PUBLIC WORKS DEPARTMENT

CITY OF PORTSMOUTH
680 Peverly Hill Road
Portsmouth N.H. 03801
(603) 427-1530 FAX (603) 427-1539

January 30, 2012

Mark Pollins
Director of Water Enforcement
U.S. Environmental Protection Agency
Room # 3142
USEPA Ariel Rios Building (AR)
1200 Pennsylvania Avenue N.W.
Washington, D.C. 20004

Re: Consent Decree 09-cv-283-PB
Quarterly Report No. 9
Portsmouth, New Hampshire

Dear Mr Pollins.:

In accordance with Consent Decree 09-cv-283-PB, Section V, item paragraph 20, dated August 12, 2009, the City of Portsmouth is submitting this quarterly status report.

The Consent Decree requires the filing of quarterly reports as follows:

> Within 30 days after the end of each calendar quarter (i.e., by April 30, July 30, October 30, and January 30) after the Effective Date of this Consent Decree, until termination of this Decree pursuant to Section XVI, the City shall submit a written report for the preceding calendar quarter that shall include a description of the following: i) the status of any construction or compliance measures; ii) the status of all Consent Decree milestones; iii) any problems encountered or anticipated, together with the proposed or implemented solutions; iv) the status of permit applications; v) operation and maintenance operations; and vi) reports to State agencies.

The following is the list of compliance requirements listed in Section IV of the Consent Decree. For clarity the requirements are listed in plain text and the status of the item is shown in ***Bold Italics.***

8. <u>Nine Minimum Controls Compliance Plan</u>. Attached (***in the referenced CD***) as Appendix A is the Nine Minimum Controls Compliance Plan. The City shall implement the Nine Minimum Controls Compliance Plan in accordance with the schedule specified in Appendix A.

i) There are no construction related activities with this item. The compliance measures associated with this item are on-going.
ii) There is no Consent Decree milestone associated with this item.

iii) There have been no problems encountered or anticipated with this item.
iv) There are no permit applications associated with this item.
v) Operation and maintenance is on-going
iv) There are no reports to State Agencies associated with this item.

9. Wastewater Master Plan. Attached as Appendix B is the WMP SOW dated May 17, 2007. The City shall implement the WMP in Appendix B, and comply with all milestones and schedules in Appendix B.1.

The Schedule listed in Appendix B.1 has been superseded by a schedule submitted as part of the Wastewater Master Plan Final Submission submitted to EPA on November 15, 2010. An implementation schedule was included in section 1.2.5 of that submission. The initial effort included piloting potential technologies with a final report due to the EPA and DES by September 2012. The City anticipates meeting that compliance deadline.

On Wednesday January 25, 2012 the City received a draft Consent Decree Modification including a proposed schedule for upgrade to the Peirce Island WWTF. This proposed schedule is under review and a final revised schedule is anticipated to go to the Portsmouth City Council for vote in the near future.

i) There are minor pilot related construction activities with this item (see AECOM monthly reports). The compliance measures associated with this item are on-going.
ii) The original Consent Decree milestones associated with this item have been met with the exception of the final submission of the Wastewater Master Plan, which based mutual agreement between the City and the EPA was submitted on November15, 2010. The final revised schedule will be formally incorporated into a revised Consent Decree.
iii) The problems encountered meeting the Consent Decree milestones have been previously identified by the City. Those problems relate to critical regulatory input in the areas of anti-degradation and future permit limits. In addition, we have had a number of start-up related pilot issues (see attached AECOM monthly reports) that have delayed the pilot study. We anticipate the submission of the final pilot report (September 30, 2012) will not be impacted by the delays discussed above.
iv) The Peirce Island WWTF NPDES permit reapplication was submitted in December, 2011.
v) Operation and maintenance activities with this item are being done by AECOM and Blueleaf as part of the pilot study contract.
iv) There are no reports to State Agencies associated with this item that have not also been submitted to the EPA as part of the milestone deadlines. Included for information are pilot study monthly status reports prepared by AECOM which outlines the various issues encountered during startup and operation of the pilot study technology selection process. In addition, AECOM has prepared a revised schedule which is consistent with the overall schedule submitted as part of the City's Wastewater Master Plan November 15, 2010 Final Submission.

10. Combined Sewer Overflow Facility Upgrades. The City shall implement its April 2005 Final CSO Long Term Control Plan in accordance with the following schedule and shall complete all construction for implementation of the 2005 LTCP by October, 2012:

A schedule revision was requested as part of the November 15, 2010 Final Wastewater Master Plan Submission. Additional time was requested for Lincoln Phase I, II, and III as well as Islington #2 (Cass Street). The schedule adjustment to Islington #2 (Cass St) project was to allow the piloting effort at Peirce Island to move forward sooner. The money allocated for Islington #2 (Cass St) was reallocated to the Peirce Island piloting effort.

In addition to the time extension the scope of the Lincoln Area projects have been adjusted to accommodate construction of the City's Middle School. Revised project area figures have been submitted under separate cover and a copy of that submission is attached.

In summary, the schedule and project scope adjustments have been necessary to address the difficulties encountered as part of construction in a tight urban environment. Narrow streets, limited staging areas as well as deep sewer in ledge impact the construction schedule. In addition, public concerns related to traffic, dust control, pedestrian traffic, school buses, etc., requires flexibility in construction sequencing.

Planning Area I.D.	Contract I.D.	Project Start Date	Project Completion Date
Lincoln 3	Phase I	In Progress	10/1/2011
Lincoln 3	Phase II	In Progress	10/1/2012
Lincoln 3	Phase III	In Progress	10/1/2013
Court/State	Court #3	1/1/2008	1/1/2012
Islington	Islington #1	Under Design	10/1/2010
Islington	Islington #2	Under Design	1/1/2012

Revised LTCP Schedule *

Planning Area I.D.	***Contract I.D.***	***Project Start Date***	***Project Completion Date***
Lincoln 3	***Phase I***	***In Progress***	***6/1/2012***
Lincoln 3	***Phase II***	***In Progress***	***10/1/2014***
Lincoln 3	***Phase III***	***In Progress***	***10/1/2013***
Islington	***Islington #2***	***Under Design***	***6/1/2013***

*** As outlined in the proposed Consent Decree Modification received by the City of Portsmouth on January 25, 2012.**

i) The construction related activities with this item are shown on the table above. The compliance measures associated with this item are on-going. Construction on a part of Contract 3 Phase III is in conjunction with work at the adjacent Portsmouth Middle School is underway. The balance of Phase III and Islington #2 are anticipated to bid in February of 2012.
ii) The Consent Decree milestones associated with this item have met the adjusted schedule.
iii) There are no problems encountered or anticipated with this item.
iv) Wetland and Shore-land permit applications for Lincoln Area Contract 3 Phase III are completed and approved.
v) There are no operation and maintenance activities with this item.
iv) There are no reports to State Agencies associated with this item.

11. <u>Interim Emissions/Effluent Limits</u>. Until the City completes construction of and achieves full operation of secondary treatment facilities in accordance with the schedule contained in this Consent Decree, the City shall comply with the interim limits and measures set forth in Appendix C. (See Current AO effluent limits). Thereafter, the City shall comply with the applicable NPDES permit limits then in effect.

With the exception of BOD_5 effluent concentration and pounds the City has met the Interim Emission/Effluent Limits for the Quarter covered by this report. Wastewater Treatment Facility Staff have investigated the issue and have concluded that the soluble fraction of the influent wastewater has increased. Despite 70 - 80% TSS removal of the higher soluble BOD_5 fraction is making it harder for the chemically enhanced primary to achieve the necessary permit limits. Wastewater Staff is conducting additional tests to further define this issue.

i) There are no construction related activities with this item. The compliance measures associated with this item are on-going.
ii) There are no Consent Decree milestones associated with this item.
iii) There are no problems encountered or anticipated with this item.
iv) There is no permit application pending associated with this item.
v) There have been no exceptional operation and maintenance activities outside of routine wastewater treatment facility operation associated with this item
iv) There are no reports to State Agencies associated with this item that have not also been submitted to the EPA as part of the milestone deadlines.

12. <u>Post Construction Monitoring Plan</u>:

This item was submitted as part of the June 4, 2010 Wastewater Master Plan Draft submission. The implementation schedule will be adjusted to reflect the new schedule listed in item 10 above.

i) There are no construction related activities or compliance measure associated with this item.
ii) The Consent Decree milestones associated with this item will be met subject to the concerns raised above under paragraph 9, item iii.
iii) There have been no problems encountered or anticipated with this item.
iv) There is no permit application pending associated with this item.
v) There are no operation and maintenance activities associated with this item.
iv) There are no reports to State Agencies associated with this item.

As required by the Consent Decree:

> I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Please call me at 603-766-1416 if you have any questions or require additional information.

Very truly yours,

Peter H. Rice, P.E.
City Engineer, Water and Sewer Divisions

cc: Chief, Environmental Enforcement Section w/encl.
Joy Hilton, USEPA Region 1 w/encl.
Tracy L. Wood, P.E., NHDES Wastewater Engineering Bureau w/encl.
Allen Brooks, Esq., Department of Justice, Environmental Protection Bureau w/encl.
Mr. John P. Bohenko, City Manager, City of Portsmouth w/o encl.
Robert P. Sullivan, City Attorney w/encl.
Suzanne Woodland, Assistant City Attorney w/encl.
David S. Allen, P.E., Deputy Director of Public Works w/encl.

PUBLIC WORKS DEPARTMENT

CITY OF PORTSMOUTH
680 Peverly Hill Road
Portsmouth N.H. 03801
(603) 427-1530 FAX (603) 427-1539

January 24, 2012

Joy Hilton
US Environmental Protection Agency
Region 1
5 Post Office Square - Suite 100
Boston, MA 02109-3912

RE: Consent Decree LTCP Schedule Clarification

Dear Ms. Hilton:

Previous correspondence from the City inadvertently cited conflicting dates for Sewer Separation Projects 3B and 3C. The confusion was due to change in the order with which the two projects were to be completed. The order was changed to address the City's Middle School construction schedule. This schedule required completing the Richards Avenue, Parrott Avenue area first, therefore Project 3C became 3B.

The table below reflects the current designation being used by the City. Please let us know if this is acceptable or if a change back to the original project name is necessary. To avoid additional confusion the three project description will include streets from now on.

Original Project Name	Adjusted Project Name	Original CD Completion Date	New CD Completion Date
3A (Phase I)	3A - Lincoln from Richards to Middle	10/1/11	6/1/12
3B (Phase II)	3C - Side Streets off of Lincoln including part of Broad, Union, Wibird, Park, and Richards	10/1/12	6/1/14
3C (Phase III)	3B - Richards from Lincoln to Middle; Miller from Lincoln to Middle; Highland; Rockland, Merrimack	10/1/13	6/1/13
Islington 2	Cass Street Area	1/1/12	6/1/13

In addition, attached please find figures showing the extent of the three Projects. I apologize for any confusion this change in nomenclature may have caused. Please call if you have any questions.

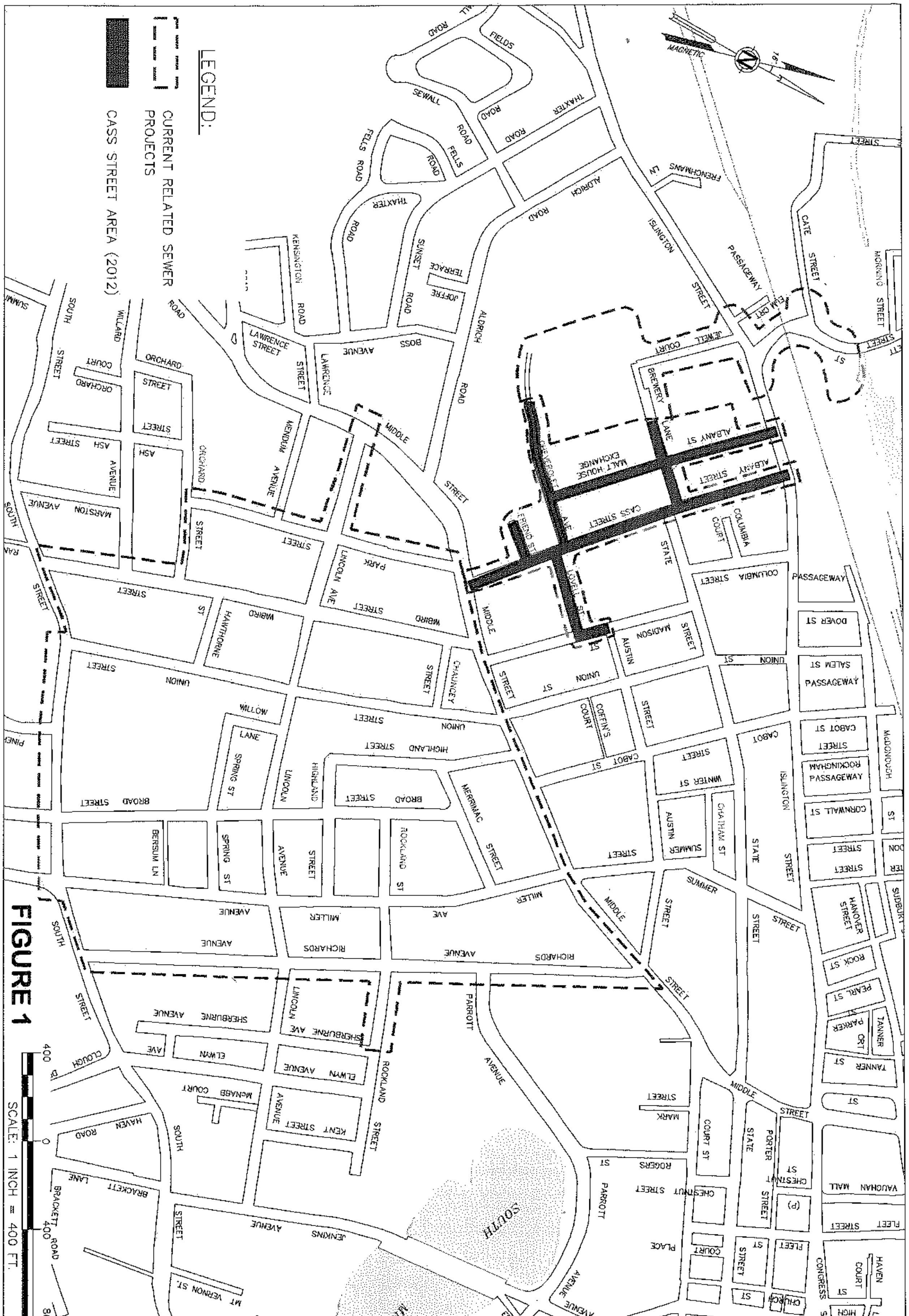
Sincerely,

Peter Rice, P.E.
City Engineer

PHR/phr

enclosure

cc: Dave Allen, P.E. Deputy Director of Public Works
Suzanne Woodland, Assistant City Attorney
E. Tupper Kinder, Esq.



DWG NO	CASS ST. AREA SEWER IMPROVEMENTS	
	LINCOLN AREA SEWER SEPARATION	
SHEET OF	CITY OF PORTSMOUTH PORTSMOUTH, NH	

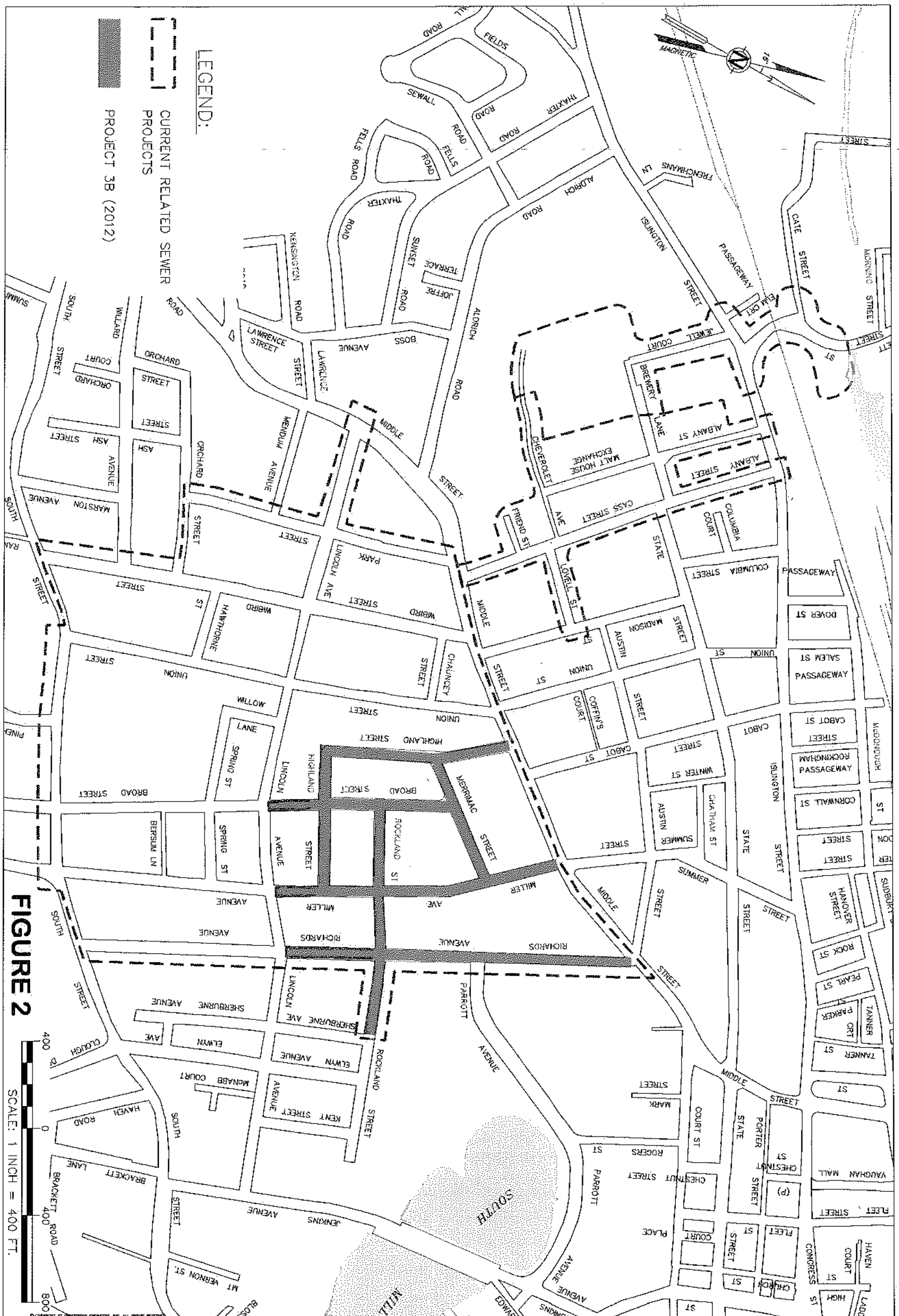
Underwood Engineers, Inc.

25 Vaughan Mall; Portsmouth, N.H. 03801
Tel. 603-436-6192 Fax. 603-431-4733

Drawn	RMG
Designed	
Checked	
Approved	
Date	11/3/11
Book No.	
Project No.	1565
Dwg. ID	
Scale	AS SHOWN

NO.	REVISIONS	APP'D

ISSUE FOR	
APPROVAL	
Date	By
CONSTRUCTION	
Date	By
RECORD DRAWING	
Date	By



©COPYRIGHT AT UNDERWOOD ENGINEERS, INC. ALL RIGHTS RESERVED

DWG NO	PROJECT 3B SEWER IMPROVEMENTS
	LINCOLN AREA SEWER SEPARATION
SHEET OF	CITY OF PORTSMOUTH PORTSMOUTH, NH

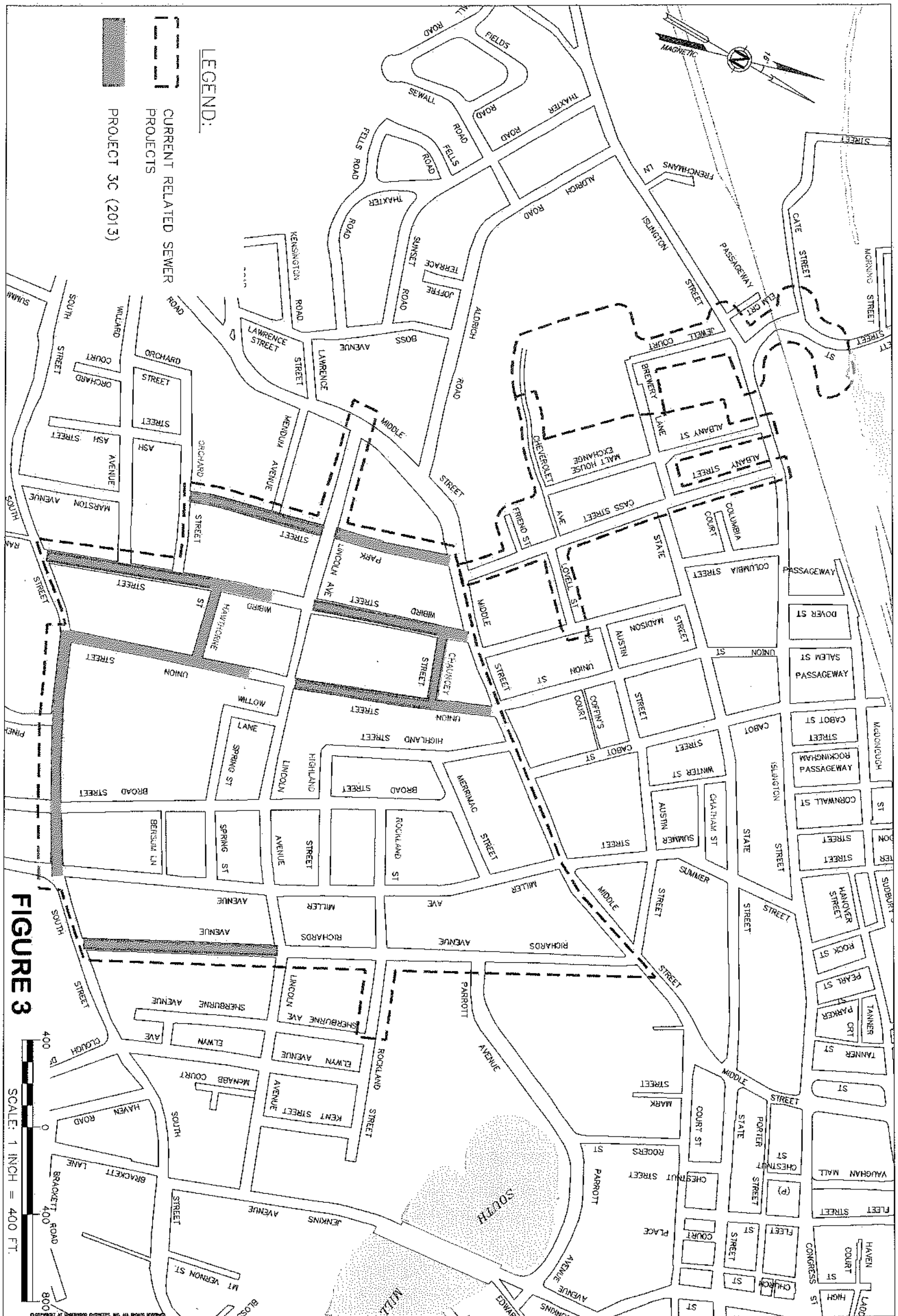
Underwood Engineers, Inc.

25 Vaughan Mall, Portsmouth, N.H. 03801
Tel. 603-436-6192 Fax. 603-431-4733

Drawn	RMG
Designed	
Checked	
Approved	
Date	11/3/11
Book No.	
Project No.	1565
Dwg. ID	1565_RG_PHAS...3B
Scale	AS SHOWN

NO.	REVISIONS	APP'D
△		
△		
△		
△		
△		

ISSUE FOR	
APPROVAL	
Date	By
CONSTRUCTION	
Date	By
RECORD DRAWING	
Date	By



PROJECT 3C SEWER IMPROVEMENTS

LINCOLN AREA SEWER SEPARATION

CITY OF PORTSMOUTH
PORTSMOUTH, NH

DWG NO
SHEET
OF -

Underwood Engineers, Inc.
25 Vaughan Mall, Portsmouth, N.H. 03801
Tel. 603-436-6192 Fax. 603-431-4733

Drawn	RMG
Designed	
Checked	
Approved	
Date	11/3/11
Book No.	
Project No.	1565
Dwg. ID	1565_SID_PHAS_3C
Scale	AS SHOWN

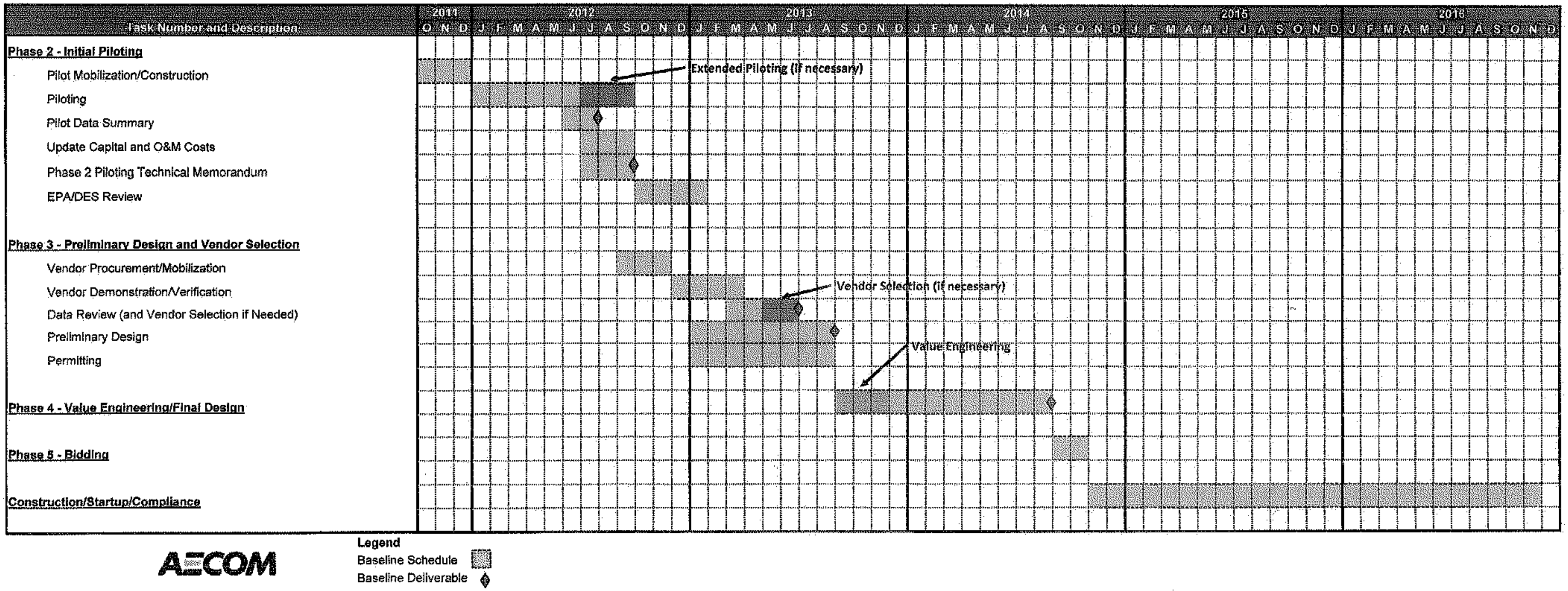
NO.	REVISIONS	APP'D
△		
△		
△		
△		
△		

ISSUE FOR
APPROVAL
Date By
CONSTRUCTION
Date By
RECORD DRAWING
Date By

City of Portsmouth, New Hampshire
Wastewater Master Plan Piloting Evaluation

Updated Project Schedule

Revised: 1-26-12



AECOM

AECOM

AECOM
701 Edgewater Drive
Wakefield, MA 01880
www.aecom.com

781.246.5200 tel
781.245.6293 fax

Memorandum

To	Peter Rice, City Engineer	Page	1 of 2
CC	David Allen, Deputy Director, Paula Anania, Chief Operator		
Subject	Monthly Pilot Activities Summary Mid December 2011 through Mid January 2012 WWMP Piloting – Phase 2 Initial Piloting Peirce Island WWTF, Portsmouth, New Hampshire		
From	Jon Pearson and Terry Desmarais		
Date	January 13, 2012		

This memorandum summarizes piloting activities for the referenced period. The summary is intended to provide an overall indication of pilot activities. Additional specifics can be provided as requested. Where the name "AECOM" is used it is meant to include AECOM and/or its subcontractors.

Pilot Status:

On-site construction of the PC, MBBR reactor tank and BioMag reactor tank and clarifiers is complete. The prefabricated DAF and BAF reactors are on-site. Pilot system equipment and tank piping is complete except for the BAF. The bottom half of the reactor tanks and ancillary equipment is enclosed and insulated to protect it from the elements and to conserve heat. The PC and BioMag are in continuous operation. The MBBR is in batch mode on weekends and at night, but is in flow through mode during the day while attended. MBBR continuous mode will begin once certain alarms are connected into the WWTF SCADA system.

Ongoing Activities:

- Collection and analysis of continuous monitoring and field data from operational pilot units.
- Discussions with Kruger to expedite the startup of the BAF.
- Electrical and process alarm system installation.

Completed Activities this Period:

- Changed influent feed pump to chopper type pump and added basket strainers on the PC effluent at the inlet of the MBBR and BioMag reactors.
- Replaced the VFD for the blower.
- Performed a review of the pilot system to identify potential weak links that could impact system operation.
- Finalized Experimental Plan 01 – Treating Primary Effluent to 30/30 Standards at Average Day Flow for the PC, MBBR pilot system and BioMag pilot system.
- Collection of continuous and field data for operational pilot units.
- Batch and flow through operation of MBBR and startup of DAF.

- Additional testing for optimal polymer for BioMag system.
- Begin weekly pilot performance review meetings.

Scheduled Activities Next Period:

- Completion of process alarm system installation.
- Startup of BAF pending delivery of Kruger provided equipment and materials.
- Experimental Plan 01 performance evaluation for MBBR and BioMag systems.
- Development of Experimental Plan 02 – Determine the Maximum Flow Rate that can be Achieved Treating Primary Effluent to 30/30 Standards
- Begin development of biomass for TN treatment levels

Major Challenges and Resolution:

1. **Blower VFD Failure:** The MBBR and BioMag reactors were seeded with mixed liquor from the Hampton, NH WWTF during the week of December 19th. During this time period the reactors were being operated in a modified mode to support development of biomass. On the afternoon of Friday, December 23rd, the blower VFD suffered an electrical failure that made the unit unusable. As a result, there was no way to provide oxygen to support biomass life. The pilot units were not in operation for the weekend and progress was delayed while a new VFD was installed the following week. The biological reactors were reseeded December 30th.

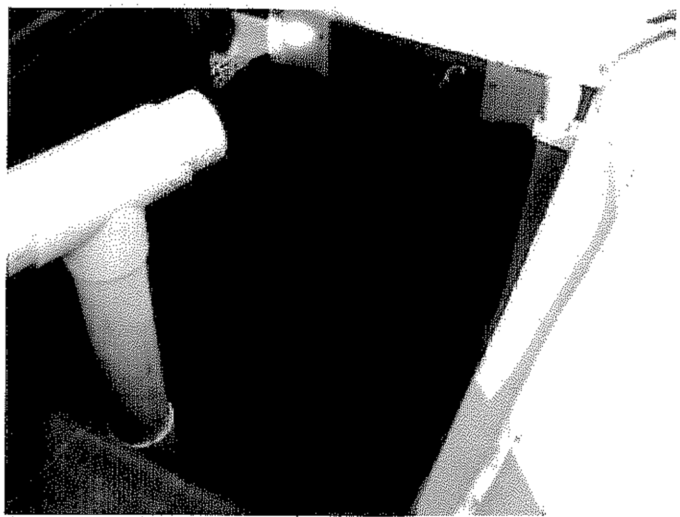
2. **Media Loss Protection.** The City and AECOM worked together to develop a system for all pilot units that use fixed film media to prevent accidental discharge of media into the main WWTF flow. For the MBBR system, this required all effluent from the system be discharged to a 1,000 gallon holding tank. Effluent is pumped from the 1,000 gallon holding tank via two submersible sump pumps. If media is in the effluent it will float to the top of the tank and be contained. In addition, there are three 5 mm mesh screens in the effluent piping downstream of the 1,000 gallon storage tank. Alarms have been tied into the City's SCADA system to alert the City and AECOM of potential backups or equipment failure.

3. **MBBR Media Clogging.** The MBBR reactors have cylindrical media with a high specific surface area that provides the surface area for biological growth. The media for the pilots was supplied by World Water Works through an Israeli company named AqWise. Either during the manufacturing process or in shipment some of the media was damaged and was smaller than the typical media piece. The pieces were just small enough to get lodged in the horizontal slotted vertical media retention pipes for the MBBR bioreactors. This required the system be occasionally pumped down and the small pieces removed from the media retention pipes by hand. Pictures have been provided in the attachment. It is anticipated that the small pieces will ultimately be removed through periodic maintenance. However, in the case that the operation is continuously impacted by this situation, new bags of media will be available on site for full media replacement.

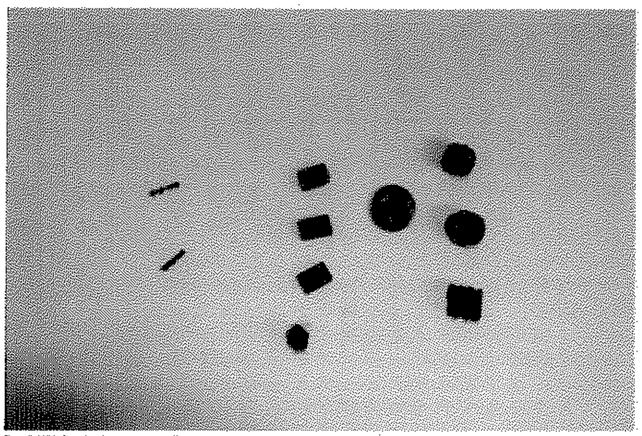
Attachments:

1. Construction Photos
2. Site Visit Notes
3. Experimental Plan 01 – Treating Primary Effluent to 30/30 Standards at Average Day Flow for the PC, MBBR pilot system and BioMag pilot system.

Pilot Photos Mid December 2011 through Mid January 2012:

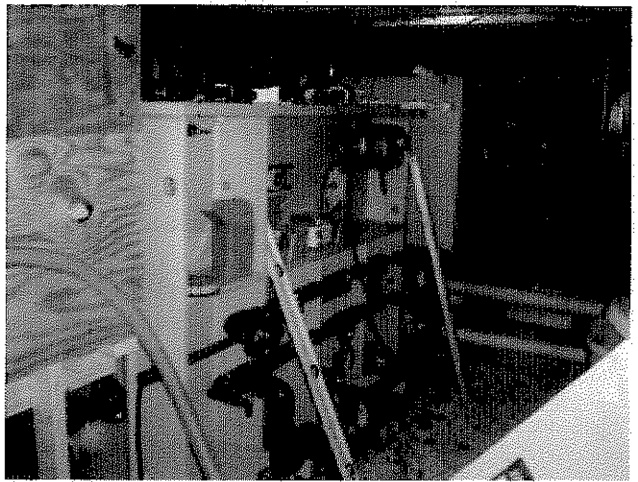


1. MBBR Virgin Media in Post Denit Tank

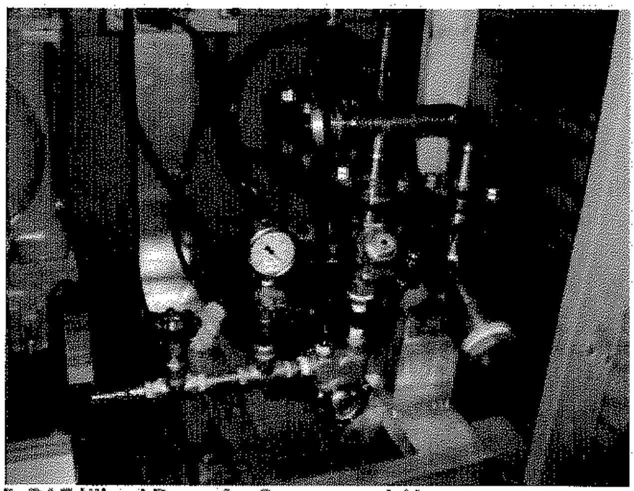


2. MBBR Media Showing Faulty Media Pieces in Middle and Left

3. MBBR Media Retention Pipes Clogged with Faulty Media



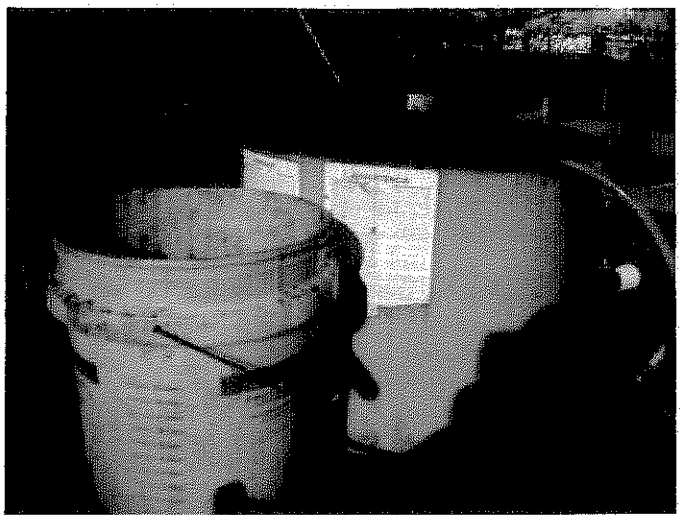
4. Prefabricated DAF Under Enclosure



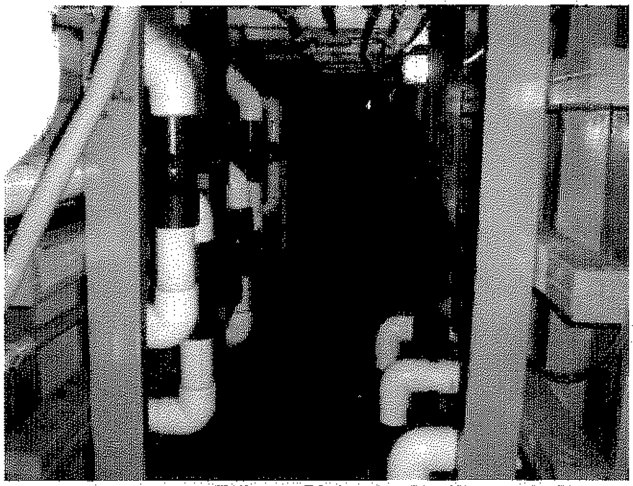
5. DAF Nikuni Pump for Compressed Air

6. BioMag Mixed Liquor

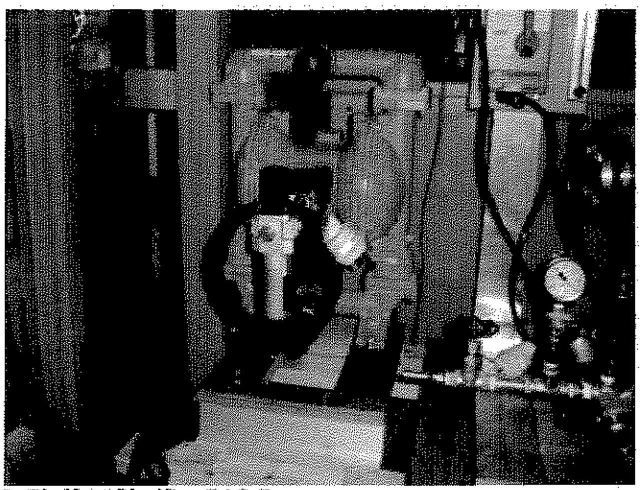
Pilot Photos Mid December 2011 through Mid January 2012:



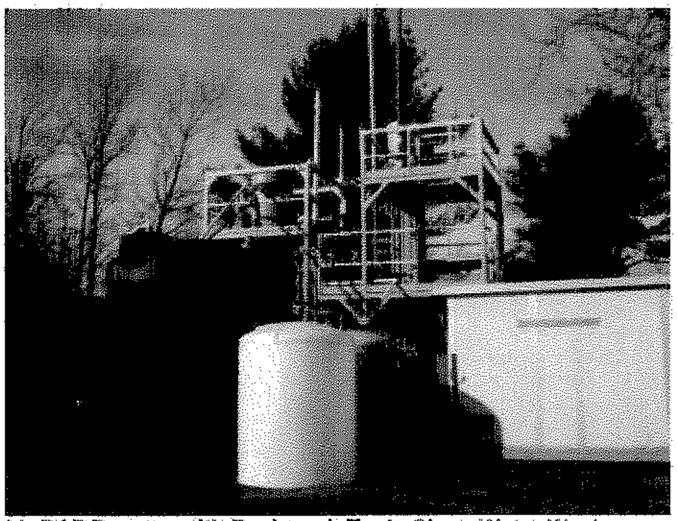
7. BioMag Magnetite Slurry Makeup Drum



10. BioMag Reactor Effluent Piping to Clarifier on Left



8. BioMag Clarifier RAS Pump



11. BAF Reactor with Backwash Tank, Clean Water Wash Tank, and PLC Shed

9. View Under Decking with PC to Left and MBBR Reactor to Right

12. 11. BAF Reactor with PLC Shed

AECOM

AECOM
701 Edgewater Drive
Wakefield, MA 01880
www.aecom.com

781.246.5200 tel
781.245.6293 fax

Memorandum

To	Erik Grotton, Blueleaf Water	Page	1 of 2
CC	Peter Rice, City Engineer, Paula Anania, Chief Operator and Jon Pearson, AECOM		
Subject	Pilot Site Visit on January 4, 2012 WWMP Piloting – Phase 2 Initial Piloting Peirce Island WWTF, Portsmouth, New Hampshire		
From	Terry Desmarais and Mark Laquidara		
Date	January 5, 2011		

AECOM technical staff visited the pilot system at the Peirce Island WWTF on the referenced date. The purpose of the visit was to observe the physical arrangement and operation of the pilot systems with consideration to identify and mitigate potential risks for malfunction. Paula Anania, Chief Operator participated in the review with Erik Grotton, Terry Desmarais, and Mark Laquidara. In particular, the team identified process and mechanical equipment that may be weak links in the systems that would result in an interruption of process operation. Alternative options for failed equipment and ways to work around operation malfunctions were discussed. The following is a list of items discussed during the site visit:

Raw Wastewater Pump and Force Main

In case of pump failure:

Option 1: Use the standby solids handling centrifugal pump to replace the existing failed grinder pump. This pump will remain on site as an uninstalled stand-by. A new grinder type pump could be obtained locally within one to two days.

Option 2: Purchase a second grinder pump as a redundant unit to have as an uninstalled stand-by. A new grinder pump will cost $2000 to $3000.

It was agreed that Option 1 would be implemented.

In case of force main failure or clogging:

The CEPT force main will act as a redundant raw water force main. This changeover can be accomplished with minor plumbing performed by Blueleaf Water.

Screening of the Raw Wastewater

In lieu of screening raw effluent at the primary clarifier (PC) inlet, bucket strainers will be used to screen primary effluent at the BioMag and MBBR bioreactors.

Biological Aeration Source for BioMag and MBBR

In case of blower/VFD failure, use a trailer mounted air compressor to maintain a dissolved air concentration that supports biological life. The City agreed to investigate the capacity and available of a city owned compressor that could be stored on-site. Blueleaf Water will install the necessary taps for emergency connection to an outside air source.

MBBR and DAF

The team is working with the media vendor to resolve an issue where faulty media is clogging the vertical slotted media retention screens. In case of clogged media retention screens (vertical slotted pipe) as a result of faulty media or another unforeseen reason, Blueleaf Water will have sump type pumps that can pump from reactor to reactor as necessary.

Blueleaf Water will investigate the lead time for replacement anoxic mixers.

The DAF clarifier was not in operation at the time of the meeting, but should be reviewed once up and running.

BioMag and Clarifiers

BioMag mixers and return sludge pumps are available locally within 24 hours.

The BioMag return sludge pumps require an air supply, which is currently taken from a small air compressor. This air supply will ultimately be provided by the BAF air compressor and the existing compressor in use will remain as a back-up.

BAF

Blueleaf Water intends to shrink wrap the superstructure supporting the two BAF reactors and the associated tanks to prevent freezing.

The BAF reactors were not in operation at the time of the meeting, but should be reviewed once up and running.

Snow Protection and Removal

Option 1: Use rubber sheeting over the decking around the PC, MBBR and BioMag pilots to ease in snow removal and request assistance from plant staff for snow removal after storms.

Option 2: Construct a timber roof. Blueleaf Water indicated they felt snow removal via Option 1 was feasible and that the expense and effort to construct a timber roof was not the best choice. In addition, there were concerns that a building permit may be needed for this type of structure.

It was agreed that Option 1 will be implemented

Miscellaneous Pumps and Equipment

Blueleaf water has multiple backup sampling, polymer and other small pumps units on-site.

Experimental Plan 01 for Primary Clarifier Pilot System

Date: 20 December 2011

Purpose: Determine the effluent water quality from the Pilot-Scale Pilot System.

Conditions:

The following target values were proposed by AECOM.

The pilot	**Average Day**	**Max Month**
Flow (mgd)	4.30	5.99
Primary Effluent TSS (mg/L)	**91**	**84**
Primary Effluent BOD_5 (mg/L)	**131**	**122**

Methodology:

Start up

The Pilot Scale Primary Clarifier will be operated at 50 gpm. The scum removal frequency will be adjusted to remove scum as needed. The screening removal will be completed manually as needed. The settled solids will be removed daily.

Operation

The process will be operated continuously with no change to the feed flow rate. Samples will be collected in accordance with the sample schedule. The frequency of all removal processes will be recorded.

Experimental Plan 01 for BioMag Pilot System

Date: 20 December 2011

Purpose: Confirm that BioMag System treats Portsmouth Primary Effluent to 30/30 Standards at Average Daily Flows

---

Conditions:

Parameter	Pilot Scale	Proposed Full Scale
Tank Volume	2,693 ga (13' 4"L x 4'W x 6' 9"H)	903,000 ga (134'L x 30'Wx30'D)
Flow Rate	8.9 gpm	4.3 MGD
Detention Time	5.04 hours	5.04 hours
Magnetite Concentration	3,000 mg/L	3,000 mg/L
MLSS Concentration	3,000 mg/L	3,000 mg/L
Polymer Use	Cationic HMW, HSC	Not defined
Clarifier Hydraulic Loading Rate	953 gpd/sf	1,038 gpd/sf

Methodology:

Start up

The BioMag Aeration Tank (Zone #2) will be filled with effluent from the pilot-scale primary clarifier. The feed hose will be placed into the Magnetite Mix Tank, and the valves will be closed to the other tanks in the Bioreactor. The aeration system will be started and operated to provide spiral roll aeration with a dissolved oxygen concentration of approximately 2 mg/L. All flow will be to Clarifier 1, and the recycle rate will be set to 100%. The system will be operated for at least 24 hours to confirm that all components are operational.

Mixed liquor will be obtained from the Hampton WWTF. At least 25% of the reactor volume (675 gallons) will be replaced with the mixed liquor. Polymer addition will be started at a dose of 1 ppm. Magnetite will be added over a period of 48 hours, with approximately 100 pounds added initially. Additional magnetite may be needed to be added to establish the target magnetite dose, as some magnetite will be deposited in the corners of the tank.

Operation

The process will be operated continuously with no change to the feed flow rate. The recycle rate will be adjusted to maintain solids concentration. No solids wasting is planned until the target MLSS concentration is reached. Samples will be collected in accordance with the sample schedule until the BOD and TSS are both consistently below 30 mg/l.

Experimental Plan 01 for MBBR Pilot System

Date: 20 December 2011

Purpose: Confirm that MBBR System treats Portsmouth Primary Effluent to 30/30 Standards at Average Daily Flows

---

Conditions:

Parameter	**Pilot Scale**	**Proposed Full Scale**
Tank Volume	993 gallons	244,180 gallons
Flow Rate	12.1 gpm	4.3 MGD
Detention Time	1.36 hours	1.36 hour
Media Fill	61% (81 cf)	61%
Media Migration Velocity	1.2 m/hr	6.7 m/Hr
Polymer Use	Cationic HMW, HSC	Not defined
DAF Hydraulic Loading Rate	5-15 gpm/sf	5 gpm/sf

Methodology:

Start up

The MBBR Aeration Tank (Zone #1) will be filled with effluent from the pilot-scale primary clarifier. The aeration system will be started and operated to provide complete mixing with a dissolved oxygen concentration of approximately 2 mg/L. The system will be operated for at least 24 hours to confirm that all components are operational.

Mixed liquor will be obtained from the Hampton WWTF. 80% of the reactor volume will be replaced with mixed liquor. Initial operation will be in a batch mode, with the following steps occurring 2 times per day:

- Shut off aeration system, allow mixed liquor to settle in reactor tank.
- Pump out top 12" (162 gallons) of supernatant.
- Add 162 gallons of primary effluent into the tank.
- Restart aeration system.

Photos of the media will be taken each day to provide a visual assessment of biological growth on the media. Collect COD(s) and BOD_5(s) in accordance with sampling schedule once media growth is apparent.

Operation

The process will be operated continuously with no change to the feed flow rate. A portion of the flow (5-12 gpm) will be treated in the DAF Clarifier. Samples will be collected in accordance with the sample schedule until the BOD and TSS are both consistently below 30 mg/l.

Experimental Plan 01 for Primary Clarifier Pilot System

Date: 20 December 2011

Purpose: Determine the effluent water quality from the Pilot-Scale Pilot System.

Conditions:

The following target values were proposed by AECOM.

The pilot	Average Day	Max Month
Flow (mgd)	4.30	5.99
Primary Effluent TSS (mg/L)	**91**	**84**
Primary Effluent BOD_5 (mg/L)	**131**	**122**

Methodology:

Start up

The Pilot Scale Primary Clarifier will be operated at 50 gpm. The scum removal frequency will be adjusted to remove scum as needed. The screening removal will be completed manually as needed. The settled solids will be removed daily.

Operation

The process will be operated continuously with no change to the feed flow rate. Samples will be collected in accordance with the sample schedule. The frequency of all removal processes will be recorded.

Experimental Plan 01 for BioMag Pilot System

Date: 20 December 2011

Purpose: Confirm that BioMag System treats Portsmouth Primary Effluent to 30/30 Standards at Average Daily Flows

---

Conditions:

Parameter	Pilot Scale	Proposed Full Scale
Tank Volume	2,693 ga (13' 4"L x 4'W x 6' 9"H)	903,000 ga (134'L x 30'Wx30'D)
Flow Rate	8.9 gpm	4.3 MGD
Detention Time	5.04 hours	5.04 hours
Magnetite Concentration	3,000 mg/L	3,000 mg/L
MLSS Concentration	3,000 mg/L	3,000 mg/L
Polymer Use	Cationic HMW, HSC	Not defined
Clarifier Hydraulic Loading Rate	953 gpd/sf	1,038 gpd/sf

Methodology:

Start up

The BioMag Aeration Tank (Zone #2) will be filled with effluent from the pilot-scale primary clarifier. The feed hose will be placed into the Magnetite Mix Tank, and the valves will be closed to the other tanks in the Bioreactor. The aeration system will be started and operated to provide spiral roll aeration with a dissolved oxygen concentration of approximately 2 mg/L. All flow will be to Clarifier 1, and the recycle rate will be set to 100%. The system will be operated for at least 24 hours to confirm that all components are operational.

Mixed liquor will be obtained from the Hampton WWTF. At least 25% of the reactor volume (675 gallons) will be replaced with the mixed liquor. Polymer addition will be started at a dose of 1 ppm. Magnetite will be added over a period of 48 hours, with approximately 100 pounds added initially. Additional magnetite may be needed to be added to establish the target magnetite dose, as some magnetite will be deposited in the corners of the tank.

Operation

The process will be operated continuously with no change to the feed flow rate. The recycle rate will be adjusted to maintain solids concentration. No solids wasting is planned until the target MLSS concentration is reached. Samples will be collected in accordance with the sample schedule until the BOD and TSS are both consistently below 30 mg/l.

Experimental Plan 01 for MBBR Pilot System

Date: 20 December 2011

Purpose: Confirm that MBBR System treats Portsmouth Primary Effluent to 30/30 Standards at Average Daily Flows

---

Conditions:

Parameter	Pilot Scale	Proposed Full Scale
Tank Volume	993 gallons	244,180 gallons
Flow Rate	12.1 gpm	4.3 MGD
Detention Time	1.36 hours	1.36 hour
Media Fill	61% (81 cf)	61%
Media Migration Velocity	1.2 m/hr	6.7 m/Hr
Polymer Use	Cationic HMW, HSC	Not defined
DAF Hydraulic Loading Rate	5-15 gpm/sf	5 gpm/sf

Methodology:

Start up
The MBBR Aeration Tank (Zone #1) will be filled with effluent from the pilot-scale primary clarifier. The aeration system will be started and operated to provide complete mixing with a dissolved oxygen concentration of approximately 2 mg/L. The system will be operated for at least 24 hours to confirm that all components are operational.

Mixed liquor will be obtained from the Hampton WWTF. 80% of the reactor volume will be replaced with mixed liquor. Initial operation will be in a batch mode, with the following steps occurring 2 times per day:

- Shut off aeration system, allow mixed liquor to settle in reactor tank.
- Pump out top 12" (162 gallons) of supernatant.
- Add 162 gallons of primary effluent into the tank.
- Restart aeration system.

Photos of the media will be taken each day to provide a visual assessment of biological growth on the media. Collect COD(s) and BOD_5(s) in accordance with sampling schedule once media growth is apparent.

Operation
The process will be operated continuously with no change to the feed flow rate. A portion of the flow (5-12 gpm) will be treated in the DAF Clarifier. Samples will be collected in accordance with the sample schedule until the BOD and TSS are both consistently below 30 mg/l.

	Upstream Processes			BioMag					MBBR			BAF			
Parameter	Raw	CEPT Effluent	Pilot Primary Effluent	Bioreactor Effluent	RAS	Waste Sludge	Clarifier 1	Clarifier 2	MBBR Bioreactor	DAF	DAF Residuals	BAF Stage 1	BAF Stage 2	BAF 1 BW	BAF 2BW
Status	On	OFF	On	On			On	Off	On	On	Manual	On	Off	Manual	Off
Online Instrumentation															
Dissolved Oxygen				C x 2					C x 2			C			
Temperature				C x 2					C x 2			C			
Flowrate															
Influent to Process			C	C					C	C		C	C		
Recycle Rate					1/d										
Effluent from Process						1/d	C	C							
Grab Samples															
BOD_5			3r/ 4d				3r/ 4d			3r/ 4d		3r/ 4d			
BOD_5(s)				3r/ 8d					3r/ 8d						
COD			3r/ 4d				3r/ 4d			3r/ 4d		3r/ 4d			
COD(s)				3r/ 8d					3r/ 8d						
TSS			3r/ 4d		2r/2d		3r/ 4d		3r/ 8d	3r/ 4d	1/7d	3r/ 4d			
Ortho-P															
Ammonia N															
NO_2															
NO_3															
TN															
pH				1/d					1/d			1/d			
Laboratory Samples															
Set 1			3				3			3		3			
Set 2			2				2			2		2			
QAQC			5%				5%			5%		5%			
Observations															
Photo of reactor surface			1/d	1/d			1/d		1/d	1/d					
SVI				1/4d											
Media Mass									1/7d						
Flowrate					1/d										
Volume						1/d					1/7d			1/d	

Legend:

r = replicate samples

d = day

c = continious

3r/4d represents 3 replicate samples collected every four days (Day 1 and Day 4, with no samples collected on Day 2, 3)

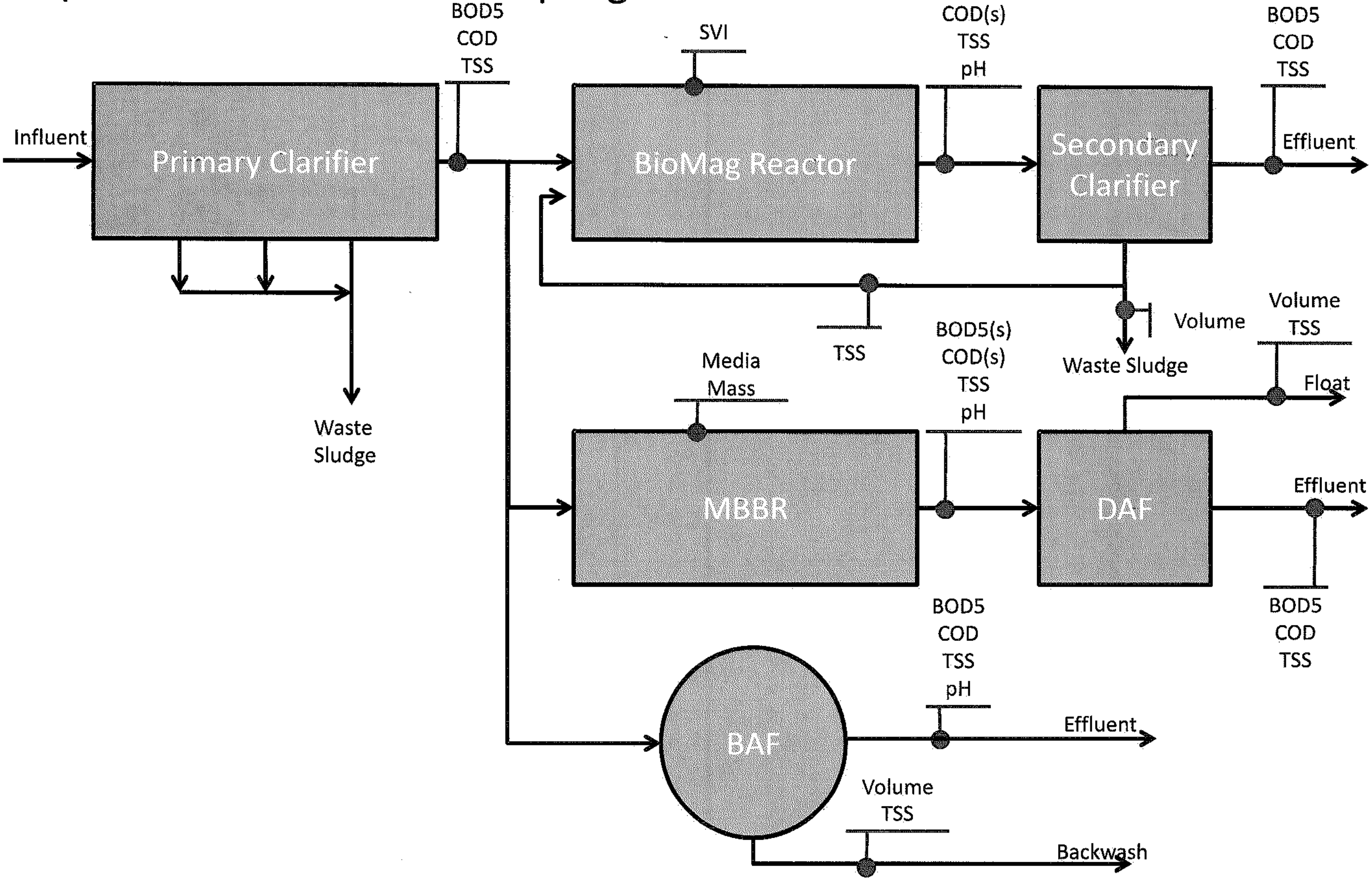
Set 1 = BOD, TSS. Collect from 24-hour composite samples when field results show process is stable and meeting goals to show regulatory compliance.

Set 2 = BOD, COD, TSS, FOG, TN, NH_3-N, NO_3, NO_2 during stable periods from grab samples

QAQC = split samples with field analyses may include BOD_5, BOD_5(s), TSS

Portsmouth WWMP Pilot – Phase 2 Initial Pilot

Experimental Plan 01 – Sampling Plan



AECOM

AECOM
701 Edgewater Drive
Wakefield, MA 01880
www.aecom.com

781.246.5200 tel
781.245.6293 fax

Memorandum

To	Peter Rice, City Engineer	Page	1 of 2
CC	David Allen, Deputy Director, Paula Anania, Chief Operator		
Subject	Monthly Pilot Activities Summary Mid November 2011 through Mid December 2011 WWMP Piloting – Phase 2 Initial Piloting Peirce Island WWTF, Portsmouth, New Hampshire		
From	Jon Pearson and Terry Desmarais		
Date	December 16, 2011		

This memorandum summarizes piloting activities for the referenced period. The summary is intended to provide an overall indication of pilot activities. Additional specifics can be provided as requested. Where the name "AECOM" is used it is meant to include AECOM and/or its subcontractors.

Pilot Status:

Pilot unit on-site construction is ongoing. The inside of the pilot primary clarifier (PC), MBBR reactor tank, BioMag reactor tank, and BioMag clarifiers have been lined and welded watertight and reactor piping is installed. The prefabricated BAF reactors are on-site and parts are arriving that are needed for the system operation. The shell of the pilot scale BioMag clarifier tanks are being built out of wood and steel. The prefabricated DAF was delivered and set on-site.

Ongoing Activities:

- Construction of pilot infrastructure including decking and an enclosure from the decking to the ground to conserve heat.
- Construction of the pilot units including instrumentation and controls, installation of mechanical equipment and ancillary components.
- Protection of equipment and pipe from freezing including heat tracing where necessary.
- Installation of power to pilot equipment.
- Discussions with Kruger to expedite the delivery of BAF components needed for system operation.
- Review and discussion of Experimental Plan 01 – Treating Primary Effluent to 30/30 Standards at Average Day Flow for the PC, MBBR pilot system, and BioMag pilot system.

Completed Activities this Period:

- Clean water testing of PC, MBBR reactor, BioMag reactor, and BioMag clarifiers.
- Startup and continuous operation of PC.
- Received virgin MBBR media and filled MBBR reactors with media.
- BioMag reactor magnetite make-up and RAS return feed systems.

- Startup of MBBR reactor in batch mode.
- Startup of BioMag reactor in flow through mode.
- BAF PLC shed was delivered to the site.

Scheduled Activities Next Period:

- Completion and distribution of Experimental Plan 01.
- Collection of continuous and field data for operational pilot units.
- Flow through operation of MBBR and startup of DAF.
- Optimize operation of BioMag reactor and clarifiers. Once optimized, perform data collection and analysis to confirm BioMag meets requirements of Experimental Plan No. 1.
- Startup of BAF pending delivery of Kruger provided equipment and materials.
- Begin weekly pilot performance review meetings.

Major Challenges and Resolution:

1. **Influent Pumping and Screening.** The raw wastewater feed to the pilot system is pumped from the aerated grit tank. In order to protect the pilot units, the system was designed with a centrifugal solids handling feed pump and a ½" screen at the PC. Upon initial startup of the PC, the screens quickly plugged and the system had to be shut down. It was determined that there was significant solids in the influent wastewater because the bar screens at the Mechanic Street Pump Station were down for maintenance and because the flow from Newcastle, which discharges at the distribution box of the grit chamber, is not screened. In order to minimize disruption due to solids, the PC screens were removed and the centrifugal solids handling feed pump was replaced with a chopper type pump. Screens will later be added downstream of the PC at the inlet to the biological reactors.

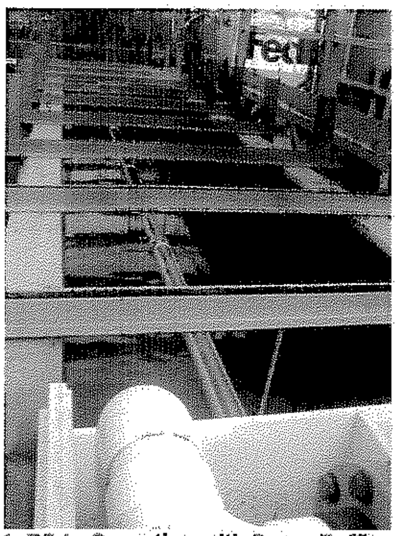
2. **BioMag Sizing.** The BioMag process by CWT is a relatively young technology. As a result, there have been a number of modifications to the pilot design during the construction and startup phases. A discussion on the clarifier design modification was provided in the previous monthly summary. Following a visit to the site, CWT indicated they wanted to resize the post aerobic zone and make the zone adjustable for different TN treatment levels. This required additional planning and consideration during active construction of the reactor.

3. **VFD Availability.** A critical component of the MBBR and BioMag reactors is the aeration system required to support mixing and biological activity. AECOM installed a blower able to provide enough air capacity for the pilot units. However, since the rated capacity of the blower was more than the air required, a VFD was needed for the blower starter and to control output. An appropriately sized VFD was not available locally and could not be easily obtained. In the short term, a VFD was obtained from the electrical subcontractor's stock and was wired up for use. A new VFD was ordered and will be shipped to the site.

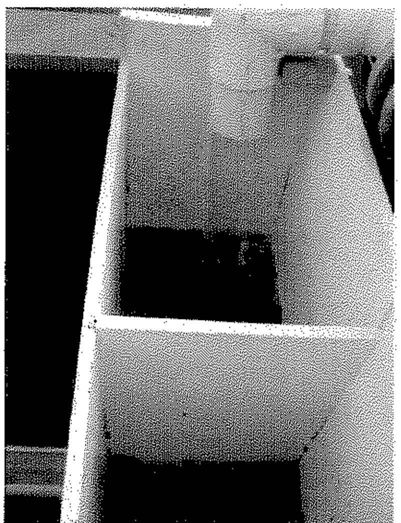
Attachments:

1. Construction Photos

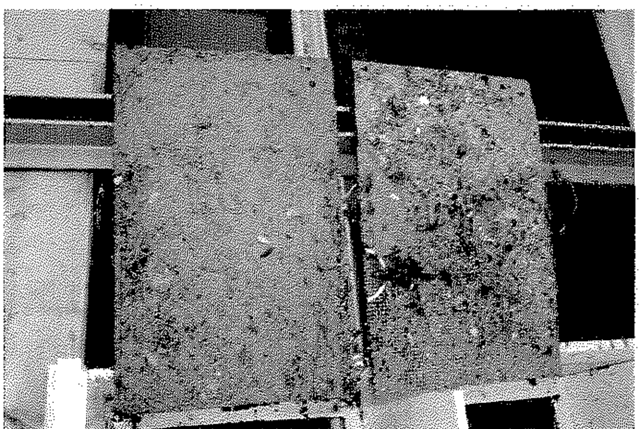
Pilot Photos Mid November 2011 through Mid December 2011:



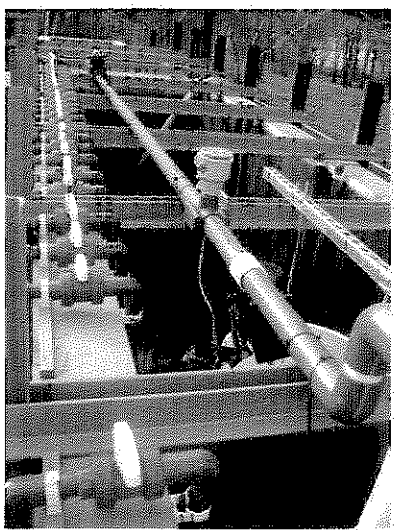
1. PC in Operation with Scum Baffle



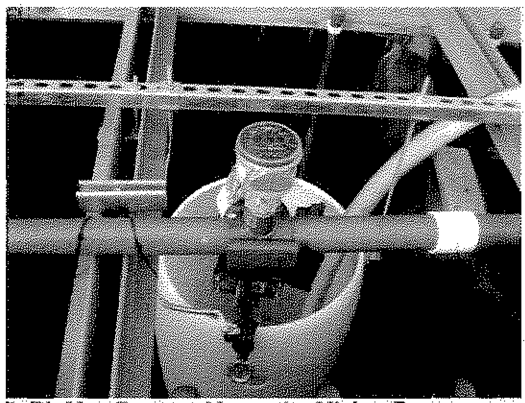
2. PC Influent Screens



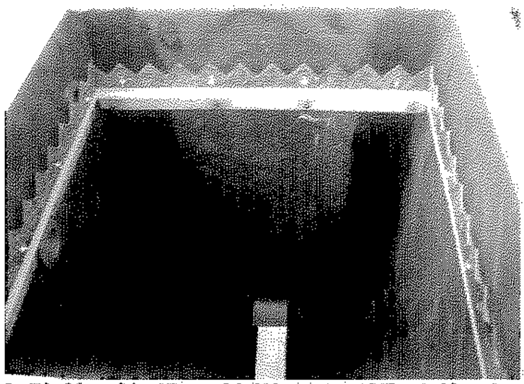
3. Blinded PC Screens



4. BioMag Reactor with Aeration Headers



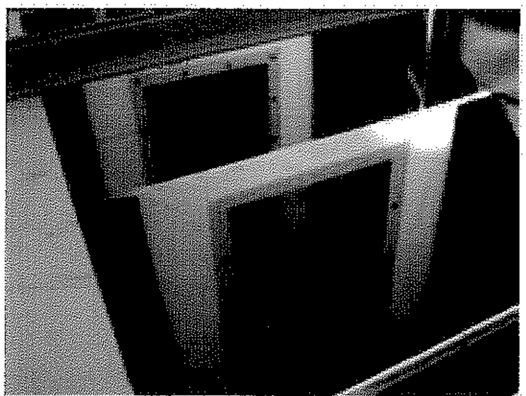
5. BioMag Reactor Magnetite Mixing Drum



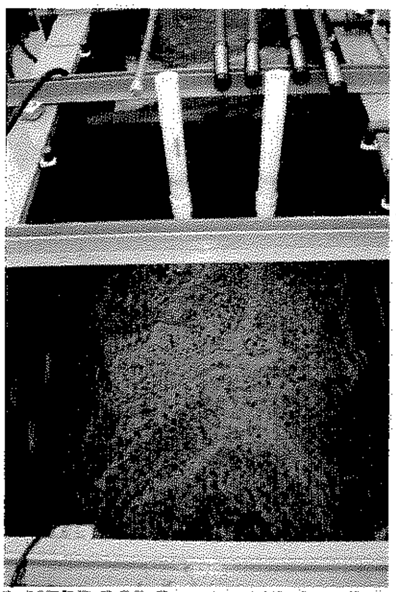
6. BioMag Clarifier with Waterproof Tank Membrane and Peripheral Weir

Pilot Photos Mid November 2011 through Mid December 2011:

7. MBBR BOD Reactor with Horizontally Slotted Vertical Media Retention Pipes



8. MBBR Nitrification Reactor Zone Separation Walls



9. MBBR BOD Reactor with Aeration

10. MBBR BOD Reactor without Aeration

AECOM

AECOM
701 Edgewater Drive
Wakefield, MA 01880
www.aecom.com

781.246.5200 tel
781.245.6293 fax

Memorandum

To	Peter Rice, City Engineer	Page	1 of 3
CC	David Allen, Deputy Director, Paula Anania, Chief Operator		
Subject	Monthly Pilot Activities Summary Mid October 2011 through Mid November 2011 WWMP Piloting – Phase 2 Initial Piloting Peirce Island WWTF, Portsmouth, New Hampshire		
From	Jon Pearson and Terry Desmarais		
Date	November 18, 2011		

This memorandum summarizes piloting activities for the referenced period. The summary is intended to provide an overall indication of pilot activities. Additional specifics can be provided as requested. Where the name "AECOM" is used it is meant to include AECOM and/or its subcontractors.

Pilot Status

The pilot units are being constructed on-site. All site work needed to prepare the site has been completed. The shell of the pilot scale primary clarifier (PC), MBBR reactor tank, BioMag reactor tank, and BioMag clarifier tanks are fabricated onsite from wood and steel. The reactor watertight membrane liners have been loosely fitted to the tanks. The prefabricated BAF reactors were delivered and set on-site. The location for the prefabricated DAF has been prepared and is ready for DAF delivery. The laboratory trailer has been delivered to the site.

Ongoing Activities

- Construction of the pilot units including watertight internal tank liner, site piping, tank piping, tank internal components (e.g. weirs, baffles, etc.) and ancillary components.
- Selection of MBBR media (See Major Challenges and Resolutions).

Completed Activities this Period

- Installation of influent pumps at the existing aerated grit tank and primary clarifier effluent sump.
- Preparation and submittal of Draft Pilot Study Protocol dated November 11, 2011.
- Final agreement with Kruger for BAF contract and BAF delivery.
- Final agreement with World Water Works (WWW) for DAF contract.
- Final agreement with WWW for delivery of MBBR media.

Scheduled Activities Next Period

- Field welding of watertight internal tank linings.

- Installation of internal tank components.
- Clean water testing of tanks for leakage.
- Mechanical work for pilot unit equipment.
- Installation of electrical power.
- Startup of PC.

Major Challenges and Resolution

1. **BioMag Pilot Clarifier Design.** The BioMag vendor proposed rectangular clarifiers for full scale design. The pilot clarifier was proposed as a single rectangular clarifier that could be split into two units to vary the solids loading rate and surface overflow rate. During development of the pilot design, the vendor indicated that a circular clarifier with operational sludge rake arms would be preferred and the pilot team looked for alternative clarifiers. After determining that there were no rentable circular clarifiers that met these criteria, the pilot team looked at modifying the rectangular clarifiers design to a configuration that was agreeable between AECOM and the vendor. It was decided that two square clarifiers with very steep side slopes, peripheral baffles and weirs and center feed wells would be used. The clarifiers were sized to minimize hydraulic currents and wall effects that might impact performance. The design has steep side slopes as requested by the vendor to collect the settled sludge and magnetite mixture. Providing the pilot BioMag process with two clarifiers allows the pilot team to test different solids loading rates and surface overflow rates.

2. **DAF Pilot Unit Size and Availability.** The DAF vendor indicated that they had a pilot scale DAF unit available during the conceptual evaluation phase of this work. The pilot team then finalized loading rates for the proposed full scale DAF unit. Once the decision was made to move ahead with the pilot project, AECOM looked closer into scaled down reactor flow rates. It was determined at that time the available DAF unit did not would not mimic the proposed full scale design loading rates at the pilot scale reactor flow rates. The DAF vendor could, however, build a new DAF unit for this pilot system. The DAF unit would not be available until the middle of January 2012. The timeframe was unacceptable, so the piloting team looked for alternatives. There were very few alternatives available and the earliest timeframe that a previously constructed pilot unit could be received was mid December. The pilot team negotiated with the original DAF vendor to meet the same time schedule. The benefit of using the original DAF vendor was that the vendor has paired MBBR and DAF system currently in operation.

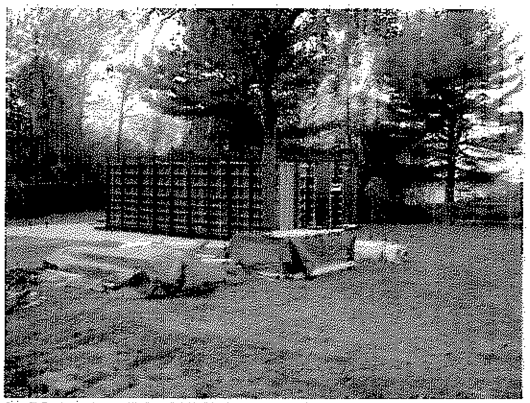
3. **BAF Pilot Unit.** AECOM worked with a BAF vendor who had existing decommissioned BAF pilot scale reactors. It was agreed the BAF reactors would be re-commissioned and refurbished for this project. An agreement and terms were reached for delivery of the refurbished BAF reactors to the site the first week in November. Following a last minute repair needed before shipment, the BAF reactors were received the third week in November. It was discovered at that time, however, that the materials and equipment needed to complete the BAF setup for actual operation were due to arrive in sporadic shipments sometime before the end of January. This time frame was unacceptable and through close coordination with the BAF vendor and AECOM, the delivery of most of the equipment was expedited and/or procured locally. However, this situation will still affect the schedule for the planned startup of the BAF unit.

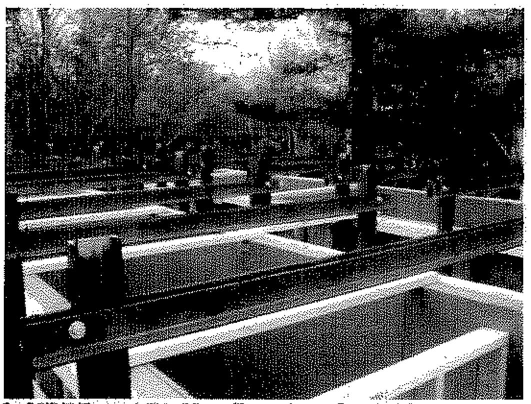
4. **MBBR Media and Biomass Development**. One of the challenges of startup pilot testing for fixed film technologies is the time needed for growth of the biomass on the fixed film. All vendors offered to provide virgin media (e.g. brand new). To speed the process, AECOM investigated obtaining "primed" media, or media taken from an existing operating treatment facility. This would expedite the growth of the biomass, in particular the nitrifying organisms which have the slowest growth rate. One vendor offered to obtain primed media for half the required pilot reactor media volume. While it initially appeared that this approach seemed like the best solution, the pilot scale reactor configuration was different than the proposed configuration of the MBBR vendor offering to provide the media. The pilot team did not want to create controversy by mixing and matching reactor configuration and media vendors, so an alternative option to speed biomass development was used. Once the MBBR system is ready for operation, the MBBR bioreactor will be filled with the media and a seed mixed liquor suspended solids from a nearby WWTF. The reactor will be run in batch mode until growth is observed on the media and preliminary laboratory analysis shows COD removal in the bioreactor.

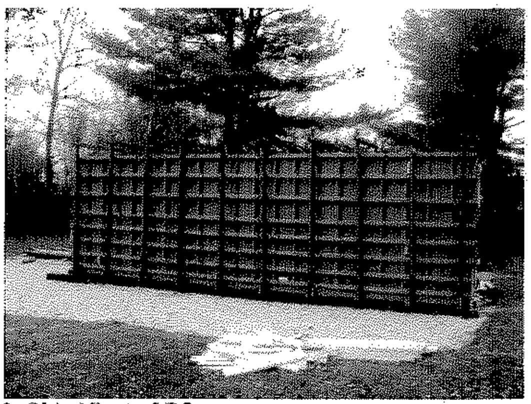
Attachments:

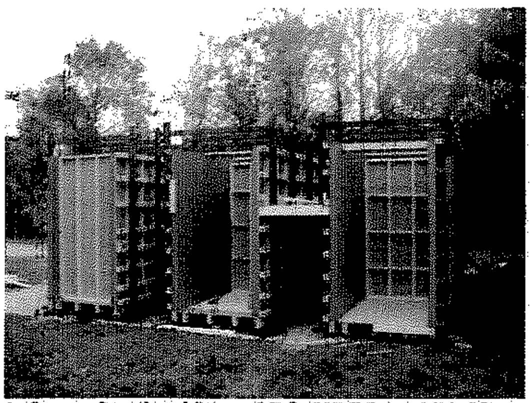
1. Construction Photos
2. Draft Pilot Study Protocol, November 11, 2011

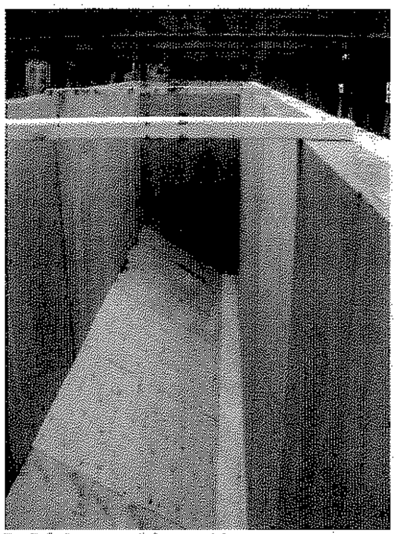
Pilot Photos Mid October 2011 through Mid November 2011:

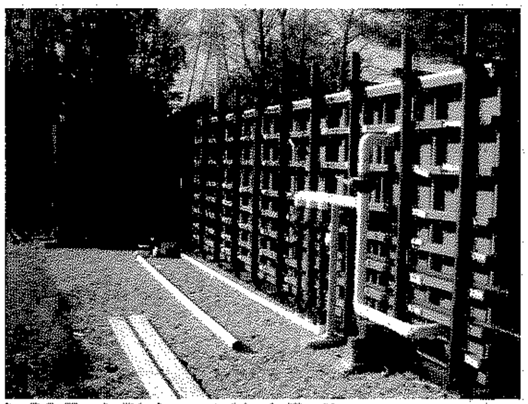

1. Site with PC, MBBR and BioMag Reactors


2. MBBR and BioMag Reactors from Above


3. Side View of PC


4. Cross Section View of PC, MBBR and BioMag

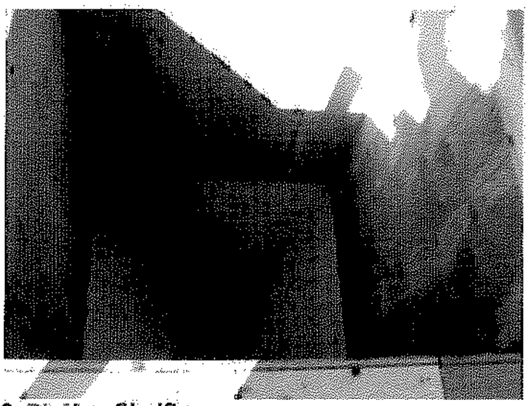

5. PC Internal from Above


6. PC Tank Piping and Lab Trailer


7. Piping Between Reactors

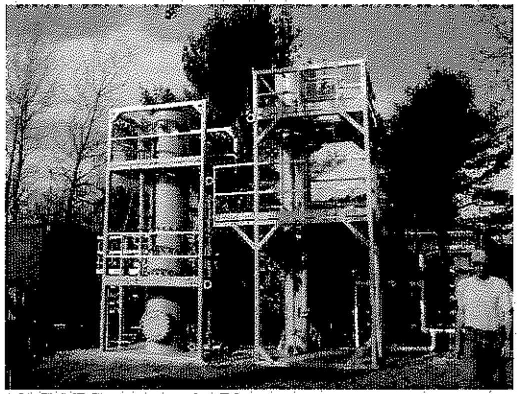
Pilot Photos Mid October 2011 through Mid November 2011:


8. Pilot Influent and Effluent Piping


9. BioMag Clarifier


10. Reactor Decking


11. Carbon/Nitrif BAF Reactor Being Set


12. BAF Reactors in Place

Blueleaf, Inc.

RESEARCH · INVESTIGATE · EXPERIMENT · SOLVE · AUDIT · ANALYZE · EXPLORE · INSPECT · EVALUATE · CHARACTERIZE · DEMONSTRATE · PILOT

DRAFT
PILOT STUDY PROTOCOL FOR WASTEWATER MASTER PLAN PILOTING EFFORT PHASE 2 – INITIAL PILOT PHASE

PORTSMOUTH NH
PEIRCE ISLAND WASTEWATER TREATMENT FACILITY

NOVEMBER 2011

Submitted by: Blueleaf, Inc.
57 Dresser Hill Road
Charlton MA 01507

For: AECOM
701 Edgewater Drive
Wakefield, MA 01880

Date: November 11, 2011

SUMMARY

This Pilot Testing Protocol details the methods and approach to be used during a wastewater treatment pilot study for BOD, TSS, and Total Nitrogen removal at the Peirce Island Wastewater Treatment Facility in the City of Portsmouth NH. The main objectives of the pilot study are to evaluate and compare the performance of three technologies preselected in Phase 1 of the Piloting Evaluation to be the most likely to provide a cost-effective solution. The three technologies to be tested are BAF, MBBR and DAF, and Conventional Activated Sludge with BioMag with conventional clarification. The pilot study is to determine effective operating conditions for carbonaceous BOD and TSS removal, to evaluate the flexibility that each technology provides the City in handling high flow conditions and potential future limits on the Total Nitrogen (TN) effluent concentrations, and to gather other information specifically requested by the City and Engineer. The data obtained from the pilot study is to be used as a basis for selecting a technology for side-by-side comparison of vendors, and for eventual full scale design.

The primary focus of the Pilot Study Protocol is the treatment levels to be evaluated. The treatment level impacts the biological process configuration and the analytical parameters under evaluation. Pilot operation increases in complexity from the carbonaceous BOD and TSS removal treatment level to total nitrogen removal treatment level. The total nitrogen removal treatment levels increase in complexity as the effluent limit reduces from a TN less than 8 mg/L to a TN less than 3 mg/L. This protocol outlines the operating configuration and methodology for all treatment levels. The approach during the pilot study, however, will be to prioritize the execution of experiments for the carbonaceous BOD and TSS removal treatment level. If the pilot study schedule and budget allow for additional experiments, the team will modify the pilot systems to perform to the total nitrogen removal treatment levels of less than 8 mg/L, initially, and then to as low as 3 mg/L. Piloting for total nitrogen removal treatment levels will only be considered after acceptable results have been obtained for the carbonaceous BOD and TSS removal treatment level. The ability to accommodate total nitrogen treatment level pilot experiments into the pilot program will be highly dependent on the amount of time it takes for the biological reactors to initially develop the biomass and to subsequently

adjust to changing conditions and stabilize to a point where representative data can be obtained. It is not known how quickly the reactors will respond at this time so the full scope of work can only be finalized once the units are operational and a better estimate of the process response time can be made.

This Pilot Study Protocol is intended to serve as the Scope of Work. It was reviewed by AECOM and the City of Portsmouth to ensure that the goals, methods, and approach will produce the information required for each party. Note that the Pilot Study Protocol must be a flexible document that allows changes in response to data collected or observation.

Table of Contents

SUMMARY i
Table of Contents iii
List of Tables iv
Abbreviations and Nomenclature v
1 INTRODUCTION 1
1.1 Background 1
1.2 Applicable Standards 2
1.3 Design Flow Rates 3
1.4 Design Contaminant Loading 4
1.5 Design Temperature 4
1.6 Pilot Study Scope and Objectives 6
2 Treatment Processes and Pilot Equipment Description 9
2.1 MBBR 13
2.2 BioMag 25
2.3 Biological Aerated Filter (BAF) 30
3 Pilot Study Plan and Protocol 33
3.1 Test Schedule 33
3.2 Experimental Design 33
3.3 Analytical Sampling Plan 37
3.4 Field Analytical Methods 38
4 Pilot Implementation 41

List of Tables

Table 1: Peirce Island NPDES Permit #NH0100234 Discharge Limits 2
Table 2: Design Flow Rates 3
Table 3: Influent Contaminant Loading 4
Table 4: MBBR Design Parameters from Vendors – 30/30 Treatment Option 14
Table 5: MBBR Design Parameters from Vendors – Total Nitrogen <8 16
Table 6: MBBR Design Parameters from Vendors – Total Nitrogen <5 17
Table 7: MBBR Design Parameters from Vendors – Total Nitrogen <3 18
Table 8: MBBR Pilot System Dimensions and Flowrates for 30/30 Treatment Option ... 22
Table 9: MBBR Pilot System Dimensions and Flowrates for TN<8 Treatment Option ... 22
Table 10: MBBR Pilot System Dimensions and Flowrates for TN<5 Treatment Option . 23
Table 11: MBBR Pilot System Dimensions and Flowrates for TN<3 Treatment Option . 24
Table 12: BioMag Bioreactor Design Parameters 25
Table 13: BioMag Clarifier Design Parameters 26
Table 14: BioMag Bioreactor Pilot Scale Design Parameters 28
Table 15: Proposed BioMag Pilot Scale Clarifier Design Parameters 29
Table 16: Proposed Full-Scale BAF Design Parameters 31
Table 17: Proposed Pilot-Scale BAF Design Parameters 32
Table 18: Proposed Experimental Conditions 34

Abbreviations and Nomenclature

AECOM	The Consulting Engineering Firm for this project
BAF	Biological Aerated Filter
BW	Backwash
BWLR	Backwash loading rate
CAS	Conventional Activated Sludge
City	City of Portsmouth
cf	cubic foot
DAF	Dissolved Air Flotation
EPA	Environmental Protection Agency
Gal	Gallons
gpm	Gallons per minute
gpm/sf	Gallons per minute per square foot
MBBR	Moving Bed Bioreactor
MG	Million gallons
MGD	Million gallons per day
mg/L	Milligrams per liter (equivalent to ppm)
MLE	Modified Ludzack-Ettinger (MLE) activated sludge process
MOR	Monthly Operating Report
µg/L	Micrograms per liter (equivalent to ppb)
MRL	Minimum Reporting Limit
MCL	Maximum Contaminant Level
n/a	Not available / not applicable
ND	Not Detected (at laboratory MRL)
NHDES	New Hampshire Department of Environmental Services
NSDWR	National Secondary Drinking Water Regulations (secondary standards)
NPDES	National Pollution Discharge Elimination System
ppb	Parts per billion
ppm	Parts per million
sf	Square foot
TN	Total Nitrogen

1 INTRODUCTION

1.1 Background

The City of Portsmouth NH has been issued a Consent Decree by the US Environmental Protection Agency (EPA) to upgrade the existing Peirce Island WWTF to provide secondary treatment. The Pilot Study to be conducted is part of the planning process undertaken by the City in meeting the requirements of the Consent Decree. A Wastewater Master Plan was completed in 2010, with Drafts submitted to the EPA in March and June, and a Final Supplement submitted in November. The final recommendation was to construct upgrades to the Sand Filter Building at Peirce Island WWTF to treat approximately 5 MGD Average Daily Flow, and 7.5 MGD Maximum Monthly Flow to Secondary Treatment Standards.

Additional engineering services were begun by AECOM in the spring of 2011 to evaluate and select small footprint treatment processes for implementation at Peirce Island WWTF. This work took into consideration the ability of the processes to reduce effluent total nitrogen. Total nitrogen performance was considered in part due to a review of the ecological health of Great Bay that suggested nitrogen from point and non-point sources are contributing to seasonal anoxic conditions within the estuary. In addition, other communities around Great Bay have received NPDES permits limiting effluent nitrogen concentration in their treated wastewater effluent. Though nitrogen limits are not currently included in the treatment requirements for the Peirce Island WWTF, based on discussions with the EPA, the City believes that a nitrogen limit may be implemented in the future, and wants to be prepared to include reasonable provisions in any capital improvements to include nitrogen removal. Total nitrogen limits may be set not to exceed 8, 5, or 3 mg/L, and there is little evidence to guide the City on the eventual limit that may be imposed. Since the timeframe for a potential total nitrogen permit limit and the treatment level is unknown, total nitrogen removal is not the primary focus of this pilot. Achieving results for secondary treatment is the first priority and operation of pilot units to achieve total nitrogen removal will be completed as the schedule and budget allow.

As part of Phase 1 of the piloting project, AECOM completed a *Technology Evaluation Final Technical Memorandum* in September 2011, in which three processes were selected for an initial 6-month pilot scale evaluation. The three processes are: Biologically Activated Filtration (BAF), Moving Bed Bioreactor (MBBR), and a proprietary Ballasted Activated Sludge process marketed as BioMag. The intention of the initial phase of piloting in Phase 2 is to develop data to choose one of the three processes. The initial pilot testing is the subject of this *Pilot Testing Protocol*. Additional pilot testing may be undertaken in a second piloting phase to compare competing Vendors of the technology, to allow the selection of a Vendor for the upgrade of the Peirce Island WWTF, and to provide operational experience for the Portsmouth wastewater treatment plant operators, but the additional testing is not described in this document.

1.2 Applicable Standards

The current NPDES permit Discharge Limits are included in Table 1.

Table 1: Peirce Island NPDES Permit #NH0100234 Discharge Limits

Effluent Characteristics	Discharge Limitations		
	Average Monthly	Average Weekly	Maximum Daily
Flow, MGD	Report	-	Report
BOD_5, Effluent, mg/l (lbs/day)	30 (1201)	45 (1801)	
BOD_5, Influent, mg/l	Report	-	
TSS, Effluent, mg/l (lbs/day)	30 (1201)	45 (1801)	
TSS, Influent, mg/l	Report	-	
pH Range, Standard units	6.0 - 8.0		
Total Residual Chlorine, mg/l	0.33	-	
Fecal Coliform, %	-	-	Report
Fecal Coliform, MPN/100 ml	14	-	
Enterococci Bacteria, Colonies/100 ml	Report	-	Report
Whole Effluent Toxicity, LC50, % Effluent	-	-	Report
Ammonia Nitrogen as Nitrogen, mg/l	-	-	Report
Total Recoverable Aluminum, mg/l	-	-	Report
Total Recoverable Cadmium, mg/l	-	-	Report
Total Recoverable Chromium, mg/l	-	-	Report

At a meeting on June 4, 2010, the EPA and NHDES stated that the City should consider meeting a TN limit as low as 3 mg/l in upcoming permits. The EPA and NHDES also advised that a limit on phosphorus was unlikely to be added.

For the remainder of this protocol, the limits in the current NPDES permit will be referenced as the "30/30" limits, or "BOD Only". Future potential permits which may include a limit on the concentration of Total Nitrogen in the effluent are referenced as "TN<8", "TN<5", and "TN<3". The specific requirements of a future TN effluent permit limit for the Peirce Island WWTF are not known. The TN limit may be seasonal, with stricter concentration or mass limits imposed during the summer months, and the requirements only to report the TN concentration or mass in the cold weather seasons. It is also unclear if the permit conditions will require a monthly average TN concentration.

1.3 Design Flow Rates

AECOM reviewed three years of historical data, and provided a technical memorandum to the City of Portsmouth detailing the Dry Weather Flows that should form the basis of design for the proposed treatment systems at Peirce Island. The proposed secondary dry weather design flow rates are shown in Table 2.

Table 2: Design Flow Rates

Criteria	Flow (MGD)
Average Day Dry Weather Flow	4.30
Maximum Month	5.99
Maximum Day	7.62

The proposed flow rates have been submitted to the regulatory agencies, and they have indicated that they are lower than expected. The City is continuing to discuss the flows with the regulatory agencies, and they will likely be revised. Changes to the design flow rates will not impact the results of the pilot study since the pilot study will evaluate hydraulic loading rates and hydraulic detention times for each process, and the data can be used to size the processes at whatever flow rates are eventually adopted.

It is likely that the Peirce Island WWTF will discontinue the use of Chemically-Enhanced Primary Treatment (CEPT) during dry weather flows, and only utilize CEPT during storm events. Therefore the technologies will be tested with non-CEPT primary effluent to determine the maximum flow rates that provide satisfactory treatment for 30/30, TN<8, and TN<5/3 conditions. Treatment of CEPT effluent will then be confirmed at the maximum flow rate selected. This experimental approach is detailed in Section 3.

1.4 Design Contaminant Loading

AECOM reviewed three years of MOR data to calculate raw, CEPT and Primary Effluent (PE) loadings, and reported the results in the *Flow and Load Memo* on June 3, 2011. The results are summarized in Table 3.

Table 3: Influent Contaminant Loading

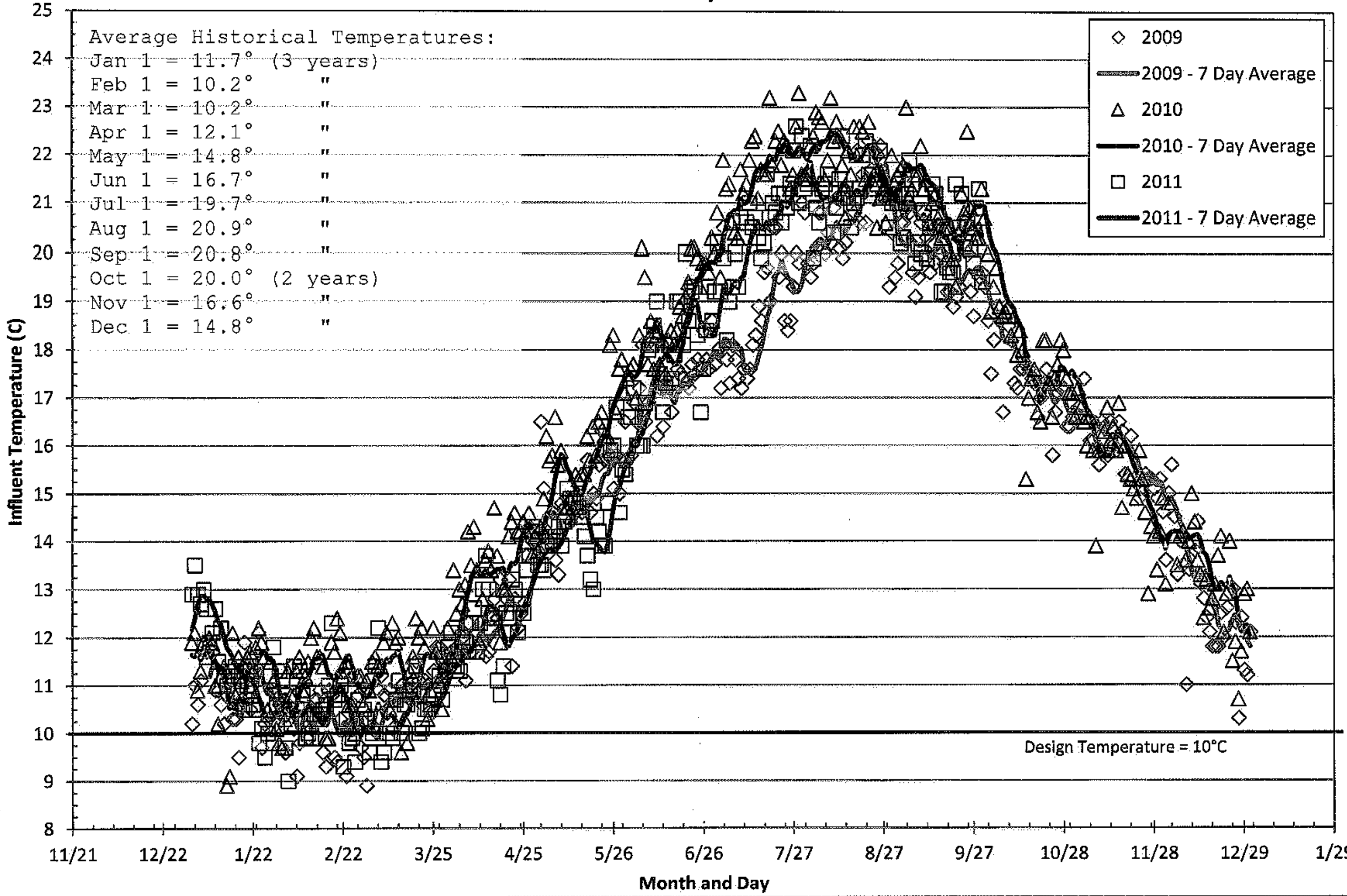
Parameter	Average Day	Max Month
Flow (mgd)	4.30	5.99
Influent TSS (mg/L) [lb/day]	181 [6,491]	169 [8,438]
Influent BOD_5 (mg/L) [lb/day]	187 [6,706]	175 [8,718]
Primary Effluent TSS (mg/L) [lb/day]	91 [3246]	84 [4219]
Primary Effluent BOD_5 (mg/L)	131 [4694]	122 [6103]
CEPT Effluent TSS (mg/L) [lb/day]	52[1865]	72 [3600]
CEPT Effluent BOD_5 (mg/L) [lb/day]	107 [3837]	98[4900]

1.5 Design Temperature

AECOM has determined that the design temperature for the facility is to be 10°C.

Historical influent wastewater temperature data was collected for the period January 2009 through September 2011 and plotted on Figure 1.

Figure 1: Seasonal Variation in Influent Wastewater Temperature at Peirce Island WWTF, Portsmouth NH



1.6 Pilot Study Scope and Objectives

There are several objectives the team would like to address during evaluation of the treatment technologies. A comprehensive list of objectives has been provided below and many will be directly addressed through the experiments detailed in Section 3. All the objectives cannot be addressed, however, because the pilot program is limited in duration and budget. Similar to the approach to treatment level evaluation, the team will modify the experiments based on the available schedule and budget during execution of the program to address as many of the stated objectives as feasible.

1. Evaluate the ability of each technology to operate at the design flow rates and meet the effluent treatment goals for the 30/30. If adequate time and budget remain, evaluate each technology at TN<8 and TN<3 performance limits. Again, if time and budget allow, evaluate each technology at TN< 5 performance limits. If TN<5 performance limits cannot be tested, it will be inferred that the technology can perform at a TN<5 treatment level if the technology can perform at a more stringent TN<3 treatment level.

2. Evaluate the hydraulic and solids loading limitations for each technology to determine appropriate sizing and design considerations for increasing the capacity at the Peirce Island WWTF.

3. Evaluate the ability of each technology to perform during hydraulically-stressed periods, including:
   a. Short term hydraulic peaks associated with rain events.
   b. Sustained (5-7 days) hydraulic peaks with low-temperature influent water associated with spring runoff events.

4. Provide data for evaluation and selection of the technology. It is anticipated that the criteria used in the Phase 1 will be refined and used to select the best technology at the conclusion of the initial Phase 2 pilot study. The pilot study is expected to provide significant data and observations to revise the "operability" category, and may provide data to revise other categories if they relate to sizing or costs. The criteria are as follows:

(a) Operational Track Record/Established Process – The pilot study is not expected to modify the ranking or individual technology score for this criterion.

(b) Operability (No. of Processes/Complexity of Processes) – The pilot study is expected to provide significant revision to this criterion, and should provide data on the following points:

- Impacts due to rapid increase in flow
- Impacts due to increases in solids loading rate (for processes where SLR is critical design criteria)
- How sensitive the technology is to process upsets (e.g. loss of aeration or chemical) and how quickly it recovers
- Odors (evaluate by observation)
- Filamentous growth (evaluate by observation)
- Foaming (evaluate by observation)
- Ease of operation
- BioMag related component wear
- Chemical consumption (quantitative evaluation)
- Carbon dosage (quantitative evaluation)

(c) Ability to retrofit selected conventional technology to meet future nitrogen limits of 8 mg/l – If the TN<8 treatment level if tested, the pilot study will change the ranking or individual technology score for this criterion if loading rates or footprints are modified as a result of the pilot study results.

(d) Ability to Retrofit TN 8 to Meet Future Nitrogen Limits of 5/3 mg/l - If the TN<3 or TN<5 treatment level if tested, the pilot study will change the ranking or individual technology score for this criterion if loading rates or footprints are modified as a result of the pilot study results.

(e) Constructability – The pilot study is not expected to modify the ranking or individual technology score for this criterion

(f) Site Layout Hydraulic Complexity – The pilot study is not expected to modify the ranking or individual technology score for this criteria

(g) Ability to Stay Within Fence Line for Secondary Treatment - The pilot study will change the ranking or individual technology score for this criterion if loading rates or footprints are modified as a result of the pilot study results.

(h) Ability to Stay Within Fence Line for Future TN Treatment - If the TN treatment levels are tested, the pilot study will change the ranking or individual technology score for this criterion if loading rates or footprints are modified as a result of the pilot study results.

(i) Ability to Treat High FOG Levels - No change – treat fog upstream of technology.

2 Treatment Processes and Pilot Equipment Description

This Section describes the three processes selected during the Phase 1 Piloting Engineering Evaluation, as well as the ancillary equipment necessary to operate the pilot system. Sections 2.1 through 2.3 provide data from each of the Vendors which responded to the AECOM *Request for Preliminary Sizing and Cost Estimate* dated June 7, 2010.

Process configurations, tank sizing (full scale and pilot) and equipment described herein are inclusive of the 30/30 and TN treatment levels. Pilot units will be constructed so that the different treatment configurations can be achieved with minimal manipulation. However, TN treatment level pilot configurations and equipment discussed are only applicable if TN treatment levels are piloted as part of the work. This will be determined during the course of the piloting work.

The pilot system includes the following equipment:

1. A submersible pump and appurtenant piping to deliver CEPT effluent water from the existing CEPT clarifier to the pilot system. The pump is designed for 86 gpm at 44 TDH, and will have a flow meter and flow control valve.
2. A submersible pump and appurtenant piping to deliver screened raw wastewater to the pilot-scale primary clarifier. The pump is designed for 72 gpm at 44 TDH, and will have a flow meter and flow control valve.
3. A basket strainer with a 3/8" opening size will be installed in the line between the Grit chamber and the pilot-scale primary clarifier.
4. A primary clarifier to treat screened raw wastewater for the three biological processes under consideration. The primary clarifier will be 4' wide, 22' long to provide a surface area of 88 sf, and will operate at 0.34 gpm/sf. The full scale primary clarifiers are 75' in diameter and operate at 0.34 gpm/sf at the projected average daily flow 4.3 gpm/sf. Surface skimming will be achieved by using a valve to shut the effluent flow, increasing the water surface elevation of the tank, and allowing the top 1" of the clarifier to flow into a scum trough. The frequency of the skimming events will be adjustable. Settled solids will be collected in the bottom of the tank, and removed by manually opening a waste valve.
5. MBBR Pilot System (described in Section 2.1)
6. BioMag Pilot System (described in Section 2.2)

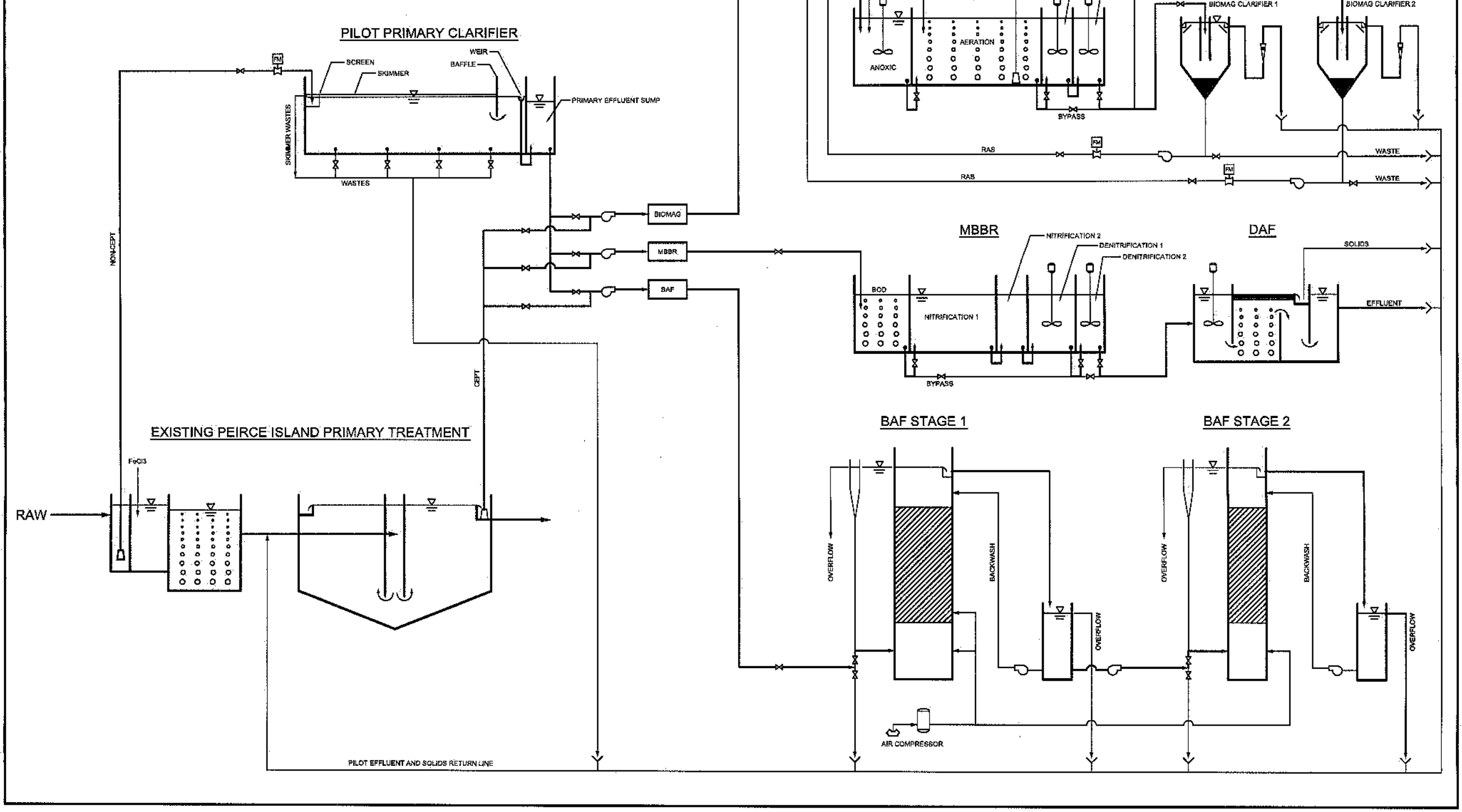
Note that the Bioreactors for the two processes (#5, #6) will be constructed of a wood framed tank, 4' wide x 26' long x 8' high, with steel bracing and a vinyl liner. The sizing and flow rates are described in Sections 2.1 and 2.2, below.

7. BAF Pilot System (described in Section 2.3)
8. Chemical Feed Systems. Each treatment system is expected to require the following chemical feed systems:
    - Alkalinity Feed system – Potassium hydroxide (KOH) will be stored in contained 30-gallon carboys and feed to the beginning of each process (MBBR, BioMag, and BAF) if required to increase alkalinity. KOH has been selected because it is less likely than sodium hydroxide to crystallize in cold weather, and it is simpler to handle than soda ash. Prominent Gamma 4 electrically actuated chemical dosing pumps will be used, and the feed rate will be adjusted manually using speed and stroke control.
    - Supplementary Carbon Source system – MicroC glycerin will be stored in contained 30-gallon carboys and feed to the beginning of each denitrification process (MBBR, BioMag, and BAF) if required to increase available carbon. MicroC has been selected because it is much safer to handle in the piloting environment than methanol. Prominent Gamma 4 electrically actuated chemical dosing pumps will be used and the feed rate will be adjusted manually using speed and stroke control.
    - Supplemental Ammonia Feed system – A supplemental ammonia feed system may be required in order to increase TN into the feed wastewater. If it is required, Prominent Gamma 4 electrically actuated chemical dosing pumps will be used, and the feed rate will be adjusted manually using speed and stroke control.
9. Aeration Blower will be a Speedair positive displacement blower capable of 500 SCFM at 5 psi. Note that the total air use estimated by the vendors was 14,530 SCFM for the 4.3 MGD flow rate. Using the ratio of pilot flows to full-scale flow rates (50gpm/4.3 MGD = 1:60), the air flow would need to be 242 SCFM. Since the reactor tanks are much shallower than the full-scale tanks, it is anticipated that the oxygen transfer rates in the pilot scale system will be inefficient, and the pilot scale blower is designed to provide twice the air flow.
10. PLC type control panel for collecting online data from flow and dissolved oxygen and temperature probes.
11. Onsite laboratory to perform field samples described in Section 3.

12. Various piping, valves, hoses, as required.

A process flow diagram is shown in Figure 2. The three main process components are described below.

FIGURE 2: CONCEPTUAL FLOW SCHEMATIC
CITY OF PORTSMOUTH
WASTEWATER MANAGEMENT PLAN - PILOTING EFFORT
AECOM / BLUELEAF
NOVEMBER 7, 2011



2.1 MBBR

Moving bed biological reactors incorporate suspended media with a high specific surface area in the aeration basin. This increased surface area allows organisms fixed sites for attachment and thus results in reducing the footprint of tanks or increasing the capacity of existing tanks. The biomass that treats the wastewater is attached to the media and is retained in the reactor with no return sludge. The media is continuously agitated by the medium bubble aeration systems used to support biomass growth and treatment. The suspended media is retained in the aerations tanks by retention screen at the outlets of the tanks. A separation or clarification step is required following the MBBR to remove solids that pass through the system and for removal of biomass that comes off the media. The level of treatment provided in an MBBR can be modified by the percentage of media in the reactor, which typically does not exceed 60 percent. The media does not require cleaning or backwashing.

2.1.1 Proposed Full Scale MBBR Designs

Three vendors supplied proposed designs for the MBBR process. Each Vendor included a different solids separation process to treat the MBBR Effluent. The designs for the various treatment conditions are summarized in Tables 4 through 7. Detention times are included in the tables in order to compare the full-scale tank volumes with the pilot-scale volumes.

Table 4: MBBR Design Parameters from Vendors – 30/30 Treatment Option

Parameter	World Water Works	Infilco Degremont METEOR®	Kruger AnoxKaldness ™
Tank Qty and Size	4 @ 30'Lx16'Wx17'D	Not detailed	2 @ 33'Lx27'Wx21.5'D
Tank Volume (ga)	244,180	396,300	233,271
Media Fill (cf)	19,915	34,432	31,185
Media Fill (%)	61%	65%	50%
Total Media Effective Surface Area (sf)	3,946,050	4,722,666	3,771,674
Detention Time (hours) @ 4.30 MGD	1.36	2.21	1.3
Detention Time (hours) @ 5.99 MGD	0.98	1.59	0.93
Detention Time (hours) @ 7.62 MGD	0.77	1.25	0.73

Note that the total tank volumes required to meet the 30/30 treatment requirements vary from 244,180 gallons to 396,300 gallons.

Designs for the Treatment Options to reduce TN to below 8 are detailed in Table 5. Note that each Vendor proposed to use a different number of tanks, and different tank volumes. The lowest highlighted block in Table 5 summarizes the tank volumes and detention times, and shows that the proposed tank volumes varied from 1,247,143 to 2,725,000 gallons, but had similar total effective surface areas of the media ($20x10^6$ to $24x10^6$ sf).

Designs for the Treatment Options to reduce TN to below 5 are detailed in Table 6. World Water Works added a denitrification reactor to each of the treatment trains, and increased the volume of media. There appears to be a slight calculation error with either the dimensions or the volume provided for the World Water Works Post Nitrification Reactor #2, as the total volume for the two post denitrification tanks should be 64,800 cf, but is listed in the proposal as 60,750 cf. Kruger reduced the volume of the Post Anoxic Tank, but added media. IDI did not change any tank volumes, but did slightly increase the volume of media in the aerobic zone. The total proposed tank volumes varied from 1,428,931 to 2,725,000 gallons, but had similar total effective surface areas of the media ($20.9x10^6$ to $26.1x10^6$ sf).

Designs for the Treatment Options to reduce TN to below 3 mg/L are detailed in Table 7. Both World Water Works and IDI maintained the tank volumes the same as the TN<5 option, but increased media fill in one or more tanks. Kruger slightly modified the tank volumes and added media volume.

Table 5: MBBR Design Parameters from Vendors – Total Nitrogen <8

Parameter	World Water Works	Infilco Degremont METEOR®	Kruger AnoxKaldness ™
Tank Qty and Size	8 @ 19'Lx16'Wx17'D	Not detailed	4 @ 28'Lx32.5'Wx21.5'D
Tank Purpose	BOD Reactor	Pre Anoxic	Pre Anoxic
Tank Volume (gal)	309,294	500,000	585,463
Media Fill (cf)	26,870	32,651	38,152
Media Fill (%)	62.5%	50.0%	50.0%
Tank Qty and Size	8 @ 30'Lx16'Wx17'D	Not detailed	4 @ 43'Lx32.5'Wx21.5'D
Tank Purpose	Nitrification 1	Aerobic	Aerobic
Tank Volume (gal)	488,360	1,600,000	899,104
Media Fill (cf)	42,427	104,485	58,590
Media Fill (%)	62.0%	50.0%	50.0%
Tank Qty and Size	8 @ 9'Lx16'Wx17'D	Not detailed	2 @ 21'Lx32.5'Wx21.5'D
Tank Purpose	Nitrification 2	Post Anoxic	Deoxygenation
Tank Volume (gal)	146,508	500,000	219,549
Media Fill (cf)	12,728	32,651	14,307
Media Fill (%)	62.0%	50.0%	45.0%
Tank Qty and Size	3 @ 25'Lx30'Wx18'D	Not detailed	2 @ 15.5'Lx20'Wx21.5'D
Tank Purpose	Post Denitrification	Post Anoxic	Post Anoxic
Tank Volume (gal)	302,981	125,000	99,721
Media Fill (cf)	18,997	8,163	6,498
Media Fill (%)	48.0%	25.0%	50.0%
Tank Qty and Size	No 5th Tank Needed	No 5th Tank Needed	2 @ 8'Lx20'Wx21.5'D
Tank Purpose			Reaeration
Tank Volume (gal)			51,469
Media Fill (cf)			3,354
Media Fill (%)			25.0%
Total Tank Volume (gal)	1,247,143	2,725,000	1,855,307
Total Media Fill (cf)	101,022	177,951	120,901
Total Media Fill (%)	60.6%	48.9%	48.7%
Total Media Effective Surface Area (sf)	20,017,106	24,407,705	24,085,326
Detention Time (hours) @ 4.30 MGD	6.96	15.21	10.36
Detention Time (hours) @ 5.99 MGD	5.00	10.92	7.43
Detention Time (hours) @ 7.62 MGD	3.93	8.58	5.84

Table 6: MBBR Design Parameters from Vendors – Total Nitrogen <5

Parameter	World Water Works	Infilco Degremont METEOR®	Kruger AnoxKaldness ™
Tank Qty and Size	8 @ 19'Lx16'Wx17'D	Not detailed	4 @ 28'Lx32.5'Wx21.5'D
Tank Purpose	BOD Reactor	Pre Anoxic	Pre Anoxic
Tank Volume (gal)	309,294	500,000	585,463
Media Fill (cf)	26,870	33,418	39,130
Media Fill (%)	62.5%	50.0%	50.0%
Tank Qty and Size	8 @ 30'Lx16'Wx17'D	Not detailed	4 @ 43'Lx32.5'Wx21.5'D
Tank Purpose	Nitrification 1	Aerobic	Aerobic
Tank Volume (gal)	488,360	1,600,000	899,104
Media Fill (cf)	42,427	119,770	60,093
Media Fill (%)	62.0%	56.0%	50.0%
Tank Qty and Size	8 @ 9'Lx16'Wx17'D	Not detailed	2 @ 21'Lx32.5'Wx21.5'D
Tank Purpose	Nitrification 2	Post Anoxic	Deoxygenation
Tank Volume (gal)	146,508	500,000	219,549
Media Fill (cf)	12,728	33,418	13,206
Media Fill (%)	62.0%	50.0%	45.0%
Tank Qty and Size	3 @ 25'Lx30'Wx18'D	Not detailed	4 @ 14'Lx20'Wx21.5'D
Tank Purpose	Post Denitrification	Post Anoxic	Post Anoxic
Tank Volume (gal)	302,981	125,000	180,142
Media Fill (cf)	19,440	4,177	12,040
Media Fill (%)	48.0%	25.0%	50.0%
Tank Qty and Size	3 @ 15'Lx30'Wx18'D	No 5th Tank Needed	2 @ 8'Lx20'Wx21.5'D
Tank Purpose	Post Denitrification		Reaeration
Tank Volume (gal)	181,788		51,469
Media Fill (cf)	5,832		3,354
Media Fill (%)	24.0%		25.0%
Total Tank Volume (gal)	1,428,931	2,725,000	1,935,727
Total Media Fill (cf)	107,297	190,783	127,823
Total Media Fill (%)	56.2%	52.4%	49.4%
Total Media Effective Surface Area (sf)	20,933,653	26,165,990	24,914,147
Detention Time (hours) @ 4.30 MGD	7.98	15.21	10.80
Detention Time (hours) @ 5.99 MGD	5.73	10.92	7.76
Detention Time (hours) @ 7.62 MGD	4.50	8.58	6.10

Table 7: MBBR Design Parameters from Vendors – Total Nitrogen <3

Parameter	World Water Works	Infilco Degremont METEOR®	Kruger AnoxKaldness ™
Tank Qty and Size	8 @ 19'Lx16'Wx17'D	Not detailed	4 @ 26'Lx32.5'Wx21.5'D
Tank Purpose	BOD Reactor	Pre Anoxic	Pre Anoxic
Tank Volume (gal)	309,294	500,000	543,644
Media Fill (cf)	26,870	33,418	36,335
Media Fill (%)	62.5%	50.0%	50.0%
Tank Qty and Size	8 @ 30'Lx16'Wx17'D	Not detailed	4 @ 43.5'Lx32.5'Wx21.5'D
Tank Purpose	Nitrification 1	Aerobic	Aerobic
Tank Volume (gal)	488,360	1,600,000	909,558
Media Fill (cf)	42,427	139,019	60,791
Media Fill (%)	62.0%	65.0%	50.0%
Tank Qty and Size	8 @ 9'Lx16'Wx17'D	Not detailed	2 @ 20'Lx32.5'Wx21.5'D
Tank Purpose	Nitrification 2	Post Anoxic	Deoxygenation
Tank Volume (gal)	146,508	500,000	209,093
Media Fill (cf)	12,728	33,418	12,578
Media Fill (%)	62.0%	50.0%	45.0%
Tank Qty and Size	3 @ 25'Lx30'Wx18'D	Not detailed	4 @ 20.5'Lx25'Wx21.5'D
Tank Purpose	Post Denitrification	Post Anoxic	Post Anoxic
Tank Volume (gal)	302,981	125,000	329,725
Media Fill (cf)	19,440	4,177	22,038
Media Fill (%)	48.0%	25.0%	50.0%
Tank Qty and Size	3 @ 15'Lx30'Wx18'D	No 5th Tank Needed	2 @ 8'Lx20'Wx21.5'D
Tank Purpose	Post Denitrification		Reaeration
Tank Volume (gal)	181,788		51,469
Media Fill (cf)	11,664		3,354
Media Fill (%)	48.0%		25.0%
Total Tank Volume (gal)	1,428,931	2,725,000	2,043,491
Total Media Fill (cf)	113,129	210,032	135,095
Total Media Fill (%)	59.2%	57.7%	49.5%
Total Media Effective Surface Area (sf)	21,899,176	28,805,839	25,818,315
Detention Time (hours) @ 4.30 MGD	7.98	15.21	11.41
Detention Time (hours) @ 5.99 MGD	5.73	10.92	8.19
Detention Time (hours) @ 7.62 MGD	4.50	8.58	6.44

In addition to the bioreactor portion of each MBBR proposal, AECOM evaluated three possible clarification technologies to remove solids from the MBBR bioreactor: DAF, Actiflo, and CoMag.

AECOM has recommended that DAF be utilized for MBBR clarification. DAF systems use microbubbles to float floc formations to the water surface for wasting. A typical system includes two stages of floc formation and in-line mixing upstream of the dissolved air section. Microbubbles are produced by a pressurized stream of clarified water and air. Clarified water passes under the surface float, which is wasted on a periodic basis. The World Water Works DAF process parameters were used for the technology evaluation. World Water Works proposed that the design parameters for the full scale treatment system include:

Air:Solids: 0.0378
Hydraulic Loading Rate: 1.56 to 2.49 gpm/sf
Solids Loading Rate: 0.10 to 0.16 lbs/hr/sf

WWW's DAF clarifiers are pre manufactured tanks with internal components and an in-line mixing system for polymer addition. The air pumps are provided loose and are typically located adjacent to the units. The proposed system consists of 2 DAFs where each can handle half of the peak flow. The proposed process flow path includes piping directly from the MBBR effluent channel to the DAF influent connection. Each pre-manufactured tank is approximately 20 feet by 12 feet and 15 feet high. The two tanks fit within the existing pump station while leaving adequate space for process pumps and access to the tanks. Effluent from the DAF system will discharge to the existing clearwell, which will be converted to a new wetwell. Effluent will be pumped to the existing effluent channel in the Odor Control Room.

2.1.2 Proposed Pilot Scale MBBR Design

There are several MBBR pilot systems that are housed in trailers, but each operates at approximately 5 gpm when treating to secondary standards, and at less than 1 gpm when treating to meet stringent TN limits. AECOM and the City of Portsmouth has expressed the desire to operate the pilot system at flow rates between 10 and 20 gpm whenever possible to provide more representative operating conditions that more closely represent the full scale systems.

Blueleaf is proposing to construct a bioreactor on site which is 26' long, 4' wide, with a sidewall depth of 8'. The water depth in the tank will be maintained at 6' to provide a 2' freeboard. The length in use, volume of media fill, and pilot flowrate can be modified to mimic the operation of the proposed MBBR systems.

The World Water Works MBBR design parameters have been selected for initial piloting. The operating conditions for the 12 design conditions are listed in Table 8.

The first six columns in Tables 8 through 11 show the design parameters from the World Water Works full-scale proposal. Detention time is calculated based on the empty tank volume (no media fill) and the design flow rate. Media migration velocity is calculated from the cross-sectional area of the tank (height x width) and the design flow rate. The 26 ft-long pilot-scale bioreactor will be partitioned into smaller tanks to meet the requirements for the TN<5,3 conditions. The reactor sizes required for these two treatment conditions were used for the 30/30 and TN<8 conditions to prevent the need to remove media from the bioreactor.

The MBBR pilot system will be fabricated to allow operation of the 5.63' long BOD Reactor during the initial phases of the study. When nitrogen removal is added as a treatment goal, additional tank sections will be filled with media. The flowrate though the pilot system will be 9.8 gpm to mimic average daily flow, 13.6 gpm to mimic max month flow, and 17.3 gpm to mimic max day flow. The pumps and piping will be designed to increase the flow rate through the pilot system to 30 gpm, in the event that higher flow rates need to be evaluated.

The pilot scale media migration velocities are much lower than those proposed for the full-scale process. Since media migration is mainly a concern with the hydraulics of the system, and hydraulics are not being evaluated by this pilot, the differences in media migration velocities should not impact the results of the pilot study. Low media migration velocities may make the operation of the pilot simpler, and avoid screen plugging in the pilot scale bioreactor.

Other differences between the full-scale and pilot scale processes include the side water depth. The relatively short side water depth will reduce the oxygen transfer efficiency of the medium bubble diffusers and will require more air flow to maintain the target dissolved oxygen concentration. The pilot study will not be able to predict full scale air use.

Table 8: MBBR Pilot System Dimensions and Flowrates for 30/30 Treatment Option

Proposed Full-Scale Design						Proposed Pilot-Scale Design						
Q (MGD)	Tank	Volume (gal)	Media Fill (%)	Detention Time (hours)	Media Migration Velocity (M/Hr)	Length (ft)	Volume (gal)	Media Fill (%)	Media Fill (cf)	Detention Time (hours)	Flow Rate (gpm)	Media Migration Velocity (M/Hr)
4.3	BOD Reactor	244,180	61.0	1.36	6.7	5.63	1010.8	61.0	82.4	1.36	12.4	1.3
5.99				0.98	9.3					0.98	17.2	1.8
7.62				0.77	11.9					0.77	21.9	2.2

Table 9: MBBR Pilot System Dimensions and Flowrates for TN<8 Treatment Option

Proposed Full-Scale Design						Proposed Pilot-Scale Design						
Q (MGD)	Tank	Volume (gal)	Media Fill (%)	Detention Time (hours)	Media Migration Velocity (M/Hr)	Length (ft)	Volume (gal)	Media Fill (%)	Media Fill (cf)	Detention Time (hours)	Flow Rate (gpm)	Media Migration Velocity (M/Hr)
4.3	BOD Reactor	309,294	62.5%	1.73	3.4	5.63	1010.8	62.5%	84.5	1.73	9.8	1.0
	Nitrification Reactor 1	488,360	62.0%	2.73	3.4	8.89	1596.1	62.0%	132.3	2.73		1.0
	Nitrification Reactor 2	146,508	62.0%	0.82	3.4	2.67	478.8	62.0%	39.7	0.82		1.0
	Post Denitrification Reactor 1	302,981	48.0%	1.69	4.5	5.51	990.2	48.0%	63.5	1.69		1.0
5.99	BOD Reactor	309,294	62.5%	1.24	4.7	5.63	1010.8	62.5%	84.5	1.24	13.6	1.4
	Nitrification Reactor 1	488,360	62.0%	1.96	4.7	8.89	1596.1	62.0%	132.3	1.96		1.4
	Nitrification Reactor 2	146,508	62.0%	0.59	4.7	2.67	478.8	62.0%	39.7	0.59		1.4
	Post Denitrification Reactor 1	302,981	48.0%	1.21	6.3	5.51	990.2	48.0%	63.5	1.21		1.4
7.62	BOD Reactor	309,294	62.5%	0.97	5.9	5.63	1010.8	62.5%	84.5	0.97	17.3	1.8
	Nitrification Reactor 1	488,360	62.0%	1.54	5.9	8.89	1596.1	62.0%	132.3	1.54		1.8
	Nitrification Reactor 2	146,508	62.0%	0.46	5.9	2.67	478.8	62.0%	39.7	0.46		1.8
	Post Denitrification Reactor 1	302,981	48.0%	0.95	8.0	5.51	990.2	48.0%	63.5	0.95		1.8

Table 10: MBBR Pilot System Dimensions and Flowrates for TN<5 Treatment Option

	Proposed Full-Scale Design					Proposed Pilot-Scale Design						
Q (MGD)	Tank	Volume (gal)	Media Fill (%)	Detention Time (hours)	Media Migration Velocity (M/Hr)	Length (ft)	Volume (gal)	Media Fill (%)	Media Fill (cf)	Detention Time (hours)	Flow Rate (gpm)	Media Migration Velocity (M/Hr)
4.3	BOD Reactor	309,294	62.5%	1.73	3.4	5.63	1010.4	62.5%	84.4	1.73	9.8	1.0
	Nitrification Reactor 1	488,360	62.0%	2.73	3.4	8.89	1595.4	62.0%	132.2	2.73		
	Nitrification Reactor 2	146,508	62.0%	0.82	3.4	2.67	478.6	62.0%	39.7	0.82		
	Post Denitrification Reactor 1	302,981	48.0%	1.69	4.5	5.51	989.8	48.0%	63.5	1.69		
	Post Denitrification Reactor 2	181,788	24.0%	1.01	4.5	3.31	593.9	24.0%	19.1	1.01		
5.99	BOD Reactor	309,294	62.5%	1.24	4.7	5.63	1010.4	62.5%	84.4	1.24	13.6	1.4
	Nitrification Reactor 1	488,360	62.0%	1.96	4.7	8.89	1595.4	62.0%	132.2	1.96		
	Nitrification Reactor 2	146,508	62.0%	0.59	4.7	2.67	478.6	62.0%	39.7	0.59		
	Post Denitrification Reactor 1	302,981	48.0%	1.21	6.3	5.51	989.8	48.0%	63.5	1.21		
	Post Denitrification Reactor 2	181,788	24.0%	0.73	6.3	3.31	593.9	24.0%	19.1	0.73		
7.62	BOD Reactor	309,294	62.5%	0.97	5.9	5.63	1010.4	62.5%	84.4	0.97	17.3	1.8
	Nitrification Reactor 1	488,360	62.0%	1.54	5.9	8.89	1595.4	62.0%	132.2	1.54		
	Nitrification Reactor 2	146,508	62.0%	0.46	5.9	2.67	478.6	62.0%	39.7	0.46		
	Post Denitrification Reactor 1	302,981	48.0%	0.95	8.0	5.51	989.8	48.0%	63.5	0.95		
	Post Denitrification Reactor 2	181,788	24.0%	0.57	8.0	3.31	593.9	24.0%	19.1	0.57		

Table 11: MBBR Pilot System Dimensions and Flowrates for TN<3 Treatment Option

Proposed Full-Scale Design						Proposed Pilot-Scale Design						
Q (MGD)	Tank	Volume (gal)	Media Fill (%)	Detention Time (hours)	Media Migration Velocity (M/Hr)	Length (ft)	Volume (gal)	Media Fill (%)	Media Fill (cf)	Detention Time (hours)	Flow Rate (gpm)	Media Migration Velocity (M/Hr)
4.3	BOD Reactor	309,294	62.5%	1.73	3.4	5.63	1010.4	62.5%	84.4	1.73	9.8	1.0
	Nitrification Reactor 1	488,360	62.0%	2.73	3.4	8.89	1595.4	62.0%	132.2	2.73		
	Nitrification Reactor 2	146,508	62.0%	0.82	3.4	2.67	478.6	62.0%	39.7	0.82		
	Post Denitrification Reactor 1	302,981	48.0%	1.69	4.5	5.51	989.8	48.0%	63.5	1.69		
	Post Denitrification Reactor 2	181,788	48.0%	1.01	4.5	3.31	593.9	48.0%	38.1	1.01		
5.99	BOD Reactor	309,294	62.5%	1.24	4.7	5.63	1010.4	62.5%	84.4	1.24	13.6	1.4
	Nitrification Reactor 1	488,360	62.0%	1.96	4.7	8.89	1595.4	62.0%	132.2	1.96		
	Nitrification Reactor 2	146,508	62.0%	0.59	4.7	2.67	478.6	62.0%	39.7	0.59		
	Post Denitrification Reactor 1	302,981	48.0%	1.21	6.3	5.51	989.8	48.0%	63.5	1.21		
	Post Denitrification Reactor 2	181,788	48.0%	0.73	6.3	3.31	593.9	48.0%	38.1	0.73		
7.62	BOD Reactor	309,294	62.5%	0.97	5.9	5.63	1010.4	62.5%	84.4	0.97	17.3	1.8
	Nitrification Reactor 1	488,360	62.0%	1.54	5.9	8.89	1595.4	62.0%	132.2	1.54		
	Nitrification Reactor 2	146,508	62.0%	0.46	5.9	2.67	478.6	62.0%	39.7	0.46		
	Post Denitrification Reactor 1	302,981	48.0%	0.95	8.0	5.51	989.8	48.0%	63.5	0.95		
	Post Denitrification Reactor 2	181,788	48.0%	0.57	8.0	3.31	593.9	48.0%	38.1	0.57		

2.2 BioMag

BioMag uses an inert iron ore (magnetite) ballast in the aeration tank and clarifiers to increase secondary settling rates, which allows plants to operate with higher mixed liquor suspended solids concentrations in the aeration tanks. The magnetite has a specific gravity of 5.2 and when combined with biological floc increases settling rates. The ballasted floc is settled in the clarifiers and the majority of the magnetite ballasted floc is returned to the aeration tank in the return activated sludge (RAS) flow. Waste sludge is sent through a magnetite recovery process before being processed. Magnetite that is lost in the recovery process is processed with the WAS. Virgin magnetite is added to the recovered magnetite to replace the amount lost in the WAS and the recovered and virgin magnetite are returned to the aeration tank via RAS flow. The recovery process includes a shear mixer to split the ballast form the floc and a magnetic recovery drum to separate the magnetite from the biosolids.

BioMag uses conventional rectangular or circular secondary sedimentation tanks for clarification. The BioMag system is expected to operate at surface overflow rates and solid loading rates that are higher than those used for conventional secondary sedimentation tanks. One of the goals of the pilot study is to quantify the operational parameters of the BioMag clarifiers.

2.2.1 Proposed Full-Scale BioMag Design

Cambridge Water Technology submitted two proposed designs for the full scale BioMag treatment system. The 30/30 tank sizing is from the first proposal, and represents a smaller tank volume. All other bioreactor tank volumes and all clarifier designs are from the CWT Revision 2. Tank dimensions and volumes are shown in Table 12.

Table 12: BioMag Bioreactor Design Parameters

Treatment Scenario	Tank Purpose	Dimensions	Volume (gallons)
30/30	Activated Sludge	1 @ 134'Lx30'Wx30'D	903,000
TN<8	Anoxic Zone	2 @ 81'Lx30'Wx30'D	327,600
	Aeration		764,400
TN<5,3	Anoxic		327,600
	Aeration	2 @ 81'Lx30'Wx30'D	764,400
	Post Anoxic 1	1 @ 52'Lx30'Wx30'D	175,000
	Post Anoxic 2		175,000

For nitrogen removal, a nitrate recycle pump and piping is required to recycle approximately 24 MGD of aeration tank effluent back to the anoxic zone. The need for a 5xQi recycle was discussed during a subsequent conversation with CWT.

There are four chemical feed systems included in the CWT proposal: Alkalinity, coagulant, polymer and magnetite. The location and purpose for each chemical feed was discussed in a subsequent conversation with CWT, the current proposal includes:

1. Full-Scale Alkalinity will be added at the beginning of the bioreactor. The form of the alkalinity is to be chosen by the Engineer.
2. Full-Scale Coagulant is not required.
3. Full-Scale Polymer will be added to the bioreactor effluent, prior to the clarifier.
4. Full Scale Magnetite addition would be completed by recovering magnetite from the WAS, and both recovered magnetite and virgin magnetite is added into the RAS line.

Cambridge Water Technology also proposed that rectangular clarifiers be used downstream of the BioMag bioreactors. The clarifier dimensions and design parameters are shown in Table 13.

Table 13: BioMag Clarifier Design Parameters

Treatment Scenario	Dimensions	Flow Rate (MGD)	Surface Overflow Rate (gpd/sf)	Solids Loading Rate (lb/day-sf)
30/30 and TN<8	4 @ 74'Lx14'Wx15'D 4,144 sf	4.3	1,038	45
		5.99	1,444	71
		7.62	1,835	115
TN<5,3	4 @ 74'Lx14'Wx15'D 2 @ 74'Lx30'Wx15'D 8,580 sf	4.3	504	36
		5.99	704	70
		7.62	894	88

2.2.2 Proposed Pilot-Scale BioMag Design

Cambridge Water Technology has BioMag pilot trailers available, but they are designed to perform magnetite recovery and feed into existing full-scale activated sludge or MLE systems.

Blueleaf is proposing to construct a bioreactor on site which is 26' long, 4' wide, with a sidewall depth of 8'. The water depth in the tank will be maintained at 6' to provide a 2' freeboard. The length, and pilot flowrate can be modified to mimic the operation of the proposed BioMag system. Table 14 shows the configurations for the BioMag Bioreactor and Clarifier pilot system.

A recycle system will be installed to transfer aeration tank effluent to the anoxic zone, when treating for TN removal. The system will allow the flow rate to be varied up to 5xQi. Mixers are to be installed in the Anoxic zones. Air diffusers will be medium bubble diffusers arrange to provide spiral roll aeration.

Table 14: BioMag Bioreactor Pilot Scale Design Parameters

Condition	Proposed Full-Scale			Proposed Pilot-Scale			
	Volume (ga)	Q (MGD)	Dt (hrs)	L (ft)	Volume (ga)	Dt (hours)	Q (gpm)
30/30							
Aeration	1090730	4.30	5.04	13.8	2477.7	5.04	8.2
		5.99	3.62			3.62	11.4
		7.62	2.84			2.84	14.5
TN<8							
Anoxic	327600	4.30	1.83	5.9	1059.3	1.83	9.7
Aeration	764400		4.27	13.8	2477.7	4.27	
Anoxic	327600	5.99	1.31	5.9	1059.3	1.31	13.5
Aeration	764400		3.06	13.8	2477.7	3.06	
Anoxic	327600	7.62	1.03	5.9	1059.3	1.03	17.1
Aeration	764400		2.41	13.8	2477.7	2.41	
TN<3,5							
Anoxic	327600	4.30	1.83	5.9	1060.5	1.83	9.7
Aeration	764400		4.27	13.8	2474.6	4.27	
Post Anoxic 1	175000		0.98	3.2	566.5	0.98	
Post Anoxic 2	175000		0.98	3.2	566.5	0.98	
Anoxic	327600	5.99	1.31	5.9	1060.5	1.31	13.5
Aeration	764400		3.06	13.8	2474.6	3.06	
Post Anoxic 1	175000		0.70	3.2	566.5	0.70	
Post Anoxic 2	175000		0.70	3.2	566.5	0.70	
Anoxic	327600	7.62	1.03	5.9	1060.5	1.03	17.1
Aeration	764400		2.41	13.8	2474.6	2.41	
Post Anoxic 1	175000		0.55	3.2	566.5	0.55	
Post Anoxic 2	175000		0.55	3.2	566.5	0.55	

Two parallel 4' x 4' square pilot clarifiers will be constructed at the end of the bioreactor in order to vary the loading rates of the clarifiers without varying the flow rate through the bioreactor. Table 15 compares the proposed full-scale clarifier with the proposed pilot-scale clarifier.

Table 15: Proposed BioMag Pilot Scale Clarifier Design Parameters

Treatment Condition	Full Scale Design			Proposed Pilot Scale Design		
	SA (sf)	Plant Flow (MGD)	SOR (gpd/sf)	Flow (gpm)	Average SOR (half of bioreactor flow to each clarifier)	Max SOR (all bioreactor flow to one Pilot Clarifier)
30/30 and TN<8	4,144	4.3	1,038	8.2	369	737
		5.99	1,445	11.4	514	1,027
		7.62	1,839	14.5	653	1,307
TN<5,3	8,580	4.3	504	9.7	435	870
		5.99	704	13.5	606	1,212
		7.62	894	17.1	771	1,542

RAS will be collected in the bottom of the clarifier and returned to the head of the BioMag Bioreactor using a pump with a flow control valve and meter.

2.3 Biological Aerated Filter (BAF)

Upflow biological filters are attached growth processes, which act in a similar manner to packed filter beds. In these systems the media provides a surface for the organisms to attach themselves. The wastewater flows upward through the media. The media is retained in the filter while the treated effluent is discharged. The upward flow passing through the packed media provides a level of solids removal, eliminating the need for further solids separation.

2.3.1 Proposed Full Scale BAF Systems

Two vendors submitted proposals to supply the BAF equipment.

Kruger's BIOSTYR process utilizes high-density polystyrene beads as the filter media, which float. There is a ceiling plate with nozzles to retain the media. Backwashing is completed with air scour and a downward flow of filtered water. Kruger proposes that the BAF filter sizes are independent of the TN goal, and that only methanol dose must be increased to reduce TN effluent (estimated methanol use increased from 425 gal/day for TN<8 to 546 gal/day for TN<3). Kruger provided two alternative designs; one with separate filters for BOD removal, nitrification, and denitrification, and the other with a single set of filters for both BOD and nitrification, with a second set of filters for denitrification. The filter sizes are shown in Table 16.

Infilco Degremont's BIOFOR®C, BIOFOR®N, and BIOFOR®DN are used in series to provide carbonaceous BOD, nitrification, and denitrification, respectively, utilizing an expanded clay material. The filter media is heavier than water, and operates in upflow mode, so the media expands as filter rates increase. There is no ceiling or upper deck on the filters. Backwash is accomplished with air scour and upflow backwash with filtered water. IDI proposed to provide three sets of filters to complete BOD removal, Nitrification, and denitrification.

Table 16: Proposed Full-Scale BAF Design Parameters

Filter	Number of Filters	Surface Area each filter (sf)	Total SA (sf)	Filter Loading rate at Max Month Flow (all filter in operation) (gpm/sf)	Filter Loading rate at Peak Day Flow (one filter out of service) (gpm/sf)
Kruger Proposal to complete in 3 stages					
BOD	8	468	3,744	1.11	1.62
N	6	468	2,808	1.48	2.26
DN	5	304	1,520	2.74	4.35
Kruger Proposal to complete in 2 stages					
BOD/N	8	468	3,744	1.11	1.62
DN	4	304	1,216	3.42	5.80
IDI Proposal to complete in 3 stages					
BOD	4	480	1,920	2.17	3.67
N	6	480	2,880	1.44	2.20
DN	4	274	1,096	3.80	6.44

2.3.2 Proposed Pilot Scale BAF System

Kruger has two BAF pilot systems that could be made available for the pilot (36" and 25.5" diameters). IDI has no BAF pilot equipment available. It is not feasible to fabricate BAF pilot equipment in a shorter period of time.

We are proposing to use the two pilot filters from Kruger to pilot the BOD/N/DN + PDN option (the 2-stage BAF option). If this option does not succeed during the first few months of operation, the pilot system can be converted to operate in the 3-stage BAF mode, and it may be feasible to fabricate an 18" BAF pilot to mimic the proposed DN filter. The flow rates are shown in Table 17.

Table 17: Proposed Pilot-Scale BAF Design Parameters

Filter	Surface Area (sf)	Flow Rate for Max Month (gpm)	Filter Loading rate at Max Month Flow (gpm/sf)	Flow Rate for Max Day (gpm)	Filter Loading rate at Peak Day Flow (gpm/sf)
Kruger Proposal to complete in 2 stages					
BOD/N (36")	7.07	7.9	1.11	11.4	1.62
DN (25.5")	3.55	12.1*	3.42	20.6*	5.80
		7.8	2.20	11.4	3.21
Potential Future 3 stage pilot setup					
BOD	7.07	7.9	1.11	11.4	1.62
N	3.55	5.3	1.48	8.0	2.26
DN (18")	1.77	4.8	2.74	7.7	4.35

* Flow rates exceed BOD/N filter effluent

Note that the flow rates needed to operate the 2-stage DN filter at the design loading rates exceed the flow rate produced by the upstream BOD/N filter, so the DN filter will need to operate at flows and filter loading rates lower than the proposed design rates during some of the pilot testing. Consideration will be given to recycling a portion of the first stage effluent and adding MicroC to increase the hydraulic and organic loading. When testing the DN filter at design hydraulic loading rates, the DN effluent will be recycled into the DN filter, and nitrate will be added.

The pilot system is shipped to the site fully assembled except for the brine, recycle and waste tanks. The tanks are shipped loose and placed adjacent to the pilot equipment. Flexible hose is assembled between the pilot unit, the tanks, the raw water supply, and the finished water discharge at the test site.

3 Pilot Study Plan and Protocol

3.1 Test Schedule

The scheduled duration for pilot testing is six months. The pilot system will be staffed during daytime hours (normally 7 am to 5 pm), and will operate unattended overnight.

Experiments for 30/30, TN<8 and TN<3 treatment levels are described in this Section. Experiments for TN<8 and TN<3 treatment levels will be conducted after experiments for the 30/30 treatment level if there is sufficient time and budget remaining in the initial pilot program. Experiments for TN<5 will be consistent with the TN<3 experiments but will generally require less supplemental carbon addition than TN<3. TN<5 experiments are the last priority. The ability to accommodate total nitrogen treatment level pilot experiments into the pilot program will be highly dependent on the amount of time it takes for the biological reactor to adjust to changing conditions and stabilize to a point where the representative data can be obtained.

3.2 Experimental Design

There are a number of experiments planned for the Initial Pilot Study Phase. A summary of the Experiments is included in Table 18, and each experiment is outlined below. Pilot studies on biological treatment systems are normally operated for extended periods of time in order to evaluate the performance of the system under a range of raw wastewater characteristics, weather, and seasonal conditions experienced at the full-scale facility. The duration of each experiment will be determined based on the variability in the raw wastewater, effluent water quality results, and other issues discovered during the course of the study.

Prior to conducting each experiment, AECOM, Blueleaf and the City will develop a detailed testing plan which includes the field sampling analyses to be included in the test, the frequency and total number of samples, the duration of the test, ranges of acceptable influent water quality, thresholds for completion of the experiment, statistical analyses expected on the data, and format for experimental results. Often, the weekly testing plan is revised and adapted due to results from earlier testing results.

Table 18: Proposed Experimental Conditions

	Experiment	Flow Source		Variables			
		PC	CEPT	HRT/SOR	SLR	Organic Load	Supp Carbon
30/30	1 Ability to treat at average day flow	A		C	C		N/A
	2 Maximum flow treatment capacity	>MD		V	C		N/A
	3 Maximum flow treatment capacity w/dilute effluent		>MD	C			N/A
TN<8	4 Ability to treat at average day flow	A		C			C
	5 Maximum flow treatment capacity	>MD		V			C
	6 Maximum flow treatment capacity w/dilute effluent		>MD	C			C
TN<3	7 Ability to treat at average day flow	A		C			C
	8 Maximum flow treatment capacity	>MD		V			V
	9 Maximum flow treatment capacity w/dilute effluent		>MD	C			C

Where: A=Average, MD = Maximum Day, >MD = Greater than Maximum Day, C = Constant, V = Variable

Note: Configuration and testing program for TN<5 is the same as TN<3

Experiments 1-3 will be completed with the processes set up in the 30/30 configuration.

Experiment 1 – Will the technologies meet 30/30 treatment goals at the Average Daily Flow rates? Each process will be operated at the hydraulic loading rates or empty-vessel hydraulic detention time matching the full scale average daily flow. The influent to the processes will be primary effluent, and each process will be sampled daily until carbonaceous BOD removal rates have stabilized.

Experiment 2 – What is the maximum hydraulic flow rate that each technology is capable of meeting the 30/30 requirements? The flow rate through each process will be increased every three days, and allowed to stabilize between flow rate increases. The influent to the processes will be primary effluent, and each process will be sampled daily. If BOD removal rates do not meet the 30/30 requirements, and other factors are not discovered and corrected, the maximum hydraulic loading rate will be established as the highest successful flow rate tested.

Experiment 3 – Is each technology able to meet the 30/30 treatment goals when operating at the maximum flow rate when treating CEPT effluent? CEPT effluent should be tested with each process to confirm that coagulant and polymer present in the CEPT effluent does not have a negative impact on the performance of the media or ballast present in the various processes under consideration. Each process will be operated at the maximum successful flow rate established in Experiment 2, but with CEPT influent. Each process will be sampled daily until carbonaceous BOD removal rates have stabilized.

Experiments 4-6 will be completed with the processes set up in the TN<8 configuration.

Experiment 4 – Will the technologies meet TN<8 treatment goals at the Average Daily Flow rates? Each process will be operated at the hydraulic loading rates or empty-vessel hydraulic detention time matching the full scale average daily flow. The influent to the processes will be primary effluent, the supplemental carbon feed rate will be used if recommended for the Technology (only World Water Works (MBBR) recommended supplemental carbon to meet the TN<8 goal), and each process will be sampled daily until TN removal rates have stabilized.

Experiment 5 – What is the maximum hydraulic flow rate that each technology is capable of meeting the TN<8 requirements ? The flow rate through each process will be increased every three days, and allowed to stabilize between flow rate increases. The influent to the processes will be primary effluent, the supplemental carbon feed rate will be adjusted to match the nitrate load if recommended for the Technology (only World Water Works (MBBR) recommended supplemental carbon to meet the TN<8 goal), and each process will be sampled daily. If TN removal rates do not meet the removal requirements, and other factors are not discovered and corrected, the maximum hydraulic loading rate will be established as the highest successful flow rate tested. Note that the increase in flow rate may be more frequent than every three days and will be modified based on the actual time the reactor needs to stabilize.

Experiment 6 – Is each technology able to meet the TN<8 treatment goals when operating at the maximum flow rate when treating CEPT effluent? CEPT effluent should be tested with each process to confirm that coagulant and polymer present in the CEPT effluent does not have a negative impact on the performance of the media or ballast present in the various processes under consideration. Each process will be operated at the maximum successful flow rate established in Experiment 5, but with CEPT influent. Each process will be sampled daily until TN removal rates have stabilized.

Experiments 7-9 can be completed with the processes set up in the TN<3 configuration.

Experiment 7 – Will the technologies meet TN <3 treatment goals at the Average Daily Flow rates? Each process will be operated at the hydraulic loading rates or empty-vessel hydraulic detention time matching the full scale average daily flow. The influent to the processes will be primary effluent, the supplemental carbon feed rate will be used, and each process will be sampled daily until TN removal rates have stabilized.

Experiment 8 – What is the maximum hydraulic flow rate that each technology is capable of meeting the TN<3 requirements ? The flow rate through each process will be increased by approximately 5% every three days, and allowed to stabilize between flow rate increases. The influent to the processes will be primary effluent, the supplemental carbon feed rate will be adjusted to match the nitrate load, and each process will be sampled daily. If TN removal rates do not meet the removal requirements, and other factors are not discovered and corrected, the maximum hydraulic loading rate will be established as the highest successful flow rate tested. Note that the increase in flow rate may be more frequent than every three days and will be modified based on the actual time the reactor needs to stabilize.

Experiment 9 – Is each technology able to meet the TN<3 treatment goals when operating at the maximum flow rate when treating CEPT effluent? CEPT effluent should be tested with each process to confirm that coagulant and polymer present in the CEPT effluent does not have a negative impact on the performance of the media or ballast present in the various processes under consideration. Each process will be operated at the maximum successful flow rate established in Experiment 8, but with CEPT influent. Each process will be sampled daily until TN removal rates have stabilized.

3.3 Analytical Sampling Plan

The data collected during the pilot study will be composed of three parts: 1) influent/effluent chemical analyses performed by onsite field analyses and by an outside laboratory, 2) operational parameters, and 3) observation by the pilot operators.

In general, field analyses will be performed daily with parameters included that are pertinent to the trials conducted, and detailed in the experimental plan. For example, when TN removal goals are under investigation, ammonia, nitrate, nitrite and total nitrogen will be included in the daily field samples. Field analyses are detailed in Section 3.4

Operational parameters will include:

1. Flow rates
2. Headloss across filters, or where applicable
3. Backwash frequency and conditions (loading rates, duration, air scour use)
4. Process air flow rate, and number and location of air distribution manifold
5. Clarifier sludge blanket levels
6. For each Chemical Feed System; Day Tank Volume, Feed Rate, Stock Concentration, and Dose
7. Sludge wasting rate
8. Sludge Volume Index

Daily observations by the pilot operators will include:

1. Presence, source and nature of odors
2. Presence, source and nature of foaming
3. Presence, source and nature of filamentous organisms
4. Cause of process upsets
5. Mechanical repairs and impact on pilot processes
6. Weather condition
7. Flow rate into full-scale facility

3.4 Field Analytical Methods

Field samples will be collected and analyzed on-site in accordance with the methods detailed below. The frequency of the field samples will be determined by field conditions, with the total number of samples for any given trial sufficient to determine differences between trials.

3.4.1 Alkalinity

Alkalinity will be analyzed in accordance with the Standard Methods 2320 Titration Method. 100 mL samples will be titrated using 0.020N H_2SO_4 into 100 mL samples. The endpoint of the titration is a pH of 4.5. Results will be expressed as mg/L of calcium carbonate per liter (mg $CaCO_3$/L).

3.4.2 pH Measurements

pH measurements will be made in accordance with Standard Methods 4500-H+B using an Orion glass pH Triode with temperature compensation, and an Orion 3-Star pH meter. A two-point calibration is performed using standard buffer solutions of 4.00, 7.00 and 10.00. Calibration is performed throughout each day of the pilot study. During pH readings the pH probe will be placed in a beaker with a flowing 1/4" sample line (raw, influent or effluent). The sample discharge is submerged to prevent off-gassing.

3.4.3 Dissolved Oxygen

Dissolved Oxygen measurements will be made using an Extech Model 407510 dissolved oxygen meter with a remote sensor probe. Calibration is performed by sampling the oxygen in air (typically 20.9%). Altitude compensation during calibration is available if working at high elevations. Calibration will be performed periodically during the pilot study.

3.4.4 Nitrate

Nitrate samples will be analyzed in accordance with the Hach (Loveland CO) Cadmium Reduction Method #8039. Samples will be distributed to 25 ml sample vials. NitraVer 5 reagent will be added and mixed, and 1 minute then allowed for reaction. The samples will be read using a Hach DR5000 colorimeter. The colorimeter will be zeroed with each set of readings using a blank from the appropriate sample site.

3.4.5 Nitrite

Nitrite samples will be analyzed in accordance with the Hach (Loveland CO) Ferrous Sulfate Method #8153. Samples will be distributed to 10 ml sample vials. NitriVer 2 reagent will be added, mixed, stoppered and 10 minutes then allowed for reaction. The samples will be read using a Hach DR5000 colorimeter. The colorimeter will be zeroed with each set of readings using a blank from the appropriate sample site.

3.4.6 Total Nitrogen

Total nitrogen will be measured using the HACH TNT 826 test kits and a DR5000 spectrophotometer. Samples will be added to the TNT sample vials using a 200 µL fixed volume auto pipet. The sample vials are prepared with premeasured chemical additions included in the kits. Samples vials are heated in a HACH digester block at 100°C for 60 minutes. The samples are then cooled, and analyzed in accordance with the method instructions.

3.4.7 BOD

300 mL samples are collected and placed into BOD incubation bottles. Samples should be analyzed within two hours of sampling or stored at 4°C until analyses are conducted.

To ensure that all other conditions are equal, a very small amount of micro-organism seed is added to each sample being tested. This seed will be consistent with the seed used by the Peirce Island operators for onsite BOD testing. The BOD test is carried out by diluting the sample with oxygen saturated dilution water, inoculating it with a fixed aliquot of seed, measuring the dissolved oxygen (DO) and then sealing the sample to prevent further oxygen dissolving in. The sample is kept at 20°C in the dark to prevent photosynthesis (and thereby the addition of oxygen) for five days, and the dissolved oxygen is measured again. The difference between the final DO and initial DO is the BOD.

The loss of dissolved oxygen in the sample, once corrections have been made for the degree of dilution, is called the BOD_5. For measurement of carbonaceous BOD (cBOD), a nitrification inhibitor is added after the dilution water has been added to the sample. The inhibitor hinders the oxidation of ammonia nitrogen.

BOD can be calculated by:
Undiluted: Initial DO - Final DO = BOD
Diluted: ((Initial DO - Final DO) - BOD of Seed) x Dilution Factor

3.4.8 COD

COD will be measured using the HACH TNT 821 test kits and a DR5000 spectrophotometer. A 100 mL sample will be homogenized in a blender and then added to the TNT sample vials using a 200 µL fixed volume auto pipet. Samples vials will be heated in a HACH digester block at 150°C for 120 minutes. The samples are then cooled, and analyzed in accordance with the method instructions.

3.4.9 TSS

TSS of a water sample is determined by pouring a carefully measured volume of water (typically one liter; but less if the particulate density is high, or as much as two or three liters for very clean water) through a pre-weighed filter of a specified pore size, then weighing the filter again after drying to remove all water. Filters for TSS measurements are typically composed of glass fibers. The gain in weight is a dry weight measure of the particulates present in the water sample expressed in units derived or calculated from the volume of water filtered (typically milligrams per liter).

3.4.10 Oxidation Reduction Potential (ORP)

ORP measurements are taken using Thermo Orion 4-star meters and ORP probes. The meter and probe combinations will be checked against known standard solutions at the beginning and end of each set of readings and the results are corrected for temperature [ORP mV Reading + 224 – $_o$C]. Results are recorded in units of millivolts (mV).

4 Pilot Implementation

Implementation of the pilot work will begin with Experiment 1 as soon as the pilots systems are operational. Prior to conducting the first experiment, AECOM, Blueleaf and the City will develop a detailed testing plan for each technology, which will include the field sampling analyses to be included in the test, the frequency and total number of samples, the duration of the test, ranges of acceptable influent water quality, thresholds for completion of the experiment, statistical analyses expected on the data, and format for experimental results. Each experiment will be performed based on a testing plan developed specifically for the proposed experiment. Testing results will be reviewed weekly and the testing plan and/or experiment will be modified as needed to obtain the necessary performance data for the evaluation. Following completion of an experiment the testing plan and results will be incorporated into a final report.