EXAMPLE EXAM QUESTIONS

CERTIFIED PROFESSIONAL IN STORMWATER QUALITY®

EXAMPLE EXAM QUESTIONS

CPSWQ®
ENVIROCERT

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ENVIROCERT International, Inc.®

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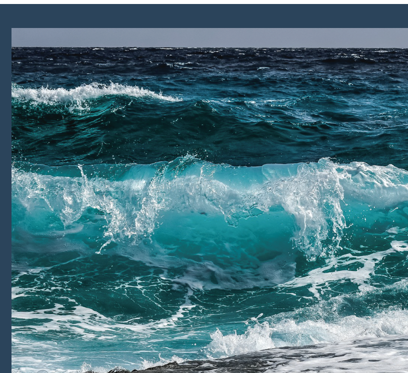

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CPSWQ EXAMPLE EXAM QUESTIONS COMBINED IMPERIAL AND STANDARD INTERNATIONAL VERSION

ECI has provided the following questions as examples as to what to expect on the Certification Exam for CPSWQ. An answer sheet with a brief explanation is provided after the questions.

Values in italics represent Standard International values. If there are no italics the values are the same in both Imperial and Standard International units.

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Example Questions:

1. What is the definition of a stormwater pollutant?

    a. anything that enhances stormwater runoff and can positively impact water quality
    b. anything that enhances stormwater runoff and can negatively impact water quality
    c. anything that contaminates stormwater runoff and can positively impact water quality
    d. anything that contaminates stormwater runoff and can negatively impact water quality

2. An aerobic environment, by definition is saturated with:

    a. Oxygen
    b. Microorganisms
    c. Light
    d. Nutrients

3. Which of the following is NOT a stream classification system

    a. Strahler Stream Order Classification
    b. Montgomery-Buffington Stream Classification
    c. Stream Channel Profile and Pattern Classification
    d. Rosgen Stream Classification

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4. What does an Isohyetal Map represent?

   a. An isohyetal map is a map that uses isohyets (lines) to connect points that have the same elevation on the land surface
   b. An isohyetal map is a map that uses isohyets (lines) to connect points that have the same amount of precipitation over a specific period of time.
   c. An isohyetal map is a map that uses isohyets (lines) to connect points that have the same amount of rainfall erosivity.
   d. An isohyetal map is a map that uses isohyets (lines) to connect points that depict the same type of soil.

5. What does the term quantification mean when discussing pollutants?

   a. The calculation of determining the quantity difference of a pollutant before and after construction
   b. The process of measuring and assessing the amount and type of pollutants in a specific environment
   c. The effect of a pollutant measured in miles (kilometers) downstream of the source
   d. The effect of a pollutant measured in time

6. As a SWM designer you have determined that the four and a half (4 ½) acres *(1.82 hectares)* draining to the proposed detention pond needs to be temporarily stabilized prior to construction of the pond. After consulting with the Soils Scientist and Landscape Architect it has been determined that two and a half (2 ½) tons *(5.60 tonnes)* of straw needs to be applied per acre *(hectare)*. If one (1) bale of straw weighs 88 pounds *(40.0 kilograms)* how many bales will be required to mulch the area draining to the pond.

   a. 57 straw bales *56 straw bales*
   b. 142 straw bales *141 straw bales*
   c. 256 straw bales *255 straw bales*
   d. 102 straw bales *101 straw bales*

7. After performing sampling data on highway runoff, a discharge concentration of 0.148 mg/l of a pollutant was identified, 0.132 mg/l above the concentration of the pollutant found in the receiving waters. Per regulations the threshold for aquatic life, discharge is restricted to 0.0069 mg/l of the pollutant above background (existing conditions). Using the formula initial pollutant concentration (C_1) $*$ initial discharge volume (V_1) = final pollutant concentration (C_2) $*$ final volume (V_2),how much volume of stream water would be needed to dilute three (3) liters of the discharge to required concentrations.

   a. 22.6 liters
   b. 19.4 liters
   c. 6.8 liters
   d. 16.4 liters

8. The project you are working on will expand an existing paved parking area from 10 acres *(4.05 hectares)* to 12 acres *(4.86 hectares)*. Currently there is no treatment of existing parking lot runoff. Local regulations require a "no increase" pre verses post project in TSS loading. You have selected a stormwater wetland to provide for the required TSS removal. A stormwater wetland has a TSS removal rate of 76%. Determine the amount of paving needs to be treated to meet the "no increase" requirement.

a.	1.34 acres	*0.54 hectares*
b.	2.63 acres	*1.07 hectares*
c.	9.12 acres	*3.69 hectares*
d.	2.00 acres	*0.81 hectares*

Questions 9 through 16 are based on the following Scenario

You have just purchased a seventy-five (75) acre *(30.35 hectares)* parcel of land to develop as town houses with retail/commercial space. The local jurisdiction is requiring that the wooded area of the site to remain undisturbed and ignored when performing calculations for stormwater treatment.

TR-55 Worksheets and Quantification Worksheets can be found at the end of this document.

<u>Site Parameters:</u>

Soils

- Groton Soil – Hydrologic Soil Group A
- Acton Soil – Hydrologic Soil Group B
- Paxton Soil – Hydrologic Soil Group C

RCN Factors –Same in both imperial and standard international

- Woods good conditions – A = 30, B = 55, C = 70, D = 77
- Meadow – A = 30, B = 58, C = 71, D = 78
- Pasture poor condition – A = 68, B = 79, C = 86, D = 89
- Farmstead – A = 59, B = 74, C = 82, D = 86
- Town Houses – A= 77, B = 85, C = 90, D = 92
- Retail/Commercial – A = 89, B = 92, C = 94, D = 95
- Newly Graded Areas – A= 77, B = 86, C = 91, D = 94

Isohyetal Value for twenty-four (24) hour storm

2-year storm	3.2 inches	*(8.128 cm)*
10-year storm	5.1 inches	*(12.954 cm)*
100-year storm	7.3 inches	*(18.542 cm)*

Rainfall Distribution – Type 2

Manning's n Values

- Sheet Flow Smooth surfaces = 0.011
- Sheet Flow Short grass = 0.05
- Sheet Flow Dense grass = 0.24
- Grass Lined Channel = 0.03

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Existing Travel Segments

Segment 1 - 75 feet *(22.86 meters)* of overland flow on a 4.0% slope through dense grass

Segment 2 - 20 feet *(6.10 meters)* of overland flow on a 3% slope through short grass

Segment 3 – 1,500 feet *(457.20 meters)* of shallow concentrated flow through pasture on a 3% slope resulting in a velocity of 2.8 feet per second *(0.85 meters per second)*

Segment 4 - 15 feet *(4.57 meters)* over a paved driveway with a 2% reversed crown resulting in a velocity of 2.9 feet per second *(0.88 meters per second)*

Segment 5 – 3,000 feet *(914.40 meters)* of concentrated flow in a constructed grass lined trapezoidal channel at 2.5% with a bottom width of 4 feet *(1.22 meters)* and side slopes of 3:1. Design flow depth within the swale is 2.0 feet (0.61 meters) which results in a flow area of 20.0 square feet *(1.86 square meters)* and a wetted perimeter of 16.64 feet (5.07 meters).

Proposed Travel segments

Segment 1 - 35 feet *(10.67 meters)* of overland flow on a 4.0% slope through dense grass

Segment 2 - 24 feet *(7.32 meters)* of overland flow a 3% slope over a reverse crown roadway, resulting in a velocity of 3.5 feet per second *(1.07 meters per second)*

Segment 3 – 2,100 feet *(640.08 meters)* of concentrated flow at 2.5% in a constructed grass lined trapezoidal channel with a bottom width of 4 feet *(1.22 meters)* and side slopes of 3:1. Design flow depth within the swale is 2.0 feet (0.61 meters) which results in a flow area of 20.0 square feet *(1.86 square meters)* and a wetted perimeter of 16.64 feet (5.07 meters).

Ia Factors

60 = 1.333	*(33.87)*	70 = 0.857	*(21.77)*	80 = 0.500	*(12.70)*
61 = 1.279	*(32.49)*	71 = 0.817	*(20.75)*	81 = 0.469	*(11.91)*
62 = 1.226	*(31.14)*	72 = 0.778	*(19.76)*	82 = 0.439	*(11.15)*
63 = 1.175	*(29.85)*	73 = 0.740	*(17.87)*	83 = 0.410	*(10.41)*
64 = 1.125	*(28.58)*	74 = 0.703	*(17.87)*	84 = 0.381	*(9.667)*
65 = 1.077	*(27.36)*	75 = 0.667	*(16.94)*	85 = 0.353	*(8.966)*
66 = 1.030	*(26.16)*	76 = 0.632	*(16.05)*	86 = 0.326	*(8.280)*
67 = 0.985	*(25.02)*	77 = 0.597	*(15.16)*	87 = 0.299	*(7.595)*
68 = 0.941	*(23.90)*	78 = 0.564	*(14.32)*	88 = 0.273	*(6.934)*
69 = 0.899	*(22.83)*	79 = 0.532	*(13.51)*	89 = 0.247	*(6.274)*

Pond and Swamp Adjustment – 1.0

Q_u Existing =	600	*(0.230)*
Q_u Proposed =	900	*(0.385)*
Vs /Vr =	*0.285*	*(0.300)*

TSS Constant Concentrations

Forest/Rural Open = 51

Agriculture/Pasture = 145

Farmstead (using low density residential) = 70

High Density Residential = 97

Commercial = 77

TP Constant Concentrations

Forest/Rural Open = 0.11

Agriculture/Pasture = 0.37

Farmstead (using low density residential) = 0.52

High Density Residential = 0.24

Commercial = 0.33

Impervious Cover

Forest = 2%

Meadow = 2%

Pasture = 2%

Farmstead = 40%

Town Houses = 65%

Retail/Commercial = 85%

Annual rainfall	35 inches	889 millimeters
Annual rainfall correction factor	0.9	(0.9)

Existing Conditions: The site consist of twenty-five (25) acres *(10.12 hectares)* of woods in good condition on Groton soil, twenty (20) acres *(8.09 hectares)* of meadow on Acton Soil, twenty-five (25) acres *(10.12 hectares)* of pasture in poor condition on Paxton soil, and five (5) acres *(2.02 hectares)* of farmstead on Paxton soil.

Proposed Conditions: You will be maintaining the woods in existing conditions. The remainder of the site will be developed as town houses and retail/commercial space. with twenty (20) acres *(8.09 hectares)* of town houses on the Acton soil, twenty (20) acres *(8.09 hectares)* of town houses on the Paxton soil, with the ten acres *(4.05 hectares)* as retail/commercial.

NOTE – Meadow can be considered as agriculture when harvested for hay on a regular basis, or as rural open space if left in natural conditions. In this scenario under existing conditions the current use is agriculture thus meadow will be considered as agriculture/pasture for pollutant loading calculations. A comparison calculation will be provided in blue (NOT TO BE USED TO DETERMINE ANSWERS TO THE QUESTIONS) to show the difference in pollutant loading when meadow is considered as forest/rural open but.

Equations

Weighted RCN – Weighted RCN = [Total of each (RCN x area)] / total area

Potential Maximum Retention – $S = (1000 / CN) - 10$

$S = [(1000 / CN) - 10] * 25.4$ (2.54 to convert to centimeters)

Peak Flow Rate – $Q = (P - (0.2 * S))^2 / (P + (0.8 * S))$

Acre-Feet of Runoff = (Q * acres) / 12 inches per foot

*Hectare-Meters of Runoff = (Q * hectare) / 100*

Travel Time Sheet Flow – $T_t = ((0.007 * (n * L)^{0.8}) / P_2^{0.5} * s^{0.4}$

$T_t = ((0.007 * (n * L)^{0.8}) / P_2^{0.5} * s^{0.4}$

Travel Time Shallow Concentrated Flow – $T_t = L / 3600 * V$

$T_t = L / 3600 * V$

r – $r = a / p_w$

$r = a / p_w$

V – $V = (1.49 * r^{2/3} * s^{1/2}) / n$

$V = (1.00 * r^{2/3} * s^{1/2}) / n$

Travel Time Channel Flow - $T_t = L / 3600 * V$

$T_t = L / 3600 * V$

Peak Discharge – $q_p = q_u * A_m * Q * F_p$

$q_p = q_u * A_m * Q * F_p$

V_r – $V_r = Q * A_m * 53.33$

$V_r = Q * A_m * 1{,}000$

V_s – $V_s = V_r * (V_s / V_r)$

$V_s = V_r * (V_s / V_r)$

L – $L = [(P * P_j * R_v / 12] * C * A * 2.72$

$L = [(P * P_j * R_v / 1{,}000] * C * A * 10.09$

$Rv = 0.05 +(0.009 * I)$

$Rv = 0.05 +(0.009 * I)$

Questions

9: Determine the composite runoff curve number for the construction portion of the site in existing, construction, and proposed conditions.

	Existing	Construction	Proposed
a.	74	89	89
b.	60	78	83
c.	67	84	86
d.	76	87	89

10: Using the composite CNs developed in Question 9 for the area of development and the rainfall values provided in the site parameters, calculate the existing storm runoff for the two (2) year, ten (10) year, and one hundred (100) year storm events (ex) and two (2) year, ten (10) year, and one hundred (100) year storm events for construction and proposed (cp) conditions.

		2-year	10-year	100-year
a.	ex	5.33 acre feet	19.84 acre feet	30.75 acre feet
	cp	10.66 acre feet	31.55 acre feet	43.05 acre feet
b.	ex	4.33 acre feet	10.17 acre feet	17.92 acre feet
	cp	8.67 acre feet	16.13 acre feet	25.00 acre feet
c.	ex	3.51 acre feet	13.07 acre feet	20.25 acre feet
	cp	7.02 acre feet	20.78 acre feet	28.35 acre feet
d.	ex	4.81 acre feet	18.02 acre feet	27.75 acre feet
	cp	9.62 acre feet	28.65 acre feet	38.85 acre feet

		2-year	*10-year*	*100-year*
a.	*ex*	*0.65 hectare meters*	*2.45 hectare meters*	*3.80 hectare meters*
	cp	*1.31 hectare meters*	*3.87 hectare meters*	*5.32 hectare meters*
b.	*ex*	*0.53 hectare meters*	*1.26 hectare meters*	*2.21 hectare meters*
	cp	*1.07 hectare meters*	*1.99 hectare meters*	*3.09 hectare meters*
c.	*ex*	*0.43 hectare meters*	*1.61 hectare meters*	*2.50 hectare meters*
	cp	*0.86 hectare meters*	*2.54 hectare meters*	*3.50 hectare meters*
d.	*ex*	*0.59 hectare meters*	*2.21 hectare meters*	*3.43 hectare meters*
	cp	*1.19 hectare meters*	*3.49 hectare meters*	*4.80 hectare meters*

11: Using the travel time segments found in the site parameters calculate the existing and the proposed time of concentration.

	Existing Tc	Proposed Tc	*Existing Tc*	*Proposed Tc*
a.	0.211 hours	0.132 hours	*0.209 hours*	*0.116 hours*
b.	0.255 hours	0.158 hours	*0.317 hours*	*0.139 hours*
c.	0.143 hours	0.089 hours	*0.1435 hours*	*0.079 hours*
d.	0.0.404 hours	0.145 hours	*0.406 hours*	*0.147 hours*

12: The local jurisdiction is requiring that peak storm discharge from the site in proposed conditions matches the existing conditions for a 100 year storm. Using the provided site parameters and the calculated values, determine the existing and proposed peak storm discharges.

	Existing	Proposed	*Existing*	*Proposed*
a.	227.40 cfs	507.13 cfs	*6.37 cm/s*	*14.24 cm/s*
b.	201.24 cfs	421.20 cfs	*5.31 cm/s*	*11.88 cm/s*
c.	160.89 cfs	338.09 cfs	*4.25 cm/s*	*9.50 cm/s*
d.	221.20 cfs	464.87 cfs	*5.84 cm/s*	*13.05 cm/s*

13: Using the values calculated in previous questions determine the storage volume required to store stormwater to allow for peak storm discharge from the site in proposed conditions to match the existing conditions for a 100-year storm.

a. 8.51 acre feet | *a. 11,121.18 cubic meters*
b. 7.11 acre feet | *b. 9,255.23 cubic meters*
c. 5.679 acre feet | *c. 7,414.12 cubic meters*
d. 7.80 acre feet | *d. 10,194.41 cubic meters*

14: Using the annual rainfall, the annual rainfall correction factor, the pollutant concentrations, and the percent of impervious cover found in the site parameters, determine the difference in annual pollutant loading for total phosphorus under existing and proposed conditions.

a. 47 pounds per year | *21.5 kilograms per year*
b. 56 pounds per year | *25.8 kilograms per year*
c. 37 pounds per year | *17.2 kilograms per year*
d. 51 pounds per year | *23.7 kilograms per year*

15: Using the annual rainfall, the annual rainfall correction factor, the pollutant concentrations, and the percent of impervious cover found in the site parameters, determine the difference in annual pollutant loading for total suspended solids under existing and proposed conditions.

a. 21,268 pounds per year | *9,833 kilograms per year*
b. 14,178 pounds per year | *6,555 kilograms per year*
c. 19,496 pounds per year | *9,013 kilograms per year*
d. 17,548 pounds per year | *8,033 kilograms per year*

16: You have been provided the following Median Pollutant Removal (%) for total nitrogen for the following treatment practices: Stormwater Wetlands – 30%, Stormwater Wet Ponds – 33%, Stormwater Dry Ponds – 25%, and filtering practices – 38%. If the water quality treatment volume of 40 pounds *(18.14 kilograms)* is collected in the most effective treatment practice, calculate the remaining total nitrogen would be after treatment.

a. 29.8 pounds 13.50 kilograms
b. 19.8 pounds 9.00 kilograms
c. 24.8 pounds 11.25 kilograms
d. 27.28 pounds 12.38 kilograms

Questions 17 through 19 are based on the following Scenario

A new commercial site has been required to capture/treat 600 cubic feet *(17 cubic meters)* of storm water runoff. You will be using a Bioretention facility. Assume the following Site Parameters.

Site Soils Report

> The project soils report has indicated that the soils are silty sands. Percolation testing was conducted at several areas across the site at varying depths. Percolation rates measured at the surface measured approximately 0.55 inches per hour *(1.4 centimeters per hour)* while testing at depths between two (2) feet *(0.61 meters)* and six (6) feet *(1.83 meters)* below the surface measured consistently at 0.75 inches per hour *(1.8 centimeters per hour).*

Jurisdiction Water Quality BMP Requirements

> The jurisdiction in which the project is located requires that Bioretention facilities shall be designed with a minimum surface area such that ponding water be infiltrated within forty-eight (48) hours. In addition, the entire system volume must have a maximum drawdown time of seventy-two (72) hours. In addition, amended planter media shall be used and have a minimum thickness of four (4) feet *(1.22 meters)* to ensure adequate space for plants to take root. If a gravel layer is used, the gravel shall be a minimum of ¾ inch *(2 centimeter)* angular stone with a minimum void ratio of 35 percent (%) with a depth of two (2) feet *(0.61 meters)*. A perforated underdrain shall be installed at a minimum slope of 0.5 percent (%) if percolation rates are 0.50 inches per hour *(1.3 centimeters per hour)* or less.

The jurisdiction also provides the following BMP sizing calculations.

$\mathbf{t_{ponding}}$ =	required drain time of surface ponding (hours)
$\mathbf{d_p}$ =	selected surface ponding water depth in feet *(meters)* -
$\mathbf{d_{max}}$ =	max depth of surface ponding that can be infiltrated within the required drain time in feet *(meters)*
$\mathbf{p_{design}}$ =	site percolation rates
$\mathbf{l_{media}}$ =	thickness of amended planter media in feet *(meters)*
$\mathbf{n_{media}}$ =	porosity of amended planter media in feet per feet *(meters per meters)* - (assume 30 percent (%) for the referenced questions)
$\mathbf{n_{gravel}}$ =	porosity of gravel layer in feet per feet *(meters per meters)*
$\mathbf{l_{gravel}}$ =	depth of gravel layer in feet *(meters)* - (assume two (2) feet *(0.61 meters)* for the referenced questions)
$\mathbf{d_{effective}}$ =	total effective storage depth of bio-retention facility in feet *(meters)*
$\mathbf{t_{total}}$ =	the total depth of water that can infiltrate during the required draw down time. (hours)
$\mathbf{A_{req}}$ =	required infiltrating surface area in cubic feet *(cubic meters)*

Equations

$d_{max} = (P_{design} \times t_{ponding}) / 12$

$d_{max} = (P_{design} \times t_{ponding}) / 100$

$d_{effective} \geq (d_p + n_{media} \cdot l_{media} + n_{gravel} \cdot l_{gravel})$

$d_{effective} \geq (d_p + n_{media} \cdot l_{media} + n_{gravel} \cdot l_{gravel})$

$t_{total} = (d_{effective} / P_{design}) \times 12$

$t_{total} = (d_{effective} / P_{design}) \times 100$

$A_{req} =$ Req. treatment volume/$d_{effective}$

$A_{req} =$ Req. treatment volume/$d_{effective}$

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Questions

17: Calculate the maximum depth of surface ponding (d_{max}) that can be infiltrated within the required drain time ($t_{ponding}$) based on the site percolation rates (P_{design}).

a. 3.0 feet	*a. 0.86 meters*
b. 2.5 feet	*b. 76 meters*
c. 1.7 feet	*c. 0.52 meters*
d. 2.2 feet	*d. 0.67 meters*

18: Using the calculated ponding depth from Question 17, calculate the total effective storage depth of the Bio-retention facility assuming the gravel layer has been installed.

a. 4.7 feet	*a. 1.44 meters*
b. 4.1 feet	*b. 1.25 meters*
c. 3.1 feet	*c. 0.94 meters*
d. 4.2 feet	*d. 1.28 meters*

19: Using the calculated ponding depth from Question 17 and the total effective calculated in question 18, does the entire depth of the bioretention system infiltrate in the required drain time?

a. Yes, the effective drawdown time is 89.4 hours
b. No, the effective drawdown time is 89.4 hours
c. Yes, the effective drawdown time is 67.5 hours
d. No, the effective drawdown time is 67.5 hours

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20: Which of the following has not been used as a mitigation of CSO impacts?

a. Stormwater and sewage pipe combination
b. Reducing stormwater flows
c. Retention basins
d. Screening and disinfection facilities

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CPSWQ ANSWER SHEET WITH ANNOTATED ANSWERS

Question 1: The correct answer is d.

a. Is incorrect because pollutants typically do not enhance water quality
b. Is incorrect because pollutants typically do not enhance water quality
c. Is incorrect because pollutants typically do not positively impact water quality

Question 2: The correct answer is a. An aerobic condition means that oxygen is present (saturated in the aquatic system)

b., c., and d. are incorrect because while microorganisms, light, and nutrients in the aquatic system may show that the aquatic system is in good health, oxygen is the determinant factor if the system is aerobic or anaerobic

Question 3: The correct answer is c. The other three answers are common methods used when classifying streams. Stream channel profile and pattern characteristics may be used within the other methods but is not a method of classifying streams.

Question 4: The correct answer is b.

a. Is incorrect because a map that uses isohyets (lines) to connect points that have the same elevation on the land surface is a contour map
c. Is incorrect because a map that uses isohyets (lines) to connect points that have the same amount of rainfall erosivity is an isoerodent map.
d. Is incorrect because a map that uses isohyets (lines) to connect points that depict the same type of soil is a soils map.

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Question 5: The correct answer is b.

a. Is incorrect because the calculation of the difference is a pollutant loading calculation performed on both before and after construction quantities of the pollutant of concern
c. Is incorrect because this is a spatial characteristic
d. Is incorrect because this is a temporal characteristic

For Questions 6 through 8, the following annotated answers show the required calculation steps performed to achieve the answer. If you calculate a different answer, please verify that you used the proper data as provided in the question.

Question 6:

Step 1 - Collect the data

Area to be temporarily stabilized	4.5 acres	*1.82 hectares*
Amount of straw to be applied	2.5 tons/acre	*5.60 tonnes/hectare*
Weight of straw bale	88 pounds	*40 kilograms*

Step 2 - Determine the total weight of straw to be applied

4.5 acres ∗ 2.5 tons = 11.25 tons *1.82 hectares ∗ 5.60 tonnes = 10.19 tonnes*

Step 3 - Determine the number of bales in a ton *(tonne)*

2000 pounds per ton / 88 pounds per bale = 22.73 straw bales per ton

1000 kilograms per tonne / 40 kilograms per bale = 25 straw bales per tonne

Step 4 – Determine the total number of bales required

4.5 acres ∗ 22.73 straw bales/ton ∗ 2.5 tons/acre = 255.71 bales USE **256 bales**

1.82 hectares ∗ 25 straw bales/tonne ∗ 5.60 tonnes/hectare= 254.8 bales USE ***255 bales***

Step 5 – Check the number of bales against the total weight required

256 bales ∗ 88 pounds = 22,528 pounds / 2000 pounds/ton = 11.26 tons

255 bales ∗ 40 kilograms = 10,200 kilograms / 1000 kilograms/tonne = 10.20 tonnes

Question 7:

Step 1 - Collect the data

C_1 = 0.148 mg/l of the pollutant in the highway stormwater discharge

0.132 mg/l of the pollutant above the receiving waters

0.0069 mg/l of the pollutant permitted above background (existing condition)

V_1 = three (3) liters discharge to be treated

Step 2 - Determine receiving water background (existing) concentration

0.148 mg/l – 0.132 mg/l = 0.016 mg/l

Step 3 - Determine threshold effect mg/l allowed

C2 = 0.016 mg/l + 0.0069 mg/l = 0.0229mg/l

Step 4 - Determine V_2 using the formula $C_1 * V_1 = C_2 * V_2$

0.148 mg/l ∗ 3 liters = 0.0229 mg/l ∗ V_2

0.444 = 0.0229 mg/l ∗ V_2

19.39 liters = V_2

Step 5 - Determine volume of stream water required to dilute solution to the required concentration

19.39 liters – 3 liters = **16.39 liters**

Question 8

Step 1 - Collect the data

10 acres *(4.05 hectares)* existing parking lot

12 acres *(4.86 hectares)* proposed parking lot

76% TSS removal rate for stormwater wetlands

Step 2 – Determine increase in parking lot

12.0 acres -10.0 acres = 2 acres

4.86 hectares – 4.05 hectares = 0.81 hectares

Step 3 – Determine acres of pavement to be treated

Acres of pavement to be treated = 2 acres / 76% (0.76)

Acres of pavement to be treated = 2.63 acres

Acres of pavement to be treated = 0.81 hectares / 76% (0.76)

Acres of pavement to be treated = 1.07 hectares

For Questions 9 through 16, the following annotated answers show the required calculation steps performed to achieve the answer. If you calculate a different answer, please verify that you used the proper data as provided in the question or in the Site Parameters provided.

REMINDER: - The local jurisdiction is requiring that the wooded area of the site to remain undisturbed and ignored when performing TR-55 calculations for stormwater treatment.

Question 9:

You will be using the Weighted RCN equation, RCN = [Total of each area (RCN x area)] / total area, to determine the answer.

Step 1 – Collect the Data. Since the jurisdiction requires the woods to remain, the area of woods on Groton soil, 25 acres (10.12 hectares), will be removed from the calculations reducing the total area to 50 acres (20.23 hectares).

Existing Conditions

Meadow – 20 acres *(8.09 hectares)*,
RCN 58 (Acton = Hydrologic group B)

Pasture in poor condition – 25 acres *(10.12 hectares)*,
RCN 86 (Paxton = Hydrologic group C)

Farmstead – 5 acres *(2.02 hectares)*,
RCN 82 (Paxton = Hydrologic group C)

Construction Conditions

Newly Graded Areas – 20 acres *(8.09 hectares)*,
RCN 86 (Acton = Hydrologic group B)

Newly Graded Areas – 30 acres *(12.14 hectares)*,
RCN 91 (Paxton = Hydrologic group C)

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Proposed Conditions

Town Houses – 20 acres *(8.09 hectares),*

RCN 85 (Acton = Hydrologic group B)

Town Houses – 20 acres *(8.09 hectares),*

RCN 90 (Paxton = Hydrologic group C)

Retail/Commercial – 10 acres *(4.05 hectares),*

RCN 94 (Paxton = Hydrologic group C)

Step 2 – Plug the data into the Weighted RCN equation

Weighted RCN = [Total of each (RCN x area)] / total area

Existing Conditions

Weighted RCN = [(20 ∗ 58) + (25 ∗ 86) + (5 ∗ 82)] / 50

Weighted RCN = [1,160 + 2,150 + 410] / 50

Weighted RCN = 3,720 / 50

Weighted RCN = 74.4

Rounded to the nearest whole number - **Weighted RCN = 74**

Weighted RCN = [(8.09 ∗ 58) + (10.12 ∗ 86) + (2.02 ∗ 82)] / 20.23

Weighted RCN = [469 + 870 + 166] / 20.23

Weighted RCN = 1,505 / 20.23

Weighted RCN = 74.4

Rounded to the nearest whole number - ***Weighted RCN = 74***

Construction Conditions

Weighted RCN = [(20 ∗ 86) + (30 ∗ 91)] / 50

Weighted RCN = [1,720 + 2,730] / 50

Weighted RCN = 4,450 / 50

Weighted RCN = 89.0

Rounded to the nearest whole number - **Weighted RCN = 89**

Weighted RCN = [(8.09 ∗ 86) + (12.14 ∗ 91)] / 20.23

Weighted RCN = [696 + 1,105] / 20.23

Weighted RCN = 1,801 / 20.23

Weighted RCN = 89.0

Rounded to the nearest whole number - ***Weighted RCN = 89***

Proposed Conditions

Weighted RCN = [(20 ∗ 85) + (20 ∗ 90) + (10 ∗ 94)] / 50

Weighted RCN = [1,700 + 1,800 + 940] / 50

Weighted RCN = 4,440 / 50

Weighted RCN = 88.8

Rounded to the nearest whole number - **Weighted RCN = 89**

Weighted RCN = [(8.09 ∗ 85) + (8.09 ∗ 90) + (4.05 ∗ 94)] / 20.23

Weighted RCN = [688 + 728 + 381] / 20.23

Weighted RCN = 1,797 / 20.23

Weighted RCN = 88.8

Rounded to the nearest whole number - ***Weighted RCN = 89***

Question 10:

You will be using the following equations to determine the answer

Potential Maximum Retention – S = (1000 / CN) – 10

*(S = [(1000 / CN) – 10] * 25.4 (2.54 to convert to centimeters),*

Peak Flow Rate – $Q = (P - (0.2 * S))^2 / (P + (0.8 * S))$, and

Acre-Feet of Runoff = (Q * acres) / 12 inches per foot

*Hectare-Meters of Runoff = (Q * hectare) / 100*

Step 1 - Collect the data

Calculated CN from Question 9

Existing = 74

Construction = 89

Proposed = 89

Rainfall values

2-year storm	3.2 inches	*(8.13 cm)*
10-year storm	5.1 inches	*(12.95 cm)*
100-year storm	7.3 inches	*(18.54 cm)*

Step 2 – Calculate the Potential Maximum Retention value for each storm

Existing	Construction and Proposed (same CN)
S = (1000 / 74) – 10	S = (1000 / 89) – 10
S = 13.514 – 10	S = 11.235 – 10
S = 3.514 inches	S = 1.235 inches
*S = [(1000 / 74) – 10] * 2.54*	*S = [(1000 / 89) – 10] * 2.54*
*S = [13.514 -10] * 2.54*	*S = [11.235 -10] * 2.54*
*S= 3.514 * 2.54*	*S = 1.235 * 2.54*
S = 8.926 centimeters	*S = 3.137 centimeters*

Step 3 – Calculate the Peak Flow Rate for each storm

Existing 2 year

$Q = (3.2 - (0.2 * 3.514))^2 / (3.2 + (0.8 * 3.514))$

$Q = (3.2 - 0.703)^2 / (3.2 + 2.811)$

$Q = 2.497^2 / 6.011$

$Q = 6.235 / 6.011$

Q = 1.04 inches

$Q = (8.128 - (0.2 * 8.926))^2 / (8.128 + (0.8 * 8.926))$

$Q = (8.128 - 1.785)^2 / (8.128 + 7.141)$

$Q = 6.343^2 / 15.269$

$Q = 40.234 / 15.2691$

Q = 2.64 centimeters

Existing 10 year

$Q = (5.1 - (0.2 * 3.514))^2 / (5.1 + (0.8 * 3.514))$

$Q = (5.1 - 0.703)^2 / (5.1 + 2.811)$

$Q = 4.397^2 / 7.911$

$Q = 19.334 / 7.911$

Q = 2.44 inches

$Q = (12.954 - (0.2 * 8.926))^2 / (12.954 + (0.8 * 8.926))$

$Q = (12.954 - 1.785)^2 / (12.954 + 7.141)$

$Q = 11.165^2 / 20.095$

$Q = 124.747 / 20.095$

Q = 6.21 centimeters

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Existing 100 year

$Q = (7.3 - (0.2 * 3.514))^2 / (7.3 + (0.8 * 3.514))$

$Q = (7.3 - 0.703)^2 / (7.3 + 2.811)$

$Q = 6.597^2 / 10.111$

$Q = 43.520 / 10.111$

Q = 4.30 inches

$Q = (18.542 - (0.2 * 8.926))^2 / (18.542 + (0.8 * 8.926))$

$Q = (18.542 – 1.785)^2 / (18.542 + 7.141)$

$Q = 66.757^2 / 25.683$

$Q = 280.797 / 25.683$

Q = 10.93 centimeters

Construction and Proposed 2year

$Q = (3.2 - (0.2 * 1.235))^2 / (3.2 + (0.8 * 1.235))$

$Q = (3.2 - 0.247)^2 / (3.2 + 0.988)$

$Q = 2.953^2 / 4.188$

$Q = 8.720 / 4.188$

Q = 2.08 inches

$Q = (8.128 - (0.2 * 3.137))^2 / (8.128 + (0.8 * 3.137))$

$Q = (8.128 - 0.627)^2 / (8.128 + 2.510)$

$Q = 7.501^2 / 10.638$

$Q = 56.265 / 10.638$

Q = 5.28 centimeters

Construction and Proposed 10 year

$Q = (5.1 - (0.2 * 1.235))^2 / (5.1 + (0.8 * 1.235))$

$Q = (5.1 - 0.247)^2 / (5.1 + 0.988)$

$Q = 4.853^2 / 6.088$

$Q = 23.552 / 6.088$

Q = 3.87 inches

$Q = (12.954 - (0.2 * 3.137))^2 / (12.954 + (0.8 * 3.137))$

$Q = (12.954 - 0.627)^2 / (12.954 + 2.510)$

$Q = 12.3273^2 / 15.464$

$Q = 151.955 / 15.464$

Q = 9.83 centimeters

Construction and Proposed 100 year

$Q = (7.3 - (0.2 * 1.235))^2 / (7.3 + (0.8 * 1.235))$

$Q = (7.3 - 0.247)^2 / (7.3 + 0.988)$

$Q = 7.053^2 / 8.288$

$Q = 49.745 / 8.288$

Q = 6.00 inches

$Q = (18.542 - (0.2 * 3.137))^2 / (18.542 + (0.8 * 3.137))$

$Q = (18.542 - 0.627)^2 / (18.542 + 2.510)$

$Q = 17.915^2 / 21.052$

$Q = 320.947 / 21.052$

Q = 15.25 centimeters

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Step 4 - Calculate the storm runoff in acre feet (hectare meters) for each storm using the Acre-Feet of Runoff = (Q ∗ acres) / 12 inches per foot *(Hectare-Meters of Runoff = (Q ∗ hectare) / 100)* equation.

<u>Existing 2 Year</u>

Acre Feet of Runoff = (1.04 ∗ 50) / 12

Acre Feet of Runoff = 52 / 12

Acre Feet of Runoff = 4.33

Hectare-Meters of Runoff = (2.64 ∗ 20.23) / 100

Hectare-Meters of Runoff = 53.41 / 100

Hectare-Meters of Runoff = 0.53

<u>Existing 10 Year</u>

Acre Feet of Runoff = (2.44 ∗ 50) / 12

Acre Feet of Runoff = 122.00 / 12

Acre Feet of Runoff = 10.17

Hectare-Meters of Runoff = (6.21 ∗ 20.23) / 100

Hectare-Meters of Runoff = 125.63 / 100

Hectare-Meters of Runoff = 1.26

<u>Existing 100 Year</u>

Acre Feet of Runoff = (4.30 ∗ 50) / 12

Acre Feet of Runoff = 215.00 / 12

Acre Feet of Runoff = 17.92

Hectare-Meters of Runoff = (10.93 ∗ 20.23) / 100

Hectare-Meters of Runoff = 221.11 / 100

Hectare-Meters of Runoff = 2.21

<u>Construction and Proposed 2 Year</u>

Acre Feet of Runoff = (2.08 ∗ 50) / 12

Acre Feet of Runoff = 104.00 / 12

Acre Feet of Runoff = 8.67

Hectare-Meters of Runoff = (5.28 ∗ 20.23) / 100

Hectare-Meters of Runoff = 106.81 / 100

Hectare-Meters of Runoff = 1.07

<u>Construction and Proposed 10 Year</u>

Acre Feet of Runoff = (3.87 ∗ 50) / 12

Acre Feet of Runoff = 193.50 / 12

Acre Feet of Runoff = 16.13

Hectare-Meters of Runoff = (9.83 ∗ 20.23) / 100

Hectare-Meters of Runoff = 198.94 / 100

Hectare-Meters of Runoff = 1.99

<u>Construction and Proposed 100 Year</u>

Acre Feet of Runoff = (6.00 ∗ 50) / 12

Acre Feet of Runoff = 300.00 / 12

Acre Feet of Runoff = 25.00

Hectare-Meters of Runoff = (15.25 ∗ 20.23) / 100

Hectare-Meters of Runoff = 308.51 / 100

Hectare-Meters of Runoff = 3.09

Question 11:

You will be using the following formulas to determine the answer.

Travel Time Sheet Flow - $T_t = ((0.007 * (n * L)^{0.8}) / P_2^{0.5} * s^{0.4}$

$T_t = ((0.093 * (n * L)^{0.8}) / P_2^{0.5} * s^{0.4}$

Travel Time Shallow Concentrated Flow -$T_t = L / 3600 * V$

$T_t = L / 3600 * V)$

r – $r = a / p_w$

$r = a / p_w$

V – $V = (1.49 * r^{2/3} * s^{1/2}) / n$

$V = (1.00 * r^{2/3} * s^{1/2}) / n$

Travel Time Channel Flow - $T_t = L / 3600 * V$

$T_t = L / 3600 * V$

Step 1 - Collect the data

Existing Travel Segments

Segment 1 - 75 feet *(22.86 meters)* of overland flow on a 4.0% slope through dense grass. Mannings n value = 0.24. P_2 = 3.2 inches (*81.28 millimeters)*

Segment 2 - 20 feet *(6.10 meters)* of overland flow on a 3% slope through short grass. Mannings n value = 0.05. P_2 = 3.2 inches *(81.28 millimeters)*

Segment 3 – 1,500 feet *(457.20 meters)* of shallow concentrated flow through pasture on a 3% slope resulting in a velocity of 2.8 feet per second *(0.85 meters per second)*

Segment 4 - 15 feet *(4.57 meters)* over a paved driveway with a 2% reversed crown resulting in a velocity of 2.9 feet per second *(0.88 meters per second)*

Segment 5 – 3,000 feet *(914.40 meters)* of concentrated flow in a constructed grass lined trapezoidal channel at 2.5% with a bottom width of 4 feet *(1.22 meters)* and side slopes of 3:1. Design flow depth within the swale is 2.0 feet (0.61 meters) which results in a flow area of 20.0 square feet *(1.86 square meters)* and a wetted perimeter of 16.64 feet (5.07 meters).

Proposed Travel segments

Segment 1 - 35 feet *(10.67 meters)* of overland flow on a 4.0% slope through dense grass

Segment 2 - 24 feet *(7.32 meters)* of overland flow a 3% slope over a reverse crown roadway, resulting in a velocity of 3.5 feet per second *(1.07 meters per second)*

Segment 3 – 2,100 feet *(640.08 meters)* of concentrated flow at 2.5% in a constructed grass lined trapezoidal channel with a bottom width of 4 feet *(1.22 meters)* and side slopes of 3:1. Design flow depth within the swale is 2.0 feet (0.61 meters) which results in a flow area of 20.0 square feet *(1.86 square meters)* and a wetted perimeter of 16.64 feet (5.07 meters).

Step 2 – Calculate the time of travel for existing conditions

Segment 1 (overland)

$T_t = ((0.007 * (0.24 * 75)^{0.8}) / 3.2^{0.5} * 0.04^{0.4}$

$T_t = (0.007 * 18.0^{0.8}) / 1.789 * 0.276$

$T_t = (0.007 * 10.098) / 0.494$

$T_t = 0.071 / 0.494$

$T_t = 0.144$ hours

$T_t = ((0.093 * (0.24 * 22.86)^{0.8}) / 81.28^{0.5} * 0.04^{0.4}$

$T_t = (0.093 * 5.486^{0.8}) / 9.016 * 0.276$

$T_t = (0.093 * 3.903) / 2.488$

$T_t = 0.363 / 2.488$

$T_t = 0.146$ hours.

Segment 2 (overland)

$T_t = ((0.007 * (0.05 * 20)^{0.8}) / 3.2^{0.5} * 0.03^{0.4}$

$T_t = (0.007 * 1.0^{0.8}) / 1.789 * 0.246$

$T_t = (0.007 * 1.000) / 0.440$

$T_t = 0.007 / 0.440$

$T_t = 0.016$ hours

$T_t = ((0.093 * (0.05 * 6.1)^{0.8}) / 81.28^{0.5} * 0.030^{0.4}$

$T_t = (0.093 * 0.305^{0.8}) / 9.016 * 0.246$

$T_t = (0.093 * 0.387) / 2.218$

$T_t = 0.036 / 2.218$

$T_t = 0.016$ hours.

Segment 3 (shallow concentrated)

$T_t = 1{,}500 / 3{,}600 * 2.8$

$T_t = 1{,}500 / 10{,}080$

$T_t = 0.149$ hours

$T_t = 457.20 / 3{,}600 * 0.85$

$T_t = 457.20 / 3{,}060$

$T_t = 0.149$ hours

Segment 4 (shallow concentrated)

$T_t = 15 / 3{,}600 * 2.9$

$T_t = 15 / 10{,}440$

$T_t = 0.001$ hours

$T_t = 4.57 / 3{,}600 * 0.88$

$T_t = 4.57 / 3{,}168$

$T_t = 0.001$ hours

Segment 5 (concentrated flow)

Cross sectional area is given as 20 square feet *(0.09 square meters)*

Wetted perimeter is given as 16.5 feet *(5.02 meters)*

Calculate the hydraulic radius = r = 20 / 16.64 *r = 1.86 / 5.07*

r = 1.202 *r = 0.367*

Channel slope is given at 2.5%

Mannings n is given at 0.03

Calculate the velocity of flow $V = (1.49 * 1.202^{2/3} * 0.025^{1/2}) / 0.03$

$V = (1.49 * 1.130 * 0.158) / 0.03$

$V = 0.266 / 0.03$

$V = 8.867$

$V = (1.00 * 0.367^{2/3} * 0.025^{1/2}) / 0.03$

$V = (1.00 * 0.513 * 0.158) / 0.03$

$V = 0.081 / 0.03$

$V = 2.700$

Length is given at 3,000 feet *(914.40 meters)*

Calculate the time of travel $T_t = 3,000 / 3,600 * 8.867$

$T_t = 3,000 / 31921.20$

$T_t = 0.094$ hours

$T_t = 914.40 / 3,600 * 2.700$

$T_t = 914.40 / 9720$

$T_t = 0.094$ *hours*

Step 3 - add the total time of travel from each segment to determine the time of concentration under existing conditions.

Segment 1 - 0.144 hours	*Segment 1 - 0.146 hours*
Segment 2 - 0.016 hours	*Segment 2 - 0.016 hours*
Segment 3 - 0.149 hours	*Segment 3 - 0.149 hours*
Segment 4 - 0.001 hours	*Segment 4 - 0.001 hours*
Segment 5 - 0.094 hours	*Segment 5 - 0.094 hours*
Tc 0.404 hours	***Tc 0.406 hours***

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Step 4 - Calculate the time of travel for proposed conditions

Segment 1 (overland)

$T_t = ((0.007 * (0.24 * 35)^{0.8}) / 3.2^{0.5} * 0.04^{0.4}$

$T_t = (0.007 * 8.40^{0.8}) / 1.789 * 0.276$

$T_t = (0.007 * 5.488) / 0.494$

$T_t = 0.038 / 0.494$

$T_t = 0.077$ hours

$T_t = ((0.093 * (0.24 * 10.67)^{0.8}) / 81.28^{0.5} * 0.04^{0.4}$

$T_t = (0.093 * 2.561^{0.8}) / 9.016 * 0.276$

$T_t = (0.093 * 2.122) / 2.488$

$T_t = 0.197 / 2.488$

$T_t = 0.079$ hours.

Segment 2 (shallow concentrated)

$T_t = 24 / 3{,}600 * 3.5$

$T_t = 24 / 12{,}600$

$T_t = 0.002$ hours

$T_t = 7.32 / 3{,}600 * 1.07$

$T_t = 7.32 / 3{,}852$

$T_t = 0.002$ hours

Segment 3 (concentrated flow)

Cross sectional area is given as 20 square feet *(0.09 square meters)*

Wetted perimeter is given as 16.5 feet *(5.02 meters)*

Calculate the hydraulic radius = r = 20 / 16.64 *r = 1.86 / 5.07*

r = 1.202 *r = 0.367*

Channel slope is given at 2.5%

Mannings n is given at 0.03

Calculate the velocity of flow $V = (1.49 * 1.202^{2/3} * 2.5^{1/2}) / 0.03$

$V = (1.49 * 1.130 * 0.158) / 0.03$

$V = 0.266 / 0.03$

$V = 8.867$

$V = (1.00 * 0.367^{2/3} * 2.5^{1/2}) / 0.03$

$V = (1.00 * 0.513 * 0.158) / 0.03$

$V = 0.081 / 0.03$

$V = 2.700$

Length is given at 2,100 feet *(640.08 meters)*

Calculate the time of travel $T_t = 2,100 / 3,600 * 8.867$

$T_t = 2,100 / 31,921$

$T_t = 0.066$ hours

$T_t = 640.08 / 3,600 * 2.700$

$T_t = 640.08 / 9720$

$T_t = 0.066$ *hours*

Step 5 - add the total time of travel from each segment to determine the time of concentration under proposed conditions.

Segment 1 - 0.077 hours	*Segment 1 - 0.079 hours*
Segment 2 - 0.002 hours	*Segment 2 - 0.002 hours*
Segment 3 - 0.066 hours	*Segment 3 - 0.066hours*
Tc 0.145 hours	***Tc 0.147 hours***

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Question 12:

You will be using the following formula to determine the answer

Peak Discharge - $q_p = q_u * A_m * Q * F_p$ *($q_p = q_u * Km^2 * Q * F_p$)*

Step 1 – Collect the Data

Drainage area -	50 acres	*(20.23 hectares)*
Runoff curve number existing –	74	*(74)*
Runoff curve number proposed –	89	*(89)*
Time of concentration existing –	0.404 hours	*(0.406 hours)*
Time of concentration proposed –	0.145 hours	*(0.147 hours)*
Rainfall distribution –	2	*(2)*
Pond/swamp Factor –	1.0	*(1.0)*
Rainfall for 100-year storm -	7.3 inches	*(185.42 mm)*
I_a existing -	0.703	*(17.87)*
I_a proposed	0.247	*(6.274)*
Existing Q_{100}	*4.30 inches*	*(109.30 mm)*
Proposed Q_{100}	6.00 inches	*(152.50 mm)*
Existing Q_u	600	0.230Proposed Q_u
900	0.385	

Step 2 – Convert the area into square miles *(square kilometers)*

50 acres / 640 = 0.078 square miles

20.23 / 100 = 0.2023 square kilometers

Step 3 – Compute I_a / P

Existing

0.703 / 7.3 = 0.096 *17.87 / 185.42 = 0.096*

Proposed

0.247 / 7.3 = 0.034 *6.274 / 185.42 = 0.034*

Step 4 – From Unit Peak Discharge Table (table can be found in the General Principles Review Manual). For this sample problem and on the exam this value has/will be provided.

Existing

T_c = 0.404 hours, I_a/p = 0.096 (use I_a/P of 0.10)

q_u = 600

T_c = 0.406 hours, I_a/p = 0.096 (use I_a/P of 0.10)

q_u = 0.24

Proposed

T_c = 0.145 hours, I_a/p = 0.034 (use I_a/P of 0.10)

q_u = 900

T_c = 0.147 hours, I_a/p = 0.034 (use I_a/P of 0.10)

q_u = 0..385

Step 5 – Calculate the q_p

Existing

$q_p = 600 * 0.078 * 4.30 * 1.0$

q_p = 201.24 cfs

$q_p = 0.240 * 0.2023 * 109.30 * 1.0$

q_p = 5.31 cms

Proposed

$q_p = 900 * 0.078 * 6.00 * 1.0$

q_p = 421.20 cfs

$q_p = 0.385 * 0.2023 * 152.50 * 1.0$

q_p = 11.88 cms

Question 13:

You will be using the following equations to determine the answer.

$V_r = Q * A_m * 53.33$

$V_r = Q * A_m * 1{,}000$

$V_s = V_r * (V_s / V_r)$

$V_s = V_r * (V_s / V_r)$

Step 1 – Collect the Data

Drainage area -	0.078 mi^2	*0.2023 km^2*
Rainfall distribution –	2	*2*
Design storm -	100-year	*100-year*
Peak inflow q_i (proposed q_p)–	421.20 cfs	*11.881 cms*
Peak outflow q_o (existing q_p) –	201.24 cfs	*5.31 cms*
Q_{100} –	6.00 inches	*152.50 mm*

Step 2 – Calculate q_o / q_i

201.24 / 421.20 = 0.48 *5.31 / 11.88 = 0.45*

Step 3 – From Graphical Detention Basin Storage Estimation Table (table can be found in the General Principles Review Manual) determine the value of V_s / V_r. For this sample problem and on the exam this value has/will be provided.

0.285 *0.300*

Step 4 – Calculate V_r

$V_r = 6.00 * 0.078 * 53.33$ *$V_r = 152.50 * 0.2023 * 1{,}000$*

V_r = 24.96 acre feet *V_r = 30,850.75 cubic meters*

Step 5 – Calculate the V_s

$V_s = 24.96 * 0.285$ *$V_s = 30{,}850.75 * 0.300$*

V_s = 7.11 acre feet ***V_s = 9,255.23 cubic meters***

Question 14:

You will be using the following equations to determine the answers.

Simple Method Pollutant Loading formula

$L = [(P * P_j * R_v / 12] * C * A * 2.72$

$L = [(P * P_j * R_v / 1{,}000] * C * A * 10.09$

Rv formula

$Rv = 0.05 + (0.009 * I)$

$Rv = 0.05 + (0.009 * I)$

Step 1 – Collect the Data

Annual rainfall (P) = 35 inches 889 millimeters

Rainfall correction factor (P_j) = 0.9 *(0.9)*

Percent impervious (I) =

- Forest = 2%
- Meadow = 2%
- Pasture = 2%
- Farmstead = 40%
- Town Houses = 65%
- Retail/Commercial = 85%

Flow weighted pollutant concentration for TP

- Forest/Rural Open = 0.11
- Agriculture/Pasture = 0.37
- Farmstead (using low density residential) = 0.52
- High Density Residential = 0.24
- Commercial = 0.33

Total site area =	75 acres	*20.23 hectares*
Existing woods (to remain)	25 acres	10.12 hectares
Existing meadow	20 acres	*8.09 hectares*
Existing pasture	25 acres	*10.12 hectares*
Existing farmstead	5 acres	*2.02 hectares*
Proposed high density residential	40 acres	*16.19 hectares*
Proposed commercial	10 acres	4.05 hectares

Step 2 – Calculate R_v values for different land uses,

Woods = 2%

Rv = 0.05 +(0.009 ∗ 2) *Rv = 0.05 +(0.009 ∗ 2)*

Rv = 0.068 *Rv = 0.068*

Meadow = 2%

Rv = 0.05 +(0.009 ∗ 2) *Rv = 0.05 +(0.009 ∗ 2)*

Rv = 0.068 *Rv = 0.068*

Pasture = 2%

Rv = 0.05 +(0.009 ∗ 2) *Rv = 0.05 +(0.009 ∗ 2)*

Rv = 0.068 *Rv = 0.068*

Farmstead = 40%

Rv = 0.05 +(0.009 ∗ 40) *Rv = 0.05 +(0.009 ∗ 40)*

Rv = 0.410 *Rv = 0.410*

Town Houses = 65%

Rv = 0.05 +(0.009 ∗ 65) *Rv = 0.05 +(0.009 ∗ 65)*

Rv = 0.635 *Rv = 0.635*

Retail/Commercial = 85%

Rv = 0.05 +(0.009 ∗ 85) *Rv = 0.05 +(0.009 ∗ 85)*

Rv = 0.815 *Rv = 0.815*

Step 3 – Calculate the TP pollutant loading for different land uses in existing conditions

Woods

L = [(35 ∗ 0.9 ∗ 0.068 / 12] ∗ 0.11 ∗ 25.00 ∗ 2.72

L = 0.1785 ∗ 0.11 ∗ 25.00 ∗ 2.72

L = 1.34 pounds per year

Meadow

L = [(35 ∗ 0.9 ∗ 0.068 / 12] ∗ 0.37 ∗ 20.00 ∗ 2.72

L = 0.1785 ∗ 0.37 ∗ 20.00 ∗ 2.72

L = 3.59 pounds per year

Meadow Comparison as Rural Open ***(do not use to calculate final answer)***

L = [(35 ∗ 0.9 ∗ 0.068 / 12] ∗ 0.11 ∗ 20.00 ∗ 2.72

L = 0.1785 ∗ 0.11 ∗ 20.00 ∗ 2.72

L = 1.07 pounds per year A difference of 2.52 pounds of TP per year

Pasture

L = [(35 ∗ 0.9 ∗ 0.068 / 12] ∗ 0.37 ∗ 25.00 ∗ 2.72

L = 0.1785 ∗ 0.37 ∗ 25.00 ∗ 2.72

L = 4.49 pounds per year

Farmstead

L = [(35 ∗ 0.9∗ 0.410 / 12] ∗ 0.52 ∗5.00 ∗ 2.72

L = 1.0763 ∗ 0.52 ∗5.00 ∗ 2.72

L = 7.61 pounds per year

Woods

L = [(889 ∗ 0.9 ∗ 0.068 / 1000] ∗ 0.11 ∗ 10.12 ∗ 10.09

L = 0.054 ∗ 0.11 ∗ 10.12 ∗ 10.09

L = 0.61 kilograms per year

Meadow

L = [(889 ∗ 0.9 ∗ 0.068 / 1000] ∗ 0.37 ∗ 8.09 ∗ 10.09

L = 0.054 ∗ 0.37 ∗ 8.09 ∗ 10.09

L = 1.63 kilograms per year

Meadow Comparison as Rural Open ***(do not use to calculate final answer)***

L = [(889 ∗ 0.9 ∗ 0.068 / 1000] ∗ 0.11 ∗ 8.09 ∗ 10.09

L = 0.054 ∗ 0.11 ∗ 8.09 ∗ 10.09

L = 0.49 kilograms per year A difference of 1.14 kilograms of TP per year

Pasture

L = [(889 ∗ 0.9 ∗ 0.068 / 1000] ∗ 0.37 ∗ 10.12 ∗ 10.09

L = 0.054 ∗ 0.37 ∗ 10.12 ∗ 10.09

L = 2.04 kilograms per year

Farmstead

L = [(889 ∗ 0.9∗ 0.410 / 1000] ∗ 0.52 ∗2.02 ∗ 10.09

L = 0.328 ∗ 0.52 ∗2.02 ∗ 10.09

L = 3.48 kilogram per year

Step 4 – Calculate total TP pollutant loading in existing conditions

1.34 + 3.59 + 4.49 + 7.61 = 17.03 pounds per year

0.61 + 1.63 + 2.04 + 3.48 = 7.76 kilograms per year

Step 5 – Calculate the TP pollutant loading for different land uses in existing conditions

Woods

L = [(35 ∗ 0.9 ∗ 0.068 / 12] ∗ 0.11 ∗ 25.00 ∗ 2.72

L = 0.1785 ∗ 0.11 ∗ 25.00 ∗ 2.72

L = 1.34 pounds per year

High density residential

L = [(35 ∗ 0.9 ∗ 0.635 / 12] ∗ 0.24 ∗ 40.00 ∗ 2.72

L =1.667 ∗ 0.24 ∗ 40.00 ∗ 2.72

L = 43.53 pounds per year

Commercial

L = [(35 ∗ 0.9 ∗ 0.815 / 12] ∗ 0.33 ∗ 10.00 ∗ 2.72

L = 2.139 ∗ 0.33 ∗ 10.00 ∗ 2.72

L = 19.20 pounds per year

Woods

L = [(889 ∗ 0.9 ∗ 0.068 / 1000] ∗ 0.11 ∗ 10.12 ∗ 10.09

L = 0.054 ∗ 0.11 ∗ 10.12 ∗ 10.09

L = 0.61 kilograms per year

High density residential

L = [(889 ∗ 0.9 ∗ 0.635 / 1000] ∗ 0.24 ∗ 16.19 ∗ 10.09

L = 0.508 ∗ 0.24 ∗ 16.19 ∗ 10.09

L = 19.92 kilograms per year

Commercial

L = [(889 ∗ 0.9 ∗ 0.815 / 1000] ∗ 0.33 ∗ 4.04 ∗ 10.09

L = 0.652 ∗ 0.33 ∗ 4.05 ∗ 10.09

L = 8.79 kilograms per year

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Step 6 – Calculate total TP pollutant loading in proposed conditions

1.34 + 43.53 + 19.20 = 64.07 pounds per year

0.61 + 19.92 + 8.79 = 29.30 kilograms per year

Step 7 – Calculate the TP pollutant loading difference between existing and proposed conditions

64.07 pounds per year - 17.03 pounds per year = 47.04 pounds per year

Use 47 pounds per year

29.30 kg per year - 7.76 kg per year = 21.54 kilograms per year

Use 21.5 kilograms per year

Question 15:

You will be using the following equations to determine the answers.

Simple Method Pollutant Loading formula

L – L = [(P ∗ P_j ∗ R_v / 12] ∗ C ∗ A ∗ 2.72

L = [(P ∗ P_j ∗ R_v / 1,000] ∗ C ∗ A ∗ 10.09

Rv formula

Rv = 0.05 +(0.009 ∗ I)

Rv = 0.05 +(0.009 ∗ I)

Step 1 – Collect the Data

Annual rainfall (P) = 35 inches 889 millimeters

Rainfall correction factor (P_j) = 0.9 *(0.9)*

Percent impervious (I) =

- Forest = 2%
- Meadow = 2%
- Pasture = 2%
- Farmstead = 40%
- Town Houses = 65%
- Retail/Commercial = 85%

Flow weighted pollutant concentration for TSS

- Forest/Rural Open = 51
- Agriculture/Pasture = 145
- Farmstead (using low density residential) = 70
- High Density Residential = 97
- Commercial = 77

Total site area =	75 acres	*20.23 hectares*
Existing Woods (to remain)	25 acres	10.12 hectares
Existing meadow	20 acres	*8.09 hectares*
Existing pasture	25 acres	*10.12 hectares*
Existing farmstead	5 acres	*2.02 hectares*
Proposed high density residential	40 acres	*16.19 hectares*
Proposed commercial	10 acres	4.05 hectares

Step 2 – Calculate R_v values for different land uses,

Woods = 2%

Rv = 0.05 +(0.009 ∗ 2) *Rv = 0.05 +(0.009 ∗ 2)*

Rv = 0.068 *Rv = 0.068*

Meadow = 2%

Rv = 0.05 +(0.009 ∗ 2) *Rv = 0.05 +(0.009 ∗ 2)*

Rv = 0.068 *Rv = 0.068*

Pasture = 2%

Rv = 0.05 +(0.009 ∗ 2) *Rv = 0.05 +(0.009 ∗ 2)*

Rv = 0.068 *Rv = 0.068*

Farmstead = 40%

Rv = 0.05 +(0.009 ∗ 40) *Rv = 0.05 +(0.009 ∗ 40)*

Rv = 0.410 *Rv = 0.410*

Town Houses = 65%

Rv = 0.05 +(0.009 ∗ 65) *Rv = 0.05 +(0.009 ∗ 65)*

Rv = 0.635 *Rv = 0.635*

Retail/Commercial = 85%

Rv = 0.05 +(0.009 ∗ 85) *Rv = 0.05 +(0.009 ∗ 85)*

Rv = 0.815 *Rv = 0.815*

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Step 3 – Calculate the TSS pollutant loading for different land uses in existing conditions

Woods

L = [(35 ∗ 0.9 ∗ 0.068 / 12] ∗ 51 ∗ 25.00 ∗ 2.72

L = 0.1785 ∗ 51 ∗ 25.00 ∗ 2.72

L = 619.04 pounds per year

Meadow

L = [(35 ∗ 0.9 ∗ 0.068 / 12] ∗ 145 ∗ 20.00 ∗ 2.72

L = 0.1785 ∗ 145 ∗ 20.00 ∗ 2.72

L = 1,408.01 pounds per year

Meadow Comparison as Rural Open ***(do not use to calculate final answer)***

L = [(35 ∗ 0.9 ∗ 0.068 / 12] ∗ 51 ∗ 20.00 ∗ 2.72

L = 0.1785 ∗ 51 ∗ 20.00 ∗ 2.72

L = 495.23 pounds per year A difference of 912.78 pounds of TSS per year

Pasture

L = [(35 ∗ 0.9 ∗ 0.068 / 12] ∗ 145 ∗ 25.00 ∗ 2.72

L = 0.1785 ∗ 145 ∗ 25.00 ∗ 2.72

L = 1,760.01 pounds per year

Farmstead

L = [(35 ∗ 0.9∗ 0.410 / 12] ∗ 70 ∗5.00 ∗ 2.72

L = 1.0763 ∗ 70 ∗5.00 ∗ 2.72

L = 1,024.64 pounds per year

Woods

L = [(889 ∗ 0.9 ∗ 0.068 / 1000] ∗ 51 ∗ 10.12 ∗ 10.09

L = 0.054 ∗ 51 ∗ 10.12 ∗ 10.09

L = 281.21 kilograms per year

Meadow

L = [(889 ∗ 0.9 ∗ 0.068 / 1000] ∗ 145 ∗ 8.09 ∗ 10.09

L = 0.054 ∗ 145 ∗ 8.09 ∗ 10.09

L = 639.15 kilograms per year

Meadow Comparison as Rural Open ***(do not use to calculate final answer)***

L = [(889 ∗ 0.9 ∗ 0.068 / 1000] ∗ 51 ∗ 8.09 ∗ 10.09

L = 0.054 ∗ 51 ∗ 8.09 ∗ 10.09

L = 224.80 kilograms per year A difference of 414.35 kilograms of TSS per year

Pasture

L = [(889 ∗ 0.9 ∗ 0.068 / 1000] ∗ 145 ∗ 10.12 ∗ 10.09

L = 0.054 ∗ 145 ∗ 10.12 ∗ 10.09

L = 799.53 kilograms per year

Farmstead

L = [(889 ∗ 0.9∗ 0.410 / 1000] ∗ 70 ∗2.02 ∗ 10.09

L = 0.328 ∗ 70 ∗2.02 ∗ 10.09

L = 467.97 kilogram per year

Step 4 – Calculate total TSS pollutant loading in existing conditions

619.04 + 1,408.01 + 1,760.01 + 1,024.64 = 4,811.70 pounds per year

281.21 + 639.15 + 799.53 + 467.97 = 2,187.86 kilograms per year

Step 5 – Calculate the TSS pollutant loading for different land uses in existing conditions

Woods

L = [(35 ∗ 0.9 ∗ 0.068 / 12] ∗ 51 ∗ 25.00 ∗ 2.72

L = 0.1785 ∗ 51 ∗ 25.00 ∗ 2.72

L = 619.04 pounds per year

High density residential

L = [(35 ∗ 0.9 ∗ 0.635 / 12] ∗ 97 ∗ 40.00 ∗ 2.72

L =1.667 ∗ 97 ∗ 40.00 ∗ 2.72

L = 17,592.85 pounds per year

Commercial

L = [(35 ∗ 0.9 ∗ 0.815 / 12] ∗ 77 ∗ 10.00 ∗ 2.72

L = 2.139 ∗ 77 ∗ 10.00 ∗ 2.72

L = 4,479.92 pounds per year

Woods

L = [(889 ∗ 0.9 ∗ 0.068 / 1000] ∗ 51 ∗ 10.12 ∗ 10.09

L = 0.054 ∗ 51 ∗ 10.12 ∗ 10.09

L = 281.21 kilograms per year

High density residential

L = [(889 ∗ 0.9 ∗ 0.635 / 1000] ∗97 ∗ 16.19 ∗ 10.09

L = 0.508 ∗ 97 ∗ 16.19 ∗ 10.09

L = 8,049.58 kilograms per year

Commercial

L = [(889 ∗ 0.9 ∗ 0.815 / 1000] ∗ 77 ∗ 4.04 ∗ 10.09

L = 0.652 ∗ 77 ∗ 4.05 ∗ 10.09

L = 2,051.56 kilograms per year

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Step 6 – Calculate total TP pollutant loading in proposed conditions

619.04 + 17,592.85 + 4,479.92 = 22,691.81 pounds per year

281.21 + 8,049.58 + 2051.56 = 10,382.35 kilograms per year

Step 7 – Calculate the pollutant loading for difference between existing and proposed conditions

22,691.81 lbs. per year – 4,811.70 lbs. per year = 17,880.11 pounds per year

Use 17,880 pounds per year

10,382.35 kg per year – 2,187.86 kg per year = 8,194.49 kilograms per year

Use 8,194 kilograms per year

Question 16:

Step 1 – Collect the Data

TN collected = 40 pounds *18.14 kilograms*

Stormwater Wetlands – 30%

Stormwater Wet Ponds – 33%

Stormwater Dry Ponds – 25%

Filtering Practices – 38%

Step 2 – Determine the most effective treatment. Since Filtering Practices removes 38% and the other treatments remove a lower percentage Filtering Practices are the most effective for removal of total nitrogen

Step 3 - Calculate the removal of total nitrogen

40 ∗ 0.38 = 15.2 pounds removed

18.14 ∗ 0.38 = 6.89 kilograms removed

Step 4 - Calculate the remaining total nitrogen

40 – 15.2 = **24.8 pounds remain**

18.14 – 6.89 = ***11.25 kilograms remain***

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For Questions 17 through 19, the following annotated answers show the required calculation steps performed to achieve the answer. If you calculate a different answer, please verify that you used the proper data as provided in the question or in the Site Parameters provided.

Question 17

You will be using the d_{max} equation, $d_{max} = (P_{design} * t_{ponding}) / 12$ (*$d_{max} = (P_{design} * t_{ponding}) / 100$*), to determine the answer.

Step 1 – Collect the Data

Required volume of stormwater runoff capture = 600 cubic feet *(17 cubic meters)*

Surface percolation rate = 0.55 inches per hour *(1.4 centimeters per hour)*

Two (2) feet *(0.61 meters)* to six (6) feet *(1.83 meters)* = 0.75 inches per hour *(1.8 centimeters per hour)*

Required ponding time = 48 hours

Required maximum drawdown time = 72 hours

Planting media porosity = 30%

Planting media minimum thickness = 4 feet *(1.22 meters)*

Minimum gravel void ratio (if used) = 35%

Gravel depth (if used) = 2 feet *(0.61 meters)*

Minimum underdrain slope(if used) = 0.5%

Step 2 – Calculate ponding depth. Since the ponding is affected by the surface infiltration rate P_{design} will be the surface rate.

$d_{max} = (0.55 * 48) / 12$

$d_{max} = (26.4) / 12$

$d_{max} = 2.20$ feet

$d_{max} = (1.4 * 48) / 100$

$d_{max} = (67.2) / 100$

$d_{max} = 0.67$ meters

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Question 18

You will be using the $d_{effective}$ equation, $d_{effective} \geq (d_p + n_{media} \cdot l_{media} + n_{gravel} \cdot l_{gravel})$ *($d_{effective} \geq (d_p + n_{media} \cdot l_{media} + n_{gravel} \cdot l_{gravel})$)*, to determine the answer.

Step 1 – Collect the Data

Required volume of stormwater runoff capture = 600 cubic feet *(17 cubic meters)*

Surface percolation rate = 0.55 inches per hour *(1.4 centimeters per hour)*

Two (2) feet *(0.61 meters)* to six (6) feet *(1.83 meters)* = 0.75 inches per hour *(1.8 centimeters per hour)*

Required ponding time = 48 hours

Required maximum drawdown time = 72 hours

Planting media porosity = 30%

Planting media minimum thickness = 4 feet *(1.22 meters)*

Minimum gravel void ratio (if used) = 35%

Gravel depth (if used) = 2 feet *(0.61 meters)*

Minimum underdrain slope(if used) = 0.5%

Calculated ponding depth from Question 17 = 2.2 feet (0.67 meters)

Step 2 – Calculate the effective storage depth

$d_{effective} \geq (2.2 + 30\% \cdot 4 + 35\%_{l} \cdot 2)$

$d_{effective} \geq (2.2 + 1.2 + 0.7)$

$d_{effective} \geq 4.1$ feet

$d_{effective} \geq (0.67 + 30\% \cdot 1.22 + 35\% \cdot 0.61)$

$d_{effective} \geq (0.67 + 0.366 + 0.214)$

$d_{effective} \geq 1.25$ meters

Question 19

You will be using the total time, $t_{total} = (d_{effective}/P_{design}) * 12$ *($t_{total} = (d_{effective}/P_{design}) * 100$)*, to determine the answer.

Step 1 – Collect the Data

Required volume of stormwater runoff capture = 600 cubic feet *(17 cubic meters)*

Surface percolation rate = 0.55 inches per hour *(1.4 centimeters per hour)*

Two (2) feet *(0.61 meters)* to six (6) feet *(1.83 meters)* = 0.75 inches per hour *(1.8 centimeters per hour)*

Required ponding time = 48 hours

Required maximum drawdown time = 72 hours

Planting media porosity = 30%

Planting media minimum thickness = 4 feet *(1.22 meters)*

Minimum gravel void ratio (if used) = 35%

Gravel depth (if used) = 2 feet *(0.61 meters)*

Minimum underdrain slope(if used) = 0.5%

Calculated ponding depth from Question 17 = 2.2 feet (0.67 meters)

Calculated effective storage depth from Question 18 = 4.1 feet (1.25 meters)

Step 2 - Determine the effective drain time. Since the ponding is affected by the subsurface infiltration rate P_{design} will be the subsurface rate.

$t_{total} = (4.1/0.75) * 12$

$t_{total} = 5.47 * 12$

$t_{total} = 65.64$ hours

$t_{total} = (1.25/1.8) * 100$

$t_{total} = (0.694) * 100$

$t_{total} = 69.4$ hours

Step 3 – Compare calculated effective drain time to required drain time

Since the effective drawdown times vary slightly due to rounding and the number of decimal points used the t_{total} = 65.64 hours and t_{total} = *69.4 hours* have been averaged to 67.5 hours.

The maximum drawdown time is 72 hours; thus, the calculated total drawdown time is adequate for the entire bioretention system.

Question 20: The correct answer is a. Combining stormwater and sewage systems will lead to an increased CSO problem, not a reduction in the CSO problem

b. Is incorrect because many communities have implemented low impact development / green infrastructure techniques in an attempt to reduce stormwater runoff into the collection system and thus effectively reduce the number of CSO events.
c. Is incorrect because retention basins or large concrete tanks have been constructed to collect, hold, and sometimes treat CSO discharges. While each facility is unique, a typical facility operation is as follows. Flows from the overloaded sewers are pumped into a basin that is divided into compartments. The first flush compartment captures and stores flows with the highest level of pollutants from the first part of a storm. The flows from this compartment are stored and sent to the wastewater treatment plant when there is capacity in the interceptor sewer after the storm. The second compartment is a treatment or flow-through compartment. The flows are disinfected by injecting sodium hypochlorite, or bleach, as they enter this compartment. It then takes about 20 to 30 minutes for the flows to move to the end of the compartment. During this time, bacteria are killed, and large solid materials settle out. At the end of the compartment, any remaining sanitary trash is skimmed off the top and the treated flows are discharged into the river or lake.

d. Is incorrect because screening and disinfection facilities, also known as flow through facilities are used in some municipalities to treat CSO events. They use fine screens to remove solids and sanitary trash from the combined sewage. Flows are injected with sodium hypochlorite for disinfection and mixed as they travel through a series of fine screens to remove debris. The fine screens have openings that range in size from 4 to 6 mm, or a little less than ¼ inch. The flow is sent through the facility at a rate that provides enough time for the sodium hypochlorite to kill bacteria. All of the materials removed by the screens are then sent to the wastewater treatment plant through the interceptor sewer.

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IMPERIAL

UNIT

WORKSHEETS

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Project	By	Date
Location	Checked	Date

Check one: ☐ Present ☐ Developed

1. Runoff curve number

Soil name and hydrologic group	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN 1/ Tables 6-2, 6-3 6-4, 6-5	Area ☐ acres ☐ mi^2 ☐ %	Product of CN x area

1/ Use only one CN source per line

Totals ➡ | | |

CN (weighted) = $\frac{\text{total product}}{\text{total area}}$ = ______________ = ________ ; **Use CN** ➡ ☐

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr			
Rainfall, P (24-hour)	in			
Runoff, Q .... (Use P and CN with Figure 6-7, or equations found on Figure 6-7)	in			

Project	By	Date
Location	Checked	Date

Check one: ☐ Present ☐ Developed

Check one: ☐ T_c ☐ T_t through subarea

Notes: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to Tc only)

Segment ID		
1. Surface description (table 6-6)		
2. Manning's roughness coefficient, n (table 6-6)		
3. Flow length, L (total † 300 ft) .... ft		
4. Two-year 24-hour rainfall, P_2 .... in		
5. Land slope, s .... ft/ft		
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{\ 0.5}\ s^{0.4}}$ Compute T_t .... hr		+	=

Shallow concentrated flow

Segment ID		
7. Surface description (paved or unpaved)		
8. Flow length, L ....ft		
9. Watercourse slope, s .... ft/ft		
10. Average velocity, V (figure 6-8) .... ft/s		
11. $T_t = \frac{L}{3600\ V}$ Compute T_t .... hr		+	=

Channel flow

Segment ID		
12. Cross sectional flow area, a .... ft^2		
13. Wetted perimeter, p_w .... ft		
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r .... ft		
15 Channel slope, s .... ft/ft		
16. Manning's roughness coefficient, n		
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V ....ft/s		
18. Flow length, L .... ft		
19. $T_t = \frac{L}{3600\ V}$ Compute T_t .... hr		+	=
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... Hr		

Project	By	Date
Location	Checked	Date

Check one: ☐ Present ☐ Developed

1. Data

Drainage area .... A_m = ______________ mi^2 (acres/640)

Runoff curve number ....CN = ______________ (From worksheet 6-1)

Time of concentration .... T_c = ______________ hr (From worksheet 6-2)

Rainfall distribution .... = ______________ (I, IA, II, III)

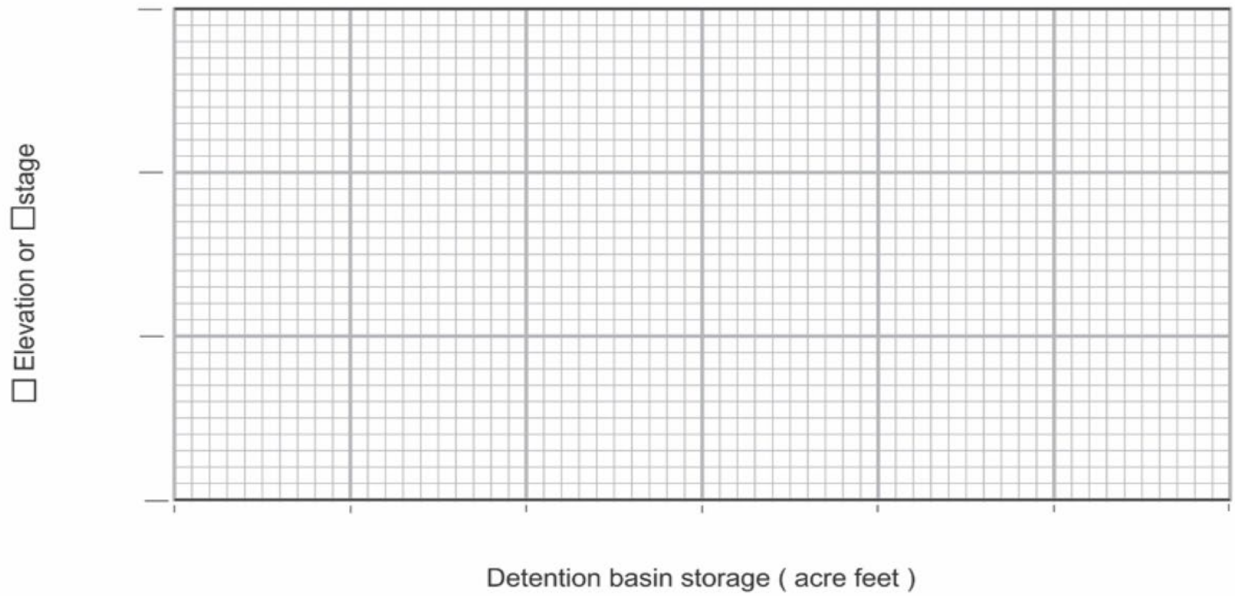
Pond and swamp areas spread throughout watershed .... = ____________ percent of A_m (________ acres or mi^2 covered)

	Storm #1	Storm #2	Storm #3
2. Frequency .... yr			
3. Rainfall, P (24-hour) .... in			
4. Initial abstraction, I_a .... in (Use CN with table 6-8)			
5. Compute I_a / P			
6. Unit peak discharge, q_u .... csm/in (Use T_c and I_a / P with Figure 6-10 _____)			
7. Runoff, Q .... in (From worksheet 1)			
8. Pond and swamp adjustment factor, F_p .... (Use percent pond and swamp area with table 6-9. Factor is 1.0 for zero percent pond ans swamp area.)			
9. Peak discharge, q_p .... ft^3/s			

(Where $q_p = q_u A_m Q F_p$)

Project	By	Date
Location	Checked	Date

Check one: ☐ Present ☐ Developed



1. Data:
   Drainage area .... A_m = __________ mi²
   Rainfall distribution type (I, IA, II, III) = __________

	1st Stage	2nd Stage
2. Frequency .... yr		
3. Peak inflow discharge q_i .... ft³/s (from worksheet 6-3, Developed)		
4. Peak outflow discharge q_u .... ft³/s (from worksheet 6-3, Present) 1/		
5. Compute $\frac{q_o}{q_i}$		
6. $\frac{V_s}{V_r}$ .... (Use $\frac{q_o}{q_i}$ with figure 6-11)		
7. Runoff, Q .... in (From worksheet 1)		
8. Runoff volume V_r.................. ac ft ($V_r = QA_m$ 53.33)		
9. Storage volume, V_s .... ac-ft ($V_s = V_r$ ($\frac{V_s}{V_r}$))		
10. Maximum storage E_{max} (from plot)		

1/ 2nd stage q_o includes 1st stage q_o.

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$L = [(P \times P_j \times R_v)/12] \times C \times A \times 2.72$

$R_v = 0.05 + 0.009\,(I)$

Pollutant Loading Table Worksheet

Existing Condition

Land Use	%I	R_V	Area	Concentration (mg/l)			Pollutant Load (lbs.)		
				BOD	TSS	TP	BOD	TSS	TP
1.									
2.									
3.									
4.									

Future Condition

Land Use	%I	R_V	Area	Concentration (mg/l)			Pollutant Load (lbs.)		
				BOD	TSS	TP	BOD	TSS	TP
1.									
2.									
3.									

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STANDARD INTERNATIONAL UNIT WORKSHEETS

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Project	By	Date
Location	Checked	Date

Check one: ☐ Present ☐ Developed

1. Runoff curve number

Soil name and hydrologic group	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN 1/ Tables 6-2, 6-3 6-4, 6-5	Area ☐ Hectares ☐ Km² ☐ %	Product of CN x area
		Totals ➡		

1/ Use only one CN source per line

$$\text{CN (weighted)} = \frac{\text{total product}}{\text{total area}} = \underline{\qquad\qquad} = \underline{\qquad} \;;$$

Use CN ➡ ☐

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr			
Rainfall, P (24-hour)	mm			
Runoff, Q .... (Use P and CN with Figure 6-7, or equations found on Figure 6-7)	mm			

Project	By	Date
Location	Checked	Date

Check one: ☐ Present ☐ Developed

Check one: ☐ T_c ☐ T_t through subarea

Notes: Space for as many as two segments per flow type can be used for each worksheet. Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to Tc only)

Segment ID		
1. Surface description (table 6-6)		
2. Manning's roughness coefficient, n (table 6-6)		
3. Flow length, L (total L ≤ 90) ....m		
4. Two-year 24-hour rainfall, P_2 ....mm		
5. Land slope, s ....m/m		
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{\ 0.5}\ s^{0.4}}$ Compute T_t	+	=

Shallow concentrated flow

Segment ID		
7. Surface description (paved or unpaved)		
8. Flow length, L ....m		
9. Watercourse slope, s ....m/m		
10. Average velocity, V (figure 6-8) ....m/s		
11. $T_t = \frac{L}{3600\ V}$ Compute T_t .... hr	+	=

Channel flow

Segment ID		
12. Cross sectional flow area, a ....m²		
13. Wetted perimeter, p_w ....m		
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r ....m		
15 Channel slope, s ....m/m		
16. Manning's roughness coefficient, n		
17. $V = \frac{1.00\ r^{2/3}\ s^{1/2}}{n}$ Compute V ....m/s		
18. Flow length, L ....m		
19. $T_t = \frac{L}{3600\ V}$ Compute T_t .... hr	+	=

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... Hr ☐

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Project	By	Date
Location	Checked	Date

Check one: ☐ Present ☐ Developed

1. Data

Drainage area .... A_m = ______________ Km²

Runoff curve number ....CN = ______________ (From worksheet 6-1)

Time of concentration .... T_c = ______________ hr (From worksheet 6-2)

Rainfall distribution .... = ______________ (I, IA, II, III)

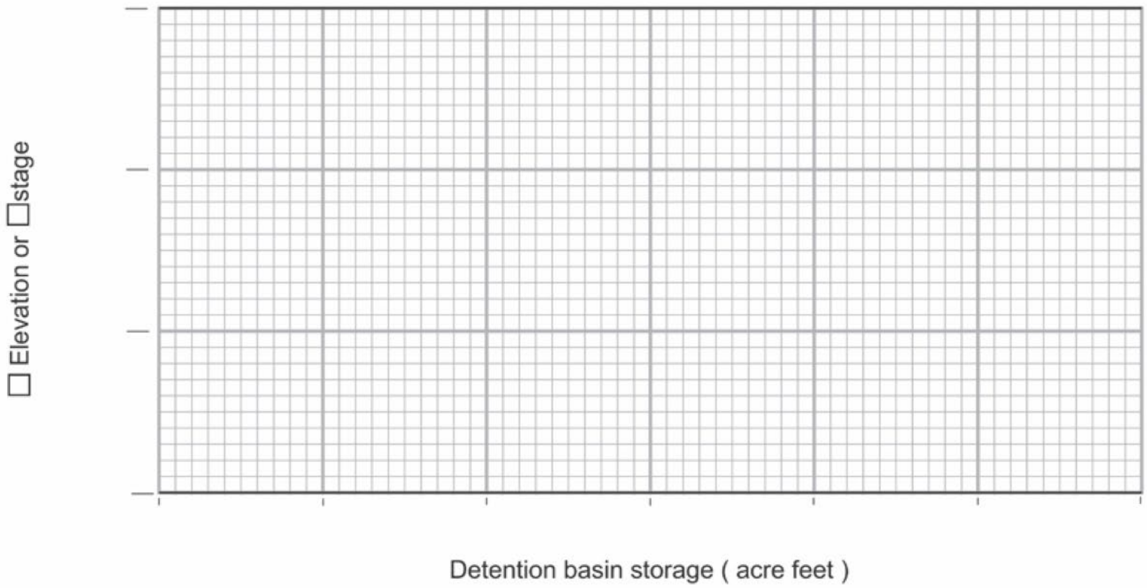
Pond and swamp areas spread throughout watershed .... = ____________ percent of A_m (________ Hectares or Km2 covered)

		Storm #1	Storm #2	Storm #3
2. Frequency	yr			
3. Rainfall, P (24-hour)	mm			
4. Initial abstraction, I_a (Use CN with table 6-8)	mm			
5. Compute I_a / P				
6. Unit peak discharge, q_u (Use T_c and I_a / P with Figure 6-10 _____)	m³/s per Km² per mm			
7. Runoff, Q (From worksheet 1)	mm			
8. Pond and swamp adjustment factor, F_p (Use percent pond and swamp area with table 6-9. Factor is 1.0 for zero percent pond ans swamp area.)				
9. Peak discharge, q_p	m³/s			

(Where $q_p = q_u A_m Q F_p$)

Project	By	Date
Location	Checked	Date

Check one: ☐ Present ☐ Developed



1. Data:
   Drainage area .... A_m = __________ Km²
   Rainfall distribution type (I, IA, II, III) = __________

	1st Stage	2nd Stage
2. Frequency .... yr		
3. Peak inflow discharge q_i .... m³/s (from worksheet 6-3, Developed)		
4. Peak outflow discharge q_u .... m³/s (from worksheet 6-3, Present) 1/		
5. Compute $\frac{q_o}{q_i}$		
6. $\frac{V_s}{V_r}$ .... (Use $\frac{q_o}{q_i}$ with figure 6-11)		
7. Runoff, Q ....mm (From worksheet 1)		
8. Runoff volume V_r.................. m³ ($V_r = QA_m$ 53.33)		
9. Storage volume, V_s .... m³ ($V_s = V_r (\frac{V_s}{V_r})$)		
10. Maximum storage E_{max} (from plot)		

1/ 2nd stage q_o includes 1st stage q_o.

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$$L = [(P \times P_j \times R_v)/1000] \times C \times A \times 10.09$$

$$R_v = 0.05 + 0.009\ (I)$$

Pollutant Loading Table Worksheet

Existing Condition

Land Use	%I	R_V	Area	Concentration (mg/l)			Pollutant Load (kilograms)		
				BOD	TSS	TP	BOD	TSS	TP
1.									
2.									
3.									
4.									

Future Condition

Land Use	%I	R_V	Area	Concentration (mg/l)			Pollutant Load (kilograms)		
				BOD	TSS	TP	BOD	TSS	TP
1.									
2.									
3.									