Notice of Intent

Muddy River Flood Damage Reduction and Environmental Restoration Project Phase 1

Contents

Form WPA 3

Provided by MassDEP:

MassDEP File Number

Document Transaction Number

Boston
City/Town

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.

Note: Before completing this form consult your local Conservation Commission regarding any municipal bylaw or ordinance.

A. General Information

1. Project Location (**Note:** electronic filers will click on button to locate project site):

Riverway and Back Bay Fens	Boston	02118
a. Street Address	b. City/Town	c. Zip Code

Latitude and Longitude: 42 20 34.407 (d. Latitude) 71 6 10.301 (e. Longitude)

f. Assessors Map/Plat Number: 0401994000, 0504175000, 0401994002, 0401994001

2. Applicant:

a. First Name: Antonia
b. Last Name: Pollak
c. Organization: Boston Department of Parks and Recreation
d. Street Address: 1010 Massachusetts Avenue
e. City/Town: Boston
f. State: MA
g. Zip Code: 02118
h. Phone Number: 617-635-4989
i. Fax Number: 617-635-4063
j. Email Address: toni.pollak@cityofboston.gov

3. Property owner (required if different from applicant): ☒ Check if more than one owner

a. First Name: Jack
b. Last Name: Murray
c. Organization: owned in part by the Department of Conservation and Recreation (see attached)
d. Street Address: 251 Causeway Street
e. City/Town: Boston
f. State: MA
g. Zip Code: 02114
h. Phone Number: 617-626-4992
i. Fax Number:
j. Email address: jack.murray@state.ma.us

4. Representative (if any):

a. First Name: Margaret
b. Last Name: Dyson
c. Company: Boston Department of Parks and Recreation
d. Street Address: 1010 Massachusetts Avenue
e. City/Town: Boston
f. State: MA
g. Zip Code: 01568
h. Phone Number: 617-961-3028
i. Fax Number: 617-635-3256
j. Email address: margaret.dyson@cityofboston.gov

5. Total WPA Fee Paid (from NOI Wetland Fee Transmittal Form):

a. Total Fee Paid: N.A.
b. State Fee Paid: N.A.
c. City/Town Fee Paid: N.A.

A. General Information (continued)

6. General Project Description:

The City of Boston, Town of Brookline, Massachusetts DCR and the U.S. Army Corps of Engineers-New England District (Corps) are proposing to construct a flood control and environmental restoration project in the Muddy River. Phase I of the Project will daylight approximately 700 feet of the Muddy River and restore a portion of the Back Bay Fens known as the Upper Fens Pond. See attached.

7a. Project Type Checklist:

1. ☐ Single Family Home
2. ☐ Residential Subdivision
3. ☐ Limited Project Driveway Crossing
4. ☐ Commercial/Industrial
5. ☐ Dock/Pier
6. ☐ Utilities
7. ☐ Coastal Engineering Structure
8. ☐ Agriculture (e.g., cranberries, forestry)
9. ☐ Transportation
10. ☒ Other

7b. Is any portion of the proposed activity eligible to be treated as a limited project subject to 310 CMR 10.24 (coastal) or 310 CMR 10.53 (inland)?

1. ☐ Yes ☒ No If yes, describe which limited project applies to this project:

10.53(4): projects which will improve the natural capacity of a resource area(s) to protect the interests identified in M.G.L. c. 131, § 40

8. Property recorded at the Registry of Deeds for:

Suffolk - Ch 185 Acts of 1875 and Ch 403 Acts of 1954

b. Certificate # (if registered land)

c. Book

d. Page Number

B. Buffer Zone & Resource Area Impacts (temporary & permanent)

1. ☐ Buffer Zone Only – Check if the project is located only in the Buffer Zone of a Bordering Vegetated Wetland, Inland Bank, or Coastal Resource Area.
2. ☒ Inland Resource Areas (see 310 CMR 10.54-10.58; if not applicable, go to Section B.3, Coastal Resource Areas).

Check all that apply below. Attach narrative and any supporting documentation describing how the project will meet all performance standards for each of the resource areas altered, including standards requiring consideration of alternative project design or location.

For all projects affecting other Resource Areas, please attach a narrative explaining how the resource area was delineated.

Resource Area	Size of Proposed Alteration	Proposed Replacement (if any)
a. ☒ Bank	1750 1. linear feet	1750 (restored); 2470 (new) 2. linear feet
b. ☐ Bordering Vegetated Wetland	4850 (loss); 1520 (altered) 1. square feet	27,670 net gain 2. square feet
c. ☒ Land Under Waterbodies and Waterways	875 1. linear feet 4845 3. cubic yards dredged	875 2. linear feet

B. Buffer Zone & Resource Area Impacts (temporary & permanent) (cont'd)

Resource Area	Size of Proposed Alteration	Proposed Replacement (if any)
d. ☒ Bordering Land Subject to Flooding	261,000 1. square feet	261,000 2. square feet
	0 3. cubic feet of flood storage lost	4. cubic feet replaced
e. ☐ Isolated Land Subject to Flooding	0 1. square feet	
	0 2. cubic feet of flood storage lost	0 3. cubic feet replaced
f. ☒ Riverfront Area	Muddy River 1. Name of Waterway (if available)	

2. Width of Riverfront Area (check one):

☒ 25 ft. - Designated Densely Developed Areas only

☐ 100 ft. - New agricultural projects only

☐ 200 ft. - All other projects

3. Total area of Riverfront Area on the site of the proposed project: 45,100 (existing); 90,700 (proposed)

4. Proposed alteration of the Riverfront Area:

45,100 a. total square feet	b. square feet within 100 ft.	c. square feet between 100 ft. and 200 ft.

5. Has an alternatives analysis been done and is it attached to this NOI? ☒ Yes ☐ No

6. Was the lot where the activity is proposed created prior to August 1, 1996? ☒ Yes ☐ No

3. ☐ Coastal Resource Areas: (See 310 CMR 10.25-10.35)

Check all that apply below. Attach narrative and supporting documentation describing how the project will meet all performance standards for each of the resource areas altered, including standards requiring consideration of alternative project design or location.

Online Users: Include your document transaction number (provided on your receipt page) with all supplementary information you submit to the Department.

Resource Area	Size of Proposed Alteration	Proposed Replacement (if any)
a. ☐ Designated Port Areas	Indicate size under Land Under the Ocean, below	
b. ☐ Land Under the Ocean	1. square feet	
	2. cubic yards dredged	
c. ☐ Barrier Beach	Indicate size under Coastal Beaches and/or Coastal Dunes below	
d. ☐ Coastal Beaches	1. square feet	2. cubic yards beach nourishment
e. ☐ Coastal Dunes	1. square feet	2. cubic yards dune nourishment

B. Buffer Zone & Resource Area Impacts (temporary & permanent) (cont'd)

		Size of Proposed Alteration	Proposed Replacement (if any)
f. ☐	Coastal Banks	1. linear feet	
g. ☐	Rocky Intertidal Shores	1. square feet	
h. ☐	Salt Marshes	1. square feet	2. sq ft restoration, rehab., creation
i. ☐	Land Under Salt Ponds	1. square feet 2. cubic yards dredged	
j. ☐	Land Containing Shellfish	1. square feet	
k. ☐	Fish Runs	Indicate size under Coastal Banks, inland Bank, Land Under the Ocean, and/or inland Land Under Waterbodies and Waterways, above 1. cubic yards dredged	
l. ☐	Land Subject to Coastal Storm Flowage	1. square feet	

4. ☒ Restoration/Enhancement
If the project is for the purpose of restoring or enhancing a wetland resource area in addition to the square footage that has been entered in Section B.2.b or B.3.h above, please enter the additional amount here.

5880 (impact)
a. square feet of BVW

b. square feet of Salt Marsh

C. Other Applicable Standards and Requirements

Streamlined Massachusetts Endangered Species Act/Wetlands Protection Act Review

1. Is any portion of the proposed project located in **Estimated Habitat of Rare Wildlife** as indicated on the most recent Estimated Habitat Map of State-Listed Rare Wetland Wildlife published by the Natural Heritage and Endangered Species Program (NHESP)? To view habitat maps, see the *Massachusetts Natural Heritage Atlas* or go to http://www.mass.gov/dfwele/dfw/nhesp/nhregmap.htm.

a. ☐ Yes ☒ No **If yes, include proof of mailing or hand delivery of NOI to:**

Natural Heritage and Endangered Species Program
Division of Fisheries and Wildlife
Route 135, North Drive
Westborough, MA 01581

b. Date of map

If *yes*, the project is also subject to Massachusetts Endangered Species Act (MESA) review (321 CMR 10.18). To qualify for a streamlined, 30-day, MESA/Wetlands Protection Act review, please complete Section C.1.C, and include requested materials with this Notice of Intent (NOI); *OR* complete Section C.1.d, if applicable. *If MESA supplemental information is not included with the NOI, by completing Section 1 of this form, the NHESP will require a separate MESA filing which may take up to 90 days to review (unless noted exceptions in Section 2 apply, see below).*

C. Other Applicable Standards and Requirements (cont'd)

1. c. Submit Supplemental Information for Endangered Species Review *

1. ☐ Percentage/acreage of property to be altered:

(a) within wetland Resource Area ______ percentage/acreage

(b) outside Resource Area ______ percentage/acreage

2. ☐ Assessor's Map or right-of-way plan of site

3. ☐ Project plans for entire project site, including wetland resource areas and areas outside of wetlands jurisdiction, showing existing and proposed conditions, existing and proposed tree/vegetation clearing line, and clearly demarcated limits of work **

(a) ☐ Project description (including description of impacts outside of wetland resource area & buffer zone)

(b) ☐ Photographs representative of the site

(c) ☐ MESA filing fee (fee information available at: http://www.mass.gov/dfwele/dfw/nhesp/nhenvmesa.htm)
Make check payable to "Natural Heritage & Endangered Species Fund" and ***mail to NHESP*** at above address

*Projects altering **10 or more acres** of land, also submit:*

(d) ☐ Vegetation cover type map of site

(e) ☐ Project plans showing Priority & Estimated Habitat boundaries

d. OR Check One of the Following

1. ☐ Project is exempt from MESA review.
Attach applicant letter indicating which MESA exemption applies. (See 321 CMR 10.14, http://www.mass.gov/dfwele/dfw/nhesp/nhenvexemptions.htm; the NOI must still be sent to NHESP if the project is within estimated habitat pursuant to 310 CMR 10.37 and 10.59.)

2. ☐ Separate MESA review ongoing.

a. NHESP Tracking Number ______ b. Date submitted to NHESP ______

3. ☐ Separate MESA review completed.
Include copy of NHESP "no Take" determination or valid Conservation & Management Permit with approved plan.

* Some projects **not** in Estimated Habitat may be located in Priority Habitat, and require NHESP review (see www.nhesp.org regulatory review tab). Priority Habitat includes habitat for state-listed plants and strictly upland species not protected by the Wetlands Protection Act.

** MESA projects may not be segmented (321 CMR 10.16). The applicant must disclose full development plans even if such plans are not required as part of the Notice of Intent process.

C. Other Applicable Standards and Requirements (cont'd)

2. For coastal projects only, is any portion of the proposed project located below the mean high water line or in a fish run?

a. ☒ Not applicable – project is in inland resource area only

b. ☐ Yes ☐ No If yes, include proof of mailing or hand delivery of NOI to either:

South Shore - Cohasset to Rhode Island, and the Cape & Islands:

Division of Marine Fisheries -
Southeast Marine Fisheries Station
Attn: Environmental Reviewer
838 South Rodney French Blvd.
New Bedford, MA 02744

North Shore - Hull to New Hampshire:

Division of Marine Fisheries -
North Shore Office
Attn: Environmental Reviewer
30 Emerson Avenue
Gloucester, MA 01930

Also if yes, the project may require a Chapter 91 license. For coastal towns in the Northeast Region, please contact MassDEP's Boston Office. For coastal towns in the Southeast Region, please contact MassDEP's Southeast Regional Office.

3. Is any portion of the proposed project within an Area of Critical Environmental Concern (ACEC)?

Online Users: Include your document transaction number (provided on your receipt page) with all supplementary information you submit to the Department.

a. ☐ Yes ☒ No If yes, provide name of ACEC (see instructions to WPA Form 3 or MassDEP Website for ACEC locations). **Note:** electronic filers click on Website.

b. ACEC

4. Is any portion of the proposed project within an area designated as an Outstanding Resource Water (ORW) as designated in the Massachusetts Surface Water Quality Standards, 314 CMR 4.00?

a. ☐ Yes ☐ No

5. Is any portion of the site subject to a Wetlands Restriction Order under the Inland Wetlands Restriction Act (M.G.L. c. 131, § 40A) or the Coastal Wetlands Restriction Act (M.G.L. c. 130, § 105)?

a. ☐ Yes ☒ No

6. Is this project subject to provisions of the MassDEP Stormwater Management Standards?

a. ☒ Yes. Attach a copy of the Stormwater Report as required by the Stormwater Management Standards per 310 CMR 10.05(6)(k)-(q) and check if:

1. ☐ Applying for Low Impact Development (LID) site design credits (as described in Stormwater Management Handbook Vol. 2, Chapter 3)

2. ☒ A portion of the site constitutes redevelopment

3. ☐ Proprietary BMPs are included in the Stormwater Management System.

b. ☐ No. Check why the project is exempt:

1. ☐ Single-family house

2. ☐ Emergency road repair

3. ☐ Small Residential Subdivision (less than or equal to 4 single-family houses or less than or equal to 4 units in multi-family housing project) with no discharge to Critical Areas.

D. Additional Information

Applicants must include the following with this Notice of Intent (NOI). See instructions for details.

Online Users: Attach the document transaction number (provided on your receipt page) for any of the following information you submit to the Department.

1. ☒ USGS or other map of the area (along with a narrative description, if necessary) containing sufficient information for the Conservation Commission and the Department to locate the site. (Electronic filers may omit this item.)

2. ☒ Plans identifying the location of proposed activities (including activities proposed to serve as a Bordering Vegetated Wetland [BVW] replication area or other mitigating measure) relative to the boundaries of each affected resource area.

3. ☒ Identify the method for BVW and other resource area boundary delineations (MassDEP BVW Field Data Form(s), Determination of Applicability, Order of Resource Area Delineation, etc.), and attach documentation of the methodology.

4. ☒ List the titles and dates for all plans and other materials submitted with this NOI.

Muddy River Flood Damage Reduction and Environmental Restoration Project
a. Plan Title

Army Corps of Engineers - New England
b. Prepared By

c. Signed and Stamped by

11/21/08
d. Final Revision Date

varies
e. Scale

Narrative; Photographs
f. Additional Plan or Document Title

11/24/08
g. Date

5. ☒ If there is more than one property owner, please attach a list of these property owners not listed on this form.

6. ☐ Attach proof of mailing for Natural Heritage and Endangered Species Program, if needed.

7. ☐ Attach proof of mailing for Massachusetts Division of Marine Fisheries, if needed.

8. ☐ Attach NOI Wetland Fee Transmittal Form

9. ☒ Attach Stormwater Report, if needed.

E. Fees

1. ☒ Fee Exempt: No filing fee shall be assessed for projects of any city, town, county, or district of the Commonwealth, federally recognized Indian tribe housing authority, municipal housing authority, or the Massachusetts Bay Transportation Authority.

Applicants must submit the following information (in addition to pages 1 and 2 of the NOI Wetland Fee Transmittal Form) to confirm fee payment:

2. Municipal Check Number

3. Check date

4. State Check Number

5. Check date

6. Payor name on check: First Name

7. Payor name on check: Last Name

F. Signatures and Submittal Requirements

I hereby certify under the penalties of perjury that the foregoing Notice of Intent and accompanying plans, documents, and supporting data are true and complete to the best of my knowledge. I understand that the Conservation Commission will place notification of this Notice in a local newspaper at the expense of the applicant in accordance with the wetlands regulations, 310 CMR 10.05(5)(a).

I further certify under penalties of perjury that all abutters were notified of this application, pursuant to the requirements of M.G.L. c. 131, § 40. Notice must be made by Certificate of Mailing or in writing by hand delivery or certified mail (return receipt requested) to all abutters within 100 feet of the property line of the project location.

Antonia M Pollak — 1/21/09
1. Signature of Applicant — 2. Date

Antonia M Pollak — 1/21/09
3. Signature of Property Owner (if different) Boston Parks and Recreation Dept — 4. Date

1/21/09
~~5. Signature of Representative (if any)~~ — 6. Date
3.b. Signature of Property Owner - Department of Conservation and Recreation

For Conservation Commission:
Two copies of the completed Notice of Intent (Form 3), including supporting plans and documents, two copies of the NOI Wetland Fee Transmittal Form, and the city/town fee payment, to the Conservation Commission by certified mail or hand delivery.

For MassDEP:
One copy of the completed Notice of Intent (Form 3), including supporting plans and documents, one copy of the NOI Wetland Fee Transmittal Form, and a **copy** of the state fee payment to the MassDEP Regional Office (see Instructions) by certified mail or hand delivery.

Other:
If the applicant has checked the "yes" box in any part of Section C, Item 3, above, refer to that section and the Instructions for additional submittal requirements.

The original and copies must be sent simultaneously. Failure by the applicant to send copies in a timely manner may result in dismissal of the Notice of Intent.

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands
NOI Wetland Fee Transmittal Form
Massachusetts Wetlands Protection Act M.G.L. c. 131, §40

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.

A. Applicant Information

1. Applicant:

Antonia	Pollak
a. First Name	b. Last Name

Boston Parks and Recreation Department
c. Organization

1010 Massachusetts Ave
d. Mailing Address

Boston	MA	02118
e. City/Town	f. State	g. Zip Code

617-635-4989		toni.pollak@cityofboston.gov
h. Phone Number	i. Fax Number	j. Email Address

2. Property Owner (if different):

Jack	Murray
a. First Name	b. Last Name

owned in part by Massachusetts Department of Conservation and Recreation
c. Organization

251 Causeway Street
d. Mailing Address

Boston	MA	02114
e. City/Town	f. State	g. Zip Code

617-626-4992		jack.murray@state.ma.us
h. Phone Number	i. Fax Number	j. Email Address

3. Project Location:

Riverway and Back Bay Fens	Boston
a. Street Address	b. City/Town

B. Fees

To calculate filing fees, refer to the category fee list and examples in the instructions for filling out WPA Form 3 (Notice of Intent).

The fee should be calculated using the following six-step process and worksheet. **Please see Instructions before filling out worksheet.**

Step 1/Type of Activity: Describe each type of activity that will occur in wetland resource area and buffer zone.

Step 2/Number of Activities: Identify the number of each type of activity.

Step 3/Individual Activity Fee: Identify each activity fee from the six project categories listed in the instructions.

Step 4/Subtotal Activity Fee: Multiply the number of activities (identified in Step 2) times the fee per category (identified in Step 3) to reach a subtotal fee amount. Note: If any of these activities are in a Riverfront Area in addition to another Resource Area or the Buffer Zone, the fee per activity should be multiplied by 1.5 and then added to the subtotal amount.

Step 5/Total Project Fee: Determine the total project fee by adding the subtotal amounts from Step 4.

Step 6/Fee Payments: To calculate the state share of the fee, divide the total fee in half and subtract $12.50. To calculate the city/town share of the fee, divide the total fee in half and add $12.50.

B. Fees (continued)

Step 1/Type of Activity	Step 2/Number of Activities	Step 3/Individual Activity Fee	Step 4/Subtotal Activity Fee

Step 5/Total Project Fee: ____________

Step 6/Fee Payments:

Total Project Fee: ____________
a. Total Fee from Step 5

State share of filing Fee: ____________
b. 1/2 Total Fee **less $**12.50

City/Town share of filling Fee: ____________
c. 1/2 Total Fee **plus** $12.50

C. Submittal Requirements

a.) Complete pages 1 and 2 and send with a check or money order for the state share of the fee, payable to the Commonwealth of Massachusetts.

Department of Environmental Protection
Box 4062
Boston, MA 02211

b.) **To the Conservation Commission:** Send the Notice of Intent or Abbreviated Notice of Intent; a **copy** of this form; and the city/town fee payment.

To MassDEP Regional Office (see Instructions): Send a copy of the Notice of Intent or Abbreviated Notice of Intent; a **copy** of this form; and a **copy** of the state fee payment. (E-filers of Notices of Intent may submit these electronically.)

ATTACHMENT A

PROJECT NARRATIVE

NARRATIVE TABLE OF CONTENTS

Acronyms and Abbreviations	
BGH	Boston Gatehouse
BMP	Best Management Practice
BWSC	Boston water and Sewer Commission
CDM	Camp Dresser and McKee
cfs	Cubic foot per second
Corps	U.S. Army Corps of Engineers
CSO	Combined Sewer Overflow
cy	Cubic yard
D.A.	Drainage Area
DO	Dissolved Oxygen
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DBH	Diameter at Breast Height
EMC	Event Mean Concentration
FEMA	Federal Emergency Management Agency
Ft	Foot or feet
HEP	Habitat Evaluation Procedure
HSI	Habitat Suitability index
HU	Habitat Unit
MADEP	Massachusetts Department of Environmental Protection
MA NHESP	MA Natural Heritage and Endangered Species Program
MBTA	Massachusetts Bay Transit Authority
MDC	Metropolitan District Commission
mg	Milligram
Mg/l	Milligram per liter
MWRA	Massachusetts Water Resources Authority
NAVD88	North American Vertical Datum of 1988
NED	National Economic Development (plan)
NER	National Ecosystem Restoration (plan)
NPDES	National Pollutant Discharge Elimination System
PEC	Probable Effects Concentration
PCB	Polychlorinated Biphenyl
SPF	Standard Project Flood
SOD	Sediment Oxygen Demand
TCLP	Toxic Characteristic Leaching Procedure
TPH	Total Petroleum Hydrocarbons
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

1.0 Introduction

The City of Boston (City,)and Town of Brookline (Town,) in cooperation with Commonwealth of Massachusetts (Commonwealth) and the U.S. Army Corps of Engineers-New England District (Corps) are proposing to construct Phase I of a flood control and environmental restoration project in the Muddy River. Phase I of the Project will daylight approximately 700 feet of the Muddy River and restore a portion of the Back Bay Fens informally designated the Upper Fens Pond. Phase II will involve dredging for flood control and environmental restoration.

The Muddy River is a 3.5 mile long urban waterway with a 5.6 square mile drainage area situated in the greater Boston metropolitan area. The Muddy River originates at Jamaica Pond and flows in a general northeasterly direction through Boston and Brookline to its confluence with the Charles River. The upper watershed is primarily residential with some commercial areas, while the lower watershed is characterized by high-density residential, institutional and commercial development. The river also flows through the heart of Frederick Law Olmsted's famed "Emerald Necklace", one of the most carefully crafted park systems in America. Due to the historic significance of the park system, it is listed on the National Register of Historic Places and has been designated a Local Landmark in the City. A location map showing the Muddy River and the Phase I project area is shown on Figure 1. The project area work limits are shown on Figure 2.

Flooding, degraded riverine habitats, poor water quality, and other related water resource problems have worsened in the past 10-15 years along the Muddy River in Boston and Brookline, Massachusetts and the conditions resulted in several prior studies along the river. In 1989, the Commonwealth of Massachusetts completed the Emerald Necklace Parks Master Plan which identified the need for environmental restoration and correction of potential flooding problems. However, it was a severe storm in October 1996 that resulted in flooding causing over $70 million in flood damages along and adjacent to the Muddy River that resulted in the prioritization of water resource improvements. The City and Town in cooperation with Commonwealth, neighboring institutions, property owners and other stakeholders updated the Emerald Necklace Master Plan and developed a Draft Environmental Impact Report (EIR) for “Phase I Muddy River Flood Control, Water Quality, Habitat Enhancement, and Historic Preservation” in 2001. The Final EIR and Supplemental Final EIR were completed, respectively, in 2003 and 2005.

The Phase I EIR identified actions to reduce potential flood damages, improve water quality and aquatic/riparian habitat within the Muddy River, rehabilitate the historic landscape, and enhance recreational uses of adjacent parklands. Specific elements of the Master Plan include dredging the Muddy River system from Wards Pond to the Charles River Basin, increasing the channel capacity and removing flow restrictions, stabilizing riverbanks, removing invasive vegetation and rehabilitating the historic landscape.

The Corps was authorized to evaluate the Master Plan and determine whether these flood damage reduction and environmental restoration improvements were in the Federal interest. This required the preparation of a Decision Document that evaluated alternative solutions to identified flood control and ecosystem restoration needs, selected and recommended a plan based on economic, environmental and public acceptability criteria, and demonstrated a Federal and non-Federal interest in proceeding to the project implementation phase.

The final Corps’ Muddy River Decision Document (dated September, 2003) built upon the Master Plan and evaluating the flooding and environmental restoration problems and needs of this 3.5-mile long urban waterway. Evaluation of these concerns and development of alternative measures resulted in a comprehensive solution that is both feasible and acceptable to the study sponsors. Major features of this plan include:

1) daylighting two sections of the Muddy River that are presently in culverts,
2) environmental dredging of the Fens, Riverway, and Leverett, Willow and Wards Ponds,

3) eradication of *Phragmites* by dredging & cutting/herbicide treatment; and,
4) preservation and rehabilitation of the historic park shoreline in construction areas.

The Muddy River Flood Damage Reduction and Environmental Restoration Project provides flood control benefits and environmental restoration benefits, however the project will require the expertise of two different types of contractors in the implementation. For this reason, the design and implementation of the project will be conducted in two separate phases. The current (first) phase will consist of the major structural features of the flood control improvements to protect against a flood with return frequency of 20 years and the daylighting of two sections (about 700 linear feet) of the Muddy River will which provide both flood damage reduction and environmental benefits. The second phase of design and implementation will consist of removal of sediment for both flow conveyance and environmental restoration in the Fens, Riverway, and Leverett, Willow and Wards Ponds, eradication of *Phragmites* from wetland and riparian areas, preservation and rehabilitation of the historic park shoreline in construction areas and the installation of boulders, instream deflectors and habitat logs to improve fisheries and amphibian habitat. Dredging and rehabilitation of the Charlesgate section of the Muddy River was completed by the City of Boston in 2005.

2.0 Existing Environment

This section contains a baseline description of environmental resources of the study area. Information was obtained from previous studies of the Muddy River, including ACOE (1992, 1998, 2003), MDWPC (1976), C.E. Maguire (1977), Metcalf and Eddy (1990), USGS (1997), Pressley (2001), and CDM (2003, 2005).

2.1 General Description of the Study Area

The Muddy River is a small tributary of the Charles River. Its watershed is located within the cities of Boston, Brookline and Newton. The river channel forms the boundary between Boston and Brookline for almost its entire length. It originates at Jamaica Pond (a 68-acre spring-fed "kettle" pond) flowing north through a series of small ponds (Ward's Pond, Willow Pond, Leverett Pond, and the Back Bay Fens) for approximately 2.9 miles before entering the Charles River Basin. The reach between Leverett Pond and the Back Bay Fens is known as the Riverway. Prior to construction of the original Charles River Dam (ca. 1910) the lower Charles River and the Muddy River (upstream to Leverett Pond) were tidally influenced.

The Muddy River watershed, as shown on has a drainage area of 5.6 square miles. About 70 percent of the watershed is developed.

The ACOE 2003 study area included elements of the historic park system that is known as the Emerald Necklace. The Emerald Necklace consists of a series of parks that was planned by Frederick Law Olmsted to extend from the Boston Common and Public Garden, along Commonwealth Avenue, and out the Muddy River through the Back Bay Fens, Riverway, Olmsted Park and Jamaica Pond to the Arnold Arboretum and Franklin Park. Elements of the park system include:

- Back Bay Fens
- Riverway
- Olmsted Park (Leverett Pond, Willow Pond, Wards Pond)
- Arnold Arboretum
- Jamaica Pond
- Franklin Park

The Emerald Necklace and its components are listed on the National Register of Historic Places and located near several other districts, individual structures, and institutions that also are listed on the National Register. In addition they are designated landmarks by the Boston Landmarks Commission.

Phase I of the Corps project involves work in the Riverway and the Back Bay Fens. Descriptions of these areas are provided below.

Riverway Section of Muddy River

The Riverway section of the Muddy River flows north from Leverett Pond for about 1 mile to Park Drive. Width of river ranges from about 20 to 120 ft. and averages about 40 feet. Water surface area is about 6.5 acres. Mean depth is about 1.5 feet and maximum depth is 6.5 feet based on a 1997 USGS survey. Flow is sluggish since elevation through the reach drops only about six inches. The historic downstream boundary was located at Brookline Avenue, before a 350-ft. segment was filled for construction of the Sears parking lot. The Riverway currently ends at the twin, 6-foot culverts at Park Drive.

The Riverway contains a number of stormwater outfalls. The largest are Huntington Avenue Drain, which discharges on the Boston side of the Muddy River, Tannery Brook Drain, and the Longwood Avenue Drain, both of which are located in Brookline.

Considerable lengths of the bank are either eroding and/or being undercut by stormwater runoff and river flow. Erosion may be exacerbated by fluctuating water levels caused by flow restrictions at the Park Drive culvert. The channel is protected by riprap immediately downstream of the Route 9 bridge and the area under the Longwood Avenue Bridge.

Many areas of the Riverway have shoaled significantly since it was last dredged in 1963. Sedimentation from storm drains, accumulation of poorly decomposed organic material, encroachment by *Phragmites,* and streambank erosion all contribute to the problem. The channel is nearly blocked by *Phragmites* in several areas, particularly immediately upstream of the two six-foot culverts at Park Drive.

The “Riverway” comprises a linear park along both sides of the Muddy River and consists of a maintained grassy parkland with paved and unpaved paths, and a mixture of mature Olmsted-period trees, younger volunteer trees and some shrubs.

The DCR-owned and maintained Riverway parkway runs parallel along the River’s east side (Boston) with the MBTA Green Line tracks running along the west side (Brookline) until Netherlands Road where local Brookline streets are encountered. Riparian vegetation is well developed along some sections of the river. In others, turf with some tree cover is often maintained nearly to the river’s edge. The Riverway contains three islands along its length, all designed by Olmsted. The largest, Riverwalk Island, is accessible by footbridge. Shoaling caused by *Phragmites* has linked one of the islands to shore.

Back Bay Fens

The Back Bay Fens is a series of shallow basins located between the Riverway and the Charlesgate section of the Muddy River. The Fens is all that remains of the 750-acre Back Bay of the Charles River which was filled in the mid-nineteenth century. The area was modified by Olmsted in the 1890’s to become part of the Emerald Necklace. The Fens, as envisioned by Olmsted, however, has been greatly altered over the last century. The area was a tidal marsh until about 1910 when a dam created the Charles River Basin and all but eliminated tidal influence.

Various other endeavors encroached upon open water and intruded on parklands through the 1970's.

The total existing water surface area of the Fens today is about 16 acres (including emergent wetland). The two largest basins, located upstream and downstream of Agassiz Road, are referred to here as the "Northern" and "Southern" basins. Water depth generally ranges from 2 to 4 feet. The Muddy River flows from the Northern basin to the Charlesgate section of the river, where it enters the Charles River Basin through a submerged conduit.

The Back Bay Fens also contains two sections of river where the original channel has been culverted and filled over. These areas are located under the former Sears parking lot adjacent to the Landmark Center redevelopment and abutting roadways, and upstream of the bridge at Avenue de Louis Pasteur. The total length of river filled is about 700 ft.

The Muddy River flows from the Riverway through two 6-foot diameter culverts under the former Sears parking to a diversion chamber. This structure was constructed by as part of the Muddy River Sanitary Improvement to divert water directly to the Charles River through a conduit (the Muddy River Conduit). At the time, the Fens were tidal and the purpose was to limit saltwater intrusion into the Riverway. The gates once diverted about 90 percent of Riverway flow through the Muddy River Conduit. The gates were apparently removed in the late 1940's allowing more water to flow through the Fens. In the early 1990's a new gate was installed to control flow to the conduit. The gate has been closed since late 1994 and all flow from the Riverway currently passes through the Back Bay Fens. After the diversion structure, flow passes through a 7 by 9-foot conduit to an overflow control structure and through two six-foot diameter culverts to the Fens.

The Back Bay Fens receives stormwater overflow from the Stony Brook Conduit, the Emmanuel College storm drain, and several smaller storm drains.

A great deal of sediment has accumulated in the Fens. The main source of the sediment was the Stony Brook Combined Sewer Overflow which enters the Southern pond at the Boston Gatehouse. Approximately 10,000 cubic yards of sediment discharged from the CSO was dredged from the Southern pond by the MDC in 1978. Modifications to the Stony Brook system completed in 2006 helped decrease sediment loading from the conduit into the Fens.

Parkland in the Back Bay Fens contains well maintained lawn areas, numerous mature shade trees and smaller trees, and shrubs. Many paved and unpaved paths transect the park. There are abundant cultural and institutional resources adjacent to the Back Bay Fens.

2.2 Hydrology and Flood History

Muddy River is one of the more important tributaries in the lower Charles River watershed. Muddy River, along with Stony Brook, has a combined drainage area of about 21 square miles in the southeastern part of the lower watershed. Significant flooding along these streams has occurred in August 1955, October 1962, and more recently in October 1996 and June 1998. The October 1996 event resulted in the Muddy River backing up and flooding the MBTA Green Line tracks and flowing through the Riverway portal and flooding the Kenmore Square station (see Figure 3 for portal location). Stony Brook contributes flood flows to the Muddy River through an overflow located in the Back Bay Fens at Boston Gate House No. 1.

2.2.1 Watershed Description

a. General. The Muddy River watershed (D.A. approximately = 5.6 square miles), a tributary of the Charles River (D.A. = 309 square miles), is located within the communities of Boston, Brookline, and Newton. The river channel forms the boundary between Boston and

Brookline for about half its entire length. It originates at Jamaica Pond (a 68-acre spring and minor tributary fed "kettle" pond) and flows north through a series of small ponds inter-connected by short stretches of covered and uncovered river lengths approximately 2.9 miles. It enters the Charles River about 3 miles upstream from its mouth.

b. Topography. The elevations in the Muddy River Basin range from an elevation of approximately 290 feet above North American Vertical Datum 1988 (NAVD88) in the western part of the basin in Newton to slightly under 10 feet NAVD88 at the confluence of the Muddy River with the Charles River in Boston. There are small hills scattered throughout the upper basin with flat lands prevailing in the filled-in Back Bay portion of Boston. Other than the ponds directly connected to the Muddy River, the only major water bodies included in the basin are the Brookline Reservoir and the Chestnut Hill reservoir. The entire basin is crossed by major traffic arteries and smaller side streets and, with the exception of several parks, is totally urbanized.

c. Muddy River. The Muddy River loses 20 feet in elevation in approximately 500 feet of length between Jamaica Pond and Ward's Pond. From Ward's Pond, the river flows north as a small meandering stream to Willow Pond, a one-acre shallow pond. The drop is approximately 30 feet in a distance of approximately 1,400 feet. The outlet from Willow Pond is a culvert which surfaces just above Leverett Pond. The river drops approximately 9 feet in the 400-foot length between the ponds. Leverett Pond is a shallow (approximately 3 to 4 feet deep during dry weather conditions), oblong, 12.8-acre pond surrounded by grassed park land. Two moderately-sized drains contributing flow to the upper portion of the pond include Chestnut Street (which discharges to Willow Pond) and Daisy Field Drains. The largest tributary of the river (3.65 sq. mi.), draining over half the area above the Riverway, is the Village Brook Drain. This drain enters Leverett Pond from the northwest just upstream of the pond's outlet.

From Leverett Pond, the Muddy River flows north under Route 9 and under Brookline Avenue, continuing through park land containing grassed areas, walking trails, and benches, and running parallel to the Riverway parkway and MBTA green line until it reaches the intersection of Park Drive and the Riverway parkway near the former Sears building. In this area, under normal flow conditions, the river is extremely shallow and slow-moving. In the upstream southern portion of this reach, the river is straight, 10 to 20 feet wide and 1 to 2 feet deep, with dense emergent vegetation on either bank. A moderately-sized drain, Huntington Avenue discharges in this reach. In the downstream northern portion of this reach from Netherlands Road to the Park Drive/Riverway intersection, the river broadens from approximately 50 to 150 feet wide, respectively. Two large drains enter within this reach, Tannery Brook and Longwood Avenue.

At the Park Drive/Riverway intersection, the river flows through two 6-foot diameter culverts to the Brookline Avenue Gate House which is a gated diversion structure. This gate house was originally installed to divert water directly to the Charles River while limiting saltwater intrusion into the Riverway portion of the Muddy River (this was when the lower Muddy River was a tidal estuary).

d. Muddy River Conduit. The present purpose of the gated structure is to divert flood flows of the Muddy River into the Muddy River Conduit which runs under Brookline Avenue, continuing under Kenmore Square to Deerfield Street, and eventually to the Charles River. The Brookline Avenue Gate House has been equipped with a new 92" X 78" gate (installed in 1995) so that during low and average flow conditions, the gate can be closed and all flow diverted to the Fens to enhance water quality in the lower portion. Connection of the Muddy River to the Brookline Avenue gatehouse is still required with the proposed flood damage reduction improvements reported herein. It is currently proposed to extend the headwall for the Brookline Avenue conduit to allow for a connection to the gatehouse through the existing two 6-foot diameter openings that currently discharge into the gatehouse.

e. Back Bay Fens. After the gated diversion structure, flow to the Back Bay Fens passes through a 7' X 9' conduit which enters a Brookline Avenue overflow structure and then through two 6-foot diameter culverts prior to entering the Fens.

The Back Bay Fens is approximately 1.5 miles long and discharges to the Charles River just above the Massachusetts Avenue Bridge at the Charlesgate interchange. The Fens is what remains of the 750-acre Back Bay of the Charles River which was filled in the mid-nineteenth century. The Muddy River enters the 9-mile long, nearly constant-level Charles River Basin, approximately 2.2 miles upstream from the Charles River Dam (3.3 miles upstream from the mouth). During dry weather, the water level in the Fens remains nearly constant as a result of the near consistent level of the Charles River Basin.

f. Stony Brook Conduit. The Stony Brook Conduit collects flows from West Roxbury and Hyde Park and conveys them through Jamaica Plain into the Fenway area where it discharges into the Charles River at the MWRA's Charlesgate Gate House located at the Charlesgate interchange of Storrow Drive. Conditions in this area have been substantially improved by the $45 million Stony Brook Sewer Separation project completed by the Boston Water and Sewer Commission in 2006 which produced a 99.7 % reduction in CSO volume. Before the project the Stony Brook discharged 44.5 million gallons a year, after the project that has been reduced to 0.13 million gallons. However during times of significant wet weather, a combined sewage overflow from the Stony Brook Conduit can occur into the Muddy River at the Fens Pond at Boston Gate House No. 1 or at the MWRA's Fens gate house into the Charles River. Estimates indicate overflows occur at Gate House No. 1 approximately twice per year down from an estimated 22 times per year before the project.

g. Charles River Basin. Flows within the Charles River Basin are generally eastward from the Watertown Dam, Watertown, at river mile 9.8, through parts of Newton, Cambridge, and Boston to the present Charles River Dam, Boston, at river mile 0.8. The basin was a tidal estuary until a dam was constructed at Leverett Street in 1910. This dam was located approximately 0.4 mile upstream from the present dam. The primary objectives of the original dam were to create a fresh water pool eliminating the extensive mud flats and noxious odor at low tide, to protect the low areas in Boston and Cambridge from high tides, and to maintain a fairly constant basin level to stabilize the groundwater table in the adjacent areas. In addition to the old dam, marginal combined sewage conduits were constructed along both the Boston and Cambridge riverbanks to reduce the pollution in the basin by carrying sewage directly to the harbor.

The total contributing drainage area of the Charles River Basin is about 309 square miles. This drainage area can be divided into two distinct hydrologic areas. The upper Charles River has a drainage area of 251 square miles and is characterized by numerous natural storage areas which result in considerable flood storage and sluggish runoff. The lower basin has a local drainage area of 58 square miles and is almost totally urbanized. Analysis of floods shows that the lower watershed is the contributor of 90% of the peak flood flows within the Charles River Basin. This is primarily the consequence of the high percentage of impervious ground cover, which is characteristic of the urban watershed. The terrain is mostly flat to gently rolling with elevations ranging from less than 10 feet NAVD88 to about 200 feet NAVD88. The normal elevation of the Charles River Basin is about 2 feet NAVD88. The basin has a surface area of about 700 acres and a maximum width of 2,000 feet at its downstream end which gradually decreases to less than 400 feet at the Boston University Bridge. The depth of water varies from approximately 3 feet just downstream from the Watertown Dam to approximately 30 feet near the present dam.

The current Charles River Dam was constructed in 1978 to provide for dependable flood protection of low-lying urban areas adjacent to the basin during major coincident fresh-water and/or tidal events. Major flood control components of the dam are 6 flood control pumps which have a total capacity of 8,400 cfs when pumping against 9 feet of static head. In addition to this pumping capacity, the dam has two sluiceways and a boat lock system, which can be operated at low tide to release significant flow by gravity drainage. With all components operating, total gravity outflow of this system at mean low tide and normal basin level is about 11,000 cfs.

2.2.2 Climatology

a. General. The Muddy River watershed has a variable climate characterized by frequent but usually short periods of precipitation. The basin lies in the path of a weather pattern known as the “prevailing westerlies” which often include cyclonic disturbances that cross the country from the west or southwest. It is also exposed to occasional coastal storms that travel up the Atlantic seaboard in the form of hurricanes of tropical origin and storms of extratropical nature, often called “northeasters.” Coastal storms are often the cause of flood-producing short-duration high intensity rainfall. Intense thunderstorms, either of local origin or associated with frontal systems, also occur during the summer months.

b. Temperature. Average monthly temperature in the Boston area varies from about 72 degrees F in July to near 20 degrees in January with an average annual temperature of about 51 degrees. Extremes in temperature range from a high of over 100 degrees to lows near minus 20 degrees.

c. Precipitation. The mean annual precipitation at Boston is 41.5 inches. At Blue Hills Reservation, about 10 miles southeast of the Muddy River watershed, the average annual precipitation is 47.2 inches. This station is located on a hill at elevation 628 feet NAVD88.

d. Snow Fall and Snow Cover. The mean annual snowfall as recorded at Logan airport in Boston is 43 inches occurring mostly during December through March. There are no snow surveys available for the Muddy River but based on data recorded by the Corps within the inland Blackstone River watershed, it is estimated that the average water equivalent of the snow cover is in the 2 to 4 inch range normally reaching its maximum in early March. Snowmelt in combination with rainfall runoff can add to flooding in the Muddy River watershed, but snowmelt alone is seldom the cause of a flood.

2.2.3 Streamflow Records

There are no streamflow records available for the Muddy River. Measuring stream flow along the Muddy River is complicated due its physical location, which is in the backwater of the much larger Charles River basin as well as the numerous hydraulic restrictions along the river. A river stage gage, however, was installed by the USGS in 1999. This gage is located 20 feet downstream of Netherlands Road and records river stages at a location upstream of the Riverway. This gage aids in decision making for installation of the stop log structure at the portal entrance along the MBTA “D” line. This structure is installed when high flood levels threaten the MBTA track and portal.

2.2.4 Historic Floods

a. General. Records of floods on the Muddy River (and lower Charles River watershed) prior to 1900 are meager. From available information the largest flood prior to 1900 occurred in February 1886. Other noteworthy floods occurred in 1807 and 1818. Prior to 1910, however, the lower Charles River, including the Muddy River tributary, was a tidal estuary making flood experience along this reach of less consequence.

b. Recent Floods. Some major floods that have been experienced relatively recently, and would be considered more representative of today’s conditions, which occurred in August 1955, October 1962, March 1968, and the most recent October 1996 and June 1998. The largest of these floods was by far the August 1955 event. This flood was the result of rainfall associated with Hurricane Diane. The total rainfall for this event (as recorded at Logan airport) was 11.9 inches with the peak hourly rainfall of 1.42 inches. The October 1962 event was the result of about 8 inches of rainfall in a 2-day period with a maximum 1 hour rainfall of about 0.6 inches. Both of these events resulted in extensive flooding along the Muddy River.

c. Design Flood. The most recent significant flooding occurred as a result of heavy rainfall from a coastal storm that occurred on October 20-21, 1996. This storm produced the highest levels along the Muddy River since the record 1955 event. Rainfall totals ranged from 7.9 inches at Logan to 8.5 inches at Blue Hill, and over 10 inches at Reading, about 15 miles north of Boston. This flood resulted in extensive flooding along the Muddy River and Stony Brook. Flood water escaped the Muddy River above the Riverway, flowed down the MBTA rail tracks, through the MBTA tunnel portal and flooded the Kenmore Square station resulting in major flood damages and loss of Green Line services for an extensive period of time. In addition adjacent hospitals, academic institutions and private properties were damaged by floodwaters.

2.2.5 Hydrologic Analysis of Floods

a. General. Extensive past analyses of floods have been conducted for the Muddy River. Many of these studies were conducted by the engineering firm Camp Dresser & McKee (CDM) for the Corps of Engineers, City of Boston, and others. Since most (or all) of the tributary streams to the Muddy River, as well as sections of the Muddy River itself, are enclosed in pipes and conduits, the adopted analysis tool was the SWMM computer model. Hydrology of the Muddy River was developed using the RUNOFF block in SWMM, which produces flood hydrographs which are then input to the EXTRA model which is used to simulate the hydraulics of open channels and closed pipes and conduits. In addition to analysis of the Muddy River, CDM has analyzed the larger Stony Brook as part of flooding and CSO abatement studies conducted for others. As part of these studies CDM has made estimates of overflows from Stony Brook to the Muddy River through Boston Gate House No. 1.

b. Affects of Improvements. A series of historic and synthetic storm events were analyzed in the development and calibration of the SWMM and other hydraulic models. The main event analyzed and used for model calibration was the relatively recent October 1996 flood which is also the design event. Results of these simulations as well as past Corps of Engineers rainfall runoff and hydraulic routings for the project condition were reviewed and summarized.
Graphical presentation of the Corps of Engineers analysis of the design event above the Riverway (Park Drive) is shown on Figure 4. Numerous other events were analyzed ranging from the 2-year event up to and including the Standard Project Flood (SPF). The hydrologic affect of the new structures and channel improvements, in general, is to reduce floodplain storage and increase flood discharges. It is noted that the affect of the new conveyance structures at the Riverway and Brookline Avenue is to reduce flood levels above the Riverway and release more flows into the Fens. Therefore as part of the comprehensive flood reduction plan, a flood reduction channel will be dredged through the Fens to Ipswich Street. This channel will help mitigate the increase in flood discharges, however there will be an increase in flood stages through the Fens parkland.

Muddy River Peak Discharges with Project Condition

Location	Oct 1996 Flood (cfs)	100 Year Flood (cfs)
D/S BGH #1*	2000	2500
U/S BGH #1	1100	1850

* BGH #1 is Boston Gate House No. 1

2.2.6 Water Surface Profiles

Pre-project October 1996, 100-year and post-project October 1996 and 100-year flood profiles are shown on Figures 5 and 6. These profiles were computed by inputting pre- and post-discharges, as determined from the various computer modeling efforts, into a HEC RAS computer model. River cross-sectional input to the model was determined from 2006 river surveys by associates as part of these design efforts. The HEC RAS model was calibrated by estimating the experienced October 1996 flood discharges and comparing the computed profiles to surveyed high water marks. Mannings “n” coefficients ranged from 0.030 - 0.035 for the channel to 0.07 for overbanks. The calibration is shown on Figure 6 along with surveyed October 1996 high water marks. Note that the computed flood elevations in the lower Fens are considerably lower than the surveyed high water marks. This is due to the dredging that has been accomplished (since the occurrence of the 1996 event) from the Storrow Drive culvert to upstream of Ipswich Street. This dredging has had a significant affect on Muddy River flood stages in the lower Fens. Once the model was calibrated, the existing condition 100-year was analyzed by inputting the flood flows reported in Reference 2 and is shown on Figure 6. The project condition was analyzed by inputting the project flood discharges (as shown in Table 1), the Riverway and Brookline Avenue structures, as well as the new open channels and dredged channel from downstream of Louis Pasteur Avenue to Charlesgate. A general plan of the proposed improvements is shown in the main report. The improved condition flood profiles for the October 1996 flood (design flood) and the 100-year improved condition (with the October 1996 design) is shown on Figure 7. Comparison of flood profiles shows an increase in flood stages through the Back Bay Fens area. This area is mainly parkland with no increase in flood damages with the exception of the Boston Fire Department facility. This facility is located between Agassiz Road and Boylston Street and will need to be flood-proofed with a low level (2 feet high with no freeboard) ringed dike/wall. This will be fully evaluated in Phase 2 design studies.

2.2.7 Standard Project Flood

The flood damage reduction improvements for the Muddy River will not be designed to provide Standard Project Flood Protection (SPF); however, an SPF was hydrologically analyzed for comparison purposes and in compliance with ER 1110-2-1405, ETL 1110-2-230, and EC 1105-2-86. The Standard Project Flood Storm runoff was determined by applying Standard Project Storm rainfall to the developed SWMM computer model described earlier.

a. Rainfall. Standard Project Storm Rainfall for the Muddy River watershed was developed based on procedures presented in Civil Engineer Bulletin No. 52-8 and EM 1110-2-1411, “Standard Project Flood Determinations.” The resulting SPS 24-hour rainfall was 12.06 inches.

b. Standard Project Flood Profiles. Standard Project Flood Profiles were computed by CDM (with the EXTRA module of SWMM) with and without project condition and are presented in Reference 9. The results of these analyses show for the with project condition the SPF levels above the Riverway would be about four feet lower than the SPF without the project. The SPF with project condition would be about 2 feet higher than the experienced October 1996 event with flood levels approaching overtopping of the Riverway or about 13 feet NAVD88. The CDM analysis of the SPF (with October 1996 flood improvements) through the Fens shows elevations of about 10 feet NAVD88.

2.2.8 Hydrologic Design Criteria

Project design capacity is that required for a recurrence of the October 1996 event (approximately a 20-year event) as affected by the new conveyance structures at the Riverway and Brookline Avenue. In addition to the contributions from its various tributaries, the Muddy River also receives flow from Stony Brook which overflows into the Back Bay Fens during events such as

October 1996. Estimates of this overflow have been included in the hydraulic modeling of the river. An additional project feature is required because the new conduit under Brookline Avenue intercepts two storm drains. These drains currently discharge into the Muddy River conduit. It is planned to intercept these two drains into a new structure and redirect their flow to the Muddy River downstream of the Brookline Avenue conduit.

2.2.9 Temporary Flow Restriction

There is a need to provide an interim flow restriction after construction of the new culverts so that flood flows higher than existing conditions are not discharged into the Fens prior to completion of the Phase 2 dredged channel that is to be located downstream from this project. It is estimated that the restriction may stay in place at least two years while the downstream channel is modified. This flow restriction must be equivalent to the flow capacity of the existing two 6 foot diameter culverts that currently convey flow to the Fens. Based upon the HEC modeling for existing conditions, the maximum flow that should be passed through the structure is approximately 500 cfs. For flows to exceed that amount, the water levels would have to exceed the channel banks in the area upstream of Riverway Road. It is uncertain at this time the exact flow restriction that will be proposed by the contractor as a weir structure could be located upstream of the Riverway or one located upstream from Louis Pasteur Avenue. Either structure could be accomplished with sheet piling, circular cofferdams, with and without stop logs. These concepts will need to be further evaluated as the design of the various structures proceeds.

2.3 Water Quality

2.3.1 Water Quality Classification

Waters in the Muddy River are currently classified as Class B according to the Massachusetts Division of Water Pollution Control (MADWPC). Class B waters are considered acceptable for bathing and other recreational purposes, protection and propagation of fish, other aquatic life and wildlife, and after adequate treatment, for use as water supplies. In addition, the Muddy River has been classified as a warm water fishery. Massachusetts Class B standards require a minimum dissolved oxygen (DO) concentration of 5.0 mg/l for warm water fisheries, pH in the range of 6.5 to 8.0 standard units or as naturally occurring, fecal coliform not to exceed 200 colonies/100 ml, and color, turbidity, and suspended solids in concentrations that would exceed the recommended limits of the most sensitive receiving water use. Also, Class B waters shall be free of floating oils, grease, petrochemicals, and pollutants that form objectionable deposits or nuisances.

Water quality conditions within the Muddy River appear to have improved since 1986 when the Massachusetts DWPC completed a water quality survey. However, the improvement has not been sufficient to meet state water quality classification criteria since waters of the Muddy River, with the exception of Jamaica Pond, still do not meet Class B standards. The most significant problem is high fecal coliform levels which can occur for the entire length below Jamaica Pond, followed in order by: low dissolved oxygen levels which occur regularly below the Route 9 bridge; high nutrient levels and associated excessive algal growth problems (significant variations in pH, DO, turbidity, etc,); high organic, metals, and trash releases from storm drain discharges; releases of organic acids, odors, and gasses from bottom sludges after DO has been depleted; and occasional accidental oil spills throughout the entire length. Waters also have occasional problems with floating debris and grease that form objectionable, aesthetic nuisances.

Many of the cross connections between sanitary sewers and combined sewers in the upstream portions of the Muddy River drainage system have been corrected and sewer separation work is continuing. Work by the BWSC and Brookline to improve water quality includes the completion of the Stony Brook Conduit Project, the implementation of the Boston Catch Basin Improvement Project, continuing efforts to eliminate illegal cross connections, stormwater management programs, infiltration/inflow catch basin stenciling, public education programs, hazardous waste and used motor oil collections, permitting of large sewer users and regulation of industrial discharges, permitting of new or retrofitted building project through the BWSC's Site Plan Review procedure, and other NPDES-related compliance efforts. The street sweeping and catch basin cleaning programs in both municipalities continue, as well as substantial improvements to storm drain maintenance by the Massachusetts Department of Conservation and Recreation which manages the parkways that border much of the project area. These programs have resulted in substantial water quality improvements .

2.3.2 Dissolved Oxygen

The USEPA has established several dissolved oxygen criteria to protect warmwater fish (USEPA, 1986). For early life stages the 7 day mean concentrations should not drop below 6.0 mg/l, and should be maintained above 5 mg/l at all times (1 day minimum). For other life stages the 30 day mean is 5.5 mg/l, the 7 day minimum is 4.0 mg/l, and the 1 day minimum is 3.0 mg/l. DO levels should be maintained above 4 mg/l to avoid acute mortality of sensitive invertebrates and early life stages of fish, and above 3 mg/l to avoid acute mortality of other life stages. The criteria are meant to protect sensitive species such as white catfish and largemouth bass. Other species, including common carp and others which inhabit the study area, are able to tolerate temporary exposure to much lower dissolved oxygen levels.

Several studies have measured dissolved oxygen levels in the study area (see Corps 2003).

Predicted average dissolved oxygen levels in the study area based on water quality modeling done for the 1998 Corps study are shown on Figure 8. The results show that baseline (without project) conditions are likely to improve slightly due to enhanced source controls, elimination of cross connections, and other improvements, but that DO levels in the Riverway and Back Bay Fens are likely to remain below 5 mg/l. Lower DO levels than shown on may occur due to diurnal fluctuations during low flow, warm dry weather periods and near the bottom of the waterbody at other times.

2.3.3 Phosphorous

Phosphorous is usually the nutrient in shortest supply and becomes the limiting factor in plant growth in freshwater surface waters. Although there is no official EPA criterion for phosphorus, in order to prevent development of nuisance plant growth, the EPA recommends that total phosphorus (P) should not exceed 50 ug/l in any stream at the point where it enters a lake or reservoir or 25 ug/l within the lake or reservoir (USEPA, 1986). Testing in 1986, 1992, and 1995 indicates that phosphorus levels in the Fens and Riverway greatly exceed these recommendations. Generally, phosphorous levels needed to be above 0.05 mg/l in a flowing river to cause excessive algal growth. In more quiescent ponds, levels as low as 0.015 mg/l can produce algal blooms.

In 1986 and 1992 studies, total phosphorous levels ranged from 0.015 mg/l at Jamaica Pond to 0.072 mg/l at the downstream side of the Route 9 bridge, with a minor increase occurring in the Leverett Pond area (possibly as a result of the discharge of from Village Brook Drain). Immediately after the Tannery Brook Drain, dry weather phosphorous levels jumped significantly to 0.48 mg/l and then rose even higher to 0.72 mg/l after the Brookline Avenue gatehouse indicating another source of sewage (possibly Longwood Avenue storm drain). Wet weather results showed dilution impacts from runoff downstream from the Route 9 bridge. However, there were higher concentrations than the dry weather concentrations in the area between Willow Pond and the Route 9 bridge. These higher concentrations may be the result of surface runoff of fertilizer in the parkland or possibly the release of nutrients from scouring of sewage sludge from upstream cross-connected storm drains.

In 1995, Northeastern University noted levels of phosphorous in the Muddy River system, including the water column and sediments, higher than typical values for strongly eutrophic lakes and rivers. Orthophosphate levels measured in the water column at several locations from Leverett Pond to the Fens ranged from 0.34 mg/l to 0.56 mg/l. Sediment release rates averaged 70 mg phosphorous/square meter/hr based on Northeastern's measurements for a 24-hour period using an in-situ measuring devise.

In compliance with Section 303(d) of the Clean Water Act, the MA DEP (2007) has prepared a TMDL Report for nutrients in the lower Charles River Basin. TMDL establishes the amount of a pollutant that a waterbody can assimilate without exceeding its water quality standard for that pollutant. The TMDL calls for a 62 percent decrease in phosphorus export from the Muddy River watershed to protect the Charles River.

2.3.4 Key Factors Affecting Water Quality

Water quality of the Muddy River is controlled by numerous factors including: 1) flow regime of the lower Muddy River (*i.e.,* flat gradient of the river and non-varying backwater elevation controlled by Charles River Dam; 2) organic loading from storm drains, illegal sewer connections, and combined sewers; 3) other pollutant loads (nutrients, heavy metals, oils, floatables) from storm drains and combined sewers; 4) sediment oxygen demand (SOD); 5) release of nutrients from anaerobic sediment; 6) organic loading from extensive submergent (fanwort), emergent (*Phragmites*) vegetation, and leaf fall from deciduous trees and shrubs; 8) waste from wildlife; and 9) overland loading of sediment and nutrients from surrounding park lands and erosion from unprotected shoreline. Each of these is briefly discussed below.

a. Flow Regime: The flow regime of the Muddy River is the one of the most important factors influencing water quality. Low flow rate in combination with the pond-like character of the Riverway and Fens prevents flushing of sediments and organic material from the system. The relatively stagnant conditions result in low dissolved oxygen levels, which in turn lead to nutrient (phosphorus and ammonia) release from sediments.

b. Pollutant Loads: The majority of suspended solids, metals, floating debris, nutrients and oils entering the Muddy River are supplied as a result of the storm drain system. While substantial improvements have been made and work is continuing, the age and complexity of the sewer and storm drain systems (over 100 storm drain outlets), and the need for detailed study and significant funds required to identify and eliminate illegal connections, eliminating every dry-weather sewage source is a challenge However, as dry weather sources are reduced, bacterial exceedances will be reduced significantly.

In the 1998 Corps report, average annual pollutant loads to the Muddy River were developed using EPA's Simplified Method as described in the 1992 "Guidance Manual for the Preparation of Part 2 of the NPDES Permit Applications for Discharges from Municipal Separate Storm Sewer Systems." This method consistently yielded results similar to more detailed modeling methods for long-term, annual pollutant estimates. Event mean concentrations (EMC) of common urban pollutants from cities similar to Boston and Brookline were taken from (National Urban Runoff Program (NURP) data to compute this loading.

Annual loads of total suspended solids, Biological Oxygen Demands, total organic carbon, nitrate, total phosphate, total lead, and total zinc were computed based on NURP EMCs, average annual precipitation, and land use. These estimated annual pollutant loads are listed in Table EA-8 (see Corps 2003). The estimated average and maximum total suspended solids loading of the Muddy River were approximately 1.8 and 8.5 million pounds (lbs.), respectively. In the 1998 Report estimates of sediment loads were further refined. Based on site specific data results show an estimated loading rate of 2.7 million pounds. Assuming an in-place sediment density equal to approximately 80 lbs./ cubic feet (cf), this amount of suspended solids loading could conceivably add 1200 cy of sediment to the Muddy River per year.

c. <u>Sediment Oxygen Demand</u>: Because of the stagnant nature of the river, low volume to surface area ratio, and the high organic content of the sediments, sediment oxygen demand has a significant impact on DO levels in surface waters. Biological activity associated with decomposition of organic material utilize oxygen and exert a drain (sediment oxygen demand) on the DO within the water column. Other factors, specifically, respiration of plants (algae and rooted fanwort), and chemical and organic releases into the river from overland source and storm drains, cause an added demand on DO. High SOD also leads to anaerobic conditions within the sediments.

d. <u>Nutrient and Contaminant Release from Anaerobic Sediments</u>: Anaerobic conditions in sediment led to release of phosphorus, ammonia, and hydrogen sulfide into the water column. Phosphorus and ammonia are plant nutrients that can stimulate growth of algae and aquatic plants. Ammonia and hydrogen sulfide may be toxic to aquatic life.

e. <u>Plant Growth</u>: Growth of algae, aquatic plants, emergent plants, and leaf fall from trees and shrubs add organic material to the Muddy River system. Given the flow regime, much of this matter settles out in the sediments, exerting a sediment oxygen demand. Low DO levels resulting from high SOD stimulate release of nutrients that in time, may stimulate growth of algae and other aquatic vegetation. This positive feedback loop is characteristic of highly eutrophic aquatic ecosystems such as the Muddy River. Emergent and aquatic vegetation slow water velocity, allowing suspended solids to settle out of the water column more readily and accumulate in sediment deposits. This may improve water quality, but can have a long-term, adverse effect on aquatic habitat as nutrients and contaminants accumulate in sediment as water volume decreases.

2.4. Sediment Quality

The most extensive recent studies of Muddy River sediment quality were conducted by the Corps in 2001 and CDM in 2000. The CDM studies were conducted primarily to characterize material sufficiently to determine dredged material disposal requirements. Core samples were collected at 2-foot depth intervals to native material, which was typically encountered from 6-10 feet below the surface of the sediment layer. Samples were analyzed for RCRA metals (silver, arsenic, barium, cadmium, chromium, mercury, lead, and selenium), volatile petroleum hydrocarbons, PAHs, PCBs, pesticides, TCLP metals, reactivity, conductance, and grain size (sieve and hydrometer). The Corps testing was conducted primarily to characterize ecological risk. Surface sediment samples were analyzed for metals, PAHs, PCBs, pesticides, grain size, and biotoxicity.

Numerous other studies have tested Muddy River sediments. These include studies by the Corps in 1992, 1995, 1996, and 2000 and USGS in 1997. Results of these studies are summarized in Corps (2003). Sediment data from the Phase I project area is summarized in Table 1.

2.4.1 Test Results

Samples from Willow Pond, Leverett Pond, the Riverway, and Fens contain elevated levels of metal, PAHs, petroleum hydrocarbons, and PAHs. PCBs and DDT and its metabolites are also frequently detected. Concentrations of contaminants are generally highest in surface sediments and decline with depth. Accumulation of contaminants in sediment is believed to be the result of years of loading from storm drains, combined sewer overflows, point source discharges (fuel oil), and atmospheric deposition (dust and precipitation). Conditions are exacerbated by the highly urbanized nature of the watershed, sluggish nature of the Muddy River and resulting lack of significant flushing, and low dissolved oxygen levels which slow decomposition of petroleum hydrocarbons and other organic contaminants. In general, sediments from Wards Pond contain much lower level of contaminants than other studies, undoubtedly because it receives no significant loading from storm drains or surface runoff.

a. Metals: Elevated levels of lead, copper, zinc cadmium, chromium, arsenic and mercury occur in Muddy River sediment samples. Concentrations are generally highest in the Fens, Riverway, and Leverett Pond and lowest in Ward's Pond. Lead levels are unusually high. Average lead concentrations in surface sediments tested by CDM ranged from about 500 to 700 ppm well above the average for Massachusetts freshwater sediments (Rojko, 1990). USGS and Corps studies also found high levels of lead in the Fens, Riverway, and Leverett Pond. Peak lead concentration exceeded 2000 ppm. CDM found that metal concentrations generally decline with depth, with lead levels in the underlying (2-4 feet.) sediment about half that in surface sediment (0-2 feet).

b. PCBs: Most studies have detected PCBs in Muddy River sediment samples. Peak concentration reported is 9.1 mg/kg in the Fens, with most values reported less than 2 ppm. Most studies have found highest PCB levels in the Fens or the Riverway, with much lower concentrations in Leverett Pond, Willow Pond, and Ward's Pond sediment. CDM found highest PCB levels in the Fens (1.4 mg/kg) and did not detect PCBs in Riverway sediment. Mean levels found by the USGS were 2.20 mg/kg in the Fens, 0.29, mg/kg in the Riverway, and 0.21 mg/kg in Leverett pond. In the 1992 Corps study, average concentrations of PCBs in the Fens and Riverway sediment were 1.6 and 2.2 mg/kg.

c. PAHs: Highly elevated levels of PAHs occur in Muddy River sediment samples. Average concentration sediments from the Fens, Riverway, Leverett Pond, and Willow Pond range between about 50 and 250 mg/kg in studies by the Corps, USGS, and CDM. CDM and Corps studies found lowest levels in Ward's Pond. Pyrene, flouranthene, chrysene, benzo (a) anthracene, and phenanthrene are the most abundant PAHs detected. As with metals, CDM found PAH concentrations in underlying (2-4 feet) sediment about half that in surface sediment (0-2 feet). PAHs in the urban environments derive largely from automobile and diesel exhaust and reach the river in urban runoff.

d. Petroleum Hydrocarbons: Total petroleum hydrocarbon (TPH) levels in surficial sediments samples from the study area are extremely elevated. The average level found by the Corps in 1996 was about 22,000 g/kg (2.2 percent). In the 2000 Corps study, TPH levels in Willow Pond averaged more than 50,000 mg/kg (or 5 percent). Analysis indicates that the material is likely to be derived from No. 2 fuel oil (ref). The oil apparently reached Willow Pond via the Chestnut Street storm drain system.

e. Pesticides: DDT and its metabolites (DDE and DDD) and chlordane are the only pesticides normally detected in Muddy River sediment. Concentration of total DDT (DDT+DDD+DDE) range up to about 3 mg/kg, but is commonly less than 1 mg/kg. Concentrations generally increase with depth of sediment.

f. Toxicity Characteristic Leaching Procedure (TCLP): TCLP testing was conducted by the Corps in 1992, and 1996, the USGS in 1997, and CDM in 2000. Lead is the only contaminant for which the TCLP regularity limit was exceeded in any sample. The most extensive testing was conducted by CDM in 2000 and is summarized below:

Location	Number of Tests	Number exceeding 5.0 mg/l
Back Bay Fens	82	9
Riverway	48	0
Leverett Pond	30	0
Willow Pond	4	0
Wards Pond	4	1

None of the CDM these tests were conducted on sediment from areas vegetated with *Phragmites*. One sediment sample from within a *Phragmites* area was tested for TCLP lead by the Corps in 1996. The TCLP lead level was 6.0 mg/l.

g. Biotoxicty: In 1995 the Corps analyzed surficial sediment samples from Leverett Pond, the Riverway, and Fens for biotoxicity using the fathead minnow (*Pimephales promelas*) and the amphipod, *Hyalella azteca*. Sediments from Leverett Pond and the Riverway were highly toxic to the amphipod, with survivorship < 30 %. Chronic (28 day) exposure to sediment from the Southern Fens Basin had a moderate impact on amphipod survival and greatly reduced growth. Sediment from the Northern Fens Basin was not acutely toxic to the amphipod. Exposure to sediment from the Fens significantly impacted fathead minnow survival. Sediment from Leverett Pond and the other two Riverway samples had no impact on fathead minnow survival or growth. There was no clear relationship between contaminant levels in sediment and toxicity.

In 2001, sediment samples were collected from 16 sampling stations including: one from Jamaica Pond, two from Wards Pond, one from Willow Pond, three from Leverett Pond, three from the Riverway, five from the Back Bay Fens, and one from Turtle Pond in the Stony Brook Reservation. The Jamaica Pond and Stony Brook samples were reference stations, expected to have good sediment quality and high survivorship. A detailed description of the sediment sampling and testing methods is provided in Appendix J. Sediments were analyzed for contaminants with a 10-day sediment toxicity test using the midge *Chironomid tentans* conducted and 42 day sediment toxicity using *Hyalella azteca*.

Tables EA-9 and EA-10 of Corps (2003) summarize results of the 2001 toxicity tests. For *Hyalella*, percent survival at the end of the test (42 days) was significantly reduced in samples from the Back Bay Fens, the Riverway, Leverett Pond, and Willow Pond. Survivorship from these locations generally ranged between 50 and 80 percent, compared to above 90% at Jamaica Pond, Turtle Pond, and Ward's Pond. The *Hyallela* test also detected effects on reproduction (average number of young/female) at all study locations, including Ward's Pond. No effects on growth were evident at 42 days. For *Chironomus*, about 50 % of samples showed evidence of toxicity, including 4 or 5 samples from the Fens, 1 out of three samples from the Riverway and Leverett Pond, and the Willow Pond sample. Survivorship ranged from 20% at Willow Pond to over 90 % at Jamaica Pond, Turtle Pond, and Ward's Pond. Growth was significantly reduced in all samples from the Fens, Riverway, Leverett Pond, and Willow Pond.

2.4.2 Sediment Quality Evaluation

Multiple lines of evidence indicate that chemicals in Muddy River sediment pose a risk to biota (see Appendix D in Corps, 2003). Sediment is likely to adversely affect fish and benthic invertebrates at all stations, except Ward's Pond. Principal lines of evidence in support of this assessment are comparison with probable effect concentrations (PECs) developed by McDonald et al. (2000) and bioassay test results. Levels of metals, PAHs, pesticides and PCBs in sediment from Willow Pond, Leverett Pond, the Riverway, and Back Bay Fens generally exceed PECs. In many cases, PECs are exceeded several fold, making adverse impacts on benthic invertebrate communities probable. Contaminant levels in Wards Pond are generally low, but PECs are exceeded for some pesticides and PAHs. Studies conducted in 1995 and 2001, found sediment from Willow, Pond, Leverett Pond, the Riverway, and the Back Bay Fens toxic to test organisms. Chronic studies conducted in 2001 using *Hyallela* noted effects on survivorship, growth, and reproduction. Food chain modeling also suggests that metals and/or PCBs in sediment may pose a risk to piscivorous wildlife and songbirds.

2.5 Biological Resources

2.5.1 Habitat

Community types in the Muddy River study area were mapped by the Corps (2003). The entire Muddy River study area includes about 40 acres of wetland habitat and 120 acres of upland habitat (Table 2). Mapped habitat in the Phase I Project area is shown on Figures 9 and 10. The Phase I project area primarily consists of developed areas, and turf. Phragmites and bordering vegetated wetland occurs upstream of the Riverway. Riparian habitat in the vicinity of the Upper Fens Pond is mostly forested upland. There is little BVW associated with the Upper Fens Pond or downstream of Avenue Louis Pasteur. No Phragmites occurs in the Upper Fens Pond, but two small stands occur within or near the Phase I project area downstream of Avenue Louis Pasteur.

2.5.2 Fish

A list of fish species reported to occur in the study area is presented in Table 3. The list is a compilation from many observations made over the last 30 years that are summarized below. No specific information is available for the Upper Fens Pond. This area however is likely supports most or all fish species occurring in the study area.

Efforts to restore anadromous fish runs in the Charles River have been underway for many years. Passage facilities have been built or improved at several dams upstream of the Charles River Dam. The river currently has one of the most productive blueback herring fisheries in Massachusetts. Runs of alewife are also quite good and have been improving in recent years. Although shad restoration efforts have had limited success, some shad pass upstream of the Watertown dam each year.

A small population of blueback (river) herring, occur in the Muddy River. The herring likely spawn in Leverett Pond. The MA Department of Marine Resources, however, considers the contribution of the Muddy River to the Atlantic coastal populations to be potentially important, and notes that many of the Commonwealth's 100 active river herring runs are smaller in area than the Muddy River. Spawning likely occurs between March 1 and June 15. Outmigration of juveniles occurs in the fall (September 15 – November 1).

Fish collected from the Riverway and Fens in 1990 were analyzed for PCBs, mercury, and other metals (Maietta, 1990). Seven of the 14 fish analyzed had PCB levels which met or exceeded the U.S. Department of Agriculture (USDA) action level of 2 ppm for commercial fish (see Appendix D). Common carp had the highest PCB levels. Concentrations of mercury and other metals in fish are low, and do not pose a public health risk (Oleo, 1992). Because of the elevated PCB levels, a public health advisory was issued recommending people not consume carp, brown bullhead, or American eel from the Muddy River and limit consumption of other species to two meals per month.

2.5.3 Riparian and Emergent Wetland Vegetation

Plant communities along the Muddy River originate from plantings made in the 1890's during construction of the Emerald Necklace parks. Plans called for planting a great variety of trees, shrubs, and herbaceous species (see Zaitzevsky, 1982). However, much of the intended diversity has been lost over the years due to the introduction of non-native exotics such as Oriental knotweed, purple loosestrife, *Phragmites,* Norway maple, and glossy buckthorn. Table 4 lists plant species noted to occur in the study area.

<u>Riverway</u>

The Riverway area extends from Route 9 to the Riverway/Park Drive intersection. A pair of continuous footpaths parallels the river on the eastern and western sides of the river south of Route 9. The areas landward of the footpath are vegetated by a mosaic of wooded riparian vegetation and turf. Trees present include oaks, maples, gray, white, and river birch, weeping willow, box elder, black cherry and others. Common small trees, shrubs, and vines include European (glossy) buckthorn, northern arrowwood, Oriental barberry, Oriental bittersweet, honeysuckles, red-panicled dogwood, and sweet perpperbush. *Phragmites* (see below) and oriental knotweed are the most common herbaceous species. *Phragmites* grows primarily in wet areas in or along the channel while knotweed occurs mostly in drier areas on embankments. Both are highly invasive exotics. Other emergents growing along the shore in areas free of *Phragmites* include cattail, purple loosestrife, sedges, smartweed, beggars-ticks, yellow flag, jewelweed, pickerelweed, sweet fern, and aquatic grasses.

The Phase I project area upstream of the Riverway is vegetated primarily by *Phragmites* and knotweed and grasses (turf). Several trees occur in the work area, including two very large (48" and 52" diameter) oaks.

<u>Back Bay Fens</u>

The Back Bay Fens extends from the intersection of Riverway and Park Drive near the former Sear lot to Charlesgate. The Back Bay Fens is used intensively by the public due to the wide flanks of parkland adjacent to the river. Riparian vegetation is much less well developed along the Back Bay Fens section of the Muddy River downstream of the Upper Fens Pond. This area is intensely landscaped and contains a War Memorial, a ball-field and playground, a Rose Garden and an expansive community garden, the Victory Gardens. Vegetation in wetland and riparian areas along the Northern and Southern pools is dominated by *Phragmites* (see below). Wooded riparian vegetation is well developed along the Upper Fens Pond, downstream of Brookline Ave and just downstream of Avenue Louis Pasteur. Tree species include gray birch, paper birch, oaks, silver maple, Tree and Heaven, and Norway maple. Common shrubs include European buckthorn and northern arrowwood. Elsewhere shoreline vegetation is generally limited to shrubs and scattered trees. Emergent species noted in the Fens include *Phragmites,* cattail, purple loosestrife, jewelweed, sedges, smartweed, beggars-ticks, yellow flag, sweet fern, and aquatic grasses.

There is very little emergent vegetation in the Upper Fens Pond and no *Phragmites*. Tree and shrub species present in wooded riparian habitat along the pond include oaks, Norway maple, gray birch, red maple, silver maple, black cherry (rare), tree of heaven, northern arrowwood, and glossy buckthorn.

The Phase I project area downstream of Avenue Louis Pasteur is wooded on the north bank, primarily with oaks and Norway maple. The southern bank is vegetated with Phragmites, grasses (turf), and several trees, including a large (36" diameter) willow. Much of the southern embankment is eroding and very poorly vegetated.

2.5.4 *Phragmites*

Extensive stands of *Phragmites* are present in the Riverway and Back Bay Fens. Although *Phragmites* is native to the northeastern United States, studies indicate that all native New England varieties have been supplanted by a highly invasive Eurasian variety (Saltonstall, 2002). The 1992 and 2003 Corps studies mapped the occurrence of *Phragmites* in the Riverway and Back Bay Fens and chronicled the spread of *Phragmites* through analysis of aerial photographs dating back to 1951.

<u>Riverway</u>

Phragmites currently occurs along about 30 percent of the Riverway shoreline and occupy about 2.3 acres the river surface. An additional 0.4 acres of *Phragmites* is present along embankments up to several feet above the above the normal water elevation. *Phragmites* growth in the Riverway is robust. In well established stands, shoots frequently exceed 5 meters in height, and range up to nearly 7 m. *Phragmites* aboveground live standing crop near Park Drive in October, 1992 was about 4,000 g/m^2 (dry weight), well above values typically reported for the species in North America.

Phragmites has constricted the river channel in numerous locations. Growth is most extensive upstream of Park Drive, near Brookline Avenue, and downstream of Route 9. Stands extend along both banks of the river for about 500 feet upstream of the Park Drive culverts. *Phragmites* extends nearly across the entire river for a 130 ft. reach, within which the average width of the open channel is only about 10 ft. The edge of the stand appears to be semi-floating in about 4 feet of water.

North of Brookline Avenue, the river splits around Riverwalk Island and rejoins at the pedestrian bridge just south of Netherlands Road. The eastern branch of the channel is choked by *Phragmites*, while the western channel is clear. Adjacent to the Riverwalk Island, the maximum water depth in the channel has decreased from about 6 ft. after dredging in 1963, to about 1 ft. in 1996. *Phragmites* has also colonized the entire channel near a small island upstream of Park Drive.

Conditions are favorable for continued rapid expansion of *Phragmites* throughout much of the Riverway. Shallow water, lack of heavy shading, nutrient rich sediments, slow current, and low salinity provide near optimal conditions for *Phragmites* growth. Although the river was dredged to a four foot depth in 1963, sedimentation has reduced water depth to three feet or less throughout most of the river. Existing stands in the river typically grow in up to 3 feet of water, so water depth is not likely to greatly impede *Phragmites* expansion. Lack of shading by trees along most of the river, particularly between Netherlands Road and the Chapel Street Foot Bridge also favors rapid *Phragmites* growth. Moderate shading at some locations may slow, but not prevent expansion of existing stands or establishment of new stands. *Phragmites* are unlikely to colonize a few areas, such as deep water habitat near the Park Drive culvert, the steeply sloped, heavily shaded western channel near Riverwalk Island, and the shaded, colonized reach downstream of the Leverett Pond outlet.

<u>Back Bay Fens</u>

Phragmites occupies about 3.5 acres in the Back Bay Fens, including along about 90 percent of the Northern basin shoreline and about 50 % of the shoreline along the Southern (?) basin. A few small stands totaling < 0.2 acre occur elsewhere in the Fens upstream of the Agassiz Bridge. As along other areas of the Muddy River, *Phragmites* stands in the Fens are extremely robust (maximum shoot height is 6-7 meters). The stands have eliminated scenic vistas envisioned by Olmsted and strongly detract from the aesthetics of the area. *Phragmites* also poses a threat to public safety. Numerous assaults have occurred in or near *Phragmites* growing around the Northern basin.

Conditions in the Southern Fens Basin are also favorable for continued *Phragmites* expansion. A substantial amount of open water with depth less than 3 feet is present and vulnerable to colonization. Locations that appear most vulnerable include near shore areas upstream of the lagoon and the remainder of the shoreline. Potential for *Phragmites* expansion is more limited in the Northern Basin, where much of the remaining open water is deeper than 3 feet.

2.5.5 Wildlife

As natural areas linked together in a highly urbanized setting, Jamaica Pond Park, Olmsted Park comprised of Ward's Pond, Spring Pond, the Babbling Brook, Willow Pond and Leverett Pond, the Riverway, and the Back Bay Fens provide extremely valuable wildlife habitat in a local landscape context. The parks are also valuable on a wider scale, because of linkage with the Arnold Arboretum to the south through Jamaica Pond Park, and proximity to Franklin Park to the east and the Charles River Basin to the north. The most valuable wildlife habitat are wooded habitat in the vicinity of Ward's and Willow Pond, islands and riparian habitat at the southern end of Leverett Pond, naturalized areas along the Riverway, and wooded riparian habitat along the Upper Fens pond. The extensive *Phragmites* stands in the Northern Fens basin also provide excellent cover for songbirds and other wildlife.

Numerous birds, mammals, amphibians, and reptiles are known to occur in the Back Bay Fens and vicinity (see Corps, 2003). The area supports resident (breeding) populations of many bird species and provides a valuable refuge for songbirds, wading birds, and waterfowl migrating through the Boston area. A large population of ducks, mostly black duck/ mallard hybrids, is present in the Riverway and Back Bay Fens throughout the year. Canada goose is also common.

PCB levels found in fish from the Fens pose a risk to fish eating birds such as belted kingfisher, double crested cormorant, black crowned night heron, and green-backed heron.

2.5.6 Protected Species and Rare Species Habitat

The Phase I Project Area is not mapped as priority habitat of rare species or estimated habitat of rare wetlands wildlife (MA NHESP, 2008). No Federally-listed threatened or endangered species occur in the study area.

3.0 Project Description

3.1 Overall Project Description

The recommended plan in the 2003 Corps DPR included the following components

- Flood control improvements to protect against a flood with return frequency of 20 years,
- Daylighting two sections (ca. 700 lf) of the Muddy River,
- Environmental dredging of the Fens, Riverway, and Leverett, Willow and Ward's Ponds, and

- Eradication of *Phragmites* from wetland and riparian areas by dredging and herbicide treatment.

The components of the recommended plan include those that serve a flood control function only, those that provide environmental restoration, and those that provide both. The following presents each project feature as it was originally envisioned and its purpose. Section 3.2 (below) describes changes made in the Phase 1 design:

- Dredging the Fens to historic 1920's limits will include the dredging necessary for flood conveyance and additional dredging for environmental restoration. The cross sections on Plate 30 of Corps (2003) define each area. Within the Fens, about 53,000 cubic yards of sediment and debris will be removed for flood control and about 66,000 cubic yards will be removed for environmental restoration. The plan also includes additional deepening of the channel in three areas where sediment has historically collected.

- Within the upper Fens area, two sections of Muddy River will be daylighted. The first is a section about 360 feet long situated upstream of the culvert under Avenue Louis Pasteur. The second is a section about 330 feet long at the former Sears parking lot. In both areas, existing twin six-foot diameter culverts would be removed. Although all costs for these features are allocated to flood control, however, opening up these sections of river will provide considerable environmental and historic restoration benefits. Daylighted sections will be restored to 1920 contours. Embankments will be planted with appropriate trees and shrubs.

- The existing culverts under Brookline Avenue would be replaced with a 10 x 24-foot arched culvert about 330 feet long. Included with this culvert is an overflow connection to the underground gatehouse at the entrance to the Muddy River Conduit. These improvements are required for flood conveyance.

- The existing twin 6-foot diameter culverts under the rotary and access roads at the downstream end of the Riverway would remain and be supplemented with a 10 x 16-foot arched culvert. This new culvert is required for flood control.

- Removing over 31,000 cubic yards of accumulated sediment from the Riverway will provide both flood control and restoration benefits. Dredging of nearly 7,000 cubic yards is needed to remove flow restrictions at five areas along the Riverway. The plan also includes additional deepening of the channel in three areas where sediment has historically collected.

- Dredging at Leverett Pond consists of the removal of nearly 29,000 cubic yards of accumulated sediment. The majority of this is for environmental restoration with about 1,000 cubic yards being removed to improve flood flow characteristics at the outlet of Village Brook. The plan also includes additional deepening of the pond near the Village Brook drain where sediment has historically accumulated.

- Dredging of about 5,000 cubic yards of sediment at Willow Pond and about 16,000 cubic yards at Wards Pond for environmental restoration purposes.

- Eradication of *Phragmites* from the Fens and Riverway through dredging and cutting/herbicide application.

- Restoration of wetland vegetation in dredged areas by planting appropriate emergent wetland plants in selected areas in the Fens, and along the Fens, Riverway, Leverett Pond, and Willow Pond shoreline. Approximately 3.5 acres of emergent vegetation will be planted.

- Restoration of riparian vegetation in upland areas where *Phragmites* is eradicated by planting trees and shrubs.

- Restoration of vegetation and other landscape features disturbed at staging areas.

- Installation of boulders in the Fens, Riverway, and Leverett Pond to improve fisheries habitat. Approximately 100 boulders or boulder clusters will be installed.

- Installation of 10 in-stream deflectors in the Riverway to create scour holes to diversify aquatic habitat.

- Installation of 25 - 50 habitat logs to restore lost basking sites for turtles and amphibians in dredged areas.

- Removal of sediment and erosion control at Spring Pond to restore and protect threespine stickleback habitat.

3.2 Changes to the Recommended Plan During Phase I Design.

Several changes the recommend plan were made during design. A Notice of Project Change was filed in 2006 pursuant to MEPA regulations. The changes are described below:

a. Riverway Culvert. The recommended plan in Corps (2003) called for maintaining the two existing 6-foot diameter culverts under the Riverway and installing a new 10-foot by 16-foot arch culvert adjacent to those culverts to supplement their flow capacity. After looking at layout options for the supplemental culvert the Project Design Team (PDT) decided that abandoning the existing culverts and replacing their flow capacity with one larger culvert provided more options for laying out the work and also provided the aesthetic benefit of only having one arch culvert opening rather than three openings. A hydraulic analysis of a single culvert under the Riverway determined that a 10-foot by 24-foot arch culvert would be necessary to pass the design flood flow.

b. Brookline Avenue Culvert. The recommended plan included two culverts, one under the Riverway as discussed above and another that extended under both Brookline Avenue and its "jughandle" turning road. The Value Engineering study recommended dividing this second culvert into two separate culverts, one under Brookline Avenue and another under the jughandle, with a daylighted area in between. This plan would reduce the length of culvert to be installed and increased the amount of open channel by 300-400 linear feet providing both a reduction in cost and an increase in environmental benefits. The hydraulic analysis confirmed that the proposed 10-foot by 24-foot culvert was adequately sized to pass the design flood flow. However, beneath Brookline Avenue is a 48-inch diameter water main. The water main could not pass above a 10-foot high culvert without creating a crown in the road that would require the reconstruction of 2 nearby intersections that would cause unacceptable traffic considerations. The recommended plan proposed 3 alternatives to route the water main by the proposed culvert:

1) route the water main below the culvert,
2) bifurcate the water main into 3 separate lines, or
3) route the water main off the roadway and above the culvert within a berm.

Routing the water main below the culvert was rejected because of difficulty of installation due to caisson spacing for the culvert, and length of roadway disruption, and difficulty of future access and maintenance.

Bifurcating the pipe was rejected by Boston Water and Sewer. Separating the pipeline into three separate lines would increase the head losses through the pipelines which would require the sum of the size of three lines to be bigger than a single waterline.

While locating the water main within a berm off the roadway was initially considered undesirable due to the unappealing aesthetics of a large berm between the road and the proposed open channel, it was determined to be the only feasible option. The PDT believed that the creation of the berm which would be visible within the park system would require maintaining an appropriate balance of the engineering, environmental, and aesthetic aspects of the design.

c. Jughandle Culvert. A Value Engineering Study recommended constructing a separate culvert under the Jughandle with daylighting of the river between Brookline Avenue and the Jughandle. However, the design team found that this daylighted reach of the river would be aesthetically unpleasant. The outlet to the Brookline Avenue culvert and the inlet to the Jughandle culvert would be only approximately 100 feet apart while the wing walls for each would "encircle" much of this reach of daylighted river. The design team decided to explore the possibility of closing and removing the Jughandle and thereby eliminating the need for a culvert under the Jughandle and creating a larger integrated reach of daylighted river. The purpose of the Jughandle is to allow left turns from Brookline Avenue onto Park Drive without backing up traffic in the intersection. The Corps of Engineers' traffic consultant (VHB) stated that the regulatory agencies for this stretch of roadway (Boston Transportation Department and the Commonwealth of Massachusetts Division of Conservation and Recreation) would not approve of left turns directly from Brookline Avenue to Park Drive with the current traffic patterns due to the high volume of traffic through this intersection. The consultant stated that the only way that the Jughandle could be eliminated would be if the Riverway/Park Drive intersection was reconfigured to allow left turns from the Riverway onto Park Drive since much of the traffic using the Jughandle comes from vehicles travelling north on the Riverway that want to turn left (west) onto Park Drive. However, since there is no left turn allowed from the Riverway onto Park Drive, these vehicles must travel east on the Fenway to Brookline Avenue and then use the Jughandle to turn west onto Park Drive. A concept of a reconfiguration of the Riverway/Park Drive intersection allowing left turns onto Park Drive and the eliminating the Jughandle was prepared and submitted to the regulatory agencies. Since the elimination of the Jughandle and the reconfiguration of the Riverway/Park Drive intersection had been long contemplated by the regulatory agencies, but never implemented due to lack of funding, it was approved. While the reconfiguration of the Riverway increases the scope and cost of the project, the elimination of the proposed culvert under the Jughandle results in a significant decrease in cost and an overall cost savings to the project.

d. Relocation of the Connection to the Muddy River Gatehouse. Currently the Muddy River culverts that begin upstream of the Riverway connect to the Boston "Gatehouse". Within the Gatehouse flows can be directed through a 9' x 11' culvert which connects to 2 – 6' diameter culverts which outlet in the Upper Fens Pond area of the Muddy River or flows can be diverted to the Muddy River Conduit which outlets directly to the Charles River bypassing the downstream reaches of the Muddy River. This diversion down the Muddy River Conduit is only used during periods of high flow to reduce flooding along the Muddy River.

The culverted area between the Riverway and Brookline Avenue will be daylighted as part of the Phase 1 effort. This daylighting would eliminate the current connection between the twin 72-inch culverts and the Muddy River Conduit. Corps (2003) called for re-establishing this connection by having the overflow to the Gatehouse conveyed through a pipe opening that would be made in the side of the new culvert to be installed under Brookline Avenue. This is shown on Figure 1-6 of Corps (2003).

Because of the age of the Boston Gatehouse and potential for damage to and undermine of the structure and the limited information available regarding this structure, the project team decided to review other possible options to allow for an overflow connection to the Gatehouse without disrupting the integrity of the Gatehouse. It was also believed that having the overflow connection inlet in the side of the new culvert would not be hydraulically efficient.

Based on their review, the project team determined that the overflow connection to the Gatehouse should be made through the existing culvert openings by retaining a short portion of the existing culverts to where their inlets would be in the slope of the nearby daylighted river. This change would also eliminate the concerns that the team had relative to connecting to the existing Gatehouse.

e. Avenue Louis Pasteur Culvert. A test pit dug in the vicinity of the inlet to the culvert under Avenue Louis Pasteur determined that the existing 2 – 6' culverts tie into a concrete inlet structure that is tied into the inlet of the culvert. The team was concerned that if the inlet structure was removed along with the existing culverts that the integrity of the bridge culvert to remain could be compromised. The team decided that the best course of action would be to partially retain the inlet structure, partially removing only the face to the inlet structure, where the existing culverts tie into it. To do this and to keep the work away from the existing bridge culvert so as not to affect its integrity, the team decided to extend the inlet structure by attaching culvert segments to its upstream end. This will keep culvert and wingwall construction from impacting upon the integrity of the existing bridge culvert.

3.3 Phase I Project Description and Design Considerations

3.3.1 General

The current phase of the Muddy River Flood Damage Reduction & Environmental Restoration Project is located in the Fenway section of Boston, Massachusetts. The project starts immediately upstream of the Riverway/Park Drive intersection where the Muddy River currently enters a concrete intake structure. The intake structure directs the flow through twin six (6) foot diameter culverts under the Riverway and the Sears Rotary (also known as the former Sears parking lot). The culverts connect to the Boston Gatehouse at the corner of Park Drive and Brookline Avenue where the culverts continue underneath Brookline Avenue and the jug handle Roadway. Downstream of the Jug Handle Roadway, the culverts empty into Upper Fens Pond. At the lower end of Fens Pond, the river again enters twin 6-foot diameter culverts to travel under the park between Fenway and Park Drive and under the Avenue Louis Pasteur roadway before emptying back into the Muddy River downstream of Avenue Louis Pasteur.

The comprehensive plan identified calls for the installation of larger culverts and day lighting sections of the river to return the Muddy River to open channel flow that will both allow conveyance of flood flows but also will return these sections to the open waterway developed by Frederick Law Olmsted when he designed this section of the Emerald Necklace. Starting at the upstream portion of the project area upstream of the Riverway, a new 24-foot by 10-foot concrete culvert will be installed (with upstream and downstream headwalls) to convey flows under the Riverway roadway. The river between the Riverway and Brookline Avenue will be day lighted returning this reach of river to open channel flow. Another 24-foot by 10-foot culvert (with upstream and downstream headwalls) will be constructed to convey flow underneath Brookline Avenue. The area downstream of Brookline Avenue will be day lighted all the way to Avenue Louis Pasteur. This will involve the removal of the existing culverts between Brookline Avenue and the jug handle road, the elimination of the jug handle road and the extension of the Upper Fens Pond which currently stops approximately halfway between the jug handle road and Avenue Louis Pasteur. At the end of the extended Upper Fens Pond another headwall will be constructed to allow flows to enter the existing Avenue Louis Pasteur culvert conveying flows under that roadway. A small island will be created upstream of Avenue Louis Pasteur to re-create a feature that was in the original Olmsted design.

The project will also restore the existing Upper Fens Pond area. This area is located between the two day lighted areas. Restoration efforts will include removal of contaminated sediment, stabilization of eroding stream banks, removal of invasive vegetation, and replanting in general accordance with the Olmsted planting lists and design elements. To satisfy Massachusetts Department of Environmental Protection (MADEP), the design includes establishment of shallow “shelf” areas planted with emergent wetland plants.

The culverts that are being installed will be pre-cast concrete arches. The culverts and head/end walls will have a stone (granite) veneer installed so that the culvert and walls will look similar to the other bridges located both upstream and downstream of the project area. An advisory opinion was earlier sought to assist in identifying the material to be used and the overall appearance of these walls. On top of the walls will be a stone cap similar to other area bridges and a metal pedestrian hand rail similar to the look of other pedestrian bridges in the park. This will provide both fall protection as well as allowing for views of the day lighted areas. Along the project length pedestrian pathways will be installed to allow pedestrians to walk along the river and visit scenic overlooks that will allow views of the river. The day lighted areas as well as the banks and shoreline will be regraded to match the historic banks from Olmsted’s design to the greatest extent possible and will be planted with trees, shrubs and emergent plants, also in general accordance with the Olmsted planting lists and design. The intake structure above the Riverway will be demolished as will the existing culverts in the day lighted reaches.

Table 5 summarizes the impacts of Phase I activities to land under water, bordering vegetated wetland, and riverfront area. The proposed work will result in a net increase in land under water, bordering vegetated wetland, the 25 ft. riverfront area, and vegetated riparian habitat.

3.3.2 Excavated Material and Sediment Disposal or Reuse

a. Sediment: Removal of 3950 cubic yards of sediment from the Upper Fens Pond is required for flood control. Bank to bank dredging is required for ecosystem restoration. The dredging will remove contaminated surface sediment, reduce sediment oxygen demand, and increase the volume of aquatic habitat by removing mudflats. Some additional sediment excavation is required upstream of the Riverway and Downstream of Avenue Louis Pasteur during installation of scour protection and bank restoration.

Existing information about sediment quality in the Phase I work area is summarized in Table 1. The existing data is more than three years old and MADEP regulations (314 CMR 9.00) require test data be no older than 3 years. The MADEP, however, has indicated that no additional testing is required (Ken Chin, personal communication). No elutriate test information is available from sediment from the Upper Fens Pond. Testing of sediment from elsewhere in the Fens and Riverway, however, indicates metal levels in elutriate are low. Concentration of organics contaminants in elutriate has not been measured. The excavated material will be processed on site using a filter press and that wastewater will be filtered prior to discharge back into the Fens. The filtration step should remove most organics and some metals from the discharge water. The water quality of the discharge water will be tested (see below).

The sediment to be excavated from the Muddy River during Phase 1 does not meet the contaminant level requirements under 310 CMR 30.110 for classification as a hazardous waste material nor does it exceed the contaminant levels for soil reuse at landfills in accordance with Commonwealth of Massachusetts Department of Environmental Protection Policy# COMM-97-001, Table 1.

b. Excavated Material**:** Topsoil will be salvaged for reuse to the extent practical**.** The sand/gravel fill materials excavated from the daylighted sections may be reused for backfill material behind the arch culverts or wingwalls in Phase1. Some of the material may also be used to manufacture topsoil. This material has tested clean enough to meet the Commonwealth of Massachusetts criteria for residential reuse. Any additional excavated fill material not meeting project requirements or DEP reuse criteria may be trucked to local landfills for use as a daily cover material.

The excavation of organic material from the daylighted sections may require disposal at a lined out-of-state landfill such as Waste Management's Turnkey facility in Rochester, NH. It cannot be used as daily cover. The excavation of this material will be minimized where possible.

3.3.3 Erosion Control and Stormwater Management

The Contractor shall be responsible for providing erosion and sediment control measures in accordance with Federal, State, and local laws and regulations. The erosion and sediment controls selected and maintained by the Contractor shall be such that water quality standards are not violated as a result of the Contractor's construction activities. The area of bare soil exposed at any one time by construction operations should be kept to a minimum. The Contractor will construct or install temporary and permanent erosion and sediment control best management practices (BMPs) as indicated on the contract drawings and specifications. BMPs may include, but not be limited to, vegetation cover, slope stabilization, silt fences, sediment traps, and inlet and outfall protection. Any temporary measures shall be removed after the area has been stabilized.

3.3.4 Water Control During Construction – Water Diversion

Project plans propose to conduct most of the construction in the dry. Conceptual water diversion plans divert the Muddy River from the Riverway through conduits to discharge points located in the Upper Fens Pond and Avenue Louis Pasteur (see Sheets C-110 and C-111). Final water management plan will be developed by the construction contractor and could vary significantly from the conceptual plan. At a minimum, to establish the final locations of the diversion system and flow restriction control structure, the construction contractor will conduct a new subsurface investigation program along the proposed center line of each location of the diversion system prior to design and selection of such a system.

The final Muddy River controlled diversion system will be designed to pass all flows up to a maximum of 500 cfs. Normal flow above Riverway/Park Drive intersection is estimated to be 6 cubic feet per second (cfs). The system will maintain river surface elevation within plus or minus 6 inches of normal water level. The system will be designed to pass maximum flows without exceeding a river surface elevation of 9.5 feet NAVD88 upstream of the existing Riverway conduit entrance, and also not exceeding 8 feet NAVD88 downstream of the existing Ave. Louis Pasteur culvert entrance. The existing twin 6-foot conduit gravity system currently in operation will likely be utilized to the maximum extent possible during the construction. The system currently handles flows up to 500 cfs during higher flow events. The existing system will be maintained and operated during construction to pass flow.

Localized cofferdam systems will likely use vertical sheet pile walls to channelize the water through the construction area project. Channels through the project should be of sufficient width and depth to safely handle the river flows. The minimum height for the top of the cofferdam system is at elevation +8.0. Open channels may need to be protected to stop bank erosion. Outboard toe scour protection will also need to be provided for these sheet pile walls. A pumping system will need to be put into place to handle leakage through and seepage under the wall as well as rainfall into the construction site. The water pumped from this system will be treated before it is released back into the river or downstream.

Any temporary piped gravity system to be used at the Riverway will be of sufficient size to pass the maximum flow without exceeding the river elevations as stated above. Pipe thickness will be selected to withstand required internal pressures as well as depth of burial and vehicle loading.

Pipe supports and restraints will be provided as required to maintain system integrity throughout the flow range. Air release and vacuum vents will be provided as necessary. A manually operated slide gate or other shut off valve will be provided for each pipe at or near its upstream end to allow prompt closure of the pipe in the event of a pipe break. Pipes will tie into the existing intake structure for the twin 6-foot conduits. Any pumped diversion system will use multiple pumps of varying capacity to provide smooth flow transitions over the design flow range. Sufficient redundancy will be provided such that the maximum design flow can be accommodated if any one of the pumps fails to operate. The smallest pump will be sized to pump a minimum flow of 20 cfs and will be provided with both an electric driver for normal operation and a back up diesel driver. All other pumps will be provided with diesel drivers. Diesel drivers will have critical grade silencers. Pumps will have variable speed drives and will be controlled by an automatic system which varies the pump speed and brings additional pumps on line in response to a level control to a change in the river level. There will be a manual override switch which will disable the automatic controls and allow manual operation of each pump. The control system will be provided with 48 hour battery back-up, and will include an alarm with modem which can be programmed to call up to 5 telephone numbers. System will alarm if any one of the pumps fails to start on signal, and/or if intake sump water level rises above or falls below high and low set points. (Set points to be determined in field.) Intake sumps will be designed and constructed in accordance with the pump manufacturer's recommendations with regard to minimum submergence, intake water velocity, pump spacing and location within the sump, and sump lining materials. Discharge piping will meet requirements of gravity system above. Baffle block or other provisions will be made to minimize erosion at the discharge end of the piping.

The conceptual Phase I pumped diversion scheme shown on the contract drawings provides for construction of a sheet pile cofferdam and pump station to divert the Muddy River around the new culvert construction at the Riverway Drive to an outlet within the Upper Fens Pond. This pumping scheme will need to permit in-the-dry construction of the new culvert and channel sections between the cofferdams. The conceptual Phase I diversion includes sheet pile cofferdams upstream and downstream of the work area and will include a pump station with two 6-ft pipelines that will be run down the existing river channel and through the new culverts at Riverway and Brookline Avenue to an exit headwall within Upper Fens Pond. The upstream cofferdam structures will be constructed to elevation +9.5 (NAVD88) and the downstream to elevation +5 (NAVD88). Slope and bank protection and seepage control measures will be provided in accordance with the approved design. All excavation and new construction to be performed within the cofferdam areas will be performed during this phase, as specified in other sections of the concept Phase II pumped diversion scheme shown on the contract drawings provides for construction of a sheet pile cofferdam and pump station to divert the Muddy River from Upper Fens Pond around the new culvert construction at Avenue Louis Pasteur to a determined headwall location downstream of the culvert. This pumping scheme will need to permit in-the-dry construction of the new culvert, flood control channel and streambed and streambank protection within Upper Fens Pond and upstream and downstream of Avenue Louis Pasteur. The conceptual Phase II diversion includes sheet pile cofferdams upstream and downstream of the work area and will include a pump station with two 6-ft pipelines that will be mainly surface run except when they will need to be buried under Avenue Louis Pasteur. The upstream cofferdam structures will be constructed to elevation +9.5 (NAVD88) and the downstream cofferdam to elevation +5 (NAVD88). Slope and bank protection and seepage control measures will be provided in accordance with the approved design. All excavation and new construction to be performed within the cofferdam area will be performed during this phase, as specified in other sections of the specifications.

During all time periods when cofferdams and pumping diversion systems are in operation, the Contractor will not breach or remove cofferdams for the passage of flood control releases. All cofferdam structures and pumps will be designed to hold flood control releases and be able to pass the required flows. If structural integrity of the cofferdams does become critical, then the breaching and removal of cofferdams will be done only at the direction of, or with the approval of, the Contracting Officer.

The Contractor will continuously monitor all cofferdams for evidence of movement, erosion, deterioration, and excessive seepage throughout their use. The cofferdams and diversion channels will be maintained in good working order as directed and as necessary for the safety of workmen, the public, and protection of the permanent work.

3.3.5 Construction Dewatering

The typical excavation in the work area is granular and miscellaneous fill, with the lowest part of the excavation terminating in either fill or organic deposits. The fill and granular layers within the organic deposits are water bearing. The steel sheeting of the excavation support system will therefore be driven into the low permeability marine clays, to act as a cutoff. As such, the quantities of groundwater seeping into the excavations are expected to be relatively small. It will be required to keep the water level at least two feet below the excavation base, to stabilize the soils, especially where they consist of organic deposits. It is expected that drainage from sumps within the excavation, coupled with the placement of a crushed-stone working blanket, would be sufficient to stabilize the base of the excavations.

Dewatering from within the excavations is expected to have an influence on the groundwater levels outside the excavations, but the extent will likely be limited, particularly given the recharging effect of the nearby river. The closest of the abutting buildings is located around 100 feet from the alignment. Observation wells will be installed between the major excavation sites and the abutting buildings. Should a lowering of groundwater exceeding the response values given in Table 2 be detected, the groundwater will be recharged via trenches filled with crushed stone within which the groundwater is maintained at a predetermined level during construction.

The excavation for the new daylighted portions of the alignment will be performed via sloped and/or benched excavation to form the banks of the river, coupled with temporary cofferdams to allow the existing culverts to be removed in the dry. Ground and surface water accumulated within these excavations, as well as river water leaking through the cofferdam sheeting, will be removed by means of pumps through sumps from within the excavation.

Ground and surface water removed from the excavations will be pumped into settling tanks, for sediment removal prior to discharge back into the river.

3.3.6 Post Construction Flow Restriction

There is a need to provide a flow restriction after construction of the new culverts such that flood flows higher than existing conditions are not discharged into the Fens prior to completion of the Phase 2 dredged channel that is to be located downstream of Avenue Louis Pasteur. It is estimated that the restriction may stay in place at least two years before the downstream channel is modified. This flow restriction must be equivalent to the flow capacity of the existing two 6 foot diameter culverts that currently convey flow to the Fens. Based upon the HEC modeling for existing conditions, the maximum flow that should be passed through the structure is approximately 500 cfs. For flows to exceed that amount, the water levels would have to exceed the channel banks in the area upstream of Riverway parkway. It is uncertain at this time the exact flow restriction that will be proposed by the contractor as a weir structure could be located upstream of the Riverway or one located upstream from Louis Pasteur Avenue. Either structure could be accomplished with sheet piling (as will likely be used for water diversion during construction) or other materials as proposed by the construction contractor and approved by the Corps, project sponsors, and regulatory authorities.

3.3.7 Wastewater Management

Wastewater from dewatering or dredged material processing operations, concrete processing, or other sources will not be discharged directly into the Muddy River, the storm drain system, sanitary sewers, or the Muddy River Conduit. Prior to discharge, water from dewatering operations will be treated by filtration, settling basins, or other approved methods to reduce the amount of sediment and contaminants contained in the water to allowable levels.

The following standards shall apply to wastewater discharged directly or indirectly into the Muddy River, Back Bay Fens, or Muddy River Conduit:

Total Suspended Sediments: < 40 mg/l

Dissolved Lead: < 1.0 mg/l above background

Dissolved Oxygen: 5.0 mg/l

Discharge standards for others parameter may be established by the MADEP during the permit process.

3.3.8 Water Quality Monitoring

Treated wastewater from dewatering, dredged material processing operations, or other activities that is discharged directly or indirectly into surface water will be testing daily for TSS and weekly for dissolved lead and dissolved oxygen. Surface water will be tested weekly for dissolved oxygen and turbidity. Sampling locations will be upstream of the Riverway intake structure, the diversion pipe discharge point downstream of Avenue Louis Pasteur, and in the Back Bay Fens, approximately 200 ft downstream of the discharge. Parameters measured will include temperature, dissolved oxygen, turbidity, and conductivity.

The contractor will prepare a plan for monitoring water and wastewater quality. The plan will include the following elements:

1) list of parameters to monitor and detection limits
2) sampling method
3) frequency of monitoring
4) Monitoring locations (including a map)
5) Reporting
6) List of Personnel, Roles and Responsibilities
7) Analytical Laboratory
8) Equipment required
9) Safety Plan
10) Quality Assurance Project Plan (QAAP)

At completion of the sampling, test results will be summarized in a report submitted to the Conservation Commission and MADEP.

3.3.9 Scour and Bank Protection

a. Excavation Slopes**:** Based on the boring information, the slopes of open cuts along the alignment will be either entirely in fill or will have the organics deposits in their lower portions and the bottom of the river. The side slopes for open short term (temporary) construction during Phase 1 of the project should be maintained at 2 horizontal to 1 vertical. Slopes in soft organic deposits should be closely monitored during construction for evidence of softening and instability. All vertical cuts will require the use of earth support systems as defined in Section 3.6 below. Permanent daylighted river sections have been designed with a maximum slope of 1V: 3H. Where the slopes bottom out in organic deposits, there is potential for erosion and undercutting of the fine grained deposits. It will be necessary to protect the toe of the slopes in organic deposits with a stone revetment. Placement of such protection is particularly important near the wingwalls, for scour protection. The portions of slope above normal river level will be seeded and planted with local vegetation. A biodegradable turf reinforcement mat installed on the seeded slope will help stabilize the slope and reduce surface erosion, while the vegetation is established over the initial few seasons.

b. Articulated Concrete Block: To prevent scour near culverts, about 23,200 sf of the restored river channel will be lined with articulated concrete block. Articulated concrete block is also required to prevent scour upstream of the Riverway and downstream of Avenue Louis Pasteur. The articulated block will include void spaces (ca. 25 percent of surface area) which will fill with sediment and provide habitat for soft-bottom dwelling benthic organisms.

ACB's are a flexible revetment system that provides effective erosion. Articulated concrete blocks are effective and economical for a wide range of erosion problems, and are easily installed above or below the water line, as either cabled or non-cabled systems.

ACB's were chosen for performance and economy. Six inch-thick ACB's with a 12 inch-thick bedding layer and geotextile will provide long-lasting erosion protection under conditions that may have required larger riprap, more excavation. The Muddy River design velocities are expected to be in the 6 to 10 feet per second range, while ACB systems in general can withstand velocities in the range of 20 to 30 feet per second. Generally, the lower thickness of an ACB system is possible because of the difference in the level of engineering involved in the design of the system. ACB's are produced under controlled conditions that provide consistent and predictable strengths and allow precise placement and interlock. Riprap stability, on the other hand, varies with stone shape, size, weight and durability, which cannot be precisely controlled. The ACB's can be placed as cabled mats, about 8 feet wide by 40 feet long, which can be assembled on-site using the concrete blocks, high strength polyester cables and aluminum sleeves. The cables facilitate placement, particularly on steep slopes or in underwater applications. The cabled mats can be lifted by crane and set into place, quickly covering the slope. The system can also be constructed as individual units, placed by hand, to form an interlocking mat system.

c. Rockfill Material for Stone Protection: Below elevation -1.0 ft. NAVD88 and at higher elevations near culverts and at the toe of the daylighted slopes where organic deposits are present. sideslopes will be protected with sub rounded stone. Stone protection should generally consist of riprap placed on a 12-inch layer of granular bedding. A layer of non-woven geotextile filter fabric may be placed beneath the granular bedding layer, to prevent the passage of silt and fine sand material through the stone protection layer.

d. Cellular Confinement System: Sideslopes will be reinforced with a cellular confinement system (geocells) in most areas from elevation -1 ft. to 3.0 NAVD88. The geocells were sized to allow installation of shrubs and herbaceous wetland plants and will not interfere with growth of vegetation. Restored slopes above elevation 3.0 NAVD88 will be protected with turf reinforcement matting and plantings. The resulting plant community should be resistant to scour. However, erosion could still occur during a high flow event and expose the geocells. The alternative, lining the embankments in most locations to elevation 3.0 NAVD88 with stone protection, in unacceptable from an wetland restoration standpoint and is incompatible with historic restoration objectives. Cellular confinement systems consist of a mesh (similar to honeycomb) of high density polyethylene cells which are UV stable and chemically inert, and can be filled with topsoil and seed, gravel or concrete if necessary. The cell thickness is available in standard sizes of three to eight inches, and the cell width is up to 20 inches. The cells confine the infill material, resist the forces imparted by the river flows and the forces of erosion, and inhibit the downward migration of embankment materials. A slope angle of 1V:1.5H is assumed to be the steepest constructible slope while remaining stable. The Muddy River project slopes will be no steeper than 1V:3H. To install the cellular confinement system, the mesh is laid out, and the infill material is spread in the cells. The cellular mesh (plastic) can be spread by hand, and staked into place. The anchors can be driven by hand, and the anchors hook the edge of the cell wall to hold the system securely in place. The number and type of anchors is determined by subgrade density, weight and type of infill, and slope grade, etc. Anchors should be left in place after installation. The infill material can be spread by excavator bucket or similar equipment into the cells and graded by hand.

e. Erosion Control Matting:

Above elevation 3.0 NGVD, all slopes greater than 3:1 will be stabilized with 100 percent biodegradable erosion control matting or a long duration (> 18 month) hydromulch (e.g. Flexterra.) Strands of the matting will move independently to minimize the risk of wildlife entrapment.

3.3.10 Soil

Six to eight inches of topsoil will be spread throughout the restored area. No topsoil will be placed underwater except in areas to be planted with emergent where 3 - 6" of topsoil will be installed. Topsoil will likely be obtained from on-site (reuse) and off-site. Existing topsoil from daylighted areas will be stripped and stockpiled on-site for reuse. Topsoil will conform to the following limits:

Silt (0.002–0.05mm)	15 to 30 percent
Clay (< 0.002 mm)	5 to 15 percent
Sand (0.05-2.0 mm)	60 – 75 percent
> ¼ inch	< 3 % by volume
> ¾ inch	< 1 % by volume
> 2 inch	none
pH	6.0 to 7.0
Soluble Salts	< 75 parts per million
Organic matter	6 to 12 percent (loss on ignition)
Contaminants	Concentrations not to exceed MA RS1 levels.

The on or off-site topsoil may be adjusted to meet composition requirements by adding compost or inorganic components. Any compost used will be derived from organic wastes including leaf and yard residues, and biosolids. Compost will have the following properties:

Parameter	Range
pH	5.5 - 8.0
Moisture Content	35% - 55%
Soluble Salts	< 4.0 mmhos (dS)
C:N Ratio	15 - 30:1
Particle Size	< ¾"
Organic Matter Content	> 20%
Bulk Density	< 1200 lbs./cubic yard
Foreign Matter	< 1% (dry weight)

3.3.11 Planting

a. General: The landscape plan was prepared with assistance from Pressley Associates, a landscape architecture firm specializing in historic landscape restoration. The intent of the plan is to recreate the historic (1920's) look of the area as closely as possible. Historic conditions are known from surviving historic landscape plans and historic photographs. Plant species were selected based on a species list of historic plantings (Boston Parks Department, n.d.), site conditions, and availability of plant material from local or regional nurseries. Although species listed as invasive were avoided, the plant list does include non-native varieties, consistent with historic landscape restoration objectives. Shrub plantings are sized and spaced to provide for rapid establishment of shrub cover. In general for trees, the largest size (caliper diameter) readily available from local growers was specified. Ferns will be container grown. Plugs or rhizomes will generally be used to establish emergent vegetation.

b. Restoration of Emergent Vegetation: Little information is available regarding historic planting of freshwater emergent plants in Olmsted's Emerald Necklace park system. There is no evidence that emergents were planted in the reach of the Muddy River to be daylighted or the Upper Fens Pond. Planting of emergents is included in the design because historic pictures do show an emergent fringe along the river and such a fringe occurs today in some areas along the Riverway. Also, there is a regulatory driven need to restore emergent vegetation to the extent possible to compensate for expected removal of Phragmites in Phase II of the project. During a review of pre-90 percent plans, the MA DEP and local sponsor requested expanded planting of emergent vegetation throughout the area. The 90 percent design includes planting a narrow band of emergent vegetation along the entire streambank and establishes several emergent "shelf" areas, the largest of which is within a cove in the Upper Fens Pond. These areas will be planted with a variety of emergent plants native to eastern Massachusetts. Most of the species selected have low stature, a requirement for historic restoration and aesthetics. Several species (e.g. swamp loosestrife, pickerelweed, blue flag, and sweet flag) that are expected to be somewhat resistant to grazing. The emergent plants will be protected by an herbivore exclusion fence for at least two years to allow the roots system/rhizome system to become resistant to grazing. The effort to restore emergent vegetation during Phase I should be considered a pilot for a larger effort planned for Phase II.

c. Planting Zones: Emergents will be planted between elevation 0.0 NGVD and elevation 0.0. All trees and shrubs will be planted above elevation 1.5 NGVD. No upland species will be planted below elevation 3.0 NGVD. Biological benchmarks indicate shrubs currently grow to about elevation 2.0 NGVD and emergent species (*Phragmites* and purple loosestrife) to about elevation 0.8 (Table 6). The Muddy River is protected from tidal influence by the Charles River Dam.

d. Plant Performance Standards and Guarantee Period: There will be a two year guarantee period for all plantings. One-hundred percent survival of trees, shrubs, and ferns will be required. Performance standards for emergent vegetation will be based on percent cover. Areas planted with emergents will have > 75 percent cover after two years.

f. Herbivore Exclusion Fencing: Temporary fencing will be installed to protect emergent plantings from grazing by ducks, geese, and fish (carp) during the plant establishment period. The fencing will be installed along the water-side edge of all emergent plantings. The fencing will have a mesh size of 0.5 to 1 inch to exclude carp. Fencing will not be needed along the upland side of the emergent plantings because waterfowl are unlikely to traverse bordering upslope areas densely planted with trees and shrubs.

g. Seed Mix: Seed mixes for lawn areas contain a mix of typical turf species, primarily fescues and ryegrasses. Mixes tailored for sun and shade areas and dense shade were specified. A seed mix of native wildflowers and grasses was developed for areas planted with trees and shrubs. The mix contains non invasive species which typically grow less than about three feet tall.

f. Tree Protection: Many trees occur within or near the limit of work. All trees to remain will be protected with fencing or trunk protectors as directed by an arborist. The condition of certain trees near work limits will be evaluated during construction. If an arborist determines the tree can be saved, the construction contractor will be directed to do so.

h. Habitat Logs and Boulders: Habitat logs and boulders will be installed to enhance fisheries and wildlife habitat. Habitat logs will be installed in restored areas. About 1/3 will extend into the water to provide basking locations for turtles and perches for wading birds. The other logs will be placed in wooded areas and will provide habitat for fungi, insects, and other organisms as they decompose. Logs will be hardwoods salvaged from on site with a minimum butt diameter of 8" and length between 8 and 12 feet. Boulder clusters will be placed within the river to provide cover and resting habitat for fish. Boulders will be 2-3 ft diameter. Habitat boulders were not used by Olmsted and will be set below the normal water surface elevation to avoid visual impacts to the historic landscape design.

i. Other Restoration Design Elements:

1) Perimeter Fencing: The slopes will be fenced to prevent public access for two growing seasons. The fencing is required to limit vandalism and unintentional incidental damage by the public to plant material and side slopes. Use of 4 foot high black coated chain link fencing is anticipated.
2) Watering: Watering will be required during the plant establishment period. Water will likely be supplied from watering trucks. Pumping irrigation water from the river will not be permitted.
3) Staking: All trees will be staked according to standard industry practice.
4) Tree Wrap: At this time there are no plans to use tree wrap or plastic tree protectors to protect trees or shrubs from herbivores or sun scald. Populations of meadow voles, beaver, and other mammals which might

damage plantings are expected to be low. The monitoring/adaptive management plan will require protection if damage by herbivores becomes apparent.

5) Pruning: Planted trees and shrubs will be pruned by an arborist during the plant establishment period to remove dead branches and improve growth form. Standard industry pruning practices will be adhered to. Wound dressing will not be applied.

3.3.12 Invasive Plant Species Control

a. General: Restored habitat in daylighted areas will be very vulnerable to colonization by invasive species during the establishment phase. Primary invasive species of concern in the work area include Norway Maple (*Acer platanoides*), Tree of Heaven (*Ailanthus altissima*), buckthorn (*Frangula alnus*), Oriental Bittersweet (*Celastrus orbiculatus*), Japanese knotweed (*Polygonum cuspidatum*), Common Reed (*Phragmites australis*), and Purple loosestrife (*Lythrum salicaria*). Control of other plant species classified as “invasive” by the Massachusetts Invasive Plant Advisory Group may also be required. Reused or imported topsoil may also contain viable seeds of invasive species. Norway maple, buckthorn and other woody invasive plants are prevalent in the Upper Fens Pond. All invasives will be removed from the Upper Fens Pond below elevation 3.0 NAVD88 during bank restoration. At higher elevations all woody invasives will be removed by selective clearing and cut stump herbicide treatment. For the most part, existing topsoil will remain above elevation 3.0 NAVD88 and will likely contain viable seeds of invasive species. Invasive species are also present upstream of the Riverway and downstream of Avenue Louis Pasteur. There is an extensive stand of Phragmites between the Riverway and the proposed diversion barrier. Small patches of Phragmites occur near Avenue Louis Pasteur. Monitoring and control of invasive species will occur at the daylighted areas, the Upper Fens Pond, upstream of the Riverway to the diversion barrier and downstream of Avenue Louis Pasteur to the diversion barrier. The control effort will rely on application of appropriate herbicides.

b. Application Methods: The following herbicide application methods are acceptable: foliar application using hand held spray equipment, foliar application using a wipe (cloth or glove) technique, cut stem or cut stump treatment, and injection (Japanese knotweed only). All herbicide use will be in accordance with label instructions, state and federal law, and the Order of Conditions received from the Boston Conservation Commission. Herbicides will be applied by Massachusetts certified pesticide applicators.

Foliar application using hand held spray equipment or the wipe technique will wet the leaves of the target plant sufficiently to provide an effective dose of the herbicide. This technique will be used primarily on herbaceous plants, seedling of invasive trees and shrubs, and root suckers (tree of heaven).

Stem “cut and treat” herbicide applications involve the cutting and removal of the growing plant stems and then the spot application of herbicide to the freshly cut surface of the remaining rooted portion of the stem. This technique will be applied mostly to trees and shrubs with a basal diameter greater than ca. ¼ inches. The “spot” application should be accomplished with a swab and should occur immediately after the stem is cut. A marking dye will be used to identify which stems have been treated. Tress and shrubs will be cut using loping shears or a handsaw. Trees larger than 3” in diameter may be cut with a chain saw.

c. Species Specific Guidelines: Table 7 provides recommendations for control of invasive plant species likely to occur in the Muddy River project area. Mechanical control (i.e. pulling) is not considered effective since knotweed, purple loosestrife, and Phragmites can regrow from small pieces of rhizome remaining in the soil. Woody species such as Norway maple will readily regrow from cut stumps unless treated with herbicide. Control measures for other species will be developed as necessary. In all cases, herbicides must be used according to the USEPA approved product label.

d. Application Period: The pesticide application period runs from July 1 to September 15 unless otherwise approved. Herbicide application operations will be suspended when any one of the following conditions exist in a treatment area: 1) wind velocity exceeds ten (10) miles per hour; 2) heavy dew is present on leaf surfaces; 3) precipitation is expected to be received in quantities sufficient to wash chemicals off plants within 6 hours of application. 4) non compliance with local, state, or federal regulations or the Product Label, and 5) as directed by the Contracting Officer.

e. Area Specific Requirements and Site Conditions:

1) Daylighted Areas: invasive species control in these areas is expected to largely involve control of seedlings of targeted species. The preferred method of application in these areas will be the wipe method or highly focused foliar application using a hand held squirt bottle.

2) Upper Fens Pond Restoration Area: The Upper Fens Pond restoration area includes two zones. Zone A is includes areas generally below approximately EL 3.0. Zone B includes areas above Elevation 3.0. Zone A will be cleared of all existing vegetation, backfilled and replanted. Invasive species control in these areas is expected to largely involve control of seedlings of targeted species. The preferred method of application in these areas will be the wipe method or highly focused foliar application using a hand held squirt bottle. Zone B is moderately to densely vegetation with trees shrubs, and vines. Much of the shrub community consists of invasive species interspersed with tree saplings. An estimated 90 percent of shrub and saplings in this zone will require removal and cut stump treatment. Invasive trees, mostly Norway maple and Tree of Heaven, will also require removal and cut stump treatment. Prior to cutting and removal the Contractor will mark non-invasive trees and shrubs to remain with blue TRECODER marking paint or an equivalent durable lead-free exterior paint. Trees and shrubs to remain will be marked at the base of the stump and 2 – 4 ft. above the ground. Stump markings will extend completely around the base of the plant. Marking will occur during the growing season after full leaf-out when to aid in plant identification.

3) Restoration Area Downstream of Avenue Louis Pasteur: All trees growing on the Puddingstone revetment downstream of Avenue Louis Pasteur will be removed. The trees, which range in dbh up to about 12", will be removed by a licensed arborist using a bucket truck. Care must be taken not to dislodge or damage the puddingstone during the removal operation. Trees will be sectioned and lowered to the ground by ropes. Stumps should be cut flush with the ground surface and treated with an herbicide to prevent resprouting. The Contractor is responsible for traffic control. This area includes two small patches of *Phragmites*. If the overall project construction schedule allows it, the *Phragmites* will be sprayed with glyphosate herbicide prior to disturbance of the site for water control activities. *Phragmites* will be sprayed only between August 1 and October 15, and at least 10 days prior to disturbance of the site.

4) Restoration Area Upstream of the Riverway: This area contains extensive stands of *Phragmites* and knotweed and control of both species will extend upstream to the diversion barrier. *Phragmites* will be cut in mid summer (ca. August 1). After allowing a few weeks for regrowth, stems will be treated with a foliar spray application. Follow-up applications will use hand held sprayers or the wipe method.

f: Safety: Pesticide applicators will wear appropriate personal protective equipment, including long sleeved shirts, neoprene gloves, and other measures recommended in the product label. Although not required in the product label, gloves will be worn during application of herbicide containing glyphosate. The public will be excluded from all restoration areas by fencing during the invasive species control period. Herbicides will be applied so that pesticide drift outside the work area is avoided. Signage will be installed to alert the public of herbicide application as required in local, state, and federal pesticide control laws and regulations.

g. Performance Standards and Monitoring: At the completion of control efforts each growing season, targeted invasive plant species should be largely absent from the daylighted areas. "Absent" is defined as less than 0.5 live invasive plant per 100 square meters as measured in 10 randomly placed 5 x 5 m quadrants within the two daylighted areas. After completion of the first year control efforts, most invasive shrubs and trees will be eradicated from the Upper Fens Pond restoration area. At completion of control efforts, targeted invasive plant species should be largely absent from the Upper Fens Pond restoration area. "Absent" is defined as less than one live invasive plant per 100 square meters as measured in 10 randomly placed 5 x 5 m quadrants within the restoration area.

4. Alternatives Analysis

This section is drawn from the Environmental Assessment prepared for the Corps Feasibility study (Corps 2003). It explains why and how the recommended plan was formulated and selected. Please note that cost estimates presented in the economic analysis are from the 2003 Corps report and were for planning purposes only. A cost estimate for proposed Phase I work is in preparation.

4.1 Screening of Measures to Meet Objectives

4.1.1 Flood Control Measures

Flood damage can be reduced by either structural or non-structural measures. Structural measures include construction of dams, floodwalls or dikes to reduce flooding within a floodplain, and channelization to improve flood flow conveyance. Construction of floodwalls or dikes and channelization may be combined to reduce flood damage.

Dams control flooding by retaining water during high runoff events to reduce peak downstream flows and floodflow elevations. This measure is only feasible if suitable sites for dam and flood control reservoir are available. No suitable sites are available in the highly urbanized Muddy River watershed. Construction of a dam on the Muddy River is not feasible due to topography and adverse impacts to the historic Emerald Necklace park system.

Dikes or floodwalls act to restrict floodwaters within a limited portion of the floodplain, protecting adjacent low-lying areas that would otherwise be flooded. Construction of dikes and floodwalls to control flooding from the Muddy River is not feasible because the structures would have unacceptable adverse impacts on the historic Emerald Necklace park system.

Channelization includes modifying the alignment/configuration of a river/stream channel by removing obstructions, widening/deepening, or straightening the channel to increase conveyance of flood waters. Improved conveyance enhances discharge of floodwaters from the system, lowers peak flood stage, and reduces the extent of flooding. Removing of obstructions and deepening existing channels (dredging) to reduce flooding is feasible in the Muddy River. Widening channels beyond historic limits or straightening channels is not feasible since this would have an adverse effect on the landscape of the historic Emerald Necklace park system.

An extreme form of channelization involves diverting flows through fully constructed culverts, pipes and/or tunnels. Diversion of floodwaters by constructing a tunnel from the Muddy River to the Charles River basin is a possible alternative.

Non-structural measures include evacuation of residences, businesses, and institutions from the affected flood plain, or raising first floor elevations of structures that are inundated. Other flood proofing techniques include installation of temporary shields such as sandbags prior to a potential flood event.

For this study, non-structural elements were generally considered to be impracticable. Evacuating several prominent institutions, dozens of apartment buildings, numerous business/industrial facilities and abandonment of museums, schools, hospitals is not practical. Raising the first floors of hundreds of structures, many of them historic, is cost prohibitive and not implementable. Providing temporary shields is also not feasible since hundreds of structures need to be protected and sufficient reaction time needed to install the shields is often not available due to rapid runoff within the heavily paved (impervious) watershed.

4.1.2 Aquatic and Riparian Habitat Restoration Measures

This section identifies measures that could improve water quality, sediment quality, and aquatic and riparian habitat in the Muddy River.

a. Measures to Improve Water Quality

Several measures to improve water quality were identified and evaluated. These are: flow augmentation, off-stream treatment, aeration, flow recirculation, sediment removal (dredging), control of aquatic vegetation, and upstream source control (source control devices and implementation of best management practices).

Flow Augmentation

Water quality modeling done for the Corps 1998 study showed that discharges of 15 to 30 cubic feet per second (cfs) of aerated water in the Riverway would maintain dissolved oxygen (DO) concentrations above 5.0 mg/l (the minimum for a Class B warmwater fishery) throughout both the Riverway and Fens. Flow augmentation could also be used to increase DO in Leverett Pond, Willow and Wards Pond. The 1998 Corps study identified several potential augmentation sources and plans. These include diversion of wet weather flows from Stony Brook to a discharge point at Wards Pond and pumping of water from the Charles River to potential discharge points at the Brookline Avenue Gatehouse and Wards Pond. Also considered was a reverse flow option that would pump water from the Fens to the Muddy River conduit, causing aerated Charles River water to be drawn from the mouth of the Muddy River.

Off-Stream Treatment

Off stream treatment systems would pump water from the Muddy River, treat it to improve water quality, and discharge treated water back to the river. One option would remove contaminants such as suspended solids, organics, and nutrients, and aerate the water before it returns to the river. A second option would aerate the water but not remove pollutants. The Corps 1998 report considered placing a treatment plant or enclosed aeration system near the intersection of Brookline Avenue and Park Drive (the former Sears parking lot). Intakes would be in the Fens, with discharge points located upstream of the Riverway. Water quality benefits would be greatest near the discharge point and attenuate rapidly downstream.

Designs for floating aeration/biological treatment units are available. These units pump water from the waterbody (often using solar power), treat it and discharge it. Benefits are highly localized and units are most useful in small ponds. Units would be operated during low flow periods and removed during wintertime.

<u>Aeration (Instream treatment)</u>

Instream aeration involves using compressors to pump air through discharge lines placed within a body of water. Aeration could increase DO levels to over 5 mg/l in localized areas. Compressors could be placed within existing structures (*e.g.,* The Boston Gatehouse No. 1), in new aboveground structures, or underground. Siting opportunities for new structures would be limited due to the historic nature of the area. Aeration lines could be placed in open water areas, under bridges, or inside culverts.

<u>Aeration (Flow Recirculation)</u>

This alternative consists of aerating and recirculating the Muddy River by pumping water from the Fens to a cascade discharge structure located in the Riverway. Water would be aerated by the discharge structure, flow downstream through the Riverway to the Fens, and be pumped back upstream (recirculated). Water quality modeling done for the 1998 Corps reports found that flows on the order of 15 – 30 cfs discharged into the Riverway would maintain 5 mg/l DO levels throughout the Riverway and Fens during low flow periods.

The 1998 Corps report also provided conceptual plans for a recirculation/aeration system. The plan proposed constructing an intake and pump station in the Charlesgate area immediately downstream of Ipswich Street. Water would be pumped via a 10,300 foot long, 30-inch diameter line to a discharge structure located on the west bank of the Riverway near Route 9. The discharge structure would aerate water as it flowed from top of bank, through a series of steps and pools, to the Riverway. Siting a discharge structure on Leverett Pond was considered, but was unacceptable to historic resource agencies.

<u>Aeration (Flow Augmentation)</u>

This alternative is similar to the flow recirculation/aeration alternative. Instead of recirculating water from the Fens, however, water would be pumped to the Riverway from an intake constructed in the Charles River Basin. Resource agencies are opposed to this approach because of potential impacts to anandromous fish migration and other concerns.

<u>Sediment Removal (Dredging)</u>

Removal of accumulated sediment can improve water quality in several ways. Dredging of organic rich sediment reduces sediment oxygen demand (SOD) and increases water volume, both of which can increase DO levels in surface waters. Water quality modeling by the Corps for the 1998 report indicated that dredging could increase DO levels above 5 mg/l throughout the Fens, Riverway and Leverett Pond. Benefits of dredging gradually decline over time as sediment oxygen demand increases due to deposition of organic matter from external sources (*e.g.,* leaf fall and non-point runoff) and internal production (algae and aquatic vegetation). This necessitates maintenance dredging to maintain long-term water quality benefits.

Dredging also reduces nutrient availability, alleviating water quality problems associated with excessive growth of aquatic weeds (*e.g.,* fanwort) and algae. Dredging also can reduce contaminant levels (*e.g.,* metals) in surface waters by removing contaminants in sediment that may be released into the water.

Material would be dredged from the system using mechanical or hydraulic dredging equipment. Dredged material will likely be dewatered on site and disposed of at an upland landfill.

Control of Aquatic Vegetation

Excessive growth of aquatic vegetation such as fanwort can cause water quality and odor problems as the vegetation decomposes at the end of the growing season. Growth of aquatic vegetation can be controlled by various measures, including mechanical harvesting, application of aquatic herbicides such as SONAR, dredging to remove vegetation, removing nutrients and /or deepening the bottom of the waterbody to below the photic zone, and exercising biological control using insects, plant pathogens, or herbaceous fish (*e.g.,* grass carp).

Upstream Source Controls (Point Sources)

Point sources, such as storm drains, combined sewer overflow, and industrial discharges can degrade surface water quality by loading organic matter, pathogens, nutrients, and contaminants. Storm drains and overflow from the Stony Brook drainage system are the only known remaining point sources in the Muddy River watershed. Numerous illegal connections between storm drains and sanitary sewer systems once severely degraded water quality. Since the early 1990's, Brookline and Boston have identified and corrected numerous illegal connections (CDM, 2001). Although the majority of readily detectable illegal connections have been found, work will continue to detect and eliminate any other illegal connections. The Stony Brook drainage system is the only remaining system in the Muddy River watershed that discharges combined sewer overflow into the river. Boston is undertaking an ambitious project to eliminate CSO's and make other improvements to the Stony Brook system.

Upstream Source Controls (Best Management Practices)

BMP's include a variety of practices that can reduce loading of sediment, organic material, nutrients, and contaminants to surface waters from non-point sources. They include both structural measures such as installation of particle separators from storm drains and non-structural practices such as street sweeping, catch basin maintenance, regulatory reform and public education. Collectively, implementation of BMP's can improve both water quality and sediment quality. Phase I of Boston and Brookline's Muddy River restoration project recommends instituting numerous BMP's (CDM, 2001).

b. Measures to Improve Sediment Quality

Environmental Dredging

Dredging can improve sediment quality by removing contaminated surficial sediments and exposing less contaminated underlying material. Studies conducted by CDM (2003) and the Corps (see Appendix D, Corps 2003) indicate that removal of 2 –3 feet of sediment from the Fens, Riverway, Leverett Pond and Willow Pond would greatly improve sediment quality. After dredging, non-point pollution from the highly urbanized Muddy River watershed would gradually increase contaminant levels in sediments. However, instituting BMP's would reduce non-point loading of contaminants and maintain long-term sediment quality.

Sediment Capping

Poor sediment quality can be mitigated by capping sediment with clean material. This option is only practical in locations were adequate water depth is available. Given the shallow nature of surface waters in the Muddy River system and plans to dredge a flood control channel in the Fens, this alternative is not appropriate or feasible.

Best Management Practices (BMP's)

BMP's (see above) can reduce loading of contaminants from non-point sources to surface waters and, ultimately, the accumulation of contaminants in sediment.

Innovative Technologies

Research studies suggest that it may be possible to enhance microbial degradation (bioremediation) of organic compounds such as PAHs and PCBs in sediment. Both in place (in-situ) treatment of sediment and treatment of dredged material are under study. Use of plants to remove metals and other contaminants from dredged material is also under study. While pilot studies show promise, application of this technology in the Muddy River is not yet feasible.

Another innovative technology under investigation is sediment washing. This involves using varies mechanical and chemical processes to reduce contaminant levels in dredged material. The "washed material" may be suitable for placement back in an aquatic system, for use in manufactured topsoil, or use as fill material. Again, this experimental technology shows promise, but is not yet feasible for application in the Muddy River.

c. Measures to Manage Invasive Vegetation

A variety of invasive species has proliferated in the Muddy River. These include *Phragmites*, purple loosestrife, oriental knotweed, and fanwort. Control of these species would increase species diversity of riparian and wetland plant communities and improve wildlife habitat. Control of dense fanwort stands in the Fens would also improve water quality. Measures available to manage these species and their efficacy are discussed below.

Phragmites

Glyphosate herbicides can effectively control *Phragmites*. The herbicides may be applied from hand sprayers, backpack sprayers, painted on leaves or cut stems with a brush or sponge, or injected into hollow cut stems with a syringe. Glyphosate herbicides are used to control *Phragmites* and are considered safe. Commercially available formulations have low toxicity to aquatic life and quickly degrade in the environment to non-toxic by-products. The effectiveness of herbicide is enhanced when application is combined with cutting. Treatment occurs in late summer. Repeated cutting and follow-up herbicide applications, over several growing seasons, can eradicate even well established stands. A demonstration study conducted by the Corps in the Back Bay Fens found the cut stem technique to be effective, but very labor intensive and impractical for large scale use (ACOE, 2008).

Excavation of rhizomes may also effectively control *Phragmites*. In wetland areas excavation to depths of 1.5 to 2 feet will remove most of the rhizomes and roots. On steep slopes, however, rhizomes may grow several feet or more below the ground surface, making eradication through excavation difficult and expensive. In all excavated areas, follow-up control with spot herbicide application is essential for eradication since viable rhizomes will likely remain and can quickly reestablish the stand.

Combined use of dredging to remove *Phragmites* in wetland areas, cutting and herbicide application in riparian areas and follow-up monitoring and herbicide application should result in substantial eradication of *Phragmites* from the Muddy River. Eradication is expected to take 3 – 5 years. Follow-up monitoring would be needed to guard against reinfestation.

Control using cutting and plastic shading can be effective for very small stands. However, large-scale experimental efforts to control *Phragmites* in the Fens by cutting and shading with black plastic were unsuccessful (Cortell, 1996). There are currently no biological control measures available to control *Phragmites.*

Oriental Knotweed

Knotweed can be controlled by repeated glyphosate herbicide applications. Cutting may enhance efficacy of herbicide application. Long-term control efforts may reduce abundance of knotweed and allow establishment of more desirable native vegetation. It is extremely difficult, if not impossible, to eradicate large established stands of Oriental knotweed. Control efforts should also focus on monitoring and eradication of small, newly established stands. There are currently no biological control measures available for oriental knotweed.

Purple Loosestrife

Small newly established stands of Purple loosestrife can be controlled by application of glyphosate herbicide and mechanical control (pulling). Eradication by chemical or mechanical measures is difficult since loosestrife produces enormous numbers of small seeds and readily regrow from perennial rhizomes. In recent years, biological control using *Galerucella* beetles and other insects has become the accepted control measure for well-established stands growing in wet meadow or shallow water habitats. Once established, beetles can greatly reduce density of loosestrife, allowing recolonization by more desirable native species. *Galerucella* beetles have been released at several locations in Massachusetts.

Fanwort

Infestations of fanwort can be controlled by mechanical harvesting, use of aquatic herbicides such as SONAR, and dredging. Mechanical harvesting is accomplished by floating equipment which rake weeds from the water. Harvested material can be disposed in municipal composting facilities. Harvesting once a year would provide adequate control but eradication is unlikely. SONAR is applied as a liquid or slow release pellet. It has low toxicity to aquatic life, but may harm many non-target native aquatic plants such as water lilies and some emergents. Repeat applications of SONAR would be needed approximately every 5 years. Dredging can greatly reduce fanwort populations by physically removing plants and seeds.

d. Other Measures to Enhance Aquatic and Riparian Habitat

Daylighting

Daylighting refers to restoration of streams that are enclosed in culverts or other conduits. Typically, these streams are in highly urbanized areas and were culverted to reduce flooding, alleviate aesthetic problems caused by poor water quality, allow development of a recreational landscape feature, or facilitate development. Daylighting involves restoration of historic natural stream channels and adjacent riparian habitat. The recommended plan, if implemented, includes daylighting of about 700 feet of the Muddy River within the Fens area.

Removal of Fill to Restore or Create Wetland Habitat

Wetland habitat that has been filled by past “reclamation” projects can be restored by removal of the fill material. To create wetland, the site must be excavated to a sufficient depth to restore adequate hydrology to assure development of wetland (hydric) soils and vegetation. Restored areas can be planted or seeded with native vegetation or allowed to revegetate naturally. Planting or seeding is oft.en desirable to reduce colonization of newly created habitat by undesirable invasive species. To create open water aquatic habitat, water depth must be 2 – 3 ft. to prevent colonization by emergent vegetation.

Restoration of filled wetlands is consistent with Boston and Brookline's historic landscape restoration objectives. Based on coordination with cultural resource agencies, restoration of wetland and aquatic habitat in the Fens to the historic shoreline present in ca. 1920 is appropriate and very desirable. This is considered the "second period of significance" for the Fens and reflects redesign of this area by Arthur Shurtleff (see Section 4.7). Restoration of additional historic aquatic habitat in the Fens is technically possible, but would adversely effect the Victory Gardens and other well-established competing uses.

Riparian Habitat Revegetation

Loss of tree and shrub cover along streambanks can have adverse effects on water quality, aquatic habitat, streambank stability, and wildlife habitat. Oft.en loss of tree cover is a result of cultural practices (*e.g.,* mowing, grazing) that can be altered to allow natural reestablishment of woody vegetation. Regrowth of woody vegetation can be accelerated by planting native trees and shrubs. Bank stabilization measures and invasive species control may be needed in conjunction with plantings.

Structural Habitat Improvement

Aquatic habitat can be improved by adding "structure" to provide underwater cover. Structure provides fish protection from predators, resting areas, feeding sites, and can enhance productivity and diversity of aquatic invertebrate communities. Methods to provide cover include installing boulders, logs, root wads, or commercially available artificial structures. In the Muddy River system, these features would generally need to be completely submerged to avoid visual impacts to the historic park landscape.

Installation of partially exposed habitat logs to provide basking sites for turtles and amphibians is also beneficial. If carefully placed, the logs would not have an adverse visual impact.

Deflectors

Deflectors are spurs of rock, logs, gabion baskets or other hard structures that extend from a stream bank perpendicular to the stream channel. They provide cover and add habitat diversity to the channel by concentrating flow and creating deep pools. Double deflectors spaced opposite each other can cause long deep scour holes to from downstream. Deflectors can also stabilize steam banks by creating backwater areas adjacent to banks. Deflectors would also need to be submerged to avoid visual impacts to the park landscape.

4.1.3 Results of Screening of Flood Control and Habitat Restoration Measures

Measures to control flooding, improve water and sediment quality, and enhance aquatic and riparian habitat were screened based on technical feasibility, effectiveness, acceptability to project Sponsors and regulatory authorities, and potential for long-term adverse environmental affects. Measures were placed into one of three categories:

1) eliminated from further consideration;

2) retained for further analysis; or

3) retained for possible implementation by the Sponsors and included in the baseline (no action) alternative.

Results of the screening are discussed in Corps (2003) and summarized in Table 8.

4.2 Project Alternatives

4.2.1 Flood Control

This section describes four flood control plans that were selected for further study. Three plans offer a comprehensive solution to flooding in the Muddy River and its major tributary, Stony Brook. To establish a plan that maximized economic benefits, three levels of flood protection were evaluated. These included the 20, 25 and 100-year floods. Since a large percentage of expected flood losses would occur to the MBTA system (see Section II of Corps (2003)), an independent plan to protect this essential public resource was also developed. The proposed plans are illustrated in Plates 6 through 27 of Corps (2003).

<u>Alternative 1: MBTA Portal Barrier Plan</u>

The extensive inundation damage to underground MBTA facilities during the October 1996 storm was caused by flood flows entering through a tunnel entrance portal located just east of the Fenway station on the Riverside line (see Plate 5, Corps 2003). This portal is currently protected by a stoplog structure about three feet high that must be manually closed. Hydrologic analysis (see Appendix C, Corps 2003) indicates that flooding along the tracks does not become a serious concern until flows exceed about the 10-year flood event. Flows exceeding this event overtop the stop-log structure and flood the underground portions of the MBTA system.

To prevent the major flooding associated with floods exceeding the 10-year event, the feasibility of raising the portal walls and stop log structure was evaluated. Given the peak flows developed for the 1996 and 1955 events, preliminary studies indicate that the portal walls and stop log structure would need to be raised about 4 feet.

Although raising the stoplog structure and portal walls would be a relatively straightforward solution to flooding of the underground portions of the MBTA, it will induce flooding in other areas. These areas include adjacent parking lots, apartment buildings, and railroad tracks owned by the CSX Corporation. Since raising the height of protection at the portal will induce serious flooding in other areas, additional flood control measures were necessary to mitigate for this damage. Although the parking lots and apartment buildings could be protected by structural or non-structural means, preventing inundation of the CSX tracks would only transfer the flooding to other areas. Consequently, the only feasible solution was a tunnel/culvert to divert flows from the portal area to the Charles River Basin. Due to space limitations in the vicinity of the existing stoplog structure, the control structure needed to be moved to the west side of the Fenway station where a new floodwall (about 865 feet long), gate structure and tunnel entrance would be situated at this point. The required tunnel to direct flows from the area of the new closure to the Charles River Basin would be 12 feet in diameter and about 3200 feet long. The tunnel alignment and other project features are shown on Plate 5 of Corps (2003).

The cost of this measure alone is approximately $24,283,100. However, it only serves to protect the MBTA system and does not reduce flooding to other areas along the Muddy River or alleviate flood conditions caused by Stony Brook Conduit overflows.

<u>Alternative 2: Flood Improvements for a 20-year Storm</u>

This plan provides flood control by implementing a variety of measures to increase flow conveyance in the Back Bay Fens, Riverway, and Leverett Pond. The major flood control features of this plan were adopted from the Phase I Muddy River Flood Control, Water Quality and Habitat

Enhancement and Historic Preservation Project currently under development by the city of Boston and town of Brookline. Proposed improvements are presented below for each section of the study area (Fens, Riverway, and Leverett Pond). The plans are illustrated in Plates 56– 16 of Corps (2003).

Back Bay Fens

This section of the river, from Ipswich Street to just upstream of the former Sears parking lot at The Riverway, is approximately 6,600 feet long . This section consists of three main areas; the Northern Basin from Ipswich Street to Agassiz Road, the Southern Basin from Agassiz Road to Avenue Louis Pasteur, and the upper Fens Pond upstream of Avenue Louis Pasteur. Flood control measures that are proposed within the Back Bay Fens area include the following (see Plates 6 through 15 of Corps (2003):

- The improvement of the flood carrying capacity by dredging an engineered channel that runs through the center of the Muddy River. Approximately 37,252 cubic yards (cy) of accumulated sediment and debris from the river would be removed.
- Daylighting of presently culverted sections upstream of the Fens Bridge (Avenue Louis Pasteur) and at the former Sears parking lot and removing the existing twin 6-foot diameter culverts;
- Construction of a new 10 foot by 16-foot arch culvert under The Riverway at the former Sears parking lot while maintaining the twin 72 inch diameter pipelines under The Riverway;
- Construction of a new 10 foot by 24-foot arch culvert under Brookline Avenue at the Sears rotary with an overflow to the Muddy River Conduit; and
- Dredging the culvert under the Fens Bridge, rebuilding/restoring the upstream headwall and restoring the downstream headwall.
- Preservation of the historic park shoreline and restoration of the natural bank in areas disturbed by construction.

Riverway

The Riverway section of the Muddy River is approximately 5,800 ft. long and runs from Route 9 to the culvert entrance just upstream of the Sears Parking Lot area. Flood control measures proposed within the Riverway area include (see Plates 9 and 10 of Corps, 2003):

- The opening of restricted flood channels at five locations through the removal of approximately 6,687 cy of sediment; and
- Preservation of the historic park shoreline and the restoration of the natural bank in channel areas to be widened or cleared.

The channel immediately upstream from the culverts under the former Sears parking lot would be widened to a 40-foot bottom width while other restricted channel areas would be dredged to a 15-foot bottom width.

Leverett Pond

Leverett Pond is located upstream of the Riverway within the city of Boston and the town of Brookline. (See Plate 11 of *Decision Document*) The major discharge into Leverett Pond is Village Brook, which drains about 3.2 square miles of urban area. A sandbar has formed in Leverett Pond at the discharge point of the Village Brook drain due to the sand and grit that is washed from area roadways. Construction activities that are proposed in the Leverett Pond area include:

- The improvement of the flood carrying capacity at the outlet of the Village Brook drain via dredging and removal of the sandbar (approximately 1,000 cy of accumulated sediment); and

- Restoration of areas of the shoreline disturbed by project construction activities upon completion of the work.

The flood control improvements also include eight sedimentation basins excavated in the riverbed to trap sediments and prevent rapid loss of flow capacity. A list of the basins and their location is provided in Section II of Corps (2003).

The total first cost of the 20-year flood control plan is $24,0896,200. This includes dredging a total of about 65,000 cy of sediment, daylighting about 700 feet of river, installing two new culverts, and restoring the Fens Bridge.

Alternative 3: Flood Improvements for a 25-Year Storm

The proposed flood improvements for a 25-year storm event would include all of the features just presented for the 20-year storm, with the following additions or changes. Plans are shown on Plates 16 and 17 of Corps (2003).

The first additional project requirement would be the removal of about 870 cubic yards of sediment from the Muddy River Conduit. With operation of the gate on the upstream end of the conduit, this would allow additional flow through the conduit (See Plate 16, Corps 2003). The Muddy River Conduit runs beneath Brookline Avenue from just west of the former Sears parking lot to Kenmore Square and then into the Charles River (see also Plate 4, Corps 2003). This conduit is approximately 3600 feet long and is generally rectangular in shape with varying dimensions in the range of ten feet by 11 feet high. The Boston Sewer and Water Commission (BWSC) owns and maintains this conduit and uses it to collect stormwater from adjacent streets. Coordination with BWSC determined that utilizing the conduit for additional Muddy River flood flows would reduce its storm drainage effectiveness and cause flooding in the Queensbury Street section of the Back Bay Fens. To mitigate for this induced flooding, a 60-inch conduit would be required to convey flood flows from Queensbury Street to the Muddy River at a point downstream from Boylston Street.

The second change/addition to the 20-year plan is necessary to convey the higher flow associated with the 25-year storm at the Riverway at the former Sears parking lot. Where the 20-year plan called for retaining the existing twin six-foot culverts and constructing a single new 10 x 16-foot arch culvert, the 25-year plan would include construction of twin 10 x 22 arch culverts and removal of the existing twin 6-foot culverts. The last change to the 20-year plan would be the construction of twin 10 x 22-foot arch culverts instead of the single 10 x 24-foot arch proposed for the 20-year plan.

The total volume of dredged material (flood channel and sedimentation basins) is approximately 65,000 cy from the Muddy River channel, with an additional 870 cy from the Muddy River conduit. The cost of the 25-year flood control plan is $29,944,500. This excludes the cost of removing sediment from the Muddy River Conduit as this is considered a local maintenance requirement.

Alternative 4: Flood Improvements for a 100-Year Storm

The proposed improvements to the Muddy River for a 100-year storm event are the same as those proposed for the 20-year event (storm of October 1996) with the addition of two major drainage tunnels and the cleaning of the Muddy River Conduit. The tunnels are required to convey storm water from the Muddy River to the Charles River in the larger storms since there is insufficient capacity to discharge the stormwater through the Muddy River channel area. Plans are shown on Plates 18 - 22 of Corps (2003).

The first tunnel will begin at Boston Gatehouse #2 and run under the Charlesgate area to an outlet at the Charles River (See Plates 19 and 20, Corps 2003). The tunnel is estimated to be 3,800 feet long with a diameter of 14 feet. The second tunnel, estimated at 3,600 feet long with a 14-foot diameter, begins at the former Sears parking lot adjacent to the Muddy River Conduit, runs parallel to this conduit, and discharges to the Charles River (See Plate 22, Corps 2003). As in the 25-year flood alternative , the Muddy River Conduit also needs to be cleaned of sediments to pass sufficient flow during the 100-year flood to meet target elevations (See Plate 21, Corps 2003), and a 60-inch conduit would be required between Queensbury Street and the Muddy River

The total volume of dredged material (flood channel and sedimentation basins) remains the same as in the previous alternatives, approximately 65,000 cy from the Muddy River channel with an additional 870 cy from the Muddy River conduit. The estimated cost for 100-year flood control improvements is about $72,558,100 (Note: This excludes the cost of removing sediment from the Muddy River Conduit as this is considered a local maintenance requirement).

4.2.2 Ecosystem Restoration

Alternatives were identified by applying measures selected in Section 4.2 to the various ponds and waterways in the study area. Alternatives formulated ranged from no action to dredging the entire Muddy River system, from Wards Pond, downstream through the Fens. No more than one main water quality improvement measure (dredging, recirculation, or aeration) was applied to any one location. Potential alternatives likely to have little or no support from the Sponsors or provide minimal environmental benefits (*e.g.,* dredging only Wards Pond and Willow Pond) were excluded from the analysis.

<u>Alternative 1 – No Action</u>

The No Action alternative would involve no changes to the present situation except dredging sediments from the Muddy River in the Charlesgate section of the river by others. This dredging was completed during 2002 using a combination of City, State and FEMA funding.

<u>Alternative 2 – Flood Control</u>

Alternative 2 includes dredging a flood control channel in the Fens, daylighting a section of the river in the Fens and at the former Sears parking lot, restoring the Fens Bridge (Avenue Louis Pasteur), and constructing a new culvert at Brookline Avenue and an additional Riverway culvert. Also included is dredging to remove flow restrictions at 5 locations in the Riverway, and dredging at the Village Brook outlet at Leverett Pond.

<u>Alternative 3 – Flood Control and Environmental Dredging</u>

Alternative 3 has a series of sub-alternatives, which include flood control dredging and environmental dredging.

3a – Alternative 3a includes dredging the entire Fens, flood control dredging to remove flow restrictions at 5 locations in the Riverway, and flood control dredging at the Village Brook outlet at Leverett Pond.

3b – Alternative 3b includes dredging the entire Fens and Riverway, and flood control dredging at the Village Brook outlet at Leverett Pond.

3c – Alternative 3c includes dredging the entire Fens and Riverway flood control dredging at the Village Brook outlet at Leverett Pond, and environmental dredging of Willow Pond.

3d – Alternative 3d includes dredging the entire Fens and Riverway and environmental dredging of Leverett Pond and Willow Pond.

3e – Alternative 3e includes dredging the entire Fens and Riverway and environmental dredging of Leverett Pond, Willow Pond, and Wards Pond.

Alternative 4 – Flood Control with Recirculation

Alternative 4 includes flood control dredging at the Fens, Riverway (remove flow restrictions at 5 locations in the Riverway) and Leverett Pond (Village Brook outlet). The alternative also includes recirculation in the Fens and Riverway, with an intake and pump station in the Charlesgate area and a cascade aeration structure in the Riverway near Route 9.

Alternative 5 – Flood Control, Recirculation, and Environmental Dredging

Alternative 5 has three sub-alternatives which include flood control dredging with recirculation, and/or environmental dredging.

5a – Alternative 5a includes flood control dredging in the Fens, flood control dredging to remove flow restrictions at 5 locations in the Riverway, flood control dredging at the Village Brook outlet at Leverett Pond, and environmental dredging at Willow Pond. The alternative also includes recirculation at the Fens and Riverway with an intake and pump station in the Charlesgate area and a cascade aeration structure in the Riverway near Route 9.

5b – Alternative 5b includes flood control dredging in the Fens, flood control dredging to remove flow restrictions at 5 locations in the Riverway, and environmental dredging at Leverett Pond and Willow Pond. The alternative also includes recirculation at the Fens and Riverway.

5c – Alternative 5c includes flood control dredging in the Fens, flood control dredging to remove flow restrictions at 5 locations in the Riverway, and environmental dredging at Leverett Pond, Willow Pond, and Wards Pond. The alternative also includes recirculation at the Fens and Riverway.

Alternative 6 – Flood Control, Environmental Dredging and Aeration

Alternative 6 includes dredging the entire Fens and Riverway, environmental dredging at Leverett Pond and Willow Pond, and aeration at Wards Pond.

Alternative 7 – Flood Control, Environ.Dredging, Recirculation and Aeration

Alternative 7 includes flood control dredging in the Fens, flood control dredging to remove flow restrictions at 5 locations in the Riverway, and environmental dredging at Leverett Pond and Willow Pond. The alternative also includes recirculation at the Fens and Riverway as well as aeration at Wards Pond.

Alternative 8 – Flood Control, Aeration and Limited Environmental Dredging

Alternative 8 includes flood control dredging in the Fens, flood control dredging to remove flow restrictions at 5 locations in the Riverway, and flood control dredging at the Village Brook outlet at Leverett Pond (Figure EA-16, Corps 2003). The alternative also includes environmental dredging at Willow Pond, installation of aeration lines, and construction of compressor buildings at six (6) locations to provide aeration in the Fens, Riverway, and Leverett and Wards Ponds.

All alternatives, except No Action, include flood control improvements. These include dredging a flood control channel (bottom width of 80 feet, including sideslopes) in the Fens, dredging to remove flow restrictions at 5 locations in the Riverway, dredging at the Village Brook outlet at Leverett Pond, daylighting about 700 feet of the Muddy River restoring the Fens bridge, and installing new culverts at the Riverway and Brookline Avenue. All environmental dredging alternatives in the Fens include restoration of the historic shoreline in ca. 1920. This is a critical element of Boston and Brookline's historic preservation plan for the area (see CDM, 2001).

All alternatives that include bank to bank dredging in the Fens and Riverway include eradication of *Phragmites* from wetland and riparian habitat using herbicides and cutting. Lost emergent wetland will be restored by planting emergent wetland along the shoreline in the Fens and Riverway. Several large patches of emergent wetland will also be reestablished in the Fens.

Measures that include environmental dredging also include installation of habitat boulders in Leverett Pond, the Riverway, and the Fens, habitat logs in the Fens and Riverway, and deflectors in the Riverway.

For each alternative, two maintenance scenarios were evaluated. Scenario I assumed maintenance dredging of flood control channels and all other areas dredged by the alternative. Maintenance dredging would be required once during the 50-year project life. Scenario II assumed no maintenance dredging except to maintain the flood control project and, if applicable, improvements at Willow Pond.

All plans assume Boston and Brookline will institute BMPs and Point Source Controls as described in the Draft. Muddy River EIR (CDM, 2001).

4.3 Plan Selection

4.3.1 Flood Control

<u>Cost and Benefits of Flood Control Plans</u>

The following summary shows total first costs, and annual costs and benefits for the four flood control alternatives under consideration. Total annual costs include costs for maintenance dredging of the flood control channels and sedimentation basins. Additional information on cost estimation is provided in Appendix G of Corps (2003).

Costs and Benefits of Flood Control Alternatives (from Corps (2003).

Alternative Plan	Total First Costs*	Total Annual Costs**	Annual Benefit	Net Annual Benefits	Benefit/Cost Ratio
MBTA Portal Barrier	$24,283,100	$1,711,800	$5,292,900	$3,581,100	3.1
20-Year Plan	$24,896,200	$1,823,700	$6,299,500	$4,475,700	3.5
25-Year Plan	$29,944,500	$2,177,500	$6,789,500	$4,612,400	3.1
100-Year Plan	$72,558,100	$5,163,900	$6,886,700	$1,722,800	1.3

Note: * Total First Costs do not include escalation

** Total annual costs include first costs, interest during construction and operation and maintenance costs. Please note that cost estimates presented in this economic analysis are from the 2003 Corps report and were for planning purposes only. An updated cost estimate for proposed Phase I work is in preparation.

Selection of the NED Plan

Corps planning guidance (ER 1105-2-100) specifies that the plan that maximizes net benefits shall be selected and recommended for Federal implementation (the National Economic Development or NED Plan). Net annual benefits are defined as excess annual benefits over costs, or, simply, annual benefits minus annual costs. Using the cost and benefit information from Table EA-3, annual net benefits range from $1,722,800 for the 100-year plan to $4,612,000 for the 25-year plan. All evaluated flood control plans have annual benefits exceeding annual costs and are economically justified. However, the 25-year plan has the largest net benefits and is the NED Plan.

Selection of Preferred Flood Control Plan

Although the NED Plan provides a higher level of flood control protection, the 20-year plan was selected as the preferred plan. The NED plan was rejected because it was not compatible with the historic restoration goals outlined in the Emerald Necklace Master Plan (Pressely Associates, 2001). The Master Plan recommends recreating the landscape and watercourse in the former Sears parking lot area and stressed that a historically sensitive design was imperative. Considering the original width of the river in this area (about 30-35 feet), twin 10x22-foot culverts required for the NED plan are inappropriate. The NED plan also relied on full utilization of the Muddy River Conduit to convey flood flows. This would, however, worsen flood conditions in the Queensberry Street portion of the Back Bay Fens. For these reasons, the study Sponsors preferred that the 20-year plan be retained for further consideration and used as the basis upon which environmental restoration measures were added and evaluated.

4.3.2 Ecosystem Restoration

The recommended plan was selected based on the results of a cost effectiveness and incremental cost analysis, an assessment of the environmental benefits and impacts of the alternatives, coordination with state and local governments, resource agencies, and views of the interested public.

Cost Effectiveness and Incremental Cost Analysis

The benefits of ecosystem restoration projects cannot be evaluated using a cost to benefit ratio as is done for flood control benefits. This is because ecosystem restoration benefits cannot readily be quantified in monetary terms. To compare alternative restoration plans, the Corps of Engineers Institute of Water Resources (IWR) developed an incremental cost analysis approach. This approach examines how the costs of additional units of environmental benefits increase as the level of environmental benefits increases. Environmental benefits are measured in terms of habitat units (HUs), acres, or some other non-monetary measure.

The analysis is conducted in accordance with IWR Report 95-R-1, Evaluation of Environmental Investments Procedures Manual-Interim: Cost Effectiveness and Incremental Cost Analyses, May 1995 using a computer program (IWR-PLAN), developed by the IWR. IWR-Plan generates an incremental cost curve to display cost effective solutions. Cost effective solutions are those increments that result in same output, or number of habitat units, for the least cost. An increment is cost effective if there are no others that cost less and provide the same, or more, habitat units. Alternatively, for a given increment cost, there will be no other increments that provide more habitat units. The program also identifies “best buy plans”. Best buy plans provide the same level of output at a lower incremental cost than any other plan.

Costs

The incremental analysis was conducted using average annual costs. Cost were estimated using the Corps of Engineers MCACES cost estimating system (see Appendix G). The estimates include cost to develop plans and specifications, engineering and design during construction, construction supervision, and a 20 percent contingency. Operation and maintenance costs over a 50-year project life are also included in the estimate.

Benefits

Benefits were measured in habitat units (HU's) using an approach based on United States Fish and Wildlife Service (USFWS) Habitat Evacuation Procedures (HEP) developed for the Muddy River Study (see Appendix J of Corps (2003)). Four ecological guilds were included in the evaluation: the benthic invertebrate community, fish, piscivorous wildlife, and wetland/riparian dependent songbirds. The HEP study was guided by a "HEP Team" composed of representatives from the Corps, USFWS, and Corps consultants (Battelle and Northern Ecological Associates).

The underlying assumption of HEP is that the value of habitat for an organism or a guild (a group of organisms that share a similar habitat and use resources in a similar manner) can be described by a Habitat Suitability Index (HSI) model. HSI models typically denote habitat suitability of a species as the relationship between two or more environmental variables that are deemed to affect the species' presence, distribution, and/or abundance. The HSI is defined as a value between 0.0 and 1.0, with 1.0 representing maximum habitat quality of a species in a defined area at a specific point in time, and is assumed to be positively correlated to habitat carrying capacity. The HSI value is multiplied by the area of available habitat to obtain Habitat Units (HUs). The HU values provide a quantitative estimate of overall habitat benefits.

For the Muddy River Study, fish HU's are based on predicted dissolved oxygen (DO) levels. Predicted DO levels above 5 mg/l (the USEPA 5 mg/l ambient water quality standard for warmwater fisheries) was given an HSI of 1, predicted levels below 5 mg/l an HSI of 0. Benthic habitat value relied on a sediment toxicity model by Ingersoll et.al. (2000) that relates sediment toxicity to benthic invertebrates to concentrations of PAHs, metals, and PCBs in sediment. HEP models were used to assess benefits on piscivorous wildlife (green heron) and wetland dependent songbirds (common yellow throat and wren). The analysis included a risk based degradation factor to account for effect of sediment chemistry on wildlife habitat quality.

Results of HEP Analysis

Table 9 provides a summary of the HEP analysis. Typically, total HUs were highest for the Fens and the Riverway, largely a result of higher habitat acreage in those areas. Overall, Plan 3e (Flood Control and Environmental Dredging with maintenance) and Plan 6 (Flood Control, Dredging, and Aeration, with maintenance) provided the greatest number of total HUs, with 76.2 and 75.8, respectively. The analysis shows that alternatives with environmental dredging require maintenance dredging to maintain benefits over the 50 year project life. Most of the decline in habitat benefits without maintenance reflects loss of fish habitat benefits.

Results of Incremental Analysis

Costs and benefits of environmental restoration alternatives are presented in Table 10 Actual annual project cost is displayed in Column 4 and project cost, netting out the flood control component, is shown in Column 5. Column 6 shows actual HUs associated with each plan. Column 7 displays the increase in HUs over Plan 2, the recommended flood control plan.

Table 11 shows the best buy plans. The first increment is Plan 4, which has 15.2 HU and an incremental cost of $37,300 per HU. This plan consists of recirculation at the Fens and the Riverway. The second increment is Plan 4, recirculation at the Fens and Riverway and an incremental cost of $91,000. The third increment is Plan 7, which has an incremental cost of $112,700 per HU. This plan is a combination of recirculation at the Fens and Riverway, dredging at Leverett and Willow Ponds and aeration at Wards Pond. The fourth increment , Plan 6, would increase HU by 7.8 with an incremental cost of $145,200 per HU. This plan consists of dredging at the Fens, Riverway, Leverett Pond, Willow Pond and aeration at Wards Pond with maintenance. The final increment is Plan 3e, dredging of the entire Muddy River system. This plan produces 0.4 more HU's than Plan 6, but at a high incremental cost ($468,500/HU).

Selection of the NER Plan

The NER plan was selected based on results of a cost effectiveness and incremental cost analysis, an assessment of the environmental benefits and impacts of the alternatives, coordination with the Sponsors, resources agencies, and views of the interested public.

Based on the above cost analysis environmental dredging of the Fens, Riverway, Leverett Pond, Willow Pond and aeration at Wards Pond (Plan 6) was selected as the NER plan. This plan also meets the final screening criteria listed in EC 1105-2-210, Ecosystem Restoration in the Civil Works Program (see Appendix F, Corps 2003). Screening criteria include:

• Significance of Ecosystem Outputs- Environmental benefits of restoration plan are significant based on technical merit, institutional considerations, and public support.

• Acceptability - The restoration plan is generally acceptable to state and local governments who are eager to proceed to project implementation. The Sponsor has continued to appropriate funds as necessary for restoration efforts in the Muddy River.

• Completeness - The relatively conservative design combined with post construction monitoring and best management practices will ensure realization of the planned restoration outputs.

• Efficiency - The plan is the most cost-effective means of removing accumulated sediment, improving water quality, and eradicating *Phragmites* from the Muddy River to achieve environmental restoration goals.

• Effectiveness - The plan will be effective in improving the fisheries and benthic habitats. Riparian and wetland habitat will also be substantially improved through improved sediment quality and eradication of *Phrgamites*.

• Partnership context - Although no other Federal resource agencies have a role in implementing the plan, there was strong partnering between Federal, state and local governments in developing the plan. Of particular note was the strong support expressed by officials from the State, city of Boston and town of Brookline. The partnering between these three agencies and the Corps, and their support of Corp's efforts has been noteworthy.

• Reasonableness of Costs - Considering the significant values associated with restoring about 27 habitat units within the largest park system in Boston and Brookline, the environmental restoration cost of $35,670,000 is reasonable considering the National significance of the park system. In addition to providing a significant improvement to the aquatic habitat of the entire area, it would contribute to improvement of associated wildlife habitats and add substantially to the recreational value of the resource.

During coordination of the recommended plan with fish and wildlife agencies it was agreed that removing contaminated sediments in the Muddy River would significantly improve the fishery by increasing dissolved oxygen and improving the benthic habitat. The current plan to dredge contaminated sediments, daylight sections of the river and enlarge culverts has the support of both Federal and state fish and wildlife agencies. Anadromous fish resources are also expected to benefit from this project, and operation and maintenance requirements will be clearly identified and coordinated to maximize the project's effectiveness. An essential element in maintaining the long-term benefits of the project is continued utilization of best management practices to control sources of sediment and contamination.

The three other less expensive best buy plans, Plans 4 and 7, rely on recirculation of Muddy River water from the Charlesgate area to a cascade aeration structure in the Riverway. Coordination with cultural resource agencies indicates that neither of these plans is feasible because of unavoidable significant adverse impacts on the historic landscape of the park.

The NER plan would also provide several important environmental benefits that are not provided by the best buy recirculation plans. These include: improved sediment quality; habitat, aesthetic, and public safety benefits resulting from eradication of *Phragmites*; restoration of a recreational fishery by reducing PCB levels in fish in the Riverway and Fens; control of fanwort in the Fens; and creation of an additional 8 acres of open water aquatic habitat.

4.3.3 Selection of Combined Flood Control/Ecosystem Restoration Plan

The final step in plan formulation is selection of a combined flood control/environmental restoration plan that could be recommended by the Corps for Federal implementation. Based the results of the economic and environmental analysis, this plan would include the 20-year flood control plan and environmental restoration measures included in Plan 6. This plan, would have a total estimated first cost of $ 59,730,000.

4.3.4 Identification of the Locally Preferred Plan

The combined NED/NER plan that could be recommended for Federal implementation was presented to the study Sponsors (Commonwealth of Massachusetts, city of Boston and Town of Brookline) for concurrence and support. This plan is identical to the locally preferred plan (20 year flood control plan and Restoration Plan 3E), except that Wards Pond is restored through aeration rather than dredging. Study sponsors prefer dredging of Wards Pond because of historic restoration objectives and water quality concerns. Because water quality concerns can be addressed by aeration at a much lower cost than dredging and sediment quality is good (as evidenced by sediment toxicity test results) federal interest in dredging the pond cannot be supported.

Dredging Wards Pond could only be recommended provided that non-Federal interests fund 100 percent of the cost difference between environmental dredging and aeration ($3,100,000). The Sponsors were informed of this cost difference and remain in favor of environmental dredging at Wards Pond. The locally preferred plan is therefore identified as the 20-year flood control improvements combined with environmental dredging of the Fens, Riverway, and Leverett, Willow and Wards Ponds (Plan 3.e). The total cost of this plan is $62,830,000. Elements of the plan are summarized in Figure 11. Benefits are summarized in Table 12.

4.3.5 Environmental Consequences of Alternative Plans

Environmental consequences of alternative plans are summarized in Table EA-33 in Corps (2003). The recommended plan offers a technically feasible, comprehensive solution to many of the Muddy River's environmental problems. While more costly than the recirculation plan, it addresses numerous problems that the recirculation plan does not address. These include poor sediment quality, proliferation of *Phragmites* and fanwort, loss of historic aquatic habitat, elevated PCB levels in fish in the Fens and Riverway, and loss of historic landscape features and vistas.

Although the recommended plan has adverse short-term impacts on water quality, fisheries, recreational use of the area, and traffic, it has no significant long-term adverse effects on environmental resources. This contrasts with the recirculation plan, which has a significant long-term adverse effect on historic resources in the Riverway and the Charlesgate areas, and is therefore unacceptable to cultural resource agencies and the Sponsors. The recirculation alternative may also have unacceptable adverse effects on spawning runs of blueback herring and on the outmigration of juvenile herring.

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TABLES

Table 1: Summary of Sediment Test Results from the Phase I Project Area (page 1 of 3)

Chemical	Units	Upper Fens Pond													
		BBF-SED-01	BBF-SED-02	BBF-SED-02	BBF-SED-02	BBF-SED-03	BBF-SED-03	BBF-SED-04	BBF-SED-04	BBF-SED-04	BBF-SED-05	BBF-SED-05	BBF-SED-05	USGS 07	USGS 08
		0-2 Feet	0-2 Feet	6-8 Feet	8-10 Feet	0-2 Feet	2-4 Feet	0-2 Feet	2-4 Feet	6-8 Feet	0-2 Feet	2-4 Feet	8-10 Feet	0-20 cm	0-110 cm
Volatile Petroleum Hydrocarbons															
C5-C8 Aliphatic Hydrocarbons	mg/kg	ND	3.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-
C9-C10 Aromatic Hydrocarbons	mg/kg	3	1.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-
C9-C12 Aliphatic Hydrocarbons	mg/kg	5.1	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-
Benzene	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-
Ethylbenzene	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-
m,p-Xylene	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-
Methyl tert-butyl ether	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-
Naphthalene - Volatile	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-
o-Xylene	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-
Toluene	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-
Extractable Petroleum Hydrocarbons															
Total Petroleum Hydrocarbons	mg/kg	-	-	-	-	-	-	-	-	-	-	-	-	16,000	4,700
C11-C22 Aromatic Hydrocarbons	mg/kg	ND	64	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-
C19-C36 Aliphatic Hydrocarbons	mg/kg	330	ND	ND	ND	ND	ND	180	ND	ND	ND	ND	ND	-	-
C9-C18 Aliphatic Hydrocarbons	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-
2-Methylnaphthalene	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.28	1.72
Acenaphthene	mg/kg	ND	0.56	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.76	0.46
Acenaphthylene	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.48	0.49
Anthracene	mg/kg	ND	1.3	0.36	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.3	1.7
Benz(a)Anthracene	mg/kg	1.9	2.5	0.5	ND	ND	ND	0.82	ND	ND	ND	ND	ND	12	7.9
Benzo(a)Pyrene	mg/kg	2.2	2	0.49	ND	ND	ND	0.86	ND	ND	ND	ND	ND	11	11
Benzo(b)Fluoranthene	mg/kg	3.2	2.7	0.59	ND	ND	ND	1.7	ND	ND	ND	ND	ND	18	18
Benzo(g,h,i)Perylene	mg/kg	1.3	1.2	ND	ND	ND	ND	0.33	ND	ND	ND	ND	ND	7.9	8.5
Benzo(k)Fluoranthene	mg/kg	1.1	1.2	ND	ND	ND	ND	0.53	ND	ND	ND	ND	ND	6.1	6.2
Chrysene	mg/kg	2.3	2.4	0.58	ND	ND	ND	0.97	ND	ND	ND	ND	ND	16	12
Dibenz(a,h)Anthracene	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.2	2.2
Fluoranthene	mg/kg	4.3	5.8	1.3	0.43	ND	ND	1.7	0.48	ND	ND	ND	ND	32	19
Fluorene	mg/kg	ND	0.56	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.3	7.2
Indeno(1,2,3-cd)Pyrene	mg/kg	1.5	1.2	ND	ND	ND	ND	0.46	ND	ND	ND	ND	ND	10	10
Naphthalene - Extractable	mg/kg	ND	0.55	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.39	0.27
Phenanthrene	mg/kg	1.3	5.2	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	11	4.9
Pyrene	mg/kg	3.9	4.5	1	0.37	ND	ND	1.5	0.43	ND	ND	ND	ND	26	14
Total PAHs	mg/kg	23.00	31.67	5.82	0.80	0.00	0.00	8.87	0.91	0.00	0.00	0.00	0.00	158.7	125.5
Pesticides/PCBs															
Aroclor 1016	mg/kg	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	ND	<0.04	<0.04
Aroclor 1221	mg/kg	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	ND	<0.04	<0.04
Aroclor 1232	mg/kg	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	ND	<0.04	<0.04
Aroclor 1242	mg/kg	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	ND	<0.04	<0.04
Aroclor 1248	mg/kg	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	ND	<0.04	<0.04
Aroclor 1254	mg/kg	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	ND	<0.04	0.04
Aroclor 1260	mg/kg	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	ND	<0.04	<0.04
Aroclor 1262	mg/kg	-	-	-	-	-	-	-	-	-	-	-	-	<0.04	<0.04
Aroclor 1268	mg/kg	-	-	-	-	-	-	-	-	-	-	-	-	<0.04	<0.04
4,4 DDD	mg/kg	0.29	0.14	ND	ND	-	ND	0.0046	ND	ND	0.0066	0.022	ND	0.026	0.046
4,4 DDE	mg/kg	0.042	0.011	0.0049	0.0024	-	ND	0.0018	0.0025	ND	0.0044	0.0072	ND	0.011	0.012
4,4 DDT	mg/kg	ND	0.017	ND	ND	-	ND	0.0023	ND	ND	0.0032	0.0028	ND	0.021	0.013
Total DDT	mg/kg	0.332	0.168	0.0049	0.0024	-	ND	0.0087	0.0025	ND	0.0142	0.032	ND	0.058	0.071
Aldrin	mg/kg	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	ND	<0.008	<0.003
a-BHC	mg/kg	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	ND	<0.008	<0.003
alpha Chlordane	mg/kg	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	0.0027	ND	0.008	0.0069
b-BHC	mg/kg	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	ND	<0.008	<0.003
d-BHC	mg/kg	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	ND	<0.008	<0.003
Dieldrin	mg/kg	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	0.0035	ND	<0.008	<0.003
Endosulfan I	mg/kg	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	ND	<0.008	<0.003
Endosulfan II	mg/kg	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	ND	<0.008	<0.003
Endosulfan sulfate	mg/kg	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	ND	<0.008	<0.003
Endrin	mg/kg	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	ND	<0.008	<0.003
Endrin aldehyde	mg/kg	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	ND	<0.008	<0.003
Endrin ketone	mg/kg	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	ND	0.046	0.043
g-BHC	mg/kg	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	ND	-	-
g-Chlordane	mg/kg	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	0.0036	ND	<0.008	<0.003
Heptachlor	mg/kg	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	ND	<0.008	<0.003
Heptachlor epoxide	mg/kg	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	ND	<0.008	<0.003
Methoxychlor	mg/kg	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	ND	<0.008	<0.003
Technical Chlordane	mg/kg	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	ND	<0.8	<0.3
Toxaphene	mg/kg	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	ND	<0.8	<0.3
Metals															
Arsenic	mg/kg	31	ND	ND	ND	ND	ND	ND	7.6	11	11	ND	ND	<60	<30
Barium	mg/kg	91	ND	ND	ND	ND	42	ND	28	60	60	28	ND	-	-
Cadmium	mg/kg	4	ND	ND	ND	ND	ND	ND	0.3	0.27	0.27	ND	ND	<2.6	<2.6
Chromium	mg/kg	70	30	18	11	13	25	15	24	18	16	21	16	37.9	26.6
Copper	mg/kg	-	-	-	-	-	-	-	-	-	-	-	-	225	85.7
Lead	mg/kg	440	87	18	10	39	13	31	39	160	56	26	ND	360	156
Mercury	mg/kg	1.4	0.54	0.19	0.091	0.067	ND	0.15	0.59	0.77	0.044	ND	0.041	1	1.4
Nickel	mg/g	-	-	-	-	-	-	-	-	-	-	-	-	31.6	481
Selenium	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	3.6	3.6	ND	ND	15.5	220
Silver	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-
TCLP Metals															
Arsenic	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chromium	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lead	mg/l	1.0	-	-	-	-	-	-	-	ND	-	-	-	-	-
Mercury	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Sources:

1) Phase 1 Muudy River Flood Control, Water Quality and Habitat Enhancement, and Historic Preservation Project. Volume 5. Appendix F. (CDM, April 2001).

2) Channel morphology and streambed-sediment quality in the Muddy River, Boston and Brookline, Massachusetts, October 1997 (USGS Water Resources Investigation Report 98-4027).[depth of sample estimated from Figure 2]

Table 1: Summary of Sediment Test Results from the Phase I Project Area (page 2 of 3)

Chemical	Units	Riverway						Downstream Avenue Louis Pasteur						
		RW-SED-38	RW-SED-38	RW-SED-38	RW-SED-39	RW-SED-39	Corps	BBF-SED-06	BBF-SED-06	BBF-SED-06	BBF-SED-07	BBF-SED-07	BBF-SED-07	Corps
		0-2 Feet	2-4 Feet	4-6 Feet	0-2 Feet	4-6 Feet	92-8	0-2 Feet	4-6 Feet	6-8 Feet	0-2 Feet	2-4 Feet	6-8 Feet	92-8
Volatile Petroleum Hydrocarbons														
C5-C8 Aliphatic Hydrocarbons	mg/kg	ND	ND	ND	ND	ND	-	-	-	-	-	-	-	-
C9-C10 Aromatic Hydrocarbons	mg/kg	ND	ND	ND	ND	ND	-	-	-	-	-	-	-	-
C9-C12 Aliphatic Hydrocarbons	mg/kg	4.4	ND	ND	3.0	6.0	-	-	-	-	-	7	2.5	-
Benzene	mg/kg	ND	ND	ND	ND	ND	-	-	-	-	-	-	-	-
Ethylbenzene	mg/kg	ND	ND	ND	ND	ND	`	`	`	`	`	`	`	`
m,p-Xylene	mg/kg	ND	ND	ND	ND	ND	-	-	-	-	-	-	-	-
Methyl tert-butyl ether	mg/kg	ND	ND	ND	ND	ND	-	-	-	-	-	-	-	-
Naphthalene - Volatile	mg/kg	0.13	ND	ND	0.12	ND	-	-	-	-	-	-	-	-
o-Xylene	mg/kg	ND	ND	ND	ND	ND	-	-	-	-	-	-	-	-
Toluene	mg/kg	ND	ND	ND	ND	ND	-	-	-	-	-	-	-	-
Extractable Petroleum Hydrocarbons														
Total Petroleum Hydrocarbons	mg/kg	-	-	-	-	-	1800	-	-	-	-	-	-	4200
C11-C22 Aromatic Hydrocarbons	mg/kg	550	ND	ND	772	ND	-	ND	ND	ND	ND	ND	ND	-
C19-C36 Aliphatic Hydrocarbons	mg/kg	2070	ND	ND	522	ND	-	570	230	ND	430	610	ND	-
C9-C18 Aliphatic Hydrocarbons	mg/kg	340	ND	ND	200	ND	-	ND	ND	ND	ND	ND	ND	-
2-Methylnaphthalene	mg/kg	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	-
Acenaphthene	mg/kg	ND	ND	ND	ND	ND	`	ND	ND	ND	ND	ND	ND	`
Acenaphthylene	mg/kg	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	-
Anthracene	mg/kg	1.26	ND	ND	0.87	ND	-	ND	ND	ND	1.6	0.92	ND	-
Benz(a)Anthracene	mg/kg	5.28	ND	ND	3.54	ND	-	0.6	ND	ND	3.7	2.5	ND	-
Benzo(a)Pyrene	mg/kg	5.7	ND	ND	2.73	ND	-	0.58	ND	ND	3.5	2.9	ND	-
Benzo(b)Fluoranthene	mg/kg	6.07	ND	ND	2.97	ND	-	0.8	0.3	ND	4.6	3.9	ND	-
Benzo(g,h,i)Perylene	mg/kg	8.61	ND	ND	ND	ND	-	ND	ND	ND	2.2	1.8	ND	-
Benzo(k)Fluoranthene	mg/kg	4.29	ND	ND	2.54	ND	-	0.38	ND	ND	1.7	1.5	ND	-
Chrysene	mg/kg	7.71	ND	ND	4.47	ND	-	0.56	ND	ND	3.4	2.9	ND	-
Dibenz(a,h)Anthracene	mg/kg	1.15	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	-
Fluoranthene	mg/kg	10.6	1.13	ND	5.58	ND	-	1.4	0.58	0.43	8	5.7	ND	-
Fluorene	mg/kg	1.1	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	-
Indeno(1,2,3-cd)Pyrene	mg/kg	4.16	ND	ND	1.78	ND	`	0.38	ND	ND	1.9	1.7	ND	`
Naphthalene - Extractable	mg/kg	ND	ND	ND	NND	ND	-	ND	ND	ND	ND	ND	ND	-
Phenanthrene	mg/kg	6.07	ND	ND	2.52	ND	-	1	0.36	0.43	6.1	3.3	ND	-
Pyrene	mg/kg	10.5	1.09	ND	5.52	ND	-	13	0.52	ND	7.1	5.3	ND	-
Total PAHs	mg/kg	72.50	2.22	0.00	32.52	0.00	-	18.70	1.76	0.86	43.80	32.42	0.00	-
Pesticides/PCBs														
Aroclor 1016	mg/kg	-	-	-	ND	ND	-	-	ND	ND	ND	ND	ND	-
Aroclor 1221	mg/kg	-	-	-	ND	ND	-	-	ND	ND	ND	ND	ND	-
Aroclor 1232	mg/kg	-	-	-	ND	ND	-	-	ND	ND	ND	ND	ND	-
Aroclor 1242	mg/kg	-	-	-	ND	ND	-	-	ND	ND	ND	ND	ND	-
Aroclor 1248	mg/kg	`	`	`	ND	ND	-	-	ND	ND	ND	ND	ND	-
Aroclor 1254	mg/kg	-	-	-	ND	ND	-	-	ND	ND	ND	ND	ND	-
Aroclor 1260	mg/kg	-	-	-	ND	ND	-	-	ND	ND	ND	ND	ND	-
Aroclor 1262	mg/kg	-	-	-	-	-	-	-	-	-	-	-	-	-
Aroclor 1268	mg/kg	-	-	-	-	-	-	-	-	-	-	-	-	-
4,4 DDD	mg/kg	-	-	-	ND	ND	-	-	ND	0.0062	0.063	ND	ND	-
4,4 DDE	mg/kg	`	`	`	ND	ND	-	-	ND	ND	0.075	ND	ND	-
4,4 DDT	mg/kg	-	-	-	ND	ND	-	-	0.0035	0.0045	ND	ND	ND	-
Total DDT	mg/kg	-	-	-	ND	ND	-	-	0.0035	0.0107	0.138	ND	ND	-
Aldrin	mg/kg	-	-	-	ND	ND	-	-	ND	ND	ND	ND	ND	-
a-BHC	mg/kg	-	-	-	ND	ND	-	-	ND	ND	ND	ND	ND	-
alpha Chlordane	mg/kg	-	-	-	ND	ND	-	-	ND	ND	ND	ND	ND	-
b-BHC	mg/kg	`	`	`	ND	ND	-	-	ND	ND	ND	ND	ND	-
d-BHC	mg/kg	-	-	-	ND	ND	-	-	ND	ND	ND	ND	ND	-
Dieldrin	mg/kg	-	-	-	ND	ND	-	-	ND	ND	ND	ND	ND	-
Endosulfan I	mg/kg	-	-	-	ND	ND	-	-	ND	ND	0.048	ND	ND	-
Endosulfan II	mg/kg	-	-	-	ND	ND	-	-	ND	ND	ND	ND	ND	-
Endosulfan sulfate	mg/kg	-	-	-	ND	ND	-	-	ND	ND	ND	ND	ND	-
Endrin	mg/kg	-	-	-	ND	ND	-	-	ND	ND	ND	ND	ND	-
Endrin aldehyde	mg/kg	`	`	`	ND	ND	-	-	ND	ND	ND	ND	ND	-
Endrin ketone	mg/kg	-	-	-	ND	ND	-	-	ND	ND	ND	ND	ND	-
g-BHC	mg/kg	-	-	-	ND	ND	-	-	ND	ND	ND	ND	ND	-
g-Chlordane	mg/kg	-	-	-	ND	ND	-	-	ND	ND	ND	ND	ND	-
Heptachlor	mg/kg	-	-	-	ND	ND	-	-	ND	ND	ND	ND	ND	-
Heptachlor epoxide	mg/kg	-	-	-	ND	ND	-	-	ND	ND	ND	ND	ND	-
Methoxychlor	mg/kg	`	`	`	ND	ND	-	-	ND	ND	ND	ND	ND	-
Technical Chlordane	mg/kg	-	-	-	ND	ND	-	-	ND	ND	ND	ND	ND	-
Toxaphene	mg/kg	-	-	-	ND	ND	-	-	ND	ND	ND	ND	ND	-
Metals														
Arsenic	mg/kg	28.2	ND	ND	31.1	12.5	23	ND	ND	ND	ND	40	16	21
Barium	mg/kg	184	69.4	46.6	99.9	26.4	-	40	ND	`	160	230	46	-
Cadmium	mg/kg	7.78	2.11	ND	3.14	1.22	2.2	0.9	0.74	ND	4.7	9.6	ND	6.5
Chromium	mg/kg	192	40	38.5	70.9	26.5	53	31	12	22	160	390	42	590
Copper	mg/kg	-	-	-	-	-	230	-	-	-	-	-	-	690
Lead	mg/kg	1340	169	18	411	12.7	380	57	20	31	920	1600	31	1900
Mercury	mg/kg	1.6	0.24	ND	0.9	ND	0.7	0.18	0.094	0.09	4.4	5.4	0.39	6.4
Nickel	mg/g	-	-	-	-	-	37	-	-	-	-	-	-	100
Zinc	mg/g	-	-	-	-	-	450	-	-	-	-	-	-	1400
Selenium	mg/kg	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	-
Silver	mg/kg	1.87	ND	ND	ND	ND	-	ND	ND	ND	ND	14	ND	-
TCLP Metals														
Arsenic	mg/l	-	-	-	-	-	-	-	-	`	-	-	-	-
Cadmium	mg/l	-	-	-	-	-	-	-	-	`	`	`	`	-
Chromium	mg/l	-	-	-	-	-	-	-	-	`	ND	ND	`	-
Lead	mg/l	-	-	-	-	-	-	-	ND	`	1	1.9	`	-
Mercury	mg/l	-	-	-	-	-	-	-	-	`	ND	ND	`	-

Sources:
1) Phase 1 Muudy River Flood Control, Water Quality and Habitat Enhancement, and Historic Preservation Project. Volume 5. Appendix F. (CDM, April 2001).
2) Channel morphology and streambed-sediment quality in the Muddy River, Boston and Brookline, Massachusetts, October 1997 (USGS Water Resources Investigation Report 98-4027).[depth of sample estimated from Figure 2].
3) Corps (2003).

Table 1: Summary of Sediment Test Results from the Phase I Project Area (page 3 of 3)

Chemical	Units	Upper Fens Pond											
		BBF-SED-01	BBF-SED-02	BBF-SED-02	BBF-SED-02	BBF-SED-03	BBF-SED-03	BBF-SED-04	BBF-SED-04	BBF-SED-04	BBF-SED-05	BBF-SED-05	BBF-SED-05
		0-2 Feet	0-2 Feet	6-8 Feet	8-10 Feet	0-2 Feet	2-4 Feet	0-2 Feet	2-4 Feet	6-8 Feet	0-2 Feet	2-4 Feet	8-10 Feet
Grain Size Analysis													
Gravel	percent	16	-	-	13	-	14	-	14	5	-	8	36
Sand	percent	72	-	-	76.2	-	62.9	-	65.7	59	-	86.1	57.9
Fines	percent	12	-	-	10.8	-	23.1	-	20.3	36	-	5.9	6.1
Clay	percent	0	-	-	0	-	0	-	0	0	-	0	0

Chemical	Units	Riverway					Downstream Avenue Louis Pasteur					
		RW-SED-38	RW-SED-38	RW-SED-38	RW-SED-39	RW-SED-39	BBF-SED-06	BBF-SED-06	BBF-SED-06	BBF-SED-07	BBF-SED-07	BBF-SED-07
		0-2 Feet	2-4 Feet	4-6 Feet	0-2 Feet	4-6 Feet	0-2 Feet	4-6 Feet	6-8 Feet	0-2 Feet	2-4 Feet	6-8 Feet
Gravel	percent	-	1	-	6	30	-	13	3	0	-	0
Sand	percent	-	27	-	47	53	-	79.5	91.9	31.2	-	10.2
Fines	percent	-	68	-	43	14	-	7.5	5.1	54.7	-	51.1
Clay	percent	-	4	-	4	3	-	0	0	14.1	-	38.7

Source:

1) Phase 1 Muudy River Flood Control, Water Quality and Habitat Enhancement, and Historic Preservation Project. Volume 5. Appendix F. (CDM, April 2001) and unpublished data from CDM.

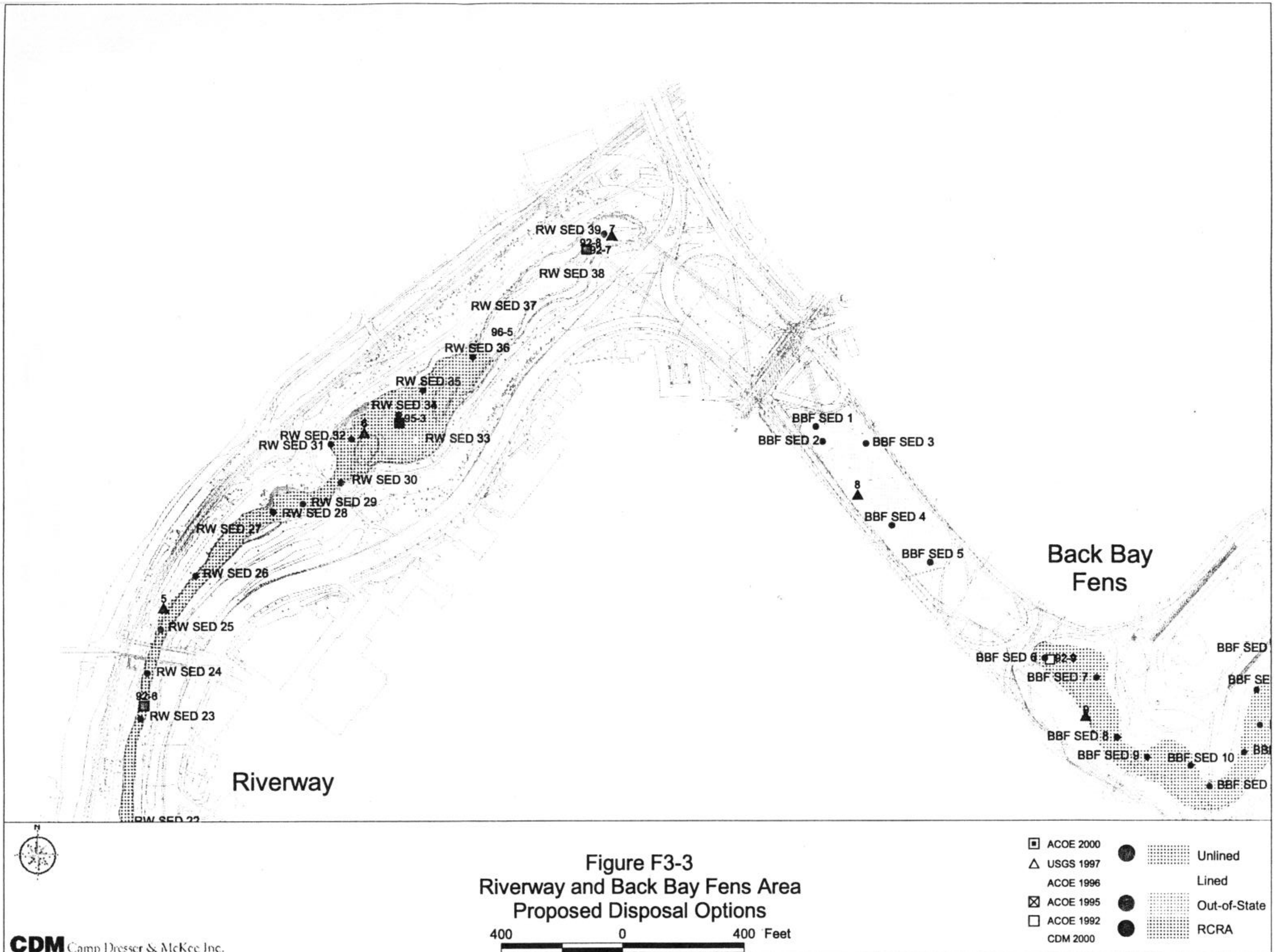

Figure F3-3
Riverway and Back Bay Fens Area
Proposed Disposal Options

CDM Camp Dresser & McKee Inc.

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Table 2: Results of Habitat Mapping

Habitat Type	**Acres**
Aquatic/Wetland Habitat	
Open Water	30.1
Phragmites	5.8
Herbaceous	1.4
Herbaceous/Scrub-Shrub	1.7
Forest/Scrub-Shrub	1.3
Sandbar	0.3
Total	40.6
Upland Habitat	
Forest-Shrub	38.6
Herbaceous or Grass	16.1
Phragmites	0.4
Herbaceous/Shrub	1.3
Urban Park	64.3
Total	**120.7**
Developed (Roads)	63.1

Table 3

Fish Reported from the Muddy River

Species	Back Bay Fens	Riverway	Leverett Pond	Willow Pond	Wards Pond
<u>Anadromous</u>					
Alewife	•	•	•		
Blueback herring	•				
<u>Catadromous</u>					
American eel	•		•		
<u>Resident</u>					
Banded killifish	•	•	•		
Bluegill	•		•		•
Brown bulhead	•		•		
Chain pickerel		•	•		
Common carp	•	•	•		
Golden shiner	•	•	•		
Goldfish	•				•
Killifish			•		•
Largemouth bass	•		•		•
Pumpkinseed	•		•		
Yellow perch	•				
White bass	•				
Threespine stickleback				•	
Unidentifed species				•	

Table 4 Common Plant Species of Habitats in the Muddy River Project Area

Layer	Common Name	Scientific Name
Trees	Pumpkin Ash	*Fraxinus tomentosa*
	Green Ash	*Fraxinus pennsylvanica*
	Black Cherry	*Prunus serotina*
	Red Oak	*Quercus rubra*
	Weeping Willow	*Salix babylonica*
	Black Willow	*Salix nigra*
	Box Elder	*Acer negundo*
	Silver Maple	*Acer saccharinum*
	Red Maple	*Acer rubrum*
	Swamp Oak	*Quercus palustris*
	Gray Birch	*Betula populifolia*
	Black Locust	*Robinia pseudoacacia*
	Sycamore	*Platanus occidentalis*
	Honey Locust	*Gleditsia triacanthos*
	Tree of Heaven	*Ailanthus altissima*
Shrubs/ Vines	Indigobush	*Amorpha fruticosa*
	Northern Arrowwood	*Viburnum recognitum*
	Glossy Buckthorn	*Rhamnus frangula*
	American Elm	*Ulmus americana*
	Black Locust	*Robinia pseudoacacia*
	Elderberry	*Sambucus canadensis*
	Pin Cherry	*Prunus pensylvanica*
	Bittersweet Nightshade	*Solanum dulcamara*
	Asiatic Bittersweet	*Celastrus orbiculatus*
	Hawthorn Species	*Crataegus spp.*
	Japanese Honeysuckle	*Lonicera japonica*
	Multiflora Rose	*Rosa multiflora*
	Common Greenbriar	*Smilax rotundifolia*
	Raspberry Species	*Rubus spp.*
	Northern Honeysuckle	*Caprifoliaceae spp.*
	Japanese Barberry	*Berberis thunbergii*
	Hazelnut	*Corylus americana*
Herbs	Spotted Touch-me-not	*Impatiens capensis*
	Aster Species	*Aster spp.*
	Water Smartweed	*Polygonum hydropiper*
	Cattail	*Typha spp.*
	Goldenrod Species	*Solidago spp.*
	Water Horehound	*Marrubium vulgare*
	Common Reed	*Phragmites australis*
	Purple Loosestrife	*Lythrum salicaria*
	Lady's Thumb	*Polygonum persicaria*
	Beggars Tick	*Bidens connata, B. frondosa*
	New York Aster	*Aster novi-belgii*
	Lily Species	*Liliaceae*
	Bulrush	*Scirpus atrovirens*
	Arrow Arum	*Peltandra virginica*
	Duckweed Species	*Lemna spp.*
	Coontail	*Ceratophyllum demersum*
	Fanwort	*Cabomba caroliniana*
	Spadderdock	*Nuphar luteum*
	Poison Ivy	*Rhus radicans*
	Sweet Fern	*Comptonia peregrina*
	Japanese Knotweed	*Polygunum cuspidatum*
	Wild Carrot	*Daucus carota*
	Grass Species	
	Sedge Species	*Carex spp.*

Table 5: Summary of Resource Area Impacts.

Resource	Unit	Location						
		Upstream Riverway		Upper Fens Pond		Downstream Avenue Louis		Restored (Daylighted) Areas
		Existing	Proposed	Existing	Proposed	Existing	Proposed	
Bank (LF)	LF	220	220	1370	1370	160	160	2470
Bordering Vegetated Wetland	SF	5880	1030	1520	16640	0	0	10000
Land Under Water (total, including ACB)	SF	6000	6000	43500	43500	4700	4700	63800
Land Under water (ACB)	SF	0	5200	0	4500	0	3700	9800
Area excavated	SF		6900		53200		5200	67200
Riverfront Area (25ft. zone	SF	900	900	39300	39300	4900	4900	45600
Vegetated riparian habitat	SF	5240 (wd & tot)	7330 (wd) 8650 (tot)	35000 (wd) 39500 (tot)	35000(wd) 39500 (tot)	3970 (wd) 7650 (tot)	7470 (wd) 7650 (tot)	56500 (wd) 62000 (tot)
Volume excavated	CY		510		3950		385	43700
Volume new fill (below EL 0.5)	CY		90		5000		0 (See Note 2)	
Volume H20 at EL 0.5	Acre ft.	0.14	0.51	5.0	2.5	0.12	0.36	6.0
100 year floodplain	SF	See Note 1	See Note 1	142,300	142,300	2880	2880	116,000
Area of Subrounded Stone	SF		0		19900		0	20700
Phragmites	SF	4850	0	0	0	500 (est)	0	0

Note 1: 100 yr storm water surface elevation (approx. 11.2 at Riverway) is above roadway and limit of floodplain could not be determined. In areas along Park Drive and the Fenway where the 100 yr floodplain extends onto adjacent roadway only the area up to the curb line has been calculated.

Note 2: Entire area within the footprint of the protection that is below EL 0.5 will be excavated to the design elevations. No fill will be required in this area.

Wd – wooded (tree and shrub)
Tot: total (wooded and grass)

Table 6: Biological Benchmarks

Location	Elevation ft NGVD	Description
BB-1	0.88	Lower Limit - Phragmites
BB-1	0.72	Water Surface
BB-2	0.89	Lower Limit - Phragmites
BB-2	0.71	Water Surface
BB-3	1.26	Lower Limit - Purple Loosestrife
BB-3	0.68	Water Surface
BB-4	0.79	Lower Limit - Phragmites
BB-4	0.64	Water Surface
BB-6	2.35	Top of Bank - Shrub
BB-6	0.87	Toe of Bank (no vegetation)
BB-6	0.59	Water Surface

Note: Sites BB1 - BB4 located downstream of Avenue Louis Pasteur;
Site 6 located within Upper Fens Pond.

Table 7: Species Specific Treatment Recommendations

Species	Life form	Suggested Active Ingredient[1,2]	Suggested Application Method[3]
Norway Maple	Tree/sapling	Tricopyr or glyphosate	Cut stump
	Stump sprout	Tricopyr or glyphosate	Foliar
	Seedling	Tricopyr or glyphosate	Foliar
Tree of Heaven	Tree/sapling	Tricopyr	Cut stump
	Stump sprout, sucker	Tricopyr or gylphosate	Foliar
	Seedling	Tricopyr or glyphosate	Foliar
Buckthorn & Honeysuckle	Mature plant, sapling	Tricopyr or glyphosate	Cut stump
	Stump sprout, sucker	Tricopyr or glyphosate	Foliar
	Seedling	Tricopyr or glyphosate	Foliar
Bittersweet	Mature plant	Tricopyr or glyphosate	Cut stump
	Stump sprout, sucker	Tricopyr or glyphosate	Foliar
	Seedling	Tricopyr or glyphosate	Foliar
Knotweed	Mature plant	Tricopyr	Foliar
	Mature plant	Glyphosate	Injection or cut stump
	Basal regrowth, seedling	Tricopyr	Foliar
Phragmites	Mature plant	Glyphosate	Foliar
	Basal regrowth, seedling	Glyphosate	Foliar
Purple Loosestrife	Mature plant	Glyphosate	Foliar
	Basal regrowth, seedling	Glyphosate	Foliar

Notes:

1. Active ingredient
2. Foliar application of Tricopyr is not permitted for vegetation growing along the shoreline.
3. Foliar: hand held spray equipment or wipe

Table 8: Screening of Habitat Restoration Measures

Objective/Measure	Evaluation Factor				Result of Screening		
	Technical Feasible	Effectivness	Acceptable Permittable	Adverse Long-term Effects	Eliminated	Retained	Implemented by Others
Water Quality Improvement							
Flow Augmentation	N	Y	N	Y	x		
Off-Stream Treatment	Y	P	N	Y	x		
Aeration	Y	P	Y	N		x	
Flow Reirculation/Aeration	Y	Y	?	?		x	
Flow Augmentation/Aeration	Y	Y	N	Y	x		
Sediment Removal	Y	Y	Y	N		x	
Aquatic Weed Control (Fanwort)	Y	P	Y	N		x	
Point Source Controls	Y	P	Y	N			x
BMPs	Y	P	Y	N			x
Sediment Quality Improvement							
Sediment Removal	Y	Y	Y	N		x	
Sediment Capping	N	Y	N	Y	x		
In-Situ Bioremediation	N	?	N	?	x		
BMPs	Y	P	Y	N			x
Invasive Species Control							
Phragmites (D,H,M)	Y	Y	Y	N		x	
Purple Loosestrife (D)	Y	Y	Y	N		x	
Purple Loosestrife (H,M,B)	Y	P	Y	N			x
Oriental Knotweed (H,M)	Y	P	Y	N			x
Fanwort (D)	Y	Y	Y	N		x	
Fanwort (H)	Y	P	?	N			x
Other Restoration Measures							
Daylighting	Y	Y	Y	N		x	
Create/Restore Wetland Habitat	Y	Y	Y	N		x	
Provide In-stream Cover	Y	Y	Y	N		x	
Install In-stream deflectors	Y	Y	Y	N		x	

D: Dredging; H: herbicide; M: mechanical (cutting); B: Biological; Y: Yes; N: No

Table 9: Summary of HUs by Restoration Plan.

		Scenario 1						Scenario 2					
Plan	**Location**	**Fish**	**Benthic**	**Heron**	**Yellowthroat**	**Wren**	**Total**	**Fish**	**Benthic**	**Heron**	**Yellowthroat**	**Wren**	**Total**
1	**Ward's Pond**	1.3	1.9	0.6	0.2	0.5	4.5	1.3	1.9	0.6	0.2	0.5	4.5
	Willow Pond	0.3	0.5	0.3	0.2	0.2	1.5	0.3	0.5	0.3	0.2	0.2	1.5
	Leverett Pond	4.2	7.6	0.7	0.8	0.3	13.6	4.2	7.6	0.7	0.8	0.3	13.6
	The Riverway	0.0	5.7	0.7	0.6	1.3	8.4	0.0	5.7	0.7	0.6	1.3	8.4
	Back Bay Fens	0.0	8.0	1.6	1.2	2.4	13.2	0.0	8.0	1.6	1.2	2.4	13.2
		5.8	**23.7**	**3.9**	**3.1**	**4.7**	**41.2**	**5.8**	**23.7**	**3.9**	**3.1**	**4.7**	**41.2**
2	**Ward's Pond**	1.3	1.9	0.6	0.2	0.5	4.5	1.3	1.9	0.6	0.2	0.5	4.6
	Willow Pond	0.3	0.5	0.3	0.2	0.2	1.5	0.3	0.5	0.2	0.2	0.1	1.4
	Leverett Pond	4.4	7.9	0.7	0.8	0.3	14.0	4.4	7.9	0.7	0.8	0.3	14.0
	The Riverway	0.0	6.1	0.6	0.6	0.8	8.2	0.0	6.1	0.6	0.6	0.8	8.1
	Back Bay Fens	3.7	10.8	1.6	1.4	2.0	19.5	3.7	10.8	1.6	1.4	2.0	19.5
		9.7	**27.2**	**3.7**	**3.2**	**3.8**	**47.7**	**9.7**	**27.2**	**3.7**	**3.2**	**3.8**	**47.6**
3a	**Ward's Pond**	1.3	1.9	0.6	0.2	0.5	4.5	1.3	1.9	0.6	0.2	0.5	4.5
	Willow Pond	0.3	0.5	0.3	0.2	0.2	1.5	0.4	0.5	0.2	0.2	0.1	1.5
	Leverett Pond	4.4	7.9	0.7	0.8	0.3	14.0	4.4	7.9	0.7	0.8	0.3	14.0
	The Riverway	0.0	6.7	0.6	0.6	0.8	8.8	0.0	6.4	0.6	0.6	0.8	8.4
	Back Bay Fens	8.9	14.7	1.7	0.9	2.3	28.5	5.6	13.2	2.0	0.9	2.9	24.6
		14.9	**31.7**	**3.9**	**2.7**	**4.2**	**57.4**	**11.7**	**29.9**	**4.1**	**2.7**	**4.7**	**53.1**
3b	**Ward's Pond**	1.3	1.9	0.6	0.2	0.5	4.5	1.3	1.9	0.6	0.2	0.5	4.5
	Willow Pond	0.3	0.5	0.3	0.2	0.2	1.5	0.4	0.5	0.2	0.2	0.1	1.5
	Leverett Pond	4.4	7.9	0.7	0.8	0.3	14.0	4.4	7.9	0.7	0.8	0.3	14.0
	The Riverway	3.0	7.3	0.7	0.9	0.6	12.5	1.0	7.0	0.8	0.9	0.6	10.2
	Back Bay Fens	14.8	14.7	1.7	0.9	2.3	34.4	7.1	13.2	2.0	0.9	2.9	26.1
		23.8	**32.3**	**4.0**	**3.0**	**3.9**	**67.0**	**14.2**	**30.5**	**4.3**	**3.0**	**4.5**	**56.4**
3c	**Ward's Pond**	1.3	1.9	0.6	0.2	0.5	4.5	1.3	1.9	0.6	0.2	0.5	4.5
	Willow Pond	0.8	0.9	0.2	0.2	0.1	2.2	0.8	0.9	0.2	0.2	0.1	2.2
	Leverett Pond	4.4	7.9	0.7	0.8	0.3	14.0	4.4	7.9	0.7	0.8	0.3	14.0
	The Riverway	3.0	7.3	0.7	0.9	0.6	12.5	1.0	7.0	0.8	0.9	0.6	14.0
	Back Bay Fens	14.8	14.7	1.6	1.4	2.0	34.5	7.1	13.2	1.6	1.4	2.0	25.3
		24.3	**32.7**	**3.8**	**3.5**	**3.5**	**67.7**	**14.6**	**30.9**	**3.8**	**3.5**	**3.5**	**56.2**
3d	**Ward's Pond**	1.3	1.9	0.6	0.2	0.5	4.5	1.3	1.9	0.6	0.2	0.5	4.5
	Willow Pond	0.8	0.9	0.2	0.2	0.1	2.2	0.8	0.9	0.2	0.2	0.1	2.2
	Leverett Pond	7.9	8.2	0.9	0.8	0.3	18.1	5.3	7.8	1.0	0.8	0.4	15.3
	The Riverway	6.7	7.3	0.7	0.9	0.6	16.2	1.9	7.0	0.8	0.9	0.6	11.2
	Back Bay Fens	14.8	14.7	1.7	0.9	2.3	34.4	7.1	13.2	2.0	0.9	2.9	26.1
		31.5	**33.0**	**4.1**	**3.0**	**3.8**	**74.4**	**16.4**	**30.8**	**4.5**	**3.0**	**4.6**	**59.3**
3e	**Ward's Pond**	2.1	2.2	0.5	0.2	0.4	5.4	1.5	1.9	0.6	0.2	0.5	4.7
	Willow Pond	0.8	0.9	0.2	0.2	0.1	2.2	0.8	0.9	0.2	0.2	0.1	2.2
	Leverett Pond	7.9	8.2	0.9	0.8	0.3	18.1	5.3	8.0	1.0	0.8	0.4	15.5
	The Riverway	6.7	7.3	0.7	0.9	0.6	16.2	1.9	7.0	0.8	0.9	0.6	11.2
	Back Bay Fens	14.8	14.7	1.7	0.9	2.3	34.5	7.1	13.2	2.0	0.9	2.9	26.2
		32.3	**33.3**	**4.0**	**3.0**	**3.7**	**76.2**	**16.6**	**31.0**	**4.6**	**3.0**	**4.6**	**59.7**
4	**Ward's Pond**	1.3	1.9	0.6	0.2	0.5	4.5	1.3	1.9	0.6	0.2	0.5	4.5
	Willow Pond	0.3	0.5	0.3	0.2	0.1	1.5	0.4	0.5	0.2	0.2	0.1	1.5
	Leverett Pond	4.4	7.9	0.7	0.8	0.3	14.0	4.4	7.9	0.7	0.8	0.3	14.0
	The Riverway	6.7	6.1	0.6	0.6	0.8	14.9	6.7	6.1	0.6	0.6	0.8	14.8
	Back Bay Fens	12.2	10.8	1.6	1.4	2.0	28.1	12.2	10.8	1.6	1.4	2.0	28.0
		24.9	**27.2**	**3.7**	**3.2**	**3.8**	**62.9**	**25.0**	**27.2**	**3.7**	**3.2**	**3.8**	**62.9**
5a	**Ward's Pond**	1.3	1.9	0.6	0.2	0.5	4.5	1.3	1.9	0.6	0.2	0.5	4.5
	Willow Pond	0.8	0.9	0.2	0.2	0.1	2.2	0.8	0.9	0.2	0.2	0.1	2.2
	Leverett Pond	4.4	7.9	0.7	0.8	0.3	14.0	4.4	7.9	0.7	0.8	0.3	14.0
	The Riverway	6.7	6.1	0.6	0.6	0.8	14.9	6.7	6.1	0.6	0.6	0.8	14.8
	Back Bay Fens	12.2	10.8	1.6	1.4	2.0	28.0	12.2	10.7	1.6	1.4	2.0	27.9
		25.4	**27.6**	**3.7**	**3.2**	**3.8**	**63.5**	**25.4**	**27.5**	**3.7**	**3.2**	**3.8**	**63.4**
5b	**Ward's Pond**	1.3	1.9	0.6	0.2	0.5	4.5	1.3	1.9	0.6	0.2	0.5	4.5
	Willow Pond	0.8	0.9	0.2	0.2	0.1	2.2	0.8	0.9	0.2	0.2	0.1	2.2
	Leverett Pond	7.9	8.2	0.9	0.8	0.3	18.1	5.3	8.0	1.0	0.8	0.4	15.5
	The Riverway	6.7	6.1	0.6	0.6	0.8	14.9	6.7	6.1	0.6	0.6	0.8	14.8
	Back Bay Fens	12.2	10.8	1.6	1.4	2.0	28.0	12.2	10.8	1.6	1.4	2.0	28.1
		28.9	**27.9**	**3.9**	**3.2**	**3.8**	**67.6**	**26.3**	**27.7**	**4.0**	**3.2**	**3.9**	**65.0**
5c	**Ward's Pond**	2.1	2.2	0.5	0.2	0.4	5.4	1.5	1.9	0.6	0.2	0.5	4.7
	Willow Pond	0.8	0.9	0.2	0.2	0.1	2.2	0.8	0.9	0.2	0.2	0.1	2.2
	Leverett Pond	7.9	8.2	0.9	0.8	0.3	18.1	5.3	7.9	1.0	0.8	0.4	15.4
	The Riverway	6.7	6.1	0.6	0.6	0.8	14.9	6.7	6.1	0.6	0.6	0.8	14.8
	Back Bay Fens	12.2	10.8	1.6	1.4	2.0	28.0	12.2	10.8	1.6	1.4	2.0	28.0
		29.7	**28.2**	**3.7**	**3.2**	**3.7**	**68.4**	**26.5**	**27.6**	**4.0**	**3.2**	**3.9**	**65.1**
6	**Ward's Pond**	1.7	1.9	0.6	0.2	0.5	4.9	1.7	1.9	0.6	0.2	0.5	4.9
	Willow Pond	0.8	0.9	0.2	0.2	0.1	2.2	0.8	0.9	0.2	0.2	0.1	2.2
	Leverett Pond	7.9	8.2	0.9	0.8	0.3	18.1	5.3	8.0	1.0	0.8	0.4	15.5
	The Riverway	6.7	7.3	0.7	0.9	0.6	16.2	4.6	7.0	0.8	0.9	0.6	13.9
	Back Bay Fens	14.8	14.7	1.7	0.9	2.3	34.4	7.1	13.2	2.0	0.9	2.9	26.1
		31.9	**33.0**	**4.1**	**3.0**	**3.8**	**75.8**	**19.5**	**31.0**	**4.6**	**3.0**	**4.6**	**62.6**
7	**Ward's Pond**	1.7	1.9	0.6	0.2	0.5	4.9	1.7	1.9	0.6	0.2	0.5	4.9
	Willow Pond	0.8	0.9	0.2	0.2	0.1	2.2	0.8	0.9	0.2	0.2	0.1	2.2
	Leverett Pond	7.9	8.2	0.9	0.8	0.3	18.1	5.3	8.0	1.0	0.8	0.4	15.5
	The Riverway	6.7	6.1	0.6	0.6	0.8	14.9	6.7	6.1	0.6	0.6	0.8	14.8
	Back Bay Fens	12.2	10.8	1.6	1.4	2.0	28.0	12.2	10.8	1.6	1.4	2.0	28.0
		29.3	**27.9**	**3.9**	**3.2**	**3.8**	**68.0**	**26.7**	**27.7**	**4.0**	**3.2**	**3.9**	**65.4**
8	**Ward's Pond**	1.7	1.9	0.6	0.2	0.5	4.9	1.7	1.9	0.6	0.2	0.5	4.9
	Willow Pond	0.8	0.9	0.2	0.2	0.1	2.2	0.8	0.9	0.2	0.2	0.1	2.2
	Leverett Pond	5.3	7.9	0.7	0.8	0.3	14.9	5.3	7.9	0.7	0.8	0.3	14.9
	The Riverway	2.3	6.1	0.6	0.6	0.8	10.5	2.3	6.1	0.6	0.6	0.8	10.4
	Back Bay Fens	4.9	10.8	1.6	1.4	2.0	20.7	4.9	10.8	1.6	1.4	2.0	20.7
		15.0	**27.6**	**3.7**	**3.2**	**3.8**	**53.2**	**15.0**	**27.6**	**3.7**	**3.2**	**3.8**	**53.2**

Table 10: Plan Increments

Plan	Main. Scenario	Description	Project Cost ($000)		HU	
			Actual	Relative to Plan 2	Actual	Relative to Plan 2
1	-	No Action	-	-	41.2	-6.5
2	-	Flood Control (FC)	1,823.7	-	47.7	0.0
3.a.	I	FC & Dredging (F)	3,181.3	1,357.6	57.3	9.6
3.b	I	FC & Dredging (F,R)	3,523.6	1,699.9	67.0	19.3
3.c	I	FC & Dredging (F,R,WL)	3,600.9	1,777.2	67.7	20.0
3.d	I	FC & Dredging (F,R,L,WL)	3,951.5	2,127.8	75.4	27.7
3.e	I	FC & Dredging (F,R,L,WL,WA)	4,184.0	2,360.3	76.2	28.5
4	I & II	FC & Recirculation	2,391.2	567.5	62.9	15.2
5.a	I	FC, Recirculaion & Dredging (WL)	2,468.5	644.8	63.5	15.8
5.b	I	FC, Recirculaion & Dredging (L,WL)	2,819.1	995.4	67.6	19.9
5.c	I	FC, Recirculaion & Dredging (L,WL,WA)	3,051.6	1,227.9	68.4	20.7
6	I	FC, Dredging (F,R,L,WL) & Aeration (WA)	3,996.6	2,172.9	75.8	28.1
7	I	FC, Dredging (L,WL) & Aeration (WA)	2,864.2	1,040.5	68.0	20.3
8	I & II	FC, Dredging (WL) & Aeration (F,R,L,WA)	2,056.6	232.9	53.2	5.5
3.a.	II	FC & Dredging (F)	3,161.9	1,338.2	53.1	5.4
3.b	II	FC & Dredging (F,R)	3,485.1	1,661.4	56.4	8.7
3.c	II	FC & Dredging (F,R,WL)	3,554.0	1,730.3	56.2	8.5
3.d	II	FC & Dredging (F,R,L,WL)	3,895.0	2,071.3	59.3	11.6
3.e	II	FC & Dredging (F,R,L,WL,WA)	4,121.8	2,298.1	59.7	12.0
5.a	II	FC, Recirculaion & Dredging (WL)	2,460.1	636.4	63.4	15.7
5.b	II	FC, Recirculaion & Dredging (L,WL)	2,801.1	977.4	65.0	17.3
5.c	II	FC, Recirculaion & Dredging (L,WL,WA)	3,028.0	1,204.3	65.1	17.4
6	II	FC, Dredging (F,R,L,WL) & Aeration (WA)	3,940.1	2,116.4	62.6	14.9
7	II	FC, Dredging (L,WL) & Aeration (WA)	2,846.2	1,022.5	65.4	17.7

Costs reported as average annual costs.

Maintenance Scenarios: I: maintenance dredging; II: no maintenance dredging.

F = Fens, R = Riverway, L = Leverett, WA = Wards, WL = Willow, FC+ Flood Control

Table 11: Incremental Cost Curve Best Buy Plans

Description	Plan & Main. Scenario	HU	Cost ($000)	Cost/HU ($000)	Inc. Cost ($000)	Inc. Output (HU)	Inc. Cost per HU ($000)
Flood Control	2	47.7	0.0	0.0	-	-	-
Recirculation	4	62.9	567.5	9.0	567.5	15.2	37.3
Recirculation, Dredging (L,WL)	5.b(I)	67.6	995.4	14.7	427.9	4.7	91.0
Recirculation, Dredging (L,WL) & Aeration(WA)	7 (I)	68.0	1,040.5	15.3	45.1	0.4	112.7
Dredging (F,R,L,WL) & Aeration (WA)	6 (I)	75.8	2,172.9	28.7	1,132.4	7.8	145.2
Dredging (F, R, L, WL, WA)	3.e.(I)	76.2	2,360.3	31.0	187.4	0.4	468.5

Maintenance Scenarios: I: maintenance dredging; II: no maintenance dredging.

F = Fens, R = Riverway, L = Leverett, WA = Wards, WL = Willow

Table 12: Benefits of the Recommended Plan

Resource	Benefit	Location: Wards	Willow	Leverett	Riverway	Fens
Hydrology	• Significant increase in hydraulic capacity of the river.				•	•
Economics	• Significant reduction in flood losses.			•	•	•
Water Quality	• Dissolved oxygen levels increase to consistently meet water quality criteria.	•	•	•	•	•
	• Improved dry weather water quality (reduced metal, ammonia levels).			•	•	•
	• Reduced nutrient levels.	•	•	•	•	•
Sediment Quality	• Reduced sediment oxygen demand.	•	•	•	•	•
	• Reduced levels of metals, petroleum hydrocarbons, PAHs, and PCBs.		•	•	•	•
Aquatic Habitat and Riparian Habitat	• Daylighting, removal of storm drain sediment deposits and *Phragmites* (Riverway, Fens) restores over 8 acres of open water habitat.		•	•	•	•
	• Daylighting adds new riparian habitat in Fens.					•
Wildlife	• *Phragmites* removal (with restoration of emergent and riparian vegetation) improves wildlife habitat.				•	•
	• Riparian habitat restored along daylighted sections of Muddy River.					•
	• Elimination of mudflats and improved water quality reduce outbreaks of avian botulism.		•	•	•	•
	• PCB risk to fish eating birds reduced.				•	•
	• Exposure of aquatic mammals and birds to contaminated sediment reduced.		•	•	•	•
	• Habitat value of island for nesting birds restored.				•	

Table 12: Benefits of the Recommended Plan (*continued)*

Resource	Benefit	Location				
		Wards	Willow	Leverett	Riverway	Fens
Aquatic Life	• Improved water quality and fisheries management shifts community composition in favor of native species (carp and goldfish populations reduced).		•	•	•	•
	• Increased diversity/productivity of benthic invertebrate community. Reduced sediment toxicity.		•	•	•	•
	• Improved sediment quality reduces incidence of tumors and other abnormalities in fish.		•	•	•	•
	• Elimination of fanwort improves fish habitat quality.					•
	• Reduced algal blooms (lower nutrient levels).	•	•	•	•	•
	• Reduced PCB levels in fish tissue.				•	•
	• Improved habitat (sediment quality) for threespine stickleback (a state-listed threatened species).		•			
Wetland and Aquatic Vegetation	• Elimination of *Phragmites* allows restoration of more diverse emergent and riparian communities.				•	•
	• Removal of fanwort allows restoration of more diverse submerged aquatic community.					•
Recreation and Aesthetics	• Improved recreational warmwater fishery. Public health advisory (PCBs) against eating fish may be lifted.			•	•	•
	• Reduced odor problems.		•	•	•	•
	• Removal of *Phragmites* (Riverway, Fens), shoal areas (Leverett Pond, Willow Pond, Fens) and algal mats (Wards Pond, Willow Pond, Fens) improves aesthetics.	•	•	•	•	•
Public Safety	• *Phragmites* removal improves public safety and reduces risk of wildfire.				•	•
	• Reduced human exposure to contaminated sediment (skin contact, accidental ingestion).		•	•	•	•
Historic/Cultural Resources	• Preservation and restoration of the historic park shoreline in construction areas.	•	•	•	•	•
	• Restoration (daylighting) of two sections (700 linear feet) of river in the Upper Fens.					•
	• Restoration of scenic qualities and aesthetics of historic park system.	•	•	•	•	•

FIGURES

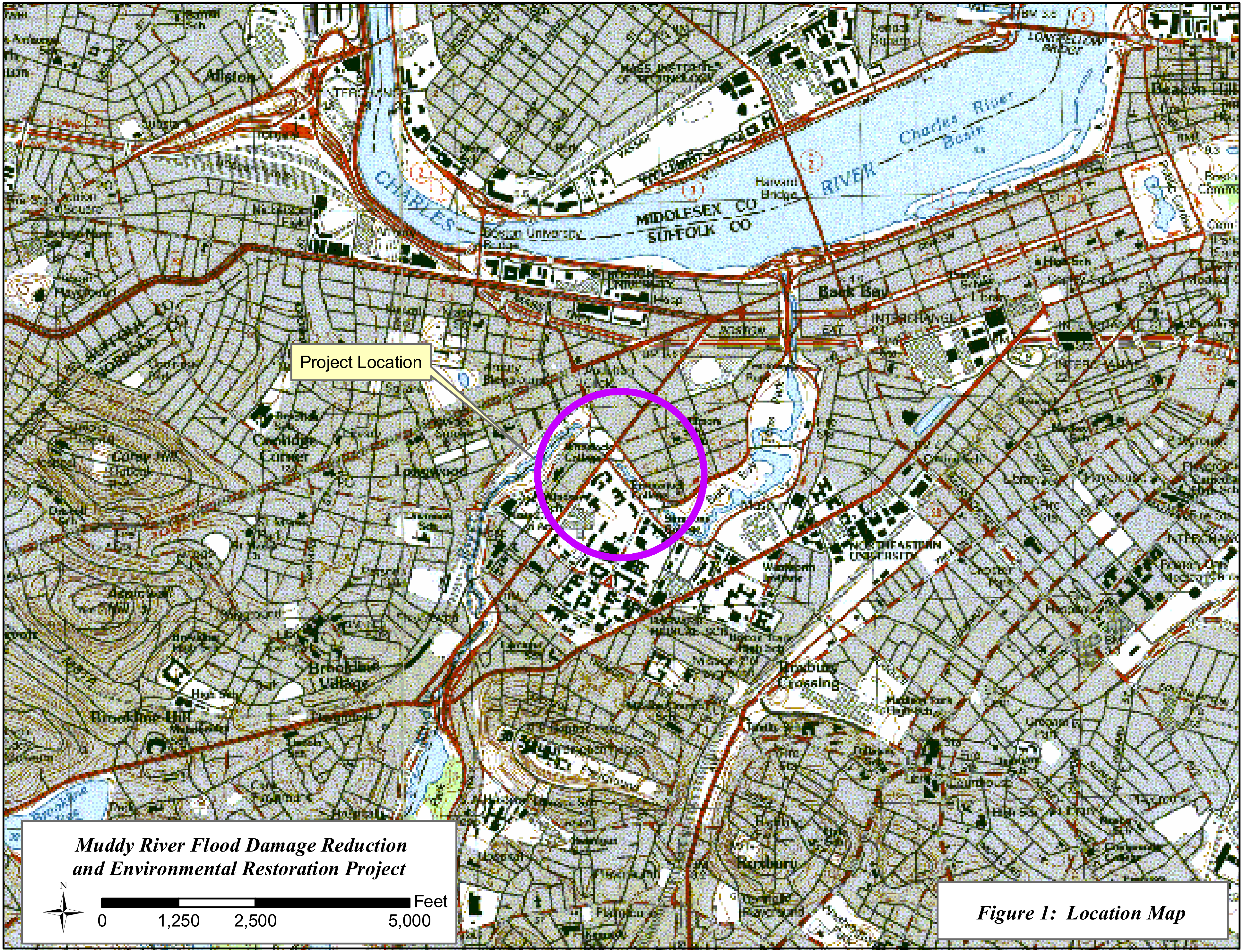
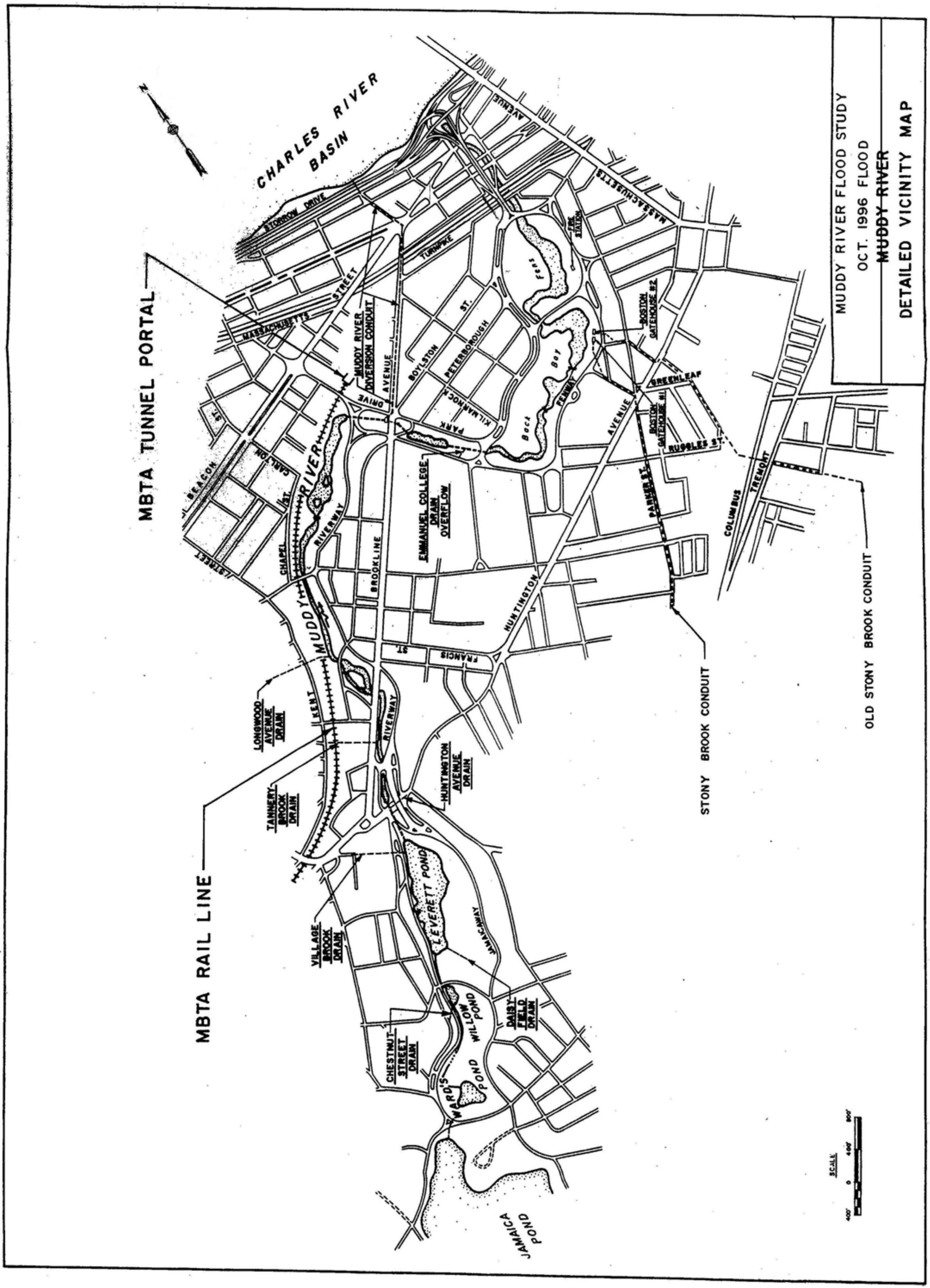


Figure 1: Location Map

Figure 2: Aerial Photograph of Project Area



MUDDY RIVER FLOOD STUDY
OCT. 1996 FLOOD
~~MUDDY RIVER~~
DETAILED VICINITY MAP
FIGURE I
CHARLES RIVER BASIN
MBTA TUNNEL PORTAL
MBTA RAIL LINE
MUDDY RIVER DIVERSION CONDUIT
EMMANUEL COLLEGE DRAIN OVERFLOW
LONGWOOD AVENUE DRAIN
TANNERY BROOK DRAIN
VILLAGE BROOK DRAIN
CHESTNUT STREET DRAIN
DAISY FIELD DRAIN
HUNTINGTON AVENUE DRAIN
BOSTON GATEHOUSE #2
BOSTON GATEHOUSE #1
STONY BROOK CONDUIT
OLD STONY BROOK CONDUIT
MUDDY RIVER
Back Bay Fens
LEVERETT POND
WILLOW POND
WARD'S POND
JAMAICA POND
STORROW DRIVE
MASSACHUSETTS AVENUE
TURNPIKE
BOYLSTON ST.
PETERBOROUGH
KILMARNOCK
PARK DRIVE
FENWAY
HUNTINGTON AVENUE
BROOKLINE AVENUE
RIVERWAY
JAMAICAWAY
FRANCIS ST.
RUGGLES ST.
PARKER ST.
GREENLEAF
TREMONT
COLUMBUS
BEACON STREET
CARLTON ST.
CHAPEL
KENT
SCALE

Figure 3

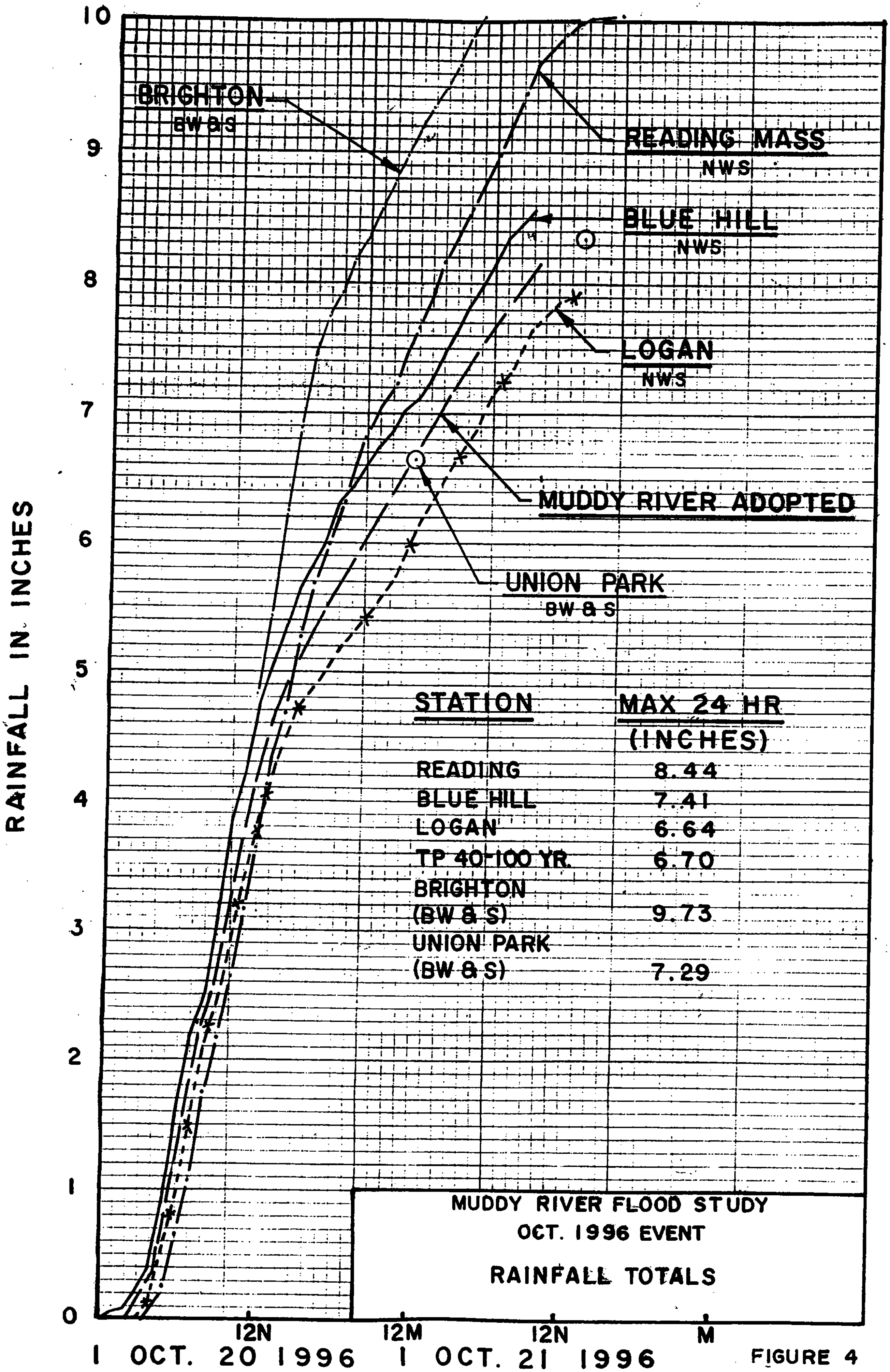
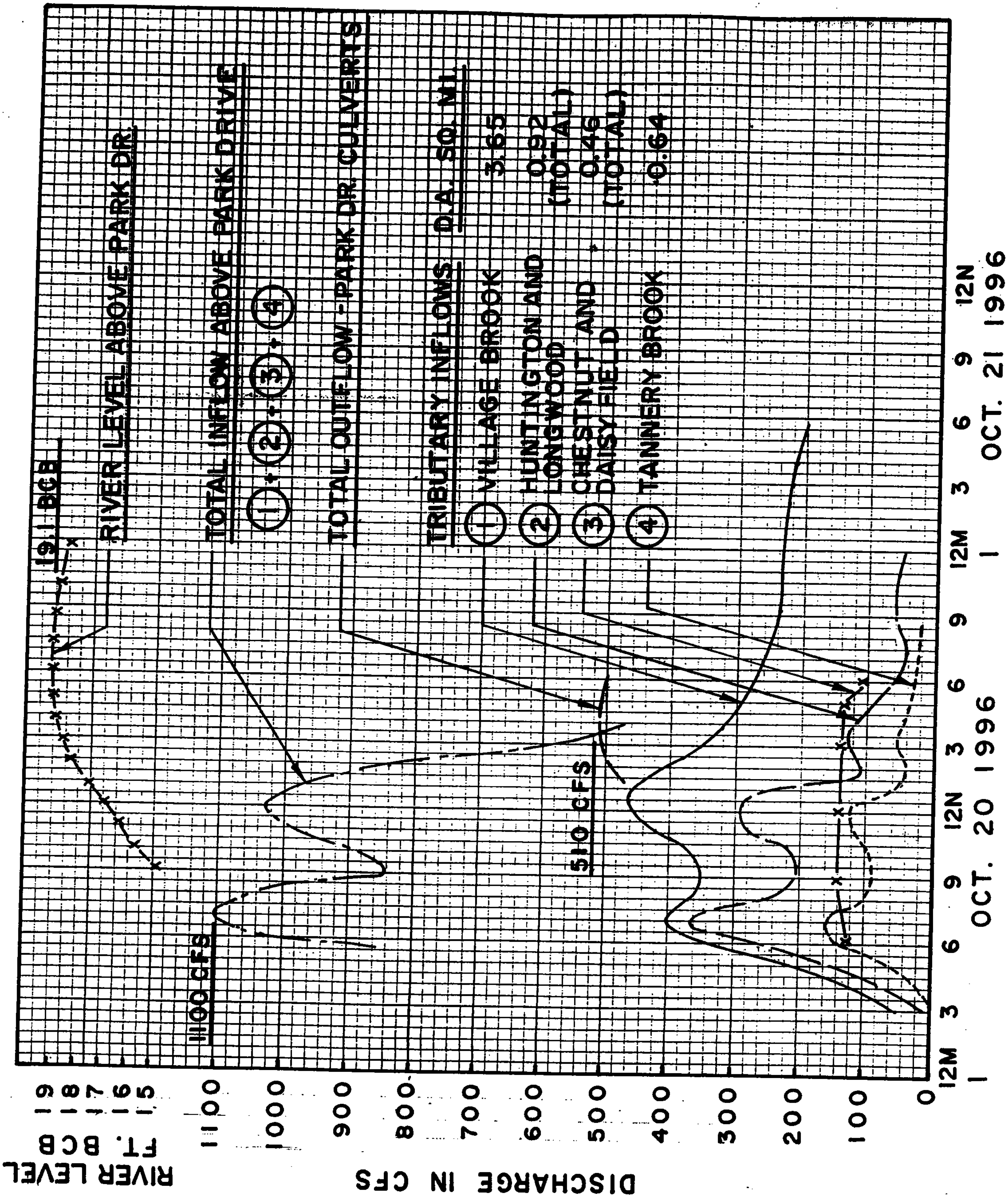
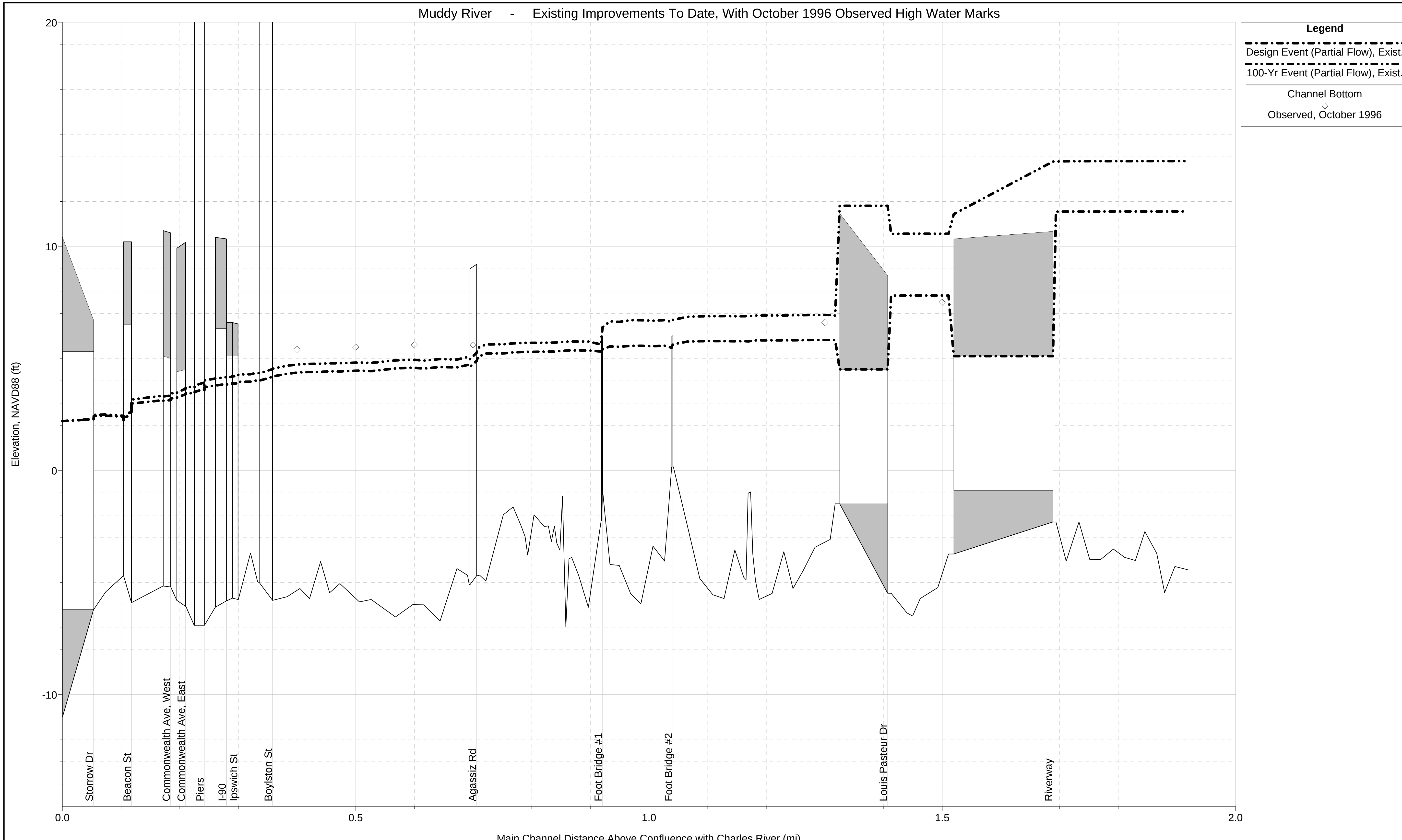

RAINFALL IN INCHES
0
1
2
3
4
5
6
7
8
9
10
BRIGHTON
BW & S
READING MASS
NWS
BLUE HILL
NWS
LOGAN
NWS
MUDDY RIVER ADOPTED
UNION PARK
BW & S
STATION
MAX 24 HR (INCHES)
READING 8.44
BLUE HILL 7.41
LOGAN 6.64
TP 40-100 YR. 6.70
BRIGHTON (BW & S) 9.73
UNION PARK (BW & S) 7.29
MUDDY RIVER FLOOD STUDY
OCT. 1996 EVENT
RAINFALL TOTALS
12N
12M
12N
M
1 OCT. 20 1996 1 OCT. 21 1996

FIGURE 4



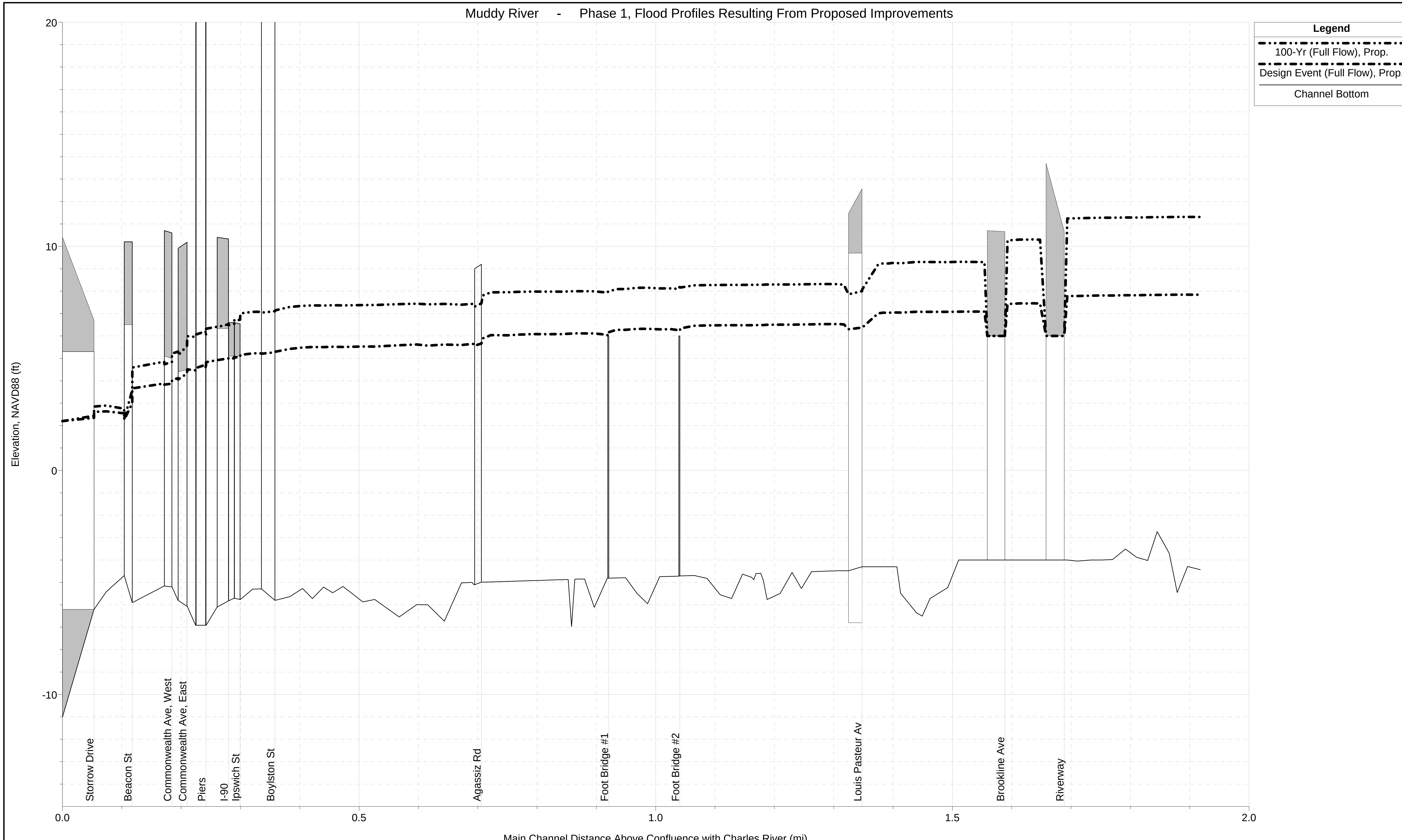
MUDDY RIVER FLOOD STUDY
OCT. 1996
HYDROGRAPH ANALYSIS
ABOVE PARK DRIVE

FIGURE 5



Muddy River - Existing Improvements To Date, With October 1996 Observed High Water Marks
Legend
Design Event (Partial Flow), Exist.
100-Yr Event (Partial Flow), Exist.
Channel Bottom
Observed, October 1996
Elevation, NAVD88 (ft)
20
10
0
-10
Storrow Dr
Beacon St
Commonwealth Ave, West
Commonwealth Ave, East
Piers
I-90
Ipswich St
Boylston St
Agassiz Rd
Foot Bridge #1
Foot Bridge #2
Louis Pasteur Dr
Riverway
0.0
0.5
1.0
1.5
2.0
Main Channel Distance Above Confluence with Charles River (mi)

Figure 6



Muddy River - Phase 1, Flood Profiles Resulting From Proposed Improvements
Legend
100-Yr (Full Flow), Prop.
Design Event (Full Flow), Prop.
Channel Bottom
Elevation, NAVD88 (ft)
20
10
0
-10
Storrow Drive
Beacon St
Commonwealth Ave, West
Commonwealth Ave, East
Piers
I-90
Ipswich St
Boylston St
Agassiz Rd
Foot Bridge #1
Foot Bridge #2
Louis Pasteur Av
Brookline Ave
Riverway
0.0
0.5
1.0
1.5
2.0
Main Channel Distance Above Confluence with Charles River (mi)

Figure 7

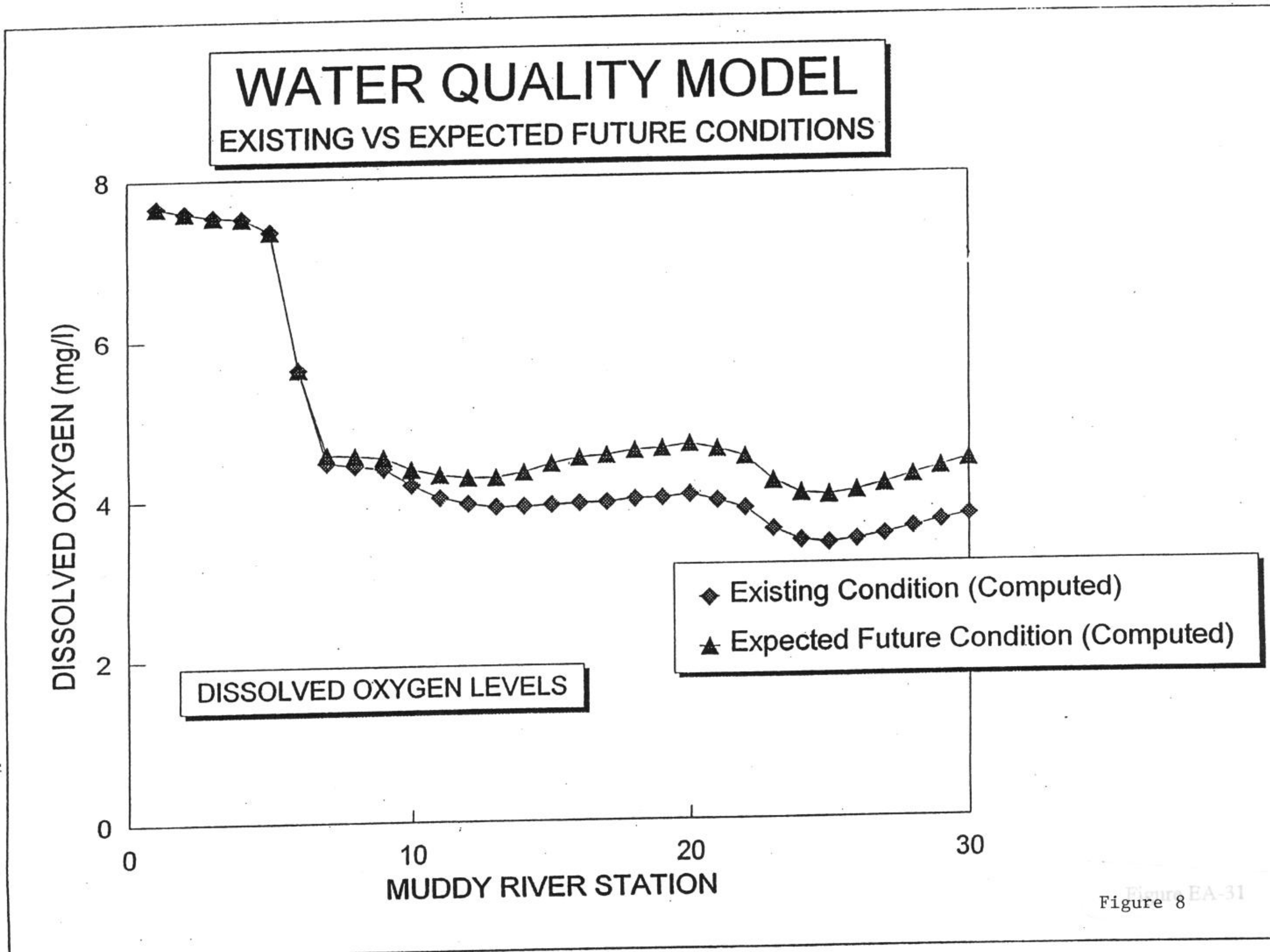
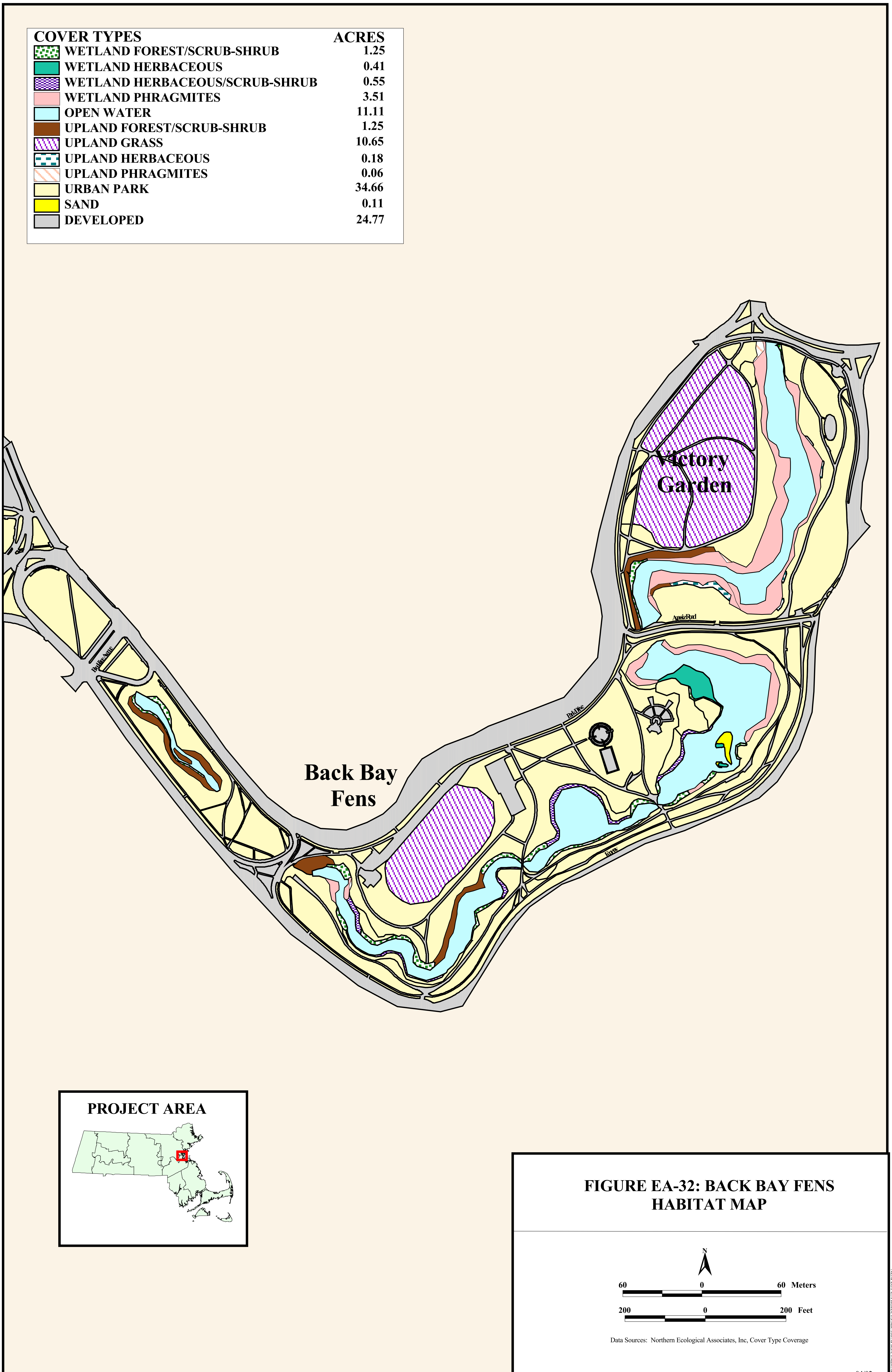

WATER QUALITY MODEL
EXISTING VS EXPECTED FUTURE CONDITIONS
DISSOLVED OXYGEN (mg/l)
8
6
4
2
0
0
10
20
30
MUDDY RIVER STATION
DISSOLVED OXYGEN LEVELS
Existing Condition (Computed)
Expected Future Condition (Computed)

Figure 8


COVER TYPES
ACRES
WETLAND HERBACEOUS/SCRUB-SHRUB 0.33
WETLAND PHRAGMITES 2.28
OPEN WATER 6.44
UPLAND FOREST/SCRUB-SHRUB 11.72
UPLAND HERBACEOUS 0.97
UPLAND HERBACEOUS/SCRUB-SHRUB 0.48
UPLAND PHRAGMITES 0.31
URBAN PARK 14.80
DEVELOPED 21.90
PROJECT AREA
Fens Study Area
Riverway Study Area
Ponds Study Area
FIGURE EA-33: RIVERWAY HABITAT MAP
N
200 0 200 Meters
500 0 500 Feet
Data Sources: Northern Ecological Associates, Inc, Cover Type Coverage
04/02

Figure 9



COVER TYPES
ACRES
WETLAND FOREST/SCRUB-SHRUB 1.25
WETLAND HERBACEOUS 0.41
WETLAND HERBACEOUS/SCRUB-SHRUB 0.55
WETLAND PHRAGMITES 3.51
OPEN WATER 11.11
UPLAND FOREST/SCRUB-SHRUB 1.25
UPLAND GRASS 10.65
UPLAND HERBACEOUS 0.18
UPLAND PHRAGMITES 0.06
URBAN PARK 34.66
SAND 0.11
DEVELOPED 24.77
Victory Garden
Back Bay Fens
PROJECT AREA
FIGURE EA-32: BACK BAY FENS HABITAT MAP
N
60 0 60 Meters
200 0 200 Feet
Data Sources: Northern Ecological Associates, Inc, Cover Type Coverage
04/02

Figure 10

Muddy River Recommended Plan

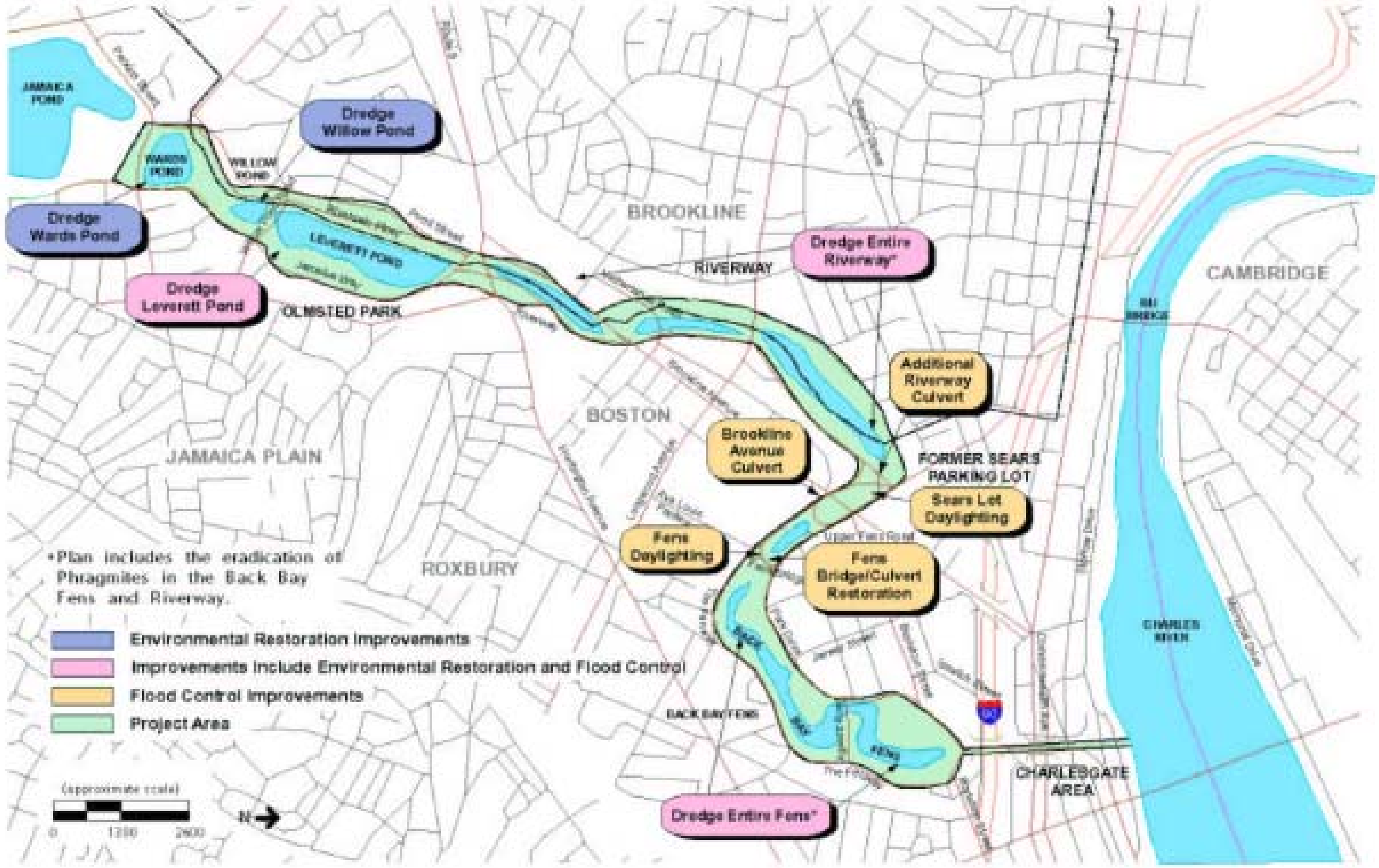


Figure 11

ATTACHMENT B

ENGINEERING PLANS AND DETAILS

ATTACHMENT C

REPRESENTATIVE PHOTOGRAPHS

Riverway Bridge

Upstream of Riverway

Upstream of Riverway

Upstream of Riverway

Daylighting Area Downstream of Riverway

Existing Culverts

Jug Handle

Upper Fens Pond

Upper Fens Pond

Upper Fens Pond

Daylighting Area Upstream of Avenue Louis Pasteur

Headwall Remnant at Avenue Louis Pasteur

Headwall Downstream of Avenue Louis Pasteur

Downstream of Avenue Louis Pasteur

Downstream of Avenue Louis Pasteur

ATTACHMENT D

STORMWATER REPORT AND CHECKLIST

Stormwater Management Report

Project: Muddy River Flood Damage Reduction and Environmental Restoration Project (Phase 1)

Applicant: City of Boston & MA Department of Conservation and Recreation

Prepared by: U.S. Army Corps of Engineers, New England District
696 Virginia Road, Concord, MA.

Date: January 20, 2009

1. Introduction

This report is submitted to document compliance with the Massachusetts Stormwater Standards. The Stormwater Management Standards address water quality and water quantity by establishing standards that require the implementation of a wide variety of stormwater management strategies. These strategies include environmentally sensitive site design, Low Impact Design (LID) techniques to minimize impervious surface and land disturbance, source control and pollution prevention, structural BMPs, construction period erosion and sedimentation control, and the long-term operation and maintenance of stormwater management systems.

Phase I of the Muddy River project is a flood control and habitat restoration project (see Project Narrative). The proposed redevelopment project includes alterations to existing stormwater conveyances, including a major storm drain which currently flows into the Charles River via the Muddy River Conduit.

2. Compliance with Massachusetts Stormwater Management Standards

Standard 1: No new stormwater conveyances (e.g. outfalls) may discharge untreated stormwater directly to or cause erosion in wetlands or waters of the Commonwealth.

The project area is a complex, fully developed environment. Project plans show the location of all known stormwater conveyances. The stormwater conveyances and proposed alterations are summarized in Table 1 and discussed below.

<u>Minor Storm Drains</u>

Five existing small storm drains which flow into the Riverway, Upper Fens Pond, and Back Bay Fens downstream of Avenue Louis Pasteur will be disturbed by the proposed project. In most cases the storm drain headwalls will need to be relocated. All the drains will discharge onto stone swales to prevent bank erosion.

Four small storm drains and one 30” drain which currently discharge into one of the twin 72” Muddy River culverts will be altered by daylighting. After construction, each of these existing conveyances will be discharge into daylighted areas (the twin 72” culverts having been removed). The drains will discharge onto stone swales to prevent bank erosion. The 30” drain will discharge into a stone swale upstream of Avenue Louis Pasteur, near the restored island. The banks and island will be sufficiently protected with stone to prevent erosion. These conveyances all currently discharge indirectly into the Muddy River, via the 72” Muddy River culverts, so there will be no increase in stormwater discharge to the river.

All proposed discharges will be adequately protected to prevent erosion on banks or within receiving waterways.

Culverts

The flow from two storm drains will be diverted to the daylighted area downstream of Brookline Avenue. The two drain lines, 45” in diameter, and 51” x 51”, currently discharge into the Muddy River Conduit. The Muddy River Conduit runs beneath Brookline Avenue from the Muddy River Gatehouse located beneath the former Sears parking lot to Kenmore Square and then into the Charles River. The conduit is approximately 3600 feet long and is generally rectangular in shape with varying dimensions in the range of 10 feet wide by 11 feet high. The Boston Sewer and Water Commission (BWSC) owns and maintains this conduit and uses it to convey stormwater from adjacent streets. The Muddy River Gatehouse can be used to divert water from the Muddy River to the Charles River via the conduit.

Currently all flow from the 45” and 51” x 51” drain lines enter the Muddy River Conduit and flow into the Charles River. The two drain lines bypass (do not connect to) the existing Muddy River culvert. The two drain lines have a drainage area which includes the Longwood Medical area, Emmanuel College, Simmons College, and adjacent areas. The proposed plan will divert this existing stormwater discharge from the Charles River to the Muddy River. Flow from the two culverts will be combined and conveyed through a 72” diameter drain inlet which will discharge through a flap gate on the downstream Brookline Avenue wingwall. The riverbank will be protected with stone to prevent erosion. The river bed will be lined with articulated concrete block (ACB) to prevent scour.

Because of the configuration of the proposed 10 foot x 24 foot Brookline Avenue Muddy River culvert and the existing Muddy River Conduit, there is no practicable way for flow from the existing 45” and 51” x 51” storm drains to continue to discharge to the Muddy River Conduit. In order for the drains to continue to discharge into the Muddy River Conduit it would be necessary to convey their combined flow in a 72” culvert past the new 10 foot x 24 foot Muddy River culvert. This is not practicable. There is not enough head space to pass the 72” culvert above the new Muddy River culvert. The 72” culvert cannot be routed below the Muddy River culvert because of caissons needed to support the new Muddy River culvert and the lack of access for maintenance. Routing the 72” culvert through the new 10 x 24 Muddy River culvert would significantly reduce flood flow conveyance.

The proposed Muddy River flood damage reduction and environmental restoration project can be classified as a redevelopment project pursuant to Massachusetts Wetland Protection Act Regulations. Standard 7 of the Massachusetts Stormwater Management Standards states the following:

A redevelopment project is required to meet the following Stormwater Management Standards only to the maximum extent practicable: Standard 2, Standard 3, and the pretreatment and structural best management practice requirements of Standards 4, 5, and 6. ***Existing stormwater discharges shall comply with Standard 1 only to the maximum extent practicable.*** *A redevelopment project shall also comply with all other requirements of the Stormwater Management Standards* ***and improve existing conditions****. (Emphasis added)*

The proposed project includes a new stormwater conveyance that will discharge existing stormwater. The plan complies with Standard 1 to the extent practicable.

The proposed project will modify the discharge point of an existing stormwater system. There will be no net increase in stormwater discharge and a decrease in the direct discharge of stormwater to the Charles River. The project will increase stormwater discharge into the Muddy River by diverting stormwater that currently flows directly into the Charles. Discharge of stormwater from the 72" culvert into the Muddy River will not significantly alter flood flows.

The new conveyance will not cause erosion in wetlands or waters of the Commonwealth.

The existing discharge is treated to the extent sediment and contaminants are captured in existing catch basins within the contributing drainage area. BMPs to be implemented as part of the overall Muddy River Improvement Project will provide additional stormwater treatment (see discussion of Standard 4, below).

The proposed project will unquestionably improve existing conditions. The project will restore approximately 1.7 acres of aquatic and wetland habitat, 2,470 linear feet of bank, and create 1 acre of Riverfront Area (see Project Narrative, Table 5).

Standard 2: Stormwater management systems shall be designed so that post-development peak discharge rates do not exceed pre-development peak discharge rates. This Standard may be waived for discharges to land subject to coastal storm flowage as defined in 310 CMR 10.04.

See Section 2.2 of the narrative for a discussion of the hydrological effects of the proposed flood control and habitat restoration project. Following completion of Phase 2, the Muddy River project will have a significant flood reduction benefit in the study area. By itself, Phase I will have no impact on flooding.

Land use changes associated with daylighting are expected to have a negligible effect on post redevelopment peak discharge. The following table shows pre and post construction land use in daylighted areas:

Cover Type	Hydrological Soil Group	Runoff Curve Number	Acres	
			Pre	Post
Turf (existing and proposed)	B	69	2.72	0.13
Wooded	B	55	0	1.30
Impervious		98	1.57	1.32
Water		0	0	1.46

The proposed work will decrease the area of impervious land (pavement). There will also be a net loss of land (turf), an increase is wooded areas, and an increase in water surface area. The infiltration rate in post construction wooded areas will exceed the infiltration rate in pre existing paved and turf areas. Overall, they will be a net decrease in post redevelopment peak discharge from the project site.

The Muddy River has a total drainage area of about 21 square miles so the proposed minor alterations in land use will have no measurable impact on peak discharge.

Standard 3: Loss of annual recharge to groundwater shall be eliminated or minimized through the use of infiltration measures including environmentally sensitive site design, low impact development techniques, stormwater best management practices, and good operation and maintenance. At a minimum, the annual recharge from the post-development site shall approximate the annual recharge from pre-development conditions based on soil type.

Soil type and land use indicate that the annual recharge from the post-development site will be less than recharge for pre-development conditions. Infiltration will occur in vegetated areas but conversion of 1.46 acres of land to water will reduce the opportunity for recharge. The impact is unavoidable.

Standard 4: Stormwater management systems shall be designed to remove 80% of the average annual post-construction load of Total Suspended Solids (TSS).

Suitable practices for source control and pollution prevention are identified in a long term stormwater/management pollution prevention plan [see Chapter 7, of the Supplemental Final Environmental Impact Report prepared for Phase I of the Muddy River Flood Control, Water Quality, and Habitat Enhancement and Historic Preservation Project (CDM, February 2005)]. The plan will reduce re-sedimentation rates, maintain project improvements, and contribute towards an improvement of the Muddy River to class B water quality standards. Measures that will be employed within the Phase 1 and Phase 2 restoration areas include street sweeping, catch basin maintenance, pet waste control, reduced use of pesticides and fertilizers, turf maintenance, leaf removal, liter patrol, trail maintenance and elimination of desire lines, and waterfowl control programs.

Standard 5. For land uses with higher potential pollutant loads, source control and pollution prevention shall be implemented in accordance with the Massachusetts Stormwater Handbook to eliminate or reduce the discharge of stormwater runoff from such land uses to the maximum extent practicable.

The proposed project will not create or expand land area subject to higher potential pollutant loads. Approximately 6 existing catch basins which service highly trafficked roadways will be upgraded to current MA DEP standards. One new catch basin will be installed to current DEP standards.

Standard 6. Stormwater discharges within the Zone II or Interim Wellhead Protection Area of a public water supply, and stormwater discharges near or to any other critical area, require the use of the specific source control and pollution prevention measures and the specific structural stormwater best management practices determined by the Department to be suitable for managing discharges to such areas, as provided in the Massachusetts Stormwater Handbook.

No stormwater discharges will occur within a Zone II or Interim Wellhead Protection Area of a public water supply or to Outstanding Resource Waters.

Standard 7. A redevelopment project is required to meet the following Stormwater Management Standards only to the maximum extent practicable: Standard 2, Standard 3, and the pretreatment and structural best management practice requirements of Standards 4, 5, and 6. Existing stormwater discharges shall comply with Standard 1 only to the maximum extent practicable. A redevelopment project shall also comply with all other requirements of the Stormwater Management Standards and improve existing conditions.

The proposed redevelopment project meets Stormwater Management Standards to the extent practicable and improves existing conditions.

Standard 8. A plan to control construction-related impacts including erosion, sedimentation and other pollutant sources during construction and land disturbance activities (construction period erosion, sedimentation, and pollution prevention plan) shall be developed and implemented.

The project is highly complex. The construction contactor will develop final plans for control and diversion of water, construction sequencing, and stormwater control. Therefore, a construction period pollution prevention and erosion and sedimentation control plan is not included with this report. The construction contractor will be required to submit a plan for approval before land disturbance begins. The contractor will also prepare and submit a stormwater management and pollution prevention plan pursuant to the US EPA construction general permit.

Standard 9. A long-term operation and maintenance plan shall be developed and implemented to ensure that stormwater management systems function as designed.

In additional to the long-term management plan described in the 2005 EIR (see response for Standard 4), an Operation and Maintenance Plan will be prepared at the end of Phase II construction. The plan will describe measures to maintain the improvements, including stormwater management. The property owners (City of Boston and the DCR) will be responsible for implementing the plan.

Standard 10. All illicit discharges to the stormwater management system are prohibited.

There are no known illicit discharges to the stormwater management system in the work area. If any illicit discharges (e.g. cross connections) are discovered during project construction they will be eliminated.

Registered Professional Engineer Signature

Name: **Date**

Table SR-1: Summary of Stormwater Conveyances in the Phase I Project Area.

Location	Description	Location of Existing Discharge	Location of Proposed Discharge	Notes
Upstream Riverway				
	Storm drain	Riverway	Riverway	Existing discharge location unknown, possibly located in dense Phragmites along left bank
	Storm drain	Riverway	Riverway	Right bank near culvert headwall.
Between Riverway and Brookline Avenue (Daylighted Reach)				
	Storm drain	To 72" culvert	Daylighted Area	Right bank
	Storm drain	To 72" culvert	Daylighted Area	Left bank
Between Brookline Avenue and Upper Fens Pond (Daylighted Reach)				
	45" diameter and 51"x 51" culverts	Charles River via the Muddy River Conduit	Daylighted Area	The two culverts will combine into a 72 inch drain and discharge downstream of Brookline Avenue through a flap gate installed on the Brookline Avenue wingwall. The river will be protected from erosion by articulated concrete block (ACB).
Upper Fens Pond				
	Storm drain	Upper Fens Pond	Upper Fens Pond	Near existing Jughandle, left bank. Headwall will need to be relocated.
	Storm drain	Upper Fens Pond	Upper Fens Pond	Right bank, Existing headwall to be retained
	Storm drain	Upper Fens Pond	Upper Fens Pond	Near downstream end of Upper Fens Pond, left bank. Headwall will need to be relocated
Between Upper Fens Pond and Avenue Louis Pasteur (Daylighted Reach)				
	30" culvert	To 72" culvert	Daylighted Area	Right bank near proposed island
	Storm drain	To 72" culvert	Daylighted Area	Right bank near Avenue Louis Pasteur
	Storm drain	To 72" culvert	Daylighted Area	Left bank near Avenue Louis Pasteur
Downstream Avenue Louis Pasteur				
	Storm drain	Back Bay Fens	Back Bay Fens	Right bank, near Avenue Louis Pasteur. The headwall will be reconstructed.

Note: Left/right bank refers to perspective when facing downstream.

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands Program

Checklist for Stormwater Report

A. Introduction

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.

A Stormwater Report must be submitted with the Notice of Intent permit application to document compliance with the Stormwater Management Standards. The following checklist is NOT a substitute for the Stormwater Report (which should provide more substantive and detailed information) but is offered here as a tool to help the applicant organize their Stormwater Management documentation for their Report and for the reviewer to assess this information in a consistent format. As noted in the Checklist, the Stormwater Report must contain the engineering computations and supporting information set forth in Volume 3 of the Massachusetts Stormwater Handbook. The Stormwater Report must be prepared and certified by a Registered Professional Engineer (RPE) licensed in the Commonwealth.

The Stormwater Report must include:

- The Stormwater Checklist completed and stamped by a Registered Professional Engineer (see page 2) that certifies that the Stormwater Report contains all required submittals.[1] This Checklist is to be used as the cover for the completed Stormwater Report.
- Applicant/Project Name
- Project Address
- Name of Firm and Registered Professional Engineer that prepared the Report
- Long-Term Pollution Prevention Plan required by Standards 4-6
- Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan required by Standard 8[2]
- Operation and Maintenance Plan required by Standard 9

In addition to all plans and supporting information, the Stormwater Report must include a brief narrative describing stormwater management practices, including environmentally sensitive site design and LID techniques, along with a diagram depicting runoff through the proposed BMP treatment train. Plans are required to show existing and proposed conditions, identify all wetland resource areas, NRCS soil types, critical areas, Land Uses with Higher Potential Pollutant Loads (LUHPPL), and any areas on the site where infiltration rate is greater than 2.4 inches per hour. The Plans shall identify the drainage areas for both existing and proposed conditions at a scale that enables verification of supporting calculations.

As noted in the Checklist, the Stormwater Management Report shall document compliance with each of the Stormwater Management Standards as provided in the Massachusetts Stormwater Handbook. The soils evaluation and calculations shall be done using the methodologies set forth in Volume 3 of the Massachusetts Stormwater Handbook.

To ensure that the Stormwater Report is complete, applicants are required to fill in the Stormwater Report Checklist by checking the box to indicate that the specified information has been included in the Stormwater Report. If any of the information specified in the checklist has not been submitted, the applicant must provide an explanation. The completed Stormwater Report Checklist and Certification must be submitted with the Stormwater Report.

[1] The Stormwater Report may also include the Illicit Discharge Compliance Statement required by Standard 10. If not included in the Stormwater Report, the Illicit Discharge Compliance Statement must be submitted prior to the discharge of stormwater runoff to the post-construction best management practices.

[2] For some complex projects, it may not be possible to include the Construction Period Erosion and Sedimentation Control Plan in the Stormwater Report. In that event, the issuing authority has the discretion to issue an Order of Conditions that approves the project and includes a condition requiring the proponent to submit the Construction Period Erosion and Sedimentation Control Plan before commencing any land disturbance activity on the site.

Checklist for Stormwater Report

B. Stormwater Checklist and Certification

The following checklist is intended to serve as a guide for applicants as to the elements that ordinarily need to be addressed in a complete Stormwater Report. The checklist is also intended to provide conservation commissions and other reviewing authorities with a summary of the components necessary for a comprehensive Stormwater Report that addresses the ten Stormwater Standards.

Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the item is not applicable (N.A.) and provide the reasons for that determination.

A complete checklist must include the Certification set forth below signed by the Registered Professional Engineer who prepared the Stormwater Report.

Registered Professional Engineer's Certification

I have reviewed the Stormwater Report, including the soil evaluation, computations, Long-term Pollution Prevention Plan, the Construction Period Erosion and Sedimentation Control Plan (if included), the Long-term Post-Construction Operation and Maintenance Plan, the Illicit Discharge Compliance Statement (if included) and the plans showing the stormwater management system, and have determined that they have been prepared in accordance with the requirements of the Stormwater Management Standards as further elaborated by the Massachusetts Stormwater Handbook. I have also determined that the information presented in the Stormwater Checklist is accurate and that the information presented in the Stormwater Report accurately reflects conditions at the site as of the date of this permit application.

Registered Professional Engineer Block and Signature

Signature and Date

Checklist

Project Type: Is the application for new development, redevelopment, or a mix of new and redevelopment?

☐ New development

☒ Redevelopment

☐ Mix of New Development and Redevelopment

Checklist for Stormwater Report

Checklist (continued)

LID Measures: Stormwater Standards require LID measures to be considered. Document what environmentally sensitive design and LID Techniques were considered during the planning and design of the project:

- ☐ No disturbance to any Wetland Resource Areas
- ☐ Site Design Practices (e.g. clustered development, reduced frontage setbacks)
- ☒ Reduced Impervious Area (Redevelopment Only)
- ☒ Minimizing disturbance to existing trees and shrubs
- ☐ LID Site Design Credit Requested:
  - ☐ Credit 1
  - ☐ Credit 2
  - ☐ Credit 3
- ☐ Use of “country drainage” versus curb and gutter conveyance and pipe
- ☐ Bioretention Cells (includes Rain Gardens)
- ☐ Constructed Stormwater Wetlands (includes Gravel Wetlands designs)
- ☐ Treebox Filter
- ☐ Water Quality Swale
- ☐ Grass Channel
- ☐ Green Roof
- ☒ Other (describe): Restoration of bank, bordering vegetated wetland, Riverfront, and land under water

Standard 1: No New Untreated Discharges

- ☒ No new untreated discharges
- ☒ Outlets have been designed so there is no erosion or scour to wetlands and waters of the Commonwealth
- ☐ Supporting calculations specified in Volume 3 of the Massachusetts Stormwater Handbook included.

Checklist (continued)

Standard 2: Peak Rate Attenuation

☐ Standard 2 waiver requested because the project is located in land subject to coastal storm flowage and stormwater discharge is to a wetland subject to coastal flooding.

☒ Evaluation provided to determine whether off-site flooding increases during the 100-year 24-hour storm.

☐ Calculations provided to show that post-development peak discharge rates do not exceed pre-development rates for the 2-year and 10-year 24-hour storms. If evaluation shows that off-site flooding increases during the 100-year 24-hour storm, calculations are also provided to show that post-development peak discharge rates do not exceed pre-development rates for the 100-year 24-hour storm.

Standard 3: Recharge

☒ Soil Analysis provided.

☐ Required Recharge Volume calculation provided.

☐ Required Recharge volume reduced through use of the LID site Design Credits.

☐ Sizing the infiltration, BMPs is based on the following method: Check the method used.

☐ Static ☐ Simple Dynamic ☐ Dynamic Field[1]

☐ Runoff from all impervious areas at the site discharging to the infiltration BMP.

☐ Runoff from all impervious areas at the site is *not* discharging to the infiltration BMP and calculations are provided showing that the drainage area contributing runoff to the infiltration BMPs is sufficient to generate the required recharge volume.

☐ Recharge BMPs have been sized to infiltrate the Required Recharge Volume.

☐ Recharge BMPs have been sized to infiltrate the Required Recharge Volume *only* to the maximum extent practicable for the following reason:

- ☐ Site is comprised solely of C and D soils and/or bedrock at the land surface
- ☐ M.G.L. c. 21E sites pursuant to 310 CMR 40.0000
- ☐ Solid Waste Landfill pursuant to 310 CMR 19.000
- ☐ Project is otherwise subject to Stormwater Management Standards only to the maximum extent practicable.

☐ Calculations showing that the infiltration BMPs will drain in 72 hours are provided.

☐ Property includes a M.G.L. c. 21E site or a solid waste landfill and a mounding analysis is included.

[1] 80% TSS removal is required prior to discharge to infiltration BMP if Dynamic Field method is used.

Checklist (continued)

Standard 3: Recharge (continued)

☐ The infiltration BMP is used to attenuate peak flows during storms greater than or equal to the 10-year 24-hour storm and separation to seasonal high groundwater is less than 4 feet and a mounding analysis is provided.

☐ Documentation is provided showing that infiltration BMPs do not adversely impact nearby wetland resource areas.

Standard 4: Water Quality

The Long-Term Pollution Prevention Plan typically includes the following:
- Good housekeeping practices;
- Provisions for storing materials and waste products inside or under cover;
- Vehicle washing controls;
- Requirements for routine inspections and maintenance of stormwater BMPs;
- Spill prevention and response plans;
- Provisions for maintenance of lawns, gardens, and other landscaped areas;
- Requirements for storage and use of fertilizers, herbicides, and pesticides;
- Pet waste management provisions;
- Provisions for operation and management of septic systems;
- Provisions for solid waste management;
- Snow disposal and plowing plans relative to Wetland Resource Areas;
- Winter Road Salt and/or Sand Use and Storage restrictions;
- Street sweeping schedules;
- Provisions for prevention of illicit discharges to the stormwater management system;
- Documentation that Stormwater BMPs are designed to provide for shutdown and containment in the event of a spill or discharges to or near critical areas or from LUHPPL;
- Training for staff or personnel involved with implementing Long-Term Pollution Prevention Plan;
- List of Emergency contacts for implementing Long-Term Pollution Prevention Plan.

☐ A Long-Term Pollution Prevention Plan is attached to Stormwater Report and is included as an attachment to the Wetlands Notice of Intent.

☐ Treatment BMPs subject to the 44% TSS removal pretreatment requirement and the one inch rule for calculating the water quality volume are included, and discharge:

- ☐ is within the Zone II or Interim Wellhead Protection Area
- ☐ is near or to other critical areas
- ☐ is within soils with a rapid infiltration rate (greater than 2.4 inches per hour)
- ☐ involves runoff from land uses with higher potential pollutant loads.

☐ The Required Water Quality Volume is reduced through use of the LID site Design Credits.

☐ Calculations documenting that the treatment train meets the 80% TSS removal requirement and, if applicable, the 44% TSS removal pretreatment requirement, are provided.

Checklist (continued)

Standard 4: Water Quality (continued)

☐ The BMP is sized (and calculations provided) based on:

- ☐ The ½" or 1" Water Quality Volume or
- ☐ The equivalent flow rate associated with the Water Quality Volume and documentation is provided showing that the BMP treats the required water quality volume.

☐ The applicant proposes to use proprietary BMPs, and documentation supporting use of proprietary BMP and proposed TSS removal rate is provided. This documentation may be in the form of the propriety BMP checklist found in Volume 2, Chapter 4 of the Massachusetts Stormwater Handbook and submitting copies of the TARP Report, STEP Report, and/or other third party studies verifying performance of the proprietary BMPs.

☐ A TMDL exists that indicates a need to reduce pollutants other than TSS and documentation showing that the BMPs selected are consistent with the TMDL is provided.

Standard 5: Land Uses With Higher Potential Pollutant Loads (LUHPPLs)

☐ The NPDES Multi-Sector General Permit covers the land use and the Stormwater Pollution Prevention Plan (SWPPP) has been included with the Stormwater Report.

☐ The NPDES Multi-Sector General Permit covers the land use and the SWPPP will be submitted ***prior to*** the discharge of stormwater to the post-construction stormwater BMPs.

☐ The NPDES Multi-Sector General Permit does ***not*** cover the land use.

☐ LUHPPLs are located at the site and industry specific source control and pollution prevention measures have been proposed to reduce or eliminate the exposure of LUHPPLs to rain, snow, snow melt and runoff, and been included in the long term Pollution Prevention Plan.

☐ All exposure has been eliminated.

☐ All exposure has ***not*** been eliminated and all BMPs selected are on MassDEP LUHPPL list.

☐ The LUHPPL has the potential to generate runoff with moderate to higher concentrations of oil and grease (e.g. all parking lots with >1000 vehicle trips per day) and the treatment train includes an oil grit separator, a filtering bioretention area, a sand filter or equivalent.

Standard 6: Critical Areas

☐ The discharge is near or to a critical area and the treatment train includes only BMPs that MassDEP has approved for stormwater discharges to or near that particular class of critical area.

☐ Critical areas and BMPs are identified in the Stormwater Report.

Checklist (continued)

Standard 7: Redevelopments and Other Projects Subject to the Standards only to the maximum extent practicable

☒ The project is subject to the Stormwater Management Standards only to the maximum Extent Practicable as a:

- ☒ Limited Project
- ☐ Small Residential Projects: 5-9 single family houses or 5-9 units in a multi-family development provided there is no discharge that may potentially affect a critical area.
- ☐ Small Residential Projects: 2-4 single family houses or 2-4 units in a multi-family development with a discharge to a critical area
- ☐ Marina and/or boatyard provided the hull painting, service and maintenance areas are protected from exposure to rain, snow, snow melt and runoff
- ☒ Bike Path and/or Foot Path
- ☒ Redevelopment Project
- ☐ Redevelopment portion of mix of new and redevelopment.

☐ Certain standards are not fully met (Standard No. 1, 8, 9, and 10 must always be fully met) and an explanation of why these standards are not met is contained in the Stormwater Report.

☒ The project involves redevelopment and a description of all measures that have been taken to improve existing conditions is provided in the Stormwater Report. The redevelopment checklist found in Volume 2 Chapter 3 of the Massachusetts Stormwater Handbook may be used to document that the proposed stormwater management system (a) complies with Standards 2, 3 and the pretreatment and structural BMP requirements of Standards 4-6 to the maximum extent practicable and (b) improves existing conditions.

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control

A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan must include the following information:

- Narrative;
- Construction Period Operation and Maintenance Plan;
- Names of Persons or Entity Responsible for Plan Compliance;
- Construction Period Pollution Prevention Measures;
- Erosion and Sedimentation Control Plan Drawings;
- Detail drawings and specifications for erosion control BMPs, including sizing calculations;
- Vegetation Planning;
- Site Development Plan;
- Construction Sequencing Plan;
- Sequencing of Erosion and Sedimentation Controls;
- Operation and Maintenance of Erosion and Sedimentation Controls;
- Inspection Schedule;
- Maintenance Schedule;
- Inspection and Maintenance Log Form.

☐ A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan containing the information set forth above has been included in the Stormwater Report.

Checklist (continued)

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control (continued)

☒ The project is highly complex and information is included in the Stormwater Report that explains why it is not possible to submit the Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan with the application. A Construction Period Pollution Prevention and Erosion and Sedimentation Control has ***not*** been included in the Stormwater Report but will be submitted ***before*** land disturbance begins.

☐ The project is ***not*** covered by a NPDES Construction General Permit.

☐ The project is covered by a NPDES Construction General Permit and a copy of the SWPPP is in the Stormwater Report.

☒ The project is covered by a NPDES Construction General Permit but no SWPPP been submitted. The SWPPP will be submitted BEFORE land disturbance begins.

Standard 9: Operation and Maintenance Plan

☐ The Post Construction Operation and Maintenance Plan is included in the Stormwater Report and includes the following information:

- ☐ Name of the stormwater management system owners;
- ☐ Party responsible for operation and maintenance;
- ☐ Schedule for implementation of routine and non-routine maintenance tasks;
- ☐ Plan showing the location of all stormwater BMPs maintenance access areas;
- ☐ Description and delineation of public safety features;
- ☐ Estimated operation and maintenance budget; and
- ☐ Operation and Maintenance Log Form.

☐ The responsible party is ***not*** the owner of the parcel where the BMP is located and the Stormwater Report includes the following submissions:

- ☐ A copy of the legal instrument (deed, homeowner's association, utility trust or other legal entity) that establishes the terms of and legal responsibility for the operation and maintenance of the project site stormwater BMPs;
- ☐ A plan and easement deed that allows site access for the legal entity to operate and maintain BMP functions.

Standard 10: Prohibition of Illicit Discharges

☒ The Long-Term Pollution Prevention Plan includes measures to prevent illicit discharges;

☐ An Illicit Discharge Compliance Statement is attached;

☐ NO Illicit Discharge Compliance Statement is attached but will be submitted ***prior to*** the discharge of any stormwater to post-construction BMPs.

ATTACHMENT E

ORDER OF TAKING

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ORDER OF TAKING
COMMONWEALTH OF MASSACHUSETTS
METROPOLITAN DISTRICT COMMISSION

Boston, March 5, 1959.

ORDERED: That the Metropolitan District Commission by virtue of the authority conferred upon it by Chapter 403 of the Acts of 1954 and every other power and authority hereto enabling, for the purpose of said Act and Chapter 92 of the General Laws does hereby take in fee under the provisions of Chapter 79 of the General Laws in the name and for the benefit of the Commonwealth of Massachusetts, the land situated in Boston in the County of Suffolk and Commonwealth of Massachusetts shown on a plan entitled "Commonwealth of Massachusetts, Metropolitan District Commission, Parks Division, Riverway-Park Drive-Fenway, Boston, Plan of Taking from City of Boston Parks Department and City of Boston Department of Public Works, * * * February 25, 1959, Benjamin W. Fink, Director of Park Engineering," being plan accession number 37657-V.T. a copy of which shall be recorded with a copy of this order in the Suffolk County Registry of Deeds and made a part of this order, bounded and described as follows:

Parcel one:

Beginning at the intersection of the southwesterly side line of Park Drive with the southeasterly side line of the location of the Boston & Albany Railroad at land of the City of Boston, Parks Department, as shown on said plan;

Thence the line runs northeasterly by said southeasterly side line of said railroad location one hundred four (104) feet more or less to a point in the northeasterly side line of Park Drive at land now or formerly of Sears, Roebuck & Co.;

Thence southeasterly by a line curving to the left with a radius of one thousand seven hundred nineteen and 12/100 (1719.12) feet by said northeasterly side line of Park Drive six hundred seventy-five and 24/100 (675.24) feet to a point;

Thence southeasterly by said northeasterly side line of Park Drive seventy and 02/100 (70.02) feet to a point in the northwesterly side line of Brookline Avenue;

Thence southwesterly by said Brookline Avenue seventy-six and 09/100 (76.09) feet to a point in the southwesterly side line of Park Drive at land now or formerly of Sears, Roebuck & Co.;

Thence northwesterly by said southwesterly side line of Park Drive seventy-
7380 24 seven and 91/100 (77.91) feet to a point;

Thence southwesterly, northerly and northeasterly by a line curving to the right with a radius of one thousand seven hundred ninety-four and 12/100 (1794.12) feet, by said southwesterly side line of Park Drive, three hundred seventy and 27/100 (370.27) feet to a point;

Thence northeasterly, northerly and northwesterly, westerly and southwesterly by a line curving to the left with a radius of fifteen (15) feet, thirty-six and 78/100 (36.78) feet to a point at land now or formerly of the City of Boston, said line forming the intersection of said Park Drive and land now or formerly of the City of Boston;

Thence southwesterly by a line curving to the right with a radius of four hundred twenty-two and 78/100 (422.78) feet, by said land of the City of Boston ninety-four and 49/100 (94.49) feet to a point;

Thence southwesterly by a line curving to the right with a radius of five hundred forty-nine and 98/100 (549.98) feet, by said land of the City of Boston

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two hundred nine and 32/100 (209.32) feet to a point;

Thence southwesterly, southerly, and southeasterly by a line curving to the left with a radius of fifteen (15) feet, thirty-two and 97/100 (32.97) feet to a point in the northeasterly side line of Riverway, said line forming the intersection of said land of the City of Boston and Riverway;

Thence southeasterly by a line curving to the right with a radius of three hundred eighty-five and 60/100 (385.60) feet, by said northeasterly side line of Riverway two hundred forty-nine and 36/100 (249.36) feet to a point;

Thence southeasterly by a line curving to the right with a radius of one thousand eight hundred eighty-eight and 79/100 (1888.79) feet by said northeasterly side line of Riverway one hundred thirty-two and 75/100 (132.75) feet to a point in the northwesterly side line of Brookline Avenue;

Thence southwesterly by said northwesterly side line of Brookline Avenue eighty and 40/100 (80.40) feet to a point in the southwesterly side line of Riverway;

Thence northwesterly by a line curving to the left with a radius of one thousand eight hundred eight and 79/100 (1808.79) feet, one hundred thirty-five and 0/10 (135.0) feet to a point;

Thence northwesterly, westerly and southwesterly by a line curving to the left with a radius of three hundred five and 60/100 (305.60) feet, four hundred seventeen and 78/100 (417.78) feet to a point;

Thence southwesterly by a line curving to the left with a radius of six hundred fifteen and 57/100 (615.57) feet, three hundred one and 98/100 (301.98) feet to a point;

Thence southwesterly forty-nine and 86/100 (49.86) feet to a point;

Thence southwesterly by a line curving to the right with a radius of one thousand eight hundred eighty-seven and 96/100 (1887.96) feet, two hundred twenty-nine and 81/100 (229.81) feet to a point;

Thence southwesterly by a line curving to the right with a radius of five hundred seventy-three and 69/100 (573.69) feet, two hundred twenty-one and 37/100 (221.37) feet to a point;

Thence southwesterly by a line curving to the right with a radius of one thousand four hundred thirty-two and 69/100 (1432.69) feet, two hundred ninety-two and 91/100 (292.91) feet to a point; the last seven (7) courses and distances being by said Riverway;

Thence southwesterly, southerly and southeasterly by a line curving to the left with a radius of fifteen and 0/10 (15.0) feet, thirty-one and 74/100 (31.74) feet to a point in the northerly side line of Plymouth Street; said line forming the intersection of Riverway and Plymouth Street;

Thence southwesterly crossing Plymouth Street forty-eight (48) feet more or less to a point in the southerly side line of Plymouth Street;

Thence northwesterly, westerly and southwesterly by a line curving to the left with a radius of fifty and 0/10 (50.0) feet, forty-seven and 68/100 (47.68) feet to a point in the southeasterly side line of Riverway; said line forming the intersection of Plymouth Street and Riverway;

Thence southwesterly by a line curving to the right with a radius of one thousand four hundred thirty-two and 69/100 (1432.69) feet, twenty-five and 92/100 (25.92) feet to a point;

Thence southwesterly eighty-five and 60/100 (85.60) feet to a point;

Thence southwesterly by a line curving to the left with a radius of three hundred ninety-three and 65/100 (393.65) feet, two hundred thirty-three and 05/100 (233.05) feet to a point;

Thence southwesterly by a line curving to the left with a radius of six hundred ten and 0/10 (610.0) feet, forty-eight and 16/100 (48.16) feet to a point; the last four (4) courses and distances being by said Riverway;

Thence southwesterly, southerly and southeasterly by a line curving to the left with a radius of twenty and 0/10 (20.0) feet to a point in the northerly side line of Longwood Avenue; said line forming the intersection of Riverway and Longwood Avenue;

Thence southwesterly crossing Longwood Avenue seventy-one and 67/100 (71.67) feet to a point in the southerly side line of Longwood Avenue;

Thence northwesterly, westerly and southwesterly by a line curving to the left with a radius of twenty and 0/10 (20.0) feet to a point in the southeasterly side line of Riverway; said line forming the intersection of said Longwood Avenue and Riverway;

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Thence southwesterly by a line curving to the left with a radius of one thousand eight hundred thirteen and 5/10 (1813.5) feet, by said southeasterly side line of Riverway two hundred six and 38/100 (206.38) feet to a point;

Thence southwesterly by a line curving to the left with a radius of six hundred seventy-four and 69/100 (674.69) feet, by said southeasterly side line of Riverway one hundred sixty-seven and 34/100 (167.34) feet to a point;

Thence southwesterly, southerly and southeasterly by a line curving to the left with a radius of twenty and 0/10 (20.0) feet, nineteen and 44/100 (19.44) feet to a point in the northeasterly side line of Autumn Street; said line forming the intersection of said Riverway and Autumn Street;

Thence southerly crossing Autumn Street fifty-six and 69/100 (56.69) feet to a point in the southwesterly side line of Autumn Street;

Thence northwesterly, westerly and southwesterly by a line curving to the left with a radius of ten and 0/10 (10.0) feet, twenty-two and 42/100 (22.42) feet to a point in the southeasterly side line of Riverway; said line forming the intersection of Autumn Street and Riverway;

Thence southwesterly by said southeasterly side line of Riverway thirteen and 23/100 (13.23) feet to a point at land of the Commonwealth of Massachusetts;

Thence northwesterly by said land of the Commonwealth of Massachusetts ninety and 0/10 (90.0) feet to a point in the northwesterly side line of Riverway;

Thence northeasterly forty-two (42) feet more or less to a point;

Thence northeasterly by a line curving to the right with a radius of seven hundred sixty-four and 69/100 (764.69) feet, two hundred forty-eight (248) feet more or less to a point;

Thence northeasterly by a line curving to the right with a radius of one thousand nine hundred three and 5/10 (1903.5) feet, one hundred ninety (190) feet more or less to a point; the last three (3) courses anddistances being by said northwesterly side line of Riverway;

Thence northeasterly, northerly and northwesterly by a line curving to the left with a radius of twenty and 0/10 (20.0) feet, thirty-five (35) feet more or less to a point in the southerly side line of Longwood Avenue; said line forming the intersection of Riverway and Longwood Avenue;

Thence northeasterly crossing Longwood Avenue seventy-one (71) feet more or less to a point;

Thence southeasterly, easterly and northeasterly by a line curving to the left with a radius of twenty and 0/10 (20.0) feet, twenty-four (24) feet more or less to a point in the northwesterly side line of Riverway; said line forming the intersection of Longwood Avenue andRiverway;

Thence northeasterly by a line curving to the right with a radius of seven hundred and 00/100 (700.00) feet, one hundred nine (109) feet more or less to a point;

Thence northeasterly by a line curving to the right with a radius of four hundred eighty-three and 65/100 (483.65) feet, two hundred eighty-six and 33/100 (286.33) feet to a point;

Thence northeasterly eighty-five and 60/100 (85.60) feet to a point;

Thence northeasterly by a line curving to the left with a radius of one thousand three hundred forty-two and 69/100 (1342.69) feet, three hundred ninety-two (392) feet more or less to a point;

Thence northeasterly by a line curving to the left with a radius of four hundred eighty-three and 69/100 (483.69) feet, one hundred eighty-six and 64/100 (186.64) feet:

Thence northeasterly by a line curving to the left with a radius of one thousand seven hundred ninety-seven and 96/100 (1797.96) feet, two hundred eighteen and 85/100 (218.85) feet to a point;

Thence northeasterly forty-nine and 86/100 (49.86) feet to a point;

Thence northeasterly by a line curving to the right with a radius of seven hundred five and 57/100 (705.57) feet, one hundred ninety-two and 85/100 (192.85) feet to a point;

Thence northeasterly five hundred sixty-five (565) feet more or less to a point;

Thence northeasterly, northerly and northwesterly by a line curving to the left with a radius of sixty and 0/10 (60.0) feet, forty (40) feet more or less to a point;

Thence northwesterly one hundred forty-six (146) feet more or less to a point;

Thence northwesterly by a line curving to the left with a radius of one hundred and 0/10 (100.0) feet, sixty-five (65) feet more or less to a point;

Thence northwesterly sixty-eight (68) feet more or less to the point of beginning; the last thirteen (13) courses and distances being by said northwesterly side line of Riverway; being shown on the aforesaid plan as Parcel 1 and comprising three hundred eighty thousand two hundred (380,200) square feet more or less of land supposed to be owned by City of Boston, Parks Department.

Parcel two:

Beginning at the intersection of the southwesterly side line of Park Drive with the northwesterly side line of the location of the Boston & Albany Railroad at land of owner unknown, as shown on said plan;

Thence the line runs northwesterly by said southwesterly side line of Park Drive three hundred eighty-four and 23/100 (384.23) feet to a point;

Thence northwesterly by a line curving to the left with a radius of twenty and 0/10 (20.0) feet, by said southwesterly side line of Park Drive twenty-one and 34/100 (21.34) feet to a point in the southerly side line of Beacon Street;

Thence southeasterly, easterly and northeasterly by a line curving to the left with a radius of one hundred twenty-five and 0/10 (125.0) feet, by said southerly side line of Beacon Street, one hundred twenty-five and 95/100 (125.95) feet to a point in the northeasterly side line of Park Drive;

Thence southwesterly, southerly and southeasterly by a line curving to the left with a radius of twenty and 0/10 (20.0) feet, by said northeasterly side line of Park Drive twenty-one and 34/100 (21.34) feet to a point;

Thence southeasterly by said northeasterly side line of Park Drive three hundred fifty-four and 47/100 (354.47) feet to a point in the northwesterly side line of said railroad location;

Thence southwesterly by said northwesterly side line of said railroad location one hundred four and 34/100 (104.34) feet to the point of beginning; being shown on the aforesaid plan as Parcel 2 comprising thirty-seven thousand five hundred twenty-five (37,525) square feet more or less of land within the limits of Park Drive supposed to be owned by the City of Boston, Parks Department.

Parcel three:

Beginning at the intersection of the northeasterly side line of Park Drive with the northwesterly side line of Brookline Avenue at land now or formerly of Sears, Roebuck & Co., as shown on said plan;

Thence the line runs northeasterly by a line curving to the left with a radius of twenty and 0/10 (20.0) feet by said northwesterly side line of Brookline Avenue thirty-four and 53/100 (34.53) feet to a point;

Thence northeasterly by said northwesterly side line of Brookline Avenue two hundred eighty and 20/100 (280.20) feet to a point;

Thence southeasterly crossing Brookline Avenue sixty and 0/10 (60.0) feet to a point in the southeasterly side line of Brookline Avenue;

Thence southwesterly by said southeasterly side line of Brookline Avenue one hundred eighty-two and 63/100 (182.63) feet to a point;

Thence southwesterly, southerly, southeasterly, easterly and northeasterly by a line curving to the left with a radius of twenty and 0/10 (20.0) feet, fifty-one and 67/100 (51.67) feet to a point in the northwesterly side line of Boylston Street; said line forming the intersection of Brookline Avenue and Boylston Street;

Thence southeasterly crossing Boylston Street eighty and 0/10 (80.0) feet to a point in the southeasterly side line of Boylston Street;

Thence southwesterly by said southeasterly side line of Boylston Street two hundred eleven and 54/100 (211.54) feet to a point;

Thence southwesterly, southerly and southeasterly by a line curving to the left with a radius of twenty and 0/10 (20.0) feet, thirty-seven and 95/100 (37.95) feet to a point in the northeasterly side line of Park Drive;

Thence southeasterly by a line curving to the rightwith a radius of two thousand one hundred forty-eight and 79/100 (2148.79) feet by said northeasterly side line of Park Drive, one hundred forty-four and 90/100 (144.90) feet to a point;

Thence southeasterly by said northeasterly side line of Park Drive forty and 0/10 (40.0) feet to a point;

Thence southwesterly crossing Park Drive, by land now or formerly of the City of Boston, Parks Department, and crossing the Fenway, three hundred forty and 0/10 (340.0) feet to a point in the southwesterly side line of the Fenway;

Thence northwesterly by said southwesterly side line of the Fenway forty and 0/10 (40.0) feet to a point;

Thence northwesterly by a line curving to the left with a radius of one thousand eight hundred eight and 79/100 (1808.79) feet, by said southwesterly side line of the Fenway, eighty-nine and 33/100 (89.33) feet to a point;

Thence northwesterly, westerly and southwesterly by a line curving to the left with a radius of twenty and 0/10 (20.0) feet, thirty-six and 49/100 (36.49) feet to a point in the southeasterly side line of Brookline Avenue; said line forming the intersection of the Fenway and Brookline Avenue;

Thence southwesterly by the southeasterly side line of Brookline Avenue one hundred forty-five and 0/10 (145.0) feet to a point;

Thence northwesterly crossing Brookline Avenue seventy-five and 00/100 (75.00) feet to a point in the northwesterly side line of Brookline Avenue;

Thence northeasterly seventy-five (75) feet more or less to a point;

Thence northeasterly thirty-seven and 3/10 (37.3) feet to a point;

Thence northerly sixty and 0/10 (60.0) feet to a point;

Thence northerly and northwesterly by a line curving to the left with a radius of eighteen and 0/10 (18.0) feet, twenty-six and 86/100 (26.86) feet to a point;

Thence northeasterly eighty and 40/100 (80.40) feet to a point;

Thence northeasterly one hundred eighty-seven and 50/100 (187.50) feet to a point;

Thence northeasterly seventy-six and 09/100 (76.09) feet to the point of beginning; the last seven (7) courses and distances being by said northwesterly side line of Brookline Avenue; being shown on the aforesaid plan as Parcel 3 comprising three thousand sixty-four (3,064) square feet more or less of land supposed to be owned by the City of Boston, Parks Department; Parcel 4 comprising sixty-one thousand three hundred (61,300) square feet more or less of land supposed to be owned by the City of Boston, Parks Department; and, Parcel 5 comprising ninety-one thousand three hundred (91,300) square feet more or less of land supposed to be owned by the City of Boston, Department of Public Works.

Said Metropolitan District Commission does also hereby order the taking of and does hereby take in the name and behalf of the Commonwealth of Massachusetts for the purposes aforesaid the right and easement to occupy and use for the passage of men and vehicles, the transportation of machinery and materials and for depositing machinery, tools, dirt and other materials thereon, together with the right to remove said machinery, tools, dirt and other materials so deposited thereon but in no event later than October 1, 1959, the following described parcels of land situated in said Boston, shown on the aforesaid plan, and comprising land of the following owners:

Parcel	Owner	Area In Square Feet In Which Temporary Easement Is Taken
A	City of Boston, Parks Department	20,200
B	City of Boston, Parks Department	95,800
C	City of Boston, Parks Department	13,600

Excepting and reserving the right of the City of Boston to maintain, repair, and renew sewerage works within the area marked "Muddy River Culvert" on said plan.

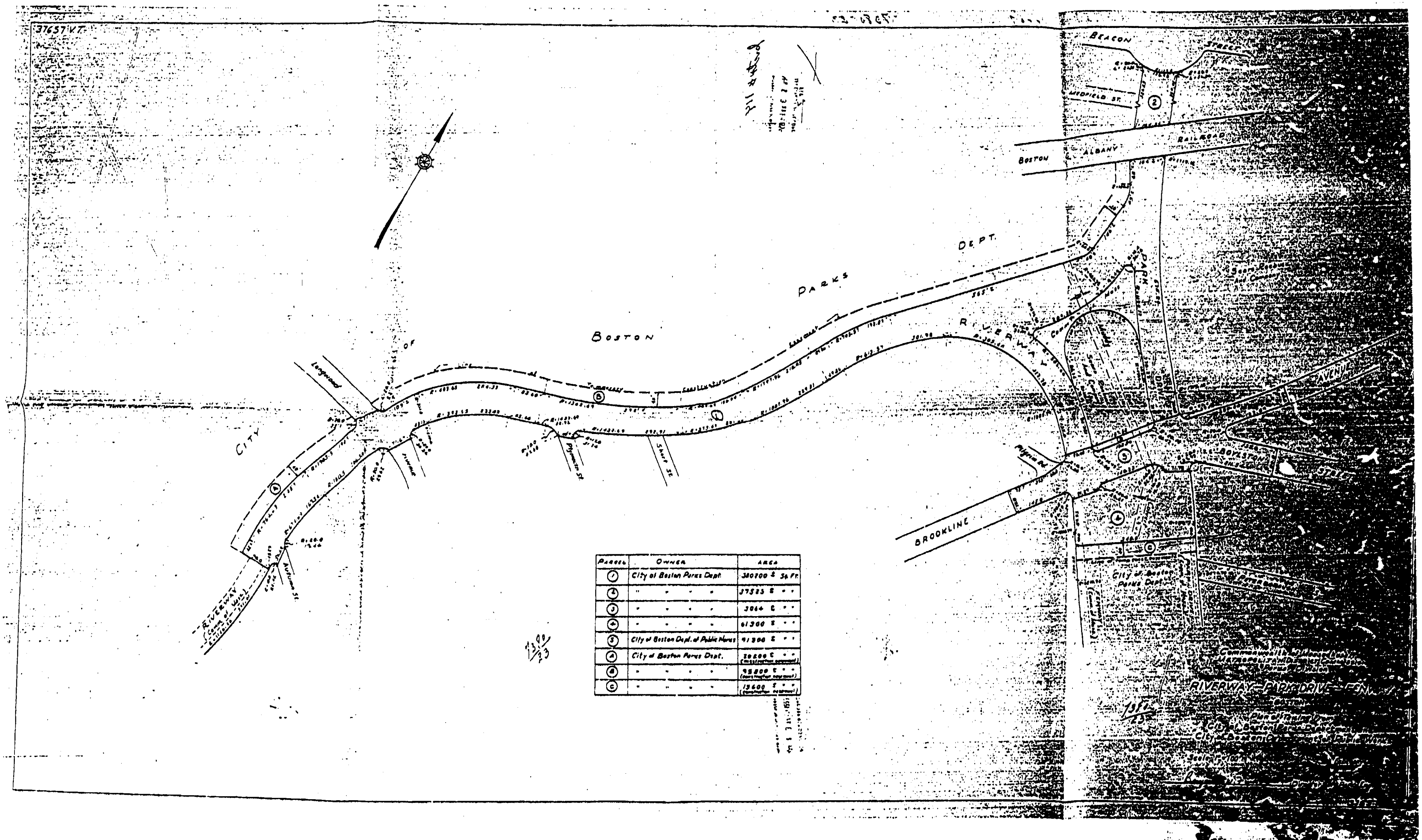
Trees on said land and structures affixed to said land are included in this taking with the exception of wires, pipes, conduits, poles and their appurtenances for the conveyance of water, sewage, steam, gas and electricity and for

7380 28 telephone and telegraph communications, and the tracks and appurtenances of the Metropolitan Transit Authority now lawfully in or upon said land.

A true copy,

ATTEST: Richard J. [illegible]
Secretary, Metropolitan District Commission.

March 6, 1959. At 3 o'clock & 11 mins. P.M.
Rec'd. Ent'd. & Exam'd.-114



Parcel	Owner	Area
1	City of Boston Parks Dept.	380700 ± Sq. Ft.
2	" " " "	37523 ± " "
3	" " " "	3064 ± " "
4	" " " "	61300 ± " "
5	City of Boston Dept. of Public Works	91300 ± " "
A	City of Boston Parks Dept.	20200 ± " " (construction easement)
B	" " " "	95800 ± " " (construction easement)
C	" " " "	13600 ± " " (construction easement)

MPC #1328
37657 V.T.

ATTACHMENT F

ORAD

WPA Form 4B – Order of Resource Area Delineation

Massachusetts Wetlands Protection Act M.G.L. c. 131, §40

DEP File Number:
6-0867
Provided by DEP

A. General Information

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.

From:

Boston
Conservation Commission

This Issuance is for (check one):

☒ Order of Resource Area Delineation

☐ Amended Order of Resource Area Delineation

To: Applicant:

Boston Parks and Recreation Department
Name
1010 Massachusetts Avenue
Mailing Address
Boston | MA | 02118
City/Town | State | Zip Code

Property Owner (if different from applicant):

same
Name

Mailing Address

City/Town | State | Zip Code

1. Project Location:

   Muddy River (Ward's Pond, Willow Pond, Leverett Pond, Riverway, Back Bay Fens, Charlesgate)
   Boston/Brookline
   City/Town

   Assessors Map/Plat Number
   Parcel /Lot Number

2. Title and Date of Final Plans and Other Documents:

   Muddy River Restoration Project- Wetlands Delineation:
   Title
   September 2000
   Final Date (or Revised Date, if applicable)
   Key Plan; Plans No. 1-34

3. Dates:

   September 6, 2000
   Date Notice of Intent Filed

   September 20, 2000
   Date Public Hearing Closed

   February 21, 2001
   Date of Issuance

B. Order of Delineation

The Conservation Commission has determined the following (check whichever is applicable):

☒ **Accurate:** The boundaries described on the referenced plan(s) above and in the Abbreviated Notice of Resource Area Delineation are accurately drawn for the following resource area(s):

- ☒ Bordering Vegetated Wetlands
- ☐ Other Resource Area(s), specifically:

___

___

☐ **Modified:** The boundaries described on the plan(s) referenced above, as modified by the Conservation Commission from the plans contained in the Abbreviated Notice of Resource Area Delineation, are accurately drawn from the following resource area(s):

- ☐ Bordering Vegetated Wetlands
- ☐ Other Resource Area(s), specifically:

___

___

☐ **Inaccurate:** The boundaries described on the referenced plan(s) and in the Abbreviated Notice of Resource Area Delineation were found to be inaccurate and cannot be confirmed for the following resource area(s):

- ☐ Bordering Vegetated Wetlands
- ☐ Other Resource Area(s), specifically:

___

___

The boundaries were determined to be inaccurate because:

___

___

___

B. Order of Delineation (cont.)

This Order of Resource Area Delineation determines the boundaries of those resource areas noted above and is binding as to all decisions rendered pursuant to the Massachusetts Wetlands Protection Act (M.G.L. c.131, § 40) and its regulations (310 CMR 10.00) regarding such boundaries. This Order does not, however, determine the boundaries of any resource area or Buffer Zone to any resource area not specifically noted above, regardless of whether such boundaries are contained on the plans attached to this Order or to the Abbreviated Notice of Resource Area Delineation.

This Order must be signed by a majority of the Conservation Commission. The Order must be sent by certified mail (return receipt requested) or hand delivered to the applicant. A copy also must be mailed or hand delivered at the same time to the appropriate DEP Regional Office (see Appendix A)

Signatures:

This Order is valid for three years from the date of issuance.

This Order is issued to the applicant and the property owner (if different) as follows:

☐ by hand delivery on

Date

☐ by certified mail, return receipt requested on

Date

C. Appeals

The applicant, the owner, any person aggrieved by this Order, any owner of land abutting the land subject to this Order, or any ten residents of the city or town in which such land is located, are hereby notified of their right to request the appropriate DEP Regional Office (see Appendix A) to issue a Superseding Order of Resource Area Delineation. The request must be made by certified mail or hand delivery to the Department, with the appropriate filing fee and a completed Appendix E: Request for Departmental Action Fee Transmittal Form, as provided in 310 CMR 10.03(7) within ten business days from the date of issuance of this Order. A copy of the request shall at the same time be sent by certified mail or hand delivery to the Conservation Commission and to the applicant, if he/she is not the appellant.

The request shall state clearly and concisely the objections to the Order which is being appealed and how the Order does not contribute to the protection of the interests identified in the Massachusetts Wetlands Protection Act, (M.G.L. c. 131, § 40) and is inconsistent with the wetlands regulations (310 CMR 10.00). To the extent that the Order is based on a municipal bylaw or ordinance, and not on the Massachusetts Wetlands Protection Act or regulations, the Department of Environmental Protection has no appellate jurisdiction.

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands

WPA Form 7 – Extension Permit for Orders of Conditions

Massachusetts Wetlands Protection Act M.G.L. c. 131, §40

DEP File Number:
6-867
Provided by DEP

A. General Information

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.

1. Applicant:

Boston Parks and Recreation Department
Name
1010 Massachusetts Avenue
Mailing Address

Boston	MA	02118
City/Town	State	Zip Code

2. Property Owner (if different):

Name

Mailing Address

City/Town	State	Zip Code

B. Finding Information

The Order of Conditions (or Extension Permit) issued to the applicant or property owner listed above on:

February 21, 2001 (Order of Resource Area Delineation)
Date

for work at:

Muddy River (Riverway, Back Bay Fens, Charlesgate), Ward's Pond, Willow Pond, Leverett Pond	N/A	N/A
Street Address	Assessor's Map/Plat Number	Parcel/Lot Number

recorded at the Registry of Deeds for:

N/A	N/A	N/A
County	Book	Page

Certificate (if registered land)

is hereby extended until:

February 21, 2007 (See Attachment A.)
Date

This date can be no more than 3 years from the expiration date of the Order of Conditions or the latest extension. Only unexpired Orders of Conditions or Extension may be extended.

Date the Order was last extended (if applicable):

N/A
Date

Issued by:

Boston
Conservation Commission

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands
WPA Form 7 – Extension Permit for Orders of Conditions
Massachusetts Wetlands Protection Act M.G.L. c. 131, §40

DEP File Number: 6-867
Provided by DEP

B. Finding Information (cont.)

This Order of Conditions Extension must be signed by a majority of the Conservation Commission and a copy sent to the applicant and the appropriate DEP Regional Office (see Appendix A).

Signatures:

Charles Button

James M McHallam

On 7th
Day

Of ~~Januray 2004~~ January 2004
Month and Year

before me personally appeared

Charles Button, John P. Sullivan, Jr., Jeanne M. McHallam, Stephen T. Kunian

to me known to be the person described in and who executed the foregoing instrument and acknowledged that he/she executed the same as his/her free act and deed.

Timothy James Famulare
Notary Public

June 11, 2010
My Commission Expires

TIMOTHY JAMES FAMULARE
Notary Public
Commonwealth of Massachusetts
My Commission Expires
June 11, 2010

C. Recording Confirmation

The applicant shall record this document in accordance with General Condition 8 of the Order of Conditions (see below), complete the form attached to this Extension Permit, have it stamped by the Registry of Deeds, and return it to the Conservation Commission.

Note: General Condition 8 of the Order of Conditions requires the applicant, prior to commencement of work, to record the final Order (or in this case, the Extension Permit for the Order of Conditions) in the Registry of Deeds or the Land Court for the district in which the land is located, within the chain of title of the affected property. In the case of recorded land, it shall be noted in the Registry's Granter Index under the name of the owner of the land upon which the proposed work is to be done. In the case of registered land, it shall also be noted on the Land Court Certificate of Title of the owner of the land upon which the proposed work is done.

Detach page 3 of Form 7 and submit it to the Conservation Commission prior to the expiration of the Order of Conditions subject to this Extension Permit.

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands

WPA Form 7 – Extension Permit for Orders of Conditions

Massachusetts Wetlands Protection Act M.G.L. c. 131, §40

DEP File Number:

6-867

Provided by DEP

C. Recording Confirmation (cont.)

To:

Conservation Commission

Please be advised that the Extension Permit to the Order of Conditions for the project at:

Project Location DEP File Number

has been recorded at the Registry of Deed of:

County

for:

Property Owner

and has been noted in the chain of title of the affected property in accordance with General Condition 8 of the original Order of Conditions on:

Date Book Page

If recorded land the instrument number which identifies this transaction is:

Instrument Number

If registered land, the document number which identifies this transaction is:

Document Number

Signature of Applicant

Attachment A

DEP File No. 6-867: Extension Permit for Order of Resource Area Delineation
Boston Parks and Recreation Department, Muddy River Restoration Project

The Boston Conservation Commission ("Commission") finds that, due to a clerical error, the Order of Resource Area Delineation, issued on February 21, 2001, did not accurately reflect its original determination. The Commission determined that, in addition to the boundaries of Bordering Vegetated Wetlands, the delineation of the boundaries of Inland Bank, Riverfront Area, Bordering Land Subject to Flooding, and Land Under Water as described on the plans referenced in the Order of Resource Area Delineation, DEP File No. 6-867, are also accurately drawn.

From: Busch, Chris
Sent: Friday, November 21, 2008 4:03 PM
To: Dyson, Margaret - Parks Dept.
Cc: Dunk, Dwight
Subject: ORAD Extension

Margaret,

The Order of Resource Area Delineation (DEP File No. 006-0867) for the Muddy River was extended by the Commission until February 21, 2010

Chris Busch, Executive Secretary
Boston Conservation Commission
Boston Environment Department
Boston City Hall, Room 805
Boston, MA 02201
Ph: 617-635-4417
Fax: 617-635-3435

ATTACHMENT G

ABUTTER INFORMATION

Muddy River Phase One Abutters List

Park Drive - Queensbury to Riverside D line

0504250000- 51 Park Dr.
Fifty 1 Park Drive Condo
51 Park Dr.
Boston, MA 02215

0504251000- 55 Park Dr.
Anthony M Nader
895 Huntington Av. #1
Boston MA, 02115

0504252000 - 61 Park Dr.
Fens Drive Condo Trust
61 Park Dr.
Boston, MA 02215

0504253000 - 63 Park Dr
Park Drive Condominium Trust
63 Park Dr.
Boston, MA 02215

0504255000 - 73 Park Dr.
Handler Sidney R Trusts
248 Newbury St.
Boston, MA 02116

0504256000 - 77 Park Dr.
Handler Sidney R Trusts
248 Newbury St.
Boston, MA 02116

0504258000 - 81 Park Dr.
Handler Sidney R Trusts
248 Newbury St.
Boston, MA 02116

0504259000 - 85 Park Dr.
Fenview Condo Trust
121 Captains Row,
Chelsea, MA 02150

0504261000 - 89 Park Dr.
Fenway Park Tower LLC
19 Needham St.
Newton, MA 02461

0504262000 - 95 Park Dr.
Fenway Park Tower LLC

19 Needham St.
Newton, MA 02461

0504263000 - 130 Jersey St.
Kowng Cheuk Leung
132 Jersey St.
Boston, MA 02215

0504271000 - 107 Park Dr.
Community Resources
355 Boylston St.
Boston, MA 02116

0504272000 - 111 Park Dr.
Guarini Rosalyn E Trust
896 Beacon St.
Boston, MA 02215

0504273000 - 117 Park Dr.
Levenson Norman A Mtgee
896 Beacon St.
Boston, MA 02215

0504274000 - 121 Park Dr
Hemenway Park Towers LLC
19 Needham St.
Newton, MA 02461

0504275000 - 125 Park Dr
Fenway by the Park Condo Trust
125 Park Dr.
Boston, MA 02215

0504277000 - 137 Park Dr
Gilbert Joy S Trust
11 Tetlow St.
Boston, MA 02115

0504278000 - 143 Park Dr.
Gilbert Joy S Trust
11 Tetlow St.
Boston, MA 02115

0504279000 - 149 Park Dr
Parkside Tower LLC
19 Needham St.
Newton, MA 02461

0504280000 - 151 Park Dr.
Parkside Tower LLC
19 Needham St.

Newton, MA 02461

2100001000 - 165 Park Dr
Parish of Holy Trinity
165 Park Dr.
Boston, MA 02215

2100002000 Park Dr
Emmanuel College
400 The Fenway
Boston, MA 02115

2100003000 - 191 Park Drive
Norman A. Levenson Trust
896 Beacon Street
Boston, MA 02215

2100004000 – 195 Park Drive
Norman A. Levenson Trust
896 Beacon Street
Boston, MA 02215

2100005010 – 199 Park Drive
President and Fellows
199 Park Drive
Boston, MA 02215

2100008000 – 211 Park Drive
LDJ Development LLC
252 Newbury Street
Boston, MA 02116

2100026000 – 219 Park Drive
Park Drive Inc.
POB 10082
Van Nuys CA 91410

2100028000 – 227 Park Drive
Two 27 Park Drive LLC
345 Boylston Street
Newton Ma 02459

2100029000 – 231 Park Drive
Park 231-235 Assoc LLC
1 Washington Street
Wellesley MA 02481

2100045000 Park and Peterborough
Star Market Co
POB 600 #E
Bridgewater, MA 02333

2100046000 – 1390 Boylston
Elias Enterprise LLC
1420 Boylston Street
Boston, MA 02215

2100054000 – 1393 Boylston
Brookline Ave Assoc
27 Mica Lane, #201
Wellesley, MA 02481

2100077000 – 201 Brookline
Abbey Group
575 Boylston Street
Boston, MA 02116

21000171001 – MBTA
MBTA Green Line
500 Arborway
Jamaica Plain, MA 02130

The Fenway
Short Street to Louis Prang

0401995020
The Winsor School
103 Pilgrim Road
Boston, MA 02115

0202001000, 0402007000
Wheelock College
164 Riverway
Boston, MA 02115

0402005000
Riverway Square Condo Trust
122 Riverway
Boston, MA 02115

0402006000
One Hundred Riverway Condo
110 Riverway
Boston, MA 02115

0401847000
Emmanuel College
274 Brookline Ave
Boston, MA 02115

0402017000, 0401842000

Simmons College
300 Fenway
Boston, MA 02115

0401837000
Isabella Stewart Gardner Museum
163 Palace Rd
Boston, MA 02115

0401806000
Museum School/Museum of Fine Arts
230 Fenway
Boston, MA 02115

Other Parties

Michael A. Stoffel, P.E.
MBTA Design and Construction
Ten Park Plaza, Room 6720
Boston, MA 02116

Muddy River MMOC
P.O. Box 470535
Brookline, MA 02447

Fenway Civic Association
P.O. Box 230435
Astor Station
Boston, MA 02123

Emerald Necklace Conservancy
891 Centre Street
Jamaica Plain, MA 02130

Brookline Conservation Commission
Town Hall
333 Washington St
Brookline, MA 02445

Park Drive and
MBTA D Line
Queensberry and
Park Drive
Riverway and
Short Street
Fenway and Louis
Prang
Soldiers Field Playground
Boston University
Storrow Dr
James J Storrow Memorial Dr
Commonwealth Ave
Massachusetts Turnpike (Toll road)
Kenmore
Fenway Park
Yawkey
Boylston St
Fenway
Brookline Ave
Wheelock College
Emmanuel College
Simmons College
Muddy River
Back Bay Fens
Longwood
Longwood Ave
Longwood Playground
Amory Playground
Longwood Square
Brigham and Womens Hospital
Massachusetts College of Art
Huntington Ave
Roxbury
Ruggles
Mission Hill Playground
Roxbury Crossing
Tremont St
Hynes Convention Center/ICA
Brookline Avenue Playground
Riverway