VERMONT

# Design Examples Using RCN Approach

**Vermont Stormwater Management Manual Update, Meeting #5**

**Central Vermont Chamber of Commerce, Berlin**

**March 14, 2014**

STONE ENVIRONMENTAL INC

Horsley Witten Group
Sustainable Environmental Solutions

Adamant Accord
Meeting Facilitation and Mediation Services

# RCN Tables: HSG B
# Woods in “Good Condition”

**HydroGroup B**

Predevelopment CN 55

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% | 61 | | | | | | | | | |
| 5% | 63 | | | | | | | | | |
| 10% | 65 | | | | | | | | | |
| 15% | 67 | | | | | | | | | |
| 20% | 68 | | | | | | | | | |
| 25% | 70 | | | | | | | | | |
| 30% | 72 | | | | | | | | | |
| 35% | 74 | 56 | | | | | | | | |
| 40% | 76 | 58 | | | | | | | | |
| 45% | 78 | 60 | | | | | | | | |
| 50% | 80 | 62 | | | | | | | | |
| 55% | 81 | 64 | 56 | | | | | | | |
| 60% | 83 | 66 | 59 | | | | | | | |
| 65% | 85 | 68 | 62 | | | | | | | |
| 70% | 87 | 71 | 65 | 55 | | | | | | |
| 75% | 89 | 73 | 68 | 60 | | | | | | |
| 80% | 91 | 76 | 71 | 64 | | | | | | |
| 85% | 92 | 78 | 74 | 68 | 58 | | | | | |
| 90% | 94 | 81 | 76 | 71 | 64 | | | | | |
| 95% | 96 | 83 | 79 | 75 | 68 | 58 | | | | |
| 100% | 98 | 86 | 82 | 78 | 73 | 65 | | | | |

# RCN Tables: HSG B
# Meadow in "Good Condition"

**HydroGroup B**

Predevelopment CN 58

meadow "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% | 61 | | | | | | | | | |
| 5% | 63 | | | | | | | | | |
| 10% | 65 | | | | | | | | | |
| 15% | 67 | | | | | | | | | |
| 20% | 68 | | | | | | | | | |
| 25% | 70 | | | | | | | | | |
| 30% | 72 | | | | | | | | | |
| 35% | 74 | | | | | | | | | |
| 40% | 76 | | | | | | | | | |
| 45% | 78 | 60 | | | | | | | | |
| 50% | 80 | 62 | | | | | | | | |
| 55% | 81 | 64 | | | | | | | | |
| 60% | 83 | 66 | 59 | | | | | | | |
| 65% | 85 | 68 | 62 | | | | | | | |
| 70% | 87 | 71 | 65 | | | | | | | |
| 75% | 89 | 73 | 68 | 60 | | | | | | |
| 80% | 91 | 76 | 71 | 64 | | | | | | |
| 85% | 92 | 78 | 74 | 68 | 58 | | | | | |
| 90% | 94 | 81 | 76 | 71 | 64 | | | | | |
| 95% | 96 | 83 | 79 | 75 | 68 | 58 | | | | |
| 100% | 98 | 86 | 82 | 78 | 73 | 65 | | | | |

# RCN Tables: HSG C
# Woods in “Good Condition”

**HydroGroup C**

Predevelopment CN 70

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% | 74 | | | | | | | | | |
| 5% | 75 | | | | | | | | | |
| 10% | 76 | | | | | | | | | |
| 15% | 78 | | | | | | | | | |
| 20% | 79 | 72 | | | | | | | | |
| 25% | 80 | 72 | | | | | | | | |
| 30% | 81 | 73 | 71 | | | | | | | |
| 35% | 82 | 73 | 71 | | | | | | | |
| 40% | 84 | 74 | 71 | | | | | | | |
| 45% | 85 | 74 | 71 | | | | | | | |
| 50% | 86 | 75 | 72 | | | | | | | |
| 55% | 87 | 76 | 72 | | | | | | | |
| 60% | 88 | 76 | 73 | | | | | | | |
| 65% | 90 | 77 | 74 | | | | | | | |
| 70% | 91 | 78 | 75 | 70 | | | | | | |
| 75% | 92 | 79 | 76 | 71 | | | | | | |
| 80% | 93 | 81 | 77 | 72 | | | | | | |
| 85% | 94 | 82 | 78 | 74 | | | | | | |
| 90% | 96 | 83 | 79 | 75 | | | | | | |
| 95% | 97 | 85 | 81 | 76 | 71 | | | | | |
| 100% | 98 | 86 | 82 | 78 | 73 | | | | | |

# RCN Tables: HSG C
# Meadow in “Good Condition”

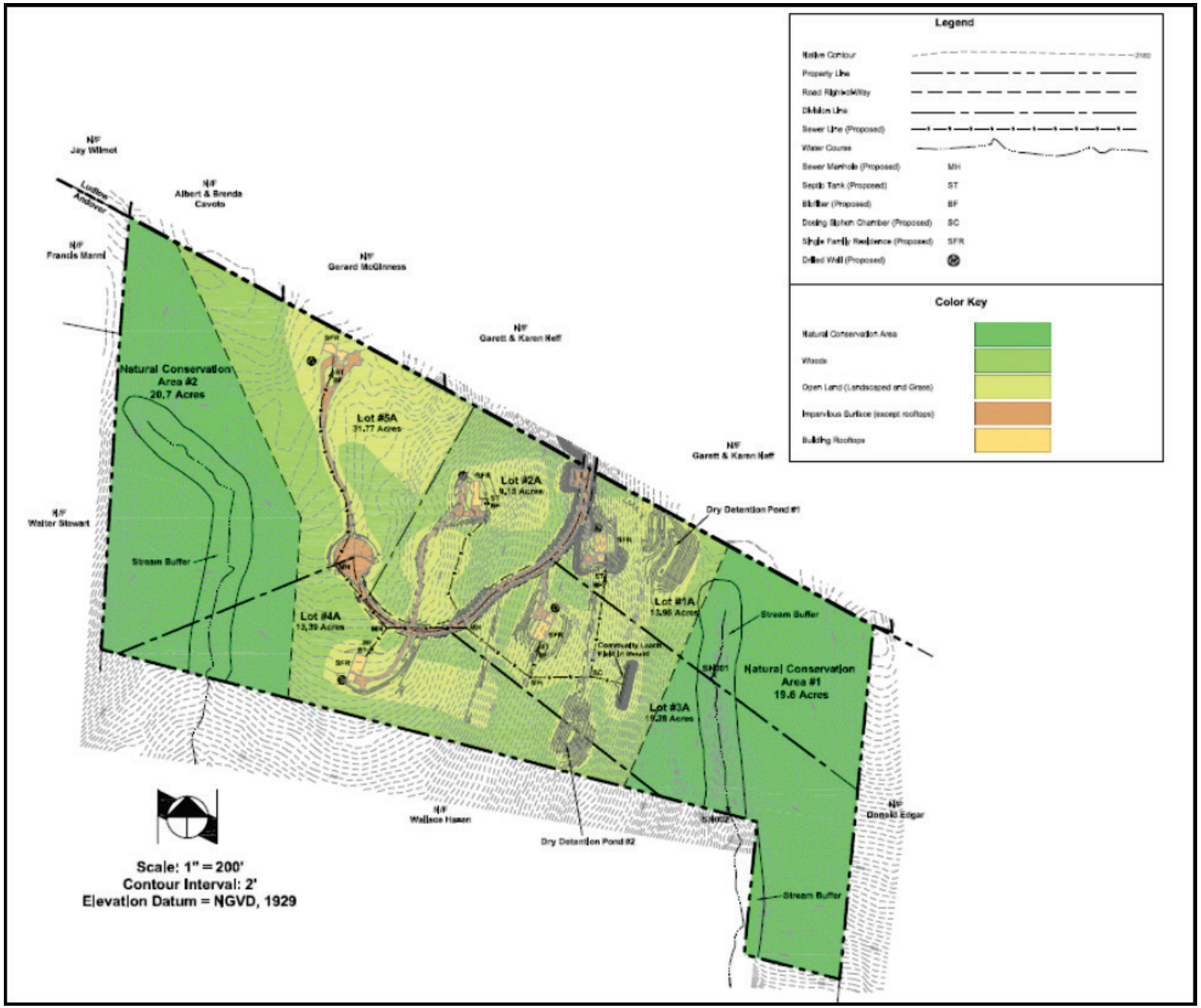
**HydroGroup C**

Predevelopment CN 71

meadow "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% | 74 | | | | | | | | | |
| 5% | 75 | | | | | | | | | |
| 10% | 76 | | | | | | | | | |
| 15% | 78 | | | | | | | | | |
| 20% | 79 | 72 | | | | | | | | |
| 25% | 80 | 72 | | | | | | | | |
| 30% | 81 | 73 | | | | | | | | |
| 35% | 82 | 73 | | | | | | | | |
| 40% | 84 | 74 | | | | | | | | |
| 45% | 85 | 74 | 71 | | | | | | | |
| 50% | 86 | 75 | 72 | | | | | | | |
| 55% | 87 | 76 | 72 | | | | | | | |
| 60% | 88 | 76 | 73 | | | | | | | |
| 65% | 90 | 77 | 74 | | | | | | | |
| 70% | 91 | 78 | 75 | | | | | | | |
| 75% | 92 | 79 | 76 | 71 | | | | | | |
| 80% | 93 | 81 | 77 | 72 | | | | | | |
| 85% | 94 | 82 | 78 | 74 | | | | | | |
| 90% | 96 | 83 | 79 | 75 | | | | | | |
| 95% | 97 | 85 | 81 | 76 | | | | | | |
| 100% | 98 | 86 | 82 | 78 | 73 | | | | | |

# Residential Site – Mountainside Meadows






VERMONT

# Residential Site – Mountainside Meadows

## Site Data:

- Location: Windsor County, VT
- Parcel Area: 87.6 acres
- Site Area: 20.0 acres
  - DA #1: 8.0 acres
  - DA #1 Imperv: 1.3 acres
  - DA #2: 12.0 acres
  - DA #2 Imperv: 1.0 acres
- Soils: 100% HSG C

# Step 1: Site Planning

**VSMM 2014?, VOL. 1**

Section 1 – Stormwater Treatment Practice Sizing Criteria

Section 2 – Required Site Planning Practices

Section 3 – Non-Structural Stormwater Treatment Practices

Section 4 –Structural Stormwater Treatment Practices

Section 5 – Limited Applicability Structural STPs

# Step 1: Site Planning

**VSMM 2014?, VOL. 1**

Section 1 – Stormwater Treatment Practice Sizing Criteria

Section 2 – Required Site Planning Practices

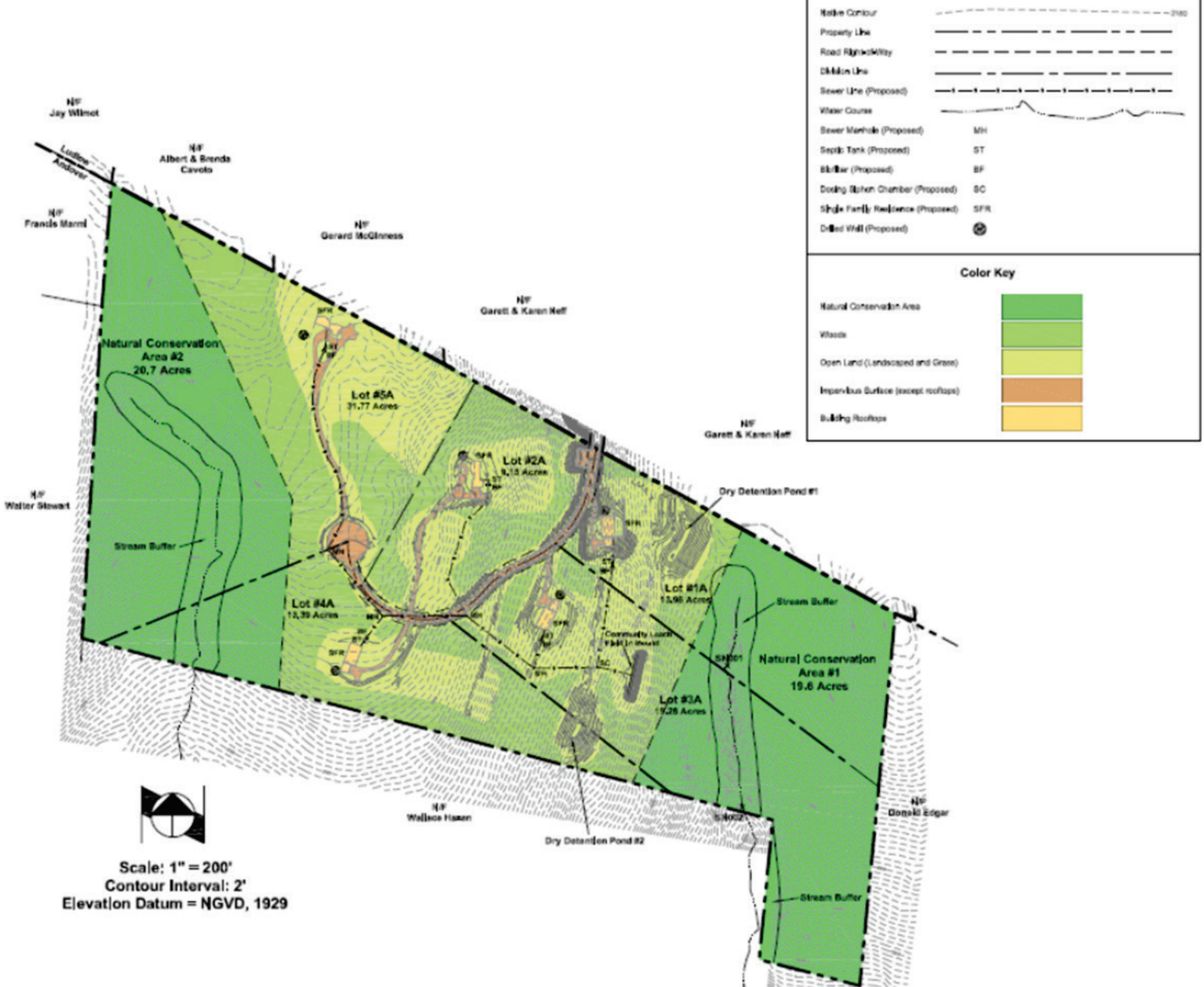
Section 3 – Non-Structural Stormwater Treatment Practices

Section 4 –Structural Stormwater Treatment Practices

Section 5 – Limited Applicability Structural STPs

# Step 1: Site Planning

- Project Layout and Site Design
  - Natural Area Conservation: 47.6 acres of wooded land will be conserved and remain wooded once the project is complete, and thus does not count towards Site Area.
  - Buffer/Floodplain Protection: Stream buffers within the wooded conservation areas will remain undisturbed
  - Limit Site Clearing/Grading: The residential lots will not be completely cleared/graded. Roughly half of non-conserved land (20 acres) will ultimately be cleared and remain open or developed after project completion.
  - 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.



Native Contour
Property Line
Road Right-of-Way
Division Line
Sewer Line (Proposed)
Water Course
Sewer Manhole (Proposed) MH
Septic Tank (Proposed) ST
Biofilter (Proposed) BF
Dosing Siphon Chamber (Proposed) SC
Single Family Residence (Proposed) SFR
Drilled Well (Proposed)
Color Key
Natural Conservation Area
Woods
Open Land (Landscaped and Grass)
Impervious Surface (except rooftops)
Building Rooftops
N/F Jay Wilmot
Ludlow
Andover
N/F Albert & Brenda Cavoto
N/F Francis Marmi
N/F Gerard McGinness
N/F Garett & Karen Neff
N/F Garett & Karen Neff
N/F Walter Stewart
Natural Conservation Area #2 20.7 Acres
Lot #5A 31.77 Acres
Lot #2A 9.15 Acres
Lot #4A 13.39 Acres
Lot #1A 13.96 Acres
Lot #3A 19.28 Acres
Natural Conservation Area #1 19.6 Acres
Dry Detention Pond #1
Dry Detention Pond #2
Stream Buffer
Stream Buffer
Stream Buffer
Community Leach Field in Mound
N/F Wallace Hazen
N/F Donald Edgar
Scale: 1" = 200'
Contour Interval: 2'
Elevation Datum = NGVD, 1929

# Step 1a: Determine Stormwater Management Goal

- Pre-development conditions:

| HSG | RCN† | Site Area (acres) | % of Site Area |
|---|---|---|---|
| A | 38 | - | - |
| B | 55 | - | - |
| C | 70 | 20.0 | 100% |
| D | 77 | - | - |

- Since the site is entirely underlain by HSG C soils, RCN = 70

# Step 1a: Determine Stormwater Management Goal

- To determine target rainfall for sizing practices ($P_E$), first calculate proposed imperviousness (%I):

- %I = Impervious Area (acres)/ Drainage Area (acres)
  - DA #1 %I = 1.3 acres / 8.0 acres = 16%
  - DA #2 %I = 1.0 acres / 12.0 acres = 8%

# Step 1a:
# Determine Stormwater Management Goal

**HydroGroup C**

Predevelopment CN: 70

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% | 74 | | | | | | | | | |
| 5% | 75 | | | | | | | | | |
| 10% | 76 | | | | | | | | | |
| 15% | 78 | | | | | | | | | |
| 20% | 79 | 72 | | | | | | | | |
| 25% | 80 | 72 | | | | | | | | |
| 30% | 81 | 73 | 71 | | | | | | | |
| 35% | 82 | 73 | 71 | | | | | | | |
| 40% | 84 | 74 | 71 | | | | | | | |
| 45% | 85 | 74 | 71 | | | | | | | |
| 50% | 86 | 75 | 72 | | | | | | | |
| 55% | 87 | 76 | 72 | | | | | | | |
| 60% | 88 | 76 | 73 | | | | | | | |
| 65% | 90 | 77 | 74 | | | | | | | |
| 70% | 91 | 78 | 75 | 70 | | | | | | |
| 75% | 92 | 79 | 76 | 71 | | | | | | |
| 80% | 93 | 81 | 77 | 72 | | | | | | |
| 85% | 94 | 82 | 78 | 74 | | | | | | |
| 90% | 96 | 83 | 79 | 75 | | | | | | |
| 95% | 97 | 85 | 81 | 76 | 71 | | | | | |
| 100% | 98 | 86 | 82 | 78 | 73 | | | | | |

# Step 1a:
# Determine Stormwater Management Goal

**HydroGroup C**

Predevelopment CN 70

woods "in good condition"

## DA #1 %I = 16%

| | | 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% | 74 | | | | | | | | | |
| 5% | 75 | | | | | | | | | |
| 10% | 76 | | | | | | | | | |
| 15% | 78 | | | | | | | | | |
| 20% | 79 | 72 | | | | | | | | |
| 25% | 80 | 72 | | | | | | | | |
| 30% | 81 | 73 | 71 | | | | | | | |
| 35% | 82 | 73 | 71 | | | | | | | |
| 40% | 84 | 74 | 71 | | | | | | | |
| 45% | 85 | 74 | 71 | | | | | | | |
| 50% | 86 | 75 | 72 | | | | | | | |
| 55% | 87 | 76 | 72 | | | | | | | |
| 60% | 88 | 76 | 73 | | | | | | | |
| 65% | 90 | 77 | 74 | | | | | | | |
| 70% | 91 | 78 | 75 | 70 | | | | | | |
| 75% | 92 | 79 | 76 | 71 | | | | | | |
| 80% | 93 | 81 | 77 | 72 | | | | | | |
| 85% | 94 | 82 | 78 | 74 | | | | | | |
| 90% | 96 | 83 | 79 | 75 | | | | | | |
| 95% | 97 | 85 | 81 | 76 | 71 | | | | | |
| 100% | 98 | 86 | 82 | 78 | 73 | | | | | |

1.2 inches >=$P_E$>= 1.0 inches will reduce the RCN to reflect "woods in good condition"

# Step 1a:
# Determine Stormwater Management Goal

**HydroGroup C**

Predevelopment CN: 70

woods "in good condition"

## DA #2 %I = 8%

| | | 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% | 74 | | | | | | | | | |
| 5% | 75 | | | | | | | | | |
| 10% | 76 | | | | | | | | | |
| 15% | 78 | | | | | | | | | |
| 20% | 79 | 72 | | | | | | | | |
| 25% | 80 | 72 | | | | | | | | |
| 30% | 81 | 73 | 71 | | | | | | | |
| 35% | 82 | 73 | 71 | | | | | | | |
| 40% | 84 | 74 | 71 | | | | | | | |
| 45% | 85 | 74 | 71 | | | | | | | |
| 50% | 86 | 75 | 72 | | | | | | | |
| 55% | 87 | 76 | 72 | | | | | | | |
| 60% | 88 | 76 | 73 | | | | | | | |
| 65% | 90 | 77 | 74 | | | | | | | |
| 70% | 91 | 78 | 75 | 70 | | | | | | |
| 75% | 92 | 79 | 76 | 71 | | | | | | |
| 80% | 93 | 81 | 77 | 72 | | | | | | |
| 85% | 94 | 82 | 78 | 74 | | | | | | |
| 90% | 96 | 83 | 79 | 75 | | | | | | |
| 95% | 97 | 85 | 81 | 76 | 71 | | | | | |
| 100% | 98 | 86 | 82 | 78 | 73 | | | | | |

$P_E >= 1.0$ inches

will reduce the RCN to reflect "woods in good condition"

# Step 1a: Determine Stormwater Management Goal

- Stormwater management target for Mountainside Meadows subdivision project is $P_E$ = 1.0 inches
- Target rainfall then needs to be translated into a volume target ($V_{PE}$):

$$V_{PE} = \frac{(P_E)(R_V)(A)}{12}$$

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)

# Step 1a:
# Determine Stormwater Management Goal

$$V_{PE\ DA\ \#1} = \frac{(P_E)(R_V)(A)}{12} = \frac{(1.0)(.194)(8)}{12} = 0.129 \text{ ac-ft}$$

$$= 5{,}619 \text{ ft}^3$$

$$V_{PE\ DA\ \#2} = \frac{(P_E)(R_V)(A)}{12} = \frac{(1.0)(.122)(12)}{12} = 0.122 \text{ ac-ft}$$

$$= 5{,}314 \text{ ft}^3$$

# Step 2:
# Apply Non-Structural Practices

- Rooftop Disconnection:
  - Two houses in DA #1, two houses in DA #2
  - Average rooftop area is 2,500ft$^2$
  - (2 houses) x (2,500 ft2) / (43,560 ft2/ac) = 0.11 acres in each DA
- Assume disconnection flow path length will be 35 feet for all houses

| | Disconnection Flow Path Length (ft.) | | | |
|---|---|---|---|---|
| | 15 | 35 | 55 | 75 |
| $P_E$ (in.) = | 0.2 | 0.4 | 0.6 | 0.8 |

# Step 2:
# Apply Non-Structural Practices

- Rooftop Disconnection:
  - Need to "translate" $P_E$ to and equivalent $V_{PE}$ so that the cumulative volume for structural and non-structural practices

$$\mathbf{V_{PE}} = \frac{(P_E)(R_V)(A)}{12} = \frac{(0.4)(.95)(0.11)}{12} = 0.003 \text{ ac-ft}$$

**= 152 ft$^3$ for each DA**

# Step 2:
# Apply Non-Structural Practices

- Rooftop Disconnection:
  - The remaining $V_{PE}$ that must be captured and treated for each drainage area is:

$$V_{PE\ DA\ \#1} = 5{,}634\ ft^3 - 152\ ft^3 = \mathbf{5{,}482\ ft^3}$$

$$V_{PE\ DA\ \#2} = 5{,}314\ ft^3 - 152\ ft^3 = \mathbf{5{,}162\ ft^3}$$

# Step 3:
# Apply Structural (GSI) Practices

- Permeable Pavements for the Driveways:
  - All driveways will be constructed w/ permeable pavements and include 9" of subbase
  - ~1600 $ft^2$ of driveway in DA #1 and ~2700 $ft^2$ of driveway in DA #2

| Hydrologic Soil Group | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | A | | | B | | | C | | |
| subbase | RCN | $V_{PE}/ft^2$ | Equiv $P_E$ (in) | RCN | $V_{PE}/ft^2$ | Equiv $P_E$ (in) | RCN | $V_{PE}/ft^2$ | Equiv $P_E$ (in) |
| 6" | 76 | 0.138 | 1.7 | 84 | 0.101 | 1.3 | 93 | 0.043 | 0.5 |
| 9" | 62 | 0.183 | 2.3 | 65 | 0.175 | 2.2 | 77 | 0.134 | 1.7 |
| 12" | 40 | 0.206 | 2.6 | 55 | 0.196 | 2.5 | 70 | 0.160 | 2.0 |

# Step 3:
# Apply Structural (GSI) Practices

- Permeable Pavements for the Driveways:
  - Calculate $V_{PE}$ addressed by the practice

$$V_{PE\ DA\ \#1} = 0.134\ ft \times 1{,}600\ ft^2 = \mathbf{214\ ft^3}$$

$$V_{PE\ DA\ \#2} = 0.134\ ft \times 2{,}700\ ft^2 = \mathbf{362\ ft^3}$$

  - Calculate the remaining, unmanaged $V_{PE}$

$$V_{PE\ DA\ \#1} = 5{,}482\ ft^3 - 214\ ft^3 = \mathbf{5{,}268\ ft^3}$$

$$V_{PE\ DA\ \#2} = 5{,}162\ ft^3 - 362\ ft^3 = \mathbf{4{,}800\ ft^3}$$

# Step 3:
# Apply Structural (GSI) Practices

- Bioretention:
  - The large cul-de-sac in DA #1 will be treated using a bioretention facility
  - Total area draining to the facility is 0.85 acres, of which 0.50 acres is impervious
  - Surface area of proposed bioretention facility is 2,500 $ft^2$

- Calculate the amount of rainfall captured ($P_E$):

$$P_E = \frac{15'' \times A_f}{DA} = \frac{15'' \times 2{,}500\ ft^2}{37{,}026\ ft^2} = 1.01 \text{ inches}$$

# Step 3:
# Apply Structural (GSI) Practices

- Bioretention:
  - Area draining to bioretention facility is 59% impervious ($R_v$ = 0.58), so the volume of water captured by the facility is calculated as follows:

$$V_{PE} = \frac{(P_E)(R_V)(A)}{12} = \frac{(1.01 \text{ inches})\ (0.58)\ (37{,}026 \text{ ft}^2)}{12}$$

$$= \mathbf{1{,}807\ ft^3}$$

  - Calculate the remaining, unmanaged $V_{PE}$

$$V_{PE\ DA\ \#1} = 5{,}268 \text{ ft}^3 - 1{,}807 \text{ ft}^3 = \mathbf{3{,}461\ ft^3}$$

# Step 3:
# Apply Structural (GSI) Practices

- Swales:
  - Remaining $V_{PE}$ in DA #1 (3,461 $ft^3$) and DA #2 (4,800 $ft^3$) will be treated using grass swales, installed along roads within the subdivision
  - Swales in DA #1 will capture and treat runoff from 0.65 acres of roadway (impervious) surface (or 925 lineal feet) and 0.10 acres of open space
    *(87% impervious; $R_v$ = 0.83)*
  - Swales in DA #2 will capture and treat runoff from 0.83 acres of roadway (or 1,250 lineal feet) and 0.15 acres of open space
    *(87% impervious; $R_v$ = 0.83)*
  - Swale bottoms will be 6' wide and run the full length of the road

# Step 3:
# Apply Structural (GSI) Practices

- Swales:
  - For DA #1:

$$P_{E\ DA\ \#1} = \frac{10'' \times A_f}{DA} = \frac{10'' \times 5{,}550\ ft^2}{32{,}670\ ft^2} = \mathbf{1.70\ inches}$$

where: DA = the area draining to the practice (acres)

$A_f$ = the surface area of the practice

10" = a constant specific to the practice type, based on the relationship of drainage area to surface area of the practice

# Step 3:
# Apply Structural (GSI) Practices

- Swales:
  - For DA #1:

$$V_{PE} = \frac{(P_E)(R_V)(A)}{12} = \frac{(1.70 \text{ inches})\ (0.83)\ (32{,}670 \text{ ft}^2)}{12}$$

$$= \mathbf{3{,}839\ ft^3}$$

  - The remaining $V_{PE}$ (3,544ft$^3$) will therefore be fully treated by the swale

# Step 3:
# Apply Structural (GSI) Practices

- Swales:
  - For DA #2:

$$P_{E\ DA\ \#2} = \frac{10'' \times A_f}{DA} = \frac{10'' \times 7{,}500\ ft^2}{42{,}689\ ft^2} = \mathbf{1.76\ inches}$$

and

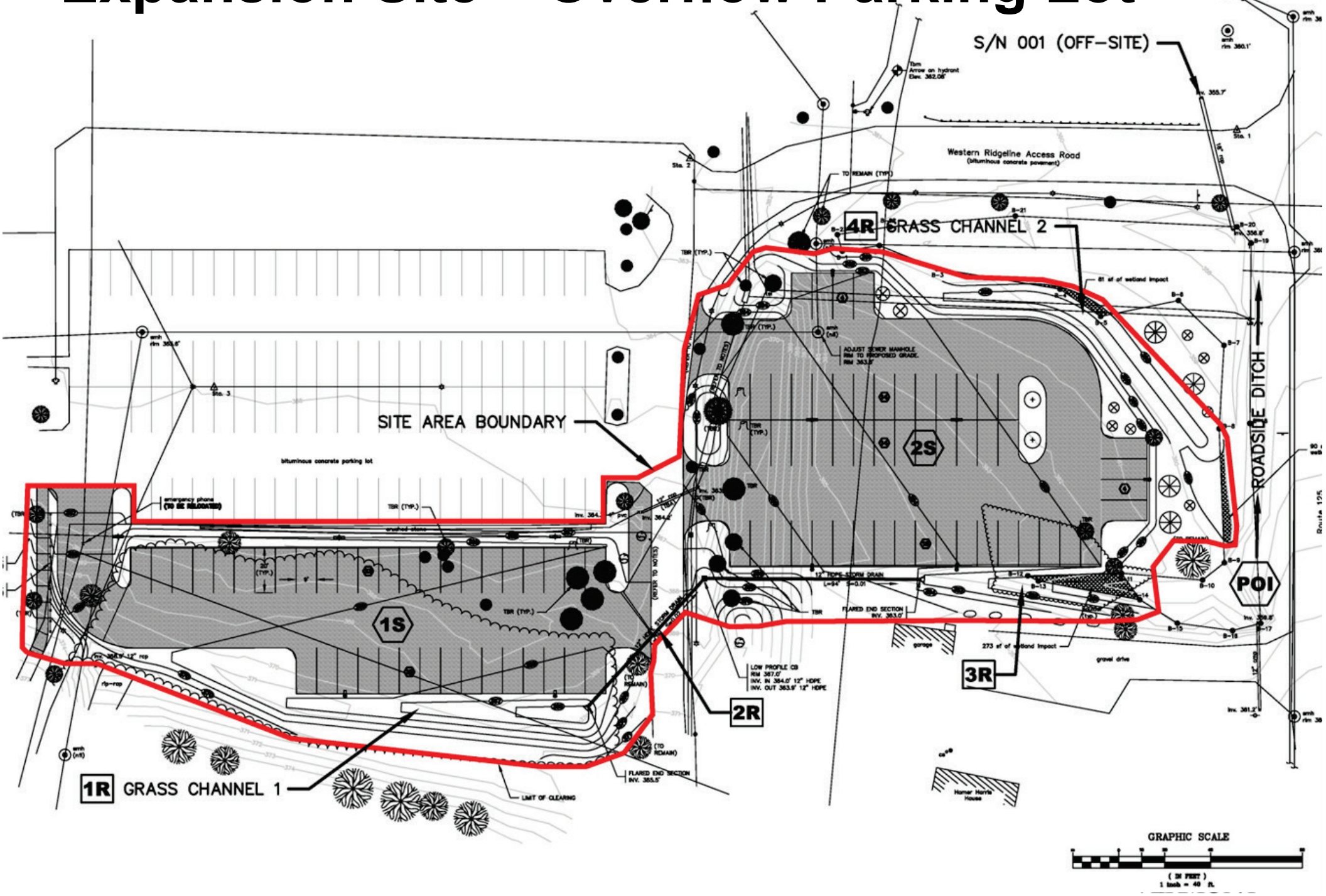
$$V_{PE} = \frac{(P_E)(R_V)(A)}{12} = \frac{(1.70\ inches)\ (0.83)\ (32{,}670\ ft^2)}{12}$$

$$= \mathbf{5{,}124\ ft^3}$$

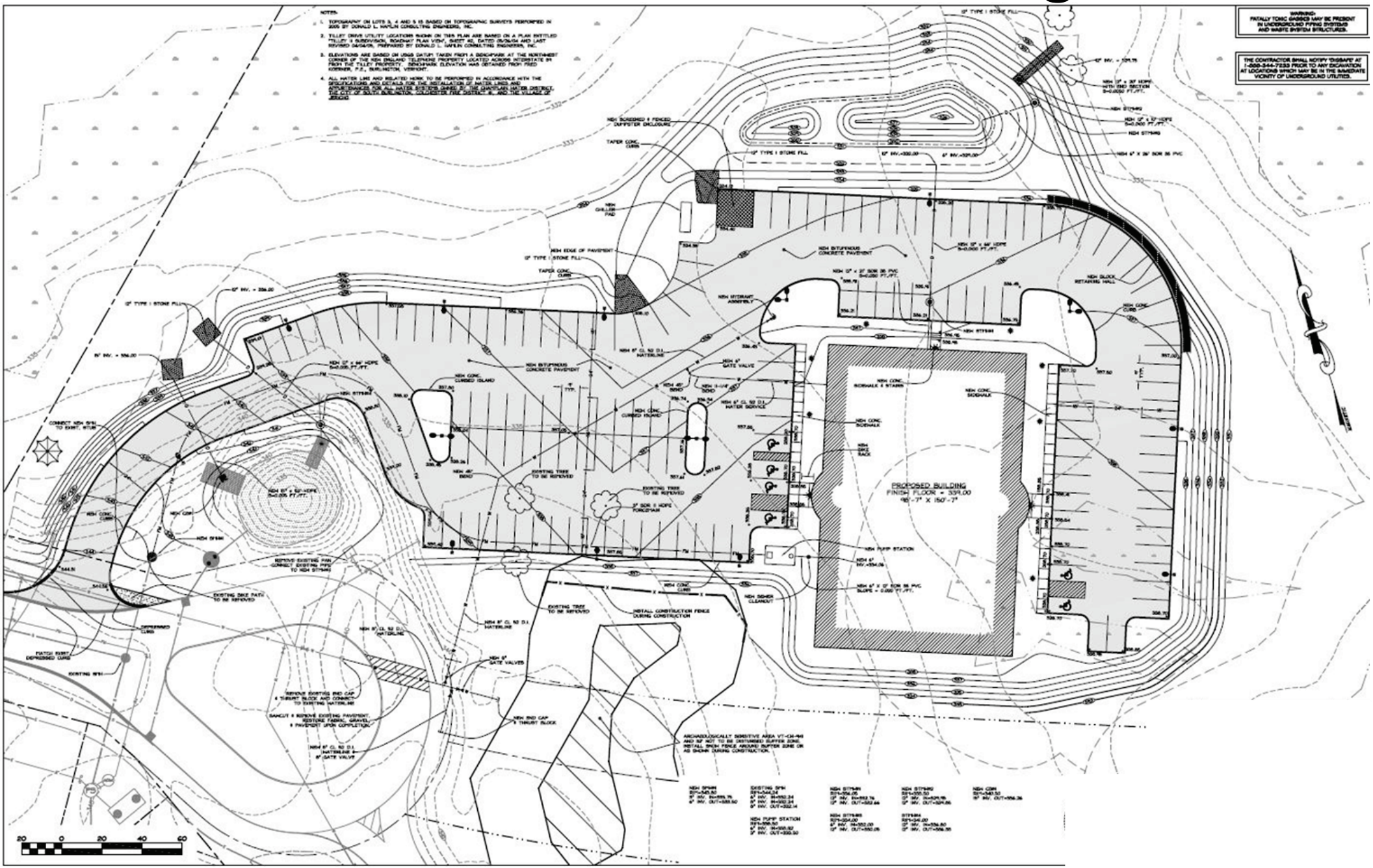
  - The remaining $V_{PE}$ (4,800 $ft^3$) will therefore be fully treated by the swale

# Questions?

# Expansion Site – Overflow Parking Lot



# Commercial Site – Lacustrine Lodge



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