MIDDLETOWN SPRINGS VOLUNTEER FIRE ASSOCIATION
PO Box 1216
Middletown Springs, VT 05757

Middletown Springs Green Stormwater Mitigation
2015-ERP-1-08

Introduction

Through the Vermont Ecosystem Restoration Program, the Middletown Springs Volunteer Fire Department was awarded $10,580 to undertake a feasibility analysis and develop an engineered bio-infiltration design for a green stormwater project in the town of Middletown Springs. The project is intended to convey stormwater runoff from multiple municipal properties to the Green owned by the Community Church, where it will be treated. The Middletown Springs Green Stormwater Mitigation project will avert stormwater runoff from entering the Poultney River, serving the dual purpose of protecting the State's water quality and supporting the town's goal to protect and restore the Poultney River and its tributaries.

Through this grant Long Trail Engineering completed a feasibility analysis of four green stormwater systems intended to capture sediment- and nutrient-laden stormwater runoff from the municipal shed, equipment storage area, and all of the rooftop and parking/driving surfaces near the buildings to the north of the town green, and direct it to a bioretention area located in the town green. Also included in the analysis was one conventional system with catch basins piped directly to the existing stormwater infrastructure, which drains the Poultney River.

The least expensive alternative was the conventional alternative. The Church and its partners hesitated to use that alternative since, in addition to the volume of water generated during thunderstorms and other precipitation events, the water draining from the gravel roads and parking areas around this site carries sediment and nutrients, which is a source of pollution for the Poultney River and Lake Champlain. Based on the aesthetic appearance and cost of the other alternatives, the Church chose to complete the engineered design on the rain garden option.

In addition to the rain garden in the Green, the final project design included a rain garden on private property uphill of the Historical Society Building and Museum. This additional rain garden will capture runoff directly from the town-leased property to the north of the municipal buildings. The final design also called for a water diversion feature installed to drain water from the north side of the Fire Department, past their septic area behind the building, and allow that water to spread and infiltrate in the land to the east of the Fire Department.

The Fire Association partnered with the Poultney Mettowee Natural Resources Conservation District (PMNRCD) to facilitate completion of this project and the necessary community outreach to ensure that all partners participated in the decision-making process.

Community Partnerships and Outreach

Due to the shared responsibility of the drainage issues in this project, there were many outreach and educational meetings associated with this grant. The Town, Fire Association, Church, Historical Society, and several neighbors are all impacted in some way by this issue and/or project. Both multi-group meetings and site visits and individual meetings and outreach were conducted throughout the project duration. The Poultney Mettowee Natural Resources Conservation District assisted with this project and took the lead on community outreach and general project coordination. A schedule of site visits and meetings is available upon request.

Alternatives Analysis

The following is based on a document provided by Long Tail Engineering.

Stormwater treatment is typically provided for both quantity and quality. Treatment for quantity refers to providing flow attenuation. That means providing stormwater storage with a controlled release, so that the runoff rates from a proposed project are less than or equal to the runoff rates that currently exist. In this case, since we are not adding any impervious surfaces, the pre and post runoff rates are the same. Treatment for water quality refers to the amount and type of contaminants suspended within the runoff itself (silts, phosphorus, etc.), and how much water is allowed to infiltrate into the ground to recharge groundwater. For this project, providing water quality treatment & recharge is the main goal.

For the following alternatives, please refer to the plan sets that accompany this assessment.

<u>Alternate 1</u>

Alternate 1 is simple collection of the runoff into a couple of catch basins, ultimately discharging to the storm sewer. This option reduces some runoff through the green, but provides almost nothing in terms of water quality or recharge treatment. No flow attenuation is provided. The engineer did not recommend this option.

<u>Alternate 2/2A/2C</u>

Alternate 2 is a "dry pond" in the town green. The pond would fill up during large runoff events, and slowly release water over a 24 hour period. The pond would be two feet deep when full, otherwise it would be dry. This provides flow attenuation (not really a goal), but very little water quality treatment. It would also be very unsightly. The engineer did not recommend this option.

Alternatives 2A & 2C are to turn the dry pond into a wet pond or a constructed wetland. It would have the same dimensions as the dry pond, but a portion of the pond would always have water in it. These options would provide water quality treatment and flow attenuation, but no recharge.

The engineer did not recommend these options either, as the standing water would create a liability issue for the town, and could lead to mosquito growth. Also, without a steady supply of water, the wet pond or wetland would not stay full and would not be effective.

Alternate 3

Alternative 3 is the rain garden. This was the preferred alternative. The rain garden is the most aesthetically pleasing of the various options. In addition, it provides water quality treatment and groundwater recharge, as well as some flow attenuation. The engineer thought the gardens were the most fitting option, consistent with the public use of the green. They can also be easily maintained by any volunteer with some gardening knowledge. The other alternatives would need to be maintained by employees or residents knowledgeable in those technologies.

Alternate 4

Alternative 4 is a series of underground filter chambers. These contain plastic chambers that are full of crushed stone that fill with runoff, which is slowly released. The chambers can provide water quality, recharge, and flow attenuation. Other than some access risers, the chambers would be buried and unseen. However, they are quite expensive and are typically only used when space is not available for other treatment methods.

The initial estimates from the engineer were as follows:

> *As to some rough expenses: A direct connection to the town storm sewer would be the least expensive, perhaps $10,000. A dry or wet pond would be in the range of $20,000, a constructed wetland would be in the range of $25,000. A rain garden would be in the range of $35,000, and underground filter systems would be the most expensive, perhaps $50,000. These are pretty rough estimates, if we wanted more specific numbers we'd need to have a general contractor give us some figures.*

Based on the above cited report, the Church chose to continue design on the raingarden. Once design was finished and they saw how large the lower raingarden, located in the Green, would be, they pursued additional information on the underground treatment options. The Church will make a final decision once they review additional cost information on alternate 4 and additional sizing and location information on alternate 3.

Performance Report of Selected Design (Rain Garden/Bioinfiltration)

The raingardens were sized using the most conservative of the perc test rates at each site and following guidance provided in the stormwater manual. Analyses were completed for stormwater volume of water treated and for water recharge rates. The measured area of the subwatershed treated in the Upper Garden was 0.57 acres and the area of the subwatershed treated in the Lower Garden was 1.34 acres. The soil type is Warwick Quonset Complex.

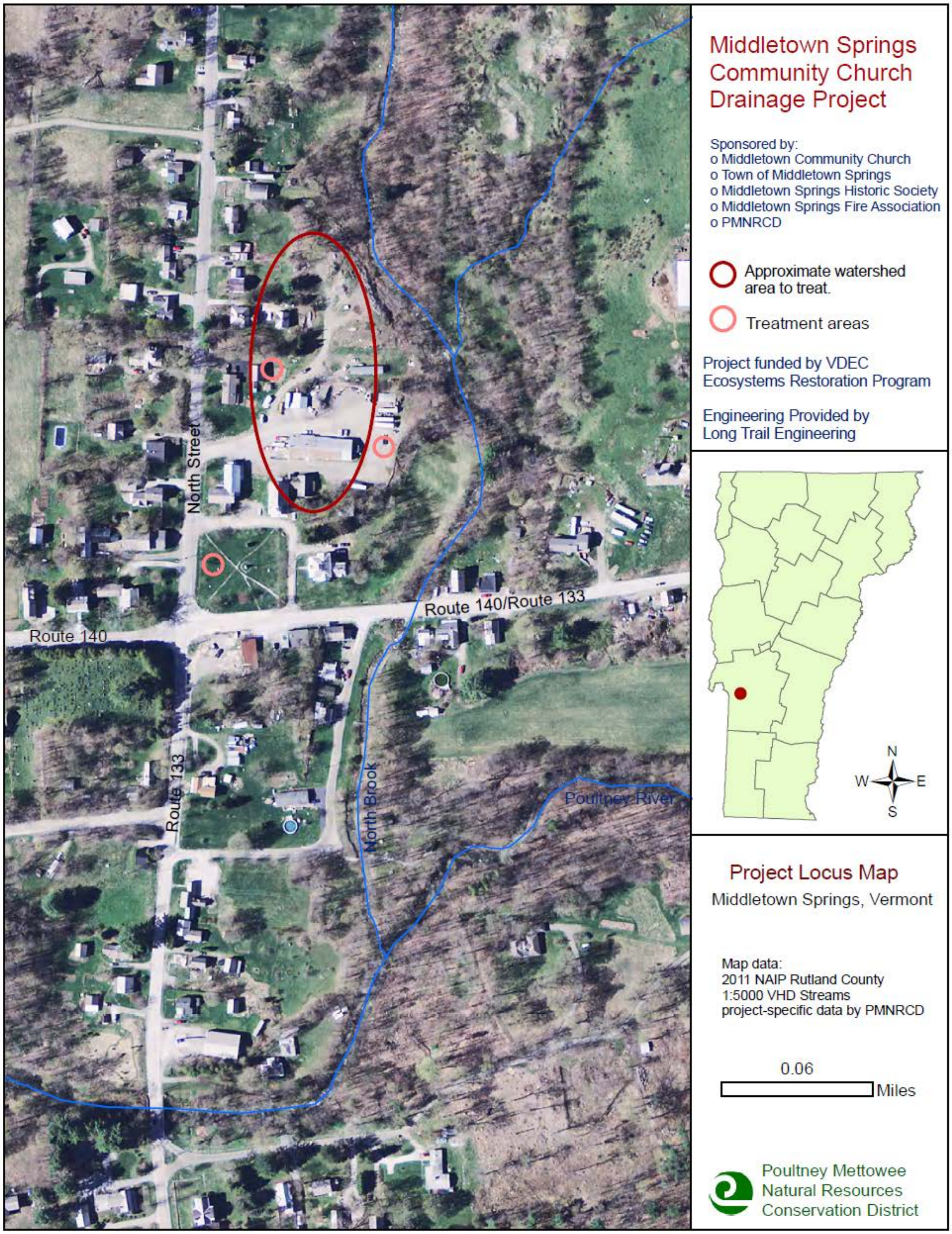
Based on an average storm (0.9 inches of rainfall), the Upper Rain Garden will treat approximately 411 cf of water and the Lower Rain Garden will treat 1,769 cf. According to weather statistics, Rutland, Vermont, receives an average of 40 rainfall days and roughly 40 inches of rain per year (https: www.currentresults.com/Weather/Vermont and www.vermont.com/weather). Using those statistics and knowledge of local weather patterns, one might assume that the rain gardens would treat all rainfall under 0.9 inches and most storms, and that some thunder storms, larger storms, and spring melt events will leave a portion of runoff untreated. A conservative estimate of the water volume treated per year might be 43,600-65,400 cf of water (326,151 - 474,265 gallons), assuming that 20 to 30 inches of rain are treated (and that one quarter to one half of rainfall is not treated).

Conclusions

This planning grant was written as a result of chronic flooding in the Middletown Springs Community Church's basement. The Church, Town, Fire Department, and Historical Society, all residing in the heart of Middletown Springs, are working toward implementing a solution to the identified stormwater drainage issues. Installing the rain gardens (or any equivalent type of stormwater treatment) to treat stormwater runoff generated in the project area will treat up to 474,000 gallons of water per year during storm events, water that would, if directly piped to the existing storm drains potentially affect downstream landowners during storm events.

Below is a photo of the drainage issue in Middletown Springs. The Community Church is to the right, the Historical Society to the left, and the Fire Department in the background. The shared septic for the Historical Society and the Church is between the two buildings.

Map 1: Site location and treatment areas (final location in the Green tbd)



APPENDIX A- Rain Garden Performance Report

Site Areas

Middletown Springs Fire Department/Congregational Church	Long Trail Engineering, P.C.
Middletown Springs, VT	Job No. 1228
Proposed Rain Garden	Copyright 2015
Drainage Areas	December 2, 2015

S/N 001

1	A	Warwick Quonset Cmplx	24,686	0.0009	0.57
	Imp		0	0.0000	0.00
			Start	End	Slope
Watercourse Lengths & Slopes		Length (ft)	Elev (ft)	Elev (ft)	(ft/ft)
	Sheet	50	1029	1026	0.020
	Channel	225	1026	1022	0.018
	Channel Details				
		Bott. Width (ft)	2	Side (ft)	2.2
		Top Width (ft)	6	P (ft)	6.5
		Depth (ft)	1	A (sf)	4

2A	A	Warwick Quonset Cmplx	19,773	0.0007	0.45
	Imp		1,671	0.0001	0.04
			Start	End	Slope
Watercourse Lengths & Slopes		Length (ft)	Elev (ft)	Elev (ft)	(ft/ft)
	Sheet	60	1022	1015.5	0.108

2B	A	Warwick Quonset Cmplx	2,324	0.0001	0.05
	Imp	Proposed	14,922	0.0005	0.34
			Start	End	Slope
Watercourse Lengths & Slopes		Length (ft)	Elev (ft)	Elev (ft)	(ft/ft)
	Sheet	91	1015	1011.75	0.036

2C	A	Warwick Quonset Cmplx	13,446	0.0005	0.31
	Imp	Proposed	6,361	0.0002	0.15
			Start	End	Slope
Watercourse Lengths & Slopes		Length (ft)	Elev (ft)	Elev (ft)	(ft/ft)
	Sheet	100	1012	1008.5	0.035
	Shallow	120	1008.5	1003	0.046

Peak Flows

Middletown Springs Fire Department/Congregational Church
Middletown Springs, VT
Proposed Rain Garden
Peak Flows

Long Trail Engineering, P.C.
Job No. 1228
Copyright 2015
December 2, 2015

Subarea 1

Storm Event	Pre-Development Peak Flow (cfs)	t(c) (hrs)
1	0.00	0.11
10	0.1	0.11
100	0.9	0.11

Subarea 2B

Storm Event	Pre-Development Peak Flow (cfs)	t(c) (hrs)
1	1.14	0.02
10	2.1	0.02
100	3.5	0.02

Subarea 2A

Storm Event	Pre-Development Peak Flow (cfs)	t(c) (hrs)
1	0.00	0.06
10	0.06	0.06
100	1.2	0.06

Subareas 2C

Storm Event	Pre-Development Peak Flow (cfs)	t(c) (hrs)
1	0.09	0.15
10	0.6	0.15
100	1.6	0.15

Water Quality Volume- subarea 1 Upper Rain Garden

Middletown Springs Fire Department/Congregational Church
Middletown Springs, VT
Proposed Rain Garden
Water Quality Volume

Long Trail Engineering, P.C.
Job No. 1228
Copyright 2015
December 2, 2015

Version: 9/06

For the area draining to*: Subarea 1 - Upper Rain Garden
Located in drainage area for S/N: 001

WQ Volume Calculation for Volume-Based Practice

Use this worksheet to calculate the water quality volume draining to your volume based STP if you are not using any of the site design credits in section 3 of the 2002 VSWMM. ***Do not*** *use this worksheet to calculate your WQv if you need to determine the Peak Q for the WQ storm (i.e. designing a grass channel, flow-splitter or other flow based practice). See the worksheet "Water Quality Volume and Modified Curve Number Calculation for Water Quality Treatment in a Flow-Based Practice"*

Water Quality Volume Calculations

Line			value/calculation	units
1	Site Area (impervious + disturbed pervious)	A=	0.57	acres
2	Impervious area		0.00	acres
3	Percent Impervious Area = [(line 2/line 1) * 100] =	I =	0.00	% (whole #)
4	Precipitation	P =	**0.9**	inches
5	**Runoff coefficient calculation** = (0.05 + (0.009*I))	Rv =	0.050	
6	**WQ Volume (in watershed inches) Calculation** =(P * Rv) =		0.045	Qa (watershed inches, a.k.a. inches of runoff)
7	Minimum WQ Volume[1]		**0.2**	watershed inches
8	Enter the greater of line 6 or line 7	**WQv =**	0.200	watershed inches
9	**WQ Volume Calculation** = (line 8 *A)/12 =	**WQv =**	0.009	ac. ft.
10	**WQ Volume Calculation** = (line 9 * 43560) =	**WQv =**	411	cu. ft.

Notes:

Recharge—subarea 1 Upper Rain Garden

Middletown Springs Fire Department/Congregational Church
Middletown Springs, VT
Proposed Rain Garden
Recharge

Long Trail Engineering, P.C.
Job No. 1228

December 2, 2015

Version: 2/12

For the area draining to*: Subarea 1 - Upper Rain Garden
Located in drainage area for S/N: 001

Groundwater Recharge Treatment Standard - Calculation & Waiver Worksheet

The average annual groundwater recharge rate for the prevailing hydrologic soil group(s) (HSG) must be maintained in order to preserve existing water table elevations. Recharge is determined as a function of annual predevelopment recharge for a given HSG, the average annual rainfall and the amount of impervious surface at the site. The Groundwater Recharge Treatment Standard can be met by using one or both of the following methods: volume method and/or percent area method. See Table 2.2 in the VSMM - Volume I for a list of acceptable STPs or credits that satisfy this requirement. Use NRCS's Web Soil Survey to obtain specific soil data at your site, available at:
http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

Site Information		value/calculation	units
Site Area (impervious + disturbed pervious)	A=	0.57	acres
Impervious area		0.00	acres
Percent Impervious Area = [(line 2/line 1)] =	I =	0.00	% (decimal percent)

Composite Recharge Factor Calculation

Enter site acreage of each HSG draining to POI or S/N	value/calculation	
HSG A	0.57	acres
HSG B		acres
HSG C		acres
HSG D		acres
Total Site Area	0.000	
Composite Recharge Factor	0.400	

ReV (Percent Volume Method)	**0.000**	acre feet
	0	cubic feet

The percent volume method is commonly used to meet recharge. Designers must demonstrate that a proposed STP allows at least the Rev to enter the ground. The Rev is contained within the WQv. So, if a practice is infiltrating the entire WQv, then Rev is automatically met. Please use the applicable STP worksheets to verify the Groundwater Recharge Treatment Standard has been met. Note that not all STPs can be used to meet this standard.

ReA (Percent Area Method)	**0.000**	acres
	0	square feet

The percent area method is used when meeting recharge via nonstructural design credits(disconnection of rooftop/non-rooftop surfaces, stream buffer, grass channel credit, or ESRD). In this case, the designer must demonstrate that stormwater runoff from a portion of the new **impervious area, equivalent to the area calculated under the percent area method,** drains into a nonstructural design credit practice.

Additional notes:

*Recharge is one of the unified sizing criteria that can be achieved site wide, rather than at each point of interest (POI) or discharge point (S/N), assuming the receiving water is the same for each discharge point.

Water Quality Volume—subarea 2 Lower Rain Garden

Middletown Springs Fire Department/Congregational Church
Middletown Springs, VT
Proposed Rain Garden
Water Quality Volume

Long Trail Engineering, P.C.
Job No. 1228

December 2, 2015

Version: 9/06

For the area draining to*: Subarea 2 -Lower Rain Garden
Located in drainage area for S/N: 001

WQ Volume Calculation for Volume-Based Practice

Use this worksheet to calculate the water quality volume draining to your volume based STP if you are not using any of the site design credits in section 3 of the 2002 VSWMM. ***Do not use*** *this worksheet to calculate your WQv if you need to determine the Peak Q for the WQ storm (i.e. designing a grass channel, flow-splitter or other flow based practice). See the worksheet "Water Quality Volume and Modified Curve Number Calculation for Water Quality Treatment in a Flow-Based Practice"*

Water Quality Volume Calculations

Line			value/calculation	units
1	Site Area (impervious + disturbed pervious)	A=	1.34	acres
2	Impervious area		0.53	acres
3	Percent Impervious Area = [(line 2/line 1) * 100] =	I =	39.24	% (whole #)
4	Precipitation	P =	**0.9**	inches
5	**Runoff coefficient calculation** = (0.05 + (0.009*I))	Rv =	0.403	
6	**WQ Volume (in watershed inches) Calculation** =(P * Rv) =		0.363	Qa (watershed inches, a.k.a. inches of runoff)
7	Minimum WQ Volume[1]		**0.2**	watershed inches
8	Enter the greater of line 6 or line 7	**WQv =**	0.363	watershed inches
9	**WQ Volume Calculation** = (line 8 *A)/12 =	**WQv =**	0.041	ac. ft.
10	**WQ Volume Calculation** = (line 9 * 43560) =	**WQv =**	1769	cu. ft.

Notes:

Recharge – subarea 2 Lower Rain Garden

Middletown Springs Fire Department/Congregational Church
Middletown Springs, VT
Proposed Rain Garden
Recharge

Long Trail Engineering, P.C.
Job No. 1228

December 2, 2015

Version: 2/12

For the area draining to*: Subarea 2 - Lower Rain Garden
Located in drainage area for S/N: 001

Groundwater Recharge Treatment Standard - Calculation & Waiver Worksheet

The average annual groundwater recharge rate for the prevailing hydrologic soil group(s) (HSG) must be maintained in order to preserve existing water table elevations. Recharge is determined as a function of annual predevelopment recharge for a given HSG, the average annual rainfall and the amount of impervious surface at the site. The Groundwater Recharge Treatment Standard can be met by using one or both of the following methods: volume method and/or percent area method. See Table 2.2 in the VSMM - Volume I for a list of acceptable STPs or credits that satisfy this requirement. Use NRCS's Web Soil Survey to obtain specific soil data at your site, available at: http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

Site Information		value/calculation	units
Site Area (impervious + disturbed pervious)	A=	1.34	acres
Impervious area		0.53	acres
Percent Impervious Area = [(line 2/line 1)] =	I =	0.39	% (decimal percent)

Composite Recharge Factor Calculation

Enter site acreage of each HSG draining to POI or S/N	value/calculation	
HSG A	1.34	acres
HSG B		acres
HSG C		acres
HSG D		acres
Total Site Area	0.000	
Composite Recharge Factor	0.400	

ReV (Percent Volume Method)	0.018	acre feet
	765	cubic feet

The percent volume method is commonly used to meet recharge. Designers must demonstrate that a proposed STP allows at least the Rev to enter the ground. The Rev is contained within the WQv. So, if a practice is infiltrating the entire WQv, then Rev is automatically met. Please use the applicable STP worksheets to verify the Groundwater Recharge Treatment Standard has been met. Note that not all STPs can be used to meet this standard.

ReA (Percent Area Method)	0.211	acres
	9,182	square feet

The percent area method is used when meeting recharge via nonstructural design credits(disconnection of rooftop/non-rooftop surfaces, stream buffer, grass channel credit, or ESRD). In this case, the designer must demonstrate that stormwater runoff from a portion of the new **impervious area, equivalent to the area calculated under the percent area method,** drains into a nonstructural design credit practice.

Additional notes:

*Recharge is one of the unified sizing criteria that can be achieved site wide, rather than at each point of interest (POI) or discharge point (S/N), assuming the receiving water is the same for each discharge point.

<u>Rain Garden Design</u>

Middletown Springs Fire Department/Congregational Church	Long Trail Engineering, P.C.
Middletown Springs, VT	Job No. 1228
Proposed Rain Garden	Copyright 2015
	December 2, 2015

Rain Garden Sizing Criteria
Rain Gardens are being designed to treat WQ(v) and Recharge for existing pervious and impervious surfaces. No new impervious surfaces are proposed. Rain gardens are not designed to treat Cp(v), Qp(10) or Qp(100).

Design Rain Garden as a "Bioretention Filter" per VT Stormwater Manual

Subarea 1

Wq(v)	411		cf
Compute minimum surface area of rain garden			
A(f), surface area required		= WQv*d(f)/[k*(h(f) +d(f))*t(f)	
d(f), filter bed depth	1		ft
k (permeability coefficient	0.5		(bioretention soil)
h(f), average height above filter bed	0		ft (from HydroCAD)
t(f), design drain time	3		days (40 hours)
WQ(v)	411		cf
A(f) (minimum area)	274		sf
Rain Garden Area	721		sf

Subarea 2 (incudes Subareas 2A, 2B, & 2C)

Wq(v)	1,769		cf
Compute minimum surface area of rain garden			
A(f), surface area required		= WQv*d(f)/[k*(h(f) +d(f))*t(f)	
d(f), filter bed depth	1		ft
k (permeability coefficient	0.5		(bioretention soil)
h(f), average height above filter bed	0		ft (from HydroCAD)
t(f), design drain time	3		days (40 hours)
WQ(v)	1,769		cf
A(f) (minimum area)	1,179		sf
Rain Garden Area	1,745		sf