8.0 Cost Analysis

This section provides a summary of the methodology used to prepare the capital, operation and maintenance, and present worth costs for each of the alternatives presented in Section 7. The costs presented are conceptual level planning estimates intended to evaluate the cost effectiveness of the CSO control alternatives.

8.1 Capital Costs

The following references were used to develop the capital costs. All costs are referenced to March 2009 conditions using the *Engineering News Record* Construction Cost Index (ENRCCI) of 8434.

Storage Costs

The following information sources were used for the basis of costs for the storage alternatives:

- US EPA cost equations included in the USEPA Manual for Combined Sewer Overflow Control, September 1993.

- Storage costs developed for CSO Control Plans in Newport RI (1986), Augusta, ME (2006), Indianapolis, IN (2004), Allegheny County Sanitary District, PA (2008) and based on recent construction costs in Milwaukee, WI.

Conveyance and Treatment Costs

The following information sources were used for the basis of costs for various components of the conveyance and treatment alternatives:

- Gravity pipeline, force main pipeline and appurtenance costs were developed based on similar costs for AECOM projects bid in 2007 and 2008 in New England. Cost data from the 2008 edition of the RS Means Construction Cost Manual were also utilized.

- Pumping costs developed for CSO Control Plans in Augusta, ME and Indianapolis, IN as well as pump station costs bid locally in New England.

- Costs for the marine pipeline were based on discussions with marine pipeline construction contractors and on recent projects for AECOM in Miami, FL and Henderson, NC.

- Disinfection costs developed in the USEPA CSO Control Plan Manual and the CSO Control Plans in August, ME and Indianapolis, IN.

Sewer Separation Costs

The following information sources were used as the basis of costs for the sewer separation alternative:

- Costs for the field program elements such as flow metering, building inspections, flow isolation, smoke testing, manhole inspections, dye testing, and cleaning and closed circuit television inspection were based on costs for the work in Newport's Phase 1 Parts 2 and 3 field programs and recent field investigation projects in New England.

- Costs for sewer pipeline rehabilitation and replacement were based on recent projects bid in New England. Costs for catch basin separation were based on the construction costs for the Phase 1 Part 3 Catch Basin Separation project in Newport, RI.

The construction costs for each of the CSO control alternatives were developed based on its specific elements. Table 8.1 includes the factors (as applicable to each CSO control alternative) that were applied to the construction cost to develop the base construction cost.

TABLE 8.1
CONSTRUCTION COST ADJUSTMENT FACTORS TO DEVELOP BASE CONSTRUCTION COST

Factor	Adjustment Percentage
Construction Contingency	25% of Construction Cost
Recreational Improvements (for Centralized and Decentralized Storage Alternatives)	10% of Construction Cost
Mobilization, Bonds, Insurance	5% of Construction Cost
Contractor Overhead and Profit	15% of Construction Cost

After applying these factors, a base construction cost subtotal (BCCS) is established.

Using the base construction cost subtotal, an additional cost equal to 25% of the base construction cost subtotal is added for the costs associated with design engineering, construction engineering and administration. Finally, costs for land acquisition and permitting were estimated as a percentage of the base construction cost subtotal at 10% and 4%, respectively. The cost calculation is shown below.

$$TCC = BCCS + ENG + LA + P, \text{ or}$$

$$TCC = BCCS + 25\%*BCCS + 10\%*BCCS + 4\%*BCCS,$$

Where:

TCC is the Total Construction Cost,
BCCS is the Base Construction Cost Subtotal = Construction costs plus the cost adjustments presented in Table 8.1,
ENG is Design and Construction Engineering costs and Administration costs (25%),
LA is the Land Acquisition cost (10%), and
P is Permitting (4%)

Appendix G includes the cost breakdowns for each of the CSO control alternatives.

8.2 Operation and Maintenance Costs

The additional costs for the CSO alternatives for operation and maintenance include energy consumption, labor requirements, solids handling and disposal, equipment maintenance, and chemical costs. These costs are site-specific and difficult to predict due to the intermittent nature of combined sewer overflows. The operation and maintenance costs are a function of overflow frequency and facility activation, the volume of overflow treated, and the components in each facility. Operation and maintenance costs were based on an average annual overflow frequency of 16 activations and a total volume of 20 million gallons. Unit costs were developed based on discussions with United Water, the system contract operator, for labor and operating costs for the collection system, pump stations, CSO facilities, and at the Newport Water

Pollution Control Plant. For the full separation alternative, it was assumed that there would be no additional operation and maintenance costs associated with the replacement system and that present staffing levels would not change.

8.3 Present Worth Costs

The Present Worth of the annual operation and maintenance costs for each CSO control alternative was estimated using an interest rate of 6% and a 20 year planning period.

8.4 Cost Summary

Costs have been developed for the following CSO control alternatives:

- Centralized Storage;
- Decentralized Storage;
- Conveyance of flow to Long Wharf Pump Station via marine pipeline and treatment at the Water Pollution Control Plant;
- Conveyance of flow to Long Wharf Pump Station via an overland pipeline and treatment at the Water Pollution Control Plant;
- Conveyance directly to WPCP for treatment via a marine pipeline;
- Conveyance directly to the WPCP via an overland pipeline;
- Filed investigations to identify infiltration and inflow sources on private property and sewer separation consisting of replacement of all sewer pipe in the system; and
- Field investigations, sewer separation to eliminate 30% of infiltration and inflow, and storage.

Table 8.2 presents the significant unit prices used to develop costs for the preceding CSO control alternatives.

TABLE 8.2
UNIT COSTS

Item	Unit	Unit Cost
Centralized Storage	Per Million Gallons Stored	$4
Decentralized Storage	Per Million Gallons Stored	$5
Wet Weather Pumping for Conveyance to WPCP	Per Million Gallons	$300,000
Sub-aqueous Force Main to Long Wharf PS/WPCP	Per Linear Foot	$3,000
Overland Force Main to Long Wharf Pump Station	Per Linear Foot	$1,000
Overland Force Main to WPCP	Per Linear Foot	$2,000*
Reconfiguration of the Wellington Avenue Microstrainer Chamber	Lump Sum	$750,000
Modifications to Effluent Pumping at WPCP	Per Million Gallons	$250,000
Disinfection Modifications at WPCP	Per Million Gallons	$55,000
Slip Lining of Sewer Pipes	Per Linear Foot	$85
Replacement of Sewer Pipes	Per Linear Foot	$400
Catch Basin Disconnection	Each	$60,000

*Additional construction cost for the overland force main to the WPCP is to account for crossing Route 138 and the portion of the route parallel to the railroad corridor between Route 138 and the WPCP.

Table 8.3 presents a summary of the costs for the CSO control alternatives. Appendix G includes the cost break down for each alternative.

Table 8.3
Cost Estimates for CSO Control Alternatives

CSO Control Alternative	Construction Cost	Engineering and Administration Cost	Inflow/Infiltration Sewer System Evaluation Study Costs	Other Costs	Total Capital Cost	Annual Operation and Maintenance Cost	Present Worth Cost Operation and Maintenance	Total Present Worth Cost
Centralized Storage	$45.0M	$12.8M	$0	$2.3M	$60.1M	$27,500	$315,000	$60.4M
Decentralized Storage	$79.5M	$21.9M	$0	$4.0M	$105.4M	$37,800	$435,000	$105.8M
Conveyance to Long Wharf- Marine Route	$59.8M	$18.0M	$0	$0	$77.8M	$52,300	$600,500	$78.3M
Conveyance to Long Wharf- Overland Route	$52.5M	$15.2M	$0	$0	$68.0M	$52,300	$600,500	$66.4M
Conveyance to WPCP - Marine Route	$88.7M	$25.7M	$0	$0	$114.4M	$51,800	$594,000	$115.0M
Conveyance to WPCP - Overland Route	$65.0M	$18.8M	$0	$0	$83.7M	$51,800	$594,000	$84.3M
Sewer Separation: Full Replacement	$152.7M	$13.4M	$0.4M	0	$166.5M	$0	$0	$166.5M
Sewer Separation and Storage	$46.4M	$12.2M	$2.1M	$0.8M	$61.5M	$15,300	$175,000	$61.7M

8.5 Knee-of -the Curve Analysis

As discussed in EPA's document EPA/625/R-93/007 Manual: Combined Sewer Overflow Control, a knee-of-the-curve analysis can be performed on a particular CSO control. The knee-of-the-curve analysis is developed based on the range of design capacities and costs plotted against corresponding performance levels; in this case, capture of larger CSO events than the largest storm in the typical year. As noted in EPA's guidance document, the cost of storage generally will increase uniformly as performance levels increase. However, space availability and other site issues will likely place an upper limit on the total volume of storage that could be provided.

Table 8.4 presents the design storm events that were simulated in the model for the Wellington Avenue CSO Facility in order to generate the knee-of-the-curve data:

TABLE 8.4
DESIGN STORMS

Frequency of Storm (Year, 24-hour duration)	Peak Intensity (in/hour)	Total Rainfall (in)
1	1.1	2.7
2	1.3	3.4
5	1.7	4.4
10	2.1	5.0
20	2.23	5.5
25	2.3	5.8
50	2.6	6.4
100	3.0	7.2

The model was simulated for each of these design storms to determine the volume of CSO at the Wellington Avenue CSO Facility. Table 8.5 presents the results and associated costs of storage for the simulated design storms.

TABLE 8.5
DESIGN STORM SIMULATION RESULTS

Design Storm (Year)	Wellington Avenue CSO Facility Overflow Volume (MG)	Estimated Capital Cost ($Mil)
1	6.33	59.5
2	9.17	83.9
5	13.57	121.8
10	16.25	144.8
20	18.66	165.5
25	19.86	175.9
50	22.62	199.5
100	26.34	231.6

Figure 8.1 presents the knee-of-the-curve plot for costs associated with construction of larger volumes of storage.

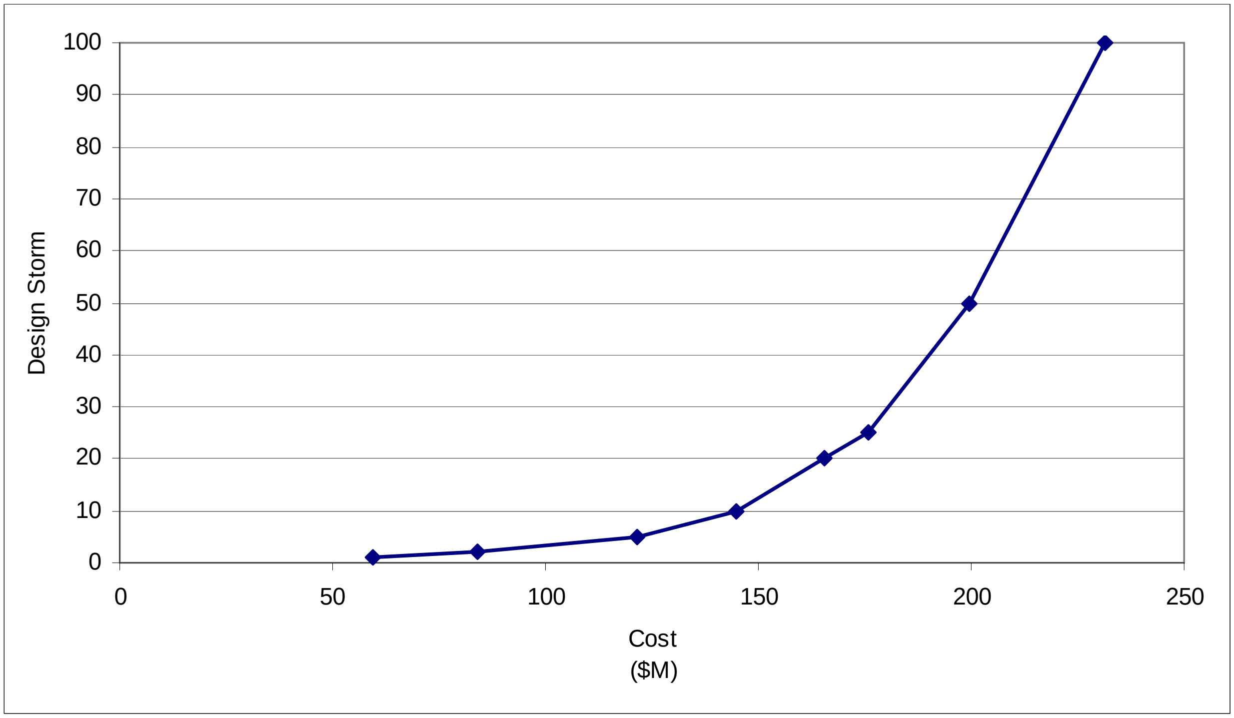

Figure 8.1
Knee-of-the Curve Analysis

Review of Figure 8.1 indicates that costs to achieve a higher level of performance (i.e. larger design storm) begin to increase significantly beginning at the 2-year storm. Therefore, with respect to the storage alternative, it appears that design for the 1-year storm, which is equivalent to the largest storm in the typical year of 1996, is reasonable. However, as noted in Table 8.3, the most cost-effective alternative appears to be a combination of sewer separation and storage.