Chapter 8

Additional Non-Wastewater Nutrient Mitigation Alternatives

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ADDITIONAL NON-WASTEWATER NUTRIENT MITIGATION ALTERNATIVES

8.1 INTRODUCTION

This chapter discusses additional options available to reduce nitrogen inputs to the groundwater and phosphorus impacts to the ponds beyond those associated with improved wastewater facilities. The sources of nutrients that are typically evaluated when modeling nutrient loading to watersheds include road and roof runoff, precipitation on natural areas (including surface water bodies), and lawn fertilizers. This chapter will discuss the non-wastewater nutrient management and mitigation methodologies which could be implemented to reduce nutrients from these sources. These methodologies will include management/regulation of fertilizer use, stormwater management, tidal and mechanical flushing improvements to coastal estuaries, modifications to the watersheds to improve natural attenuation, in-pond treatments, and modification of zoning laws (or sewer use regulations) in sewer service areas.

8.2 REDUCTION OF NUTRIENTS FROM FERTILIZERS AND PET WASTES

A. **Fertilizer Reduction.** The possible reduction of nutrient leaching from fertilized areas is difficult to predict due to the popular desire of growing green lawns with minimal effort. Public education programs have been initiated by the Town and should be continued. Education on proper fertilizer types, application techniques, and frequency of use can help reduce overfertilization, which is the most common cause of fertilizer leaching into the groundwater system. Overfertilization is a problem that is not limited to just the planning areas discussed in this report, but to all parts of Barnstable.

Two notable public participation programs have been initiated and are on-going in the nearby towns of Falmouth and Dennis. The Falmouth Friendly Lawns (FFL) program created a means of rewarding those organizations and individuals who volunteer to limit their use of fertilizer nitrogen, and signifying those products considered Falmouth Friendly.

A similar program was established in Dennis by the Comprehensive Wastewater Management Task Force's Public Outreach Subcommittee, working with the Cape Cod Collaborative Extension. The *Clean-Green Lawn Program*, which is patterned after Falmouth's Friendly Lawn program, is intended to make the public aware of the potential damage improper use of lawn fertilizers can do to estuaries and groundwater. It also provides a simple program from soil preparation to proper fertilizer application, maintenance, watering, and weeding to help them have a healthier lawn, avoid over fertilization, and reduce nitrogen leaching into our groundwater.

More recently, the Pleasant Bay Alliance has been investigating opportunities to reduce nitrogen loading impacts associated with fertilizer use as funded through a grant from the Cape Cod Water Protection Collaborative. They recently put on a community workshop focusing on the following Intelligent Lawn Care items:

- Alternatives to traditional fertilizers.
- Controlling weeds, bugs, and disease.
- Rethinking your landscape – Alternatives to conventional landscapes that can reduce fertilizer use.

This forum is part of a larger effort to investigate many methods of promoting improved fertilizer management including:

- Review of fertilizer management strategies used by other communities across the country.
- Review of regulatory programs and standards used by other communities.
- Development of strategies on fertilizer reduction that could meet MassDEP compliance assurance goals.

A final report on these evaluations was completed in January 2011 with the following high priority and recommended fertilizer management concepts:

- Fertilizer management on Town/municipal properties.
- Fertilizer management at municipal and private golf courses.
- Greater buffer areas at Wetland Resource Areas.

- Public education and outreach on fertilizer management.
- Turf grass management training for the public.
- Lawn size limits for new development.

Carol Ridley, Pleasant Bay Alliance Director, presented the findings of this report to the CAC on February 14th which initiated much discussion on appropriate fertilizer management strategies in Barnstable. Subsequent CAC meetings and round-table discussions have recommended the following items to be pursued by Barnstable and GHD during detailed evaluations:

- Summarizing the golf course loading rates used in the MEP landuse model with the rates that are currently being practiced now.
- Summarizing the municipal Town property loading rates used in the MEP landuse model with the rates that are currently being practiced now.
- Further explanation with MassDEP to understand possible redactions that will be allowed by MassDEP for other fertilizer management options such as Town bylaws to limit fertilizer use on individual residential or commercial properties.

These detailed evaluations will be used to form the watershed nitrogen budgets used in the final recommended plan.

B. **Landscape Design Practices.** Although the majority of the population does not realize it, landscaping practices have a significant impact on water quality. Education to inform homeowners of ways to minimize negative impacts can reduce the effect that landscaping has on water quality. Certain landscape design practices can reduce fertilizer needs, reduce impervious area, and increase runoff control. One program initiated to promote the use of landscape practices that maintain and/or improve water quality is the 2006 Greenscapes program (http://www.greenscapes.org/). This program is an effort by several non-profit groups and southeastern Massachusetts towns. The program provides workshops and guidebooks to educate consumers on environmentally-conscious landscape designs. Landscape practices recommended include pesticide and fertilizer alternatives, composting, and low maintenance plants. Programs such as this are voluntary and therefore will rely on thorough public education. However, the Town's cost could be as low as a few cents per resident reached. Therefore, public education is important to obtain support for these practices from homeowners and land care providers.

C. **Animal Waste Management.** In addition to being a source of bacterial contamination, nutrients from animal waste can result in eutrophication of lakes and ponds or algal blooms. Several options should be considered to encourage pet owners to control animal waste.

1. Ordinances and associated fines can be implemented requiring removal of pet waste from public areas (roads, beaches, parks, etc.) and other peoples' property. Reminders of the ordinance in public parks along with supplies for waste removal may improve compliance.

2. Dog parks can be created where pets are allowed off the leash. Parks can include reminder signs and waste removal supplies.

3. Public education programs can be used to educate pet owners on the link between animal waste and water quality, thereby making it more likely that owners will clean up after their animals.

8.3 WATERSHED MODIFICATIONS AND CONSTRUCTED WETLANDS FOR NUTRIENT ATTENUATION

Wetland areas have demonstrated the ability to attenuate nutrients in the groundwater as it moves through the watershed. Research by the School of Marine Science and Technology (SMAST) as part of the Massachusetts Estuaries Project has documented various wetlands and ponds in Barnstable with as much as 60% nitrogen attenuation. Their work has allowed MassDEP to credit this type of attenuation in their Nitrogen TMDL compliance planning. These findings have promoted the concept of modifying the watershed to create freshwater ponds and wetlands where increased nitrogen attenuation can occur.

Several of the treated water recharge sites identified in Chapter 5 by the Site Identification Working Group could incorporate this concept to create wetlands and restore waterways. There is great interest to restore an impacted area by creating riparian areas where nitrogen attenuation can occur at the same time wildlife habitat improvements can occur.

The Mill Pond sediment removal project in Marstons Mills is an example where evaluations by SMAST indicate that deepening of the pond can increase nitrogen attenuation for the waters

flowing down the Marstons Mills River. This project is being used by the Cape Cod Water Protection Collaborative as a model project to develop streamlined regulatory approvals.

8.4 STORMWATER MANAGEMENT AND TREATMENT

The nitrogen loading associated with road and roof runoff used in the nitrogen assessment was also developed as part of the CCC Technical Bulletin (TB 91-001) and updated as part of the work done for the MEP. Concentrations of nitrogen in precipitation and runoff were examined, and average concentrations of 1.5 ppm NO_3-N from paved surfaces and 0.75 ppm NO_3-N from roofs were used in the calculations. The calculations also assume that 90 percent of the stormwater is recharged to the aquifer from impervious surfaces. Precipitation on Cape Cod was identified as 44.44 in/yr; and 90 percent of that value equals 40 in/yr of recharge from road and roof runoff.

Stormwater treatment for nitrogen typically involves using constructed wetland systems to biologically denitrify the oxidized nitrogen in the stormwater. This type of treatment is similar to the constructed wetland treatment technologies described in Chapter 7 and requires a large land area to construct. In addition, the nitrogen removal performance for constructed wetlands for treatment of stormwater is highly variable and dependent on several factors, including climate, season, vegetation types, and surrounding land use. Most road layouts do not have sufficient space for constructed wetland facilities.

The best management practice (BMP) for stormwater has been to catch the stormwater in catch basins, retain the “settleables” and “floatables” in the catch basin, and then infiltrate the water in subsurface leaching pits. This BMP is successful at reducing flooding on the roads and reducing bacterial contamination of surface waters. It may not be the best way to remove nitrogen from the stormwater because it introduces the stormwater into the subsoil where there is little biology that could remove the nitrogen.

Whenever possible, stormwater should be directed to vegetated swales or basins where suspended solids and fecal coliform are removed and nitrogen (and phosphorus) is used by the biological material in the swale or basin. The pretreated stormwater should also be directed to constructed (when space allows) or natural wetlands where the nitrogen can be further removed. The practice of directing stormwater to natural wetlands is typically not allowed by conservation

commissions, as empowered by the Wetlands Protection Act. The Highway Department is working with the Town's Conservation Commission to allow this BMP as much as possible while minimizing impacts to the wetlands.

A visible example of this type of design is the stormwater management system for the recently upgraded portion of Route 132 from Route 6 to Bearses Way. Most stormwater exits the road surface to the median strip where it flows and infiltrates in a vegetated swale. Most of the particulate solids are removed as it flows in the swale. If the flow exceeds the infiltration capacity, it enters a catch basin and is directed to one of three constructed ponds and wetlands where it infiltrates to the ground. This design is a good example of the new best management practices available for road and roof runoff.

8.5 ESTUARINE INLET MODIFICATIONS FOR INCREASED TIDAL FLUSHING

Another method of reducing nitrogen impacts to embayments is to increase the tidal flushing experienced by the embayment. This increased flushing often means that a larger volume of water is entering and exiting the embayment, providing dilution of the groundwater that reaches the estuary.

A larger inlet is planned for Stewarts Creek to replace the undersized culvert under Ocean Avenue. This improvement in combination with planned sediment removal in the creek, and sewer extension to many of the homes around the creek, is expected to improve the water quality to this tidal creek.

The 3-Bay inlets have recently been dredged to reduce shoaling. It is hoped that the dredging will improve water quality at the same time that boat access is improved.

The Rushy Marsh Pond outlet has been evaluated by SMAST as part of the Massachusetts Estuaries Project and an improved outlet has been designed. Final permitting is proceeding. Evaluations by SMAST indicate that the improved outlet will address the current eutrophic conditions in the pond. The outlet will require maintenance to ensure that it does not become restricted.

The Massachusetts Estuaries Project is very thorough in identifying possible improvements to tidal flushing by removing undersized culverts in their technical reports. The three modifications discussed above offer good opportunities to restore tidal flow and improve water quality.

8.6 MECHANICALLY INDUCED TIDAL FLUSHING

This concept would utilize large pumps and pipes to increase tidal flushing of coastal estuaries to increase the allowable watershed nitrogen loads. The concept was investigated for the Three Bay System in 1998 by the Three Bay Preservation Inc. and utilized the following concepts:

- Large diameter plastic pipe buried under the estuary connecting Nantucket Sound to the upper reaches of the estuary.
- Two or more Archimedes pumps (screw pumps) in the upper reaches of the estuaries to pull water from Nantucket Sound to the upper reaches to increase tidal flushing. The larger diameter pipe and the screw pumps were utilized to avoid impacts to marine organisms that might be conveyed with the water through the pump.
- Necessary pump controls to operate the pumps at the portions of the tidal cycle where tidal flushing could be enhanced.

These initial investigations considered the regulatory feasibility of such a municipal watershed and nutrient management approved with the following observations:

- The regulatory agencies typically want to see source reductions to meet the limits, not mechanical manipulation of the environment to gain dilution.
- As a mechanical system, it would be subject to power outages and/or breakdowns that could impact marine organisms that could become dependant on the enhanced flushing.
- There are many regulatory sections in the State and Federal regulations that would not allow this type of activity in a marine wetland.

The next step in technical evaluations would involve hydrodynamic and water quality modeling by the Massachusetts Estuaries Project to determine the level of pumping needed to increase the nitrogen assimilative capacity of the estuary and thereby increase the allowable nitrogen load. It is unlikely that the Massachusetts Estuaries Project would even agree to conduct such modeling.

This concept is believed to be infeasible from a regulatory approval perspective. If there is interest in evaluating this concept further, the water quality model should be utilized to investigate the water quality benefits.

8.7 POND TREATMENT OPTIONS

The Pond Action Plan in the Needs Assessment Report reviewed many treatment and management options for ponds. This section provides further screening of the treatment options.

Pond treatment options are designed to manage, chemically bind, or remove the phosphorus that cycles internally in the pond to minimize algal growth and other impacts of eutrophication. There are three primary techniques to manage phosphorus in this way:

1. Aeration and/or water circulation devices to enhance water clarity and accelerate the rate of decomposition of organic matter in the sediments.

2. Alum application to sweep dissolved phosphorus from portions of the water column and to seal bottom sediments and prevent phosphorus release.

3. Selective dredging to deepen ponds and remove organic matter with the associated phosphorus content.

Brief descriptions of these primary options with benefits and drawbacks are summarized in Appendix 8-1. These options are described in greater detail in a 2004 document entitled *"The Practical Guide to Lake Management in Massachusetts,"* This reference also identifies many additional (less feasible) pond treatment and management options, including reverse layering, algae and macrophyte harvesting techniques, and use of herbicides and algaecides. Interested readers are directed to this comprehensive source.

These options should be considered as the Pond Action Plan proceeds. Often these technologies are considered on a pond by pond basis as part of a Remedial Investigation and Feasibility Study.

8.8 MODIFIED ZONING OR SEWER USE REGULATION

Following sewer installations in any of the planning areas, increased growth could conceivably occur as a direct result of the removal of the current growth limitation that on-site systems may have provided. Currently, Title 5 regulations control the number of bedrooms allowed per acre. If these areas are sewered, the Title 5 regulations may no longer apply. To counteract this potential increased growth, zoning modifications could be instituted to regulate development and remain in accordance with the Town's LCP. Zoning modifications can also be used to limit growth in other areas to prevent future nitrogen discharges into sensitive embayments. These zoning modifications could include increasing the allowable minimum lot sizes and establishing restrictions on building sizes and uses.

MassDEP is currently (May 2011) revising the State Revolving Fund (SRF) regulations (310 CMR 44) to encourage towns to adopt landuse controls to limit wastewater flows from sewered areas. These landuse controls are often called "Growth Neutral" or "Flow Neutral" requirements. The landuse controls would be subject to the review and approval of MassDEP in consultation with the Department of Housing and Economic Development (MassDHED) as a prerequisite for a 0% low interest loan from the SRF. If the landuse controls do not meet MassDEP or MassDHED requirements, the town would receive a higher interest rate (typically 2%) depending on the other funding rules at the time of SRF application. These regulations are expected to be finalized by the end of 2011.

These revised regulations are a result of the "Environmental Bond Bill" Chapter 313 of the Acts of 2008 (also known as the O'Leary Bill) to allow towns to receive 0% low interest loans for wastewater infrastructure projects that meet specific requirements such as the Flow Neutral requirement identified above. The four other primary requirements are:

1. The project must be primarily intended to remediate or prevent nutrient enrichment of a surface water body or a source of water supply;

2. The applicant is not currently subject, due to a violation of a nutrient-related total maximum daily load standard or other nutrient based standard, to a MassDEP enforcement order, administrative consent order or unilateral administrative order, enforcement action

by the United States Environmental Protection Agency, or subject to a state or federal court order relative to the proposed project;

3. The applicant has a Comprehensive Wastewater Management Plan (CWMP) approved pursuant to regulations adopted by MassDEP;

4. The project has been deemed consistent with the regional water resources management plans if one exists.

Once the regulations are promulgated, applicants will need to demonstrate that they meet the five requirements through an application process.

The Town's Growth Management Department has been evaluating this issue and is interested in adopting a sewer use regulation similar to that adopted for sewer service areas in Chatham and Falmouth to limit future growth in the planning area. This work is ongoing.

8.9 NITRATE BARRIER WALL CONSIDERATIONS

The groundwater system in the planning area watershed carries nitrogen from the various watershed sources (septic systems, fertilizers, stormwater, atmospheric deposition, etc.) to the estuaries where the nitrogen causes water quality problems. Barrier wall technology has been identified as a possible method to treat the nitrogen in the groundwater before it recharges to the marine waters.

This concept would involve the construction of a "permeable wall" of reactive material that would allow the groundwater to flow through but would react with the nitrate in the groundwater and convert it to nitrogen gas. The reactive material would be NITREX® patented media (as discussed in Chapter 3) that would reduce the dissolved oxygen in the groundwater and supply organic carbon to a level where biological denitrification would occur. The barrier wall would need to be constructed the full length of the estuary's shoreline where groundwater recharges to the marine water. It would need to be deep enough to prevent any nitrogen-laden groundwater from going under the wall.

The technology has been studied by a group of scientists led by Dr. Joseph Vallino and Dr. Kenneth Foreman of Marine Biological Laboratory. Funding has been provided to conduct two pilot studies of the technology at the Waquoit Bay watershed.

The technology does not appear to be ready for full-scale application due to the following questions/issues:

1. Affects of salt water flooding of the NITREX® media.

2. Feasibility of installing the wall deep enough to prevent the nitrogen-laden groundwater flowing under the wall.

3. Full understanding of the nitrogen removal mechanism (denitrification versus nitrogen immobilization) occurring at the NITREX® material.

The ability to permit this concept with the associated soil borings (for system design and long-term monitoring) and excavation (for wall installation) is still an unresolved issue. This work would need to occur in close proximity to the marine waters (in areas subject to the Wetlands Protection Act) and on private property. Due to these unresolved issues, this concept requires additional scientific research before it can be further considered for the Barnstable Nutrient Management Project.

8.10 PHOSPHORUS BARRIER WALL CONSIDERATIONS

This option would involve the placement of a barrier wall between the upgradient portion of a pond watershed and the pond by excavating a trench and filling it with reactive media. The media would most likely contain reactive metallic media such as iron or aluminum that have a great affinity for soluble phosphorus and would be porous to groundwater flow.

This type of approach has commonly been used to intercept chlorinated hydrocarbon plumes. Also, it has been used on Cape Cod to intercept a phosphorus plume emanating from the Massachusetts Military Reservation (MMR) upgradient of Ashumet Pond in Falmouth, MA. The plume originated from a wastewater treatment plant that had recharged treated effluent (with minimal phosphorus removal) upgradient of the pond for over 50 years. Much information is

available on the project at the USGS web site: (http://toxics.usgs.gov/topics/rem_act/phosphorus_plume.html) or at the MMR web site: (http://mmr.org/construction/ashpondgeoproj_summaries.htm).

This phosphorus management option is very experimental and has rarely been used. It would cause significant disruption along the shoreline and would require significant hydrogeologic and engineering study before it could proceed. It should only be considered as part of a remedial investigation and feasibility study.

8.11 AQUACULTURE TO HARVEST NITROGEN AND/OR ALGAE FROM THE ESTUARIES

This management concept would utilize aquaculture to harvest the nitrogen and/or algae and shellfish from the estuaries, which would improve water quality and could produce a valuable product. This concept has three main variations:

- Aquaculture of marketable sea plants that would remove nitrogen from the water column and have a value in the food and cosmetics market.
- Harvest of the naturally occurring algae and production of a biofuel or other product.
- Shellfish aquaculture to support the fishing community on Cape Cod and to convert the algae (and its nitrogen) to shellfish meats that would be removed from the system and to foster increased environmental nitrogen cycling and removal.

Each of these concept variations is discussed below.

Aquaculture of marketable sea plants would involve the allocation of aquaculture grants (areas of the estuary) where aquaculturists could grow the plants in sufficient quality to remove a measurable mount of nitrogen from the water column which would, in turn, reduce the production of naturally occurring algae that impacts water quality. There currently is no aquaculture of this type on Cape Cod but it does exist in Maine and Canada (kelp production) and in other parts of the world. Nitrogen removal rates would depend on the type of sea plants produced and harvested and the area committed to the production of these plants. Significant research and demonstration projects on Cape Cod would be needed before this type of

aquaculture could be incorporated into a municipal program to meet TMDLs, but it may hold promise in the future.

The harvest of naturally occurring algae and production of a biofuel or other products is being researched by large energy companies and universities, but its commercial viability is uncertain. Fresh water weeds (rooted aquatic plants) are often harvested to maintain fishing, boating, and swimming areas in freshwater ponds and lakes. The plant material is typically composted and used by farms. Research has indicated that this technique would not easily be applied to algae harvest in the estuaries because the alga is typically suspended in the water. Also, the harvesting equipment would be cost prohibitive because it would need to be constructed of expensive material (stainless steel) to withstand the corrosive environment of the marine waters

Shellfish aquaculture is an established industry on Cape Cod; it employs many fishermen; and it produces valuable shellfish. It is believed that shellfish aquaculture could also remove significant amounts of nitrogen from the water column due to the shellfish filtering the algae (with its nitrogen content) from the water for use as food. Also, the shellfish waste product may be in a form that is more easily denitrified to nitrogen gas. Significant research has been completed and indicates that shellfish aquaculture may have technical feasibility to reduce nitrogen in the estuaries while it is meeting other goals of fisheries development. Appendix 8-2 contains three papers which discuss this feasibility. Two of the papers are quite technical, while the third is written by a water resource planner (W. Wilcox) on Martha's Vineyard and is written for the lay person. Several of Mr. Wilcox's points are listed below.

- An adult oyster can filter and pump 20 to 50 gallons of water per day. A portion of the algae filtered from the water is converted into shellfish meat.
- 13 to 27 kilograms of nitrogen are removed for every 1,000 kilograms of shellfish meat harvested.
- An adult oyster contains 0.5 grams of nitrogen in its tissue and shell.
- The bio-deposits from oysters foster significant conversion of the organic nitrogen of the algae filtered from the water to nitrogen gas released to the environment.
- Research indicates that an oyster can convert and remove (meat harvest and bio-deposit conversion) approximately 1.2 grams of nitrogen during its three year lifetime.

- The harvest of 3,750 oysters is estimated to compensate for the nitrogen waste from one person.

The technical feasibility of this concept depends on the number of oysters that would need to be grown to remove a measurable amount of nitrogen and to produce a measurable improvement in water quality. The institutional feasibility depends on the availability of significant areas of the estuaries to be dedicated to this type of aquaculture, and the ability of the regulatory agencies to recognize the benefits of this type of nitrogen management approach to meet nitrogen TMDLs. Research continues on this concept and it should be recognized as a "nitrogen sink" in the estuaries by the regulators at any scale of development. The development of intensive shellfish aquaculture should also be considered as part of the town's nitrogen planning process.