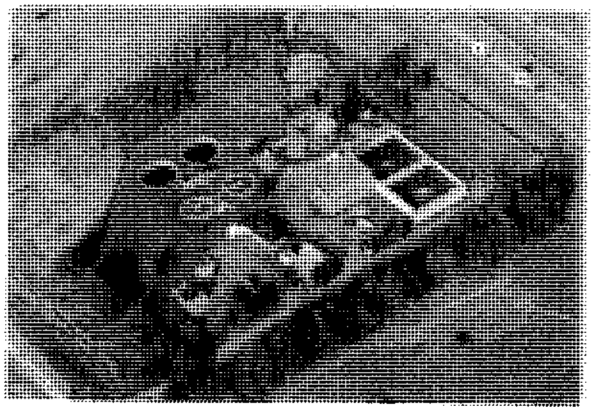
Draft Report to the City of Portsmouth, New Hampshire On the Wastewater Master Plan Value Engineering Review

March 2, 2010



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March 2, 2010

Mr. Peter Rice
City Engineer
City of Portsmouth, New Hampshire
Department of Public Works
680 Peverly Hill Road
Portsmouth, NH 03801

Subject: City of Portsmouth Wastewater Master Plan
Draft Value Engineering Study Report

Dear Mr. Rice:

AECOM in association with ARCADIS U.S., Inc. are pleased to submit three copies of the subject value engineering (VE) study report documenting the workshop that took place February 2-5, 2010. The report evaluates the three scenarios developed by your Wastewater Master Plan (WWMP) development team, Weston & Sampson and Brown and Caldwell, for conveying and treating wastewater generated in the City of Portsmouth and surrounding areas.

During the workshop each scenario was modified and a new VE scenario was developed based on the information gathered by the team and the City's desire to generate a more affordable plan that will comply with its Consent Order from the U.S Environmental Protection Agency. The original scenarios, the modified original scenarios and the VE Scenario were then evaluated against one another to identify an approach to achieving the City's goal at a lower cost. As a result of this effort, a phased VE scenario that would meet the City's needs was identified. This new approach has to be reviewed in detail by the WWMP development team to ensure its viability and validate its costs. Once this occurs, the City can finalize its WWMP.

The VE team wishes to take this opportunity to thank you and David Allen for your support during the workshop. We also want to thank the development team for providing us with complete and timely information so that we could execute our task efficiently. Once you have reviewed this draft report, please contact us to discuss any comments you may have. We can then revise the report to incorporate your comments and provide a final report.

Please do not hesitate to call if you have any questions regarding the information presented. We appreciate the opportunity to work with the City on this project.

Very truly yours,

Donald J. Chelton
Vice President
AECOM

CITY OF PORTSMOUTH, NH WASTEWATER MASTER PLAN VALUE ENGINEERING STUDY REPORT

1.0 INTRODUCTION

This value engineering (VE) study report documents the events and results of the VE study conducted by AECOM Technical Services, Inc. in association with ARCADIS U.S., Inc. for the City of Portsmouth, NH. The subject of the study was the City of Portsmouth, NH Wastewater Master Plan (WWMP), dated January 20, 2010, being developed for the City by the team of Weston & Sampson and Brown and Caldwell (study team). The 3-1/2-day study was conducted February 2-5, 2010, at the City's Public Works office.

Comprising the VE team were a wastewater process specialist, a wastewater collection specialist, a CSO/ wet weather specialist, a environmental planner/affordability analyst, a cost/constructability specialist, and a Certified Value Specialist team leader. Team members, their specialty and their affiliation are provided in Appendix A of the report. The VE team used the following six-phase VE Job Plan to guide its deliberations.

- Information Gathering Phase
- Function Analysis Phase
- Creative Idea Generation Phase
- Evaluation/Judgment of Creative Idea Phase
- Scenario Development Phase
- Presentation of Results Phase

Each of these phases is described in detail following a description of the current status of the Wastewater Master Plan.

2.0 CURRENT STATUS OF THE WASTEWATER MASTER PLAN

The City of Portsmouth sewerage area encompasses areas of combined storm water and sanitary sewers and areas where the storm water and sanitary flows are separate. The wastewater and combined wastewater and storm water flows are conveyed to the two wastewater treatment facilities (WWTFs) owned and operated by the City. One is located on Peirce Island (PI) with a current average daily flow (ADF) of 4.8 million gallons per day (mgd), (design ADF capacity of 5.0 mgd), and a peak wet weather flow (WWF) of 22 mgd. The PI WWTF provides advanced-primary treatment for wastewater flows from the City, the Town of Newcastle, and portions of the Towns of Rye and Greenland.

The second facility located at the Pease International Tradeport (PIT) has current ADF of 0.6 mgd (a design ADF capacity of 1.2 mgd), and a peak capacity of 1.8 mgd . The PIT WWTF is located on PIT property leased to the City and only serves the PIT. This facility provides secondary treatment using the sequencing batch reactor (SBR) process and provides biological nitrogen removal (BNR).

Treated effluent in the PIT plant outfall is combined with the flow from the Newington treatment plant prior to discharge. Each plant discharges into the Piscataqua River which flows into the Atlantic Ocean. The river experiences tidal flows where the outfalls discharge and during flood tides, the flow in the river runs upstream into Great Bay. The outfall capacity for the PI WWTF is 25 mgd and 4.8 mgd for the PIT WWTF. However, the current permit for the PIT WWTF outfall is 1.8 mgd.

The combined sewer system also has three permitted overflow points, CSO 10A, CSO 10 B and Deer Street, which periodically discharge into South Mill Pond and the Piscataqua River. The City is currently implementing a CSO abatement program.

In 2007, the U.S. Environmental Protection Agency (EPA) denied the renewal of the 301(h) waiver under which the PI WWTF was operating and issued a new National Pollutant Discharge Elimination System (NPDES) permit requiring secondary treatment. An Administrative Order was issued to set interim limits which the PI WWTF must meet until such time that a new secondary treatment process is constructed at the PI WWTF, or a new secondary treatment WWTF is constructed elsewhere.

In addition to the new NPDES permit for the PI WWTF, it is anticipated that EPA will include a total nitrogen (TN) limit in future NPDES permits for both the PI WWTF and the PIT WWTF. The new PI permit does not contain a limit on total nitrogen. In the absence of scientifically-supported data, a TN limit of 8 mg/L has been assumed. The actual TN limit is expected to result from the final waste load allocations for the lower Piscataqua River. The final waste load allocations will take into account the evaluation of nutrient impacts to the Great Bay watershed recently completed by the New Hampshire Department of Environmental Services (NHDES). The City also has several ongoing projects designed to provide separation of storm water and sanitary sewers in selected parts of the service area to reduce the wet weather flows at the PI WWTF. As part of the WWMP there is also a need to continue CSO abatement measures.

Because the location of the discharge from the PIT WWTF in the Piscataqua River is in close proximity to the Spinney Creek shell fish grounds, and based on a recent dye study the river's tidal movement will reportedly convey the treatment plant effluent discharges to this area within four hours, it is assumed that the new discharge permit will require a discharge limit of TN = 5 mg/L or lower if the quantity discharged is over the current permitted limit of 1.8 mgd. The likelihood of obtaining a permit for a discharge greater than 1.8 mgd is also questionable.

The study team determined that the design basis for dry weather sanitary wastewater flows in the Portsmouth area is 8.9 MGD ADF for year 2060, with the potential of 13.0 MGD as a maximum monthly flow. The purpose of the master plan was to address how the City could treat flow from its separate and combined sanitary and storm sewer systems to allow growth over the next 50 years and meet changing effluent quality requirements. Of major concern was providing facilities to accommodate flows and discharge limits for the next 20 years and then consider how these facilities could be expanded to treat additional future flows and meet stricter effluent limits.

One of the first steps in the process was to select sites for treating the wastewater. Based on recent discussions with the regulatory agencies, the study team concluded that the sites considered must be capable of supporting full secondary and advanced treatment facilities to a TN level of 3 mg/L. The space available at the PI WWTF site is limited and it is partially bordered by the remains of Fort Washington, but could be organized to accommodate the necessary facilities. The existing PIT WWTF site could be expanded and upgraded to treat full build-out flow, but would require significant flow re-direction in the collection system as well as the effluent outfall. Therefore, locating a new WWTF at other sites in the Portsmouth area was considered. The Public Service of New Hampshire (PSNH) and adjacent Sprague Storage site were considered viable alternatives. Thus the three sites considered in the Master Plan are:

- Peirce Island
- PIT
- PSNH or the adjacent Sprague storage site

Another step undertaken by the study team included the evaluation of several treatment processes which led to the selection of the following:

- Modified Ludzak-Ettinger (MLE)
- Integrated Fixed Film Activated Sludge (IFFAS)
- Sequencing Batch Reactor (SBR)

Because the SBR process minimzed the additional facilities outside the existing PI WWTF site fence line, and because the SBR process already exists at the PIT WWTF, the SBR technology was used as the basis of future work on the Master Plan.

With this background, the study team developed three all encompassing scenarios to address the City's wastewater issues. They are:

Scenario 1

This scenario limits the flow at the PIT WWTP to ultimately 1.2 ADF mgd, its current permitted flow, and directs all other flows to the PI WWTP. The following elements comprise this scenario:

- Upgrade the PI WWTF to treat an ADF of 7.7 mgd by adding secondary treatment and nitrogen removal as required using the SBR process
- Add nitrogen removal as required at the PIT WWTF by expanding the SBR process
- Refurbish the Mechanic Street Pump Station to deliver 25 MGD to the PI WWTF

For CSO abatement, the following were recommended:

- For the South Mill Pond CSOs (overflows 010A/010B), construct a 2.9 million gallon (MG) off-line storage tank or additional sewer separation

Scenario 2

This scenario splits the flows between the two wastewater plants so that ultimately the PIT WWTF will ultimately treat 4.8 mgd ADF and the PI WWTP will treat 4.1 mgd ADF and wet weather flows. The following elements comprise this scenario:

- Redirect flow from Lafayette Road, Gosling Road, and Atlantic Heights Pump Stations to the PIT WWTF
- Construct a new Borthwick Avenue Pump Station to pump flows from that portion of the local sewer shed into the new Lafayette Road Pump Station force main

- Redirect a portion of the Deer Street Pump Station to the PIT WWTF – the Deer Street Pump Station would be able to simultaneously pump to both the Mechanic Street Pump Station and the PIT WWTF
- Expand the PIT WWTF to treat 4.8 MGD by expanding the SBR process and solids handling process

For CSO abatement, the following was recommended:

- For the South Mill Pond CSOs (overflows 010A/010B), debottleneck line between CSOs 010A/010B and Mechanic Street Pump Station or additional sewer separation

Scenario 3

This scenario redirects all of the sanitary flows to the PIT WWTF, or alternatively the PSNH/Sprague storage site, and uses the PI WWTF to treat only wet weather flows. The following elements comprise this scenario:

- Redirect the entire Deer Street Pump Station flow to the PIT WWTF or alternative new site
- Provide a new dry weather Mechanic Street Pump Station to pump flow to the Deer Street Pump Station
- Provide a new Peirce Island Pump Station to pump flow from both the Town of Newcastle and any return flows associated with continued CSO treatment at the PI WWTF to the new dry weather Mechanic Street Pump Station

For CSO abatement, the following was recommended:

- For the South Mill Pond CSOs (overflows 010A/010B), debottleneck line between CSOs 010A/010B and Mechanic Street Pump Station, PI WWTF Improvements to treat wet weather flows or additional sewer separation

The wastewater flows and present worth life cycle costs (in millions) for the treatment facilities based on a TN = 8 mg/L and using SBR technology described above are shown in Table 1.

Table 1- Build-out Condition Flows in Year 2060 and Present Worth Costs Associated with WWMP Flow Scenarios

WWTF	**Scenario 1**	**Scenario 2**	**Scenario 3**
Peirce Island	7.7 MGD	4.1 MGD	0 MGD
PIT or PSNH/Sprague Site	1.2 MGD	4.8 MGD	8.9 MGD
Costs			
WWTF	$158	$238	$150
Redirect/Shed	0	$13	$22
CSOs	$27.2	$4.2	$29
Total	$185.2	$255.2	$201

Note: Costs in millions

Potential concerns with sending more than 1.2 MGD of flow to the PIT WWTF or PSNH/Sprague storage site is that the EPA may impose lower nitrogen limits because of the nearness of the outfalls, existing and/or new, to shellfish beds up river that could be affected during tidal movements. Also the ability to permit the new outfall is questionable at the current location, which may require conveying the treated effluent from the PIT or the Sprague site to the PI WWTF outfall at a significant capital cost.

Also noted was that a TN limit of 5 mg/L or lower will result in an additional 30 to 40 percent increase in capital cost as well as additional operation and maintenance costs.

3.0 INFORMATION GATHERING PHASE

The VE study was conducted over a three and one-half-day period using a workshop format. Prior to the workshop, team members were provided with the City of Portsmouth, NH Wastewater Master Plan as described in Technical Memorandum TM 5 WWTF Process and Siting and CSO Abatement Evaluations, dated January 20, 2010, for review. Members of the team had also previously visited the two WWTPs and some of the key pipeline routes.

To kick off the workshop, the representatives from the study team presented the project to the entire VE team. The goal was to highlight the key elements of the basis for the Master Plan and the scenarios developed to address them. They also discussed issues not addressed in the Master Plan to provide the team with a more in-depth understanding of the project.

The study team shared with the VE team the results of an affordability study conducted for the three scenarios. The studies indicated that because the projected sewer user charge for a typical residential household would exceed 2.0 percent of the City's median household income, none of the scenarios were affordable for the City in their current form by a wide margin. Thus each had to be refined to meet the affordability criteria. If this could not be accomplished, then another approach was necessary. The study team again shared with the VE team some of its thoughts in this regard.

It was noted during the presentation that it was highly unlikely that an outfall with a 13 mgd capacity would get permitted in the same area as the existing PIT outfall. Thus any treated effluent discharge from an upgraded or expanded WWTF in this area would have to be sent back to the PI WWTF outfall via a new pump station and force main with an estimated cost of about $12 million.

As a result of the presentation by the study team, the City representatives directed the VE team to identify opportunities to optimize the three scenarios generated by the study team and also generate an alternative scenario that would make the plan affordable over at least the next 20 years. The VE team was also requested to review the order of magnitude of the flows and loads.

Following the presentation, the VE team visited all of the potential WWTF sites and some of the key force main routes, both existing and proposed.

Upon returning from the site visit, the team developed the following problem statement to guide the remainder of its work:

"Identify a plan that will treat the year 2030 flow to a level of TN = 8 mg/L now and TN = 5 mg/L in 2030 that is affordable and also meets the wet weather treatment goals."

4.0 FUNCTION ANALYSIS PHASE

Having gained some additional information on the project, the VE team proceeded to define the functions provided by the project, identifying the high cost functions, and determining whether the value provided by the functions has been optimized. Function analysis is a means of evaluating a project to see if the expenditures actually meet the performance requirements of the project or if there are disproportionate amounts of money spent on support functions. Elements performing support functions add cost to the project but have a relatively low worth to the basic function.

Function is defined as the intended use of a physical or process element. The team attempted to identify functions in the simplest manner using measurable noun/verb word combinations with adjectives sometimes added to clarify the nouns. To accomplish this, the team first looked at the project in its entirety and randomly listed its functions, which were recorded on Random Function Analysis Worksheets (see Table 2 below). Then the individual functions of the major components of the project depicted on the Cost Histogram were identified.

After identifying the functions, the team classified the functions according to the following:

Abbreviation	Type of Function	Definition
HO	Higher Order	The primary reason the project is being considered or project goal.
B	Basic	A function that must occur for the project to meet its higher order functions.
S	Secondary	A function that occurs because of the concept or process selected and may or may not be necessary.
R/S	Required Secondary	A secondary function that may not be necessary to perform the basic function but must be included to satisfy other requirements or the project cannot proceed.
G	Goal	Secondary goal of the project.
O	Objective	Criteria to be met
LO	Lower Order	A function that serves as a project input.

Higher order and basic functions provide value, while secondary functions tend to reduce value. The goal of the next job phase is to reduce the impact of secondary functions and thereby enhance project value. Table 2 – Random Function Analysis presents the project functions identified by the team.

TABLE 2 – RANDOM FUNCTION ANALYSIS

DESCRIPTION	FUNCTION		
	VERB	NOUN	KIND
PROJECT FUNCTIONS	Remove	Pollutants	B
	Transport	Wastewater	B
	Discharge	Treated Effluent	B
	Process	Residuals	R/S
	Reduce	Overflows	HO
	Protect	Environment	HO
	Protect	Public Health	HO
	Treat	Dry Weather Flows	B

5.0 IDEA GENERATION PHASE

The VE team reviewed each of the scenarios to ascertain how they addressed the project functions. It then used the classic brainstorming technique to generate many ideas to provide the necessary functions at a lower total life cycle cost, or to improve the quality of the project for each scenario. Ideas for improving operation and maintenance, reducing project risk, and simplifying constructability were also encouraged. At this stage of the process, the VE team was looking for a large quantity of ideas and free association of ideas for each scenario.

The following Table 3 – Creative Idea Listing was generated as a result of this exercise. It is organized by the scenario being addressed and each idea was identified with an alternative number (Alt. No.) that can be tracked through the value analysis process. Several general ideas were also conceived. The Alt. No. includes a prefix that refers to the scenario.

TABLE 3 – CREATIVE IDEA LISTING and EVALUATION

ALT. NO.	IDEA DESCRIPTION	RATING
GENERAL (G)		
G-1	Design WWTFs for year 2030 flows (7.5 mgd total = 6.3 at PI + 1.2 at PIT)	Y
G-2	Size plant for TN = 8 mg/L with the ability to expand/retrofit to TN = 5 mg/L	Y
G-3	Size PI for TN = 8 mg/L. Scenario 1 size PIT for TN = 5 mg/L	Y
G-4	Refine flows to separate sanitary flows from I/I	Y

ALT. NO.	IDEA DESCRIPTION	RATING
G-5	Refine projected flows based on new wastewater generation numbers	Y
G-6	Consider reuse of treated effluent	Y
SCENARIO 1		
1-1	Use biological activated filtration (BAF) for secondary treatment in lieu of SBR	Y
1-2	Use stacked clarifiers with higher rate unit processes	Y
1-3	See G-4	Y
1-4	See G-5	Y
1-5	Use equalization tank off site	N
1-6	Use filter building for denitrification filter	N
1-7	Size units with a secondary bypass	Y
1-8	Use membrane biological reactors (MBRs) in existing filter building	Y
1-9	Size suspended cell systems with wet weather bypass	Y
1-10	Use MBR for polishing nitrogen from TN=8 mg/L to TN = 5 mg/L	VE
1-11	Do not provide redundant tankage for high rate clarification (HRC), provide redundant equipment only.	N/A
1-12	Use detention treatment and screening disinfection in lieu of HRC	N/A
1-13	Convert existing round primary clarifiers to secondary clarifiers and build new rectangular clarifiers	Combine w/1-2
SCENARIO 2		
2-1	Use in-line storage	N
2-2	Use BAF at Peirce Island	Y
2-3	Use a moving bed bioreactor (MBBR) at Peirce Island	Y
2-4	Convert existing primary clarifiers to secondary clarifiers and build new rectangular clarifiers	Y
2-5	Use equalization tank off site	N
2-6	Refine flows	Y
2-7	Use stacked clarifiers at Peirce Island	See 2-4
2-8	Do not send Lafayette P.S. flows to Pease International Tradeport WWTP	Y

ALT. NO.	IDEA DESCRIPTION	RATING
2-9	Do not split Deer Street flows and send them all to P. I.T. WWTP. Send treated flow from P.I.T. back to Deer Street Pump Station through a new line and then on to Mechanic Street Pump Station.	N
2-10	Do not send Lafayette Pump Station flows to P. I.T. WWTP	See 2-8
2-11	Divert Lafayette Pump Station flows to Deer Street Pump Station	Y
2-12	Use four-stage Barden-pho process at P. I.T. WWTP	Y
2-13	Use activated sludge process at P.I.T.	Y
2-14	Use split flow wet weather treatment at P.I.T. – ballasted Floc	N
2-15	Use existing primary tanks at P.I.T. WWTP	Y
2-16	Store some wet weather flow at P.I.T.	N
2-17	Use higher unit process loading at P.I. T. since there is a low peaking factor	Y
2-18	Consider reuse of effluent	Y
SCENARIO 3		
3-1	Consider reuse of effluent from P.I.T. WWTP	Y
3-2	Use higher unit process loading at P.I.T. WWTP since there is a low peaking factor	Y
3-3	Use existing primary tanks at P.I.T. WWTP	Y
3-4	Abandon grit chambers at P.I. and capture in primary tanks	Y
3-5	Use a conventional screen at P.I.	N
3-6	Use gravity sedimentation in lieu of chemically enhanced primary treatment (CPET)	N
3-7	Use an oxidation ditch flow through process for treatment	Y
3-8	Revisit MLE cost	See 3-7
3-9	Delete denitrification filter and add force main back to Peirce Island	Y
3-10	Indefinitely postpone demolition of Peirce Island facilities	Y

In addition, the VE team generated a series of alternatives that could be turned into its own scenario to address the required functions. These ideas are recorded below.

6.0 EVALUATION/JUDGMENT OF CREATIVE IDEAS

Since the goal of the Creative Idea Generation Phase was to conceive as many ideas as possible without regard for technical merit or applicability to the project goals, the Evaluation Phase focused on identifying those ideas that do respond to the project value objectives and are worthy of additional research and development before being presented to the owner. The selection process consisted of evaluating the ideas based on the City of Portsmouth's value objectives identified through conversations during the workshop kick-off presentation. The following value objectives were identified:

- Reduces costs – meets funding requirements
- Meets functionality requirements
- Provides flexibility to meet future effluent requirements
- Incorporates proven technologies
- Is sustainable
- Allows for schedule flexibility
- Allows phasing of facilities

Based on the team's understanding of the owner's value objectives, each idea was compared with the present design concept for each scenario, and the advantages and disadvantages of each idea were discussed. How well an idea met the design criteria was also reviewed. Based on the results of these reviews, the VE team rated the idea by consensus by indicating "Y – yes" this idea is worthy of further study and potential implementation, or "N – No" there are too many negative factors and the idea should be dropped from further consideration. The ratings assigned by the team to each idea are recorded on Table 3 – Creative Idea Listing and Evaluation above in the right column.

7.0 DEVELOPMENT OF MODIFIED SCENARIOS

Having identified several ideas for improving the value of each scenario, the team then modified each of the scenarios to include the following:

Creative Idea Number G-1: Design the WWTFs for year 2030 flows.

Issue: The master plan is based on flows projected for year 2060, the full build-out which increases both the capital and annual present worth costs.

Suggested Approach: Develop only the facilities necessary to provide service for year 2030, but ensure that facilities necessary to provide for year 2060 flows can be added at a later date.

Creative Idea Number G-2: Design the facilities for an effluent with TN = 8 mg/L and allow for the addition of facilities to produce an effluent with TN = 5 mg/L.

Issue: It is unknown what TN effluent limits will be required by the NHDES at this time. The new PI NPDES permit does not contain a TN limit.

Suggestion: Design the facilities for the least restrictive anticipated limit at this time, TN = 8 mg/L.

Creative Idea Number G-3: For Scenario 1, design the PI WWTF for an effluent with TN = 8 mg/L and the PIT WWTF for an effluent with TN = 5 mg/L.

Issue: It is unknown what TN effluent limits will be required by the NHDES at this time, however there is a concern over the ability to discharge at the existing PIT outfall given its proximity to the shellfish beds.

Suggestion: Design the facilities at the PIT WWTF for the least restrictive anticipated limit at this time, TN = 5 mg/L.

Creative Idea Number G-4: Refine the analysis of existing flows to isolate sanitary and infiltration flow components from total daily flows.

Issue: Technical Memorandum #3 indicates that the sanitary fraction of total daily flow was estimated based on water use (see page 3 of 50). This may be a reasonable assumption when considering flows on an annual average basis (as inflow then becomes a fairly small fraction of the total annual flow volume). However, it appears that the sanitary flow component is added to a maximum monthly I/I estimate in Table 3.2 on page 8 of 50 in TM #3. This becomes a concern because the inflow percentage is likely greater in the maximum month than when considered on an annual basis. This could be contributing to an over-estimation of flows used to size the various alternatives.

Suggested approach: Parse the total daily flow data into dry versus wet days. The attached spreadsheet illustrates a suggested approach. The approach is based on classifying each daily flow value as "dry" or "wet" based on rainfall conditions (see spreadsheet). Then, it is reasonable to estimate infiltration on those "dry" days as a percentage of the minimum daily flow value. Sanitary flow is then computed as total daily flow minus infiltration.

Peirce Island Flow and Rainfall Analysis

Jan-08

Day	Min Q	Max Q	Total Q	Rain	D or W	Dry Total Q	Dry Min Q	Infil Q	San Q
1	0.1	16.3	6.705	0.59	W				
2	6	7.8	6.875	0	D	6.875	6	4.8	2.075
3	4.9	6.8	5.995	0	D	5.995	4.9	3.92	2.075
4	4.4	6.9	5.523	0	D	5.523	4.4	3.52	2.003
5	3.9	6.2	5.035	0	D	5.035	3.9	3.12	1.915
6	2	6.1	4.812	0.18	W				
7	3.5	6.2	5.035	0.04	D	5.035	3.5	2.8	2.235
8	0.1	21.7	5.214	0	D	5.214	0.1	0.08	5.134
9	4.5	10.8	7.339	0.07	W				
10	6.6	8.7	7.918	0	D	7.918	6.6	5.28	2.638
11	5.7	17	12.777	0.99	W				
12	8.7	12.6	10.603	0.01	W				
13	7.3	9.2	8.32	0	D	8.32	7.3	5.84	2.48
14	6.3	8.1	7.343	0	D	7.343	6.3	5.04	2.303
15	0.1	15.3	6.729	0.07	W				
16	5.1	6.8	6.069	0	D	6.069	5.1	4.08	1.989
17	4.6	6.7	5.678	0	D	5.678	4.6	3.68	1.998
18	4.5	16.5	10.639	0.64	W				
19	0.1	12	7.992	0	D	7.992	0.1	0.08	7.912
20	5.5	8.6	6.746	0.89	W				
21	5	7.3	5.984	0.16	W				
22	0.1	17.2	5.677	0	D	5.677	0.1	0.08	5.597
23	0.1	11.3	5.324	0	D	5.324	0.1	0.08	5.244
24	4	6.2	5.011	0	D	5.011	4	3.2	1.811
25	3.7	5.7	4.734	0.05	W				
26	2	5.5	4.427	0	D	4.427	2	1.6	2.827
27	2.1	5.2	4.272	0.04	D	4.272	2.1	1.68	2.592
28	2.1	5	4.293	0.01	D	4.293	2.1	1.68	2.613
29	0.1	14.4	4.275	0	D	4.275	0.1	0.08	4.195
30	1.7	7.5	4.463	0.24	W				
31	1.7	5.7	4.059	0	D	4.059	1.7	1.36	2.699
Sum	106.5	301.3	195.866			114.335	65	52	62.335
Avg	3.435484	9.719355	6.318258			5.71675	3.25	2.6	3.11675
Day	Min Q	Max Q	Total Q	Rain	D or W	Dry Total Q	Dry Min Q	Infil Q	San Q

Wet = any day with 0.05" or more + day of and 1 day after if more than 1" rain + day of and 2 days after if more than 2" rain

Take Infil Q as 0.8 of Min Q

Creative Idea Number G-5: Refine projected flows based on new wastewater generation numbers.

Issue: Technical Memo #3 (TM #3) outlines the assumptions made to develop projected flows based on anticipated population and employment growth and the sanitary flows associated with that growth. Many of the assumptions appear to be highly conservative, and in some cases, the basis of the assumption is not fully clear in the memo. Some of these assumptions in TM #3 are identified below:

- ***Population growth***: The persons per household (pph) number used for projecting population growth in TM #3 is 2.4. The US census 2000 data indicates that pph was 2.04. Using the higher pph figure results in approximately 17% higher estimation of persons per household.
- ***Area for Development***: It is not clear in section 3.4.1.2 if a parcel's developable area includes a reduction allowance for roads and utility right-of-ways (ROWs). This allowance typically

results in an approximately 15% reduction over what would otherwise be considered developable land (which does account for reduction due to sensitive areas, etc). Thus the estimation of available land area for future growth may be overestimated.

- ***Wastewater flows for current and projected conditions***: Section 3.6 provides an explanation of development of wastewater generation rates. While water use data is available and was matched to respective parcels, it appears that there is some discrepancy between the total water use records and the metered sanitary flow at Peirce Island. Thus the WWMP team calibrated the sanitary flow generation rates until the rates matched the expected flow rates at the WWTFs. This calibration resulted in development of higher per capita flow rates (gpcd) than water use data would indicate (i.e., 72 gpcd versus 39 gpcd for single family housing units). A similar calibration for non-residential uses also resulted in higher estimates for wastewater generation per building area flow rate (for example, 0.07 calibrated gpsfd for hotel use versus 0.022 matched gpsfd for hotel use, and 0.24 calibrated gpsfd for restaurant use versus 0.111 matched gpsfd matched for restaurant use).

Suggested Approach: Use less conservative assumptions to determine a lower but justified projection for sanitary wastewater generation:

- Use 2.04 persons per household (2.04 pph) to predict future population
- Verify if the area required for roadway and utility ROW has been deducted from developable area; if not, consider applying reduction allowance of up to 15%
- Use engineering standards and or matched water use data for residential and non-residential wastewater flow generation, as opposed to using the calibrated numbers shown in TM #3. For example, use of the 60 gpcd flow rate for residential sanitary flow generation would result in approximately 16% reduction in projected residential sanitary flow.

Using the above as a starting point for each of the current scenarios as well as the specific ideas evaluated yes for each of the scenarios, the team proceeded to modify each of the three scenarios as follows:

Scenario 1A

- Reduce the size of the treatment facilities for sanitary wastewater flows from 8.9 mgd to7.5 mgd for year 2030 with 6.3 mgd being treated at the PI WWTF and 1.2 mgd being treated at the PIT WWTF. Continue to treat wet weather flows at the PI WWTF
- Design facilities for a TN = 8 mg/L at PI and TN = 5 mg/L at PIT
- At the PI WWTF use the following treatment process for secondary treatment in lieu of SBRs
    - Fine screens (1/4 inch)
    - Aerated grit removal
    - New rectangular clarifiers (3)
    - BNR reactors using the MLE process with blower building and sludge pump station
    - Final clarifiers (convert two existing primary clarifiers to secondary clarifiers and construct one new secondary clarifier)
    - Actiflo type process for wet weather flows
    - Biosolids processing same as existing Scenario 1
- Future TN polishing at the PI WWTF would require the addition of an MBBR or BAF reactor`

- Debottleneck force main at Parrott Avenue
- Store 2.9 MG of wet weather flows in a precast concrete box culvert system (20 rows of 10-ft. by 10-ft. x 200-ft. long concrete boxes) located in the parking lot where the proposed cast-in-place concrete tank is currently located. See attached article about the Davis Brook CSO Storage Facility in Bangor, Maine in Appendix D.

  Capital Cost: $106.9 million (See Appendix C)

Scenario 3A

- Reduce the size of the treatment facilities for sanitary wastewater flows from 8.9 mgd to 7.5 mgd for year 2030 with all flows being treated at the PIT WWTF and all wet weather flows being treated at the PI WWTF
- Design the facilities for a TN = 8 mg/l (since with the increase in the PIT flow, the effluent must be conveyed back to the PI outfall for discharge). Discharge all effluent at the PI WWTF outfall by installing a new pump station and effluent discharge line from the PIT WWTF to the PI WWTF via the Deer Street Pump Station
- Use a secondary treatment process consisting of primary clarifiers, influent pump station, reactor with anoxic and aerobic zones (three combined tanks 190 ft. long, 50 ft. wide and 15 ft. deep with common walls), secondary clarifiers (three tanks 75 ft. in diameter with a 14 ft. side water depth), sludge pump station with 5 RAS pumps and 3 WAS pumps 50 ft. by 50 ft., and ultraviolet disinfection. Convert the existing SBR tanks to sludge holding tanks. Provide sludge thickening and dewatering.

  Capital Cost: $118.9 million (See Appendix C)

Along with Scenario 3, Creative Idea 3-1 suggests that the City consider the reuse of effluent from PIT. With the recent information from the NHDES that any request to increase the permitted flow discharged from the PIT through the existing outfall will trigger a need to provide a total nitrogen level of 5.0 mg/l, as well as the time of travel to shellfish beds, consideration should be given to looking at reuse of all or a portion of the PIT flow in conjunction with the PSNH Northern Wood wood chip power plant at Schiller Station. If the PIT plant is expanded, these constraints may necessitate redirecting the treated effluent back to Peirce Island for discharge through the existing PI outfall. Any effluent that can be used for cooling water reduces the flow that has to be pumped back to Pierce Island and will reduce operating costs.

Thus it is suggested that the City contact PSNH to review the potential for use of treated effluent for cooling water similar to current practice in Manchester NH, Cranston RI, Southbridge, MA and other operating power plant installations.

In going through the scenario reformulation process, the VE team realized that there could be four potential options for Scenario 2. They are:

Scenario 2A.1:

- Treat 4.8 mgd at the PIT WWTF and 4.1 mgd at the PI WWTF
- Use a space saving process at the PI WWTF

Scenario 2A.2:

- Treat 4.8 mgd at the PIT WWTF and 4.1 mgd at the PI WWTF
- Place the secondary process in the abandoned filter building at the PI WWTF

Scenario 2B.1:

- Treat 4.3 mgd at the PIT WWTF and 3.2 mgd at the PI WWTF
- Use a flow through process at both WWTFs

Scenario 2B.2:

- Treat 4.3 mgd at the PIT WWTF and 3.2 mgd at the PI WWTF
- Place the secondary process in the abandoned filter building at the PI WWTF

However, due to the high initial cost of this scenario compared to the other two scenarios, it was determined that none of the ideas or combination of ideas would bring the costs down to an affordable level for the City. Thus only revised Scenarios 1A and 3A were developed along with the VE scenario. However, the team also sought out a low cost scenario to consider and thus developed the following VE Scenario.

VE Scenario

- Reduce the size of the treatment facilities for sanitary wastewater flows from 8.9 mgd 7.5 mgd for year 2030 with 6.3 mgd being treated at the PI WWTF and 1.2 mgd being treated at the PIT WWTF. Continue to treat up to 22 MGD of flow during wet weather at the PI WWTF and 1.2 MGD of flow at the PIT WWTF
- Design facilities for a TN = 8 mg/L at PI and TN = 5 mg/L at PIT
- At the PI WWTF use biological activated filters (BAFs) for secondary treatment in lieu of SBRs. Install the BAFs and its associated pump station capable of treating a peak flow of 9.5 mgd (6.5 mgd dry weather flow x 1.5 peaking factor) in the existing abandoned filter building.
- Build a 50-ft. by 50-ft. by 18-ft. deep anoxic tank with media and include associated internal recycle piping and pumping for denitrification.
- It is suggested further evaluation be carried-out to optimize the denitrification process further. It was suggested that additional sampling of the existing PI effluent be analyzed for ammonia and BOD to ensure internal recycle operation as most efficient. Once the quality of the PI effluent is known, it is further suggested that a comparison of operation using internal pumping to series treatment using BAFs in series or BAFs-MBBRs in series with carbon addition be carried-out.
- To achieve a TN = 5 mg/L in the future, add an anoxic MBBR or BAF in the existing abandoned filter building. See Appendix B for Process Flow Diagram.

- Add two rotary drum screw presses for thickening and two dewatering screw presses
- Provide a disc filter at the PIT WWTF to achieve a TN = 5 mg/L
- Debottleneck the force main at Parrott Avenue
- Store 2.9 MG of wet weather flows in a precast concrete box culvert system located where the designed cast-in-place concrete tank is currently located.

Capital Cost: $ 81.2 million (See Appendix C)

8.0 SELECTION OF A PREFERED SCENARIO

In addition to evaluating the individual creative ideas generated, the team desired to identify which master plan scenario provides the greatest value. To accomplish this, the team first prioritized the criteria using the Criteria Evaluation Matrix shown as Table 3 below. The team used similar criteria to those employed in evaluating the individual ideas, but eliminated those that addressed like issues.

The paired comparison technique was used to weigh the criteria. In this technique, each pair of criteria were evaluated by the team by deciding first which criterion is the more important one to consider and then its relative importance to the other criterion using a scale of 1 – 3 where:

1 – indicates it is only slightly more important;
2 – indicates its importance is somewhere between the extremes; and
3 – indicates its importance is very much greater.

The points accumulated by each criterion when compared to the other criteria were then summed to obtain a score and the scores normalized to 100 to create the weighting factors as shown below.

TABLE 3 – CRITERIA EVALUATION MATRIX

	B	C	D	E	F	G	H	Evaluation Criteria	Score	Weighting factor
A	A 1	A 3	A 1	A 1	A 1	A 3	A 3	Ability to meet TN = 8 mg/L in cold weather	13	36
B								Ability to expand to meet a TN = 5 mg/L in cold weather	0	0
C			D 2	E 2	F 3	C 1	H 2	Ability to meet the City's Sustainability Goals	1	3
D				E 1	F 1	D 2	H 1	Operational Track Record	4	11
E					E 1	E 1	H 1	Operability (Pumping/No. of Processes/Type of Processes)	5	14
F						F 2	H 1	Ability to Phase Construction/Expand WWTP	6	17
G							H 2	Training Requirements	0	1
H								Minimize Impacts of treating WW at Peirce Island	7	19
										100

During the criteria evaluation process, the "training requirements" criteria received a score of 0, which means it is not more important than any of the other criteria considered. However, it is a criterion that should be used in the evaluation of the alternatives. Thus the team assigned a weighting factor of 1 to this criterion. The ability to expand to meet a TN = 5 mg/L in cold weather was judged to be the same in all cases, so it was eliminated from the matrix.

These criteria were placed in the Alternative Evaluation Matrix, Table 4, where all the alternatives are listed. The team then determined how well each alternative met each criterion using a scale of 1 – 10 where 10 indicates almost perfect conformance to the criterion and 1 indicates almost no compliance with the criterion. The points assigned each alternative for each criterion were then multiplied by the weighting factor, and the results summed to identify the non-economic value points for each alternative.

To decide how to rate the scenarios for the operability criterion, the team developed the following matrix:

Scenario	Pumping	No. of Processes	Rating
1A	Good	3	6
3A	Bad	2	6
VE	Good	2	7
1	Good	1	8
2	Bad	1	7
3	Bad	2	6

The team then estimated the cost of the four alternatives and the scores were divided by the costs (in millions) to obtain a value ratio.

TABLE 4 – ALTERNATIVE EVALUATION MATRIX

		Scenario 1A		Scenario 3A		VE Scenario		Scenario 1		Scenario 2		Scenario 3	
Evaluation Criteria	Weight	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
Ability to meet TN = 8 mg/L in cold weather	36	8	288	9	324	8	288	5	180	6	216	9	324
Ability to expand to meet a TN = 5 mg/L in cold weather													
Ability to meet the City's Sustainability Goals	3	8	24	3	9	9	27	7	21	4	12	3	9
Operational Track Record	11	8	88	8	88	7	77	7	77	7	77	7	77
Operability (Pumping/No. of Processes/Type of Processes)	14	6	84	6	84	7	98	8	112	7	98	6	84
Ability to Phase Construction/Expand WWTP	17	5	85	5	85	7	119	6	102	6	102	6	102
Training Requirements	1	4	4	5	5	6	6	9	9	7	7	8	8
Minimize Impacts of treating WW at Peirce Island	19	6	114	9	171	7	133	6	114	7	133	9	171
Total Weighted Criteria		687		766		748		615		645		775	
Construction Cost (estimated - in millions)		$106.9		$118.9		$81.2		$106.5		$148.2		$125.0	
Value Ratio (criteria/ cost)		6.427		6.442		9.212		5.775		4.352		6.200	

[shaded] = Best Value

This exercise illustrates that the VE Scenario appears to provide the best value. The VE Scenario uses the existing facilities as much as possible and keeps mostly within the fence line at the PI WWTF. It also avoids having to redirect flows to the PIT WWTF. However, the $81.2 million cost was determined to still be unaffordable to the City. The City requested that the VE Team seek out ways to phase in the new facilities to reduce the impacts of the project costs on the sewer user rates.

A two-phase approach was generated for the work on Pierce Island that includes the following:

Pierce Island Phase 1

- At the PI WWTF build the new headworks, perform piping modifications and clarifier modifications, build a sludge storage tank, install a BAF to provide secondary treatment in the existing filter building, and perform other site and minor process improvements.
- Rehabilitate the biosolids processing building rather than replacing it
- Reconstruct the Mechanic Street Pump Station

Phase 1 PI Cost = $39.0 million

Pierce Island Phase 2

- At the PI WWTF install new disinfection and additional structures, and add the new anoxic MBBR tank and associated internal recycle piping and pumping to provide nitrogen removal.
- Rehabilitate the existing lab/office, construct the planned equipment building and garage, and implement the outfall modifications

Phase 2 PI Cost = $17.0 million

PIT and CSO Work:

- Construct the storage tank to control CSOs 10A and 10B using precast concrete box culverts
- At the PIT WWTF, add a disc filter, rehabilitate the Lab/Office building and the Shop building, and perform other minor process and site modifications
- Perform Parrott Avenue Debottleneck

PIT and CSO Work Cost = $22.2 million

This approach reduced the total cost to $78.2 million (Refer to Appendix C). Although the cost for Phase 1 was still high from an affordability perspective, it presented a viable approach.

9.0 PRESENTATION OF THE STUDY RESULTS

On Friday morning, February 5, 2010, the VE team presented the results of the workshop to the City and the study team. The team presented an overview of the VE process and the revised scenarios and the generation of the VE scenario and its potential phasing. During the discussions, the potential for additional phasing items were discussed including:

- Retain only $1 million of the $5 million Mechanic Street Pump Station upgrade cost for Phase 1 and let the other $4 million be part of a maintenance program that implements improvements over time.
- Consider the potential to eliminate the $3 million for the outfall modifications.
- Consider reducing the scope of, or eliminating, the proposed additional equipment building or garage.
- Do not perform any work at the PIT WWTF since there is no compliance need to upgrade the level of treatment. The replacement of the headworks equipment is a maintenance item and not a NHDES or U.S. EPA compliance requirement.

- For CSO abatement, perform the debottlenecking and pump more flow to the PI WWTF and defer construction of the storage tank and/or downsize it.

These changes would further reduce the project cost, and/or extend the implementation period to further reduce the impacts of the project cost on the sewer user rates.

10.0 PATH FORWARD

The next step is for the study team to verify the assumptions made by the VE team, provide further optimization for the VE alternative, ensure that the proposed processes can be installed as envisioned, and develop more accurate costs for both Phase 1 and Phase 2 work. The Study Team should then confer with the City on its findings to obtain concurrence and subsequently proceed to modify the Wastewater Master Plan as appropriate.

APPENDIX A – VALUE ENGINEERING STUDY PARTICIPANTS

VALUE ENGINEERING TEAM PARTICIPANTS

Participant	Specialization	Organization
Donald Chelton, PE	Principal	AECOM
Jon Pearson, PE	PM/Collection Systems	AECOM
Betty Shreve-Gibb, CP	Environmental/Affordability	AECOM
Mark Laquidara, PE	Wastewater Process	AECOM
Gregory Heath, PE	CSO/Wet Weather	AECOM
Donald Roper	Cost/Constructability	NCM Management
Howard Greenfield, PE, CVS	Facilitator	ARCADIS U.S.

CITY OF PORTSMOUTH PARTICIPANTS

Peter Rice, PE	Deputy Director of Public Works
David Allen, PE	City Engineer

WASTEWATER MASTER PLAN STUDY TEAM

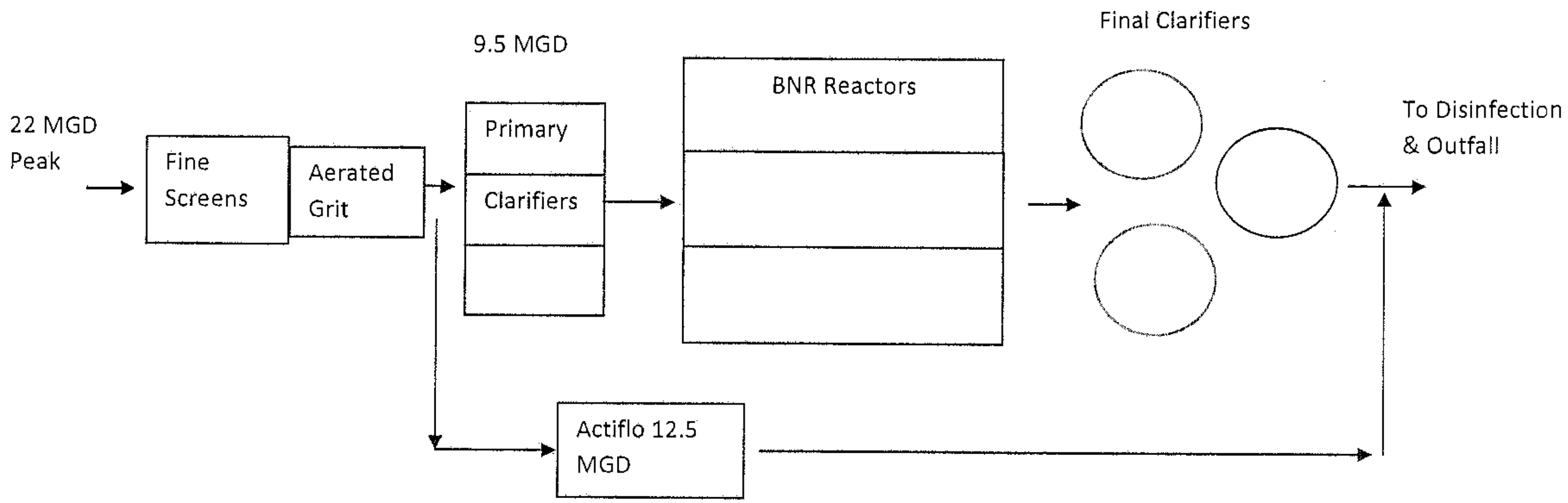
Peter Goodwin, PE	Vice President	Weston & Sampson
Mark Allenwood, PE	Project Manager	Brown and Caldwell
Steven Freedman, PE	Vice President	Brown and Caldwell

APPENDIX B – SCENARIO PROCESS FLOW DIAGRAMS

SCENARIO 1A: PEIRCE ISLAND WASTEWATER TREATMENT FACILITY

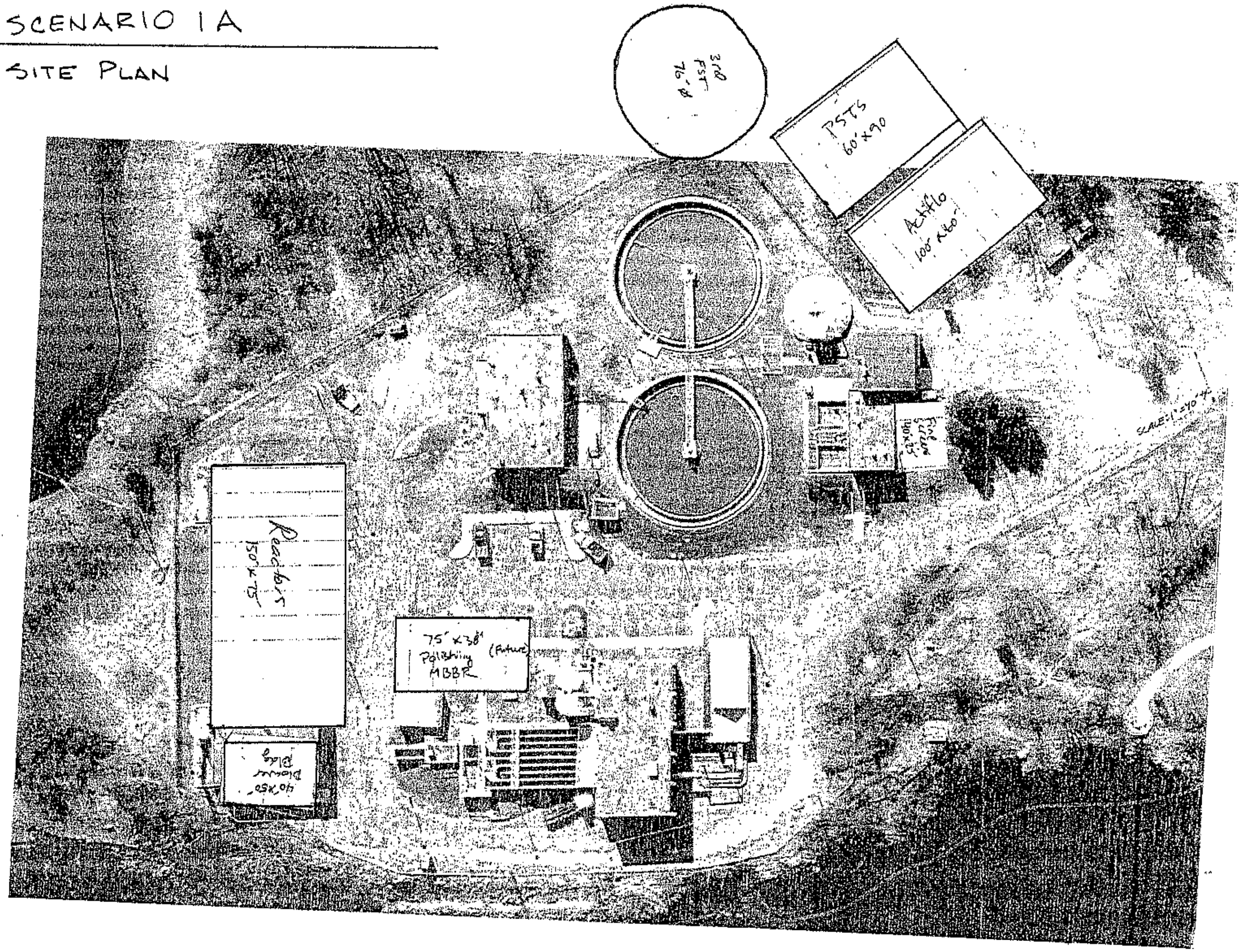
PROCESS FLOW DIAGRAM

TIGHT/SPACE

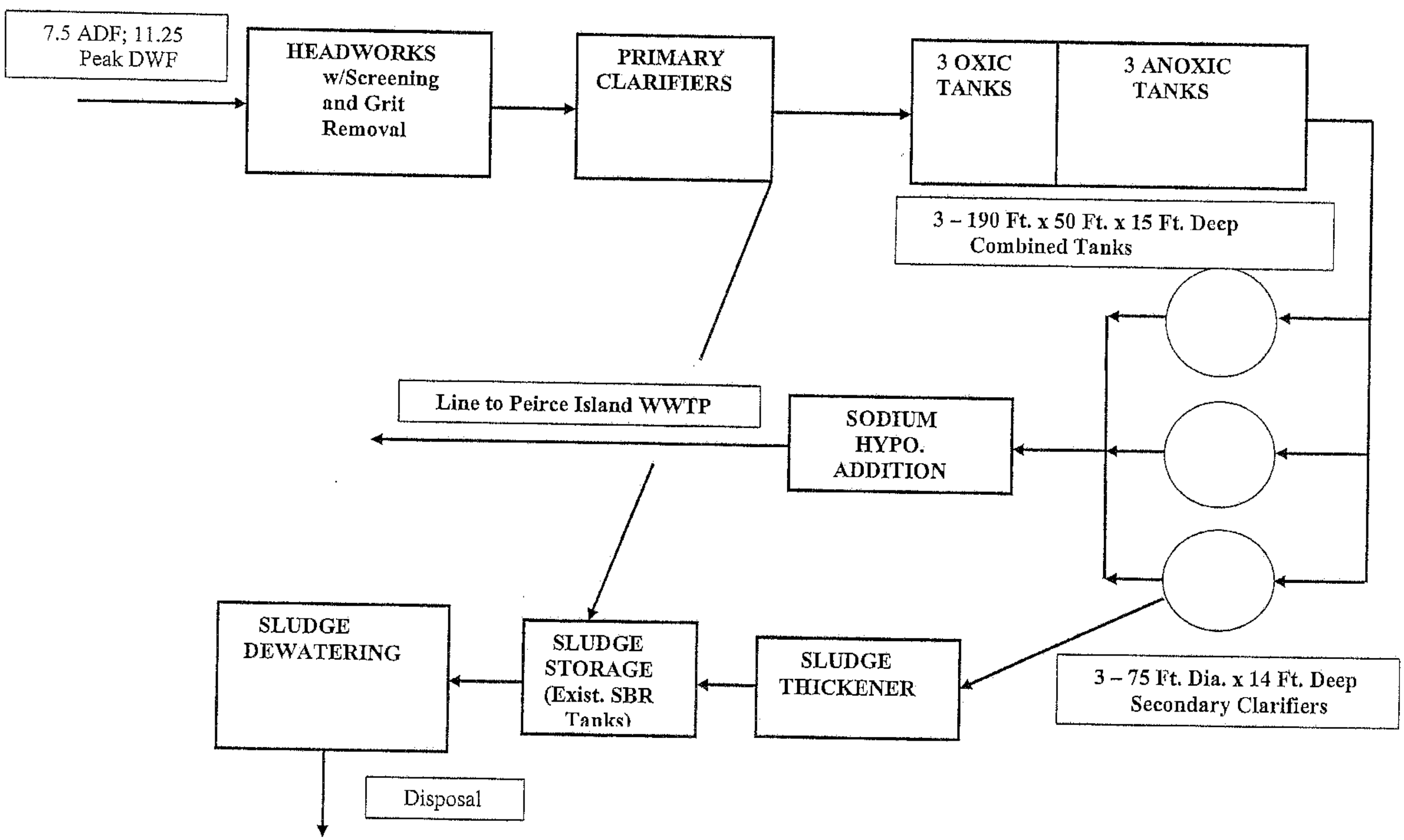


SCENARIO 1A

SITE PLAN



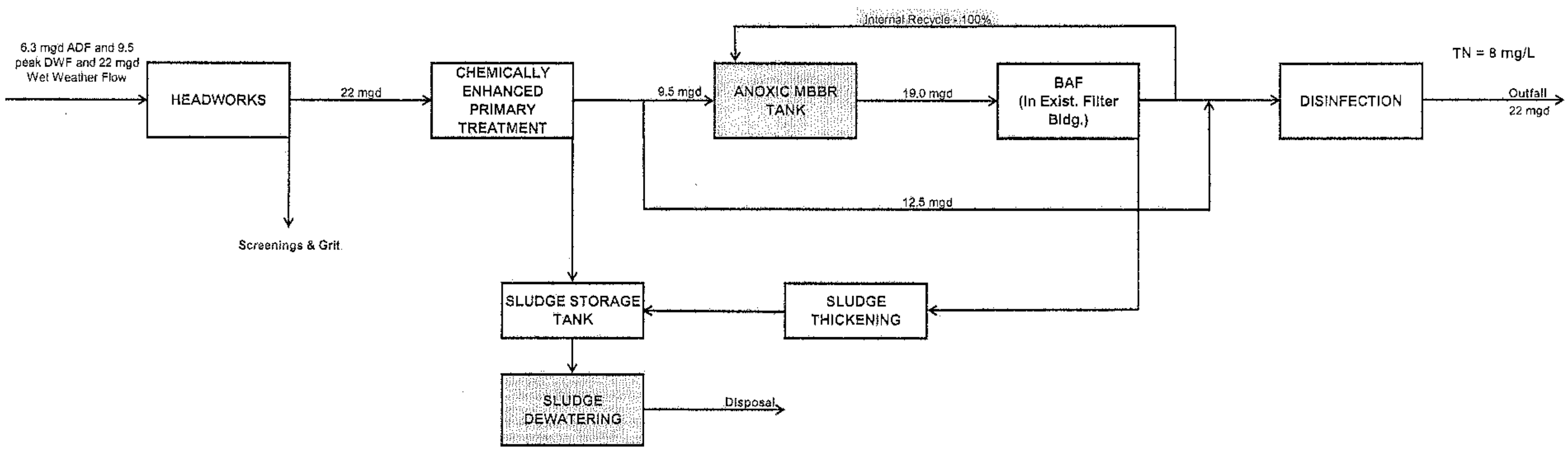
SCENARIO 3A
PEASE TRADEPORT WASTEWATER TREATMENT FACILITY
PROCESS FLOW DIAGRAM



VALUE ENGINEERING SCENARIO

PEIRCE ISLAND WASTEWATER TREATMENT FACILITY

PROCESS FLOW DIAGRAM



VE SCENARIO – VE BAF and Anoxic MBBR Design

MBBR Denitrification MBBR - Nitrification BAF After CEPT

Flow Conditions

6.3 MGD Average

9,45 MGD Peak Conditions

CEPT Effluent Quality & Mass Loading

BOD 50 mg/L	Average 980 kg/Day (Peak 1470 kg/Day)
Estimated COD	Average 1470 kg/Day (Peak 2205 kg/Day)
TSS 50 mg/L	Average 980 kg/Day (Peak 1470 kg/Day)
NH3-N 18 mg/L	Average 352 kg/Day (Peak 528 kg/Day)

BAF Loading Criteria from M&E Text

BOD Removal & Nitrification 4-5 kg COD/M3-day

Nitrification 1.0 – 1.7 kg/M3-day

Available Reactor Volume in Filter Building 135 x 13 x 35 = 61.425 sq ft (8 cells)

Assume 6 Cells On-Line 2 Cells Stand-By

Process Available Reactor Volume = 46,000 cu ft (1303 M3)

COD Loading Rates Nitrification BAF

Average	1.2 kg COD/M3-day
Peak	1.7kg COD/M3-day

N Loading Rates Nitrification BAF

Average	0.3 kg COD/M3-day
Peak	0.4kg COD/M3-day

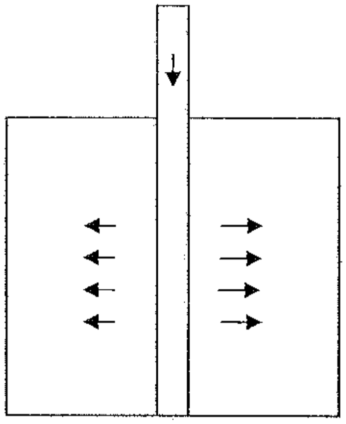
Anoxic MBBR

1 Hour HRT at Peak Flow 1.5 Hour HRT at Average Flow

40% Media Fill Volume (21,000 cu ft) and Sieves	$	0.5M
Tank Sizing 52,600 cu ft (50 x 50 x20)	$	0.4M

Tank Layout

2 – 25 x 50



Horizontal Velocity

Average (2,000 sq ft) – 18 ft/hr (5.5 M/hr)

Peak (2000 sq ft) – 27 ft/hr (8.2 M/hr)

APPENDIX C – SCENARIO COSTS

SCENARIO 1A COSTS

FACILITIES

Flow 6.3 MGD Maximum Month Peak to 9.45 MGD

1. New Fine Screens ¼ inch (25'40') 950 sq ft	$2.0 M
2. New Rectangular Primary Clarifiers – Peak 2000 gpd/sq ft – Need 4725 sq ft	
Average 1200 gpd/sq ft – Need 5250 sq ft	
Cost Based on From Facility Plan $1,5 Million for 10500 sq ft Unburdened	
Need New Primary Clarifiers –3 Clarifiers 20 Wide 90 Long	$0.75M
3. BNR MLE Process New Deep Reactors 10.5 hours HRT Based on Max Month and 7.0 hours HRT Based on Peak 2.5 MG	
Reactors - 3 Trains each (25 X 150 X 30 deep) 30 X 150 X 75	
3a. Anoxic Reactors Anoxic Volume (75 x 45 x 30) Average HRT 3 hours	
Tank Cost $670 per sq ft 30 ft Deep Tank	$ 2.3M
Three Cells per Train 3 Trains Anoxic Mixers – 9 Mixers	$0.05M
3b. Aerobic Volume (75 x 105 x 30) Average HRT 7.5 hours	
Tank Cost $670 per sq ft 30 ft Deep Tank	$ 5.3M
Surface Area – 7825 sq ft Equipment -	$ 0.2M
3c. Internal Pumps 100% (3- 3 MGD Submersible)	$ .15M
3d. RAS Pump Station 100% and Pumps 4-3 MGD	$ 1.2M
3e Blower Building & Blowers	$1.5M
Subtotal BNR	$ 10.7M
4a Existing Clarifiers as Final Clarifiers (Existing 9068 sq ft)	
SOR Peak Flow – 960 gpd/sq ft	
SOR Average Flow – 694 gpd/sq ft	
Rehab Existing Clarifiers	$0.6M

4b One New Clarifiers as Final Clarifiers 76 'Diameter	$ 0.7M
(New Total 13,602 sq ft)	
SOR Peak Flow – 694 gpd/sq ft	
SOR Average Flow – 463 gpd/sq ft	
5 Biosolids Processing Same as Plan	$3.4M
6 Disinfection Improvements	$1.0M
7 Conduits and Channels	$3.0M
8. Odor Control for Headworks & Biosolids Processing Same as Plan	$0.5M
9. Additional Structures	$12.4M
10. Wet Weather	
10a Actiflo (60 X 100) (12.5 MGD) Based on actual Construction Cost	$6.1M
10b Parrot Avenue Debottlenecking	$2.3M
10c Storage Tank (Precast Concrete Box Culvert)	$15.0M
11. PIT Work	$2.0M
Subtotal Unburdened Costs	$32.5M
Burdened	$78.85M
Burdened Cost for Actual Project Estimates	$28.00M
Total Burdened Costs	**$106.9M**

Future TN Polishing at Peirce Island

Anoxic MBBR

11a. Tank

1 Hour HRT at Peak Flow 1.5 Hour HRT at Average Flow

Tank Sizing 52,600 cu ft (75' x 38 ' x 18 ')

11b. 40% Media Fill Volume

Media Volume 21,000 cu ft

11b	$0.5M
Scenario 1A Future Peirce Island	
Subtotal Unburdened Costs	$0.5M
Burdened	$1.0M
Burdened Cost from Actual Project Estimates	$0.5M
Total Burden Costs	**$1.5M**

Cost Estimate Scenerio 3A
MLE Secondary Treatment, PIT Site, 7.5 MGD, TN 8

CAPITAL COST ESTIMATE							
ITEM	QUANTITY INSTALLED	UNIT		UNIT PRICE		AMOUNT	SUBTOTAL
Headworks							
Structure	2500	SF	$	300.00	$	750,000.00	
Equipment:							
Odor Control	1	EA	$	250,000.00	$	362,500.00	
Bar Screens	2	EA	$	250,000.00	$	725,000.00	
Screenings Washer & Compactor	2	EA	$	50,000.00	$	145,000.00	
Grit Pumps	3	EA	$	35,000.00	$	152,250.00	
Vortex Grit Removal	2	EA	$	75,000.00	$	217,500.00	
Grit Classifier & Washer	2	EA	$	40,000.00	$	116,000.00	
							$ 2,098,012.50
Primary Clarifiers							
Structure Renovation (use existing)	4	EA	$	100,000.00	$	400,000.00	
Equipment:	4	EA	$	175,000.00	$	1,015,000.00	
Longitudenal Sludge Collector	1	EA			$	-	
Cross Collector	1	EA			$	-	
Scum Pipes	1	EA			$	-	
							$ 1,415,000.00
Secondary Clarifiers							
Structure (includes Excavation, Backfill and Concrete)	3	EA	$	780,000.00	$	2,340,000.00	
Complete Drive Setups	3	EA	$	135,000.00	$	587,250.00	
							$ 2,927,250.00
Disinfection							
Structure (includes Excavation, Backfill and Concrete)	1	EA			$	-	
Equipment:							
Chemical Storage Tanks	20000	GAL	$	1.00	$	29,000.00	
Chemical Feed Systems	6	EA	$	4,000.00	$	34,800.00	
Mechanical Mixers	4	EA	$	20,000.00	$	116,000.00	
Pierce Island Dechloranation	1	EA	$	50,000.00	$	72,500.00	
							$ 252,300.00
Biosolids Processing							
Structure	0	SF	$	200.00	$	-	Reuse Existing
Equipment:							
Odor Control	1	EA	$	250,000.00	$	362,500.00	
Rotory Drum Thickener	2	EA	$	150,000.00	$	435,000.00	
Dewatering Screw Press	3	EA	$	400,000.00	$	1,740,000.00	
Converyors	2	EA	$	50,000.00	$	145,000.00	
							$ 2,280,125.00
Additional Structures and Modifications							
Lab/Office	1	EA	$	100,000.00	$	100,000.00	Rehab Existing
PE Splitter	2200	SF	$	500.00	$	1,100,000.00	
SE Splitter	2376	SF	$	500.00	$	1,188,000.00	
Pump Building - Demo Existing	1	EA	$	50,000.00	$	50,000.00	
Pump Building	1848	SF	$	200.00	$	369,600.00	
Rehabilitate Shop Building	1	EA	$	500,000.00	$	500,000.00	
Chemical Building Pre-engineered	2500	SF	$	150.00	$	375,000.00	
Odor Control	1	EA	$	250,000.00	$	362,500.00	
Sludge Storage Tank	6400	SF	$	40.00	$	256,000.00	
Garage	2240	SF	$	125.00	$	280,000.00	
Redirect Flow to PI					$	12,000,000.00	
							$ 16,581,100.00
MLE Secondary Treatment							
Structure (includes Excavation, Backfill and Concrete)	1	EA	$	3,280,000.00	$	3,280,000.00	
Equipment:							
Blowers	3	EA	$	300,000.00	$	1,305,000.00	
EDI Fine Bubble Aeration	4	EA	$	75,000.00	$	435,000.00	
Mechanical Mixers	8	EA	$	20,000.00	$	232,000.00	
Internal Recycle	3	EA	$	20,000.00	$	87,000.00	
RAS Pumps (Centrifugal)	5	EA	$	25,000.00	$	181,250.00	
WAS Pumps (Centrifugal)	2	EA	$	20,000.00	$	58,000.00	
							$ 4,741,512.50
ITEM TOTAL							**$ 30,295,300.00**
Yard Piping (20%)							$ 6,059,060.00
Electrical (22%)							$ 6,664,966.00
Instrumentation and Controls (6%)							$ 1,817,718.00
Site Work and Landscaping (10%)							$ 3,029,530.00
TOTAL CAPITAL							**$ 47,866,574.00**
Engineering (20%)							$ 9,573,314.80
Contingency (30%)							$ 14,359,972.20
GRAND TOTAL USE							**$ 72,000,000**

Cost Estimate Scenerio 3A
CSO Treatment at PI

PEIRCE ISLAND CAPITAL COST ESTIMATE					
ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	Subtotal
Headworks					
Structure	2500	SF		$ -	
Equipment:					
Odor Control	1	EA		$ -	
Grit Pumps	3	EA		$ -	
Vortex Grit Removal	2	EA		$ -	
Grit Classifier & Washer	2	EA		$ -	
					$ -
Disinfection					
Structure (includes Excavation, Backfill and Concrete)	1	EA	$ 550,000.00	$ 550,000.00	
Demo Existing	1	EA	$ 250,000.00	$ 250,000.00	
Chemical Storage Tanks	20000	GAL	$ 1.00	$ 29,000.00	
Chemical Feed Systems	6	EA	$ 4,000.00	$ 34,800.00	
Mechanical Mixers	4	EA	$ 20,000.00	$ 116,000.00	
					$ 979,800.00
Additional Structures and Modifications					
PE Splitter - Upstream - Rehab Existing	1	EA	$ 500,000.00	$ 500,000.00	
Primary Clarifier Drive Replacement	2	EA	$ 175,000.00	$ 507,506.00	
Existing Headworks Mods (CEPT Storage)	1	EA	$ 100,000.00	$ 100,000.00	Reuse for CEPT Chemical
Mechanic Street PS Reconstruct	1	EA	$ 5,000,000.00	$ 5,000,000.00	
Outfall Modifications	1	EA	$ 3,000,000.00	$ 3,000,000.00	
					$ 9,107,500.00
ITEM TOTAL					$ 10,087,300.00
Yard Piping (12%)					$ 1,210,476.00
Electrical (22%)					$ 2,219,206.00
Instrumentation and Controls (6%)					$ 605,238.00
Site Work and Landscaping (7%)					$ 706,111.00
Island Construction Premium (15%)					$ 1,513,095.00

TOTAL CAPITAL	$ 16,341,426.00
Engineering (20%)	$ 3,268,285.20
Contingency (30%)	$ 4,902,427.80
TOTALL	**$ 25,000,000.00**

Redirect / Shed	**21,875,000**

GRAND TOTAL	**$ 118,875,000**

Cost Estimate VE Scenerio - (Outside Fence Line)

BAF MBBR Treatment at PI Site (6.3 MGD), TN 8 ----- PIT Site (1.2 MGD) TN 5

PEIRCE ISLAND CAPITAL COST ESTIMATE							
ITEM	QUANTITY	UNIT	UNIT PRICE		AMOUNT	Subtotal	
Headworks							
Structure	2500	SF	$ 300.00	$	750,000.00		
Equipment:							
Odor Control	1	EA	$ 250,000.00	$	362,500.00		
Bar Screens	2	EA	$ 250,000.00	$	725,000.00		
Screenings Washer & Compactor	2	EA	$ 50,000.00	$	145,000.00		
Grit Pumps	3	EA	$ 35,000.00	$	152,250.00		
Vortex Grit Removal	2	EA	$ 75,000.00	$	217,500.00		
Grit Classifier & Washer	2	EA	$ 40,000.00	$	116,000.00		
						$	2,468,250.00
Disinfection							
Structure (includes Excavation, Backfill and Concrete)	1	EA	$ 550,000.00	$	550,000.00		
Demo Existing	1	EA	$ 250,000.00	$	250,000.00		
Equipment:							
Chemical Storage Tanks	20000	GAL	$ 1.00	$	29,000.00		
Chemical Feed Systems	6	EA	$ 4,000.00	$	34,800.00		
Mechanical Mixers	4	EA	$ 20,000.00	$	116,000.00		
						$	979,800.00
Biosolids Processing							
Structure	4800	SF	$ 200.00	$	960,000.00		
Demo Existing Process Building	1	EA	$ 350,000.00	$	350,000.00		
Equipment:							
Odor Control	1	EA	$ 250,000.00	$	362,500.00		
Rotory Drum Thickener	2	EA	$ 150,000.00	$	435,000.00		
Dewatering Screw Press	2	EA	$ 400,000.00	$	1,160,000.00		
Converyors	2	EA	$ 50,000.00	$	145,000.00		
						$	3,412,500.00
Additional Structures							
Lab/Office - Rehab Existing	1	EA	$ 500,000.00	$	500,000.00	Reuse Existing w/expansion	
PE Splitter - Upstream - Rehab Existing	1	EA	$ 500,000.00	$	500,000.00		
PE Splitter - Downstream	2200	SF	$ 500.00	$	1,100,000.00		
Rehab Filter Building	12000	SF	$ 50.00	$	600,000.00	Use for equipment bldg	
Primary Clarifier Drive Replacement	2	EA	$ 175,000.00	$	507,500.00		
Existing Headworks Mods (CEPT Storage)	1	EA	$ 100,000.00	$	100,000.00	Reuse for CEPT Chemical	
Sludge Storage Tank	4360	SF	$ 175.00	$	763,000.00		
Equipment Building	4000	SF	$ 200.00	$	800,000.00	Use Filter Building	
Garage	2240	SF	$ 125.00	$	280,000.00		
Mechanic Street PS Reconstruct	1	EA	$ 5,000,000.00	$	5,000,000.00		
Outfall Modifications	1	EA	$ 3,000,000.00	$	3,000,000.00		
						$	13,150,500.00
BAF Secondary Treatment/Nitrogen Removal							
Structure (includes Excavation, Backfill and Concrete)	1	EA	$ -	$	-		
Equipment:	1	EA		$	3,200,000.00		
Anoxic Tank	1	LS		$	400,000.00		
Cource Bubble Diffusers							
3 PD Blowers IR Pumps	1	LS		$	500,000.00		
						$	4,100,000.00
PI ITEM TOTAL						$	**24,111,050.00**
Yard Piping (12%)						$	2,893,326.00
Electrical (22%)						$	5,304,431.00
Instrumentation and Controls (6%)						$	1,446,663.00
Site Work and Landscaping (7%)						$	1,687,773.50
Island Construction Premium (15%)						$	3,616,657.50
PI TOTAL CAPITAL						$	**39,059,901.00**

TOTAL CAPITAL	$	**39,059,901.00**
Engineering (20%)	$	7,811,980.20
Contingency (30%)	$	11,717,970.30
GRAND TOTAL	**$**	**59,000,000.00**

PIT CAPITAL COST ESTIMATE

ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	Subtotal
Deep Bed Denitrification Filter					
Structure (includes Excavation, Backfill and Concrete)		1 EA		$ 2,000,000.00	
Equipment:					
Internals					
Methanol Storage Tanks 45 day Storage (gal)					
Methanol Feed Systems					
					$ 2,000,000.00
Additional Structures					
Lab/Office		1 EA	$ 100,000.00	$ 100,000.00	Rehab Existing
Rehabilitate Shop Building		1 EA	$ 500,000.00	$ 500,000.00	
					$ 600,000.00
PIT ITEM TOTAL					$ 2,600,000.00
Yard Piping (12%)					$ 312,000.00
Electrical (12%)					$ 312,000.00
Instrumentation and Controls (6%)					$ 156,000.00
Site Work and Landscaping					$ 100,000.00
PIT TOTAL CAPITAL					**$ 3,480,000.00**

Engineering (10%)	$ 348,000.00
Contingency (30%)	$ 1,044,000.00
TOTAL	**$ 4,872,000.00**

Offline Storage Tank (220'X220'X16')		1 LS		$ 15,000,000.00	
Volume 2,900,000 gal.					
Parrot Island Debottelneck				$ 2,300,000.00	
OFF SITE STORAGE TOTAL CAPITAL					**$ 17,300,000.00**

GRAND TOTAL	**$ 81,172,000.00**

Cost Estimate VE Scenerio - Phased Approach (Inside Fence Line at Peirce Island)
BAF/Anoxic MBBR Secondary Treatment at PI Site (6.3 MGD), TN = 8 mg/L PIT Site (1.2 MGD) TN = 5 mg/L

TOTAL CAPITAL COST: $ 78,172,000.00

PEIRCE ISLAND CAPITAL COST ESTIMATE PHASE 1

ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	Subtotal
Headworks					
Structure	2500	SF	$ 300.00	750,000	
Equipment:					
Odor Control	1	EA	$ 250,000.00	362,500	
Bar Screens	2	EA	$ 250,000.00	725,000	
Screenings Washer & Compactor	2	EA	$ 50,000.00	145,000	
Grit Pumps	3	EA	$ 35,000.00	152,250	
Vortex Grit Removal	2	EA	$ 75,000.00	217,500	
Grit Classifier & Washer	2	EA	$ 40,000.00	116,000	
					$ 2,468,250.00
Biosolids Processing					
Rehab Existing Structure	4800	SF	$ 50.00	240,000	
Equipment:					
Odor Control	1	EA	$ 250,000.00	362,500	
Rotory Drum Thickener	2	EA	$ 150,000.00	435,000	
Dewatering Screw Press	2	EA	$ 400,000.00	1,160,000	
Converyors	2	EA	$ 50,000.00	145,000	
					$ 2,342,500.00
Additional Structures					
PE Splitter - Upstream - Rehab Existing	1	EA	$ 300,000.00	300,000	
PE Splitter - Downstream	1	EA	$ 500,000.00	500,000	
Rehab Filter Building	12000	SF	$ 50.00	600,000	Use for equipment bldg
Primary Clarifier Drive Replacement	2	EA	$ 75,000.00	217,500	
Existing Headworks Mods (CEPT Storage)	1	EA	$ 100,000.00	100,000	Reuse for CEPT Chemical
Sludge Storage Tank	4360	SF	$ 175.00	763,000	
Mechanic Street PS Reconstruct	1	EA	$ 5,000,000.00	5,000,000	
					$ 7,480,500.00
BAF Secondary Treatment					
Equipment:	1	EA		3,500,000	
Coarse Bubble Diffusers					
3 PD Blowers					
1 Control System					
					$ 3,500,000.00
PI ITEM TOTAL					**$ 15,791,250.00**
Yard Piping (12%)					$ 1,894,950.00
Electrical (22%)					$ 3,474,075.00
Instrumentation and Controls (6%)					$ 947,475.00
Site Work and Landscaping (7%)					$ 1,105,387.50
Island Construction Premium (15%)					$ 2,368,687.50
PI TOTAL CAPITAL					**$ 25,581,825.00**

TOTAL CAPITAL	**$ 25,581,825.00**
Engineering (20%)	$ 5,116,365.00
Contingency (30%)	$ 7,674,547.50
GRAND TOTAL	**$ 39,000,000.00**

PEIRCE ISLAND CAPITAL COST ESTIMATE PHASE 2

ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	Subtotal
Disinfection					
Structure (includes Excavation, Backfill and Concrete)	1	EA	$ 550,000.00	550,000	
Demo Existing	1	EA	$ 250,000.00	250,000	
Equipment:					
Chemical Storage Tanks	20000	GAL	$ 1.00	29,000	
Chemical Feed Systems	6	EA	$ 4,000.00	34,800	
Mechanical Mixers	4	EA	$ 20,000.00	116,000	
					$ 979,800.00
Additional Structures					
Lab/Office - Rehab Existing	1	EA	$ 500,000.00	500,000	Reuse Existing w/expansion
Sludge Storage Tank	0	SF	$ 175.00	0	
Equipment Building	4000	SF	$ 200.00	800,000	Use Filter Building
Garage	2240	SF	$ 125.00	280,000	
Outfall Modifications	1	EA	$ 3,000,000.00	3,000,000	
					$ 4,580,000.00
BAF Nitrogen Removal					
Equipment:	1	EA			
Anoxic MBBR Tank	1	LS		400,000	
IR Pumps	1	LS		200,000	
Media and Sieves	1	LS		500,000	
					$ 1,100,000.00
PI ITEM TOTAL					**$ 6,659,800.00**
Yard Piping (12%)					$ 799,176.00
Electrical (22%)					$ 1,465,156.00
Instrumentation and Controls (6%)					$ 399,588.00
Site Work and Landscaping (7%)					$ 466,186.00
Island Construction Premium (15%)					$ 998,970.00
PI TOTAL CAPITAL					**$ 10,788,876.00**

TOTAL CAPITAL	**$ 10,788,876.00**
Engineering (20%)	$ 2,157,775.20
Contingency (30%)	$ 3,236,662.80
GRAND TOTAL	**$ 17,000,000.00**

GRAND TOTAL PHASE 1 & 2	**$ 56,000,000.00**

PIT CAPITAL COST ESTIMATE

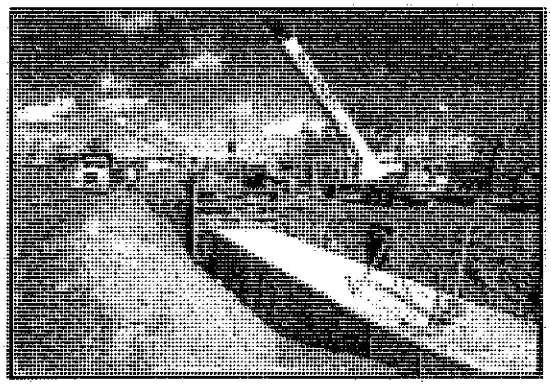
ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	Subtotal
Fabric Filter					
Structure (includes Excavation, Backfill and Concrete)	1	EA		2,000,000	
Equipment:					
					$ 2,000,000.00
Additional Structures					
Lab/Office	1	EA	$ 100,000.00	100,000	Rehab Existing
Rehabilitate Shop Building	1	EA	$ 500,000.00	500,000	
					$ 600,000.00
PIT ITEM TOTAL					$ 2,600,000.00
Yard Piping (12%)					$ 312,000.00
Electrical (12%)					$ 312,000.00
Instrumentation and Controls (6%)					$ 156,000.00
Site Work and Landscaping					$ 100,000.00
PIT TOTAL CAPITAL					$ 3,480,000.00

Engineering (10%)	$ 348,000.00
Contingency (30%)	$ 1,044,000.00
TOTAL	$ 4,872,000.00

Offline Storage Tank (220'X220'X16')	1 LS	15,000,000	
Volume 2,900,000 gal.			
Parrot Avenue Debottleneck		2,300,000	
OFF SITE STORAGE TOTAL CAPITAL			$ 17,300,000.00

GRAND TOTAL	$ 78,172,000.00

APPENDIX D – PRECAST CONCRETE BOX CULVERT STORAGE



Davis Brook CSO Storage Facility in Bangor, Maine

John L. Murphy, PE
James D. Ring, PE
James F. Seiler, PE

City of Bangor Engineering Department
73 Harlow Street
Bangor, ME 04401

The City of Bangor, Maine, with a population of 33,000 people, is located in east central Maine. The development of Bangor occurred initially along the banks of the Penobscot River and the Kenduskeag Stream. By the mid-nineteenth century, the city had grown to 20,000 people, and had evolved into a major trade center. The Penobscot River, connecting the large pine forests to the north and the Atlantic Ocean to the south became the catalyst for the development of Bangor as the largest port in the world for the shipping of lumber in the 1870's.

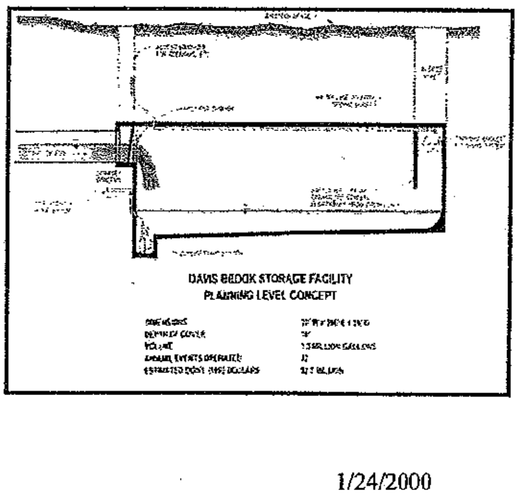
The early sewer records date back to around 1850, a time where cess pools and open ditches were the dominant waste disposal method. As development took place, piped sewers became more common to take residential sewage to the closest brook -- Barkersville Brook, Davis Brook, Sanford Brook, Carr Brook, Meadow Brook, or Arctic Brook. As more and more sewage entered the brooks, the conditions became intolerable, and there were requests for the City to do something about the situation. The solution was to construct large brick pipes in or near the brooks to carry the combined storm and sanitary flows to either the Kenduskeag Stream or the Penobscot River.

By the early 1960s, the Stream and the River were essentially dead, with dissolved oxygen readings of zero. Fishing and water contact recreation were non-existent, and odors were atrocious. In order to alleviate this environmental, health and aesthetic nuisance, Bangor began a multiyear program to collect and treat its wastewater. The City constructed a wastewater treatment plant in 1968, and began construction of a nine-mile interceptor sewer system to collect flows from approximately 25 sewers that discharged wastewater into the Stream and River.

At 22 of these discharge points, Combined Sewer Overflow (CSO) structures were built. Flow exceeding approximately four times the normal dry weather flow during rainfall or snowmelt events overflow untreated into the River and the Stream. In the mid-1980s, CSOs began to be recognized as a significant source of waterway pollution, and policies were developed to address the issue. Since 1987, Bangor has been working on a multi-million dollar program to control Combined Sewer Overflows.

In 1992, a CSO Control Plan was prepared. The Plan identified the most cost effective and water quality effective projects to control CSO discharges. The plan called for a variety of methods, such as sewer separation, treatment plant upgrade, pump station upgrade, overflow structure modification, and storage -- treatment. Sewer separation has been the dominant method of CSO control. To date, the City has expended in excess of $25 million in mostly local funds. Ten of the original twenty-two CSO locations have been eliminated, and CSO activity has been reduced by approximately fifty percent. Projects are scheduled through 2009 and capital expenditures are expected to total in excess of $50 million.

To control CSO discharges in the Davis Brook drainage area of Bangor, the CSO Control Plan recommended the construction of a 1.2 million-gallon storage tank as the preferred method of control. The concept outlined in the CSO Control Plan was a rectangular cast-in-place concrete tank with dimensions of 150 feet long by 70 feet wide by 16 feet high, buried deeply underground.



The tank, through a series of structures and pipes, would capture CSO discharges from the Davis Brook Sewer system. After the overflow event had passed and treatment capacity became available at the wastewater treatment plant, the tank would be pumped out into the interceptor sewer located adjacent to the tank. Included in this storage tank project were washdown facilities, odor control equipment, and the provision for overflow out of the tank should volume of CSO discharge exceed the volume of the tank. The planning level cost estimate was $3.9 million.

Design of this type of storage tank was commenced, with early attention given to subsurface exploration. Several issues of concern were presented to the City at the preliminary design conference. The net result of these issues was a significantly increased estimated cost for the project. The $3.9 million cost estimate had now become a $6.97 million. Bangor City Manager Edward Barrett responded that the City would not spend that amount of money on a CSO storage tank. He then directed the City Engineering Department to find a better, cheaper way to address the Davis Brook CSO discharge issue.

STARTING OVER

So, in early 1996 with a significant amount of geotechnical data that provided lots of reasons not to build the Davis Brook CSO storage tank as originally conceived, the City of Bangor Engineering Department started over.

For the Engineering Department to find a better, cheaper way to do the Davis Brook CSO storage tank, the project would need to be done in a completely different way in order to avoid all of the costly issues that had been identified previously.

NEW SITE

In 1995, additional siting options opened up when the City purchased the adjacent 30-acre switching yard from the Maine Central Railroad.

The City proposed that a part of this property should be reserved for a waterfront park. Siting the tank under the future park area seemed ideal. The existing Davis Brook CSO discharge was located in this area, the tank could be located further away from the river than the previous site, there was no wooden cribwork to deal with, and construction would not disrupt traffic or residents.

NEW DESIGN

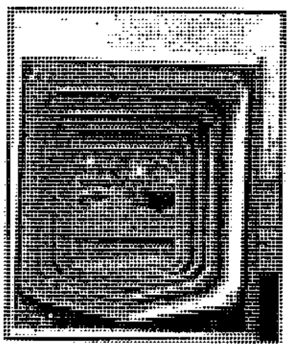
Building the same tank in a different location would solve some but not all of the issues associated with the high costs of the original plan. So the City began to explore other ideas. One idea was the use of pre-cast concrete. Locally, pre-cast concrete has been used for Bangor's parking garage, for building floor systems, for septic tanks, for curbing, for retaining walls, for bridges, for drainage structures, for sewer pipe, and for sewer manhole structures.

Bangor staff talked to local and regional pre-cast companies to see what has been done and what products were available. Practically any shape and size could be supplied provided a crane could lift it and a truck could carry it. Fabricating components for the Davis Brook CSO storage tank off-site, possibly during the winter, then doing the installation during the construction season certainly had much merit. Over a period of several weeks using the City's 40-scale maps and cardboard cutouts, many variations of a 1.2-million gallon tank were composed. After many discussions, a single row of pre-cast sections parallel to the existing 42-inch Penobscot Interceptor along the railroad yard near the river seemed to offer the best solution.

With the concept established, the city went to work on the preliminary design. The size was finalized at 8-feet wide by 9-feet high (inside dimensions) by approximately 2400-feet long, sufficient to provide the recommended volume of 1.2 million gallons. Each pre-cast section would be 5-feet long. There would be rubberized sealant between sections. The sections would be bolted together at all four corners. Access openings would be integral. Bends of 4-degrees in the alignment would be achieved by making one side of selected pre-cast sections 8-inches shorter than the other side.

The proposed new concept essentially addressed the issues associated with deep excavations. With maximum excavation depth calculated at around 13-feet, shoring could be accomplished by trench box. There would be no expensive sheet piling, slurry trench construction or water cut-off walls.

It was envisioned that the facility would operate as a surge tank that would take a wide range of inflow with a more or less constant outflow, storing up to 1.2 million gallons in the process.



City staff discussed solids deposition at great length. Box sections have a flat bottom that spreads out the flow, enhancing solids deposition. For this project, a V-shaped bottom was designed into the project to maintain velocity over a wide range of flows

PRE-CAST DESIGN

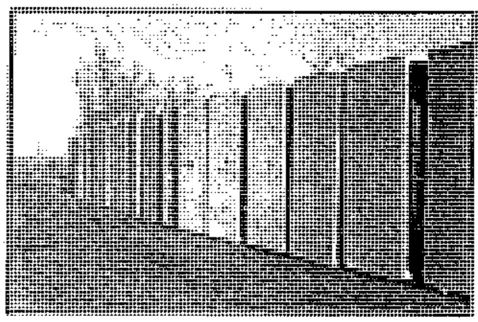
CSO STORAGE TANK OUTLET

Flow control, when required, is by SCADA operated modulating sluice gates at the inlet and outlet of the tank. Generally, control is not expected to be necessary, with operation relying on the outlet capacity of the structure under most conditions. The existing 42-inch interceptor will be retained for additional storage capacity and to allow the tank to be taken out of service if necessary.

The tank has an overflow provision for high flow conditions. Overflows will be monitored for frequency, duration, and volume by ultrasonic equipment located in a small building at the point of overflow

The construction schedule was discussed with several interested contractors. All contractors agreed that eight 5-foot sections per day would be a reasonable expectation, or about 60 working days to install the pre-cast sections. If this time estimate were doubled to include all other aspects of the project, the entire project could be completed in about six months, considerably less than the fifteen-month construction time estimate for the previous design.

It was decided to have the City pre-purchase the pre-cast concrete sections. The fabrication bid was advertised on June 1, 1998 and the bid opening was held on June 10, 1998. American Concrete Industries of Bangor was awarded the contract in the amount of $602,175.



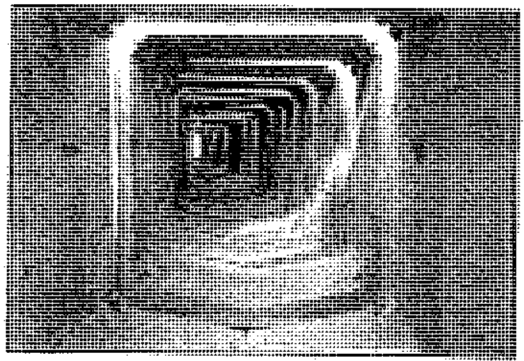
STOCKPILED PRE-CAST UNITS

The construction contract was advertised for bids on July 29, 1998. The bids were opened on August 12, 1998. Bangor contractor Lou Silver submitted the low bid for construction at $617,924.

CONSTRUCTION

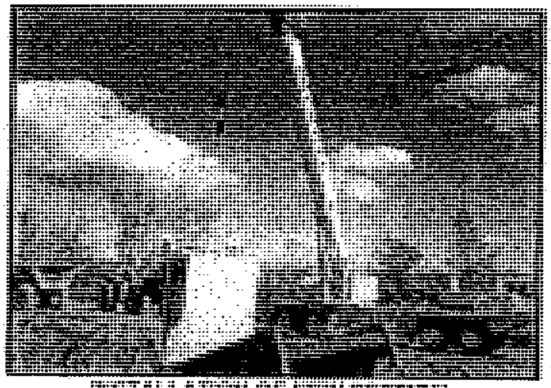
Construction of the Davis Brook CSO Storage Facility began in early September 1998.

The pre-cast sections were manufactured by American Concrete Industries. The company procured three sets of custom designed forms to construct the 8-ft wide by 9-ft high by 5-ft long sections. They were able to produce six sections per day using each form twice daily. The sections were reinforced for H-20 wheel loading, used 5,000 psi concrete, and had steel bolt pockets cast into each corner. ACI provided 1-in thick by 4-in wide flexible butyl resin sealant and 3/4-in stainless steel threaded rods, nuts, and washers to join adjacent sections. Each section weighed 21,000 pounds. Pre-cast sections were delivered to the site two at a time on flatbed trailers. 475 sections were manufactured.



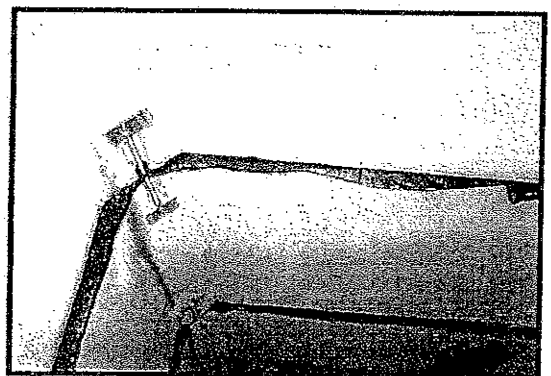
STOCKPILED PRE-CAST UNITS INSIDE VIEW

Construction was by Lou Silver Inc. On a typical day, an excavator dug the trench slightly ahead of the pre-cast installation. Clean excavated materials were used for backfill of the pre-cast sections already installed. Other materials, such as rocks, logs, and materials otherwise not exactly suited for backfill were stockpiled on the site for other uses. Once subgrade was reached, the excavator placed 12 inches of crushed stone in the bottom of the trench. Workers adjusted the grade using lasers. While these activities were taking place, another crew was attaching lifting bolts to a pre-cast section. Then a crane lowered the section into the excavation where workers placed strips of sealant against the face of the tongue end of the section.



INSTALLATION OF NEW SECTION

Once the sealant was in place, the crane placed the section against the previously installed section. Workers using hand-operated hydraulic jacks and a custom designed apparatus that fit into the bottom bolt pockets to pull the sections together. While being held together by jacks at the bottom, the workers bolted the top corners. Then the jacks were removed and the bottom corners were bolted. Twenty sections per day were common.

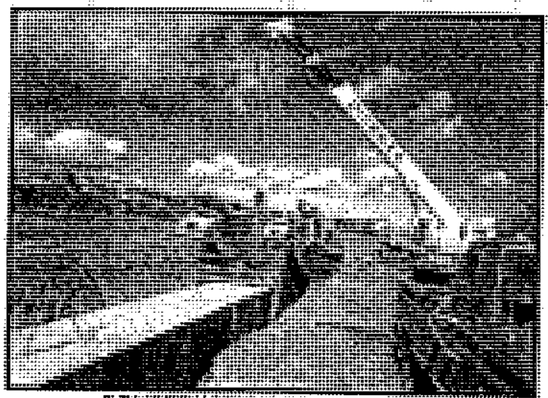


BOLTED JOINT CONNECTION

Crews trimmed the sealant that had been compressed and had extruded into the tank. Also as part of the project, the bottom joints and all bolt pockets were grouted flush with the surface.

All things considered, the project went very well. The site was open, allowing for work to progress rapidly without concern for traffic, residences, businesses, or other issues that usually arise in a built-up area. The site was also large enough to stockpile the estimated 10,000 cubic yards of excess material taken from the excavation. Although anticipated, there were no contaminated soils encountered.

Some initial assumptions proved to be incorrect. It was contemplated that a large backhoe could do both digging and setting the pre-cast sections. However, a large crane was required due to the weight of the sections and the reach required by the width of the excavation. It was thought that perhaps the bolts could be used to pull the sections together. The weight was too much and the threads stripped out on the rods and nuts. The hydraulic jacking equipment was required to pull the sections together. It was thought that the sealant should be installed on the angled face of the tongue. That did not work well, and the contractor found that placing the sealant on the flat face of the tongue worked best. For some undetermined reason, the tunnel tended to creep to the left as progress was made. The contractor adjusted the alignment by periodically installing a double row of sealant on the left side on the pre-cast sections. Tidal intrusion was negligible until the structure reached the old Davis Brook Overflow Tunnel. The new CSO tank crossed the old tunnel, requiring the top of the old tunnel to be removed. The project was then open to the river, and everything flooded at every high tide. (There is a 13 foot elevation difference between high and low tide). The pre-cast tunnel filled approximately 90 percent until the contractor was able to work beyond this point.



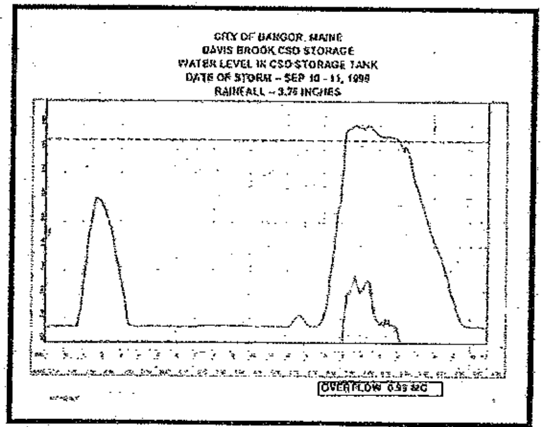
CONSTRUCTION PROGRESSES

Connection of the Davis Brook CSO Storage Facility to the existing system required bypass pumping of flows around the work area.

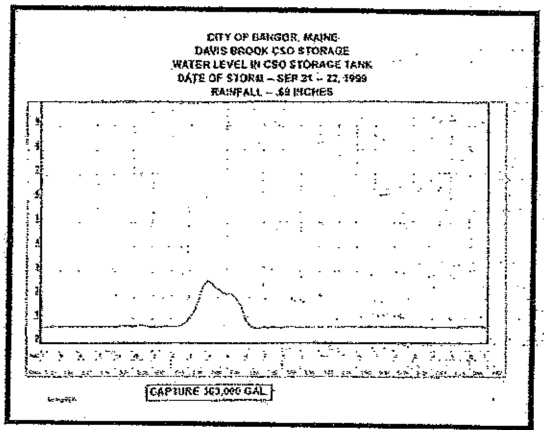
There was an unanticipated bottleneck in the project. The contractor started the project with about 75 pre-cast sections on site with fabrication continuing at six per day. No one expected that the contractor would be able to consistently install twenty sections per day. The contractor caught up with the fabricator and had to suspend installation of the precast sections for a two-week period.

OPERATION

On June 1, 1999, the Davis Brook CSO Tunnel was placed in operation. Approximately 80% of Bangor's sewage now flows through this facility on a continuous basis. Normal daily flows stay in the V-shaped area in the bottom of the facility. Several rain events have shown that the facility is operating as anticipated.



SEPTEMBER 10 - 11, 1999



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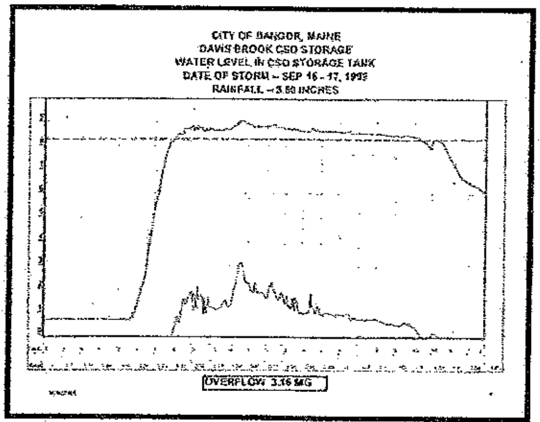

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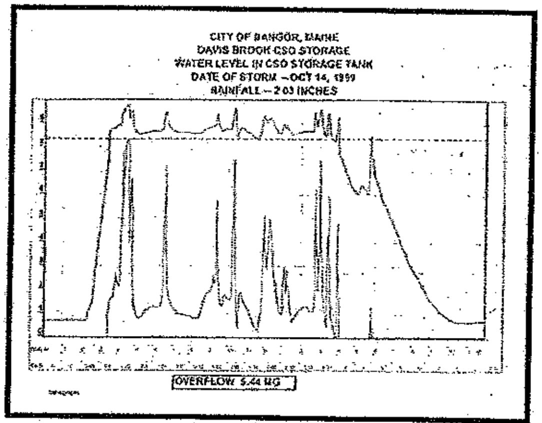

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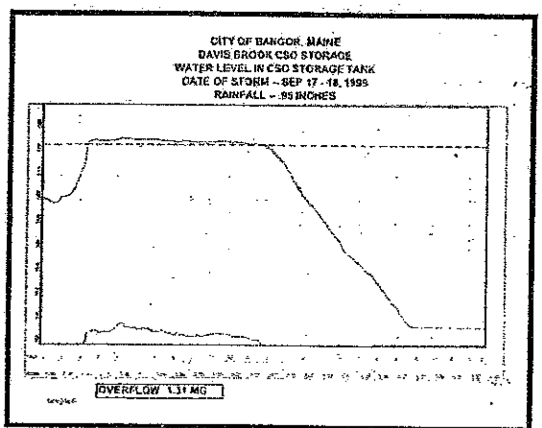

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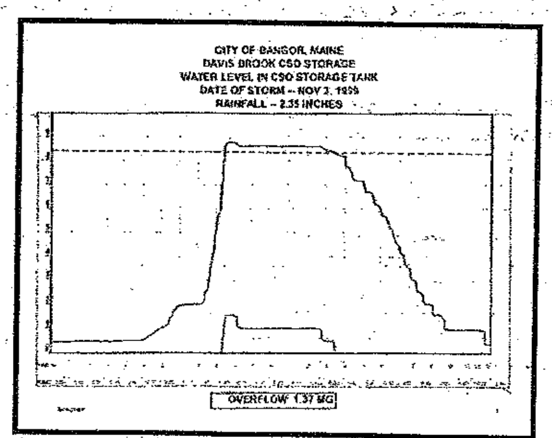
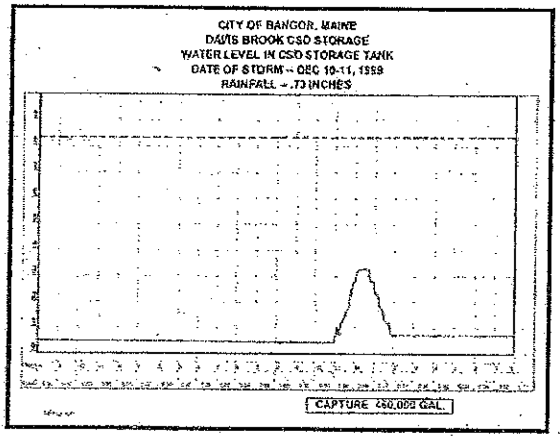
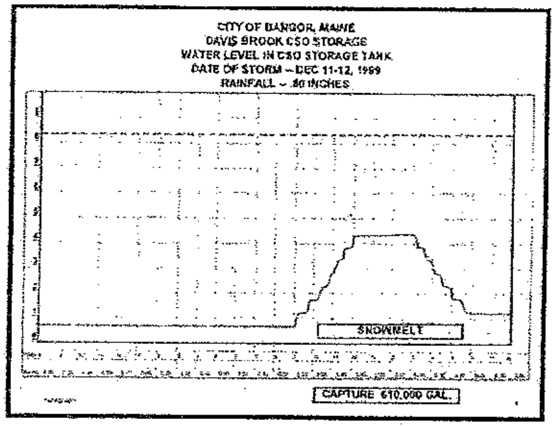


NOVEMBER 3, 1999



DECEMBER 10-11, 1999



DECEMBER 11-12, 1999

The red line on the above charts records the water level in the Davis Brook CSO Storage Facility.

The vertical axis measures feet of depth.

The horizontal axis measures time in hours. A 24-hour range is depicted, generally beginning near the start of the storm event.

The dashed line near the top of the chart represents the height of the overflow weir at the overflow structure. When the red line goes above the dashed line, the tank has filled and an overflow occurs.

The green line records the overflow at an exaggerated scale. The overflow volume is recorded by the SCADA system and is shown below the chart.

Rainfall is recorded on the bottom line of the chart at hourly intervals.

CONCLUSIONS

The concept of a pre-cast concrete storage facility should be of interest to any community considering CSO storage and treatment projects. For the City of Bangor, there have been numerous benefits, some of which are as follows:

- The total cost of this facility will be less than $1.4 million. This is significantly less than either the planning level cost projection of $3.9 million or the preliminary design cost estimate of $6.9 million. Bangor has saved in excess of $5 million by the use of this concept.

- Most of the project funds will provide economic benefit to the LOCAL community.

  The project was conceived and designed LOCALLY by the City of Bangor staff.

  A LOCAL fabricator, American Concrete Industries, manufactured the pre-cast concrete sections.

  A LOCAL contractor, Lou Silver Inc., constructed the project.

- Specialty (foundation, dewatering, and mechanical) contractors were not required.

- The project was constructed in a relatively shallow excavation avoiding expensive shoring and dewatering costs.

- Construction time was less than one construction season, creating virtually no disruption of the activities along Bangor's waterfront.

- A flow-through design eliminated the need for expensive pumps and other sophisticated equipment.

- Only three small structures were required for SCADA control and monitoring equipment.

- The land above the tank will become a waterfront park.