NOTICE OF INTENT

FOR THE CITY OF HAVERHILL MASSACHUSETTS

RECONSTRUCTION OF BROADWAY (ROUTE 97)
HAVERHILL, MASSACHUSETTS

PREPARED FOR:
CITY OF HAVERHILL ENGINEERING DEPARTMENT
ENGINEERING DIVISION
CITY HALL - ROOM 300
4 SUMMER STREET
HAVERHILL, MASSACHUSETTS 01830

PREPARED BY:
GREENMAN-PEDERSEN, INC.
181 BALLARDVALE STREET, SUITE 202
WILMINGTON, MA 01887

November, 2016

TABLE OF CONTENTS

SECTION I **Notice of Intent Forms**
- DEP WPA Form 3

SECTION II **Notice of Intent Figures**
- Figure 1 – USGS Location Map
- Figure 2 - NHESP Map
- Figure 3 – FEMA Flood Insurance Rate Map

SECTION III **Notice of Intent Narrative**

1.0 Project Overview 1
2.0 Existing Conditions 1
2.1 Inland Bank 2
2.2 Bordering Vegetated Wetland 3
2.3 Land Under Water Bodies and Waterways 3
2.4 Bordering Land Subject to Flooding 3
2.5 Riverfront Area 4
2.6 Buffer Zone and No-Disturbance Zone 4
Table 2 – Wetland Resource Area Impacts 5
3.0 Proposed Work 6
3.1 Bank and Land under Water Bodies and Waterways 6
3.2 Bordering Vegetated Wetland 7
3.3 Bordering Land Subject to Flooding 7
3.4 Riverfront Area 8
3.5 Work in Buffer Zones 8
4.0 Mitigation Measures 8
4.1 Wetland Resource Area Replacement and Restoration 8
4.2 Riverfront Area 9
Riverfront Area Alternatives Analysis 9
4.3 Work in Buffer Zone 11
4.4 Erosion and Sedimentation Controls 11
4.5 Stormwater Management 12
5.0 Stream Crossing Standards 12
6.0 Regulatory Compliance 14
7.0 Conclusion 15

LIST OF APPENDICES

Appendix A Site Photographs
Appendix B Wetland Delineation Forms and Information
Appendix C Project Special Provisions
Appendix D Checklist for Stormwater Report
Stormwater Report
Appendix E Affidavit of Service, Notice to Abutters, Certified Abutters List
Appendix F NOI Permit Drawings – Bound Separately

SECTION I

DEP WPA FORM 3 – NOTICE OF INTENT FORMS

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands

WPA Form 3 – Notice of Intent

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

Provided by MassDEP:

MassDEP File Number

Document Transaction Number

Haverhill
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):

Route 97 (Broadway) — a. Street Address
Haverhill — b. City/Town
01832 — c. Zip Code

Latitude and Longitude:
42°47'11.79"N — d. Latitude
71° 7'55.97"W — e. Longitude

N/A — f. Assessors Map/Plat Number
N/A — g. Parcel /Lot Number

2. Applicant:

John — a. First Name
Pettis — b. Last Name
City of Haverhill — c. Organization
4 Summer Street, Room 300 — d. Street Address
Haverhill — e. City/Town
MA — f. State
01830-5885 — g. Zip Code
978-374-2335 — h. Phone Number
978-373-8475 — i. Fax Number
jpettis@cityofhaverhill.com — j. Email Address

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

Same — a. First Name
b. Last Name
c. Organization
d. Street Address
e. City/Town
f. State
g. Zip Code
h. Phone Number
i. Fax Number
j. Email address

4. Representative (if any):

William — a. First Name
Murphy — b. Last Name
Greenman-Pedersen, Inc. — c. Company
181 Ballardvale Street, Suite 202 — d. Street Address
Wilmington — e. City/Town
MA — f. State
01887 — g. Zip Code
978-570-2969 — h. Phone Number
978-658-3044 — i. Fax Number
bmurphy@gpinet.com — j. Email address

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

Fee Exempt — a. Total Fee Paid
b. State Fee Paid
c. City/Town Fee Paid

A. General Information (continued)

6. General Project Description:

Reconstruction of Route 97 (Broadway) from Silver Birch Lane to Research Drive will include minor roadway widening and geometric improvements at Lake St., West Meadow Rd. and Forest St. This project will also construct new granite curbing, sidewalks on both sides of the street, traffic signals and reconstruction of the drainage system. See attached narrative for more information.

7a. Project Type Checklist: (Limited Project Types see Section A. 7b.)

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

7b. Is any portion of the proposed activity eligible to be treated as a limited project (including Ecological Restoration 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. (See 310 CMR 10.24 and 10.53 for a complete list and description of limited project types)

310 CMR 10.53(3)(f) - Maintenance and improvement of existing public roadways

2. Limited Project Type

If the proposed activity is eligible to be treated as an Ecological Restoration Limited Project (310 CMR10.24(8), 310 CMR 10.53(4)), complete and attach Appendix A: Ecological Restoration Limited Project Checklist and Signed Certification.

8. Property recorded at the Registry of Deeds for:

N/A

a. County
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.

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

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	170 1. linear feet	170 2. linear feet
b. ☒ Bordering Vegetated Wetland	319 Permenant 401 Temporary	330 Permenant 401 Temporary
c. ☒ Land Under Waterbodies and Waterways	64 1. square feet 3. cubic yards dredged	0 2. square feet

Resource Area	Size of Proposed Alteration	Proposed Replacement (if any)
d. ☐ Bordering Land Subject to Flooding	1. square feet 3. cubic feet of flood storage lost	2. square feet 4. cubic feet replaced
e. ☐ Isolated Land Subject to Flooding	1. square feet 2. cubic feet of flood storage lost	3. cubic feet replaced
f. ☒ Riverfront Area	Creek Brook 1. Name of Waterway (if available) - **specify coastal or inland**	

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: 41,625 square feet

4. Proposed alteration of the Riverfront Area:

29,501	12,713	16,788
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)

Note: for coastal riverfront areas, please complete **Section B.2.f**. above.

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

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
	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.

a. square feet of BVW

b. square feet of Salt Marsh

5. ☒ Project Involves Stream Crossings

a. number of new stream crossings

b. number of replacement stream crossings: 2

C. Other Applicable Standards and Requirements

☐ This is a proposal for an Ecological Restoration Limited Project. Skip Section C and complete Appendix A: Ecological Restoration Notice of Intent – Required Actions (310 CMR 10.11).

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://maps.massgis.state.ma.us/PRI_EST_HAB/viewer.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
   1 Rabbit Hill Road
   Westborough, MA 01581

   2008
   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.2.f, 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. 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

2. ☐ 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

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* Some projects **not** in Estimated Habitat may be located in Priority Habitat, and require NHESP review (see http://www.mass.gov/eea/agencies/dfg/dfw/natural-heritage/regulatory-review/). 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)

(c) ☐ MESA filing fee (fee information available at http://www.mass.gov/dfwele/dfw/nhesp/regulatory_review/mesa/mesa_fee_schedule.htm). Make check payable to "Commonwealth of Massachusetts - NHESP" 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

(f) 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/regulatory_review/mesa/mesa_exemptions.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 # _____ 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.

3. 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, hand delivery, or electronic delivery of NOI to either:

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

Division of Marine Fisheries -
Southeast Marine Fisheries Station
Attn: Environmental Reviewer
1213 Purchase Street – 3rd Floor
New Bedford, MA 02740-6694
Email: DMF.EnvReview-South@state.ma.us

North Shore - Hull to New Hampshire border:

Division of Marine Fisheries -
North Shore Office
Attn: Environmental Reviewer
30 Emerson Avenue
Gloucester, MA 01930
Email: DMF.EnvReview-North@state.ma.us

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.

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

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

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

   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

5. 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

6. 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

7. 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

☐ This is a proposal for an Ecological Restoration Limited Project. Skip Section D and complete Appendix A: Ecological Restoration Notice of Intent – Minimum Required Documents (310 CMR 10.12).

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.

D. Additional Information (cont'd)

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.

Massachusetts Department of Transporation Highway Division Plan and Profile of Broadway (Route 97) in the City of Haverhill Essex County

Greenman-Pedersen, Inc	John Diaz
b. Prepared By	c. Signed and Stamped by
November 2016	Varies
d. Final Revision Date	e. Scale

f. Additional Plan or Document Title | 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

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands

WPA Form 3 – Notice of Intent

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

Provided by MassDEP:

MassDEP File Number

Document Transaction Number

Haverhill
City/Town

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.

1. Signature of Applicant — 2. Date: 11.07.2016

3. Signature of Property Owner (if different) — 4. Date

5. Signature of Representative (if any) — 6. Date: 11/7/16

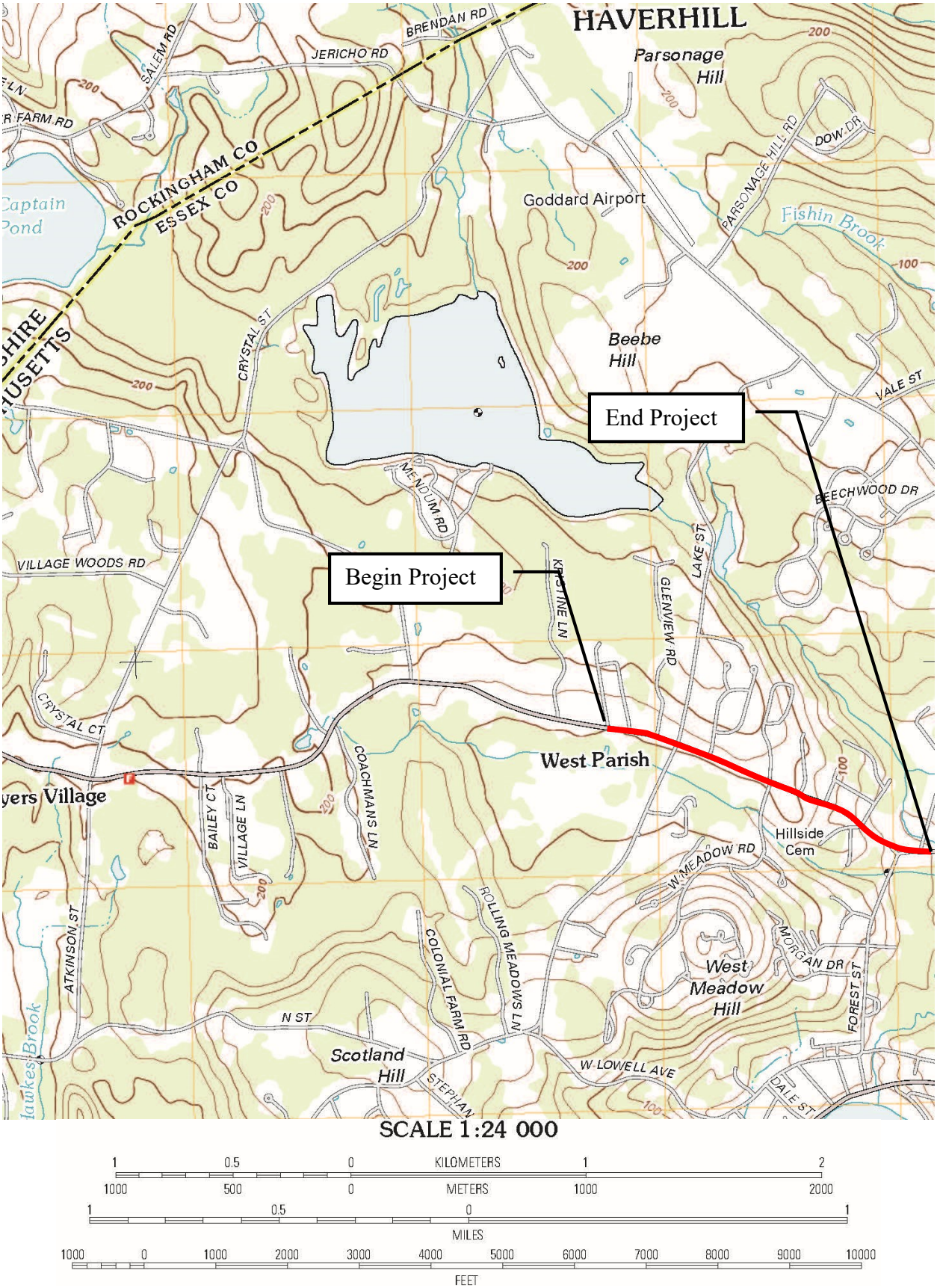
For Conservation Commission:
Two copies of the completed Notice of Intent (Form 3), including supporting plans and documents, two copies of the NOI Wetland Fee Transmittal Form, and the city/town fee payment, to the Conservation Commission by certified mail or hand delivery.

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.

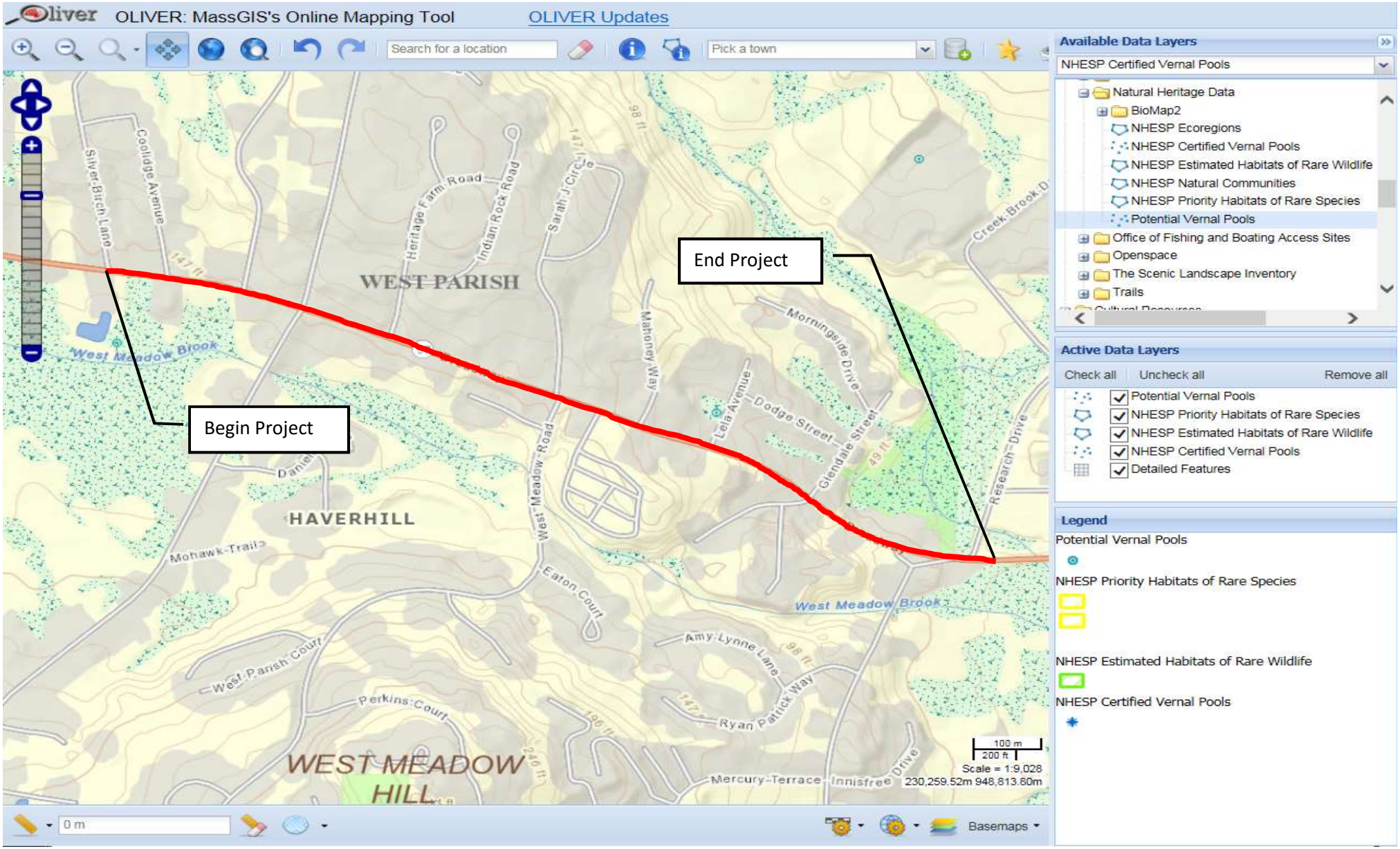
Other:
If the applicant has checked the "yes" box in any part of Section C, Item 3, above, refer to that section and the Instructions for additional submittal requirements.

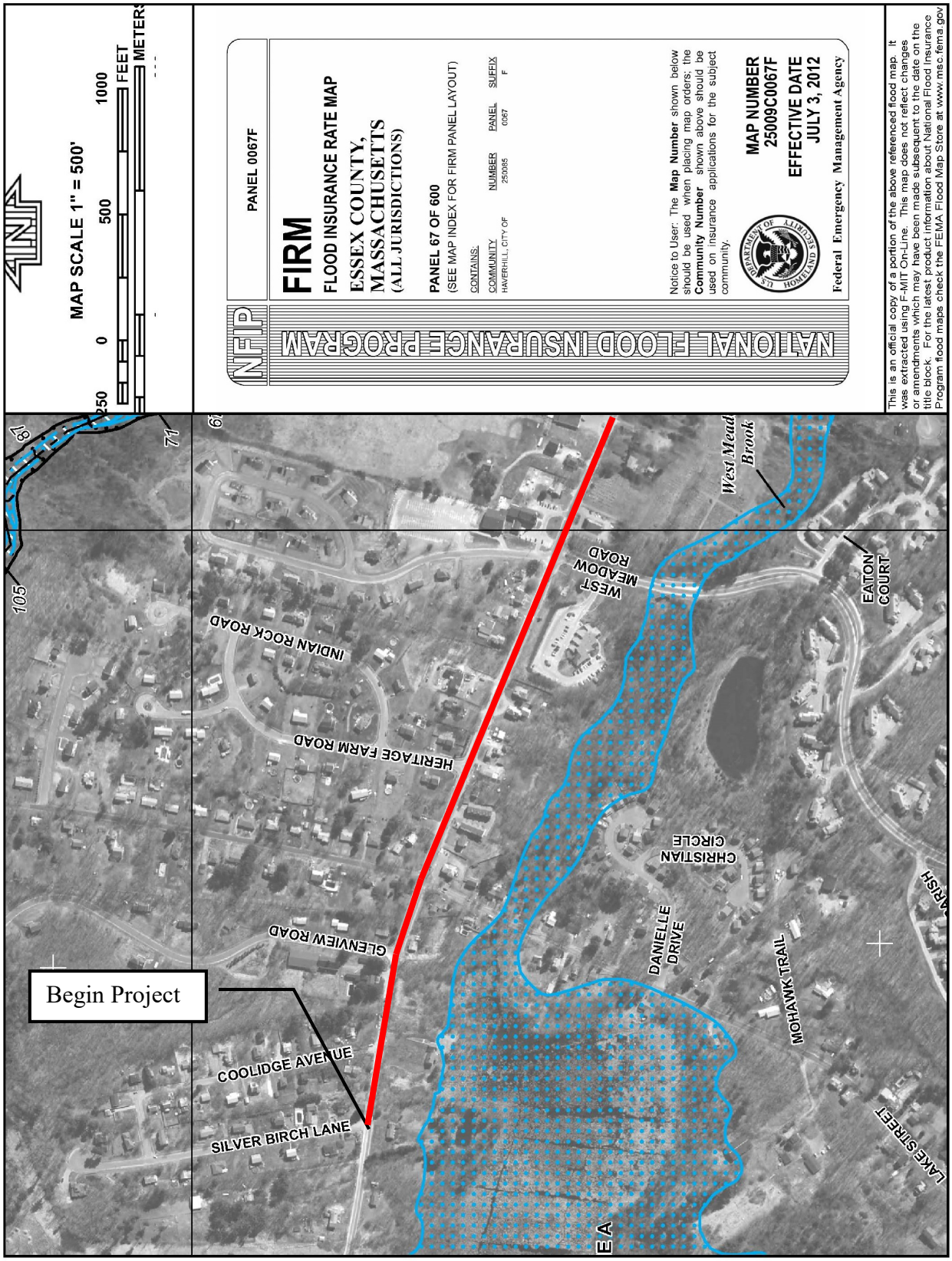
The original and copies must be sent simultaneously. Failure by the applicant to send copies in a timely manner may result in dismissal of the Notice of Intent.

SECTION II
NOTICE OF INTENT FIGURES

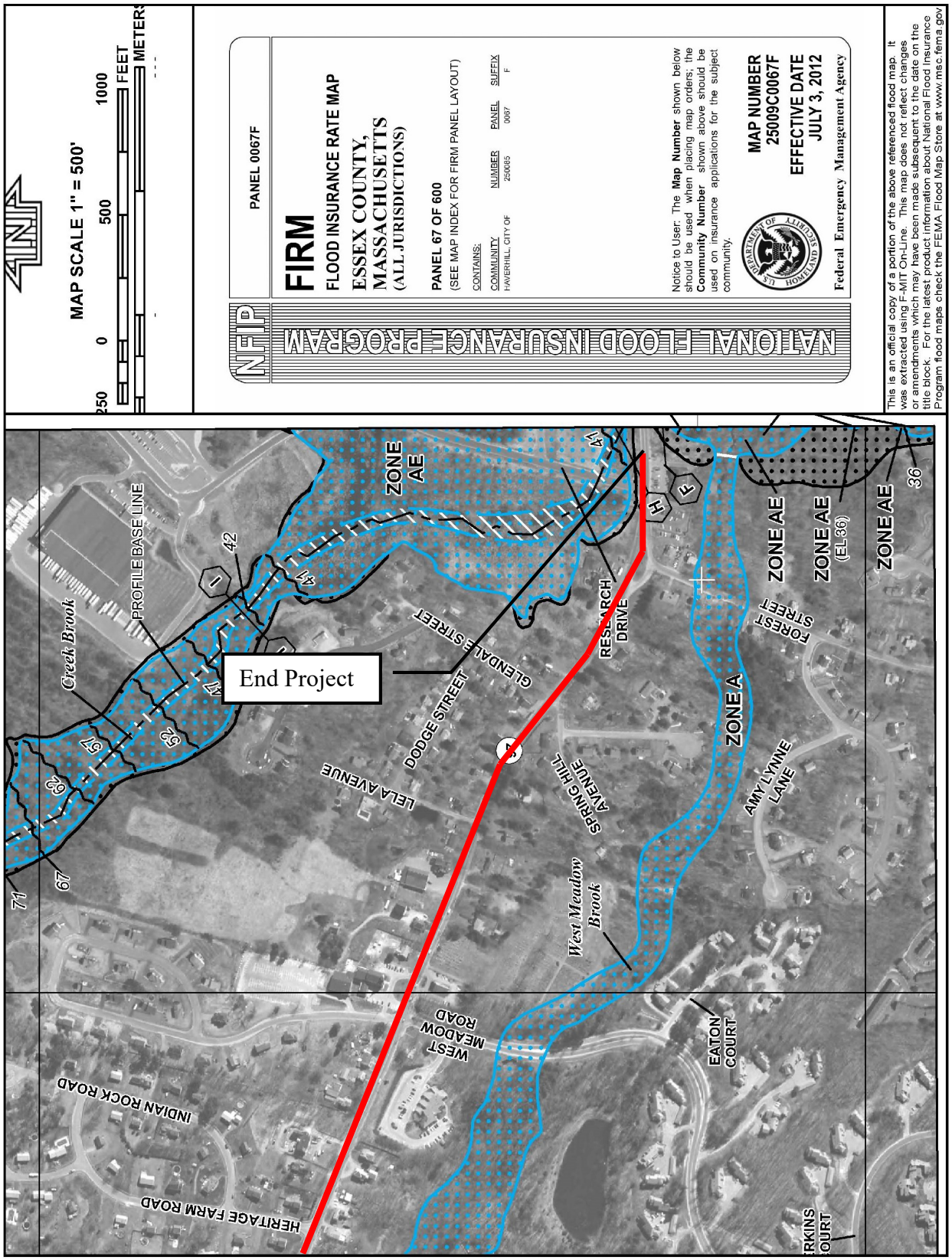


Project Location Map **Figure 1**


OLIVER: MassGIS's Online Mapping Tool
OLIVER Updates
Search for a location
Pick a town
Available Data Layers
NHESP Certified Vernal Pools
Natural Heritage Data
BioMap2
NHESP Ecoregions
NHESP Certified Vernal Pools
NHESP Estimated Habitats of Rare Wildlife
NHESP Natural Communities
NHESP Priority Habitats of Rare Species
Potential Vernal Pools
Office of Fishing and Boating Access Sites
Openspace
The Scenic Landscape Inventory
Trails
Active Data Layers
Check all
Uncheck all
Remove all
Potential Vernal Pools
NHESP Priority Habitats of Rare Species
NHESP Estimated Habitats of Rare Wildlife
NHESP Certified Vernal Pools
Detailed Features
Legend
Potential Vernal Pools
NHESP Priority Habitats of Rare Species
NHESP Estimated Habitats of Rare Wildlife
NHESP Certified Vernal Pools
End Project
Begin Project
WEST PARISH
HAVERHILL
WEST MEADOW HILL
West Meadow Brook
Silver Birch Lane
Coolidge Avenue
Heritage Farm Road
Indian Rock Road
Sarah J Circle
Mahoney Way
Morningside Drive
Leila Avenue
Dodge Street
Glendale Street
Research Drive
West Meadow Road
Mohawk Trail
Eaton Court
Amy Lynne Lane
Ryan Patrick Way
West Parish Court
Perkins Court
Mercury Terrace
Innisfree Drive
100 m
200 ft
Scale = 1:9,028
230,259.52m 948,813.80m
0 m
Basemaps



FEMA Flood Insurance Rate Map **Figure 3A**



FEMA Flood Insurance Rate Map **Figure 3B**

SECTION III
NOTICE OF INTENT NARRATIVE

1.0 PROJECT OVERVIEW

On behalf of the City of Haverhill, Greenman-Pedersen, Inc. (GPI) is pleased to submit this Notice of Intent (NOI) application and associated documents. The NOI has been prepared in accordance with the Massachusetts Wetland Protection Act (MGL c.131 S.40) and City of Haverhill Wetlands Protection Ordinance, City Code Chapter 253. The proposed work is being filed under the Limited Project provision found in the Massachusetts Wetland Regulation 310 CMR 10.53(3)(f). However, the project has been designed to meet the General Performance Standards found in the Wetlands Protection Act.

The proposed project consists of reconstructing the Broadway (Route 97) Corridor from Silver Birch Lane to Research Drive in Haverhill, Massachusetts, for a distance of approximately one mile. The work will also extend down adjacent side streets as needed to tie the proposed work into existing features.

Roadway reconstruction work will improve vehicular safety and capacity as well as provide pedestrian and bicycle accommodations/accessibility throughout the corridor. The project entails pavement reconstruction (removal of the existing asphalt and fine grading of the existing gravel box) and adding left turn lanes at both approaches to Lake Street and Forest Street. Both of these intersections will have traffic signals installed. A dedicated left turn lane will also be added westbound on Broadway for West Meadow Road. Additionally, five foot wide bicycle lanes will be added to both sides of the roadway as well as adjacent handicap accessible sidewalks. Other improvements shall include intersection geometry, establishing a consistent roadway cross section width throughout the corridor, pavement reconstruction, new granite curbing, rehabilitation of the existing drainage system and cross culverts, the addition of new sidewalks along both sides of the roadway and ADA compliant wheelchair ramps, landscaping, pavement markings and signing. A water quality swale is proposed to provide treatment of a portion of the roadway runoff before recharging to groundwater or overflowing to Creek Brook.

The proposed project includes a typical section of 11 foot travel lanes and 5 foot shoulders. Where right-of-way allows, the project provides a grass strip buffer between the Broadway (Route 97) curb line and proposed sidewalk.

The applicant for this Project is the City of Haverhill. This Project has been designed to comply with the City of Haverhill Wetlands Protection Ordinance (the local bylaw). The Project will be funded by the State Transportation Improvement Plan (STIP) through the Massachusetts Department of Transportation (MassDOT). Every attempt to comply with the local bylaw where reasonably practicable and economically feasible were incorporated into the proposed work.

2.0 EXISTING CONDITIONS

Broadway (Route 97) is a two lane road that runs in a general east-west direction (although signed as a north/south roadway) through the center of Haverhill. The roadway provides a

connection from Salem to the west, through Haverhill Center, to Groveland to the east. Broadway is functionally classified as an urban minor arterial within the project limits and is under local (City of Haverhill) jurisdiction.

The limit of work begins east of the intersection of Broadway (Route 97) with Silver Birch Lane and extends in an easterly direction east of the intersection with Research Drive. Sidewalks exist in limited sections on the north side of Broadway. The project transitions from residential usage on the west side of the project to commercial and religious uses on the east end of the project. Notable businesses and religious abutters include the West Congregational Church, the Have A Heart Animal Hospital, a cemetery, an office building and The Grill Next Door.

The project does not fall within an area mapped as Priority Habitat of Rare Species and Estimated Habitat of Rare Wildlife by the Natural Heritage and Endangered Species Program (NHESP) under the Massachusetts Endangered Species Act (321 CMR 10.00) (MESA). There are no NHESP-mapped Certified Vernal Pools within or adjacent to the project limits (see Figure 2 – NHESP map). MassDOT typically coordinates with the NHESP on all construction projects and will provide further coordination as necessary.

Wetland Resource Areas

This NOI has been submitted under the Massachusetts Wetlands Protection Act, M.G.L. Chapter 131, Section 40 and the City of Haverhill Wetlands Protection Ordinance, City Code Chapter 253. Work is proposed within areas subject to protection under the Act as well as their 100' buffer zones. Work is also proposed within the local regulation's 25' No Build-No-Disturbance Zone and the 50' No-Build Zone.

Site inspections were conducted by GPI's personnel on 8/19/2014 and March, 2016 to identify and delineate the boundary of existing wetland resource areas on the project and in the immediate vicinity of the project site. Resource area boundaries were identified and delineated in accordance with methods developed by the Massachusetts Department of Environmental Protection's Delineating Bordering Vegetated Wetlands Under the Massachusetts Wetlands Protection Act, dated 1995 (the Act), as well as definitions set forth in the Wetland Regulations, 310 CMR 10.00. Five areas subject to protection under the Act exist on the site and are described below.

2.1 Bank

According to 310 CMR 10.54(2), the definition of Bank is the portion of the land surface which normally abuts and confines a water body, occurring between a water body and a vegetated bordering wetland and adjacent floodplain, or, in the absence of these, it occurs between a water body and an upland. The upper boundary of a bank is the first observable break in the slope or the mean annual flood level, whichever is lower. Intermittent streams were identified crossing the Broadway (Route 97) corridor from north to south and are located within Resource Area A flowing to Resource Area B and Resource Area C flowing to Resource Area D. The intermittent stream in Resource Area A is culverted for a short stretch and then daylighted for a short segment prior to being diverted under Broadway.

2.2 Bordering Vegetated Wetland

According to 310 CMR 10.55(2), Bordering Vegetated Wetlands (BVW) are freshwater wetlands which border on creeks, rivers, streams, ponds and lakes and are areas where the soils are saturated and/or inundated such that they support a predominance of wetland indicator plants. The boundary of BVW is the line within which 50% or more of the vegetation community consists of wetland indicator plants and saturated or inundated conditions exist.

GPI identified seven separate resource areas meeting the Act definition of Bordering Vegetated Wetland (BVW) within or in proximity to the Project area. Table 1 identifies and describes each BVW in detail.

TABLE 1
BORDERING VEGETATED WETLAND LOCATION AND DESCRIPTION

Series	Location	Station Location
A	Between Silver Birch Ln and Coolidge Ave, North side of Broadway	3+00 thru 3+70 LT
B	Between Silver Birch Ln and Coolidge Ave, South side of Broadway	2+70 thru 4+10 RT
D	Between Coolidge Ave and Glenview Rd, South side of Broadway	5+70 thru 8+60 RT
E	Between Forest St and Research Dr, North side of Broadway	46+85 thru 49+15 LT
F	East of Research Dr, North side of Broadway	49+80 thru 52+00 LT
G	East of Research Dr, South side of Broadway	50+45 thru 52+00 RT
H	Behind Grill Next Door parking lot.	41+20 thru 43+40 LT

2.3 Land under Water Bodies and Waterways

In accordance with 310 CMR 10.56(2), the definition of Land under Water (LUW) is the land beneath any creek, river, stream, pond or lake. The boundary of Land under Water Bodies and Waterways is the mean annual low water level. LUW is associated with the intermittent stream in Resource Areas A and C.

2.4 Bordering Land Subject to Flooding

According to its definition at 310 CMR 10.57(2), the boundary of Bordering Land Subject to Flooding (BLSF) is determined by the most recently available community flood profile calculated by FEMA. Work proposed below the base flood elevation is subject to jurisdiction under the Act and local regulations. According to the Federal Emergency Management Agency – Flood Insurance Rate Map for Essex County, Massachusetts, Map Number #25009C0067F effective date July 3, 2012, portions of work on Research Drive falls within a Zone AE floodplain (see Figure 3 – FEMA

maps). Per the Flood Insurance Study for Essex County, Massachusetts, revision date of July 16, 2014, there are three cross sections for Creek Brook around the project site. Cross sections "F" (downstream of Broadway) and "G" (downstream of Research Drive) have a base flood elevation of 37.9 NAVD, while cross section "H" (upstream of Research Drive) has a base flood elevation of 40.6 NAVD.

2.5 Riverfront Area

According to 310 CMR 10.58(2), the definition of Riverfront Area is the area of land between a perennial stream's mean annual high water line and a parallel line measured horizontally outward from the river 200 feet away. Riverfront Area exists within the proposed project in association with Creek Brook. Creek Brook originates adjacent to Providence Hill in Atkinson, New Hampshire and flows southeast through Haverhill until draining into the Merrimack River. Portions of the Riverfront Area are considered to be Previously Developed per the Act in 10.58(5) due to the presence of impervious surface and/or soil excavation prior to August 7, 1996.

2.6 Buffer Zone and No-Disturbance Zone

According to 310 CMR 10.02(2)(b), a 100-foot buffer zone is established from the limits of wetlands described above. The City of Haverhill Wetlands Protection Ordinance, City Code Chapter 253, also establishes a 25' No Build-No-Disturbance Zone and a 50' No-Build Zone from the limits of resource areas. Due to the linear nature of the project, work within these zones is unavoidable. The majority of the work in buffer and no-disturbance zones is previously disturbed area associated with the existing roadway. Undisturbed buffer zone will be left unaltered to the maximum extent practicable. Proper erosion controls and construction techniques will be employed and maintained to protect adjacent wetland resource areas as described below.

TABLE 2
WETLAND RESOURCE AREA IMPACTS

Station Location	Series	BVW	BVW	Bank	LUW	LUW	Comments
		Perm (SF)	Temp (SF)	(LF)	Perm (SF)	Temp (SF)	
3+00 thru 3+70 LT	A	205	162	138	16	0	Impact due to sidewalk and slope construction and dewatering activities for culvert replacement. Temporary vegetated wetland impacts will be restored in place. Permanent impacts will be replicated. Bank impacts include 124' due to culvert modifications, either outright removal or replacement.
2+70 thru 4+10 RT	B	0	15				Impact due to separating street drainage from stream crossing and headwall reconstruction.
6+25 thru 6+40 LT	C			15	46	0	Impact due to sidewalk and slope construction.
5+70 thru 8+60 RT	D	114	96	97	12		Impacts due to sidewalk and slope construction and dewatering activities for culvert replacement. Temporary vegetated wetland impacts will be restored in place. Permanent impacts will be replicated. Bank impacts include 90' due to culvert replacement.
41+20 thru 43+40 LT	H	0	143				Impact due to outfall reconstruction. Temporary vegetated wetland impacts will be restored in place.
Total		319	416	250	74	0	

Notes:

1. **Total 200-Foot Riverfront Area is approximately 41,625. Total 200-Riverfront Area alteration is approximately 29,501 square feet, of which 12,713 square feet is within the Inner 100-Feet. Additionally, 29,058 square feet of the 29,501 square feet of Riverfront Area impact is Previously Developed Riverfront Area.**

3.0 PROPOSED WORK

The improvements proposed for this project result in impacts to resource areas protected by the Massachusetts Wetland Protection Act. Every attempt has been made to reduce the impacts, listed in Table 2.

Work In Wetland Resource Areas

3.1 Bank and Land under Water Bodies and Waterways

The proposed work includes alterations to the Series A, C and D bank and LUW.

The intermittent stream in Resource Area A passes through a short culvert before daylighting at the headwall on the north side of Broadway. The project proposes to remove this short culvert (26 feet of Bank impact), and fill in the existing daylighted area (14' of Bank impact) upstream of the headwall on the north side of Broadway to construct the sidewalk. Additionally, the project proposes to separate the stream and street runoff, and replace the culverted stream crossing under Broadway (98' of Bank impact). With the short culvert removed and a new headwall installed for the stream crossing, approximately 14' of earthen bank will be created.

The work to fill the stream between the culvert and the upstream headwall in the Series A resource area will require the filling of 16 SF of LUW. The removal of the short culvert, sidewalk and headwall installation, approximately 7 SF of LUW will be created.

An analysis determined an 18" pipe would be needed to accommodate the 50 year storm event (see backup for calculations). To comply with the Stream Crossing Standards to the maximum extent possible, a 19"x30" elliptical pipe is proposed, with 5" of streambed material within the pipe.

The work at Resource Areas C and D includes work associated with extending the roadway shoulder and construction of a sidewalk on the north and south side of Broadway (Route 97) and side slopes. Extending the side slopes resulted in 15' of Bank impact and 46 SF of LUW impacts in Resource Area C and 7' of Bank impact and 12 SF of LUW impacts in Resource Area D. The work also includes the replacement of the existing cross culvert under Broadway to the new side slopes, resulting in 90' of Bank Impacts to Resource Area D.

An analysis determined an 18" pipe would be needed to accommodate the 50 year storm event (see backup for calculations). To comply with the Stream Crossing Standards to the maximum extent possible, a 19"x30" elliptical pipe is proposed, with 5" of streambed material within the pipe.

This work will not impair the ability of the Bank and LUW to support the General Performance Standards in 310 CMR 10.54(4)(a) and 310 CMR 10.56(4)(a). The

intermittent streams intersect the roadway at somewhat perpendicular angles, therefore the stability of the banks and the channel capacities shall be maintained. The work will replace and extend the culverts and will not impact the ground water or surface water quality, except for temporary dewatering. The work will not inhibit the capacity of the bank or land under water to provide breeding habitat, escape cover and food for fisheries as the streams are intermittent. While a formal Habitat Study was not performed, a significant majority of the culvert Bank impacts are related to the culvert replacements. The existing culvert walls do not provide a viable habitat. The project will replace the culverts with streambed material on the bottom and sides of the culvert, which will provide a more suitable habitat. Please note the stream in Resource Area C originates approximately 30 feet from the current edge of roadway.

Flow within the streams will be bypassed if necessary but it is expected that permit conditions will require that culvert replacement will be conducted during low or no flow conditions. Temporary impacts will be fully restored in place. Section 5.0 of this document provides a further detailed discussion.

The work shall also include seeding the newly created bank and slopes from proposed sidewalks with a grass mix, both to prevent erosion and to promote the growth of additional vegetation.

3.2 Bordering Vegetated Wetland

Proposed work includes temporary and permanent alterations to the Series A, B and D BVW associated with the construction of sidewalks and side slopes as well as the reconstruction of the drainage outfalls. Impacts to Series H BVW are associated with the reconstruction of the drainage outfall. Temporary impacts to BVW are related to necessary construction access and equipment maneuvering. Permanent impacts will be limited to 319 square feet of permanent alteration and 416 square feet of temporary impact, as depicted on the accompanying design plans. BVW temporarily impacted will be restored in place. Permanently impacted BVW will be fully mitigated through the construction of a 330 square feet wetland replication area. Refer to attached plans and Special Provisions for details on the proposed wetland replication area.

3.3 Bordering Land Subject to Flooding

According to the Flood Insurance Study for Essex County, Massachusetts, revision date July 16, 2014, there are three cross sections for Creek Brook around the project site. Cross sections “H” (upstream of Research Drive) has a base flood elevation of 40.6 NAVD, which is the highest base flood elevation within the project area. The lowest work on Research Drive within Bordering Land Subject to Flooding will occur at 43.6 NAVD. As the project will not fill any land below the Base Flood Elevation within the mapped floodplain, there are no impacts to Bordering Land Subject to Flooding associated with this project.

3.4 Riverfront Area

In total, approximately 29,501 square feet of Riverfront Area associated with Creek Brook will be altered as a result of this project. Of the 29,501 square feet to be impacted, approximately 29,058 square feet (98%) is Previously Developed Riverfront Area. The work includes the construction of sidewalks to the project limit, the construction of drainage outfalls with riprap splash pads as well as realignment of Broadway (Route 97) and Forest Street. The installation of curbing and sidewalk at the intersection of Research Drive will help prevent erosion due to vehicles traveling off the roadway to cut the corner. The curbing will also redirect roadway runoff to drainage structures. The work also includes seeding the slopes from proposed sidewalks with a grass mix to prevent erosion and promote the growth of additional vegetation. The work falls under the Limited Project provisions of 310 CMR 10.53.

3.5 Work in Buffer Zones

Portions of the Project are proposed to occur within the 100-foot buffer zone to BVW, the 25' No Build-No-Disturbance Zone and the 50' No-Build Zone. Some of these impacts also occur within Riverfront Area. Due to the linear nature of roadway work, the majority of buffer zone impacts are unavoidable. The 100% design plans were designed to impose the least possible impacts to buffer zone practicable while still accomplishing the pedestrian safety, traffic calming, and stormwater management improvement goals of the project. All adjacent wetland resources will be protected from work within buffer zones via the proper installation and maintenance of erosion controls as described below.

4.0 MITIGATION MEASURES

The project has been developed to avoid, minimize and mitigate impacts to wetland resource areas, wildlife habitat and other sensitive areas. Mitigation measures provide for unavoidable impacts and allow the project to be conditioned to comply with the General Performance Standards in the Wetland Regulations to the maximum extent practicable and to contribute to the interests found in the Massachusetts Wetland Protection Act.

Impacts to resource areas Subject to Protection under the Act have been adequately compensated for. Temporary impacts to BVW will be restored in place. Permanent alteration of BVW will be compensated through the creation of a vegetated wetland replication area providing 1:1 permanent impact / replication ratio. Construction of a water quality swale and riprap splash pads at selected outfalls will provide substantial stormwater quality improvements where none exist today.

4.1 Wetland Resource Area Replacement and Restoration

The proposed permanent alteration of 319 square feet of BVW in the B and D Series will be mitigated fully through the construction of a 330 square foot wetland replication area located directly adjacent to D series BVW. Please refer to Attachment C – Project Special

Provisions for replication details of Non-Tidal Wetland Resource Mitigation Areas in accordance with the Performance Standards.

4.2 Riverfront Area

In total, approximately 29,501 square feet of Riverfront Area associated with Creek Brook will be altered as a result of this project. Of the 29,501 square feet to be impacted, approximately 29,058 square feet (98%) is Previously Developed Riverfront Area. The work includes the construction of sidewalks to the project limit, the construction of drainage outfalls with riprap splash pads as well as realignment of Broadway (Route 97) and Forest Street. The work falls under the Limited Project provisions of 310 CMR 10.53.

Riverfront Area Alternatives Analysis

As required by the General Performance Standards for Riverfront Area at 310 CMR 10.58(4)(c)(1-3), there must be no practicable and substantially equivalent economic alternative to the proposed project with less adverse effects on the interests identified in M.G.L. c. 131 S 40. An alternative is practicable and substantially equivalent economically if it is available and capable of being done after taking into consideration costs, existing technology, proposed use, and logistics in light of overall project purposes. Available and capable of being done means the alternative is obtainable and feasible.

Based on the Evaluation of Alternatives presented herein, it has been determined that no practicable and substantially equivalent economic alternative to the current design of the Broadway (Route 97) Reconstruction project with less adverse effects on the interests identified in M.G.L. c. 131 S 40 exists.

The purpose of this project is to improve vehicular safety and capacity as well as provide pedestrian and bicycle accommodations/accessibility throughout the corridor. This project is intended to improve the overall safety for both vehicles and pedestrians.

Scope of Alternatives

According to 310 CMR 10.58(4)(c)(2), the scope of alternatives to consider shall be commensurate with the type and scope of the project. The issuing authority shall presume that alternatives beyond the scope are not practicable and therefore need not be considered.

The various alternatives for a roadway reconstruction project are primarily related to the overall width of the roadway cross section and provisions for multi-modal use. The roadway typically can be designed to accommodate any combination and dimensions of vehicular lanes, shoulders, bicycle and pedestrian accommodations, and public transit stops, as well as incorporation of traffic-related features, intersection styles, edge features, utility provisions, and stormwater management features. The alternatives analyzed for the Broadway (Route 97) project considered a variety of these options, with the overall purpose of providing traffic and safety improvements and safe bicycle and pedestrian accommodations. The analysis included several alternatives for the roadway cross section, as well as several alternatives for the treatment of major intersections within the project.

Evaluation of Alternatives

Several alternative roadway configurations were considered.

- Lane Widths: Standard lane widths are 12 feet. It was determined, both for a traffic calming feature and to reduce impacts to abutters, to use the minimum lane width of 11 feet.
- Shoulder Widths: Minimum shoulder widths for this roadway classification are 4 feet. 5 foot shoulder widths are proposed not only to separate vehicles and bikes for safety but to explicitly identify the shoulder for bikes.
- Sidewalk Widths: 6 foot sidewalk widths are proposed where possible. This allows for the installation of utility poles offset from the roadway with enough width to satisfy ADA requirements. In many cases, the minimum width of 5 feet was used to avoid abutter impacts. This width also allows for a sidewalk plow to clear the sidewalk of snow.
- Intersection configurations: An alternative that was considered was to create a roundabout at the Broadway/Forest Street intersection. While minimal additional Rights Of Way would be required, the roundabout alternative was deemed not viable do to operational limitations. A traffic signal with dedicated left turn lanes is now proposed.
- Horizontal Geometry: In order to meet current design requirements, Broadway (Route 97) is proposed to be realigned and has been pulled away from Creek Brook.

The project also includes:

- In an effort to keep the residential appearance of the street, a grass strip is provided between the sidewalk and roadway at some locations. All sidewalks are pitched to the road. A grass strip allows for water flowing from the sidewalk to be filtered by the grass strip prior to mixing with roadway runoff at the curb.
- Landscaping is proposed with the installation of trees both in the grass strip and behind the sidewalk.
- Sidewalks: Sidewalks currently exist on one side of the road in one area along the project. To improve safety for pedestrians, sidewalks are now proposed on both sides of the road for the entire project length, thus connecting all neighborhoods together for pedestrian access.
- Runoff from Broadway (Route 97) is collected in a closed drainage system and discharged through 6 outfalls. The closed drainage system is proposed to be reconstructed and almost all catch basins within project limits shall be replaced with deep sump catch basins. Five outfalls will be rebuilt and crushed stone placed at these outfalls to reduce the velocity of the runoff and help trap sediment prior to discharge to wetlands.
- The project proposes additional stormwater BMP's to help mitigate impacts. The BMPs consist of leaching structures at select locations and a water quality swale.
- There are impacts to bordering vegetated wetlands due to sidewalk installation and minor roadway widening. The project shall replicate the permanent impacts with the

expansion of an existing bordering vegetated wetland and shall replant temporarily impacted areas with a wetland seed mix.

- Two culverts with intermittent streams will be replaced and the size upgraded.

Findings

The analysis of alternatives concluded that the proposed combination of lane, shoulder and sidewalk widths were best to provide increased capacity and safety for vehicles, bicycles and pedestrians within the project. To mitigate impacts to wetland resources, the project will replicate impacted bordering vegetated wetlands, reconstruct the drainage system, add crushed stone at the outfalls, add several infiltration structures and a water quality swale. This proposed work will greatly improve the condition of the stormwater discharged to wetlands.

4.3 Work in Buffer Zone

The proposed project has been designed to address the requirements set forth in the WPA regulations (310 CMR 10.53(1)) and the City of Haverhill Wetlands Protection Ordinance, City Code Chapter 253 to the maximum extent practicable. As identified below, an erosion and sedimentation control program will be implemented to prevent adverse impacts to wetland resource areas during construction. Loam and seed will be spread outside the edge of roadway and project area to restore a vegetated edge along the road and sidewalk. There will not be extensive excavation, filling or grading on this project.

4.4 Erosion and Sedimentation Controls

Erosion and sedimentation controls will be installed and maintained where activities are proposed within 100-feet of BVW, Bank or LUW. They will provide a limit of work barrier while preventing silt and sediments from migrating into or towards the wetland resource areas. Inspectors will assess conditions and identify problems in the field during and after construction activities.

Erosion controls shall consist of compost filter tubes. No hay bales shall be used at any time on this project. The erosion and sedimentation control measures will be constructed in accordance with the Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas, March 1997 and the U.S.D.A. SCS's Erosion and Sediment control in the Site Development, Massachusetts Conservation Guide, September - 1983. Best management practices for erosion and sedimentation control will be adhered to for all phases of construction to minimize potential impacts to wetland resource areas and wildlife habitat.

As per the standard, the contractor will be responsible for obtaining the NPDES Construction General Permit. A Stormwater Pollution Prevention Plan (SWPPP) will be submitted prior to any land disturbance.

All barriers will remain in place until disturbed areas are stabilized. An adequate stockpile of erosion control materials will be onsite at all times for emergency or routine replacement.

4.5 Stormwater Management

The project is subject to the Stormwater Standards. The Stormwater Checklist and a Stormwater Report have been completed and submitted with the NOI as required. The Stormwater Management Standards were incorporated into the Wetlands Protection Regulations, 310 CMR 10.05:(6)(b) and defined at 310 CMR 10.05:(6)(k) through (q). Maintenance and improvement of existing roadways, including widening less than a single lane, adding shoulders, correcting substandard intersections, improving existing drainage, and repaving are defined as redevelopment projects in the Standards. This project shall be considered a "redevelopment" project and will meet the stormwater standards to the maximum extent practicable.

Stormwater runoff discharges from the project will continue to connect to the existing drainage networks that convey the runoff from the project site area. As far as practical, the majority of the existing drainage structures are being retained in their present locations. Where existing drainage structures or pipes are in poor condition or inefficient configuration, new drainage facilities are proposed to improve the existing drainage system. New catch basins with 4-foot deep sumps will be installed to replace existing catch basins and remove catch basin to catch basin connections where possible. A portion of the stormwater runoff will be diverted to a new water quality swale and riprap splash pads for outfalls are proposed. Refer to Appendix D, Stormwater Management Checklist and Report, for full details regarding stormwater improvements and compliance with the Act.

5.0 STREAM CROSSING STANDARDS

The project as designed will meet the Massachusetts River and Stream Crossing Standards (2011) to the maximum extent practicable, however will not be able to fully meet the Stream Crossing Standards at intermittent streams at approximate Sta. 3+57 and Sta. 6+25. The existing 12"/18" pipe configuration at Sta. 3+57 and the existing 12" RCP culvert at Sta. 6+25 will be replaced with an elliptical 19"x30" RCP culvert. The crossing was designed to meet the General Standards to the maximum extent practicable.

In their current condition, the existing culverts do not meet several of the General Standards. They do not provide the embedment criteria of two feet, do not contain a natural bottom substrate within the structure, and the downstream end are submerged or partially underwater, restricting aquatic and terrestrial wildlife passage. Furthermore, they do not meet the openness ratio requirements of General Standard #6.

The elliptical 19"x30" RCP replacement culverts are proposed to meet capacity requirements. The crossing was sized using the rational method and it was determined an 18" pipe is required to accommodate flow for a 50 Year storm. See attached calculations in the Stormwater Report. Both culverts are very shallow and are within feet of the roadway surface. To provide as much cover over the pipe as possible, Elliptical pipes were reviewed, with a 14"x23" the equivalent of an 18" pipe. In an effort to provide a natural bottom substrate within the pipe, an elliptical 19"x30" RCP will allow for 5" of substrate. The increase in size will improve existing conditions by using a larger diameter and should allow

the pipe crown to be above the water level, however it still will not meet several of the General Standards.

Upon completion of work, continuity will be maintained along the stream channel and vegetation will be maintained along the stream corridor. The Massachusetts Division of Marine Fisheries has not designated a Time Of Year (TOY) restriction for marine fisheries resources within this unnamed intermittent stream per the Massachusetts Division of Marine Fisheries Technical Report TR-47: *Recommended Time of Year Restrictions (TOYs) for Coastal Alteration Projects to Protect Marine Fisheries Resources in Massachusetts*; April 2011. According to the U.S. Army Corps of Engineers Massachusetts General Permit 10, General Condition 18 would apply, in which no work can occur between October 1 and June 30. This restriction has been included in the Contract.

A summary of the General Standards of the Stream Crossing Standards (2011) as applied to the proposed culvert replacement is provided below.

<u>General Standards</u>
#1 – Spans that preserve the natural stream channel are strongly preferred.

The proposed pipe culverts are replacements of existing pipe culverts which carries intermittent streams beneath the existing roadway. The proposed culverts do not meet General Standard #1.

#2 – If a culvert, then it should be embedded:
- A minimum of 2 feet for all culverts,
- A minimum of 2 feet and at least 25 percent for round pipe culverts
- When embedment material includes elements > 15 inches in diameter, embedment depths should be at least twice the D84 (particle width larger than 84% of the particles) of the embedment material

The elliptical 19”x30” RCP culverts are proposed to have 5” of embedment. However they do not meet the 2’ embedment requirement. To embed a standard round pipe to meet the standard would require a 42” culvert, and extend the pipe an additional 2’ below the current invert. There are is an 8 inch and a 16 inch water line and an existing sewer line that run in the street, likely below the culvert. Fully embedding the pipe will at a minimum result in the replacement of the existing water lines to a deeper depth, and may impact the sewer as well. Therefore a smaller embedment depth was used in an attempt to meet the spirit of the General Standard if not the letter. However, the proposed culverts do not meet General Standard #2.

#3 – Spans channel width (a minimum of 1.2 times the bankfull width)

The streams are currently conveyed within an existing 12” RCP pipe and a 12”/18” configuration. An increase in pipe size to an elliptical 19”x30” RCP pipe exceeds the

standard of the channel width span of 1.2 times. The proposed culverts meet General Standard #3.

#4 – Natural bottom substrate within the structure

The elliptical 19”x30” RCP pipe culverts are proposed to have a natural bottom substrate within the structure. The depth of the substrate will be 5”, with the grade of the substrate matching existing stream inverts where possible. In some cases, the grades will be lower to maintain cover over the pipe. As the culvert will not be embedded, the culvert will not contain a natural bottom substrate. The proposed culverts meet General Standard #4.

#5 – Designed with appropriate bed forms and streambed characteristics so that water depths and velocities are comparable to those found in the natural channel at a variety of flows.

The elliptical 19”x30” RCP culvert was designed such that the culvert could pass the 50 year storm to meet current design requirements. The existing grades and slopes will be maintained and the stream banks will be rebuilt to conform to existing. The proposed culverts meet General Standard #5.

#6 – Openness > 0.82

The proposed culverts do not meet the openness ratio of 0.82. Given the length of the crossing of approximately 54 feet, the replacement culverts would need to be nearly 8-feet in diameter to achieve the required openness ratio. An 8 foot diameter culvert in this location would require raising the road 5 feet, resulting in additional impacts to wetland resources from the slopes and walls required to retain the roadway. Additionally, an 8 foot culvert would require relocating utilities and additional permanent Rights Of Way impacts to abutting properties. The proposed elliptical 19”x30” RCP culvert is designed to minimize alterations to the existing stream hydraulics and provide improved conditions for aquatic wildlife passage. The proposed culvert does not meet General Standard #6.

6.0 REGULATORY COMPLIANCE

The project has been designed to comply with General Performance Standards and Limited Project provisions listed in 310 CMR 10.00 to the maximum extent feasible and practicable. Table 2 – Wetland Resource Area Impacts provides a detailed analysis of all proposed resource area impacts and compensation provided.

The project as proposed results in a total of 416 square feet of temporary impact to BVW, 319 square feet of permanent impact to BVW and 29,501 square feet of impact to Riverfront Area. Of the 29,501 square feet of Riverfront Area to be impacted, 29,058 square feet (98%) is Previously Developed. The project will also result in 250’ of bank and 74 square feet of land under water impacts at two intermittent streams. The entire project qualifies as a Limited Project under the Act at 310 CMR 10.53(3)(f). As such, the Project is required to meet the performance standards to the extent practicable.

BVW impacts will be mitigated through construction of a wetland replication area and in-place wetland restoration of temporary impacts. The replication area will create 330 square feet of new vegetated wetland adjacent to the roadway ROW providing 1:1 replacement of the permanently impacted BVW. The replication area has been designed to comply with the General Performance Standards listed at 310 CMR 10.55(4)(b)(1-7).

No practicable and substantially equivalent economic alternatives to the proposed project with less adverse effects on the interests of the Act exist. As such, impacts to Riverfront Area are minimized and mitigated to the extent practicable. The linear nature of the roadway ROW restricts alternative access routes. Location and availability of land owned or controlled by MassDOT and/or the City of Haverhill prohibits alternative vehicular access routes. Riverfront Area alteration that will result from the construction activities have been minimized to the extent practical and feasible.

7.0 CONCLUSION

The proposed Broadway (Route 97) reconstruction project will result in improved pedestrian safety, promote traffic calming and upgrade stormwater and drainage systems. The project has been designed to meet all local and state standards where feasible and has minimized impacts to the greatest extent practical.

APPENDIX A
SITE PHOTOGRAPHS

WETLAND RESOURCE AREAS

A Series

B Series

C Series

D Series

D Series

E Series

F Series

G Series

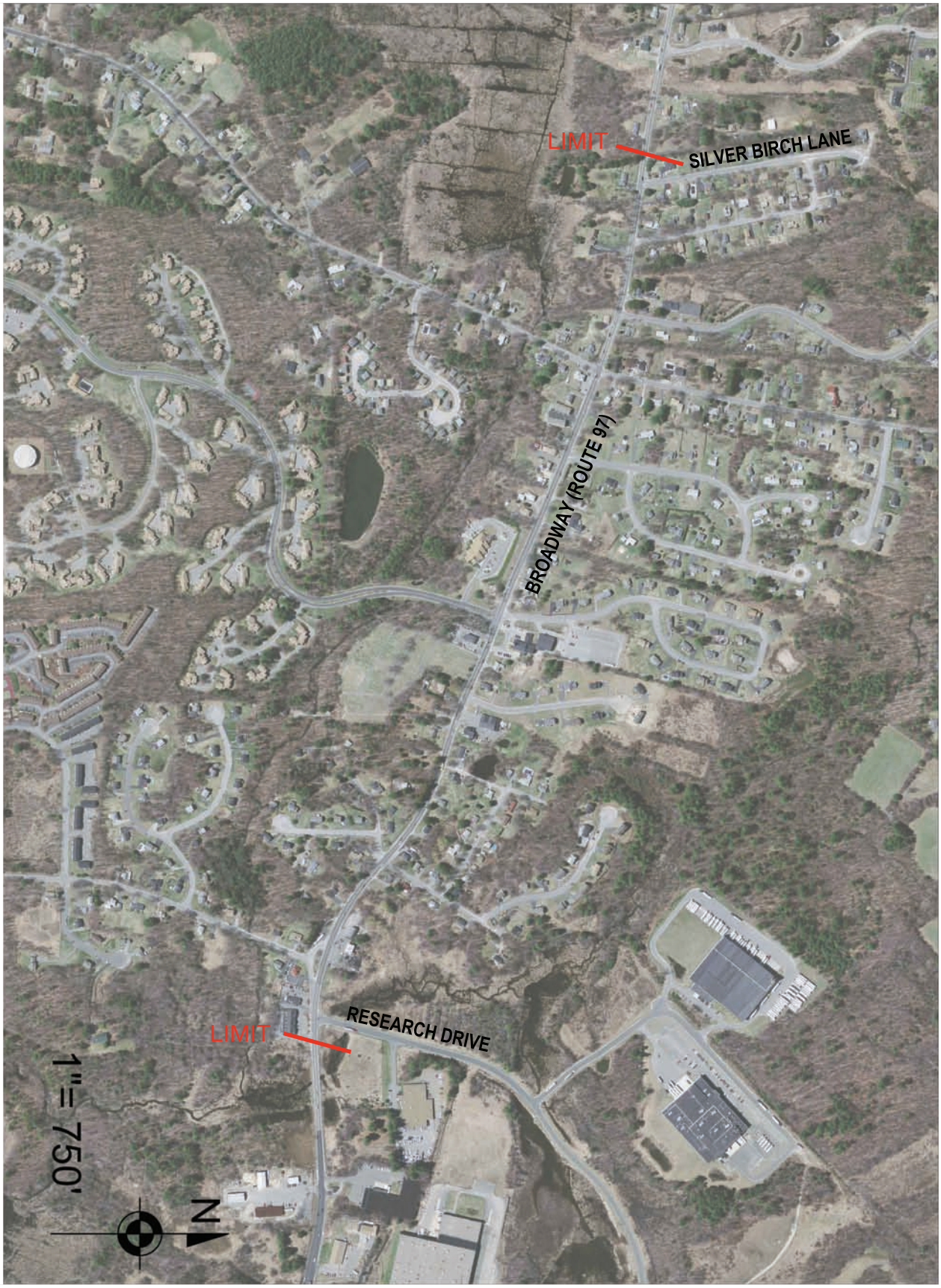
H Series

WETLAND REPLICATION AREA

Sta 6+00 RT

APPENDIX B
WETLAND DELINEATION REPORT

Figure 1
Aerial Photograph



MASS GIS

Figure 2
Mass GIS Topographic Map

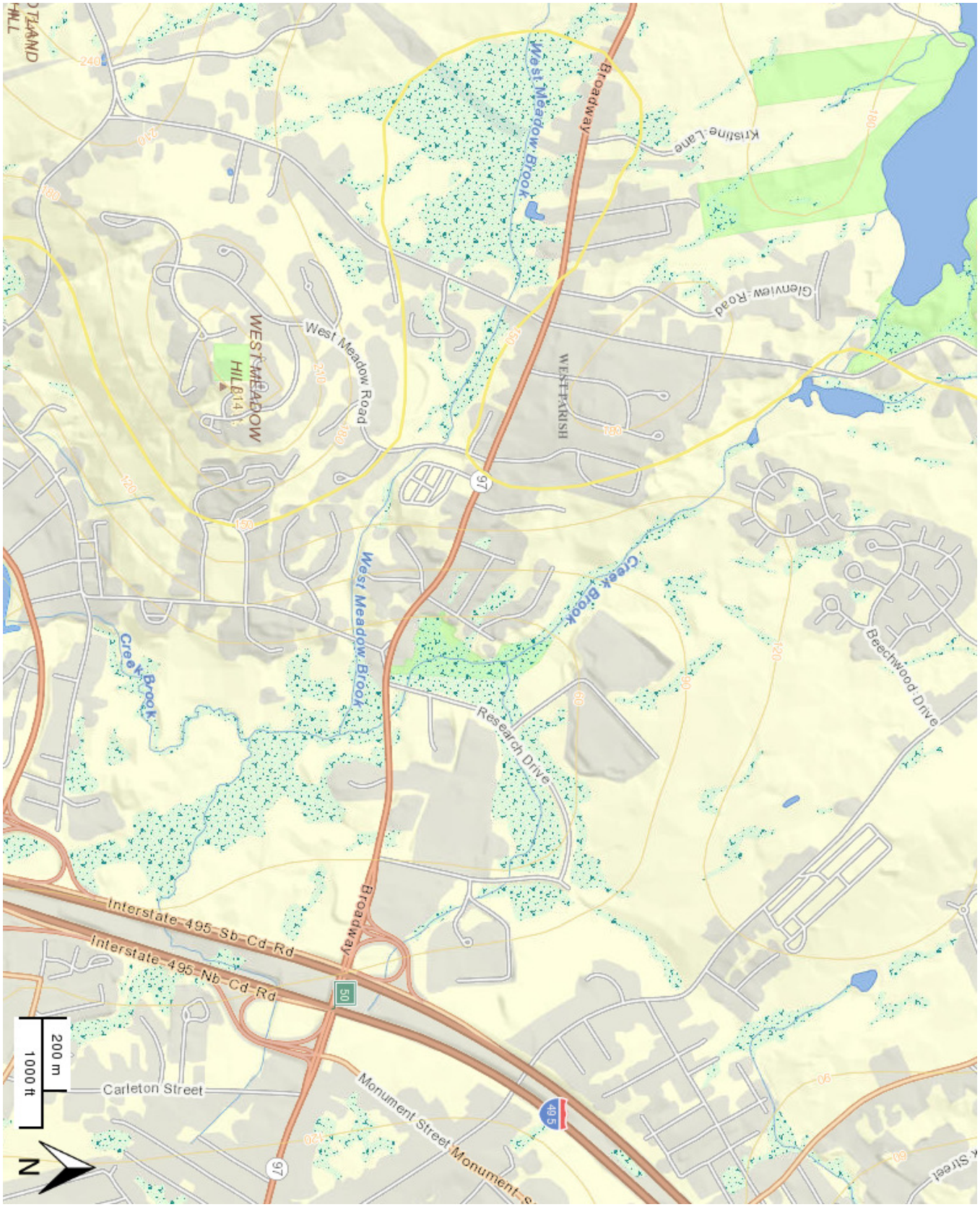


Figure 2
USGS Topographic Map

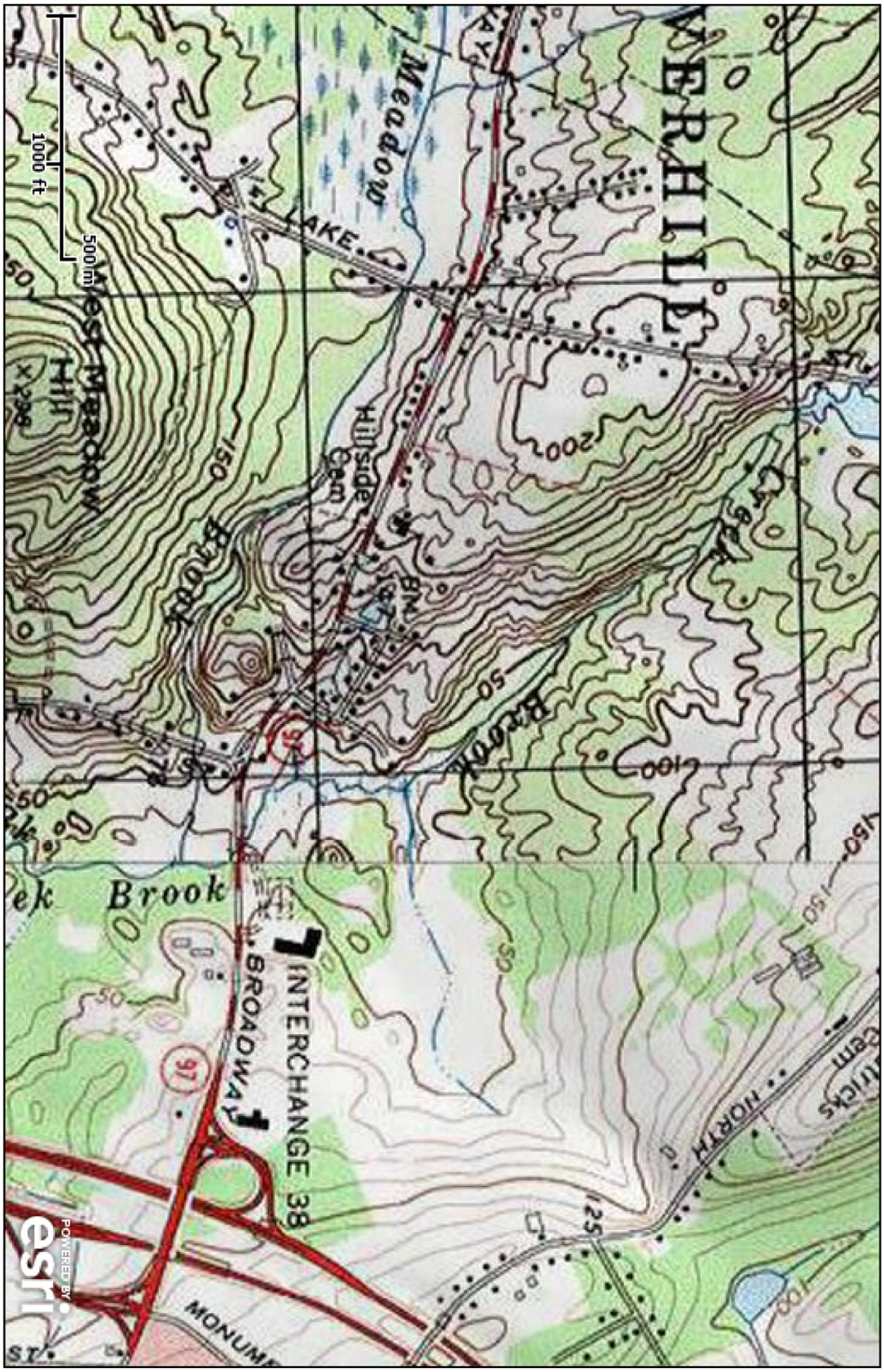


Figure 3
USDA Soil Map – Essex County, Massachusetts

Soil Map—Essex County, Massachusetts, Northern Part
(BROADWAY (ROUTE 97), HAVERHILL, MA)

Map Scale: 1:9,910 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 100 200 400 600

Feet: 0 450 900 1800 2700

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 19N WGS84

Figure 4
U.S. Fish and Wildlife Service National Wetlands Inventory

U.S. Fish and Wildlife Service

National Wetlands Inventory

BROADWAY (ROUTE 97), HAVERHIIL, MA

Aug 5, 2014

Wetlands

- Freshwater Emergent
- Freshwater Forested/Shrub
- Estuarine and Marine Deepwater
- Estuarine and Marine
- Freshwater Pond
- Lake
- Riverine
- Other

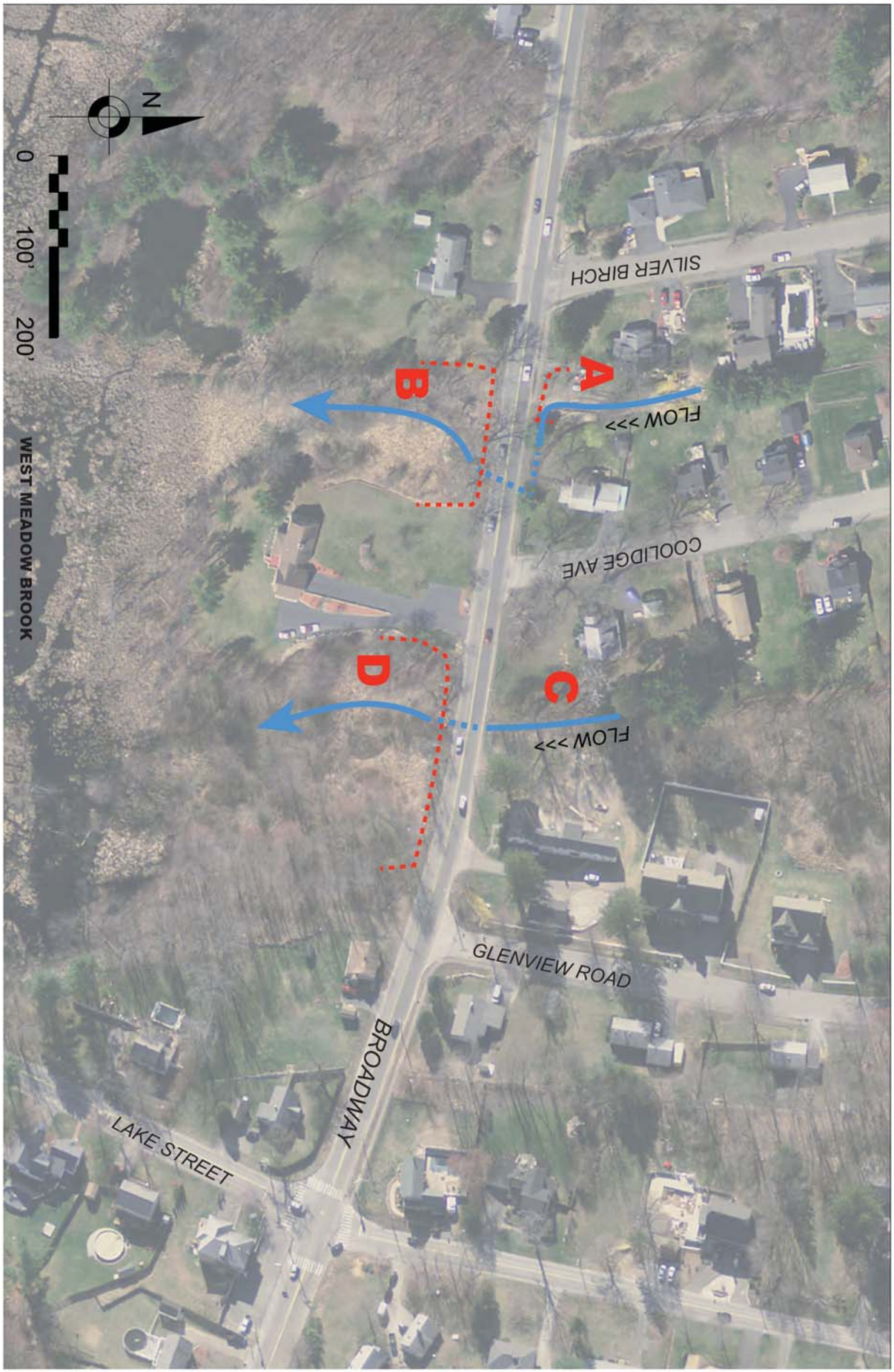
This map is for general reference only. The US Fish and Wildlife Service is not responsible for the accuracy or currentness of the base data shown on this map. All wetlands related data should be used in accordance with the layer metadata found on the Wetlands Mapper web site.

User Remarks:

Figure 5
FEMA Insurance Map

Figure 5
FEMA Insurance Map

Appendix A
Location 1



MASSGIS 2013

Appendix A
Location 2

A

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant:_____ Prepared by: B.EWING CPI Project location: BROADWAY (RT 97) HAVERHILL DEP File #:_____

Check all that apply:

- ☐ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- ☒ Vegetation and other indicators of hydrology usedto delineateBVW boundary: fill out Sections I and II
- ☐ Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: A		Transect Number:	Date of Delineation: 2019 8/19
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*
TREES - Silver Maple / ACER SACCHARINUM	12%*	100%	yes	FACW
SAPLINGS - Staghorn Sumac RHUS TYPHINA	3%*	100%	yes	FACU
GROUND COVER - Spotted Touch Me Not IMPATIENS CAPENIS	100%	98%	yes	FACW
- Purple Loostrife LYTHRUM SALICARIA	3%			OBL

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.*

Vegetation conclusion:

Number of dominant wetland indicator plants: 2 Number of dominant non-wetland indicator plants: 1

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? (yes) no

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

* Roadside-Poisen Ivy.

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? (yes) no
title/date:
map number: 301B
soil type mapped: MONTAUK FINE SANDY LOAM
hydric soil inclusions:

Are field observations consistent with soil survey? (yes) no
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color
O			
A	6"	10YR 3/1	
	6"+	10YR 7/1	5YR 2/6

Remarks:

F3- Frequently Inudated

3. Other:

Conclusion: Is soil hydric? (yes) no

- INTERMITTENT STREAM
- DRAINAGE FROM ABUTTING RESIDENTIAL AREA. DETENTION BASIN.

Other Indicators of Hydrology: (check all that apply & describe)

- [x] Site Inundated: _____
- [ ] Depth to free water in observation hole: _____
- [ ] Depth to soil saturation in observation hole: _____
- [ ] Water marks: _____
- [ ] Drift lines: _____
- [ ] Sediment Deposits: _____
- [ ] Drainage patterns in BVW: _____
- [x] Oxidized rhizospheres: _____
- [ ] Water-stained leaves: _____
- [ ] Recorded Data (streams, lake, or tidal gauge; aerial photo; other): _____
- [ ] Other: _____

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants	✓	
Wetland hydrology present:		
Hydric soil present	✓	
Other indicators of hydrology present	✓	
Sample location is in a BVW	✓	

Submit this form with the Request for Determination of Applicability or Notice of Intent.

B

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant:_____ Prepared by: B. EWING GPI Project location: BROADWAY (RT 97) HAVERHILL DEP File #:_____

Check all that apply:

- ☐ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- ☑ Vegetation and other indicators of hydrology usedto delineateBVW boundary: fill out Sections I and II
- ☐ Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: B		Transect Number:	Date of Delineation: 2014 8/19
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*
TREES				
Swamp OAK QUERCUS BI-COLOR	58%	83% ⊗	yes	FACW
Norway maple ACER PLATANOIDES	12%	17%		UPL
SHRUB				
ARROWOOD - VIBURNUM DENTATUM	12%	50%	yes	FAC
GLOSSY BUCKTHORN - RHAMNUS FRANGULA	12%	50%	yes	UPL
SAPLINGS				
Norway Maple ACER PLATNOIDES	3%		yes	
GROUND COVER				
CAT TAILS - TYPHA AUGUSTIFOLIA	12%		yes	OBL
SENSITIVE fern - ONCLEA SENSIBILIS	12%		yes	FACW
Spotted Touch me NOT - IMPATIENT CAPENIS	3%		yes	FACW

* Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.

Vegetation conclusion:

Number of dominant wetland indicator plants: 6 Number of dominant non-wetland indicator plants: 2

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? (yes) no

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

*Phragmites Australis - FACW - easterly extent

*ROADSIDE - Poison Ivy

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? (yes) no
title/date: 1/19/2015
map number: 72A
soil type mapped: whitman Loam 0-3% slopes
hydric soil inclusions:

Are field observations consistent with soil survey? (yes) no
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color
O	8"	10YR 2/1	
A	8-16"	10YR 5/2	

Remarks:

All -

3. Other:

Conclusion: Is soil hydric? (yes) no

FORESTED WETLAND, PERENIAL STREAM,

Other Indicators of Hydrology: (check all that apply & describe)

- ☐ Site Inundated: _____
- ☐ Depth to free water in observation hole: _____
- ☐ Depth to soil saturation in observation hole: _____
- ☐ Water marks: _____
- ☐ Drift lines: _____
- ☐ Sediment Deposits: _____
- ☐ Drainage patterns in BVW: _____
- ☑ Oxidized rhizospheres: _____
- ☐ Water-stained leaves: _____
- ☐ Recorded Data (streams, lake, or tidal gauge; aerial photo; other): _____
- ☐ Other: _____

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants	✓	___
Wetland hydrology present:		
Hydric soil present	✓	___
Other indicators of hydrology present	✓	___
Sample location is in a BVW	✓	___

Submit this form with the Request for Determination of Applicability or Notice of Intent.

D

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant:_____ Prepared by: B-EWING - GPI Project location: BROADWAY (Rt 97) DEP File #:_____

Check all that apply:

- ☑ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- ☐ Vegetation and other indicators of hydrology usedto delineateBVW boundary: fill out Sections I and II
- ☐ Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: D		Transect Number:	Date of Delineation: 2014 8/19
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*
TREES - American Elm ULMUS AMERICANA	12%	100%	yes	FACW
Silver Maple - Acer Saccharinum	3%	17%	no	FACW
Norway Maple - Acer Platanoides	3%	17%	NO	UPL
SAPLINGS - Glossy Buckthorn - FRAGULA ALNUS	3%	33%	yes	
Arrowood - VIBURNUM DENTATUM	3%	33%	yes	FAC
Speckled Alder - ALNUS INCANA	3%	33%	yes	FAC
GROUND. - Cat tails - TYPHA AUGUSTIFOLIA	32%	73%	yes	OBL
Sensitive Fern: Onclea sensibilis	12%	27%		FACW
* PHRAGMITES AUSTRALIS				FACW

* Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.

Vegetation conclusion:

Number of dominant wetland indicator plants: 6 Number of dominant non-wetland indicator plants: 3

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? (yes) no

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

PALUSTRINE PERSISTANT EMERGENT

* ROADSIDE - Poison Ivy - TAXICODENDRON RADICANS

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? (yes) no
title/date: 1/19/2015
map number: 310 B
soil type mapped: MONTAUK FINE SANDY LOAM
hydric soil inclusions:

Are field observations consistent with soil survey? (yes) no
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color
O	10"	10YR 3/1	
A	10+"	10YR 5/2	

Remarks:
All – gleyed matrix w/ Redox concentrations

3. Other:

Conclusion: Is soil hydric? (yes) no

Other Indicators of Hydrology: (check all that apply & describe)

- ❑ Site Inundated: _____
- ❑ Depth to free water in observation hole: _____
- ❑ Depth to soil saturation in observation hole: _____
- ❑ Water marks: _____
- ❑ Drift lines: _____
- ❑ Sediment Deposits: _____
- ❑ Drainage patterns in BVW: _____
- ❑ Oxidized rhizospheres: _____
- ❑ Water-stained leaves: _____
- ❑ Recorded Data (streams, lake, or tidal gauge; aerial photo; other): streams
- ❑ Other: _____

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants	✓	___
Wetland hydrology present:		
Hydric soil present	✓	___
Other indicators of hydrology present	✓	___
Sample location is in a BVW	✓	___

Submit this form with the Request for Determination of Applicability or Notice of Intent.

E

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant:_____ Prepared by: B.EWING GPI Project location: BROADWAY (R+97) HAVERHILL DEP File #:_____

Check all that apply:

- ☑ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- ☐ Vegetation and other indicators of hydrology usedto delineateBVW boundary: fill out Sections I and II
- ☐ Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: E		Transect Number:	Date of Delineation: 2014 8/19
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*
GROUND COVER				
CAT TAIL - TYPHA AUGUSTIFOLIA	68%			OBL
BLUE JOINT - CALAMAGROSTIS CANADENSIS	32%			OBL
BROOM SEDGE - CAREX SCIRPOIDEA	12%			FACW
SHRUB				
* SILKY DOGWOOD - CORNUS AMOMUM				FACW
* SPECKLED ALDER - ALNUS INCANA				FACW
* recently planted on bank.				

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.*

Vegetation conclusion:

Number of dominant wetland indicator plants: 5 Number of dominant non-wetland indicator plants: —

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? (yes) no

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

* Wetland Replacement area ABUTS CREEK BROOK.
* BANKED TO ROADWAY

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? yes no
title/date:
map number: 311 B
soil type mapped: WOOD BRIDGE FINE SANDY LOAM
hydric soil inclusions:

Are field observations consistent with soil survey? yes no
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color

Remarks:

3. Other:

Conclusion: Is soil hydric? yes no

Other Indicators of Hydrology: (check all that apply & describe)

- ❑ Site Inundated: _____
- ❑ Depth to free water in observation hole: _____
- ❑ Depth to soil saturation in observation hole: _____
- ❑ Water marks: _____
- ❑ Drift lines: _____
- ❑ Sediment Deposits: _____
- ❑ Drainage patterns in BVW: _____
- ❑ Oxidized rhizospheres: _____
- ❑ Water-stained leaves: _____
- ❑ Recorded Data (streams, lake, or tidal gauge; aerial photo; other): _____
- ❑ Other: _____

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants	✓	___
Wetland hydrology present:		
Hydric soil present	___	___
Other indicators of hydrology present	___	___
Sample location is in a BVW	✓	___

Submit this form with the Request for Determination of Applicability or Notice of Intent.

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant:_____ Prepared by: B.EWING - GPI Project location: BROADWAY/RT97 HAVERHILL DEP File #:_____

Check all that apply:

- ☑ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- ☐ Vegetation and other indicators of hydrology usedto delineateBVW boundary: fill out Sections I and II
- ☐ Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: F		Transect Number:	Date of Delineation: 2014 8/19
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*
Ground cover				
CAT TAILS - TYPHA AUGUSTIFOLIA	32%			OBL
PHRAGMITES AUSTRALIS	12%		yes	OBL
SHRUB -				
SPECKLED ALDER - ALNUS INCANA	32%			FACW
WINTERBERRY - ILEX VERTICULATA	12%		yes	FACW

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.*

Vegetation conclusion:

Number of dominant wetland indicator plants: 4 Number of dominant non-wetland indicator plants:

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? (yes) no

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

- RIVERINE - LOWER PERENNIAL

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? yes no
title/date:
map number: 71&A
soil type mapped: Saco variant silt loam 0-3% SLOPE
hydric soil inclusions:

Are field observations consistent with soil survey? yes no
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color

Remarks:

3. Other:

Conclusion: Is soil hydric? yes no

Other Indicators of Hydrology: (check all that apply & describe)

- ❑ Site Inundated: _____
- ❑ Depth to free water in observation hole: _____
- ❑ Depth to soil saturation in observation hole: _____
- ❑ Water marks: _____
- ❑ Drift lines: _____
- ❑ Sediment Deposits: _____
- ❑ Drainage patterns in BVW: _____
- ❑ Oxidized rhizospheres: _____
- ❑ Water-stained leaves: _____
- ❑ Recorded Data (streams, lake, or tidal gauge; aerial photo; other): _____
- ❑ Other: _____

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants	✓	___
Wetland hydrology present:		
Hydric soil present	___	___
Other indicators of hydrology present	___	___
Sample location is in a BVW	✓	___

Submit this form with the Request for Determination of Applicability or Notice of Intent.

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant:_____ Prepared by: B.EWING - GPI Project location: BROADWAY (Rte 97) HAVERHILL DEP File #:_____

Check all that apply:

- ❑ Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- ❑ Vegetation and other indicators of hydrology usedto delineateBVW boundary: fill out Sections I and II
- ❑ Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: G		Transect Number:	Date of Delineation: 2014 8/19
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*
GROUND COVER				
PHRAGMITES AUSTRALIS	100%	100%	yes	OBL
SHRUB				
GLOSSY BUCKTHORN RHAMNUS FRANGULA	32%	73%	yes	FAC
SPECKLED ALDER - ALNUS INCANA	12%	27%	yes	FACW
TREE				
BLACK LOCUST - Robina pseudoacacia	12%	100%	yes	FAC

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.*

Vegetation conclusion:

Number of dominant wetland indicator plants: 3 Number of dominant non-wetland indicator plants: 1

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? (yes) no

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

EASTERLY - PHRAGMITES AUSTRALIS

WESTERLY - Scrub Shrub

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? yes no
title/date:
map number: 718 A
soil type mapped: SALL variant silt loam 0-3% slope
hydric soil inclusions:

Are field observations consistent with soil survey? yes no
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color

Remarks:

3. Other:

Conclusion: Is soil hydric? yes no

Other Indicators of Hydrology: (check all that apply & describe)

- ❑ Site Inundated: _____
- ❑ Depth to free water in observation hole: _____
- ❑ Depth to soil saturation in observation hole: _____
- ❑ Water marks: _____
- ❑ Drift lines: _____
- ❑ Sediment Deposits: _____
- ❑ Drainage patterns in BVW: _____
- ❑ Oxidized rhizospheres: _____
- ❑ Water-stained leaves: _____
- ❑ Recorded Data (streams, lake, or tidal gauge; aerial photo; other): _____
- ❑ Other: _____

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants	✓	___
Wetland hydrology present:		
Hydric soil present	___	___
Other indicators of hydrology present	___	___
Sample location is in a BVW	✓	___

Submit this form with the Request for Determination of Applicability or Notice of Intent.

#

MassDEP Bordering Vegetated Wetland (310 CMR 10.55) Delineation Field Data Form

Applicant:_____ Prepared by: B.EWING GPI Project location: BROADWAY (RT 97) HAVERHILL DEP File #:_____

Check all that apply:

- [x] Vegetation alone presumed adequate to delineate BVW boundary: fill out Section I only
- [ ] Vegetation and other indicators of hydrology usedto delineateBVW boundary: fill out Sections I and II
- [ ] Method other than dominance test used (attach additional information)

Section I.

Vegetation	Observation Plot Number: H		Transect Number:	Date of Delineation: 2016/3
A. Sample Layer & Plant Species (by common/scientific name)	B. Percent Cover (or basal Area)	C. Percent Dominance	D. Dominant Plant (yes or no)	E. Wetland Indicator Category*
TREES				
GIANT WILLOW – Salix	83%	59%	yes	FACW
SILVER MAPLE - Acer Saccharinum	58%	41%	yes	FACW
SAPLINGS				
CHERRY - Prunus Avium FACU	12%		yes	FACU
SHRUB				
HONEYSUCKLE - Lonicera Japonica	58%	62%	yes	FACU
RUGOSA — Rosa rugosa	32%	34%	yes	FACU
ARROW OOD - Viburnum Dentatum	3%			FAC
GROUND				
SKUNK CABBAGE Symplocarpus Foetidus	58%	51%	yes	OBL
SENSITIVE FERN - Onoclea sensibilis	12%			FACW
TOUCHMENOT - IMPATIENS CAPENIS	32%	28%	yes	FACW
HORSETAIL - EQUISETUM PALUSTRE	12%			FACW

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk.*

Vegetation conclusion:

Number of dominant wetland indicator plants: 4 Number of dominant non-wetland indicator plants: 3

Is the number of dominant wetland plants equal to or greater than the number of dominant non-wetland plants? (yes) no

If vegetation alone is presumed adequate to delineate the BVW boundary, submit this form with the Request for Determination of Applicability or Notice of Intent

* LOCATION ALTERED SUBJECT TO CONSTRUCTION OF PARKING AREA (2012)

* DRAINAGE PIPE -1' - HIGH WATER - WATER RUNS BOTH DIRECTIONS ABUTS PROTECTED RESOURCE AREA

Section II. Indicators of Hydrology

Hydric Soil Interpretation

1. Soil Survey

Is there a published soil survey for this site? yes no
title/date:
map number: 311 B
soil type mapped: Woodbridge Fine Sandy Loam 0-8% Slope
hydric soil inclusions:

Are field observations consistent with soil survey? yes no
Remarks:

2. Soil Description

Horizon	Depth	Matrix Color	Mottles Color

Remarks:

3. Other:

Conclusion: Is soil hydric? yes no

Other Indicators of Hydrology: (check all that apply & describe)

- ☐ Site Inundated: _____
- ☐ Depth to free water in observation hole: _____
- ☐ Depth to soil saturation in observation hole: _____
- ☐ Water marks: _____
- ☐ Drift lines: _____
- ☐ Sediment Deposits: _____
- ☒ Drainage patterns in BVW: _____
- ☐ Oxidized rhizospheres: _____
- ☒ Water-stained leaves: _____
- ☐ Recorded Data (streams, lake, or tidal gauge; aerial photo; other): _____
- ☐ Other: _____

Vegetation and Hydrology Conclusion

	Yes	No
Number of wetland indicator plants ≥ # of non-wetland indicator plants	✓	
Wetland hydrology present:		
Hydric soil present		
Other indicators of hydrology present	✓	
Sample location is in a BVW	✓	

Submit this form with the Request for Determination of Applicability or Notice of Intent.

A) December 19, 2014

A) August 19, 2014

A) North side of Broadway culverts

B) South side of Broadway culvert

B) December 19, 2014

B) South side of Broadway

B) August 19, 2014

C) north of Broadway Dec. 2014

C) north of Broadway culvert Dec. 2014

D) south of Broadway westerly limit Dec. 2014

D) south of Broadway westerly outlet Dec. 2014

D) south of Broadway easterly outlet Dec. 2014

D) south of Broadway Dec. 2014

D) south of Broadway Dec. 2014

E) north of Broadway, west of Research Drive Aug. 2014

E) west of Research Drive Dec. 2014

F) north of Broadway, east Research Drive Dec. 2014

F) north of Broadway, east Research Drive Aug. 2014

G) south of Broadway Dec. 2014

G) south of Broadway Dec. 2014

G) south of Broadway / plaza drive Dec. 2014

LOCATION H
April 2016

APPENDIX C
PROJECT SPECIAL PROVISIONS

ITEM 697.1 **SILT SACK** **EACH**

Work under this item shall conform to the relevant provisions of Sections 227 and 670 of the Standard Specifications and the following:

The work under this item includes the furnishing, installation, maintenance and removal of a reusable fabric sack to be installed in drainage structures for the protection of wetlands and other resource areas and the prevention of silt and sediment from the construction site from entering the storm water collection system. Devices shall be ACF Environmental (800)-448-3636; Reed & Graham, Inc. Geosynthetics (888)-381-0800; The BMP Store (800)-644-9223; or approved equal.

CONSTRUCTION

Silt sacks shall be installed in existing and proposed catch basins and drop inlets within the project limits and as required by the Resident Engineer.

The silt sack shall be as manufactured to fit the opening of the drainage structure under regular flow conditions, and shall be mounted under the grate. The insert shall be secured from the surface such that the grate can be removed without the insert discharging into the structure. The filter material shall be installed and maintained in accordance with the manufacturer's written literature and as directed by the Engineer.

Silt sacks shall remain in place until the placement of the pavement overlay or top course and the graded areas have become permanently stabilized by vegetative growth. All materials used for the filter fabric will become the property of the Contractor and shall be removed from the site.

The Contractor shall inspect the condition of silt sacks after each rainstorm and during major rain events. Silt sacks shall be cleaned periodically to remove and dispose of accumulated debris as required. Silt sacks, which become damaged during construction operations, shall be repaired or replaced immediately at no additional cost to the Department.

When emptying the silt sack, the contractor shall take all due care to prevent sediment from entering the structure. Any silt or other debris found in the drainage system at the end of construction shall be removed at the Contractors expense. The silt and sediment from the silt sack shall be legally disposed of offsite. Under no condition shall silt and sediment from the insert be deposited on site and used in construction.

All curb openings shall be blocked to prevent stormwater from bypassing the device.

All debris accumulated in silt sacks shall be handled and disposed of as specified in Section 227 of the Standard Specifications

COMPENSATION

Silt sacks will be measured and paid at the Contract unit price per each, complete in place, which price shall include all labor, materials, equipment and incidental costs required to complete the work. No separate payment will be made for removal and disposal of the sediment from the insert, but all costs in connection therewith shall be included in the Contract unit price bid.

ITEM 755.3 NON-TIDAL WETLAND MITIGATION AREAS LUMP SUM

Work under this item shall conform to the relevant provisions of Sections 120, 770, 771 and the following:

The work under this Item includes the furnishing of all labor, transportation, equipment, and materials required for protection, construction, and maintenance of Non-Tidal Wetland Mitigation Areas as compensation for proposed impacts to existing wetlands. Tasks include erosion controls, excavation, fine grading, soil and soil amendments as needed, planting, maintenance and removals as shown on the Plans.

The construction and re-vegetation of the replacement areas shall be in accordance with the Plans and Cross Sections and as directed by the Wetland Specialist. Limits of replacement and proposed plantings shown on the plans are approximate and may require adjustment in the field to accommodate actual conditions.

DESCRIPTION OF WORK

To ensure that no loss of wetland function results from the proposed project, Non-Tidal Wetland Mitigation Area(s) characterized by Bordering Vegetated Wetlands (BVW) shall be replicated through constructed wetlands and/or restored by planting in existing wetland areas shown on the Plans. Non-Tidal Wetland Mitigation Areas shall hereafter be referred to as Mitigation Areas. The following minimum area requirements shall be met for each area shown on the Plans.

Replication:
BVW Replication area STA 6+00 RT= 330 sf.

Restoration:
BVW Restoration area (Resource Series A) STA 3+25 LT = 162 sf.
BVW Restoration area (Resource Series D) STA 6+25 RT = 96 sf.
BVW Restoration area (Resource Series H) STA 41+40 LT = 143 sf.

Mitigation Areas shall be constructed to meet the requirements of permits and certifications including relevant performance standards of the Massachusetts Wetlands Protection Act (MGL C. 131, s40) and U.S. Army Corps of Engineers.

The Contractor shall be responsible for protection and preservation of natural areas adjacent to the Mitigation Areas both within and outside of the project limits for the duration of the contract period. Access to Mitigation Areas shall be clearly defined in order to minimize damage to existing vegetation and soils. The Contractor shall use duck boards or mats, as necessary, to minimize impacts from foot paths or construction equipment. All labor and materials required for protection and preservation of site shall be incidental to this item.

Damage to soils or vegetation due to trampling, vehicles, storing of materials, debris, or negligence shall be repaired to the satisfaction of the Engineer and at the Contractor's expense.

RELATED ITEMS:

The following tasks related to work within the Mitigation Areas shall be paid for under these

separate items.

ITEM 102.52 TEMPORARY TREE PROTECTION FENCE
ITEM 755.7 WETLAND SPECIALIST
ITEM 767.12 COMPOST FILTER TUBES

SUBMITTALS:
Photographic Documentation: Prior to any disturbance, clear and legible digital photographs with date and time stamps shall be taken of the existing site conditions including existing wetlands to be impacted, all proposed wetland mitigation sites and reference/model wetland areas, typically an adjacent undisturbed wetland. These shall be submitted to the Engineer on CD or DVD format.

Contractor shall submit the following for approval by the Engineer in consult with the MassDOT Landscape Architect at least sixty (60) days prior to installation. The Contractor shall be responsible for making all submittals to the Engineer in a timely and complete manner.

Soil and soil amendments: Contractor shall submit for approval all sources of soil and other amendments including compost prior to ordering. Off-site sources shall be identified and available for inspection by the Wetland Specialist prior to transport of material to the site to verify that they are likely to be free of invasive plant species including all viable plant parts.

Plants: Confirmation of availability, source of plant material and certification of provenance from the nursery supplier.

Seed: Source, certification of compliance and certification of provenance from supplier shall be submitted and approved prior to ordering materials.

Compost Filter Tubes: Product literature and samples of all material including compost fill.

Samples:
Cut sheets for erosion controls
Sample(s) of soils and soil amendments tested and accepted, if needed.

MATERIALS
All materials are incidental to this item unless specified otherwise.

Erosion Controls:
Compost Filter Tubes:
Materials shall conform to the requirements of Section 751 and 767 of the Standard Specifications, Plans, and the following:

Fill material for the filter tubes shall be compost meeting M1.06.0, except that no manure or bio-solids shall be used. In addition, no kiln-dried wood or construction debris shall be allowed.

Tubes for compost filters shall be a minimum of 12 inches (300 mm), a maximum of 18” (450mm) in diameter, and shall be jute mesh or approved biodegradable material. Additional tubes may be used at the direction of the Engineer.

As shown in the drawing details, the 1 foot (0.2 meters) wide by 2 inch (50 mm) deep wedge of compost spread along the top of the filter tube shall be incidental to this item.

Stakes for anchors shall be nominal 2" x 2" untreated hardwood stakes.

Planting Soil:
Wetland soil for wetland restoration or replacement may be either soil excavated from impacted wetland area or manufactured hydric soil. If using soil from the impacted wetland area, soil shall not be compacted or grubbed. If the proposed mitigation site is in an area free of invasive species, wetland soil from the impacted wetland that is infested with invasive plant species shall not be used so as to avoid bringing invasive species to a new location. If the mitigation is adjacent to the infested area, wetland soils from the impacted site may be used as they will inevitably spread into the mitigation site. Manufactured wetland soil shall consist of on-site borrow from the proposed replacement site thoroughly mixed with compost to achieve a target organic content of 10-12% by weight. Where empirical data are lacking, compost to soil ratio shall be 1:1 by volume. Off-site borrow may be used for mixing if approved in advance by the Engineer per these Special Provisions.

No soil, compost, or other soil amendment imported to the work site shall contain seeds, roots, stems, or other viable parts of invasive plants. No soil or soil amendment shall be brought on site without prior approval of the material source. Soils used in the replacement area should be free of rocks greater than 4 inches (100 mm) in diameter.

Wetland soils for mitigation area shall be stockpiled outside resource areas and stored at least 100 feet from the edge of the wetland. Precautions shall be taken as necessary to prevent erosion of the stockpiled material. In the event there is excess borrow, it shall be disposed of without additional compensation.

Compost Topsoil:
Compost shall be compost meeting the requirements for Organic Soil Additives, Section M 1.06.0 of the Standard Specifications and the following:

No kiln-dried wood or construction debris shall be allowed.

Organic matter content shall be minimum 30 percent (dry weight basis) as determined by ASTM D2974 (method A) Standard Test Methods for Moisture, Ash and Organic Matter of Peat and Other Organic Soils.

Moisture content shall be 40-60 percent as measured by ASTM D2216 Standard Test Method for Laboratory Determination of Water Content of Soil and Rock and ASTM D2974 (cited above).

Plant Material:
Plants in Mitigation Areas shall conform to SECTION 771 PLANTING TREES, SHRUBS AND GROUNDCOVER of the Division I Standard Special Provisions and as amended below.

Plant Species:

Shall be as specified on the plans.

All plant material shall be species native to the region. As per current recommendations by the NOAA Restoration Center and the EPA Ecoregion Assessment, in order to maintain genetic diversity, only native species of seed and plants from the EPA Level III Ecoregion of the project area shall be used for ecosystem restoration. The EPA Level III Ecoregions of Massachusetts are Ecoregion 84 Atlantic Coastal Pine Barrens which encompasses Barnstable, Dukes, Nantucket and Plymouth Counties. Ecoregion 59 Northeastern Coastal Zone encompasses the remainder of Massachusetts. The current EPA map, Ecoregions of the Continental United States, is available through the following link: ftp://ftp.epa.gov/wed/ecoregions/us/Eco_Level_III_US.pdf
The nursery source shall certify that the provenance, or origin, of the seed from which the plants were produced is from the applicable EPA Level III Ecoregion.

Transplants and plant material collected from the wild is prohibited unless approved in writing by the MassDOT Landscape Architect and Wetland Specialist. Plant materials shall be selected from certified nurseries that have been inspected by state and/or federal agencies. Nursery inspection certificates shall be furnished to the Engineer upon request.

No plants shall be installed until the Wetland Specialist approves the condition of the plant material and the process of installation.

Water:
Plant material shall be saturated with fresh water before delivery, upon delivery to the site and twice daily up to time of installation. The Contractor shall provide water and all equipment required at no extra cost. Water shall be suitable for irrigation and free from ingredients harmful to plants and wildlife. Per DEP requirements, water from the adjacent water body shall not be utilized. It is the Contractor's responsibility to correct injury or damage due to the lack of water, too much water or use of contaminated water.

Requests for substitutions shall be submitted in writing to the Engineer for review by the MassDOT Landscape Architect at least ninety (90) days prior to planting. The Contractor shall submit a list of nurseries that were contacted and unable to supply the species as shown on the Plans. All proposed substitutes shall be in conformance with the requirements herein and suitable for the site conditions.

Seed Mix:
Seed in the Mitigation Areas shall conform the Standard Specifications as amended by the 2010 Standard Special Provisions, SUBSECTION M6, ROADSIDE DEVELOPMENT MATERIALS and as amended herein.

BOTANICAL NAME	COMMON NAME	PERCENTAGE
Carex vulpinoidea	Fox Sedge	25%
Elymus virginicus	Virginia Wildrye	25%
Carex lurida	Lurid (Shallow) Sedge	12%
Carex lupulina	Hop Sedge	6%
Verbena hastata	Blue Vervain	4%
Juncus effusus	Soft Rush	3%
Carex comosa	Cosmos (Bristly) Sedge	3%
Aster umbellatus (Doellingeria umbellate)	Flat Topped White Aster	3%
Aster prenanthoides (Symphyotrichum p.)	Zigzag Aster	3%

Scirpus atrovirens	Green Bulrush	3%
Helenium autumnale	Common sneezeweed	2%
Zizia aurea	Golden Alexanders	2%
Ludwigia alternifolia	Seedbox	2%
Lobelia siphilitica	Great Blue Lobelia	1%
Aster puniceus (Symphyotrichum puniceum)	Purplestem Aster	1%
Vernonia gigantea (V. altissima)	Giant Ironweed	1%
Scirpus cyperinus	Woolgrass	1%
Eupatorium perfoliatum	Boneset	1%
Euthamia graminifolia (Solidago g.)	Grassleaf Goldenrod	1%
Asclepias incarnata	Swamp Milkweed	1%
	Total:	100%

Seeding rate shall be 20 lbs. per acre or 0.5 lbs. per 1,000 square feet. All species shall be of a local ecotype meeting the EPA Level III Ecoregion requirements as described in the Plant Materials section.

Fertilizer and soil amendments shall not be used for seeding in Mitigation Areas.

METHODS

Site Preparation:
Prior to an initial site meeting, the Contractor shall stake out Mitigation Area boundaries and set grade stakes in the field. Prior to start of work, the Contractor shall walk the site with the Engineer, Wetland Specialist, and MassDOT Landscape Architect for an initial site meeting. The purpose of the meeting is to verify limits of work, locations and installation of Phase 1 erosion controls, proposed construction methods, and grade stake elevations.

Erosion and Sediment Control:
The Contractor shall plan and execute operations in a manner minimizing the amount of excavated and exposed fill or other foreign materials that could be washed or otherwise carried into Mitigation Areas and nearby wetland resource areas. The Engineer and Wetland Specialist shall inspect and approve erosion and sediment control measures prior to excavation work. Erosion controls shall be in place prior to any construction activities.

Compost Filter Tubes shall serve as temporary erosion control during construction until establishment of erosion control seeding. Compost Filter Tubes shall also act as a limit of work barrier.

Where restoration requires planting in existing grade to fill in among existing vegetation, disturbance to existing soils will be minimal and erosion controls may not be necessary around these restoration planting areas.

Erosion controls shall be installed along the downslope perimeter of Mitigation Areas beginning and ending in the surrounding upland so that no excavated material or disturbed soil can enter adjacent wetlands or waters.

The Contractor shall remove sediment deposits as necessary to maintain the filters in working condition. The Contractor shall maintain erosion controls in a functional condition at all times,

including inspections after each rainfall and at least daily during prolonged rainfall and shall immediately correct all deficiencies including replacing compost filter tubes as needed.

Upon final acceptance of seeding, the compost filter tubes shall be cut open, compost spread evenly over the soil surface a maximum depth of 2-inches and the composted area shall be seeded with same seed mix used in the surrounding area. Stakes, ropes and other non-biodegradable materials shall be removed and disposed of offsite by the Contractor. Existing vegetation disturbed by erosion control installation and removals shall be replanted as directed by the Engineer.

Excavation and Grading:
Final grades in the Mitigation Areas shall conform to target elevations as shown on the Plans and as approved by the Wetland Specialist. Restoration areas shall conform to existing and/or adjacent grades.

Mitigation Areas shall be staked and grades set for approval by the Wetland Specialist prior to excavation. To the extent possible, limits shall be a minimum of 6 feet from trunk of trees. Actual limits of mitigation areas may be adjusted in the field to protect root systems of existing trees. However, the total area of Wetland Mitigation required by all permits shall not be reduced.

Mitigation area shall be covered with 2-inch layer of Compost Topsoil to provide compost mulch for erosion control and better seed establishment. Typically, hydraulic application equipment will be required for this item, unless otherwise permitted by the Engineer, in writing.

Note: to avoid compaction, once soil has been placed, no heavy equipment shall travel across placed soil. Do not work with wet or moist soils. Work that results in compaction of soils shall result in replacement of wetland soils at no additional cost to the contract.

It is the Contractor's responsibility to identify existing areas of established invasive plants and notify the Engineer and Wetland Specialist of the condition. Soil containing invasive plant material shall be excavated and disposed of off-site at an approved facility.

All cut trees, stumps, brush, wrack or vegetation not specified to remain shall be removed from Mitigation Areas unless directed otherwise by the Engineer. Materials shall not to be stockpiled in the resource areas or buffer zone while awaiting disposal.

Sequence and execution of work shall ensure minimal compaction and heavy equipment moving over placed planting soil. If heavy equipment is required to travel over existing wetland soils, wood mats shall be placed to minimize impacts. Upon acceptance of final grades, no heavy equipment shall travel across mitigation areas or adjacent wetland resource areas.

The finished grade shall be at an elevation that will provide a hydrologic connection between the replacement area and adjacent resource areas. The hydrologic connection should be in keeping with restoring the intended function of the replacement wetland. The Contractor shall verify that this elevation is not at a level that could alter the hydrology of an adjacent wetland.

Mitigation Area Planting:
Planting in Mitigation Areas shall conform to SECTION 771 PLANTING TREES, SHRUBS AND GROUNDCOVER of the Division I Standard Special Provisions and as amended below.

Planting shall be overseen by the Wetland Specialist. Mitigation Areas shall be planted in the dry and according to the planting details within the range of target elevations and at the spacing shown on the Plans. If Mitigation Area includes more than one planting zone, the Wetland Specialist shall flag out limits prior to planting. Plants shall be installed. Discrepancies shall be resolved by the Engineer in consultation with the Wetland Specialist and MassDOT Landscape Design Section.

Plant material shall be installed as soon as possible after delivery. Plants stored on-site prior to installation shall be maintained in acceptable condition as described in materials section. Plants showing signs of stress or compromised health may be rejected by the Engineer or Wetland Specialist with replacement at the Contractor's expense.

Mitigation Performance Standards:
The Contractor shall fulfill the following minimum Mitigation Performance Standards for the Mitigation Areas within a Planting Guarantee Period of two (2) full growing seasons. Monitoring shall be performed by the Wetland Specialist according to Item 755.7 WETLAND SPECIALIST.

1. The target elevations for Mitigation Areas and planting types have been met and maintained. A minimum of 90 percent of each wetland mitigation area must meet desired hydrology. Areas that are too high or too low should be identified along with suggested corrective measures.
2. Establish at least 80 percent uniform cover of the intended herbaceous wetland plant community.
3. Establish at least 95 percent of woody plants installed.

Plant species listed as invasive by Massachusetts Invasive Plant Advisory Group (MIPAG) and the USACE – New England District shall be identified as such in the monitoring reports and corrective measures taken to control them within the limits of the Mitigation Areas for the duration of the Planting Guarantee Period.

If at the end of the Planting Guarantee Period, the Mitigation Performance Standards have not been met according to the monitoring report, the Contractor shall provide corrective measures and install replacement plant material to achieve the required establishment. All costs associated with achieving the Mitigation Performance Standards through the Planting Guarantee Period shall be incidental to this item.

As-Built Drawings:
Following acceptance of the planting by MassDOT, as-built drawings of the Wetland Mitigation Areas shall be surveyed and prepared by the Contractor for use by the Wetland Specialist as per the USACE - New England District's Compensatory Mitigation Guidance. As-built drawings shall be prepared at a clearly legible scale including 1-ft. contours and polygons outlining each wetland mitigation area. The as-built drawings shall serve to confirm that area requirements have been met and as the base map for mitigation monitoring. The as-built drawings shall be provided in printed paper format (full size 30" x 42" sheets, unless otherwise directed) as well as Portable Document Format (e.g., Adobe PDF) and AutoCAD files on compact disk. As-built drawings shall be completed within 30 days of acceptance of initial wetland mitigation planting.

Monitoring and Maintenance:
Monitoring shall be performed by the Wetland Specialist in order to ensure compliance with the Mitigation Performance Standards. Monitoring methods and report content shall conform to the Wetland Mitigation Report as approved by the regulatory agencies. The monitoring schedule shall be as per Item 755.7 WETLAND SPECIALIST. Work performed by the Wetland Specialist shall be according to and paid for under Item 755.7 WETLAND SPECIALIST.

Based on monitoring results and as directed by the Engineer in consult with the MassDOT Landscape Design Section, the Contractor shall make corrective measures to achieve compliance with the Mitigation Performance Standards. All plants not showing satisfactory evidence of establishment during the Planting Guarantee Period shall be replaced within the appropriate planting window. Unsatisfactory plants shall be removed and replaced along with dead and missing plants. All maintenance shall be incidental to this item.

METHOD OF MEASUREMENT AND BASIS OF PAYMENT

Basis of Payment

Within 10 days of the award of the contract, the Contractor shall submit, in duplicate, for approval by the Engineer, a schedule of quantities and unit prices for the major components of the Mitigation Areas as listed on the following table. The cost of labor and materials for any item not listed but required to complete the work under this item shall be considered incidental to the item and no further compensation will be allowed.

Item Component	Quantity BVW	Unit	Unit Price	Amount
Excavation	25	CY		
Planting soil	25	CY		
Compost Topsoil	65	SY		
Bordering Vegetated Wetland Seeding	65	SY		
Highbush Blueberry (*Vaccinium corymbosum*) 18”-24”	13	EA		
Silky Dogwood (Cornus amomum) 18”-24”	10	EA		
Summersweet (Clethra alnifolia) 18”-24”	10	EA		

Work for Item 755.3 NON-TIDAL WETLAND MITIGATION AREAS shall be measured and paid at the contract bid price per LUMP SUM, which price shall include full compensation for work herein.

Such payment shall be considered full compensation for all labor, tools, equipment, materials, travel and incidentals necessary to complete the work as described herein and in a manner satisfactory to the Engineer. No separate payment will be made for restoration of temporarily impacted areas, but all costs in connection therewith shall be included in the Contract bid price.

PAYMENT SCHEDULE
75 percent paid upon acceptance of initial planting
25 percent paid at end of second growing season.

ITEM 755.7 WETLAND SPECIALIST HOUR

The Contractor shall retain the services of a Coastal Ecologist, Wetland Scientist, Wetland Ecologist, Restoration Ecologist, or other professional with similar qualifications hereafter referred to as the Wetland Specialist. The Wetland Specialist shall possess the knowledge and expertise to coordinate and oversee all work associated with wetland replication as defined herein, as shown on the Plans and as in Item 755.3 NON-TIDAL WETLAND MITIGATION.

The Wetland Specialist shall serve as an expert advisor to the Engineer and report directly to the Resident Engineer.

QUALIFICATIONS

The Wetland Specialist shall have a minimum of five (5) years' experience in successful construction and monitoring of wetland mitigation areas that is similar to the project. The Wetland Specialist shall be thoroughly versed in the Commonwealth of Massachusetts Wetlands Protection Act (MGL C.131, s.40); U.S. Army Corps of Engineers New England District Compensatory Mitigation Guidance; and all other relevant regulations of the Massachusetts Department of Environmental Protection and the U.S. Army Corps of Engineers - New England District.

SUBMITTALS

Within sixty (60) days following the Notice to Proceed, the Contractor shall furnish proof of qualifications for the Wetland Specialist to the Engineer for approval in consult with the MassDOT Landscape Architect.

Proof of qualifications shall include, but not be limited to, the following items:

a. Narrative describing company, its expertise, technical qualifications and experience with wetland construction.
b. Resumes of individuals who will perform the work, if different from company description.
c. At least three (3) references from prior work of a similar nature that was completed in last five (5) years by the individuals who will perform the work. Provide contact information for each reference including address, phone number and email.
d. Provide a summary of each of reference project including nature of the work, project size, dates and period of construction and monitoring, methodologies used, and summary of success or not in terms of meeting performance objectives.
e. Provide a minimum of one before and one after photo for each reference project.
f. Provide a minimum of one complete set of monitoring reports for a similar project including a Final Assessment Report as per the U.S. Army Corps of Engineers New England District Compensatory Mitigation Guidance.

SCOPE OF WORK

The Wetland Specialist shall be responsible for oversight and monitoring of work associated with Item 755.3 NON-TIDAL WETLAND MITIGATION including, but not limited to, the following tasks:

- Review environmental permits relevant to wetland replication and ensure compliance through the duration of the contract.
- Evaluate site and conditions prior to construction. Identify and inform the Engineer of

unique site conditions that could require adjustments to the schedule, design or construction methods. For example, wildlife nesting, illegal dumping or presence of invasive plant species.

- Review suitability of material submittals prior to submission to the Engineer with copies to MassDOT Landscape Architect.
- Participate in site meetings as outlined in Item 755.3 NON-TIDAL WETLAND MITIGATION.
- Review erosion controls (within the Mitigation Areas only), monitor construction impacts to adjacent areas and regulated wetland resources.
- Provide updates at project milestones according to Item 755.3 NON-TIDAL WETLAND MITIGATION.
- Perform digital photo documentation through the duration of the contract and submit a photo archive on compact disk upon completion.
- Perform site observations at least two times during the growing season in late spring/early summer and again in late summer/early fall.
- Submit annual monitoring reports in the format provided in the US Army Corps of Engineers - New England District: Compensatory Mitigation Guidance.
- Make written recommendations on maintenance and corrective measures following each site observation in order to achieve the Mitigation Performance Standards.

The Wetland Specialist shall be responsible for oversight and approval of, including but not limited to, the following activities in coordination with the Contractor and Engineer.

- Location and boundaries of wetland replication area, location of tree protection associated with the wetland replication areas, limits of clearing and limits of work in the replication areas
- Installation and removal of erosion controls
- Target elevations and grade stakes prior to excavation
- Final grades prior to planting and/or seeding
- Flagging wetland plant locations prior to installation
- Planting installation and/or seeding procedures.
- Removal of perimeter controls, such as goose fence

Monitoring reports shall be submitted no later than November 1 of each monitoring period. For each project update and monitoring report, submit one (1) printed copy and a digital copy in Portable Document Format (e.g., Adobe PDF) to the Engineer for distribution to the MassDOT Landscape Architect, MassDOT Environmental Services, U.S. Army Corps of Engineers, National Marine Fisheries Service (Habitat Conservation) and the US Environmental Protection Agency. All reports shall be marked with the applicable permit numbers and identifying information as required in the permits.

<u>Monitoring:</u>
Monitoring will be performed for the wetland replication areas in order to ensure satisfactory plant establishment and compliance with the Mitigation Performance Standards as defined in Item 755.3 NON-TIDAL WETLAND MITIGATION and as defined in the Wetland Mitigation Report approved by the US Army Corps of Engineers.

Plant species listed as invasive by Massachusetts Invasive Plant Advisory Group (MIPAG) and

the USACE – New England District shall be identified as such in the monitoring reports and corrective measures taken to control them within the limits of the wetland mitigation areas for the duration of the contract. The definition of invasive plant species referred to herein shall be as defined by Massachusetts Invasive Plant Advisory Group (MIPAG) and classified as Invasive, Likely Invasive or Potentially Invasive according to their current classification lists. MIPAG link: http://www.massnrc.org/MIPAG/

Invasive plant species shall also include those listed by the USACE New England District.

As per the monitoring schedule, the Wetland Specialist shall complete and submit a monitoring report detailing the relative success of the replication areas and make recommendations for maintenance and/or corrective measures. According to the USACE permit conditions, a growing season starts no later than May 31. Reports shall include data sheets. Data summaries shall be cumulative in each successive report.

Monitoring report requirements shall be as outlined in the USACE New England District Compensatory Mitigation Guidance and include the following.

- Identification of all plant species present
- Quantity installed and total mortality of each target plant species
- Percent cover for each plant species and overall percent cover for replication area
- Description of health and vigor of installed target species as well as volunteer plant species within the replication areas
- Changes in site conditions including topography, such as erosion, gullies, shifting or accretion of sediment, and hydrology, such as ponding, damming, breaches or other observed changes in water levels
- Condition of perimeter controls (such as goose fence) and erosion controls
- Evidence of pests, disease and invasive plant species
- If invasive plant species are identified in replication areas, measure and map approximate area of establishment for each species
- Photo documentation with date and time stamped photos
- Visual observations of fauna using or in the vicinity of the site at the time of monitoring
- Any other information required by permits, Massachusetts DEP and U.S. Army Corps of Engineers regulations and requirements.

Monitoring Report & Schedule:

1. End of First Growing Season

At the end of the first full growing season before plants enter dormancy, typically in September, inspect to document the monitoring parameters defined above.

2. End of Second Growing Season

At the end of the second growing season before plants enter dormancy, typically in September, inspect to document the monitoring parameters defined above.

Monitoring Report Appendices:

Appendix A: Soil profile description shall be provided from within wetland mitigation areas.
Appendix B: A vegetative species list of colonizing species in each plant community type. The volunteer species list shall include those that cover at least 5% of their vegetative layer.

Appendix C: Representative photos taken from the same locations for each monitoring event. Photos shall be dated and clearly labeled with the direction from which the photo was taken.

Maintenance Requirements:
Wetland replication shall show satisfactory establishment as defined according the Mitigation Performance Standards in Item 755.3 NON-TIDAL WETLAND MITIGATION. The Contractor shall be responsible for maintenance and replacement according to those items. Corrective measures requiring earth movement or changes in hydrology shall not be implemented without written approval from the Corps to MassDOT.

Maintenance of wetland mitigation areas shall include replacement of dead or missing plant material, maintaining goose fence in effective and satisfactory condition, maintaining compost filter tubes in functioning condition, removal of debris within and around perimeter of mitigation area, correcting erosion or gullies.

Based on monitoring results, plants that have not shown satisfactory evidence of establishment shall be replaced and corrective measures taken. Dead or missing plants shall be replaced within the next appropriate planting window.

If at the end of the second growing season and upon acceptance of the monitoring report, the Mitigation Performance Standards have not been met and the Contractor is required to perform corrective measures, the Wetland Specialist shall be compensated for work ordered.

The permits require a total of five-years monitoring of mitigation areas. MassDOT shall be responsible for fulfilling the permitting requirements beyond the end of the second growing season. The post-construction Final Wetland Assessment monitoring report to be submitted to the applicable regulatory agencies at the end of the fifth growing season is not included in the scope of this item.

Method of Measurment

The work described under this item shall be measured per HOUR. The basis for measurement is as follows:
1. Permit Review\ Site Assessment\Construction Oversight - 24 Hours
2. 1st year Spring and Fall field observation\Spring Update\Monitoring Report - 8 Hours
3. 2nd year Spring and Fall field observations\Spring Update\ Monitoring Report – 8 hours

Basis of Payment

The work described under this item shall be measured and paid at the contract unit price per HOUR, which price shall include labor, tools, equipment, materials, travel and incidentals necessary to complete the work as described herein and in a manner satisfactory to the Engineer.

ITEM 756. NPDES STORM WATER POLLUTION PREVENTION PLAN LUMP SUM

This Item addresses the preparation and implementation of a Storm Water Pollution Prevention Plan required by the National Pollutant Discharge Elimination System (NPDES) and applicable Construction General Permit (CGP) issued by the U.S. Environmental Protection Agency (EPA).

Pursuant to the Federal Clean Water Act, construction activities which disturb one acre or more are required to apply to the EPA for coverage under the NPDES General Permit for Storm Water Discharges from Construction Activities. On February 16, 2012 (77 FR 12286), EPA issued the final NPDES Construction General Permit (CGP) for construction activity. The Contractor shall be fully responsible for compliance with the CGP. Should a fine or penalty be assessed against it, or MassDOT, as a result of a local, state, or federal enforcement action due to non-compliance with the CGP, the Contractor shall take full responsibility.

The NPDES CGP requires the submission of a Notice of Intent (NOI) to the EPA prior to the start of construction (defined as any activity which disturbs land, including clearing and grubbing). There is a 14 day review period commencing from the date on which EPA enters the Notice into their database. The Contractor is advised that, based on the review of the NOI, EPA may require additional information, including but not limited to, the submission of the Storm Water Pollution Prevention Plan (SWPPP) for review. Work may not commence on the project until final authorization has been granted by EPA. Any additional time required by EPA for review of submittals will not constitute a basis for claim of delay.

In addition, if the project discharges to an Outstanding Resource Water, vernal pool, or is within a coastal ACEC as identified by the Massachusetts Department of Environmental Protection (DEP), a separate notification to DEP is required. DEP may also require submission of the Storm Water Pollution Prevention Plan for review and approval. Filing fees associated with the notification to DEP and, if required, the SWPPP filing to DEP shall be paid by the Contractor.

The CGP also requires the preparation and implementation of a SWPPP in accordance with the afore-mentioned statutes and regulations. The Plan will include the CGP conditions and detailed descriptions of controls of erosion and sedimentation to be implemented during construction. It is the responsibility of the Contractor to prepare the SWPPP to meet the requirements of the most recently issued CGP. The Contractor shall submit the Plan to the Engineer for approval at least 4 weeks prior to any site activities. It is the responsibility of the Contractor to comply with the CGP conditions and the conditions of any state Wetlands Protection Act Order, Water Quality Certification, Corps of Engineers Section 404 Permit and other environmental permits applicable to the project and to include in the SWPPP the methods and means necessary to comply with applicable conditions of said permits (reference to Part 9.1.1 of the 2012 CGP).

It is the responsibility of the Contractor to complete the SWPPP in accordance with the EPA CGP, provide all information required, and obtain any and all certifications as required by the CGP. Any amendments to the SWPPP required by site conditions, schedule changes, revised work, construction methodologies, and the like are the responsibility of the Contractor. Amendments will require the approval of the Engineer prior to implementation.

Included in the CGP conditions is the requirement for inspection of all erosion controls and site conditions on a weekly basis as well as after each incidence of rainfall exceeding 0.25 inches in twenty-four hours. For multi-day storms, EPA requires that an inspection must be performed during or after the first day of the event and after the end of the event. The CGP requires that inspections be performed by a qualified individual. MassDOT requires proof of completion of a 4 hour minimum sedimentation and erosion control training class current to the latest CGP. This individual can be, but not limited to, someone that is either a certified inspector, certified professional, or certified storm water inspector. The documentation shall be included as an

appendix in the SWPPP. The Engineer must approve the contractor's inspector. This individual shall be on-site during construction to perform these inspections. In addition, if the Engineer determines at any time that the inspector's performance is inadequate, the Contractor shall provide an alternate inspector. Written weekly inspection forms, storm event inspection forms, and Monthly Summary Reports must be completed and provided to the Engineer. Monthly Summary Reports must include a summary of construction activities undertaken during the reporting period, general site conditions, erosion control maintenance and corrective actions taken, the anticipated schedule of construction activities for the next reporting period, any SWPPP amendments, and representative photographs.

The Contractor is responsible for preparation of the Plan, all SWPPP certifications, inspections, reports and any and all corrective actions necessary to comply with the provisions of the CGP. Work associated with performance of inspections is not included under this Item. The Standard Specifications require adequate erosion control for the duration of the Contract. All Control measures must be properly selected, installed, and maintained in accordance with manufacturer specifications and good engineering practices. If periodic inspections or other information indicates a control has been used inappropriately or is no longer adequate, it is the responsibility of the Contractor to replace or modify the control for site conditions at no additional cost to the Department. The Contractor must maintain all control measures and other protective measures in effective operating condition and shall consider replacement of erosion controls for each construction season.

This Item addresses acceptable completion of the SWPPP, any revisions/amendments required during construction, and preparation of monthly reports. In addition, any erosion controls beyond those specified in bid items elsewhere in this contract which are selected by the Contractor to facilitate and/or address the Contractor's schedule, methods and prosecution of the work shall be considered incidental to this item.

The Contractor is advised The CGP provides specific requirements for temporary and final stabilization. This shall be incorporated into the project schedule. The permit defines specific deadline requirements for Initial Stabilization ("immediately", i.e., no later than the end of the next work day following the day when earth-disturbing activities have temporarily or permanently ceased) and for Complete Stabilization Activities (no later than 14 calendar days after the initiation of stabilization). Stabilization criteria for vegetative and non-vegetative measures are provided in the CGP.

The CGP requires the submission of a Notice of Termination (NOT) from all operators when final stabilization has been achieved, as well as removal and proper disposal of all construction materials, waste and waste handling devices, removal of all equipment and construction vehicles, removal of all temporary stormwater controls, etcetera. Approval of final stabilization by the Engineer and confirmation of submission of the NOT will be required prior to submission of the Resident Engineer's Final Estimate. The permittee is required to use EPA's electronic NOI system or "eNOI system" to prepare and submit NOT. The electronic NOT form can be found at www.epa.gov/npdes/stormwater/cgpenoi. If you are given approval by the EPA Regional Office to use a paper NOT, you must complete the form in Appendix K of the 2012 CGP.

COMPENSATION

Payment for all work under this Item shall be made at the contract unit price, lump sum, which

shall include all work detailed above, including plan preparation, required revisions, revisions/addenda during construction, monthly reports and filing fees.

Payment of 50% of the contract price shall be made upon acceptance of the Storm Water Pollution Prevention plan. Payment of 40% of the contract price shall be made in equal installments for implementation of the Stormwater Pollution Prevention plan. Payment of the final 10% of the contract price shall be paid upon satisfactory submissions of a Notice of Termination (NOT) when final stabilization has been achieved.

ITEM 765.31 BASIN SEEDING MIX SQUARE FOOT

Work under this Item shall conform to the relevant provisions of Section 765, "Seeding" of the MassDOT Standard Specifications for Highways and Bridges, supplemental specifications and details thereto and the following:

DESCRIPTION

The following seed mix shall be used in the proposed water quality swale areas indicated on the Plans and as directed by the Engineer.

MATERIALS

Samples and Submittals
At least 30 days prior to ordering, the Contractor shall submit to the Engineer seed packing certificates with source and date, as well as material specifications for all mulch materials. No material shall be ordered until submittals have been approved by the Engineer. Delivered materials shall match approved materials.

Seed shall be brought to the site in unopened bags for approval by the Engineer. Engineer shall collect certification from bag prior to opening bag and prior to any seeding activity. Certification list shall match species and approximate percentages listed herein or as recommended by the supplier. Species substitutions shall be approved by the MassDOT Landscape Design Section (617) 973-7738. Seeding without approval of the Engineer shall be considered unacceptable for payment.

A manufacturer's Certificate of Compliance shall be submitted with each seed shipment. These Certificates shall include the guaranteed percentages of Pure Live Seed, based on purity and germination rates, as well as the net weight, harvest, and shipment dates.

Quantities specified are Pure Live Seed (PLS). Greater quantities of ordered seed may be required to achieve actual specified seeding rates. Pure Live Seed is defined as the fraction of pure seed species within the mix that, by standard seed testing practices, will germinate. This is determined by multiplying the percent of seed purity by the percent of seed germination.

Seed Mixes
Submittals for approval must list actual percentages.

Rate of application shall be 35 lbs/acre:

	Botanical Name	Common name	% PLS By Weight
Grass			
	Schizachyrium scoparium	Little Blue Stem	25.0%
	Elymus virginicus	Virginia Wild Rye	23.0%
	Festuca rubra	Creeping Red Fescue	15.0%
	Andropogon gerardii	Big Bluestem	12.0%
	Panicum virgatum	Shelter Switch Grass	8.0%
	Carex vulpinoidea	Fox Sedge	3.0%
	Agrostis alba	Redtop	2.0%
	Scirpus atrovirens	Green Bulrush	1.0%
	Scirpus cyperinus	Woolgrass	0.5%
	Juncus effusus	Soft Rush	0.5%
			90.0%
Herb/Forb			
	Verbena hastata	Blue Vervain	5.0%
	Eupatorium perfoliatum	Boneset	2.0%
	Symphyotrichum novae-angliae	New England Aster	2.0%
	Euthamia graminifolia	Grass-leaved Goldenrod	1.0%
			10.0%
		Total	**100.0%**

Any species substitutions shall be with a species having similar characteristics and native to New England. Substantial changes in the mix shall be approved by MassDOT Landscape Design Section.

Fertilizer
No fertilizers shall be applied.

Water
Water, including hose and all other watering equipment required for the work, shall be furnished by the Contractor to the site at no extra cost. Water shall be suitable for irrigation and free from ingredients harmful to plant life. All plants injured or work damaged due to the lack of water or the use of too much water shall be the Contractor's responsibility to correct.

CONSTRUCTION METHODS

Soil preparation and seeding shall occur only when the bed is in a friable condition, not muddy or hard. Do not seed when ground is wet or water is visible. The Contractor shall notify the Engineer of the presence of high groundwater before proceeding with seeding.

Bare soil shall be seeded within 3 days of excavation or placement.

Seeding seasons shall be May 1- June 15 and August 15-October 15. Seeding that occurs outside

of this period shall be overseeded per these specifications during the next season, at no additional cost to the department.

Loam Borrow and Screened Loam Borrow shall be installed and paid for according Section 751, LOAM BORROW.

For all seeded areas the Contractor will notify the Engineer and arrange for inspections at the following times:

A. Before seeding, after loam has been spread and amendments have been incorporated.
B. During hand seeding operations
C. Upon completion of hand seeding operations to establish the Maintenance Period.
D. End of Maintenance Period to determine Acceptance of Work

For all top-dressed areas the Contractor will notify the Engineer and arrange for inspections when:

A. When overseeding is complete to establish a Maintenance Period.
B. End of maintenance period to determine Acceptance of Work.

SURFACE PREPARATION AND SEEDING OF BARE SOILS

Bare soils shall be raked to remove large stiff clods, lumps, brush, roots, stumps, litter and other foreign matter. All depressions caused by settlement or rolling shall be filled with additional loam or compost and the soil shall be re-graded and rolled until presenting a firm, smooth and even finish corresponding to the required grades. No tracking or rolling shall be done on wet soil. Contractor shall obtain Engineer's written approval of fine grading and bed preparation before doing any seeding.

Seeding in Combination with Compost

Seeding shall be done after placement of Composted has been approved by the Engineer. Contractor shall notify Engineer prior to seeding operation. Application method shall be per Section 765. of the Standard Specifications.

Alternatively, compost and seed may be applied in one operation using equipment designed for this application. Equipment must be approved by Engineer. If seeding and composting are done as one operation, seed rate specified above shall be increased by 50%.

Seeding Methods

Hydroseeding: Hydroseeding shall be per the Standard Specifications and per the manufacturer's directions.

Mulch for hydroseeding shall be wood fiber only.

Broadcast Seeding: Seed may be broadcast by using a cyclone or whirlwind seeder, or by hand. If spread by hand, small or light-seeded species such as bluestem may be mixed with filler (e.g., sawdust, rice, kitty litter, or clean washed sand) to achieve an even distribution. Seed shall be applied in two directions, each perpendicular to one another. One-half the seeding rate shall be applied in each direction. Seed shall be incorporated 1/8 to 1/4-inch deep by raking or dragging,

cultipacking, or tracking with heavy machinery. Raked areas shall be rolled with a weighted roller to provide good seed to soil contact. Do not roll or track the seed if the soil is wet.

Upon completion of broadcast seeding and packing, or within 24 hours, straw mulch or dry pelletized mulch shall be hand broadcast uniformly over the entire planting area. Straw mulch shall be free of weed seeds and shall be applied at a uniform rate of 1500 lbs/acre.

OVERSEEDING

Overseeding shall include top-dressing and overseeding of existing grassed areas within the contract area. Areas to be overseeded will include existing grass, areas of failed grass, and areas that were seeded out of season. Overseeding for failed or out-of-season areas, as determined by the Engineer, shall be incidental to the satisfactory completion of seeding and shall not be paid for separately.

Contractor shall top dress all overseeded areas ¼ inch to ½ inch of compost. Compost shall be watered with a fine mist to ensure proper settlement of compost material. Contractor shall obtain Engineer's written approval of top-dressing of compost before doing any seeding. Seed only when the top-dressed bed is in a friable condition, not muddy or hard.

Application rates for overseeding shall be the same as those listed under Seed Mixes. To ensure seed-to-soil contact, areas with existing grass shall be seeded using a broadcast method, rather than hydraulic method. Seed may be mixed with damp sand to ensure adequate distribution. Broadcast seeding shall be undertaken in two separate passes at ninety degrees to each other. Water seeded areas with a fine mist to ensure firm contact with soil and moisten soil to a depth of at least 2 inches.

ESTABLISHMENT

Establishment shall begin immediately after any area is seeded, mulched, and erosion control matting (if used) is in place, and shall continue for a minimum of 60 days active growing period following the completion of all grass installation work and until final acceptance of the project. In the event that seeding operations are completed past October 1, then Establishment shall continue into the following spring and reseeding shall take place as necessary at that time.

The Contractor shall provide all labor and water required for establishment. Contractor shall water all seeded areas as necessary during Establishment period to ensure uniform soil moisture to a depth of 2 inches or greater. Watering shall provide uniform coverage without eroding soil or grassed surfaces. Establishment shall include placement and resetting of protective barriers as required.

Maintenance and monitoring shall begin concurrently with Establishment period. Maintenance will include all necessary watering, repair, and reseeding to ensure establishment of perennials and grasses. Maintenance shall also include monitoring for invasive species. Any invasive species shall be immediately removed. All plant remains, including roots and shoots, shall be appropriately disposed off-site.

INSPECTION AND ACCEPTANCE OF WORK

A satisfactory stand of grasses, as determined by the Engineer or MassDOT Landscape Architect

shall be required for acceptance. Seeded areas shall have a close stand of grass with no weeds present and no bare spots greater than 6 inches in diameter. At least 95 percent of the grass established shall be permanent grass species. At the time of acceptance, the Contractor shall remove temporary barriers used to protect grassed areas. Absolutely no debris may be left on the site.

All areas and parts of areas which, in the opinion of the Engineer, fail to show a uniform stand of grass, for any reason whatsoever, shall be reseeded by a method approved by the Engineer and during an approved season. Reseeding shall be repeated until all areas are covered with a satisfactory growth of grass. All reseeding, together with necessary re-grading, soil amendment and erosion control, shall be done at the expense of the Contractor.

COMPENSATION

Basin seeding mix will be measured for payment by the square yard, complete in place. Measurement shall not include any overlap.

Basin seeding mix will be paid for at the Contract unit price per square yard, which price shall include all labor, materials, equipment and incidental costs required to complete the work.

ITEM 767.12 COMPOST FILTER TUBE FOOT

The purpose of this item is to provide a linear, compost-filled tube for filtering suspended sediments from storm water flow. This item shall conform to the requirements of Section 751 and 767 of the Standard Specifications and the following:

MATERIALS

Material for the filter tubes shall be compost meeting M1.06.0, except that no manure or bio-solids shall be used. In addition, no kiln-dried wood or construction debris shall be allowed. Particle size analysis: 98% shall pass through a 3 inch sieve; 30-50% shall pass 3/8 inch sieve.

Tubes for compost filters shall be a minimum of 12 inches, a maximum of 18” in diameter. Tube material shall be a knitted mesh with 1/8” - 3/8” openings, and made of biodegradable (cotton or jute) materials. **Photodegradable fabric may be used; however, photodegradable fabric must be removed and disposed of by the contractor, at his expense, at the end of the contract.** Additional tubes shall be used at the direction of the Engineer.

As shown in the detail, the 1 foot wide by 2 inch deep wedge of compost spread along the top of the filter tube shall be incidental to this item. Stakes for anchors, if required, shall be nominal 2 x 2 stakes.

CONSTRUCTION METHODS

Tubes of compost may be filled on site or shipped. Tubes shall be placed, filled and staked in place as required to ensure stability against water flows. All tubes shall be tamped to ensure good contact with soil. The Contractor shall ensure that the filter tubes function as intended at all times. Tubes shall be inspected after each rainfall and at least daily during prolonged rainfall.

The Contractor shall immediately correct all deficiencies, including, but not limited, to washout, overtopping, clogging due to sediment, and erosion. The Contractor shall review location of tubes in areas where construction activity causes drainage runoff to ensure that the tubes are properly located for effectiveness. Where deficiencies exist, such as overtopping or wash-out, additional staking or compost material shall be installed as directed by the Engineer. Contractor shall remove sediment deposits as necessary to maintain the filters in working condition.

The functional integrity of filter tubes shall be maintained in sound condition at all times. Filter tubes that are decomposing, cut, or otherwise compromised shall be repaired or replaced as directed by the Engineer and be incidental to this item.

Filter tube fabric and stakes shall be removed by the Contractor when site conditions are sufficiently stable to prevent surface erosion, and after receiving permission to do so from the Engineer. All biodegradable tube fabric shall be cut and laid flat in place to decompose on-site at the direction of the Engineer. Tube fabric that is not decomposing satisfactorily shall be removed and disposed off-site by the Contractor. At the direction of the Engineer, the Contractor may rake out and seed compost so that it is no greater than 2 inches in depth on soil substrate.

COMPENSATION

Compost filter tubes will be measured for payment by the foot installed, complete in place. Measurement shall not include any overlap.

Compost filter tubes will be paid for at the Contract unit price per foot, which price shall include all labor, materials, equipment and incidental costs required to complete the work. No separate payment will be made for stakes and tube fabric, compost mulch wedge along top of tubes, removal and disposal of fabric and stakes, raking and seeding of compost, but all costs in connection therewith shall be included in the Contract unit price bid.

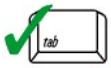
APPENDIX D
STORMWATER MANAGEMENT REPORT

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.

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

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

COMMONWEALTH OF MASSACHUSETTS
CHRISTER ERICSSON
CIVIL
No. 38429
REGISTERED PROFESSIONAL ENGINEER

11/7/16

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): Leaching Structures

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 for Stormwater Report

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 for Stormwater Report

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 for Stormwater Report

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 for 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 for 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.

CITY OF HAVERHILL
RECONSTRUCTION OF BROADWAY (ROUTE 97)

PROPOSED DRAINAGE AND STORMWATER MANAGEMENT PLAN

PREPARED BY:
GREENMAN-PEDERSEN, INC.
181 BALLARDVALE STREET, SUITE 202
WILMINGTON, MA 01887

November, 2016

TABLE OF CONTENTS

Section	Page
TABLE OF CONTENTS	1
PROJECT DESCRIPTION	2
REGULATORY REQUIREMENTS	2
STORMWATER MANAGEMENT DESCRIPTION	3
STORMWATER MANAGEMENT STANDARDS	5

LIST OF APPENDICES

HydroCAD Analysis

Drainage Network Calculations

Cross Culvert Sizing

Leaching Structure Recharge System Sizing Calculations

Hydrologic Soil Group Map

Water Quality Swale BMP Design Data

Operation and Maintenance Plan

NPDES Phase II Small MS4 General Permit Annual Report (2014)

PROJECT DESCRIPTION

This project involves the reconstruction of Broadway (Route 97) in the City of Haverhill from Silver Birch Lane to Research Drive in Haverhill, Massachusetts, for a distance of approximately one mile.

The project will improve safety and capacity at Broadways (Route 97) intersections with Lake Street, West Meadow Road and Forest Street. New traffic signal equipment as well as exclusive left turn lanes will be incorporated into the corridor.

The proposed improvements also include full depth pavement reconstruction, mill and overlay of existing pavement, realignment of the existing edge of pavement, minor widening, shoulder construction, new signage and pavement markings. The existing sidewalks, where present, will be removed and replaced with cement concrete sidewalks constructed to Americans with Disabilities Act (ADA) requirements. New sidewalks will be constructed on both sides of the street throughout the project, with grass strips of varying widths where Right of Way allows. Wheelchair ramps will be constructed at street intersections along the project corridor. All wheelchair ramps and crossings will conform to ADA requirements.

REGULATORY REQUIREMENTS

The Massachusetts Department of Environmental Protection (MassDEP) issued the Stormwater Policy that established Stormwater Management Standards aimed at encouraging recharge and preventing stormwater discharges from causing or contributing to the pollution of surface waters and ground waters of the Commonwealth. The Stormwater Management Standards were incorporated into the Wetlands Protection Regulations, 310 CMR 10.05:(6)(b) and defined at 310 CMR 10.05:(6)(k) through (q). The project is subject to the Stormwater Standards.

The Stormwater Managements Standards allow projects to be classified as one of three types, new development, redevelopment, or a combination of new and redevelopment. New projects must meet the Stormwater Management Standards to the full extent, and redevelopment projects must meet specific Standards to the maximum extent practicable, comply with all other requirements of the Stormwater Management Standards and improve existing conditions.

Maintenance and improvement of existing roadways, including widening less than a single lane, adding shoulders, correcting substandard intersections, improving existing drainage, and repaving are defined as redevelopment projects in the Standards. The Standards shall also apply to the maximum extent practicable for “Footpaths, bikepaths and other paths for pedestrian and/or nonmotorized vehicle access”.

The project will result in an increase of 40,205 SF of impervious surface, primarily due to the construction of paved shoulders, new sidewalks and widening at intersections for new

signals and turn lanes. This project shall be considered a "Redevelopment" project and will meet the stormwater standards to the maximum extent practicable.

STORMWATER MANAGEMENT DESCRIPTION

EXISTING STORMWATER MANAGEMENT

The existing stormwater management within the Broadway (Route 97) project consists of a system of curb and open inlets that collects stormwater runoff from the roadway and adjacent streets and properties. There are six separate closed drainage systems within the project, two cross culverts, private closed drainage and overland flow. One of the cross culverts functions as a discharge for one of the closed drainage systems. Runoff captured by the inlets is conveyed through closed pipe networks that discharge adjacent to the roadway or adjacent property, or continue off the project area, such as down Lake Street. The flow west of West Meadow Road flows south through adjacent wetlands to West Meadow Brook, while the runoff east of West Meadow Road is discharged north through adjacent wetlands to Creek Brook. West Meadow Brook discharges to Creek Brook southeast of the project site. Creek Brook continues south and flows into the Merrimack River.

PROPOSED STORMWATER MANAGEMENT

Stormwater runoff discharges from the project will continue to discharge at 6 outfalls as well as an additional outfall that convey the runoff from the project site. Drainage & Utility Plans for the project are provided in the NOI. With the exception of limited locations, the existing drainage structures and piping shall be replaced. All new catch basins with 4-foot deep sumps will be installed to replace existing catch basins and remove catch basin to catch basin connections. One discharge location will be relocated to eliminate a drainage easement through adjacent property. Leaching basins are proposed to be installed throughout the project limits. A portion of the stormwater runoff will be diverted to a proposed water quality swale. The water quality swale is designed to treat the diverted runoff before either recharging the groundwater or discharging back to the closed pipe drainage system to Creek Brook.

The following are descriptions of 5 analyzed drainage networks. These networks combine the proposed 7 outfalls. HydroCAD analysis and pipe sizing calculations for each Network and trunkline are provided in the Appendix.

<u>Drainage Network 1</u>

This drainage network collects stormwater runoff from Silver Birch Lane as well as Coolidge Lane and Broadway. The network extends to the east to the west side of the Glenview Road/Broadway intersection. While the existing drainage systems in the side streets shall remain, the closed drainage system within Broadway will be replaced.

Drainage Network 2

This drainage network collects stormwater runoff from Glenview Road and Broadway, and extends to the east to Lake Street. While the location and inverts of the outfall remain the same, all piping and structures within Broadway will be replaced.

Drainage Network 3

This drainage network collects stormwater runoff along Broadway from Lake Street to the roadway highpoint between Heritage Farm Road and Sara J Circle. The system also collects runoff from Heritage Farm Road. This network continues down Lake Street to outfall at West Meadow Brook. Almost all catch basins along Broadway will be replaced with deep sump catch basins and two leaching structures will be installed at Heritage Farm Road. Most of the manholes and larger pipe diameters will be retained and reused.

Drainage Network 4

This drainage network collects stormwater runoff along Broadway from the roadway highpoint between Heritage Farm Road and Sara J Circle to West Meadow Road. The system also collects runoff from Sara J Circle. The system discharges to a ditch running parallel to West Meadow Road. The project will replace all drainage structures and pipes within Broadway and two leaching structures will be installed at Sara J Circle. The Sara J Circle system will be left in place.

Drainage Network 5

This drainage network is composed of three closed drainage systems that extend from West Meadow Road to Research Drive. All discharge to the wetlands between Broadway and Creek Brook.

The drainage system between West Meadow Road and 683 Broadway collects runoff from Spring Hill Ave, as well as private drainage, and will be completely replaced. Seven leaching structures are proposed to infiltrate runoff. A new outfall will be created and stone for pipe end installed from the outfall to the wetlands. The existing system outfalls in the wetlands by welling out of the ground. The existing outlet pipes are not visible.

The next drainage system within Network 5 extends from 683 Broadway to the Forest Street/Broadway intersection. This system will abandon an existing outfall that extends under the convenience store and replace it with a new outfall to constructed wetlands east of the Grill Next Door. This system is composed of two catch basins to a Water Quality Swale, as well as two deep sump catch basins to the relocated outfall.

The last drainage system within Network 5 collects stormwater runoff from Forest Street to Research Drive. A new outfall will be constructed adjacent to the constructed wetlands located to the north of Broadway. Currently, the runoff flows onto adjacent properties to catch basins or flows overland to the wetlands adjacent to Research Drive and Broadway. The project will redirect street runoff away from adjacent properties and outfall at the constructed wetlands.

STORMWATER MANAGEMENT STANDARDS

Standard #1: Untreated Discharges

> *No new Stormwater conveyances (e.g. outfalls) may discharge untreated Stormwater directly to or cause erosion in wetlands or waters of the Commonwealth.*

There are no proposed new outfalls located on the project. Currently, the runoff flows into closed drainage systems throughout the project, onto adjacent properties to catch basins and private systems or flows overland to wetlands adjacent to Broadway. Stormwater runoff from the project will continue to discharge to 6 existing locations. The project will redirect street runoff away from adjacent properties, reconstruct outfalls at existing outfalls or nearby locations, and move outfalls (such as to the constructed wetlands adjacent to Broadway and Research Drive). A portion of the stormwater runoff will be diverted to a proposed water quality swale. The water quality swale is designed to treat the diverted runoff before either recharging the groundwater or overflowing to Creek Brook.

Riprap (stone for pipe end) will be installed at all outlets except the two intermittent stream outlets. This riprap will prevent erosion at the outfall.

Standard #2: Peak Rate and Flood Prevention

> *Stormwater management systems shall be designed so that the 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.*

The site was reviewed to determine locations of potential Best Management Practices (BMP's). According to the Natural Resources Conservation Service Web Soil Survey, slightly more than half of the project is within Hydrologic Soils Group Type B, with the remainder in Type C/D. Wetlands are located, both horizontally and vertically, adjacent to several sections of the corridor. Seasonal high groundwater was anticipated to be very close to the surface at those locations. There are several intersections where walls were constructed adjacent to the Right-Of-Way (ROW). Due to wetlands, the limited ROW and developed adjacent property, types of BMP's and their proposed locations are limited. It was determined leaching structures and a water quality swale with sediment forebay would be the proposed BMP's.

A TR-20 analysis was performed using HydroCAD and the pre-development and post-development peak discharge rates are shown below. See the Appendix for the full HydroCad output. Due to the offline nature of the leaching structures, they are not included in the HydroCAD analysis. If included, runoff for the smaller storm events would have been reduced, however due to their small size, the leaching structures would have limited impacts on larger storm events. As this project is considered a redevelopment project, this standard must be met to the maximum extent practicable.

Drainage Network # 1 (CFS)		
Storm	Pre-Development	Post-Development
2-Year	1.62	2.75
10-Year	2.82	4.55
100-Year	5.70	8.89

Drainage Network #2 (CFS)		
Storm	Pre-Development	Post-Development
2-Year	2.05	1.56
10-Year	3.61	2.48
100-Year	7.41	4.70

Drainage Network #3 (CFS)		
Storm	Pre-Development	Post-Development
2-Year	4.15	4.64
10-Year	7.09	7.58
100-Year	14.17	14.64

Drainage Network #4 (CFS)		
Storm	Pre-Development	Post-Development
2-Year	1.79	2.12
10-Year	3.06	3.47
100-Year	6.11	6.70

Drainage Network #5 (CFS)		
Storm	Pre-Development	Post-Development
2-Year	10.90	11.96
10-Year	18.92	20.38
100-Year	38.34	40.72

Totals (CFS)		
Storm	Pre-Development	Post-Development
2-Year	20.51	23.03
10-Year	35.50	38.46
100-Year	71.73	75.65

Standard #3: Recharge to Groundwater

Loss of annual recharge to groundwater shall be eliminated or minimized through the use of management practices, and good operation and maintenance. At a minimum, the annual recharge from the post- development site shall approximate the annual recharge from predevelopment conditions based on soil type. This Standard is met when the Stormwater management system is designed to infiltrate the required recharge volume as determined in accordance with the Massachusetts Stormwater Handbook.

The project results in an increase of 40,205 SF of impervious surface. According to the Natural Resources Conservation Service Web Soil Survey, slightly more than half of the project is within Hydrologic Soils Group Type B, with the remainder in Type C/D. Assuming the increase in impervious area is proportional, 26,937 SF would be in Type B soils while 13,268 SF would be in Type C soils.

Per the Stormwater Handbook, the target depth factor for Type B soils is .35", while Type C is .25". Therefor the required recharge volume is 1,062 CF.

The 11 leaching basins and surrounding crushed stone will provide a total of 1,360 CF of storage. See leaching structure recharge system sizing calculations in the Appendix.

Therefore this standard has been satisfied.

Standard #4: TSS Removal

Stormwater management systems shall be designed to remove 80% of the average annual postconstruction load of Total Suspended Solids (TSS). This Standard is met when:

A. *Suitable practices for source control and pollution prevention are identified in a long-term pollution prevention plan, and thereafter are implemented and maintained;*
B. *Structural Stormwater best management practices are sized to capture the required water quality volume determined in accordance with the Massachusetts Stormwater Handbook; and*

C. *Pretreatment is provided in accordance with the Massachusetts Stormwater Handbook.*

The City of Haverhill Department of Public Works has filed a Notice of Intent for the NPDES Phase II Small MS4 General Permit with the Massachusetts Department of Environmental Protection and the U.S. Environmental Protection Agency, and files an Annual Report on the status of Best Management Practices (BMPs) within categories listed in the Permit. As part of the Cities compliance with the Permit, suitable practices for source control and pollution prevention measures required by a Long-Term Pollution Plan are addressed. A copy of the latest Annual Report can be found in the Appendix.

From Standard 3 above, the project results in an increase of 40,205 SF of impervious area.

Per the Stormwater Handbook, the water quality depth is 0.5". Therefore the required water quality volume is 1,675 CF.

The 11 leaching basins and surrounding crushed stone will provide a total of 1,360 CF of storage. See leaching structure recharge system sizing calculations in the Appendix. Also, the water quality swale has 669 CF available, for a total of 2,029 CF of volume available for storage. Please see the water quality swale BMP Design Data sheet in the Appendix.

Therefore this standard has been satisfied.

Standard #5: Higher Potential Pollutant Loads (HPPL)

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. If through source control and/or pollution prevention all land uses with higher potential pollutant loads cannot be completely protected from exposure to rain, snow, snow melt, and Stormwater runoff, the proponent shall use the specific structural Stormwater BMPs determined by the Department to be suitable for such uses as provided in the Massachusetts Stormwater Handbook. Stormwater discharges from land uses with higher potential pollutant loads shall also comply with the requirements of the Massachusetts Clean Waters Act, M.G.L. c. 21, §§ 26-53 and the regulations promulgated thereunder at 314 CMR 3.00, 314 CMR 4.00 and 314 CMR 5.00.

Roadways are not considered land uses with higher potential pollutant loads. Redevelopment of the roadway and sidewalks does not qualify as an area with higher potential pollutant loads.

Therefore this standard is not applicable.

Standard #6: Critical Areas

> *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. A discharge is near a critical area if there is a strong likelihood of a significant impact occurring to said area, taking into account site-specific factors. Stormwater discharges to Outstanding Resource Waters and Special Resource Waters shall be removed and set back from the receiving water or wetland and receive the highest and best practical method of treatment. A "storm water discharge" as defined in 314 CMR 3.04(2)(a)1 or (b) to an Outstanding Resource Water or Special Resource Water shall comply with 314 CMR 3.00 and 314 CMR 4.00. Stormwater discharges to a Zone I or Zone A are prohibited unless essential to the operation of a public water supply.*

The seven discharge locations that will convey the runoff from the project site area will still discharge to the same watershed areas. There are no discharges to a Zone II, Interim Wellhead Protection Area, Outstanding Resource Waters (ORWs,) Coldwater Fisheries, Areas of Critical Environmental Concern (ACECs), NHESP-designated endangered species habitats or certified vernal pools within the project extent.

Therefore this standard is not applicable.

Standard #7: Redevelopment of a Previously Developed Site

> *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.*

To improve existing conditions, the project proposes to construct a new water quality swale, install 11 new leaching structures, and install approximately 45 new catch basins with deep sumps (4 feet) to replace existing catch basins and remove catch basin to catch basin connections where possible. Otherwise, the existing roadway right-of-way, soil composition, and the nature of the land surrounding the project area prevent the practical installation of additional BMPs.

Standard #8: Erosion, Sediment Control

> *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 erosion and sediment control measures have been included on the construction plans and in the Operation and Maintenance Plan. These measures include straw wattles and silt sacks (catch basin inserts).

In addition, since the project will disturb more than one acre of land, a Notice of Intent will be submitted to the Environmental protection Agency for coverage under the national Pollution Discharge Elimination System (NPDES) Construction General Permit. As part of this application the Applicant is required to prepare a Stormwater Pollution Prevention Plan (SWPPP). The SWPPP will be prepared by the Contractor and will include erosion and sediment controls, temporary stormwater management measures, Contractor inspection schedules, materials management, waste disposal, spill prevention and response, sanitation, and non-stormwater discharges.

Standard #9: Operation and Maintenance

> *A long-term operation and maintenance plan shall be developed and implemented to ensure that Stormwater management systems function as designed.*

Operation and Maintenance plans for project specific BMPs have been included in the Appendix. In addition the City of Haverhill Department of Public Works has filed a Notice of Intent for the NPDES Phase II Small MS4 General Permit with the Massachusetts Department of Environmental Protection and the U.S. Environmental Protection Agency, and files an Annual Report on the status of BMPs within categories listed in the Permit. The City will maintain the BMPs in City jurisdictional areas in accordance with the requirements of the current Permit to discharge stormwater. A copy of the latest Annual Report can be found in the Appendix.

Standard #10: Illicit Discharges

> *All illicit discharges to the Stormwater management system are prohibited.*

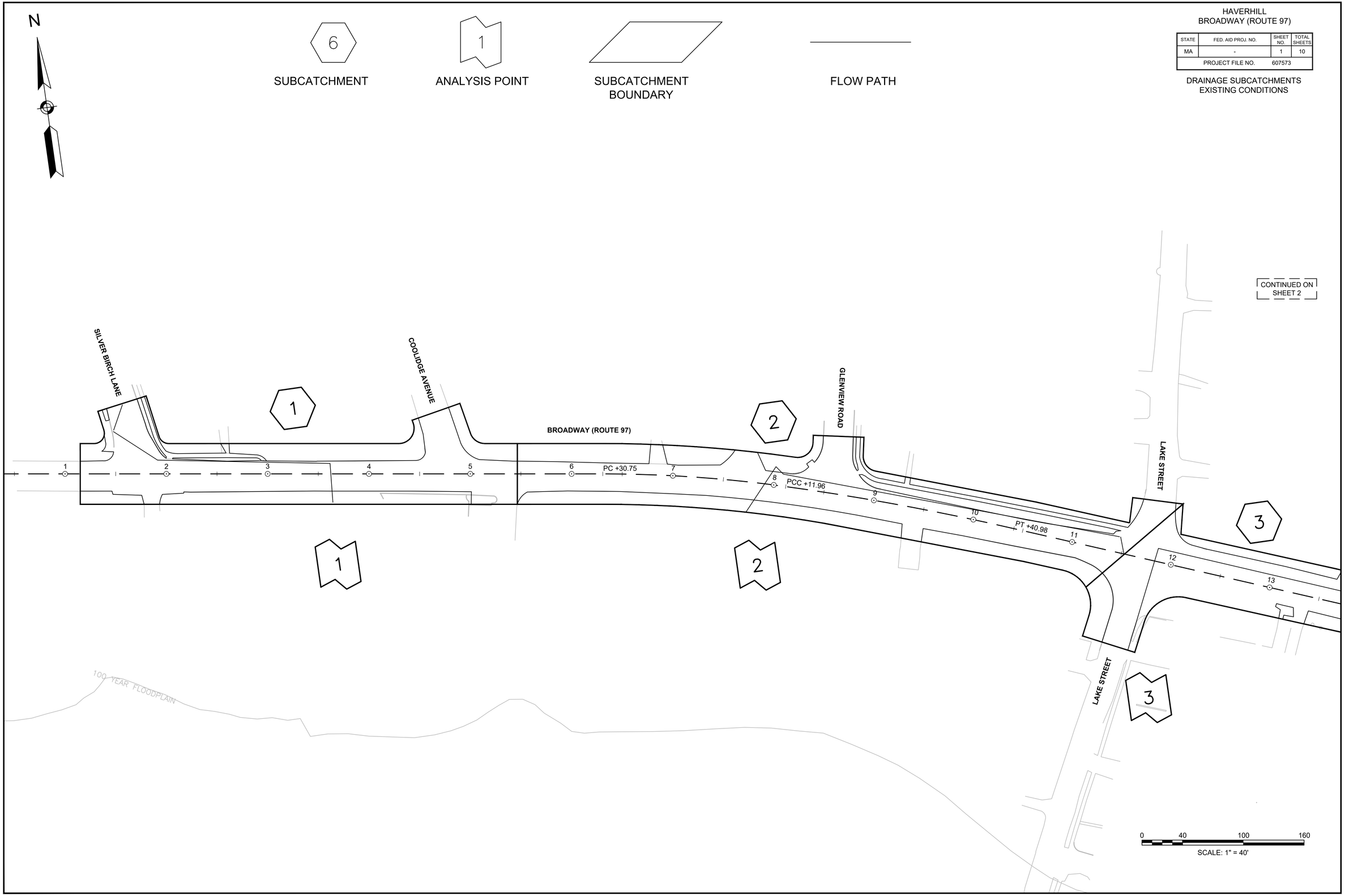
The stormwater management system is also subject to coverage under the NPDES General Permit for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems (the MS4 Permit). The City of Haverhill Department of Public Works will comply with the permit. The last paragraph in the Massachusetts Stormwater Handbook, Volume 1, Chapter 1 states *"To prevent duplication of effort, the proponent may submit copies of reports prepared to satisfy the illicit discharge detection and elimination program requirements of*

the MS4 Permits as its Illicit Discharge Compliance Statement." Please find in the Appendix, the latest NPDES Phase II Small MS4 General Report for the City of Haverhill to satisfy the requirements of this Standard.

HAVERHILL
BROADWAY (ROUTE 97)

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	-	1	10
PROJECT FILE NO.	607573		

DRAINAGE SUBCATCHMENTS
EXISTING CONDITIONS



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HAVERHILL
BROADWAY (ROUTE 97)

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	-	2	10
PROJECT FILE NO.	607573		

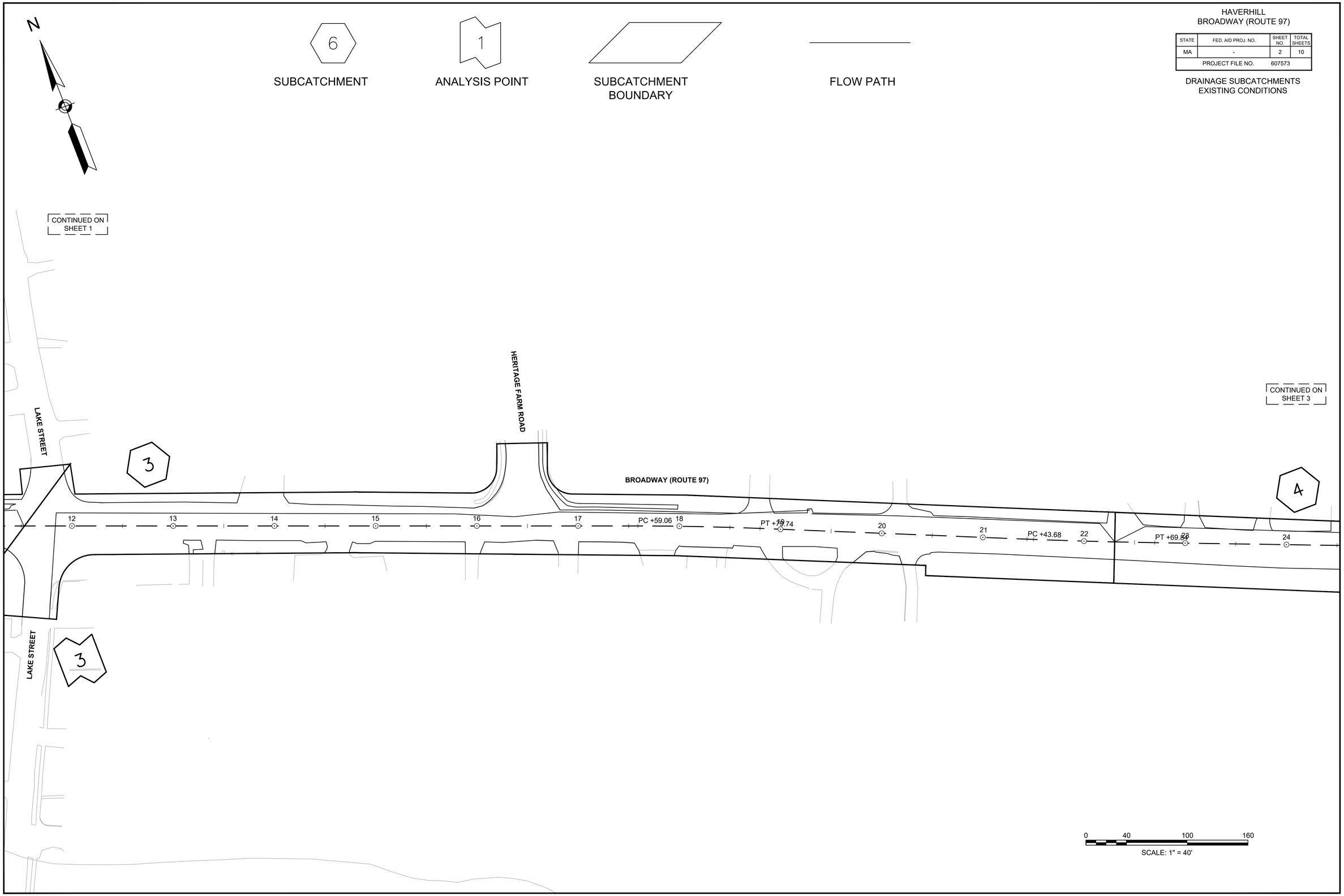
DRAINAGE SUBCATCHMENTS
EXISTING CONDITIONS

SUBCATCHMENT

ANALYSIS POINT

SUBCATCHMENT BOUNDARY

FLOW PATH



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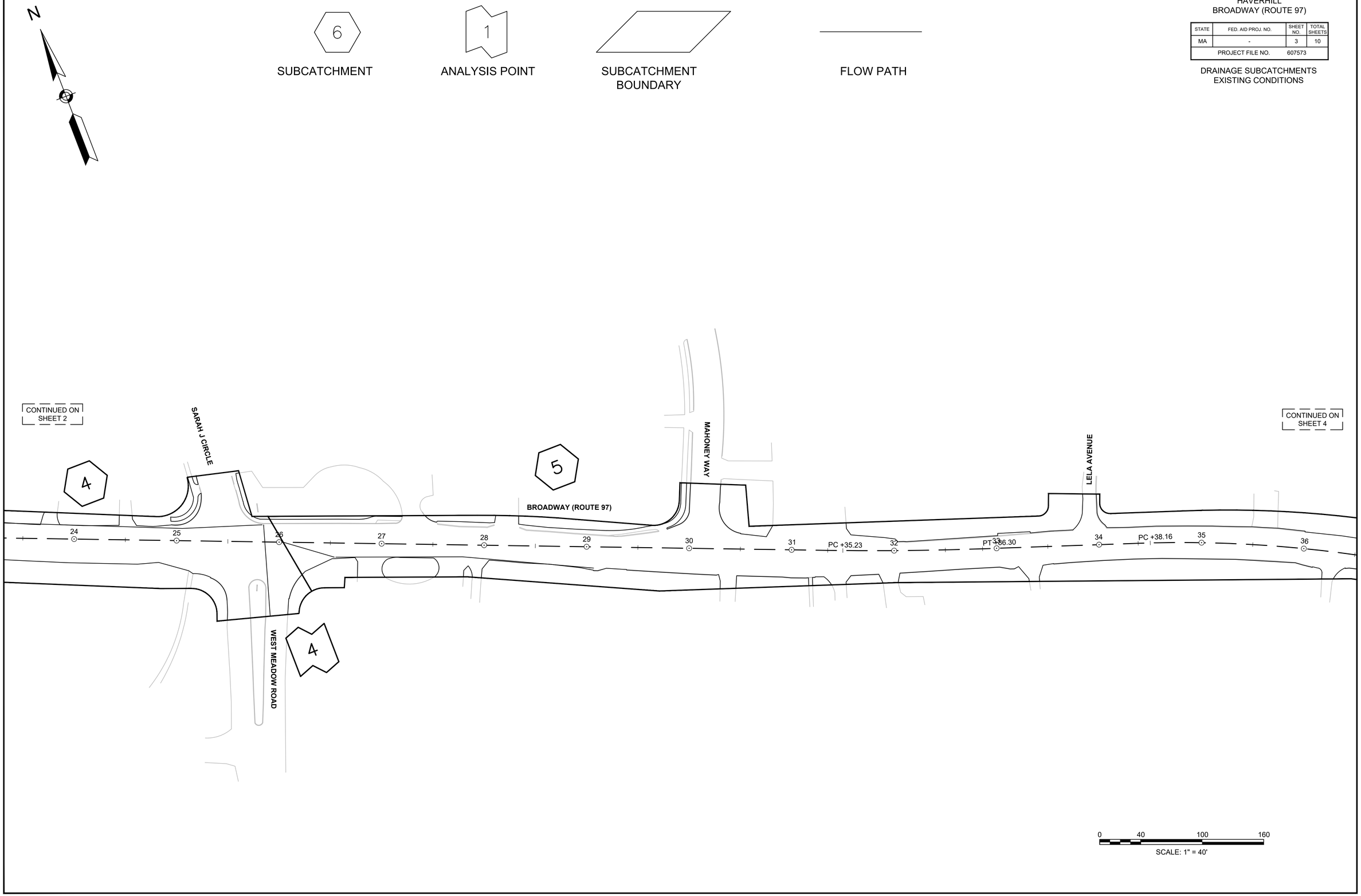
HAVERHILL
BROADWAY (ROUTE 97)

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	-	3	10
PROJECT FILE NO.	607573		

DRAINAGE SUBCATCHMENTS
EXISTING CONDITIONS



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HAVERHILL
BROADWAY (ROUTE 97)

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	-	4	10
PROJECT FILE NO.	607573		

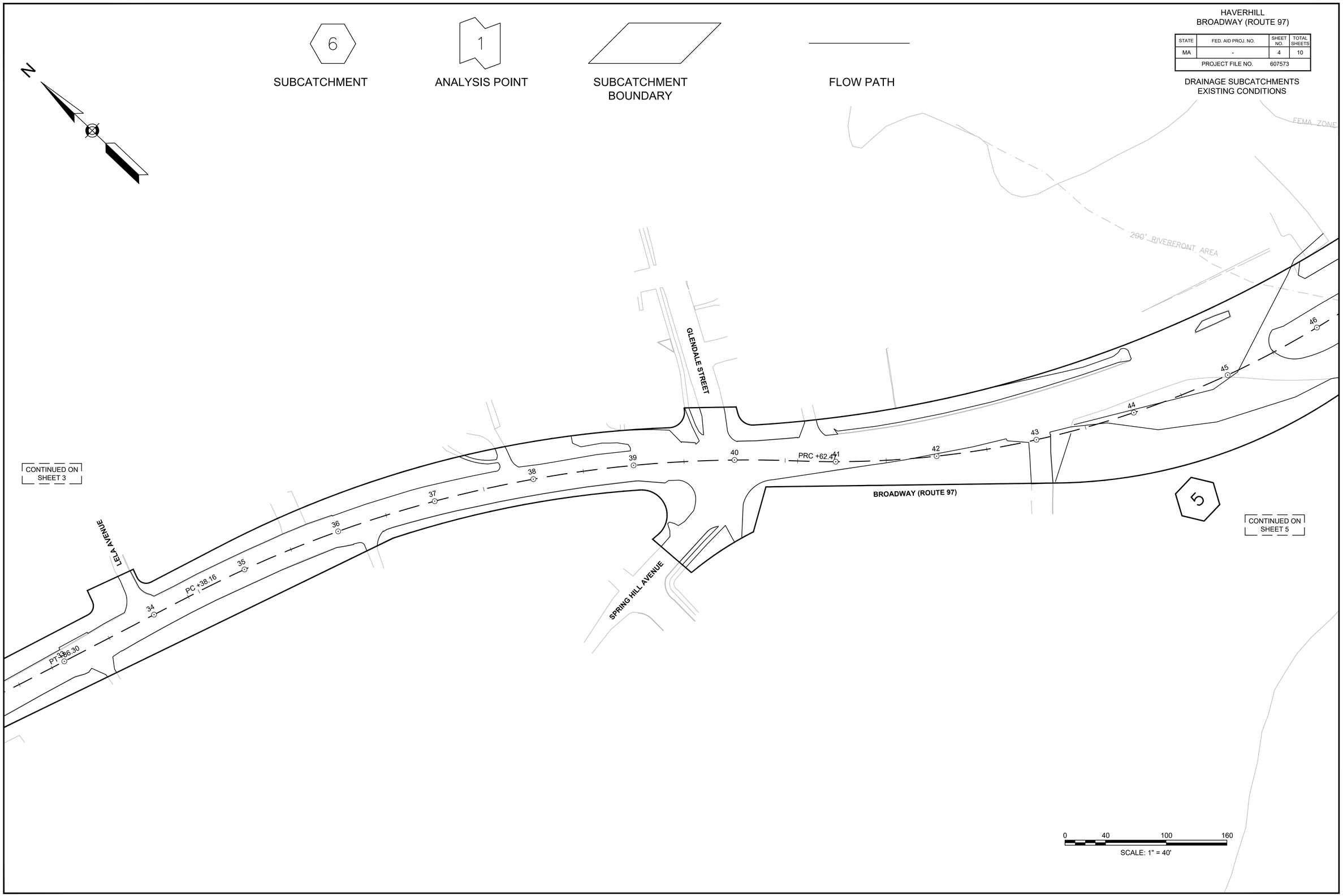
DRAINAGE SUBCATCHMENTS
EXISTING CONDITIONS

6 SUBCATCHMENT

1 ANALYSIS POINT

SUBCATCHMENT BOUNDARY

FLOW PATH



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HAVERHILL
BROADWAY (ROUTE 97)

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
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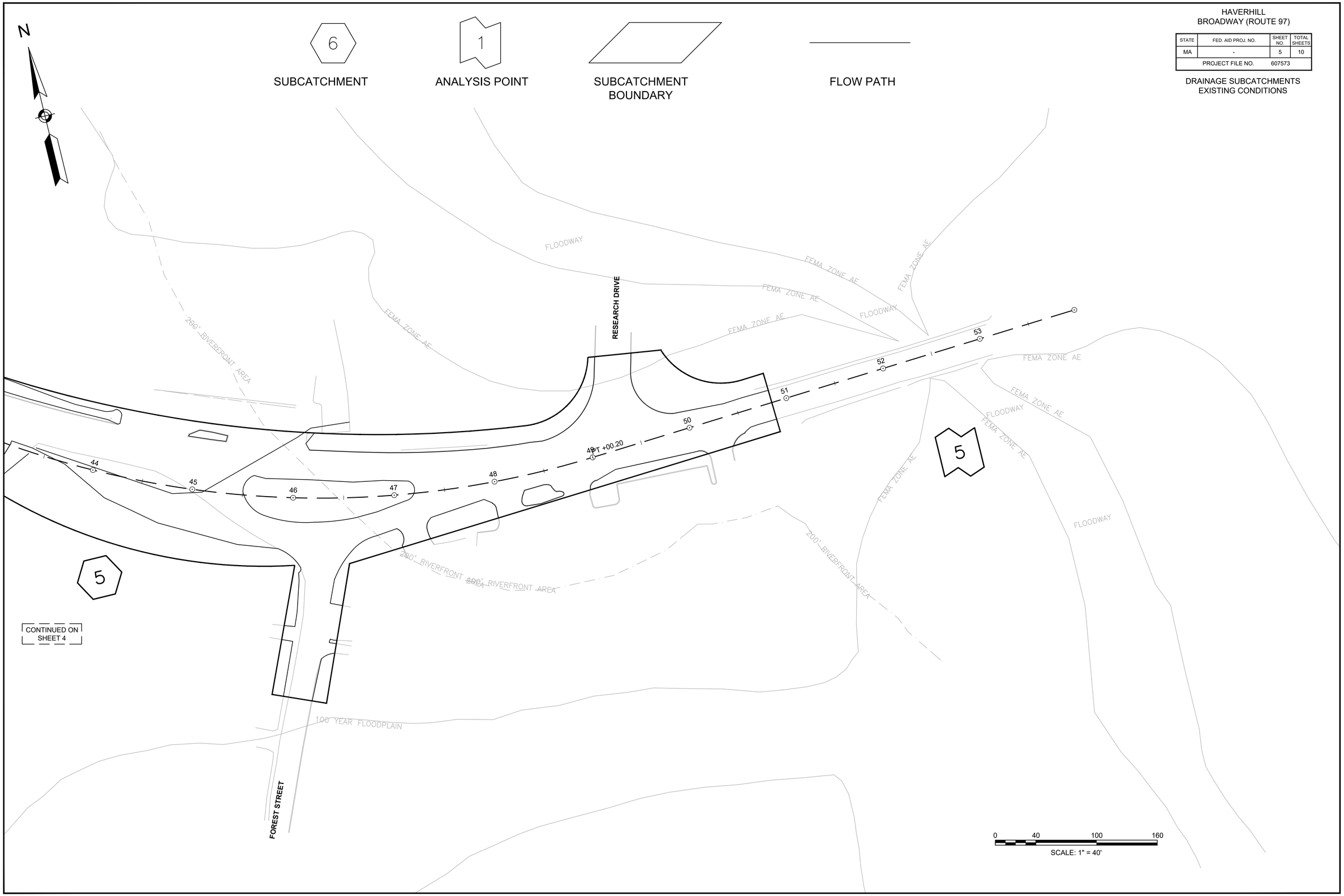
PROJECT FILE NO.	607573		

DRAINAGE SUBCATCHMENTS
EXISTING CONDITIONS



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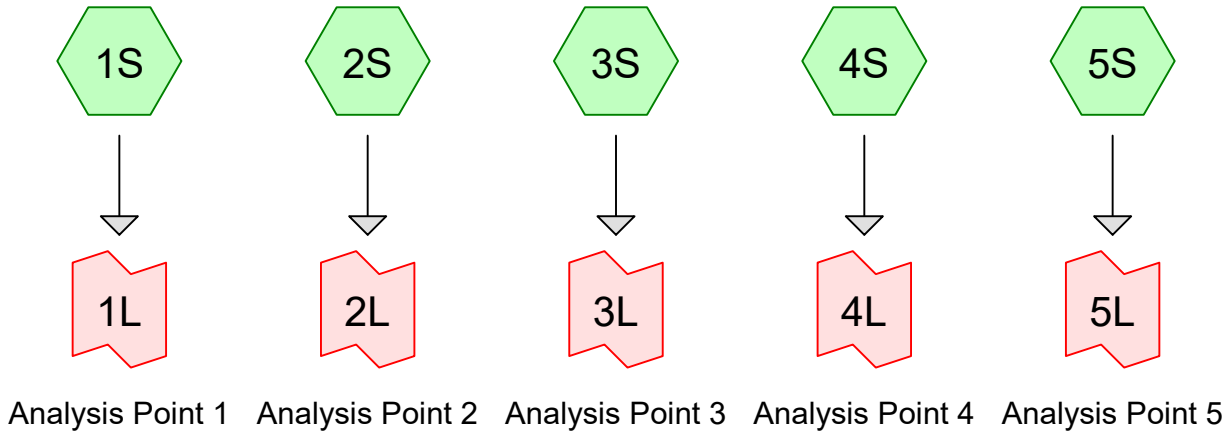
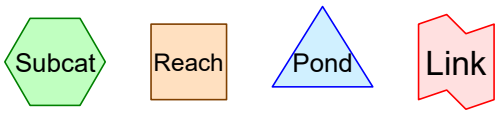




Routing Diagram for Route 97 - Exist
Prepared by Microsoft, Printed 11/4/2016
HydroCAD® 10.00-15 s/n 01074 © 2015 HydroCAD Software Solutions LLC

Time span=0.00-72.00 hrs, dt=0.01 hrs, 7201 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Runoff Area=29,791 sf 63.80% Impervious Runoff Depth=2.04"
Flow Length=287' Tc=6.0 min CN=89 Runoff=1.62 cfs 0.116 af

Subcatchment 2S: Runoff Area=39,078 sf 59.57% Impervious Runoff Depth=1.95"
Flow Length=420' Tc=6.0 min CN=88 Runoff=2.05 cfs 0.146 af

Subcatchment 3S: Runoff Area=73,346 sf 68.42% Impervious Runoff Depth=2.12"
Flow Length=1,158' Tc=6.0 min CN=90 Runoff=4.15 cfs 0.298 af

Subcatchment 4S: Runoff Area=31,630 sf 67.07% Impervious Runoff Depth=2.12"
Flow Length=447' Tc=6.0 min CN=90 Runoff=1.79 cfs 0.128 af

Subcatchment 5S: Runoff Area=214,978 sf 61.94% Impervious Runoff Depth=2.04"
Flow Length=385' Tc=8.1 min CN=89 Runoff=10.90 cfs 0.837 af

Link 1L: Analysis Point 1 Inflow=1.62 cfs 0.116 af
Primary=1.62 cfs 0.116 af

Link 2L: Analysis Point 2 Inflow=2.05 cfs 0.146 af
Primary=2.05 cfs 0.146 af

Link 3L: Analysis Point 3 Inflow=4.15 cfs 0.298 af
Primary=4.15 cfs 0.298 af

Link 4L: Analysis Point 4 Inflow=1.79 cfs 0.128 af
Primary=1.79 cfs 0.128 af

Link 5L: Analysis Point 5 Inflow=10.90 cfs 0.837 af
Primary=10.90 cfs 0.837 af

Total Runoff Area = 8.926 ac Runoff Volume = 1.526 af Average Runoff Depth = 2.05"
36.52% Pervious = 3.259 ac 63.48% Impervious = 5.667 ac

Summary for Subcatchment 1S:

Runoff = 1.62 cfs @ 12.09 hrs, Volume= 0.116 af, Depth= 2.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.15"

Area (sf)	CN	Description
19,008	98	Paved parking, HSG C
10,783	74	>75% Grass cover, Good, HSG C
29,791	89	Weighted Average
10,783		36.20% Pervious Area
19,008		63.80% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	26	0.0570	1.57		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
0.6	261	0.0200	7.58	5.95	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.011 Concrete pipe, straight & clean
0.9	287	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 2S:

Runoff = 2.05 cfs @ 12.09 hrs, Volume= 0.146 af, Depth= 1.95"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.15"

Area (sf)	CN	Description
23,280	98	Paved parking, HSG C
15,798	74	>75% Grass cover, Good, HSG C
39,078	88	Weighted Average
15,798		40.43% Pervious Area
23,280		59.57% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	18	0.0200	0.96		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
3.3	348	0.0073	1.73		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.1	54	0.0335	10.79	8.48	**Pipe Channel,** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.010 PVC, smooth interior
3.7	420	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 3S:

Runoff = 4.15 cfs @ 12.09 hrs, Volume= 0.298 af, Depth= 2.12"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.15"

Area (sf)	CN	Description
50,180	98	Water Surface, HSG C
23,166	74	>75% Grass cover, Good, HSG C
73,346	90	Weighted Average
23,166		31.58% Pervious Area
50,180		68.42% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.4	23	0.0200	1.01		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
2.3	285	0.0105	2.08		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
2.0	850	0.0070	7.12	22.37	**Pipe Channel,** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.011 Concrete pipe, straight & clean
4.7	1,158	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 4S:

Runoff = 1.79 cfs @ 12.09 hrs, Volume= 0.128 af, Depth= 2.12"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.15"

Area (sf)	CN	Description
21,213	98	Paved parking, HSG C
10,417	74	>75% Grass cover, Good, HSG C
31,630	90	Weighted Average
10,417		32.93% Pervious Area
21,213		67.07% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.5	34	0.0200	1.09		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
2.1	323	0.0167	2.62		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.2	90	0.0400	9.74	4.30	**Pipe Channel,** 9.0" Round Area= 0.4 sf Perim= 2.4' r= 0.19' n= 0.010 PVC, smooth interior
2.8	447	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 5S:

Runoff = 10.90 cfs @ 12.11 hrs, Volume= 0.837 af, Depth= 2.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.15"

Area (sf)	CN	Description
133,160	98	Paved parking, HSG C
81,818	74	>75% Grass cover, Good, HSG C
214,978	89	Weighted Average
81,818		38.06% Pervious Area
133,160		61.94% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.6	50	0.1000	0.13		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.10"
1.5	335	0.0330	3.69		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
8.1	385	Total			

Summary for Link 1L: Analysis Point 1

Inflow Area = 0.684 ac, 63.80% Impervious, Inflow Depth = 2.04" for 2-Year event
Inflow = 1.62 cfs @ 12.09 hrs, Volume= 0.116 af
Primary = 1.62 cfs @ 12.09 hrs, Volume= 0.116 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Summary for Link 2L: Analysis Point 2

Inflow Area = 0.897 ac, 59.57% Impervious, Inflow Depth = 1.95" for 2-Year event
Inflow = 2.05 cfs @ 12.09 hrs, Volume= 0.146 af
Primary = 2.05 cfs @ 12.09 hrs, Volume= 0.146 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Summary for Link 3L: Analysis Point 3

Inflow Area = 1.684 ac, 68.42% Impervious, Inflow Depth = 2.12" for 2-Year event
Inflow = 4.15 cfs @ 12.09 hrs, Volume= 0.298 af
Primary = 4.15 cfs @ 12.09 hrs, Volume= 0.298 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Summary for Link 4L: Analysis Point 4

Inflow Area = 0.726 ac, 67.07% Impervious, Inflow Depth = 2.12" for 2-Year event
Inflow = 1.79 cfs @ 12.09 hrs, Volume= 0.128 af
Primary = 1.79 cfs @ 12.09 hrs, Volume= 0.128 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Summary for Link 5L: Analysis Point 5

Inflow Area = 4.935 ac, 61.94% Impervious, Inflow Depth = 2.04" for 2-Year event
Inflow = 10.90 cfs @ 12.11 hrs, Volume= 0.837 af
Primary = 10.90 cfs @ 12.11 hrs, Volume= 0.837 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Time span=0.00-72.00 hrs, dt=0.01 hrs, 7201 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Runoff Area=29,791 sf 63.80% Impervious Runoff Depth=3.61"
Flow Length=287' Tc=6.0 min CN=89 Runoff=2.82 cfs 0.206 af

Subcatchment 2S: Runoff Area=39,078 sf 59.57% Impervious Runoff Depth=3.51"
Flow Length=420' Tc=6.0 min CN=88 Runoff=3.61 cfs 0.262 af

Subcatchment 3S: Runoff Area=73,346 sf 68.42% Impervious Runoff Depth=3.71"
Flow Length=1,158' Tc=6.0 min CN=90 Runoff=7.09 cfs 0.521 af

Subcatchment 4S: Runoff Area=31,630 sf 67.07% Impervious Runoff Depth=3.71"
Flow Length=447' Tc=6.0 min CN=90 Runoff=3.06 cfs 0.225 af

Subcatchment 5S: Runoff Area=214,978 sf 61.94% Impervious Runoff Depth=3.61"
Flow Length=385' Tc=8.1 min CN=89 Runoff=18.92 cfs 1.484 af

Link 1L: Analysis Point 1 Inflow=2.82 cfs 0.206 af
Primary=2.82 cfs 0.206 af

Link 2L: Analysis Point 2 Inflow=3.61 cfs 0.262 af
Primary=3.61 cfs 0.262 af

Link 3L: Analysis Point 3 Inflow=7.09 cfs 0.521 af
Primary=7.09 cfs 0.521 af

Link 4L: Analysis Point 4 Inflow=3.06 cfs 0.225 af
Primary=3.06 cfs 0.225 af

Link 5L: Analysis Point 5 Inflow=18.92 cfs 1.484 af
Primary=18.92 cfs 1.484 af

Total Runoff Area = 8.926 ac Runoff Volume = 2.698 af Average Runoff Depth = 3.63"
36.52% Pervious = 3.259 ac 63.48% Impervious = 5.667 ac

Summary for Subcatchment 1S:

Runoff = 2.82 cfs @ 12.09 hrs, Volume= 0.206 af, Depth= 3.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.83"

Area (sf)	CN	Description
19,008	98	Paved parking, HSG C
10,783	74	>75% Grass cover, Good, HSG C
29,791	89	Weighted Average
10,783		36.20% Pervious Area
19,008		63.80% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	26	0.0570	1.57		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
0.6	261	0.0200	7.58	5.95	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.011 Concrete pipe, straight & clean
0.9	287	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 2S:

Runoff = 3.61 cfs @ 12.09 hrs, Volume= 0.262 af, Depth= 3.51"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.83"

Area (sf)	CN	Description
23,280	98	Paved parking, HSG C
15,798	74	>75% Grass cover, Good, HSG C
39,078	88	Weighted Average
15,798		40.43% Pervious Area
23,280		59.57% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	18	0.0200	0.96		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
3.3	348	0.0073	1.73		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.1	54	0.0335	10.79	8.48	**Pipe Channel,** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.010 PVC, smooth interior
3.7	420	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 3S:

Runoff = 7.09 cfs @ 12.09 hrs, Volume= 0.521 af, Depth= 3.71"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.83"

Area (sf)	CN	Description
50,180	98	Water Surface, HSG C
23,166	74	>75% Grass cover, Good, HSG C
73,346	90	Weighted Average
23,166		31.58% Pervious Area
50,180		68.42% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.4	23	0.0200	1.01		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
2.3	285	0.0105	2.08		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
2.0	850	0.0070	7.12	22.37	**Pipe Channel,** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.011 Concrete pipe, straight & clean
4.7	1,158	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 4S:

Runoff = 3.06 cfs @ 12.09 hrs, Volume= 0.225 af, Depth= 3.71"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.83"

Area (sf)	CN	Description
21,213	98	Paved parking, HSG C
10,417	74	>75% Grass cover, Good, HSG C
31,630	90	Weighted Average
10,417		32.93% Pervious Area
21,213		67.07% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.5	34	0.0200	1.09		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
2.1	323	0.0167	2.62		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.2	90	0.0400	9.74	4.30	**Pipe Channel,** 9.0" Round Area= 0.4 sf Perim= 2.4' r= 0.19' n= 0.010 PVC, smooth interior
2.8	447	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 5S:

Runoff = 18.92 cfs @ 12.11 hrs, Volume= 1.484 af, Depth= 3.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.83"

Area (sf)	CN	Description
133,160	98	Paved parking, HSG C
81,818	74	>75% Grass cover, Good, HSG C
214,978	89	Weighted Average
81,818		38.06% Pervious Area
133,160		61.94% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.6	50	0.1000	0.13		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.10"
1.5	335	0.0330	3.69		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
8.1	385	Total			

Summary for Link 1L: Analysis Point 1

Inflow Area = 0.684 ac, 63.80% Impervious, Inflow Depth = 3.61" for 10-Year event
Inflow = 2.82 cfs @ 12.09 hrs, Volume= 0.206 af
Primary = 2.82 cfs @ 12.09 hrs, Volume= 0.206 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Summary for Link 2L: Analysis Point 2

Inflow Area = 0.897 ac, 59.57% Impervious, Inflow Depth = 3.51" for 10-Year event
Inflow = 3.61 cfs @ 12.09 hrs, Volume= 0.262 af
Primary = 3.61 cfs @ 12.09 hrs, Volume= 0.262 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Summary for Link 3L: Analysis Point 3

Inflow Area = 1.684 ac, 68.42% Impervious, Inflow Depth = 3.71" for 10-Year event
Inflow = 7.09 cfs @ 12.09 hrs, Volume= 0.521 af
Primary = 7.09 cfs @ 12.09 hrs, Volume= 0.521 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Summary for Link 4L: Analysis Point 4

Inflow Area = 0.726 ac, 67.07% Impervious, Inflow Depth = 3.71" for 10-Year event
Inflow = 3.06 cfs @ 12.09 hrs, Volume= 0.225 af
Primary = 3.06 cfs @ 12.09 hrs, Volume= 0.225 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Summary for Link 5L: Analysis Point 5

Inflow Area = 4.935 ac, 61.94% Impervious, Inflow Depth = 3.61" for 10-Year event
Inflow = 18.92 cfs @ 12.11 hrs, Volume= 1.484 af
Primary = 18.92 cfs @ 12.11 hrs, Volume= 1.484 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Time span=0.00-72.00 hrs, dt=0.01 hrs, 7201 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Runoff Area=29,791 sf 63.80% Impervious Runoff Depth=7.61"
Flow Length=287' Tc=6.0 min CN=89 Runoff=5.70 cfs 0.434 af

Subcatchment 2S: Runoff Area=39,078 sf 59.57% Impervious Runoff Depth=7.49"
Flow Length=420' Tc=6.0 min CN=88 Runoff=7.41 cfs 0.560 af

Subcatchment 3S: Runoff Area=73,346 sf 68.42% Impervious Runoff Depth=7.73"
Flow Length=1,158' Tc=6.0 min CN=90 Runoff=14.17 cfs 1.085 af

Subcatchment 4S: Runoff Area=31,630 sf 67.07% Impervious Runoff Depth=7.73"
Flow Length=447' Tc=6.0 min CN=90 Runoff=6.11 cfs 0.468 af

Subcatchment 5S: Runoff Area=214,978 sf 61.94% Impervious Runoff Depth=7.61"
Flow Length=385' Tc=8.1 min CN=89 Runoff=38.34 cfs 3.130 af

Link 1L: Analysis Point 1 Inflow=5.70 cfs 0.434 af
Primary=5.70 cfs 0.434 af

Link 2L: Analysis Point 2 Inflow=7.41 cfs 0.560 af
Primary=7.41 cfs 0.560 af

Link 3L: Analysis Point 3 Inflow=14.17 cfs 1.085 af
Primary=14.17 cfs 1.085 af

Link 4L: Analysis Point 4 Inflow=6.11 cfs 0.468 af
Primary=6.11 cfs 0.468 af

Link 5L: Analysis Point 5 Inflow=38.34 cfs 3.130 af
Primary=38.34 cfs 3.130 af

Total Runoff Area = 8.926 ac Runoff Volume = 5.677 af Average Runoff Depth = 7.63"
36.52% Pervious = 3.259 ac 63.48% Impervious = 5.667 ac

Summary for Subcatchment 1S:

Runoff = 5.70 cfs @ 12.08 hrs, Volume= 0.434 af, Depth= 7.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=8.94"

Area (sf)	CN	Description
19,008	98	Paved parking, HSG C
10,783	74	>75% Grass cover, Good, HSG C
29,791	89	Weighted Average
10,783		36.20% Pervious Area
19,008		63.80% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	26	0.0570	1.57		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
0.6	261	0.0200	7.58	5.95	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.011 Concrete pipe, straight & clean
0.9	287	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 2S:

Runoff = 7.41 cfs @ 12.08 hrs, Volume= 0.560 af, Depth= 7.49"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=8.94"

Area (sf)	CN	Description
23,280	98	Paved parking, HSG C
15,798	74	>75% Grass cover, Good, HSG C
39,078	88	Weighted Average
15,798		40.43% Pervious Area
23,280		59.57% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	18	0.0200	0.96		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
3.3	348	0.0073	1.73		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.1	54	0.0335	10.79	8.48	**Pipe Channel,** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.010 PVC, smooth interior
3.7	420	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 3S:

Runoff = 14.17 cfs @ 12.08 hrs, Volume= 1.085 af, Depth= 7.73"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=8.94"

Area (sf)	CN	Description
50,180	98	Water Surface, HSG C
23,166	74	>75% Grass cover, Good, HSG C
73,346	90	Weighted Average
23,166		31.58% Pervious Area
50,180		68.42% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.4	23	0.0200	1.01		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
2.3	285	0.0105	2.08		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
2.0	850	0.0070	7.12	22.37	**Pipe Channel,** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.011 Concrete pipe, straight & clean
4.7	1,158	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 4S:

Runoff = 6.11 cfs @ 12.08 hrs, Volume= 0.468 af, Depth= 7.73"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=8.94"

Area (sf)	CN	Description
21,213	98	Paved parking, HSG C
10,417	74	>75% Grass cover, Good, HSG C
31,630	90	Weighted Average
10,417		32.93% Pervious Area
21,213		67.07% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.5	34	0.0200	1.09		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
2.1	323	0.0167	2.62		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.2	90	0.0400	9.74	4.30	**Pipe Channel,** 9.0" Round Area= 0.4 sf Perim= 2.4' r= 0.19' n= 0.010 PVC, smooth interior
2.8	447	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 5S:

Runoff = 38.34 cfs @ 12.11 hrs, Volume= 3.130 af, Depth= 7.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=8.94"

Area (sf)	CN	Description
133,160	98	Paved parking, HSG C
81,818	74	>75% Grass cover, Good, HSG C
214,978	89	Weighted Average
81,818		38.06% Pervious Area
133,160		61.94% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.6	50	0.1000	0.13		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.10"
1.5	335	0.0330	3.69		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
8.1	385	Total			

Summary for Link 1L: Analysis Point 1

Inflow Area = 0.684 ac, 63.80% Impervious, Inflow Depth = 7.61" for 100-Year event
Inflow = 5.70 cfs @ 12.08 hrs, Volume= 0.434 af
Primary = 5.70 cfs @ 12.08 hrs, Volume= 0.434 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Summary for Link 2L: Analysis Point 2

Inflow Area = 0.897 ac, 59.57% Impervious, Inflow Depth = 7.49" for 100-Year event
Inflow = 7.41 cfs @ 12.08 hrs, Volume= 0.560 af
Primary = 7.41 cfs @ 12.08 hrs, Volume= 0.560 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Summary for Link 3L: Analysis Point 3

Inflow Area = 1.684 ac, 68.42% Impervious, Inflow Depth = 7.73" for 100-Year event
Inflow = 14.17 cfs @ 12.08 hrs, Volume= 1.085 af
Primary = 14.17 cfs @ 12.08 hrs, Volume= 1.085 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Summary for Link 4L: Analysis Point 4

Inflow Area = 0.726 ac, 67.07% Impervious, Inflow Depth = 7.73" for 100-Year event
Inflow = 6.11 cfs @ 12.08 hrs, Volume= 0.468 af
Primary = 6.11 cfs @ 12.08 hrs, Volume= 0.468 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Summary for Link 5L: Analysis Point 5

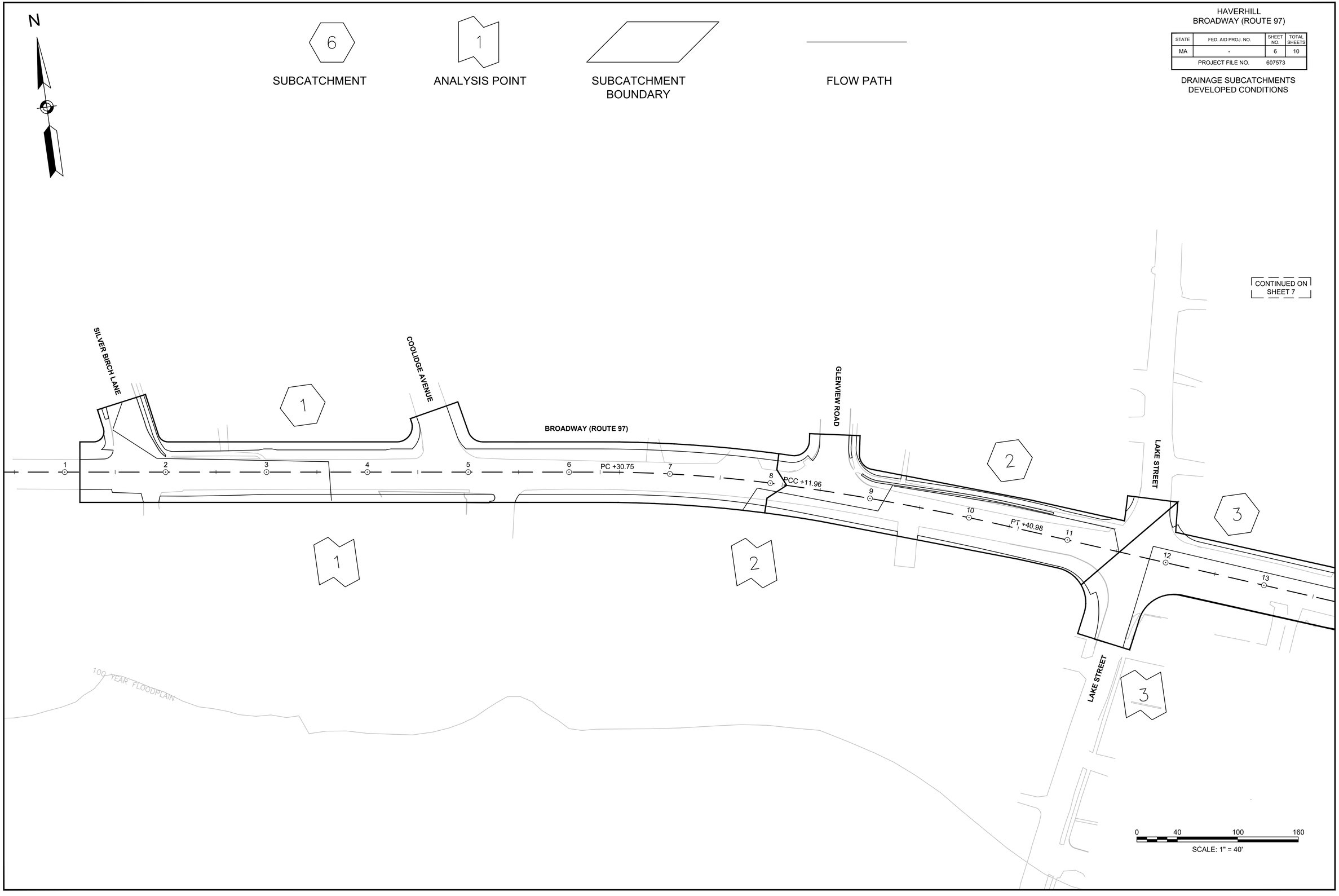
Inflow Area = 4.935 ac, 61.94% Impervious, Inflow Depth = 7.61" for 100-Year event
Inflow = 38.34 cfs @ 12.11 hrs, Volume= 3.130 af
Primary = 38.34 cfs @ 12.11 hrs, Volume= 3.130 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

HAVERHILL
BROADWAY (ROUTE 97)

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	-	6	10
PROJECT FILE NO.	607573		

DRAINAGE SUBCATCHMENTS
DEVELOPED CONDITIONS



607573_HD (DEVDA).DWG Plotted on 15-Jul-2016 2:07 PM

HAVERHILL
BROADWAY (ROUTE 97)

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	-	7	10
PROJECT FILE NO.	607573		

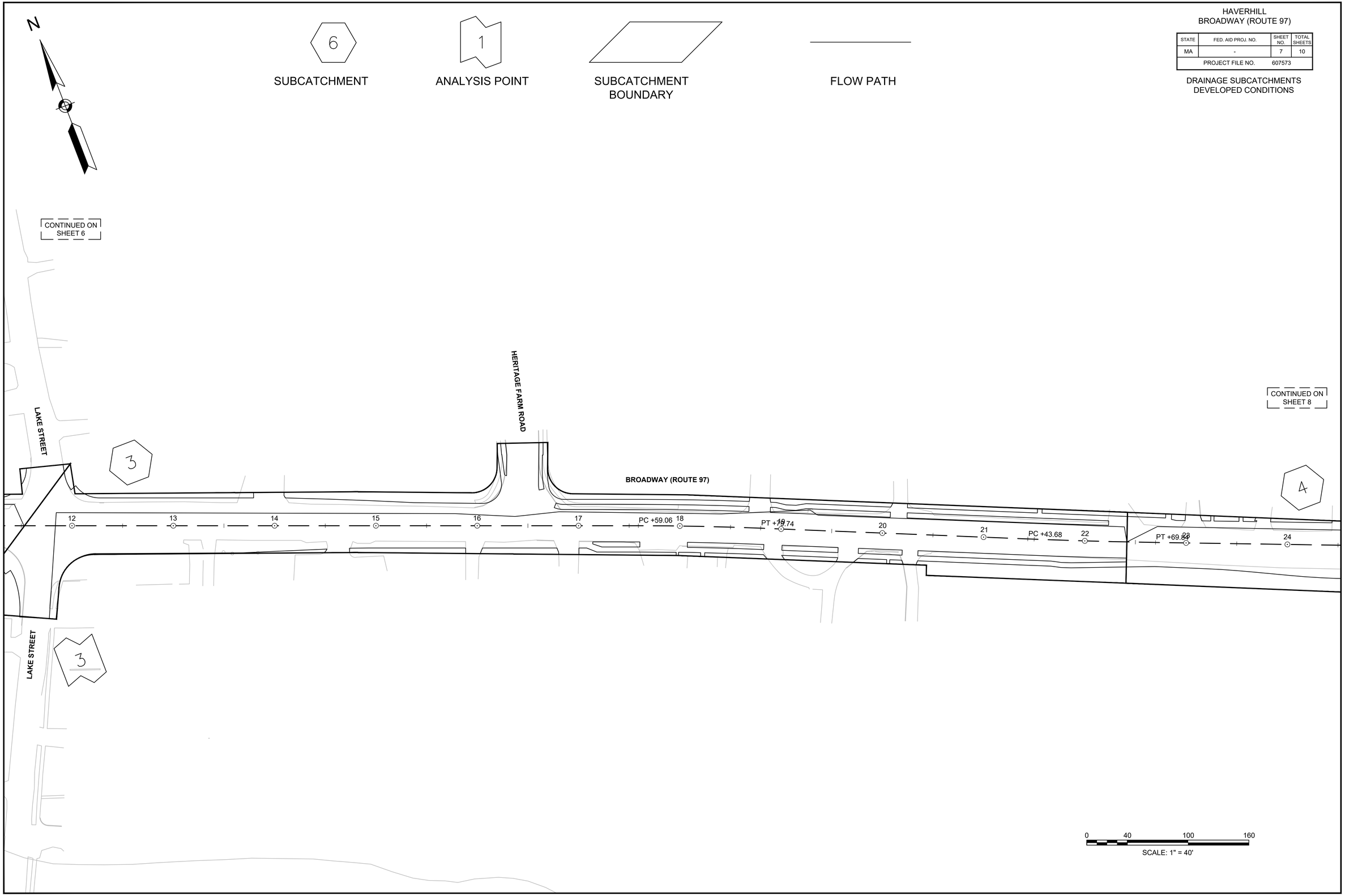
DRAINAGE SUBCATCHMENTS
DEVELOPED CONDITIONS

SUBCATCHMENT (6)

ANALYSIS POINT (1)

SUBCATCHMENT BOUNDARY

FLOW PATH



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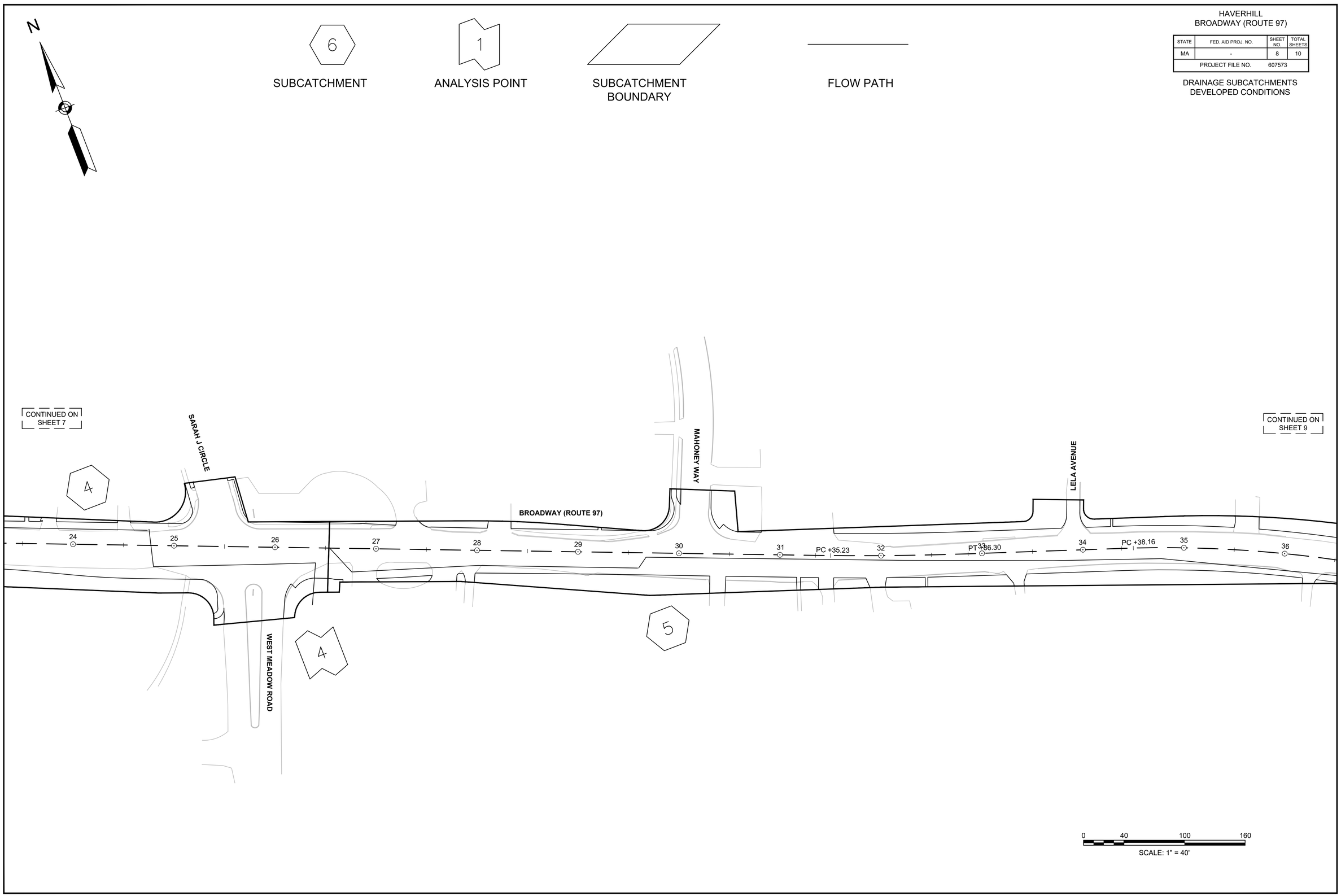
HAVERHILL
BROADWAY (ROUTE 97)

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	-	8	10
PROJECT FILE NO.	607573		

DRAINAGE SUBCATCHMENTS
DEVELOPED CONDITIONS



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HAVERHILL
BROADWAY (ROUTE 97)

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	-	9	10
PROJECT FILE NO.	607573		

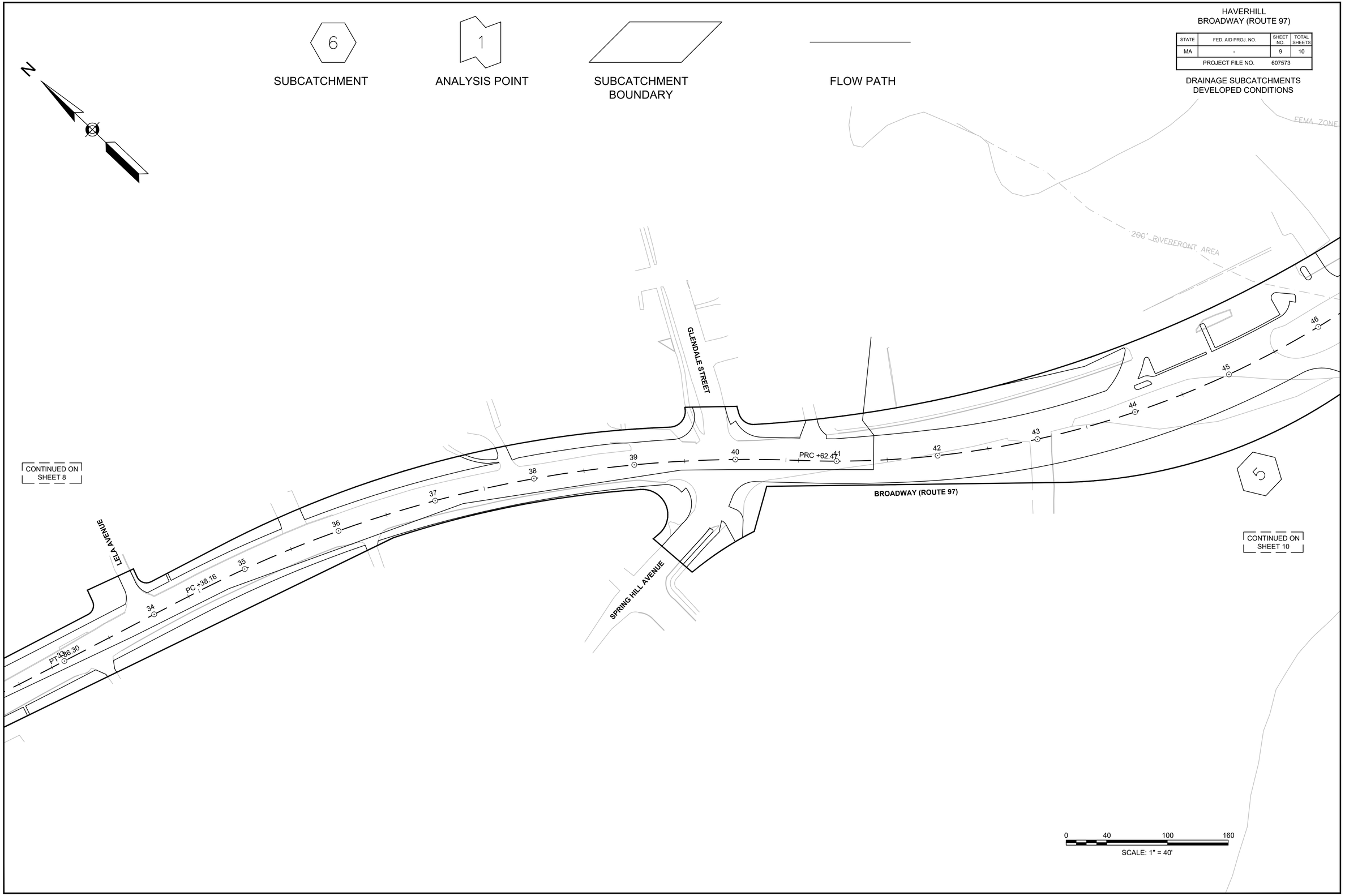
DRAINAGE SUBCATCHMENTS
DEVELOPED CONDITIONS

6 SUBCATCHMENT

1 ANALYSIS POINT

SUBCATCHMENT BOUNDARY

FLOW PATH

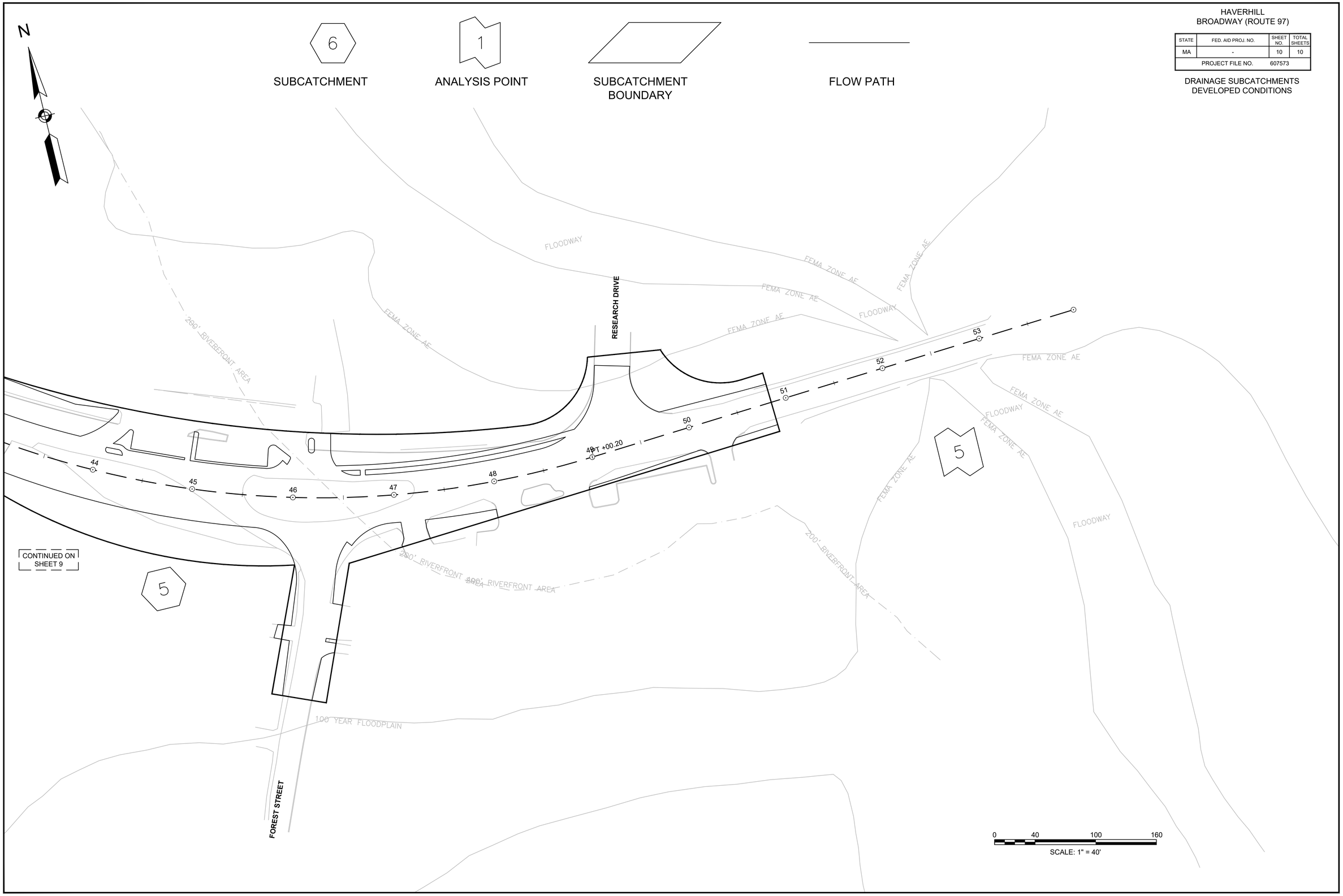


607573_HD (DEVDA).DWG Plotted on 15-Jul-2016 2:07 PM

HAVERHILL
BROADWAY (ROUTE 97)

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	-	10	10
PROJECT FILE NO.	607573		

DRAINAGE SUBCATCHMENTS
DEVELOPED CONDITIONS



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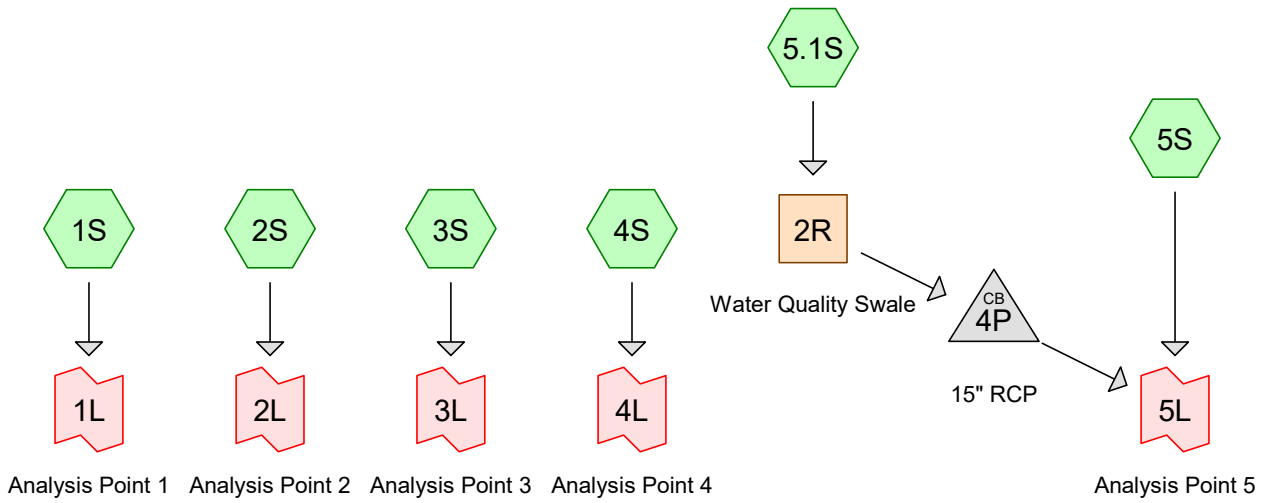

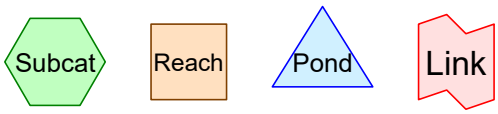

Routing Diagram for Route 97 - Developed
Prepared by Microsoft, Printed 11/4/2016
HydroCAD® 10.00-15 s/n 01074 © 2015 HydroCAD Software Solutions LLC

Time span=0.00-72.00 hrs, dt=0.01 hrs, 7201 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Runoff Area=45,318 sf 75.84% Impervious Runoff Depth=2.30"
Flow Length=287' Tc=6.0 min CN=92 Runoff=2.75 cfs 0.200 af

Subcatchment 2S: Runoff Area=23,551 sf 87.77% Impervious Runoff Depth=2.60"
Flow Length=424' Tc=6.0 min CN=95 Runoff=1.56 cfs 0.117 af

Subcatchment 3S: Runoff Area=74,157 sf 78.22% Impervious Runoff Depth=2.40"
Flow Length=1,176' Tc=6.0 min CN=93 Runoff=4.64 cfs 0.340 af

Subcatchment 4S: Runoff Area=33,908 sf 79.75% Impervious Runoff Depth=2.40"
Flow Length=475' Tc=6.0 min CN=93 Runoff=2.12 cfs 0.156 af

Subcatchment 5.1S: Runoff Area=15,286 sf 85.99% Impervious Runoff Depth=2.60"
Flow Length=321' Tc=6.0 min CN=95 Runoff=1.01 cfs 0.076 af

Subcatchment 5S: Runoff Area=196,624 sf 68.07% Impervious Runoff Depth=2.12"
Flow Length=1,628' Tc=6.0 min CN=90 Runoff=11.12 cfs 0.798 af

Reach 2R: Water Quality Swale Avg. Flow Depth=0.22' Max Vel=1.20 fps Inflow=1.01 cfs 0.076 af
n=0.050 L=130.0' S=0.0154 '/' Capacity=38.69 cfs Outflow=0.98 cfs 0.076 af

Pond 4P: 15" RCP Peak Elev=55.49' Inflow=0.98 cfs 0.076 af
15.0" Round Culvert n=0.012 L=154.0' S=0.0065 '/' Outflow=0.98 cfs 0.076 af

Link 1L: Analysis Point 1 Inflow=2.75 cfs 0.200 af
Primary=2.75 cfs 0.200 af

Link 2L: Analysis Point 2 Inflow=1.56 cfs 0.117 af
Primary=1.56 cfs 0.117 af

Link 3L: Analysis Point 3 Inflow=4.64 cfs 0.340 af
Primary=4.64 cfs 0.340 af

Link 4L: Analysis Point 4 Inflow=2.12 cfs 0.156 af
Primary=2.12 cfs 0.156 af

Link 5L: Analysis Point 5 Inflow=11.96 cfs 0.874 af
Primary=11.96 cfs 0.874 af

Total Runoff Area = 8.927 ac Runoff Volume = 1.687 af Average Runoff Depth = 2.27"
26.17% Pervious = 2.337 ac 73.83% Impervious = 6.590 ac

Summary for Subcatchment 1S:

Runoff = 2.75 cfs @ 12.09 hrs, Volume= 0.200 af, Depth= 2.30"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.15"

Area (sf)	CN	Description
34,370	98	Paved parking, HSG C
10,948	74	>75% Grass cover, Good, HSG C
45,318	92	Weighted Average
10,948		24.16% Pervious Area
34,370		75.84% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	26	0.0570	1.57		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
0.6	261	0.0200	7.58	5.95	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.011 Concrete pipe, straight & clean
0.9	287	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 2S:

Runoff = 1.56 cfs @ 12.08 hrs, Volume= 0.117 af, Depth= 2.60"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.15"

Area (sf)	CN	Description
20,670	98	Paved parking, HSG C
2,881	74	>75% Grass cover, Good, HSG C
23,551	95	Weighted Average
2,881		12.23% Pervious Area
20,670		87.77% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.4	23	0.0200	1.01		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
2.1	223	0.0073	1.73		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.3	178	0.0335	10.79	8.48	**Pipe Channel,** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.010 PVC, smooth interior
2.8	424	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 3S:

Runoff = 4.64 cfs @ 12.09 hrs, Volume= 0.340 af, Depth= 2.40"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.15"

Area (sf)	CN	Description
58,003	98	Water Surface, HSG C
16,154	74	>75% Grass cover, Good, HSG C
74,157	93	Weighted Average
16,154		21.78% Pervious Area
58,003		78.22% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	15	0.0200	0.93		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
2.4	303	0.0105	2.08		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
2.0	858	0.0070	7.12	22.37	**Pipe Channel,** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.011 Concrete pipe, straight & clean
4.7	1,176	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 4S:

Runoff = 2.12 cfs @ 12.09 hrs, Volume= 0.156 af, Depth= 2.40"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.15"

Area (sf)	CN	Description
27,040	98	Paved parking, HSG C
6,868	74	>75% Grass cover, Good, HSG C
33,908	93	Weighted Average
6,868		20.25% Pervious Area
27,040		79.75% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.5	34	0.0200	1.09		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
1.3	202	0.0167	2.62		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.4	239	0.0400	9.74	4.30	**Pipe Channel,** 9.0" Round Area= 0.4 sf Perim= 2.4' r= 0.19' n= 0.010 PVC, smooth interior
2.2	475	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 5.1S:

Runoff = 1.01 cfs @ 12.08 hrs, Volume= 0.076 af, Depth= 2.60"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.15"

Area (sf)	CN	Description
13,145	98	Paved parking, HSG C
2,141	74	>75% Grass cover, Good, HSG C
15,286	95	Weighted Average
2,141		14.01% Pervious Area
13,145		85.99% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	20	0.0400	1.29		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
1.2	268	0.0350	3.80		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.1	33	0.0200	6.95	5.46	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.012 Concrete pipe, finished
1.6	321	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 5S:

Runoff = 11.12 cfs @ 12.09 hrs, Volume= 0.798 af, Depth= 2.12"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.15"

Area (sf)	CN	Description
133,837	98	Paved parking, HSG C
62,787	74	>75% Grass cover, Good, HSG C
196,624	90	Weighted Average
62,787		31.93% Pervious Area
133,837		68.07% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.5	32	0.0200	1.08		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
1.6	283	0.0220	3.01		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
1.2	1,313	0.0650	17.91	31.65	**Pipe Channel,** 18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38' n= 0.011 Concrete pipe, straight & clean
3.3	1,628	Total, Increased to minimum Tc = 6.0 min			

Summary for Reach 2R: Water Quality Swale

Inflow Area = 0.351 ac, 85.99% Impervious, Inflow Depth = 2.60" for 2-Year event
Inflow = 1.01 cfs @ 12.08 hrs, Volume= 0.076 af
Outflow = 0.98 cfs @ 12.13 hrs, Volume= 0.076 af, Atten= 3%, Lag= 3.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Max. Velocity= 1.20 fps, Min. Travel Time= 1.8 min
Avg. Velocity = 0.33 fps, Avg. Travel Time= 6.6 min

Peak Storage= 106 cf @ 12.10 hrs
Average Depth at Peak Storage= 0.22'
Bank-Full Depth= 1.50' Flow Area= 11.3 sf, Capacity= 38.69 cfs

3.00' x 1.50' deep channel, n= 0.050 Scattered brush, heavy weeds
Side Slope Z-value= 3.0 '/' Top Width= 12.00'
Length= 130.0' Slope= 0.0154 '/'
Inlet Invert= 56.20', Outlet Invert= 54.20'

‡

Summary for Pond 4P: 15" RCP

Inflow Area = 0.351 ac, 85.99% Impervious, Inflow Depth = 2.60" for 2-Year event
Inflow = 0.98 cfs @ 12.13 hrs, Volume= 0.076 af
Outflow = 0.98 cfs @ 12.13 hrs, Volume= 0.076 af, Atten= 0%, Lag= 0.0 min
Primary = 0.98 cfs @ 12.13 hrs, Volume= 0.076 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 55.49' @ 12.13 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	55.00'	**15.0" Round RCP_Round 15"** L= 154.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 55.00' / 54.00' S= 0.0065 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 1.23 sf

Primary OutFlow Max=0.98 cfs @ 12.13 hrs HW=55.49' (Free Discharge)
└─**1=RCP_Round 15"** (Barrel Controls 0.98 cfs @ 3.28 fps)

Summary for Link 1L: Analysis Point 1

Inflow Area = 1.040 ac, 75.84% Impervious, Inflow Depth = 2.30" for 2-Year event
Inflow = 2.75 cfs @ 12.09 hrs, Volume= 0.200 af
Primary = 2.75 cfs @ 12.09 hrs, Volume= 0.200 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Summary for Link 2L: Analysis Point 2

Inflow Area = 0.541 ac, 87.77% Impervious, Inflow Depth = 2.60" for 2-Year event
Inflow = 1.56 cfs @ 12.08 hrs, Volume= 0.117 af
Primary = 1.56 cfs @ 12.08 hrs, Volume= 0.117 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Summary for Link 3L: Analysis Point 3

Inflow Area = 1.702 ac, 78.22% Impervious, Inflow Depth = 2.40" for 2-Year event
Inflow = 4.64 cfs @ 12.09 hrs, Volume= 0.340 af
Primary = 4.64 cfs @ 12.09 hrs, Volume= 0.340 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Summary for Link 4L: Analysis Point 4

Inflow Area = 0.778 ac, 79.75% Impervious, Inflow Depth = 2.40" for 2-Year event
Inflow = 2.12 cfs @ 12.09 hrs, Volume= 0.156 af
Primary = 2.12 cfs @ 12.09 hrs, Volume= 0.156 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Summary for Link 5L: Analysis Point 5

Inflow Area = 4.865 ac, 69.36% Impervious, Inflow Depth = 2.16" for 2-Year event
Inflow = 11.96 cfs @ 12.09 hrs, Volume= 0.874 af
Primary = 11.96 cfs @ 12.09 hrs, Volume= 0.874 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Time span=0.00-72.00 hrs, dt=0.01 hrs, 7201 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Runoff Area=45,318 sf 75.84% Impervious Runoff Depth=3.92"
Flow Length=287' Tc=6.0 min CN=92 Runoff=4.55 cfs 0.340 af

Subcatchment 2S: Runoff Area=23,551 sf 87.77% Impervious Runoff Depth=4.25"
Flow Length=424' Tc=6.0 min CN=95 Runoff=2.48 cfs 0.192 af

Subcatchment 3S: Runoff Area=74,157 sf 78.22% Impervious Runoff Depth=4.03"
Flow Length=1,176' Tc=6.0 min CN=93 Runoff=7.58 cfs 0.572 af

Subcatchment 4S: Runoff Area=33,908 sf 79.75% Impervious Runoff Depth=4.03"
Flow Length=475' Tc=6.0 min CN=93 Runoff=3.47 cfs 0.261 af

Subcatchment 5.1S: Runoff Area=15,286 sf 85.99% Impervious Runoff Depth=4.25"
Flow Length=321' Tc=6.0 min CN=95 Runoff=1.61 cfs 0.124 af

Subcatchment 5S: Runoff Area=196,624 sf 68.07% Impervious Runoff Depth=3.71"
Flow Length=1,628' Tc=6.0 min CN=90 Runoff=19.00 cfs 1.396 af

Reach 2R: Water Quality Swale Avg. Flow Depth=0.29' Max Vel=1.40 fps Inflow=1.61 cfs 0.124 af
n=0.050 L=130.0' S=0.0154 '/' Capacity=38.69 cfs Outflow=1.57 cfs 0.124 af

Pond 4P: 15" RCP Peak Elev=55.63' Inflow=1.57 cfs 0.124 af
15.0" Round Culvert n=0.012 L=154.0' S=0.0065 '/' Outflow=1.57 cfs 0.124 af

Link 1L: Analysis Point 1 Inflow=4.55 cfs 0.340 af
Primary=4.55 cfs 0.340 af

Link 2L: Analysis Point 2 Inflow=2.48 cfs 0.192 af
Primary=2.48 cfs 0.192 af

Link 3L: Analysis Point 3 Inflow=7.58 cfs 0.572 af
Primary=7.58 cfs 0.572 af

Link 4L: Analysis Point 4 Inflow=3.47 cfs 0.261 af
Primary=3.47 cfs 0.261 af

Link 5L: Analysis Point 5 Inflow=20.38 cfs 1.521 af
Primary=20.38 cfs 1.521 af

Total Runoff Area = 8.927 ac Runoff Volume = 2.886 af Average Runoff Depth = 3.88"
26.17% Pervious = 2.337 ac 73.83% Impervious = 6.590 ac

Summary for Subcatchment 1S:

Runoff = 4.55 cfs @ 12.08 hrs, Volume= 0.340 af, Depth= 3.92"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.83"

Area (sf)	CN	Description
34,370	98	Paved parking, HSG C
10,948	74	>75% Grass cover, Good, HSG C
45,318	92	Weighted Average
10,948		24.16% Pervious Area
34,370		75.84% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	26	0.0570	1.57		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
0.6	261	0.0200	7.58	5.95	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.011 Concrete pipe, straight & clean
0.9	287	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 2S:

Runoff = 2.48 cfs @ 12.08 hrs, Volume= 0.192 af, Depth= 4.25"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.83"

Area (sf)	CN	Description
20,670	98	Paved parking, HSG C
2,881	74	>75% Grass cover, Good, HSG C
23,551	95	Weighted Average
2,881		12.23% Pervious Area
20,670		87.77% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.4	23	0.0200	1.01		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
2.1	223	0.0073	1.73		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.3	178	0.0335	10.79	8.48	**Pipe Channel,** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.010 PVC, smooth interior
2.8	424	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 3S:

Runoff = 7.58 cfs @ 12.08 hrs, Volume= 0.572 af, Depth= 4.03"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.83"

Area (sf)	CN	Description
58,003	98	Water Surface, HSG C
16,154	74	>75% Grass cover, Good, HSG C
74,157	93	Weighted Average
16,154		21.78% Pervious Area
58,003		78.22% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	15	0.0200	0.93		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
2.4	303	0.0105	2.08		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
2.0	858	0.0070	7.12	22.37	**Pipe Channel,** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.011 Concrete pipe, straight & clean
4.7	1,176	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 4S:

Runoff = 3.47 cfs @ 12.08 hrs, Volume= 0.261 af, Depth= 4.03"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.83"

Area (sf)	CN	Description
27,040	98	Paved parking, HSG C
6,868	74	>75% Grass cover, Good, HSG C
33,908	93	Weighted Average
6,868		20.25% Pervious Area
27,040		79.75% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.5	34	0.0200	1.09		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
1.3	202	0.0167	2.62		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.4	239	0.0400	9.74	4.30	**Pipe Channel,** 9.0" Round Area= 0.4 sf Perim= 2.4' r= 0.19' n= 0.010 PVC, smooth interior
2.2	475	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 5.1S:

Runoff = 1.61 cfs @ 12.08 hrs, Volume= 0.124 af, Depth= 4.25"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.83"

Area (sf)	CN	Description
13,145	98	Paved parking, HSG C
2,141	74	>75% Grass cover, Good, HSG C
15,286	95	Weighted Average
2,141		14.01% Pervious Area
13,145		85.99% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	20	0.0400	1.29		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
1.2	268	0.0350	3.80		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.1	33	0.0200	6.95	5.46	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.012 Concrete pipe, finished
1.6	321	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 5S:

Runoff = 19.00 cfs @ 12.09 hrs, Volume= 1.396 af, Depth= 3.71"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.83"

Area (sf)	CN	Description
133,837	98	Paved parking, HSG C
62,787	74	>75% Grass cover, Good, HSG C
196,624	90	Weighted Average
62,787		31.93% Pervious Area
133,837		68.07% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.5	32	0.0200	1.08		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
1.6	283	0.0220	3.01		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
1.2	1,313	0.0650	17.91	31.65	**Pipe Channel,** 18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38' n= 0.011 Concrete pipe, straight & clean
3.3	1,628	Total, Increased to minimum Tc = 6.0 min			

Summary for Reach 2R: Water Quality Swale

Inflow Area = 0.351 ac, 85.99% Impervious, Inflow Depth = 4.25" for 10-Year event
Inflow = 1.61 cfs @ 12.08 hrs, Volume= 0.124 af
Outflow = 1.57 cfs @ 12.13 hrs, Volume= 0.124 af, Atten= 2%, Lag= 2.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Max. Velocity= 1.40 fps, Min. Travel Time= 1.6 min
Avg. Velocity = 0.38 fps, Avg. Travel Time= 5.7 min

Peak Storage= 147 cf @ 12.10 hrs
Average Depth at Peak Storage= 0.29'
Bank-Full Depth= 1.50' Flow Area= 11.3 sf, Capacity= 38.69 cfs

3.00' x 1.50' deep channel, n= 0.050 Scattered brush, heavy weeds
Side Slope Z-value= 3.0 '/' Top Width= 12.00'
Length= 130.0' Slope= 0.0154 '/'
Inlet Invert= 56.20', Outlet Invert= 54.20'

‡

Summary for Pond 4P: 15" RCP

Inflow Area = 0.351 ac, 85.99% Impervious, Inflow Depth = 4.25" for 10-Year event
Inflow = 1.57 cfs @ 12.13 hrs, Volume= 0.124 af
Outflow = 1.57 cfs @ 12.13 hrs, Volume= 0.124 af, Atten= 0%, Lag= 0.0 min
Primary = 1.57 cfs @ 12.13 hrs, Volume= 0.124 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 55.63' @ 12.13 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	55.00'	**15.0" Round RCP_Round 15"** L= 154.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 55.00' / 54.00' S= 0.0065 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 1.23 sf

Primary OutFlow Max=1.57 cfs @ 12.13 hrs HW=55.63' (Free Discharge)
└─**1=RCP_Round 15"** (Barrel Controls 1.57 cfs @ 3.69 fps)

Summary for Link 1L: Analysis Point 1

Inflow Area = 1.040 ac, 75.84% Impervious, Inflow Depth = 3.92" for 10-Year event
Inflow = 4.55 cfs @ 12.08 hrs, Volume= 0.340 af
Primary = 4.55 cfs @ 12.08 hrs, Volume= 0.340 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Summary for Link 2L: Analysis Point 2

Inflow Area = 0.541 ac, 87.77% Impervious, Inflow Depth = 4.25" for 10-Year event
Inflow = 2.48 cfs @ 12.08 hrs, Volume= 0.192 af
Primary = 2.48 cfs @ 12.08 hrs, Volume= 0.192 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Summary for Link 3L: Analysis Point 3

Inflow Area = 1.702 ac, 78.22% Impervious, Inflow Depth = 4.03" for 10-Year event
Inflow = 7.58 cfs @ 12.08 hrs, Volume= 0.572 af
Primary = 7.58 cfs @ 12.08 hrs, Volume= 0.572 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Summary for Link 4L: Analysis Point 4

Inflow Area = 0.778 ac, 79.75% Impervious, Inflow Depth = 4.03" for 10-Year event
Inflow = 3.47 cfs @ 12.08 hrs, Volume= 0.261 af
Primary = 3.47 cfs @ 12.08 hrs, Volume= 0.261 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Summary for Link 5L: Analysis Point 5

Inflow Area = 4.865 ac, 69.36% Impervious, Inflow Depth = 3.75" for 10-Year event
Inflow = 20.38 cfs @ 12.09 hrs, Volume= 1.521 af
Primary = 20.38 cfs @ 12.09 hrs, Volume= 1.521 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Time span=0.00-72.00 hrs, dt=0.01 hrs, 7201 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Runoff Area=45,318 sf 75.84% Impervious Runoff Depth=7.97"
Flow Length=287' Tc=6.0 min CN=92 Runoff=8.89 cfs 0.691 af

Subcatchment 2S: Runoff Area=23,551 sf 87.77% Impervious Runoff Depth=8.34"
Flow Length=424' Tc=6.0 min CN=95 Runoff=4.70 cfs 0.376 af

Subcatchment 3S: Runoff Area=74,157 sf 78.22% Impervious Runoff Depth=8.10"
Flow Length=1,176' Tc=6.0 min CN=93 Runoff=14.64 cfs 1.149 af

Subcatchment 4S: Runoff Area=33,908 sf 79.75% Impervious Runoff Depth=8.10"
Flow Length=475' Tc=6.0 min CN=93 Runoff=6.70 cfs 0.525 af

Subcatchment 5.1S: Runoff Area=15,286 sf 85.99% Impervious Runoff Depth=8.34"
Flow Length=321' Tc=6.0 min CN=95 Runoff=3.05 cfs 0.244 af

Subcatchment 5S: Runoff Area=196,624 sf 68.07% Impervious Runoff Depth=7.73"
Flow Length=1,628' Tc=6.0 min CN=90 Runoff=37.98 cfs 2.909 af

Reach 2R: Water Quality Swale Avg. Flow Depth=0.42' Max Vel=1.70 fps Inflow=3.05 cfs 0.244 af
n=0.050 L=130.0' S=0.0154 '/' Capacity=38.69 cfs Outflow=3.00 cfs 0.244 af

Pond 4P: 15" RCP Peak Elev=55.93' Inflow=3.00 cfs 0.244 af
15.0" Round Culvert n=0.012 L=154.0' S=0.0065 '/' Outflow=3.00 cfs 0.244 af

Link 1L: Analysis Point 1 Inflow=8.89 cfs 0.691 af
Primary=8.89 cfs 0.691 af

Link 2L: Analysis Point 2 Inflow=4.70 cfs 0.376 af
Primary=4.70 cfs 0.376 af

Link 3L: Analysis Point 3 Inflow=14.64 cfs 1.149 af
Primary=14.64 cfs 1.149 af

Link 4L: Analysis Point 4 Inflow=6.70 cfs 0.525 af
Primary=6.70 cfs 0.525 af

Link 5L: Analysis Point 5 Inflow=40.72 cfs 3.152 af
Primary=40.72 cfs 3.152 af

Total Runoff Area = 8.927 ac Runoff Volume = 5.893 af Average Runoff Depth = 7.92"
26.17% Pervious = 2.337 ac 73.83% Impervious = 6.590 ac

Summary for Subcatchment 1S:

Runoff = 8.89 cfs @ 12.08 hrs, Volume= 0.691 af, Depth= 7.97"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=8.94"

Area (sf)	CN	Description
34,370	98	Paved parking, HSG C
10,948	74	>75% Grass cover, Good, HSG C
45,318	92	Weighted Average
10,948		24.16% Pervious Area
34,370		75.84% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	26	0.0570	1.57		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
0.6	261	0.0200	7.58	5.95	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.011 Concrete pipe, straight & clean
0.9	287	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 2S:

Runoff = 4.70 cfs @ 12.08 hrs, Volume= 0.376 af, Depth= 8.34"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=8.94"

Area (sf)	CN	Description
20,670	98	Paved parking, HSG C
2,881	74	>75% Grass cover, Good, HSG C
23,551	95	Weighted Average
2,881		12.23% Pervious Area
20,670		87.77% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.4	23	0.0200	1.01		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
2.1	223	0.0073	1.73		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.3	178	0.0335	10.79	8.48	**Pipe Channel,** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.010 PVC, smooth interior
2.8	424	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 3S:

Runoff = 14.64 cfs @ 12.08 hrs, Volume= 1.149 af, Depth= 8.10"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=8.94"

Area (sf)	CN	Description
58,003	98	Water Surface, HSG C
16,154	74	>75% Grass cover, Good, HSG C
74,157	93	Weighted Average
16,154		21.78% Pervious Area
58,003		78.22% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	15	0.0200	0.93		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
2.4	303	0.0105	2.08		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
2.0	858	0.0070	7.12	22.37	**Pipe Channel,** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.011 Concrete pipe, straight & clean
4.7	1,176	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 4S:

Runoff = 6.70 cfs @ 12.08 hrs, Volume= 0.525 af, Depth= 8.10"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=8.94"

Area (sf)	CN	Description
27,040	98	Paved parking, HSG C
6,868	74	>75% Grass cover, Good, HSG C
33,908	93	Weighted Average
6,868		20.25% Pervious Area
27,040		79.75% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.5	34	0.0200	1.09		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
1.3	202	0.0167	2.62		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.4	239	0.0400	9.74	4.30	**Pipe Channel,** 9.0" Round Area= 0.4 sf Perim= 2.4' r= 0.19' n= 0.010 PVC, smooth interior
2.2	475	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 5.1S:

Runoff = 3.05 cfs @ 12.08 hrs, Volume= 0.244 af, Depth= 8.34"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=8.94"

Area (sf)	CN	Description
13,145	98	Paved parking, HSG C
2,141	74	>75% Grass cover, Good, HSG C
15,286	95	Weighted Average
2,141		14.01% Pervious Area
13,145		85.99% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	20	0.0400	1.29		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
1.2	268	0.0350	3.80		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.1	33	0.0200	6.95	5.46	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.012 Concrete pipe, finished
1.6	321	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 5S:

Runoff = 37.98 cfs @ 12.08 hrs, Volume= 2.909 af, Depth= 7.73"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=8.94"

Area (sf)	CN	Description
133,837	98	Paved parking, HSG C
62,787	74	>75% Grass cover, Good, HSG C
196,624	90	Weighted Average
62,787		31.93% Pervious Area
133,837		68.07% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.5	32	0.0200	1.08		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
1.6	283	0.0220	3.01		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
1.2	1,313	0.0650	17.91	31.65	**Pipe Channel,** 18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38' n= 0.011 Concrete pipe, straight & clean
3.3	1,628	Total, Increased to minimum Tc = 6.0 min			

Summary for Reach 2R: Water Quality Swale

Inflow Area = 0.351 ac, 85.99% Impervious, Inflow Depth = 8.34" for 100-Year event
Inflow = 3.05 cfs @ 12.08 hrs, Volume= 0.244 af
Outflow = 3.00 cfs @ 12.12 hrs, Volume= 0.244 af, Atten= 2%, Lag= 2.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Max. Velocity= 1.70 fps, Min. Travel Time= 1.3 min
Avg. Velocity = 0.47 fps, Avg. Travel Time= 4.6 min

Peak Storage= 229 cf @ 12.10 hrs
Average Depth at Peak Storage= 0.42'
Bank-Full Depth= 1.50' Flow Area= 11.3 sf, Capacity= 38.69 cfs

3.00' x 1.50' deep channel, n= 0.050 Scattered brush, heavy weeds
Side Slope Z-value= 3.0 '/' Top Width= 12.00'
Length= 130.0' Slope= 0.0154 '/'
Inlet Invert= 56.20', Outlet Invert= 54.20'

‡

Summary for Pond 4P: 15" RCP

Inflow Area = 0.351 ac, 85.99% Impervious, Inflow Depth = 8.34" for 100-Year event
Inflow = 3.00 cfs @ 12.12 hrs, Volume= 0.244 af
Outflow = 3.00 cfs @ 12.12 hrs, Volume= 0.244 af, Atten= 0%, Lag= 0.0 min
Primary = 3.00 cfs @ 12.12 hrs, Volume= 0.244 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 55.93' @ 12.12 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	55.00'	**15.0" Round RCP_Round 15"** L= 154.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 55.00' / 54.00' S= 0.0065 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 1.23 sf

Primary OutFlow Max=3.00 cfs @ 12.12 hrs HW=55.92' (Free Discharge)
└─**1=RCP_Round 15"** (Barrel Controls 3.00 cfs @ 4.29 fps)

Summary for Link 1L: Analysis Point 1

Inflow Area = 1.040 ac, 75.84% Impervious, Inflow Depth = 7.97" for 100-Year event
Inflow = 8.89 cfs @ 12.08 hrs, Volume= 0.691 af
Primary = 8.89 cfs @ 12.08 hrs, Volume= 0.691 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Summary for Link 2L: Analysis Point 2

Inflow Area = 0.541 ac, 87.77% Impervious, Inflow Depth = 8.34" for 100-Year event
Inflow = 4.70 cfs @ 12.08 hrs, Volume= 0.376 af
Primary = 4.70 cfs @ 12.08 hrs, Volume= 0.376 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Summary for Link 3L: Analysis Point 3

Inflow Area = 1.702 ac, 78.22% Impervious, Inflow Depth = 8.10" for 100-Year event
Inflow = 14.64 cfs @ 12.08 hrs, Volume= 1.149 af
Primary = 14.64 cfs @ 12.08 hrs, Volume= 1.149 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Summary for Link 4L: Analysis Point 4

Inflow Area = 0.778 ac, 79.75% Impervious, Inflow Depth = 8.10" for 100-Year event
Inflow = 6.70 cfs @ 12.08 hrs, Volume= 0.525 af
Primary = 6.70 cfs @ 12.08 hrs, Volume= 0.525 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Summary for Link 5L: Analysis Point 5

Inflow Area = 4.865 ac, 69.36% Impervious, Inflow Depth = 7.78" for 100-Year event
Inflow = 40.72 cfs @ 12.09 hrs, Volume= 3.152 af
Primary = 40.72 cfs @ 12.09 hrs, Volume= 3.152 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

GPI

Greenman-Pedersen, Inc.
181 Ballardvale St.
Suite 202
Wilmington, MA 01887
978-570-2999

Client MassDOT
Project Haverhill Route 97

Proj. No. MAX-201420.00
Date 7/1/2016
Calc. by CLS
Check by WJM

Design Parameters
10 Year Storm
10 in Min. Pipe Size
Project File: 605573

paved C= 0.9
unpaved C= 0.3

Location in Massachusetts 1 (1-Boston, 2-Barnstable, 3-Worcester, 4-Springfield, 5-Pittsfield)
Manning's roughness coefficient 0.013

Rainfall Data is For **Boston**

Line No.	Line ID	Junct Type	User Sta Up (ft)	User Sta Dn (ft)	Pipe Travel (min)	Tc (min)	Runoff Coeff (C)	Total Area (ac)	Total CxA	i Inlet (in/hr)	Total Runoff (cfs)	Line Size (in)	n-value Pipe	Line Slope (%)	Line Length (ft)	Flow Rate (cfs)	Capacity Full (cfs)	Vel Ave (ft/s)	Invert Up (ft)	Invert Dn (ft)	Cover Up (ft)	Cover Dn (ft)	Grnd/ Rim Elev Up (ft)	HGL Up (ft)	Grnd/ Rim Elev Dn (ft)	HGL Dn (ft)
1	101-O	MH	364.41	361.56	0.15	6.50	0.00	1.07	0.83	0.00	4.20	18.00	0.01	1.43	38.54	7.70	12.54	6.06	140.06	139.51	1.88	n/a	143.44	141.13	0.00	140.47
2	104.00	MH	361.56	456.49	0.47	5.90	0.00	0.66	0.50	0.00	2.59	12.00	0.01	0.49	94.96	2.59	2.51	3.35	140.63	140.16	2.20	2.28	143.83	141.56	143.44	141.13
3	105.00	MH	456.49	493.98	0.21	5.70	0.00	0.58	0.43	0.00	2.24	12.00	0.01	0.51	37.50	2.24	2.75	2.85	140.82	140.63	2.22	2.20	144.04	141.82	143.83	141.74
4	109.00	Comb.	493.98	517.48	0.72	5.00	0.90	0.14	0.13	5.39	0.68	12.00	0.01	0.54	37.22	0.68	2.61	0.91	141.10	140.90	2.01	2.14	144.11	141.96	144.04	141.95
5	101-I	Hdwall	361.56	354.58	0.10	5.00	0.00	0.00	0.00	0.00	0.00	12.00	0.01	2.52	15.46	2.00	5.66	3.47	140.70	140.31	-0.73	2.13	140.97	141.30 j	143.44	141.13
6	106.00	Comb.	456.49	451.74	0.69	5.00	0.90	0.08	0.07	5.39	0.39	12.00	0.01	0.98	20.38	0.39	3.53	0.53	140.93	140.73	2.28	2.10	144.21	141.74	143.83	141.74
7	110.00	MH	361.56	346.81	0.06	6.40	0.00	0.41	0.33	0.00	1.68	12.00	0.01	0.68	14.75	3.18	3.18	4.05	140.16	140.06	2.26	2.38	143.42	141.23	143.44	141.13
8	111.00	MH	346.81	316.57	0.18	6.30	0.00	0.18	0.13	0.00	0.64	12.00	0.01	0.63	30.25	2.14	3.06	2.73	140.35	140.16	2.10	2.26	143.45	141.58	143.42	141.48
9	114.00	Comb.	316.57	310.50	0.26	5.00	0.60	0.12	0.07	5.39	0.39	12.00	0.01	0.65	7.73	0.39	2.86	0.49	140.40	140.35	1.97	2.10	143.37	141.69	143.45	141.69
10	115.00	Comb.	316.57	310.50	1.25	5.00	0.90	0.06	0.05	5.39	0.29	12.00	0.01	0.54	27.88	0.29	2.83	0.37	140.50	140.35	1.87	2.10	143.37	141.69	143.45	141.69
11	113.00	Comb.	346.81	340.50	0.67	5.00	0.90	0.11	0.10	5.39	0.53	12.00	0.01	0.44	27.36	0.53	2.55	0.68	140.28	140.16	2.05	2.26	143.33	141.49	143.42	141.48
12	112.00	Grate	346.81	340.93	0.18	5.00	0.90	0.12	0.11	5.39	0.58	12.00	0.01	0.63	7.96	0.58	3.06	0.74	140.21	140.16	2.12	2.26	143.33	141.49	143.42	141.48
13	107.00	Comb.	493.98	491.77	0.33	5.00	0.61	0.21	0.13	5.39	0.69	12.00	0.01	0.52	17.22	0.69	2.57	0.89	140.99	140.90	2.34	2.14	144.33	141.95	144.04	141.95
14	108.00	Comb.	493.98	520.13	0.37	5.00	0.76	0.23	0.17	5.39	0.94	12.00	0.01	0.49	26.33	0.94	2.50	1.22	141.03	140.90	2.10	2.14	144.13	141.96	144.04	141.95

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10 Year Storm
10 in Min. Pipe Size
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paved C= 0.9
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Location in Massachusetts 1 (1-Boston, 2-Barnstable, 3-Worcester, 4-Springfield, 5-Pittsfield)
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1	201.00	MH	778.68	787.74	0.09	6.30	0.00	1.24	0.88	0.00	4.49	15.00	0.01	1.00	19.59	4.49	6.46	3.77	143.00	142.80	3.39	0.27	147.63	144.11	144.32	144.05
2	202.00	MH	787.74	799.87	0.23	6.10	0.00	0.70	0.46	0.00	2.38	15.00	0.01	1.05	27.58	2.38	6.62	4.45	144.14	143.85	2.73	2.53	148.12	144.76	147.63	144.37
3	EX	MH	799.87	858.32	0.71	5.40	0.00	0.52	0.34	0.00	1.79	15.00	0.01	0.64	62.52	1.79	5.17	3.71	144.95	144.55	2.77	2.32	148.97	145.48	148.12	145.06
4	EX 2.2	Comb.	858.32	869.91	0.24	5.00	0.75	0.27	0.20	5.39	1.09	12.00	0.01	0.50	19.94	1.09	2.52	3.10	145.55	145.45	3.00	2.52	149.55	146.01	148.97	145.91
5	EX 2.1	Comb.	858.32	842.23	0.37	5.00	0.54	0.25	0.14	5.39	0.73	12.00	0.01	0.49	20.50	0.73	2.49	2.75	145.25	145.15	3.00	2.82	149.25	145.62	148.97	145.52
6	203.00	Comb.	799.87	805.98	0.13	5.00	0.70	0.18	0.13	5.39	0.68	12.00	0.01	0.45	6.61	0.68	2.40	1.68	144.26	144.23	2.41	2.89	147.67	144.76	148.12	144.76
7	205.00	MH	787.74	909.97	0.83	5.30	0.00	0.47	0.36	0.00	1.91	12.00	0.01	0.80	121.82	1.91	3.19	2.97	144.07	143.10	3.56	3.53	148.63	144.73	147.63	144.35
8	206.00	Comb.	909.97	919.89	0.30	5.00	0.71	0.34	0.24	5.39	1.30	12.00	0.01	1.99	29.62	1.30	5.03	2.80	144.77	144.18	2.79	3.45	148.56	145.25 j	148.63	144.91
9	207.00	Comb.	909.97	920.02	0.30	5.00	0.90	0.13	0.12	5.39	0.63	12.00	0.01	2.01	14.43	0.63	5.05	0.80	143.79	143.50	3.70	4.13	148.49	144.92	148.63	144.91
10	204.00	Comb.	787.74	799.86	0.62	5.00	0.90	0.07	0.06	5.39	0.34	12.00	0.01	2.00	16.00	0.34	5.04	0.48	143.58	143.26	3.00	3.37	147.58	144.35	147.63	144.35

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1	EX-3.0	MH	1166.15	1184.42	1.10	10.50	0.00	2.77	1.96	0.00	8.42	24.00	0.01	4.48	280.63	12.92	47.87	6.23	145.01	132.44	3.61	5.49	150.62	146.30	139.93	133.66
2	301.00	MH	1184.42	1233.00	0.22	10.30	0.00	2.18	1.59	0.00	6.88	24.00	0.01	0.68	48.58	11.38	18.64	5.98	145.99	145.66	2.64	2.96	150.63	147.20	150.62	146.79
3	304.00	MH	1233.00	1483.00	1.32	8.90	0.00	1.54	1.12	0.00	5.11	24.00	0.01	0.62	250.00	9.61	17.75	5.16	147.55	146.01	3.38	2.62	152.93	148.66 j	150.63	147.20
4	EX 3.1	MH	1483.00	1578.28	0.54	8.40	0.00	1.30	0.96	0.00	4.44	24.00	0.01	0.72	95.28	8.94	19.25	5.45	148.34	147.65	3.52	3.28	153.86	149.41	152.93	148.66
5	EX-3.2	MH	1578.28	1637.34	0.37	8.00	0.00	1.05	0.77	0.00	3.61	24.00	0.01	0.58	59.00	8.11	17.17	4.92	148.68	148.34	3.78	3.52	154.46	149.69 j	153.86	149.41
6	308.00	MH	1637.34	1680.94	0.29	7.70	0.00	0.88	0.62	0.00	2.97	15.00	0.01	5.04	43.85	2.97	14.50	3.59	150.94	148.73	2.58	4.48	154.77	151.63 j	154.46	149.69
7	311.00	MH	1680.94	1928.66	2.36	5.40	0.00	0.54	0.40	0.00	2.12	15.00	0.01	1.00	248.18	2.12	6.99	3.57	153.47	150.99	2.11	2.53	156.83	154.05 j	154.77	151.63
8	313.00	Comb.	1928.66	1930.00	0.37	5.00	0.90	0.17	0.15	5.39	0.83	12.00	0.01	0.99	23.29	0.83	3.54	2.61	153.80	153.57	1.89	2.26	156.69	154.18 j	156.83	154.05
9	312.00	Comb.	1928.66	1935.00	0.11	5.00	0.67	0.37	0.25	5.39	1.34	12.00	0.01	1.02	10.81	1.34	3.59	3.54	153.68	153.57	2.02	2.26	156.70	154.17	156.83	154.05
10	309.00	MH	1680.94	1686.60	0.17	5.10	0.00	0.34	0.22	0.00	1.18	12.00	0.01	4.20	15.47	1.18	7.30	3.83	151.90	151.25	2.42	2.52	155.32	152.36	154.77	151.63
11	310.00	Comb.	1686.60	1690.00	0.14	5.00	0.65	0.34	0.22	5.39	1.19	12.00	0.01	3.15	12.68	1.19	6.32	3.39	152.30	151.90	1.51	2.42	154.81	152.76	155.32	152.36
12	3.11	Comb.	1578.28	1591.96	0.18	5.00	0.76	0.25	0.19	5.39	1.02	12.00	0.01	1.47	14.27	1.02	4.32	3.86	149.45	149.24	3.45	3.62	153.90	149.88	153.86	149.57
13	307.00	Comb.	1637.34	1637.00	0.42	5.00	0.85	0.17	0.14	5.39	0.78	12.00	0.01	1.51	25.14	0.78	4.38	2.00	149.16	148.78	4.16	4.68	154.32	149.53	154.46	149.69
14	306.00	Comb.	1483.00	1490.00	1.12	5.00	0.90	0.07	0.06	5.39	0.34	12.00	0.01	0.52	29.05	0.34	2.56	2.26	148.77	148.62	3.16	3.31	152.93	149.02	152.93	148.87
15	300.00	Comb.	1184.42	1197.67	0.18	5.00	0.63	0.59	0.37	5.39	2.00	12.00	0.01	1.99	28.08	2.00	5.03	5.04	147.83	147.27	3.00	2.35	151.83	148.43	150.62	147.71
16	305.00	Comb.	1483.00	1490.00	0.22	5.00	0.62	0.17	0.11	5.39	0.57	12.00	0.01	1.03	9.70	0.57	3.62	3.03	148.88	148.78	3.00	3.15	152.88	149.19	152.93	149.05
17	302.00	Comb.	1233.00	1240.00	0.08	5.00	0.68	0.50	0.34	5.39	1.83	12.00	0.01	0.99	11.15	1.83	3.54	4.23	147.16	147.05	2.59	2.58	150.75	147.74	150.63	147.56
18	303.00	Comb.	1233.00	1240.00	0.67	5.00	0.90	0.14	0.13	5.39	0.68	12.00	0.01	2.00	35.03	0.68	5.03	1.18	146.64	145.94	2.60	3.69	150.24	147.20	150.63	147.20

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1	401.00	MH	2637.91	2640.38	0.15	9.10	0.00	0.57	0.44	0.00	1.98	15.00	0.01	1.24	41.79	5.48	7.20	5.45	148.58	148.06	3.13	0.00	152.96	149.53 j	149.31	149.02
2	402.00	MH	2640.38	2592.00	0.22	8.90	0.00	0.30	0.20	0.00	0.93	15.00	0.01	1.51	48.43	4.43	7.93	4.98	149.41	148.68	2.98	3.03	153.64	150.26	152.96	149.53
3	403.00	MH	2592.00	2480.00	1.35	7.50	0.00	0.30	0.20	0.00	0.98	12.00	0.01	1.50	112.07	0.98	4.36	2.36	151.19	149.51	3.28	3.13	155.47	151.61 j	153.64	150.26
4	404.00	Comb.	2480.00	2470.01	2.53	5.00	0.50	0.02	0.01	5.39	0.05	12.00	0.01	2.02	10.42	0.05	5.06	1.42	151.72	151.51	2.85	2.96	155.57	151.81 j	155.47	151.61
5	405.00	Comb.	2480.00	2475.00	0.47	5.00	0.69	0.28	0.19	5.39	1.04	12.00	0.01	0.80	37.30	1.04	3.19	3.44	151.58	151.28	3.00	3.19	155.58	152.01	155.47	151.67
6	406.00	MH	2592.00	2584.62	0.20	5.00	0.00	0.00	0.00	0.00	0.00	15.00	0.01	0.74	34.00	3.50	5.54	4.53	149.76	149.51	2.75	2.88	153.76	150.51	153.64	150.26
7	408.00	Comb.	2640.38	2650.28	0.26	5.00	0.90	0.14	0.13	5.39	0.68	12.00	0.01	0.52	13.47	0.68	2.57	1.00	148.75	148.68	2.88	3.28	152.63	149.53	152.96	149.53
8	407.00	Comb.	2640.38	2650.99	0.79	5.00	0.84	0.13	0.11	5.39	0.59	12.00	0.01	0.51	35.42	0.59	2.54	0.94	148.86	148.68	2.86	3.28	152.72	149.53	152.96	149.53

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1	502.00	MH	4139.31	4126.80	0.36	9.20	0.00	3.09	2.44	0.00	11.00	24.00	0.01	2.00	82.91	13.00	32.00	4.65	55.66	54.00	13.22	1.67	70.88	57.15	57.67	57.00
2	503.00	MH	4126.80	4137.84	0.08	9.10	0.00	3.09	2.44	0.00	11.03	24.00	0.01	0.99	18.21	13.03	22.49	6.73	57.84	57.66	11.75	11.22	71.59	59.14	70.88	58.75
3	505.00	MH	4137.84	4136.08	0.15	9.00	0.00	2.97	2.34	0.00	10.61	24.00	0.01	7.03	34.14	12.61	59.97	10.53	62.74	60.34	6.49	9.25	71.23	64.02	71.59	60.96
4	507.00	MH	4136.08	3992.64	0.36	8.60	0.00	2.89	2.26	0.00	10.43	18.00	0.01	4.74	143.60	12.43	22.87	10.35	72.05	65.24	6.33	4.49	79.88	73.38	71.23	66.03
5	511.00	MH	3992.64	3945.71	0.15	8.40	0.00	2.64	2.11	0.00	9.76	18.00	0.01	5.86	46.57	9.76	25.42	9.93	77.23	74.50	4.10	3.88	82.83	78.43	79.88	75.15
6	516.00	MH	3945.71	3726.22	0.75	7.70	0.00	2.42	1.91	0.00	9.12	18.00	0.01	6.24	217.52	9.12	26.23	9.84	91.90	78.33	3.05	3.00	96.45	93.07	82.83	78.94
7	521.00	MH	3726.22	3477.72	0.66	7.00	0.00	2.03	1.61	0.00	7.90	15.00	0.01	6.67	245.94	7.90	16.68	6.97	108.40	92.00	3.05	3.20	112.70	109.51	96.45	93.07
8	526.00	MH	3477.72	3370.73	0.32	6.70	0.00	1.73	1.39	0.00	6.92	15.00	0.01	7.58	106.64	6.92	17.78	6.39	116.58	108.50	2.25	2.95	120.08	117.63	112.70	109.51
9	528.00	MH	3370.73	3222.98	0.48	6.20	0.00	1.54	1.26	0.00	6.42	15.00	0.01	6.13	147.95	6.42	15.99	6.19	125.75	116.68	3.35	2.15	130.35	126.77	120.08	117.63
10	534.00	MH	3222.98	2965.32	1.00	5.20	0.00	0.74	0.63	0.00	3.36	12.00	0.01	5.80	257.80	3.36	8.58	4.77	140.81	125.85	3.50	3.50	145.31	141.59 j	130.35	126.77
11	535.00	Comb.	2965.32	2955.61	0.12	5.00	0.85	0.49	0.42	5.39	2.25	12.00	0.01	0.50	19.87	2.25	2.53	3.63	141.45	141.35	3.00	2.96	145.45	142.19	145.31	142.08
12	536.00	Comb.	2965.32	2960.63	0.17	5.00	0.85	0.25	0.21	5.39	1.15	12.00	0.01	0.85	15.32	1.15	3.28	3.15	141.23	141.10	3.00	3.21	145.23	141.68 j	145.31	141.59
13	533.00	Comb.	3222.98	3207.02	0.16	5.00	0.84	0.47	0.39	5.39	2.13	12.00	0.01	0.49	26.29	2.13	2.50	3.58	127.23	127.10	3.00	2.25	131.23	127.94	130.35	127.81
14	529.00	Comb.	3222.98	3217.01	0.13	5.00	0.71	0.33	0.23	5.39	1.26	12.00	0.01	3.87	12.41	1.26	7.00	5.10	127.01	126.53	2.53	2.82	130.54	127.48	130.35	126.82
15	527.00	Comb.	3370.73	3356.83	0.56	5.00	0.67	0.19	0.13	5.39	0.69	12.00	0.01	0.51	29.25	0.69	2.55	1.04	116.92	116.77	3.00	2.31	120.92	117.64	120.08	117.63
16	522.00	Comb.	3477.72	3439.78	2.04	5.00	0.79	0.07	0.06	5.39	0.30	12.00	0.01	4.93	46.44	0.30	7.91	1.85	111.49	109.20	2.92	2.50	115.41	111.71 j	112.70	109.51
17	525.00	Comb.	3477.72	3465.27	0.19	5.00	0.73	0.23	0.17	5.39	0.91	12.00	0.01	1.50	13.33	0.91	4.36	3.74	109.40	109.20	3.06	2.50	113.46	109.80	112.70	109.51
18	517.00	Comb.	3726.22	3714.86	0.56	5.00	0.63	0.19	0.12	5.39	0.65	12.00	0.01	5.46	27.84	0.65	8.32	2.11	94.02	92.50	2.50	2.95	97.52	94.35 j	96.45	93.07
19	520.00	Comb.	3726.22	3715.79	0.16	5.00	0.90	0.20	0.18	5.39	0.97	12.00	0.01	4.13	12.11	0.97	7.24	2.64	93.00	92.50	2.98	2.95	96.98	93.41 j	96.45	93.07
20	515.00	Comb.	3945.71	3936.25	0.21	5.00	0.90	0.16	0.14	5.39	0.78	12.00	0.01	4.53	12.59	0.78	7.58	4.59	79.90	79.33	2.49	2.50	83.39	80.27	82.83	79.55
21	512.00	Comb.	3945.71	3939.76	1.14	5.00	0.90	0.06	0.05	5.39	0.29	12.00	0.01	1.73	25.38	0.29	4.69	2.78	79.27	78.83	3.00	3.00	83.27	79.49	82.83	79.00
22	508.00	MH	3992.64	3980.01	0.18	5.20	0.00	0.25	0.16	0.00	0.84	15.00	0.01	1.98	24.77	2.84	9.08	5.37	74.24	73.75	4.81	4.88	80.30	74.92	79.88	74.23
23	510.00	Comb.	3980.01	3989.74	0.17	5.00	0.63	0.25	0.16	5.39	0.85	12.00	0.01	0.97	11.32	0.85	3.51	3.36	75.63	75.52	3.00	3.78	79.63	76.02	80.30	75.86
24	504.00	Comb.	4137.84	4126.57	0.32	5.00	0.90	0.12	0.11	5.39	0.58	12.00	0.01	1.97	14.24	0.58	4.99	3.49	67.63	67.35	3.00	3.24	71.63	67.95	71.59	67.58
25	506.00	Comb.	4136.08	4126.97	0.38	5.00	0.90	0.08	0.07	5.39	0.39	12.00	0.01	3.27	11.32	0.39	6.44	3.47	67.60	67.23	3.00	3.00	71.60	67.86	71.23	67.40

GPI

Greenman-Pedersen, Inc.
181 Ballardvale St.
Suite 202
Wilmington, MA 01887
978-570-2999

Client MassDOT
Project Haverhill Route 97

Proj. No. MAX-201420.00
Date 7/1/2016
Calc. by CLS
Check by WJM

Design Parameters
10 Year Storm
10 in Min. Pipe Size
Project File: 605573

paved C= 0.9
unpaved C= 0.3

Location in Massachusetts 1 (1-Boston, 2-Barnstable, 3-Worcester, 4-Springfield, 5-Pittsfield)
Manning's roughness coefficient 0.013

Rainfall Data is For **Boston**

Line No.	Line ID	Junct Type	User Sta Up (ft)	User Sta Dn (ft)	Pipe Travel (min)	Tc (min)	Runoff Coeff (C)	Total Area (ac)	Total CxA	i Inlet (in/hr)	Total Runoff (cfs)	Line Size (in)	n-value Pipe	Line Slope (%)	Line Length (ft)	Flow Rate (cfs)	Capacity Full (cfs)	Vel Ave (ft/s)	Invert Up (ft)	Invert Dn (ft)	Cover Up (ft)	Cover Dn (ft)	Grnd/ Rim Elev Up (ft)	HGL Up (ft)	Grnd/ Rim Elev Dn (ft)	HGL Dn (ft)
1	605.00	MH	4433.19	4402.63	0.32	6.60	0.00	0.43	0.33	0.00	1.67	12.00	0.01	0.51	43.05	1.67	2.55	3.53	56.42	56.20	3.01	-56.03	60.43	57.04	1.17	56.75
2	607.00	Comb.	4402.63	4335.94	1.60	5.00	0.90	0.12	0.11	5.39	0.58	12.00	0.01	1.99	71.27	0.58	5.03	2.48	58.26	56.84	3.17	2.59	62.43	58.58 j	60.43	57.21
3	606.00	Comb.	4402.63	4392.54	0.17	5.00	0.73	0.31	0.23	5.39	1.22	12.00	0.01	1.00	16.06	1.22	3.55	2.62	56.58	56.42	3.00	3.01	60.58	57.05	60.43	57.21
4	601.00	MH	4709.13	4601.69	0.54	7.00	0.00	0.90	0.58	0.00	2.87	15.00	0.01	1.21	125.00	4.54	7.10	5.56	47.51	46.00	5.85	-1.98	54.61	48.37	45.27	46.73
5	603.00	MH	4601.69	4572.17	0.32	5.00	0.50	0.40	0.20	5.39	1.08	15.00	0.01	2.01	43.30	2.75	9.15	5.33	50.00	49.13	4.55	4.23	55.80	50.66	54.61	49.60
6	604.00	Comb.	4601.69	4535.97	1.99	5.00	0.82	0.10	0.08	5.39	0.44	12.00	0.01	6.62	67.23	0.44	9.16	4.26	52.86	48.41	2.50	5.20	56.36	53.13	54.61	48.56
7	602.00	Comb.	4601.69	4603.41	0.28	5.00	0.75	0.40	0.30	5.39	1.62	12.00	0.01	2.48	35.06	1.62	5.61	4.96	49.28	48.41	4.65	5.20	54.93	49.82	54.61	48.78

GPI

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Client MassDOT
Project Haverhill Route 97

Proj. No. MAX-201420.00
Date 7/1/2016
Calc. by CLS
Check by WJM

Design Parameters
10 Year Storm
10 in Min. Pipe Size
Project File: 605573

paved C= 0.9
unpaved C= 0.3

Location in Massachusetts 1 (1-Boston, 2-Barnstable, 3-Worcester, 4-Springfield, 5-Pittsfield)
Manning's roughness coefficient 0.013

Rainfall Data is For **Boston**

Line No.	Line ID	Junct Type	User Sta Up (ft)	User Sta Dn (ft)	Pipe Travel (min)	Tc (min)	Runoff Coeff (C)	Total Area (ac)	Total CxA	i Inlet (in/hr)	Total Runoff (cfs)	Line Size (in)	n-value Pipe	Line Slope (%)	Line Length (ft)	Flow Rate (cfs)	Capacity Full (cfs)	Vel Ave (ft/s)	Invert Up (ft)	Invert Dn (ft)	Cover Up (ft)	Cover Dn (ft)	Grnd/ Rim Elev Up (ft)	HGL Up (ft)	Grnd/ Rim Elev Dn (ft)	HGL Dn (ft)
1	701.00	MH	4818.00	4820.10	0.08	5.30	0.00	0.87	0.73	0.00	3.90	12.00	0.01	1.45	24.90	3.90	4.28	5.25	42.36	42.00	3.49	0.25	46.85	43.20 j	43.25	43.00
2	702.00	Comb.	4820.10	4834.87	0.11	5.00	0.88	0.39	0.34	5.39	1.85	12.00	0.01	1.01	14.85	1.85	3.58	3.18	42.90	42.75	2.50	3.10	46.40	43.48	46.85	43.68
3	703.00	Comb.	4820.10	4833.44	0.26	5.00	0.81	0.48	0.39	5.39	2.10	12.00	0.01	2.00	42.00	2.10	5.04	3.39	43.30	42.46	2.44	3.39	46.74	43.92 j	46.85	43.68

GPI

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Haverhill Cross Culvert
Client *
Subject *

Proj. No. MAX-
Date *
Calc. by *
Check by 1

Design Parameters
50 Year Storm
12 in Min. Pipe Size
Project File: *

paved C= 0.9
unpaved C= 0.2

Location in Massachusetts 1 (1-Boston, 2-Barnstable, 3-Worcester, 4-Springfield, 5-Pittsfield)
Manning's roughness coefficient 0.013

Rainfall Data is For Boston

LOCATION OF STRUCTURES		DISCHARGE										PIPE DATA								VERTICAL CONTROL			
UPPER DMH.CBCI LOCATION	LOWER DMH/CBCI LOCATION	TIME OF CONCENTRATION, T_C PERIOD IN MINUTES		COMB. RUNOFF COEFF.	DRAINAGE AREA IN ACRES			C x A		RAIN-FALL INTEN.	DES. DISCH.	DIAM. OF PIPE	n VALUE	SLOPE OF PIPE	LENGTH OF PIPE	FULL CAP.	FULL VEL.	PEAK FLOW CONDITIONS		PIPE INVERT ELEVATION		RIM ELEVATION & DEPTH OF COVER	
FROM STATION	TO STATION	PIPE FLOW TIME	TOTAL, T_C (min. = 5)	C	paved area ACRES	unpaved area ACRES	TOTAL AREA ACRES	INC	TOTAL	i in/HR	Q cfs	in		in/in	ft	cfs	ft/s	VELOCITY ft/s	d/D	UPPER END	LOWER END	UPPER RIM	DEPTH OF PIPE COVER
Inlet Headwall	Outlet Headwall		21.00	0.27	1.23	11.57	12.800	3.42	3.42	4.20	17.24	18	0.013	0.032	55	18.784	10.6	12.04	0.75	141.39	139.63	145.20	2.31
Road Grade at Inlet = 145.2																							
Road Grade at Outfall = 144.5																							

Rechage System Sizing Calculations

Station: 16+81 LT

Volume 3, Chapter 1 of the Massachusetts Stormwater Handbook

Soil type in Infiltration Layer	Sandy Loam	
NRCS Hydrologic Soil Type	B	
Test Pit # =	N/A	
Impervious Area to Leaching Catch Basin	5760	SF
Volume of Storage Available in Leaching Basin and Stone	See Detail	
Depth of Structure from Invert (out at CB) to Bottom of Structure	3.25	FT
Internal Diameter of Structure	4	FT
External Diameter of Structure	5	FT
Diameter of Stone around Structure	9	FT
Depth of Stone Below Structure	1	FT
Porosity of Stone	0.4	
Number of Leaching Basins within Subcatchment Area	2	EA
Area Inside of Structure	12.57	SF
Area of Stone Below Structure	63.62	SF
Area of Stone deducting Structure	43.98	SF
Volume Inside Structure	40.84	CF
Volume of Stone Layer Below Structure	63.62 CF	
Volume of Stone Layer Around Structure	142.94 CF	
Volume of Anulus within Stone		
Below Structure	25.45	CF
Around Structure	57.18	CF
Total Volume Available to store runoff per structure =	123.46	CF
Total Volume available to store runoff =	246.93	CF

RECHARGE REQUIREMENTS

Required Recharge Volume

Rv=F*Impervious Area

F = Target Depth Factor

Rv= 0.35 Inch X 5760

Rv= 168.00 CF

Sizing Storage Volumes

Using the "Static" method:

The Required Recharge Volume =	168.00 CF
The Available Recharge Volume, assuming the stored runoff will exfiltate completely within 72 hrs =	
Leaching Basins =	246.93 CF
Total Storage Volume available to recharge =	246.93 CF

This method does have enough Available Storage Volume for the amount of Required Recharge Volume.

Recharge System Drawdown

Verify the Recharge System will Drawdown within 72 Hrs

TIMEdrawdown = Rv/(K* Bottom Area of Infiltration Structure * 2 Units)

30.5 Hours

The drawdown time is less than 72 hours, therefore this size system is acceptable.

WATER QUALITY REQUIREMENTS

Required Water Quality Volume

Vwq=(Dwq/12 inches/foot) * (A * 43560 SF/Acre)

Vwq = Required Water Quality Volume

Dwq = Water Quality Depth: 1" for discharges within a Zone II or Interim Wellhead Protection Area, to or near another critical area, runoff from LUHPPL, or exfiltration to soils with infiltration rate greater than 2.4 inches/hr or greater; 1/2" for discharges near or to other areas.

A = Impervious Area (In Acres)

Vwq = (0.5 inch/12 inches/foot)* 5760 SF =

240.00 CF

Therefore, the use of leaching basins is sufficent to achieve the required water quality volume.

Rechage System Sizing Calculations

Station: 25+00 LT

Volume 3, Chapter 1 of the Massachusetts Stormwater Handbook

Soil type in Infiltration Layer	Sandy Loam	
NRCS Hydrologic Soil Type	B	
Test Pit # =	N/A	
Impervious Area to Leaching Catch Basin	5155	SF
Volume of Storage Available in Leaching Basin and Stone	See Detail	
Depth of Structure from Invert (out at CB) to Bottom of Structure	3.25	FT
Internal Diameter of Structure	4	FT
External Diameter of Structure	5	FT
Diameter of Stone around Structure	9	FT
Depth of Stone Below Structure	1	FT
Porosity of Stone	0.4	
Number of Leaching Basins within Subcatchment Area	2	EA
Area Inside of Structure	12.57	SF
Area of Stone Below Structure	63.62	SF
Area of Stone deducting Structure	43.98	SF
Volume Inside Structure	40.84	CF
Volume of Stone Layer Below Structure	63.62 CF	
Volume of Stone Layer Around Structure	142.94 CF	
Volume of Anulus within Stone		
Below Structure	25.45	CF
Around Structure	57.18	CF
Total Volume Available to store runoff per structure =	123.46	CF
Total Volume available to store runoff =	246.93	CF

RECHARGE REQUIREMENTS

Required Recharge Volume

Rv=F*Impervious Area

F = Target Depth Factor

Rv= 0.35 Inch X 5155

Rv= 150.35 CF

Sizing Storage Volumes

Using the "Static" method:

The Required Recharge Volume =	150.35 CF
The Available Recharge Volume, assuming the stored runoff will exfiltate completely within 72 hrs =	
Leaching Basins =	246.93 CF
Total Storage Volume available to recharge =	246.93 CF

This method does have enough Available Storage Volume for the amount of Required Recharge Volume.

Recharge System Drawdown

Verify the Recharge System will Drawdown within 72 Hrs

TIMEdrawdown = Rv/(K* Bottom Area of Infiltration Structure * 2 Units)

27.3 Hours

The drawdown time is less than 72 hours, therefore this size system is acceptable.

WATER QUALITY REQUIREMENTS

Required Water Quality Volume

Vwq=(Dwq/12 inches/foot) * (A * 43560 SF/Acre)

Vwq = Required Water Quality Volume

Dwq = Water Quality Depth: 1" for discharges within a Zone II or Interim Wellhead Protection Area, to or near another critical area, runoff from LUHPPL, or exfiltration to soils with infiltration rate greater than 2.4 inches/hr or greater; 1/2" for discharges near or to other areas.

A = Impervious Area (In Acres)

Vwq = (0.5 inch/12 inches/foot)* 5155 SF =

214.79 CF

Therefore, the use of leaching basins is sufficent to achieve the required water quality volume.

Rechage System Sizing Calculations

Station: 32+14 LT

Volume 3, Chapter 1 of the Massachusetts Stormwater Handbook

Soil type in Infiltration Layer	Loam	
NRCS Hydrologic Soil Type	B	
Test Pit # =	N/A	
Impervious Area to Leaching Catch Basin	5860	SF
Volume of Storage Available in Leaching Basin and Stone	See Detail	
Depth of Structure from Invert (out at CB) to Bottom of Structure	3.25	FT
Internal Diameter of Structure	4	FT
External Diameter of Structure	5	FT
Diameter of Stone around Structure	9	FT
Depth of Stone Below Structure	1	FT
Porosity of Stone	0.4	
Number of Leaching Basins within Subcatchment Area	2	EA
Area Inside of Structure	12.57	SF
Area of Stone Below Structure	63.62	SF
Area of Stone deducting Structure	43.98	SF
Volume Inside Structure	40.84	CF
Volume of Stone Layer Below Structure	63.62	CF
Volume of Stone Layer Around Structure	142.94	CF
Volume of Anulus within Stone		
Below Structure	25.45	CF
Around Structure	57.18	CF
Total Volume Available to store runoff per structure =	123.46	CF
Total Volume available to store runoff =	246.93	CF

RECHARGE REQUIREMENTS

Required Recharge Volume

Rv=F*Impervious Area

F = Target Depth Factor

Rv= 0.35 Inch X 5860

Rv= 170.92 CF

Sizing Storage Volumes

Using the "Static" method:

The Required Recharge Volume =	170.92 CF
The Available Recharge Volume, assuming the stored runoff will exfiltate completely within 72 hrs =	
Leaching Basins =	246.93 CF
Total Storage Volume available to recharge =	246.93 CF

This method does have enough Available Storage Volume for the amount of Required Recharge Volume.

Recharge System Drawdown

Verify the Recharge System will Drawdown within 72 Hrs

TIMEdrawdown = Rv/(K* Bottom Area of Infiltration Structure * 1 Units)

31.0 Hours

The drawdown time is less than 72 hours, therefore this size system is acceptable.

WATER QUALITY REQUIREMENTS

Required Water Quality Volume

Vwq=(Dwq/12 inches/foot) * (A * 43560 SF/Acre)

Vwq = Required Water Quality Volume

Dwq = Water Quality Depth: 1" for discharges within a Zone II or Interim Wellhead Protection Area, to or near another critical area, runoff from LUHPPL, or exfiltration to soils with infiltration rate greater than 2.4 inches/hr or greater; 1/2" for discharges near or to other areas.

A = Impervious Area (In Acres)

Vwq = (0.5 inch/12 inches/foot)* 5860 SF =

244.17 CF

Therefore, the use of two leaching basins is sufficent to achieve the required water quality volume.

Rechage System Sizing Calculations

Station: 32+26 RT

Volume 3, Chapter 1 of the Massachusetts Stormwater Handbook

Soil type in Infiltration Layer	Sandy Loam	
NRCS Hydrologic Soil Type	B	
Test Pit # =	N/A	
Impervious Area to Leaching Catch Basin	5385	SF
Volume of Storage Available in Leaching Basin and Stone	See Detail	
Depth of Structure from Invert (out at CB) to Bottom of Structure	3.25	FT
Internal Diameter of Structure	4	FT
External Diameter of Structure	5	FT
Diameter of Stone around Structure	9	FT
Depth of Stone Below Structure	1	FT
Porosity of Stone	0.4	
Number of Leaching Basins within Subcatchment Area	2	EA
Area Inside of Structure	12.57	SF
Area of Stone Below Structure	63.62	SF
Area of Stone deducting Structure	43.98	SF
Volume Inside Structure	40.84	CF
Volume of Stone Layer Below Structure	63.62	CF
Volume of Stone Layer Around Structure	142.94	CF
Volume of Anulus within Stone		
Below Structure	25.45	CF
Around Structure	57.18	CF
Total Volume Available to store runoff per structure =	123.46	CF
Total Volume available to store runoff =	246.93	CF

RECHARGE REQUIREMENTS

Required Recharge Volume

Rv=F*Impervious Area

F = Target Depth Factor

Rv= 0.35 Inch X 5385

Rv= 157.06 CF

Sizing Storage Volumes

Using the "Static" method:

The Required Recharge Volume =	157.06	CF
The Available Recharge Volume, assuming the stored runoff will exfiltate completely within 72 hrs =		
Leaching Basins =	246.93	CF
Total Storage Volume available to recharge =	246.93	CF

This method does have enough Available Storage Volume for the amount of Required Recharge Volume.

Recharge System Drawdown

Verify the Recharge System will Drawdown within 72 Hrs

TIMEdrawdown = Rv/(K* Bottom Area of Infiltration Structure * 2 Units)

28.5 Hours

The drawdown time is less than 72 hours, therefore this size system is acceptable.

WATER QUALITY REQUIREMENTS

Required Water Quality Volume

Vwq=(Dwq/12 inches/foot) * (A * 43560 SF/Acre)

Vwq = Required Water Quality Volume

Dwq = Water Quality Depth: 1" for discharges within a Zone II or Interim Wellhead Protection Area, to or near another critical area, runoff from LUHPPL, or exfiltration to soils with infiltration rate greater than 2.4 inches/hr or greater; 1/2" for discharges near or to other areas.

A = Impervious Area (In Acres)

Vwq = (0.5 inch/12 inches/foot)* 5385 SF =

224.38 CF

Therefore, the use of leaching basins is sufficent to achieve the required water quality volume.

Rechage System Sizing Calculations

Station: 33+55 LT

Volume 3, Chapter 1 of the Massachusetts Stormwater Handbook

Soil type in Infiltration Layer	Loam	
NRCS Hydrologic Soil Type	B	
Test Pit # =	N/A	
Impervious Area to Leaching Catch Basin	3275	SF
Volume of Storage Available in Leaching Basin and Stone	See Detail	
Depth of Structure from Invert (out at CB) to Bottom of Structure	3.25	FT
Internal Diameter of Structure	4	FT
External Diameter of Structure	5	FT
Diameter of Stone around Structure	9	FT
Depth of Stone Below Structure	1	FT
Porosity of Stone	0.4	
Number of Leaching Basins within Subcatchment Area	2	EA
Area Inside of Structure	12.57	SF
Area of Stone Below Structure	63.62	SF
Area of Stone deducting Structure	43.98	SF
Volume Inside Structure	40.84	CF
Volume of Stone Layer Below Structure	63.62	CF
Volume of Stone Layer Around Structure	142.94	CF
Volume of Anulus within Stone		
Below Structure	25.45	CF
Around Structure	57.18	CF
Total Volume Available to store runoff per structure =	123.46	CF
Total Volume available to store runoff =	246.93	CF

RECHARGE REQUIREMENTS

Required Recharge Volume

Rv=F*Impervious Area

F = Target Depth Factor

Rv= 0.35 Inch X 3275

Rv= 95.52 CF

Sizing Storage Volumes

Using the "Static" method:

The Required Recharge Volume =	95.52	CF
The Available Recharge Volume, assuming the stored runoff will exfiltate completely within 72 hrs =		
Leaching Basins =	246.93	CF
Total Storage Volume available to recharge =	246.93	CF

This method does have enough Available Storage Volume for the amount of Required Recharge Volume.

Recharge System Drawdown

Verify the Recharge System will Drawdown within 72 Hrs

TIMEdrawdown = Rv/(K* Bottom Area of Infiltration Structure * 1 Units)

17.3 Hours

The drawdown time is less than 72 hours, therefore this size system is acceptable.

WATER QUALITY REQUIREMENTS

Required Water Quality Volume

Vwq=(Dwq/12 inches/foot) * (A * 43560 SF/Acre)

Vwq = Required Water Quality Volume

Dwq = Water Quality Depth: 1" for discharges within a Zone II or Interim Wellhead Protection Area, to or near another critical area, runoff from LUHPPL, or exfiltration to soils with infiltration rate greater than 2.4 inches/hr or greater; 1/2" for discharges near or to other areas.

A = Impervious Area (In Acres)

Vwq = (0.5 inch/12 inches/foot)* 3275 SF =

136.46 CF

Therefore, the use of two leaching basins is sufficent to achieve the required water quality volume.

Rechage System Sizing Calculations

Station: 34+56 LT

Volume 3, Chapter 1 of the Massachusetts Stormwater Handbook

Soil type in Infiltration Layer	Loam	
NRCS Hydrologic Soil Type	B	
Test Pit # =	N/A	
Impervious Area to Leaching Catch Basin	2430	SF
Volume of Storage Available in Leaching Basin and Stone	See Detail	
Depth of Structure from Invert (out at CB) to Bottom of Structure	3.25	FT
Internal Diameter of Structure	4	FT
External Diameter of Structure	5	FT
Diameter of Stone around Structure	9	FT
Depth of Stone Below Structure	1	FT
Porosity of Stone	0.4	
Number of Leaching Basins within Subcatchment Area	1	EA
Area Inside of Structure	12.57	SF
Area of Stone Below Structure	63.62	SF
Area of Stone deducting Structure	43.98	SF
Volume Inside Structure	40.84	CF
Volume of Stone Layer Below Structure	63.62 CF	
Volume of Stone Layer Around Structure	142.94 CF	
Volume of Anulus within Stone		
Below Structure	25.45	CF
Around Structure	57.18	CF
Total Volume Available to store runoff per structure =	123.46	CF
Total Volume available to store runoff =	123.46	CF

RECHARGE REQUIREMENTS

Required Recharge Volume

Rv=F*Impervious Area

F = Target Depth Factor

Rv= 0.35 Inch X 2430

Rv= 70.88 CF

Sizing Storage Volumes

Using the "Static" method:

The Required Recharge Volume =	70.88	CF
The Available Recharge Volume, assuming the stored runoff will exfiltate completely within 72 hrs =		
Leaching Basins =	123.46	CF
Total Storage Volume available to recharge =	123.46	CF

This method does have enough Available Storage Volume for the amount of Required Recharge Volume.

Recharge System Drawdown

Verify the Recharge System will Drawdown within 72 Hrs

TIMEdrawdown = Rv/(K* Bottom Area of Infiltration Structure * 1 Units)

25.7 Hours

The drawdown time is less than 72 hours, therefore this size system is acceptable.

WATER QUALITY REQUIREMENTS

Required Water Quality Volume

Vwq=(Dwq/12 inches/foot) * (A * 43560 SF/Acre)

Vwq = Required Water Quality Volume

Dwq = Water Quality Depth: 1" for discharges within a Zone II or Interim Wellhead Protection Area, to or near another critical area, runoff from LUHPPL, or exfiltration to soils with infiltration rate greater than 2.4 inches/hr or greater; 1/2" for discharges near or to other areas.

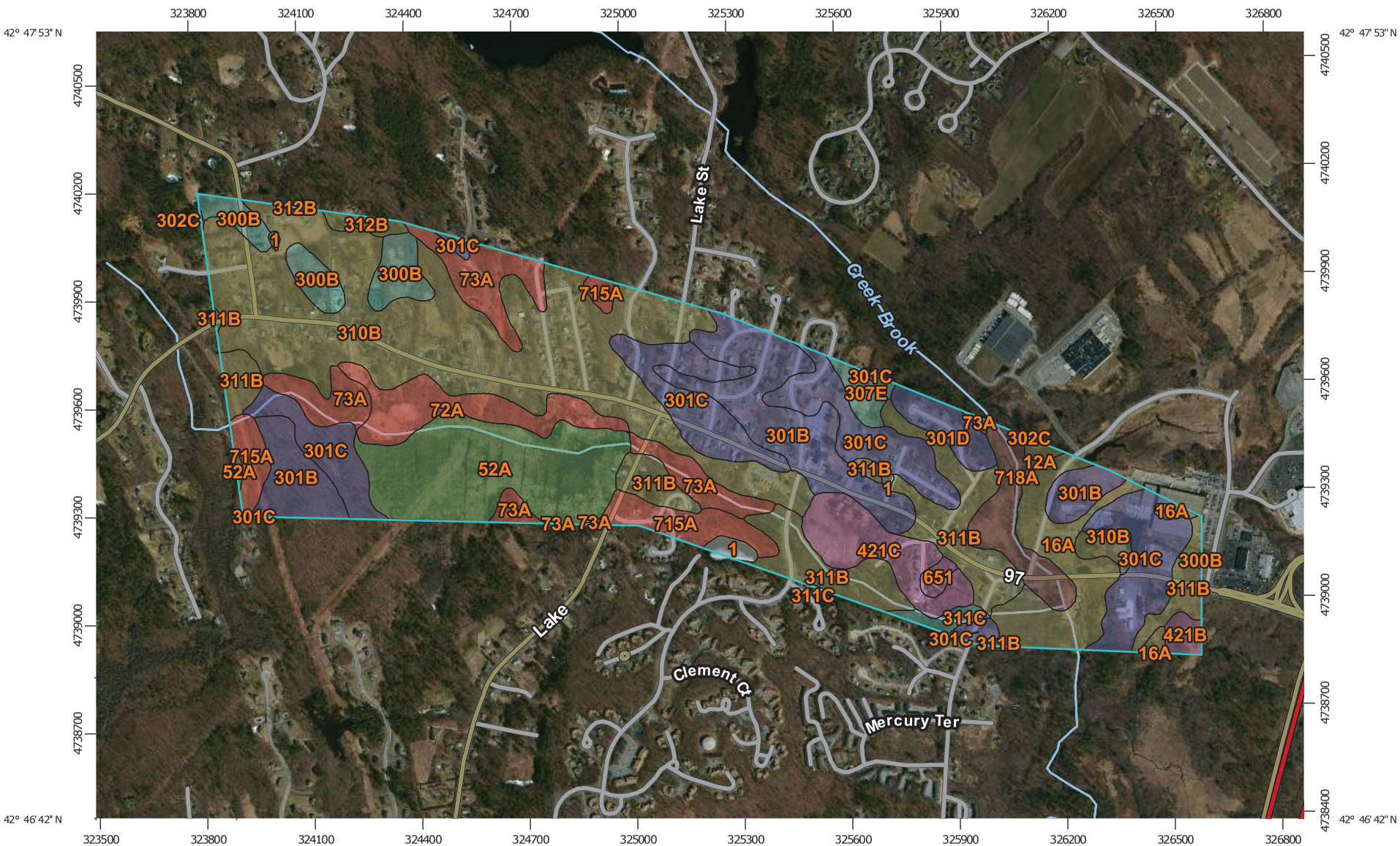
A = Impervious Area (In Acres)

Vwq = (0.5 inch/12 inches/foot)* 2430 SF =

101.25 CF

Therefore, the use of one leaching basin is sufficent to achieve the required water quality volume.

Hydrologic Soil Group—Essex County, Massachusetts, Northern Part



Map Scale: 1:15,400 if printed on A landscape (11" x 8.5") sheet.

Meters: 0 200 400 800 1200

Feet: 0 500 1000 2000 3000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 19N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Essex County, Massachusetts, Northern Part
Survey Area Data: Version 10, Sep 19, 2014

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 30, 2011—May 1, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Essex County, Massachusetts, Northern Part (MA605)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
1	Water		2.2	0.5%
12A	Maybid silt loam, 0 to 3 percent slopes	C/D	1.1	0.2%
16A	Scantic silt loam, 0 to 3 percent slopes	C/D	24.7	5.3%
52A	Freetown muck, 0 to 1 percent slopes	A/D	43.7	9.4%
72A	Whitman loam, 0 to 3 percent slopes	D	16.6	3.6%
73A	Whitman loam, 0 to 3 percent slopes, extremely stony	D	27.1	5.8%
300B	Montauk fine sandy loam, 3 to 8 percent slopes	C	14.4	3.1%
301B	Montauk fine sandy loam, 3 to 8 percent slopes, very stony	B	46.1	9.9%
301C	Montauk fine sandy loam, 8 to 15 percent slopes, very stony	B	62.1	13.4%
301D	Montauk fine sandy loam, 15 to 25 percent slopes, very stony	B	7.3	1.6%
302C	Montauk fine sandy loam, 5 to 15 percent slopes, extremely stony	B	0.1	0.0%
307E	Paxton fine sandy loam, 25 to 35 percent slopes, extremely stony	C	4.2	0.9%
310B	Woodbridge fine sandy loam, 3 to 8 percent slopes	C/D	113.9	24.6%
311B	Woodbridge fine sandy loam, 0 to 8 percent slopes, very stony	C/D	45.9	9.9%
311C	Woodbridge fine sandy loam, 8 to 15 percent slopes, very stony	C	2.5	0.5%
312B	Woodbridge fine sandy loam, 0 to 8 percent slopes, extremely stony	C/D	2.4	0.5%

Hydrologic Soil Group— Summary by Map Unit — Essex County, Massachusetts, Northern Part (MA605)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
421B	Canton fine sandy loam, 3 to 8 percent slopes, very stony	A	2.6	0.6%
421C	Canton fine sandy loam, 8 to 15 percent slopes, very stony	A	16.4	3.5%
651	Udorthents, smoothed	A	1.7	0.4%
715A	Ridgebury and Leicester fine sandy loams, 0 to 3 percent slopes, extremely stony	D	15.5	3.4%
718A	Saco variant silt loam, 0 to 3 percent slopes	B/D	12.9	2.8%
Totals for Area of Interest			**463.4**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

GPI

Greenman-Pederse	Proj. No.	MAX-2014020.00	Date	6/28/2016
181 Ballardvale St.	Client	MassDOT - District 4	Calc. by	CLS
Suite 202	Location	Route 97 Haverhill	Check by	WJM
Wilmington, MA 01887				

BMP Design Data

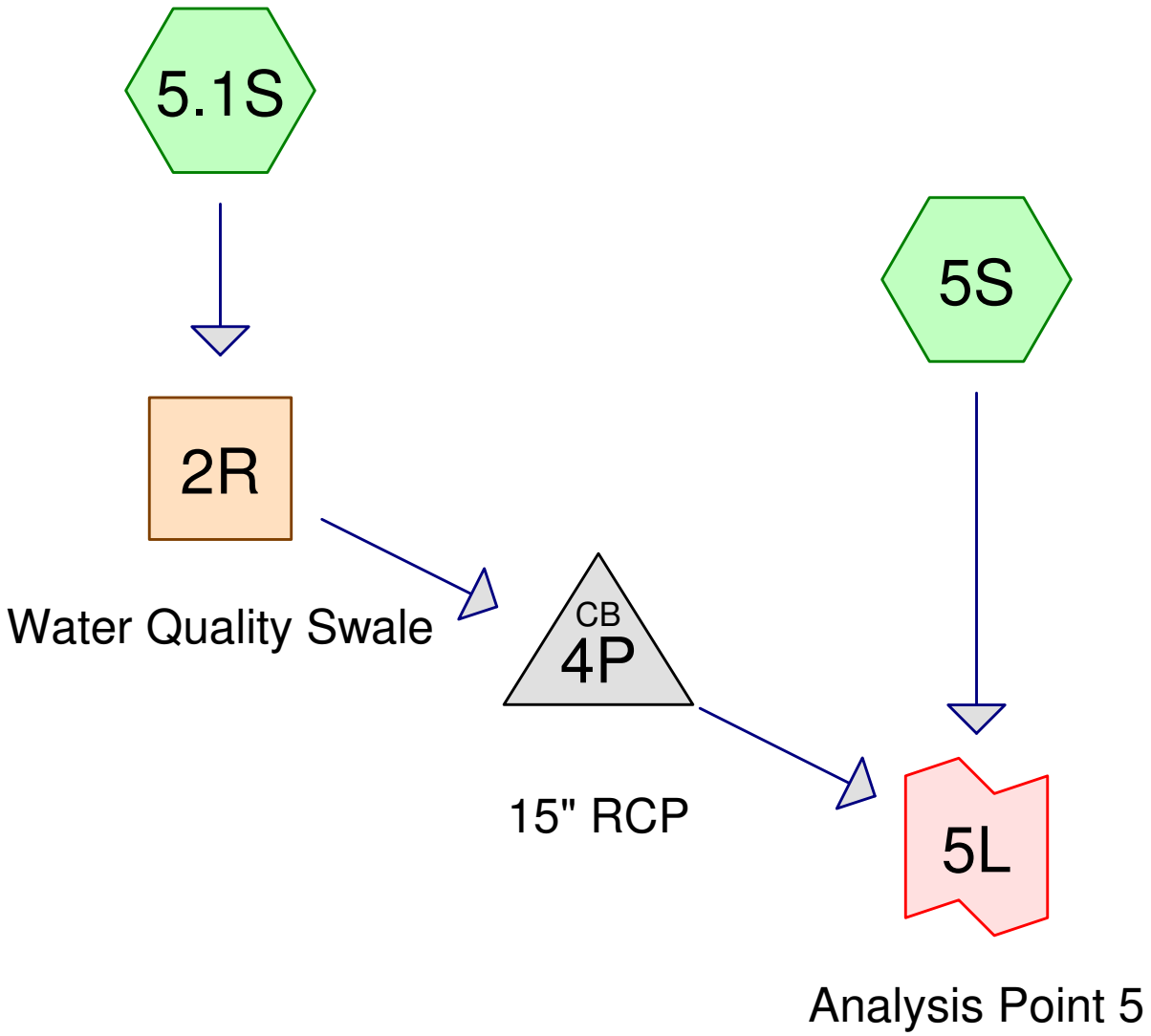
Water Quality Swale

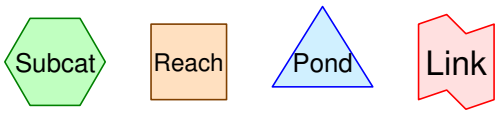
	Imp. Area (sf)	Lands. Area (sf)
SC 5.1	13,145	0
Total	13,145	0

Water Quality Volume (WQV)	548	cu-ft.
Required Forebay Volume (Based on 0.1" Runoff)	110	cu-ft.
Total Prop. Treated WQV	**557**	**cu-ft.**
Prop. Forebay	**112**	**cu-ft.**
Total Available Volume	**669**	**cu-ft.**

Swale Sizing: 2 bays, 10" check dams, 334 sf area = 557 cu-ft.

Note 1: Water Quality Volume (WQV) is based on 0.5" of runoff.





Routing Diagram for Route 97 - Developed
Prepared by Greenman - Pedersen, Inc., Printed 8/31/2016
HydroCAD® 10.00 s/n 01074 © 2012 HydroCAD Software Solutions LLC

Time span=0.00-72.00 hrs, dt=0.01 hrs, 7201 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 5.1S: Runoff Area=15,286 sf 85.99% Impervious Runoff Depth=0.44"
Flow Length=321' Tc=6.0 min CN=95 Runoff=0.18 cfs 0.013 af

Subcatchment 5S: Runoff Area=196,624 sf 68.07% Impervious Runoff Depth=0.23"
Flow Length=1,628' Tc=6.0 min CN=90 Runoff=1.08 cfs 0.085 af

Reach 2R: Water Quality Swale Avg. Flow Depth=0.08' Max Vel=0.65 fps Inflow=0.18 cfs 0.013 af
n=0.050 L=130.0' S=0.0154 '/' Capacity=38.69 cfs Outflow=0.17 cfs 0.013 af

Pond 4P: 15" RCP Peak Elev=55.20' Inflow=0.17 cfs 0.013 af
15.0" Round Culvert n=0.012 L=154.0' S=0.0065 '/' Outflow=0.17 cfs 0.013 af

Link 5L: Analysis Point 5 Inflow=1.20 cfs 0.098 af
Primary=1.20 cfs 0.098 af

Summary for Subcatchment 5.1S:

Runoff = 0.18 cfs @ 12.09 hrs, Volume= 0.013 af, Depth= 0.44"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr WQV Rainfall=0.85"

Area (sf)	CN	Description
13,145	98	Paved parking, HSG C
2,141	74	>75% Grass cover, Good, HSG C
15,286	95	Weighted Average
2,141		14.01% Pervious Area
13,145		85.99% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	20	0.0400	1.29		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
1.2	268	0.0350	3.80		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.1	33	0.0200	6.95	5.46	**Pipe Channel, RCP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.012 Concrete pipe, finished
1.6	321	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 5S:

Runoff = 1.08 cfs @ 12.10 hrs, Volume= 0.085 af, Depth= 0.23"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr WQV Rainfall=0.85"

Area (sf)	CN	Description
133,837	98	Paved parking, HSG C
62,787	74	>75% Grass cover, Good, HSG C
196,624	90	Weighted Average
62,787		31.93% Pervious Area
133,837		68.07% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.5	32	0.0200	1.08		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.10"
1.6	283	0.0220	3.01		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
1.2	1,313	0.0650	17.91	31.65	**Pipe Channel,** 18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38' n= 0.011 Concrete pipe, straight & clean
3.3	1,628	Total, Increased to minimum Tc = 6.0 min			

Summary for Reach 2R: Water Quality Swale

Inflow Area = 0.351 ac, 85.99% Impervious, Inflow Depth = 0.44" for WQV event
Inflow = 0.18 cfs @ 12.09 hrs, Volume= 0.013 af
Outflow = 0.17 cfs @ 12.18 hrs, Volume= 0.013 af, Atten= 8%, Lag= 5.4 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Max. Velocity= 0.65 fps, Min. Travel Time= 3.3 min
Avg. Velocity = 0.24 fps, Avg. Travel Time= 9.0 min

Peak Storage= 33 cf @ 12.12 hrs
Average Depth at Peak Storage= 0.08'
Bank-Full Depth= 1.50' Flow Area= 11.3 sf, Capacity= 38.69 cfs

3.00' x 1.50' deep channel, n= 0.050 Scattered brush, heavy weeds
Side Slope Z-value= 3.0 '/' Top Width= 12.00'
Length= 130.0' Slope= 0.0154 '/'
Inlet Invert= 56.20', Outlet Invert= 54.20'

‡

Summary for Pond 4P: 15" RCP

Inflow Area = 0.351 ac, 85.99% Impervious, Inflow Depth = 0.44" for WQV event
Inflow = 0.17 cfs @ 12.18 hrs, Volume= 0.013 af
Outflow = 0.17 cfs @ 12.18 hrs, Volume= 0.013 af, Atten= 0%, Lag= 0.0 min
Primary = 0.17 cfs @ 12.18 hrs, Volume= 0.013 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 55.20' @ 12.18 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	55.00'	**15.0" Round RCP_Round 15"** L= 154.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 55.00' / 54.00' S= 0.0065 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 1.23 sf

Primary OutFlow Max=0.17 cfs @ 12.18 hrs HW=55.20' (Free Discharge)
└─**1=RCP_Round 15"** (Barrel Controls 0.17 cfs @ 2.01 fps)

Summary for Link 5L: Analysis Point 5

Inflow Area = 4.865 ac, 69.36% Impervious, Inflow Depth = 0.24" for WQV event
Inflow = 1.20 cfs @ 12.11 hrs, Volume= 0.098 af
Primary = 1.20 cfs @ 12.11 hrs, Volume= 0.098 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Municipality/Organization:	City of Haverhill
EPA NPDES Permit Number:	MAR 041197
MassDEP Transmittal Number:	W-040847
Annual Report Number & Reporting Period:	Year 12 April 1, 2014 – March 31, 2015

NPDES PII Small MS4 General Permit Annual Report
(Due: May 1, 2015)

Part I. General Information

Contact Person: Paul Jessel Title: Collection System Supervisor

Telephone #: (978) 374-2382 Email: pjessel@haverhillwater.com

Mailing Address: 40 South Porter Street, Haverhill, MA 01835

Certification:

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

Signature: [signature]

Printed Name: Robert E. Ward

Title: Deputy DPW Director

Date: 4/29/15

Part II. Self-Assessment

The City of Haverhill has completed the required self-assessment and has determined that our municipality is in compliance with all permit conditions, except for the following items:

- PART II B 3 – The City has not fully implemented and enforced its illicit discharge detection and elimination (IDDE) program. A consultant is currently under agreement to assist the City with implementation and enforcement of its IDDE program (IDDE). Implementation and enforcement is expected to begin within the next permit period.

- PART II B 3 – All dry weather outfalls inspections are not complete. To date 42 percent (337 outfalls) have been completed. We expect to complete these inspections during the next permit period.

- PART II B 3(b) – Submitted a proposed ordinance to prohibit non-stormwater discharges into the stormwater system to City Council on March 23, 2010, which was not approved. The City is revising the ordinance and expects to submit it to City Council for approval within the next permit period.

- PART II B 4 – The city has a program to reduce pollutants from stormwater runoff from construction sites that disturb greater than or equal to one acre that is enforced for projects that fall under the Conservation Commission's jurisdiction. During the next permit period the City will revise the program to include all projects that disturb greater than or equal to one acre.

- PART II B 4(a) – During the next permit period the City plans on reviewing and updating its ordinances to comply with this requirement.

- PART II B 5 –. The City has a program to address stormwater runoff from new and redevelopment project that are enforced for projects that fall under the Conservation Commission's jurisdiction. During the next permit period the City will revise the program to include all projects that disturb greater than or equal to one acre.

- PART II B 5(a) – During the next permit period, the City plans on reviewing and updating its ordinances to comply with this requirement.

- PART II B 6(a) - The City did not conduct training this reporting period.

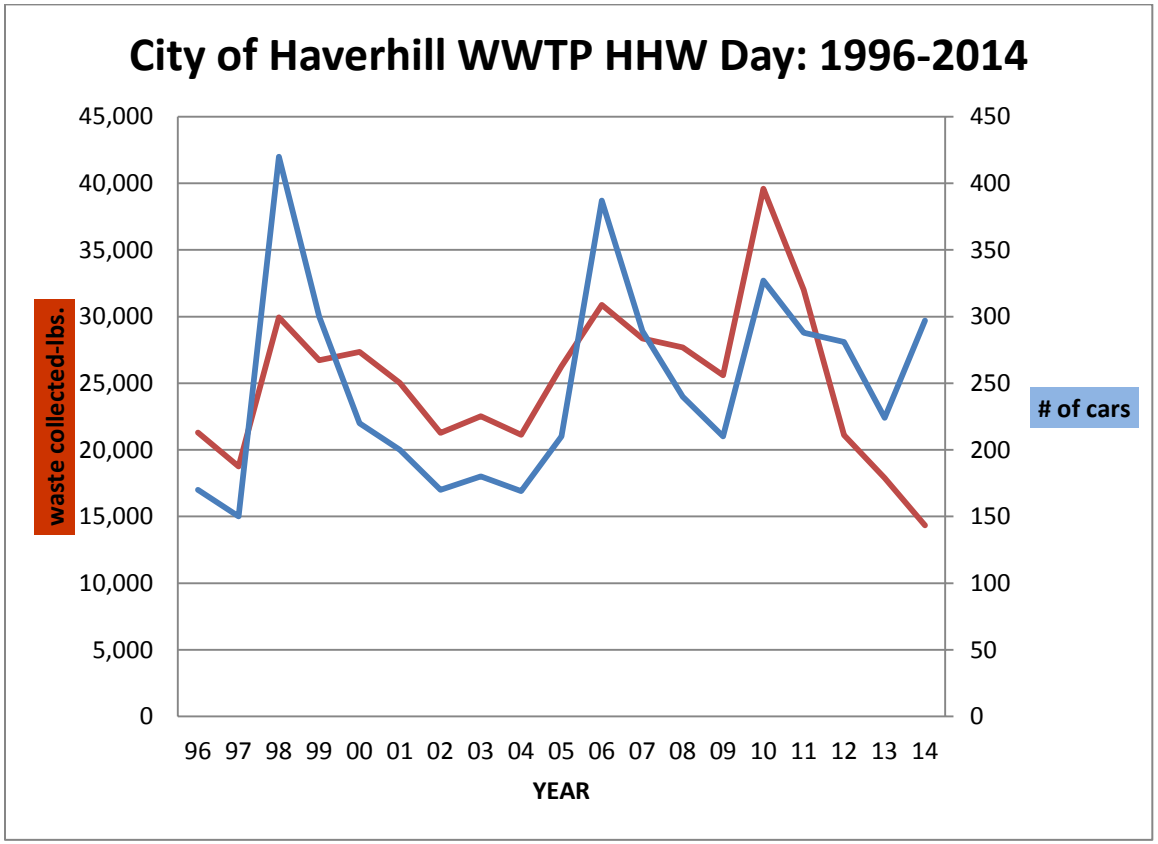
Part II. Self-Assessment, continued

Haverhill Highway Department continued the street sweeping program. The City currently has over 1,400 streets, with 266 centerline miles of streets or 532 lane miles. The City began using the street sweeping odometer to track the sweeping activity, which includes travel mile to and from the work site. The City currently has a database that has the Right of Way (ROW) length. The street sweeping list was cross reference to the City's ROW database and determines that the City cleaned 1,053 miles of streets. The odometer-reading total was 1,291 miles, a difference of 238 miles (18%) attributed to travel to and from the work site. Not all streets were swept; the City concentrated the street sweeping activity within the downtown section.

The City through the City Engineering Department has inputted all new subdivisions into GIS, which includes Stormwater features. In addition, other Stormwater features that were identified as missing are being inputted into GIS as time allows. The attached tables are the Best Management Practices (BMP's) listed in City of Haverhill's Notice of Intent, (NOI) and the City's progress in the twelfth permit year.

We continue to have a residential Household Hazardous Waste collection day twice per year Spring and Fall. In calendar year 2014, we collected 14,331 pounds of hazardous waste. Below is a graph detailing the collections activities from 1996 to 2014.

Part II. Self-Assessment - continued



Part III. Summary of Minimum Control Measures

1. Public Education and Outreach

BMP ID #	BMP	Responsible Department/ Person	Measurable Goal(s)	Progress on Goal(s) – Permit Year 12	Planned Activities - Permit Year 12
1-1	Designate Stormwater Coordinator	Mayor	Officially designate and support Stormwater Coordinator		Official designation of a Stormwater Coordinator
1-2	Add Stormwater Information to City's Website	Stormwater Coordinator	Incorporate a stormwater page onto the City's website	Completed Stormwater web page	Place Stormwater information onto the City's web page. The City's Stormwater Web page is http://www.ci.haverhill.ma.us/departments/storm_water_program/index.php Added request for catch basin cleaning and street sweeping onto the City's Web Site. http://www.ci.haverhill.ma.us/online_services/index.php
1-3	Conduct Outreach/ Coordinate City Program with Initiatives of Local Watershed Organizations	Stormwater Coordinator	Identification of groups interested in City programs. Annual contact with interested groups. Sharing information.	Completed	Initiate discussions with Haverhill's Lake Alliance, Merrimack Valley Planning Commission
1-4	Develop Brochures and Distribute to the Public	Stormwater Coordinator	Development of 2 separate brochures will be completed and disseminated.	Completed	Completed brochures.
1-5	Install and Maintain Signs at Key Stormwater Outfalls	Stormwater Coordinator	New outfall signs installed at 5 locations. Develop a list of parks, streams, ponds, etc. suitable for future signage.	Completed	City decided only CSO signs are required.
1-6	Distribute Pet Waste Fact Sheet with Dog Licenses.	Stormwater Coordinator and/or City Clerk	Pet waste fact sheet to all licensed dog owners	In Process	The City Clerk has pet waste brochure on the counter and on City's website.

2. Public Involvement and Participation

BMP ID #	BMP	Responsible Department/ Person	Measurable Goal(s)	Progress on Goal(s) – Permit Year 12	Planned Activities - Permit Year 12
2-1	Comply with State Public Notification Guidelines	City Clerk and other Department Heads	Comply with state guidelines	Completed	Continue Compliance
2-2	Hold Annual Household Hazardous Waste Day	Industrial Pretreatment Coordinator	An annual hazardous waste collection day	Held two (2) household hazardous waste collection days, collected 14,331 pounds of hazardous waste	Continue bi-annual household hazardous waste collection days in Spring and Fall
2-3	Motor Oil Collection Days	Highway Department	Monthly oil collection day to be held first Saturday of the month.	Held monthly collection days from September to June	Last Saturday of the month 9:00 AM to 1:00 PM September to June
2-4	Establish a Stormwater Hotline	Stormwater Coordinator	Establishment of hotline.	Completed	Establish email for public, which is stormwater@cityofhaverhill.com. Established and maintain hotline (978) 374-2334
2-5	Establish a Stormwater Committee	Mayor and Stormwater Coordinator	Establishment of Committee. Meeting attendance.	Completed	Designate and formally establish Stormwater Committee. Committee has not met this reporting period.
2-6	Youth Group to Stencil Catch basins	Stormwater Coordinator	Contact Groups to stencil 50 CBs per year	In Progress	No CBs stenciled during this report period

3. Illicit Discharge Detection and Elimination

BMP ID #	BMP	Responsible Department/ Person	Measurable Goal(s)	Progress on Goal(s) – Permit Year 12	Planned Activities - Permit Year 12
3-1	Map Outfalls and Receiving Waters	City Engineer & Stormwater Coordinator	Map completed	Completed June 2007	Through outfall inspections added outfalls as appropriate; updating GIS as time allows
3-2	Review Existing and Develop, If Necessary, Stormwater Bylaw	Stormwater Coordinator	Review of existing bylaws and regulations. If necessary, prepare storm sewer bylaw and present to City Council	Submitted Ordinance to City Council on March 23, 2010	Submit revised ordinance to City Council for adoption on May 23, 2010. Not approved
3-3	Continue Dry Weather Screening of Outfalls	Stormwater Coordinator	Complete first round of dry weather field screening of as many outfalls as possible in the 5 years of the first permit term.	Developed a dry weather outfall inspection program. Inspected 337 outfalls	Continue dry weather inspections of the remainder of the City's stormwater outfalls (see Appendix A and Appendix B)
3-4	Develop System for Detection and Elimination of Illicit Connections	Stormwater Coordinator, Board of Health, Wastewater	Develop procedures for elimination of illicit connections	Completed IDDE manual in 2008, available on the City's website at http://www.ci.haverhill.ma.us/haverhill/departments/storm_water_program/uploads/Haverhill_s_IDDE_Manual.pdf	Review IDDE Manual and update as needed, implement program

4. Construction Site Stormwater Runoff Control

BMP ID #	BMP	Responsible Department/ Person	Measurable Goal(s)	Progress on Goal(s) – Permit Year 12	Planned Activities - Permit Year 12
4-1	Review Existing Ordinance Requiring Stormwater Control Plan for Sites Distributing more than 1-acre. Make Changes as Necessary.	Conservation Commission, Engineering Department, Water & Wastewater Department, Stormwater Coordinator	Review existing ordinances and draft changes as necessary.	In Progress. Conservation Commission enforces the 2008 Massachusetts Stormwater Management Regulations for projects that are within its jurisdiction. For projects that will disturb an acre or more, the Commission requires proof of EPA authorization under NPDES and copies of the Stormwater Construction General Permit Notice of Intent. The Commission also requires a copy of the related NPDES Stormwater Pollution Prevention Plan to be submitted before commencement of work.	(See BMP ID#3-2)
4-2	Develop Procedure for Receipt and Consideration of Public Comment	Conservation Commission, Engineering Dept., Water & Wastewater Dept., Stormwater Coordinator	Review existing ordinances and draft changes as necessary to ensure public comment.	Completed	Established email hotline, which is stormwater@cityofhaverhill.com phone hotline 978-374-2334
4-3	Site Inspections of Stormwater Control and Construction Material Management	Conservation Commission, Engineering Dept., Water & Wastewater Dept., Stormwater Coordinator	Site inspectors regularly check erosion control measures.	Site Inspections are currently being conducted	Continue ongoing inspections of subdivisions. (see BMP ID#3-2)

5. Post-Construction Stormwater Management in New Development and Redevelopment

BMP ID #	BMP	Responsible Department/ Person	Measurable Goal(s)	Progress on Goal(s) – Permit Year 12	Planned Activities - Permit Year 12
5-1	Develop Ordinance to Require Runoff Controls for New and Re-Development	Conservation Commission, Engineering Department, Water & Wastewater Department, Stormwater Coordinator	Review of existing ordinances.	Submitted Ordinance to City Council on March 23, 2010. Not approved.	(see BMP ID#3-2)
5-2	Recommend a BMP Manual for Use by Planners and Developers	Conservation Commission, Engineering Department, Water & Wastewater Department, Stormwater Coordinator	BMP Manual selected	Currently researching appropriate manuals to comply with the new permit schedule to be issue soon	Finalize ordinance references (e.g. Massachusetts *Stormwater Management Handbooks (including Volume 2, Chapter 2: Structural BMP Specifications for the Massachusetts Stormwater Handbook), Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas – A Guide for Planners, Designers, and Municipal Officials*, and *Massachusetts Nonpoint Source Pollution Management Manual*

6. Pollution Prevention/ Good Housekeeping in Municipal Operations

BMP ID #	BMP	Responsible Department/ Person	Measurable Goal(s)	Progress on Goal(s) – Permit Year 12	Planned Activities - Permit Year 12
6-1	Continue Catch Basin Cleaning Program, Including Priority Catch Basins (i.e. near Ponds) Annually	Wastewater, Stormwater Coordinator, Planning?	Continue current program	In Progress, cleaned 65 catch basins, disposed of 225 tons of catch basin cleanings	Continue with current program
6-2	Street Sweeping	Highway Department, Stormwater Coordinator	Continue with current program	In Progress	Continue with Current Program
6-3	Adopt Appropriate Operating Procedures for Disposal of Catch Basin and Street Sweeping Residuals.	Highway Department, Stormwater Coordinator	Review current disposal procedures and modify as appropriate. Properly dispose of residuals	In Progress	Researching DEP standards
6-4	Minimize Salt Usage and Maintain Cover over Salt Storage Area	Highway Department, Stormwater Coordinator	Continue program	Completed	Salt storage is covered and maintained at the Highway Department, 500 Primrose Street, Haverhill
6-5	Develop/ Implement Program for Cleaning Pond Inlets and Trash Racks	Stormwater Coordinator and Highway Department	Develop a program to clean pond inlets and trash racks, including schedule	Began inventorying pond inlets where cleaning is likely needed	Developing and Identify what needs to be cleaned and where
6-6	Develop/Implement Employee Education Program	Stormwater Coordinator and Highway Department	Two hours of training during the permit period to all relevant employees on stormwater related topics	Completed	No training this report period

Part IV. Summary of Information Collected and Analyzed

Not applicable

Part V. Program Outputs & Accomplishments (OPTIONAL)

(Since beginning of permit coverage unless specified otherwise by a **, which indicates response is for period covering April 1, 2014 through March 31, 2015)

Programmatic

	(Preferred Units)	Response
Stormwater management position created/staffed	(y/n) (no)	no
Annual program budget/expenditures **	($)	$224,300*
Total program expenditures since beginning of permit coverage	($)	
Funding mechanism(s) (General Fund, Enterprise, Utility, etc)		

Education, Involvement, and Training

Estimated number of property owners reached by education program(s)	(# or %)	
Stormwater management committee established	(y/n)	y
Stream teams established or supported	(# or y/n)	n
Shoreline clean-up participation or quantity of shoreline miles cleaned **	(y/n or mi.)	n
Shoreline cleaned since beginning of permit coverage	(mi.)	n
Household Hazardous Waste Collection Days		
▪ days sponsored **	(#)	2 days
▪ community participation **	(# or %)	297 cars
▪ material collected **	(tons or gal)	71 tons
School curricula implemented	(y/n)	y

*Annual budget does not include city staff time.

Legal/Regulatory

	In Place Prior to Phase II	Reviewing Existing Authorities	Drafted	Draft in Review	Adopted
Regulatory Mechanism Status (indicate with "**X**")					
▪ Illicit Discharge Detection & Elimination				x	
▪ Erosion & Sediment Control				x	
▪ Post-Development Stormwater Management				x	
Accompanying Regulation Status (indicate with "**X**")					
▪ Illicit Discharge Detection & Elimination				x	
▪ Erosion & Sediment Control				x	
▪ Post-Development Stormwater Management				x	

Mapping and Illicit Discharges

	(Preferred Units)	Response
Outfall mapping complete	(%)	90
Estimated or actual number of outfalls	(#)	916
System-Wide mapping complete (complete storm sewer infrastructure)	(%)	90
Mapping method(s)		
▪ Paper/Mylar	(%)	90
▪ CADD	(%)	
▪ GIS	(%)	90
Outfalls inspected/screened **	(# or %)	337
Outfalls inspected/screened (Since beginning of permit coverage)	(# or %)	337
Illicit discharges identified **	(#)	
Illicit discharges identified (Since beginning of permit coverage)	(#)	13
Illicit connections removed **	(#); and (est. gpd)	13
Illicit connections removed (Since beginning of permit coverage)	(#); and (est. gpd)	13 removed 17,1368
% of population on sewer (based upon billable records)	(%)	90
% of population on septic systems	(%)	10

Construction

	(Preferred Units)	Response
Number of construction starts (>1-acre) **	(#)	
Estimated percentage of construction starts adequately regulated for erosion and sediment control **	(%)	
Site inspections completed **	(# or %)	
Tickets/Stop work orders issued **	(# or %)	
Fines collected **	(# and $)	
Complaints/concerns received from public **	(#)	

Post-Development Stormwater Management

Estimated percentage of development/redevelopment projects adequately regulated for post-construction stormwater control	(%)	
Site inspections (for proper BMP installation & operation) completed **	(# or %)	
BMP maintenance required through covenants, escrow, deed restrictions, etc.	(y/n)	y
Low-impact development (LID) practices permitted and encouraged	(y/n)	y

Operations and Maintenance

Average frequency of catch basin cleaning (non-commercial/non-arterial streets) **	(times/yr)	0
Average frequency of catch basin cleaning (commercial/arterial or other critical streets) **	(times/yr)	0
Qty. of structures cleaned **	(#)	53
Qty. of storm drain cleaned **	(%, LF or mi.)	0
Qty. of screenings/debris removed from storm sewer infrastructure **	(lbs. or tons)	225 tons
Disposal or use of screenings (landfill, POTW, compost, beneficial use, etc.) **	(location)	Landfill

Basin Cleaning Costs		
• Annual budget/expenditure (labor & equipment)**	($)	$62,500*
• Hourly or per basin contract rate ** (I don't have)	($/hr or $ per basin)	
• Disposal cost**	($)	$68.7/tons

*Does not include labor and in-house catch basin cleaning

Cleaning Equipment		
• Clam shell truck(s) owned/leased	(#)	1
• Vacuum truck(s) owned/leased	(#)	0
• Vacuum trucks specified in contracts	(y/n)	n
• % Structures cleaned with clam shells **	(%)	8.6%
• % Structures cleaned with vactor **	(%)	0

	(Preferred Units)	Response
Average frequency of street sweeping (non-commercial/non-arterial streets) **	(times/yr)	7
Average frequency of street sweeping (commercial/arterial or other critical streets) **	(times/yr)	
Qty. of sand/debris collected by sweeping **	(lbs. or tons)	
Disposal of sweepings (landfill, POTW, compost, beneficial use, etc.) **	(location)	
Annual Sweeping Costs		
• Annual budget/expenditure (labor & equipment)**	($)	$65,834*
• Hourly or lane mile contract rate **	($/hr. or ln mi.)	
• Disposal cost**	($)	
Sweeping Equipment		
• Rotary brush street sweepers owned/leased	(#)	
• Vacuum street sweepers owned/leased	(#)	
• Vacuum street sweepers specified in contracts	(y/n)	
• % Roads swept with rotary brush sweepers **	**%**	
• % Roads swept with vacuum sweepers **	**%**	

Reduction (since beginning of permit coverage) in application on public land of: (“N/A” = never used; “100%” = elimination)		
▪ Fertilizers	(lbs. or %)	
▪ Herbicides	(lbs. or %)	
▪ Pesticides	(lbs. or %)	
Integrated Pest Management (IPM) Practices Implemented	(y/n)	

*Does not include city staff time

	(Preferred Units)	Response
Average Ratio of Anti-/De-Icing products used ** (also identify chemicals and ratios used in specific areas, e.g., water supply protection areas)	% NaCl % $CaCl_2$ % $MgCl_2$ % CMA % Kac % KCl % Sand	
Pre-wetting techniques utilized **	(y/n or %)	
Manual control spreaders used **	(y/n or %)	
Zero-velocity spreaders used **	(y/n or %)	
Estimated net reduction or increase in typical year salt/chemical application rate	(±lbs/ln mi. or %)	
Estimated net reduction or increase in typical year sand application rate **	(±lbs/ln mi. or %)	
% of salt/chemical pile(s) covered in storage shed(s)	(%)	
Storage shed(s) in design or under construction	(y/n or #)	
100% of salt/chemical pile(s) covered in storage shed(s) by May 2008	(y/n)	y

Water Supply Protection

Storm water outfalls to public water supplies eliminated or relocated	# or y/n	n
Installed or planned treatment BMPs for public drinking water supplies and their protection areas	# or y/n	n
Treatment units induce infiltration within 500-feet of a wellhead protection area	# or y/n	n

STORMWATER MANAGEMENT SYSTEM
Operation and Maintenance Plan

System Owner – City of Haverhill

Responsible Party – Haverhill Highway Department

General Notes (from the Mass Highway Stormwater Handbook)

1. Maintain records and document inspection and cleaning of catch basins (as well as any maintenance activities for other drainage structures) including: executed contracts, certificates of completion, contractor invoices, and other type of maintenance logs.
2. Sweep roadways on an annual basis after winter deicing applications as warranted, with an emphasis on high sand accumulation and locations adjacent to sensitive receiving waters.
3. Note problems and take appropriate corrective actions to maintain outlets and BMPs in good working condition.
4. Take appropriate control measures to avoid discharge of materials to receiving wetlands and water resources during cleaning and maintenance activities.
5. Install, inspect and maintain construction BMPs to ensure appropriate sediment control is provided throughout construction and until the site is stabilized.
6. The inspection and cleaning schedules for other BMPs is found in Section 5 of the Handbook.

BMPs

Deep Sump Catch Basins

Deep Sump Catch Basins are small retention systems designed to remove trash, debris, and coarse sediment from stormwater runoff and serve as temporary spill containment devices. Deep Sump Catch Basins have a regulatory pollutant removal efficiency rating of 25% of Total Suspended Solids (TSS).

Regular maintenance is essential if Deep Sump Catch Basins are to remain effective at removing pollutants. The basins should be inspected once a year and form a basis for a periodic cleaning schedule. Cleaning should be done after the end of the foliage and winter snow removal and deicing seasons or whenever the depth of deposits is greater than or equal to one half the depth from the bottom of the invert of the lowest pipe in the basin. Frame

and grates are inspected to remove litter and debris clogging inlet or curb inlet openings in areas known for flooding prior to large forecasted rainfall events.

Sediment Forebays

Sediment Forebays are an excavated pit, bermed area or combination thereof that sometimes are used to provide pretreatment for other BMPs (in this case the water quality swale). They are designed to slow incoming stormwater runoff and facilitate the gravity separation of suspended solids. They receive a 25% TSS removal credit when they provide pretreatment for other BMPs.

Sediment Forebays shall be inspected yearly and cleaned when buildup exceeds ½ the depth of the forebay.

Water Quality Swale

Water quality swales are vegetated excavated ditches, bermed ditches or combination thereof. They are open channels designed to treat the required water quality volume and convey runoff from the 10 year storm without causing erosion. As proposed, the water quality swale will have a permeable layer and subdrain at the bottom of the ditch to ensure there is no standing water, as well as assist in removing sediments from the stormwater runoff.

Water quality swales shall be inspected once a year to insure the vegetation is adequate and slopes are not eroding. The inspection shall check for rilling and gullying. The swale shall be mowed as needed, with sediment and debris removed manually as needed. The swale shall be reseeded after sediment removal.

Leaching Catch Basins

Leaching Catch Basins are pre-cast concrete structures with an open bottom that permits runoff to infiltrate into the ground. 80% TSS removal is credited to leaching catch basins provided they are offline and combined with pretreatment deep sump catch basins.

Leaching Catch Basins are recommended to be inspected annually or more frequently if warranted by their performance. Sediment should be removed at the annual inspection that is preferably done in the spring or when the basin is 50% filled.

APPENDIX E

AFFIDAVIT OF SERVICE, NOTICE TO ABUTTERS, CERTIFIED ABUTTERS LIST

G. AFFIDAVIT OF SERVICE FOR ABUTTER NOTIFICATION

I, William J. Murphy Jr., hereby certify under the pains and penalties of perjury that on
(NAME OF PERSON MAKING AFFIDAVIT)
November 7, 2016 I gave notification to all abutters pursuant to the requirements of the second
(DATE)
paragraph of Massachusetts General Laws Chapter 131, Section 40, the DEP Guide to Abutter Notification dated April 8, 1994, and Haverhill Municipal Ordinance Chapter 253, Section 5 in connection with the following matter:

A Notice of Intent filed under the Massachusetts Wetlands Protection Act and said ordinance by
John Pettis, City Engineer, City of Haverhill with the Haverhill Conservation Commission on
(NAME OF APPLICANT)
November 7, 2016 for property located at Broadway (Route 97) Silver Birch Ln – Research Dr.
(DATE) (STREET ADDRESS AND ASSESSOR'S PARCEL ID)

The list of the abutters to whom the Abutter Notification Form sent, with their addresses and Assessor's parcel identification information that corresponds with the submitted map section, are attached to this application.

Signed: _____ 11/7/16
(NAME OF PERSON MAKING AFFIDAVIT) (DATE)

ABUTTER NOTIFICATION FORM

In accordance with the second paragraph of Massachusetts General Laws Chapter 131, Section 40 (the Wetlands Protection Act) and Haverhill Municipal Ordinance Chapter 253, Section 5, you are hereby notified of the following:

1. The name of the applicant is City of Haverhill, John Pettis, City Engineer
2. Brief Project Description: Reconstruction of Route 97 (Broadway) from Silver Birch Lane to Research Drive will include minor roadway widening and geometric improvements at Lake St, West Meadow Rd and Forest St. This project will also construct new granite curbing, sidewalks on both sides of the street, traffic signals and reconstruct the drainage system.
3. The applicant has filed a Notice of Intent ("NOI") with the Haverhill Conservation Commission seeking permission to remove, fill, dredge or alter an Area Subject to Protection Under the Wetlands Protection Act and/or Haverhill Municipal Ordinance Chapter 253 and/or to perform work within the buffer zone of such an Area.
4. The address of the lot where the activity is proposed is Broadway (Route 97)
   (INCLUDE ASSESSOR'S MAP/BLOCK/LOT)
5. Copies of the NOI may be examined at *the Haverhill Conservation Department Office* between the hours of *8am and 4pm* from *Monday through Friday*. Contact information is below. You may also find helpful application materials on the "Projects Under Review" section of the Commission's website.
6. Copies of the NOI may be obtained from either (check one) the applicant X, or the applicant's representative _____, by calling this telephone number (978) 374-2335 between the hours of 8 AM and 4 PM on the following days of the week Monday thru Friday
7. Information regarding the *date, time, and place* of the public hearing may be obtained from the *Haverhill Conservation Department Office* between the hours of *8am and 4pm* from *Monday through Friday*. Contact information is below. You may also consult the "Agenda" section of the Commission's website.

NOTE: Notice of the public hearing, including its date, time and place, will be published at least five (5) days in advance in the *Haverhill Gazette newspaper*.

NOTE: Notice of the public hearing, including its date, time, and place, will be posted in Haverhill City Hall not less than forty-eight (48) hours in advance.

NOTE: You may contact the Haverhill Conservation Department for more information about this application, the Wetlands Protection Act, and Haverhill Municipal Ordinance Chapter 253. Please note the Department has only one staff person; every effort will be made to assist you in a timely manner.

Website: http://www.cityofhaverhill.org/departments/conservation_commission/index.php.
Email: conservation@cityofhaverhill.com
Phone: 978.374.2334

NOTE: For additional information about this application and the Act, you may contact the MA Department of Environmental Protection Northeast Regional Office Service Center.

Website: http://www.mass.gov/eea/agencies/massdep/about/contacts/northeast-region.html
Phone: 978.694.3200

548-1-30
651 BROADWAY REALTY LLC
651 BROADWAY
HAVERHILL, MA 01832

548-1-3C
C-F COLD STORAGE LLC
10 CREEK BROOK DRIVE
HAVERHILL, MA 01832

548-1-27B
ADAMSON REALTY,LLC
45 RESEARCH DR
HAVERHILL, MA 01832

548-1-29
651 BROADWAY REALTY LLC
651 BROADWAY
HAVERHILL, MA 01832

572-1-5
PUGLIELLI KAREN S-ETAL
230 FOREST ST
HAVERHILL, MA 01832

572-1-5A
WHITE KERRY-ANNE R.
200 FOREST ST
HAVERHILL, MA 01832

548-1-34
ESSEX COUNTY GREENBELT ASSOC
82 EASTERN AVE
ESSEX, MA 01929

572-2-17
SUMMER REALTY TRUST
171 FOREST ST
HAVERHILL, MA 01832

572-2-19
GONYOU-LADNER REALTY TRUST
225 FOREST ST
HAVERHILL, MA 01832

572-2-20
231 FOREST ST REALTY TRUST
5 FOX RUN DRIVE
HAVERHILL, MA 01832

572-2-20A
BROADWAY SCRIVANOS RLTY TR
3 PLUFF AVENUE
NORTH READING, MA 01864

572-2-20A-1
BROADWAY SCRIVANOS RLTY TR
3 PLUFF AVENUE
NORTH READING, MA 01864

572-2-20B
CITY OF HAVERHILL
4 SUMMER ST
HAVERHILL, MA 01830

565-2-4
NADEAU RONALD J
9 COOLIDGE AVE
HAVERHILL, MA 01832

565-1-38
GRANT PAUL F ETUX
2 COOLIDGE AVE
HAVERHILL, MA 01832

571-6-20
MOORE ROBERT E JR-ETUX
34 GLENVIEW RD
HAVERHILL, MA 01832

571-1-4
MCDONALD THOMAS ETUX
334 LAKE ST
HAVERHILL, MA 01832

571-1-2
CORCORAN JOSEPHINE KELLY
318 LAKE ST
HAVERHILL, MA 01832

571-5-4B-2
STROIKA MATTHEW L ETUX
22 GLENVIEW RD
HAVERHILL, MA 01832

565-1-35
DEMARCO RICHARD K ETUX
16 COOLIDGE AVE
HAVERHILL, MA 01832

539-439-5
OLYMPIC FLAME REALTY TRUST
920 BROADWAY
HAVERHILL, MA 01832

571-1-1
TRASK DARLENE F
871 BROADWAY
HAVERHILL, MA 01832

565-2-8
THEOBALD SHARON A ETUX
25 COOLIDGE AVE
HAVERHILL, MA 01832

539-439-4
CITY OF HAVERHILL
4 SUMMER ST
HAVERHILL, MA 01830

571-5-1
VOURTSAS KONSTANTINOS ETUX
883 BROADWAY
HAVERHILL, MA 01832

565-1-34
MARY A LESICZKA LIFE ESTATE
22 COOLIDGE AVE
HAVERHILL, MA 01832

539-439-4A
CITY OF HAVERHILL
4 SUMMER ST
HAVERHILL, MA 01830

571-5-2
FRANCIS LEE A
15 GLENVIEW RD
HAVERHILL, MA 01832

565-2-6
BERUBE GUY D-ETUX
17 COOLIDGE AVE
HAVERHILL, MA 01832

539-439-3
TIMMONS EDWARD J ETUX
884 BROADWAY
HAVERHILL, MA 01832

571-5-3
DENNIS MEREDITH
23 GLENVIEW ROAD
HAVERHILL, MA 01832

565-1-37
INGHAM DAWN P
10 COOLIDGE AVE
HAVERHILL, MA 01832

539-439-2A
LAW GREGORY K
874 BROADWAY
HAVERHILL, MA 01832

571-6-1
CURRY MICHAEL A ETAL
25 GLENVIEW RD
HAVERHILL, MA 01832

565-2-2
PAPIA JAMES A
911 BROADWAY
HAVERHILL, MA 01832

539-439-2
GARDEN DEREK-ETUX
298 LAKE ST
HAVERHILL, MA 01832

565-1-40
CONNOLLY MARYANN ETAL
931 BROADWAY
HAVERHILL, MA 01832

571-5-4
GIORDANO LAWRENCE F-ETALI
897 BROADWAY
HAVERHILL, MA 01832

571-1-4
MCDONALD THOMAS ETUX
334 LAKE ST
HAVERHILL, MA 01832

571-5-4B
CORMIER BRIAN D-ETUX
14 GLENVIEW RD
HAVERHILL, MA 01832

565-1-40-2
MELE JOHN A SR
4 SILVER BIRCH LN
HAVERHILL, MA 01832

565-1-40-13
ARENBURG MICHAEL F ETUX
5 SILVER BIRCH LANE
HAVERHILL, MA 01830

539-439-4
CITY OF HAVERHILL
4 SUMMER ST
HAVERHILL, MA 01830

539-439-6A
LORRAINE M FORTIN REV TRUST
500 HIGGINS ROAD
WARTRACE, TN 37183

565-1-34
MARY A LESICZKA LIFE ESTATE
22 COOLIDGE AVE
HAVERHILL, MA 01832

539-439-6A
LORRAINE M FORTIN REV TRUST
500 HIGGINS ROAD
WARTRACE, TN 37183

574-1-8A
D‘ARCANGELO, ALFRED P
955 BROADWAY
HAVERHILL, MA 01832

574-1-8
CHAMPAGNE VERONICA J
957 BROADWAY
HAVERHILL, MA 01832

539-439-6
GOUDREAULT, ALICE M LIFE EST
801 BROADWAY
HAVERHILL, MA 01832

565-2-4
NADEAU RONALD J
9 COOLIDGE AVE
HAVERHILL, MA 01832

565-2-6
BERUBE GUY D-ETUX
17 COOLIDGE AVE
HAVERHILL, MA 01832

571-5-4
GIORDANO LAWRENCE F-ETALI
897 BROADWAY
HAVERHILL, MA 01832

565-1-35
DEMARCO RICHARD K ETUX
16 COOLIDGE AVE
HAVERHILL, MA 01832

565-1-37
INGHAM DAWN P
10 COOLIDGE AVE
HAVERHILL, MA 01832

565-1-40-14
CORCORAN MICHAEL L ETALI
3 SILVER BIRCH LN
HAVERHILL, MA 01832

565-1-40-1
GRATIANO DAVID A ETUX
2 SILVER BIRCH LANE
HAVERHILL, MA 01830

565-1-40-12
RYAN MARY
7 SILVER BIRCH LANE
HAVERHILL, MA 01832

565-2-2
PAPIA JAMES A
911 BROADWAY
HAVERHILL, MA 01832

565-2-8
THEOBALD SHARON A ETUX
25 COOLIDGE AVE
HAVERHILL, MA 01832

565-1-40
CONNOLLY MARYANN ETAL
931 BROADWAY
HAVERHILL, MA 01832

565-1-32
SHEA KELI RAE
30 COOLIDGE AVE
HAVERHILL, MA 01832

565-1-38
GRANT PAUL F ETUX
2 COOLIDGE AVE
HAVERHILL, MA 01832

565-1-40-3
BUGGEA JONATHAN
6 SILVER BIRCH LANE
HAVERHILL, MA 01832

539-439-5
OLYMPIC FLAME REALTY TRUST
920 BROADWAY
HAVERHILL, MA 01832

588-32-6
FRIAS FRANCISCO ETUX
6 WEST PARISH RIDGE RD
HAVERHILL, MA 01832

548-1-32
651 BROADWAY REALTY LLC
651 BROADWAY
HAVERHILL, MA 01832

548-34-1
SPOHN CHRISTINE ANN-ETAL
2 MORNINGSIDE DR
HAVERHILL, MA 01832

533-1-7
D‘ALESSANDRO THOMAS
21 DODGE ST
HAVERHILL, MA 01832

533-1-6
GIOIA CHARLES J-ETUX
13 DODGE ST
HAVERHILL, MA 01830

533-1-5
BROWN ROBERT M-ETAL
7 DODGE ST
HAVERHILL, MA 01832

533-2-13
HODGE RODERICK O ETUX
26 DODGE ST
HAVERHILL, MA 01832

533-2-14
SWEENEY SHIRLEY M
20 DODGE ST
HAVERHILL, MA 01832

533-3-3
VIGNEAULT MICHELLE M
7 GLENDALE STREET
HAVERHILL, MA 01832

533-1-4
GARDELLA NORMAN A ETUX LF EST
8 GLENDALE ST
HAVERHILL, MA 01832

533-2-15
KROBOTH MARK V ETUX
16 DODGE ST
HAVERHILL, MA 01832

533-2-21
IRVI LLOSHI
703 BROADWAY
HAVERHILL, MA 01832

533-2-22
DEVEREAUX FRANCIS ETUX
721 BROADWAY
HAVERHILL, MA 01832

533-3-2
THE CUSENZA FAMILY NOMINEE TRUST
5 GLENDALE ST
HAVERHILL, MA 01832

533-2-17
BUNKER MARK S-ETUX
6 GLENDALE ST
HAVERHILL, MA 01832

533-2-21
IRVI LLOSHI
703 BROADWAY
HAVERHILL, MA 01832

533-2-18
MCCARTHY JOHN J JR-ETUX
4 GLENDALE ST
HAVERHILL, MA 01832

533-2-19
MCCARTHY WILLIAM E-ETUX
693 BROADWAY
HAVERHILL, MA 01832

533-3-1
CASEY JOSEPH F ETUX LIFE EST
3 GLENDALE STREET
HAVERHILL, MA 01832

533-3-1A
McCARTHY YVETTE A
683 BROADWAY
HAVERHILL, MA 01832

588-422-32E
FERGOLA JAMES-ETAL
680 BROADWAY
HAVERHILL, MA 01832

588-32-9
GEHA BASSAM M-ETUX
1 WEST PARISH RIDGE RD
HAVERHILL, MA 01832

588-422-32BB
CALCAGNO GENEVIEVE M ETAL
672 BROADWAY
HAVERHILL, MA 01832

533-2-21
IRVI LLOSHI
703 BROADWAY
HAVERHILL, MA 01832

548-1-32
651 BROADWAY REALTY LLC
651 BROADWAY
HAVERHILL, MA 01832

548-1-34
ESSEX COUNTY GREENBELT ASSOC
82 EASTERN AVE
ESSEX, MA 01929

588-422-32C
MILLIKEN ROGER H JR., ETUX
724 BROADWAY
HAVERHILL, MA 01832

588-422-32K
PORTER WAYNE R ETAL
3 SPRINGHILL AV
HAVERHILL, MA 01832

588-422-32B
CITY OF HAVERHILL
4 SUMMER ST
HAVERHILL, MA 01830

588-422-32KK
KIM TOUCH ETAL
1 SPRINGHILL AV
HAVERHILL, MA 01832

APPENDIX F
NOI PERMIT DRAWINGS