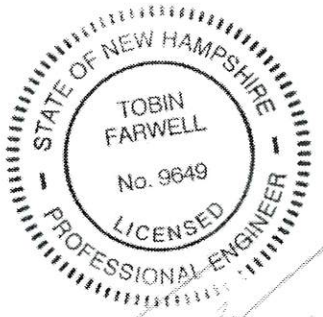
DRAINAGE ANALYSIS

Prepared for

Wildlife Ecology Center
&
Farm School:

Tax map 249
Lot 32
And Tax Map 250
Lot 133
270 Beauty Hill Road
Barrington, New Hampshire



Submitted
July 2019
Revised – March 2020

Prepared by

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PROJECT DESCRIPTION

The proposed project is to provide parking for Wildlife Encounters School, as well as a barn and green hose for farming education. The access road is approximately 450 ft long. Parking for 20 in the parking area and 12 spaces along the access road. We are proposing to detain the increase in flow from the additional gravel surface by building a detention pons with an outlet control structure.

CALCULATION METHODS

The drainage study was completed using HydroCAD. The program generates runoff hydrographs for specified storm distributions, and performs reservoir routing using the storage indication method. The criteria used for this drainage analysis is the 2, 5, and 50 24-hour Type III frequency storm events. Flow depths are based on extreme precipitation data.

The accuracy of stormwater management modeling is limited. The peak flow rates and flood elevations provided herein should not be considered absolute due to the number of variables involved in their determination. Surface roughness coefficient (n), entrance loss coefficients (ke), velocity factors (kv), time of concentration (Tc) and tail water conditions are subjective to field observation and engineering judgment. Curve Numbers (CN) describes the average conditions useful for design purposes. Modeling to simulate an actual storm event requires additional knowledge of antecedent runoff conditions (ARC). Curve numbers will vary from storm to storm dependent on the ARC.

SUMMARY

Site Soils

Soils on site are based on NRCS soil mapping. GIB Gloucester fine sand loam. 3-8% slopes Hydrolgical soil group "A" GIC Gloucester fine sandy loam 8-15% slopes. Hydrolgical soil Group "A".

Pre- and Post-Development

All runoff from the developed area of the site flows to the north east. There is a snall area that will not change that runs south toward Beauty Hill Raod. This was not part of the analysis as this is not changing.

The runoff from the proposed access road will be captured and detained in the proposed swale and detention pond as shown on the plans. The development around the existing residence cannot be captured but the flow to the study point has been attenuated by detaining more of the flow from the parking lot and access road area.

Study Point 1 – North west side

Study point 2. – North east side

Drainage Analysis

A complete summary of the flow conditions is included in Appendix A. The following compares pre- and post-development peak flow rates of runoff leaving the site.

2-year Storm Event (3.07 inches)

	Pre-Development	Post Development	
Point of Analysis	**Peak Flow(cfs)**	**Peak Flow(cfs)**	**Difference (cfs)**
SP-1	0.0	0.0	0
SP-2	0.0	0.01	0.01

5-year Storm Event (4.63 inches)

	Pre-Development	Post Development	
Point of Analysis	**Peak Flow(cfs)**	**Peak Flow(cfs)**	**Difference (cfs)**
SP-1	0.0	0.00	0.0
SP-2	0.02	0.01	-0.01

50-year Storm Event (6.99 inches)

	Pre-Development	Post Development	
Point of Analysis	**Peak Flow(cfs)**	**Peak Flow(cfs)**	**Difference (cfs)**
SP-1	0.16	0.05	-0.11
SP-2	0.73	0.81	0.07

Conclusion

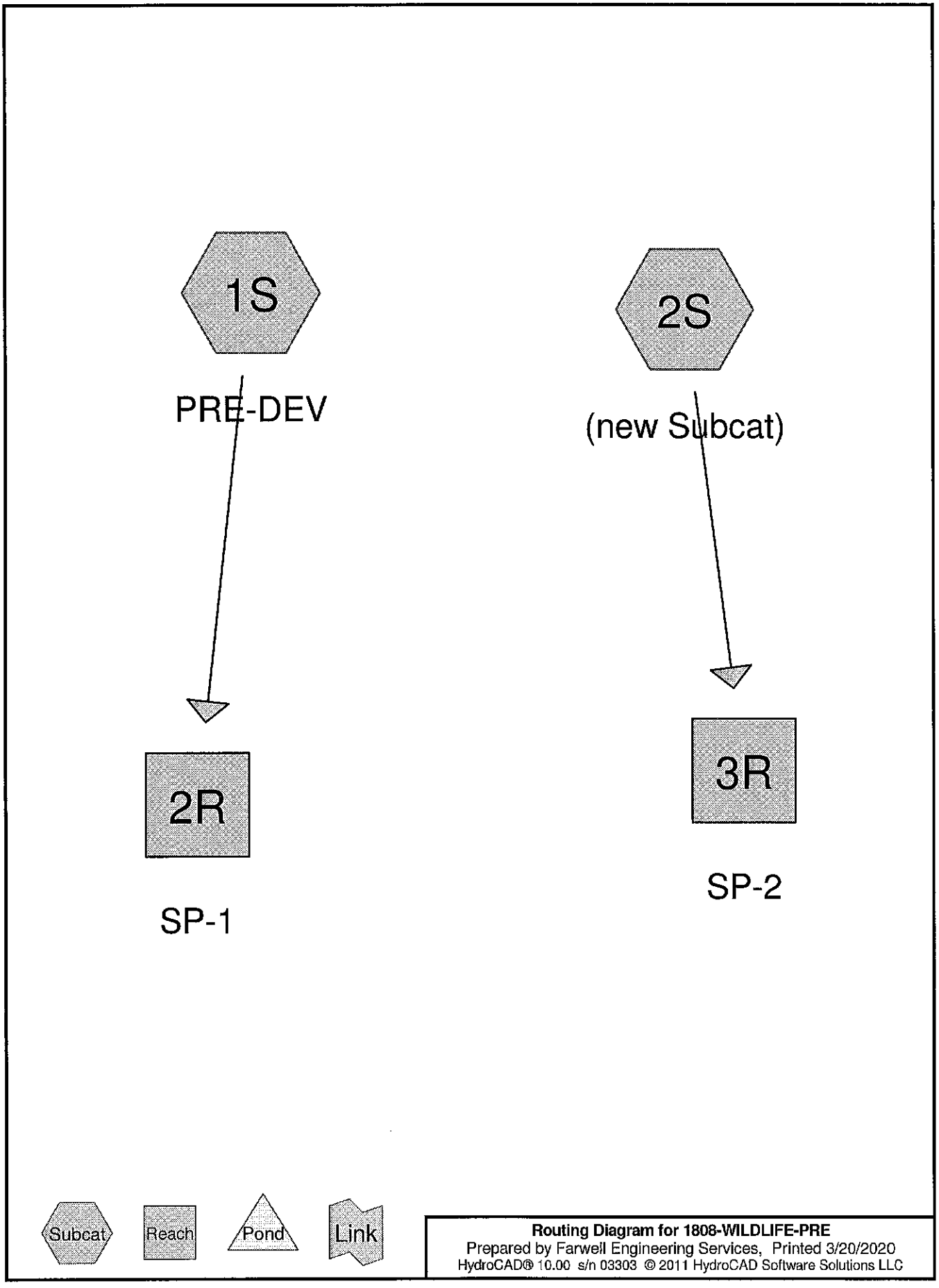
Given the soil types and ground cover there is very little flow from this site. A flow of less than 0.1 cfs is considered negligible. The peak rate of runoff for the 5 year event is reduced. The flow to study point 1 is reduced and there is a negligible increase in flow to study point 2.

APPENDIX A:

SUPPORTING CALCULATIONS

PRE-DEVELOPMENT

ANALYSIS



Routing Diagram for 1808-WILDLIFE-PRE
Prepared by Farwell Engineering Services, Printed 3/20/2020
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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

Subcatchment 1S: PRE-DEV Runoff Area=100,138 sf 1.25% Impervious Runoff Depth=0.00"
Flow Length=477' Tc=6.5 min CN=32 Runoff=0.00 cfs 0.000 af

Subcatchment 2S: (new Subcat) Runoff Area=171,501 sf 0.00% Impervious Runoff Depth=0.00"
Flow Length=477' Tc=6.5 min CN=35 Runoff=0.00 cfs 0.000 af

Reach 2R: SP-1 Inflow=0.00 cfs 0.000 af
Outflow=0.00 cfs 0.000 af

Reach 3R: SP-2 Inflow=0.00 cfs 0.000 af
Outflow=0.00 cfs 0.000 af

Total Runoff Area = 6.236 ac Runoff Volume = 0.000 af Average Runoff Depth = 0.00"
99.54% Pervious = 6.207 ac 0.46% Impervious = 0.029 ac

Summary for Subcatchment 1S: PRE-DEV

[45] Hint: Runoff=Zero

Runoff = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af, Depth= 0.00"

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=3.07"

Area (sf)	CN	Description
81,402	30	Woods, Good, HSG A
17,488	39	Pasture/grassland/range, Good, HSG A
1,248	98	Roofs, HSG A
100,138	32	Weighted Average
98,890		98.75% Pervious Area
1,248		1.25% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.8	25	0.0200	0.09		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.07"
1.7	452	0.0890	4.47		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
6.5	477	Total			

Summary for Subcatchment 2S: (new Subcat)

[45] Hint: Runoff=Zero

Runoff = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af, Depth= 0.00"

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=3.07"

Area (sf)	CN	Description
76,981	30	Woods, Good, HSG A
94,520	39	Pasture/grassland/range, Good, HSG A
171,501	35	Weighted Average
171,501		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.8	25	0.0200	0.09		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.07"
1.7	452	0.0890	4.47		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
6.5	477	Total			

Summary for Reach 2R: SP-1

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 2.299 ac, 1.25% Impervious, Inflow Depth = 0.00" for 2 YR event
Inflow = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af
Outflow = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Summary for Reach 3R: SP-2

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 3.937 ac, 0.00% Impervious, Inflow Depth = 0.00" for 2 YR event
Inflow = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af
Outflow = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, 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

Subcatchment 1S: PRE-DEV Runoff Area=100,138 sf 1.25% Impervious Runoff Depth>0.00"
Flow Length=477' Tc=6.5 min CN=32 Runoff=0.00 cfs 0.000 af

Subcatchment 2S: (new Subcat) Runoff Area=171,501 sf 0.00% Impervious Runoff Depth>0.03"
Flow Length=477' Tc=6.5 min CN=35 Runoff=0.02 cfs 0.009 af

Reach 2R: SP-1 Inflow=0.00 cfs 0.000 af
Outflow=0.00 cfs 0.000 af

Reach 3R: SP-2 Inflow=0.02 cfs 0.009 af
Outflow=0.02 cfs 0.009 af

Total Runoff Area = 6.236 ac Runoff Volume = 0.009 af Average Runoff Depth = 0.02"
99.54% Pervious = 6.207 ac 0.46% Impervious = 0.029 ac

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

Subcatchment 1S: PRE-DEV Runoff Area=100,138 sf 1.25% Impervious Runoff Depth>0.08"
Flow Length=477' Tc=6.5 min CN=32 Runoff=0.03 cfs 0.015 af

Subcatchment 2S: (new Subcat) Runoff Area=171,501 sf 0.00% Impervious Runoff Depth>0.17"
Flow Length=477' Tc=6.5 min CN=35 Runoff=0.14 cfs 0.057 af

Reach 2R: SP-1 Inflow=0.03 cfs 0.015 af
Outflow=0.03 cfs 0.015 af

Reach 3R: SP-2 Inflow=0.14 cfs 0.057 af
Outflow=0.14 cfs 0.057 af

Total Runoff Area = 6.236 ac Runoff Volume = 0.072 af Average Runoff Depth = 0.14"
99.54% Pervious = 6.207 ac 0.46% Impervious = 0.029 ac

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

Subcatchment 1S: PRE-DEV Runoff Area=100,138 sf 1.25% Impervious Runoff Depth>0.25"
Flow Length=477' Tc=6.5 min CN=32 Runoff=0.16 cfs 0.048 af

Subcatchment 2S: (new Subcat) Runoff Area=171,501 sf 0.00% Impervious Runoff Depth>0.41"
Flow Length=477' Tc=6.5 min CN=35 Runoff=0.73 cfs 0.134 af

Reach 2R: SP-1 Inflow=0.16 cfs 0.048 af
Outflow=0.16 cfs 0.048 af

Reach 3R: SP-2 Inflow=0.73 cfs 0.134 af
Outflow=0.73 cfs 0.134 af

Total Runoff Area = 6.236 ac Runoff Volume = 0.182 af Average Runoff Depth = 0.35"
99.54% Pervious = 6.207 ac 0.46% Impervious = 0.029 ac

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

Subcatchment 1S: PRE-DEV Runoff Area=271,640 sf 0.46% Impervious Runoff Depth>0.01"
Flow Length=477' Tc=6.5 min CN=34 Runoff=0.02 cfs 0.008 af

Reach 2R: (new Reach) Inflow=0.02 cfs 0.008 af
Outflow=0.02 cfs 0.008 af

Total Runoff Area = 6.236 ac Runoff Volume = 0.008 af Average Runoff Depth = 0.01"
99.54% Pervious = 6.207 ac 0.46% Impervious = 0.029 ac

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

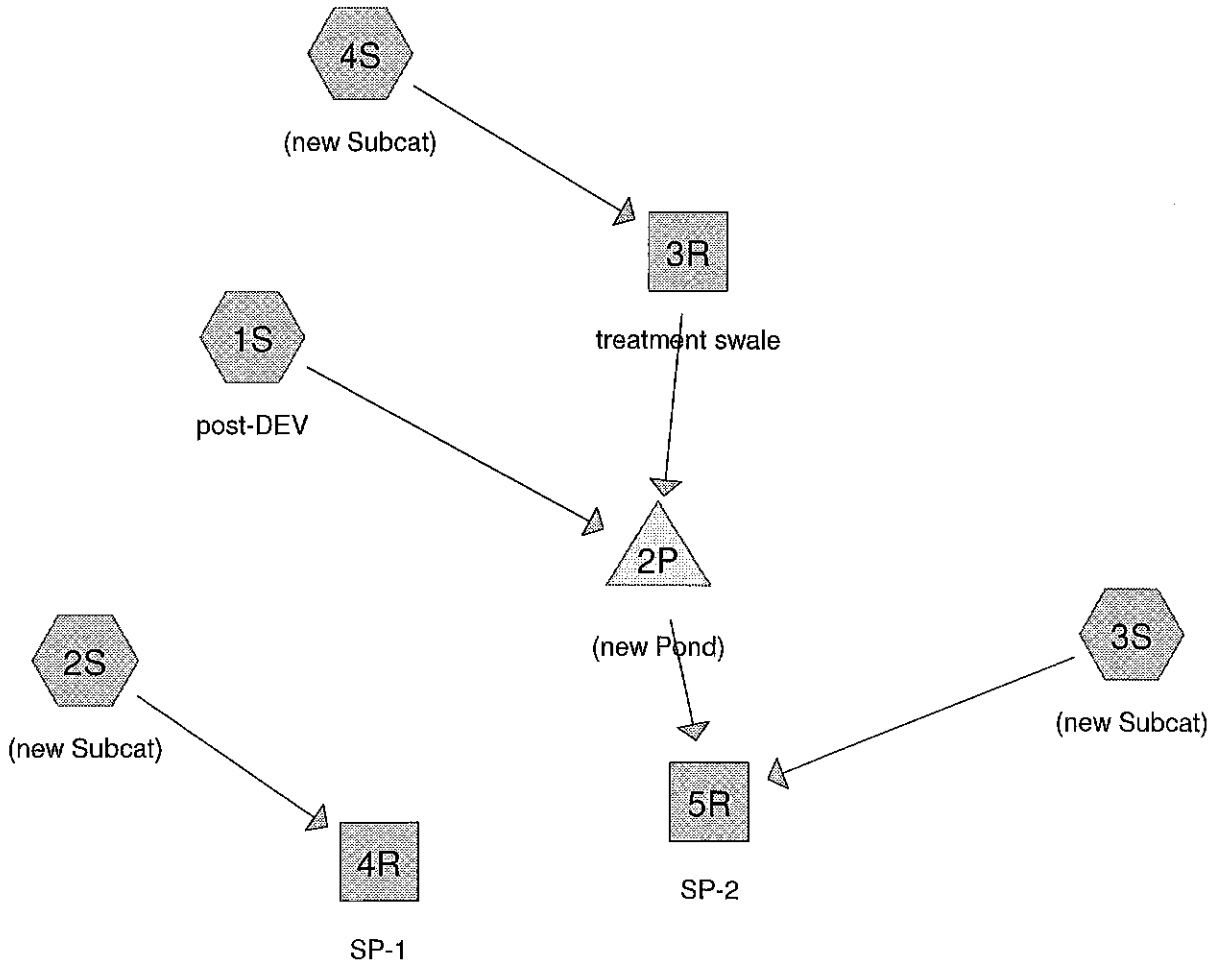
Subcatchment 1S: PRE-DEV Runoff Area=271,640 sf 0.46% Impervious Runoff Depth>0.35"
Flow Length=477' Tc=6.5 min CN=34 Runoff=0.90 cfs 0.183 af

Reach 2R: (new Reach) Inflow=0.90 cfs 0.183 af
Outflow=0.90 cfs 0.183 af

Total Runoff Area = 6.236 ac Runoff Volume = 0.183 af Average Runoff Depth = 0.35"
99.54% Pervious = 6.207 ac 0.46% Impervious = 0.029 ac

POST-DEVELOPMENT

ANALYSIS



Subcat Reach Pond Link

Routing Diagram for 1808-WILDLIFE-POST
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Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
2.102	30	Woods, Good, HSG A (1S, 2S, 3S)
0.152	39	>75% Grass cover, Good, HSG A (3S)
3.377	39	Pasture/grassland/range, Good, HSG A (1S, 2S, 4S)
0.473	96	Gravel surface, HSG A (1S, 4S)
0.131	98	Unconnected roofs, HSG A (4S)
6.236	**42**	**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

Subcatchment 1S: post-DEV Runoff Area=131,536 sf 0.00% Impervious Runoff Depth>0.02"
Flow Length=450' Tc=6.4 min CN=45 Runoff=0.01 cfs 0.005 af

Subcatchment 2S: (new Subcat) Runoff Area=50,529 sf 0.00% Impervious Runoff Depth=0.00"
Flow Length=326' Tc=5.5 min CN=31 Runoff=0.00 cfs 0.000 af

Subcatchment 3S: (new Subcat) Runoff Area=39,700 sf 0.00% Impervious Runoff Depth=0.00"
Flow Length=125' Tc=3.9 min CN=31 Runoff=0.00 cfs 0.000 af

Subcatchment 4S: (new Subcat) Runoff Area=49,868 sf 11.49% Impervious Runoff Depth>0.04"
Flow Length=375' Tc=6.2 min UI Adjusted CN=47 Runoff=0.01 cfs 0.004 af

Reach 3R: treatment swale Avg. Flow Depth=0.01' Max Vel=0.64 fps Inflow=0.01 cfs 0.004 af
n=0.035 L=182.0' S=0.0440 '/' Capacity=151.05 cfs Outflow=0.01 cfs 0.004 af

Reach 4R: SP-1 Inflow=0.00 cfs 0.000 af
Outflow=0.00 cfs 0.000 af

Reach 5R: SP-2 Inflow=0.01 cfs 0.005 af
Outflow=0.01 cfs 0.005 af

Pond 2P: (new Pond) Peak Elev=332.10' Storage=165 cf Inflow=0.02 cfs 0.008 af
Outflow=0.01 cfs 0.005 af

Total Runoff Area = 6.236 ac Runoff Volume = 0.008 af Average Runoff Depth = 0.02"
97.89% Pervious = 6.104 ac 2.11% Impervious = 0.131 ac

Summary for Subcatchment 1S: post-DEV

Runoff = 0.01 cfs @ 15.71 hrs, Volume= 0.005 af, Depth> 0.02"

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=3.07"

Area (sf)	CN	Description
15,689	30	Woods, Good, HSG A
99,016	39	Pasture/grassland/range, Good, HSG A
6,457	96	Gravel surface, HSG A
10,374	96	Gravel surface, HSG A
0	98	Unconnected roofs, HSG A
0	98	Unconnected roofs, HSG A
131,536	45	Weighted Average
131,536		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.8	25	0.0200	0.09		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.07"
1.6	425	0.0890	4.47		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
6.4	450	Total			

Summary for Subcatchment 2S: (new Subcat)

[49] Hint: Tc<2dt may require smaller dt
[45] Hint: Runoff=Zero

Runoff = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af, Depth= 0.00"

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=3.07"

Area (sf)	CN	Description
0	98	Unconnected roofs, HSG A
0	96	Gravel surface, HSG A
42,783	30	Woods, Good, HSG A
7,746	39	Pasture/grassland/range, Good, HSG A
50,529	31	Weighted Average
50,529		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.3	25	0.0200	0.13		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.07"
0.3	95	0.1000	4.74		**Shallow Concentrated Flow, PASTURE** Grassed Waterway Kv= 15.0 fps
1.9	206	0.1300	1.80		**Shallow Concentrated Flow, WOODS** Woodland Kv= 5.0 fps
5.5	326	Total			

Summary for Subcatchment 3S: (new Subcat)

[49] Hint: Tc<2dt may require smaller dt
[45] Hint: Runoff=Zero

Runoff = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af, Depth= 0.00"

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=3.07"

Area (sf)	CN	Description
6,600	39	>75% Grass cover, Good, HSG A
33,100	30	Woods, Good, HSG A
39,700	31	Weighted Average
39,700		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.8	25	0.0800	0.15		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.07"
1.1	100	0.1000	1.58		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
3.9	125	Total			

Summary for Subcatchment 4S: (new Subcat)

Runoff = 0.01 cfs @ 15.07 hrs, Volume= 0.004 af, Depth> 0.04"

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=3.07"

Area (sf)	CN	Description
1,321	96	Gravel surface, HSG A
4,000	98	Unconnected roofs, HSG A
1,728	98	Unconnected roofs, HSG A
2,470	96	Gravel surface, HSG A
40,349	39	Pasture/grassland/range, Good, HSG A
49,868	50	Weighted Average, UI Adjusted CN = 47
44,140		88.51% Pervious Area
5,728		11.49% Impervious Area
5,728		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.8	25	0.0200	0.09		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.07"
1.4	350	0.0800	4.24		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
6.2	375	Total			

Summary for Reach 3R: treatment swale

Inflow Area = 1.145 ac, 11.49% Impervious, Inflow Depth > 0.04" for 2 YR event
Inflow = 0.01 cfs @ 15.07 hrs, Volume= 0.004 af
Outflow = 0.01 cfs @ 15.23 hrs, Volume= 0.004 af, Atten= 0%, Lag= 9.2 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 0.64 fps, Min. Travel Time= 4.7 min
Avg. Velocity = 0.64 fps, Avg. Travel Time= 4.7 min

Peak Storage= 2 cf @ 15.15 hrs
Average Depth at Peak Storage= 0.01'
Bank-Full Depth= 2.00' Flow Area= 16.0 sf, Capacity= 151.05 cfs

2.00' x 2.00' deep channel, n= 0.035 Earth, dense weeds
Side Slope Z-value= 3.0 '/' Top Width= 14.00'
Length= 182.0' Slope= 0.0440 '/'
Inlet Invert= 342.00', Outlet Invert= 334.00'

Summary for Reach 4R: SP-1

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 1.160 ac, 0.00% Impervious, Inflow Depth = 0.00" for 2 YR event
Inflow = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af
Outflow = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Summary for Reach 5R: SP-2

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 5.076 ac, 2.59% Impervious, Inflow Depth > 0.01" for 2 YR event
Inflow = 0.01 cfs @ 20.00 hrs, Volume= 0.005 af
Outflow = 0.01 cfs @ 20.00 hrs, Volume= 0.005 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Summary for Pond 2P: (new Pond)

Inflow Area = 4.164 ac, 3.16% Impervious, Inflow Depth > 0.02" for 2 YR event
Inflow = 0.02 cfs @ 15.56 hrs, Volume= 0.008 af
Outflow = 0.01 cfs @ 20.00 hrs, Volume= 0.005 af, Atten= 25%, Lag= 266.5 min
Primary = 0.01 cfs @ 20.00 hrs, Volume= 0.005 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 332.10' @ 20.00 hrs Surf.Area= 1,727 sf Storage= 165 cf

Plug-Flow detention time= 143.5 min calculated for 0.005 af (55% of inflow)
Center-of-Mass det. time= 61.5 min (1,071.9 - 1,010.3)

Volume	Invert	Avail.Storage	Storage Description
#1	332.00'	12,137 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
332.00	1,670	0	0
334.00	2,847	4,517	4,517
336.00	4,773	7,620	12,137

Device	Routing	Invert	Outlet Devices
#1	Primary	332.00'	**12.0" Round Culvert** L= 40.0' CPP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 332.00' / 328.00' S= 0.1000 '/' Cc= 0.900 n= 0.020 Corrugated PE, corrugated interior, Flow Area= 0.79 sf
#2	Device 1	332.00'	**2.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	334.20'	**8.0" Vert. Orifice/Grate** C= 0.600
#4	Primary	335.00'	**5.0' long x 4.0' 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) 2.38 2.54 2.69 2.68 2.67 2.67 2.65 2.66 2.66
2.68 2.72 2.73 2.76 2.79 2.88 3.07 3.32

Primary OutFlow Max=0.01 cfs @ 20.00 hrs HW=332.10' (Free Discharge)
- **1=Culvert** (Passes 0.01 cfs of 0.04 cfs potential flow)
  - **2=Orifice/Grate** (Orifice Controls 0.01 cfs @ 1.06 fps)
  - **3=Orifice/Grate** (Controls 0.00 cfs)
- **4=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

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

Subcatchment 1S: post-DEV Runoff Area=131,536 sf 0.00% Impervious Runoff Depth>0.28"
Flow Length=450' Tc=6.4 min CN=45 Runoff=0.39 cfs 0.070 af

Subcatchment 2S: (new Subcat) Runoff Area=50,529 sf 0.00% Impervious Runoff Depth=0.00"
Flow Length=326' Tc=5.5 min CN=31 Runoff=0.00 cfs 0.000 af

Subcatchment 3S: (new Subcat) Runoff Area=39,700 sf 0.00% Impervious Runoff Depth=0.00"
Flow Length=125' Tc=3.9 min CN=31 Runoff=0.00 cfs 0.000 af

Subcatchment 4S: (new Subcat) Runoff Area=49,868 sf 11.49% Impervious Runoff Depth>0.35"
Flow Length=375' Tc=6.2 min UI Adjusted CN=47 Runoff=0.21 cfs 0.033 af

Reach 3R: treatment swale Avg. Flow Depth=0.07' Max Vel=1.40 fps Inflow=0.21 cfs 0.033 af
n=0.035 L=182.0' S=0.0440 '/' Capacity=151.05 cfs Outflow=0.21 cfs 0.033 af

Reach 4R: SP-1 Inflow=0.00 cfs 0.000 af
Outflow=0.00 cfs 0.000 af

Reach 5R: SP-2 Inflow=0.10 cfs 0.060 af
Outflow=0.10 cfs 0.060 af

Pond 2P: (new Pond) Peak Elev=333.04' Storage=2,065 cf Inflow=0.60 cfs 0.103 af
Outflow=0.10 cfs 0.060 af

Total Runoff Area = 6.236 ac Runoff Volume = 0.103 af Average Runoff Depth = 0.20"
97.89% Pervious = 6.104 ac 2.11% Impervious = 0.131 ac

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

Subcatchment 1S: post-DEV Runoff Area=131,536 sf 0.00% Impervious Runoff Depth>0.64"
Flow Length=450' Tc=6.4 min CN=45 Runoff=1.44 cfs 0.162 af

Subcatchment 2S: (new Subcat) Runoff Area=50,529 sf 0.00% Impervious Runoff Depth>0.06"
Flow Length=326' Tc=5.5 min CN=31 Runoff=0.01 cfs 0.005 af

Subcatchment 3S: (new Subcat) Runoff Area=39,700 sf 0.00% Impervious Runoff Depth>0.06"
Flow Length=125' Tc=3.9 min CN=31 Runoff=0.01 cfs 0.004 af

Subcatchment 4S: (new Subcat) Runoff Area=49,868 sf 11.49% Impervious Runoff Depth>0.76"
Flow Length=375' Tc=6.2 min UI Adjusted CN=47 Runoff=0.76 cfs 0.073 af

Reach 3R: treatment swale Avg. Flow Depth=0.14' Max Vel=2.16 fps Inflow=0.76 cfs 0.073 af
n=0.035 L=182.0' S=0.0440 '/' Capacity=151.05 cfs Outflow=0.71 cfs 0.072 af

Reach 4R: SP-1 Inflow=0.01 cfs 0.005 af
Outflow=0.01 cfs 0.005 af

Reach 5R: SP-2 Inflow=0.25 cfs 0.121 af
Outflow=0.25 cfs 0.121 af

Pond 2P: (new Pond) Peak Elev=334.36' Storage=5,597 cf Inflow=2.15 cfs 0.235 af
Outflow=0.24 cfs 0.117 af

Total Runoff Area = 6.236 ac Runoff Volume = 0.245 af Average Runoff Depth = 0.47"
97.89% Pervious = 6.104 ac 2.11% Impervious = 0.131 ac

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

Subcatchment 1S: post-DEV Runoff Area=131,536 sf 0.00% Impervious Runoff Depth>1.09"
Flow Length=450' Tc=6.4 min CN=45 Runoff=3.20 cfs 0.275 af

Subcatchment 2S: (new Subcat) Runoff Area=50,529 sf 0.00% Impervious Runoff Depth>0.20"
Flow Length=326' Tc=5.5 min CN=31 Runoff=0.05 cfs 0.020 af

Subcatchment 3S: (new Subcat) Runoff Area=39,700 sf 0.00% Impervious Runoff Depth>0.20"
Flow Length=125' Tc=3.9 min CN=31 Runoff=0.04 cfs 0.015 af

Subcatchment 4S: (new Subcat) Runoff Area=49,868 sf 11.49% Impervious Runoff Depth>1.25"
Flow Length=375' Tc=6.2 min UI Adjusted CN=47 Runoff=1.49 cfs 0.119 af

Reach 3R: treatment swale Avg. Flow Depth=0.21' Max Vel=2.65 fps Inflow=1.49 cfs 0.119 af
n=0.035 L=182.0' S=0.0440 '/' Capacity=151.05 cfs Outflow=1.41 cfs 0.119 af

Reach 4R: SP-1 Inflow=0.05 cfs 0.020 af
Outflow=0.05 cfs 0.020 af

Reach 5R: SP-2 Inflow=0.81 cfs 0.284 af
Outflow=0.81 cfs 0.284 af

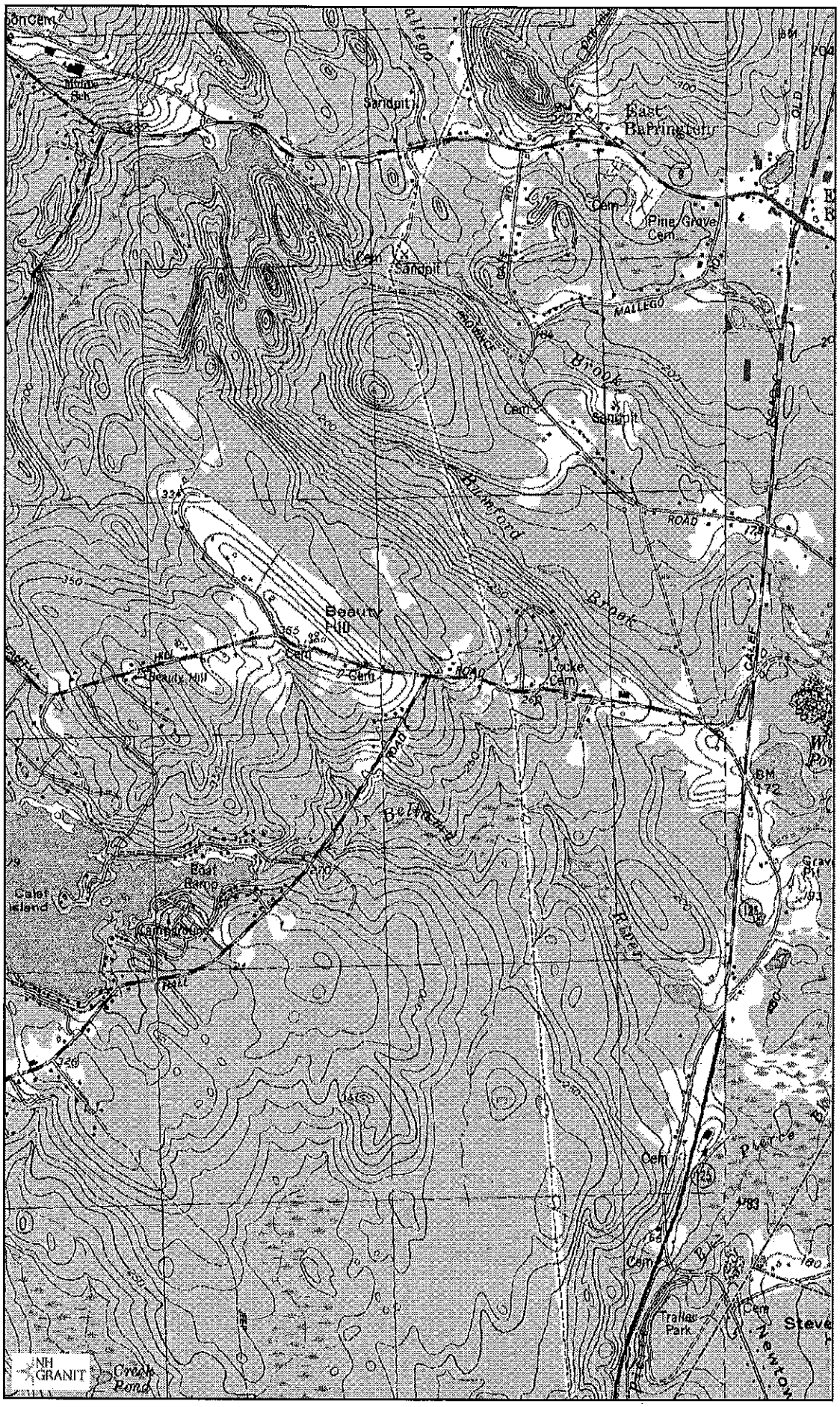
Pond 2P: (new Pond) Peak Elev=334.67' Storage=6,632 cf Inflow=4.47 cfs 0.393 af
Outflow=0.78 cfs 0.269 af

Total Runoff Area = 6.236 ac Runoff Volume = 0.429 af Average Runoff Depth = 0.83"
97.89% Pervious = 6.104 ac 2.11% Impervious = 0.131 ac

APPENDIX B:

Supporting Data

Map by NH GRANIT



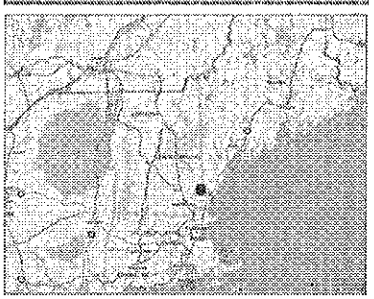
Legend

- State
- County
- City/Town

Map Scale
1: 24,000

Map Generated: 7/18/2019

Notes



NEW HAMPSHIRE DEPARTMENT OF Environmental Services

TREATMENT SWALE DESIGN CRITERIA
(Env-Wq 1508.08)

Node Name: 3R

Enter the node name in the drainage analysis (e.g., reach TS 5), if applicable.
If treatment swale is downstream of a detention structure, do not use this worksheet.

YES	Yes/No	Have you reviewed the restrictions on unlined swales outlined in Env-Wq 1508.08(a)?	
No	Yes/No	Is the system lined? (Required if not treated or if above SHWT)	
1.14	ac	A = Area draining to the practice	
0.22	ac	A_I = Impervious area draining to the practice	
6.2	minutes	T_c = Time of Concentration	
0.19	decimal	I = percent impervious area draining to the practice, in decimal form	
0.22	unitless	Rv = Runoff coefficient = 0.05 + (0.9 x I)	
0.26	ac-in	WQV= 1" x Rv x A	
926	cf	WQV conversion (ac-in x 43,560 sf/ac x 1ft/12")	
1	inches	P = amount of rainfall. For WQF in NH, P = 1".	
0.22	inches	D_{WQ} = water quality depth. D_{WQ} = WQV/A	
87	unitless	CN = unit peak discharge curve number. $CN = 1000/(10+5P+10Q-10*[Q^2 + 1.25*Q*P]^{0.5})$	
1.50	inches	S = potential maximum retention. S = (1000/CN) - 10	
0.299	inches	Ia = initial abstraction. Ia = 0.2S	
580	$cfs/mi^2/in$	qu = unit peak discharge. Obtain this value from TR-55 exhibits 4-II and 4-III	
0.23	cfs	WQF = q_u x WQV. Conversion: to convert "$cfs/mi^2/in$ * ac-in" to "cfs" multiply by $1mi^2/640ac$	
202.00	feet	L = swale length [1]	← **≥ 100'**
2.00	feet	w = bottom of the swale width[2]	← **0 - 8 feet**
332.00	feet	E_{SHWT} = elevation of SHWT. If none found, use the lowest elev. of test pit	
335.00	feet	E_{BTM} = elevation of the bottom of the practice	← **≥ E_{SHWT}**
3.0	:1	SS_{RIGHT} = right Side slope	← **≥3:1**
3.0	:1	SS_{LEFT} = left Side slope	← **≥3:1**
0.020	ft/ft	S = slope of swale in decimal form[3]	← **0.005 - .05**
2.0	inches	d = flow depth in swale at WQF (attach stage-discharge table)	← **≤ 4"**
0.15	unitless	d must be < 4", therefore Manning's n = 0.15	
0.42	ft^2	Cross-sectional area check (assume trapezoidal channel)	
3.05	feet	Check wetted perimeter	
0.16	cfs	WQF_{check} [4]	← **WQF_{check} = WQF**
-49%		Percent difference between WQF_{check} and WQF [4]	← **+/- 10%**
6	minutes	HRT = hydraulic residence time during the WQF	← **≥ 10 min**
335.10	ft	Peak elevation of the 10-year storm event[5]	
336.00	ft	Elevation of the top of the swale	
YES	Yes/No	10 peak elevation ≤ the top of swale	← **yes**

1. Any portion of the swale that is in a roadside ditch shall not count towards the swale length.
2. Widths up to 16' allowed if a dividing berm or structure is used such that neither width is more than 8'.
3. If > 0.02 (2%) then check dams are required. No additional detention time is credited for check dams.
4. The WQF_{check} & WQF should be near equal (within 10%) if you have selected the correct depth off the stage-discharge table and are using n = 0.15 for low flows in swale. If the depth is inaccurate the HRT will be incorrect.
5. If the swale does not discharge the 50-year storm without overtopping, hydrologic routing of secondary discharge to a different node may be necessary.

Designer's Notes:

WILDLIFE ENCOUNTERS
BARRINGTON NH
Riprap Stone Apron Sizing
10-Year Storm Event

FES-1

La	Apron Length, Ft.	Calculated
Tw	**Tailwater, Ft.**	**0.1**
Q	**Flow, 25 Yr Storm, CFS**	**0.24**
D50	Median Stone Dia., Ft.	Calculated
D	Depth of Stone, In	Calculated
Do	**Pipe Diameter, Ft**	**1.00**
W1	Width @ Start, Ft.	1
W2	Width @ End, Ft	Calculated
W	**Width of Channel**	**3**

W1:

3(Do)= 3 Ft.

Width @ Start: 3 Ft.

D50: $\frac{0.02(Q)^{4/3}}{Tw(Do)}$

D50= 0.03 Ft.

or 0.4 In.

Median Stone Size: 3 In.

D: 2.25*D50

Depth of Riprap: 5 In.

La: If Tw< Do/2:

$La=1.8Q/Do^{3/2} + 7Do$

and W2=width of channel

or

W2=3.0*Do+La

Do/2= 0.5 Ft.

Tw= 0.1 Ft.

If Tw>=Do/2:

$La=3.0Q/Do^{3/2}$

and W2=width of channel

or

W2=3.0*Do+0.4La

Length of Apron: 8.0 Ft.

Width @ End: 3 Ft.

Extreme Precipitation Tables

Northeast Regional Climate Center

Data represents point estimates calculated from partial duration series. All precipitation amounts are displayed in inches.

Smoothing	Yes
State	New Hampshire
Location	
Longitude	71.018 degrees West
Latitude	43.199 degrees North
Elevation	0 feet
Date/Time	Wed, 26 Jun 2019 14:19:47 -0400

Extreme Precipitation Estimates

	5min	10min	15min	30min	60min	120min		1hr	2hr	3hr	6hr	12hr	24hr	48hr		1c
1yr	0.26	0.40	0.50	0.65	0.81	1.03	**1yr**	0.70	0.98	1.20	1.53	1.97	2.55	2.80	**1yr**	2.
2yr	0.32	0.49	0.61	0.80	1.01	1.28	**2yr**	0.87	1.16	1.49	1.89	2.40	3.07	3.41	**2yr**	2.
5yr	0.37	0.57	0.72	0.96	1.23	1.57	**5yr**	1.06	1.44	1.84	2.36	3.02	3.88	4.36	**5yr**	3.
10yr	0.40	0.63	0.80	1.09	1.42	1.84	**10yr**	1.23	1.69	2.17	2.80	3.60	4.63	5.26	**10yr**	4.
25yr	0.47	0.74	0.94	1.30	1.73	2.27	**25yr**	1.49	2.09	2.69	3.50	4.53	5.85	6.74	**25yr**	5.
50yr	0.52	0.83	1.07	1.49	2.01	2.67	**50yr**	1.74	2.46	3.18	4.15	5.40	6.99	8.12	**50yr**	6.
100yr	0.58	0.94	1.22	1.72	2.34	3.14	**100yr**	2.02	2.89	3.75	4.92	6.43	8.35	9.81	**100yr**	7.
200yr	0.65	1.06	1.37	1.97	2.73	3.69	**200yr**	2.35	3.40	4.43	5.86	7.67	9.99	11.84	**200yr**	8.
500yr	0.77	1.26	1.64	2.39	3.34	4.57	**500yr**	2.88	4.22	5.52	7.34	9.67	12.66	15.19	**500yr**	11

Lower Confidence Limits

	5min	10min	15min	30min	60min	120min		1hr	2hr	3hr	6hr	12hr	24hr	48hr		1d
1yr	0.24	0.36	0.44	0.60	0.73	0.90	**1yr**	0.63	0.88	0.92	1.25	1.53	1.96	2.48	**1yr**	1.
2yr	0.31	0.48	0.60	0.81	0.99	1.18	**2yr**	0.86	1.15	1.35	1.81	2.33	2.97	3.31	**2yr**	2.
5yr	0.35	0.54	0.67	0.92	1.16	1.40	**5yr**	1.01	1.37	1.61	2.14	2.76	3.57	3.99	**5yr**	3.
10yr	0.38	0.59	0.73	1.02	1.32	1.60	**10yr**	1.14	1.56	1.81	2.43	3.12	4.07	4.60	**10yr**	3.
25yr	0.44	0.67	0.83	1.19	1.56	1.91	**25yr**	1.35	1.87	2.12	2.83	3.63	4.84	5.53	**25yr**	4.
50yr	0.49	0.74	0.92	1.33	1.78	2.19	**50yr**	1.54	2.14	2.37	3.20	4.08	5.50	6.33	**50yr**	4.
100yr	0.55	0.82	1.03	1.49	2.05	2.51	**100yr**	1.77	2.45	2.67	3.59	4.56	6.24	7.25	**100yr**	5.
200yr	0.61	0.91	1.16	1.68	2.34	2.87	**200yr**	2.02	2.81	2.99	4.03	5.10	7.06	8.84	**200yr**	6.
500yr	0.71	1.06	1.36	1.98	2.82	3.47	**500yr**	2.43	3.39	3.50	4.71	5.94	8.28	10.72	**500yr**	7.

Upper Confidence Limits

	5min	10min	15min	30min	60min	120min		1hr	2hr	3hr	6hr	12hr	24hr	48hr		1
1yr	0.28	0.43	0.53	0.71	0.87	1.07	**1yr**	0.75	1.05	1.23	1.72	2.18	2.77	3.05	**1yr**	2
2yr	0.33	0.50	0.62	0.84	1.03	1.24	**2yr**	0.89	1.21	1.46	1.93	2.49	3.19	3.54	**2yr**	2
5yr	0.39	0.60	0.75	1.03	1.31	1.57	**5yr**	1.13	1.54	1.84	2.46	3.15	4.19	4.73	**5yr**	3
10yr	0.46	0.70	0.87	1.21	1.57	1.90	**10yr**	1.35	1.86	2.21	2.99	3.79	5.19	5.91	**10yr**	4
25yr	0.56	0.85	1.05	1.50	1.98	2.45	**25yr**	1.71	2.39	2.84	3.88	4.85	6.89	7.95	**25yr**	6
50yr	0.64	0.98	1.22	1.75	2.36	2.95	**50yr**	2.04	2.88	3.44	4.71	5.86	8.54	9.97	**50yr**	7
100yr	0.75	1.13	1.42	2.05	2.82	3.56	**100yr**	2.43	3.48	4.17	5.75	7.10	10.59	12.50	**100yr**	9
200yr	0.87	1.31	1.66	2.41	3.36	4.30	**200yr**	2.90	4.21	5.06	7.01	8.59	13.19	15.00	**200yr**	1
500yr	1.07	1.59	2.04	2.97	4.22	5.51	**500yr**	3.65	5.39	6.52	9.13	11.07	17.66	20.09	**500yr**	1

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APPENDIX C:

DRAINAGE PLANS