the pond which the Town has begun to pursue. Among the recommendations, a few were direct modifications to the cranberry agricultural practices upstream including: alternating the type of fertilizers used between 'low P' and 'no P', more strategic release of the dam boards to minimize water velocities into Mill Pond, and reducing the board height when damming during harvest and flood to increase flushing in the pond. According to the SMAST report, the bog owner is agreeable to putting these recommendations into practice.

Two additional recommendations made in the SMAST report are being pursued by the Town: installation of a detention pond and harvesting the macrophytes in Mill Pond. The Town is currently discussing with MassDEP the possibility of an agricultural exemption to install a tailwater recovery system rather than a detention pond. A tailwater recovery system would allow plant matter and fine sediments to settle out prior to discharge into Mill Pond and also allow for some recycling of nutrient runoff from irrigation practices back into the cranberry bog operations. Harvesting the macrophytes below the surface of Mill Pond will remove a significant nitrogen source from the pond that is generated when the plants die off and begin to decay. The macrophyte removal will also facilitate wind-driven vertical mixing in the pond to allow for the increased dissolved oxygen levels necessary for the natural denitrification cycle to occur in the sediments.

To meet the remaining nitrogen removal requirements to achieve the TMDL, the Town's plan expects that the fertilizer bylaw and stormwater management practices will receive the State-approved nitrogen reduction credit of 25% reduction of the total attenuated load from these sources. Additionally, the Town is currently evaluating potential acreage for some shellfish aquaculture activities in Green Pond. It is estimated that the nitrogen reduction from the sewering, State-approved credits, shellfish aquaculture, and nutrient management efforts in Mill Pond will meet the TMDL. However, if these efforts do not fully meet the nitrogen removal requirements, the Town can consider I/A systems or sewer extensions on the Davisville Peninsula, and explore sites for PRBs within the watershed to achieve TMDL compliance in the Green Pond watershed.

ES.8 Bournes Pond Watershed Planning Scenario

The largest source of controllable nitrogen in Bournes Pond is from wastewater from on-site septic systems. The Town believes that it can achieve TMDL compliance in Bournes Pond by using alternative options for nitrogen removal rather than by sewering.

As a result of the additional modeling done for the inlet widening demonstration project (see Section ES.3), the Town opted to pursue inlet widening for Bournes Pond. This project will expand the current inlet width from approximately 50-feet to 90-feet (Figure ES.8). This expansion will require the construction of a new two-span bridge and modifications to the surrounding coastal areas and structures including extending the western jetty by 25-feet, reconstructing an existing groin, and dredging the inner and outer channel of the inlet. Modeling results done by SMAST indicate that this project will achieve almost half of the required nitrogen removal to meet the TMDL goal. The Notice of Project Change (NPC) for the inlet widening project was filed in 2016. Several ecological assessment studies were conducted between 2015 and 2018 by Stantec, AECOM, and Applied Coastal to evaluate flood impacts, eelgrass beds, and shellfish locations in relation to the widened inlet. The project is now in its final design and permitting phase, and to date, all pre-construction permits have been obtained. It is anticipated that construction could begin as early as Fall 2020 with completion anticipated by December of 2022.

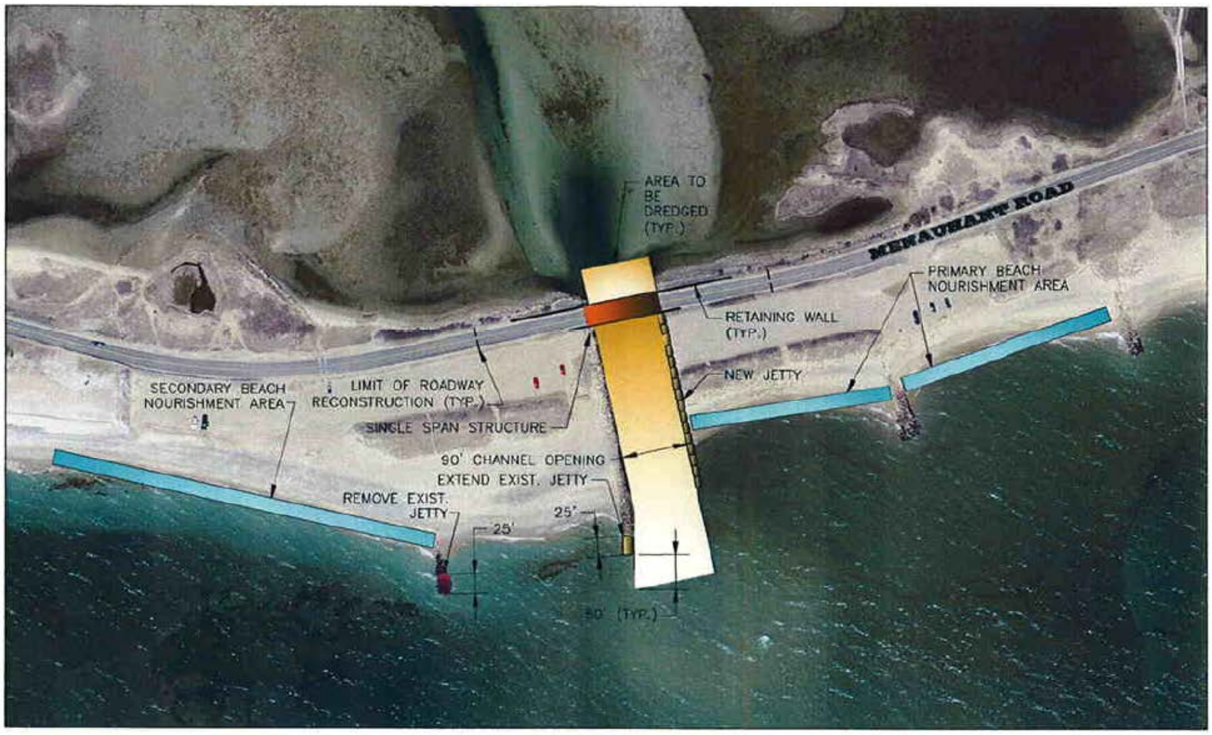


Figure ES.8 Proposed Plan for Widening the Bournes Pond Inlet

In addition to the inlet widening, the Town is currently evaluating suitable potential acreage for significant shellfish aquaculture activities in Bournes Pond which could remove about one-third of the total nitrogen needed to meet the TMDL goal. Additional nitrogen reductions are anticipated from shellfish bio-deposit denitrification.

To meet the remaining nitrogen removal requirements to achieve the TMDL, the Town's plan expects the fertilizer bylaw and stormwater management practices will receive the State-approved nitrogen reduction credit of 25% reduction of the total attenuated load from these sources. It is estimated that the nitrogen reduction from the inlet widening, State-approved credits, and shellfish aquaculture will be close to meeting the TMDL. Since Falmouth has adopted an adaptive management approach, if these efforts do not fully meet the nitrogen removal requirements, the Town can consider sewer extensions along Route 28, the use of I/A systems, exploring sites for a PRB in the upper watershed, and exploring nitrogen reduction options entering from Bournes Brook to achieve TMDL compliance in the Bournes Pond watershed.

ES.9 Eel Pond/Waquoit Bay Watershed Planning Scenario

The Waquoit Bay watershed is shared by the towns of Falmouth, Mashpee, and Sandwich (Figure ES.9). The entire Eel Pond sub-embayment and the majority of the Childs River sub-embayment fall entirely within Falmouth. The largest source of controllable nitrogen in the Waquoit Bay system is from wastewater from on-site septic systems. The three towns have begun the process of creating an Inter-municipal Agreement (IMA) to determine the allocation of nitrogen that each town is responsible for in order to plan their respective nitrogen reduction efforts. However, prior to determining this allocation, Falmouth has begun to explore options in the Eel Pond and Childs River sub-embayments because the majority of the nutrient reduction efforts for these areas lies within Falmouth. According to the MEP report, the main basin of Waquoit Bay does not require any formal reduction of nitrogen loads and therefore no specific plan has been prepared. SMAST conducted a study examining two potential nitrogen reduction approaches in the Quashnet / Moonakis River sub-embayment, dredging, and aquaculture. The study indicated tidal inlet dredging and shellfish aquaculture could address a portion of the nitrogen load reduction. No further investigation has been done in this region because the watershed is shared, and the IMA process is just beginning.

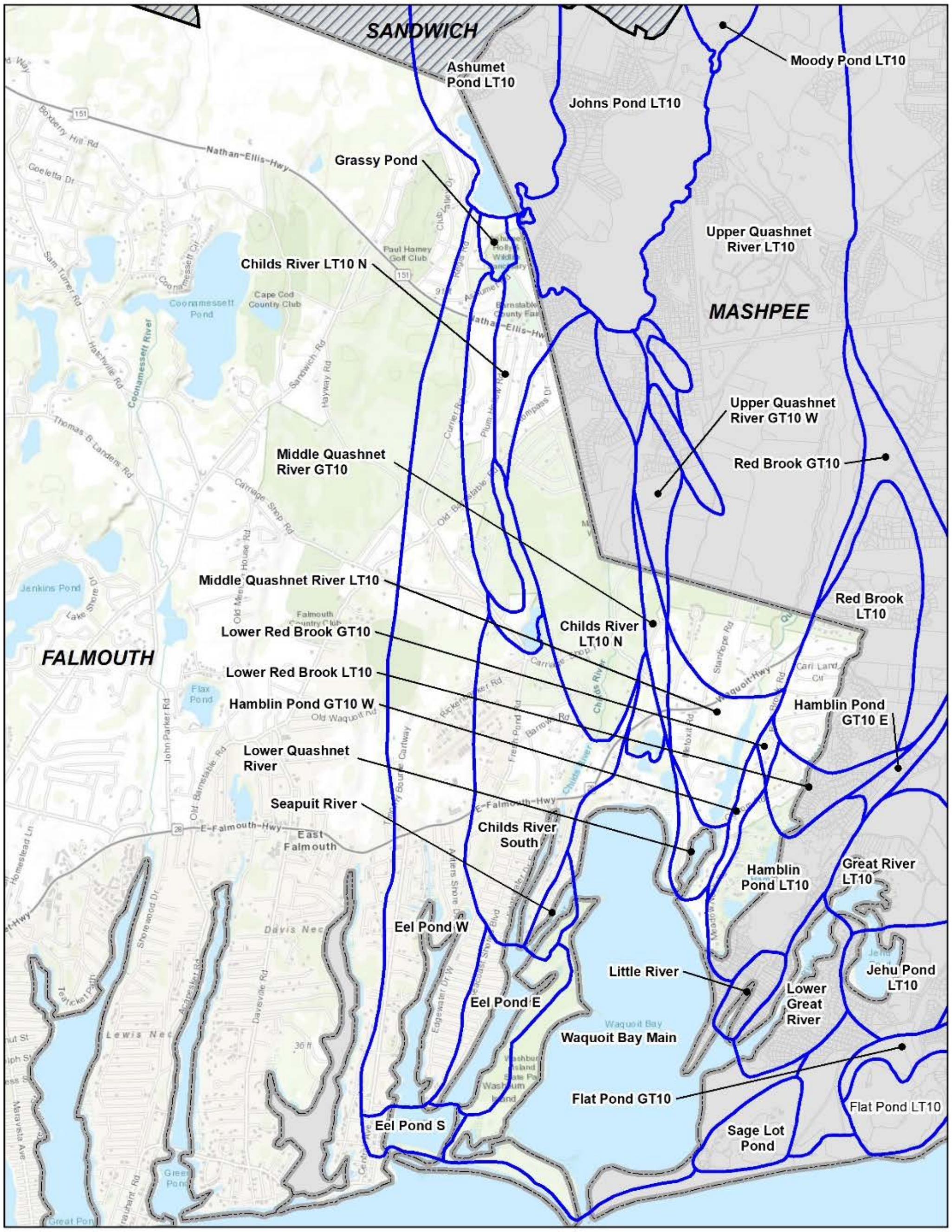


Figure ES.9 Waquoit Bay Sub-Watersheds with Town Lines

As part of the compliance effort for both Eel Pond and Childs River, the Town could consider sewer extensions for the Antler Shores, Seacoast Shores, and Seapit peninsulas. Sewering these three areas would connect an additional 1,300 properties to the sewer system. Due to the complex flow dynamics and exchange of water between the Waquoit Bay sub-watersheds, it is likely that improvements—such as sewering—made within a specific area like Eel Pond will also have some net benefit to other areas (e.g. Childs River). To accurately predict the secondary benefits to additional watersheds is a challenging task given the present level of information. Therefore, the secondary benefits have not been included in the final projections.

Prior to determining the nitrogen removal allocation, the Town has become involved in two projects with the goal of nutrient load reduction. The Town has begun efforts to develop a municipal aquaculture program that contracts commercial growers to remove a targeted amount of nitrogen per acre (see Section ES.3). Three initial sites for this project have been identified in Eel River. The project applicants have been evaluated, and it is anticipated that full-scale growing will begin in 2020. Another project in the Waquoit Bay watershed is a restoration effort that began in 2019 involving collaboration between the local Rod and Gun Club, Falmouth, and the Town of Mashpee to convert 12.4 acres of retired cranberry bogs into wetlands along the Childs River. It is too early in the implementation of this restoration project to determine the full extent of nitrogen removal potential from this effort.

After considering the potential nitrogen reduction from sewering the Antler Shores, Seacoast Shores, and Seapit Peninsulas to meet the remaining nitrogen removal requirements to achieve the TMDL, the Town is exploring several alterative options for nitrogen reduction. The Town's plan expects that the fertilizer bylaw and stormwater management practices in each sub-embayment will receive the State-approved nitrogen reduction credit of 25% reduction of the total attenuated load from these sources. Additionally, the Town is currently evaluating potentially suitable acreage for some shellfish aquaculture activities in Eel Pond and Childs River. It is estimated that the nitrogen reduction from the State-approved credits, shellfish aquaculture, and proposed sewering (including Mashpee's sewer contribution in the Childs River watershed) will meet the TMDL for Eel Pond and Childs River. However, if these efforts do not fully achieve TMDL compliance in the Waquoit Bay system, the Town can consider I/A systems or sewer extensions, and exploring sites for PRBs within the watersheds to achieve Falmouth's yet-to-be-designated allocation of the nitrogen removal load.

ES.10 Public Outreach Efforts

The Town continues to engage in public awareness and outreach efforts on Falmouth's water quality issues. Over the past five and a half years almost 80% of the Falmouth Water Quality Management Committee's regular meetings have been recorded and made available on the Falmouth Community Television local cable station and on its website. A journalist from the local newspaper, The Falmouth Enterprise, regularly attends the WQMC meetings. Approximately 129 articles have appeared in this local newspaper on water quality updates or issues raised during the WQMC meetings. On the Upper Cape, approximately 13,000 households have full access subscriptions to The Enterprise in print or online.

In addition to the regular committee meetings, the WQMC has made special outreach efforts for high-impact or localized community issues such as the Little Pond Sewer Service Area project, the initiation of the fertilizer bylaw, hosting a vendor workshop in West Falmouth for interested homeowners to speak with I/A system representatives, and frequent reports at the Falmouth Town Meetings. The Water Quality Management Committee plans to continue to work with the Board of Selectmen and relevant Town departments to inform the public and to provide a forum for open dialogue on water quality issues.

ES.11 CWMP/TWMP Notice of Project Change Summary and Next Steps

The compliance approach for each of the watersheds in this CWMP has been laid out in detail within this report; a synopsis is presented in the Notice of Project Change summary. The Town decided to implement the Comprehensive Watershed Management Plan by moving from west to east along the southern coastline. With the completion of the Little Pond TWMP, the TWMP for Great Pond has been identified as the next watershed to be evaluated. The TWMP for the Great Pond watershed will provide information on several key elements including: the background on the watershed, update and recommended effluent discharge site selection, development of a recommended plan, an update to the environmental impact analysis, and an update to the section 61 findings and mitigation measures.

The Town has prepared Table ES-1, Estimated Costs and Financing Plans, that lists in detail 15 steps that need to be taken and decisions that need to be made at both the local and state levels to achieve a funded plan for the Great Pond watershed. In the process of developing the Great Pond TWMP, Falmouth must make an important decision in choosing a site for discharge of the treated effluent. The financing plan in Table ES-1 is consistent with Falmouth's originally stated policy of funding sewer projects in those years when new debt can replace retiring debt. The next funding window is Fiscal Year 2025, and expectations are that Town Meeting and the voters would approve a bond issue of $60 million in April/May 2024 to be effective at the start of Fiscal Year 2025 starting on July 1, 2024.

ES.12 Section 61 Findings and Mitigation Measures Update

An update to the Section 61 findings and mitigations measures is a regulatory requirement. The changes to these findings have built upon those in the original CWMP. Mitigation measures are described for general construction sites, sewer construction, wastewater treatment facility, and infiltration sites. The update also includes additional mitigation measures involving adaptive management and climate change.

Table ES.1 Estimated Costs and Financing Plans

Item	Action Item	2019	2020	2021	2022	2023	2024	2025
1	Little Pond Sewer Service Area Completed	X						
2	(A) CWMP Update/NPC; (B) Oyster Pond Draft CWMP Submitted to MEPA/DEP	X						
3	Capital Plan within debt limit: add third Sequencing Batch Reactor; plant upgrade		X	X	X			
4	Receive MEPA Secretary's Certificate for CWMP Update		X					
5	Evaluate Results of Remediation to date; Engineering Contract for Great Pond TWMP		X					
6	Draft TWMP for Great Pond Sewer Service Area; Decision on Discharge Site; Submit to MEPA/DEP		X	X				
7	Sec. Certificate for Draft TWMP; Final TWMP; Sec. Certificate for Final TWMP				X			
8	Town Meeting Sets Betterment Percentage					X		
9	Construction Design Funding; Ballot Vote					X		
10	SRF PEF Application Submittal					X		
11	Obtain Listing on the SRF Intended Use Plan						X	
12	$60M Town Vote Bond for Construction Contingent on 0% SRF Loan; Ballot Vote						X	
13	SRF Full Application Submitted - all required items must be in place						X	
14	State SRF Commitment; Bid Approval							X
15	SRF-Funded Construction Projects; On-going Adaptive Management							X

Program Funding and Timetable 2025-2040	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Town Construction of $60M																
Plan Next Construction Projects																
$40M Town Vote - Spring 2030						X										
Town Construction of $40M																
$XX Town Vote - Spring 2035 (1)											X					
Town Construction																

Notes:

CWMP = Comprehensive Wastewater Management Plan

NPC = Notice of Project Change

TWMP = Targeted Watershed Management Plan

PEF = Project Evaluation Form

SRF = State Revolving Fund

1. Due to the unknowns and uncertainties related to funding in the future, the Town has not identified the appropriation goal for 2035.

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Glossary of Common Acronyms

ACRE	Applied Coastal Research and Engineering, Inc.
ASAR	Alternatives Screening Analysis Report
BBC	Buzzards Bay Coalition
BCDHE	Barnstable County Department of Health and Environment
BMP	Best Management Practices
BOD	Biochemical Oxygen Demand
CCC	Cape Cod Commission
CCWPC	Cape Cod Water Protection Collaborative
CFR	Code of Federal Regulations
CMR	Code of Massachusetts Regulations
CRWG	Coastal Resources Working Group
CWMP	Comprehensive Wastewater Management Plan
CWMP/FEIR/TWMP	Comprehensive Wastewater Management Plan and Final Environmental Impact Report, and Targeted Watershed Management Plan
CWSRF	Clean Water State Revolving Fund
CZM	Coastal Zone Management
DCWMP/DEIR	Draft CWMP and Draft Environmental Impact Report
DEP	Department of Environmental Protection
DIN	Dissolved Inorganic Nitrogen
DMF	Division of Marine Fisheries
DO	Dissolved Oxygen
DON	Dissolved Organic Nitrogen
DPW	Department of Public Works
EEA	Energy and Environmental Affairs
EIR	Environmental Impact Report
ENF	Environmental Notification Form
EOEEA	Executive Office of Energy and Environmental Affairs
EPA	Environmental Protection Agency
FCTV	Falmouth Community Television
GHD	GHD Inc.
GHG	Greenhouse Gas

GIS	Geographic information System
gpd	Gallons per day
gpd/sf	Gallons per day per square foot
GWDP	Groundwater Discharge Permit Program
IMA	Inter-Municipal Agreement
I/A	Innovative and Alternative
JBCC	Joint Base Cape Cod
kg/d	Kilograms per Day
kg/yr	Kilograms per Year
kW	Kilowatt
lbs/yr	Pounds per Year
LPSSA (or LPSA)	Little Pond Sewer Service Area
MassDEP	Massachusetts Department of Environmental Protection
MassDOT	Massachusetts Department of Transportation
MBL	Marine Biological Laboratory
MEP	Massachusetts Estuaries Project
MEPA	Massachusetts Environmental Policy Act
MES	Marine and Environmental Services
MESA	Massachusetts Endangered Species Act
mgd	million gallons per day
mg/L	milligrams per liter
M.G.L.	Massachusetts General Law
MHC	Massachusetts Historical Commission
MSL	Mean Sea Level
NAR	Needs Assessment Report
NHESP	Natural Heritage and Endangered Species Program
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NO_3	Nitrate
NPC	Notice of Project Change
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resource Conservation Services
N/L	Nitrogen per Liter
N/yr	Nitrogen per Year

ORP	Oxidation/Reduction Potential
OSHA	Occupational Safety and Health Administration
PEF	Project Evaluation Form
PGP	Programmatic General Permit
PON	Particulate Organic Nitrogen
ppm	parts per million
PRB	Permeable Reactive Barrier
psi	pounds per square inch
PSU	Practical Salinity Units
QAPP	Quality Assurance Project Plan
RMME	Responsible Municipal Management Entity
SAS	Soil Absorption System
SBR	Sequencing Batch Reactor
sf	Square Foot
SMAST	School for Marine Science and Technology
SNEP	Southeast New England Program
SRF	State Revolving Fund
STA	Soil Treatment Area
SWPPP	Stormwater Pollution Prevention Plan
TASSA	Teaticket Acapesket Sewer Service Area
TM	Technical Memorandum
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TN/L	Total Nitrogen per Liter
TWMP	Targeted Watershed Management Plan
UCWSC	Upper Cape Water Supply Cooperative
UMass	University of Massachusetts
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WFH	West Falmouth Harbor

WFHSSSR	West Falmouth Harbor Shoreline Septic System Remediation
WHOI	Woods Hole Oceanographic Institute
WHRC	Woods Hole Research Center
WNMP	Watershed Nitrogen Management Plan
WPA	Wetlands Protection Act
WQMC	Water Quality Management Committee
WWTF	Wastewater Treatment Facility

1. Introduction

1.1 Background and Purpose

This Notice of Project Change to the Comprehensive Wastewater Management Plan and Final Environmental Impact Report and Targeted Watershed Management Plan (CWMP/FEIR/TWMP) Document provides an update to several of the Town's CWMP implementation efforts and pilot projects as identified in the January 10, 2014 Executive Office of Energy and Environmental Affairs (EOEEA) Secretary Certificate [EEA#14154] as included in Appendix 1.1. This document will be the next Notice of Project Change issued for this project. The first was specifically related to the Bournes Pond Inlet Widening Project EEA # 14154 issued March 11, 2016, as included in Appendix 1.1.

The Town of Falmouth (Town) has produced six reports related to the Comprehensive Wastewater Management Planning (CWMP) Project.

The first of these reports was the Needs Assessment Report (NAR) dated October 2007, which documented the wastewater and nitrogen-management needs for the Planning Area and related areas of Falmouth. The second report was the Alternatives Screening Analysis Report (ASAR) dated November 2007, which identified possible solutions to address the wastewater and nitrogen-management needs and then "screened" these alternative solutions to retain the most feasible ones for cost development and detailed evaluation. The third was the Environmental Notification Form (ENF) document dated December 17, 2007 that summarized the findings of the Needs Assessment Report to initiate environmental review of the project (as part of the Massachusetts Environmental Policy Act or MEPA review process). The fourth was the Draft Comprehensive Wastewater Management Plan and Draft Environmental Impact Report (DEIR) and Draft Notice of Project Change (Draft Report) dated July 30, 2012 which presented the draft plan, and further advanced MEPA review of the project. A Secretary's Certificate was issued on November 14, 2012 stating that the DEIR was adequate, and provided a scope of work for the FEIR.

The CWMP/FEIR/TWMP, the fifth report dated September 16, 2013, summarized the detailed evaluations and the changes made since the review of the Draft Report, and presented the Recommended Plan to address the wastewater and nitrogen management needs of the Little Pond watershed. It also presented the estimated environmental impact (and benefits) of the Recommended Plan as compared to the consequences of not acting on the wastewater needs (also called the No-Action Alternative).

The sixth report is the Amended TWMP dated October 6, 2014. This document was issued to address a Massachusetts Department of Environmental Protection (MassDEP) request to clarify the Town's approach for addressing the Nitrogen Total Maximum Daily Load (TMDL) for Little Pond using the traditional and non-traditional management approaches identified in the 2013 CWMP Report.

Several components of the CWMP/TWMP needed further coordination and agreement, and therefore, the associated Adaptive Management Plan identified a number of pilot projects and other initiatives necessary to determine the feasibility of various non-traditional wastewater and nitrogen management technologies and approaches.

These pilot projects and other initiatives have been primarily funded by Article 17 of Spring 2011 Town Meeting and a ballot vote in May 2011 (see Appendix 1.1) and are underway. Their progress to date is summarized in this document.

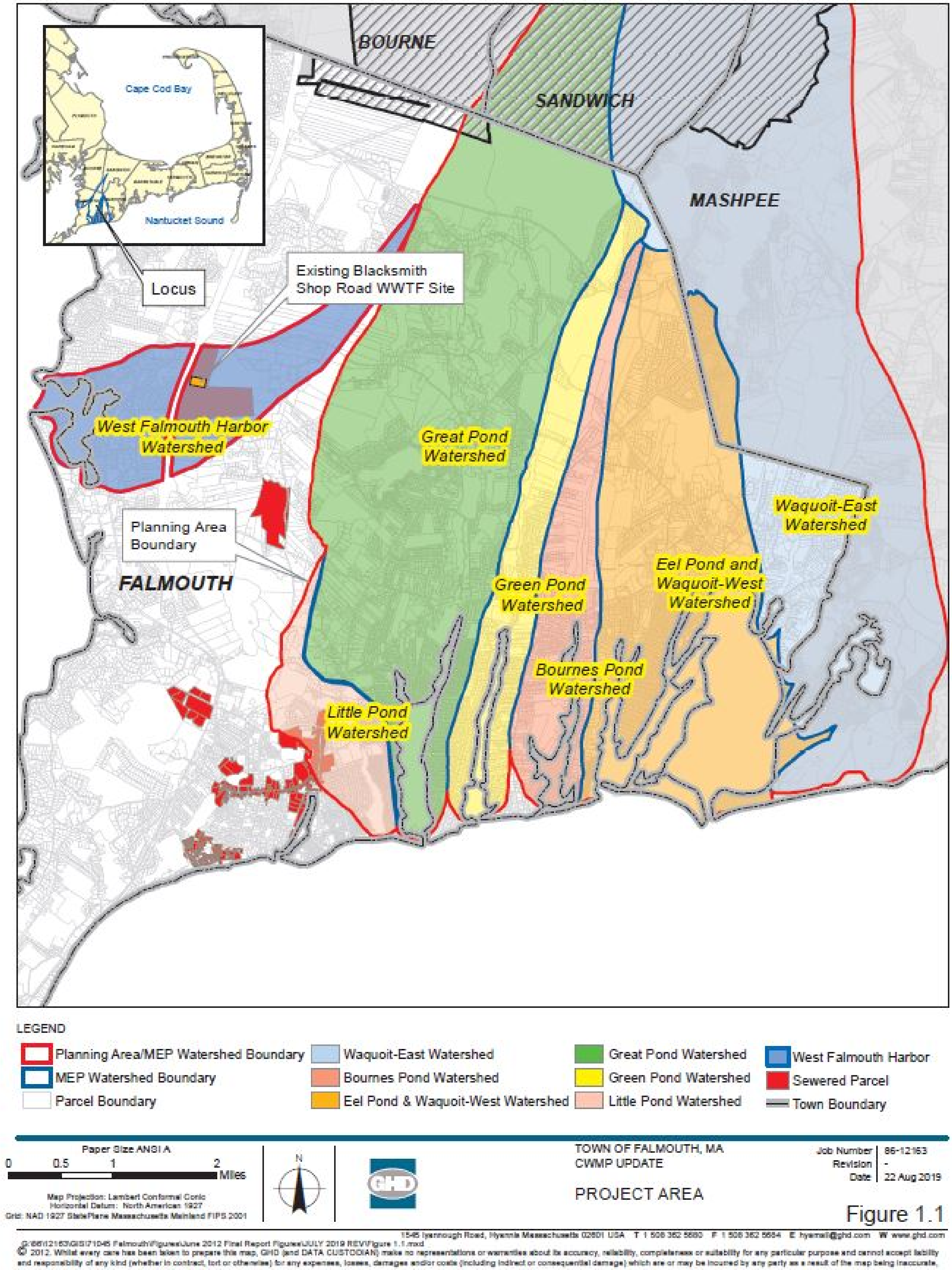
This update has been prepared by GHD, the Falmouth Water Quality Management Committee, and its contractor Science Wares, and has been approved by the Falmouth Board of Selectmen. It is a summary of the efforts and studies to date that support the Compliance Plan Approaches developed for each watershed.

1.2 Planning Area

The Town of Falmouth is located in the southwestern portion of Cape Cod as shown in the following Figure 1.1. This figure also identifies the Planning Area as the watersheds to Little, Great, Green, Bournes, and Eel Ponds, and Waquoit Bay as well as the West Falmouth Harbor watershed. All of the estuarine waters in the Planning Area are impacted by excessive nitrogen loadings in the respective watersheds.

Demonstration/pilot projects were initiated for the following non-traditional nitrogen management approaches:

- Shellfish, a Town-wide program with a focus on the West Falmouth Harbor and Little Pond watersheds.
- Eco-Toilets, a Town-wide initiative.
- Innovative and alternative (I/A) septic systems with a focus in West Falmouth Harbor watershed.
- Permeable Reactive Barrier (PRB) feasibility studies in Great Pond and Bournes Pond watersheds.
- Inlet widening in the Bournes Pond watershed.
- Fertilizer bylaw is a Town-wide initiative.


BOURNE
SANDWICH
MASHPEE
FALMOUTH
Cape Cod Bay
Nantucket Sound
Locus
Existing Blacksmith Shop Road WWTF Site
West Falmouth Harbor Watershed
Great Pond Watershed
Planning Area Boundary
Waquoit-East Watershed
Eel Pond and Waquoit-West Watershed
Green Pond Watershed
Bournes Pond Watershed
Little Pond Watershed
LEGEND
Planning Area/MEP Watershed Boundary
MEP Watershed Boundary
Parcel Boundary
Waquoit-East Watershed
Bournes Pond Watershed
Eel Pond & Waquoit-West Watershed
Great Pond Watershed
Green Pond Watershed
Little Pond Watershed
West Falmouth Harbor
Sewered Parcel
Town Boundary
Paper Size ANSI A
0 0.5 1 2
Miles
Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1927
Grid: NAD 1927 StatePlane Massachusetts Mainland FIPS 2001
N
TOWN OF FALMOUTH, MA
CWMP UPDATE
PROJECT AREA
Job Number 86-12163
Revision -
Date 22 Aug 2019
Figure 1.1

1.3 Update Outline

This Notice of Project Change (NPC) Report provides an update of the numerous efforts that the Town has been undertaking to develop a TMDL compliance approach for each of its impaired South Coast Embayments.

The document includes the following chapters:

Chapter 1: Introduction and background on the project.

Chapter 2: A summary of water quality monitoring data for Little, Great, Green, and Bournes Pond and Eel Pond/Waquoit Bay.

Chapter 3: A summary of pilot projects including: shellfish aquaculture, eco-toilets, I/A septic systems, PRBs, nitrogen control fertilizer bylaw, stormwater management, and inlet widening.

Chapter 4: Little Pond TWMP update.

Chapter 5: West Falmouth Harbor TWMP update.

Chapter 6: Great Pond watershed planning scenario.

Chapter 7: Green Pond watershed planning scenario.

Chapter 8: Bournes Pond watershed planning scenario.

Chapter 9: Eel Pond/Waquoit Bay watershed planning scenario.

Chapter 10: A summary of public outreach efforts.

Chapter 11: A summary of the NPC and next steps.

2. Water Quality Monitoring and Data Summary

2.1 Little, Great, Green, and Bournes Pond Water Quality Monitoring Data

2.1.1 Introduction

Water quality monitoring of Little Pond, Great Pond, Green Pond, and Bournes Pond was conducted by the Falmouth Pond Watch Monitoring Program through collaboration with the Town of Falmouth in conjunction with the University of Massachusetts – Dartmouth School for Marine Science and Technology (SMAST). Monitoring in these four estuaries by Pond Watch has occurred annually since 1997, with additional monitoring data prior to the establishment of the Pond Watch Monitoring Program dating back to 1989. All four ponds are post-glacial stream valleys that have been flooded by rising sea levels. Their average depth is about six feet, slightly deeper at the mouth and very shallow at the head.

In the Massachusetts Estuary Project (MEP) Report for each water body, a target threshold nitrogen concentration (with units of milligrams per liter) was established for a "sentinel location" in the water body, representing restored/desired habitat quality for the water body (Table 2.1). The MEP report then identifies a Total Maximum Daily Load (TMDL) of nitrogen (with units of kilograms per day) from the watershed expected to achieve the target nitrogen concentration at the sentinel location.

Table 2.1 Sentinel Station ID and Target Threshold Nitrogen Concentration Values Established in the MEP Reports

Estuary	Sentinel Station ID	Target Threshold Nitrogen Concentration (mg/L)
Little Pond	LP2	0.449
Great Pond	GT5	0.404
Green Pond	G4	0.421
Bournes Pond	B3	0.454

Analyses of data trends for Little Pond, Great Pond, Green Pond, and Bournes Pond are made based on the pre-MEP baseline water quality data compared to the water quality data collected through Pond Watch for each estuary. **Data presented in this chapter are for the sentinel station of each estuary.** Water quality monitoring data for all sampling sites included in the Pond Watch Monitoring Program are found in the report entitled *Pond Watch Nutrient Related Water Quality Bournes Pond, Great Pond, Green Pond, Little Pond, Oyster Pond, West Falmouth Harbor: SMAST POST-MEP Sampling Assessment (2004 -2007)* by Howes et al. 2019 (Appendix 2.1). The following are the main components of the Falmouth Pond Watch Monitoring Program:

- Primary water quality parameters measured for historical monitoring include total nitrogen, salinity, and chlorophyll *a* concentrations.
  - Additional measurements obtained include: total depth, temperature, Secchi depth, nitrate + nitrite, ammonium, dissolved organic nitrogen, particulate organic nitrogen, phosphate, and dissolved oxygen.

- Monitoring of four or more stations in each estuary.
- Monitoring of each station four times annually during July and August with annual average measurements of all data presented.
  - For each sampling date and parameter at surface and at depth, two sets of samples measured and averaged.

2.1.2 Little Pond Monitoring Data

There are four monitoring stations in the Pond Watch Monitoring Program for the Little Pond estuary. Station 'LP2' is the sentinel station and is located in the mid-reach of the pond (Figure 2.1).

Figure 2.1 Monitoring Stations for Little Pond (Howes et al. 2019)

The MEP study for Little Pond (January 2006) determined the nitrogen threshold of the Little Pond Sentinel Station to be 0.449 mg TN/L. Comparison of the monitoring data in Howes et al. 2019 is divided into three analysis periods: pre-MEP monitoring, post-MEP monitoring, and recent monitoring. The average total nitrogen concentration (± standard deviation) by Pond Watch monitoring period and an additional point generated to encompass all available post-MEP data are presented in Table 2.2. Annual average total nitrogen (± standard deviation) for the sentinel station is presented in Figure 2.2. The average annual total nitrogen (± standard deviation) by station for each of the Pond Watch analysis periods is presented in Figure 2.3.

Table 2.2 Summary of Historical Total Nitrogen Concentration at the Little Pond Sentinel Station (LP2)

	Target Threshold Nitrogen Concentration	Pre-MEP Baseline (prior to 2005)	Post-MEP Monitoring (2005 – 2014)	Recent Monitoring (2015- 2017)	Post-MEP Continuous Average (2005 – 2017)
Total Nitrogen (mg TN/L)	0.449	0.898	1.048 (± 0.465)	0.974 (± 0.392)	1.030 (± 0.447)

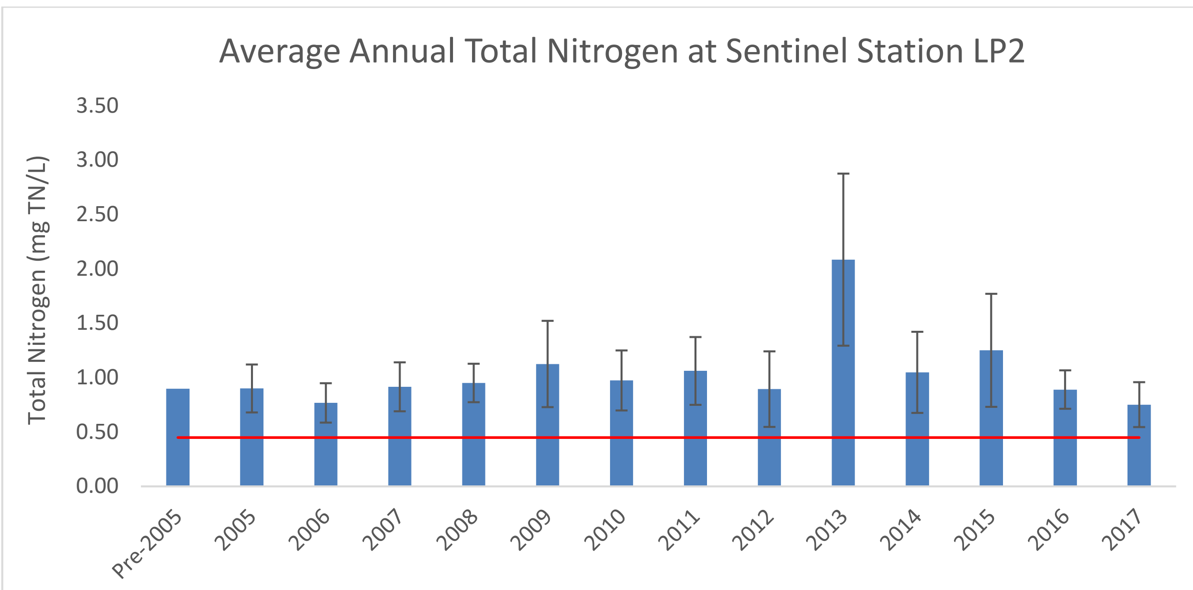


Figure 2.2 Average Annual Total Nitrogen Concentration for Little Pond Sentinel Station (LP2) (The target threshold concentration is represented by the red line.)

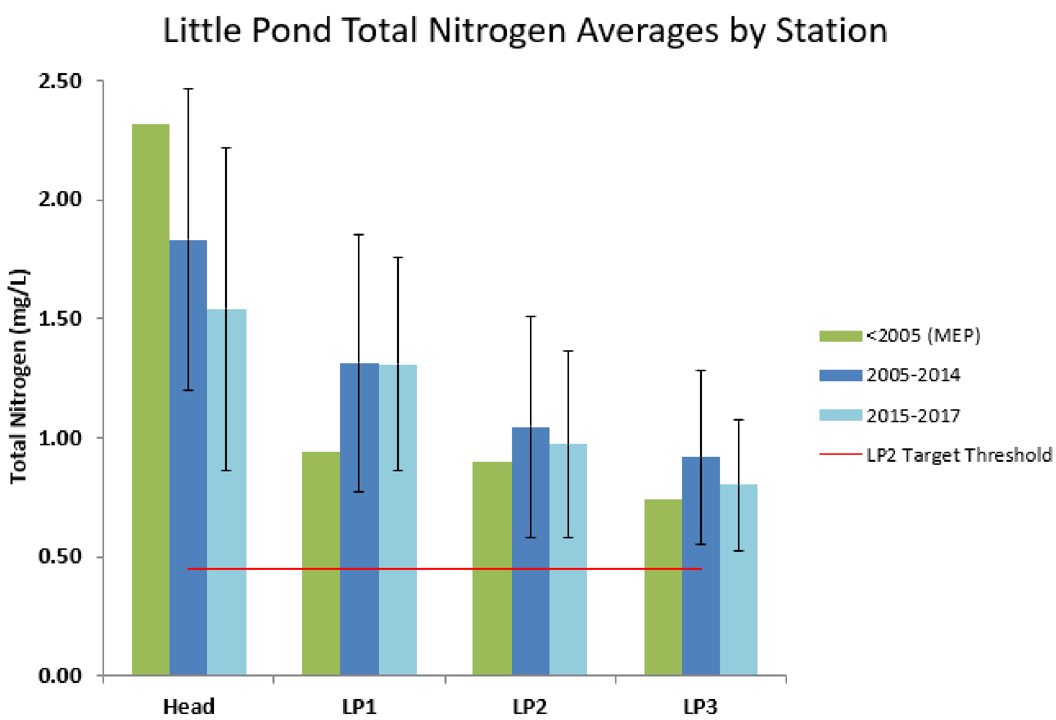


Figure 2.3 Average Annual Total Nitrogen Concentration by Monitoring Period for all Monitoring Stations in Little Pond

According to the Pond Watch data, there was slight interannual variability in the salinity measurements for the Little Pond Sentinel Station from 2005 to 2017. The average annual salinity at the sentinel station ranged from 24.5 to 29.5 PSU (Practical Salinity Unit) from 2005 to 2017 with an overall average of 27.0 PSU.

Chlorophyll *a* pigment concentration measurements are a highly variable metric. In the Little Pond estuary in 2013, an annual average of 24.1 µg/L was measured by Pond Watch, while in 2014 an annual average of 2.3 µg/L of chlorophyll *a* was measured. The range of annual average chlorophyll *a* measurements from 2005 to 2017 was from 2.3 to 24.1 µg/L. The overall average was 16.5 µg/L.

Beginning in 2016, as a baseline study, the US Geological Survey (USGS) and US Environmental Protection Agency conducted additional monitoring to examine the effects of sewer installation on groundwater quality in the Maravista Peninsula portion of the Little Pond watershed. In 2016, approximately one year prior to the start of sewer connections in the Little Pond Sewer Service Area, the USGS installed numerous wells to monitor the groundwater. The parameters monitored included nutrients, major ions, boron, and chloride. Information and data from the USGS monitoring efforts can be found at:

https://www.usgs.gov/centers/new-england-water/science/assessment-hydrologic-and-water-quality-changes-shallow?qt-science_center_objects=0%23qt-science_center_objects

Nutrient sampling by the USGS from 2016 through 2018 showed variable nitrate (NO_3) concentrations over time. No significant decrease in nutrient concentration in the groundwater has been seen to date, probably because many homes have yet to be connected to the sewer system.

The deadline for residences to connect to the sewer is April 2019. The USGS plans to continue groundwater monitoring efforts through at least 2020.

The water quality data from both the Pond Watch and USGS monitoring efforts indicate that there has been no significant reduction in the annual average total nitrogen in Little Pond at the sentinel station (LP2) to date. Little Pond remains above the threshold established by the MEP report to restore critical marine habitat and thus remains nitrogen impaired. However, it is anticipated that improvements from the Little Pond Sewer (see Chapter 4) will be seen in the water quality monitoring data within the next few years.

Key Findings from the Pond Watch Monitoring Program for Little Pond:

- As of 2017, Little Pond shows no sign of nitrogen reduction and remains impaired.
- There is no significant trend in total nitrogen concentration from 2005 to 2017.

2.1.3 Great Pond Monitoring Data

In addition to the sentinel station (GT5), five additional stations in the upper and lower reaches of the Great Pond estuary have been monitored annually by the Falmouth Pond Watch Monitoring Program (Figure 2.4). The sentinel station is located in the mid-reach of Great Pond.

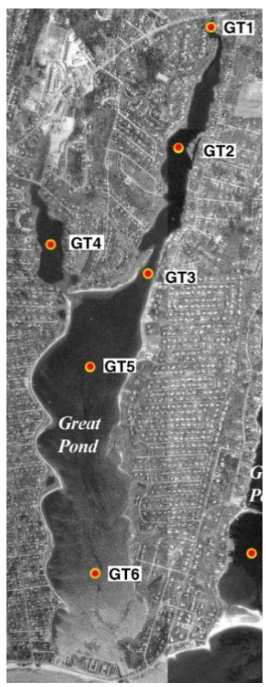


Figure 2.4 Monitoring Stations for Great Pond (Howes et al. 2019)

The MEP study for Great Pond (April 2005) established a target nitrogen threshold for the sentinel station of 0.404 mg TN/L (Table 2.3). The average total nitrogen concentration (± standard deviation) by Pond Watch monitoring period and an additional point generated to encompass all available post-MEP data are also presented in Table 2.3. The average annual total nitrogen measurements (± standard deviation) for the sentinel station are presented in Figure 2.5. The average annual total nitrogen concentration (± standard deviation) by station for each Pond Watch monitoring period is presented in Figure 2.6.

Table 2.3 Summary of Historical Total Nitrogen Concentration at the Great Pond Sentinel Station (GT5)

	Target Threshold Nitrogen Concentration	Pre-MEP Baseline (prior to 2004)	Post-MEP Monitoring (2004 – 2014)	Recent Monitoring (2015- 2017)	Post-MEP Continuous Average (2004 – 2017)
Total Nitrogen (mg TN/L)	0.404	0.644	0.788 (± 0.186)	0.748 (± 0.161)	0.779 (± 0.181)

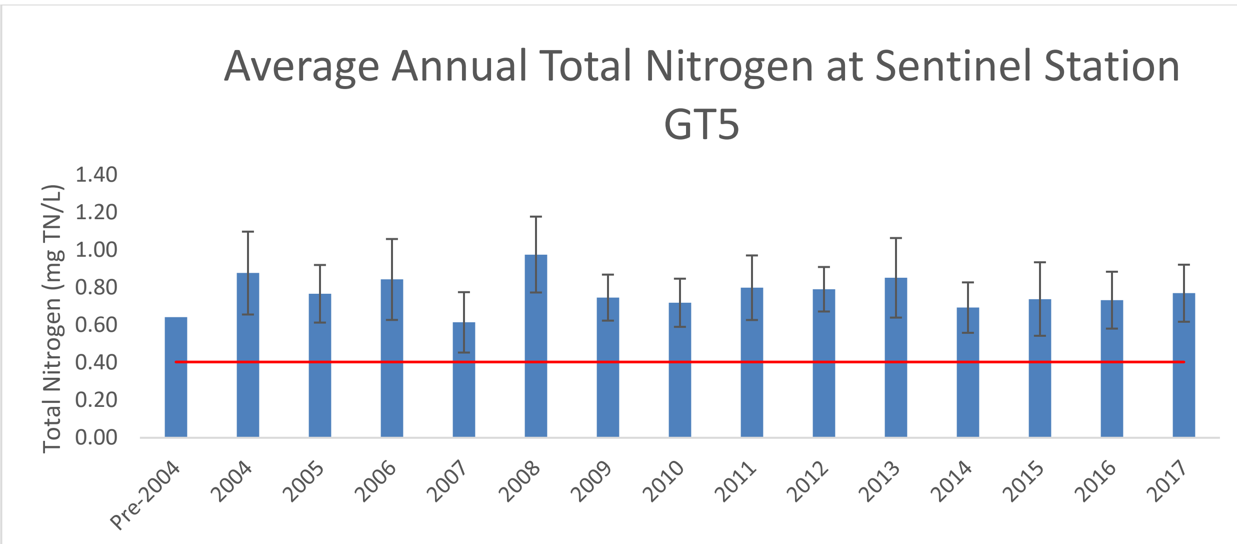


Figure 2.5 Average Annual Total Nitrogen Concentration for Great Pond Sentinel Station (GT5)

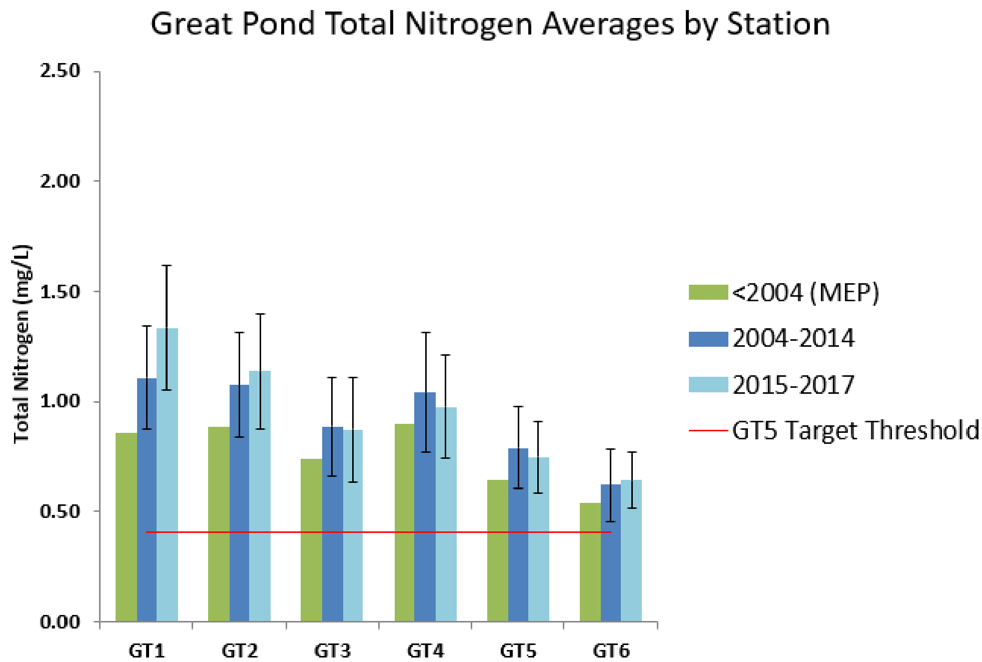


Figure 2.6 Average Annual Total Nitrogen Concentration by Monitoring Period for all Monitoring Stations in Great Pond

There was interannual variability observed in salinity measurements for the sentinel station for Great Pond from 2004 to 2017. Average annual salinity at the sentinel station ranged from 19.4 to 28.8 ppt (parts per thousand) from 2004 to 2017 with an overall average of 26.1 ppt.

Average chlorophyll *a* pigment measurements varied on an annual basis. In 2007, an average of 12.5 µg/L was measured, while in 2008 an average of 34.3 µg/L of chlorophyll *a* was measured. The range of average chlorophyll *a* concentrations from 2004 to 2017 was from 7.0 to 34.3 µg/L. The overall average chlorophyll *a* concentration for 2004 to 2017 was 17.3 µg/L.

The water quality data indicates that there has been no significant change in the average annual total nitrogen in Great Pond as indicated by the sentinel station (GT5). Great Pond remains above the threshold indicated by the MEP report to restore critical marine habitat and thus remains nitrogen impaired.

Key Findings from the Pond Watch Monitoring Program for Great Pond:

- As of 2017, Great Pond shows no sign of nitrogen change and remains impaired.
- There is no significant trend in total nitrogen concentration from 2004 to 2017.

2.1.4 Green Pond Monitoring Data

There are six monitoring stations in the Pond Watch Monitoring Program for the Green Pond estuary. Station G4 is the sentinel station and is located toward the lower reach of the pond (Figure 2.7).

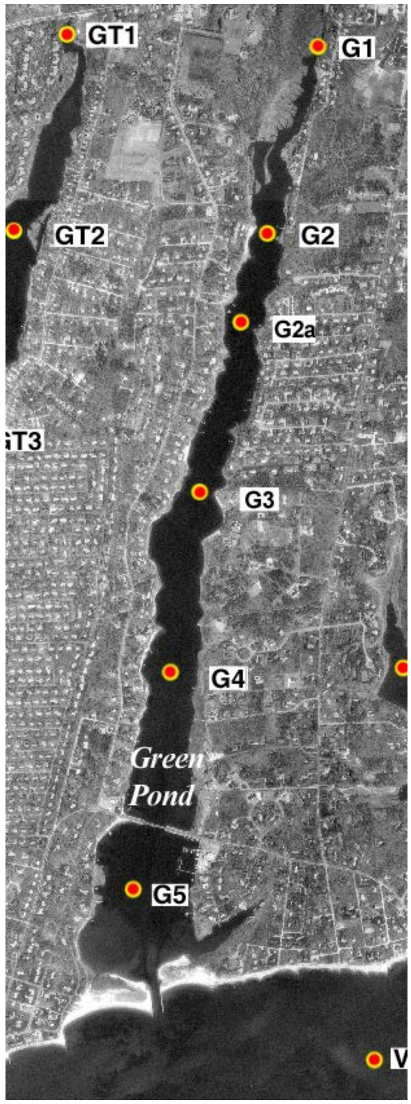


Figure 2.7 Monitoring Stations for Green Pond (Howes et al. 2019)

The MEP study for Green Pond (April 2005) determined the average annual nitrogen threshold at the sentinel station to be 0.421 mg TN/L (Table 2.4). The average total nitrogen concentration (± standard deviation) by Pond Watch monitoring period and an additional point including all available post-MEP data are presented in Table 2.4. The average annual total nitrogen measurements (± standard deviation) for the sentinel station from 2004 to 2017 are presented in Figure 2.8. The average annual total nitrogen (± standard deviation) by monitoring period for each monitoring station is presented in Figure 2.9.

Table 2.4 Summary of Historical Total Nitrogen Concentration at the Green Pond Sentinel Station (G4)

	Target Threshold Nitrogen Concentration	Pre-MEP Baseline (prior to 2004)	Post-MEP Monitoring (2004 – 2014)	Recent Monitoring (2015- 2017)	Post-MEP Continuous Average (2004 – 2017)
Total Nitrogen (mg TN/L)	0.421	0.540	0.638 (± 0.142)	0.618 (± 0.132)	0.634 (± 0.139)

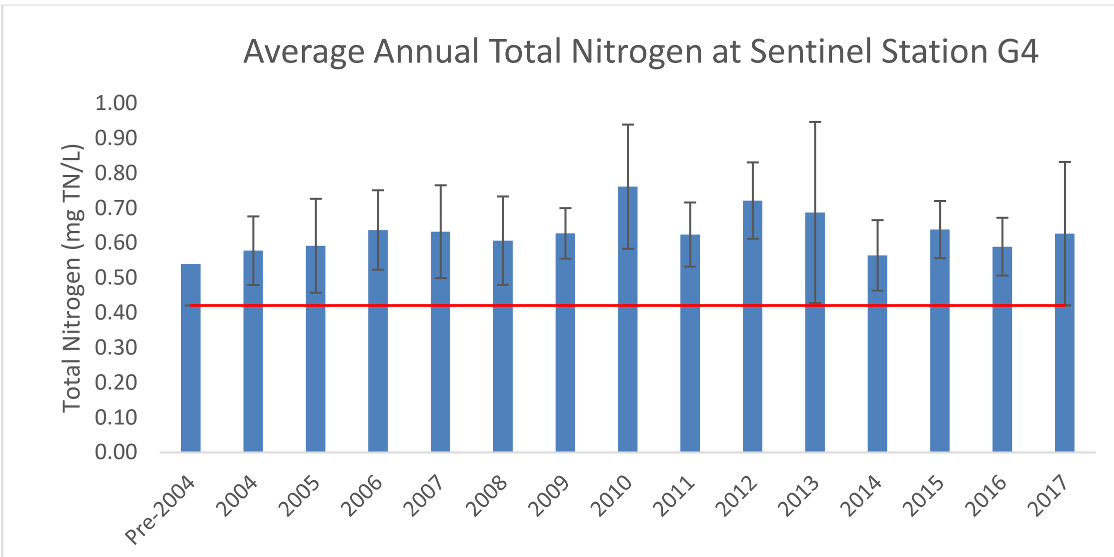


Figure 2.8 Average Annual Total Nitrogen Concentration for Green Pond Sentinel Station (G4)

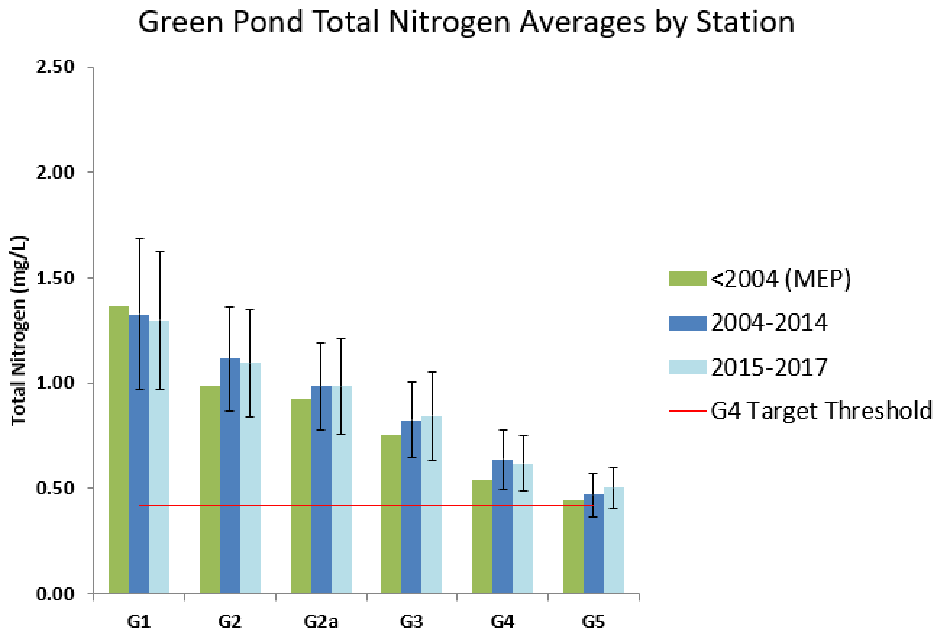


Figure 2.9 Average Annual Total Nitrogen Concentration by Monitoring Period for all Monitoring Stations in Green Pond

There was low inter-annual variability in salinity measurements for the sentinel station for Green Pond from 2004 to 2017. Average annual salinity at the sentinel station ranged from 24.0 to 28.5 ppt from 2004 to 2017 with an overall average of 27.4 ppt.

Average chlorophyll *a* pigment measurements indicated inter-annual variability. The range of annual average chlorophyll *a* measurements from 2004 to 2017 was from 4.2 to 19.4 µg/L. The overall average annual chlorophyll *a* concentrations for 2004 to 2017 was 13.3 µg/L.

The water quality data indicate that there has been no significant change in the total nitrogen in Green Pond as indicated by the sentinel station (G4). Green Pond remains above the threshold indicated to restore critical marine habitat and thus remains significantly nitrogen impaired.

Key Findings from the Pond Watch Monitoring Program for Green Pond:

- As of 2017, Green Pond shows no sign of nitrogen change and remains impaired.
- There is no significant trend in total nitrogen concentration from 2004 to 2017.

2.1.5 Bournes Pond Monitoring Data

There are six monitoring stations for Bournes Pond, two in the lower reach of the pond, one in the western lesser branch of the pond, and three stations in the upper reaches of the main branch of the pond. The sentinel station, B3, is located in the mid-reach of the main branch of the pond (Figure 2.10).

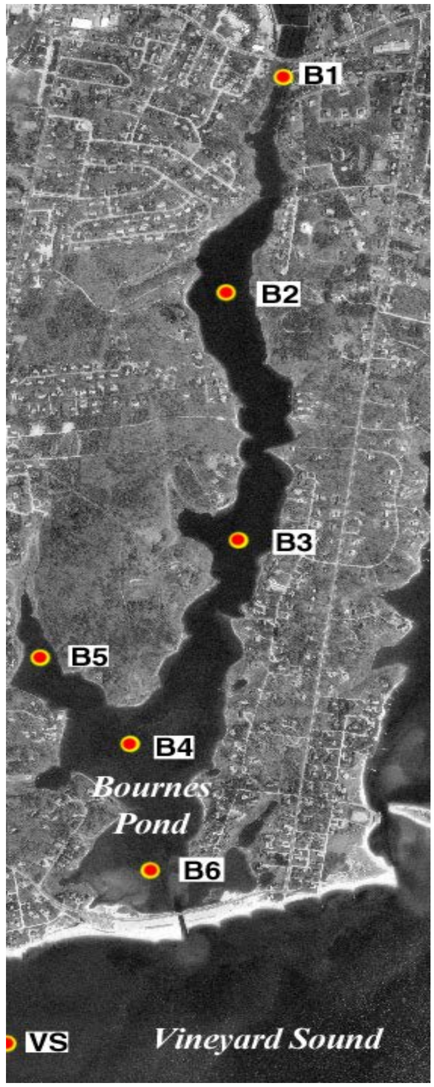


Figure 2.10 Monitoring Stations for Bournes Pond (Howes et al. 2019)

The nitrogen threshold established by the MEP study for Bournes Pond (April 2005) at the sentinel station was determined to be 0.454 mg TN/L (Table 2.5). The average total nitrogen concentration (± standard deviation) by Pond Watch monitoring period and the average of all available post-MEP data are presented in Table 2.5. The Pond Watch average annual total nitrogen measurements (± standard deviation) for the sentinel station at all sampling depths from 2004 to 2017 are presented in Figure 2.11. The average annual total nitrogen (± standard deviation) by period for each monitoring station is presented in Figure 2.12.

Table 2.5 Summary of Historical Total Nitrogen Concentration at the Bournes Pond Sentinel Station (B3)

	Target Threshold Nitrogen Concentration	Pre-MEP Baseline (prior to 2004)	Post-MEP Monitoring (2004 – 2014)	Recent Monitoring (2015- 2017)	Post-MEP Continuous Average (2004 – 2017)
Total Nitrogen (mg TN/L)	0.404	0.644	0.788 (± 0.186)	0.748 (± 0.161)	0.779 (± 0.181)

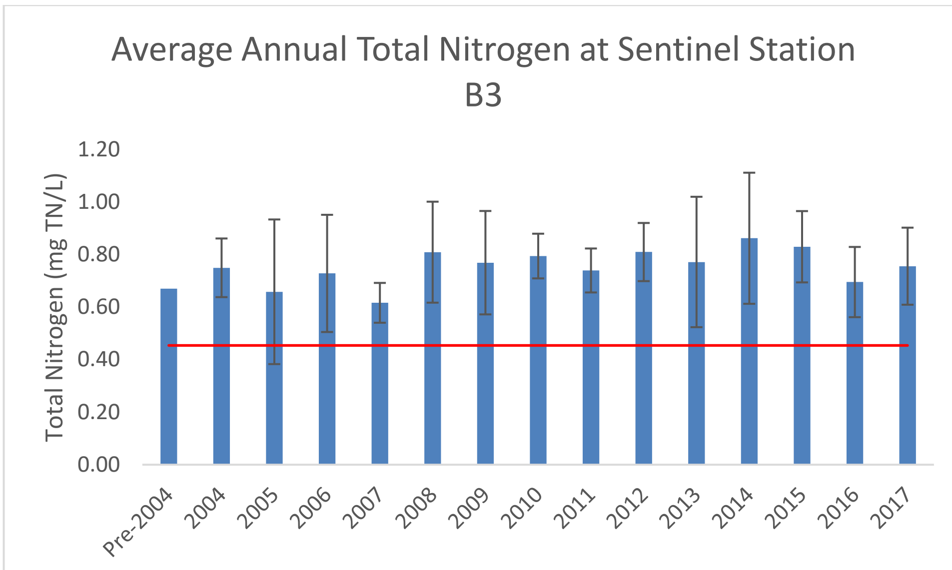


Figure 2.11 Average Annual Total Nitrogen Concentration for Bournes Pond Sentinel Station (B3)

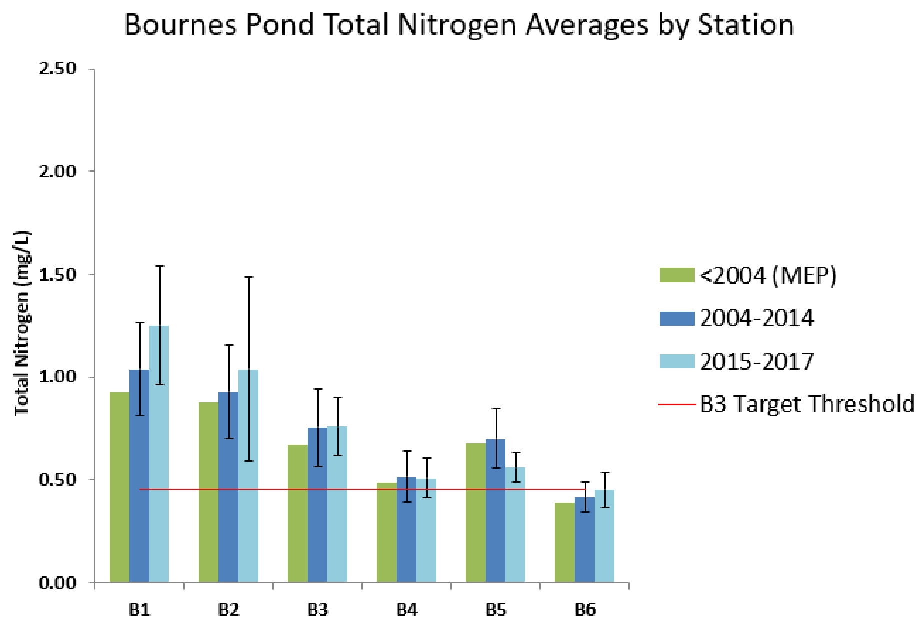


Figure 2.12 Average Annual Total Nitrogen Concentration by Monitoring Period for all Monitoring Stations in Bournes Pond

According to the Pond Watch data, there was low interannual variability in the salinity measurements for the sentinel station for Bournes Pond from 2004 to 2017. The average annual salinity at the sentinel station ranged from 26.5 to 29.0 PSU from 2004 to 2017 with an overall average of 27.9 PSU.

Chlorophyll *a* pigment concentration measurements indicated high interannual variability. The range of average chlorophyll *a* concentrations from 2004 to 2017 was from 3.3 to 23.3 µg/L. The overall average for 2004 to 2017 was 10.9 µg/L.

The water quality data indicate that there has been no significant change in the total nitrogen in Bournes Pond as indicated by the sentinel station (B3). Bournes Pond remains above the threshold indicated in the MEP to restore critical marine habitat and thus remains nitrogen impaired.

Key Findings from the Pond Watch Monitoring Program for Bournes Pond:

- As of 2017, Bournes Pond shows no sign of nitrogen change and remains impaired.
- There is no significant trend in total nitrogen concentration from 2004 to 2017.

<u>All four ponds show no sign of nitrogen change and remain impaired, and there is no significant trend in TN in any of the ponds over their study periods.</u>

2.2 Waquoit Bay/Eel River Water Quality Monitoring Data

2.2.1 Introduction

The watershed of the Waquoit Bay estuary is shared among the towns of Falmouth, Mashpee, and Sandwich. Water quality monitoring efforts for the entirety of the Waquoit Bay estuarine system were conducted by the SMAST under contract with the Mashpee Water Quality Monitoring Consortium.

The primary focus of water quality monitoring efforts in Falmouth's estuaries is to monitor the concentration of nitrogen at the sentinel location compared to the target threshold nitrogen concentration established in the estuary-specific MEP report (Table 2.6). The MEP report for Waquoit Bay (2013) established a target threshold nitrogen concentration for Waquoit Bay as a whole system as well as individual thresholds for the Childs River and Eel Pond sub-embayments. The monitored areas of the Waquoit Bay system that are in Falmouth include the main basin (including the Seapit River), Eel Pond, Childs River, Quashnet River, and a portion of Hamblin Pond. The water quality monitoring results for these relevant areas are summarized in this section.

Analyses of data trends for Waquoit Bay including the main basin, Eel Pond, Childs River, Quashnet River and Hamblin Pond are made based on the long-term baseline water quality data (2001 – 2009) and data from the periods of 2010 – 2012, 2013 – 2015, 2016 and 2017 as presented in the SMAST report entitled *Water Quality Monitoring Program for the Popponesset Bay and Waquoit Bay Estuaries* by Howes et al. 2018 (Appendix 2.1). A summary of the water quality monitoring data is found in this report.

The key features of the Waquoit Bay water quality monitoring program consisted of:

- Primary water quality measurements of parameters including dissolved nutrients, particulate nutrients, chlorophyll/pheophytin and additional field parameters
- Monitoring of the sentinel station(s) and additional established stations throughout the estuary
- Monitoring of each station four times annually during July and August

Table 2.6 Sentinel Station ID and Target Threshold Nitrogen Concentration Values Established in the MEP Reports

Sub-embayment	Sentinel Station ID	Target Threshold Nitrogen Concentration (mg/L)
Waquoit Bay – Whole System	WB12	0.38
Eel Pond – Western Branch	ER01	0.50
Childs River – Upper	CR02	0.38

2.2.2 Waquoit Bay

There are 19 sampling stations distributed throughout the Waquoit Bay system (Figure 2.13). With the exception of stations WB01 through WB05, all stations are in the Town of Falmouth. The sentinel station for the main basin of Waquoit Bay is WB12 in the upper portion of the main basin. Eel Pond is the western sub-embayment of Waquoit Bay and is further divided into the Eel River and Childs River sub-embayments. Eel River is the western-most branch of Eel Pond, and its sentinel station is ER01 in the upper portion of its main branch. The sentinel station for the Childs River sub-embayment area of Waquoit Bay is CR02, in its upper reach.

Figure 2.13 Waquoit Bay Water Quality Monitoring Stations
(image from Howes et al. 2018)

Total Nitrogen Monitoring Results

The MEP report for Waquoit Bay (March 2013) determined the nitrogen thresholds for both the Waquoit Bay sentinel station WB12 and the Childs River sentinel station CR02 to be 0.38 mg TN/L, and for the western branch of the Eel Pond sub-embayment (ER01) to be 0.50 mg TN/L. Neither the Seapit River, the Quashnet River, nor Hamblin Pond were assigned specific nitrogen thresholds in the MEP report. The Seapit River is a channel connecting Eel Pond to Waquoit Bay. The Quashnet River discharges directly into the main basin of Waquoit Bay, and Hamblin Pond discharges into the main basin of the bay by way of the Little River. Monitoring results for total nitrogen for the Waquoit Bay system including each of Falmouth's sub-embayments are presented in Figure 2.14.

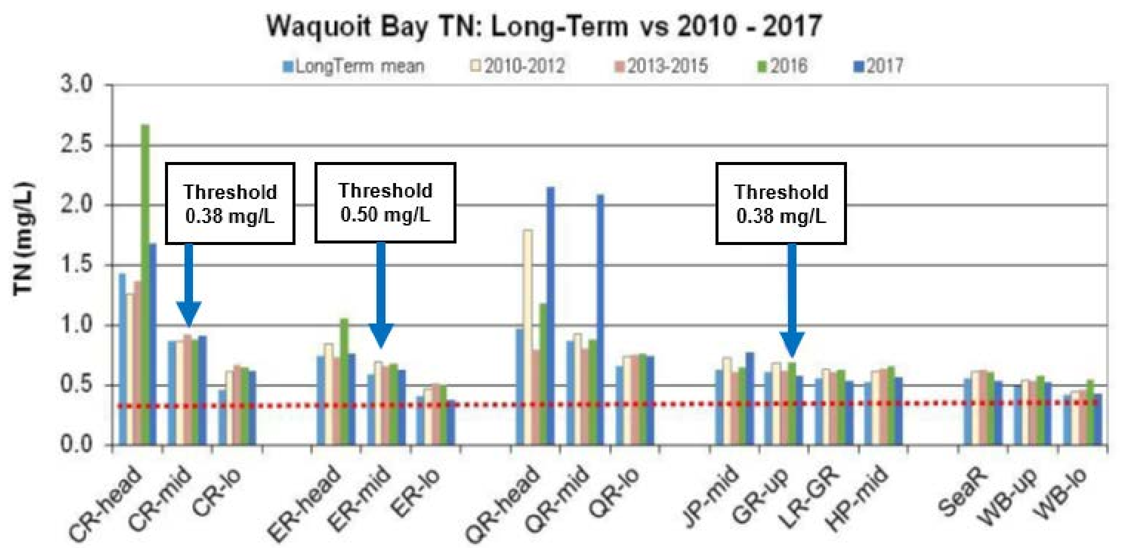


Figure 2.14 Average Total Nitrogen Concentration in the Waquoit Bay Estuary for Long-Term Data (2001 – 2009) and During 2010 – 2017

In the above figure, the target threshold nitrogen concentration for the Waquoit Bay sentinel station is indicated by the red line (0.38 mg TN/L). WB = Waquoit Bay main basin; SeaR = Seapit River; ER = Eel River; CR = Childs River; QR = Quashnet River; HP = Hamblin Pond; JP = Jehu Pond; GR = Great River; LR-GR = Little River Great River confluence; LR = Little River. Head = uppermost reach; mid = middle reach; lo = lower basin (Howes et al. 2018).

The main basin of Waquoit Bay including the Seapit River shows a potential slight increase in average total nitrogen concentrations compared to the previous long-term monitoring period (2001 – 2009). Overall there are minor fluctuations in the average total nitrogen concentrations between the long-term and recent monitoring periods. The lower basin of the bay shows some nitrogen impairment with declining water quality conditions moving towards the upper reaches of the bay into the Seapit River. No standard deviation values were provided in the Howes (2018) report.

The lower and mid-reaches for both Eel River and Childs River show a similar total nitrogen concentration trend as in the main basin. There has generally been a small increase in the average total nitrogen concentrations in these regions since the long-term monitoring data period. Both sub-embayments show the highest TN values in their upper reaches (Figure 2.14). The highest average total nitrogen values occurred in the upper reaches of both sub-embayments in 2016. These high average total nitrogen values in 2016 are associated with large rust tide blooms (Howes et al. 2018), and this is supported by a similar trend in the results of the chlorophyll *a* monitoring. The MEP report established a separate, higher threshold concentration for Eel River of 0.50 mg TN/L. Monitoring data at the Eel River sentinel station indicate that this sub-embayment still exceeds its target threshold for nitrogen and is considered impaired. The nitrogen concentration at the Childs River sentinel station exceeds its target threshold as well and Childs River water quality remains impaired.

The lower reaches of the Quashnet River follow a similar trend to the main basin of Waquoit Bay of a potential slight increase in the average total nitrogen concentration compared to the previous long-term monitoring period. There is fluctuation in the average total nitrogen in the mid and upper reaches between all monitoring periods. The 2017 monitoring of the Quashnet River shows a large increase in the average total nitrogen measured in the mid-reach and head of the river. Howes et al. (2018) states that this increase caused a large phytoplankton bloom, and this was supported by the corresponding increased chlorophyll *a* measurements (Figure 2.16). The average total nitrogen concentration at the sentinel location in the Quashnet River remains above the threshold concentration of 0.38 mg TN/L, and this region remains impaired.

The single monitoring station in Hamblin Pond shows an increase in the average total nitrogen concentration compared to the previous long-term monitoring period. The results from the recent monitoring periods indicate that the average total nitrogen concentrations in Hamblin Pond have remained relatively stable.

Salinity Monitoring Results

Water quality monitoring results for the average salinity for the Waquoit Bay system including each of Falmouth's sub-embayments are presented in Figure 2.15. Average salinity measurements for the main basin show the most fluctuations in the upper basin. Overall there appears to be low variability in the salinity of the lower Waquoit Bay basin between the monitoring periods, and minor variability in the Seapit River. The average salinity measurements in Eel River show very little variation between monitoring periods. The Childs River shows high variation in salinity at the head of the river, moderate fluctuations in the lower reach, and general consistency in the mid-reach. The variability in average salinity measurements seen at the head of Childs River is thought to be primarily driven by annual precipitation (Howes et al. 2018). The Quashnet River shows some fluctuation in salinity throughout the system. In general, the respective annual trend is reflected throughout all reaches of the river for a given monitoring period. Hamblin Pond shows some minor salinity fluctuations between the monitoring periods.

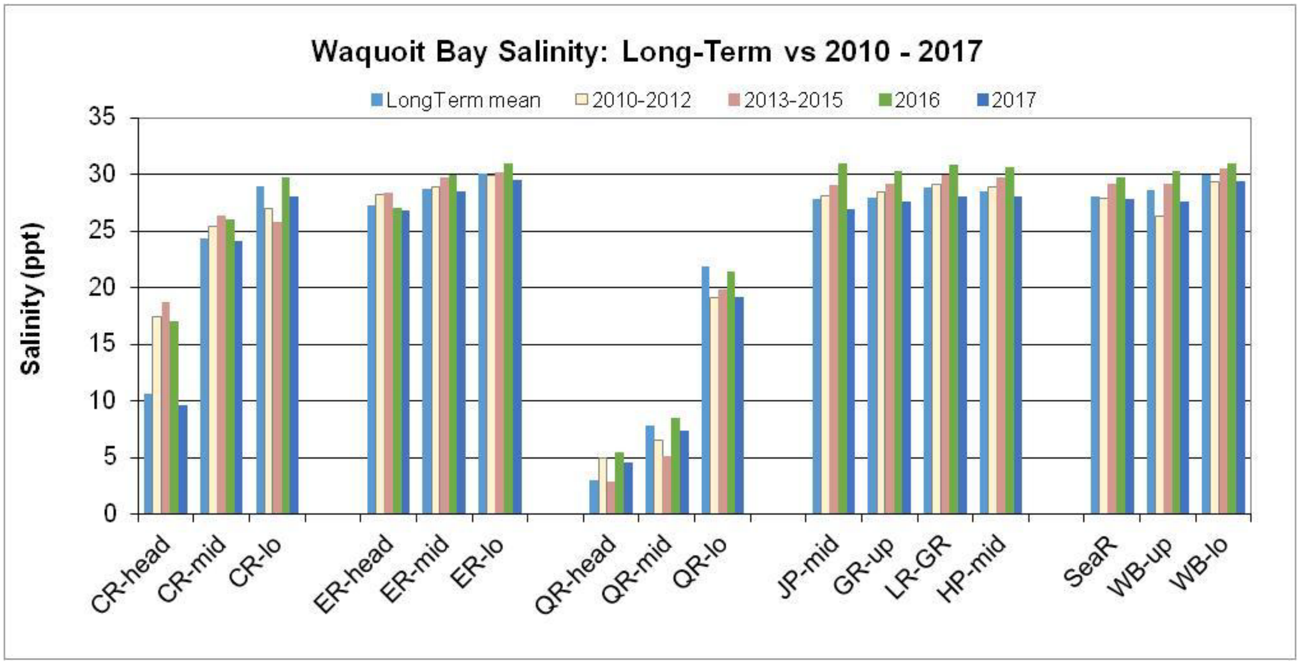


Figure 2.15 Average Salinity Measurements in the Waquoit Bay Estuary for Long-Term Data (2001 – 2009) and During 2010 – 2017

In the Figure 2.15, WB = Waquoit Bay main basin; SeaR = Seapit River; ER = Eel River; CR = Childs River; QR = Quashnet River; HP = Hamblin Pond; JP = Jehu Pond; GR = Great River; LR-GR = Little River Great River confluence; LR = Little River. Head = uppermost reach; mid = middle reach; lo = lower basin (Howes et al. 2018).

Pigment Monitoring Results

Water quality monitoring results for average chlorophyll *a* concentrations for the Waquoit Bay system including each of Falmouth's sub-embayments are presented in Figure 2.16. Chlorophyll *a* values < 3 µg/L suggest low phytoplankton biomass indicating waters that have low nitrogen enrichment. Chlorophyll *a* levels in excess of 10 µg/L indicate there is some impairment in the system (Howes et al. 2018).

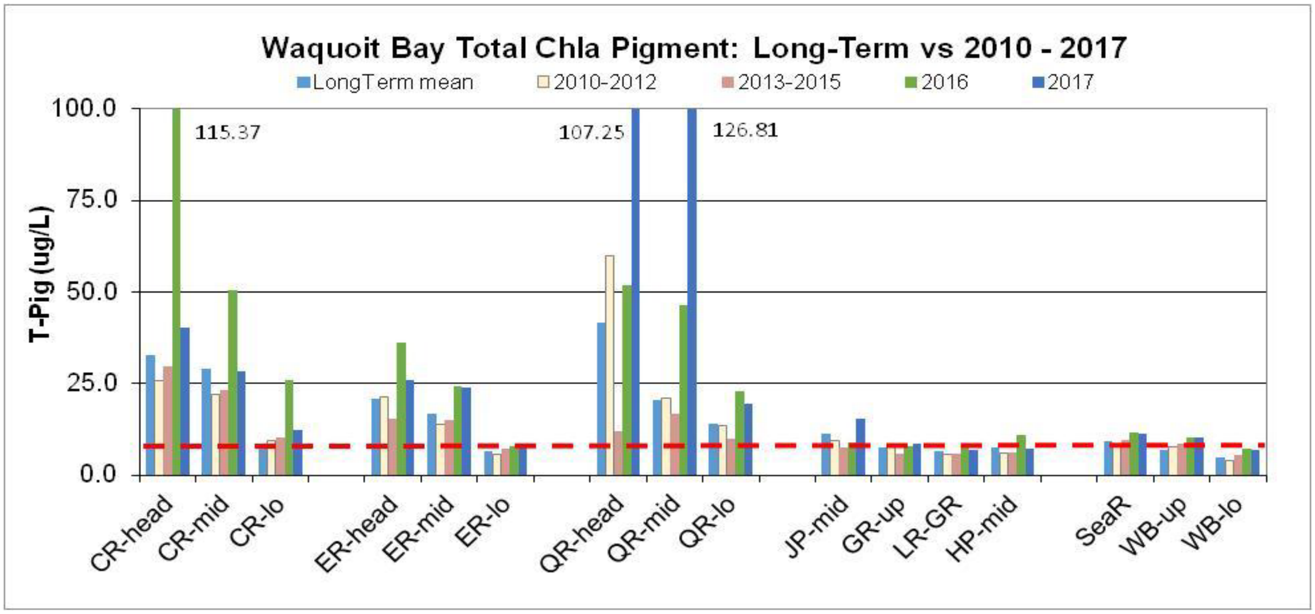


Figure 2.16 Average Total Chlorophyll *a* Concentrations in the Waquoit Bay Estuary for Long-Term Data (2001 – 2009) and During 2010 – 2017

In the above figure, the red line indicates a value of 3 µg/L. WB = Waquoit Bay main basin; SeaR = Seapit River; ER = Eel River; CR = Childs River; QR = Quashnet River; HP = Hamblin Pond; JP = Jehu Pond; GR = Great River; LR-GR = Little River Great River confluence; LR = Little River. Head = uppermost reach; mid = middle reach; lo = lower basin (Howes et al. 2018).

The main basin of Waquoit Bay including the Seapit River, the lower reach of Eel River, and Hamblin Pond generally have measures of chlorophyll *a* concentrations ≤ 3µg/L indicating low nitrogen enrichment in these regions. The mid and upper reaches of Eel River, Childs River, and the Quashnet River all show high variability in chlorophyll *a* concentrations between the monitoring periods. Large phytoplankton blooms were reported in the Childs River in 2017 and in the Quashnet River in 2016. The chlorophyll *a* monitoring indicates that Eel River, Childs River, and the Quashnet River all show some impairment.

Key Findings from the Waquoit Bay water quality monitoring efforts:

- As of 2017, Waquoit Bay and all of its sub-embayments in Falmouth remain impaired.
  - There is no significant change in the recent total nitrogen concentrations compared to the previous long-term data period.
- The main basin and Eel River show little variation in salinity among the reaches. Childs River and the Quashnet River show a strong salinity gradient with significantly lower salinity waters observed in the upper reaches of both sub-embayments.
- With the exception of the main basin and Hamblin Pond, chlorophyll *a* concentration levels generally follow the average total nitrogen concentrations and indicate that the sub-embayments remain impaired.

<u>The main basin of Waquoit Bay and all sub-embayments show no sign of nitrogen change and remain impaired, and there is no significant trend in TN in any of the sub-embayments over their study periods.</u>

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3. Summary of Pilot Projects

3.1 Introduction – Requirements of Secretary's Certificate, January 10, 2014

The Secretary's Certificate of January 2014 recognized the commitments Falmouth has made to improving water quality in its coastal pond watersheds. The Town intends to "evaluate, design, and construct both traditional and innovative technologies to reduce nitrogen loading to the watersheds."

Chapter 3 is an update on efforts made over the last five years to investigate and document alternative ways of removing nitrogen discharged to the groundwater. The Secretary's Certificate required the Town to report back by December 2019 on the effectiveness of various pilot projects.

The funding for these investigations came from Article 17, a bond issue for $2.77 million passed by Town Meeting and the voters in 2011. The intent of this article was to gather information that was missing for a comprehensive analysis of options and alternatives to conventional sewers. The article was purposely broad in scope as to on-site demonstrations and pilot projects. The sections listed below summarize the information that has been gathered on various projects and nitrogen-reduction strategies during the last five years:

- 3.2 Shellfish Aquaculture
- 3.3 Eco-toilets (composting, packaged, and urine diverting toilets)
- 3.4 Innovative and Alternative (I/A) Septic Systems
- 3.5 Permeable Reactive Barriers (PRBs)
- 3.6 Nitrogen Control Bylaw for Fertilizer
- 3.7 Stormwater Management
- 3.8 Inlet Widening – Bournes Pond

The technical reports and supporting documents are located in the associated Appendices (3.2 through 3.8).

3.2 Shellfish Aquaculture

3.2.1 Introduction

Using shellfish to reduce nitrogen concentrations is a non-traditional approach for improving estuarine water quality. Oysters (*Crassostrea virginica*) are often used because they grow rapidly, typically growing from seed to a harvestable (and marketable) size in less than two years. In the past six years the Town of Falmouth has utilized the Water Quality Management Committee (WQMC), the Town of Falmouth Department of Marine and Environmental Services (MES), and other resources to develop and engage in two significant oyster culture pilot projects: a three-year demonstration in Little Pond that began in 2013, and the development of an oyster reef in West Falmouth Harbor that began in 2014. In addition, projects in Little Pond, Waquoit Bay, and Bournes

Pond have examined the effects of various culture techniques on oyster growth rates, nitrogen sequestration by these oysters, and denitrification rates in nearby sediments.

These projects demonstrate that large numbers of oysters can be successfully grown in floating gear in Falmouth's estuaries, while producing measurable improvements in water quality. Additionally, a sustainable, naturally reproducing oyster reef has been established by planting oysters on hard bottom. In both situations, these oysters increase water clarity and convert nitrogen into soft tissue and shell by removing phytoplankton from the water. When combined with elemental analyses of soft tissues and shells, weighing oysters before and after their culture quantifies the actual removal of nitrogen specific to each site and time period. There is also evidence that the accumulation of oyster waste products on nearby sediments can lead to substantially increased rates of denitrification in these sediments, except in areas subject to episodic low oxygen events. At the same time, MES states that an extensive outreach program has been very successful in securing broad public participation in and support for these projects, from both recreational and commercial shellfishing interests.

3.2.2 Little Pond Shellfish Pilot Project – 2012 to Present

The Little Pond Shellfish Pilot project was partially funded by an allocation of $200,000 in Article 17 of the Spring 2011 Town Meeting, covering the cost of viability testing, equipment, and seed purchase for the first two years, staff support of the project for two years, and the cost of the monitoring for the first year. Grants from the Cape Cod Economic Development Council and the Cape Cod Water Protection Collaborative (CCWPC) paid for the third year of implementing the Little Pond Shellfish Pilot Project and the second and third years of monitoring, respectively. Chapter 3 of the Town's 2013 Comprehensive Wastewater Management Plan (CWMP) update provides details of the feasibility and planning studies as well as the permitting for this project. The pilot project area is shown in Figure 3.1

The goals of this project were to:

- Culture enough oysters to yield a detectable change in water quality.
- Verify nitrogen uptake by oysters to establish Total Maximum Daily Load (TMDL)-credit for these shellfish.
- Monitor and measure water quality over the three-year project period.
- Evaluate implementation logistics including winter storage.
- Determine levels of public acceptance.

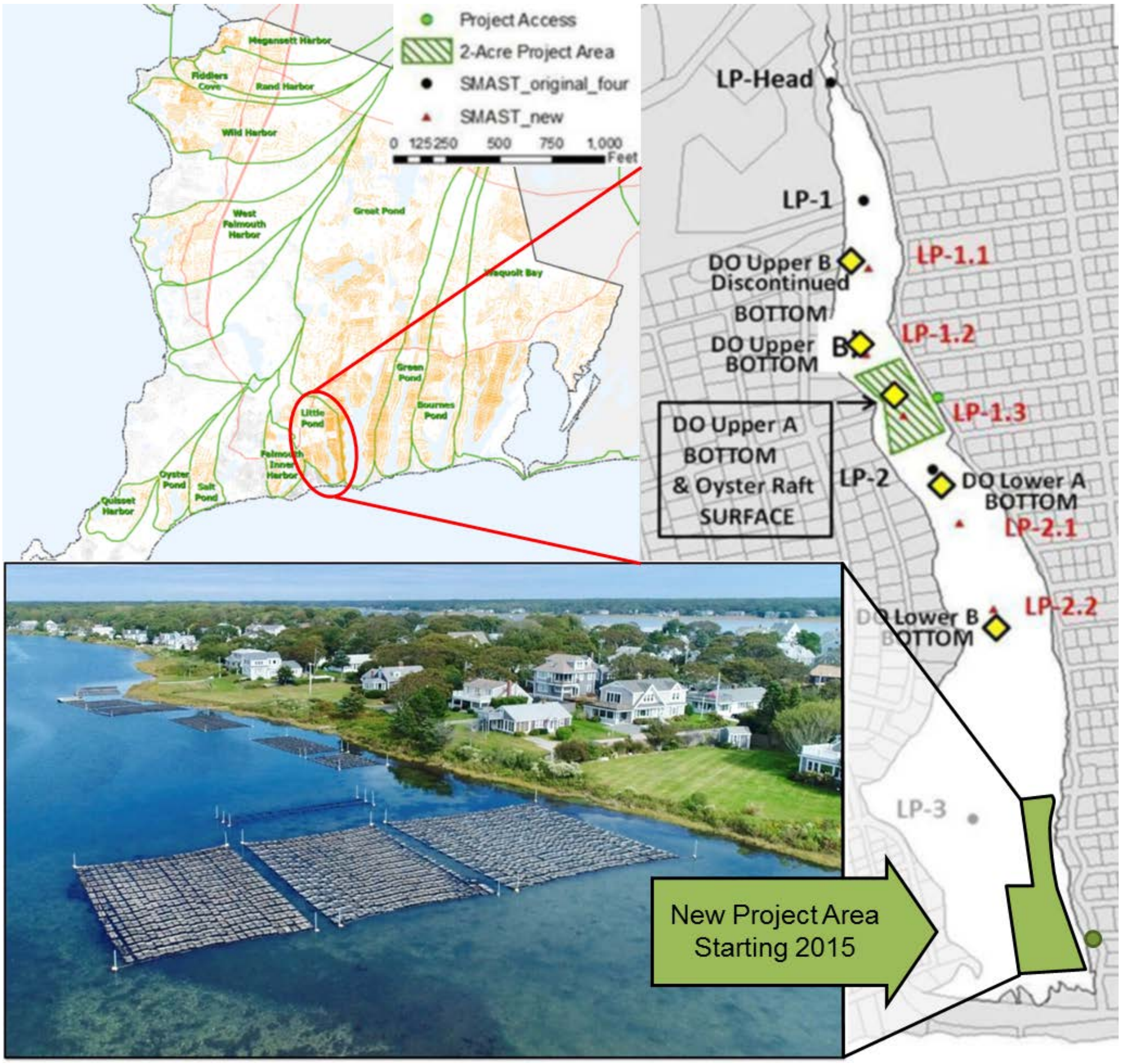


Figure 3.1 Pilot Project Location

In 2013 and 2014, 1.25 and 1.5 million oysters respectively were deployed in the project area between LP-1.2 and LP-1.3 shown in Figure 3.1. In 2015, about two million oysters were deployed in floating bags at the same location. Several weeks into the project, extended anoxic water conditions were suspected in the immediate area due to fish kills and a change in water color and were confirmed by grab sample measurements. Approximately two-thirds of the floating bags were moved to a southerly area that had been included in permitting as a backup location in case of anoxic events. The remaining one-third of the bags stayed in the original location and were able to withstand the conditions, and growth was comparable to the other two-thirds. Both oyster growth and neighborhood acceptance were immediately identified as favorable in the southerly location, so the project has continued to operate here in subsequent years; and there has been no further aquaculture activity at the northerly site.

The municipal propagation efforts undertaken by MES at the Little Pond site are partially funded by an allocation in the Town budget. Additional funds come from a variety of research projects. Starting in 2017 the program began exploring methods for optimizing propagation in impaired estuaries for shellfish other than oysters, such as quahogs and scallops. This is a direct response to concerns raised by individuals connected with regional planning about ensuring biological diversity as well as economic and ecosystem resilience in anticipation of increased aquaculture becoming a substantial contributor to nitrogen remediation strategies for many impaired estuaries on Cape Cod.

3.2.3 Little Pond Shellfish Pilot Project Monitoring

To establish and quantify the causal relationship between shellfish cultivation and improved water quality, the University of Massachusetts Dartmouth School for Marine Science and Technology (SMAST) performed three years of monitoring for this shellfish project and prepared a final report entitled *Shellfish Aquaculture Demonstration Project Little Pond Year 3 Monitoring Summer/Fall 2015 Oyster Deployment*, included as Appendix 3.2.

To meet the needs of MassDEP for TMDL compliance and potential nitrogen credit, both "grab-sampling" and continuous monitoring were done in a manner consistent with MEP Reports and in accord with the MEP Quality Assurance Project Plan (QAPP). Sampling parameters at both water surface and bottom locations (where depth is greater than 5 feet) at the sampling stations included: total nitrogen (TN), nitrate + nitrite, ammonia, dissolved organic nitrogen (DON), dissolved inorganic nitrogen (DIN), particulate organic nitrogen (PON), temperature, chlorophyll *a*, pheophytin *a*, orthophosphate, salinity, dissolved oxygen (DO), and transparency (Secchi depth). The spatial distribution of grab sampling as well as continuous monitoring of DO is shown in Figure 3.1. Continuous monitoring of salinity, chlorophyll *a*, DO, and turbidity occurred at several locations within and surrounding the pilot project site.

Key Findings of SMASTs Three-Year Monitoring Effort:

- 2013 and 2014 data demonstrate a localized reduction in TN via the removal of phytoplankton, but 2015 TN data is inconclusive because oysters had to be relocated during the growing season.
- Turbidity data demonstrate that the oysters increased water clarity.
- Absolute TN levels overall in Little Pond did not change significantly from 2006 MEP findings.
- Hypoxic conditions (low DO) in 2012 to 2015 are consistent with conditions from 2006 MEP findings.
- Deployment of oysters in Little Pond produced small-scale, localized water quality improvements, and the primary mechanism of these water quality improvements appears to be the uptake of phytoplankton.
- Removal of oysters was correlated with decreased water clarity and increased pigments.

3.2.4 Additional Findings from Little Pond Projects

Trials to evaluate the most effective overwintering techniques were conducted from 2016 to 2018. In 2016, 1st-year oysters were removed from culture bags in October and November and simply scattered in hard bottom areas that would be open to harvesting the following fall. This approach resulted in high mortality rates (>50%) due to a wide variety of negative impacts on the animals. In the second trial (2017), about 300 bags were overwintered at 12- to 15-foot depths in Little Harbor, Woods Hole, where there were significant conflicts with other users of the harbor, moderate hazards in using SCUBA to access the bags, and moderate mortality of oysters. In the third trial (2018), about 200 bags were suspended vertically among boat slips in Falmouth Inner Harbor to minimize space requirements and to reduce the bags' exposure to surface ice. Survival rates were high, but this technique required the use of circulators to reduce ice formation and involved considerable physical effort in placing and recovering the bags. The fourth technique, (2018) the late-December placement of 1st-year oysters in insulated cold-storage containers and maintaining these at about 32 degrees, required a moderate initial capital investment in equipment with low long-term costs and resulted in mortality rates less than 1%. Given this high rate of survival, MES anticipates utilizing cold storage to overwinter oysters for municipal propagation in the future and can currently store approximately one million oysters.

Denitrification rates in sediment cores from Little Pond were measured in 2014 and 2015, and these rates were significantly higher (~2X) underneath the oyster bags than at control sites.

MES has continued to grow oysters in Little Pond as part of its municipal propagation program. The comparative growth rates of different oyster seed stock were assessed in 2017, and in 2018 quahogs (*Mercenaria mercenaria*) and bay scallops (*Aequipecten irradians*) were both grown in Little Pond. In both years, oysters were grown in Little Pond and relayed to West Falmouth Harbor, Green Pond, and Great Pond for recreational and commercial harvest. MES expects to continue growing oysters and to expand the culture of quahogs and bay scallops in Little Pond, while also using it as an aquaculture training site.

3.2.5 West Falmouth Harbor Oyster Reef Pilot Project – 2014 to Present

Over a three-year period beginning in 2014, the Town planned and installed an oyster reef where Mashapaquit Creek enters Snug Harbor, in the upper reaches of West Falmouth Harbor (Figure 3.2). The goals of this project were to determine the feasibility of developing an oyster reef in this estuary, assess its potential maximum population size and self-sustainability, and develop a generic plan for using remote oyster set to establish reefs. The Town began this effort in 2014 with a viability study and continued in 2015 at a pilot-scale when 500 bags of oyster remote set were grown for one season and then planted on the sandy bottoms of the opposing shorelines. The same procedure, but with 1,500 bags of remote set, was followed in 2016, resulting in the bottom-planting of an estimated 308,000 oysters on cultch in an area of ~3,000 square feet. This area is closed to shellfish harvest and has developed into a successful spawning sanctuary as evidenced by several years of natural spat strike on hard surfaces in the vicinity. The 2015 and 2016 implementation phases were funded by a grant from the U.S. Environmental Protection Agency (EPA) through the Southeast New England Program (SNEP) Water Quality Management Grants, administered by the Buzzards Bay National Estuary Program. The West Falmouth Harbor Oyster Bed (Reef) Development Project Final Report (April 24, 2017) describes this project and its findings in detail and is included as Appendix 3.2.

Figure 3.2 West Falmouth Oyster Reef Location and 2018 Inspection

Key Findings of the Oyster Reef Project:

- Survival and growth rates of remote set are both high in bags. Of the oysters grown on cultch to a size where shell was visible, mortality was less than 5% over the growing season. Oysters grew from spat to over 30mm from early August to late October in both 2015 and 2016. This growth rate over these warm-weather periods is similar to the growth of oyster singles cultured by MES for municipal propagation.
- The oyster reef has continued to grow and mature and is thriving in spring 2019. The persistence of this reef demonstrates the potential utility of similar self-sustaining structures in reducing shoreline erosion.
- Due to the visibility of the Snug Harbor location, many people have stopped to ask questions when staff is working on site. This has provided excellent opportunities to discuss environmental issues and the role of shellfish in water quality improvements.

As shown in Figure 3.2, a visual inspection of the oyster reef area in January 2018 confirmed that the reef is growing and the oyster population is thriving. A new oyster reef has successfully been established at this location.

3.2.6 Waquoit Bay Project – 2017 to Present

MES, Woods Hole Oceanographic Institution, Stonehill College, the Waquoit Bay National Estuarine Research Reserve, and Science Wares, Inc. received a $500,000 grant from the National Estuarine Research Reserve System Science Collaborative for a project entitled, *Evaluating effectiveness of different oyster aquaculture strategies for nitrogen loading remediation to inform end user decisions to restore water quality.* This project consists of a two-year program, which uses three typical oyster culture techniques—surface, midwater, and bottom cultures—to investigate the relationship between impacts on the community beneath and near the growing gear and the surrounding water quality (Figure 3.3). Overall weight gain of 1st-year oysters was highest in mid-water bags and lowest in trays on the bottom, while the gains in 2nd-year oysters were lowest in mid-water bags and nearly identical to each other in the floating and bottom bags. In addition to the nitrogen removal represented by sequestration in both year-classes of oysters, substantially higher rates of denitrification occurred in the sediments under all three cultural techniques, when compared to rates measured in nearby control sediments, and the highest denitrification rates were measured in sediments underneath the bottom cages.

This project also has educational and end-user components. In the final year of this project (2019), participating organizations will be completing training for end-users. The Waquoit Bay study area has been used as training site for aquaculture students, high school students, children's science camps, and community tours. This work dovetails well with the oyster nitrogen reduction work conducted by Falmouth and nearby communities.

3.2.7 Bournes Pond Project – 2017 to Present

The Town funded a study to assess the denitrification enhancement associated with bottom-planted oysters in Bournes Pond in 2017. MES deployed oysters at the end of 2016 to support this project, but the research group was not able to identify the location of the oysters in time to conduct their study during the 2017 growing season. The Town confirmed the placement of the oysters, but in subsequent discussions with the research group recommended a different strategy of studying the effects on denitrification rates of oyster deployments that could be permitted for operation by commercial growers inside impaired estuaries. The result was a project in 2018 to study the effects on water quality and denitrification rates of second year oysters grown in a high-density floating bag system (Figure 3.3).

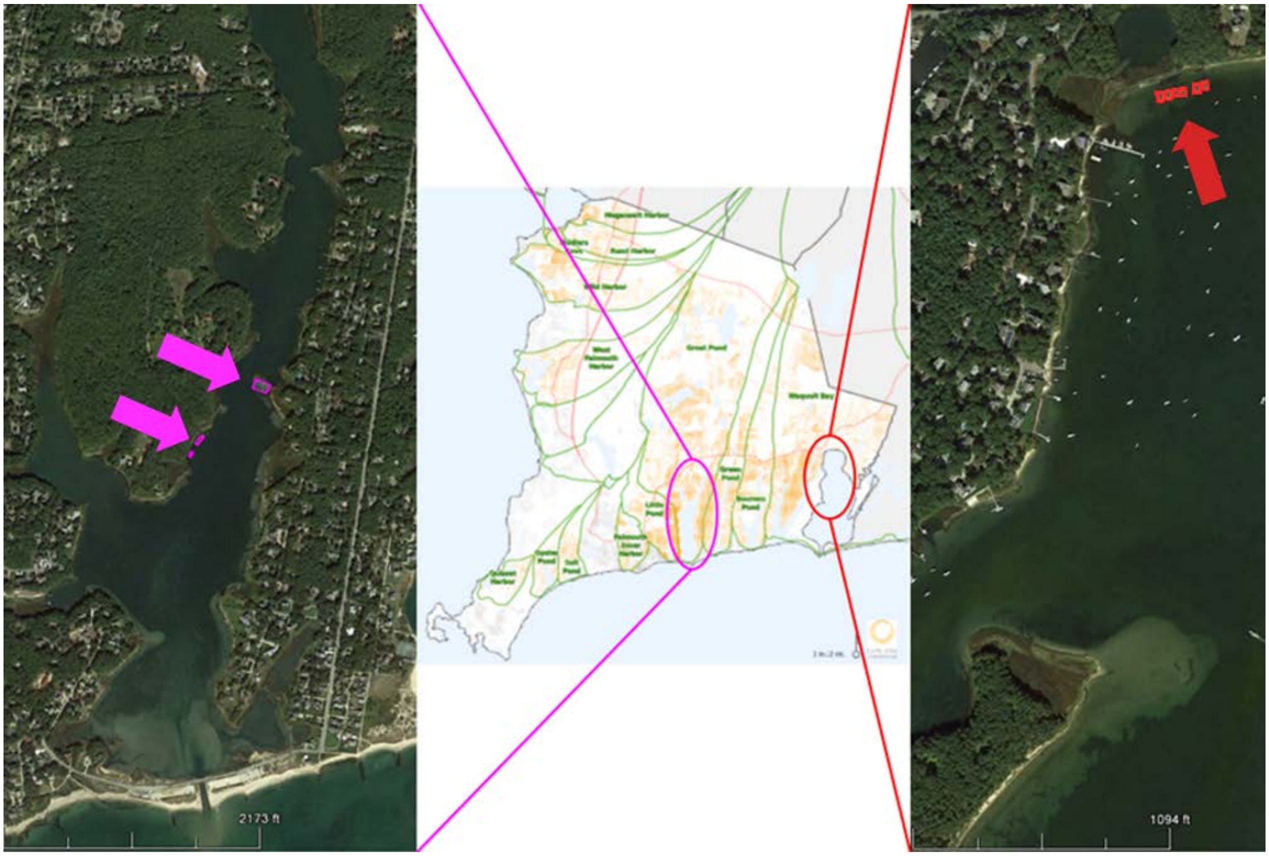


Figure 3.3 Oyster Deployments in Bournes Pond and Waquoit Bay in 2018

To quantify some of the local water quality impacts of suspended oyster culture, SMAST and MES initiated a detailed assessment of nutrient cycling in the sediments of Bournes Pond in 2018 that also utilized water quality datasets dating from 2012. Similar to other studies conducted in Falmouth estuaries, the cultured oysters significantly reduced total nitrogen and chlorophyll *a* concentrations in water passing through their vicinity, while organically enriching the nearby sediments and increasing nitrogen regeneration from these sediments. However, denitrification rates here were so variable that it was difficult to detect the substantial rate increases in the sediments near the cultured oyster bags that have been seen in other studies. It appears that sediment oxygen levels were depleted enough to suppress the coupled nitrification-denitrification process. Also, the combination of episodic low background dissolved oxygen events and the oxygen demand created by the high rate of organic deposition underneath the cages were responsible for this local oxygen depletion.

At the April 2019 Town Meeting, $40,860 was approved to fund the second year of research in Bournes Pond.

3.2.8 Quantitative Analyses of Nitrogen Sequestration by Oysters

MES has adopted quantitative analytical techniques to estimate the nitrogen sequestered by the growth of shellfish in impaired estuaries using the following equation:

$$\text{kg Nitrogen removed per Acre} = \frac{(\text{Outgoing Weight} - \text{Incoming Weight}) * (\text{N \% of Weight})}{\text{Acres Occupied by Gear}} \tag{3.1}$$

The ‘N % of Weight’ (Eq. 3.1) can be directly measured by selecting adequately sized samples of oysters, typically 25 animals, and processing as follows:

- Obtain harvest weights for each individual oyster after handling in the same way a commercial operation would handle them before weighing: drain in air, without scrubbing;
- Place a numbered identifier on each oyster so lab results can be individually linked with field-measured harvest weights; and
- Send the oysters to a capable analysis facility where they will be separated into shell and tissue that is dried, weighed, and evaluated by mass analysis for percent nitrogen content of each component.

The remaining quantities in Equation 3.1 can be directly measured in the field. A summary of measurements made during the 2018 growing season as well as the target nitrogen removal for the next phase of the commercial-scale aquaculture plan (see 3.2.9) is presented in Figure 3.4. The Town anticipates requiring, as a condition of granting a license to a commercial grower to operate in an impaired estuary, that the grower provide a representative sample of oysters which the Town will pay to have analyzed for nitrogen content. Also, the grower must self-record incoming and outgoing weights, and provide this information and the Standard Atlantic Fisheries Information System data for the grower’s harvest to the Town.

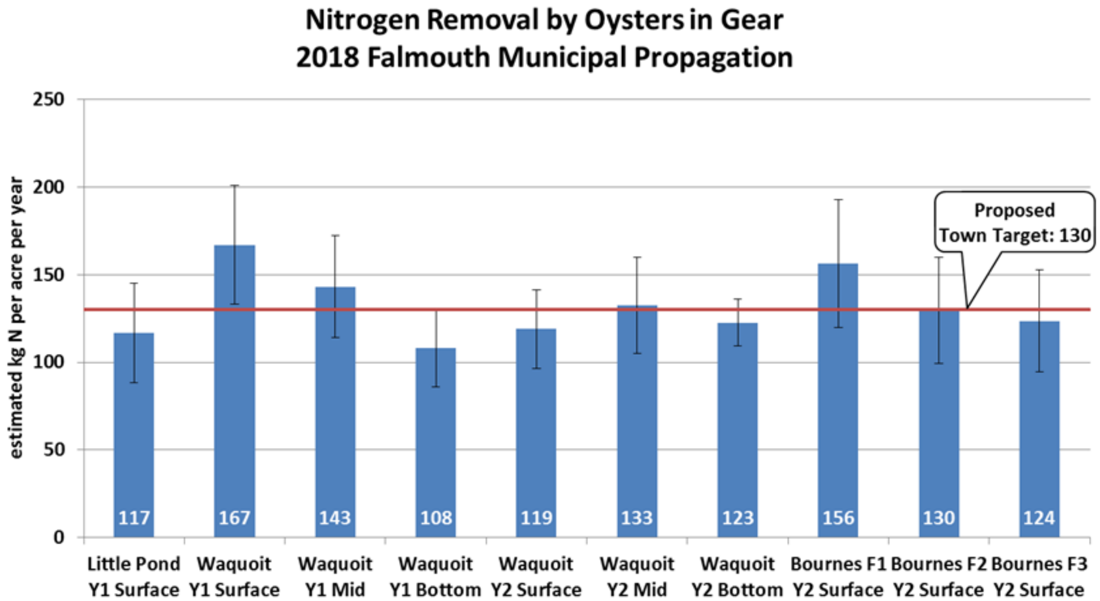


Figure 3.4 Summary of Nitrogen Removal Measurements Made by MES During 2018

3.2.9 Commercial-Scale Aquaculture Plans – 2019

In 2016 the Town contracted for the development of an aquaculture plan that would incorporate increased aquaculture as an alternative technology for removing nitrogen from its impaired estuaries (See Appendix 3.2). The plan includes an assessment suggesting that increased aquaculture may be able to account for up to 7% of the total nitrogen removal that the Town anticipates will be necessary to restore some of its impaired estuaries. The plan recommends involving growers who would be able to sell shellfish commercially, with the idea that this revenue can potentially more than cover the cost of seed and labor required in using the shellfish to remove nitrogen from these impaired estuaries. The plan further recommended pursuing a pilot program to work through siting, permitting, abutter, and contractual issues. Three sites that will support 20,000 sq. ft. of floating gear have been identified in Eel River adjacent to Washburn Island, and the process of permitting and contracting began in January of 2019. Based on a conservative average of nitrogen removal by oysters in several Falmouth estuaries as demonstrated in the 2018 municipal propagation efforts (see 3.2.8), the target is to remove 60kg of nitrogen each year at each of three sites in floating gear (Figure 3.4). Based on the data, the target nitrogen removal per site is expected to be attainable by any commercial grower when following the draft policy on aquaculture within the estuaries. By running a pilot project with three sites, the Town will be able to produce aggregate data for the pilot program for consideration by other stakeholders.

The Town had issued a Request for Proposals to commercial growers to operate the three sites identified in Eel River. Proposals are currently under review.

3.3 Eco-Toilets

3.3.1 Introduction

In 2010, as part of the public discussion process on the Draft Comprehensive Wastewater Management Plan, an organized group of citizens urged the Town to evaluate what role Eco-toilets could play in reducing the need for conventional sewering with all of its attendant monetary and energy costs. Town Meeting and the voters passed Article 17 in 2011 that included an allocation of up to $500,000 for studying composting, packaging, and urine-diverting toilets, and denitrifying septic components. The purpose was to provide in situ information on the use and function of these systems in homes and businesses and to determine their acceptability and effectiveness.

Eco-toilets separate human feces and urine from the wastewater system of a house or business. Once this source separation occurs, the human waste can be composted on-site or treated in a centralized facility. The human-derived residue is then useable as a soil amendment that is rich in nutrients. Compared to traditional sewerage systems, eco-toilet capital, operating, and maintenance expenses are all vastly lower.

3.3.2 Eco-Toilet Pilot Projects

Falmouth completed a pilot project to evaluate the nitrogen-removal, costs, and public acceptance aspects of eco-toilets, which can be either composting or urine-diverting fixtures or combinations thereof. The Eco-Toilet Incentive Program (Program) was designed to provide information on the following:

- Nitrogen-removal efficacy of eco-toilets, for TMDL-compliance.
- Total installed costs, including labor and materials.
- Critical factors involved in installation as well as operation and maintenance.
- Public acceptance.

To encourage participation in this voluntary project, three different incentive programs over a three-year period were provided:

- Up to $5,000 incentive and a septic system pump-out valued at approximately $300 for any home or business in Falmouth that would install eco-toilets in all its bathrooms;
- An exemption from an estimated $17,000 betterment assessment for over 1200 homes in the Little Pond Sewer Service Area; and
- Up to $10,000 incentive for any home within 300 feet of West Falmouth Harbor as part of the West Falmouth Harbor Shoreline Septic Remediation Program

These financial incentives were well-publicized to encourage participation in the Program. First, every Falmouth residence received a colorful notice in its water bill advertising a $5,000 incentive for installing eco-toilets. In addition to this mailing, marketing efforts included regular articles in the local newspaper, attendance at community events such as a concert in 2012 and the weekly Falmouth Farmer’s Market, and workshops held by a local non-profit, The Green Center. These outreach and promotional efforts generated a list of 170 interested people. Each of these homeowners was contacted by phone about the Program. Ultimately nine [9] homeowners participated by installing eco-toilets in their bathrooms through these public information initiatives and two [2] more homeowners with prior installations joined the monitoring program conducted by the Barnstable County Department of Health and Environment.

To encourage additional participation, over 1,200 homeowners in the Little Pond Sewer Service Area (LPSSA) were mailed a letter from the Town alerting them to the option of installing eco-toilets instead of paying an estimated $17,000 betterment. Two homeowners initially enrolled from the LPSSA, but subsequently dropped out of the Program and instead hooked up to the sewer system. A third initiative offered homeowners within 300 feet of West Falmouth Harbor a $10,000 incentive to install eco-toilets or Innovative/Alternative septic systems. None of the 30 participants in this project selected eco-toilets.

In order to ease the burden on the homeowner of permitting the installation of an eco-toilet, the Technical Consultant to the WQMC assisted all homeowners in the permitting process. The Technical Consultant first obtained a Test Site permit from the State Board of Plumbers and Gas Fitters in March 2013 that allowed up to 40 test sites. Subsequently, all installations were permitted through the local Board of Health.

Public participation in the Eco-Toilet Pilot Project was low in Falmouth, despite significant financial incentives and ongoing promotion to encourage participation. Of the 170 people who showed initial interest in eco-toilets, 55% indicated they ultimately chose not to participate due to factors such as the effort involved in ongoing operation and maintenance of the eco-toilet and a concern over resale value of the home. Cost was only a factor for 10% of respondents who did not choose to participate.

Eco-Toilet Demonstration Program Final Statistics:

- Number of people contacted: 170
- Number of people with site visits: 50
- Number of people who installed eco-toilets: 9
- Types of installations/eco-toilets chosen covered the full range:
  - central composters,
  - self-contained units, and
  - urine-diverting fixtures.

3.3.3 Eco-Toilet Performance Monitoring, Installation Costs, and Operation and Maintenance

The Barnstable County Department of Health and Environment (BCDHE) monitored all nine eco-toilet systems that were installed as part of this Program plus two more systems that joined the Program for monitoring only. BCDHE found that composting toilets removed 86% of nitrogen that would otherwise enter a septic system; urine-diverting toilets that only divert urine from the septic system removed 48% of the nitrogen. At locations that used a combination of urine diversion and composting technologies, the reduction in the nitrogen load was 80%. This report, entitled Final Report to the Town of Falmouth-Performance of Eco-Toilets, dated April 2018, is included in Appendix 3.3, and provides technical details for the different eco-toilet systems that were installed.

In addition to their nitrogen-removal effectiveness, the cost and practicality of retrofitting existing structures with eco-toilets is critical to an evaluation of whether these toilets are a viable alternative to more traditional wastewater management techniques. The Water Quality Management Committee's technical consultant tracked the costs of installation (including labor and materials) as well as findings related to public acceptance. In summary, costs (including labor and materials) to install eco-toilet system in one, first-floor bathroom ranged from $2,600 for a small, self-contained unit where the bin holding excrement and urine is directly below the toilet bowl, to $9,500 for a central composting unit with a remote bin. Additional bathrooms cost approximately $2,500 each to retrofit.

Operation and maintenance of eco-toilets includes weekly maintenance of composting bins as well as residuals management. Residuals include compost (feces and urine mixed with wood shavings) and leachate, which is the excess liquid that is not taken up during the process of composting. Leachate accumulates at approximately 2 gallons/person/month. Urine-diverting toilets require periodic pumping of urine from a holding tank. Regular turning and ultimate burial of compost is usually done by the homeowner but hauling of residuals and urine must be performed by a licensed septic hauler. All eco- toilets require some form of residuals management. All eco-toilets also required some sort of odor control, usually an exhaust fan with back-up battery. Periodic occurrences of flies and gnats were reported as well.

3.3.4 Key Findings of Eco-Toilet Pilot Project

- Measured nitrogen removal for composting systems is 86% and for urine-diverting fixtures is 48%. Hybrid systems removed 80% of the nitrogen load.
- Installation costs of most systems are significant for existing homes with more than one bathroom, ranging from $2,600 to $9,500 per unit.
- Homeowners must make a commitment to maintain their eco-toilets. Operation and maintenance includes removing compost and disposing of liquids such as urine and leachate.
- **Homeowner acceptability of installing eco-toilets is low.**
- **Homeowner concern with re-sale value of dwelling is high.**

Based on these conclusions, eco-toilets are not included as a separate non-traditional technology for watershed planning purposes in Falmouth. They continue to be listed as an I/A septic system option. In watersheds where I/A septic systems are the recommended solution for TMDL compliance, property owners will also be able to select eco-toilets that achieve the same level of nitrogen-removal as is required for I/A septic systems.

3.4 Innovative and Alternative (I/A) Septic Systems

3.4.1 Introduction

Beginning in 2010, Town officials and the general public became increasingly aware of a wide variety of alternative septic systems available either 'off the shelf' or under development as prototypes. As part of the investigation into technologies that could reduce nitrogen discharged to the groundwater at or near the source, the Water Quality Management Committee decided to pursue in situ testing of multiple concepts. The Town was fortunate to have the interest and expertise of the

Director of the Massachusetts Alternative Septic System Test Center, located at Joint Base Cape Cod. This Test Center has been in operation for over 20 years, and the monitoring data it collects and analyzes has a high level of credibility with the public and the regulators. Article 17 provided funding for this pilot project as needed along with various grants.

The DEP currently requires that advanced I/A septic systems must meet a standard of 19 mg TN/L. Based on the TMDL targets, the Town of Falmouth considered the DEP standard to be too high to effectively improve the health of an impaired estuary. Therefore, at the various locations where advanced I/A systems were installed as part of the pilot project, the goal was 12 mg TN/L for each I/A septic system or 70% removal.

3.4.2 West Falmouth Harbor Shoreline Septic System Remediation Project

The Town completed a pilot project entitled West Falmouth Harbor Shoreline Septic System Remediation Project (WFHSSSR Project) to evaluate nitrogen-removal, costs, and ongoing operational issues of I/A Septic Systems and eco-toilets in partnership with the Buzzards Bay Coalition (BBC). The main purposes of the WFHSSSR Project were to:

- Measure the nitrogen removal of off-the-shelf I/A septic systems or eco-toilets installed at single-family homes.
- Determine the real-world costs and logistics of installing these systems.
- Evaluate the ongoing operation and maintenance requirements.

With the help of the West Falmouth Village Association, more than 30 homeowners within 300 feet of West Falmouth Harbor (WFH) were identified as willing to voluntarily upgrade or replace their existing Title 5 septic systems or cesspools with I/A septic systems. The installed I/A septic systems were expected to reduce nitrogen concentrations in the septic tank effluent to at least 12 mg/L nitrogen (N) or approximately 68% (12 mg N/L versus 38 mg N/L for septic effluent from a standard Title V system per MassDEP). Homeowners were given a choice of an array of systems for their property. None of the participants installed eco-toilets although this option was presented alongside the I/A septic system choices. Phase I of this Project, involving 20 homeowners, was funded by a $250,000 grant from the United States EPA through the Buzzards Bay National Estuary Program. The West Falmouth Harbor Shoreline Septic System Remediation Project Final Report (October 12, 2016) presents the details of Phase I [Appendix 3.4]. Phase II, involving 10 additional homeowners, was funded by a $75,000 grant from the Cape Cod Water Protection Collaborative and $50,000 from the BBC to cover monitoring expenses. The BBC plans to summarize the installation and monitoring information in late 2019.

Four different I/A septic system technologies were installed in Phase I:

- Blackwater Holding Tanks
- Eliminite™
- HOOT™
- Layered Soil Treatment Area (STA) “Layer Cake”

Three additional technologies were installed in Phase II:

- Drip Dispersal System
- NitROE™
- FujiCLEAN™

The West Falmouth Nitrogen-Reducing Septic Systems Demonstration Project Status Report (May 2017) describes the monitoring results of the first four technologies that were installed [Appendix 3.4]. In terms of overall nitrogen-removal, project partners set out to reduce nitrogen from on-site septic systems at these 30 homes by at least 68%.Data collected as of August 31, 2017 indicates that overall effluent nitrogen entering a soil absorption system, also known as a drainfield, from the first 20 systems has been reduced by at least 69%. For the nine Blackwater Holding Tanks that were installed, the average nitrogen concentration of pre-installation effluent was 95 mg N/L and the average nitrogen concentration post-installation was 8 mg N/L. The reduction in nitrogen from these homes is 92%. The Falmouth Board of Health only permits Blackwater Holding Tanks as part of this pilot project and only for seasonal homes.

For the three Eliminite™ systems that were installed, the average nitrogen concentration of pre-installation effluent was 78 mg N/L and the average nitrogen concentration post-installation was 30 mg N/L. The reduction in nitrogen from these homes is 62%. One of these systems was installed during an extensive house remodel and did not perform well, likely due to solvents that were used and then disposed of improperly. The average nitrogen concentration after the upgrade of the two other Eliminite™ systems was 13.66 mg N/L or 82% removal.

For the three HOOT™ systems that were installed, the average nitrogen concentration of pre-installation effluent was 63 mg N/L and the average nitrogen concentration post-installation was 17 mg N/L. The reduction in nitrogen from these homes is 72%.

For the one Layered STA that was installed, the average nitrogen concentration of pre-installation effluent was 56 mg N/L and the average nitrogen concentration post-installation was 29 mg N/L. The reduction in nitrogen from this home is 48%.

The Layered STA is under detailed investigation by the BCDHE through a grant from the EPA. Twelve Layered STA systems are being installed across southeastern Massachusetts and performance data for this larger number of installations will be reported as part of that initiative at a later date.

Table 3.1 presents the wide range of total project costs for different I/A septic systems installed in Phase I and Phase II. Total project costs include engineering, equipment, installation and restoring landscaping. The average cost to add on to an existing, conventional Title 5 system was $20,417, while full upgrades from old cesspools cost an average of $33,225. While the cost range for the Eliminite™ and HOOT™ systems are modest, approximately $1000 and $6000 respectively, the range for the Blackwater Storage Tank option is significant (approximately $15,000). This large range for costs can be explained by the difference in installation requirements. In some cases, existing Title 5 systems were in place and the addition of a blackwater tank and plumbing modifications were all that was required. In other cases, full Title 5 upgrades, including a new soil absorption system, were needed. The cost range for the HOOT™ system illustrates the significance of site conditions on installation costs. The low end of the installed costs was a case where there were minimal site constraints. The high end case had significant landscaping constraints, adding to the time required for installation and the extent of landscaping to return the property to existing conditions. For the Layered STA system, the costs associated with a deep excavation and fill were the cost drivers. A standard drainfield would have similar costs.

Table 3.1 Installation Costs by System Type – Phase I

System Type	Average Total Installed Cost by System Type ($)	High Total Installed Cost by System Type ($)	Low Total Installed Cost by System Type ($)
Blackwater Holding Tank	$18,274	$32,327	$13,353
Eliminite™	$20,760	$21,458	$19,523
HOOT™	$34,581	$40,425	$28,158
Layered STA [1]	$42,530	Only one installation	Only one installation

Notes:

1. The cost of this installation was dominated by the required 15-foot strip-out of the STA area. The cost for a standard STA (drainfield) would have been comparable.

Using I/A septic systems as part of TMDL-compliance will likely require that these systems be installed on existing properties where there are numerous constraints that limit the area available for locating the tanks and soil absorption system (SAS), including:

- Lot size.
- Location of existing structures and driveways on the property.
- Mature landscaping, including trees.
- Proximity to wetlands.
- Soil types.
- Depth to groundwater.
- Property setbacks.

Installation costs will be significantly affected by these site-specific constraints.

To enable a comparison of capital costs for I/A systems with other traditional septic systems as well as alternative wastewater management technologies like sewering, a benchmark installed cost of $26,000 was calculated. This cost was determined by obtaining estimates from three local septic system installers for a three-bedroom, Title 5 system on a hypothetical lot. Key parameters for these cost estimates include:

- The system including a tank and a soil absorption system.
- Direct and easy access to install the Title 5 system on the hypothetical lot (for example in the front of the house).
- The hypothetical lot did not have any existing landscaping.

Based on these parameters, the cost to install a Title 5 system for a three-bedroom home, including equipment, was $12,800. The average vendor-provided cost for the equipment that is specific to the

I/A functionality for HOOT™, Eliminite™, Layer Cakes, and Nitrex™ systems was $9,900. This average cost was added to the baseline cost for a Title 5 system. An allowance of $3,300 for preparing engineering plans and Board of Health permitting was also included in the benchmark cost for a total of $26,000.

3.4.3 Key Findings of the I/A Septic System Pilot Project

- To be useful for wastewater planning in Falmouth, I/A systems that achieve an effluent standard of 10 mg N/L or 75% TN removal must be approved by MassDEP.
- Ongoing, regular maintenance and monitoring of I/A systems is needed to ensure that expected performance is realized.
- A Town entity should be identified and given explicit responsibility for oversight of I/A systems installed as part of plans for shared watersheds as well as Targeted Watershed Management Plans.
- Installed costs of I/A systems vary considerably, depending on site constraints.
- The required frequency of monitoring significantly impacts operating costs. If the required monitoring can be reduced from the currently required frequency to annual then the costs may be acceptable.
- For the cost to homeowners of I/A systems to be comparable to the cost of sewers, loans for I/A systems must be available that provide financing comparable to Falmouth's betterments (0%/30-year term/level payments).
- Barnstable County Community Septic Management Loan Program currently provides loans at 5% for 20 years.

3.4.4 Watershed Management and Monitoring Plan for Advanced I/A Septic Systems

An important lesson learned as part of the WFHSSSR Project is that I/A septic systems must be properly maintained and monitored to achieve their expected nitrogen removal. A management approach that is acceptable to both property owners as well as state and local officials is needed to ensure that I/A septic systems that are installed as part of the Town's CWMP or a watershed's Targeted Watershed Management Plan (TWMP) are appropriately maintained and monitored over the long term. The WQMC has drafted a Watershed Management and Monitoring Plan for Advanced Innovative/Alternative Nitrogen Reducing Septic Systems (Monitoring Plan) and circulated it to DEP, BCDHE and others [Appendix 3.4]. A key feature of this Monitoring Plan is that the advanced I/A septic systems must meet a standard of 10 mg TN/L or 75% removal of TN. The current DEP standard is 19 mg TN/L, which the WQMC felt was insufficient to effectively improve the health of an impaired estuary. Qualifying vendors of I/A systems will be required to achieve 10 mg TN/L or 75% TN removal.

The Monitoring Plan addresses a number of important issues:

- Requirements for owners of designated properties within a watershed who must install I/A septic systems.
- Designation and role of a Responsible Municipal Management Entity (RMME).

- Selection of vendors of advanced I/A systems and performance monitoring during the probation period.
- Frequency of monitoring after the probation period to ensure that the performance standards for installed I/A septic systems are being met.
- Operation and maintenance of the advanced I/A system including annual inspections.
- Reporting, recordkeeping, and other tasks performed by the RMME.
- Semi-annual fee paid to the Town to cover the costs of the RMME.

This Monitoring Plan will be included in the implementation strategy for advanced I/A septic systems installed as part of watershed-level planning for a given estuary.

3.5 Permeable Reactive Barriers (PRBs)

3.5.1 Introduction

A PRB is a technology that has been used for contaminated groundwater remediation for several decades. It is a recognized engineering approach in many hazardous waste sites nationwide. However, the application of the technology to nitrogen contamination in groundwater from non-point sources is relatively new. A PRB for nitrogen remediation involves the installation of a carbon substrate perpendicular to the lateral flow of groundwater. As the groundwater moves through this carbon source, the nitrate contained in the groundwater is converted by naturally occurring bacteria to nitrogen gas through the biologically mediated process of denitrification. Historically, the permeable barrier was composed of solid fragments such as wood chips installed in a trench dug into the aquifer. More recently methods involving injection of various liquid carbon sources have been used.

Falmouth committed $175,000 of Article 17 funding to hire CDM Smith in 2013 to do a desktop evaluation of all of the south coast estuaries plus the West Falmouth Harbor watershed for possible locations for PRBs. As part of this planning analysis, groundwater-profiling data from Seacoast Shores collected by the Cape Cod Commission and the US Geological Survey were used. These data indicated that a trench of over 50-feet deep would be required, which was physically impossible due to site constraints and financially prohibitive. CDM Smith suggested that injection wells might be a viable alternative. Chapter 3 of the Town’s CWMP/TWMP/EIR (September 2013) provides details on the feasibility and planning studies that were accomplished for this project.

Before an injected PRB can be installed, the groundwater hydrology of the site must first be established. The speed and direction of groundwater flow must be characterized by installing a number of monitoring wells and water table wells. Key parameters must be measured at different elevations in the groundwater, such as nitrate and dissolved oxygen concentrations, oxidation/reduction potential (ORP), pH and the presence of certain metals. Analysis of permeability of the specific soils at the site is also necessary. These investigations require several rounds of sampling and analysis to characterize seasonal and inter-annual variability in flow and chemical distributions. Only then can a determination be made as to whether a given site is a potential candidate for an injected PRB.

Using a mapping exercise to determine depth to the water table, distance from wetlands, and accessibility for monitoring wells both upstream and downstream of the potential PRB, Falmouth identified about 10 areas within the CWMP planning area where a pilot PRB project might be installed. Two sites ranked very high, one in the Great Pond Watershed (Shorewood Drive) and the other in the Bournes Pond Watershed (Sailfish Drive). Two grants from the CCWPC made it possible for Falmouth to hire MT Environmental Restoration to investigate the hydrogeology of the Shorewood Drive site. As part of its regional groundwater studies, the US Geological Survey installed a multi-port monitoring well near the intersection of Route 28 and Shorewood Drive. A grant from the EPA, Region 1, using the subcontractor WaterVision LLC, funded an investigation of the hydrogeology of the Bournes Pond site called Sailfish Drive. Some additional work was also done at the Shorewood site as part of the EPA study.

3.5.2 Groundwater Evaluations in the Great Pond Watershed

Two grants from CCWPC, totaling $75,000, funded an in-depth groundwater and soils investigation of the central and northern sections of the Acapesket peninsula in the Great Pond watershed. Figure 3.5 shows the locations of the monitoring wells within the northern section of the Acapesket peninsula, with the Town-owned 0 Shorewood Drive site outlined.

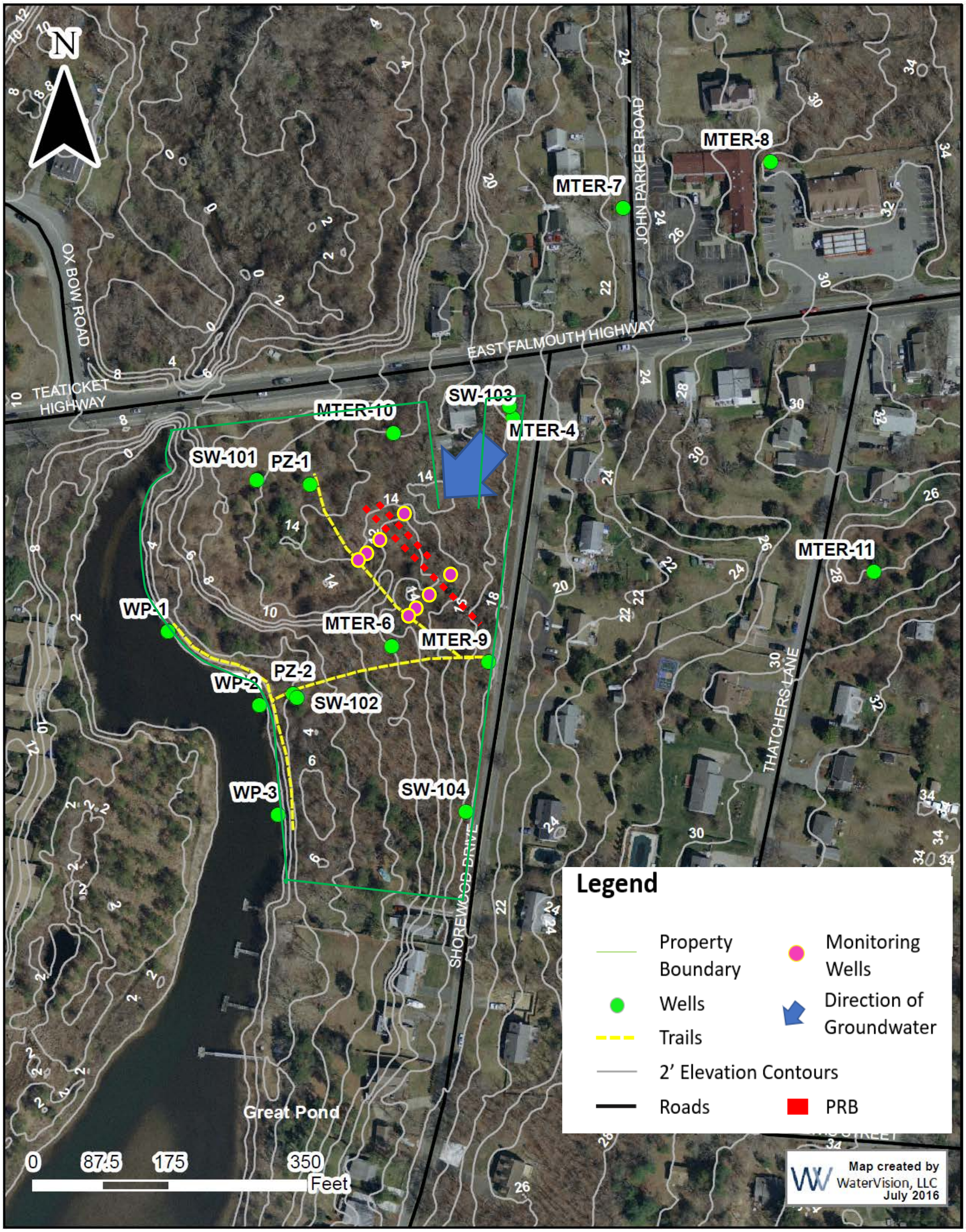


Figure 3.5 Map of Investigational Well Locations and Groundwater Flow Paths

These investigations are documented in the following list of reports (see Appendix 3.5):

- Falmouth Acapesket Peninsula Groundwater Investigation Report (MT Environmental Restoration March 23, 2015)
- Falmouth Acapesket Peninsula Groundwater Investigation Phase II Report (MT Environmental Restoration December 21, 2015)
- WaterVision LLC Technical Memorandum: Project Summary Memorandum: Site Characterization for Design of Pilot-Scale Permeable Reactive Barrier for Nitrogen Reduction in Groundwater on Cape Cod – Supplemental Field Work at Shorewood Drive, Falmouth, MA dated September 26, 2016
- WaterVision LLC Technical Memorandum: Supplemental Sampling Summary Memorandum: Site Characterization for Design of Pilot-Scale Permeable Reactive Barriers for Nitrogen Reduction in Groundwater on Cape Cod – Supplemental Fieldwork at Shorewood Drive, Falmouth, MA dated April 18, 2017)

As reported in the March 2015 report, a relatively low nitrogen mass flux was observed within monitoring wells in the central portion of the Acapesket peninsula, approximately 3,500 feet south of Route 28. In the December 2015 report, results from additional sampling of the wells in the central Acapesket peninsula confirmed the results of the first round of sampling. This low nitrogen flux is due to low nitrate concentrations in the groundwater and slow horizontal groundwater velocities. This low flux means that this would be a poor location for a PRB.

As part of Phase II, MT Environmental Restoration installed groundwater monitoring wells in the northern section of the Acapesket peninsula in the vicinity of Route 28 and 0 Shorewood Drive, a 5-acre parcel owned by the Town. Additional investigations at 0 Shorewood Drive were completed in 2016 by WaterVision, a contractor for EPA Region 1, and by the US Geological Survey which installed a multiport sampling well as part of their regional network. Two rounds of water quality samples were collected and analyzed for the northern section of the Acapesket peninsula and a third round at selected locations for an analysis of stable isotopes of nitrogen. These data showed that this Town-owned site is an advantageous location for a PRB.

Key Findings for 0 Shorewood Drive include:

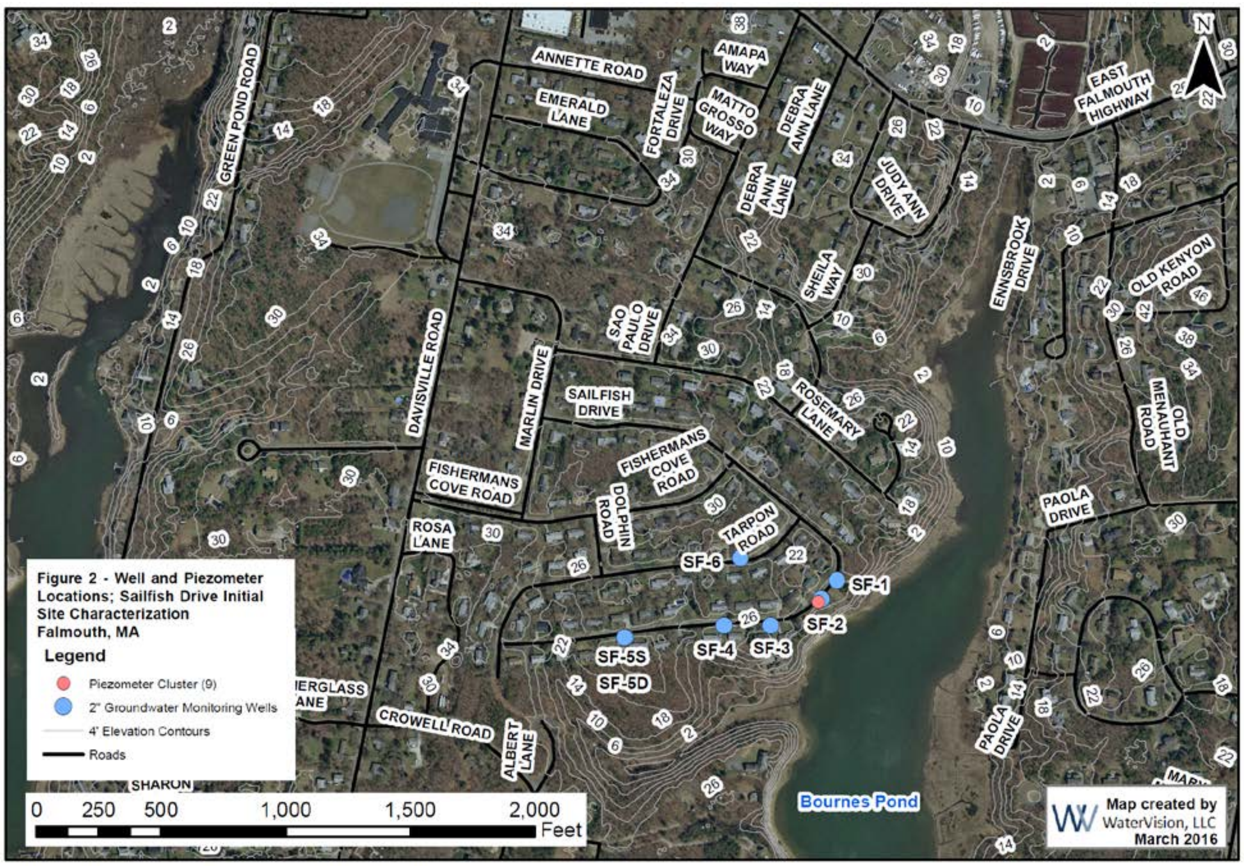
- The predominant species of nitrogen detected was nitrate.
- Nitrate concentrations are high (up to 14 mg N/L at elevations between -10msl to -20msl).
- Nitrate contaminated groundwater is present at a shallow depth that can be easily reached by injection of a liquid carbon source.
- Soil types on site are predominantly well-graded sand; shallow backfill of wood and asphalt was encountered at two locations.
- Horizontal groundwater velocity is estimated to range from 2.1 ft./day to 4.0 ft./day, which is considerably higher than the regional average rate of 1 ft./day.
- Groundwater chemistry and nitrate distribution are generally conducive to groundwater nitrate treatment.

- Compounds that compete for treatment substrate and increase costs (e.g. sulfate) are at relatively low concentrations.

There is significant flux of nitrate through the area due to two conditions: high concentrations of nitrate present in groundwater and a significant groundwater velocity. From this flux, it is estimated that 330 kg N/year flowing toward Great Pond will be removed by a 200-linear foot pilot-scale PRB using injection. Based on these reports, a Section 319 grant proposal was submitted to MassDEP in 2017 to help cover the costs of the installation of a pilot-scale PRB but was not funded. A similar proposal submitted to the EPA SNEP program in 2018 also was not funded.

3.5.3 Groundwater Evaluations in the Bournes Pond Watershed

There are several dense residential developments along the upper reaches of the Bournes Pond estuary. One of them, Fisherman's Cove, contained a road layout and a recreational area that appeared promising as a potential PRB site. Sailfish Drive (Figure 3.6) was evaluated as part of an EPA Region 1 initiative.



Sources: Aerial photography 2013-2014 and Roads from Mass GIS, Parcel Boundaries from Cape Cod Commission, Surveyed Groundwater Monitoring Well and Piezometer locations from WaterVision LLC. Elevation contours from the Cape Cod Commission.

Figure 3.6 Map of Investigational Well Locations at Sailfish Drive

The project report prepared by WaterVision, Cape Cod Permeable Reactive Barrier Initial Hydrogeologic Site Characterization Results and Evaluation of Site Suitability for Permeable Reactive Barrier Installation – Sailfish Drive, Falmouth MA (July 29, 2016), is included in Appendix

3.5. Six water-table wells were installed in this area. Sampling results from these wells were used to establish groundwater surface elevation, flow direction, and velocity as well as groundwater chemistry. Three rounds of water level measurement and two water quality sampling rounds were completed. The data indicated that the specific conditions at Sailfish Drive are favorable to installing a PRB.

Key Findings for Sailfish Drive include:

- The predominant species of nitrogen detected was nitrate.
- Nitrate concentrations are moderate (up to 8.9 mg N/L at elevations between -22 feet below ground surface (bgs) to -29 ft bgs).
- Soil types on site are predominantly well-graded sand.
- Horizontal groundwater velocity is estimated at 1.4 ft./day, which is higher than the regional average rate of 1 ft./day.
- Groundwater chemistry and nitrate distribution are generally conducive to groundwater nitrate treatment.
- Compounds that compete for treatment substrate and increase costs (e.g. sulfate) are at relatively low concentrations.
- Nitrate contaminated groundwater is present at a shallow depth that can be reached for treatment.

EPA calculated the nitrate mass flux at Sailfish Drive to be 1.13 g/day between -22 ft bgs and -26 ft bgs, and 0.55 g/day between -29 ft bgs and -36 ft bgs. With this mass flux, a 300-linear foot, pilot-scale PRB with a vertical thickness of 14 feet at this location would remove almost 400 kg N/year. Hydraulic conductivity for this flux is assumed to be 150 ft/day based on a soil type of silty fine to medium sand.

3.5.4 Next Steps

Permeable reactive barrier technology for the purpose of groundwater nitrogen remediation is still under development. On Cape Cod, there have only been three such installations: two shallow, wood chip-based PRBs beneath the shoreline of Waquoit Bay and Childs River, and a liquid carbon PRB in Orleans. Neither is deployed in a setting similar to what would be installed in the Town of Falmouth. As such, additional pilot projects are required to determine the cost and effectiveness of the technology, which will determine whether or not PRBs are a viable alternative approach for nitrogen remediation for the Town. In June 2019, the Woods Hole Oceanographic Institution in partnership with the Water Quality Management Committee/Town of Falmouth submitted a request for a $298,598 grant from the EPA-Southeast New England Program to fund a 120-foot PRB to be installed at 0 Shorewood Drive. The Town will provide $36,222 of in-kind services. The proposed project will last 30 months if funded.

3.6 Nitrogen Control Bylaw for Fertilizer

3.6.1 Introduction

Fertilizer contributes 5- to 10-percent of the controllable nitrogen sources entering Falmouth's watersheds. A summary of the nitrogen loads to the watersheds from various sources including fertilizer is included in Appendix 3.8 of the Town's CWMP (September 13, 2014). To address this controllable load, the WQMC authored a Nitrogen Control Bylaw for Fertilizer that was adopted at Fall 2012 Town Meeting and approved by the Attorney General of Massachusetts. This bylaw prohibits the application of nitrogen within 100 feet of resource areas as defined in Falmouth's Wetlands Regulations, FWR 10.02 (1)(a - d), as well as on impervious surfaces. The bylaw also prohibits the application of fertilizer anywhere in Town from October 16th to April 14th. During the growing season of April 15th to October 15th, fertilizer application is banned during heavy rain. There are exceptions for agriculture and horticulture. On golf courses, fertilizer may be applied over the entire growing season; but on greens and fairways within defined wetland resource areas, no more than 1.0 pound of nitrogen can be applied per 1,000 square feet per year and 85% or more of this fertilizer must be in an organic or inorganic, slow-release, water-insoluble form. There are also allowances for the application of organic constituents applied to improve the physical condition of the soil and the establishment of turf. Enforcement is through the Department of Marine and Environmental Services (a merging of the Harbormaster's Office and the Department of Natural Resources). A copy of this Nitrogen Control Bylaw is included in Appendix 3.6.

This Nitrogen Control Bylaw coupled with local educational efforts is expected to reduce the controllable watershed load of nitrogen attributed to fertilizer by 25%. This nitrogen-removal credit is consistent with the methodology used in the Cape Cod Commission's 208 Area-wide Plan Update.

3.6.2 Ongoing Public Education and Enforcement

Since the adoption of this Bylaw, two main efforts have been used to build public understanding of and compliance with this regulation. These include:

- Annual mailings to approximately 2,700 properties that are within 100-feet of coastal estuaries throughout the Town regardless of their level of impairment of these estuaries;
- A requirement in the Conservation Commission's Standard Order of Conditions that applicants must obey the Nitrogen Control Bylaw.

A copy of the letter that is mailed out and a copy of the Standard Condition adopted by the Conservation Commission are included in Appendix 3.6. The mailing list is updated each year through Falmouth's GIS and assessor's records. The Standard Condition is included in all Orders of Conditions issued.

3.7 Stormwater Management

3.7.1 Introduction

Stormwater runoff contributes 5- to 10-percent of the controllable nitrogen sources entering Falmouth's watersheds. A summary of the nitrogen loads to these watersheds from various sources including stormwater is included in Appendix 3.8 of the Town's CWMP (September 13, 2014). To date, little has been done to directly address this controllable load, so the WQMC has coordinated with the Department of Public Works (DPW) to review the Town's stormwater systems and identify opportunities to implement stormwater Best Management Practices (BMPs) that remove nitrogen. Actions taken to date include:

- Submission of a Statement of Interest to the EPA Region 1 Southeast New England Coastal Watershed Restoration Program in response to a grant request issued in 2014. Falmouth's proposal was not selected to participate in this program.
- Detailed review of stormwater inputs to Great Pond in collaboration with the Town's engineering department.
- Review of a promising technology based on modified catch basins (called media boxes) designed and installed by the Town of Dover, New Hampshire as part of the Berry Brook river restoration project.

Implementing stormwater BMPs is expected to reduce the controllable watershed load of nitrogen attributed to stormwater by 25%. This nitrogen-removal credit is consistent with the methodology used in the Cape Cod Commission's 208 Area-wide Plan Update.

3.7.2 Inventory of Stormwater Systems for EPA Region 1 Statement of Interest

In order to submit a Statement of Interest to the EPA Region 1, approximately 12 potential stormwater systems were reviewed by WQMC and DPW engineering staff. Through this review, three promising locations were identified where stormwater BMPs could be implemented.

Candidate sites included:

- Green Pond watershed: storm drain #10 - end of Captain's Lane that discharges directly into Green Pond (Davisville peninsula, East Falmouth).
- Falmouth Inner Harbor watershed: storm drain #50 – 180 Scranton Ave at the Harbormaster's Office that discharges directly into Falmouth Harbor.
- Waquoit Bay watershed: White's Landing – off White's Landing Road that discharges directly into Eel River via Childs River.

All locations are Town-owned and publicly accessible. A copy of this Statement of Interest is included in Appendix 3.7.

3.7.3 Great Pond Watershed

The following storm drain locations around Great Pond were reviewed with the DPW engineering staff to identify whether stormwater BMPs implementations would be feasible and advantageous:

- Route 28 at Coonamessett River crossing (under Mass. Dept. of Transportation control).
- Teaticket Path.
- Perch Pond Circle.
- Six (6) streets on the Maravista peninsula: Reynolds, Randolph, Mattapan, Milton, Morris, and Great Bay Road.

Perch Pond, a small sub-embayment of Great Pond, is of particular interest because it receives, directly or indirectly, the flow of most of the above storm drains resulting in the highest nitrogen concentrations measured in all of Great Pond. Therefore, its setting presents a good location to determine if BMPs implementations result in observable reductions in nitrogen concentrations in the receiving waters.

Because the drains discharge to the head of Perch Pond in the Great Pond watershed, calculations for the potential nitrogen input from Route 28 storm drains and the Teaticket Path stormwater system were completed. Approximately 16 kg N/year and 60 kg N/year, respectively, flow into Perch Pond from these two catchment areas. In order to implement BMPs that could remediate these sources, land would need to be acquired and wetlands permitting completed, including filing with MassDEP. Coordination with the state is also required to address the Route 28 storm drains. Initial field review of the other discharge locations immediately after a heavy rain event in early December 2017 did not show significant discharge into Great Pond. The leaf debris on the slope at the discharge end of the pipe was not disturbed. Given the existing space limitations, the decision was made to review the effectiveness of media boxes and other space-efficient solutions before implementing any specific measure.

3.8 Inlet Widening – Bournes Pond

3.8.1 Bournes Pond Inlet Widening Notice of Project Change

In January 2016, the Town of Falmouth filed their first Notice of Project Change (NPC) for the Bournes Pond Inlet Widening piloting program as part of their adaptive management approach. The NPC identified the inlet widening's potential contribution towards attaining water quality standards within the watershed and reviewed the alternatives analysis and mitigation measures needed to mitigate adverse impacts during construction and following implementation. The Town received the Certificate of the Secretary of Energy and Environmental Affairs on the Notice of Project Change on March 11, 2016 (EEA Number 14154).

3.8.2 Background

The Bournes Pond Inlet Widening Project (Project) is a water quality improvement and tidal restoration project being advanced by the Town of Falmouth and the Town's WQMC. The widened inlet will provide long-term, immediate improvements to water quality due to increased tidal flushing with an increase in water exchange of over 9 million gallons per tide. Widening will remove approximately 50% of the target nitrogen load and enhance eelgrass and shellfish habitats. This will be accomplished by increasing the width of the inlet from 50 feet to the optimal size of 90 feet.

Bournes Pond Inlet (Figure 3.7) currently has a single span bridge and two jetties. There is no change in bridge height planned, so the intentional restriction of large boats from entering this pond remains intact. The new bridge design specifies a 25-foot extension of the western jetty, complemented by the removal of 25-feet of groin currently located to the west of that jetty. This results in no net increase in the footprint of coastal structures.

Figure 3.7 Bournes Pond Inlet Location

Bournes Pond Inlet separates East and West Menauhant Beaches. Parking areas run along the south side of the road and manmade dunes serve as a seaward barrier to the parking areas, road, and bridge (Figure 3.7).

The project is within a barrier beach-coastal beach system, velocity zone, Natural Heritage and Endangered Species Program (NHESP) Priority Habitat, and Chapter 91 Jurisdiction. Required permits and authorizations are further detailed in Section 3.8.3.

Historically, the inlet was generally wider than the existing 50-foot inlet that was constructed in 1985. Based on the available historical information since 1844, the inlet width varied between 88 feet and 400 feet, where the widest inlet may be a result of storm breaching. More recently, it appears that the inlet width in 1969 was 209 feet wide. Overall, the historical inlet information for Bournes Pond demonstrates that the proposed 90-foot wide inlet is well within the range of previously mapped inlet widths and is generally at the lower end of the historical stable inlet widths observed at the Bournes Pond entrance.

Appendix 3.8 includes the "Narrative" of the January 2016 NPC which outlines the evaluations, nitrogen loads, modeling, potential environmental impacts, and permitting. In 2016 the projected costs for the proposed inlet widening totaled $5.52 million. The inlet widening is projected to have an effective nitrogen removal of approximately 2,000 kg N/year. Factoring in operating and maintenance costs over a 45-year period, it is estimated that the widening of the Bournes Pond inlet will cost approximately $84 per kilogram of nitrogen removed.

3.8.3 Permitting

The following permits have either been filed or received:

- US Army Corps of Engineers (USACE): 404 Permit – Approved July 12, 2019.
- Cape Cod Commission (CCC): Development of Regional Impact (DRI) Certificate of Compliance – Approved April 7, 2016.
- Massachusetts Historical Commission (MHC) – Project Notification Form – Approved April 26, 2017.
- Massachusetts Office of Coastal Zone Management (CZM) – Federal Consistency Review – Approved September 14, 2018.
- Massachusetts Department of Environmental Protection (MassDEP).
  - 401 Water Quality Certification and Chapter 91 Permit – Approved July 30, 2018.
  - Chapter 91 License – Approved November 19, 2018.
  - Notice of Intent /Superseding Order of Conditions – Approved January 31, 2018.
- Massachusetts Department of Transportation (MassDOT) – Chapter 85 Submission – In Development.
- Natural Heritage Endangered Species Program (NHESP) – MESA Project Review Form – Approved June 21, 2017.
- Town of Falmouth Conservation Commission – NOI – Approved June 28, 2017 (see MassDEP).
- US Coast Guard – Coast Guard Permit – Approved December 19, 2017.
- United States Environmental Protection Agency (USEPA) – NPDES General Permit – Required during construction.

A full description of the status of the Bournes Pond inlet project is outlined in Chapter 8.

4. Little Pond Targeted Watershed Management Plan Update

4.1 Current Status of Meeting the TMDL

4.1.1 Little Pond Sewer Service Area Update

The construction of the collection system serving the Little Pond Sewer Service Area (LPSSA) was initiated April 15, 2015 and included sewering 1,350 developed properties within both the Little and Great Pond watersheds, as well as properties within the lower portion of the watershed in the neighborhoods of Falmouth Heights and Maravista. The Falmouth Heights portion of the area was completed and ready for properties to connect to the sewer system in June of 2016. The remainder of the sewer system (Maravista and Teaticket Highway areas) was completed and ready for sewer connection in April of 2017. As of May 2019, 95% of those 1,350 parcels have been connected to the sewer system. It is expected that nearly 100% of the LPSSA parcels will be connected to the sewer system by the fall of 2019.

The LPSSA sewer system was constructed to improve Little Pond water quality by reducing the nitrogen load to the pond from septic systems. It increasingly serves this purpose as more properties in the service area are connected to the sewer system. Water quality in Little Pond is expected to improve over time. Water quality improvement is anticipated to be gradual, as it will take an estimated seven years for the entire nitrogen load from previous years' septic discharge to move through the groundwater and soils and seep into the pond. As this proceeds, the Town will continue to monitor water quality in Little Pond. The Town and the United States Geological Survey (USGS) have commissioned a sampling effort described in the following section.

The following Table provides an estimated breakdown of the parcels within the entire sewer service area described above. The subsequent analysis will focus on those properties of the sewer service area specifically within the Little Pond Watershed (approximately 1,010).

Table 4.1 Breakdown of Little Pond Sewer Service Area Sewered Parcels

Watershed	Parcel Count
Little Pond Watershed	1010
Great Pond Watershed	253
Outside Watershed (1)	87
Total (2)	1350

(1) Outside watershed – recharges directly to Vineyard Sound.

(2) The total number of parcels in the LPSSA required to connect to the sewer system is approximately 1,350 (that number is lower than the number of properties bettered because some of the bettered parcels are undeveloped and some parcels include multiple property units).

4.1.2 Analysis of Little Pond Water Quality Data and Groundwater Data

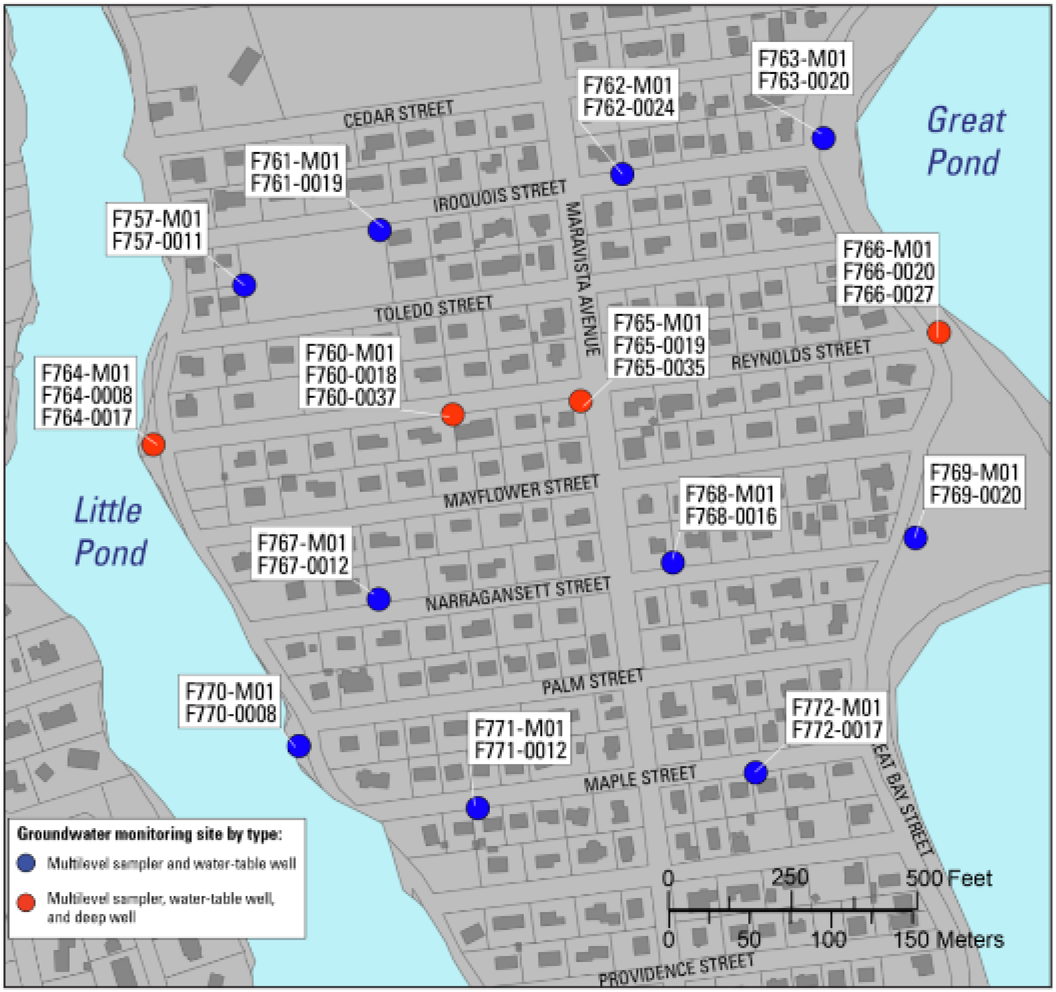
As discussed in Chapter 2, the USGS, the Town of Falmouth, and the United States Environmental Protection Agency (USEPA) have been cooperating in a groundwater sampling and modeling study of the Little Pond watershed. To date, this project has collected data since 2016 through April 2018 to establish baseline groundwater-quality data for the area as the Town moved forward with its sewer implementation.

The following information is from the USGS webpage and the work of Timothy McCobb and Jeffrey Barbaro, et. al. related to the "Assessment of Hydrologic and Water-Quality Changes in Shallow Groundwater Beneath a Coastal Neighborhood Being Converted from Septic Systems to Municipal Sewers (USGS 2019)." https://www.usgs.gov/centers/new-england-water/science/assessment-hydrologic-and-water-quality-changes-shallow?qt-science_center_objects=0#qt-science_center_objects

The study's objectives are as follows:

- "Establish a monitoring network to assess groundwater levels and water quality beneath a densely developed coastal neighborhood undergoing a conversion from septic systems and cesspools to municipal sewers; and
- Develop an understanding of water-quality conditions before and after installation of the sewers."

The effort has included the installation of 18 monitoring wells and 14 multilevel samplers at 14 locations to monitor water levels and groundwater quality beneath the Maravista Peninsula (USGS 2019). Sampling was performed in June 2016, April 2017, and April 2018, with field parameters measured including: specific conductance, dissolved oxygen, pH, alkalinity, and temperature, in addition to lab sampling for nitrate, nitrite, ammonium, and phosphorus, boron, and chloride, amongst others (USGS 2019). The sampling team completed its next round of sampling in June 2019. Figure 4.1 shows the location of the groundwater monitoring well network (USGS 2019).



"F" in site name shorthand for MA-FSW; "M01" in site name indicates 15-port multilevel sampler; For monitoring wells, four digit number after site name reflects depth of well below land surface, in feet (e.g. MA-FSW 764-0017)

Figure 4.1 USGS Groundwater Monitoring Well Locations (USGS 2019)

Once the data are collected, USGS will complete a report documenting their findings and establishing a baseline groundwater condition to be compared against future monitoring.

The Town of Falmouth is also continuing to monitor water quality in the pond itself using the Pond Watchers Program directed by University of Massachusetts School for Marine Science and Technology (SMAST). As reported in Chapter 2, during the last two decades there has been basically no change in water quality in Little Pond.

4.2 Updated Little Pond Total Maximum Daily Load Compliance Plan Approach

4.2.1 Background

On October 6, 2014, the Town of Falmouth submitted the "Amended Targeted Watershed Management Plan for Little Pond." This document outlined the TWMP components for the entire

Little Pond watershed using traditional and non-traditional nitrogen management approaches identified in the 2013 Comprehensive Wastewater Management Plan (CWMP) Report.

The compliance plan approach established in 2014 included the following potential components:

1. Sewer extension to the Little Pond Sewer Service Area.
2. Continued use of conventional septic systems for the non-sewered properties in the Little Pond Watershed.
3. Fertilizer management in compliance with the Town's approved Bylaw.
4. Stormwater management.
5. Shellfish aquaculture.
6. Little Pond inlet opening.
7. Use of enhanced innovative and alternative (enhanced I/A) systems as defined in the Cape Cod Commission (CCC) 208 Plan (CCC, 2014) for the non-sewered properties in the watershed and eco-toilets (composting and urine-diverting).

The above components were then integrated into several options to achieve the nitrogen Total Maximum Daily Load (TMDL). These options for achieving compliance are summarized below:

- First option using sewering, fertilizer and stormwater management, aquaculture, and inlet widening;
- A second option with no inlet opening but increased use of I/A systems.
- A third option with no inlet opening or shellfish and increased use of I/A systems.
- And lastly an option of expanded sewering.

As part of this current Update Report, the various components identified in 2014 are discussed and their relevance for use as part of an Updated TMDL Compliance Approach are identified.

4.2.2 Sewer Extension to the Little Pond Sewer Service Area

As identified in Section 4.1, sewer service to this area was provided in 2016 to 2017 and 95% of the developed properties have connected to the sewer system as of May 2019. It is expected that 100% of the developed properties will be connected to the sewer system by the fall of 2019. The sewer service area remains the same as presented in 2014.

4.2.3 Continued Use of Conventional Septic Systems for Non-Sewered Properties in the Watershed

As part of the 2014 TWMP, two build-out analyses were performed to estimate nitrogen load from properties not proposed to be connected to the LPSSA collection system. For the purposes of the development of the 2014 TWMP, an average of the two buildout methods was used in order to estimate the potential load from these systems. The report estimated the annual load to Little Pond from unsewered properties in the future (buildout) condition to be 4.00 kg/d.

It is anticipated that in the future some improvement to existing septic systems may be required in order to achieve TMDL compliance. At this time it is anticipated that TMDL compliance will be met through the use of the LPSSA sewers, credit for fertilizer and stormwater nitrogen reduction, shellfish aquaculture, and some form of enhanced nitrogen removal through the use of I/A systems at these unsewered properties. The number of properties required to convert to enhanced I/A systems will depend on the measured success of the other strategies (sewers, aquaculture, etc.) in achieving TMDL compliance over time.

It is important to note, however, that two significant parcels of land that could have been developed have been put into conservation and park uses in perpetuity and will therefore never be developed: a former golf driving range [10.7 acres] at the headwaters of Little Pond Stream, and a former golf course [16.69 acres]. Both parcels, instead of contributing nitrogen to the watershed, will now be attenuating nitrogen from the watershed.

4.2.4 Use of Enhanced I/A Systems for the Non-Sewered Properties in the Watershed

As outlined in the 2014 Amended TWMP, the wastewater nitrogen loadings from the non-sewered properties using enhanced I/A systems were estimated using the following steps:

1. Nitrogen load to the groundwater system for the properties in each watershed (not proposed to be sewered) was calculated by multiplying the estimated wastewater flow values for each property with a nitrogen concentration of 13 mg/L (along with several conversion factors) to obtain nitrogen loading values.[1]
2. The wastewater nitrogen load estimate to Little Pond is adjusted utilizing the nitrogen attenuation and pass-through factors identified as part of the MEP analysis.

This resultant wastewater nitrogen loading value was calculated in the 2014 Report to be 1.98 kg/d for all remaining non-sewered, wastewater generating parcels at a projected build-out level with attenuation.

For the purpose of this update, a reduction from 26.25 mg/L to 10 mg/L is assumed as the concentration reduction for these types of systems and then a factor for attenuation (depending on its subwatershed of origin) was applied. The Town has adopted 10 mg/L performance for I/A systems based on the Town's Board of Health regulations (see Appendix 4.2). This was done for a total count of existing non-sewered parcels (166) and equates to a potential removal of 340 kg/yr. This calculation does not take into account the reduction in parcels and nitrogen loading from conversion to parkland described in 4.2.3. The Town is only proposing the installation of I/A systems in this watershed if necessary based on the performance of other alternatives and sewering within the watershed.

[1] This value is identified in the Draft CCC 208 Plan as the expected nitrogen performance of enhanced I/A systems.

4.2.5 Fertilizer Management in Compliance with the Town's Approved Bylaw

As discussed in the 2013 CWMP Report and the 2014 Amended TWMP and this document, the Town passed a Nitrogen Control Bylaw for Fertilizer Management that includes the following main components:

1. Prohibits fertilizer application within 100 feet of resource areas as defined in Falmouth’s Wetland Regulations, as well as on impervious surfaces.
2. Prohibits the application of fertilizer from October 16 to April 14.
3. Prohibits fertilizer application during heavy rain in the growing season (April 15 to October 15).
4. The fertilizer application rate to golf courses is limited to 1 lb of nitrogen per 1,000 square feet for the entire growing season, and 85 percent or more of this fertilizer must be in organic, slow release, and water-insoluble form.

Enforcement is through the Town’s Department of Marine and Environmental Services. A copy of the bylaw and related information is included in Appendix 3.6, as discussed in Chapter 3.

With this bylaw in place and enforced, a nitrogen fertilizer removal of 25 percent was estimated, as allowed in the CCC 208 Plan (CCC, 2014). Per the Amended 2014 TWMP, the build-out fertilizer load to Little Pond was estimated as 476 kg/yr (653 kg/yr minus 18 kg/yr, with the remainder multiplied by 0.75 to accommodate the 25 percent removal allowed for the bylaw). This resulted in a load of 1.30 kg/d.

It is anticipated as part of this update that this same 25 percent reduction would be applied as part of the approach. For the purposes of this update the non-buildout attenuated load of 631 kg/y was used, equating to a removal of 158 kg/yr, which still leaves approximately 1.30 kg/d of contribution. The summary of these estimates are included in Appendix G of the 2014 Amended TWMP.

4.2.6 Stormwater Management

As part of the National Pollutant Discharge Elimination System (NPDES/MS-4) permitting efforts, the Falmouth Department of Public Works (DPW) provides the following items with respect to stormwater management:

1. Education and outreach.
2. Mapping of all catchment areas (Falmouth Heights and Maravista have been completed).
3. Adding new infiltration basins (leaching catch basins) for roads with inadequate or no stormwater management infrastructure.
4. Eliminating direct outfalls where possible.
5. Installing bioretention where feasible.
6. Incorporating general stormwater improvements as needed at the time of road paving operations.

Future stormwater nitrogen loadings to Little Pond were estimated from information compiled as part of the technical evaluation for Little Pond (MEP, 2006). Appendix G of the 2014 Amended TWMP contains a worksheet summarizing this evaluation. A total attenuated build-out stormwater nitrogen load of 485 kg/yr was estimated as part of the 2014 TWMP, which equates to a load of 1.33 kg/d. As part of the 2014 Amended TWMP, the Town did not elect to take the 25 percent credit allowed by the CCC 208 Plan at that time, but stated it would consider it in the future.

The Town has elected to take advantage of the 25 percent credit as part of this update. The estimated load reduction of the non-buildout load is 115.5 kg/yr, or 25 percent of the attenuated "present" load (462 kg/yr) as identified in that same Appendix G of the TWMP. In addition, as part of the LPSSA sewering project the Town has initiated improvements to its existing stormwater infrastructure in accordance with stormwater management practices outlined above.

4.2.7 Permeable Reactive Barriers (PRBs)

As described in Chapter 3, PRBs have been considered in several of the Town's watersheds. However, this technology was not identified as part of the 2014 TWMP and a credit for nitrogen removal from PRBs is not being estimated at this time. The Town may consider utilizing a credit in the future following further evaluation.

4.2.8 Shellfish Aquaculture

As discussed in Chapter 3, Section 3.2, the Town has actively investigated the use of shellfish aquaculture in order to achieve TMDL compliance in several watersheds, including Little Pond.

The Town currently has a minimum estimated effective nitrogen removal (nitrogen sink) of 29 kg/yr from Little Pond by applying oyster aquaculture on 0.25 acres of Little Pond. The municipal aquaculture program currently has the capacity to expand to approximately 1.0 acre in Little Pond. The expansion of the program is dependent on the outcome of several pilot projects and funding availability.

Removal of 33 to 53 kg/yr by applying oyster aquaculture on 0.25 acres of Little Pond will be applied as part of the proposed compliance approach.

4.2.9 Little Pond Inlet Widening

The MEP Technical Report for Little Pond (MEP, 2006) investigated possible benefits of increasing the inlet opening (summarized in Tables VIII-2 and IX-3). The effective nitrogen removal for the enlarged inlet is estimated by subtracting the threshold septic load of the Non-Widened Inlet Scenario (summarized in Table VIII-2 at 2.198 kg/d) from the threshold load of the Widened Inlet Scenario (summarized in Table IX-3 at 3.847 kg/d). The difference of 1.65 kg/d is the effective nitrogen removal (nitrogen sink) of the inlet opening and represents the amount of attenuated nitrogen to the pond that would not need to be removed through other methods if the inlet were enlarged.

At this time, the Town is not actively considering inlet widening at this waterbody and is planning to address nitrogen TMDL compliance through other means.

4.2.10 Summary of Updated Compliance Approach

The nitrogen budget, based on Table 7 of the 2014 TWMP for Little Pond (compliance approach without using inlet opening), is summarized in Table 4.2 and is the same as the original second option or "preferred scenario" identified in the 2014 Amended TWMP.

Table 4.2 TWMP Table 7 Nitrogen Budget for Little Pond (Option 2)

Watershed Nitrogen Sources and Sinks[1]	Nitrogen Loading (kg/d)
Wastewater from Sewered Properties	0.00
Wastewater from Unsewered properties (I/A)	1.98
Fertilizer[2]	1.30
Stormwater[2]	1.33
Shellfish Aquaculture[1]	-0.25
Total[1]	**4.36**
Target Threshold Watershed Load (controllable)	**5.36**

(1) Nitrogen sinks are nitrogen removals that occur in the water body.
(2) Loadings for these sources are all attenuated loadings and incorporate the nitrogen removals that occur as the groundwater flows through ponds and streams.

The applicable TMDL number for the nitrogen loading to Little Pond is 5.36 kg/d. This is the Target Watershed Load as summarized in Table 5 of the Little Pond TMDL Document (MassDEP, 2008). Because this Target Watershed Load number is greater than the total nitrogen budget loading of the above table, the Updated Compliance Approach using enhanced I/A systems and no modifications to the inlet meets the TMDL. As was identified in the 2014 TWMP, the TMDL components of Table 5 of the TMDL for Little Pond do not sum properly, and it is believed that this table has a typo or the sum was incorrectly rounded. Reviewers at MassDEP are requested to verify this belief.

As an alternative means of summary, consistent with the approach used by the Water Quality Management Committee for each of the watersheds discussed as part of this update, Table 4.3 has been created to represent the nitrogen loading removals based on "existing" conditions (no buildout) and from the perspective of load reduction vs. load remaining. The following table summarizes the estimated nitrogen removals anticipated for each "system" component as compared to the overall nitrogen removal goal for Little Pond based on the Massachusetts Estuaries Project (MEP) Table VIII-3 total attenuated load threshold of controllable sources. That goal is 5,006 kilograms of total nitrogen per year.

Table 4.3 Nitrogen Budget for Little Pond Updated Compliance Approach

Compliance Component	Nitrogen Loading Reduction (kg/yr)
Sewering	4,141 - 5,252
I/A Systems	340
Fertilizer (25% of fertilizer load)	158
Stormwater (25% of impervious load)	116
Shellfish Aquaculture (uptake)	33 - 53
Shellfish Aquaculture (denitrification)	17 - 27
Total Estimated Reduction	**4,858 – 5,946**
Nitrogen Removal TMDL Goal	**5,006**

In summary, the Town of Falmouth believes that it has taken significant steps to meet the TMDL for Little Pond and remove nitrogen from the watershed. Monitoring of water quality in Maravista over the next five years will show to what degree sewering reduces nitrogen in the groundwater prior to discharge to Little Pond. Monitoring of water quality in Little Pond itself will provide evidence of how long it takes for a shallow estuary to recover.

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5. West Falmouth Harbor Targeted Watershed Management Plan Update

5.1 Current Status of Meeting the Total Maximum Daily Load (TMDL)

5.1.1 Blacksmith Shop Road WWTF Background

The Falmouth Wastewater Treatment Facility (WWTF) was originally constructed in 1986. This original facility was a lagoon secondary treatment system with effluent recharge in the West Falmouth Harbor watershed. In 2001, the Town completed a facilities plan which proposed upgrades to the facility to improve wastewater treatment. In 2005, the treatment process at the WWTF was upgraded to a tertiary treatment process involving sequencing batch reactors (SBR) followed by denitrification filters in order to provide enhanced nitrogen removal.

The location of treated wastewater recharge from the WWTF has varied substantially over the years. Figure 5.1 shows all recharge locations used since the original WWTF began operating, relative to watershed boundaries, monitoring well locations, and other features.

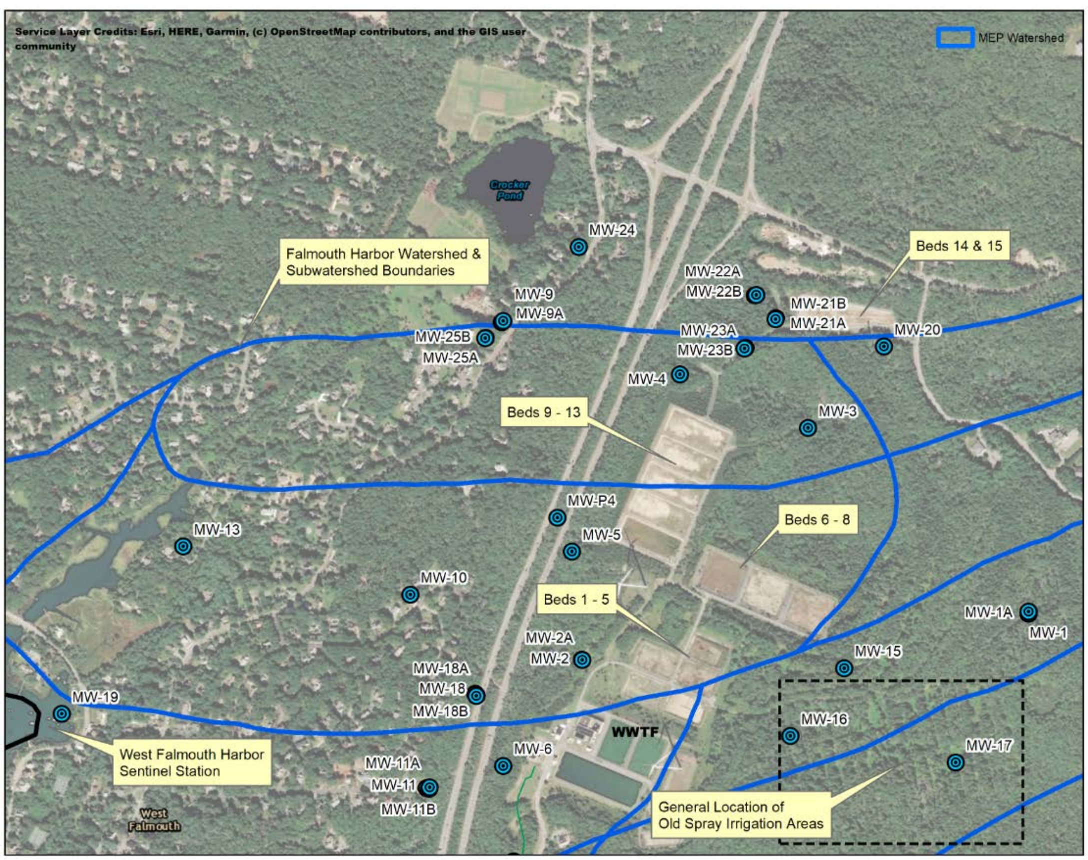

Figure 5.1 Falmouth Main WWTF – Recharge Locations, Monitoring Wells, West Falmouth Harbor Sentinel Location, and Watershed Boundaries

From start-up of the original WWTF in 1986 through 2005, a significant fraction of the recharge was distributed across five spray irrigation beds in the spring through fall. The Town ceased use of spray irrigation for recharge in 2005. In addition, the WWTF has 15 open sand recharge beds which were constructed for effluent recharge in four phases. Effluent recharge to Recharge Beds 1 through 5 was initiated in 1986. Recharge to Beds 6 through 8 began in the 1990s, to Beds 9 through 13 in 2006, and to Beds 14 and 15 in 2017. Beds 14 and 15 were constructed to accommodate effluent flow from the Little Pond Sewer Service Area. Recharge Beds 1 through 13 are located within the West Falmouth Harbor watershed, and Recharge Beds 14 and 15 are located north of the West Falmouth Harbor watershed.

The WWTF currently operates under Modified Groundwater Discharge Permit No. 168-5, effective date December 22, 2015 (2015 Permit). The 2015 Permit allocates effluent flow limits by watershed. The 2015 Permit limits average annual effluent recharge within the West Falmouth Harbor watershed (to beds 1 to 13) to 450,000 gpd, and outside of the West Falmouth Harbor watershed (to beds 14 and 15) to 260,000 gpd.

As part of the preliminary design process for the Little Pond Sewer Service Area Project (LPSSA), an evaluation of the existing facilities at the Blacksmith Shop Road WWTF was conducted to assess the facility's treatment capacity and identify operational limitations. In particular, the evaluation was intended to identify any improvements required to accommodate additional flow and nitrogen load from the LPSSA. The evaluation was summarized in the memorandum titled "Technical Memorandum WW-1, Existing WWTF and Vent Evaluation," prepared by GHD and dated March 2013.

A second evaluation titled "Nitrogen Removal Optimization Planning – Falmouth Flow and Nitrogen Planning," prepared by GHD and completed in September 2013 focused on means of improving the WWTF's ability to meet the low effluent nitrogen best effort level of 3 mg/L. Main process-related recommendations from these evaluations included:

- Installation of additional diffusers in each SBR to increase treatment capacity.
- Addition of a flow-paced sodium hydroxide feed system to provide more reliable alkalinity and pH to the SBRs.
- Installation of standard analyzer assemblies for the denitrification filters to provide continuous analysis of filter influent and effluent nitrate-nitrogen.
- Optimization of the methanol (carbon) injection location.
- Installation of a second blended sludge tank to provide operational flexibility.
- Modifications to the effluent distribution system to improve WWTF effluent flow measurement.

Construction of the recommended modifications was completed in 2015-2016 as part of the LPSSA project.

In 2019, a preliminary evaluation was conducted to assess required upgrades to accommodate proposed flow from the Teaticket/Acapesket Sewer Service Area (TASSA) as well as additional flow from the Existing Sewer Service Area. The evaluation is summarized in the "Teaticket/Acapesket Study Area Technical Memorandum No. 4 – WWTF Evaluation," prepared by GHD and dated April 2019 (Appendix 5.1). The evaluation recommended construction of a third SBR and construction of additional effluent recharge capacity outside of the West Falmouth Harbor watershed. The Wastewater Division has requested funds in the FY 2020 Capital Plan to better delineate the next phase of WWTF upgrades required, including SBR sizing and design requirements, sludge processing technology replacement options, and operations building rehabilitation needs.

5.1.2 WWTF Flow and Nitrogen Removal Performance

The effluent total nitrogen concentration from the original lagoon wastewater treatment facility averaged greater than 23 mg/L from 1994 to 2005.

Since the tertiary treatment facility replaced the original lagoon wastewater treatment facility, i.e., from January 2006 through June 2019, the WWTF's effluent total nitrogen concentration has averaged less than 4.5 mg/L.

Table 5.1 lists WWTF effluent flow and nutrient data for the first two full years after the most recent WWTF improvements were completed in 2016, compared to 2015 Permit limitations.

Table 5.1 Falmouth WWTF Effluent Flow and Nutrient Data for 2017 and 2018, Compared to 2015 Permit Limitations

Effluent Parameter	2017	2018	2015 Permit[1] Discharge Limitations
Average Flow to Recharge Beds 1 through 13 (gpd)	310,526	349,782	450,000
Average Flow to Recharge Beds 14 and 15 (gpd)	78,864	101,066	260,000
Average Total Nitrogen (mg/L)	2.81	2.49	Best efforts to meet an annual average concentration of 3 mg/L (or less)
Average Nitrate – Nitrogen (mg/L)	0.45	0.34	Best efforts to meet an annual average concentration of 3 mg/L (or less)
Cumulative Nitrogen Annual Load within the West Falmouth Harbor Watershed (lb/yr)[2]	2,733 (1,242 kg/yr)	2,733 (1,242 kg/yr)	Best efforts to discharge 4,109 lbs (or less) of nitrogen per year within the West Falmouth Harbor watershed[2]
Average Total Phosphorus (mg/L)	2.7	4.3	NA[3]
Average Ortho-phosphate (mg/L)	2.6	4.3	NA[3]

Notes:

1. Modified Individual Groundwater Discharge Permit No. 168-5', effective date December 22, 2015. (2015 Permit).
2. Not an average; total annual load. The goal is to discharge less than the Cumulative Nitrogen Annual Load. 4,109 lbs/yr = 450,000 gpd x 3 mg/L. It is a coincidence that the cumulative total nitrogen load was the same in 2017 and 2018.
3. The 2015 WWTF Permit does not have an effluent limit for phosphorus but requires monthly phosphorus monitoring.

In this period (2017-2018), effluent flow was lower than the permitted average annual flow limits, in part because LPSSA properties were still connecting to the sewer in this period, and in part because of the build-out allocation in the Permit. All LPSSA properties are expected to be connected by the fall of 2019.

The Wastewater Division reviews new development and redevelopment within the sewer service areas with regard to sewer system capacity. Based on existing flows and projected flows from development and redevelopment planned to-date, the Wastewater Division projects that total average annual flow will reach 80% of the permitted total average annual flow in year 2021 or 2022. The 2015 permit requires that when this point is reached "the permittee shall submit a report to the Department describing what steps the permittee will take in order to remain in compliance with the permit limitations…" Because the Town projects that this point will be reached in year 2021 or 2022, this CWMP/TWMP NPC Update includes plans for accommodating additional flow from TASSA and from existing sewer service areas by: implementing an additional phase of WWTF upgrades, developing additional recharge capacity, and addressing capacity-limited points in the existing collection and transmission system, all in parallel with the proposed design and construction of the TASSA collection system.

In 2017 and 2018, effluent total nitrogen and nitrogen as nitrate concentrations both averaged below the discharge permit's average annual effluent best effort level of 3 mg/L. In February 2019, a mechanical failure in one of the two SBRs necessitated the removal of one SBR from operation while maintenance was completed. During that maintenance event, the SBR manufacturer's representative recommended additional service to the SBR diffusers. This service/repair period impacted WWTF performance from February through May of 2019. After the SBR was returned to service and the WWTF returned to dual tank mode of operation, WWTF performance returned to the normal range of 2.5 – 4.0 mg/L in June 2019.

Based on the effluent flow recharged to beds 1 to 13 and the effluent total nitrogen concentration, the total nitrogen load contributed to the West Falmouth Harbor watershed was 2,733 lbs/yr in both 2017 and 2018 (it is a coincidence that the load was the same both years). That load of 2,733 lbs/yr is 33% lower than the best efforts cumulative annual load level of 4,109 lbs/yr in the 2015 Permit. Due to the issues explained above, the total nitrogen load discharged to the West Falmouth Harbor watershed in 2019 is expected to be greater than the best efforts load level.

This data demonstrates that the upgraded WWTF is capable of reducing effluent total nitrogen concentration to the best effort level of 3 mg/L for extended periods of time (in this case, for more than two years). However, like any WWTF, this WWTF is potentially subject to unforeseen conditions that can impact performance. Capital funds are being requested in FY 2020, 2021, and 2022 to evaluate, design, and construct a third SBR (and complete other WWTF upgrades) to provide greater operational flexibility and to accommodate additional flow and load from future sewer service areas.

5.1.3 Monitoring Wells

Groundwater monitoring requirements for the WWTF in the 2015 WWTF Permit include quarterly sampling for nitrogen and phosphorus through a groundwater monitoring network comprised of 17 monitoring wells (well locations shown on Figure 5.1). The groundwater monitoring network is summarized in Table 5.2.

As indicated in Table 5.2, six of the wells are intended to monitor up and downgradient of recharge beds 1 through 13, within the West Falmouth Harbor watershed, and 11 of the wells are intended to monitor up and downgradient of the newest Recharge Beds 14 and 15, outside the West Falmouth Harbor watershed.

Table 5.2 Falmouth WWTF Groundwater Monitoring Network

Effluent Recharge Location	Up-Gradient Wells	Down-Gradient Wells	Well Locations – By Watershed
Recharge Beds 1 - 13	MW-1a	MW-2A MW-P4 MW-10 MW-13 MW-19	• West Falmouth Harbor
Recharge Beds 14 - 15	MW-20 (GHD-1)	MW-21A (GHD-4A) MW-21B (GHD-4B) MW-22A (GHD-5A) MW-22B (GHD-5B) MW-23A (GHD-6A) MW-23B (GHD-6B) MW-25A (GHD-3A) MW-25B (GHD-3B) MW-24 (GHD-2) MW-4	• West Falmouth Harbor[1] • Crocker Pond • Buzzards Bay

Notes:

1. Groundwater modeling for Open Beds 14 and 15 indicates that all of the effluent recharged at Recharge Beds 14 and 15 will ultimately surface in Buzzards Bay and none of the flow will go to West Falmouth Harbor. Several groundwater monitoring wells are included in the West Falmouth Harbor watershed to validate this modeling conclusion.

Total nitrogen and total phosphorus concentration data collected from the Recharge Beds 1 through 13 monitoring network is summarized in the following Figures 5.2 and 5.3.

Figure 5.2 shows that total nitrogen concentration in the downgradient wells increased after the original lagoon WWTF began discharging and then decreased in recent years after the tertiary WWTF began operating. The timing, consistency, and scale of that trend varies from well to well based on location of the well relative to historic and current discharges. (Figure 5.1 shows locations of monitoring wells relative to recharge locations and other features.)

For example, in MW-2A which is located closest to (immediately downgradient of) the original Recharge Beds 1 through 5 (and downgradient of the old spray irrigation areas), the total nitrogen concentration was greater than 7 mg/L during many of the monitoring events from 1987 to 2005, but has declined to less than 2 mg/L in recent years. Total nitrogen concentration in MW-19, which is furthest downgradient from the recharge (immediately adjacent to West Falmouth Harbor), began to increase in 2001, about 15 years after the discharge began from the original lagoon WWTF, peaked at > 9 mg/L in 2006, and currently remains > 4 mg/L. Total nitrogen concentrations in all wells downgradient from beds 1 through 13—other than MW-19—have been below 2 mg/L for more than one year.

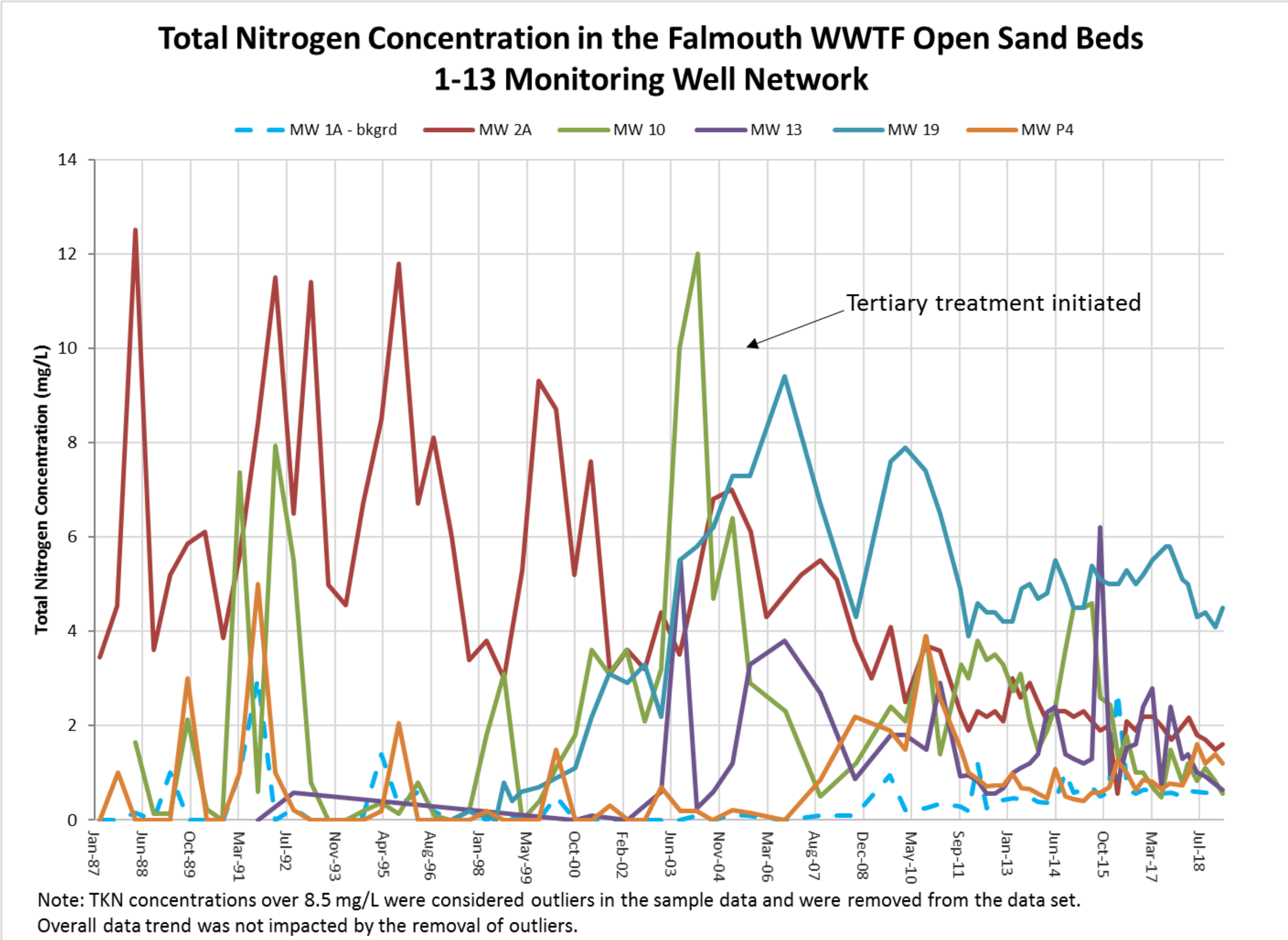

Figure 5.2 Total Nitrogen Concentration in the Falmouth WWTF Recharge Beds 1 through 13 Monitoring Well Network

In Figure 5.2, MW-1A, the background or upgradient monitoring well is shown with a dashed line. It can be seen that background nitrogen concentration appears to have increased slightly over time, likely due to upgradient septic systems and other watershed impacts. The total nitrogen concentration in the background well has averaged >0.5 mg/L over the past five years and has in some samples exceeded 1 mg/L.

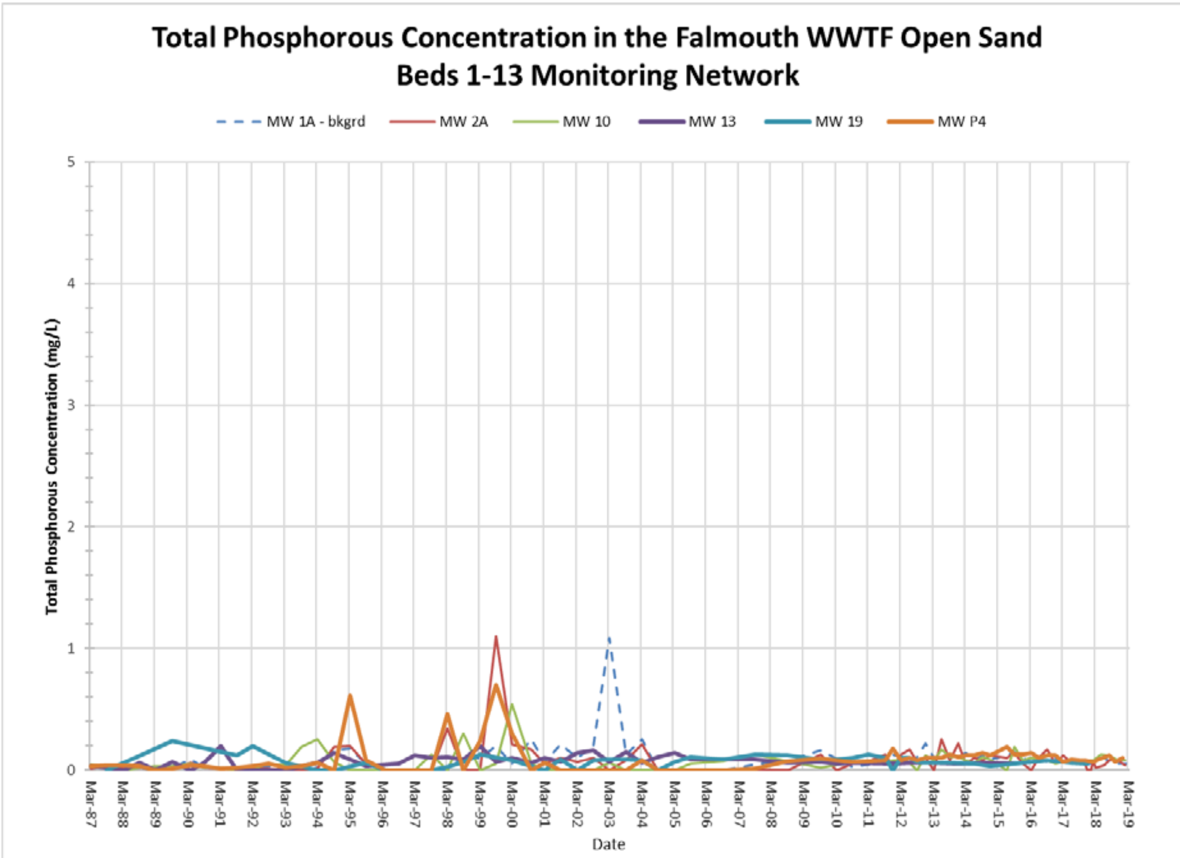

Figure 5.3 Total Phosphorus Concentration in the Falmouth WWTF Recharge Beds 1 through 13 Monitoring Well Network

Figure 5.3 demonstrates that though total phosphorus is present in low concentrations in the WWTF effluent (2.7-4.3 mg/L, see Table 5.1), phosphorus has not regularly been detected in concentrations above background levels in the monitoring well network downgradient of Recharge Beds 1 through 13.

Total nitrogen and total phosphorus concentration data collected from the Recharge Beds 14 and 15 monitoring network is summarized in Figures 5.4 and 5.5. Because Beds 14 and 15 have only received effluent from the tertiary WWTF (after upgrades were completed in 2016), their monitoring well network has not been influenced by discharge from the original lagoon WWTF, only by background conditions in the groundwater and by discharge from the upgraded WWTF.

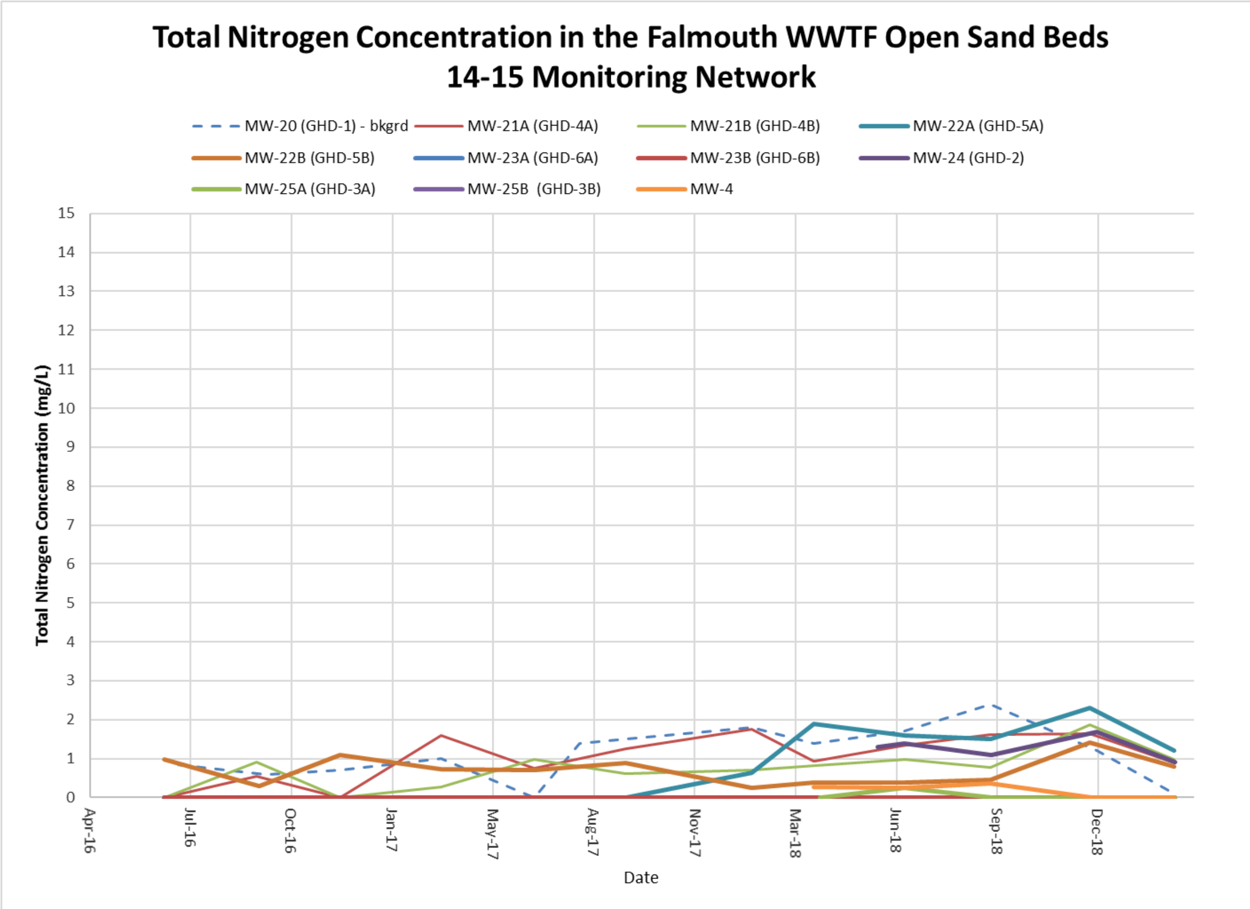

Figure 5.4 Total Nitrogen Concentration in the Falmouth WWTF Recharge Beds 14 and 15 Monitoring Well Network

In Figure 5.4, one can see that concentrations of total nitrogen have increased slightly in some of the downgradient wells (including MW-21A, MW-21B, MW-22A, and MW-22B, the downgradient wells closest to Beds 14 and 15) since discharge to Beds 14 and 15 began in 2017.

MW-20, the upgradient (background) monitoring well, is shown with a dashed line in Figure 5.4. It can be seen that total nitrogen concentration in this well has been above detection in most samples and has frequently been >1 mg/L (one sample >2 mg/L). This indicates that this well, and therefore probably other wells in this area, is impacted by other nitrogen sources upgradient of the WWTF discharge, for example, upgradient septic systems.

Total nitrogen concentration has remained below detection in wells MW-23A and MW-23B to date, which indicates that these wells have not been impacted by either the effluent discharge to Beds 14 and 15 or by other upgradient nitrogen sources. Total nitrogen concentration in MW-4, an older well north of Beds 1 through 13 and southwest of Beds 14 and 15 has been below or near the detection limit in all samples collected since Beds 14 and 15 began operating. The lack of nitrogen impact on MW-23A, MW-23B, and MW-4 helps to confirm the assumption that, as shown by the watershed lines on Figure 5.1, Recharge Beds 14 and 15 are located outside of the West Falmouth Harbor watershed.

MW-24 has contained total nitrogen concentrations ranging from 0.82 to 1.4 mg/L since sampling of this well began in May 2018 (initial sampling of this well was delayed because of difficulty locating the well because the gas company covered it after working in the area and the well had a non-ferrous cover).

Since groundwater in this region travels 1 to 2 feet per day horizontally and MW-24 is >1,400 feet from the nearest edge of recharge beds, the soonest the impact from Beds 14 and 15 could be seen at this location would be about 1.9 years (conservatively assuming 2 feet per day horizontally and not accounting for additional time to move vertically) from start of recharge. Recharge to Beds 14 and 15 first began in January of 2017 (and was intermittent, as recharge is rotated among beds), so the soonest that MW-24 could be expected to see a potential effect of recharge to Beds 14 and 15 would have been approximately December 2018. For these reasons, it is believed that the nitrogen concentrations observed to date in MW-24—like those in upgradient background well MW-20—are due to other watershed nitrogen sources, most likely septic systems. Nitrogen concentrations in MW-25A and MW-25B, south of MW-24 have been near or below detection to date (similar to MW-23A and MW-23B to the east).

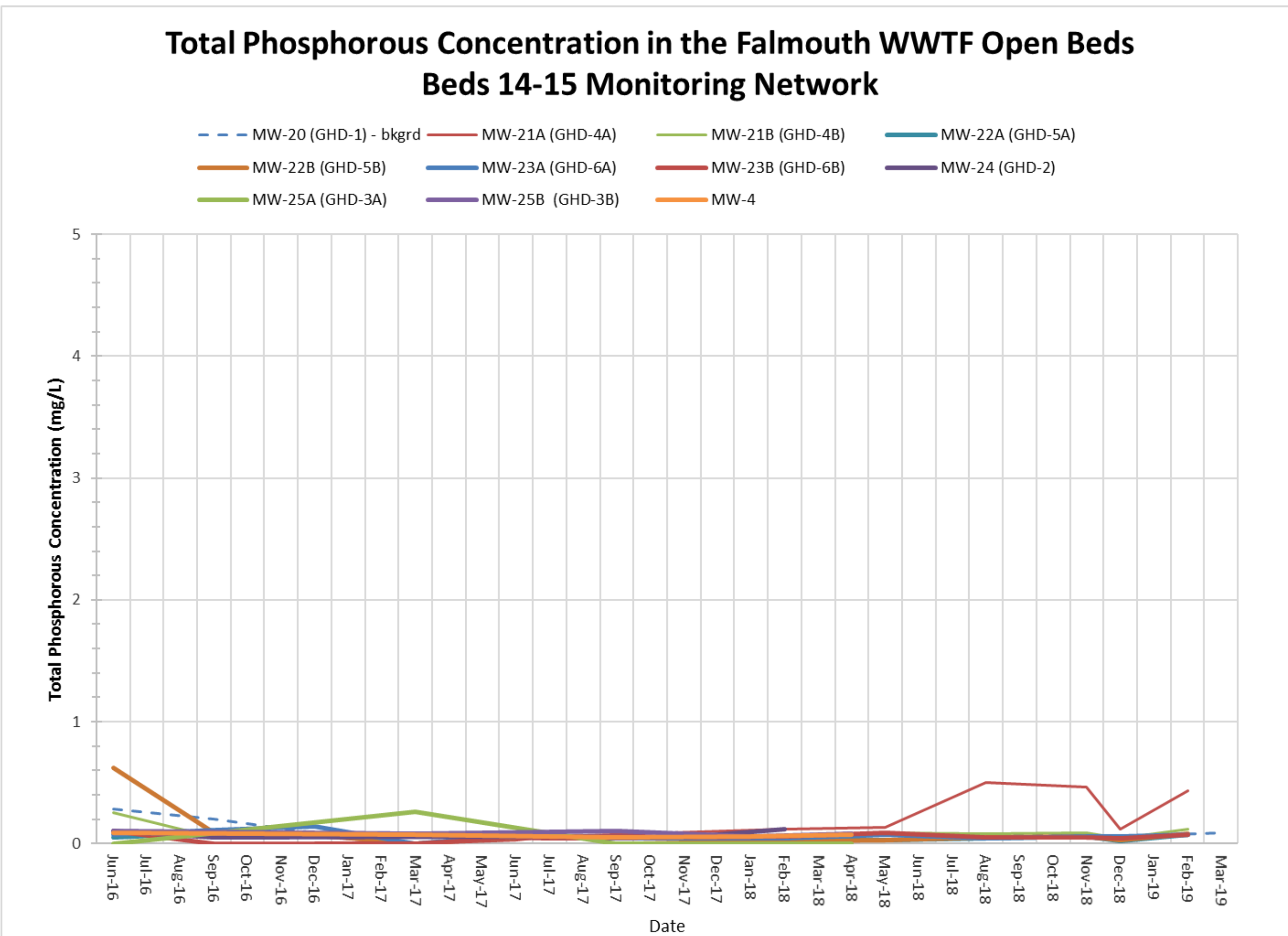

Figure 5.5 Total Phosphorus Concentration in the Falmouth WWTF Recharge Beds 14 and 15 Monitoring Well Network

As with Figure 5.3, Figure 5.5 demonstrates that though total phosphorus is present in low concentrations in the WWTF effluent (2.7-4.3 mg/L, see Table 5.1), phosphorus is not detected in concentrations above background levels in any downgradient monitoring well other than MW-21A and MW-21B. MW-21A and MW-21B are located on the berm on the west (downgradient) side of recharge Bed 14, approximately 20 feet from the edge of Bed 14. MW-21A is screened at the top of the groundwater table and MW-21B is screened 30 feet below MW-21A.

MW-21A and MW-21B were located and screened in this way to detect the effect of the discharge to Beds 14 and 15 as it initially contacts groundwater, and to observe the change in that effect over a short vertical distance (30 feet) in the water table. Since discharge to Beds 14 and 15 began, the concentration of total phosphorus in the groundwater at MW-21A (at the top of the water table) has increased from approximately 0.06 mg/L to approximately 0.5 mg/L. In MW-21B, screened 30 feet below MW-21A at the same location, the highest total phosphorus concentration to date was approximately 0.16 mg/L. In MW-22A and MW-22B, screened at the same elevations as MW-21A and MW-21B, but just 200 feet downgradient, total phosphorus concentrations remain near the detection limit (0.05 mg/L). These results are consistent with the expectation that phosphorus would take a long time (hundreds of years) to migrate with the groundwater due to the tendency of phosphorus to adsorb to soil particles.

Key Findings of Groundwater Monitoring Well Data

- Recharge Beds 1 through 13 Groundwater Monitoring Network
  - Total nitrogen concentrations in these wells increased after recharge from the original lagoon WWTF began in 1986 and have decreased to less than 2 mg/L in recent years since the tertiary WWTF began operating at the end of 2005. The partial exception to this trend is MW-19, which is the monitoring well furthest from the WWTF recharge and still contains a total nitrogen concentration >4 mg/L. It is expected that total nitrogen concentrations in MW-19 will decline over time as the plume from the original lagoon WWTF (some of which began as far away as the far edge of the spray irrigation areas, about 6,500 feet east of MW-19). Since it took approximately 15 years for the effects of discharge from the lagoon WWTF to appear at MW-19, it may take 15 years or more for that effect to dissipate.
  - Total phosphorus concentrations do not appear to have increased in the monitoring well system over background levels, even after 20 years of discharge from the original lagoon WWTF and an additional more than 13 years now from the tertiary WWTF.
- Recharge Beds 14 and 15 Groundwater Monitoring Network
  - Measured total nitrogen concentrations in some of the monitoring wells downgradient of Recharge Beds 14 and 15 have increased slightly since initiation of effluent recharge to Recharge Beds 14 and 15. A similar increase is seen in the upgradient (background) monitoring well, indicating the potential influence of non-WWTF-related nitrogen sources, such as upgradient septic systems and fertilizer use on some wells.
  - Since initiation of effluent recharge at Recharge Beds 14 and 15, total phosphorus concentrations in the monitoring well systems do not appear to have increased in any of the monitoring wells except for the two wells located only 20 feet horizontally from the recharge beds. The phosphorus concentration reduction between the shallow and the deeper well at

this location and between this location and all other downgradient wells confirms the significant attenuation of phosphorus (via adsorption to soil particles) over a short distance in the water table.

5.1.4 West Falmouth Harbor Water Quality Data

Water quality field data has been collected in West Falmouth Harbor since the early 1990's. As part of the Massachusetts Estuaries Project, a network of eight surface water monitoring stations were established by the University of Massachusetts Dartmouth SMAST. Data collected at the stations was used to develop SMAST's Linked Watershed-Embayment Model, which was used to set the Total Maximum Daily Load (TMDL) for West Falmouth Harbor. The Snug Harbor station (WFH-5) was selected as the "sentinel station" for West Falmouth Harbor. The TMDL Report identified a target total nitrogen concentration for the sentinel station of 0.35 mg/L, which if achieved would be expected to permit the entire West Falmouth Harbor system to meet water quality goals. Subsequent to the MEP project, water quality data has been collected in West Falmouth Harbor by the Buzzards Bay Coalition. In addition, since 2015, the Town of Falmouth has been contracting for water quality data collection at the sentinel station as required by the 2015 Permit. The 2015 WWTF Permit requires monitoring at the "sentinel station" twice monthly in July, August, and September for nitrogen and other parameters. Figure 5.6 shows the total nitrogen data collected at the sentinel station from 2014 to 2018 in accordance with the 2015 Permit.

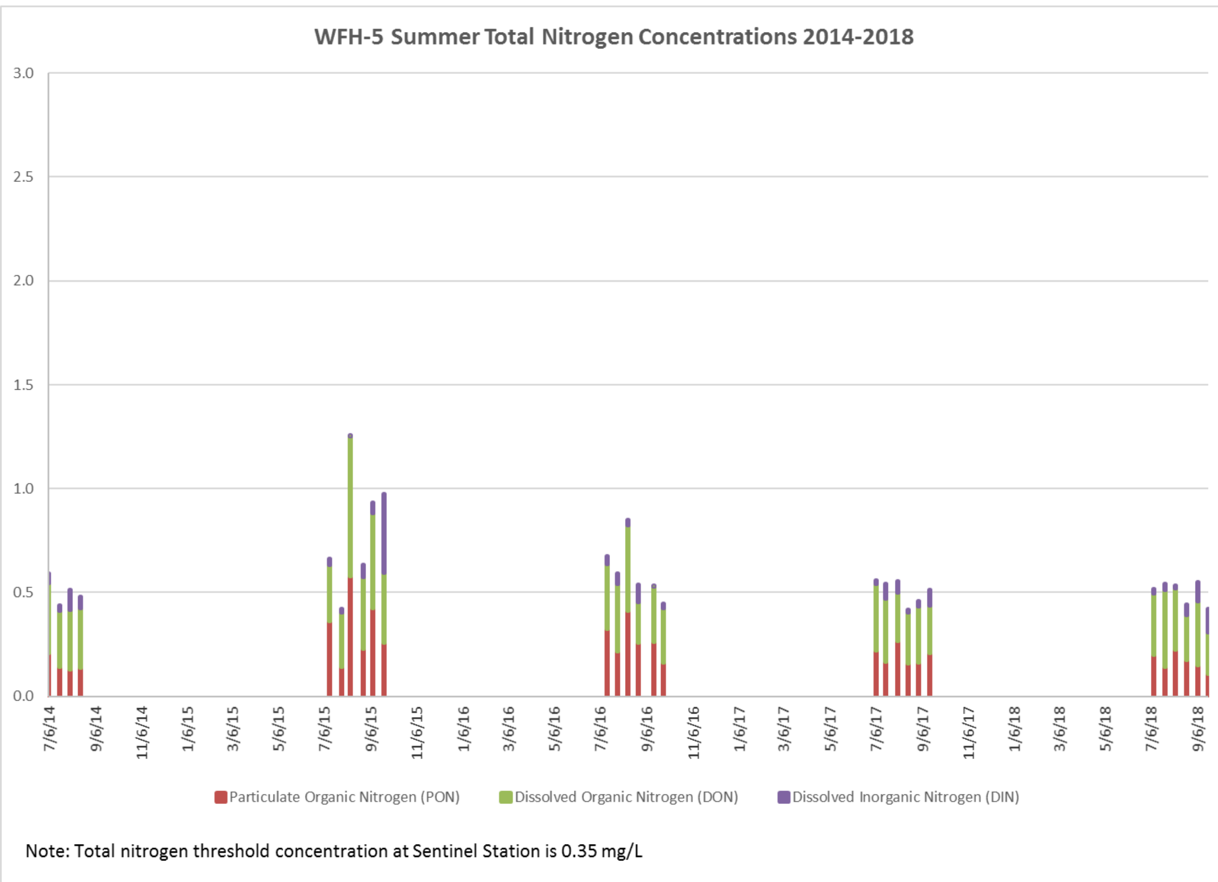

Figure 5.6 Sentinel Station WFH-5 Nitrogen Concentration 2014-2018

Key Findings of West Falmouth Harbor Water Quality Data

- West Falmouth Harbor water quality field data has indicated a general decrease in total nitrogen concentration at the sentinel station since approximately 2010. However, total nitrogen concentrations at the sentinel station are still above the target concentration of 0.35 mg/L.
- Initially it was estimated that the nitrogen plume from the original lagoon WWTF would take approximately seven to 10 years to flush out of the West Falmouth watershed. However, this projection was based simply on estimated groundwater time of travel from the recharge beds to the harbor. The closest edge of the closest open sand bed is about 3,800 feet and the far edge of the furthest open sand bed is about 5,200 feet from the closest shoreline of West Falmouth Harbor. The average horizontal groundwater migration rate in this area is generally 1 to 2 feet per day. So, at a rate of 1.5 feet per day, groundwater would reach the Harbor from the closest point in seven years and from that furthest point in 10 years. However, this projection did not take into account vertical migration distance/time, the location of the spray irrigation areas (furthest point in spray irrigation is about 6,500 feet from the harbor, which would take 12 years to traverse at 1.5 feet per day horizontally), or dispersion/retardation of the movement of some wastewater constituents in the subsurface. As discussed in Section 5.1.3, it took approximately 15 years for the effect of the original lagoon WWTF recharge to reach MW-19, the well located furthest from the WWTF and right on the nearest shore of West Falmouth Harbor. Therefore, it may take 15 years or more for the remnants of the plume from the original WWTF to reach West Falmouth Harbor, and even longer for the reduction in groundwater nitrogen input to manifest itself in reduction in West Falmouth Harbor nitrogen concentrations, because of nitrogen stored in sediments. The Town will continue to monitor nitrogen concentrations in groundwater wells and West Falmouth Harbor.

5.1.5 Crocker Pond Data and Herring Brook Consideration

Groundwater modeling and particle tracking of treated water recharge at the Recharge Beds 14 and 15 site, conducted in 2011, indicated that a portion of the recharged water could pass through Crocker Pond, a small freshwater kettle pond west of Recharge Beds 14 and 15, which is phosphorus-limited. An evaluation conducted by EcoLogic in 2013 indicated that the aquifer soils downstream of Recharge Beds 14 and 15 have a large capacity to sequester phosphorus from the groundwater and significantly retard migration of phosphorus downstream to the kettle pond. The absorptive capacity of the soil was estimated to be 100 to 1,400 years of phosphorus discharge, depending on the level of effluent treatment.

The 2015 WWTF Permit requires surface water sampling in Crocker Pond at two depths in July, August, and September of each year. Analytical parameters include total phosphorus, total nitrogen, total inorganic nitrogen, and total organic nitrogen.

Baseline data has been collected at two depths in Crocker Pond since the summer of 2016. Future data will be compared to the baseline to assess potential nutrient impacts to Crocker Pond from recharge to Recharge Beds 14 and 15. Crocker Pond baseline data collected from 2016 to 2018 for total nitrogen and total phosphorus is summarized in Table 5.3. Due to variability of summer conditions (temperature, rainfall, etc.) for the limited amount of data that has been collected so far, the data is presented as a baseline range for the pond as opposed to a trend. As more data is collected in future years a trend line for both nutrients can be established.

Table 5.3 2016 – 2018 Crocker Pond Total Nitrogen and Total Phosphorus Baseline Data Summary

Parameter	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)
0.5 Meter Depth – Concentration Range	0.30 – 0.90	0.01 – 0.03
7 Meter Depth – Concentration Range	0.38 – 1.88	0.03 – 0.20

Additional modeling and evaluations conducted in 2013 summarized in GHD Technical Memorandum 12 dated July 30, 2013 indicated that a small fraction of the discharge to Beds 14 and 15 could, after passing through Crocker Pond, flow towards Herring Brook to the north. The 2015 WWTF Permit states that three additional monitoring wells would be installed northwest of Crocker Pond if "the quarterly monitoring of the groundwater monitoring wells GHD-3A and B [MW-25A and MW-25B] and GHD-2 [MW-24] show a Boron concentration of >6uM or a nitrate concentration >0.75 mg/L." The intent of these future wells would be to monitor groundwater downgradient of Crocker Pond flowing in the direction of Herring Brook to identify any potential impact to Herring Brook. As discussed in Section 5.1.3, concentration of nitrate has been >0.75 mg/L in MW-24 since it was initially sampled, and nitrate concentrations in MW-25A and MW-25B have been near or below the nitrate detection limit (0.25 mg/L) to date, (similar to MW-23A and MW-23B to the east). As stated above, due to the distance from Recharge Beds 14 and 15 to MW-24, the estimated time of travel and the timing of commencement of discharge to Beds 14 and 15, it is believed that the nitrogen concentrations observed to date in MW-24—like those in upgradient background well MW-20—are due to other watershed nitrogen sources, namely septic systems. Nutrient concentrations in all three wells will continue to be monitored quarterly.

The University of Massachusetts Dartmouth SMAST conducted an evaluation in 2013 of the potential effect of recharge to Beds 14 and 15 on downgradient wetlands and on Buzzards Bay. The study concluded that it was unlikely that downgradient wetlands would be impacted or that the anticipated maximum nitrogen load from Recharge Beds 14 and 15 would be detectable in Buzzards Bay.

Key Findings of Crocker Pond Data and Consideration of Herring Brook

- Baseline data has been collected at two depths in Crocker Pond since the summer of 2016. Future data will be compared to the baseline to assess potential nutrient impacts to Crocker Pond from discharge to Recharge Beds 14 and 15.
- Data from MW-25A, MW-25B, MW-24, and Crocker Pond will be evaluated over time to determine the need for additional wells or monitoring for potential impact to Herring Brook.

5.2 Updated West Falmouth Harbor TMDL Compliance Plan Approach

5.2.1 Background

In 2001, the Town of Falmouth completed its Comprehensive Plan for Wastewater Management in West Falmouth Harbor, and a primary component of that work was the upgrade of the Blacksmith Shop Wastewater Treatment Facility to a tertiary treatment facility for nitrogen removal. The tertiary treatment facility began operating in 2006. Process upgrades to that tertiary treatment facility were completed in 2016. The Groundwater Discharge Permit (GWDP) issued for the WWTF in 2015 includes recharge flow and nitrogen loading restrictions intended to provide the basis for achieving Nitrogen TMDL compliance in West Falmouth Harbor.

Based on the Massachusetts Estuaries Report's Table VIII-3 for West Falmouth Harbor, approximately 8,472 kg/yr needs to be removed from the system in order to meet the West Falmouth Harbor TMDL.

Within the West Falmouth Harbor watershed, the Town has been evaluating all of and is implementing some of the following nitrogen management approaches in order to achieve TMDL compliance:

- Implementation of improvements to the WWTF;
- Innovative and alternative septic systems;
- Aquaculture;
- Fertilizer reduction;
- Stormwater management improvements; and
- Use of Permeable Reactive Barriers (PRBs).

5.2.2 Blacksmith Shop Road WWTF

As discussed in Section 5.1.2, WWTF effluent data have demonstrated that the upgraded WWTF is capable of reducing effluent total nitrogen concentration to the best effort level of 3 mg/L for extended periods of time (years). However, like any WWTF, this WWTF is potentially subject to unforeseen conditions that can impact performance. Capital funds are being requested in FY 2020, 2021, and 2022 to evaluate, design, and construct a third SBR (and complete other WWTF upgrades) to provide greater operational flexibility and to accommodate additional flow and load from future sewer service areas. Based on WWTF performance in 2017 and 2018 and with the planned additional WWTF improvements, it is expected that the annual nitrogen load from the Blacksmith Shop Road WWTF will, with the other nitrogen management approaches listed, meet the West Falmouth Harbor TMDL.

In the 2001 MEP report, it was estimated that 10,013 kg of nitrogen was being discharged per year from the original WWTF to the West Falmouth watershed. At the permitted best effort average annual effluent total nitrogen concentration of 3 mg/L and the permitted average annual flow of 450,000 gallons per day to the West Falmouth Harbor watershed, the annual load from the upgraded tertiary WWTF to the West Falmouth Harbor watershed is reduced to 1,868 kg/yr (4,109 lbs/yr). This is a reduction in load from the WWTF to the watershed of 8,145 kg/yr.

5.2.3 Use of Enhanced Innovative and Alternative (I/A) Systems

As discussed in Chapter 3, the Town has collaborated with the Buzzards Bay Coalition and others to implement a pilot program to install innovative and alternative septic systems on 25 properties in close proximity to West Falmouth Harbor. This is estimated to account for a 92 kg/yr reduction in nitrogen.

5.2.4 Aquaculture

The Town re-established an oyster reef within West Falmouth Harbor, as described in Chapter 3. At this time there is no plan to harvest the oysters in order to achieve a level of nitrogen removal, so the reef is simply a demonstration of habitat restoration.

5.2.5 Fertilizer Management in Compliance with the Town's Approved Bylaw

As discussed in Chapters 3 and 4, Falmouth enacted a fertilizer bylaw, based on the Cape Cod Commission 208 Plan update. As a result of this, communities are afforded a 25% credit for nitrogen removal. Based on Table IV-4 of the MEP report, the West Falmouth Harbor System receives approximately 365 kg/yr of nitrogen from fertilizer, which after applying a 25% credit would be reduced by 91 kg/yr.

5.2.6 Stormwater Management

The Town will continue best management practices to address stormwater impacts and consider the implementation of nitrogen-reducing options where feasible as discussed in Chapter 3. The implementation of these practices in Falmouth allows the Town to receive another 25% reduction of nitrogen credit per the CCC 208 Plan. This 25% reduces the impervious surface loads from approximately 1,139 kg/yr of nitrogen to 854 kg/yr (285 kg/yr less).

5.2.7 Permeable Reactive Barriers

The Town conducted some preliminary evaluations for the use of the PRBs within the West Falmouth Harbor watershed. However, a suitable location was not identified in this watershed and at this time the Town is not considering further use of this nitrogen removal approach in West Falmouth Harbor.

5.2.8 Updated Compliance Plan Approach Summary for West Falmouth Harbor

The following table outlines the current compliance plan approach established for West Falmouth Harbor to achieve Nitrogen TMDL compliance within the estuary.

Table 5.4 Nitrogen Budget for West Falmouth Harbor Updated Compliance Approach

Compliance Component - Nitrogen Removal Approach	Estimated Nitrogen Loading Reduction (kg N/yr)
Wastewater Treatment Improvement	8,145
I/A Systems	92
Fertilizer (25% of fertilizer load)	91
Stormwater (25% of impervious load)	285
Aquaculture	0
Total Estimated Reduction	**8,613**
Nitrogen Removal TMDL Goal	**8,472**

As demonstrated in Table 5.4, based on this approach, the Town is expected to be able to meet the requirement for Nitrogen TMDL compliance for West Falmouth Harbor with the WWTF improvements alone. However, the Town continues to move forward with other nutrient mitigation strategies as well, in order to provide the greatest flexibility to manage nitrogen and possible population growth within the watershed.

6. Great Pond Watershed Planning Scenario

6.1 Current Status of Meeting the TMDL

6.1.1 Great Pond TMDL

The Great Pond System watershed is sub-divided into 24 sub-watersheds, one of which is the Coonamessett River (see section6.3). The Total Maximum Daily Load (TMDL) Report presents a target threshold watershed load for two waterbodies in the Great Pond System—Great Pond and Perch Pond. The TMDL allocation outlines the maximum nitrogen loading that the waterbody may receive while maintaining its water quality standards and designated uses. Table 6.1 outlines the TMDL for the two waterbodies.

Table 6.1 Great Pond and Perch Pond Total Maximum Daily Loads (TMDL)

Major Watershed	Waterbody Segment[1]	Description[1]	TMDL (kg/d)[2]	Estimated Equivalent Annual Load Target (kg/y)
Great Pond System	Great Pond	From the inlet of Coonamessett River to Vineyard Sound (excluding Perch Pond), Falmouth	22.50	8,213
	Perch Pond	Connects to northwest end of Great Pond, west of Keechipam Way, Falmouth	0.59	215

Sources:

1. Massachusetts Year 2016 Integrated List of Waters.
2. 'Table 5 – The Total Maximum Daily Loads (TMDL) for the Great, Green, and Bournes Pond Embayment Systems, represented as the sum of the calculated target threshold loads (from controllable watershed sources), atmospheric deposition, and sediment sources (benthic flux)' of the 'Final Great, Green and Bournes Pond Embayment Systems Total Maximum Daily Loads for Total Nitrogen' (report #96-TMDL-6 Control #181.0), dated April 6, 2006.

The largest source of controllable nitrogen in the Great Pond watershed comes from on-site septic systems. Water usage data provided by the Falmouth Water Department, for the years 2014 through 2016, was used to develop estimated per-parcel nitrogen loads for properties within the Great Pond watershed. The nitrogen load evaluation methodology is outlined in "TASA TM-1 – Teaticket / Acapesket Study Area, Flow, and N Load Evaluation," prepared by GHD and dated April 2019 (Appendix 6.1). To account for the variability in effluent nitrogen concentrations and future water usage, a per parcel septic nitrogen load range was developed for estimating removals to achieve TMDL compliance. The nitrogen load for each watershed calculated using parcel specific water usage data falls within the nitrogen load range presented in this document.

6.1.2 Little Pond Sewer Service Area

A portion of the Great Pond watershed has been sewered as part of the Little Pond Sewer Service Area (LPSSA) project. As discussed in Chapter 4, construction of the collection system serving the LPSSA was completed in April 2017. LPSSA includes 253 parcels in the Great Pond watershed. As of May 2019, 95% of the parcels in LPSSA have been connected to the sewer system.

The nitrogen load removal through the sewering of these parcels is estimated at 1,037 to 1,316 kg/yr.

6.2 Conceptual Sewer Plans for Great Pond Watershed

6.2.1 Service Area, Wastewater Flow, and Nitrogen Removal

The Town has undertaken the conceptual design of the Teaticket Acapesket Sewer Service Area (TASSA) collection system in order to reduce the septic nitrogen load to the Great Pond watershed. The system would collect wastewater from 1,791 parcels and convey the flow to the Falmouth WWTF through a combination of gravity and low-pressure sewers, and includes nine new wastewater lift stations and one booster lift station. In the conceptual layout, 1,289 of the parcels are located in the Great Pond watershed. The nitrogen load removal in Great Pond through sewering of TASSA is estimated at 6,142 to 7,789 kg/yr.

This sewer extension would significantly reduce the nitrogen loading to Great Pond. It will be augmented by additional removals provided by the non-traditional nitrogen removal technologies, as discussed later in this chapter.

6.2.2 Collection and Transmission System Layouts

The conceptual TASSA is illustrated in Figure 6.1. The conceptual collection system is divided into eleven sewersheds and configured to maximize the number of properties served by gravity sewer. In the conceptual layout nine sewersheds are serviced by a new lift station, and two sewersheds connect into existing lift stations (Alphonse Street Lift Station and Spring Bars Road Lift Station). Ten of the sewersheds are located partially or completely in the Great Pond watershed, as shown in Figure 6.2.

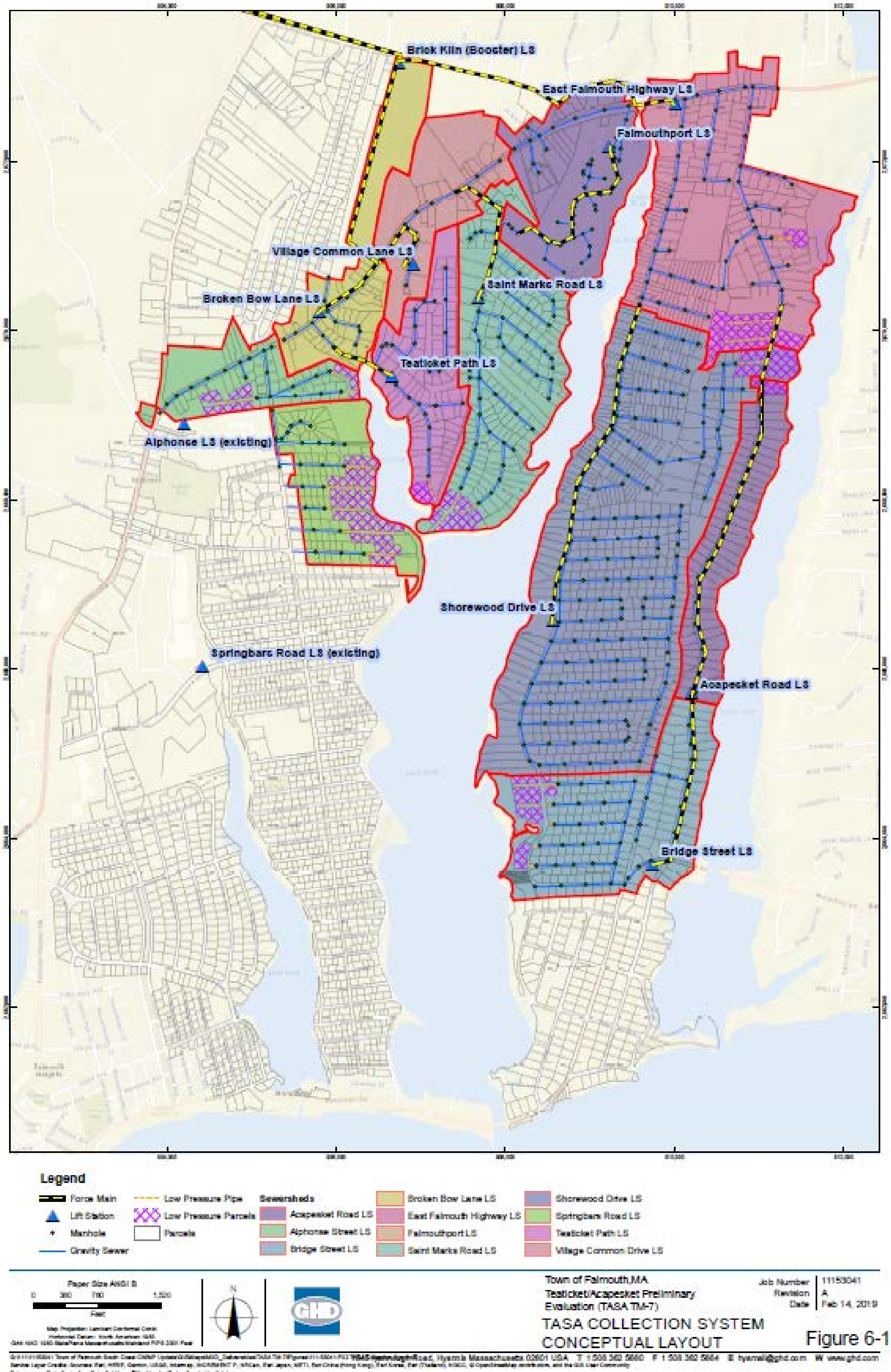

Figure 6.1 TASSA Collection System Conceptual Layout

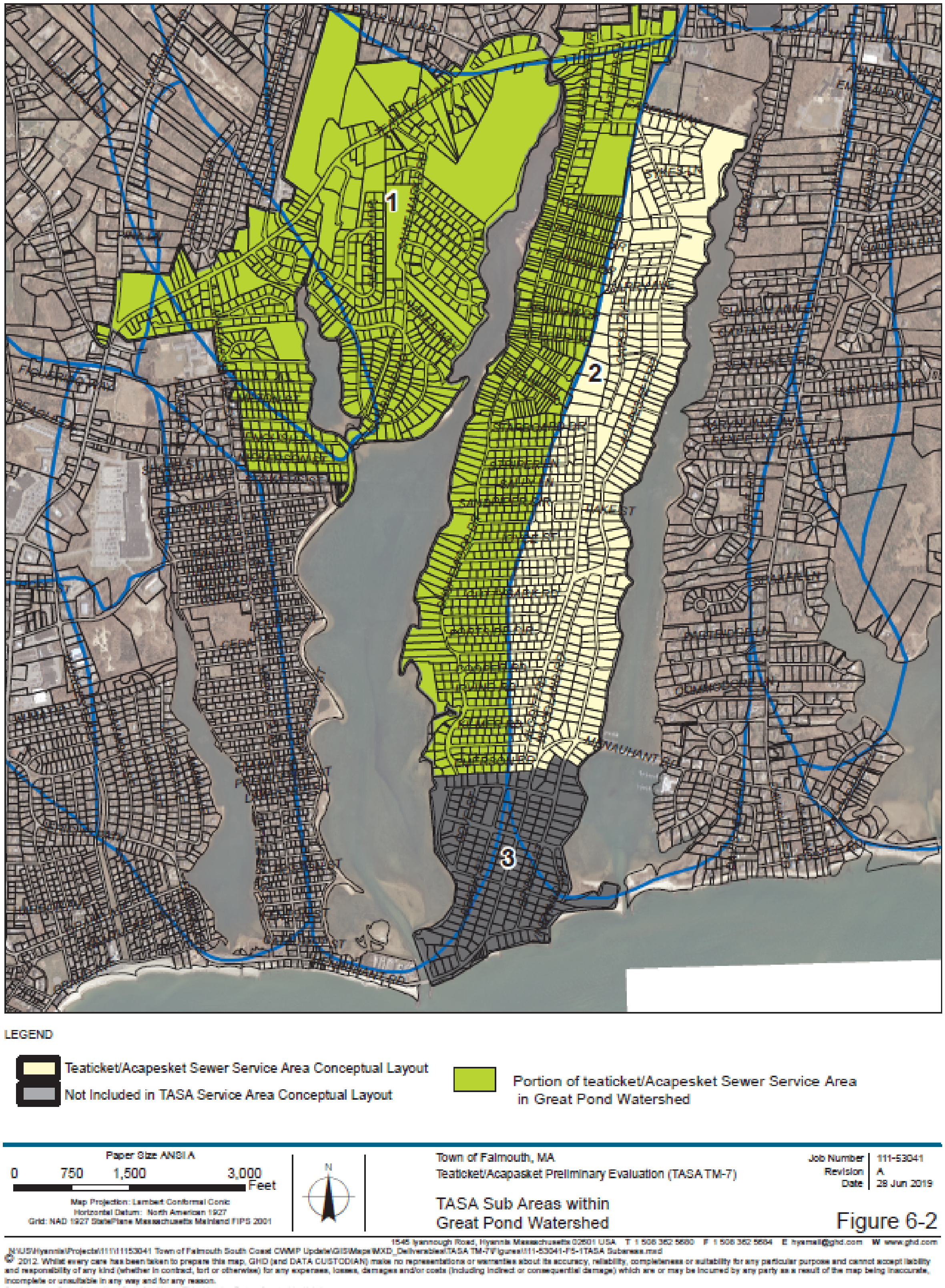

Figure 6.2 TASSA Collection System Conceptual Layout Parcels Within the Great Pond Watershed

Flow from the nine sewersheds with new lift stations is conveyed to a single booster lift station, for treatment at the Falmouth Wastewater Treatment Facility (WWTF) via a new force main system along Brick Kiln Road. The Brick Kiln Road force main system would then connect to Gifford Street Extension, to Locustfield Road, and finally to Blacksmith Shop Road for treatment at the WWTF. In areas where gravity sewers are not feasible due to topography, low-pressure sewers are proposed. The development of the conceptual TASSA layout is outlined in the TASA Technical Memorandums (Appendix 5.1).

6.2.3 Wastewater Treatment (Falmouth WWTF)

Flow collected through the TASSA collection system will be conveyed to the Falmouth WWTF. An evaluation of the existing Falmouth WWTF to treat the proposed flow from TASSA on a capacity and treatment level basis was conducted and is summarized in "TASA TM-4 – Teaticket / Acapesket Study Area Technical Memorandum No. 4," prepared by GHD and dated April 2019 (Appendix 5.1). The analysis indicated that an additional (third) Sequencing Batch Reactor tank will need to be constructed to treat the anticipated nitrogen load from TASSA and provide operational flexibility. No other major capacity or treatment level process improvements are anticipated to treat the project flow from TASSA.

6.2.4 Disposal Site Options, Including Ocean Outfall and Joint Base Cape Cod

An evaluation of effluent recharge technologies and disposal sites was performed and is summarized in "TASA TM-3 – Teaticket / Acapesket Study Area Discharge Technologies Evaluation – Technical Memorandum No. 3," prepared by GHD and dated April 2019 (Appendix 5.1). The evaluation recommended the following discharge technologies for incorporation into conceptual layouts:

1. Open sand beds are recommended for conceptual layout development due to their relatively high hydraulic loading capacity, which required less land area than other land-based options. Additionally, The Town of Falmouth currently uses this technology at the Falmouth WWTF and is familiar with the technology.
2. Leaching facilities are recommended for conceptual layout development in areas with a potential secondary use (for example under fairways in a golf course or under public parks/ballfields) due to their minimal visual impact. Additionally, the Town of Falmouth currently uses this technology at the New Silver Beach WWTF and is familiar with the technology.
3. Ocean outfalls are recommended for conceptual layout development due to the relatively small land area required for this technology, relatively high disposal capacity, and the ability to discharge outside a nutrient impacted watershed thereby reducing the nitrogen loading impacts to coastal embayments.

Four different potential discharge sites and two potential ocean outfall locations were evaluated, along with the development of discharge capacities for all six options. As part of that evaluation, the following four effluent disposal options were selected for conceptual layout development:

1. Open Sand Beds at the Allen Parcel.
2. Subsurface Effluent Disposal (Leaching Trenches) at the Falmouth Country Club.

3. Expanded Open Sand Beds 14 & 15 within the existing Town-owned parcel.

4. Buzzards Bay Ocean Outfall.

The basis of design for each conceptual layout is outlined in "TASA TM-7 – Teaticket / Acapesket Study Area Conceptual Layouts and Preliminary Cost Estimates Evaluation – Technical Memorandum No. 7," prepared by GHD and dated April 2019 (Appendix 5.1). A decision to select the effluent disposal option for TASSA is anticipated in 2021.

6.2.5 Estimated Cost and Implementation Schedule

Preliminary capital cost estimates for the TASSA collection system, WWTF improvements and effluent disposal options are outlined in "TASA TM-7 – Teaticket / Acapesket Study Area Conceptual Layouts and Preliminary Cost Estimates Evaluation – Technical Memorandum No. 7," prepared by GHD and dated April 2019 (Appendix 5.1).

The TASSA collection system is anticipated to be implemented through a two-phase approach. The anticipated mid-point of construction for Phase 1 is 2026.

6.3 Coonamessett River Restoration Project Summary

6.3.1 Introduction

The Coonamessett River flows from Coonamessett Pond to Great Pond, a total length of about 4,750 meters. It flows through multiple wetland areas and incorporates additional outflow from the Broad River, Pond 14, and Flax Pond. The Massachusetts Estuaries Project (MEP) report for the Great Pond watershed (Howes, 2005) estimates that over 50% of the unattenuated nitrogen load to Great Pond enters via the Coonamessett River. As a large source of groundwater to Great Pond, data on the dynamics of nitrogen species in the river water is useful in planning strategies to improve water quality in Great Pond.

In 1971, Falmouth acquired approximately 45 acres of cranberry bogs along the lower reach of the Coonamessett River south of Sandwich Road. The bogs are divided into three main areas: Lower Bog, Middle Bog, and Reservoir Bog. Cultivation of Lower Bog ceased in 2010, and Middle and Reservoir Bogs were retired in 2013. Lower Bog was restored to wetlands in 2018. As part of the restoration process, the river channel was physically lengthened by making it more sinuous in order to increase the water's residence time within the wetland and increase the potential for greater nitrogen attenuation prior to discharging into Great Pond. Wetland restoration for Middle Bog and Reservoir Bog are scheduled for 2019-2020. The Coonamessett River Restoration Project is being led by the Town of Falmouth (Conservation Commission) with the support of nearly two dozen partners. Major funding sources include National Oceanic and Atmospheric Administration (NOAA), Massachusetts Environmental Trust, Massachusetts Fish & Game/Division of Ecological Restoration, US Fish and Wildlife Service, and the Town of Falmouth.

To monitor the potential nitrogen attenuation due to the bog restoration efforts, the Woods Hole Research Center (WHRC) was contracted in 2018 to install several sampling wells and monitor eleven stations along the entire length of the Coonamessett River (Figure 6.3). This research project is quantifying the physical and nitrogen dynamics of the river over a three-year period (2018-2020) utilizing the following procedures:

- Monitor river height and discharge on an hourly basis
- Monitor nitrate and dissolved and particulate nitrogen concentrations every two weeks.
- Use a mass balance approach to calculate total input and output of nitrate along certain sections of the river channel south of Pond 14.
- Evaluate the performance of restored wetlands for nitrogen attenuation to infer potential nitrogen removal benefits from additional planned restoration areas along the Coonamessett River.

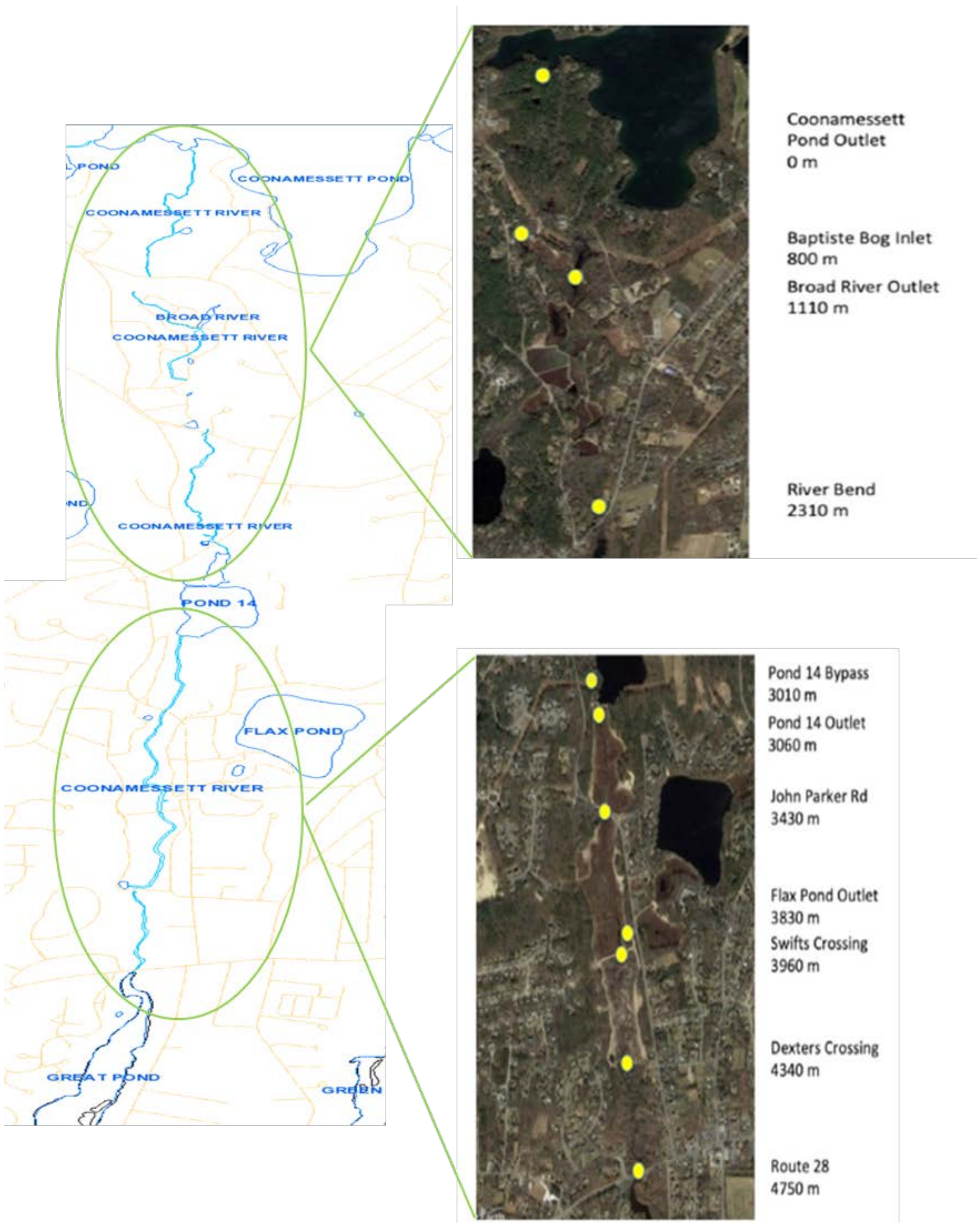

Figure 6.3 Approximate Sampling Site Distances (in meters) From the Coonamessett Pond Outlet (adapted from Neill et al. 2019)

6.3.2 Monitoring Results Summary

All results can be found in the "Data Report on Nitrogen Monitoring and Dynamics of the Coonamessett River May 2018 to April 2019" (Neill et al., 2019) (Appendix 6.2).

River Stage Results

In 2018, a staff gauge was installed in Lower Bog to measure the hourly river height in the lower reach of the Coonamessett River. The results of the 2018 river stage monitoring show that the removal of the Lower Bog dam at Dexters Crossing occasionally allows exceptionally high tidal and storm water levels from Great Pond to flow up into the restored wetland areas. Overall, monitoring data showed an expected seasonal trend of high stage heights in the spring and lower stage heights in the summer, and increased stage heights in fall and winter.

Dissolved and Particulate Nitrogen Results

Nitrate concentrations generally increase with distance from Coonamessett Pond. This downstream increase is particularly pronounced below the Pond 14 sampling location (arrow in Figure 6.4). This pronounced increase in nitrate concentrations appears to be directly related to the greater density of residential development and septic systems south of Pond 14.

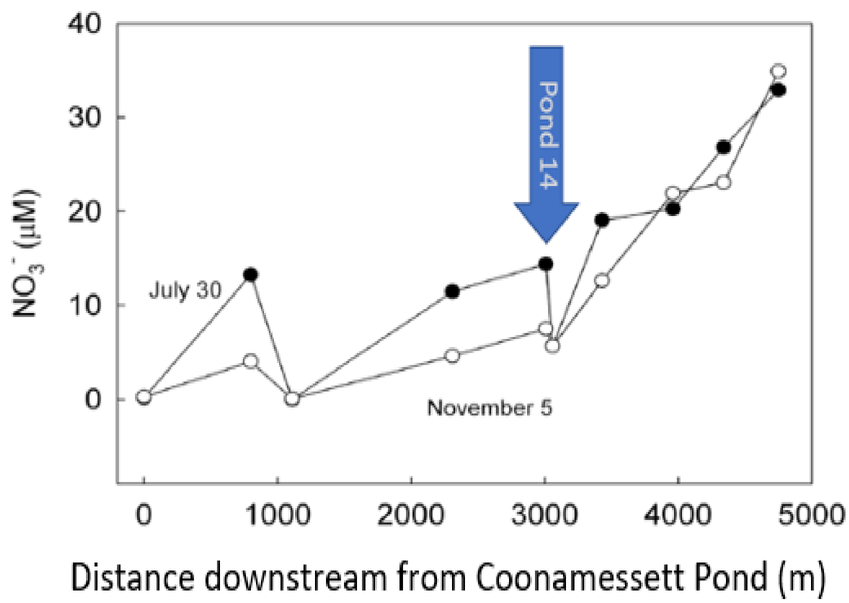

Figure 6.4 Nitrate Concentrations Measured Along the Coonamessett River on July 30th and November 5, 2018 (Neill et al. 2019)

Concentrations of nitrate varied seasonally with higher concentrations of nitrate in the lower reaches during winter (Figure 6.5). This result suggests there are temperature and light-dependent biological processes (e.g. plant uptake) removing dissolved nitrogen that are elevated during the warmer growing season. The seasonal variability in nitrate concentration was not as pronounced in the upper reaches of the river north of Pond 14. Additional nitrogen monitoring results indicate that there is little variability during summer versus winter in the concentrations of ammonium or dissolved or particulate organic nitrogen [DON or PON] along the length of the river.

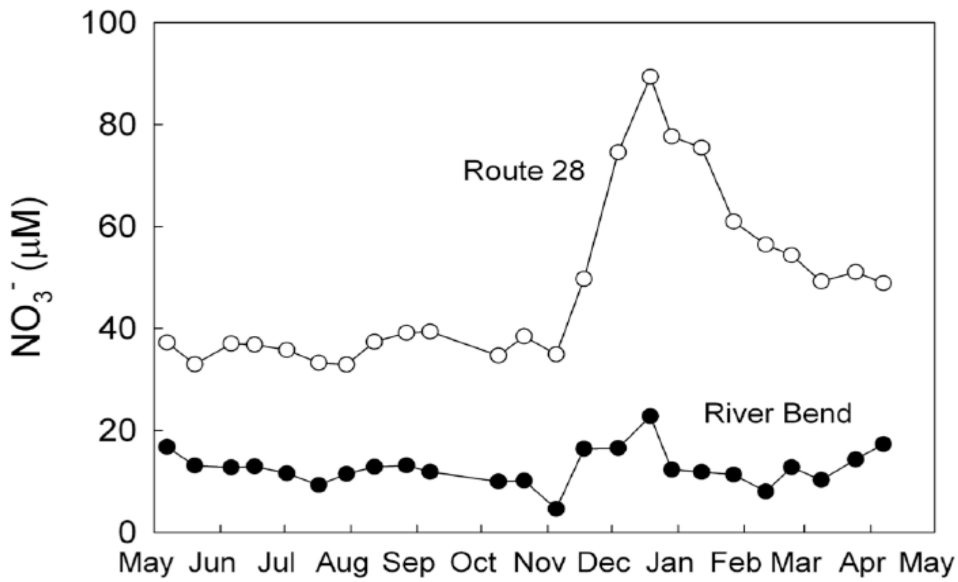

Figure 6.5 Seasonal Variation in Nitrate Concentrations Measured at the Route 28 and River Bend Stations (Neill et al. 2019)

Nitrogen Mass Balance

The mass balance analysis indicated that a net flux of 12.3 kg-N/day entered the river south of Pond 14. Of this amount, 10.1 kg-N/day (82%) entered as groundwater seepage, and the balance of 2.2-kg N/day entered from the surface waters of Pond 14 and Flax Pond. The results also showed a high amount of nitrate entering the system along the borders of the retired cranberry bogs. Specifically, the mass of nitrate seeping into the lower reaches of the river was five times greater than the mass of nitrogen from the entire upper reaches or from Flax Pond.

Based on the monitoring results and the determination that the majority of the nitrate entering the Coonamessett River enters as groundwater seepage south of Pond 14, restoration efforts of the bogs in the lower reaches have the potential to reduce the total nitrogen load entering Great Pond. Over the next two years, continued monitoring during and after restoration efforts of Middle and Reservoir Bogs will provide more information for developing the Targeted Watershed Management Plan for meeting the TMDL for Great Pond.

6.4 Great Pond TMDL Compliance Plan Approach

6.4.1 Background

The MEP report for the Great Pond watershed indicates that approximately 100% of the current septic system nitrogen load in the Great Pond and Perch Pond sub-watersheds and 50% of the current septic system nitrogen load in the Coonamessett River sub-watershed needs to be removed if the Great Pond Nitrogen TMDL was met through sewering alone (“TMDL sewering only scenario”).

This percentage represents only one of many possible nitrogen removal scenarios that could be used to meet the nitrogen concentration threshold. The MEP-estimated attenuated nitrogen loading reduction is approximately 62% of the total attenuated watershed load. Based on the Massachusetts Estuaries Reports Table VIII-3 and Nitrogen TMDL Table 4 for Great Pond Watershed, including Perch Pond and the Coonamessett River, approximately 17,637 kg/yr of the attenuated nitrogen load needs to be removed.

As the Town of Falmouth is developing and summarizing the findings of several demonstration projects and pilot efforts, the Town has considered several options of addressing nitrogen for this watershed including: centralized sewering, a satellite wastewater treatment facility, innovative and alternative septic systems (I/A systems), shellfish aquaculture, stormwater improvements, permeable reactive barriers (PRBs), and fertilizer reductions.

Specifically within the Great Pond watershed, the Town is evaluating several approaches in order to achieve TMDL compliance:

- Fertilizer reduction
- Stormwater improvements
- Shellfish aquaculture
- Installation of a PRB
- Sewer extensions

6.4.2 Fertilizer Management in Compliance with the Town's Approved Bylaw

As discussed in Chapters 3 and 4, Falmouth has enacted a fertilizer bylaw, based on the Cape Cod Commission 208 Plan update. As a result of this, Falmouth is afforded a 25 percent removal credit for nitrogen attributed to fertilizer. Based on the MEP Report Table IV-4, the Great Pond System receives approximately 1,700 kg/yr of lawn fertilizer load, which after applying a 25 percent credit would be reduced by 425 kg-N/year.

6.4.3 Stormwater Management

The Town will continue best management practices to address stormwater impacts and consider the implementation of nitrogen reducing options where feasible as discussed in Chapter 3. The implementation of these practices in Falmouth allows the Town to receive another 25 percent reduction credit of nitrogen attributed to stormwater runoff per the CCC 208 Plan. Applying this credit to the estimated impervious surfaces load of 2,319 kg/yr (as called out on MEP Report Table IV-4) would equate to approximately 580 kg-N/year reduction.

6.4.4 Shellfish Aquaculture

The Town is evaluating whether to pursue the use of shellfish aquaculture within Great Pond based on the findings at the other locations currently being evaluated throughout Town. The Town is actively exploring the establishment of a shellfish program over approximately 10 acres of potential suitable shellfish habitat within the pond. The next step in the Town's approach is to perform additional surveys to refine the available acreage number for suitable shellfish aquaculture.

Presuming that 10 acres are available within the pond, the Town is anticipating nitrogen uptake between 1,300 and 2,100 kg/yr and an additional removal of approximately 50% of the uptake through denitrification. This would be accomplished through a combination of gear types to support the shellfish growth.

6.4.5 Permeable Reactive Barriers

As discussed in Chapter 3, the Town is actively seeking funding to pursue the installation of a PRB within one or more of their impacted watersheds. One location under consideration, a site located off of Shorewood Drive, is within the Great Pond Watershed. It was identified that a 300 feet PRB at this location has the potential to remove up to 1,325 kg-N/year based on the US Environmental Protection Agency (USEPA) estimated nitrate mass flux. A pilot scale PRB of approximately 120 feet long and a vertical thickness of 20 feet is being proposed for this location. The ultimate length of the PRB for nitrogen TMDL compliance will depend on piloting performance and the performance of the other alternative nitrogen removal options.

6.4.6 Teaticket Acapesket Sewer Service Area

Completion of the LPSSA has provided an initial nitrogen reduction by sewering approximately 250 properties within the Great Pond Watershed along the Maravista Peninsula. This sewering is anticipated to provide approximately 1,037 to 1,316 kg-N/yr reduction within the watershed.

Construction of a portion of the Teaticket Acapesket Sewer Service Area (TASSA) within the Great Pond watershed is anticipated to achieve approximately 43 – 55% of the septic system nitrogen removal. Although this reduction is not enough to meet the nitrogen TMDL threshold concentration, it is a significant reduction from existing conditions. The sewering will be augmented by additional removals provided by the non-traditional nitrogen methods that are currently being evaluated by ongoing demonstration projects.

6.4.7 Summary of Compliance Approach for Great Pond

The following table outlines the overall nitrogen budget proposed for Great Pond in order to achieve Nitrogen TMDL Compliance.

Table 6.2 Nitrogen Budget for Great Pond to Achieve Nitrogen TMDL Compliance

Compliance Component – Nitrogen Removal Approach	Estimated Nitrogen Loading Reduction (kg-N/year)
Fertilizer Bylaw (25% of fertilizer load)	425
Stormwater BMPs (25% of impervious load)	580
Shellfish Aquaculture (uptake)	1,300-2,100
Shellfish (denitrification)	650-1,050
PRB at Shorewood Drive (300 feet)	1,325
Sewer Extensions (Total)	7,179-9,105
LPSSA (Great Pond)	*1,037-1,316*
TASSA Subarea 1	*3,325-4,217*
TASSA Subarea 2	*2,817-3,572*
Total Estimated Reduction	11,459-14,585
Nitrogen Removal TMDL Goal	12,154

As shown above, the nitrogen removal goal may be achieved through the use of these approaches. However, a shortfall may result due to the variability of some of the removal options and the potential phasing of any sewering within this watershed. Therefore active monitoring of the water quality within the system will be necessary and will allow the Town to apply adaptive management approaches to best target sewer infrastructure implementation, and gauge the performance of some of the other alternative approaches, namely shellfish.

The Town has also identified several options in the event that strategies from the proposed compliance plan approach are not sufficient including:

- Use of I/A Septic Systems in the upper watershed.
- Potential sewer extensions north of Route 28.
- Additional Permeable Reactive Barriers within the watershed, north of Route 28.

7. Green Pond Watershed Planning Scenario

7.1 Expected Impact of Great Pond Sewer Plan on Green Pond Nitrogen Removal

7.1.1 Green Pond TMDL

The Green Pond System watershed is divided into four subwatersheds, one of which is Mill Pond (see section 7.2). The Total Maximum Daily Load (TMDL) Report presents target threshold watershed loads for one waterbody in the Green Pond System—Green Pond. The TMDL allocation outlines the maximum nitrogen loading that the waterbody may receive while maintaining its water quality standards and designated uses. Table 7.1 outlines the TMDL for the waterbody. The largest source of controllable nitrogen in the Green Pond watershed comes from on-site septic systems.

Table 7.1 Green Pond Total Maximum Daily Loads

Waterbody Segment[1]	Description[1]	TMDL (kg/d)[2]	Estimated Equivalent Annual Load Target (kg/yr)
Green Pond	East of Acapesket Road, outlet to Vineyard Sound, Falmouth	46.26	16,885

Sources:

1. Massachusetts Year 2016 Integrated List of Waters.
2. 'Table 5 – The Total Maximum Daily Loads (TMDL) for the Great, Green, and Bournes Pond Embayment Systems, represented as the sum of the calculated target threshold loads (from controllable watershed sources), atmospheric deposition, and sediment sources (benthic flux)' of the 'Final Great, Green and Bournes Pond Embayment Systems Total Maximum Daily Loads for Total Nitrogen' (report #96-TMDL-6 Control #181.0), dated April 6, 2006.

7.1.2 Conceptual Sewer Plans for Green Pond Watershed

The Teaticket / Acapesket Sewer Service Area (TASSA) conceptual collection system, which is described in further detail in Chapter 6, would collect wastewater from approximately 1,791 parcels and convey the flow to the Falmouth Wastewater Treatment Facility (WWTF) for treatment. There are 502 TASSA parcels located within the Green Pond watershed (see Appendix 5-1). The nitrogen load removal in Green Pond through the sewering of TASSA is estimated at 2,058 to 2,610 kg/yr. A nitrogen removal range was developed for calculating TMDL compliance due to the variability of parameters required to estimate a value, such as effluent nitrogen concentration and future water usage trends.

This sewer extension would significantly reduce the nitrogen loading to Green Pond and will be augmented by additional removals provided by the non-traditional nitrogen removal technologies, as discussed later in this chapter.

7.1.3 Collection, Transmission System Layouts, and Discharge

The conceptual TASSA is illustrated in Figure 6.1. The conceptual collection system is divided into 11 sewersheds and configured to maximize the number of properties served by gravity sewer. In the conceptual layout each of nine sewersheds is serviced by a new lift station, and two sewersheds connect into existing lift stations (Alphonse Street Lift Station and Spring Bars Road Lift Station). Four of the sewersheds are located partially in the Green Pond watershed, as shown in Figure 7.1.

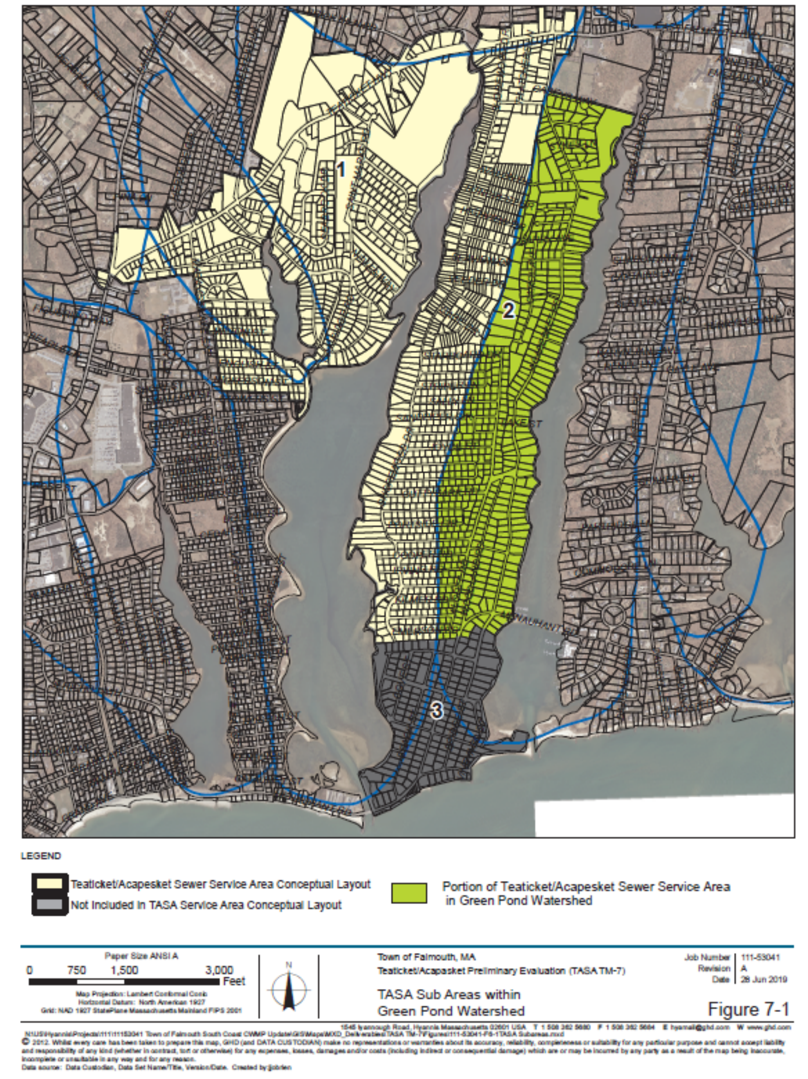

Figure 7.1 Teaticket/Acapesket Study Area Collection System Conceptual Layout Parcels Within the Green Pond Watershed

Flow from the nine sewersheds with new lift stations is conveyed to a single booster lift station, for treatment at the Falmouth WWTF via a new force main system along Brick Kiln Road. The Brick Kiln Road force main system would then connect to Gifford Street Extension, to Locustfield Road, and finally to Blacksmith Shop Road for treatment at the WWTF. In areas where gravity sewers are not feasible due to topography, low-pressure sewers are proposed. The development of the conceptual TASSA layout is outlined in the TASA Technical Memorandums (Appendix 5.1). As outlined in Chapter 6 flow collected through the TASSA collection system will be conveyed to the Falmouth WWTF and will be discharged at a new effluent disposal site. A decision to select the effluent disposal site for TASSA is anticipated to be made in 2021.

7.2 Mill Pond Investigation and Remedial Approach

7.2.1 Background

As part of Falmouth's approach for examining strategies to meet the TMDL in Green Pond, the Town partnered with the University of Massachusetts Dartmouth School of Marine Science and Technology (SMAST) to conduct a study on nutrient cycling in Mill Pond. Mill Pond is a shallow (≤ 5.25 ft (1.6 m) deep), manmade, 15.6-acre pond that intercepts groundwater and surface water runoff from upstream agricultural operations and discharges directly into Green Pond. Ninety percent of the water volume received by Mill Pond arrives via Backus Brook through 52 acres of active cranberry bogs (Figure 7.2). Nearby residents have expressed concern over the water quality of Mill Pond, particularly during the summer months. Residents report a heavy vegetation load and a foul odor (e.g. rotten-egg smell) being emitted from the pond. Both observations indicate a pond that is in a eutrophic and impaired state during a large portion of the year.

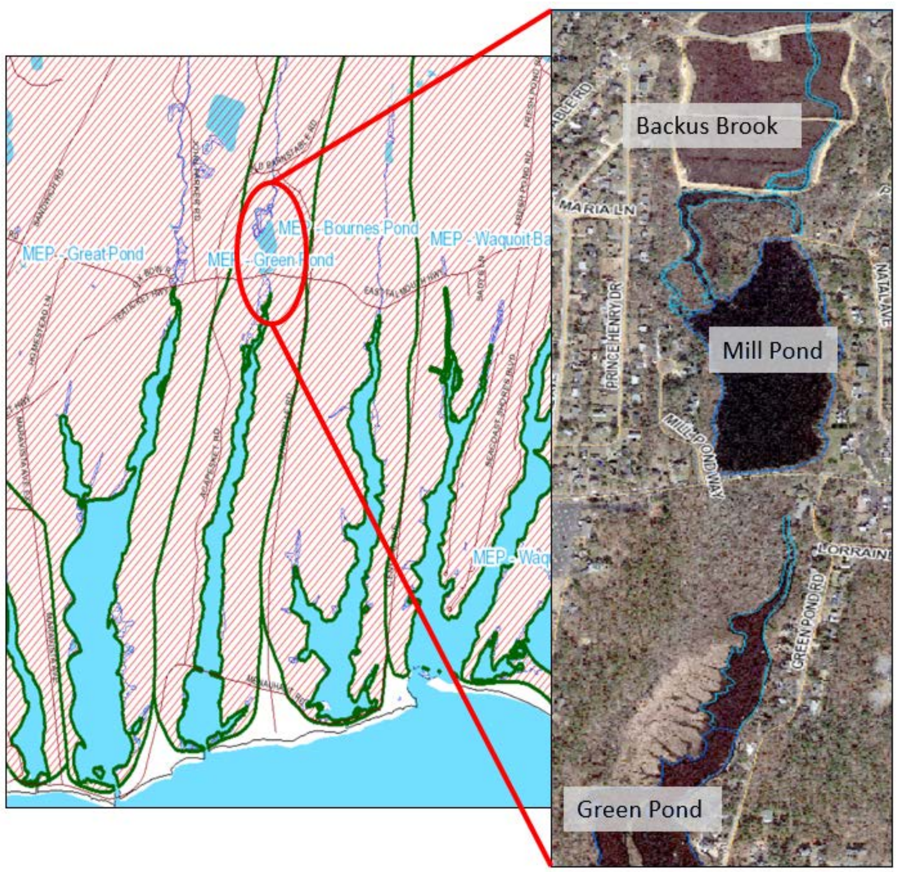

Figure 7.2 Area Map of the Mill Pond System

Efforts to restore Mill Pond are a key component of the nitrogen-reduction strategies for Green Pond. Mill Pond serves a critical role in reducing the overall nutrient load to Green Pond due to its attenuation of a significant fraction of the upstream nitrogen load prior to discharge into the head of Green Pond. During the critical impairment period (summer months) when the pond is eutrophic and the dissolved oxygen levels decline, the coupled nitrification-denitrification cycle cannot occur resulting in an efflux of nitrogen into Green Pond. It is for this reason that nutrient mitigation strategies for Mill Pond are being studied.

The University of Massachusetts Dartmouth conducted a study from September 2015 to December 2017, "Diagnostic Assessment of Nutrient Cycling in Mill Pond" (Unruh et al. 2018) (see Appendix 7.1). Data collected included nitrogen and phosphorous loads flowing into and leaving Mill Pond; in-pond measurements of sediment nitrogen and phosphorous fluxes; a vegetative profile of the pond and measurements of water level; stream flow; dissolved oxygen; chlorophyll *a*; and temperature. Select water quality parameters were measured weekly from May to October at 12 sites. Sampling efforts decreased to at least biweekly in order to establish baseline measurements during November through April when inflow to and outflow from Mill Pond are less influenced by upstream agricultural activities.

7.2.2 Results

Monitoring results from the 2015 – 2017 study indicate that Mill Pond is in a eutrophic state from June through October. Dissolved oxygen concentrations remain below 5.0 mg/L in June and July, and experience shorter periods of low levels later in the season (Figure 7.3). There is an observed correlation between periods of low dissolved oxygen and presence of phytoplankton blooms (as measured by chlorophyll *a*).

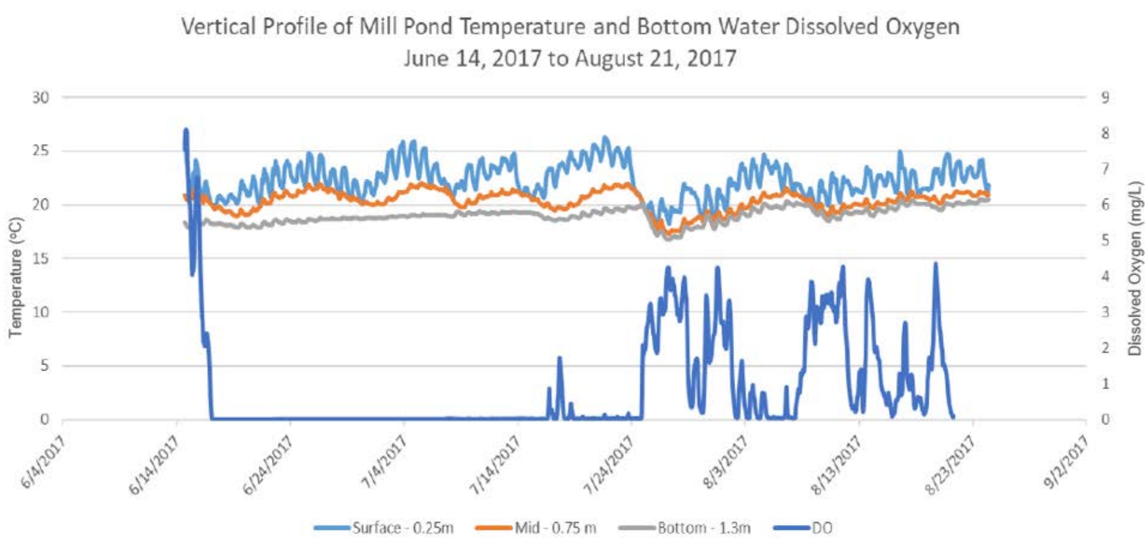

Figure 7.3 Vertical Temperature and Bottom Water Dissolved Oxygen Concentrations During the Critical Impairment Period in Mill Pond (Unruh et al. 2018)

A vegetation survey was conducted in 2017 to identify the dominant species and the associated coverage in Mill Pond. Aquatic vegetation covers approximately 90% of Mill Pond and is dominated by 11 macrophyte species. The plant growth from spring into the fall takes up approximately 453 kg of nitrogen and 10 kg of phosphorus (Unruh et al. 2018). When the plant biomass dies off, the associated nutrients accumulate in the sediments. When the pond experiences periods of low oxygen, the vegetation-associated nutrients are released back into the water column.

Nutrient monitoring of Mill Pond showed that the most significant sources of external nitrogen load come from stream inflow (58%) and groundwater (38%), and input is highest in the spring and summer months (Figure 7.4). A mass balance approach incorporating nitrogen sources and sinks was used to determine the net movement of nitrogen through Mill Pond. Nutrient monitoring results combined with the nitrogen mass balance model indicated that 59% (2016) and 64% (2017) of nitrogen entering Mill Pond was attenuated within Mill Pond and did not enter Green Pond. The rate of attenuation reported in the MEP Report (2005) was 67%, indicating the mass balance model used during this study was a comparable predictor of attenuation rates in Mill Pond.

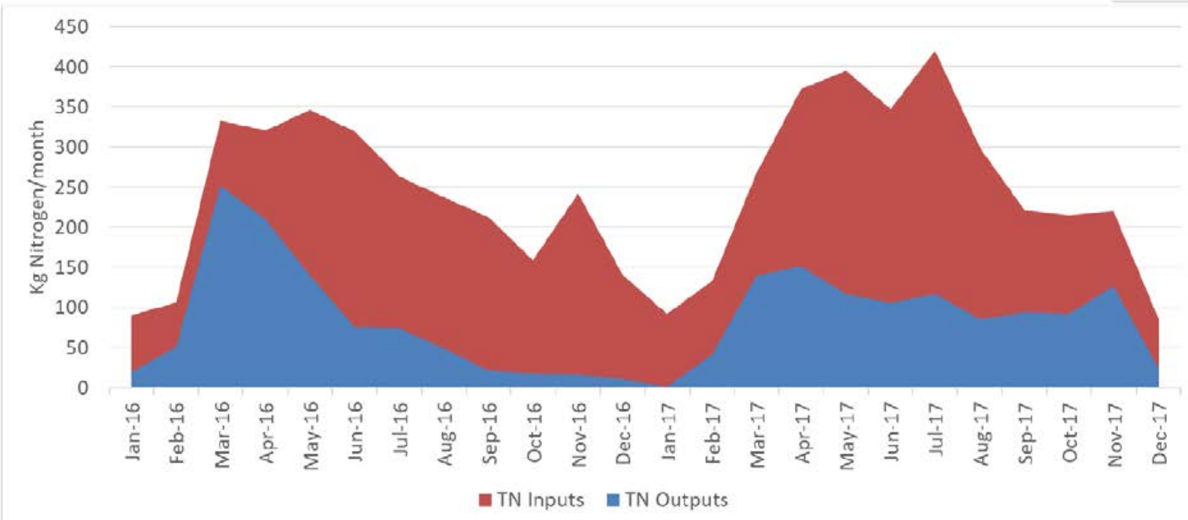

Figure 7.4 Monthly Nitrogen Dynamics of Mill Pond (Unruh et al., 2018)

Nutrient limitation determination experiments indicated that phosphorus is the limiting nutrient in Mill Pond. This suggests that management efforts for Mill Pond should be focused on phosphorus. However, due to the unique nature of Mill Pond directly discharging into a nitrogen-impaired estuary, both nitrogen and phosphorous management options need to be considered.

Key Findings from the 2015 – 2017 University of Massachusetts Dartmouth Mill Pond study:

- 58% of the nitrogen input to Mill Pond is from Backus Brook.
- Mill Pond attenuates an average 62% of the nitrogen that enters the pond.
- Mill Pond is generally eutrophic from June through October with aquatic vegetation covering 90% of the sediment and water surface.
- Phosphorus is the limiting nutrient in Mill Pond.

7.2.3 Recommendations for Nutrient Management of Mill Pond

The main objective in the management of Mill Pond is the control of the nitrogen and phosphorus loads entering Green Pond. Several of the recommendations made by Unruh et al. (2018) and efforts that the Town has made in pursuing these recommended strategies are detailed below.

Alternating Bog Fertilizers

It was recommended that the bog operations alternate between 'low P' and 'no P' fertilizers as a strategy to reduce phosphorus export from the bog. The bog owner is reported as being agreeable to altering his operating procedures and practices. There are no further efforts for this implementation needed from the Town.

Slow Release of Bog Flood Water

A strategy to remove the dam boards one at a time over a period of several days was proposed to minimize water velocities and fine sediments from being washed into the pond. The bog owner is reported as being agreeable to altering his operating procedures and practices. There are no further efforts for this implementation needed from the Town.

Increase Flow During Harvest and Winter Floods

Careful consideration of the board height placement when damming for the harvest and winter floods was recommend in order to increase flushing in the pond during these periods. The bog owner has indicated that this is a practice that can be implemented but is dependent on annual water flows. There are no further efforts for this implementation needed from the Town.

Grate Between Bog and Mill Pond

Placing a metal grate at the bog discharge point would catch debris and prevent large plant matter from being washed downstream into Mill Pond. The installation of a grate would require periodic cleaning to ensure adequate water flow. While the bog owner has indicated he is willing to alter some practices, he seems less in favor of assuming the periodic maintenance to ensure the grate is clean. The Town is pursing grate options that meet regulatory requirements and is continuing discussions with the bog owner about the feasibility of this management strategy.

Construct a Detention Pond

This is a preferred management option. Constructing a 0.25-acre detention pond at the bog discharge point would allow plant matter and fine sediments to settle prior to being washed downstream into Mill Pond. Unruh et al. (2018) estimates this strategy could reduce the nitrogen and phosphorus loads to Mill Pond by 192 and 40 kg/yr respectively.

The bog owner has agreed to work with the Town and is agreeable to the idea of installing a detention pond. The bog owner has also verbally indicated that he would be willing to accept the periodic maintenance of a detention pond. The Town is currently having discussions with the MassDEP on investigating an option of obtaining an agriculture exemption to 310 CMR 10.00 to install a tailwater recovery system rather than a detention pond. A tailwater recovery system would allow for some recycling of nutrient runoff from irrigation practices back into the cranberry bog operations. The Falmouth Conservation Commission has indicated that a hearing will be necessary.

Macrophyte Harvesting

Reducing the macrophyte biomass in the pond will reduce the nutrient load to the sediments and water column of Mill Pond when the plants begin to decay in the fall. Under hypoxic conditions denitrification in the sediments cannot occur and the nutrients from the decaying macrophytes are released back into the water column. In addition, a reduction in the surface-level plants will allow for more wind-driven surface layer mixing which may aid in odor control.

Harvesting is a process of trimming macrophytes to a depth below the surface of the water and is the primary approach to macrophyte management being explored by the Town.

Harvesting would have multiple benefits including the removal of the harvested macrophyte material and its associated nutrient load; visual and odor reduction to reduce the neighborhood concerns; and allowance for the ecosystem service of plant growth that continually removes phosphorus from the sediments. This form of macrophyte management is considered an adaptive management approach and may need to be monitored and adjusted in the future to meet the desired management outcomes for the pond.

Recommendations and informal cost estimates for macrophyte management have been obtained from an outside contractor. Discussions with the Town of Brewster on an intermunicipal agreement for utilizing the Brewster-owned macrophyte harvester have also been initiated. The Town has received verbal approval for the use of an abutting property as an access point for the equipment necessary for macrophyte management. Regulatory pathways for macrophyte harvesting have also been discussed with the Falmouth Conservation Commission, and a hearing will be required for that option to move forward.

As of July1, 2019: The initial work for filing a Notice of Intent (NOI) with MassDEP and the Falmouth Conservation Commission to harvest macrophytes from the pond has begun. The NOI will include options for macrophyte removal by mechanical and non-mechanical means. Additional options such as pond aeration are being included in the NOI filing to seek approval for alternate adaptive management approaches to improve the overall health of Mill Pond. The Town anticipates that with regulatory approval the initial macrophyte removal by harvesting could occur in the Fall of 2019.

7.3 Green Pond TMDL Compliance Plan Approach

7.3.1 Background

The Green Pond nitrogen TMDL indicates that approximately 73% of the current septic system nitrogen load needs to be removed if the Green Pond TMDL were met through sewering alone (“TMDL sewering only scenario”). This percentage represents only one of many possible nitrogen removal scenarios that could be used to meet the nitrogen concentration threshold. The MEP estimated attenuated nitrogen loading reduction is approximately 55% of the total attenuated watershed load. Based on the Massachusetts Estuaries Reports Table VIII-3 and Nitrogen TMDL Table 4 for Green Pond Watershed, including Backus Brook, approximately 4,453 kg/yr of the attenuated nitrogen load needs to be removed.

As the Town of Falmouth is developing and summarizing the findings of several demonstration projects and pilot efforts, the Town has considered several options of addressing nitrogen for this watershed including: centralized sewering, a satellite wastewater treatment facility, innovative and alternative septic systems (I/A systems), shellfish, stormwater improvements, permeable reactive barriers, and fertilizer reductions.

Specifically within the Green Pond watershed, the Town is evaluating several approaches in order to achieve TMDL compliance:

- Fertilizer reduction
- Stormwater improvements
- Shellfish propagation
- Mill Pond Improvements

- Installation of a Permeable Reactive Barrier (PRB)
- Sewer extensions
- I/A systems

7.3.2 Fertilizer Management in Compliance with the Town's Approved Bylaw

As the Town has enacted a fertilizer bylaw, based on the Cape Cod Commission 208 Plan update, it should receive a 25 percent removal credit for nitrogen attributed to fertilizer. Based on the MEP Report Table IV-4, the Green Pond System receives approximately 908 kg/yr, which after applying a 25 percent credit would be reduced by 227 kg/yr.

7.3.3 Stormwater Management

The Town will continue best management practices to address stormwater impacts and consider the implementation of nitrogen reducing options where feasible as discussed in Chapter 3. The implementation of these practices in Falmouth allows the Town to receive another 25 percent reduction of nitrogen attributed to stormwater runoff credit per the CCC 208 Plan. This would equate to approximately 172 kg N/yr. Falmouth has identified the “Captain’s Lane” catchment area as having the potential to manage an additional 120 kg-N/yr.

7.3.4 Shellfish Aquaculture

The Town is evaluating whether to pursue the use of shellfish aquaculture within Green Pond based on the findings at the other locations currently being evaluated throughout Town. Initially, three different locations were being considered to evaluate nitrogen reduction potential within the waterbody. A preliminary approach identified the relay of 1 million first year oysters and 1 million quahogs, and would require demonstration of denitrification in the sediments. This relay has the potential to remove up to a total of 945 kg N/yr when considering both the uptake by the shellfish and the potential increased denitrification in the sediments due to the presence of the shellfish.

7.3.5 Mill Pond Improvements

The Town is also evaluating management options around Mill Pond in order to take advantage of natural nitrogen uptake and attenuation. This would be through modifications to the upstream cranberry bog system, tailwater recovery pond, and natural pond attenuation.

In addition, the Town is considering macrophyte harvesting in order to remove an additional 15% of the total nitrogen passing through that system.

7.3.6 Teaticket Acapesket Sewer Service Area

Construction of the Teaticket Acapesket Sewer Service Area (TASSA) within the Green Pond watershed is anticipated to reduce the nitrogen load by 2,058 to 2,610 kg/yr. This represents 46 – 59% of the overall septic load that needs to be removed from the watershed, according to the MEP report. Although this reduction is not enough to meet the TMDL threshold concentration, it is a major reduction from existing conditions. The sewering will be augmented by additional removals provided by the non-traditional nitrogen methods that are currently being evaluated by ongoing demonstration projects.

7.3.7 Permeable Reactive Barriers

As described in Chapter 3, PRBs have been considered in several watersheds. However, this technology was not identified for use at this time in the watershed and therefore a credit for nitrogen removal from PRBs is not being estimated. The Town may consider utilizing a credit in the future following further evaluation.

7.3.8 Summary of Compliance Approach for Green Pond

The following table outlines the overall nitrogen budget proposed for Green Pond in order to achieve Nitrogen TMDL compliance.

Table 7.2 Nitrogen Budget for Green Pond Nitrogen TMDL Compliance

Compliance Component - Nitrogen Removal Approach	Estimated Nitrogen Loading Reduction (kg N/yr)
Fertilizer Bylaw (25% of fertilizer load)	227
Stormwater BMPs (25% of impervious load)	172
Stormwater – Captain's Lane Catchment Area	120
Shellfish Aquaculture (uptake)	390-630
Shellfish (denitrification)	195-315
Mill Pond	491-961
Sewer Extensions (total)	2,058-2,610
Total Estimated Reduction	**3,653-5,035**
Nitrogen Removal TMDL Goal	4,453

As demonstrated above, the nitrogen removal goal can be achieved through the use of these approaches. However, a shortfall may result due to the variability of some of the removal options and the potential phasing of any sewering within this watershed. Therefore, active monitoring of the water quality within the system will be necessary and will allow the Town to apply adaptive management approaches to best target sewer infrastructure implementation and gauge the performance of some of the other alternative approaches, namely shellfish.

The Town has also identified several options in the event that strategies from the proposed compliance plan approach are not sufficient including:

- Use of I/A septic systems on the Davisville Peninsula.
- Potential sewer extensions on the Davisville Peninsula and north of Route 28.
- PRBs within the watershed, locations to be determined.

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8. Bournes Pond Watershed Planning Scenario

8.1 Status of Inlet Widening Project

As identified in Chapter 3, a Notice of Project Change for this project was filed in 2016 and the Town received the Certificate of the Secretary of Energy and Environmental Affairs on the Notice of Project Change on March 11, 2016 (EEA Number 14154).

The inlet widening will increase the bridge inlet width from approximately 50 feet to the optimal width of 90 feet with no change in bridge height. The project also calls for the extension of the western jetty by 25 feet, and reconstruction of an existing groin. In addition, the project includes dredging of both the inner and outer areas of the pond with reuse of compatible material for dune and beach restoration.

Several studies were also performed as part of this project including evaluation of flood impacts, eelgrass studies within the proposed dredge areas, and shellfish evaluations:

- Bournes Pond Shellfish and Eelgrass Assessment Summary Report, Bournes Pond, Falmouth, MA, March 2017, Stantec
- Town of Falmouth Bournes Pond Inlet Opening Project – Eelgrass Survey, September 2018, AECOM
- Bournes Pond Inlet Opening Flooding and Coastal Erosion Analysis, January 2015, Applied Coastal

The project is currently in the final design and permitting stage. Permits received to date are listed in Chapter 3, Section 3.8.3 Permitting. As of July 2019, all permits have been received. The final design drawings are being completed and the project will be put out to bid. The Town of Falmouth is currently considering this project with other coastal resiliency projects and is in the process of implementing additional mitigation measures to protect the Town's other infrastructure (unrelated to this project) but including its existing roadways and water mains. Therefore, the current tentative schedule anticipates bidding in the summer of 2020 with completion anticipated by December of 2022.

8.2 Bournes Pond TMDL Compliance Plan Approach

As the Town of Falmouth is summarizing the findings of several demonstration projects and pilot efforts, the Town has considered several options of addressing nitrogen removal for this watershed including: centralized sewering, a satellite wastewater treatment facility, inlet widening, shellfish aquaculture, permeable reactive barriers, and fertilizer reductions.

Based on the Massachusetts Estuaries Reports Table VIII-3 and Nitrogen Total Maximum Daily Load (TMDL) Table 4 for Bournes Pond Watershed, including Bournes Pond, Israel's Cove, and Bournes Brook, approximately 4,161 kg/yr of nitrogen needs to be removed.

Specifically within the Bournes Pond watershed, the Town is evaluating several approaches in order to achieve TMDL compliance:

- Fertilizer reduction

- Stormwater improvements
- Shellfish aquaculture
- Inlet widening
- Installation of a Permeable Reactive Barrier (PRB)

8.2.1 Fertilizer Management in Compliance with the Town's Approved Bylaw

As the Town has enacted a fertilizer bylaw, based on the Cape Cod Commission 208 Plan update, it should receive a 25 percent removal credit for nitrogen attributed to fertilizer. Based on the Massachusetts Estuaries Project (MEP) Report Table IV-4, the Bournes Pond System receives approximately 485 kg/yr, which after applying a 25 percent credit would be reduced by 121 kg/yr.

8.2.2 Stormwater Management

The Town will continue best management practices to address stormwater impacts and consider the implementation of nitrogen reducing options where feasible as discussed in Chapter 3. The implementation of these practices in Falmouth allows the Town to receive another 25 percent reduction of nitrogen attributed to stormwater runoff credit per the Cape Cod Commission (CCC) 208 Plan. This is estimated to reduce the impervious surface loads from approximately 502 kg/yr of nitrogen to 377 kg/yr (126 kg/yr less).

8.2.3 Shellfish Aquaculture

The Town is also actively pursuing the evaluation of shellfish aquaculture within Bournes Pond at three different locations to evaluate nitrogen reduction potential within the waterbody. University of Massachusetts School for Marine Science and Technology (SMAST) is currently under contract to study nitrogen uptake at the three "farm" sites within the pond, tracking oyster productivity.

Falmouth Marine and Environmental Services has preliminarily indicated eight suitable areas for shellfish aquaculture. Additional survey work is required to determine actual available acreage.

8.2.4 Inlet Widening

As discussed in Chapter 3 and Section 8.1, the Town is nearing the end of the permitting process for the Bournes Pond inlet widening project that will include the construction of a new bridge and modifications to coastal structures in the vicinity of the widened inlet. The proposed inlet opening project is projected (based on modeling) to reduce the nitrogen load within the pond by 50 percent, thereby removing nearly 1,995 kg/yr of nitrogen.

8.2.5 Permeable Reactive Barriers

As discussed in Chapter 3, the Town is actively seeking funding to pursue the installation of a PRB within one or more of its impacted watersheds. One location under consideration, a site located off of Sailfish Drive, is within the Bournes Pond Watershed. It was determined that a PRB at this location has the potential to remove between 400 and 800 kg-N/year based on the United States Environmental Protection Agency (USEPA) estimated nitrate mass flux. A pilot scale PRB approximately 300 feet long with a vertical thickness of 14 feet is estimated to remove approximately 400 kg N/year. The ultimate length of the PRB for nitrogen TMDL compliance will depend on piloting performance and the performance of the other alternative nitrogen removal options.

However, at this time, the Town is not including this as part of its primary approach to achieving Nitrogen TMDL compliance.

8.2.6 Summary of Compliance Approach for Bournes Pond

The following table outlines the overall Nitrogen budget proposed for Bournes Pond in order to achieve Nitrogen TMDL compliance.

Table 8.1 Nitrogen Budget for Bournes Pond Nitrogen TMDL Compliance

Compliance Component - Nitrogen Removal Approach	Estimated Nitrogen Loading Reduction (kg N/yr)
Fertilizer Bylaw (25% of fertilizer load)	121
Stormwater BMPs (25% of impervious load)	126
Shellfish Aquaculture (uptake)	1,352-1,680
Shellfish (denitrification)	676-840
Inlet Widening (50% of controllable load)	1,995
Total Estimated Reduction	**4,270-4,762**
Nitrogen Removal TMDL Goal	4,162

As demonstrated in Table 8.1, the outlined compliance approach should achieve the nitrogen TMDL compliance goal. However, if following implementation of this approach they are unable to meet the nitrogen reduction requirements, the Town would consider several options as part of its adaptive management. These strategies include:

- Sewer extensions along Route 28 and Fisherman's Cove.
- Use of Innovative and Alternative (I/A) septic systems.
- Exploring additional sites for PRB installation in the upper watershed.
- Exploring and evaluating nitrogen reduction options associated with nitrogen loads entering the system from Bournes Brook.

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9. Eel Pond/Waquoit Bay Watershed Planning Scenario

9.1 Collaboration Under 208 Plan with Neighboring Communities

9.1.1 Moonakis River Evaluation Update

In 2017, University of Massachusetts Dartmouth School of Marine Science and Technology (SMAST) completed their "Detailed Assessment of Water and Nutrient Exchange within the Quashnet River/Moonakis River Sub-embayment to Waquoit Bay" report. In that report they evaluated the nutrient related health of this system and examined two approaches to improve water quality and habitat including improved flushing and the use of aquaculture to remove excess nitrogen.

The overall findings of the study were:

- System health is highly impaired by nitrogen, and the nitrogen load has increased since 2003.
- Although the lower and middle portions of the Quashnet Estuary could support shellfish, their performance will depend on how the shellfish are deployed (surface bags vs. bottom trays) due to variations in salinity and biofouling.
- Dredging would only be recommended in the region of the shoal at the tidal inlet.

The report stated that although the approaches outlined above could remove some nitrogen, they would be insufficient to address the entire load.

9.1.2 Mashpee Watershed Nitrogen Management Plan/Comprehensive Wastewater Management Plan Summary

The Town of Mashpee completed its Watershed Nitrogen Management Plan/Comprehensive Wastewater Management Plan (WNMP/CWMP) in 2015 and received its Massachusetts Environmental Policy Act (MEPA) Certificate in July of that same year. They also received their 208 Compliance letter from the Cape Cod Commission for the implementation of Phase 1 in 2015 and Phase 2 in 2017.

Initially, the Town of Mashpee's primary focus has been on the Popponesset Bay watershed, but they are actively advancing its shellfish program and are in joint discussions with Joint Base Cape Cod and its neighboring communities, including Falmouth, regarding the potential use of the wastewater treatment and recharge facilities at the Base.

9.1.3 Waquoit Bay Inter-Municipal Agreement Development with Mashpee and Sandwich

Currently the Towns of Falmouth, Mashpee, and Sandwich have begun discussions about establishing nitrogen loading allocations by Town for the entire system such that the towns could create an Inter-municipal Agreement (IMA) for managing nitrogen within this system in the future.

9.2 Waquoit Bay TMDL Compliance Plan Approach

9.2.1 Background

This section will consider five of the six major watersheds/subwatersheds of the Waquoit Bay system. Those are:

- Eel Pond
- Childs River
- Hamblin Pond/Little River
- Quashnet/Moonakis River
- Waquoit Bay

The remaining subwatershed, Jehu Pond/Great River is completely within the bounds of Mashpee and is therefore not part of this update analysis.

As the Town of Falmouth is developing and summarizing the findings of several demonstration projects and pilot efforts, the Town has considered several options to address nitrogen loading in this watershed including: centralized sewering, a satellite wastewater treatment facility, innovative and alternative septic systems (I/A systems), shellfish aquaculture, stormwater improvements, permeable reactive barriers (PRBs), and fertilizer reductions.

Specifically within the Waquoit Bay watershed, the Town is evaluating several approaches in order to achieve total maximum daily load (TMDL) compliance.

Eel Pond and Childs River

- Fertilizer reduction
- Stormwater improvements
- Shellfish aquaculture
- Sewer extensions

Hamblin Pond/Quashnet River

- The Mashpee Watershed Nitrogen Management Plan calls for shellfish aquaculture in Hamblin Pond/Little River within Mashpee's currently permitted shellfish areas; the plan also calls for sewering in the Quashnet River watershed and in the Hamblin Pond/Little River watershed depending on the performance of its shellfish program.

Waquoit Bay Proper and Jehu Pond/Great River

- There is no threshold removal called for in the Waquoit Bay proper estuary. The Jehu Pond/Great River watersheds, which have a threshold removal target, are entirely within Mashpee. Mashpee is proposing the use of shellfish and sewering to address its nitrogen contribution in order to achieve the TMDL.

9.2.2 Fertilizer Management in Compliance with the Town's Approved Bylaw

As discussed in Chapters 3 and 4, Falmouth has enacted a fertilizer bylaw, based on the Cape Cod Commission (CCC) 208 Plan update. As a result of this, communities are afforded a 25 percent removal credit for nitrogen attributed to fertilizer. Based on the Massachusetts Estuaries Project

(MEP) Report Table IV-3, the Waquoit Bay System receives approximately 4,184 kg/yr throughout the system just from fertilizer runoff. The following summarizes those subwatersheds that have some portion within the boundaries of Falmouth:

- Childs River = 827 kg/yr total (207 kg/yr removal @ 25%).
- Eel Pond = 778 kg/yr total (195 kg/yr removal @ 25%).
- Quashnet River = 1,506 kg/yr total (377 kg/yr removal @ 25% if applied to entire system).
- Hamblin Pond/Little River = 346 kg/yr total (87 kg/yr removal @ 25% if applied to entire system).

9.2.3 Stormwater Management

The Town will continue best management practices to address stormwater impacts and consider the implementation of nitrogen reducing options where feasible as discussed in Chapter 3. The implementation of these practices in Falmouth allows the Town to receive a 25 percent reduction of nitrogen attributed to stormwater runoff credit per the CCC 208 Plan. Applying this credit to the estimated impervious surfaces load (as called out on MEP Report Table IV-3) of 4,575 would equate to approximately 1,143 kg N/yr reduction for the system. The following summarizes those subwatersheds that have some portion within the boundaries of Falmouth.

- Childs River = 781 (195 kg/yr removal @ 25% if applied to the entire system).
- Eel Pond = 389 kg/yr total (97 kg/yr removal @ 25%).
- Quashnet River = 2,711 kg/yr total (677 kg/yr removal @ 25% if applied to entire system).
- Hamblin Pond/Little River = 370 kg/yr total (93 kg/yr removal @ 25% if applied to entire system).

9.2.4 Shellfish Aquaculture

The Town is evaluating whether to pursue the use of shellfish aquaculture within portions of the Eel Pond and Childs River portions of Waquoit Bay based on the findings at the other locations currently being evaluated throughout Town. In addition, the Town of Mashpee is using shellfish aquaculture within Hamblin Pond/Little River (they are also proceeding with this in Jehu/Great River, but as discussed above, that subwatershed is completely outside of the Falmouth Town boundaries).

- Childs River = shellfish uptake is estimated between 390-630 kg/yr and denitrification is estimated to be between 195-315 kg/yr based on the Town's studies described in Chapter 3.
- Eel Pond = shellfish uptake is estimated between 1,170 and 1,890 kg/yr and denitrification is estimated to be between 585 and 945 kg/yr based on the Town's studies described in Chapter 3.
- Hamblin Pond/Little River = based on the Mashpee WNMP, 1,025 kg/yr removal is anticipated based on estimated harvest values within the first ten years at full implementation.

9.2.5 Permeable Reactive Barriers

As described in Chapter 3, PRBs have been considered in several watersheds. However, this technology was not identified for use at this time in the watershed and therefore a credit for nitrogen removal from PRBs is not being estimated. The Town may consider utilizing a credit in the future following further evaluation.

9.2.6 Childs River Wetland Restoration

The Town is currently exploring the potential for additional nitrogen removal within the Childs River subwatershed through the restoration of the Farley Bog and the upper Childs River. The bog covers approximately 12.4 acres and the restoration project would look to increase the nitrogen uptake in waters flowing through this system (ground and surface) prior to heading into the Childs River. The Town has received funding from the Falmouth Rod and Gun Club, Falmouth Community Preservation Committee, and the Town of Mashpee Conservation Commission.

At this time the extent of the nitrogen removal potential of the wetland restoration efforts has yet to be determined.

9.2.7 Sewer Extensions

The Town is considering potential sewer extension projects in both the Eel Pond and Childs River subwatersheds including within Antler Shores, Seacoast Shores, and the Seapit Peninsula. This could potentially address the nitrogen from a total of 225, 989, and 101 properties, respectively. Due to the dynamics between the Eel Pond and Childs River subwatersheds, sewer extensions located in Eel Pond will likely also benefit the nitrogen reductions efforts in Childs River and vice versa. The Town has started the process of evaluating long-term solutions for effluent discharge, and additional evaluations will be developed as part of subsequent Targeted Watershed Management Plan and Notice of Project Change (TWMP/NPC) documents submitted as part of this overall project.

The Town of Mashpee's approved plan also calls for sewering within the Childs River subwatershed, Quashnet River subwatershed, Hamblin Pond/Little River subwatershed, and also within the Jehu Pond/Great River and Sage Lot subwatersheds (although these last subwatersheds fall completely outside the Town boundaries of Falmouth).

9.2.8 Summary of Compliance Approach for Waquoit Bay

The Waquoit Bay estuary is a complex system of subwatersheds that fall within multiple town boundaries. The complexity of the systems and the multiple towns contributing to the nitrogen load make it difficult to detail a comprehensive compliance approach. Therefore, the following Table 9-1 outlines the overall nitrogen budget proposed for Waquoit Bay related to those portions to which Falmouth contributes in order to achieve nitrogen TMDL compliance, and incorporates to the extent known the Mashpee WNMP plan to address its nitrogen loading contributions to the system.

Table 9.1 Nitrogen Budget for Waquoit Bay Nitrogen TMDL Compliance

Watershed/ Subwatershed	Compliance Component – Nitrogen Removal Approach	Estimated Nitrogen Loading Reduction (kg N/yr)
Eel Pond	Fertilizer Bylaw (25% of fertilizer load)	195
	Stormwater BMPs (25% of impervious load)	97
	Shellfish Aquaculture (uptake)	1,170-1,890
	Shellfish (denitrification)	585-945
	Sewer Extensions (Total)	3,362-4,264
	Antler Shores[1]	*923-1,170*
	Seacoast Shores	*2,440-3,094*
	Total Eel Pond Estimated Reduction[2]	**5,409 – 7,391**
	Eel Pond Nitrogen Removal Goal	**3,241**
Childs River	Fertilizer Bylaw (25% of fertilizer load)	207
	Stormwater BMPs (25% of impervious load)	195
	Shellfish Aquaculture (uptake)	390-630
	Shellfish (denitrification)	195-315
	Sewer Extensions (Total)	3,202-4,061
	Seacoast Shores	*1,615-2,049*
	Seapit	*414-525*
	Mashpee Sewering	*1,173-1,487*
	Total Childs River Estimated Reduction	**4,124-5,408**
	Nitrogen Removal Goal	**5,274**
Hamblin Pond/ Little River	Mashpee Sewering	2,394-3,037
	Mashpee Shellfish	1,850
	Fertilizer Bylaw (25% of fertilizer load)	87
	Stormwater BMPs (25% of impervious load)	93
	Total Hamblin Pond Estimated Reduction	**4,424 – 5,067**
	Hamblin Pond Nitrogen Removal Goal	**3,734**
Quashnet/ Moonakis River	Mashpee Sewering	1,349-1,711
	Fertilizer Bylaw (25% of fertilizer load)	377
	Stormwater BMPs (25% of impervious load)	677
	Total Quashnet / Moonakis River Estimated Reduction	**2,403-2,765**
	Quashnet / Moonakis River Nitrogen Removal Goal	**3,035**
Total Waquoit Bay (without Jehu Pond/Great River)	**Total of Above Removals** [2]	**16,360 – 20,631**
	Total Removal Goals of the Above Watershed [3]	**15,284**

Notes:

1. The number of properties within the individual subwatershed boundary was used to calculate reduction, but due to the dynamics of the system will have impacts in both Eel Pond and Childs River.
2. Due to the complex flow dynamics of the Waquoit Bay system, overages in the estimated nitrogen reduction in Eel Pond may compensate for the deficit in Childs River.
3. Total removal goal based on values from Table VIII-3 from the 2013 MEP Report for Waquoit Bay.

As demonstrated above, the nitrogen removal goals within Eel Pond and Hamblin Pond/Little River can be achieved through the use of these approaches. However, a shortfall may result due to the variability of some of the removal options and the potential phasing of any sewering within this watershed. In addition, Childs River and Quashnet/Moonakis River thresholds may not be achieved depending on the performance of the proposed improvement. This is all related to the complexity of the system and the tidal flushing dynamics and therefore improvements in some of these subwatersheds will likely also have benefits to the adjacent ones especially when examining the Eel Pond and Childs River embayments.

Therefore, active monitoring of the water quality within the system will be necessary and will allow the Town to apply adaptive management approaches to best target sewer infrastructure implementation and gauge the performance of some of the other alternative approaches, namely shellfish.

The Town has also identified several options in the event that strategies from the proposed compliance plan approach are not sufficient including:

Eel Pond

- Use of I/A septic systems in the upper watershed.
- PRBs within the watershed.

Childs River

- Explore sewer extensions north of Route 28.
- Use of I/A septic systems in the upper watershed.
- PRBs within the watershed.

Quashnet River

- Explore use of I/A septic systems within Falmouth.
- Explore sewer extensions within Falmouth.

10. Public Outreach Efforts

10.1 Summary of Public Outreach Efforts

From 2014 through mid-2019 the Town of Falmouth actively participated in public awareness outreach efforts on water quality issues. The Water Quality Management Committee (WQMC) is the primary means of publicly disseminating Town decisions and strategic planning efforts towards restoring the impaired estuaries. Table 10.1 is a summary of WQMC meetings and publicly available archives relating to the activities of the WQMC.

Table 10.1 Summary of Meeting Records for the Falmouth Water Quality Management Committee

Year	Regular Committee Meetings	Number of Meetings Available Through FCTV	Number of Articles in Local Newspaper
2014	22	18	19
2015	17	17	17
2016	19	18	29
2017	19	12	24
2018	21	15	32
2019	9	4	8
Total Through June 1, 2019	107	84	129

During the past five and a half years the WQMC has held regular public meetings that typically occur on the first and third Thursday of each month. In accordance with the Massachusetts Open Meeting Law, the agenda for each WQMC meeting is publicly posted on the Town's website at least 48 hours prior to the meeting. Detailed minutes from each meeting are also publicly available on the Town's website. Current and archived agendas and minutes can be found at:

https://ma-falmouth.civicplus.com/AgendaCenter/Water-Quality-Management-Committee-39

The 2014 approved Comprehensive Wastewater Management Plan, various Technical Memos, and other engineering reports can also be found in the Agenda Center archives under the headings "Wastewater Division" and "Water Quality Planning."

Falmouth Community Television (FCTV) is a local non-profit media center that provides information of local interest to the community. As part of efforts for public awareness, FCTV is notified of every WQMC meeting. FCTV has videotaped over 75% of the meetings of the WQMC in the last five and a half years. All recorded meetings are broadcast repeatedly on local cable TV, and are available for viewing on the internet at FCTVs webpage and on the FCTVs YouTube channel. FCTV can be found at: http://www.fctv.org/v3/

The Enterprise is a local weekly newspaper produced for four towns on the Upper Cape. The Falmouth Enterprise edition reports mainly on issues of interest to residents of Falmouth. According to The Enterprise there are 6,900 Falmouth subscribers during the majority of the year, increasing to approximately 9,500 subscribers from June through September. On the Upper Cape as a whole, approximately 13,000 households are subscribers and have access to The Enterprise on the internet (personal communication). The Enterprise is notified of every WQMC meeting, and a reporter typically attends each meeting. Since 2014, numerous articles have been published primarily in the Falmouth edition (Table 10.1) of The Enterprise. Archives of articles are available at: https://www.capenews.net/

In addition to regular meetings on water quality issues, the WQMC has made a number of special efforts to reach out to the public on a variety of issues.

- Little Pond Sewer Service Area Project: In 2014 there were several public informational meetings, and supporting materials were distributed to the community to address questions and concerns about the project. These materials included a document outlining financial assistance for homeowners and a betterment memo (see Section 4.1.1 and Appendix 10.1).
- Fertilizer Bylaw: The Town initiated annual fertilizer mailings to homeowners and landscapers (see Section 3.6) in 2014. This letter is distributed every year to affected homeowners to remind them of the bylaw requirements.
- Innovative/Alternative (I/A) Septic Systems: In 2016, the Town partnered with the Buzzards Bay Coalition to host a workshop with five I/A vendors for homeowners interested in participating in the West Falmouth Harbor Shoreline Septic System Remediation Project (WFHSSSR) (see Section 3.4.2). Additionally, the Town produced a Frequently Asked Questions flier for homeowners interested in the WFHSSSR Project (see Appendix 10.2).
- Sharing of Technical Information: In 2017 several members from the WQMC were invited to meet with the Martha's Vineyard Commission to share Falmouth's knowledge and experiences in addressing water quality issues and to learn what approaches were being considered on Martha's Vineyard.
- Reports to Town Meeting: In 2015, 2016, and 2017 the WQMC presented a status report to Town Meeting on all activities currently in progress.

The Water Quality Management Committee will continue to work with the Board of Selectmen and relevant Town departments to inform the public and to provide a forum for open dialogue on water quality issues.

11. CWMP/TWMP Notice of Project Change Summary and Next Steps

11.1 Notice of Project Change – Project Narrative / CWMP Update Summary

11.1.1 Introduction

The Town of Falmouth (Town) is engaged in a multi-decade effort to restore the water quality and habitats in coastal ponds that have been degraded by excess nitrogen from human activities and land development. Beginning in 2007, Falmouth has focused its planning on the southern coastal ponds—Little, Great, Green and Bournes Ponds and Waquoit Bay—as these are considered the most impaired water bodies (Figure 11.1). Watershed by watershed, the Town is developing plans to restore these estuaries. The Massachusetts Department of Environmental Protection (DEP) approved the Targeted Watershed Plan for Little Pond on October 6, 2014. As outlined in that plan the Town has submitted its first Notice of Project Change, starting the process to address the Bournes Pond watershed by widening the inlet to restore tidal flushing and improve habitat. Both Massachusetts Environmental Policy Act (MEPA) Certificates (EEA #14154) for this project are included in Appendix 1.1.

Each estuary is unique, and the Massachusetts Estuaries Project (MEP) has collected a wealth of baseline information about nitrogen loads and the level of degradation in each pond. The Environmental Protection Agency (EPA) and the DEP have established a Total Maximum Daily Load (TMDL) for each estuary that the Town must meet in order to restore a healthy habitat. Falmouth's planning approach for each estuary evaluates cost, efficacy, and environmental impact using several approaches:

- The TMDL can be met with a combination of site-appropriate alternatives including:
  - Inlet widening/dredging
  - Aquaculture
  - Permeable reactive barriers
  - Wetland/habitat restorations
  - Innovative/alternative septic systems; and
  - Sewer extensions.

The Town is implementing an "adaptive management" approach as outlined in the Cape Cod Commission's Area-wide 208 Watershed Management Update. This approach acknowledges that there is uncertainty in project design and implementation. Projects will be carefully monitored, progress assessed, and plans restructured as necessary.

As requested in the MEPA certificate, the purpose of this Notice of Project Change is to provide updates on:

- Little Pond Sewer Service Area.
- Water quality monitoring throughout the planning area.
- Adaptive Management/ Pilot Projects.
- Nutrient reduction in the planning area.
- Permitting/Mitigation Section 61 Findings (See Chapter 12).

11.1.2 Little Pond Sewer Service Area Update

As discussed in Chapter 4, the first major phase of Targeted Watershed Management Plan (TWMP) implementation was the sewering of a significant portion of the Little Pond watershed. This has resulted in 95% of the 1,350 properties in the sewershed receiving sewer service to date, thereby reducing their impact on the estuary by eliminating their septic system discharges to the groundwater system. All properties in the sewershed are expected to be connected by the fall of 2019.

As identified in Table 4.3 the sewering of this area, combined with the credits for fertilizer management and stormwater Best Management Practices (BMPs), will allow the Town to meet the nitrogen TMDL goal for this watershed. The Town and United States Geological Survey (USGS) are actively monitoring the groundwater on the peninsula, and this data will be used to provide a greater understanding of the water-quality conditions before and after the installation of sewers.

11.1.3 Water Quality Monitoring and Watershed Compliance Plan Updates

As discussed in Chapters 2 and 5, the Town has collected an extensive amount of water quality data for the Little, Great, Green, and Bournes Ponds, in addition to Waquoit Bay and West Falmouth Harbor.

Chapter 3 summarizes all of the pilot project efforts undertaken since the 2014 Certificate through the writing of this report. Report sections documenting the information that has been gathered on various projects and nitrogen-reduction strategies during the last five years are summarized below:

- 3.2 Aquaculture
- 3.3 Eco-toilets (composting, packaged, and urine diverting toilets)
- 3.4 Innovative and alternative (I/A) septic systems
- 3.5 Permeable reactive barriers (PRBs)
- 3.6 Nitrogen Control Bylaw for fertilizer
- 3.7 Stormwater management
- 3.8 Inlet widening – Bournes Pond

The technical reports and supporting documents are located in the associated appendices (3.2 through 3.8).

Through analysis of the water quality data and pilot projects, the Town has developed compliance plans for each watershed, as detailed in Chapters 4 through 9 of this report. The following are the summary tables for each watershed within the planning area. Additional detail for each proposed plan is found in its respective chapter.

Table 11.1 Little Pond (Chapter 4) Nitrogen Budget: Updated Compliance Approach

Compliance Component – Nitrogen Removal Approach	Estimated Nitrogen Loading Reduction (kg N/yr)
Sewering	4,848
I/A Systems	340
Fertilizer (25% of fertilizer load)	158
Stormwater (25% of impervious load)	116
Aquaculture	29
Total Estimated Reduction	**5,461**
Nitrogen Removal TMDL Goal	**5,006**

Table 11.2 West Falmouth Harbor (Chapter 5) Nitrogen Budget: Updated Compliance Approach

Compliance Component - Nitrogen Removal Approach	Estimated Nitrogen Loading Reduction (kg N/yr)
Wastewater Treatment Improvement	8,792
I/A Systems	92
Fertilizer (25% of fertilizer load)	91
Stormwater (25% of impervious load)	285
Aquaculture	0
Total Estimated Reduction	**9,260**
Nitrogen Removal TMDL Goal	**8,472**

Table 11.3 Great Pond (Chapter 6) Nitrogen Budget to Achieve TMDL Compliance

Compliance Component – Nitrogen Removal Approach	Estimated Nitrogen Loading Reduction (kg N/year)
Fertilizer Bylaw (25% of fertilizer load)	425
Stormwater BMPs (25% of impervious load)	580
Aquaculture (uptake)	1,300-2,100
Shellfish (denitrification)	650-1,050
PRB at Shorewood Drive (300 feet)	1,325
Sewer Extensions (Total)	7,179-9,105
LPSSA (Great Pond)	*1,037-1,316*
TASA Subarea 1	*3,325-4,217*
TASA Subarea 2	*2,817-3,572*
Total Estimated Reduction	**11,459-14,585**
Nitrogen Removal TMDL Goal	**12,154**

Table 11.4 Green Pond (Chapter 7) Nitrogen Budget to Achieve TMDL Compliance

Compliance Component - Nitrogen Removal Approach	Estimated Nitrogen Loading Reduction (kg N/yr)
Fertilizer Bylaw (25% of fertilizer load)	227
Stormwater BMPs (25% of impervious load)	172
Stormwater – Captain's Lane Catchment Area	120
Aquaculture (uptake)	390-630
Shellfish (denitrification)	195-315
Mill Pond	491-961
Sewer Extensions (total)	2,058-2,610
Total Estimated Reduction	**3,653-5,035**
Nitrogen Removal TMDL Goal	4,453

Table 11.5 Bournes Pond (Chapter 8) Nitrogen Budget to Achieve TMDL Compliance

Compliance Component - Nitrogen Removal Approach	Estimated Nitrogen Loading Reduction (kg N/yr)
Fertilizer Bylaw (25% of fertilizer load)	121
Stormwater BMPs (25% of impervious load)	126
Aquaculture (uptake)	1,352-1,680
Shellfish (denitrification)	676-840
Inlet Widening (50% of controllable load)	1,995
Total Estimated Reduction	**4,270-4,762**
Nitrogen Removal TMDL Goal	4,162

Table 11.6 Waquoit Bay (Chapter 9) Nitrogen Budget to Achieve TMDL Compliance

Watershed/ Subwatershed	Compliance Component – Nitrogen Removal Approach	Estimated Nitrogen Loading Reduction (kg N/yr)
Eel Pond	Fertilizer Bylaw (25% of fertilizer load)	195
	Stormwater BMPs (25% of impervious load)	97
	Aquaculture (uptake)	1,170-1,890
	Shellfish (denitrification)	585-945
	Sewer Extensions (Total)	3,362-4,264
	Antler Shores	*923-1,170*
	Seacoast Shores	*2,440-3,094*
	Total Eel Pond Estimated Reduction	**5,409 – 7,391**
	Eel Pond Nitrogen Removal Goal	**3,241**
Childs River	Fertilizer Bylaw (25% of fertilizer load)	207
	Stormwater BMPs (25% of impervious load)	195
	Aquaculture (uptake)	390-630
	Shellfish (denitrification)	195-315
	Sewer Extensions (Total)	3,202-4,061
	Seacoast Shores	*1,615-2,049*
	Seapit	*414-525*
	Mashpee Sewering	*1,173-1,487*
	Total Childs River Estimated Reduction	**4,124-5,408**
	Nitrogen Removal Goal	**5,274**

<table>
<tr><th>Watershed/ Subwatershed</th><th>Compliance Component – Nitrogen Removal Approach</th><th>Estimated Nitrogen Loading Reduction (kg N/yr)</th></tr>
<tr><td rowspan="6">Hamblin Pond/ Little River</td><td>Mashpee Sewering</td><td>2,394-3,037</td></tr>
<tr><td>Mashpee Shellfish</td><td>1,850</td></tr>
<tr><td>Fertilizer Bylaw (25% of fertilizer load)</td><td>87</td></tr>
<tr><td>Stormwater BMPs (25% of impervious load)</td><td>93</td></tr>
<tr><td>Total Hamblin Pond Estimated Reduction</td><td>4,424 – 5,067</td></tr>
<tr><td>Hamblin Pond Nitrogen Removal Goal</td><td>3,734</td></tr>
<tr><td rowspan="5">Quashnet/ Moonakis River</td><td>Mashpee Sewering</td><td>1,349-1,711</td></tr>
<tr><td>Fertilizer Bylaw (25% of fertilizer load)</td><td>377</td></tr>
<tr><td>Stormwater BMPs (25% of impervious load)</td><td>677</td></tr>
<tr><td>Total Quashnet / Moonakis River Estimated Reduction</td><td>2,403-2,765</td></tr>
<tr><td>Quashnet / Moonakis River Nitrogen Removal Goal</td><td>3,035</td></tr>
<tr><td rowspan="2">Total Waquoit Bay (without Jehu Pond/ Great River)</td><td>Total of Above Removals</td><td>16,360 – 20,631</td></tr>
<tr><td>Total of Above Removal Goals</td><td>15,284</td></tr>
<tr><td colspan="3">Notes:
1. Stormwater reduction range based on reduction of the entire system or only Childs River North.
2. Total removal goal based on values from Table VIII-3 from the 2013 MEP Report for Waquoit Bay.
3. Due to the complex flow dynamics of the Waquoit Bay system, overages in the estimated nitrogen reduction in Eel Pond may compensate for the deficit in the Childs River.</td></tr>
</table>

11.2 Next Steps

11.2.1 CWMP/TWMP for Great Pond Plan of Study

The Town has adopted the general approach of working west to east along its southern coastline. This allows traditional infrastructure to be extended from existing infrastructure, which is primarily located within the Town's downtown areas and the Little Pond Sewer Service Area.

Following the west to east approach, the Town has identified the Great Pond watershed as its next priority and will be seeking to develop and submit its next Targeted Watershed Management Plan for this waterbody. This update to the Comprehensive Plan/Notice of Project Change document provides a large portion of the components necessary for the development of a Targeted Watershed Management Plan/ Environmental Impact Report, and therefore the TWMP for Great Pond will focus on incorporating the following components into the work that has been outlined as part of this update:

1. Background
    a. This section would provide a brief background of the efforts that have led up to the proposed TWMP for Great Pond and reference this Update document.

2. Update and Recommended Effluent Discharge Site Selection

    a. This section will identify the proposed effluent discharge site(s) for flow collected through the proposed sewer area and will summarize additional effluent discharge site evaluations conducted subsequent to the submittal of this current Comprehensive Wastewater Management Plan (CWMP) Update/NPC.

    b. This section will also provide an analysis of the environmental and financial pros and cons of a half dozen discharge site options from two perspectives: a short-term option that accommodates the expected flow from the Great Pond watershed and a long-term option that would accommodate all of the present and future flow expected from the planning area.

3. Development of a Recommended Plan.

    a. This will outline the proposed service area and the extent of traditional and non-traditional elements proposed to address nitrogen loading within Great Pond watershed and possibly portions of Green Pond watershed (as necessary, based on design requirements).

    b. This section will also provide an update on the cost estimates for the proposed Recommended Plan to facilitate the Town's evaluation of funding opportunities. This section will also provide an updated implementation schedule regarding this.

4. Update of Environmental Impact Analysis.

    a. As necessary, this section will review the existing environment of Great / Green Pond to identify potential impacts during the next phase of implementation. The section will identify potential impacts and regulatory requirements and will rank various alternatives for this area.

5. Update the Section 61 Findings and Mitigation Measures

    a. Similar to the information found in this NPC, this section will provide an update for any Section 61 Findings and Mitigation Measures, as needed. It will also include an updated mitigation table relative to the specific work being proposed for the Great Pond TWMP.

It is our expectation that the other sections typically found in a CWMP or TWMP have been addressed through previous documents and the two Notice of Project Change documents (including this one). A Draft Targeted Watershed Management Plan/Draft Environmental Impact Report, as outlined above, is anticipated to be submitted for review and approval and will be followed by the Final TWMP/EIR.

As outlined in Chapters 6 and 7, the TWMP for Great Pond is anticipated to include portions of the Teaticket/Acapesket neighborhoods and parcels between the Little Pond Sewer Service Area and the Acapesket peninsula, as shown in Figure 6.2.

11.2.2 Regional Steps

11.2.2.1 Joint Base Cape Cod

The Town of Falmouth is actively participating in discussions and evaluations related to the potential use of the wastewater infrastructure at Joint Base Cape Cod (JBCC). This is a regional effort that includes JBCC, Falmouth, Barnstable, Bourne, Mashpee, and Sandwich.

11.2.2.2 Nitrogen Loading Allocation for Waquoit Bay Watershed

Falmouth is actively working with its neighboring communities of Mashpee and Sandwich in order to establish nitrogen loading allocations and responsibility for Waquoit Bay. It is anticipated that the communities will establish these allocations to aid in each community's approach to addressing the nitrogen impacts to this large shared watershed.

11.2.3 Overall CWMP Schedule Update

The following Table 11.7 is included to provide an update to the implementation and cost schedule presented in the 2014 CWMP/EIR and TWMP. This table outlines the specific steps and anticipated schedule for the upcoming TWMP for Great Pond and design of the project recommended in the TWMP (years 2019 through 2025). In the process of developing this TWMP, Falmouth must make an important decision in choosing a site for discharge of the treated effluent. The financing plan in Table 11.7 is consistent with Falmouth's originally stated policy of funding sewer projects in those years when new debt can replace retiring old debt, thereby not increasing the tax rate. The next funding window is Fiscal Year 2025. Town Meeting and the voters would have to approve a bond issue of $60 million in April/May 2024 to be effective at the start of Fiscal Year 2025 on July 1, 2024.

Table 11.7 also outlines the funding opportunities currently identified by the Town of Falmouth and the construction timetable for the years 2025 through 2040. Due to the overall size and complexity of the Town's South Coast Embayment Watersheds planning area, this project is anticipated to extend beyond 2040 in order to feasibly implement and achieve TMDL compliance.

Table 11.7 Estimated Costs and Financing Plans

Item	Action Item	2019	2020	2021	2022	2023	2024	2025
1	Little Pond Sewer Service Area Completed	X						
2	(A) CWMP Update/NPC; (B) Oyster Pond Draft CWMP Submitted to MEPA/DEP	X						
3	Capital Plan within debt limit: add third Sequencing Batch Reactor; plant upgrade		X	X	X			
4	Receive MEPA Secretary's Certificate for CWMP Update		X					
5	Evaluate Results of Remediation to date; Engineering Contract for Great Pond TWMP		X					
6	Draft TWMP for Great Pond Sewer Service Area; Decision on Discharge Site; Submit to MEPA/DEP		X	X				
7	Sec. Certificate for Draft TWMP; Final TWMP; Sec. Certificate for Final TWMP				X			
8	Town Meeting Sets Betterment Percentage					X		
9	Construction Design Funding; Ballot Vote					X		
10	SRF PEF Application Submittal					X		
11	Obtain Listing on the SRF Intended Use Plan						X	
12	$60M Town Vote Bond for Construction Contingent on 0% SRF Loan; Ballot Vote						X	
13	SRF Full Application Submitted - all required items must be in place						X	
14	State SRF Commitment; Bid Approval							X
15	SRF-Funded Construction Projects; On-going Adaptive Management							X

Program Funding and Timetable 2025-2040	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Town Construction of $60M																
Plan Next Construction Projects																
$40M Town Vote - Spring 2030						X										
Town Construction of $40M																
$XX Town Vote - Spring 2035 (1)											X					
Town Construction																

Notes:

CWMP = Comprehensive Wastewater Management Plan

NPC = Notice of Project Change

TWMP = Targeted Watershed Management Plan

PEF = Project Evaluation Form

SRF = State Revolving Fund

1. Due to the unknowns and uncertainties related to funding in the future, the Town has not identified the appropriation goal for 2035.

12 Section 61 Findings and Mitigation Measures Update

12.1 Introduction

The purpose of this Chapter is to identify and present the mitigation measures as identified in the approved Comprehensive Wastewater Management Plan and Final Environmental Impact Report and Targeted Watershed Management Plan (CWMP/FEIR/TWMP) with updates as applicable. Draft Section 61 Findings are outlined in the Massachusetts Environmental Policy Act (MEPA) Regulations 301 CMR 11.07, in accordance with M.G.L. c. 30, section 61 for all State agency actions. These regulations require that each agency, department, board, commission, and authority of the Commonwealth "review, evaluate, and determine the impact on the natural environment of all works, project or activities conducted by them and shall use all practicable means and measures to minimize damage to the environment." The regulation also states that, "Any determination made by an agency of the Commonwealth shall include a finding describing the environmental impact, if any, of the project and a finding that all feasible measures have been taken to avoid or minimize said impact."

The Secretary's Certificate requires that the Notice of Project Change (NPC) include a separate chapter on mitigation measures, including proposed and/or revised Section 61 Findings for State permits and a summary table of the mitigation measures proposed.

12.2 Draft Section 61 Findings for State Agency Actions

Anticipated State agency actions are listed below. These actions summarize permits and approvals that will likely be required for implementation of the Recommended Plan.

- U.S. Environmental Protection Agency (USEPA), National Pollutant Discharge Elimination System (NPDES) Permitting Program (as applicable), under 40 CFR Chapter 1, Section 122.26 (15) for NPDES Stormwater Permit for Construction Activities and review of developed Stormwater Pollution Prevention Plan (SWPPP).
- Department of the Army, New England District, Corps of Engineers (as applicable), Permit requirement under Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403); Permit requirement under Section 404 of the Clean Water Act; Massachusetts Programmatic General Permit (PGP) or Category II or III Individual Permit.
- Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA) approval of the CWMP/FEIR/TWMP Document.
- Massachusetts Department of Environmental Protection, Ground Water Discharge Permit Program, pursuant to M.G.L. c. 21 s. 43 and its regulations at 314 CMR 5.00, BRP WP 11, for facility modifications with plan approval and/or for a new effluent discharge permit.
- Massachusetts Department of Environmental Protection, Sewer System Extension and Connection Permit Program, pursuant to M.G.L. c. 21 s. 43 and its regulations at 314 CMR 7.00, BRP WP 13, 17, or 18.

- Massachusetts Department of Environmental Protection, Chapter 91 License (as applicable), pursuant to M.G.L. c. 91, the waterways licensing program.
- Massachusetts Department of Environmental Protection, Notice of Intent (NOI) Wetland Protection Act (WPA) Form 3 (as applicable) and Falmouth Conservation Commission approvals (as applicable) for work within the 100-foot buffer to a wetland, per the wetlands regulations at 310 CMR 10.00.
- Massachusetts Department of Environmental Protection, Air Quality Permits (as applicable), BWP AQ 04 - Asbestos Removal Notification that may be required for Asbestos Pipe removal and BWP AQ 06 Construction/Demolition Notification.
- Massachusetts Department of Environmental Protection, Emergency Engine and Emergency Turbine Compliance. The program applies to all new emergency or standby engines with a rated power output equal to or greater than 37 kW or emergency turbines with a rated power output less than one megawatt constructed, substantially reconstructed, or altered after March 23, 2006.
- Massachusetts Department of Environmental Protection, Air Quality Permit BWP AQ 14, 15, 16, 17 Operating Permits. These are mandated for major sources of air pollution by the Clean Air Act Amendments of 1990. Massachusetts has incorporated this program in 310 CMR 7.00 Appendix D of its Air Pollution Control Regulations. In some cases, emissions from Wastewater Treatment Facilities (WWTFs) or odor control systems trigger this requirement.
- Massachusetts Department of Environmental Protection Bureau of Waste Site Cleanup, Filing of Utility Release Abatement Plan (as applicable), for excavation within known contaminated sites.
- Office of Coastal Zone Management (CZM) Federal Consistency Review, pre-consultation to determine applicability.
- Commonwealth of Massachusetts Department of Public Works Permit for work within State Highway Layouts. These will be required for any work proposed along Route 28.
- Massachusetts Division of Fisheries & Wildlife, The Natural Heritage & Endangered Species Program (NHESP), MESA (321 CMR 10.00) and/or the WPA (310 CMR 10.00) for work below mean high water line, in a fish run, or in priority or estimated habitats.
- Massachusetts Division of Marine Fisheries (DMF) as appropriate. DMF shall include consultation on potential impacts to diadromous fish species and mitigation measures as appropriate.
- Massachusetts Historical Commission (MHC) consultation/reviews for construction of new facilities and infrastructure.
- Cape Cod Commission (CCC) review for 208 Plan consistency.
- Town of Falmouth building permits for the construction of structures as part of the Recommended Plan.
- Town of Falmouth Wastewater Department for sewer connection permitting.
- The Town of Falmouth Conservation Commission for any proposed work within its jurisdiction.

The resulting planned mitigation measures are discussed in this Chapter. The following section summarizes the proposed mitigation measures.

All mitigation measures will be funded and implemented by the Town of Falmouth, its agents, representatives, and/or contractors in addition to any State agency actions required above.

12.3 Planned Mitigation Measures Design and Construction

As called for in the 2014 Secretary's Certificate, the following mitigation measures have been identified and updated as appropriate. These measures were outlined and identified in the approved CWMP/TWMP to limit negative environmental impacts and/or create positive environmental impacts during development and operation of the preferred plan. The schedule and costs for the implementation of mitigation are also discussed where appropriate.

12.3.1 General Construction Measures

During construction, the site(s) shall be secured to prevent unauthorized entry to the construction site and to protect existing and adjacent facilities and properties. Supplemental lighting, signs, railings, and construction barriers shall be used as necessary to provide safety to employees, construction workers, visitors, and the general public during the construction process in accordance with Occupational Safety and Health Administration (OSHA) and other applicable regulations.

Water used during the construction process and that generated from runoff on the site, will be controlled by proper site grading and by providing temporary berms, drains, and other means to prevent soil erosion. These means will also be used to reduce puddling and runoff on the site. Existing and new catch basins will be protected from siltation using hay bales, siltation fence, and catch basin inserts. At no time will the pumping of silt-laden water to surface waters, stream corridors, or wetlands be allowed. Pollution controls will also be provided to prevent the contamination of soils, water, and the atmosphere from the discharge of noxious or toxic substances and pollutants during the construction process.

Erosion control measures including hay bales, siltation fencing, and erosion control fabric will be used to provide sedimentation barriers where required. Temporary seeding and mulching may also be used to minimize soil erosion and provide soil stabilization on slopes. Diversion trenches may also be used on the uphill side of disturbed areas to divert surface runoff. Land disturbances will be kept to a minimum to reduce impacts and erosion. All erosion and stormwater control methods shall be in accordance with the USEPA NPDES General Permit requirements, Commonwealth of Massachusetts regulations, and the Town of Falmouth regulations. A SWPPP will be required as part of the NPDES General Permit for those areas exceeding the threshold limits.

The site(s) will be maintained free of waste materials, debris, and trash following each day of work. Waste and other debris will be collected and disposed of off-site periodically. At no time during construction will the dumping of spoil material, waste, trees, brush, or other debris be allowed into any stream corridor, any wetland, any surface waters, or any unspecified location. The permanent or unspecified alteration of stream flow lines is not allowed during construction. Recycling of waste and construction debris will likely be mandated as well and should always be considered during construction.

Construction noise from heavy equipment will normally be limited to within normal operating hours of 7:00 a.m. to 5:00 p.m. Dust controls, including the use of street sweepers and/or watering trucks, will be used to minimize air-borne dust as necessary.

The Town, in participation in the Massachusetts Clean Water State Revolving Fund (CWSRF), also actively requires the MassDEP Diesel Retrofit Program be followed and therefore requires that contractors working on their CWMP/TWMP related projects participate in this program in order to minimize construction-period diesel emissions.

Depending on the type of non-traditional project, various other regulatory reviews may be required including Massachusetts Historical Commission, Natural Heritage and Endangered Species Program, MassDEP/US Army Corps of Engineers for dredging and coastal projects, US Coast Guard, MassDEP/Falmouth Conservation Commission regarding wetlands and resource areas, and Division of Marine Fisheries. Each of these regulatory agencies may issue specific conditions and permit requirements related to the type of project.

12.3.2 Sewer Construction Mitigation

At such time as the Town moves into the construction phase, additional mitigation measures will be implemented, in addition to those identified in the general construction section. Police details and other traffic controls will be necessary to minimize traffic problems during sewer expansion construction. Detours and trucking routes will need to be identified prior to construction as part of detailed design and these routes will need to be designed to minimize impacts to surrounding residential areas not accustomed to heavy construction and increased vehicle traffic. Construction within the future sewer service areas will have to allow for safe travel of both pedestrians and vehicle traffic.

Sewer extensions are planned in the road layouts to avoid impacts to animal habitats, wetlands, historic areas, or potential archaeological sites. Construction in these areas will impact traffic (vehicle, pedestrian, and bicycle) in the roadways during construction. Construction procedures for traffic control, erosion protection, dust control, noise prevention, and wetland protection will be implemented as appropriate and documented in the Construction Plans and Specifications for any specific project. Use of trench boxes, bracing, and other shoring methods will be utilized to provide the necessary safety for workers and others at the construction site and are employed as part of the construction contractor’s means and methods in accordance with OSHA requirements and Massachusetts open trenching laws.

To the extent practicable, any private property, including trees and vegetation, that is damaged during construction is to be repaired or replaced. All roads, both publicly and privately owned, impacted by construction associated with the implementation of the collection system shall be restored to a condition safe and appropriate for vehicular traffic. Any collection system components and lift stations to be constructed outside of road right-of-ways will be reviewed with the MHC during design. If required, archaeological monitors will be provided during construction as stipulated by MHC.

The collection system lift stations need to be located in low-elevation areas to be able to utilize gravity pipes for collection and subsequent pumping. Wetland regulations and permitting will be followed to minimize impacts to any adjacent wetlands.

Stormwater and construction runoff will be managed through the implementation of construction SWPPPs established prior to construction and regulated under USEPA NPDES General Permits for Construction.

Areas requiring sewers located within parts of Town identified as barrier beach will have to be designed and constructed to meet specific State requirements for work within these areas (Executive Order 181), and will have the following stringent requirements for the construction of sewers on a barrier beach:

1) All infrastructure must be protected from coastal flood hazards.
2) The sewers cannot promote additional growth on the barrier beach that would not have otherwise been allowed.

Previous discussions held with Massachusetts CZM, the agency that upholds Executive Order 181, have identified that the water quality benefits provided by the collection system extensions will greatly outweigh the slight risk that a catastrophic coastal hazard could damage some of the infrastructure. Collection system extensions will be designed to withstand reasonably expected coastal flood hazards; lift stations will be designed to withstand a 100-year storm, and all pipes and equipment suitably protected from wave action. Lift stations will be located outside of flood zones when possible and protected with a system of check valves in critical areas and generally protected from floods and natural hazards to the extent reasonable.

12.3.3 Wastewater Treatment Facility Site and Discharge Sites

In addition to those mitigation measures identified previously, the following measures will be provided at the existing Falmouth WWTF and any new discharge sites. The wastewater treatment system will process the wastewater collected from future sewer service areas. Removal of this local source of nitrogen will significantly reduce the amount of nitrogen entering the watersheds of the estuaries within the project planning area in order to make substantial progress towards achievement of the TMDLs during the 20-year planning period.

The greatest mitigation measure is the operation of an improved advanced wastewater treatment system designed for consistent nitrogen removal to 3 mg/L total nitrogen. Improvements to the WWTF will also provide significant removal of suspended solids and biochemical oxygen demand (BOD) in the effluent. This system will increase the production of biosolids (sludge) and increase the volume of treated water recharged to the water table. The sludge will be disposed of or reused at an approved off-site facility in accordance with MassDEP guidelines. The recharge will be monitored as part of an approved groundwater monitoring plan. Odor and noise mitigation measures will also be considered as part of the final design to minimize the impacts to adjacent properties during construction and operation.

Energy efficient design features to minimize greenhouse gas (GHG) release from the WWTF will be considered during preliminary and detailed design to maintain a high rating index of 50 or greater. GHG evaluations were completed as summarized in Chapter 7, Section 7.6.2 of the approved CWMP/TWMP and these evaluations should be considered during design of any expansions of the WWTF. Future expansions should be designed to meet a rating index of 50 or higher.

The following mitigation measures will be observed to avoid or minimize adverse environmental impacts:

- The WWTF improvements will take place on a previously developed parcel (existing Falmouth WWTF) and in existing structures.
- Any new lift stations will have exterior façades which will compliment and be consistent with neighborhood aesthetics.
- Vegetative screens will be employed, if determined necessary, for aesthetic reasons.
- Consultation with expert agencies will occur during the design phase and contact will be continued during construction if there is a resource that may be affected.
- Work will be halted if archaeological resources are uncovered during construction.
- The contractor will be required to thoroughly clean up the site before the contract is considered complete.
- Proper handling and storage of possible contaminants and hazardous substances will be required of the contractor, in addition to proper notifications.
- Access roads will be dampened to minimize construction dust if required.
- Debris will not be burned as a means of disposal.
- No construction work will normally be performed during evening, holiday, or weekend hours.
- A Resident Project Representative will be employed to ensure that the project area is kept clean and that mitigation measures are met.

12.4 Additional Mitigation Measures

12.4.1 Adaptive Management

The Town of Falmouth's CWMP includes the implementation of an adaptive management process to incorporate cost-effective non-traditional methods into the plan once they demonstrate feasibility. The adaptive management process will also monitor groundwater elevations, water quality, and performance at coastal embayments during construction and upon completion of the phased sewering and full-scale implementation of non-traditional methods (as applicable).

This adaptive management approach will enable the CWMP to be adjusted based on the monitoring results of the environmental and economic impacts associated with the construction of the new sewers or implementation of additional non-traditional projects in Falmouth. Coordination with MassDEP and the CCC will also be conducted and key factors incorporated into the adaptive management plan.

12.4.2 Climate Change Mitigation

The following provides a broader view of mitigation measures that could be evaluated or implemented in preparation of climate change planning. Given the significance of the Town's beaches and coastal wetlands as both a tourism and revenue draw, but also as natural buffers to coastal wave action, it is in the Town's best interest to implement strategies to protect these areas from detrimental impacts associated with climate change. As presented in Lewsey et. al. (2003) and the September 2011 *Massachusetts Climate Change Adaptation Report*, options to protect beaches and coastal wetlands include the following:

- Development of a Town-wide Hazard Mitigation Plan;
- Continue with long-term beach and coastal area monitoring;
- Strengthen regulations to protect ecological buffers such as coastal wetlands and estuaries;
- Use land acquisition and conservation restrictions to protect headwater streams and associated buffer areas in order to protect downstream conditions during periods of warming;
- Adapt permitting and regulatory criteria to protect and maintain natural stream flow as well as incorporate potential climate change impacts;
- Develop comprehensive land use plans which incorporate the protection of natural coastal resources such as beaches and wetlands;
- Employ land use protection tools to maintain, preserve, and restore ecological buffers; and
- Enhance engineered coastal protection systems where inland retreat or other accommodation is not an option.

As presented by Lewsey et. al. (2003), there are several ways in which the Town of Falmouth can protect shoreline residential and commercial infrastructure development, including:

- Introduce building codes that account for climate change effects such as sea level rise;
- Implement comprehensive land use planning to account for the impacts associated with sea level rise and climate change;
- Identify high hazard areas, i.e. those areas most likely to be subjected to detrimental effects of climate change such as sea level rise and introduce regulations to phase out development in high hazard areas;
- Link coastal property insurance rates with construction quality, i.e. ability to accommodate sea level rise, increased flooding, more frequent storm events;
- Implement economic and market-based incentives that promote sustainable development in coastal areas and/or deter development from high hazard areas; and
- Enhance coastal protection where retreat or other accommodation is not an option.

The Town has not made final decisions on these options.

The Falmouth Board of Selectmen appointed the Coastal Resources Working Group (CRWG) and charged this group to:

1. Identify key factors dictating the current condition of Falmouth's coastal sediment system;
2. Explore reasons for the current condition;
3. Develop future scenarios of the coastal zone based on physical processes and coastal management; and

4. Provide community outreach and recommendations concerning coastal processes and coastal management.

The CRWG was composed of volunteers with expertise in coastal geology, oceanography, coastal management, landowner issues, water quality, land use, ecology, and coastal navigation. This Group was active from May 2000 to October 2010, completing two reports, “The Future of Falmouth’s South Shore” in 2003 and "The Future of Falmouth’s Buzzards Bay Shore" in 2010.

In 2017, the Selectmen appointed the five-member Coastal Resiliency Action Committee. The purpose of this committee is to prepare action plans for submission to the Selectmen to address the risks and hazards to coastal infrastructure and coastal properties that may be caused by coastal erosion, storms, and sea level rise.

12.5 Mitigation Measures Summary Table

The following table summarizes those general mitigation measures that are identified above regarding future implementation of a specific TWMP. Funding of these measures is all anticipated to come from Town Funding and to be supported by various grant and loan opportunities including Natural Resources Conservation Service (NRCS), the Massachusetts State Revolving Fund (SRF) program, Southeast New England Program (SNEP) Grants, CZM Grants, amongst others.

Table 12.1 Mitigation Measures Summary

Category	Proposed Mitigation Measure	Implementation	Preliminary Schedule
General Construction - Site Access/Public Safety Impact	The site(s) shall be secured to prevent unauthorized entry to the construction site, and to protect existing and adjacent facilities and properties. Supplemental lighting, signs, railings, and construction barriers shall be used as necessary to provide safety to employees, construction workers, visitors, and the general public during the construction process in accordance with OSHA and other applicable regulations. Police details and detours will be implemented in accordance with Traffic Control Plans included with the Project Contract Documents.	Contractor	During Construction
General Construction - Stormwater	Provisions for stormwater management and erosion control shall be managed in accordance with the approved SWPPP and NPDES General Permit.	Contractor	During Construction
General Construction - Construction debris	The site(s) will be maintained free of waste materials, debris, and trash following each day of work. Waste and other debris will be collected and disposed of off-site periodically. At no time during construction will the dumping of spoil material, waste, trees, brush, or other debris be allowed into any stream corridor, any wetland, any surface waters, or any unspecified location. The permanent or unspecified alteration of stream flow lines is	Contractor	During Construction

Category	Proposed Mitigation Measure	Implementation	Preliminary Schedule
	not allowed during construction. Recycling of waste and construction debris will likely be mandated as well and should always be considered during construction.		
General Construction - noise and dust control	Normal construction hours will be between 7 am and 5 pm during normal business days. No work will be allowed on Holidays and the Contractor will be required to provide adequate dust control measures during construction.	Contractor	During Construction
Wastewater Facilities Construction Mitigation - resource areas	As necessary, appropriate Notice of Intent documents and Request for Determinations will be filed relative to work proposed with buffer areas or resource areas. Orders of Conditions, as received, will be incorporated into the Construction Documents.	Town / Contractor	Permitting Prior to Construction/ Mitigation during Construction through compliance with Order of Conditions.
Wastewater Facilities Construction Mitigation - flooding	To the extent practicable, facilities will be located out of flood hazard zones. Because lift stations are typically located in low lying areas to maximize gravity sewer service, additional provisions for coastal resiliency and flood protection will need to be made to mitigate impacts. During construction, management of dewatering and protection from storms will be required.	Town / Contractor	During design of facilities for coastal resiliency, and construction of the work.
Wastewater Facilities Construction Mitigation - Site Impacts	The WWTF improvements will take place on a previously developed parcel (existing Falmouth WWTF) and in existing structures.	Town / Contractor	During Construction
Wastewater Facilities Construction Mitigation - Aesthetics	Any new lift stations will have exterior façades which will compliment and be consistent with neighborhood aesthetics. Vegetative screens will be employed, if determined necessary, for aesthetic reasons.	Town / Contractor	During design and implemented during construction
Wastewater Facilities Construction Mitigation — Archeological	Development of a Post Discoveries Review Plan (if necessary). Work will be halted if archaeological resources are uncovered during construction.	Town / Contractor	Plan development prior to Bidding, implementation during construction
Wastewater Facilities Construction Mitigation - General	A Resident Project Representative will be employed to ensure that the project area is kept clean and that mitigation measures are met.	Town	During Construction

Category	Proposed Mitigation Measure	Implementation	Preliminary Schedule
Adaptive Management - TMDL Compliance	Implementation of an Adaptive Management process which will consider the performance of the demonstration projects and incorporate cost-effective non-traditional methods into the plan once they demonstrate feasibility. The Adaptive Management process will also monitor groundwater elevations, water quality, performance at coastal embayments during construction, and upon completion of the phased sewering and full-scale implementation of non-traditional methods (as applicable).	Town	Pre and post construction / implementation
Climate Change Mitigation	Town of Falmouth has created both a Coastal Resources Working Group and Coastal Resiliency Action Committee and participates on regional committees to assist with planning for and mitigation of potential impacts due to climate change in response to their projects.	Town	Pre and post construction / implementation

References

GHD Inc, September 2013. Comprehensive Wastewater Management Plan and Final Environmental Impact Report and Targeted Watershed Management Plan – Little Pond, Great Pond, Green Pond, Bournes Pond, Eel Pond, and Waquoit Bay Watersheds and Recommendations for West Falmouth Harbor Watershed, (CWMP/FEIR/TWMP)

McCobb, T. and J. Barbaro, et. al. 2019. "Assessment of Hydrologic and Water-Quality Changes in Shallow Groundwater Beneath a Coastal Neighborhood Being Converted from Septic Systems to Municipal Sewers (USGS 2019).

Reitsma J., D. Murphy and A. Franklin. 2013. Shellfish Nitrogen Content from Coastal Waters of Southeastern Massachusetts, Cape Cod Cooperative Extension and Woods Hole Sea Grant.

Reitsma, J., Murphy, D.C., Archer, A.F. and York, R.H., 2017. Nitrogen extraction potential of wild and cultured bivalves harvested from nearshore waters of Cape Cod, USA. *Marine Pollution Bulletin*.

Stearns & Wheler, LLC (GHD Inc), January 2001, Wastewater Facilities Plan and Environmental Impact Report for Wastewater Facilities Planning Study, Town of Falmouth, MA. (West Falmouth Harbor CWMP)

about GHD

GHD is one of the world's leading professional services companies operating in the global markets of water, energy and resources, environment, property and buildings, and transportation. We provide engineering, environmental, and construction services to private and public sector clients.

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