DESIGN EXAMPLE: COMPUTING STORMWATER TREATMENT PRACTICE SIZING CRITERIA (6/13/2014)

Design examples are provided to illustrate how stormwater sizing criteria are computed. Examples are drawn from actual Vermont projects, to the extent possible.

Design Example #2: Expansion Project – Overflow Parking Lot

The layout of the proposed Overflow Parking Lot is shown in Figure 1. The Site Area is outlined in red.

Site Data:

Location:	Addison County, VT
Parcel Area:	1.37 acres
Site Area:	0.99 acres
Drainage Area (DA) #1:	0.42 acres
Impervious Area in DA #1:	0.28 acres
DA #2:	0.57 acres
Impervious Area in DA #2:	0.45 acres
Soils:	100% HSG D

Step 1: Project Layout and Site Design

In this design example, several project layout and site design practices will be applied to meet the Environmental Site Design Standard:

- **Natural Area Conservation**: not applicable to this small and already-developed site.
- **Buffer/Floodplain Protection**: there are no streams, wetlands, or other sensitive areas on or adjacent to the site.
- **Limit Site Clearing/Grading**: Grading activities will be limited to the minimum needed to construct the parking lot (0.99 acres of the 1.37 acre parcel).
- **Post-Construction Soil Depth and Quality**: This standard will be met for any portion of the cleared/graded area that remains pervious (landscaped, lawn, etc.) after the project is complete.

Step 1a: Determine Stormwater Management Goals

Once project layout and site design concepts have been applied and the Site Area is known, the following basic steps should be followed to develop initial targets for stormwater management that will achieve the Water Quality Treatment Standard and the Hydrologic Conditions Standard.

A. Determine Pre-Development Conditions:

The goal for new development projects is to manage stormwater in such a way as to mimic pre-development runoff characteristics – or "woods in good condition."

HSG	RCN†	Site Area (acres)	% of Site Area
A	38	-	-
B	55	-	-
C	70	-	-
D	77	0.99	100%

† *RCN for "woods in good condition" (Table 2-2c, TR-55, USDA NRCS 1986)*

The RCN for "woods in good condition" for the site (e.g., both DA #1 and DA #2) is:

$RCN_{woods} = 77$

B. Determine Target P_E Using Table 1:

P_E = Rainfall used to size stormwater practices that will meet the Hydrologic Condition Standard

During project planning and preliminary design, site soils and proposed imperviousness are used to determine the target P_E for sizing practices to mimic woods in good condition.

Proposed Imperviousness = Impervious Area / Drainage Area

DA #1 Imperviousness = 0.28 acres / 0.42 acres = 67%

DA #2 Imperviousness = 0.45 acres / 0.57 acres = 79%

From Table 1, checking $\%I_{DA\ \#1}$ = 65% and 70%:

For D soils: $P_E >= 1.4$ inches will reduce the RCN to reflect "woods in good condition"

From Table 1, checking $\%I_{DA\ \#2}$ = 75% and 80%:

For D soils: $P_E >= 1.4$ inches will reduce the RCN to reflect "woods in good condition"

$P_E = 1.4$ inches as the target for ESD implementation for both drainage areas.

Under the 2002 *Vermont Stormwater Management Manual,* expansions involving less than or equal to one acre of impervious cover receive a waiver from meeting Cp_v requirements. Under the proposed "Hydrologic Condition Standard", Cp_v would be addressed on all sites. If a combination of non-structural and structural stormwater treatment practices presented in Chapters 3 and/or 4 of the 2014 *Vermont Stormwater Management Manual* are used to meet these targets, WQ_v and Cp_v requirements will be satisfied.

C. Determine Runoff Volume (V_{PE}) Target:

Having determined the P_E target for the project (e.g., the amount of rainfall that needs to be treated to replicate pre-development runoff conditions), the next step is to translate the rainfall amount into a volume target (V_{PE}) for the site. The volume target is calculated as follows:

$$V_{PE\ DA\ \#1} = \frac{(P_E)(R_V)(A)}{12} = \frac{(1.4)(.653)(0.42)}{12} = 0.032 \text{ ac-ft}*(43{,}560 \text{ ft}^3/ 1 \text{ ac-ft}) = 1{,}394 \text{ ft}^3$$

$$V_{PE\ DA\ \#2} = \frac{(P_E)(R_V)(A)}{12} = \frac{(1.4)(.761)(0.57)}{12} = 0.051 \text{ ac-ft}*(43{,}560 \text{ ft}^3/ 1 \text{ ac-ft}) = 2{,}204 \text{ ft}^3$$

where:

V_{PE} = Target volume (acre-feet)
P_E = Rainfall depth (inches)
R_V = Runoff coefficient [0.05 + 0.009(I)], unitless
I = Impervious cover (whole number percent)
A = Site area (acres)

The volume target may then be treated by using any one or a combination of structural and non-structural stormwater treatment practices. When two or more structural practices are used, their volumes are easily added; however, when non-structural practices are used it will be necessary to determine an equivalent V_{PE} for these practices. When the cumulative volume for all practices meets or exceeds the target V_{PE} for the project, then the Water Quality Treatment Standard and the Hydrologic Conditions Standard are met. If all options have been examined and the target V_{PE} is not managed completely, limited applicability treatment practices may need to be utilized.

Step 2: Apply Non-Structural Stormwater Management Practices

The non-structural practice of non-rooftop disconnection was selected to partially meet V_{PE} for the Overflow Parking Lot expansion.

Disconnection of Non-Rooftop Runoff

A portion (25' x 120', or 0.07 acres) of Overflow Parking Lot DA #1 will be disconnected to a vegetated area that is 25' wide and has an average slope of less than 5%. As shown in the tables below, this is the equivalent of treating a P_E of 0.25 inches. The attendant V_{PE} can then be calculated as follows:

$$V_{PE\ DA\#1} = \frac{(P_E)(R_V)(A)}{12} = \frac{(0.25)(.95)(0.07)}{12} = 0.001 \text{ ac-ft}*(43{,}560 \text{ ft}^3/ 1 \text{ ac-ft}) = 60 \text{ ft}^3$$

DRAFT Non-Rooftop Disconnection Buffer Widths by Slope Class

Buffer Slope	**<5%**	**5-10%**	**10-15%**
Minimum Buffer Width (feet)	20	35	50
Contributing Impervious Surface Width (feet)	Up to 20	Up to 20	Up to 20
Contributing Impervious Surface Widths Over 20 feet	+ 5 feet of width must be added for additional 5 feet of contributing width or fraction thereof, up to a maximum of 75 feet of total contributing width		
Maximum Buffer Width (feet)	75	90	105

DRAFT Credits for Non-Rooftop Disconnection

Hydrologic Soil Group (HSG)	**PE (in.)**
A/B	0.5
C/D	0.25

The remaining volume of runoff that must be captured and treated for drainage area #1 is:

$$V_{PE\ DA\ \#1} = 1{,}394\ ft^3 - 60\ ft^3 = 1{,}334\ ft^3$$

Step 3: Apply Structural (GSI) Stormwater Treatment Practices

The structural practices of bioswales and bioretention will be employed to partially meet V_{PE} for the Overflow Parking Lot expansion.

Bioswale

Drainage Area (DA) # 1: 0.42 acres
Impervious Area in DA #1: 0.28 acres, with 0.07 acres treated above using non-structural practices

The remainder of DA #1 (a total land area of 0.35 acres or 15,295 ft^2) drains to the southern edge of the parking lot. The configuration of this area is ideal for a bioswale.

The volume of runoff that must be treated and captured is 1,334 ft^3.

The bioswale that will be installed will have 2 feet of soil media. The swale will incorporate check dams in order to have a maximum effective slope of 1%, and which allow water to pond to a maximum depth of 6 inches. Because the site is underlain by HSG D soils, the bioswale will require an underdrain; we have elected to include a 12-inch stone sump below the invert of the underdrain in order to enhance the volume reduction performance of the swale.

Recognizing that bioswales are ultimately designed for some amount of conveyance, in addition to treatment, the treatment volume will need to be reduced; based on our design conditions it will be reduced by a factor of 0.6. Therefore, the adjusted volume of runoff that must be treated and captured is:

$$V_{PE\ adj} = V_{PE\ DA\ \#1} / 0.6 = 1{,}334\ ft^3 / 0.6 = 2{,}223\ ft^3$$

In order to calculate the surface area (SA) of a swale able to treat this volume, we must first the storage void volume available within the swale (T_v). The accepted void ratios (V_r) for the materials being employed are:

- Soil Media $V_r = 0.25$
- Gravel $V_r = 0.40$
- Surface Storage $V_r = 1.0$

$$T_v = [\ (V_r \times D) + (V_r \times D) \ldots\ ]$$

where D = media depth in feet

$$T_v = [(0.25 \times 2) + (0.40 \times 1) + (1.0 \times 0.5)] = 1.4$$

$$SA = V_{PE\ adj} / 1.4 = 2{,}223 / 1.4 = 1{,}590\ ft^2$$

If we then assume the bottom of our swale is 6 feet wide, the length required to treat the balance $V_{PE\ DA\ \#1}$ and meet the Hydrologic Condition Standard is 265 feet.

Bioretention

DA #2:	0.57 acres
Impervious Area in DA #2:	0.45 acres

Drainage Area #2 (0.57 acres or 24,829 ft^2) drains to the northeast edge of the parking lot. This location is well-suited for the construction of a bioretention treatment practice.

The volume of runoff that must be captured and treated is = 2,204 ft^3.

The bioretention practice that will be installed will have 2 feet of soil media; because of the HSG D soils we have assumed that a deeper practice would intercept seasonal high groundwater and therefore is not allowable. The bioretention practice will be designed to allow water to pond to a maximum depth of 12 inches; as such, it will require a site-specific planting plan. Again, because the site is underlain by HSG D soils, it will require an underdrain and the underdrain will be supported by a minimum of 6 inches of gravel. And because the practice will have an underdrain the treatment volume will need to be reduced by a factor of 0.6. Therefore, the adjusted volume of runoff that must be treated and captured is:

$$V_{PE\ adj} = V_{PE\ DA\ \#1} / 0.6 = 2{,}204\ ft^3 / 0.6 = 3{,}673\ ft^3$$

In order to calculate the surface area (SA) of a bioretention practice able to treat this volume, we must first determine the storage void volume available within the bioretention area (T_v). The accepted void ratios (V_r) for the materials being employed are:

- Soil Media $V_r = 0.25$
- Gravel $V_r = 0.40$
- Surface Storage $V_r = 1.0$

$$T_v = [\ (V_r \times D) + (V_r \times D) \ldots\ ]$$

where D = media depth in feet

$$T_v = [(0.25 \times 2) + (0.40 \times 0.5) + (1.0 \times 0.5)] = 1.2$$

$$SA = V_{PE\ adj} / 1.2 = 3{,}673 / 1.2 = 2{,}625\ ft^2$$

Or roughly 40' x 65'.

This meets the unadjusted target $V_{PE\ DA\ \#2}$ (2,204 ft^3) for this drainage area and therefore the Hydrologic Condition Standard for DA #2 is met.

Table 1: RCN Reductions for HSG D Soils

HydroGroup D										
Predevelopment CN		77								
woods "in good condition"										
		Storm Depth Treated by Runoff Reduction Practices (inches)								
%I	CN	1	1.2	1.4	1.6	1.8	2	2.2	2.4	2.6
0%	80									
5%	81									
10%	82									
15%	83									
20%	84									
25%	85	79								
30%	85	79								
35%	86	79								
40%	87	79	77							
45%	88	79	77							
50%	89	80	77							
55%	90	80	77							
60%	91	81	78							
65%	92	81	78							
70%	93	82	78							
75%	94	82	79							
80%	94	83	79							
85%	95	84	80							
90%	96	84	81	77						
95%	97	85	82	77						
100%	98	86	82	78						
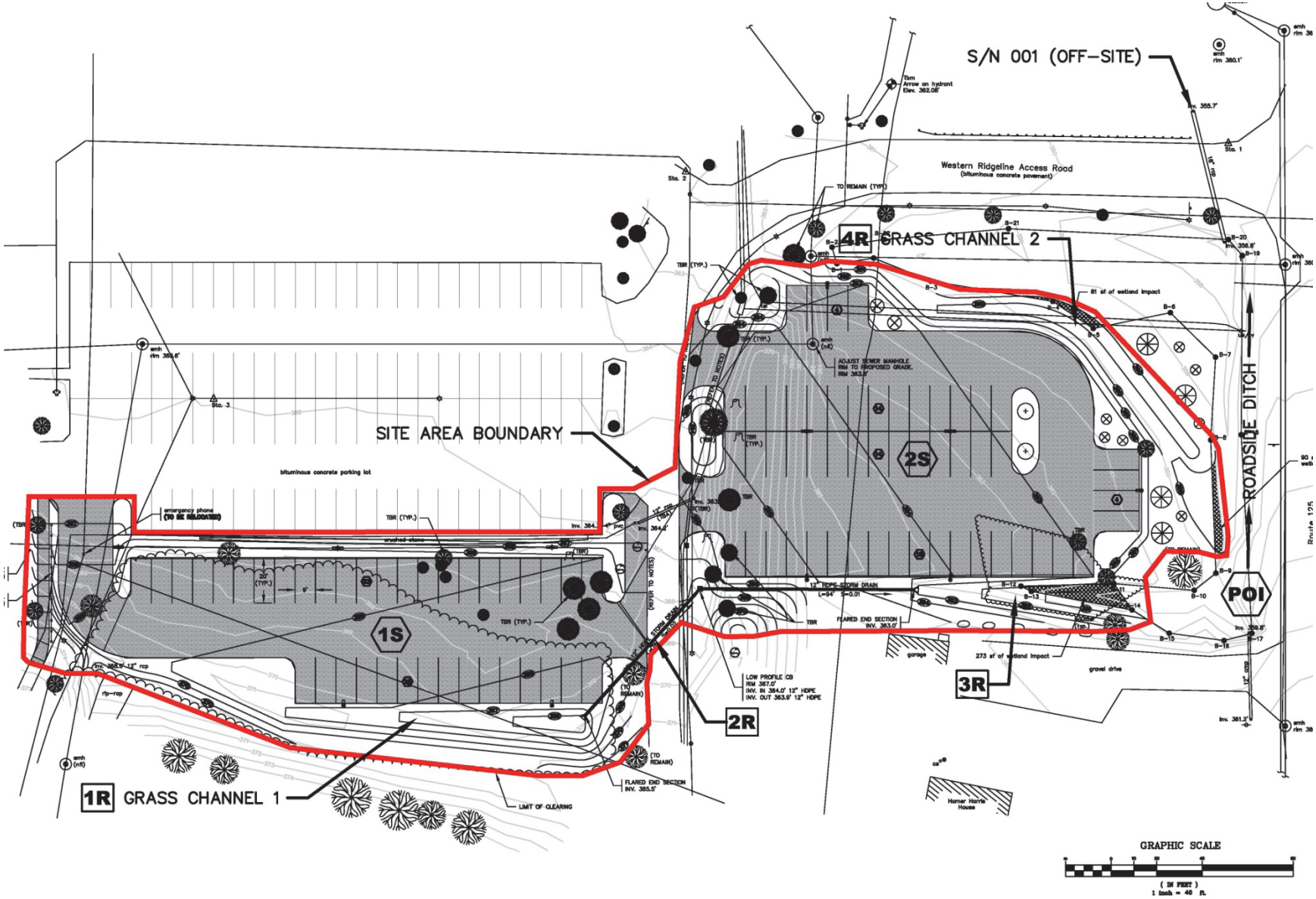
Figure 1: Overflow Parking Lot Site Plan