

Solutions: Quality Water Flow and Stormwater Runoff in Landscape Architecture

Stormwater Quantity Part 1

1. C Function Independent: A_i (area of soil type) and C_i (runoff coefficient of soil type)
Dependent: C (weighted runoff coefficient)

- Q Function Independent: C (weighted runoff coefficient) and A (total area)
Dependent: Q (peak runoff)

The C value changes from the dependent (output) variable to the independent (input) variable.

2. A stormwater management system is needed because the total area has increased, and the paved area has increased.

$$3. C = \frac{(0.20 \times 0.10) + (3.30 \times 0.20)}{0.20 + 3.30} = \frac{0.68}{3.5} = 0.19$$

$$4. Q = 0.19 \times 7.08 \times 3.5 = 4.708 \approx 4.7 \text{ cfs}$$

$$5. C = \frac{(6.0 \times 0.95) + (2.7 \times 0.35)}{6.0 + 2.7} = \frac{6.645}{8.7} = 0.76$$

$$6. Q = 0.76 \times 7.08 \times 8.7 = 46.818 \approx 46.8 \text{ cfs}$$

7. A stormwater management system is needed. The post-development peak storm runoff is greater than the pre-development peak storm runoff.
8. Composition of functions is applied when the output values from question 3 and 5 are used as the inputs to solve questions 4 and 6, respectively.

Stormwater Quality Part 2

$$9. \% \text{ Impervious} = \frac{6.0}{8.7} = 0.6897 \times 100 = 68.97\% = 69\% \text{ used as 69 in the next function}$$

$$R = 0.05 + 0.009 \times 69 = 0.67 \text{ in/in}$$

$$V = 1 \text{ in} \times 0.67 \frac{\text{in}}{\text{in}} \times 8.7 \text{ acres} = 5.83 \text{ acre-inch}$$

*Conversion to ft^3 is now required.

$$V = 5.83 \text{ acre-inch} \times 43,560 \frac{ft^2}{\text{acre}} \times \frac{1 \text{ ft}}{12 \text{ in}} = 21,159 \text{ ft}^3$$

$$10. SA = \frac{21,159 \text{ ft}^3}{1.25 \text{ ft}} = 16,927 \text{ ft}^2 = 17,000 \text{ ft}^2$$

$$d = 15 \text{ inches} \times \frac{1 \text{ ft}}{12 \text{ inches}} = 1.25 \text{ ft}$$

*Round solution to 17,000 ft^2 to accommodate for a margin of error buffer.

11. % Impervious is used to find the runoff value (**R**), which is used to find the volume (**V**), which is used to find the surface area (**SA**).
12. The landscape architect team's plan will not work, but student justification may vary. Answers should include the value they found in question 9.

Assessment Items

- Using the formulas below for runoff value, volume, and surface area, explain in detail how you would use the formulas to calculate the final surface area for a given project.

$\% \text{ Impervious} = \frac{\text{Impervious Area within Wetland Drainage Area}}{\text{Total Area of Wetland Drainage Area}}$ $R = 0.05 + 0.009 \times \% \text{ Impervious}$ R: Runoff Value [in/in] *% Impervious: use actual percentage, not decimal equivalence, i.e. 4.25%, use 4.25 not 0.0425 **0.05 and 0.009 are industry given standard values	
$V = \text{Design Storm} \times R \times \text{Drainage Area}$ V: Volume Required [make sure result is measured in ft³] Design Storm: Use 1-in for Raleigh Drainage Area: Total Wetland Drainage Area [acre] *Note: Unit conversions are required (1 acre = 43,560 ft²)	$SA = \frac{V}{d}$ SA: Surface Area of Wetland [ft²] d: Depth = 15-inches maximum (industry standard) *Note: Unit conversions are required

- You have been hired to analyze the pre-development stormwater runoff and post-development stormwater runoff at a construction site and have determined the following information:

Pre-Development

soil type A: $C_i = 0.3$
 $A_i = 1.6$ acres
soil type B: $C_i = 0.1$
 $A_i = 2.2$ acres

Post-Development

soil type C: $C_i = 0.8$
 $A_i = 2.4$ acres
soil type B: $C_i = 0.1$
 $A_i = 4.4$ acres

$C = \frac{\sum(A_i C_i)}{\sum(A_i)}$ C: Weighted Average of Runoff Coefficient A_i: Area of Surface Type [acre] C_i: Runoff Coefficient of Individual Surface Type	$Q = C \times i \times A$ Q: Peak Runoff [cfs] <i>i</i>: Rainfall Intensity of Design Storm [in/hr] (7.08-in/hr. for Wake County) A: Total Area [acres]
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Calculate the peak stormwater runoff for pre-development and post-development to determine if a stormwater management system is needed (i.e. post-development > pre-development).

Assessment Answer Key

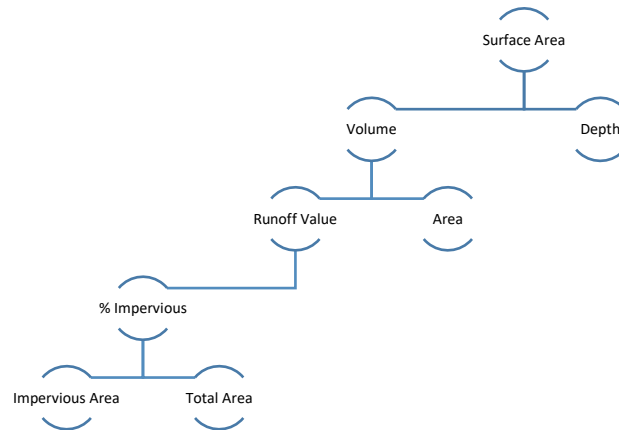
- Below is a visual representation of the solution. Student descriptions will vary but should reflect the diagram.

Impervious area and total area build % impervious.

% impervious builds runoff value.

Runoff value and drainage area build volume.

Volume and depth build surface area.



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|------------------------------|-----------|
| Pre-development peak runoff | 4.84 cfs |
| Post-development peak runoff | 16.85 cfs |

Yes, a stormwater management system is needed.