Drainage Report

Proposed Retail Development

Rochester, New Hampshire

Prepared for **G.B. New England 2, LLC**
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Project No. 51990.35

November 2010

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Introduction

The 6.6–acre Site is located along North Main Street in Rochester, New Hampshire (see Figure 1: Site Location Map). The Site is bounded by a restaurant to the north, fuel facility to the south, a vacant lot to the east, and North Main Street to the west. The Site is located within the surface watershed of the Cocheco River. Wetland Resources on the Site include wetlands and a perennial stream.

The Site is presently occupied by a car dealership. Under existing conditions, untreated storm water runoff sheet flows overland to existing drainage swales located in the northern and southern portions of the site, as well as to the wetlands to the east. The stormwater from each area eventually discharges to the Cocheco River.

The proposed redevelopment of the site includes the construction of a new 13,225 SF CVS/pharmacy and a secondary 8,025 SF retail building, which will include paved parking areas, landscaping, drainage improvements and other infrastructure. (see Figure 2: Proposed Project Layout). Under proposed conditions, stormwater runoff will be collected by a series of deep-sump hooded catch basins which will direct the stormwater to a gravel wetland for water quality. Wherever possible existing drainage and grading patterns were maintained in the proposed design. Additionally, water quality and quantity control measures such as pre-treatment and a gravel wetland have been designed to protect the surrounding natural resources from potential storm water runoff impacts.

A hydrologic model was developed to evaluate the existing and proposed drainage conditions on the Site. The results of the analyses indicate that there is no increase in peak discharge rates between the pre- and post-development conditions for the 2, 10, and 50 year storm events. The pre- and post-development peak discharge rates are presented in the Storm Water Management Impacts Section of this report.

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Existing Conditions

The following report has been prepared by Vanasse Hangen Brustlin, Inc. (VHB) to provide a brief description of existing and proposed drainage areas, design methodology, soil characteristics, and a summary of peak discharge rates for the project area.

Description of Contributing Areas

The study area for the development is located within the Cocheco River watershed (see Figure 3, Existing Conditions: Drainage Area Map). The existing drainage area is approximately 4.5-acres in size and is relatively flat with elevations ranging from 223 feet up to 232 feet. The area is currently developed and ground cover consists of compacted gravel, pavement, rooftop, and minimal landscaping.

The study area consists of one drainage area that discharges into the discharge point. The discharge point includes the wetlands encompassing the developed area, which ultimately discharge to the Cocheco River

Table 1 summarizes the study area and its characteristics.

Table 1:
Existing Conditions: Drainage Area Characteristics Summary

Discharge Point		Sub Area(s)		Area (Acres)	Tc (Min.)	CN
1	Existing Wetlands	1S	Description	4.5	6.0	76
Total				4.5	n/a	76*

* Weighted CN Value

Soil Conditions

A Site Specific Soil Survey was conducted by a Certified Soil Scientist at Vanasse Hangen Brustlin, Inc. to determine on-site soil types in accordance with the New Hampshire Supplement of the Site-Specific Soil Mapping Standards for New Hampshire and Vermont, Version 3.0, dated December 2006 Special Publication #3 of the Society of Soil Scientists of Northern New England. A Site Specific Soil Map and Report were prepared in accordance with these standards. Table 2, Soil Types, lists the designations, names, and groups of the soils located within the study area. The Appendices contains a copy of the soil mapping and soil types found within the study area.

Table 2:
Soil Types

Soil Designation	Soil Name	Soil Group
299A	Udorthent (Paved Parking Lot)*	A
299B	Udorthent (Gravel Parking Lot)*	A
299C	Udorthent (Regraded/Trash)*	A
313B	Deerfield (Regraded/Trash)*	B

*Soils exhibit profile characteristics of a Hinckley.

Existing Hydrologic Flow Patterns

Storm water runoff from the existing study area generally flows to the north and east, away from North Main Street, towards the existing wetlands. All of the runoff from the site ultimately flows to the Cocheco River.

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Proposed Conditions

Description of Contributing Areas

The proposed development for the study area includes the construction of a 13,225 SF pharmacy and a secondary 8,025 SF retail building.. The buildings will be surrounded by parking facilities, landscaping, drainage improvements, and erosion control measures (see Figure 4, Proposed Conditions: Drainage Area Map).

The proposed conditions sub-areas are comprised of the same 4.5 acre study area represented in the existing conditions drainage analysis. The proposed development will remove approximately 1.2 acres of impervious cover (i.e. pavement, gravel parking, roofs, etc), which shall be re-vegetated, resulting in an overall reduction of the impervious area.

Table 4 summarizes the proposed sub areas and their characteristics.

Table 3:
Proposed Conditions: Drainage Area Characteristics Summary

Discharge Point		Sub Area(s)		Area (Acres)	Tc (Min.)	CN
1	Existing Wetlands	11S	Proposed landscaping and existing wooded area	2.1	6.0	44
		12S	Proposed rooftop and pavement	2.4	6.0	84
Total				4.5	n/a	65*

* Weighted CN Value

Proposed Hydrologic Flow Patterns

The proposed development has been designed to direct the storm water runoff from the site's impervious areas into a gravel wetland. Runoff from the remaining areas within the study area will generally maintain their existing flow patterns.

Runoff from the proposed impervious areas will be collected by deep-sump hooded catch basins and directed into the proposed closed drainage pipe system. The system will discharged to a gravel wetland for water quality treatment.

The proposed development will eliminate approximately 1.2 acres of impervious area to the studied watershed. As a result, the peak storm water runoff rates decrease from pre- to post-development conditions.

4

Methodology & Design Criteria

VHB used two separate methodologies to evaluate the hydrologic and hydraulic impacts for proposed development's storm water runoff. VHB analyzed the proposed development's hydrologic impacts using the Soil Conservation Service (SCS) Technical Release 20 (TR-20) methodology and analyzed the development's hydraulic characteristics using the Rational Method to determine the flow rates used in the storm drain piping calculations. The following section summarizes the design parameters/constraints that were used during the drainage design for this development under the SCS and Rational Methodologies. Additionally, this section summarizes the methodology used for the development's proposed erosion control and storm water treatment methods.

Hydrologic Model Description

VHB analyzed the proposed developments storm water runoff impacts using the SCS TR-20 methodology. The hydrologic program HydroCAD, as developed by Applied Microcomputer System, was utilized to compute and develop the storm water runoff model. HydroCAD's SCS TR-20 program is designed to model complex watersheds, such as the watershed analyzed in this report. The complexity of the watershed has been based on multiple land uses (surface conditions) with varying soil conditions and inter-connected sub-watersheds reflecting complex hydrologic flow patterns.

Design Storms

VHB analyzed the proposed storm water impacts for the 2, 10, and 50-year design storms. These rainfall events are based on a 24-hour storm duration using a Type III distribution curve. The appendices contain copies of the rainfall data charts used in the calculations.

Curve Number

VHB developed weighted curve numbers for each sub-area based on the different ground covers and hydrologic soil group types found within each area. The curve numbers were based on the SCS TR-55 methodology and are included in hydrologic

calculations. For proposed areas of disturbance, including lot development, the hydrologic condition for woods, meadows, or pastures was assumed to be "good."

■

Travel Times & Time of Concentration

VHB calculated the Travel Times (Tt) and the Time of Concentrations (Tc) for each of the individual sub-areas using the hydraulically most distant point within each area. Sheet flow was limited to 100 ft and a minimum time of 6 minutes was used in the calculations. The Tt's and Tc's were based on SCS TR-55 methodology and are included in hydrologic calculations.

Hydraulic Calculations (Storm Drain Piping System)

VHB used the rational method to develop the flows used in the design the development's subsurface storm drain piping system. The drainage system was sized based on a 25 year design storm under pressurized flow conditions. VHB used the following design parameters and criteria to design the system:

Minimum Pipe Size:	12 inches
HDPE Pipe Coefficient of Friction:	0.011
Minimum Time of Concentration (Tc):	6 minutes
Runoff Coefficient:	0.2 open space
Runoff Coefficient:	0.9 pavement and roofs

The storm drain piping calculations are included in the appendices.

Storm Water Detention

The proposed development decreases the amount of impervious area from that of the existing conditions; as a result, the runoff curve numbers will decrease for the proposed conditions. The lower curve numbers will decrease the calculated storm water runoff rate from that of the existing site, therefore, storm water detention is not required for this project.

Gravel Wetland Routing

The gravel wetland was designed to treat a minimum Water Quality Volume (WQV), which constitutes 1" of runoff from the system area.

The gravel wetland outlet structure was designed such that there would be limited outflow up to the WQV. This was accomplished by setting the elevation of an internal weir above the maximum 2-year storm event elevation

Refer to the appendices for further information and design calculations.

Table 4:
Gravel Wetland Characteristics Summary

Characteristic		Proposed
Storage Volume (cf)		7,880 CF
Max. Storage Height (ft)		3.0 feet
Peak Water Elevation	2 Year	227.07'
	10 Year	227.31'
	50 Year	227.44'

Outlet Control Structure

The storm water that discharges from the gravel wetland will be controlled through an outlet control structure. The outlet control structure has been designed to maintain appropriate water levels to ensure proper water quality control.

The gravel wetland has also been designed with an overflow outlet to handle emergency overflow conditions (i.e. malfunctioning or clogging of inlets) and consists of an emergency riprap stone-protected overflow spillway set below the top of the proposed berm.

Details of the Outlet Structure and Overflow Spillway are shown on the Detail Sheets of the project's Site Plans.

Riprap Outlet Protection

VHB sized the riprap outlet protection using Chapter 4, Section 4-6.6, pp. 172 to 174, of the New Hampshire Stormwater Manual, Volume 2, Post-Construction Best Management Practices Selection & Design, NHDES (December 2008). The following design parameters represent the minimum acceptable riprap apron dimensions used for design (refer to the appendices for design computations):

Apron Width:	≥10 feet
Apron Length:	≥10 feet
Median Stone Diameter:	0.5 feet
Depth of Stone:	6 inches (minimum)

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Storm Water Management Impacts/Conclusion

Storm Water Quantity Mitigation

Under the proposed conditions, the peak flow rates were calculated for the 2, 10, and 50 year storm events. Due to the reduction in impervious area, the peak runoff rates for the proposed conditions are anticipated to decrease over the existing condition rates. The proposed development will incorporate a storm water collection system that will capture runoff from impervious areas by means of deep sump (4' deep) catch basins and will then direct runoff to the proposed gravel wetland.

The outlet control structure for the gravel wetland includes restrictive outlet control devices and an emergency overflow spillway. The outlet structure will meter outflow rates from the gravel wetland to ensure appropriate water quality levels., Table 5 provides a summary of the peak storm water runoff rates from the proposed development.

Table 5:
Peak Storm Water Runoff Rate Summary

			Peak Flow for Given Storm (cfs)		
Discharge Point		Condition	2-yr	10-yr	50-yr
1	Existing Wetlands	Existing	4.93	10.19	16.16
		Proposed	2.14	6.50	10.36

Storm Water Quality Mitigation – Best Management Practices (BMP's)

The proposed Storm Water Management System contains several Best Management Practices (BMP's) that will provide treatment of site generated storm water runoff. The proposed BMP's are described below:

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Catch Basins with Sumps

Storm Water from the paved surfaces on-site will be collected in deep sump (4-foot) catch basins. Catch basin sumps are effective pollution control devices for removal of large particulate and adsorbed pollutants. Catch basins with sumps are designed to collect sediment particles that are the largest constituents of the pollutant load in urban runoff. Regular maintenance and cleaning of catch basins is required to assure adequate performance of these structures.

■

Gravel Wetlands

A gravel wetland is designed to treat the water quality volume and control peak flows for the analyzed storm events. The gravel wetland consists of two cells constructed of stone and soil layers, connected by a series of solid and perforated pipes. The gravel wetland is designed to maintain standing water in the system. A sediment forebay is provided upstream of the gravel wetland to remove sediments prior to entering the treatment system.

■

Energy Dissipators

Energy dissipators (i.e. riprap stone protection) will be constructed below outlets of all pipes in the storm water management system. The energy dissipators will allow the concentrated runoff from the drainage system to be discharged at non-erosive velocities to protect the receiving water resources. The appendices contain design information and calculations for the energy dissipators.

Erosion Control Measures

■

Temporary Erosions Control

During construction of the proposed development, the contractor shall be responsible for installation and maintenance of temporary sedimentation and erosion control measures to prevent off-site tracking and waterborne loss of earth sediment and debris. The specific measures proposed as a part of the project plan are shown in the Site Plan Package on the Sedimentation and Erosion Control Plan and the Erosion Control Details.

Removal of temporary erosion control measures will be prohibited until paving has been installed and vegetation (grass) is well established.

■

Permanent Erosion Control

At the completion of construction, all soils will be permanently stabilized by one or more of the following measures:

- Parking/Access: Driveways, parking areas and access roads will be stabilized with bituminous concrete pavement.
- Landscaped Areas: All disturbed areas, not permanently stabilized by pavement or buildings, will be covered with bark mulch, stone, sod or a minimum of six (6) inches of topsoil and seeded.
- Pipe Outlets: Scour protection (riprap) shall be constructed at the headwall outlet to prevent scouring.

Additionally, all catch basins will be constructed with deep sumps to collect sediment from parking areas and access roads.

Conclusion

By reducing the impervious areas on the site, the proposed development results in no impacts on peak storm water runoff rates. Furthermore, storm water quality issues can be addressed through the proposed implementation of standard practices (i.e. gravel wetlands, deep sump catch basins], etc) that are accepted by the NH Department of Environmental Services Water Supply and Pollution Control Division.

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Figures

- Figure 1: Site Location Map (USGS)
- Figure 2: Proposed Site Layout
- Figure 3: Existing Conditions Drainage Area Map
- Figure 4: Proposed Conditions Drainage Area Map

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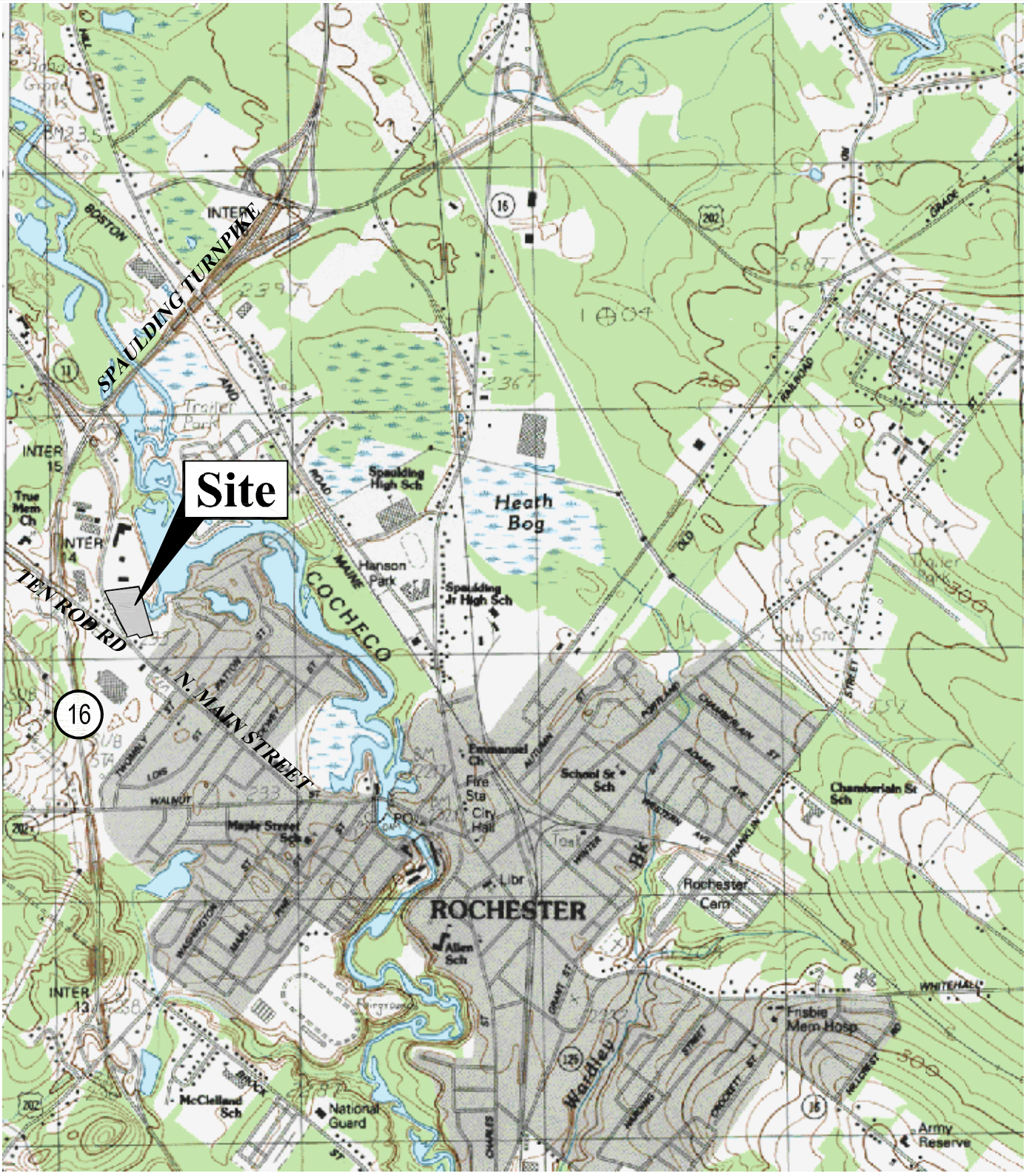

Vanasse Hangen Brustlin, Inc.

Site Location Map
Proposed Retail Development
301 N. Main Street
Rochester, New Hampshire

Figure 1

0 1000 2000 Feet

J:\51990.35\cad\ld\Eng\DRAINAGE\51990.35 Proposed Site Layout.dwg

PROPOSED PHARMACY
13,225 SF
1 STORY

PROPOSED RETAIL
8,025 SF

GRAVEL WETLAND

WETLANDS (TYP)

APPROXIMATE LOCATION OF THE 250' SHORELAND PROTECTION BUFFER

MAP 115, LOT 72
N/F
GLORIA A. MARTEL
BOOK 1548, PAGE 148

MAP 115
PARCEL 72
RESIDENTIAL

MAP 114
PARCEL 8
RESTAURANT

MAP 114, LOT 8
N/F
MAINLY ROCHESTER
PIZZA LLC
BOOK 2425, PAGE 804

MAP 115
PARCEL 40
COMMERCIAL

MAP 115, LOT 42
N/F
MACHRIE LLC
BOOK 2162, PAGE 200

MAP 115
PARCEL 42
RESTAURANT

MAP 115
PARCEL 41
GAS STATION
MAP 115, LOT 41
N/F
VSH REALTY INC.

MAP 115
PARCEL 39
AUTO BODY
SHOP

NHDOT DRAINAGE EASEMENT

PSNH EASMENT

10-FT SIDE YARD PARKING SETBACK

15-FT FRONT YARD PARKING SETBACK

50 FT WETLAND BUFFER

50' WETLAND BUFFER

25 FT NO-DISTURB WETLAND BUFFER

ARROWS DEPICT TRAFFIC FLOW; SEE LAYOUT & MATERIALS PLAN FOR PAVEMENT MARKINGS (TYP)

PYLON SIGN

18"MAPLE W/NAIL AND EVIDENCE OF BARB WIRE

CBDH (FND)

549°11'40"E 204.79' (TIE)

S11°15'34"E 241.31' (TIE)

OFFSITE ROADWAY IMPROVEMENTS ARE TAKEN FROM A PROPOSED ROADWAY IMPROVEMENT PLAN FOR NHDOT. THE IMPROVEMENTS HAVE NOT YET BEEN CONSTRUCTED - 37

NHDOT BASELINE PER PLAN REFERENCE #6

NORTH MAIN STREET
(NH ROUTE 11)

TEN ROD ROAD

0 40 80 Feet

Vanasse Hangen Brustlin, Inc.

Figure 2

Proposed Site Layout
Proposed Retail Development
North Main Street
Rochester, New Hampshire

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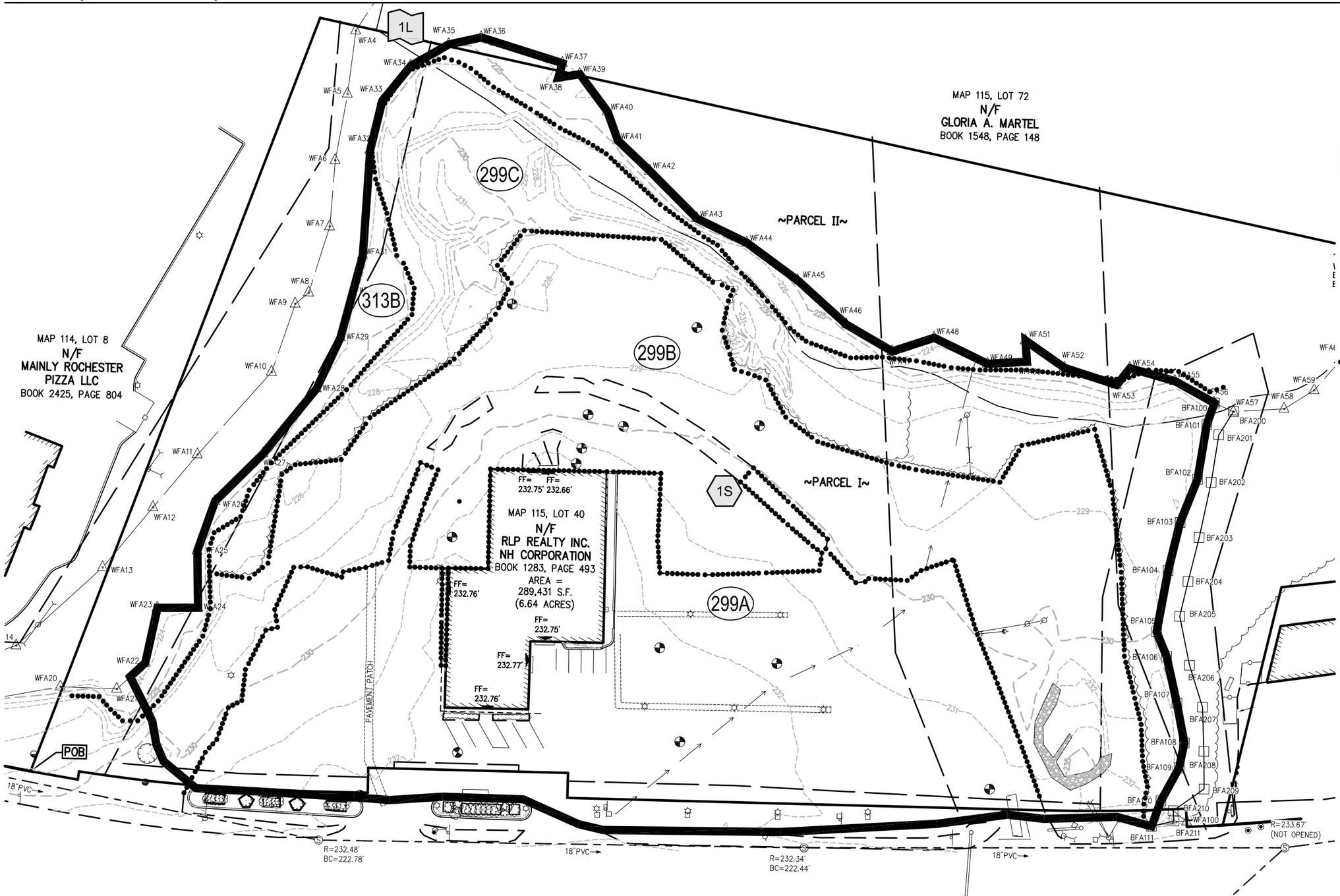


Symbol	Description
#	Drainage Area
	Drainage Area Boundary
#	Detention Basin/Pond
#	Discharge Point
→	Tc Path
●●●●●	Soil Boundary

NRCS SOIL CLASSIFICATIONS (HSG)

299A	UDORTHENT, PAVED LOT HYDROLOGIC SOIL GROUP A
299B	UDORTHENT, GRAVEL LOT HYDROLOGIC SOIL GROUP A
299C	UDORTHENT, REGRADED/TRASH HYDROLOGIC SOIL GROUP A
313B	DEERFIELD, REGRADED HYDROLOGIC SOIL GROUP B

0 30 60 Feet

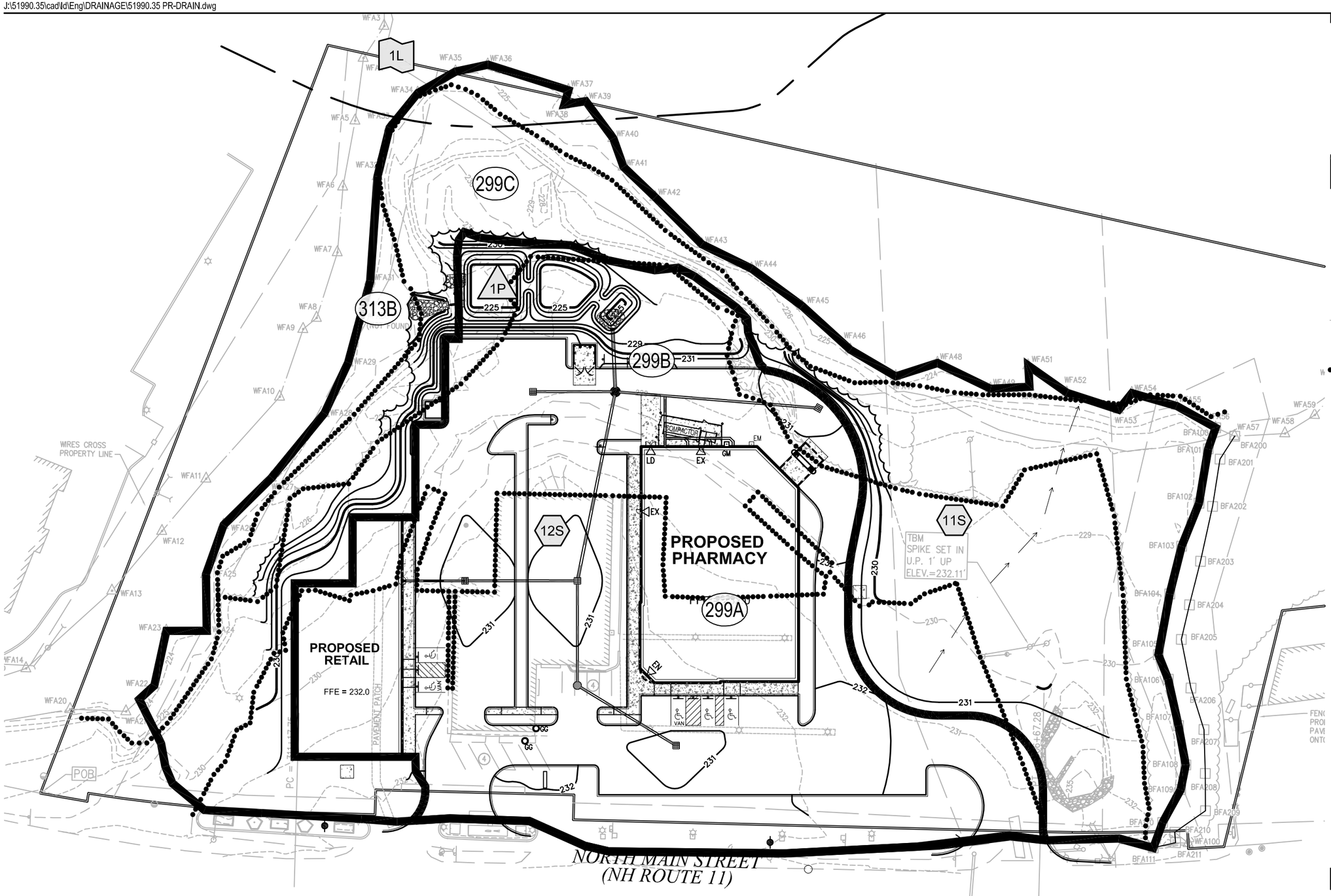
THIS SITE SPECIFIC SOIL MAP WAS PREPARED BY NANCY B. RENDALL, CSS #83 BASED ON FIELD WORK CONDUCTED AT AND SITE CONDITIONS ON THE SITE IN OCTOBER, 2010. THIS SOIL MAP WAS PREPARED IN ACCORDANCE WITH THE SSSNNE SPECIAL PUBLICATION #3, VERSION 3.0, DECEMBER 2006, "SITE-SPECIFIC SOIL MAPPING STANDARDS FOR NEW HAMPSHIRE & VERMONT". THIS MAP PRODUCT IS WITHIN THE TECHNICAL STANDARDS OF THE NATIONAL COOPERATIVE SOIL SURVEY. IT IS A SPECIAL PURPOSE PRODUCT, INTENDED FOR USE IN THE DEVELOPMENT OF A COMMERCIAL BUILDING AND STORMWATER MANAGEMENT PRACTICES TO BE CONSTRUCTED ON THE SITE. IT WAS PRODUCED BY A CERTIFIED SOIL SCIENTIST AND IS NOT A PRODUCT OF THE USDA NATURAL RESOURCES CONSERVATION SERVICE. THERE IS A NARRATIVE REPORT PREPARED BY THE CERTIFIED SOIL SCIENTIST THAT IS MEANT TO ACCOMPANY THIS MAP.

Vanasse Hangen Brustlin, Inc.

Figure 3

Existing Conditions Drainage Area Map
Proposed Retail Development
301 N. Main Streeet
Rochester, New Hampshire

J:\51990.35\cad\ld\Eng\DRAINAGE\51990.35 PR-DRAIN.dwg



Symbol	Description
#	Drainage Area
	Drainage Area Boundary
#	Gravel Wetland
#	Discharge Point
→	Tc Path
●●●●●●●●●●●●●	Soil Boundary

NRCS SOIL CLASSIFICATIONS (HSG)

299A	UDORTHENT, PAVED LOT HYDROLOGIC SOIL GROUP A
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0 40 80 Feet

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Vanasse Hangen Brustlin, Inc.

Figure 4

Proposed Conditions Drainage Area Map
Proposed Retail Development
301 N. Main Street
Rochester, New Hampshire

Appendix A: Hydrologic Calculations

- Existing Conditions
- Proposed Conditions

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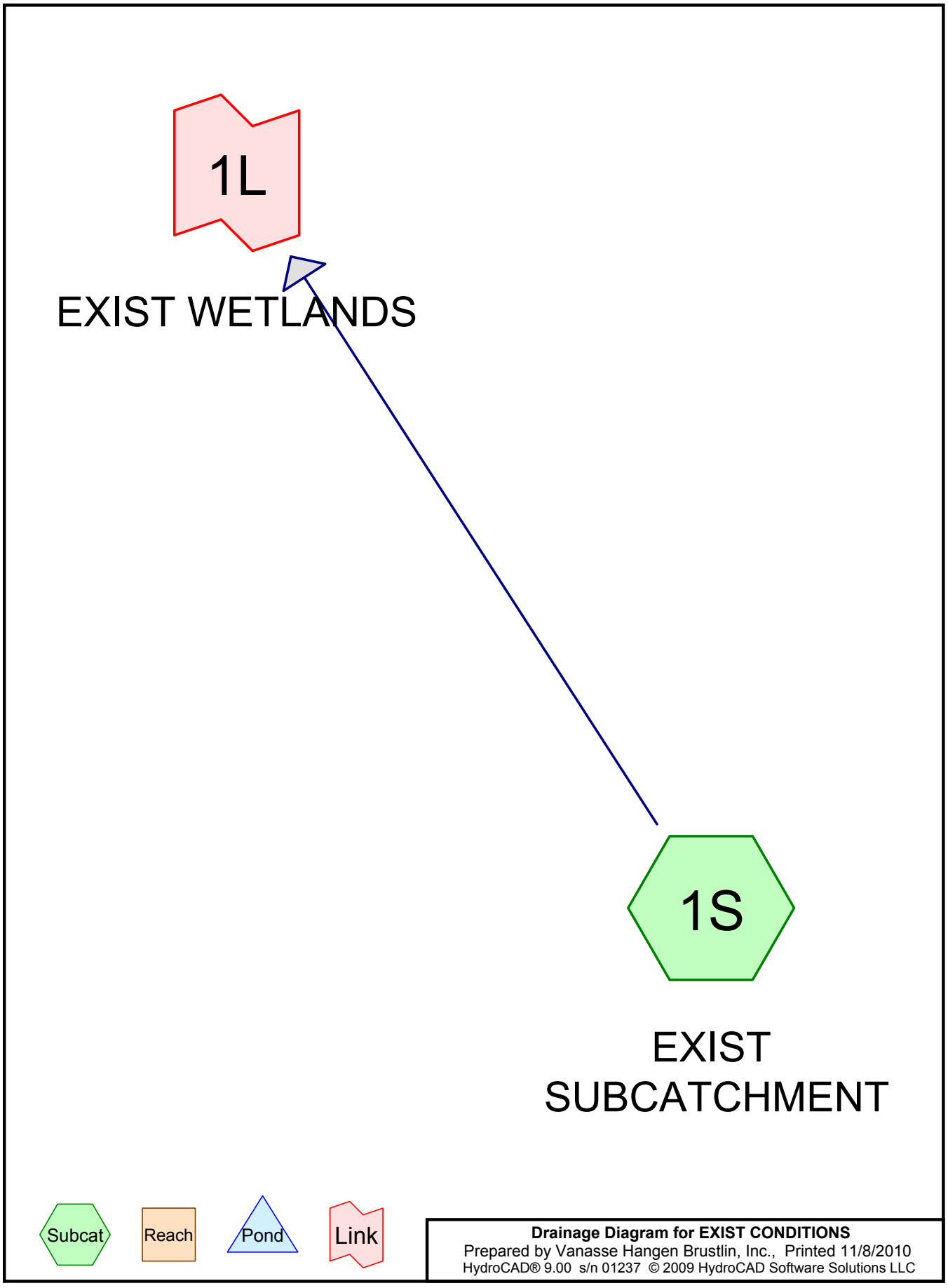
Existing Conditions



Drainage Diagram for EXIST CONDITIONS
Prepared by Vanasse Hangen Brustlin, Inc., Printed 11/8/2010

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
1.030	43	Woods/grass comb., Fair, HSG A (1S)
0.300	65	Woods/grass comb., Fair, HSG B (1S)
1.460	76	Gravel roads, HSG A (1S)
1.510	98	Paved parking, HSG A (1S)
0.240	98	Roofs, HSG A (1S)
4.540		**TOTAL AREA**

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1S: EXIST SUBCATCHMENT Runoff Area=4.540 ac 38.55% Impervious Runoff Depth>0.90"
Flow Length=370' Tc=6.0 min CN=76 Runoff=4.93 cfs 0.341 af

Link 1L: EXIST WETLANDS Inflow=4.93 cfs 0.341 af
Primary=4.93 cfs 0.341 af

Total Runoff Area = 4.540 ac Runoff Volume = 0.341 af Average Runoff Depth = 0.90"
61.45% Pervious = 2.790 ac 38.55% Impervious = 1.750 ac

Summary for Subcatchment 1S: EXIST SUBCATCHMENT

Runoff = 4.93 cfs @ 12.10 hrs, Volume= 0.341 af, Depth> 0.90"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-YR Rainfall=2.96"

Area (ac)	CN	Description
0.240	98	Roofs, HSG A
1.460	76	Gravel roads, HSG A
1.510	98	Paved parking, HSG A
1.030	43	Woods/grass comb., Fair, HSG A
0.300	65	Woods/grass comb., Fair, HSG B
4.540	76	Weighted Average
2.790		61.45% Pervious Area
1.750		38.55% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.7	50	0.0200	1.15		**Sheet Flow, A-B** Smooth surfaces n= 0.011 P2= 2.96"
1.5	250	0.0200	2.87		**Shallow Concentrated Flow, B-C** Paved Kv= 20.3 fps
0.8	70	0.0800	1.41		**Shallow Concentrated Flow, C-D** Woodland Kv= 5.0 fps
3.0					**Direct Entry,**
6.0	370	Total			

Summary for Link 1L: EXIST WETLANDS

Inflow Area = 4.540 ac, 38.55% Impervious, Inflow Depth > 0.90" for 2-YR event
Inflow = 4.93 cfs @ 12.10 hrs, Volume= 0.341 af
Primary = 4.93 cfs @ 12.10 hrs, Volume= 0.341 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1S: EXIST SUBCATCHMENT Runoff Area=4.540 ac 38.55% Impervious Runoff Depth>1.82"
Flow Length=370' Tc=6.0 min CN=76 Runoff=10.19 cfs 0.687 af

Link 1L: EXIST WETLANDS Inflow=10.19 cfs 0.687 af
Primary=10.19 cfs 0.687 af

Total Runoff Area = 4.540 ac Runoff Volume = 0.687 af Average Runoff Depth = 1.82"
61.45% Pervious = 2.790 ac 38.55% Impervious = 1.750 ac

Summary for Subcatchment 1S: EXIST SUBCATCHMENT

Runoff = 10.19 cfs @ 12.10 hrs, Volume= 0.687 af, Depth> 1.82"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-YR Rainfall=4.29"

Area (ac)	CN	Description
0.240	98	Roofs, HSG A
1.460	76	Gravel roads, HSG A
1.510	98	Paved parking, HSG A
1.030	43	Woods/grass comb., Fair, HSG A
0.300	65	Woods/grass comb., Fair, HSG B
4.540	76	Weighted Average
2.790		61.45% Pervious Area
1.750		38.55% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.7	50	0.0200	1.15		**Sheet Flow, A-B** Smooth surfaces n= 0.011 P2= 2.96"
1.5	250	0.0200	2.87		**Shallow Concentrated Flow, B-C** Paved Kv= 20.3 fps
0.8	70	0.0800	1.41		**Shallow Concentrated Flow, C-D** Woodland Kv= 5.0 fps
3.0					**Direct Entry,**
6.0	370	Total			

Summary for Link 1L: EXIST WETLANDS

Inflow Area = 4.540 ac, 38.55% Impervious, Inflow Depth > 1.82" for 10-YR event
Inflow = 10.19 cfs @ 12.10 hrs, Volume= 0.687 af
Primary = 10.19 cfs @ 12.10 hrs, Volume= 0.687 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1S: EXIST SUBCATCHMENT Runoff Area=4.540 ac 38.55% Impervious Runoff Depth>2.89"
Flow Length=370' Tc=6.0 min CN=76 Runoff=16.16 cfs 1.092 af

Link 1L: EXIST WETLANDS Inflow=16.16 cfs 1.092 af
Primary=16.16 cfs 1.092 af

Total Runoff Area = 4.540 ac Runoff Volume = 1.092 af Average Runoff Depth = 2.89"
61.45% Pervious = 2.790 ac 38.55% Impervious = 1.750 ac

Summary for Subcatchment 1S: EXIST SUBCATCHMENT

Runoff = 16.16 cfs @ 12.09 hrs, Volume= 1.092 af, Depth> 2.89"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 50-YR Rainfall=5.67"

Area (ac)	CN	Description
0.240	98	Roofs, HSG A
1.460	76	Gravel roads, HSG A
1.510	98	Paved parking, HSG A
1.030	43	Woods/grass comb., Fair, HSG A
0.300	65	Woods/grass comb., Fair, HSG B
4.540	76	Weighted Average
2.790		61.45% Pervious Area
1.750		38.55% Impervious Area

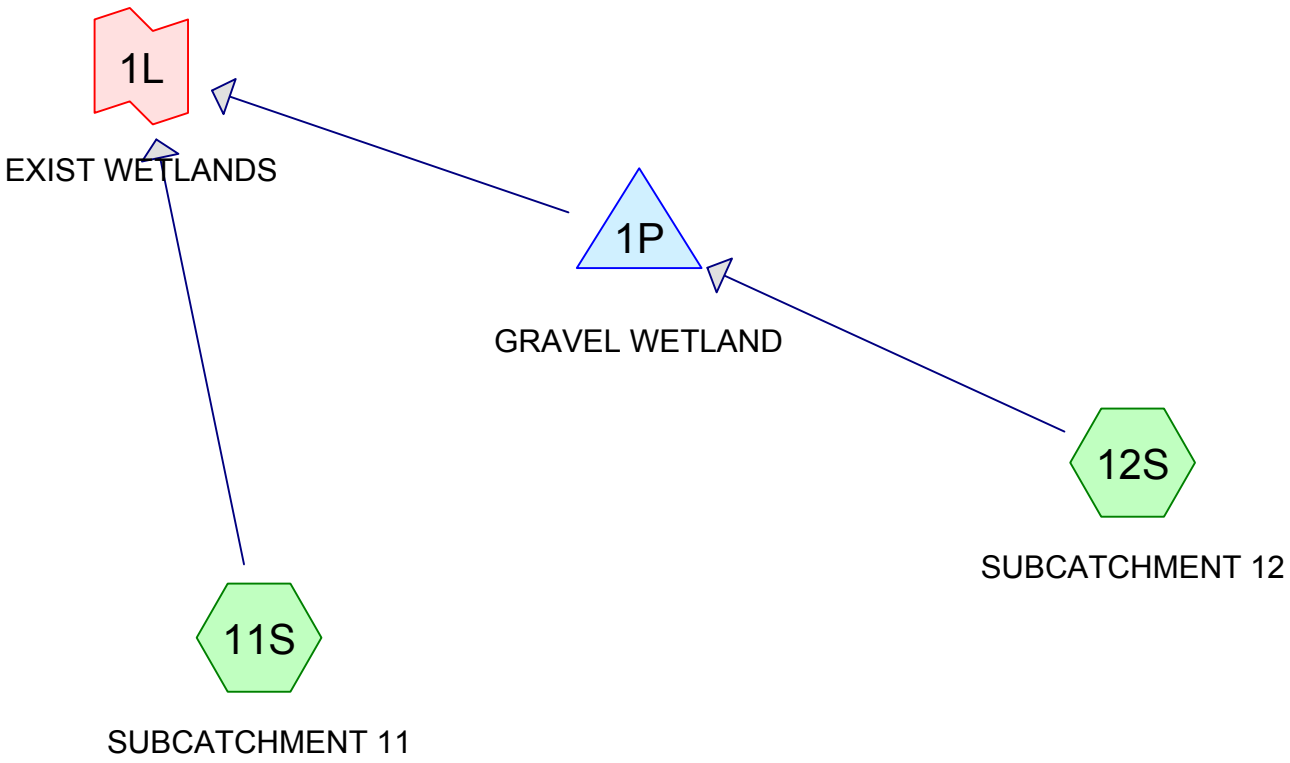
Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.7	50	0.0200	1.15		**Sheet Flow, A-B** Smooth surfaces n= 0.011 P2= 2.96"
1.5	250	0.0200	2.87		**Shallow Concentrated Flow, B-C** Paved Kv= 20.3 fps
0.8	70	0.0800	1.41		**Shallow Concentrated Flow, C-D** Woodland Kv= 5.0 fps
3.0					**Direct Entry,**
6.0	370	Total			

Summary for Link 1L: EXIST WETLANDS

Inflow Area = 4.540 ac, 38.55% Impervious, Inflow Depth > 2.89" for 50-YR event
Inflow = 16.16 cfs @ 12.09 hrs, Volume= 1.092 af
Primary = 16.16 cfs @ 12.09 hrs, Volume= 1.092 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Proposed Conditions



Subcat Reach Pond Link

Drainage Diagram for PROP CONDITIONS
Prepared by Vanasse Hangen Brustlin, Inc., Printed 11/8/2010

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
1.670	39	>75% Grass cover, Good, HSG A (11S, 12S)
0.750	43	Woods/grass comb., Fair, HSG A (11S)
0.300	65	Woods/grass comb., Fair, HSG B (11S)
1.330	98	Paved parking, HSG A (12S)
0.490	98	Roofs, HSG A (12S)
4.540		**TOTAL AREA**

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment11S: SUBCATCHMENT11 Runoff Area=2.140 ac 0.00% Impervious Runoff Depth>0.01"
Tc=6.0 min CN=44 Runoff=0.00 cfs 0.001 af

Subcatchment12S: SUBCATCHMENT12 Runoff Area=2.400 ac 75.83% Impervious Runoff Depth>1.38"
Tc=6.0 min CN=84 Runoff=4.09 cfs 0.276 af

Pond 1P: GRAVEL WETLAND Peak Elev=227.07' Storage=4,640 cf Inflow=4.09 cfs 0.276 af
Outflow=2.14 cfs 0.183 af

Link 1L: EXIST WETLANDS Inflow=2.14 cfs 0.184 af
Primary=2.14 cfs 0.184 af

Total Runoff Area = 4.540 ac Runoff Volume = 0.277 af Average Runoff Depth = 0.73"
59.91% Pervious = 2.720 ac 40.09% Impervious = 1.820 ac

Summary for Subcatchment 11S: SUBCATCHMENT 11

Runoff = 0.00 cfs @ 20.00 hrs, Volume= 0.001 af, Depth> 0.01"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-YR Rainfall=2.96"

Area (ac)	CN	Description
1.090	39	>75% Grass cover, Good, HSG A
0.750	43	Woods/grass comb., Fair, HSG A
0.300	65	Woods/grass comb., Fair, HSG B
2.140	44	Weighted Average
2.140		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry,**

Summary for Subcatchment 12S: SUBCATCHMENT 12

Runoff = 4.09 cfs @ 12.09 hrs, Volume= 0.276 af, Depth> 1.38"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-YR Rainfall=2.96"

Area (ac)	CN	Description
0.490	98	Roofs, HSG A
1.330	98	Paved parking, HSG A
0.580	39	>75% Grass cover, Good, HSG A
2.400	84	Weighted Average
0.580		24.17% Pervious Area
1.820		75.83% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry,**

Summary for Pond 1P: GRAVEL WETLAND

Inflow Area = 2.400 ac, 75.83% Impervious, Inflow Depth > 1.38" for 2-YR event
Inflow = 4.09 cfs @ 12.09 hrs, Volume= 0.276 af
Outflow = 2.14 cfs @ 12.26 hrs, Volume= 0.183 af, Atten= 48%, Lag= 10.2 min
Primary = 2.14 cfs @ 12.26 hrs, Volume= 0.183 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 227.07' @ 12.27 hrs Surf.Area= 3,091 sf Storage= 4,640 cf

Plug-Flow detention time= 124.1 min calculated for 0.183 af (66% of inflow)
Center-of-Mass det. time= 52.5 min (848.7 - 796.2)

Volume	Invert	Avail.Storage	Storage Description
#1	225.00'	7,880 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
225.00	1,475	0	0
226.00	2,166	1,821	1,821
226.85	2,895	2,151	3,971
228.00	3,902	3,908	7,880

Device	Routing	Invert	Outlet Devices
#1	Primary	225.00'	**18.0" Round Culvert** L= 4.0' RCP, sq.cut end projecting, Ke= 0.500 Outlet Invert= 224.80' S= 0.0500 '/' Cc= 0.900 n= 0.009 Corrugated PE, smooth interior
#2	Device 1	226.85'	**2.0' long Sharp-Crested Rectangular Weir X 3.00** 2 End Contraction(s) 0.5' Crest Height
#3	Primary	227.45'	**8.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Primary OutFlow Max=2.10 cfs @ 12.26 hrs HW=227.07' (Free Discharge)
- **1=Culvert** (Passes 2.10 cfs of 9.78 cfs potential flow)
  - **2=Sharp-Crested Rectangular Weir** (Weir Controls 2.10 cfs @ 1.62 fps)
- **3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Link 1L: EXIST WETLANDS

Inflow Area = 4.540 ac, 40.09% Impervious, Inflow Depth > 0.49" for 2-YR event
Inflow = 2.14 cfs @ 12.26 hrs, Volume= 0.184 af
Primary = 2.14 cfs @ 12.26 hrs, Volume= 0.184 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment11S: SUBCATCHMENT11 Runoff Area=2.140 ac 0.00% Impervious Runoff Depth>0.17"
Tc=6.0 min CN=44 Runoff=0.12 cfs 0.030 af

Subcatchment12S: SUBCATCHMENT12 Runoff Area=2.400 ac 75.83% Impervious Runoff Depth>2.46"
Tc=6.0 min CN=84 Runoff=7.23 cfs 0.492 af

Pond 1P: GRAVEL WETLAND Peak Elev=227.31' Storage=5,397 cf Inflow=7.23 cfs 0.492 af
Outflow=6.50 cfs 0.399 af

Link 1L: EXIST WETLANDS Inflow=6.50 cfs 0.429 af
Primary=6.50 cfs 0.429 af

Total Runoff Area = 4.540 ac Runoff Volume = 0.522 af Average Runoff Depth = 1.38"
59.91% Pervious = 2.720 ac 40.09% Impervious = 1.820 ac

Summary for Subcatchment 11S: SUBCATCHMENT 11

Runoff = 0.12 cfs @ 12.43 hrs, Volume= 0.030 af, Depth> 0.17"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-YR Rainfall=4.29"

Area (ac)	CN	Description
1.090	39	>75% Grass cover, Good, HSG A
0.750	43	Woods/grass comb., Fair, HSG A
0.300	65	Woods/grass comb., Fair, HSG B
2.140	44	Weighted Average
2.140		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry,**

Summary for Subcatchment 12S: SUBCATCHMENT 12

Runoff = 7.23 cfs @ 12.09 hrs, Volume= 0.492 af, Depth> 2.46"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-YR Rainfall=4.29"

Area (ac)	CN	Description
0.490	98	Roofs, HSG A
1.330	98	Paved parking, HSG A
0.580	39	>75% Grass cover, Good, HSG A
2.400	84	Weighted Average
0.580		24.17% Pervious Area
1.820		75.83% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry,**

Summary for Pond 1P: GRAVEL WETLAND

Inflow Area = 2.400 ac, 75.83% Impervious, Inflow Depth > 2.46" for 10-YR event
Inflow = 7.23 cfs @ 12.09 hrs, Volume= 0.492 af
Outflow = 6.50 cfs @ 12.13 hrs, Volume= 0.399 af, Atten= 10%, Lag= 2.5 min
Primary = 6.50 cfs @ 12.13 hrs, Volume= 0.399 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 227.31' @ 12.13 hrs Surf.Area= 3,298 sf Storage= 5,397 cf

Plug-Flow detention time= 83.9 min calculated for 0.399 af (81% of inflow)
Center-of-Mass det. time= 32.9 min (815.7 - 782.9)

Volume	Invert	Avail.Storage	Storage Description
#1	225.00'	7,880 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
225.00	1,475	0	0
226.00	2,166	1,821	1,821
226.85	2,895	2,151	3,971
228.00	3,902	3,908	7,880

Device	Routing	Invert	Outlet Devices
#1	Primary	225.00'	**18.0" Round Culvert** L= 4.0' RCP, sq.cut end projecting, Ke= 0.500 Outlet Invert= 224.80' S= 0.0500 '/' Cc= 0.900 n= 0.009 Corrugated PE, smooth interior
#2	Device 1	226.85'	**2.0' long Sharp-Crested Rectangular Weir X 3.00** 2 End Contraction(s) 0.5' Crest Height
#3	Primary	227.45'	**8.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Primary OutFlow Max=6.37 cfs @ 12.13 hrs HW=227.30' (Free Discharge)
- **1=Culvert** (Passes 6.37 cfs of 10.61 cfs potential flow)
  - **2=Sharp-Crested Rectangular Weir** (Weir Controls 6.37 cfs @ 2.45 fps)
- **3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Link 1L: EXIST WETLANDS

Inflow Area = 4.540 ac, 40.09% Impervious, Inflow Depth > 1.13" for 10-YR event
Inflow = 6.50 cfs @ 12.13 hrs, Volume= 0.429 af
Primary = 6.50 cfs @ 12.13 hrs, Volume= 0.429 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment11S: SUBCATCHMENT11 Runoff Area=2.140 ac 0.00% Impervious Runoff Depth>0.53"
Tc=6.0 min CN=44 Runoff=0.72 cfs 0.095 af

Subcatchment12S: SUBCATCHMENT12 Runoff Area=2.400 ac 75.83% Impervious Runoff Depth>3.66"
Tc=6.0 min CN=84 Runoff=10.57 cfs 0.732 af

Pond 1P: GRAVEL WETLAND Peak Elev=227.44' Storage=5,847 cf Inflow=10.57 cfs 0.732 af
Outflow=9.68 cfs 0.638 af

Link 1L: EXIST WETLANDS Inflow=10.36 cfs 0.732 af
Primary=10.36 cfs 0.732 af

Total Runoff Area = 4.540 ac Runoff Volume = 0.826 af Average Runoff Depth = 2.18"
59.91% Pervious = 2.720 ac 40.09% Impervious = 1.820 ac

Summary for Subcatchment 11S: SUBCATCHMENT 11

Runoff = 0.72 cfs @ 12.16 hrs, Volume= 0.095 af, Depth> 0.53"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 50-YR Rainfall=5.67"

Area (ac)	CN	Description
1.090	39	>75% Grass cover, Good, HSG A
0.750	43	Woods/grass comb., Fair, HSG A
0.300	65	Woods/grass comb., Fair, HSG B
2.140	44	Weighted Average
2.140		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry,**

Summary for Subcatchment 12S: SUBCATCHMENT 12

Runoff = 10.57 cfs @ 12.09 hrs, Volume= 0.732 af, Depth> 3.66"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 50-YR Rainfall=5.67"

Area (ac)	CN	Description
0.490	98	Roofs, HSG A
1.330	98	Paved parking, HSG A
0.580	39	>75% Grass cover, Good, HSG A
2.400	84	Weighted Average
0.580		24.17% Pervious Area
1.820		75.83% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry,**

Summary for Pond 1P: GRAVEL WETLAND

Inflow Area = 2.400 ac, 75.83% Impervious, Inflow Depth > 3.66" for 50-YR event
Inflow = 10.57 cfs @ 12.09 hrs, Volume= 0.732 af
Outflow = 9.68 cfs @ 12.13 hrs, Volume= 0.638 af, Atten= 8%, Lag= 2.1 min
Primary = 9.68 cfs @ 12.13 hrs, Volume= 0.638 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 227.44' @ 12.13 hrs Surf.Area= 3,415 sf Storage= 5,847 cf

Plug-Flow detention time= 66.4 min calculated for 0.636 af (87% of inflow)
Center-of-Mass det. time= 28.1 min (801.6 - 773.5)

Volume	Invert	Avail.Storage	Storage Description
#1	225.00'	7,880 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
225.00	1,475	0	0
226.00	2,166	1,821	1,821
226.85	2,895	2,151	3,971
228.00	3,902	3,908	7,880

Device	Routing	Invert	Outlet Devices
#1	Primary	225.00'	**18.0" Round Culvert** L= 4.0' RCP, sq.cut end projecting, Ke= 0.500 Outlet Invert= 224.80' S= 0.0500 '/' Cc= 0.900 n= 0.009 Corrugated PE, smooth interior
#2	Device 1	226.85'	**2.0' long Sharp-Crested Rectangular Weir X 3.00** 2 End Contraction(s) 0.5' Crest Height
#3	Primary	227.45'	**8.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Primary OutFlow Max=9.47 cfs @ 12.13 hrs HW=227.44' (Free Discharge)
- **1=Culvert** (Passes 9.47 cfs of 11.05 cfs potential flow)
  - **2=Sharp-Crested Rectangular Weir** (Weir Controls 9.47 cfs @ 2.86 fps)
- **3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Link 1L: EXIST WETLANDS

Inflow Area = 4.540 ac, 40.09% Impervious, Inflow Depth > 1.94" for 50-YR event
Inflow = 10.36 cfs @ 12.13 hrs, Volume= 0.732 af
Primary = 10.36 cfs @ 12.13 hrs, Volume= 0.732 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Appendix B: Hydraulic Calculations

- Storm Drainage Piping Calculations
- Riprap Sizing Calculations

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Storm Drainage Piping Calculations

Vanasse Hangen Brustlin, Inc.
Transportation
Land Development
Environmental Services
6 Bedford Farms Drive, Bedford, NH

Storm Drainage Computations

Name: Proposed Retail Development
Rochester, NH
Client: GB New Hampshire 2, LLC

Proj. No.: **51990.35**
Date: **11/3/2010**
Computed by: **DHF**
Checked by: **BAA**

Design Parameters:
25 Year Storm
k_e= **0.5**

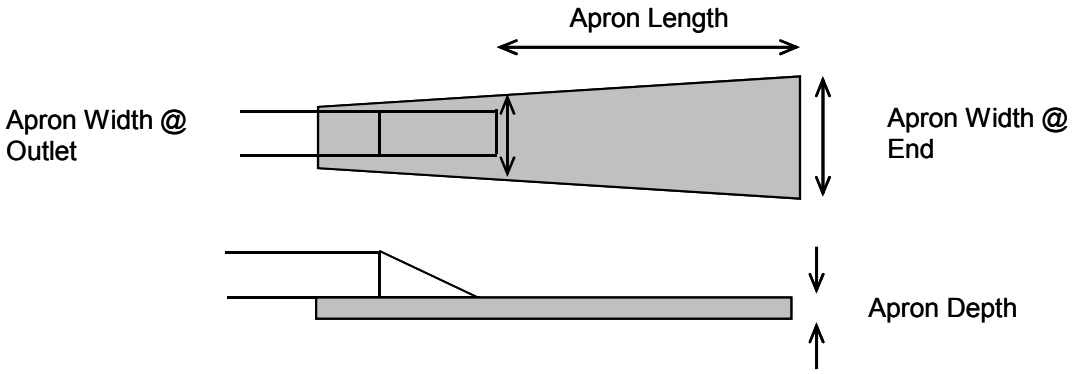
DESCRIPTION	LOCATION		AREA	C	C x A	SUM	FLOW TIME (MIN)		i*	DESIGN					CAPACITY		PROFILE						
	FROM	TO	(AC.)			C x A	PIPE	CONC TIME		Q cfs	V fps	n	PIPE SIZE	SLOPE	Q full ft^3/s	V full ft/s	LENGTH ft	FALL ft	RIM	INV UPPER	INV LOWER	W.S.E. ft	Freeboard ft
	CB 10	DMH 7	0.67	0.63	0.42	0.42	0.30	6.0	5.1	2.1	3.6	0.011	12	0.0050	3.0	3.8	64	0.32	230.7	228.2	227.9	228.0	2.7
	DMH 7	CB 5	---	---	---	0.42	0.28	6.0	5.1	2.1	3.6	0.011	12	0.0050	3.0	3.8	60	0.30	231.4	227.9	227.6	227.7	3.7
	RD A	CB 8	0.18	0.90	0.17	0.17	0.20	6.0	5.1	0.8	2.8	0.011	10	0.0050	1.8	3.4	34	0.17	232.0	228.0	227.8	227.9	4.1
	CB 8	CB 7	0.37	0.82	0.31	0.47	0.28	6.0	5.1	2.4	3.7	0.011	12	0.0050	3.0	3.8	62	0.31	230.7	227.9	227.6	227.7	3.0
	CB 7	DMH 4	0.28	0.85	0.24	0.71	0.47	6.0	5.1	3.6	4.0	0.011	15	0.0050	5.4	4.4	113	0.57	230.7	227.6	227.0	227.3	3.4
	RD B	CB 6	0.30	0.90	0.27	0.27	0.16	6.0	5.1	1.4	3.2	0.011	10	0.0050	1.8	3.4	30	0.15	232.0	228.0	227.9	227.9	4.1
	CB 6	DMH 4	0.19	0.82	0.15	0.43	0.55	6.0	5.1	2.2	3.6	0.011	12	0.0050	3.0	3.8	118	0.59	230.6	227.6	227.0	227.4	3.2
	CB 5	DMH 4	0.16	0.88	0.14	0.14	0.29	6.0	5.1	0.7	2.6	0.011	12	0.0050	3.0	3.8	46	0.23	231.3	227.3	227.1	227.2	4.1
	DMH 7	FES 2	---	---	---	1.28	0.12	6.0	5.1	6.5	4.7	0.011	18	0.0050	8.8	5.0	34	0.17	231.6	227.0	226.8	226.7	4.9

Riprap Sizing Calculations

Computations

Project #:	51990.35		
Project:	Proposed Retail Development		
Location:	Rochester, NH		
Calculated by:	DHF	Date:	11/3/2010
Checked by:	BAA	Date:	11/5/2010
Title:	Riprap Outlet Protection Sizing		

Source: New Hampshire Stormwater Manual, Volume 2,
Post-Construction Best Management Practices Selection & Design
NHDES, December 2008, Section 4-6.6. p. 172.



Apron Width at Outlet:	Width = 3*pipe dia. (or width of channel)	
Apron Length:	Length = (1.8*Q) / (dia.^3/2) + 7*dia.	if Tw depth is < 1/2 dia.
	Length = (3.0*Q) / (dia^3/2) + 7*dia.	if Tw dwpth is >= 1/2 dia.
Apron Width at End:	Width = 3*dia. + apron length	if Tw depth is < 1/2 dia.
	Width = 3*dia. + 0.4*apron length	if Tw dwpth is >= 1/2 dia.
	or apron width = channel width if a well defined channel exists	
Rock Riprap:	Median Diameter = (0.02 * Q^4/3) / (Tw * dia)	
	Depth = 6" or 1.5 * largest stone dia	(largest stone dia = 1.5 * d50)

	Outlet Description	
Design Element	HW 1	FES 3
Design Storm (yr):	25	25
Defined Channel (yes/no)	no	no
Channel Width, ft	n/a	n/a
Pipe Dia (D), in	18	15
Tail Water (Tw), ft	1.0	0.5
	Tw>=0.5D	Tw<0.5D
Flow (Q), cfs	8.5	9.0
Apron Width (outlet), ft	4.5	3.8
Apron Length, ft	24.4	20.3
Apron Width (end), ft	14	24
Apron Width (channel), ft	n/a	n/a
Median Stone Dia., ft	0.23	0.55
Median Stone Dia., in	2.78	6.66
Largest Stone Dia., ft	0.35	0.83
Largest Stone Dia., in	4.16	9.98
Apron Depth, ft	0.5	1.2
Apron Depth, in	6.2	15.0

Appendix C: Support Data

- Base Calculations (GRV, WQV, & WQF)
- BMP Work Sheets
- FEMA Floodplain Map
- Rainfall Data

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Base Calculations (GRV, WQV, & WQF)

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Groundwater Recharge Volume (GRV) Calculation

0.07	ac	Area of HSG A soil that was replaced by impervious cover	0.40"
-	ac	Area of HSG B soil that was replaced by impervious cover	0.25"
-	ac	Area of HSG C soil that was replaced by impervious cover	0.10"
-	ac	Area of HSG D soil or impervious cover that was replaced by impervi	0.0"
0.40	inches	Rd = weighted groundwater recharge depth	
0.028	ac-in	GRV = AI * Rd	
102	cf	GRV conversion (ac-in x 43,560 sf/ac x 1ft/12")	

**The colored cells contain formulas and cannot be edited.

Designer's Notes: Project will have a net decrease in impervious area of approximately 1.2 ac.
(i.e. pavement, gravel lots, roofs, etc)

General Calculations - WQV and WQF

This worksheet may be useful when designing a BMP that does not fit into one of the specific worksheets already provided. For example, if proposing a new technology, which is not a stormwater wetland, infiltration practice, etc., then this worksheet may be useful.

Water Quality Volume (WQV)

2.40	ac	Area (A) draining to the system
1.82	ac	Impervious area draining to the system
0.76	decimal	Percent Impervious area (I) draining to the pond
0.73	unitless	Runoff coefficient (Rv) = 0.05 + (0.9 x I)
1.76	ac-in	WQV= 1" x Rv x A
6,382	cf	WQV conversion (ac-in x 43,560 sf/ac x 1ft/12")

Water Quality Flow (WQF) - note you must first calculate the WQV using the above calculations

1	inches	P is the rainfall. For WQF in NH, P = 1".
0.73	inches	Q is the water quality depth. Q = WQV/A
97	unitless	CN is the unit peak discharge curve number. $CN = 1000/(10+5P+10Q-10*[Q^2 + 1.25*Q*P]^{0.5})$
0.3	inches	S is the potential maximum retention. S = (1000/CN) - 10
0.055	inches	Ia is the initial abstraction. Ia = 0.2S
6.0	minutes	Time of Concentration
700.0	$cfs/mi^2/in$	qu is the unit peak discharge. Obtain this value from TR-55 exhibits 4-II and 4-III
1.923	cfs	$WQF = q_u$ x WQV. Conversion: to convert "$cfs/mi^2/in$ * ac-in" to "cfs" multiply by $1mi^2/640ac$

Designer's Notes:

BMP Worksheets

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STORMWATER WETLAND DESIGN CRITERIA (Env-Wq 1508.04)

Type/Node Name: **Gravel Wetland**

Enter the type of stormwater wetland (e.g., gravel wetland) and the node name in the drainage analysis, if applicable

2.40	ac	Area (A) draining to the pond	
1.82	ac	Impervious area draining to the pond	
0.76	decimal	Percent Impervious area (I) draining to the pond	
0.73	unitless	Runoff coefficient (Rv) = 0.05 + (0.9 x I)	
1.76	ac-in	WQV= 1" x Rv x A	
6,382	cf	WQV conversion (ac-in x 43,560 sf/ac x 1ft/12")	
638	cf	10% x WQV (check calc for sediment forebay volume)	
2,872	cf	45% x WQV (check calc for treatment bay volume, if a gravel wetland is proposed)	
3,191	cf	50% x WQV (check calc for ext. detention volume, if extended detention proposed)	
647	cf	Sediment forebay volume	← **≥ 10%WQV**
3,971	cf	If a Gravel Wetland: Volume of Treatment bay 1 (V_{TB})	← **≥ 45%WQV**
3,971	cf	If a Gravel Wetland: Volume of Treatment bay 2 (V_{TB})	← **≥ 45%WQV**
8,589	cf	Permanent pool volume (V_P)	
	cf	Extended detention volume (V_{ED}), if applicable	← **≤ 50%WQV**
8,589	cf	$V_P + V_{ED}$	← **≥ WQV**
-	cfs	If Ext. Detention is provided: *design* Qavg = V_{ED} / 24 hrs * (1hr / 3600 sec)	
-	cfs	If Ext. Detention: 2 * *design* Qavg (use to check Q_{max} below)	
	cfs	If Ext. Detention: What is the Q_{ED}? (attach table to worksheet)[1]	← **<2Qavg**
-	hours	If Ext. Detention: Actual drawdown time = $2V_{ED}/Q_{max}$	← **≥ 24-hrs**
3.00	:1	Pond side slopes	← **≥3:1**
2.00	ft	Maximum depth of permanent pool	← **≤ 8 ft**
227.00	ft	Elevation of the permanent pool (E_{PP})	
227.72	ft	Peak elevation of the 50-year storm event (E_{50})	
0.7	ft	Depth above the permanent pool (E_{50} - E_{PP})	← **≤ 4'**
96.00	ft	Length of the flow path between the inlet and outlet at mid-depth	
32.00	ft	Average Width ([average of the top width + average bottom width]/2)	
3.0	:1	Length to Average Width ratio	← **≥ 3:1**
YES	Yes/No	The perimeter should be curvilinear.	
YES	Yes/No	The inlet and outlet should be located as far apart as possible.	
	Yes/No		
If no state why:			
Trash Grate		What mechanism is proposed to prevent the outlet structure from clogging (applicable for orifices/weirs with a dimension of ≤6")?	
227.7	ft	Peak elevation of the 50-year storm event (E_{50})	
228.00	ft	Berm elevation of the pond	
YES		E_{50} ≤ the berm elevation?	**ß yes**
Qualified professional that developed the planting plan:			
Name, Profession:		R. Gordon Leedy, AICP, ASLA, LEED-AP	

*Design criteria in bold font, located in the right margin, are requirements of Env-Wq 1508.04

**The colored cells contain formulas and cannot be edited.

1. Using the Stage-Discahrge table, find the elevation at which the V_{ED} is achieved and read off the Q_{ED}

FEMA Floodplain Map

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° 00′ 00 "

1165000 FT

JOINS PANEL 0203

ZONE X

ZONE AE

226

BEAUVIEW ST

INDUSTRIAL WAY

SPAULDING TPK

OC1084

SITE

CLAIRE ST

MCDUFFEE ST

FORTIER ST

PATTON ST

LETOURNEAU ST

ZONE X

TWOMBLY ST

MARGARET ST

JENNESS ST

PARK ST

DEWEY ST

NUTTER BLVD

LOIS ST

WILLEY ST

HIGH ST

WALNUT ST

MADISON AV

HALE ST

SNOW ST

GLORIA ST

GERARD ST

STEWART CT

CHASSE ST

HUSSEY RD

KENDALL ST

LYONS ST

HARVARD ST

YALE ST

HOOVER ST

City of Rochester
330150

ZONE X

AF

AE

225

RIVERSIDE DR

RUSSELL ST

Footbridge

CHESTNUT HILL EXT

HANSON

SCHLEY ST

HUSSEY ST

RAY DR

ZONE AE

COCHECHO RIVER

WAKEFIELD ST

ZONE AE

LINSCOTT CT

COVE CT

NORTH MAIN ST

NORTH ST

ZONE X

AD

AC

AB

AA

224

UNION ST

OC0387

BRIDGE ST

Dam

219

219

RIVER ST

Z

Y

199

ZONE

192

X

DOW CT

LAFAYETTE ST

GAGNE ST

WASHINGTON ST

JACKSON ST

MAPLE ST

PINE ST

CHESTNUT ST

ROY ST

ADELIA ST

HIGHLAND ST

CLEVELAND ST

WALDRON AV

ZONE X

MOORES CT

SPRING FIELD CT

BRATTLE ST

BROCHU CT

ELA CT

CONGRESS ST

WOODMAN

OAK ST

PINE ST

CHESTNUT ST

MAPLE ST ST

190

ZONE X

188

W

MAP NUMBER
33017C0211D

EFFECTIVE DATE
MAY 17, 2005

LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT T INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the floo that has a 1% chance of being equaled or exceeded in any given year. The Speci Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Are of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Ba Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Floo Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain average depths determined. For areas of alluvial fan flooding, velociti also determined.
ZONE AR	Special Flood Hazard Area formerly protected from the 1% annu chance flood by a flood control system that was subsequent decertified. Zone AR indicates that the former flood control system being restored to provide protection from the 1% annual chance greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Feder flood protection system under construction; no Base Flood Elevatio determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Floo Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevatio determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must b kept free of encroachment so that the 1% annual chance flood can be carried witho substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X	Areas of 0.2% annual chance flood; areas of 1% annual chance floo with average depths of less than 1 foot or with drainage areas less tha 1 square mile; and areas protected by levees from 1% annual chan flood.

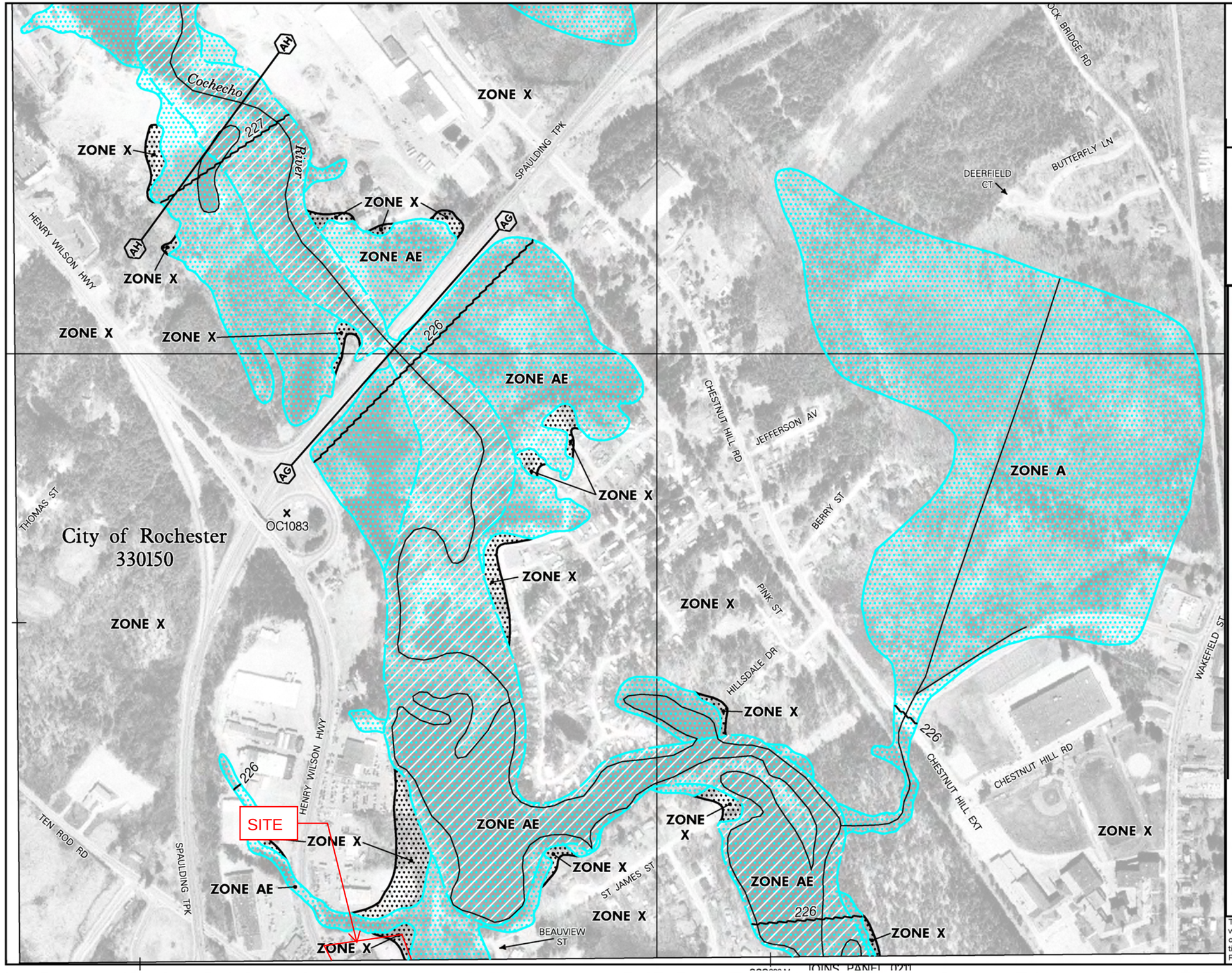
OTHER AREAS

ZONE X	Areas determined to be outside the 0.2% annual chance floodplain.
ZONE D	Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Area



MAP NUMBER
33017C0203D

EFFECTIVE DATE
MAY 17, 2005

LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, A1-, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

- **ZONE A** — No Base Flood Elevations determined.
- **ZONE AE** — Base Flood Elevations determined.
- **ZONE AH** — Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
- **ZONE AO** — Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
- **ZONE AR** — Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
- **ZONE A99** — Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
- **ZONE V** — Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
- **ZONE VE** — Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

- **ZONE X** — Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

- **ZONE X** — Areas determined to be outside the 0.2% annual chance floodplain.
- **ZONE D** — Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas

Rainfall Data

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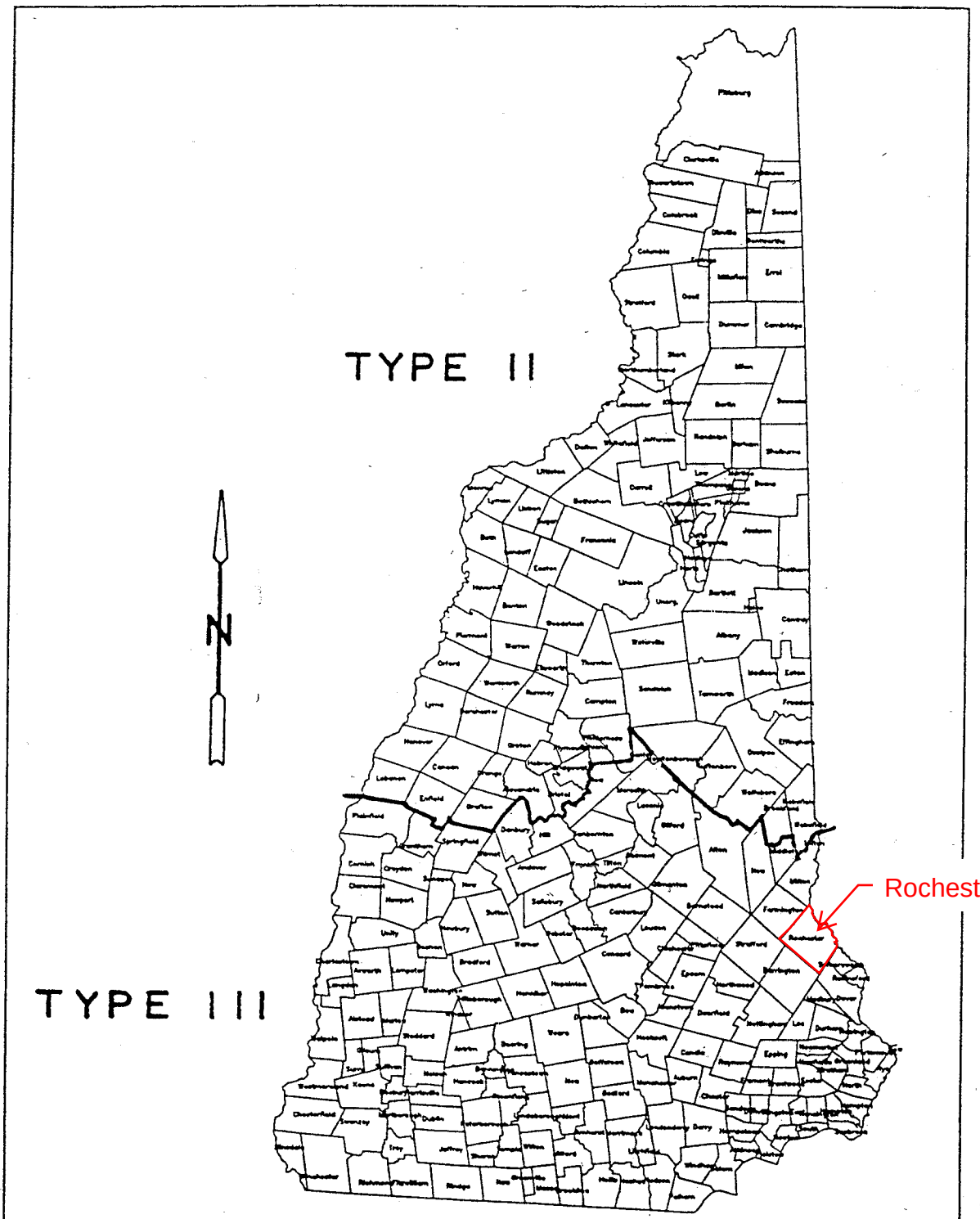

FIGURE 6-5 -- BOUNDARY FOR SCS RAINFALL DISTRIBUTION

Source: USDA Soil Conservation Service

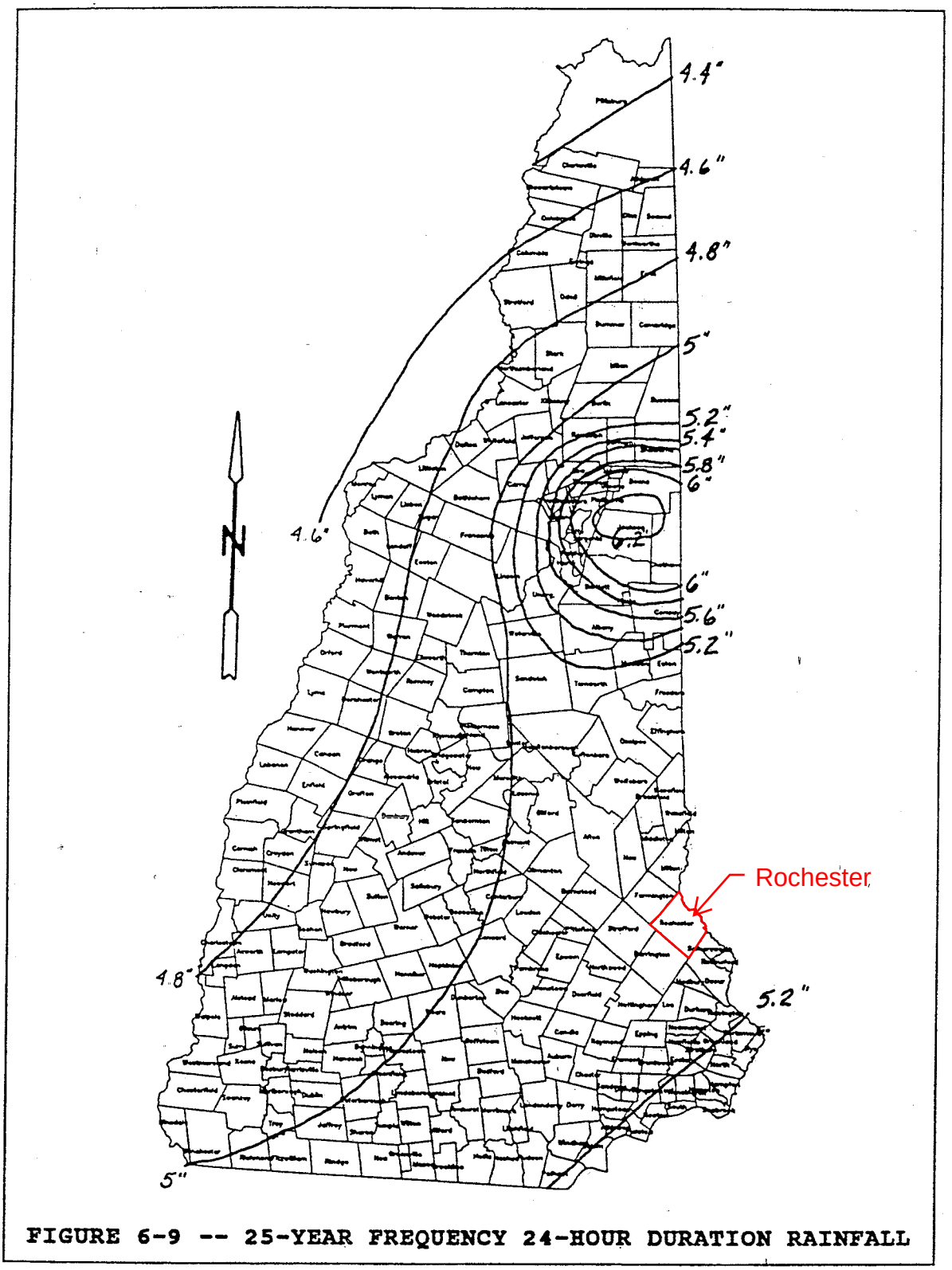

FIGURE 6-9 -- 25-YEAR FREQUENCY 24-HOUR DURATION RAINFALL

Source: USDA Soil Conservation Service

NEW HAMPSHIRE 24-HOUR RAINFALL BY TOWNS
1-YR, 2-YR, 5-YR, 10-YR, 25-YR, 50-YR & 100-YR STORM EVENTS

"ODELL",2.40,2.48,3.40,3.86,4.73,4.99,5.70
"ORANGE",2.30,2.63,3.58,4.03,4.82,5.28,5.90
"ORFORD",2.30,2.55,3.48,3.95,4.73,5.13,5.77
"OSSIPEE",2.50,2.92,3.82,4.30,5.16,5.52,6.16
"PELHAM",2.60,3.01,3.87,4.35,5.19,5.80,6.47
"PEMBROKE",2.40,2.89,3.74,4.23,5.04,5.61,6.24
"PETERBOROUGH",2.40,2.85,3.77,4.22,5.01,5.64,6.30
"PIERMONT",2.30,2.52,3.48,3.93,4.73,5.10,5.75
"PINKHAM'S GRANT",3.00,3.80,4.70,5.20,6.15,6.60,7.20
"PITTSBURG",2.30,2.43,3.30,3.70,4.40,4.85,5.15
"PITTSFIELD",2.50,2.90,3.74,4.24,5.06,5.59,6.22
"PLAINFIELD",2.30,2.59,3.53,4.01,4.75,5.23,5.85
"PLAISTOW",2.60,3.05,3.87,4.36,5.20,5.79,6.47
"PLYMOUTH",2.40,2.70,3.63,4.15,4.90,5.31,5.94
"PORTSMOUTH",2.60,3.06,3.84,4.37,5.20,5.75,6.45
"RANDOLPH",2.70,3.30,3.80,4.60,5.20,6.10,6.40
"RAYMOND",2.50,2.98,3.80,4.31,5.13,5.70,6.37
"RICHMOND",2.40,2.83,3.77,4.21,5.01,5.62,6.30
"RINDGE",2.40,2.88,3.81,4.24,5.04,5.67,6.36
"ROCHESTER",2.50,2.96,3.75,4.29,5.13,5.63,6.29
"ROLLINSFORD",2.50,3.00,3.78,4.33,5.16,5.67,6.36
"ROXBURY",2.40,2.79,3.72,4.17,4.94,5.56,6.26
"RUMNEY",2.40,2.63,3.59,4.10,4.85,5.25,5.89
"RYE",2.60,3.08,3.86,4.38,5.22,5.77,6.48
"SALEM",2.50,3.03,3.87,4.35,5.19,5.80,6.47
"SALISBURY",2.40,2.77,3.66,4.14,4.93,5.45,6.08
"SANBORNTON",2.40,2.78,3.68,4.10,4.97,5.44,6.05
"SANDOWN",2.50,3.01,3.83,4.33,5.16,5.74,6.42
"SANDWICH",2.50,2.95,3.79,4.38,5.08,5.50,6.15
"SARGENT'S PURCHASE",2.90,3.80,4.70,5.20,6.10,6.60,7.20
"SEABROOK",2.60,3.09,3.88,4.39,5.22,5.81,6.52
"SECOND COLLEGE GRANT",2.30,2.48,3.38,3.84,4.67,4.95,5.50
"SHARON",2.40,2.88,3.79,4.23,5.03,5.67,6.35
"SHELBURNE",2.70,3.50,4.20,5.05,5.40,6.20,6.80
"SOMERSWORTH",2.50,2.98,3.77,4.31,5.15,5.66,6.33
"SOUTH HAMPTON",2.60,3.06,3.87,4.38,5.21,5.80,6.49
"SPRINGFIELD",2.30,2.66,3.59,4.06,4.82,5.33,5.95
"STARK",2.40,2.60,3.44,3.95,4.85,5.10,5.90
"STEWARTSTOWN",2.30,2.44,3.30,3.73,4.51,4.88,5.30
"STODDARD",2.40,2.77,3.68,4.14,4.92,5.51,6.19
"STRAFFORD",2.50,2.94,3.74,4.27,5.11,5.61,6.26
"STRATFORD",2.40,2.47,3.38,3.81,4.70,4.97,5.60
"STRATHAM",2.60,3.05,3.84,4.36,5.19,5.75,6.44
"SUCCESS",2.50,3.20,3.80,4.50,5.10,5.60,6.15
"SUGAR HILL",2.40,2.55,3.46,3.93,4.81,5.11,5.80
"SULLIVAN",2.30,2.77,3.70,4.15,4.92,5.52,6.21
"SUNAPEE",2.30,2.67,3.60,4.07,4.82,5.35,5.98
"SURRY",2.30,2.75,3.68,4.14,4.89,5.48,6.18
"SUTTON",2.30,2.73,3.63,4.12,4.88,5.43,6.06
"SWANZEY",2.40,2.80,3.74,4.18,4.97,5.58,6.27
"TAMWORTH",2.50,3.05,3.96,4.55,5.20,5.95,6.22
"TEMPLE",2.40,2.88,3.80,4.24,5.04,5.68,6.35
"THOMPSON & MESERVE'S PURCHASE",3.00,3.60,4.50,5.00,5.90,6.45,7.10
"THORNTON",2.50,2.85,3.70,4.30,4.95,5.34,5.95
"TILTON",2.40,2.80,3.70,4.15,4.97,5.45,6.08
"TROY",2.40,2.83,3.76,4.20,4.99,5.62,6.29
"TUFTONBORO",2.50,2.92,3.80,4.20,5.15,5.52,6.16
"UNITY",2.30,2.67,3.60,4.07,4.80,5.36,6.00
"WAKEFIELD",2.40,2.92,3.78,4.20,5.16,5.52,6.16
"WALPOLE",2.30,2.73,3.66,4.12,4.86,5.44,6.13
"WARNER",2.40,2.77,3.66,4.15,4.93,5.48,6.12