Appendix 1-4

Regional Wastewater Evaluations for Yarmouth and Barnstable

STEARNS & WHELER LLC
Environmental Engineers & Scientists

Technical Memorandum

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Date: January 15, 2009

Subject: Regional Wastewater Evaluations for Yarmouth and Barnstable, Massachusetts
Summary of Task A Evaluations

BACKGROUND

The Town of Yarmouth is in the process of developing a Comprehensive Wastewater Management Plan to address nitrogen loading to its coastal estuaries. As part of this process, sewer needs and alternatives have been evaluated. One alternative is to connect a portion of flow from Yarmouth to the Hyannis Water Pollution Control Facility (WPCF), with treated water returned to Yarmouth for groundwater recharge. Stearns & Wheler has been tasked with evaluating the feasibility and costs associated with the transport of wastewater from Yarmouth to the Hyannis WPCF, treatment at this facility, and return of the treated water to Yarmouth. Three scenarios of varying flow contribution have been identified for evaluation.

Stearns & Wheler's tasks have been divided into two groups: Task A evaluations and Task B evaluations. The Task A evaluations are broad perspective evaluations to present initial findings, order of magnitude costs, and the identification of important issues that should be evaluated in further detail if desired by the Towns of Yarmouth and Barnstable. The Task B evaluations would have more detailed evaluations and cost development if requested by the two Towns.

The purpose of this memorandum is to outline the findings and costs of the Task A evaluation for the possible transport of wastewater from the Town of Yarmouth to the Hyannis WPCF for treatment and transport of the treated water back to Yarmouth.

SCENARIOS & EVALUATIONS

Three potential flow scenarios have been identified, as depicted in Table 1 below.

Table 1: Scenarios for Connection of Yarmouth Areas

Scenario	Pump Station	Areas Connected	Max Mo. Flow (MGD)
1	VP1	VS1	0.18
2	P1	VS1, PS1, GS1	0.30
3	P1	VS1, PS1, GS1, PS2.1, PS2.2, VS2, GS2	0.64

The source of the wastewater flows (pumpstations and areas connected) is depicted in the Town of Yarmouth Phase IV CWMP figure, included as Attachment A. As shown in Table 1, three scenarios exist for connection of Yarmouth areas to the Hyannis WPCF. The scenarios vary in their coverage and flow, encompassing either only a smaller section of western Yarmouth, or a significant portion of the west side of the Town. The flows depicted will have a varying impact on the Hyannis WPCF. All unit processes at the WPCF are currently capable of handling flows of this magnitude, but the capacity is currently allocated to sewer expansion in the Town of Barnstable. As such, treatment facility expansion at the Hyannis WPCF would be required regardless of the scenario chosen.

For each scenario, the costs have been developed for connection to the WPCF, with a treated water force main returning to Yarmouth for groundwater recharge. A sub-evaluation is completed for each scenario. The sub-evaluation develops costs for connecting a wastewater force main directly to the Hyannis WPCF as well as the costs for connecting a wastewater force main from Yarmouth to the existing gravity sewer closest to the Barnstable-Yarmouth border.

The shortest route to the Hyannis WPCF from the Yarmouth border is along State Routes 132 and 28, with a small portion on Bearse's Way (see Figure 1 attached). Installation along this busy stretch may cause difficulties. In addition, installation of piping in and around state roads requires special construction methods and materials, increasing the cost of installation in these areas. While there are no known restrictions to installing sewers in these roads (such as Mass. Highway prohibitions to cut the pavement after road reconstruction) at this time, this route should be investigated further as a more detailed design is developed.

Connection to the closest gravity sewer also has drawbacks. Recent evaluation of sewer capacity in the Town of Barnstable has shown severe limits to the capacity of existing gravity sewer near the Yarmouth border. In order to connect flows on the order proposed in the scenarios above, a complete rebuild of the sewer would be required to prevent surcharging. In addition, the pump station which receives this flow currently operates near full capacity and additional capacity is currently allocated to sewer expansion in Barnstable. This pump station would require significant upgrades to accommodate any flow from Yarmouth. As such, the evaluation for connection to the existing gravity system incorporates the costs for rebuilding the existing gravity sewer, upgrading the receiving pump station, and installing a new force main to the WPCF (see Figure 2 attached). The treated water force main could be installed in the same trench with the rebuilt gravity sewer and new wastewater force main. This route is less direct, but avoids installation in state roads.

The cost estimates are based on the installation of two wastewater force mains. Current Town of Barnstable practices dictate that two wastewater force mains should be installed to assist with startup flows and to allow operational flexibility. This has been the preferred method of installation and operation on all recent force main extensions in the Town of Barnstable. In general, only one force main will be in use at a given time, with the other serving as backup. As such, one force main is sized to accommodate the peak flow for each scenario, with an additional smaller force main installed as well to handle startup flows and provide a level of redundancy. The installation of dual force mains will assist in keeping velocities high in the force mains during startup to promote scouring and prevent sediment deposition and in limiting the residence time within the force main. The required force main lengths for each scenario are shown in Table 2 below.

Table 2: Force Main Distances – WPCF and Gravity Sewer Connections

	Connect Directly to WPCF	Connect to Existing Sewer
Primary Wastewater Force Main[1] (ft)	10,300	100
Secondary Wastewater Force Main[1] (ft)	10,300	100
Additional Pump Station Force Main (ft)	-	9,400
Treated Water Main[2] (ft)	9,800	13,100
Total Force Main Length (ft)	30,400	22,700

Notes:

1. From Yarmouth border only. Does not include force main in Yarmouth.
2. To Yarmouth border only. Does not include treated water main in Yarmouth.

Sewer Sizing

The wastewater and treated water force mains were sized to achieve the necessary velocities to prevent settling, as noted above. For the wastewater force mains, the velocity is maintained above 3 feet per second (fps) to prevent settling, while in the treated water force main 2 fps is maintained. Lack of settleable solids in the treated water allows for the lower value in the treated water main. TR-16 standards dictate that sewer systems (and thus force mains) should be design for peak flows. Thus, the maximum month flows displayed in Table 1 must be scaled to represent peak conditions. However, the relevant peaking factor depends on the total flow in question. TR-16 supplies peaking factors from average to peak flow over a wide range of total flow conditions. Average flows for each scenario are based on information provided by CDM. The average flows and relevant peaking factors are displayed in Table 3.

Table 3: Peak Flows and Pipe Sizing for Flow Scenarios

Scenario	1	2	3
Max. Mo. Flow (MGD)	0.18	0.30	0.64
Average Flow (MGD)	0.11	0.19	0.40
Average to Peak PF (TR-16)	5.4	5	4.4
Peak Flow (MGD)	0.59	0.93	1.8
Peak Flow (gpm)	410	650	1210
Pipe Size (in)	6	8	12
Velocity (fps)	4.7	4.1	3.5

The pipe sizes determined in Table 3 were used to estimate costs for the installation of the force mains for each scenario. For each scenario, one smaller pipe was included for a secondary wastewater force main, in agreement with good engineering practice, and one larger pipe was included to convey treated water (at a lower velocity). The pipe sizes for each scenario are shown in Tables 4.

Table 4: Force Main Sizes for Different Scenarios

Scenario	1	2	3
Primary Wastewater Force Main Size[1]	6 in.	8 in.	12 in.
Secondary Wastewater Force Main Size[2]	4 in.	6 in.	10 in.
Treated Water Main Size[3]	8 in.	10 in.	14 in.

Notes:

1. Sized to achieve 3 ft/s at peak flow.
2. Smaller wastewater force main to provide redundancy, assist with startup flows.
3. Sized to achieve 2 ft/s at peak flow.

WPCF Improvements

The Hyannis WPCF is currently undergoing an upgrade to its treatment processes which is expected to be complete by early 2009. This upgrade will expand the maximum month treatment capacity of the facility to 4.2 MGD. The heart of the upgrade is the installation of a new aeration tank, which expands the advanced secondary treatment process and nitrogen removal capabilities of the facility, which are the components that had been limiting the capacity of the overall facility. The new capacities of the various liquid stream unit processes are shown in Table 5 below.

Table 5: Capacities of Liquid Stream Unit Processes

Unit Process	Flow Condition	Capacity (MGD)
Grit Chambers	Peak	16.4
Parshall Flumes	Peak	15.6
Primary Clarifiers	Average	5.6
Secondary Treatment/Nutrient Removal	Max. Month	4.2
Secondary Clarifiers	Max. Month	4.8
Chlorination	Peak	13.8

While the current maximum month flow to the WPCF is approximately 2.5 MGD, wastewater facilities planning in the Town of Barnstable has resulted in the allocation of the additional flow capacity to several planned sewer extension areas within Barnstable. Thus, the connection of any portion of Yarmouth would require expansion of the Hyannis WPCF. This expansion would include an additional aeration tank to match the three existing. Each aeration tank provides approximately 1.4 MGD of treatment capacity under maximum month conditions. As such, none of the three scenarios considered would result in Yarmouth consuming the entire capacity of the upgrade.

However, as noted in Table 5, the current maximum month capacity of the secondary clarifiers is 4.8 MGD. Thus, although the current limiting factor can be upgraded by adding an additional aeration tank, the clarifiers would then become the limiting factor. While none of the scenarios for connecting flows from Yarmouth would result in total maximum month flows greater than 4.8 MGD, they would consume the remaining available capacity of the secondary clarifiers and necessitate an upgrade before additional Barnstable flows can be accommodated. The method for expanding the secondary clarification process

at the WPCF has not yet been determined. As such, costs developed in this memorandum do not incorporate costs associated with upgrading this unit process to meet flows beyond 4.8 MGD. Further investigation or negotiation will be required to determine a flow sharing agreement that accommodates the capacity of the clarification process. Other unit processes listed in Table 5 have sufficient capacity to accommodate the addition of Yarmouth flows, but Yarmouth may be responsible for some of the invested capital costs for the existing facilities.

In addition, the Hyannis WPCF will need to undergo a solids handling upgrade. This upgrade is planned for the time when the maximum month flow approaches 3.0 MGD, as the current solids handling capabilities do not reflect the upgraded maximum month capacity of the secondary treatment process. The design criteria of this upgrade may be altered depending on flow contributions from Yarmouth.

As part of the current upgrade, spare force main connections were installed in the headworks for future connections. Thus, if the force main is conveyed to the WPCF, there is an area for connection in place.

Once the wastewater has been treated at the Hyannis WPCF, the treated water is conveyed to a wet well and pump gallery that disperses treated water to the many sand beds on the site for groundwater recharge. Yarmouth's wastewater will be treated in conjunction with all other wastewater currently treated at the site and Yarmouth's share of the treated water will flow to a dedicated pump station to convey the water back to Yarmouth through the treated water force main. As such, the effluent quality will be similar to that which is currently achieved at the Hyannis WPCF. However, with a long treated water force main, there is potential for regrowth of bacteria in the pipe and exceedance of disinfection requirements at the discharge point in Yarmouth. The Town of Yarmouth should be prepared to make provisions for additional disinfection at the recharge site. These costs are not included in this evaluation. The costs are based on the installation of a dedicated pump station at the Hyannis WPCF to convey treated water back to Yarmouth. Further investigation may be performed in the future to determine if modifications to the pump gallery could alleviate the need for a separate pump station.

Capital Cost Estimating Methodology

In general, unit costs are used to estimate construction costs for items such as sewer piping, pump stations, excavation, backfill, mobilization, surface restoration, and other costs. Unit costs are developed based on a combination of the following:

- Schedule of values from recent pipeline construction jobs (water main, gravity sewer, force main and low pressure sewer) in Falmouth, Hyannis and other coastal areas in the Northeast.
- Past engineering experience for similar projects.
- Direct quotes from equipment manufacturers for selected items and other material costs.
- All costs reflect a December 2008 Engineering News-Record Cost Index of 8551.
- All capital costs include a 30% Contingency factor and a 30% Fiscal, Legal, and Engineering factor.

Costs for upgrades at the WPCF are based on the recent construction project of similar scope (installation of new aeration tank and blower) and similar engineering needs.

Sewer Capital Costs

The following is a list of unit cost items that have been included in developing the cost estimate, and a general identification, understanding and basis of these costs:

General Items -

1. *Sewer Testing* – a cost to the contractor to test the sewer for leaks and pressure in force main applications.

Sewer Items – Pipe and other appurtenance costs include:

1. *Gravity Mains* – a cost to excavate, install and backfill the gravity mains including pipe bedding. Costs rise as the size of the pipe installed and the depth of installation increases.

2. *Manholes* – cost to install manholes for gravity sewer service.

3. *Bypass Pumping* – a cost for the contractor to rent and operate bypass pumping equipment. Because the gravity sewer system is being replaced, the current system must be kept active

while the new pipes are being installed. When a portion of the existing system must be interrupted, bypass pumping will be required.

4. *Force Mains* – a cost to the contractor to excavate, install and backfill the force mains including pipe bedding required for the installation. Costs depend on the size of the pipe.

5. *Air Release / Flushing Manholes* – a cost to the contractor to install air release manholes at the high points in the force main and flushing manholes at the low points.

Trench and Restoration Items – Because all installation will be in a common trench (except in the immediate vicinity of the WPCF) one cost can be considered for trench excavation. The estimated trench width to install three pipes is 7 feet. Trench and restoration unit costs include:

1. *Control Density Fill* – a cost to install flowable fill required on state roads. Approximately 2.5 feet depth will be required in the trench for installation in state roads.

2. *Trench Base* – a cost to install trench sub-base prior to paving. Approximately 20" depth will be required on state roads, with 6" required on Town roads.

3. *Paving* – a cost to install paving for the full trench width. 7" is estimated for state roads, with 3-6" required on Town roads.

4. *Loam* – cost to install loam above trenches not located within the road.

5. *Police Detail* – a cost for police officers to direct traffic while the pipe is installed. Four officers per day are estimated for installation in the road, with two required when installed on the shoulder. 150 feet per day of trench is estimated due to the number of pipes being installed and the congested nature of the installation location.

6. *Directional Drilling* – Costs to directional drill and install piping beneath intersections. It is believed that this will be necessary for installation at the airport rotary and the intersection of Route 28 and Bearse's Way.

For the Task A sub-evaluations to connect to the closest gravity sewer, most existing gravity mains are increased by two sizes to accommodate the new flow, regardless of the scenario. For larger gravity

mains, the increase will be only one size. For instance, existing 8" sewer will be increased to 12", while existing 21" sewer will be increased to 24". This determination can be refined in the Task B evaluations with hydraulic modeling of the existing collection system to determine specific capacity requirements under each of the three scenarios.

WPCF Capital Costs

Costs for upgrades at the Hyannis WPCF are based on the recent construction that took place there that had a similar scope of work. In addition, upgrades to the solids handling facilities and installation of a treated water pump station would be required for full integration of flow from Yarmouth into the operations of the WPCF. The scope of work at the treatment facility is as follows:

- Construct new aeration tank
- Expand aeration building
- Install two new aeration blowers
- Upgrade sludge handling facilities
- Construct treated water pumping station
- Electrical additions/modifications
- Install yard piping and distribution box modifications
- Install new SCADA equipment

Of the items listed, the Town of Yarmouth would be expected to be fully responsible for the costs of the treated water pump station. For the other items, the flow from Yarmouth would only take up a portion of the capacity created. Costs for each scenario have been developed such that Yarmouth is only responsible for its proportion of the costs based on the flow contributed versus the capacity created by the project. As noted previously, costs for any upgrade to the secondary clarifiers is not included at this time, as no determination has been made as to the future upgrades necessary for this process.

No estimate is made for Yarmouth's use of capital facilities that are already installed, have excess capacity, and have significant value. These estimates would need to be completed through

discussions with the two Towns during the Task B evaluations. Upgrades to certain unit processes would not be required to accept flow from Yarmouth. However, Yarmouth will be utilizing a certain portion of the existing capacity, the value of which is yet to be determined. In the future, some discussion regarding or means of estimating the value of invested capital will need to take place and be incorporated before the full costs to Yarmouth for any WPCF upgrade can be determined in detail.

O&M Costs

There are three major additions to the operations and maintenance costs resulting from the addition of flow from Yarmouth:

- Additional power consumption
- Additional sludge disposal costs
- Additional maintenance of piping and treatment processes

The additional O&M costs do not reflect on-going operations and maintenance of the other facilities that would need to be shared with Yarmouth. Similar to the discussion on this subject in the capital costs section, no estimate is made for Yarmouth's portion of the O&M costs of the facilities that are already installed. **These estimates would need to be completed through discussions with the two Towns during the Task B evaluations.**

Power consumption and sludge disposal will be managed in a similar manner to the WPCF upgrade costs. Current power costs and sludge disposal costs are based on fiscal year 2008. Future sludge production quantities were scaled based on current values. Further investigation and negotiation at a later date will be required to precisely quantify the costs Yarmouth will be responsible for.

Cost Estimate Summaries

There are two aspects to the cost estimates for each scenario. The first is the wastewater and treated

water force mains from the Yarmouth border. The Town of Yarmouth is assumed to be responsible for the full cost of installation. As noted in the WPCF costs section above, the cost estimates for the WPCF upgrade have been adjusted based on the amount of flow that the Town of Yarmouth contributes. As noted in Table 1, this varies between 0.18 and 0.64 MGD on a maximum month basis. The addition of a new aeration tank will add 1.4 MGD to the overall plant capacity. Thus Yarmouth is responsible for between 12% and 43% of the total costs, depending on the scenario. The calculation is repeated for the sludge upgrade, which is forecast to increase the solids handling capacity to 5.5 MGD on a maximum month basis. The costs for each scenario using direct connection by force main as shown in Figure 1 are summarized in Table 6 below

Table 6: Sewer and WPCF Capital Costs for Direct Connection to WPCF[1]

Scenario	1	2	3
Wastewater Force Main Costs	$2.5 million	$2.8 million	$3.8 million
Treated Water Main Costs	$1.3 million	$1.5 million	$2.2 million
Trench Costs	$3.5 million	$3.5 million	$3.5 million
Total Force Main Costs	**$7.3 million**	**$7.8 million**	**$8.5 million**
Aeration Tank Costs	$600,000	$1.0 million	$2.2 million
Sludge Upgrade Costs	$40,000	$70,000	140,000
Yarmouth Share of WPCF Upgrade	12%	20%	43%
Effluent Pump Station Costs	$1.1 million	$1.6 million	$2.1 million
Yarmouth's Share of WPCF Costs	**$1.7 million**	**$2.7 million**	**$4.4 million**
Total	**$9.0 million**	**$11 million**	**$13 million**

Notes:
1. Costs estimated to 2 significant digits.

Table 7 summarizes the capital costs if the existing gravity collection system is rebuilt, and a new force main connects the Old Colony pumping station to the WPCF.

Table 7: Sewer and WPCF Capital Costs for Connection to Collection System[1]

Scenario	1	2	3
Wastewater Force Main Costs	$3.6 million	$3.6 million	$3.6 million
Treated Water Main Costs	$1.8 million	$2.0 million	$3.0 million
Gravity Sewer Rebuilding Costs	$1.3 million	$1.3 million	$1.3 million
Trench Costs	$1.5 million	$1.5 million	$1.5 million
Pump Station Upgrade Costs[2]	$4.1 million	$4.5 million	$4.9 million
Total Sewer Upgrade Costs	**$12 million**	**$13 million**	**$14 million**
Aeration Tank Costs	$600,000	$1.0 million	$2.2 million
Sludge Upgrade Costs	$40,000	$70,000	140,000
Yarmouth Share of WPCF Upgrade	12%	20%	43%
Effluent Pump Station Costs	$1.1 million	$1.6 million	$2.1 million
Yarmouth's Share of WPCF Costs	**$1.7 million**	**$2.7 million**	**$4.4 million**
Total	**$14 million**	**$16 million**	**$18 million**

Notes:
1. Costs estimated to 2 significant digits.
2. Details of the pump station and are uncertain and may include relocation to accommodate the future performing arts center.

As shown in Tables 6 and 7, preliminary cost estimates show that direct connection to the WPCF is less costly than rebuilding existing gravity sewer. These estimates can be refined in Task B when more detailed evaluation allows adjustment of the sizes of new gravity sewer.

Table 8 below summarizes the estimated operations and maintenance costs. Electrical costs represent a sharing of all power costs at the facility. While new power will be required to operate the new aeration tank, additional power will be consumed to operate other pieces of equipment at the site as well. Thus a straight line projection (based on flow) from current power consumption is utilized to predict

Yarmouth's share of future power costs. Labor and maintenance costs will have to be negotiated between the two towns.

Table 8: Yearly Electrical and Sludge Disposal Costs[1]

Scenario	1	2	3
Electrical Costs	$32,000	$53,000	$110,000
Sludge Disposal Costs	$16,000	$26,000	$56,000
Total	$48,000	$79,000	$170,000
Notes: 1. Costs estimated to 2 significant digits.			

Another method that should be considered to estimate O&M costs is the current sewer user rate. This is the rate charged by the Town of Barnstable to users for collection and treatment of wastewater. The current rate is $3.63 per 100 ft^3 for residential customers and varies slightly for other user types. This corresponds to a rate of approximately $4,900 per million gallons. Thus, the total cost per year for each scenario can be estimated based on the average flow, as shown in Table 9 below.

Table 9: Yearly Costs at Sewer Billing Rate[1]

Scenario	1	2	3
Average Flow (MGD)	0.11	0.19	0.40
Total Yearly Flow (MG)	40	69	146
Billing Rate ($/MG)	$4,900	$4,900	$4,900
Total Yearly Cost	$200,000	$340,000	$720,000
Notes: 1. Costs estimated to 2 significant digits.			

As shown in Tables 8 and 9, there is a significant difference between a projection based on current electrical and sludge disposal costs and a projection based on the full sewer billing rate. Further discussion between the two municipalities is recommended in the future to determine what structure any agreement on cost-sharing would take. This will allow more detailed study concerning the cost impacts of connecting flow from Yarmouth to the Hyannis WPCF.

SUMMARY OF FINDINGS AND RECOMMENDED NEXT STEPS

Direct connection to the Hyannis WPCF with force mains for wastewater treatment and treated water return is less expensive than connection to the closest portion of the existing gravity system. The capital costs range from $9 million to $13 million and the operating maintenance costs range from $0.048 million to $0.17 million per year based on current electricity and sludge disposal costs. If operations costs are based on the full sewer billing rate, the yearly costs to Yarmouth rise substantially.

These costs should be combined with the costs for the collection and recharge facilities needed in Yarmouth for each scenario to develop total regional scenario costs. The total regional scenario costs can be compared with costs for Yarmouth to treat the flows at new treatment facilities in Yarmouth to provide input on which treatment concept could be less expensive.

If the regional treatment concept appears to be less expensive, additional cost development should be pursued as part of the Task B evaluations.

Attachment A

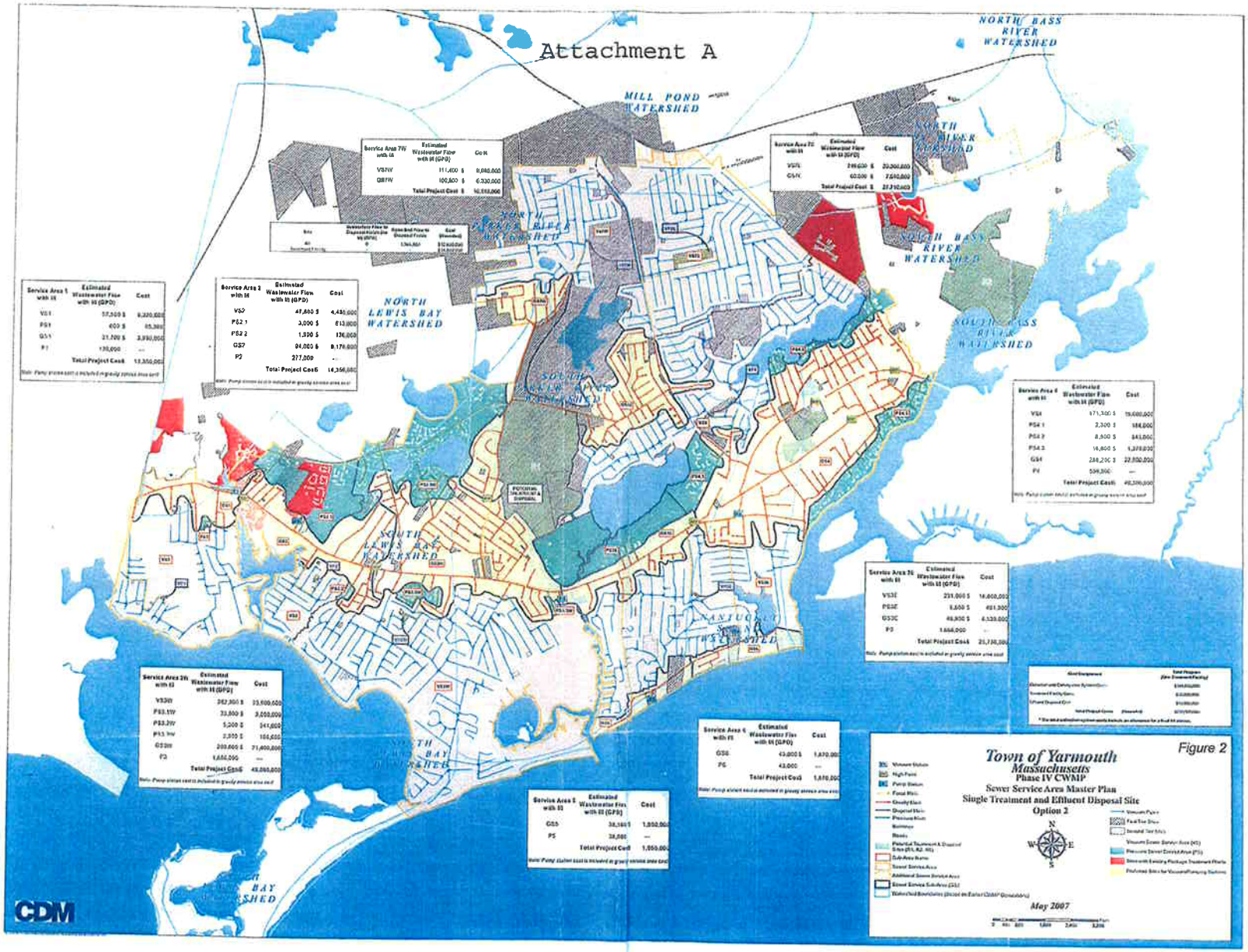
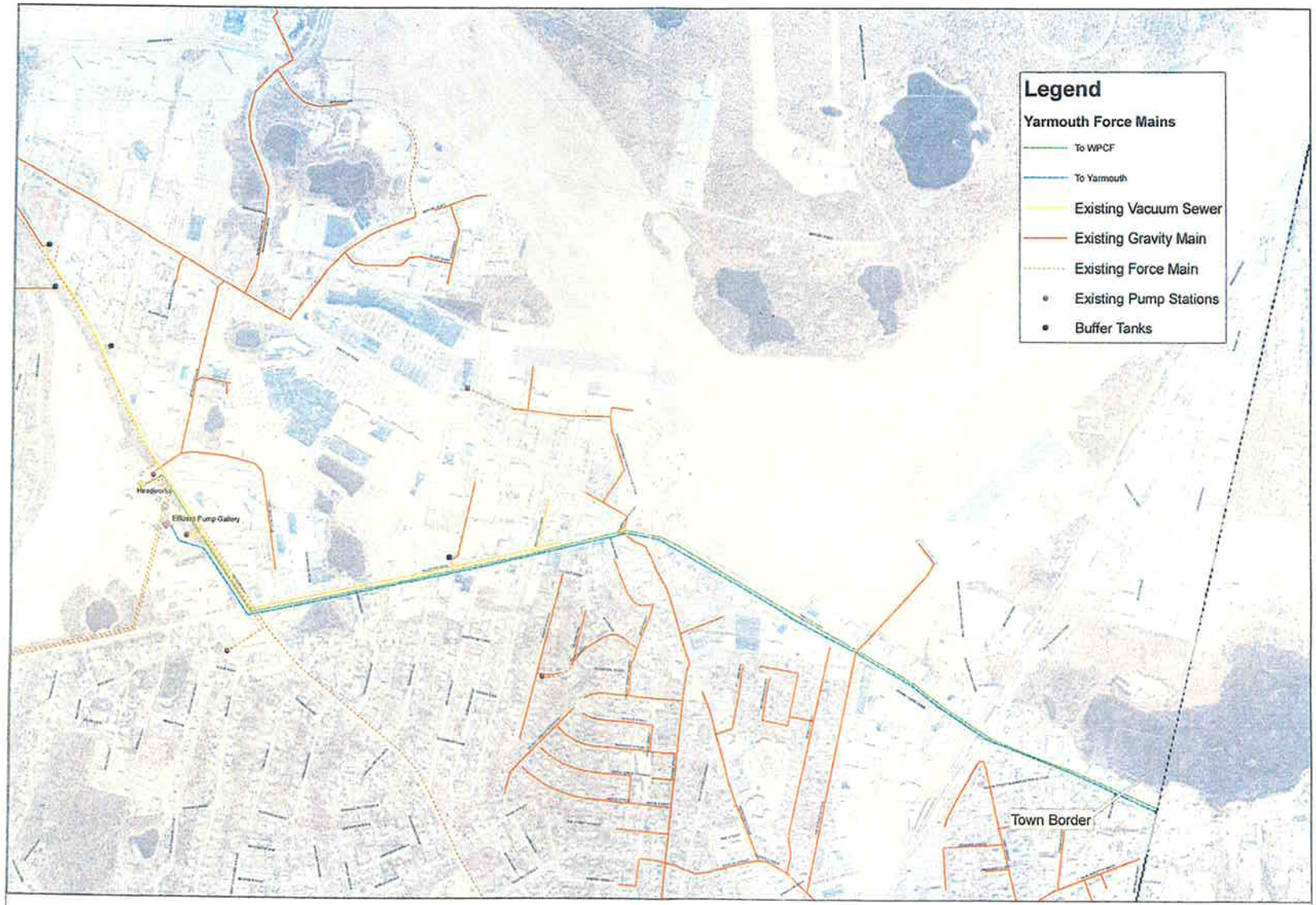
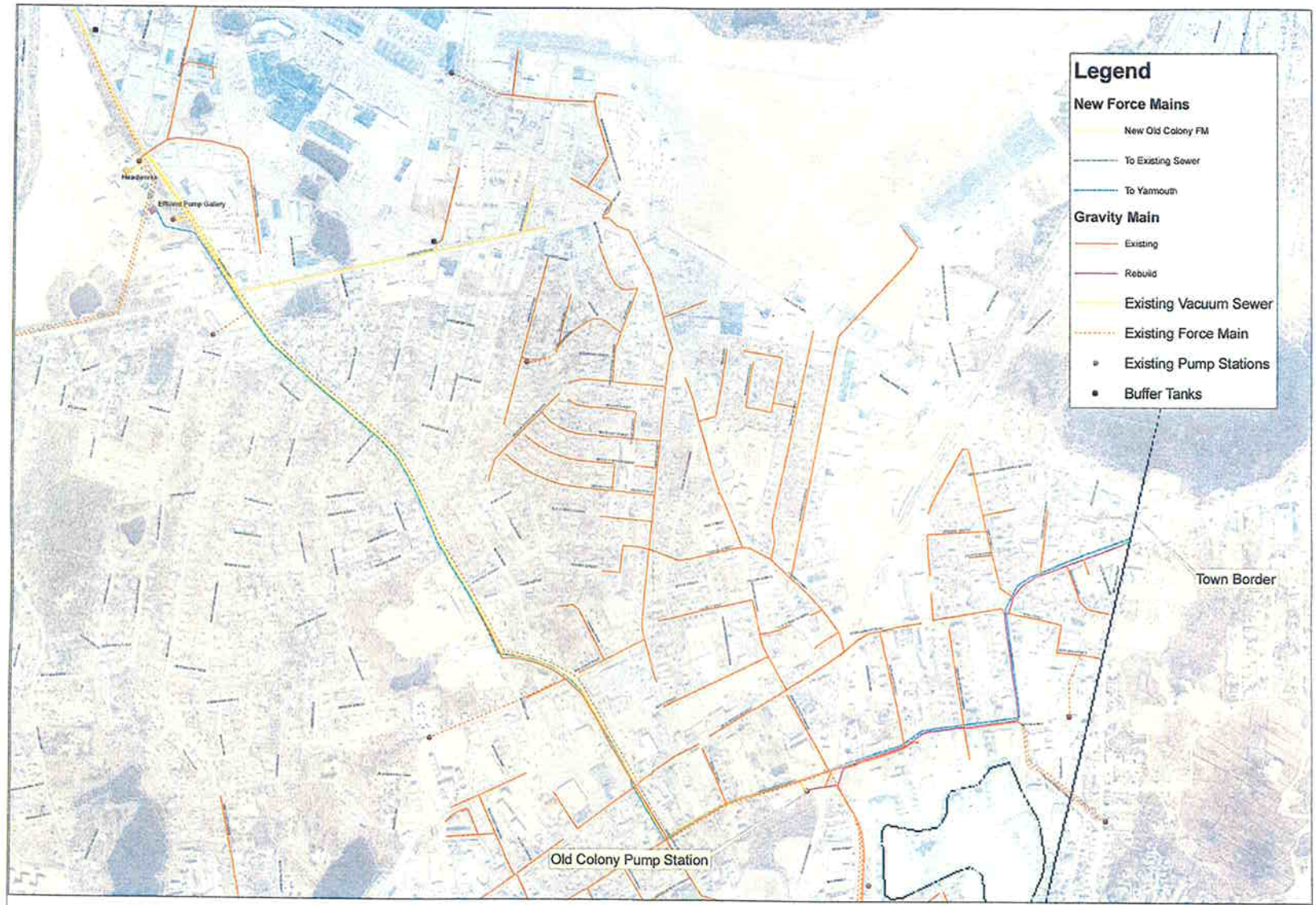


Figure 2


Legend
Yarmouth Force Mains
To WPCF
To Yarmouth
Existing Vacuum Sewer
Existing Gravity Main
Existing Force Main
Existing Pump Stations
Buffer Tanks
Effluent Pump Gallery
Town Border
0 250 500 1,000 1,500 2,000 Feet
1 inch equals 250 feet
STEARNS & WHELER
TOWN OF BARNSTABLE, MASSACHUSETTS
Yarmouth Sewer Area Connection
Direct Force Main Connection
FIGURE 1


Legend
New Force Mains
New Old Colony FM
To Existing Sewer
To Yarmouth
Gravity Main
Existing
Rebuild
Existing Vacuum Sewer
Existing Force Main
Existing Pump Stations
Buffer Tanks
Effluent Pump Gallery
Old Colony Pump Station
Town Border
0 250 500 1,000 1,500 2,000 Feet
1 inch equals 250 feet
STEARNS & WHEELER
TOWN OF BARNSTABLE, MASSACHUSETTS
Yarmouth Sewer Area Connection
Existing Collection System Connection
FIGURE 2