DRAFT

WASTEWATER MASTER PLAN AND LONG TERM CONTROL PLAN UPDATE

Prepared for

City of Portsmouth, New Hampshire

June 1, 2010

DRAFT

WASTEWATER MASTER PLAN AND LONG TERM CONTROL PLAN UPDATE

VOLUME 1
WASTEWATER MASTER PLAN

Prepared for

City of Portsmouth, New Hampshire

June 1, 2010

This is a draft and is not intended to be a final representation of the work done or recommendations made by Weston and Sampson/ Brown and Caldwell.
It should not be relied upon; consult the final report.

Weston & Sampson

100 International Drive, Suite 152
Portsmouth, New Hampshire 03801

Brown and Caldwell

155 Fleet Street, Suite 209
Portsmouth, New Hampshire 03801

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

AO	Administrative Order
BAF	Biological Activated Filter
BAT	Best Available Technology
BC	Brown and Caldwell
BCT	Best Control Technology
BMP	Best Management Practices
BNR	Biological Nutrient Removal
BOD	Biochemical Oxygen Demand
BSF	Base Sanitary Flow
cBOD	Carbonaceous Biochemical Oxygen Demand
CD	Consent Decree
CEPT	Chemically Enhanced Primary Treatment
CIP	Capital Improvement Program
City	The City of Portsmouth, New Hampshire
CMOM	Capacity, Management, Operations and Maintenance
COD	Chemical Oxygen Demand
Corps	U.S. Army Corps of Engineers
CSO	Combined Sewer Overflow
CWA	Clean Water Act
DO	Dissolved Oxygen
EDU	Equalivent Dwelling Unit
EPA	Environmental Protection Agency
FOG	Fats, oils and grease
FY	Fiscal Year
g/L	Grams per Liter
GIS	Geographic Information System
gpd	gallons per day
gpm	gallons per minute
g/yr	gallons per year
HDPE	High Density Polyethylene
I/I	Infiltration and Inflow
IFFAS	Integrated Fixed Film Activated Sludge
JHB	Johannesburg
lbpcd	Pounds per capita per day
lbs/d	Pounds per day
lbsfd	Pounds per square foot per day
LTCP	Long Term Control Plan
MBBR	Moving Bed Biological Reactor
MBR	Membrane Biological Reactor
mg/L	milligrams per liter
mgd	million gallons per day
MLE	Modified Ludzak-Ettinger
MLSS	Mixed Liquor Suspended Solids
MMF	Micromedia Filtration
Mods	Modifications
NGO	Non Governmental Organization
NH_3N	Ammonia as Nitrogen
NHDES	New Hampshire Department of Environmental Services
NH OEP	New Hampshire Office of Energy and Planning
NO_2	Nitrite
NO_3	Nitrate
NPDES	National Pollutant Discharge Elimination System
O_2	Elemental Oxygen
O&M	Operation and Maintenance
PS	Pump Station
PSNH	Public Service of New Hampshire
PWWF	Peak wet weather flow
RBC	Rotating Biological Contactor
RDI/I	Rainfall dependent infiltration and inflow

SBR Sequencing Batch Reactor

TF/SC Trickling Filter/Solids Contact
TKN Total Kjeldahl Nitrogen
UCT University of Capetown

WMP/LTCP Update – Wastewater Master Plan / Long Term Control Plan Update

1. INTRODUCTION

1.1 Purpose of the Wastewater Master Plan and Long Term Control Plan Update

Wastewater from the City of Portsmouth (the City) is treated at the Peirce Island wastewater treatment facility (WWTF) and wastewater from the Pease International Tradeport is treated at the Pease WWTF. Both WWTFs discharge to the Piscataqua River at different outfall locations. More detailed descriptions of the WWTFs are provided in the Wastewater Treatment Facilities section below, as well as in Section 5 of this Wastewater Master Plan and Long Term Control Plan (WMP/LTCP) Update.

In 1985, the City, recognizing the probable need for secondary treatment at Peirce Island, designed a secondary treatment plan and applied for funding. It would have qualified for 95% state and federal funding available at that time. The State NHDES requested that the City withdraw this application so that the state could use the funds for what it considered to be higher priority projects. NHDES applied for a 301(h) waiver on behalf of Portsmouth which was granted by EPA and NHDES. The 301(h) waiver application is included in Appendix A. Thereafter, the Peirce Island Plant operated under a 301(h) waiver. The EPA was prepared to grant the 301(h) waiver again in 2005, ruling that the advanced primary treatment discharge would not have an adverse impact act on the estuary. However, the EPA subsequently discovered that it was procedurally prohibited from granting the 301(h) waiver. As further detailed in the Regulatory section below, and in Section 3 of this WMP/LTCP Update, the 301(h) waiver allowing the Peirce Island WWTF to discharge primary treated effluent was revoked in 2007 and a National Pollutant Discharge Elimination System (NPDES) permit requiring secondary treatment was issued. Because the Peirce Island WWTF cannot meet secondary treatment standards without significant upgrades, the Environmental Protection Agency (EPA) issued an Administrative Order (AO) to the City in August of 2007. The AO set interim discharge limits for the Peirce Island WWTF and required that this WMP/LTCP Update be developed. Subsequent to the issuance of the AO, the City of Portsmouth entered into a Consent Decree (CD) with EPA and NHDES in September of 2009. A copy of the CD is provided in Appendix B.

The purpose of this WMP/LTCP Update is to identify the City's course of action to comply with the CD. The WMP/LTCP Update planning process evaluated options which include the upgrade of the Peirce Island WWTF, the expansion of the Pease WWTF, or to construct a new WWTF at an alternative location. As presented later in this WMP/LTCP Update, the planning process narrowed down to the upgrade of the Peirce Island WWTF or the expansion of the Pease WWTF. Under the Consent Decree, the City also agreed to continue to implement its Long Term Control Plan to complete combined sewer overflow facility upgrades by October, 2013.

Ultimately, this plan selects as the preferred alternative, the expansion, through a phased design and construction approach, of the Pease Facility to serve as the WWTF for the City, discharging to the Lower Piscataqua in the vicinity of the current Pease outfall. The Peirce Island WWTF will be converted to a wet weather facility thus improving the City's ability to deal with stormwater treatment issues. Under the Consent Decree, the City also agreed to continue to implement its Long Term Control Plan to complete combined sewer overflow facility upgrades by October 2013. The preferred alternative is consistent with the City

Council's previous expressions of preference. However, the report recognizes that there are outstanding regulatory and financial issues which could, depending on their outcome, affect the choice of the preferred alternative when resolved. For this reason, the City still considers expansion of the Peirce Island WWTF as a possible alternative.

1.2 Wastewater Treatment Facility Background

The City owns and operates the Peirce Island WWTF which serves the entire sewered area of the City with the exception of the Pease International Tradeport. The Peirce Island WWTF was originally constructed in 1964, and was upgraded in 1992. The major components of this upgrade included new circular primary clarifiers, a sand filtration system, and new disinfection system. The sand filtration system failed to operate as designed, was taken out of service, and a chemically enhanced primary treatment (CEPT) system was placed into operation in 2002.

The Peirce Island WWTF is located on Peirce Island, which is off Marcy Street in the downtown area of the City, as show in Figure 1-1. An aerial view of the Peirce Island WWTF is show in Figure 1-2.

The Peirce Island WWTF has a design capacity of 4.8 million gallons per day (mgd). Because the urban area of Portsmouth is a combined sewer system, peak flows to the Peirce Island WWTF are near 22 mgd during high wet weather flow events. All flow is pumped to the Peirce Island WWTF via the Mechanic Street Pump Station, with the exception of flows from Newcastle, which are pumped to the Peirce Island WWTF via a small pump station in Newcastle. The majority of sanitary flow to the Peirce Island WWTF is residential and commercial wastewater, since there is limited industry within the Peirce Island WWTF collection system.

Figure 1-1. Peirce Island WWTF Location

It is the City's desire to relocate sanitary treatment from Peirce Island and not expand the Peirce Island WWTF, if possible, because of the historical and recreational value Peirce Island provides to the City. This WMP/LTCP Update evaluates this option including the re-use of the Peirce Island WWTF as a wet weather only WWTF.

Figure 1-2. Peirce Island WWTF Aerial View

There are three (3) permitted combined sewer overflows (CSOs) in the City. Combined sewer overflows 10a and 10b are located at South Mill Pond and are activated when system flows exceed the capacity of the collection system and the Mechanic Street Pump Station. Combined sewer overflow 13 is located near the Deer Street Pump Station and is active when flows exceed the capacity of the Deer Street Pump Station.

In addition to the Peirce Island WWTF, the City also owns and operates the Pease WWTF under a long term lease from the Pease Development Authority. The Pease WWTF was an upgrade to the tricking filter WWTF previously owned and operated by the United States Air Force. The Pease WWTF upgrade was constructed in the mid 1990's and treats flows from the Pease International Tradeport using the Sequencing Batch Reactor (SBR) treatment process.

The Pease WWTF is located on Corporate Drive within the Pease International Tradeport, as shown in Figure 1-3. An aerial view of the Pease WWTF is shown in Figure 1-4.

The Pease WWTF has a design capacity of 1.2 mgd, and on average, receives approximately 0.6 mgd of wastewater. The Pease International Tradeport is comprised of commercial and industrial businesses.

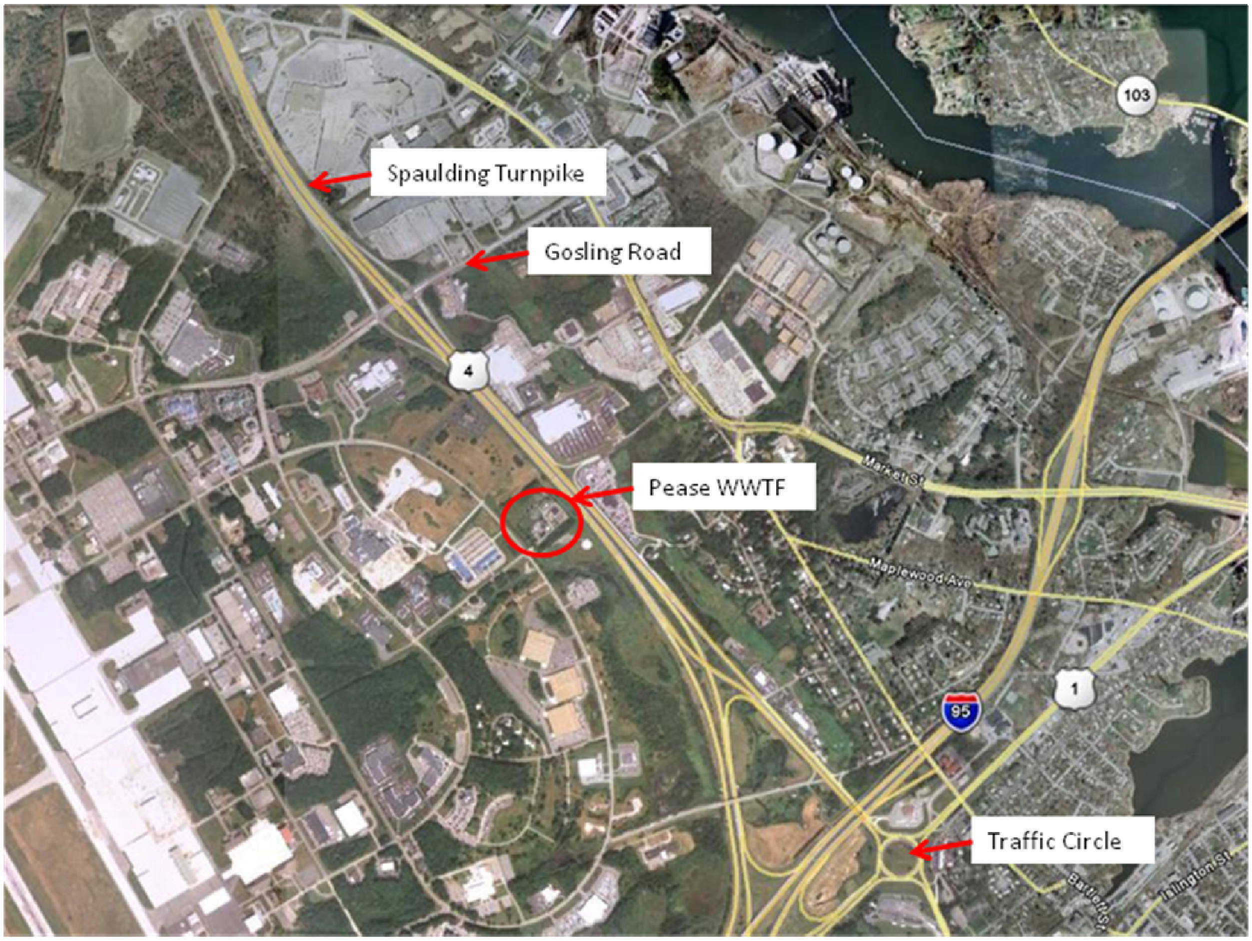


Figure 1-3. Pease WWTF Location

Figure 1-4. Pease WWTF Aerial View

More in-depth information on the Peirce Island WWTF and Pease WWTF is presented in Section 5 of the WMP/LTCP Update.

1.3 Regulatory Issues

The City has operated the Peirce Island WWTF under a 301(h) waiver from 1985 until 2007, when the waiver was rescinded and a NPDES permit requiring secondary treatment standards was issued. The City is currently operating the Peirce Island WWTF under the 2009 CD requirements. The permit does not contain an effluent limit for total nitrogen (TN).

Since the summer of 2007, the EPA and NHDES have stated that TN limits will be set in a future NPDES permit. These permits are issued on a 5 year cycle; therefore, the 2012 permit may have a TN limit. At this time, that limit is not defined by EPA or NHDES. The EPA, NHDES and the City have been engaged in discussions about the development of necessary data to allow setting of effluent limits which are scientifically based. It is believed that these discussions will result in a consensus on discharge limits which will be protective the Great Bay Estuary while assuring the efficient use of municipal resources. Refer to Appendix C for correspondence with NHDES on this subject. The City recognizes that either a Peirce Island WWTF upgrade or the expansion of the Pease WWTF will be required to meet secondary standards and a TN limit. However, the limits established may vary depending on the location of the outfall. The City has asked for guidance from NHDES relative to whether an outfall at an expanded Pease WWTF would be feasible or severely limited. As of the date of this draft report, the City has not received a response. Ultimately, the NHDES response may affect the preferred alternative selection, and the extent of the upgrade will remain undefined until such time that the permit limits are established.

In mid-April 2010, the NHDES stated that a total phosphorus (TP) limit may also be included in a future NPDES permit. Since this WMP/LTCP Update is due in draft form to the EPA and NHDES no later than June 4, 2010, and since the impact of a TP limit may require additional unit processes to meet that limit, the TP issue has not been addressed in this draft WMP/LTCP Update due to time limitations.

More in-depth discussion of the regulatory issues is presented in Section 3 of this WMP/LTCP Update.

1.4 LTCP Update

As discussed above, there are three (3) permitted CSOs within the Peirce Island WWTF collection system. Since 1997 the City has invested over $25 million in the design and construction of dedicated sanitary and storm sewers in the combined sewer area to reduce CSO volumes. Ongoing works to further reduce CSO volumes include the following projects:

- Mechanic Street Pump Station Upgrades, completed in 2009
- Bartlett Street Sewer Separation Project, under construction
- State Street Sewer Separation Project, under construction
- Lincoln Area 3A Sewer Separation Project, construction starts in the summer of 2010
- Cass Street Area Sewer Separation Project, under design
- Evaluating interim measures to control nitrogen and total suspended solids which can be implemented within the current NPDES Permit cycle, on-going

Figure 1-5 shows the impact of these efforts in the reduction of CSO volumes discharged.

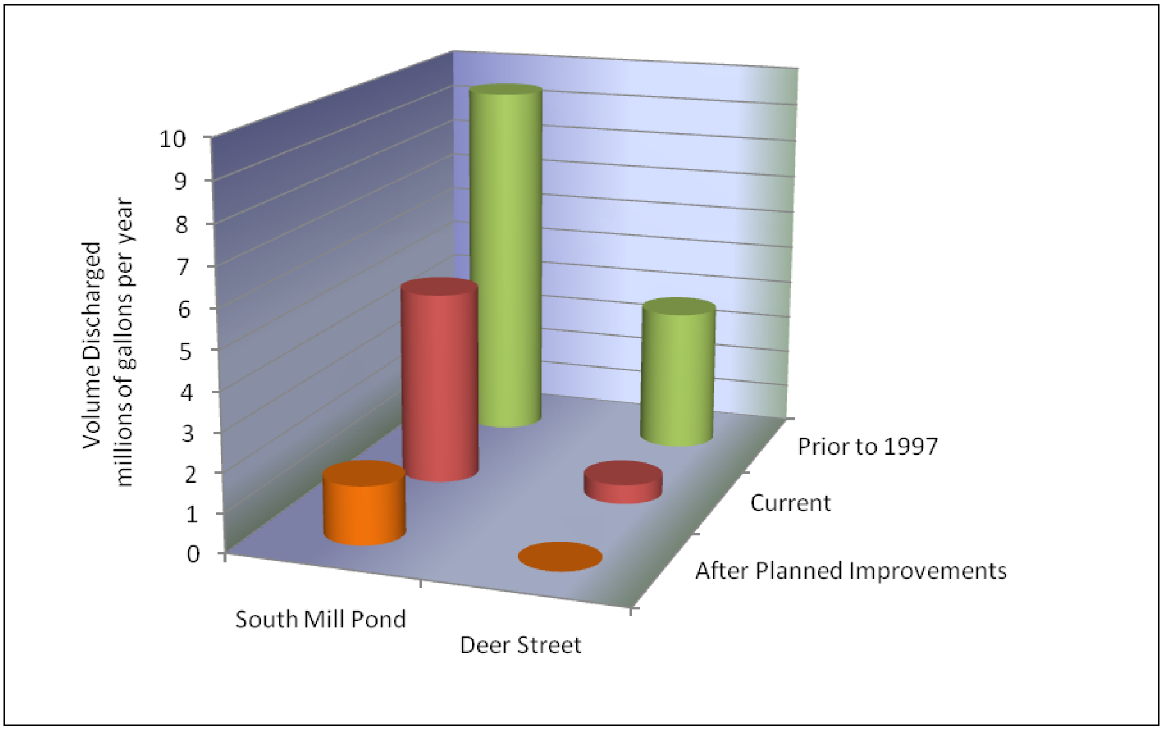


Figure 1-5. Impact of CSO Abatement Efforts

1.5 Master Planning Process

Developing a Master Plan for wastewater treatment is an iterative process that must take into account a number of issues, including regulatory requirements, technical requirements, the City's financial capabilities, and the City's overall goals of sustainability and land use. All of these issues are centered on public and governmental input.

The process begins with an evaluation of the project study parameters, which set the boundaries for the project, both geographically and the planning period(s). The next step is to evaluate the regulatory requirements including the permit limits, which will dictate the treatment processes which may be considered. Once the treatment processes are identified, site layouts can be produced which will identify the land area needed to construct the facility. Once the WWTF location is identified, the impacts to the collection system and LTCP are identified and cost estimates are produced. With the cost estimates, an affordability analysis is completed and, if deemed unaffordable, the process is repeated until a viable solution is found.

A graphical representation of this process is presented in Figure 1-6. Changes to any of the parameters and requirements depicted in Figure 1-6, which may occur throughout the mater planning process, can significantly affect the outcome which means iteration will be necessary to incorporate the modifications.

As an additional step to this process, a value engineering exercise was completed to determine if other alternatives were available which may be more affordable and/or sustainable.

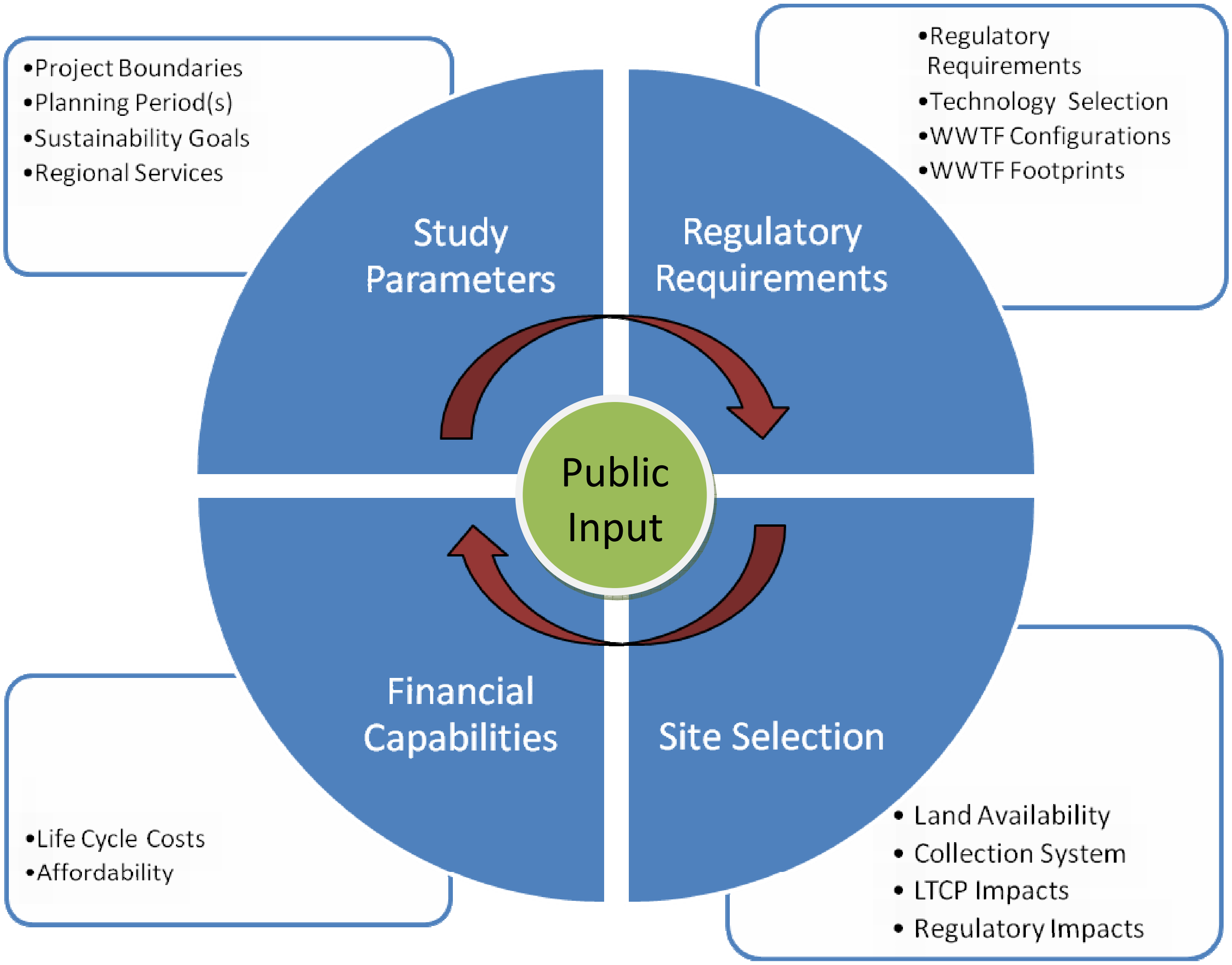


Figure 1-6. Iterative Master Planning Process

1.6 Conclusions

Based upon the WMP/LTCP process, the City's planning team arrived at the following conclusions, which need to be reviewed by EPA and NHDES. Ultimately, the City Council will perform its final review and adopt a preferred alternative and implementation schedule.

1.6.1 Alternatives Considered

The planning process determined that the two most practicable options for long term solutions for both wastewater treatment and CSO events were:

a. expansion of the Pease WWTF on a phased basis, reserving the Peirce WWTF as a wet weather treatment facility, or

b. expansion of the Peirce WWTF for wastewater treatment and resolution the CSO problem through construction of other infrastructure/designed for that purpose.

1.6.2 Alternative Evaluation

However, at this time, the selection between these two alternatives is difficult because of unknowns. The unknowns include regulatory determinations that have not yet been made and increased costs which may result from regulatory decisions. These include the following:

- Expansion of the Pease WWTF would require permitting a major outfall which may prove impractical or overly expensive.
- Thus, future regulatory and financial outcomes could make the expansion of the Pease WWTF overly costly and make the Peirce expansion preferable.

1.6.3 Alternative Selection

The expansion of the Pease WWTF on a "phased basis" is deemed the preferred alternative for a number of reasons including the fact that it preserves Peirce Island as a historical, cultural and recreational resource for the City. Phased construction will allow the City to "right size" the expansion and to take advantage of emerging technologies for the later phases.

The costs of the preferred alternative will require the City to spend roughly $90 million over the next 15 years - the state and federal regulatory programs recognize that affordability may be an issue for some communities and allow for phasing in of improvements to prevent an overly high financial burden on some communities. The City believes that the costs of the WMP and LTCP will require some accommodation from the regulators to prevent overly high impact on ratepayers.

2. STUDY PARAMETERS AND PROJECT BOUNDARIES

2.1 Purpose

The purpose of this section of the Wastewater Master Plan/Long Term Control Plan (WMP/LTCP) Update is to present the study parameters and project boundaries task evaluation. The study parameters include WWTF land needs and siting criteria. The project boundaries include potential regional wastewater treatment; regional ancillary service solutions, including: septage disposal, biosolids processing, and fats, oils and grease (FOG) processing. Please refer to Technical Memorandum (TM) 2, in Volume 3, for the initial findings of this task.

2.2 WMP/LTCP Update Study Parameters

The WMP/LTCP Update study parameters include land needs and site selection criteria, the planning horizons and sustainability goals.

2.2.1 Land Needs for Potential WWTF Sites

As presented in Section 5 of this WMP/LTCP Update, the wastewater treatment scenarios include an upgrade to the Peirce Island WWTF, the expansion of the Pease WWTF, or the construction of a new WWTF as an alternative location to replace either the Peirce Island WWTF or both the Peirce Island WWTF and Pease WWTF.

Using flow and load projections presented in Section 4 of this WMP/LTCP Update, a 4-stage Bardenpho treatment process was sized to serve the City of Portsmouth's wastewater treatment needs through the year 2060, assuming a TN limit of 3 milligrams per liter (mg/L) were issued in a future NPDES permit. This treatment process was used in the land needs analysis since it can meet this potential permit limit in warmer months, and also requires the most land area of the treatment processes considered (presented in Section 5 of this WMP/LTCP Update). Based on our evaluation of the Bardenpho process, a minimum lot size of 10 acres would be required for a new WWTF.

Using the City's Geographic Information System (GIS), potential new WWTF sites were identified based on available GIS overlays. The criteria for selection is based on parcels which are 10 acres or larger of buildable land, or can be combined from contiguous parcels to total 10 acres or more of buildable land. Non-buildable areas were not included in the 10 acre lot size. Non-buildable areas are those that include one or more of the following:

- Wetlands
- Conservation land
- Parks
- Cemeteries
- 50' setback from open water

- Archaeological sites
- Protected wildlife area

Figure 2-1 shows potential WWTF candidate sites which meet the criteria set forth above.

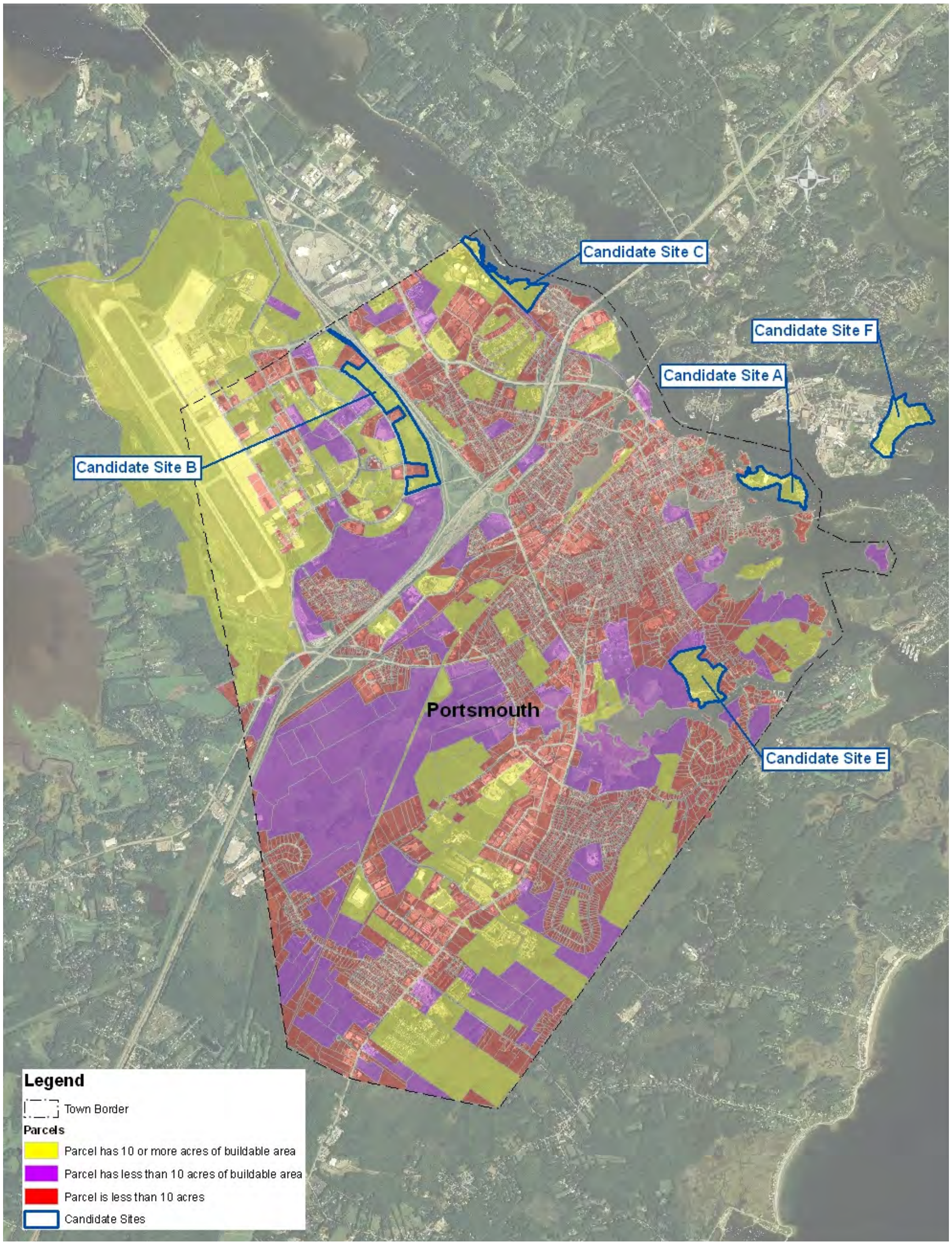


Figure 2-1. Candidate WWTF Sites

2.2.2 Wastewater Treatment Site Evaluation

The space available to construct a secondary treatment process at the Peirce Island WWTF site is limited. The existing Pease WWTF could be expanded and upgraded to treat full build-out flow which would require flow re-direction. Therefore, the Pease WWTF and other sites in the Portsmouth area were evaluated.

2.2.2.1 Candidate WWTF Sites

The candidate WWTF sites identified in the City based on a 10-acre requirement for the Bardenpho process are as follows:

Site Name and Description	Site Reference	Location
Peirce Island WWTF	A	PIT/Portsmouth
Pease WWTF	B	PIT/Portsmouth
Public Service of New Hampshire & Sprague storage site	C	Portsmouth
Jones Avenue	E	Portsmouth
Portsmouth Naval Shipyard	F	Kittery, Maine

2.2.2.2 Preliminary Site Screening

Non-cost site evaluation criteria were developed to evaluate each of the above sites. Each criterion was ranked based on the following scoring system:

- Poor (P): -1 point
- Satisfactory (S): +1 point
- Exceptional (E): +2 points

Site selection screening criteria included the following:

- Candidate sites are undeveloped, under developed, or have potential for redevelopment.
- Size of individual lots or contiguous undeveloped lots are 10 acres or greater in size.
- The candidate site has no historic significance.
- Candidate site is owned by the City, or the City may have the ability to acquire the parcel(s) without the need for a land taking.
- Economic impacts may be minimal to the surrounding area.
- Zoning would allow construction of a WWTF.
- Neighborhood impacts / aesthetics are not a significant concern.
- The candidate site is within a reasonable distance from an existing outfall location (Pease or Peirce Island).
- Transportation access to the candidate site is primarily via roadways which currently handle truck traffic.
- Odor control needs would be minimal based on proximity to residential areas.

Based on the results of the evaluation, the highest ranking alternative sites were as follows:

- The PSNH or Sprague site (Site C), and
- The Pease WWTF (Site B)

The Peirce Island site was evaluated further as a candidate site because it currently hosts one of the City's existing WWTFs and offers potential capital cost savings from the re-use of existing facilities at the WWTF and minimizes changes to the current collection system flow direction. The Peirce Island WWTF also has an existing permitted outfall, in an advantageous location in the Lower Piscataqua River.

Brief descriptions of each candidate site are included in the following sections. The complete site evaluation criteria are provided in Volume 3, TM 5, Appendix A.

2.2.2.2.1 Peirce Island WWTF

As discussed previously, it is the City's desire to relocate the Peirce Island WWTF and reclaim Peirce Island for recreational purposes. If treatment at Peirce Island WWTF is deemed necessary, the City would prefer to keep all treatment within the existing fence line; however, the fenced land area at the Peirce Island WWTF is less than 10 acres. Development outside the current WWTF area could provide upwards of 10 acres of buildable land, although existing 100 foot and 250 foot shore land zoning setbacks would require shore land zoning variances. Smaller footprint, "high rate" treatment processes could be used, which would reduce the land area need compared to the Bardenpho process, and could therefore fit on the site within the existing fence line.

2.2.2.2.2 Pease WWTF

The Pease WWTF site has less than 10 acres of buildable area. However, land adjacent to the WWTF is available to meet the minimum land area required. Portions of the existing WWTF infrastructure could be used with a new WWTF. In addition, the Pease WWTF site lends itself to a phased construction approach, as detailed in Section 5 of this WMP/LTCP Update. The ability to phase construction is integral to the successful implementation of this WMP/LTCP Update, because:

- It will allow the City to use existing excess capacity of the Pease WWTF prior to full expansion of the WWTF, thereby accomplishing environmental benefits sooner,
- It will allow the City to further evaluate design flows as sewer separation projects continue and "right-size" the WWTF, thus providing for a more sustainable solution.
- It will allow the city to take advantage of developing information on technological solutions which may reduce overall costs thereby mitigating important affordability issues which are identified herein.

2.2.2.2.3 PSNH/Sprague Site

Initial investigations ranked the Sprague site high because of its proximity to the river for outfall construction and because the property was on the market, and could therefore be acquired by the City without necessitating a land taking. In addition, Public Service of New Hampshire (PSNH) indicated a willingness to work with the City on the site selection, and offered a land swap, if necessary, for property owned by PSNH. This land swap would provide better access to a river outfall. Both properties ranked nearly equal in the siting criteria and were therefore considered to be one and the same.

However, further investigations completed in TM 5, *WWTF Process, Siting and CSO Abatement Evaluations,* showed the Sprague / PSNH properties held no clear benefit over the Pease WWTF site and would require significant investment by the City for purchase. Therefore, this site was dropped from further evaluation.

2.2.3 Planning Horizons

Planning horizons have been identified as 20 years for the WWTF (Year 2030) and 50 years (Year 2060) for the collection system infrastructure. Additionally, the WWTF site will be evaluated for sustaining flow based expansions for 50 years.

Growth and build-out scenarios for current baseline conditions, 20-year forecasts, 50-year forecast and build-out conditions are presented in Section 4 of this WMP/LTCP Update.

2.2.4 Sustainability Goals

During initial meetings with the City, sustainability goals for the project were established as follows:

- Systems must be expandable as set forth in the planning horizons.
- LEED goals will be used for office areas.
- For operational areas, LEED goals will be considered, but "functionality and durability" must take precedence.
- Systems will be designed to allow reuse and recycling.
- The overall carbon footprint will be considered.
- Costs to achieve sustainability must be acknowledged and the design basis must be validated.
- The utilization of electrical load shedding, utilizing waste heat, water reuse and other sustainable approaches will be evaluated, where appropriate.
- Phasing the project will allow "right sizing."

2.3 Project Boundaries

The project boundaries are the geographical limits of the project. These boundaries include the City of Portsmouth, the Pease International Tradeport, and existing flows from Newcastle, Greenland and Rye, as well as additional municipalities which may desire regional wastewater treatment and/or ancillary services described above.

2.3.1 Regional Services

There are many regional services which the City can provide to neighboring communities, including wastewater treatment, septage receiving, biosolids processing and FOG treatment and disposal. Each of the opportunities is discussed below. It should be noted that for the Peirce Island WWTF alternative septage and FOG receiving was not considered; biosolids processing from other WWTFs was not considered; and only treatment of wastewater from current municipality tributaries to the Peirce Island WWTF was considered.

2.3.1.1 Wastewater Treatment

Municipalities surrounding the City, which may require sanitary sewer service, have been identified as follows:

- Newcastle
- North Hampton
- Greenland
- Stratham
- Rye
- Newington

Only a small portion of Greenland is currently served and this by an agreement with the property owner in Greenland and not via an inter-municipal agreement between Greenland and Portsmouth. Rye has an inter-municipal agreement with Portsmouth for sewer service. Based on past studies, the Route 1 corridor in North Hampton may require sewering to the Hampton border at some time in the future.

2.3.1.2 Biosolids, Septage and FOG

Entities which may desire the City to provide biosolids processing and disposal, septage receiving and FOG processing and disposal have been identified as all 44 communities in the Seacoast Regional Wastewater Management Study, as well as select wastewater treatment facilities in Maine, including Kittery, York, Berwick and South Berwick. These communities are shown in Figure 2-2.

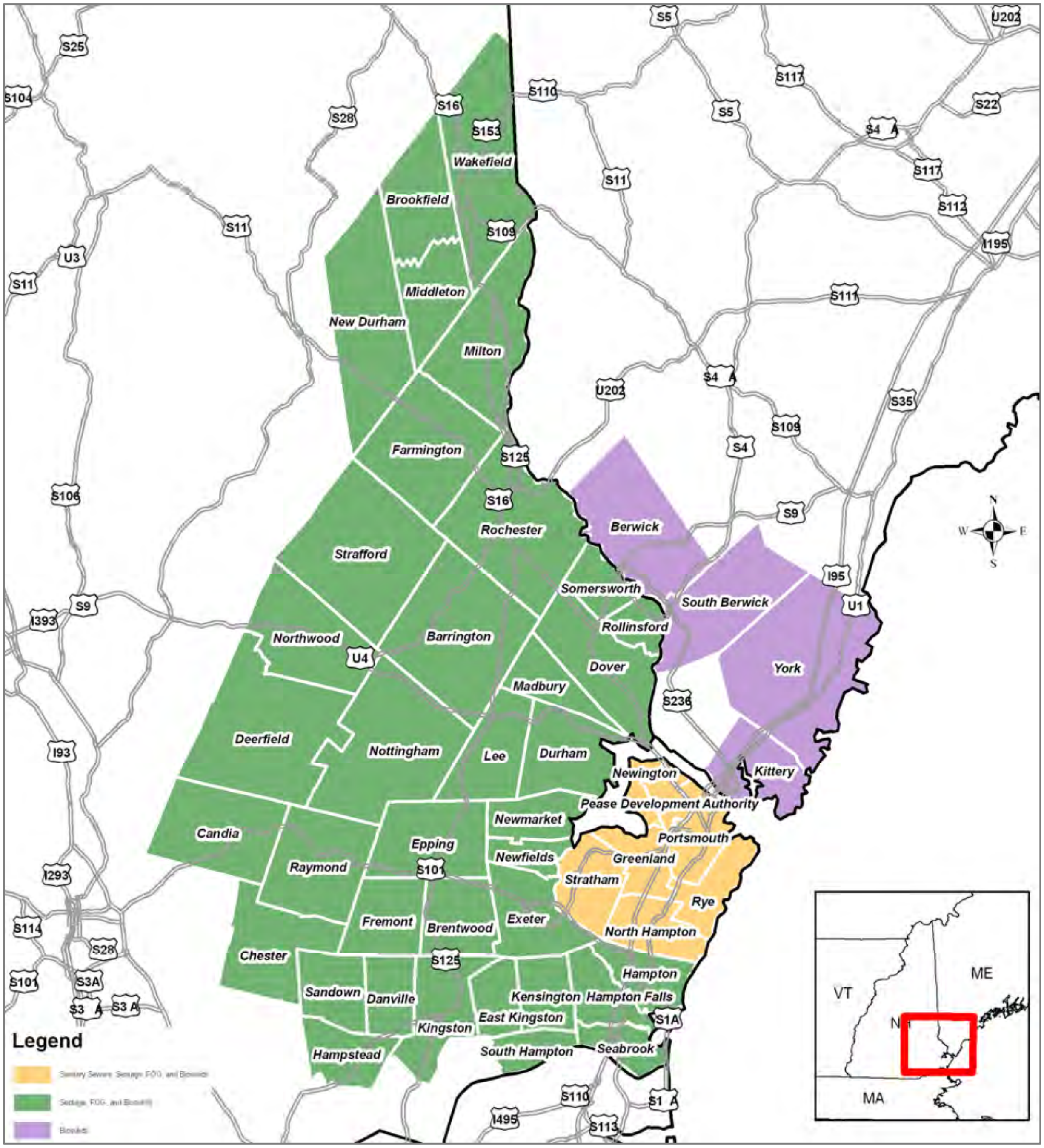


Figure 2-2. Regional Communities

3. REGULATORY EVALUATION

3.1 Peirce Island WWTF NPDES Permit History and Status

In 1977 the City prepared a "201 Facilities Plan" to identify wastewater collection and treatment needs for the City, as required by the EPA. In 1980, the City designed a secondary WWTF for the Peirce Island WWTF. In 1982, prior to commencement of construction and in NHDES' recommendation, the City and NHDES co-applied for a 301(h) waiver to allow the Peirce Island WWTF to continue operations as a primary treatment facility. In January of 1985, the City was issued its first NPDES permit (No. NH0100234) for the Peirce Island WWTF concurrent with a 301(h) waiver, which allowed the City to operate the Peirce Island WWTF as a primary treatment facility with discharge to the Piscataqua River. The City therefore did not have to upgrade the Peirce Island WWTF to meet secondary standards at that time.

In 1990, the City submitted a NPDES permit renewal application, with a 301(h) waiver, to the EPA. A Draft NPDES permit with a 301(h) waiver was issued in 2005. The issuance of the Draft NPDES permit with the waiver was challenged by a non-governmental organization (NGO) which argued that because the Piscataqua River was in non-attainment due to mercury, polychlorinated biphenyls (PCBs), dioxin and entrococcus, continuation of the 301(h) waiver could not be granted.

EPA accepted this argument and rescinded the Draft 301(h) waiver. A NPDES permit requiring secondary treatment was issued in June of 2007. A copy of this permit is included in Appendix D. Following the issuance of the NPDES permit requiring secondary treatment, the WMP/LTCP Update process began.

In August of 2009, the City entered into a Consent Decree (CD) with the EPA and NHDES (provided in Appendix B). The CD requires that the Draft WMP/LTCP Update be submitted to the EPA and NHDES by June 4, 2010 and that a final WMP/LTCP Update be submitted by September 1, 2010. The CD then requires that the recommendations of the WMP/LTCP Update be executed based on a reasonable schedule to be agreed upon by the City, EPA and NHDES as part of the WMP/LTCP Update.

Throughout the development of the WMP/LTCP Update, both the EPA and NHDES have indicated that only nitrogen is a nutrient of concern for the Peirce Island WWTF discharge. The WMP/LTCP Update approach was modified in the summer of 2007 to address the potential for future nitrogen limits. These modifications are not reflected in the Work Plan that forms the basis of the AO, since the need for a TN limit was not brought forth by the regulators prior to the issuance of the AO. At the time of writing this WMP/LTCP Update, TN limits have not been set by either the EPA or NHDES for the Peirce Island WWTF. However, the WMP/LTCP Update has been developed to address TN limits ranging from 8 mg/L down to 3 mg/L, which is considered the limit of biological nutrient reduction (BNR) technology. The actual limit will have a significant impact on the footprint and life cycle cost of the selected WWTF alternative

In addition to the TN limits, the NHDES stated verbally in April of 2010 that the Peirce Island WWTF may also have a TP limit in a future NPDES permit. Given that this information was neither made available until approximately six (6) weeks prior to the required submission of the Draft WMP/LTCP Update, nor stated in writing, a potential TP limit has not been addressed in this Draft WMP/LTCP Update.

3.2 Pease WWTF NPDES Permit Status

The Pease WWTF was issued its most recent NPDES permit (permit No. NH0090000) in August of 2000. A copy of this permit is provided in Appendix E. The permit has not been renewed since that time. The permit allows for the discharge of treated effluent to the Piscataqua River at an outfall location approximately 2.75 miles northwest of the Peirce Island WWTF outfall. The NPDES permit requires secondary treatment standards, and does not contain TN or TP limits. The permit does not include a flow limit. However, based on allowable mass and concentration limits, the permit is based on an average monthly flow rate of 1.20 mgd. NHDES has advised that a TN limit will be contained in a future permit, and TP may potentially be included as well.

3.3 Receiving Waters Evaluation

Concurrent with the development of the WMP/LTCP Update, the NHDES has issued a document which purports to establish Nutrient Criteria for the Great Bay watershed. Upon issuance of the Final Nutrient Criteria in June of 2009, NHDES then developed a Draft Wasteload Allocation protocol. The NHDES has yet to complete Wasteload Allocations for the Peirce Island WWTF and Pease WWTF outfall locations in the Piscataqua River. The City is engaged in discussions with NHDES concerning procedural and substantive problems relating to the Final Nutrient Criteria Document (refer to Appendix C and F).

3.3.1 Nutrient Criteria, Wasteload Allocation and Waste Allocation

3.3.1.1 Nutrient Criteria

The Draft Numeric Nutrient Criteria for the Great Bay Estuary (the Criteria), dated November 12, 2008, was provided to the City and the WMP/LTCP Update team for review on its release date. Comments on the Draft Criteria were provided to the City by the WMP/LTCP Update Consulting Team and were issued to the NHDES on March 20, 2009. These comments were reviewed by the NHDES and addressed, in part, in the Final Criteria dated June 2009. A copy of the comments on the Draft Criteria and Final Criteria are provided in Appendix F.

The stated purpose of the Criteria is to establish numeric-based nutrient loadings to protect the Great Bay watershed's designated uses. NHDES has stated that the designated use to support aquatic life, specifically eel grass habitat, was the prime consideration in the establishment of the Criteria. The Criteria, as written, concludes a causal link between the decline of eel grass beds and excess nitrogen for much of the Great Bay Estuary. The links claimed by the NHDES are that:

- Excess nitrogen causes an increases in algae growth,
- Algae creates excess turbidity,
- Excess turbidity causes light attenuation,
- Light attenuation limits eel grass growth.

It has been and remains the City's assertion that data used to establish the Criteria are too sparse and are incomplete; that data sets have been improperly aggregated and not analyzed in accordance with sound scientific principles; that life cycle impacts of eel grass have not been considered; and that the impact of other factors affecting eelgrass such as ship traffic and dredging have not been fully evaluated. The City also asserts that the NHDES has failed to follow the required rulemaking procedures for the promulgation of this document. (Refer to Appendix C and F).

3.3.1.2 Wasteload Allocation

Upon completion of the Final Criteria, the NHDES developed a Draft Methodology to Determine Wasteload Allocations. This first draft was developed for the Cocheco River and included the communities of Rochester and Farmington, NH. Comments on this draft were prepared at the request of the City and submitted to the NHDES. A copy of the Draft Methodology and comments on the methodology are provided in Appendix G.

The purpose of the Wasteload Allocation is to assign an allowable mass loading to each water body or segment thereof based upon the allowable nutrient level from the Criteria. Upon completion of the Wasteload Allocation, waste allocations will then be determined for each WWTF in the watershed.

A Wasteload Allocation has not been developed for the Piscataqua River. Therefore, the waste allocation for the Peirce Island WWTF and Pease WWTF has not been determined, and nutrient limits have not been set.

3.3.2 Dye-Tracer Study

A dye tracer study was performed on October 27 through October 30, 2009. The purposes of the study were to establish the mitigation pattern of the effluent from the Pease WWTF at a theoretical effluent flow rate of 8.9 mgd for future flow considerations and to determine the travel time to local shell fish beds in the watershed.

The tracer study was observed by Brown and Caldwell staff, and data from the study was provided to Brown and Caldwell for evaluation in February of 2010. The results of this analysis show that:

- The effluent dye-tracer concentration varied and led to uncertain river dilution calculations,
- The discharge plume dye-tracer concentration was at or very near background levels and fluorometer readings were therefore questionable,
- The standards used to calibrate the bench fluorometer which was then used for testing the grab samples were not based upon the same dye as that used for the field work, and
- Grab sample tests were not temperature corrected in the laboratory.

In addition, the calibration records for the fluorometers used on the EPA vessel could not be found.

Based on the above, the dye-tracer study results are inconclusive. The City is currently evaluating alternative methods to evaluate dilution and travel time of effluent from the Pease WWTF outfall. These may include a particle tracking model and velocity metering.

3.3.3 Future Permit Limit Impacts

The Peirce Island WWTF NPDES permit currently requires that secondary treatment standards be met. The Work Plan which forms the basis of this WMP/LTCP Update and was approved by the EPA and NHDES in June of 2007 does not address NPDES permit nutrient limits. However, based on information provided by the EPA and NHDES following the approval of the Work Plan, a TN limit may be included in subsequent NPDES permits for both the Peirce Island WWTF and the Pease WWTF. The impact to the Pease WWTF is outside the scope of this WMP/LTCP Update. However, as presented in Section 5, solutions that incorporate the Pease WWTF address TN limits.

Currently, the final TN limit for either the Peirce Island WWTF or Pease WWTF is unknown. At the request of EPA and NHDES, our evaluations have included potential TN limits of 8, 5, and 3 mg/L. As presented in Section 5, depending upon the treatment technology selected, a TN limit of 8 mg/L would allow the City to construct a WWTF with smaller secondary reactors than those required for a TN limit of 5 or 3 mg/L. Life cycle costs will increase significantly as TN limits decrease.

Depending on the technology selected, compared to a TN limit of 8 mg/L, TN limits of 5 or 3 mg/L would require larger secondary reactor tanks and may require a denitrification filter as a tertiary processes. Methanol addition would also be required for TN limits of 5 and 3 mg/L. A limit of 3 mg/L would require up to twice the methanol as compared to a limit of 5 mg/L. Therefore, a TN limit of 5 or 3 mg/L will have greater capital and long term operating costs as compared to a TN limit of 8 mg/L.

In April of 2010, the NHDES stated verbally that a TP limit may be included in future NPDES permits for the Peirce Island WWTF and Pease WWTF. In previous discussions with the NHDES and EPA, the regulatory officials indicated that phosphorus would not be a nutrient of concern. Because the potential for a TP limit was announced less than two months before the Draft WMP/LTCP Update is due, and because the actual limit is unknown, the impacts of a TP limit have not been fully evaluated. It can be stated that a limit of 1 mg/L or greater could be addressed with biological nutrient removal or with chemical precipitation. Both these options would require additional treatment tanks or a tertiary treatment process.

3.3.4 Outstanding Regulatory Issues

There are a number of outstanding regulatory issues which may result in revisiting the preferred alternative for wastewater treatment and the CSO LTCP. The WWTF solution and LTCP are inter-related. If the Peirce Island WWTF is upgraded to meet secondary treatment with BNR, then it cannot be used to its full capacity to treat wet weather flow, since a portion of that capacity will be required for sanitary flow. Therefore, additional work in the collection system would be required to mitigate CSO events.

If a Pease WWTF is expanded to meet the permit needs, then the Peirce Island WWTF could be used to its full capacity for wet weather flow, and CSO control work within the collection system to mitigate CSO events would be reduced.

To confirm that the best solution has been identified, the following issues must be resolved with the EPA and NHDES:

1. For the Pease WWTF outfall:
    a. What will be the anti-degradation requirements at the Pease WWTF outfall for flows in excess of its current capacity of 1.2 mgd?
    b. What credit will be considered in the anti-degradation analysis and "anti-backsliding" analysis for the Pease Outfall with respect to the Peirce Island WWTF outfall if all sanitary flow is treated at Pease WWTF?
2. What are the regulatory impacts of retaining the Peirce Island WWTF for both sanitary and wet weather flow?
3. What will the TN limit be for either the Peirce Island WWTF or Pease WWTF?
4. Will a TP limit be issued for either the Peirce Island WWTF or Pease WWTF, and if so, what will that limit be?
5. Can a waiver from the four-hour travel time from an outfall to a shell fish bed be obtained if additional measures are taken, such as:
    a. Automated notification via teledialers or reverse 911.
    b. Redundant disinfection systems which will automatically activate should a main component fail.
    c. Other additional measures.

6. What will the permit framework be for the Peirce Island WWTF and Pease WWTF?
   a. Will nutrient limits be based on year–round limits or seasonal limits?
   b. Will nutrient limits be based on annual rolling average?
   c. If the NPDES permit is issued for full build-out flow, can the City discharge the equivalent mass load under lower flow scenarios?

3.4 Other Permitting Issues

In addition to the NPDES permit issues, there are a number of additional permitting issues which must be addressed prior the construction of a WWTF upgrade/expansion, whether at Peirce Island or at Pease.

3.4.1 Peirce Island WWTF

A shore land setback variance will be required if the Peirce Island WWTF is upgraded to secondary treatment with BNR.

The EPA would be the lead agency for the Section 106 process relative to the impacts of the expanded WWTF on the existing historic structures on Peirce Island, including Fort Washington.

3.4.2 Pease WWTF

1. Wetlands permitting may be required if the Pease WWTF is expanded to a higher flow rate with BNR.
2. Outfall permitting for the Pease WWTF will be required for a new diffuser if higher flow capacity is pursued.
3. Miscellaneous wetland and shore land zoning permits will be required for pipeline crossings for flow redirection within the City.

4. FLOW AND LOAD PROJECTIONS

4.1 Introduction and Purpose

This section of the WMP/LTCP Update evaluates flows and organic loads under existing and forecasted conditions. Further, this section evaluates the potential for additional septage, biosolids, and fats, oil and grease (FOG) handling capacity is also evaluated. The purpose is to determine future flows and organic loads which an upgraded or expanded WWTF will need to be sized for.

The loads analyzed include biochemical oxygen demand (BOD), total suspended solids (TSS), and TN. It was brought to the attention of the City that a total phosphorus (TP) limit may also be included in the NPDES Permit for the City's two wastewater treatment facilities (WWTFs). However, due to the lateness of this information, a TP limit has not been considered and forecasts for future TP loads have not been evaluated.

A software package developed by Brown and Caldwell, the Capacity Assurance Planning Environment (CAPE) model, was used to assist with the development of the wastewater flow and load forecasts. CAPE is a GIS-based application developed for wastewater master planning. It performs tasks such as estimating population and employment distributions, developing buildout forecasts, analyzing water usage data and performing wastewater forecasts.

If the Peirce Island WWTF is upgraded to meet secondary treatment standards with biological nutrient reduction (BNR), the Pease WWTF will continue in operation. However, if the Pease WWTF is expanded to treat sanitary flows from the entire City, then the Peirce Island WWTF will only be used for wet weather flows. Therefore, the required hydraulic capacity of the Pease WWTF will be greater than that for the Peirce Island WWTF. Design flows and loads for each WWTF are addressed below.

Additional details regarding the flow and load projections may be found in TM No. 4, provided in Volume 3 of this WMP/LTCP Update.

4.2 Planning Horizon and Study Area

Planning horizons and the study area for the WMP/LTCP Update have been presented in Section 2. For the purposes of developing flow and load forecasts, the planning horizon for the WWTFs extends to the year 2030 which is approximately a 20-year planning period. Additionally, the WWTF sites have been evaluated for sustaining flow based expansions through the year 2060. The planning horizon for the collection system infrastructure extends through the year 2060 which is approximately a 50-year planning period.

In addition to looking at conditions through 2030 and 2060, the maximum level of development expected in the City has also been analyzed. This level of development is referred to as "buildout" conditions. Buildout conditions were used to evaluate the potential for growth in the City and to ensure that planned infrastructure would be properly sized for all future conditions.

As presented in Section 2, the Study Area has been divided into several categories based on type of wastewater service, and are summarized as follows:

4.2.1 Sanitary Sewer Service

The Sanitary Sewer Service area includes the City of Portsmouth and the following communities which currently discharge wastewater to the Portsmouth wastewater collection system: Greenland, Newcastle, and Rye. It also includes the following communities which have the potential to discharge to the City's system in the future: North Hampton, Stratham, and Newington.

Only a small portion of Greenland is currently served. This service is provided through a private agreement with property owners in Greenland and not via inter-municipal agreements between Greenland and Portsmouth.

Rye has an inter-municipal agreement with Portsmouth for sewer service.

Based on past studies, the Route 1 corridor in North Hampton may require sewering to the Hampton border at some time in the future.

The Pease Development Authority which oversees activities at the Pease International Tradeport is served by the Pease WWTF, which is owned and operated by the City of Portsmouth. Expansion at the Pease International Tradeport has been considered in these flow evaluations as well.

4.2.2 Biosolids Handling, Septage and FOG

The biosolids, septage and FOG service area includes all 44 communities in the Seacoast Regional Wastewater Management Study, as well as select wastewater treatment facilities in Maine, including Kittery, York, Berwick and South Berwick. These communities are shown in Figure 2-2.

4.3 Peirce Island WWTF

The Peirce Island WWTF is permitted for an average monthly flow of 4.8 mgd and serves the City of Portsmouth, which includes the combined sewers in urban areas, as well as regional flows from Rye, Newcastle and Greenland. Flows from the Pease International Tradeport are not treated at the Peirce Island WWTF and are not included this portion of the evaluation. Pease WWTF flow and load forecasting is presented later in this section.

4.3.1 Wastewater Flows

Wastewater flows to the Peirce Island WWTF include sanitary flows, baseline infiltration and wet weather infiltration and inflow. Because of the combined sewers, the majority of the flow during wet weather is inflow.

4.3.1.1 Current Wastewater Flows

Flow records dating back to 1994 were collected for the Peirce Island WWTF. The average annual flows from 1994 to 2007 for the Peirce Island WWTF are shown in Table 4.1. Based on this data, the average annual flow is 4.99 mgd, which is driven by wet weather events.

The average annual flow has been disaggregated into sanitary flow and an infiltration and inflow (I/I) components. The sanitary flow component was estimated from City water use records. Annual water use in Portsmouth (excluding Pease) was 2.06 mgd in 1997, 2.40 mgd in 2002, and 2.90 mgd in 2007. It was assumed that 90% of the water use is returned as wastewater. As a result, the estimated sanitary wastewater was 1.85 mgd in 1997, 2.16 mgd in 2002, and 2.60 mgd in 2007.

The I/I component was estimated by subtracting the sanitary flow component from the total measured flow. The I/I component includes combined flows with the exception of that which are discharged through the City's permitted combined sewer overflows (CSOs). Based on this information, the Peirce Island WWTF is at its design capacity due to the significant I/I component, which is to be expected with a combined collection system.

Table 4-1. Average Annual Flow at the Peirce Island WWTF

Year	Total Flow (MGD)	Estimated Sanitary Flow (1) (MGD)	Estimated I/I (2) (MGD)
1994	4.80		
1995	4.96		
1996	5.64		
1997	4.56	1.85	2.71
1998	4.71		
1999	4.16		
2000	4.72		
2001	4.59		
2002	4.98	2.16	2.82
2003	5.57		
2004	4.64		
2005	5.81		
2006	5.99		
2007	4.75	2.60	2.15

(1) Assuming 90% of water use is returned as wastewater
(2) Difference between total flow and Estimated Sanitary Flow

4.3.1.2 Inflow and Infiltration

In accordance with Phase I of its 2005 Long Term Control Plan, the City of Portsmouth has on ongoing program to separate targeted combined sewers. When completed, it is expected that this program will reduce the amount of extraneous flows entering the City's collection system, reduce CSO activity, and some level of I/I. It is also recognized that the system will continue to age and deteriorate with time, and that this will lead to more I/I entering the system, which will require the on-going collection system rehabilitation program to continue. As a result, it is assumed that the current maximum month flow, driven by I/I, will remain unchanged during the planning horizon.

4.3.1.3 Future Wastewater Flows

Population and employment forecasts provide the basis for developing the wastewater flow and load forecasts. Population forecasts were provided by the New Hampshire Office of Energy and Planning (NH OEP). The forecasts extend to the year 2030. The population peaked at 26,900 in 1960 and remained above a level of 25,000 people until the 1990s, at which time the population began to decline. This decline was due to the closing of the Pease Air Force Base. The population data from the NH OEP indicates that the population has fluctuated slightly between 20,000 and 21,000 people since 2000.

Employment forecasts for the City of Portsmouth were not available from NH OEP or any other planning agencies. There is a significant potential for growth in employment in Portsmouth, and as a result, the employment forecast could have a strong impact on the wastewater flow and load forecasts.

With no forecasts available from planning agencies, low, medium, and high employment growth forecasts were developed. With input from the City, the medium employment growth rate of 1.0 percent was used for the flow and load forecasts.

The population and employment in the years 2000, 2006 and in the forecast years is shown in Table 4.2.

Table 4-2. City of Portsmouth Historic and Forecasted Population and Employment

Demographic	Year							
	2000		2006		2030		2060	
Population	20,825	(1)	20,811	(2)	24,390	(2)	27,450	(3)
Employment	28,258	(2)	28,768	(2)	35,672	(4)	44,239	(4)

1. Source: United States Census Bureau
2. Source: New Hampshire Office of Energy and Planning
3. Assumes the average growth rate of the New Hampshire Office of Energy and Planning forecasts continues beyond 2030 until reaching the buildout population of 27,450 in the year 2051.
4. Medium growth employment forecast: 1.0% annual growth rate. Employment reaches buildout level of 44,239 in the year 2054

Based on the above population and employment projections, the total forecasted wastewater flows for the Peirce Island WWTF are presented in Table 4-3. The flows shown in the table include sanitary flow and I/I. Buildout of both population and employment will occur between year 2051 and 2054; therefore, the year 2060 flows and loads reflect buildout conditions for the City of Portsmouth.

Table 4-3. Derivation of Average Daily Flow – Peirce Island WWTF

Source	Current Facility Rating (MGD)	Increase through Year 2030 (MGD)	2030 Facility Rating (MGD)	Flow Increase through Year 2060 (MGD)	2060 Facility Rating (MGD)
Peirce Island WWTF	4.8	0.9	5.7	1.3	6.1
Regional	N/A	0.5	0.5	0.8	0.8
Combined	4.8	1.4	6.2	2.1	6.9

4.3.2 Organic Loads

The WWTF must treat organic loads, including BOD, TSS and TN. The secondary BNR processes must be sized based on these values.

4.3.2.1 Current Organic Loads

Historic influent BOD and TSS records were collected from Monthly Discharge Reports at the Peirce Island WWTF. The average annual influent loadings are presented in Table 4-4. These loads include Portsmouth's contribution (without Pease) and the regional contributions from Rye, Greenland, and New Castle. While there is variation from year to year, there does not seem to be a trend of either increasing or decreasing loads.

Table 4-4. Average Annual Influent Loading Rates at the Peirce Island Wastewater Treatment Facility

Year	Load (Lb/d)	
	BOD	TSS
2003	7,295	8,304
2004	7,090	6,416
2005	8,144	8,090
2006	7,887	7,368
2007	6,812	6,004

The discharge of nitrogen is not regulated at the Peirce Island WWTF. However, the City intermittently sampled influent inorganic nitrogen levels in 2008 and collected data to develop a baseline for future considerations, since nitrogen may be regulated in a future NPDES permit. Influent grab samples were collected at the Peirce Island and analyzed at the Peirce Island WWTF and at Resource Laboratories in Portsmouth, NH for ammonia, nitrate, and nitrite. Since little to no nitrate or nitrite typically exists in influent wastewater, the data generated from these analyses were assumed to provide the influent ammonia concentrations received at the Peirce Island WWTF. The influent ammonia concentrations ranged from 3 mg/l to 33 mg/l.

Influent BOD concentrations were used with these ammonia data to determine the specific BOD-to ammonia ratio for influent at the Peirce Island WWTF. This ratio was used to determine the influent ammonia load based on historical BOD concentrations at the WWTF. In the absence of influent organic nitrogen or TKN data for the Peirce Island WWTF, the influent total nitrogen load was determined using an ammonia-to-TKN ratio defined for similar facilities based on project experience. This calculated TKN load was used to project the total nitrogen load received at the Peirce Island WWTF. Given the limited industry tributary to the Peirce Island WWTF, and based on data collected to date, the maximum total nitrogen load of 2,180 lbs/d will be used as a design basis, which equates to approximately 50 g/L at a design flow of 4.8 mgd.

4.3.2.2 Future Organic Loads

Historical BOD and TSS loads have remained fairly level at the Peirce Island WWTF. It is assumed that the average of BOD and TSS loadings from 2003 through 2007 represent average conditions. As mentioned, limited total nitrogen data is available for the Peirce Island WWTF.

BOD and TSS loading rates were assumed to be 0.2 pounds per capita per day (lbpcd) for the residential population. These rates are typical values (Metcalf and Eddy, 1991). The BOD and TSS loading rates for commercial/institutional/industrial development were then calibrated to achieve the target system-wide values. Different loading rates were developed for commercial/institutional/industrial development tributary to the WWTFs. The BOD and TSS loading rates for commercial/institutional/industrial development were expressed in pounds per square feet of building floor space per day (lbsfd).

The total nitrogen loading was assumed to be 0.03 lbpcd for the residential population. This value is towards the upper end of typical values for total Kjeldahl nitrogen (Metcalf and Eddy, 1991)[1]. The BOD and TSS loading rates for commercial/institutional/industrial development were then calibrated to achieve the target system-wide values. The projected organic loads for the Peirce Island WWTF are presented in Table 4-5.

Table 4-5. Forecasted Organic Loads for the Peirce Island WWTF

Parameter	Design Year		
	2010	2030	2060
BOD, lb/d	7,491	8,875	10,245
TSS, lb/d	7,283	8,632	9,966
TKN, lb/d	3,035	3,744	4,098

4.3.3 Biosolids Generation

WWTFs produce various organic and chemical wastes that must be disposed of. Organic sludges are produced in primary clarifiers, at WWTFs so equipped. The sludges can be both organic and chemical in nature, if the WWTF utilizes chemically enhanced primary treatment (CEPT), as employed at the Peirce Island WWTF. In general the chemical is usually a metal salt utilized enhance coagulation.

Biosolids are an organic byproduct of secondary treatment, and the rate of production is dependent on the treatment process employed. Lagoons have a very low biosolids yield, while high rate treatment processes have a relatively high yield. In general, lagoon systems do not waste sludge, and instead allow it to build in the settling lagoon. Activated sludge facilities usually waste biosolids on a daily basis.

Facilities which utilize tertiary treatment may also produce chemical sludges containing metal salts. Currently, only the Somersworth, NH WWTF utilizes tertiary treatment. However, it is likely that many of the WWTFs in the area may be producing tertiary sludges in the future, as discharge permit limits become more stringent.

As presented herein, growth through the year 2030 must be considered to provide for a sustainable system. Project flows and loads for the City's WWTFs as well as specific WWTFs in the surrounding area have been developed. However, sludge and biosolids production is not only driven by an increase in flow or organic load. More stringent permit conditions will also increase WWTF sludge and biosolids production. For example, if a WWTF is required to reduce effluent nutrients, then biosolids production associated with the biological nutrient removal (BNR) processes will increase. Also, if a WWTF is required to utilize chemical precipitates to reduce pollutants, such as phosphorus, this will also increase sludge production.

The largest increase in biosolids production will be associated with the Peirce Island WWTF, which will be converted from a primary to a secondary WWTF, or the load to the Peirce Island WWTF will be redirected to the Pease WWTF, which will increase biosolids production at the Pease WWTF.

[1] Typical range identified in Metcalf and Eddy (1991) is 0.020 – 0.031 for total Kjeldahl nitrogen. Total nitrogen loading rates were not identified in Metcalf and Eddy (1991).

Sludge and biosolids generation projections at the Peirce Island WWTF have been developed based on the following:

- The highest TSS/BOD forecasts are utilized,
- Evaluations have been performed for the following two scenarios:
  - CEPT will either remain at the Peirce Island WWTF when converted to secondary treatment or will be applied to a new replacement secondary WWTF. Influent BOD will be reduced by 55% and TSS by 77% in the primary clarifiers.
  - CEPT will not be utilized, and influent BOD will be reduced by 30% and TSS by 50% in the primary clarifiers.
- Secondary biosolids will be generated at a rate of 1.5 lbs per pound of BOD applied to the secondary process, assuming that a high rate biological nutrient reduction (BNR) process is utilized.
- No reduction in volatile solids will occur.

In addition to sludge and biosolids loading, nitrogen loading associated with dewatered sludge has also been considered. Data specific to the Peirce Island WWTF for actual nitrogen levels in the dewatering filtrate is not available; therefore, text book values of 150 mg/l have been used for this evaluation.

Assuming that CEPT remains in use, biosolids and sludge yield will increase, as presented in Table 4-6. Should CEPT be discontinued, sludge and biosolids yield will increase as presented in Table 4-7. Should sludge be further dried from 30% solids to 90% solids, the total nitrogen load associated with the condensate will increase by approximately 5%.

Table 4-6. Sludge/Biosolids Production with CEPT

		Design Year		
		2010	2030	2060
BOD Load (wet)	(lbs/day)	7,491	8,875	10,245
TSS Load (wet)	(lbs/day)	7,283	8,632	9,966
Primary Sludge Generation [(a)]	(lbs/day)	5,608	6,647	7,674
Primary Effluent BOD [(b)]	(lbs/day)	3,371	3,994	4,610
Secondary Biosolids [(c)]	(lbs/day)	5,056	5,990	6,915
Total Sludge	**(lbs/day)**	**10,640**	**12,637**	**14,589**
Total Sludge (dry) [(d)]	**(tons/yr)**	**582**	**692**	**799**
Total Nitrogen Load [(d)]	**(lbs/day)**	**301**	**352**	**382**

(a) Based on 77% TSS reduction in primary clarifiers.
(b) Based on 55% BOD reduction in primary clarifier.
(c) Based on sludge yield of 1.5 lbs biosolids per pound BOD applied
(d) Based on thickening and dewatering to 30% solids and TN of 150 mg/l in filtrate.

Table 4-7. Sludge/Biosolids Production without CEPT				
		Design Year		
		2010	2030	2060
BOD Load (wet)	(lbs/day)	7,491	8,875	10,245
TSS Load (wet)	(lbs/day)	7,283	8,632	9,966
Primary Sludge Generation [(a)]	(lbs/day)	3,642	4,316	4,983
Primary Effluent BOD [(b)]	(lbs/day)	5,244	6,213	7,172
Secondary Biosolids [(c)]	(lbs/day)	7,866	9,319	10,757
Total Sludge	**(lbs/day)**	**11,508**	**13,635**	**15,740**
Total Sludge (dry) [(d)]	**(tons/yr)**	**582**	**692**	**862**
Total Nitrogen Load [(d)]	**(lbs/day)**	**325**	**380**	**412**

(a) Based on 50% TSS reduction in primary clarifiers.
(b) Based on 30% BOD reduction in primary clarifier.
(c) Based on sludge yield of 1.5 lbs biosolids per pound BOD applied
(d) Based on thickening and dewatering to 30% solids and TN of 150 mg/l in filtrate.

4.4 Pease WWTF

The Pease WWTF is designed to treat 1.2 mgd average daily flow. The collection system is limited to the Pease International Tradeport. No other flows, either regionally or from Portsmouth, are treated at the Pease WWTF. The Pease WWTF services a mix of commercial and industrial developments in the Tradeport.

4.4.1 Wastewater Flows

The Pease WWTF collection system is a separate system and I/I is not as significant as for the Peirce Island WWTF. Wastewater flows to the Pease WWTF changed from 2004 through 2007 due to changes in the Pease Development Authority's industrial customer base. For example, there were several significant industrial expansions. As a result, it is difficult to estimate the variation in the base sanitary flow component during this time. Accordingly, the measured flows were not disaggregated into sanitary flow and I/I components as they were for the Peirce Island WWTF flows.

4.4.1.1 Current Wastewater Flows

Based on the monthly flow data from 2007, it is estimated that the current sanitary flow to the Pease WWTF is 410,000 gpd. The average annual flow for 2007 was 586,000 gpd. Accordingly, the average annual I/I for 2007 was approximately 176,000 gpd.

A statistical analysis of the I/I was not performed for the Pease WWTF. The statistical analysis requires many data points for the results to be reliable. For Peirce Island, the 14 years of historical data provided a solid foundation for the analysis. However, for the Pease WWTF, the uncertainty in the historical sanitary flow data made it difficult to develop a historic record of I/I. As a result, there is not enough data to perform a reliable statistical analysis.

4.4.1.2 Future Wastewater Flows

Growth at the Pease International Tradeport will be commercial and residential in nature. Based on the buildout analysis and a medium growth rate for employment of 1.0 percent, the forecasted flows to the Pease WWTF are presented in Table 4-8, assuming that the Peirce Island WWTF remains in operation. Should the Peirce Island WWTF become a dedicated wet weather facility and the Pease WWTF be expanded to treat all flow from the Tradeport, the City and the region, the required flow capacity for the Pease WWTF is presented in Table 4-9.

Table 4-8. Derivation of Average Daily Flow – Pease WWTF with Peirce Island WWTF in Operation

Source	Current Facility Rating (MGD)	Increase through Year 2030 (MGD)	2030 Facility Rating (MGD)	Flow Increase through Year 2060 (MGD)	2060 Facility Rating (MGD)
Pease WWTF	1.2	0.5	1.7	1.1	2.3

Table 4-9. Derivation of Average Daily Flow – Pease WWTF Expanded, Peirce Island WWTF Converted to Wet Weather Only

Source	Current Facility Rating Required (MGD)	Increase through Year 2030 (MGD)	2030 Facility Rating (MGD)	Flow Increase through Year 2060 (MGD)	2060 Facility Rating (MGD)
City of Portsmouth	4.8	0.9	5.7	1.3	6.1
Pease WWTF	1.2	0.5	1.7	1.1	2.3
Regional	N/A	0.5	0.5	0.8	0.8
New Pease WWTF Capacity	6	1.9	7.9	3.2	9.2

4.4.2 Organic Loads

Organic loads include BOD, TSS and TN. These loads are treated in the primary and secondary processes and are the design basis for sizing the secondary and BNR process.

4.4.2.1 Current Organic Loads

Historic influent BOD and TSS records were collected from Monthly Discharge Reports at the Pease WWTF. The average annual influent loadings are shown in Table 4-10. As mentioned previously, changes in industrial customer base have taken place since 2004.

Table 4-10. Average Annual Influent Loading Rates at the Pease Wastewater Treatment Facility

Year	Load (Lb/d)	
	BOD	TSS
2004	1,406	2,035
2005	1,977	2,466
2006	2,577	2,325
2007	2,137	2,337

Historical influent nitrogen data for the Pease WWTF was limited due to changes in influent nitrogen sampling and analysis procedures at the WWTF. In 2005, influent wastewater was analyzed for total Kjeldahl nitrogen (TKN), which determines the combined concentration of organic nitrogen and ammonia. However, since December 2007 influent samples have been analyzed for a modified total nitrogen concentration that includes ammonia, nitrate, and nitrite, but not organic nitrogen compounds. These data represent essentially the total inorganic nitrogen concentration entering the WWTF. Based on these data, the following ranges were determined:

- Influent concentrations
  - TKN (organic N, ammonia): 10 to 71 mg/L
  - Total inorganic nitrogen (ammonia, nitrate, nitrite): 21 to 76 mg/L
- Influent loading
  - TKN: 89 to 379 lbs/day
  - Total inorganic nitrogen: 148 to 457 lbs/day

It is assumed that the highest measured total inorganic nitrogen measured (457 lb/days) is a reasonable estimate of the total average daily nitrogen loading. Although a conservative approach, it is assumed that using this maximum value will yield an overestimate that may account for the organic nitrogen load that would be included in an average of actual total nitrogen loading to the WWTF. These data and the assumptions will be revisited once additional nitrogen data is collected at the WWTF.

4.4.2.2 Future Organic Loads

The influent organic load forecasts for the Pease WWTFs are presented in Table 4-11 for the projected employment growth at the Pease International Tradeport, assuming that the Peirce Island WWTF remains in operation. In Table 4-12, organic loads for the Pease WWTF are presented, assuming the Peirce Island WWTF is converted to a wet weather only treatment facility. The organic loading rates for commercial/institutional/industrial development are based on pounds per square feet of building floor space per day (lbsfd) calculations and the available land area. Please refer to Volume 3, TM 3 for additional details.

Table 4-11. Forecasted Organic Loads for the Pease WWTF, with Peirce Island WWTF in Operation

Parameter	Design Year		
	2010	2030	2060
BOD, lb/d	2,546	3,009	4,010
TSS, lb/d	2,517	2,605	3,040
TKN, lb/d	497	584	779

Table 4-12. Forecasted Organic Loads for the Pease WWTF, with Peirce Island WWTF Converted to Wet Weather Treatment			
	Design Year		
Parameter	2010	2030	2060
BOD, lb/d	10,037	11,884	14,255
TSS, lb/d	9,800	11,237	13,006
TKN, lb/d	3,532	4,328	4,877

It should be noted that the TKN loads presented in Tables 4-11 and 4-12 include both influent TKN and the TKN load associated with the current dewatering process.

4.4.3 Biosolids Generation

The Pease WWTF operates as a secondary process with primary clarifiers. It is assumed that biosolids and sludge production will increase proportional to the increase in projected BOD.

In addition to sludge and biosolids loading, nitrogen loading to the Pease WWTF has also been considered.

The biosolids and nitrogen loading forecasts are presented in Table 4-13 and 4-14, assuming the Peirce Island WWTF remains in operation and is converted to wet weather treatment only, respectively.

Table 4-13. Pease WWTF Sludge/Biosolids Production with Peirce Island WWTF in Operation					
		Year			
		2007	2010	2030	2060
BOD Load (wet)	(lbs/day)	2,340	2,546	3,009	4,010
% Increase over 2007		N/A	8.8%	28.6%	71.4%
Total Sludge / Biosolids	**(dry tons/yr)**	**160**	**174**	**206**	**274**
Total Nitrogen Load (1)	**(lbs/day)**	**457**	**497**	**587**	**783**

(1) Includes influent nitrogen loads and nitrogen loads associated with dewatering process.

Table 4-14. Pease WWTF Sludge/Biosolids Production with Peirce Island WWTF Converted to Wet Weather Treatment

		Year		
		2010	2030	2060
Sludge/Biosolids Pease WWTF	(dry tons/yr)	174	206	274
Sludge/Biosolids Peirce Island WWTF	(dry tons/yr)	582	692	862
Total Sludge / Biosolids	**(dry tons/yr)**	**756**	**898**	**1,136**
Nitrogen Load Pease WWTF (1)		497	587	783
Nitrogen Load Peirce Island WWTF (1)		3,360	4,124	4,510
Total Nitrogen Load (1)	**(lbs/day)**	**3,857**	**4,711**	**5,293**

(1) Includes influent nitrogen loads and nitrogen loads associated with dewatering process.

4.4.3.1 Regional Biosolids Generation Processed at Pease WWTF

4.4.3.1.1 Current

In addition to the Peirce Island and Pease WWTFs, there are 14 other WWTFs in the Study Area which, if a regional sludge and biosolids handing facility were constructed, might utilize it for disposal. In addition, four (4) local Maine communities might also utilize a regional facility, if it were available. Therefore, a total of 18 additional WWTFs might utilize a regional facility for sludge / biosolids disposal, if it were available.

Of the additional WWTFs included in this analysis, five (5) are either current or former lagoon systems. The sludge/biosolids production from these facilities are stored in lagoons, and these facilities were not been considered in this analysis. Typically, lagoon storage systems are desludged every 10 to 15 years, and while a regional facility may be identified as a disposal option, the impact would be short term. Therefore, sizing of the regional facility would not be based on the capacity required for the lagoon systems.

The breakdown of WWTFs which may contribute sludge and/or biosolids to a regional handling facility and its current production is summarized in Table 4-15.

All of the facilities listed dewater the sludge/biosolids prior to disposal, with dewatered sludge solids content ranging from a low of 12% solids to a high of 30% solids. The wet ton quantity includes both the sludge/biosolids residual liquid, as well as the actual solids. The dry ton quantity includes only the actual weight of the solids.

Table 4-15. Current WWTF Annual Sludge/Biosolids Production					
Wastewater Facility	Sludge/Biosolids Produced (Wet Tons)		Concentration (% TS)	Sludge/Biosolids Produced (Dry Tons)	
	2006	2007		2006	2007
Dover, NH	3,450	3,450	20.0%(e)	690	690
Durham, NH	1,800	1,860	22.5%	400	420
Epping, NH (a)	0	0	-	0	0
Exeter, NH (a)	0	0	-	0	0
Farmington, NH	1,800	1,800	19.5%	350	350
Hampton, NH	3,200	2,700	23.0%	740	620
Newfields, NH	0	0	-	0	0
Newington, NH	440	250	12% (2006), 19% (2007)	55	50
Newmarket, NH	130	160	17.0%	20	30
Rochester, NH (a)	0	0	-	0	0
Rockingham County, NH (a)	0	0	-	0	0
Rollinsford, NH (b)	0	0	-	0	0
Seabrook, NH	1,500	1,415	13.0%	225	210
Somersworth, NH (c)	2,200	2,400	19.0%	440	480
Berwick, ME	1,945	1,810	25.0%(f)	485	450
Kittery, ME	720	800	20.0%(e)	180	200
South Berwick, ME	2,600	2,600	23.0%	600	600
York, ME	1,340	1,480	12.0%	160	180
Pease WWTF	890	860	18.0%	160	155
Peirce Island WWTF (d)	2,515	2,815	30.0%	755	845
TOTALS:	**24,530**	**24,400**	**-**	**5,260**	**5,280**

a. Biosolids retained in lagoon system
b. Included in South Berwick, ME data
c. Estimated, data currently unavailable
d. Includes chemical sludge from CEPT system
e. Sludge concentration estimated from typical belt filter press performance
f. Sludge concentration estimated from typical centrifuge performance

4.4.3.1.2 Future

To account for growth and the impact of more stringent discharge permit limits in the future, sludge and biosolids production at the regional facilities has been projected to increase by 50% in the year 2030. This factor is based on a 20% increase in biosolids yield due to increased BOD load associated with growth and a 30% increase in biosolids yield, assuming most regional WWTFs will implement BNR processes, resulting in higher biosolids yields.

Table 4-16 summarizes projected biosolids loads associated with Peirce Island WWTF, Pease WWTF and Regional WWTFs.

Table 4-16. Projected WWTF Sludge/Biosolids Production

Wastewater Facility	Sludge/Biosolids Produced (Annual Dry Tons) 2007	Sludge/Biosolids Produced (Annual Dry Tons) 2030
Dover, NH	690	1,035
Durham, NH	420	630
Epping, NH [(a)]	0	0
Exeter, NH [(a)]	0	0
Farmington, NH	350	525
Hampton, NH	620	930
Newfields, NH	0	0
Newington, NH	50	75
Newmarket, NH	30	45
Rochester, NH [(a)]	0	0
Rockingham County, NH [(a)]	0	0
Rollinsford, NH [(b)]	0	0
Seabrook, NH	210	315
Somersworth, NH [(c)]	480	720
Berwick, ME	450	675
Kittery, ME	200	300
South Berwick, ME	600	900
York, ME	180	270
Pease WWTF	155	268
Peirce Island WWTF	845	668
TOTALS:	**5,280**	**7,356**

(a) Biosolids handled in lagoon system
(b) Included in South Berwick, ME data
(c) Estimated, data currently unavailable

Based on the above sludge/biosolids volumes, and assuming that sludge/biosolids would be brought to a regional facility, the nitrogen component of the filtrate would reach an estimated 2,070 pounds per day in the year 2030, assuming 150 mg/l total nitrogen in the filtrate.

4.4.3.2 Regional Septage Disposal at Pease WWTF

Historic data utilized to develop septage disposal forecasting has been provided by the following sources:

- Operational data for the Pease WWTF, including septage receiving records, provided by the City.

- Data collected from phone surveys of the 16 New Hampshire and four Maine wastewater treatment facilities (WWTF) within the study area for 2006 and 2007.
- Data provided by the DES, which includes 2006 theoretical (estimated) septage and actual septage data for 2006 and 2007 within the study area.

Septage is generated when the septic tank of an on-site septic system is pumped and brought to a WWTF via private septic haulers. The City currently only accepts septage at the Pease WWTF, and from non-sewered users in Portsmouth, and from Greenland, Newcastle and Rye.

In 2007, the City received approximately 1.6 million gallons of septage from these four communities. The NHDES tracks septage disposal by town. In contrast, the four communities which disposed of septage at the Pease WWTF generated approximately 2.2 million gallons of septage in 2007, or 600,000 gallons more than was disposed of at the Pease WWTF. This discrepancy is due in part to the fact that while the City only accepts septage from the four communities utilizing the service, the private septic hauler can dispose of septage at any WWTF willing to accept it. In recent years, the South Berwick, Maine WWTF has positioned itself as a regional septage disposal facility, and by offering favorable disposal rates, received over 10 million gallons of septage in 2007, three (3) million gallons of which came from New Hampshire communities.

The NHDES currently has a grant program in place which provides for a 2% grant for each community with which a grantee formulates an agreement to accept its septage, up to a maximum grant of 50%. The City is currently eligible for a 30% baseline grant; therefore, an additional 20% grant could be obtained for septage receiving and treatment, if the City were to seek formal agreements with 10 towns. The septage grant can be applied to all aspects of the WWTF affected by the receiving of septage, based on the following septage characteristics:

- BOD = 7,000 mg/L
- TSS = 15,000 mg/L
- NH_3-N = 150 mg/L

Five (5) septage generation scenarios for the planning of a potential septage receiving and handling facility have been evaluated, as presented in TM 3, provided in Volume 3 of this WMP/LTCP Update. Each Scenario presents the current estimated annual septage volumes for municipalities within the seacoast study area as identified in Section 2. These volumes will be used as a baseline for septage generation and loading scenarios and will be adjusted based on the development projections presented in TM 3 for the planning period. Of the five scenarios evaluated, Scenario B was considered the most realistic, and has been used as a basis for the flow and load analysis.

Scenario B presents septage data from the City of Portsmouth and the six (6) local municipalities surrounding Portsmouth. These municipalities were Greenland, Newcastle, Newington, North Hampton, Rye, and Stratham. The City already receives septage from Greenland, Newcastle and Rye. The annual septage generation for Scenario B is 4,133,000 gallons.

The nutrient impact of septage receiving is significant, assuming that the septage is treated as a biosolid, in that the material is dewatered and only the filtrate is introduced to the biological process. With Scenario B, an additional 5,810 lbs/day of TN would be added to the treatment process, on average.

4.4.3.3 Regional FOG Disposal at Pease WWTF

In 2006 the New Hampshire Legislature passed HB 1373 which established a "Commission" to study fats, oils, and greases (FOG) generation and to recommend best management practices for FOGs. The Commission was comprised of various entities within the State of NH including representatives from the state government (Speaker of the House and Senate President), **Department of Environmental Services**

(NHDES), NH Association of Septage Haulers, NH Lodging and Restaurant Association, NH Water Pollution Control Association, and the University of New Hampshire.

FOG is commonly derived from food products such as deep-fried foods, meats, sauces, gravy, dressings, baked goods, cheeses, and butter. Food-derived FOG can end up going down the drain and ultimately into the sewer system during the cleaning of plates, pots and pans to remove food residue or by improper disposal of leftovers or grease. Once inside the sewer, FOG can form a thick layer on the inside of pipes blocking sewage from traveling through the sewer pipe.

Using the same region as Scenario B for septage, the annual FOG range of loading would be 68,000 gal/yr from Portsmouth and an additional 545,000 gal/yr form the surrounding communities. The actual volume of FOG received would depend upon tipping fees, alternative disposal options, and volumes generated.

4.5 Design Parameters Summary

The following tables summarize the design basis for sizing alternatives for wastewater treatment, as presented in Section 5 of the WMP/LTCP Update. Table 4-17 is based on the Peirce Island WWTF remaining in operation. Table 4-18 is based on the Peirce Island WWTF being converted to wet weather treatment only and the Pease WWTF becoming the main WWTF for the City.

It must be understood that the combined sewers tributary to the Peirce Island WWTF significantly skew the historic average daily flow for the Peirce Island WWTF. Therefore, as presented later in this report, a phased construction approach must be implemented, which will allow the City to continue its sewer separation program and measure the impacts of these efforts. The reduction in flow due to the sewer separation efforts will allow the City to construct a WWTF properly sized for the future wastewater flow. The information presented below has been used as a "worse case" basis for WWTF sizing and associated costs.

Table 4-17. Peirce Island WWTF Design Parameters

Parameter	Units	Design Year		
		2010	2030	2060
Average Daily Flow	MGD	4.8	6.2	6.9
BOD	Lbs/Day	7,491	8,875	10,245
TSS	Lbs/Day	7,283	8,632	9,966
TKN (1)	Lbs/Day	3,360	4,124	4,510
Sludge/Biosolids	Dry Tons/Year	582	692	862

(1) Includes both influent and biosolids processing.

Table 4-18. Pease WWTF Design Parameters with Peirce Island WWTF Converted to Wet Weather Treatment

Parameter	Units	Design Year		
		2010	2030	2060
Average Daily Flow	MGD	6.0	7.9	9.2
BOD	Lbs/Day	10,037	11,884	14,255
TSS	Lbs/Day	9,800	11,237	13,006
TKN (1)	Lbs/Day	3,857	4,711	5,293
Sludge/Biosolids	Dry Tons/Year	756	898	1,136

(1) Includes both influent and biosolids processing.

5. WASTEWATER TREATMENT ALTERNATIVES

This section of the WMP will address work completed under Task 5, the Alternatives Evaluation, identified in the WMP work plan. Specifically, this section will focus on the wastewater treatment portion of the alternatives evaluation. The wastewater treatment alternatives evaluation has been continuously evolving throughout the master planning process due to the lack of established regulatory parameters, and the ever-changing indications as to what they will be, discussed in Section 3 of this WMP/LTCP Update. As part of the WMP work plan, the City has submitted updates to the EPA and NHDES in the form of technical memoranda. Updates pertaining to the wastewater treatment alternatives were provided on December 1, 2009 in *Technical Memorandum 5: WWTF Process and Siting and CSO Abatement Evaluations* (TM5) in draft form, with an additional submission provided as a supplement to the December draft on March 1, 2010. Both of these documents are provided in Volume 3. The following section will review the critical information contained in TM 5 and present the additional work that has been done on the alternative evaluation since its submission.

5.1 Alternatives Evaluation Background

5.1.1 Treatment Technology Evaluation

At the outset of the master-planning process, a comprehensive technology screen was undertaken to evaluate all potential forms of wastewater management available to the City. This evaluation considered the feasibility of implementing the following wastewater management strategies:

- Single-family waste management (i.e. composting toilets)
- Engineered Wetlands
- Bioshelters
- Lagoons
- Decentralized WWTFs
- Centralized WWTFs

The only management strategy deemed feasible for the City of Portsmouth was a centralized wastewater treatment facility. The other strategies were eliminated due to cost, issues with reliability, excessive land requirements or excessive operating and maintenance requirements. A detailed description of the process technology evaluation for a centralized wastewater treatment facility was included in TM 5 which has been provided in Volume 3 of this report. A summary of the evaluation is included below.

5.1.1.1 Centralized Wastewater Treatment Facility Process Selection

Process selection was focused on meeting the secondary treatment requirement included in the 2007 Peirce Island WWTF NPDES permit as well as potential future TN limits. Biological nutrient removal (BNR) process technologies, which use microbiological activity within the existing wastewater and process control to achieve reduction of TN through the nitrification and denitrification processes, have the ability to incorporate both of these items. As stated previously, NHDES has recently indicated that a total phosphorus (TP) limit will likely be included in a future permit cycle. As this information has yet to be provided officially, and since discussion of possibly including a TP limit started so late in the master planning process, the following treatment technology evaluations did not take phosphorus removal into account. Additional review during preliminary design will be necessary to assure that all potential nutrient limits can be met by the selected technology.

5.1.1.2 Biological Nutrient Removal (BNR) Process Overview

The BNR process reduces the concentration of nutrients, specifically nitrogen and phosphorus, in WWTF effluent. The BNR process is a multistage treatment system consisting of anoxic and aerobic treatment tanks for nitrogen reduction; anaerobic and aerobic treatment tanks are utilized for phosphorus removal.

Effluent TN is reduced by transforming the chemical composition of nitrogen compounds in wastewater through biological nitrification and denitrification processes. Nitrogen exists in typical domestic wastewater as ammonia (N-NH_3) that enters the waste stream from human urine and other sources. BNR processes are designed to transform ammonia-nitrogen into compounds that are easily removed and are not harmful to receiving waters or the environment. To this extent, most BNR processes transform nitrogen compounds to elemental nitrogen (N_2) that is released as a gas under normal conditions to the atmosphere, which is made up of mostly nitrogen gas (78% by volume).

In order to form nitrogen gas, ammonia-nitrogen must be first oxidized to nitrate (nitrification) and then reduced (denitrification) biologically. Various species of bacteria involved in the nitrification process (nitrifiers) use dissolved oxygen (DO) provided by supplying air or pure oxygen through wastewater held in aeration tanks to oxidize ammonia-nitrogen to nitrite (NO_2-) and then nitrate (NO_3-). Once nitrates are formed, the wastewater is then moved to an anoxic tank to allow other bacteria (denitrifiers) to transform nitrates to nitrogen gas, which is then released to the atmosphere. Denitrifiers use the oxygen available in nitrate compounds to live since elemental oxygen (O_2) is not available.

BNR process technologies are designed in different ways to provide the optimal conditions for bacteria to grow and to promote the nitrification and denitrification reactions to occur. The following sections summarize the BNR processes evaluated as part of the WMP and describe how each process technology is configured to promote nitrification and denitrification reactions.

5.1.1.3 BNR Process Technologies

The City and the WMP Team identified BNR treatment technologies that are currently used in the US to reduce total nitrogen to meet effluent discharge permit limits in WWTFs. The technologies selected for evaluation included both traditional suspended and fixed growth technologies as well as some emerging process technologies. Detailed descriptions and process flow diagrams of the BNR technologies evaluated were provided in TM 5 which is available in Volume 3 of this report.

5.1.1.3.1 Suspended Growth Processes

Suspended growth processes were originally developed to remove organic matter, expressed as carbonaceous biochemical oxygen demand (cBOD), from wastewater and expanded upon to remove nitrogen through BNR. The process is referred to as “activated sludge” because it promotes the growth of a mass of microorganisms, mostly bacteria, to consume organic matter in wastewater. The mass of microorganisms or activated sludge is recycled within the process and kept in suspension in wastewater to maintain growth and consumption of organic matter and nutrients by mixing. The mixture of circulated or returned activated sludge (RAS) with wastewater entering the process is referred to as "mixed liquor" and measured by the concentration of "mixed liquor suspended solids" (MLSS).

Oxygen is transferred to the mixed liquor in aeration basins to maintain a DO concentration of at least 2 mg/L. Because nitrifying bacteria grow slower than most heterotrophic bacteria in activated sludge, sludge retention time (SRT) within the aeration portion and within the entire process must be long enough so nitrifiers can thrive and are not removed or washed out of the system with settled solids. Bacteria growth rate is a function of temperature and must be considered during process design. Therefore, the additional treatment levels required to remove TN impact treatment tank size and the associated capital and operational costs.

Denitrification can be promoted by the addition of an anoxic zone before the aerobic zone (pre-anoxic) or after the aerobic zone (post-anoxic). A mixed liquor recycle is required for pre-anoxic zones to achieve high nitrate removal. For lower TN limits, an additional carbon source (typically methanol) may be required to promote growth of denitrifying bacteria in post-anoxic zones because of the low levels of organic matter remaining in wastewater leaving the aerobic zone.

The following suspended growth technologies were evaluated:

- Multiple Stage Activated Sludge
  - Modified Ludzak-Ettinger (MLE)
  - Bardenpho
  - University of Capetown (UCT)
  - Johannesburg (JHB)
- Oxidation Ditches
- Sequencing Batch Reactors (SBR)
- Membrane Bioreactor (MBR)

5.1.1.3.2 Fixed Growth/Hybrid Processes

Similar to multiple-stage activated sludge BNR systems, fixed growth BNR systems were originally developed to remove organic matter in the form of cBOD and have been modified to remove nutrients over the years. Hybrid systems are one example of these modifications. In contrast to suspended growth processes, the microbial mass in a fixed film and hybrid process is grown as a biofilm slime layer on support media through contact with wastewater. Commonly used support media include stone, wood, and plastic. Fixed growth processes are also referred to as "fixed film" or "attached growth" systems. Conventional fixed film processes used for BNR include trickling filters and rotating biological contactors (RBCs).

Like activated sludge BNR systems, conventional fixed film processes were modified for BNR by adding separate stages for nitrification and denitrification. For fixed-film processes, nitrification only occurs with very low organic loading rates because nitrifying bacteria must compete with heterotrophic bacteria that have an abundant food source: cBOD. In some cases, downstream nitrifying trickling filters are added to reach the level of nitrification required to meet nitrogen limits. In response to footprint concerns and nutrient requirements, some hybrid processes were developed that allowed higher solids loading and enhanced nitrification within activated sludge systems by providing carrier media on which microorganisms could grow and form a biofilm. Both fixed-growth and hybrid systems require a downstream clarifier for solids removal. Hybrid processes also need downstream denitrification processes, such as a denitrifying filter.

The following fixed growth/hybrid process technologies were evaluated:

- Biologically Aerated Filters (BAF)
- Trickling Filter/Solids Contact (TF/SC)
- Rotating Biological Contactor (RBC)
- Integrated Fixed Film Activated Sludge (IFFAS) and Moving Bed Bioreactor (MMBR)

5.1.1.3.3 Emerging Technologies

5.1.1.3.3.1 BioMag™

The BioMag™ system is an emerging biological treatment technology that incorporates magnetite ballast into biological floc to increase specific gravity and improve settling of the biological floc as compared to traditional suspended growth/activated sludge processes. The magnetite ballast is recovered and reused using shearing and magnetic separation equipment. This equipment includes an in-line shear mixer and magnetite recovery drum. The system is patented and produced by a single manufacturer, Cambridge Water Technologies (CWT).

Initially, the system was designed to allow significantly higher solids loading and MLSS concentrations in a conventional activated sludge system within the same process footprint. Some recent pilot testing has indicated potential enhancements to nitrogen removal, and this is being confirmed by the manufacturer through a variety of full scale operational tests throughout the country.

It is the understanding of the WMP team that the BioMag™ system is most beneficial when integrated with an SBR system because of potential settling issues with magnetite in return flow lines for activated sludge systems.

5.1.1.3.3.2 MicroMedia Filtration and CleanScreen System

The MicroMedia Filtration (MMF) System is a new system that combines physical separation and biological processes into a packaged system. The system includes influent screening to remove large particulate solids from raw wastewater, followed by a sand filtration vessel and a biological treatment vessel.

The system has been used on a limited basis for treatment of small flows from 0.1 to 2.4 mgd for pilot scale demonstration and for full scale installation. A pilot-scale demonstration facility has been operating in Deerfield, NH since September, 2008 treating approximately 0.06 mgd. The largest installation of the MMF system is scheduled to be fully operational at the City of Adelanto, CA WWTP (2.4 mgd).

Limited information and performance data for the MMF system has been provided by local representatives Green Power Management in Newmarket, NH. The system's performance for nitrogen removal was unclear at the time of this WMP/LTCP Update.

5.1.1.4 BNR Process Technology Screening Criteria

The City and WMP project team developed evaluation criteria to perform a preliminary screening of BNR process technologies in order to focus the more detailed WWTF layouts and cost analysis efforts on realistic treatment alternatives for the City.

Preliminary screening of treatment technologies was based on criteria developed for the selected WWTF sites (Peirce Island, Pease, and at PSNH/Sprague) and permit requirements of 30 mg/L, 30 mg/L, and 8 mg/L for BOD, TSS, and TN, respectively. Technologies not meeting any of the preliminary criteria were not evaluated further. Additional criteria were also developed to evaluate:

- The ability of the technology to meet TN limits as low as 3 mg/L.
- The ability to provide for advanced biosolids handling.
- Operability, resiliency and energy use.
- Ease of upgrading to more stringent limits and/or higher flows and loads.

The detailed criteria and ranking results were presented TM 5 Appendix B which is provided in Volume 3.

5.1.1.5 BNR Process Technology Screening Results

The highest ranking secondary treatment technologies were as follows with final rank shown in parentheses:

- IFFAS (1)
- SBR (1)
- MLE (2)

A brief description of the selected technologies is provided below:

5.1.1.5.1.1 Integrated Fixed Film Activated Sludge (IFFAS)

An IFFAS system forms a hybrid process that increases the loading rate and enhances nitrification in activated sludge systems, especially in colder climates, by using fixed-growth on carrier media. These systems are used primarily to lower the footprint needed for nitrification and denitrification at land-constrained sites. The carrier media is suspended and mixed in the aeration basins of an activated sludge process and provide high surface area growth sites for microorganisms and be maintained as a biofilm.

Because IFFAS is primarily a modification to an existing activated sludge process, the process flow for the hybrid system formed will resemble the process it is used with for BNR such as MLE, Bardenpho, etc. Adjustments include additional mixing energy to keep media in suspension and internal mixed liquor and recycle stream pumping modifications for IFFAS processes. IFFAS systems require downstream solids removal from effluent wastewater using clarifiers or other physical separation processes. Dissolved air flotation (DAF) is often used after an IFFAS process because experience shows that a highly loaded IFFAS bioreactor may result in poorly settleable but easily floatable sludge, and also because it is a small footprint separation technique.

5.1.1.5.1.2 Sequencing Batch Reactor (SBR)

An SBR is a multi-stage activated sludge process in which all stages take place in a single reactor or tank in a batch process. These stages include cBOD reduction, nitrification, denitrification and clarification and are represented by different “modes” during operation of the SBR.

The SBR process typically requires a significantly smaller footprint than other multi-stage activated sludge processes because it uses a single reactor tank and does not need separate clarifiers. SBRs are currently used at over 100 New England WWTFs and over 1,000 WWTFs worldwide. The City of Portsmouth currently owns and operates an SBR at its Pease Facility.

5.1.1.5.1.3 Multiple Stage Activated Sludge

A multiple stage activated sludge system uses a conventional activated sludge system with additional aerobic and anoxic zones to enhance nitrogen removal and sludge settling characteristics. The configurations and complexity of additional zones varies by the type of multiple stage process, and can include multiple pre- and post-anoxic and aerobic zones. Pre-anoxic zones are added for denitrification of nitrates in RAS and to inactivate or restrict the growth of filamentous microorganisms that form in the aeration zone and impede settling performance of solids in downstream clarifiers. Post-aerobic zones are added to agitate denitrified mixed liquor to release entrained nitrogen gas that will also impede settling performance of solids.

5.1.1.5.2 Further Evaluation of Selected Technologies

These process technologies were evaluated further through preliminary modeling and process sizing. The assumptions and methodology used for preliminary modeling were described in TM5, Appendix C which has been provided in Volume 3. For the purposes of this report, BioMag™ modeling considered the SBR process similar to the Bardenpho process.

Although BioMag™ did not rank as high as the MLE, IFAS, or SBR processes, it presented a potential method for significantly reducing process tank size and capital costs and improving effluent quality when used in conjunction with an SBR system. Because of the reduction in required tankage, an integrated SBR-BioMag™ process has the potential to make some WMP flow scenarios feasible, that may not have been previously, due to required footprint and available land space. According to the vendor, integration of the BioMag™ system to a conventional SBR process could provide a 75 to 100 percent increase in process capacity.

While a SBR- BioMag™ system shows promise, the WMP team recognizes that the BioMag™ system is an emerging technology and has not yet been applied full scale to an SBR facility for BNR at flows similar to future wastewater flows that the City is facing. Therefore, the BioMag™ system may be evaluated further and considered for pilot testing at the existing Pease WWTF in the future.

5.1.2 Initial WWTF Alternative Evaluation

5.1.2.1 Initial Wastewater Treatment Scenarios

The initial WMP alternative evaluations were centered on three basic scenarios for WWTF upgrade. The scenarios were developed to focus on the primary goal of meeting secondary treatment and nutrient removal requirements for those wastewater flows currently being treated at the Peirce Island WWTF. The three scenarios are as follows:

Scenario 1 - Wastewater continues to be treated on Peirce Island: Resembles existing conditions and involves virtually no changes to the City's current wastewater collection system infrastructure. The City would continue to own and operate two WWTFs, the existing Pease WWTF and an upgraded WWTF at Peirce Island. The current pumping and gravity conveyance configuration would not require modification beyond those intended for CSO abatement.

Scenario 2 - Wastewater is split evenly between the Peirce Island WWTF and the Pease WWTF: Involves redirecting a portion of the current Peirce Island WWTF flow to the Pease WWTF by modifying select pump stations. A sufficient amount of flow would need to be diverted such that the Peirce Island WWTF could be upgraded to safely accommodate the secondary treatment and nitrogen removal processes required by potential new effluent discharge limits in future NPDES permits. The City would continue to own and operate the two WWTFs at Peirce Island and Pease, both of which will require upgrades.

Scenario 3 - Wastewater is not treated on Peirce Island, all wastewater is redirected to Pease or a new site: Involves the complete removal of sanitary flow from Peirce Island and the construction of a single WWTF at either the existing Pease WWTF site or a new site.

These scenarios formed the basis of both the WWTF and CSO abatement plans presented in December 1st 2009 TM 5 submission. Details of the CSO abatement plans and the collection system modifications and improvements (flow re-direction) associated with these scenarios will be discussed in subsequent sections of the WMP/LTCP Update.

5.1.2.2 Initial Assumptions

5.1.2.2.1 Design Flows

In TM 5, 2060 flows were used for sizing the wastewater treatment facilities. Using the 2060 projections for site technology screening was considered appropriate because sufficient room on the WWTF site should be provided for final build out, and the layout of the WWTF components, including tanks, piping and electrical conduit runs should be designed such that the required additional components meet year 2060 flows. However, it is important to note that actual design and construction of the WWTF would be based on 20 year projections, in keeping with standard engineering practices. Derivations of the projected 2030 and 2060 average daily sanitary flows were discussed in Section 4 of this WMP/LTCP Update and are summarized in Table 5-1 below.

Table 5-1. Average Daily Design Flow

Source	Current Plant Rating	Increase through Year 2030	2030 Plant Rating	Flow Increase through Year 2060	2060 Plant Rating
	(mgd)	(mgd)	(mgd)	(mgd)	(mgd)
PI WWTF	4.8	0.9	5.7	1.3	6.1
PIT WWTF	1.2	0.5	1.7	1.1	2.3
Regional	N/A	0.5	0.5	0.8	0.8
Combined	6	1.9	7.9	3.2	9.2

It was assumed that the continuation of sewer separation projects will reduce the peaking factor associated with the maximum month flow, and that the maximum month flow will remain unchanged from the historic value of 13.0 mgd through the year 2060.

5.1.2.2.2 Nutrient Limits

As discussed previously, each flow scenario in TM 5 was based on a TN limit of 8 mg/L. However, because the final decision in regards to TN limits throughout the watershed has yet to be determined, each scenario also considered a TN limit as low as 3 mg/L. A TN limit of 3 mg/L is considered the limit of technology for warm weather climates and year-round compliance may not be possible in a cold weather climate such as Portsmouth.

With the exception of the SBR process, the tank volumes required to meet a TN limit of 8, 5, or 3 mg/L are identical for each of the individual BNR processes being considered. The SBR process benefits from simultaneous nitrification and denitrification in a single tank, and requires longer detention times and thus larger tank volumes, to meet lower TN limits. For each BNR process, the tank volumes that are required to meet a TN limit of either 5 or 3 mg/L are identical. However, the quantity of additional carbon (i.e., methanol) needed to meet a limit of 3 mg/L can be significantly greater than that required for a limit of 5 mg/L. For TN limits of 5 and 3 mg/L, a tertiary denitrification filter was included to meet the lower limits.

In the December 1, 2009 TM 5 submission, the evaluation of BNR treatment processes focused around a TN of 8 mg/L and, as a result, did not include costs for a tertiary denitrification filter or the use of additional carbon sources. However, space allowances for these facilities were provided in the event they became necessary.

No consideration was given to meeting TP limits in TM 5.

5.1.2.2.3 Required Unit Processes and Equipment

All treatment scenarios included additional necessary infrastructure to support the wastewater treatment technology and maintain the City's overall wastewater treatment system. In the December 1st 2009 TM 5 submission it was assumed that all equipment, process facilities and administrative buildings would be new, or repaired and/or replaced at the time of the upgrade to secondary treatment.

5.1.2.2.4 Site Limitations

Some treatment technologies were not feasible for all scenarios. The MLE and IFFAS process technologies require large footprints and secondary clarifiers. Due to the limited amount of space on Peirce Island, MLE and IFFAS were deemed inappropriate for further analysis in Scenarios 1 and 2 because both of these scenarios involved treatment on the island. The footprint for an SBR facility requires less area since secondary clarifiers are not required; therefore, the technology was considered to have potential on Peirce Island.

It was determined that if expansion at the Peirce Island WWTF were restricted to within the existing fence line, the capacity of a new SBR process was limited to approximately 2.2 mgd. This would require the Pease WWTF to treat 7 mgd at 2060 build out. It was not considered logical to reroute such a high percentage of the flow to Pease because the City would need to expand and operate both the Peirce Island and Pease WWTFs in addition to making significant changes to the collection system and pump stations. If the City were going to put in the required effort to reroute 7 mgd to Pease, the more effective measure would be to reroute all the flow and operate only one WWTF. For this reason, the option of constructing an upgrade to the Peirce Island WWTF within the fence line was not considered in TM 5. Instead construction options outside the fence line were considered for Scenarios 1 and 2.

Because only the SBR process had the potential to fit on the Peirce Island WWTF site (outside the fence line) within the required setbacks, and because the SBR process already exists at the Pease WWTF, TM 5 treatment Scenarios 1 and 2 only included the SBR technology. Scenario 3 alternatives were developed for all three of the selected technologies MLE, IFFAS and SBR.

5.1.2.3 Initial Preferred Alternative

In the draft of TM 5 submitted on December 1, 2009, Scenario 3 using SBRs at the Pease WWTF was identified as the preferred option of all 3 initial scenarios developed and presented. This alternative was selected as the preferred option for the following reasons:

- Moving sanitary wastewater treatment off of Peirce Island is desired by the City. This honors the reaffirmed intentions of City residents, and allows the City to remove an industrial use from the City's historic and residential downtown. Moving sanitary treatment off of Peirce Island also preserves and protects the remains of historic Fort Washington.
- Scenario 3 also allowed for expansion as TN limits or other effluent limits may change over time. It allowed for potential future regional efforts for wastewater treatment and/or sludge reuse and/or disposal. The lack of available land at Peirce Island limits future expansion possibilities if TN limits below 8 mg/L are incorporated into future permits.

- Finally, Scenario 3 with SBRs included a phased approach to design construction and implementation of secondary treatment. The phased approach had the benefit of delivering positive environmental impacts sooner rather than later by shifting some flow to utilizing existing secondary capacity at the Pease facility and possibly makes the construction of a new facility more affordable. While an expansion at Pease was not dependent on the viability of the emerging technology, BioMag™, there is the potential to combine BioMag™ with the SBR system to increase the capacity of the existing tanks, and reduce the size of future ones. If piloting of BioMag™ is successful, the City may have the opportunity at Pease to reduce its costs. If BioMag™ is not successful, the City can still proceed with construction using more traditional technologies.

5.1.2.4 Areas of Concern

A couple areas of concern were also identified at the time of the December 1, 2009 submission. These concerns were primarily related to unresolved regulatory issues which had the potential to alter the preferred alternative once decisions about them were made and affordability issues were resolved.

The major concern was that the Pease outfall would not be permitted for the full 2060 design flow. NHDES comments on the December 1, 2009 submission supported these concerns and indicated that the current mass load from the plant may need to be held to current discharges and an anti-degradation study performed.

Another source of concern for the city and the WMP team was the magnitude of the costs associated with all the alternatives evaluated for the three scenarios. TM 5 draft tables 5-17 and 5-18 show the opinions of life cycle and capital cost associated with each scenario for a TN limit of 8 mg/l. As the project progressed these opinions of cost evolved. The updated opinions of cost were provided in March 2010 TM 5 supplement Tables 5-18 and 5-19. In both cases the life cycle costs for the 3 scenarios are in the 200 million dollar range with the capital costs well over 100 million. It was the City's concern that a capital expenditure of this size would force sewer rates to increase to a point where they would no longer be affordable for the average user. Inputting these opinions of costs to the City's user rate model confirmed that rate impacts would be significant and prompted the WMP team to begin an affordability analysis per the EPA guidelines. This analysis will be discussed further in Section 7 of this WPM/LTCP Update.

Having such high costs associated with meeting a TN limit of 8 mg/l increased the City's concern with the possibility that the EPA and NHDES may not support this limit and push for a TN limit of 5 or even 3 mg/l. These lower limits have even higher life cycle and capital costs associated with them and, if not achievable in Portsmouth's cold weather climate, could add the additional burden associated with not meeting permit requirements.

5.1.2.5 VE Analysis

In order to confirm that the master planning process was on track, the City had AECOM perform a value engineering (VE) exercise in February of 2010. The draft report is attached in Appendix H. Due to concerns with the viability of the Pease outfall, and the affordability issues stated above, the City requested that AECOM focus on finding a WWTF alternative with the following constraints:

- Upgrade the Peirce Island WWTF to treat an annual average flow of 6.1 mgd and a peak flow of 9.5 mgd, which would serve the City through year 2030 projections. Flows above 9.5 mgd would be treated with chemically enhanced primary treatment, using the existing primary clarifiers on Peirce Island, and discharged after disinfection. Plant infrastructure should be contained within the existing fence line if possible.
- Initial permit limits may be an average TN limit of 8 mg/L. However, based on indications from the NHDES, provisions should be made for a TN limit of 5 mg/L.

- Capital expenditure, including design, construction, and construction management should be limited in order to keep the project affordable to the community. For this purpose, the existing, but unused, filter building on Peirce Island should be utilized when possible. The maximum capacity of the existing building within the filter area is estimated to be approximately 0.5 MG with a surface area of approximately 3,800 ft^2.

Based on these decisions and limitations, it was clear that the initial alternatives for the three scenarios would either not fit within the site constraints of the Peirce Island WWTP, or would be too capital intensive. For this reason "Scenario 4" was developed, which took into account the aforementioned constraints and required a new approach focusing on compact, lower cost options.

The alternative for "Scenario 4" proposed by AECOM during the VE comprised a denitrification moving bed biofilm reactor (MBBR) followed by a combined carbonaceous and nitrifying biological aerated filter (BAF) with a 100-percent recycle for denitrification. This alternative was proposed without intermediate or final clarification by filters or another polishing step. The approach represents high rate system using technologies which had been previously eliminated during the technology screen. The approach is considered a "stripped down version" compared to the previous alternatives as it focused solely on designing for 2030 flows, took into account only the construction required to meet secondary treatment, and did not include any repair or modifications to existing facilities.

The approach represented by this alternative has merit. However, with the wastewater characterization data available to date, it is questionable if this alternative would be able to meet a TN limit of 8 mg/L without carbon addition and/or additional polishing steps. Carbon addition and additional unit processes would certainly be required to meet a TN limit of 5 mg/L.

5.1.2.6 "Scenario 4"

Recognizing the potential of the high rate approach put forward by AECOM to achieve a viable cost effective solution on Peirce Island, a number of additional alternatives were identified by the WMP team to be evaluated for "Scenario 4" in the March 1st supplement to TM 5. The alternatives identified were as follows:

1. Denitrification moving bed biofilm reactor (MBBR) followed by biological aerated filter (BAF). Post-denitrifying filters would be provided if a TN limit of 5 mg/L is imposed.
2. Denitrification MBBR followed by aerated MBBR. Either a clarifying dissolved-air flotation or secondary clarifiers would be provided for effluent clarification. Post denitrification MBBRs would be provided (before the clarifiers) if a TN limit of 5 mg/L is imposed.
3. Membrane bioreactor (MBR) system with reactor zones arranged in a Bardenpho configuration. No post treatment will be required to meet 5 mg/L TN in this alternative.

Each of these was discussed in detail in the March 1, 2010 TM 5 supplement and it was recommended that they be evaluated further before any decisions were made.

After further analysis and discussions with the manufacturers of the three technologies in question, it was determined given the site constraints that the only alternative that truly had the potential to be implemented at the Peirce Island site was the MBR. For this reason it has been carried forward in the updated WMP alternative discussed below. It should be noted that MBR was originally eliminated from the master plan during the Treatment Technology Selection summarized earlier in this section. MBRs were initially eliminated due to the fact that they are operations and maintenance intensive and susceptible to the type of grease issues which the City of Portsmouth has historically experienced. The only reason they are being carried forward in the current evaluation is the relatively small footprint and capital cost requirements associated with them.

5.2 Updated WMP Wastewater Treatment Alternatives

Since the submission of the draft TM 5 and its final supplement, the wastewater treatment alternatives evaluation has continued to evolve. Financial, regulatory and siting constraints have led the WMP team to refine both the project assumptions and the wastewater treatment alternatives. The Phased Expansion of Pease represented by initial scenario 3 was the preferred alternative; however, due to the regulatory and other unknowns discussed above, which could have a significant impact of this alternative, the WMP is also including the Peirce Island Upgrade as a possible alternative. Where the evaluation stands now is discussed below.

5.2.1 Updated Assumptions

5.2.1.1.1 Design Flows

While the original intent of the WMP team was to compare alternatives based on the 2060 year buildout, the magnitude of costs associated with this buildout were so far beyond the City's reach it was impossible to provide a proper comparison since none of the alternatives were financially feasible. For this reason it was determined that a typical 20 year buildout using the 2030 flows would be the basis for comparison. The derivations of these flows were discussed in Section 4 of this report and have been summarized in Table 5-1.

As discussed in Section 4, the combined sewers tributary to the Peirce Island WWTF significantly skew the historic average daily flow for the Peirce Island WWTF, which impacts the projection of flows shown in that section and in Table 5-1. The City is in the midst of its sewer separation program which is discussed in detail in Volume 2 of the WMP/LTCP Update. The impacts of the reduction in flow due to the sewer separation efforts will need to be measured to allow the City to construct a WWTF properly sized for the future wastewater flow. Due to the schedule outlined by the City's consent decree, there was not sufficient time to complete the sewer separation efforts and monitor this effect of flow before the completion of the WMP. For this reason the WWTF uses the "worse case" flow projections for sizing and associated costs.

5.2.1.1.2 Nutrient Limits

As discussed previously, no official decision has been made about what nutrient limits will be imposed in the upcoming permit. However, recent indications from the regulators have suggested that the total nitrogen limit may be less than the 8 mg/l assumed in TM 5. For the purposes of this WMP/LTCP Update, evaluation of the alternatives with all 3 potential TN limits (8, 5 and 3 mg/l) is being carried forward.

Recently the possibility of the permit including a total phosphorus limit of 1 mg/l has been introduced. The potential for each alternative to meet this TP will be discussed in their descriptions below.

5.2.1.1.3 Required Unit Processes and Equipment

The magnitude of the costs predicted for all 3 scenarios in TM 5 was higher than expected, to a point where none of the alternatives were deemed financially feasible. The current alternative evaluation addressed this issue by taking a more frugal approach to determining the new construction, repair and replacement of unit processes or equipment necessary to meet the City's consent decree. The new approach focuses on reusing as much existing infrastructure as possible, and distinguishes between the consent decree improvements and work related to the Capital Improvements Plan (CIP). The implications of this will be discussed in greater detail in Section 7 of this WMP/LTCP Update.

5.2.2 Current WWTF Alternatives

The current alternative evaluation involved only 2 scenarios, an upgrade at Peirce Island or an expansion at Pease. These two options are essentially TM 5 Scenarios 1 and 3, with a slight modification to the design flows now that the evaluation will be based on 2030 buildout. The option of splitting flow evenly between the two existing facilities (TM 5 Scenario 2) was discarded due to the high cost of upgrading and running both plants relative to focusing on one. As mentioned previously the City's option on the PSNH site, which was to be an alternate to Pease for Scenario 3, has been given up and will no longer be considered as a potential WWTF site. The build-out flow rates associated with the current scenarios are presented in Table 5-2.

Table 5-2. Average Daily Flows for Current WMP Flow Scenarios

Design Year	Peirce Island Scenario (1B) 2030 (mgd)	Pease Scenario (3B) 2030 (mgd)
Peirce Island WWTF	6.2	0
Pease WWTF	1.7	7.9

5.2.2.1 Peirce Island Upgrade

The option of upgrading the existing Peirce Island WWTF is being carried forward in the current alternatives evaluation because of the question described above concerning the cost of the initial preferred alternative at Pease. Upgrading Peirce Island has the greatest potential to reuse the City's existing infrastructure and therefore may present some cost savings. The Peirce Island alternative involves upgrading the existing chemically enhanced primary treatment plant by installing an MBR system for secondary treatment and nutrient removal.

Expanding sanitary treatment facilities on Peirce Island is contrary to City residents' expressed goal of reclaiming Peirce Island. The island adds recreational value to the city through its walking trails and has historical significance from being the site of Fort Washington during the Revolutionary War. A portion of the fort was destroyed during the construction of the original WWTF and it is one of the City's goals to preserve the remaining structures. In order to protect the City's interests on the island, the current Peirce Island alternative is based on keeping the upgrade within the existing WWTF fence line. Even with the goal of staying within the fence line, there could still be issues with the Shoreline Protection Setbacks, which may need to be waived for new construction since the existing site does not meet the current 250 foot requirement.

The MBR was chosen as the appropriate technology for the Peirce Island alternative as it is the only one evaluated which has potential to treat the projected 2030 Peirce Island flow of 6.2 mgd, and meet potential nutrient limits, within the existing WWTF fence line. In order to keep the facility within the existing fence line, and accommodate a portion of wet weather treatment with the existing CEPT capacity, a maximum sanitary flow of 9.5 mgd has been established for the Peirce Island alternative. Flows in excess of 9.5 mgd would be considered wet weather only and bypassed around the secondary process after receiving chemically enhanced primary treatment.

In addition to the Peirce Island upgrade, a small expansion of the Pease WWTF would be necessary to accommodate all of the projected sanitary flow for the city at 2030 buildout as shown in Table 5-2.

5.2.2.1.1 Treatment Process

The membrane bioreactors would be applied within a Bardenpho treatment configuration. The process would consist of pre-anoxic and aerobic process reactors, followed by a secondary anoxic zone and the MBRs as the final aerobic process. The advantage of this MBR setup for Peirce Island is that nitrification and denitrification are achieved within one set of reactors, with no additional process reactors required to meet potential nutrient limits. An MBR Bardenpho system should be able to meet all three potential TN limits

(3, 5 and 8mg/l) provided that an additional carbon source such as methanol can be added. The system should also be able to achieve the potential TP limit of 1 mg/l based on its ability to remove particulates.

While primary clarification is not always a requirement for an MBR Bardenpho system, the Peirce Island alternative includes primary treatment in order to minimize the footprint requirements of the secondary process by reducing the load it is required to treat. Using the primary clarifiers for treating sanitary flow affects the capacity available for their reuse as wet weather treatment. The implications of this will be addressed in detail in the CSO treatment section of the WMP/LTCP Update.

5.2.2.1.2 Implementation

An upgrade of the existing headworks, disinfection and biosolids processing facilities would be necessary if a secondary process is added to the Peirce Island WWTF. The existing clarifiers would be used for primary treatment with minor rehabilitation.

The membrane tanks and secondary anoxic zone could be housed in the existing filter building structure to save as much space on the site as possible. The existing filter boxes would be modified to remove the false floor and to allow flow-through the eight filter cells. Half of the cells would be the secondary anoxic zones with mixers, and the remaining cells would house the membranes. The existing filter gallery would be used to house permeate pumps, and other MBR appurtenant equipment.

New tankage would be required to house the upstream anoxic and aerobic process reactors. The new tanks could potentially be housed in a new building at the WWTF, or the existing filter building could be modified such that the new reactors would be housed above the current filters in a nested tank configuration. Either option would involve complex construction due to the limited space available at the existing WWTF and the sites' location on an island.

5.2.2.1.3 Advantages of a Peirce Island Upgrade

- Can meet low total nitrogen and phosphorus limits
- Maximize use of existing infrastructure
  - Both with collection system and WWTF

5.2.2.1.4 Disadvantages of a Peirce Island Upgrade

- Contrary to City's expressed goal of reclaiming Peirce Island
- Limited upgrade capacity
  - Upgrade to 2030 flows pushing limits of existing fence line
  - No room for future expansion within fence line
  - Waiver of the Shoreline Protection setback will likely be required for any work outside fence line
- Upgrade at Pease facility would still be necessary (particularly if phosphorus limit is issued)
- Upgrade cannot be phased
- MBR process is complex and operations & maintenance intensive
- Reduction of wet weather treatment capacity at Peirce Island
- Difficulty of on-island construction
- Potential need for nested tanks will increase construction costs
- Potential impacts to Fort Washington requiring a 106 Historic Review Process
- Additional truck traffic through central business district during construction and operations
- Challenging operations

5.2.2.2 Pease Expansion

The Pease alternative is almost identical to that described for Scenario 3 in TM 5. The SBR facility at the Pease WWTF would be expanded to treat an average daily flow of 7.9 mgd, which is the entire sanitary flow projected for 2030 buildout. SBRs tied for first during the technology screening effort and were one of the lower cost options for Pease as presented in both TM 5 submissions. While some slight modifications to the City's long-term lease of site may be required, there is adequate space at the existing facility to not only build the 7.9 mgd facility required for 2030 flows but also room for future expansion to the projected 2060 average daily flow of 9.2 mgd. Furthermore, the additional space available at the site could be used for a potential septage/biosolids handling facility to generate green energy.

All sanitary flow would thus be removed from Peirce Island and the existing WWTF would be converted to treat wet-weather flow only. This will be described in greater detail in subsequent sections of this WMP/LTCP Update.

5.2.2.2.1 Treatment Process

For the current alternative evaluation the only treatment technology being considered for the Pease Expansion is an SBR process. In an SBR system the entire treatment process, including nitrification and denitrification, is completed within a single batch reactor. The reactor is filled with wastewater and based on the timing of the mixing, aeration, settle and decant steps can be run as a traditional activated sludge, MLE or Bardenpho batch process. Multiple reactor basins are cycled so that at least one basin is always receiving influent flow in a fill cycle. An SBR system should be able to meet potential TN limits of 5 and 8mg/l provided that an additional carbon source such as methanol can bee added to the SBR for a TN of 5 mg/l. A deep bed denitrification filter would need to be added to the system to achieve a TM limit as low as 3 mg/l. An SBR will also be able to achieve the potential TP limit of 1 mg/l if a coagulant is added on the settle cycle to increase the removal of particulates.

5.2.2.2.2 Implementation

TM 5 assumed a brand new 4-tank SBR system would be constructed at Pease with the existing SBR tanks reused in some other capacity. As stated, the current evaluation is based upon reusing as much of the existing infrastructure as possible. Therefore, the current Pease alternative includes the expansion of the existing 2-basin 1.2 mgd system to a 4- basin 2.4 mgd system and then constructing a second 4- basin system to further expand the plants capacity.

5.2.2.2.2.1 Phased Implementation

With the expansion of the existing SBR facility as described above, the expansion would be phased by building SBR tanks as the City sheds the flow from Peirce Island. With the current proposal each of the new small basins would be added on to the existing 2- basins individually, and the new system would be built in 2-basin sets to reach 7.9 mgd. Expanding the secondary treatment process from 1.2 mgd to 7.9 mgd will require the majority of the ancillary process to be expanded also. The Pease facility will need a new headworks, new primary clarifiers, upgraded biosolids processing and upgraded disinfection. The construction of these processes would also be phased.

There is existing capacity immediately available at the current 2-basin facility that could accommodate sanitary flow from Peirce Island as soon as modifications to the collection system are in place to redirect the flow. This would provide the immediate environmental benefit of increasing CSO treatment capacity available at Peirce Island, as will be discussed further in the CSO Abatement section of this WMP/LTCP Update. The requirements for shedding flow for a phased Pease expansion will be described further in the Collection System Modifications section of the WPM/LTCP Update.

Phasing the expansion allows time to evaluate the impact of the City's ongoing sewer separation projects on the actual sanitary flow that the Portsmouth WWTF will need to treat. It is feasible that as wet-weather flow continues to be removed from the sanitary stream, the "worst-case" 2030 design flow used for this master-planning effort will become obsolete and a more representative design sanitary flow will be established. Phasing also allows time to further evaluate emerging technologies, such as BioMag™, so that their potential benefits to the SBR treatment process, such as improved effluent quality and reduced tank size, can be tested and proven. This step will require an evaluation of installations at facilities around New England and pilot testing technologies by the City of Portsmouth are completed. Because phasing allows time to refine design flows and understand the impact of emerging technologies, both of which have the potential reduce overall project costs and positively impact the sustainability of the City's wastewater treatment, it is considered a necessary component of the Pease Expansion Alternative.

5.2.2.2.3 Advantages of a Pease Expansion

- Can meet low total nitrogen limits and phosphorus limits
- Proven technology
- City currently runs SBR system
- Construction can be phased over time
- Space available for future expansion
- Easily accessible to truck traffic during construction and operations
- Consistent with the City residents goal of moving all sanitary flow from Peirce Island

5.2.2.2.4 Disadvantages of a Pease Expansion

- Will require additional pumping to reroute flow to Pease
- May require pumping back to Peirce Island outfall for discharge increasing cost
- If Pease outfall is used, EPA may impose stricter permit limits than at the Peirce Island outfall
- The Peirce Island WWTF will continue to operate as a wet weather treatment system

5.2.3 WWTF Alternatives Comparison

An isolated comparison of the two wastewater treatment facility alternatives, MBR on Peirce Island or SBR at Pease, would select Pease as a preferred option. The Pease site is easily accessible and has ample room for expansion and the SBR process is a proven technology and straightforward to operate. The Pease expansion has the added benefits of phased construction, and removes all sanitary treatment from Peirce Island so its recreational and historic value can be preserved.

While the Phased Expansion of Pease is clearly the preferred wastewater treatment facility alternative, it is not reasonable to base the alternative comparison solely on the wastewater treatment facility itself, without taking into account its overall impact to the City. One of the main issues encountered through the master planning process was the magnitude of the opinions of cost. In order to make sure that the overall cost to the City for each WWTF alternative is compared as accurately as possible, the impacts of each WWTF alternative on the City's collection system and CSO abatement program must also be taken into account. This ensures that the WMP identifies a holistic solution to the city's wastewater treatment needs. Impacts of the wastewater treatment facility alternatives on the collection system and CSO abatement will be discussed in Section 6 of this report. Subsequently, the overall costs related to the treatment facility, collection system and CSO abatement represented by each alternative will be presented in Section 7.

6. IMPACT OF WWTF ALTERNATIVES ON COLLECTION SYSTEM MODIFICATIONS AND COMBINED SEWER OVERFLOW ABATEMENT

While collection system modifications and CSO abatement strategies are considered part of the LTCP, there are significant portions of the work that will be dictated by the selection of the WMP preferred WWTF alternative. In order to truly compare the current WWTF alternatives discussed in Section 5, and select a preferred alternative for the Wastewater Master Plan, their impacts to the city's collection system and CSO abatement program must be taken into account. The following section discusses how each WWTF alternative will affect the measures selected for the LTCP collection system modifications and CSO abatement and their significance to the WMP. The complete LTCP Update will be presented in Volume 2 of this WMP/LTCP Update.

6.1 Collection System Modifications

6.1.1 Common Work

This work would be necessary regardless of the WWTF alternative.

6.1.1.1 Lafayette Road PS Improvements

The Lafayette Road Pump Station (PS) is located on the eastern side of the Route 1 Bypass near Greenleaf Woods Rd. The station was originally constructed in the late 1960's and receives wastewater flows from the southern portion of the City and the Town of Rye. The tributary areas to the PS are **not** combined; however, historic flow metering and previous studies have shown a significant wet weather flow contribution. Previous studies have identified considerable growth with associated peak flows. The PS conveys flow through a force main along the Route 1 Bypass and Lafayette Rd. to a gravity sewer near Willard Ave. The gravity sewer travels through the Lincoln Ave. combined sewer system to the Mechanic St. PS. Hydraulic modeling indicates that design year flows for this sewer-shed will require a PS capacity of 3.5 MGD.

Due to the age and condition of the existing pump station, a new wet pit/dry pit PS would be constructed adjacent to the existing station. The PS would be designed for 3.5 MGD and a new 16-inch force main would be constructed to convey flow to the existing discharge location.

6.1.2 Peirce Island Upgrade Alternative

The existing Peirce Island WWTF is being considered for expansion/upgrade to meet the regulatory requirements of the current and future potential NPDES Permits. Because all wastewater flow is currently conveyed to Peirce Island, there are no significant upgrades required for the existing collection and conveyance systems other than those ongoing projects that are necessary to upgrade the City's existing infrastructure due to age or condition. Continued implementation of the ongoing LTCP will progress in order to reduce wet weather flows from the combined sewer areas. Additionally, the City will continue to monitor and address wet weather flows from the outlying separated sewer system areas and identify and remove extraneous flows that are found to be cost-effective. The existing collection system and pumping stations have been evaluated in previous wastewater planning studies and were not evaluated in detail as part of this WMP.

6.1.2.1 Sewer Pumping Stations and Force Mains

The Deer Street and Mechanic Street PS's have previously been upgraded as part of the 2005 LTCP. Both stations convey the majority of wastewater and combined sewer flows from the City, ultimately to Peirce Island for treatment. The Deer Street PS is capable of pumping 12.5 MGD while the Mechanic Street PS was designed to convey 22.0 MGD to the existing Peirce Island WWTF. Based on our discussions with City staff the Mechanic Street PS may require refurbishment to address pump reliability within the implementation period of the WMP.

6.1.2.2 Gravity Sewer Lines

There are minor modifications to the existing gravity sewers required under this alternative. As previously discussed, the ongoing LTCP projects will continue to proceed based on the existing Consent Decree schedule. Additional capital improvements to other components of the collection system required as a result of system age or condition were not evaluated within the WMP.

6.1.3 Pease Expansion Alternative

As previously presented in this WMP, this alternative includes an expansion to the Pease WWTF. This expansion will be necessary to meet current and future anticipated regulatory requirements. The scenario also includes shedding of wastewater flow from the Peirce Island WWTF over time to the expanded and upgraded Pease WWTF. This section discusses the modifications within the collection and conveyance system necessary to accomplish this alternative.

As previously discussed, since all wastewater is currently conveyed to the Peirce Island WWTF through the Mechanic Street PS, there are no changes necessary for the Mechanic Street PS and force main. However, under this scenario, wastewater flows tributary to the Deer Street PS will be systematically re-routed to the Pease WWTF over time, and therefore, an automated flow re-direction manifold structure will be required to accomplish a split flow regime from the Deer Street PS and is discussed below. The following sections discuss the pump station, force main, and collection system modifications necessary to meet the current and future potential NPDES Permit requirements.

6.1.3.1 Deer St Pump Station and Force Main

The Deer Street PS is the second largest pump station in the City and is located at the corner of Deer Street and Market Street. Wastewater from Gosling Road, Atlantic Heights, Leslie Drive Maplewood Avenue, Borthwick Avenue and the Deer Street Box Sewer (Islington and Bartlett Street areas) sewersheds are tributary to the pump station. The PS underwent a major upgrade in 2008 to increase capacity to 12.5 MGD. Based on flow metering and the upgraded hydraulic model, wet weather peak flows can activate CSO 13 adjacent to the pump station. However, activation events have declined over recent years as a result of the increased hydraulic capacity of the station and the reduction in peak wet weather flows due to the completion of sewer separation projects with the tributary sewer-sheds as part of the ongoing LTCP.

The intent of alternative is to systematically convey wastewater flows to the Pease WWTF. This would require the design and construction of an automated flow re-direction manifold within a concrete vault on Market Street. The automated manifold would include isolation valves, magnetic flow meters, automated flow control valves, and controls and instrumentation to convey wastewater flows to either the Pease WWTF or the Peirce

Island WWTF based on specific treatment capacities available at each facility during the phased implementation of this alternative.

In order to convey flow to the Pease WWTF, a new force main would be constructed in a westerly direction along Market Street to Woodbury Avenue, Arthur Brady Drive, and then crossing Route 16, to the Pease WWTF. Directional drilling may be required to cross North Mill Pond on Market Street and to cross Route 16 at the southern end of Arthur Brady Drive adjacent to the WWTF. A preliminary hydraulic evaluation concluded that a 30-inch force main would be required to convey the 12.5 MGD of peak wet weather flow to the Pease WWTF. However, based on the phase implementation schedule, two 20-inch force mains are recommended to provide hydraulic flexibility during the overall implementation of the project, and to provide operational flexibility during low flow periods once the overall plan is complete.

Because the Deer Street PS was recently upgraded with mechanical and electrical systems, it is not anticipated that major modifications will be required to re-direct the wastewater to the Pease WWTF. However, more detailed analysis will be required during the preliminary and final design phase.

6.1.3.2 Mechanic St PS Dry Weather Pump Station

Sanitary flows within the existing Mechanic Street sewershed will need to be re-directed to the Deer Street PS under this scenario. Ultimately, the existing Mechanic Street PS would become a wet-weather only PS which would convey peak wet weather flows to the existing primary WWTF on Peirce Island which will be operated as a wet weather CSO facility. The completed, ongoing, and future sewer separation project(s) that are part of the current LTCP will continue to reduce peak wet weather flows based on the documented success concluded by the recent flow metering and completion of the updated hydraulic model.

In order to separate base sanitary flows during average conditions, a custom designed flow diversion structure will be required on the existing 36-inch gravity sewer upstream of the Mechanic Street PS. The Flow Diversion Structure (FDS) would be designed to convey the base sanitary flows identified in the hydraulic model based on the completion of the currently scheduled sewer separation projects in the Lincoln Avenue sewershed. During wet weather events, peak flows will pass through a self cleaning, weir-mounted fine-screen (1/4-inch opening) and flow by gravity to the existing Mechanic Street PS. Base sanitary flow and screenings will flow by gravity to a new submersible type PS adjacent to the Peirce Island Bridge. The submersible PS wetwell will include a sewage grinder to macerate all screenings/solids prior to pumping. Based on the available footprint and location, a mechanical screening component is not recommended. A submersible type PS was selected based on the available footprint and for the aesthetic aspects due to the proximity to Prescott Park. The standby power equipment and controls could be housed in a small structure with architectural consideration for the area.

Based on the completed hydraulic modeling, the required PS capacity is 2.0 MGD which includes the projected base sanitary flows with minor wet weather peaks, wastewater flows from Newcastle, New Hampshire, and residual/wash-down flows from a wet weather facility on Peirce Island, which would now be used exclusively for CSO treatment. A 12-inch force main will be required to convey these flows to the Deer Street PS and subsequently to the Pease WWTF. The force main route will mirror the existing gravity line from Deer Street Based on discussions with the City, 2,100 linear feet of force main will be required as the force main can be connected to 1,500 linear feet of the existing force main. The new force main will travel from the PS along Mechanic Street, along Marcy Street, crossing State Street, to the existing force main in the vicinity of Bow St were it will be conveyed to the gravity sewer line leading to the Deer Street PS wetwell.

6.1.3.3 Peirce Island/Newcastle and CSO Residual/Washdown PS

Wastewater flow from Newcastle is pumped directly to Peirce Island via a sub-aqueous force main from Newcastle Avenue to the existing Peirce Island WWTF headworks. This alternative removes all sanitary wastewater flows from the Peirce Island WWTF thus allowing the existing facility to be retrofit to a CSO wet weather only facility. However, a CSO wet-weather facility will generate residuals during wet weather events. Also, once a wet weather event is over, the facility will require a washdown which will generate wastewater that must be conveyed off the Island. Based on anticipated wet weather facility design residual loadings, the permitted capacity for Newcastle flows, and washdown flow rates, a design capacity of 0.5 MGD is estimated for Peirce Island PS. Preliminary assessments of the existing site, along with the ability to drain potential wet weather treatment facility tanks via gravity and to allow for the potential for using existing subsurface structures for the PS, have indicated that a combined washdown water booster station and wastewater PS adjacent to the filter building and chlorine contact chamber would be necessary.

A 3,200 linear foot 6-inch force main would convey flows from the new Peirce Island PS to the Mechanic Street Dry Weather PS along Peirce Island Road crossing the bridge and discharging upstream of the sewage grinder.

6.1.3.4 Gravity Sewer Lines

The gravity sewer lines were evaluated as part of previous planning efforts. As previously noted, the City is proceeding with the implementation of the LTCP which will continue to reduce wet weather peak flow conditions. Hydraulic modeling discussed previously has identified peak flow restrictions in the Parrott Avenue Interceptor downstream from CSOs 10A and 10B. Therefore, an upgrade in the hydraulic capacity of this interceptor is required. The existing interceptor is located along Parrott Avenue and travels through Strawberry Banke and Prescott Park to Marcy Street, and ultimately to the Mechanic Street PS.

Planning level options include construction of a deep rock tunnel, a 36-inch relief interceptor, and a 54-inch replacement interceptor. A preliminary evaluation and planning level cost of a deep-rock tunnel determined the option not to be cost-effective. Due to construction in this historic area of the City, alternative alignments for a relief interceptor should be considered during a preliminary design evaluation. For the purposes of this Alternative, a 54-inch replacement interceptor has been considered. The interceptor would be constructed adjacent to the existing interceptor to reduce or eliminate bypass pumping requirements. Construction costs are estimated to be high due to the historic nature of the area, groundwater considerations, geotechnical concerns, etc. It should be noted that final design considerations will require significant archeological and geotechnical investigations.

6.1.3.5 Debottlenecking

A new parallel sewer and/or enlargement of the existing sewers would be required to debottleneck the hydraulic capacity of the lines between the South Mill Ponds CSOs on Parrott Avenue and the Mechanic Street PS in order to maximize the full amount of additional available capacity at the Peirce Island WWTF. Modeling has revealed that the existing line would need to be upsized to a 54-inch diameter line.

6.1.3.6 Effluent Force Main (if required)

As previously discussed, subsequent to the December 2009 submission of Technical Memorandum 5-Alternatives Analysis, additional data provided by NHDES cast doubt as to the feasibility of utilizing the existing Pease WWTF Outfall for increased flows. The City has asked NHDES for a statement of feasibility of an expanded Pease outfall but has not yet received a response. The results of the DES/EPA dye tracer study completed in October 2009 have raised the concern that significant increases in flow might cause a "loss of use" due to potential impacts on shellfish bed areas in Great Bay. Therefore, in order to utilize the Pease WWTF to treat the projected wastewater flow from the City, additional infrastructure may need to be constructed to convey effluent from the Pease WWTF to the existing Peirce Island WWTF outfall which has the hydraulic capacity and location to meet projected regulatory requirements.

To accomplish this, a triplex vertical turbine style pump station would be constructed at the Pease WWTF. The effluent force main would be directional drilled under Rte 16, conventionally trenched along Arthur Brady Avenue, a section of Woodbury Avenue, and Market Street to the bridge near North Mill Pond. At this point it has been determined to be most cost-effective to construct a sub-aqueous force main along the bottom of the Piscataqua River to the existing PI outfall. The total length of the outfall force main from Pease WWTF to the existing Peirce Island outfall is approximately 17,350 linear feet. Significant design and permitting considerations will be necessary to finalize this component of the project.

6.2 CSO Abatement

6.2.1.1 CSO Abatement Objectives

The goal of this and previous CSO planning efforts was to bring the City's existing CSO discharges into compliance with EPA- and NHDES-administered laws and regulations pertaining to CSO abatement and water quality standards. The City currently has 3 permitted CSO discharges 10 A, 10 B and 13. The key pollutants of concern to the CSO discharges in Portsmouth remain floatable solids and fecal coliform bacteria. As a minimum, all technologies and practices considered for CSO abatement needed to address these pollutants.

6.2.1.2 CSO Abatement Alternatives Background

The impact of the three original WMP scenarios on CSO abatement was discussed in detail in TM 5, which has been provided in Volume 3. The three scenarios evaluated in TM 5 were defined as follows:

1. Wastewater continues to be treated on Peirce Island.
2. Wastewater is split evenly between the Peirce Island WWTF and the Pease WWTF.
3. Wastewater is not treated on Peirce Island: all wastewater is redirected to Pease or a new site.

These original scenarios still apply for the current WWTF alternatives, with the exception of Scenario 2 the split flow option which was eliminated for the reasons discussed in previous sections of this WMP/LTCP Update. Since little has changed with respect to the CSO abatement measures described in TM 5, the following will simply summarize the work presented therein in terms of the current WWTF alternatives.

6.2.2 CSO Alternatives

Co-treatment of sanitary and wet-weather flow at the Peirce Island WWTF has been a key aspect of the City's CSO abatement program beginning in the early 1990s when the facility was upgraded to accommodate peak flows up to 22 MGD, well in excess of what was required for the City's base wastewater needs.

As discussed, there are two alternatives for the location of the upgraded WWTF and each having a direct impact on the available capacity for continued CSO treatment at the Peirce Island facility. Table 6-1 shows the resultant available peak instantaneous capacities for CSO treatment for each alternative.

Table 6-1. Available Peak Instantaneous CSO Abatement Capacity at Peirce Island with Current WWTF Alternatives

Peirce Island Upgrade	Pease Expansion
10 MGD	22 MGD

The Peirce Island Upgrade essentially represents current conditions, as projected to 2030. With this alternative, no additional capacity would be available for CSO treatment beyond what is currently available. Further, while the 2005 LTCP evaluated increasing the advanced-primary capacity to 36 MGD, space for this expansion would not be available when the WWTF was upgraded for both secondary treatment and nitrogen removal.

The Pease Expansion represents the removal of all non-CSO treatment functions from Peirce Island with the result that all 22 MGD of capacity would be available for CSO treatment. The required collection system and pump station redirection components to accomplish each of these scenarios were described earlier in this section.

The available CSO treatment capacities on Peirce Island with these alternatives were the baseline considerations for the CSO abatement measures evaluated.

6.2.3 Sizing CSO Abatement Facility for WWTF Alternatives

An analysis was performed to determine the size of the CSO abatement facilities needed for each of the alternatives. The goal of the analysis was to size facilities for a *reasonable* level of control, applied uniformly across the scenarios. *It is important to note that this level of control is only being used to assist in the selection of a preferred alternative*. Once the preferred alternative has been selected, additional analysis will be required to select an appropriate final level of control for the City's CSO facilities using processes and procedures described under both the Presumptive and Demonstrative Approaches of the 1994 CSO Control Policy.

A one-year level of control was deemed to be a reasonable level of control for the purposes of evaluating the alternatives. A number of large storm events were witnessed during the flow monitoring period of 2008. The event which occurred on June 15, 2008 produced the largest measured overflow volume during the monitoring period and had intensities and duration consistent with a 1-year storm[1]. This storm was selected for evaluating the sizes of the CSO abatement facilities for the alternatives.

Hydraulic models were developed to represent the alternatives. The flows used in the analysis take into account anticipated reductions in combined flows resulting from planned separation projects (see Volume 2). Aside from the planned wet-weather projects, it was assumed that wet-weather flows will remain at current levels. The flows correspond to population and commercial/industrial/ institutional development conditions in the year 2030 which is consistent with the WWTF alternatives evaluation.

Table 6-2. Characteristics for CSOs 010A/010B Under WWTF Alternatives

WWTF Alternatives	CSO Volume at 010A/010B (MG)	Peak Flow at 010A/010B (MGD)
Peirce Island Upgrade	2.9	18.2
Pease Expansion	0	0

Notes:

CSO characteristics for the June 15, 2008 storm, (equivalent to a 1-year storm) under 2030 development conditions. Flows take into account anticipated reductions from planned separation projects.

CSO 013 was not active.

[1] The total rainfall during the event was 2.5 inches. The storm was consistent with a 1-year storm across a range of durations. It was equivalent to a 1-year storm with a 1-hour duration, an 8-month storm with a 2-hour duration, a 1.5-year storm with a 3-hour duration, and 1-year storm with a 4-hour duration.

The results of the model runs are shown in Table 6-2. With the Peirce Island Upgrade alternative, CSOs 010A and 010B discharge approximately 2.9 MG and have a peak flow of 18.2 MGD. No CSO discharge is expected with the Pease Expansion since 22-MGD of wet-weather treatment is then available on Peirce Island. Therefore, in order to achieve a 1-yr level of CSO control, the only abatement measure required for the Pease Expansion alternative is the conversion of Peirce Island to a wet-weather only facility. For the Peirce Island Upgrade alternative, however, additional CSO abatement measures will be necessary to treat the CSO characteristics presented in Table 6-2.

6.2.4 CSO Abatement Measures for WWTF Alternatives

6.2.4.1 Peirce Island Upgrade – Co-Treatment on Peirce Island and Additional Abatement Measures

In addition to the existing practice of co-treatment of sanitary and wet-weather flows at the Peirce Island WWTF, there are other viable technologies that could be used to reduce the frequency of the City's CSOs to a 1-yr level of control. These additional measures were considered for the Peirce Island Upgrade WWTF alternative. As was noted earlier, CSO 013 is not predicted to overflow in a typical year. For this reason the technology evaluation focused on the South Mill Pond CSOs (010A/010B). Technologies evaluated included:

- In-line Storage
- Offline-Storage
- End-of-pipe Treatment
- Additional Sewer Separation (in addition to the 2005 LTCP work already underway)

The two control measured deemed appropriate for the Peirce Island Upgrade alternative were off-line storage and additional sewer separation. It was assumed that the level of effort associated with each would be approximately the same. The requirements for each control are described below.

6.2.4.1.1 Off-Line Storage

In accordance with the 2005 LTCP, off-line storage was considered for the open-air Municipal Parking Lot off of Parrott Avenue for CSOs 010A/010B. The components of an off-line storage tank facility for CSOs 010A/010B would include:

- New or modified CSO regulator chamber.
- Conduit from the new CSO regulator chamber to the off-line storage tank.
- Enclosed underground tank equipped with automatic flushing system consisting of tipping buckets or flushing gates and odor control.
- Pumps to dewater the tank and convey flow back into the Parrott Avenue sewer following the storage event.

The updated model revealed that a 2.9 MG storage tank would be necessary to reduce the overflows to a 1-yr level of control under the Peirce Island Upgrade WWTF alternative. A layout of a 2.9 MGD off-line storage facility at the open-air parking lot was shown in TM 5 Figure 5-44.

6.2.4.1.2 Additional sewer separation

Additional sewer separation is viable for CSOs 010A/010B, and to a lesser extent CSO 013, as both stand-alone measures or in conjunction with other measures should additional abatement be warranted. The degree of additional sewer separation, beyond what the City is currently committed to performing, would be determined following the build-out of the next phases of the CSO abatement program. This build-and-measure approach would be consistent with the City's CSO abatement efforts as documented in the 2005 LTCP.

6.2.4.2 Pease Expansion – CSO Treatment on Peirce Island

The hydraulic model revealed that the Peirce Island WWTF, if dedicated for CSO treatment per the Pease Expansion alternative, would abate the overflows at South Mill Pond CSOs (010A/010B) to the 1-year level of control with the addition of downstream hydraulic debottlenecking.

There are a few modifications to the collection system and the Peirce Island WWTF that would be needed to convert it from a CEPT wastewater facility to a wet-weather only facility. The collection system modifications have been described previously. The treatment facility modifications required include:

- The aerated grit tanks and processing systems would remain in service but refurbished as generally described in a Memo to Steven Clifton, UEI, from Steven Freedman, Brown and Caldwell, on the Peirce Island WWTF Headworks Evaluation, dated March 7, 2006. This memo was included in TM 5 Appendix G which has been provided in Volume 3.
- The primary clarifiers and disinfection system, including chemical systems, would remain in service, but require some minor refurbishment.
- All sludge processing systems (gravity thickener, storage tanks, etc.) and their support facilities and structures would be abandoned and could be demolished at a convenient time.
- During treatment events, unthickened or diluted primary sludge would be continually pumped back to a new dry weather Mechanic St. PS.
- Following a treatment event, the aerated grit tanks, clarifiers and disinfection tanks would be dewatered and cleaned with the contents pumped back to a new dry weather Mechanic St. PS.
- Flow from the Town of Newcastle would also be continually pumped from Peirce Island to a new dry weather Mechanic St. PS.
- The previously described Peirce Island PS would perform these three pumping functions – dilute primary sludge, tank dewatering and Town of Newcastle.

The unused capacity of the existing Pease WWTF could start receiving sanitary flow from Peirce Island as soon as the Deer Street Pump station has been modified to send flow in two directions as was described in the collection system modification discussion. Removing sanitary flow from Peirce Island will increase the capacity available for CSO treatment and therefore reduce the volume that is discharged at 10A/10B. As the capacity at Pease is increased through phased construction, the CSO treatment capacity on Peirce Island also increases and overflows are reduced.

6.2.5 CSO Abatement Summary

Based upon the previous evaluations it appears that the following abatement measures are most suitable for the South Mill Pond CSOs (010A/010B) for the WWTF alternatives being evaluated.

- Peirce Island Upgrade – Co-treatment at Peirce Island WWTF and 2.9 MG Off-line Storage Tank or additional sewer separation
- Pease Expansion – Debottleneck Line between CSOs 010A/010B and Mechanic Street PS plus Peirce Island WWTF modification to a 22 MGD wet-weather facility.

These CSO abatement strategies will be carried forward in the further evaluation of the WWTF alternatives with respect to their cost of implementation. While offline storage and additional sewer separation were considered equally viable measures for the Peirce Island Upgrade alternative, the opinions of cost shown in the subsequent sections of this WMP/LTCP Update were based on the 2.9 MG storage. This is considered a placeholder for either the construction of the storage tank or a comparable level of sewer separation effort.

7. OPINION OF COST AND AFFORDABILITY ANALYSIS

7.1 Opinion of Cost

As discussed in previous sections, one of the critical issues throughout the master-planning process has been developing opinions of cost for the alternative evaluation. The original opinions of cost presented in the TM 5 documents were of such a magnitude that they raised serious concerns with the City and the WMP team about the project's feasibility. The opinions of life cycle costs for the initial scenarios were in the 200 million dollar range with capital costs well over 100 million. It was feared that a capital expenditure of this size would force sewer rates to increase to a point where they would no longer be affordable for the average user. Inputting these opinions of costs to the City's user rate model confirmed that rate impacts would cause significant widespread impact.

7.1.1 Cost Related Changes to the WMP

The concerns with project cost led the WMP team to reevaluate the preferred alternative as well as some of the initial project assumptions. The most significant changes that have been incorporated to address cost issues since the December 1, 2009 TM 5 submission is listed below:

- Design flows were changed to reflect a 2030 rather than 2060 buildout
- An alternative was developed using MBR high rate treatment on Peirce Island
- Focused on a "stripped down" approach to project implementation

The implications of the altered design flows and the addition of the Peirce Island MBR alternative have been discussed in previous sections of this report.

The "stripped down" approach reduced the new construction, repair and replacement of unit processes or equipment and focused only on what was considered absolutely necessary to meet the consent decree (CD) and keep the City's overall wastewater management system in working order. The approach focused on reusing as much existing infrastructure as possible. The current opinions of cost distinguish between the CD improvements and work related to the Capital Improvements Plan (CIP). CD improvements are those measures necessary to legally meet the City's CD secondary treatment and CSO abatement requirements, while CIP work encompasses the additional work that is not mandated but is still considered important to keep the wastewater treatment systems functioning and in compliance.

7.1.2 Opinion of Cost Development

While the City is legally obligated to complete only CD related work at this time, it is necessary that the WMP take into account both the CD and CIP work associated with implementing each alternative, so that the true cost to the City of each can be compared. Table 7.1 and 7.2 shows the breakdown of CD and CIP required improvements that have been included in the opinions of cost for each of the WWTF alternatives.

Table 7-1. Improvements Included in the Opinion of Cost for the Peirce Island Upgrade

	@ Peirce Island	@ Pease	CSO Abatement	Collection System
Consent Decree	New Headworks Process Reactors MBR UV Disinfection Biosolids Upgrade Methanol Storage Sludge Storage Splitter Box (2)		2.9 MGD Storage Tank	
Capital Improvements Plan	Existing Headworks Mods Primary Clarifier Rehab Lab/Office Rehab Garage Rehab Outfall Mods	Headworks Upgrade SBR (expand to 1.7 MGD) Denite Filter (TN 3) Methanol Storage (TN 5 or 3) Post Equalization Tank Pump Building Garage Chemical Building		Lafayette Road PS

Table 7-2. Improvements Included in Opinion of Cost for the Pease Expansion

	@ Peirce Island	@ Pease	CSO Abatement	Collection System
Consent Decree		Headworks Primary Clarifiers Disinfection (UV @TN 3 or 5) SBR (expand to 7.9 mgd) Denite Filter (TN 5 or 3) Methanol Storage (TN 5 or 3) Sludge Storage Equipment Building Outfall Mods (PIT or PI)	Debottlenecking	Deer Street PS Mechanic Street PS PI/Newcastle PS Effluent PS (if required)
Capital Improvements Plan	Grit Rehab Primary Clarifier Rehab Existing Headworks Mods Biosolids Upgrade Outfall Mods	Biosolids Lab/Office Expansion Pump Building Garage	PI Upgrades (see @ Peirce Island)	Lafayette Road PS

An opinion of cost for each of the improvements listed in Tables 7.1 and 7.2 were developed from vendor price quotes, previous project experience and engineering judgment. Capital costs for each improvement were based on structural requirements, including concrete, excavation and backfill, necessary equipment, typical electrical, instrumentation and controls, yard piping and site work percentages, and industry standards for engineering and contingency. An additional contingency was added for Peirce Island to account for the difficulties associated with island construction and the limited space on site. Operations and maintenance costs were developed based on the City's existing expenditures, horsepower or kilowatt usage of required equipment, and chemical use and media replacement needs for individual processes.

The capital and O&M costs were compiled for each of the current WWTF alternatives being considered in the wastewater master plan at all three of the potential TN limits. These alternatives include the Peirce Island Upgrade, and the Pease Expansion with and without the potential pump station to return effluent to the Peirce Island outfall. Costs were broken out into the CD and CIP requirements for each WWTF, CSO treatment, the collection system modifications and O&M requirements. The detailed cost estimating spreadsheets for each of these options are shown in Appendix I. The cost breakdowns for each alternative are summarized in Table 7-3.

Table 7-3. Alternative Cost Comparison

	Peirce Island Alternative		Pease Alternative		Pease Alternative w/ Effluent PS	
TN 3 mg/l	*Consent Decree*	*Additional CIP*	*Consent Decree*	*Additional CIP*	*Consent Decree*	*Additional CIP*
Peirce Island Facility	$42.7	$8.0	$0.0	$0.5	$0.0	$0.5
Pease Facility	$0.0	$11.8	$62.2	$2.1	$62.2	$2.1
CSO Treatment	$20.3	$0.0	$4.1	$0.0	$4.1	$0.0
Collection System	$0.0	$3.4	$14.1	$3.4	$28.6	$3.4
Subtotal	**$63.0**	**$23.2**	**$80.4**	**$6.0**	**$94.9**	**$6.0**
Total Capital	**$86.2**		**$86.4**		**$100.9**	
O&M Present Value*	$67.0	$1.7	$67.4	$0.0	$67.9	$0.0
Total Lifecycle	**$154.9**		**$153.8**		**$168.8**	
TN 5 mg/l	*Consent Decree*	*Additional CIP*	*Consent Decree*	*Additional CIP*	*Consent Decree*	*Additional CIP*
Peirce Island Facility	$42.7	$8.0	$0.0	$0.5	$0.0	$0.5
Pease Facility	$0.0	$10.7	$43.2	$2.1	$43.2	$2.1
CSO Treatment	$20.3	$0.0	$4.1	$0.0	$4.1	$0.0
Collection System	$0.0	$3.4	$14.1	$3.4	$28.6	$3.4
Subtotal	**$63.0**	**$22.1**	**$61.4**	**$6.0**	**$75.9**	**$6.0**
Total Capital	**$85.1**		**$67.4**		**$81.9**	
O&M Present Value*	$65.0	$1.5	$66.8	$0.0	$67.3	$0.0
Total Lifecycle	**$151.6**		**$134.2**		**$149.2**	
TN 8 mg/l	*Consent Decree*	*Additional CIP*	*Consent Decree*	*Additional CIP*	*Consent Decree*	*Additional CIP*
Peirce Island Facility	$36.7	$8.0	$0.0	$0.5	$0.0	$0.5
Pease Facility	$0.0	$10.2	$42.0	$2.1	$42.0	$2.1
CSO Treatment	$20.3	$0.0	$4.1	$0.0	$4.1	$0.0
Collection System	$0.0	$3.4	$14.1	$3.4	$28.6	$3.4
Subtotal	**$57.0**	**$21.6**	**$60.2**	**$6.0**	**$74.7**	**$6.0**
Total Capital	**$78.6**		**$66.2**		**$81**	
O&M Present Value*	$58.2	$1.1	$66.7	$0.0	$66.4	$0.8
Total Lifecycle	**$137.9**		**$132.9**		**$148.2**	

Note: All values are presented in 2010 dollars. *O&M Present Value assumes 20 yrs @ 5%

7.1.3 Cost Comparison

A comparison of the costs presented in Table 7-3 for the WWTF alternatives shows the following trends:

General:

The consent decree related capital for the Peirce Island Upgrade is lower that that required for Pease at all three potential TN limits; however, the amount of additional capital improvements the city would need to perform in conjunction with the CD work is far higher for the Peirce Island alternative than for Pease. This is due to the fact the Peirce Island Alternative will also require a small upgrade at the existing Pease facility in order to treat all sanitary flow projected for year 2030 to lower TN limits which are likely to be imposed in the facilities next NPDES permit.

- When both CD and CIP capital are combined, the city's required capital expenditure for both alternatives is in the same general range.
- Total capital and life cycle costs for the Pease Expansion, at a TN limit of 3 mg/l are notably higher than for limits of 5 and 8 mg/l.
- Total capital and life cycle costs for the Peirce Island Upgrade, at TN limits of 3 and 5 mg/l are notably higher than for a limit of 8 mg/l.

TN 3 mg/l:

- If the effluent pump station is not required for the Pease Expansion, the total capital and life cycle costs are basically identical to the Peirce Island Upgrade.
- If the effluent pump station is required for the Pease Expansion then the total capital and life cycle costs are greater than those required for the Pierce Island Upgrade.

TN 5 mg/l:

- If the effluent pump station is not required for the Pease Expansion, the total capital and life cycle costs are notable lower than those for the Peirce Island Upgrade.
- If the effluent pump station is required for the Pease Expansion, then the total capital and life cycle costs are slightly lower than those required for the Pierce Island Upgrade.

TN 8 mg/l:

- If the effluent pump station is not required for the Pease Expansion, the total capital and life cycle costs are slightly lower than those for the Peirce Island Upgrade.
- If the effluent pump station is required for the Pease Expansion then the total capital and life cycle costs are slightly higher than those required for the Pierce Island Upgrade.

7.1.4 Opinion of Cost Discussion

It should be noted that the level of detail included in the cost estimates shown in Appendix I is much higher than is typically included in master planning efforts. Typically, an estimate of cost based on the size of the treatment plant in question is generated from a cost curve of existing projects and include a 50% contingency. The opinions of cost generated for the City of Portsmouth WMP were based on the construction costs of required structures and the equipment necessary for each of the improvements summarized in Tables 7.1 and 7.2 and therefore it was considered appropriate to include a contingency of only 30% which is typically associated with preliminary design. The increased level of detail was deemed necessary due to the magnitudes of the costs in question; the difference in costs associated with the various potential TN limits and outfall locations; the importance of cost on determining project feasibility; and the impact to the public associated with selecting a preferred alternative. While the estimates developed for this WMP were more detailed than is typical, this was done only to assist with the selection of a preferred alternative and should not be considered comparable to a preliminary design cost estimate.

The updated opinions of capital and life-cycle costs presented for the WWTF alternatives are in the same general range, and the least expensive alternative changes depending on the TN limit and outfall location in question. Therefore, with the lack of established regulatory parameters, it was impossible to determine which alternative is most desirable to the City from a cost standpoint. However, a comparison of the affordability of each alternative had the potential to accomplish what the side by side cost comparison presented above could not. The affordability of each alternative to the City could be different due to the fact that construction of the Pease Expansion would likely be phased over time while the Peirce Island Upgrade would need to be constructed all at once.

In order to compare the affordability of the Peirce Island Upgrade with the Phased Expansion of Pease, the phases presented were developed for planning purposes only and would likely be reconfigured significantly during preliminary design. The detailed spreadsheets of these costs are presented in Appendix J. The phased costs for Pease are slightly different then those presented in Appendix I due to the fact that some additional work would be required at the Peirce Island WWTF to keep it functioning as a sanitary plant until it can be converted to a wet-weather only facility when the Pease Expansion is complete and receiving all of the City's sanitary flow. This additional work is fairly minor and does not significantly affect the numbers presented above. The benefits of phasing have been described throughout the WMP/LTCP Update, the potential to reduce design sanitary flows once the sewer separation is complete and the potential of BioMag to increase SBR capacity could also reduce the final cost of the project; however, these potential benefits have not been incorporated into the affordability analysis for consistency's sake as this WMP is evaluating the alternatives based solely on the information currently accessible.

The affordability analysis performed for the Portsmouth WMP is discussed in detail in the following sections.

7.2 Affordability Analysis

A critical component to any successful wastewater master plan is determining the financial impact that its implementation will have on the city and the community. To address this concern, the City of Portsmouth performed the EPA's Financial Capability Assessment, along with additional affordability analyses, reviewed in this section. The purpose of a financial assessment / affordability analysis is to "ensure that any schedule for improvements is as expeditious as possible while maintaining affordable rates for all consumers" (EPA's 1997 Combined Sewer Overflow Guidance for Financial Capability Assessment and Schedule Development). Affordability has many dimensions and requires multiple perspectives to adequately arrive at a reasonably acceptable definition from the community's perspective. There are several financial and economic factors that were included in the analysis. These factors are listed below in Table 7-4.

Table 7-4. Financial Factors

EPA's Financial Capability Assessment

EPA's Combined Sewer Overflow Guidance for Financial Capability Assessment and Schedule Development

USEPA-832-B-97-004

February 1997

The **residential indicator** measures the financial impact of the current and proposed capital and O&M costs on the statistical median residential users in the service area.

The **financial capability** of the community includes three categories of indicators.

Debt Indicators

- Bond rating
- Overall net debt as a percentage of full market property value

Socioeconomic Indicators

- Unemployment
- Median household income factors

Financial Management Indicators

- Property Tax Revenues as a Percent of Full Market Value
- Property Tax Collection Rate

Other Pertinent Socioeconomic Information

- EPA's Interim Economic Guidance for Water Quality Standards
  USEPA, EPA-823-B-95-002
  March 1995
  Worksheet M, Qualitative Description of *Estimated change in Socioeconomic Indicators due to Pollution Control Costs*
  Median household income
  Unemployment rate
  Overall net debt as a percent of full market value of taxable property
  Percent of households below the poverty line
  Impact on commercial development potential
  Impact on property values

Other affordability-related data
- Residential units
- Sewer rates
- Project / Schedule Impacts

The estimated capital costs related to the 2009 Master Plan are used together with existing capital costs (as they are represented in debt expenditures). There are also numerous operations and maintenance costs associated with these projects along with day-to-day operations and maintenance costs. All of the costs to the City are tallied and used to project costs for each residential rate payer.

The EPA financial analysis has been conducted in 2010 dollar terms. The city-specific socioeconomic indicators come from the 2009 City of Portsmouth *Comprehensive Annual Financial Report* (CAFR); this is the latest year that all financial information was available for analysis. The primary assumptions used in the analysis are shown below.

- All costs, unless otherwise noted, are in, or have been adjusted to 2010 dollars.
- The bond interest rate is 5 percent; the bond term is 20 years.
- Operations and maintenance incremental increases include: standard budget O&M increases at 3 percent.
- Population growth rate is considered static at 0 percent per year.
- The residential share of total sewer costs is 42 percent.
- Total number of households as measured by equivalent residential dwelling units is 3,926.
- Census data from the year 2000 was used for select parameters. National, state, county and tract data were used where applicable.

The key to an affordability calculation is the definition of the number of households served by the sewer system. There are a number of ways to determine the number of households including, census information, number of sewer bills and the number of equivalent dwelling units (EDU). For this evaluation the City used EDUs based on an average household water use as defined by the NHDES. This approach is consistent with how the City currently sets its sewer user rates and the methods used previously as part of its 2005 LTCP. Therefore, the financial feasibility of the projects was analyzed using the number of EDU. This is discussed further in Section 7.2.2.7. Refer to Appendix K for further information regarding EDU determinations.

It should also be noted that the residential share of the costs is less than one half of the total costs. This indicates that the EPA's financial capability assessment should take into consideration the other pertinent economic factors that apply to the remaining users – commercial and industrial. The impact to these users is discussed in Sections 7.2.2.2 and 7.2.2.5.

7.2.1 EPA's Financial Capability Assessment

7.2.1.1 Phase One: Residential Indicator

The cost per household (CPH) was calculated based on current and projected costs. Operations and maintenance costs along with debt service costs (based on capital and Master Plan needs shown in Table 7-5) were summed.

Table 7-5. Capital and O&M Cost Summary			
Existing Costs			
Existing Debt Service			$33,470,822
Annual O&M Costs for existing operations			$ 5,874,278
Projected Costs			
2009-2019 Budget: Sewer Capital ($)			$16,250,000
(in millions)	**Peirce Island Alternative**	**Pease Alternative**	**Pease Alternative w/ Effluent PS**
TN 3 mg/l			
Total Capital	**$86.2**	**$91.1**	**$102.3**
O&M Annual Cost	$1.9	$0.9	$0.7
TN 5 mg/l			
Total Capital	**$85.1**	**$72.2**	**$83.3**
O&M Annual Cost	$1.7	$0.9	$0.5
TN 8 mg/l			
Total Capital	**$78.6**	**$67.8**	**$83.1**
O&M Annual Cost	$1.1	$0.8	$1

The total annualized cost was multiplied by the percentage of costs paid by residents, and divided by the number of equivalent households in the service area. The 2010 MHI for the City's service area was estimated using income data from the 2000 Census for the City of Portsmouth. Over the past several years the City has grown to keep pace with the consumer price index (CPI). Therefore, an adjusted MHI was calculated based on the CPI each year. This adjusted MHI value is $59,630.

U.S. EPA guidelines establish three levels for the residential indicator (RI) measure.

- *Low* – Average score of below 1 percent
- *Medium* – Average score between 1 and 2 percent
- *High* – Average score above 2 percent

Since the final costs for the Master Plan have not been set yet, a range of costs was used. The specific alternatives evaluated are discussed in greater detail in Section 7.2.2. The resulting average residential indicator, calculated according to the EPA's Financial Capability Assessment tool, ranged from 2.8 percent to 3.3 percent. The analysis indicates that for these scenarios the costs result in a "high impact" residential indicator for the alternatives evaluated.

7.2.1.2 Financial Capability Assessment Phase Two: Financial Capability Indicators

The second part of U.S. EPA's matrix is the financial capability of the community using three categories of indicators as follows:

- *Debt Indicators* – Current debt of the permittee or the communities within the service area is assessed to test for the ability to issue additional debt to finance wet weather improvements.
- *Socioeconomic Indicators* – The general economic well being of the residential users in the service area is assessed.
- *Financial Management Indicators* – The community's ability to manage financial operations is assessed.

Debt Indicators

The bond rating for the City of Portsmouth was taken from the City's 2009 *CAFR*. The most recent sewer revenue bond issue was giving the rating Aa2 in 2009. This issue was rated by Moody's Investor Services, Inc. This corresponds to a "strong" rating using U.S. EPA's guidelines.

Table 7-6. Net Debt

Parameter	Value (2009 $)
Direct Net Debt	$ 81,716,289
Debt of Overlapping Entities	$ 335,149
Overall Net Debt	$ 82,051,438
Market Value of Property	$ 4,244,939,572
Overall Net Debt as a percent of Full Market Value, %	**1.93 %**

The second component of debt indicators used in the U.S. EPA matrix is overall net debt as a percentage of full market property value. This parameter is a measure of the existing level of general obligation debt on the residents within the service area and the ability of local government to issue additional debt. For this indicator, the City used data from the 2009 *CAFR*. Table 7-6. shows the calculation of net debt as a percentage of full market value.

The calculated value of 1.93 percent falls in the "strong" range of U.S. EPA's benchmark.

Socioeconomic Indicators

U.S. EPA's matrix defines socioeconomic indicators to address the unemployment rate and median household income. The City looked at other socioeconomic information to present a more complete understanding of impacts to the community.

- **Unemployment:** Data from the Bureau of Labor Statistics was used for the United States average, for February 2010. Unemployment in the United States averaged 9.7 percent, whereas unemployment in Portsmouth averaged 6.4 percent (in January 2010). New Hampshire had an unemployment rate of 7.1 percent in February 2010.
- Using the U.S. EPA benchmark, the Portsmouth unemployment rate corresponds to a "strong" rating.
- **Median Household Income:** Data from the U.S. Census Bureau, 2000 Census and the consumer price index (CPI) were used for this analysis. The Portsmouth MHI was $46,299 in the year 2000, which was above the U.S. MHI of $41,994 (in 2000). The CPI was used to adjust the MHI from the census year to the present. This adjusted MHI value is $59,630 for Portsmouth, and $52,510 for the U.S. MHI.
- Using the U.S. EPA benchmark, the Portsmouth MHI corresponds to a "mid-range" rating.

Financial Management Indicators

The U.S. EPA guidelines examine property tax revenues as a percent of full market value and property tax collection rates. These parameters are used to evaluate the community's financial management ability.

- **Property Tax Revenues as a Percent of Full Market Value:** Data for this analysis was obtained from the 2009 City of Portsmouth CAFR. The full market value of property was estimated to be $4,244,939,572, and property tax revenues in that year were $63,041,949. The resulting property tax as a percent of full market value becomes 1.49 percent. Using U.S. EPA's benchmarks, this indicator is "strong."
- **Property Tax Collection Rate:** The 2009 City of Portsmouth CAFR listed the property taxes collected as $63,041,949 versus the property taxes levied of $63,263,633. These values represent a collection rate of 99.65 percent. This is in the "strong" range in the U.S. EPA benchmarks.

7.2.1.3 Financial Capability Indices: Summary and Matrix

Table 7-7 summarizes the ratings for financial capability. U.S. EPA guidelines establish three levels for the financial capability measure.

- *Weak* – Average score of below 1.5
- *Mid Range* – Average score between 1.5 and 2.5
- *Strong* – Average score above 2.5

The average score for Portsmouth is 2.8 which rates "strong" in U.S. EPA guidelines.

Table 7-7. Financial Capability Summary

Indicator	Actual Value	Score
Bond Rating	Aa2	3
Overall Net Debt as a Percent of Full Market Value, %	1.93%	3
Unemployment Rate, as % of national	-3.3%	3
MHI as % of national, 2009 Dollars	11.5%	2
Property Tax as a Percent of Full Market Value, %	1.49%	3
Property Tax Collection Rate, %	99.65%	3
Average Score		**2.83**

U.S. EPA's matrix combines the residential indicator and the financial capability indicator as shown in Table 7-8. For Portsmouth, the financial capability rating is "strong." The residential indicator is "high impact" for the alternatives. Therefore, the program is classified as "medium burden." In Section 7.2.2.9, the results for each of the alternatives are shown, along with the resulting burden level. (See Section 7.2.2.7 for an additional discussion on this outcome.)

Table 7-8. Financial Capability Matrix

		Low Impact Residential Indicator <1 percent	Mid-Range Impact Residential Indicator	**High Impact Residential Indicator >2 percent**
Financial Capability	Weak <1.5 percent	Medium Burden	High Burden	High Burden
	Mid-Range	Low Burden	Medium Burden	High Burden
	Strong >2.5 percent	Low Burden	Low Burden	**Medium Burden**

7.2.2 Other Pertinent Socioeconomic Information

U.S. EPA's guidance document recognizes that its matrix may not present a complete picture of a community's financial capability, and therefore it encourages submitting additional information to provide a complete picture. The application of U.S. EPA's matrix to the circumstances of Portsmouth allows for comparison of standardized affordability criteria, but it does not provide a complete picture of the community's financial capability. In order to adequately analyze the community's ability to pay for the Master Plan, the City compiled and analyzed additional information.

The first six subsections correspond to the EPA's Interim Economic Guidance for Water Quality Standards (USEPA, EPA-823-B-95-002, March 1995) as listed in Worksheet M, *Qualitative Description of Estimated change in Socioeconomic Indicators due to Pollution Control Costs*. The worksheet includes a discussion about the following six topics:

- Median household income
- Unemployment rate
- Overall net debt as a percent of full market value of taxable property
- Percent of households below the poverty line
- Impact on commercial development potential
- Impact on property values

7.2.2.1 Median Household Income

The ability to pay for LTCP projects and related costs is highly dependent on the median household income of the customers in the service area. It is the most critical parameter in the analysis. The calculations are sensitive to fluctuations in the value. The MHI is also closely tied to the local economy. If (good paying) jobs decline then it can be expected that the MHI will follow. Lower income households have a more difficult time accommodating increases in necessities such as utility bills. These households have lower disposable personal incomes and therefore less discretion regarding reallocation of scarce income and are most impacted by rate increases.

Currently, the City of Portsmouth has a median household income above national average, and below the county and state levels. A table showing the median household incomes for the areas in the City is included in Table 7-9. The vast majority of the City's MHI over the past 20 years are within 25 percent of the comparison areas (all but 1990 compared to the county), corresponding with the EPA's strong rating.

Table 7-9. Median Household Income

	1990	2000	2009*
U.S.	$30,056	$41,994	$52,510
New Hampshire	$36,329	$49,467	$ 62,261
Rockingham County	$41,881	$58,150	$ 73,191
City of Portsmouth	$30,254	$46,299	$59,630
Census Tract 691, Rockingham County, New Hampshire	$28,365	$46,122	
Census Tract 692, Rockingham County, New Hampshire	$24,971	$42,977	
Census Tract 693, Rockingham County, New Hampshire	$32,193	$38,778	
Census Tract 694, Rockingham County, New Hampshire	$26,853	$41,300	
Census Tract 695, Rockingham County, New Hampshire	$28,703	$54,635	
Census Tract 696, Rockingham County, New Hampshire	$35,238	$47,355	
Census Tract 697, Rockingham County, New Hampshire	$35,456	$54,397	

*Based on 2000 census data and CPI.

7.2.2.2 Impacts on Existing and Potential Employment and Unemployment

The impacts on employment for the City due to increases in the costs of unfunded sewer mandates are based on recent economic research for a similar community with a similar purpose. A report prepared by the Economics Center for Education & Research at the University of Cincinnati for the City of Columbus, Ohio, as part of an overall affordability analysis, analyzed the impact of increasing sewer costs on employment. Based on research and econometric models assessing the impact of similar situations, the study concluded that every 0.4 percent increase in the sewer cost as a percentage of median household income results in a 0.5 percent decrease in employment with all other factors being equal.

Studies by the New Hampshire Employment Security Economic and Labor Market Information Bureau for the end of the calendar year 2008 and first quarter of 2009, summarized in Table 7-10., shows the City of Portsmouth had a total of 24,675 private employment positions as of the latter date. Correlating the findings of the University of Cincinnati study with the estimated first quarter of 2009 employment of the City provides an indication of expected job losses per percent increase in sewer costs, as shown in Table 7-10.

Table 7-10. Employment Loss

Cost Increase as % of MHI	Employment Total	Employment Incremental Losses
0.00%	24,675	-
0.40%	24,552	123
0.80%	24,429	246
1.20%	24,307	368
1.60%	24,185	490
2.00%	24,064	611
2.40%	23,944	731
2.80%	23,824	851
3.20%	23,705	970
3.60%	23,587	1,088
4.00%	23,469	1,206

7.2.2.3 Overall net debt as a percent of full market value of taxable property

The City's debt to market value is in the strong range, and has been for the past two years, but is trending upward. If the overall net debt increases significantly more, it may push above 2 percent of the full market value of taxable property, which is the cutoff to the mid range.

Table 7-11. Overall Net Debt as % of Full Market Value

CAFR Year	Percent
2009	1.93
2008	1.41
2007	1.30

7.2.2.4 Percent of people below the poverty line

Median household income alone is inadequate to describe the ability of people to afford new utility costs from the wet weather program. The City also gathered information regarding poverty to understand the current state of economic conditions in the state and nationally. The American Community Survey prepared by the US Census Bureau collected information regarding poverty. The City of Portsmouth has a poverty rate below the national average, but above the state and county level. Below is a table showing the poverty levels for the city, state and national population.

Table 7-12. Percent of individuals below the poverty line (Census Bureau)

Year	National Percent Poverty	State Percent Poverty	Rockingham County	City Percent Poverty
2008	13.2	7.8	4.3	10.9 *
2000	12.4	6.5	4.5	8.9
1990	12.8	6.2	4.4	8.1

** Poverty rate from http://www.city-data.com/poverty/poverty-Portsmouth-New-Hampshire.html*

7.2.2.5 Impacts on Potential Commercial and Industrial Development

The discussions herein are intended to provide summary understanding regarding potential economic impacts to the City of Portsmouth to address unfunded regulatory mandated changes for wastewater treatment and disposal. The underlining basis and criteria used to develop the findings provided herein were obtained from economic, engineering and land use studies and information of the City and other communities with similar conditions.

Approximately 58 percent of the user rates is collected from industrial and commercial rate payers. Information from City sources identified approximated 65,419 acres of commercial and industrial zoned properties within the City limits, including the Pease Industrial area. Zoning for these properties includes thirteen categories with uses ranging from light business/commercial to relative heavy industrial. The remaining undeveloped properties have the potential of adding approximately 7.6 million sf of new building floor space range from approximately 18,000 square feet (sf) to almost 1.8 million sf collectively per zoning category as summarized in Table 7-13. The potential total wastewater loading pursuant to the City's master planning criteria is 2.04 million gallons per day (MGD), consisting of 1.37 MGD for the developed properties and 0.671 MGD for the undeveloped properties, as shown on Table 7-13.

Table 7-13. Building Areas and Wastewater Loading

	Building Area in Square Feet				Wastewater Loading				
Zoning [1]	Total	Developed	Undeveloped	% of Total	Per SF	Total	Developed	Undeveloped	% of Total
WB	80,668	98,462	17,794	0.23%	0.10	9,846	8,067	1,779	0.27%
CBA	421,384	634,636	213,252	2.81%	0.15	95,195	63,208	31,988	4.76%
AI	379,756	732,070	352,314	4.65%	0.08	58,566	30,380	28,185	4.20%
WI	752,606	1,118,984	366,378	4.83%	0.05	55,949	37,630	18,319	2.73%
B	825,493	1,200,785	375,292	4.95%	0.05	60,039	41,275	18,765	2.79%
PI	920,836	1,340,077	419,241	5.53%	0.10	134,008	92,084	41,924	6.24%
OR/MV	197,518	646,356	448,838	5.92%	0.04	25,854	7,901	17,954	2.67%

Table 7-13. Building Areas and Wastewater Loading									
	Building Area in Square Feet				Wastewater Loading				
Zoning [1]	Total	Developed	Undeveloped	% of Total	Per SF	Total	Developed	Undeveloped	% of Total
AIR	100,579	599,195	498,616	6.57%	0.05	29,960	5,029	24,931	3.71%
OR	1,633,357	2,168,071	534,714	7.05%	0.05	108,404	81,668	26,736	3.98%
I	2,051,400	2,714,050	662,650	8.74%	0.15	407,108	307,710	99,398	14.80%
ABC	2,245,917	3,193,192	947,275	12.49%	0.05	159,660	112,296	47,364	7.05%
GB	2,571,541	3,552,222	980,681	12.93%	0.05	177,611	128,577	49,034	7.30%
CBB	3,037,837	4,805,003	1,767,166	23.30%	0.15	720,750	455,676	265,075	39.48%
	15,218,892	22,803,103	7,584,211	100.00%		2,042,950	1,371,499	671,450	100.00%

1. See Table 7-16.

Although property use and wastewater loading characteristics vary, the economic forces influencing employment will also directly affect the viability of the developed areas and development of the undeveloped properties. Predictably, assuming all other factors equal, as the costs for wastewater service increase beyond the costs at other nearby locations undeveloped properties will remain undeveloped and developed properties will experience economic declines.

Table 7-14. 2008 Employment Distribution by Industry for Portsmouth, NH			
NAICS	Industry	Units	Employment
	Total, Private plus Government	1,786	28,254
	Total Private	1,737	26,400
101	Goods-Producing Industries	138	2,789
11	Agriculture/Forestry/Fishing	na	na
21	Mining	na	na
23	Construction	na	na
31	Manufacturing	52	2,178
102	Service-Providing Industries	1,600	23,611
22	Utilities	na	na
42	Wholesale Trade	157	1,090
44	Retail Trade	251	3,854
48	Transportation and Warehousing	39	431
51	Information	36	1,557
52	Finance and Insurance	134	2,597
53	Real Estate and Rental and Leasing	72	568
54	Professional and Technical Service	293	2,977
55	Management of Companies/Enterprises	17	594
56	Administrative and Waste Services	98	1,809
61	Educational Services	19	282
62	Health Care and Social Assistance	180	3,483
71	Arts, Entertainment, and Recreation	33	461
72	Accommodation and Food Services	144	2,954

Table 7-14. 2008 Employment Distribution by Industry for Portsmouth, NH			
NAICS	**Industry**	**Units**	**Employment**
81	Other Services Except Public Admin	120	769
99	Unclassified Establishments	na	na
	Total Government	49	1,855
	Federal Government	12	465
	State Government	27	407
	Local Government	10	983

Source: 2008 Covered Employment & Wage Annual Averages
New Hampshire Economic and Labor Market Information Bureau

Table 7-15. Firms by Size - Portsmouth, New Hampshire. First Quarter 2009.						
	Firms	**January Employment**	**February Employment**	**March Employment**	**Total Quarterly Wages**	**Average Weekly Wage**
Total, Private plus Government						
No Quarter	133	0	0	0	$0	$0.00
No March	49	73	44	0	$790,510	$1,559.19
1 – 4	719	1,519	1,511	1,470	$19,873,297	$1,019.14
5 – 9	357	2,405	2,405	2,390	$29,214,089	$936.35
10 – 19	243	3,365	3,322	3,292	$46,920,490	$1,085.06
20 – 49	194	6,059	6,018	5,973	$68,656,824	$877.78
50 – 99	50	3,433	3,398	3,372	$39,751,217	$899.08
100 – 249	27	4,217	4,164	4,130	$46,513,712	$857.96
250 – 499	8	2,826	2,810	2,790	$34,503,315	$944.97
500 or more	4	3,092	3,145	3,147	$70,372,263	$1,730.58
Totals	**1,651**	**26,989**	**26,817**	**26,564**	**$356,595,717**	**$1,023.91**
Total Private						
No Quarter	126	0	0	0	$0	$0.00
No March	49	73	44	0	$790,510	$1,559.19
1 – 4	713	1,507	1,499	1,458	$19,556,419	$1,010.98
5 – 9	352	2,370	2,370	2,355	$28,712,104	$933.88
10 – 19	236	3,279	3,234	3,207	$46,079,916	$1,094.02
20 – 49	187	5,746	5,717	5,738	$65,519,074	$879.01
50 – 99	47	3,198	3,165	3,145	$36,677,636	$890.21
100 – 249	27	4,217	4,164	4,130	$46,513,712	$857.96
250 – 499	6	2,089	2,078	2,067	$25,975,422	$961.55
500 or more	3	2,513	2,554	2,575	$63,898,523	$1,929.58
Totals	**1,620**	**24,992**	**24,825**	**24,675**	**$333,723,316**	**$1,033.84**

Note: Totals DO NOT include firms with no employment or wages in the first quarter (No Quarter)
Firms with no employment in March are tallied separately (No March).
Individual work sites for companies are summed together as one firm within each county.
Prepared by: Economic and Labor Market Information Bureau,
New Hampshire Employment Security, Concord, New Hampshire 03301

Table 7-16. Zoning Abbreviation Key	
Zoning Classification	**Code**
Airport	AIR
Airport Business Commercial	ABC
Airport Industrial	AI
Business	B
Central Business A	CBA
Central Business B	CBB
General Business	GB
Industrial	I
Office Research	OR
Office Research/Marine's Village	OR/MV
Pease Industrial	PI
Waterfront Business	WB
Waterfront Industrial	WI

The connection between increased sewer rates and negative economic development impacts is both direct and indirect. A massive sewer project will not only require increases in sewer use fees, but will also necessitate growth in local government expenditures and debt levels. This will have effects on economic variables such as employment and personal income. It will also affect community demographics (population, households, labor force), and this will also produce adverse impacts on the local economy, since the size of the labor force is positively related to employment and firm growth.

7.2.2.6 Impact on property values

Over the past couple of decades, the City of Portsmouth's property values have outpaced and exceeded the county, state and national levels for median property values. It should be noted that the City of Portsmouth has developed an Economic Development Commission Action Plan for 2010 to help address housing livability in the area. This plan includes a focus on developing diverse housing options affordable to persons within a wide range of income.

Table 7-17. Property Values			
	1990	**2000**	**2006-2008***
U.S.	$ 78,500	$119,600	$192,400
New Hampshire	$129,300	$133,300	$260,300
Rockingham County	$149,800	$164,900	$323,000
City of Portsmouth	$138,214	$190,485	$368,000
Census Tract 691, Rockingham County	$155,800	$229,100	
Census Tract 692, Rockingham County	$138,400	$159,800	
Census Tract 693, Rockingham County	$111,300	$157,500	
Census Tract 694, Rockingham County	$134,300	$161,000	
Census Tract 695, Rockingham County	$126,300	$145,800	
Census Tract 696, Rockingham County	$137,200	$153,100	
Census Tract 697, Rockingham County	$164,200	$327,100	

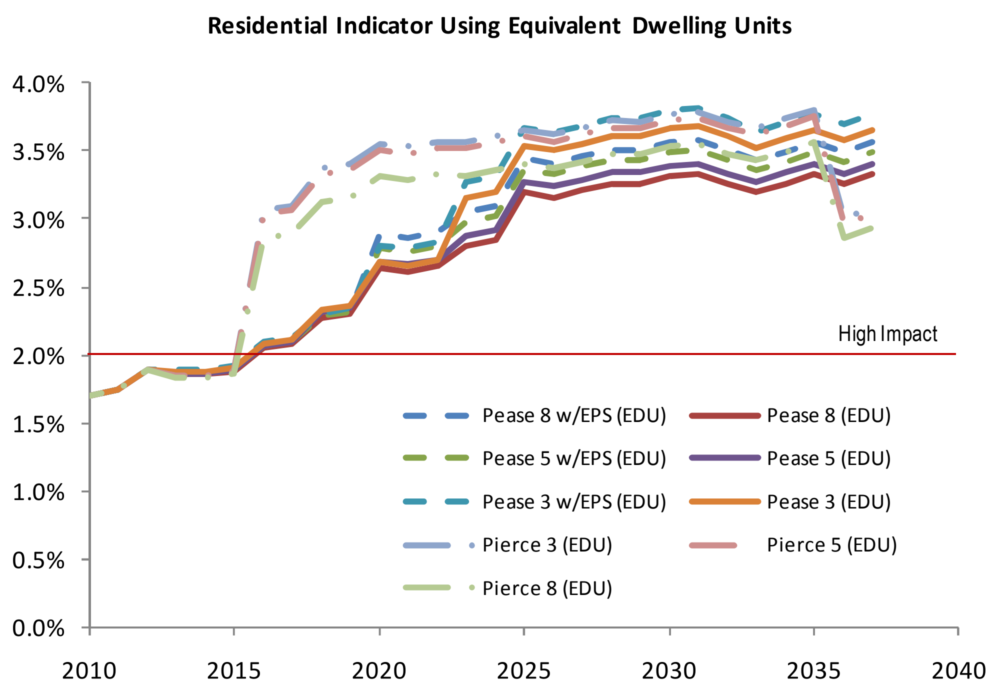
** From 2006-2008 American Community Survey*

7.2.2.7 Residential Units

The key to an affordability calculation is the definition of the number of households served by the sewer system. There are a number of ways to determine the number of households including, census information, number of sewer bills and the number of equivalent dwelling units (EDUs). For this evaluation the City used EDUs based on an average household water use as defined by the NHDES. This approach is consistent with how the City currently sets its sewer user rates and the methods used previously as part of its 2005 LTCP.

The number of EDU's is derived from State of New Hampshire calculations based on typical residential usage per year and the total residential volume of flow treated each year. The City believes that the number of EDUs more accurately reflects the component of the City's residential revenue base, the impacted revenue stream, and the impact of costs on the customers. Therefore, the financial feasibility of the projects was analyzed using the number of EDU, and is shown below.

When the project, debt and O&M costs are analyzed, the residential indicator ranges from 2.8 percent to 3.3 percent, in the EPA's "high impact" range, which leads to an overall burden in the "high burden" category. The graph below shows the RI for each of the alternatives, over the analysis period – highlighting the fluctuation in RI and the significant peaks that result from the costs.



7.2.2.8 Sewer Rates

In an effort to reduce the impact that large capital wastewater projects would have on the City's rate payers, the utility began issuing rate increases several years ago. Since 1995 the City has raised rates a total of 81 percent as shown in Table 7-18. These rates will continue to increase as needed to fund the expected costs over the span of the Master Plan. In 2006 the City commissioned a Water and Wastewater Rate Study. The findings of the study included recommendations to change the rate structure and to increase rates each year for the next five years (until 2012).

Table 7-18. Wastewater Rate Increases from 2006 Rate Study			
Year	Rate	% Increase	Annual Average Household*
1995	$2.92	24.26%	$350.40
1996	$3.53	20.89%	$423.60
1997	$3.70	4.82%	$444.00
1998	$4.30	16.22%	$516.00
2000	$4.45	3.49%	$534.00
2002	$4.60	3.37%	$552.00
2004	$4.70	2.17%	$564.00
2006	$4.80	2.13%	$576.00
July 1, 2007	$4.89/$5.33	1.88%	$586.80
July 1, 2008	$5.00/$5.50	2.25%	$600.00
July 1, 2009	$5.00/$5.50	-	$600.00

**Average household consumption based on State's measurement of 120 units per year.*

7.2.2.9 Financial Impacts Due to Project Components and Schedule

The project costs were evaluated for several alternatives. The approach looked at the engineering, capital and O&M costs starting in 2013, 2016, and 2018 respectively (per the alternatives shown in Table 7-5.). The analysis also included existing costs and debt. The resulting residential impact based on number of EDU was the EPA's "high-impact" level for the alternatives, as shown in Table 7-19.

Table 7-19. EPA's Average Residential Indicator			
	Peirce Island Alternative	Pease Alternative	Pease Alternative w/ Effluent PS
TN 3 mg/l			
Residential Indicator using EDUs	3.3	2.9	3.0
TN 5 mg/l			
Residential Indicator using EDUs	3.2	2.8	2.8
TN 8 mg/l			
Residential Indicator using EDUs	3.1	2.8	2.9

7.2.3 Affordability Analysis Discussion

Drawing on the findings from the EPA's Financial Capability Assessment and the additional socioeconomic criteria, the following points can be made from the affordability analysis:

- The financial capability of the community to deal with the increased cost is in the strong range, but the effects of the increased cost will erode that standing in the future.
- The financial impact of the Master Plan based on number of households is determined to be in the EPA's medium burden range. The EPA calculated RI was above 3 percent for many of the alternatives. This indicates a "high-impact" for the residents in the City.
- The effects to the local economy and business health resulting from the increased costs of implementing this program have the potential to be negative. Since such a significant portion of the cost is borne by the commercial and industrial user (approximately 58%), this potentially negative impact should be weighted accordingly.
- Affordable solutions and schedules may need to be developed with EPA and NHDES involvement.

Community Impact Summary

Residential Rate Payers: The EPA calculated residential indicator was above 3 percent for many of the alternatives. This indicates a "high-impact" for the residents in the City.

Commercial / Industrial Rate Payers: The effect to the local economy and business health resulting from the increased costs of implementing the WMP is expected to change the city's financial capability from Strong to Mid-Range or even Weak. The City of Portsmouth is particularly susceptible to this due to its higher than typical ratio of commercial to residential ratepayers. The residential burden is in the medium range; however, it is not reasonable to assume that the increase in rates can be as easily accommodated by for-profit businesses. Substantial rate increases have the potential to erode the economic health of the City, and should therefore be minimized where possible in the implementation of the WMP.

Affordability is something that should be measured on an on-going basis to test whether the sewer costs which result from any projects remain as affordable as possible. This will allow for adjustments in the schedule to maintain affordability. The City should continue to monitor parameters that are believed to be reliable and reflect the multiple dimensions of affordability for the community.

Addressing unfunded regulatory changes to the City's wastewater treatment and disposal facilities through increases to the wastewater user rates and charges may materially contribute to significant employment losses in the City and reverse economic development. This can seriously affect both private and local government goals to prosper and sufficiently address the health, safety and welfare of the community. Provisions to manage and address any necessary cost increases through grants, low interest loans and postponement of costly activities should be identified and thoroughly analyzed prior to the selection of any costly changes to the wastewater treatment and disposal facilities.

7.3 Cost and Affordability Conclusions

- At this time, a side by side cost comparison of the WWTF alternatives is inconclusive as to the "least cost" alternative due to the lack of established regulatory parameters.
- Despite the high impact to residents, the EPA's Financial Capability Assessment only allows a medium burden range designation for communities with strong financial capability.

- As calculated all alternatives at all total nitrogen limits represent a high residential impact/medium burden to the residential rate payers.
- The effect to the local economy and business health resulting from the increased costs of implementing the WMP is expected to change the city's financial capability from Strong to Mid-Range or even Weak. The City of Portsmouth is particularly susceptible to this due to its higher than typical ratio of commercial to residential ratepayers. While the residential burden may be in the medium range, it is not reasonable to assume that the increase in rates can be as easily accommodated by for-profit businesses. Substantial rate increases have the potential to erode the economic health of the City, and should therefore be minimized where possible in the implementation of the WMP.

8. CONCLUSIONS AND RECOMENDATIONS

8.1 Selection of a Preferred Alternative

The preferred alternative is to expand the Pease WWTF and use the current Pease WWTF outfall location consistent with the decision expressed by the City Council in September of 2009. This expressed preference is contingent upon further regulatory input and analysis of costs. There are recognized outstanding regulatory determinations that could greatly influence the City's ability to proceed with its preferred alternative. As a result, the WMP/LTCP Update includes additional alternatives for the City Council's future consideration based on future regulatory input and further financial considerations.

8.1.1 Wastewater Treatment Alternatives

As discussed throughout the WPM/LTCP Update, the plan has focused on the following alternatives for wastewater treatment:

1. Upgrade of the Peirce Island WWTF
2. Phased expansion of the Pease WWTF
   a) Using the Pease Outfall Location
   b) Using the Peirce Island Outfall Location

In order to select a preferred alternative, a decision matrix style evaluation was performed to quantitatively rank the alternatives.

8.1.2 Evaluation Criteria

Evaluation criteria were developed to assist in selection of a preferred alternative for the wastewater treatment portion of the WMP/LTCP Update. The criteria were developed based on how well each alternative was able to meet the project goals, including regulatory limits, community interest, environmental benefits and affordability. A rating scale was used to determine how well each alternative met the evaluation criteria.

The rating scale is as follows:

- Poor (P): 0 points
- Satisfactory (S): 1 point
- Exceptional (E): 2 points

1. <u>Ability to Achieve Current and Future Permit Limits</u>
   - E: When constructed the alternative has the ability to meet and exceed existing secondary treatment and potential future nutrient removal permit limits

- S: When constructed the alternative has the ability to meet existing secondary treatment and potential future nutrient removal permit limits
- P: When constructed the alternative does not have the ability to meet existing secondary treatment and potential future nutrient removal permit limits

2. Potential for Future Expansion
   - E: Once constructed there is adequate room on the site for future WWTF expansion and the potential regional biosolids processing facility
   - S: Once constructed there is adequate room on the site for future expansion
   - P: Once constructed there is no room on the site for future expansion

3. Impact on CSO abatement and the LTCP
   - E: All the wet-weather treatment necessary to achieve 1- yr level of CSO can be accommodated on Peirce Island
   - S: A portion of the wet-weather treatment necessary to achieve 1- yr level of CSO can be accommodated on Peirce Island
   - P: The wet-weather treatment necessary to achieve 1- yr level of CSO can not be accommodated on Peirce Island

4. Affordability TN 3 mg/l
   - E: Low impact by EPA affordability standards
   - S: Mid-Range impact by EPA affordability standards
   - P: High impact by EPA standards

5. Affordability TN 5 mg/l
   - E: Low impact by EPA affordability standards
   - S: Mid-Range impact by EPA affordability standards
   - P: High impact by EPA standards

6. Affordability TN 8 mg/l
   - E: Low impact by EPA affordability standards
   - S: Mid-Range impact by EPA affordability standards
   - P: High impact by EPA standards

7. Technical Complexity
   - E: Current operations staff can operate with no training
   - S: Current operations staff can operate with minimal training
   - P: Current operations staff will require significant training to operate

8. Operability
   - E: Current operations staff can operate with current staff level
   - S: Operations will require expansion of current staff level

- P: Operations will require expansion of current staff level and expansion of operating shifts

9. Accessibility
   - E: Convenient to drivers and the community for required truck traffic to access sites: Inconvenient to drivers and the community for required truck traffic to access site
   - P: Not accessible to truck traffic

10. Ability to Reclaim Peirce Island for the Community
    - E: All treatment is removed from Peirce Island
    - S: All sanitary flow is removed from Peirce Island
    - P: Sanitary flow to Peirce Island is maintained or increased

11. Other Environmental Impacts
    - E: No disruption to protected areas (i.e. wetlands, archeological sites, etc.)
    - S: Minor disruption to protected areas
    - P: Major disruption to protected areas

8.1.3 Ranking Results

The scores for each alternative based on how well it met the evaluation criteria is presented in both qualitative and quantitative form in Tables 8-1 and 8-2. The qualitative scores were added together to determine which alternative ranked highest.

Table 8-1. Qualitative Ranking Summary of Wastewater Treatment Alternatives

Criteria No.	Peirce Island	Pease (Pease)	Pease (Peirce Island)
1	S	S	S
2	P	E	E
3	S	E	E
4	P	P	P
5	P	P	P
6	P	P	P
7	P/S	E	E
8	S	S	S
9	S	E	E
10	P	S	S
11	S	E	E

Table 8-2. Quantitative Ranking Summary of Fixed Growth / Hybrid Processes			
Criteria No.	**Peirce Island**	**Pease (Pease)**	**Pease (Peirce Island)**
1	1	1	1
2	0	2	2
3	1	2	2
4	0	0	0
5	0	0	0
6	0	0	0
7	0.5	2	2
8	1	1	1
9	1	2	2
10	0	1	1
11	1	2	2
Total	**5.5**	**13**	**13**

8.1.4 Recommendation of a Preferred Alternative

Based on the ranking results presented above the recommendation of this WMP/LTCP is the Phased Expansion of the Pease WWTF. Information provided in Section 7 shows that even with this phased approach, the user rates will exceed two percent of the MHI as the project progresses and so further modification of the approach may be required. Phased construction is integral to the success of the preferred alternative because:

- It will allow the City to use existing excess capacity of the Pease WWTF prior to full expansion of the WWTF, thereby providing environmental benefits sooner,
- It will allow the City to further evaluate design flows as sewer separation projects continue and “right-size” the WWTF and provide for a more sustainable solution, and
- It will allow the City to continue to explore technological advancements to reduce overall project costs, and can lead to an affordable solution.

This recommendation holds true even if an effluent pump station and force main are required to send the WWTF effluent back to the vicinity of the current Peirce Island Outfall. The Pease Expansion ranked highest due to its overall benefit to the Portsmouth community from both a financial and cultural perspective. Since the expansion is constructed in phases it may represent the lowest impacts to user rates. It also meets the goal of removing sanitary treatment from Peirce Island. There is also the benefit of being able to accommodate expansion in the future which, while not directly impacting current residents, will benefit future generations. As discussed above, the City Council will be reviewing the preferred alternative after considering future regulatory impacts and associated financial impacts.

9. SCHEDULE OF IMPLEMENTATION

The schedule for implementation of the preferred alternative, Phased Expansion of the Pease WWTF, is presented in Appendix L. The schedule is divided into major and minor sub tasks. A brief description of each of these tasks is presented below.

Based on best engineering judgment and past municipal project experience, this implementation schedule is as expeditious as practicable consistent with sound engineering practice and normal construction practices. It also takes into account the City's need to provide a schedule which is "affordable" for its ratepayers, as that term is defined by EPA. In developing an implementation schedule, the City is faced with some uncertainty with respect to future regulatory decisions and their financial impact. Constructing the preferred alternative all at once has technological and financial disadvantages.

As the project moves forward, the City wants to be able to take advantage of the scheduled sewer separation work thereby allowing it to "right size" the system. In addition, phasing will enable the City to take advantage of an emerging technology. Phasing allows the City to capture these while delivering timely environmental benefits. The phases are described below.

Phasing may still cause affordability problems for the City during certain stages of the project; therefore, the schedule presented here may need to be revised as the project goes forward.

9.1 WMP/LTCP Update Completion September 2010 – September 2012

Subsequent to the completion of the WMP/LTCP Update in September 2010, the City will be embarking on additional studies and piloting to generate the data necessary to move to design phase and to provide regulators with necessary information for their permitting processes. For example, a wastewater characterization must be completed to ensure that the secondary treatment process is properly sized prior to preliminary design effort. Because the collection system is combined, it is important to capture both low and high flow events while sampling. In addition, seasonal variations also need to be captured.

In addition, a pilot test of the selected technology, anticipated to be BioMag™, is required to ensure that the technology will be effective without undue maintenance. Emerging technologies, which may be considered as part of the preferred alternative cannot be fully evaluated without first pilot testing. As with the wastewater characterization, the pilot test must address both low and high flow events as well as season variations.

The City is also seeking an independent peer review of the NHDES Nutrient Criteria document to evaluate NHDES's assumptions and conclusions relative to nutrient levels in the Piscataqua.

A hydrodynamic study of the upper and lower Piscataqua will also be performed to provide additional information about the migration of WWTF effluent within the Estuary.

9.2 PHASE I - WWTF Pre-Design Work January 2011 – July 2013

Preliminary design of the preferred alternative will be required to ensure that all design issues have been identified and to further refine the opinion of costs for construction.

Before the pre-design work can commence, the City must identify, obtain and appropriate funds for the work. It is envisioned that the work performed would be funded through a State Revolving Fund (SRF) loan, which will require approval by both the City Council and the NHDES.

The design effort includes an environmental review of the Pease WWTF site. This effort includes the selection of a consultant to perform the review and the field work, such as wetlands identification as well as develop an environmental review report, which must then be submitted to the NHDES. In order to proceed upon approval by the NHDES, a Finding of No Significant Impact (FONSI) will be necessary.

This pre-design effort also includes obtaining the legal right(s) necessary to proceed. The Pease WWTF is located on land leased from the Pease Development Authority. Leasing additional land adjacent to the existing WWTF from the PDA is required.

A new subaqueous outfall and diffuser is required for the preferred alternative. This requires the selection of a design consultant.

9.3 PHASE II - WWTF Design March 2013 – August 2016

The design of the WWTF is divided into several sub tasks including: funding for the design (which requires City Council approval and approval by the NHDES and City Council for an SRF loan); selection and retention of a specialized design consultant; design milestones; a value engineering exercise as well as NHDES approval for bidding the project.

The preferred alternative is based on the phased construction of an expansion of the Pease WWTF. However, the design of the entire facility would be undertaken during this step to ensure the constructability of future phases as well as to identify all structural and equipment needs.

The construction of the WWTF expansion would be publicly bid to retain a qualified construction contractor. Each phase would be bid separately, as shown in the implementation schedule. The bidding would include the issuance of the final design documents to potential bidders, a bid period to allow potential bidders to prepare their bid, the bid opening, and the recommendation of award.

9.4 WWTF Construction Phase 3 through Phase 7 September 2015 - April 2028

The phased expansion of the Pease WWTF would be divided into five (5) construction phases and bid in distinct phases. Each phase has been developed to provide for a construction period to begin approximately every three (3) years. As with previous tasks, funding of the construction phase must be approved by City Council and the SRF loan must be approved by the NHDES. Only those funds necessary for construction of the specific phase bid would be authorized. Authorization of funding for each phase will be required on approximately 30 month intervals.

The implementation of each WWTF expansion phase would include the construction of the necessary infrastructure, the startup of the new systems and the transition to the City for operation.

PHASE III: The third phase will start with construction (September 2015 to August 2017) which will include the installation of the force main(s) from the Deer Street PS to the Pease WWTF and the modifications necessary to the PS. This will deliver environmental benefits by August 2017 by delivering 600,000 to 1.2 mgd (if the BioMag™ pilot test is successful) for secondary treatment at Pease. This is equivalent to 25% of the City's average dry weather sanitary flow. It also increases the Peirce Island WWTF's capacity to provide an equivalent amount of additional stormwater treatment.

PHASE IV: This phase will add an additional SBR unit to the Pease WWTF and make upgrades at the Peirce Island WWTF. This will provide an additional 600,000 to 1.2 mgd (if BioMag™ is successful) for secondary treatment at Pease by February 2020. This will mean that the Pease WWTF will have capacity for roughly 100% of the City's dry weather sanitary flow. It also increases the Peirce Island WWTF's capacity to provide additional stormwater treatment.

PHASE V: The fifth phase will add an additional SBR unit and other treatment processes by September 2022 providing additional 600,000 to 1.2 mgd (if BioMag™ is successful) by September 2022. Additionally, a sludge storage tank and biosolids dewatering would be added.

PHASE VI: This phase would add two additional SBR units providing an additional 1.2 mgd to 2.4 mgd (if BioMag™ is successful) by April 2025. Additionally, methanol storage and pumping capability would be added.

PHASE VII (ONLY IF NECESSARY): This phase includes two additional SBR's which will provide an additional 2.8 mgd and upgrades to the Peirce Island WWTF for wet weather treatment. If BioMag™ has been successful, then this Phase will be unnecessary.

APPENDIX A: 301(H) WAIVER APPLICATION

APPENDIX B: CONSENT DECREE

APPENDIX C: CORRESPONDENCE WITH COMMISSIONER BURACK

APPENDIX D: PEIRCE ISLAND WWTF NPDES PERMIT

APPENDIX E: PEASE WWTF NPDES PERMIT

APPENDIX F: NUMERIC NUTRIENT CRITERIA DOCUMENTS

APPENDIX G: WASTELOAD ALLOCATION

APPENDIX H: AECOM VALUE ENGINEERING ANALYSIS

APPENDIX I: DETAILED COST ESTIMATING SPREADSHEETS

APPENDIX J: DETAILED COST ESTIMATING SPREADSHEETS FOR PHASED APPROCAH

APPENDIX K: DEVELOPMENT OF EQUIVALENT DWELLING UNIT

APPENDIX L: SCHEDULE OF IMPLEMENTATION FOR PREFERRED ALTERNATIVE