PLEASANT BAY ALLIANCE

Report on Nitrogen Trading Opportunities Among Watershed Towns

Task 2 of Regional Watershed Permit Implementation Project funded by EPA Southeast New England Program (SNEP)

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September 24, 2021

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SUMMARY

The four towns in the Pleasant Bay watershed (Brewster, Chatham, Harwich, and Orleans) have committed to removing nitrogen loads from their portions of the watershed to reduce this contaminant's significant influence on water quality in the Bay. The towns' nitrogen removal commitments are included in the 2018 Watershed Permit issued by MassDEP.

Each town has developed a plan for meeting its nitrogen removal commitments and those plans are being fine-tuned as more is learned about the expected performance and costs of certain technologies and as the Bay's assimilative capacity is better understood. The towns' plans include seven projects involving five technologies that have a range of costs:

- Low cost—golf course fertilizer management and shellfish harvesting
- Moderate cost—public sewers
- Higher cost—on-site denitrification and permeable reactive barriers

It may be possible and economical for one town to remove more nitrogen than called for in the Watershed Permit in exchange for payment by another town whose responsibility would be commensurately less. This concept is called "nitrogen credit trading", or simply "nitrogen trading". By increasing the use of the lower-cost technologies and reducing the use of the more expensive approaches, trading could reduce the overall cost for nitrogen removal. This report explores the nitrogen trading concept as it applies to Pleasant Bay. Key findings are:

Regional and National Experience

Contaminant credit trading is relatively new but has become widespread across the country. One of the most successful nitrogen trading systems is in place in Connecticut as part of the program to protect Long Island Sound. MassDEP and the Cape Cod Commission each have nitrogen offset policies that represent a form of nitrogen trading.

Unit Costs for Town Projects

Analysis of town cost data indicates that public sewers proposed in Chatham, Harwich, and Orleans cost about \$320 to \$430 per pound of nitrogen removed, considering capital costs for new facilities and long-term operation and maintenance costs. Unit costs for golf course fertilizer controls and shellfish harvesting are significantly less (\$10 to \$150 per pound), but these projects are of limited capacity. The most expensive technologies are on-site denitrification and permeable reactive barriers that carry costs of \$700 to \$750 per pound.

Potential Trading Scenarios

Three trading scenarios have been identified and evaluated. These scenarios involve Brewster, Harwich, and Orleans wherein the Seller would expand its nitrogen removal project on behalf of the Buyer, who would save money by reducing its more expensive plan. Some of the savings to the Buyer would serve as an incentive to the Seller to participate. The transfers of nitrogen removal responsibility in these three illustrative scenarios would involve about 10% of the overall removal need Bay-wide.

Potential Cost Savings

The three illustrative scenarios offer cost savings totaling over $670,000 per year, equivalent to an up-front cost of about $11 million. The savings to the Buyers represent about 14% of the buyers' expected costs for the more expensive technologies.

Considerations Related to Trading

Numerous issues related to nitrogen trading are discussed, including

- Coordination with the Watershed Permit
- Provisions of intermunicipal agreements
- Forms of payment
- Grants and loans
- Impacts of new development in the watershed and changes in the Bay's assimilative capacity.

Schedule

If one or more of these trading opportunities is implemented, detailed evaluation and negotiations will be required. Changes in the Watershed Permit would be needed and could be accomplished by the permit review scheduled for 2028.

INTRODUCTION

Pleasant Bay is a 6,200-acre estuary, the largest on Cape Cod. The Bay's watershed is 11,800 acres in extent and spans the towns of Brewster, Chatham, Harwich, and Orleans.

Extensive studies over the last 15 years have documented a decline in water quality in the Bay and those studies have quantified the nitrogen loading from the four towns that have contributed to that decline. The principal components of the current nitrogen load are on-site septic systems (75%), lawn and golf course fertilization (16%) and stormwater runoff (9%).

Evaluation of many Cape Cod embayments has been accomplished under the Massachusetts Estuaries Project (MEP). Studies in 2006 and 2010 by the School of Marine Science and Technology (SMAST) at UMass-Dartmouth have estimated the "threshold loads" of nitrogen (the loads that just maintain receiving water quality) for 19 sub-embayments that comprise Pleasant Bay. The four towns in the watershed have agreed that each town's responsibility to meet these thresholds should be proportional to each town's current loading to the Bay.

When this allocation concept is applied to loadings and thresholds in the 19 sub-embayments, the responsibilities are as follows:

- Brewster 2,262 kg/yr (12.8%)
- Chatham 4,076 kg/yr (23.0%)
- Harwich 4,399 kg/yr (24.8%)
- Orleans 6,980 kg/yr (39.4%)
- Total 17,717 kg/yr (100% of total responsibility)

In August 2018, the four towns signed a MassDEP Watershed Permit that binds each town to its share of removal responsibility and sets forth milestones for accomplishing those removals in four 5-year time blocks. The third year of the first 5-year block has just been completed.

It may be possible and economical for one town to remove more nitrogen than called for in the Watershed Permit in exchange for payment by another town whose responsibility would be commensurately less. This concept is called “nitrogen credit trading”, or simply “nitrogen trading”. If possible and economical, trading could reduce the overall cost for nitrogen removal. This report explores the nitrogen trading concept as it applies to Pleasant Bay.

NATIONAL AND REGIONAL EXPERIENCE WITH NUTRIENT TRADING

Pollutant trading programs have been used across the United States and cover such diverse issues as atmospheric emissions of air pollutants, discharges of greenhouse gases, and point- and non-point sources of nitrogen and phosphorus. Prominent water-quality-related programs exist in the Chesapeake Bay region (focusing on phosphorus loading from Pennsylvania, Virginia, and Maryland), the Miami River watershed (Ohio), North Carolina (dealing with phosphorus and nitrogen from point and non-point sources), Oregon (focusing on point sources) and Connecticut (related to Long Island Sound--see below).

These programs are either two-party arrangements or involve a third party, such as a “nutrient bank” or “carbon bank”. Considering the complexity of three-party arrangements, especially the need to create the bank, it is recommended that Pleasant Bay towns conduct two-party trading between the Buyer and the Seller.

Connecticut DEEP Program for Long Island Sound

The Connecticut Department of Energy and Environmental Protection (DEEP) prepared, and EPA approved, a nitrogen-based TMDL for Long Island Sound in 2001. The TMDL establishes the need to reduce the nitrogen loads to the Sound by 58% overall, or by 63% if reductions are achieved only on point sources (*i.e.*, the 79 wastewater treatment plants in the watershed). CT DEEP created a Nitrogen Credit Exchange, and all wastewater treatment facilities operate under a Nitrogen General Permit.

Equivalency Factors (trading ratios) are set by a HydroQual model; the factors range from 1.00 (near the anoxic zone on the west end of the Sound) down to 0.14 to 0.16 (in northeastern Connecticut).

Early in the program, the Nitrogen Credit Exchange (the “bank”) set the trading price at about $2.00 per pound and in recent years the price has been about $6.00 per pound. (These prices seem very low by Cape Cod standards. In the Long Island Sound program, buyers and sellers all own wastewater treatment facilities and established sewer systems, and the trading prices relate to end-of-pipe modifications that are much less expensive than the full collection-treatment-disposal systems needed on Cape Cod.)

CT DEEP believes that this is the most complex and extensive trading program for water quality parameters in the US. Because it involves the buyer, the seller and the Nitrogen Credit Exchange, this is considered a three-party trading system.

Since the initiation of this program, wastewater treatment plans have achieved 88% of the targeted removal and atmospheric deposition has dropped by 26%. The TMDL was achieved in 2014, but anoxic conditions persist in the western Sound. Accordingly, DEEP has embarked on its “second generation” plan to include non-point sources of nitrogen.

In recent years, CT DEEP has found that there is more money going out to sellers than there is money coming in from buyers. To make the program sustainable, there is now a buy/sell differential. For 2018, buyers pay $6.61 per pound and sellers receive $2.59 per pound.

Massachusetts DEP No-Net-Nitrogen Policy

MassDEP requires that a permitee for a new groundwater discharge in a nitrogen sensitive watershed must have a plan to remove as much existing nitrogen load as the new discharge would create. The permittee’s “nitrogen offset” must occur in the same watershed as the proposed new discharge, and the offset must be in place before the new discharge can begin. In essence, this policy creates a nitrogen credit trade between a Buyer (the new permittee, generally a developer) and another party (the Seller) who institutes a reduction in current nitrogen load that is paid for by the Buyer.

There are no DEP-imposed cost considerations; the developer must find and pay fully for whatever offset makes sense in the given circumstances.

Examples of projects that have been permitted under this DEP policy are:

- Cotuit Meadows in Barnstable: the developer oversized the private wastewater treatment facility to be able to receive wastewater flow from an existing nearby nursing home (located in Mashpee).
- Canalside Commons in Bourne: the permitted flow from an existing abandoned grocery store was used to provide part of an offset for a mixed-use development.

This is an example of a two-party trading system.

Cape Cod Commission Nitrogen Offset Policy

Under the 2019 *Regional Policy Plan* and the *Water Resources Technical Bulletin*, the Commission can require proponents of a Development of Regional Impact to completely offset the new nitrogen load from that project if it is located in a nitrogen-sensitive watershed. The Commission can allow a nitrogen offset fee in lieu of the actual offset. The *Bulletin* allows a developer to pay the offset for projects in certain "placetypes" located in nitrogen-sensitive watersheds, where development is being encouraged, and where sewer systems are planned.

The load to be offset is computed based on expected actual wastewater flows, 26.25 mg/l effluent from on-site treatment and disposal, and allowances for non-wastewater loads (e.g., lawn fertilization and stormwater disposal).

The one-time fee paid to the Commission can be as much as $8,290 per annual kilogram. This is based on data from the 2010 Barnstable County Cost Report and assumes the developer is responsible for capital costs and 20 years of O&M costs. The fee is equivalent to $230 per pound, applied to all pounds expected to be discharged over 20 years.

Monetary offsets are held by the Commission and are made available to the municipality where the project is located for use in planning activities or for projects related to nutrient management.

This is an example of a trading program focused on "new" nitrogen load (load that did not exist at the time of the 2006 MEP study). It is in essence a three-party program: the developer, the Commission, and the municipality.

CURRENT TOWN PROGRAMS FOR NITROGEN MANAGEMENT

Each of the four Pleasant Bay watershed towns has prepared a comprehensive wastewater management plan, or equivalent, to set forth the technologies, sites, and costs for its intended nitrogen control plan. Since the publication of these plans, the towns have proceeded to fine-tune their intentions based on evolving information on the capabilities of various removal approaches. The current mix of technologies proposed to be implemented is summarized in Table 1.

About 60% of the planned nitrogen removal would be accomplished through traditional means, primarily public sewering in Chatham, Harwich, and Orleans. Sewering and fertilizer reduction at golf courses are considered traditional technologies, while fertigation, on-site denitrification, permeable reactive barriers (PRBs) and shellfish harvesting are considered non-traditional. MassDEP has required that towns using non-traditional approaches must have a traditional-technology-based contingency plan to be implemented if the non-traditional technologies prove ineffective. (This requirement must be considered if nitrogen trading scenarios include both traditional and non-traditional approaches.)

Chatham has agreed to accomplish its share of nitrogen removal under the Watershed Permit. Further, the town's plan is to provide sewers to all Chatham developed properties, and that will result in a significant "over-removal" compared to strict TMDL compliance.

Table 1. Nitrogen Load Removal Commitments by Town and by Technology

	Nitrogen Load Removal Commitment, kg/yr				
Technology	**Brewster**	**Chatham**	**Harwich**	**Orleans**	**Total**
Residential fertilizer controls	121	247	200	241	809
Golf course fertilizer controls	930				930
Golf course fertigation	230				230
On-site denitrification	981				981
Public sewers		3,829	4,199	2,014	10,042
Permeable reactive barriers				2115	2,115
Shellfish harvesting				300	300
Not yet identified				2310	2,310
Total	**2,262**	**4,076**	**4,399**	**6,980**	**17,717**
Subtotal--traditional	930	3,829	4,199	2,014	10,972
Subtotal--non-traditional	1,332	247	200	4,966	6,745

Removal commitments are as stated in the Targeted Watershed Management Plan and Watershed Permit. Recent modeling by SMAST indicates that better estimates of attenuation may impact removal responsibilities in Brewster, Chatham and Harwich.

Based on data that was used to support the Watershed Permit, Chatham's approach will remove 13,059 kg/yr from Pleasant Bay sub-watersheds, about three times its 4,076 kg/yr commitment under the Watershed permit.

On the other hand, Orleans has committed to 6,980 kg/yr of nitrogen removal but has not yet identified projects to remove all of that obligation. As shown on Table 1, there is still 2,310 kg/yr in nitrogen removal to be addressed, about one-third of the town's obligation.

Considering these deviations from the removal requirements, the aggregate load removal that is now planned is about 24,500 kg/yr, nearly 40% higher than the 17,717 kg/yr requirement.

While the aggregate amount is large, there would be several sub-watersheds that would not meet their threshold loads.

The original MEP modeling conducted in 2006 has recently been updated to address changes in watershed loads, attenuation, and hydrodynamics. This new information indicates that the towns' relative responsibilities may have changed.

ESTIMATED COSTS FOR TOWN-SELECTED TECHNOLOGIES

The costs of each selected technology or project will vary depending on the nature of the technology, local conditions, site availability, economies of scale and many other factors. Costs typically include the initial expenses to design, purchase, install or set up the technology/approach (the capital cost) and the on-going costs for operation, maintenance, equipment replacement and monitoring (the O&M cost).

Wright-Pierce acquired cost data from the towns and their consultants, and reviewed and adjusted those data for consistency and inflation. O&M costs were combined with debt service on the capital cost (at 2%, 20 years) to arrive at the equivalent annual cost. The amount of annual nitrogen removal effected by each technology was also estimated using a consistent set of assumptions. By combining the equivalent annual cost (in dollars per year) with the nitrogen removal (in kilograms per year) a "unit cost" can be derived in terms of dollars per kilogram (or converted to dollars per pound).

The results of this cost analysis are summarized in Table 2, which shows the estimated cost per kilogram (and cost per pound) for all five of the selected technologies in seven projects. This information is also shown graphically in Figure 1.

Figure 1. Pleasant Bay Unit Costs for Nitrogen Removal Technologies

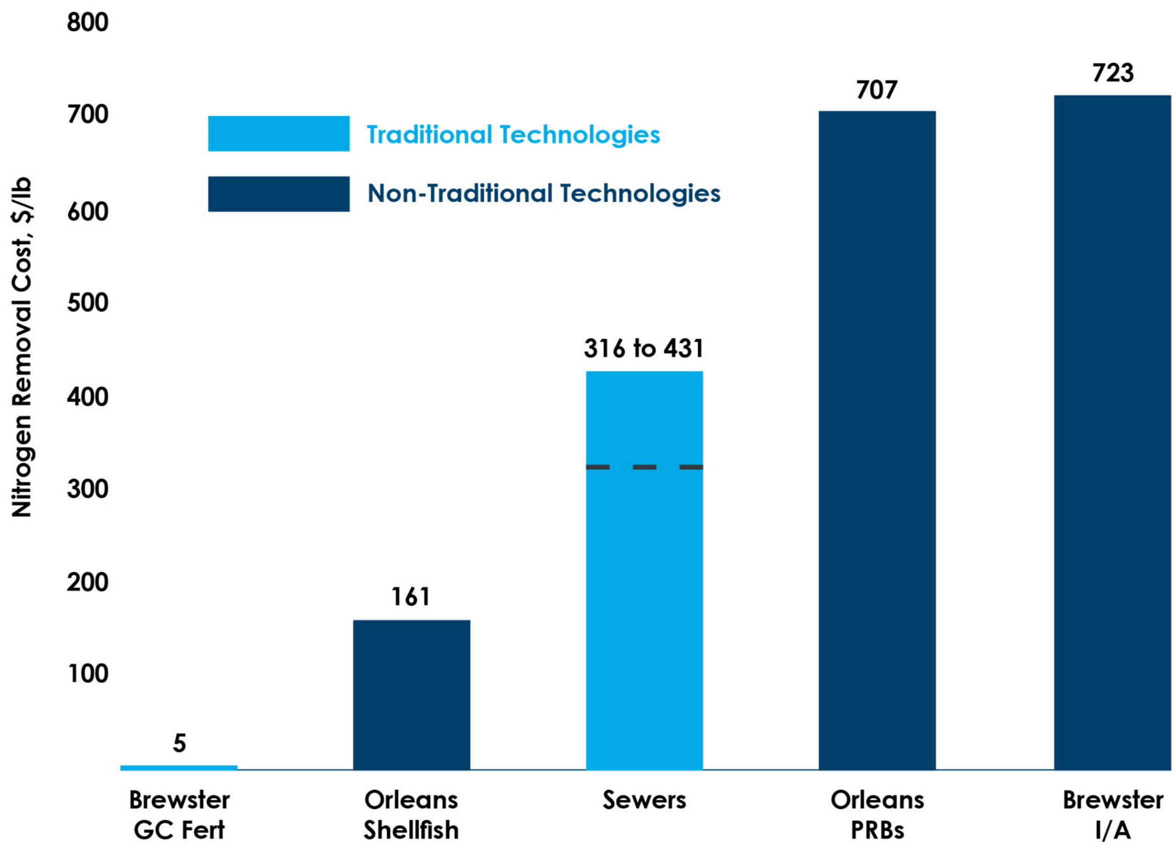


Table 2. Nitrogen Load Removal Costs by Technology and by Town

Technology	Nitrogen Removal Costs, $/kg ($/lb)				
	Brewster	Chatham	Harwich	Orleans	Average
Golf Course fertilizer controls and fertigation	10 **5**				10 **5**
On-site denitrification	1,595 **723**				1,595 **723**
Public sewers		734 **333**	698 **316**	950 **431**	736 **333**
Permeable reactive barriers				1,559 **707**	1,560 **707**
Shellfish harvesting				356 **161**	356 **161**
Overall	**736** **334**	**734** **333**	**698** **316**	**1,161** **526**	**835** **379**
Capital costs, $M	10.9	152.6	61.8	69.0	294
O&M costs, $M/yr	0.76	1.54	1.02	2.56	5.88
Equivalent Annual Cost, $M/yr	1.58	10.87	4.80	6.77	24.0

Cost data were provided by Towns and their consultants and adjusted by Wright-Pierce for consistency (ENR Cost Index of 11,630--early 2021)
Unit costs reflect the specific circumstances in each town and may not be applicable elsewhere
Each technology has a different level of reliability, scalability and resistance to environmental factors

The unit costs fall into three groups:

- Low Golf course fertilizer controls, shellfish harvesting ($10 to $150/lb)
- Medium Public sewers ($320 to $430/lb)
- High PRBs and on-site denitrification ($700 to $750/lb)

Combining the total Bay-wide cost with the total removal by all four towns results in an aggregate cost of about $380 per pound. Aggregate unit costs are in the range of $310 to $340 per pound in Brewster, Chatham, and Harwich and about $530 per pound in Orleans.

The projects reported in Table 1 represent a $300-million investment (before grants) watershed-wide and entail about $6 million in total annual O&M costs. The expenditures translate to an equivalent annual cost of $24 million with the standard SRF financing terms (2%) and $20 million with enhanced (zero percent) financing. (These watershed-wide costs do not include the costs for the 2,310 kg/yr "shortfall" in the Orleans program or any costs that may be related to changes in the Brewster program related to new attenuation estimates.)

Enhanced SRF financing and other grant programs reduce these unit costs. Compared to 2% financing, zero percent loans reduce the unit costs by 14 to 16% for sewering projects and by 4% to 9% for the more O&M-intensive non-traditional technologies. Chatham received sewer funding from Rural Development program which further reduced its unit costs by about 7%.

(It should be noted that the costs reported herein for a given technology reflect its use in very specific circumstances that may not apply elsewhere. Further, towns have selected technologies recognizing that each is different with respect to reliability, scalability, ability to withstand extreme natural conditions, etc. Costs are not the only factor that towns have considered.

EQUIVALENCY FACTORS

With nitrogen trading, one town would remove more than its share of nitrogen and the other town removes less than its share. If that trade occurs in the same sub-watershed, then the two load removals are equivalent and would have an Equivalency Factor of 1.0. If the trade involves removals in different sub-watersheds, then the town load removals may not be equivalent (Equivalency Factor < 1.0). For example, if Chatham were to remove 100 kg/yr in the Chatham Harbor (far southern) sub-watershed on behalf of Orleans, it might be equivalent to Orleans removing, say, 20 kg/yr in the Pochet (far northern) sub-watershed (Equivalency Factor of 0.2). The more distant the trade, the less likely that the full economy of the trade will be achieved.

Natural attenuation also factors into equivalency. Technologies applied upgradient of natural attenuation sources have a lower cost per kilogram of <u>un-attenuated</u> load removed than their costs per <u>attenuated</u> load removal. That is, a technology that removes 100 kg of load upgradient of a freshwater pond will only get credit for removing 50 kg of attenuated load reaching the bay. Considering attenuation, the unit cost per <u>attenuated</u> kilogram is twice the cost per <u>unattenuated</u> kilogram.

IDENTIFICATION OF SCENARIOS

Differing nitrogen removal costs are the driver for nitrogen trading. Towns proposing expensive technologies (*e.g.*, on-site denitrification and PRBs) are likely buyers of nitrogen credits and Towns proposing lower-cost technologies (*e.g.*, sewers) are the likely sellers. More specifically, target buyers of nitrogen credits would be Brewster (related to its potential I/A program) and perhaps Orleans (related to its PRB system). Target sellers would be towns with sewer projects (Chatham, Harwich, and Orleans).

It is also important to consider the expandability of a certain nitrogen removal project. The nitrogen credits gained by Brewster at the Captains Golf Course are very inexpensive, but that project cannot be expanded because of the limits of the golf course.

Similarly, Orleans' low-cost shellfish harvesting project in Lonnies Pond is constrained by the area of the pond available for growing oysters. Thus, these projects are not amenable to nitrogen trading.

Considering all of these factors, the following scenarios are proposed for analysis.

Scenario 1. Brewster and Orleans in their shared sub-watersheds (the River System)

These two towns are the only contributors to six sub-embayments:

- Upper River
- Lower River
- Lonnies Pond
- Arey's Pond
- Namequoit River
- Quanset Pond

The total load removal need is 1,900 kg/yr, with 95% of that removal need being Orleans' responsibility. Brewster's unattenuated loads in those 6 sub-watersheds is 957 kg/yr and that aggregate load is subject to 676 kg/yr of natural attenuation (70%). If Brewster were to install on-site denitrification systems in these sub-watersheds, the cost would be about $720 per un-attenuated pound and about $2,400 per attenuated pound. By comparison, on-site denitrification systems installed in Orleans' portion of these sub-watersheds down-gradient of the natural attenuation sources would cost $720 per attenuated pound.

Orleans has proposed PRBs in these sub-watersheds that are expected to remove only 914 kg/yr of Orleans' 1,805 kg/yr removal commitment. That means that Orleans must either expand its PRB network or identify another technology to address the remaining 891 kg/yr. If that expanded or new technology could remove 986 kg/yr, it would address both towns' needs (95 kg/yr for Brewster and 891 kg/yr for Orleans). Brewster would be responsible for 10% of that cost (95 kg/yr out of 986 kg/yr).

For the purposes of this illustrative example, it is assumed that Orleans will expand its PRB network in these sub-watersheds to fully meet its commitment here and to provide removals on behalf of Brewster. (While PRBs are relatively expensive, the natural attenuation affecting Brewster's loads makes Orleans' PRBs much less expensive than Brewster's I/A systems in this setting).

If Brewster's removal responsibilities are addressed by Orleans in the same sub-watersheds, the Equivalency Factor is 1.0.

Scenario 2. Brewster and Orleans in the Little Pleasant Bay sub-watershed

The Pleasant Bay sub-watershed is the aggregate of four sub-watersheds analyzed in the 2006 MEP study, three of which are aggregated into a single TMDL. Those four sub-watersheds are Pleasant Bay (main), Little Pleasant Bay, Tar Kiln Stream, and the Horseshoe.

In the aggregated Pleasant Bay sub-watershed, there is a removal need of 5,593 kg/yr, of which 3,427 (61%) is attributable to Brewster and Orleans. In the Little Pleasant Bay portion, Brewster and Orleans are the only contributors of nitrogen load.

Other than fertilizer management at Captains Golf Course, the technologies proposed to address Brewster's and Orleans' needs are either expensive or not yet determined. Brewster has put forth a potential I/A program, but its high cost (over $700 per pound) has prompted Brewster to consider other technologies for 891 kg/yr. Orleans needs to expand other options or find a new way to remove 2,310 kg/yr. As the two towns fine-tune their removal plans, they should be watchful for a trade of responsibilities that effects a net savings.

For the purposes of this report, it is assumed that Brewster will identify a technology and sites that can remove 500 kg/yr more than Brewster's sole needs and that the added 500 kg/yr removal will be offered to Orleans to help it fulfill its needs in the Little Pleasant Bay sub-embayment.

Scenario 3. Brewster and Harwich in the Pleasant Bay Main sub-watershed

In the aggregate Pleasant Bay sub-watershed, there is a removal need of 5,593 kg/yr, of which 3,785 (68%) is attributable to Brewster and Harwich.

Brewster's nitrogen removal plan in this sub-watershed is a combination of fertilizer management at the Town-owned Captain's Golf Course (1,160 kg/yr) and (tentatively) 319 on-site denitrification systems in portions of the sub-watershed that are not subject to natural attenuation (981 kg/yr).

Harwich's nitrogen removal plan is focused on public sewers to remove septic nitrogen in four sub-watersheds: Pleasant Bay (1,621 kg/yr), Round Cove (1,209 kg/yr), and Muddy Creek (upper and lower combined 1,577 kg/yr). The recent update of the watershed-embayment model appears to indicate that Harwich's sewering plans in the Muddy Creek sub-watersheds may not need to be as extensive as previously thought. If Harwich could adjust its sewering plan to be less focused on Muddy Creek and more focused on Pleasant Bay, then the added sewering in Pleasant Bay could benefit Brewster and be the subject of a nitrogen credit trade.

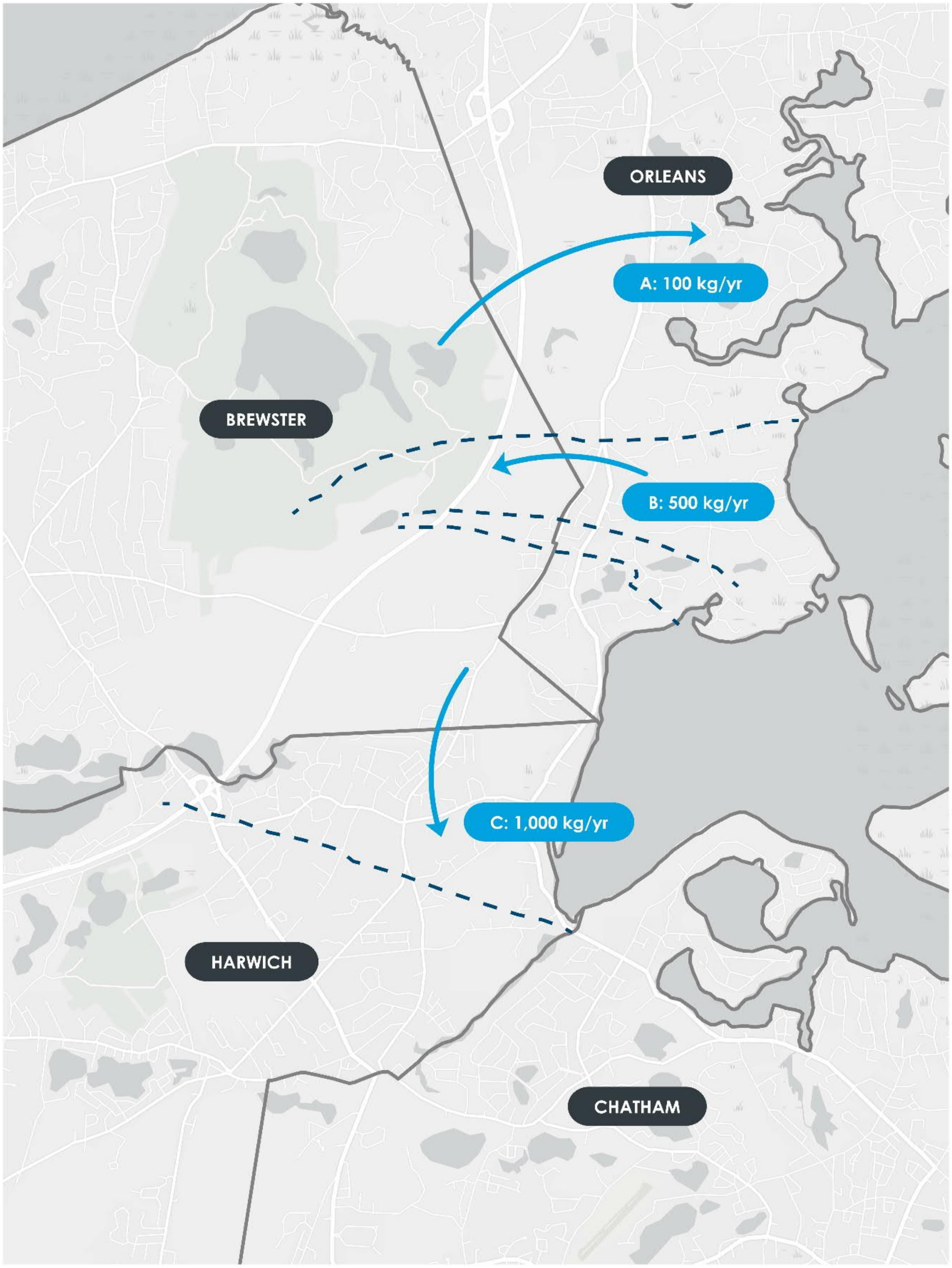
In short, Harwich could "over-remove" nitrogen in its portion of the Pleasant Bay sub-watershed (at a cost of about $350/lb) to allow Brewster to reduce its reliance on on-site denitrification (at about $700/lb).

If Brewster's removal responsibilities are addressed by Harwich in the same sub-watershed, the equivalency factor is 1.0.

Without this hypothetical trade, Harwich flows to the Chatham sewer system are expected to be 220,000 gallons per day (gpd) of the 300,000-gpd capacity allotted by Chatham to Harwich. If Harwich were to expand its sewer system on behalf of Brewster, an additional flow of about 30,000 gpd would result, leaving Harwich with about 50,000 gpd of unused capacity within the Chatham limit.

These hypothetical trades are illustrated in Figure 2. The arrows in Figure 2 represent the transfer of nitrogen removal responsibility between the noted towns.

Figure 2. Transfer of Nitrogen Removal Responsibility



(Scenarios 1 and 2 involve Orleans and Brewster in both Buyer and Seller roles. It would be possible to combine these two scenarios into a single trade. Orleans could "over-remove" nitrogen (100 kg/yr) in the six sub-watersheds it shares only with Brewster (the River System) in exchange for Brewster taking responsibility for 100 kg/yr more removal in the Pleasant Bay sub-watershed.)

ESTIMATES OF COSTS AND SAVINGS

If these nitrogen trading scenarios are brought to fruition, there must be much more detailed analysis than summarized here, and the actual cost savings will depend on the negotiations between Buyer and Seller. To illustrate potential savings and costs, hypothetical "strike prices" (the negotiated price per pound of removal) have been assumed for each scenario. The hypothetical economics are shown in Table 3.

Scenario 1. Brewster and Orleans in their shared sub-watersheds (the River System)

It is assumed, for illustration purposes, that Orleans would expand its proposed PRB network to provide 100 kg/yr extra nitrogen removal for the benefit of Brewster. The hypothetical strike price is $1,600/lb, half way between the $2,400/lb price Brewster would incur for I/A systems (after attenuation) and an assumed $800/lb for additional PRBs in Orleans (that may be slightly more expensive that the ones already selected).

Brewster would pay $352,000 annually to Orleans, one-third less than the cost of the I/A systems Brewster would otherwise implement. With those funds, Orleans would install additional PRBs costing $176,000 per year, and gain a "premium" of $176,000 per year. That premium could be used to offset other components of Orleans' nitrogen management program.

The savings and premium noted above are expressed as equivalent annual costs to include both capital and O&M costs. Alternatively, these figures could be expressed as present worth, the lump sum equivalent to the equivalent annual cost. In these terms, Brewster would save $2.9 million, and Orleans would earn $2.9 million over the $2.9 million cost of the added PRB.

Scenario 2. Brewster and Orleans in the Little Pleasant Bay sub-watershed

Based on the latest SMAST modeling, both Orleans and Brewster fall short of the nitrogen removals needed in the Little Pleasant Bay sub-watershed to restore water quality.

Each town needs to supplement its current nitrogen management program to provide more removal in this sub-watershed. For illustration purposes, it is assumed that Brewster selects a technology that costs $500/lb (say a cluster sewer system and modular treatment plant) and Orleans selects I/A systems at $700/lb. The assumed strike price is $600/lb.

Based on these assumptions, if Brewster could expand its technology to provide 500 kg/yr more removal (for the benefit of Orleans), and negotiations led to a strike price of $600/lb, then Orleans would save $110,000 per year and Brewster would earn $110,000 per year over the cost of the technology expansion. In terms of present worth, the savings and premium are $1.8 million.

Table 3. Savings Associated with Nitrogen Trading Scenarios

	Scenario 1	**Scenario 2**	**Scenario 3**
Sub-watershed	River System	Little Pleasant Bay	Pleasant Bay Main
Buyer	Brewster	Orleans	Brewster
Seller	Orleans	Brewster	Harwich
Buyer's technology	I/A systems	Not yet identified	I/A systems
Seller's technology	PRBs	Not yet identified	Sewers
Pre-trade unit costs, $/lb			
Buyer	2,400	700	700
Seller	800	500	350
Strike price, $/lb	1,600	600	525
Trade amount			
kg/yr	100	500	1,000
lb/yr	221	1,103	2,205
Cost to buyer, $/yr	352,000	662,000	1,158,000
Buyer savings, $/yr	176,000	110,000	386,000
Present worth of Buyer savings, $M	2.88	1.80	6.31
Seller income, $/yr	352,000	662,000	1,158,000
Seller costs, $/yr	176,000	552,000	772,000
Seller premium earned, $/yr	176,000	110,000	386,000
Present worth of Seller premium, $M	2.88	1.80	6.31

Scenario 3. Brewster and Harwich in the Pleasant Bay Main sub-watershed

In this scenario, it is assumed that Harwich would expand its sewer system in the Pleasant Bay Main sub-watershed to remove 1,000 kg/yr (by serving an additional 80 homes). For illustration purposes, Harwich's costs are assumed to be $350/lb, compared to Brewster's costs of $700/lb. The negotiated strike price would be $525/lb. Harwich's $13 million (present worth) project would be funded by Brewster as a way to avoid I/A systems that would cost more than that amount. Brewster's savings would be $386,000 per year, and Harwich would earn that same amount to offset other portions of its nitrogen management program.

Summary

Taken together, these three trading scenarios involve 1,600 kg/yr in removal responsibility, or about 9% of the Bay-wide 17,700 kg/yr removal need. The illustrative savings are about $670,000 per year in equivalent annual cost, or about $11 million in present worth. This represents a savings of about 14% of the estimated expenditures currently planned for non-traditional technologies in Orleans and Brewster.

(In these calculations, the strike price is assumed to be midway between the Buyer's and Seller's unit costs, so the Buyer's savings are equal to the premium earned by the Seller. It is likely, however, that the strike price will not be at that midpoint, due to several factors that are specific to the individual circumstances.)

IMPORTANT CONSIDERATIONS

There are many important considerations that must be addressed in a nitrogen credit trade.

The Watershed Permit

The August 2018 Watershed Permit stipulates the nitrogen removal commitments of each of the four towns and sets a schedule for those removals. If one town is to remove less nitrogen, through an agreement with a second town for that town to remove more nitrogen, that arrangement must be codified in the Watershed Permit.

The 20-year Watershed Permit is scheduled to be reviewed each five years to allow changes that may be necessary due to adaptive management. A nitrogen credit trade could be reflected in a revised permit at any of the five-year renewals. The change would not affect the watershed-wide removal but would shift a portion of that removal commitment from one town to another.

Each town's removal commitment must be addressed within the implementation schedule contained in the Watershed Permit. For example, Chatham has committed to removing about 3,400 kg/yr of nitrogen load in years 11 to 15 of the permit. It is presumed that the current removal schedule would remain unchanged if that removal were to be accomplished by another town.

For a nitrogen trade to be reflected in the Watershed Permit, there must be approval by the permitting agency, MassDEP. Therefore, the trading concept, schedule and details should be all be developed with MassDEP involvement.

Intermunicipal Agreements

The details of the nitrogen credit trade must be spelled out in detail in a written agreement between the Buyer and the Seller and would take the form of an inter-municipal agreement (IMA). Such a document should be expected to require considerable time to be developed, due both to the complicated nature of a trade, and the general lack of similar prior executed IMAs to build on. The need for and timing of Town Meeting approvals must be addressed.

The parties should not execute an IMA unless and until MassDEP and the other towns have approved the trade in concept. Further, the Watershed Permit should not be revised to reflect the trade unless and until the two Boards of Selectmen have agreed that the IMA is ready for execution. The IMA and Watershed Permit modification should come to fruition simultaneously.

While an IMA is presumed to be the final form of agreement between the Buyer and the Seller, earlier memoranda of understanding (MOUs) may be advisable to give both parties assurances of the intent to move forward and to expend engineering and legal fees toward the final IMA.

Costs

The unit costs used in this report are based on" equivalent annual cost", the sum of O&M expenses and debt service on the capital costs. It is important to understand that the Buyer would be agreeing to pay the Seller both a portion of the Seller's capital cost and a portion of the Seller's O&M costs.

The trading agreement must address both components of cost. Simplistically, the Buyer would make an up-front payment of a stipulated share of the capital cost (say the cost of building a sewer extension in Harwich in Scenario 3) and an annual payment of the incremental O&M costs of the Seller. Alternatively, the deal could be for a single lump sum payment that combines capital costs and 20 years of O&M. Or the trade could entail an annual payment for a given share of the combination of O&M and debt service. The choice of the payment approach would be determined in the trade negotiations.

Grants and Loans

If a nitrogen removal project is eligible for grants and/or loans, in most cases the funding benefits to the Seller should be passed on to the Buyer. The funding agency should recognize that a separate project by the Buyer could have been implemented at higher cost, and therefore the funding agency should treat the Seller's expanded project as grant/loan-eligible. For example, if Brewster were to implement a nitrogen removal project that would be large enough to satisfy both Brewster's and Orleans' needs in the Little Pleasant Bay sub-watershed (Scenario 2), it is expected that MassDEP would view both the Brewster-only and the expanded Brewster projects as eligible for SRF funding.

If the Seller's project included some features that are not loan-eligible, such as roadway improvements in a sewer project, then the Seller would be obligated to properly account for the eligible and non-eligible costs and pass on the benefits to the Buyer.

Equivalency Factors

The three example trades put forth in this report each occur in a single sub-watershed shared by the Buyer and Seller. In each case the Equivalency Factor is 1.0. There may be other opportunities where trades between subwatersheds is necessary and where nitrogen attenuation is important. In these cases, the Linked Watershed-Embayment model would be used to determine the Equivalency Factors.

Growth in Watershed Load

The nitrogen removal commitments in the Watershed Permit reflect the removals needed to reduce "current' watershed loads (reflective of 2003 to 2006 conditions) to the threshold load determined in the 2006 MEP report. Towns are responsible for those load reductions, plus 100% of any "new" loads that have occurred since 2006 due to development or redevelopment in the watershed. Revisions in the watershed permit over time are expected to address increasing removal requirements due to growth.

An agreement to trade nitrogen credits could address just current removal needs but would be much more effective if growth were considered in the trade. For Scenario 1, Orleans could agree to expand its program by 100 kg/yr to address just Brewster's "current" removal needs in the River System. With growth in watershed loads in Brewster's portion of these subwatersheds, Brewster would still have some obligation beyond the 100 kg/yr handled by Orleans. If Brewster expects, say, 20% growth in watershed loads in those areas, then the trade could cover 120 kg/yr.

Future Changes in Removal Needs

It should be recognized that estuarine modeling and the determination of threshold loads are not exact sciences. For example, changes in the hydrodynamics of the receiving water could result in larger or smaller nitrogen removal requirements than first thought. While the current Watershed Permit reflects the best available estimates of removal needs at the time it was issued, future changes in town-to-town responsibilities should be expected, and these changes must be accounted for in a trading arrangement. In Scenario 3, Harwich must recognize that apparent "over-removals" (based on 2021 modeling results compared with the MEP 2006 report) might be partially reversed in the future. In this example, it would be prudent for Harwich to keep this possibility in mind.

Back-up Plan for Non-Traditional Technologies

Of the seven projects that are part of the current town plans (excluding residential fertilizer controls; see Table 1), only sewering and golf course fertilizer controls are considered to be traditional technologies. The others (on-site denitrification, PRBs and shellfish harvesting) are considered non-traditional and therefore require a back-up plan based on traditional methods. Should Orleans agree to expand its PRB plan to accommodate Brewster loads in the River System (Scenario 1), Orleans would need to expand its back-up plan accordingly. The details of the back-up plan should be spelled out in the IMA, including any associated costs.

Town Recovery of Buyer Costs

For the typical nitrogen removal project, such as sewering, the town must decide how to recover costs that are not covered by grants. Typically, towns decide to recover some of the local capital costs through property taxation and some of the capital costs are borne by users as betterment assessments. O&M costs are typically recovered from users. When a town contracts with another town for nitrogen removal, the Buyer has no "users" to pay betterments or user fees.

The simplest approach would be for the Buyer to pay the Seller from property tax revenues. If there are special benefits that accrue to just some of the property tax payers in the buying town, alternatives should be considered, but may be cumbersome. In this case, financial and legal advisors should be consulted.

Other Agreements

Both the Buyer and the Seller must be aware of other agreements that might impact the potential trade of nitrogen credits. Nitrogen removals dictated by a consent order may not be amenable to a trade, in part due to the needed time needed to negotiate the trade. (There are no known consent orders for nitrogen removal in any of the four towns at this time.) Harwich's wastewater treatment and disposal needs are now met by an agreement with Chatham. Chatham has agreed to receive 300,000 gpd of wastewater flow from Harwich. If Harwich were to engage in a trade with Brewster (Scenario 3 above), the total flow from Harwich must not exceed that 300,000-gpd cap, and Chatham's approval of such a trade is needed under the terms of the Chatham/Harwich IMA.

Public Perceptions

There should be a public consultation process to gain citizen input on a nitrogen trading opportunity. Public support is needed to ensure passage of Town Meeting appropriations that are needed, and for authorization for the IMA.

For the Buyer, the public issues may be simpler, in that construction will be occurring in another town. In Scenario 3 for instance, those property owners in Brewster that would be spared from an I/A system would likely support a proposal to fund expanded sewering in Harwich.

The Seller might expect opposition to public projects that would be more extensive due to a trade. In Scenario 1, for instance, if Orleans expanded its PRB network to accommodate Brewster loads in the River System, Orleans might expect public concerns over the added construction disruption that would occur in Orleans.

The issues associated with nitrogen control are complicated and sometimes controversial. A thorough public consultation process is always beneficial.

MODEL IMA

The contents of an IMA for nitrogen trading must reflect the specific conditions of the trading arrangement and the requirements of each town. Nonetheless, there are many provisions that can be anticipated in a typical IMA, as outlined in Table 4. The issues associated with nitrogen trading can be complex, and both Buyer and Seller should plan for the time and expense of appropriate legal representation.

Table 4. Elements of an Inter-Municipal Agreement for Nitrogen Trading

Identification of the parties (Buyer and Seller)
Statement of goals
Acknowledgement of relevant prior MOUs and/or IMAs
Citation of applicable laws
Reference to Watershed Permit and identification of its provisions related to this sub-watershed
Identification of nitrogen trade amount (kg/yr) and sub-watershed location
Establishment of payment amounts and timing
Discussion of growth in sub-watershed loads and establishment of associated responsibilities for nitrogen removal
Discussion of potential changes in towns' removal responsibilities related to potential future improved understanding of the Bay's assimilative capacity
Assignment of risks due to underperformance of Seller's technology (added costs for operation and monitoring, early replacement, etc.)
Establishment of a back-up plan for non-traditional technologies
Discussion of grant and loans (trading price reflects current grants or expectations) and Seller's obligation to pursue other grants/subsidies for the benefit of both parties
Language regarding Seller's use of funds
Establishment of date of agreement and duration
Addressing of IMA mechanics (termination, applicable law, acts of God, etc.)

IMPLEMENTATION SCHEDULE

The purpose of this report is to describe the features of a potential nitrogen credit trading program and to use three examples to illustrate some of the specific benefits and constraints. The three examples set forth in this report are not the only possibilities for the Pleasant Bay watershed, and the towns' review of this document may lead to other possibilities being identified. Whether it be one of these three examples or others, it will take some time for a nitrogen trade to be accomplished.

A key feature of such an arrangement is the incorporation of revised town responsibilities into the Watershed Permit. The Permit is structured to allow revisions every five years. August 2021 was the end of the first three years. While it is conceivable that a simple trade might be finalized in the remaining two years of the first 5-year cycle (that is, by August 2023), it is a more realistic expectation that one or more trades might be incorporated in the August 2028 permit renewal.

There is one important step that should be accomplished before there is any detailed consideration of potential trades, and that is the completion of estuary modeling update now underway by SMAST. Recent SMAST tasks include the quantification of the increases in watershed loads, improved hydrodynamics, and natural attenuation changes. These factors may lead to revised threshold loads. If the threshold loads change, then the town's removal requirements will change. The magnitude and location of these changes should be better understood before further work is undertaken on trading opportunities.

Concurrent with the ongoing SMAST work, there will be changes to the towns' removal plans. Orleans should expand its technology selection as appropriate to its planning efforts. Brewster may need to modify its removal plans to account for revised (higher) estimates of attenuation in Tar Kiln Stream. More information is needed on how Harwich's plan may change in the face of a revised (lower) estimate of attenuation in Upper Muddy Creek. Further, traditional back-up plans are needed for all non-traditional projects.

CRITERIA FOR IDENTIFYING TRADING OPPORTUNITIES ELSEWHERE

It is likely that nitrogen trading opportunities exist in many watersheds across Cape Cod. Prime opportunities are where:

- Watersheds span multiple towns
- A range of technologies has been selected by the towns, some of which have expansion capabilities
- The technologies have well-documented costs that cover a significant range of unit costs
- Watershed-embayment modeling is available to estimate equivalency factors when trading opportunities exist between sub-watersheds.

WAY FORWARD

If there is interest in these or other trading scenarios, representatives of each town should meet informally to set forth a plan of action. Next steps would include:

- The parties should prepare an initial MOU to establish responsibilities and expected timing of initial tasks. This document must give both parties the assurance of the other's intent so that each can be comfortable moving forward with expending funds to accomplish the trade.
- The Seller should engage an engineer to refine cost estimates related to the real or expected costs for its existing plan elements, and to estimate the incremental costs of an expanded project to accommodate this trade.
- Concurrently, the Buyer's technical staff and consultants should refine its estimates of costs for the nitrogen removal that Buyer would avoid, so as to have a sound basis for negotiations.
- An attorney should draft the IMA (or in intermediate MOU) to set forth the issues that will influence the price negotiations.
- Each party should provide for public consultation.
- The Seller must determine the permitting requirements for its expanded plan as they impact cost and timing.
- The parties then can negotiate the amount, form, and timing of payments. The essential issues should be documented in an MOU for review by financial and technical advisors and for input from MassDEP related to the Watershed Permit.
- The Seller would then seek Town Meeting approval for appropriations to design and build the expanded facilities.
- Once construction bids are received and O&M budgets are established, the parties can refine the IMA and seek its approval at Town Meetings, including Buyer's appropriation for its costs.
- The Watershed Permit would then be updated to reflect the transfer of responsibility.

It is clear that the Buyer and Seller must work closely to address and resolve technical and financial issues and the significant time is needed to conduct all needed activities with appropriate public consultation and Town Meeting actions.

ACKNOWLEDGMENT

This project was funded by a 2018 Watershed Grant from the Southeast New England Program (SNEP). SNEP is an initiative of the US Environmental Protection Agency and is administered by Restore America's Estuaries. Significant support to this study was provided by the Pleasant Bay Alliance's Watershed Work Group and by the technical consultants for the four watershed towns.