Applying the Water Quality Volume

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Post-Construction Storm Water Mgmt.

"So that a receiving stream's physical, chemical and biological characteristics are protected, and stream functions are maintained, post-construction practices shall provide long-term management of runoff quality and quantity."

General Permit Authorization for Storm Water Discharges Associated with Construction Activity Under The NPDES. OEPA Permit #OHC00005, Effective 4/23/2018

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1. Effective BMP

Table 4a Extended Detention Post-Construction Practices with Minimum Drain Times

Extended Detention Practices	Minimum Drain Time of WQv
Wet Extended Detention Basin[1,2]	24 hours
Constructed Extended Detention Wetland[1,2]	24 hours
Dry Extended Detention Basin[1,3]	48 hours
Permeable Pavement – Extended Detention[1]	24 hours
Underground Storage – Extended Detention[1,4]	24 hours
Sand & Other Media Filtration - Extended Detention[1,5]	24 hours

Table 4b Infiltration Post-Construction Practices with Maximum Drain Times

Infiltration Practices	Maximum Drain Time of WQv
Bioretention Area/Cell[1,2]	24 hours
Infiltration Basin	24 hours
Infiltration Trench[2]	48 hours
Permeable Pavement – Infiltration[3]	48 hours
Underground Storage – Infiltration[3,4]	48 hours

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2. Water Quality Volume (WQv)

$$WQv = P_{wq} \times Rv \times A \div 12$$

WQv = water quality volume (ac-ft)

P_{wq} = 0.90 inches

Rv = volumetric runoff coefficient

A = disturbed or contributing drainage area (acres)

Runoff Coefficient

$$Rv = 0.05 + 0.9(i)$$

- i = fraction impervious (impervious area ÷ total area)

- Volumetric, not influenced by conditions such as intensity
  - Similar but not same as rational method coefficient “C”

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CALCULATION SCENARIOS

- New Construction
- Previously Developed Areas (Redevelopment)
- Water Quality Flow

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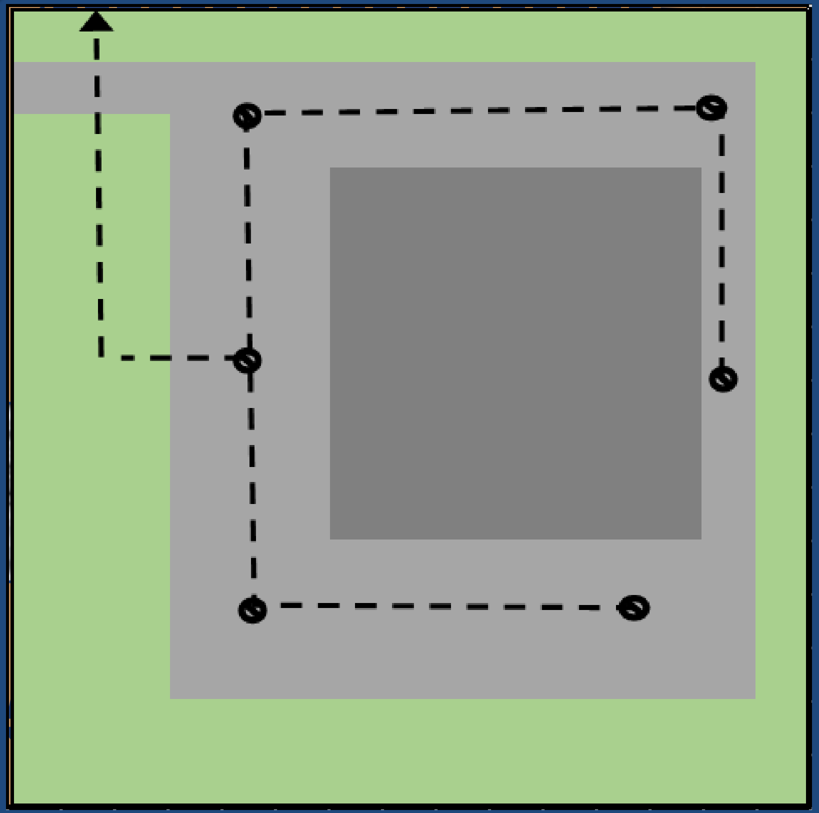
Example Site

Total site area:	2.25 acres
Total disturbed area:	2.25 acres
Planned impervious area:	1.35 acres



<u>All WQv's will be shown in cubic feet</u>

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NEW DEVELOPMENT

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WQv Required

$$WQv = P_{wq} \times Rv \times A_{disturbed} \div 12$$

$$Rv = 0.05 + 0.9(i)$$

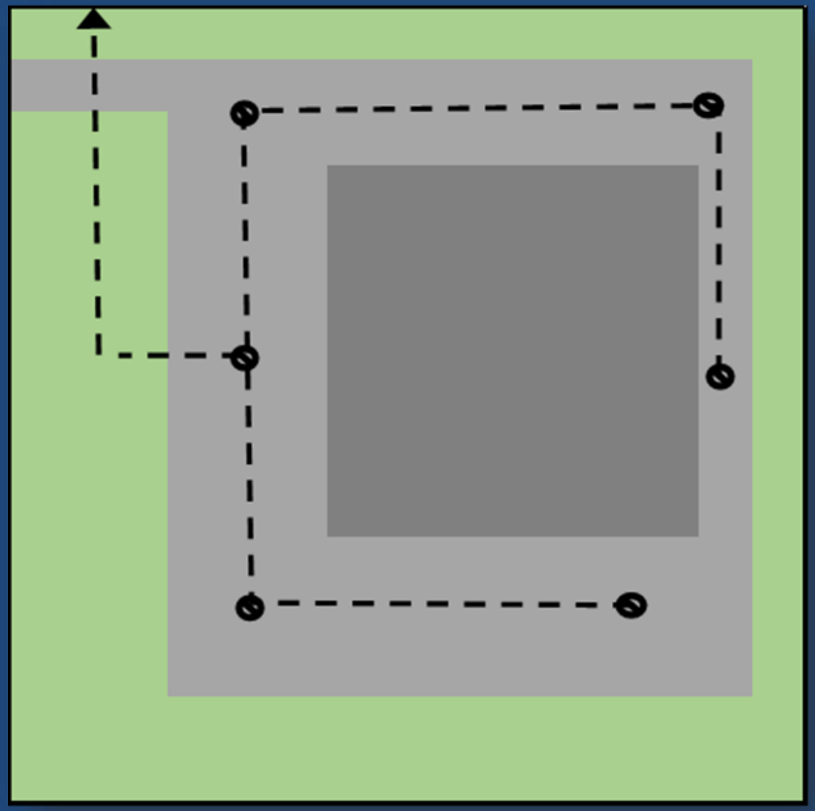
Where:

$i = 1.35\ ac \div 2.25\ ac = 0.60$ (60%)

$Rv = 0.05 + 0.9(0.60) = 0.59$

$P_{wq} = 0.90$ in

$A = 2.25$ ac



WQv (required) = 0.100 ac-ft (4,337 ft^3)

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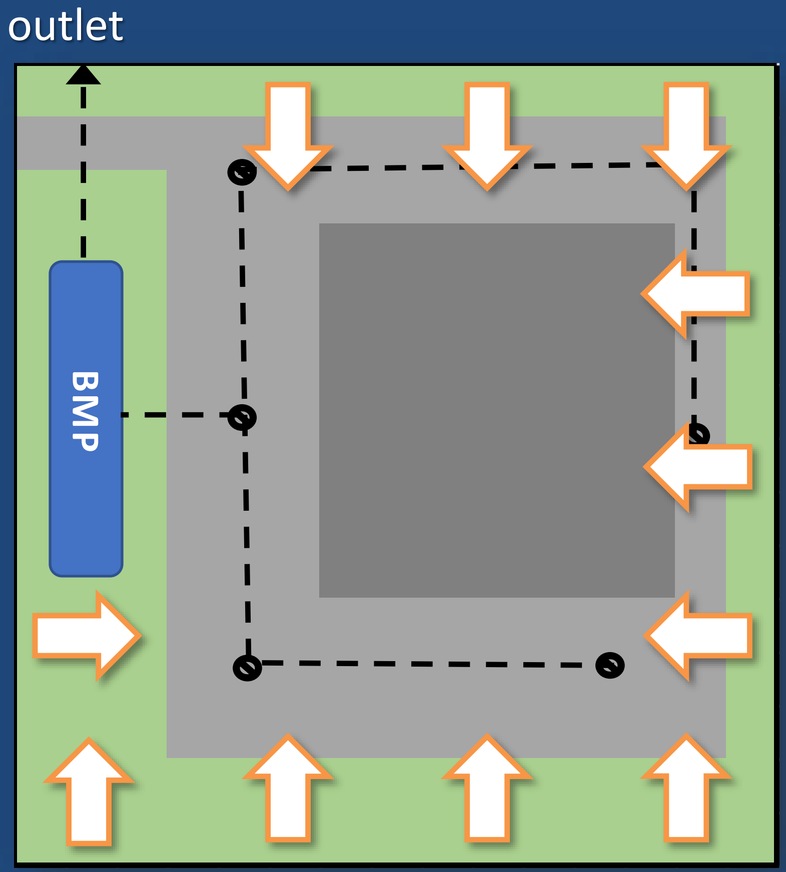
WQv Design

The site is required to treat 4,337 ft^3 with post-construction BMPs; however each post-construction BMP must be designed to treat 100% of the WQv for its contributing area.

The full 2.25 acre disturbance is graded toward a single post-construction BMP. In this case, the disturbed area and BMP drainage area are both 2.25 acres with Rv = 0.59:

WQv (design) = WQv (required) = 4,337 ft^3



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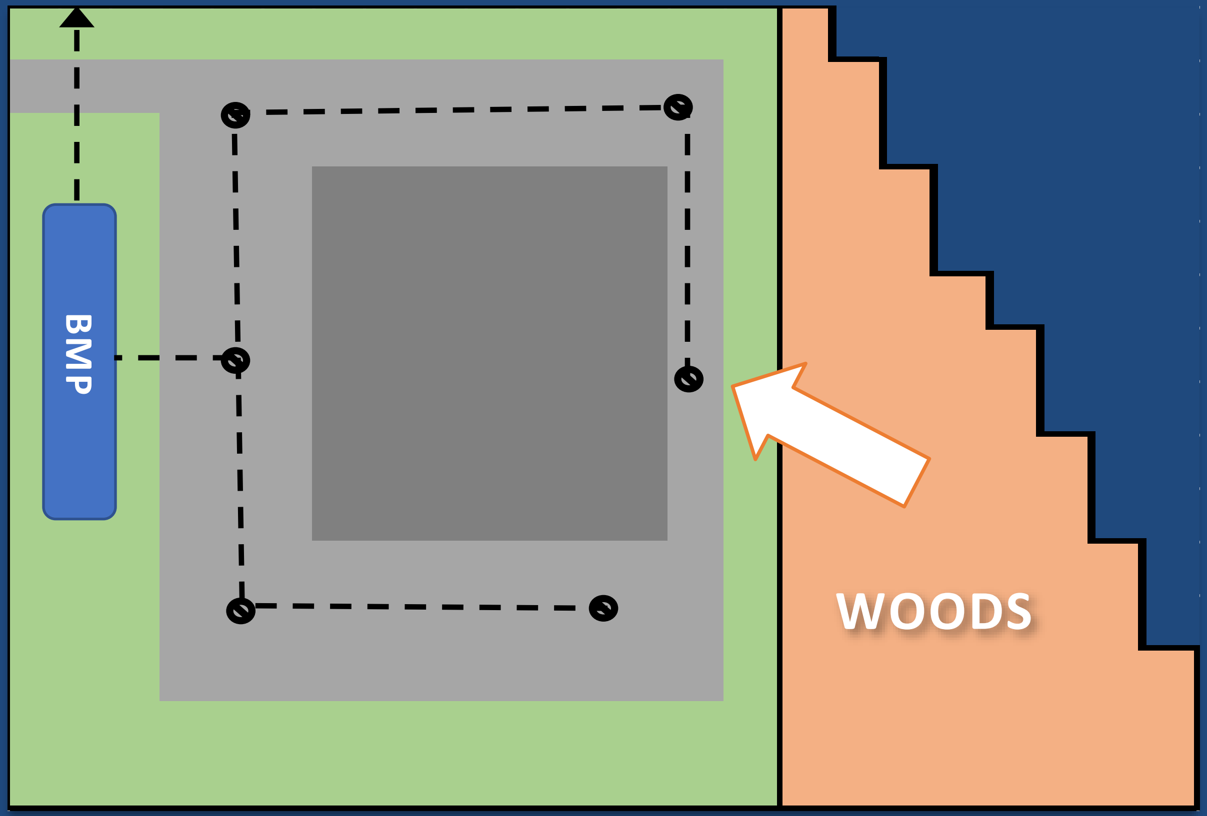
Offsite Run-on

An additional 0.75 acres runs onto the site from beyond the disturbance, draining to the post-construction BMP.

Unless diverted, the BMP design WQv must include this contributing drainage area.



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Offsite Run-on

$$Rv = 0.05 + 0.9(i)$$

$i = 1.35$ ac ÷ 3.00 ac $= 0.45$ (45%)

$Rv = 0.05 + 0.9(0.45) = 0.455$

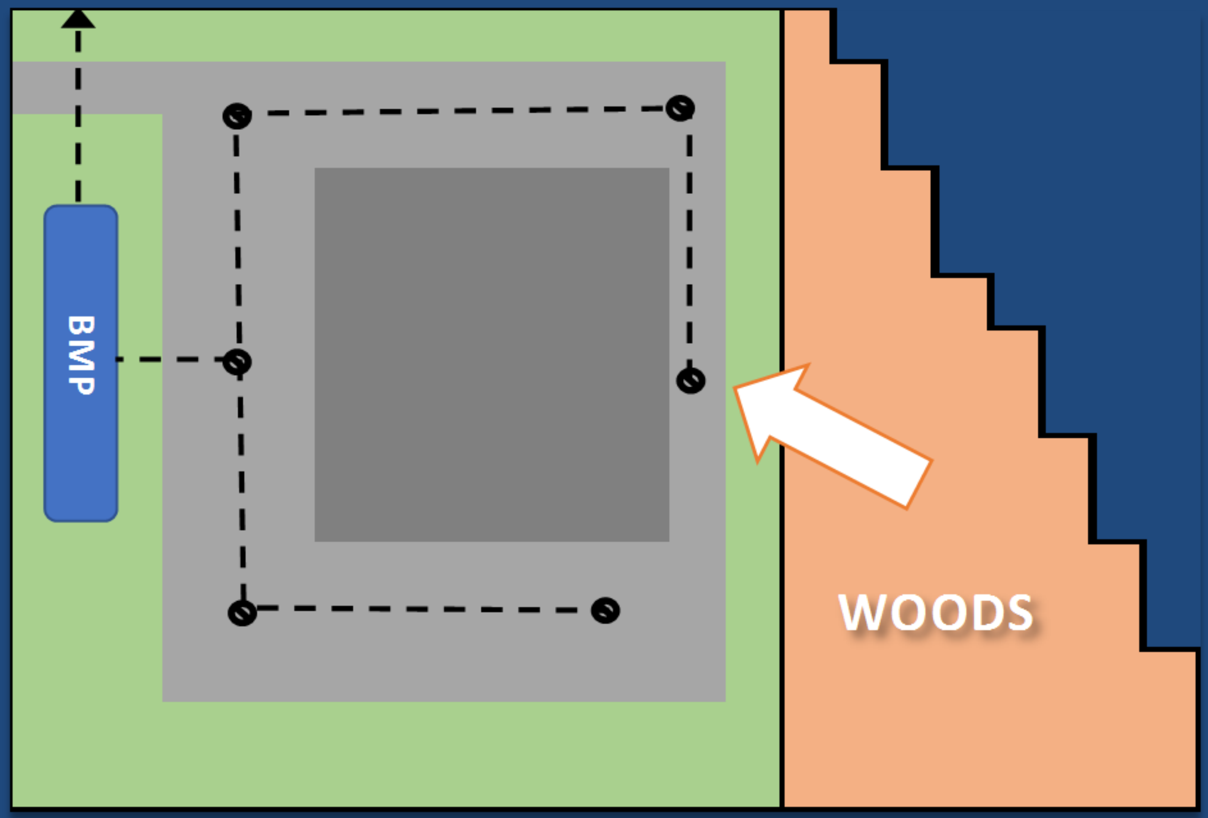
$$WQv = P_{wq} \times Rv \times A_{drained} \div 12$$

Where:

$P_{wq} = 0.90$ in

$Rv = 0.455$

$A = 3.00$ ac



WQv (design) = 4,460 ft^3

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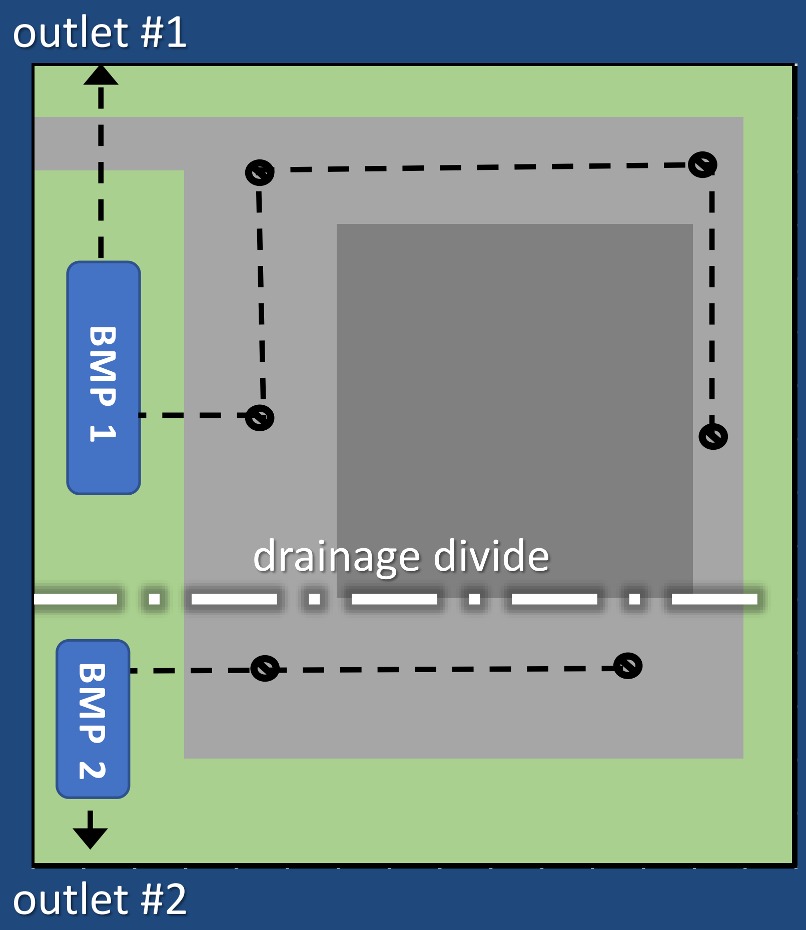
Multiple Drainage Areas

If the disturbed area contains separate drainage areas, each must have a post construction BMP sized to its contributing drainage area.



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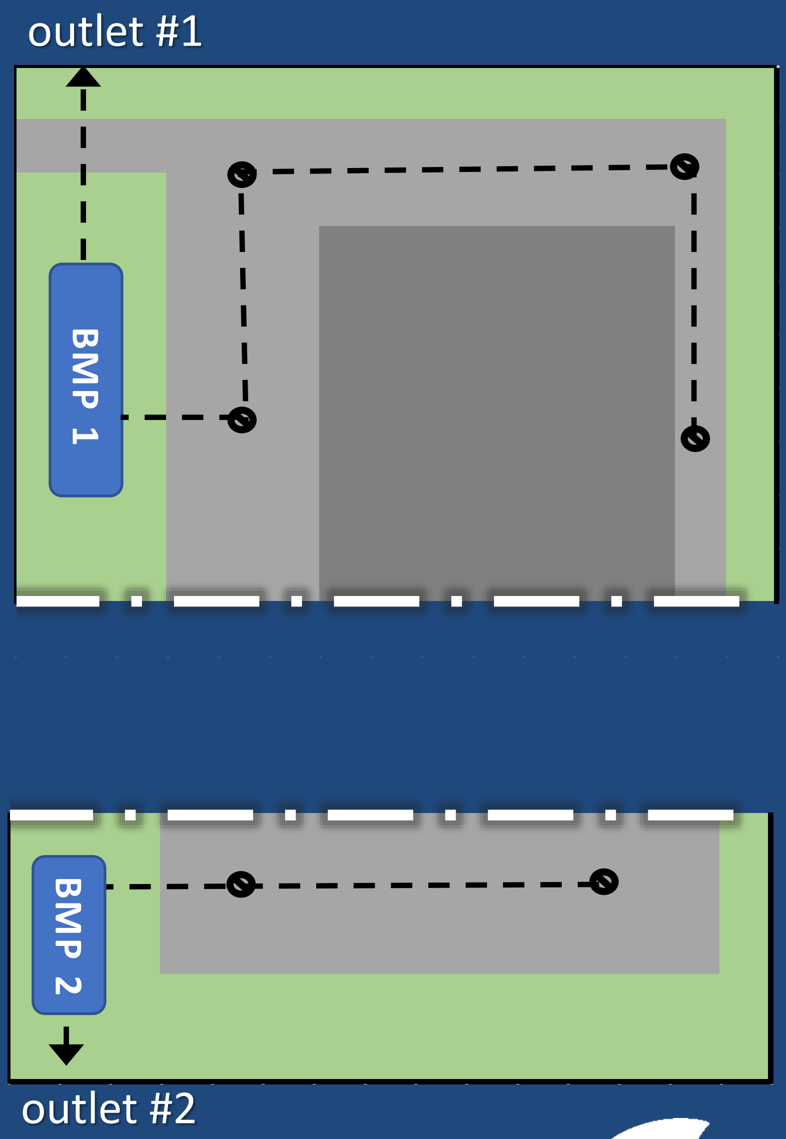
Multiple Drainage Areas



Drainage Area #1

Total area: 1.50 ac

Impervious: 68%

$Rv = 0.05 + 0.9(0.68) = 0.662$

Drainage Area #2

Total area: 0.75 ac

Impervious: 44%

$Rv = 0.05 + 0.9(0.44) = 0.446$

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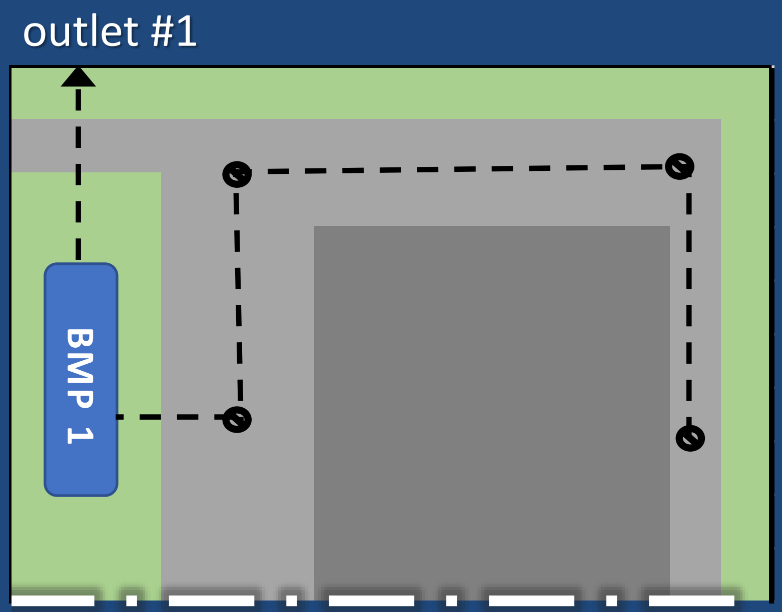
Multiple Drainage Areas



Drainage Area #1

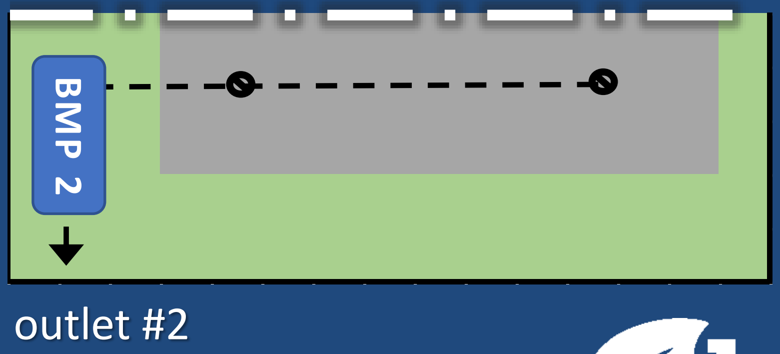
WQv = 0.90 in x 0.662 x 1.50 ac ÷ 12

WQv (design) = 3,244 ft^3

Drainage Area #2

WQv = 0.90 in x 0.446 x 0.75 ac ÷ 12

WQv (design) = 1,093 ft^3



WQv (design) = 3,244 + 1,093 = 4,337 ft^3

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Multiple Drainage Areas

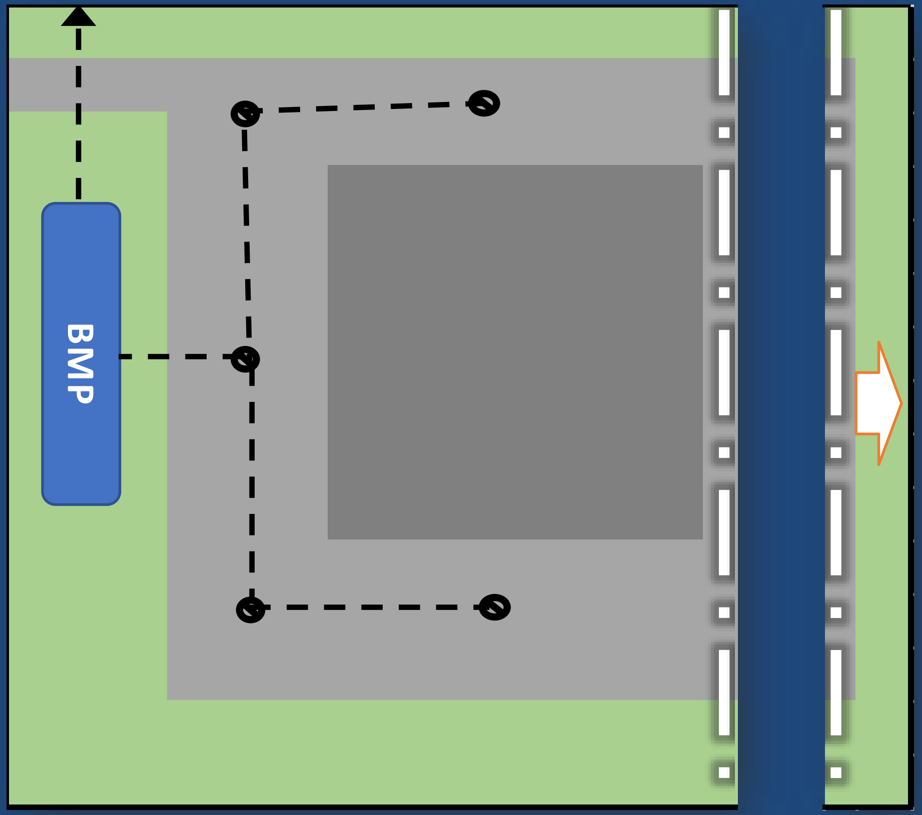
Total area: 0.225 ac

Impervious: 27%

$Rv = 0.05 + 0.9(0.27) = 0.293$

$WQv = 0.9 \text{ in} \times 0.293 \times 0.225 \div 12$

$WQv = 215 \text{ ft}^3$



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Minor Drainage Areas

RRM using a grass filter strip or infiltration trench (to spec.):

Runoff Reduction Practice	Impervious Cover in Contributing Drainage Area	Pervious Cover in Contributing Drainage Area	Volume Received by Practice	
	(ft^2)	(ft^2)	(ft^3)	
Sheetflow to Grass Filter Strip with C/D Soils	2644	7157	215	R fi

Disconnection Area of Practice	Storage Volume Provided by Practice	Runoff Reduction Volume	Remaining Volume
(ft^2)	(ft^3)	(ft^3)	(ft^3)
7157	N/A	215	1

Runoff Reduction Practice	Impervious Cover in Contributing Drainage Area	Pervious Cover in Contributing Drainage Area	Volume Received by Practice
	(ft^2)	(ft^2)	(ft^3)
7. Infiltration Practice			
Infiltration Practice	2644	7157	215

Storage Volume Provided by Practice	Runoff Reduction Volume	Remaining Volume
(ft^3)	(ft^3)	(ft^3)
1560	215	0

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PREVIOUSLY DEVELOPED AREAS

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Options for Previously Developed Areas

1. Reduce the site Rv at least 20%, or

2. Use a post-c BMP with the WQv from CGP equation 3:

$$WQv = [(0.2 \times Rv_1) + (Rv_2 - Rv_1)] \times P_{wq} \times A_{dist}$$

Where:

Rv_1 = Pre-development runoff coefficient

Rv_2 = Post-development runoff coefficient

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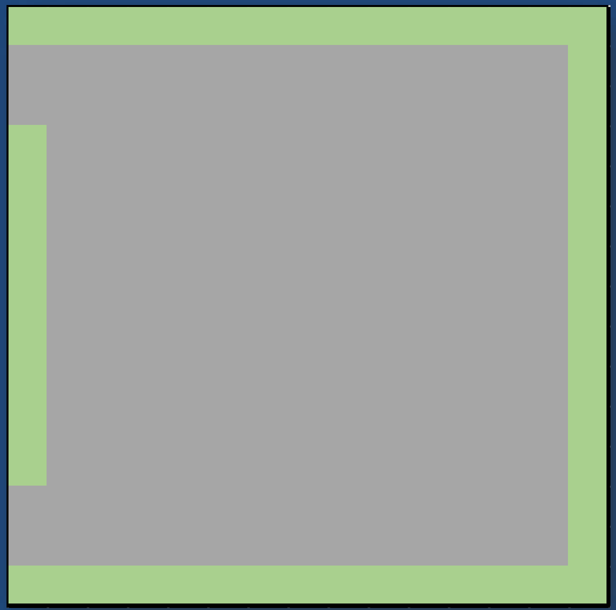
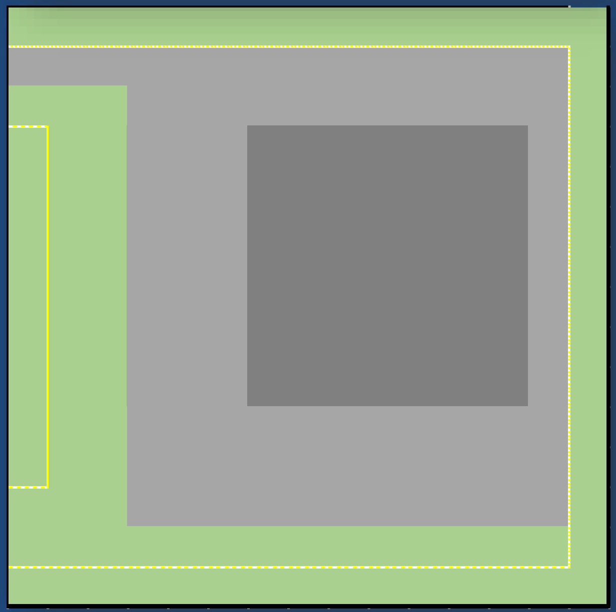
1. Decrease Rv ≥ 20%



Existing site

impervious = 77%

$Rv_1 = 0.05 + 0.9(0.77) = 0.743$



Proposed site

impervious = 60%

$Rv_2 = 0.05 + 0.9(0.60) = 0.590$

Rv decreases by 20%, no additional BMP required

(0.59 ÷ 0.743) - 100% = 21% decrease

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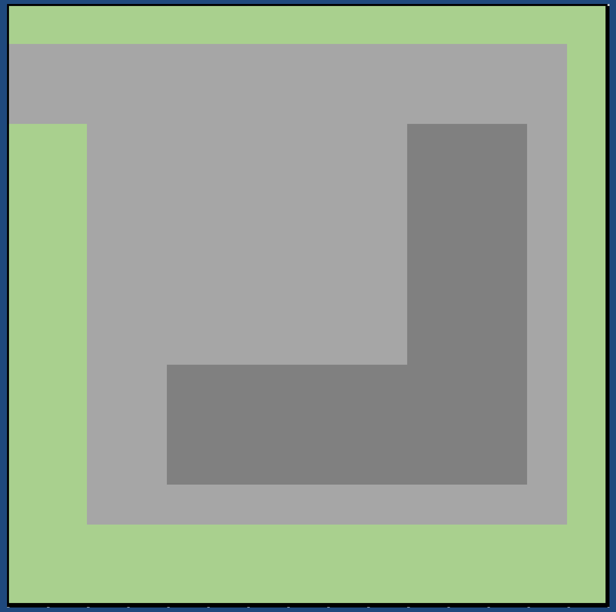
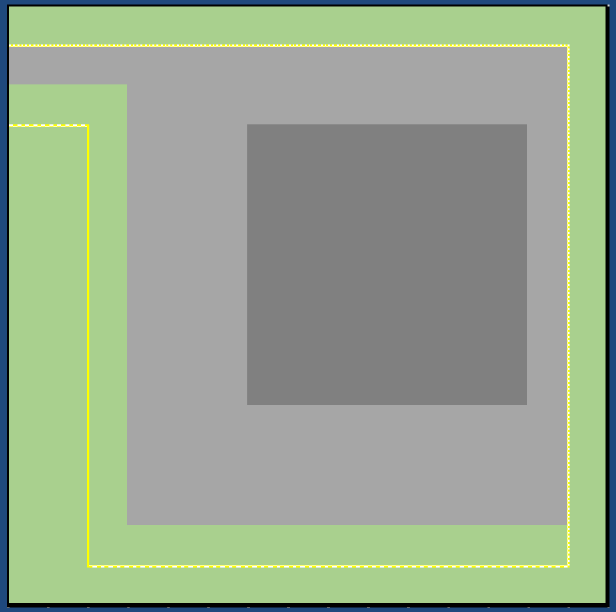
2. BMP w/ Decreased Rv



Existing site

impervious = 66%

$Rv_1 = 0.05 + 0.9(0.66) = 0.644$



Proposed site

impervious = 60%

$Rv_2 = 0.05 + 0.9(0.60) = 0.590$

100% - (0.590 ÷ 0.644) = 8.4% decrease

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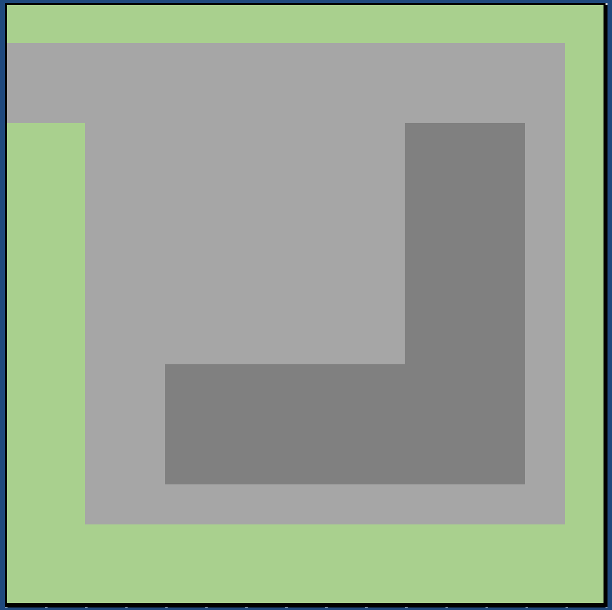

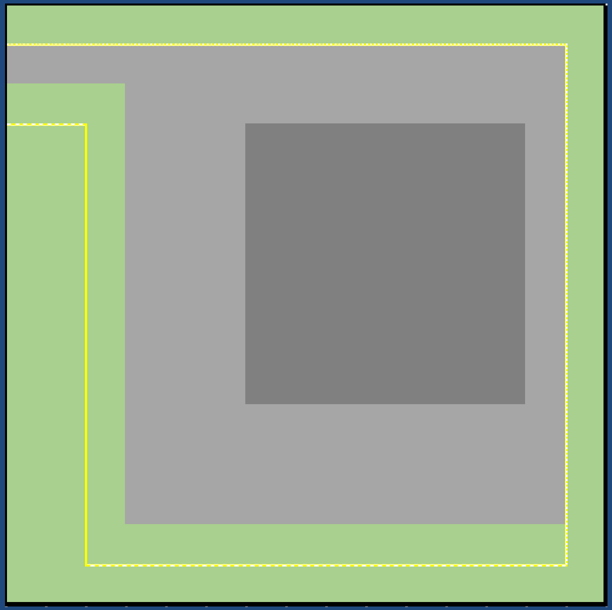

2. BMP w/ Decreased Rv

A post construction BMP is required for the WQv as calculated:

$$WQv = [(Rv_1 \times 0.2) + (Rv_2 - Rv_1)] \times P_{wq} \times A_{dist}$$

$$= [(0.644 \times 0.2) + (0.590 - 0.644)] \times 0.9 \text{ in} \times 2.25 \text{ ac}$$

WQv (required) = 550 ft^3

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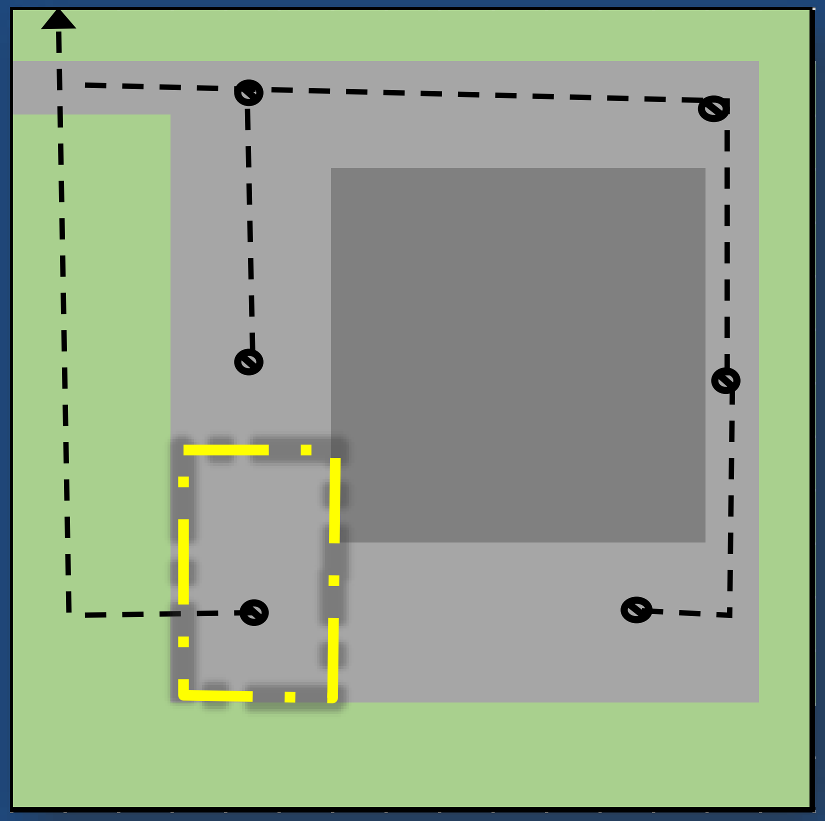
2. BMP w/ Decreased Rv

The site is required to treat 550 ft³ with post-construction BMPs; however each post-construction BMP must be designed to treat 100% of the WQv for its contributing area. Place the BMP such that its drainage area* is equal to or greater than:

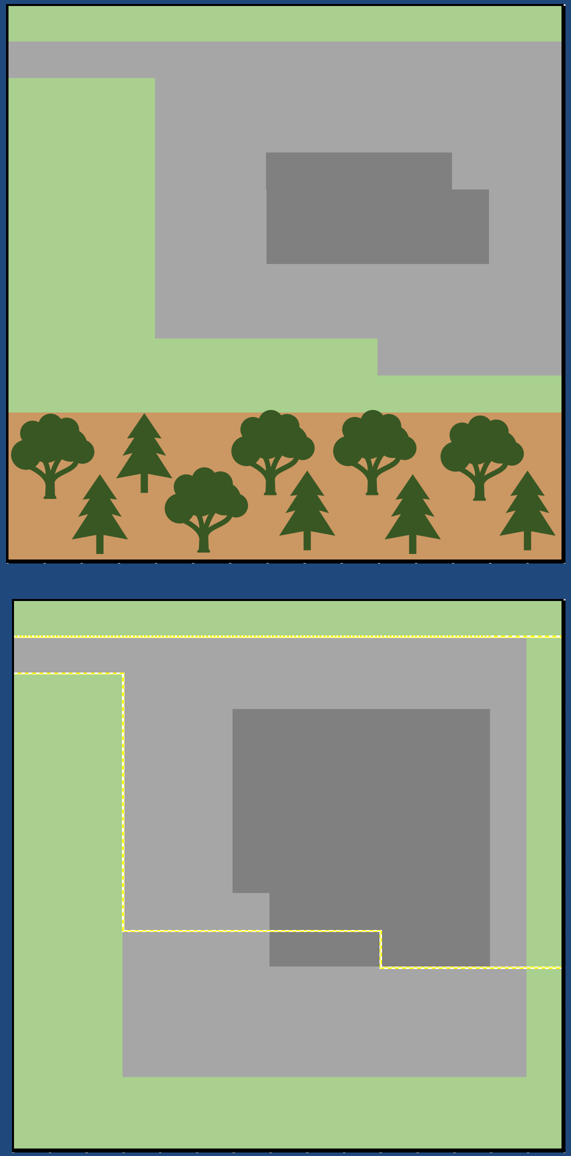
$$A_{drainage} = \frac{WQ_v}{P_{wq} \times Rv} \times \frac{12}{43{,}560}$$

$$\frac{550\ ft^3}{0.9'' \times 0.95} \times \frac{12}{43{,}560} = 0.18\ ac$$



* Should be highest expected pollutant load area

What if Rv will increase ?



Existing site

impervious = 43%

$Rv_1 = 0.05 + 0.9(0.43) = 0.437$

Proposed site

impervious = 60%

$Rv_2 = 0.05 + 0.9(0.60) = 0.590$

(0.590 ÷ 0.437) - 100% = 35% increase

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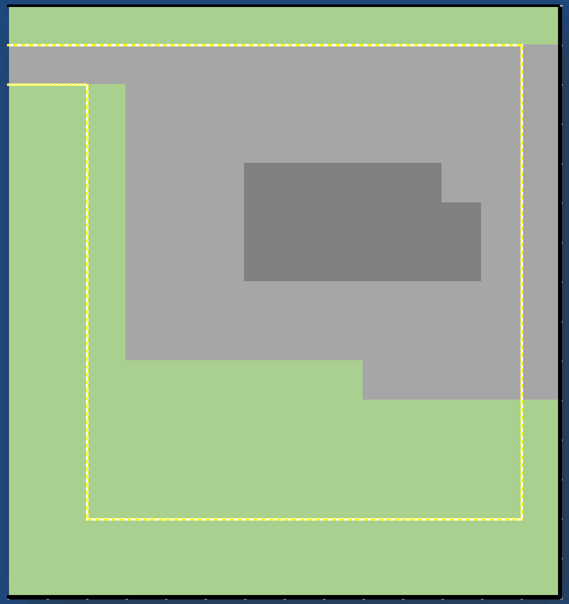

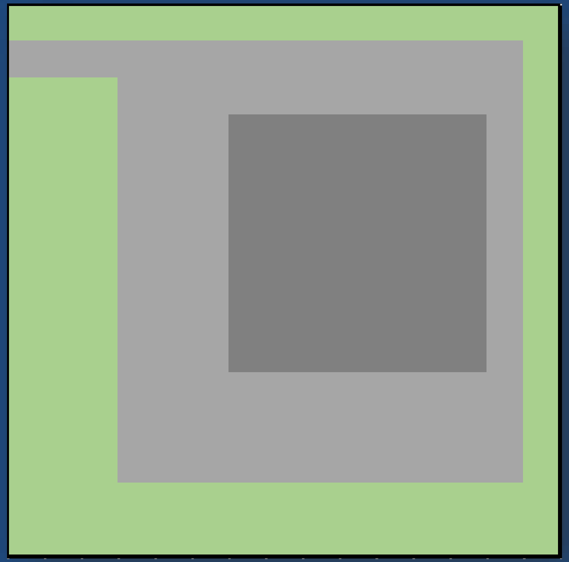

What if Rv will increase ?

Using CGP Equation 3 (weighted Rv):

$$WQv = [(Rv_1 \times 0.2) + (Rv_2 - Rv_1)] \times P_{wq} \times A_{dist}$$

$$= [(0.437 \times 0.2) + (0.590 - 0.437)] \times 0.9 \text{ in} \times 2.25 \text{ ac}$$

WQv (required) = 1,766 ft^3

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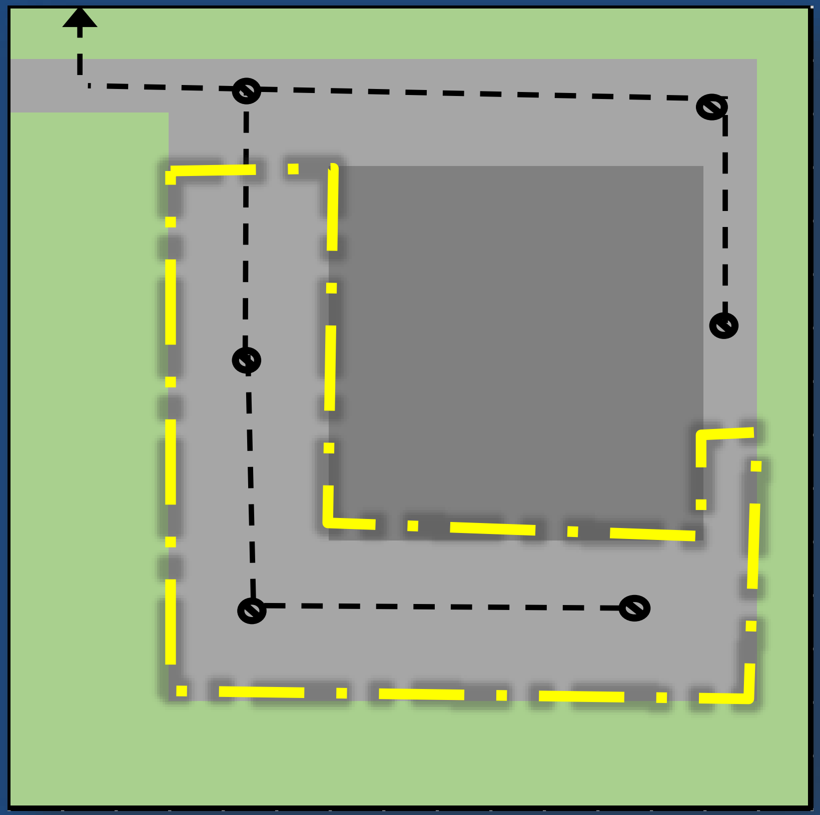
Rv Increases - Applied

The site is required to treat 1,766 ft^3 with post-construction BMPs; however each post-construction BMP must be designed to treat 100% of the WQv for its contributing area. Place the BMP such that its drainage area* is equal to or greater than:

$$A_{drainage} = \frac{WQ_v}{P_{wq} \times Rv} \times \frac{12}{43{,}560}$$

$$\frac{1{,}766\ ft^3}{0.9\ in \times 0.95} \times \frac{12}{43{,}560} = 0.57\ ac$$



* Should be highest expected pollutant load area

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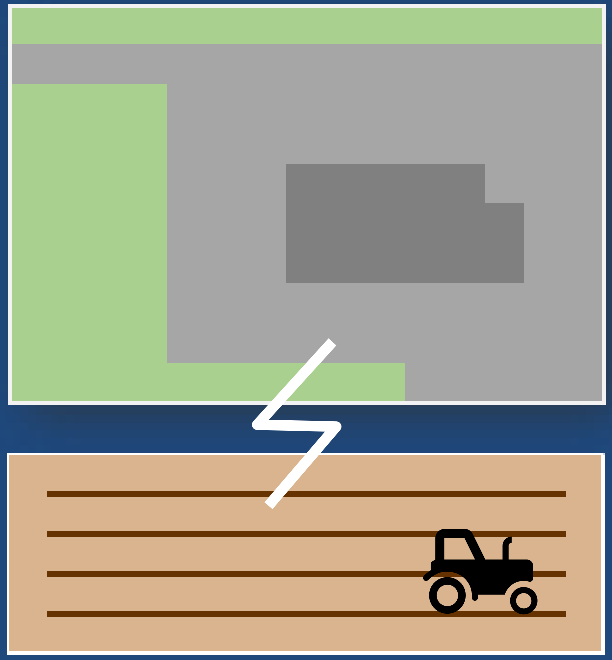
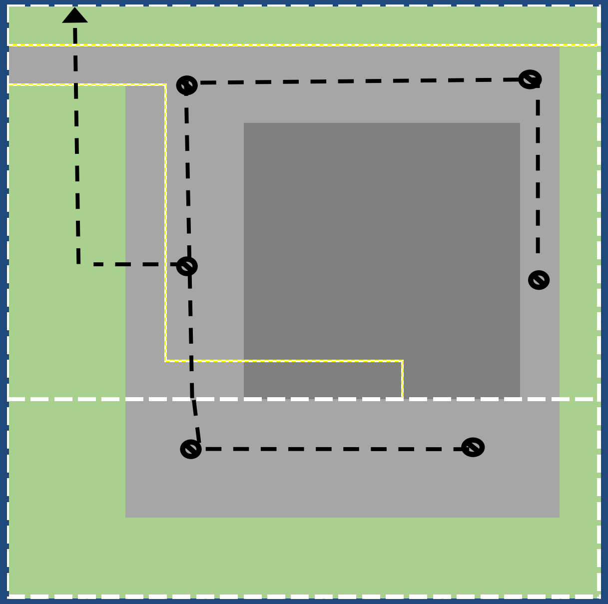
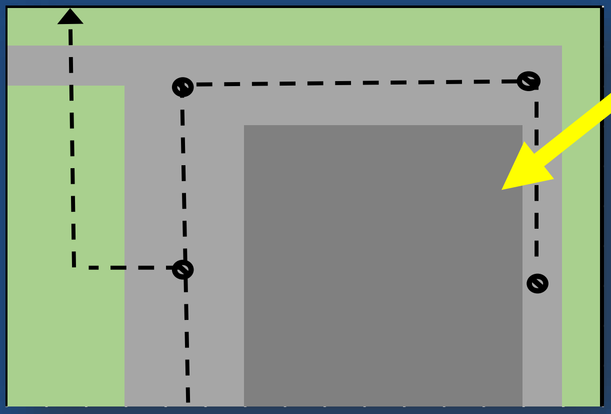
What if I mix new and old ?





1.50 acre site w/ existing impervious will be joined to a 0.75 acre undeveloped site to form a singular development.

What if I mix new and old ?



Redevelopment

$$WQv = [(Rv_1 \times 0.2) + (Rv_2 - Rv_1)] \times 0.9 \text{ in} \times 1.5 \text{ ac}$$

Where:

$i_1 = 0.97 \text{ ac} \div 1.50 \text{ ac} = 0.63$ (64.5%)

$Rv_1 = 0.05 + 0.9(0.60) = 0.59$

$i_2 = 1.02 \text{ ac} \div 1.50 \text{ ac} = 0.66$ (68%)

$Rv_2 = 0.05 + 0.9(0.60) = 0.59$

WQv (required) = 771 ft^3

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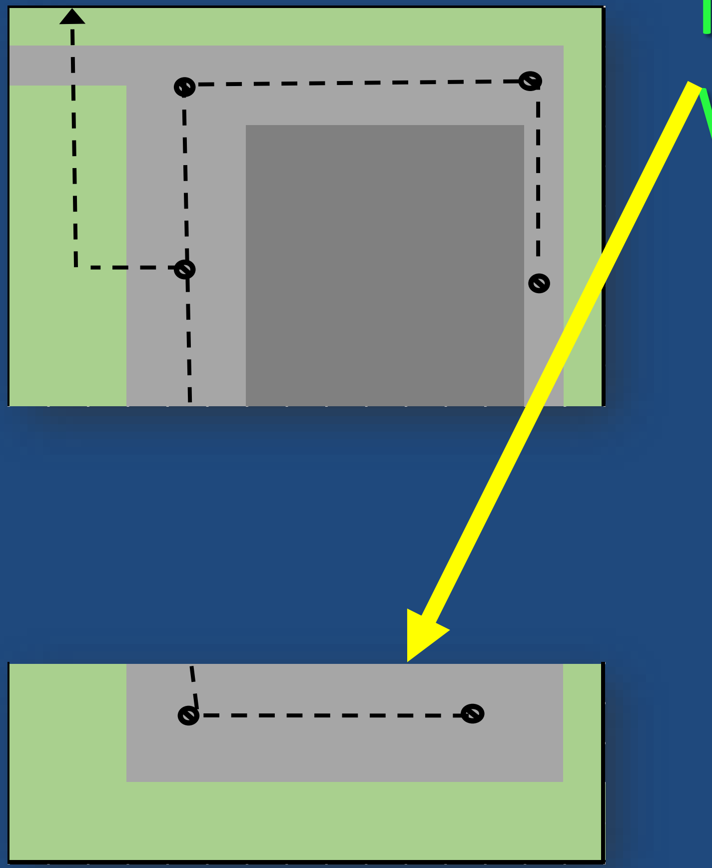
What if I mix new and old ?



New Development

$$WQv = 0.9\ in \times Rv \times 0.75\ ac \div 12$$

Where:

$i = 0.33\ ac \div 0.75\ ac = 0.45$ (44%)

$Rv = 0.05 + 0.9(0.60) = 0.59$

WQv (required) = 1,093 ft^3

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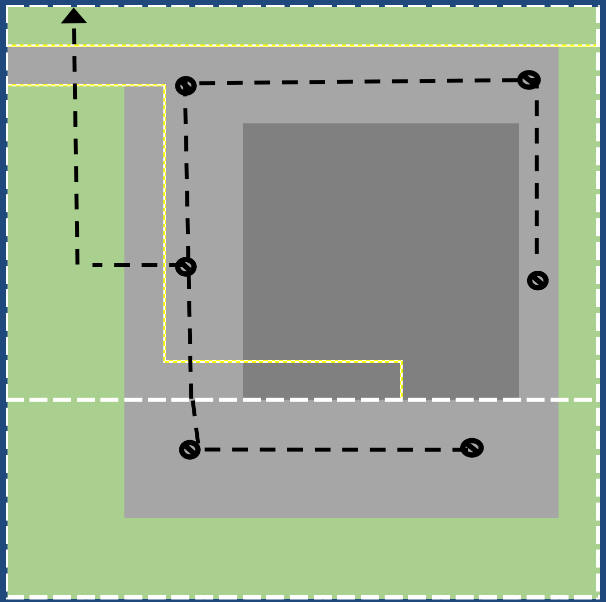
What if I mix new and old ?



WQv (required) =

$1{,}093\ ft^3 + 771\ ft^3 = 1{,}864\ ft^3$

WATER QUALITY FLOW

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Water Quality Flow

Flow-through practices (hydrodynamic separators, media / cartridge filters, grass swales) that do not provide a significant detention volume must use the Water Quality Flow (WQF):

$$WQF = C \times i \times A$$

Where:

WQF	= water quality discharge rate (cfs)
C	= runoff coefficient for use with rational method for estimating peak discharge
i	= rainfall intensity (in/hr)
A	= drainage area (ac)

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Table 3-1. Runoff Coefficients for Rational Formula.[14]

Type of Drainage Area	Runoff Coefficient, C*
Business:	
Downtown areas	0.70 - 0.95
Neighborhood areas	0.50 - 0.70
Residential:	
Single-family areas	0.30 - 0.50
Multi-units, detached	0.40 - 0.60
Multi-units, attached	0.60 - 0.75
Suburban	0.25 - 0.40
Apartment dwelling areas	0.50 - 0.70
Industrial:	
Light areas	0.50 - 0.80
Heavy areas	0.60 - 0.90
Parks, cemeteries	0.10 - 0.25
Playgrounds	0.20 - 0.40
Railroad yard areas	0.20 - 0.40
Unimproved areas	0.10 - 0.30
Lawns:	
Sandy soil, flat, 2%	0.05 - 0.10
Sandy soil, average, 2 - 7%	0.10 - 0.15
Sandy soil, steep, 7%	0.15 - 0.20
Heavy soil, flat, 2%	0.13 - 0.17
Heavy soil, average, 2 - 7%	0.18 - 0.22
Heavy soil, steep, 7%	0.25 - 0.35
Streets:	
Asphaltic	0.70 - 0.95
Concrete	0.80 - 0.95
Brick	0.70 - 0.85
Drives and walks	0.75 - 0.85
Roofs	0.75 - 0.95

*Higher values are usually appropriate for steeply sloped areas and longer return periods because infiltration and other losses have a proportionally smaller effect on runoff in these cases.

$WQF = C \times i \times A$

C - the runoff coefficient for use with rational method for estimating peak discharge.

14. American Society of Civil Engineers, 1960. Design Manual for Storm Drainage, New York, NY.

Residential:	
Single-family areas	0.30 - 0.50
Multi-units, detached	0.40 - 0.60
Multi-units, attached	0.60 - 0.75
Suburban	0.25 - 0.40
Apartment dwelling areas	0.50 - 0.70

If not provided in MS4 drainage manual.

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Water Quality Flow

Rainfall intensity (i) is determined from an intensity-duration-frequency curve for an event.

- The intensity should be selected for a duration equal to the time of concentration (tc) of the drainage area.
- I-D curve for Water Quality Event is provided in tabular format in Appendix C of the CGP.
- Tc should utilize a velocity based equation for each flow condition encountered (sheet, shallow concentrated, pipe, open channel, etc.)
- If the total Tc is <5 minutes, a 5 minute duration should be used[1]
- Sub areas may yield larger peak discharges than then entire area and should be evaluated separately.[2]

1 FWHA, HEC-22, third edition, Urban Drainage Design Manual (2009)
2 WEF/ASCE, Design and Construction of Urban Stormwater Management Systems (1992)

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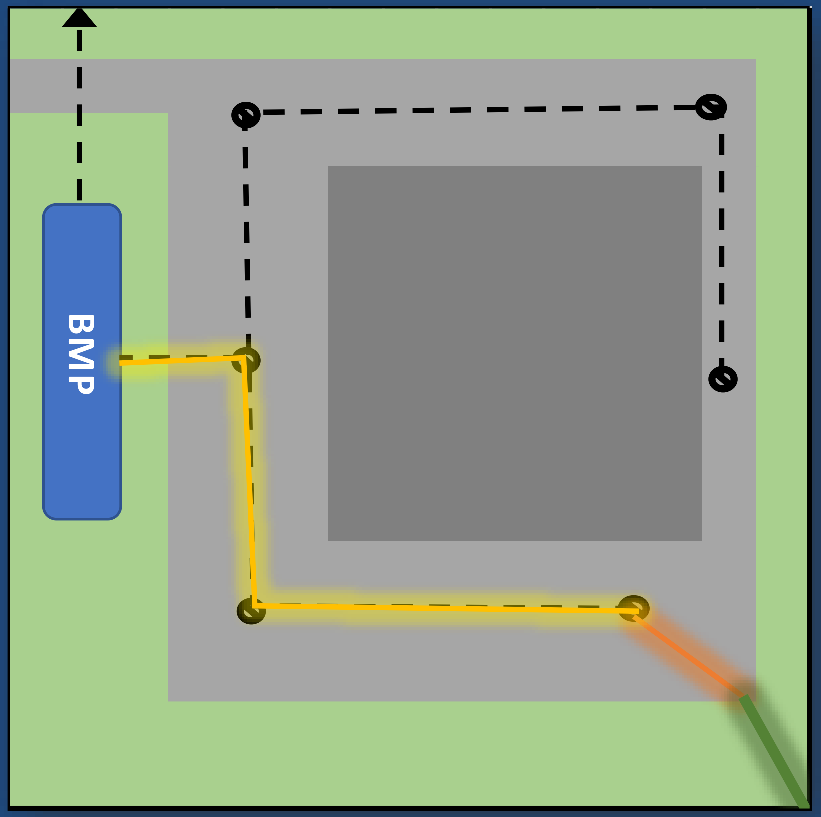
Time of Concentration (t_c)

WQF for the entire drainage area:



50’	overland grass	26.7 min
60’	overland pavement	2.0 min
300’	pipe flow	1.3 min
410’	total	Tc = 30 minutes

DURATION t_c (minutes)	WATER QUALITY INTENSITY [i_{wq}] (inches/hour)
5	2.37
28	1.05
29	1.03
30	1.01
31	0.99
32	0.97

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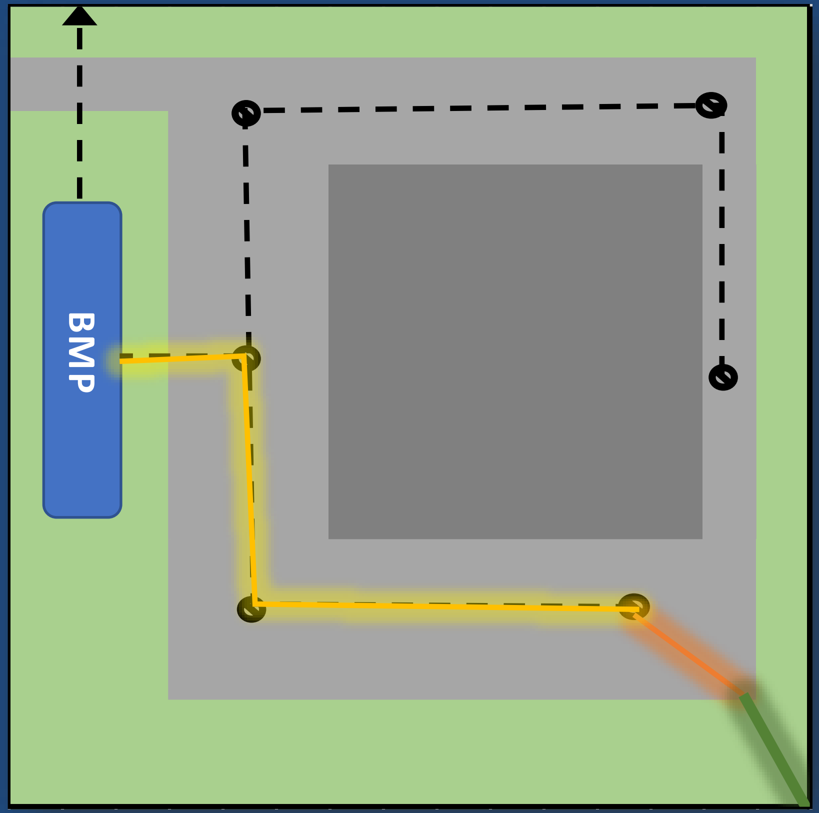
Water Quality Flow

WQF for the entire drainage area:

$$WQF = C \times i \times A$$



Where:

C = 0.85 (commercial area)

i = 1.01 in/hr

A = 2.25 ac

WQF = 0.85 × 1.01 in/hr × 2.25 ac

WQF = 1.93 cfs

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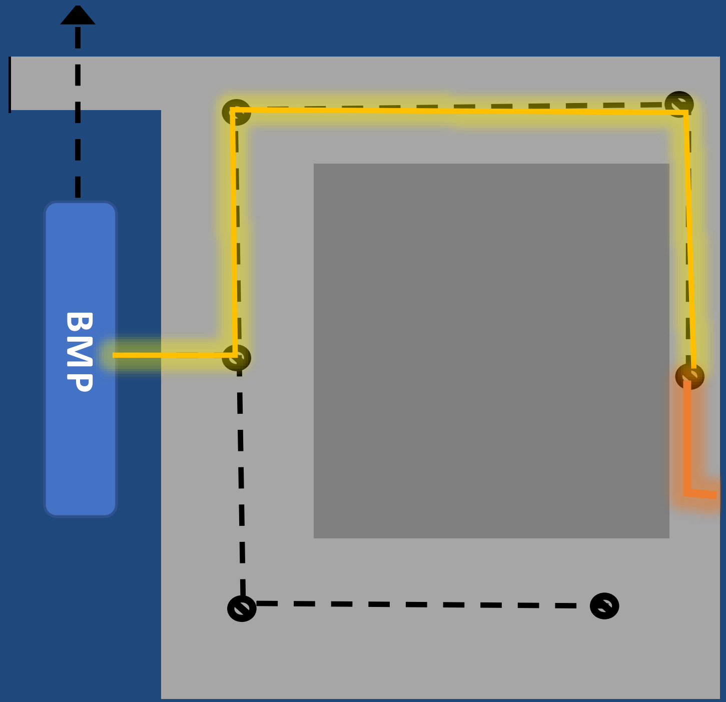
Time of Concentration (t_c)

WQF for the impervious sub-area:



0’	overland grass	0.0 min
50’	overland pavement	1.8 min
420’	pipe flow	1.8 min
470’	total	Tc = 3.6 minutes

DURATION t_c (minutes)	WATER QUALITY INTENSITY [i_{wq}] (inches/hour)
5	2.37
6	2.26
7	2.15
8	2.04
9	1.94
10	1.85
11	1.76
12	1.68
13	1.62
14	1.56
15	1.51

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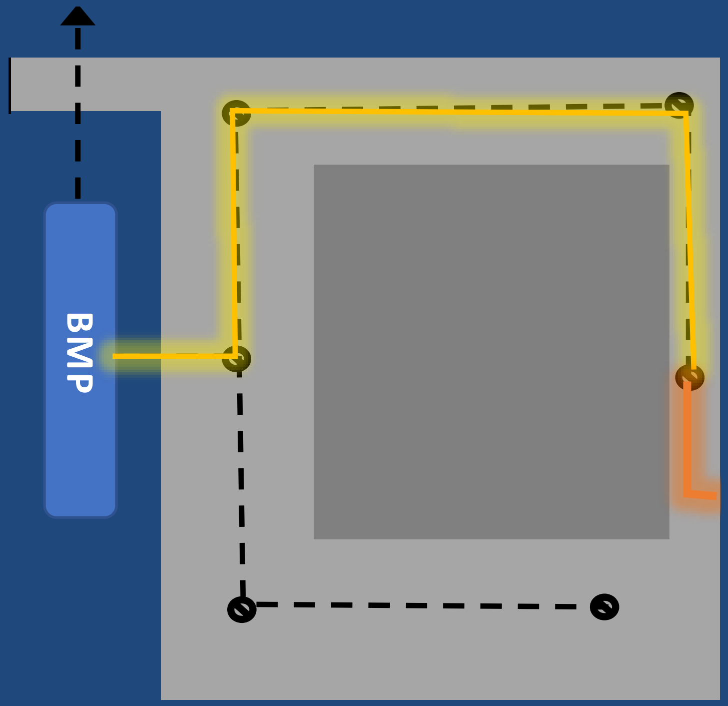
Water Quality Flow

WQF for the impervious sub-area:



$$WQF = C \times i \times A$$

Where:

C = 0.90 (impervious, flat)

i = 2.37 in/hr

A = 1.35 ac

WQF = 0.90 × 2.37 in/hr × 1.35 ac

WQF = 2.88 cfs

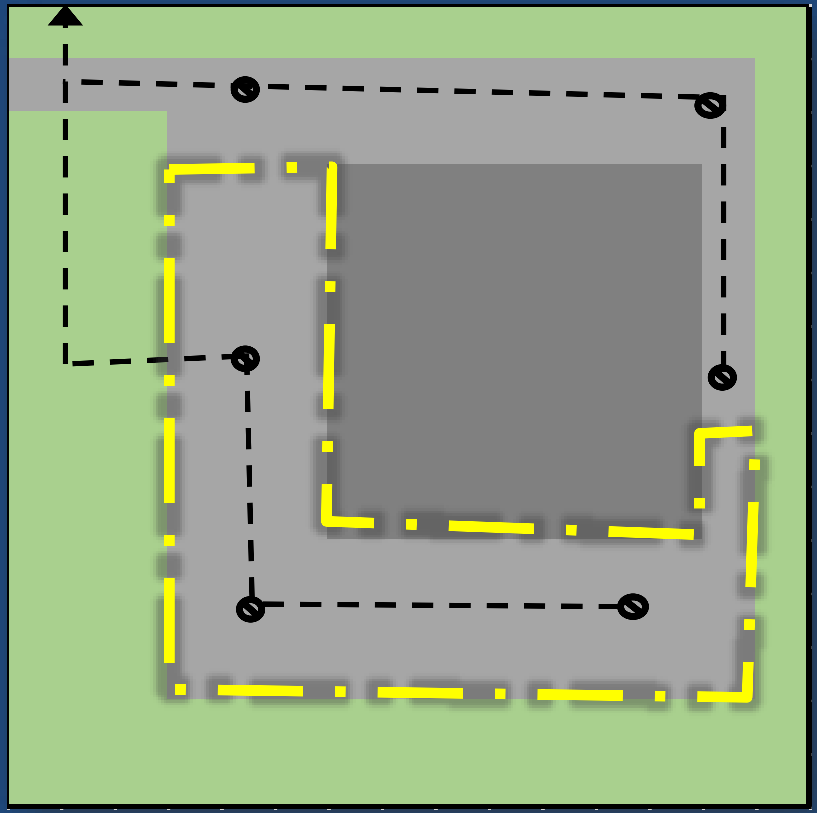
Water Quality Flow - Redevelopment

From our previous redevelopment example:

The site is required to treat 1,766 ft^3 with post-construction BMPs; however each post-construction BMP must be designed to treat 100% of the WQv for its contributing area. Place the BMP such that its drainage area* is equal to or greater than:

$$A_{drainage} = \frac{WQ_v}{P_{wq} \times Rv} \times \frac{12}{43{,}560}$$

$$\frac{1{,}766\ ft^3}{0.9\ in \times 0.95} \times \frac{12}{43{,}560} = 0.57\ ac$$



* Should be highest expected pollutant load area

Water Quality Flow - Redevelopment

$$WQF = C \times i \times A$$

Where:

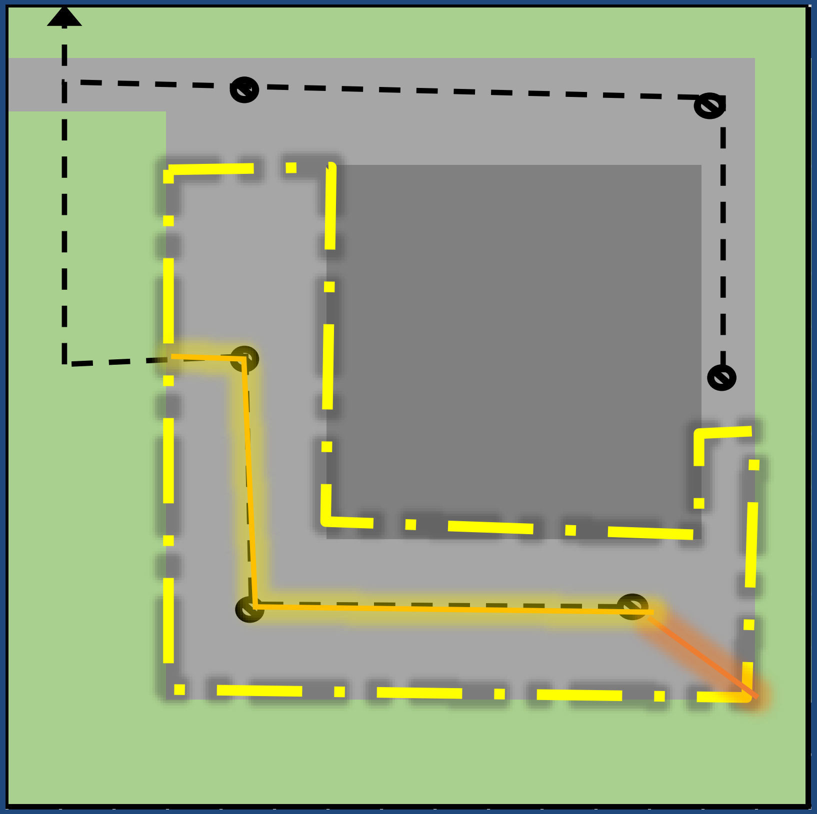
C = 0.90

i = 2.37 in/hr [tc = 3.3 min.]

A = 0.57 ac

WQF = 0.90 × 2.37 in/hr × 0.57 ac

WQF = 1.22 cfs



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