TOWN OF ORLEANS

COMPREHENSIVE WASTEWATER MANAGEMENT PLAN

DRAFT

ALTERNATIVES SCREENING REPORT

December 2007

WRIGHT-PIERCE
Engineering a Better Environment

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COMPREHENSIVE WASTEWATER MANAGEMENT PLAN
ALTERNATIVES SCREENING REPORT

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EXECUTIVE SUMMARY

1.0 INTRODUCTION

The Town of Orleans has embarked on a multi-year, multi-phase process to determine if improved methods of wastewater management are needed, and if so, what those improved methods would entail and what they would cost. The process has been called Comprehensive Wastewater Management Planning, and the result will be a Comprehensive Wastewater Management Plan or CWMP. The CWMP will be prepared in phases, each with a separate report:

- **Needs Assessment**
- **Development and Screening of Alternatives**
- **Detailed Evaluation of Alternatives**
- **Development of Recommended Plan**

The Needs Assessment was summarized in a draft report dated February 2007 and was the subject of a public meeting on February 26, 2007.

In formulating a wastewater management plan, it is useful to think of its major components: collection, treatment and disposal. In this phase of the project, the Town has considered the options available for each of these components, selected the most viable ones, and used those to assemble a large number of overall plans. Those plans were then evaluated with respect to a number of important criteria, and three plans were chosen for more detailed review in the next phase of the project.

This Executive Summary presents key findings of the Alternatives Screening phase, organized by major report section. The reader will find more detail on each subject by referring to the specific section of the full report and associated appendices.

2.0 IDENTIFICATION AND EVALUATION OF WASTEWATER PLAN COMPONENTS

2.1 Wastewater Flows and Loads

In the first phase of the CWMP project, wastewater needs were evaluated in five categories for each of the four major watersheds in Orleans. It was determined that the addressing of all documented needs would require the collection of 517,000 gallons of wastewater per day (gpd, annual average), approximately 65% of all wastewater generated under current circumstances. At the end of the 20-year planning horizon, growth in town is expected to cause that wastewater volume to increase to 750,000 gpd.

Categories of Wastewater Management Needs

1. Sanitary
2. Water Supply Protection
3. Surface Water Protection
   - Ponds
   - Estuaries
4. Convenience & Aesthetics
5. Economic Development

Several methods were evaluated to reduce wastewater flow, or slow its growth. The measures that should be pursued in Orleans are: 1) low-flow plumbing fixtures; 2) progressive water pricing; 3) use of outside showers; and 4) elimination of garbage grinders. See Section 2.1 and Appendix A.

2.2 Wastewater Collection

A conventional gravity sewer system is the most practical and economical choice for Orleans. It should be supplemented by grinder pumps and low-pressure sewers to serve those homes were topography does not allow simple gravity connections. See Section 2.2 and Appendix B

As the wastewater collection system is laid out, the overall goal should be the cost-effective elimination of septic systems to protect embayments from excess nitrogen loading and to protect ponds from excess phosphorus loading. The secondary goal is to address other wastewater management needs. The Town should first connect those lots near sensitive ponds and embayments, those lots with the highest nitrogen loads, and those neighborhoods with the highest wastewater flows per street-mile. Other considerations include addressing remaining wastewater management needs, serving lots with high costs for Title 5 replacement, and planning for future sewer system expansion.

2.3 Wastewater Treatment

Wastewater treatment systems must be capable of meeting the traditional limits imposed by DEP under its Groundwater Discharge Permit program. Higher levels of treatment may also be warranted for cost-effective nitrogen control and for reuse of effluent. For centralized wastewater options, the preferred treatment technologies are: 1) sequencing batch reactors, 2) oxidation ditches, 3) membrane bioreactors (MBRs), and 4) biological aerated filters. Technologies for smaller decentralized treatment include: 1) Bioclere, 2) Amphidrome, 3) FAST, 4) MBRs, and 5) Cromoglass. See Section 2.3 and Appendix C.

Any wastewater plan must also include a cost-effective and environmentally-sound method for handling the residual solids that are created in treatment, including septage and liquid sludges from decentralized facilities. Orleans' best option for residuals management is to include septage receiving in any new wastewater plant, where septage and sludge solids can be dewatered for out-of-town disposal.

2.4 Wastewater Reuse and Disposal

The most feasible and effective effluent disposal technologies are: 1) subsurface leaching, 2) rapid infiltration in open sand beds, and 3) spray irrigation on vegetated surfaces. New technologies, including drip irrigation and wicks, may deserve consideration as adjuncts to these conventional methods. See Section 2.3 and Appendix D

The reuse of highly treated effluent allows the recycling of water and the nutrients remaining after treatment. Three types of reuse are allowed under the DEP Reclaimed Water Guidelines: 1) landscape irrigation; 2) toilet flushing and 3) indirect aquifer recharge. Reuse opportunities of particular application to Orleans include: toilet flushing and lawn irrigation at public buildings, and irrigation of ballfields and golf courses.

2.5 Siting of Wastewater Treatment and Disposal Facilities

The Town's Geographic Information System was used to identify potential sites for wastewater treatment and disposal, with the goal of finding capacity for 3 million gallons per day as a short-term peak flow. Conceptual designs of effluent disposal systems were prepared for 25 sites that may have aggregate capacity exceeding that goal. While such a relatively large disposal capacity is a favorable finding, only one-third of the potential sites are owned by the Town or by quasi-municipal organizations, and there are very few large vacant sites that might accommodate centralized facilities. These findings indicate that the Town may need more than one disposal site and that dual use should be considered, such as spray irrigation of ballfields or subsurface leaching below large parking lots. A focused subsurface exploration program is warranted to confirm the capability of the best sites. See Section 2.5.

2.6 Non-Traditional Nitrogen Control Measures

While public sewers to eliminate nitrogen from septic systems may be the best single means of protecting surface waters, there are several non-traditional methods for addressing nitrogen loads that Orleans should evaluate further. These include: 1) control of lawn fertilization, 2) improved stormwater management, 3) control of development density through municipal bylaws and regulations, 4) optimization of natural attenuation processes, particularly in salt marshes, and 5) enhancing the flushing rates of restricted embayments. See Section 2.6 and Appendix E.

3. FORMULATION OF COMPOSITE WASTEWATER MANAGEMENT PLANS

3.1 Initial Plan Formulation

Over the course of 9 months, the Orleans Wastewater Management Steering Committee (WMSC) evaluated the available options for the wastewater plan components, reviewed technical reports on nitrogen loading to local embayments, met with DEP staff, and participated in the search for treatment and disposal sites. At the conclusion of this process, the WMSC formulated 9 composite plans. These 9 plans embody a range of wastewater solutions, including centralized and decentralized options, Orleans-only and regional systems, and both traditional effluent disposal and effluent reuse. See Section 3.1 for a description of the 9 plans.

3.2 Evaluative Criteria

As the WMSC developed these 9 wastewater plans, it also identified 16 criteria for evaluating these plans. Each plan was assigned a score for each criterion. Each of the WMSC members applied weighting factors to each criterion to reflect his/her own opinions as to their importance, and produced overall scores for the 9 plans. The highest scores were associated with wastewater facilities at the site of the existing Tri-Town Septage Treatment Facility, but by only a small margin over several other plans. This rating exercise helped to focus WMSC thinking on the nature of the best options for Orleans. See Section 3.2 and Appendix F.

Evaluative Criteria Used in Rating Wastewater Plans

- Overall Cost
- Use of Proven Technology
- Regulatory Acceptability
- Environmental Impact
- Energy Consumption
- Ease of Operation
- Production of Residuals
- Overall Public Acceptability
- Need for Land Purchase and/or Easements
- Potential for Neighbor Impacts
- Benefits from Natural Attenuation
- Retention of Water in Water Supply Area
- Removal of Contaminants of Emerging Concern
- Nitrogen and Phosphorus Removal
- Expandability for Regionalization
- Extent of Collection System

3.3 Wastewater Plans Recommended for Detailed Evaluation

Of the nine identified wastewater plans, three were selected for detailed review. All plans include collection of wastewater from all three major watersheds to satisfy all identified needs. The plans are:

Plan 1: Collection of wastewater and transport to 3 new decentralized wastewater treatment plants, with the balance taken to a new plant at the Tri-Town site, with effluent disposal by rapid infiltration at the Tri-Town site and by subsurface leaching at seven sites at or near the decentralized plants.

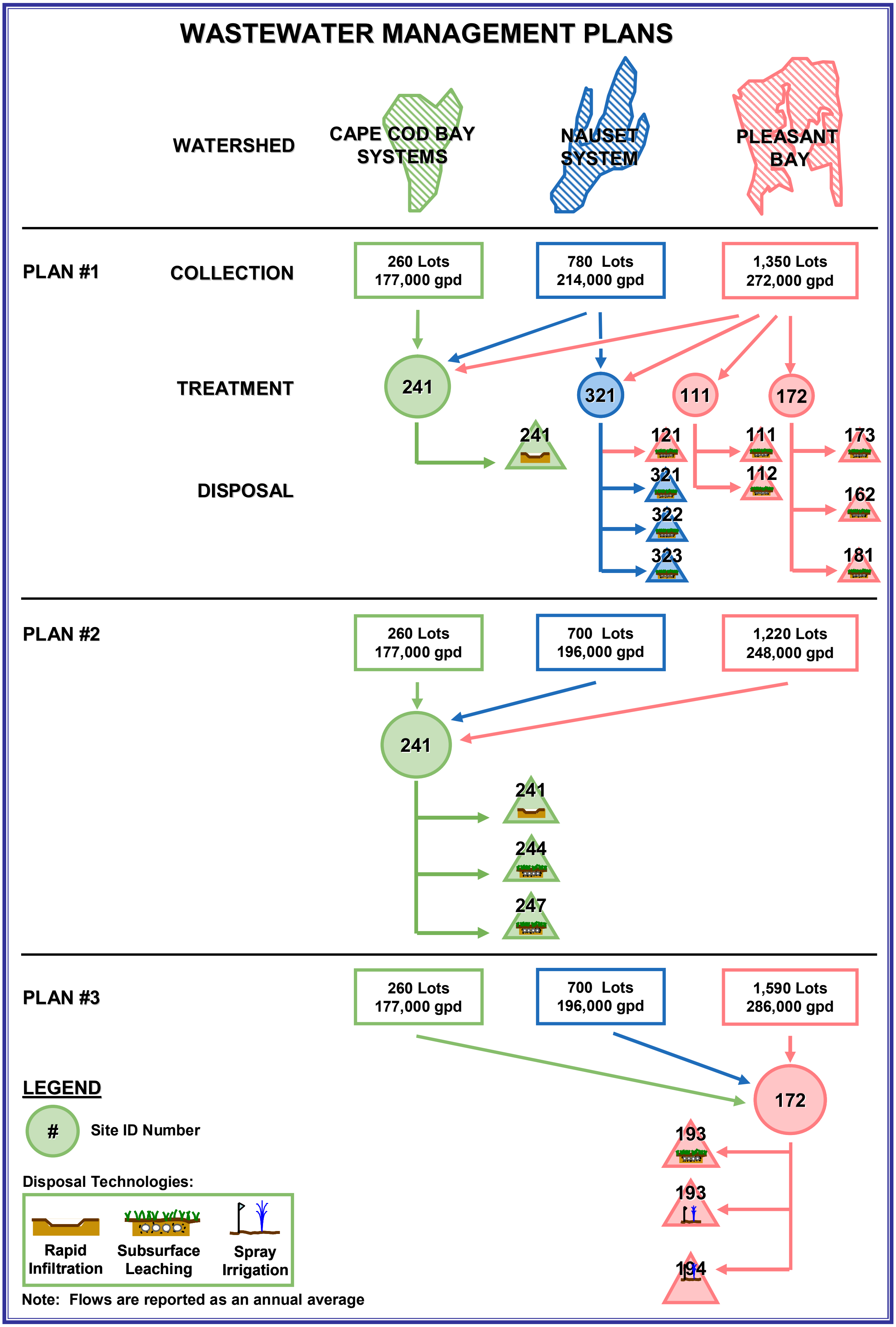
Plan 2: Collection of wastewater and transport to a new wastewater treatment plant at the Tri-Town site, with effluent disposal by rapid infiltration at the Tri-Town site and by subsurface leaching or rapid infiltration at one or two other nearby sites.

Plan 3: Collection of wastewater and transport to a new wastewater treatment plant in South Orleans, with effluent disposal at one or two golf courses in Brewster/Harwich (spray irrigation in warm months, subsurface leaching during remainder of year).

The evaluative process highlighted the importance of regionalization and effluent reuse, and these two factors will be considered as sub-options for each of the three plans described above. It is important to note that none of the 9 original plans was "eliminated". The three plans, together with the parallel investigations of reuse and regionalization, represent all 9 original plans. These three wastewater management plans are the recommended focus of the next phase of the CWMP. Each plan will be evaluated in detail, cost estimates will be prepared, environmental impacts will be identified, and a single plan will be chosen.

Comparison of Wastewater Plans

	Plan 1	Plan 2	Plan 3
Wastewater Collection			
Properties served			
Cape Cod Bay watersheds	260	260	260
Nauset System watershed	780	700	700
Pleasant Bay watershed	1,350	1,220	1,590
Total	2,390	2,180	2,550
Annual average wastewater flow, gpd	663,000	621,000	659,000
Wastewater Treatment			
Number of plants	4	1	1
Location and capacity (mgd) of plants			
Cape Cod Bay watersheds	1 @ 1.0 mgd	1 @ 1.5 mgd	
Nauset System watershed	1 @ 0.3 mgd		
Pleasant Bay watershed	1 @ 0.2 mgd 1 @ 0.1 mgd		1 @ 1.6 mgd
Wastewater Disposal			
Number of sites			
Cape Cod Bay watersheds	1	3	0
Nauset System watershed	3	0	0
Pleasant Bay watershed	6	0	2
Total	10	3	2
Technology	rapid infiltration subsurface leaching	rapid infiltration subsurface leaching	spray irrigation subsurface leaching
Septage and Sludge Handling			
Septage receiving location	Tri-Town site	Tri-Town site	Tri-Town site
Liquid sludge dewatering	Tri-Town site	Tri-Town site	Tri-Town site
Dewatered sludge disposal	Out-of-town	Out-of-town	Out-of-town
Land Acquisition			
Number of sites			
Treatment	3	0	1
Disposal	9	2	2
Total	12	2	3


WASTEWATER MANAGEMENT PLANS
WATERSHED
CAPE COD BAY SYSTEMS
NAUSET SYSTEM
PLEASANT BAY
PLAN #1
COLLECTION
260 Lots 177,000 gpd
780 Lots 214,000 gpd
1,350 Lots 272,000 gpd
TREATMENT
241
321
111
172
DISPOSAL
241
121
321
322
323
111
112
173
162
181
PLAN #2
260 Lots 177,000 gpd
700 Lots 196,000 gpd
1,220 Lots 248,000 gpd
241
241
244
247
PLAN #3
260 Lots 177,000 gpd
700 Lots 196,000 gpd
1,590 Lots 286,000 gpd
172
193
193
194
LEGEND
#
Site ID Number
Disposal Technologies:
Rapid Infiltration
Subsurface Leaching
Spray Irrigation
Note: Flows are reported as an annual average

SECTION 1
INTRODUCTION

The Town of Orleans has embarked on a multi-year, multi-phase process to determine if improved methods of wastewater management are needed, and if so, what those improved methods would entail and what they would cost. The process has been called Comprehensive Wastewater Management Planning, and the result will be a Comprehensive Wastewater Management Plan, or CWMP. The CWMP process is being conducted in 5 phases, as follows:

Phase 1: Project Administration and Support
Phase 2: Data Review and Scoping
Phase 3: Needs Assessment
Phase 4: Development and Screening of Alternatives
Phase 5: Detailed Evaluation of Alternatives, Regulatory Filings, and Development of Recommended Plan

Phase 2 was completed in late 2005, allowing the start of technical work on later phases. The Needs Assessment Report (Phase 3) was issued in draft form in February 2007 and was the subject of a public hearing on February 26, 2007. This current report summarizes the approach and findings of Phase 4. The alternative wastewater management plans identified in this report will be the subject of more detailed investigation in Phase 5, which will start in late 2007 and be completed in 2008. Phase 1 includes activities that span all other phases.

The Town has elected to call this process Comprehensive Wastewater Management Planning. Other related terms in use in the industry include Comprehensive Water Resources Planning and Integrated Water Resource Planning. The Town has chosen the CWMP title for consistency with Town Meeting appropriations, requests for proposals and engineering agreements. Its intention is to incorporate many of the broader aspects implicit in the alternative titles.

Orleans is blessed with significant access to marine resources, with frontage on Pleasant Bay, the Atlantic Ocean, Nauset Inlet and Cape Cod Bay. Whenever possible, this and prior reports present both town-wide data and information specific to the areas in Orleans tributary to those water bodies. These major watersheds are the fundamental building blocks of this analysis; their geographic extent is shown in Figure 1-1.

SECTION 2

IDENTIFICATION AND EVALUATION OF WASTEWATER PLAN COMPONENTS

A municipal wastewater system has three principal components, as illustrated in Figure 2-1:

- Collection
- Treatment
- Disposal or Reuse

This section of the report identifies and evaluates feasible options applicable to Orleans for each of these components. It also looks into methods to reduce current and future wastewater flows and associated pollutant loads so that each component can be smaller and less expensive. Also reported are the results of a search for sites for wastewater treatment and disposal. The last portion of this section discusses non-traditional methods for reducing nitrogen loads from wastewater and other sources.

2.1 WASTEWATER FLOWS AND LOADS

Before alternative wastewater management options can be identified and evaluated, it is first necessary to confirm the quantities of wastewater that must be managed. It is also important to consider ways to reduce the wastewater volume, or manage its rate of growth, and to reduce the contaminants contained in the wastewater.

2.1.1 Summary of Wastewater Management Needs

The Needs Assessment Report was presented in draft form and subject to public comment in February 2007. Table 2-1 is a summary of that assessment. For each of the major watersheds in

FIGURE 2-1

GENERIC WASTEWATER MANAGEMENT SYSTEM

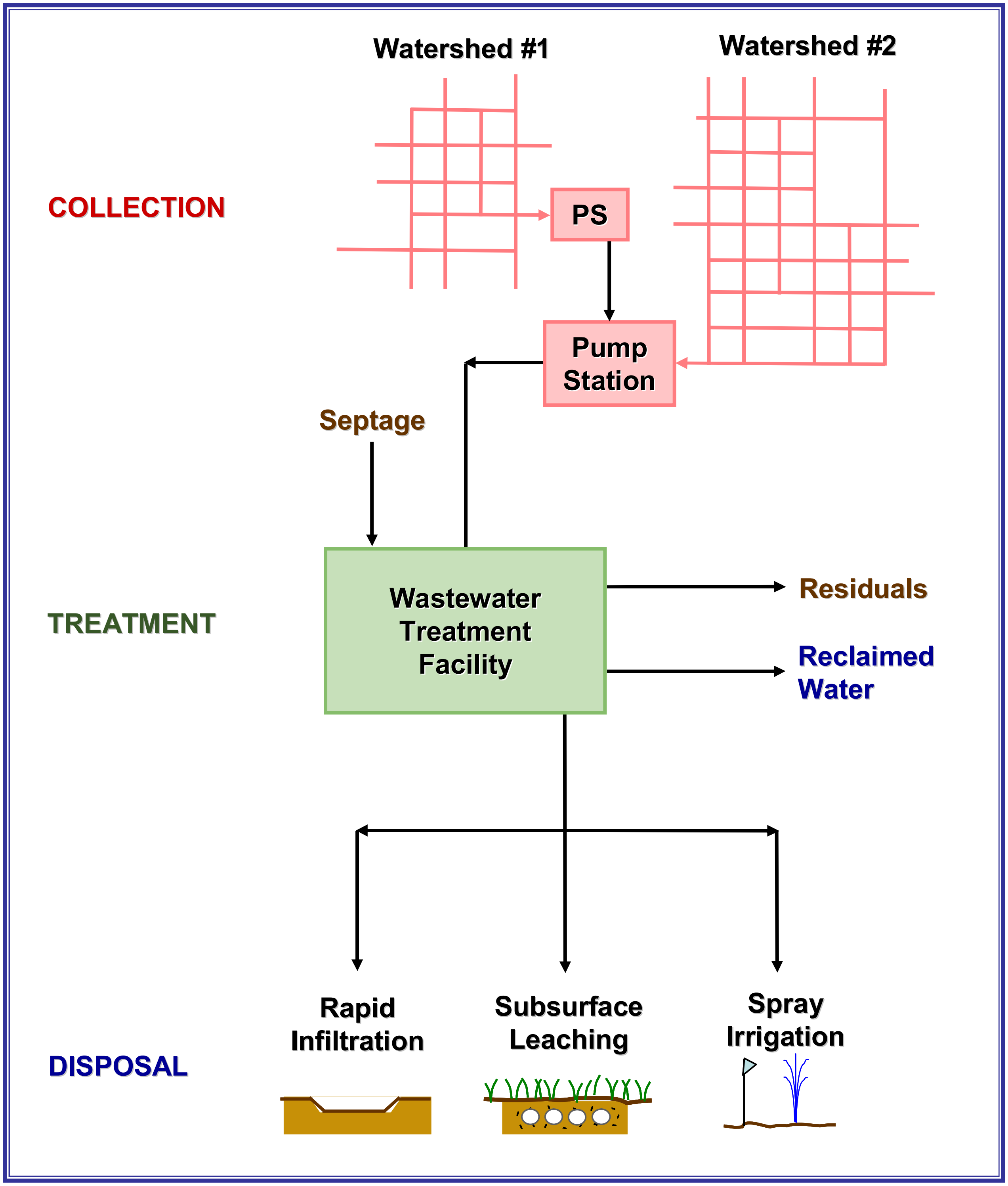


TABLE 2-1

SUMMARY OF WASTEWATER MANAGEMENT NEEDS

NEEDS CATEGORY	WATERSHED				
	CAPE COD BAY	NAUSET SYSTEM	ATLANTIC OCEAN	PLEASANT BAY	TOWN-WIDE
Sanitary					
Number of Parcels	66	79	5	48	198
Current Flow, gpd	78,900	63,500	3,900	16,100	162,400
Future Flow, gpd	97,300	77,500	4,800	19,600	198,200
Water Supply Protection					
Number of Parcels	0	0	0	0	0
Current Flow, gpd	0	0	0	0	0
Future Flow, gpd	0	0	0	0	0
Surface Water Protection (ponds)					
Number of Parcels	0	9	0	50	59
Current Flow, gpd	0	2,400	0	5,800	8,200
Future Flow, gpd	0	3,300	0	9,800	13,100
Surface Water Protection (estuaries)					
Number of Parcels	220	790	0	1,480	2,490
Current Flow, gpd	57,000	155,000	0	200,000	412,000
Future Flow, gpd	107,000	217,000	0	277,000	599,000
Convenience and Aesthetics					
Number of Parcels	40	39	6	29	120
Current Flow, gpd	53,900	36,500	4,700	9,600	104,700
Future Flow, gpd	72,000	44,500	6,100	11,700	134,300
Economic Development					
Number of Parcels	5	5	0	0	10
Current Flow, gpd	0	0	0	0	0
Future Flow, gpd	8,600	8,600	0	0	17,200
Total					
Number of Parcels	257	838	11	1,544	2,650
Current Flow, gpd	103,700	191,500	8,600	213,200	517,000
Future Flow, gpd	175,700	270,500	10,900	293,100	750,200

Note: Town-wide totals are additive across the row. Totals by major watershed are not additive by column. The category total by watershed accounts for parcels that have more than one need. The number of parcels does not reflect possible subdivisions.

Source: See Needs Assessment Report, February 2007 Draft.

Orleans, this table documents the number of parcels and the current and projected future wastewater flows for five categories of need, as follows:

1. Ensuring sanitary conditions
2. Protection of public and private drinking water supplies
3. Protection of surface waters against nutrient enrichment
    - Nitrogen loading to embayments
    - Phosphorus loading to freshwater ponds
4. Addressing convenience and aesthetic issues
5. Enabling sustainable economic development

It is clear from Table 2-1 that the control of nutrient loading to surface waters (specifically nitrogen loading to embayments) is the principal wastewater need in Orleans. Surface water protection accounts for a large fraction of needs in the Pleasant Bay and Nauset estuary systems. In the Cape Cod Bay watersheds, nitrogen control, sanitary issues and convenience/aesthetics are all significant.

It is important to recognize that the nitrogen control needs in the Cape Cod Bay and Nauset systems, as reported in the February 2007 draft Needs Assessment are based on "placeholder" estimates, given the fact that the Massachusetts Estuaries Project (MEP) technical reports for these systems had not been issued. In the interim, MEP technical reports have been issued in draft form that generally support the placeholder value for the Cape Cod Bay systems. No new information is yet available on the Nauset system.

2.1.2 Strategies for Reductions of Flows and Loads

As technologies are identified to address the needs summarized in Table 2-1, it is appropriate to ask: "Could the costs for satisfying these needs be reduced if the quantities of wastewater or the associated pollutant loads were reduced at the source?"

"Wastewater flows" are the volumes of wastewater generated over a given time period, expressed in such units as gallons per day (gpd). "Wastewater loads" are the quantities of pollutants contained in the wastewater, expressed in mass-per-time units such as pounds per day.

Table 2-2 lists all of the alternative wastewater components that have been considered in this report. The first column of that table summarizes the wastewater flow and load reduction measures that may be appropriate to Orleans. These options are discussed in detail in Appendix A. The highlighted technologies in Table 2-2 are those considered most applicable to Orleans and are candidate "building blocks" for composite wastewater management plans. These options are:

Low-flow plumbing fixtures: Low-flow washing machines and sink and shower fixtures are now readily available that can reduce water consumption by at least 10% over older devices. Reducing water consumption with modern fixtures will reduce the wastewater production, save costs for wastewater treatment and disposal, and perhaps reduce the number of effluent disposal sites that must be developed.

Outside showers: Outdoor showers are widely used on Cape Cod in the summer time. This current practice provides a significant reduction in wastewater generation by removing this otherwise indoor activity from the wastewater stream. If this practice is continued and expanded, there will be attendant benefits to wastewater system sizing and cost.

Progressive water pricing: Water service pricing is an effective tool for promoting flow reduction. A progressive pricing structure includes fees that are based on the size of the service and the quantity of water used. The larger the service connection, the higher the quarterly fee. The quantity of water used is billed incrementally. Generally, the first fee bracket covers the majority of the water used in a water-conserving single-family residence. Subsequent brackets are associated with higher fees. Water pricing can also vary seasonally. It is feasible to charge increased rates in the summer when demand is the highest. All of these practices can provide an economic incentive to reduce water consumption and subsequently reduce wastewater generation rates and wastewater management costs.

TABLE 2-2
SUMMARY OF ALTERNATIVES FOR
WASTEWATER MANAGEMENT COMPONENTS

Flow and Load Reduction	Wastewater Collection	Wastewater Treatment	Effluent Disposal	Effluent Reuse	Non-Traditional Nitrogen Control
Low-flow Plumbing	**Conventional Gravity**	**Large Scale**	**Subsurface Leaching**	**Landscape Irrigation**	**Fertilizer Controls**
Progressive Pricing	Low Pressure STEP	**Sequencing Batch Reactors**	**Rapid Infiltration**	**Toilet Flushing**	**Stormwater Management**
Outside Showers	**Grinder Pumps**	**Oxidation Ditches**	**Spray Irrigation**	Aquifer Recharge	**Density Controls**
Waterless Toilets	Small diameter	Rotating Biological Contactors	**Drip Irrigation**		**Natural Attenuation**
Eliminate Garbage Grinders	Vacuum	**Membrane Bioreactors**	Wicks		Permeable Barriers
		Biological Aerated Filters			**Flushing Enhancements**
		Small Scale			Sediment removal or Alteration
		Amphidrome			Aquaculture
		Bioclere			
		FAST			
		Nitrex			
		Chromoglass			

Legend:
Included in plans for more detailed review
Not evaluated further

Elimination of Garbage Grinders: Disposing of food waste through garbage grinders adds pollutant load to the wastewater stream. Instituting a ban on this practice, or enforcing existing such rules, will help reduce the cost of wastewater management. Conventional wastewater constituents would be reduced by about 25% and nitrogen load would be reduced by about 5%.

(Removing food waste from the wastewater stream means that it must be incorporated into an alternative waste stream, such as municipal refuse or home composting. Proper disposal or reuse of food waste is important to prevent nutrients from reaching receiving waters by other means.)

There is a disincentive for garbage grinder use built into Title 5. Homes that have garbage grinders are required to have two-compartment septic tanks and to oversize their leaching systems by 50%. That disincentive disappears when a homeowner ties into a public sewer system. The Orleans Board of Health should institute a ban on garbage grinders to both sewered and unsewered properties, and the public outreach program associated with this CWMP should emphasize the importance of this ban.

Waterless toilets were investigated as a means of reducing both wastewater flows and pollutant loads. While some significant benefits may accrue, this option is not likely to gain sufficient public acceptability for it to be widely used. It has not been carried forward as a formal part of this program, but may have applicability in certain circumstances in Orleans.

2.2 WASTEWATER COLLECTION

To address the wastewater needs identified in Orleans, wastewater from certain homes and businesses must be collected and conveyed to one or more locations for treatment and disposal. The collection system is a major structural component of a municipality's wastewater management system. The best type of collection system for a given community is determined by comparing use, capacity, costs, operation and maintenance requirements, and benefits to the specific environment and landscape. The collection system includes all components from the source of the wastewater (typically the internal building plumbing) to the treatment plant. (The pipe from the home or business to the public system in the street is called the "service connection" and it is usually the responsibility of the property owner.) With some collection system options, the publicly-owned system may include components on the property to be served.

In addition to selecting collection technology, Orleans must also develop a strategy for determining which properties will be served by the collection system.

2.2.1 Collection System Options

As listed in Table 2-2, the proven technologies for wastewater collection include conventional gravity systems, low pressure (STEP and grinder pump) systems, vacuum systems, and small diameter gravity systems. Appendix B provides a detailed description of each of these options, lists their advantages and disadvantages, and provides local examples.

This evaluation of alternatives has identified the most appropriate system for Orleans; see the highlighted technologies in Table 2-2. The Town should plan to use a conventional gravity sewer system, supplemented with grinder pumps and low pressure sewers in those locations where gravity system is expensive or environmentally disruptive. This choice provides ease in long-term maintenance, cost-effectiveness, lowest energy use and the best ability to deal with power outages.

2.2.2 Criteria for Identifying Properties to be Served

The Needs Assessment has shown that nitrogen control is the largest driving factor for municipal wastewater systems. In certain areas of town, sanitary needs, pond protection, and convenience/aesthetic factors also come into play. As town-wide plans are developed, certain criteria should guide the layout of a wastewater collection system. Important considerations include:

- Connect the lots with the highest wastewater nitrogen load per lot. The Town's lot-by-lot database will allow for the identification of those parcels with the highest water use which generally indicates the highest wastewater nitrogen load. If, say, a 65% nitrogen load reduction is required is a certain watershed, it should be possible to achieve that goal with fewer than 65% of the properties sewered.

- Connect all commercial lots in areas with nitrogen needs. These parcels tend to have higher-than-average water use and may have higher nitrogen concentrations in their effluents.
- Focus on those streets with the highest wastewater flow per mile of street length. This approach should result in the most "efficient" sewer systems, that is, the least amount of pipe per property served.
- Give priority to lots closest to the embayment or pond to be protected, preferably within the 10-year groundwater travel time.
- Other factors being equal, avoid those neighborhoods requiring grinder pumps or numerous conventional pump stations. (Note that this goal may be contrary to focusing on lots nearest the shore from a travel-time perspective.)
- Provide sewer service that can address multiple needs. That is, try to include those parcels with sanitary or other non-nitrogen needs as part of the overall nitrogen-control goal. Even where a documented need does not exist, try to include those properties that face high costs for future Title 5 replacement.
- Consider opportunities for natural attenuation of nitrogen in wetland systems (avoid reliance on ponds for natural attenuation due to potential for negative impacts).
- Locate neighborhoods that could be easily added to the core system when growth dictates the expansion of the system to offset new nitrogen loads.
- Consider the locations of potential treatment sites to minimize transport costs.
- Consider connecting more properties than indicated by Orleans' strict pro-rata share of Pleasant Bay nitrogen control needs to account for areas in Brewster that are not easily served by public facilities.

When wastewater collection, treatment and disposal alternatives are combined into composite plans, these collection priorities should be accounted for.

2.3 WASTEWATER TREATMENT

Where high levels of nitrogen removal are required to protect estuarine water quality, wastewater treatment systems will be needed as the principal nitrogen control mechanism. Wastewater treatment can also provide high levels of phosphorus removal if necessary for pond protection. It is important to consider the likely effluent limitations that will govern wastewater treatment, the proven technologies available to meet those limits, and the handling of residual solids that are a byproduct of treatment.

2.3.1 Effluent Limitations and Expected Performance

The selection of technologies for wastewater treatment must be driven by two goals:

- Adherence to effluent limitations established by a DEP Groundwater Discharge Permit and
- Ability to achieve low effluent nitrogen concentrations to ensure TMDL compliance at the lowest possible cost.

Table 2-3 summarizes the effluent limits that have been established by DEP for a range of applications, as well as assumptions related to the phosphorus limits that might also be put in place in the future. Table 2-3 addresses the conventional parameters, such as Biochemical Oxygen Demand (BOD) and Total Suspended Solids (TSS), as well as the principal nutrients of concern (nitrogen and phosphorus). The expected effluent limitations for these parameters are shown for 5 scenarios, as follows:

1. Traditional groundwater discharge permit standards, such as are in force for numerous small wastewater treatment plants across Cape Cod.
2. A higher level of nitrogen removal for those cases where this nutrient must be reduced to the minimum concentration achievable by current technology.
3. Conventional removal of phosphorus using low-cost chemical addition.
4. A higher level of phosphorus removal, as might be needed where phosphorus must be reduced to the lowest level possible with available technology; and
5. Effluent reuse standards, that apply to three categories of reuse (landscape irrigation, toilet flushing and aquifer recharge).

The traditional limits of a groundwater discharge permit are common and well established. The DEP's Reclaimed Water Guidelines define the reuse standards quite definitively. For phosphorus removal and the higher level of nitrogen control, there is much less precedent on the effluent limits. Therefore, it will be important to gain DEP's concurrence on the projected limits on phosphorus limits that might in the future be included in groundwater discharge permits.

The wastewater treatment technologies that are selected for more detailed evaluation must of course be capable of meeting the various standards shown in Table 2-3. As a practical matter, most technologies are capable of even better performance, and will be conservatively designed to meet the applicable standards with a safety margin. Since the embayments are sensitive only to annual average nitrogen loads, it is the average effluent concentration, not the monthly permit limit, that is pertinent to TMDL compliance. Therefore, in formulating composite wastewater systems for more detailed evaluation, it is important to predict the annual average performance of each technology. Table 2-4 presents information on the expected performance of conventional technologies at various sized plants.

The performance of any given wastewater technology is very size-dependent. The smaller the facility, the less its ability to adapt to changing influent flows and loads, which become relatively more pronounced at lower flows. For the smallest satellite plants, it should be assumed that the average performance will be very close to the permit limits. At plants greater than 200,000 gpd, the average effluent concentration will be 30 to 50% below the permit limits.

The performance estimates in Table 2-4 are very important. The extent of sewers needed to reach the TMDL, other things being equal, will be proportional to the average nitrogen concentration in the treatment plant discharge. That is, a collection system leading to a treatment plant with a 7-mg/l average nitrogen discharge will be about 10% smaller than a collection system leading to a plant with a 10-mg/l discharge. Therefore, it is very important to predict the average performance of these systems, and it is critical that DEP concur in these estimates.

TABLE 2-3
EXPECTED EFFLUENT LIMITATIONS

	Effluent Discharged to Groundwater				**5. Effluent Reuse**			
	1. Traditional GWD Permit	**2. High Level N Removal**	**3. Average P Removal**	**4. High Level P Removal**	**Landscape Irrigation***	**Toilet Flushing**	**Zone II Recharge <2-yr Travel**	**Zone II Recharge >2-yr Travel**
BOD, mg/l	30	30	30	30	10	30	10	30
TSS, mg/l	30	30	30	30	5	10	50	10
Nitrogen, mg/l								
Nitrate/Nitrite	10	5	10	10	---	---	---	---
Total	10	5	10	10	10	10	10	10
Oil & Grease, mg/l	15	15	15	15	15	15	15	15
pH, Standard Units	6.5 to 8.5	6.5 to 8.5	6.5 to 8.5	6.5 to 8.5	6 to 9	6 to 9	6 to 9	6 to 9
Phosphorus, mg/l	---	---	1.0	0.3	---	---	---	---
Turbidity, NTU								
Average	---	---	---	---	2	5	2	5
Maximum	---	---	---	---	5	5	5	5
Fecal Coliform, #/100 ml								
Mean	200	200	200	200	---	---	---	---
Median	---	---	---	---	0	---	0	0
Maximum	---	---	---	---	14	100	14	200

*Includes use at golf courses and landscape nurseries.

This concept also provides support for a phased program. If the Town moves forward with a treatment plant based on an expected effluent quality of 8 mg/l, and the plant actually produces 7 mg/l, then later phases of the program can be scaled back or deferred accordingly.

TABLE 2-4
EXPECTED EFFLUENT QUALITY

	Flow Range, gpd		Nitrogen, mg/l		Phosphorus, mg/l	
	From	To	Effluent Limit	Expected Performance	Effluent Limit	Expected Performance
Title 5 Systems						
Individual	400	2,000	None	35	None	10
Cluster	2,000	10,000	None	35	None	10
Title 5 Systems w/ Enhanced Treatment						
Individual	400	2,000	19	19	N/A	9
Cluster	2,000	10,000	19	15	5	5
Satellite Systems						
Small						
Traditional GWD Permit	10,000	25,000	10	10	N/A	9
High Level N Removal	10,000	25,000	N/A	N/A	N/A	9
P Removal	10,000	25,000	---	---	2	2
Medium						
Traditional GWD Permit	25,000	75,000	10	8	N/A	9
High Level N Removal	25,000	75,000	N/A	N/A	N/A	9
P Removal	25,000	75,000	---	---	1	1
Large						
Traditional GWD Permit	75,000	200,000	10	7	N/A	9
High Level N Removal	75,000	200,000	5	5	N/A	3
P Removal	75,000	200,000	---	---	1	0.5
High Level P Removal	75,000	200,000	---	---	0.3	0.3
Centralized Systems						
Traditional GWD Permit	200,000	1,500,000	10	7	---	---
High Level N Removal	200,000	1,500,000	5	3	---	---
P Removal	200,000	1,500,000	---	---	1	0.5
High Level P Removal	200,000	1,500,000	---	---	0.3	0.2

In some cases, phosphorus control is the primary concern with respect to surface water protection. Phosphorus removal from wastewater is easily achieved by chemical addition to the secondary or tertiary treatment process. Once a nitrogen removal technology is selected, an "add-on" for phosphorus removal is easily incorporated into the treatment design for those systems that serve areas tributary to freshwater ponds and lakes that require phosphorus load reduction. For this reason, this report focuses on a detailed evaluation of nitrogen-removing technologies.

An important decision in wastewater planning is the number and size of wastewater treatment facilities that will be developed. Many towns elect to build a single centralized plant. Other towns have developed decentralized systems that combine a number of small-scale plants. It is helpful to consider four categories of wastewater systems:

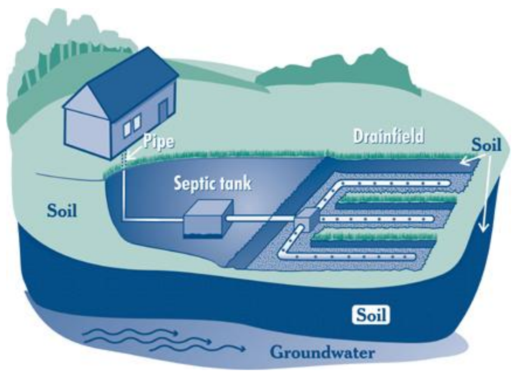
- Individual on-site systems,
- Cluster systems,
- Satellite plants, and
- Centralized plants.

These terms are defined and illustrated in Table 2-5. The first three types of systems are the building blocks of a decentralized system. Decentralized options are best suited to serving dispersed pockets of wastewater needs, because they reduce costs for transporting wastewater long distances. They also are well-suited for communities with no large sites for centralized plants.

This evaluation of wastewater treatment technologies looked separately at large-scale (design flows over 200,000 gpd) and small-scale (smaller than 200,000 gpd) applications. Large-scale options relate to centralized and larger decentralized plants. Small-scale technologies are applicable to decentralized plans.

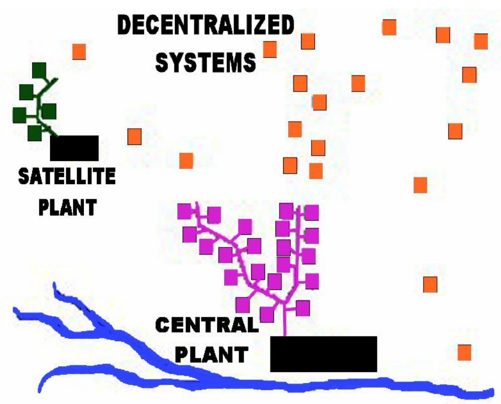
TABLE 2-5

GENERAL CATEGORIES OF WASTEWATER SYSTEMS



Individual On-site Systems: generally, septic tank and leaching field systems serving a single home or business, and located on the same parcel as the home or business. In Massachusetts, these are typically referred to as Title 5 systems, which imply treatment in a simple septic tank prior to discharge to a subsurface disposal system. Some individual on-site systems involve nitrogen and/or phosphorus removal. These systems are permitted by local boards of health and managed by individual property owners.

Cluster Systems: systems for wastewater collection, treatment and disposal that involve multiple parcels and multiple wastewater generators, served by a single system. Cluster systems typically have capacities between 1,000 and 10,000 gallons per day (gpd). In Title 5 these are also called "shared systems". Cluster systems may be as simple as gravity pipes leading to a shared septic tank and shared disposal field, but may also include grinder pumps, low pressure sewer systems and modular plants providing enhanced treatment. These systems are typically permitted by local boards of health and by DEP, and are managed by associations of property owners.



Satellite Systems: those facilities for wastewater collection, treatment and disposal that require a DEP groundwater discharge permit (that is, have wastewater flows exceeding 10,000 gallons per day) and are intended to serve a closely defined area. Many of the satellite systems on Cape Cod have been built by private developers to serve condominium projects, nursing homes, and shopping centers. While many are privately developed, satellite systems can be publicly owned. Private satellite plants are typically managed by the commercial property owner or condominium association; publicly-owned satellite plants are managed by the local public works department, school department or other town entity.

Centralized Wastewater System: the provision of public sewerage through a wastewater collection system leading to a publicly-owned wastewater treatment plant with effluent disposal. These systems are typically managed by local sewer commissioners or departments of public works.

Source: Wright-Pierce, "Enhancing Wastewater Management on Cape Cod: Planning, Administrative and Legal Tools", July 2004.

Column C of Table 2-2 lists the wastewater treatment technologies considered for Orleans. Appendix C contains a description of each technology, as well as a discussion of advantages and disadvantages and a listing of local examples. The highlighted technologies in Table 2-2 are those considered most applicable to Orleans and are candidate "building blocks" for composite wastewater management plans.

Large-Scale Alternatives

The most applicable large-scale technologies for Orleans are all variations of biological treatment systems that use bacteria to remove organic matter and nitrogen. They differ in the manner in which the bacteria are exposed to the wastewater and the means by which the bacterial culture is then removed and recycled. The best options are:

Sequencing Batch Reactors (SBRs): SBR systems operate on a very simple concept of introducing a quantity of waste to a reactor and providing several process steps in a sequence that would traditionally require a single tank for each step. That sequence includes filling the reactor with wastewater, and then providing sequential periods of aerobic treatment, settling, and anaerobic treatment. Then the effluent can be decanted and a portion of the sludge removed before the process is repeated. Combing several treatment steps into a single tank reduces the land area requirement over other technologies, and the tanks are covered.

Oxidation Ditches: Wastewater is treated as it flows around a long oval-shaped concrete channel. Instead of providing several process tanks like some other technologies, the length of the channels allows for different types of treatment to occur as the wastewater moves around the ditch. Wastewater alternately passes through aerobic and anoxic zones allowing a mixed culture of bacteria to remove organic matter and nitrogen. A separate tank (a clarifier) is needed for removing and recycling the bacteria. This technology requires a relatively large footprint to accommodate the ditch. Unlike other technologies, the oxidation ditch is nearly always located outside. It has been widely used in the US and is capable of reliably achieving a low nitrogen concentration.

Membrane Bioreactors. Membrane Biological Reactors (MBRs) include a semi-permeable membrane barrier system, either submerged in, or following an activated sludge process, that provides the solids separation that is accomplished in a clarifier with other technologies. This technology ensures removal of virtually all suspended pollutants.

The membrane technology is relatively new, and operating data from systems installed in the past few years is promising, with results indicating very high effluent quality is achievable. Membranes are expensive and require regular cleaning and periodic replacement. The cost of the membrane is partially offset by the smaller building needed to house the system, compared to other technologies. This treatment process requires a relatively small footprint, and above-grade or below-grade installation of the treatment process is possible.

Biological Aerated Filters (BAFs): This system consists of flooded tanks filled with polystyrene beads which provide the required surface area for biological growth and filter the wastewater as it passes through. The BAF unit acts is a "fixed film" process resulting in reduced sludge production, roughly 60%, in comparison to SBR, oxidation ditch and MBR "suspended" growth processes. The BAF unit can be housed inside or outside and either above or below grade. The overall footprint of this process can be very small relative to traditional alternatives.

Small-Scale Alternatives

As with the large-scale systems, the most applicable small-scale technologies for Orleans are all variations of biological treatment systems that use bacteria to remove organic matter and nitrogen. The small-scale systems are largely proprietary modular systems consisting of factory-built components installed with pre-cast concrete tanks. The best options are: 1) Amphidrome, a fixed-film sequencing batch reactor; 2) Bioclere, which uses a fixed-film trickling filter process; 3) Cromaglass, which provides treatment in a sequencing batch reactor sludge system; 4) MBRs as described above; and 5) FAST, which utilizes both fixed- and suspended-growth nitrogen removal methods. Nitrex is a new technology that uses a nitrate-reactive media to convert nitrate to nitrogen gas, following a nitrification step to convert other nitrogen forms to nitrate. Early testing shows promise, but the long-term cost and performance are yet unproven.

These small-scale technology choices have been widely used for flows less than 50,000 gpd. For larger decentralized systems (50,000 gpd to 300,000 gpd), the large-scale technology options are more appropriate.

2.3.2 Management of Residuals

Wastewater treatment systems (whether they are on-site septic systems, cluster systems, satellite plants or centralized wastewater treatment facilities) purify wastewater and create concentrated byproducts in various forms. These "residuals" fall into the following categories: 1) septage, including grease; 2) grit and screenings; 3) liquid sludge; and 4) dewatered sludge or sludge "cake". The CWMP must include cost-effective and environmentally sound means to handle these residuals.

The Tri-Town Septage Treatment Facility (see Figure 2-2) is near Namskaket Marsh and is owned by the Orleans Brewster Eastham Groundwater Protection District. It now receives septage from Orleans, Brewster and Eastham (the members of the three-town District), septage from other Lower Cape towns, and some limited quantities of liquid sludge from small-scale wastewater treatment systems (cluster and satellite plants). The sludge generated from processing this incoming waste is dewatered on-site and hauled by contractor to out-of-town disposal locations. A study of the Tri-Town plant, conducted in 2005 and 2006, showed that the plant has capacity to receive septage generated in the three District towns well into the future, albeit with some upgrading needs. If Orleans were to build wastewater treatment systems elsewhere in town, either a single centralized plant or a series of decentralized facilities, Tri-Town is the only logical destination for the liquid sludges generated from those wastewater facilities. The sludge produced through wastewater treatment would be offset by the reduction in Orleans septage quantities (resulting from elimination of septic systems on those lots served by public sewers).

If the Tri-Town site were the home of a new wastewater treatment plant, that facility would be designed to thicken and dewater its own sludge. That new sludge handling equipment could be easily enlarged to handle the septage now received at the existing Tri-Town plant, allowing the demolition of the now 20-year-old facility. Out-of-town disposal of dewatered sludge is the best method for Tri-Town because the site is not large enough for processing options such as composting, and their cost-effectiveness is hampered by the relatively small quantities of sludge. For the same reasons, any new wastewater facility would be best served by out-of-town sludge disposal. The transport and disposal of dewatered sludges is a mature industry with significant competition. The Town of Orleans should make use of those private options for both sludge cake and grit/screenings. Therefore, no detailed evaluation of on-site sludge processing facilities is recommended.

FIGURE 2-2

TRI-TOWN SEPTAGE TREATMENT FACILITY

2.4 WASTEWATER REUSE AND DISPOSAL

Once wastewater is collected and treated, it must then be properly disposed of or put to productive use. Unlike other parts of the country where surface water discharge is a viable option, effluent disposal on Cape Cod must be land-based and is land-intensive. The available disposal technologies must be carefully considered to match the availability of appropriate disposal sites. Given the site limitations in Orleans (see Section 2.5), the Town should consider opportunities for reuse of effluent that allow more sites to be considered.

2.4.1 Wastewater Disposal Technology

Five technologies are listed in Column D of Table 2-2 that are applicable for effluent disposal in Orleans.. These include subsurface leaching, rapid infiltration, spray irrigation, drip irrigation and wicks. Appendix D provides a detailed description of each of these option, lists their advantages and disadvantages, and provides local examples.

All of the identified effluent disposal options may have applicability to Orleans. Two alternatives, wicks and drip irrigation, are less common and subject to more regulatory constraints, and should be considered further only if the more traditional options prove inadequate. (Drip irrigation may have applicability for effluent disposal on ballfields in either the "disposal" or "reuse" setting) The three more traditional alternatives should be part of the composite plans that are evaluated in more detail. Those traditional effluent disposal options are:

Subsurface leaching: By far the most common example of this type is the soil adsorption system found in the backyard of the typical Cape Cod home. A soil adsorption system includes of a network of rigid perforated piping buried below grade that distributes effluent into surrounding gravel trenches or beds that provide dispersal of effluent over a large area at a low dosing rate. If well maintained, these systems last for at least 20 years. Land must be available for the active disposal area as well as additional space earmarked as reserve, which can be developed in the event of a failure. These systems are designed to operate year-round and work best with regular dosing of effluent. The entire disposal system is buried which eliminates the chance of human contact, and can be located under public parks or sports fields, and under parking lots with proper design. Subsurface leaching requires more land than rapid infiltration (see below) and is usually more expensive.

Rapid Infiltration: Also referred to as open sand beds, these systems can operate at high loading rates on sites with good permeability and significant depth to groundwater. Year-round application is routine, but there is little opportunity for dual use of a site. The significantly reduced footprint compared with other technologies often outweighs the benefit of dual use. A smaller disposal footprint also broadens the number of parcels that could be viable disposal sites. The reduced footprint sometimes allows a single site to provide both treatment and disposal, which is less likely for other systems. Locating the treatment and disposal processes on the same site minimizes the transport costs.

Spray irrigation: Landscape irrigation is another example of technology that can be used on a site with another use. Effluent can be applied to parks, sports fields, golf courses, or landscaping. All of these activities are associated with human interaction and require meeting the effluent reuse guidelines, which usually adds to the cost of wastewater treatment (see Section 2.4.2 below). Irrigation is certainly restricted to seasonal operation which requires either winter storage or a complementary effluent disposal system, either of which can add substantially to the cost. This technique uses moderate application rates. Spray irrigation can also be accomplished at public-access-controlled sites, which with adequate buffers, may be permissible without meeting the effluent reuse requirements.

2.4.2 Wastewater Reuse Opportunities

Given the lack of large traditional effluent disposal sites in Orleans, the Town should consider a formal effluent reuse program. The fundamental premise behind any reuse program is recognition of the value of water and the nutrients it may carry, tempered by the public health aspects of public contact with wastewater-derived material. The allowable effluent disposal methods following traditional wastewater treatment (rapid infiltration, subsurface disposal, etc.) are in large part aimed at getting the effluent into the ground, and keeping it there, thus protecting the public from contact with a liquid that retains some undesirable characteristics even after tertiary treatment. The DEP reuse program stipulates higher levels of treatment that address those undesirable characteristics so that certain levels of human exposure are tolerable.

Massachusetts DEP has established a program to guide the reuse of wastewater effluents. Its publication "Interim Guidelines on Reclaimed Water" was issued in January 2000, and is expected to be updated in late 2007 or early 2008. The current guidelines allow four types of reuse:

- Spray irrigation of golf courses,
- Reuse at landscape nurseries,
- Artificial aquifer recharge, and
- Toilet flushing.

More uses may be allowed under the new guidelines, perhaps including private lawn irrigation.

The use of reclaimed water requires a higher level of treatment than traditional effluent disposal techniques. The more stringent effluent limits relate primarily to suspended solids and bacteria (see Table 2-3). The treatment technologies recommended in Section 2.3 can be readily adapted to meet the Reclaimed Water Guidelines, albeit at additional cost for enhanced solids removal and high-intensity disinfection. If membrane bioreactors are chosen for traditional wastewater treatment, they can most easily meet those reuse requirements with only minor cost increases.

A large number of possible reuse applications have been identified: see Appendix D. The most attractive alternatives include:

- Toilet flushing at public buildings,
- Lawn irrigation at public sites,
- Irrigation of ballfields,
- Irrigation of golf courses, and
- Use of reclaimed water in concrete production.

Serious consideration would be given to including reuse in the composite wastewater plans that are evaluated in more detail, either as primary means of effluent disposal or as seasonal supplements to traditional methods.

2.5 SITING OF WASTEWATER TREATMENT AND DISPOSAL FACILITIES

2.5.1 Initial Site Identification and First-Level Screening

The staff of the Orleans Planning Department, with assistance from Wright-Pierce, used the Town's geographic information system (GIS) to identify potential sites for wastewater facilities. This GIS search first considered undeveloped sites of 5 acres or greater, with ground surface elevation higher than 30 feet, located outside the water supply Zone IIs. Particular emphasis was placed on sites in public ownership. This search identified only a few such sites, clearly not sufficient for the overall town wastewater needs.

The site search was then expanded to consider all sites greater than 2 acres in size, including privately-owned land. While vacant parcels are preferred, this second search also considered some larger sites that are currently only partially developed (for example, a 5-acre site with a home in one corner, or a site used only for parking).

The sites identified in the GIS search were then reviewed by Wright-Pierce, both from aerial photography and by direct observation in the field. Some sites were eliminated due to significant development constraints. A total of 30 sites were deemed suitable for further investigation.

2.5.2 Target Effluent Disposal Capacity

The Needs Assessment determined that a municipal wastewater system, aimed at satisfying a broad range of current wastewater needs, would accept an average wastewater flow of approximately 500,000 gpd. At the planning horizon, that flow would grow to about 700,000 gpd. (By strategic sewer layouts--see Section 2.3.2--smaller wastewater volumes are possible.)

Summer peak flows must be accounted for in the sizing of wastewater facilities, and effluent disposal systems are designed for the short-term (one-day or two-day) peak flows during the summer season. Peaking factors were derived from Town water records, and when applied to the estimated annual average wastewater flows, the following general target capacities were established for site identification and screening:

- Current 1.2 million gallons per day (mgd)
- Planning horizon 1.7 mgd

Given the uncertainties associated with determining actual site capacities, the goal of the site search was to identify as much at 3 mgd of apparent capacity.

2.5.3 Second-Level Site Screening

Data were compiled on each of the 30 sites identified by GIS methods. This information included surficial soils descriptions, location with respect to ACECs, ready accessibility of public water service, depth to permanent groundwater, potential for perched water table, and distance to the nearest boundary of a public water supply Zone II.

The next step was to prepare scale drawings of each site, using aerial photography from the Mass GIS system. A conceptual layout was prepared for each site, assuming rapid infiltration or subsurface leaching, the most common effluent disposal methods. These conceptual designs were based on effluent loading rates of either 3 gallons per day per square foot (gpd/sf) for subsurface leaching or 5 gpd/sf for rapid infiltration. Set backs were assumed to be:

From property lines of developed parcels:	100 feet	(rapid infiltration)
	50 feet	(subsurface leaching)
From property lines of protected parcels:	50 feet	(rapid infiltration)
	30 feet	(subsurface leaching
From wetlands:	100 feet	(all cases)

Provision was made for access roads and other peripheral facilities.

Based on these conceptual designs, each site was assigned an estimated capacity range. (Five of the 30 sites were deemed suitable only with non-traditional disposal technologies, such as wicks or drip irrigation, and capacities were not estimated for these 5 sites.) Table 2-6 lists the 25 sites where rapid infiltration or subsurface leaching designs were prepared, and includes the range of estimated disposal capacity.

As shown in Table 2-6, the conceptual designs indicate an aggregate disposal capacity of 3.8 to 4.6 mgd, well in excess of the 3 mgd target. While this is a favorable finding, it must recognized that there are many reasons why the actual capacity could turn out to be less than these estimates:

- The soils may not allow the relatively favorable application rates that were assumed.
- There may be site constraints, such as steep slopes or pockets of poor soils that are not apparent from the available mapping.
- Detailed site design may find that larger setbacks are appropriate.
- Some portion of these sites may be needed for modular wastewater treatment facilities.
- The nitrogen control needs of certain embayments may not allow as much effluent disposal as the site would allow.
- Groundwater mounding may limit the disposal volume.
- Private sites may be available only at very high cost or through an adversarial process.

On the other hand, there may be more suitable area than was assumed and favorable soils, once fully tested, might allow higher loading rates than DEP currently permits for these disposal technologies.

While a relatively large aggregate disposal capacity was identified, there are several factors that complicate the analysis:

- Only one-third of the apparent capacity is located at sites owned by the Town or by quasi-municipal entities. Land acquisition negotiations and costs for private sites represent significant hurdles.
- There are very few large sites, and providing adequate capacity for all wastewater needs will likely require several sites.

TABLE 2-6
INITIAL CAPACITY ESTIMATES FOR IDENTIFIED DISPOSAL SITES

Site ID	Total Acres	Ownership	Development Status	Disposal Technology	Capacity, gpd	
					Low	High
111	< 2	Private	Parking	SL	60,000	60,000
112	2 to 5	Public	Parking	SL	75,000	75,000
121	5 to 10	Private	Dev--Residential	SL	150,000	150,000
161	< 2	Private	Vacant	SL	30,000	40,000
162	2 to 5	Private	Dev--Residential	SL	125,000	125,000
172	5 to 10	Private	Dev--Residential	SL	150,000	150,000
173	2 to 5	Private	Vacant	SL	60,000	60,000
181	5 to 10	Private	Dev--Recreational	SL	150,000	150,000
191	5 to 10	Private	Dev--Resid/Agric.	SL	50,000	75,000
Pleasant Bay Subtotal					**1,350,000**	**1,415,000**
221	2 to 5	Private	Vacant	SL	70,000	75,000
222	5 to 10	Private	Dev--Commercial	SL	100,000	150,000
231	5 to 10	Private	Dev--Recreational	SL	150,000	150,000
241	> 10	Public	Dev--Utility	RI	500,000	750,000
244	5 to 10	Private	Dev--Utility	RI	200,000	225,000
245	5 to 10	Private	Dev--Resid/Agric.	SL/RI	150,000	200,000
246	> 10	Private	Dev--Commercial	SL	150,000	225,000
247	2 to 5	Private	Dev--Commercial	SL	45,000	60,000
Cape Cod Bay Subtotal					**1,365,000**	**1,835,000**
312	2 to 5	Private	Dev--Utility	SL	50,000	75,000
313	> 10	Public	School	SL/DI	150,000	150,000
314	> 10	Public	School	SL/DI	300,000	300,000
316	> 10	Public	Gardens	SL	120,000	250,000
321	> 10	Private	Dev--Residential	SL	120,000	270,000
322	5 to 10	Private	Dev--Residential	SL	150,000	150,000
323	5 to 10	Private	Dev--Residential	SL	50,000	55,000
Nauset Subtotal					**940,000**	**1,250,000**
411	5 to 10	Private		RI	100,000	120,000
Atlantic Ocean Subtotal					**100,000**	**120,000**
Town Wide Total					**3,755,000**	**4,620,000**

Disposal Technology
RI Rapid Infiltration
SL Subsurface Leaching
DI Drip Irrigation

- Only about 5% of the identified capacity is associated with vacant land. Including land now associated with parking or utility uses increases that percentage to 12%.
- The identified capacity is well distributed across the major watersheds, although there is a deficit in the Pleasant Bay watershed when aggregate needs are considered.

This analysis leads to the following conclusions:

- The Town will likely need more than one disposal site, even in a centralized solution.
- Focused subsurface explorations are needed to obtain better estimates of capacity at the most favorable sites.
- Dual use of disposal sites is likely, such as effluent disposal under parking lots or ballfields.
- Sites for significant spray irrigation of effluent do not exist, given Orleans' lack of golf courses. If large-scale spray irrigation is to be considered, it must occur at an out-of-town site.

This site identification and screening process has focused on effluent disposal. The 25 sites listed in Table 2-6 were also evaluated as possible sites for wastewater treatment plants. The traditional 50-plus-acre undeveloped site in a remote area simply does not exist in Orleans. The most favorable sites for a centralized treatment plant are Site 241 (the location of the existing Tri-Town Septage Treatment Plant, where effluent disposal is also possible) and the existing Town landfill (where traditional effluent disposal is not feasible). Other sites for centralized facilities would require acquisition of privately owned land, demolition or relocation of existing structures, and very serious attention to design and set-back issues. Small modular wastewater treatment facilities could be accommodated at many of the effluent disposal sites listed in Table 2-4, albeit with reduced disposal capacity. If further investigation of the sites leads to unidentified constraints, the Town may need to expand its search to include sites in adjacent towns.

2.5.4 Site-Specific Exploration Needs

One drawback to developing multiple small sites is the potential cost of subsurface explorations to better define disposal capacity. Therefore it is recommended that the Town embark on a phased program of subsurface explorations that focuses first on the largest and best-situated sites.

Eight sites were selected for the initial exploration program; they fall in the following categories:

- Publicly-owned sites that are vacant or only partially developed
    - Site 241
- Publicly-owned sites that are developed in compatible uses
    - Site 313
    - Site 314
- Quasi-public sites developed in compatible uses
    - Site 244
    - Site 312
- Privately-owned sites developed in compatible uses
    - Site 246
    - Site 247
    - Site 222

Further study should include these steps:

- Compilation of existing data on soils properties and groundwater levels
- Test pits and percolation tests to supplement existing data
- Hydraulic loading tests and groundwater modeling

The Tri-Town site was evaluated previously by Wright-Pierce (see report dated August 2005). This site should be included in the first round of site-specific testing because it has the greatest potential for large-scale effluent disposal. The results of testing at Tri-Town would then help guide the next phase of this program.

2.5.5 Next Steps

Certain sites listed in Table 2-6 should be included in the town-wide wastewater plans that are to be subject to more detailed evaluation in the next phase of the CWMP. The formulation of those plans must consider all of the wastewater system components (collection, treatment, disposal, etc., as discussed elsewhere in this report), as well as nature of the wastewater needs in each major watershed and the logistics of linking needs with sites. This formulation and detailed evaluation of wastewater plans should be accomplished concurrently with the site-specific investigations noted above. It is conceivable that sites could be eliminated from consideration for non-technical reasons including public concerns, cost-effectiveness of decentralized options, acquisition problems with private parcels, etc. Expenditures on detailed site investigations should not precede steps to determine if targeted sites might be eliminated for these reasons.

Many of the candidate disposal sites are located near the boundaries between the major watersheds. Large-scale application of effluent at these sites could cause those boundaries to shift, resulting in nitrogen migration to a different embayment than is currently the case. This potential for shifting boundaries must be addressed if any of the composite wastewater plans includes large discharges at these locations.

Due to this lack of large suitable disposal sites in Orleans, the Town should closely review flow and load reduction measures, and such non-traditional nitrogen control methods as fertilization reductions (see Section 2.6). This situation should also trigger discussions with neighboring towns about disposal sites, including golf courses, and multi-town facilities.

2.6 NON-TRADITIONAL NITROGEN CONTROL MEASURES

In the needs assessment phase of the CWMP, it has been shown that the control of nitrogen is the largest driving force toward improved wastewater management in Orleans. Nitrogen reaches the embayments from various sources and through multiple pathways. The "traditional" approach to controlling nitrogen is to replace septic systems with public wastewater facilities that remove large amounts of nitrogen, and discharge the effluent either at appropriate locations within the watershed, or in the watershed of a less sensitive embayment. While public sewerage is a readily permitted and predictable method for nitrogen control, it can also be very expensive. There are a number of "non-traditional" methods for nitrogen control that offer significant cost savings.

In broad terms, non-traditional controls fall into the following categories:

- Options that prevent future nitrogen loads;
- Options that reduce current nitrogen loads before they reach the groundwater;
- Options that take advantage of natural processes that impact groundwater quality as it moves toward the embayments;
- Options that improve the ability of the embayments to assimilate nitrogen loads; and
- Options that remove nitrogen from the water column or sediments within the embayments.

Eight alternatives are listed in Column E of Table 2-2 that are potentially applicable to nitrogen control in Orleans. Appendix E provides a detailed description of each of these options, lists their advantages and disadvantages, and provides local examples. Five of these alternatives (highlighted in Table 2-2) should be considered further and included as supplements to the composite plans that are subject to more detailed review.

Control of Fertilization: When lawn and garden fertilizer is applied, some portion of the nitrogen nourishes the plants, another portion is converted to harmless nitrogen gas by soil organisms, and the excess nitrogen leaches to the groundwater. The MEP technical report for Pleasant Bay estimated that 30% of the un-attenuated nitrogen load from the watershed comes from fertilizer and stormwater runoff, with most of that from fertilizer. Therefore, after septic nitrogen, fertilizer nitrogen is the next largest source. In the Pleasant Bay sub-watershed (one portion of the overall watershed), nearly one-half of the watershed nitrogen load comes from lawn fertilization, principally from three golf courses within that watershed.

There are many steps that can be taken to reduce fertilizer nitrogen load to the groundwater. First, fertilized lawn area can be reduced. Second, where fertilizer is used, the application rate can be reduced, and the timing of applications can be spread out. Third, fertilizers with organic slow-release nitrogen can be substituted for traditional inorganic forms. These steps can be taken by all fertilizer users, but the greatest potential for reduction is where large fertilizer use occurs, which includes golf courses, town parks, and school district ballfields.

Education of the public on the need to modify lawn care practices should occur regardless of other steps. In addition, the Town should institute changes in its own practices and should work with the Nauset Regional School District in a similar fashion. Other possible steps include restriction on lawn area in new development, working with local lawn and garden retailers to stock only more appropriate fertilizer products, and working with the County to institute a fertilizer ban. While not within the direct control of Orleans, every effort should be made to reduce the very large fertilizer use in the Pleasant Bay sub-watershed at golf courses in Brewster, Harwich and Chatham. Controls on fertilizer use on cranberry bogs should also be considered as appropriate.

Stormwater Management: Precipitation that falls on impervious surfaces runs off and takes with it a variety of pollutants, including nitrogen. If stormwater is discharged directly to a pond or embayment (or to a pipe or channel leading directly there) it is considered a "point source". If runoff infiltrates into the ground and transports pollutants to the groundwater it is considered a "nonpoint source". In either case, actions are warranted to reduce the pollutant load from stormwater. For all of Pleasant Bay, runoff from impervious surfaces is estimated to produce 9,000 pounds of nitrogen per year, or 9% of the total un-attenuated load from all watershed sources.

In general, the Town should try to remove all point sources by infiltrating stormwater instead of discharging it to surface waters. Where this is not possible, some "end-of-pipe" treatment may be warranted, such as exists at Lonnies Pond. While infiltration is most efficient through bare soil, vegetated surfaces provide considerable pollutant removal. Pollutants in runoff can also be addressed at the source, through such programs as regular street sweeping, owner control of pet wastes, requirements for nutrient management plans for large developments, etc.

There are many reasons why stormwater management should occur in Orleans independent of nitrogen control. Phosphorus transport to ponds is an important issue, as is bacterial contamination at beaches and shell fishing areas from road runoff. These reasons for stormwater management are important enough on their own to warrant a town-wide plan. Implementation of that plan will also reduce nitrogen loads to embayments.

Density Controls through Municipal Bylaws and Regulations: The Needs Assessment documents how current wastewater generation rates in Orleans are expected to increase by 22% over the planning period ending in 2030. Considering a somewhat lower rate of increase in non-wastewater nitrogen sources (such as lawn fertilization), the town-wide nitrogen load may increase by about 20% as a result of growth in the community. Town-wide, the **current** nitrogen load must be reduced by perhaps 20% to 25% (depending on the findings of the MEP studies for the Nauset system). The **growth** in nitrogen load is approximately the same as the amount of the **current** load that must be removed. Any steps the Town can take to slow the growth in nitrogen load will directly impact the extent and cost of structural solutions.

A number of actions have been discussed among the WMSC, the Board of Health and the Planning Board. The most promising ones include:

- Reducing minimum lot sizes for new residential development or reducing the allowable development intensity on commercial properties;
- Instituting nitrogen-based performance standards for expansions and redevelopment, such as the "no net nitrogen increase" approach or a maximum pound-per-acre load (the "fair share" approach);
- Accelerating land purchases or conservation easements; and
- Instituting a "checkerboard" sewer system with limitations on increased flows from properties not served.

Natural Attenuation: As groundwater moves toward and into embayments, it may pass through freshwater ponds and bogs and through salt marshes. In these environments, there may be some removal of nitrogen by natural means that lessens the impact on the embayment. These processes are called "natural attenuation". Natural attenuation has been included in the modeling of embayments on Cape Cod as part of the Massachusetts Estuaries Program. For Pleasant Bay as a whole, natural attenuation is estimated to reduce the raw watershed nitrogen load by 4%.

Natural attenuation can be part of Orleans' overall plan in several ways. First, the selection of properties to be connected to traditional wastewater systems should focus on those properties that are not subject to natural attenuation; that is, once pond protection needs are addressed by sewering in areas immediately upgradient of ponds, wastewater collection should focus first on those properties that are downgradient from the ponds and wetlands that provide natural attenuation.

Second, effluent disposal sites can be located upgradient from these natural attenuation resources to allow further pollutant removals as the effluent-impacted groundwater moves toward the embayment. Great care must be taken to avoid secondary impacts, however, such as overloading the nitrogen attenuation capacity or introducing more phosphorus than is appropriate. Some studies have shown that salt marshes may have significant nitrogen removal capability with less potential for overloading than freshwater systems. In Orleans, where pond protection has high priority, salt marshes represent the best opportunity for natural attenuation and should be considered in effluent disposal siting. The Tri-Town site in Orleans is upgradient from Namskaket Marsh, and the marsh that may now be providing renovation of the Tri-Town plume and might provide attenuation of nitrogen from wastewater effluent infiltrated at the Tri-Town site. Similarly, the salt marshes separating Pochet Neck from Pochet Creek might provide a similar benefit for effluent disposed of in areas that are immediately upgradient.

The third opportunity for taking advantage of natural attenuation is in the restoration of damaged wetlands or the conversion of abandoned cranberry bogs. Some natural attenuation may be occurring at these locations, and restoring them to their original state may allow additional attenuation. In cranberry bogs, deepening the bog or increasing the water surface may increase the detention time of groundwater passing through these systems and allow for greater natural attenuation.

Flushing Enhancement: The residence time of nitrogen in an embayment in part determines the susceptibility of that embayment to water quality degradation. Enhancing the flushing rate of the embayment can improve water quality and lessen the impacts of a given nitrogen load. Dredging channels, widening inlets, and replacing constricting culverts are all ways to enhance tidal flushing. A number of sub-embayments in the Pleasant Bay system (for example Lonnie's Pond and Areys Pond) and perhaps Rock Harbor could potentially benefit from dredging to deepen their inlets. It is expected that less nitrogen control would be needed in the watersheds of these sub-embayments after dredging of their inlets, although additional modeling of the hydrodynamics and water quality would be needed to quantify the impact. (It is important to note that enhanced flushing in "headwaters" sub-embayments does not reduce the overall load to the Pleasant Bay system, but merely moves the load downstream more quickly. In that these sub-embayments are influenced by the quality of the downstream waters that flush them, this technique is less attractive than similar actions in embayments that discharge directly to the Atlantic Ocean or Cape Cod Bay.)

(The MEP technical report for Pleasant Bay predicts that a significantly higher level of nitrogen control will be needed if the current breach off Chatham reverts to its prior, more southerly location. The principal behind this conclusion is the same as discussed above. The towns around Pleasant Bay should formulate a plan to deal with this possible "flushing diminishment".)

Flushing enhancement options have many advantages and disadvantages. Any modifications to the coastal environment require significant permitting. Dredging is only permittable in the ACECs if that location has been previously dredged. (Historical dredging has occurred in Areys Pond, Lonnies Pond and Paw Wah Pond, and perhaps others.) The nitrogen control needs documented in the MEP technical report are intended to restore eelgrass and habitat for benthic organisms. Dredging would certainly destroy, at least temporarily, some of the habitat that the nitrogen control is intended to benefit. Dredging, if permittable, would not be a one-time event, but would need to be repeated over time to maintain the flushing enhancement.

SECTION 3

FORMULATION OF COMPOSITE WASTEWATER PLANS

Sections 2.2 through 2.6 review the elements of town-wide wastewater management plans and recommend those components that are most applicable to Orleans. Based on that review, many plans were formulated that utilize these components. Those plans were evaluated and three were selected for detailed evaluation in the next phase of the CWMP.

3.1 INITIAL PLAN FORMULATION

Over the course of nine meetings, the WMSC discussed the advantages and disadvantages of options for each of the major components of a town-wide management plan, as summarized in Table 2-2. During that same period, the MEP released its technical report on Pleasant Bay, and members of the WMSC reviewed this document in detail and participated in workshops sponsored by the Pleasant Bay Alliance related to TMDL setting and compliance. Also during that period, the WMSC heard a presentation by senior DEP staff members on the DEP water reuse program, and participated in a search for wastewater treatment and disposal sites. As a result of all of these meetings and discussions, a number of broad principles emerged as important to the formulation of town-wide wastewater management plans in Orleans:

- Collection and treatment of wastewater from the Pleasant Bay watershed with disposal in another, less sensitive watershed would provide the highest level of protection of Pleasant Bay.
- The lack of large and publicly-owned vacant sites, remote from residential development, prompts the consideration of decentralized solutions that are compatible with a larger number of small dispersed sites.
- The significantly degraded nature of certain coastal waters, particularly the "headwaters" sub-embayments in the Pleasant Bay system, may warrant the implementation of focused early actions to remove wastewater nitrogen from their watersheds as the first priority in a phased plan.

- The Tri-Town site is already used for wastewater-related functions and has some significant undeveloped area that makes it the most likely candidate site for a centralized plan.
- There are many opportunities for reuse of wastewater effluent that allow the recycling of nutrients and water in a controlled fashion with significant protection of the public.
- The most viable reuse alternative at large scale, the irrigation of golf course fairways, is not possible in Orleans, where no golf courses exist. Golf course irrigation may be feasible in the neighboring towns of Brewster and Harwich.
- Regional solutions have the benefits of economies of scale and effectiveness of treatment, but site availability and embayment nutrient sensitivity may make such solutions difficult.

Given these findings, the WMSC and its consultant developed a set of nine town-wide wastewater management plans for more detailed review. The plans are described in Table 3-1, and include centralized and decentralized options and a range of effluent reuse and disposal methods.

As a starting point, it was agreed that each of these plans would be assumed to address all of the needs documented in the draft Needs Assessment (that is, needs in the categories of sanitary, water supply protection, surface water protection, aesthetics/convenience, and economic development). Each plan should also have those applicable non-structural and non-traditional measures that reduce flows and loads and to minimize environmental impact.

3.2 EVALUATIVE CRITERIA

Once the nine wastewater plans were formulated, the WMSC identified a wide range of criteria that should be used to compare and contrast the plans. These criteria are summarized in Table 3-2.

TABLE 3-1
INITIAL PLAN IDENTIFICATION

A. Tri-Town--Orleans Only. All of the collected wastewater would be transported to the Tri-Town site where it would be treated to the typical 10-mg/l level of effluent nitrogen. Effluent disposal would be at the Tri-Town site, and at other nearby sites.

B. Tri-Town--Regional. This plan is similar to Plan A, but would include the receipt of wastewater from Brewster and/or Eastham. More effluent disposal sites would probably be needed nearby, compared with Plan A.

C. Tri-Town--Reuse. The Tri-Town plant would receive all of Orleans wastewater flows and provide a very high degree of treatment so that effluent could be reused under DEP's Reclaimed Water Guidelines. This high degree of treatment allows effluent to be used to irrigate Town parks and cemeteries, and be used for toilet flushing in public buildings. Effluent reuse during the summer peak conditions would reduce the need for effluent disposal at other sites.

D. Decentralized Plan #1 (Pleasant Bay). This plan would use the Tri-Town site for wastewater treatment from the Nauset and Cape Cod Bay watersheds, and use two decentralized plants for treating wastewater collected in the Pleasant Bay watershed. One such plant would be located in East Orleans; the other would be located in South Orleans and would discharge to sites in the Arey's Pond and Namequoit River sub-watersheds.

E. Decentralized Plan #2 (Nauset and Pleasant Bay). This plan is similar to Plan D, and also involves three plants. It includes a larger decentralized treatment plant in East Orleans, to treat both Pleasant Bay and Nauset wastewaters, with disposal in both the Pochet Neck and Nauset Harbor sub-watersheds. This plan goes further than Plan D in keeping wastewater local and reducing the demand on disposal sites at or near Tri-Town.

F. Decentralized Plan #3 (Sub-Watersheds). In this plan, small decentralized plants would be constructed in the "headwaters" sub-embayments (Meetinghouse Pond, Arey's Pond, Lonnie's Pond and Pah Wah Pond) to facilitate early progress in the most critical areas, with the remainder of the plan similar to Plan E. This plan would include five plants.

G. South Orleans--Orleans Only. In this plan, all Orleans wastewater would be transported to a site in South Orleans for treatment. Effluent disposal would occur on one or more golf courses in Brewster and/or Harwich, either by spray irrigation in the warm months or by subsurface leaching in the winter. This plan takes advantage of spray irrigation, both as a low-cost way to polish the effluent, and as a means to reduce fertilizer use at the golf courses.

H. South Orleans--Regional. This plan is an extension of Plan G that adds the treatment and disposal of wastewaters from portions of Brewster and Harwich.

I. Two Regional Plants. This plan combines Plan B with Plan H. There would be two moderately-sized plants, one at Tri-Town and one in South Orleans, and each would receive flow from neighboring towns.

TABLE 3-2
EVALUATIVE CRITERIA
USED IN RATING WASTEWATER PLANS

• Overall Cost	• Need for Land Purchase and/or Easements
• Use of Proven Technology	• Potential for Neighbor Impacts
• Regulatory Acceptability	• Benefits from Natural Attenuation
• Environmental Impact	• Retention of Water in Water Supply Area
• Energy Consumption	• Removal of Contaminants of Emerging Concern
• Ease of Operation	• Nitrogen and Phosphorus Removal
• Production of Residuals	• Expandability for Regionalization
• Overall Public Acceptability	• Extent of Collection System

Wright-Pierce scored each plan in these categories on a one-to-three scale, with the higher scores representing the most favorable. For example, the plans that require the most energy use were given a score of 1, and the most energy-efficient plans were given a score of 3. The scores for each plan and criterion are presented in Appendix F. Spreadsheets were prepared that allowed each member of the WMSC to individually rate the nine plans against these 16 criteria. Ratings were first prepared using each member's choice of weighting factors from one to four. That is, if an individual placed high priority on cost, he or she could use a weighting factor of 4, versus a weighting factor of 1 for a less important factor to him or her. Scores were aggregated and analyzed to determine which criteria contributed most significantly to the overall rating. Then the scoring was repeated using weighting factors of one to ten, and the aggregate scores were again analyzed for the most significantly contributing criteria. Conclusions of this exercise were:

- Plan A had broad support, but only by a small margin.
- The criteria that added most significantly to the high scores varied by committee member, but cost, public acceptability, need for land acquisition and environmental impact were often mentioned.
- An evaluation of the scoring revealed that the lack of a single clear favorite may have related to the large number of evaluative criteria, some of which overlap (for example, "high energy consumption" contributes to "high cost", both of which

detract from "public acceptability"). Although clear consensus was not gained for any one or two plans, there was support for regionalization (based in large part on economies of scale), decentralization (reduction of transport costs and suitability for small dispersed sites), and the Tri-Town options (no need for land acquisition and public acceptability for continuation of wastewater-related activities there).

3.3 WASTEWATER PLANS RECOMMENDED FOR DETAILED EVALUATION

The initial set of nine plans was consolidated to three plans that will be the subject of detailed evaluation. Those three plans are:

Plan 1. Decentralized Treatment and Disposal in All Major Watersheds

Plan 2. Centralized Treatment at the Tri-Town site with Disposal in the Cape Cod Bay Watershed

Plan 3. Centralized Treatment in South Orleans with Disposal on Golf Courses in the Pleasant Bay Watershed.

Plan 1 is described in more detail in Table 3-3 and Figure 3-2. Similarly, Tables 3-4 and 3-5 summarize Plans 2 and 3, which are shown graphically in Figures 3-3 and 3-4. These figures show the number of properties served and the associated wastewater flow collected in each watershed. Also shown are the watershed locations and capacities of the treatment and disposal facilities. Figure 3-1 provides a legend to aid in interpretation of the wastewater plan schematics.

During the evaluation of the nine initial plans, it became clear that the WMSC places great importance on low-cost solutions. Perhaps the greatest potential for cost savings lies with regionalization. Therefore each of the three plans will be evaluated as to its ability to accommodate wastewater flows from adjacent towns; that is, from Eastham and Brewster.

The environmental benefits of effluent reuse were also important factors in the WMSC deliberations, both for recycling water and nutrients and to open up the possibility of better nutrient and water management at local golf courses. The use of reclaimed water on golf courses is a fundamental element of Plan 3. Effluent reuse opportunities will also be investigated as adjuncts to Plans 1 and 2.

It is important to note that none of the original nine plans was "eliminated". The three plans, together with the parallel investigations of reuse and regionalization, represent all nine of the original plans.

The three wastewater plans are summarized and compared in Table 3-6.

These three plans, supplemented by parallel investigations of regionalization and reuse, will be the focus of the next phase of the CWMP, the detailed evaluation of alternatives and selection of a recommended plan. In that phase, each of the plans will be described in detail. Estimates will be prepared of both capital and operation and maintenance costs. An appraisal of environmental impacts will be prepared to contrast the three plans and the "no action" alternative. Non-financial factors will be evaluated, such as public acceptability, operational flexibility, ease of phased development, and resource impacts (including energy consumption). As a result of those evaluations and associated public input, a recommended plan will emerge.

FIGURE 3-1
WASTEWATER PLAN LEGEND

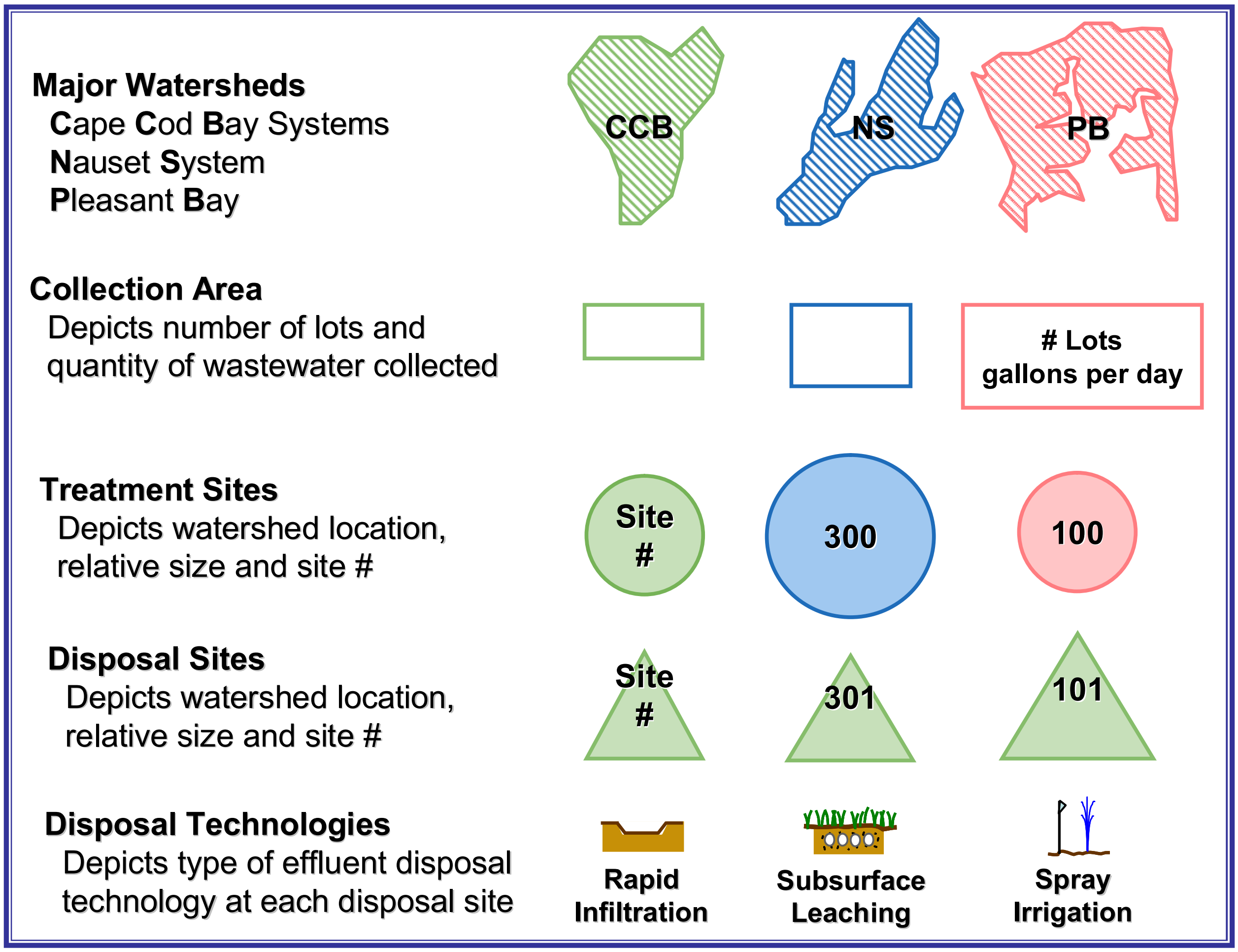


TABLE 3-3
SUMMARY OF WASTEWATER PLAN #1

Summary:

Collection of wastewater from all 3 major watersheds to satisfy all identified needs, transport to 3 new decentralized wastewater treatment plants, with the balance taken to a new plant at the Tri-Town site, with effluent disposal by rapid infiltration at the Tri-Town site and by subsurface leaching at seven sites at or near the decentralized plants.

Wastewater Collection:

Collection by conventional gravity sewers supplemented by grinder pumps

From Cape Cod Bay watershed	177,000 gpd (260 properties)
From Nauset watershed	214,000 gpd (780 properties)
From Pleasant Bay watershed	272,000 gpd (1,350 properties)
Overall	663,000 gpd (2,390 properties, 70% of all wastewater)

Wastewater Treatment: (Total of four wastewater treatment facilities)

Three decentralized treatment plants (with short-term peak capacities of 100,000 gpd, 220,000 gpd and 300,000 gpd) using

- Primary treatment
- Biological secondary treatment and nitrogen removal (SBRs or equivalent)
- Standard ultraviolet disinfection
- Filtration

One new plant at Site 241 (1.0 mgd) using:

- Primary treatment
- Biological secondary treatment and nitrogen removal (SBRs or equivalent)
- Ultraviolet disinfection
- Filtration

Wastewater Disposal:

Rapid infiltration Site 241

Subsurface leaching at:

Site 111	Site 162	Site 321
Site 112	Site 173	Site 322
Site 121	Site 181	Site 323

Disposition of effluent by watershed (annual average):

Cape Cod Bay	408,000 gpd	(61%)
Nauset system	125,000 gpd	(19%)
Pleasant Bay	130,000 gpd	(20%)

Septage and Sludge Handling:

The treatment plant at the Tri-Town site would receive and dewater septage from all 3 District towns, as well as liquid sludge trucked from the 3 decentralized plants. Dewatered sludge would be trucked away for ultimate disposal out of town.

Land Acquisition Needs:

Purchase land at 3 treatment plant sites (all privately owned)

Purchase land or acquire easements at 9 sites for effluent disposal (8 privately owned)

FIGURE 3-2
WASTEWATER PLAN #1

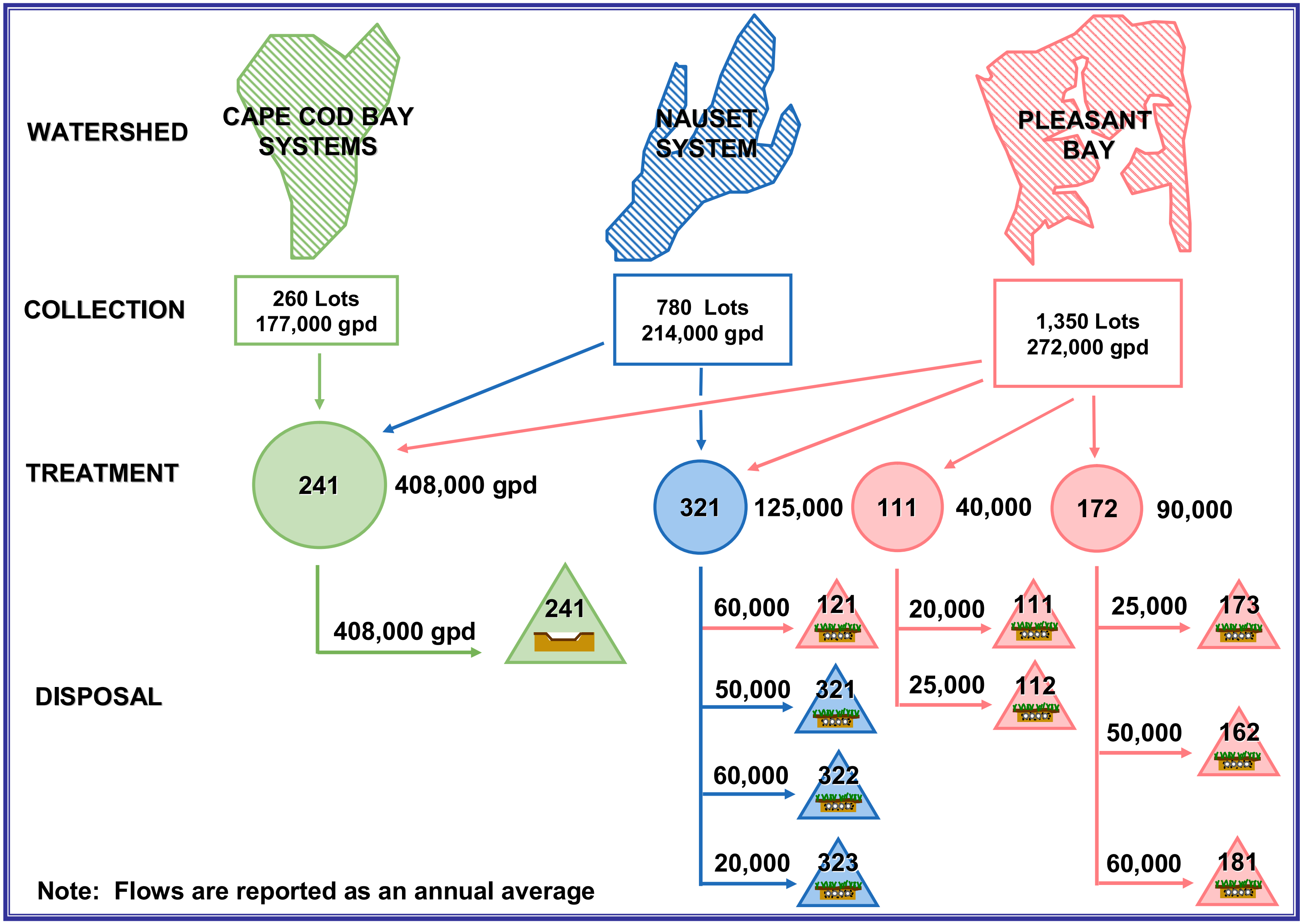


TABLE 3-4
SUMMARY OF WASTEWATER PLAN #2

Summary:

Collection of wastewater from all 3 major watersheds to satisfy all identified needs, transport to a new wastewater treatment plant at the Tri-Town site, with effluent disposal by rapid infiltration at the Tri-Town site and by subsurface leaching or rapid infiltration at one or two other nearby sites.

Wastewater Collection:

Collection by conventional gravity sewers supplemented by grinder pumps

From Cape Cod Bay watershed	177,000 gpd (260 properties)
From Nauset watershed	196,000 gpd (700 properties)
From Pleasant Bay watershed	248,000 gpd (1,220 properties)
Overall (current)	621,000 gpd (2,180 properties, 65% of all wastewater)

Wastewater Treatment:

A single treatment plant (with short-term peak capacity of 1.5 mgd) using:

- Primary treatment
- Biological secondary treatment and nitrogen removal (SBRs or equivalent)
- Standard ultraviolet disinfection
- Filtration

Wastewater Disposal:

Rapid infiltration Site 241 (the Tri-Town site), supplemented as necessary by

- subsurface leaching at Site 247 and
- rapid infiltration at Site 244

Disposition of effluent by watershed (annual average):

Cape Cod Bay	621,000 gpd	(100%)
Nauset system	0 gpd	(0%)
Pleasant Bay	0 gpd	(0%)

Septage and Sludge Handling:

The treatment plant at the Tri-Town site would receive and dewater septage from all 3 District towns. Dewatered sludge would be trucked away for ultimate disposal out of town.

Land Acquisition Needs:

Purchase land or acquire easements at two sites for effluent disposal (1 privately owned)

FIGURE 3-3
WASTEWATER PLAN #2

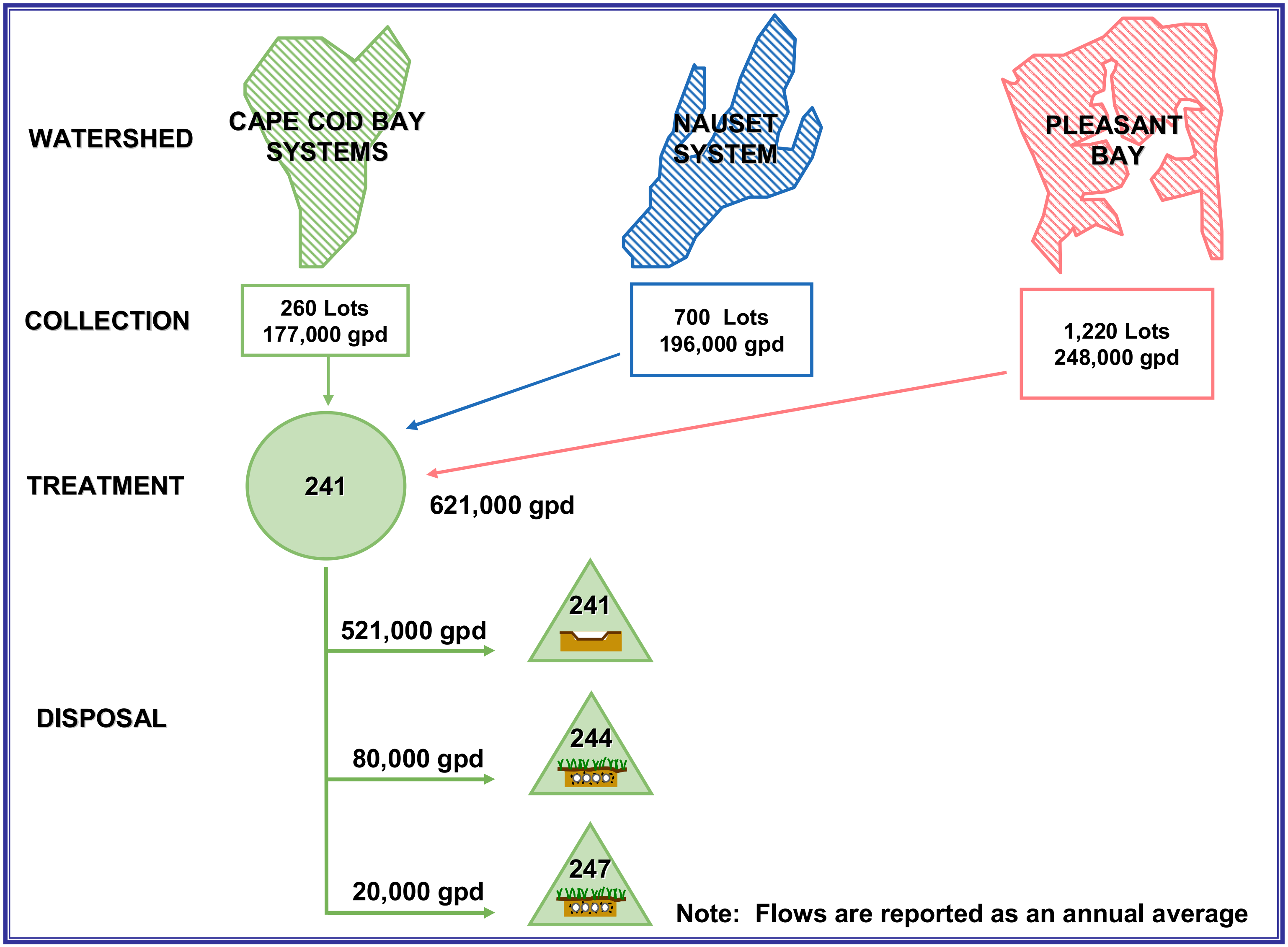


TABLE 3-5
SUMMARY OF WASTEWATER PLAN #3

Summary:
Collection of wastewater from all 3 major watersheds to satisfy all identified needs, transport to a new wastewater treatment plant in South Orleans, with effluent disposal at one or two golf courses in Brewster/Harwich (spray irrigation in warm months, subsurface leaching during remainder of year).

Wastewater Collection:

Collection by conventional gravity sewers supplemented by grinder pumps

From Cape Cod Bay watershed	177,000 gpd (260 properties)
From Nauset watershed	196,000 gpd (700 properties)
From Pleasant Bay watershed	286,000 gpd (1,590 properties)
Overall	659,000 gpd (2,550 properties, 69% of all wastewater)

Wastewater Treatment:

A single treatment plant (with short-term peak capacity of 1.6 mgd) using:

- Primary treatment
- Biological secondary treatment and nitrogen removal (MBRs or equivalent)
- Redundancy features necessary to meet Reclaimed Water Guidelines
- Filtration
- High-intensity ultraviolet disinfection
- Sludge thickening for transport to Tri-Town

Wastewater Disposal:

Spray irrigation at Site 193 and/or Site 194 during warm months

Subsurface leaching at Site 193 and/or Site 194 during cold months

Disposition of effluent by watershed (annual average):

Cape Cod Bay	0 gpd	(0%)
Nauset system	0 gpd	(0%)
Pleasant Bay	659,000 gpd	(100%)

Septage and Sludge Handling:

The upgraded Tri-Town Septage Treatment Facililty would receive and dewater septage from all 3 District towns, as well as liquid sludge trucked from the South Orleans centralized plant. Dewatered sludge would be trucked away for ultimate disposal out of town.

Land Acquisition Needs:

Purchase land for one treatment plant site (privately owned)

Purchase land or acquire easements at 2 sites for effluent disposal (1 public, 1 private)

Sign long-term contracts for golf course irrigation (1 public, 1 private)

FIGURE 3-4
WASTEWATER PLAN #3

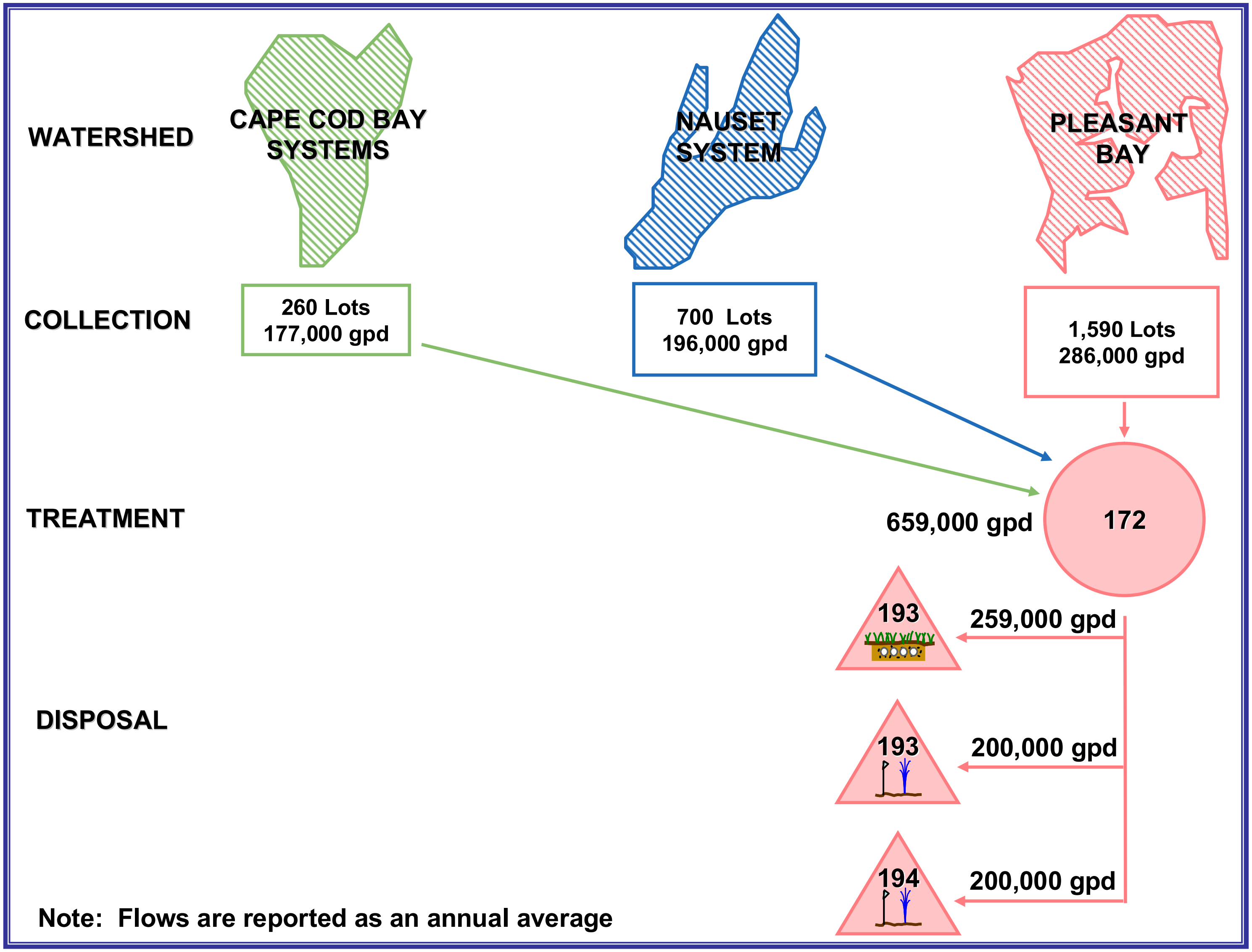


TABLE 3-6
COMPARISON OF WASTEWATER PLANS

	Plan 1	Plan 2	Plan 3
Wastewater Collection			
Properties served			
Cape Cod Bay watersheds	260	260	260
Nauset System watershed	780	700	700
Pleasant Bay watershed	1,350	1,220	1,590
Total	2,390	2,180	2,550
Annual average wastewater flow, gpd	663,000	621,000	659,000
Wastewater Treatment			
Number of plants	4	1	1
Location and capacity (mgd) of plants			
Cape Cod Bay watersheds	1 @ 1.0 mgd	1 @ 1.5 mgd	
Nauset System watershed	1 @ 0.3 mgd		
Pleasant Bay watershed	1 @ 0.2 mgd 1 @ 0.1 mgd		1 @ 1.6 mgd
Wastewater Disposal			
Number of sites			
Cape Cod Bay watersheds	1	3	0
Nauset System watershed	3	0	0
Pleasant Bay watershed	6	0	2
Total	10	3	2
Technology	rapid infiltration subsurface leaching	rapid infiltration subsurface leaching	spray irrigation subsurface leaching
Septage and Sludge Handling			
Septage receiving location	Tri-Town site	Tri-Town site	Tri-Town site
Liquid sludge dewatering	Tri-Town site	Tri-Town site	Tri-Town site
Dewatered sludge disposal	Out-of-town	Out-of-town	Out-of-town
Land Acquisition			
Number of sites			
Treatment	3	0	1
Disposal	9	2	2
Total	12	2	3

APPENDIX A

APPENDIX A: OPTIONS FOR REDUCING WASTEWATER FLOWS AND LOADS

The Needs Assessment report documents the number of parcels and wastewater flows associated with five categories of wastewater management needs. As the Town identifies feasible means to address those needs, it is appropriate to ask: could the costs for satisfying these needs be reduced is the quantities of wastewater or the associated pollutant loads were reduced at the source?

DEFINITIONS OF "FLOWS", "LOADS" AND "CONCENTRATIONS"

It is important to understand how three terms related to one another: "flow", "concentration" and "load".

The wastewater **flow** is defined as the quantity of wastewater generated in a given time period. In this project, wastewater flows have been expressed primarily in terms of gallons per day.

The **load** of a given pollutant (say nitrogen) is the mass of that pollutant generated in a certain time period. The TMDLs for Pleasant Bay have been expressed as kilograms per day and as pounds per year, as examples.

The **concentration** of a pollutant is the ratio of its load to the flow that is transporting it. A nitrogen concentration in septic tank effluent of 35 milligrams per liter (mg/l) means 35 milligrams of nitrogen (mass) contained in one liter of septic tank effluent, for example.

These terms are inter-related. For example, untreated wastewater may have a nitrogen concentration of 45 mg/l. If the wastewater flow is 100,000 gpd, then the load is 13,700 lb/yr (See Case A below). If the flow is reduced by 10%, with no change in concentration, the load is also reduced by 10% (Case B). If the load is the same, and the flow is reduced by 10%, the concentration increases by 10% (Case C).

A.	100,000 gpd	45 mg/l	13,700 lb/yr
B.	90,000 gpd	45 mg/l	12,300 lb/yr
C.	90,000 gpd	50 mg/l	13,700 lb/yr

This interrelationship is important in understanding nitrogen control strategies. For example, reducing wastewater generation rates (by reducing water consumption) is a desirable goal, but has no effect on the nitrogen load (compare Case A with Case C). Only by reducing the mass of nitrogen in the waste stream does the nitrogen load go down.

BENEFITS OF FLOW AND LOAD REDUCTION

Collection, treatment, and disposal are the three major structural components of a wastewater management system. The cost of a system is directly tied to the size and complexity of each component. Measures to reduce the flow or load from system users can result in reductions in system size, which can translate to a reduction in capital costs or operation and maintenance costs. Each component is affected differently by reductions in wastewater flows and loads.

Collection

In traditional wastewater collection systems, there is a moderate reduction in cost associated with a reduction in wastewater flow. Within the upper reaches of the sewer system, savings are quite small, due to the fact that minimum pipe sizes are needed for maintenance purposes, and smaller volumes of wastewater do not translate to smaller pipes. Further, the cost of the pipe itself is only a very small percentage of the total construction cost. As you proceed downstream in the collection system, capital savings are more direct because pumps and pumping stations can be smaller with reduced wastewater volumes. Once the system is built, the operation and maintenance (O&M) costs piping system are largely unrelated to flow, while the energy portion of the O&M costs of pumping stations is directly related to flow.

In traditional collection systems, a reduction in pollutant load has no impact on collection system costs. However, in situations such as exist on Cape Cod, where nitrogen control governs, nitrogen load reductions can be significant. If a given embayment requires a certain nitrogen load reduction, the number of homes connected to the sewer system is directly related to the degree of nitrogen load reduction that can be accomplished at the source. A 10% reduction in nitrogen load, at the source, would translate to a 10% reduction in the number of homes to be served, resulting in a geographically less extensive sewer system and significantly reduced costs.

Treatment

The capital and O&M costs of wastewater treatment systems vary with both the flow and the pollutant loads. Some plant components could be made smaller as a result of flow reductions, and others are not impacted at all. The same can be said for reductions in pollutant loads. For the technologies likely to be employed in Orleans, a reduction in nitrogen load may be slightly more advantageous than a comparable percentage reduction in flow. The best case for treatment plant cost reduction is a reduction in both flow and load.

Disposal

The wastewater treatment facilities will reduce the pollutant loads to the point that they will have no impact on effluent disposal costs, either capital or O&M. Most effluent disposal technologies are sized volumetrically, that is, their size and cost is directly related to wastewater flows. Therefore, flow reduction can result in fewer or smaller effluent disposal sites.

On-Site Systems

Individual systems (typically less than 10,000 gpd) are designed and constructed based on Title 5 regulations. The size of a residential system is determined based on the number of bedrooms in a residence. There are no "credits" available for implementing flow or load reduction measures, and consequently such practices do not affect the size or nature of the standard Title 5 wastewater system design requirements. (Note that Title 5 requires a larger system if the home it serves has a garbage grinder.) However, flow and load reduction can increase the longevity of an individual system. Maximizing the period between the installation of a new system and the replacement of that system at the end of its life, minimizes the annualized capital cost of the system. This is beneficial for failing systems, and can also reduce the frequency of emergency pumping. Certainly flow and load reduction at the individual level conserves water supplies and reduces nutrient loading to groundwater which reduces environmental impacts and should be considered as part of the comprehensive plan.

OPTIONS FOR FLOW REDUCTION

Overall water use includes that portion that becomes wastewater and the consumptive use (the portion that does not0. Reductions in consumptive use are not relevant to this discussion, but are important to town-wide water supply management. Pertinent options for wastewater flow reduction include:

Low-flow plumbing fixtures

Low-flow sinks, showers, and washing machines are available and can reduce water consumption by 10% over older devices. Reducing water consumption with modern fixtures will reduce the wastewater production.

Outside showers

Already common to most homes on the Cape outdoor showers are widely used in the summer time. This current practice provides a significant reduction in wastewater generation by removing this otherwise indoor activity from the wastewater stream. When many more residents are at their homes in the summer, this practice can be very beneficial. Peak wastewater flow in the summer is largely related to the surge in population. If the majority of residents take an outdoor shower after a trip to the beach, instead of an indoor shower, the opportunity exists to reduce peak flows by this practice.

Progressive water pricing

Water service pricing is among the top actions to promote conservation as stated by the MA Water Conservation Standards, and an effective tool for promoting flow reduction. Contrary to the pricing structure for most services where the more you buy, the less it costs; effective water use pricing fees increase incrementally. A progressive pricing structure charges fees based on the size of the service and quantity of water used. The larger the service connection, the higher the quarterly fee. The quantity of water used is charged incrementally. Generally, the first fee bracket covers the majority of the water used in a single family residence. Subsequent brackets are associated with higher fees. Water pricing can also change with season. It is possible to increase rates in the summer when demand is the highest. All of these practices can further the economic incentive to reduce water consumption and reduce wastewater generation.

Waterless toilets

The components of domestic wastewater are often referred to as black water and gray water, the former being that generated from flushing toilets, and the later, the composite of all remaining sources. Utilizing a waterless toilet is one method for removing black water from the wastewater stream. Black wastewater is treated most commonly in the waterless toilet by composting, or by incinerating the waste. In both cases, the water that would have gone to the sewer is evaporated. The remaining waste that otherwise would have entered the wastewater system must be incorporated in a different waste stream. Alternatives include waste from composting toilets ending up at in a landfill or at a septage treatment facility, or incinerated waste going to a landfill. Subsequently, these locations must be able adequately handle the additional waste.

OPTIONS FOR LOAD REDUCTION

Waterless toilets

Waterless toilets are also an effective method of load reduction. The same technologies described above are effective means of reducing the wastewater load. The solids and nitrogen that would have gone to the sewer instead become compost or ash and enter a different waste stream.

Elimination of Garbage Grinders

A common convenience in most kitchens is the garbage grinder. Disposing of food waste in this method can be a significant contributor to the load of the wastewater stream. Changing this practice would reduce the concentration of the wastewater stream. Many communities ban the use of garbage grinders in homes served by on-site systems. Removing food waste from the wastewater stream means that it must be incorporated into an alternative waste stream. The final destination should be weighed with the traditional practice. Many avid gardeners compost their food waste with other yard products and use the cured product as a soil amendment, and much of the nutrients are taken up by plants. Food waste can also end up in the trash. The final destination may be an incineration facility or landfill, where by-products like leachate must be treated and disposed.

BASIS FOR PLANNING

By the end of the comprehensive planning process, the Town must decide on the flows and loads that will form the design basis for wastewater facilities that will be constructed. A key question will be: To what extent can the favorable flow and load reduction techniques listed above be counted on to reduce project costs?

In large part, the success of these techniques depends on public acceptability. While a town-wide ban on garbage grinders may allow a firm basis for load reduction, the benefits of all of the other techniques is difficult to quantify in advance. Therefore, the town should proceed with implementation of these options and closely monitor flows and load through the first few phases of the program, and use the results in fine-tuning later phases.

APPENDIX B

APPENDIX B: WASTEWATER COLLECTION SYSTEM ALTERNATIVES

The collection system is a major structural component of a municipality's wastewater management system. The best type of collection system for a given community is determined by comparing use, capacity, costs, operation and maintenance requirements, and benefits to the specific environment and landscape.

OVERVIEW

The principal components of a traditional wastewater system are:

- Collection
- Treatment
- Disposal

In some cases, there also may be significant transport facilities between the collection system and the treatment plant, and between the treatment plant and the effluent disposal site. This evaluation covers the collection system options open to Orleans, and includes all components from the source of the wastewater (typically the internal building plumbing) to the treatment plant. The pipe from the home or business to the public system in the street is called the "service connection" and it is usually the responsibility of the property owner. With some collection system options, the publicly-owned system may include components on the property to be served. This letter includes a description of conventional, low pressure (STEP and grinder pump), vacuum, and small diameter systems.

CONVENTIONAL COLLECTION AND PUMPING SYSTEMS

In traditional gravity systems, wastewater flows by gravity from the house source through the service connection and through a piping network to a common collection point. At this location, a central pumping station is usually installed to lift the wastewater to another downstream stretch of gravity sewer or to transport the wastewater to its final destination for treatment and disposal. Conventional gravity systems are prevalent throughout New England. For example, the Cape Cod towns of Falmouth, Barnstable and Chatham have gravity sewers in downtown areas and other areas of town.

Gravity sewers are normally constructed of polyvinyl chloride (PVC), ductile iron, or concrete pipe materials. Extremely flat or hilly terrain and areas with high groundwater may pose problems to gravity sewer installation. These conditions often result in increasingly deep excavations or the need for intermediate pump stations.

Wastewater pumping stations are typically located at low points in the system to collect and pump the wastewater to the next high point in the collection system or to the wastewater treatment facility. Both the deep excavations and the pump stations are expensive, and the latter represents a considerable operation and maintenance (O&M) expense.

These systems are often preferred over grinder pump of STEP systems because the municipality is in control of all the mechanical system components and has the ability to maintain the system at its own schedule. The systems are relatively simple and thus fairly reliable.

LOW PRESSURE SEWERS

In a low pressure sewer system, an individual pumping system conveys the wastewater generated from the house or business into the low pressure piping network where it is transported to a central location for re-pumping or treatment. The piping network is comprised of small-diameter pipe, buried just below the frost line (typically 3 to 4 feet deep on Cape Cod), and generally following the profile of the ground. The piping system requires smaller open cuts during installation than a conventional gravity system due to the shallower depth of burial. Typical pipe diameters are 2 to 6 inches for the mains and 1.25 to 1.5 inches for the services. Each home or source uses either an effluent pump in a septic tank or a grinder pump to discharge to the main. The pressure main and service pipe are generally manufactured from PVC or high density polyethylene (HDPE).

Low pressure systems have proven to be viable alternatives especially in low-lying areas with high groundwater. Low pressure sewer systems also work well in extremely hilly areas and waterfront areas where deep excavations and extensive dewatering could cause environmental harm. Additionally, low pressure systems are well suited to installation in coastal areas subject to periodic flooding, areas with narrow streets and areas with shallow depth to bedrock.

To effectively manage a low pressure system, the Town must consider ownership of the components located on private property, the potential need for easements, limitations on system expansion, pumping system compatibility and delineation of operation and maintenance responsibilities. If the Town wishes to own the pumping system, easements will be required to permit system installation and to enable periodic and emergency maintenance to be performed. Alternately, each user could own the pumping system and schedule maintenance as needed. In this case, the Town would adopt regulations prohibiting users from modifying the system. The maintenance may be more difficult in areas of seasonal housing where residents are often not at home.

Low pressure sewers work well in some areas of the Cape and Islands because they are well suited for the relatively flat terrain, areas with perched groundwater, areas with narrow streets and properties close to surface waters. Low pressure sewers are used in Oak Bluffs, Edgartown, Tisbury, areas of Nantucket and at the Bailey's Path development in Chatham.

Septic Tank and Effluent Pump (STEP) Type - Low Pressure Systems

STEP systems are a variation of the low pressure collection system that includes septic tank pretreatment. On each sewered property, there is a septic tank and septic tank effluent pump. Depending on the site layout, the septic tank can be the existing one or it may be entirely new. The septic tank of a STEP system captures the solids, grit, grease, and stringy material that could cause problems in pumping and conveyance through the small diameter piping. STEP systems can be used to convey wastewater to a treatment facility or to a common subsurface leaching system. Periodic removal of the sludge and grease collected within the septic tank by a licensed septage hauler is essential to the long term performance of the system. STEP pumps require only fractional horsepower. The City of Gloucester has 1,200 STEP systems in the North Gloucester collection system.

While standby power is easily provided to a single pump station in a treatment system, it is more difficult to keep individual grinder pumps going during an extended power outage. Some towns have used small portable generators that are moved through the neighborhood served by grinder pumps. In other cases, homeowners are on their own to provide back-up power.

Grinder Pump Type - Low Pressure Systems

A grinder pump system is another variation of the low pressure collection system which utilizes a grinder pump to grind the solids present in the waste to a slurry in a similar manner as a kitchen garbage grinder. The grinder pump macerates the solids present in the raw wastewater and discharges to the low pressure piping system. Although the grinder pumps can be installed indoors, they are generally located outside, close to the user's existing septic tank or cesspool so that the service connection can be easily made with minimal alterations to the indoor plumbing. Grinder pumps which serve individual homes are usually 1 horsepower in size, but 2-horsepower units are also used. Some installations require 3- to 5-horsepower motors, and these are usually used when serving several units with one pumping unit.

VACUUM SYSTEMS

Like the low pressure sewer system, a vacuum sewer system can be used where conventional sewer systems are impractical and not economically feasible. Vacuum sewers employ a central vacuum source. Vacuum sewers are limited by the available lift and are therefore most suited to flat terrain. Although not prevalent in New England, vacuum systems are in place in Provincetown, a limited area of Barnstable and on Plum Island in Newbury/Newburyport.

The collection mains in vacuum systems are typically constructed of PVC or HDPE ranging in size from 4 to 10 inches in diameter. Vacuum systems can be buried at shallow depths as the high velocities (15 to 18 feet per second) attained by the system keeps the lines from freezing. The collection mains can follow the profile of the ground provided that modest elevation changes are maintained.

The vacuum collection system consists of three main components: (1) services, (2) wastewater collection mains, and (3) the vacuum station. After a preset time interval, the vacuum valve located on each property closes and a slug of wastewater is propelled into the collection main. Numerous cycles eventually propel the wastewater to a collection tank located at a central vacuum station. Buffer tanks are also used as holding tanks to collect and regulate large flows such as those flows from apartment buildings, schools and other large users.

This technology is the newest of the options presented. It may be subject to a greater number of problems than systems that have been in use for a longer period of time.

SMALL DIAMETER GRAVITY SEWERS

Small diameter gravity collection systems include a septic tank on the building service connection prior to discharge to the sewer main. The septic tank eliminates grit, grease and other troublesome solids which might cause obstructions allowing the collection system to be constructed with smaller pipe sizes. Other than pipe size, these systems are configured similar to conventional gravity systems requiring straight runs between manholes to convey wastewater to a low point where a pumping station is typically sited. Solids settlement is not as significant of a concern in a conventional gravity system, but periodic pumping of the individual septic tanks is required to remove sludge, scum and grease.

Construction costs are often reduced because the sewers may be laid to follow the topography more closely than with conventional gravity sewers. Designers must still be cognizant of infiltration and inflow and ultimate growth in sizing these systems. The Town of Westford operates a small diameter gravity system for one of its schools.

SUMMARY

Table B-1 is a summary of the advantages and disadvantages of the collection system options described above.

TABLE B-1
SUMMARY OF ADVANTAGES AND DISADVANTAGES OF COLLECTION SYSTEM OPTIONS

Technology	Advantage	Disadvantage
Conventional Gravity Sewer System	• Ease of long-term maintenance • Power outages handled with centralized backup power at pump station • Provides excess capacity for future connections • Centralized solids management • Lowest energy use • Limited need for service connection easements	• Deep excavations disrupt traffic and private property • Not all properties can easily be served by gravity connections • Stream and road crossings more expensive • Not amenable to narrow streets • Flat areas require multiple intermediate pump stations • Higher capital costs • Interior plumbing modifications may be required
Low Pressure Sewer System	• Potential for lower capital cost • Easier construction due to shallow excavation • Environmental disruption reduced • Duration of construction reduced • Suitable for challenging terrain • Reduces stream and road crossing effort • Amenable to narrow streets • Less sensitivity to I/I	• Increased service call effort • Pumps located on each lot • Alarm panels mounted on buildings • Electrical costs paid by property owner • Ownership and O&M responsibility are shared by many entities • Easements may be required • Must provide decentralized standby power system • Interior plumbing modifications may be required
Vacuum Sewer System	• Lower O&M costs • Easier construction due to shallow excavation	• Limited number of vendors and service providers • Limited to flat terrain • Maintenance concerns with valves • Construction and design costs higher than low pressure systems • Modification to interior plumbing is required

APPENDIX C

APPENDIX C: WASTEWATER TREATMENT SYSTEM ALTERNATIVES

Of all the wastewater management issues identified in the Needs Assessment, protecting the health of surface waters from nutrient enrichment is the largest single concern. Wastewater effluent is the largest source of nutrients entering embayments. After addressing ways to reduce other nutrient sources such as stormwater and fertilizer, the remainder of the nutrient removal must be addressed by providing more advanced wastewater treatment. Identifying the best wastewater treatment technologies is one of the most important aspects of the CWMP.

INTRODUCTION

In most cases, smaller wastewater systems cost more per user and are less reliable. To balance cost-effectiveness and reliability, This evaluation focuses on systems that are feasible at flows greater than 50,000 gallons per day. Therefore individual and cluster systems have limited applicability to this evaluation. However, this analysis will consider such systems in cases where properties with a wastewater need are in a cost-prohibitive location to reach with a sewer extension or are surrounded by other properties that adequately meet their wastewater needs.

The capital investment in a collection system is a significant portion of the overall wastewater system cost. In reducing the nitrogen load to an embayment the extent of the wastewater collection system is directly tied to the nitrogen removal capabilities of the treatment facility. Therefore, the focus will be identifying and evaluating technologies that can meet effluent concentrations less than 10 ppm.

In some cases, phosphorus control is the primary concern with respect to surface water protection. Phosphorus removal is easily achieved by chemical addition to the secondary or tertiary treatment process. Once a nitrogen removal technology is selected, an "add-on" for phosphorus removal is easily incorporated into the treatment design for those systems that serve areas tributary to ponds and lakes that require phosphorus load reduction. For this reason, this evaluation includes a detailed evaluation of nitrogen-removing technologies.

HIGH NITROGEN REMOVAL TECHNOLOGIES

All the treatment systems identified herein are capable of meeting effluent nitrogen limits less than 10 ppm. The basic issues in determining which of these systems is the most appropriate include: 1) the volume of wastewater requiring treatment; 2) the relative ease of permitting the technology; 3) the projected capital and operation and maintenance expenses associated with each system; and, 4) the public acceptability of the proposed facility housing the treatment technology.

The technologies identified as part of this evaluation include: rotating biological contactors, Amphidrome, sequencing batch reactors, membrane bioreactors, biological aerated filters and oxidation ditches. A description of each technology is provided below.

There are two fundamental types of biological treatment. The bacterial mass that is the vehicle for treating the wastewater is encouraged to form either as a "suspended growth" or as a "fixed film". Activated sludge is another term for suspended growth systems in which the wastewater is mixed and aerated to provide constant contact between the bacteria and wastewater in the presence of oxygen. Sequencing batch reactors, membrane bioreactors and oxidation ditches utilize this technique. Fixed film treatment provides a surface for the bacteria to grow on that comes in contact with the wastewater. This technique is utilized by rotating biological contactors, biological aerated filters and the Amphidrome system.

Rotating Biological Contactors (RBC)

Rotating biological contactors employ a series of polyethylene discs, mounted on a steel shaft. These contactors are partially submerged in the wastewater. Bacteria adhere to the discs forming a biological layer and utilize the soluble organic compounds in the wastewater as a source of energy and as a supply of the basic elements necessary to produce new cell material. Rotation of the media alternately exposes the organisms to organic-rich wastewater, and to the atmosphere which provides the oxygen needed for respiration. Second-stage RBCs are fully submerged in wastewater in covered tanks to create a low-oxygen environment where nitrogen removal occurs.

RBC's are capable of producing a fairly uniform effluent while operating over a range of hydraulic and organic loading. The biological colony will wax and wane in response to the strength and volume of the influent wastewater. This flexibility is applicable to systems that serve schools where flows significantly drop off over vacation. This technology was selected at the Dennis-Yarmouth High School for that reason. Another advantage of this fixed film process is reduced sludge production compared with suspended growth systems.

Although the majority of rotating biological contactor treatment systems in Massachusetts are constructed within a building, exterior installations using fiberglass covers have proven effective and are the norm in other areas of the country. Installing RBC’s inside a building have the advantage of ready access to view and assess the condition of the equipment. Year-round temperature regulation is also possible with indoor installations. However, extra consideration is needed in selecting moisture-resistant building material that will withstand the humid environment. All installations must be above-grade.

Exterior installations may require larger RBC units to compensate for reduced bacterial treatment levels during winter months due to decreased biological activity at lower temperatures. However, the potential for lower capital costs may make this an attractive option.

RBC's have a long history of use as a biological treatment process for private and small public wastewater treatment facilities. The Community of Jesus is one local example of a small enclosed RBC treatment facility. This facility is located on privately owned land and is in a residential setting. The architectural features of the treatment facility building are suited to its surroundings. RBC's are also used at the Tri-Town Septage Treatment Facility and are located outside along with other treatment process units. The RBC's are protected by unheated fiberglass enclosures.

There are almost 100 RBC facilities with groundwater discharge permits with flows as high as 300,000 gpd in the Commonwealth. One large facility is located at New Seabury in Mashpee.

Sequencing Batch Reactors (SBR)

The SBR process is a modification to traditional activated sludge treatment process, which utilizes a batch treatment system to perform the required steps of wastewater treatment. SBR systems operate on a very simple concept of introducing a quantity of waste to a reactor and providing several process steps in a sequence that would traditionally require a single tank for each step. That sequence includes filling the reactor with wastewater, providing a period of aerobic treatment, settling, and anaerobic treatment. Then the effluent can be decanted and a portion of the sludge removed before the process is repeated.

SBR's are capable of producing a uniformly high quality effluent while operating over a wide range of hydraulic and organic loadings. During periods of low hydraulic or organic loading, the biological growth can be concentrated and maintained within the reactor by reducing the frequency of sludge wasting. As the flow (or organic load) is increased, the organisms begin to proliferate and a larger percent can be removed from the system for disposal by increasing sludge wasting, while maintaining the same level of treatment. Thus, the system is quickly able to adjust to the strength and volume of the influent wastewater stream.

One of the primary attributes of the SBR system is that this variation of the activated sludge process provides considerable flexibility to meet the requirements of specific waste treatment applications. Due to process flexibility, SBRs are being employed in a variety of process design variations with increased frequency in both municipal and industrial wastewater treatment applications.

A batch treatment approach reduces the number of treatment units commonly required in traditional biological treatment facility designs. Limiting the number of process units may decrease capital costs, minimize facility footprint, and reduce treatment complexity. SBR's can be located above or below grade.

SBR's operated by municipalities on the Cape are located in Falmouth and Provincetown. Both of these installations are located in a traditional centralized treatment facility, but this technology is effective on a smaller scale as well.

Amphidrome

The Amphidrome system is a fixed film sequencing batch reactor. The treatment process consists of an anoxic equalization tank, sand filters and clear well. Effluent from the anoxic tank flows downward through the sand filter, providing contact with the bacterial population adhering to the sand particles, and then flow into a clear well. From the clear well the wastewater is mixed with a supplemental carbon source and pumped through a second sand filter where the nitrogen removal process is completed. Liquid from the clear well is pumped back through the sand filter to backwash the filter and return liquid to the anoxic tank.

Amphidrome systems have been used for design flows up to 150,000 gpd. There are about 20 systems with groundwater discharge permits in the state. Amphidrome system components can be located largely below grade. The Amphidrome system at Chatham Bars Inn is a good example of a facility with minimum above-grade structures. Process tanks are located below grade in a guest parking lot, which is a good dual use of space.

Membrane Bioreactor (MBR)

Membrane Biological Reactors (MBRs) includes a semi-permeable membrane barrier system either submerged in or following an activated sludge process. This technology ensures removal of virtually all suspended and some dissolved pollutants.

The membrane technology is relatively new and applicable to small and large flows. The track record of systems installed in the past few years is promising with results indicating very high effluent quality is achievable. Membranes are expensive and require regular cleaning and periodic replacement. The cost of the membrane is partially offset by the smaller building needed to house the system, compared to other technologies.

This treatment process requires a relatively small footprint. Above- and below-grade installation of the treatment process is possible. A good example of a combination of below and above grade components is the system that serves the Cotuit Stop N Shop. Several tanks are located below grade and a small treatment building houses the process tanks, pumps and controls. This facility has very high nitrogen removal.

Biological Aerated Filter (BAF)

The biological aerated filter process consists of one or more units in series, depending on the level of nitrogen removal required. The BAF will require an upstream settling tank to remove the large particulate material. Each BAF unit consists of a flooded tank filled with polystyrene beads which provide the required surface area for biological growth and filter the wastewater as it passes through. The BAF unit acts is a fixed film process resulting in reduced sludge production, roughly 60%, in comparison to SBR and MBR suspended growth processes.

The BAF unit can be housed inside or outside and either above or below grade. The overall footprint of this process can be very small relative to other alternatives. This process can be intensive in terms of process controls, piping and valving requirements. Examples of this technology include the Binghamton/Johnson City Joint Wastewater Treatment Plant in New York.

Oxidation Ditch

An oxidation ditch is a suspended growth system that can maintain aerobic and anaerobic treatment zones. This technology has been utilized for wastewater treatment for longer than any of the other technologies evaluated and can provide a highly "polished" effluent. Wastewater is treated as it flows around a long oval-shaped channel. Instead of providing several process tanks like other technologies, the length of the channels allows for different types of treatment to occur as the wastewater moves around the ditch. Wastewater alternately passes through aerobic and anoxic zones allowing a mixed culture of bacteria to remove nitrogen.

This technology requires a large footprint to accommodate the ditch. Unlike other technologies the oxidation ditch is always located outside. Proper design of visual buffers and setbacks are critical in avoiding significant negative impacts on abutting properties. An oxidation ditch is used at the Yarmouth Septage Treatment Facility to treat septage. This technology has been selected for use in Chatham. Oxidation ditches are widely used in the Chesapeake Bay area.

SMALL-SCALE NITROGEN REMOVING SYSTEMS

There is a wide variety of systems available to provide enhanced treatment for individual and cluster applications. In general, these systems are not capable of the highest nitrogen removal requirements. This lower efficiency is attributable to several factors, including widely ranging flows and load, less attention to operation and maintenance, and start-up time after seasonal shut-downs. In addition, these systems are relatively expensive on a per-user basis; that is, they do not enjoy the economies-of-scale that benefit larger systems. The lower efficiency and higher per-user costs translate to a higher cost per pound of nitrogen removed compared with larger systems. Where significant nitrogen control is required to protect embayments, as faced by Orleans, the focus should be on systems larger than 50,000 gpd. The applicability of small-scale systems is limited to properties, or clusters of properties, where a higher level of treatment is warranted to reduce impacts of significant Title 5 variances, and where the remoteness of the property makes the transport costs to a larger system uneconomical.

Among the most common small-scale nitrogen removing systems are: 1) Bioclere which uses a fixed-film trickling filter process; 2) Cromaglass provides treatment in a sequencing batch reactor sludge system; 3) Nitrex uses a nitrate-reactive media to convert nitrate to nitrogen gas, following a nitrification step to convert other nitrogen forms to nitrate; 4) MBRs as described above; and 5) FAST utilizes both fixed and suspended growth nitrogen removal methods.

SUMMARY

Table 2-3 of this Alternatives Screening Report outlines the range of effluent limitations that may apply to Orleans. The five categories of effluent limits include two levels of nitrogen removal, two levels of phosphorus removal and a set of limits related to effluent reuse. This evaluation focuses on the technologies needed to meet the high level of nitrogen removal. As noted above, both levels of phosphorus removal can be achieved by adding chemical feed equipment to any of these technologies. The extra filtration provided by membrane systems yields the most reliable phosphorus removal to the lowest levels. For effluent reuse, the focus must be bacterial and viral removals and the higher suspended solids removals needed to ensure proper disinfection. Effluent reuse standards can be achieved by adding separate membrane components and efficient disinfection to any of the above-described systems, but is inherently provided by the MBR system.

The technologies identified and evaluated herein provide high levels of nitrogen removal and are most efficient when sized to treat 50,000 gpd or more. Included in Table C-1 is a summary of technologies which lists their applicability to treatment size, and the most local example of each. This table includes common small-scale systems as well.

TABLE C-1
TREATMENT TECHNOLOGIES

Technology	Examples	Applicability to Treatment System Size		
		Less than 50,000 gpd	50,000 to 200,000 gpd	Greater than 200,000 gpd
RBC	Community of Jesus	X	X	X
Amphidrome	Chatham Bars Inn	X	X	
SBR	Provincetown	X	X	X
MBR	Cotuit Stop N Shop	X	X	X
BAF	Prominent in NY		X	X
	and the mid-Atlantic			
Ox. Ditch	Yarmouth (septage)			X
FAST	Wrentham High School	X		
Bioclere	Wise Living	X		
Chromaglass	Carriage Crossing in	X		
	East Bridgewater			
Nitrex	Currently Piloting	X		
	at MA test center			

While all of the treatment technologies described in detail are capable of meeting the more stringent nitrogen limits, there are a number of subtle differences in sizing and performance that will be addressed when composite systems are evaluated for overall cost-effectiveness.

APPENDIX D

APPENDIX D: OPTIONS FOR EFFLUENT REUSE AND DISPOSAL

INTRODUCTION

Historically, effluent from wastewater treatment facilities has been discharged to a surface water body, be it a river, lake or ocean. In southeastern Massachusetts, the Ocean Sanctuaries Act prohibits new or expanded surface water discharges, so effluent disposal to the groundwater is the only viable option.

Groundwater effluent disposal systems fall into one of two major categories. One type applies the effluent at the ground surface, the other disperses the effluent below the surface. The goal of both is to get the effluent to percolate down to the groundwater and be carried away by the regional groundwater flow.

Surface application options include spray irrigation and rapid infiltration. Subsurface systems include leaching facilities (trenches, beds or chambers), wicks, and drip irrigation.

The relative weighting of advantages and disadvantages for a given disposal technology is best determined by considering the features of the specific site. Once potential effluent disposal sites are identified, the best pairing of sites and technologies will be addressed as composite wastewater plans are developed. The pairing depends on both the site and the disposal technology.

With respect to the physical characteristics of a site, size, topography, permeability of the soils and depth groundwater all determine suitability. Technology attributes include the opportunity for additional nitrogen removal, dual-use potential, and the effluent loading rate (volume that can be applied per square foot of area).

DISPOSAL TECHNOLOGIES

From well-established technologies to those at the forefront of new designs, the technologies identified in this report were selected because they provide a wide range of capabilities, such that very different types (size, location, soils) of disposal sites can be considered.

Subsurface Leaching

By far the most common example of this type is the soil adsorption system in the typical backyard. A soil adsorption system includes of a networking of rigid perforated piping buried below grade that distributes effluent into surrounding gravel trenches or beds that provide dispersal of effluent over a large area at a low dosing rate. If well maintained they last for at least 20 years or more. Land must be available for the active disposal area as well as an equivalent area of land earmarked as reserve, which can be developed in the event of a failure.

These systems are designed to operate year-round and work best with regular dosing of effluent. The entire disposal system is buried which eliminates the chance of human contact, and can be located under public parks or sports fields, and under parking lots with proper design. Systems can be very small like those that serve businesses in downtown Orleans, many of whom have their systems located under parking lots. The entire sewered portion of Oak Bluffs is served by a system of 28 leaching fields of 360,000 gpd capacity located under Ocean Park.

Drip Irrigation

Drip irrigation is a subsurface installation of flexible small-diameter plastic piping that provides pressure dosing of effluent to the soil. Loading rates are comparable to subsurface leaching fields because the concepts are similar. This is a relatively new technology that has been tested at the Massachusetts Alternative Septic System Test Center and just received "general use" approval in 2006. These systems can be buried at very shallow depths if desired; however, shallow depths can preclude year-round operation. These systems require a pressurized application; usually a pump station is located near the disposal system and require effluent filtration to avoid plugging.

These systems can be sited under parks, sports fields, or parking lots. The flexible hosing can follow surface contours and run around trees or landscaping, and can be installed in some wooded settings. The drip tubing can be installed in the soil through narrow trenching or single blade plow. It is possible to install a system in a matter of days and avoid tearing up turf. The low-cost materials and easy installation translate into a relatively low capital cost. Due to the lack of long-term experience with the technology, DEP will probably require 100% back-up with conventional technology elsewhere. DEP may also require reuse-quality effluent when drip irrigation is used.

Rapid Infiltration

Also referred to as open sand beds, these systems can operate at high loading rates on sites with good permeability and significant depth to groundwater. Year-round application is routine, but there is little opportunity for dual use of a site. The significantly reduced footprint compared with other technologies often outweighs the benefit of dual use. A smaller disposal footprint also broadens the number of parcels that could be viable disposal sites. The reduced footprint sometimes allows a single site to provide both treatment and disposal, which is less likely for other systems. Locating the treatment and disposal processes on the same site minimizes the transport costs.

The Tri-Town Septage Treatment Facility utilizes rapid infiltration basins for effluent disposal, as so does the 4-million-gallon-per-day municipal facility in Hyannis. Rapid infiltration systems require fencing around the perimeter to keep out wildlife or people. The maintenance of the system includes periodic solids removal from the application surface, and infrequent weeding.

Spray Irrigation

Landscape irrigation is another example of technology that can be used on a site with another use. Effluent can be applied to parks, sports fields, golf courses, or landscaping. All of these activities are associated with human interaction and require meeting the effluent reuse guidelines, which adds to the cost of wastewater treatment. Irrigation is certainly restricted to seasonal operation which requires either winter storage or a complementary effluent disposal system. This technique uses moderate application rates.

Yarmouth uses spray irrigation to dispose of effluent from its septage treatment facility. A portion of Yarmouth's effluent goes to a dedicated spray irrigation site with closely controlled access. The remainder of the effluent is subject to further treatment and used to irrigate the Bayberry Hills golf course.

Wicks

The fundamental goal of effluent disposal is to effectively introduce effluent into the groundwater. The type of soil and the depth to groundwater affect how fast surface-applied effluent reaches the water table. Wicks are the most space-efficient method of disposal because they disperse effluent both horizontally and vertically. A wick is a vertical cylinder of highly permeable material that provides an efficient path for effluent to travel from the surface point of discharge to the groundwater. This allows for very high loading rates on a very small footprint. Another advantage to wicks is the ability to bypass less permeable material. In limited areas of Orleans, layers of clay exist that impede the ability of water to percolate through the soil. A wick provides a conduit through impervious soil at the surface to more pervious soil below.

This technology is relatively new and therefore DEP has stringent permitting requirements. First, the design must include standby wicks to provide more than 100% disposal capacity, so that if a wick were to fail or be overloaded, another wick can be brought on-line immediately. Second, there must be another permitted disposal location that could be developed with a traditional system if the wicks fail prematurely. Extensive hydrogeologic evaluations are required to determine the suitability of the soil for wicks.

While other technologies need 3 to 5 acres to distribute 100,000 gpd of effluent, the same volume could be handled by wicks on a site as small as one tenth of an acre. Wicks are not very intrusive. The only above-grade components include an access vault and cover. Wicks are best considered after an unsuccessful search for sites large enough for more traditional technologies.

Wicks are used on West Island in Buzzard's Bay and were sited on conservation land where very tight near-surface soils overlay highly permeable soil with a significant depth to groundwater. Three wicks were installed to handle 100,000 gpd. Wicks are also used for effluent disposal from a senior housing complex in Hingham. They are installed in the rough of an adjacent golf course and sized for 300,000 gpd. Both of these installations have experienced some operational problems.

COMBINING TECHNOLOGIES

It is possible to combine technologies, such as year-round subsurface application below golf course fairways, and seasonal spray irrigation of the remainder on the course. It is also possible to install wicks within rapid infiltration basins to maximize the application area.

EFFLUENT DISPOSAL AS PART OF THE TREATMENT PROCESS

Utilizing the disposal system as part of the treatment process is worth consideration. Specific rapid infiltration bed loading cycles can provide additional nitrogen removal. Spray irrigation of effluent removes additional nitrogen, phosphorus and most other parameters, providing effective effluent "polishing". While such polishing is well documented, DEP may not give credit for the additional pollutant removal because it is difficult to monitor and quantify.

YEAR-ROUND VERSUS SEASONAL APPLICATION

Some of the technologies presented herein are limited to seasonal application. Providing storage of wastewater in cold weather would be required if spray irrigation were the only selected technology. Instead, some combination of technologies is a viable option. Pairing, say year-round rapid infiltration with seasonal spray irrigation could match the typical Cape Cod fluctuation in population and associated flow, and thus avoid winter storage.

REUSE: DEFINITIONS AND BACKGROUND

DEP uses the term "reclaimed water", which it defines as "wastewater that has been treated at a wastewater treatment plant to an advanced degree and used again for various purposes."

The fundamental premise behind any reuse program is recognition of the value of water and the nutrients it may carry, tempered by the public health aspects of public contact with wastewater-derived material. The allowable effluent disposal methods following traditional wastewater treatment (rapid infiltration, subsurface disposal, etc.) are in large part aimed at getting the effluent into the ground, and keeping it there, thus protecting the public from contact with a liquid that retains some undesirable characteristics even after tertiary treatment. The DEP reuse program stipulates higher levels of treatment that address those undesirable characteristics so that certain levels of human exposure are tolerable.

A good way to contrast "effluent disposal" and "use of reclaimed water" is to consider spray irrigation. A spray irrigation site that receives typical treatment plant effluent must include fencing or other means of preventing public access, as well as significant vegetated buffers to control spray drift. If a higher level of treatment is provided, the DEP program allows spray irrigation on golf courses where the public has access. The first example of spray irrigation is best termed "effluent disposal"; the second is "use of reclaimed water".

NATIONAL REUSE EXPERIENCE

In many water-short regions of the country, effluent reuse has been widely employed to counter low stream flow conditions, dropping waters tables, and inadequate potable water supplies that are taxed by non-potable uses, such as irrigation. There are hundreds of examples of effluent reuse in states such as California, Texas and Florida. One of the most extensive examples of effluent reuse is in St. Petersburg Florida, where reclaimed water is pumped through an irrigation water supply system to residential neighborhoods where it is used, with some restrictions, for private lawn watering.

REUSE EXPERIENCE IN MASSACHUSETTS

Reclaimed water is used for toilet flushing at Gillette Stadium in Foxborough, at a car wash in Westford, for golf course irrigation in Yarmouth, for cooling water at a power plant, and for toilet flushing at the Wrentham outlet mall.

MASSACHUSETTS REGULATORY PROGRAM

Massachusetts DEP has established a program to guide the reuse of wastewater effluents. Its publication "Interim Guidelines on Reclaimed Water" was issued in January 2000, and is about to be updated. Alan Slater leads the DEP program, and he met with the Wastewater Management Steering Committee on September 20, 2007 to discuss the current and upcoming guidelines.

The current guidelines allow four types of reuse:

- Spray irrigation of golf courses
- Reuse at landscape nurseries
- Artificial aquifer recharge, and
- Toilet flushing

More uses may be allowed under the new guidelines, perhaps including include private lawn irrigation.

For artificial aquifer recharge, DEP divides projects into two categories:

- The effluent is discharged at a point where the groundwater travel time to the nearest water supply well is more than 2 years, or
- The groundwater travel time is less than 2 years.

LEVEL OF WASTEWATER TREATMENT PRIOR TO REUSE

Wastewater reuse requires a higher quality effluent compared to traditional effluent disposal, and it is important to understand the effluent limits that DEP will apply to the plant producing the reclaimed water. Table 2-3 in Section 3 of this report summarizes the likely effluent limits for a range of scenarios including reuse. Consider the key regulated parameters of BOD, suspended solids, nitrogen and fecal coliform:

- **BOD,** or Biochemical Oxygen Demand, is a broad measure of organic material in the wastewater that consumes oxygen as it decays. The traditional limit on BOD is 30 mg/l. For golf courses and nurseries, and for aquifer recharge with less than 2-year travel time, the BOD must be reduced to 10 mg/l.
- **TSS**, or total suspended solids, is a measure of the solid material that would remain if the effluent were passed through a fine laboratory filter. The traditional limit on TSS is 30 mg/l. For reuse applications, the TSS must be reduced to either 5 mg/l (landscape irrigation and less-than-2-year-travel-time aquifer recharge) or 10 mg/l (toilet flushing or more-than-2-year-travel-time aquifer recharge). The primary reason to reduce TSS is to improve the effectiveness of downstream disinfection processes. The most common

disinfection process, exposure of the effluent to intense ultraviolet light, is very sensitive to the TSS level. Turbidity is another measure of suspended matter, that is easily detected with an in-line device that can continuously measure and record the degree to which light is prevented from passing through the effluent by suspended material. DEP requires that turbidity be continuously below 5 turbidity units (NTUs) for all reuse applications, and that the average of all readings be below 2 NTU for landscape irrigation and aquifer recharge with less than 2-year travel time.

- **Nitrogen** comes in many forms, the principal of which are organic nitrogen, ammonia and nitrate. The typical discharge permit limits the sum of these nitrogen forms to 10 mg/l and also limits the nitrate form to 10 mg/l (which is also the drinking water limit). For effluent reuse, no further nitrogen removal is needed; indeed for landscape irrigation, the presence of nitrogen is a good thing.
- **Pathogenic material** is present in wastewater, and includes such things as bacteria, parasites and viruses that are difficult to measure individually. Fecal coliform bacteria are used as an indicator of the likely presence of pathogens, and are measured as the number of colonies that will grow in a Petri dish under controlled conditions from 100 milliliters (ml) of sample. Although groundwater discharge permits have historically not explicitly required disinfection, DEP is increasingly imposing a limit of 200 fecal coliform colonies per 100 ml, as an **average**, on new discharges. In the reuse setting, that 200 col/100ml standard applies to more-than-2-year-travel-time aquifer recharge, as the **maximum** for any one sample. The maximum fecal coliform count is only 100 col/100ml for toilet flushing and only 14 col/100ml for landscape irrigation and less-than-2-yr-travel-time aquifer recharge. For aquifer recharge and for landscape irrigation, DEP also requires that the **median** fecal coliform count be "zero". That is, more than half of the effluent fecal coliform counts in a given week must be zero.

AVAILABLE TREATMENT TECHNOLOGY

Given the effluent limits discussed above, wastewater treatment systems that produce effluent suitable for reuse must provide a higher-than-normal removal of BOD and TSS, normal levels of nitrogen, and very-high-quality disinfection. Many of the local reuse applications have employed membrane bioreactors (MBRs), such as the WMSC visited in 2006 at the Cotuit Stop n Shop. Another applicable technology uses chemical precipitation to enhance TSS removal. In both cases, a high-intensity ultraviolet disinfection system would be included, although disinfection with ozone is also a possibility.

High quality effluent is required for reuse, and that high quality must be consistently achieved. Treatment plants must be designed for a higher-than-usual level of reliability, and extra monitoring is needed.

The demand for reclaimed water may vary seasonally and would be impacted by the weather. Therefore, DEP requires that a conventional effluent disposal system be provided as a back-up for all effluent reuse programs that involve landscape irrigation (golf courses and landscape nurseries).

ASSURANCES AND OPERATIONAL CONSIDERATIONS

A enforceable contract is necessary between the supplier of reclaimed water and the user, and its principal terms are stipulated by DEP. The user must agree to implement Best Management Practices (BMPs) to avoid or mitigate undesirable impacts. Through the groundwater discharge permit, the supplier of reclaimed water, in this case the Town, is ultimately responsible for the user's failure to use BMPs.

Signs must be posted at key locations where reclaimed water is used, to alert the public to its non-potable character. Use of reclaimed water must be limited to hours when the public is not present at golf courses and nurseries. Reclaimed water cannot be used inside greenhouses.

POSSIBLE REUSE APPLICATIONS IN ORLEANS

Reclaimed water could be produced for a single large user, connected to the treatment plant by a dedicated pipeline. Alternatively, a high quality effluent would be produced at, say, the Tri-Town site, and a reclaimed water distribution system could be installed to serve a number of possible customers in the westerly portion of town. Those customers would be allowed to tap into the distribution system and their connection piping would include a meter that would allow the Town to document the volume used and, if appropriate, issue a bill for that water.

The following list of potential customers and uses was discussed with Alan Slater of DEP at the WMSC meeting on September 20, 2007:

1. **Toilet Flushing in Public Buildings**. Reclaimed water could be used to flush toilets at the Town Hall, the fire station, the police station, the highway garage, the pubic toilets on Main Street, the Snow Library, and similar facilities. Administrative issues would be reduced (compared to private reuse) because of Town ownership. Internal plumbing changes would be needed. Presumably, all of these buildings would be connected to the public sewer, so the reused water would return to the treatment plant.
2. **Lawn Irrigation at Public Sites**. The Town could use reclaimed water to irrigate lawns and vegetation at all of the sites listed above. To the extent that irrigation systems have already been installed, they could merely be disconnected from the potable water supply (or from on-site irrigation wells) and re-connected to the reclaimed water distribution system. The reused water would infiltrate to the groundwater. Best Management Practices would govern the application rates (to avoid runoff, for example) and other operational issues, but presumably groundwater discharge permits would not be required at each individual site.
3. **Toilet Flushing at High-Water-Consumption Commercial Establishments**. Compared with Item 1 above, providing reclaimed water to restaurants and motels increases the administrative burden, but it significantly increases the volume of reused water. Most of the high water users would be connected to the public sewer, so the reused water would be returned to the treatment plant.
4. **Irrigation of the Natural Areas within the Route 6/Route 6A Interchange**. Above-ground irrigation piping could be used to apply reclaimed water in these wooded areas.

No vegetation removal would occur. An agreement would be struck between the Town and Mass Highway to control the application operation.

5. **Irrigation of NStar Rights-of-Way**. The Town should expect that NStar will not be in favor of permanent wastewater disposal facilities under and near its power lines. Irrigation through above-ground, removable distribution equipment might be a more acceptable alternative. Control of vandalism would be an issue, unless sites were fenced off, something that NStar might support. With irrigation of NStar rights-of-way, it would be important to address the pruning of excessive vegetation, a regular concern of NStar.
6. **Irrigation of Cemeteries.** Town Counsel has expressed concern about effluent disposal at cemeteries because of the likely difficulty in gaining all necessary approvals and sign-offs from individual plot owners. These concerns might be addressed by the Town selling irrigation water (effluent meeting the Reclaimed Water Guidelines) to the cemetery association or other controlling entity. Presumably, the extra treatment and monitoring provided to produce reclaimed water would change the character of the liquid from "a waste material requiring disposal" to "valuable alternative irrigation water", and eliminate some of the legal concerns.
7. **Irrigation of Golf Courses with Reclaimed Water**. This option is already addressed in the current DEP guidelines. Given the fact that there are no golf courses in Orleans, this option would require approval and close cooperation with Brewster where several golf courses are located.
8. **Irrigation of Golf Courses with Effluent-Impacted Groundwater**. At the Pinehills in Plymouth, golf course irrigation wells intercept a significant portion of the plume from the development's effluent disposal system, thus recycling some of the wastewater nitrogen entering the groundwater. If Orleans and Brewster developed a rapid infiltration site upgradient of one of the Brewster golf courses, and used capture wells to produce irrigation water, the Reclaimed Water Guidelines might not apply, avoiding the higher level of treatment.
9. **Irrigation of Ball Fields.** The Elementary and Middle School playing fields have been identified as potential sites of subsurface leaching facilities for effluent disposal. Instead, reclaimed water might be used to irrigate those fields, eliminating the demand on the potable water system (or local irrigation wells) and providing additional nutrient uptake. The new Reclaimed Water Guidelines are expected to address this option. The Town should consider a dual system, involving both warm-weather irrigation of reclaimed water and cold-weather subsurface disposal of effluent.
10. **Irrigation of the Bike Path.** A permanent irrigation system could be installed along the Bike Path, enabling seasonal irrigation of the vegetation along the old railroad right-of-way. Presumably this option would be akin to irrigation of playing fields, since it presents some of the same risks such as exposure of children.
11. **Irrigation of Land Surrounding the Radio Tower**. This open land near the Tri-Town plant was initially identified as a potential effluent disposal site, before realizing it has relatively shallow groundwater. If the Town were to build a subsurface leaching system there, surrounding the tower, could it apply reclaimed water there to offset the lack of the usual 4 feet of groundwater separation?
12. **Irrigation of Capped Landfill**. The closed landfill could be considered as a site for a dedicated spray irrigation facility, where the application rates would be controlled to limit runoff, and a hay crop could be grown to remove nitrogen and phosphorus. The landfill

is near the potential route of a reclaimed water distribution system. DEP might require the use of reclaimed water instead of the traditional 30/30/10 effluent.

13. **Irrigation of Private Lawns**. If the proposed distribution system passes through residential neighborhoods, reclaimed water could be sold to individual homeowners. There would be more administrative costs here than with a single public or quasi-public landowner, but much more potential for widespread use and public acceptance. This reuse option could be associated with a "reuse loop" from a centralized facility at Tri-Town, but it could also allow reuse near any decentralized plant that might be built, provided the appropriate level of treatment is assured.
14. **Irrigation at Private Nurseries.** Private landscape nurseries could be provided with reclaimed water from the distribution system. This use is covered in the existing Reclaimed Water Guidelines.
15. **Irrigation of Private Tree Farms.** There is at least one private tree farm in the region (off Route 39 in Brewster). The use of reclaimed water here would presumably be similar to the private nursery situation.
16. **Use at Car Washes.** There are two car washes that could easily be served by the proposed reclaimed water distribution system; one at the Underground Mall (open to the public) and one at the Toyota dealership near the landfill. DEP has previously approved reuse at a commercial car wash on an experimental basis, so there is some precedent for this application.
17. **Irrigation of Wellfields Outside of Zone 2.** Some of the Town wellfield property is located outside the mapped Zone 2 boundaries. If convenient to the proposed distribution system, might such land be irrigated with reclaimed water? If not prohibited by the Town Meeting language through which the land was acquired, this reuse opportunity would not be covered by the current DEP guidelines.
18. **Use in Concrete Production**. Cape Cod Ready Mix in Brewster near the Orleans line uses water for a number of purposes in its business. Might reclaimed water be an appropriate substitute?

This list of potential reuse opportunities was developed to provoke some innovative thinking and to elicit input from DEP on regulatory issues. DEP was generally supportive of these concepts and offered to work with the WMSC to develop a specific plan.

APPENDIX E

APPENDIX E: NON-TRADITIONAL NITROGEN CONTROL OPTIONS

In the needs assessment phase of the CWMP, it was demonstrated that the control of nitrogen is the largest driving force toward improved wastewater management in Orleans. Nitrogen reaches the embayments from various sources and through multiple pathways. The "traditional" approach to controlling nitrogen is to replace septic systems with public wastewater facilities that remove large amounts of nitrogen, and discharge the effluent either at appropriate locations within the watershed, or in the watershed of a less sensitive embayment. While public sewerage is a readily permitted and predictable method for nitrogen control, it is also very expensive. There are a number of "non-traditional" methods for nitrogen control that offer significant cost savings.

INTRODUCTION

In broad terms, non-traditional controls fall into the following categories:

- Options that prevent future nitrogen loads;
- Options that reduce current nitrogen loads before they reach the groundwater;
- Options that take advantage of natural processes that impact groundwater quality as it moves toward the embayments;
- Options that improve the ability of the embayments to assimilate nitrogen loads; and
- Options that remove nitrogen from the water column or sediments within the embayments.

Within that context, the following nitrogen control methods were considered:

- Density controls through municipal bylaws or regulations
- Control of fertilization
- Stormwater management
- Natural attenuation
- Permeable treatment barriers
- Flushing enhancements
- Aquaculture
- Removal or modification of sediments

DESCRIPTION OF OPTIONS

Density Controls through Municipal Bylaws and Regulations

The Needs Assessment documents how current wastewater generation rates in Orleans are expected to increase by 22% over the planning period ending in 2030. Considering a somewhat lower rate of increase in non-wastewater nitrogen sources (such as lawn fertilization), the town-wide nitrogen load may increase by about 20% as a result of growth in the community. Town-wide, the **current** nitrogen load must be reduced by perhaps 20% to 25% (depending on the findings of the MEP studies for the Nauset system). The **growth** in nitrogen load is approximately the same as the amount of the **current** load that must be removed. Any steps the Town can take to slow the growth in nitrogen load will directly impact the extent and cost of structural solutions.

Possible land use controls were discussed in detail at a September 21, 2006 joint meeting of the Board of Health, the Planning Board and the WMSC. The most promising options include:

- Reducing minimum lot sizes for new residential development or reducing the allowable development intensity on commercial properties;
- Instituting nitrogen-based performance standards for expansions and redevelopment, such as the "no net nitrogen increase" approach or a maximum pound-per-acre load (the "fair share" approach);
- Accelerating land purchases or conservation easements; and
- Instituting a "checkerboard" sewer system with limitations on increased flows from properties not served.

These and other programs will be further developed as part of the non-structural plan that will be part of the final CWMP.

Control of Fertilization

When lawn and garden fertilizer is applied, some portion of the nitrogen nourishes the plants, another portion is converted to harmless nitrogen gas by soil organisms, and the excess nitrogen leaches to the groundwater. The MEP technical report for Pleasant Bay estimated that 30% of the un-attenuated nitrogen load from the watershed comes from fertilizer and stormwater runoff, with most of that from fertilizer. Therefore, after septic nitrogen, fertilizer nitrogen is the next largest source. In the Pleasant Bay sub-watershed (one portion of the overall watershed), nearly one-half of the watershed nitrogen load comes from lawn fertilization, principally from three golf courses within that watershed.

There are many steps that can be taken to reduce fertilizer nitrogen load to the groundwater. First, fertilized lawn area can be reduced. Second, where fertilizer is used, the application rate can be reduced, and the timing of applications can be spread out. Third, fertilizers with organic slow-release nitrogen can be substituted for traditional inorganic forms. These steps can be taken by all fertilizer users, but the greatest potential for reduction is where large fertilizer use occurs, which includes golf courses, town parks, and school district ballfields.

The MEP technical report for Pleasant Bay assumed that the typical lawn in Orleans leaches 1.08 pounds of nitrogen per year. That report also refers to a separate SMAST study of lawn care in Orleans which found significantly higher fertilizer use (and presumably nitrogen leaching) on those homes that use private lawn services. One might conclude that private lawn care should be curtailed, but an alternate approach might be to work with the private lawn care companies to seek modified application procedures and materials that might allow green lawns at substantially lower risk of nitrogen leaching.

Education of the public on the need to modify lawn care practices should occur regardless of other steps. In addition, the Town should institute changes in its own practices and should work with the school district in a similar fashion. Other possible steps include restriction on lawn area in new development, working with local lawn and garden retailers to stock only more appropriate fertilizer products, and working with the County to institute a fertilizer ban. While not within the direct control of Orleans, every effort should be made to reduce the very large fertilizer use in the Pleasant Bay sub-watershed at golf courses in Brewster, Harwich and Chatham. Controls on fertilizer use on cranberry bogs should also be considered as appropriate.

Stormwater Management

Precipitation that falls on impervious surfaces runs off and takes with it a variety of pollutants, including nitrogen. If stormwater is discharged directly to a pond or embayment (or to a pipe or channel leading directly there) it is considered a "point source". If runoff infiltrates into the ground and transports pollutants to the groundwater it is considered a "nonpoint source". In either case, actions are warranted to reduce the pollutant load from stormwater. For all of Pleasant Bay, runoff from impervious surfaces is estimated to produce 9,000 pounds of nitrogen per year, or 9% of the total un-attenuated load from all watershed sources.

In general, the Town should try to remove all point sources by infiltrating stormwater instead of discharging it to surface waters. Where this is not possible, some "end-of-pipe" treatment may be warranted, such as exists at Lonnies Pond. While infiltration is most efficient through bare soil, vegetated surfaces provide considerable pollutant removal. Pollutants in runoff can also be addressed at the source, through such programs as regular street sweeping, owner control of pet wastes, requirements for nutrient management plans for large developments, etc. In some communities, surface wasters have been significantly impacted by runoff from failed septic systems. The investigation of sewer needs in Orleans have found this problem to be non-existent.

There are many reasons why stormwater management should occur in Orleans independent of nitrogen control. Phosphorus transport to ponds is an important issue, as is bacterial contamination at beaches and shellfishing areas from road runoff. These reasons for stormwater management are important enough on their own to warrant a town-wide plan. Implementation of that plan will also reduce nitrogen loads to embayments.

Natural Attenuation

As groundwater moves toward and into embayments, it may pass through freshwater ponds and bogs and through salt marshes. In these environments, there may be some removal of nitrogen by natural means that lessens the impact on the embayment. These processes are called "natural attenuation". Natural attenuation has been included in the modeling of embayments on Cape Cod as part of the Massachusetts Estuaries Program. For Pleasant Bay as a whole, natural attenuation is estimated to reduce the raw watershed nitrogen load by 4%.

Natural attenuation can be part of Orleans' overall plan in several ways. First, the selection of properties to be connected to traditional wastewater systems should focus on those properties that are not subject to natural attenuation; that is, once pond protection needs are addressed by sewering in areas immediately upgradient of ponds, wastewater collection should focus first on those properties that are downgradient from the ponds and wetlands that provide natural attenuation.

Second, effluent disposal sites can be located upgradient from these natural attenuation resources to allow further pollutant removals as the effluent-impacted groundwater moves toward the embayment. Great care must be taken to avoid secondary impacts, however, such as overloading the nitrogen attenuation capacity or introducing more phosphorus than is appropriate. Some studies have shown that salt marshes may have significant nitrogen removal capability with less potential for overloading than freshwater systems. In Orleans, where pond protection has high priority, salt marshes represent the best opportunity for natural attenuation and should be considered in effluent disposal siting. The Tri-Town site in Orleans is upgradient from Namskaket Marsh, and the marsh that may now be providing renovation of the Tri-Town plume and might provide attenuation of nitrogen from wastewater effluent infiltrated at the Tri-Town site. Similarly, the salt marshes separating Pochet Neck from Pochet Creek might provide a similar benefit for effluent disposed of in areas that are immediately upgradient.

The third opportunity for taking advantage of natural attenuation is in the restoration of damaged wetlands or the conversion of abandoned cranberry bogs. Some natural attenuation may be occurring at these locations, and restoring them to their original state may allow additional attenuation. In cranberry bogs, deepening the bog or increasing the water surface may increase the detention time of groundwater passing through these systems and allow for greater natural attenuation.

Permeable Treatment Barriers

Permeable treatment barriers are narrow, deep trenches excavated along the shoreline and filled with a medium such as wood chips. The wood chips provide the substrate for bacteria that remove nitrogen from the groundwater passing through the trench. This option, in concept, partially replicates some of the features of riparian wetlands that provide natural attenuation. This method of nitrogen control is very focused in that it intercepts whatever nitrogen has previously reached the groundwater in the watershed upgradient of the barrier. In order for the barrier to remove significant percentages of the nitrogen reaching the embayment, it must cover a large portion of the shoreline and must be deep enough to intercept most of the vertical depth of the nitrogen-impacted groundwater. This approach has been pilot tested at locations in Rhode Island and on Cape Cod. Drawbacks include the need to obtain property rights along the shore, the potential for construction impacts, and the uncertain frequency of media replacement.

Flushing Enhancement

The residence time of nitrogen in an embayment in part determines the susceptibility of that embayment to water quality degradation. Enhancing the flushing rate of the embayment can improve water quality and lessen the impacts of a given nitrogen load. Dredging channels, widening inlets and replacing constricting culverts are all ways to enhance tidal flushing. A number of sub-embayments in the Pleasant Bay system (for example Lonnie's Pond and Areys Pond) and perhaps the Nauset system could potentially benefit from dredging to deepen their inlets. It is expected that less nitrogen control would be needed in the watersheds of these sub-embayments after dredging of their inlets, although additional modeling of the hydrodynamics and water quality would be needed to quantify the impact. (It is important to note that enhanced flushing in these "headwaters' sub-embayments does not reduce the overall load to the Pleasant Bay system, but merely moves the load downstream more quickly. In that these sub-embayments are influenced by the quality of the downstream waters that flush them, this technique is less attractive than similar actions in embayments that discharge directly to the Atlantic Ocean or Cape Cod Bay.)

The MEP technical report for Pleasant Bay predicts that a significantly higher level of nitrogen control will be needed if the current breach off Chatham reverts to its prior, more southerly location. The principal behind this conclusion is the same as discussed above. The towns around Pleasant Bay should formulate a plan to deal with this possible "flushing diminishment".

Flushing enhancement options have many advantages and disadvantages. Any modifications to the coastal environment require significant permitting. Dredging is only permittable in the ACECs if that location has been previously dredged. (Historical dredging has occurred in Areys Pond, Lonnies Pond and Paw Wah Pond, and perhaps others.) The nitrogen control needs documented in the MEP technical report are intended to restore eelgrass and habitat for benthic organisms. Dredging would certainly destroy, at least temporarily, some of the habitat that the nitrogen control is intended to benefit. Dredging, if permittable, would not be a one-time event, but would need to be repeated over time to maintain the flushing enhancement.

Aquaculture

Shellfish are filter-feeders; they filter water to capture organic matter, and in so doing take up nitrogen. By harvesting the shellfish, the nitrogen is removed from the water column. Some studies have been conducted on Cape Cod to assess the viability of aquaculture systems as part of a planned nitrogen removal program. This nitrogen control option is attractive because it might actually generate revenue in excess of its costs. However, it has not been studied sufficiently for it to be included in a formal program. Nonetheless, it is sufficiently attractive to warrant the close review of any ongoing studies to document its effectiveness and economics.

Sediment Removal or Modification

The release of nitrogen from sediments in the embayments represents a large percentage of the total nitrogen load. MEP studies have categorized this nitrogen source as not "controllable" due to the difficulties in removing the sediments or effecting changes in their geochemistry to reduce nitrogen release. While the details of this option and its feasibility need to be better determined, the Town should support investigations and stay abreast of progress on this front. To put this issue in perspective, the nitrogen removal predicted by the MEP technical report for Pleasant Bay is about 37,000 lb/yr, while the current benthal demand is 187,000 lb/yr.

APPLICABILITY OF OPTIONS TO ORLEANS' CWMP

As one reviews the options described above, it is important to keep in mind several factors.

- First, these options hold considerable promise as low-cost substitutes or supplements to traditional systems.
- Second, there are significant permitting and approval hurdles for some options that may make them impractical over the near term.

- Third, there is the need to develop a mechanism to demonstrate the effectiveness of any of the options that is implemented. That is, it is not sufficient to merely **estimate** the degree of nitrogen removal that may occur. It is also necessary to **document** the extent to which nitrogen loads are being reduced. While this is easily done with the discharge from a wastewater treatment plant (by monitoring the effluent), how would it occur with a fertilizer control program, or the restoration of an abandoned cranberry bog?

- Fourth, DEP must concur with the nitrogen control capabilities of any of these options. When the CWMP is approved, DEP must concur in the capabilities of each aspect of a multi-pronged approach. If DEP is not convinced that one of these non-traditional options will be effective, the Town might have to modify the CWMP to include more extensive traditional controls.

None of these issues constitutes a "fatal flaw", but they are very important considerations as these options receive further review and are incorporated into composite plans later in this phase of the project.

APPENDIX F

Appendix F

Legend:
3 = most favorable
1 = least favorable

Scoring of Nine Plans With Respect to 16 Evaluative Criteria

		Composite Plans:	1	2	3	4	5	6	7	8	9
			Tri-Town	Tri-Town	Tri-Town	Decent.	Decent.	Decent.	So. Orleans	So. Orleans	Regional
Evaluative Factors:			Orleans	Regional	Reuse	#1	#2	#3	Orleans	Regional	Two Plants
1	Overall Cost		2	3	1	1	1.5	1.5	1	2	2.5
	1	Likely cost premium									
	2	Average cost									
	3	Significant cost savings									
2	Need for Land Purchase/easements		3	2	3	1.5	1	1	2	2	2
	1	Many purchases									
	2	Some purchases, easements									
	3	Few purchases, easements									
3	Uses Proven Technology		3	3	1	3	3	3	1	1	1
	1	Many new features									
	2	Some new features									
	3	Well proven									
4	Regulatory Acceptability		3	2	2	3	3	3	2	2	2
	1	Needs major reg input									
	2	Some reg issues									
	3	Generally acceptable									
5	Environmental Impact		2	2	3	2	2	2	3	3	3
	1	High									
	2	Medium									
	3	Low (+ distinct env. benefits)									
6	Energy Consumption		2	2	1.5	3	3	3	1	1	1.5
	1	High									
	2	Average									
	3	Low with unique benefits									
7	Potential Neighbor Impacts		2	1	2	2	1.5	1	2.5	1.5	2.5
	1	High									
	2	Average									
	3	Low									
8	Production of Residuals		3	3	3	2	2	2	3	3	1
	1	High, with transport									
	2	Average									
	3	Low, no transport									

			Composite Plans:	1	2	3	4	5	6	7	8	9
				Tri-Town	Tri-Town	Tri-Town	Decent.	Decent.	Decent.	So. Orleans	So. Orleans	Regional
	Evaluative Factors:			Orleans	Regional	Reuse	#1	#2	#3	Orleans	Regional	Two Plants
	9	Benefits from Natural Attenuation		1	1	1	2	2	2	1	1	1
		1	None									
		2	Some									
		3	Significant									
	10	Produces low N/P Concentrations		2	2	3	1	1	1	3	3	2.5
		1	Just meets limits									
		2	Well below limits									
		3	Best available									
	11	Expandability for Regionalization		2.5	3	2.5	3	3	3	2.5	3	3
		1	Not expandable									
		2	Expandable, with constraints									
		3	Easily expandable									
	12	Removes Emerging. Contaminants.		1	1	3	2	2	2	3	3	2
		1	No removal									
		2	Some removal									
		3	High removal									
	13	Ease in Operation		2	2	1	2	2	2	1	1	1.5
		1	Requires special skills									
		2	Average									
		3	Very simple									
	14	Retains Water in Water Supply Area		1	1	1	3	2.5	3	1	1	1
		1	Little									
		2	Some									
		3	Most									
	15	Minimizes Collection System		1	1	2	1	1	1	3	3	2
		1	No reduction									
		2	Some reduction									
		3	Significant reduction									
	16	Overall Public Acceptability		2.5	1.5	3	3	3	3	2	1.5	2.5
		1	Negative									
		2	Average									
		3	Positive									

WRIGHT-PIERCE

Engineering a Better Environment