Town of Orleans
Comprehensive Wastewater Management Plan
and
Single Environmental Impact Report

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Appendix
Material

WRIGHT-PIERCE
Engineering a Better Environment

ORLEANS, MASSACHUSETTS

COMPREHENSIVE WASTEWATER MANAGEMENT PLAN

AND

SINGLE ENVIRONMENTAL IMPACT REPORT

APPENDIX MATERIALS

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Prepared By:

Wright-Pierce
40 Shattuck Road, Suite 305
Andover, MA 01810

TOWN OF ORLEANS

COMPREHENSIVE WASTEWATER MANAGEMENT PLAN

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Prepared by ENSR Corporation
2 Technology Park Drive
Westford, MA 01886

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EVALUATION OF FRESHWATER PONDS

FRESH WATER PONDS BACKGROUND

One of the important aspects of the Comprehensive Wastewater Management Plan is to evaluate the potential for impacts of watershed loads of nutrients on the water quality and designated water uses in adjacent water bodies. In the case of freshwater ponds, unlike the estuarine and marine environments, the primary limiting nutrient (i.e., that which controls the amount of growth in the system) is phosphorus. Due to the importance of groundwater loads derived from residential land use as a source of phosphorus to ponds within Orleans, this evaluation becomes an important criterion for determining the extent to which off-site wastewater management options are warranted to protect, maintain, or improve the condition of the ponds.

Orleans has 63 named lakes or ponds of local interest of varying size, shape, and quality (CCC, 2003). For convenience, all Orleans fresh water bodies will be collectively referred to as ponds, regardless of size or name. As part of the CWMP, eight ponds were selected for evaluation of their current water quality and trophic condition (i.e., relative fertility of the pond), potential to meeting designated water uses, and relative susceptibility to current or future nutrient loads. The ponds include: Bakers Pond, Cedar Pond, Crystal Lake, Pilgrim Lake, Boland Pond, Ice House Pond, Shoal Pond, and Sarah's Pond. These ponds were selected to provide a spectrum of sizes, depths, water uses, and geographic representation in Orleans. Four of these ponds (Bakers, Cedar, Crystal, Pilgrim) are identified Great Ponds by the MA DEP (MA DEP, 2006). The location of these ponds is shown in Figure 2-5.

Data Sources

Currently publicly-available data were used to provide the evaluation of trophic conditions and meeting of designated uses. Water quality (nutrients) and trophic indicators (e.g., chlorophyll concentrations, dissolved oxygen (DO), and secchi disk transparency (SDT) depth) have been regularly monitored from 2001-2005 in many Orleans ponds as part of the Pond and Lake Stewards (PALS) program. Much of this information is described and summarized by the Cape Cod Commission (CCC) in two documents:

- Cape Cod Commission. 2003. *Cape Cod Pond and Lake Atlas. Final Report.* CCC Water Resources Office, Massachusetts Executive Office of Environmental Affairs, Umass School of Marine Sciences and Technology. May 2003; and
- Cape Cod Commission. 2006. *Review and Interpretation of Orleans Ponds Volunteer Monitoring Data* (Draft Final Report). CCC Water Resources Office. September 2006.

In addition to these two primary sources, additional information was used related to pond water quality data, water use, and general conditions. This additional information includes but is not restricted to: scientific articles, related technical reports (e.g., Horsley and Witten (H&W), 2003; SMAST, 2006), newspaper articles, etc. For further information on sources of pond data see Section 2.2.2.

Determination of contributing groundwater watershed areas was based on models and maps originally developed by the USGS and divided into areas contributing to Pleasant Bay, Nauset Harbor, and Cape Cod Bay (see Figure 2-4). For specific ponds, further refinement of groundwater basins was conducted based on available information (e.g., CCC, 2006; SMAST, 2006) and best professional judgment.

Trophic Benchmarks and Pond Classification

One way of assessing whether ponds are currently supporting their designated water uses is by comparison of ambient values of trophic indicator data (i.e., phosphorus and nitrogen fractions, chlorophyll a, and SDT) to State water quality criteria or thresholds. The focus for water chemistry is principally phosphorus, since previous work has shown that most Cape Cod ponds are phosphorus limited (Ahrens and Siver, 2000), although in some cases, nitrogen may be seasonally limiting (i.e., late summer). The exception to this situation is Cedar Pond, which is a tidally-influenced pond, and therefore phosphorus is not likely to be the primary limiting nutrient.

Since the MA DEP is still in the process of developing a state water quality numeric total phosphorus criterion for Massachusetts lakes and ponds, this assessment considered a combination of alternative benchmarks such as the USEPA ecoregional water quality recommendations (U.S. EPA, 2001), the 25th percentile marks from the CCC database of more than 185 Cape Cod ponds (CCC, 2003), accepted trophic state boundaries from the limnological literature (e.g., Wetzel, 2001, Kalff 2002), or other benchmarks.

Ultimately, it was considered appropriate to use the numerical criterion suggested by CCC (2003) for classifying the trophic status of Cape Cod ponds (Table 1. *Orleans Pond Trophic Status)*. This was due to the severe under-representation of Cape Cod ponds in the USEPA database for this ecoregion (Atlantic Coastal Pine Barrens; sub-ecoregion 84) and the acknowledgment that the CCC PALS database provides a more extensive collection of lakes, parameters measured and frequency of measurement that any other available source. For this same reason, the site-specific database and interpretation is preferred over relying on the geographically-diverse collection of northern temperature lakes discussed in standard limnological texts.

Two major caveats come with application of this system, however. This system identifies both reference (i.e., *"unimpacted")* and target *("healthy")* values for nutrient and trophic indicators. The CCC pond benchmark system derives nutrient and indicator (chl a) thresholds in a similar fashion to U.S.EPA water quality recommendation methodology through a fairly simplistic statistical approach, (i.e., the adoption of the upper or lower 25th percentile of an appropriate database).

For Cape Cod ponds the CCC established *"unimpacted"* levels as the upper 75% of values from reference ponds judged not to have been significantly altered from historic (1948) trophic levels and *"healthy"* levels as the upper 25% of values from all ponds in the database. This approach for derivation of nutrient criteria has not been adopted by any of the New England states without significant modification. Some criticisms of this method include the relatively arbitrary choice of the 25th percentile (indicating that 75% of ponds are always out of compliance), that selected levels may not be correlated with important ecological shifts in ponds, or that it does not consider the rooted aquatic plant community (i.e., aquatic macrophytes), which often comprises an important ecological component, particularly in shallow ponds on Cape Cod (e.g., Roman et al., 2001).

The second concern, more semantic than limnological, has to do with use of the term *"healthy"*, as the criterion for non-impacted ponds. While the term *"unimpacted"* seems appropriate with regard to near-pristine or reference natural water quality conditions, the term *"healthy"* is much more ambiguous in the limnological sense, and may likely be misinterpreted in popular usage since if follows that ponds not meeting these target criteria may be considered not *"healthy."* This will be misleading since many mesotrophic ponds that provide water quality and habitats for a diverse biological assemblage and support all designated water uses may be considered not *"healthy"* under a strict application of these criteria (i.e., minor exceedances of criterion). It is suggested that the less judgmental term "target" criterion be considered here.

These criticisms aside, the CCC criteria provide a useful screening tool for sorting ponds into classes with various trophic characteristics. This information was used as part of the assessment of the present and future conditions of the Orleans Ponds of interest.

Protection of Designated Water Uses

All of the eight ponds are classified as Class B waters under the Massachusetts surface water quality standards (314 CMR 4.00); with the additional designation of Outstanding Resource Water (ORW) for Crystal Lake, Pilgrim Lake and Sarah's Pond. The MA water quality standards identify a series of water uses that must be supported for Class B waters. These include: protection of aquatic life, contact (e.g., swimming) and non-contact (e.g., boating) recreation, fish consumption, irrigation, and navigation. Due to the depth of some of the Orleans ponds (e.g., Bakers, Crystal), both cold water (i.e., trout) and warm water fishery habitat may be ecologically appropriate, but only the warm-water fishery is designated.

Based on the information available, it was assumed that non-contact recreational uses (both motorized and non-motorized) were supported by all ponds. Irrigation such as transfer of water to cranberry bogs is limited (Crystal Lake historic use) and navigational uses are not relevant to these ponds. No information was available regarding fish consumption, but the existence of a State-mandated fish consumption advisory (e.g., for mercury) is not based on pond-specific conditions.

Accordingly, the focus was on evaluating the ability of the ponds to support aquatic life and contact recreational water uses. The trophic information available for the pond was most useful to evaluate protection of aquatic life (based on DO) and support of swimming (SDT visibility criterion of 4 ft (1.3 m)). Additional evidence for aquatic life support can be inferred from other trophic indicators (nutrients, chl).

Based on the available water quality and trophic indicator data, the selected Orleans ponds were assessed as to

- data indicates the pond is meeting designated water uses;
- data indicates the pond is impaired (i.e., not meeting designated water uses); or
- the data are ambiguous or are not available (i.e., do not allow a classification).

Comments on the ability of ponds to meet their designated uses are contained in Table 1.

Assessment of Potential Groundwater Contribution in Watershed

Numerous studies have shown that many freshwater ponds on Cape Cod receive a sizeable fraction of their nutrient budget from nutrient inputs from groundwater discharge from the watershed to the pond (septic systems, fertilizer, infiltrated stormwater, etc). Due to this importance of this, the potential susceptibility of ponds to meet their designated water uses was qualitatively estimated from examination of land use in the watershed, proximity to the pond and potential for future development. The Needs Assessment identified the number of dwellings in the pond watershed and the relative nutrient loads to the ponds within the three larger Orleans contributing zones of coastal interest (i.e., Pleasant Bay, Nauset Harbor or Cape Cod Bay). Dwellings were further delineated as to whether they were located within a 300-ft distance from the pond. This 300-ft distance has been selected by some to represent the distance that phosphorus in groundwater is likely to travel over a sufficient time period (91 years) to allow full assessment of future nutrient impacts to the pond (CCC, 2006). This 300-ft distance is considered an approximate linear limit of temporal groundwater influence during the planning horizon. While distance could be refined further on a pond-specific basis, it is sufficient to serve as an indicator of future water quality for this data assessment. This information is summarized in Table 2 *Summary of Freshwater Pond Watershed Wastewater Sources.* It is also important to recall that due to the age of development in a watershed not all the nutrients derived from dwellings, etc. may have arrived at a pond.

Based on this qualitative evaluation, the Orleans ponds were assessed as to:

- potentially high risk of water quality degradation from future development in the watershed (i.e., future development could produce marginal or impaired conditions);
- potentially low risk of water quality degradation from future development in the watershed (current status unlikely to significantly change), or
- the available data do not allow a prediction.

POND-SPECIFIC EVALUATIONS

Each of the Orleans ponds of interest was evaluated for current water quality or trophic state, potential susceptibility to watershed inputs and potential applicability for off-site sanitary management as a potential watershed nutrient management tool. Surface areas were taken from relevant CCC reports (CCC, 2003; 2006).

Bakers Pond

Bakers Pond is a 28-acre Great Pond that is an important regional recreational resource for Orleans (see Figure 2-5). Recreational uses include swimming (public beach), boating and fishing. The lake is considered a coldwater fishery and is stocked by the State with trout species during spring and fall periods (CCC, 2003).

Evaluation of the trophic indicators shows that the current water quality in the pond is excellent and meeting all designated uses, including good support of coldwater fishery (Table 1). There is a slight trend of increasing hypolimnetic anoxia (and reduction of summertime coldwater fish habitat) and a small increase of hypolimnetic TP release from the sediments under low DO conditions. This pond would be considered oligotrophic based on its current water quality and trophic indicators.

The pond watershed is located at the northern edge of the contributing zone to Pleasant Bay. Upgradient land use in the pond watershed is favorable; Bakers Pond gets recharge from groundwater flowing northwest from largely undeveloped land in Brewster. The current number of Orleans parcels in the Bakers Pond watershed is estimated at 10, with 7 of these in the 300-ft buffer (Table 2). There are several developed parcels in Brewster, and several parcels with development potential, that were included in the evaluation of potential water quality degradation with respect to phosphorus from septic tank effluent. Table 2 only includes Orleans parcel data. The entire pond shoreline is described as sparsely developed with single family homes (CCC, 2003). Projected future septic system discharges in the entire watershed increases from the estimated existing 1,100 gallons per day (gpd) to a future estimated 1,700 gpd. Within the proximal 300-ft buffer zone, a more modest increase from 800 to 1,400 gpd is projected.

Due to the current excellent water quality, small amount of existing and future Orleans or Brewster development in the watershed (much of which is protected and located in Brewster), and the potential for assimilation of the projected increase, significant investment in off-site sanitary management is not warranted for the Bakers Pond watershed. Application of general watershed best management practices such as timely septic system repair and maintenance, stormwater management, and reduction of nutrient fertilizers and/or incorporation of naturalistic buffers is appropriate.

Boland Pond

Boland Pond is a 4.7-acre pond located in the northern portion of Orleans (see Figure 2-5). Due to its small size, dense surrounding vegetative cover, and poor public access, Boland Pond doesnot have a public beach or a boat landing and is not considered an important recreational waterbody, but it does provide ecological and aesthetic functions. Due to its proximity to the local middle and elementary schools, this pond is assumed to have educational value as well.

Evaluation of the trophic indicators shows that the current water quality in the pond is poor with high nutrient concentrations and significant excursions below acceptable DO levels. There is some indication that phosphorus recycling from the sediments is an important component of nutrient loading to the pond. The SDT depth indicates poor visibility would impair swimming uses there. Based on this data, it is clear that Boland Pond is not meeting all designated uses. This pond would be considered eutrophic based on its current water quality and trophic indicators.

The pond watershed is located at the northern edge of the contributing zone to Town Cove in the Nauset estuarine system. Upgradient land use in the pond watershed to the south is mixed. There is a significant number of contributing parcels in the watershed, but much of the immediate upgradient watershed (i.e., 300-ft buffer) is undeveloped or used as playing fields for the local schools (but which may be well fertilized for turf management). The current number of parcels in the Bolands Pond watershed is estimated at 45 with only 4 of these within the 300-ft buffer (Table 2), but one of these parcels is a large inn located to the southwest. Projected future septic system discharges in the entire watershed increases from the estimated existing 10,100 gallons to 14,100 gpd. Within the proximal 300-ft buffer zone, the present input of 2,100 would only increase to 2,500 gpd. The modest increase in the 300-ft buffer is apparently due to the lack of developable parcels in this zone.

Due to the current impaired water quality, location in fairly close proximity to Town Cove (a presumed nitrogen-sensitive embayment), and the availability of publicly-owned land in the near watershed area, this pond watershed should be considered for off-site sanitary management. This is particularly attractive for management of sanitary waste from a large single source (inn). The expectations for reduction of inputs to Bolands Pond would be for gradual improvement to surface water quality (TP, DO) in the upper waters of the pond, although nutrient recycling from bottom sediments might persist for a longer period. Another advantage of reducing nutrient inputs to Boland Pond is to reduce nutrient loading (especially nitrogen) to Town Cove as well.

Cedar Pond

Cedar Pond is a 15.1-acre, relatively shallow (maximum depth is 15 ft) Great Pond located in the northern portion of Orleans (see Figure 2-5). This pond is subject to tidal influence through two culverts that are hydrologically connected to Rock Harbor. Pond salinity ranges from 6 to 18 parts per thousand (ppt) (CCC, 2006), thus the pond is not considered freshwater (freshwater limits are typically 1-2 ppt). Cedar Pond does not a formal boat landing and is not considered an important active recreational waterbody for Orleans, but it does provide ecological and aesthetic functions.

Evaluation of the trophic indicators shows that the current water quality in the pond is poor with high concentrations of both TP and TN and significant excursions below acceptable DO levels. The poor DO and high nutrients in bottom waters may also reflect poor mixing due to density-based stratification (i.e., freshwater water overlies saltier, denser water). The SDT depth indicates poor visibility below the swimming criterion (< 4-ft). Based on these data, it is clear that Cedar Pond is not meeting all designated uses. This pond would be considered eutrophic based on its current water quality and trophic indicators. However, since it is not a freshwater pond, the nature of its nutrient limitation is still not fully resolved (CCC, 2006).

The pond watershed is located within the contributing zone to Cape Cod Bay. Cedar Pond has a large watershed that incorporates some of the more developed urban land uses in Orleans. The current number of parcels in the Cedar Pond watershed is estimated at 69 with 13 of these in the 300-ft buffer (Table 2). Projected future septic system discharges in the entire watershed increase from the estimated existing 31,100 gallons to 35,300 gpd. Within the proximal 300-ft buffer zone, the present input of 500 would only increase to 800 gpd since further shoreline development is not likely.

Cedar Pond may be a future candidate for off-site sanitary management but this decision should be deferred for now. It is a good candidate due to the large number of contributing parcels, large sanitary flow and direct hydrologic connection with Cape Cod Bay. However, at the present time, the influence of the watershed, pattern of mixing with tidal water and resulting nutrient fluxes to Rock Harbor are not fully understood. As recommended by CCC (2006), this waterbody will require future investigation, probably as part of the planned Massachusetts Estuary Project (MEP) modeling of the Cape Cod Bay system before informed management decisions can be reached regarding the necessity or magnitude of nutrient reductions.

Crystal Lake

Crystal Lake is a 37-acre Great Pond that is an important regional recreational resource for Orleans (see Figure 2-5). Recreational uses include swimming, boating and fishing and there are two town landings (H&W, 2003). The lake is considered a coldwater fishery and stocked by the State with trout (rainbow trout, brown trout) during spring and fall periods.

Evaluation of the trophic indicators shows that the water quality in the pond is good to excellent and meeting all expected designated uses (Table 1). There is some concern regarding a trend of increasing hypolimnetic anoxia (and reduction of summertime coldwater fish habitat) and accompanying release of TP from the sediments under low DO conditions. This pond would be considered oligo-mesotrophic based on its current water quality and trophic indicators.

The pond watershed is located at the northern edge of the contributing zone to Pleasant Bay. Upgradient land use in the pond watershed seems generally favorable; Crystal Lake is downstream of Bakers Pond and undeveloped land in Brewster. The pond shoreline is described as moderately developed with single family homes (CCC, 2003). It has also been noted that a discharge pipe from Route 28 may be a potential source of pollutants (H&W, 2003).

The current number of parcels in the Crystal Lake watershed is estimated at 60 with 1/3 of these in the 300-ft buffer (Table 2). Projected future septic system discharges increase in the buffer zone from 2,300 to 3,600 gpd or an approximate 50% increase; slightly less than the expected increase in flow from the entire watershed.

Due to the current good-to-excellent water quality, signs of deterioration in the DO levels and hypolimnetic release of TP, and the status of the pond as oligo-mesotrophic, this pond watershed should be considered for off-site sanitary management. The rationale is that there is an expected 50% increase in septic load for a pond that could easily shift Crystal Lake to a mesotrophic category. While a mesotrophic condition is not necessarily incompatible with meeting all fully designated uses, it would be likely the reduction in water quality would eliminate the possibility of a viable summertime cold water fishery. In addition, the presence of the public beach indicates that water transparency would be important parameter to preserve and reduction of groundwater nutrients would help support this. Overall, the Crystal Lake watershed would be a good candidate for watershed management of septic wastes (including off-site solutions) and/or application of best management practices regarding septic system repair, stormwater management, and maintenance to prevent accelerated eutrophication of Crystal Lake.

Ice House Pond

Ice House Pond is a relatively small 5.7-acre, shallow (non-stratified) pond located in northeastern Orleans (see Figure 2-5). Based on its small size, dense surrounding vegetative cover, and poor public access, Ice House Pond is not considered an important active recreational waterbody, but it does provide ecological and aesthetic functions.

Evaluation of the trophic indicators shows that the water quality in the pond is good to excellent and meeting all expected designated uses (Table 1). Nutrient levels and chlorophyll slightly exceed the “healthy” levels but are considered acceptable for a small pond. Surface water DO levels are good and SDT levels are very high for a small pond. There is significant anoxia in the bottom station but TP at depth is not especially elevated indicating low amounts of phosphorus release from the sediments. This pond would be considered oligo-mesotrophic based on its current water quality and trophic indicators. No information was available on the aquatic macrophyte community, which are often important ecological components in shallow ponds.

The pond watershed is located within the contributing zone to Nauset Harbor near the groundwater divide between flows going to Town Cove and thus going to Nauset Harbor. Upgradient land use in the pond watershed is generally residential, but there are few houses in the buffer zone and a sizeable wetland is also present.

The current number of parcels in the Icehouse Pond watershed is estimated at 66 with only 5 of these in the 300-ft buffer (Table 2). Projected future septic system discharges in the entire watershed increases from the estimated existing 6,400 gallons to 9,500 gpd. Projected future septic system discharges increase in the buffer zone from 300 to 800 gpd.

Due to the current good to excellent water quality, small amount of future development in the immediate watershed and the potential for natural attenuation of nutrients from more distant watershed sources through existing wetland features, off-site sanitary management is not warranted for the Ice House Pond watershed. Application of general watershed best management practices such as timely septic system repair and maintenance, stormwater management, reduction of nutrient fertilizers and/or incorporation of naturalistic buffers are appropriate, however.

Pilgrim Lake

Pilgrim Lake is the largest pond in Orleans at 43 acres located in the central portions of the town (see Figure 2-5). It is a Great Pond that is an important regional recreational resource for Orleans. Recreational uses include swimming, boating and fishing and there is large public beach and boat ramp on the northeast shore. There is a herring run leading to Kescayogansset Pond at the northern end of the lake (CCC, 2003).

Evaluation of the trophic indicators shows that the water quality in the pond is good and meeting all expected designated uses (Table 1). There is some concern regarding a trend of increasing hypolimnetic anoxia and accompanying release of TP from the sediments under low DO conditions. This pond would be considered mesotrophic based on its current water quality and trophic indicators.

The pond watershed is located within the contributing zone to Pleasant Bay. The lake is recharged by groundwater flow from the west, included area which is protected for water supply. Upgradient land use in the pond watershed includes a good number of residential homes. The pond shoreline is described as lightly developed with single family homes (CCC, 2003). It has also been noted that the pond also appears to receive stormwater from Rohmer's Road which may be a potential source of pollutants (H&W, 2003).

The current number of parcels in the Pilgrim Lake watershed is estimated at 55 with 16 of these in the 300-ft buffer (Table 2). Projected future septic system discharges increase in the entire watershed is from 7,100 gpd to a future estimated 12,400 gpd. Within the proximal 300-ft buffer zone, an increase from 1,500 to 2,700 gpd is projected.

Due to the current good water quality, signs of deterioration in the DO levels and significant hypolimnetic release of TP, and the status of the pond as mesotrophic, this pond watershed should be considered for off-site sanitary management. The rationale is that there is a large expected increase in groundwater loading for a pond for both the entire watershed as well as the more critical 300-ft buffer zone. This increase in nutrients could easily shift Pilgrim Lake into a meso-eutrophic or fully eutrophic category. This would likely result in a reduction in water quality and support of aquatic life. Recreational water quality at the public beach could also suffer from decreases in water transparency and increased frequency of nuisance algal blooms. Overall, the Pilgrim Lake watershed would be a good candidate for watershed management of septic wastes (including off-site solutions) as well as application of best management practices regarding septic system repair, stormwater management, and maintenance to prevent accelerated eutrophication of Pilgrim Lake.

Sarah's Pond

Sarah's Pond is a relatively small (5.6-acre), shallow (non-stratified) pond located in southern Orleans (see Figure 2-5). Based on its small size, dense surrounding vegetative cover, and poor public access, Sarah's Pond does not have a public beach or a boat landing and is not considered an active recreational waterbody, but it does provide significant ecological and aesthetic functions.

Evaluation of the trophic indicators shows that the water quality in the pond is moderate and meets most expected designated uses (Table 1). Nutrient levels and chlorophyll do exceed the "healthy" levels and the TN and chlorophyll levels at the bottom are particularly high. Surface water DO levels are good but there is significant anoxia in the bottom station. SDT levels are low and can occasionally fail the 4-ft visibility criterion. This pond would be considered mesotrophic based on its current water quality and trophic indicators. Despite the moderate water quality levels, Sarah's Pond is considered one of the more pristine pond environments in the Pleasant Bay watershed. It has a shoreline stand of the regionally rare Atlantic White Cedar *(Chamaecyparis thyoides)* and dense stands of slender pondweed *(Potamogeton pusillus)* observed in the pond (H&W, 2003).

Sarah's Pond is located within the contributing zone to Pleasant Bay. It has a long linear watershed which originates to the west near Brewster. Upgradient land use in the pond watershed is residential, but there is very little in the 300-ft buffer zone. The pond shoreline is described as having two single family homes and a single dock (H&W, 2003).

The current number of parcels in the Sarah's Pond watershed is estimated at 59 with only 5 of these in the 300-ft buffer (Table 2). Projected future septic system discharges in the entire watershed increase from the estimated existing 6,700 gallons to 13,900 gpd. Projected future septic system discharge increases in the buffer zone from 100 to 300 gpd.

Sarah's Pond constitutes an excellent ecological resource for Orleans. While the water quality is at best moderate, existing evidence suggests that the pond is providing important ecological functions for shoreline vegetation, aquatic macrophytes and wildlife. This is a naturally mesotrophic lake that is unlikely to be significantly impacted by nutrients in groundwater due to the small amount of existing and predicted future loadings from the immediate watershed as well as the large amount of open space and protected land in the vicinity. Accordingly, off-site sanitary management is not warranted for the Sarah's Pond watershed. Application of general watershed best management practices such as timely septic system repair and maintenance, stormwater management, and reduction of nutrient fertilizers in the upper watershed portions are appropriate, however.

Shoal Pond

Shoal Pond is a small (8.6-acre) and very shallow (non-stratified) pond located in southern

Orleans between Twinings Pond and Deep Pond (see Figure 2-5). Shoal Pond does not have a public beach or a boat landing and is not considered an important recreational waterbody, but it may provide ecological and aesthetic functions.

Evaluation of the trophic indicators shows that the water quality is poor and does not support expected designated uses (Table 1). Nutrient levels and chlorophyll significantly exceed the "healthy" levels." Shoal Pond was the only Orleans pond reviewed by CCC that did not meet acceptable average DO levels even in the surface waters (CCC, 2006). The SDT in this pond is also consistently below the visibility criterion, which may be related to its overall shallowness. This pond would be considered eutrophic based on its current water quality and trophic indicators.

The pond watershed is located within the contributing zone to Pleasant Bay. It has a long linear watershed which originates to the west; about half of the watershed area is located in Brewster. Upgradient land use in the pond watershed is generally residential, with less in the buffer zone. The current number of parcels in the Shoal Pond watershed is estimated at 40 with 7 of these in the 300-ft buffer (Table 2). Projected future septic system discharges in the entire watershed increase from the estimated existing 4,700 gallons to 8,000 gpd. Projected future septic system discharges increase in the buffer zone from 1,200 to 2,200 gpd.

Shoal Pond is not well studied relative to other Orleans Pond. While it is deemed a eutrophic waterbody based its water quality parameters, no additional information was available on other ecological features of the pond. No bathymetric map was available for this pond, but sampling depths reported suggest that much of the pond is less than 2 meters (CCC, 2006), which would be conducive to colonization by aquatic macrophytes. Aerial photographs suggest that at least some of the pond basin is already filling in (east and northern embayment (Google-Earth ®, 2006). The pond watershed has residential development largely located outside of the 300-ft buffer but there is not a great deal of open space within an intermediate distance. It is also uncertain how the nutrient budget of Shoal Pond may be affected by imports/exports from adjacent water bodies.

It seems unlikely that reduction in groundwater nutrients would significantly improve water quality in the Shoal Pond. It appears that this waterbody will move towards more wetland characteristics, improvement in water quality would be unlikely to restore or enhance designated uses. Therefore, off-site sanitary management is not recommended for the Shoal Pond watershed. Application of general watershed best management practices such as timely septic system repair, stormwater management, and maintenance and reduction/elimination of nutrient fertilizers is warranted.

SUMMARY OF FRESHWATER POND ASSESSMENT

A summary of the evaluation of the eight freshwater ponds is shown in Table 3. This table summarizes the important water quality concerns, potential impairments to designated uses (slight impairments were interpreted as no concerns), and watershed concerns relative to potential groundwater nutrient loading. Finally, the potential applicability for off-site sanitary management was evaluated. Based on the information assessed, each pond was categorized as (1) high priority for nutrient reduction through wastewater management; (2) low priority for nutrient reduction through wastewater management; or (3) decision deferred at this time but should revisited when additional information is available (i.e., relevant MEP report).

Ponds which were recommended as a high priority for wastewater management include Bolands Pond, Crystal Lake, and Pilgrim Lake. Those ponds recommended as a lower priority for wastewater management include Bakers Pond, Ice House Pond, Sarah's Pond and Shoal Pond. Cedar Pond is of potential interest, but due to the complexity of the mixing and nutrient exchange in this tidally-influenced pond, this decision is deferred until further information is available as part of the Cape Cod Bay MEP investigation. The use of watershed BMPs for reduction of nutrient loading from point (stormwater) and non-point sources or good environmental stewardship (e.g., reduction or elimination of fertilizer inputs) is recommended for all watersheds.

It should be recognized that there are several sources of uncertainty regarding these pond assessments and recommendations. Some of the more important sources include:

- Interpretation of ecological significance and potential designated use impairment from exceedances of CCC "healthy" thresholds;
- Use of 300-ft buffer as limits of potential near-term groundwater loading;
- Determination of the future projected or "buildout" totals for watershed; and
- Uncertainty regarding morphometric data of some of the smaller ponds.

Phosphorus from the septic systems discharging in the 300-foot buffer zones of these eight ponds may not have reached the ponds yet, and it is unclear when those loads will fully reach the ponds and to what extent they may be attenuated. In contrast, the phosphorus loads derived from stormwater and lawn fertilizer (since they enter via the much quicker overland runoff route) may be both larger in magnitude and more likely to have reached the ponds than the septic loads. Accordingly, sewering of up-gradient lots within the 300-foot buffer is a good long-term investment for limiting the wastewater phosphorus load to all these ponds, but should not be undertaken without having considered and addressed the stormwater loads, near-shore fertilization practices and establishment of vegetated buffers. It will therefore be appropriate to proceed with sewering plans for the watersheds of Crystal Lake, Pilgrim Lake, and Bolands Pond concurrent with actions on stormwater.

Finally, it should be noted that this assessment has only dealt with 8 of the 63 identified ponds in Orleans (albeit many of the eight included are considered major recreational or aesthetic resources for the Town). Therefore it is possible that improvement in the water quality, ecological health and recreational function of other Orleans ponds could be achieved due to watershed nutrient reductions and adaptive wastewater and/or stormwater management. Additional water quality data and/or watershed information would be required to make such a determination. As with most long-term watershed management programs, protection of the water quality in ponds in Orleans will likely be achieved in an iterative fashion, through diagnosis and treatment of larger or societally important water bodies first, then successive efforts focusing on smaller or less prominent ponds as time and resources allow. Therefore, an assessment of all phosphorus sources for the remaining ponds is warranted before sewering is considered, Integration of this purpose with the Town-wide wastewater planning and management effort inherent in the CWMP is an important first step.

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TABLE 1
POND TROPHIC DATA

Waterbody	WQ Para.	units	CCC (2003) benchmarks: Unimpacted	CCC (2003) benchmarks: Healthy	Representative Pond Data			CCC Criteria Compliance	Designated Water Use Comments
Baker's Pond	**TP**	ug/L	7.5	10	epilimion	5.1-5.4 ug/L	(a)	Unimpacted	Meets all designated uses including
			7.5	10	hypolimnion	11.8 ug/L	(a)	Sl. Impacted	CW fishery; oligotrophic conditions.
	TN	mg/L	0.16	0.31	mean	0.16 > TN < 0.31 mg/L	(b)	Healthy	
	Chl a	ug/L	1.0	1.7	epilimnion	most chl a < 1.0 ug/L	(b)	Unimpacted	
	SDT	m		> 1.3	mean&range	7.5 m; 3.2 -10.4 m	(a)	Meets visibility criteria	
	DO	mg/L	6.0	>1.0	epilimion	>6.0 mg/L	(b)	Meets CW criteria	
		mg/L	6.0	>1.0	hypolimnion	>2.0 mg/L	(b)	Healthy	
Boland's Pond	**TP**	ug/L	7.5	10	pond	> 30 ug/L	(a)	Heavily impacted	Concerns meeting aquatic life uses
	TN	mg/L	0.16	0.31	mean	TN > 0.31 mg/L	(b)	Impacted	due to low DO; high TP, chl a in
	Chl a	ug/L	1.0	1.7	pond	chl a > 1.7 ug/L	(b)	Impacted	bottom waters; visibility may not be
	SDT	m		> 1.3	mean&range	1.4 m; 0.4 -2.6 m	(a)	Can fail visibility criteria	suitable for swimming at times;
	DO	mg/L	5.0	>1.0	lake	DO << 5.0 mg/L at times	(b)	Impacted; much anoxia	eutrophic condtions.
Cedar Pond	**TP**	ug/L	7.5	10	pond	77 ug/L	(a)	Not Healthy	Concerns meeting aquatic life uses
	TN	mg/L	0.16	0.31	mean	TN > 0.31 mg/L	(b)	Impacted	due to low DO; high TP, chl a in
	Chl a	ug/L	1.0	1.7	pond	chl a > 1.7 ug/L	(b)	Impacted	bottom waters; visibility may not be
	SDT	m		> 1.3	mean&range	1.0 m; 0.7 -1.4 m	(a)	Fails visibility criteria	suitable for swimming; eutrophic
	DO	mg/L	5.0	>1.0	pond	DO << 5.0 mg/L at times	(b)	Impacted; much anoxia	conditions, but may be N-limited.
Crystal Lake	**TP**	ug/L	7.5	10	epilimion	6.2-7.2 ug/L	(a)	Unimpacted	Meets all major designated uses but
			7.5	10	hypolimnion	11.3-33.8 ug/L	(a)	Impacted	poor DO support of CW fishery;
	TN	mg/L	0.16	0.31	mean	0.16 > TN < 0.31 mg/L	(b)	Healthy	oligo-mesotrophic conditions
	Chl a	ug/L	1.0	1.7	epilimnion	1.0 > chl a < 1.7 ug/L	(b)	Healthy	
	SDT	m		> 1.3	mean&range	5.1 m; 1.8 - 7.6 m	(a)	Meets criteria	
	DO	mg/L	6.0	>1.0	epilimion	>6.0 mg/L	(b)	Meets CW criteria	
		mg/L	6.0	>1.0	hypolimnion	DO < 1.0 mg/L at times	(b)	Impacted	
Ice House Pond	**TP**	ug/L	7.5	10	pond	0.10 > TP < 0.31 mg/L	(b,c)	Healthy	Meets all major designated uses but
	TN	mg/L	0.16	0.31	mean	TN > 0.31 mg/L	(b)	Sl. Impacted	some anoxia in bottom waters;
	Chl a	ug/L	1.0	1.7	pond	chl a > 1.7 ug/L	(b)	Impacted	oligo-mesotrophic conditions
	SDT	m		> 1.3	mean	> 4 m	(b)	Meets visibility criteria	
	DO	mg/L	5.0	>1.0	pond	>5.0 mg/L; some <2.0	(b)	Sl. Impacted	
Pilgrim Lake	**TP**	ug/L	7.5	10	epilimion	11.8-14.6 ug/L	(a)	Not Healthy	Supports all designated uses, but
			7.5	10	hypolimnion	72.1 ug/LL	(a)	Not Healthy	aquatic life support is declining in the
	TN	mg/L	0.2	0.31	mean	TN > 0.31 mg/L	(b)	Not Healthy	hypolimnion; mesotrophic conditions.
	Chl a	ug/L	1.0	1.7	epilimnion	chl a > 1.7 ug/L	(b)	Not Healthy	
	SDT	m		> 1.3	mean&range	3.4 m; 1.4 - 5.2 m	(a)	Meets visibility criteria	
	DO	mg/L	6.0	>1.0	epilimion	> 6.0 mg/L	(b)	Meets CW criteria	
		mg/L	6.0	>1.0	hypolimnion	<5.0 mg/L; often <2.0	(b)	Impaired	

TABLE 1 (CONTINUED)
POND TROPHIC DATA

Waterbody	WQ Para.	units	CCC (2003) benchmarks Unimpacted	Healthy	Representative Pond Data			CCC Criteria Compliance	Designated Water Use Comments
Sarah's Pond	**TP**	ug/L	7.5	10	pond	approx. 20 ug/L	(b,c)	Not Healthy	Meets most major designated uses
	TN	mg/L	0.16	0.31	mean	TN > 0.31 mg/L	(b)	Impacted	but some anoxia in bottom waters
	Chl a	ug/L	1.0	1.7	pond	chl a > 1.7 ug/L	(b)	Impacted	and low transparency; mesotrophic.
	SDT	m		> 1.3	mean&range	approx. 2.3 m	(b)	Can fail visibility criteria	Excellent ecological habitat
	DO	mg/L	5.0	>1.0	pond	<2.0 in bottom waters	(b)	Impacted	
Shoal Pond	**TP**	ug/L	7.5	10	pond	approx. 30+ ug/L	(b,c)	Not Healthy	Concerns meeting aquatic life uses
	TN	mg/L	0.16	0.31	mean	TN > 0.31 mg/L	(b)	Impacted	due to low DO; high TP, and chl a
	Chl a	ug/L	1.0	1.7	pond	chl a > 1.7 ug/L	(b)	Impacted	SDT depth not suitable for swimming
	SDT	m		> 1.3	mean&range	< 2 m all year	(b)	Fails visibility criteria	shallow, wetland characteristics
	DO	mg/L	5.0	>1.0	pond	low DO throughout	(b)	Heavily impacted	eutrophic condtions.

Notes on WQ data:
(a) Water quality values cited in Eichner et al (2006)
(b) Data extrapolated from tables or figures in Eichner et al (2006)
(c) Available data considered from Eichner et al (2003).

TABLE 2

SUMMARY OF POND WATERSHED WASTEWATER SOURCES

	WATERSHED							
WATER BODY	PLEASANT BAY		NAUSET SYSTEM		CAPE COD BAY SYSTEMS		TOTAL	
	GW Basin	300-ft Buffer	GW Basin	300-ft Buffer	GW Basin	300-ft Buffer	GW Basin	300-ft Buffer
CEDAR POND								
Number of Parcels					69	13	69	13
Current Flow, gpd					31,100	500	31,100	500
Future Flow, gpd					35,300	800	35,300	800
BOLANDS POND								
Number of Parcels			45	4			45	4
Current Flow, gpd			10,100	2,100			10,100	2,100
Future Flow, gpd			14,100	2,500			14,100	2,500
ICE HOUSE POND								
Number of Parcels			66	5			66	5
Current Flow, gpd			6,400	300			6,400	300
Future Flow, gpd			9,500	800			9,500	800
PILGRIM LAKE								
Number of Parcels	55	16					55	16
Current Flow, gpd	7,100	1,500					7,100	1,500
Future Flow, gpd	12,400	2,700					12,400	2,700
BAKERS POND								
Number of Parcels	10	7					10	7
Current Flow, gpd	1,100	800					1,100	800
Future Flow, gpd	1,700	1,400					1,700	1,400
CRYSTAL LAKE								
Number of Parcels	60	20					60	20
Current Flow, gpd	6,000	2,300					6,000	2,300
Future Flow, gpd	14,700	3,600					14,700	3,600
SHOAL POND								
Number of Parcels	40	7					40	7
Current Flow, gpd	4,700	1,200					4,700	1,200
Future Flow, gpd	8,000	2,200					8,000	2,200
SARAH'S POND								
Number of Parcels	59	5					59	5
Current Flow, gpd	6,700	100					6,700	100
Future Flow, gpd	13,900	300					13,900	300
TOTAL								
Number of Parcels	224	55	111	9	69	13	404	77
Current Flow, gpd	25,600	5,900	16,500	2,400	31,100	500	74,100	8,800
Future Flow, gpd	50,700	10,200	23,600	3,300	35,300	800	109,600	14,300

TABLE 3
SUMMARY OR FRESHWATER POND ASSESSDMENT

	Bakers Pond	Boland Pond	Cedar Pond	Crystal Lake	Ice House Pond	Pilgrim Lake	Sarah's Pond	Shoal Pond
Major watershed	Pleasant Bay	Nauset Inlet	Cape Cod	Pleasant Bay	Nauset Inlet	Pleasant Bay	Pleasant Bay	Pleasant Bay
Pond Morphometrics								
Pond surface area (acres)	28	5	15	37	6	43	6	9
Pond volume (m^3)	809,200	41,400	113,400	976,300	57,500	770,700	61,300	52,100
Residence time (yr)	1.2	0.4	0.4	1.2	NA	0.5	NA	NA
Public Beach or Boat Ramp Access	PB, BR	-	PB, BR	-	-	PB, BR	-	-
Water Quality Concerns								
Phosphorus	-	X	X	X	-	X	X	X
Chlorophyll	-	X	X	-	X	X	X	X
Secchi Depth	-	X	X	-	-	-	X	X
Dissolved Oxygen	-	X	X	X	-	-	X	X
Trophic Status *	Oligotrophic	Eutrophic	Eutrophic	Oligo-mesotrophic	Oligo-mesotrophic	Mesotrophic	Mesotrophic	Eutrophic
Designated Use Impairment								
Aquatic Life Support	-	X	X	X	-	X	X	X
Contact Recreation	-	X	X	-	-	-	X	X
Non-contact Recreation	-	-	-	-	-	-	-	-
Concern Over P Loading								
Current development in 300-ft buffer	-	-	-	X	-	X	-	-
Future development in 300-ft buffer	-	-	-	X	-	X	-	-
Development in entire watershed	-	X	X	-	X	X	X	X
Nutrient Reduction								
High Priority	-	X	-	X	-	X	-	-
Low Priority	X	-	-	-	X	-	X	X
Deferred	-	-	X	-	-	-	-	-
Application of general BMPs	X	X	X	X	X	X	X	X

X = positive indication
* watershed nitrogen impacts are being separately addressed by Massachusetts Estuary Project.

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APPENDIX B

INFORMATION ON WASTEWATER MANAGEMENT COMPONENTS

APPENDIX B

INFORMATION ON WASTEWATER MANAGEMENT SYSTEMS

B.1 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.

Alternative toilets

The components of domestic wastewater are often referred to as black water (that generated from flushing toilets), yellow water (separated urine, if applicable) and gray water (the composite of all remaining sources). Utilizing an alternative toilet is one method for removing black water or yellow water from the wastewater stream. Black wastewater is treated most commonly in a composting (or incinerating) toilet. Yellow wastewater would be collected in a concentrated and sent to a treatment or nutrient recovery facility. In either case, the wastewater that would have gone to the sewer is eliminated. 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

Alternative toilets

Alternative 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) or concentrated urine, 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.

B.2 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

B.3 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 the draft 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 B-2 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 B-2

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.

B.4 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.

B.5 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 C

PUBLIC CONSULTATION

APPENDIX C
PUBLIC CONSULTATION

C.1 ROLE OF WASTEWATER MANAGEMENT STEERING COMMITTEE

The Town of Orleans began wastewater management planning activities in the year 2000 and has been steadily making progress over the intervening nine years. In 2000, the Wastewater Management Steering Committee (WMSC) was established to guide the progress of addressing the long-standing need to provide protection of the environment from any negative impacts of wastewater disposal.

The Board of Selectmen established the WMSC in July 2000 and gave it the following tasks:

- Compile a working library of wastewater-related documents;
- Investigate the experiences of other towns;
- Research new and innovative options for wastewater treatment and disposal;
- Formulate a plan for professional assistance in wastewater planning and assist in the hiring of a qualified consultant;
- Work with the consultant to complete a needs survey and develop options for wastewater management;
- Increase public awareness of wastewater issues; and
- Present a final report to the Board of Selectmen upon completion of necessary studies.

The WMSC is comprised of members of certain town boards and committees that advise municipal departments and include planning, health, water, finance and conservation. In addition to these five areas, one member of the Board of Selection sits on the WMSC. The Director of Planning serves as the town staff liaison. Committee members are appointed for several-year terms and the Committee maintains continuity through a permanent connection with the Planning Department. The six volunteer committee members serve as the first mechanism for soliciting public consultation. Each member brings regular reports back to his or her respective board or committee so that many groups receive up-to-date briefings from, and in-turn report feedback to the WMSC. This is the first step in disseminating information to active and involved residents about wastewater planning.

Copies of all reports and work products created during the CWMP process (including the many letters and memos discussed at WMSC meetings) are available for review in the Planning Department.

The past three years of WMSC effort (since September 2005) have included the most intensive work that has focused on developing the CWMP. Since the inception of the WMSC, meetings have been held on the first and third Thursdays of each month. The meetings are open to the public, and since the opening of the new Town Hall (2006), have also been televised on Channel 18. More than 500 hours of public discussion on the topic of wastewater has occurred during regular meetings. The members of the WMSC should be commended for volunteering the many additional hours that went into reading material and preparing for discussion at those meetings.

C.2 PUBLIC MEETINGS ON INTERIM REPORTS

In addition to regular meetings, the WMSC has held well-advertized public meetings to present the most recent information at key milestones in the CWMP process. While Channel 18 has allowed residents unable to attend daytime meetings to catch up on events in the evening, public meetings were held during the evening, and in many cases also during the day, to assist in reaching as many residents as possible wishing to attend. Notices of public meetings were posted in Town Hall, on the Town website and advertised in the local newspapers. All public meetings were televised and replayed on Channel 18. DVD's are available at Town Hall.

Public meetings were held to present the following key reports:

Needs Assessment, draft February 2006
Snow Library 6:00 pm on February 26, 2006

Identification and Screening of Alternatives, draft December 2006
Snow Library 1:00 and 6:00 pm on January 17, 2007

Evaluation of Alternatives, draft May 2008
Snow Library 1:00 pm, Elementary School 6:00 pm, on May 22, 2008

Each public meeting was attended by more than 100 residents.

Public consultation was at the forefront of each public meeting, where as much time was devoted to questions and comments from the attendees as was spent in the presentations by the WMSC and consultant. At the end of each public meeting, attendees were asked to fill out surveys that would provide feedback on the material presented. The results of the public surveys are included in Tables C-1 and C-2 (Identification of Alternatives Report) and C-3 (Evaluation of Alternatives Report).

C.3 PRESENTATION TO SELECTMEN BY WMSC

One member of the Board of Selectmen (BOS) serves on the WMSC and participates in its activities. Month-to-month, WMSC members read, review and discuss significant amounts of information. Even with the BOS member reporting back to the full BOS at its weekly meetings, selectmen receive copies of each report for review, prior to that information being presented at a public meeting. The WMSC also makes periodic presentations at regular BOS meetings so that individual selectmen have additional opportunity to discuss and comment on the latest phase of the evaluation and to offer direction. BOS meetings are all televised, offering additional dissemination of current wastewater planning, and all BOS meetings offer a public comment period. The BOS was briefed on major milestones at regular meetings throughout the development of the CWMP.

C.4 PUBLIC WORKSHOPS TO PRESENT THE BEST ALTERNATIVES

Once the Evaluation of Alternatives was complete, a series of public workshops was held during July and August of 2008. These workshops were designed to present the best wastewater management alternatives to small groups of residents, so lengthy question and answer sessions could be accommodated. One member of the WMSC and one member of the CAC made a joint presentation that was supported by a series of posters on display around the room. After the presentation, attendees had the chance to walk around the room and view the details of each poster, and participate in a question-and-answer session.

The schedule focused on inviting individual neighborhoods (the town was divided into six neighborhoods) to aid in addressing questions and concerns that might be a theme to a specific area. Although the WMSC urged residents to attend with their neighborhood, all workshops were open to any resident. A seventh workshop was open to all residents that did not focus on a specific neighborhood, but followed the same format as the first six.

In total seven workshops were attended by 414 residents. Two of those workshops were televised and replayed on Channel 18. Workshops were advertized in Town Hall, on the Town website and in the local newspapers. The presentation posters were on display in the Skaket Room for the duration of the workshop series. Handouts were available for a self-guided tour any time the room was not in use for meetings.

Survey forms were distributed at each workshop. The feedback from surveys is summarized in Table C-4. Overall, the majority of input supported the selection of Plan 2. Based on that feedback, the WMSC created a modified plan that supported many of the Plan 2 attributes but also incorporated other favorably-rated components of Plans 1 and 3 such as cluster systems, potential for wastewater reuse and flexibility to work with neighboring communities in regional endeavors.

C.5 WASTEWATER FIELD TRIP

The WMSC, in conjunction with the Friends of Areys Pond (FOAP), sponsored a field trip for viewing wastewater treatment facilities on Cape Cod. After an introductory presentation by Wright-Pierce, a chartered bus transported 40 interested citizens to nine local wastewater facilities, giving all participants a first-hand view of many of the treatment and disposal options available to Orleans.

C.6 PUBLIC MEETING ON DRAFT CWMP

There was a public meeting on October 2, 2008 to present the draft CWMP to interested citizens. This meeting was jointly sponsored by the BOS and the WMSC. It l allowed the Town to gain important public feedback on the overall progress to date.

C.7 SPECIAL TOWN MEETING ENDORSEMENT

While the CWMP is not scheduled for completion until mid 2009, the Town held a Special Town Meeting to seek voter endorsement of the draft CWMP on October 27, 2008. Over 700 citizens were in attendance and gave a positive majority vote which solidified feedback to the BOS and WMSC that the planning process is on the right track as it enters its final phase.

Table C-1
December 2006 Public Meeting
Results of Component Preference Survey

Do you feel sufficiently informed to answer the questions below?

No	Yes	Maybe	Not Yet / No Answer
6	46	1	2 / 8

If yes:

Would you favor a decentralized over a centralized plan?

No	Yes	Don't know	No Answer
19	16	22	4

Would you support regionalization (developing joint wastewater facilities with Brewster and/or Eastham)?

No	Yes	Don't know	No Answer
6	43	7	5

Would you support a project including the reuse of highly treated wastewater for activities like irrigation of public parks or toilet flushing in public buildings?

No	Yes	Don't know	No Answer
2	52	2	5

Table C-2
December 2006 Public Meeting
Importance of Evaluative Criteria

Evaluative Criteria	Very Important	Important	Less Important	No Answer
Uses Proven Treatment and Disposal Technology	38	19	5	1
Is Readily Accepted by Regulatory Agencies	25	25	10	2
Has Low Environmental Impact	46	14	1	1
Uses Energy Efficient Components	33	23	4	2
Is Easy to Operate	20	30	10	3
Is Readily Expandable	27	26	6	3
Does Not Rely on Town Purchase of Private Land	15	20	25	3
Has Overall Public Acceptability	29	26	6	1
Has the Least Overall Cost	23	24	13	3

Table C-3
May 2008 Public Meeting
Comments on Plans 1, 2 and 3

	Plan 1 Decentralized (4 Plants)	Plan 2 Centralized (Tri-Town)	Plan 3 Centralized (So Orleans)
Based on information provided today, which Plan is			
Most favorable (check one)	3	99	20
Least favorable (check one)	107	5	9

What features of each Plan do you find most attractive?

Plan 1: Flexibility in Implementation

Plan 2: Cost (capital and operation), Energy Use

Plan 3: Reuse of Wastewater, "Greenest"

What features of each Plan do you find least attractive?

Plan 1: Cost, Land Acqusition

Plan 2: Less Expandability

Plan 3: Highest Energy Cost, Greatest Implementation Hurdles

Consider such factors as:

- Cost
- Energy use
- Treatment facility siting
- Need for land purchase
- Potential for water reuse
- Environmental impacts
- Ease in implementation
- Expandability
- Flexibility in phasing
- Regulatory acceptability

On what street do you live?

6	Village Center and Business District
28	Northeast Orleans (Town Cove, Nauset Heights)
25	East Orleans (Pochet and Barley Neck)
9	West Orleans (Skaket and Rock Harbor)
36	South Orleans (North of Quanset Rd and Route 39)
16	South Orleans (South of Quanset Rd and Route 39)
10	Un-specific about neighborhood

Table C-4
Summer 2008 Workshops
Summary of Attendee Feedback

Number of attendees at workshop presentations: 368

Number of surveys submitted,

at end of evening:	117
at end of week:	28

Number of walk-in surveys picked-up: 32

Number of walk-in surveys turned-in: 6

# Responding	Neighborhood
6	Village Center and Business District
47	Northeast Orleans (Town Cove, Nauset Heights)
28	East Orleans (Pochet and Barley Neck)
23	West Orleans (Skaket and Rock Harbor)
24	South Orleans (North of Quanset Rd and Route 39)
17	South Orleans (South of Quanset Rd and Route 39)
3	Un-specific about neighborhood
3	Other

Based on the presentation and question and answer period, attendees found:	Plan 1 Decentralized (4 facilities)	Plan 2 Decentralized (Tri-Town)	Plan 3 Centralized (So. Orleans)
Most Favorable	12	104	31
Least Favorable	100	21	19

Most attractive features of:

Plan 1	Quickest restoration of environment
Plan 2	Least expensive
Plan 3	Reuse and regionalization

Least attractive features of:

Plan 1	Most expensive, numerous locations
Plan 2	Slowest cleanup
Plan 3	More work in multi-town implementation

APPENDIX D

PRELIMINARY SIZING DATA FOR WASTEWATER TREATMENT AND DISPOSAL ELEMENTS OF RECOMMENDED PLAN

APPENDIX D

PROCESS SELECTION AND SIZING FOR WASTEWATER TREATMENT FACILITY

D-1. COST EFFECTIVENESS OF NITROGEN REMOVAL TECHNOLOGIES

INTRODUCTION

Based on the site location in the Namskaket Creek watershed, and the preferences of the Wastewater Management Steering Committee, processes which can meet effluent Total Nitrogen concentrations of 5 mg/l to 10 mg/l will be considered. The existing Tri-Town wastewater treatment facilities are not sufficiently sized to treat the anticipated flows and loads for the Town; accordingly, new facilities are required. The anticipated effluent limits for the proposed treatment facilities are summarized in Table D-1.

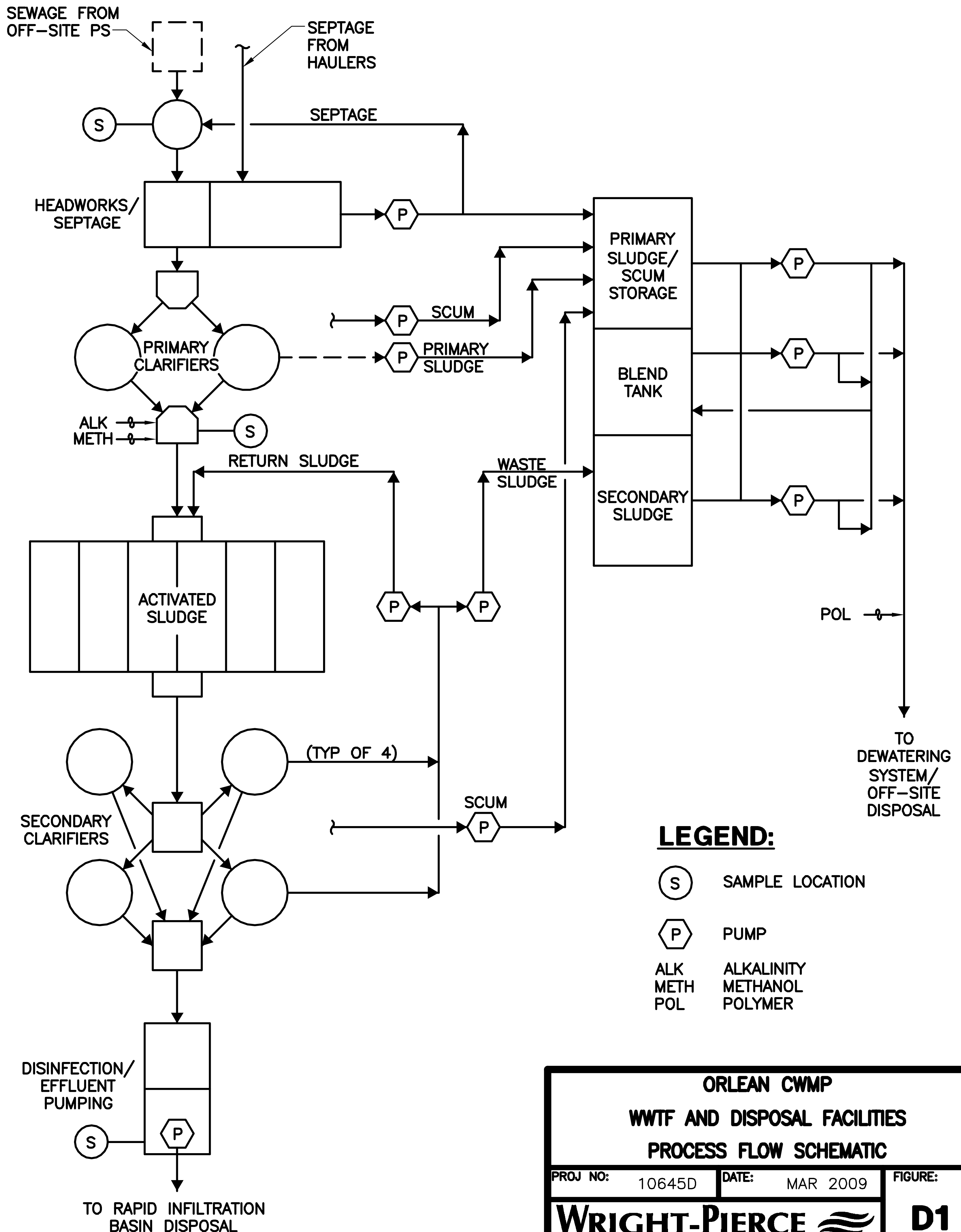
TABLE D-1
ANTICIPATED EFFLUENT LIMITS

Effluent Limits	Units	Maximum Day
Biochemical Oxygen Demand	mg/l	30
Total Suspended Solids	mg/l	30
Total Nitrogen as N	mg/l	10
Total Phosphorus as P	mg/l	-
Fecal Coliform (Geo. Mean)	#/100ml	200

General process description and flow diagrams, expected effluent quality, advantages/ disadvantages and summary format cost-effectiveness analysis are presented in this section. The recommended overall process flow diagram for the treatment facilities is shown in Figure D-1.

APPLICABLE TECHNOLOGIES

Some amount of nitrogen is removed in conventional activated sludge processes by way of biomass cell growth and wasting from the process. This amount is rather small and is not generally sufficient to achieve nitrogen removal criteria for more sensitive surface water bodies or for groundwater discharge. The generally accepted levels of treatment for Total Nitrogen are summarized below.



ORLEAN CWMP
WWTF AND DISPOSAL FACILITIES
PROCESS FLOW SCHEMATIC

PROJ NO: 10645D
DATE: MAR 2009
FIGURE: D1

WRIGHT-PIERCE
Engineering a Better Environment

- **Level 1 Nitrogen Limit (7 to 8 mg/l, annual average)** - Level 1 nitrogen limits, generally referred to as biological nitrogen removal (BNR), can be achieved biologically through a number of activated sludge process modifications. These process modifications, which all include the baseline requirement of having aerated (oxic) and anoxic conditions occurring in the bioreactors, typically include:

  - ✓ Modified Ludzack-Ettinger (MLE)
  - ✓ Extended Aeration oxidation ditches
  - ✓ Sequencing Batch Reactors (SBR)
  - ✓ Cyclic Aeration processes
  - ✓ Integrated Fixed Film Activated Sludge (IFAS)
  - ✓ Membrane Bioreactors (MBR)

- **Level 2 Nitrogen Limit (3 to 5 mg/l, annual average)** - Level 2 nitrogen limits, generally referred to as enhanced nitrogen removal (BNR), can be achieved biologically through a number of activated sludge process modifications. The lower end of Level 2 is considered the current limit of technology. Similar to Level 1, these process modifications all include the baseline requirement of having aerated (oxic) and anoxic conditions occurring in the bioreactors; however, also typically have secondary oxic and anoxic conditions in the bioreactors. In some cases a filtration step is required. In many cases, supplemental carbon is required for the secondary anoxic bioreactors. The process modifications typically include:

  - ✓ 4-Stage Bardenpho (MLE with secondary anoxic and oxic zones)
  - ✓ Extended Aeration Oxidation Ditches or SBRs, with denitrification filters
  - ✓ Integrated Fixed Film Activated Sludge (IFAS)
  - ✓ Membrane Bioreactors (MBR)

The Town has expressed some preference for Level 2 nitrogen removal for several reasons, including likely long-term regulatory trends (i.e., toward more stringent conditions) and the flexibility it provides to the Town in the implementation of its adaptive management approach. In the final analysis, any added costs for Level 2 nitrogen removal must be weighed against these unknowns.

PRELIMINARY SCREENING OF ALTERNATIVES

Summary of Alternatives

A review of the nitrogen removal technologies and a preliminary screening analysis were conducted in an effort to identify nitrogen removal technologies that might be applicable for the Town. The following nitrogen removal technologies were screened for evaluation:

- **Modified Ludzack-Ettinger Process:** The MLE process has been used extensively for the removal of nitrogen and is generally considered the "baseline" alternative when evaluating nutrient removal facilities for Level 1 treatment.

- **4-Stage Bardenpho Process:** The 4-Stage Bardenpho process has been used extensively for the removal of nitrogen and is generally considered the "baseline" alternative when evaluating nutrient removal facilities for Level 2 treatment.

- **Membrane Bioreactor Process:** Membrane bioreactors are an activated sludge process modification which uses membrane filtration as a physical barrier (vs gravity settling or clarification). This typically allows for the system to operate at nearly 3 times the MLSS concentration of a typical activated sludge process (with clarifiers) ultimately reducing the amount of aeration tank volume required. The MBR process can be configured as either a MLE or 4-Bardenpho process and therefore can achieve either Level 1 or Level 2 treatment. The MBR process has significant capital and operating costs due to the extensive equipment required and the energy intensive process. Typically, the MBR process is not cost effective unless physical space is a limitation or where extremely high effluent water quality is required (i.e. discharge to a small stream, pretreatment for reverse osmosis, etc.). The MBR process also has applicability in effluent reuse situations because it effects a high level of suspended solids removal that enhances disinfection.

- **Integrated Fixed Film Activated Sludge (IFAS) Process**: The IFAS technology combines suspended growth (i.e., MLSS) and attached growth (i.e., bacteria attached to a surface) to effectively increase the capacity of an activated sludge system. In the IFAS system, "media" is added to the mixed liquor to provide the surface for biofilm growth. The main benefit to the IFAS technologies is its ability to provide effective treatment with considerable less aeration tank volume than competing conventional technologies. Similar to the MBR alternative, the IFAS process can be configured as either a MLE or Bardenpho process. Typically, the IFAS process is not cost effective if alternative conventional technologies are available for implementation (i.e., if space is available on site for additional aeration tanks).

- **Extended Aeration Systems including Simultaneous Nitrification/Denitrification (SNDN) Processes (including cyclic aeration, various oxidation ditch processes, Schreiber process)**: These processes perform in a similar manner to MLE and Bardenpho, except that the kinetic rates are generally accepted to be lower than MLE or Bardenpho due to the simultaneous nature of nitrification and denitrification (i.e. less efficient zones). These processes will require large bioreactor volumes that MLE or Bardenpho processes for the same design loadings. Typically, these processes are cost effective on sites where there are no space limitations.

- **Denitrification Filters:** There are two main, commercially available, process configurations for denitrification filters - downflow and upflow continuous backwash filters. Downflow denitrification filters operate in a conventional filtration mode and consist of media and support gravel supported by an underdrain. Upflow continuous-backwash filters differ in that influent wastewater flows upward through the filter, countercurrent to the movement of the sand bed. Backwashing is required at regular intervals. During the process, nitrate is metabolized to nitrogen gas, which becomes embedded in the filter media. Denitrification filters would be combined with MLE (or similar appropriate) biological process. This approach has added benefits if very low total suspended solids are desired in the effluent.

Key Selection Criteria

The key selection criteria form the structure around which the processes will be selected.

- **Relative Capital Cost.** For the purposes of this specific analysis, capital cost is the estimated cost to construct the facilities, including construction and construction contingency but excluding technical services, legal, administrative, etc. Planning-level costs were developed using standard cost estimating procedures consistent with industry standards utilizing concept layouts, unit cost information, and planning-level cost curves, as necessary.

- **Relative Operating Cost.** Annual operations and maintenance cost is the estimated cost to run the facility on an annual basis, including electricity, chemicals, labor, etc. Alternatives are expected to have very similar operating requirements, thus the operating cost analysis considers the differential between the alternatives.

- **Ease of Operation.** Ease of operation is a subjective measure of operational considerations. This factor also considers the presence of similar facilities and technologies in the local vicinity of the town.

- **Process Scalability.** Careful consideration should be given to treatment solutions that are flexible (i.e., cost effective to operate both during the winter and the summer seasons), scalable (i.e., can the process be cost effectively upgraded to meet the current and potential future nitrogen removal levels), and work well within an adaptive management framework.

- **Limited Site Footprint.** Preference will be given to processes which have a smaller footprint because of the need to maximize the space available for rapid infiltration basins for effluent disposal.

- **Level 2 Treatment/ Reliability.** The selected alternative(s) must be able to reliably and consistently achieve the discharge criteria, now and in the future. This item represents a measure of regulatory acceptability.

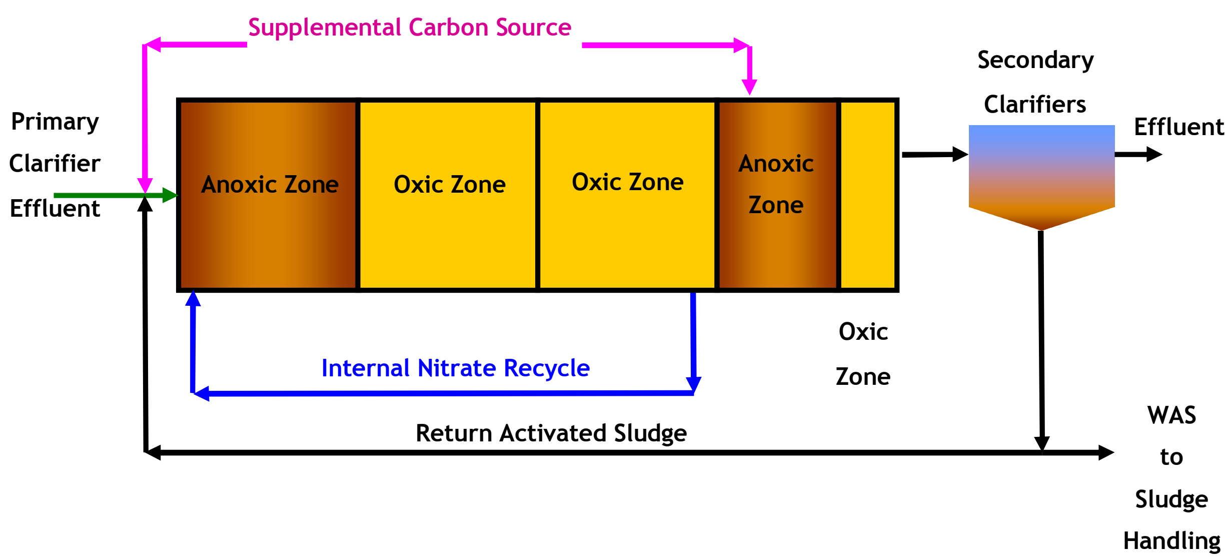
Based on the above, criteria, the following process alternatives were "shortlisted" for further evaluation:

- Alternative #1: 4-Stage Bardenpho Process, Conventional configuration
- Alternative #2: 4-Stage Bardenpho, Sequencing Batch Reactor configuration
- Alternative #3: MLE, SBR configuration, followed by Denitrification Filters

Four-Stage Bardenpho Process (Conventional)

The Four-Stage Bardenpho Process incorporates two distinct denitrification conditions (exogenous and endogenous denitrification) to achieve nitrogen removal. The Bardenpho process would provide nearly complete nitrification and denitrification throughout the year. As shown in Figure D-2, the first part of the Bardenpho process is very similar to the MLE process in that an un-aerated anoxic zone is incorporated into the first part of the tank followed by a series of aerated zones (nitrification). An internal recycle pump brings nitrates formed in the aerobic zone back to the initial anoxic zone where they are allowed to come in contact with the influent carbon and are subsequently removed (exogenous denitrification). Following the aerated zones, a secondary anoxic zone is provided to remove additional nitrate that was not recycled back to the front zone in an effort to further reduce the effluent total nitrogen level. Denitrification in the secondary anoxic zone is achieved either through carbon release from cell decay (endogenous denitrification) or through the addition of a supplemental carbon source. A small aerated zone is provided at the end of the process to reduce the potential for septic conditions to form in the secondary clarifiers, which could result in rising sludge and/or odor concerns.

FIGURE D-2
FOUR-STAGE BARDENPHO PROCESS FLOW DIAGRAM



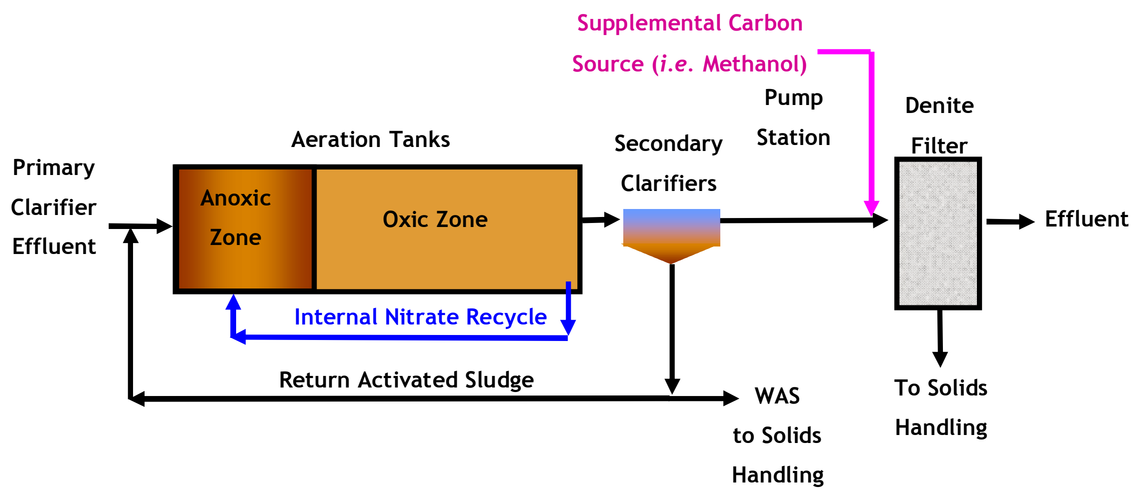
Four-Stage Bardenpho Process (SBR)

The Four-Stage Bardenpho Process can also be utilized in an SBR process configuration. The general process schematic is similar to the conventional Bardenpho described above, except that the activated sludge is sequencing through the oxic and anoxic phases by timers. Also, in this scenario, there are no secondary clarifiers and the process operates more like a simultaneous nitrification-denitrification process (i.e. at lower kinetic rates, with larger tank volumes). Since there is not separate clarification tankage, this process is considered slightly less robust than the conventional Bardenpho when considering its ability to achieve a maximum of 5 mg/l Total Nitrogen.

MLE Followed By Denitrification Filters

The previously identified MLE Process Alternative could be enhanced through the use of an effluent denitrification filter. Essentially, effluent from the secondary clarifiers (or the SBR) would be filtered via a deep bed sand filter. When combined with a supplemental carbon source, denitrification within the filter is possible. This alternative is capable of achieving an effluent total nitrogen concentration of 3 mg/l to 5 mg/l. Deep bed effluent filtration could be accomplished with the products of multiple manufacturers (e.g. Parkson Dynasand, Blue Water Technologies, Degremont Technologies, Veolia). A process schematic is shown in Figure D-3.

FIGURE D-3
MLE PROCESS WITH DENITRIFICATION FILTER PROCESS FLOW DIAGRAM



ALTERNATIVES ANALYSIS

Each of the above alternatives was evaluated against the key selection criteria and given a score ranging from 1 (best) to 3 (least favorable). The results of this analysis are presented below in Table D-2. Advantages and disadvantages of the major alternatives are summarized in Table D-3.

TABLE D-2
ALTERNATIVES ANALYSIS

Selection Criteria	Alternative #1 Bardenpho Conventional	Alternative #2 Bardenpho SBR	Alternative #3 MLE Bardenpho w/ Denit Filters
Relative Capital Cost	2	1	3
Relative Operating Cost	2	1	3
Ease of Operation	2	1	3
Process Scalability/ Adaptive Management	1	2	3
Limited Site Footprint	1	2	3
Level 2 Treatment/ Reliability	1	3	2
Total Score	9	10	17
Ranking	1	2	3

TABLE D-3
SUMMARY OF ADVANTAGES AND DISADVANTAGES

System	*Advantages*	*Disadvantages*
Alternative #1 Conventional Bardenpho	Reliable process, proven track record for Level 1 and 2 limits. Most robust process to meet Level 2 limits.	More manual process control requirements than SBRs.
	Slightly smaller tank volumes than Alternatives #2 or #3.	Relatively high equipment cost.
	Scaleable in its ability to add process tanks or equipment in trains.	
Alternative #2 SBR Bardenpho	Reliable process, proven track record for Level 1 and 2 limits.	SBR configuration less robust for the Level 2 limits. Performs better than Level 1 limits.
	SBR is most similar to other WWTFs on Cape Cod and the Islands.	Can result in different sludge composition between different SBR tanks.
	Scaleable in its ability to add process tanks or equipment in trains, OR to change time cycles or elevations.	Slightly larger tank volume than Conventional Bardenpho due to simultaneous nitrification/ denitrification (SNDN) and secondary equalization tankage.
	More automated process control.	
Alternative #3 MLE SBR w/ Denitrification Filters	Reliable process, proven track record for Level 1 and 2 limits.	Extra level of complexity given two unit processes required.
	SBR is most similar to other WWTFs on Cape Cod and the Islands.	Extra headloss through process, so more pumping energy is required.
	Scaleable in its ability to add process tanks or equipment in trains, OR to change time cycles or elevations.	
	More automated process control.	

CONCLUSIONS AND RECOMMENDATIONS

This alternatives analysis considers both relative cost and non-cost factors. In the case of Orleans, the ability to fit within an adaptive management approach is considered equally important to the cost factors (i.e. capital, operations and maintenance). The following conclusions are presented:

- Conventional Bardenpho process is the most robust and most cost-effective approach to reliably meeting the Level 2 limits. In this case, Total Nitrogen in the effluent would be 3 mg/l to 4 mg/l under annual average conditions and 5 mg/l to 6 mg/l under maximum month/ week conditions. The major advantages of this selection are the greatest flexibility with regard to TN removal and the relative ease of scaling. The major disadvantages of this selection are the amount of process equipment and the potential for different equipment manufacturers through the phased implementation.

- SBR Bardenpho process is the least robust of the three alternatives in terms of strictly and reliably meeting the Level 2 limits. That said, Total Nitrogen in the effluent would be 3 mg/l to 5 mg/l under annual average conditions and 5 mg/l to 7 mg/l under maximum month or maximum week conditions. The major advantages of this selection are the greatest ease of scaling (i.e. may be able to achieve Phase 1/ 2 via modifications in timers or elevations without the need for capital upgrades). The major disadvantages of this selection are the reduced ability to achieve the Level 2 limits.

- SBR MLE with denitrification filters is a robust means to reliably meet the Level 2 limits (same as Alternative #1). The major advantages of this selection are the relative ease of scaling (i.e. similar to Alternative #2, also can add denitrification filters in latter phases to meet additional TN removal requirements). The major disadvantages of this selection are requiring two unit processes to achieve Level 2 limits and the anticipated chemical costs.

Important factors in this evaluation are the incomplete nature of some the Massachusetts Estuaries Project (MEP) technical reports (and associated Total Maximum Daily Loads--TMDLs) and the pending regionalization study. Given this uncertainty, it appears prudent to select a more conservative, cost-effective alternative at this time. Accordingly, based on this analysis, conventional 4-stage Bardenpho is recommended for inclusion in the CWMP recommended plan. However, a more detailed cost-effectiveness analysis, sensitivity analysis and phasing analysis should be performed in the Preliminary Design phase once the MEP technical reports and TMDLs are completed and once on-going regionalization studies are completed.

D-2. ENERGY CONSERVATION MEASURES

As a part of the preliminary design phase of the project, specific energy conservation measures will be considered. Measures that are typically considered are as follows.

Collection, Transport to Treatment, and Transport to Disposal

- Minimizing the number of pumping stations.
- Utilizing variable frequency drives on medium and large pumping stations (larger than 500 gpm).
- Minimizing total dynamic head on pumping stations.

Wastewater Treatment

- Minimizing the number of on-site pumping stations required.
- Using on-site plant water system to maximize water efficiency and minimize use of potable water for process needs.
- Utilizing variable frequency drives on process-dependent equipment (i.e., aeration blowers, return sludge pumping, waste sludge pumping, press feed pumping, etc.).
- Balancing capital costs, project phasing, and design flows and loadings to provide for energy efficient and flexible process design.
- Utilizing code-compliant ventilation systems which take advantage of provisions for reduced ventilation rates for cold exterior temperatures and unoccupied times (e.g., NFPA 820).
- Utilizing energy efficient building envelope design and building orientation.
- Utilizing energy- and fuel-efficient heating and cooling systems.
- Utilizing a Supervisory Control and Data Acquisition (SCADA) System to automate operator-defined processes such that they optimize energy or process efficiency (e.g. processing recycle loads during night-time hours, etc.).

The requirement of MGL Chapter 149, Section 44M (Energy Systems; Life-Cycle Cost Estimates) will be addressed for any new buildings, as well as any existing building which will be renovated. Elements of "green design" should be evaluated for cost-effectiveness during the preliminary design phase, including such items as photovoltaic systems, solar hot water systems, and wind.

D-3. BASIC DESIGN DATA FOR TREATMENT AND DISPOSAL FACILITIES

Given the selection of the 4-phase Bardenpho process, basic design data have been developed for all of the principal unit processes in the proposed facilities for wastewater treatment and disposal. Those data are presented in tabular form in the pages that follow.

INFLUENT

Design Flows & Loads (excluding Recycles) - CORE PLAN

		Phase 1 Annual Average	Phase 4 Annual Average	Phase 4 Maximum Month	Phase 4 Maximum 2-Day	Phase 4 Peak Hour
Sanitary	mgd	0.250	0.504	1.004	1.210	-
Infiltration/ Inflow	mgd	0.050	0.110	0.040	0.155	-
Septage	mgd	0.025	0.031	0.050	0.075	-
Design Flow (Wastewater)	mgd	0.32	0.64	1.09	1.44	2.23
Biochemical Oxygen Demand	lbs/day	1,240	2,480	4,580	5,950	-
Total Suspended Solids	lbs/day	1,615	3,230	5,870	7,750	-
Total Kjeldahl Nitrogen	lbs/day	200	400	750	960	-
Total Phosphorus-P	lbs/day	30	60	110	140	-

Design Flows & Loads (excluding Recycles) - EXTENDED PLAN/ TOWN-WIDE SEWERS

		Annual Average	Maximum Month	Maximum 2-Day	Peak Hour
Sanitary	mgd	0.950	1.900	2.280	-
Infiltration/ Inflow	mgd	0.165	0.066	0.248	-
Septage	mgd	0.027	0.041	0.063	-
Design Flow (Wastewater)	mgd	1.14	2.01	2.59	4.13
Biochemical Oxygen Demand	lbs/day	3,890	6,610	9,330	-
Total Suspended Solids	lbs/day	4,780	8,120	11,460	-
Total Kjeldahl Nitrogen	lbs/day	660	1,130	1,590	-
Total Phosphorus-P	lbs/day	100	150	240	-

EFFLUENT LIMITS

		Annual Average	Weekly Average	Maximum Day
Effluent Limits (All Flow)				
Flow	mgd	-	-	-
Biochemical Oxygen Demand	mg/l	-	-	30
Total Suspended Solids	mg/l	-	-	30
Total Nitrogen as N	mg/l	-	-	10
Total Phosphorus as P	mg/l	-	-	-
Fecal Coliform (Geo. Mean)	#/100ml	-	-	200

REV. 21 Apr 2009, EJL

TOWN OF ORLEANS, MASSACHUSETTS ADVANCED WASTEWATER TREATMENT FACILITIES DESIGN DATA SUMMARY - ALL FLOW		No. Installed During Phase 1	4/ 5	EXT
Mechanical Screening				
Type	Fine, 1/4-inch			
Number of Units	1	1	0	0
Screenings Washing Compactor	Yes	1	0	0
Bypass	Manual, 1-inch	1	0	0
Grit Removal				
Grit Chamber				
Type	Vortex			
Number of Units	1	1	0	1
Diameter, ft	6			
Grit Pumping				
Type	Centrifugal, Recessed Impeller			
Number of Units	1	1	0	0
Unit Capacity, gpm	250			
Grit Classifier				
Type	Inclined Conveyor			
Number of Units	1	1	0	0
Unit Capacity, gpm	250			
Septage Receiving				
Screening				
Type	Fine, 1/4-inch			
Number of Units	2	1	1	0
Screenings Washing Compactor	Yes	1	0	0
Bypass	Manual, 1-inch	1	0	0
Screened Septage Storage Tanks				
Number of Units	3	2	1	0
Design Receiving Volume, gpd (during Max Month)	50,000			
Design Storage Duration, days	3			
Volume, Total, gal	150,000			
Unit Volume, gal	50,000			
Screened Septage Pumps				
Type	Positive Displacement			
Number of Units	3	3	0	0
Unit Capacity, gpm	100			
Primary Clarifiers				
Number of Units	2	1	1	0
Diameter, ft	30			
Side water depth, ft	12			
Activated Sludge - Biological Nutrient Removal				
Process	Four-Stage Bardenpho			
Number of Trains	4	2	2	2
Width per Train, ft	18			
Length per Train, ft	72			
Depth, ft	15			
Total Volume, cf.	78,000			
Total Volume, gal.	585,000			880,000
Design MLSS, mg/l	3,000			3,500
Mixers (Anoxic, Deoxygenation Zones)				
Type	Submersible, Horizontal, Propeller			
Number of Units per Train	6			
Total Number of Units	24	12	12	12
Nominal speed, rpm	200			
Unit Capacity, HP per 1,000 CF	0.4			

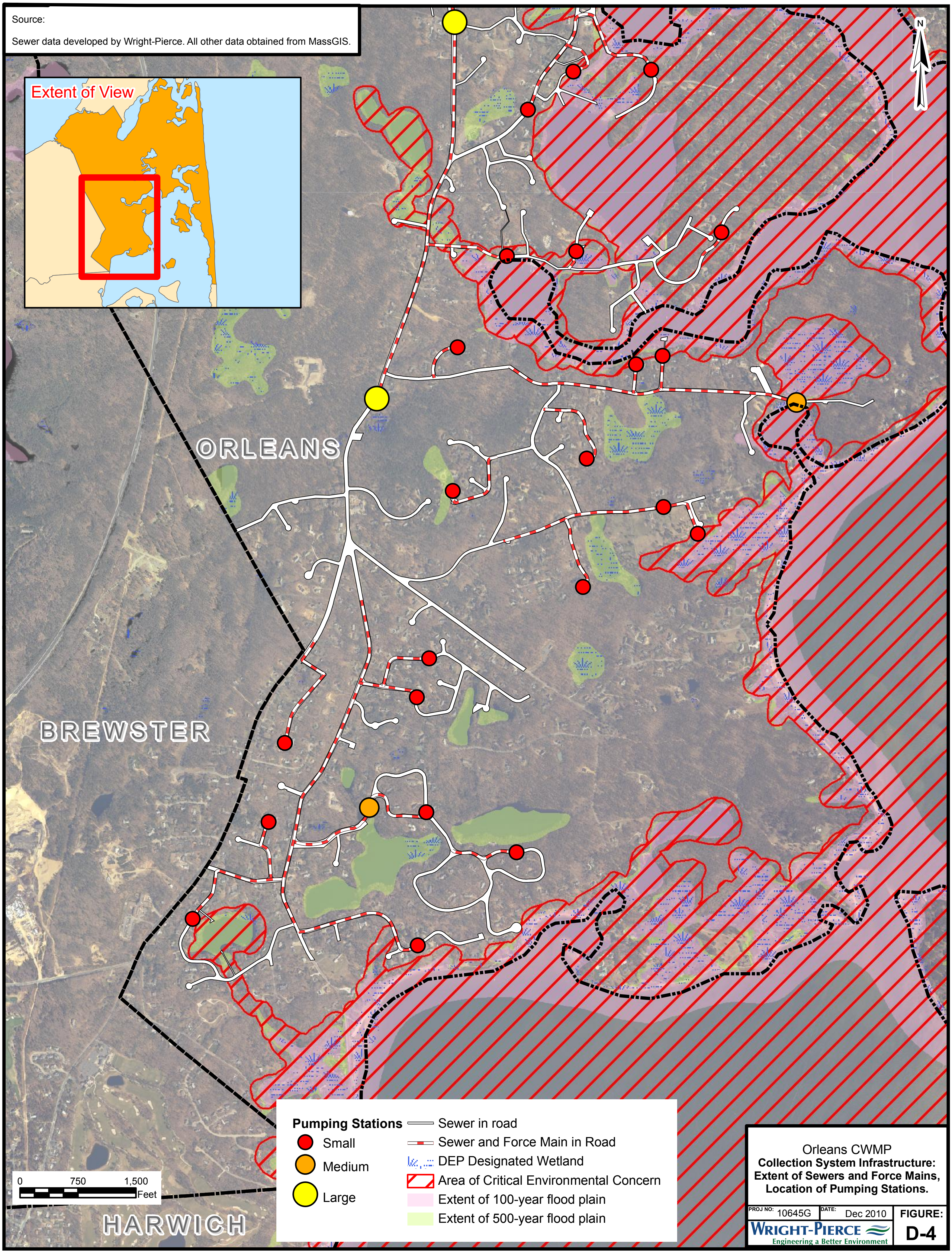
		No. Installed During Phase 1	4/ 5	EXT
Internal Recycle Pumps				
Type	Submersible, Propeller			
Number of Units per Train	1			
Total Number of Units	4	2	2	2
Unit Capacity, mgd	3.4			
Total Capacity. mgd	13.6			
Aeration Equipment				
Type	Positive Displacement			
Number of Units	4	3	1	Replace blowers
Unit Capacity, CFM	1,900			
System Capacity, CFM	5,700			
Diffuser Type	Fine Bubble, 9" dia. Membrane			
Secondary Clarifiers				
Type	Rapid Sludge, Suction Header Type			
Number of Units	3	2	1	1
Diameter, ft	30			
Side water depth, ft	12			
Supplemental Alkalinity System				
Type	Magnesium Hydroxide (Liquid)			
Storage Tank				
Number of Units	1	1	0	0
Volume, gallons	6,500			
Design Dosage, mg/l as $CaCO_3$	150			
Chemical Usage, gallons per day	10 - 50			
Pumps				
Type	Positive Displacement, Tubing Pump			
Number of Units	2	2	0	0
Unit Capacity, gallons per hour	0.1 - 10			
Supplemental Carbon System				
Type	Methanol, MicroC, or equal			
Storage Tank				
Number of Units	1	1	0	0
Volume, gallons	1,000			
Design Dosage, mg/l as COD	40 - 100			
Chemical Usage, gallons per day	5 - 40			
Pumps				
Type	Positive Displacement, Tubing Pump			
Number of Units	2	2	0	0
Unit Capacity, gallons per hour	0.1 - 10			
Disinfection Systems - Ultraviolet Light				
Type	Low Pressure - High Output			
Number of Banks	3	2	1	1
Design Peak Intensity (End of Lamp Life), µW-s/cm2	30,000			
End of Lamp Life Output, % of New Lamp	65%			
Design Transmissivity	65%			
Cleaning Method	Chemical/ Mechanical			
Effluent Pumping				
Type	Centrifugal			
Number of Units	4	3	1	1
System Capacity (mgd), Peak Hour	2.23			
Unit Capacity (gpm)	530			

TOWN OF ORLEANS, MASSACHUSETTS ADVANCED WASTEWATER TREATMENT FACILITIES DESIGN DATA SUMMARY - ALL FLOW		No. Installed During Phase 1	4/ 5	EXT
Effluent Disposal				
Type	Rapid Infiltration Basins			
Design Maximum Month Flow Rate, gpd	1,090,000			
Design Application Rate (gpd/sf for Max Month)	7.7	50%	50%	Partial
Total Area Required (sf)	142,000	71,000	71,000	Partial
Number of Units	10	5	5	Partial
Scum Pumping				
Primary Scum				
Type	Vertical Wetwell, Chopper			
Number of Units	1	1	0	0
Unit Capacity, gpm	150			
Secondary Scum				
Type	Vertical Wetwell, Chopper			
Number of Units	1	1	0	0
Unit Capacity, gpm	150			
Primary Sludge Pumping (PSL)				
Type	Positive Displacement			
Number of Units	2	2	0	0
Unit Capacity, gpm	250			
Return Sludge Pumping (RSL)				
Type	Centrifugal, Screw Impeller			
Number of Units	4	3	1	1
Design Return Rate (% of Q Max Month)	100%			
System Capacity, mgd	1.09			
Unit Capacity, gpm	250			
Waste Sludge Pumping (WSL)				
Type	Centrifugal, Screw Impeller			
Number of Units	2	2	0	0
Unit Capacity, gpm	150			
Plant Water (PW)				
Type	Multi-stage centrifugal			
Number of Units	2	2	0	0
Unit Capacity, gpm	200			
Service Pressure, psi	100			
Hydropneumatic Tank	Yes			
On-Site Pump Station (Sanitary & Recycle)				
Type	Centrifugal, non-clog			
Number of Units	2	2	0	0
Unit Capacity, gpm	250			
Sludge Storage Tanks (Waste Sludge)				
Number of Units	2	1	1	0
Length, ft	45			
Width, ft	10			
Side Water Depth, ft	15			
Total Volume, cf.	13,500			
Total Volume, gal.	101,000			
Design Waste Sludge Volume (Max. Month), gpd	22,000			
Design Waste Sludge Solids (Max. Month), %	0.75			
Storage, days	4.6			

		No. Installed During Phase 1	4/ 5	EXT
Aeration System				
Type	Positive Displacement/ Diffused Aeration			
Number of units	2			
Aeration, cfm/1000cf	40			
Unit Capacity, cfm	540			
Sludge Storage Tanks (Primary Sludge)				
Number of Units	1	1	0	0
Length, ft	45			
Width, ft	10			
Side Water Depth, ft	15			
Total Volume, cf.	6,800			
Total Volume, gal.	51,000			
Design Primary Sludge Volume (Max. Month), gpd	20,000			
Design Primary Sludge Solids (Max. Month), %	2.5			
Storage, days	2.6			
Mixing	Pump Mix			
Sludge Storage Tanks (Dewatering Blend Tank)				
Number of Units	1	1	0	0
Length, ft	45			
Width, ft	10			
Side Water Depth, ft	15			
Total Volume, cf.	6,800			
Total Volume, gal.	51,000			
Total Weekly Waste Sludge during Max Month	154,000			
Total Weekly Primary Sludge during Max Month	140,000			
Total Weekly Sludge during Max Month	294,000			
Dewatering, days per week during Max Month	5			
Dewatering, gallons per day during Max Month	58,800			
Storage, days during Max Month	0.9			
Dewatering System				
Sludge Pumping (Blend, Waste, Primary)				
Number of Units	3	3	0	0
Type	Positive Displacement Duplex Plunger			
Unit Capacity, gpm	150			
Sludge Dewatering System				
Number of Units	2	2	0	0
Type	Belt Filter Press			
Size	1.5-Meter			
Capacity, lb/hr	1,000			
Belt Alignment/ Tensioning System	Hydraulic			
Sludge Conditioning System	In-Line Venturi Mixing Valve			
Sludge Conveyors	Shaftless Screw Conveyor			
Polymer System				
Number of Units	2	2	0	0
Type	Liquid Emulsion, Mechanical Mixing			
Odor Control System				
System No. 1 (Headworks/ Sludge Storage)				
Type	Chemical Scrubber			
Capacity, cfm	To be determined			
System No. 2 (Dewatering)				
Type	Activated Carbon			
Capacity, cfm	To be determined			

D-4. COLLECTION SYSTEM INFRASTRUCTURE

The extent of the collection system is depicted in Figure 11-1 on a town-wide scale. Figures D-4 through D-9 provide a more detailed scale and illustrate the extent of sewers and force mains, and the proposed location for pump stations.



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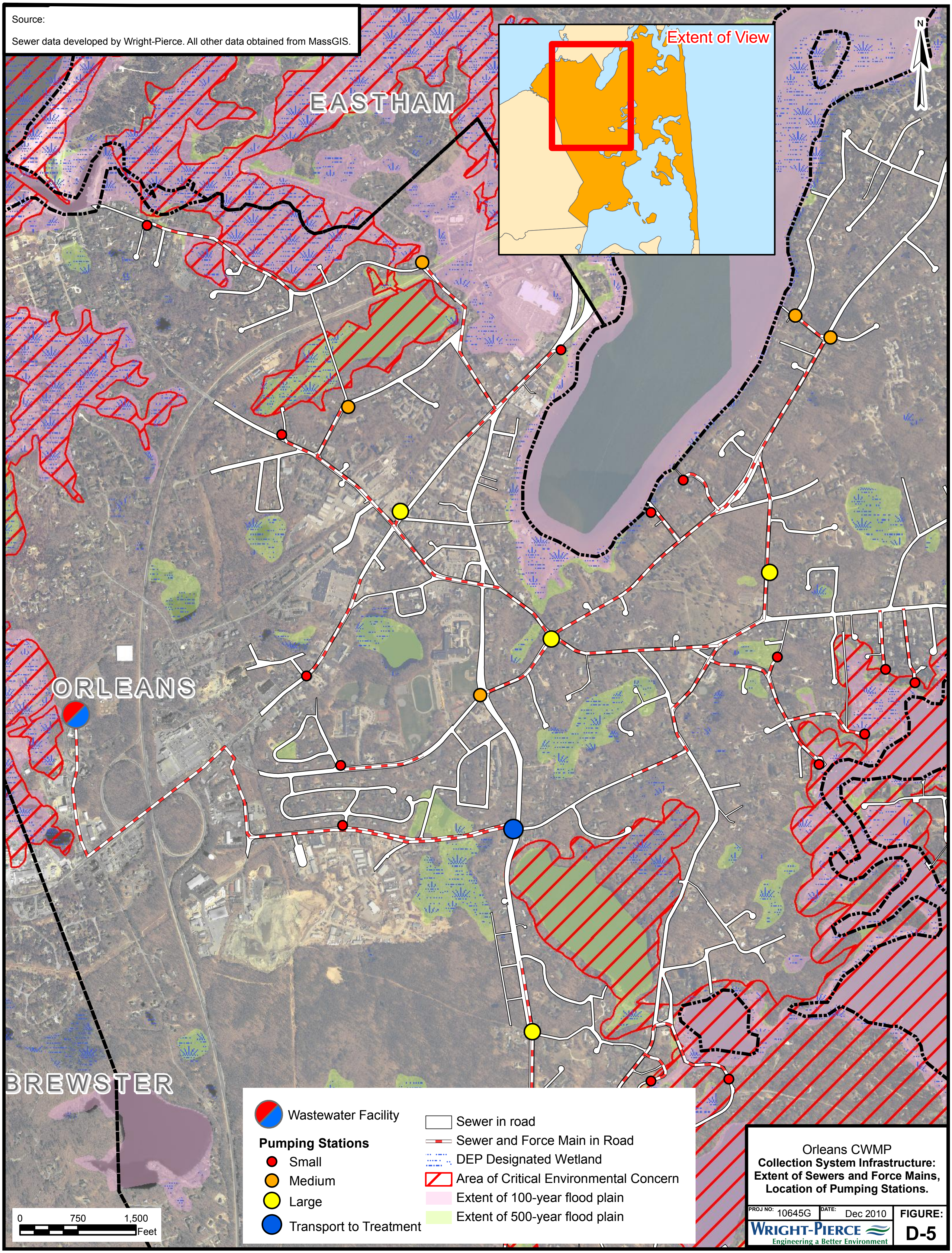
Source:
Sewer data developed by Wright-Pierce. All other data obtained from MassGIS.
EASTHAM
ORLEANS
BREWSTER
Extent of View
N
Wastewater Facility
Pumping Stations
Small
Medium
Large
Transport to Treatment
Sewer in road
Sewer and Force Main in Road
DEP Designated Wetland
Area of Critical Environmental Concern
Extent of 100-year flood plain
Extent of 500-year flood plain
0 750 1,500
Feet
Orleans CWMP
Collection System Infrastructure:
Extent of Sewers and Force Mains,
Location of Pumping Stations.
PROJ NO: 10645G
DATE: Dec 2010
FIGURE:
D-5
WRIGHT-PIERCE
Engineering a Better Environment
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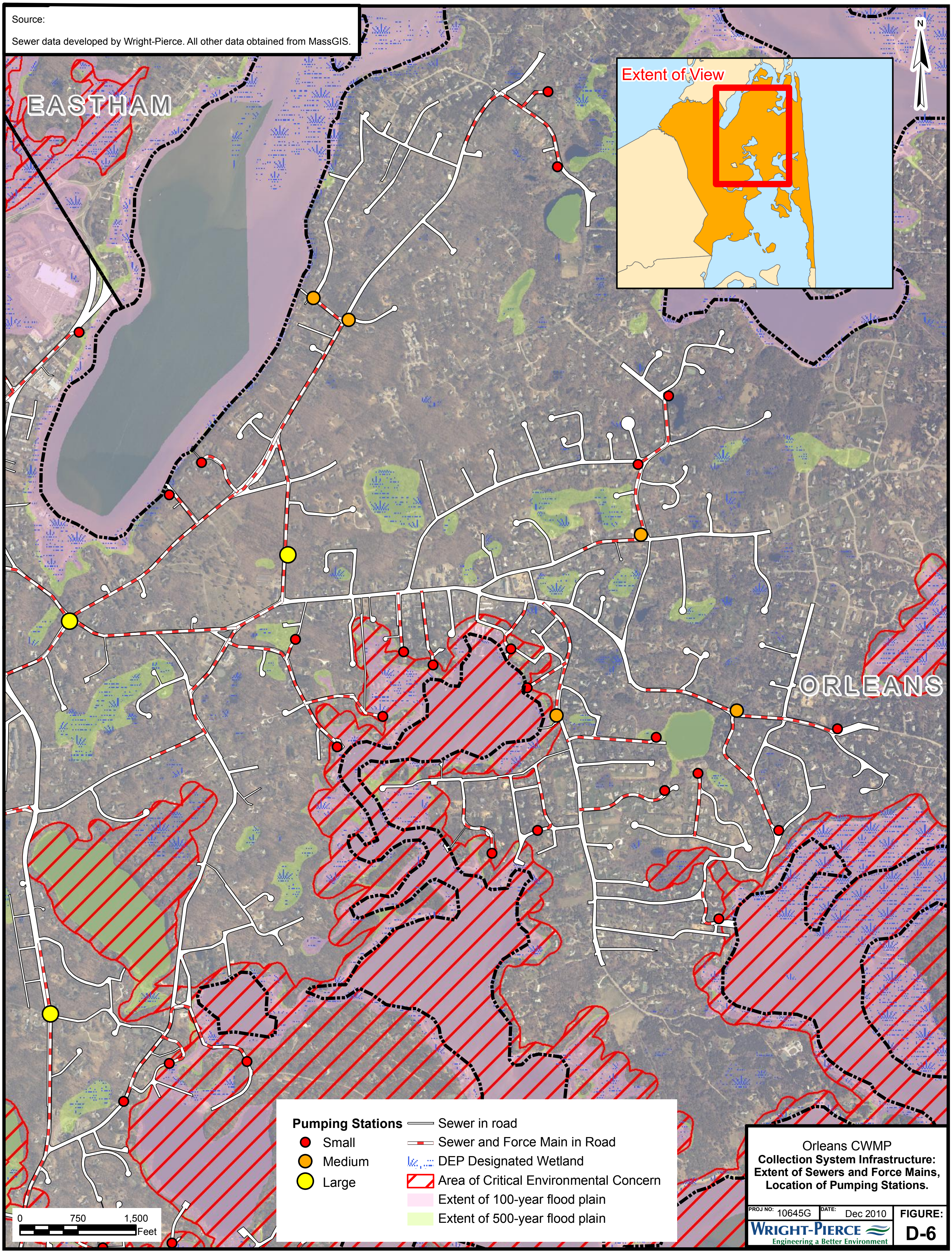

Source:
Sewer data developed by Wright-Pierce. All other data obtained from MassGIS.
EASTHAM
ORLEANS
Extent of View
N
Pumping Stations
Small
Medium
Large
Sewer in road
Sewer and Force Main in Road
DEP Designated Wetland
Area of Critical Environmental Concern
Extent of 100-year flood plain
Extent of 500-year flood plain
0
750
1,500
Feet
Orleans CWMP
Collection System Infrastructure: Extent of Sewers and Force Mains, Location of Pumping Stations.
PROJ NO: 10645G
DATE: Dec 2010
FIGURE: D-6
WRIGHT-PIERCE
Engineering a Better Environment
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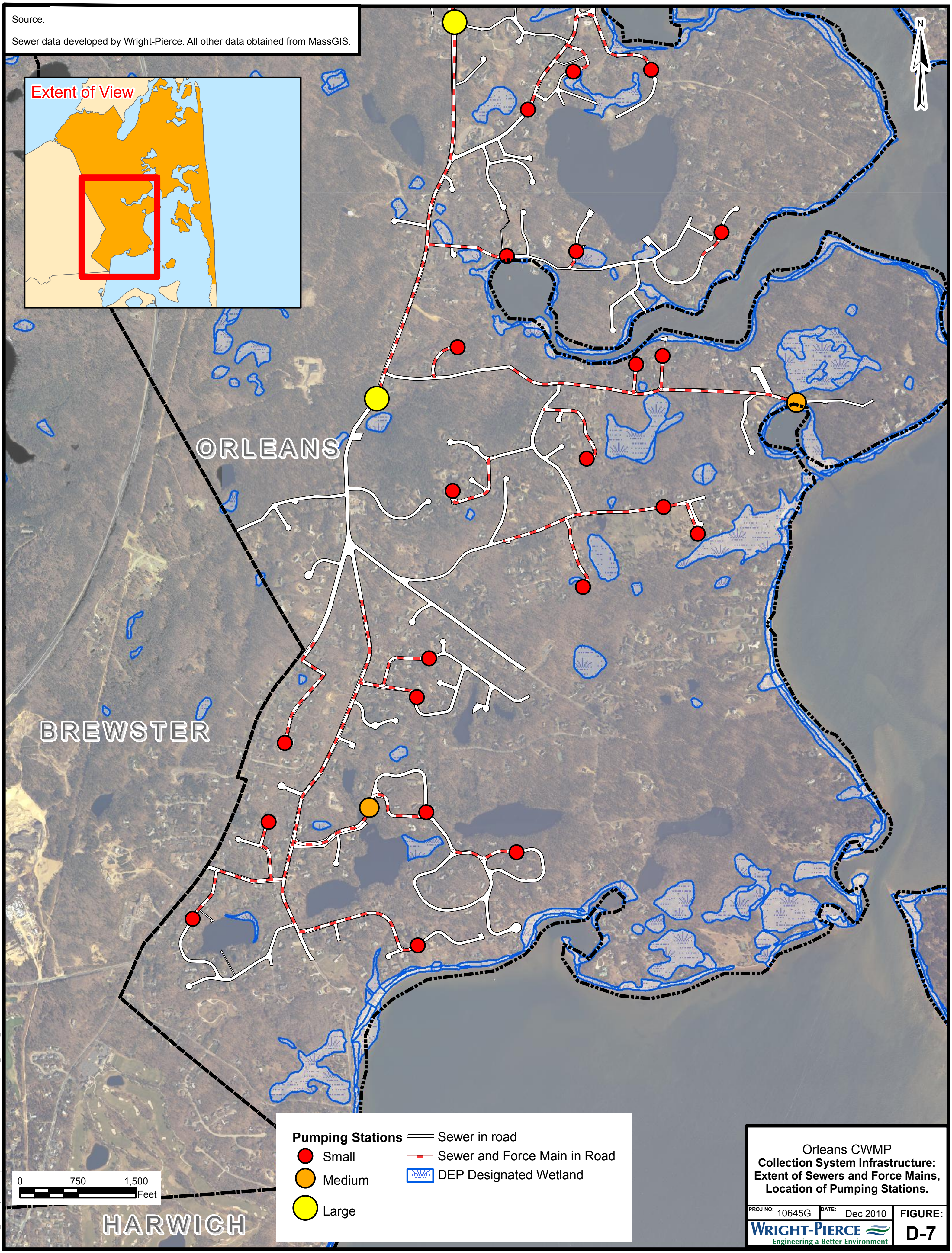

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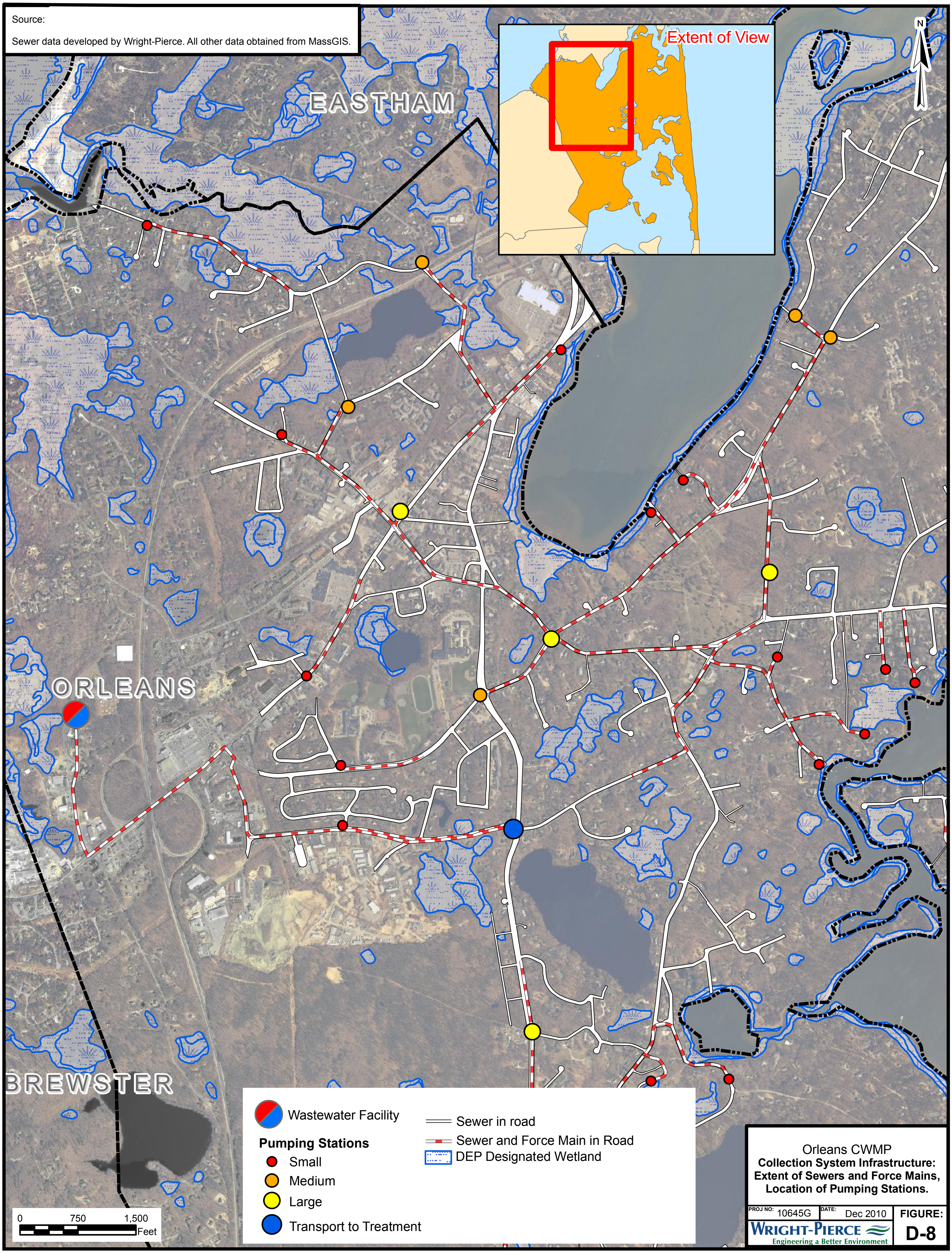

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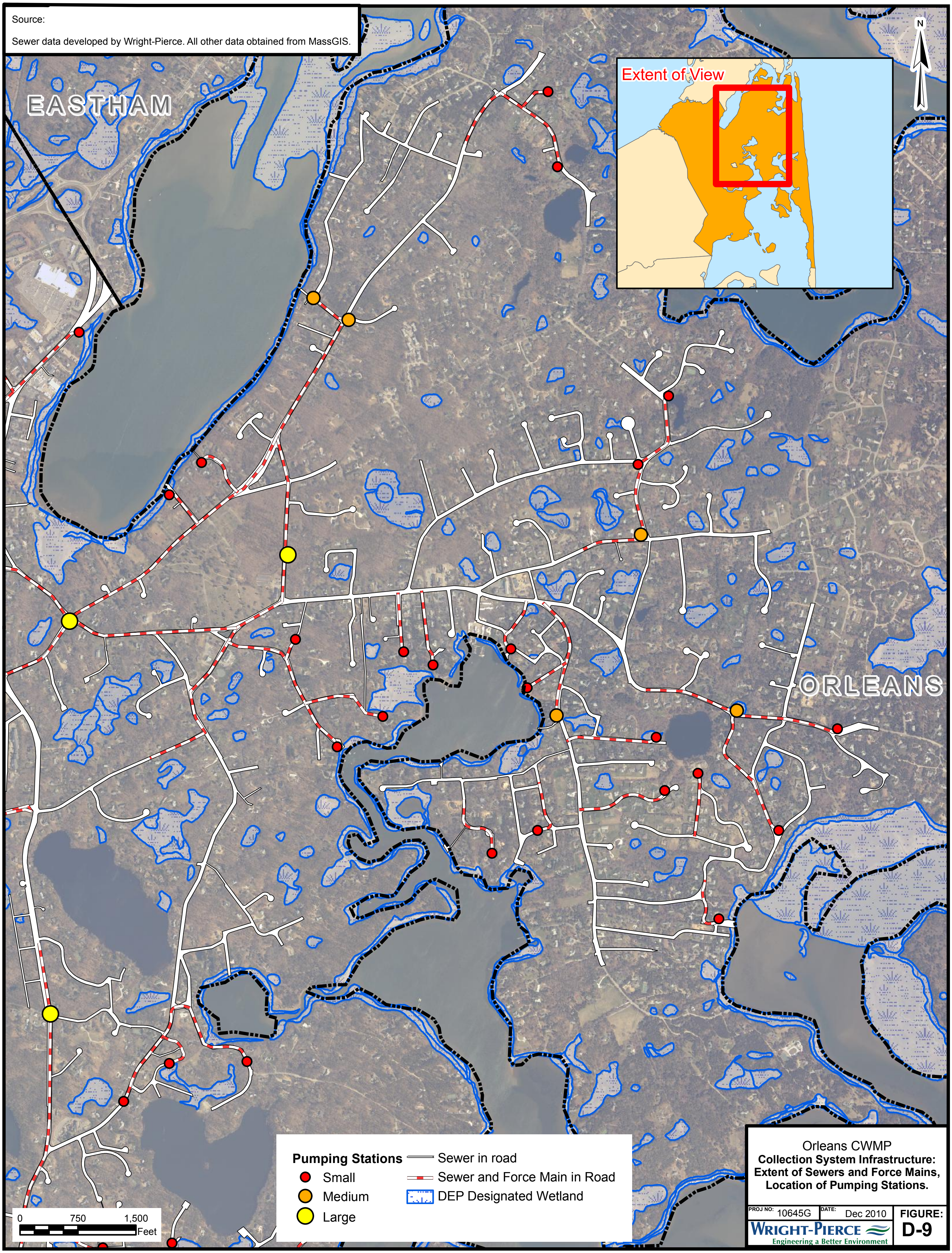

Source:
Sewer data developed by Wright-Pierce. All other data obtained from MassGIS.
EASTHAM
ORLEANS
Extent of View
N
Pumping Stations
Small
Medium
Large
Sewer in road
Sewer and Force Main in Road
DEP Designated Wetland
0 750 1,500
Feet
Orleans CWMP
Collection System Infrastructure:
Extent of Sewers and Force Mains,
Location of Pumping Stations.
PROJ NO: 10645G
DATE: Dec 2010
FIGURE: D-9
WRIGHT-PIERCE
Engineering a Better Environment
W:\GIS_Development\Projects\10645B-Orleans\10645G\2010_CWMP_SEIR\D-9.mxd

APPENDIX E

HYDROGEOLOGIC INVESTIGATIONS AT SITE 241

TOWN OF ORLEANS
COMPREHENSIVE WASTEWATER MANAGEMENT PLAN

PRELIMINARY SITE INVESTIGATIONS HYDRO GEOLOGIC EXPLORATION AT SITE 241

APPENDIX E

FEBRUARY 2008

WRIGHT-PIERCE
Engineering a Better Environment™

ORLEANS COMPREHENSIVE WASTEWATER MANAGEMENT PLAN
PHASE 6 - SITE INVESTIGATIONS HYDROGEOLOGIC INVESTIGATION
AT SITE 241

1.0 INTRODUCTION

Assessments conducted as part of the Comprehensive Wastewater Management Plan (CWMP) indicate that the Town of Orleans has a current need for 1.2 million gallons per day (mgd) of effluent disposal capacity, and a potential future need of 1.6 mgd. To date, 26 sites have been identified whose potential aggregate capacity is about 4 mgd. Many of the identified sites are small and privately owned. Wright-Pierce has recommended that the Town defer any study of these sites until more is known about the capacity of the larger sites, particularly those in public or utility ownership.

This report focuses on the results of exploration at Site 241, the site of the Tri-Town Septage Treatment Facility, see Figure 1. This site was selected as the first property for further evaluation because: 1) it has large portions of undeveloped land (as compared to remaining vacant land available elsewhere in town), 2) it is in municipal ownership, and 3) its current land use is consistent with wastewater activities. This report provides a summary of the work completed in the fall of 2007 at the Tri-Town site in support of the Comprehensive Wastewater Management Plan. The scope of this work is summarized as follows.

- Review of existing subsurface information collected during the construction of the septage treatment facility. See Section 2.0.
- Identification of soil conditions in previously unexplored areas of the site, as well as confirmation of soils in the vicinity of the existing effluent disposal system. See Section 3.0.
- Observation of soil permeability through selective percolation testing in areas of the site previously unexplored. See Section 4.0.
- Execution of a hydraulic loading test to determine the hydraulic capacity of the soil at a large-scale and the associated response of the local groundwater to a significant application of water at the surface. See Section 5.0.
- Preliminary determination as to the capability of the site to handle some or all of the Town's future disposal needs. See Section 6.0.
- Simulation of groundwater mounding using computer modeling based on the results of the hydraulic loading test See Section 7.0.
- Recommendation of future steps for exploration at the Tri-Town site. See Section 8.0.

Legend

Hydrant
Monitoring Wells
Parcels

Test Pits 2007 Percolation Rate

<2 min/inch
>5 min/inch
None

Test Pits by Others Percolation Rate

<2 min/in
2-5 min/in
>5 min/in
* Estimated based on Soil Logs

0 50 100 Feet

SOURCE:
Well Cluster Sites and Test Pits created by Wright-Pierce.
All other data obtained from Town of Orleans and MassGIS.

Orleans CWMP
Site Investigations
Site 241
Site Plan

PROJ NO 10645E		WRIGHT-PIERCE	FIGURE: 1
DATE: Feb. 2008			
SCALE: AS SHOWN			

2.0 REVIEW OF EXISTING INFORMATION

Extensive subsurface information for portions of the site is available from the original design and permitting of the septage treatment facility. All available information on soil exploration, permeability testing, borings, test/monitoring wells, and subsurface documentation was reviewed by our staff and used to shape this most recent investigation.

The review of documents included information developed by GZA in 1984 to support the permitting of the existing rapid infiltration basins. That exploration included a hydraulic loading test (in an area adjacent the existing basins) that demonstrated the soils are capable of infiltrating approximately 270,000 gpd.

Also reviewed were test pit data and boring logs compiled as part of USGS study (1995) of the migration of nitrogen-enriched groundwater moving away from the Tri-Town site and its potential impacts on surface water in Namskaket Marsh.

More recently, the Namskaket Marsh system has been studied by the Massachusetts Estuaries Project. Preliminary results indicate that this salt marsh system is not currently nutrient stressed, and therefore not negatively impacted by the nitrogen in the groundwater contributed by all sources in the watershed including the nitrogen that reaches the groundwater from the disposal of effluent at the Tri-Town site.

3.0 SUBSURFACE EXPLORATION

Based on all of this existing information, we developed and then executed a program of additional test pits to define soil types and to determine percolation rates to get preliminary estimates of soil permeability in areas that were, until now, unexplored.

A review of existing subsurface information exposed the lack of information in several portions of the site. These areas include the portion of the site south and southeast of the existing rapid infiltration basins (RIB), and northeast of the treatment facility buildings but south of the compost shed, see Figure 1.

Several test pits were excavated in the southern portion of the site, and more test pits were located as feasible in the region northeast of the treatment buildings, but no exploration occurred at the highest elevation of the knoll. The soil constituting the knoll would likely be removed as part of any construction, and therefore any information collected on surface soils would not be useful in the design of effluent disposal beds. Test pits were also located in the area defined as: west of the infiltration basins, south of the treatment buildings and east of the access road. While there is some information available in that area, it is derived from the logs of the monitoring wells installed by USGS. A better classification of soil in that area was needed. No work was done on the portion of the site to the west of the access road, since that land is low-lying and least suited for effluent disposal. Test pits were also located immediately adjacent to the best- and worst-performing RIBs to better characterize the extent of different soil types, and serve as an additional benchmark in the evaluation of the hydraulic loading test.

A total of thirteen test pits, numbered 1-07 through 13-07, were excavated on the site. The location of these test pits can be seen on Figure 1. The test pit logs are in Attachment 1.

Each test pit enabled the visual observation of soil from the ground surface to a depth 10 or 12 ft below ground surface (bgs). Groundwater was not encountered in any of the test pits. Previous mapping of the site indicates the groundwater table is generally 30 to 40 ft bgs in the areas of exploration. This information was also confirmed when recording the groundwater elevation in monitoring wells surrounding the hydraulic loading test.

The soil in the test pits has been classified as follows. In general, silty fine sand, ranging from 4 ft bgs to 9 ft bgs, was observed in test pits 1-07, 3-07, 6-07, 7-07, 9-07, 11-07 and 13-07. Orange tan medium sand ranging from 4 ft bgs to 9 ft bgs, was encountered in test pits 2-07, 4-07, 5-07 and 8-07. This soil stratum was also observed in test pits 11-07 and 13-07 from a depth of 6 ft to the bottom of the excavation (11-12 ft). Gray silt and clay was encountered in test pits 3-07 and 10-07, ranging from 5 to 6 ft bgs to the bottom of each excavation. Water infiltrating through the soil as part of the hydraulic loading test was observed weeping into test pit 1-07 (approximately 10 ft south of RIB No. 2, the worst performing RIB) at a depth of 7 ft bgs, on top of the dense silty fine sand strata. Soil mottling, apparently from perched groundwater, was observed as several depths.

4.0 SOIL PERMEABILITY

A single percolation test was performed in test pits 4-07 through 9-07 and 12-07, and two percolation tests were performed at different depths in 2-07 (See Figure 1 for locations and Table 1 percolation rates). Conducting a percolation test includes the following: excavating the top layers of organic soil to expose lower horizons, digging a 1-ft by 1-ft hole 1.5 ft deep, filling the hole with water to a depth of 1 ft and allowing the water to soak in while maintaining that water elevation for 15 minutes by adding more water as needed, and measuring the drop in water elevation for the next 15 minutes while no additional water is added. The key to the percolation test is the change in water level elevation during the second 15-minute interval. The change in elevation divided by the time it takes to make the change is called the percolation rate. For example, if the water level dropped 3 inches in 15 minutes, the resulting percolation rate is 5 minutes per inch (mpi). The smaller the value in mpi, the faster the water moves through the soil.

Table 1

Percolation Test Results

Test Pit Number	Depth ft	Percolation Rate min/in
2-07	4.5	1.5
2-07	9	0.5
4-07	5	0.75
5-07	4	0.5
6-07	6	6.0
7-07	5	6.0
8-07	5	0.5
9-07	5	6.5
12-07	6	0.5

Percolation test results ranged from 0.5 mpi to 6.5 mpi. Percolation tests were not performed in test pits 3-07 and 10-07 due to the presence of silt and or clay. A percolation test was not performed in test pit 1-07 due to the presence of water weeping into the pit from the ongoing hydraulic loading test.

5.0 HYDRAULIC LOADING TEST

A third and significant segment of the study was a hydraulic loading test to stress the soils for a long duration to quantify the upper limit of the local soil to infiltrate water. As this report details, these 3 aspects of our field work: test pits, percolation tests, and a hydraulic loading test, have significantly increased our knowledge of the site capacity, and provides the Town with timely information needed to further their comprehensive wastewater management planning.

Given the land available at the Tri-Town site, and the lack of large, vacant, publicly owned property elsewhere that could be used for future wastewater activities, a large-scale hydraulic loading test at the Tri-Town site was warranted.

5.1 Design Philosophy

The test pits and percolation tests conducted as part of this study have provided some indication of the soil types and soil permeability in several unexplored areas of the site. Relying exclusively on percolation testing allows conservative design loading rates. This is because these evaluations measure the permeability of only a small area of soil to accept a small volume of water. Based on DEP guidance for the type of effluent disposal being considered at the Tri-Town site, soils with good permeability (percolation rates less than 10 mpi) generally correlate to design loading rates of 4 to 5 gallons per day per square foot (gpd/sf) using only the results of percolation testing. However, when considering disposal of large quantities of effluent, a large-scale hydraulic loading test is appropriate to reduce the very high safety factor inherent in design based only on a percolation test.

To better gauge the amount of land that may be required for effluent disposal and determine if the Tri-Town site could accommodate a centralized disposal system, Wright-Pierce designed a long-term hydraulic loading test to get specific information about the soil capacity. The loading tests must demonstrate an application rates higher than the design rates to account for a factor of safety when converting the test results to full-scale design. The following criteria are critical when considering how the loading test conditions will differ from the day-to-day operating conditions:

- **The size of the test basin.** The larger the test area, the more representative the results and the smaller safety factor that can be applied to determine full-scale application rates.
- **Duration of the test.** The longer the test period, the more likely the test results will approximate actual effluent disposal and the smaller the safety factor that is necessary.
- **Application liquid.** It is most convenient to use potable water for the test, but actual wastewater effluent is more representative of ultimate loading conditions.

Considering the factors above, Wright-Pierce proposed the following test conditions to most closely simulate full-scale conditions with the best available resources.

- **Selecting a test basin.** Effluent from the septage treatment facility is currently discharged to a series of basins each approximately 2,000 sf in area. It is usually not practical to construct basins this large for the hydraulic loading test. The Tri-Town staff was able to dedicate one of its basins to the loading test.
- **Running the test.** With the assistance of Tri-Town staff, the test ran for 25 days, without interrupting the operation of the facility.
- **Applying liquid.** With the assistance of Tri-Town staff, all effluent was directed to the basin being used as the test basin to provide test conditions most representative of design conditions. The daily effluent discharge was supplemented with potable water.

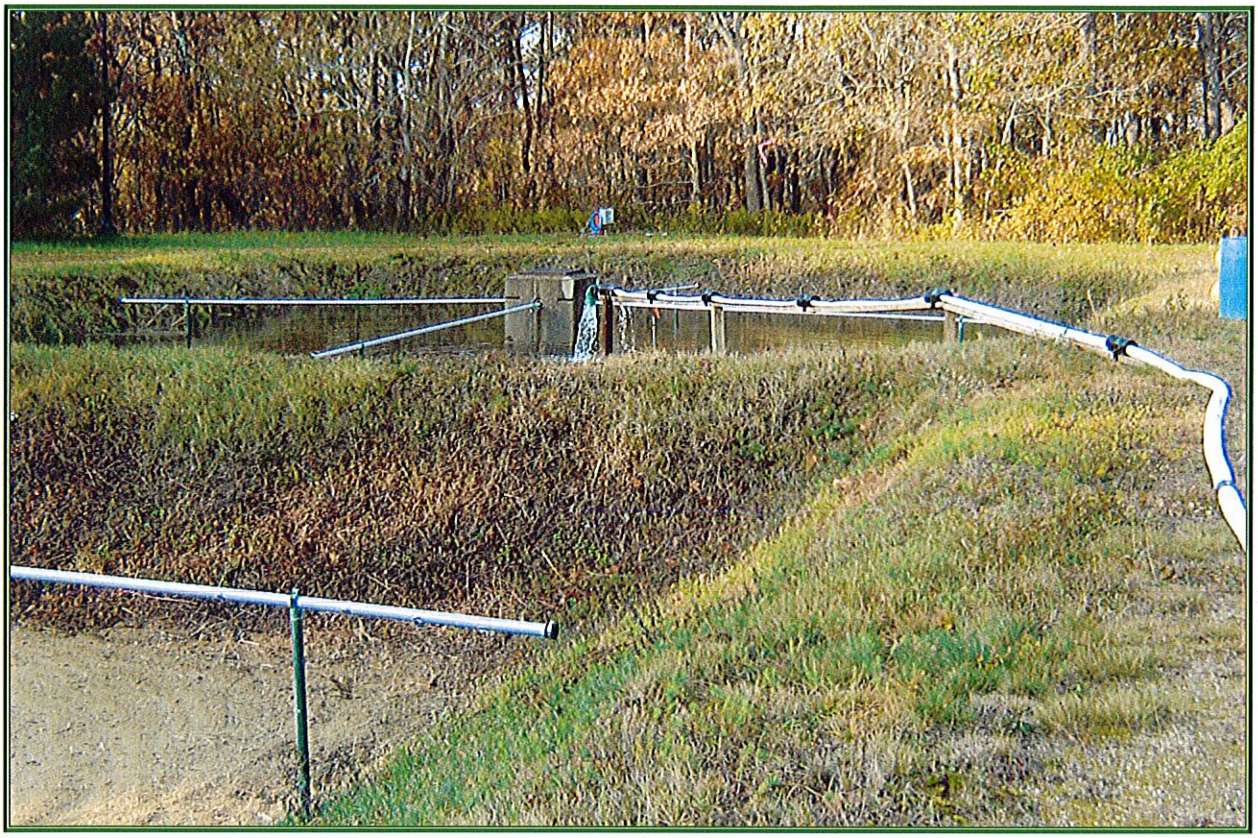
One of the eight existing RIBs (RIB No. 2) was used as the test basin for the hydraulic loading test (see Figure 2). According to Tri-Town staff, RIB No. 2 is one of the worst performing among the eight basins, meaning that effluent percolates through the most slowly. Over the course of the 25-day loading test, 600,000 gallons of treatment facility effluent, and 1,200,000 gallons of potable water was applied to RIB No. 2, resulting in an average loading rate of approximately 30 gpd/sf. The details of the construction, operation, and monitoring of the loading test follows.

5.2 Construction of Loading Test Facilities

Each of the 8 RIBs at Tri-Town is approximately 45-ft by 45-ft (a bottom area of 2,025 sq. ft) and is 5 ft deep. Each of the RIBs contains an effluent dosing system. This system includes a 5-ft concrete post located in the center of the basin, and four perforated pipes that span the distance from the center of the basin to the edge of the basin. When effluent is pumped to the basin from the treatment building, water sprays out the holes in the perforated pipe. During the regular operation of the treatment facility, a basin may be dosed with effluent several times per day for 15 or 20 minutes. Each dose applies a volume of effluent equivalent to a few inches of water if it were applied instantaneously to the basin.

Figure 2

View of RIB No. 2 During the Operation of the Loading Test



RIB No. 2 in the background is partially full. Potable water is being discharged in the center of the bed through the flexible hose. RIB No. 4 (in the foreground) is dry. Only a small earthen berm separates the two beds.

Preparation of RIB No. 2 consisted of clearing vegetation and scarifying the bottom of the bed to expose the sand, and constructing a system to convey potable water the basin. Potable water is available at a hydrant a few hundred feet from RIB No. 2. Flexible hosing ran from the hydrant to the basin. A wooden structure was constructed to support hose from the edge to the center of the basin. This was done to ensure even distribution, to prevent erosion of the side slope, and to keep the hose from coming in contact with the effluent. Figure 3 depicts the test set-up.

5.3 Operation of Loading Test Basin

Tri-Town staff continued with the normal operation of the septage treatment facility during the hydraulic loading test. The hydraulic loading test did not require the staff to suspend or compromise the treatment process. However, the staff did modify the rotation schedule for effluent disposal among the basins. During the hydraulic loading test, all of the effluent was applied to RIB No. 2. During November and December, the facility discharged 15,000 to 20,000 gpd of effluent. During this time frame total suspended solids in the effluent was 5 mg/l or less. The effluent was supplemented with 20,000 to 40,000 gpd of potable water.

Figure 3

Potable Water Being Applied to RIB No. 2

Over the course of the test, 30,000 and 60,000 gpd of applied liquid (potable water and effluent) were required to keep the water level in the basin relatively constant. One goal of the test was to maintain a steady state, that is, the rate at which water was going into the bed was equal to the rate at which water was seeping into the ground.

The discharge of effluent and potable water was measured with flow meters. The effluent flow alternated between zero and a constant rate for a short duration. The discharge rate of potable water could be regulated and therefore varied to maintain a constant level in the basin. A flow meter and regulating valve were attached at the hydrant, and as the water level in the basin rose and fell, the flow rate could be changed.

5.4 Test Monitoring and Coordination

In addition to monitoring the total volume of liquid applied to the bed, and having ready visual observation of water levels in the basin, it was also critical to monitor the groundwater levels below and near the bed. Wright-Pierce provided coordination and monitoring equipment to facilitate groundwater data collection during the test.

Water level data were collected continuously in the 11 wells listed in Table 2 and shown on Figure 1 via InSitu Level Log® pressure transducers. The groundwater monitoring well numbering, elevation range of the well screen interval and distance to RIB No. 2 are summarized in Table 2. Manual water level data were also collected daily in these observation wells. The monitoring wells were chosen based on their proximity to RIB No. 2 and their screened intervals. Wright-Pierce staff identified the location and verified the hydraulic response of the wells. Well BMW-22 was utilized to record ambient water level fluctuations. The manual and electronic water level data are summarized in Attachment 2. Graphical summaries of the manual and electronic water level data are presented in Figures 4 and 5, respectively. The manual readings confirm the accuracy of the electronic measurements.

The shallow screened wells TOMW-3 and -4 were chosen to determine if any mounding would occurred above the discontinuous clay layer located on the western and northwestern portions of the site in the vicinity of Namskaket Marsh.

Precipitation data were collected and recorded daily from the existing Tri-Town rain gauge by Tri-Town staff. Precipitation data were also collected by Wright-Pierce through internet sources from the nearest weather station. The precipitation data are shown on Figures 4 and 5. During the course of the loading test, precipitation accounted for less than 1% of the total volume applied to the basin.

Table 2
Monitoring Well Summary

OSW Monitoring Well I.D.	Associated USGS Well Cluster Site	Screened Interval ft msl[1]	Approximate Distance from RIB No. 2 ft
115	99	-12 to -13	100
108	94	6 to -1	25
137	86	10 to -0.5	200
143	148	1.5 to -3.5	275
178	93	3.5 to -1.5	35
GMW-1	126	17 to -2.5	50
GMW-3	128	20 to 0.0	50
GMW-4	129	20 to 0.0	330
TOMW-2	132	11 to -9	500
TOMW-3	133	10 to -10	650
BMW-22	NA	1.5 to -1.5	6,700

1. Source: USGS Open File Report 95-439

5.5 Hydraulic Loading Test

The design, startup and shutdown of the loading test was a collaborative effort among Wright-Pierce, the Town and Tri-Town staff. Wright-Pierce coordinated water level monitoring through the use of automated data collection instruments. Manual back-up measurements were collected by Tri-Town staff.

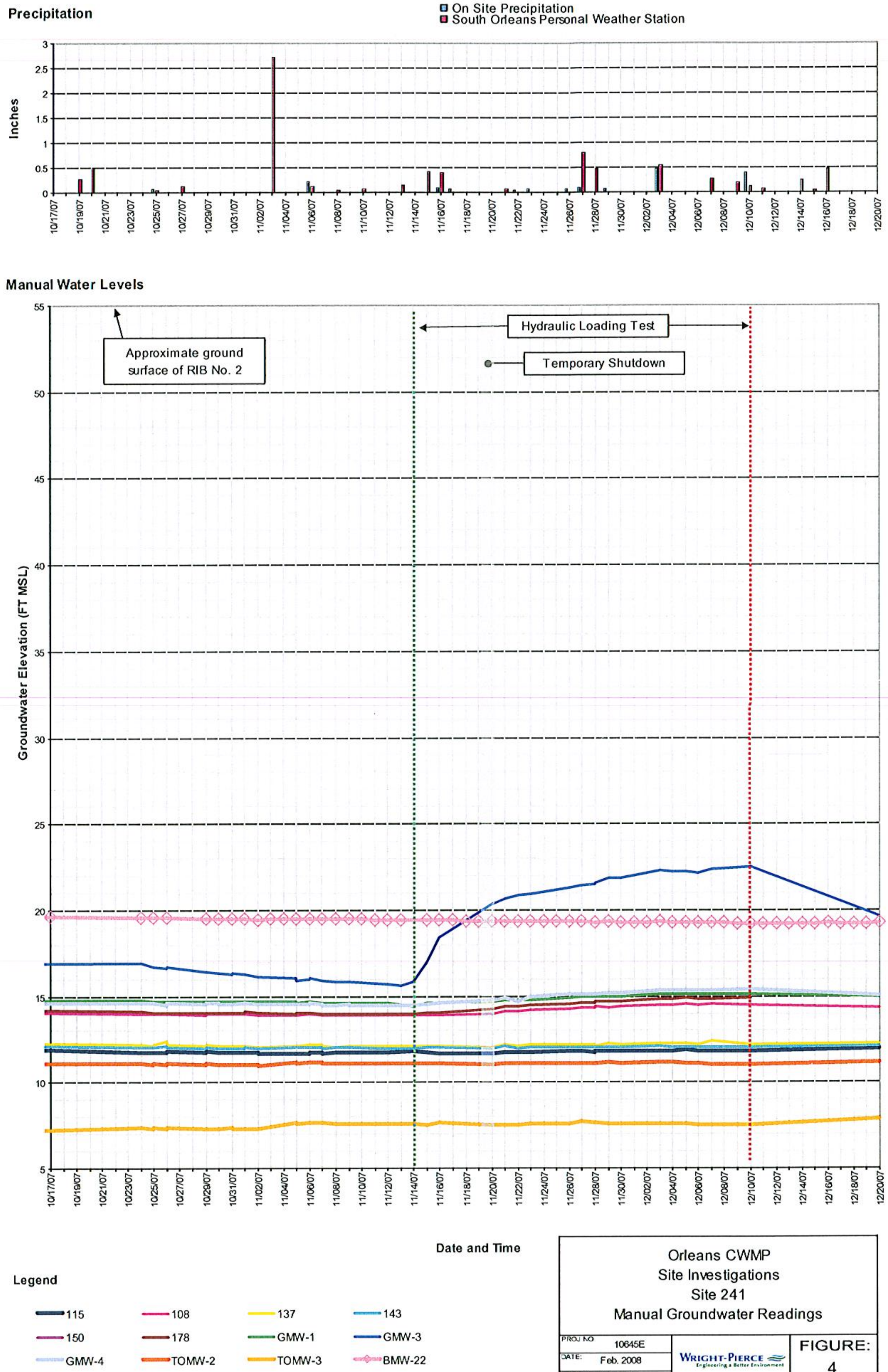
The loading test was comprised of the following monitoring periods: antecedent (26 days); pretest/saturation (2 days); loading (25 days); and recovery period (7 days).

5.5.1 Antecedent Period

Manual water level measurements were obtained by Tri-Town staff twice daily in the monitoring wells listed in Table 1 prior to the start of the loading test from October 17 through November 12, 2007. Water level measurements were also obtained via pressure transducers every fifteen minutes from October 24 through November 12, 2007.

5.5.2 Pre-Test

A pre-test was conducted on November 12, 2007, to determine the appropriate loading rate for the constant rate test. The pretest was conducted at increasing stepped loading rates to



Orleans CWMP
Site Investigations
Site 241
Manual Groundwater Readings

PROJ NO	10645E	FIGURE:
DATE:	Feb. 2008	4
SCALE:	As Shown	

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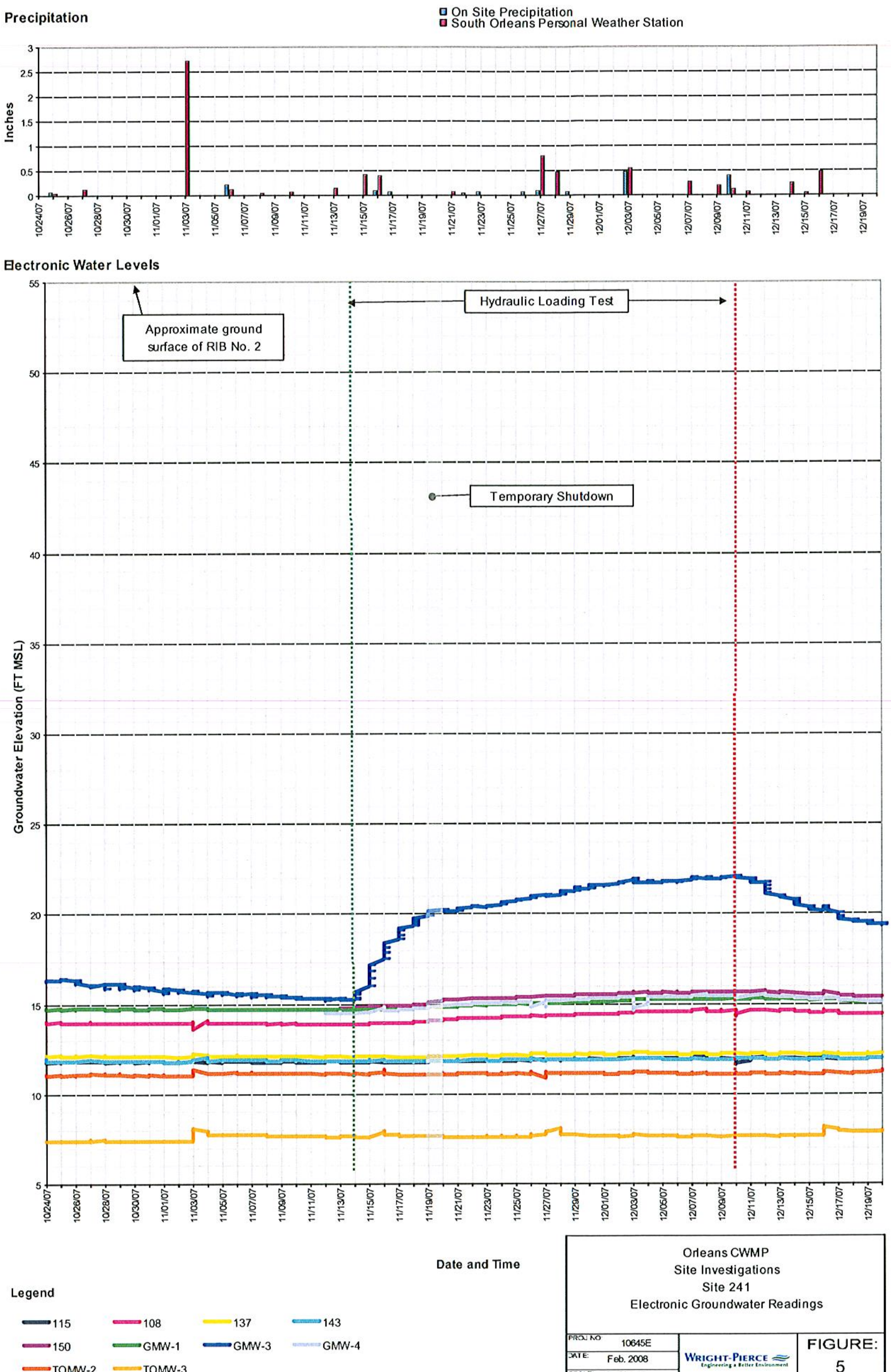


Orleans CWMP
Site Investigations
Site 241
Electronic Groundwater Readings

PROJ NO: 10645E	WRIGHT-PIERCE Engineering a Better Environment	FIGURE:
DATE: Feb. 2008		5
SCALE: As Shown		

ensure that flooding did not occur. Discharge rates were adjusted to maintain a constant loading rate and a constant water level over 1- to 2-hour increments. The water levels recorded on November 12, 2007, prior to the start of the pre-test, were used to generate a static water level contour plan. The static water levels and resulting contours are shown in Figure 6. RIB No. 2 was saturated for a period of 24 hours before the loading test began.

5.5.3 Loading Test

The loading test was conducted from November 14, 2007 to December 10, 2007. Water level measurements were obtained via pressure transducers every fifteen minutes in the select monitoring wells listed in Table 2. Tri-Town staff also collected manual water level readings twice a day.

The loading rate varied over the course of the test to maintain an average water elevation in the basin. The water level in RIB No. 2 reached a relatively constant head of 2 ft. Lower volumes of treated effluent are typically generated during the weekends which corresponded to a lower water level in the basin of approximately 1.2 ft.

The loading test was initiated at a rate of 45 gpm of potable water. In addition to the discharge of potable water, an average of 17 gpm of effluent was applied to Basin RIB No. 2. The test was suspended on November 19, 2007 to allow for repair of a nearby gate valve. Over that 5-day period (Nov 14 through Nov 19), a combined average of 60 gpm was discharged to the basin.

The test was restarted on November 20, 2007 at rate of 27 gpm of potable water. After two days, the potable water rate was lowered to 25 gpm. In combination with the application of effluent at an average of 15 gpm, a total of 40 gpm was maintained until the end of the test on December 10, 2007.

At the end of the test on December 10, 2007, the total volume of treated effluent discharged was 595,000 gallons and the total volume of potable water discharged was 1,2010,000 gallons for a combined total volume of treated effluent and potable water of 1,805,000 gallons. Effluent represented about one-third of the total applied volume on average. This test resulted in an average loading rate of approximately 29 gpd/sq. ft.

Legend

- Hydrant
- Monitoring Well
- Parcels
- Groundwater Contours (FT MSL) **(November 12, 2007)**

0 50 100 Feet

N

SOURCE:
Well Cluster Sites and Test Pits created by Wright-Pierce
All other data obtained from Town of Orleans and MassGIS

Orleans CWMP
Site Investigations
Site 241
Groundwater Levels Pre-Test

PROJ NO	10645E	WRIGHT-PIERCE Engineering a Better Environment	FIGURE: 6
DATE:	Feb. 2008		
SCALE:	AS SHOWN		

5.5.4 Recovery Period

From December 10 to December 20, 2007, water level measurements were obtained via pressure transducers every fifteen minutes for ten days in all monitoring wells following shutdown of the loading test.

5.6 Observation of Groundwater Response

The observed change at each of the monitoring wells is summarized in Table 3. Groundwater contours of the mounding are shown on Figure 7 from manual water level readings collected on December 10, 2007.

Of the eleven wells, water levels in four of the wells showed a rise ranging between 0.5 ft and 0.9 ft as of December 10, 2007. Water levels in the wells responded in the following categories:

Number of Wells	Change in Elevation
6	< 0.5 ft
4	0.5 to 1.0 ft
1	> 5 ft

The greatest change in groundwater level was observed in well GMW-3. This well is used for routine groundwater sampling and, according to Tri-Town staff, usually goes dry when pumped indicating that the well may be screened in tight soils. The subsurface geology may have directed the flow of the infiltrating discharge toward the area of GMW-3 and artificially raising the groundwater table due to these less permeable soils. Moreover, possible improper construction of the well may result in short circuiting the infiltrating discharge down the annulus of the well casing which would also artificially raise the water table in the well.

Ten days after the cessation of the test, the groundwater had recovered by approximately half the height of the change in elevation between pre-and post-test conditions.

Legend

- Hydrant
- Monitoring Well
- Parcels
- Groundwater Contour (FT MSL) (December 10, 2007)

0 50 100 Feet

N

SOURCE:
Well Cluster Sites and Test Pits created by Wright-Pierce.
All other data obtained from Town of Orleans and MassGIS.

Orleans CWMP
Site Investigations
Site 241
Groundwater Levels Post-Test

PROJ NO: 10645E	WRIGHT-PIERCE Engineering a Better Environment	FIGURE: 7
DATE: Feb. 2008		
SCALE: AS SHOWN		

6.0 PRELIMINARY LAYOUT OF DISPOSAL BEDS AND RECOMMENDED APPLICATION RATES

To establish a basis for modeling the groundwater to predict mounding, we made an estimate of the capacity of the site to accept effluent based on surface loading.

First we laid out 23 rapid infiltration beds, each 100 feet by 100 feet. These would be located on the easterly portion of the site to leave room for wastewater treatment facilities near the existing septage treatment plant. This bed layout would leave 100 feet of buffer along Route 6. See Figure 8.

Table 3
Observed Mounding at End of Hydraulic Loading Test

OSW Monitoring Well I.D.	Associated USGS Well Cluster Site	Screened Interval ft msl[1]	Observed Mound at End of Test-Manual ft	Observed Mound at End of Test-Electronic ft	Approximate Distance from RIB No. 2 ft
115	99	-12 to -13	0.12	0.10	100
108	94	6 to -1	0.61	0.53	25
137	86	10 to -0.5	0.08	0.15	200
143	148	1.5 to -3.5	0.03	0.05	275
150	150	3.5 to -1.5	0.57	0.93	7
178	93	3.5 to -1.5	0.90	NA	35
GMW-1	126	17 to -2.5	0.49	0.60	50
GMW-3	128	20 to 0.0	6.82	6.80	50
GMW-4	129	20 to 0.0	0.91	0.92	330
TOMW-2	132	11 to -9	-0.05	0.00	500
TOMW-3	133	10 to -10	-0.04	0.04	650
BMW-22	NA	1.5 to -1.5	NA	-0.20	6,700

1. Source: USGS Open File Report 95-439. 2. NA - Not applicable.

In estimating the disposal capacity of each bed, we considered the soil characteristics determined from this and prior explorations, the percolation testing conducted in 2007 and the large-scale hydraulic test. The basins fall in three categories:

- **9 beds (Numbered 4 through 12) including the area of the existing RIBs and the most favorable percolation testing.** For these beds, we have estimated a long-term capacity of 14 gpd/sf, about one-half the rate demonstrated in the loading test. This is a


N
12-07
22
23
19
11-07
20
21
16
17
18
TOMW-2
13
6-07
14
15
137
10
11
12
GMW-1
5-07
Hydrant
GMW-3
150
7
8
9
RIB No. 1
RIB No. 3
RIB No. 5
RIB No. 7
178
143
115
4-07
RIB No. 2
RIB No. 4
RIB No. 6
RIB No. 8
3-07
1-07
2-07
5
6
13-07
GMW-4
4
8-07
108
1
7-07
2
3
10-07
9-07
Legend
Hydrant
Monitoring Wells
Parcels
Conceptual Basins
Test Pits 2007
Percolation Rate
<2 min/inch
>5 min/inch
None
Test Pits by Others
Percolation Rate
<2 min/in
2-5 min/in
>5 min/in
Estimated based on Soil Logs
0 50 100
Feet
Orleans CWMP
Site Investigations
Site 241
Conceptual Diposal Layout
PROJ NO 10645E
DATE: Feb. 2008
SCALE: AS SHOWN
WRIGHT-PIERCE
FIGURE: 8

relatively high percentage of a loading test result, but justified by the scale and duration of the test. The selection of 14 gpd/sf considers the fact that the test results may have been biased downward by the 20-year history of effluent application in existing RIB 2.

- **3 beds (Number 1 through 3) located at the south end of the site.** The percolation testing here is the least favorable on site. We selected a rate of 4 gpd/sf based substantially on the rate allowed by DEP based only on percolation tests.
- **11 beds (Numbers 13 through 23) located in the central and northern portions of the site.** Here we selected a rate of 10 gpd/sf based on some favorable percolation testing, and prior soils characterizations. While we believe that large-scale hydraulic loading tests here might allow a higher rate, we suggest the 10 gpd/sf figure for planning purposes.

Table 4 lists the recommended loading rates for each basin. If all beds were in use, these estimates indicate a total capacity of 2.48 mgd. It would be prudent to base further planning on the fact that 5 beds would be kept idle to allow periodic cleaning and repair of other beds. If the idle beds were those with the highest predicted capacity, then the total design loading rate would be 1.78 mgd.

Table 4 also shows our estimate of the site capacity if the favorable loading test results were ignored. Using DEP-allowed rates based only on the percolation testing, the site would accommodate 1.10 mgd with all beds in service and 0.85 mgd with 5 beds idle.

On the basis of this analysis, we recommend that the Town proceed with site planning based on a short-term peak capacity of 1.78 mgd. Further site testing, including borings on the knoll, should be conducted to confirm and refine these estimates.

7.0 PRELIMINARY GROUNDWATER MODELING

Prior to the hydraulic loading test and the test pit excavations, a desktop analytical evaluation of groundwater mounding was conducted to see if mounding was likely to be a factor at this site. That analytical approach, using the Hantusch method and a peak flow of 1.6 mgd, resulted in an estimated mound height of approximately 10 feet. Given the fact that the ground surface elevation is higher than 40 feet above sea level across most of the upland portions of the site, and existing water table is typically at elevation 10 to 15, this would leave at least 40 feet of unsaturated soil above the mounded groundwater. Therefore, we proceeded with the test pits and loading test, knowing that mounding is not likely to limit the use of this site.

Table 4

Recommended Loading Rates

Basin Number	Basin Area	Loading Rates Based on Percolation Test Results		Loading Rates Based on All Test Results	
		Rate	Total Application	Rate	Total Application
	sf	gpd/sf	gpd	gpd/sf	gpd
1	10,000	4	40,000	4	40,000
2	10,000	4	40,000	4	40,000
3	10,000	4	40,000	4	40,000
4	10,000	5	50,000	14	140,000
5	10,000	5	50,000	14	140,000
6	10,000	5	50,000	14	140,000
7	10,000	5	50,000	14	140,000
8	10,000	5	50,000	14	140,000
9	10,000	5	50,000	14	140,000
10	10,000	5	50,000	14	140,000
11	10,000	5	50,000	14	140,000
12	10,000	5	50,000	14	140,000
13	10,000	4	40,000	10	100,000
14	10,000	5	50,000	10	100,000
15	10,000	5	50,000	10	100,000
16	10,000	4	40,000	10	100,000
17	10,000	5	50,000	10	100,000
18	10,000	5	50,000	10	100,000
19	10,000	5	50,000	10	100,000
20	10,000	5	50,000	10	100,000
21	10,000	5	50,000	10	100,000
22	10,000	5	50,000	10	100,000
23	10,000	5	50,000	10	100,000
Total, gpd		23 beds	1,100,000	23 beds	2,480,000
		18 beds	850,000	18 beds	1,780,000

After the successful hydraulic loading test, further groundwater modeling was conducted to refine the estimate of mounding at the site. The groundwater model was based on the USGS model of the Monomoy Lens of the Cape Cod Aquifer (Walter and Whealan, 2004). A sub-regional model, comprising the Town of Orleans and portions of Brewster and Eastham, was developed from the USGS regional model using a technique known as telescopic mesh refinement (TMR). The model grid was refined in the process. The original USGS model had uniform grid nodes with dimensions of 400 by 400 feet. The revised model has grid nodes ranging from 200 by 200 feet to 50 by 50 feet. This provides for significantly greater detail within the model. The newly-developed Orleans sub-regional model produces groundwater levels and flow directions that are virtually identical to those produced from the regional USGS model.

Following the refinement of the model, it was used to simulate the loading test conducted in November and December of 2007. The last 22 days of the loading test were simulated (the period after the unintended shutdown of the test). The loading test was simulated under steady state conditions. Modeling the discharge under transient conditions (that is, 22 days of discharge) resulted in nearly identical results. This means that the discharge had approached a steady state condition. The model predicted a groundwater mound that was generally higher than the observed mound – by as much as 1 to 2 feet in some areas. This was considered to be a significant deviation.

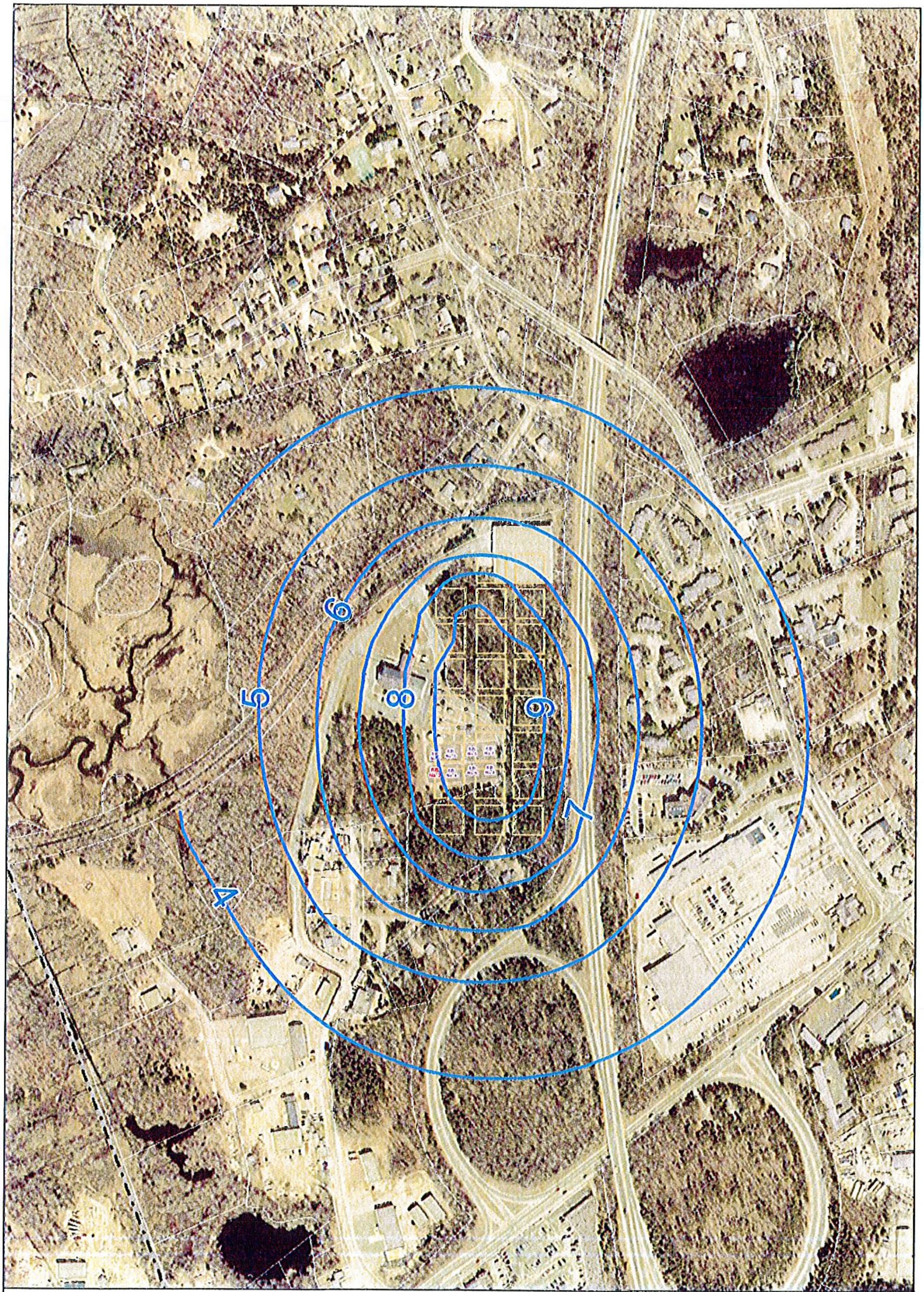
The hydraulic conductivity (K) field within the model was examined to determine the potential cause of the high mound. It was found that the K field in the model did not accurately reflect observed subsurface conditions, as represented by subsurface cross sections developed by the USGS in Desimone and Barlow (1996). The model K values represented a thin layer of relatively coarse material (medium to coarse sand) overlying a relatively fine grained material (fine sand). However, the USGS geologic cross sections through this area indicate that there is a relatively thin layer of fine-grained material overlying a coarser grained material – precisely the opposite of what was simulated in the model. The model K field was adjusted in the vicinity of the proposed discharge area to more closely reflect the actual subsurface data. The simulated groundwater mound resulting from this change was much closer to the mound observed during the loading test.

Once the model produced results that closely resembled the results of the loading test, the model was run to simulate the potential groundwater mound that would occur with the discharge of 1.6 mgd. The discharge was spread over an area of approximately 320,000 square feet in an area that has been determined to be suitable on the basis of test pits and percolation tests. (This is the gross area associated with 23 beds shown in Figure 8, whose net bottom area is 230,000 square feet.) The simulated groundwater mound is shown in Figure 9. Around the edges of the application area, the mound is expected to be about 8 feet high, rising to near 10 feet at the center of this area. Under these conditions there will be at least 20 feet from the top of the mound to the bottom of the discharge beds, far in excess of the four-foot minimum requirement.

The model indicates that there will be significantly more groundwater flow to the downgradient wetlands. However, there will be no groundwater discharges in areas that do not already receive groundwater discharges (i.e., wetlands), although in areas where groundwater currently discharges on steep slopes adjacent to wetlands, these may occur at slightly higher elevations.

It is important to note that these model simulations are quite conservative for two reasons. First, we assumed a conservative maximum monthly flow of 1.6 mgd, based on the Needs Assessment report, and not the 1.5 mgd maximum monthly flow that would be associated with the short-term peak flow of 1.78 mgd. Second, the modeling assumes that the maximum monthly flow would continue for three months. The maximum **monthly** flow associated with a 1.78 mgd short-term peak would be about 1.5 mgd, and the **90-day** maximum flow would be even less than that.

In later project phases, the model will undergo further revisions and calibration. Subsequent simulations will be based on the specific flow rates (annual average, monthly maximum and short-term maximum) associated with the wastewater management plan focused on the Tri-Town site (Plan 2). However, it is expected that the general conclusions of this preliminary modeling will hold – the groundwater mound resulting from a maximum-month discharge of up to 1.6 mgd is not expected to result in any excessive mounding.



Legend

- Simulated Groundwater Mound Contours (FT)
- Conceptual Basins
- Parcels

SOURCE:
Well Cluster Sites and Test Pits created by Wright-Pierce.
All other data obtained from Town of Orleans and MassGIS.

Orleans CWMP
Site Investigations
Site 241
Simulated Mounding - 1.6 mgd

PROJ NO	10645E	WRIGHT-PIERCE	FIGURE: 9
DATE:	Feb 2008		
SCALE:	AS SHOWN		

8.0 Conclusions and Recommendations

An extensive evaluation of Site 241, the site of the Tri-Town Septage Treatment Facility, was conducted to assess its capability to accept wastewater effluent through rapid infiltration. These investigations included:

- Review of historic test pit and boring logs from the original plant construction and from the USGS studies on site.
- Excavation of 13 new test pits and performance of 8 percolation tests.
- A 25-day large-scale hydraulic loading test using one of the exiting Tri-Town rapid infiltration basins and application of 1.8 million gallons of potable water and septage plant effluent.
- Refinement of the USGS regional groundwater model and simulation of expected mounding from effluent application.

The hydraulic loading test demonstrated that one of the existing rapid infiltration basins could be loaded at a long-term rate of 29 gpd/sf, with only a moderate rise in the underlying groundwater. This is an encouraging result because of the long duration of the loading test, the presence of suspended solids in the septage effluent, and the near surface soil plugging from 20 years of effluent application.

Test pits and percolation tests demonstrated the generally permeable nature of the site soils, tempered by occasional lenses of less permeable materials. By considering the distribution of soils and the location of the loading test, the site capacity was estimated for a proposed configuration of 23 future rapid infiltration basins:

- In the central, most favorable, area that was extensively tested: 9 beds loaded at 14 gpd/sf (about one-half of the rate demonstrated during the loading test);
- In the high northerly area of the site where permeable soils are expected but deep borings are needed for confirmation: 11 beds at 10 gpd/sf (about one-third the rate demonstrated during the loading test); and
- In the southerly portion of the site that had moderate percolation rates: 3 beds at 4 gpd/sf (the rate DEP would allow based only on percolation testing).

In the aggregate, this bed configuration and estimated loading rates would allow a short-term peak flow of 1.78 mgd, assuming 18 beds on-line and 5 beds in reserve.

Numerical modeling results indicate that the anticipated groundwater mound under the proposed discharge area would be well below the bottom of the proposed rapid infiltration basins. The highest predicted height of the mound at a conservative 1.6 mgd maximum-month loading rate is approximately 10 feet. The separation between the bottom of the rapid infiltration basins and the groundwater mound will likely be maintained at or greater than 20 feet.

The model predicts that "break outs" will not occur. Increased flooding or ponding of the existing wetlands may occur at slightly higher elevations. Effects from the loading test on the water table in the area of Namskaket Marsh were not observed.

Although extensive geological data exists for the site, test borings should be advanced to the elevation of the proposed RIBs to classify and test the permeability of the soil, on the northern portion of the site where soil boring data are lacking. This work is expected to confirm the loading rates estimated for that portion of the site.

APPENDIX F

HYDROGEOLOGIC MODELING AT SITE 241

ORLEANS COMPREHENSIVE WASTEWATER MANAGEMENT PLAN

PHASE 6 -- SITE INVESTIGATIONS HYDROGEOLOGIC MODELING AT SITE 241

JANUARY 2009

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SECTION 1

INTRODUCTION

1.1 INTRODUCTION

The Town of Orleans is considering several alternative wastewater management plans, one of which involves a facility that would treat wastewater and discharge effluent at the site of the existing Tri-Town Septage Facility. The location of the site is shown in Figure 1. Preliminary groundwater modeling of the proposed wastewater discharge was conducted in 2005 by the U.S. Geological Survey (USGS) on behalf of the Town of Orleans through the Cape Cod Commission (CCC). The purpose of the groundwater modeling effort described in this report was to conduct more detailed site-specific groundwater modeling and analyses that would be appropriate for determining the site's capacity and to lay the groundwork for possible future DEP permitting activities.

The rate of discharge that can be accepted at a given site is based on several limiting factors. These factors include: 1) the ability of site's surficial soils to accept the quantity of discharge; 2) the regulatory requirement to maintain a four-foot separation between the bottom of the discharge structure and the high groundwater table; 3) the potential for groundwater mounding to result in groundwater discharge to areas that do not currently receive groundwater discharge, or the potential for basement flooding or negative impacts on local septic systems; and 4) the need to limit the migration of nitrogen-enriched waters to sensitive ecosystems – in this case Rock Harbor.

The first of these issues has already been addressed by previous efforts conducted by Wright-Pierce which are described in "Orleans Comprehensive Wastewater Management Plan Phase 6 – Site Investigations, Hydrogeological Investigation at Site 241" (February, 2008). The remainder of the factors listed above are addressed in the current report.

Legend

Tri-Town Property Boundary

SOURCE: USGS Quad
obtained from MassGIS.

0 3,000
Feet

Orleans CWMP
Site Investigations
Site 241
Locus Map

PROJ NO:	10645E	DATE: April 2008	FIGURE: 1

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SECTION 2

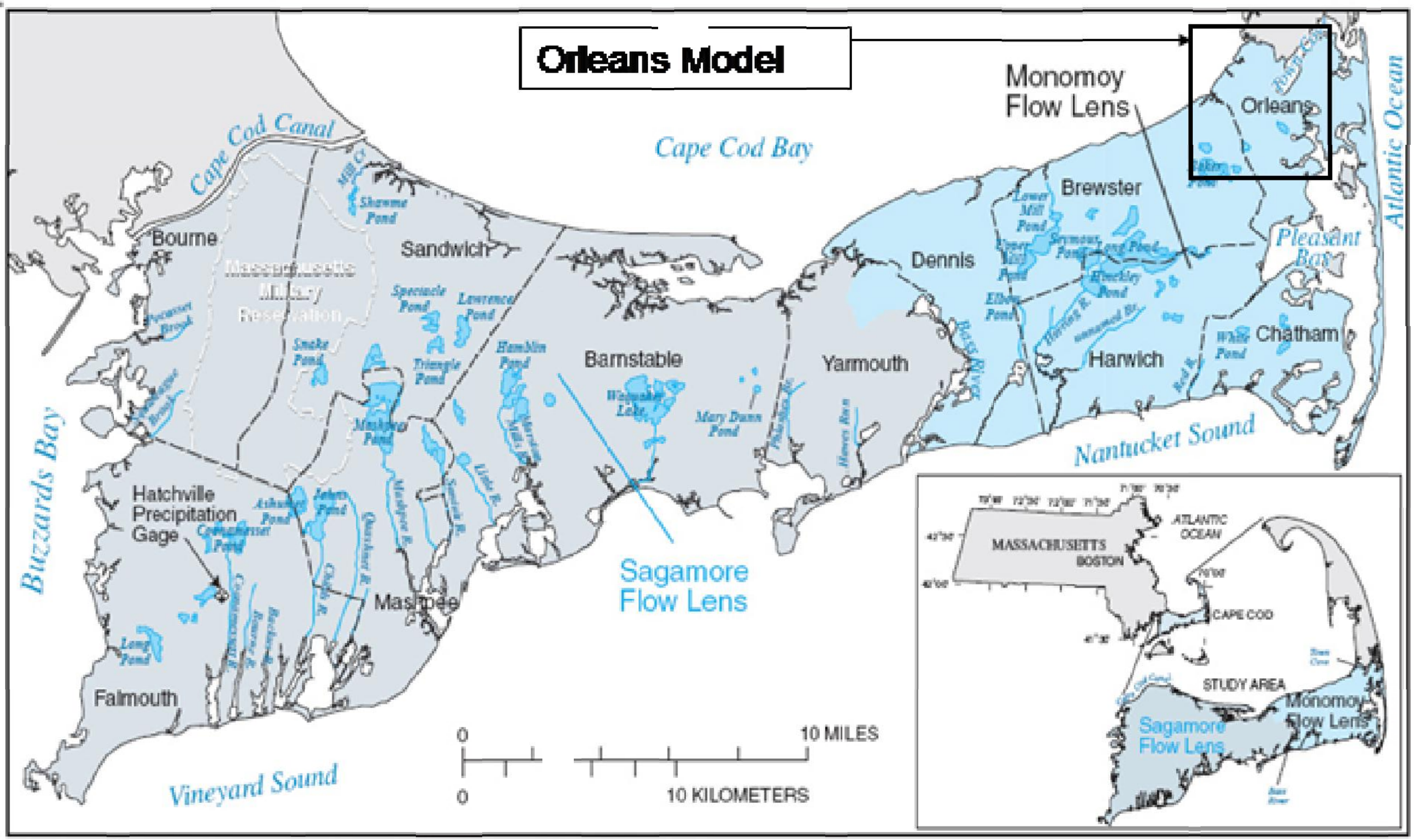
MODELING METHOD

2.1 MODELING METHOD

The groundwater flow modeling program used in this analysis is the U.S. Geological Survey's three-dimensional groundwater flow model MODFLOW (McDonald and Harbaugh, 1988; and Harlen and others, 2000). The modeling analysis is based on the regional groundwater model of Cape Cod developed by the USGS (Walter and Whealan, 2004). The portion of the Cape Cod model used in this analysis is referred to as the Monomoy Flow Lens and covers the eastern portion of Cape Cod from Bass River (the Yarmouth-Dennis border) in the west to Town Cove (the Eastham-Orleans border) in the east. The USGS model has been the basis for technical studies prepared by the Massachusetts Estuaries Project (Massachusetts Estuaries Project, 2007a, 2007b and 2007c), as well as the prior investigation of potential wastewater discharge at the Tri-Town site (Wright-Pierce, 2005). A smaller sub-regional model was developed from this regional model by means of a process known as telescopic mesh refinement (TMR). An area of primary interest was defined (most of the Town of Orleans and a small portion of Brewster and Eastham) and this portion of the regional model was isolated and extracted from the regional model and a finer grid spacing was developed. The sub-regional Orleans Model area in relation to the regional Monomoy Model is shown in Figure 2.

Groundwater Vistas (Environmental Simulations, Inc., 2004) was used as a graphical processor for the TMR process and subsequent model runs. Once the sub-regional model was defined and developed, some site-specific changes were made to the model to reflect more detailed local conditions. These changes to the original model are discussed below.

The approach to the development of the Orleans sub-regional model was to use the input parameters of the regional USGS model as much as possible, and to only make changes that: 1) were necessary to develop a finer model grid and smaller model domain and 2) were supported by more detailed sub-surface data that were not included in the regional model.



Base from U.S. Geological Survey topographic quadrangles, Chatham, Cotuit, Dennis, Falmouth, Harwich, Hyannis, Onset, Orleans, Pocasset, Sagamore, Sandwich, and Woods Hole, Massachusetts, Universal Transverse Mercator grid, Polyconic projection, zone 19 NAD, 1:25,000

EXPLANATION

- SAGAMORE FLOW LENS
- MONOMOY FLOW LENS
- TOWN BOUNDARY
- PRECIPITATION GAGE

Orleans CWMP
Site Investigations
Site 241
Model Extents

PROJ NO: 10645E | DATE: April 2008 | FIGURE: 2

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SECTION 3

CONCEPTUAL MODEL OF AQUIFER

3.1 CONCEPTUAL MODEL OF AQUIFER

The Monomoy Lens of the Cape Cod Aquifer is composed primarily of glacial deposits of the Pleistocene Epoch. Details on the surficial geology of the site vicinity are presented in Oldale and others (1971). The subsurface materials are a combination of coarse stratified outwash deposits (sands and gravels) and finer-grained lake deposits (fine sands, silts and clays). These finer-grained deposits interfinger near the site and this interfingering may be further complicated by later glacial re-advance.

The original USGS regional model simulated the aquifer in this region as a simple water table aquifer with hydraulic conductivity values ranging from 30 to 150 ft/day (a range comparable to fine to coarse sand). However, boring logs in the vicinity of the existing septage facility and surrounding area (DeSimone and Barlow, 1996) (GZA, 1981) (Wright-Pierce, 2005 and 2008) indicate the widespread presence of layers of very fine sand, silt and possibly clay. Although these layers do not appear to be extensive enough to represent significant confining units, they do act locally as semi-confining units. Work by DeSimone and Barlow (1996) and others suggest that the complex stratigraphy may have resulted in preferred flow paths for groundwater and contaminants. Attempts to better define the stratigraphy and its effects on groundwater flow are described in the next section of this report.

The primary source of water to the aquifer is rainfall recharge. This is supplemented to some extent by wastewater discharge, primarily through on-site septic systems. Water leaves the system primarily through groundwater discharge at coastal wetlands and estuaries.

SECTION 4

MODEL DESIGN AND DEVELOPMENT

4.1 MODEL DESIGN AND DEVELOPMENT

The development of the regional USGS model is described in Walter and Whealan (2004). The only changes to this original model were the development of a sub-regional model as described above and site-specific changes to specific parameters as described below.

The extent of the Orleans sub-regional groundwater model (herein referred to as the Orleans Model) is shown in Figure 2 and 3. The model area consists primarily of the Town of Orleans but includes portions of Brewster to the west and Eastham to the north. The model extends to Cape Cod Bay, Eastham and Town Cove in the north, Pleasant Bay in the east, South Orleans in the south and the Town of Brewster in the west. The area of the model is approximately 17 square miles (21,000 by 24,000 feet). The model grid consists of 236 rows, 206 columns and 15 layers. The upper five layers of the regional model were eliminated because these layers were not saturated within the Orleans Model domain. The model nodes are a uniform 100 by 100 feet throughout the model domain.

The boundary conditions for the Orleans Model are shown in Figure 3. The primary difference in boundary conditions between the regional USGS Monomoy model and the Orleans Model is in the western and southern portion of the Orleans model where upgradient groundwater flowing into the model domain is simulated using constant head nodes. The head values for these constant head nodes were obtained directly from the calibrated regional model.

The coastal wetlands and creeks are simulated as drain nodes and the discharge of groundwater into Cape Cod Bay is simulated as a general head boundary. The drains in the Orleans model have been modified to better reflect the geometry and elevation of these wetlands and creeks. In addition, wetland drains have been added to include some of the smaller tributaries to Namskaket, Little Namskaket and Rock Harbor Creeks that were not included in the USGS regional model.

Legend

- Tri-Town Property Boundary
- Constant Head
- Drain
- General Head
- No Flow

SOURCE: Orthophoto obtained from MassGIS.

Orleans CWMP
Site Investigations
Site 241
Model Grid and
Boundary Conditions

PROJ NO:	DATE:	FIGURE:
10645E	April 2008	3

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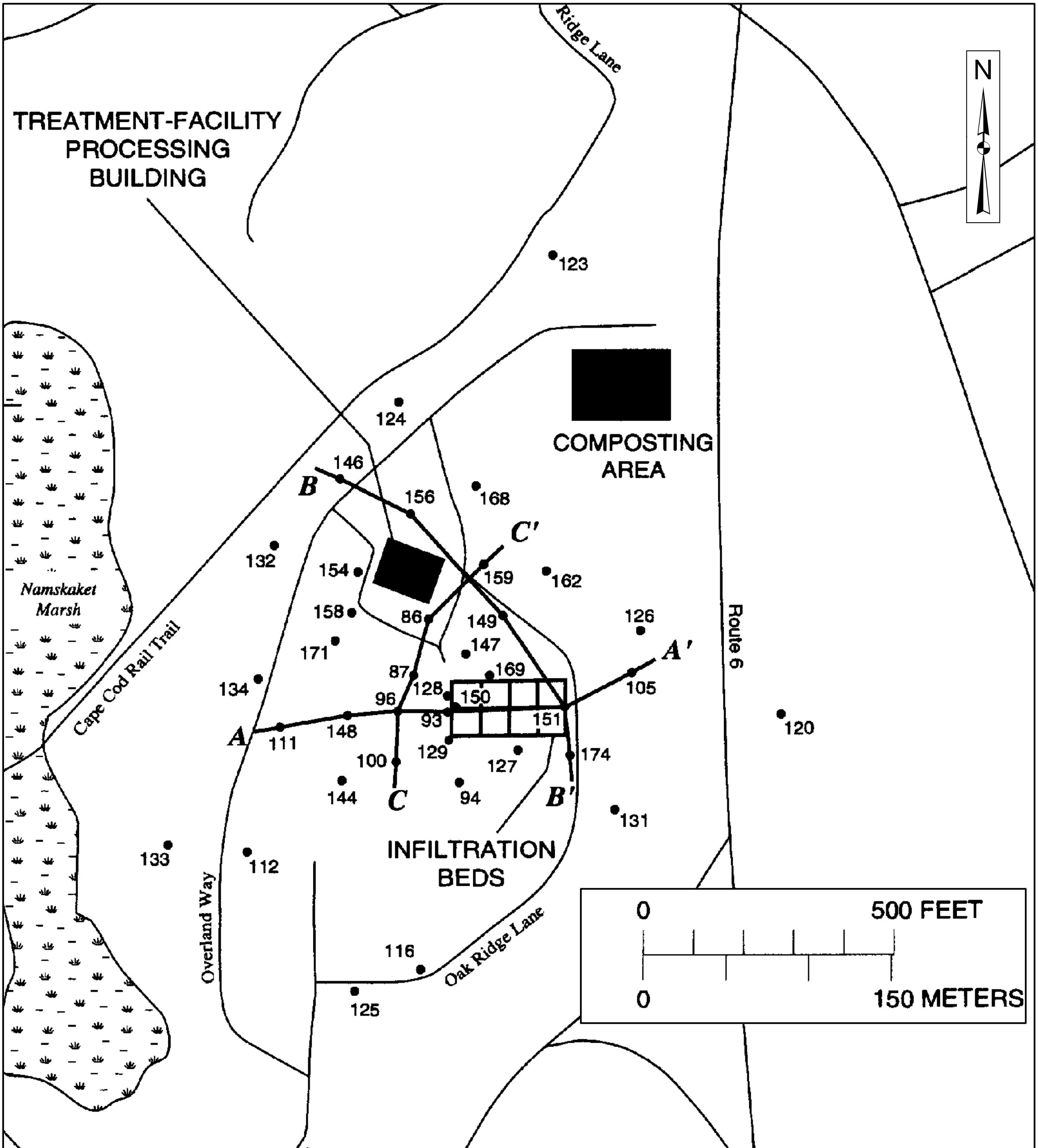
Changes were made to the hydraulic conductivity (K) values in the model in order to take into account site-specific data that were not included in the regional model and to provide a better model calibration. In most cases, the revisions have resulted in lower K values than the regional model.

The majority of the changes in K value are in the area between the Tri-Town site and Cape Cod Bay. The changes were made on the basis of more detailed data from boring logs, mostly from USGS files, and from a detailed hydrogeological analysis provided in a USGS report on the Tri-Town site conducted in the early 1990's (DeSimone and others, 1996). Numerous borings were installed by USGS in the vicinity of the Tri-Town site and the hydrogeological conditions are described. The subsurface conditions are illustrated in a series of cross sections. The lines of cross sections are shown in Figure 4. The cross sections themselves are reproduced in Figures 5 through 7. It should be borne in mind that the stratigraphy of the individual borings is rather complex and that these cross sections are somewhat generalized. The authors of the USGS work identified four stratigraphic units that we have attempted to maintain in our conceptual model, at least within the vicinity of the Tri-Town site. The four units are: 1) an upper fine-grained unit (very fine or silty sand), 2) an intermediate coarse-grained unit (medium to very coarse sand with gravel), 3) a lower fine-grained unit (very fine to medium sand with silt or clay) and 4) a lower coarse-grained unit (medium to coarse sand). It was not always possible to identify all four units in each of the deep borings.

In the Orleans Model, the fine-grained units were assigned horizontal K values ranging from 10 to 30 ft/day. A horizontal-to-vertical K ratio of 10 to 1 was also assumed. The coarse-grained units were assigned K values ranging from 100 to 150 ft/day with horizontal to vertical K ratios ranging from 10-to-1 to 3-to-1. These are in accordance with values reported in DeSimone and others (1996) and with values used in the regional model. Table 1 provides a summary of the changes in K values between the regional model and the Orleans sub-regional model. The only significant changes were made in the upper six layers of the model (the portion of the aquifer from the water table to an elevation of -40 feet NGVD. There were three primary bases for changing K values: data from DeSimone and others (1996), boring log data (primarily from



Legend

A ——— A' LINE OF HYDROGEOLOGIC SECTION--

•118 WELL CLUSTER SITE--Site of one or more observation wells completed at different depths.

SOURCE: USGS Open-File Report 95-290

Orleans CWMP
Site Investigations
Site 241
Base Map with Lines of
Geologic Cross Section

PROJ NO:	DATE:	FIGURE:
10645E	April 2008	4

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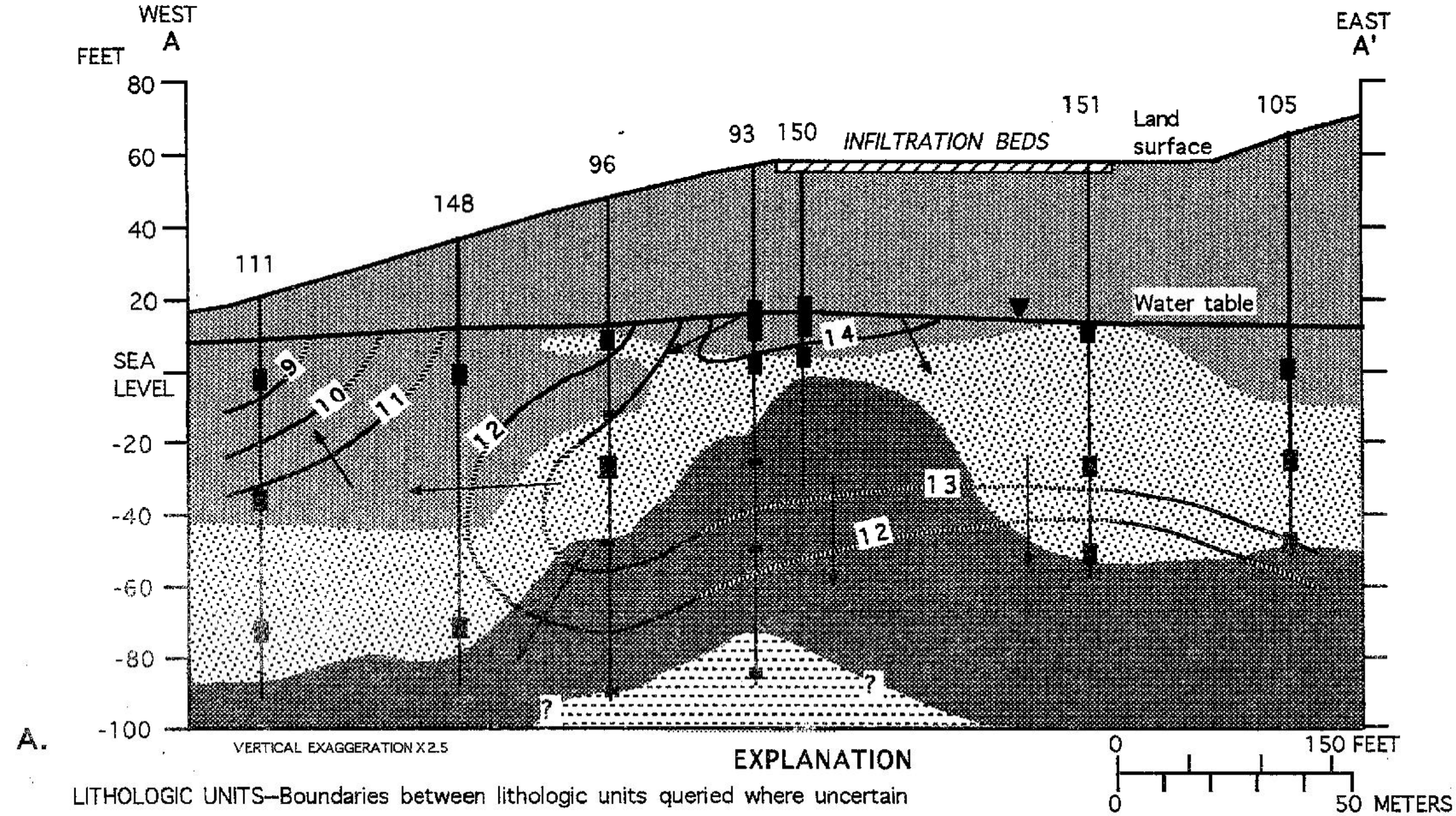

EXPLANATION

LITHOLOGIC UNITS--Boundaries between lithologic units queried where uncertain

- UPPER FINE-GRAINED UNIT--Fine to very fine or fine to medium sand, with silt
- INTERMEDIATE COARSE-GRAINED UNIT--Medium to very coarse sand, with gravel
- LOWER FINE-GRAINED UNIT--Fine to very fine or medium to fine sand, with silt
- LOWER COARSE-GRAINED UNIT--Medium to coarse sand

—12······· POTENTIOMETRIC CONTOUR--Shows altitude at which water level would have stood in tightly cased wells. Dashed where approximately located. Contour interval, 1 foot. Datum is sea level

→ GENERAL DIRECTION OF GROUND-WATER FLOW

WELL CLUSTER SITE IDENTIFIER AND SCREENED INTERVAL OF OBSERVATION WELL-- Site of one or more observation wells completed at different depths. Length of screened interval is variable

interval of well

SOURCE: USGS Open-File Report 95-290

Orleans CWMP
Site Investigations
Site 241
Geologic Cross Section
A-A'

PROJ NO: 10645E DATE: April 2008 FIGURE: 5

WRIGHT-PIERCE
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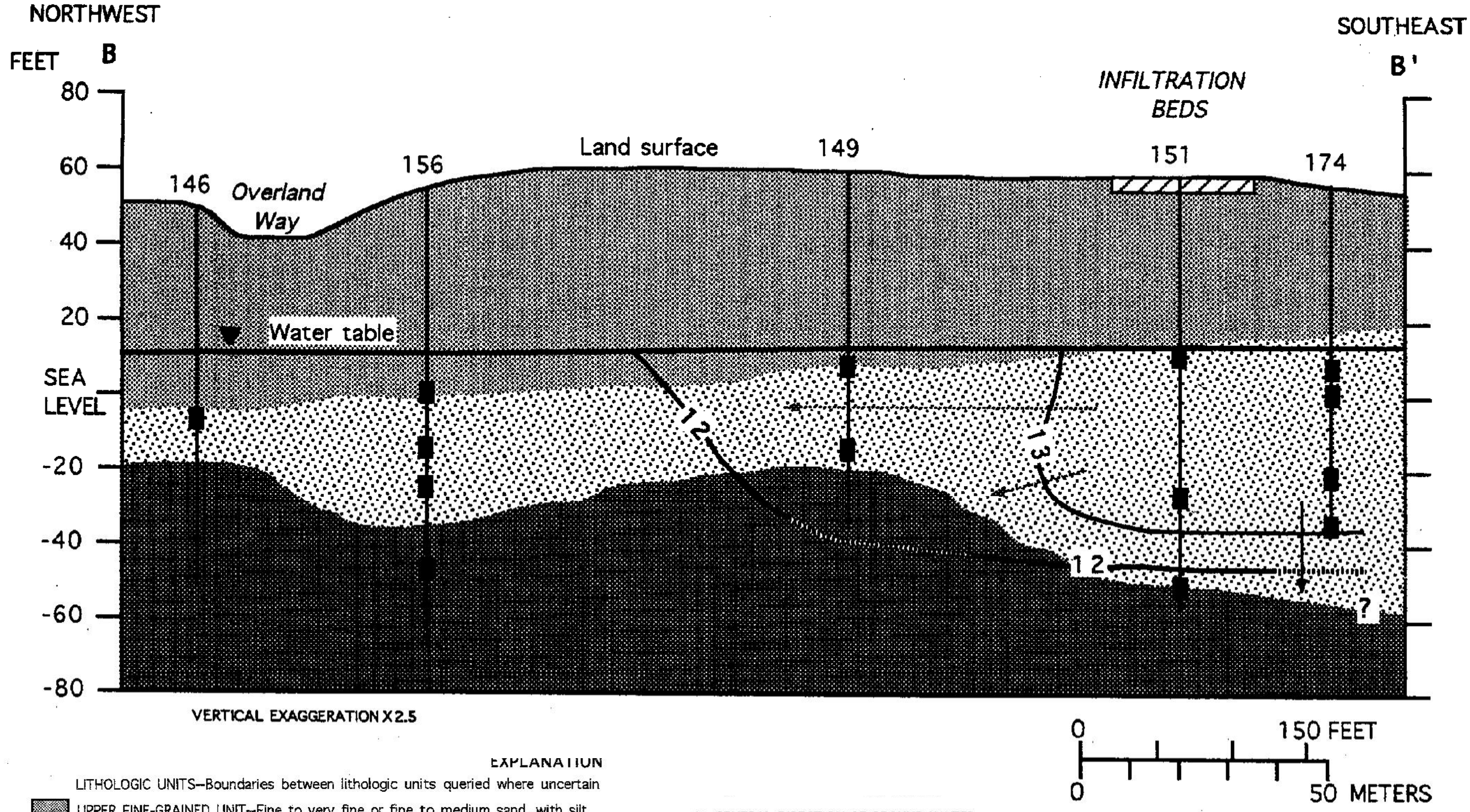

EXPLANATION

LITHOLOGIC UNITS--Boundaries between lithologic units queried where uncertain

- UPPER FINE-GRAINED UNIT--Fine to very fine or fine to medium sand, with silt
- INTERMEDIATE COARSE-GRAINED UNIT--Medium to very coarse sand, with gravel
- LOWER FINE-GRAINED UNIT--Fine to very fine or medium to fine sand, with silt
- LOWER COARSE-GRAINED UNIT--Medium to coarse sand

—12······ POTENTIOMETRIC CONTOUR--Shows altitude at which water level would have stood in tightly cased wells. Dashed where approximately located. Contour interval, 1 foot. Datum is sea level

→ GENERAL DIRECTION OF GROUND-WATER FLOW

WELL CLUSTER SITE IDENTIFIER AND SCREENED INTERVAL OF OBSERVATION WELL-- Site of one or more observation wells completed at different depths. Length of screened interval is variable

screened interval of well

SOURCE: USGS Open-File Report 95-290

Orleans CWMP
Site Investigations
Site 241
Geologic Cross Section
B-B'

PROJ NO 10645E DATE April 2008 FIGURE: 6

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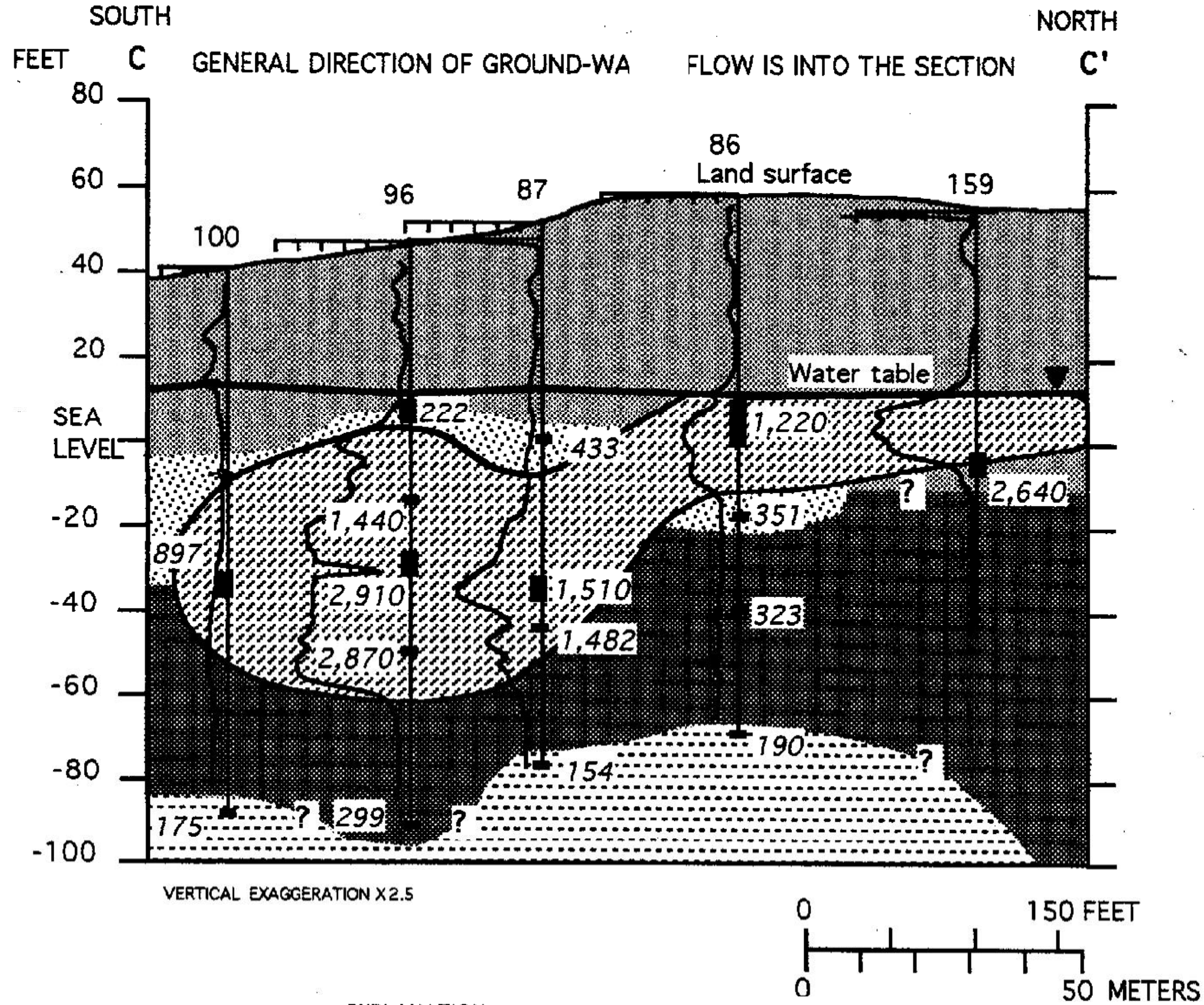

EXPLANATION

LITHOLOGIC UNITS--Boundaries between lithologic units queried where uncertain

UPPER FINE-GRAINED UNIT--Fine to very fine or fine to medium sand, with silt

INTERMEDIATE COARSE-GRAINED UNIT--Medium to very coarse sand, with gravel

LOWER FINE-GRAINED UNIT--Fine to very fine or medium to fine sand, with silt

LOWER COARSE-GRAINED UNIT--Medium to coarse sand

—12········ POTENTIOMETRIC CONTOUR--Shows altitude at which water level would have stood in tightly cased wells. Dashed where approximately located. Contour interval, 1 foot. Datum is sea level

——→ GENERAL DIRECTION OF GROUND-WATER FLOW

WELL CLUSTER SITE IDENTIFIER AND SCREENED INTERVAL OF OBSERVATION WELL-- Site of one or more observation wells completed at different depths. Length of screened interval is variable

screened interval of well

SOURCE: USGS Open-File Report 95-290

Orleans CWMP
Site Investigations
Site 241
Geologic Cross Section
C-C'

PROJ NO: 10645E | DATE: April 2008 | FIGURE: 7

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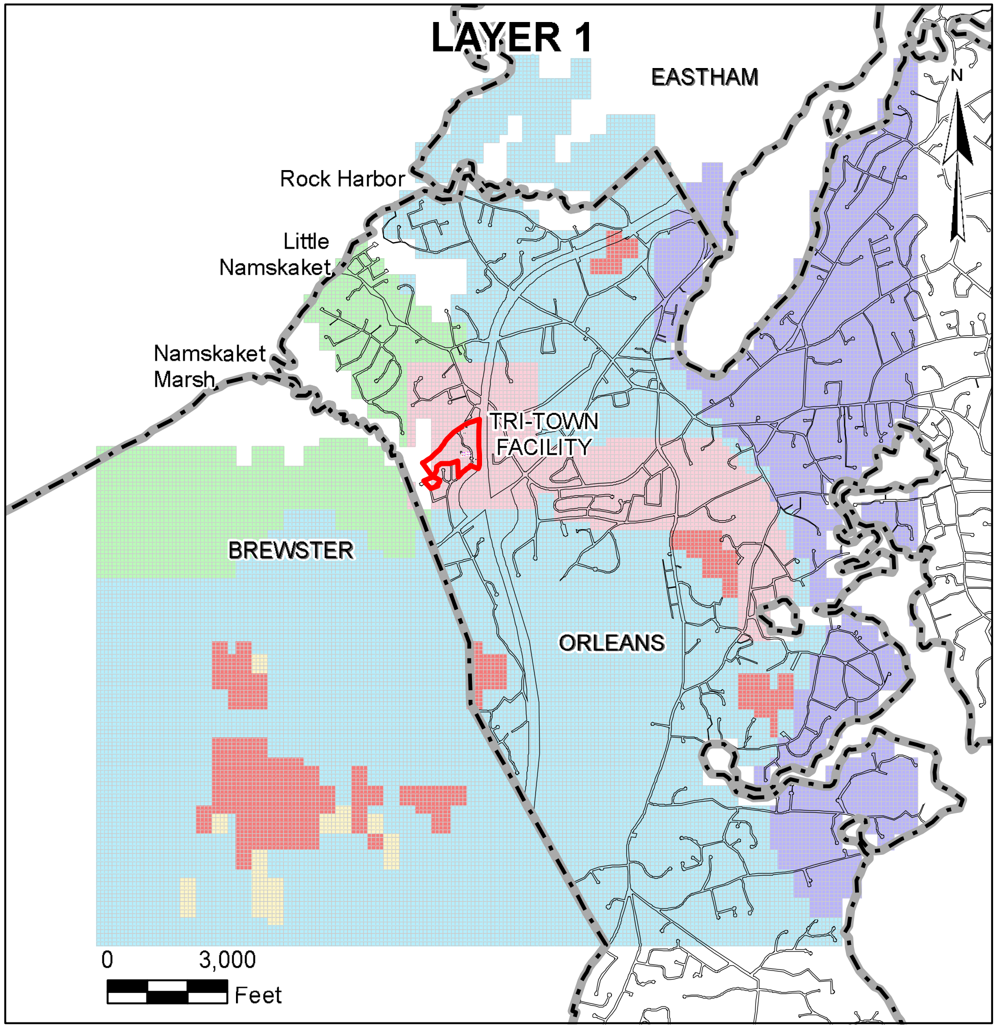
USGS files) and assumed K values that resulted in a better calibration. The final distribution of K values for the upper six layers of the Orleans Model is shown in Figures 8 through 10.

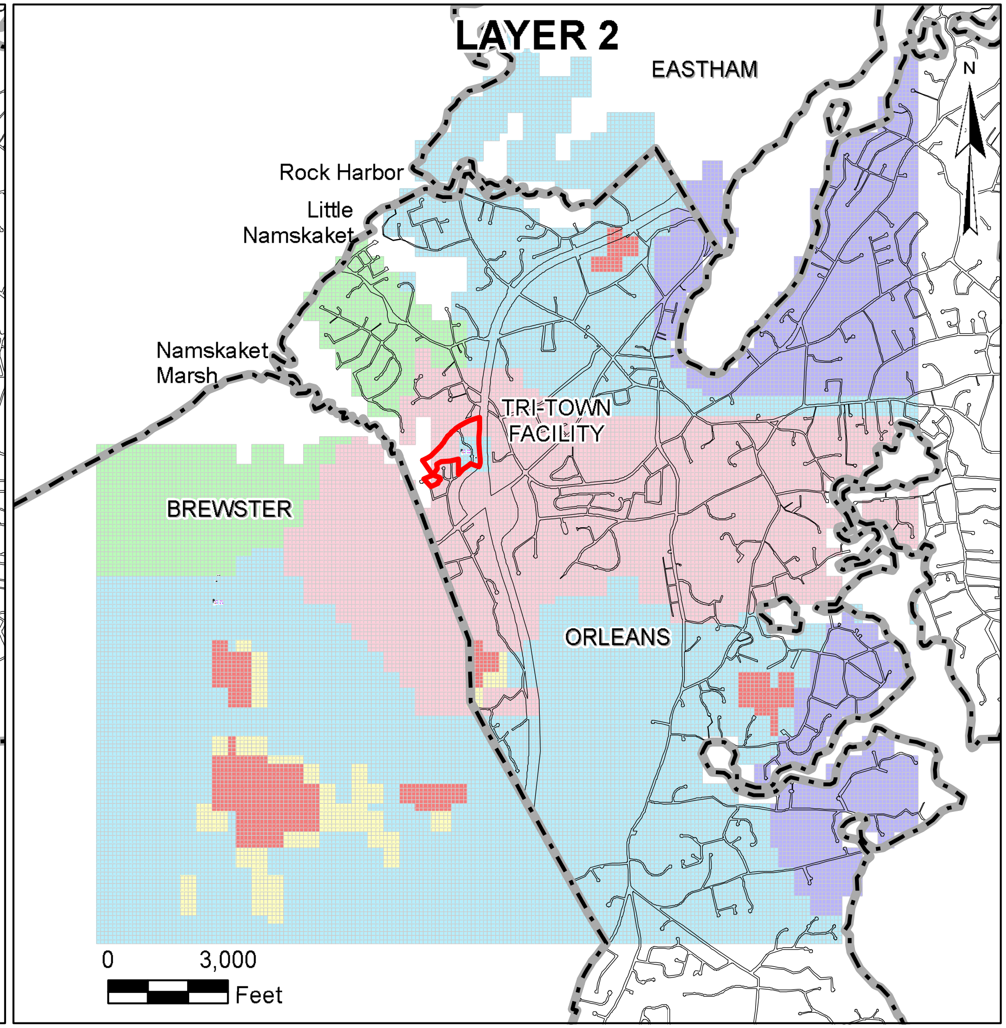
TABLE 1
SUMMARY OF MAJOR K CHANGES BETWEEN ORLEANS AND MONOMOY MODELS

Area	Regional Model		Orleans Model		Basis
	Layer(s)	K (ft/day)	Layer(s)	K (ft/day)	
Tri-Town east to Crystal Lake	6	150	1	50	DeSimone and others, calibration
Most of model domain	6,7,8	150	1,2,3	100	calibration
Tri-Town Property	7,10	30	2,5	100	DeSimone and others
Tri-Town east to Crystal Lake	8	30	3	10	DeSimone and others
Tri-Town Property	9	30	4	100	DeSimone and others
Namskaket Creek	9,10	70	4,5	35	Boring data[1]
Namskaket Creek	11	100	6	50	Boring data[1]

1. Boring data obtained from USGS records.

In general, the Orleans Model has lower K values than the regional model, especially in the area between the Tri-Town site and Cape Cod Bay. As a result of these changes, the Orleans Model calibrated closer to observed long-term average conditions within the model domain than the regional model. Model calibration is discussed in the following section.





Legend

- Town Boundary
- Tri-Town Property Boundary
- Roads

Hydraulic Conductivity - Layer 1

- 50 ft/day
- 100 ft/day
- 105 ft/day
- 230 ft/day
- 300 ft/day
- 50,000 ft/day

Hydraulic Conductivity - Layer 2

- 30 ft/day
- 70 ft/day
- 105 ft/day
- 230 ft/day
- 300 ft/day
- 50,000 ft/day

SOURCE: Basemap Obtained from MassGIS.

Orleans CWMP
Site Investigations
Site 241
Hydraulic Conductivity
Layer 1 and 2

PROJ NO: 10645E DATE: April 2008

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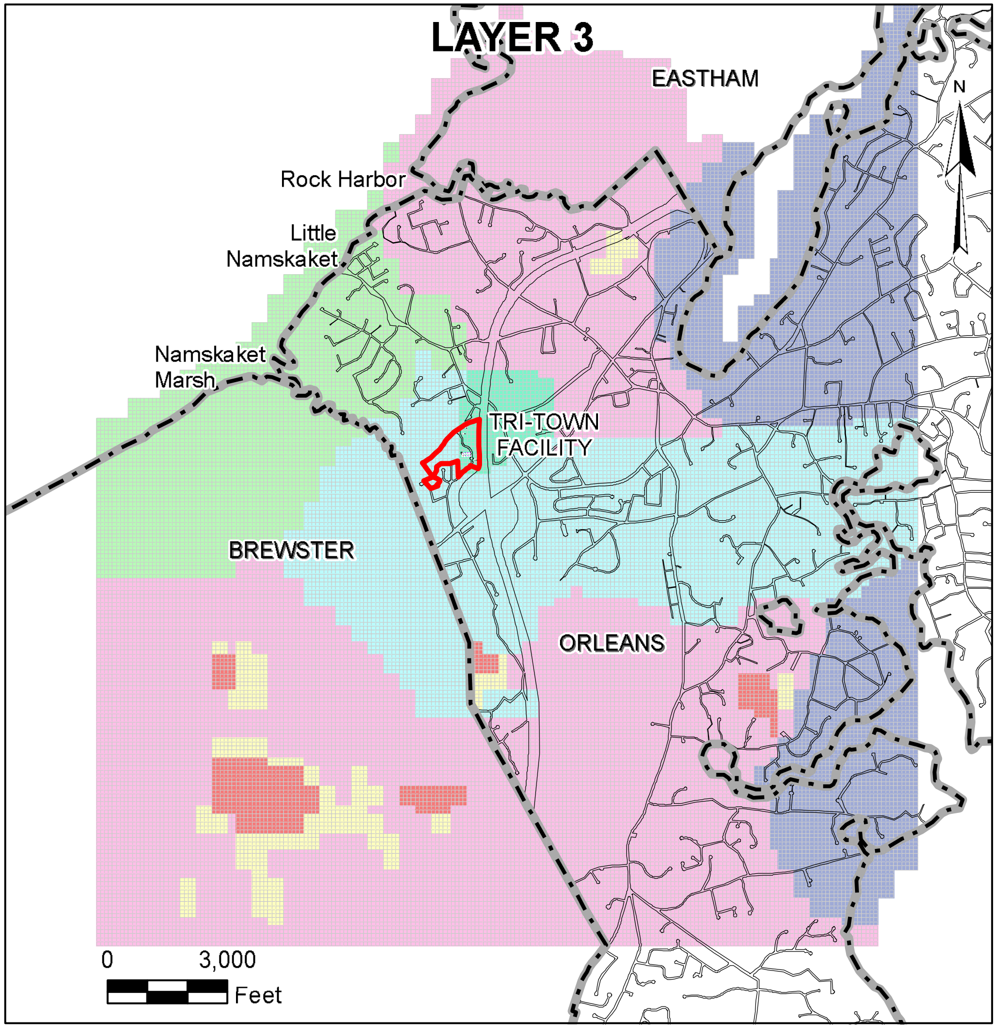
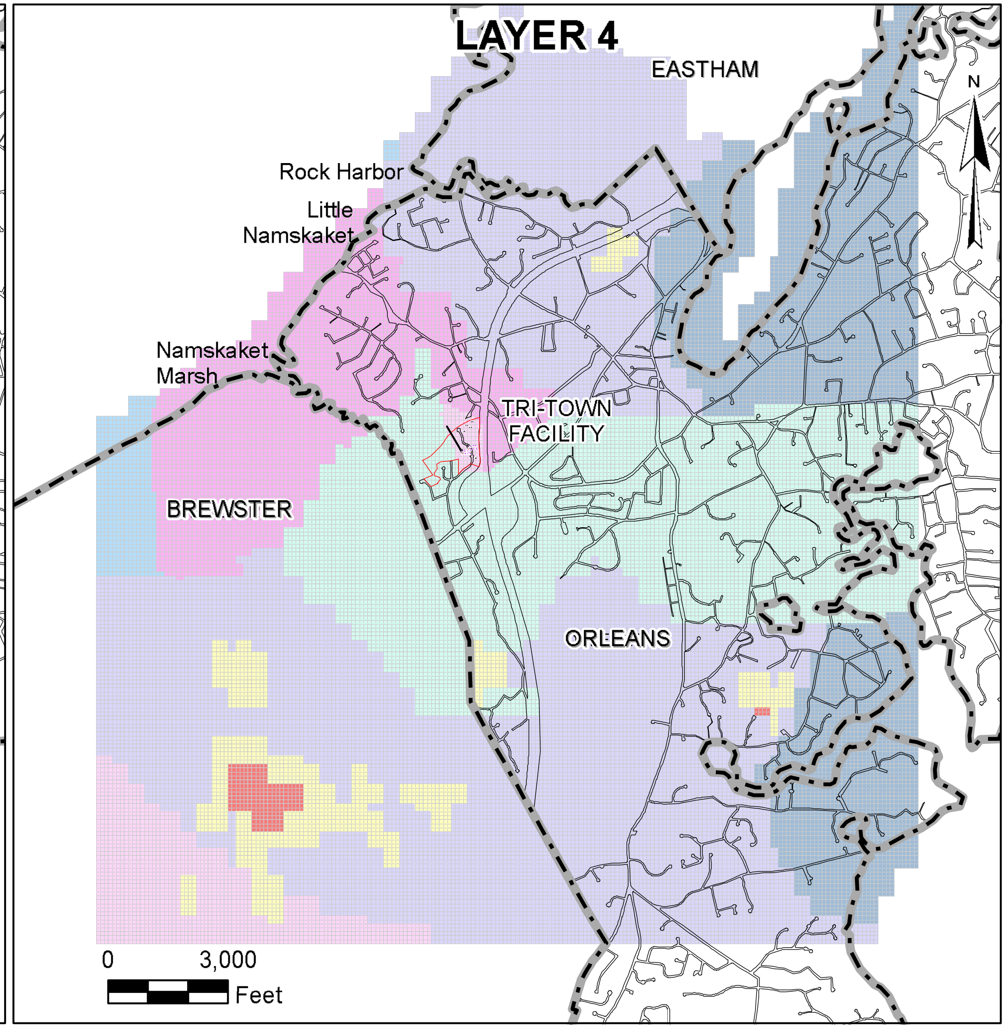
FIGURE: 8





Legend

- Town Boundary
- Tri-town Property Boundary
- Roads

Hydraulic Conductivity - Layer 3

- 30 ft/day
- 35 ft/day
- 70 ft/day
- 130 ft/day
- 140 ft/day
- 200 ft/day
- 290 ft/day
- 50000 ft/day

Hydraulic Conductivity - Layer 4

- 30 ft/day
- 35 ft/day
- 70 ft/day
- 130 ft/day
- 140 ft/day
- 200 ft/day
- 290 ft/day
- 50000 ft/day

Orleans CWMP
Site Investigations
Site 241
Hydraulic Conductivity
Layer 3 and 4

PROJ NO: 10645E DATE: April 2008

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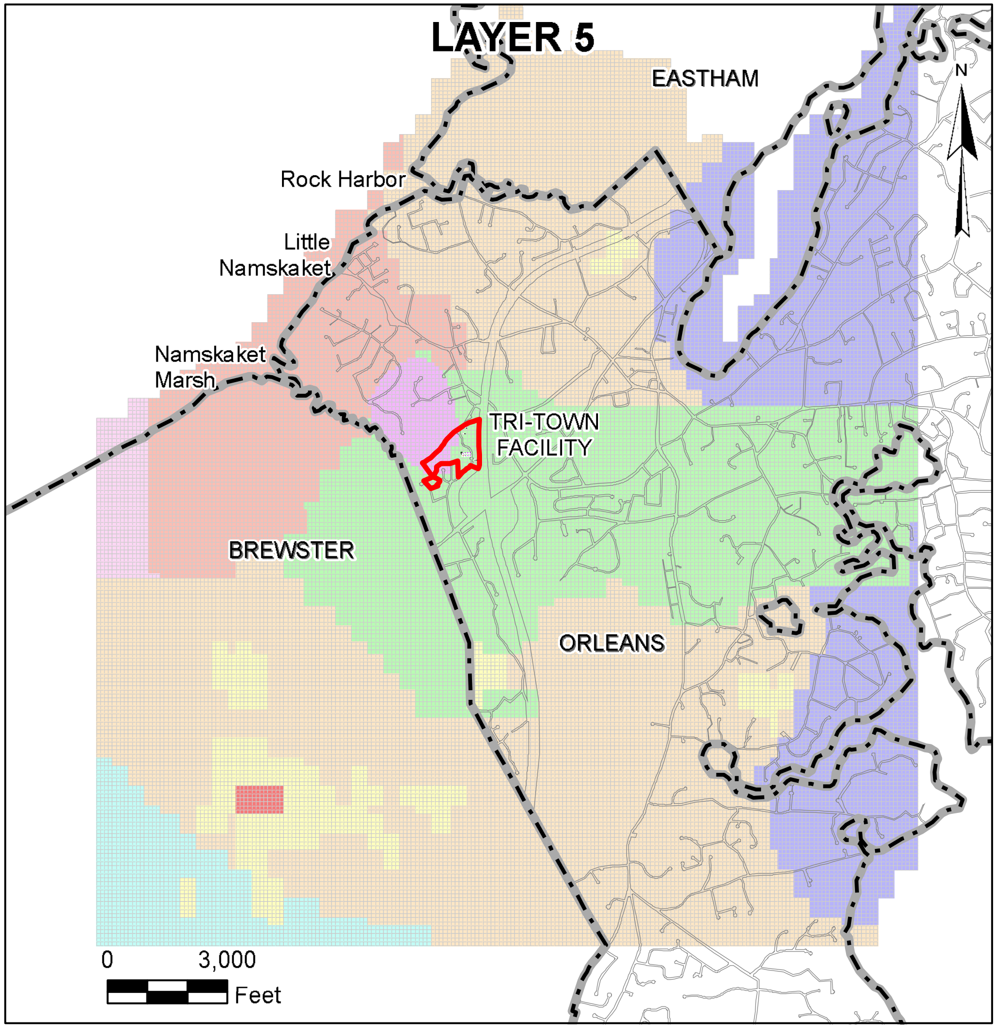
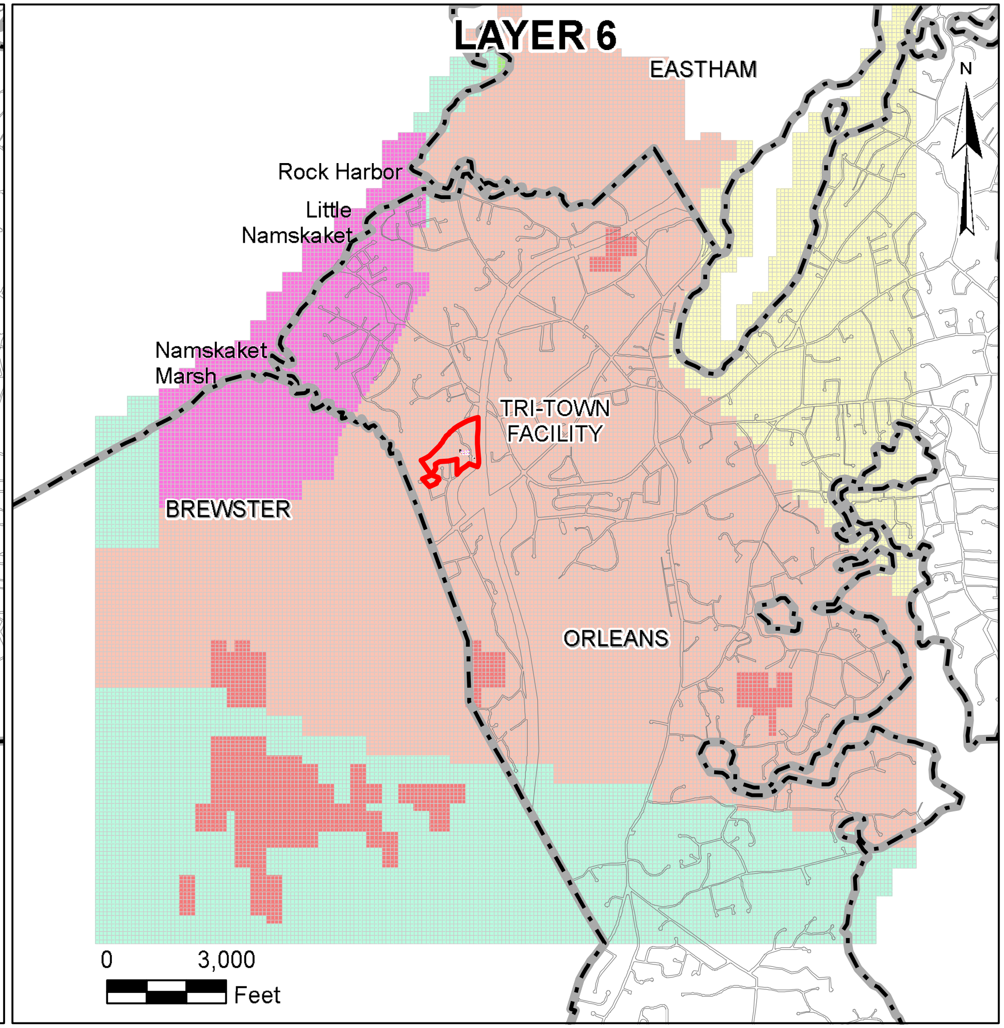
FIGURE: 9





Legend

- Town Boundary
- Tri-Town Property Boundary
- Roads

SOURCE: Basemap Obtained from MassGIS.

Hydraulic Conductivity - Layer 5

30 ft/day	104 ft/day	150 ft/day
35 ft/day	130 ft/day	280 ft/day
70 ft/day	140 ft/day	50000 ft/day

Hydraulic Conductivity - Layer 6

20 ft/day	130 ft/day
50 ft/day	150 ft/day
100 ft/day	280 ft/day

Orleans CWMP
Site Investigations
Site 241
Hydraulic Conductivity
Layer 5 and 6

PROJ NO: 10645E | DATE: April 2008 | FIGURE: 10

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SECTION 5

MODEL CALIBRATION

5.1 MODEL CALIBRATION

The original calibration of the USGS regional model included relatively few data points within the domain of the Orleans Model. There are long-term average water level data from five wells and four ponds. However, there does not appear to be any other suitable long-term average water data within the model domain with which to calibrate the model. There is a large quantity of water level data from various hydrogeologic reports in the area but none of these have been related to long-term average conditions. The available calibration targets are summarized in Table 2. The locations of these calibration targets are shown in Figure 11.

Recharge in the original USGS regional model was 27.25 inches per year over non-developed land. Additional recharge was added in developed areas to simulate the recharge attributed to on-site septic systems. The sub-regional Orleans Model calibrated best assuming a non-developed recharge rate of 28.5 inches per year.

Several statistical techniques are used to evaluate how well a model has been calibrated to observed conditions (Anderson & Woessner, 1992). One is to calculate the mean error, which is the mean of the residuals (the difference between observed and simulated groundwater elevations). Table 2 lists the residuals at the 9 calibration points. The mean of residuals was found to be 0.26 foot.

One drawback to using the mean residual to evaluate calibration is that positive and negative residuals tend to cancel each other out, making the calibration appear better than it might be. A better overall indication of error is the mean absolute residual. For this, the mean is taken of the absolute values of all the residuals. The mean absolute residual for the model calibration was 0.84 feet.

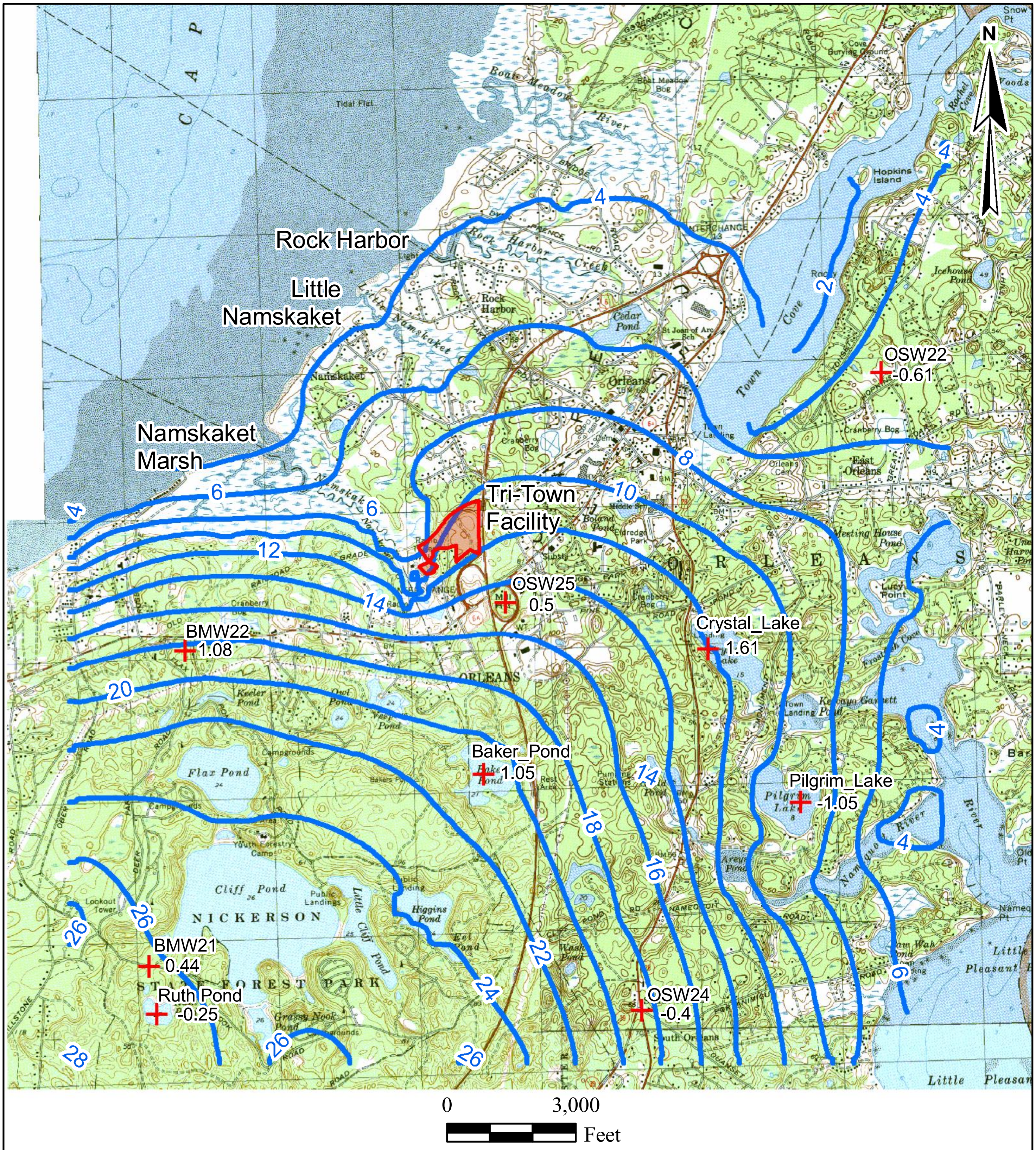
Another measure of the accuracy of a model calibration is the residual standard deviation divided by the range of head values. The residual standard deviation for the calibrated model was 0.84 ft.

The observed range in head was 22.48 ft. Therefore, the residual standard deviation divided by the range in head is 0.037 ft.

TABLE 2
SUMMARY OF MODEL CALIBRATION STATISTICS

Well Number	Observed Water Elevation (ft)	Simulated Water Elevation (ft)	Residual (ft)
OSW 22	4.29	4.89	-0.61
OSW 24	18.21	18.61	-0.23
OSW 25	15.37	26.29	0.40
BMW 21	26.76	26.32	0.44
BMW 22	19.46	18.38	1.08
Ruth Pond	26.42	26.67	-0.25
Pilgrim Lake	8.34	9.39	-1.05
Baker Pond	21.40	20.35	1.05
Crystal Lake	13.68	12.07	1.61
		Residual Mean	0.26
		Res. Std Dev.	0.84
		Sum of Squares	7.00
		Abs. Res. Mean	0.78
		Min Residual	-1.05
		Max Residual	1.61
		Range in Target Values	22.48
		Std Dev./Range	0.037

By all of these measures, the model calibration is considered to be quite good for the scale and head difference within the model. The calibrated average groundwater levels for the Orleans sub-regional model are shown in Figure 11.



Legend

Tri-Town Property Boundary

Calibration Target with Residual

Steady State Groundwater Contour (ft msl)

SOURCE: USGS Quad maps obtained from MassGIS.

Orleans CWMP
Site Investigations
Site 241
Steady State Groundwater
Contours and Target Residuals

PROJ NO: 10645E	DATE: April 2008	FIGURE: 11

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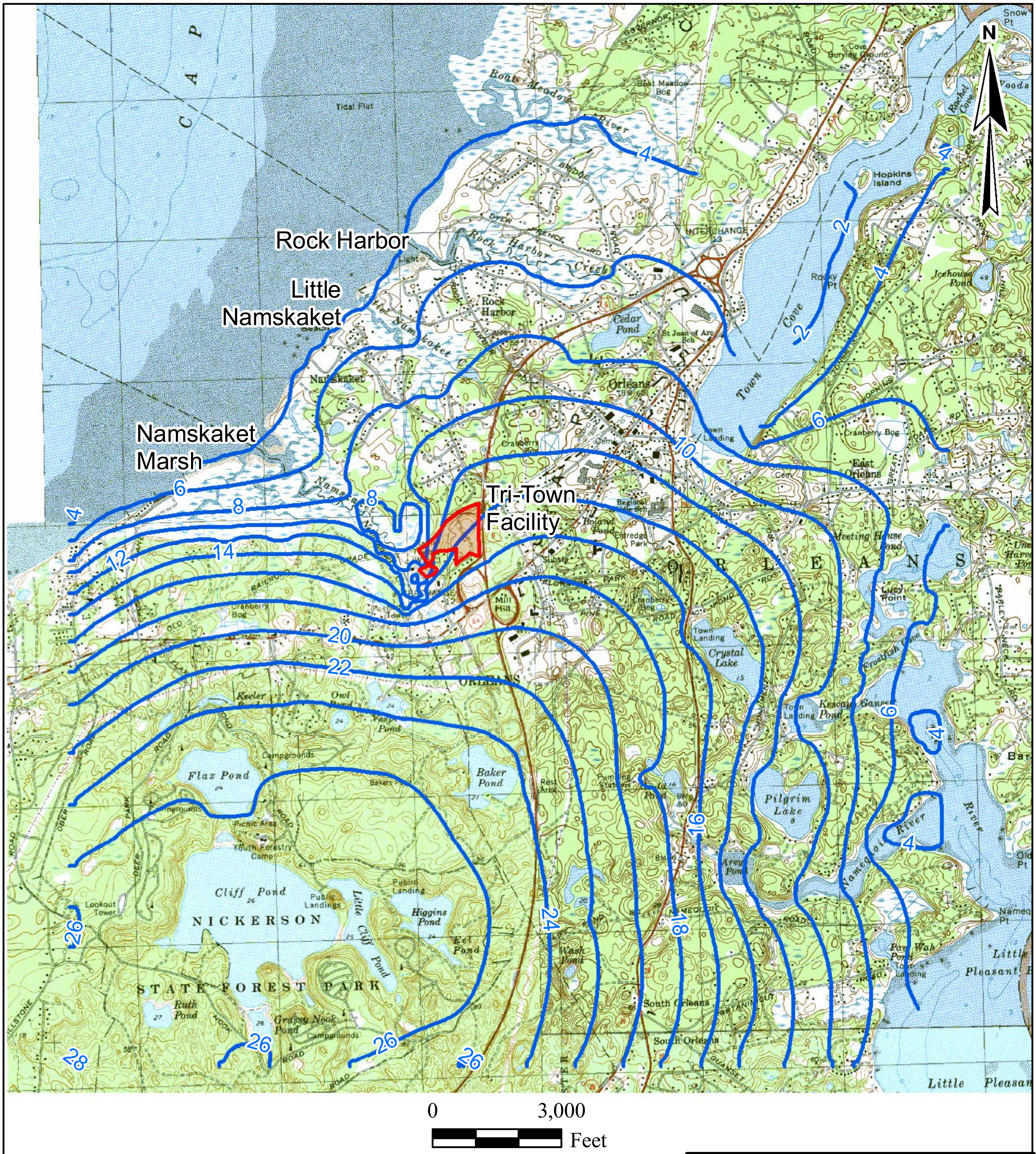
SECTION 6

SIMULATED HIGH GROUNDWATER CONDITIONS

6.1 SIMULATED HIGH GROUNDWATER CONDITIONS

One of the primary purposes of the groundwater model is to predict the groundwater mounding that would occur at the proposed discharge site under maximum discharge conditions and high ambient groundwater levels. For each of the mounding model runs, the base condition was assumed to be high groundwater conditions. High groundwater levels were estimated using long-term water level data from the closest USGS well to the Tri-Town site with a long-term record – well BMW-22. The well is located approximately 3,000 feet west of the Tri-Town site. Water level records at this well date back to 1962. Statistics from the USGS Groundwater watch web site (www.groundwaterwatch.usgs.gov) indicate that the highest groundwater level at this well typically occurs in June and mean high water level for that month is 20.67 feet NGVD. Using this water level as a target, the rate of recharge was increased until the best fit was found. This corresponded to an average annualized recharge rate of 48 inches per year. The model simulated high groundwater conditions are shown in Figure 12.



Legend

Tri-Town Property Boundary

Model Simulated High Groundwater Contour (ft msl)

SOURCE: USGS Quad maps obtained from MassGIS.

Orleans CWMP
Site Investigations
Site 241
Model-Simulated High
Groundwater Contours

PROJ NO: 10645E	DATE: April 2008	FIGURE: 12

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SECTION 7

MODEL SIMULATIONS

7.1 MODEL SIMULATIONS

Discharged wastewater was simulated as additional recharge over the area of the proposed infiltration beds. Several different scenarios of discharge rate and discharge bed configuration were simulated. There were essentially two types of model runs: 1) maximum monthly discharge runs for determining the highest potential groundwater mound and 2) annual average discharge runs for determining the ultimate fate of effluent-impacted groundwater. The scenarios are summarized in Table 3.

TABLE 3
MODEL-SIMULATED DISCHARGE SCENARIOS

Scenario	Description	Annual Average Discharge (gpd)	Maximum Month Discharge (gpd)
1	Current Flow Conditions	30,000	NA
2	Maximum Surficial Site Capacity	740,000	1,480,000
3	Plan 2 at Planning Horizon Flows	504,000	1,010,000
4	Plan 2 at Current Flows	370,000	740,000
5	Town-wide and Eastham Flows	1,035,000	2,070,000

Three maximum monthly discharge rates were simulated corresponding to: 1) the estimated maximum potential capacity of the rapid infiltration beds; 2) the maximum estimated discharge for Plan 2 at 2030, the end of the planning horizon; and 3) the maximum estimated discharge for Plan 2 at current flows. These maximum monthly rates were estimated to be 1.48, 1.01 and 0.74 million gallons per day (mgd), respectively. The proposed discharge was distributed over an area of 260,000 square feet. This is a conservatively small area; although the proposed beds themselves have a combined bottom area of 230,000 square feet, there is space between the beds. The total discharge area including the spaces between the beds is closer to 320,000 square feet.

The predicted groundwater mound under high groundwater conditions for the highest discharge scenario (1.48 mgd) is presented in Table 4, and groundwater contours are presented in

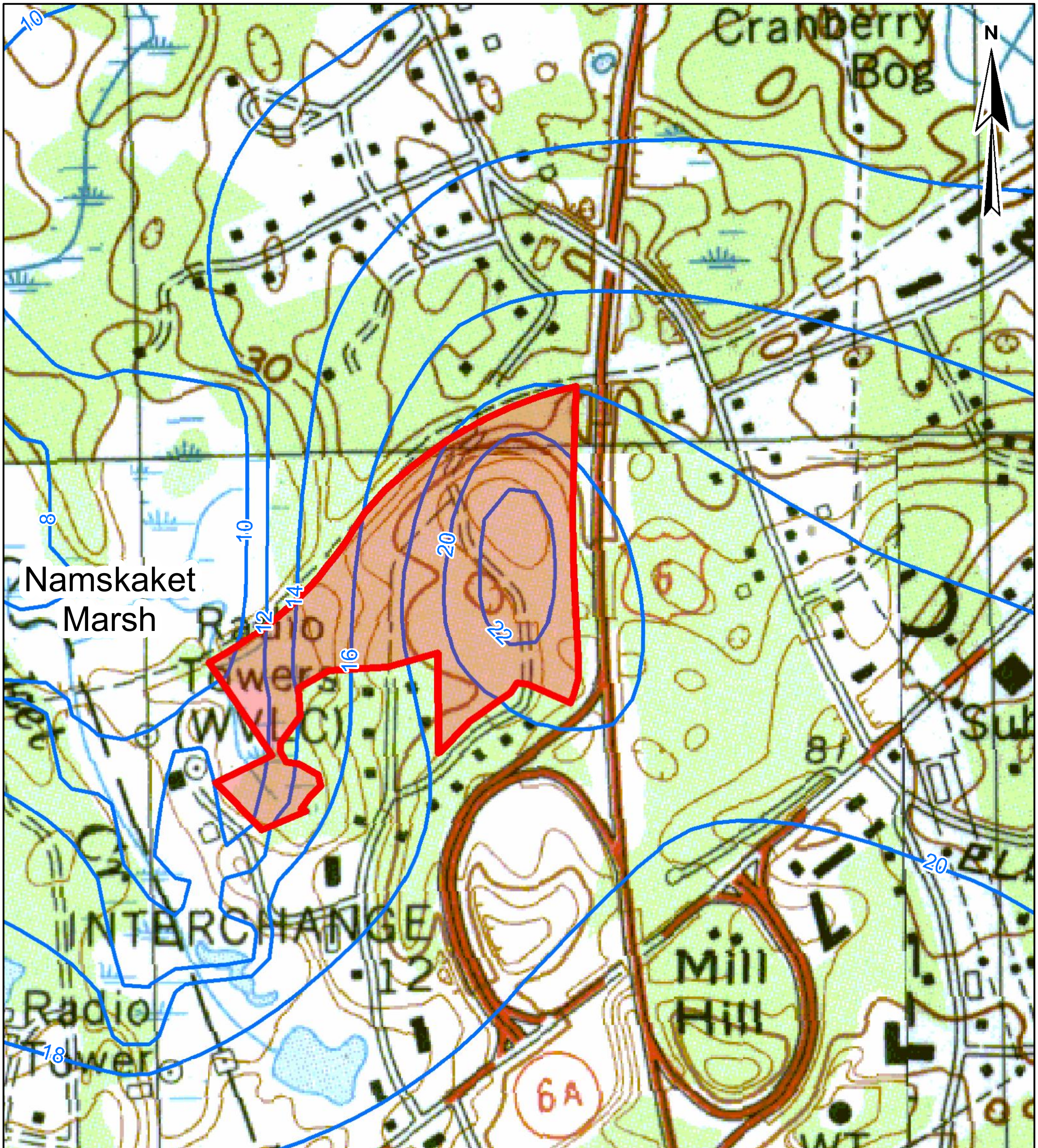
Figure 13. Under this highest discharge scenario, the simulated groundwater mounds remained greater than four feet below the bottom of the proposed discharge beds. The highest projected groundwater mound (approximately 11 feet under the maximum potential discharge rate) is at an elevation of approximately 25 feet and the lowest ground surface at the Tri-Town site is approximately 50 feet. The highest mound does not result in any groundwater levels at or near the surface of the ground in the region surrounding the Tri-Town site. The highest predicted groundwater level is also more than 10 feet below the ground surface at the homes to the north of the Tri-Town Site. Based on the results of these model runs it appears that increased water levels, even under seasonal high groundwater conditions and the highest projected discharge rate, will not result in any negative impacts at or near the site. The projected groundwater mounds under discharge rates of 1.01 and 0.74 mgd were 8.2 and 5.7 feet, respectively.

TABLE 4
GROUNDWATER MOUNDING SIMULATION
AT MAXIMUM-MONTH FLOWS

Scenario #	Maximum Month Discharge (mgd)	Seasonal High Water Table (ft)	Mound Height (ft)	Water Table Elevation w/ Discharge (ft)	Ground Surface Separation (ft)
2	1,480,000	14	11	25	25
3	1,010,000	14	8	22	28
4	740,000	14	6	20	30
5	2,070,000	14	16	30	20

The potential movement of effluent-impacted groundwater through the aquifer was evaluated by means of a particle tracking analysis. The particle tracking program MODPATH (Pollock, 1994) was used for this purpose. Particles were initiated at the water table beneath the potential effluent discharge beds. Nine particles were initiated at each of the 100-ft by 100-ft nodes representing the discharge beds. The particles were tracked through the steady state flow field for a maximum of 270 years.

The particles trace analysis was conducting on the basis of projected average annual flows for each of the three scenarios described above – the maximum potential, Phase 2 at the planning horizon and Phase 2 with current flows. The respective estimated average annual discharges for



Legend

Tri-Town Property Boundary

Model Simulated High Mound Contour (ft msl) at 1.48 mgd Discharge Scenario

0 500 Feet

SOURCE: USGS Quad maps obtained from MassGIS.

Orleans CWMP
Site Investigations
Site 241
Model-Simulated High
Mound Contours

PROJ NO: 10645E | DATE: April 2008 | FIGURE: 13

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these three scenarios are 0.74, 0.504 and 0.37 mgd. The particle tracks for each of these scenarios is illustrated in Figures 14 through 16. In each scenario, the largest number of particles are discharged to Namskaket Creek. Discharges also occurred to Little Namskaket Creek. The particle trace analysis also indicates that a significant percent of the effluent-impacted groundwater will flow beneath the coastal wetlands and estuaries and emerges in Cape Cod Bay. No effluent-impacted water was predicted to flow to Rock Harbor. A summary of the ultimate fate of the wastewater discharge for each of the scenarios is presented in Table 5.

TABLE 5
MODEL-PREDICTED FATE OF WASTEWATER DISCHARGES

Scenario	Application Volume	Percentage of Total Discharge by Watershed			
		Namskaket	Little Namskaket	Cape Cod Bay	Rock Harbor
#	mgd	%	%	%	%
2	0.740	65	10	25	0
3	0.504	68	8	24	0
4	0.370	71	3	26	0
1	0.030	100	0	0	0

There is a significant difference in groundwater travel times associated with the discharges or ultimate fate of nitrogen-enriched groundwaters. Travel times to the upper portion of Namskaket Creek, particularly to the wetlands located approximately one thousand feet to the west of the Tri-Town site, will be on the order of months or years. Groundwater travel times to the remainder of the Namskaket Creek system and Little Namskaket Creek would be on the order of decades. Groundwater travel times to Cape Cod Bay are greater than 50 years and can be as long as 300 years. This is because these groundwater flow paths go deep into the aquifer. Because the model does not account for saltwater, it is not possible to accurately predict these flows. However, because the flows are deep within the aquifer, the discharges will not occur at the Cape Cod Bay beaches. Those near-shore discharges are derived from much more shallow groundwater and water quality at the beaches is impacted by stormwater discharges.

In addition to the first four scenarios summarized in Table 5, an additional simulation (Scenario 5) was conducted to determine the potential impacts associated with a theoretical planning horizon (year 2030) maximum wastewater discharge. Scenario 5 considers an annual average

Legend

Tri-Town Property Boundary

Particle Track

0 2,000 Feet

SOURCE: USGS Quad maps obtained from MassGIS.

Orleans CWMP
Site Investigations
Site 241
Particle Tracks
Scenario 2

PROJ NO:	DATE:	FIGURE:
10645E	April 2008	14

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Legend

Tri-Town Property Boundary

Particle Track

0 2,000 Feet

SOURCE: USGS Quad maps obtained from MassGIS.

Orleans CWMP
Site Investigations
Site 241
Particle Tracks
Scenario 3

PROJ NO: 10645E	DATE: April 2008	FIGURE: 15

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Legend

Tri-Town Property Boundary

Particle Track

0 2,000 Feet

SOURCE: USGS Quad maps obtained from MassGIS.

Orleans CWMP
Site Investigations
Site 241
Particle Tracks
Scenario 4

PROJ NO: 10645E
DATE: April 2008
FIGURE: 16

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flow of 1.035 mgd and a maximum-month flow of 2.07 mgd. These flows are the aggregation of Orleans' town-wide wastewater generation in addition to contributions from the Eastham portion of Rock Harbor and Town Cove. At the maximum monthly rate, the groundwater mound was calculated to be approximately 16 feet. This still provides greater than four feet of unsaturated soils beneath the proposed discharge structures. The model also predicts that even at this high discharge rate there would be no discharge to areas that do not already have groundwater discharges and there would be no flow of effluent-impacted groundwater to Rock Harbor.

SECTION 8

SUMMARY AND CONCLUSIONS

8.1 SUMMARY AND CONCLUSIONS

Based on the calibration criteria, the groundwater flow model simulates existing and potential groundwater conditions at the site reasonably well. Due to the complex stratigraphy in the region of the model between the Tri-Town Site and Cape Cod Bay and the limited amount of subsurface data, there is some uncertainty with respect to potential preferential pathways of groundwater flow. However, it is clear that the primary control of groundwater flow in this region of the model is the presence of discharge areas – wetlands, coastal estuaries and Cape Cod Bay. The model uncertainty is not expected to have a significant impact on the predicted groundwater mounding or on the potential for effluent-impacted groundwater to reach Rock Harbor.

The groundwater mounding analysis conducted under high groundwater conditions indicate that even under the highest expected discharge rates, groundwater mounding beneath the site: 1) will be lower than four feet from the bottom of the discharge bed; 2) will not impact nearby basements or septic systems; and 3) will not result in any new locations of groundwater discharge. The results of the particle tracking analysis indicate that the ultimate fate of the effluent impacted groundwater is not radically different from previous analyses conducted by the USGS although there have been changes in the predicted percentages of effluent impacted groundwater reaching the major discharge locations. Of most significance is our finding that effluent-impacted groundwater will emerge in the Namskaket and Little Namskaket marsh systems (whose current nitrogen loads are less than threshold values) and not in the Rock Harbor system (where current nitrogen loads exceed threshold values).

SECTION 9

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ORLEANS COMPREHENSIVE WASTEWATER MANAGEMENT PLAN

PHASE 8 -- SUPPLEMENTAL SITE INVESTIGATIONS AT SITE 241

May 2009

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ORLEANS COMPREHENSIVE WASTEWATER MANAGEMENT PLAN

PHASE 8 -- SUPPLEMENTAL SITE INVESTIGATIONS AT SITE 241

1.0 INTRODUCTION

The Town of Orleans Draft Comprehensive Wastewater Management Plan (CWMP) sets forth a recommended plan to construct a new wastewater treatment facility (WWTF) at Site 241, the existing Tri-Town site. Numerous previous studies have been completed on-site, including work by GZA in 1981 to 1984, USGS in 1995 and Wright-Pierce in 2007 to 2009. Wright-Pierce efforts are documented in the reports entitled: *Phase 6 - Hydrogeologic Investigation at Site 241* (February 2008) and *Phase 6 - Hydrogeologic Modeling at Site 241* (January 2009). The previous efforts included reviewing existing subsurface investigations as well as completing test pits, soil borings, monitoring wells, percolation testing, a large-scale hydraulic loading test and computerized groundwater modeling.

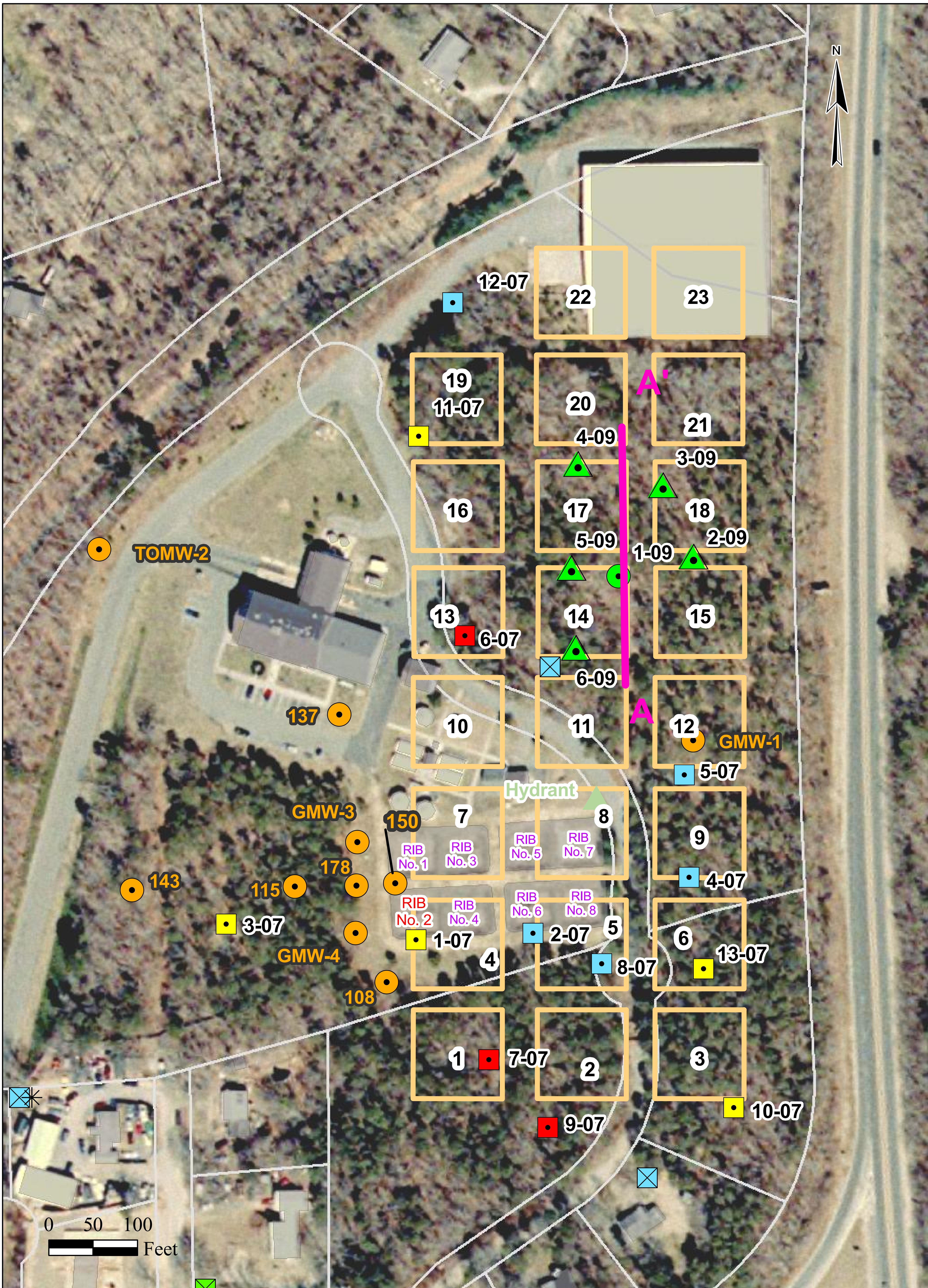
One area of the site which has not been well explored to date is the hill northeast of the treatment buildings and south of the Compost Shed. This is primarily due to the fact that the top of the hill is approximately 20 feet higher than the anticipated bottom elevation of the future rapid infiltration basins. The primary purpose of this supplemental evaluation is to determine whether the anticipated application rates for this area of the site are better, worse or the same as previously assumed.

2.0 SUBSURFACE EXPLORATIONS

A program of test boring investigations was developed and implemented for the site. A total of six test borings (numbered 1-09 through 6-09) were advanced at the site between April 7 and April 9, 2009. The drilling was performed with a track-mounted drill rig utilizing the drive-and-wash method with 3.25-inch hollow stem augers. Monitoring wells were constructed with 3-inch diameter flush joint casing. The locations of the test borings are shown on Figure 1. The boring logs are provided in Attachment A.

In general, the soil borings indicate that an upper silty fine sand layer overlays a clean medium sand layer ranging in thickness from approximately 22 to 50 feet at elevations ranging from 26.5 to 54 feet above mean sea level (ft msl). The medium sand was encountered in each of the borings except 5-09 in which fine sand was found. The clean medium sand layer in the remainder of the borings extends down to elevations ranging from 8 to 20 ft msl. At most of the borings the medium sand was underlain by fine or silty sand. An intermediate fine sand layer was observed within the clean medium sand layer on the northern portion of the knoll (test borings 2-09, 3-09, 4-09, and 5-09) ranging in thickness from 2 to 6 feet at elevations ranging from 24 to 39 feet msl. Many "stringers" of very thin 1/8" to 2" layers of dense silty fine sand were observed through out the borings. These stringers likely pinch out and are discontinuous. A generalized cross-section of the site is included as Figure 2.

A summary of the monitoring wells on-site, including the newest monitoring well, is provided in Table 1.



Legend

- Monitoring Well April 2009
- Test Boring April 2009
- Monitoring Wells (USGS)
- Line of Geologic Cross Section
- Hydrant
- Parcels
- Conceptual Basins

Test Pits 2007 Percolation Rate	Test Pits by Others Percolation Rate
<2 min/inch	<2 min/in
>5 min/inch	2-5 min/in
None	>5 min/in
	Estimated based on Soil Logs

SOURCE: Well Cluster Sites and Test Pits created by Wright-Pierce. All other data obtained from Town of Orleans and MassGIS.

Orleans CWMP
Site Investigations
Site 241
Test Borings April 2009

PROJ NO: May 2009
DATE:
SCALE: AS SHOWN

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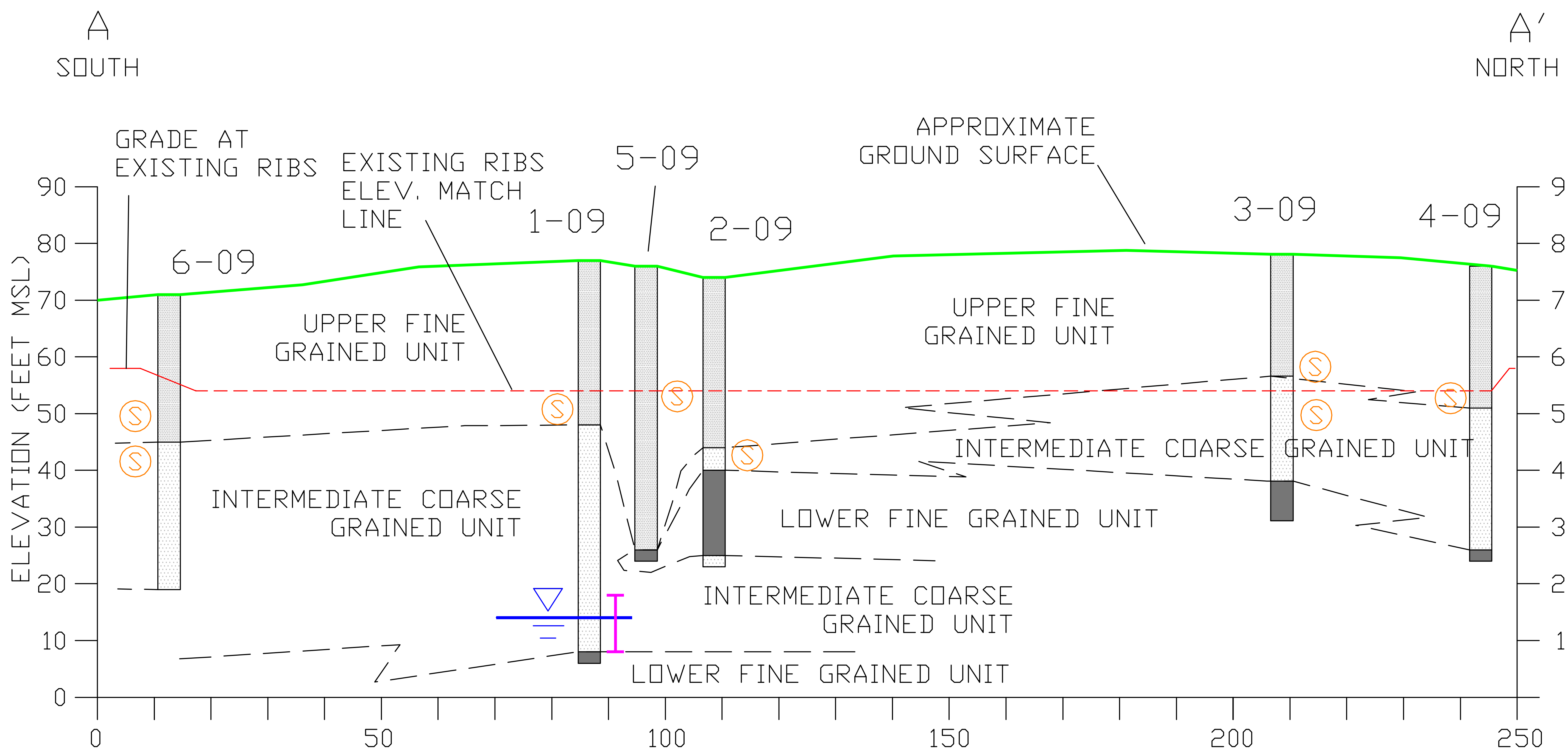
FIGURE:
1



VERTICAL TO HORIZONTAL RATIO 1:1
DASHED WHERE INFERRED

LEGEND

- UPPER FINE GRAINED UNIT (FINE SAND)
- UPPER COARSE GRAINED UNIT (MEDIUM SAND)
- LOWER FINE GRAINED UNIT (SILT AND FINE SAND)
- WELL SCREEN
- SIEVE ANALYSIS SOIL SAMPLE LOCATION

GEOLOGIC CROSS SECTION
A–A'
ORLEANS, MA

PROJ NO:	10645G
DATE:	MAY 2009
SCALE:	SEE DRAWING
FIGURE:	2

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Table 1
Monitoring Well Summary

Monitoring Well I.D. (Figure 1)	Associated USGS Well Cluster Site	Screened Interval ft msl[1,2]
115	99	-12 to -13
108	94	6 to -1
137	86	10 to -0.5
143	148	1.5 to -3.5
150	150	3.5 to -1.5
178	93	3.5 to -1.5
GMW-1	126	17 to -2.5
GMW-3	128	20 to 0.0
GMW-4	129	20 to 0.0
TOMW-2	132	11 to -9
TOMW-3	133	10 to -10
BMW-22	NA	1.5 to -1.5
1-09	NA	16 to 6

1. Source: USGS Open File Report 95-439
2. Wright-Pierce, April 2009.

Test boring 1-09 was drilled from a grade elevation of approximately 77 ft msl to a depth of 71 feet below ground surface (ft bgs). The soils observed consisted of brown fine to medium sand, little coarse sand, from the ground surface to a depth of 10 ft bgs; varved gray fine sand and silt, from 10 to 24 ft bgs; light brown fine sand, some medium sand, trace silt, from 24 to 29 ft bgs; brown fine to medium sand, little coarse sand, from 29 to 34 ft bgs; clean brown medium sand little fine and coarse sand, some fine sand, trace silt, from 34 to 39 ft bgs; clean brown fine to medium sand, some coarse sand trace silt and fine gravel, from 39 to 66 ft bgs; and varved gray fine sand and silt with orange fine to medium sand, from 66 to 71 ft bgs. Ten feet of 10 slot PVC screen was set in test boring 1-09 from 60 to 70 ft bgs. The static water level was measured at approximately 62.8 ft bgs.

Test boring 2-09 was drilled from a grade elevation of approximately 74 ft msl to a depth of 51 feet below ground surface (ft bgs). The soils observed consisted of gray light brown fine sand and silt, from the ground surface to a depth of 4 ft bgs; light brown fine sand, from 4 to 9 ft bgs; orange brown fine sand, from 9 to 14 ft bgs; gray silt and fine sand, from 14 to 30 ft bgs; clean brown medium sand little fine and coarse sand, from 30 to 34 ft bgs; clean brown fine sand, from 34 to 46 ft bgs; and clean brown/orange medium sand, little fine and coarse sand from 46 to 51 ft bgs. Perched water was observed at 14 to 20 ft bgs.

Test boring 3-09 was drilled from a grade elevation of approximately 76.5 ft msl to a depth of 47 feet below ground surface (ft bgs). The soils observed consisted of gray light brown fine sand and silt, from the ground surface to a depth of 5 ft bgs; brown silty fine to medium sand, from 5 to 10 ft bgs; light brown fine sand, some medium sand, from 10 to 21.5 ft bgs; orange brown medium sand, trace fine and coarse sand, from 21.5 to 40 ft bgs; clean white fine sand, from 40 to 41 ft bgs; and gray brown find sand and silt from 41 to 47 ft bgs.

Test boring 4-09 was drilled from a grade elevation of approximately 75 ft msl to a depth of 52 feet below ground surface (ft bgs). The soils observed consisted of gray light brown fine sand and silt, from the ground surface to a depth of 5 ft bgs; brown silty fine to medium sand, from 5 to 10 ft bgs; light brown fine sand, some medium sand, from 10 to 20 ft bgs; gray brown silt and fine sand, from 20 to 26 ft bgs; clean brown gray fine to medium sand, from 26 to 46 ft bgs; and gray brown fine sand, little medium sand, from 46 to 52 ft bgs.

Test boring 5-09 was drilled from a grade elevation of approximately 76.5 ft msl to a depth of 52 feet below ground surface (ft bgs). The soils observed consisted of gray light brown fine sand and silt, from the ground surface to a depth of 5 ft bgs; brown silty fine to medium sand, from 5 to 10 ft bgs; light brown fine sand, some medium sand, from 10 to 20 ft bgs; light brown/orange fine sand, some medium sand, from 20 to 21 ft bgs; and clean brown/white loose fine sand, from 21 to 2 ft bgs.

Test boring 6-09 was drilled from a grade elevation of approximately 72 ft msl to a depth of 52 feet below ground surface (ft bgs). The soils observed consisted of gray light brown fine sand and silt, from the ground surface to a depth of 5 ft bgs; brown silty fine to medium sand, from 5 to 10 ft bgs; light brown fine sand, some medium sand, from 10 to 20 ft bgs; clean brown/orange medium, trace of fine & coarse sand, from 20 to 41 ft bgs; Brown dense fine sand, from 41 to 50 ft bgs; and clean orange brown medium sand, little fine and coarse sand, from 50 to 52 ft bgs.

3.0 LABORATORY TESTING

Eight soil samples collected during the test boring program were submitted for laboratory particle size analysis. Particle size analysis reports are included as Attachment B. The particle size analyses were used to calculate the hydraulic conductivity of the soils via the Hazen method per Freeze and Cherry (1979), Vukovic and Soro (1992) and Fetter (2001). A summary of the hydraulic conductivity results is provided in Table 2. Hydraulic conductivity values ranged from less than 0.2 feet per day to 6 feet per day for the silty fine sand and from 47 feet per day to 189 feet per day for the sand. Average values were 2 to 3 feet per day for the silty fine sand and 84 to 120 feet per day for the sand.

TABLE 2
HYDRAULIC CONDUCTIVITY VALUES COMPUTED FROM SIEVE ANALYSIS
TRI-TOWN SEPTAGE TREATMENT FACILITY
ORLEANS, MA

				Hydraulic Conductivity Via the Hazen Method Validation Criteria: 0.1mm<d10 <0.6mm (Cu<5)				
Sample ID	**Matrix**	**d_{10} (mm)**	**C_u**	**ft/day[A]**	**ft/day[B]**	**ft/day[C]**	**Median (ft/day)**	**Avg (ft/day)**
1-09 24-26 ft[D]	Moist, yellowish brown silty sand	0.04	3.753	4	5	6	5	5
2-09 29-31 ft	Moist, yellowish brown sand	0.14	3.245	47	58	79	60	61
3-09 20-22 ft	Moist, yellowish brown sand	0.26	4.619	151	189	187	175	176
3-09 25-27 ft	Moist, yellowish brown sand with silt	0.14	5.827	47	58	61	55	55
4-09 25-27 ft	Moist, yellowish brown sand	0.17	2.821	66	82	106	83	85
5-09 20-22 ft[D]	Moist, olive yellow silty sand	0.03	7.372	3	3	3	3	3
6-09 20-22 ft[D]	Moist, light yellowish brown silty sand	0.01	1036	0.3	0.4	0.2	0.3	0.3
6-09 25-27 ft	Moist, yellowish brown sand	0.22	3.377	108	135	164	134	136
			Site Median (ft/day)	75	94	110	**for Sand**	
			Site Avg (ft/day)	84	105	120	**for Sand**	
			Silty Sand Median (ft/day)	1	2	2		
			Silty Sand Avg (ft/day)	2	3	3		

[A] (Fetter, 2001)
[B] (Freeze and Cherry, 1979)
[C] (MVASK; Vukovic and Soro, 1992)
[D] Not within validation criteria. Values omitted from site median and average values.

4.0 INTERPRETATION AND ANALYSIS

Overall, the test boring investigation and particle size analyses indicate that permeable soils exist at or below the approximate elevation of the proposed RIBs. However, these permeable soils are underlain and overlain by less permeable material and there are numerous and unpredictable "stringers" of less permeable material which may control the flow of the discharge. The presence of heterogenous fine grained soils is consistent with previous investigations conducted by Wright-Pierce, GZA, USGS on-site. Accordingly, the results of these investigations do not change the previous modeling results with regard to mound height or ultimate disposition of nitrogen.

The site soils are very heterogeneous and are not well suited to broad generalizations. This is illustrated by the fact that some of the existing RIBs have very well drained soils, while some others do not. This is also illustrated by the perched groundwater in GMW-3 during the large-scale loading test conducted in December 2007 (i.e., indicative of pockets of low permeability soils in the soil column).

Given that the anticipated bottom surface of the future RIBs is at approximate elevation 53 ft msl, the upper silty fine sand layer will be removed during construction to expose the more permeable layers below. In some areas, "over-excavation" (i.e., below the desired bed depth) may be required to remove pockets of undesirable materials which may exist below the desired rapid infiltration basin application elevation. Based on the generalized cross-section, the target elevation of the proposed RIBs should range between approximately 40 to 54 feet msl. Additional investigations, including hydraulic loading test(s), will need to be conducted in this area to determine the ultimate capacity of the soils underlying this portion of the site. This testing could be done prior to construction or after the first phase of construction is completed.

The February 2008 Hydrogeologic Report included a preliminary rapid infiltration bed layout (23 beds, each 100 feet by 100 feet) as shown in Figure 1. This layout was subsequently utilized in the January 2009 Hydrogeologic Modeling Report to predict ground water mounding. The capacity range for each of these 23 beds was estimated based on the field work conducted at that time. This table has been replicated herein as Table 3. The explorations completed as a part of the April 2009 field work were intended to provide additional subsurface information for the 11 beds located in the central and northern portions of the site (Numbered 13 through 23).

5.0 CONCLUSIONS AND RECOMMENDATIONS

As noted above, one of the primary goals of this evaluation is to address the question of whether the site capacity is better, worse or the same as previously assumed. Given the heterogeneous nature of the site soils, it is prudent to characterize the site capacity as roughly the same as previously assumed. Permeable soils do exist at or below the approximate elevation of the proposed rapid infiltration basins. However, these permeable soils are underlain and overlain by less permeable silty material which may restrict the infiltration rate. While large scale infiltration testing at the central portion of the site showed that the silty layers do not pose significant limitations on effluent disposal, the impact of the silty layers at the northern portion of the site can not be quantified at this time.

As was concluded in earlier investigations, the ability of the surficial soils to accept the effluent will govern the capacity of this site but will not change the previous conclusions from the modeling efforts (i.e., mound height and general location, ultimate disposition of nitrogen, etc.). Accordingly, the aggregate recommended disposal capacity remains at 7.7 gpd/sf (based on a maximum month flow) and indicates a site capacity range of 1.78 mgd, including the area currently occupied by the Compost Shed, and approximately 1.40 mgd, excluding the area currently occupied by the Compost Shed. The ultimate capacity of the site will be determined when treated effluent is applied to the soils and may be somewhat less than that estimated herein if the silty soils can not be cost-effectively removed.

The heterogeneous geomorphology of the site is due to its location at the head of the glacial outwash (i.e. the transition zone between relatively coarse materials washed out of the glacier and the relatively fine materials deposited from glacial lakes). The heterogeneous nature of the site will result in a higher cost per gallon of disposal capacity to construct than a similar capacity would cost on a more homogeneous medium sand site (e.g., Chatham). The additional costs will be related to additional design aspects (e.g., additional field explorations and modeling to substantiate loading rates in the permit application) to additional construction aspects (e.g. over-excavation of unsuitable silty sands to create a conduit to higher permeability soils below).

Table 3
Recommended Loading Rates

Basin No.	Basin Area	Loading Rates Based on Percolation Tests		Loading Rates Based on All Tests	
		Rate	Total Application	Rate	Total Application
		gpd/sf	gpd	gpd/sf	gpd
1	10,000	4	40,000	4	40,000
2	10,000	4	40,000	4	40,000
3	10,000	4	40,000	4	40,000
4	10,000	5	50,000	14	140,000
5	10,000	5	50,000	14	140,000
6	10,000	5	50,000	14	140,000
7	10,000	5	50,000	14	140,000
8	10,000	5	50,000	14	140,000
9	10,000	5	50,000	14	140,000
10	10,000	5	50,000	14	140,000
11	10,000	5	50,000	14	140,000
12	10,000	5	50,000	14	140,000
13	10,000	4	40,000	10	100,000
14	10,000	5	50,000	10	100,000
15	10,000	5	50,000	10	100,000
16	10,000	4	40,000	10	100,000
17	10,000	5	50,000	10	100,000
18	10,000	5	50,000	10	100,000
19	10,000	5	50,000	10	100,000
20	10,000	5	50,000	10	100,000
21	10,000	5	50,000	10	100,000
22	10,000	5	50,000	10	100,000
23	10,000	5	50,000	10	100,000
Total, gpd		23 beds	1,100,000	23 beds	2,480,000
		18 beds	850,000	18 beds	1,780,000
Total, gpd/sf		23 beds	4.8		10.8
		18 beds	4.7		9.9
		Composite			7.7

The subsurface conditions in the northerly portions of the Tri-Town site appear to be better suited than those found in the southerly areas of the site. From disposal capacity and setback perspectives, the soils in the northern portion of the site are more advantageous than those in the southern portion of the site. That said, a cost effectiveness analysis of shifting the Phase 1 RIBs to the northerly areas of the site should be completed in Preliminary Design. The analysis would need to balance the costs of removing the hill versus the costs of lower disposal capacity.

Based on these investigations, we estimate the site capacity to be approximately 1.78 mgd based on the maximum monthly flow, including the area currently occupied by the Compost Shed. This represents 163% of the Core Plan (1.09 mgd maximum month flow) and approximately 88% of the Extended Plan (2.01 mgd maximum month flow). Based on the rapid infiltration basin layouts included in the Draft CWMP, we estimate the site capacity to be 1.40 mgd based on maximum monthly flow, excluding the area currently occupied by the Compost Shed. This represents 128% of the Core Plan (1.09 mgd maximum month flow) and approximately 70% of the Extended Plan (2.01 mgd maximum month flow)

The Town should apply for a Groundwater Discharge Permit based on the flows documented in the Draft CWMP for the Core Plan, specifically those associated with a 1.09 mgd maximum month flow. A Groundwater Discharge Permit should be readily obtainable with the three existing hydrogeologic reports (including this report) and perhaps some limited additional information. The Groundwater Discharge Permit Application could state the Town's intention to request an increased flow rate in the future based on large-scale testing of constructed rapid infiltration basins (reference Section 11.9.2 of the Draft CWMP), if implementation of a regional plan or the Extended Plan are contemplated.

Consistent with the Draft CWMP, it is also recommended that the Town secure rights to future development of effluent disposal sites in the vicinity of the proposed WWTF, if the Extended Plan or Regionalization is expected or desired.

6.0 REFERENCES

Fetter, C.W., 2001, 4th Edition, Applied Hydrogeology, Prentice Hall.

Freeze, R.A. and Cherry, J.A., 1979, Groundwater, Prentice Hall.

Vukovic, M. and Soro, A., 1992, "Determination of Hydraulic Conductivity of Porous Media From Grain Size Composition," Water Resources Publications, Littleton, CO.

Wright-Pierce, 2005, "Tri-Town Septage Treatment Facility Evaluation."

Wright-Pierce, 2008, "Orleans Comprehensive Wastewater Management Plan -- Phase 6 Site Investigations, Hydrogeological Investigation at Site 241."

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Wright-Pierce, 2009, "Orleans Comprehensive Wastewater Management Plan."

ATTACHMENT A
SOIL BORING LOGS

WRIGHT-PIERCE
Engineering a Better Environment

200 Brickstone Square, Suite 505, Andover, MA 01810
Telephone: 978-470-0666 Fax: 978-470-3558
Website: www.wright-pierce.com

TB/MW 1-09

PROJECT: Orelans, MA - TriTown Follow-on Planning					JOB NO. 10645G
CLIENT: Orleans, MA					DATE STARTED: 4/7/09
BORING CONTRACTOR: NH Boring					DATE FINISHED: 4/8/09
	CAS.	SAMP.	CORE	TUBE	ELEVATION (ground):
TYPE	Steel	Wash/SS	-	-	ELEVATION (PVC):
DIAMETER	3"		-	-	GROUNDWATER (ft bgs): 62.8
WEIGHT	300 lbs		-	-	DRILLER: Jay
FALL	30"		-	-	INSPECTOR: Peter Wilson

DEPTH (ft)	WELL CONSTRUCTION	FORMATION CLASSIFICATION	SAMPLE NO.	SAMPLE INTER. (ft)	SAMPLE REC. (in)	SAMPLE BLOWS/24"	NOTES
0		Brown fine to medium SAND, little coarse sand		0-10	NA		Wash sample
10		Gray fine SAND & SILT. Varved.		10-20	NA		Wash sample
20		Gray fine SAND & SILT. Varved.		19-21	24	41	3 inch Split Spoon
25	Native Backfill	Light Brown FINE SAND, some medium sand, trace silt.		24-26	12	34	3 inch Split Spoon
30		Brown fine to medium SAND, little coarse SAND		29-31	13	38	3 inch Split Spoon
35		Clean brown medium to coarse SAND, some fine sand, trace silt		34-36	9	45	3 inch Split Spoon
40		Brown fine to medium SAND, some coarse sand, trace silt & fine gravel		39-41	8	70	3 inch Split Spoon
45	**Screen:** 5' of 2" Sch 40 PVC 10- slot screen set at 60-70' **Riser:** 2" PVC	Same as above		44-46	0	71 .	3 inch Split Spoon
50	4"steel protective	Same as above		49-51	9	95	3 inch Split Spoon
55	Bentonite	Same as above		54-56	8	123	3 inch Split Spoon
60		SAA to 60.5' then 2" layer of gray FINE SAND & SILT, varved, then brown medium to fine SAND, little coarse sand.		59-61	13	91	3 inch Split Spoon
65	No 1 Sand Pack	Brown fine to medium SAND, stringer (0.5") of gray FINE SAND & SILT		64-66	11	102	
70		Gray SILT & FINE SAND. Varved lenses of orange stained fine to medium sand.		69-71	24	98	3 inch Split Spoon End of boring

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Engineering a Better Environment
200 Brickstone Square, Suite 505, Andover, MA 01810
Telephone: 978-470-0666 Fax: 978-470-3558
Website: www.wright-pierce.com

TB 2-09

PROJECT: Orelans, MA - TriTown Follow-on Planning					JOB NO. 10645G
CLIENT: Orleans, MA					DATE STARTED: 4/8/09
BORING CONTRACTOR: NH Boring					DATE FINISHED: 4/8/09
	CAS.	SAMP.	CORE	TUBE	ELEVATION (ground):
TYPE	Auger		-	-	ELEVATION (PVC):
DIAMETER	2.5"ID		-	-	GROUNDWATER (ft bgs): Not Encountered
WEIGHT	180 lbs	2 'Split Spoon	-	-	DRILLER: Jay
FALL	30"		-	-	INSPECTOR: Peter Wilson

DEPTH (ft)	WELL CONSTRUCTION	FORMATION CLASSIFICATION	SAMPLE NO.	SAMPLE INTER. (ft)	SAMPLE REC. (in)	SAMPLE BLOWS/24"	NOTES
0	Test Boring - No Well Installed	Gray/light brown FINE SAND & SILT		0-4			Off augers
5		Light brown FINE SAND		4-9			Off augers
10		Orange brown FINE SAND		9-14			Off augers
15		uppper 5" Orange brown medium SAND lower 5" Gray SILT & FINE SAND with 1/8" layers of orange medium sand.		14-16	10	75	Begin Split Spoon
20		Same as above		19-21	14	30	Wet -Perched water
25		Same as above		24-26	16	21	
30		Same as above to 30' then Clean brown medium SAND, little fine & coarse sand.		29-31	12	26	
35		Gray SILT & FINE SAND with 1/8" layers of orange medium sand.		34-36	18	23	
40		Clean Brown FINE SAND. Gray Fine SAND at soon tip.		39-41	6	32	
45		Light brown Fine SAND, dense		44-46	8	28	
50		Clean brown/orange medium SAND, little fine & coarse sand		49-51	10	27	End of boring
55							
60							
65							
70							

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200 Brickstone Square, Suite 505, Andover, MA 01810
Telephone: 978-470-0666 Fax: 978-470-3558
Website: www.wright-pierce.com

TB 3-09

PROJECT: Orelans, MA - TriTown Follow-on Planning					JOB NO. 10645G
CLIENT: Orleans, MA					DATE STARTED: 4/8/09
BORING CONTRACTOR: NH Boring					DATE FINISHED: 4/8/09
	CAS.	SAMP.	CORE	TUBE	ELEVATION (ground):
TYPE	Auger		-	-	ELEVATION (PVC):
DIAMETER	2.5"ID		-	-	GROUNDWATER (ft bgs): Not Encountered
WEIGHT	180 lbs	2 'Split Spoon	-	-	DRILLER: Jay
FALL	30"		-	-	INSPECTOR: Peter Wilson

DEPTH (ft)	WELL CONSTRUCTION	FORMATION CLASSIFICATION	SAMPLE NO.	INTER. (ft)	REC. (in)	BLOWS/24"	NOTES
0	Test Boring - No Well Installed	Gray/light brown FINE SAND & SILT		0-5			Off augers
5		Brown Silty fine to medium SAND.		5-10			Off augers
10		Light brown FINE SAND, some medium sand		10-20			Off augers
15							
20		Same as above to 21.5' then Clean orange brown medium SAND, trace fine & coarse sand		20-22	8	10	Begin split spoon
25		Same as above		25-27	10	26	1/2 stone in spoon
30		Same as above		30-32	8	29	
35		Upper 4": gray fine SAND & SILT Lower 7" Clean orange brown medium SAND, trace fine & coarse		35-37	11	12	
40		Upper 3" White Clean brown FINE SAND, some very fine sand Lower 10" Gray brown Fine SAND & SILT		40-42	13	19	
45		Same as above.		45-47			End of boring
50							
55							
60							
65							
70							

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TB 4-09

PROJECT: Orelans, MA - TriTown Follow-on Planning					JOB NO. 10645G
CLIENT: Orleans, MA					DATE STARTED: 4/9/09
BORING CONTRACTOR: NH Boring					DATE FINISHED: 4/9/09
	CAS.	SAMP.	CORE	TUBE	ELEVATION (ground):
TYPE	Auger		-	-	ELEVATION (PVC):
DIAMETER	2.5"ID		-	-	GROUNDWATER (ft bgs): Not Encountered
WEIGHT	180 lbs	2 'Split Spoon	-	-	DRILLER: Jay
FALL	30"		-	-	INSPECTOR: Peter Wilson

DEPTH (ft)	WELL CONSTRUCTION	FORMATION CLASSIFICATION	SAMPLE NO.	SAMPLE INTER. (ft)	SAMPLE REC. (in)	SAMPLE BLOWS/24"	NOTES
0	Test Boring - No Well Installed	Gray/light brown FINE SAND & SILT		0-5			Off augers
5		Brown Silty fine to medium SAND.		5-10			Off augers
10		Light brown FINE SAND, some medium sand		10-20			Off augers
15							
20		Gray/brown FINE SAND & SILT		20-22	18	20	Begin split spoon
25		Upper 6" Same as above Lower 10" brown/gray fine to medium SAND, clean.		25-27	16	10	1/2 stone in spoon
30		Brown/orange fine to medium SAND, clean.		30-32	8	29	
35		Upper 5" Same as above Lower 5 " brown white VF-FINE SAND, some medium sand, clean.		35-37	10	30	
40		Alternating layers (1") brown fine to medium SAND/ Brown FINE SAND/Dense Brown FINE		40-42	10	15	
45		Upper 9" Orange brown fine to medium SAND, clean Lower 8" Gray brown FINE SAND, little medium sand.		45-47	16	21	
50		Alternating layers (1.5") of clean medium SAND/Gray brown FINE SAND, little medium sand.		50-52	10	28	End of boring
55							
60							
65							
70							

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Engineering a Better Environment

200 Brickstone Square, Suite 505, Andover, MA 01810
Telephone: 978-470-0666 Fax: 978-470-3558
Website: www.wright-pierce.com

TB 5-09

PROJECT: Orelans, MA - TriTown Follow-on Planning					JOB NO. 10645G
CLIENT: Orleans, MA					DATE STARTED: 4/9/09
BORING CONTRACTOR: NH Boring					DATE FINISHED: 4/9/09
	CAS.	SAMP.	CORE	TUBE	ELEVATION (ground):
TYPE	Auger		-	-	ELEVATION (PVC):
DIAMETER	2.5"ID		-	-	GROUNDWATER (ft bgs): Not Encountered
WEIGHT	180 lbs	2 'Split Spoon	-	-	DRILLER: Jay
FALL	30"		-	-	INSPECTOR: Peter Wilson

DEPTH (ft)	WELL CONSTRUCTION	FORMATION CLASSIFICATION	SAMPLE NO.	INTER. (ft)	REC. (in)	BLOWS/24"	NOTES
0	Test Boring - No Well Installed	Gray/light brown FINE SAND & SILT		0-5			Off augers
5		Brown Silty fine to medium SAND.		5-10			Off augers
10		Light brown FINE SAND, some medium sand		10-20			Off augers
15							
20		Light brown/white/orange FINE SAND, little medium sand, Clean. 1/8" thick layer of gray/brown FINE SAND		20-22	12	23	Begin split spoon
25		Clean Brown/White FINE SAND, loose		25-27	24	34	
30		Same as above		30-32	18	30	
35		Same as above with 0.5" gray FINE SAND & SILT		35-37	10	30	
40		Same as above		40-42	13	50	
45		Same as above		45-47	16	21	
50		Same as above with Gray dense FINE SAND AND SILT at spoon tip		50-52	10	28	End of boring
55							
60							
65							
70							

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Engineering a Better Environment
200 Brickstone Square, Suite 505, Andover, MA 01810
Telephone: 978-470-0666 Fax: 978-470-3558
Website: www.wright-pierce.com

TB 6-09

PROJECT: Orelans, MA - TriTown Follow-on Planning					**JOB NO. 10645G**
CLIENT: Orleans, MA					**DATE STARTED: 4/9/09**
BORING CONTRACTOR: NH Boring					**DATE FINISHED: 4/9/09**
	CAS.	**SAMP.**	**CORE**	**TUBE**	**ELEVATION (ground):**
TYPE	**Auger**		-	-	**ELEVATION (PVC):**
DIAMETER	**2.5"ID**		-	-	**GROUNDWATER (ft bgs): Not Encountered**
WEIGHT	**180 lbs**	**2 'Split Spoon**	-	-	**DRILLER: Jay**
FALL	**30"**		-	-	**INSPECTOR: Peter Wilson**

DEPTH (ft)	WELL CONSTRUCTION	FORMATION CLASSIFICATION	SAMPLE NO.	INTER. (ft)	REC. (in)	BLOWS/24"	NOTES
0	Test Boring - No Well Installed	Gray/light brown FINE SAND & SILT		0-5			Off augers
5		Brown Silty fine to medium SAND.		5-10			Off augers
10		Light brown FINE SAND, some medium sand		10-20			Off augers
15							
20		Light brown FINE SAND & SILT		20-22	10	15	Begin split spoon
25		Same as above to 26' change to Clean brown orange medium SAND, trace fine & coarse sand.		25-27	24	34	
30		Same as above		30-32	14	10	
35		Same as above. Yellowish brown		35-37	10	30	
40		Upper 8" same as above. Lower 8" Brown FINE SAND, loose. Stringer (1/4") of dense FINE SAND & SILT at spoon tip.		40-42	16	27	
45		Brown orange silty medium to fine SAND.		45-47	18	16	
50		Clean orange brown medium SAND, little fine to coarse sand.		50-52	10	20	End of boring
55							
60							
65							
70							

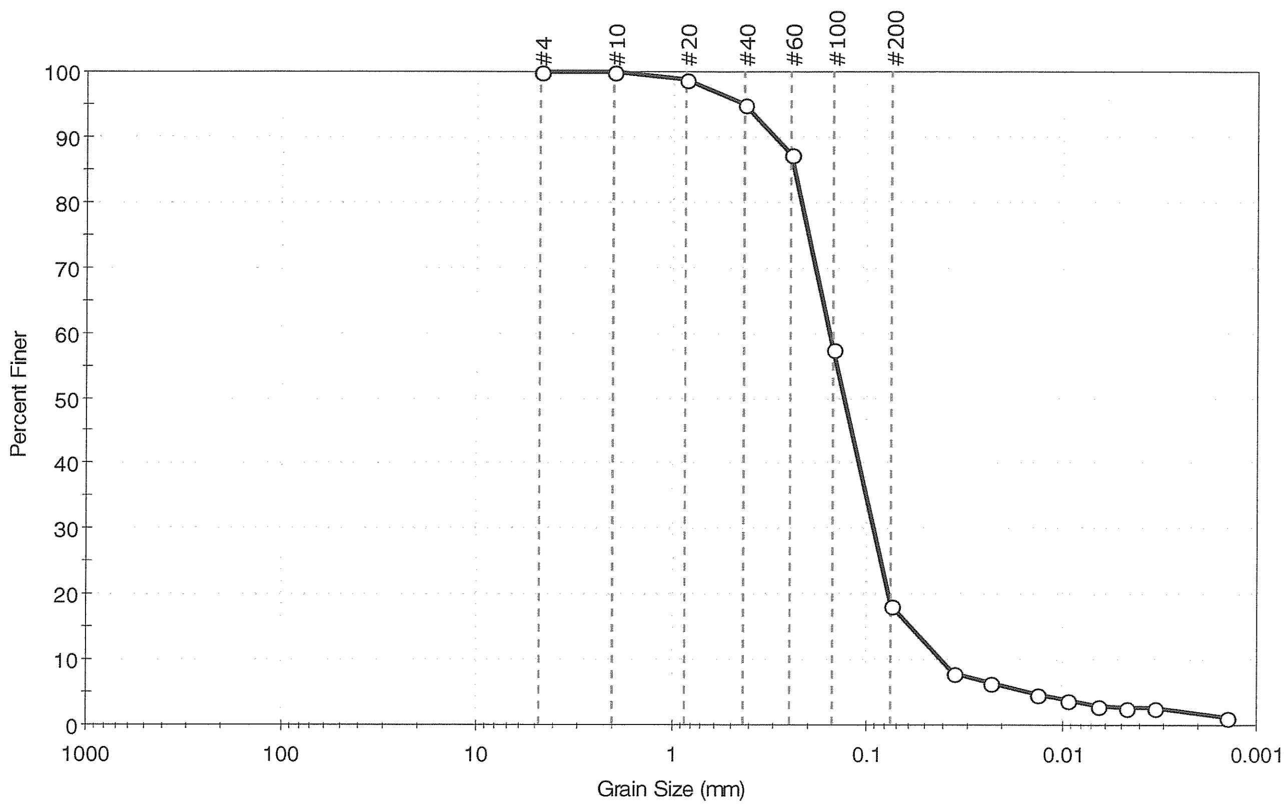
ATTACHMENT B
PARTICLE SIZE ANALYSES

GeoTesting express
a subsidiary of Geocomp Corporation

Client:	Wright-Pierce				
Project:	Tri-Town				
Location:	Orleans, MA			Project No:	GTX-8978
Boring ID:	---	Sample Type:	bag	Tested By:	jbr
Sample ID:	1-09	Test Date:	04/28/09	Checked By:	jdt
Depth :	24-26 ft	Test Id:	151610		

Test Comment: ---
Sample Description: Moist, yellowish brown silty sand
Sample Comment: ---

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	0.0	81.8	18.2

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.85	99		
#40	0.42	95		
#60	0.25	87		
#100	0.15	58		
#200	0.075	18		
---	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0362	8		
---	0.0235	6		
---	0.0135	5		
---	0.0095	4		
---	0.0067	3		
---	0.0047	3		
---	0.0034	3		
---	0.0014	1		

Coefficients

D_{85} =0.2408 mm
D_{30} =0.0924 mm
D_{60} =0.1565 mm
D_{15} =0.0597 mm
D_{50} =0.1314 mm
D_{10} =0.0417 mm
C_u =N/A
C_c =N/A

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

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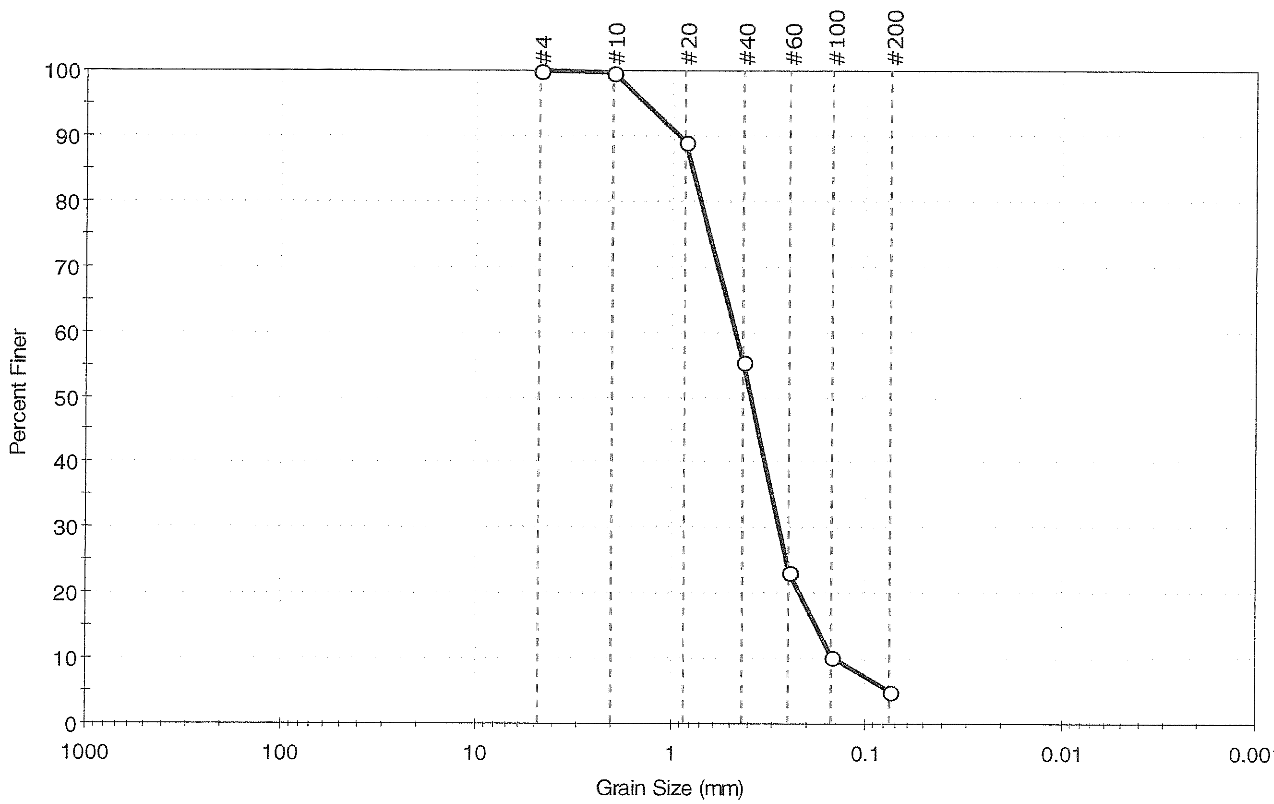
GeoTesting express
a subsidiary of Geocomp Corporation

Client: Wright-Pierce			
Project: Tri-Town			
Location: Orleans, MA		Project No:	GTX-8978
Boring ID: ---	Sample Type: bag	Tested By:	jbr
Sample ID: 2-09	Test Date: 04/27/09	Checked By:	jdt
Depth : 29-31 ft	Test Id: 151605		

Test Comment: ---
Sample Description: Moist, yellowish brown sand with silt
Sample Comment: ---

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	---	94.9	5.1

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.85	89		
#40	0.42	56		
#60	0.25	23		
#100	0.15	10		
#200	0.075	5		

Coefficients

D_{85} =0.7798 mm D_{30} =0.2788 mm
D_{60} =0.4657 mm D_{15} =0.1801 mm
D_{50} =0.3877 mm D_{10} =0.1435 mm
C_u =3.245 C_c =1.163

Classification

ASTM N/A

AASHTO Fine Sand (A-3 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

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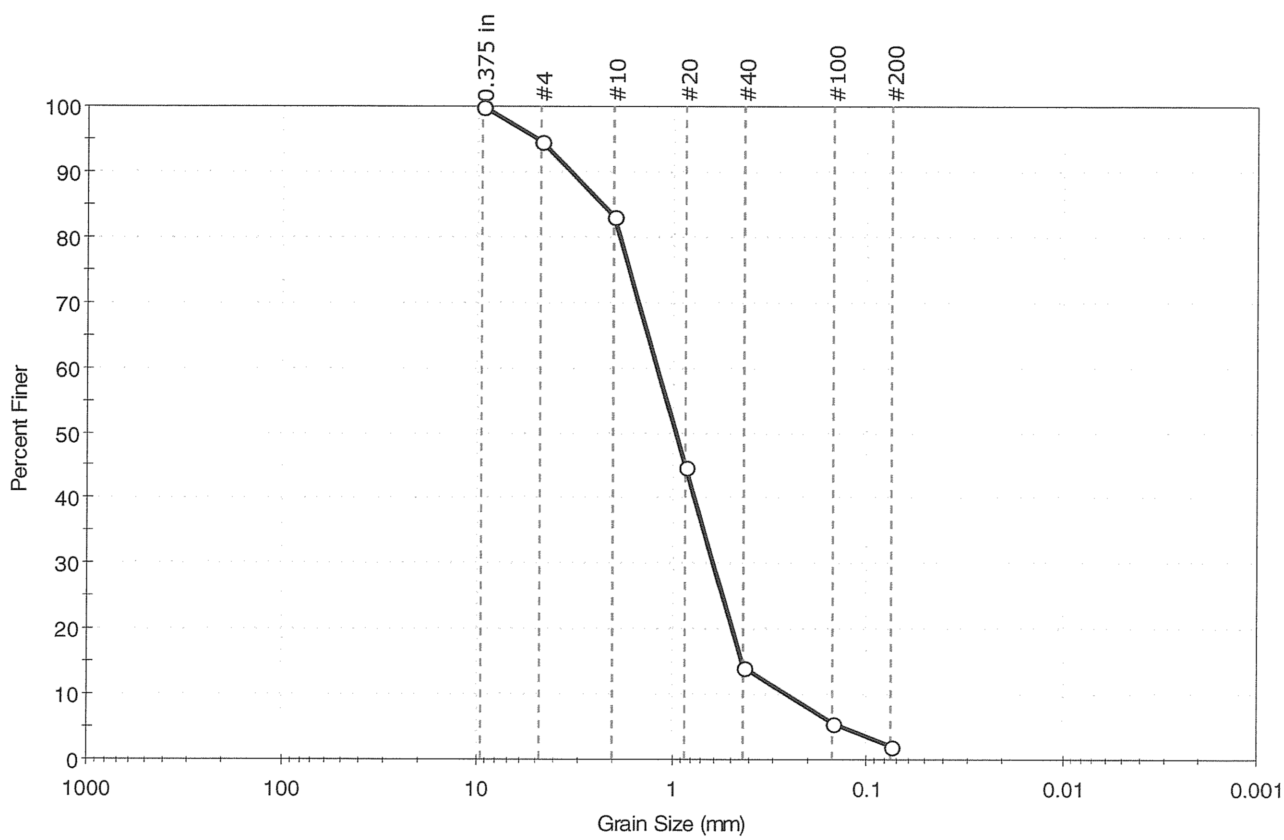
GeoTesting express
a subsidiary of Geocomp Corporation

Client:	Wright-Pierce				
Project:	Tri-Town				
Location:	Orleans, MA			Project No:	GTX-8978
Boring ID:	---	Sample Type:	bag	Tested By:	jbr
Sample ID:	3-09	Test Date:	04/27/09	Checked By:	jdt
Depth :	20-22 ft	Test Id:	151606		

Test Comment: ---
Sample Description: Moist, yellowish brown sand
Sample Comment: ---

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	5.3	92.6	2.1

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.375 in	9.50	100		
#4	4.75	95		
#10	2.00	83		
#20	0.85	45		
#40	0.42	14		
#100	0.15	6		
#200	0.075	2		

Coefficients

D_{85} =2.3035 mm | D_{30} =0.6085 mm
D_{60} =1.1931 mm | D_{15} =0.4340 mm
D_{50} =0.9540 mm | D_{10} =0.2583 mm
C_u =4.619 | C_c =1.201

Classification

ASTM Poorly graded sand (SP)

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

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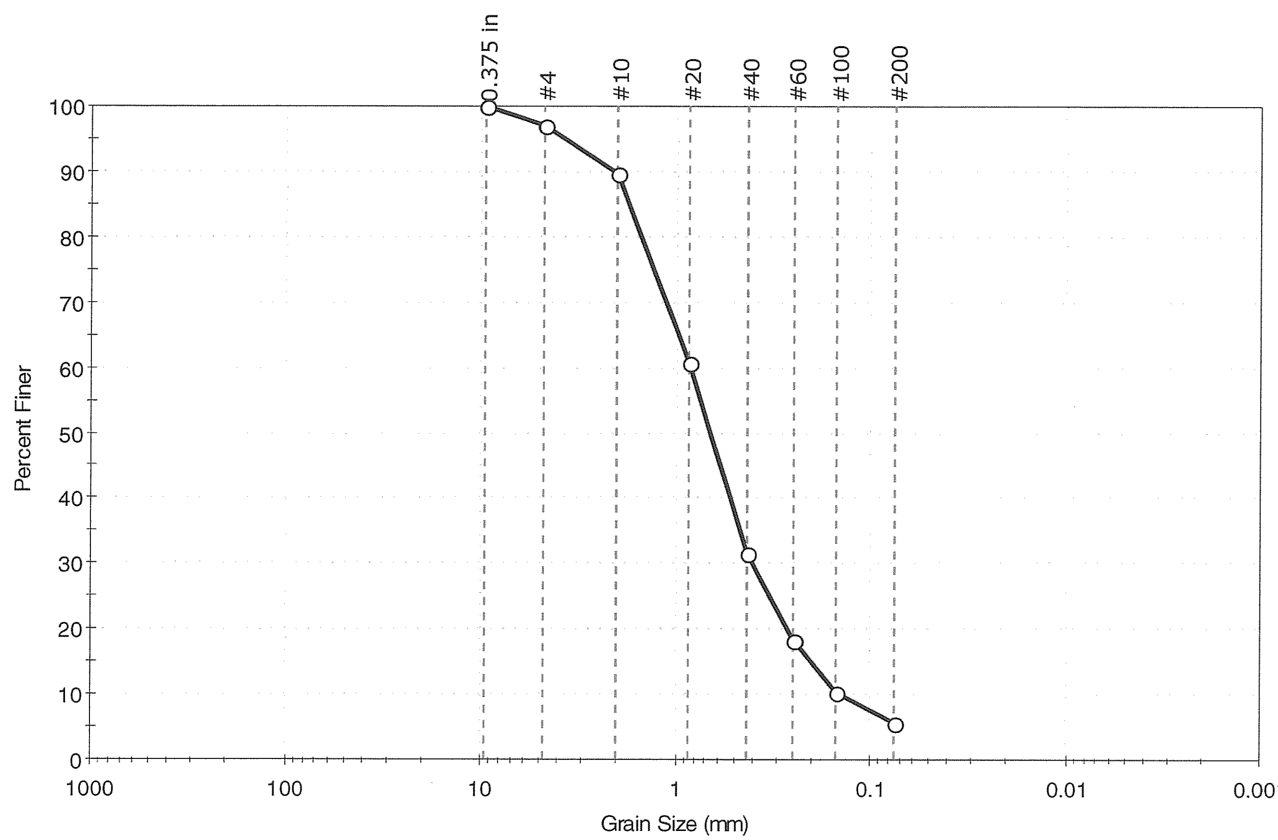
GeoTesting express
a subsidiary of Geocomp Corporation

Client:	Wright-Pierce		
Project:	Tri-Town		
Location:	Orleans, MA	Project No:	GTX-8978
Boring ID: ---	Sample Type: bag	Tested By:	jbr
Sample ID:3-09	Test Date: 04/27/09	Checked By:	jdt
Depth : 25-27 ft	Test Id: 151607		
Test Comment:	---		
Sample Description:	Moist, yellowish brown sand with silt		
Sample Comment:	---		

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	3.1	91.3	5.6

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.375 in	9.50	100		
#4	4.75	97		
#10	2.00	90		
#20	0.85	61		
#40	0.42	31		
#60	0.25	18		
#100	0.15	10		
#200	0.075	6		

Coefficients

D_{85} =1.7428 mm D_{30} =0.4007 mm

D_{60} =0.8356 mm D_{15} =0.2032 mm

D_{50} =0.6593 mm D_{10} =0.1434 mm

C_u =5.827 C_c =1.340

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

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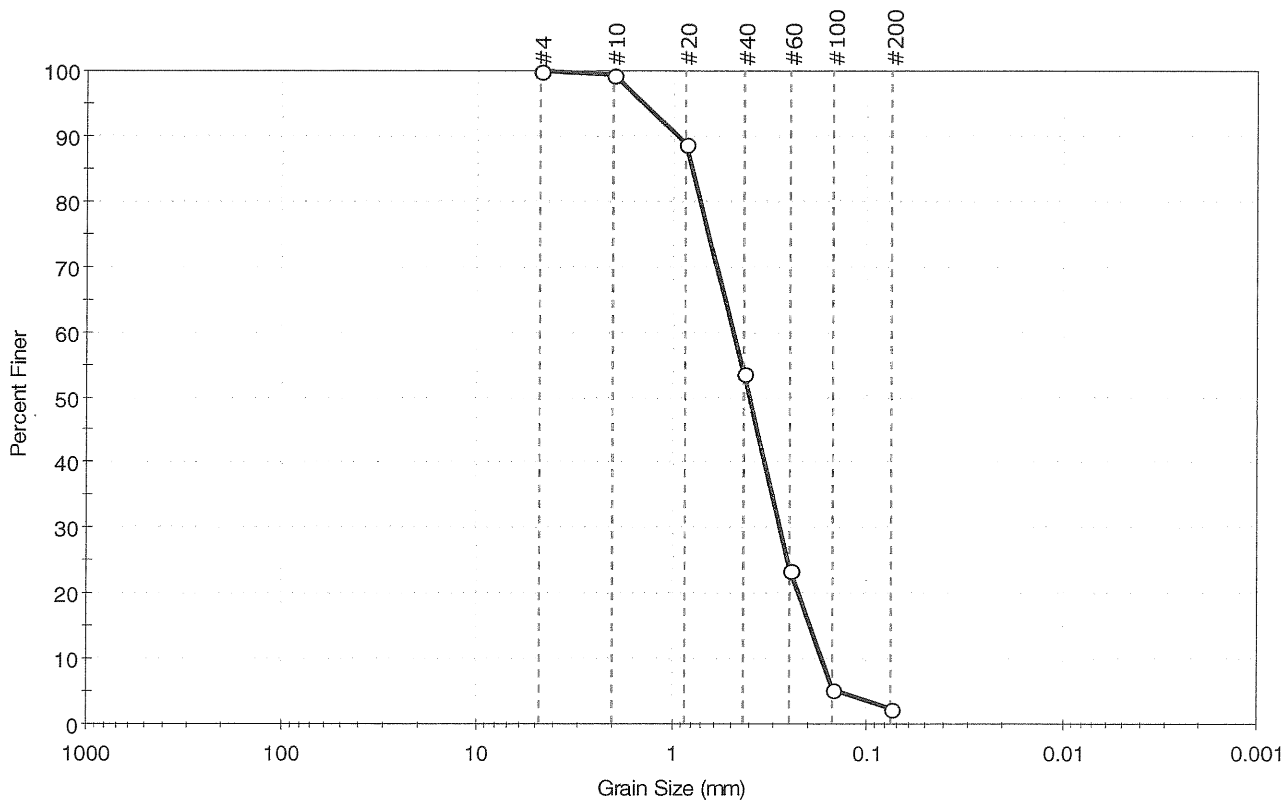
GeoTesting express
a subsidiary of Geocomp Corporation

Client: Wright-Pierce			
Project: Tri-Town			
Location: Orleans, MA		Project No:	GTX-8978
Boring ID: ---	Sample Type: bag	Tested By:	jbr
Sample ID: 4-09	Test Date: 04/27/09	Checked By:	jdt
Depth : 25-27 ft	Test Id: 151608		
Test Comment: ---			
Sample Description: Moist, light yellowish brown sand			
Sample Comment: ---			

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	---	97.7	2.3

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	99		
#20	0.85	89		
#40	0.42	54		
#60	0.25	24		
#100	0.15	5		
#200	0.075	2		

Coefficients

D_{85} = 0.7888 mm	D_{30} = 0.2799 mm
D_{60} = 0.4813 mm	D_{15} = 0.1964 mm
D_{50} = 0.3982 mm	D_{10} = 0.1706 mm
C_u = 2.821	C_c = 0.954

Classification

ASTM Poorly graded sand (SP)

AASHTO Fine Sand (A-3 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

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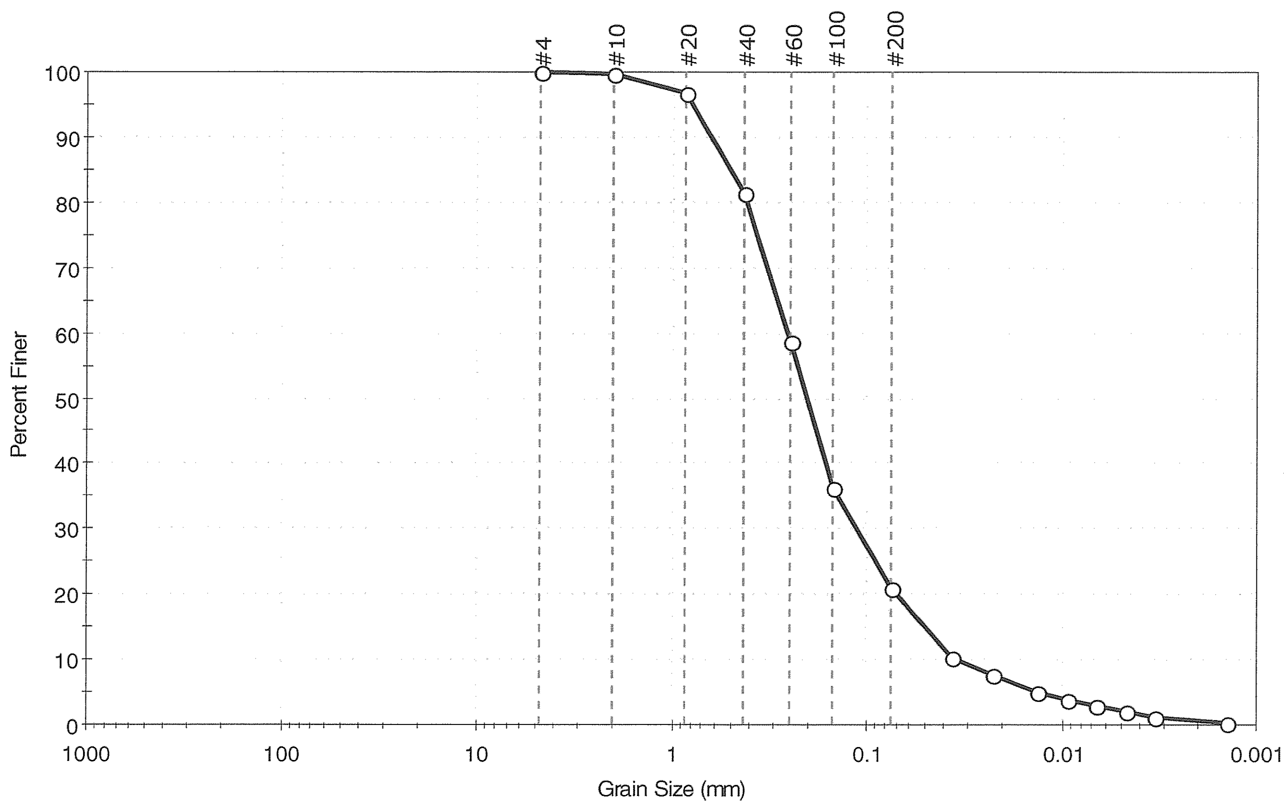
GeoTesting express
a subsidiary of Geocomp Corporation

Client: Wright-Pierce			
Project: Tri-Town			
Location: Orleans, MA		Project No:	GTX-8978
Boring ID: ---	Sample Type: bag	Tested By:	jbr
Sample ID: 5-09	Test Date: 04/28/09	Checked By:	jdt
Depth : 20-22 ft	Test Id: 151611		
Test Comment: ---			
Sample Description: Moist, olive yellow silty sand			
Sample Comment: ---			

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	0.0	79.1	20.9

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.85	97		
#40	0.42	81		
#60	0.25	59		
#100	0.15	36		
#200	0.075	21		
---	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0369	10		
---	0.0227	8		
---	0.0134	5		
---	0.0094	4		
---	0.0067	3		
---	0.0047	2		
---	0.0034	1		
---	0.0014	0		

Coefficients

D_{85} = 0.5021 mm D_{30} = 0.1127 mm

D_{60} = 0.2573 mm D_{15} = 0.0506 mm

D_{50} = 0.2046 mm D_{10} = 0.0349 mm

C_u = N/A C_c = N/A

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

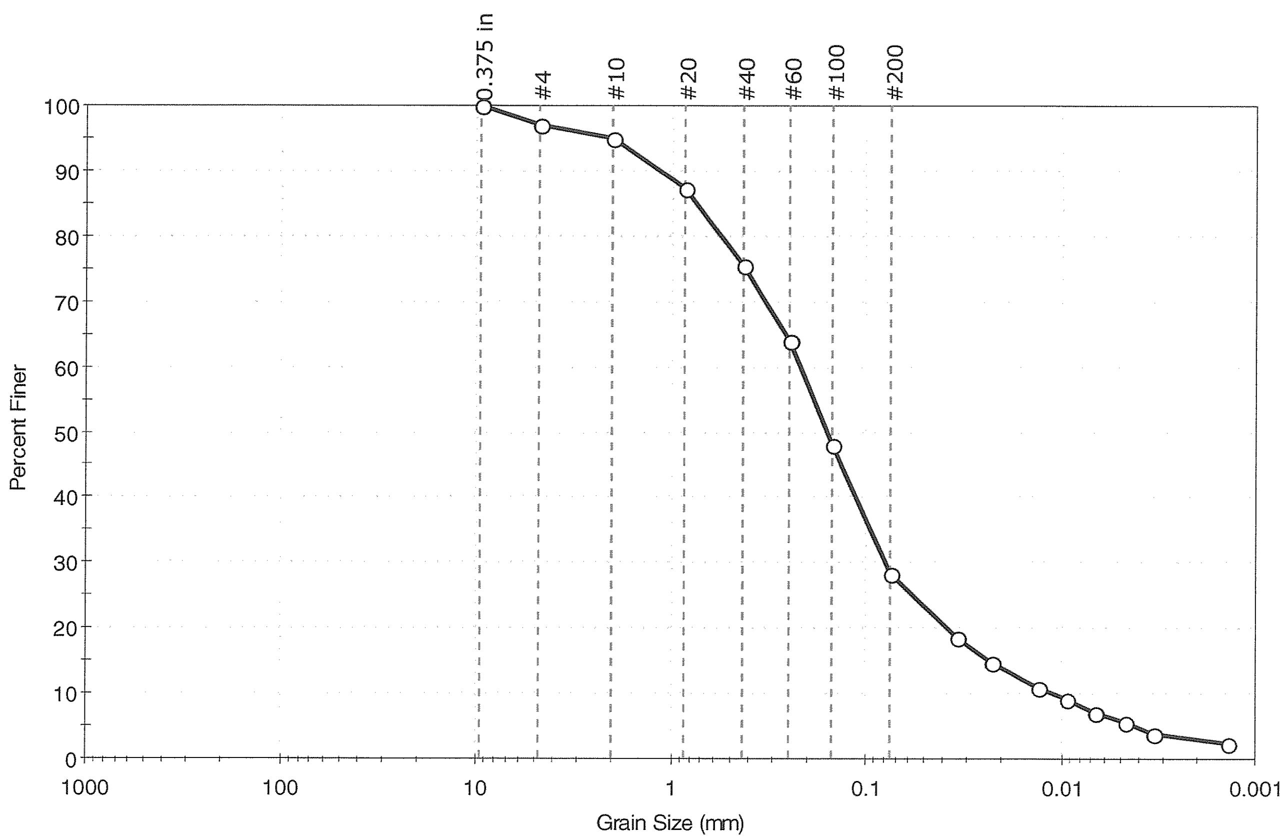
Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

GeoTesting express
a subsidiary of Geocomp Corporation

Client:	Wright-Pierce				
Project:	Tri-Town				
Location:	Orleans, MA			Project No:	GTX-8978
Boring ID:	---	Sample Type:	bag	Tested By:	jbr
Sample ID:	6-09	Test Date:	04/28/09	Checked By:	jdt
Depth :	20-22 ft	Test Id:	151612		
Test Comment:	---				
Sample Description:	Moist, light yellowish brown silty sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	2.8	68.8	28.4

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.375 in	9.50	100		
#4	4.75	97		
#10	2.00	95		
#20	0.85	87		
#40	0.42	76		
#60	0.25	64		
#100	0.15	48		
#200	0.075	28		
---	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0340	19		
---	0.0229	15		
---	0.0133	11		
---	0.0094	9		
---	0.0067	7		
---	0.0047	6		
---	0.0033	4		
---	0.0014	2		

Coefficients

D_{85} =0.7384 mm — D_{30} =0.0795 mm

D_{60} =0.2193 mm — D_{15} =0.0235 mm

D_{50} =0.1600 mm — D_{10} =0.0112 mm

C_u =N/A — C_c =N/A

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ---

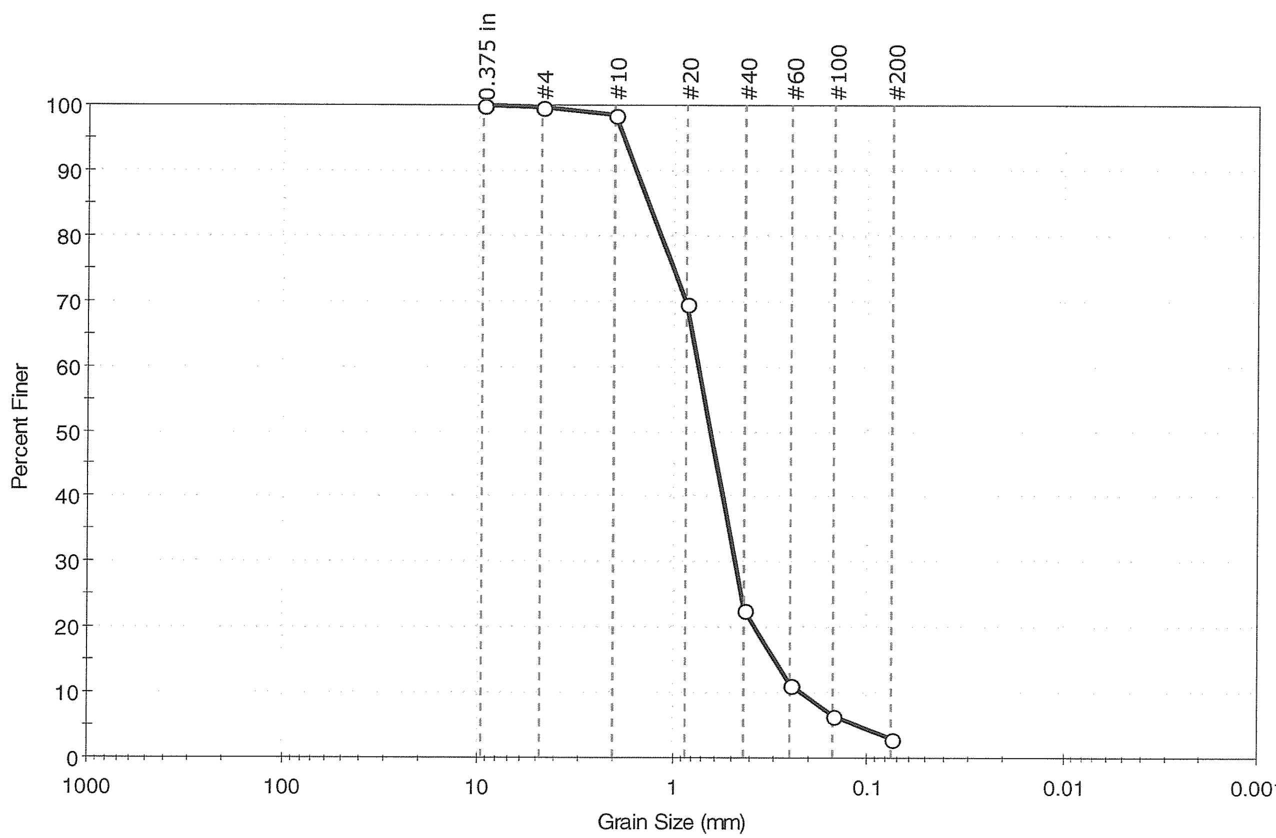
Sand/Gravel Hardness : ---

Client:	Wright-Pierce		
Project:	Tri-Town		
Location:	Orleans, MA	Project No:	GTX-8978
Boring ID: ---	Sample Type: bag	Tested By:	jbr
Sample ID:6-09	Test Date: 04/27/09	Checked By:	jdt
Depth : 25-27 ft	Test Id: 151609		

GeoTesting express
a subsidiary of Geocomp Corporation

Test Comment: ---
Sample Description: Moist, light yellowish brown sand
Sample Comment: ---

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	0.2	96.8	3.0

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.375 in	9.50	100		
#4	4.75	100		
#10	2.00	99		
#20	0.85	70		
#40	0.42	23		
#60	0.25	11		
#100	0.15	7		
#200	0.075	3		

Coefficients

D_{85} =1.3409 mm D_{30} =0.4727 mm
D_{60} =0.7373 mm D_{15} =0.2970 mm
D_{50} =0.6358 mm D_{10} =0.2183 mm
C_u =3.377 C_c =1.388

Classification

ASTM Poorly graded sand (SP)

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

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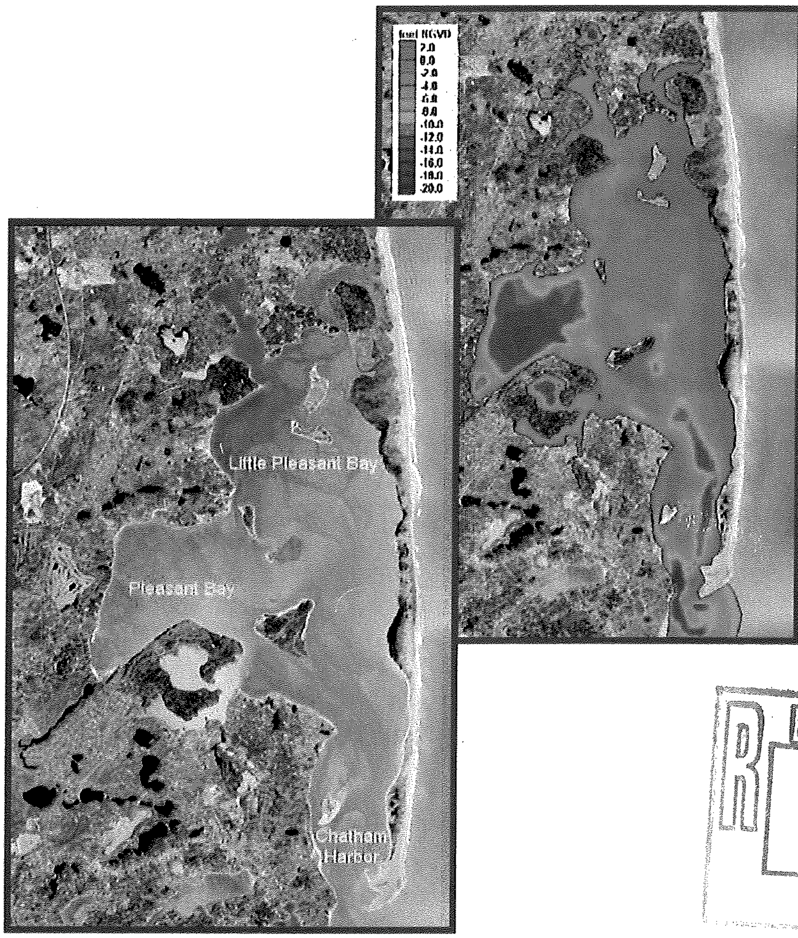
APPENDIX G

EXECUTIVE SUMMARIES OF RELEVANT TECHNICAL REPORTS BY THE MASSACHUSETTS ESTUARIES PROJECT

Massachusetts Estuaries Project

Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Pleasant Bay System, Orleans, Chatham, Brewster and Harwich, Massachusetts



University of Massachusetts Dartmouth
School of Marine Science and Technology

Massachusetts Department of
Environmental Protection

FINAL REPORT –MAY 2006

Massachusetts Estuaries Project

Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Pleasant Bay System, Massachusetts

FINAL REPORT – MAY 2006

Brian Howes
Roland Samimy
David Schlezinger

Sean Kelley
John Ramsey

Applied COASTAL

COUNTY OF BARNSTABLE MASSACHUSETTS

Ed Eichner

CAPE COD COMMISSION

Contributors:

US Geological Survey
Don Walters and John Masterson

Applied Coastal Research and Engineering, Inc.
Elizabeth Hunt and Trey Ruthven

Massachusetts Department of Environmental Protection
Charles Costello and Brian Dudley (DEP project manager)

SMAST Coastal Systems Program
Jennifer Antosca, Michael Bartlett, Sara Sampieri, and Elizabeth White

Cape Cod Commission
Xiaotong Wu

SMAST University of Massachusetts Dartmouth
The School for Marine Science and Technology

Massachusetts Department of Environmental Protection

Massachusetts Estuaries Project

Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Pleasant Bay System, Towns of Orleans, Chatham, Brewster and Harwich, Massachusetts

Executive Summary

1. Background

This report presents the results generated from the implementation of the Massachusetts Estuaries Project's Linked Watershed-Embayment Approach to the Pleasant Bay embayment system, a coastal embayment situated within the Towns of Chatham, Harwich and Orleans, Massachusetts. Analyses of the Pleasant Bay embayment system was performed to assist the Towns with up-coming nitrogen management decisions associated with current and future wastewater planning efforts, as well as wetland restoration, anadromous fish runs, shell fishery, open-space, and harbor maintenance programs. As part of the MEP approach, habitat assessment was conducted on the embayment based upon available water quality monitoring data, historical changes in eelgrass distribution, time-series water column oxygen measurements, and benthic community structure. Nitrogen loading thresholds for use as goals for watershed nitrogen management are the major product of the MEP effort. In this way, the MEP offers a science-based management approach to support the Towns of Chatham, Harwich and Orleans resource planning and decision-making process. The primary products of this effort are: (1) a current quantitative assessment of the nutrient related health of the Pleasant Bay embayment, (2) identification of all nitrogen sources (and their respective N loads) to embayment waters, (3) nitrogen threshold levels for maintaining Massachusetts Water Quality Standards within embayment waters, (4) analysis of watershed nitrogen loading reduction to achieve the N threshold concentrations in embayment waters, and (5) a functional calibrated and validated Linked Watershed-Embayment modeling tool that can be readily used for evaluation of nitrogen management alternatives (to be developed by the Towns) for the restoration of the Pleasant Bay embayment system.

Wastewater Planning: As increasing numbers of people occupy coastal watersheds, the associated coastal waters receive increasing pollutant loads. Coastal embayments throughout the Commonwealth of Massachusetts (and along the U.S. eastern seaboard) are becoming nutrient enriched. The elevated nutrients levels are primarily related to the land use impacts associated with the increasing population within the coastal zone over the past half-century.

The regional effects of both nutrient loading and bacterial contamination span the spectrum from environmental to socio-economic impacts and have direct consequences to the culture, economy, and tax base of Massachusetts's coastal communities. The primary nutrient causing the increasing impairment of our coastal embayments is nitrogen, with its primary sources being wastewater disposal, and nonpoint source runoff that carries nitrogen (e.g. fertilizers) from a range of other sources. Nitrogen related water quality decline represents one of the most serious threats to the ecological health of the nearshore coastal waters. Coastal embayments, because of their shallow nature and large shoreline area, are generally the first coastal systems to show the effect of nutrient pollution from terrestrial sources.

In particular, the Pleasant Bay embayment system within the Towns of Chatham, Harwich and Orleans is at risk of eutrophication (over enrichment) in its upper reaches due to enhanced nitrogen loads entering through groundwater and surface water from the increasingly developed watersheds to this large estuarine system. Eutrophication is a process that occurs naturally and gradually over a period of tens or hundreds of years. However, human-related (anthropogenic) sources of nitrogen may be introduced into ecosystems at an accelerated rate that cannot be easily absorbed, resulting in a phenomenon known as cultural eutrophication. In both marine and freshwater systems, cultural eutrophication results in degraded water quality, adverse impacts to ecosystems, and limits on the use of water resources.

The Towns that exist in the Pleasant Bay watershed (including the Town of Brewster that does not share Pleasant Bay shoreline) have recognized the severity of the problem of eutrophication and the need for watershed nutrient management. By example, the Town of Chatham is currently developing Comprehensive Wastewater Management Plans, which it plans to rapidly implement. The Town of Chatham and Orleans have also completed and implemented wastewater planning in other regions of those Towns that are not associated with the Pleasant Bay embayment system and as such look to integrate restoration of Pleasant Bay with wastewater planning efforts already underway. All of the Towns currently have nutrient management activities related to their tidal embayments, which have been associated with the MEP effort in Pleasant Bay as well as other embayments such as Namskaket marsh, Little Namskaket Marsh, Rock Harbor, Nauset and Nantucket Sound systems such as Saquatucket and Allens Harbors. The Towns and specific work groups have recognized that a rigorous scientific approach yielding site-specific nitrogen loading targets was required for decision-making and alternatives analysis. The completion of this multi-step process has taken place under the programmatic umbrella of the Massachusetts Estuaries Project, which is a partnership effort between all MEP collaborators, the Pleasant Bay Alliance and the Towns. The modeling tools developed as part of this program provide the quantitative information necessary for the Towns' nutrient management groups to predict the impacts on water quality from a variety of proposed management scenarios.

Nitrogen Loading Thresholds and Watershed Nitrogen Management: Realizing the need for scientifically defensible management tools has resulted in a focus on determining the aquatic system's assimilative capacity for nitrogen. The highest-level approach is to directly link the watershed nitrogen inputs with embayment hydrodynamics to produce water quality results that can be validated by water quality monitoring programs. This approach when linked to state-of-the-art habitat assessments yields accurate determination of the "allowable N concentration increase" or "threshold nitrogen concentration". These determined nitrogen concentrations are then directly relatable to the watershed nitrogen loading, which also accounts for the spatial distribution of the nitrogen sources, not just the total load. As such, changes in nitrogen load from differing parts of the embayment watershed can be evaluated relative to the degree to which those load changes drive embayment water column nitrogen concentrations toward the "threshold" for the embayment system. To increase certainty, the "Linked" Model is independently calibrated and validated for each embayment.

Massachusetts Estuaries Project Approach: The Massachusetts Department of Environmental Protection (DEP), the University of Massachusetts – Dartmouth School of Marine Science and Technology (SMAST), and others including the Cape Cod Commission (CCC) have undertaken the task of providing a quantitative tool to communities throughout southeastern Massachusetts (the Linked Watershed-Embayment Management Model) for nutrient management in their coastal embayment systems. Ultimately, use of the Linked Watershed-Embayment Management Model tool by municipalities in the region results in effective screening of nitrogen reduction approaches and eventual restoration and protection of valuable coastal resources. The MEP provides technical guidance in support of policies on nitrogen loading to embayments, wastewater management decisions, and establishment of nitrogen Total Maximum Daily Loads (TMDLs). A TMDL represents the greatest amount of a pollutant that a waterbody can accept and still meet water quality standards for protecting public health and maintaining the designated beneficial uses of those waters for drinking, swimming, recreation and fishing. The MEP modeling approach assesses available options for meeting selected nitrogen goals that are protective of embayment health and achieve water quality standards.

The core of the Massachusetts Estuaries Project analytical method is the Linked Watershed-Embayment Management Modeling Approach, which links watershed inputs with embayment circulation and nitrogen characteristics.

The Linked Model builds on well-accepted basic watershed nitrogen loading approaches such as those used in the Buzzards Bay Project, the CCC models, and other relevant models. However, the Linked Model differs from other nitrogen management models in that it:

- requires site-specific measurements within each watershed and embayment;
- uses realistic "best-estimates" of nitrogen loads from each land-use (as opposed to loads with built-in "safety factors" like Title 5 design loads);
- spatially distributes the watershed nitrogen loading to the embayment;
- accounts for nitrogen attenuation during transport to the embayment;
- includes a 2D or 3D embayment circulation model depending on embayment structure;
- accounts for basin structure, tidal variations, and dispersion within the embayment;
- includes nitrogen regenerated within the embayment;
- is validated by both independent hydrodynamic, nitrogen concentration, and ecological data;
- is calibrated and validated with field data prior to generation of "what if" scenarios.

The Linked Model Approach's greatest assets are its ability to be clearly calibrated and validated, and its utility as a management tool for testing "what if" scenarios for evaluating watershed nitrogen management options.

For a comprehensive description of the Linked Model, please refer to the *Full Report: Nitrogen Modeling to Support Watershed Management: Comparison of Approaches and Sensitivity Analysis*, available for download at http://www.state.ma.us/dep/smerp/smerp.htm. A more basic discussion of the Linked Model is also provided in Appendix F of the *Massachusetts*

Estuaries Project Embayment Restoration Guidance for Implementation Strategies, available for download at http://www.state.ma.us/dep/smerp/smerp.htm. The Linked Model suggests which management solutions will adequately protect or restore embayment water quality by enabling towns to test specific management scenarios and weigh the resulting water quality impact against the cost of that approach. In addition to the management scenarios modeled for this report, the Linked Model can be used to evaluate additional management scenarios and may be updated to reflect future changes in land-use within an embayment watershed or changing embayment characteristics. In addition, since the Model uses a holistic approach (the entire watershed, embayment and tidal source waters), it can be used to evaluate all projects as they relate directly or indirectly to water quality conditions within its geographic boundaries. Unlike many approaches, the Linked Model accounts for nutrient sources, attenuation, and recycling and variations in tidal hydrodynamics and accommodates the spatial distribution of these processes. For an overview of several management scenarios that may be employed to restore embayment water quality, see *Massachusetts Estuaries Project Embayment Restoration Guidance for Implementation Strategies*, available for download at http://www.state.ma.us/dep/smerp/smerp.htm.

Application of MEP Approach: The Linked Model was applied to the Pleasant Bay embayment system by using site-specific data collected by the MEP and water quality data from the Chatham WaterWatchers, the Orleans and the Pleasant Bay Alliance Water Quality Monitoring Programs (see Chapter 2). Evaluation of upland nitrogen loading was conducted by the MEP, data was provided by the Planning Departments in each of the Towns, and watershed boundaries delineated by USGS. This land-use data was used to determine watershed nitrogen loads within the Pleasant Bay embayment system and each systems sub-embayments (current and build-out loads are summarized in Chapter IV). Water quality within a sub-embayment is the integration of nitrogen loads with the site-specific estuarine circulation. Therefore, water quality modeling of this tidally influenced estuary included a thorough evaluation of the hydrodynamics of the estuarine system. Estuarine hydrodynamics control a variety of coastal processes including tidal flushing, pollutant dispersion, tidal currents, sedimentation, erosion, and water levels. Once the hydrodynamics of the system was quantified, transport of nitrogen was evaluated from tidal current information developed by the numerical models.

A two-dimensional depth-averaged hydrodynamic model based upon the tidal currents and water elevations was employed for the Pleasant Bay embayment system. Once the hydrodynamic properties of the estuarine system was computed, two-dimensional water quality model simulations were used to predict the dispersion of the nitrogen at current loading rates. Using standard dispersion relationships for estuarine systems of this type, the water quality model and the hydrodynamic model was then integrated in order to generate estimates regarding the spread of bio-available and total nitrogen from the site-specific hydrodynamic properties. The distributions of nitrogen loads from watershed sources were determined from land-use analysis while nitrogen entering the coastal embayment was quantified by direct measurement of stream nutrient concentrations and freshwater flow, predominantly groundwater, in streams discharging directly to the embayment. Boundary nutrient concentrations in the Atlantic Ocean source waters were taken from water quality monitoring data. Measurements of current salinity distributions throughout the estuarine waters of the Pleasant Bay embayment system was used to calibrate the water quality model, with validation using measured nitrogen concentrations (under existing loading conditions). The underlying hydrodynamic model was calibrated and validated independently using water elevations measured in time series throughout the embayments.

MEP Nitrogen Thresholds Analysis: The threshold nitrogen level for an embayment represents the average water column concentration of nitrogen that will support the habitat quality being sought. The water column nitrogen level is ultimately controlled by the watershed nitrogen load and the nitrogen concentration in the inflowing tidal waters (boundary condition). The water column nitrogen concentration is modified by the extent of sediment regeneration. Threshold nitrogen levels for the embayment systems in this study were developed to restore or maintain SA waters or high habitat quality. High habitat quality was defined as supportive of eelgrass and infaunal communities. Dissolved oxygen and chlorophyll a were also considered in the assessment.

The approach for determining nitrogen loading rates, which will maintain acceptable habitat quality throughout and embayment system, is to first identify a sentinel location within the embayment and second to determine the nitrogen concentration within the water column which will restore that location to the desired habitat quality (threshold nitrogen level). The sentinel location is selected such that the restoration of that one site will necessarily bring the other regions of the system to acceptable habitat quality levels. Once the sentinel site and its target nitrogen level are determined, the Linked Watershed-Embayment Model is used to adjust nitrogen loads sequentially until the targeted nitrogen concentration is achieved. For the Pleasant Bay System, the restoration target should reflect both recent pre-degradation habitat quality and be reasonably achievable. The load reductions presented in the report represent only one of a suite of potential reduction approaches that need to be evaluated by the community. The presentation in this report of load reductions aims to establish the general degree and spatial pattern of reduction that will be required for restoration of this nitrogen impaired embayment.

The Massachusetts Estuaries Project's thresholds analysis, as presented in this technical report, provides the site-specific nitrogen reduction guidelines for nitrogen management of the Pleasant Bay embayment system. Future water quality modeling scenarios should be run which incorporate the spectrum of strategies that result in nitrogen loading reduction to the embayment. These scenarios should be developed in coordination with all the Towns in the Pleasant Bay watershed in order to effectively examine the effect of load reductions on water column nutrient concentrations. The MEP analysis has initially focused upon nitrogen loads from on-site septic systems as a test of the potential for achieving the level of total nitrogen reduction for restoration of each embayment system. The concept was that since septic system nitrogen loads generally represent 70%-80% of the controllable watershed load to the Pleasant Bay embayment system and are more manageable than other of the nitrogen sources, the ability to achieve needed reductions through this source is a good gauge of the feasibility for restoration of these systems.

2. Problem Assessment (Current Conditions)

A habitat assessment was conducted throughout Pleasant Bay based upon available water quality monitoring data, historical changes in eelgrass distribution, time-series water column oxygen measurements, and benthic community structure. The Pleasant Bay System is comprised of a variety of basins showing a range of habitat health form "Healthy" (supportive of eelgrass, infaunal communities and with little oxygen stress) to "Degraded" (absence of eelgrass and benthic animals and periodic hypoxia/anoxia). There appears to be a clear relationship between habitat quality and the level of nitrogen enrichment. The less well flushed enclosed basins tend to be focal points for watershed nitrogen inputs and have relatively lower tidal flushing rates and greater habitat impairment. In contrast, the larger basins and areas near the tidal inlet have a range in habitat quality, Moderately Impaired to Healthy, related to their flushing rate and depth.

The spatial distribution of habitat quality among the Pleasant Bay sub-embayments shows significant spatial variation, typical of other embayments within the MEP region. Although there are a large number of sub-embayments to the Pleasant Bay System, the habitat health or impairment associated with each of the key indicators (oxygen/chlorophyll a, eelgrass, infauna communities) tends to follow the 4 classifications listed below based upon the basin type:

(A) small enclosed basin (Meetinghouse Pond, Lonnies Pond, Areys Pond, Round Cove, Quanset Pond, Paw Wah Pond, Upper Muddy Creek),
(B) moderate sized tributary sub-embayment (The River, Muddy Creek),
(C) salt marsh dominated tidal sub-estuary (Pochet),
(D) large lagoonal estuarine basin (Little Pleasant Bay, Pleasant Bay, Chatham Harbor).

The underlying quantitative data is presented on nitrogen (Section VI.1.3), oxygen and chlorophyll *a* (Section VII.2), eelgrass (Section VII.3), and benthic infauna (Section VII.4).

The effect of nitrogen enrichment is to cause oxygen depletion; however, with increased phytoplankton (or epibenthic algae) production, oxygen levels will rise in daylight to above atmospheric equilibration levels in shallow systems (generally ~7-8 mg L^{-1} at the mooring sites). The clear evidence of oxygen levels above atmospheric equilibration indicates that the upper tidal reaches of the Pleasant Bay System (particularly in the terminal sub-embayments are eutrophic.

The extent of oxygen related stress among the Pleasant Bay sub-embayments showed significant spatial variation, typical of other embayments within the MEP region. Although there are a large number of sub-embayments to the Pleasant Bay System, the habitat impairment associated with oxygen depletion tended to follow the 4 groups mentioned above.

The general pattern is for a high level of oxygen stress (frequent hypoxia or anoxia) in the bottomwaters of the small enclosed basins (group A) which tend to have higher nitrogen levels and high rates of sediment metabolism, associated with their circulation and focus of watershed nitrogen loads. The Meetinghouse Pond basin and outlet channel, Lonnies Pond and its outlet channel, the Areys Pond outlet channel (Namequoit River), Quanset Pond all showed significant levels of oxygen depletion were routinely hypoxic and except for Quanset Pond levels were frequently <2 mg/L. In the same group of enclosed basins, Areys Pond, Paw Wah Pond and upper Muddy Creek showed frequent anoxia (absence of oxygen). Among the enclosed basins only Round Cove showed only mild hypoxia with levels above 4 mg/L and generally above 5 mg/L during the full deployment.

In contrast, the salt marsh dominated tidal creek of Pochet (group C) showed frequent oxygen depletions to 3-4 mg/L, but was generally above 4 mg/L. The oxygen conditions in Pochet creek are consistent with the biogeochemistry of salt marshes. Salt marsh creeks (that do not empty at low tide) frequently become hypoxic in summer as a result of the high organic matter loading associated with marshes. Even pristine salt marshes can exhibit this behavior.

The large main basins of the lagoonal estuarine component (group D) showed oxygen conditions consistent with their rates of sediment metabolism associated with their deep waters and depositional nature (Little Pleasant Bay, Pleasant Bay) or their high tidal velocities (Chatham Harbor and eastern channel form Chatham Harbor to Little Pleasant Bay, channel between Strong Island and Bassing Harbor). The Upper Pleasant Bay at Namequoit Point showed oxygen levels frequently declining to 4-5 mg/L and the western most basin of Pleasant Bay (between Round Cove and Muddy Creek) had a single event to 2-4 mg/L, although was generally >5 mg/L. Approaching Chatham Harbor oxygen conditions improved (see Strong Island results), with oxygen conditions generally >6 mg/L with short declines to 5 mg/L associated with the outflow of lower oxygen waters from Pleasant Bay.

At present, eelgrass is present within large portions of the Pleasant Bay System, indicative of a system with high habitat quality areas. These eelgrass beds are generally restricted to the larger lagoonal basins, Little Pleasant Bay, Pleasant Bay and Chatham Harbor. There are also smaller eelgrass areas in Pochet and fringing shallow areas in The River and Meetinghouse Pond. The only tributary embayment to Pleasant Bay with significant eelgrass habitat is Bassing Harbor. The basins presently supporting eelgrass habitat also supported habitat in the 1951 historical analysis. However, it is clear from the 1951, 1995 and 2001 temporal sequence that the eelgrass areas in each basin, except Chatham Harbor, are declining in coverage. In The River and Pochet the eelgrass areas were always patchy and in the shallows. By the 2001 survey this pattern continues, but the beds appear to be declining, although they persist.

Virtually all of the small enclosed basins (group A) did not appear to support eelgrass historically and do not support it today, with the exception of the small patch in the shallows of Meetinghouse Pond and in lower Muddy Creek. The general pattern is consistent with the deeper waters of these basins and their location and structure which tends to result in nitrogen enrichment.

The overall pattern of eelgrass distribution and temporal decline in coverage fully consistent with the spatial pattern of nitrogen enrichment (Chapter VI) and oxygen and chlorophyll levels in the various basins (see above). The pattern of decline is typical of environmental changes wrought by nutrient enrichment. It is possible to determine a general idea of short- and long-term rates of change in eelgrass coverage from the mapping data, although there are only 3 surveys. Over the 50 year period1951-2001 the Pleasant Bay System has lost ~583 acres of eelgrass habitat. Interestingly, the rate of loss has been relatively constant at ~11 acres per year. This loss has occurred as watershed nitrogen loading rates gradually increased several fold due to changes in land use within the Pleasant Bay watershed

The Infauna Study indicated that as for the oxygen and chlorophyll indicators and the distribution of sediment metabolism, the enclosed basins (group A, above) are generally significantly to severely impaired relative to benthic infaunal habitat quality. Among the enclosed basins, all were at least significantly impaired. Paw Wah Pond is virtually devoid of benthic animals (only 1-4 individuals per sample) as would be expected from its high level of oxygen stress. Similarly, Areys Pond, Quanset Pond, Upper Muddy Creek supported significantly depleted benthic animal populations, consistent with their nitrogen related oxygen stress. The other enclosed basins were able to support benthic infauna, but the community was dominated by opportunistic species indicative of very high organic matter loading (Lonnies Pond, Meetinghouse Pond outlet channel) or by intermediate stress indicators. The dominance of these intermediate indicators in The River, Round Cove, Meetinghouse Pond suggests that these systems, which also showed only moderate oxygen stress, are only moderately beyond their nitrogen loading limits (Chapter VII).

The larger lagoonal basins of Little Pleasant Bay generally supported infaunal communities indicative of a moderate level of stress from organic matter loading and oxygen depletion. However, the pattern was for a decrease in habitat quality moving from the marginal to depths. This pattern is typical of a system near, but beyond its nitrogen loading limit, where organic matter deposition in the deep basin areas is the proximate cause of the impairment of benthic habitat quality. Chatham Harbor habitat supported only moderate numbers of individuals and species, but this appeared to result from the dynamic nature of the bottom sediments (unstable bottom), due to the high tidal velocities, rather than nutrient related impairment.

3. Conclusions of the Analysis

The threshold nitrogen level for an embayment represents the average watercolumn concentration of nitrogen that will support the habitat quality being sought. The watercolumn nitrogen level is ultimately controlled by the integration of the watershed nitrogen load, the nitrogen concentration in the inflowing tidal waters (boundary condition) and dilution and flushing via tidal flows. The water column nitrogen concentration is modified by the extent of sediment regeneration and by direct atmospheric deposition.

Threshold nitrogen levels for each of the sub-embayment systems in this study were developed to restore or maintain SA waters or high habitat quality. In these systems, high habitat quality was defined as supportive of eelgrass and diverse benthic benthos animal communities. Dissolved oxygen and chlorophyll *a* were also considered in the assessment.

Watershed nitrogen loads (Tables ES-1 and ES-2) for the Pleasant Bay embayment system was comprised primarily of wastewater nitrogen. Land-use and wastewater analysis found that generally about 70%-80% of the controllable watershed nitrogen load to the embayment was from wastewater.

Based upon the significant historical and present eelgrass habitat within the Pleasant Bay System, 2400 acres and 1800 acres respectively (Chapter VII), eelgrass was selected as the target for the development of the site-specific nitrogen threshold. In addition, a secondary threshold supportive of benthic animal communities (infauna) was developed in areas that do not have documented eelgrass habitat. The eelgrass threshold applies to the sentinel station (and secondary eelgrass station in Ryders Cove) and the secondary "check" thresholds for infauna habitat is for the smaller sub-basins not naturally supportive of eelgrass based on historical records.

The MEP's previous analysis of Bassing Harbor found very high levels of dissolved organic nitrogen within the embayment's waters (based upon data from the Chatham and Pleasant Bay Alliance Water Quality Monitoring Programs). While some portion of the dissolved organic nitrogen is actively cycling, the vast majority is refractory (non-biologically active) within the timeframe of the flushing of the Pleasant Bay System. The result is that the dissolved organic nitrogen presents a large non-active pool generally separate from the nitrogen fractions active in eutrophication (i.e. ammonium and nitrate+nitrite, particulate organic nitrogen). The biologically active nitrogen pools are represented by the species directly available to phytoplankton and algae (plant available nitrogen), ammonium and nitrate+nitrite, and the particulate organic nitrogen comprised primarily of phytoplankton (live and dead). Together this nitrogen group is termed bioactive nitrogen. Given the large dissolved organic nitrogen pool within Pleasant Bay the MEP Technical Team adopted the same approach used previously for the TMDL analysis of Bassing Harbor. The threshold was developed based upon the bioactive nitrogen pool, which appears to be relatively consistent between embayments both within and outside of Pleasant Bay, and then the bioactive threshold was transformed to the total nitrogen level by adding back in the dissolved organic nitrogen concentration derived for the site from direct measurements.

The threshold nitrogen levels for the Pleasant Bay embayment system in the Towns of Brewster, Chatham, Harwich and Orleans were determined as follows:

Pleasant Bay Threshold Nitrogen Concentrations

- While there is significant variation in the dissolved organic nitrogen levels, hence total nitrogen levels supportive of healthy eelgrass habitat, the level of bioactive nitrogen supportive of this habitat appears to be relatively constant. Therefore, the MEP Technical Team set a single eelgrass threshold based upon stable eelgrass beds, tidally averaged bioactive N levels and the stability of eelgrass as depicted in coverages from 1951-2001. The eelgrass threshold was set at 0.16 mg bioactive N/L based upon the Chatham (Dec 2003 MEP report) analysis for Bassing Harbor. That report for Bassing Harbor indicated a bioactive level for high quality eelgrass habitat of 0.160 mg bioactive N/L based upon Healthy eelgrass community in both Bassing Harbor at 0.135 bioactive N/L and in Stage Harbor at 0.160 bioactive N/L (Oyster River Mouth). The higher value was used as the eelgrass habitat in Bassing Harbor was below its nitrogen loading limit at that time. Taking into consideration the analysis of the Pleasant Bay System, the bioactive nitrogen threshold of 0.160 mg N/L yields an equivalent Total Nitrogen Threshold for the Bassing Harbor Sub-embayment (average upper and lower Ryders Cove stations) of 0.523 mg N L^{-1}. This value is very close to the previous Bassing Harbor specific threshold range of 0.527-0.552 mg N L^{-1}. The slight shift in threshold level results from the greatly expanded water quality database for the present versus previous analysis. The nitrogen boundary condition (concentration of N in inflowing tidal waters from Pleasant Bay) for the Bassing Harbor System is 0.45 mg N L^{-1}.

- The sentinel station for the Pleasant Bay System based on a nitrogen threshold targeting restoration of eelgrass was placed within the uppermost reach of Little Pleasant Bay (PBA-12) near the inlets to The River and Pochet. The threshold bioactive nitrogen level at this site (as for Ryders Cove) is 0.160 mg bioactive N L^{-1}. Based upon the background dissolved organic nitrogen average of upper Little Pleasant Bay and Lower Pochet 0.563 mg N L^{-1} and the bioactive threshold value, the total nitrogen level at the sentinel station (PBA-12) is 0.723 mg N L^{-1}. The restoration goal is to improve the eelgrass habitat throughout Little Pleasant Bay and the historic distribution in Pleasant Bay, which will see lower nitrogen levels when the threshold is reached. In addition, the fringing eelgrass beds within The River and within Pochet should also be restored, as they are in shallower water than the nearby sentinel site and therefore are able to tolerate slightly higher watercolumn nitrogen levels. Moreover, the same threshold bioactive nitrogen level should be met for the previous sentinel station (upper Ryders Cove) in Bassing Harbor System when levels are achieved at the sentinel station in upper Little Pleasant Bay. However, given the partial independence of the Bassing Harbor sub-embayment system relative to the greater Pleasant Bay System (i.e. its own local watershed nitrogen load plays a critical role in its health), the upper Ryders Cove sentinel station should be maintained as the guide for this sub-embayment to Pleasant Bay. It should also be noted that while the bioactive threshold is the same at both sites, the Total Nitrogen level in Ryders Cove is 0.523 mg N L^{-1}, due to the lower dissolved organic nitrogen levels in the lower Bay.

- While eelgrass restoration is primary nitrogen management goal within the Pleasant Bay System, there are small basins which do not appear to have historically (1951) supported eelgrass habitat. For these sub-embayments, restoration and maintenance of healthy animal communities is the management goal. At present, moderately impaired infaunal communities are present in Ryders Cove (PBA-03) at tidally averaged bioactive nitrogen levels of 0.244 mg N L^{-1}. Similarly, there are moderately impaired infaunal communities, designated primarily by the dominance of amphipods (amphipod mats) in most of the 8 sub-embayments of focus. These communities are present adjacent the inlet to Lonnies Pond (in The River Upper) at bioactive nitrogen levels of 0.217 mg N L^{-1}, in the Namequoit River at 0.216-0.239 mg N L^{-1} and in Round Cove at mg N L^{-1} at 0.239 mg N L^{-1}. These communities can be found at even higher levels in the fringing shallow areas of deep basins like Areys Pond (0.299 mg N L^{-1}) and Meetinghouse Pond (0.411 mg N L^{-1}). Very shallow waters tend to minimize oxygen depletion that severely stress infaunal communities in deeper basins. Paw Wah Pond is periodically hypoxic and as a result does not presently support infaunal habitat. These data are at higher bioactive nitrogen levels than the healthy infaunal habitat in the lower Pochet Basin (WMO-03) at 0.178 mg N L^{-1}. It appears that the infaunal threshold lies between 0.18 and 0.22 mg N L^{-1} tidally averaged bioactive nitrogen. Based upon the animal community and nitrogen analysis discussed in Chapter VIII, the restoration goal for the 8 small tributary sub-basin systems to Pleasant Bay is to restore a healthy habitat to the full basin in the shallower or more open waters and to the margins in the deep drowned kettles that periodically stratify. This would argue for a bioactive nitrogen threshold of 0.21 mg N L-1, lower than the lowest station with significant amphipod presence. Translation to Total Nitrogen is presented in detail in Chapter VIII.

- Development of nitrogen load reductions needed to meet the threshold concentration of 0.16 mg/l bioactive nitrogen (DIN+PON) in Ryders Cove (the average of PBA-03 and CM-13) and Upper Little Pleasant Bay (PBA-13) focused primarily on septic load removal within the River and Bassing Harbor systems. Due to the relatively large size of the Pleasant Bay system, achieving the primary threshold concentration for the restoration of eelgrass at the sentinel stations alone did not achieve the secondary threshold at the series of small embayments surrounding Pleasant and Little Pleasant Bays. The secondary threshold concentration of 0.21 mg/l bioactive nitrogen (DIN+PON) in Meetinghouse Pond (Outer), Lonnies Pond, Upper Namequoit River, Upper Pochet, Paw Wah Pond, Little Quanset Pound, Round Cove and Lower Muddy Creek required site-specific removal of septic nitrogen from the watersheds directly impacting these sub-embayments. Chapter VIII presents the percent of septic load removed from the various watersheds to achieve both the primary and secondary threshold concentrations of bioactive nitrogen at the sentinel stations

It is important to note that the analysis of future nitrogen loading to the Pleasant Bay estuarine system focuses upon additional shifts in land-use from forest/grasslands to residential and commercial development. However, the MEP analysis indicates that significant increases in nitrogen loading can occur under present land-uses, due to shifts in occupancy, shifts from seasonal to year-round useage and increasing use of fertilizers (presently less than half of the parcels use lawn fertilizers). Therefore, watershed-estuarine nitrogen management must include management approaches to prevent increased nitrogen loading from both shifts in land-uses (new sources) and from loading increases of current land-uses. The overarching conclusion of the MEP analysis of the Pleasant Bay estuarine system is that restoration will necessitate a reduction in the present nitrogen inputs and management options to negate additional future nitrogen inputs.

Table ES-1a. Existing total and sub-embayment nitrogen loads to the estuarine waters of the Pleasant Bay system, observed nitrogen concentrations, and sentinel system threshold nitrogen concentrations. Loads to estuarine waters of Pleasant Bay include both upper watershed regions contributing to major surface water inputs.

Sub-embayments	Natural Background Watershed Load [1] (kg/day)	Present Land Use Load [2] (kg/day)	Present Septic System Load (kg/day)	Present Watershed Load [4] (kg/day)	Direct Atmospheric Deposition [5] (kg/day)	Present Net Benthic Flux (kg/day)	Present Total Load [6] (kg/day)	Observed TN Conc. [7] (mg/L)	Observed Bioactive N Conc. [7] (mg/L)	Threshold Bioactive N Conc. (mg/L)
PLEASANT BAY SYSTEM										
Meetinghouse Pond	0.693	1.058	5.140	6.197	0.584	14.365	21.146	0.72-0.98	0.28-0.41	
The River – upper	0.526	0.701	2.071	2.773	0.288	6.263	9.324	0.85-0.86	0.22-0.25	0.200[8]
The River – lower	0.756	1.008	2.871	3.879	2.241	10.480	16.600	0.56	0.18	0.160[8]
Lonnies Pond	0.682	0.811	1.630	2.441	0.225	1.591	4.257	0.78	0.28	0.200[8]
Areys Pond	0.468	0.526	0.778	1.304	0.181	5.996	7.480	0.73	0.30	
Namequoit River	0.562	0.726	2.011	2.737	0.523	14.570	17.830	0.73-0.83	0.24-0.30	0.200[8]
Paw Wah Pond	0.233	0.351	1.510	1.860	0.082	3.630	5.572	0.71	0.27	0.200[8]
Pochet Neck	1.233	1.808	6.614	8.422	1.767	-0.791	9.398	0.72-0.78	0.24-0.28	0.200[8]
Little Pleasant Bay	1.660	3.148	4.986	8.134	24.086	37.226	69.446	0.57-0.77	0.14-0.18	
Quanset Pond	0.296	0.378	1.403	1.781	0.170	5.988	7.939	0.56-0.60	0.19-0.21	0.200[8]

[1] assumes entire watershed is forested (i.e., no anthropogenic sources)
[2] composed of non-wastewater loads, e.g. fertilizer and runoff and natural surfaces and atmospheric deposition to lakes
[3] existing wastewater treatment facility discharges to groundwater
[4] composed of combined natural background, fertilizer, runoff, and septic system loadings
[5] atmospheric deposition to embayment surface only
[6] composed of natural background, fertilizer, runoff, septic system atmospheric deposition and benthic flux loadings
[7] average of 2000 – 2005 data, ranges show the upper to lower regions (highest-lowest) of an sub-embayment.
[8] Threshold for sentinel sites correspond to monitoring station locations: The River (upper) WMO-10, The River (mouth) PBA-13, Lonnies Pond PBA-15, Namequoit River WMO-06, Paw Wah Pond PBA-11, Pochet Neck WMO-05, Quanset Pond WMO-12, Round Cove PBA-09, Muddy Creek PBA-05, Ryder Cove PBA-13 and CM-13.

Table ES-1b. Existing total and sub-embayment nitrogen loads to the estuarine waters of the Pleasant Bay system, observed nitrogen concentrations, and sentinel system threshold nitrogen concentrations. Loads to estuarine waters of Pleasant Bay include both upper watershed regions contributing to major surface water inputs.

Sub-embayments	Natural Background Watershed Load [1] (kg/day)	Present Land Use Load [2] (kg/day)	Present Septic System Load (kg/day)	Present Watershed Load [4] (kg/day)	Direct Atmospheric Deposition [5] (kg/day)	Present Net Benthic Flux (kg/day)	Present Total Load [6] (kg/day)	Observed TN Conc. [7] (mg/L)	Observed Bioactive N Conc. [7] (mg/L)	Threshold Bioactive N Conc. (mg/L)
PLEASANT BAY SYSTEM										
Round Cove	0.603	1.063	3.162	4.225	0.170	8.416	12.811	0.71	0.25	0.200[8]
Muddy Creek - upper	1.951	2.825	7.156	9.981	0.162	4.560	14.702	1.26	0.70	
Muddy Creek - lower	1.471	2.137	6.340	8.477	0.205	-1.226	7.457	0.57	0.24	0.200[8]
Pleasant Bay	3.808	14.408	14.874	29.282	37.005	108.821	175.108	0.44-0.73	0.14-0.19	
Bassing Harbor - Ryder Cove	2.003	2.682	7.137	9.819	1.296	9.356	20.471	0.42-0.72	0.16-0.25	0.160[8]
Bassing Harbor - Frost Fish Creek	0.400	0.704	2.200	2.904	0.096	-0.154	2.846	1.16	0.35	
Bassing Harbor - Crows Pond	0.534	0.893	3.326	4.219	1.389	0.612	6.220	0.84	0.21	
Bassing Harbor	0.233	0.268	1.400	1.668	1.071	-4.976	-2.237	0.49	0.12	
Chatham Harbor	1.838	2.904	14.195	17.099	14.153	-40.208	-8.956	0.35-0.43	0.10-0.11	
Pleasant Bay System Total	**19.951**	**38.400**	**88.803**	**127.203**	**85.693**	**184.519**	**397.415**	**0.35-1.26**	**0.10-0.70**	**0.160[8]**

1 assumes entire watershed is forested (i.e., no anthropogenic sources)
2 composed of non-wastewater loads, e.g. fertilizer and runoff and natural surfaces and atmospheric deposition to lakes
3 existing wastewater treatment facility discharges to groundwater
4 composed of combined natural background, fertilizer, runoff, and septic system loadings
5 atmospheric deposition to embayment surface only
6 composed of natural background, fertilizer, runoff, septic system atmospheric deposition and benthic flux loadings
7 average of 2000 – 2005 data, ranges show the upper to lower regions (highest-lowest) of an sub-embayment.
8 Threshold for sentinel sites correspond to monitoring station locations: The River (upper) WMO-10, The River (mouth) PBA-13, Lonnies Pond PBA-15, Namequoit River WMO-06, Paw Wah Pond PBA-11, Pochet Neck WMO-05, Quanset Pond WMO-12, Round Cove PBA-09, Muddy Creek PBA-05, Ryder Cove PBA-13 and CM-13.

Table ES-2a. Present Watershed Loads, Thresholds Loads, and the percent reductions necessary to achieve the threshold concentrations identified for the Pleasant Bay system.

Sub-embayments	Present Watershed Load [1] (kg/day)	Target Threshold Watershed Load [2] (kg/day)	Direct Atmospheric Deposition (kg/day)	Benthic Flux Net [3] (kg/day)	Percent watershed reductions needed to achieve threshold load levels
PLEASANT BAY SYSTEM					
Meetinghouse Pond	6.197	1.058	0.584	7.857	-82.9%
The River - upper	2.773	1.737	0.288	4.102	-37.4%
The River - lower	3.879	2.444	2.241	8.517	-37.0%
Lonnies Pond	2.441	1.626	0.225	1.304	-33.4%
Areys Pond	1.304	0.915	0.181	4.929	-29.8%
Namequoit River	2.737	1.732	0.523	12.232	-36.7%
Paw Wah Pond	1.860	0.728	0.082	2.665	-60.9%
Pochet Neck	8.422	4.123	1.767	-0.622	-51.0%
Little Pleasant Bay	8.134	5.878	24.086	35.222	-27.7%
Quanset Pond	1.781	1.079	0.170	4.787	-39.4%

(1) Composed of combined natural background, fertilizer, runoff, and septic system loadings.
(2) Target threshold watershed load is the load from the watershed needed to meet the embayment threshold concentration identified in Table ES-1.
(3) Projected future flux (present rates reduced approximately proportional to watershed load reductions).

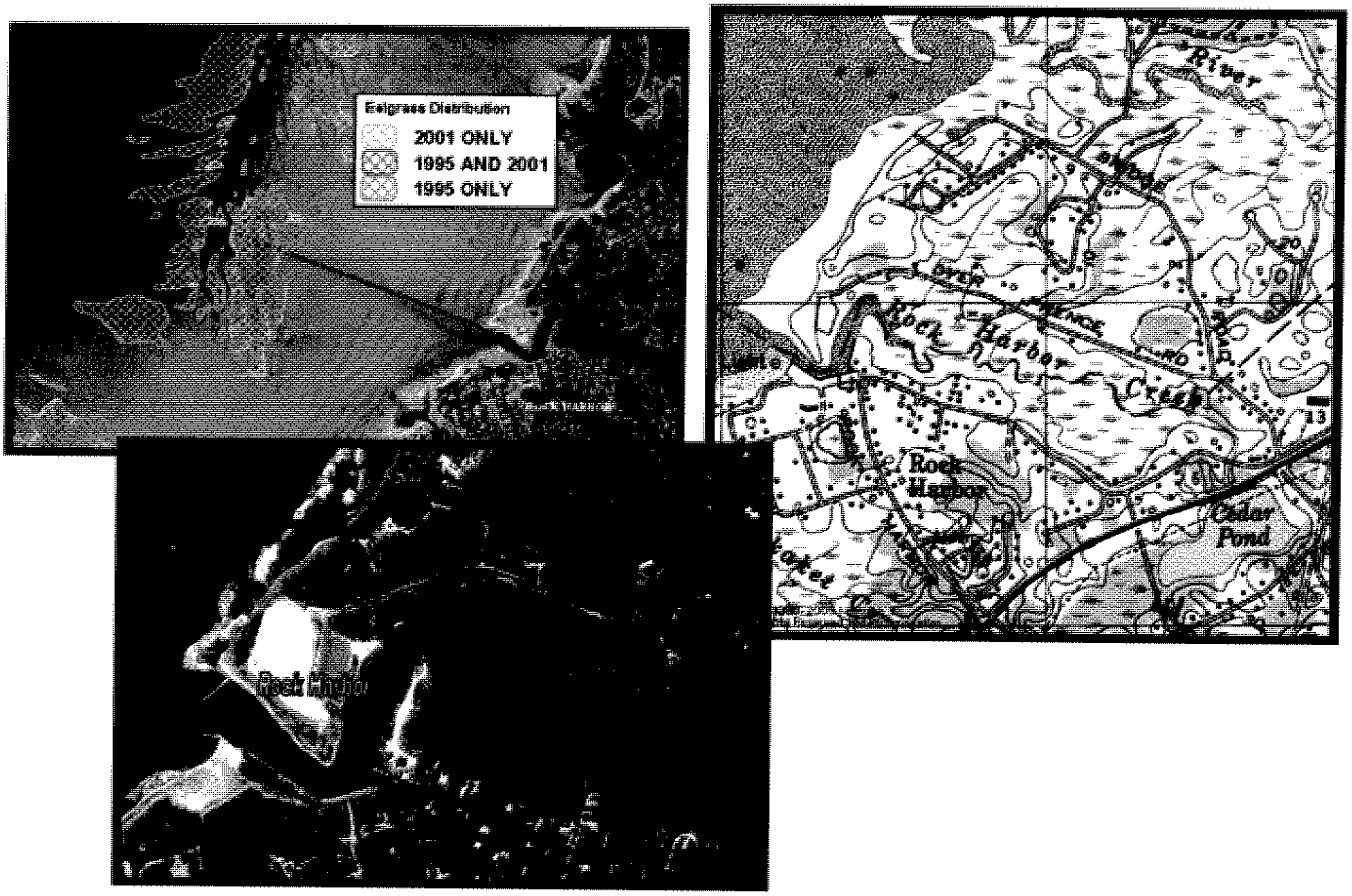
Table ES-2b. Present Watershed Loads, Thresholds Loads, and the percent reductions necessary to achieve the threshold concentrations identified for the Pleasant Bay system.

Sub-embayments	Present Watershed Load [1] (kg/day)	Target Threshold Watershed Load [2] (kg/day)	Direct Atmospheric Deposition (kg/day)	Benthic Flux Net [3] (kg/day)	Percent watershed reductions needed to achieve threshold load levels
PLEASANT BAY SYSTEM					
Round Cove	4.225	2.960	0.170	6.739	-29.9%
Muddy Creek - upper	9.981	4.614	0.162	2.700	-53.8%
Muddy Creek - lower	8.477	2.137	0.205	-0.710	-74.8%
Pleasant Bay	29.282	21.845	37.005	96.170	-25.4%
Bassing Harbor - Ryder Cove	9.819	4.466	1.296	6.705	-54.5%
Bassing Harbor - Frost Fish Creek	2.904	0.704	0.096	-0.087	-75.8%
Bassing Harbor - Crows Pond	4.219	4.219	1.389	0.612	0.0%
Bassing Harbor	1.668	1.668	1.071	-4.460	0.0%
Chatham Harbor	17.099	17.099	14.153	-38.398	0.0%
Pleasant Bay System Total	**127.203**	**81.032**	**85.693**	**150.264**	**-36.3%**

(1) Composed of combined natural background, fertilizer, runoff, and septic system loadings.
(2) Target threshold watershed load is the load from the watershed needed to meet the embayment threshold concentration identified in Table ES-1.
(3) Projected future flux (present rates reduced approximately proportional to watershed load reductions).
(4) Sum of target threshold watershed load, atmospheric deposition load, and benthic flux load.

Massachusetts Estuaries Project

Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Threshold for the Rock Harbor Embayment System, Orleans, Massachusetts



University of Massachusetts Dartmouth
School of Marine Science and Technology

Massachusetts Department of
Environmental Protection

FINAL REPORT – December 2008

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Brian Howes
Roland Samimy
David Schlezinger

Sean Kelley
John Ramsey

Ed Eichner

Contributors:

US Geological Survey
Don Walters and John Masterson

Applied Coastal Research and Engineering, Inc.
Elizabeth Hunt and Trey Ruthven

Massachusetts Department of Environmental Protection
Charles Costello and Brian Dudley (DEP project manager)

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Executive Summary

1. Background

This report presents the results generated from the implementation of the Massachusetts Estuaries Project's Linked Watershed-Embayment Approach to the Rock Harbor embayment system, a coastal embayment situated within the Town of Orleans, Massachusetts. Analyses of the Rock Harbor embayment system was performed to assist the Town with up-coming nitrogen management decisions associated with current and future wastewater planning efforts, as well as wetland restoration, anadromous fish runs, shell fishery, open-space, and harbor maintenance programs. As part of the MEP approach, habitat assessment was conducted on the embayment based upon available water quality monitoring data, historical changes in eelgrass distribution, time-series water column oxygen measurements, and benthic community structure.

Nitrogen loading thresholds for use as goals for watershed nitrogen management are the major product of the MEP effort. In this way, the MEP offers a science-based management approach to support the Town of Orleans resource planning and decision-making process. The primary products of this effort are: (1) a current quantitative assessment of the nutrient related health of the Rock Harbor embayment, (2) identification of all nitrogen sources (and their respective N loads) to embayment waters, (3) nitrogen threshold levels for maintaining Massachusetts Water Quality Standards within embayment waters, (4) analysis of watershed nitrogen loading reduction to achieve the N threshold concentrations in embayment waters, and (5) a functional calibrated and validated Linked Watershed-Embayment modeling tool that can be readily used for evaluation of nitrogen management alternatives (to be developed by the Town) for the restoration / protection of the Rock Harbor embayment system.

Wastewater Planning: As increasing numbers of people occupy coastal watersheds, the associated coastal waters receive increasing pollutant loads. Coastal embayments throughout the Commonwealth of Massachusetts (and along the U.S. eastern seaboard) are becoming nutrient enriched. The elevated nutrients levels are primarily related to the land use impacts associated with the increasing population within the coastal zone over the past half-century.

The regional effects of both nutrient loading and bacterial contamination span the spectrum from environmental to socio-economic impacts and have direct consequences to the culture, economy, and tax base of Massachusetts's coastal communities. The primary nutrient causing the increasing impairment of our coastal embayments is nitrogen, with its primary sources being wastewater disposal, and nonpoint source runoff that carries nitrogen (e.g. fertilizers) from a range of other sources. Nitrogen related water quality decline represents one of the most serious threats to the ecological health of the nearshore coastal waters. Coastal embayments, because of their shallow nature and large shoreline area, are generally the first coastal systems to show the effect of nutrient pollution from terrestrial sources.

In particular, the Rock Harbor embayment system within the Town of Orleans is at risk of eutrophication (over enrichment) in its lower reaches due to enhanced nitrogen loads entering through groundwater and surface water from the increasingly developed watersheds to this complicated estuarine system that includes significant areas of salt marsh. Eutrophication is a process that occurs naturally and gradually over a period of tens or hundreds of years. However, human-related (anthropogenic) sources of nitrogen may be introduced into ecosystems at an accelerated rate that cannot be easily absorbed, resulting in a phenomenon known as cultural eutrophication. In both marine and freshwater systems, cultural eutrophication results in degraded water quality, adverse impacts to ecosystems, and limits on the use of water resources.

The Towns that exist in the Rock Harbor watershed (including the Town of Eastham) have recognized the severity of the problem of eutrophication and the need for watershed nutrient management. Concern over declining resource quality of the estuarine systems of Orleans (inclusive of Rock Harbor) prompted the Town of Orleans to initiate the town-wide Orleans Water Quality Monitoring Program in 2001, which continues in a reduced form through present (2008). The 2001 Program was an expansion of a previous effort targeting Pleasant Bay, begun in 1997 by the Orleans Water Quality Task Force. The town-wide monitoring program is focused on restoring and protecting the estuarine habitats associated with the Town of Orleans and is being undertaken in concert with the DEP/SMAST Massachusetts Estuaries Project. This is a collaborative effort whereby the Town of Orleans provides the support, coordination and oversight of the program through its Planning Office and through its Wastewater Management Steering Committee and SMAST provides the technical and analytical aspects needed for the project through the MEP Technical Team.

The investigations undertaken prior to the Massachusetts Estuaries Project analysis summarized in this report provided significant information related directly to the implementation of the MEP Linked Management Modeling Approach and helped yield insight into the interpretation of the results. In addition, the Town of Orleans' comprehensive Water Quality Monitoring Program was of sufficient rigor to be used as the water quality baseline required for the MEP threshold analysis presented in this MEP Technical Report.

Nitrogen Loading Thresholds and Watershed Nitrogen Management: Realizing the need for scientifically defensible management tools has resulted in a focus on determining the aquatic system's assimilative capacity for nitrogen. The highest-level approach is to directly link the watershed nitrogen inputs with embayment hydrodynamics to produce water quality results that can be validated by water quality monitoring programs. This approach when linked to state-of-the-art habitat assessments yields accurate determination of the "allowable N concentration increase" or "threshold nitrogen concentration". These determined nitrogen concentrations are then directly relatable to the watershed nitrogen loading, which also accounts for the spatial distribution of the nitrogen sources, not just the total load. As such, changes in nitrogen load from differing parts of the embayment watershed can be evaluated relative to the degree to which those load changes drive embayment water column nitrogen concentrations toward the "threshold" for the embayment system. To increase certainty, the "Linked" Model is independently calibrated and validated for each embayment.

Massachusetts Estuaries Project Approach: The Massachusetts Department of Environmental Protection (DEP), the University of Massachusetts – Dartmouth School of Marine Science and Technology (SMAST), and others including the Cape Cod Commission (CCC) have undertaken the task of providing a quantitative tool to communities throughout southeastern Massachusetts (the Linked Watershed-Embayment Management Model) for nutrient management in their coastal embayment systems. Ultimately, use of the Linked Watershed-Embayment Management Model tool by municipalities in the region results in effective screening of nitrogen reduction approaches and eventual restoration and protection of valuable coastal resources. The MEP provides technical guidance in support of policies on nitrogen loading to embayments, wastewater management decisions, and establishment of nitrogen Total Maximum Daily Loads (TMDLs). A TMDL represents the greatest amount of a pollutant that a waterbody can accept and still meet water quality standards for protecting public health and maintaining the designated beneficial uses of those waters for drinking, swimming, recreation and fishing. The MEP modeling approach assesses available options for meeting selected nitrogen goals that are protective of embayment health and achieve water quality standards.

The core of the Massachusetts Estuaries Project analytical method is the Linked Watershed-Embayment Management Modeling Approach, which links watershed inputs with embayment circulation and nitrogen characteristics.

The Linked Model builds on well-accepted basic watershed nitrogen loading approaches such as those used in the Buzzards Bay Project, the CCC models, and other relevant models. However, the Linked Model differs from other nitrogen management models in that it:

- requires site-specific measurements within each watershed and embayment;
- uses realistic "best-estimates" of nitrogen loads from each land-use (as opposed to loads with built-in "safety factors" like Title 5 design loads);
- spatially distributes the watershed nitrogen loading to the embayment;
- accounts for nitrogen attenuation during transport to the embayment;
- includes a 2D or 3D embayment circulation model depending on embayment structure;
- accounts for basin structure, tidal variations, and dispersion within the embayment;
- includes nitrogen regenerated within the embayment;
- is validated by both independent hydrodynamic, nitrogen concentration, and ecological data;
- is calibrated and validated with field data prior to generation of "what if" scenarios.

The Linked Model Approach's greatest assets are its ability to be clearly calibrated and validated, and its utility as a management tool for testing "what if" scenarios for evaluating watershed nitrogen management options.

For a comprehensive description of the Linked Model, please refer to the *Full Report: Nitrogen Modeling to Support Watershed Management: Comparison of Approaches and Sensitivity Analysis*, available for download at http://www.state.ma.us/dep/smerp/smerp.htm. A more basic discussion of the Linked Model is also provided in Appendix F of the *Massachusetts*

Estuaries Project Embayment Restoration Guidance for Implementation Strategies, available for download at http://www.state.ma.us/dep/smerp/smerp.htm. The Linked Model suggests which management solutions will adequately protect or restore embayment water quality by enabling towns to test specific management scenarios and weigh the resulting water quality impact against the cost of that approach. In addition to the management scenarios modeled for this report, the Linked Model can be used to evaluate additional management scenarios and may be updated to reflect future changes in land-use within an embayment watershed or changing embayment characteristics. In addition, since the Model uses a holistic approach (the entire watershed, embayment and tidal source waters), it can be used to evaluate all projects as they relate directly or indirectly to water quality conditions within its geographic boundaries. Unlike many approaches, the Linked Model accounts for nutrient sources, attenuation, and recycling and variations in tidal hydrodynamics and accommodates the spatial distribution of these processes. For an overview of several management scenarios that may be employed to restore embayment water quality, see *Massachusetts Estuaries Project Embayment Restoration Guidance for Implementation Strategies*, available for download at http://www.state.ma.us/dep/smerp/smerp.htm.

Application of MEP Approach: The Linked Model was applied to the Rock Harbor embayment system by using site-specific data collected by the MEP and water quality data from the Orleans Water Quality Task Force Water Quality Monitoring Programs (see Chapter 2). Evaluation of upland nitrogen loading was conducted by the MEP, data was provided by the Planning Departments in each of the Towns represented in the Rock Harbor watershed, and watershed boundaries delineated by USGS. This land-use data was used to determine watershed nitrogen loads within the Rock Harbor embayment system and associated sub-embayments (current and build-out loads are summarized in Chapter IV). Water quality within a sub-embayment is the integration of nitrogen loads with the site-specific estuarine circulation. Therefore, water quality modeling of this tidally influenced estuary included a thorough evaluation of the hydrodynamics of the estuarine system. Estuarine hydrodynamics control a variety of coastal processes including tidal flushing, pollutant dispersion, tidal currents, sedimentation, erosion, and water levels. Once the hydrodynamics of the system was quantified, transport of nitrogen was evaluated from tidal current information developed by the numerical models.

A two-dimensional depth-averaged hydrodynamic model based upon the tidal currents and water elevations was employed for the Rock Harbor embayment system. Once the hydrodynamic properties of the estuarine system was computed, two-dimensional water quality model simulations were used to predict the dispersion of the nitrogen at current loading rates. Using standard dispersion relationships for estuarine systems of this type, the water quality model and the hydrodynamic model was then integrated in order to generate estimates regarding the spread of bio-available and total nitrogen from the site-specific hydrodynamic properties. The distributions of nitrogen loads from watershed sources were determined from land-use analysis while nitrogen entering the coastal embayment was quantified by direct measurement of stream nutrient concentrations and freshwater flow, predominantly groundwater, in streams discharging directly to the embayment. Boundary nutrient concentrations in the Cape Cod Bay source waters were taken from water quality monitoring data. Measurements of current salinity distributions throughout the estuarine waters of the Rock Harbor embayment system was used to calibrate the water quality model, with validation using measured nitrogen concentrations (under existing loading conditions). The underlying hydrodynamic model was calibrated and validated independently using water elevations measured in time series throughout the embayments.

MEP Nitrogen Thresholds Analysis: The threshold nitrogen level for an embayment represents the average water column concentration of nitrogen that will support the habitat quality being sought. The water column nitrogen level is ultimately controlled by the watershed nitrogen load and the nitrogen concentration in the inflowing tidal waters (boundary condition). The water column nitrogen concentration is modified by the extent of sediment regeneration. Threshold nitrogen levels for the embayment systems in this study were developed to restore or maintain SA waters or high habitat quality. High habitat quality was defined as supportive of eelgrass and infaunal communities. Dissolved oxygen and chlorophyll a were also considered in the assessment.

The approach for determining nitrogen loading rates, which will maintain acceptable habitat quality throughout and embayment system, is to first identify a sentinel location within the embayment and second to determine the nitrogen concentration within the water column which will restore that location to the desired habitat quality (threshold nitrogen level). The sentinel location is selected such that the restoration of that one site will necessarily bring the other regions of the system to acceptable habitat quality levels. Once the sentinel site and its target nitrogen level are determined, the Linked Watershed-Embayment Model is used to adjust nitrogen loads sequentially until the targeted nitrogen concentration is achieved. For the Rock Harbor System, the restoration target should reflect both recent pre-degradation habitat quality and be reasonably achievable. The load reductions presented in the report represent only one of a suite of potential reduction approaches that need to be evaluated by the community. The presentation in this report of load reductions aims to establish the general degree and spatial pattern of reduction that will be required for restoration of this nitrogen impaired embayment.

The Massachusetts Estuaries Project's thresholds analysis, as presented in this technical report, provides the site-specific nitrogen reduction guidelines for nitrogen management of the Rock Harbor embayment system (a unique combination of salt marsh and open water in the form of an artificially created open water basin). Future water quality modeling scenarios should be run which incorporate the spectrum of strategies that result in nitrogen loading reduction to the embayment. These scenarios should be developed in coordination with both the Towns in the Rock Harbor watershed in order to effectively examine the effect of load reductions on water column nutrient concentrations. The MEP analysis has initially focused upon nitrogen loads from on-site septic systems as a test of the potential for achieving the level of total nitrogen reduction for restoration of each embayment system. The concept was that since septic system nitrogen loads generally represent 88%-92% of the controllable watershed load to the Rock Harbor embayment system and are more manageable than other of the nitrogen sources, the ability to achieve needed reductions through this source is a good gauge of the feasibility for restoration of these systems.

2. Problem Assessment (Current Conditions)

A habitat assessment was conducted throughout Rock Harbor system based upon available water quality monitoring data, historical changes in eelgrass distribution, time-series water column oxygen measurements, and benthic community structure. The Rock Harbor system is showing high habitat quality throughout its upper salt marsh reach (above WMO-17) and significant habitat impairment in its lower "embayment" reach (e.g. harbor portion, WMO-17 to inlet). The upper reach appears to be a fully functional tidal salt marsh with deeply incised narrow creeks surrounded by significant areas of emergent marsh. This reach is typical of New England "pocket" marshes, with smaller tidal creeks and a marsh plain dominated by low marsh and high marsh plant communities, along with patches of fringing brackish marsh vegetation.

In Contrast, the lower "embayment reach, comprised primarily of the harbor basin, functions as a small open water cove or harbor. This basin is depositional by structure, collecting both algal and salt marsh organic matter with accumulation of anoxic organic-rich fine sediments (sulfidic); it is highly tidal, with sufficient light penetration to allow periodic development of benthic algal mats; and its tidal inlet is influenced by sand transport via nearshore coastal processes associated with adjacent Cape Cod Bay. These features in combination with the observed levels of summer oxygen depletion (to 2 mg L^{-1}), indicate a significantly impaired habitat. This assessment is supported by the impoverished infaunal animal community which is dominated by small opportunistic stress indicator species common to disturbed or organic matter enriched basins.

Based upon all available information the present lack of eelgrass throughout the Rock Harbor System does not appear to be a response to watershed sourced nitrogen loading (e.g. changing watershed land-use). Instead, the absence of eelgrass habitat appears to result from the structure of the upper reach supportive of salt marsh and the lower reach being a maintained depositional basin. The absence of eelgrass within the harbor basin is likely the result of its configuration, in that it is a "relatively deep" depositional basin. In addition, in the lower reach, harbor activities also likely have limited the potential for colonization of this system. Most important relative to MEP nitrogen thresholds analysis, it does not appear that eelgrass beds have been present within the Rock Harbor System at any time over the past century, as indicated by MassDEP Eelgrass Mapping Program analysis and MEP Technical Team historical analysis. Therefore, nitrogen threshold development for protection/restoration of this estuarine system will necessarily focus on restoration of the impaired infaunal habitat within the harbor (embayment reach) and protection of the high quality infaunal habitat within the upper salt marsh reach

3. Conclusions of the Analysis

The threshold nitrogen level for an embayment represents the average watercolumn concentration of nitrogen that will support the habitat quality being sought. The watercolumn nitrogen level is ultimately controlled by the integration of the watershed nitrogen load, the nitrogen concentration in the inflowing tidal waters (boundary condition) and dilution and flushing via tidal flows. The water column nitrogen concentration is modified by the extent of sediment regeneration and by direct atmospheric deposition.

Threshold nitrogen levels for each of the sub-embayment systems in this study were developed to restore or maintain SA waters or high habitat quality. In these systems, high habitat quality was defined as supportive of diverse benthic benthos animal communities. Dissolved oxygen and chlorophyll *a* were also considered in the assessment.

Watershed nitrogen loads (Tables ES-1 and ES-2) for the Rock Harbor embayment system was comprised primarily of wastewater nitrogen. Land-use and wastewater analysis found that generally about 88%-92% of the controllable watershed nitrogen load to the embayment was from wastewater.

The Rock Harbor estuary is a composite of 2 different estuarine systems; an upper salt marsh reach and a lower embayment reach (the harbor). These systems have very different tolerances to nitrogen enrichment and are presently supporting habitats of very different quality, with high quality habitat in the salt marsh and significantly impaired habitat quality within the embayment (Table VIII-1). Since the embayment reach is clearly over its ability to assimilate its present nitrogen load without impairment, restoration will require nitrogen management. A correlative effect of nitrogen management will be that nitrogen loading to the upper salt marsh will also be reduced, although the upper salt marsh is well below its likely nitrogen loading threshold level to maintain its high quality habitats. Therefore the nitrogen threshold for the Rock Harbor System focusing on the habitat quality of the embayment reach will necessarily be protective of the upper salt marsh reach.

The threshold nitrogen levels for the Rock Harbor embayment system in the Towns of Orleans and Eastham were determined as follows:

Rock Harbor Threshold Nitrogen Concentrations

- As a result of the present significant impairment of the infaunal habitat within the embayment reach of the Rock Harbor Estuary and given that there is no evidence that this system has supported eelgrass over the past century, the threshold development necessarily focuses on the embayment reach. The threshold for restoring and maintaining high quality infaunal habitat within the embayment reach of Rock Harbor is 0.500 mg TN L^{-1} (tidally averaged) at the sentinel station located at the head of the harbor (upper region of harbor basin, Town of Orleans Water Quality Monitoring Program station WMO-17). .

- At present, the embayment reach of the Rock Harbor System has elevated total nitrogen levels (0.686 mg N L^{-1}, tidally averaged), with stressful levels of summer oxygen depletion (to 2 mg L^{-1}), sulfidic sediments and depleted infaunal communities dominated by stress indicator species. These observations strongly support the contention that this basin is significantly impaired through nitrogen enrichment. As this basin does not presently support high quality infaunal habitat, the nitrogen threshold analysis was based upon comparisons to a number of small embayments on Cape Cod.

- Based upon these observations, the MEP Technical Team concluded that an upper limit of 0.50 mg N L^{-1} tidally averaged TN would support healthy infaunal habitat in the lower embayment reach of the Rock Harbor System. Equally important, lowering nitrogen levels from the present 0.686 mg N L^{-1} to the threshold 0.500 mg N L^{-1} will lower nitrogen levels within the upper salt marsh (e.g. WMO-18, from 0.829 to 0.615 mg N L^{-1}), protective of those habitats. Therefore, it appears that achieving the nitrogen target at the sentinel location is restorative of infaunal habitat throughout the lower basin and protective of habitats within the upper salt marsh reach.

- The nitrogen concentration thresholds developed through the MEP analysis were used to determine the amount of total nitrogen mass loading reduction required for restoration of infaunal habitats in the Rock Harbor system. Watershed nitrogen loads were sequentially lowered, using reductions in septic effluent discharges only, until the nitrogen levels reached the threshold level at the sentinel stations chosen for Rock Harbor. It is important to note that load reductions can be produced by reduction of any or all sources or by increasing the natural attenuation of nitrogen within the freshwater systems to the embayment. The load reductions presented in the report represent only one of a suite of potential reduction approaches that need to be evaluated by the community. As discussed in Chapter 8, the nitrogen load reductions within the system necessary to achieve the threshold nitrogen concentrations required nearly 70% removal of septic load (associated with direct groundwater discharge to the embayment) for the entire system. The distribution of tidally-averaged nitrogen concentrations associated with the above thresholds analysis is shown in Figure VIII-1

It is important to note that the analysis of future nitrogen loading to the Rock Harbor estuarine system focuses upon additional shifts in land-use from forest/grasslands to residential and commercial development. However, the MEP analysis indicates that significant increases in nitrogen loading can occur under present land-uses, due to shifts in occupancy, shifts from seasonal to year-round usage and increasing use of fertilizers (presently less than half of the parcels use lawn fertilizers). Therefore, watershed-estuarine nitrogen management must include management approaches to prevent increased nitrogen loading from both shifts in land-uses (new sources) and from loading increases of current land-uses. The overarching conclusion of the MEP analysis of the Rock Harbor estuarine system is that restoration will necessitate a reduction in the present nitrogen inputs and management options to negate additional future nitrogen inputs.

Table ES-1. Existing total and sub-embayment nitrogen loads to the estuarine waters of the Rock Harbor system, observed nitrogen concentrations, and sentinel system threshold nitrogen concentrations. Loads to estuarine waters of the Rock Harbor system include both upper watershed regions contributing to the major surface water inputs.

Sub-embayments	Natural Background Watershed Load [1] (kg/day)	Present Land Use Load [2] (kg/day)	Present Septic System Load (kg/day)	Present WWTF Load [3] (kg/day)	Present Watershed Load [4] (kg/day)	Direct Atmospheric Deposition [5] (kg/day)	Present Net Benthic Flux (kg/day)	Present Total Load [6] (kg/day)	Observed TN Conc. [7] (mg/L)	Threshold TN Conc. [8] (mg/L)
ROCK HARBOR SYSTEM										
Rock Harbor	0.822	1.126	6.787	0.065	7.978	0.079	1.382	9.4393	0.66-1.10	--
Rock Harbor Creek	0.107	0.177	0.910	-	1.088	0.000	0.000	1.088	1.14	--
Rock Harbor System Total	0.929	1.303	7.698	0.065	9.066	0.079	1.382	10.527	**0.66-1.14**	**0.500**

1 assumes entire watershed is forested (i.e., no anthropogenic sources)
2 composed of non-wastewater loads, e.g. fertilizer and runoff and natural surfaces and atmospheric deposition to lakes
3 existing unattenuated wastewater treatment facility discharges to groundwater
4 composed of combined natural background, fertilizer, runoff, and septic system loadings
5 atmospheric deposition to embayment surface only.
6 composed of natural background, fertilizer, runoff, septic system atmospheric deposition and benthic flux loadings
7 average of data collected between 2001 and 2006, ranges show the upper to lower regions (highest-lowest) of the indicated sub-embayment.
8 benthic infauna threshold for sentinel site located at the head of the lower basin of the Harbor system.

Table ES-2. Present Watershed Loads, Thresholds Loads, and the percent reductions necessary to achieve the Thresholds Loads for the Acushnet River system.

Sub-embayments	Present Watershed Load [1] (kg/day)	Target Threshold Watershed Load [2] (kg/day)	Direct Atmospheric Deposition (kg/day)	Benthic Flux Net [3] (kg/day)	TMDL [4] (kg/day)	Percent watershed reductions needed to achieve threshold load levels
ROCK HARBOR SYSTEM						
Upper Basin	7.978	2.633	0.079	1.207	3.919	-67.0%
Acushnet River (fresh water)	1.088	1.088	0.000	0.000	1.088	0.0%
Rock Harbor System Total	9.066	3.720	0.079	1.207	5.006	-59.0%

(1) Composed of combined natural background, fertilizer, runoff, WWTF, and septic system loadings.
(2) Target threshold watershed load is the load from the watershed needed to meet the embayment threshold concentration identified in Table ES-1.
(3) Projected future flux (present rates reduced approximately proportional to watershed load reductions).
(4) Sum of target threshold watershed load, atmospheric deposition load, and benthic flux load.

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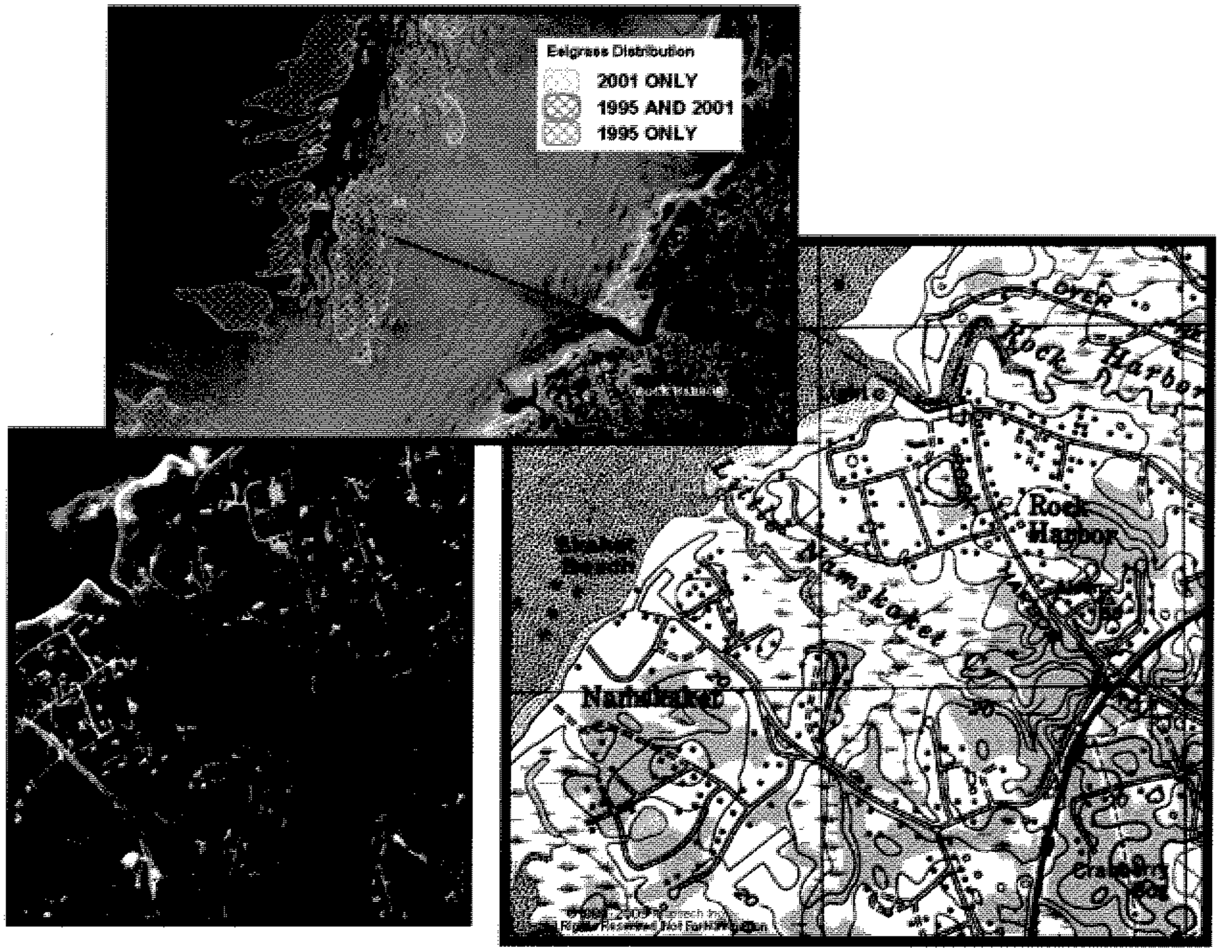

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A two-dimensional depth-averaged hydrodynamic model based upon the tidal currents and water elevations was employed for the Little Namskaket Marsh embayment system. Once the hydrodynamic properties of the estuarine system was computed, two-dimensional water quality model simulations were used to predict the dispersion of the nitrogen at current loading rates. Using standard dispersion relationships for estuarine systems of this type, the water quality model and the hydrodynamic model was then integrated in order to generate estimates regarding the spread of bio-available and total nitrogen from the site-specific hydrodynamic properties. The distributions of nitrogen loads from watershed sources were determined from land-use analysis while nitrogen entering the coastal embayment was quantified by direct measurement of stream nutrient concentrations and freshwater flow, predominantly groundwater, in streams discharging directly to the embayment. Boundary nutrient concentrations in the Cape Cod Bay source waters were taken from water quality monitoring data. Measurements of current salinity distributions throughout the estuarine waters of the Little Namskaket Marsh embayment system was used to calibrate the water quality model, with validation using measured nitrogen concentrations (under existing loading conditions). The underlying hydrodynamic model was calibrated and validated independently using water elevations measured in time series throughout the embayments.

MEP Nitrogen Thresholds Analysis: The threshold nitrogen level for an embayment represents the average water column concentration of nitrogen that will support the habitat quality being sought. The water column nitrogen level is ultimately controlled by the watershed nitrogen load and the nitrogen concentration in the inflowing tidal waters (boundary condition). The water column nitrogen concentration is modified by the extent of sediment regeneration. Threshold nitrogen levels for the embayment systems in this study were developed to restore or maintain SA waters or high habitat quality. High habitat quality was defined as supportive of eelgrass and infaunal communities. Dissolved oxygen and chlorophyll a were also considered in the assessment.

The approach for determining nitrogen loading rates, which will maintain acceptable habitat quality throughout and embayment system, is to first identify a sentinel location within the embayment and second to determine the nitrogen concentration within the water column which will restore that location to the desired habitat quality (threshold nitrogen level). The sentinel location is selected such that the restoration of that one site will necessarily bring the other regions of the system to acceptable habitat quality levels. Once the sentinel site and its target nitrogen level are determined, the Linked Watershed-Embayment Model is used to adjust nitrogen loads sequentially until the targeted nitrogen concentration is achieved. For the Little Namskaket System, the restoration target should reflect of both pre-degradation habitat quality and be reasonably achievable. The presentation in this report of nitrogen loading limits aims to establish the general degree and spatial pattern of loading that will be required for protection of this healthy salt marsh dominated embayment system.

The Massachusetts Estuaries Project's thresholds analysis, as presented in this technical report, provides the site-specific nitrogen loading guidelines for future nitrogen management in the watershed to the Little Namskaket Marsh embayment system. Future water quality modeling scenarios should be run which incorporate the spectrum of strategies that result in changes to nitrogen loading (increase or decrease) to the embayment. These scenarios should be developed in coordination with the Town of Orleans in the Little Namskaket Marsh watershed in order to effectively examine the effect of load increases/reductions on water column nutrient concentrations.

It is important to note that contrary to most other estuarine systems evaluated as part MEP, the threshold concentration for Little Namskaket Marsh was set higher than present conditions, meaning that the system would be allowed to have a higher load than present while still being able to meet the threshold. Therefore, watershed nitrogen loads were sequentially raised in the model until the nitrogen levels reached the threshold level at the sentinel station (WMO-20) chosen for Little Namskaket Creek. It is important to note that load increases could be produced by increasing any or all sources of nitrogen to the system.

2. Problem Assessment (Current Conditions)

A habitat assessment was conducted throughout Little Namskaket Marsh system based upon available water quality monitoring data, historical changes in eelgrass distribution, time-series water column oxygen measurements, and benthic community structure. The Little Namskaket Estuary is showing high habitat quality throughout its salt marsh reach. The upper reach appears to be a fully functional tidal salt marsh with deeply incised narrow creeks surrounded by extensive emergent marsh. This reach is typical of New England "pocket" marshes, with smaller tidal creeks and a marsh plain dominated by low marsh and high marsh plant communities with patches of fringing brackish marsh vegetation. The lower reach of the central tidal creek supports bordering marsh plain that is similar to, but less expansive than, the upper tidal reach. The lower tidal reach is influenced by sand transport via nearshore coastal processes associated with adjacent Cape Cod Bay. Plant communities in the lower reach are similar to the upper reach except that there is less fringing brackish water species and the marsh grades to barrier beach/dune vegetation near the tidal inlet. All of the key habitat indicators support the assessment that Little Namskaket Marsh, and particularly its tidal creeks, are supporting high quality habitat relative to the system's salt marsh structure and function (described in detail in Chapter VII).

3. Conclusions of the Analysis

The threshold nitrogen level for an embayment represents the average watercolumn concentration of nitrogen that will support the habitat quality being sought. The watercolumn nitrogen level is ultimately controlled by the integration of the watershed nitrogen load, the nitrogen concentration in the inflowing tidal waters (boundary condition) and dilution and flushing via tidal flows. The water column nitrogen concentration is modified by the extent of sediment regeneration and by direct atmospheric deposition.

Threshold nitrogen levels for each of the sub-embayment systems in this study were developed to restore or maintain SA waters or high habitat quality. In these systems, high habitat quality was defined as supportive of diverse benthic benthos animal communities. Dissolved oxygen and chlorophyll *a* were also considered in the assessment.

Watershed nitrogen loads (Tables ES-1 and ES-2) for the Little Namskaket Marsh embayment system were comprised primarily of wastewater nitrogen. Land-use and wastewater analysis found that generally about 87% of the controllable watershed nitrogen load to the embayment was from wastewater.

As a salt marsh dominated estuary, Little Namskaket Marsh does not support eelgrass habitat. As a result, threshold development for protection/restoration of this system focuses on infaunal habitat quality. The primary mechanism for infaunal habitat quality decline in salt marsh creeks of this type is through stimulation of macroalgal production and accumulation.

Determination of the critical nitrogen threshold for maintaining high quality habitat within the Little Namskaket estuarine system is based primarily upon: 1) the systems structure and function as a salt marsh, 2) macroalgal distribution, 3) current benthic community indicators and 4) nitrogen levels. Given the database it is possible to develop a site-specific threshold, which is a refinement upon general threshold analysis frequently employed.

The Little Namskaket Estuary is presently supportive of high quality salt marsh infaunal habitat throughout its tidal reach. While there is periodic summertime oxygen depletion of creek waters, the levels are consistent with unimpaired New England salt marsh systems. At present, significant macroalgal accumulations do not occur within this macro-tidal estuary at tidally averaged total nitrogen levels of 1.044 mg N L^{-1}(headwaters) to 0.604 mg N L^{-1} (tidal inlet).

The threshold nitrogen levels for the Little Namskaket Marsh embayment system in the Towns of Orleans and Eastham were determined as follows:

Little Namskaket Marsh Threshold Nitrogen Concentrations

- Little Namskaket Marsh is presently below the level of nitrogen loading that would cause impairment to its infaunal habitats (i.e. below its nitrogen threshold level), therefore, a conservative estimate of the threshold was established. The threshold was based upon site-specific data and comparison to other similar systems on Cape Cod where detailed nitrogen threshold studies have been completed. The inter-estuarine comparison focused upon similar salt marshes which are presently experiencing higher nitrogen levels, with and without impairment.

- A principal component of the high tolerance of salt marsh systems to nitrogen inputs from groundwater and surface water inflows is that unlike embayments, creek waters cannot accumulate nutrients over multiple tidal cycles as embayments do. In addition, increasing the nitrogen concentration in the tidal waters that flood the marsh plain will have a negligible or possibly a stimulatory effect on marsh primary and likely secondary production (i.e. an enhancement of habitat). In addition, since the inflowing fresh waters flow down gradient through the marsh creek and out to the adjacent offshore waters, the nitrogen level will never exceed the inflowing freshwater nitrogen level.

- A detailed nitrogen threshold analysis of Cockle Cove Creek (Chatham), a similarly configured salt marsh to Little Namskaket Creek, has recently been completed (SMAST 2006). In addition to having similar structures, Cockle Cove Creek and Little Namskaket Creek both support similar benthic communities, macroalgal accumulations are sparse to absent in both systems and tidal velocities within the central creek are similar. In addition, the infaunal habitats within Little Namskaket and Cockle Cove Marsh are similar in composition and diversity (dominated by polychaetes and crustaceans, with some mollusks). Based on MEP analysis, it was ascertained that the major infaunal habitat issue related to nitrogen levels in salt marshes (e.g. Little Namskaket Marsh and Cockle Cove) was associated with the potential accumulation of macroalgae within the tidal creek bottom.

- Putting all the assessment elements together, it appears that for Little Namskaket Creek, the critical values are a total nitrogen level of 2 mg N L^{-1} in the headwaters and a level of 1 mg N L^{-1} at the border of the upper and lower reach (Station WMO-20). As this upper/lower boundary station is the uppermost long-term marine water quality sampling site and integrates all of the watershed and upper marsh nitrogen inputs and removals, it was selected as the sentinel station for this system (WMO-20). The threshold (tidally averaged) total nitrogen level of 1 mg N L^{-1} was determined to be appropriate for the sentinel station (WMO-20). This threshold applies as long as the tidal creek maintains its present hydrodynamic characteristics (flushing and velocity). The nitrogen threshold for Little Namskaket Marsh is intentionally conservative based upon all available data from comparable systems. However, it indicates that additional nitrogen may enter this system without impairment of its habitat quality throughout the estuary

The overarching conclusion of the MEP analysis of the Little Namskaket Marsh estuarine system is that protection of this currently healthy salt marsh system will allow for increased nitrogen loading from a variety of watershed sources, however, limits to nitrogen loading have been determined as detailed further in the report. This requires careful long term monitoring of conditions in the marsh system and watershed based management of present and future nitrogen inputs such that nitrogen concentration thresholds specified as supportive of health marsh habitat are not exceeded in the future.

Table ES-1. Existing total and sub-embayment nitrogen loads to the estuarine waters of the Little Namskaket Marsh Creek system, observed nitrogen concentrations, and sentinel system threshold nitrogen concentrations. Loads to estuarine waters of the Little Namskaket system include both upper watershed regions contributing to the major surface water inputs.

Sub-embayments	Natural Background Watershed Load [1] (kg/day)	Present Land Use Load [2] (kg/day)	Present Septic System Load (kg/day)	Present WWTF Load [3] (kg/day)	Present Watershed Load [4] (kg/day)	Direct Atmospheric Deposition [5] (kg/day)	Present Net Benthic Flux (kg/day)	Present Total Load [6] (kg/day)	Observed TN Conc. [7] (mg/L)	Threshold TN Conc. [8] (mg/L)
LITTLE NAMSKATET MARSH SYSTEM										
Little Namskaket marsh	0.249	1.036	6.391	0.049	7.427	0.019	1.140	8.586	0.58-1.24	--
Little Namskaket Creek (freshwater)	0.014	0.060	0.225	-	0.285	-	-	0.285	-	--
Little Namskaket Marsh System Total	0.263	1.096	6.616	0.049	7.712	0.019	1.140	8.871	**0.58-1.24**	**1.000**

[1] assumes entire watershed is forested (i.e., no anthropogenic sources)
[2] composed of non-wastewater loads, e.g. fertilizer and runoff and natural surfaces and atmospheric deposition to lakes
[3] existing unattenuated wastewater treatment facility discharges to groundwater
[4] composed of combined natural background, fertilizer, runoff, and septic system loadings
[5] atmospheric deposition to embayment surface only.
[6] composed of natural background, fertilizer, runoff, septic system atmospheric deposition and benthic flux loadings
[7] average of data collected between 2001 and 2006, ranges show the upper to lower regions (highest-lowest) of the indicated sub-embayment.
[8] threshold for sentinel site located at mid-point WQ monitoring station of the system.

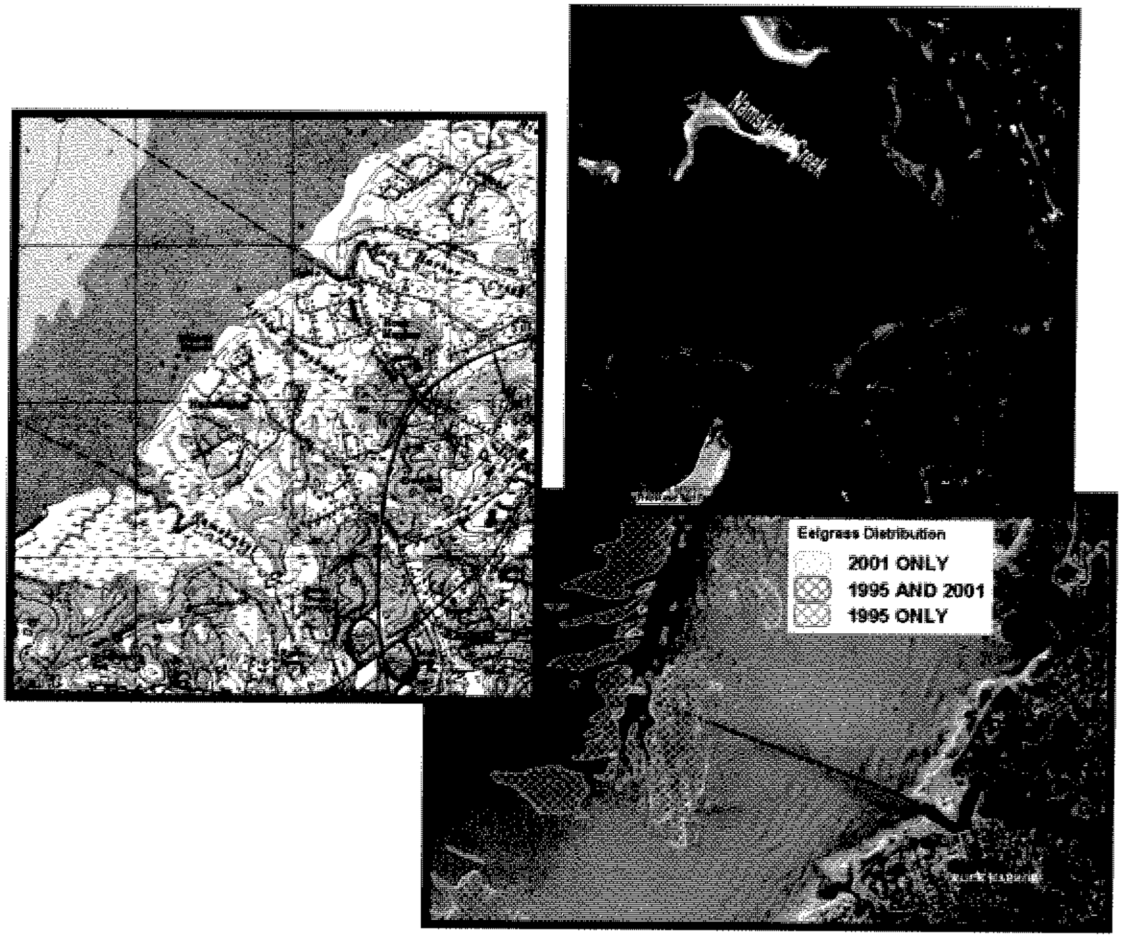
Table ES-2. Present Watershed Loads, Thresholds Loads, and the percent reductions necessary to achieve the Thresholds Loads for the Little Namskaket system.

Sub-embayments	Present Watershed Load [1] (kg/day)	Target Threshold Watershed Load [2] (kg/day)	Direct Atmospheric Deposition (kg/day)	Benthic Flux Net [3] (kg/day)	TMDL [4] (kg/day)	Percent change in watershed load to achieve allowed threshold load levels
LITTLE NAMSKAKET MARSH SYSTEM						
Little Namskaket marsh	7.427	12.381	0.019	1.570	13.970	+66.7%
Little Namskaket Creek (freshwater)	0.285	0.359	-	-	0.359	+26.0%
Little Namskaket Marsh System Total	7.712	12.740	0.019	1.570	14.329	+65.2%

(1) Composed of combined natural background, fertilizer, runoff, and septic system loadings.
(2) Target threshold watershed load is the load from the watershed that meets the embayment threshold concentration identified in Table ES-1.
(3) Projected future flux (present rates reduced approximately proportional to watershed load reductions).
(4) Sum of target threshold watershed load, atmospheric deposition load, and benthic flux load.

Massachusetts Estuaries Project

Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Namskaket Marsh Estuarine System, Orleans, MA



University of Massachusetts Dartmouth
School of Marine Science and Technology

Massachusetts Department of
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FINAL REPORT – December 2008

Massachusetts Estuaries Project

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Brian Howes
Roland Samimy
David Schlezinger

Sean Kelley
John Ramsey

Ed Eichner

Contributors:

US Geological Survey
Don Walters and John Masterson

Applied Coastal Research and Engineering, Inc.
Elizabeth Hunt and Trey Ruthven

Massachusetts Department of Environmental Protection
Charles Costello and Brian Dudley (DEP project manager)

SMAST Coastal Systems Program
Jennifer Benson, Michael Bartlett, Sara Sampieri and Elizabeth White

Cape Cod Commission
Xiaotong Wu

SMAST University of Massachusetts Dartmouth
The School for Marine Science and Technology

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Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Namskaket Marsh Embayment System Town of Orleans, Massachusetts

Executive Summary

1. Background

This report presents the results generated from the implementation of the Massachusetts Estuaries Project's Linked Watershed-Embayment Approach to the Namskaket Marsh embayment system, a coastal embayment situated within the Town of Orleans, Massachusetts. Analyses of the Namskaket Marsh embayment system was performed to assist the Town with up-coming nitrogen management decisions associated with current and future wastewater planning efforts, as well as wetland restoration, anadromous fish runs, shell fishery, and open-space programs. As part of the MEP approach, habitat assessment was conducted on the embayment based upon available water quality monitoring data, historical changes in eelgrass distribution, time-series water column oxygen measurements, and benthic community structure.

Nitrogen loading thresholds for use as goals for watershed nitrogen management are the major product of the MEP effort. In this way, the MEP offers a science-based management approach to support the Town of Orleans resource planning and decision-making process. The primary products of this effort are: (1) a current quantitative assessment of the nutrient related health of the Namskaket Marsh embayment, (2) identification of all nitrogen sources (and their respective N loads) to embayment waters, (3) nitrogen threshold levels for maintaining Massachusetts Water Quality Standards within embayment waters, (4) analysis of watershed nitrogen loading reduction to achieve the N threshold concentrations in embayment waters, and (5) a functional calibrated and validated Linked Watershed-Embayment modeling tool that can be readily used for evaluation of nitrogen management alternatives (to be developed by the Town) for the restoration / protection of the Namskaket embayment system.

Wastewater Planning: As increasing numbers of people occupy coastal watersheds, the associated coastal waters receive increasing pollutant loads. Coastal embayments throughout the Commonwealth of Massachusetts (and along the U.S. eastern seaboard) are becoming nutrient enriched. The elevated nutrients levels are primarily related to the land use impacts associated with the increasing population within the coastal zone over the past half-century.

The regional effects of both nutrient loading and bacterial contamination span the spectrum from environmental to socio-economic impacts and have direct consequences to the culture, economy, and tax base of Massachusetts's coastal communities. The primary nutrient causing the increasing impairment of our coastal embayments is nitrogen, with its primary sources being wastewater disposal, and nonpoint source runoff that carries nitrogen (e.g. fertilizers) from a range of other sources. Nitrogen related water quality decline represents one of the most serious threats to the ecological health of the nearshore coastal waters. Coastal embayments, because of their shallow nature and large shoreline area, are generally the first coastal systems to show the effect of nutrient pollution from terrestrial sources.

In particular, the Namskaket embayment system within the Town of Orleans (though primarily a large salt marsh environment) is at risk of eutrophication (over enrichment) in its upper reaches if enhanced nitrogen loads entering through groundwater and surface water from the increasingly developed watersheds to this complicated estuarine system eventually exceed the salt marshes ability to uptake the nutrient loads. Eutrophication is a process that occurs naturally and gradually over a period of tens or hundreds of years. However, human-related (anthropogenic) sources of nitrogen may be introduced into ecosystems at an accelerated rate that cannot be easily absorbed, resulting in a phenomenon known as cultural eutrophication. In both marine and freshwater systems, cultural eutrophication results in degraded water quality, adverse impacts to ecosystems, and limits on the use of water resources.

The Town of Orleans has recognized the severity of the problem of eutrophication and the need for watershed nutrient management. Concern over declining resource quality of the estuarine systems of Orleans (inclusive of Namskaket Marsh) prompted the Town of Orleans to initiate the town-wide Orleans Water Quality Monitoring Program in 2001, which continues in a reduced form through present (2008). The 2001 Program was an expansion of a previous effort targeting Pleasant Bay, begun in 1997 by the Orleans Water Quality Task Force. The town-wide monitoring program is focused on restoring and protecting the estuarine habitats associated with the Town of Orleans and is being undertaken in concert with the DEP/SMAST Massachusetts Estuaries Project. This is a collaborative effort whereby the Town of Orleans provides the support, coordination and oversight of the program through its Planning Office and through its Wastewater Management Steering Committee and SMAST provides the technical and analytical aspects needed for the project through the MEP Technical Team.

The investigations undertaken prior to the Massachusetts Estuaries Project analysis summarized in this report provided significant information related directly to the implementation of the MEP Linked Management Modeling Approach and helped yield insight into the interpretation of the results. In addition, the Town of Orleans' comprehensive Water Quality Monitoring Program was of sufficient rigor to be used as the water quality baseline required for the MEP threshold analysis presented in this MEP Technical Report.

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- spatially distributes the watershed nitrogen loading to the embayment;
- accounts for nitrogen attenuation during transport to the embayment;
- includes a 2D or 3D embayment circulation model depending on embayment structure;
- accounts for basin structure, tidal variations, and dispersion within the embayment;
- includes nitrogen regenerated within the embayment;
- is validated by both independent hydrodynamic, nitrogen concentration, and ecological data;
- is calibrated and validated with field data prior to generation of "what if" scenarios.

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For a comprehensive description of the Linked Model, please refer to the *Full Report: Nitrogen Modeling to Support Watershed Management: Comparison of Approaches and Sensitivity Analysis*, available for download at http://www.state.ma.us/dep/smerp/smerp.htm. A more basic discussion of the Linked Model is also provided in Appendix F of the *Massachusetts Estuaries Project Embayment Restoration Guidance for Implementation Strategies*, available for download at http://www.state.ma.us/dep/smerp/smerp.htm. The Linked Model suggests which management solutions will adequately protect or restore embayment water quality by enabling towns to test specific management scenarios and weigh the resulting water quality impact against the cost of that approach. In addition to the management scenarios modeled for this report, the Linked Model can be used to evaluate additional management scenarios and may be updated to reflect future changes in land-use within an embayment watershed or changing embayment characteristics. In addition, since the Model uses a holistic approach (the entire watershed, embayment and tidal source waters), it can be used to evaluate all projects as they relate directly or indirectly to water quality conditions within its geographic boundaries. Unlike many approaches, the Linked Model accounts for nutrient sources, attenuation, and recycling and variations in tidal hydrodynamics and accommodates the spatial distribution of these processes. For an overview of several management scenarios that may be employed to restore embayment water quality, see *Massachusetts Estuaries Project Embayment Restoration Guidance for Implementation Strategies*, available for download at http://www.state.ma.us/dep/smerp/smerp.htm.

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A two-dimensional depth-averaged hydrodynamic model based upon the tidal currents and water elevations was employed for the Namskaket Marsh embayment system. Once the hydrodynamic properties of the estuarine system was computed, two-dimensional water quality model simulations were used to predict the dispersion of the nitrogen at current loading rates. Using standard dispersion relationships for estuarine systems of this type, the water quality model and the hydrodynamic model was then integrated in order to generate estimates regarding the spread of bio-available and total nitrogen from the site-specific hydrodynamic properties. The distributions of nitrogen loads from watershed sources were determined from land-use analysis while nitrogen entering the coastal embayment was quantified by direct measurement of stream nutrient concentrations and freshwater flow, predominantly groundwater, in streams discharging directly to the embayment. Boundary nutrient concentrations in the Cape Cod Bay source waters were taken from water quality monitoring data. Measurements of current salinity distributions throughout the estuarine waters of the Namskaket Marsh embayment system was used to calibrate the water quality model, with validation using measured nitrogen concentrations (under existing loading conditions). The underlying hydrodynamic model was calibrated and validated independently using water elevations measured in time series throughout the embayments.

MEP Nitrogen Thresholds Analysis: The threshold nitrogen level for an embayment represents the average water column concentration of nitrogen that will support the habitat quality being sought. The water column nitrogen level is ultimately controlled by the watershed nitrogen load and the nitrogen concentration in the inflowing tidal waters (boundary condition). The water column nitrogen concentration is modified by the extent of sediment regeneration. Threshold nitrogen levels for the embayment systems in this study were developed to restore or maintain SA waters or high habitat quality. High habitat quality was defined as supportive of eelgrass and infaunal communities. Dissolved oxygen and chlorophyll a were also considered in the assessment.

The approach for determining nitrogen loading rates, which will maintain acceptable habitat quality throughout and embayment system, is to first identify a sentinel location within the embayment and second to determine the nitrogen concentration within the water column which will restore that location to the desired habitat quality (threshold nitrogen level). The sentinel location is selected such that the restoration of that one site will necessarily bring the other regions of the system to acceptable habitat quality levels. Once the sentinel site and its target nitrogen level are determined, the Linked Watershed-Embayment Model is used to adjust nitrogen loads sequentially until the targeted nitrogen concentration is achieved. For the Namskaket Marsh system, the restoration target should reflect both pre-degradation habitat quality and be reasonably achievable. The presentation in this report of nitrogen loading limits aims to establish the general degree and spatial pattern of loading that will be required for protection of this healthy salt marsh dominated embayment system.

The Massachusetts Estuaries Project's thresholds analysis, as presented in this technical report, provides the site-specific nitrogen loading guidelines for future nitrogen management in the watershed to the Namskaket Marsh embayment system. Future water quality modeling scenarios should be run which incorporate the spectrum of strategies that result in changes to nitrogen loading (increase or decrease) to the embayment. These scenarios should be developed in coordination with the Town of Orleans in the Namskaket Marsh watershed in order to effectively examine the effect of load increases/reductions on water column nutrient concentrations.

It is important to note that contrary to most other estuarine systems evaluated as part MEP, the threshold concentration for Namskaket Marsh (similar to the adjacent Little Namskaket Marsh) was set higher than present conditions, meaning that the system would be allowed to have a higher load than present while still being able to meet the threshold. Therefore, watershed nitrogen loads were sequentially raised in the model until the nitrogen levels reached the threshold level at the sentinel station (WMO-23) chosen for Namskaket Creek. It is important to note that load increases could be produced by increasing of any or all sources of nitrogen to the system. The load increases presented in this report represent only one of a suite of potential approaches that need to be evaluated by the community. The current presentation is to establish the general degree and spatial pattern of loading that will be allowable for this system.

2. Problem Assessment (Current Conditions)

A habitat assessment was conducted throughout Namskaket Marsh system based upon available water quality monitoring data, historical changes in eelgrass distribution, time-series water column oxygen measurements, and benthic community structure. The Namskaket Estuary is showing high habitat quality throughout its salt marsh reach. The upper reach appears to be a fully functional tidal salt marsh with deeply incised narrow creeks surrounded by extensive emergent marsh. This reach is typical of New England "pocket" marshes, with smaller tidal creeks and a marsh plain dominated by low marsh and high marsh plant communities with patches of fringing brackish marsh vegetation. The lower reach of the marsh supports a large wetland area to the west along with larger tidal creeks. The lower portion of the system is also heavily influenced by sand transport via nearshore coastal processes associated with adjacent Cape Cod Bay. Plant communities in the lower reach are similar to the upper reach except that there is less fringing brackish water species and the marsh grades to barrier beach/dune vegetation near the tidal inlet. All of the key habitat indicators are consistent within Namskaket Marsh, and particularly its tidal creeks, supporting high quality habitat in line with the system's salt marsh structure and function (Chapter VII).

3. Conclusions of the Analysis

The threshold nitrogen level for an embayment represents the average watercolumn concentration of nitrogen that will support the habitat quality being sought. The watercolumn nitrogen level is ultimately controlled by the integration of the watershed nitrogen load, the nitrogen concentration in the inflowing tidal waters (boundary condition) and dilution and flushing via tidal flows. The water column nitrogen concentration is modified by the extent of sediment regeneration and by direct atmospheric deposition.

Threshold nitrogen levels for each of the sub-embayment systems in this study were developed to restore or maintain SA waters or high habitat quality. In these systems, high habitat quality was defined as supportive of diverse benthic benthos animal communities. Dissolved oxygen and chlorophyll *a* were also considered in the assessment.

Watershed nitrogen loads (Tables ES-1 and ES-2) for the Namskaket Marsh embayment system were comprised primarily of wastewater nitrogen. Land-use and wastewater analysis found that generally about 85% of the controllable watershed nitrogen load to the embayment was from wastewater.

As a salt marsh dominated estuary, Namskaket Marsh does not support eelgrass habitat. As a result, threshold development for protection/restoration of this system focuses on infaunal habitat quality. The primary mechanism for infaunal habitat quality decline in salt marsh creeks of this type is through stimulation of macroalgal production and accumulation.

Determination of the critical nitrogen threshold for maintaining high quality habitat within the Namskaket estuarine system is based primarily upon: 1) the systems structure and function as a salt marsh, 2) macroalgal distribution, 3) current benthic community indicators and 4) nitrogen levels. Given the database it is possible to develop a site-specific threshold, which is a refinement upon general threshold analysis frequently employed.

The Namskaket Estuary is presently supportive of high quality salt marsh infaunal habitat throughout its tidal reach. While there is periodic summertime oxygen depletion of creek waters, the levels are consistent with unimpaired New England salt marsh systems. At present, significant macroalgal accumulations do not occur within this macro-tidal estuary at tidally averaged total nitrogen levels of 0.662 mg N L-1 (headwaters) to 0.421 mg N L-1 (tidal inlet).

The threshold nitrogen levels for the Namskaket embayment system in the Towns of Orleans and Eastham were determined as follows:

Namskaket Marsh Threshold Nitrogen Concentrations

- Namskaket Marsh is presently below the level of nitrogen loading that would cause impairment to its infaunal habitats (i.e. below its nitrogen threshold level), therefore, a conservative estimate of the threshold was established. The threshold was based upon site-specific data and comparison to other similar systems on Cape Cod where detailed nitrogen threshold studies have been completed. The inter-estuarine comparison focused upon similar salt marshes which are presently experiencing higher nitrogen levels, with and without impairment.

- A principal component of the high tolerance of salt marsh systems to nitrogen inputs from groundwater and surface water inflows is that unlike embayments, creek waters cannot accumulate nutrients over multiple tidal cycles as embayments do. In addition, increasing the nitrogen concentration in the tidal waters that flood the marsh plain will have a negligible or possibly a stimulatory effect on marsh primary and likely secondary production (i.e. an enhancement of habitat). In addition, since the inflowing fresh waters flow down gradient through the marsh creek and out to the adjacent offshore waters, the nitrogen level will never exceed the inflowing freshwater nitrogen level.

- A detailed nitrogen threshold analysis of Cockle Cove Creek (Chatham), a similarly configured salt marsh to Namskaket Creek, has recently been completed (SMAST 2006). In addition to having similar structures, Cockle Cove Creek and Namskaket Creek both support similar benthic communities, macroalgal accumulations are sparse to absent in both systems and tidal velocities within the central creek are similar. In addition, the infaunal habitats within Namskaket and Cockle Cove Marsh are similar in composition and diversity (dominated by polychaetes and crustaceans, with some mollusks). The dominant species (*Leptocheirus, Paranais*) was also observed in a study of a healthy salt marsh, Great Sippewisset Marsh on Cape Cod.

- Putting all the assessment elements together, it appears that for Namskaket Creek, the critical values are a total nitrogen level of 2 mg N L^{-1} in the headwaters and a level of 1 mg N L^{-1} at the border of the upper and lower reach (Station WMO-23). As this upper/lower boundary station is the uppermost long-term marine water quality sampling site and integrates all of the watershed and upper marsh nitrogen inputs and removals, it was selected as the sentinel station for this system (WMO-23). The threshold (tidally averaged) total nitrogen level of 1 mg N L^{-1}.was determined to be appropriate for the sentinel station (WMO-23). It should be noted that the tidally averaged total nitrogen level at the middle marsh station in Cockle Cove Creek is currently 1.378 mg N L^{-1} and the tidal inlet station shows concentrations of 0.472 mg N L^{-1}, consistent with the 1 mg N L^{-1} at the sentinel station in Namskaket Marsh. This threshold applies as long as the tidal creek maintains its present hydrodynamic characteristics (flushing and velocity). The nitrogen threshold for Namskaket Marsh is intentionally conservative based upon all available data from comparable systems. However, it indicates that additional nitrogen may enter this system without impairment of its habitat quality throughout the estuary.

- As presented in Chapter VIII, the threshold set for this system would allow up to 3.6 times (261% increase) the present watershed loading. The distribution of tidally-averaged nitrogen concentrations associated with the above thresholds analysis is shown in Figure VIII-1.

The overarching conclusion of the MEP analysis of the Namskaket Marsh estuarine system is that protection of this currently healthy salt marsh system will allow for increased nitrogen loading from a variety of watershed sources, however, limits to nitrogen loading have been determined as detailed further in the report. This requires careful long term monitoring of conditions in the marsh system and watershed based management of present and future nitrogen inputs such that nitrogen concentration thresholds specified as supportive of health marsh habitat are not exceeded in the future.

Table ES-1. Existing total and sub-embayment nitrogen loads to the estuarine waters of the Namskaket Marsh system, observed nitrogen concentrations, and sentinel system threshold nitrogen concentrations. Loads to estuarine waters of the Namskaket system include both upper watershed regions contributing to the major surface water inputs.

Sub-embayments	Natural Background Watershed Load [1] (kg/day)	Present Land Use Load [2] (kg/day)	Present Septic System Load (kg/day)	Present WWTF Load [3] (kg/day)	Present Watershed Load [4] (kg/day)	Direct Atmospheric Deposition [5] (kg/day)	Present Net Benthic Flux (kg/day)	Present Total Load [6] (kg/day)	Observed TN Conc. [7] (mg/L)	Threshold TN Conc. [8] (mg/L)
NAMSKATET MARSH SYSTEM										
Namskaket marsh	5.334	3.346	5.944	3.245	9.29	0.118	-0.409	8.999	0.52-0.84	--
Namskaket Creek (freshwater)	0.8	1.306	2.088	-	3.395	-	-	3.395	1.21	--
Namskatet Marsh System Total	6.134	4.652	8.032	-	12.685	0.118	-0.409	12.394	**0.52-1.21**	**1.000**

1 assumes entire watershed is forested (i.e., no anthropogenic sources)
2 composed of non-wastewater loads, e.g. fertilizer and runoff and natural surfaces and atmospheric deposition to lakes
3 existing unattenuated wastewater treatment facility discharges to groundwater
4 composed of combined natural background, fertilizer, runoff, and septic system loadings
5 atmospheric deposition to embayment surface only.
6 composed of natural background, fertilizer, runoff, septic system atmospheric deposition and benthic flux loadings
7 average of data collected between 2001 and 2006, ranges show the upper to lower regions (highest-lowest) of the indicated sub-embayment.
8 threshold for sentinel site located at mid-point WQ monitoring station of the system.

Table ES-2. Present Watershed Loads, Thresholds Loads, and the percent reductions necessary to achieve the Thresholds Loads for the Namskaket system.

Sub-embayments	Present Watershed Load [1] (kg/day)	Target Threshold Watershed Load [2] (kg/day)	Direct Atmospheric Deposition (kg/day)	Benthic Flux Net [3] (kg/day)	TMDL [4] (kg/day)	Percent change in watershed load to achieve allowed threshold load levels
NAMSKATET MARSH SYSTEM						
Namskaket marsh	9.29	31.510	0.118	-0.317	31.628	+239.2%
Namskaket Creek (freshwater)	3.395	14.381	-	-	14.381	+323.6%
Namskatet Marsh System Total	12.685	45.890	0.118	-0.317	46.008	+261.8%

(1) Composed of combined natural background, fertilizer, runoff, and septic system loadings.
(2) Target threshold watershed load is the load from the watershed that meets the embayment threshold concentration identified in Table ES-1.
(3) Projected future flux (present rates reduced approximately proportional to watershed load reductions).
(4) Sum of target threshold watershed load, atmospheric deposition load, and benthic flux load.

APPENDIX H

HABITAT ASSESSMENT LETTER REPORT
LEC ENVIRONMENTAL CONSULTANTS, INC.

WETLANDS WILDLIFE WATERWAYS

December 8, 2010

CERTIFIED MAIL

Kristin Black
Natural Heritage & Endangered Species Program
MA Division of Fisheries & Wildlife
Route 135/North Drive
Westborough, MA 01581

Re: NHESP File #08-26003
Town of Orleans
Comprehensive Wastewater Management Plan
Orleans, Massachusetts

[LEC File#: WP\09-012.01]

Dear Ms. Black:

On behalf of the Applicant, the Town of Orleans (c/o George Meservey, Planning Director), LEC has prepared the following supplemental information to assist the Natural Heritage and Endangered Species Program (NHESP) with review of the Town of Orleans' Comprehensive Wastewater Management Plan (CWMP). The CWMP consists of a proposed municipal sewer system, pumping stations, small wastewater treatment systems (cluster sites), and a primary wastewater treatment facility at 29 Overland Way in Orleans, Massachusetts. In response to a MESA Project Review Application and concept plans (Figures 1-4, dated Nov. 2008), NHESP issued a letter on January 8, 2009, stating that the existing Tri-Town Septage Treatment Facility is located within Priority Habitat for the Eastern Box Turtle (*Terrapene carolina*), Diamond-backed Terrapin (*Malaclemys terrapin*), Salt Reedgrass (*Spartina cynosuroides*), and Mitchell's Sedge (*Carex mitchelliana*). In order for NHESP to continue project review under the *Massachusetts Endangered Species Act* (MESA, M.G.L. c. 131A) and its implementing *Regulations* (321 CMR 10.00), an Eastern Box Turtle Habitat Assessment was requested for the property. Consequently, LEC was retained and a site evaluation was conducted on February 11, 2009, to document existing habitat cover types in relation to potential *T. carolina* habitat.

On April 14, 2009, LEC submitted a *Terrapene carolina* Habitat Assessment report to NHESP. The report provided a description of the treatment facility's existing site conditions, *T. carolina* habitat analysis, and impact assessment in conjunction with a *Terrapene carolina Habitat Cover Type Map* prepared by LEC and dated April 3, 2009. At the time, the Town was reviewing several alternative site layouts for the proposed wastewater treatment facility. Accordingly, Wright-Pierce (Project Engineer) prepared four figures representing the varying alternatives (Figures 1, 2, 3, and 4). The Habitat Assessment Report provided specific details on the four alternative site layouts.

Following preliminary review, Brian Madden (LEC) and Heather Merriman (Wright-Pierce) met with you on April 23, 2009, to discuss the varying alternatives and corresponding state-listed rare species concerns at the Tri-Town site in advance of filing an Expanded Environmental Notification Form (EENF) with the Massachusetts Environmental Policy Act (MEPA) Office. The EENF was published in the Environmental Monitor and a Certificate was issued on July 10, 2009, indicating that while the project requires the preparation of an

Environmental Impact Report (EIR), a Single EIR (SEIR) may be submitted in fulfillment of Section 11.03 of the MEPA Regulations.

The following provides updated details on the CWMP that address the EENF comments received by NHESP in a letter dated June 24, 2009 and the comments issued by MEPA in the EENF Certificate. Specifically, the Town has selected a Recommended Layout (Figure 11-2, Dec 2010) that avoids, minimizes, and mitigates impacts to *T. carolina* at the Tri-Town site. As redesigned, LEC believes the project can be conditioned to avoid a "take" of *T. carolina*.

General Site Description

The 26± acre Tri-Town site is located southeast of the Namskaket Creek Salt Marsh at the terminus of Overland Way within a mixed residential/commercial/industrial portion of Orleans, Massachusetts. The property is bounded by Route 6 to east, residential/commercial/industrial development to the south, radio towers to the west, and the Cape Cod Rail Trail (bike path) to the west and north. The site itself is currently improved by the existing Tri-Town Septage Treatment Facility, comprised of a primary maintenance/office building, smaller maintenance buildings, various storage and treatment tanks, eight effluent disposal (infiltration) basins, paved access roads, and associated parking areas. The existing facility, enclosed by chain-linked fencing on three sides (west, north, and east), is accessed from Overland Way, via a gated, paved roadway extending northerly into the site and eventually terminating at an abandoned compost shed. Currently, a dilapidated wooden stockade fence extends through the southern portion of the site, partially abutting developed conditions. Remaining portions of the property are primarily occupied by undeveloped forested upland and wetland areas.

On-Site Habitat Conditions

Forested Upland

Forested upland conditions occur south and east of the existing facility and west of the paved entranceway. The moderately dense canopy is dominated by pitch pine (*Pinus rigida*), scarlet oak (*Quercus coccinea*), red oak (*Q. rubra*), and white oak (*Q. alba*), along with scattered individuals of black cherry (*Prunus serotina*), eastern white pine (*Pinus strobus*), red maple (*Acer rubrum*), sycamore maple (*Acer pseudoplatanus*), gray birch (*Betula populifolia*), and black locust (*Robinia pseudoacacia*). Density of the shrub layer varies across the site, ranging from fairly sparse to dense thickets with common greenbrier (*Smilax rotundifolia*) entanglements. Scattered sassafras (*Sassafras albidum*) saplings and small patches of black huckleberry (*Gaylussacia baccata*) occur sporadically throughout the understory, in addition to clusters and individuals of highbush blueberry (*Vaccinium corymbosum*), bayberry (*Myrica pensylvanica*), arrowwood (*Viburnum dentatum*), tartarian honeysuckle (*Lonicera tatarica*), and poison ivy (*Toxicodendron radicans*). Seedlings from the canopy and shrub layer dominate the groundcover with scattered tufts of Pennsylvania sedge (*Carex pensylvanica*). These forested upland conditions are fairly typical of the oak/pine natural communities found across Cape Cod.

Mild, rolling topography characterizes the forested upland. Various dirt/earthen woods trails traverse throughout the forested upland areas. In total, forested upland habitat covers approximately 13.1± acres of the site as depicted on the *Terrapene carolina Habitat Cover Type Map*.

Forested Wetland Areas

Forested wetland conditions occupy the southwestern portion of the site. Red maple trees dominate the moderately dense canopy with scattered individuals of tupelo (*Nyssa sylvatica*), pussy willow (*Salix discolor*), and various oaks. The shrub layer is primarily comprised of sweet pepperbush (*Clethra alnifolia*), arrowwood, and highbush blueberry. Cinnamon fern (*Osmunda cinnamomea*), sensitive fern (*Onoclea sensibilis*), skunk cabbage (*Symplocarpus foetidus*), and mats of sphagnum moss (*Sphagnum* spp.) occupy portions of the groundcover with seedlings from the canopy and shrub layer. Common greenbrier entanglements are also prevalent throughout the BVW.

A system of excavated, linear ditches occupies the interior of the wetland system. A small, ephemerally flooded depression containing elevated, vegetated hummocks is located within the BVW northwest of the paved entranceway. Based on water marks and staining, the interior of the forested wetland may hold between 0-8" of standing water following snow melt and during the spring hydroperiod.

The westernmost corner of the wetland system transitions to a fringing emergent marsh system dominated by common reed (*Phragmites australis*). This brackish wetland area receives tidal exchange from an unnamed creek extending underneath the Cape Cod Rail Trail via a buried culvert.

In total, wetland areas cover approximately 4.5± acres of the site (4.0± acres Forested Wetland and 0.50± acres Emergent Marsh).

Developed Conditions

Based on aerial interpretation and field reconnaissance, existing developed conditions, comprised of access roads, parking areas, structures, disposal/infiltration basins, and surrounding lawn/landscaped areas, occupy approximately 8.4± acres of the site. While the embankments along the main entranceway are dominated by ornamental juniper (*Juniperus* spp.) plantings, a variable mix of native and invasive species immediately abuts developed conditions, including, but not limited to, multiflora rose (*Rosa multiflora*), common blackberry (*Rubus allegheniensis*), autumn olive (*Elaeagnus umbellata*), tree-of-heaven (*Ailanthus altissima*), black locust, tartarian honeysuckle, poison ivy, common greenbrier, sweet fern (*Comptonia peregrina*), staghorn sumac (*Rhus typhina*), and various goldenrods (*Solidago* spp.).

Currently, eight disposal/infiltration basins are located within southeastern portion of the developed Tri-Town Septage Treatment facility. Each basin contains a centrally-located concrete column with four steel arms that allow dispersion of effluent across the bottom of the basin. The basins are surrounded by maintained lawn conditions and grassy/earthen access roads utilized for maintenance purposes. Documented herbaceous species within and immediately abutting the basin include Pennsylvania sedge, goldenrods (*Solidago* spp.), asters (*Aster* spp.), little bluestem (*Schizachyrium scoparium*), switchgrass (*Panicum virgatum*), round-headed bush clover (*Lespedeza capitata*), and chicory (*Cichorium* spp.). Additionally, one basin is dominated by common reed. Small, scattered sandy openings occur within the access roads and along the basins' earthen slopes. A paved access road, extending northerly from the terminus of Bay Ridge Lane (gated), and a row of eastern white pine trees occur along the eastern perimeter of the basins' footprint.

Off-Site Habitat Conditions

Adjacent undeveloped habitat cover types surrounding the site primarily consist of forested upland and wetland areas, including emergent marsh, wet meadow, and a salt marsh system.

Forested Upland

Considering the presence of Route 6 and moderately dense commercial development off Route 6A, forested upland conditions south of the site are primarily small, isolated, and fragmented. North of the site and the Cape Cod Rail Trail (bike path), forested upland conditions dominate areas surrounding existing residential development. Vegetative composition and species diversity of off-site forested upland areas are generally consistent with the on-site habitat descriptions.

Wetland Areas

Areas west/southwest of the site are occupied by emergent marsh, wet meadow, and forested/scrub shrub wetland habitat. Vegetative composition and species diversity of off-site forested wetland and emergent marsh habitat are generally consistent with the on-site habitat descriptions. The wet meadow occupies the majority of the aforementioned radio tower property. Broom sedge (*Andropogon virginicus*), soft rush (*Juncus effusus*), various sedges (*Carex* spp.), sensitive fern, cattails (*Typha* spp.), and common reed occupy portions of the wet meadow.

The expansive Namskaket Creek Salt Marsh system occurs northwest of the site and is generally characterized as a typical New England high marsh with brackish-water transition zones primarily dominated by saltmarsh cordgrass *(Spartins patens)* and smooth cordgrass *(Spartina alterniflora)*.

Terrapene carolina Habitat Analysis

T. carolina populations found on Cape Cod occur within a wide variety of connected habitat cover types (e.g., oak/pine upland forests, forested red maple swamps, and open, successional field areas), frequently abutting residential, commercial, and industrial development. Mesic forest areas providing vertical stratification, structure, and plant species composition/diversity, offer adequate *T. carolina* habitat to favor "thermoregulation (of the turtle) by providing cool areas in summer and favorable habitats in which to overwinter" and functioning to "maintain higher humidity than surrounding open zones" (Reagan, 1974). *T. carolina* are not adverse to utilizing wet habitats, especially during drought periods in the summer months (Dodd, 2001), however, individuals typically prefer areas with varying habitat types in fairly close proximity, particularly favoring ecotones between habitats (Madden, 1975). The most favorable conditions for *T. carolina* include warm temperatures, high humidity, and frequent rains (Dodd, 2001, Stickel, 1950; Dolbeer, 1969). Thus, the forested upland and wetland areas immediately surrounding the existing Tri-Town Septage Treatment facility appear to function as viable *T. carolina* Feeding, Breeding, and Migratory habitat on the 26± acre site, constituting 17.6± acres of actual *T. carolina* habitat, albeit fragmented. Appropriate Overwintering Habitat is located throughout the undeveloped forested upland and majority of the forested wetland. Furthermore, areas immediately surrounding the disposal/infiltration basins may function as limited Nesting Habitat.

Forested upland areas containing a mix of oaks and pines posses an accumulated duff layer (leaf litter) and an adequate topsoil depth to thermally protect overwintering *T. carolina* individuals. Additionally, more terrestrial portions of the forested wetland may function as potential Overwintering habitat. Following brumation, the

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entire site possesses the ability to function as Feeding, Breeding, and Migratory Habitat. Edge (ecotone) habitat surrounding existing developed conditions may be sought out for thermoregulation and feeding purposes upon emergence from brumation. All on-site wetland areas provide a cooler microclimate for thermoregulation during the hot summer months, while *T. carolina* individuals aestivate and/or replenish depleted water levels. The on-site habitat cover types also likely provide a sustainable food source for *T. carolina*, including fallen berries and seeds from the overstory and understory, in addition to various fungi/mushrooms that may exist on the forest floor. Furthermore, these habitats likely contain ample carnivorous prey species, including macroinvertebrates (i.e., slugs, snails, earthworms, spiders, isopods, caterpillars, beetles, crickets, etc.) and small amphibians (i.e., frogs, toads, and salamanders).

As noted above, Nesting Habitat appears to be limited on-site. While small, scattered sandy openings occur within the access roads and along the basins' upper slopes, potential Nesting Habitat is likely diminished by maintenance vehicles and equipment accessing the basins (soil compaction and direct disturbance). Furthermore, the interior of these basins are routinely dosed with effluent and cannot function as potential Nesting Habitat.

While the project site affords potential habitat cover types for *T. carolina*, it should be noted that the property offers low estimated population viability due to the on-site developed conditions and overall surrounding habitat landscape. As stated above, the site is bounded by Route 6 to the east, while residential, commercial, and industrial development exist directly to the south, partially abutting Route 6's westbound off-ramp. Additionally, the site is fragmented by existing developed conditions, including multiple buildings, a compost shed, driveways, parking areas, and Overland Way which is routinely utilized by heavy trucks for discharging septic waste. Should *T. carolina* be present on-site, migration activities to undeveloped habitat conditions to the north and west may be disrupted by the presence of the chain-linked fence partially encircling the existing Tri-Town Septage Treatment Facility. However, LEC did note sporadic gaps in the fencing that would not totally exclude migration off-site. Considering the size, fragmented nature, condition, and use of the property in the context of the surrounding habitat landscape, LEC can conclude that the local *T. carolina* population, if present, would likely have a poor probability of long-term persistence due to the limited possibility of genetic exchange.

Prior Site Layouts

Based on existing and future projected needs, while balancing sanitation and environmental concerns, the Town of Orleans initially evaluated various alternative layouts for the proposed wastewater treatment facility. Following review of many factors and through consultation with the Town, Wright Pierce selected a Preferred Layout (see attached Figure 1, April 2009) as part of the Town's draft Comprehensive Wastewater Management Plan (CWMP, draft dated October 2008). The Preferred Alternative and three (3) alternative layouts (Figures 2, 3, and 4) were included with the *Terrapene carolina Habitat Assessment Report* (4/23/09) and EENF. The following reviews each alternative and associated impacts on potential *T. carolina* habitat. As stated above, NHESP's comments on these alternatives ultimately lead to the final CWMP design (described below).

Preferred Layout (Figure 1)

The Preferred Layout included constructing a new wastewater treatment facility, including multiple buildings and storage tanks, immediately south of the existing Tri-Town Septage Treatment Facility parking lot, primarily within forested upland conditions. This would allow the new facility to be constructed if the Tri-Town Septage

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Treatment Facility must remain operational during construction activities. The Tri-Town Septage Treatment Facility currently services the un-sewered property owners in the Towns of Orleans, Brewster, and Eastham. That service must continue through the proposed construction period.

The Preferred Layout also included constructing five new disposal/infiltration basins (#'s 1, 2 and 8-10) in Phase I, slated to be built during a 2-year construction period beginning in 2013. The majority of these new basins would have resulted in alteration to existing forested upland habitat within the eastern portion of the site. However, the western portion of Basin #9 would have replaced a portion of an existing paved roadway east of the existing main building. The Preferred Layout proposed to utilize the eight existing disposal/infiltration basins during the construction period of 2013 to 2015, after which they would be abandoned. Presumably in a later phase of the project (now scheduled for the period of 2022 to 2027), Basin #'s 3-7 would have been constructed in the location of the eight existing disposal/infiltration basins. The majority of the work activities associated with constructing Basin #'s 3-7 were proposed to occur within existing developed conditions. However, there would have needed to be minimal alterations to forested upland conditions within the eastern portion of the site (Basin #'s 3, 4, and 6). In comparison to the existing basins, all proposed basins would have contained vertical retaining walls to define each basin. However, access ramps were to be present for maintenance purposes within each basin's interior. Following construction of all basins, a 10-foot wide gravel drive would have encircled the outer perimeter of the basins footprint. Areas in between each basin were to be reseeded with a native herbaceous seed mix for stabilization purposes. Those areas would receive occasional vehicle traffic for the purposes of maintaining the basins.

Figure 1 depicted the proposed Limit of Work (orange) and disturbed areas (yellow) within forested upland habitat associated with the Preferred Layout. As proposed, the Preferred Layout resulted in approximately 6.5± acres of disturbance (temporary and permanent) to existing *T. carolina* undeveloped habitat; approximately 2.0± acres for proposed structures, storage tanks, and associated lawn/landscaped areas and 4.5± acres for Basin #'s 1-10. In summary, the Preferred Alternative resulted in 6.5± acres of alteration to the existing 17.6± acres (36.9%) of actual *T. carolina* undeveloped habitat present on-site or 49.6% of existing forested upland. However, following construction and regrading activities, approximately 1.6± acres surrounding proposed structures and basins would have been restored and revegetated with a native herbaceous seed mix. Thus, 4.9± acres represent the total loss of actual *T. carolina* habitat on-site (27.8%). Additionally, herbaceous field habitat was to be maintained between the basins and could have functioned as potential *T. carolina* Feeding/Breeding, Migration, and potentially Limited Nesting Habitat.

Alternative A (Figure 2)

Alternative A proposed to reconstruct the existing wastewater facilities, essentially within the same footprint of the Tri-Town Septage facilities. In order to site all new structures and storage tanks, a minimal amount of forested upland habitat would have been altered directly south of the existing parking lot. Additionally, a new paved driveway was proposed to be constructed off Overland Way to provide secondary access to the new structures. During the construction process, measures would have been implemented to provide temporary septage handling. Alternative A included constructing five new disposal/infiltration basins #'s 6-10 in Phase 1 (2013 to 2015). The majority of these new basins resulted in alteration to existing forested upland habitat within the eastern portion of the site. However, portions of Basin #'s 6, 7, and 9 were proposed to occur within developed conditions. Similar to the Preferred Layout, Alternative A proposed to utilize the eight existing disposal/infiltration basins during the construction period of 2013 to 2015, after which they will be abandoned. Presumably in a later phase of the project (tentatively scheduled for the period of 2022 to 2027), Basin #'s 1-5 would have been constructed in the location of the eight existing disposal/infiltration basins. The majority of the work activities associated with constructing Basin #'s 3-5 were proposed to occur within developed conditions, although, portions of Basin #'s 1, 2, and 4 would have occurred within forested upland habitat. As stated above, the proposed basins would contain vertical retaining walls to define each basin along with a perimeter 10-foot wide gravel access drive. Areas in between each basin would be reseeded with a native herbaceous seed mix for stabilization purposes.

As proposed, Alternative A resulted in approximately 5.4± acres of disturbance (temporary and permanent) to existing *T. carolina* undeveloped habitat; approximately 0.7± acres for the proposed expansion south of the Tri-Town's existing parking lot and 4.7± acres for Basin #'s 1-10. In summary, Alternative A resulted in 5.4± acres of the existing 17.6± acres (30.7%) of actual *T. carolina* undeveloped habitat present on-site or 41.2% of existing forested upland. However, following construction and regrading activities, approximately 1.6± acres surrounding the proposed structures and basins were proposed to be restored and revegetated with a native herbaceous seed mix. Thus, 3.8± acres represented the total loss of actual *T. carolina* habitat on-site (21.6%). Additionally, herbaceous field habitat were to be maintained between the basins and could have functioned as potential *T. carolina* Feeding/Breeding, Migration, and potentially Limited Nesting Habitat.

Alternative B (Figure 3)

Alternative B proposed to construct the new wastewater treatment facility south of the project site on Town-owned land off Bay Ridge Lane. Currently, this site is utilized by the Town of Orleans Highway Department as a storage/maintenance yard, containing multiple buildings and garages (see Photograph). Under existing conditions, approximately 2.3± acres of the 2.9± acre Highway Department property are developed. Undeveloped, fringing areas immediately surrounding the storage yard are comprised of a mix of native and invasive species, including, but not limited to black cherry, black locust, eastern red cedar (*Juniperus virginiana*), pussy willow, autumn olive, Japanese knotweed (*Polygonum cuspidatum*), fox grape (*Vitis labrusca*), and Asiatic bittersweet (*Celastrus orbiculata*). In order to accommodate the proposed wastewater facilities, a small portion of forested upland south of the existing development footprint would have needed to be altered (0.1± acres), north of an off-site, unnamed brackish pond.

Under Alternative B, utility lines (effluent force main) would have needed to be installed under Bay Ridge Lane extending northerly along Overland Way to the proposed disposal/infiltration basins located within the northeastern portion of the project site. As represented on Figure 3, Basin #'s 1, 2, 4, 6, and 8 would have been constructed primarily within forested upland conditions (highlighted in yellow), although portions of Basin #'s 1 and 2 would have occurred within the footprint of the existing compost shed and surrounding paved surfaces. This would have required complete removal of the compost shed and revegetating the northern portion of the shed's footprint.

As proposed, the Alternative B resulted in approximately 4.5± acres of disturbance (temporary and permanent) to existing *T. carolina* undeveloped habitat (17.6± acres) on the 26± acre project site, comprised of the basins' footprint within forested upland conditions. Thus, Alternative B will have temporarily altered 25.6% of actual *T. carolina* undeveloped habitat present on-site or 34.3% of existing forested upland. However, following construction and regrading activities, approximately 0.5± acres surrounding the proposed basins were to be

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restored and revegetated with a native herbaceous seed mix. Thus, 4.0± acres represented the total loss of actual *T. carolina* habitat on-site (22.7%), in addition to the 0.1± acres on the Orleans Highway Department property. Additionally, herbaceous field habitat were to be maintained between the basins and could have functioned as potential *T. carolina* Feeding/Breeding, Migration, and potentially Limited Nesting Habitat.

Alternative C (Figure 4)

Alternative C proposed to renovate and utilize as much of the existing Tri-Town Septage Facility as practicable. However, in order to handle the new disposal/infiltration basins, new maintenance buildings and storage tanks would have needed to be constructed within forested upland areas immediately south of the existing parking lot. Basin construction would be phased similar to Alternative A described above.

As proposed, the Alternative C resulted in approximately 5.9± acres of disturbance to existing *T. carolina* undeveloped habitat; approximately 1.3± acres for the proposed expansion of the maintenance buildings and storage tanks and 4.6± acres for Basin #'s 1-10. Approximately 5.9± acres of the existing 17.6± acres (33.5%) of actual *T. carolina* undeveloped habitat present on-site or 45.0% of existing forested upland would be altered under Alternative C. However, following construction and regrading activities, approximately 1.5± acres surrounding the proposed structures and basins were to be restored and revegetated with a native herbaceous seed mix. Thus, 4.4± acres represented the total loss of actual *T. carolina* habitat on-site (25.0%). Additionally, herbaceous field habitat would have been maintained between the basins and could have functioned as potential *T. carolina* Feeding/Breeding, Migration, and potentially Limited Nesting Habitat.

Alternative Summary Table (in acres)

	Preferred Alternative	**Alternative A**	**Alternative B**	**Alternative C**
Structures*	2.0	0.7	0.1	1.3
Basin Footprint**	4.5	4.7	4.5	4.6
Restored/Revegetated Areas (post-construction)	1.6	1.6	0.5	1.5
Temporary & Permanent Alteration	6.5	5.4	4.6	5.9
Permanent Alteration	**4.9**	**3.8**	**4.1**	**4.4**

*Includes structures and surrounding lawn or landscaped conditions.

**Includes proposed developed conditions (e.g., 10-foot wide gravel drive) surrounding the basins.

Expanded Environmental Notification Form Rare Species Review

Following review of the EENF, NHESP issued a comment letter on June 24, 2009, stating that *the NHESP anticipates that depending upon the selected alternative, the currently proposed project may or may not result in a "take" of the Eastern Box Turtle. While the majority of the proposed sewers and pumping stations occur outside of Priority Habitat or are exempt from MESA review pursuant to 321 CMR 10.14, the proposed construction of the wastewater treatment and disposal facilities located at the Tri-Town site will occur fully within the mapped habitat of the Eastern Box Turtle and is subject to MESA review...It is the opinion of the*

NHESP that alternatives which result in the least amount of direct and indirect (e.g., fragmentation of habitat) impacts to state-listed species habitat are preferred for the proposed wastewater treatment and disposal facilities. Therefore, the NHESP prefers Alternative B over the other alternatives. New alternative designs that maximize reuse of existing disturbed areas and avoid fragmentation of remaining undisturbed habitat area also likely to be preferred by the NHESP. The EENF Certificate emphasizes the need for the SEIR to evaluate avoidance/mitigation strategies and identify necessary project construction and post-construction conditions and commitments to avoid any adverse impacts to Eastern Box Turtle habitat.

Final Comprehensive Wastewater Management Plan

Tri-Town Septage Treatment Facility

Based on NHESP's EENF comments, the Town has selected a revised alternative layout that avoids, minimizes, and mitigates impacts to *T. carolina* at the Tri-Town site. The Recommended Layout depicted on Figure 11-2 (Dec 2010) implements a combination of the prior alternatives to reduce the amount of direct and indirect impacts to Eastern Box Turtle habitat. The design proposes to largely reconstruct the existing wastewater facilities, essentially within the same footprint of the Tri-Town Septage facilities. A new paved driveway is proposed to be constructed off Overland Way to provide secondary access to the new structures. The driveway has been consolidated close to the proposed new buildings and storage tanks. In order to site the driveway extension, a minimal amount of forested upland habitat will be altered directly south of the existing parking lot and abutting lawn areas. During the construction process, measures will be implemented to provide temporary septage handling.

The Recommended Layout includes constructing five new disposal/infiltration basins #'s 6-10 in Phase 1 (2015 to 2017). These proposed basin footprints primarily occur within forested upland habitat between the existing basins and compost shed. However, the western edges of Basin #'s 7 and 9 minimally occur within developed conditions. The Recommended Layout proposes to utilize the eight existing disposal/infiltration basins during the construction period of 2015 to 2017, after which they will be abandoned. Presumably in a later phase of the project (tentatively scheduled for the period of 2024 to 2029), Basin #'s 1-5 will be constructed in the location of the eight existing disposal/infiltration basins. The majority of the work activities associated with constructing Basin #'s 1, 3, and 5 are proposed to occur within developed conditions. Perimeter portions of Basin #'s 1, 2, 4, and 5 are located within forested upland habitat. All proposed basins will contain vertical retaining walls to define each basin along with a perimeter 10-foot wide gravel access drive. Areas in between each basin would be reseeded with a native herbaceous seed mix for stabilization purposes.

As proposed, the Recommended Layout results in approximately 6.0± acres of disturbance (temporary and permanent) to existing *T. carolina* undeveloped habitat; approximately 0.4± acres for the proposed expansion south of the Tri-Town's existing parking lot and 5.6 ± acres for the proposed basins and abutting 10-foot wide gravel access drives. Following construction and regrading activities, approximately 1.1± acres surrounding the outer perimeter of the proposed basins will be restored and revegetated with a native herbaceous seed mix. Thus, 4.9± acres represents the permanent disturbance of actual *T. carolina* habitat on-site (27.8%).

The Recommended Layout serves to maximize reuse of the existing developed and disturbed areas, while avoiding the fragmentation of remaining undisturbed habitat as requested by NHESP. As proposed, the Recommended Layout will afford contiguous forested upland habitat preservation south of the wastewater facilities and basins. Once all construction is complete and the temporary work activities are stabilized by vegetation (Early Successional Edge Habitat), potential migration corridors will be maintained along the far eastern portion of the site, extending parallel to Route 6. Existing developed areas located west of proposed Basin #'s 1 and 3 may also be revegetated following construction. In summary, the Recommended Layout serves to promote the continued protection of *T. carolina* Overwintering, Feeding/Breeding, Migration, and Limited Nesting Habitat.

Final CWMP Summary Table (in acres)

	Recommended Layout
Structures/Driveway*	0.4
Basin Footprint**	5.6
Restored/Revegetated Areas (post-construction)	1.1
Temporary & Permanent Alteration	6.0
Permanent Alteration	**4.9**

*Includes structures, driveway, and surrounding lawn or landscaped conditions.

**Includes proposed developed conditions (e.g., 10-foot wide gravel drive) surrounding the basins.

Small Wastewater Treatment Systems (Cluster Systems)

Similar to the proposed sewers and pumping stations, the CWMP includes the construction of small wastewater treatment systems or clusters systems that occur outside of Priority Habitat or are exempt from MESA review pursuant to 321 CMR 10.14. The cluster systems are meant to provide collection, treatment, and disposal of wastewater to small neighborhoods within watersheds proximate to either impacted coastal embayment or a freshwater Pond. Five cluster systems are proposed in total, only two of which occur within Priority Habitat.

Figure I-2 (Dec 2010) depicts a cluster system proximate to Lonnie's Pond and Crystal Pond and Figure I-5 (Dec 2010) depicts a cluster system south of Bakers Pond. Priority Habitat extends off both Ponds, generally engulfing undeveloped land. Presumably these Pond systems and abutting habitat areas are mapped for the presence of state-listed rare invertebrates and/or plants specific to the Ponds' shoreline or benthic habitat. Portions of sewering activities may occur within Priority Habitat, but will likely fall within an exempt category. Any associated treatment facility or effluent disposal area will be located outside Priority Habitat surrounding these Ponds.

Mitigating Measures

The Town is proposing a series of mitigating measures to avoid and minimize adverse impacts to *T. carolina* during and post-construction at the Tri-Town site.

Temporary Turtle Barriers

Prior to the initiation of any work, between April 1st and October 31st, the entire Limit of Work will be fully encircled with a continuous and properly installed silt fencing or a similar temporary turtle barrier approved by NHESP. Installation of the silt fencing will be conducted so as to minimize vegetation disturbance. The bottom of the silt fencing will be carefully buried in a 4-6 inch deep trench, to be backfilled and compacted. Any hay or straw bales shall be placed on the work-side of the siltation barrier or eliminated from use.

Pre-Construction Turtle Sweeps

Prior to the beginning of any work, including any tree clearing, the NHESP-approved wildlife biologist will review with NHESP the extent of required pre-construction turtle sweeps for all phased construction activities and associated Limit of Work. The wildlife biologist will utilize NHESP-approved protocols (specifying timing and duration of surveying effort) to locate *T. carolina* individuals. The wildlife biologist must obtain a Scientific Collection Permit in advance of the searches. All searches must be conducted during appropriate weather conditions and should occur between May 1st and October 15th, unless otherwise approved by NHESP. Any state-listed vertebrate species encountered during these searches shall be released in appropriate habitat near, but outside of, the construction areas. Within 10 days of the completion of searches by the qualified wildlife biologist, a report will be submitted to the NHESP indicating the dates of each pre-work search, the number of hours searched per date, all state-listed rare species encountered, and the condition of all turtle barriers. All state-listed species encountered will also be reported to the NHESP through a Rare Animal Observation Form to be included in the aforementioned report.

Pre-construction turtle sweeps are not necessary if work activities occur solely within existing developed conditions and commence during the *T. carolina* inactive season (October 31st through April 1st). Should temporary turtle barriers not be installed by April 1st, turtle sweeps must be conducted as approved by NHESP.

Contractor Education

A NHESP-approved wildlife biologist will conduct a training session to educate contractors on the likely presence of *T. carolina* within the vicinity of the Project Reference materials will be distributed to describe proper identification of *T. carolina* and appropriate protocols should a turtle be encountered within the active construction area.

Construction Monitoring

Throughout the construction period, the temporary turtle barriers will be maintained in good condition and repaired as necessary. Materials to repair the barriers (i.e., additional siltation fencing and stakes) will be stockpiled on-site and be accessible to all persons. A full length check of the turtle barrier will be conducted daily by a person familiar with siltation barrier maintenance between March 15th and November 15th of each year to ensure that barriers prevent state-listed turtles from entering the limits of work.

If any *T. carolina* individuals are found within the Limit of Work: 1) the turtle will be immediately moved to the side of the barrier opposite the Limit of Work side, AND 2) within 24 hours, a full-length perimeter evaluation of the turtle barrier will be conducted to locate and repair, as necessary, any breaches that may have allowed turtles to enter into the Limit of Work area.

Proposed Field Edge Habitat Areas

As stated above, approximately 1.1± acres surrounding the wastewater facilities are proposed to be restored and revegetated with a native herbaceous seed mix. The restored field edge habitat will be maintained to function as potential *T. carolina* Feeding/Breeding, Migration, and potentially Limited Nesting Habitat. These habitat areas will not be mowed between May 15th and September 15th of any year. Should mowing occur between April 15th and May 14th and/or September 16th and October 15th, mower blade heights will be set at a minimum of 7 inches off the ground. In accordance with NHESP's *MOWING ADVISORY GUIDELINES IN RARE TURTLE HABITAT: PASTURES, SUCCESSIONAL FIELDS, AND HAYFIELDS* (February 23, 2009), mowing will be conducted in low gear or at slow speeds commencing within the interior of the site and working outward to allow turtles maximum time to move out of the field areas.

Summary

On behalf of the Town of Orleans, LEC has provided NHESP with this supplemental information on the Town of Orleans' Comprehensive Wastewater Management Plan (CWMP). Based on NHESP comments during the EENF process, the Town has selected a Recommended Layout for the primary wastewater treatment facility at the Tri-Town Septage Treatment Facility. The Recommended Layout depicted on Figure 11-2 (Dec 2010) avoids habitat fragmentation, while consolidating proposed work activities within existing developed conditions, thereby promoting on-site habitat protection. The Town is proposing a series of mitigating measures, including temporary turtle barriers, phase-specific pre-construction turtle sweeps, contractor education, construction monitoring, and field edge habitat creation and appropriate management, to achieve a conditional no "take" under MESA. As currently proposed, the project serves to avoid, minimize, and mitigate impacts to state-listed rare species habitat

The Town will be submitting the SEIR shortly and wishes to complete NHESP review in order to obtain a conditional no "take" determination. Should you have any questions or require additional information, please do not hesitate to contact me in our Plymouth office at 508-746-9491 or bmadden@lecenvironmental.com.

Sincerely,

LEC Environmental Consultants, Inc.

Brian T. Madden
Wildlife Scientist

Ann M. Marton (BTM)
Ann M. Marton
Director of Ecological Services

cc: Town of Orleans (c/o George Meservey)
Wright-Pierce (Michael D. Giggey)


Photograph 1: Northeasterly view of forested upland conditions (typical) located south of existing parking lot and southwest of eight disposal/infiltration basins.*


Photograph 2: Northeasterly view of forested upland conditions and earthen cart path located within the eastern/northeastern portion of project site.*

*Photographs taken on February 11, 2009

Photograph 3: Southeasterly view of the existing eight disposal/infiltration basins.*

Photograph 4: Southwesterly view of forested upland habitat located within western portion of project site and abutting chain-linked fence.*

*Photographs taken on February 11, 2009

Photograph 5: Westerly/northwesterly view of forested wetland conditions located within the western portion of project site.*

Photograph 6: Southeasterly view of Orleans Highway Department property off Bay Ridge Lane.*

*Photographs taken on February 11, 2009

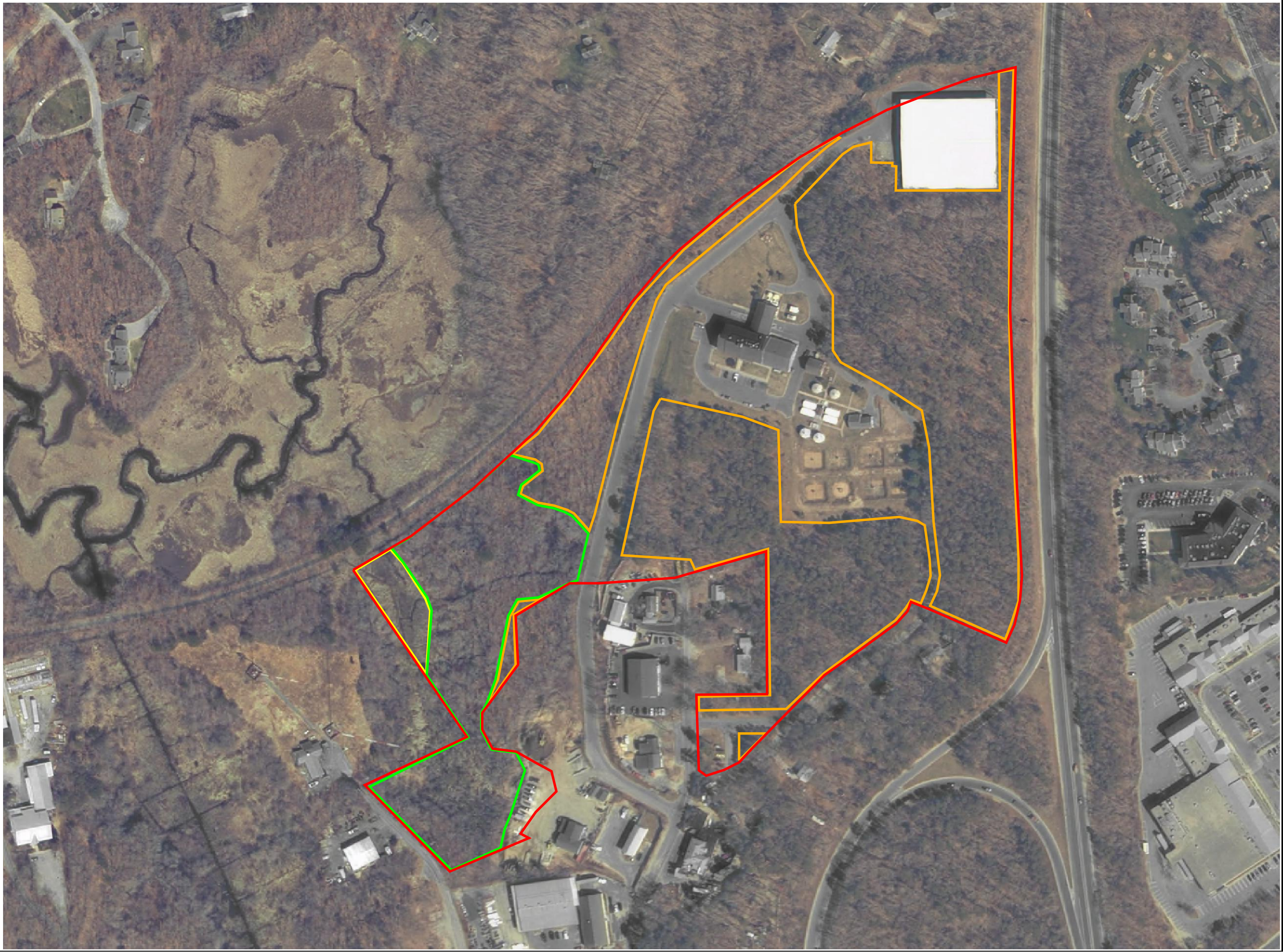
LEC
Environmental Consultants, Inc.
36 Cordage Park Circle, Suite 312
Plymouth, MA 02360
508.746.9491; 508.746.9492 Fax
southlec@lecenvironmental.com

Aerial Orthophoto

Proposed Wastewater Treatment Facility
29 Overland Way
Orleans, MA

Approx Scale
1:350

April 3, 2009



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36 Cordage Park Circle, Suite 312
Plymouth, MA 02360
508.746.9491; 508.746.9492 Fax
southlec@lecenvironmental.com

Terrapene carolina Habitat Cover Type Map

Proposed Wastewater Treatment Facility
29 Overland Way
Orleans, MA

April 3, 2009

Legend

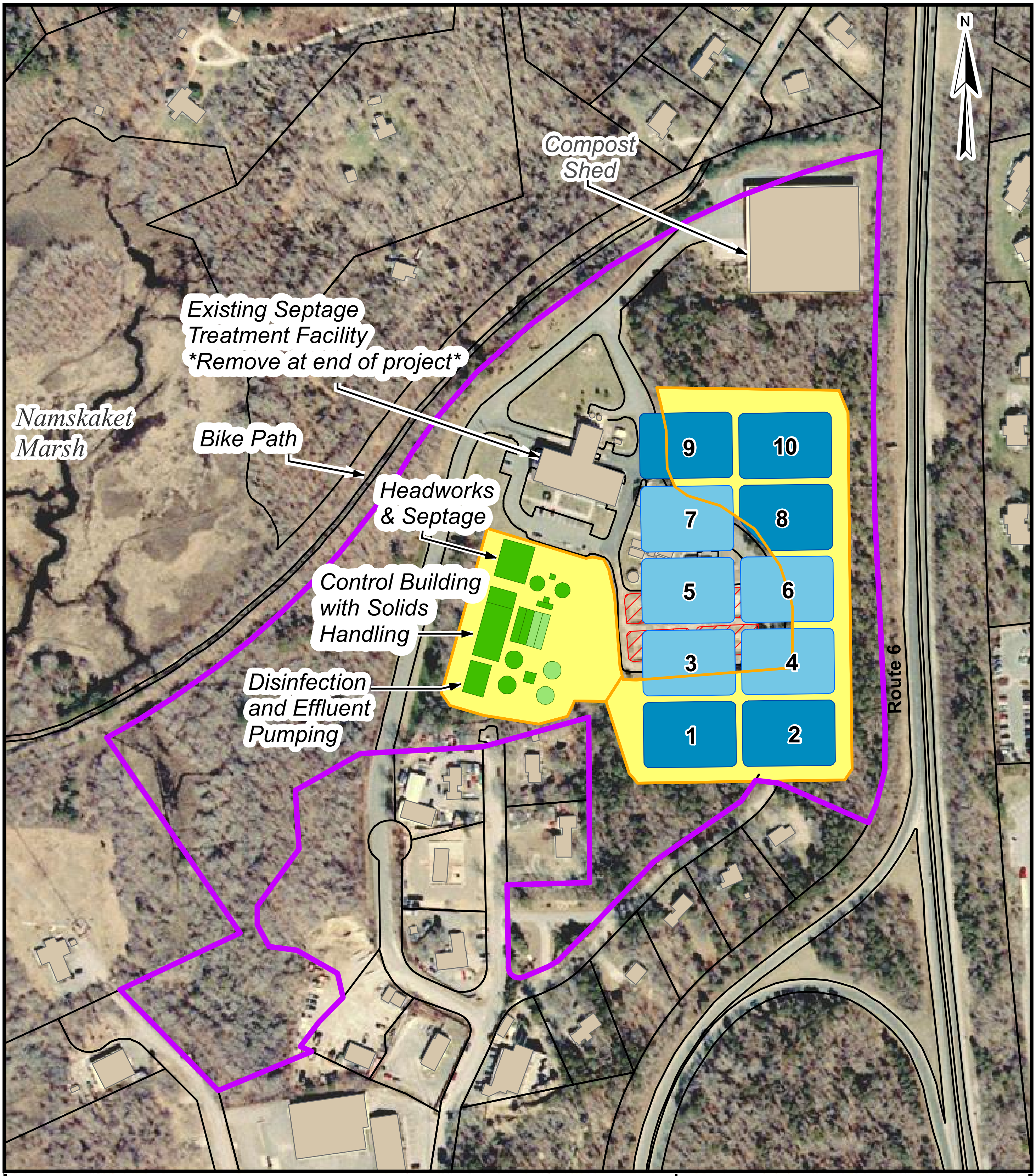
- Property Boundary (approx)
- Forested Upland (Overwintering, Feeding/ Breeding, & Migratory Habitat)
- Forested Wetland (Feeding/Breeding, Migratory, & limited Overwintering Habitat)
- Emergent Marsh (Limited Feeding/Breeding, & Migratory Habitat)

N

Approx. Scale 1:300

MASS GIS

Office of Geographic and Environmental Information (MASS GIS), Commonwealth of Massachusetts Executive Office of Environmental Affairs
1:5,000 MassGIS 2005 Orthophoto Aerial Image



Proposed Disposal Basins

- Phase 1
- Phase 4/5

Proposed Wastewater Treatment Plant

- Phase 1
- Phase 4

- Tri-Town Property Line
- Existing Buildings
- Existing Disposal Basins
- Limits of Work

0 125 250 375 500 Feet

Orleans CWMP

Layout of Proposed Wastewater Treatment and Disposal Facilities at Tri-Town Site

PROJ NO: 10645D	DATE: Apr 2009	FIGURE: 1

WRIGHT-PIERCE Engineering a Better Environment

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Proposed Disposal Basins

- Phase 1
- Phase 4/5

Proposed Wastewater Treatment Plant

- Phase 1
- Phase 4

- Tri-Town Property Line
- Existing Buildings
- Existing Disposal Beds
- Limits Of Work

0 100 200 300 400 Feet

Orleans CWMP
Proposed Wastewater Treatment and Disposal Facilities Alternate Layout A Demolish Existing Facilities

PROJ NO: 10645G	DATE: Apr 2009	FIGURE:
WRIGHT-PIERCE Engineering a Better Environment		2

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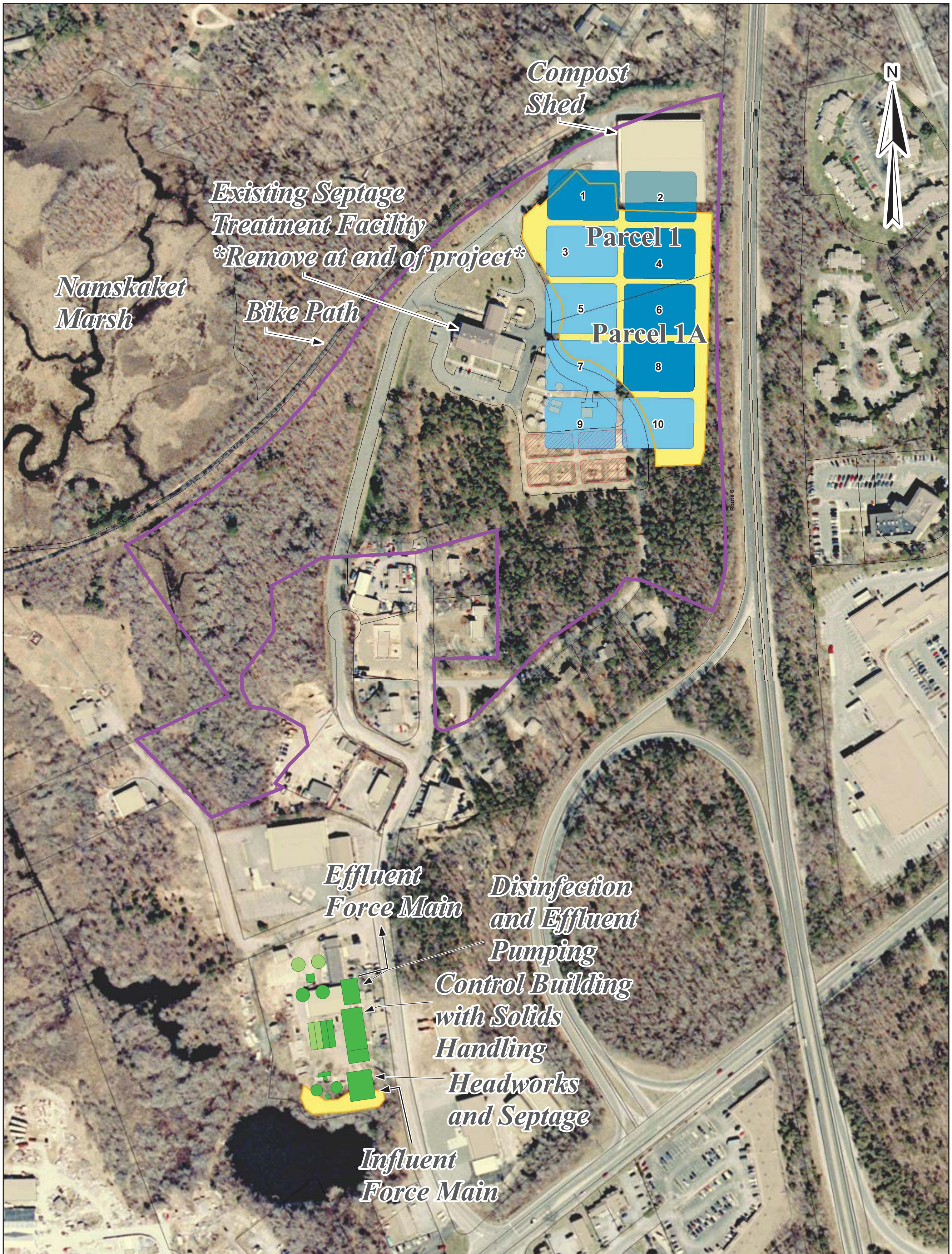

Proposed Disposal Basins
- Phase 1
- Phase 4/5

Proposed Wastewater Treatment Plant
- Phase 1
- Phase 4

- Tri-Town Property Line
- Existing Buildings
- Existing Disposal Beds
- Limits Of Work

0 100 200 300 400 Feet

Orleans CWMP
Proposed Wastewater Treatment and Disposal Facilities
Alternate Layout B
Maximize use of Parcel 1/1A for Effluent Disposal

PROJ NO:	DATE:	FIGURE:
10645G	Apr 2009	3

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Engineering a Better Environment

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Proposed Disposal Basins
- Phase 1
- Phase 4/5

Proposed Wastewater Treatment Plant
- Phase 1
- Phase 4

- Tri-Town Property Line
- Existing Buildings
- Existing Disposal Basins
- LimitsOfWork

0 100 200 300 400 Feet

Orleans CWMP
Proposed Wastewater Treatment and Disposal Facilities Alternate Layout C Existing Facilities Reused

PROJ NO: 10645G | DATE: Apr 2009 | FIGURE: 4

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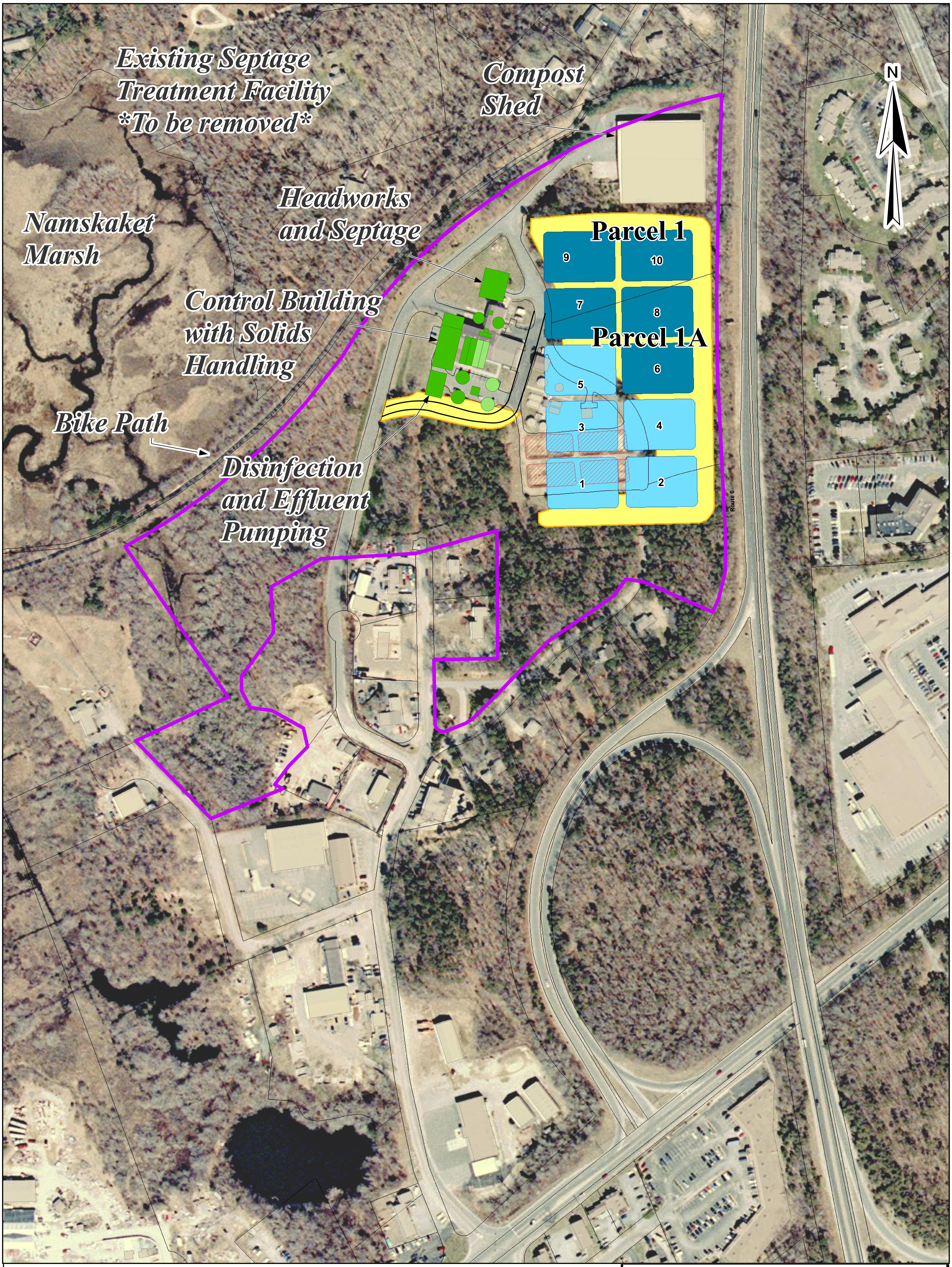

Proposed Disposal Basins

- Phase 1
- Phase 4/5

Proposed Wastewater Treatment Plant

- Phase 1
- Phase 4

- Tri-Town Property Line
- Existing Buildings
- Existing Disposal Beds
- Disturbed Area

0 100 200 300 400 Feet

Orleans CWMP

Proposed Wastewater Treatment and Disposal Facilities

PROJ NO: 10645G	DATE: Dec 2010	FIGURE:
WRIGHT-PIERCE Engineering a Better Environment		11-2

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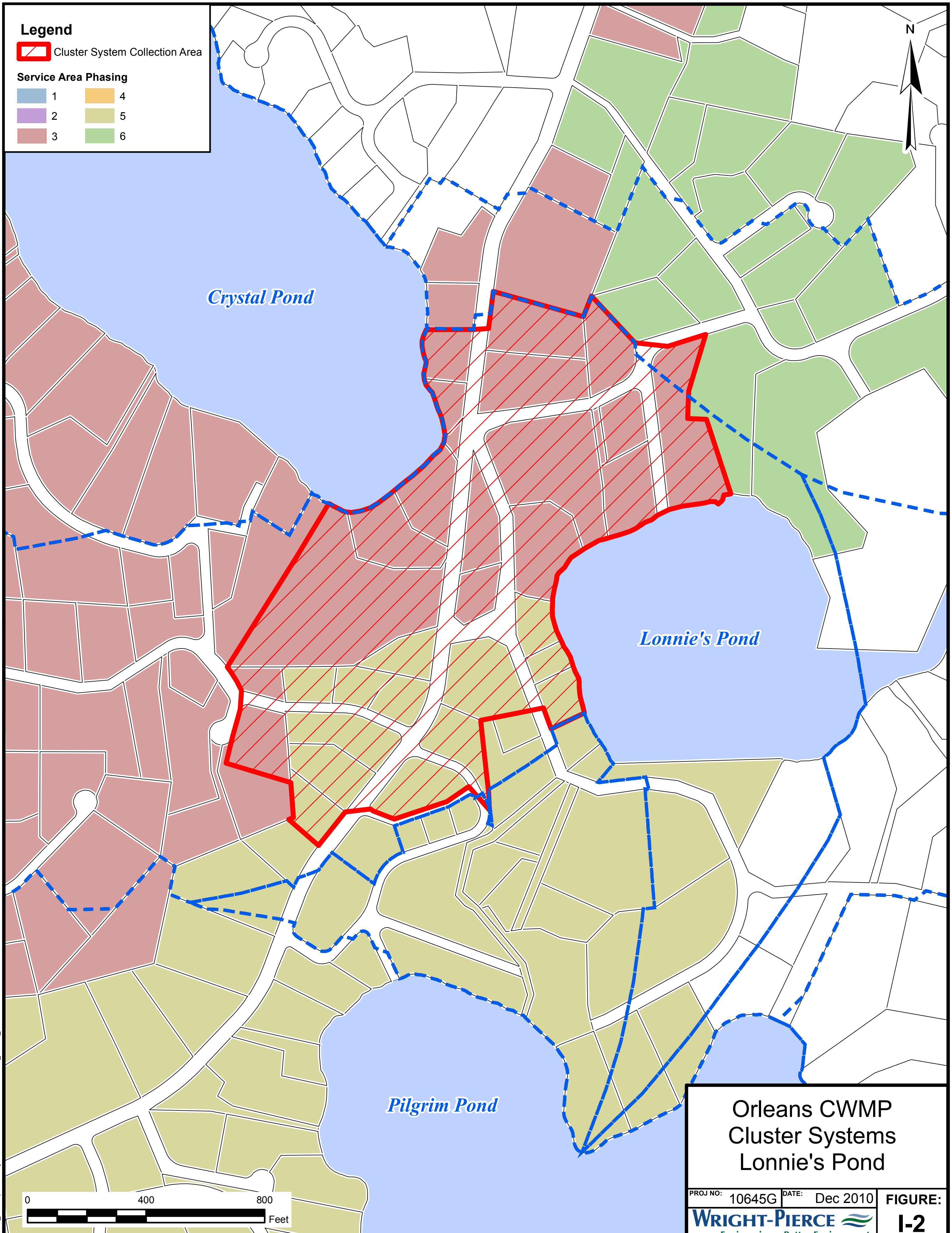
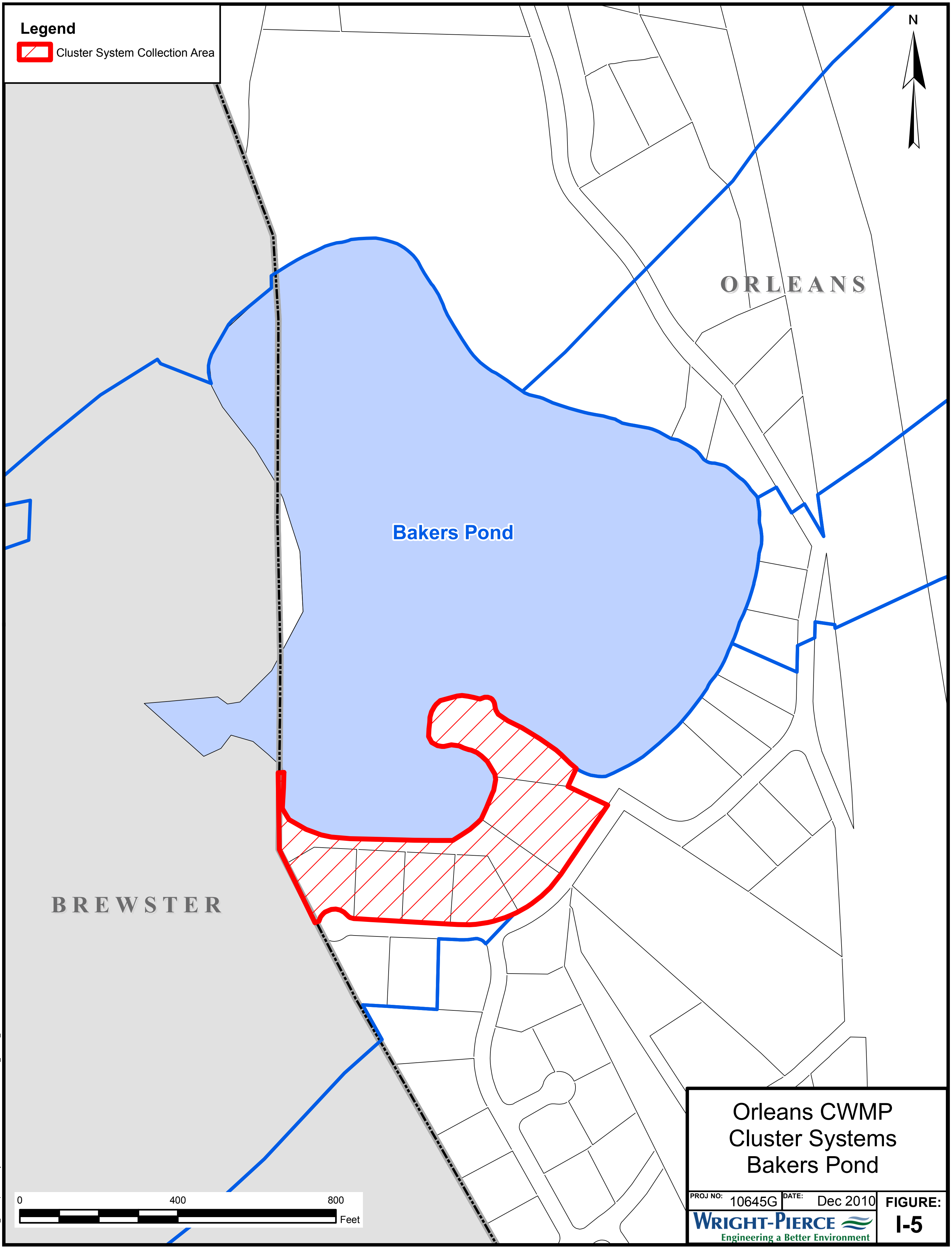


Orleans CWMP
Cluster Systems
Lonnie's Pond

PROJ NO: 10645G DATE: Dec 2010 FIGURE: I-2

WRIGHT-PIERCE
Engineering a Better Environment


Legend
Cluster System Collection Area
N
ORLEANS
Bakers Pond
BREWSTER
0
400
800
Feet
Orleans CWMP
Cluster Systems
Bakers Pond
PROJ NO: 10645G
DATE: Dec 2010
FIGURE: I-5
WRIGHT-PIERCE
Engineering a Better Environment

APPENDIX I

LOCAL (CLUSTER) SYSTEMS

APPENDIX I

LOCAL (CLUSTER) SYSTEMS

1.1 DESCRIPTION OF CLUSTER SYSTEMS

Part of Phase 2 of the Core Plan involves the construction of small wastewater treatment systems, or cluster systems. Each system provides collection, treatment and disposal of wastewater in a small neighborhood. Four of the cluster systems (that follow) serve neighborhoods that are in the watershed of an impacted coastal embayment. The goal of this facet of the CWMP is to reduce watershed nitrogen loading to improve coastal water quality many years before the sewer extensions reach these regions in the later phases. The collection area for each system is, in general terms, immediately upgradient of the water body, thereby providing timely improvement (but not complete remediation) of water quality. The degree of impact has not been modeled. It will be the completion of sewering in the Core Plan and conveyance to a centralized facility that will comply with the appropriate nitrogen reduction to meet the TMDLs. A fifth cluster system will serve the watershed of a freshwater body, unlike the four other cluster systems that reduce nutrient loading to coastal embayments. The Town wishes to protect the good water quality in Bakers Pond whose watershed is not readily served by the proposed Core Plan sewer system, which will service freshwater bodies with impaired water quality. Therefore, a cluster system is proposed for the Bakers Pond watershed, with the goal of significantly reducing phosphorus loading there to forestall the degradation that has occurred in other ponds.

1.1.1 General Characteristics

The wastewater collection infrastructure for each of the cluster systems fall within roadways slated for sewering as part of the Core Plan. Proposed pump station locations for the Core Plan will overlap with those for the cluster systems. The treatment process facilities may be contained completely below grade depending on the technology selected. An above-ground control panel may be the only visible addition post-construction. In other cases, a few above-grade tanks and a small building may be required, but appropriately screened with fencing and landscaping. The proposed effluent disposal technology in all cases is subsurface leaching. This may result in additional green area adjacent to the treatment facilities, or may be located in a mowed right-of-way, or put to dual use with parking or athletic activities. A conventional gravity sewer would collect the wastewater, supplemented by grinder pumps and low pressure sewers where appropriate.

1.1.2 Cluster System around Little Cove

Little Cove is a sub-watershed in the Nauset system. A small-scale system in this watershed would serve 29 properties. Figure I-1 depicts the extent of the service area for this cluster system. The expected annual average flow is 5,900 gpd; that translates to a design flow of 14,000 gpd. This system would be designed around a target effluent nitrogen concentration of 5 mg/l. This system would require a groundwater discharge permit. Treatment of the wastewater could be achieved with a multi-stage fixed-film process or a membrane bioreactor. Other key statistics of this system are provided side-by-side with the other cluster systems in Table I-1.

1.1.3 Cluster System around Lonnie's Pond

Lonnie's Pond is a sub-watershed in the Pleasant Bay system. A small-scale system in this watershed would serve 31 properties. Figure I-2 depicts the extent of the service area for this cluster system. The expected annual average flow is 5,500 gpd; that translates to a design flow of 14,000 gpd. This system would be designed around a target effluent nitrogen concentration of 5 mg/l. This system would require a groundwater discharge permit. Treatment of the wastewater could be met with a multi-stage fixed-film process or a membrane bioreactor. Other key statistics of this system are provided side-by-side with the other cluster systems in Table I-1.

1.1.4 Cluster System around Areys Pond

Areys Pond is a sub-watershed in the Pleasant Bay system. A small-scale system in this watershed would serve 27 properties. Figure I-3 depicts the extent of the service area for this cluster system. The expected annual average flow is 3,400 gpd; that translates to a design flow of 9,900 gpd. This system would be designed around a target effluent nitrogen concentration of 8 mg/l. This system would require Board of Health review and approval under Title 5. Treatment of the wastewater could be achieved with a fixed-film process. Other key statistics of this system are provided side-by-side with the other cluster systems in Table I-1.

Table I-1

Characteristics of Cluster Systems

	Sub-watershed to be Served			
Characteristics	**Little Cove**	**Lonnie's Pond**	**Areys Pond**	**Paw Wah Pond**
Major watershed	Nauset System	Pleasant Bay	Pleasant Bay	Pleasant Bay
Properties to be served	29	31	27	37
Flows, gpd				
Design	14,000	14,000	9,900	21,000
Expected annual average	5,900	5,500	3,400	9,400
Target effluent N conc., mg/l	5	5	8	5
N removal, lb/yr	379	439	187	611
N removal, as % of TMDL	unknown	67	60	67
Percentage of properties within 10-yr travel time of embayment	unknown	about 90%	nearly 100%	about 60%
Centralized sewer phase	4	3 and 5	5	5
Land acquisition	yes	yes	yes	yes
Effluent disposal area, sq.ft.	7,000	7,000	27,000	10,700
Impact on undisturbed land				
Sewers and pump stations	no	no	no	yes
Treatment facility	no	maybe	yes	yes
Effluent disposal	no	yes	yes	yes
Pump stations within floodplains	no	no	yes	yes
Facilities within 100 feet of wetlands	yes	yes	yes	yes
Presence of:				
Rare species habitat	no	no	no	no
Historic/archaeological resources	no	no	yes	no

1.1.5 Cluster System around Paw Wah Pond

Paw Wah Pond is a sub-watershed in the Pleasant Bay system. A small-scale system in this watershed would serve 29 properties. Figure I-4 depicts the extent of the service area for this cluster system. The expected annual average flow is 5,900 gpd; that translates to a design flow of 14,000 gpd. This system would be designed around a target effluent nitrogen concentration of 5 mg/l. This system would require a groundwater discharge permit. Treatment of the wastewater could be achieved with a multi-stage fixed-film process or a membrane bioreactor. Other key statistics of this system are provided side-by-side with the other cluster systems in Table I-1.

1.1.6 Cluster System around Bakers Pond

Bakers Pond is a sub-watershed in the Pleasant Bay system. A small-scale system in this watershed would serve 7 properties. Figure I-5 depicts the extent of the service area for this cluster system. The expected annual average flow is 1,400 gpd; that translates to a design flow of 2,640 gpd. This system would require Board of Health review and approval under Title 5. Treatment of the wastewater would be achieved with a conventional Title 5 system. Phosphorus enrichment in this watershed is the primary concern. Septic system effluent immediately upgradient of the pond is a primary source. Unlike the other four cluster systems, nitrogen enrichment is not a critical factor. Additionally, the driving factor behind the installation of the Bakers Pond cluster system is not level of treatment, but relocation of effluent disposal. Therefore, conventional Title 5 treatment and disposal is appropriate. Relocating the effluent disposal from immediately upgradient of the pond, to a downgradient location, provides protection from nutrient enrichment. A portion of the pond shoreline extends into the Town of Brewster. Providing wastewater collection for upgradient parcels in Brewster would aid in the preservation of Bakers Pond water quality and should be explored prior to the design of Phase 2.

1.2 DEGREE OF NITROGEN REMOVAL

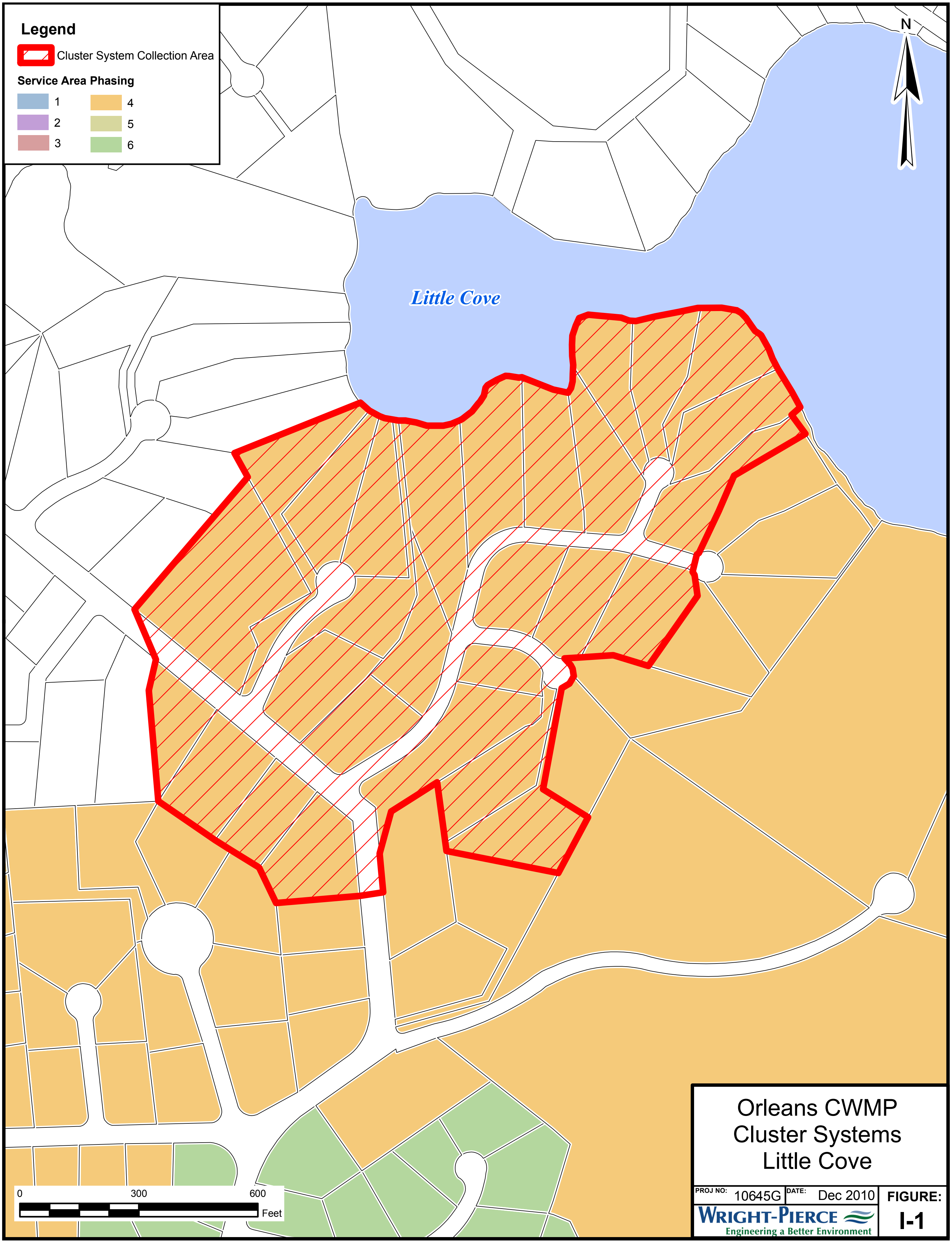
The degree of nitrogen removal provided at the cluster systems was evaluated to strike a balance between cost and water quality improvement. A consensus was reached at a meeting with DEP and the Cape Cod Commission that small-scale systems could reach effluent nitrogen concentrations of 5 or 10 mg/l. If these concentrations are regularly met (feasible with appropriate oversight and maintenance) these cluster systems could achieve 60% or more of the TMDL in their respective sub-watersheds. Prior to the construction of these cluster systems in Phase 2 of the project, the Town will work with MEP to quantify the water quality improvement that is expected as a result of the nitrogen load reduction these systems provide. At that time, the Town will weigh the costs against the improvement and decide if some or all of the cluster systems should be built. As Core Plan phases are completed, an evaluation of the extent of new sewer required in watersheds with cluster systems should be conducted to determine if the cluster systems should remain in operation, or be replaced by sewers leading to the centralized facility.

1.3 IMPLEMENTATION STEPS

Each of the sites identified for wastewater facilities have been reviewed by the Massachusetts Historical Commission. Undisturbed portions of the sites are either within, or proximate to, areas where archaeological resources could be present. The archaeological sensitivity is primarily due to the environmental setting (proximity to water and in level areas with well-drained soils). A reconnaissance archaeological survey should be conducted to assess all of the cluster sites. The Town has committed to this work and set a budget in its capital plan for surveys during the design phase of the project.

1.4 CAPITAL COSTS

Capital costs for the cluster systems have been estimated in three categories: 1) collection, 2) treatment and disposal, and 3) land costs. The collection costs for the 4 coastal cluster systems are technically associated with the Core Plan, because the portion of the overall sewer system that would lead to the cluster system would be constructed as part of the central collection system if the cluster systems are not built. Treatment and disposal costs have been separately estimated (see Table 11-7) to provide a basis for deciding if early nitrogen control is cost effective for the systems serving coastal water bodies. Land costs for treatment and disposal sites are included with other project land costs in Table 11-7 and the associated text provides the basis for the land cost estimates.



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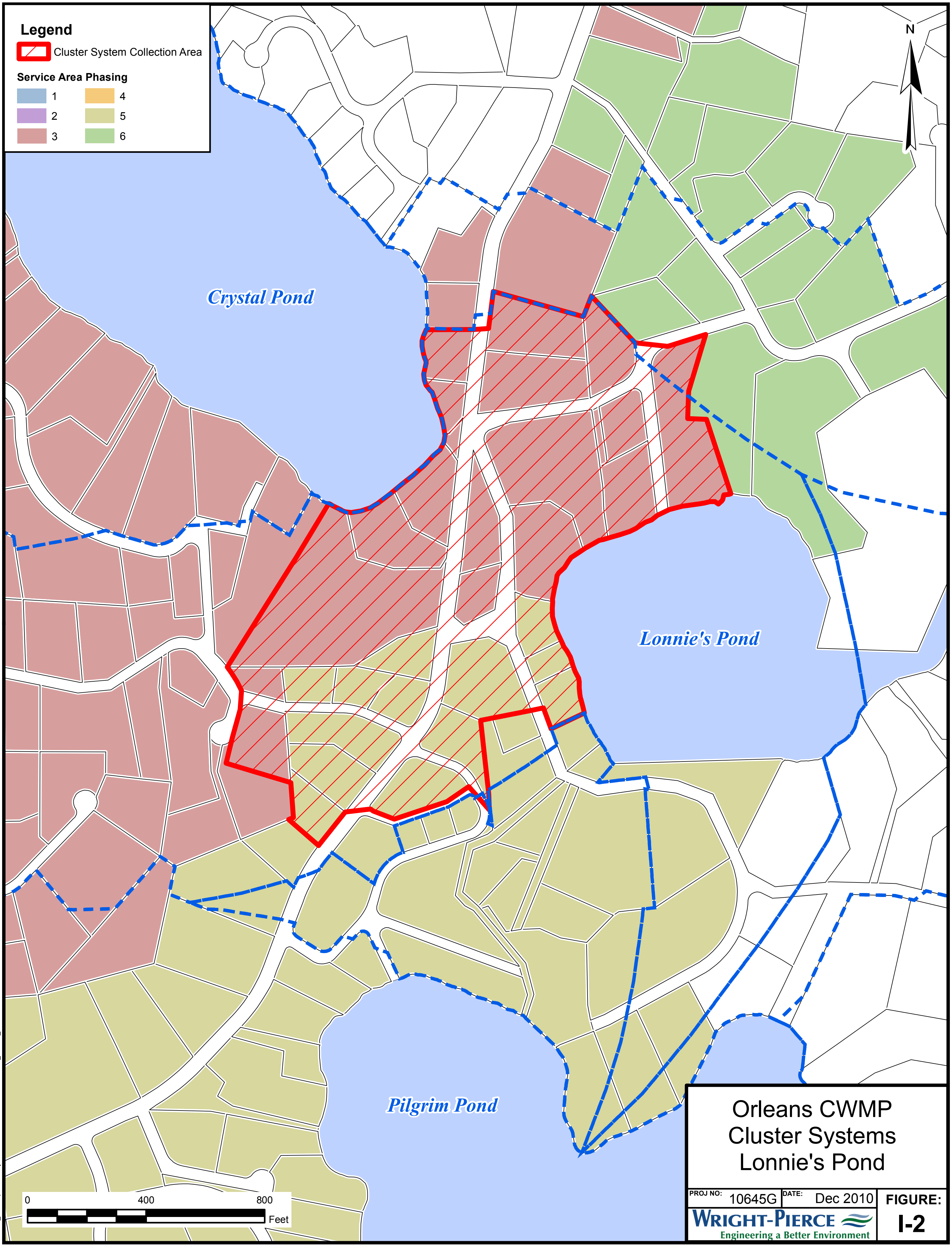

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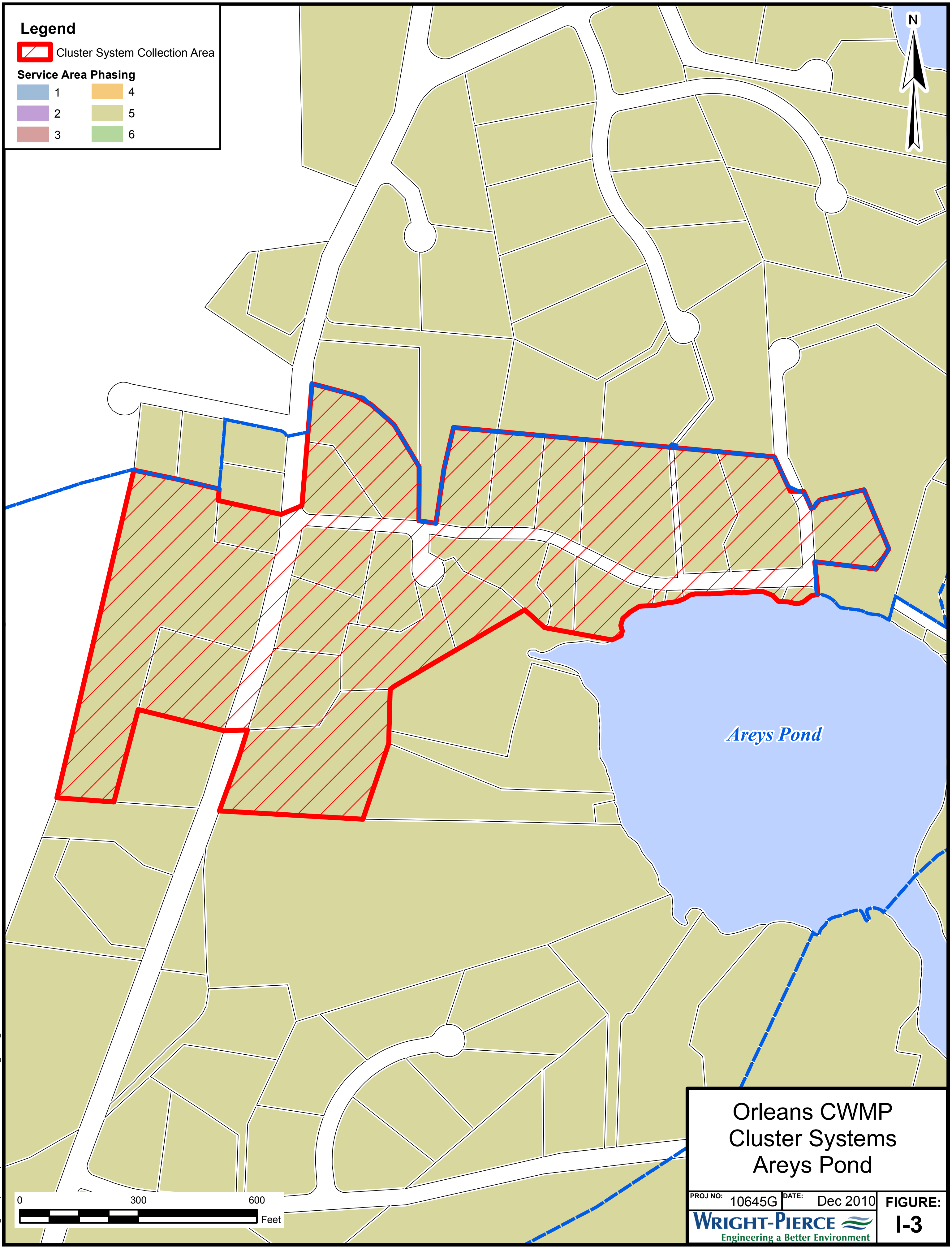

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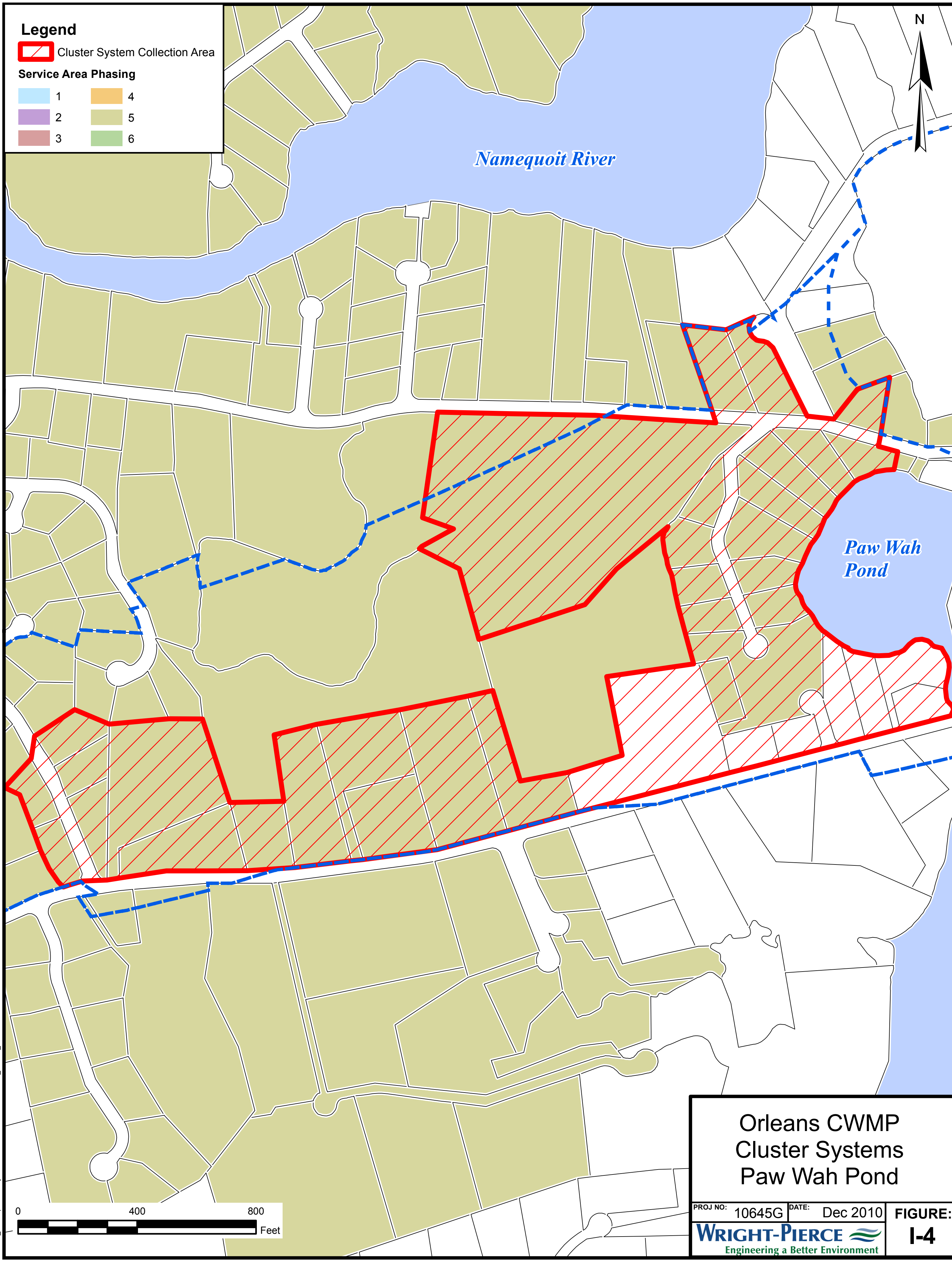

Orleans CWMP Cluster Systems Paw Wah Pond

PROJ NO: 10645G
DATE: Dec 2010
FIGURE: I-4

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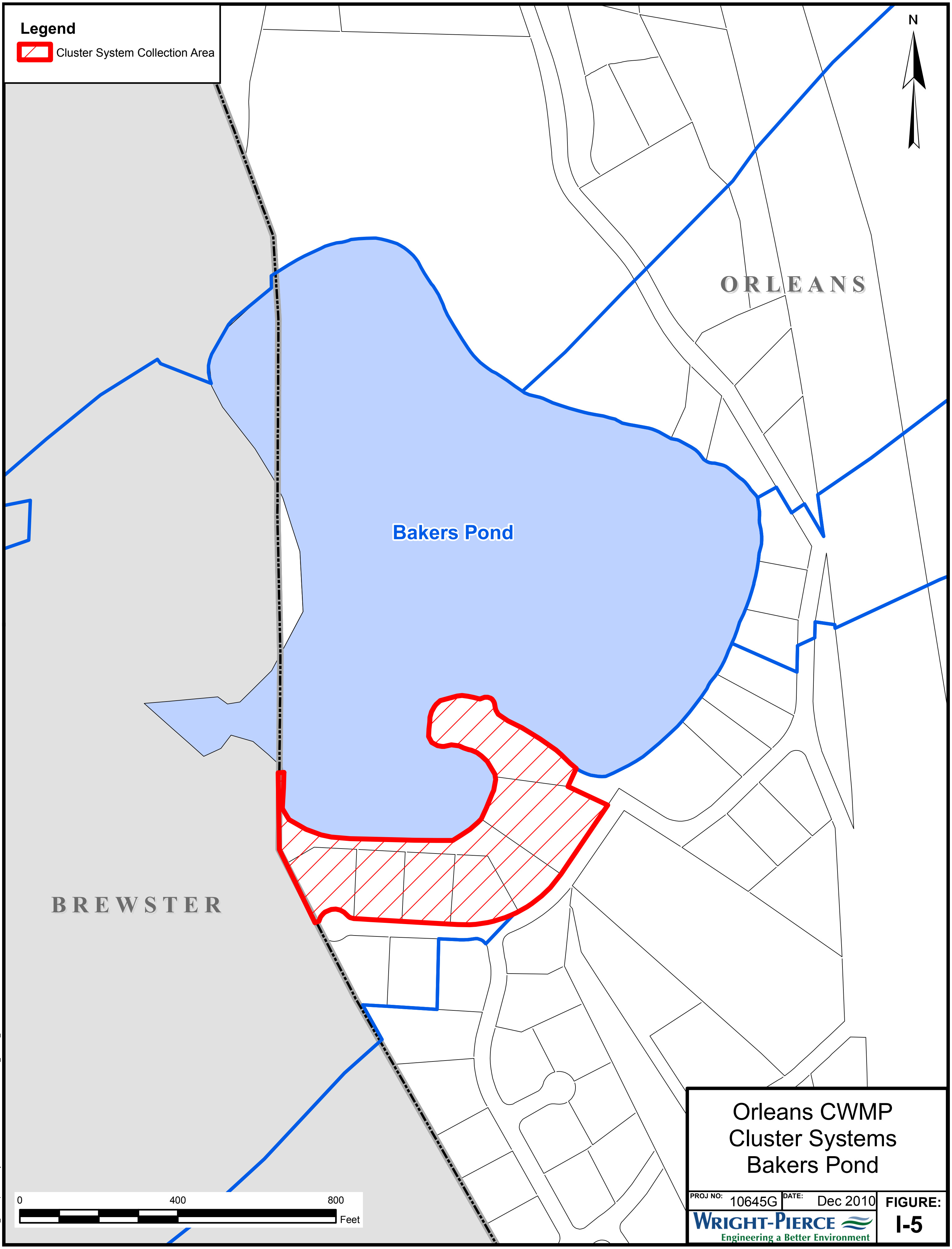

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APPENDIX J

GREENHOUSE GAS EMISSIONS ANALYSIS

APPENDIX J

Memorandum, GHG Emission Analysis, September 28, 2010

Memorandum, GHG Emission Analysis, June 30, 2010

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MEMORANDUM

TO:	George Meservey - Town of Orleans	DATE:	28 September 2010
FROM:	Ed Leonard, Mike Giggey	PROJECT NO.:	10645G
SUBJECT:	Orleans Comprehensive Wastewater Management Plan (CWMP) Greenhouse Gas Emissions Analysis		

MEPA and DOER jointly prepared a 6 August 2010 memorandum which provided comments on the Greenhouse Gas Emissions Analysis dated 30 June 2010. This memorandum summarizes the comment (italics) and the response to each comment (standard font) below.

1) *To cross-check the GHG emissions for the Proponent's Baseline WWTF design, the Proponent employed the EPA Portfolio Manager program. The EPA Portfolio Manager calculated the baseline design as having Direct & Indirect GHG emissions totaling 429 tons CO2eq/year and rated the Orleans' Baseline WWTF with Benchmark Score of 34 out of 100 (100 being highest score). Although the design of the Baseline WWTF incorporates good practice efficiency measures such as variable speed drives and premium efficiency motors, the Proponent has indicated that the Baseline design does not perform well from an energy perspective compared to the EPA Portfolio Manager's database because of unique factors associated with the Orleans WWTF. According to the Proponent, the factors listed below make the Orleans WWTF an outlier from a data input perspective.*
   - *the Orleans WWTF will have very strong (460 mg/l BOD) influent concentrations; and,*
   - *strong seasonality to its wastewater flows and loads.*

   The Proponent should provide a detailed explanation of how 1) strong influent concentrations and 2) strong seasonality of wastewater flows and loads anticipated for the Orleans WWTF will negatively impact the energy efficiency of the proposed Orleans WWTF when compared to the EPA Portfolio Manager database.

   The *EPA Portfolio Manager* program was developed based on research funded by the American Water Works Association (AWWA) Research Foundation (*Energy Index Development for Benchmarking Water and Wastewater Utilities*, 2007). The research involved statistical analysis of 266 wastewater facilities throughout the United States. The facilities sizes ranged from 0.6 mgd to over 150 mgd, with the majority of respondents in the 1.5-mgd to 12-mgd range. The recommended range of facility sizes for which the *EPA Portfolio Manager* is considered applicable is from 0.6-mgd to 150-mgd. Influent concentrations for the surveyed plants ranged from 75 mg/l to 325 mg/l, with the majority of the respondents in the 150-mg/l to 250-mg/l range. This range is consistent with the weak to average sewage strength. The *EPA Portfolio Manager* tool was developed to give existing facilities a way to see how they "match up" to other facilities and a way to see how any implemented energy improvements actually impact their site energy use and/or GHG emissions.

Based on our experience with the *EPA Portfolio Manager* program, and our knowledge of the existing Tri-Town Septage Treatment Facility (which is locating on the proposed WWTF Site) and with other similarly sized seasonal wastewater treatment, we believe that the proposed Orleans facility is an outlier for the reasons identified below.

- Strong Influent Concentration - From a general perspective, a hypothetical 1.0-mgd facility with an "average" influent BOD concentration of 200 mg/l will have a lower energy use than a second 1.0-mgd facility with a "strong" influent BOD concentration of 460-mg/l because the organic load that must be oxidized is 1,670 pounds per day vs 3,840 pounds per day. This increased load requires more energy for aeration as well as more energy for solids handling and dewatering .

- Strong Influent Concentration - The reason for the strong influent concentration at this facility is relatively high percentage of septage and grease which would be received at the facility. This will require large equalization storage tanks for septage and grease, each with aeration, mixing, pumping and odor control requirements, all with attendant energy use.

- Strong Influent Concentration - As noted in the 30 June 2010 memorandum, the facility compares favorably when utilizing the "Source Energy per BOD Removed" metric (Orleans at 9.1 btu/mg BOD removed per day vs. average value of 11.5 btu/ mg BOD removed per day at other New England facilities). This metric is tracked by EPA staff for facilities in New England (Jason Turgeon, personal communication) but is not an output from the *EPA Portfolio Manager*.

- Seasonality - A wastewater treatment facility in a seasonal community has a higher peaking factor than a typical community. Peaking factors of 5-10 are not uncommon when one considers the broad range of flow requirements for average conditions (minimum weekly flow in the winter versus the maximum weekly flow in the summer) and then peak daily flows in the summer,. This results in mechanical systems that must run across a broad range of conditions, and not necessarily at optimum efficiencies over the whole range, compared with a typical community or facility.

- Stringent Effluent Limits - This facility was conceptually size for 5-mg/l effluent total nitrogen. In 2007, "typical" nutrient removal was in the range 7-mg/l to 10-mg/l effluent total nitrogen.

- Size of the Facility - The proposed facility is sized at 0.64 mgd. It is just above the minimum recommended threshold for use of the program.

The Town fully intends to construct the most energy efficient treatment plant that is cost effective in order to minimize its long-term operational costs and its impacts to sewer user rates and taxation. The *EPA Portfolio Manager* program was utilized primarily as a means to cross-check our baseline GHG emission calculations and was not intended to be basis for which the facility was evaluated. Once we were satisfied that the our GHG emission calculation methodology was reasonable, the GHG emission reduction measures were evaluated using our calculation methodology.

2) *The Proponent has committed to GHG reduction measures identified as Preferred Measures. The SEIR should include additional information and analysis of other energy efficient measures identified as (Measures to be Considered in Final Design) and should provide a detailed explanation as to why these measures were not included as part of the Proponent's Preferred Measures design alternative.*

Detailed information and analysis were provided for all energy efficiency measures described in the 30 June 2010 memorandum -- including Preferred Measures, Not Preferred Measures and Measures to be Considered in Final Design (narrative information on pages 7 to 15 and numerical information in Table 5 on page 21). Table 5 summarizes the percentage reductions from baseline as well as estimated capital cost, annual operation and maintenance cost and payback period for all measures. Based on this analysis, measures were categorized as Preferred and Not Preferred; however, numerous additional measures were considered desirable <u>if</u> they can be determined to be feasible from a technical and cost perspective. This latter category was titled "Measures to be Considered in Final Design".

This project is currently a planning-level study and is not detailed design; accordingly, there are numerous items for which there is not sufficient technical information available to commit the Town to an approach which may not be feasible. For example, a wind turbine would allow a substantial reduction in GHG emission if sufficient wind speed were available at the project site and if it could be permitted in the Old King's Highway Historic District. We are not aware of wind studies performed at this site to substantiate the investment. A second example is the potential to process septage as biosolids versus liquids. This alternative could reduce the GHG emissions from the site, but would result in increased GHG emissions off-site (carbon dioxide and/or methane generation will occur elsewhere), potentially increased odor generation on-site, and potentially less long-term viability from the perspective of off-site sludge receptors. These two examples summarize the subtleties and complexities of the Measures to be Considered in Final Design category. The Town does commit to reviewing these measures when sufficient technical information is available to make informed decisions.

3) *Proponent should discuss any increase in energy intensity (kWh/gal-day) due to the selection of the Bartonpho process as opposed to a chemical-based method of controlling nitrogen and phosphorous.*

   Nitrogen - There are no financially viable or sustainable chemical-based methods to remove nitrogen to the effluent limitations required for this project. The two chemical/physical methods for ammonia reduction are breakpoint chlorination and air stripping, both of which results in nitrogen gas emissions to the atmosphere (with subsequent deposition). Breakpoint chlorination is very costly to operate and requires significant chlorine doses.

   Phosphorus - Based on the hydrogeologic modeling done for the project by the Town/Wright-Pierce and based on the Massachusetts Estuaries Project (MEP) work, there are no downstream freshwater receptors and, therefore, there have been no effluent phosphorus limitations proposed or discussed. If a phosphorus limit were imposed at a later date, it is expected that it would be addressed via a chemical-based approach (i.e. add chemical to primary clarifier influent and to secondary clarifier influent).

   Given the above, there is no increase in energy intensity for the proposed project over a feasible chemical-based approach.

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MEMORANDUM

TO:	George Meservey - Town of Orleans	DATE:	30 June 2010
FROM:	Ed Leonard, Mike Giggey	PROJECT NO.:	10645G
SUBJECT:	Orleans Comprehensive Wastewater Management Plan (CWMP) Greenhouse Gas Emissions Analysis		

BACKGROUND

The Executive Office of Energy and Environmental Affairs (EOEEA) requires that project proponents evaluate Greenhouse Gas (GHG) emissions as a part of the Massachusetts Environmental Policy Act (MEPA) process in accordance with the MEPA GHG Emissions Policy and Protocol. The requirements for the Orleans project are outlined in the 10 July 2009 Certificate of the Secretary of EOEEA on the Expanded Environmental Notification Form (EENF). The purpose of this memorandum is to summarize the methodology utilized to estimate the "project baseline" condition, to analyze options to achieve GHG emission reductions and to develop a listing of recommended measures for implementation. The content of this memorandum and analysis is based on the "Core Plan" as defined in the draft CWMP.

Wright-Pierce prepared a preliminary estimate of GHG emissions based on the Orleans CWMP recommended plan (documented in two memoranda, dated 17 September 2009 and 15 October 2009). These previous documents provide a preliminary estimate of "current" or "existing" GHG emissions. Following submittal of these documents to MEPA, Wright-Pierce and MEPA participated in a conference call on 17 December 2009 to discuss the scope and breadth of this GHG analysis. The parameters for inclusion in and exclusion from the analysis were agreed upon during this conference call and are summarized on Table 1. Direct emissions from septic systems, related septage truck hauling, and the wastewater collection system have been excluded from this analysis. By agreement of all parties, we have focused this analysis on the two principal GHGs, carbon dioxide (CO_2) and methane (CH_4).

RESOURCE MATERIALS

The following materials and data sources were utilized as references for this analysis:

- "MEPA Greenhouse Gas Emissions Policy and Protocol".
- "Unit Conversions, Emissions Factors, and Other Reference Data", US EPA, 2004. http://www.epa.gov/climatechange/emissions/downloads/emissionsfactorsbrochure2004.pdf
- "Calculation Tool for Direct Emissions from Stationary Combustion", WRI/WBCSD, V3, July 2005.
- "EBRD Methodology for Assessment of Greenhouse Gas Emissions" (Feb 2009)
- "2007 New England Marginal Emission Rate Analysis", ISO New England, July 2009.

GENERAL APPROACH

The analysis followed six steps, as summarized below:

1. Establish the "project baseline condition". This step took significant effort to establish detailed parameters (e.g. motor sizes, equipment runtime, building square footage, etc.) which are not normally developed during the planning phases of a project.
2. Estimate the GHG emissions for the project baseline condition.
3. Identify a wide range of options for GHG emission reduction.
4. Analyze each option and estimate GHG emission reductions associated with each option.
5. Estimate the cost impacts, capital and operation and maintenance, associated with each option.
6. Segregate options into "preferred" measures" and "not preferred" measures.

DESCRIPTION OF PROJECT BASELINE

The project baseline was formulated using an "industry standard" approach to designing robust and reliable wastewater collection, treatment and disposal facilities. With regard to the design of the wastewater "process components", the project baseline and CWMP recommended plan was developed based on document entitled "Guides for the Design of Wastewater Treatment Works, Technical Report 16" (New England Interstate Water Pollution Control Commission, 1998). Where appropriate, other "industry standard" approaches to energy efficiency were utilized (e.g. using variable frequency drives for pumps and blowers, using premium efficiency process motors, etc.). Process components include pumping, mixing, aeration, odor control, biosolids handling and dewatering systems as well as standby power systems. The preliminary equipment list and annual electrical load profile for the "process components" project baseline condition are presented in Appendix A Table A-1 and A-2.

With regard to the "general building systems", the project baseline and CWMP recommended plan was developed based on the 7^{th} Edition Building Code, 780 CMR Chapter 13 (IECC 2009 with Massachusetts Amendments). The design parameters utilized for eQuest model inputs are summarized in tabular format in Appendix A.

Since this project is only in the "planning phase" (i.e. no detailed design information is available), we have utilized engineering judgment and available information for similar projects in order to develop the required information. These values can be better refined in the "design phase" of the project in the upcoming years. A summary of these major categories and the key assumptions utilizing is presented below.

Building Systems

As shown on Figure 11-2 of the Draft CWMP, the site buildings are oriented with large west/east faces primarily due to site access, site traffic flow and site abutter considerations. These buildings are identified as follows:

- Headworks & Septage Building
- Solids Handling & Control Building
- Disinfection & Effluent Pumping Building

Based on recent projects of similar size and treatment processes, and based on the configuration of the site, we estimate the building configurations as listed below. Each building will include concrete block exterior walls with continuous rigid insulation, wood truss roofs with R-38 batt insulation above the ceiling level, double pane glazing, ventilation supply duct insulation and other standard energy efficiency items, as required by the state building code. We have assumed that natural gas will be used for the heating system on-site.

- The Headworks & Septage Building will be a one-story, approximately 60' x 70' building with an average exterior wall height of 14'. The building will also have a full basement under the building. The floor-to-floor height of the basement floor to the main floor will be approximately 14'. The first floor will consist of a septage receiving bay, a septage receiving room, a headworks room, a mechanical room and an electrical room. The basement will consist of a septage storage chamber, a grit vortex space and a pump room.
- The Solids Handling & Control Building will be a one-story, approximately 50' x 130' building with an average exterior wall height of 14'. The building will also have a full basement under the building. The floor-to-floor height of the basement floor to the main floor will be approximately 14'. The building will have solids handling equipment spaces, mechanical/electrical spaces, pump rooms, a control room, offices, a workshop, a lab and locker rooms.
- The Disinfection & Effluent Pumping Building will be a one-story, approximately 40' x 60' building with an average exterior wall height of 12'. The main floor will be slab-on-grade with no lower level, and an exterior wetwell. The building will have a disinfection room, an effluent pumping room and mechanical and electrical spaces.

Process Systems

The wastewater treatment process (activated sludge, four-stage Bardenpho configuration) and the wastewater collection and treatment systems are as outlined in the draft CWMP. Energy consumption and indirect emissions were estimated in the following manner.

- Electricity for Collection System: Baseline electricity use in the collection was estimated by developing a pump station list based on information contained in Appendix D of the April 2009 Draft CWMP (Table 11-1). Estimated electrical consumption was derived by estimating average pumping rate and total dynamic head, pump efficiency, motor efficiency and total hours per year in service. This estimate assumes that variable frequency drives are provided on large pumping stations.
- Electricity for Wastewater Treatment Facility Process: Baseline electricity use was estimated by developing an equipment list from the information and process flow diagram contained in Appendix D of the April 2009 Draft CWMP as well as an estimated influent flow and load profile generated for this analysis. Estimated electrical consumption was derived by estimating motor size, amount of full motor load required and total hours per year in service. This estimate assumes that variable frequency drives are provided on major equipment systems, specifically including activated sludge aeration blowers, return sludge pumping, and sludge storage tank aeration blowers.
- Standby Power for Wastewater Treatment Facility: Wastewater treatment systems also require standby power. Accordingly, a standby generator size was estimated (from the loads on Table 4) at 500 kw based on a diesel fuel source. A total of 1,730 gallons of fuel oil per year was calculated based on weekly 30-minute exercise under load and three 12-hr power loss events (62 hrs per year) for an assumed 500 kw generator set (28 gallons per hour at 75% load).

Transportation

Transportation components related to the project consist of WWTF staff vehicles as well as Collection System staff and maintenance vehicles. As noted previously, septage hauling vehicles are excluded from this analysis.

ESTIMATE OF GHG EMISSIONS FOR PROJECT BASELINE

GHG emissions are either "direct" and are generated on-site (e.g. by the burning of fuel in a heating system) or "indirect" and generated off-site by others (e.g. by purchasing electricity from the grid where the electricity is generated elsewhere). This memorandum presents direct and indirect emissions for the following major categories: Building Systems; Process Systems; Transportation; and Renewable Sources. To establish the baseline GHG emissions for building systems, we have modeled the energy use of the above structures with a MEPA-recommended software model (eQuest) using criteria meeting the 7th Edition Building Code 780 CMR Chapter 13 (IECC 2009 with amendments) and using a Chatham weather file. The eQuest model output was used for the direct and indirect GHG emissions associated with the buildings. Process system components have been treated as indirect emissions (i.e. electric motors) and direct emissions (i.e. standby power only). Transportation components have been treated as direct emissions (gasoline, diesel) and estimated utilization figures (number of trips per day, miles per trip, etc.). No transportation-related indirect emissions have been identified.

The estimated GHG emissions for the "Baseline Project" are presented in Table 2. The Baseline GHG emissions are 900 tons CO_2eq/year, of which approximately 50% is related to electrical energy required to treat the wastewater.

CROSS-CHECK OF BASELINE GHG EMISSIONS FOR WWTF

To cross check the baseline GHG emissions estimates for the WWTF, we have utilized the internet-based *EPA Portfolio Manager* program. (For more information go to: http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager). This program was developed from research funded by the American Water Works Association (AWWA) Research Foundation (Energy Index Development for Benchmarking Water and Wastewater Utilities, 2007).

Input parameters to this program are relatively straight-forward and are summarized as follows:

- Plant name/ location/ zip code: Orleans WWTF (Future)/ Orleans, MA/ 02653
- Annual Average Flow: 0.64 mgd (Appendix D-12)
- Annual Average Influent BOD Concentration: 460 mg/l (Appendix D-12)
- Annual Average Effluent BOD Concentration: 10 mg/l (Appendix D-12)
- Whether the facility has Trickling Filters: No
- Whether the facility has Nutrient Removal: Yes
- Twelve months, minimum, of energy use for all energy sources (e.g. electricity, fuel oil, natural gas, propane, etc.): estimated energy inputs as described above.

Based on these input parameters, the *EPA Portfolio Manager* program rates the proposed Orleans facility with a *Benchmark Score of 34* (0-100, 100 is best) and calculates the Direct and Indirect GHG emissions as 429 tonsCO2eq/year . Based on the values in Table 2, our estimate of Direct and Indirect GHG emissions for the comparable items is 470 tonsCO2eq/year (i.e. Building-Direct at 6 tonsCO2eq/year, Building-Indirect at 19 tonsCO2eq/year, WWTF-Direct at 19 tonsCO2eq/year, and WWTF-Indirect at 426 tonsCO2eq/year. These values indicate a reasonable correlation between the EPA Portfolio Manager and our estimates of the project baseline.

This cross-check analysis also suggests that the proposed Orleans WWTF does not perform well from an energy perspective when compared to the EPA Portfolio Manager database. We believe that this is due to two key factors:

- This plant will have a very strong influent concentration (i.e. 460 mg/l BOD) due to large anticipated septage and off-site sludge loadings (~40% of total BOD loadings), which makes it an outlier from a data input perspective.
- This plant will have a strong seasonality to its flows and loads, which also makes it an outlier from a data input perspective. We are involved with several seasonal communities in Maine which are energy efficient operations but which score similarly poorly in the EPA Portfolio Manager program.

Conversely, based on information provided by EPA staff for facilities in New England (Jason Turgeon, personal communication), the proposed Orleans WWTF does compare well from an energy perspective based on the "Source Energy per BOD Removed" metric (Orleans at 9.1 btu/ mg BOD removed per day vs average value of 11.5 btu/ mg BOD removed per day at other New England facilities). Based on the foregoing discussion, we believe that the information presented herein represents a reasonable baseline for evaluating possible options for reducing GHG emissions.

IDENTIFICATION OF OPTIONS FOR GHG EMISSION REDUCTIONS

The following concepts were considered as options to reduce GHG emissions from the proposed WWTF and collection system:

Process

1. Process all septage and off-site sludges received at the WWTF via the biosolids treatment process. Process thickening/dewatering filtrate only through the liquid treatment process.
2. Use high efficiency aeration blowers and aeration diffusers for the liquid treatment processes.
3. Use high efficiency biological nutrient removal (BNR) activated sludge mixing devices and optimize placement (i.e. number and location).
4. Consider alternate BNR processes and alternative effluent quality goals.
5. Eliminate effluent pumping, if possible, by carefully reviewing hydraulic gradeline.
6. Add sludge reduction/digestion process.
7. Reduce odor control requirements.

Building, Siting and Site Energy

8. Orient the buildings with larger southern and northern faces to maximize daylighting and to reduce heating and cooling loads.
9. Use sun shades to allow for daylighting while minimizing heat gain in the summer.
10. Use high-efficiency lighting.
11. Use effluent heat pumps (or geothermal heating system) to recover waste heat from the effluent.
12. Increase the building R-value through additional insulation at the roof, walls and floors.
13. Use high-efficiency windows instead of code-compliant windows.

14. Use motion sensors for interior lighting control and ventilation/climate control (while maintaining compliance with NFPA 820)
15. Add a solar photovoltaic system(s) to provide some of the facility's base electrical needs.
16. Add an on-site wind turbine to provide some of the facility's base electrical needs.

Management

17. Add BOD reduction measures to the Sewer Use Ordinance -- specifically banning garbage grinders and recommending waterless and/or urine diverting toilets.
18. Use low pressure sewers in areas susceptible to infiltration/inflow to minimize extraneous flow to the WWTF.
19. Use large sludge hauling trucks (30-cy roll-offs) vs small sludge trucks (10-cy truck).
20. Use of supplemental carbon chemicals (if needed) that result in relatively lower GHG emissions.

Based on the values shown on Table 2, it is clear that the largest sources of GHG emissions are indirect emissions related to the process systems. Accordingly, more explanatory discussion is provided for these items in the analysis section of this memorandum. These process systems are required to collect, convey, treat and dispose of the town's wastewater and in some cases can not be compromised.

ANALYSIS OF OPTIONS FOR GHG EMISSION REDUCTIONS

Each of the concepts identified above has been evaluated for applicability and for the potential to reduce GHG emission for the Orleans facility. The resolution of each item is summarized below and the options are categorized as the following:

- *Preferred Measure* - these items are preferred and recommended for implementation.
- *Not Preferred Measure* - these items are not preferred and not recommended for implementation; however, the GHG emission reductions have been calculated and are presented in the "All Measures Scenarios".
- *Measure to be Considered in Final Design* - these items may be preferred but the analysis requires more details to make an informed decision. Placeholder values, when applicable, have been presented under the All Measures Scenarios.
- *Not Applicable* - these items do not meet project goals and requirements and are not recommended for implementation.

As required by the GHG Emissions Policy any measures which are not preferred measures are grouped in an "All Measures" category. Accordingly, the direct and indirect GHG emissions for these categories are presented in Table 2 (Baseline Measures), Table 3 (Preferred Measures) and Table 4 (All Measures).

Process

1. **Process all septage and off-site sludges received at the WWTF via the biosolids treatment process. Process thickening/dewatering filtrate only through the liquid treatment process.**
Septage and off-site sludge represent approximately 30 to 40 percent of the loading to the proposed facility. These trucked wastes can be handled as "wastewater" and blended with incoming sewage, or they can be handled separately as "sludge" or biosolids with only the filtrate (i.e. the liquid that results from dewatering the septage) treated as wastewater. The Baseline project includes treating septage as wastewater because it produces a more stable biosolid for handling and disposal. Processing septage/off-site sludges through the biosolids treatment process will reduce the aeration system requirements but will increase primary sludge storage volume requirements (from 50,000 gallons to 75,000 gallons) and its associated aeration/mixing requirements. Dewatering system run-time was held constant. Since the thickening/dewatering filtrate will still require treatment, the liquid treatment process loadings associated with septage was reduced to 25% of the original values.

	CWMP WWTF Load	Septage Load (100%)	Reduction in Septage Load (75%)	Revised WWTF Load	% Total Reduction
BOD, lb/day	2,480	775	580	1,900	24%
TSS, lb/day	3,230	1,290	970	2,260	30%
TKN, lb/day	400	90	65	335	16%
TP, lb/day	60	12	10	50	17%

For the purposes of this analysis, activated sludge aeration system blower size was reduced by 20% and the primary sludge storage tank aeration system blower size was increased by 50%. In the Baseline scenario, BOD is exerted on-site in the presence of biomass and aeration (electrical energy). In this alternative, a large percentage of BOD is sent off-site in the form of waste biosolids; however, this loading will manifest itself in the form of carbon dioxide and/or methane production at its disposal location, which is outside the parameters of this analysis per Table 1. This item is a Measure to be Considered in Final Design.

2. **Use high efficiency aeration blowers and aeration diffusers for liquid treatment processes.**
The baseline scenario consists of four 50 hp, dual-lobe positive displacement blowers with 9" disk diffusers. Alternative scenarios could include tri-lobe positive displacement blowers, high speed centrifugal blowers ("turbo blowers"), and/or high-efficiency plate diffusers. Tri-lobe blowers are marginally more efficient than dual-lobe blowers (approximately 5%) and high speed centrifugal blowers are substantially more efficient than dual-lobe blowers (approximately 25%). High speed centrifugals are typically not cost effective on a present worth basis for less than 75 hp; while they are very cost effective on a present worth basis for

greater than 100 hp. High-efficiency plate diffusers are substantially more efficient than disk diffusers but run at a higher back pressure (net approximately 10% more efficient). There are very few high-efficiency plate diffusers in the United States at this time, primarily in large treatment plants (i.e., >10 mgd) where power costs are high (i.e., California). Centrifugal blowers would not be recommended for an SBR application (Item 6 below). The Preferred Measure (shown as Item "2A") is tri-lobe blowers with standard disk diffusers and, for this analysis, we have used a 5% reduction in blower horsepower for the activated sludge aeration system and the sludge storage tank aerations systems. Although a Not Preferred Measure for a plant of this size, a 25% reduction in activated sludge aeration system blower horsepower (turbo blowers and high-efficiency plate diffusers) and a 5% reduction in the sludge storage tank aeration systems (tri-lobe blowers) has been utilized to compute the "All Measures" emissions (shown as Item "2B").

3. **Use high efficiency BNR activated sludge mixing devices and optimize placement (i.e. number and location).**
The Baseline scenario consists of submersible mixers with optimized placement for mixing and process efficiency. Available high-efficiency mixers for BNR systems currently include hyperbolic mixers, which work best in square or circular tanks/zones. Standard submersible mixers are well-suited for use in rectangular tanks or zones. Activated sludge anoxic zone mixing energy represents approximately 10% of the overall plant energy and is unlikely to be significantly reduced. This item is a Measure to be Considered in Final Design. As a placeholder value, a 5% reduction in activated sludge anoxic zone mixing energy has been used.

4. **Consider alternate BNR processes and alternative effluent quality goals.**
The proposed effluent quality goals for the proposed project are fundamental to long-term TMDL compliance and <u>can not</u> be relaxed or modified for GHG emissions reduction. The proposed process configuration (4-Stage Bardenpho) is the "industry benchmark" for effluent limits less than 5-mg/l total nitrogen. In addition, the proposed configuration was selected to allow for optimum tank sizing in a multi-phased implementation schedule. An alternative design approach could consist of utilizing sequencing batch reactors (SBRs) configured to operate like a 4-Stage Bardenpho. This alternative approach has the advantage of being similar to numerous other facilities in Barnstable and Plymouth Counties (e.g., Falmouth, Plymouth, Pine Hills, etc.) and being a relatively simpler operation. A detailed description of advantages and disadvantages of Conventional Bardenpho versus SBR Bardenpho is presented in Appendix D of the draft CWMP. This item will not be evaluated as a GHG emission reduction approach at this time but will be considered in detailed design.

5. **Eliminate effluent pumping, if possible, by carefully reviewing hydraulic gradeline.**
The Baseline scenario consists of a "pump in/ pump out" treatment facility. This conservative assumption is based on the fact that effluent must be conveyed to the appropriate elevation for disposal at rapid infiltration basins. This elevation could be

obtained in one of two ways: 1) by constructing "low profile" treatment tanks which closely match existing earth grade and pumping to the disposal elevation (similar to the existing Tri-Town facility); or 2) by constructing "raised" or "tall" treatment tanks which would require additional concrete volume but which could eliminate effluent pumping. Ultimately, this analysis and decision will require careful consideration and will involve detailed cost analyses related to site work (e.g., earth grades, cuts and fills), structural work (e.g., concrete tanks) as well as local permitting and zoning considerations. In addition, there are numerous construction-related GHG emissions factors that are outside the analysis based on Table 1. It is premature to evaluate this item as a GHG emission reduction approach at this time but this is a Measure to be Considered in Final Design.

6. Add sludge reduction/digestion process.

Sludge reduction/digestion processes typically consist of either: 1) proprietary, side-stream, batch treatment reactors designed to endogenously break down sludge; 2) aerobic digestion processes; or 3) anaerobic digestion processes. Of these three approaches, only aerobic digestion would be considered applicable for a plant the size of the proposed Orleans facility. Historically, anaerobic digestion has only been considered to be realistic for plants greater than 5-10 mgd due to the operational complexity and cost associated with these processes. Aerobic digestion is generally considered energy intensive. For this analysis, we have assumed that an aerobic digester would involve the following:

- Digestion of waste sludge only (i.e, excluding primary sludges).
- Increase sludge storage time from 4.6 days (100,000 gallons) to 15 days (300,000 gallons).
- Increase sludge storage tank aeration system blower size from 20 HP to 60 HP, based on providing 40 scfm/thousand cubic feet for the larger volume.
- Increase sludge storage tank aeration system runtime from 50% to 100% of annual hours.
- Initial volatile solids content of 80% with volatile solids reduction of 40%. Net sludge reduction is 32% or total net volume is 68% of original volume. Reduction of thickening system runtime, dewatering system runtime and sludge truck hauling trips accordingly.
- Reduce sludge hauling truck trips from 26,000 miles per year to 17,500 miles per year. Reduce GHG emissions associated with truck trips by 18,500 lbsCO2eq/year.
- Increase WWTF electricity use from 845,000 kw-hrs/year to 997,000 kw-hrs/year. Increase WWTF GHG emissions by 153,000 lbsCO2eq/year. Net GHG emissions increase by 134,500 lbsCO2eq/year (+15%).

The added electricity use more than offsets the reduction in biosolids handling and transportation; accordingly, this item is considered Not Applicable and is not carried forward.

7. **Reduce odor control requirements.**
   Odor control involves large ventilation fans to collect potentially odorous air and electricity use can be significant. The Baseline project includes odor control for the major odor sources at the proposed facility (e.g., septage receiving, sludge storage and biosolids processing). The odor control requirements for the proposed project are fundamental to the Town's desire to be a good neighbor to owners of property closely surrounding the plant site. The Town is not willing to reduce or eliminate odor control requirements for GHG emissions reduction; however, during final design, opportunities for "odor prevention" will be evaluated. While this may not decrease the installed cost of the odor control systems, it may allow for reduced operating time during cooler weather and lower loadings; accordingly, this item is considered Not Applicable and is not carried forward.

Building, Siting and Site Energy

8. **Orient the buildings with larger southern and northern faces to maximize daylighting and to reduce heating and cooling loads.**
   The site layout is based on maximizing effluent disposal areas, maximizing distances to property lines and minimizing impacts to Eastern Box Turtle habitat. The use of daylighting, via skylights and large windows, was reviewed for the site buildings. In the context of the total WWTF electricity use, lighting represents approximately 4% of the total use. Several other factors are related to this item: 1) the site is in the Old King's Highway historic district, which will restrict the architectural design features allowed; 2) due to site constraints, the buildings must be located relatively close together which limits the effectiveness of daylighting; and 3) the use of solar photovoltaic systems would reduce the ability to utilize skylights for daylighting. This item is a Measure to be Considered in Final Design.

9. **Use sun shades to allow for daylighting while minimizing heat gain in the summer.**
   Refer to Item 8. Sun shades provide limited value if large windows are not possible. This item is a Measure to be Considered in Final Design.

10. **Use high-efficiency lighting.**
    High-efficiency lighting is highly occupied spaces (>25% occupancy) will result in electrical energy reductions. High-efficiency lighting in occupied spaces is a Preferred Measure. High-efficiency lighting in all spaces is a Not Preferred Measure.

11. **Use effluent heat pumps (or geothermal heating system) to recover waste heat from the effluent.**
    The buildings have a relatively low heat load due to the state building code energy efficiency requirements and to the heat generated from electric motors. Effluent heat pumps have a relatively low impact on energy consumption at the facility. For the purposes of this analysis, effluent heat pumps are categorized as a Measure to be Considered in Final Design with an assumed reduction in Solids Handling & Control Building heat load by 10%.

12. Increase the building R-value through additional insulation at the roof/walls/floors.

The Baseline scenario is based on the 2009 IECC building envelope standards which are already very high. Additional building insulation at the roofs, walls and floors had a negligible impact on overall energy consumption at the facility. This is a Not Preferred Measure.

13. Use high-efficiency windows instead of code-compliant windows.

Based on the building model, increasing the window efficiency over code-compliant windows had a negligible impact on overall energy consumption at the facility. This is a Not Preferred Measure.

14. Use motion sensors for interior lighting control and ventilation/climate control (while maintaining compliance with NFPA 820)

Setback thermostats were included in the Baseline scenario to reduce energy costs associated with unoccupied spaces or times. Motion sensors for interior lighting control and ventilation/climate controls systems can be added to turn off lighting automatically and could also be used to reduce ventilation requirements in some spaces when not occupied. Motion sensors are a Preferred Measure.

15. Add solar photovoltaic system(s) to provide some of the facility's base electrical needs.

Solar photovoltaic (PV) systems provide for renewable electrical energy. These systems tend to be quite costly. There are two potential types of solar PV systems -- roof mounted and ground mounted. Given that the majority of the available land is dedicated to effluent disposal (in the form of rapid infiltration basins) and access drives, there is not expected to be much excess available land for a ground mounted solar PV system. For the purposes of this analysis, we have incorporated a 20-kW roof mounted system, which would generate an estimated 25,000 kWh annually. This item is included in the Measures to be Considered in Final Design. During design, it will be important to consider any grant and/or Solar Renewable Energy Credit (SREC) programs in place at that time. These programs could improve the cost effectiveness of a solar PV system. Regardless, the buildings would be designed such that solar PV systems could be easily added at a later date.

16. Add on-site wind turbine to provide some of the facility's base electrical needs.

This site has been considered by the Town as a potential site for an on-site wind turbine; however, we are not aware of any studies performed to document the long-term direction and intensity of wind at the site. For the purposes of this analysis, we have incorporated a 100-kW turbine which would generate an estimated 400,000 kWh annually. This item is included in the Measures to be Considered in Final Design. During design, it will be important to consider any grant and/or renewable energy credit programs in place at that time. These programs could improve the cost effectiveness of a wind turbine system. Regardless, the site would be designed such that a wind turbine could be readily added at a later date.

Management

17. **Add BOD reduction measures to the Sewer Use Ordinance -- specifically banning garbage grinders and recommending waterless and/or urine diverting toilets.**
    As reported in the draft CWMP (pg. 5-4), eliminating garbage grinders would result in an estimated 25% reduction in conventional constituents (BOD, TSS, etc) and a 5% reduction in nitrogen per household. As recommended in the draft CWMP, this measure should be implemented in the sewered and non-sewered areas, which would result in reductions in wastewater strength and in septage quantities. Banning garbage grinders by Sewer Use Ordinance would likely grandfather existing units until failure and ban all new installations. This measure would be relatively easy to adopt but may take 5 to 10 years to fully see the reductions. For the purposes of this analysis, we have assumed that 20% of all homes in Orleans have garbage grinders which, if eliminated, would result in a reduction in BOD loading of 5% (say 25% reduction of 20% of homes) and a reduction in nitrogen loading of 1% loading (say 5% reduction of 20% of homes). This is a Preferred Measure (shown as Item "17A"). For the purposes of this analysis, the activated sludge aeration system blower size was reduced by 5% and the primary and waste sludge storage tank aeration systems blower sizes were reduced by 5% each.

    Urine represents approximately 1% of the wastewater flow but contains about 50% of the phosphorus and 80% of the nitrogen. The use of waterless or urine diverting toilets in a typical household or building would require a urine holding tank, which would need to be pumped out at some frequency. The collected urine could be treated through the WWTF processes (for smaller flows) or through a specialized side stream treatment process (for larger flows). For this analysis, we have assumed that the urine would be trucked to the Orleans WWTF, equalized and added to the liquid treatment process on a uniform basis throughout the day. Under this scenario, this would be an enhancement to the treatment process (i.e., more stable and equalized loadings) but would not impact the total nutrient loadings at the WWTF or GHG emissions from the plant. Based on Table 1, the primary GHG emission comparison for this analysis is between the methods of conveyance of the urine (i.e., collection system vs trucking). For this analysis, we have assumed:

    - Urine generated is 0.4 gpcd.
    - Flushwater associated with urine is 3.2 gpcd (1.6 gallons per flush, twice per day).
    - Total number of properties in town served by sewer in core plan is 2,830 (Table 11-1, draft CWMP). Total number of properties in town under practical buildout scenario in the Core Plan is 5,150.
    - Total number of properties supporting urine diversion is 10%. Average occupancy is 2.0 people per household.
    - Each home or business has a urine storage tank sized for 2 pickups per year.

	All Measures
% Properties Adopting Urine Diversion	10%
Properties/ Population for Urine Diversion	600/ 1,000
Urine Flow	400
Flushwater Flow	3,200
Total Annual Flow	3,600
Truck Trips/ Round Trip Mileage	1,000/ 10
Total Miles	10,000
Reduction of Electrical Consumption in Collection System Associated with Total Annual Flow (vs 640,000 gpd)	0.7%

Additional GHG emission reductions associated with urine diversion would accrue via the reduction of the extent of the collection system needed to meet the TMDLs in various watersheds; however, these reductions are primarily associated with construction-related GHG emissions. Because of this potential benefit, as well as others not included in this analysis, urine diversion warrants additional study. A pilot study of urine diversion was recommended in the draft CWMP. This is a Measure to be Considered in Final Design (shown as Item "17B").

18. **Use low pressure sewers in areas susceptible to infiltration/inflow to minimize extraneous flow to the WWTF.**
The Baseline scenario includes an annual average allowance of 100,000 gallons per day of infiltration/inflow (I/I) based on 300 gpd/inch/mile of sewer for 248,000 linear feet of sewers (conservative value). The Baseline scenario also included an allowance for use of low pressure sewers in flat, low lying or seasonal areas. We estimate that approximately 50,000 linear feet of the collection system is located in areas of perched water table or shallow water table. Based on this figure, we estimate that 20,000 gpd of I/I is related to areas susceptible to infiltration/inflow. For the purposes of this analysis, we have estimated a reduction of 10,000 gpd assuming that 50% of the susceptible area I/I can be removed via the use of low pressure sewers in these areas. For the purposes of this analysis, the electrical energy (kw-hrs) associated with collection system pumping less water will reduced by 1.6% (10,000 gpd out of total of 640,000 gpd). This item is a Measure to be considered in Final Design. If more I/I can be removed through the use of low pressure sewers, then the allowance carried in the draft CWMP should be increased.

19. **Use large sludge hauling trucks (30-cy roll-offs) vs small sludge trucks (10 cy truck).**
The use of larger sludge hauling trucks would reduce the number of truck trips required to convey dewatered sludge cake to off-site facilities for post-processing. The use of larger trucks would require that the Town purchase a roll-off truck and roll-off containers (2) in lieu of continuing to utilize the existing sludge trucks. This item is a Preferred Measure.

20. **Use of supplemental carbon chemicals (if needed) that result in relatively lower GHG emissions.**
    Biological nitrogen removal is limited by the amount of carbon available for the biomass to consume. Once the available carbon is depleted, additional nitrogen removal is typically not achieved; accordingly, supplemental carbon may be needed to achieve the total nitrogen effluent goal of 5 mg/l. If it is required, the industry standard has historically been liquid methanol; however, due to safety issues associated with the handling of this product, there is a growing list of supplemental carbon sources. This list includes ethanol, acetic acid, potassium acetate, MicroC (manufactured chemical made from agricultural products) and, in some cases, nutrient deficient wastewater from food processing plants. These alternative sources may have relatively higher or lower GHG emissions associated with their generation. We would typically design a chemical storage and feed system to accommodate multiple products sources, if feasible. The GHG emissions for these alternatives are outside the scope of this analysis per Table 1. This item is a Measure to be Considered in Final Design.

SUMMARY AND CONCLUSIONS

The MEPA Greenhouse Gas Emissions Policy requires that the project proponent evaluate measures to reduce GHG emissions as alternate metric. This requirement is instructive in focusing on the items that result in GHG emissions reductions, particularly those that produce reductions at little cost. Ultimately, MEPA requires that the Town commit to implementing the Preferred Measures. It is interesting to note that the five Preferred Measures will achieve a 6% reduction in GHG emissions over the Baseline Project, while 11 more Measures to be Considered in Final Design could achieve a much greater reduction (26%). This situation is testimony to the fact that the proposed Orleans WWTF can now be described only in conceptual terms (typical of any CWMP), and that the details needed to commit to other options simply will not be developed until later phases of the project. The MEPA staff recognizes that its new policy best applies to a "typical project" going through the MEPA process, where project details are more developed. Application of this policy to a CWMP can only result in a great deal of uncertainty. We have attempted to deal with that uncertainty by using the category of Measures to be Considered in Final Design to identify possibilities, without committing the Town to measures that may later turn out to be less favorable than now thought.

The Preferred Measures produce an estimated 6% reduction in GHG emissions from the proposed Baseline scenario. The Measures to be Considered in Final Design could produce an additional 26% reduction in GHG emissions over the Preferred Measures. Clearly, each of these measures has an impact on the capital cost of the project as well as the on-going operation and maintenance (O&M) costs of the facility. Table 5 summarizes the estimated GHG emission reduction, capital cost impact, O&M cost impact and "payback period" for each measure.

Although outside the parameters of this analysis, a significant number of septic systems would be removed and replaced with a sewer connection. Based on our initial estimated (17 September 2009 memorandum), the net impact of septic system removals including septage hauling is a significant reduction in GHG emissions.

Some of these measures could be eligible for energy incentive grant monies (e.g., high-efficiency lighting, solar photovoltaic, wind turbines, etc.) in order to make the payback period much more reasonable. The grant, energy incentive and renewable energy credit programs *available at the time the project is designed/constructed* will need to be reviewed in detail during the design phase of the project.

Several measures have a "0 year payback" - meaning the payback is immediate - and have GHG emission reductions. These items should be given strong consideration for implementation. Examples in this category are Item No. 17A (BOD Reduction Measures program), Item No. 1 (Process Septage as Biosolids) and Item 17B (Urine Diversion).

Several measures have relatively low costs and should be considered for implementation even if the GHG emission reduction is modest. Examples in this category are Item No. 10 (High Efficiency Lighting) and Item No. 14 (Motions Sensors for Lighting and Ventilation).

Item No. 16 (Wind Turbine) has a relatively high capital cost, a relatively reasonable payback period and substantial GHG emission reduction. The Town should commission a study to determine long-term wind speed, direction and frequency on-site.

TABLE 1 - PARAMETERS OF GREENHOUSE GAS EMISSION ANALYSIS

	Included in Analysis	**Not Included in Analysis**
Greenhouse Gases	CO2, CH4	NOx, SOx, VOCs
Direct Sources	WWTF building boiler/ heating WWTF standby generator Staff vehicles Sludge trucks (plant to disposal) Urine trucks (homes to plant)	Treatment process (biogenic) Individual septic systems Septage trucks (homes to plant) Collection system
Indirect Sources	Electricity for collection system Electricity for treatment process Electricity for building systems	Electricity for chemical production (e.g. methanol)
Project Phases	Operations	Construction
Scenarios	1. Standard Design 2. High-Efficiency Design	
Other Issues		Purchased offsets

TABLE 2 - ESTIMATE OF GHG EMISSIONS FOR CORE PLAN
SUMMARY OF BASELINE SCENARIO

Sources	Quantity	Units	Conversion	Units	Tons CO_2eq/yr
Building Systems					
Direct	107,800	cf/yr (NG)	0.120	lbsCO2eq/cf	6
Indirect	37	mwh/yr	1008	lbsCO2eq/mwh	19
Process Systems					
Direct - Standby Generator	1,736	gal (Diesel)	22.2	lbsCO2eq/gal	19
Indirect - Collection System	750	mwh/yr	1008	lbsCO2eq/mwh	378
Indirect - WWTF	845	mwh/yr	1008	lbsCO2eq/mwh	426
Transportation					
Direct - WWTF Staff	347	gal (Gas)	19.4	lbsCO2eq/gal	3
Direct - Collection System Staff	1,300	gal (Diesel)	22.2	lbsCO2eq/gal	14
Direct - Sludge Hauling	3,120	gal (Diesel)	22.2	lbsCO2eq/gal	35
Direct - Urine Hauling	n/a	n/a	n/a	n/a	0
Indirect (not applicable)	n/a	n/a	n/a	n/a	0
Renewable Energy On-Site					
Direct	n/a	n/a	n/a	n/a	0
Indirect	0	mwh/yr	1008	lbsCO2eq/mwh	0
SUBTOTAL					
Direct					78
Indirect					822
TOTAL					901

TABLE 3 - ESTIMATE OF GHG EMISSIONS FOR CORE PLAN
SUMMARY OF PREFERRED MEASURES

Sources	Quantity	Units	Conversion	Units	Tons CO_2eq/yr
Building Systems					
Direct	129,800	cf/yr (NG)	0.120	lbsCO2e/cf	8
Indirect	25.0	mwh/yr	1008	lbsCO2e/mwh	13
Process Systems					
Direct - Standby Generator	1,736	gal (Diesel)	22.2	lbsCO2e/gal	19
Indirect - Collection System	738	mwh/yr	1008	lbsCO2e/mwh	372
Indirect - WWTF	804	mwh/yr	1008	lbsCO2e/mwh	405
Transportation					
Direct - WWTF Staff	347	gal (Gas)	19.4	lbsCO2e/gal	3
Direct - Collection System Staff	1,300	gal (Diesel)	22.2	lbsCO2e/gal	14
Direct - Sludge Hauling	1,040	gal (Diesel)	22.2	lbsCO2e/gal	12
Direct - Urine Hauling	0	gal (Diesel)	22.2	lbsCO2e/gal	0
Indirect (not applicable)	n/a	n/a	n/a	n/a	0
Renewable Energy On-Site					
Direct	n/a	n/a	n/a	n/a	0
Indirect	0	mwh/yr	1008	lbsCO2eq/mwh	0
SUBTOTAL					
Direct					56
Indirect					790
TOTAL					846
% Reduction from Baseline					-6.0%

TABLE 4 - ESTIMATE OF GHG EMISSIONS FOR CORE PLAN
SUMMARY OF ALL MEASURES

Sources	Quantity	Units	Conversion	Units	Tons CO_2eq/yr
Building Systems					
Direct	146,100	cf/yr (NG)	0.120	lbsCO2e/cf	9
Indirect	25.0	mwh/yr	1008	lbsCO2e/mwh	13
Process Systems					
Direct - Standby Generator	1,736	gal (Diesel)	22.2	lbsCO2e/gal	19
Indirect - Collection System	735	mwh/yr	1008	lbsCO2e/mwh	370
Indirect - WWTF	685	mwh/yr	1008	lbsCO2e/mwh	345
Transportation					
Direct - WWTF Staff	347	gal (Gas)	19.4	lbsCO2e/gal	3
Direct - Collection System Staff	1,300	gal (Diesel)	22.2	lbsCO2e/gal	14
Direct - Sludge Hauling	1,040	gal (Diesel)	22.2	lbsCO2e/gal	12
Direct - Urine Hauling	1,000	gal (Diesel)	22.2	lbsCO2e/gal	11
Indirect (not applicable)	n/a	n/a	n/a	n/a	0
Renewable Energy On-Site					
Direct	n/a	n/a	n/a	n/a	0
Indirect (Solar PV & Wind)	-407	mwh/yr	1008	lbsCO2eq/mwh	-205
SUBTOTAL					
Direct					68
Indirect					523
TOTAL					592
% Reduction from Baseline					-34.3%

Note: This summary is cumulative and includes the Preferred Measures, Measures to be Considered in Final Design and Not Preferred Measures.

TABLE 5 - SUMMARY OF GHG EMISSION REDUCTION MEASURES

Measures		GHG % Reduction from Baseline	Capital Cost Impact	Annual O&M Savings	Payback Period (yrs)
PREFERRED MEASURES					
2A	Use High Efficiency Blowers and Aeration (Preferred)	1.0%	$50,000	$3,920	13
10	Use High Efficiency Lighting	0.1%	$12,500	$350	36
14	Motion Sensors for Lighting and Ventilation	0.3%	$10,000	$850	12
17A	Add BOD Reduction Measures Program	3.0%	-$104,000	$14,200	0
19	Use Large Sludge Hauling Truck	1.5%	$250,000	$11,240	22
	SUM - Preferred	6.0%	$218,500	$30,560	7
ALL MEASURES					
MEASURES TO BE CONSIDERED IN FINAL DESIGN					
1	Process Septage as Biosolids not Liquid	2.5%	-$88,000	$9,190	0
3	Use High Efficiency BNR Mixers	0.2%	$120,000	$560	214
4	Alternate BNR Process and Limits	n/a	n/a	n/a	n/a
5	Eliminate Effluent Pumping	n/a	n/a	n/a	n/a
8	Adjust Building Orientation	n/a	n/a	n/a	n/a
9	Use Sun Shades	n/a	n/a	n/a	n/a
11	Use Effluent Heat Pumps	0.2%	$50,000	$700	71
15	Use Solar Photovoltaic (20kw)	1.5%	$150,000	$3,500	43
16	Use Wind Turbine (100kw)	21.2%	$650,000	$56,000	12
17B	Add Urine Diversion Toilet Program	0%	-$530,000	$9,520	0
18	Use Low Pressure Sewers to Reduce I/I	0.5%	$0	$1,540	0
	SUM - Consider in Final Design	26.1%	$352,000	$81,010	4
NOT PREFERRED/ NOT APPLICABLE MEASURES					
2B	Use High Efficiency Blowers and Aeration	2.0%	$140,000	$12,530	11
6	Add Sludge Reduction/ Digestion	n/a	n/a	n/a	n/a
7	Reduce Odor Control	n/a	n/a	n/a	n/a
10	Use High Efficiency Lighting	0.2%	$25,000	$400	63
12	Increase Building Envelope R-value	n/a	n/a	n/a	n/a
13	Use High Efficiency Windows	n/a	n/a	n/a	n/a
	SUM - Not Preferred or Applicable	2.2%	$165,000	$12,930	13
ALL MEASURES					
	SUM - All	34.3%	$735,500	$124,500	6

Note: Capital Cost increase is shown as a positive number and decrease is shown as a negative number.
Refer to 27 May 2010 memorandum for a description of each of the measures.

ORLEANS CWMP

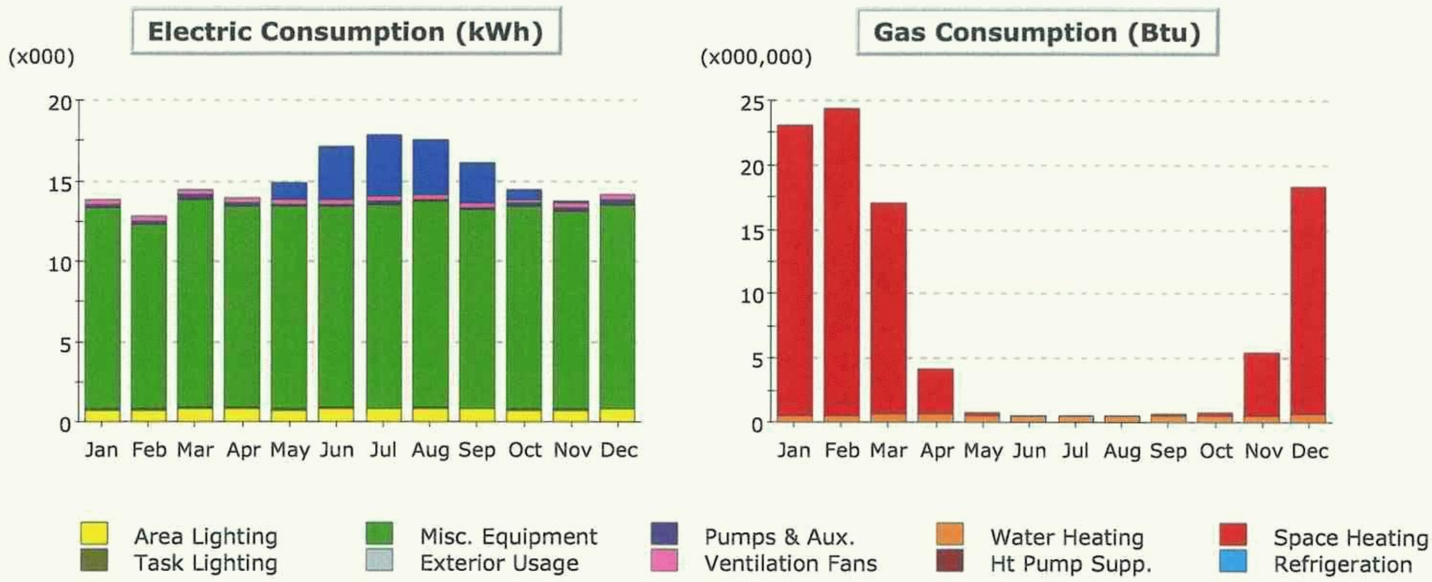
23-Jun-2010

ATTACHMENT A - GREEN HOUSE GAS EMISSIONS ANALYSIS

Design Conditions -- Core Plan	BASELINE	PREFERRED	ALL	
Wastewater Collection System -- Direct Emissions				
Not included, presumed to be negligible	- -	- -	- -	
Wastewater Treatment Process -- Direct Emissions				
Not included, biogenic	- -	- -	- -	
Wastewater Treatment Buildings -- Direct Emissions				
On-Site Heating Plant				
Fuel	Nat Gas	Nat Gas	Nat Gas	
Fuel consumption, BTU/yr	110,700,000	133,300,000	150,000,000	<< Modelled, eQuest
Fuel consumption, cf/yr	107,800	129,800	146,100	<< 1027BTU/cf
CO2 emissions,. lbs per cf	0.120	0.120	0.120	<<US EPA, 2004
GHG emissions, lbs CO2 eq/yr	12,936	15,576	17,532	
Standby Generator				
Fuel	Diesel	Diesel	Diesel	
Runtime, hrs/yr	62	62	62	
Estimated Genset Size, kW	500	500	450	<<Caterpillar
Fuel consumption, gal/hr	28	28	28	<<Caterpillar, 75% load
Fuel consumption, gal/yr	1736	1736	1736	
CO2 emissions,. lbs per gallon	22.2	22.2	22.2	<<US EPA, 2004
GHG emissions, lbs CO2 eq/yr	38,539	38,539	38,539	
Staff Vehicles -- Direct Emissions				
Fuel	Gasoline	Gasoline	Gasoline	
Vehicle miles per year--current				
Miles per day, weekday	15	15	15	
Miles per day, weekend	0	0	0	
Miles per year	3,900	3,900	3,900	
Vehicle miles per year--Phase 4				
Miles per day, weekday	20	20	20	
Miles per day, weekend	0	0	0	
Miles per year	5,200	5,200	5,200	
Miles per gallon	15	15	15	
Gallons per year	347	347	347	<<Gasoline
lb CO2 per gallon	19.4	19.4	19.4	<<US EPA, 2004
lb CO2 per year	6,725	6,725	6,725	
Collection System Maintenance				
Fuel	Diesel	Diesel	Diesel	
Vehicle miles per year--current				
Miles per day, weekday	0	0	0	
Miles per day, weekend	0	0	0	
Miles per year	0	0	0	
Vehicle miles per year--Phase 4				
Miles per day, weekday	50	50	50	
Miles per day, weekend	0	0	0	
Miles per year	13,000	13,000	13,000	
Miles per gallon	10	10	10	
Gallons per year	1,300	1,300	1,300	<<Diesel
lb CO2 per gallon	22.2	22.2	22.2	<<US EPA, 2004
lb CO2 per year	28,860	28,860	28,860	
Sludge Hauling to Disposal				
Fuel	Diesel	Diesel	Diesel	
Vehicle miles per year--current				
Miles per day, weekday	80	80	80	
Miles per day, weekend	0	0	0	

ATTACHMENT A - GREEN HOUSE GAS EMISSIONS ANALYSIS

Design Conditions -- Core Plan	BASELINE	PREFERRED	ALL	
Miles per year	20,800	20,800	20,800	
Vehicle miles per year--Phase 4				
Miles per day, weekday	120	40	40	
Miles per day, weekend	0	0	0	
Miles per year	31,200	10,400	10,400	
Miles per gallon	10	10	10	
Gallons per year	3,120	1,040	1,040	<<Diesel
lb CO2 per gallon	22.2	22.2	22.2	<<US EPA, 2004
lb CO2 per year	69,264	23,088	23,088	
Urine Hauling to Treatment				
Fuel	Diesel	Diesel	Diesel	
Vehicle miles per year--current				
Miles per day, weekday	0	0	0	
Miles per day, weekend	0	0	0	
Miles per year	0	0	0	
Vehicle miles per year--Phase 4				
Miles per trip	0	0	10	10 miles
Trips per year	0	0	1000	500 trips/ 1000 trips
Miles per year	0	0	10,000	
Miles per gallon	10	10	10	
Gallons per year	0	0	1,000	<<Diesel
lb CO2 per gallon	22.2	22.2	22.2	<<US EPA, 2004
lb CO2 per year	0	0	22,200	
		0	*22,200*	
Wastewater Collection - Indirect emissions				
Power usage, KWH per year	750,000	738,000	735,000	<< TABLE A-1
Power usage, MWH per year	750	738	735	
GHG emissions, lbs CO2/ Million KWH	1,008	1,008	1,008	<<ISO-NE, 2007
GHG emissions, lbs CO2/ yr	756,000	743,904	740,880	
		-12,096	*-15,120*	
Wastewater Treatment Process - Indirect emissions				
Power usage, KWH per year	845,000	804,000	685,000	<< TABLE A-2, 3, 4
Power usage, MWH per year	845	804	685	
GHG emissions, lbs CO2/ Million KWH	1,008	1,008	1,008	<<ISO-NE, 2007
GHG emissions, lbs CO2/ yr	851,760	810,432	690,480	
Wastewater Treatment Bldgs - Indirect emissions				
Power usage, KWH per year	36,800	25,000	25,000	<< Modelled, eQuest
Power usage, MWH per year	36.8	25.0	25.0	
GHG emissions, lbs CO2/ Million KWH	1,008	1,008	1,008	<<ISO-NE, 2007
GHG emissions, lbs CO2/ yr	37,094	25,200	25,200	
Renewable Energy Sources - Indirect emissions				
Power usage, KWH per year	0	0	-407,100	<< Estimated
Power usage, MWH per year	0.0	0.0	-407.1	
GHG emissions, lbs CO2/ Million KWH	1,008	1,008	1,008	<<ISO-NE, 2007
GHG emissions, lbs CO2/ yr	0	0	-410,357	

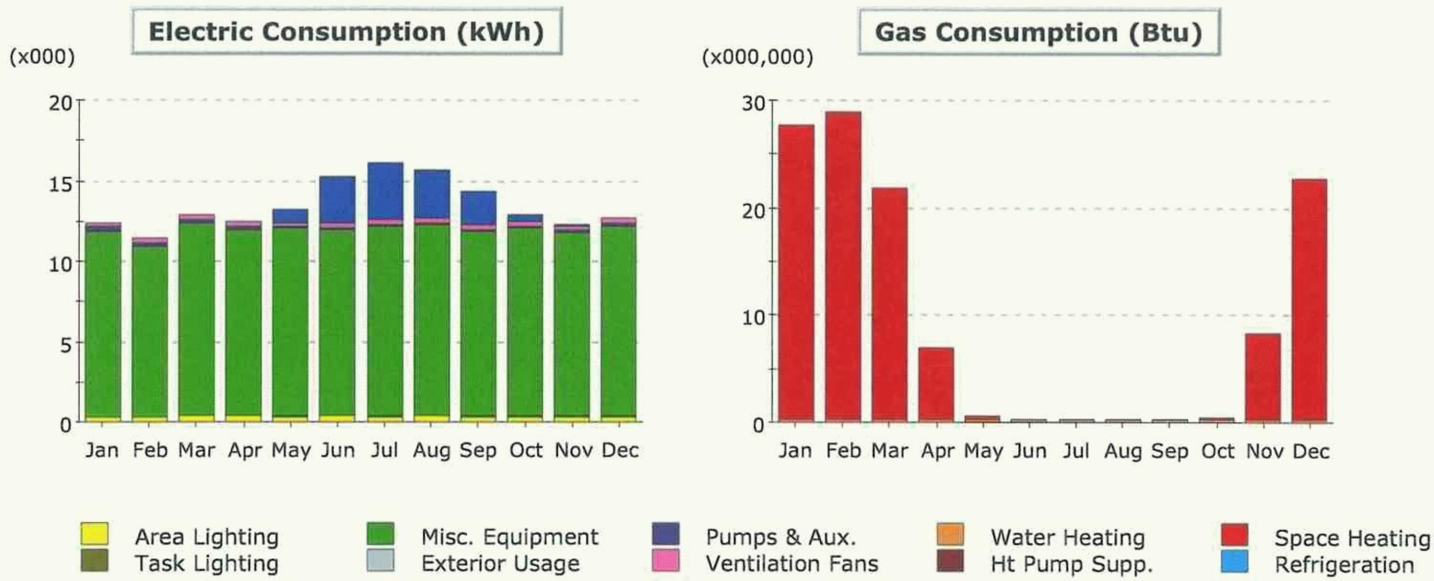


Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	0.04	1.03	3.34	3.89	3.41	2.41	0.61	0.12	0.02	14.87
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	0.01	0.01	0.01	0.00	-	-	-	-	-	-	0.00	0.01	0.05
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.28	0.28	0.34	0.33	0.30	0.33	0.31	0.33	0.31	0.30	0.30	0.31	3.71
Pumps & Aux.	0.23	0.21	0.23	0.20	0.14	0.12	0.12	0.12	0.12	0.16	0.21	0.22	2.08
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	12.46	11.46	12.90	12.46	12.57	12.46	12.68	12.79	12.35	12.57	12.24	12.68	149.64
Task Lights	0.06	0.06	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.85
Area Lights	0.73	0.72	0.87	0.84	0.76	0.84	0.80	0.84	0.80	0.76	0.76	0.80	9.51
Total	13.78	12.75	14.43	13.94	14.87	17.15	17.88	17.56	16.06	14.47	13.70	14.12	180.71

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	22.52	23.82	16.32	3.46	0.19	-	-	-	0.10	0.23	4.86	17.77	89.26
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	0.56	0.58	0.70	0.65	0.56	0.57	0.51	0.51	0.48	0.48	0.52	0.58	6.69
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	23.08	24.40	17.01	4.11	0.74	0.57	0.51	0.51	0.58	0.72	5.37	18.35	95.95

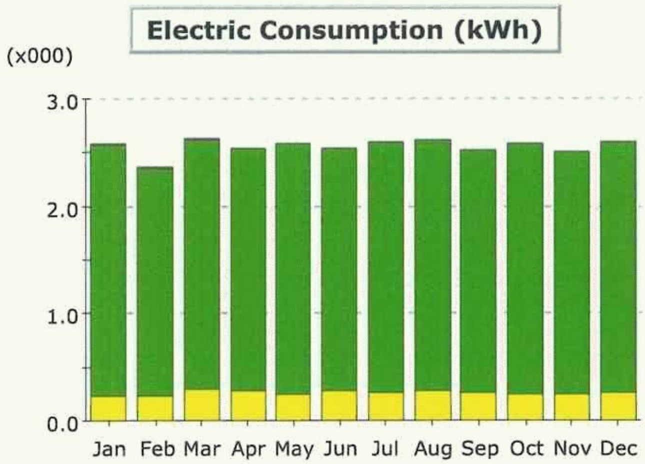


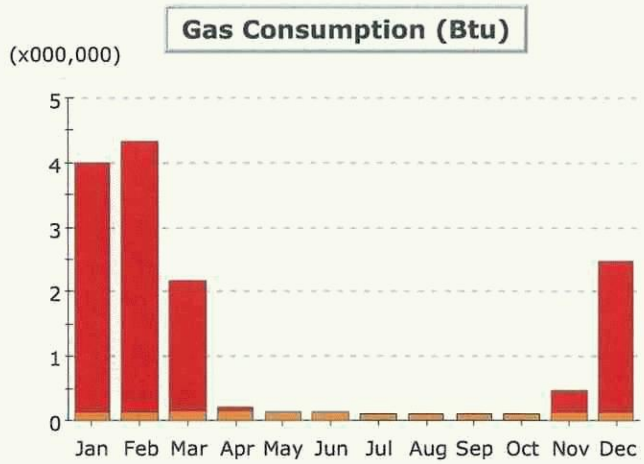
Electric Consumption (kWh x000)

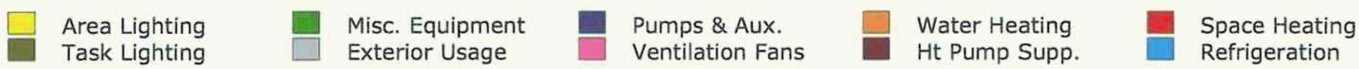
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	0.03	0.82	2.94	3.51	3.02	2.07	0.45	0.09	0.00	12.93
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	0.01	0.02	0.01	0.00	0.00	-	-	-	-	0.00	0.01	0.01	0.06
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.25	0.25	0.30	0.29	0.26	0.29	0.27	0.29	0.27	0.26	0.26	0.27	3.27
Pumps & Aux.	0.23	0.21	0.23	0.20	0.14	0.12	0.12	0.12	0.12	0.16	0.21	0.22	2.08
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	11.55	10.62	11.96	11.55	11.65	11.55	11.76	11.86	11.45	11.65	11.34	11.76	138.70
Task Lights	0.03	0.03	0.04	0.04	0.03	0.04	0.04	0.04	0.04	0.03	0.03	0.04	0.43
Area Lights	0.32	0.31	0.38	0.36	0.33	0.36	0.35	0.36	0.35	0.33	0.33	0.35	4.13
Total	12.39	11.44	12.92	12.47	13.24	15.30	16.04	15.68	14.30	12.89	12.27	12.65	161.60

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	27.36	28.63	21.51	6.57	0.27	0.01	-	-	0.12	0.18	8.02	22.47	115.13
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	0.30	0.31	0.37	0.35	0.30	0.30	0.27	0.27	0.26	0.26	0.28	0.31	3.56
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	27.66	28.94	21.88	6.92	0.56	0.30	0.27	0.27	0.37	0.44	8.30	22.78	118.69





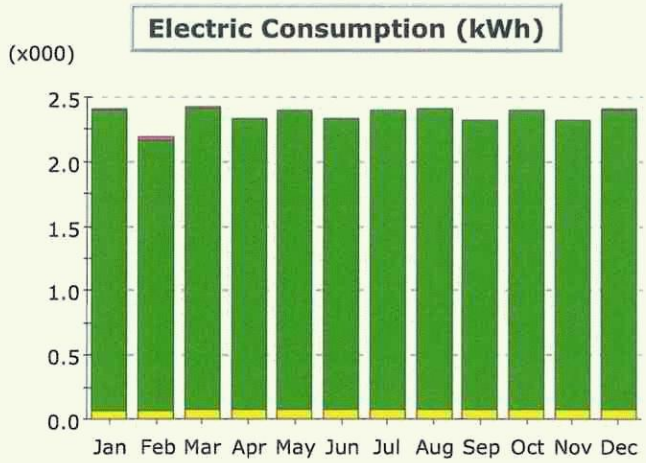


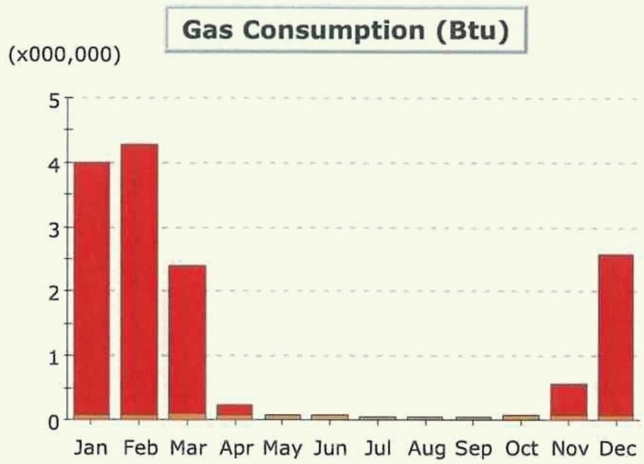
Electric Consumption (kWh x000)

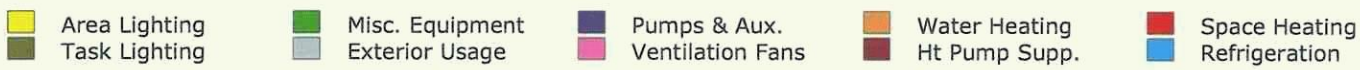
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.02	0.02	0.01	0.00	-	-	-	-	-	-	0.00	0.01	0.06
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	2.33	2.10	2.33	2.25	2.33	2.25	2.33	2.33	2.25	2.33	2.25	2.33	27.43
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	0.24	0.24	0.29	0.28	0.25	0.28	0.26	0.28	0.26	0.25	0.25	0.26	3.15
Total	2.59	2.36	2.63	2.53	2.58	2.53	2.59	2.61	2.52	2.58	2.51	2.61	30.64

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	3.87	4.19	1.99	0.06	-	-	-	-	-	-	0.35	2.34	12.79
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	0.13	0.14	0.16	0.15	0.13	0.13	0.11	0.12	0.11	0.11	0.12	0.14	1.55
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	4.00	4.32	2.16	0.21	0.13	0.13	0.11	0.12	0.11	0.11	0.47	2.47	14.35





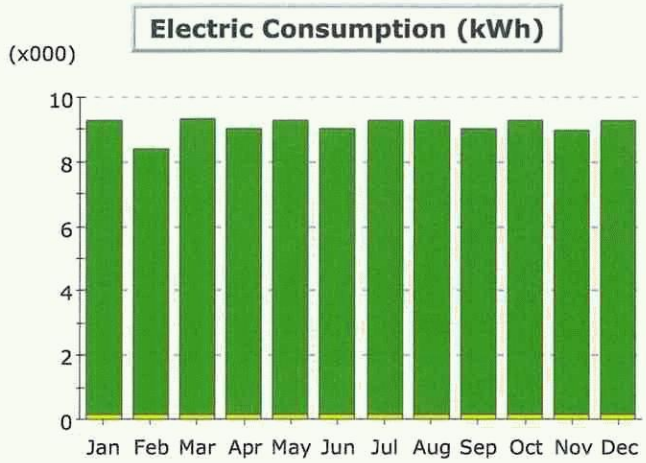


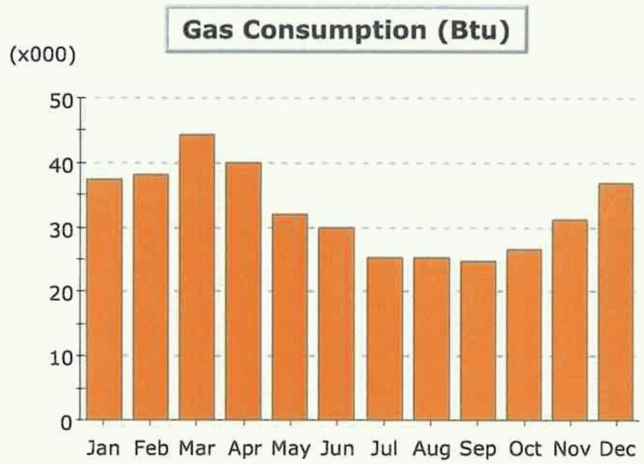
Electric Consumption (kWh x000)

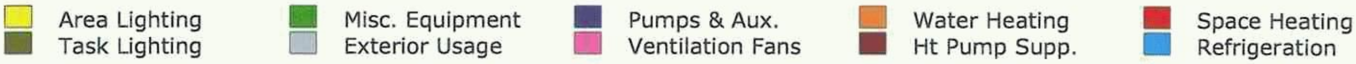
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.02	0.02	0.01	0.00	-	-	-	-	-	-	0.00	0.01	0.07
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	2.32	2.10	2.33	2.25	2.33	2.25	2.33	2.33	2.25	2.33	2.25	2.33	27.38
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	0.07	0.07	0.08	0.08	0.07	0.08	0.07	0.08	0.07	0.07	0.07	0.07	0.89
Total	2.41	2.19	2.42	2.33	2.40	2.33	2.40	2.40	2.33	2.40	2.32	2.41	28.34

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	3.91	4.20	2.30	0.14	-	-	-	-	-	-	0.50	2.50	13.54
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	0.08	0.08	0.09	0.09	0.07	0.07	0.06	0.06	0.06	0.07	0.07	0.08	0.88
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	3.99	4.28	2.39	0.22	0.07	0.07	0.06	0.06	0.06	0.07	0.57	2.58	14.43





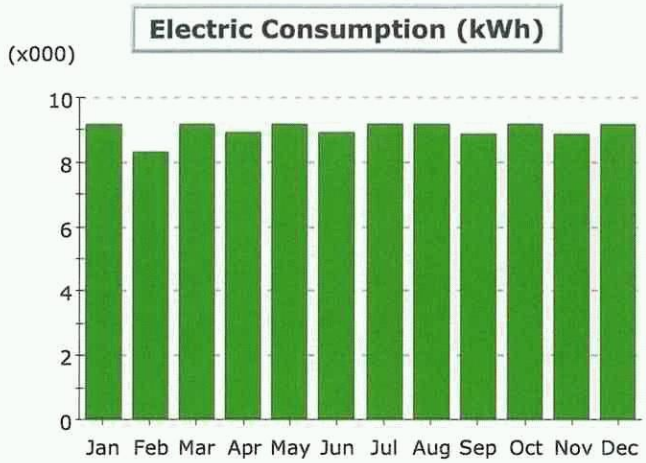


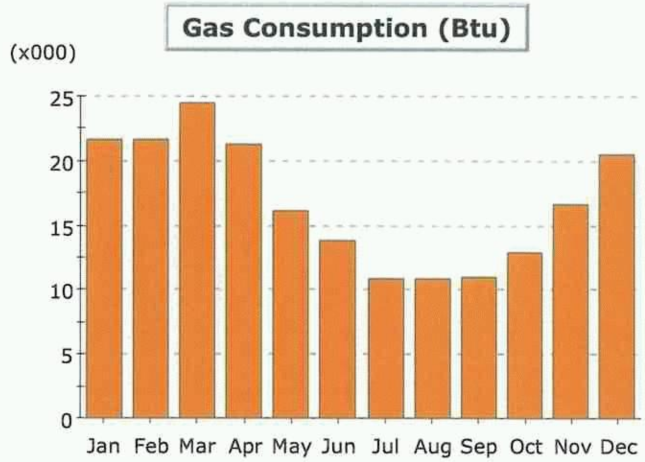
Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	9.14	8.26	9.14	8.85	9.14	8.85	9.14	9.14	8.85	9.14	8.85	9.14	107.64
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	0.14	0.14	0.17	0.16	0.14	0.16	0.15	0.16	0.15	0.14	0.14	0.15	1.80
Total	9.28	8.39	9.31	9.01	9.29	9.01	9.29	9.30	9.00	9.29	8.99	9.29	109.44

Gas Consumption (Btu x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	37.48	38.03	44.37	40.02	31.98	29.96	25.31	25.21	24.63	26.48	31.10	36.92	391.50
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	37.48	38.03	44.37	40.02	31.98	29.96	25.31	25.21	24.63	26.48	31.10	36.92	391.50





Area Lighting
Task Lighting
Misc. Equipment
Exterior Usage
Pumps & Aux.
Ventilation Fans
Water Heating
Ht Pump Supp.
Space Heating
Refrigeration

Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	9.14	8.26	9.14	8.85	9.14	8.85	9.14	9.14	8.85	9.14	8.85	9.14	107.64
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	0.04	0.04	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.51
Total	9.18	8.30	9.19	8.89	9.18	8.89	9.19	9.19	8.89	9.18	8.89	9.19	108.15

Gas Consumption (Btu x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	21.60	21.60	24.42	21.26	16.08	13.75	10.88	10.80	10.91	12.89	16.57	20.48	201.25
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	21.60	21.60	24.42	21.26	16.08	13.75	10.88	10.80	10.91	12.89	16.57	20.48	201.25

ORLEANS - COMPREHENSIVE WASTEWATER MANAGEMENT PLAN *25-May-2010*
PRELIMINARY EQUIPMENT LIST AND ANNUAL ELECTRICAL LOAD PROFILE *Wright-Pierce*

APPENDIX TABLE A-1 - COLLECTION SYSTEM

TAG NO.	EQUIP. NAME	NO. OF SITES	EST AVG FLOW	EST AVG TDH	EST PUMP EFF	EST MOTOR EFF	ELECTRICAL INFO AVG HP	% FL	% Running	Annual KWH	% of TOTAL
	Wetwell/ Drywell (500 - 1,500 gpm)	6									
	1500 gpm peak flow	1	450	50	70%	92%	8.8	100%	90%	51,940	6.9%
	1000 gpm peak flow	1	300	50	70%	92%	5.9	100%	90%	34,630	4.6%
	750 gpm peak flow	2	200	50	70%	92%	3.9	100%	90%	46,170	6.1%
	500 gpm peak flow	2	150	50	70%	92%	2.9	100%	90%	34,630	4.6%
	Submersible (100 - 500 gpm)	56									
	400 gpm peak flow	10	400	45	60%	91%	8.3	100%	30%	163,380	21.7%
	300 gpm peak flow	10	300	45	60%	91%	6.3	100%	30%	122,530	16.3%
	200 gpm peak flow	18	200	45	60%	91%	4.2	100%	30%	147,040	19.5%
	100 gpm peak flow	18	100	45	60%	91%	2.1	100%	30%	73,520	9.8%
	Grinder Pump Station (10-50 gpm)	78									
	50 gpm peak flow	5	50	40	50%	92%	1.1	100%	30%	10,770	1.4%
	40 gpm peak flow	5	40	40	50%	92%	0.9	100%	30%	8,620	1.1%
	30 gpm peak flow	23	30	40	50%	92%	0.7	100%	30%	29,730	3.9%
	20 gpm peak flow	25	20	40	50%	92%	0.4	100%	30%	21,550	2.9%
	10 gpm peak flow	20	10	40	50%	92%	0.2	100%	30%	8,620	1.1%
	Total Pump Stations	140							**Total KWH**	**753,130**	
	Average KWH per Pump Stations	5,380								**per year**	

Preferred	**-2.0%**
All	**-2.3%**

TOTAL KWH, PREFERRED MEASURES -->> 738,067
TOTAL KWH, ALL MEASURES -->> 735,808

ORLEANS - COMPREHENSIVE WASTEWATER MANAGEMENT PLAN

25-May-2010

PRELIMINARY EQUIPMENT LIST AND ANNUAL ELECTRICAL LOAD PROFILE

Wright-Pierce

APPENDIX TABLE A-2 - WASTEWATER TREATMENT FACILITY

TAG NO.	EQUIP. NAME	NO. OF UNITS	NO. RUNNING	NO. OF UNITS ON STANDBY	ELECTRICAL INFO HP	% FL	% Running	Annual KWH	% of TOTAL
	MECHANICAL SCREEN	1	1	0	2	50%	20%	1,310	0.2%
	SCREEN WASH PRESS	1	1	0	2	50%	20%	1,310	0.2%
	SEPTAGE RECEIVING UNIT	3	2	1	3	50%	20%	3,920	0.5%
	SEPTAGE TRANSFER PUMP	2	1	1	5	50%	20%	3,270	0.4%
	SEPTAGE BLOWERS	2	1	1	20	50%	50%	32,670	3.9%
	GRIT CHAMBER	1	1	0	1.5	50%	100%	4,900	0.6%
	GRIT PUMP	1	1	0	7.5	50%	25%	6,130	0.7%
	GRIT CLASSIFIER	1	1	0	1	50%	25%	820	0.1%
	PRIMARY CLARIFIER DRIVES	2	2	0	1.0	50%	100%	6,530	0.8%
	PRIMARY SLUDGE PUMP/MIXING	2	1	1	10	50%	25%	8,170	1.0%
	PRIMARY SCUM PUMP	1	1	0	5	50%	25%	4,080	0.5%
	AERATION BLOWERS	5	2	3	50	50%	100%	326,750	38.7%
	BNR MIXERS	24	12	12	2	50%	100%	78,420	9.3%
	IR PUMPS	4	2	2	2	50%	100%	13,070	1.5%
	SECONDARY CLARIFIERS	3	2	1	1	50%	100%	6,530	0.8%
	RETURN SLUDGE PUMP	3	2	1	10	50%	100%	65,350	7.7%
	WASTE SLUDGE PUMP	2	1	1	3	50%	25%	2,450	0.3%
	SECONDARY SCUM PUMP/MIXING	1	1	0	5	50%	25%	4,080	0.5%
	UV DISINFECTION (4 KW, Ann Avg)	3	2	1	4	50%	100%	25,980	3.1%
	EFFLUENT PUMPING	4	2	2	10	50%	100%	65,350	7.7%
	FOAM SPRAY WATER SYSTEM	2	1	1	15	50%	25%	12,250	1.5%
	PLANT WATER SYSTEM	2	1	1	15	50%	50%	24,510	2.9%
	ON-SITE RECYCLE PUMP STATION	2	1	1	5	50%	25%	4,080	0.5%
	SLUDGE STORAGE - WASTE/ BLOWERS	2	1	1	20	50%	50%	32,670	3.9%
	SLUDGE STORAGE - PRIMARY/ BLOWERS	2	1	1	20	50%	50%	32,670	3.9%
	SLUDGE STORAGE - BLENDED/ BLOWERS	2	1	1	15	50%	20%	9,800	1.2%
	MECHANICAL THICKENING SYSTEM	1	1	0	5	50%	20%	3,270	0.4%
	DEWATERING SLUDGE FEED GRINDERS	2	1	1	5	50%	20%	3,270	0.4%
	DEWATERING SLUDGE FEED PUMPS	2	1	1	15	50%	20%	9,800	1.2%
	DEWATERING SYSTEM (BFP)	2	1	1	20	50%	20%	13,070	1.5%
	ODOR CONTROL SYSTEM #1	1	1	0	7.5	50%	75%	18,380	2.2%
	ODOR CONTROL SYSTEM #2	1	1	0	7.5	50%	75%	18,380	2.2%
							Total KWH	**843,240**	
					BASELINE MEASURES			**per year**	

ORLEANS - COMPREHENSIVE WASTEWATER MANAGEMENT PLAN

3-Jun-2010

PRELIMINARY EQUIPMENT LIST AND ANNUAL ELECTRICAL LOAD PROFILE

Wright-Pierce

APPENDIX TABLE A-3 - WASTEWATER TREATMENT FACILITY/ PREFERRED MEASURES

TAG NO.	EQUIP. NAME	NO. OF UNITS	NO. RUNNING	NO. OF UNITS ON STANDBY	ELECTRICAL INFO HP	% FL	% Running	Annual KWH	% of TOTAL
	MECHANICAL SCREEN	1	1	0	2	50%	20%	1,310	0.2%
	SCREEN WASH PRESS	1	1	0	2	50%	20%	1,310	0.2%
	SEPTAGE RECEIVING UNIT	3	2	1	3	50%	20%	3,920	0.5%
	SEPTAGE TRANSFER PUMP	2	1	1	5	50%	20%	3,270	0.4%
	SEPTAGE BLOWERS	2	1	1	20	50%	50%	32,670	4.1%
	GRIT CHAMBER	1	1	0	1.5	50%	100%	4,900	0.6%
	GRIT PUMP	1	1	0	7.5	50%	25%	6,130	0.8%
	GRIT CLASSIFIER	1	1	0	1	50%	25%	820	0.1%
	PRIMARY CLARIFIER DRIVES	2	2	0	1.0	50%	100%	6,530	0.8%
	PRIMARY SLUDGE PUMP/MIXING	2	1	1	10	50%	25%	8,170	1.0%
	PRIMARY SCUM PUMP	1	1	0	5	50%	25%	4,080	0.5%
	AERATION BLOWERS	5	2	3	45	50%	100%	294,070	36.6%
	BNR MIXERS	24	12	12	2	50%	100%	78,420	9.8%
	IR PUMPS	4	2	2	2	50%	100%	13,070	1.6%
	SECONDARY CLARIFIERS	3	2	1	1	50%	100%	6,530	0.8%
	RETURN SLUDGE PUMP	3	2	1	10	50%	100%	65,350	8.1%
	WASTE SLUDGE PUMP	2	1	1	3	50%	25%	2,450	0.3%
	SECONDARY SCUM PUMP/MIXING	1	1	0	5	50%	25%	4,080	0.5%
	UV DISINFECTION (4 KW, Ann Avg)	3	2	1	4	50%	100%	25,980	3.2%
	EFFLUENT PUMPING	4	2	2	10	50%	100%	65,350	8.1%
	FOAM SPRAY WATER SYSTEM	2	1	1	15	50%	25%	12,250	1.5%
	PLANT WATER SYSTEM	2	1	1	15	50%	50%	24,510	3.0%
	ON-SITE RECYCLE PUMP STATION	2	1	1	5	50%	25%	4,080	0.5%
	SLUDGE STORAGE - WASTE/ BLOWERS	2	1	1	18	50%	50%	29,410	3.7%
	SLUDGE STORAGE - PRIMARY/ BLOWERS	2	1	1	18	50%	50%	29,410	3.7%
	SLUDGE STORAGE - BLENDED/ BLOWERS	2	1	1	15	50%	20%	9,800	1.2%
	MECHANICAL THICKENING SYSTEM	1	1	0	5	50%	20%	3,270	0.4%
	DEWATERING SLUDGE FEED GRINDERS	2	1	1	5	50%	20%	3,270	0.4%
	DEWATERING SLUDGE FEED PUMPS	2	1	1	15	50%	20%	9,800	1.2%
	DEWATERING SYSTEM (BFP)	2	1	1	20	50%	20%	13,070	1.6%
	ODOR CONTROL SYSTEM #1	1	1	0	7.5	50%	75%	18,380	2.3%
	ODOR CONTROL SYSTEM #2	1	1	0	7.5	50%	75%	18,380	2.3%
							Total KWH	**804,040**	
					PREFERRED MEASURES			**per year**	

ORLEANS - COMPREHENSIVE WASTEWATER MANAGEMENT PLAN *25-May-2010*

PRELIMINARY EQUIPMENT LIST AND ANNUAL ELECTRICAL LOAD PROFILE *Wright-Pierce*

APPENDIX TABLE A-4 - WASTEWATER TREATMENT FACILITY/ ALL MEASURES

TAG NO.	EQUIP. NAME	NO. OF UNITS	NO. RUNNING	NO. OF UNITS ON STANDBY	ELECTRICAL INFO HP	% FL	% Running	Annual KWH	% of TOTAL
	MECHANICAL SCREEN	1	1	0	2	50%	20%	1,310	0.2%
	SCREEN WASH PRESS	1	1	0	2	50%	20%	1,310	0.2%
	SEPTAGE RECEIVING UNIT	3	2	1	3	50%	20%	3,920	0.6%
	SEPTAGE TRANSFER PUMP	2	1	1	5	50%	20%	3,270	0.5%
	SEPTAGE BLOWERS	2	1	1	20	50%	50%	32,670	4.8%
	GRIT CHAMBER	1	1	0	1.5	50%	100%	4,900	0.7%
	GRIT PUMP	1	1	0	7.5	50%	25%	6,130	0.9%
	GRIT CLASSIFIER	1	1	0	1	50%	25%	820	0.1%
	PRIMARY CLARIFIER DRIVES	2	2	0	1.0	50%	100%	6,530	1.0%
	PRIMARY SLUDGE PUMP/MIXING	2	1	1	10	50%	25%	8,170	1.2%
	PRIMARY SCUM PUMP	1	1	0	5	50%	25%	4,080	0.6%
	AERATION BLOWERS	5	2	3	25	50%	100%	163,370	23.8%
	BNR MIXERS	24	12	12	1.9	50%	100%	74,500	10.9%
	IR PUMPS	4	2	2	2	50%	100%	13,070	1.9%
	SECONDARY CLARIFIERS	3	2	1	1	50%	100%	6,530	1.0%
	RETURN SLUDGE PUMP	3	2	1	10	50%	100%	65,350	9.5%
	WASTE SLUDGE PUMP	2	1	1	3	50%	25%	2,450	0.4%
	SECONDARY SCUM PUMP/MIXING	1	1	0	5	50%	25%	4,080	0.6%
	UV DISINFECTION (4 KW, Ann Avg)	3	2	1	4	50%	100%	25,980	3.8%
	EFFLUENT PUMPING	4	2	2	10	50%	100%	65,350	9.5%
	FOAM SPRAY WATER SYSTEM	2	1	1	15	50%	25%	12,250	1.8%
	PLANT WATER SYSTEM	2	1	1	15	50%	50%	24,510	3.6%
	ON-SITE RECYCLE PUMP STATION	2	1	1	5	50%	25%	4,080	0.6%
	SLUDGE STORAGE - WASTE/ BLOWERS	2	1	1	18	50%	50%	29,410	4.3%
	SLUDGE STORAGE - PRIMARY/ BLOWERS	2	1	1	28	50%	50%	45,740	6.7%
	SLUDGE STORAGE - BLENDED/ BLOWERS	2	1	1	15	50%	20%	9,800	1.4%
	MECHANICAL THICKENING SYSTEM	1	1	0	5	50%	20%	3,270	0.5%
	DEWATERING SLUDGE FEED GRINDERS	2	1	1	5	50%	20%	3,270	0.5%
	DEWATERING SLUDGE FEED PUMPS	2	1	1	15	50%	20%	9,800	1.4%
	DEWATERING SYSTEM (BFP)	2	1	1	20	50%	20%	13,070	1.9%
	ODOR CONTROL SYSTEM #1	1	1	0	7.5	50%	75%	18,380	2.7%
	ODOR CONTROL SYSTEM #2	1	1	0	7.5	50%	75%	18,380	2.7%
							Total KWH ALL MEASURES	**685,750 per year**	

eQuest Modeling Inputs
Orleans - Wastewater Treatment and Disposal Facilities
Control Building - 6/30/2010

Model Input	*Baseline*	*Preferred**
GENERAL INFORMATION		
Building Type (retail or other)	Manufacturing, General	
Location Set	All eQuest Locations	
State	Massachusetts	
City	Chatham	
Building Area (square feet)	9,750	
Number of Floors, Above Grade	1	
Number of Floors, Bbove Grade	.5	
Cooling Equipment	DX Coils	
Heating Equipment	Furnace	
Analysis Year	2010	
Daylighting Controls (Y/N)	N	
Usage Details	Simplified Schedules	
BUILDING FOOTPRINT		
Footprint Shape	Rectangle	
Zoning Pattern	By Activity Area	
Building Orientation	North	
Footprint Dimensions, X1 (feet)	50.00	
Footprint Dimensions, Y1 (feet)	130.00	
Floor to Floor Height (feet)	14.0	
Floor to Ceiling Height (feet)	13.5	
Pitched Roof	33 deg./1.3' overhang	
BUILDING ENVELOPE CONSTRUCTION		
Roof Construction Type	Wood Advanced Frame, 24" oc	
Roof Finish	Shingle	
Roof Color (solar reflectance)	Gray, light oil	
Roof Insulation	R-38	
Exterior Wall Construction Type	8" CMU, grout 24" oc & empty cells	
Exterior Wall Color	Medium (abs=.06)	
Exterior Wall Insulation	3" polystyrene (R-12)	
Ground Floor Exposure	Earth contact	
Ground Floor Construction	12" concrete	
Ground Floor Insulation	R-5 at 2' wide	
Ground Floor Finish	No finish	
Below Grade Walls, Construction	12" Concrete	
Below Grade Walls, Insulation	R-5, 8' deep	

** Note, only differences are shown in the Preferred column.*

eQuest Modeling Inputs
Orleans - Wastewater Treatment and Disposal Facilities
Control Building - 6/30/2010

Model Input	***Baseline***	***Preferred****
EXTERIOR DOORS/WINDOWS		
Door Type 1, type	Opaque	
Door Type 1, # of doors by orientation	0-N, 1-S, 2-E, 2-W	
Door Type 1, size	7'h x 3'w	
Door Type 1, construction	Steel, Polyurethane core w/o brk	
Door Type 2, type	Overhead	
Door Type 2, # of doors by orientation	0-N, 0-S, 0-E, 3-W	
Door Type 2, size	12'h x 12'w	
Door Type 2, construction	Insulated Steel	
Window U-factor	U-Value=0.40, SC=0.84, VT=0.81	
ACTIVITY AREAS ALLOCATION		
Area 1, Type	Mech/Elec Room	
Area 1, % of total area	15.4	
Area 1, design max. occ. (sf/person)	300.0	
Area 1, design ventilation	0.00	
Area 2, Type	Comm/Ind Work (General, Low Bay)	
Area 2, % of total area	41.5	
Area 2, design max. occ. (sf/person)	300.0	
Area 2, design ventilation	400.00	
Area 3, Type	Office (General)	
Area 3, % of total area	43.1	
Area 3, design max. occ. (sf/person)	400.0	
Area 3, design ventilation	20.00	
OCCUPIED LOADS BY ACTIVITY AREA		
Area 1, Lighting (W/sf)	1.00	0.85
Area 1, Task Lt (W/sf)	0.00	
Area 1, Plug Lds (W/sf)	0.20	
Area 2, Lighting (W/sf)	1.00	0.85
Area 2, Task Lt (W/sf)	0.00	
Area 2, Plug Lds (W/sf)	15.61	14.35

** Note, only differences are shown in the Preferred column.*

eQuest Modeling Inputs
Orleans - Wastewater Treatment and Disposal Facilities
Control Building - 6/30/2010

Model Input	*Baseline*	*Preferred**
Area 3, Lighting (W/sf)	1.30	1.10
Area 3, Task Lt (W/sf)	0.20	
Area 3, Plug Lds (W/sf)	1.50	
UNOCCUPIED LOADS BY ACTIVITY AREA (% OF OCCUPIED LOADS)		
Area 1, Occupancy (%)	0.00	
Area 1, Lighting (W/sf)	0.00	
Area 1, Task Lt (W/sf)	0.00	
Area 1, Plug Lds (W/sf)	20.0	
Area 2, Occupancy (%)	0.00	
Area 2, Lighting (W/sf)	0.00	
Area 2, Task Lt (W/sf)	0.00	
Area 2, Plug Lds (W/sf)	100.0	
Area 3, Occupancy (%)	0.00	
Area 3, Lighting (W/sf)	0.00	
Area 3, Task Lt (W/sf)	0.00	
Area 3, Plug Lds (W/sf)	20.0	
MAIN SCHEDULE INFORMATION		
Day 1 (Days)	Mo, Tu, We, Th, Fr, CD, HD	
Day 1, Schedule	Opens at 8 am/ Closes at 5 am	
Occup %	90.0	45.0
Lites Ld %	90.0	45.0
Equip Ld %	100.0	
Day 2, (Days)	Sa, Su, Hol	
Day 1, Schedule	Unoccupied	
HVAC SYSTEM DEFINITIONS		
Cooling Source	DX Cooling	
Heating Source	Furnace	
System Type	Split System Single Zone DX with Furnace	
Return Air Path	Ducted	
HVAC ZONES: TEMPERATURES AND AIR FLOWS		
Cooling Set Point, Occupied	76 F	
Cooling Set Point, Unoccupied	82 F	

** Note, only differences are shown in the Preferred column.*

eQuest Modeling Inputs
Orleans - Wastewater Treatment and Disposal Facilities
Control Building - 6/30/2010

Model Input	*Baseline*	*Preferred**
Heating Set Point, Occupied	70 F	
Heating Set Point, Unoccupied	64 F	
Cooling Design Temp, Indoor	75 F	
Cooling Design Temp, Supply	55 F	
Heating Design Temp, Indoor	72 F	
Heating Design Temp, Supply	95 F	
Minimum Design Air Flow (cfm/f^2)	0.50	
PACKAGED HVAC EQUIPMENT		
Cooling, Overall Size	Auto-size	
Cooling, Typical Unit Size	90-135 kBtu or 7.5-11.25 tons	
Cooling, Condenser Type	Air-cooled	
Cooling, Efficiency	EER, 8.900	
Heating, Size	Auto-size	
Heating, Typical Unit Size	< 225 kBtu	
Heating, Efficiency	AFUE, 0.780	
HVAC SYSTEM FANS		
Supply Fan, Power & Mtr Eff	1.00 in. WG, High	
Fan Flow & OSA	Auto-size Flow (w/ 1.15 safety fac.)	
Fan Schedule	Operate fans 1 hour before open and 1 hour after close	
HVAC ZONE HEATING, VENT AND ECONOMIZERS		
Baseboards	Hot Water, -195.0 kBtu	
BBD HW Src	Hot Water Loop	
Economizers, Type	Drybulb Temperature	
Economizers, High Limit	65.0 F	
HEATING PRIMARY EQUIPMENT		
HW Loop, Head	36.6 ft	
HW Loop, Design DT	40.0 F	
Pump Configuration	Single System Pump Only	
Number of System Pumps	1	
HW Loop Flow	Constant	
Motor Efficiency	High	
Boiler Type	HW Boiler Forced Draft	

** Note, only differences are shown in the Preferred column.*

eQuest Modeling Inputs
Orleans - Wastewater Treatment and Disposal Facilities
Control Building - 6/30/2010

Model Input	***Baseline***	***Preferred****
Boiler Fuel	Nat. Gas	
Boiler Count	1	
Boiler Output	Auto-size, < 300 kBtuh	
Boiler Efficiency	80.0	
Efficiency Spec	Efficiency	
HOT WATER SYSTEM CONTROL AND SCHEDULE		
Setpoint is	Fixed	
Setpoint Value	180.0 F	
Operation	Standby	
DOMESTIC WATER HEATING		
Heater Fuel	Natural Gas	
Heater Type	Storage	
Hot Water Use (gal/person/day)	1.00	
Input Rating (kBtuh)	19.3	
Efficiency Spec	Energy Factor	
Energy Factor	0.59	
Storage Capacity (gal)	15	
Insulation R-Value (h-ft2-F/Btu)	12.0	
Supply Temperature	135 F	
Inlet Water Temperature	Ground Temp	
Recirculation (%)	0	

** Note, only differences are shown in the Preferred column.*

eQuest Modeling Inputs
Orleans - Wastewater Treatment and Disposal Facilities
Headworks Building - 6/30/2010

Model Input	*Baseline*	*Preferred**
GENERAL INFORMATION		
Building Type (retail or other)	Manufacturing, General	
Location Set	All eQuest Locations	
State	Massachusetts	
City	Chatham	
Building Area (square feet)	7,200	
Number of Floors, Above Grade	1	
Number of Floors, Bbove Grade	.7	
Cooling Equipment	No Cooling	
Heating Equipment	Furnace	
Analysis Year	2010	
Daylighting Controls (Y/N)	N	
Usage Details	Simplified Schedules	
BUILDING FOOTPRINT		
Footprint Shape	Rectangle	
Zoning Pattern	By Activity Area	
Building Orientation	North	
Footprint Dimensions, X1 (feet)	60.00	
Footprint Dimensions, Y1 (feet)	70.00	
Floor to Floor Height (feet)	14.0	
Floor to Ceiling Height (feet)	13.5	
Pitched Roof	33 deg./1.3' overhang	
BUILDING ENVELOPE CONSTRUCTION		
Roof Construction Type	Wood Advanced Frame, 24" oc	
Roof Finish	Shingle	
Roof Color (solar reflectance)	Gray, light oil	
Roof Insulation	R-38	
Exterior Wall Construction Type	8" CMU, grout 24" oc & empty cells	
Exterior Wall Color	Medium (abs=.06)	
Exterior Wall Insulation	3" polystyrene (R-12)	
Ground Floor Exposure	Earth contact	
Ground Floor Construction	12" concrete	
Ground Floor Insulation	R-5 at 2' wide	
Ground Floor Finish	No finish	
Below Grade Walls, Construction	12" Concrete	
Below Grade Walls, Insulation	R-5, 8' deep	

** Note, only differences are shown in the Preferred column.*

eQuest Modeling Inputs
Orleans - Wastewater Treatment and Disposal Facilities
Headworks Building - 6/30/2010

Model Input	*Baseline*	*Preferred**
EXTERIOR DOORS/WINDOWS		
Door Type 1, type	Opaque	
Door Type 1, # of doors by orientation	2-N, 2-S, 3-E, 3-W	
Door Type 1, size	7'h x 3'w	
Door Type 1, construction	Steel, Polyurethane core w/o brk	
Door Type 2, type	Overhead	
Door Type 2, # of doors by orientation	0-N, 0-S, 1-E, 1-W	
Door Type 2, size	13.5'h x 14'w	
Door Type 2, construction	Insulated Steel	
Window U-factor	U-Value=0.40, SC=0.84, VT=0.81	
ACTIVITY AREAS ALLOCATION		
Area 1, Type	Comm/Ind Work (General, Low Bay)	
Area 1, % of total area	28.6	
Area 1, design max. occ. (sf/person)	300.0	
Area 1, design ventilation	400.00	
Area 2, Type	Comm/Ind Work (Precision)	
Area 2, % of total area	42.9	
Area 2, design max. occ. (sf/person)	300.0	
Area 2, design ventilation	800.00	
Area 3, Type	Mech/Elec Room	
Area 3, % of total area	28.6	
Area 3, design max. occ. (sf/person)	300.0	
Area 3, design ventilation	0.00	
OCCUPIED LOADS BY ACTIVITY AREA		
Area 1, Lighting (W/sf)	1.00	0.85
Area 1, Task Lt (W/sf)	0.00	
Area 1, Plug Lds (W/sf)	1.72	
Area 2, Lighting (W/sf)	1.00	0.85
Area 2, Task Lt (W/sf)	0.00	
Area 2, Plug Lds (W/sf)	0.56	

** Note, only differences are shown in the Preferred column.*

eQuest Modeling Inputs
Orleans - Wastewater Treatment and Disposal Facilities
Headworks Building - 6/30/2010

Model Input	*Baseline*	*Preferred**
Area 3, Lighting (W/sf)	1.00	0.85
Area 3, Task Lt (W/sf)	0.00	
Area 3, Plug Lds (W/sf)	0.20	
UNOCCUPIED LOADS AS % OF OCCUPIED LOADS		
Area 1, Occupancy (%)	0.00	
Area 1, Lighting (W/sf)	0.00	
Area 1, Task Lt (W/sf)	0.00	
Area 1, Plug Lds (W/sf)	100.0	
Area 2, Occupancy (%)	0.00	
Area 2, Lighting (W/sf)	0.00	
Area 2, Task Lt (W/sf)	0.00	
Area 2, Plug Lds (W/sf)	100.0	
Area 3, Occupancy (%)	0.00	
Area 3, Lighting (W/sf)	0.00	
Area 3, Task Lt (W/sf)	0.00	
Area 3, Plug Lds (W/sf)	20.0	
MAIN SCHEDULE INFORMATION		
Day 1 (Days)	Mo, Tu, We, Th, Fr, CD, HD	
Day 1, Schedule	Opens at 8 am/ Closes at 10 am	Opens at 8 am/ Closes at 9 am
Occup %	100.0	50.0
Lites Ld %	100.0	50.0
Equip Ld %	100.0	
Day 2, (Days)	Sa, Su, Hol	
Day 1, Schedule	Unoccupied	
HVAC SYSTEM DEFINITIONS		
Cooling Source	No Cooling	
Heating Source	Furnace	
System Type	Gas or Fuel Furnace w/ No zone ventilation	
HVAC ZONES: TEMPERATURES AND AIR FLOWS		
Heating Set Point, Occupied	55 F	
Heating Set Point, Unoccupied	55 F	
Heating Design Temp, Indoor	55 F	

** Note, only differences are shown in the Preferred column.*

eQuest Modeling Inputs
Orleans - Wastewater Treatment and Disposal Facilities
Headworks Building - 6/30/2010

Model Input	*Baseline*	*Preferred**
Heating Design Temp, Supply	95 F	
Minimum Design Air Flow (cfm/f^2)	0.50	
PACKAGED HVAC EQUIPMENT		
Size	Auto-size	
Typical Unit Size	>= 225 kBtu	
Efficiency	0.806	
HVAC SYSTEM FANS		
Supply Fan, Power & Mtr Eff	0.75 in. WG, High	
Fan Flow & OSA	Auto-size Flow (w/ 1.15 safety fac.)	
Fan Schedule	Operate fans 1 hour before open and 1 hour after close	
HVAC ZONE HEATING, VENT AND ECONOMIZERS		
Baseboards	None	
DOMESTIC WATER HEATING		
Heater Fuel	Natural Gas	
Heater Type	Storage	
Hot Water Use (gal/person/day)	0.20	
Input Rating (kBtuh)	3.7	
Efficiency Spec	Energy Factor	
Energy Factor	0.61	
Storage Capacity (gal)	6	
Insulation R-Value (h-ft2-F/Btu)	12.0	
Supply Temperature	135 F	
Inlet Water Temperature	Ground Temp	
Recirculation (%)	0	

** Note, only differences are shown in the Preferred column.*

eQuest Modeling Inputs
Orleans - Wastewater Treatment and Disposal Facilities
Disinfection Building - 6/30/2010

Model Input	*Baseline*	*Preferred**
GENERAL INFORMATION		
Building Type (retail or other)	Manufacturing, General	
Location Set	All eQuest Locations	
State	Massachusetts	
City	Chatham	
Building Area (square feet)	2,400	
Number of Floors, Above Grade	1	
Number of Floors, Bbove Grade	0	
Cooling Equipment	No Cooling	
Heating Equipment	Furnace	
Analysis Year	2010	
Daylighting Controls (Y/N)	N	
Usage Details	Simplified Schedules	
BUILDING FOOTPRINT		
Footprint Shape	Rectangle	
Zoning Pattern	One Per Floor	
Building Orientation	North	
Footprint Dimensions, X1 (feet)	40.00	
Footprint Dimensions, Y1 (feet)	60.00	
Floor to Floor Height (feet)	12.0	
Floor to Ceiling Height (feet)	11.5	
Pitched Roof	33 deg./1.3' overhang	
BUILDING ENVELOPE CONSTRUCTION		
Roof Construction Type	Wood Advanced Frame, 24" oc	
Roof Finish	Shingle	
Roof Color (solar reflectance)	Gray, light oil	
Roof Insulation	R-38	
Exterior Wall Construction Type	8" CMU, grout 24" oc & empty cells	
Exterior Wall Color	Medium (abs=.06)	
Exterior Wall Insulation	3" polystyrene (R-12)	
Ground Floor Exposure	Earth contact	
Ground Floor Construction	12" concrete	
Ground Floor Insulation	R-5 at 2' wide	
Ground Floor Finish	No finish	
Below Grade Walls, Construction	12" Concrete	
Below Grade Walls, Insulation	R-5, 8' deep	

** Note, only differences are shown in the Preferred column.*

eQuest Modeling Inputs
Orleans - Wastewater Treatment and Disposal Facilities
Disinfection Building - 6/30/2010

Model Input	*Baseline*	*Preferred**
EXTERIOR DOORS/WINDOWS		
Door Type 1, type	Opaque	
Door Type 1, # of doors by orientation	0-N, 0-S, 3-E, 3-W	
Door Type 1, size	7'h x 3'w	
Door Type 1, construction	Steel, Polyurethane core w/o brk	
Window U-factor	U-Value=0.40, SC=0.84, VT=0.81	
ACTIVITY AREAS ALLOCATION		
Area 1, Type	Mech/Elec Room	
Area 1, % of total area	100.0	
Area 1, design max. occ. (sf/person)	300.0	
Area 1, design ventilation	0.00	
OCCUPIED LOADS BY ACTIVITY AREA		
Area 1, Lighting (W/sf)	1.00	0.85
Area 1, Task Lt (W/sf)	0.00	
Area 1, Plug Lds (W/sf)	5.12	
UNOCCUPIED LOADS BY ACTIVITY AREA (% OF OCCUPIED LOAD)		
Area 1, Occupancy (%)	0.00	
Area 1, Lighting (W/sf)	0.00	
Area 1, Task Lt (W/sf)	0.00	
Area 1, Plug Lds (W/sf)	100.0	
MAIN SCHEDULE INFORMATION		
Day 1 (Days)	Mo, Tu, We, Th, Fr, CD, HD	
Day 1, Schedule	Opens at 8 am/ Closes at 10 am	Opens at 8 am/ Closes at 9 am
Occup %	100.0	50.0
Lites Ld %	100.0	50.0
Equip Ld %	100.0	
Day 2, (Days)	Sa, Su, Hol	
Day 1, Schedule	Unoccupied	

** Note, only differences are shown in the Preferred column.*

eQuest Modeling Inputs
Orleans - Wastewater Treatment and Disposal Facilities
Disinfection Building - 6/30/2010

Model Input	***Baseline***	***Preferred****
HVAC SYSTEM DEFINITIONS		
Cooling Source	No Cooling	
Heating Source	Furnace	
System Type	Gas or Fuel Furnace w/ No zone ventilation	
HVAC ZONES: TEMPERATURES AND AIR FLOWS		
Heating Set Point, Occupied	55 F	
Heating Set Point, Unoccupied	55 F	
Heating Design Temp, Indoor	55 F	
Heating Design Temp, Supply	95 F	
Minimum Design Air Flow (cfm/f^2)	0.50	
PACKAGED HVAC EQUIPMENT		
Size	Auto-size	
Typical Unit Size	>= 225 kBtu	
Efficiency	0.806	
HVAC SYSTEM FANS		
Supply Fan, Power & Mtr Eff	0.75 in. WG, High	
Fan Flow & OSA	Auto-size Flow (w/ 1.15 safety fac.)	
Fan Schedule	Operate fans 1 hour before open and 1 hour after close	
HVAC ZONE HEATING, VENT AND ECONOMIZERS		
Baseboards	Electric, -21.1 kW	
DOMESTIC WATER HEATING		
Heater Fuel	Natural Gas	
Heater Type	Storage	
Hot Water Use (gal/person/day)	0.20	
Input Rating (kBtuh)	1.1	
Efficiency Spec	Energy Factor	
Energy Factor	0.61	
Storage Capacity (gal)	6	
Insulation R-Value (h-ft2-F/Btu)	12.0	
Supply Temperature	135 F	
Inlet Water Temperature	Ground Temp	
Recirculation (%)	0	

** Note, only differences are shown in the Preferred column.*

APPENDIX K

REGIONALIZATION STUDY

Town of Orleans

Wastewater Regionalization Study
Orleans-Brewster-Eastham

December 2009

Prepared by:

Wright-Pierce
Engineering a Better Environment

TOWN OF ORLEANS
WASTEWATER REGIONALIZATION STUDY

ORLEANS--BREWSTER--EASTHAM

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SECTION 1

INTRODUCTION

1.1 BACKGROUND

The Town of Orleans has embarked on a multi-year, multi-phase planning 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. This process has been called Comprehensive Wastewater Management Planning and is documented in the report entitled *Orleans Comprehensive Wastewater Management Plan, April 2009 Draft*.

Section 9 of the Orleans draft CWMP provides the rationale for Orleans working with its neighbors to determine if regional wastewater facilities make sense. The Town of Orleans secured a grant from the Cape Cod Water Protection Collaborative (CCWPC), under its "Shared Watersheds, Shared Responsibilities" program, to undertake this regionalization study. The intent is to complete this evaluation while the draft CWMP is undergoing environmental review and then incorporate its findings in the final CWMP in early 2010.

The Town of Eastham is in the process of wastewater management planning and the Town of Brewster is currently securing consulting engineering services for water resources planning. Both towns are now completing assessments of freshwater ponds. Even though Eastham and Brewster are several years behind Orleans in their planning activities, the potential for cost savings through regionalization warrants this evaluation. If sufficient benefits accrue to all towns, Orleans should retain the capability for incorporating wastewater flows from these towns into its project, subject to later confirmation once Eastham and Brewster complete their planning activities.

1.2 STUDY AREA

Orleans and Eastham share the watersheds of the Nauset System, Rock Harbor and Boat Meadow. Both Towns have responsibility for controlling nitrogen to meet the needs as documented in published Massachusetts Estuaries Project (MEP) studies or as projected by MEP staff, which are assumed to lead to nitrogen-based Total Maximum Daily Loads (TMDLs).

Orleans and Brewster (as well as Harwich and Chatham) share the watershed of Pleasant Bay. All four of these towns have responsibility to comply with nitrogen-based TMDLs adopted by EPA in 2007, based on MEP technical reports completed earlier.

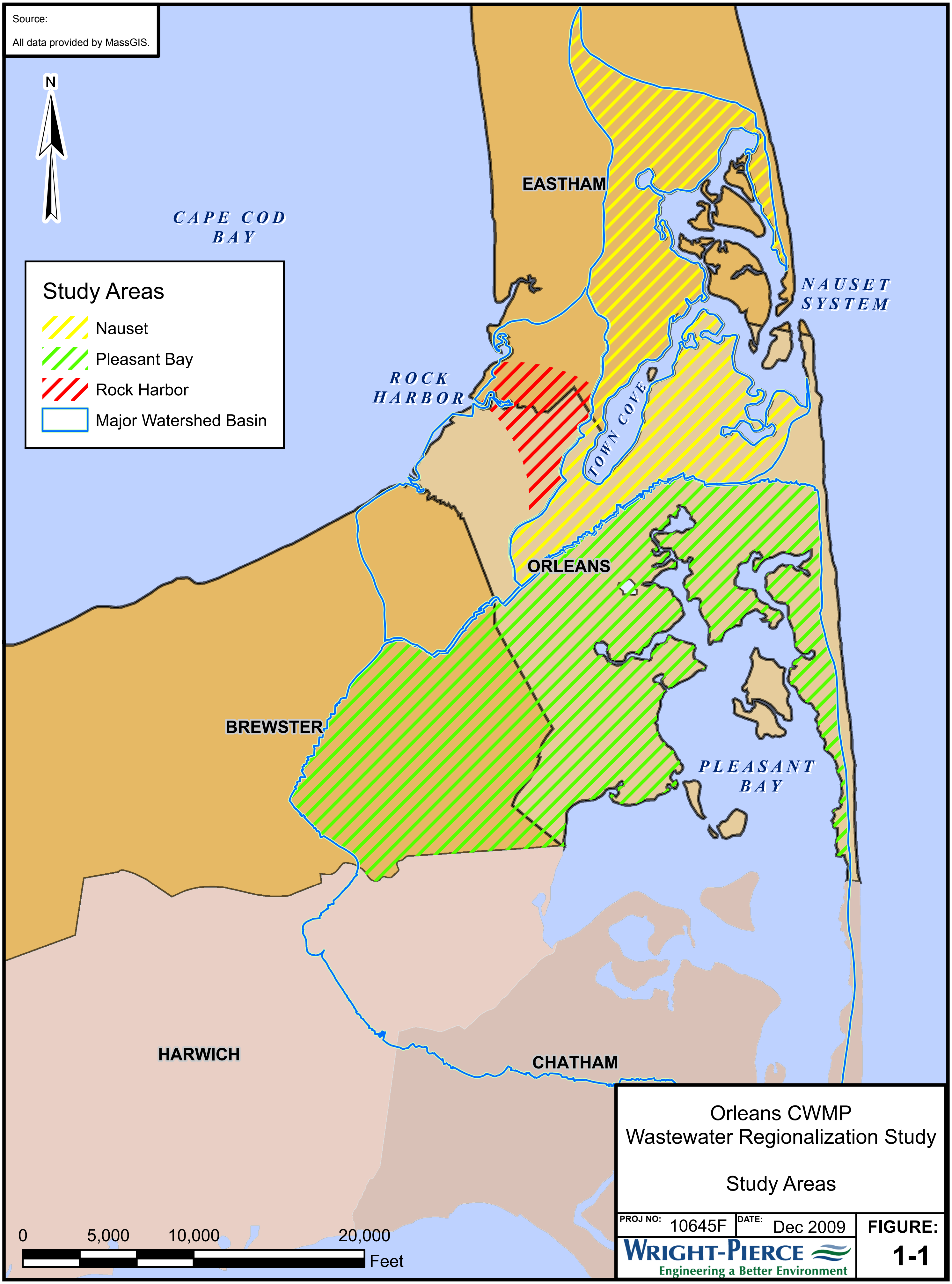
Orleans and Brewster also share the watershed of Namskaket Marsh. The draft MEP technical report for this system indicates that current and projected nitrogen loads in its watershed are well below thresholds, so no nitrogen control needs exist there.

The study area for this project consists of the towns of Orleans, Brewster and Eastham and is depicted on Figure 1-1. Given this sharing of watersheds, it is logical to consider regionalization opportunities.

1.3 PURPOSE OF STUDY

The purpose of this study is to identify and evaluate regionalization alternatives and to determine if they make economic, environmental and political sense. This study will include the following steps:

- Identifying logical options for joint wastewater facilities;
- Estimating wastewater flows in the portions of Eastham and Brewster that are tributary to coastal systems with nitrogen control needs to supplement similar prior estimates for Orleans;
- Identifying prospective sites in Brewster and Eastham where these Towns could address their needs on their own, including possible sewer service areas;



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- Estimating costs for both local and regional solutions;
- Developing and applying cost-sharing formulas; and
- Evaluating non-financial issues.

The principal reason for regional cost savings is "economies of scale"; that is, the cost to treat a gallon of wastewater decreases with increasing plant size. As flows increase at a wastewater treatment facility, some costs (such as chemicals or sludge disposal) increase in direct proportion to the flow. Other costs, such as labor, do not increase in proportion to flow. If two or more towns participate in a regional facility, they can share those "fixed costs" and save money over separate individual plants.

Transport costs are the principal factor offsetting these economies of scale. Any town must weigh the cost to build a pipeline to a regional facility against the costs savings attributable to joint treatment. Towns the size of Orleans, Brewster and Eastham are prime candidates to take advantage of economies of scale, provided that transport costs are not excessive.

1.4 REPORT ORGANIZATION

This report consists of six sections. Following this introduction are the following sections:

Section 2:	Estimates of Wastewater Flows
Section 3:	Identification and Description of Regionalization Alternatives
Section 4:	Development and Application of Cost Model
Section 5:	Evaluation of Cost Allocation Methods
Section 6:	Suggested Next Steps

1.5 THREE-TOWN WORKING GROUP

The Towns of Orleans, Brewster and Eastham each provided staff to serve on a "Working Group" for this study. In addition, staff members of DEP, the Cape Cod Commission and the Orleans Brewster Eastham Groundwater Protection District (OBEGWPD) have participated. The Working Group members played an active role in development of wastewater flows, selection of wastewater disposal sites, and review of the report and its concepts. The working group members are:

George Meservey	Town of Orleans
Jillian Douglass	Town of Brewster
Susan Leven	Town of Brewster
Chris Miller	Town of Brewster
Nancy Ellis Ice	Town of Brewster
Jane Crowley	Town of Eastham
Brian Dudley	DEP
Tom Cambareri	Cape Cod Commission
Jay Burgess	OBEGWPD

The efforts of the Working Group members have significantly benefited this project, and their work is appreciated.

SECTION 2

ESTIMATES OF WASTEWATER FLOW

2.1 INTRODUCTION

In order to evaluate economies of scale, it is necessary to prepare estimates of wastewater flow that would be collected, treated and disposed of. That work has been accomplished for Orleans, and is reported in Sections 2, 3 and 4 of the draft CWMP. Similar, but more generalized flow estimates have been prepared for Eastham and Brewster since actual figures are not yet available. This section of the report summarizes the evaluations used to estimate the wastewater flows now generated in pertinent areas of each town, and the portion of those flows that should be collected for treatment. All wastewater flows have been computed and reported as annual averages for consistency with the Orleans draft CWMP. For each community, an estimate of current wastewater flows was calculated as well as an estimate of future flows at a planning horizon, approximately 20 years from now (2030).

2.2 DEMOGRAPHIC AND WATER USE STATISTICS

Consistent with standard practice in wastewater planning, water use records were utilized to serve as the basis for estimating wastewater flows. Public water supplies serve the majority of developed properties in Brewster and Orleans. Average water consumption for properties served by public water systems in those two communities has been used to estimate water use for Brewster and Orleans properties served by private wells. For Brewster, the initial analysis was based on 2007 water billing records provided by the Brewster Water Department, and a listing of property type provided by the Brewster Assessing Department to determine seasonality. Supplemental data were provided by Brewster for water use from 2002 to 2007. These data have been linked to a GIS database so that water consumption is geographically tied to specific parcels.

There is no public water system in Eastham, so water consumption data from Brewster and Orleans have been selectively applied to demographic information for Eastham to estimate Eastham's water consumption.

The following methodology was utilized to establish wastewater flows for each community:

1. Develop statistics on water use per property for all properties served by town water, regardless of watershed.

2. Compare those statistics with analogous ones from Orleans.

3. Apply the most appropriate statistics to properties in the applicable watersheds that are not served by town water.

4. Add the estimated water use figures from Step 3 to the actual data for properties that are served by town water.

5. Apply a factor to account for water consumption that does not contribute to wastewater flow.

Table 2-1 presents a summary of the data used in this analysis. The top of Table 2-1 shows the assessors' data on the number of residential properties in each town, distinguishing between seasonal and year-round homes (based on personal property taxes), and presenting subtotals for single-family residences based on the number of bedrooms. These house counts are presented town-wide for all three towns. In addition, Table 2-1 shows the house counts in the areas of Eastham within the Rock Harbor and Town Cove watersheds that are closest to Orleans.

The middle block of data in Table 2-1 shows the percentage distribution of homes by bedroom count for each town. Although there is some variability, the size of homes (as measured by bedroom count) is approximately the same in each town: about 3.1 to 3.2 bedrooms per home on average. Across the entire study area, about 60% of the single-family homes are year-round dwellings, ranging from 57% in Orleans to 65% in Brewster. There is much more variability in the multi-family home distribution, ranging from 25% year-round in Orleans to 81% year-round in Eastham.

TABLE 2-1
SUMMARY OF HOUSING DATA AND RECENT PER-PROPERTY WATER USE

	Orleans			Brewster			Eastham			
							Rock Harbor & Town Cove Only			Total Town-wide
	Year-round	Seasonal	Total	Year-round	Seasonal	Total	Year-round	Seasonal	Total	
A. Number of Homes										
Single-family homes										
2 or fewer BR	469	387	856	643	386	1,029	35	29	64	1,140
3 BR	1,006	712	1,718	2,047	992	3,039	85	55	140	2,640
4 BR	471	347	818	733	409	1,142	43	27	70	1,104
5 BR	109	81	190	93	70	163	6	2	8	142
6 or more BR	15	33	48	18	17	35	2	-	2	42
Total	2,070	1,560	3,360	3,534	1,874	5,408	171	113	284	5,068
Multi-family properties	71	212	283	89	82	171	34	8	42	295
B. Percentage of Homes										
Single-family homes										
2 or fewer BR	23%	25%	24%	18%	21%	19%	20%	26%	23%	22%
3 BR	49%	46%	47%	58%	53%	56%	50%	49%	49%	52%
4 BR	23%	22%	23%	21%	22%	21%	25%	24%	25%	22%
5 BR	5%	5%	5%	3%	4%	3%	4%	2%	3%	3%
6 or more BR	1%	2%	1%	1%	1%	1%	1%	0%	1%	1%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	57%	43%	-	65%	35%	-	60%	40%	-	-
Multi-family properties	25%	75%	100%	52%	48%	100%	81%	19%	100%	-
C. Water Use per Home (gpd)										
Single-family homes										
2 or fewer BR	126	90	109	130	76	109	-	-	-	-
3 BR	163	116	144	173	108	152	-	-	-	-
4 BR	187	152	172	202	131	177	-	-	-	-
5 BR	226	206	218	232	154	198	-	-	-	-
6 or more BR	378	164	231	259	408	339	-	-	-	-
Overall	164	123	147	174	112	152	-	-	-	-
Multi-family properties	360	298	330	196	258	229	-	-	-	-

The last section of data in Table 2-1 summarizes the average water consumption per property served by the public water systems in Brewster and Orleans. The Orleans data represent a four-year average (2002 to 2006) and are the same as presented in Section 2 of the draft CWMP. The Brewster data represent the average water use for 2002 to 2006 as well.

These data indicate that the average residential property served by the public water system in Brewster uses 3.4% more water than the average such home in Orleans. There are two plausible reasons for this difference. First, Brewster has a greater percentage of year-round homes. Second, based on the 2000 US Census, the occupancy of Brewster's year-round homes is slightly higher than in Orleans.

Brewster	2.37 persons per dwelling unit (DU),
Orleans	2.12 persons per DU, and
Eastham	2.27 persons per DU.

2.3 ESTIMATES OF WASTEWATER FLOWS

Brewster

Table 2-2 reports the estimated wastewater flows for the developed properties in Brewster that are located in the Pleasant Bay watershed. First, the wastewater flow was estimated for properties on the public water system, based on actual water usage from the period 2002 to 2006 and an assumed 10% consumptive use (the water used in irrigation, car washing and similar activities). We estimate that these properties now produce an aggregate wastewater flow of about 85,000 gallons per day (gpd). Table 2-2 shows the average wastewater flow for each category of development; for example, the average single family residential property on public water produces 135 gpd of wastewater. Next, the same per-property flows were applied to those developed parcels using private wells, where no public water use information is available. This approach results in an estimated 32,000 gpd from those properties not on the public water system. The overall estimate for the Brewster portion of the Pleasant Bay watershed is about

TABLE 2-2
WASTEWATER FLOW ESTIMATES FOR BREWSTER IN PLEASANT BAY WATERSHED

	Properties on Public Water			Properties not on Public Water			All Properties		
Activity	Number of Properties	Gpd per Property	Gpd	Number of Properties	Gpd per Property	Gpd	Number of Properties	Gpd per Property	Gpd
1. Single-family Residential	502	135	67,770	115	135	15,525	617	135	83,295
2. Multi-family Residential	5	188	940	4	188	752	9	188	1,692
3. Commercial									
Athletics	2	-	-	1	3,380	3,380	-	-	-
Nursing Home *(Note 1)*	1	9,992	9,992	1	1,000	1,000	-	-	-
Other	-	-	-	6	925	5,550	-	-	-
All Commercial	3	3,331	9,992	8	1,241	9,930	11	1,811	19,922
4 Other (State Class 9000)	5	1,224	6,120	91	65	5,915	96	125	12,035
All properties	515	165	84,822	218	147	32,122	733	160	116,944

Notes:
1. *The "nursing home" line item refers to Pleasant Bay Health & Living Center which has a private wastewater treatment plant that discharged 12,000 gpd in 2008.*

117,000 gpd. Approximately 72% of this figure is associated with properties for which water use information is available and 28% from properties where the water use was estimated.

Eastham

Table 2-3 presents the approach that was taken to estimate wastewater flows in Eastham, both town-wide and for the Rock Harbor and Town Cove watersheds. Per-property water use figures were assigned that are intermediate between those calculated for Brewster and Orleans, and a 10% consumptive use factor was applied. This analysis results in wastewater flows of about 52,000 gpd in the Rock Harbor and Town Cove watersheds, and about 830,000 gpd town-wide. (The town-wide estimate was prepared to judge consistency with the town-wide estimates for Orleans that are reported in the draft CWMP; the Orleans town-wide estimate is 779,000 gpd.)

While this study was underway, Stearns & Wheler prepared flow estimates for Eastham as part of a preliminary needs assessment (*Draft Interim Needs Assessment and Alternatives Screening Analysis Report*, *January 2009*). Although different approaches have been used, the Stearns & Wheler flow estimates are quite close to those reported herein. This estimate of 830,000 gpd town-wide compares well with the Stearns & Wheler estimate of 820,000 gpd. For the Town Cove and Rock Harbor watersheds, this estimate of 52,000 gpd also compares well with the Stearns and Wheler estimate of 55,000 gpd. The Stearns & Wheler estimates have been used in the remainder of the report.

2.4 ESTIMATES OF WASTEWATER FLOWS TO BE TREATED

The flow estimates reported in Tables 2-2 and 2-3 represent the wastewater flows across the entire town or the noted watershed. To meet the established or expected TMDLs, a portion of the total wastewater must be collected and treated. Those percentages are as follows for current conditions:

Brewster portion of Pleasant Bay watershed	50% (from the MEP technical report)
Rock Harbor	79% (from the draft MEP report)
Nauset System	55% (estimated by MEP staff)

TABLE 2-3
WASTEWATER FLOW ESTIMATES FOR EASTHAM

Activity	Rock Harbor & Town Cove Watersheds			Town-Wide		
	Number of Properties	Gpd per Property	Gpd	Number of Properties	Gpd per Property	Gpd
1. Single-family Residential						
Year-Round	171	160	27,360			
Seasonal	113	110	12,430			
All Single-family	284	140	39,790	5,068	140	709,520
2. Multi-family Residential						
Year-Round	34	200	6,800			
Seasonal	8	250	2,000			
All Multi-family	42	210	8,800	295	210	61,950
3. Commercial	6	600	3,600	101	600	60,600
All properties	332	157	52,190	5,464	152	832,070

In Tables 2-4 and 2-5, these percentages are applied to the overall wastewater flows to estimate the wastewater flows that must be collected and treated. Table 2-4 summarizes "current" conditions while Table 2-5 presents "future" conditions. For Eastham, a 10% growth in collected wastewater has been used in Table 2-5 as reported by Stearns & Wheler. For Brewster, the Town requested inclusion of a 26% growth factor for its portion of the Pleasant Bay watershed. For TMDL compliance, 50% of current septic nitrogen loads must be removed and 100% of future loads. The requested 26% growth in watershed-wide flow translates to the need to collect 52% of the future wastewater flow. This concept is illustrated graphically below in Figure 2-1.

To illustrate the linkage between the various tables, note that Table 2-2 estimates a flow of about 117,000 gpd from the Pleasant Bay portion of Brewster. Since 50% of that wastewater must be collected and treated, 58,000 gpd is shown in Table 2-4 and 88,000 gpd (52% growth) in Table 2-5. Tables 2-4 and 2-5 report the flow estimates prepared by Stearns & Wheler for Eastham.

Pleasant Bay Health & Living Center is located in Brewster in the Pleasant Bay watershed. In 2007, a private wastewater treatment facility was built there to serve both the original nursing home and the new adjacent development. That treatment facility has operated under a DEP groundwater discharge permit and has produced effluent nitrogen well below the 10 mg/l standard. The 2008 average flow was approximately 12,000 gpd. The nitrogen contribution from that 12,000-gpd facility is accounted for in this evaluation.

The Orleans draft CWMP presents estimates of wastewater flow from the watersheds impacted by Orleans. Here is how those figures change in the various regionalization scenarios, expressed as annual averages at the planning horizon:

Brewster alone	88,000 gpd (Pleasant Bay watershed)
Eastham alone	160,000 gpd (Rock Harbor & Nauset watersheds)
Orleans alone	504,000 gpd (town-wide, core plan)
Orleans and Brewster	592,000 gpd (17% increase over Orleans alone)
Orleans and Eastham	664,000 gpd (32% increase over Orleans alone)
All three towns	752,000 gpd (49% increase over Orleans alone)

FIGURE 2-1
ILLUSTRATION OF CURRENT AND FUTURE NITROGEN LOAD REDUCTIONS

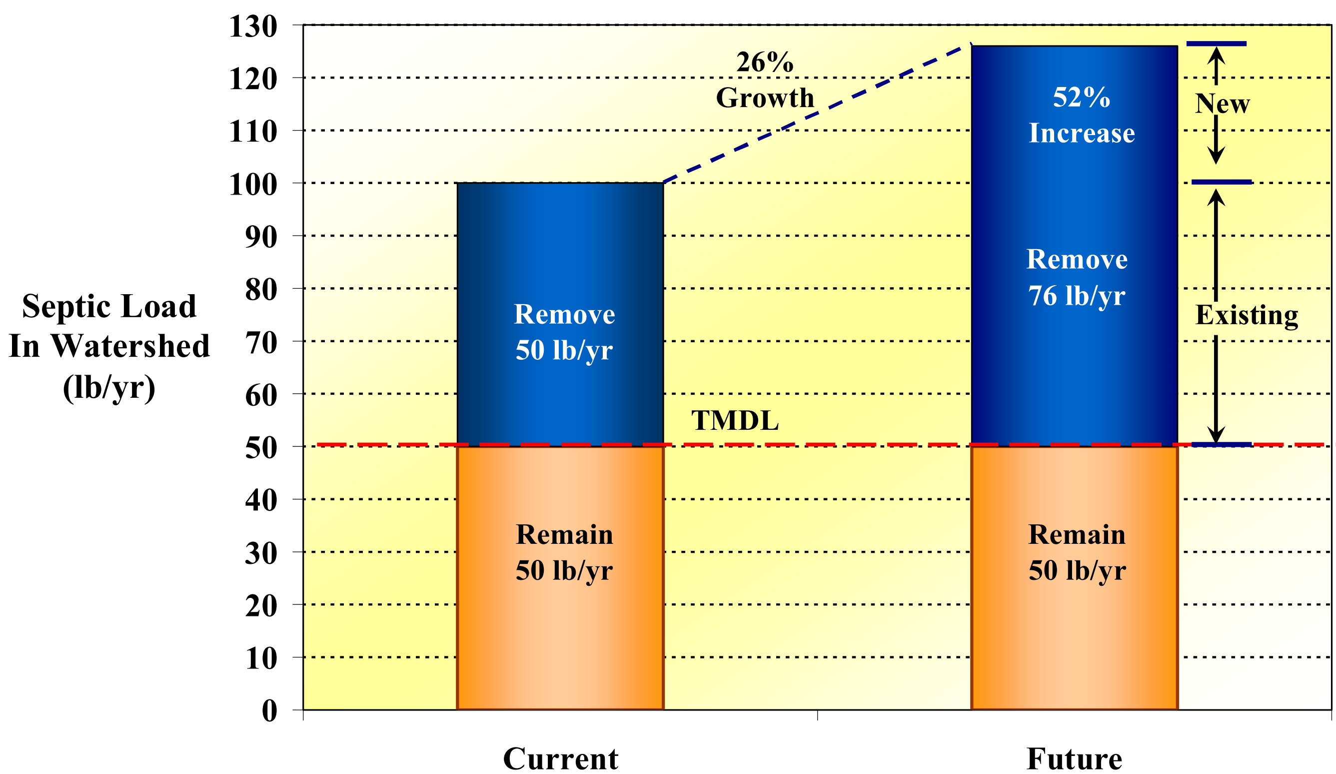

TABLE 2-4
REGIONAL WASTEWATER FLOWS REQUIRING TREATMENT UNDER CURRENT CONDITIONS

Watershed	Wastewater Flows, gpd, originating in:			
	Orleans	**Brewster**	**Eastham**	**Total**
			Note 4	
Pleasant Bay	183,000	58,000	0	241,000
Cape Cod Bay System				
Namskaket	0	0	0	0
Little Namskaket	0	0	0	0
Rock Harbor	51,000	0	10,000	61,000
Subtotal	51,100	0	10,000	61,000
Nauset System				
Town Cove	96,000	0	45,000	141,000
Remainder	41,000	0	85,000	126,000
Subtotal	137,000	0	130,000	267,000
Total--All Watersheds Impacted by Orleans	371,000	58,000	140,000	569,000
		Note 2	*Notes 3 and 4*	
Other Watersheds not Impacted by Orleans	0	Not Available	80,000	Not Available
Town-wide Totals	371,000	Not Available	220,000	Not Available

Notes:
1. *All flows expressed as annual averages, without infiltration/inflow.*
2. *Brewster has flows in watersheds of Herring River and Quivett Creek, where treatment requirements are unknown.*
3. *Eastham has flows in watersheds of Boat Meadow, Herring River and Wellfleet Harbor; the figure shown relates only to freshwater pond watersheds.*
4. *Based on Feb 18, 2009 letter from Stearns & Wheler for tentative sewer service areas in these watersheds.*

The wastewater flows shown in Tables 2-4 and 2-5 represent the volumes of wastewater that would be collected from the various potential service areas. Tables 2-4 and 2-5 will form the basis for cost estimating. Where appropriate for cost estimating, an allowance has been added for infiltration and inflow (I/I), the extraneous surface water and groundwater that inevitably enters the sewer system from leaking pipes and manholes, and from illicit cellar or storm drains. The effluent disposal capacity at the Tri-Town site has been evaluated for the regional flows including appropriate I/I allowances.

Brewster and Eastham Working Group members were each provided an opportunity to review and comment on the wastewater flow estimates. Eastham took no exception to the estimates generated by Wright-Pierce. Brewster provided a number of comments related to existing water use, estimated consumptive use, as well as long-term growth trends. These comments were addressed, are included in the numbers presented in the tables herein, and are utilized in the development of cost estimates in Section 4.

TABLE 2-5
REGIONAL WASTEWATER FLOWS REQUIRING TREATMENT UNDER FUTURE CONDITIONS

Watershed	Wastewater Flows, gpd, originating in			
	Orleans	Brewster	Eastham	Total
			Note 4	
Pleasant Bay	249,000	88,000	0	337,000
Cape Cod Bay System				
Namskaket	0	0	0	0
Little Namskaket	0	0	0	0
Rock Harbor	69,000	0	10,000	79,000
Subtotal	69,000	0	10,000	79,000
Nauset System				
Town Cove	130,000	0	50,000	180,000
Remainder	56,000	0	100,00	156,000
Subtotal	186,000	0	150,000	336,000
Total--All Watersheds Impacted by Orleans	504,000	88,000	160,000	752,000
		Note 2	*Notes 3 and 4*	
Other Watersheds not Impacted by Orleans	0	Not Available	90,000	Not Available
Town-wide Totals	504,000	Not Available	250,000	Not Available

Notes:
1. *All flows expressed as annual averages, without infiltration/inflow.*
2. *Brewster has flows in watersheds of Herring River and Quivett Creek, where treatment requirements are unknown.*
3. *Eastham has flows in watersheds of Boat Meadow, Herring River and Wellfleet Harbor; the figure shown relates only to freshwater pond watersheds.*
4. *Based on Feb 18, 2009 letter from Stearns & Wheler for tentative sewer service areas in these watersheds.*

SECTION 3

IDENTIFICATION AND DESCRIPTION OF ALTERNATIVES

3.1 IDENTIFICATION OF ALTERNATIVES

Eleven regional alternatives were identified for evaluation, as summarized in Table 3-1. Alternatives A-1 through A-4 are "two-town" options involving Orleans and Brewster. Similarly, Alternatives B-1 through B-3, are "two-town" options for cooperation between Orleans and Eastham. The last four options, Alternatives C-1 through C-4, are "three-town" solutions involving Orleans, Brewster and Eastham. These options were selected to determine if the economies of scale afforded by joint treatment exceed the transport costs associated with conveying Brewster and Eastham wastewater to Orleans. Some of the options were selected to determine if Orleans could meet the nitrogen control needs of all three towns by expanding its collection system and treatment facility, so that construction could be avoided in Brewster and Eastham.

Figure 3-1 depicts the alternatives where Eastham and Brewster have their own treatment and disposal (A-1, B-1, C-1**).** Figure 3-2 shows the alternatives where Eastham and Brewster collect wastewater within the respective towns and transport it to the Tri-Town site for treatment and disposal (A-2, B-2, C-2). Figure 3-3 depicts the alternatives where Orleans constructs additional collection and transport-to-treatment facilities in Orleans to offset the nitrogen loadings from Eastham and Brewster (A-3, B-3, C-3). Figure 3-4 shows the alternatives where the Tri-Town site would accept Orleans and Eastham wastewater from the Rock Harbor and Nauset Systems, and where Orleans and Brewster wastewater from the Pleasant Bay Systems would be collected, transported, treated and disposed at a site in the easterly portion of Brewster.

TABLE 3-1
LISTING OF REGIONALIZATION OPTIONS

Option No.	Description	
A. Two-Town Options---Orleans and Brewster		
A-1	Each Town acts on its own	
	Orleans	Builds the plan recommended in the draft CWMP
	Brewster	Builds a satellite plant for its portion of Pleasant Bay
A-2	Collection of Brewster wastewater in Pleasant Bay watershed and transport to the Orleans collection system for treatment at the Tri-Town site	
A-3	Increased collection of Orleans wastewater in Pleasant Bay watershed with transport to Tri-Town site for treatment; no facilities in Brewster	
A-4	Collection of Brewster wastewater in Pleasant Bay watershed and transport to South Orleans site for treatment with Orleans wastewater from Pleasant Bay watershed	
B. Two-Town Options---Orleans and Eastham		
B-1	Each Town acts on its own	
	Orleans	Builds the plan recommended in the draft CWMP
	Eastham	Builds a satellite plant for its portion of Rock Harbor and Nauset watersheds
B-2	Collection of Eastham wastewater in Rock Harbor and Nauset watersheds and transport to the Orleans collection system for treatment at the Tri-Town site	
B-3	Increased collection of Orleans wastewater in the Rock Harbor and Nauset watersheds with transport to Tri-Town site for treatment; no facilities in Eastham	
C. Three-Town Options---Orleans, Brewster and Eastham		
C-1	Each Town acts on its own	
	Orleans	Builds the plan recommended in the draft CWMP
	Brewster	Builds a satellite plant for its portion of Pleasant Bay
	Eastham	Builds a satellite plant for its portion of Rock Harbor and Nauset watersheds.
C-2	Collection of Eastham and Brewster wastewater in Rock Harbor, Nauset and Pleasant Bay watersheds and transport to the Orleans collection system for treatment at the Tri-Town site	
C-3	Increased collection of Orleans wastewater in the Rock Harbor, Nauset and Pleasant Bay watersheds with transport to Tri-Town site for treatment; no facilities in Brewster or Eastham	
C-4	Collection of Brewster and Orleans wastewater in Pleasant Bay watershed and transport to Brewster site for treatment and disposal.	
	Collection of Eastham and Orleans wastewater in Rock Harbor and Nauset watersheds and transport to the Tri-Town site treatment and disposal	

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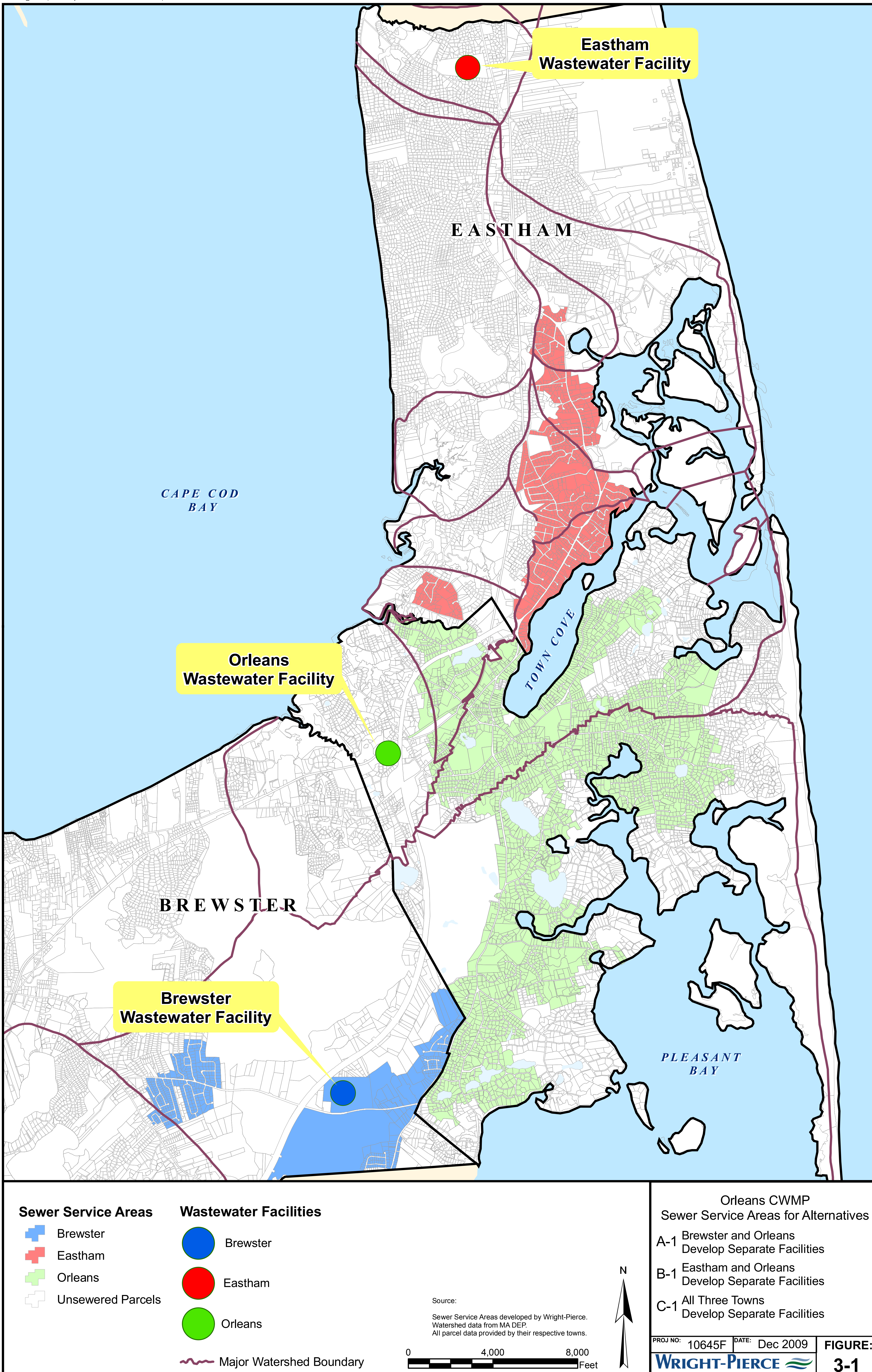

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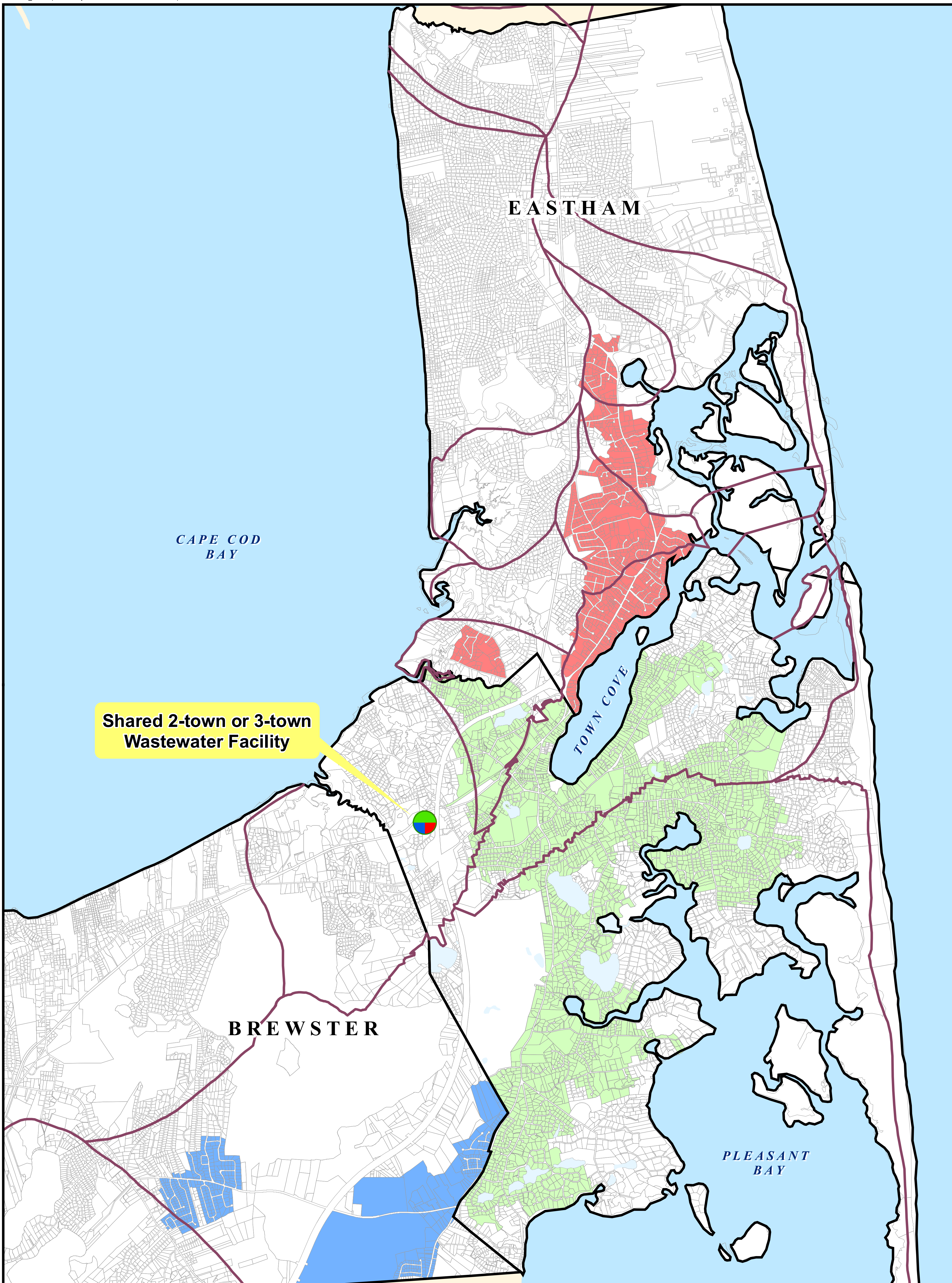

Sewer Service Areas

- Brewster
- Eastham
- Orleans
- Unsewered Parcels

Wastewater Facilities

Combination of: Brewster, Eastham and/or Orleans wastewater

Major Watershed Boundary

Source:

Sewer Service Areas developed by Wright-Pierce.
Watershed data from MA DEP.
All parcel data provided by their respective towns.

0 4,000 8,000 Feet

N

Orleans CWMP
Sewer Service Areas for Alternatives

A-2 Brewster and Orleans collect wastewater with treatment at Tri-Town

B-2 Eastham and Orleans collect wastewater with treatment at Tri-Town

C-2 All three towns collect wastewater with treatment at Tri-Town

PROJ NO: 10645F	DATE: Dec 2009	FIGURE:
WRIGHT-PIERCE Engineering a Better Environment		3-2

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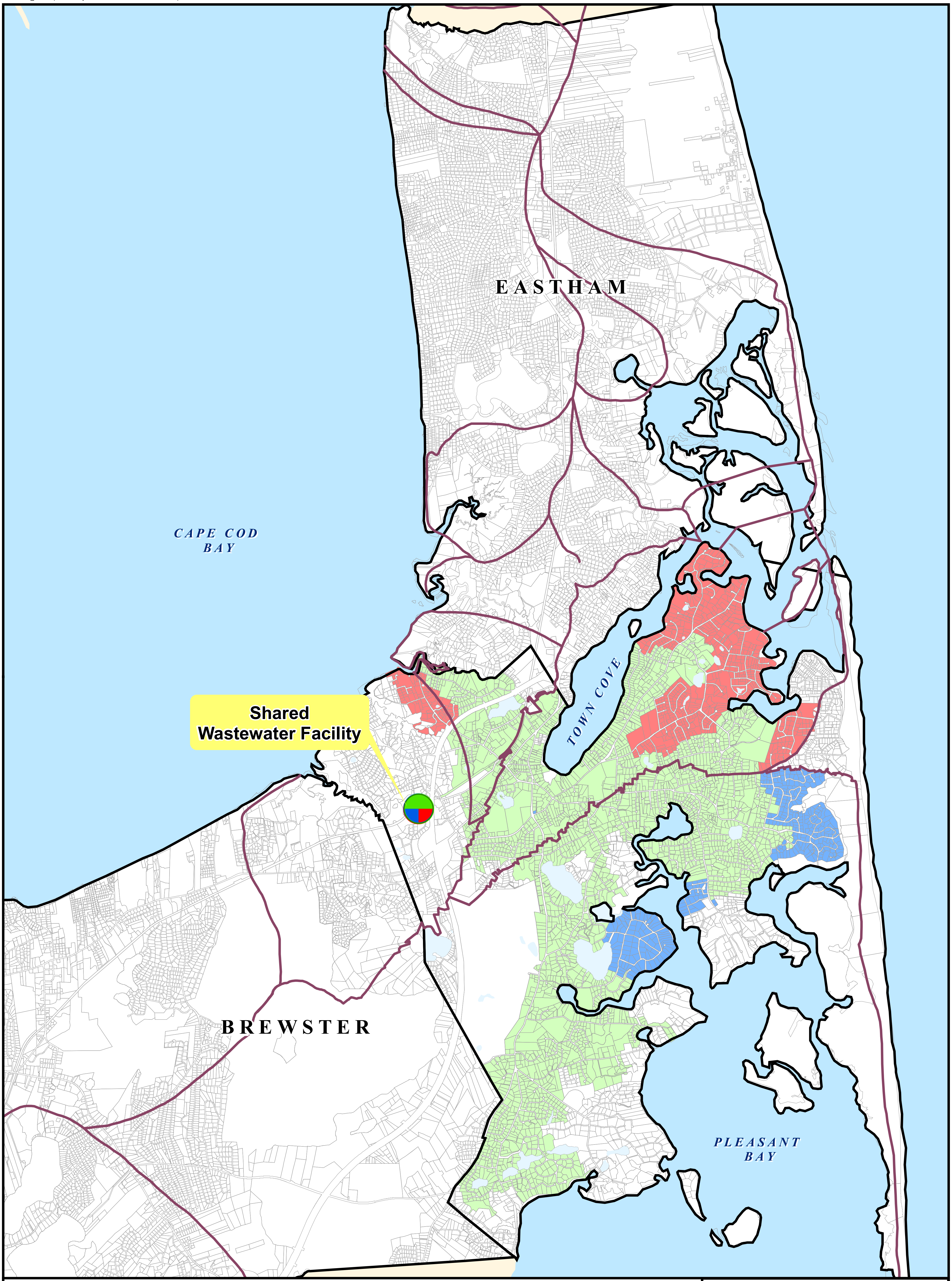

Sewer Service Areas

- Sewer service area in Orleans to offset Nitrogen removal in Brewster
- Sewer service area in Orleans to offset Nitrogen removal in Eastham
- Orleans service area - Core Plan
- Unsewered Parcels

Wastewater Facilities

- Orleans wastewater including offset of either Brewster, Eastham, or both.
- Major Watershed Boundary

Source:

Sewer Service Areas developed by Wright-Pierce.
Watershed data from MA DEP.
All parcel data provided by their respective towns.

0 4,000 8,000 Feet

N

Orleans CWMP
Sewer Service Areas for Alternatives

A-3 Orleans Expands Collection System to Offset Brewster Nitrogen Load
B-3 Orleans Expands Collection System to Offset Eastham Nitrogen Load
C-3 Orleans Expands Collection System to Offset Brewster and Eastham Nitrogen Load

PROJ NO: 10645F	DATE: Dec 2009	FIGURE: 3-3

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Engineering a Better Environment

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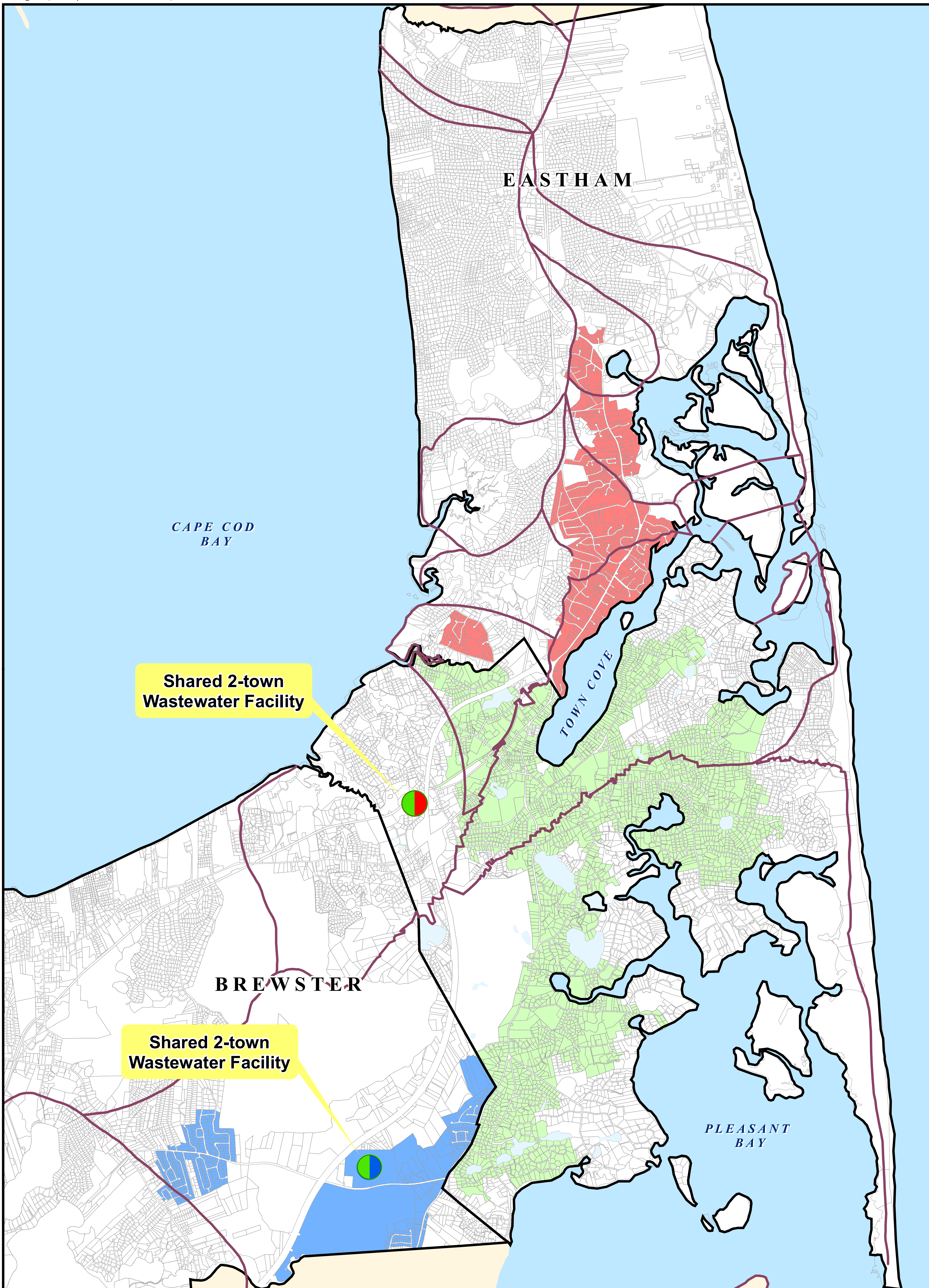

Sewer Service Areas

- Brewster
- Eastham
- Orleans
- Unsewered Parcels

Wastewater Facilities

- Serves Brewster and Orleans in the Pleasant Bay watershed
- Serves Eastham and Orleans in Rock Harbor and Nauset watersheds
- Major Watershed Basins

Source:

Sewer Service Areas developed by Wright-Pierce.
Watershed data from MA DEP.
All parcel data provided by their respective towns.

0 4,000 8,000 Feet

N

Orleans CWMP
Sewer Service Areas for
Alternative C-4

Collect Brewster and Orleans wastewater in Pleasant Bay with treatment in Brewster. Collect Eastham and Orleans wastewater in Rock Harbor and Nauset with treatment at Tri-Town.

PROJ NO: 10645F	DATE: Dec 2009	FIGURE: 3-4

WRIGHT-PIERCE
Engineering a Better Environment

3.2 DESCRIPTION OF ALTERNATIVES

All eleven of the alternatives include wastewater treatment and disposal facilities at the Tri-Town site in Orleans. These facilities are the same as, or are expanded versions of, the Orleans Recommended Plan as described in Section 11 of the Draft CWMP. In order to make fair comparisons, some of the alternatives also include smaller treatment and disposal facilities in Brewster, Eastham or both. The wastewater flows summarized in Section 2 were used to size the various treatment and disposal facilities. For all of the alternatives considered, septage from unsewered properties in all three towns would continue to go to the Tri-Town site.

Alternative A-1

This option was formulated to serve as the baseline for the other Brewster-Orleans alternatives. Orleans would provide for its own wastewater management needs at the Tri-Town site, and Brewster would build its own wastewater facilities to serve its Pleasant Bay needs. The only regional aspect of this plan would be the use of the Tri-Town facility for disposal of sludge from the Brewster facility.

Alternative A-2

For this option, Brewster would build sewers to eliminate enough septic systems to comply with the Pleasant Bay TMDL. The collected wastewater would be piped to the nearest point in the Orleans sewer system, which would convey it to the Tri-Town site, where an expanded facility would treat and dispose of the combined Orleans-Brewster wastewater flow.

Alternative A-3

This option is similar to Alternative A-2, in that an expanded Tri-Town facility would treat and dispose of the combined Brewster-Orleans flow. Instead of a sewer system in Brewster, however, more sewers would be built in the Orleans part of the Pleasant Bay watershed to remove the same septic nitrogen load as would be removed in Brewster in Alternative A-2. The collection system cost would be borne by Brewster. This option may have a lower cost to transport wastewater to the treatment plant site than would Alternative A-2; and would avoid the need for Brewster to build any new facilities.

Alternative A-4

In the evaluation of alternatives for Orleans (see Section 7 of the Orleans Draft CWMP), one option involved a treatment and disposal facility in South Orleans, that could also serve Brewster. Alternative A-4 of this regionalization evaluation is based in part on that concept. Orleans would build two wastewater facilities; one at the Tri-Town site to serve the northern part of Orleans (and perhaps some of Eastham), and one in South Orleans to serve the southerly part of Orleans and some of Brewster. Sewers would be built in Brewster to fulfill its TMDL responsibility with respect to Pleasant Bay, and a pipeline would connect those Brewster sewers to the South Orleans facility. While this option was called the "South Orleans Plan" in the CWMP, the second treatment facility could also be located in the easterly portion of Brewster.

Alternative B-1

This option was formulated to serve as the baseline for the other Eastham-Orleans alternatives. Orleans would provide for its own wastewater management needs at the Tri-Town site, and Eastham would build its own wastewater facilities to serve its nitrogen control needs in the Nauset and Rock Harbor watersheds. The only regional aspect of this plan would be the use of the Tri-Town facility for disposal of sludge from the Eastham facility.

Alternative B-2

For this option, Eastham would build sewers to eliminate enough septic systems to comply with the nitrogen control requirements expected for the Nauset and Rock Harbor systems. The collected wastewater would be piped to the nearest point in the Orleans sewer system, which would convey it to the Tri-Town site, where an expanded facility would treat and dispose of the combined Orleans-Eastham wastewater flow.

Alternative B-3

This option is similar to Alternative B-2, in that an expanded Tri-Town facility would treat and dispose of the combined Eastham-Orleans flow. Instead of a sewer system in Eastham, however, more sewers would be built in the Orleans parts of the Nauset and Rock Harbor watersheds to remove the same septic nitrogen load as would be removed in Eastham in Alternative B-2. The collection system costs would be borne by Eastham. This option may have a lower cost to transport wastewater to the treatment plant site than would Alternative B-2, and it would avoid construction of facilities in Eastham.

Alternative C-1

This alternative is a combination of Alternatives A-1 and B-1. Each town would provide for its own wastewater needs without reliance on each other, expect for the receipt of sludge at Tri-Town.

Alternative C-2

This option is a combination of Alternatives A-2 and B-2. Both Brewster and Eastham would build sewer systems that would be connected to the closest part of the Orleans collection system, and the Tri-Town facility would provide wastewater treatment and disposal for all three towns.

Alternative C-3

An expanded sewer system in Orleans would eliminate enough septic systems in the Pleasant Bay, Nauset and Rock Harbor watersheds to permit this alternative to meet the expected nitrogen control needs for all three watersheds, without construction in Brewster and Eastham.

Alternative C-4

This option is a combination of Alternatives A-4 and B-2. The Tri-Town facility would treat and dispose of wastewater collected in Eastham and in the northerly areas of Orleans. The South Orleans facility would treat and dispose of wastewater collected in Brewster and in the southerly parts of Orleans.

3.3 ESTIMATED SEWER SERVICE AREAS

In order to evaluate the costs of wastewater transport in regional alternatives, it is necessary to make assumptions as to where wastewater would be collected in Brewster and Eastham. The shaded areas in Figures 3-1 through 3-4 represent the neighborhoods where public sewers would be constructed to allow the elimination of existing septic systems, as the primary way to achieve TMDL compliance.

These projected sewer service areas were developed using two principal criteria. First, the GIS database for the project was used to identity neighborhoods with relatively dense development, and the highest current water use. This assumption is based on the premise that the most cost-effective solution is to maximize the amount of nitrogen collected per foot of sewer pipe. Since water use is the best estimator of wastewater flow, and the existing land use is largely residential (that is, with comparable nitrogen concentrations) this approach should lead to relatively cost-efficient collection systems. The second criterion is the distance to the proposed Orleans collection system, as detailed in Appendix D of the draft CWMP.

Use of these two criteria should lead to good candidate collection areas. Nonetheless, the densest development is not always near the Orleans border, so some trade-offs are needed. For example, part of the selected service area in Brewster is some distance from the Orleans-Brewster town line because of that area's high development density, and because neighborhoods more proximate to Orleans do not have sufficient septic nitrogen load to address the full TMDL.

3.4 PRINCIPAL ASSUMPTIONS

The development of alternatives and cost estimates for a study of this nature involves numerous assumptions that are required to estimate the physical features of each of the alternatives. The principal assumptions are summarized as follows:

Identified Sites for Wastewater Treatment and Disposal:

- **Orleans:** wastewater treatment and disposal would be located at the Tri-Town site. This location is applicable for all alternatives. If additional effluent disposal capacity is needed beyond that which can be obtained at the Tri-Town site, then this would occur at nearby school athletic fields.
- **Brewster:** wastewater treatment and disposal would be located at a site near the Orleans town line, identified as Site 193 in the draft CWMP. This location is applicable for Alternatives A-1, A-4, C-1 and C-4. This site was assumed to require higher levels of treatment due to its location within a Zone II.
- **Eastham:** wastewater treatment and disposal would be located on a public parcel identified by Stearns & Wheler in its February 18, 2009 letter to Wright-Pierce. This location is applicable for Alternatives B-1 and C-1.

Site Capacity for Treated Effluent Disposal:

- **Orleans:** The Orleans Core Plan does not utilize all of the disposal capacity at the Tri-Town site. All of the Tri-Town capacity is needed to accommodate Orleans' Extended Plan. It has been assumed that space on the Tri-Town site would be reserved for Orleans' Extended Plan, and the regionalization options would bear the cost of alternate sites, if needed.
- **Brewster:** The site in Brewster is assumed to have sufficient space to handle treatment and disposal activities for all applicable alternatives.
- **Eastham:** The identified parcel is assumed to have sufficient space to handle treatment and disposal activities for all applicable alternatives.

Nutrient Considerations:

- **Orleans:** the residual nitrogen in the effluent disposed at the Tri-Town site will not exceed the estimated nitrogen assimilative capacity for Namskaket Creek in any of the applicable alternatives; see Appendix G of the draft CWMP.
- **Interbasin Transfer:** Some of these alternatives involve inter-basin transfer of nitrogen. The collection system associated with all Brewster alternatives reflects the removal of all the collected wastewater from the Pleasant Bay watershed. A somewhat larger collection area would be needed for alternatives involving effluent disposal in the Pleasant Bay watershed. This distinction has not been quantitatively accounted for.
- **Natural Attenuation:** Some of the sewered areas in Brewster are upgradient from freshwater ponds that may provide some natural attenuation of nitrogen. That factor was not explicitly accounted for. Alternative collection areas, downgradient from freshwater ponds, could also be considered.
- **Phosphorus:** Pond protection was not considered in this analysis. Collections systems may be able to satisfy multiple needs by removing phosphorus from watersheds of freshwater ponds and nitrogen from watersheds of sensitive coastal embayments. Hypothetical sewer systems were not extended solely for pond protection purposes.

Infrastructure Sizing:

- Assumptions used in the Orleans draft CWMP have been adapted to estimate the nature and extent of Eastham and Brewster facilities to ensure a consistent comparison. Where possible, these estimates have been adjusted to reflect documented differences among the towns, such as development density in the neighborhood to be served by public sewers.
- This analysis includes estimates of the septic system flows that would be eliminated by municipal sewers, as well as the wastewater flows that would require treatment. The difference between these two figures is the infiltration and inflow (I/I) that the sewer system will receive. (The I/I flow includes groundwater leaking into pipes and manholes, and the illicit connection of roof, cellar or storm drains to the sewer system.) The estimate of I/I flows for the proposed collection system in Orleans has been prorated to the Brewster and Eastham collection systems (based on linear feet of collection pipe in each scenario) to provide some uniformity in this analysis estimates. (Stearns & Wheler included an I/I

allowance in the Eastham flow estimates that is somewhat higher than the estimate carried herein.) A similar prorating approach was used for other elements of the collection system cost, including land required for pump station sites.

MEP Technical Reports:

- MEP Technical Reports and subsequent TMDLs are not yet issued for the Nauset, Quivett Creek, Boat Meadow, and Wellfleet Harbor systems. These documents could impact the extent of sewering required (upward or downward) for some of these regionalization alternatives. This evaluation is based on the placeholder value of 55% nitrogen control in the Nauset watershed, applied to both the Town Cove and Nauset Harbor systems, as provided by MEP staff and as used in the draft CWMP.

Land Acquisition:

- It has been assumed that the sites for treatment and disposal in all three towns are publicly owned and no land costs have been included for those options. Land needs for pump stations have been assumed on a scale appropriate to the specific option.

SECTION 4

DEVELOPMENT AND APPLICATION OF COST MODEL

4.1 DEVELOPMENT OF COST ESTIMATING MODEL

The Towns of Orleans, Brewster and Eastham will each be faced with costs in two categories, regardless of whether they act individually or cooperatively in a regional solution. The first category is "capital cost", the cost to design and build the needed facilities. The second category is "operation and maintenance (O&M) costs" which include the ongoing annual expenses to run the facilities (e.g., labor, electrical energy, fuel, chemicals, biosolids disposal, laboratory testing, equipment maintenance, etc.).

A spreadsheet-based cost estimating model was developed for the preparation of the Orleans CWMP. For consistency with previous efforts, that same cost model was used in the analysis.. The cost model was populated with key technical data on each of the alternatives (linear feet of pipe, number of pump stations, for example), and "unit costs" (such as dollars per foot of pipe, or dollars per pump station) were applied based on an extensive database of publicly-bid wastewater projects across New England. Similar information was used to predict operation and maintenance (O&M) costs for a range of plant sizes.

For each alternative, costs were estimated in the following standard categories:

- wastewater collection,
- transport-to-treatment,
- wastewater treatment,
- transport-to-disposal,
- effluent disposal,
- sludge/septage handling,
- cluster systems, and
- land acquisition.

Once basic construction costs were estimated, allowances were added for:

- Contingencies,
- Engineering and legal expenses,
- Site investigation costs, and
- Land costs.

All costs presented herein are expressed in mid 2008 dollars for consistency with the Orleans draft CWMP. It was assumed that all the facilities would be built at one time. While that is not likely, it does provide the simplest basis for comparison and creates a platform for later phasing analyses.

4.2 COST ESTIMATES FOR EACH ALTERNATIVE

Table 4-1 presents a summary of the capital and O&M cost estimates for the most cost-effective of the major alternatives, presented in mid 2008 dollars. This table shows the costs for individual towns acting along, as well as for multi-town solutions. Table 4-1 also indicates the "present worth" of each alternative. A "present worth analysis" is a standard economic tool that allows the calculation of a single "cost" to represent the combination of capital costs and annual expenses for operation and maintenance. In essence, the present worth represents the amount of money that one would invest to be able to pay the capital costs at the beginning of the project and allow periodic withdrawals to pay the annual O&M expenses over a certain period at a given interest rate. For the purposes of this study, the present worth has been computed assuming a 4% interest rate and a 20-year planning period.

The capital, O&M and present worth costs are also presented in Tables 4-2, 4-3 and 4-4, and represent the "regional costs" for each alternative (i.e., Alternative A-1 represents the sum of costs for Orleans and Brewster, Alternative B-2 includes all costs for Orleans and Eastham, and Alternative C-2 represents the regional costs for Orleans, Brewster and Eastham).

TABLE 4-1

SUMMARY OF FLOWS AND COSTS

	Local Solutions			Multi-Town Solutions		
	Brewster Alone	Eastham Alone	Orleans Alone	Brewster & Orleans	Eastham & Orleans	All 3 Towns
Septic flow eliminated, gpd	88,000	160,000	504,000	592,000	664,000	752,000
Flows treated, gpd						
Annual average	108,000	194,000	644,000	752,000	838,000	945,000
Maximum month	183,000	329,000	1,095,000	1,263,000	1,399,000	1,567,000
Short-term peak	278,000	484,000	1,417,000	1,632,000	1,809,000	2,033,000
Capital Costs, $M, mid-2008 basis						
Collection	14.7	23.4	99.5	115.5	123.0	139.1
Transport to treatment	2.4	3.9	3.0	4.0	3.0	3.0
Treatment	13.0	14.9	29.6	32.6	35.4	40.6
Transport to disposal	0.4	0.4	0.4	0.4	0.4	1.5
Disposal	1.6	2.7	7.4	8.5	9.2	11.8
Land	0.6	0.7	5.5	6.2	6.2	6.9
Other	0.0	0.0	5.5	5.5	5.5	5.5
Total	32.7	46.0	150.9	172.8	182.8	208.4
O&M Costs, $/yr, mid-2008 basis	405,000	581,000	1,159,000	1,278,000	1,382,000	1,603,000
Present Worth, $M, mid-2008 basis	37.7	53.2	165.3	188.7	200.0	228.4
Unit Costs for N Removal, $/lb removed	430	335	330	320	300	300

TABLE 4-2
SUMMARY OF COSTS FOR BREWSTER-ORLEANS OPTIONS

	A-1 Brewster and Orleans Develop Separate Facilities		**A-2** Brewster and Orleans Collect Wastewater with Treatment at Tri-Town		**A-3** Orleans Expands Collection System to Offset Brewster N Load		**A-4** Collect all Pleasant Bay Wastewater and Treat in Brewster; Remaining Orleans Wastewater Treated at Tri-Town
Capital Costs, $M, mid-2008 basis							
Collection	114.2		115.5		119.9		112.4
Transport to treatment	5.1		4.0		3.0		5.4
Treatment, with site invest.	42.7		32.6		32.7		54.1
Transport to disposal	0.9		0.4		0.4		0.9
Disposal, with site invest.	9.0		8.5		8.5		9.4
Septage/Sludge handling	3.3		3.3		3.3		3.3
Clusters--treat/disp, land, site invest	1.9		1.9		1.9		1.9
Land	6.2		6.2		6.2		6.3
Non-structural	0.3		0.3		0.3		0.3
Total	183.5		172.8		176.2		194.1
Operation & Maintenance Costs, $M/yr	1.56		1.28		1.28		1.66
Present Worth							
Capital cost, $M	183.5		172.8		176.2		194.1
PW of O&M, $M	19.5		15.9		16.0		20.7
Total PW, $M	203.0		188.7		192.1		214.8
Equiv. Annual Cost, $M/yr	16.3		15.1		15.4		17.2
Savings with respect to Alternative A-1							
Capital cost, %, $M	--	*5.8%*	10.7	*4.0%*	7.3	*-5.8%*	-10.6
O&M, %, $M/yr	--	*18.3%*	0.29	*18.1%*	0.28	*-6.2%*	-0.10
Total PW, %, $M	--	*7.0%*	14.2	*5.3%*	10.8	*-5.8%*	-11.8

TABLE 4-3
SUMMARY OF COSTS FOR EASTHAM-ORLEANS OPTIONS

	B-1 Eastham and Orleans Develop Separate Facilities		**B-2** Eastham and Orleans Collect Wastewater with Treatment at Tri-Town		**B-3** Orleans Expands Collection System to Offset Eastham N Load
Capital Costs, $M, mid-2008 basis					
Collection	122.8		123.0		128.3
Transport to treatment	6.9		3.0		3.0
Treatment, with site invest.	44.5		35.4		35.5
Transport to disposal	0.9		0.4		0.4
Disposal, with site invest.	10.1		9.2		11.8
Septage/Sludge handling	3.3		3.3		3.3
Clusters--treat/disp, land, site invest	1.9		1.9		1.9
Land	6.2		6.2		6.4
Non-structural	0.3		0.3		0.3
Total	196.9		182.8		191.0
Operation & Maintenance Costs, $M/yr	1.74		1.38		1.39
Present Worth					
Capital cost, $M	196.9		182.8		191.0
PW of O&M, $M	21.7		17.2		17.3
Total PW, $M	218.6		200.0		208.3
Equiv. Annual Cost, $M/yr	17.5		16.0		16.7
Savings with respect to Alternative B-1					
Capital cost, %, $M	--	*7.2%*	14.1	*3.0%*	5.9
O&M, %, $M/yr	--	*20.6%*	0.36	*20.3%*	0.35
Total PW, %, $M	--	*8.5%*	18.6	*4.7%*	10.3

TABLE 4-4
SUMMARY OF COSTS FOR EASTHAM-ORLEANS-BREWSTER OPTIONS

	C-1 All Three Towns Act Independently	**C-2** All Three Towns Collect Wastewater with Treatment at Tri-Town		**C-3** Orleans Expands Collection System to Offset Brewster and Eastham N Loads		**C-4** Collect all Pleasant Bay Wastewater with Treatment in Brewster, and Collect all Rock Harbor and Town Cove Wastewater with Treatment at Tri-Town	
Capital Costs, $M, mid-2008 dollars							
Collection	137.5		139.1		148.7		135.4
Transport to treatment	9.3		3.0		3.0		5.4
Treatment, with site invest.	57.5		40.6		43.5		57.4
Transport to disposal	1.3		1.5		1.5		0.9
Disposal, with site invest.	11.7		11.8		11.9		13.9
Septage/Sludge handling	3.3		3.3		3.4		3.3
Clusters--treat/disp, land, site invest	1.9		1.9		1.9		1.9
Land	6.9		6.9		7.0		7.0
Non-structural	0.3		0.3		0.3		0.3
Total	229.7		208.4		221.3		225.4
Operation & Maintenance Costs, $M/yr	2.14		1.60		1.61		1.94
Present Worth							
Capital cost, $M	229.7		208.4		221.3		225.4
PW of O&M, $M	26.7		20.0		20.1		24.1
Total PW, $M	256.4		228.4		241.4		249.5
Equiv. Annual Cost, $M/yr	20.6		18.3		19.4		20.0
Savings with respect to Alternative C-1							
Capital cost, %, $M	--	*9.3%*	21.3	*3.7%*	8.4	*1.9%*	4.4
O&M, %, $M/yr	--	*25.3%*	0.54	*24.9%*	0.53	*9.7%*	0.21
Total PW, %, $M	--	*10.9%*	28.1	*5.9%*	15.1	*2.7%*	6.9

Based on this analysis, there are a number of preliminary conclusions which can be drawn:

1. With respect to Orleans and Brewster, Alternatives A-2 and A-3 are the most cost-effective on a present worth basis. About $10 million in capital costs could be saved in the region by Orleans accepting Brewster wastewater. Annual O&M cost savings would be approximately $280,000. These savings represent about 6% of the capital costs and 18% of the O&M costs for each town acting alone.

2. With respect to Orleans and Eastham, Alternative B-2 and B-3 are the most cost-effective on a present worth basis. That is, a regional solution would save about $14 million in capital and $360,000 per year in O&M costs over each town acting alone. These savings represent about 7% of the capital costs and 21% of the O&M costs for separate facilities in each town.

3. Considering all three towns, Alternatives C-2 and C-3 are the most cost-effective on a present worth basis. A three-town solution, compared to each town acting alone, would save $21 million in capital cost (9% savings) and $540,000 in annual O&M cost (25% savings).

4. The above savings are based on Orleans implementing its Core Plan, as described in the Draft CWMP, which represents 504,000 gpd of septic flow removed and 640,000 gpd of influent wastewater (including I/I). The Town of Orleans must allow for a future Extended Plan, also described in the Draft CWMP, which represents 950,000 gpd of septic flow removed and 1.14 mgd of influent wastewater. The Extended Plan exceeds the anticipated effluent disposal capacity of the Tri-Town site and an off-site disposal location would be required to accommodate the three-town regional alternatives that use only the Tri-Town site. The costs of this second disposal site are included in Alternative C-2 so that Orleans can preserve available capacity for its Extended Plan.

5. While not the least cost solution, Alternative C-4 provides the benefit of preserving effluent disposal space and capacity at the Tri-Town site. Alternative C-4 may warrant additional consideration or modification, especially if Brewster and Harwich express serious interest in regionalization within the Pleasant Bay watershed.

6. Alternatives A-3, B-3 and C-3 were developed as a means to balance the desire of Orleans to maintain provisions for the Extended Plan with the presumed desire of all three towns to address nitrogen removal at the least cost. In this scenario, a three-town solution would save $8.4 million in capital and $530,000 in annual O&M costs when compared to each town acting alone.

7. The current schedule calls for the implementation of Phase 1 of the Orleans Recommended Plan in 2013; implementation of future phases in Orleans and early phases in Brewster and Eastham would be expected to occur no sooner than 2013 to 2015. Given the relatively long period of times before construction bids are received and the uncertainty associated with inflation, it is expected that inflation will increase the cost of these projects by 3% to 7% per year. For Alternative C-2, the least-cost three-town solution, this represents approximately $6 million per year in project cost increases.

8. A review of specific line items in Tables 4-1 through 4-4 shows that the regional options allow significant cost saving for wastewater treatment. The collection costs are generally the same for the single-town and multi-town alternatives, because the same amount of nitrogen must be removed from the watershed in all options. The cost model reflects the differing transport costs, but these are generally much less than the savings associated with joint treatment.

There are many considerations which will go into allocation of these costs and savings, especially in scenarios where facilities in Orleans need to be larger to accommodate regionalization (e.g., Alternatives A-2, B-2, and C-2) or where additional facilities are constructed in Orleans to offset requirements in another town (e.g., Alternatives A-3, B-3, C-3). The allocation of these costs and savings is addressed in Section 5.

4.3 ASSUMPTIONS AND DISCUSSION OF COSTS

A full understanding of these cost estimates and their ramifications requires a discussion of the principal assumptions, which are outlined below:

1. This cost analysis is based on the assumption that nitrogen load reductions mandated by existing or expected TMDLs will be accomplished by eliminating septic systems and the construction of municipal sewer systems. To the extent that any of the Towns is able to reduce nitrogen loads by other means, such as through fertilizer reductions, actual costs will be lower than these estimates. This cost analysis does not address sanitary, convenience, or pond protection needs in Eastham and Brewster, unless those needs are addressed by first addressing the nitrogen control needs.

2. This cost analysis is based on the nitrogen load reductions mandated by existing or expected TMDLs. Modifications to these existing or expected requirements may impact the cost analysis contained herein.

3. The cost impacts to the anticipated sewers and forcemains in the outlying areas of the proposed Orleans system have been implicitly addressed at this time (i.e increased pipe sizes). The actual cost impacts will need to be estimated after regionalization decisions are made.

4. The Town of Harwich has requested to be considered in this regionalization study. A review of watershed mapping shows that the far easterly portions of Harwich are as close, or closer, to the proposed Orleans sewer system than are some of the selected neighborhoods in Brewster. Two options for sewering this area of Harwich are: 1) conveyance to the hypothetical treatment plant in Brewster, and 2) conveyance to the proposed Orleans sewer system. Except for possible limitations on effluent disposal capacity at the Tri-Town site, the conclusions of this study would also apply to these neighborhoods in Harwich; that is, there is money to be saved through regionalization. It

must be recognized, however, that Harwich has at least two other options, including building its own facility in Harwich and regionalization with Chatham. Considering any of the Harwich options is beyond the scope of this study.

5. Some of the properties that have been identified for potential sewering in Brewster are located up-gradient of freshwater ponds that may provide some degree of natural attenuation for septic-impacted groundwater. This analysis has not accounted for that factor. (Indeed, the Brewster Freshwater Ponds Report, issued in September 2009, raises questions about pond water quality.) In reality, a larger sewered area in Brewster might be required to remove sufficient septic nitrogen to meet Brewster's share of the Pleasant Bay TMDL if natural attenuation is occurring. That larger sewer area would result in a higher collection cost than has been estimated here. It is the treatment cost savings that drive the regionalization analysis. If a larger sewered area is needed in Brewster, then the collection costs would be higher for both the "local" and the "regional" treatment options, and the savings through regionalization would not change. Alternatively, a different area of sewers could be identified that is downgradient of these ponds.

6. The collection system selected for Brewster reflects the fact that, in the regional option, the collected nitrogen would be conveyed outside the Pleasant Bay watershed for treatment and disposal, and the small amount of nitrogen remaining after treatment would not impact Pleasant Bay. The collection system leading to the hypothetical treatment facility in Brewster should be larger than in the regional option, because that residual nitrogen remains in the watershed. This factor has not been accounted for in this analysis. If it were quantified, the savings associated with regionalization would be larger than reported here.

7. The site of the hypothetical treatment and disposal facilities in Brewster is located within the Zone II of Brewster water supply wells in an area that Brewster has designated as a Groundwater Protection District. Recent revisions to the DEP groundwater discharge permit regulations impose very stringent effluent limits on Zone II discharges. Not knowing how these new regulations will be applied, or the details of the Brewster Zone II

mapping, it has been assumed that the treatment costs at the Brewster site would be 20% higher than in a non-Zone-II situation. That premium is equivalent to a capital cost of about $2 million, or about 20% of the projected savings through regionalization. This factor is of about the same magnitude as the underestimate described in Item 6 above (i.e., larger service area required to address residual nitrogen remaining in Pleasant Bay in Brewster), and would not change the overall conclusion that a joint facility with Orleans is cost-effective. If Brewster were to locate a disposal site outside a Zone II, then this $2 million premium could be avoided, and the capital cost savings with regionalization would be $2 million less.

8. The recommended Core Plan for Orleans would use about 60% of the available effluent disposal capacity at the Tri-Town site. The three-town regional option would use most of the remaining capacity and leave no room for Orleans' Extended Plan. It has been assumed that ongoing site explorations will show that the site cannot handle the flows from Brewster and Eastham, as well as Orleans' Extended Plan, and that a supplemental disposal site would be needed for the portion of the combined flow. Section 10 of the draft CWMP presents a cost estimate for an effluent reuse option for the Orleans Core Plan (i.e., 504,000 gpd septic flow removed) that involves drip irrigation at ballfields at the elementary and middle schools. The incremental cost increases for that option are $7 million in capital costs and $120,000 per year in operation and maintenance costs, which includes some enhanced treatment. For the purposes of this analysis 75% of the incremental costs have been included for the appropriate three-town options. If the Tri-Town site is shown to be capable of accepting the entire three-town flow, then this incremental cost would not be applicable. It is important to note that this incremental increase may also be applicable to the two-town scenarios, depending on the likelihood of Orleans Extended Plan implementation; however, we have not included that allowance in this analysis.

9. Using Brewster's predicted flows, a sensitivity analysis was performed to see how regionalization cost savings would change if the flow predictions in Section 2 were 20% higher or 20 % lower. That analysis indicates that regionalization capital cost and present

worth savings would be within 4% to 6% of those presented herein; (i.e., the $10.7 million capital cost savings would range from $10.3 million to $11.4 million). This demonstrates that the majority of the costs are related to collection and the majority of the savings result from treatment economies of scale.

SECTION 5

EVALUATION OF COST ALLOCATION METHODS

5.1 INTRODUCTION

Section 4 presents the estimated costs to build and operate regional wastewater facilities, without consideration of how the costs would be allocated to the participating towns. This section of the report presents concepts and methods to allocate the costs associated with regionalization or how to allocate the savings.

5.2 HYPOTHETICAL BASIS FOR ANALYSIS

In order to illustrate the cost sharing concepts, the following hypothetical example is presented, involving two towns. The "Host Town", where the regional wastewater treatment facility would be located, would own and operate the facility. The "Customer Town" would provide its own collection system and piping to transport its wastewater to the collection system of the Host Town. Treatment services would be provided by the Host Town to the Customer Town through an inter-municipal agreement that would establish the basis for sharing of capital and operating costs.

For this discussion, it is assumed that the treatment facilities would be owned and operated by the Host Town. It is also possible that a District could be formed to accomplish the same functions. In the case of Orleans and its neighbors, single-town ownership is believed to be more practical. This assumption is based on the fact that Orleans is several years ahead of Brewster and Eastham in its wastewater planning, and the formation of a district could not occur until those towns "catch up" with Orleans. This would delay Orleans for several years.

The cost sharing concepts are most easily understood with a simple hypothetical cost example. Assume the following for the capital costs of treatment facilities serving each town individually and for one joint plant:

Facility serving only Host Town	$30 million
Facility serving only Customer Town	$15 million
Total of individual facilities	$45 million
Regional facility	$35 million
Savings with regional facility	$10 million

Further assume that, of all the wastewater flow the regional facility would be designed to treat, the Host Town generates 75% and the Customer Town generates 25%.

In this analysis, the key question is: "What is the best way to allocate the $35 million capital cost of a joint treatment facility to the Host and Customer Towns?" Said another way: "How should the two Towns share the $10 million cost savings attributable to regionalization?" This key question is utilized to illustrate the allocation concepts that follow.

5.3 COST ALLOCATION CONCEPTS - CAPITAL COSTS

There are many possible ways to answer the questions identified above. The paragraphs that follow describe some of the common ones.

Option 1. Customer Town Pays Incremental Cost

With this approach, the Customer Town pays all the "extra" capital costs that would be incurred by the Host Town to accommodate the Customer Town's wastewater flow. The Host Town would incur $5 million more capital expense ($35 million for the regional facility less the $30 million it would have paid for its own plant) and that increment would be paid by the Customer Town. In this scenario, all of the regional capital cost savings accrue to the Customer Town, and there is no capital cost advantage to the Host Town. Nevertheless, the Host Town might be willing to consider this option, due to the potential savings in O&M costs through a separate cost-sharing formula.

Option 2. Customer Town Pays What It Would Have Paid for Its Own Facility

In the reverse of the first option, The Customer Town pays the $15 million that it would have paid to deal solely with its own wastewater treatment obligation. The Host Town pays the difference, or $20 million. In this scenario, all of the regional capital cost savings accrue to the Host Town, and there is no capital cost advantage to the Customer Town. As with the first option, the Customer Town might be willing to agree with this approach based on potential O&M cost savings over the life of the project.

Option 3. Regional *Costs* are Allocated Based on Wastewater Flow

Since the Host Town generates 75% of the overall wastewater flow, it would pay that percentage of the capital cost of the regional facility, or $26.25 million. The Customer Town's share would be 25% of the total, or $8.75 million. In this option, the Host Town would realize 38% of the $10 million savings associated with regionalization, and the Customer Town would realize 62% of the savings.

Option 4. Regional *Savings* are Allocated Based on Wastewater Flow

With this approach, the Host Town would realize 75% of the $10 million savings, since it generates 75% of the wastewater flow. Its capital cost share would be $22.5 million ($30 million less 75% of $10 million). The Customer Town would pay $12.5 million ($15 million less 25% of $10 million).

Option 5. The Cost Savings are Split Equally.

This approach is perhaps the simplest. Each Town saves $5 million compared to what it would have spent on its own facility. The Host Town pays $25 million and the Customer Town pays $10 million.

Option 6. The Host Town is Paid a Flat Host Fee

There are a number of hard-to-quantify disadvantages of being the Host Town. These include the potential negative impacts on homes and businesses near the facility, the risk associated with compliance with the discharge permit, the potential liabilities associated with worker and visitor safety, and the impacts on local groundwater quality. In some circumstances, host communities ask for a flat "host community fee" to account for these issues. For illustrative purposes, assume that this flat fee would be $2 million or about 5% of the capital cost of the joint treatment facility. The addition of the host fee could be coupled with any of the cost allocation approaches listed above. If the hypothetical $2 million host fee were applied to Option 5 (equal sharing of capital cost savings), the Host Town would pay $23 million of the $35 million capital cost ($30 million less 50% of savings, less $2 million), and the Customer Town would pay $12 million ($15 million less 50% of savings, plus $2 million).

Option 7. *Cost* Allocation Equal to Allocation of *Savings*

In this example, the costs to the Host Town for its separate facility represent two-thirds of the sum of the costs for two individual facilities. If the capital costs of the joint facility were split on this two-thirds-one-third basis, The Host Town would pay $23.33 million and the Customer Town would pay $11.67 million. Mathematically, this approach results in the same percentage sharing of **costs** and **savings**: $6.67 million of savings go to the Host Town and $3.33 million in savings go to the Customer Town.

Table 5-1 summarizes the application of these seven options to the hypothetical cost example. Options 1 and 2 bracket the full range of results; the Host Town's share of capital cost would fall between $20 and $30 million. The most likely alternatives fall in a smaller range, $23 to $26 million, or 65% to 75% of the total cost. For the Customer Town, the most likely options fall in the range of 25% to 35% of the total cost, or $9 to 12 million.

5.4 COST ALLOCATION CONCEPTS - O&M COSTS

With respect to O&M costs, there are fewer common options. Most O&M cost-sharing formulas are based on actual wastewater flow, often with a small percentage surcharge on the per-gallon price paid by the Customer Town. Sometimes wastewater strength is also accounted for in either capital or O&M cost sharing, but that approach may not be necessary due to the absence of any significant high-strength waste sources in Orleans or neighboring towns.

TABLE 5-1
SUMMARY OF COST SHARING EXAMPLES

	Option 1 Customer Pays Incremental Costs	**Option 2** Customer Pays Individual Costs	**Option 3** Costs Allocated on Flow Basis	**Option 4** Savings Allocated on Flow Basis	**Option 5** Savings Split Equally	**Option 6** Option 5 Plus Host Fee	**Option 7** Equal % of Costs & Savings
Capital Cost Share, $ million							
Host Town	30.0	20.0	26.25	22.5	25.0	23.0	23.33
Customer Town	5.0	15.0	8.75	12.5	10.0	12.0	11.67
Share of Savings, $ million							
Host Town	0	10.0	3.75	7.5	5.0	7.0	6.67
Customer Town	10.0	0	6.25	2.5	5.0	3.0	3.33
Capital Cost Share, %							
Host Town	85.7%	57.1%	75.0%	64.3%	71.4%	65.7%	66.7%
Customer Town	14.3%	42.9%	25.0%	35.7%	28.6%	34.3%	33.3%
Share of Savings, %							
Host Town	0%	100%	37.5%	75%	50%	70%	66.7%
Customer Town	100%	0%	62.5%	25%	50%	30%	33.3%

5.5 APPLICATION OF COST SHARING FORMULAS

The Working Group reviewed the cost sharing example presented herein, and discussed the advantages and disadvantages of each candidate approach for cost allocation It selected two methods, Option 3 and Option 6, to apply to the cost estimates presented in Section 4. These cost allocation options were selected because they are intuitively simple and they bracket the greatest reasonable range for cost sharing. The most desirable cost-sharing scenario may fall somewhere between the costs presented from applying Option 3 and Option 6. The illustrative costs are presented in Table 5-2, where Cost Allocation Options 3 and 6 are applied to Regionalization Alternatives A-2, B-2, and C-2. Table 5-2 illustrates the costs and savings related only to regional treatment, and do not include collection and disposal costs.

With Cost Allocation Option 3 (costs apportionment based on flow), the greatest benefits accrue Eastham and Brewster. For the two-town regionalization alternatives, Brewster would accrue 81% of the savings (Alternative A-2) and Eastham would accrue 70% of the savings (Alternative B-2). In the three-town alternative (Alternative C-2), Brewster and Eastham together receive 90% of the savings. In general, cost sharing on a flow basis accrues the greatest percentage of the savings to the smaller contributor.

With Cost Allocation Option 6 (equal sharing of savings tempered by payment of a host fee), the greatest benefits accrue to Orleans. For the two-town regionalization alternatives (Alternatives A-2 and B-2), Orleans would accrue about 70% of the savings. Orleans would accrue 54% of the savings in the three-town alternative (Alternative C-2). In general, this cost allocation option provides most of the savings to the host and major flow contributor.

Table 5-2 accomplishes the goal of the Working Group to demonstrate a broad range of cost per town that can serve as a framework for more detailed evaluation and negotiation. While other approaches are possible, this exercise shows that Brewster's share of regional treatment costs could be in the range of $5 million to $10 million, compared to the $13 million it might spend on its own. Eastham's share could be in the range of $8 to $12 million, compared with the $15 million it might spend on its own.

TABLE 5-2

SUMMARY OF TREATMENT CAPITAL COST ALLOCATIONS FOR TWO POSSIBLE APPROACHES

	Alternative A-2		Alternative B-2		Alternative C-2	
Wastewater Flow, gpd						
Orleans	504,000	*(85%)*	504,000	*(76%)*	504,000	*(67%)*
Brewster	88,000	*(15%)*	0		88,000	*(12%)*
Eastham	0		160,000	*(24%)*	160,000	*(21%)*
Total	592,000		664,000		752,000	
Cost Allocation Option 3 - Cost Apportioned on Flow Basis						
Capital Cost, $M						
Orleans	27.7	*(85%)*	26.9	*(76%)*	25.6	*(67%)*
Brewster	4.9	*(15%)*	0		4.6	*(12%)*
Eastham	0		8.5	*(24%)*	8.0	*(21%)*
Total	32.6		35.4		38.2	
Cost savings, $M						
Orleans	1.9	*(19%)*	2.7	*(30%)*	4.0	*(10%)*
Brewster	8.2	*(81%)*	0		8.4	*(22%)*
Eastham	0		6.4	*(70%)*	6.9	*(68%)*
Total	10.1		9.1		19.3	
Cost Allocation Option 6 - Savings Split Equally Plus Host Fee						
Capital Cost, $M						
Orleans	22.6	*(76%)*	23.0	*(78%)*	19.1	*(65%)*
Brewster	10.0	*(77%)*	0		8.6	*(66%)*
Eastham	0		12.4	*(83%)*	10.5	*(70%)*
Total	32.6		35.4		38.2	
Cost savings, $M						
Orleans	7.1	*(70%)*	6.6	*(72%)*	10.5	*(54%)*
Brewster	3.0	*(30%)*	0		4.4	*(23%)*
Eastham	0		2.5	*(28%)*	4.4	*(23%)*
Total	10.1		9.1		19.3	

5.6 UNIT COSTS FOR FUTURE NITROGEN TRADING

While traditional cost sharing is based on wastewater flows (and sometimes wastewater strength), Orleans, Brewster and Eastham should also consider cost allocation based on the amount of nitrogen removed. The over-riding goal of wastewater management in the region is removal of nitrogen from the watersheds of sensitive coastal embayments. One way to evaluate nitrogen removal options is to express their costs on the basis of the dollars spent per pound of nitrogen removed from the watershed. The first step is to combine the capital cost of a project with its expected annual operational costs. This is done by amortizing the capital cost (converting it to an equivalent annual costs based on some interest rate and term), and then adding the annual operating and maintenance costs to the amortized capital cost. The result is the annual amount needed to build and operate the facility, assuming replacement at the original cost at the end of the term. Next, the annual cost is divided by the pounds of nitrogen removed from the target watershed over a year. The result is the overall cost per pound of nitrogen removed. The 11 options evaluated in this report have costs ranging from $300 per pound to $430 per pound. Table 4-1 presents such costs for individual and regional options.

If Brewster were to build its own facilities, under the assumptions used in the analysis, it would pay $430 per pound of nitrogen removed from the Pleasant Bay watershed. Orleans has the ability to offer Brewster a share in a regional wastewater facility at some number higher than the cost of that regional facility ($300 per pound). If Orleans were to extend its sewer system to serve other Orleans properties, and the nitrogen removed is equivalent (in embayment protection terms) to the nitrogen that would have been removed in Brewster, then Orleans could use the dollar-per-pound method for assessing charges to Brewster.

One application of this cost accounting method is in a "cap and trade" approach, as is used in the air pollution industry. Each town in the watershed would be assessed a fee for each pound of nitrogen that enters the watershed above the embayment's threshold. (That is, the nitrogen load would be "capped" at the TMDL threshold.) If the fee that is charged (say $450 per pound) is more than Brewster can negotiate with Orleans (say $325 per pound), than Brewster has an incentive to buy credits from Orleans. In Alternative A-3, Orleans would be "trading" the credits it would generate by removing more nitrogen than Orleans is required to remove.

Considering costs on this basis is a convenient way to combine capital and O&M costs into a single number that also accounts for the effectiveness of the nitrogen removal system. This approach may have applicability in negotiations among the three towns. Any "cap and trade" system would only be possible if some regulatory entity had the legislative authority to set up such a system and to impose fees based on measurable performance.

SECTION 6

SUGGESTED NEXT STEPS

This evaluation of regionalization alternatives demonstrates that there are significant opportunities for meaningful savings, both in capital costs and in annual O&M expenses, that could accrue to Orleans, Eastham and Brewster. That said, regionalization is an inherently difficult process through which to navigate, often due to non-technical and non-financial factors. Some examples of non-technical and non-financial factors related to regionalization include:

- Multi-town public education and outreach is necessary on the source and extent of the nitrogen control problem, the options to address the problem, the location of town boundaries versus watershed boundaries, the importance of making forward progress, and the advantages and disadvantages of acting regionally.
- There may be a lack of public will to act regionally (versus independently) due to the perceived or actual loss of local control for the "customer communities".
- The "host community" may not be willing to act regionally (versus independently) due to the perception of "selling" its resources (such as effluent disposal site capacity) to others or bearing too much of the burden of environmental impacts.
- There is the need to select the proper administrative entity (e.g., municipal structure or quasi-municipal district).
- The completion of complex legal documents and gaining Town Meeting approvals can be challenging tasks.

Based on the foregoing discussion, in conjunction with the numerous financial and technical considerations, one would expect that preliminary commitments on regionalization could take months if not years to obtain. Accordingly, in order to ensure that each community is expending its limited time and financial resources appropriately, an agreed-upon implementation approach and milestone schedule should be developed and followed by each community. A suggested implementation approach includes the following steps:

1. Conduct thorough reviews of the May 2009 and June 2009 drafts of this report by the Working Group, and incorporate pertinent comments into a final report. (This step was accomplished in second half of 2009.)

2. Submit the second draft (June 2009) report to the Boards of Selectmen from Orleans, Brewster and Eastham, and discuss it in a public meeting held jointly by the three Boards. It may also be appropriate for that meeting to include specific discussions related to Orleans building regional septage capacity at its wastewater facility. Topics could include: Tri-Town facility contingency planning and funding; continuation or dissolution of the Tri-Town District; and future septage receiving provisions at the Orleans municipal wastewater treatment facility. (That meeting was held on September 10, 2009.)

3. Solicit and secure a commitment from each of the three Boards (or Town Meetings as appropriate) on wastewater regionalization and septage regionalization. The following simplified choices are suggested:

    a. **Opposed to regionalization** (will not participate in planning, design or construction);
    b. **Committed to regionalization now** (will begin formal negotiations for reserving capacity); or
    c. **Open to regionalization long-term** (may negotiate in the future).

4. Address the following issues with those towns that are "committed to" or "open to" regionalization:

    a. Wastewater volume from each community,
    b. Septage volume from each community,
    c. Participation in capital costs, and
    d. Participation in O&M costs.

5. Finalize this Regionalization Report to address the input from the three Boards, including their choice of level of commitment, if that input can be obtained at this early stage. (This final report has been prepared in December 2009, following a statement by the Eastham Board of Selectmen in support of continuing to discuss regionalization options. No other commitments have been obtained as of this date.)

6. Present the Regionalization Report to the Cape Cod Water Protection Collaborative. (This presentation occurred at the September 9, 2009 meeting of the Collaborative.)

7. Include the final Regionalization Report in the Final Orleans CWMP, with appropriate modifications to the schedule and implementation plan contained in Section 11 of that CWMP.

In that Orleans is the farthest along in wastewater planning of the three communities, the schedule for decision-making on regionalization must be coordinated with the completion of the Orleans CWMP, currently scheduled for early 2010. To the extent that regionalization is elected, the CWMPs for each Town should ultimately include an implementation schedule that reflects the necessary administrative steps. The Orleans CWMP should also report on any confirmatory model runs (conducted through the MEP) which would be necessary to show that the proposed regional plan is TMDL compliant, particularly for options involving sewers in Orleans to offset nitrogen loads in the other towns.

The proposed phased construction of the Orleans wastewater facilities will dictate deadlines for firm commitments from Eastham and Brewster. In Phase 1, one half of the wastewater treatment capacity would be built at the Tri-Town site. The remaining treatment plant capacity would be built in Phase 4, either at Tri-Town or at a site near the Orleans-Brewster town line. Binding commitments related to participation by Eastham and Brewster could be deferred until the start of the Phase 4 design. However, earlier commitments would be beneficial, in that they would allow the design of Phase 1 facilities to accommodate later inclusion of Eastham and Brewster flows. (Such accommodations might include designing pump stations to be readily expanded in the future for regional flows.) During the preliminary design (2010 to 2011), it will be important for Orleans to estimate the added costs to facilitate later inclusion of the other Towns. Orleans would then make an informed decision (with Brewster and Eastham), on whether or not to incur those costs in Phase 1, or to expect a higher cost in Phase 4. Choosing to "commit to regionalization now" would allow Eastham or Brewster to benefit from that advance planning for future participation. Choosing to remain "open to regionalization long-term" would keep either Town's options open for participation in Phase 4, but without the benefits of that advance planning.

WRIGHT-PIERCE

Engineering a Better Environment

APPENDIX L

TOWN REGULATIONS AND POLICIES

APPENDIX L

Establishment of Board of Water and Sewer Commissioners, May 13, 2008

Board of Selectmen Wastewater Financing Policy, August 21, 2008

Sewer Use Regulations: draft Table of Contents and proposed Flow Neutral Provisions

Board of Health Nutrient Management Regulations, November 18, 2008

Acceptance of MGL Chapter 83 §1A, May 11, 2009

TOWN OF ORLEANS

OFFICE OF
TOWN CLERK

19 SCHOOL ROAD ORLEANS MASSACHUSETTS 02653-3699
Telephone (508) 240-3700 Extension 305 - Fax (508) 240-3388

The following is a certified copy of Article #45 and the "DOINGS" thereof from the Annual Town Meeting of May 13, 2008:

ARTICLE 45. AMEND HOME RULE CHARTER CHAPTER 6 APPOINTED MULTI-MEMBER BODIES, BOARD OF WATER AND SEWER COMMISSIONERS

To see if the Town will vote to adopt the following proposed Order of Amendment to the Orleans Home Rule Charter:

Delete clause 8 in its entirety, which currently reads as follows:
"~~Section 8 Board of Water Commissioners~~

~~6-8-1 The provisions of Chapter 418 of the Acts of 1953 shall be modified by this Section concerning all matters delineated herein. Effective July 1, 2001, the members of the Board of Selectmen will cease to be Water Commissioners, the Water Advisory Board shall be disestablished and its five (5) members shall be sworn in as members of the Board of Water Commissioners and continue to serve as such until expiration of a period of time equal to their remaining term as a member of the Water Advisory Board prior to its disestablishment. Thereafter appointments to the Board of Water Commissioners shall be made in accordance with Clause 6-8-2.~~

~~6-8-2 The Board of Selectmen shall appoint four members of the Board of Water Commissioners for three-year over-lapping terms. The Board of Health shall appoint one member of that board for the same term.~~

~~6-8-3 The Board of Water Commissioners shall set policy ensuring the adequate production and high quality of potable water. The Board shall be responsible for all functions cited in Chapter 418 of the Acts of 1953, except for the following functions vested in the Board of Selectmen for which they shall consult with the Board of Water Commissioners: establish water rates; contract with a municipality; acquire or take water resources, rights-of-way or easements; issue bonds to defray development and construction costs. In discharging its duties and responsibilities, the Board of Water Commissioners shall coordinate~~

~~with the Town Administrator and receive technical support from the Water Superintendent.~~

~~6-8-4 The Board shall develop annual operating and capitol projections, and Capital Improvement Plan projections for the Water Commission/Department, and make recommendations to the Town Administrator in accordance with Chapter8 of this Charter.~~

And insert in place thereof the following new clause 8, as follows:

§8. Board of Water and Sewer Commissioners

6-8-1 The provisions of Chapter 418 of the Acts of 1953 shall be modified by this Section concerning all matters delineated herein. **Effective July 1, 2009 or after passage of a Comprehensive Wastewater Management Plan by Town Meeting, whichever shall occur later,** the Board of Water Commissioners will be disestablished and a new Board of Water and Sewer Commissioners shall be established. Appointments to the Board of Water and Sewer Commissioners shall be made in accordance with clause 6-8-2.

6-8-2 The Board of Selectmen shall appoint three members and two associate members to the Board of Water and Sewer Commissioners for three-year overlapping terms. The Board of Health and the Planning Board shall each appoint one member to the Board of Water and Sewer Commissioners for three-year overlapping terms.

6-8-3 The Board of Water and Sewer Commissioners shall be responsible for all functions cited in Chapter 418 of the Acts of 1953, except for the following functions vested in the Board of Selectmen for which the Board of Selectmen shall consult with and receive recommendations from the Board of Water and Sewer Commissioners: establish water rates; contract with a municipality; acquire or take **water** resources, rights-of-way or easements; issue bonds to defray development and construction costs. In discharging its duties and responsibilities, the Board of Water and Sewer Commissioners shall coordinate with the Town Administrator and receive technical support from the Water/Sewer Superintendent(s). The Board of Water and Sewer Commissioners shall set policy ensuring: 1) the adequate production and the high quality of potable water; 2) development of a sewer works system consistent with the Comprehensive Wastewater Management Plan and oversight of that system when operational. **The Board of Selectmen shall establish sewer rates and shall consult with and receive recommendations from the Board of Water and Sewer Commissioners with respect to sewer rates**.

6-8-4 The Board of Water and Sewer Commissioners shall develop annual operating and capital budget projections and Capital Improvements Plan projections for the Water and Sewer Department, and make recommendations to the Town Administrator and Board of Selectmen in accordance with Chapter 8 of this Charter.

(2/3 vote required)

MOTION: To accept and adopt Article #45 as printed in the warrant.

ACTION: Voted, voice vote carries unanimously.

A TRUE COPY, ATTEST:

Cynthia S. May, Town Clerk

BOARD OF SELECTMEN
MEETING MINUTES

August 27, 2008

Approved on September 10, 2008

A meeting of the Orleans Board of Selectmen was held in the Nauset Meeting Room of the Town Hall. Present were Chairman David Dunford, Vice Chairman Mark Carron, Clerk Jon Fuller, Selectman John Hinckley, Selectwoman Margie Fulcher, Town Administrator John Kelly, and Recording Secretary Lindsay Stranger.

Chairman Dunford called the meeting to order at 6:30 pm.

Public Comment (00:00:18)
Gary Clinton spoke about the article that was in the newspaper regarding the wastewater financing. (00:00:30)

Leo Byrnes spoke about funding for the wastewater project, and that there may be opportunities through the County for financing. (00:06:39)

Approval of Meeting Minutes (00:13:52)
On a motion by Mr. Carron and seconded by Mrs. Fulcher, the Board voted to approve the Executive Session meeting minutes of August 13, 2008. Vote 5-0-0 (00:13:59)
On a motion by Mr. Fuller and seconded by Mrs. Fulcher, the Board voted to approve the meeting minutes of August 13, 2008, as amended. Vote 5-0-0 (00:14:23)
On a motion by Mrs. Fulcher and seconded by Mr. Hinckley, the Board voted to approve the meeting minutes of May 21, 2008. Vote 5-0-0 (00:16:18)
On a motion by Mrs. Fulcher and seconded by Mr. Hinckley, the Board voted to approve the meeting minutes of November 28, 2007, as amended. Vote 5-0-0 (00:18:26)

Committee Interview/Appointment (00:20:02)
- Zoning Bylaw Task Force Committee Appointment
On a motion by Mr. Carron and seconded by Mrs. Fulcher, the Board voted to appoint Jim O'Brien to the Zoning Bylaw Task Force Committee with a term ending date of 6/30/11. Vote 5-0-0

Police Chief Report (00:21:52)
Chief Roy gave an update on the Police Department for the month of July.
On a motion by Mrs. Fulcher and seconded by Mr. Fuller, the Board authorized Mr. Kelly to send a letter to Officer Wilcox for a great job while

off duty and a letter to Lt. Wells for a job well done with the Block Party and Pops in the Park. Vote 5-0-0 (00:32:57)

Fire Chief Report (00:37:11)
Chief Quinn gave an update on the Fire Department for the month of July.

Police Station Feasibility Review Committee (00:46:45)
On a motion by Mr. Fuller and seconded by Mrs. Fulcher, the Board voted to put the Design Article Request for the proposed new police station on the Fall Special Town Meeting Warrant in the amount of $425,000. Vote 5-0-0 (01:04:14)

Meet with Wastewater Management Steering Committee (01:11:10)
- Wastewater Financing Policy
On a motion by Mr. Carron and seconded by Mrs. Fulcher, the Board voted to amend the plan with the addition of "and prior to submission of said plan" after established in the first sentence on the second page. Vote 5-0-0 (02:05:15)
On a motion by Mr. Hinckley and seconded by Mr. Carron, the Board voted to amend the plan with the addition of "with the goal of balancing costs between user and non user" on the first page at the end of the first bullet. Vote 5-0-0
On a motion by Mr. Carron and seconded by Mr. Fuller, the Board voted to amend the plan with the addition of "and", in between draft and final in the first paragraph on the first page. Vote 5-0-0
→ **On a motion by Mrs. Fulcher and seconded by Mr. Fuller, the Board voted to approve the plan as amended.** Vote 5-0-0

Town Maintenance Facility Committee Charge (02:18:03)
On a motion by Mrs. Fulcher and seconded by Mr. Fuller, the Board voted to approve the Town Maintenance Facility Committee Charge as revised by the Town Administrator. Vote 5-0-0 (02:19:43)

Town Administrator FY09 Goals (02:20:18)
On a motion by Mrs. Fulcher and seconded by Mr. Hinckley, the Board approved the Town Administrator's Goals for FY09 as amended. Vote 5-0-0 (02:27:33)

Town Administrator's Report (02:28:19)
- Preservation Restrictions
On a motion by Mr. Fuller and seconded by Mrs. Fulcher, the Board voted to authorize the Chairman to sign the Preservation Restrictions on behalf of the Town. Vote 5-0-0 (02:29:40)

Liaison Reports (03:04:25)

Mr. Fuller gave updates on the Lighthouse Charter School and the Planning Board.
Mr. Hinckley gave updates on the Water Quality Task Force and the Renewable Energy Wind Power Committee.
Mr. Dunford gave an update on the Citizens Advisory Committee.

Other Business

- Application for Temporary Trailer-15 Barney Way (03:15:01)

On a motion by Mr. Carron and seconded by Mr. Fuller, the Board voted to approve the application for a temporary trailer for 15 Barney Way, due to a house fire, for the period of 9/2/08 through 3/2/09. Vote 5-0-0

Adjourn

On a motion by Mr. Carron and seconded by Mr. Hinckley, the Board voted to adjourn. Vote 5-0-0

Respectfully submitted,

Lindsay Stranger

____
Jon R. Fuller, Clerk

DRAFT

POLICY STATEMENT

FINANCING TOWN-WIDE COMPREHENSIVE WASTEWATER PLAN INFRASTRUCTURE

It shall be the policy of the Orleans Board of Selectmen to develop financing methods for the capital cost of infrastructure in conjunction with the development of the Draft Final Town-Wide Comprehensive Wastewater Plan (Plan).

The purpose of this policy is as follows:

- To establish guidelines for the fair and equitable distribution of the cost of the capital outlay for infrastructure related to the Plan.
- To insure that there is a uniform and consistent payment formula for the many phases of installation of the system infrastructure.
- To reassure citizens that the increases in financial obligations will be incremental, in an effort to make it affordable.

As the funding for the required capital components of the Plan will be a multi-year and costly undertaking, all possible funding methods will be explored to insure that the best are chosen for the Town.

The repayment of the bonds that will be issued by the Town will primarily come from two sources – individual betterments that are only charged to those properties to be served by the public sewer and through property taxes to be paid by all property owners. The repayment of the bonds will be apportioned so that twenty percent (20%) comes from betterments and eighty percent (80%) comes from property taxes. All costs associated with the connection of an individual property to the public sewer will be the responsibility of the property owner.

Once the public sewer system is operational, the goal will be to have the system become fully self supporting. In order to accomplish this, the Town will implement a user fee system for those properties that are connected to the public sewer based on water usage.

As the final elements of the Plan are more fully established, the Board will review this financing policy and make any adjustments that may be necessary to insure that the overall goal of a fair and equitable assessment of capital costs is maintained.

Date Prepared: 21 August 2008
Date Revised:
Date Adopted:

SEWER USE REGULATIONS

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Any property owner who connects to the municipal sewer system shall limit the wastewater flow from that property to the quantity which could be discharged to an on-site wastewater disposal system on that property under Commonwealth and Town regulations and bylaws in effect on ____________, including 310 CMR 15, any Town supplements to 310 CMR 15, and the Orleans Board of Health Nutrient Management Regulations (adopted November 18, 2008 and effective July 1, 2009).

Wastewater flow limits shall be determined using provisions set forth in 310 CMR 15.203 (System Sewage Flow Design Criteria) and any Town supplements to those provisions.

SEWER USE REGULATIONS

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SEWER USE REGULATIONS

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PROPOSED FLOW NEUTRAL PROVISIONS

Town of Orleans
Board of Health
Nutrient Management Regulations

Article _________

Section 1 Authority

1.1 The Town of Orleans Board of Health, in accordance with, and under the authority of, Chapter 111, Section 31 of the Massachusetts General Laws, does hereby adopt the following rules and regulations.

1.2 The effective date of this regulation shall be July 1, 2009.

Section 2 Preamble

Orleans, like most of the towns on Cape Cod, has experienced rapid population growth and development since the early 1960's. Local responses have included adoption of 1 acre zoning in 1973. Also the Board of Health adopted Subsurface Sewage Disposal Regulations to supplement and augment the provisions of Title 5 of the State Environmental Code. However, many under-sized lots remain 'buildable', and numerous pre-Title 5 subsurface wastewater disposal systems continue to operate.

The Federal Clean Waters Act (1977) requires the Massachusetts Department of Environmental Protection (DEP) to limit the discharge of pollutants entering water resources. Excess nitrogen has been identified as the major contributing factor in the declining health of the marine water environment. Excess phosphorus, and to some degree excess nitrogen, are the major contributing factors in the declining health of the freshwater environments. Ninety-nine percent of sewage disposal systems in town do little to remove nitrogen or phosphorus. A few systems are in place that partially remove nitrogen for the property they serve. In Orleans, this translates to an immediate concern over the level of nitrogen entering local groundwater and its subsequent effect on marine estuaries. Phosphorus has similar effects on freshwater resources.

In 2000, Orleans and other Southeastern Massachusetts communities joined the Department of Environmental Protection's Massachusetts Estuaries Project (DEP-MEP). The result of many years of water quality testing and five years of scientific analysis was the publication of a technical report by the DEP. This technical report lead to the establishment of Total Maximum Daily Limit (TMDL) standards of nitrogen for each estuary studied.

Local health officials now realize that on-site septic systems (both Title 5-compliant and not), soil conditions and hydrology allow rapid migration of groundwater to surface water bodies (ponds and estuaries). Sewage disposal systems in Orleans, while adequately protecting public health do not remove any meaningful amounts of nitrogen or phosphorus and their discharge migrates rapidly into the groundwater. Locally controllable sources of nitrogen are primarily from septic system effluent and to a lesser extent from lawn fertilizer.

The Town of Orleans is in the process of developing a Comprehensive Wastewater Management Plan (CWMP). When adopted, the Plan will guide the phased construction of facilities to control nitrogen and phosphorus loading. This costly undertaking will likely take more than a decade to begin operating at an effective level, and longer to be fully functioning.

The documented scientific need and the regulatory mandate to address the issue of excess nitrogen released into local estuaries and the extraordinary lead-time required to fundamentally alter the way wastewater is managed are well known. *The Orleans Board of Health adopts these regulations to minimize, to the extent possible, the increase of excess nitrogen and phosphorus in the local environment.*

Section 3 Purpose

Currently nitrogen and phosphorous in groundwater is steadily increasing. The town must regulate the increase in nutrients entering the ground water from septic systems that might affect ponds and estuaries. To minimize this increase in nutrients, the town must address the generation of wastewater on a parcel-specific basis by relating development potential to parcel size.

Section 4 Definitions

For purposes of this regulation, the following definitions shall apply:

Apartment: A structure, regardless of form of tenure, containing three (3) or more dwelling units, or a mixed-use structure containing three (3) or more dwelling units having a majority of floor area devoted to non-residential use.

Approved Capacity – The capacity of a 1978 Code system reflected by the sewage flow as shown on the Disposal Works Construction Permit Application or as shown on the Certificate of Compliance, whichever is less for that system and not the calculated capacity based on 1978 Code loading rates which may account for over design or safety factors.

For a system designed in accordance with 310 CMR 15.000, the approved calculated capacity is based on the loading rates found at 310 CMR 15.242.

Bedroom: Any portion of a dwelling which meets the Minimum Standards of Fitness for Human Habitation, (Chapter II of the State Sanitary Code), and is designed to furnish the minimum isolation necessary for use as a sleeping area, and includes, but is not limited to, bedroom, den, study, sewing room, sleeping loft or enclosed porch, but does not include kitchen, bathroom, dining room, halls, living room, sun porch (as defined in these regulations) or unfinished basement.

Design Flow: The quantity of sanitary sewage, expressed in gallons per day (gpd), for which a system must be designed in accordance with 310 CMR 15.203.

Division of Land: The division of a parcel of land or the modification of lot lines to create a new lot, including preliminary and definitive subdivisions, Approval Not Required (ANR) plans, Open Space Residential Developments (OSRD) , and other legal means, and shall include re-subdivisions. The modification of existing lot lines, not resulting in the creation of additional buildable lots, shall not be a division of land.

Dwelling Unit: One (1) or more rooms intended as a single housekeeping unit for the use of one (1) or more individuals living together, and having cooking, sanitary and sleeping facilities. A "dwelling unit" does not include garages, sheds or an accessory or additional structure, whether attached or unattached.

Enhanced Treatment Systems: A septic system that is designed to increase removal of nitrogen from effluent as compared to that removed by a standard Title 5 septic system.

Facility - Any real property (including any abutting real property) and any buildings thereon, which is served, is proposed to be served, or could in the future be served, by a system or systems, where:
(a) legal title is held or controlled by the same owner or owners; or
(b) the local Approving Authority or the Department (DEP) otherwise determines such real property is in single ownership or control pursuant to 310 CMR 15.011 (aggregation).

Lot: An area or parcel of land in undivided ownership with definite boundaries, used or available for use as the site of one (1) or more buildings.

Multi–Family Housing: Condominiums, apartments, apartments incidental to commercial space, boarding houses and congregate, cluster or attached housing where the individual units are either owned or rented.

New Construction: The construction of a new building for which an occupancy permit is required or an increase in the actual or design flow to any existing structure through addition, renovation or modification or a change in use. New construction shall not include replacement or repair of an existing building totally or partially destroyed or demolished if there is no increase in flow.

Nitrogen: All nitrogenous compounds.

Non-conformity: Does not meet the requirements of Title 5 or the Orleans Board of Health Regulations.

Nutrient Sensitive Area: Those portions of the mainland of Orleans where groundwater, the aquifer, and adjacent estuarine environments can be significantly altered by addition of nitrogen or phosphorus; or those areas identified and required by Department of Environmental Protection-TMDL's to have nitrogen input mitigated.

On-site Subsurface Sewage Disposal System: A system or series of systems for the treatment and disposal of sanitary sewage below the ground as defined by 310 CMR 15.000 of the State Environmental Code, Title 5.

Phosphorus: All phosphoric compounds.

Sun Room/Porch: A room designed to have a minimum of 40% glazed area (window area) of the total combined exterior wall and ceiling area of the room. In calculating the total glazed area only the translucent or transparent window area should be considered (rough opening or unit dimension shall not be considered).

Watershed: For the purposes of this regulation a watershed is defined as the area of land under which the ground water collects and flows towards or into a specific pond and/or estuary.

Section 5 Transition Rules:

Except as explicitly set forth in Section 6.2 the provisions of the Orleans Nutrient Management Regulations shall apply to all facilities (properties) regardless of date of permit approval, construction or approved capacity of any septic system in the Town of Orleans.

5.1 Applications for New Construction, renovations, additions or change of use of a facility that increases the design flow to the septic system.

5.1.1 Disposal Works Construction Permit Application

5.1.1.1 Complete Applications for Disposal Works Construction Permits filed prior to July 1, 2009 shall be reviewed, and if approved, such system shall be constructed and a Certificate of Compliance shall be issued within three years of the date the application was approved.

5.1.1.2 Upon receipt of a written request detailing the facts that prevented the filing of an application for a Disposal Works Construction Permit prior to July 1, 2009, the Board of Health or its agent may grant an applicant a six month extension to the required submittal date as defined in Section 5.1.1.1. Only one extension may be granted per parcel.

5.1.2 Building Permit Applications filed after the effective date of this regulation shall be reviewed as follows:

5.1.2.1 If a there is an Active Disposal Works Construction Permit on file with the Health Department prior to the effective date of these regulations showing an Approved Capacity adequate for a specific project the Board of Health will sign off on a building permit application for that project if the applicant demonstrates that the sewage disposal system will be constructed and connected to the foundation wall and a Certificate of Compliance can be issued prior to the expiration of the Disposal Works Construction Permit.

5.1.2.2 If there is a complete Application for Disposal Works Construction Permit filed with the Health Department prior to the effective date of these regulations showing an Approved Capacity adequate for a specific project the Board of Health will sign off on a building permit application for that project if the applicant demonstrates that the sewage disposal system will be constructed and connected to the foundation wall and a Certificate of Compliance can be issued prior to the expiration of the Disposal Works Construction Permit.

5.1.2.3 If there is an existing septic system with an Approved Capacity as shown on the Disposal Works Construction Permit or as shown on the Certificate of Compliance on file with the Health Department, which Approved Capacity is sufficient for the proposed project, the Board of Health will approve the project if the building permit application for the project is filed prior to July 1, 2012.

5.1.2.4 Any application for a building permit filed after July 1, 2012, regardless of the Approved Capacity of the septic system will be subject to the full provisions of these regulations.

Section 6 Applicability

6.1 The following projects shall be subject to the provisions of this regulation:

6.1.1 New commercial development with a Title 5 sewage flow under 10,000 gallons per day.

6.1.2 Existing commercial development with a total Title 5 sewage flow of under 10,000 gallons per day where an addition or a change in use is proposed that will increase the sewage flow over the existing flow but still be less than 10,000 gallons per day.

6.1.3 Division of Land creating more buildable lots, regardless of existing dwelling units.

6.1.4 Construction of multi-family housing.

6.1.5 Construction of single family dwellings.

6.1.6 Alterations, additions or changes in use to existing dwellings that would increase the calculated sewage design flow.

6.1.7 The division of land involving existing dwelling units.

6.2 The following are exempt from the provisions of this regulation:

6.2.1 Facilities with a design flow of 10,000 gallons per day or greater which fall under the jurisdiction of the Massachusetts DEP Groundwater Discharge Permit Program.

6.2.2 Properties located within the Village Center District as defined by The Orleans Zoning Map.

6.2.3 Properties located within the General Business District as defined by The Orleans Zoning Map with the exception of apartment developments having three or more dwelling units.

6.2.4 Properties located in the Industrial District as defined by The Orleans Zoning Map.

Section 7 General Requirements

7.1 No Disposal System Construction Permit shall be issued by the Board of Health or its Agent for any of the projects described in Section 6.1 above unless the proposed system is designed to receive or shall receive four hundred forty (440) gallons per day or less per forty thousand square feet (40,000) of lot area or ratio thereof.

7.2 This regulation shall not prohibit the construction of a two (2) bedroom house on any lot providing that said lot is not in an area subject to Nitrogen Loading Limitations or a Nitrogen Sensitive Area, as defined in Title 5 or in District II of the Orleans Ground Water Protection District and all other Local and State requirements are met.

7.3 No facility described in Section 6.1 shall be expanded or have a change of use that increases the design flow until a Disposal System Construction Permit has first been obtained, unless the Board of Health, or its Agent, determines that the existing sewage disposal system is adequate (per Title 5 and the Orleans Board of Health Subsurface Sewage Disposal Regulations), including documentation that the facility's design flow is less than or equal to 440 gallons per 40,000 square feet of lot area or the ratio thereof.

7.4 The owner of any lot reduced in area by the laying out, and acceptance of, a road or roads as a public way or ways, or for any other municipal purposes serving the common good, shall be allowed to use the area taken in determining compliance with this regulation. This shall apply only to the owner of record at the time of the lot's reduction in area.

7.5 The division of land involving existing dwelling units shall not render the existing dwelling unit as noncompliant with these regulations.

Section 8 Variances

8.1 Variances from this regulation may be granted by the Board of Health only as follows:

8.1.1 Variance Requests not Demonstrating a Hardship:

8.1.1.1 For residential lots less than 40,000 square feet the Board may allow, by variance, an additional 110 gallons per day over the number allowed by Sections 7.1 and7.2 with the use of an Innovative/Alternative Nutrient Reducing Technology in conjunction with the on-site subsurface sewage disposal system.

8.1.1.2 If applying for a variance under Section 8.1.1.1 an applicant shall supply a nitrogen loading report, accepted by the Board of Health, prepared by a Professional Engineer or Registered Sanitarian demonstrating that the proposed septic system will offer the same level of protection to the ground or surface water resource as would be provided by the strict application of this regulation.

8.1.1.3 Only technologies approved by the DEP for enhanced nutrient removal pursuant to either the piloting, provisional or general use certification provisions in Title 5 (310 CMR 15.281 through 15.288) may be used to comply with Section 8.1.1.1.

8.1.2 Standard of Review for all other variances:

8.1.2.1 If the applicant demonstrates to the satisfaction of the Board of Health, that a literal enforcement of this regulation would involve substantial hardship, financial or otherwise, to petitioner(s), i.e. it would deprive the landowner of reasonable use of the lot in question; and

8.1.2.2 If the applicant demonstrates to the Board of Health that the discharge of effluent from the proposed septic system will offer the same level of protection to the ground or surface water resource as would be provided by the strict application of this regulation.

8.2 Every request for a variance shall be made in writing and shall state the specific variance sought and the reasons therefore. No variance shall be heard except after the applicant has notified all abutters by certified mail at his own expense at least ten (10) days before the Board of Health meeting at which the variance request will be on the agenda. The notification shall state the specific variance sought and the reasons therefore.

8.3 If applying for a variance under subsection 8.1.2 above, the petitioner shall at a minimum submit:

8.3.1 Written documentation as to why the enforcement of this regulation would cause hardship.

8.3.2 A nitrogen loading report, accepted by the Board of Health, prepared by a Professional Engineer or Registered Sanitarian demonstrating that the proposed septic system will offer the same level of protection to the ground or surface water resource as would be provided by the strict application of this regulation.

8.3.3 A plan prepared by a Professional Engineer or Registered Sanitarian indicating:

a. The Watershed and Sub-Watershed in which the proposed septic system is located;
b. Depth to ground water;
c. Soil conditions; topography;
d. All surface waters;
e. All wetlands located within two hundred feet (200') of the proposed system;
f. Any other information deemed pertinent by the Board of Health.

8.4 The Board of Health will consider, but not be limited to, the following factors when reviewing a variance application:

8.4.1 Setbacks from surface water resources.

8.4.2 Present or future private or public drinking water wells.
8.4.3 The implementation schedule of the town's Comprehensive Wastewater Management Plan.

8.5 Any variance granted by the Board of Health shall be in writing. Any denial of a variance shall also be in writing and shall contain a brief statement of the reasons for the denial. While it is in effect, a copy of each variance granted shall be made available to the public at all reasonable hours in the office of the Health Department.

8.6 Any variance or other modification authorized to be made by this regulation may be subject to such qualifications, revocations, suspensions, or expiration as the Board of Health expresses in its grant. A variance or other modification authorized to be made by this regulation may otherwise be revoked, modified, or suspended, in whole or in part, only after the holder thereof has been notified in writing and has been given the opportunity to be heard, in conformity with the requirements for an order and hearing as contained in 310 CMR 11.07 and 11.08 of the State Environmental Code, Title 5.

8.7 Any variance or modification authorized by this regulation shall be subject to a covenant from the owner which shall be recorded in the Registry of Deeds or Registry District of the Land Court, as appropriate, stating that:

> "At such time as the Town of Orleans through its Board of Health and/or Board of Water Commissioners, or the equivalent of those Boards, directs the connection of the land herein described to a municipal sewer, the construction of enhanced wastewater treatment system, connection to a shared septic system, or any other wastewater management option for the removal of nitrogen (or phosphorus), [owner], for myself and my successors and assigns, covenant and agree to comply with such direction. The Board of Health and/or the Board of Water Commissioners, or the equivalent of those Boards, shall determine the schedule for compliance."

Section 9 General Enforcement

The Orleans Board of Health, its designated agents, enforcement officers and anyone with police powers, may enforce this regulation.

Section 10 Orders: Service and Content

10.1 The Board of Health and its designated agents may issue orders requiring the owner or operator of a facility to comply with the provisions of this regulation or to take any other action necessary to protect public health, safety, welfare, or the environment.

10.2 Orders may be served on any person responsible for a violation of this regulation in accordance with the following procedure:

10.2.1 Personally, by any person authorized to serve civil process, or

10.2.2 By any person authorized to serve civil process by leaving a copy of the order at his/her last and usual place of abode, or

10.2.3 By sending the owner a copy of the order by registered or certified mail, return receipt requested, if he is within the Commonwealth, or

10.2.4 If his last and usual place of abode is unknown or outside the Commonwealth, by posting a copy of the order in a conspicuous place on or about the premises and by advertising it for at least three out of five consecutive days in one or more newspapers of general circulation within the municipality wherein the building or premises affected is situated.

Section 11 Hearing

11.1 Unless otherwise specified in this regulation, any person aggrieved by the determination of the Health Department or other personnel of the Board of Health, may request a hearing before the Board of Health by filing a written petition to the Board of Health.

11.2 Upon receipt of such petition, the Board of Health shall set a time and place for such hearing and shall inform the petitioner thereof in writing. The hearing shall be commenced no later than 30 days after the day on which the order was served. The Board of Health, upon application of the petitioner, may postpone the date of hearing for a reasonable time beyond such 30-day period if, in the judgment of the Board of Health, the petitioner has submitted a good and sufficient reason for such postponement.

11.3 At the hearing the petitioner shall be given the opportunity to be heard, to present witnesses or documentary evidence, and show why the decision of the Health Department or other agents of the Board of Health should be modified or withdrawn. Failure to hold a hearing within the time period specified shall not affect the validity of any order.

Section 12 Appeal

Any person aggrieved by the final decision of the Board of Health with respect to any order issued under the provisions of this regulation may seek relief there from in any court of competent jurisdiction, as provided by the laws of this Commonwealth.

Section 13 Penalties

13.1 Violation of this regulation will be subject to the provisions of Massachusetts General Laws, Chapter 40, Section 21D, regarding non-criminal dispositions as adopted by the Town of Orleans.

13.2 Any person who knowingly violates any provision of this regulation may be subject to a One Hundred Dollar ($100) fine for each offense. Each day of noncompliance constitutes a separate offense.

Section 14 Severability

14.1 Whenever possible, these regulations shall be deemed to be supplementary to (not contradictory with) state and federal statutes and regulations.

14.2 In the event any of these regulations shall be held invalid, any such regulation or regulations shall be deemed to be severed from the others and struck from these rules, but the remaining regulations shall continue in full force.

Sims McGrath, Jr., Chairman
Robin K. Davis, Vice Chairman
Susan B. Christie
Augusta F. McKusick
Jan Schneider, M.D.

ORLEANS BOARD OF HEALTH
November 18, 2008

Adopted: November 18, 2008
Effective: July 1, 2009

TOWN OF ORLEANS

OFFICE OF TOWN CLERK

19 SCHOOL ROAD ORLEANS MASSACHUSETTS 02653-3699
Telephone (508) 240-3700 Extension 305 - Fax (508) 240-3388

The following is a certified copy of Article #17 and the "DOINGS" thereof from the Annual Town Meeting of May 11, 2009:

ARTICLE 17. ACCEPTANCE OF M.G.L. CH. 83 §1A: REGARDING INSTALLATION OF SEWER MAINS

To see if the Town will vote to accept the provisions of M.G.L. Chapter 83 §1A, as amended by Ch. 312 of the Acts of 2008, which authorizes the Town to lay out, construct, maintain and operate a system or systems of common sewers and main drains in public or private ways for that part of its territory as it adjudges necessary to reduce or eliminate the impacts of nutrient enrichment on surface water bodies or sources of drinking water with such connections and other works as may be required for a system or systems of sewerage and drainage and sewage treatment and disposal, or to take any other action relative thereto. (Simple Majority Vote Required)

MOTION: To accept and adopt Article #17 as printed in the warrant.

ACTION: Voted, voice vote carries unanimously.

A TRUE COPY, ATTEST:

Cynthia S. May, Town Clerk

APPENDIX M

PEER REVIEW OF CWMP

APPENDIX M

In the fall of 2010, at the request of the Town, the Cape Cod Water Protection Collaborative provided funding for an independent engineering review of the Orleans April 2009 draft CWMP. This engineering review was performed by CH2M-Hill and is summarized in the attached document. A number of modifications to the body of the December 2010 final CWMP have been made to address comments and suggestions provided herein.

Engineering Review of Orleans CWMP

CH2M HILL

September 30, 2010

This report, completed on behalf of the Town of Orleans, presents the comments, conclusions and recommendations of CH2M HILL related to its engineering review of the Comprehensive Wastewater Management Plan (CWMP), dated April 2009, developed by Wright–Pierce for the Town. The scope of the review is in accordance with the Scope of Services, dated July 24, 2010, (Attachment A) issued by the Wastewater Protection Collaborative in support of the Orleans CWMP development process.

Specific recommendations for implementation are included under the particular items to which they pertain.

1. Needs Assessment

The outline of existing conditions and assessment of wastewater management needs covers all of the important water resource areas of concern. The existing and future wastewater flows are appropriately estimated and reasonable. Evaluation of sanitary, water supply protection, economic growth and convenience / aesthetic needs are well developed. Future wastewater flows for commercial and residential development may be slower to develop than anticipated, but are appropriate, with changes readily accommodated by the phasing of the program. The plan appropriately focuses on nitrogen in the Orleans estuaries and embayments that are affected by Eastham, Brewster, Chatham and, to a lesser degree, Harwich. Several comments are warranted:

1.1 The CWMP, including the *Evaluation of Freshwater Ponds* (Appendix A), conducted by a sub-consultant, indicates that, although not of the level of importance of nitrogen enrichment of embayments, nutrient loading to the freshwater ponds (primarily phosphorus, but possibly also nitrogen loading in the late Summer in certain ponds) is causing significant impairment of a number of the Orleans ponds. Both the CWMP and the pond subconsultant's report outline the insufficiency of information for other ponds, the associated necessary assumptions and the resulting uncertainty with respect processes governing eutrophication and water quality, and consequently the wastewater, stormwater and other management controls necessary to restore and protect the ponds. Given the importance of the human and aquatic uses of the freshwater ponds in Orleans, this is a significant gap in the needs assessment.

Because of the characteristics of phosphorus transport through groundwater and the potential for additional growth and/or more year-round usage of homes in the watersheds of certain ponds, continued and possibly increasing enrichment and degradation of the water quality can be expected. The CWMP recommendations to sewer tributary areas to Bolands Pond and Crystal and Pilgrim Lakes will provide some degree of protection in these cases. The CWMP recommends that the town continue to monitor and evaluate ponds conditions to determine what other controls are needed to supplement the nutrient reduction benefits of the Core Program. However, there are no line items for such activities in the Schedule for Implementation (Table 11-4) and no cost allocated their implementation in the Preliminary Cost Estimate of Operation and Maintenance Costs for the Core Program (Table 11-6).

1.2 It is unclear how the question of nutrient impacts to Eastham and Brewster freshwater ponds, if any, are being addressed. If this question will be addressed by the CWMP's being done by Eastham and Brewster, it may be helpful to mention so in the Orleans CWMP and clarify that there may be greater or lesser regional project costs pending the results of the Brewster and Eastham plans.

1.3 While the CWMP is appropriately focused on wastewater management needs of Orleans, stormwater is a significant contributor (nitrogen, phosphorus, bacteria) to the major water quality issues facing the town's estuaries , lakes and ponds and stormwater management is a significant need or requirement going forward. Although the scope of the CWMP does not include development of a stormwater management plan, reference to the existing work of the town, as well as forthcoming EPA and state regulatory requirements for more intensive stormwater management programs, and how those activities should integrate with the wastewater program, would be helpful.

1.4 Consideration should be given to the appropriate mention in the needs assessment chapter of emerging contaminants as a factor to be tracked and evaluated. It should then be referenced in the Alternatives Evaluation chapter as a risk factor in consideration of continued use of Title 5 or enhanced on-site systems vis a vis centralized facilities.

1.5 Section 2.2.3 of the CWMP references the TMDLs prepared (or being prepared) by the Massachusetts Estuaries Program (MEP). The section mentions the purposes of these studies, the data bases being used and the use of the resulting TMDLs for regulatory use in wastewater management. However, the CWMP does not explain or document the actual water quality, habitat, aesthetic effects of excessive nitrogen enrichment in the specific estuaries and embayments of Orleans, assuming that the reader has read, understands and is convinced by the MEP reports. Although the impacts of excessive nitrogen enrichment are well documented and commonly accepted, given that most of the remainder of the CWMP is based almost exclusively on remediation of these nitrogen impacts, at least a short summary of the nitrogen cycle and examples or statistics, possible summarized from the MEP documents, would be appropriate.

1.6 It is not clear whether the benefit with respect to nitrogen reduction in Pleasant Bay (Ryders Cove) of the decision by Chatham to sewer the entire town has been included in the percent reduction required by Orleans and Brewster.

1.7 The fact that the existing Tri-Town septage facility is reaching the end of its useful life and will require substantial investment in capital repair and replacement costs is documented in various reports and correspondence of the town. This need should be highlighted in the Existing Conditions, Future Needs and Wastewater Management Needs chapters of the CWMP. The need is appropriately dealt with in subsequent sections of the plan.

2. Alternatives Evaluation

The development of technology options and the configuration of wastewater collection and treatment and effluent disposal options are very clear and sound from an engineering perspective. The range of technologies considered is comprehensive and the requirements and expected performance of each technology is reasonable.

The following comments are offered:

2.1 The expected effluent quality of Title 5 systems with enhanced treatment (15-19 mg/l, Table 5-3) is reasonable looking backward in time and is consistent with currently documented experience. However, the focus on nitrogen removal in coastal environments with a predominance of on-site systems has led to a substantial level of investment in research and development of innovative, small scale systems in recent years. While individual on-site systems are impractical for numerous reasons for densely developed downtown areas, it is reasonable to project that advanced technologies will be fully approved and acceptable for less densely developed areas and could provide a more cost-effective option than conventional sewering, pumping and centralized treatment in post-Phase 1 stages of the program. Currently the CWMP includes no significant provisions for evaluation of advanced on-site systems in future phases of the program.

For the reasons outlined above, it is suggested that the CWMP consider:

a. The potential impacts of lower effluent nitrogen concentrations for enhanced on-site systems on project requirements. Between five and ten milligrams per litre (mg/l) would seem reasonable, along with testing the sensitivity of the cost of the plan to the potential range of concentrations. Similar technological improvements may benefit performance of cluster systems and should be evaluated also.

b. Implementation of a pilot program to select, install, maintain, monitor and evaluate advanced on-site systems in a small area or areas of Orleans. Consideration to the implementation of such a pilot in Brewster or Eastham, potentially providing more saving with respect to collection and transport costs, could be considered. A key goal of this pilot program would to provide experience, should such technologies prove effective for wider application, with the requirements entailed in maintaining, monitoring and overall management of a network of these systems to demonstrate compliance with the TMDL load reductions.

c. A plan for adapting future phases of the CWMP to include such systems should they prove feasible with respect to cost, operational, performance and regulatory criteria.

Consideration to piloting the use of an in-situ, permeable reactive barrier technology should also be considered, possibly in lieu of the remote cluster systems beings recommended for near-term nitrogen reduction.

The possibility of state and/or federal financial support of such pilot projects should be actively sought.

2.2 While non-structural, non-traditional control measures (stormwater management, fertilizer control, natural attenuation and flushing enhancements) will not in themselves replace structural controls in the denser residential and commercial areas of town, the high cost of the program dictates that these technologies be aggressively developed for potential application at the extensions of the sewered areas where transport costs are a substantial component of cost. At present they are somewhat loosely included in the three composite plans in Section 6.

3. Composite Management Plans

The process used for identification and screening of the nine town-wide plans was reasonable and fair. The three composite plans selected for detailed evaluation were synthesized from the nine plans using the best features of each plan and integrating regionalization options into each plan. The following comments are made:

3.1 There is no documentation of consideration of an “enhanced on-site systems” component to any of the nine options. While, as stated above, it is understood that enhanced on-site systems cannot satisfy all nitrogen removal requirements, it is reasonable to assume that advances in the technology will render such systems feasible from performance and operational perspective within the next few years and that such systems could be a viable, cost-effective option to sewer extensions.

It may be that such options were considered and eliminated for various reasons such as:

- Difficulties and costs involved in demonstrating TMDL compliance in light of a large number of such systems

- Issues related to possible future regulatory requirements for emerging pollutants

- Concerns about reliability or long-term performance of such systems

These are valid issues to consider. However, the document does not record such consideration.

3.2 Several comments regarding capital cost estimates:

3.2.1 Based on the description of the methodology stated in Section 7.6 of the report, it appears that the construction cost estimates for the wastewater treatment components of the plans were based on unit costs in terms of dollars per gallon for comparably sized plants in New England. The data base of recent capital and O&M costs for wastewater facilities developed by Wright-Pierce is very likely the most comprehensive and relevant source in New England for comparable costs of the facilities being proposed in Orleans. Such estimates are useful for alternative comparison purposes, but may not reflect actual process requirements and site-specific conditions for the Orleans facilities. For the purposes of estimating total project costs in order to provide the best estimates possible to determine financial burden to future users, cost estimates based on cost curves generally warrant the use of a higher percent contingency. In this case, it appears that 40% was added to construction costs to cover both the engineering, legal, administrative and construction cost contingency. Considering that permitting, legal services, preliminary and final design and engineering services during construction could approach or exceed 20% of the construction cost, a remaining contingency of 20% for construction contingency appears light at this stage of the project.

3.2.2 A cost item does not appear to be included for the Baker’s Pond cluster system. Possibly it is included in other line items.

3.2.3 It seems reasonable that the requirements and uncertainties related to the more complex Plans 1 and 3 would warrant a higher contingency than Plan 2.

3.2.4 The capital cost estimate for evaluation of the non-structural elements of the plan appear reasonable. An annual allowance for implementation of non-structural components of the plan appears to be missing from the O&M Estimate (Table 11-6)?

4. Site Selection Process

The site selection process was appropriate for the comprehensive planning stage of a project. The availability of the Tri-Town site, which already has a site assignment by the state and is being used for wastewater treatment, is an unusual and fortuitous situation for a town planning a new wastewater system. The technical and public issues related to finding an acceptable site for a wastewater treatment facility are typically the most difficult issues to resolve. For this reason alone the Plan 2 has an overwhelming advantage over Plans 1 and 3. In fact, it is questionable whether Plan 1 is really feasible.

In the opinion of the reviewer, finding 11 technically suitable sites for wastewater treatment and disposal and gaining local acceptance, ownership and regulatory permitting approval to use those sites would be a very unrealistic goal to set at this point in the planning process and is arguably a fatal flaw for Plan 1. Failure to obtain any one of the sites during the lengthy process of acquiring all 11 (a likely occurrence) would, by necessity, modify the requirements of one or more other sites and "reopen" the siting process at those locations, probably at some point requiring the use of the Tri-Town site in any case. The uncertainty inherent in this complex siting process would be a significant, on-going risk to the overall project during implementation, with the possible outcome being a situation in which the town is forced into a position in which a much less effective and more costly plan must be accepted. It is suggested that the CWMP explain the inherent problems with Plan 1 in more detail.

The location of the Tri-Town site with respect to Phase 1 of the Orleans plan, as well as its proximity to potential future connections from Brewster and Eastham, make it a very attractive site as well.

5. Environmental Assessment

Overall, the environmental assessment and answers to the MEPA comments is complete and responsive and adequately addresses the key environmental issues. The following comments are made:

5.1 On MEPA Comment 1005, it does not appear that the town has yet responded to the request that the CWMP consider effluent concentrations of 5 ppm for cluster systems. [It is assumed that they mean "…effluent removal rates to 5 ppm", not "…effluent removal rates of 5 ppm"]. The use of 5 ppm is probably overly optimistic, but could be considered as part of a sensitivity analyses for a range of potentially reliable effluent concentrations. Also, consideration of cluster systems for Bakers and Cedar Ponds and sewering of the Cedar Pond watershed appears to be unanswered at present.

5.2 Could a pilot program of permeable reactive barriers in one or more subwatersheds be a less expensive, short term alternative than cluster systems for expediting nitrogen reduction in the period that the sewer system and wastewater plant are being constructed?

6. Public Involvement

The public consultation program supporting the development of the plan was comprehensive, transparent, well documented and effective in developing not only public consensus in support of the plan, but also in developing the plan itself. Regular meeting of the Wastewater Management Steering Committee (WMSC) were open to the public and televised. The development and presentation to the public of the interim reports provided a productive venue for gleaning preferences, concerns and ideas from residents of the town. The televising of progress reports to the Board of Selectmen, weekly workshops in neighborhoods and the availability of the members of the WMSC to meet with and listen to the public at any time resulted, in the opinion of this reviewer, in more understanding and involvement of the public in the Orleans CWMP process than any other planning process in recent experience. A key element of the process was the availability and technical expertise and knowledge of the consultant during the process.

It is important, in the opinion of the reviewer, that this public awareness and involvement be maintained and continued during the period of state review of the plan and during other interim activities during which public involvement may tend to wane. Item 7.6 addresses this point also.

7. CWMP Recommended Plan

The plan adopted in the CWMP takes advantage of existing wastewater plant site, substantial saving relative to other plans, adaptive approach that allows adjustment of the plan within Orleans, as well as continued development of regional options, phasing that places priority on early nitrogen reduction benefits and most critical areas of town needing service. Several comments are offered:

7.1 A cost allowance for the potential need to add phosphorus removal systems or additional sewers up-gradient of freshwater ponds that have not yet been evaluated should be considered.

7.2 Integration of non-structural elements of the plan in the operating budgets and timelines of the implementation plan could be more robust. Specific goals for nitrogen reduction should be set that could either lower costs for Phases 2-6, eliminate one or more of those phases or, at least, provide a factor of safety against future modifications of the TMDL load reductions, less-than-optimal nitrogen reduction experience in other parts of the plan or other uncertainties. *[For example, according to the HW Fertilizer management study, the MEP model does not include municipal or commercial nitrogen loads. While this may be a small increment, the accumulation of several factors such as this may require higher percent N reductions in the future.]*

7.3 A preliminary review of the operations and maintenance cost estimates for the Core Program (Table 11-6) indicate that the costs are high compared to experience with contract operations in other towns in New England. However, this may reasonable considering that in most wastewater programs operations and maintenance budgets are established under conditions in which a fully operating wastewater management department incorporating sewer and plant maintenance equipment, vehicles, administrative infrastructure (hardware, software, etc.), spare parts inventory and a host of other management requirements already exist. This is obviously not the case in Orleans.

The cost for initial establishment of such capability will be significant. It can be considered as a fixed, up-front capital cost or as an operating cost, the latter-under the assumption that the wastewater system, when put in service, will be operated under contract to a private entity. In this case, it appears that the cost may be carried as a premium in the O&M budgets. In any case, it may be beneficial to add a brief discussion of this factor in the CWMP.

7.4 Regarding the overall cost of the project, the estimate of approximately $2,600 per year (2008 dollars) for the typical residential customer is very high compared to other towns in the state. For example, the annual costs in Massachusetts municipalities for wastewater services, as reported in the Tighe & Bond 2009 Massachusetts Sewer Rate Survey, ranged from $170 (Town of Dalton) to $1,632 (Town of Ashburnham). The total annual cost of wastewater services in communities served by the MWRA ranged from $304 to $1,062, with an average of $737 per year.

The high cost of the Orleans plan is due, of course, to the fact that the sewer systems of many other cities and towns were built between 30 and 100 years ago. Wastewater treatment plants of many communities were built or upgraded over 30 years ago, many with 85% grant funding under the construction grants program of the Clean Water Act. Regardless of the reason, the impact to Orleans residents and businesses will be substantial. The project Orleans is now considering must be viewed as an investment in future generations, as were those projects completed by other towns decades ago.

The high annual cost estimated at this stage of planning needs to be mitigated through a variety of initiatives, including:

- Fair allocation of the Orleans costs across the full range of businesses and residents who contribute nitrogen to the groundwater systems and who will benefit from protection and restoration of Orleans' water resources.

- Aggressive efforts to obtain state and federal grant and loan funding to offset capital costs.

- Working with state and county entities to identify new and reasonable use-based revenue sources to supplement local rates and taxes.

- Working diligently with Eastham and Brewster to resolve issues related to a regional approach to wastewater management both with respect to capital investment and on-going O&M costs. (See below)

- Monitoring and promoting innovative technologies and watershed management tools to maximize cost-effective non-structural elements of the plan.

7.5 With regard to regionalization options going forward, the *Wastewater Regionalization Study: Orleans – Brewster – Eastham* outlines potential options for joint arrangements between the three towns, some of the key issues related to capital and operating cost sharing, a preliminary estimate of potential savings due to various regional options and potential cost allocation formulas. The report identifies a number of the major issues that must be resolved by the three towns. Given the advanced stage of planning of Orleans in comparison to Brewster and Eastham, Orleans' plan to proceed with Phase 1 of its Core Plan is prudent. The phasing strategy outlined in the plan, along with the adaptive approach to management of future phases, provides a good context for further regionalization planning.

It is suggested that more emphasis be given to the cost savings of regionalization (both identifiable and unknown costs at this time) with respect to management and administrative costs associated with setting up and operating a new wastewater department "from scratch" in three separate towns (above and beyond traditional operating and maintenance budgets). Given the total population, limited areal extent of the towns and relative simplicity of the planned wastewater infrastructure, a single management entity would be most reasonable and save the considerable fixed costs of operating multiple wastewater departments.

7.6 The reviewer strongly agrees with the recommendations in Section 11.6 of the CWMP related to an annual report to DEP regarding the status of CWMP implementation. All of the items included in the list are important. Additional items to consider could include an update on regionalization plans and issues and an update on the status and results of pilot projects for innovative technologies. The town should consider means to maintain the involvement of key public constituencies as the implementation of the project goes forward.

7.7 In summary, while some of the above comments and recommendations, along with the comments of MEPA and others, may alter some aspects of the plan, particularly in its latter phases, it is the conclusion of the reviewer that the substantive recommendations and main elements of Phase 1 of the plan are sound, based on good engineering and scientific bases and should be implemented expeditiously. The plan provides a clear and necessary direction with cost-effective Phase I components and a series of latter phases that are reasonable, but adaptable as additional progress is made on regionalization options and as more detailed engineering and cost studies are completed.

Acknowledgements

The assistance of Karen Sharpless, John Jannell and George Meservey of the Orleans Planning Department in making available the considerable information and correspondence related to the comprehensive wastewater planning program is thankfully acknowledged. This assistance was made possible in large measure because of the Department's efforts in maintaining the thorough, well organized and easily accessible electronic and hard-copy library of information over a period which covers much of the last decade.

Attachment A

Scope of Services
Engineering Review of Orleans CWMP

The following questions will be addressed by the Technical Consultant in the review of the Town of Orleans' Comprehensive Wastewater Management Plan, dated April 2009:

1. Needs Assessment - Did the Wastewater Management Needs Assessment adequately define existing and future conditions and identify all important requirements and issues?

2. Alternatives Evaluation - Did the CWMP identify, appropriately evaluate and screen a full range of structural and non-structural alternatives for satisfying wastewater needs?

3. Composite Management Plans - Were feasible wastewater management alternatives appropriately combined into composite plans that satisfy wastewater needs within the planning horizon? Were the development, evaluation and screening of management alternatives, the nine composite plans and the final three alternative composite plans based on adequate information properly used in a decision-making framework to reach reasonable conclusions?

4. Site Selection Process - Was the process of site selection based on adequate evaluation of alternatives; sufficient technical, economic and environmental information; and fair consideration of public input and priorities?

5. Environmental Assessment - Were the environmental impact assessments of the three final plans based on adequate information; did they appropriately identify, evaluate and address a complete range of alternatives to the project; and were conclusions reasonable and justified based on the analyses and public input?

6. Public Involvement - Was the public involvement program comprehensive, open and transparent, and was public input requested, received, fairly evaluated and appropriately incorporated into development of the recommended plan?

7. CWMP Recommended Plan - Is the final Recommended Plan based on an adequately robust decision-making process that properly integrated and weighed the results of the engineering, economic and environmental analyses completed and public input received during the planning process? Are cost estimates reasonable at both the individual project level and the overall plan level? Will implementation of the Recommended Plan meet the wastewater management needs of the town and satisfy regulatory and nitrogen reduction requirements within the planning period?

8. Recommendations – Based on review of the CWMP process and its conclusions, what recommendations are made by the Technical Consultant that could resolve deficiencies in

the plan, attain consensus on its recommendations, facilitate implementation or otherwise benefit the Town in meetings its wastewater management needs and environmental goals?

Town of Orleans CWMP Review

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17. Various Correspondence between Town of Orleans, Wright-Pierce and others, 2006-2009

18. 2009 Massachusetts Sewer Rate Survey, Tighe & Bond, 2009.

19. Annual Water and Sewer Retail Rate Survey, MWRA Advisory Board, December 2008.

APPENDIX N

EOEEA CERTIFICATE AND RESPONSE

APPENDIX N

EOEAA Secretary's Certificate, July 10, 2009

Letter Response to Comments, December 9, 2010

The Commonwealth of Massachusetts
Executive Office of Energy and Environmental Affairs
100 Cambridge Street, Suite 900
Boston, MA 02114

Deval L. Patrick
GOVERNOR

Timothy P. Murray
LIEUTENANT GOVERNOR

Ian A. Bowles
SECRETARY

Tel: (617) 626-1000
Fax: (617) 626-1181
http://www.mass.gov/envir

July 10, 2009

CERTIFICATE OF THE SECRETARY OF ENERGY AND ENVIRONMENTAL AFFAIRS
ON THE
EXPANDED ENVIRONMENTAL NOTIFICATION FORM

PROJECT NAME	: Town of Orleans Comprehensive Wastewater Management Plan
PROJECT MUNICIPALITY	: Town of Orleans
PROJECT WATERSHED	: Cape and Islands
EOEA NUMBER	: 14414
PROJECT PROPONENT	: Town of Orleans
DATE NOTICED IN MONITOR	: May 6, 2009

Pursuant to the Massachusetts Environmental Policy Act (G. L. c. 30, ss. 61-62I) and Section 11.03 of the MEPA regulations (301 CMR 11.00), I hereby determine that this project **requires** the preparation of an Environmental Impact Report (EIR).

In accordance with Section 11.05(7) of the MEPA regulations, the Town of Orleans (the Town) has submitted an Expanded Environmental Notification Form (EENF) with a request that I allow the Proponent to fulfill its EIR obligations under MEPA with a Single EIR (SEIR), rather than the usual process of a Draft and Final EIR. The EENF received an extended comment period pursuant to Section 11.06(8) of the MEPA regulations and the Town voluntarily extended the comment period an additional four weeks. The EENF includes clear descriptions of the project, a description of the extensive planning and alternatives analysis conducted to date, identifies potential environmental impacts associated with the project and provides commitments to mitigate impacts. Comments received from the Department of Environmental Protection (MassDEP), the Cape Cod Commission (CCC) and others indicate overwhelming support for the analysis and conclusions included in the EENF and that it is consistent with legal requirements. Based on a review of the EENF and after consultation with state agencies, I hereby find that the EENF meets the regulatory requirements and I am permitting the Proponent to file a SEIR in fulfillment of Section 11.03 of the MEPA regulations.

The Scope described below is intended to identify additional analysis and information necessary to complete MEPA review and ensure that impacts and issues are fully analyzed.

Project Overview

The Town of Orleans' comprehensive wastewater management process has been undertaken for the purposes of:

1) Evaluating and planning for the impacts to the Town's marine and freshwater water resources from anticipated future residential and commercial growth and development in the Town of Orleans over the 20-year project planning period (ending in 2030);

2) Evaluating and quantifying the Town of Orleans' existing and future contributions to nitrogen loading of coastal embayments and phosphorous loading of freshwater ponds from the Town's on-site septic systems over the 20-year project planning period;

3) Evaluating the feasibility of centralized and de-centralized municipal sewer options to meet the estimated 2030 nitrogen control needs and Total Maximum Daily Loads (TMDLs) established for the marine embayments surrounding Orleans;

4) Evaluating alternative methods for the disposal of treated wastewater including on-site and off-site groundwater disposal using rapid infiltration basins and wastewater reuse for landscape spray irrigation, with the intent of reducing groundwater discharges from the proposed Orleans Wastewater Treatment Facility (WWTF);

5) Evaluating the feasibility of non-structural and non-traditional nutrient management techniques to further reduce nutrient loading to the marine embayments surrounding Orleans; and,

6) Reviewing the long-term effectiveness of regional wastewater treatment and disposal options involving the Towns of Orleans, Eastham and Brewster.

The Town's draft comprehensive wastewater management plan (Draft CWMP) has been designed to achieve reductions of nitrogen loading and meet nutrient Total Maximum Daily Loads (TMDLs) to the Town of Orleans' coastal embayments including Pleasant Bay, Nauset Marsh/Town Cove, Cape Cod Bay, and to achieve reductions of phosphorous loading to protect the water quality associated with a number of fresh water ponds located in Orleans over the 20-year project implementation period.

I note that the Inner Cape Cod Bay and Pleasant Bay have been designated as Areas of Critical Environmental Concern (ACECs) and Outstanding Resource Waters (ORW) under the Massachusetts Surface Water Quality Standards (314 CMR 4.00). Extensive areas of Priority and Estimated Habitat of rare wildlife have been mapped by the Natural Heritage and Endangered Species Program ("NHESP") within each of these ACECs.

The Town's core sewer construction plan (Core Program) involves the six phase construction of new sewers including a new wastewater treatment facility (Orleans WWTF) to be located at the existing Tri-Town Septage Treatment facility located near the intersection of Route 6 and Route 6A at 29 Overland Way in Orleans. The Core Program includes the construction of approximately 74 miles of new municipal sewer pipe, and approximately 63 sewer pump stations. Under the Core Program, 0.64 million gallons per day (MGD) of wastewater flow will be collected from 2,800 individual properties (approximately 53% percent of the Town) in the 2030 design year for treatment and on-site disposal. As currently designed, the Draft CWMP incorporates reserved treatment capacity to accommodate the projected future 2030 build-out of Orleans including reserving approximately 17,000 gallons per day (gpd) of capacity at the Orleans WWTF for anticipated future development in the Town's downtown Central District. Construction of Phase 1 of the Core Program is expected to be completed in 2015 and will include the construction of the new Orleans WWTF (to operate at 50% design capacity) and approximately 15 miles of new sewers and 7 pump stations located primarily throughout the downtown area of Orleans. Phase 2 will include the construction of approximately 11 miles of additional gravity sewers and five separate cluster wastewater treatment systems each with a design capacity of 10,000 gpd to be located at the headwaters of the Paw Wah, Lonnie's, Arey's, Baker's and Mill Ponds. As described in the EENF, these cluster systems will provide interim nitrogen and phosphorous removal in advance of the construction of the later Core Program sewer phases. The Town proposes to eventually convert and incorporate these cluster wastewater treatment systems to serve as pump stations for the Core Program municipal sewer system. The Phase 2 sewer construction work is expected to be completed in 2018. Construction of the remaining Core Program phases (Phases 3-6) is anticipated to be completed by 2030.

The Orleans WWTF will include a new septage receiving station to replace the existing Tri-Town Septage Treatment Facility and will be designed to receive, treat and dispose septage truck-transported from non-sewered areas in Orleans together with septage from the other Tri-Town District communities of Brewster and Eastham. The remaining sludge materials resulting from the Orleans WWTF's treatment of wastewater and septage will be dewatered and trucked off-site for suitable reuse and disposal. The Draft CWMP also incorporates a number of non-structural elements designed to reduce nutrient loading including proposed programs for controlling the use of fertilizer products on lawns, gardens and agricultural areas, stormwater management and water conservation.

The Town's Draft CWMP has been designed to also accommodate potential additional future wastewater flows from the remaining unsewered areas of Orleans (Extended Program) and/or the neighboring towns of Eastham and Brewster (Regional Program). However, as described in the EENF, additional wastewater disposal sites or reuse options may be required to support these potential future sewer expansion programs. The Orleans Draft CWMP also incorporates an Adaptive Management Plan (AMP) that outlines a process for reporting the results of the Town's ongoing annual groundwater quality and marine habitat monitoring program to identify the need for any adjustments or mid-course corrections to the phased construction of the Core Program to achieve compliance with TMDLs for the coastal embayments surrounding Orleans.

State Permits and Jurisdiction

The project is undergoing review pursuant to Sections 11.03(5)(a)(3) and (5)(b)(1) of the MEPA regulations, because the project will likely involve the construction of sewer mains ten or more miles in length and the development of a new wastewater treatment facility with a capacity of more than 1,000,000 gallons per day. The project will require a Groundwater Discharge Permit, a Chapter 91 License, and a 401 Water Quality Certificate from MassDEP. The project must be reviewed by the Natural Heritage Endangered Species Program (NHESP) and the Massachusetts Historical Commission (MHC) because portions of the project occur within Priority Habitat and within or adjacent to recorded archaeological sites and archaeologically sensitive areas, respectively. It may require Federal Consistency Review with the Massachusetts Coastal Zone Management (MCZM) Office. It may also require a Construction Access Permit from the Massachusetts Highway Department. The project may need to obtain a Section 404 Permit from the U.S. Army Corps of Engineers. The project should comply with the National Pollutant Discharge Elimination System (NPDES) General Permit for stormwater discharges from a construction site. It will also require an Order of Conditions from the Orleans Conservation Commission and on appeal only, a Superseding Order of Conditions from MassDEP.

The Town anticipates applying for State Revolving Fund (SRF) loans for subsequent planning and construction of proposed sewer project. Therefore, MEPA jurisdiction is broad and extends to all aspects of the project that may cause Damage to the Environment, as defined in the MEPA regulations.

SCOPE

The Town should prepare the SEIR/Final CWMP in accordance with Section 11.07 of the MEPA regulations as modified by this Certificate. The SEIR should include a copy of this Certificate. The SEIR should also contain copies of the comments received. The Town should circulate the SEIR to those who commented on the EENF, and to any party required by regulation.

Project Description

The SEIR should include a detailed executive summary explaining what is being proposed under the Town's Core Program and potential future Expanded Program and Regional Program and why. It should identify significant environmental benefits and impacts, and measures that will be taken to avoid, minimize and mitigate adverse impacts. The SEIR should describe the proposed schedule for the remaining phases of project planning, design, environmental permitting and review, and construction. Detailed information should be provided for each area where construction of new sewers or cluster systems are proposed, including maps that show where sewer lines, cross-country easements, pumping stations, and other facilities will be located. The SEIR should provide the best information currently available for the six sewer construction phases proposed under the Core Program, and explain what additional information is proposed for later collection and analysis. The SEIR should discuss the state permitting process for this project and describe how it will meet applicable performance standards.

Needs Analysis

A Needs Analysis was conducted to determine the nutrient loads generated by existing and future development and their respective septic systems in the Town of Orleans and the types of wastewater treatment and disposal alternatives that would be required to meet published and expected TMDLs for the coastal embayments and freshwater ponds in Orleans. In developing the Draft CWMP, the Town reviewed the total number of parcels located within each of the three watersheds for the marine embayments surrounding Orleans and freshwater pond watersheds, and estimated the water use, wastewater flows and nutrient loading to be generated in the 2030 project design year. Existing and future development parcels were evaluated to determine the need for sewer to address the water quality requirements and TMDLs of the Town's marine and freshwater water resources. Both MassDEP and I generally concur with the findings of the Needs Analysis.

Alternatives Analysis

The EENF includes an evaluation of decentralized, community, and regional wastewater treatment and disposal alternatives to address the Town's identified wastewater treatment needs. The Town's Draft CWMP describes a Core Program of sewering that involves the phased construction of a centralized wastewater collection, treatment and disposal system to serve approximately 53% of the Town's existing developed properties.

The SEIR should include a detailed description of the Town's preferred site layout for the proposed Orleans WWTF that would maximize the reuse of the existing septage facility infrastructure and avoid fragmentation of undisturbed areas within the site and a 'take' of the Eastern Box Turtle. The SEIR should consider incorporating the sewering of the Cedar Pond watershed area as part of the Town's Phase 1 Core Program construction activities.
The SEIR should include a discussion of additional wastewater disposal or reuse alternatives that may be required to support the Extended or Regional Programs.

Wastewater Treatment and Water Quality

Orleans Wastewater Treatment Facility

As described in the EENF, the Town conducted a review of hydrogeological studies, hydraulic load testing and other groundwater modeling analyses pertaining to the 26-acre existing Tri-Town District Septage Treatment Facility site (Tri-Town site). The Tri-Town site is located within the Namskaket Marsh embayment that has been found to have excess capacity to accept additional nitrogen loading. According to the information provided in the EENF, the majority of the treated wastewater recharged at the Tri-Town site will mix with groundwater and recharge Namskaket Marsh. The Town has concluded that the on-site disposal and groundwater recharge of treated effluent from the Orleans WWTF will not impact local groundwater and surface water resources including existing water table mound height and nutrient loading to the Namskaket Marsh embayment. As currently designed, the Orleans WWTF will employ a 4-stage Bardenpho nitrogen removal process that will provide treatment levels capable of achieving nitrogen effluent concentrations of 3-5 parts per million (ppm) with a designed capacity to treat and dispose up to 0.64 MGD. The Draft CWMP includes a commitment to monitor groundwater resources around the periphery and down gradient of the Orleans WWTF site to identify the impacts on groundwater resources and embayments surrounding the Town of Orleans. This monitoring program is expected to be incorporated into a MassDEP groundwater discharge permit for the Orleans WWTF.

The SEIR should provide a detailed description of the Town's proposed groundwater quality monitoring plan for the Tri-Town site. The SEIR should evaluate the Tri-Town site's capacity to treat the additional estimated wastewater flows to be generated under the potential future Expanded and the Regional wastewater treatment alternatives.

Marine Embayments

The Town has continued to participate in the Massachusetts Estuaries Project (MEP) to conduct water quality sampling and identify nutrient loading problems for the Town's coastal embayments. MEP was created by MassDEP, and the University of Massachusetts School of marine Science and Technology (UMass SMAST) to define the nitrogen limits of coastal estuaries in southeastern Massachusetts. The Technical Reports produced by the MEP are used by MassDEP and the US Environmental Protection Agency (EPA) to establish Total Maximum Daily Loads (TMDLs) for nitrogen loading to these coastal emabyments and their tributaries. According to the comments received from MassDEP, CCC and others, the estimated nitrogen loading reductions resulting from the Town's proposed phased Core Program for municipal sewer construction are consistent with published or expected TMDLs for the watersheds and embayments surrounding the Town of Orleans.

The SEIR should incorporate the findings of the MEP Technical Reports and/or TMDLs established for the Northside Cape Cod Bay and the Nauset Marsh/Town Cove embayments. The Town should use the Linked Water Quality Model to confirm the Core Program's ability to provide the necessary reductions in nitrogen loading to embayments surrounding the Town of Orleans in compliance with published or expected TMDLs. The SEIR should evaluate the benefit of expanding the Phase 1 sewer construction area to include properties located in the Cedar Pond watershed.

Freshwater Ponds

The Draft CWMP/EENF includes an evaluation of the impacts of phosphorous groundwater loading from residential land use on the water quality of large freshwater ponds and lakes located in Orleans. Using water quality monitoring results collected as part of the Cape Cod Ponds and Lakes Stewardship (PALS), the Town has identified the need to sewer properties located around Bolands, Baker, Ice House, Shoal and Cedar Ponds, and Crystal and Pilgram Lake. As described elsewhere in this Certificate, Phase 2 of the Town's Core sewering program includes the construction of five separate cluster wastewater treatment systems that will each serve 40-50 existing developed properties located in areas upgradient of a number of impaired freshwater ponds in Orleans including the Paw Wah, Lonnie's, Arey's, Baker's and Mill Ponds.

According to the Town, the construction and operation of these cluster systems in advance of later phases of the proposed municipal sewer system will significantly reduce phosphorous to groundwater and phosphorous loading to these ponds.

The SEIR should provide a detailed discussion of the proposed cluster wastewater treatment systems including proposed sites for locating cluster wastewater treatment systems locations, areas to be served, system design capacity and treatment efficiency. This section of the SEIR should include an analysis of the benefits of cluster systems to provide nitrogen removal from the Pleasant Bay tributaries. The Town should consider cluster treatment systems with treatment efficiencies and nitrogen removal rates of 5 parts per million (ppm). The Town should also re-evaluate the merit of the proposed cluster wastewater treatment systems for Bakers Pond and Cedar Pond and consider incorporating the sewering of the Cedar Pond watershed area as part of the Town's Phase 1 Core Program construction activities.

Adaptive Management Plan

The Draft CWMP includes an Adaptive Management Plan (AMP) that will report to MassDEP the results of the Town's annual ground water monitoring of the Tri-Town site and monitoring of water quality and eel grass coverage in Orleans' coastal embayments to document the reductions in watershed nitrogen loads achieved from the Town's phased sewer construction program. The AMP will assist the Town to evaluate the Town's compliance with established TDMLs and identify the need for adjustments or mid-course corrections to subsequent phases of the structural and non-structural components of the Core Program.

The SEIR should provide a detailed description of the Town's proposed AMP and its water quality monitoring program for the Tri-Town site and the coastal embayments surrounding the Town of Orleans. I encourage the Town to consult with the Pleasant Bay Resource Management Alliance in designing the Town's water quality monitoring program. The SEIR should also include a discussion of the Town's commitment to continue its freshwater pond assessment and restoration activities. I ask that the Town expand the distribution of its annual water quality monitoring report to also include the CCC and the Pleasant Bay Resource Management Alliance.

Wetlands

The SEIR should delineate on a plan of reasonable scale all environmental resources areas located within areas proposed for sewering including; wetlands, water bodies, drinking water supplies, sensitive habitats, fisheries, designated Areas of Critical Environmental Concern (ACEC), Article 97 lands, historic resources, and agricultural lands.

The SEIR should analyze both direct and indirect impacts on wetlands and water bodies resulting from the project, and quantify the amount of direct wetland impact. The analysis should also discuss the consistency of any proposed drainage and stormwater management systems that are included in the project with the MassDEP Stormwater Management regulations and the Wetlands Protection Act performance standards. Proposed activities, including construction mitigation, erosion and sedimentation control, phased construction, and drainage discharges or overland flow into wetland areas, should be evaluated.

The SEIR should identify all parcels that are currently deemed unbuildable within the 100-year flood plain that would potentially become buildable as a result of a sewer installation. The SEIR should provide detailed plans, at a suitable scale, illustrating the proposed project's impacts to wetland resource areas. The SEIR should examine alternatives that avoid impacts to wetland resource areas, their associated buffer zones, riverfront protection areas and 100-year flood plain areas. Where it has been demonstrated that impacts are unavoidable, the SEIR should demonstrate that the impacts have been minimized, and that the project will be accomplished in a manner that is consistent with the Performance Standards of the Wetlands Regulations (310 CMR 10.00). The Town will need to provide wetlands replication at a ratio of at least 1:1 for any unavoidable impacts to wetlands. For any amount of required wetlands replication, a detailed wetlands replication plan should be provided in the SEIR that, at a minimum, includes: replication location(s), elevations, typical cross sections, groundwater elevations, the hydrology of areas to be altered and replicated, list of wetlands plant species of areas to be altered and the proposed wetland replication species, planned construction sequence, and a discussion of the required performance standards and monitoring.

Rare Species

As described in the EENF, the existing Tri-Town Septage Treatment Facility site is located within Priority Habitat for the Eastern Box Turtle (*Terrapene carolina*), the Diamond-backed Terrapin (*Malaclemys terrapin*), Salt Reedgrass (*Spartina cynosuroides*) and Mitchell's Sedge (*Carex mitchelliana*). The EENF includes an evaluation of four alternative site layouts (Alternatives A-D) for the new WWTF facility. According to NHESP's comments on the EENF, the construction of the Orleans WWTF will occur within mapped habitat for the Eastern Box Turtle (Terrapene carolina). NHESP has recommended that the Town identify a site layout alternative that will maximize the reuse of existing disturbed areas and avoid fragmentation of undisturbed areas within the proposed Orleans WWTF site to avoid a 'take' of the Eastern Box Turtle, and I have included this requirement in the Scope for an alternatives analysis provided above.

The SEIR should include a detailed description of the Town's preferred site layout alternative for the Orleans WWTF. If NHESP should subsequently find that the project will require a Conservation Permit pursuant to the Massachusetts Endangered Species Act (MESA), the SEIR should analyze the impacts to Eastern Box Turtle and evaluate avoidance/mitigation strategies. I ask that the Town continue to work closely with NHESP and consult with the Orleans Conservation Commission during the preparation of this section of the SEIR and the final project design to identify necessary project construction and post-construction conditions and commitments to avoid an adverse impact to resource area habitats of state-listed species located within and adjacent to the Orleans WWTF site. The SEIR should report on the results of the Town's consultations with NHESP.

Historical/Archeological Resources

The Town should provide the MHC with a US Geological Survey topographical map that locates the Town's phased project area and scaled project plans showing existing and proposed conditions. These plans should be submitted to MHC as early as possible during the design phase corresponding to each of the proposed project development phases. In comments submitted on the EENF, the Massachusetts Historical Commission (MHC) indicated that a number of proposed pump stations are located within and/or adjacent to recorded archeological sites and archaeologically sensitive areas. The Town to coordinate with MHC to ensure review of any potential historic impacts from the project and the SEIR should provide an update on the status of these discussions. If MHC deems the project to have an "adverse effect" on historic or archaeological resources, the SEIR should include a discussion of mitigation measures that the Town will undertake to address the adverse effect.

Greenhouse Gas Emissions (GHG) and Sustainable Development

The project requires an EIR and therefore is subject to the requirements of the MEPA Greenhouse Gas Emissions Policy and Protocol ("the Policy"): http://www.mass.gov/envir/mepa/downloads/GHGPolicyRev1108.pdf . The policy requires project proponents to quantify the direct and indirect CO_2 emissions from the proposed project, including CO_2 emissions associated with the buildings & plant operations, and to compare those emissions to the project baseline, which includes no-build conditions as well as an assessment of the emissions associated with the current effective building code ("base case"). In connection with this requirement, the MEPA Office and the Department of Energy Resources (DOER) routinely schedule pre-filing meetings to provide technical assistance to proponents in the development of GHG analyses. I strongly encourage the Town to request a pre-filing meeting as it prepares the SEIR.

The policy requires proponents to use energy modeling software to quantify projected energy usage from stationary sources and energy consumption. The policy allows the proponent to select a model but, DEP and DOER recommend using EQUEST for stationary source modeling for buildings and building systems.

The SEIR should include the modeling printout for the base case and for the preferred alternative case. The SEIR should also present an evaluation of the feasibility of each of the mitigation measures outlined below, as well as the GHG emissions reduction potential associated with each measure. The SEIR should explain, in reasonable detail, any measure not selected- either because it is not applicable to the project or is considered technically or financially infeasible- that would result in a significant reduction of GHG.

Building Design

DOER has identified several building design measures worthy of consideration in the SEIR, and adoption into the project, where feasible.

- Building Orientation- The SEIR needs to clearly describe how the buildings will be oriented, why, and the expected impacts on energy usage including solar gain, day-lighting and effect on proposed and future solar energy collection systems;

- Duct Insulation- Duct insulation is the baseline required by code. To enhance efficiency, the SEIR should note, and construction should reflect, that all ducts will be sealed with mastic, tested and then insulated, since duct leakage can be a major factor in energy losses;

- Roof and Wall Insulation- The SEIR should evaluate using the highest R-value insulation possible. In general, providing the best building envelope possible provides the greatest gains in energy savings for building operations and insulation is generally very cost effective;

- High-Albedo Roofing Materials – The SEIR should fully consider these roofing materials, which are highly reflective and reduce cooling requirements for buildings. For roofing, USGBC provides LEED credit for low-slope roofs with a minimum SRI of 78 and for steep-slope roofs with a minimum SRI of 29. To qualify for an Energy Star label, Low Slope roofs must have an initial solar reflectance of at least 0.65. After 3 years, the solar reflectance must be at least 0.50. Steep Slope roofs must have an initial solar reflectance of at least 0.25, and at least 0.15 after 3 years. In addition, the performance of solar PV systems is improved when mounted on high albedo roofs; and,

- On-site renewable energy – At a minimum, buildings should be oriented and roofs should be constructed to support the added weight of a solar photovoltaic (PV) system for potential installation during project construction or at a future date. It should be noted that a rooftop PV system operates even more efficiently, due to added reflectivity, when installed on a high-albedo roof.

  Considering the support of subsidies through the Commonwealth Solar and RPS programs, the SEIR should include a life-cycle cost analysis should be done to evaluate the installation of a PV system during project construction under two scenarios: 1) construction, ownership and operation of a PV system by the building owner; or 2) construction, ownership, and operation of a PV system by a third party that will then enter into a long-term power purchase agreement with the building owner for the electricity produced by the system. If neither of these scenarios is economically feasible at this time, the Town should continue to consider the opportunity for installing PV at a future date and state its willingness to host a third-party owned PV array under a favorable power purchase agreement. The following website provides information on the Commonwealth Solar program and tools for performing basic life cycle cost analyses: http://www.masstech.org/renewableenergy/commonwealth_solar/index.html#

Equipment Design

The Town should explore and present modeling results in this section of the SEIR related to the use of renewable and energy efficient equipment listed below when designing new or upgraded wastewater treatment facilities, pump stations and other components of the Town's comprehensive wastewater management system.

- The SEIR should specify premium class rated motors for any new or replacement pumps, fans, or other drives larger than 1 horsepower (HP), as well as any scheduled to be upgraded;

- The SEIR should specify the use of high efficiency models for new and replacement pumps, blowers, agitators, or other rotating equipment;

- The SEIR should consider Variable Frequency Drives (VFDs) for all motors larger than ten HP;

- The SEIR should include an analysis to determine the combination of pumps (both size and type), controls and piping which will result in a system configuration which will operate at the highest average efficiency;

- The SEIR should fully consider the inclusion of renewable energy systems, such as photovoltaic panels, which could be ground mounted, to reduce the indirect CO_2 emissions due to the fossil fuel generated electricity which would otherwise be used;

- The SEIR should evaluate sizing, routing, and material selection for the extension of pumped sewer lines which will result in reducing the average pumping power required for the transfer of the sewer flow;

- The SEIR should include a detailed discussion of the design principles and measures which will result in reduced indirect GHG emissions that will be implemented should any of the satellite stations be constructed; and,

- The SEIR should include a description of the maintenance and replacement policies, activities and schedules related to equipment included in existing system pumping stations which will eventually bring them to a comparable standard of efficiency.

I note that MassDEP, in coordination with other state and local agencies has initiated a demonstration project to retrofit existing wastewater treatment plants and water treatment plants with energy efficient technology, **http://www.mass.gov/dep/water/wastewater/empilot.htm.** The costs of some of these improvements are eligible for funding through the SRF and other programs. I encourage the Town to consult with MassDEP regarding this demonstration project as it prepares the analysis required under this section.

Construction Impacts

Construction period impacts and mitigation measures should be described in the SEIR, including impacts from noise and dust, impacts on trees and other vegetation, and traffic impacts. Measures that will be taken to minimize and mitigate construction period impacts (in particular impacts on sensitive receptors or exceptional resources) should be detailed.

Sewering and Growth Management

The EENF/Draft CWMP includes a discussion of potential land use control mechanisms to limit unwanted secondary growth related to the construction of the Town's Core sewering project. The Town is proposing to implement a "checkerboard" sewer connection bylaw that will enable the Town to select specific lots that will be connected to the municipal sewer system and lots that do not need sewering and therefore will not be allowed to connect to the new sewer system. The Town is also proposing to implement a 'flow-neutral' nutrient control regulation, to be administered through the Orleans Board of Health, which would limit the redevelopment of existing properties by restricting the amount of additional wastewater flow/nitrogen load from the redeveloped property to the amount of wastewater flow the property is currently allowed under Title 5 and local zoning.

The SEIR should identify parcels located within the proposed sewer service areas and compare the potential secondary growth impacts, water use and increased wastewater flows that may be induced by public sewers and expected reductions of water use and wastewater flows with the Town's proposed growth management policies, regulations and bylaws. The SEIR should include copies of any new by-laws or regulations proposed by the Town for controlling new future development requesting municipal sewer service and located in areas outside of the proposed new sewer areas. The Town should consider adopting and implementing any proposed growth by-laws, regulations, and policies prior to the construction of any new sewers.

Costs to Homeowners

As described in the EENF/Draft CWMP, the Core Program will be constructed in six phases over 15-20 years and will cost an estimated $150,000,000. The estimated operation and maintenance costs for the proposed Core Program total approximately $1.4 million dollars. The Town proposes to recover 80% of the project debt service through user and non-user property taxation and 20% through betterment assessments to be paid by users of the sewer system. The EENF provides estimates for the average (capital and O&M) for households connected to the sewer system ($2,592.00) and households not connected to the sewer service area ($2,544.00).

The SEIR should include estimates for the costs of land acquisition associated with the proposed cluster treatment plants and corresponding groundwater disposal sites. The SEIR should document any assumptions concerning the probable cost of acquiring parcels for wastewater purposes. The Town should consult with MassDEP during the preparation of this section of the SEIR.

Future Sewer Expansion

The Town's Core Program has been designed to accommodate potential future expansion to serve the remaining unsewered areas of Orleans under the Expanded Program and/or additional wastewater flows from the neighboring towns of Eastham and Brewster under the Regional Program.

Expanded Program

The Expanded Program would provide town-wide sewers in Orleans and would cost an additional $95 million dollars. However, as described in the EENF and noted elsewhere in this Certificate, additional wastewater disposal sites or reuse options may be required to support the treatment and disposal of additional wastewater flows anticipated under the Expanded Program or the Regional Program described below. The SEIR should evaluate the Tri-Town site's capacity to treat the additional estimated wastewater flows to be generated under the Expanded and the Regional wastewater treatment alternatives.

Regional Program

I commend the Town for undertaking the Regional Economies of Scale study of potential regional approaches to address the wastewater treatment and disposal needs for the Towns of Orleans, Eastham and Brewster, and the regional issues pertaining to nutrient loading, wastewater treatment and disposal affecting the Nauset Marsh/Town Cove and Pleasant Bay coastal embayments. I ask the Town of Orleans, together with the Towns of Eastham to the north and Brewster to the south to work together with MassDEP, the Cape Cod Commission and others to continue the discussion of possible opportunities to integrate the Town of Orleans' wastewater treatment planning efforts with the planning efforts being undertaken by the Towns of Eastham and Brewster. In a separate section of the SEIR, the Town should include an update of the Regional Economies of Scale study to identify regional strategies for reducing the nutrient loading to coastal embayments and freshwater ponds in Orleans, Eastham and Brewster.

Public Participation

I note that the State's Revolving Fund (SRF) regulations require the proponent to conduct a minimum of one public meeting and one public hearing for this project. The SEIR should include a discussion of the Town's public participation program activities completed and proposed to date.

Mitigation/Section 61

The SEIR should include a separate chapter on mitigation measures. This chapter on mitigation should include Draft Section 61 Findings for all state agency actions. The Draft Section 61 Findings should contain a clear commitment to mitigation, an estimate of the individual costs of the proposed mitigation and the identification of the parties responsible for implementing the mitigation. A schedule for the implementation of mitigation should also be included. I ask the Town to continue to work closely with CCC, MassDEP, and the Pleasant Bay Resource Management Alliance to design and implement a sustainable Comprehensive Wastewater Facilities Plan and mitigation plan for the Town of Orleans that will help to offset the proposed project's municipal sewering impacts.

Comments

The SEIR/Final CWMP should respond to the comments received. I recommend that the Town use either an indexed response to comments format, or else direct narrative response. The SEIR should present any additional narrative or quantitative analysis necessary to respond fully to the comments received. This directive is not intended to, and shall not be construed to, enlarge the scope of the SEIR beyond what has been expressly identified in this Certificate.

Circulation

The Final SEIR/Final CWMP should be circulated in compliance with Section 11.16 of the MEPA regulations and copies should also be sent to the list of "comments received" below and to town officials from the Towns of Orleans, Eastham and Brewster. A copy of the SEIR should be made available for public review at the Orleans, Eastham and Brewster Public Libraries.

July 10, 2009
DATE

Ian A. Bowles, Secretary

Comments received: (continued on next page)

05/18/09 Massachusetts Historical Commission (MHC)

Comments received: (continued)

06/10/09 Cape Cod Commission (CCC)
05/21/09 Division of Marine Resources
06/08/09 Pleasant bay Resource Management Alliance
06/18/09 Town of Orleans
06/24/09 Natural Heritage & Endangered Species Program (NHESP)
06/29/09 Department of Conservation and Recreation (DCR)
06/30/09 MA Department of Environmental Protection (MassDEP) – SERO
07/01/09 Mary Hartley

EENF #14414
IAB/NCZ/ncz

December 9, 2010
W-P Proj. No. 10645H

Secretary Ian Bowles
Executive Office of Energy and Environmental Affairs
100 Cambridge Street, Suite 900
Boston, MA 02114

Subject: Orleans Comprehensive Wastewater Management Plan
MEPA File #: 14414
Response to Secretary Comments--EENF

Dear Secretary Bowles:

The Town of Orleans is submitting this Response to Comments as part of its commitment to fulfill its Environmental Impact Report (EIR) obligations under MEPA. The comments received in the review of the Expanded Environmental Notification Form are responded to herein.

Your EENF Certificate requires the Town to prepare an SEIR to include the Certificate and all EENF comments. These documents take the form of a final CWMP (Comprehensive Wastewater Management Plan) and will include materials in response to all comments documented herein.

The Environmental Monitor included a notice of this project on May 6, 2009 and set forth an extended comment period that opened on May 6, 2009 and closed on June 30, 2009. Your decision was issued on July 10, 2009.

COMMENTS AND RESPONSES RELATED TO THE SECRETARY:

Comment 1001:

A. A. The SEIR should include a detailed executive summary explaining what is being proposed under the Town's Core Program and potential Expanded Program, and Regional Program and why.

B. SEIR should identify significant environmental impacts, and measures that will be taken to avoid, minimize and mitigate adverse impacts. The SEIR should describe the proposed schedule, for the remaining phases of project planning, design, environmental permitting and review, and construction.

40 Shattuck Road, Suite 305
Andover, MA 01810 USA
Phone 978.416.8000 | Fax 978.470.3558

C. Detailed information should be provided for each area where construction of new sewers or cluster systems are proposed, including maps that show where sewer lines, cross-country easements, pumping stations, and other facilities will be located.

D. The SEIR should provide the best information currently available for the six sewer construction phases proposed under the Core Program, and explain what additional information is proposed for later collection and analysis.

E. The SEIR should discuss the state permitting process for this project and describe how it will meet applicable performance standards.

Response 1001:

A. See Executive Summary.
B. See Section 8 of the SEIR with respect to environmental impacts. The current project schedule is shown in Table 11-6.
C. See Response 1007 for mapping of the proposed areas of construction.
D. Section 11.9 of the SEIR describes the proposed 6-phase project (see Table 11-2). Section 11.6 presents the Adaptive Management Plan and describes the data that will be gathered during each project phase to help refine or redirect each subsequent phase (see Response 1006A).
E. The permitting process is summarized in Section 11.12.4 of the SEIR. Section 12 has been added to the SEIR to summarize the proposed mitigation measures as they relate to state permitting requirements.

Comment 1002:

A. The SEIR should include a detailed description of the Town's preferred site layout for the proposed Orleans WWTF that would maximize the reuse of the existing septage treatment facility infrastructure and avoid fragmentation of undisturbed areas within the site and a 'take' of the Eastern Box Turtle.

B. The SEIR should include a discussion of additional wastewater disposal or reuse alternatives that may be required to support the Extended or Regional Programs.

C. The SEIR should consider incorporating the sewering of the Cedar Pond watershed area as part of the Town's Phase 1 Core Program construction activities.

Response 1002:

A. The Town has selected a layout for the proposed WWTF which optimizes the use of currently disturbed area and should avoid a "take" of Eastern Box Turtle. The updated layout is shown in Figure 11-2. This layout concentrates the disturbance to accommodate the additional wastewater functions in the northeast corner of the site. This layout preserves a greater tract of undisturbed land to the south of the existing facility. In summary, the final layout keeps the newly disturbed area less than 5 acres and consolidates the undisturbed land to allow a better corridor for box turtles across the site.

B. The Core Plan has been fine-tuned to avoid a box turtle "take", as discussed above. Should the Town in the future choose to implement either the Extended Plan (full town sewering) or the Regional Plan (receipt of wastewater from Eastham and/or Brewster), then additional wastewater disposal area will be required. These future possibilities are not the subject of this MEPA review; however, some broad statements can be made at this time. Response 1003 addresses the capability of the Tri-Town site for disposal of the additional effluent that would result from the Extended and Regional Plans. The future decision to use the Tri-Town site for disposal of that effluent would result from a thorough evaluation of options, including disposal on the Tri-Town site, disposal at other possible sites nearby, and an effluent reuse program. Each option would have it own set of environmental issues that would be reviewed through the appropriate MEPA procedures. It is clear that further use of the Tri-Town site beyond the Core Plan would result in a "take" of the Eastern Box Turtle that would necessitate appropriate mitigation, and those issues would be at the forefront of that future evaluation of options. In this regard, the Town has other locations for wastewater disposal or reuse that are, at this time viable on a conceptual level. Locations for disposal include the athletic fields at the elementary and middle schools, and several publically-owned sites near the Route 6/Route 6A interchange. The concept for a reclaimed water pipeline (reuse of the effluent) is shown in Figure 10-1 and discussed in Section 10 of the SEIR/CWMP.

C. In the Core Plan, the watershed of Cedar Pond would be completely sewered through construction occurring in Phases 1, 4 and 6. The decision on the timing for the sewering of the Cedar Pond watershed has considered several factors. The Town intends that the phases of sewer construction will "fan out" from the treatment facility in a way that does not leave one major watershed significantly behind another in the rate at which TMDL compliance is achieved. Based primarily on the Town's geography, the trunk of the collection system is proposed to grow and branch to provide at least some nitrogen removal in all three major watersheds by the third phase. Due to the location of Cedar Pond, properties in that watershed could be sewered sooner, but at the detriment to TMDL compliance in another watershed. A step-wise approach to Cedar Pond is warranted, since studies are still underway to determine if it is to be considered a freshwater or brackish water body. If it is a brackish body, then the ultimate level of wastewater-nitrogen protection will be achieved (complete removal of septic nitrogen load) while also supporting the overall TMDL compliance of Rock Harbor. If the pond is managed as a fresh water body through water control structures, then the phosphorus associated with septic systems will also have been fully addressed upon completion of the Core Plan. In either case, at the end of the Core Plan, the entire Cedar Pond watershed will be sewered.

Comment 1003:

A. The SEIR should provide a detailed description of the Town's proposed groundwater quality monitoring plan for the Tri-Town site.

B. The SEIR should evaluate the Tri-Town site's capacity to treat the additional estimated wastewater flows to be generated under the potential future Expanded and Regional wastewater treatment alternatives.

Response 1003:

A. Additional detail on groundwater quality monitoring has been added to the SEIR/CWMP. This information is included as Section 11.7, as follows:

Section 11.7 Groundwater and Surface Water Monitoring Plan

One key element of this project is the proposed Groundwater and Surface Water Monitoring Plan. By careful and systematic monitoring, the Town can accomplish the following goals:

- Document compliance with permits;
- Establish or extend a database of environmental conditions from which to judge future actions;
- Document TMDL compliance;
- Watch for unexpected impacts;
- Continue the monitoring of the existing Tri-Town plume; and
- Establish a basis for adaptations in the plan.

Table 11-3 summarizes the elements of the proposed plan. It will involve monitoring at or near the treatment and disposal site, within sensitive coastal embayments and in selected freshwater ponds. It will include not only water quality parameters, but also the plants and animals that the project is intended to protect. It will be important that the results of this program be accurately and promptly reported, via the reporting mechanisms listed in Table 11-3 and discussed in Section 11. Coordination will occur with DEP, the Massachusetts Estuaries Project, the USGS (and its ongoing monitoring of Namskaket Marsh), embayment monitoring programs being conducted or coordinated by the Pleasant Bay Resource Management Alliance, and the pond monitoring program of the Orleans Ponds Coalition and the Orleans Marine and Fresh Water Quality Task Force. The program outlined in Table 11-3 will be expanded during the application for the Groundwater Discharge Permit for the wastewater treatment facility, and in the development of the annual TMDL compliance report discussed in Section 11. All of these activities will be coordinated with the Water Resources staff of the Cape Cod Commission, pursuant to an anticipated condition of the DRI review and approval.

B. The effluent disposal capacity at the Tri-Town site can be measured in several ways: the ability of the surficial soils to accept the effluent without ponding, the ability of the local groundwater to carry away the effluent without excessive mounding, etc. It is expected the surficial loading rate is the limiting factor. Based on extensive field investigations and most the most modern modeling simulations, the apparent surficial capacity is 1.78 mgd.

The following wording has been added to Section 11.11.4 (to compare the site's capacity with the effluent disposal needs of the Expanded and Regional Plans):

Table 11-5 shows how that apparent surficial capacity compares with the effluent quantities associated with various development scenarios. The Core Plan (all six phases) will require about 60% of the site's capacity. The Regional Plan, assuming both Eastham and Brewster participate, would require about 90% of the site capacity. If the Town chooses to sewer all of Orleans (the Extended Plan), then the Tri-Town site would not be adequate. The development of the Tri-Town site for additional effluent disposal capacity is a good example of adaptive management. The true capacity of the site will only be known when more of the site is investigated (some of the potential disposal beds are below 20 feet or more of overburden and cannot be tested by conventional means until Phase 1 is complete) and when full-scale application of effluent occurs. If the site is shown to have more capacity than is currently estimated, then it is possible that the Extended Plan can be accommodated. Conversely, the Core Plan may consume more of the site's capacity than is now estimated, making a second disposal site necessary for even the Regional Plan. The phased development of this project allows these uncertainties to be addressed in early project phases and allows modification in later phases accordingly.

As noted in Response 1002, development of the Tri-Town site beyond the Core Plan will likely result in a "take" of Eastern Box Turtle, and all viable alternatives must be considered at that time.

Comment 1004:

A. *The SEIR should incorporate the findings of the MEP Technical Reports and/or TMDLs established for the Northside Cape Cod Bay and the Nauset Marsh/Town Cove embayments. The Town should use the Linked Water Quality Model to confirm the Core Program's ability to provide the necessary reductions in nitrogen loading to embayments surrounding the Town of Orleans in compliance with published or expected TMDLs.*

B. *The SEIR should evaluate the benefit of expanding the Phase I sewer construction area to include properties located in the Cedar Pond watershed.*

Response 1004:

A. Response 1203 describes the rationale for completing the CWMP/SEIR prior to the issuance of the MEP Technical Report for the Nauset system. For those MEP Technical Reports available at the time of issuance of the CWMP/SEIR, the Town has incorporated the executive summary of each report (See CWMP Appendix G). Those reports include Pleasant Bay, Rock Harbor, Namskaket Creek and Little Namskaket Creek**.** The system of sewers in each project phase has been laid out to precisely match the septic nitrogen removal percentages contained in the pertinent MEP Technical Reports. For example, 65% septic nitrogen removal in the Pochet Neck sub-watershed will be accomplished by eliminating septic systems that represent 65% of the current septic nitrogen load in that sub-watershed. If confirmatory modeling were conducted, it would be merely a precise repetition of the model run that produced the MEP recommendation. Therefore the Town believes that the confirmatory modeling, in this circumstance, is unnecessary. If there are benefits to confirmatory modeling, even with this precise match, that the Town has not considered (such as modeling to track progress in water quality improvement), then the Town would of course reconsider its position. If confirmatory modeling is warranted, it would be most cost-effectively accomplished if it were conducted all at once, for all watersheds impacted by land uses in Orleans. Thus the Town views this as a future task, to be scheduled and budgeted for the design phase of the project. The funds will then be available to address any yet-to-be-determined benefits, and in case the septic removal percentage for the Nauset system is found to be measurably different than the current estimate.

B. In general, any impaired water body would benefit from the earliest sewering possible. The rationale to include only a portion of the Cedar Pond watershed in Phase 1, leaving the rest of the watershed sewering to Phases 4 and 6, is detailed in Response 1002.

Comment 1005:

The SEIR should provide a detailed discussion of the proposed cluster wastewater treatment systems including proposed sites for locating cluster wastewater treatment systems locations, areas to be served, system design capacity and treatment efficiency. This section of the SEIR should include an analysis of the benefits of cluster systems to provide nitrogen removal from the Pleasant Bay tributaries. The Town should consider cluster treatment systems with treatment efficiencies and nitrogen removal rates of 5 *parts per million (ppm). The Town should also re-evaluate the merit of the proposed cluster wastewater treatment systems for Bakers Pond and Cedar Pond and consider incorporating the sewering of the Cedar Pond watershed area as part of the Town's Phase 1 Core Program construction activities.*

Response 1005:
Consideration of the timeline for sewering Cedar Pond is included in Response 1002. For clarification, there is no cluster system proposed for Cedar Pond as part of the Recommended Plan.

Part of Phase 2 of the Core Plan involves the construction of five small wastewater treatment systems, called cluster systems. MEPA has made several comments related to these systems, some of which echo comments received by other agencies. Response 1005 addresses all such comments, and appropriate references to this response are located in other places in this letter. Greater detail on the topics of cluster location, technical description, service area, and degree of nitrogen removal can be found in Appendix I.

The Core Plan of public sewers is primarily aimed at controlling nitrogen loading in the watersheds of poorly flushed coastal embayments. In developing the Core Plan, the Town also sought to protect or improve water quality in freshwater ponds. The layout of the proposed sewer system allows for control of phosphorus loading to Pilgrim Lake, Crystal Lake and Boland's Pond, whose water quality should be improved by elimination of septic phosphorus loading. The Town also wishes to protect the good water quality in Bakers Pond which is not readily served by the proposed sewer system. Therefore, a Title 5 cluster system is proposed for the Baker Pond watershed, with the goal of significantly reducing phosphorus loading there to forestall the degradation that has occurred in other ponds. See Section 11.4.6 and Appendix I.

Comment 1006:

A. *The SEIR should provide a detailed description of the Town's proposed AMP (Adaptive Management Plan) and its water quality monitoring program for the Tri-Town site and the coastal embayments surrounding the Town of Orleans. I encourage the Town to consult with the Pleasant Bay Resource Management Alliance in designing the Town's water quality monitoring program.*

B. *The SEIR should also include a discussion of the Town's commitment to continue its freshwater pond assessment and restoration activities. I ask that the Town expand the distribution of its annual water quality monitoring report to also include the CCC and the Pleasant Bay Resource Management Alliance.*

Response 1006:

A. New paragraphs have been added to Section 11.6 of the SEIR, entitled Adaptive Management Plan, that bring together elements from other portions of this section. That new material is as follows:

   In dealing with complex environmental problems, precisely determining the optimum solution can take many years and require very extensive study. At some point, sufficient information is available to embark on a solution, even though all aspects of the best solution have not been determined. At that point, the risk of inaction is greater than the cost of implementing a non-optimum solution. Adaptive management is the formulation and implementation of a plan that begins to solve the problem while further information is gained to guide later phases toward the best overall solution. The basic elements of a successful adaptive management plan are:

- A solution that can be implemented in phases over time;
- Acquisition of data to show the effectiveness of the early phases of the solution; and
- A mechanism to re-assess the plan and adjust it to reflect the information gathered.

The Orleans Recommended Plan is adjustable in its content and timing so that mid-course corrections do not have large impact on overall cost. The data acquisition program must be directed at answering the question: "What information is needed about the impacts of Phases 1 and 2 (for example) so that Phases 3 and 4 can be modified if necessary?" The re-assessment of the program must be well planned to be accomplished quickly, and with results that are approvable by the regulatory agencies.

Orleans' Adaptive Management Plan addresses the following uncertainties:

1. How does the reduction in watershed nitrogen loading actually improve the water column nitrogen concentration in the impacted embayment? Is the water column concentration more or less sensitive to watershed load than predicted by the MEP model?
2. How does the eelgrass or benthic community respond to the reduction in water column nitrogen concentration? Are those communities more or less sensitive to water column nitrogen concentration than predicted in the MEP model?
3. The municipal sewer system will lead to a wastewater treatment facility outside the nitrogen-sensitive watersheds. How much nitrogen is removed from those watersheds by sewering the targeted neighborhoods? Are the occupancy and per-capita load assumptions used in the CWMP accurate in comparison with the nitrogen load actually collected?
4. The sewer system will be subject to some infiltration and inflow. How much wastewater is actually received at the treatment facility and how does the facility's capacity compare with the assumptions in the CWMP?
5. With respect to effluent disposal, does the full-scale application of effluent match the expected loading rates, and might additional disposal capacity be needed sooner than expected?
6. Does community growth follow the progression expected through the planning horizon, or might more capacity be needed sooner (or later) than planned?
7. Are non-structural components of the CWMP more or less effective than assumed?
8. For multi-town watersheds (Nauset, Rock Harbor and Pleasant Bay), should one town accelerate or delay phases of its program to match progress in the other towns? Similarly, does progress in other towns allow Orleans to defer or eliminate one phase of the Orleans program?
9. When will neighboring towns be ready to participate in regional solutions? Can the Pleasant Bay Alliance facilitate a multi-town solution for Pleasant Bay?
10. Does new research provide the basis for an expansion of the wastewater needs assessment to address contaminants of emerging concern?
11. Have new, DEP-approved, advanced on-site treatment systems become available and should they be applied in less densely developed neighborhoods in Orleans?
12. Have pilot programs for non-traditional and/or non-structural measures conducted in Orleans produced results which should be applied full-scale in Orleans?
13. Have pilot programs for non-traditional and/or non-structural measures conducted in other communities in the County produced results which could be applied in Orleans?

Table 11-2 outlines the facilities that are proposed to be built in each of the six project phases. This table also shows the information needed before the implementation of each phase. The Town will use the TMDL Compliance Report (discussed in Section 11.8) as a vehicle to document annually its findings in each of these critical areas. The Groundwater and Surface Water Monitoring Program (Section 11.7) will provide key data to support the TMDL Compliance Report. The Board of Water and Sewer Commissioners will be the responsible Town entity for overseeing the Adaptive Management Plan and coordinating it within the Town and with neighboring towns and review agencies.

B. Responsibility for monitoring the water quality in freshwater lakes and ponds lies with the Orleans Marine and Fresh Water Quality Task Force. It is recommended that the Orleans Board of Selectmen charge that entity with establishing a long-term program of continued monitoring and assessment and that the Board of Selectmen take the steps necessary to ensure its funding. These tasks have been added to the Implementation Plan set forth in Section 11 of the SEIR. As with the Adaptive Management Plan, close coordination with regulatory and review agencies is warranted, along with other towns and watershed groups such as the Pleasant Bay Resource Management Alliance.

Comment 1007:

A. The SEIR should delineate on a plan of reasonable scale all environmental resources areas located within areas proposed for sewering including; wetlands, water bodies, drinking water supplies, sensitive habitats, fisheries, designated Areas of Critical Environmental Concern (ACEC), Article 97 lands, historic resources, and agricultural lands.

B. The SEIR should analyze both direct and indirect impacts on wetlands and water bodies resulting from the project, and quantify the amount of direct wetland impact. The analysis should also discuss the consistency of any proposed drainage and stormwater management systems that are included in the project with MassDEP Stormwater Management regulations and the Wetlands Protection Act performance standards. Proposed activities, including construction mitigation, erosion and sedimentation control, phased construction, and drainage discharges or overland flow into wetland areas, should be evaluated.

C. The SEIR should identify all parcels that are currently deemed unbuildable within the 100-year flood plain that would potentially become buildable as a result of a sewer installation. The SEIR should provide detailed plans, at a suitable scale, illustrating the proposed project's impacts to wetland resource areas. The SEIR should examine alternatives that avoid impacts to wetland resource areas, their associated buffer zones, riverfront protection areas and 100-year flood plain areas. Where it has been demonstrated that impacts are unavoidable, the SEIR should demonstrate that the impacts have been minimized, and that the project will be accomplished in a manner that is consistent with the Performance Standards of the Wetlands Regulations (310 CMR 10.00). The Town will need to provide wetlands replication at a ratio of at least 1:1 for any unavoidable impacts to wetlands. For any amount of required wetlands replication, a detailed wetlands replication plan should be provided in the SEIR that, at a minimum, includes: replication location(s), elevations, typical cross sections, groundwater elevations, the hydrology of areas to be altered and replicated, list of wetlands plant species of areas to be altered and the proposed wetland replication species, planned construction sequence, and a discussion of the required performance standards and monitoring.

Response 1007:

A. The Town has provided additional detail related to environmental resources in Figures D-7 through D-9 contained in Appendix D of the SEIR, see attached.

B. See Response C below.

C. The current plan will be "flow neutral"; that is, it will allow no more flow to the public sewer than would be allowed under all other existing land use and public health requirements. Owners of land that is unbuildable for any reason would therefore not be allowed any flow to the public sewer. Tools to ensure "flow neutrality" are included in Appendix L; namely the Board of Health Nutrient Management Regulation, local adoption of Section 1A of MGL Chapter 83, and a draft paragraph for future inclusion in the Sewer Use Regulations. See further discussion in Response 1012.

   Currently, none of the major project components is sited in a manner that would infringe on wetlands. However, some minor pump stations will need to be located near wetlands; however, their exact location has not been determined during the planning phase. During the design phase, all efforts will be made to locate components outside delineated wetland areas. If construction within wetland delineated areas is determined to be unavoidable, then wetlands replication plans will be provided for all such locations and they will be reviewed by the applicable agencies. A construction sequence and monitoring plan would be agreed to by all parties at such time.

   The final design will ensure the consistency of any of the project's proposed drainage and stormwater management systems with MassDEP Stormwater Management regulations and the Wetlands Protection Act performance standards. Final design will address construction mitigation, erosion and sedimentation control, phased construction, and drainage discharges or overland flow into wetland areas, among other issues.

Comment 1008:

As described in the EENF, the existing Tri-Town Septage Treatment Facility site is located within Priority Habitat for the Eastern Box Turtle (Terrapene Carolina), The Diamond-backed Terrapin (Malaclemys terrapin), Salt Reedgrass (Spartina Cynosuroides) and Mitchell's Sedge (Carex mitchelliana). The EENF includes an evaluation of four alternative site layouts (Alternatives A-D) for the new WWTF facility. According to NHESP's comments on the EENF, the construction of the Orleans WWTF will occur within mapped habitat for the Eastern Box Turtle (Terrapene carolina) NHESP has recommended that the Town identify a site layout alternative that will maximize the reuse of existing disturbed areas and avoid fragmentation of undisturbed areas within the proposed Orleans WWTF site to avoid a 'take' of the Eastern Box Turtle, and I have included this requirement in the Scope for an alternatives analysis provided above.

The SEIR should include a detailed description of the Town's preferred site layout alternative for the Orleans WWTF. If NHESP should subsequently find that the project will require a Conservation Permit pursuant to the Massachusetts Endangered Species Act (MESA), the SEIR should analyze the impacts to Eastern Box Turtle and evaluate avoidance/mitigation strategies. I ask that the Town continue to work closely with NHESP and consult with the Orleans Conservation Commission during the preparation of this section of the SEIR and the final project design to identify necessary project construction and post-construction conditions and commitments to avoid an adverse impact to resource area habitats of state-

listed species located within and adjacent to the Orleans WWTF site. The SEIR should report on the results of the Town's consultations with NHESP.

Response 1008:
The draft CWMP evaluated four alternative layouts for the treatment and disposal facilities at the Tri-Town site. Based on consultation with NHESP staff, a fifth option was developed; see Figure 11-2. This new layout meets the preferences of NHESP with respect to both reuse of existing disturbed area and continuity of remaining undisturbed area. This layout includes concentrating the disturbance to accommodate the additional wastewater functions in the northeast corner of the site. This layout also preserves a greater tract of undisturbed land to the south of the existing facility. The Town has adopted this new layout as the Preferred Alternative as part of the Recommended Plan. Because the Preferred Alternative involves less than 5 acres of habitat disturbance, it should avoid a "take" of Eastern Box Turtle and makes unnecessary a Conservation & Management Permit.

The CWMP/SEIR lists the measures the Town will take to minimize and mitigate impacts related to Eastern Box Turtle habitat; see Section 11.4.7 and Appendix H (proposed additions to Appendix H are attached) These measures have been reviewed with the Orleans Conservation Commission during its meeting on September 14, 2010, and will be formally filed at the point of permitting.

Comment 1009:
The Town should provide the MHC with a US Geological Survey topographical map that locates the Town's phased project area and scaled project plans showing existing and proposed conditions. These plans should be submitted to MHC as early as possible during the design phase corresponding to each of the proposed project development phases. In comments submitted on the EENF, the Massachusetts Historical Commission (MHC) indicated that a number of proposed pump stations are located within and/or adjacent to recorded archeological sites and archaeologically sensitive areas. The Town {is asked} to coordinate with MHC to ensure review of any potential historic impacts from the project and the SEIR should provide an update on the status of these discussions. If MHC deems the project to have an "adverse effect" on historic or archaeological resources, the SEIR should include a discussion of mitigation measures that the Town will undertake to address the adverse effect.

Response 1009:
The CWMP/SEIR depicts preliminary information on proposed pump station and sewer line locations, and the MHC staff has reviewed the conceptual plans for the wastewater collection system and the cluster systems. MHC staff noted that archeological resources are not present at the Tri-Town site. Each of the sites identified for wastewater facilities have been reviewed by the Massachusetts Historical Commission. Based on a review by MHC, undisturbed portions of the cluster sites are either within, or proximate to, areas where archaeological resources could be present. The archaeological sensitivity is primarily due to the environmental setting (proximity to water and in level areas with well-drained soils). A reconnaissance archaeological survey will be conducted to assess all of the cluster sites. The Town has committed to this work and set a budget in its capital plan for surveys during the design phase of the project. A detailed review of the collection system placement by MHC will be warranted during the design phase. As a general rule, the Town is prepared to select locations and layouts for all wastewater-related infrastructure that will avoid construction in currently undisturbed areas. The current preliminary design keeps all sewer lines in developed rights-of-way, and includes no cross-country segments. To the extent that final design of this infrastructure does not allow complete avoidance of those undisturbed areas (it is possible that some new facilities will encroach on undeveloped areas adjacent to road rights-of-way), the Town will undertake all appropriate surveys, including the requested

reconnaissance archaeological surveys. During the design phase of the project, specific locations will be selected and then reviewed with MHC, with the goal of selecting the best technically and financially feasible location that has the least impact on sensitive areas.

Comment 1010:
The SEIR should quantify the direct and indirect CO_2 emissions from the proposed project. The SEIR should include the modeling printout for the base case and for the preferred alternative case. The SEIR should also present an evaluation of the feasibility of each of the mitigation measures outlined below, as well as the GHG emissions reduction potential associated with each measure. The SEIR should explain, in reasonable detail, any measure not selected- either because it is not applicable to the project or is considered technically or financially infeasible- that would result in a significant reduction of GHG.

DOER has identified several building design measures worthy of consideration in the SEIR, and adoption into the project, where feasible; including building orientation, duct insulation, roof and wall insulation, high-albedo roofing materials, on-site renewable energy and include a life-cycle cost analysis.

The Town should explore and present modeling results in this section of the SEIR related to the use of renewable and energy efficient equipment listed below when designing new or upgraded wastewater treatment facilities, pump stations and other components of the Town's comprehensive wastewater management system.

Response 1010:
The analysis of Greenhouse Gas Emissions is presented in Appendix J.

Comment 1011:
Construction period impacts and mitigation measures should be described in the SEIR, including the impacts from noise and dust, impacts on trees and other vegetation, and traffic impacts. Measures that will be taken to minimize and mitigate construction period impacts (in particular impacts on sensitive receptors or exceptional resources) should be detailed.

Response 1011:
Construction impacts and mitigation measures are discussed in Section 8 for all three plans that were considered. This section describes all facets of the project. Below are the items related to construction impacts, see Section 8.5.

Construction related impacts:
8.5.9 Traffic
8.5.10 Air Quality
8.5.11 Noise

[Sections 8.5.12, 8.5.13 and 8.5.14 are new report sections, excerpted below]

> 8.5.12 Erosion Control
> During construction, temporary erosion control measures will be warranted to avoid sediment migration. This is commonly achieved with the use of hay bales, siltation fencing, and geotextile materials. Storm events and construction dewatering would warrant the use of these controls. During the design process, detailed drawings and specifications will outline the controls required to

be used by the construction contractor. Drawings and specifications will meet with regulatory standards such as the National Pollution Discharge Elimination System (NPDES) and Storm Water Pollution Prevention Plans (SWPPP).

8.5.13 Waste Material
During the construction process a stream of waste material will be generated. Brush, spoil material, and scraps of wood, metal, and plastics will be collected and removed from the construction sites by the construction contractor at periodic intervals. Storage between removal days will be in a designated area. Collection and removal of such material must be by authorized individuals.

8.5.14 Existing Vegetation
During the construction process portions of the site will be cleared to make room for new wastewater structures, and leave adequate space for construction vehicle access and lay-down area. To preserve the remaining vegetation other measures will be in place to limit dust and other debris from damaging the vegetation slated to remain. See previous sections. Some of these areas will be re-vegetated with the same or similar species that were initially present. In some cases different species will be selected to provide better visual or noise buffers for adjacent properties.

Comment 1012:
Sewering and Growth Management
The SEIR should identify parcels located within the proposed sewer service areas and compare the potential secondary growth impacts, water use and increased wastewater flows that may be induced by public sewers and expected reductions of water use and wastewater flows with the Town's proposed growth management policies, regulations and bylaws. The SEIR should include copies of any new by-laws or regulations proposed by the Town for controlling new future development requesting municipal sewer service and located in areas outside of the proposed new sewer areas. The Town should consider adopting and implementing any proposed growth by-laws, regulations, and policies prior to the construction of any new sewers.

Response 1012:
Quantification of the secondary growth impacts of the project is not necessary. The Town has already put in place, or is prepared to enact controls to constrain the generation of wastewater in the public system. A Board of Health regulation has been adopted, the Town has accepted Section 1A of MGL Chapter 83, and a provision has been drafted for inclusion in new sewer use regulations. Taken together, these steps will make the wastewater project "flow neutral". These documents are presented in Appendix L of the SEIR.

The Board of Health's Nutrient Management Regulation was adopted in 2008. It restricts wastewater flow to 110 gpd per 10,000 square feet of lot area, for new development or expanded uses of existing development. The proposed sewer use regulation will limit flow to the sewer system from a given property to that flow which is allowed under all other state and local regulations. For properties subject to the Board of Health Nutrient Management Regulation, that provision of the sewer use regulations will keep sewered flow less than 110 gpd per 10,000 square feet. For all other properties, the sewered flow will be no more than what is allowed under Title 5. The sewer use regulations will be put in place prior to the imitation of construction in Phase 1.

By accepting Section 1A of MGL Chapter 83, the Town has confirmed its intentions to install public wastewater infrastructure to control nutrient loading, and it can now take advantage of the "checkerboard sewering" concept that is provided for in Sections 1B and 1C of MGL Chapter 83.

Comment 1013:
Cost to Homeowners
The SEIR should include estimates for the costs of land acquisition associated with the proposed cluster treatment plants and corresponding groundwater disposal sites. The SEIR should document any assumptions concerning the probable cost of acquiring parcels for wastewater purposes. The Town should consult with MassDEP during the preparation of this section of the SEIR.

Response 1013:
The capital costs presented in Table 11-7 include estimates of the costs for all land purchases, including cluster treatment and disposal sites. The text associated with that table has been expanded to note that the land cost line item includes $0.9M for pump station site acquisition, $0.8M for easements, and $2.5M for cluster treatment and disposal sites. These estimates have been reviewed with DEP.

Comment 1014:
The Town's Core Program has been designed to accommodate potential future expansion to serve the remaining unsewered areas of Orleans under the Expanded Program and/or additional wastewater flows from the neighboring towns of Eastham and Brewster under the Regional Program.

A. *The Expanded Program would provide town-wide sewers in Orleans and would cost an additional $95 million dollars. However, as described in the EENF and noted elsewhere in this Certificate, additional wastewater disposal sites or reuse options may be required to support the treatment and disposal of additional wastewater flows anticipated under the Expanded Program or the Regional Program described below. The SEIR should evaluate the Tri-Town site's capacity to treat the additional estimated wastewater flows to be generated under the Expanded and the Regional wastewater treatment alternatives.*

B. *I ask the Town of Orleans, together with the Towns of Eastham to the north and Brewster to the south to work together with MassDEP, the Cape Cod Commission and others to continue the discussion of possible opportunities.*

Response 1014:

A. See Response 1003 related to effluent disposal/reuse needs associated with the Expanded and Regional Plans.
B. The Orleans Selectmen met with their counterparts from Eastham and Brewster on January 29, 2009, September 10, 2009 and October 12, 2010 to discuss wastewater and septage regionalization issues. While no solid agreement to move forward on regional wastewater management were reached, all towns are still open to the concept. Eastham and Brewster are have made less progress in the planning process. The Cape Cod Water Protection Collaborative has offered its assistance in facilitating these discussions. Orleans and Eastham have begun discussions on the possible transport of drinking water from Orleans to Eastham.

Comment 1015:
I note that the State's Revolving Fund (SRF) regulations require the proponent to conduct a minimum of one public meeting and one public hearing for this project. The SEIR should include a discussion of the Town's public participation program activities completed and proposed to date.

Response 1015:
The Town of Orleans has held 3 public meetings, one special town meeting and several community workshops to encourage public consultation and participation in the crafting of the comprehensive wastewater management plan. A summary of these focused public activities is included in Appendix C and includes statistics on the number of attendees and the results of questionnaires soliciting feedback on specific components of each of the three plans that were evaluated in detail.

Comment 1016:
The SEIR should include a separate chapter on mitigation measures. This chapter on mitigation should include Draft Section 61 Findings for all state agency actions. The Draft Section 61 Findings should contain a clear commitment to mitigation, an estimate of the individual costs of the proposed mitigation and the identification of the parties responsible for implementing the mitigation. A schedule for the implementation of mitigation should also be included. I ask the Town to continue to work closely with CCC, MassDEP, and the Pleasant Bay Resource Management Alliance to design and implement a sustainable Comprehensive Wastewater Facilities Plan and mitigation plan for the Town of Orleans that will help to offset the proposed project's municipal sewering impacts.

Response 1016:
Discussion of mitigation measures and Draft Section 61 Findings are contained in Section 12. Costs for individual mitigation measures have been included in contingencies for individual project elements. See Section 12.

COMMENTS AND RESPONSE RELATED TO MASSACHUSETTS HISTORICAL COMMISSION (MHC):

Comment 1101:
Multiple proposed pump station locations and portions of unimproved roadways shown on the preliminary maps are within and/or adjacent to recorded archaeological sites and within archaeologically sensitive areas.

MHC requests that a reconnaissance archaeological survey (950 CMR 70) be conducted for the project. The purpose of the survey is to conduct an archaeological sensitivity assessment of the proposed impact areas and recommendations for intensive (locational) archaeological survey, if warranted, in order to locate and identify any significant historic or archaeological resources that may be affected by the project.

Response 1101:
The CWMP/SEIR depicts preliminary information on proposed pump station and sewer line locations, and the MHC staff has reviewed the conceptual plans for the wastewater collection system and cluster systems. As a general rule, the Town is prepared to select locations and layouts for all wastewater-related infrastructure that will avoid construction in currently undisturbed areas. The current preliminary design keeps all sewer lines in developed rights-of-way, and includes no cross-country segments. To the

extent that final design of this infrastructure does not allow complete avoidance of those undisturbed areas (it is possible that some new facilities will encroach on undeveloped areas adjacent to road rights-of-way), the Town will undertake all appropriate surveys, including the requested reconnaissance archaeological surveys. During the design phase of the project, specific locations for cluster systems and pump stations will be selected and then reviewed with MHC, with the goal of selecting the best technically and financially feasible location that has the least impact on sensitive areas. Also, see Responses 1009 and 1906 for related material.

COMMENTS AND RESPONSES RELATED TO CAPE COD COMMISSION (CCC):

Comment 1201:
Natural Resources Recommendations

A. *Avoid impacts to Eastern box turtle by consolidation of the developed areas within and adjacent to existing developed footprints, and to reuse existing facilities.*
B. *Site new sewer mains and pump stations within or adjacent to existing roadways*
C. *Avoid impacts to 100-foot buffers to wetlands.*

Response 1201:

A. The Town has selected a preferred layout at the Tri-Town site that will avoid a "take" of the Eastern Box Turtle (refer to Responses 1002 and 1008 for greater detail).
B. The CWMP includes all sewer mains sited within road right-of-way. The majority of pump stations can also be sited within the Town rights-of-way. The largest pump stations will likely require easements or land purchase to accommodate their footprint, in these few cases, siting within the road right-of-way is unlikely.
C. There may be some construction work that will be unavoidable within 100-foot buffers to wetlands. Construction activities will conform to the appropriate Conservation Commission recommendations for the avoidance and mitigation impact in the wetland. See Response 1007.

Comment 1202:
Historic and Archaeological Resources Recommendations
Prior to construction, conduct a reconnaissance archaeological survey for the project to locate and identify any significant historic archaeological resources that may be affected by the project.

Response 1202:
Some of the infrastructure shown on CWMP figures has only been generally located during the planning phase. Specific locations will be selected and reviewed with MHC during the design phase of the project to determine if surveys are applicable, and to that end, alternative sites will be discussed if they would avoid disturbing sensitive areas. See Response 1101.

Comment 1203:
Water Resources Recommendations

A. *Incorporate Final MEP technical documents into the FEIR*
B. *Evaluate and provide more detail on the extent and timing of phased sewer expansions*
C. *Provide additional detail on the site capacity and monitoring program for the selected treatment and effluent disposal facility at the Tri-Town Site*
D. *Expand annual reporting to include the Cape Cod Commission for TMDL compliance with the Regional Policy Plan*

E. Proceed with local negotiations on regional wastewater management opportunities and provide an update and status.
F. Provide additional evaluation of the interim benefit of proposed cluster systems
G. Participate in a regional assessment of planned sewering in the Pleasant Bay watershed to project the progress of improved water quality.

Response 1203:

A. The executive summaries for all available and pertinent MEP reports have been incorporated in the SEIR. For those reports currently available see Appendix G. The completion of the MEP studies of the Nauset system has been significantly delayed, and no firm schedule exists to give the Town confidence that the MEP Technical Report for Nauset will be issued any time soon. The CWMP is based on a placeholder value of 55% septic nitrogen removal within the Nauset watershed, a figure that has been reviewed by the MEP staff and found to be appropriate. Given the uncertainty associated with completion of the Nauset Technical Report, the Town has elected to complete the CWMP/SEIR using this placeholder value, with the full understanding that the plan will be updated during the design phase of the project to reflect the precise MEP finding once it is available.
B. Several phasing alternatives (extent and timing of the 6-phase program) were discussed between the Town and Consultant. Phase 1 is the most critical and well-defined phase to date in the planning process. Changes to the timing and extent of later phases would be addressed as part of adaptive management as the Town solidifies each pending phase. See Response 1002-C.
C. Details on the effluent capacity available at the Tri-Town site is provided in Response 1003, along with an outline plan for surface water and groundwater monitoring.
D. The Town is committed to expanding the distribution of annual reporting to include the CCC.
E. The Town intends to pursue regional opportunities as neighboring communities make progress on their comprehensive wastewater planning. See Response 1014 and CWMP Sections 11.12.6 and Appendix K.
F. See Response 1005, related to the proposed cluster systems.
G. The Town participates in the Watershed Work Group of the Pleasant Bay Alliance, the most currently able body for monitoring the progress of improved water quality across the entire watershed. The Town plans to continue participation in the group, which monitors Pleasant Bay waters several times each summer.

Comment 1204:
Land Use Recommendations

A. Include copies of the flow-neutral regulations or policies that have been adopted or proposed to be adopted related to a "flow neutral" approach to development of a wastewater treatment facility and sewers and identify how the flow-neutral sewer regulations will be implemented.
B. Consider increasing the sewer allocation to downtown Orleans to accommodate more growth in this area than just through Chapter 40B development.

Response 1204:

A. Included in Appendix L are copies of adopted and proposed regulations related to the implementation of the CWMP. See Response 1012.

B. The Town evaluated in detail the potential for growth in the downtown area, and the build-out analysis includes both new commercial development and the redevelopment of commercial property, in addition to residential development. After accounting for commercial and residential build-out potential, the Orleans Planning Board advised that the Town should plan for an additional 200 small apartment units within the Village Center District in the future. This added growth allowance (above the growth potential that already exists) is considered to be sufficient, based in part on the significant growth that is already possible in the downtown area as accounted for in the build-out analysis. This increase represents about 25% of the expected future growth. See Section 3.6 Economic Development. Opportunities exist to review this decision (and increase this allowance) during the design phase of the project, and prior to the initiation of each project phase.

Comment 1205:
Energy Resources Recommendations

A. *Consider whether a renewable energy system could be built into the treatment plant's design as a future source for the energy needs.*
B. *Select energy efficient processes and equipment.*

Response 1205:

A. The Town plans to investigate renewable energy systems during the preliminary design of the treatment facility. Future input from the CCC and DEP will be requested at that juncture. An on-site wind turbine and photovoltaics are considered in the GHG emissions analysis; see Appendix J. See also Response 1010.

B. A cost-benefit analysis of energy efficient equipment is presented in the GHG Analysis (see Appendix J) and will be elaborated upon in the preliminary design. See also Response 1010.

COMMENTS AND RESPONSES RELATED TO MASSACHUSETTS DIVISION OF MARINE FISHERIES:

Comment 1301:
After review, Marine Fisheries has no recommendations for this project at this time.

Response 1301:
The Town will keep the Division of Marine Fisheries apprised of the project at the appropriate junctions in the future.

COMMENTS AND RESPONSES RELATED TO PLEASANT BAY RESOURCE MANAGEMENT ALLIANCE:

Comment 1401:
Consequently, the proposed phasing in the Orleans DCWMP may afford opportunities for revised phasing through adaptive management based on changing conditions as plans in other {Pleasant Bay} watershed towns {Chatham, Harwich and Brewster} evolve. In this regard we strongly encourage Orleans to continue discussion with the towns of Brewster, Harwich and Chatham regarding a possible regional treatment facility to be located in South Orleans or Brewster.

Response 1401:
Two of the important reasons for Orleans to adopt a phased wastewater plan are the acknowledged benefits of regionalization and the recognition that Brewster and Harwich (two potential regional partners) are in the early stages of comprehensive wastewater management planning. At the end of each phase of the Orleans project, it is intended that the Town will reassess the then-current situation in Orleans and in neighboring towns and evaluate the identified opportunity for a regional facility in South Orleans. Section 11.12.6 of the CWMP/SEIR has been expanded to provide additional emphasis on the potential South Orleans option.

Comment 1402:
To compensate for the later phasing of sewering in the Pleasant Bay watershed, the preferred plan calls for installation of on-site package plants with de-nitrification to 15 mg/l at three sites located at the headwaters of Paw Wah, Lonnie's and Arey's Ponds, respectively....Given the severity of nutrient loading in these water bodies we encourage the Town to invest in the best technology feasible at the plants to achieve a level of de-nitrification below 15 mg/l if at all possible.

Response 1402:
The degree of nitrogen removal provided at the cluster systems was re-evaluated to strike a balance between cost and water quality improvement. A consensus was reached at a meeting with DEP and the CCC that small-scale systems could reach effluent nitrogen concentrations of 5 or 10 mg/l. Accordingly, target effluent concentrations for the cluster systems have been set in this range. Cluster system characteristics are provided in Appendix I and include information about expected facility performance. See Response to Comment 1005.

Comment 1403:
Growth Management
We commend the Town's Board of Health for recently adopting nutrient management regulations to limit wastewater flows from new development town-wide. These regulations are significant as interim measures that will limit nutrient loading prior to the installation of sewers. The regulations also will continue to provide critical nutrient management protection to the one-half of parcels in town that will remain on on-site septic systems. Finally, the regulations could provide a baseline for establishing flow neutral sewer connection regulations. This would ensure that growth that may be influenced by sewering is not inconsistent with broader community growth management objectives.

We encourage the Town to adopt the newly created provisions of Chapter 83A and to evaluate the need for additional growth management through zoning, conservation or other means to ensure that sewers facilitate and do not undermine desired growth patterns.

Response 1403:
The Town adopted Section 1A of MGL Chapter 83A at its Annual Town Meeting on May 11, 2009. A copy of the approved article is included in Appendix L. Consideration of additional growth management will occur as part of the adaptive management plan (see Response 1006).

Comment 1404:
The continued availability of adequate facilities to meet regional septage handling needs is of regional concern. We encourage Orleans and all towns to identify their anticipated septage treatment needs to ensure that potential changes in septage handling requirements at any facility can be considered and

that figure septage treatment needs not slow efforts to provide sewer expansions to the Pleasant Bay watershed.

Response 1404:
The Town of Orleans has provided for regional septage management in the Recommended Plan; see Table 11-1 of the CWMP/SEIR. The proposed 50,000 gallons per day of summer capacity for septage should be sufficient to serve those Orleans properties that will not be connected to the public sewer, plus all unsewered development in Eastham and Brewster (Orleans' current partners in the Tri-Town district). This septage capacity should be sufficient for the expected growth in the three communities and Orleans would allow other towns to use that capacity in the early years of the project.

COMMENTS AND RESPONSE RELATED TO TOWN OF ORLEANS

Comment 1501:
There are three items discussed in the CWMP that are not intended to be the subject of the current MEPA review:

1. *The extended sewer plan…*
2. *Regional Wastewater Facilities….*
3. *Cluster wastewater treatment systems……*

Response 1501:
The Town of Orleans wrote to Secretary Bowles on June 18, 2009 (during the MEPA public comment period) to clarify its intent with respect to certain features of the proposed wastewater management plan. That letter stated that three aspects of the plan were not intended for MEPA review at this time and would be the subject of Notices of Project Change if and when the Town decided to proceed with them. Such is still the case for regional wastewater facilities and for the extended sewer plan. However, subsequent discussions with MEPA staff led to the decision to include the cluster systems in this review. Consequently, additional information on the cluster systems is provided in Appendix I of the CWMP/SEIR, as noted in Response to Comment 1005.

COMMENTS AND RESPONSE RELATED TO NATURAL HERITAGE AND ENDANGERED SPECIES PROGRAM (NHESP) OF THE MASSACHUSETTS DIVISION OF FISHERIES & WILDLIFE:

Comment 1601:
It is the opinion of the NHESP that alternatives that result in the least amount of direct and indirect (e.g. fragmentation of habitat) impacts to state-listed species habitat are preferred for the proposed wastewater treatment and disposal facilities. Therefore the NHESP prefers Alternative B over the other alternatives. New alternative designs that maximize reuse of existing disturbed areas and avoid fragmentation of remaining undisturbed habitat are also likely to be preferred by the NHESP.

If an alternative design for the proposed wastewater treatment and disposal facilities located at the Tri-Town site is selected and this alternative does not minimize both direct and indirect impacts to state-listed species habitat, this project may result in a "take" of the Eastern Box Turtle. Projects resulting in a "take" of state-listed species may only proceed if they meet the performance standards for issuance of a MESA Conservation & Management Permit pursuant to 321 CMR 10.23. In order to qualify for a

Conservation & Management Permit, the proponent will need to minimize and avoid impacts to the Eastern Box turtle to the greatest extent practicable and produce a Net Benefit for this species.

Response 1601:
Based on the alternatives in the draft CWMP, the Town worked with NHESP to develop a new option that would preserve greater tracts of land for the Eastern Box Turtle and should avoid a "take" of species habitat. Please see Response 1008.

The CWMP/SEIR lists the measures the Town will take to minimize and mitigate impacts related to Eastern Box Turtle habitat; see Appendix H.

COMMENTS AND RESPONSE RELATED TO DEPARTMENT OF CONSERVATION AND RECREATION (DCR):

Comment 1701:
The ACEC Program supports the Project goals of improving water quality and reducing nitrogen and phosphorus loading within the Cape Cod Bay, Nauset and Pleasant Bay watersheds and several freshwater ponds. The ACEC Program also supports:

1. *The "growth neutral" concept…*
2. *The project phasing and associated adaptive management and long-term monitoring strategy…*
3. *The evaluation of regional wastewater treatment and disposal options…and*
4. *The non-structural aspects of the plan……*

In the EIR, the ACEC Program encourages a rigorous evaluation of the site design layout alternatives through continued consultation with NHESP to minimize and mitigate for unavoidable impacts to Eastern Box turtle habitat and other listed species. The ACEC Program also supports the MHC's comments requesting that a reconnaissance archaeological survey (950 CMR 70) be conducted to locate and identify any significant historic or archaeological resources that may be affected by the Project and to avoid, minimize or mitigate for any adverse effects to such resources.

Response 1701:
The Town has conducted a rigorous evaluation of site layout alternatives through continued consultation with NHESP and has selected a preferred layout at the Tri-Town site that aligns with the requests of NHESP. See Responses 1008 and 1601.

During the design phase of the project, the Town will review with MHC specific locations for infrastructure installation if those sites are not within existing developed rights-of-way, and undertake surveys as applicable. See Response 1101.

COMMENTS AND RESPONSES RELATED TO MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION (MassDEP):

Comment 1801:
The project construction activities may disturb one or more acres of land and therefore, may require a NPDES Stormwater Permit for Construction Activities. The proponent can access information regarding the NPDES Stormwater requirements and an application for the Construction General Permit at the EPA website: http//cfpub.epa.gov/npdes/stormwater/cgp.cfm

Response 1801:
Section 11.11.4 (Permitting) of the CWMP/SEIR has been amended to include the NPDES Stormwater Permit on the list of permits required to implement the project. It is the intention of the Town of Orleans to incorporate stormwater management plans in each construction contract for this project and to file a Notice of Intent with EPA for each project prior to the start of construction activity in each project phase.

Comment 1802:
In considering the need for upgrading the infrastructure in town, the assessment should include the potential for encountering contamination associated with waste sites (both known and unidentified) throughout town if excavation is necessary for the installation of the collection system or distribution systems. The filing of a Utility Release Abatement Plan would be required to excavate in contaminated areas. The location of known sites should be taken into consideration when conducting the assessment to upgrade the infrastructure.

The Project Proponent is advised that, if oil and/or hazardous material is identified during the implementation of this project, notification pursuant to the Massachusetts Contingency Plan (310 CMR 40.0000) must be made to MassDEP, if necessary. A Licensed Site Professional (LSP) may be retained to determine if notification is required and, if need be, to render appropriate opinions. The LSP may evaluate whether risk reduction measures are necessary or prudent if contamination is present. The BWSC may be contacted for guidance if questions regarding cleanup arise.

Response 1802:
During the design phase of the project, known contamination sites will be identified, and provisions will be incorporated into the construction specifications to ensure that all appropriate issues are addressed for both known and unidentified contamination sites. If necessary, Utility Release Abatement Plans will be filed at the end of the design phase, prior to construction, and appropriate notification will be provided to the Massachusetts Contingency Plan. Section 11.12.4 (Permitting) of the CWMP/SEIR has been amended to expand the list of required permits to include Utility Release Abatement Plans and Contingency Plan notification if warranted.

Comment 1803:
The project requires an EIR and will receive financial assistance from the Commonwealth {and} therefore is subject to the requirements of the MEPA Greenhouse Gas Emissions Policy and Protocol. The policy requires project proponents to quantify the direct and indirect CO2 emissions from the project site's current status and compare it to a set of scenarios that compares the CO2 emissions associated with the buildings & plant operations associated with the plan.

Response 1803:
The appropriate scope for the Greenhouse Gas (GHG) emissions estimate was negotiated with the MEPA office and the Massachusetts Office of Energy Resources. That scope was carried out and the resulting GHG emission analysis is included as Appendix J in the CWMP/SEIR. A summary of that analysis is reported in Section 11.12.8. Guidance from MassDEP (as contained in Comment 1803) was used in the completion of that analysis.

COMMENTS AND RESPONSES RELATED TO MARY HARTLEY

Comment 1901:
The Friends of Namskaket Marsh do not believe that Oak Ridge and Namskaket Marsh are safe, or appropriate areas for a centralized sewer project and discharge of wastewater.

Response 1901:
The Town of Orleans undertook an extensive screening of potential sites for facilities related to wastewater treatment and disposal. Numerous sites conducive to these activities were evaluated as part of three preliminary plans. The protection of surrounding properties and receiving waters was one of the major considerations in the determination of acceptable activities at each site, and in the preliminary layouts for structures on each parcel. All three plans are viable with respect to safety and siting. Based on extensive input from citizens all across Orleans, one of the three plans was selected as the preferred plan by the overwhelming majority of surveyed residents. That plan includes the property known as the Tri-Town Septage Treatment Facility located adjacent to Oak Ridge, and proximate to Namskaket Marsh. The recommended plan that is described in the CWMP/SEIR includes the appropriate design features to protect the surrounding environment (from the discharge of effluent) and to minimize the impact of facility operation on neighboring properties. None of the state environmental agencies that have reviewed the CWMP/EENF has raised any questions or requested any further information in regard to the safety and appropriateness of the selected site for these activities.

Comment 1902:
In conclusion, the addition of 500,000 - 750,000 gpd, (app. one billion gallons every 4 to 5 years) discharged from the proposed wastewater facility on Oak Ridge to the Namskaket and Cape Cod Bay Embayment would destroy the natural fresh/salt water balance that sustains marine and other aquatic life.

Response 1902:
The CWMP/SEIR presents a water balance for each of the major watershed systems in Orleans, comparing the natural precipitation recharge with the recharge associated with effluent disposal. The recharge from effluent disposal includes both the current volumes discharged from on-site septic systems and the volumes that would be discharged from new wastewater treatment facilities. This analysis (see Table 7-1 and Section 7.2) shows that the proposed discharge at the Tri-Town site, coupled with some sewering in the watershed, and would increase the recharge to Cape Cod Bay by approximately 6% over what occurs today. Such a small change is not expected to appreciably alter the freshwater/saltwater balance in the Bay. This issue will be evaluated in more detail as part of the Town's application for a groundwater discharge permit for this project. The agencies that review that application are charged with investigating potential negative impacts of new wastewater discharges and will not issue that permit if such concerns are not adequately addressed.

Comment 1903:
In the WHOI REPORT, Dr. Teal also implies potential problems resulting from unknown quantities of leachate and nutrients from wastewater from the LEA sewer project in 1983 and says that: "The concept of "marsh engineering" ought to be considered in the event control of the delivery, distribution and/or standing level of wastewater in the wetland becomes desirable."

A potential breakout of wastewater in the Marsh and need to "engineer" the Marsh to distribute and/or control wastewater flows, the need to remove decaying biomass from the Marsh to prevent eutrophic conditions, mosquito infestation in standing water, and other negative impacts from discharging wastewater in coastal wetlands and Cape Cod Bay, would require a complete evaluation and cost analysis. The ultimate effects on the health, and economic and aesthetic wellbeing of homeowners, who live on or near Namskaket; or the thousands of tourists who visit Skaket Beach or travel on the Bike Trail, wildlife habitat, and scenic woodlands and marshes, are unknown.

Response 1903:
This comment apparently refers to an analysis from 1983, when the potential environmental impacts of the then-proposed septage treatment facility were being debated. In the development of the draft CWMP/EEIR, Wright-Pierce analyzed information on subsurface conditions compiled over many years, (including substantial data collected by U.S.G.S.) and supplemented that data with new information gathered from subsurface explorations designed to address the current wastewater disposal plan. The more recent exploration results are summarized in Appendix E and Appendix F of the CWMP/SEIR. These reports cover several types of soil investigations, hydraulic load testing and computer modeling of the projected groundwater contours that would result from sustained disposal of effluent at this site. These investigations support the proposed plan to infiltrate highly treated effluent at this site, with effluent-impacted groundwater eventually recharging coastal marshes and Cape Cod Bay. A direct discharge of effluent to surface waters is not proposed. The Town will seek confirmatory modeling of the recommended plan by the Massachusetts Estuaries Project during the design phase of the project and that modeling will address the potential for some of the impacts the commenter has suggested.

Comment 1904:
The plume from the proposed sewer project would be 15 - 25 times greater than the septage-only plume and could breakout in the salt marsh, bogs, streets, yards, basement, or septic systems of hundreds of residents in the area on its course to Cape Cod Bay. Recent predictions by Wright-Pierce are that the plume will discharge "several hundred feet off the shoreline" at Skaket Beach. (WMSC 8/7/08)

Response 1904:
As noted in Response 1903, the hydrogeology of the Tri-Town site has been investigated with specific reference to the site's capacity for effluent disposal and the ultimate fate of effluent-impacted groundwater. The studies in Appendix E and Appendix F of the CWMP/SEIR present data that show that the commenter's concerns are unwarranted over the possibility of an elevated groundwater table impacting nearby septic systems, or flooding local basements, yards and streets. (For example, Section 7 of Appendix F discusses the groundwater simulations, and page 7-2 states that "the highest predicted groundwater level is…more than 10 feet below the ground surface at the homes north of the Tri-Town Site", including Ms. Hartley's home.) This Appendix also presents maps that depict the areas where effluent-impacted groundwater is expected to reach coastal waters. As with other groundwater-related impacts, this issue will be evaluated in more detail as part of the Town's application for a groundwater discharge permit for this project. The agencies that review that application are charged with investigating potential negative impacts of new wastewater discharges and will not issue that permit if such concerns are not adequately addressed.

Comment 1905:
Wright Pierce has introduced the concept of "allocating Assimilative Capacity" of nitrate (TMDLs) from Pleasant Bay, alleged to be "nitrogen sensitive" to Namskaket and Cape Cod Bay, described as "less nitrogen sensitive." (Wright Pierce 8/20/07) There is no scientific data anywhere which proves that Namskaket and Cape Cod Bay are any more, or less, nitrogen sensitive than any other coastal location in Orleans.

Response 1905:
The Massachusetts Estuaries Project (MEP) has investigated the nitrogen sensitivity of coastal waters impacted by activities in Orleans. Current nitrogen loads in the watersheds of Pleasant Bay and Rock Harbor have been shown to exceed the estimated assimilative capacity of those embayments. Yet-to-be-published data for the Nauset system is expected to document similar nitrogen overloading in its watershed. In contrast, the current (and projected future) loads in the watersheds of Namskaket Marsh and Little Namskaket Marsh are below the estimated assimilative capacities of those natural systems (significantly below in the case of Namskaket Marsh). These very well researched MEP studies show that Namskaket and Little Namskaket Marshes are less nitrogen sensitive than Pleasant Bay, the Nauset system and Rock Harbor. Executive summaries of all available MEP reports are presented in Appendix G of the CWMP/SEIR. The full reports are available at the Orleans Town Office and on the MEP website.

Comment 1906:
Orleans voters rejected the LEA sewer project in November, 1983 and selected the septage-only version. Linenthal, Eisenberg, and Anderson (LEA), State and Federal agencies, and the Museum of Afro American History, Roxbury, MA, coordinated the excavation, removal, and classification of artifacts from the site. Except for Loparto, an Orleans resident, no other Orleans voters, that I know of, were informed of the significance of the land they purchased in May, 1982. They were not invited to the dig, to examine any of the ancient artifacts taken from our Town, or make other plans for the site. EPA funded the removal of artifacts from about 4 acres. 22 acres remain at Oak Ridge and which may contain more material. The Namskaket site was determined to not contain significant artifacts, but, information may be withheld today to not jeopardize the $150 - $300 million dollar sewer project discharging to Namskaket.

Response 1906:
The Town of Orleans asked the Massachusetts Historical Commission (MHC) to review its files concerning past archaeological investigations and to determine what additional steps are needed to properly protect archaeological and historical resources on the 26-acre Tri-Town site. In its letter dated April 10, 2009, the MHC stated that "the alternatives for expansion of the facility as presently proposed will occur within areas previously disturbed by original facility construction and are unlikely to contain intact significant archaeological resources". No additional investigations have been requested by MHC related to further development of the Tri-Town property.

Comment 1907:
The ridge (Oak Ridge) is 79' high and acts as a buffer at this time from activities at Tri-Town for West Road commercial and residential development. Skaket Landing and Landings Edge Condos, Cape Cod Five Operations Center, restaurants, The Liquor Loft, Booksmith, CVS, a Photo Shop, Radio Shack, Olympia Sports are within 600 - 900 feet of Tri-Town and the RIBs. Removal of the hill and the woodlands for the construction of the Centralized Sewer Project will expose the project to West Road

between Skaket Corners and Old Colony Way. Prevailing SW winds will blow odors from sewage, septage, sludge, and liquid sludge throughout the area. Oak Ridge also abuts the Bike Trail.

Response 1907:
Preliminary layouts of proposed wastewater facilities at the Tri-Town site have been based on generally accepted practices for minimizing impacts on nearby development. The site will be developed with buffer zones of both naturally occurring and planted vegetation. Equipment and tanks that have the potential to release odors will be covered and subject to state-of-the-art odor control facilities. The exiting septage treatment facility has a good track record of controlling site noise and odor, and the new facility should perform even better.

Comment 1908:
The rapid transfer of sewage from Orleans and the region, would move freshwater recharge from other watersheds in the region (interwatershed transfer) to the densely populated Namskaket Marsh and Cape Cod Bay Shore. The transfer of vast quantities or freshwater to coastal wetlands and the ocean will inevitably lower the water table inland, and raise the water table between Namskaket River and Little Namskaket Creek. The ultimate effects of such a radical plan on the health, economic, and aesthetic well being of residents, tourists, and the whole environment of the West side are unknown.

Response 1908:
As noted in Response 1902, and presented in Section 7.2 of the CWMP/SEIR, water balances have been estimated for all watersheds in Orleans. Town-wide, groundwater recharge from septic systems is about 2% of the recharge from precipitation. Removing a portion of the septic system recharge from some areas in Orleans to a different watershed (Namskaket) will indeed result in a slight lowering of the water table those areas. The change in recharge will be no more than 4%, which is quite small, considering the normal variation year-to-year in precipitation. It must be recognized, however, that the water tables in most areas of Orleans are slightly higher that they were before the construction of the municipal water supply system, which distributed groundwater all across town. Response 1904 deals with concerns about elevated groundwater levels near the Tri-Town site.

Comment 1909:
A publication in 1989 by Massachusetts Audubon, "Buffer Zones: The Environment's last Defense", says, "The viability and transport of viruses are causing greater concern since many are difficult to detect. Currently there is no method used by Federal and State Agencies to monitor virus contamination in wastewater effluent, or the receiving waters of the effluent. Scientists have shown that viruses travel as far as 1,300 feet horizontally in groundwater from sewage infiltration basins."(p. 17)

Response 1909:
The proposed wastewater treatment facility will provide a very high degree of wastewater treatment. Following treatment for the removal of organic compounds, solids and nitrogen, an ultraviolet disinfection system will provide high removals of pathogenic material, including bacteria and viruses. The groundwater discharge permit for the facility will stipulate the maximum concentrations of contaminants that DEP believes should not be exceeded to protect the groundwater down-gradient from the discharge location. Except in cases involving the direct reuse of wastewater effluent, DEP has typically not set limits on effluent viruses, because the passage of effluent-impacted groundwater through the soil affords sufficient viral kill to protect down-gradient users. If the permitting process determines that there are down-gradient users of groundwater that demand a higher degree of virus removal, then DEP will set appropriate limits in Orleans' permit. In that public drinking water is

available to all properties down-gradient from the Tri-Town site, it is quite unlikely that higher-than-normal control of viruses is needed or will be required.

[End of comments]

We believe that the material in this summary, coupled with information added to the CWMP/SEIR, provide a fair, thorough and appropriate response to issues raised during the MEPA review. Please do not hesitate to contact us if any aspect of the response requires clarification or elaboration.

Very truly yours,

WRIGHT-PIERCE

Michael D. Giggey

Michael D. Giggey, P.E.
Senior Vice President

cc: George Meservey, Town of Orleans

Attachments
mdg/hbm

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