

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.

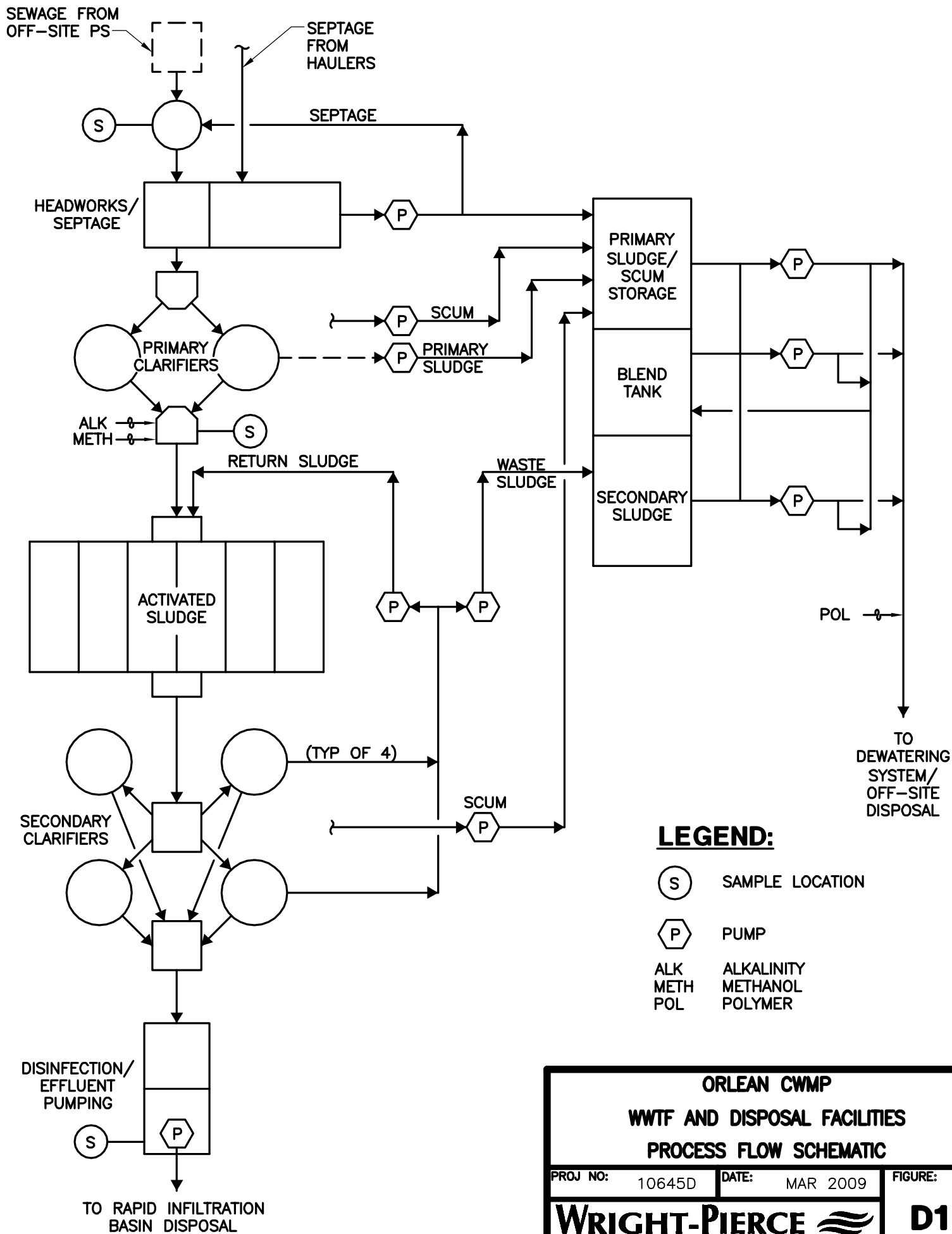
**TABLE D-1
ANTICIPATED EFFLUENT LIMITS**

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.




LEGEND:

(S) SAMPLE LOCATION

(P) PUMP

ALK ALKALINITY
 METH METHANOL
 POL POLYMER

ORLEAN CWMP		
WWTF AND DISPOSAL FACILITIES		
PROCESS FLOW SCHEMATIC		
PROJ NO:	10645D	DATE: MAR 2009
		D1
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.

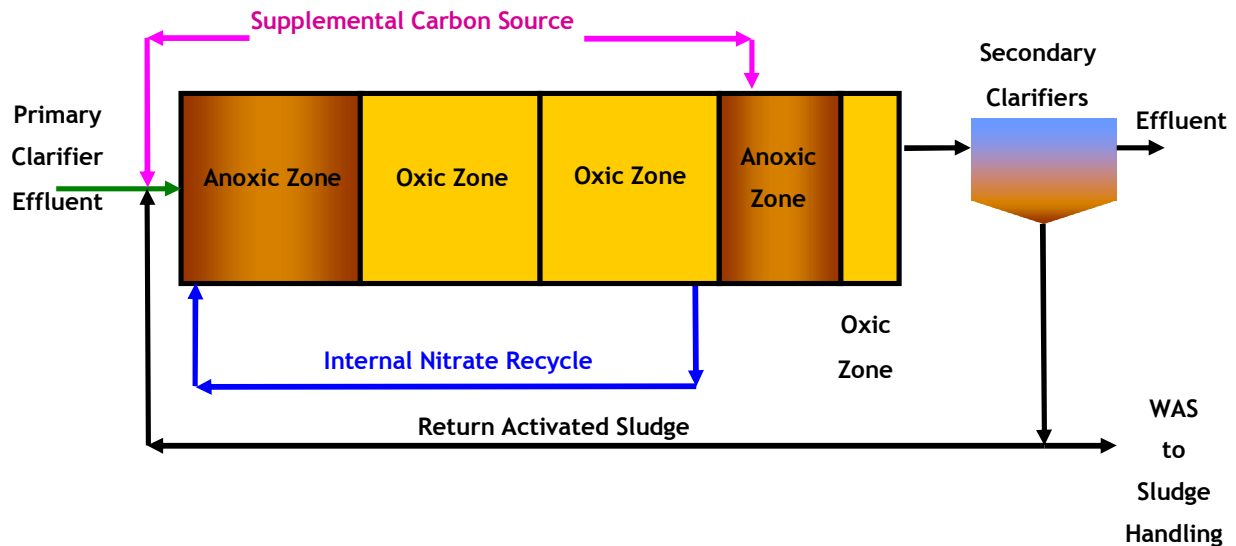
Based on the above, criteria, the following process alternatives were "shortlisted" for further evaluation:

- 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**



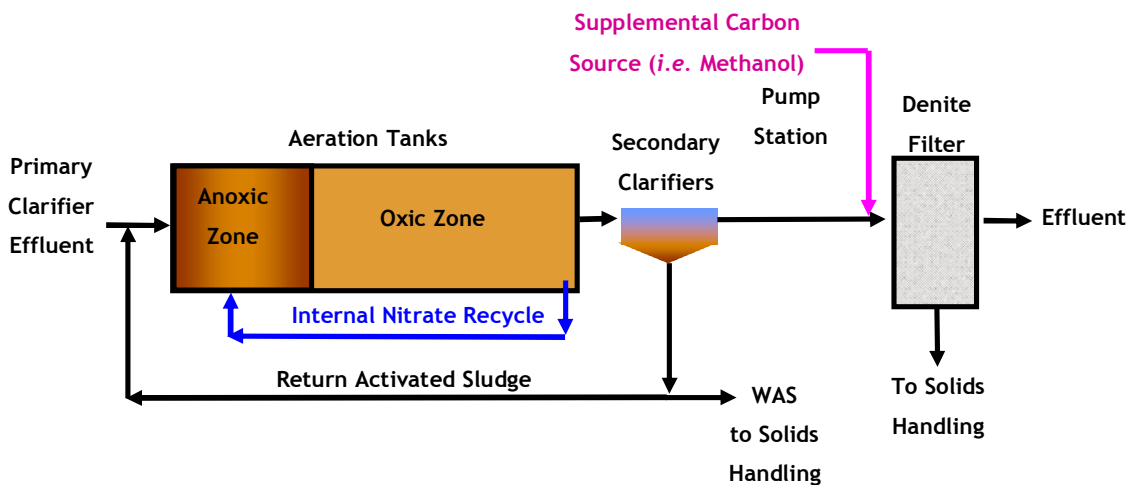
Four-Stage Bardenpho Process (SBR)

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**

<i>System</i>	<i>Advantages</i>	<i>Disadvantages</i>
<u>Alternative #1</u> <u>Conventional</u> <u>Bardenpho</u>	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.	
<u>Alternative #2</u> <u>SBR Bardenpho</u>	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.	
<u>Alternative #3</u> <u>MLE SBR w/</u> <u>Denitrification Filters</u>	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.

**TOWN OF ORLEANS, MASSACHUSETTS
 ADVANCED WASTEWATER TREATMENT FACILITIES
 BASIC DESIGN DATA**

REV. 21 Apr 2009, E/JL

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

**TOWN OF ORLEANS, MASSACHUSETTS
ADVANCED WASTEWATER TREATMENT FACILITIES
DESIGN DATA SUMMARY - ALL FLOW**

REV. 21 Apr 2009, E.JL
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			

**TOWN OF ORLEANS, MASSACHUSETTS
ADVANCED WASTEWATER TREATMENT FACILITIES
DESIGN DATA SUMMARY - ALL FLOW**

REV. 21 Apr 2009, E.JL
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), μ W-s/cm ²	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**

REV. 21 Apr 2009, E.JL
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				

**TOWN OF ORLEANS, MASSACHUSETTS
ADVANCED WASTEWATER TREATMENT FACILITIES
DESIGN DATA SUMMARY - ALL FLOW**

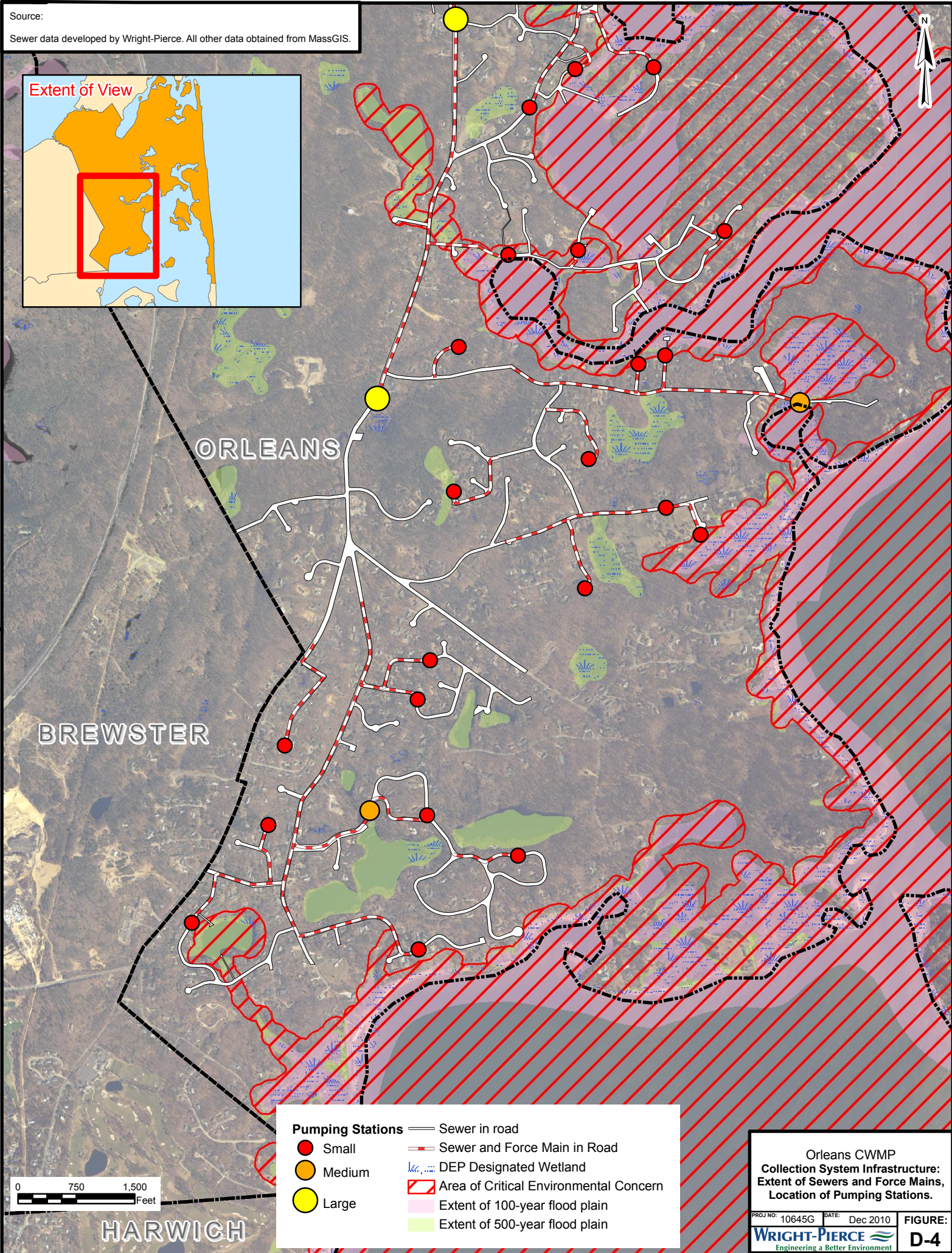
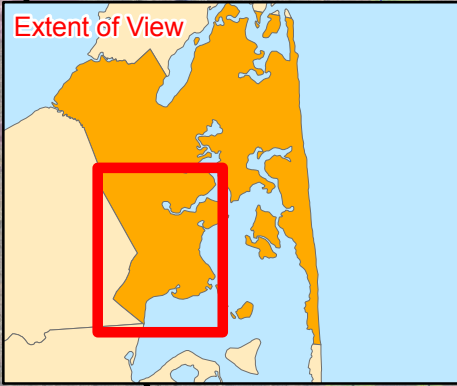
REV. 21 Apr 2009, EJJ
No. Installed
During Phase
1 4/5 EXT

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.

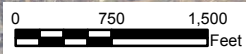
Source:
Sewer data developed by Wright-Pierce. All other data obtained from MassGIS.



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BREWSTER

HARWICH



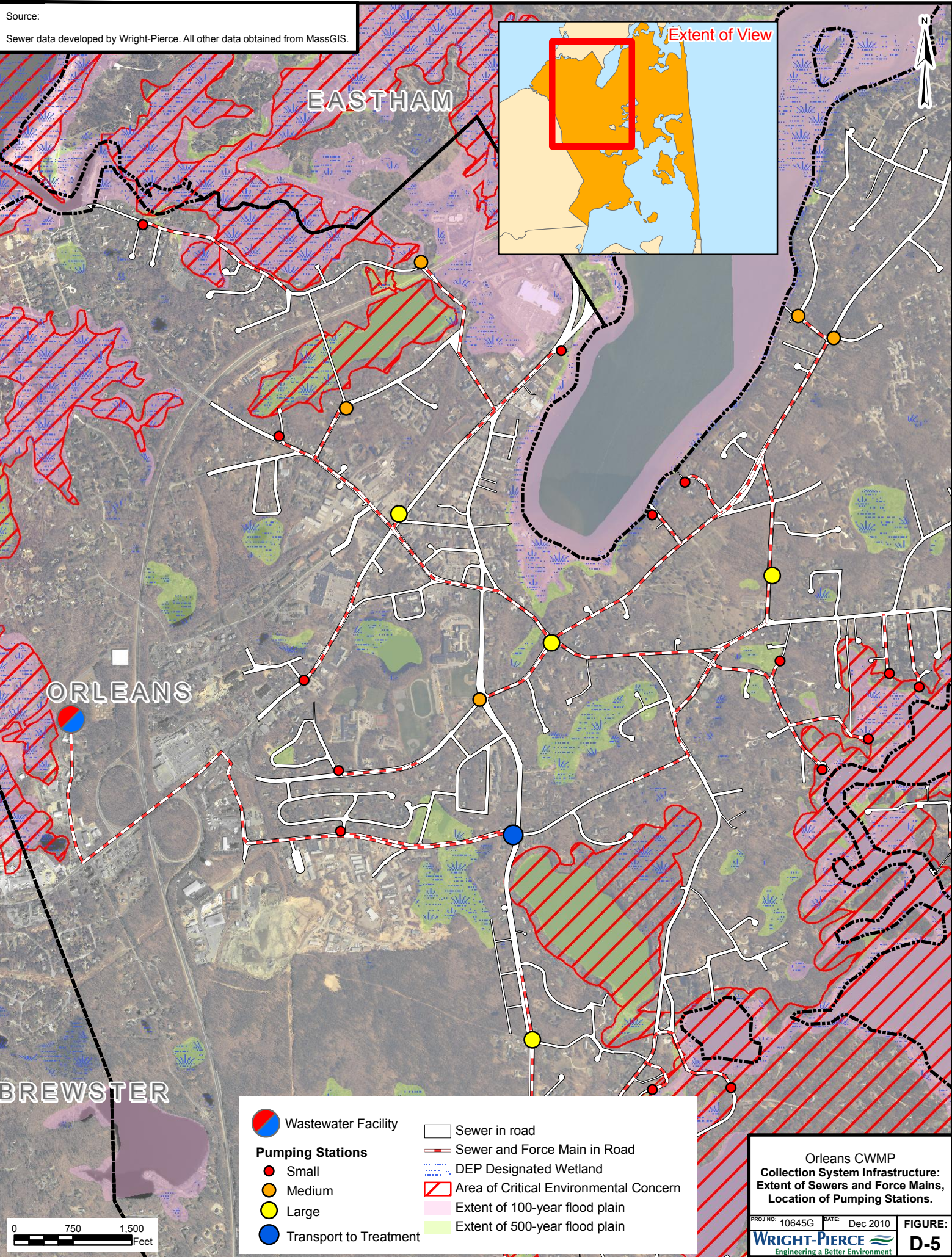
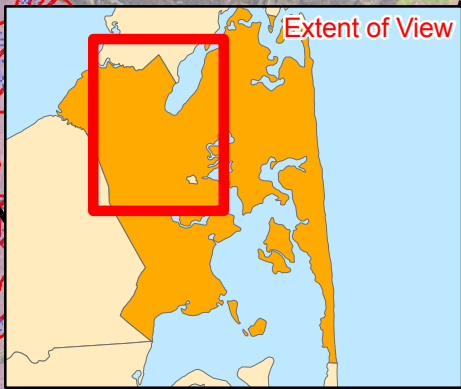
Pumping Stations	— Sewer in road
● Small	- - - Sewer and Force Main in Road
● Medium	⦿ DEP Designated Wetland
● Large	▭ Area of Critical Environmental Concern
	▭ Extent of 100-year flood plain
	▭ Extent of 500-year flood plain

Orleans CWMP
Collection System Infrastructure:
Extent of Sewers and Force Mains,
Location of Pumping Stations.

PROJ NO: 10645G	DATE: Dec 2010	FIGURE:
WRIGHT-PIERCE Engineering a Better Environment		D-4

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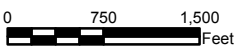
Source:
Sewer data developed by Wright-Pierce. All other data obtained from MassGIS.



	Wastewater Facility		Sewer in road
Pumping Stations			Sewer and Force Main in Road
	Small		DEP Designated Wetland
	Medium		Area of Critical Environmental Concern
	Large		Extent of 100-year flood plain
	Transport to Treatment		Extent of 500-year flood plain

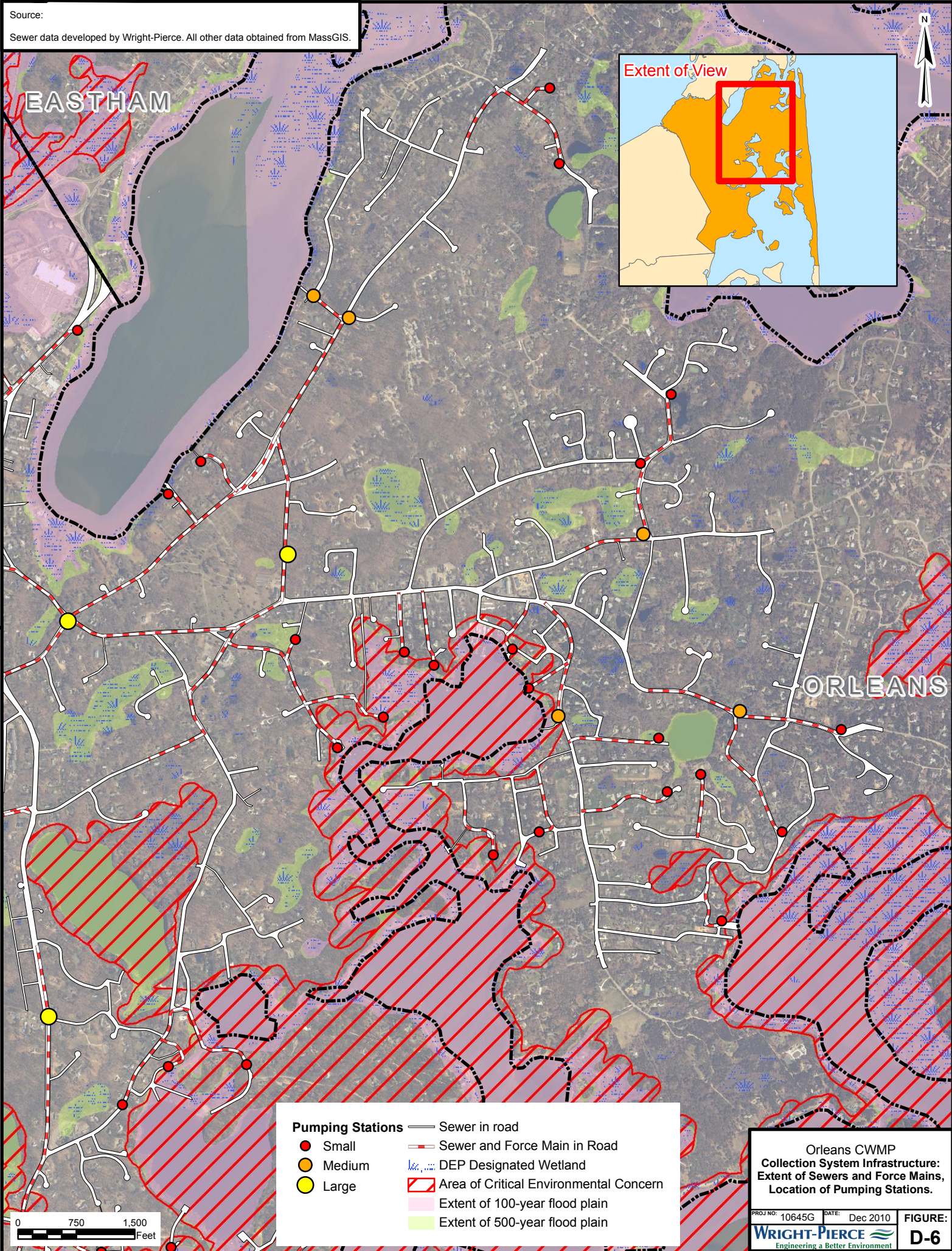
Orleans CWMP
Collection System Infrastructure:
Extent of Sewers and Force Mains,
Location of Pumping Stations.

PROJ NO: 10645G	DATE: Dec 2010	FIGURE:
		D-5
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

- | | |
|-------------------------|--|
| Pumping Stations | — Sewer in road |
| ● Small | — Sewer and Force Main in Road |
| ● Medium | DEP Designated Wetland |
| ● Large | ▨ Area of Critical Environmental Concern |
| | Extent of 100-year flood plain |
| | Extent of 500-year flood plain |

Orleans CWMP
Collection System Infrastructure:
Extent of Sewers and Force Mains,
Location of Pumping Stations.

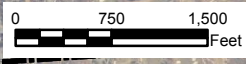
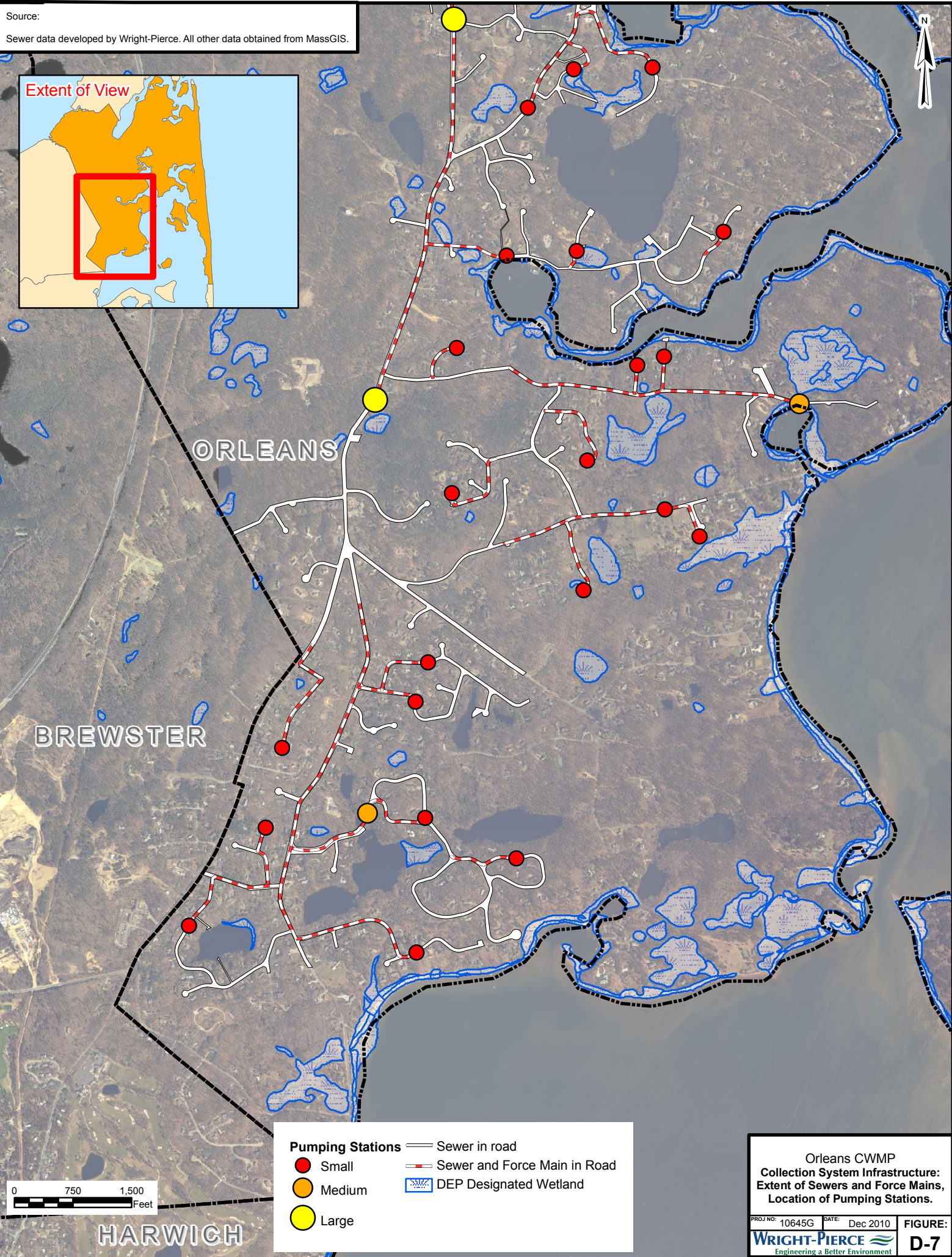
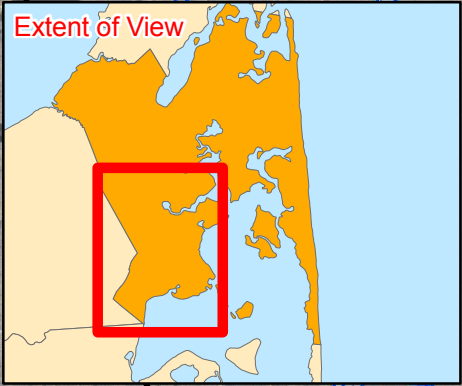
PROJ NO: 10645G DATE: Dec 2010 **FIGURE:**
WRIGHT-PIERCE **D-6**
Engineering a Better Environment

0 750 1,500
Feet



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Source:
Sewer data developed by Wright-Pierce. All other data obtained from MassGIS.



Pumping Stations	— Sewer in road
● Small	— Sewer and Force Main in Road
● Medium	■ DEP Designated Wetland
● Large	

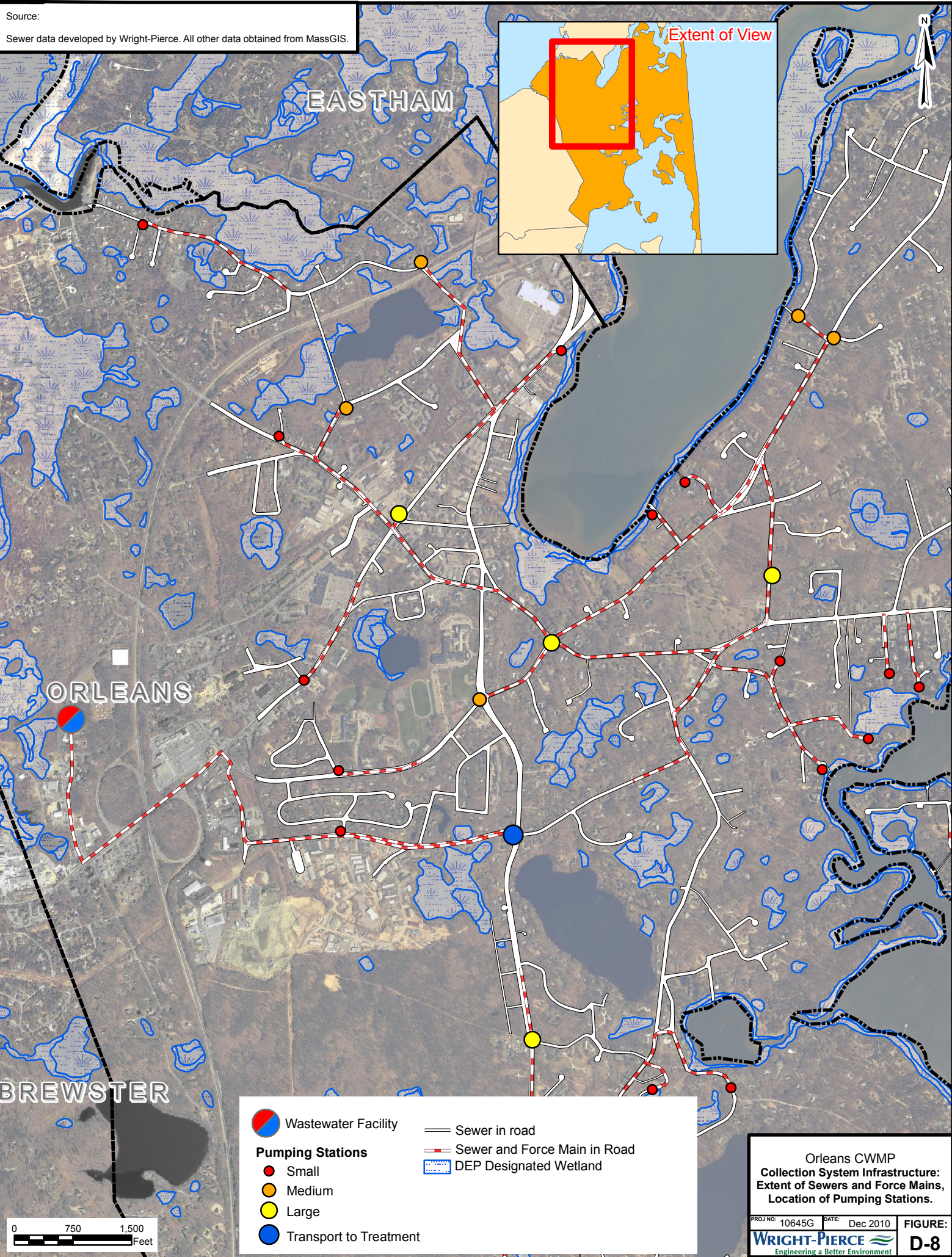
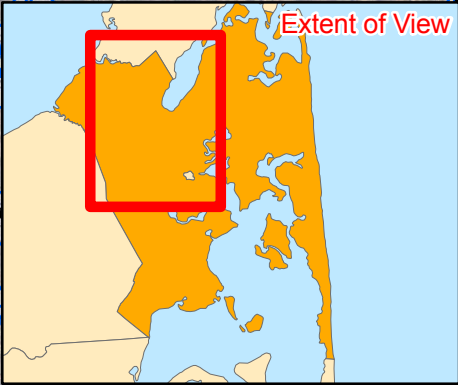
Orleans CWMP
Collection System Infrastructure:
Extent of Sewers and Force Mains,
Location of Pumping Stations.

PROJ NO: 10645G	DATE: Dec 2010	FIGURE: D-7
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WRIGHT-PIERCE
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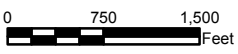
Source:
Sewer data developed by Wright-Pierce. All other data obtained from MassGIS.



	Wastewater Facility		Sewer in road
Pumping Stations			Sewer and Force Main in Road
	Small		DEP Designated Wetland
	Medium		
	Large		
	Transport to Treatment		

Orleans CWMP
Collection System Infrastructure:
Extent of Sewers and Force Mains,
Location of Pumping Stations.

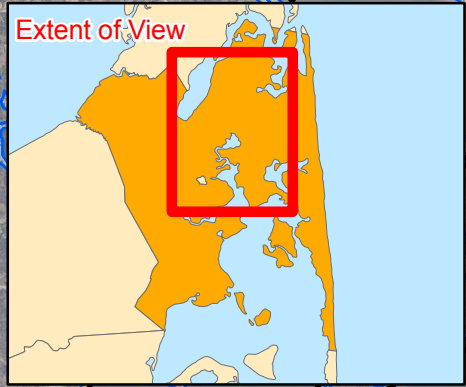
PROJ NO: 10645G	DATE: Dec 2010	FIGURE:
		D-8
<small>Engineering a Better Environment</small>		



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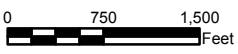
Source:
Sewer data developed by Wright-Pierce. All other data obtained from MassGIS.

EASTHAM



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Pumping Stations	— Sewer in road
● Small	— Sewer and Force Main in Road
● Medium	■ DEP Designated Wetland
● Large	



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

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