Barnstable Water Resources Protection

Special Town Council Workshop:
Comprehensive Wastewater Management Plan
Water Pollution Control Facility and Effluent

June 13, 2024
Town Hall Hearing Room

Town of Barnstable
Department of Public Works

Welcome!

- CWMP
  - Water Pollution Control Facility (WPCF)
  - Effluent
- Post CWMP
  - Water Pollution Control Facility (WPCF)
  - Effluent

CWMP Discussion – WPCF

Solids Handling Facility

- This system is nearing the end of its design life, and the additional flow from new sewers will further tax this equipment and necessitate expansion.
- Was being designed and was expected to be constructed in FY21-23.

Aeration Tanks/System–

- Originally designed to treat 4.2 MGD for Biological Oxygen Demand (BOD) removal (without nitrogen removal).
- Adding nitrification and denitrification process reduced the rated capacity to approximately 2.5 MGD
- Expansion of the aeration system to accommodate the new flows will be required within the first 3-5 years of the plan.

Nutrient Removal Technologies

- The existing facility is permitted to 10mg/l, achieves approximately 6 mg/l of Total N.
- The Town is limited to an annual mass nitrogen load limit of 49,315 pounds per year.
- Reducing the nitrogen concentration from 6 mg/l to 3 mg/l in the effluent would remove 18.9 kg/day-N of existing nitrogen load from the watershed
- This evaluation, design and construction are expected to occur in years 1-5 of the plan.

Headworks Facilities

- Though the headworks facilities are adequately sized for the projected flows from the sewer expansion, they do not have space to receive the new sewer piping
- The building and equipment is generally very dated technology that is beyond its design life.
- The evaluation, design and construction/upgrade of this facility are expected in years 3-8.

Backup Power

- With the expansion of the plant, there will be a need for additional backup power on site.
- As such the Town will need to design and install a second emergency backup generator
- The evaluation, design and construction/upgrade of this facility are expected in years 4-5.

Secondary Clarifiers

- Secondary clarifiers have the capacity to treat up to 4.7 MGD (max day).
- To accommodate the full sewer expansion, additional secondary clarifier capacity will be needed

CWMP Discussion - Effluent

WPCF
- Average monthly discharge ranges from 1.4 MGD to 1.9 MGD
  - Annual average discharge of 1.6 MGD
- Flow highest in the summer and lowest in the winter
- Modeling predicted WPCF effluent disposal limited by the depth to groundwater in low lying areas
  - Disposal capacity varies based on precipitation over the preceding three months.

Groundwater
- Levels fluctuate several feet during any given year
  - Recharge is highest in the winter and spring and lowest in the summer and fall.
- Levels fluctuate several feet from year to year.

Result
- Modeling estimated potential for limitations after average annual site recharge capacity of 2.0 MGD
  - BWPCF projected to reach the 2.0 MGD annual average discharge point in 2027.

CWMP Discussion – Categories Effluent Options

- Impact Mitigation
- Land Based Treated Effluent Disposal Options
- Ocean Outfall Effluent Disposal Options
- Effluent Disposal Outside of the Town Options
- Pump and Dispose
- Pump and Treat
  - Dispose
  - Reuse

CWMP Discussion – Categories Effluent Options

Table 5-21: Comparison of Effluent Options

Effluent Disposal Method	Technical Difficulty (Low, Med, High)	Regulatory Difficulty (Low, Med, High)	Social Difficulty(Low, Med, High)	Flow (Average Daily Flow)	Potential Costs ($)
Purchase affected structures where groundwater is expected to be within 8 feet of the ground surface	Low	Low	Low	2.5 MGD	>$82M
Purchase affected structures where groundwater is expected to be within 4 feet of the ground surface	Low	Low	Low	2.5 MGD	>$34M
Site additional effluent disposal RIBs in TOB	Low	Med	High	2.5 MGD	TBD
Site pumped groundwater disposal RIBs in TOB	Low	Low	Med	2.5 MGD	TBD
Site additional effluent disposal subsurface discharge in TOB	Med	Med	High	2.5 MGD	TBD
Site pumped groundwater disposal subsurface in TOB	Low	Low	Med	2.5 MGD	TBD
Ocean Outfall	High	High	High	2.5 MGD	TBD
JBCC	High	High	Med	1.2 MGD	$75-$100M
3TR	Med	Med	Med	1.2 MGD	$101M
Yarmouth @ 6mg/l nitrogen	Low	Med	Med	0.5MGD	$35-45M
Yarmouth @ 3mg/l nitrogen	Low	Med	Med	0.84 MGD	$35-45M + $20M for BWPCF upgrade
Pump and Treat	High	High	High	2.5 MGD	TBD

Notes: 1. 2.5 MGD is ultimately needed by the BWPCF to be able to treat and dispose of the predicted 4.5 MGD Average Daily Flow
2. JBCC and 3TR mostly address flows from what is currently planned to be Phase III sewers.

Post CWMP
Water Pollution Control Facility Update

CWMP Discussion – WPCF Update

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WPCF Nitrogen Project Objectives

PRIMARY OBJECTIVE

- Treat current and future flows to a total nitrogen level of **3 mg/L** or less

SECONDARY OBJECTIVES

- Replace/upgrade the existing headworks facility
- Provide space, and incorporate in the design, ability to easily expand the plant to address:
    - Phosphorus as Federal/State Regulations evolve
    - PFOS/PFOA as Federal/State Regulations evolve
    - Effluent quality requirements to address potential effluent uses (Indirect Potable Reuse, Direct Potable Reuse, well injection, etc.)
- Where sensible, incorporate aspects of the Facility Study findings into the design
    - Plant water upgrade, effluent pump station, disinfection, etc.
- Minimize additional yard piping; where possible create more efficient yard piping schemes
- Minimize the amount of pumped flow around the plant to create an efficient process

TERTIARY OBJECTIVES

- Leverage technology to facilitate high degrees of collaboration between the TOB and design team
- Deliver the project cost effectively
- Deliver the project on schedule
- Be cognizant of potential O&M costs associated with the design
- Design should minimize potential for odors/noise from the completed plant
- Design in such a way that contractors can easily reduce/minimize direct and indirect environmental impacts

WPCF Nitrogen Project Process

Reviewed large number of options

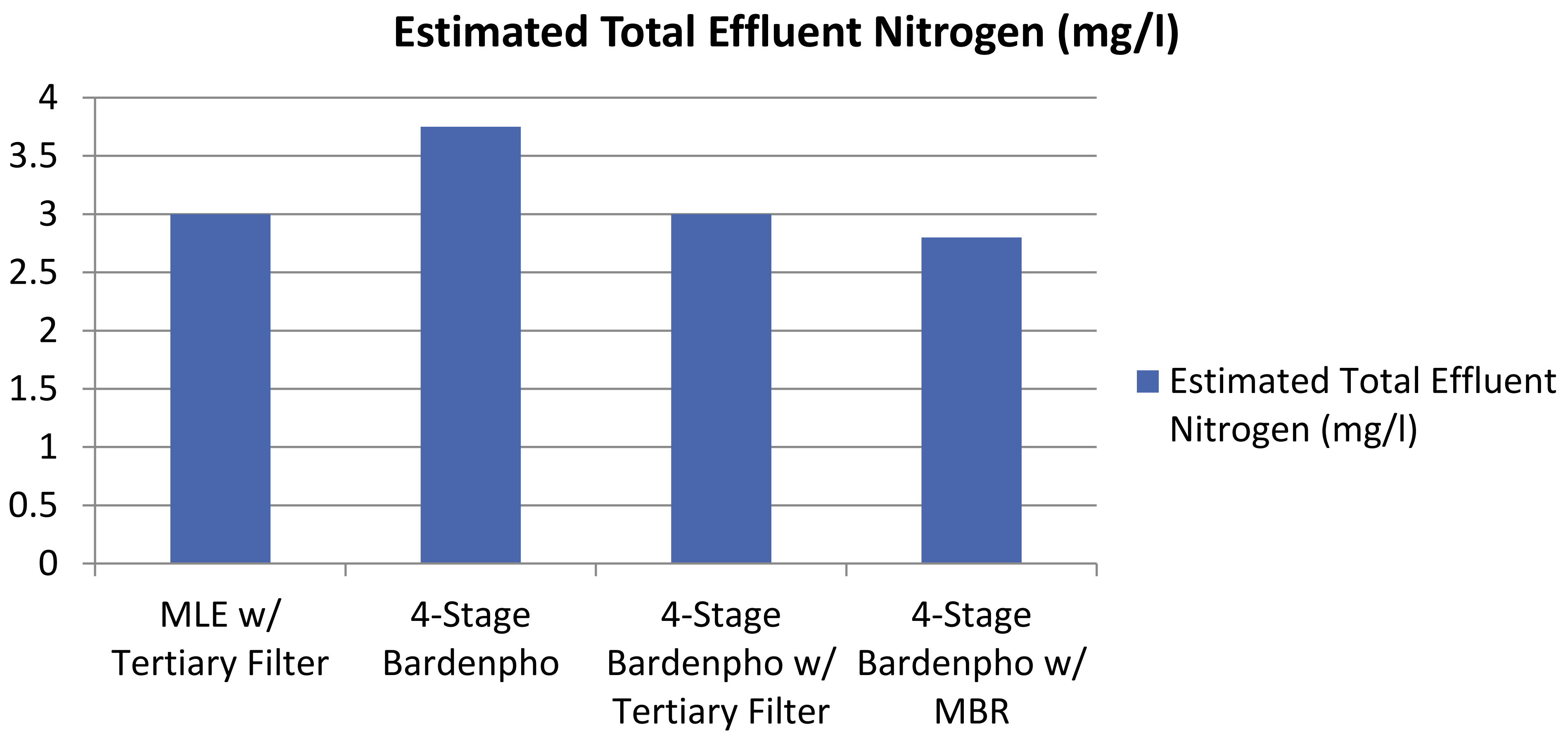
- >10 with multiple additional perturbations each

4 emerged based on

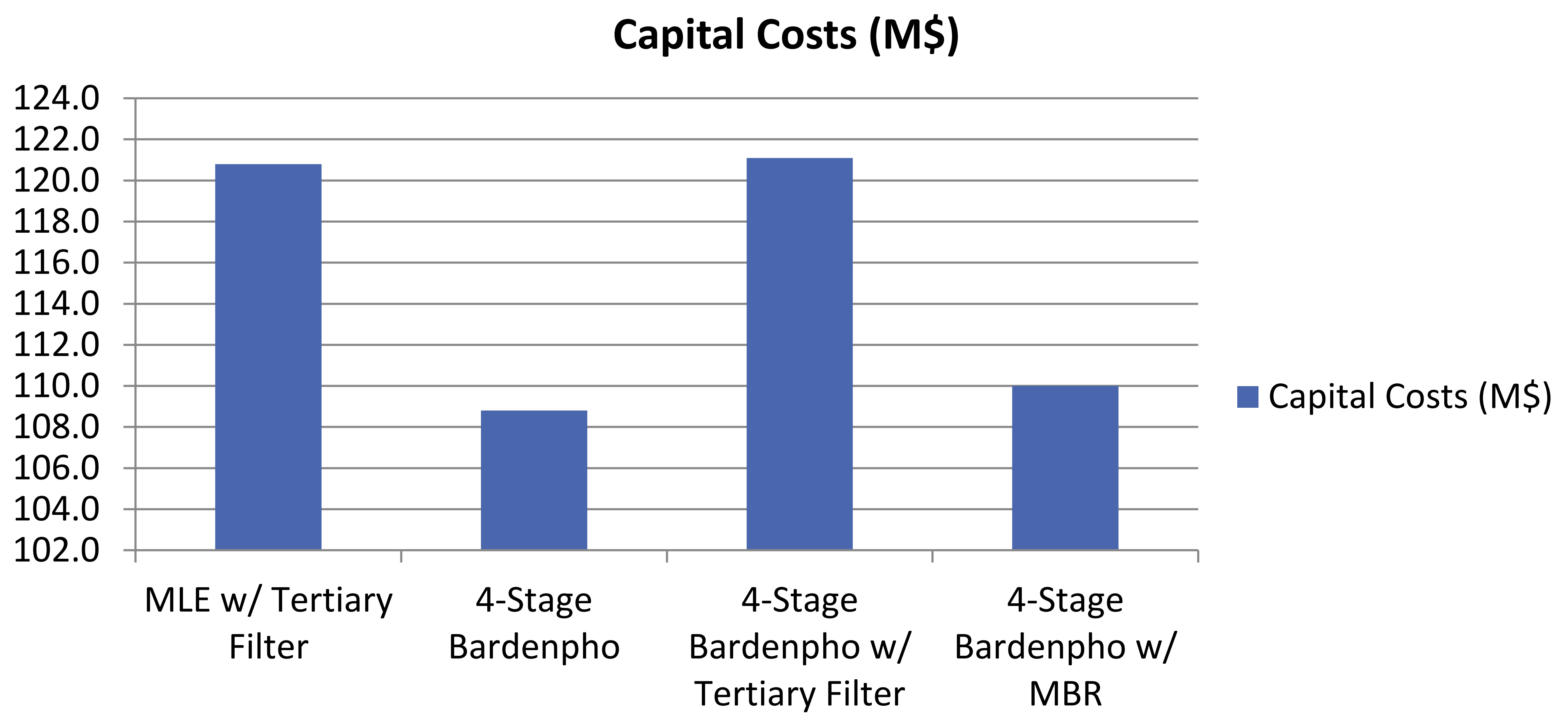
- Greatest potential to achieve 3 mg/l goal in New England
- Appropriate for our flow volumes
- Max utilization of existing infrastructure

Deep dive on those four

Alternative Evaluation – Estimated Total Effluent Nitrogen



Alternative Evaluation – Expected Capital Costs

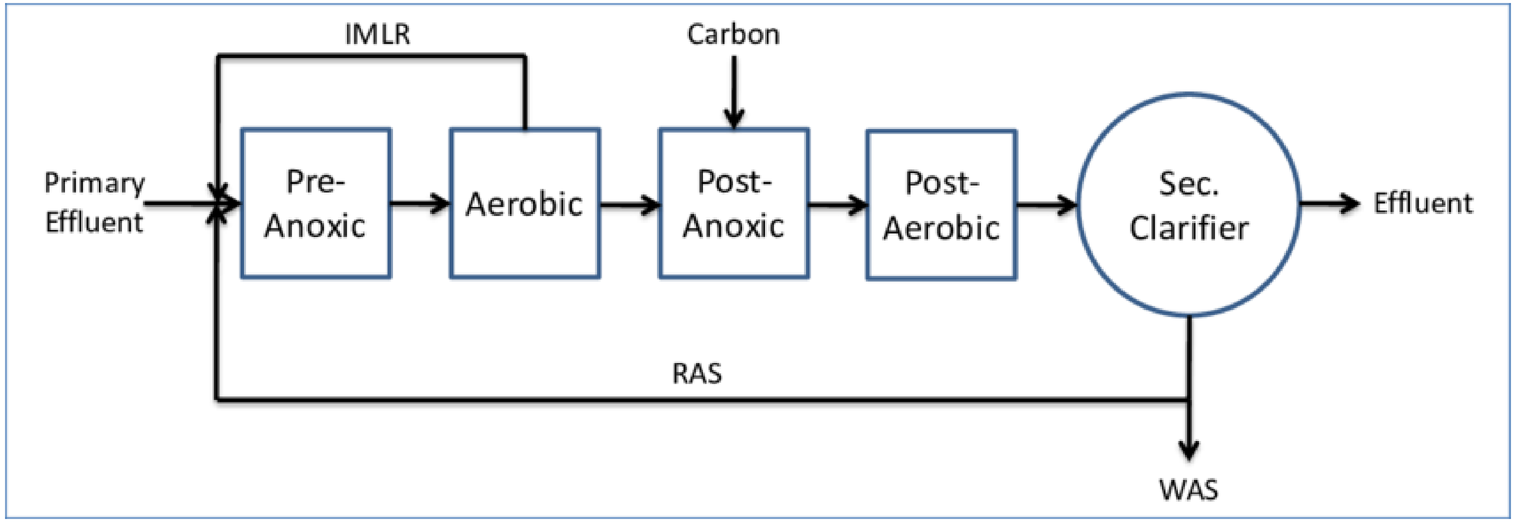


Selected Alternative

- 4-stage Bardenpho with Membrane Bioreactor (MBR)
  - Highest quality effluent
  - Proven technology in our climate
  - Minimizes tankage size
    - Smallest overall construction project
    - Lower Capital Costs
- Can utilize some existing tankage
  - Lower Capital Costs

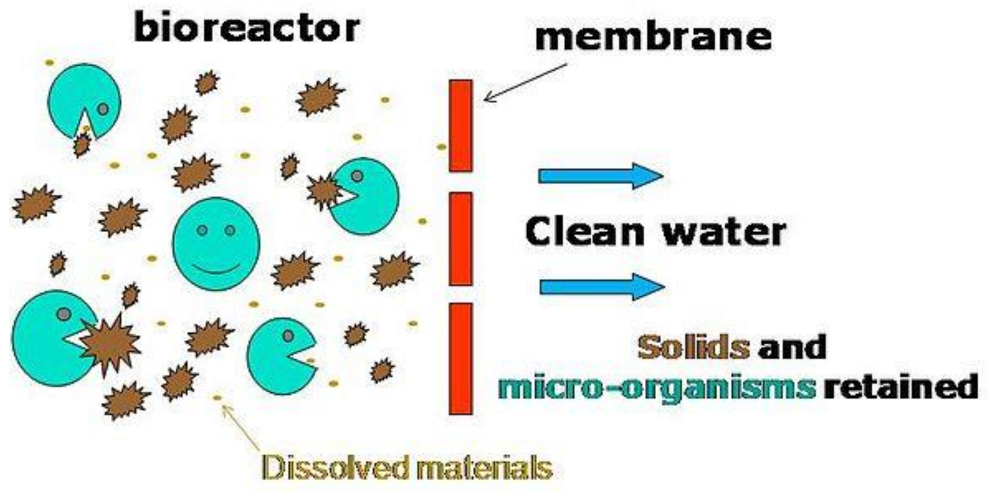
4-Stage Bardenpho

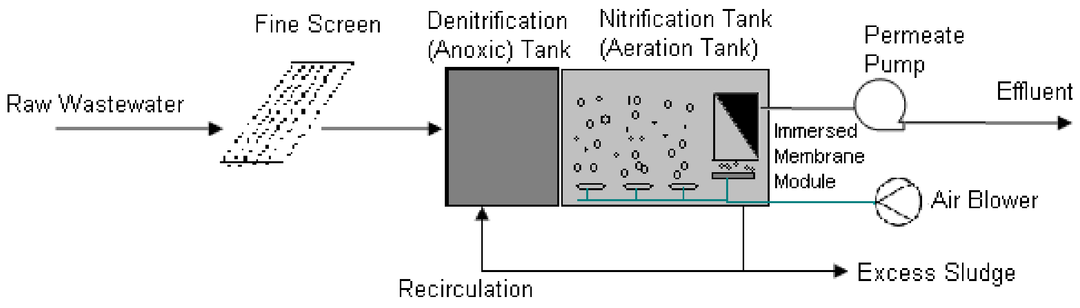
- Biological Process
- Includes multiple anoxic and aerobic zones.
- Can additionally remove phosphorus (with addition of an anaerobic zone).



Membrane Bioreactor (MBR)

- Physical filtration and biological processes
- Drawing treated wastewater through a “porous straw”
- Very high-quality effluent





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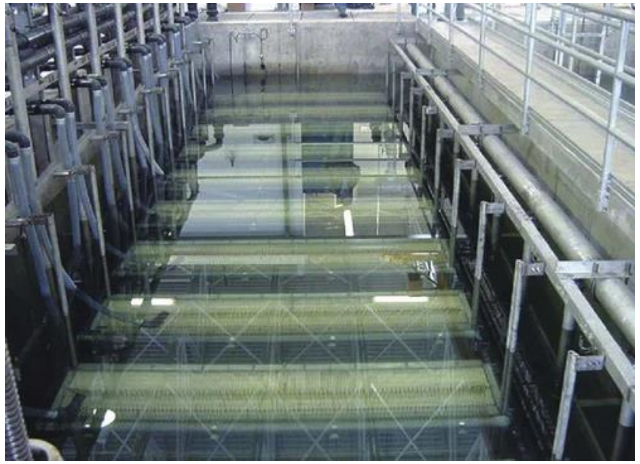
Membrane Bioreactor (MBR)

Advantages

- Very high-quality effluent
  - Almost complete solids and bacterial removal
  - Virus removal
- Consistent Performance
- Expandability
- Less odor

Disadvantages

- Higher energy costs



Current Status

- Design
  - Funding Approved
  - Approaching the 60% point of Design
- Construction
  - Funding approved for construction via CIP 2024-112
  - Projected Schedule
    - Complete design Winter 2024/2025
    - Bid Spring 2025
    - Construct Fall 2025 - 2029

WPCF - Potential Future Needs

- PFAS/PFOA
  - RO
  - GAC
- Effluent Options
  - IPR or DPR?
- Both well positioned by this project, but neither funded
  - RO estimated at ~$68M CIP

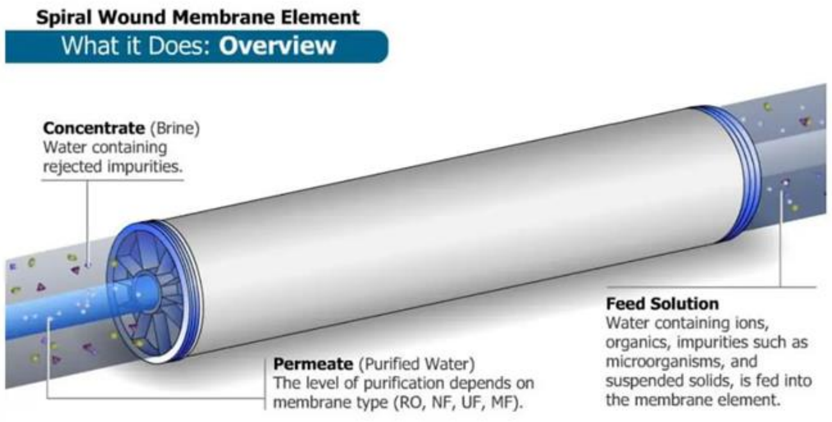
Reverse Osmosis (RO)

Removes up to 99%+ of:

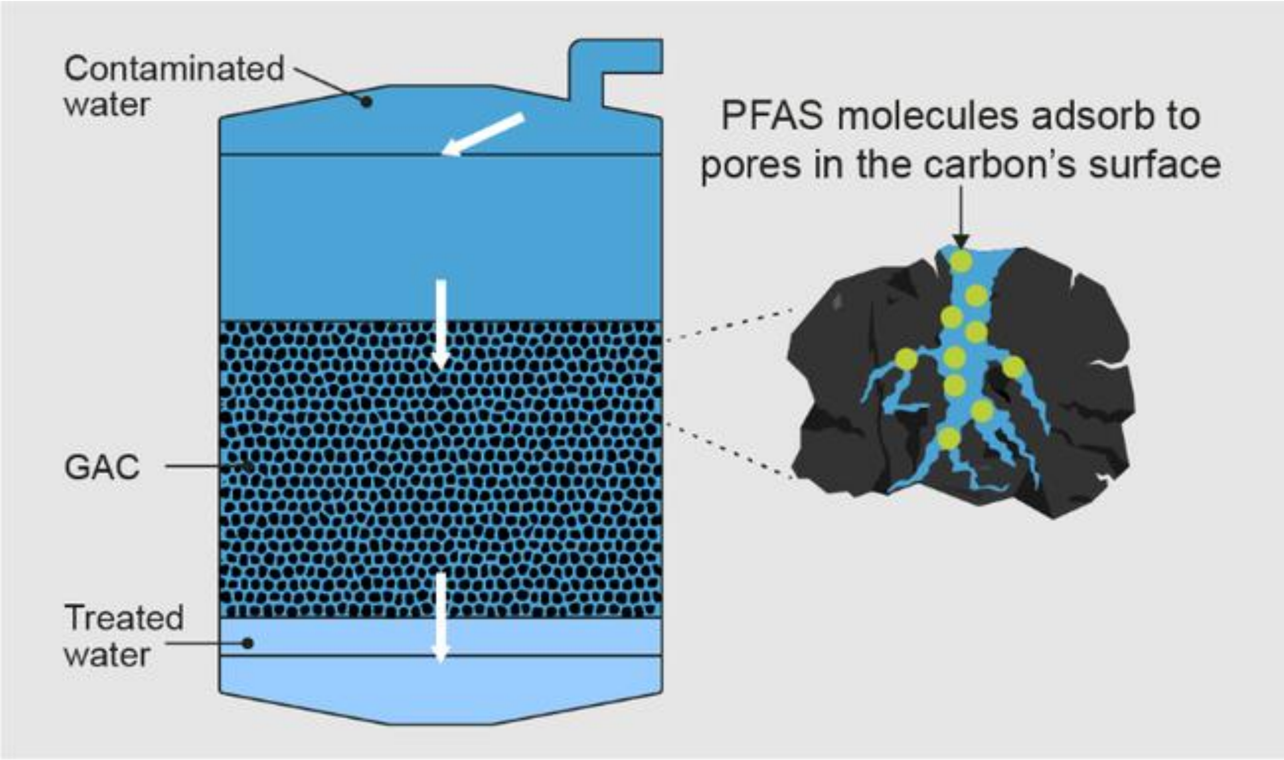
- Dissolved salts (ions)
- Particles
- Colloids
- Organics and bacteria

Recent EPA studies PFAS removal rates between 90 and 99%.

Further improves effluent nitrogen concentrations, likely removing another 0.5 mg/l of nitrogen



Granular Activated Carbon (GAC)



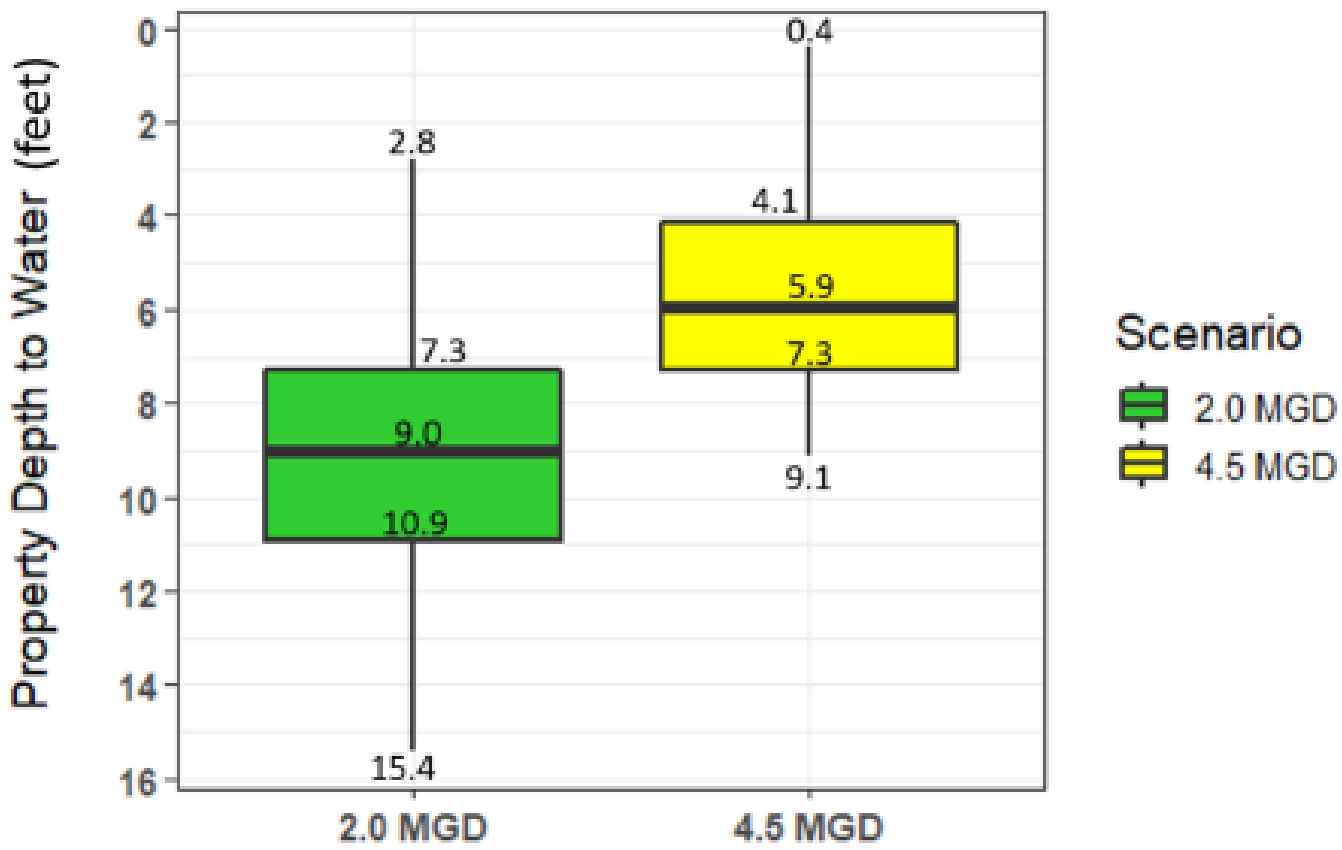
Source: GAO. | GAO-23-106970

Post CWMP
Effluent Update

Frame the Issue

We potentially have too much of a valuable resource in one area…so how do we deal with that?

CDM Smith Confirming Modeling - Low Lying Areas

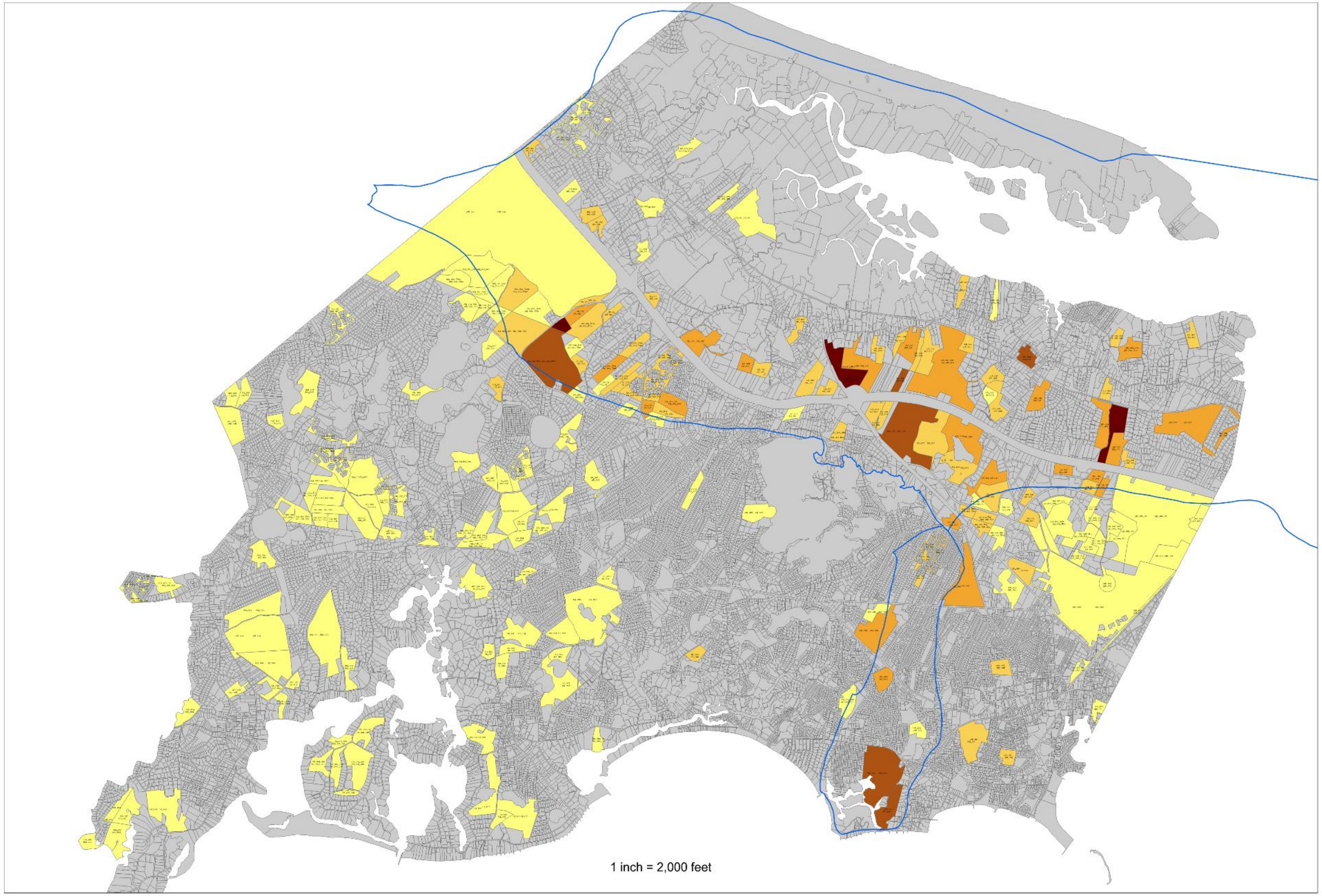


Note: Box shows the 25th to 75th percentile of data

General Effluent Disposal Options

- Land application
- Surface water discharge
- Re-use

Land-Based Disposal Site Analysis



Land-Based Disposal

Advantages

- provide additional treatment
- recharge groundwater

Disadvantages

- impacts on estuaries
- impacts on groundwater
- land availability
- land cost
- control of effluent flow direction
- public acceptability
- increased level of sewering

CWMP Review of Potential Land-Based Parcels

Table 5-20: Initial results, Top 25 scores from the GIS model

MAP & PAR ID	Owner	Address	Village	Suitability Index
236_005_W00	Commonwealth of Massachusetts (Cape Cod Community College)	2240 Iyannough Road/RT 132	WB	7,812,500
315_017	Barnstable County	0 Flint Rock Road	BA	5,859,375
299_024	Barnstable County(County Complex)	3195 Main Street Barnstable Villiage /RT6A	BA	2,695,078
104_003_W00	Town of Barnstable - Munip (Olde Barnstable Golf Course)	1500 Route 149	WB	1,952,344
256_005	Town of Barnstable - Conservation	0 Midcape Highway (West)/Rt 6	BA	1,933,594
254_016	Town of Barnstable - Land Bank (Hyannis Golf Course)	1800 Iyannough Road/Rt 132	BA	1,920,703
266_031	Hyannisport Golf Course	2 Irving Avenue	HY	1,660,156
256_001_001	Town of Barnstable - Conservation	0 Midcape Highway (West)/Rt 6	BA	1,594,922
333_012	Town of Barnstable - Hyannis Water	0 Mary Dunn Road	BA	1,530,078
236_005_B00	Commonwealth of Massachusetts (Cape Cod Community College)	2240 Iyannough Road/RT 132	BA	1,399,609
104_003_T00	Town of Barnstable - Munip (Olde Barnstable Golf Course)	1460 Route 149	MM	1,302,734
350_001	Cummaquid Golf Course	35 Marstons Lane	BA	1,301,953
314_036	GS BARNSTABLE LAND OWNER, LLC	160 Communication Way	BA	1,288,969
316_004	Barnstable County	0 Flint Rock Road	BA	1,237,109
318_025_004	MaGruder, Samuel, Mary, and Sarah	0 Indian Trail	BA	1,204,297
249_094	Town of Barnstable - Schools	744 West Main Street	HY	1,171,875
273_023	Hearth 'N Kettle Properties LP (Cape Codder Resort)	1225 Iyannough Road/RT 132	HY	1,171,875
293_001	Town of Barnstable - Munip (DPW)	382 Falmouth Road/Rt28	HY	1,171,875
296_047	Cape Cod Aggregates Corp	1550 Phinney's Lane	BA	1,171,875
269_002	Town of Barnstable - Schools (Hyannis West)	549 West Main Street	HY	1,152,422
276_002	Town of Barnstable - Conservation	0 Pond Lijah Road	BA	1,132,734
257_012	Town of Barnstable - Schools	2463 Main Street Barnstable Villiage /RT6A	BA	1,106,641
150_096	Town of Barnstable - Conservation	1350 Old Stage Road	MM	1,015,781
332_010_001	Villiage Green LLC	767 Independence Drive	BA	1,015,547
298_031	Town of Barnstable - Land Bank	0 Maraspin Road	BA	976,641

Modeling of Potential Groundwater Discharge Sites

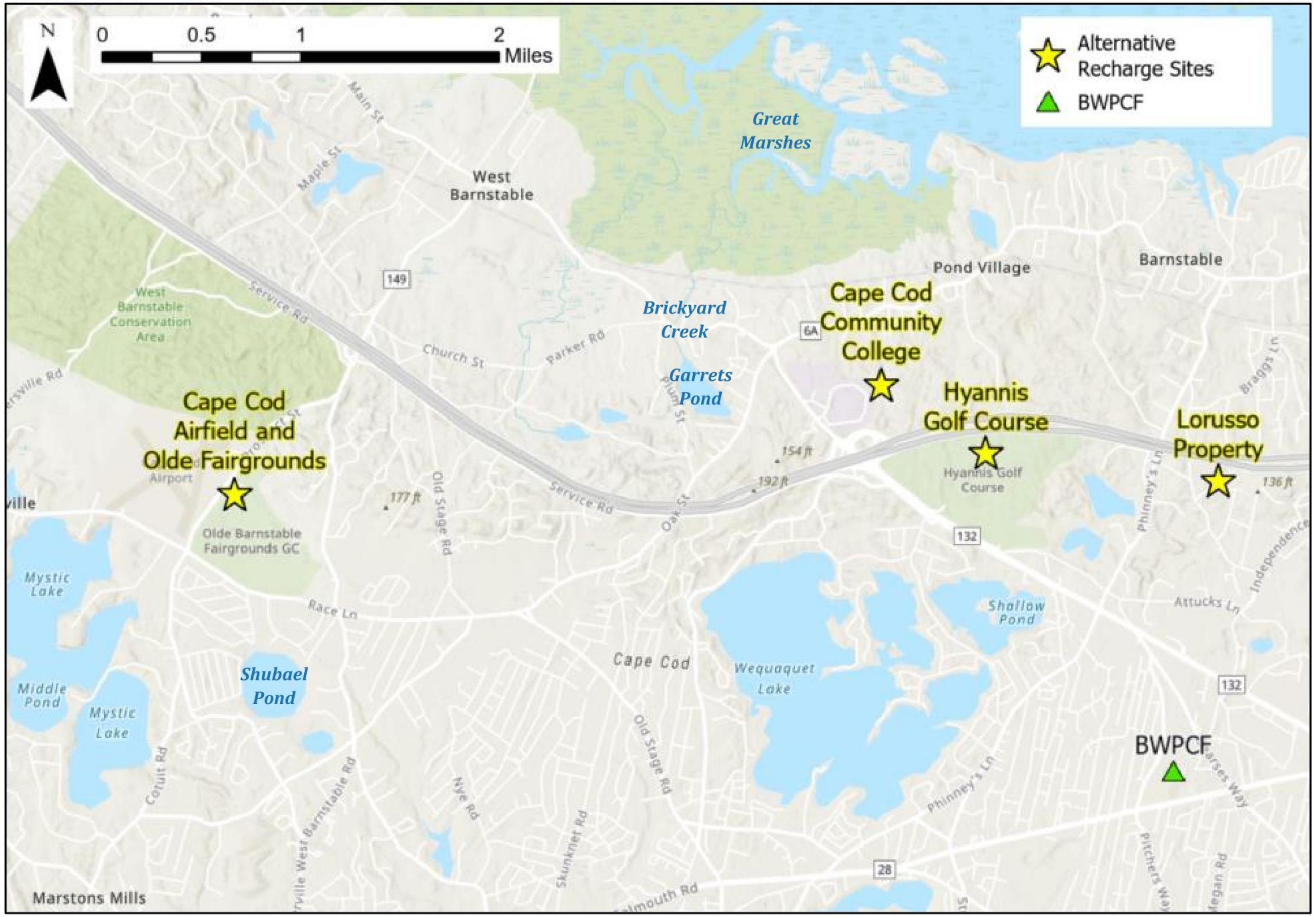
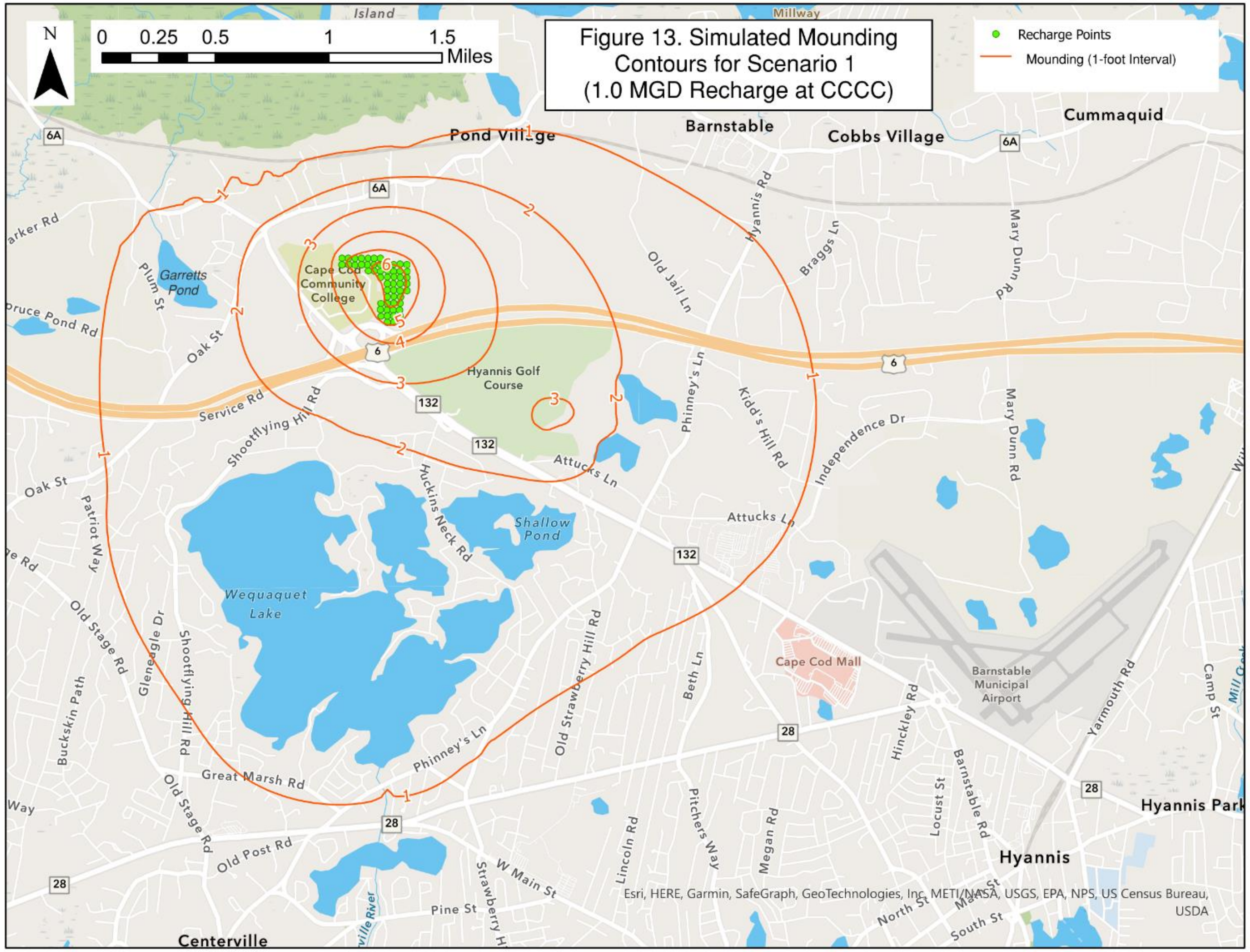


Figure 1: Alternative Recharge Locations

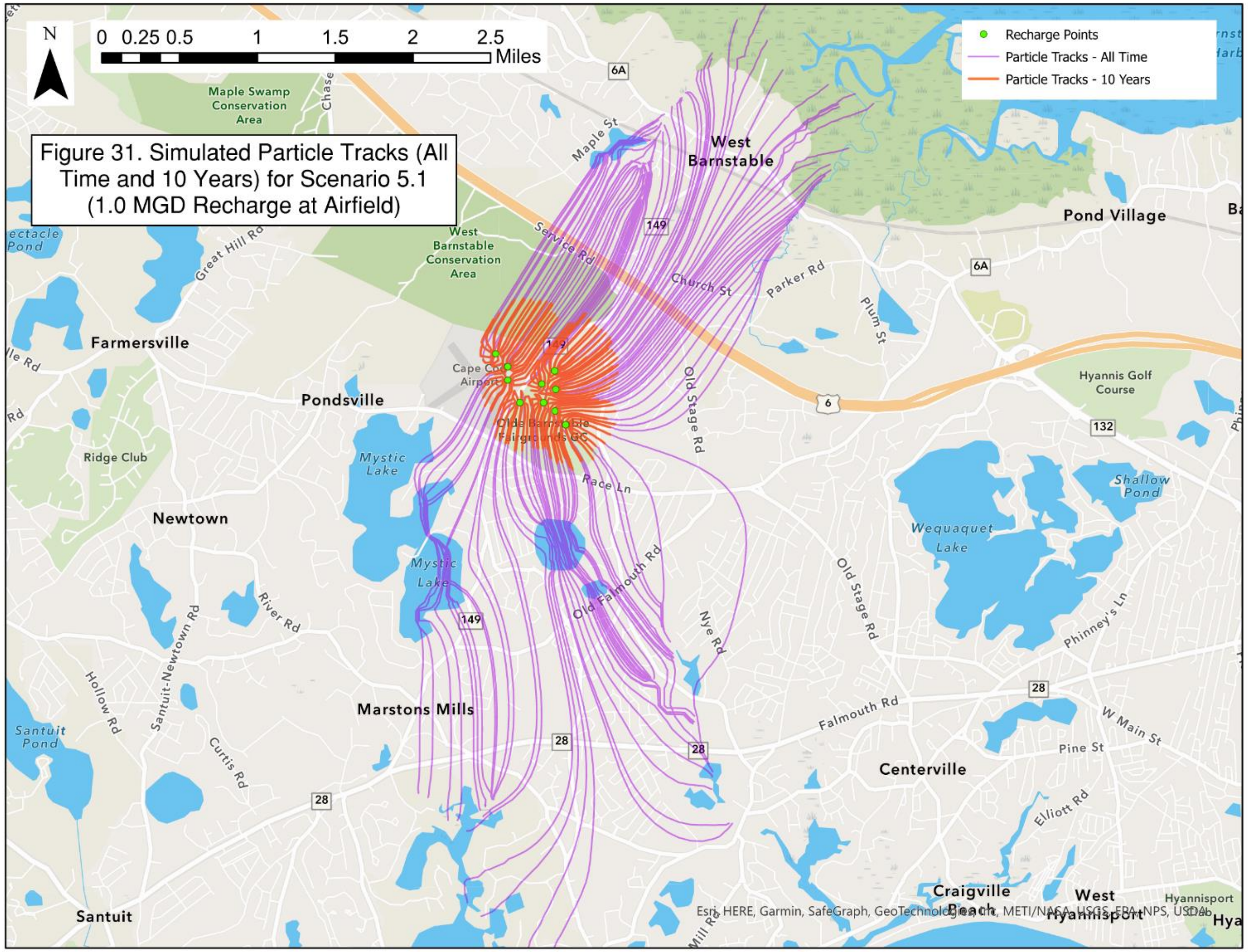
Cape Cod Community College

- Long-term Mounding Impacts
  - Garretts Pond
  - Lake Wequaquet



Cape Cod Airfield and Olde Fairgrounds

- Mounding Concerns
- Impacts on Surface Waters
- Soil Concerns
- Distance from BWPCF



Other Effluent Options Considered

Previously looked at

- Ocean Outfall
- Options outside of Barnstable
  - JBCC
  - Joint facilities with Sandwich or Yarmouth

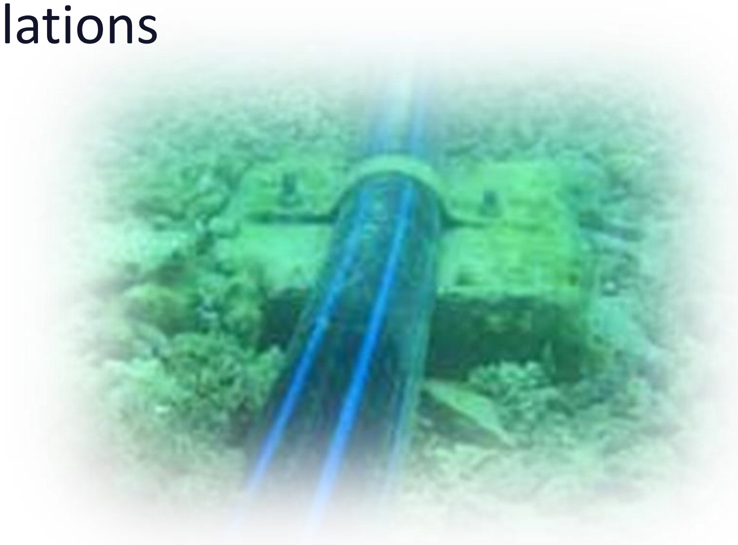
Ocean Outfall Disposal

Advantages

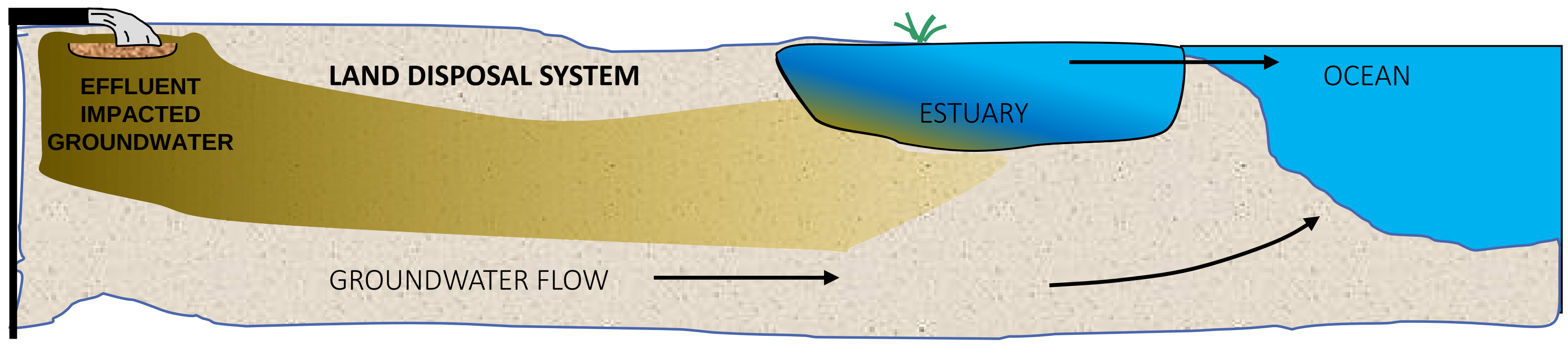
- not land intensive
- can direct disposal to less sensitive waters
- avoids sensitive estuaries/embayments /Zone II’s
- no adverse impacts on GW quality
- simple to operate

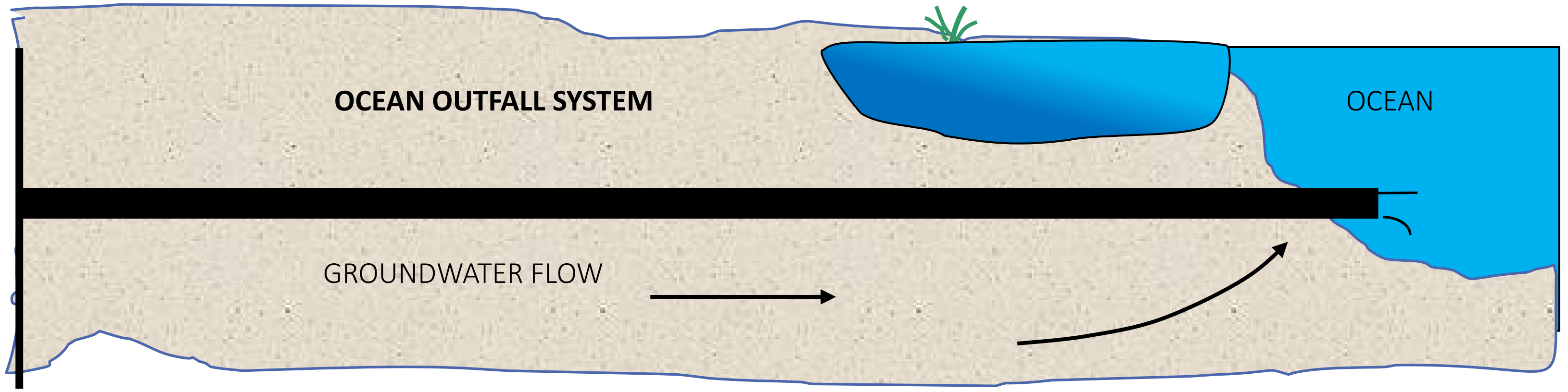
Disadvantages

- significant regulatory hurdles
- public acceptance concerns
- no soil aquifer treatment
- no groundwater recharge
- potential time delays
- federal regulations
- cost

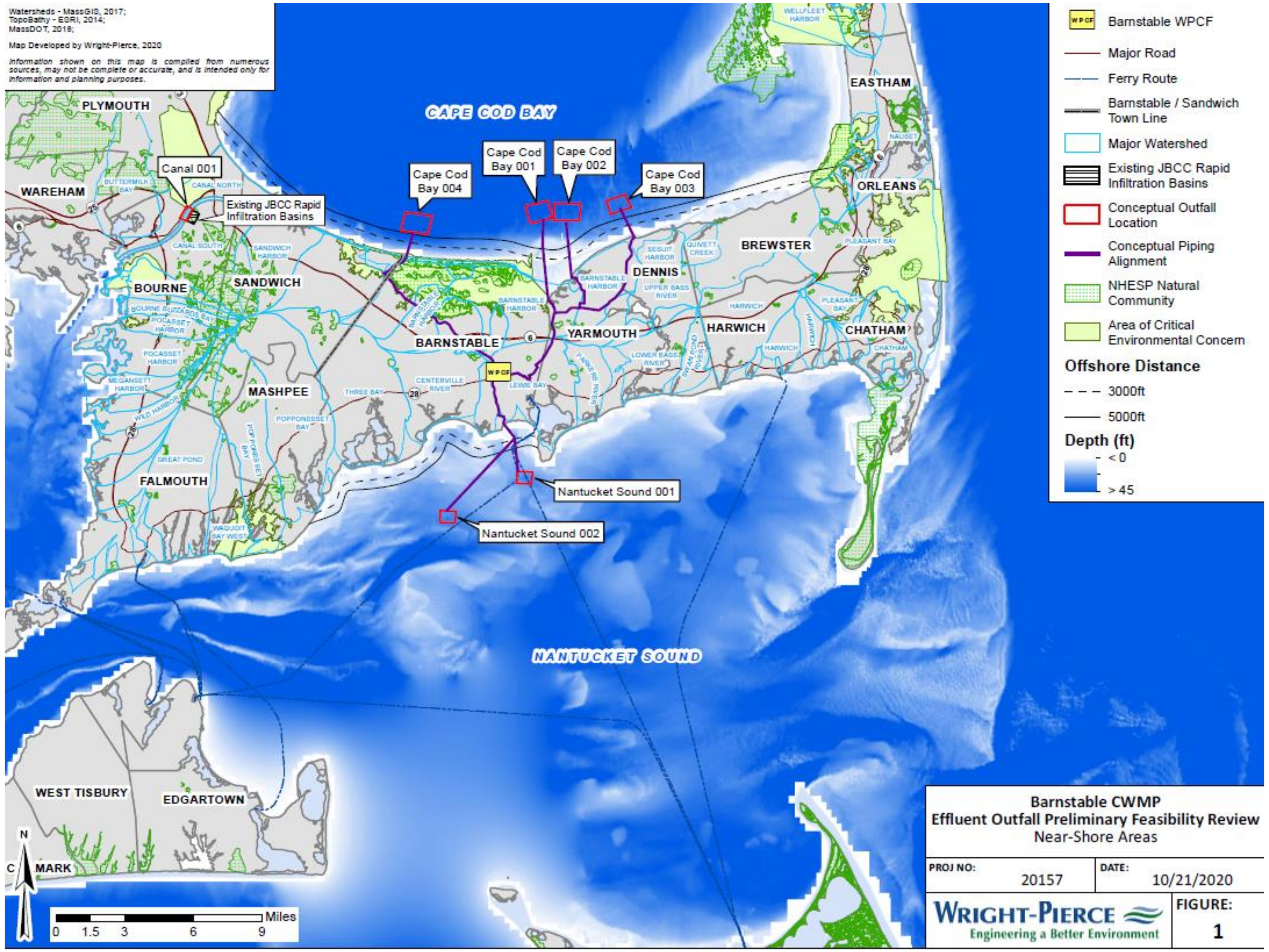


Disposal Paths to the Ocean





Ocean Outfall Treated Effluent Disposal Options



Ocean Outfall Treated Effluent Disposal Options Evaluation

Used 3.54-mgd ADF for preliminary feasibility review

Target water depth of 40 feet

- Cape Cod Bay outfall outlets 4,000 feet from shore
  - More “appropriate areas”
- Nantucket Sound outfall outlets 12,000 feet from shore
  - Fewer “appropriate areas”

Results:

- Shown to be technically possible
  - Can achieve worst case slack tide acute dilution factor of 50:1 or greater.
  - At higher ambient current velocities >= 500:1
- Significant regulatory, social, and financial hurdles

Options Looked at Outside of the Town of Barnstable

JBCC (treat and dispose)

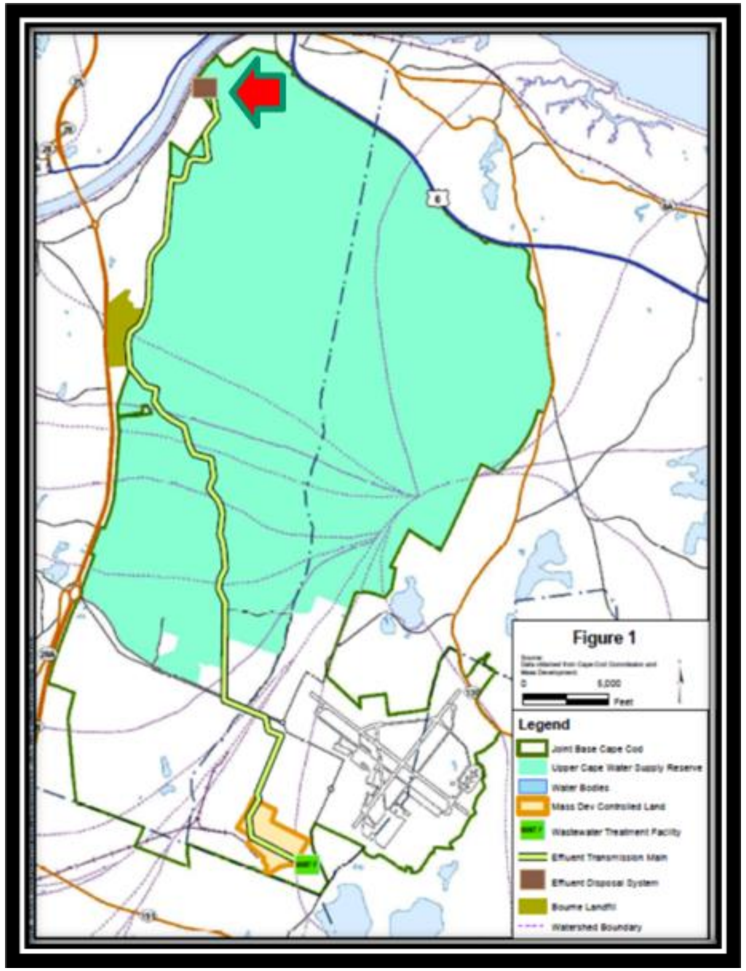
- Requires expansion of the disposal beds or Canal outfall
- Western flows 1.2 MGD
- Cost ~$100,000,000

~~Sandwich (treat and dispose)~~

- ~~Western flows 1.2 MGD~~
- ~~Cost ~$100,000,000~~

~~Yarmouth (disposal only)~~

- ~~Capacity at 3mg/l N = 0.84 MGD~~
- ~~$45,000,000 plus plant upgrades~~



...Still Other Options Considered

Began to look seriously at other options

- Mitigation via groundwater control
- Reuse

Mitigation Groundwater Control – Modeled Pump Locations

Results

It Works!

- 9 Wells
- Town Owned Properties
- Travel times > 1 year, in ½ cases > 2 years

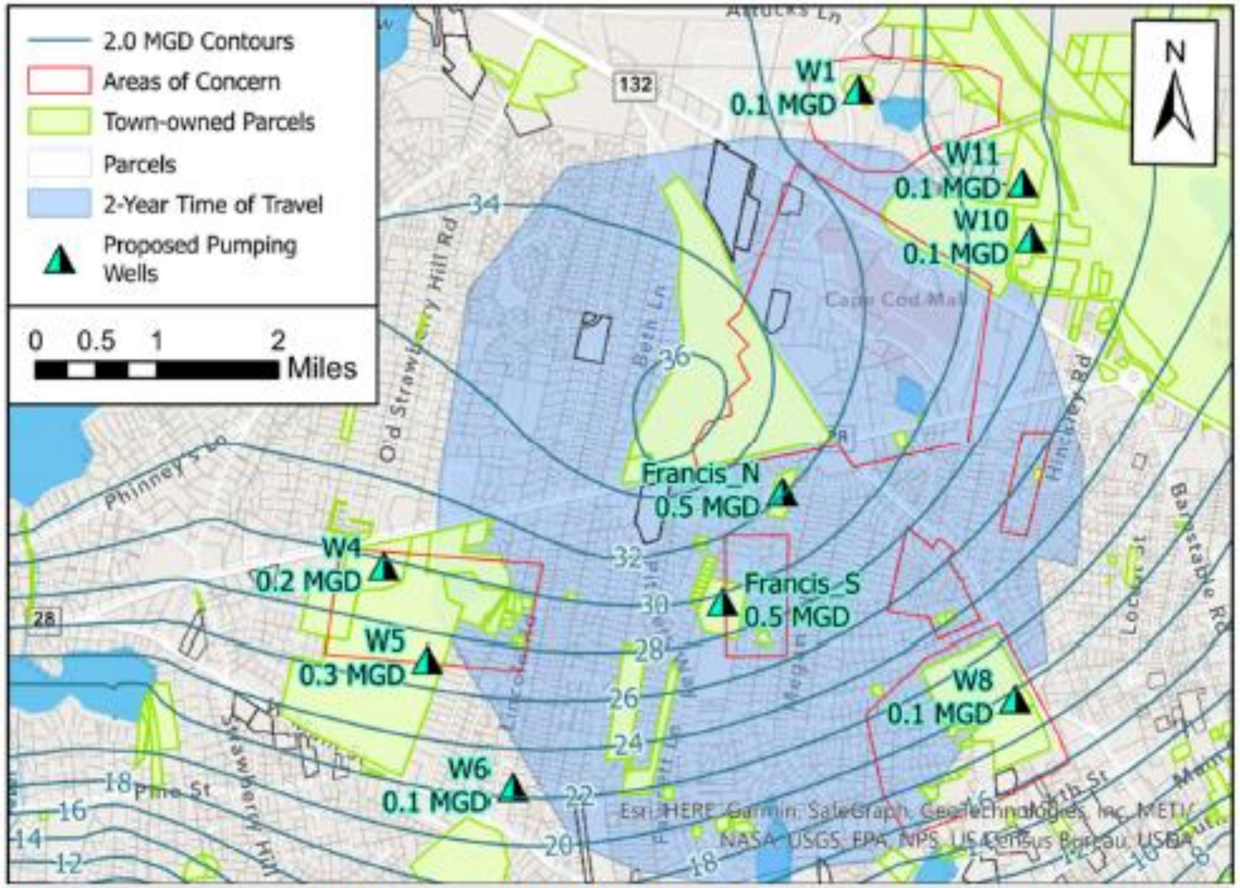
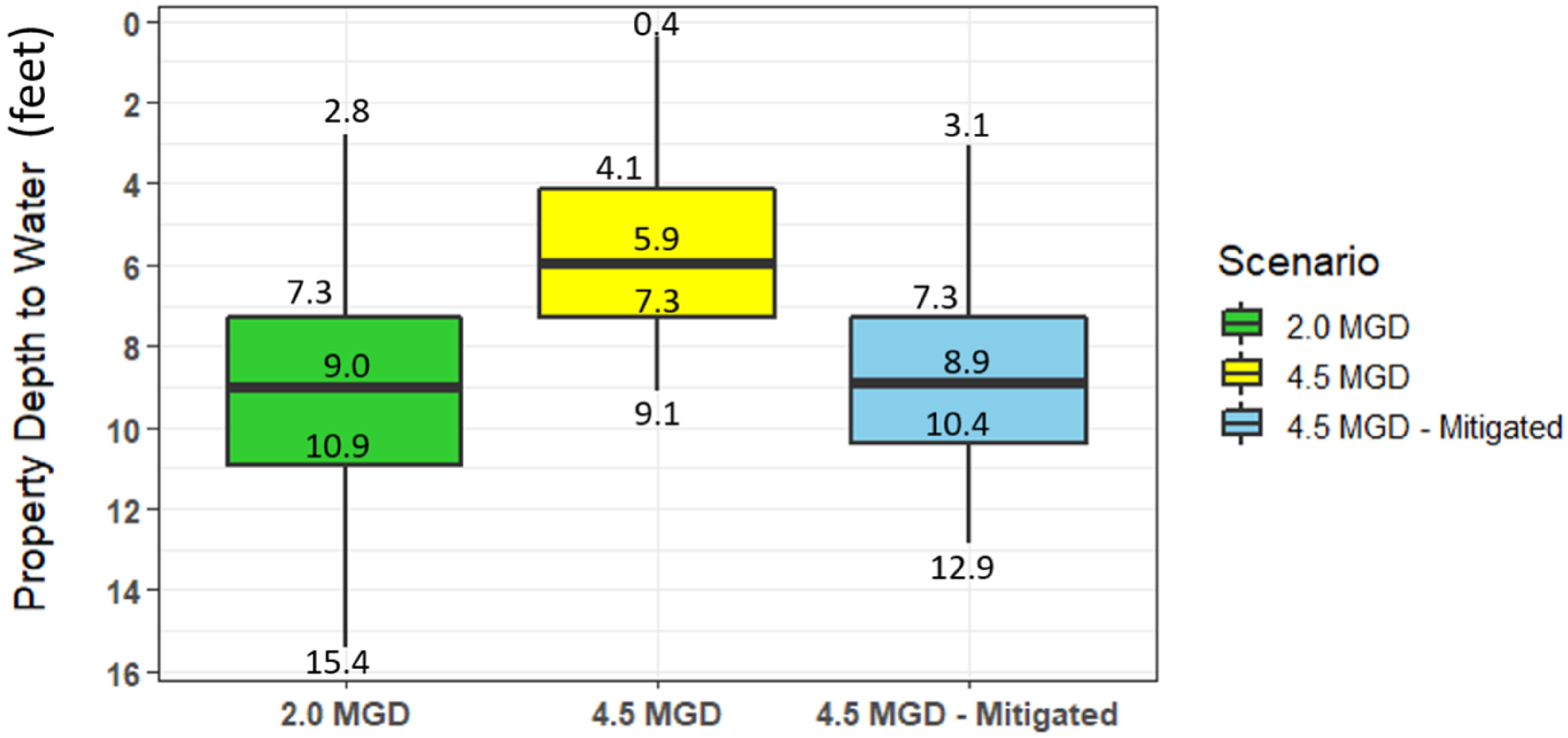


Figure 3: Proposed Extraction Wells Located on Town of Barnstable-Owned Parcels

Results


Property Depth to Water (feet)
0
2
4
6
8
10
12
14
16
2.8
7.3
9.0
10.9
15.4
0.4
4.1
5.9
7.3
9.1
3.1
7.3
8.9
10.4
12.9
2.0 MGD
4.5 MGD
4.5 MGD - Mitigated
Scenario
2.0 MGD
4.5 MGD
4.5 MGD - Mitigated

So…

What can we do with the pumped water?

Options - Dispose

Transport to land-based disposal

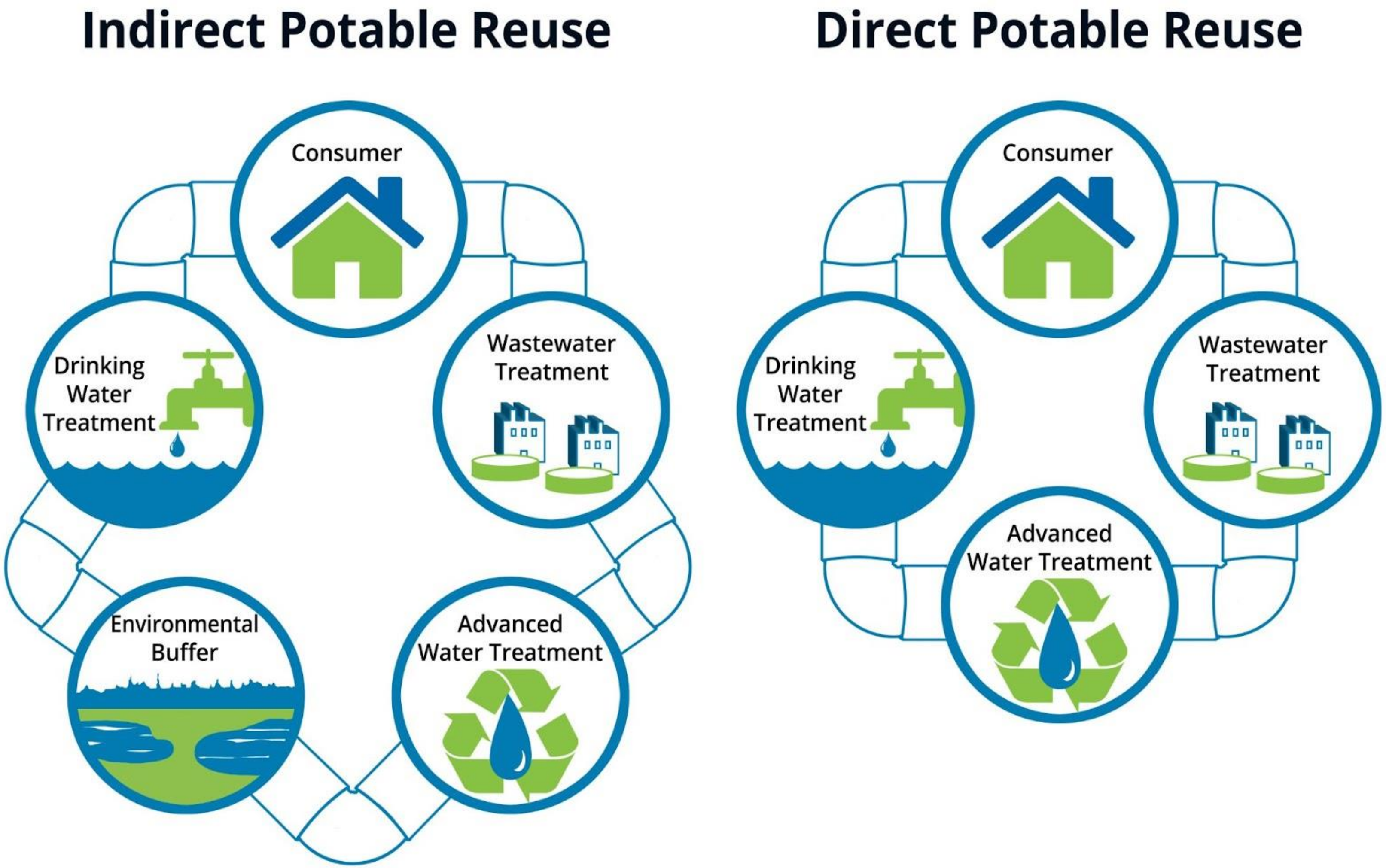
- Golf course
- Sports fields
- Airports
- General subsurface disposal

Many of the same problems as with effluent land-based disposal

Transport to ocean/stormwater outfall

- NPDES permit required
- Treated like storm water?

Options - Reuse



Options Reuse

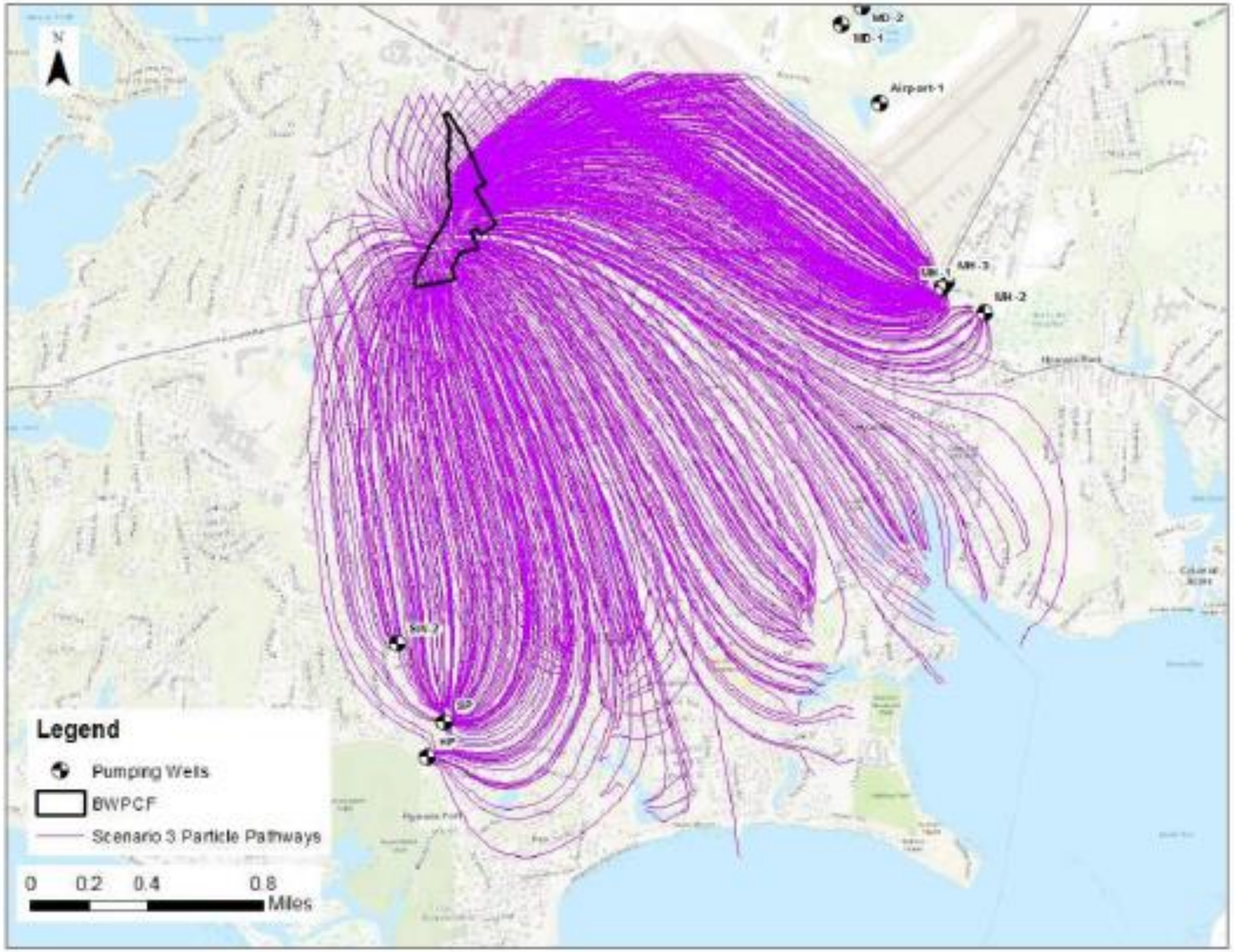
Indirect Potable Reuse (IPR)

- Ground Water Injection wells
  - Example - Airport near Maher and Mary Dunn Wells
- Currently happens with existing wells (…wait for it)

Direct Potable Reuse (DPR)

- "Connect the ends of pipe"
  - Potential to address the redundancy needs of HWS
  - Treatment requirements would address the PFOS/PFOA needs
- Bottle and sell

Particle Mapping – Existing IPR



Max Pumping Scenario

Travel times range from 20 years to > 100 years

What DPW is Doing Regarding Effluent

Meeting with two separate DEP groups

- Each 1/month
- 1st Group – short term solutions
  - 5-year expansion of plant existing permit
- 2nd Group – medium- and long-term solutions
  - Answering the question “what can we do with the pumped water”
  - Discussing potential DEP DPR regulations

What DPW is Doing Regarding Effluent

Discussions focus on technical, environmental, health, and regulatory issues

- What are the options
- Results will be brought to the Town Council/community for debate
- Decisions on how the Town proceeds will rest with Town Council

Cultural, social, and financial issues will be addressed locally

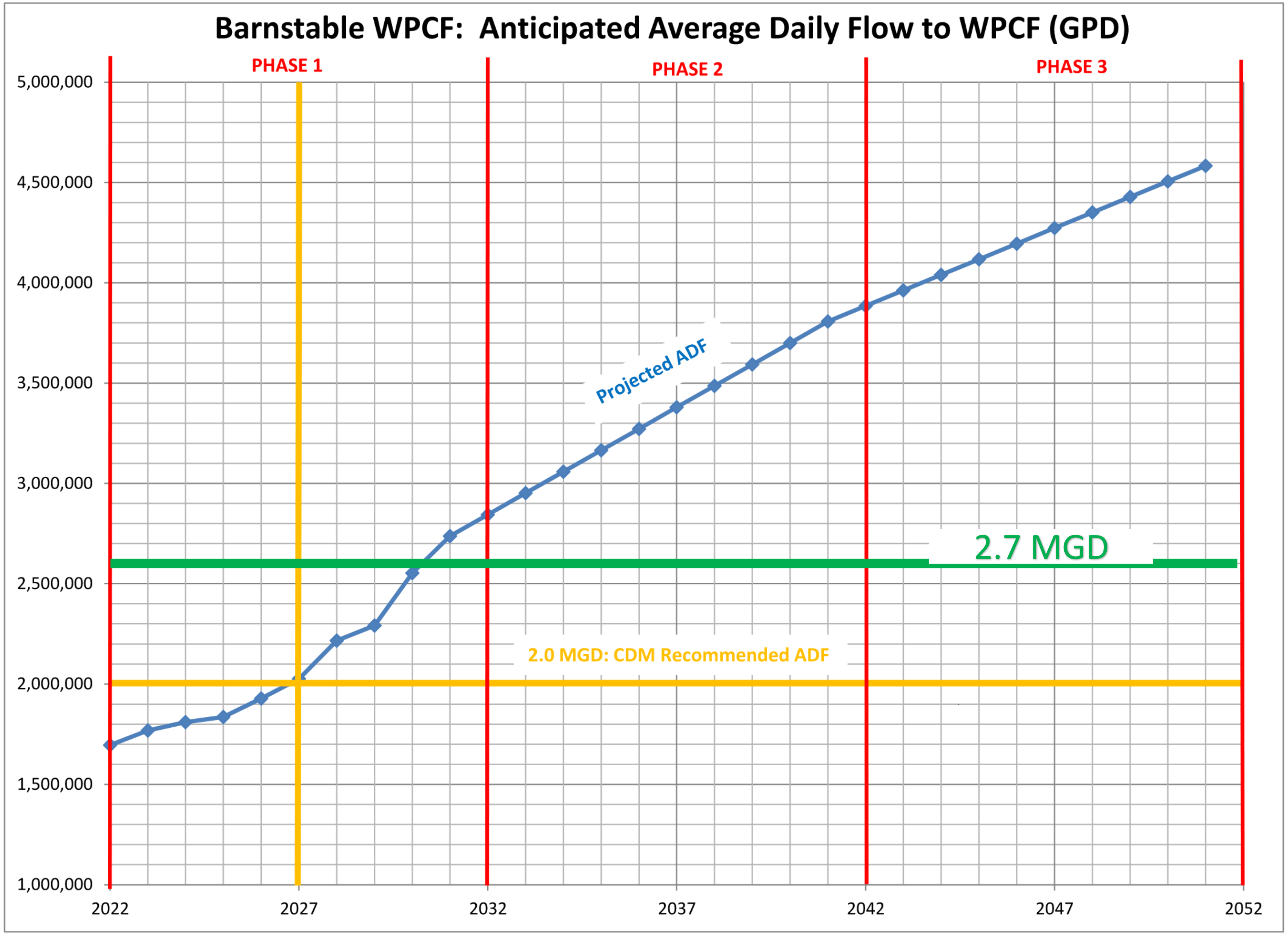
Discussion?

Resources

Travel Times to Modeled Pump Points

Table 4: Travel Times under Proposed Extraction Scenario

Well Name	Long-Term Average Pumping Rate (MGD)	Travel Time from BWPCF
Proposed Water Level Control Extraction Wells		
W1	0.10	No Impact – Upgradient Well
W4	0.20	3 to 4 years
W5	0.30	2 to 3 years
W6	0.10	3 to 4 years
W8	0.10	3 to 4 years
W10	0.10	5 to 10 years
W11	0.10	5 to 10 years
Francis_S	0.50	< 1 year
Francis_N	0.50	< 1 year
Existing Public Water Supply Wells		
HP	0.28	> 100 years
SP	0.37	> 100 years
SW-2	0.12	> 100 years
MH-1	0.29	> 20 years
MH-2	0.32	> 20 years
MH-3	0.42	> 20 years
COMM-5	0.08	> 20 years
COMM-8	0.05	> 20 years
COMM-9	0.15	> 20 years


Barnstable WPCF: Anticipated Average Daily Flow to WPCF (GPD)
PHASE 1
PHASE 2
PHASE 3
5,000,000
4,500,000
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
2022
2027
2032
2037
2042
2047
2052
Projected ADF
2.7 MGD
2.0 MGD: CDM Recommended ADF

Outfall Science

Effluent generally less dense than ambient water

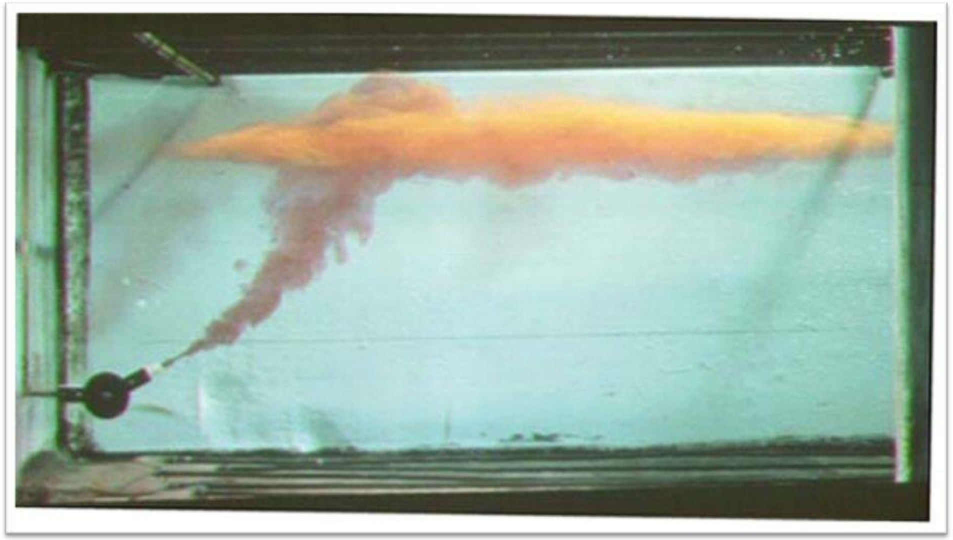
- Rises until the densities of the plume equal with ambient water.
  - If there is a thermocline or pincocline it can be trapped
  - If the water column is homogenous it will rise to the surface

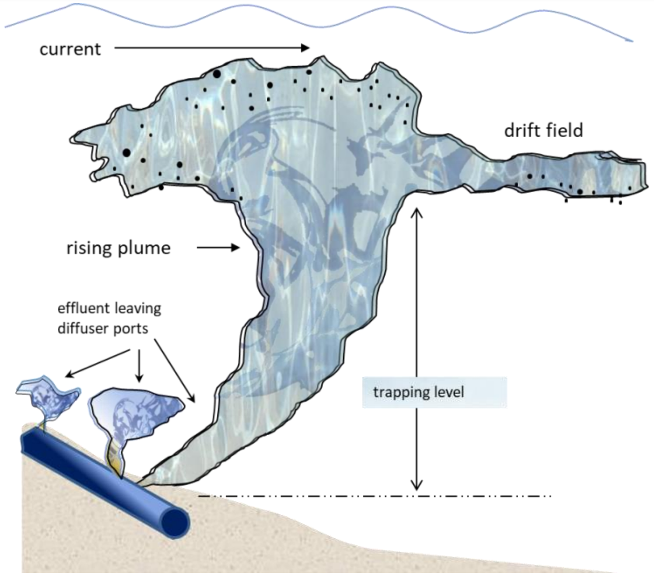
Water quality standards need to be met at the edges of an area called the Zone of Initial Dilution (ZID) **- Not at the port**

Water quality standards at the edge of the ZID are a function of:

- the depth of the outfall;
- the effluent flow rate and port velocities;
- the orientation of the outfall;
- the diffuser designs; and
- the hydrodynamics and characteristics of the ambient water.

Additionally, must meet required distance from sensitive receptors, which may dictate certain distance offshore





Travel Times to Modeled Pump Points

Table 4: Travel Times under Proposed Extraction Scenario

Well Name	Long-Term Average Pumping Rate (MGD)	Travel Time from BWPCF
Proposed Water Level Control Extraction Wells		
W1	0.10	No Impact – Upgradient Well
W4	0.20	3 to 4 years
W5	0.30	2 to 3 years
W6	0.10	3 to 4 years
W8	0.10	3 to 4 years
W10	0.10	5 to 10 years
W11	0.10	5 to 10 years
Francis_S	0.50	< 1 year
Francis_N	0.50	< 1 year
Existing Public Water Supply Wells		
HP	0.28	> 100 years
SP	0.37	> 100 years
SW-2	0.12	> 100 years
MH-1	0.29	> 20 years
MH-2	0.32	> 20 years
MH-3	0.42	> 20 years
COMM-5	0.08	> 20 years
COMM-8	0.05	> 20 years
COMM-9	0.15	> 20 years

JBCC Wastewater Treatment Plant

- Constructed in 1996
- Extended aeration activated sludge facility with biological nitrogen removal and disinfection.
  - GWDP limits for nitrate and/or total nitrogen exceeded in 11 of 27 months between January 2012 and April 2014
- Permitted to discharge an annual average flow of 360,000 gpd (existing ~140,000 gpd)

JBCC Wastewater Effluent Disposal

- Four rapid infiltration basins (RIBs), total surface area of 259,160 square feet
- Effluent force main is a 12-inch diameter ductile iron pipe. The force main is hydraulically complex and has reported capacity limitations when more than one effluent pump is running (i.e., SSOs).
- The GWDP (Application/Permit No. 41-3)
  - Disposal of 360,000 gpd on a 12-month rolling average
  - 840,000 gpd on any given day (“maximum day flow”).

WPCF Nitrogen Project Process

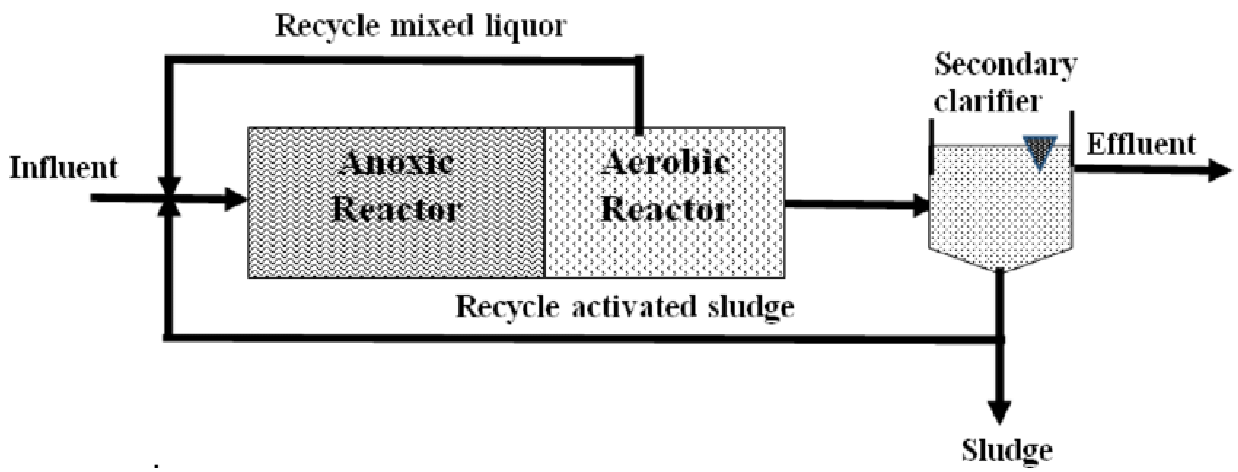
- Started with review of large number of options
  - More than 10 with multiple additional perturbations each
- 4 emerged
  - Greatest potential to achieve 3 mg/l goal in New England
  - Appropriate for volumes anticipated
  - Max utilization of existing infrastructure
- Deep dive on those four

Four Evaluated

1. Modified Ludzack-Ettinger (MLE) with Tertiary Sand Filter
2. 4-stage Bardenpho
3. 4-stage Bardenpho with Tertiary Sand Filter
4. 4-stage Bardenpho with Membrane Bioreactor (MBR)

MLE

- WPCF existing process
  - Achieves ~ 6mg/l N
- Biological Process
- Modifies conventional activated sludge process by adding an anoxic zone upstream of the aerobic zone.



Tertiary Sand Filter

- Physical filtration process
- Treated effluent pumped into an anoxic media (sand or polystyrene beads)
  - Provides combination of denitrification and solids removal

Land Based Treated Effluent Disposal Options

- The twelve criteria scores for each parcel
  - Weighted score from 0 to 5 was applied to each
  - 0 was a poison pill
- Scores were then multiplied together to produce an effluent disposal site suitability index
- Higher scores more desirable.
  - 161 parcels produced a nonzero value
  - Scores ranged from 7,812,500 to 778.

Land Based Treated Effluent Disposal Options

- Total area, or size of the parcel
- Shape factor – to do this the square of each parcel perimeter was then divided by its area to calculate a shape factor value.
- Surface slope- the GIS Spatial Analyst extension was used to calculate slope from a surface digital elevation model (DEM).
- Depth to groundwater - the Zonal Statistics tool was applied to a depth to groundwater DEM to calculate a mean depth to groundwater value for each parcel.
- Proximity to the wastewater treatment facility
- Proximity to neighboring structures - the distance from each parcel perimeter to the edge of its nearest neighboring building footprint.
- Groundcover class
- Soil drainage class
- Location within nitrogen-sensitive watersheds
- Location within Zone II wellhead protection areas
- Location within wetlands
- Location within priority habitats.

Wastewater on Cape Cod

All water travels to the Ocean