Appendix – Water Quality Volume

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Inpatient Building Project

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Version: 9/06

For the area draining to*: North Campus Pond

Located in drainage area for S/N: 001

WQ Volume and Modified Curve Number Calculation for Water Quality Treatment in Flow-Based Practice

Use *this worksheet to calculate your WQv if you need to determine the Peak Q for the WQ storm (i.e. designing a grass channel, flow-splitter or other flow based practice) and you are not using any of the site design credits in section 3 of the 2002 VSWMM. See page 2 for "Calculating Peak WQ Discharge Rate (0.9" storm) using the Modified Curve Number." Please note that in the case of grass channels you must include any off-site area draining to the practice as this will affect the peak discharge rate which will ultimately affect the hydraulics, and thus residence time, in your channel.*

Water Quality Volume Calculations

Line			value/calculation	units
1	Area draining to practice	A=	84.87	acres
2	Impervious area		42.56	acres
3	Percent Impervious Area = [(line 2/line 1) * 100] =	I =	50.15	% (whole #)
4	Precipitation	P =	0.9	inches
5	**Runoff coefficient calculation** = (0.05 + (0.009*I))	Rv =	0.501	
6	**WQ Volume (in watershed inches) Calculation** =(P * Rv) =		0.451	Qa (watershed inches, a.k.a. inches of runoff)
7	Minimum WQ Volume[1]		0.2	watershed inches
8	Enter the greater of line 6 or line 7	**WQv =**	0.451	watershed inches
9	**WQ Volume Calculation** = (line 8 *A)/12 =	**WQv =**	3.191	ac. ft.
10	**WQ Volume Calculation** = (line 9 * 43560) =	**WQv =**	139003	cu. ft.

Notes:

1: Sites with low impervious cover (~19%) but that do not employ a **significant** use of the stormwater design credits in Section 3 of the VSWMM are required to treat the minimum water quality volume of 0.2 watershed inches. Sites that have a **significant** portion of their impervious cover addressed via the stormwater credits (section 3 of the VSWMM) will be able to reduce this WQv and will only be required to treat the volume calculated on the "WQ Volume (with credit reduction)" worksheet which will be less than the 0.2 watershed inches.

* Enter the name of the STP (both type and label) which has been designed to treat this particular WQv (e.g. Wet Pond #2)

Version: 9/06

For the area draining to*: North Campus Pond

Located in drainage area for S/N: 001

Calculating Peak WQ Peak Discharge Rate (0.9" storm) using the Modified Curve Number

Because NRCS methods underestimate the peak discharge for rainfall events of less than 2", simply plugging in 0.9" of rainfall into your hydrologic model with the standard curve numbers will not produce the correct peak discharge during the WQv storm, nor will it produce a volume of runoff equivalent to that which you have calculated using the WQv formula (WQv = P*Rv*A/12). In order to calculate the peak discharge for the 0.9" storm, a modified curve number must be calculated. This modified curve number is based on the runoff (in inches) calculated using the short cut method formula (WQv = P*Rv) that is also the basis of the familiar WQv calculations provided in the 2002 VSWMM (and on the WQv calculation worksheets). Essentially, the curve number that is calculated using the methods below is the curve number that will generate the volume of runoff calculated using the WQv formula.

Above, you should have calculated the **WQv in watershed inches draining to the facility/practice** for which you need to calculate the WQ-peak discharge. As provided in the guidance listed on the grass channel worksheet, please remember that the WQv calculation should include runoff from on-site as well as **off-site area** draining to the grass channel since this will have an impact on the channel hydraulics and thus the velocity and residence time.

Steps:

1. Transfer information from WQv calculation worksheets.

Enter the Qa (line 8 from WQv sheet)

Qa = 0.451 inches

Enter the area (site +off-site draining to practice) used in calculating the percent impervious (I)

A = 84.9 acres

2. Use the following equation to calculate a corresponding curve number

where P = 0.9 inches

$$CN = 1000/(10 +(5*P)+(10*Qa) - (10*(Qa^2 + (1.25*Qa*P))^0.5))$$

CN = 94.5 – Modified Curve Number

3. If you are using **hand hydrologic runoff calculations,** use the computed CN above along with your calculated time of concentration and the drainage area (A) to calculate the peak discharge (Qwq) for the water quality storm using the TR-55 Graphical Peak Discharge Method.

OR

3. If you are using a computer aided hydrologic model, simply revise the curve number for your subwatershed(s) draining to the practice using the curve number calculated above; the computed curve number should be applied to the total area (A) used in the WQv calcuation. As a check, you should note that now when you run the 0.9" storm, your runoff depth should be roughly equal to Qa (WQ runoff in inches) and your total runoff volume roughly equal to your WQv (in ac. ft.). If this is not the case, make sure that the time span for your modelling run is long enough to capture the entire storm. Small variations are likely due to having to round your computed CN to a whole number. Remember that for storms larger than 2", you do not need to use the modified curve number and you should calculate your composite curve number based on the accepted values for different types of land-use (see TR-55).

* Enter the name of the STP (both type and label) which has been designed to treat this particular WQv (e.g. Wet Pond #2)

Subsection: Master Network Summary

Catchments Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft³/s)
North Campus	WQvstorm - Synthetic Curve, 0 yrs	0	2.861	12.300	23.18

Node Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft³/s)
Pond Outlet	WQvstorm - Synthetic Curve, 0 yrs	0	2.861	18.600	2.48

Pond Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft³/s)	Maximum Water Surface Elevation (ft)	Maximum Pond Storage (ac-ft)
North Campus (IN)	WQvstorm - Synthetic Curve, 0 yrs	0	2.861	12.300	23.18	(N/A)	(N/A)
North Campus (OUT)	WQvstorm - Synthetic Curve, 0 yrs	0	2.861	18.600	2.48	238.17	1.499

WSE = 235.7 Extended Detention to elevation 238.17'

Subsection: Diverted Hydrograph
Label: NORTH-OUT

Return Event: 0 years
Storm Event: TypeII 24hr (0.9 in)

Peak Discharge	2.48 ft³/s
Time to Peak	18.600 hours
Hydrograph Volume	2.861 ac-ft

Release flows greater than 24 hour detention

43.65 hrs − 9.75 hrs = 33.9 hrs

HYDROGRAPH ORDINATES (ft³/s)
Output Time Increment = 0.050 hours
Time on left represents time for first value in each row.

Time (hours)	Flow (ft³/s)	Flow (ft³/s)	Flow (ft³/s)	Flow (ft³/s)	Flow (ft³/s)
9.350	0.00	0.00	0.00	0.00	0.00
9.600	0.00	0.00	0.01	0.01	0.01
9.850	0.01	0.01	0.01	0.01	0.02
10.100	0.02	0.02	0.02	0.03	0.03
10.350	0.03	0.04	0.04	0.04	0.05
10.600	0.05	0.06	0.06	0.07	0.07
10.850	0.08	0.08	0.09	0.10	0.11
11.100	0.12	0.13	0.14	0.15	0.16
11.350	0.17	0.18	0.20	0.21	0.23
11.600	0.25	0.27	0.30	0.33	0.37
11.850	0.43	0.50	0.61	0.75	0.93
12.100	1.15	1.41	1.70	1.79	1.89
12.350	1.99	2.09	2.18	2.27	2.35
12.600	2.42	2.48	2.48	2.48	2.48
12.850	2.48	2.48	2.48	2.48	2.48
13.100	2.48	2.48	2.48	2.48	2.48
13.350	2.48	2.48	2.48	2.48	2.48
13.600	2.48	2.48	2.48	2.48	2.48
13.850	2.48	2.48	2.48	2.48	2.48
14.100	2.48	2.48	2.48	2.48	2.48
14.350	2.48	2.48	2.48	2.48	2.48
14.600	2.48	2.48	2.48	2.48	2.48
14.850	2.48	2.48	2.48	2.48	2.48
15.100	2.48	2.48	2.48	2.48	2.48
15.350	2.48	2.48	2.48	2.48	2.48
15.600	2.48	2.48	2.48	2.48	2.48
15.850	2.48	2.48	2.48	2.48	2.48
16.100	2.48	2.48	2.48	2.48	2.48
16.350	2.48	2.48	2.48	2.48	2.48
16.600	2.48	2.48	2.48	2.48	2.48
16.850	2.48	2.48	2.48	2.48	2.48
17.100	2.48	2.48	2.48	2.48	2.48
17.350	2.48	2.48	2.48	2.48	2.48
17.600	2.48	2.48	2.48	2.48	2.48
17.850	2.48	2.48	2.48	2.48	2.48
18.100	2.48	2.48	2.48	2.48	2.48
18.350	2.48	2.48	2.48	2.48	2.48
18.600	2.48	2.48	2.48	2.47	2.46
18.850	2.45	2.45	2.44	2.43	2.43

Subsection: Diverted Hydrograph
Label: NORTH-OUT

Return Event: 0 years
Storm Event: TypeII 24hr (0.9 in)

HYDROGRAPH ORDINATES (ft^3/s)
Output Time Increment = 0.050 hours
Time on left represents time for first value in each row.

Time (hours)	Flow (ft^3/s)	Flow (ft^3/s)	Flow (ft^3/s)	Flow (ft^3/s)	Flow (ft^3/s)
19.100	2.42	2.41	2.41	2.40	2.39
19.350	2.38	2.38	2.37	2.36	2.36
19.600	2.35	2.34	2.34	2.33	2.32
19.850	2.31	2.31	2.30	2.29	2.29
20.100	2.28	2.27	2.27	2.26	2.25
20.350	2.24	2.24	2.23	2.22	2.22
20.600	2.21	2.20	2.20	2.19	2.18
20.850	2.18	2.17	2.16	2.16	2.15
21.100	2.14	2.13	2.13	2.12	2.12
21.350	2.11	2.10	2.10	2.09	2.08
21.600	2.08	2.07	2.06	2.06	2.05
21.850	2.04	2.04	2.03	2.03	2.02
22.100	2.01	2.01	2.00	1.99	1.99
22.350	1.98	1.98	1.97	1.96	1.96
22.600	1.95	1.95	1.94	1.93	1.93
22.850	1.92	1.92	1.91	1.90	1.90
23.100	1.89	1.89	1.88	1.88	1.87
23.350	1.86	1.86	1.85	1.85	1.84
23.600	1.84	1.83	1.83	1.82	1.81
23.850	1.81	1.80	1.80	1.79	1.79
24.100	1.78	1.78	1.77	1.76	1.76
24.350	1.75	1.75	1.74	1.73	1.73
24.600	1.72	1.71	1.71	1.70	1.68
24.850	1.66	1.64	1.61	1.59	1.56
25.100	1.54	1.52	1.50	1.47	1.45
25.350	1.43	1.41	1.39	1.36	1.34
25.600	1.32	1.30	1.28	1.26	1.24
25.850	1.22	1.21	1.19	1.17	1.15
26.100	1.13	1.12	1.10	1.08	1.07
26.350	1.05	1.03	1.02	1.00	0.99
26.600	0.97	0.96	0.94	0.93	0.91
26.850	0.90	0.89	0.87	0.86	0.85
27.100	0.83	0.82	0.81	0.79	0.78
27.350	0.77	0.76	0.75	0.74	0.72
27.600	0.71	0.70	0.69	0.68	0.67
27.850	0.66	0.65	0.64	0.63	0.62
28.100	0.61	0.60	0.59	0.58	0.57
28.350	0.57	0.56	0.55	0.54	0.53
28.600	0.52	0.52	0.51	0.50	0.49
28.850	0.48	0.48	0.47	0.46	0.46
29.100	0.45	0.44	0.44	0.43	0.42
29.350	0.42	0.41	0.40	0.40	0.39
29.600	0.38	0.38	0.37	0.37	0.36
29.850	0.36	0.35	0.35	0.34	0.33

Subsection: Diverted Hydrograph
Label: NORTH-OUT

Return Event: 0 years
Storm Event: TypeII 24hr (0.9 in)

HYDROGRAPH ORDINATES (ft³/s)
Output Time Increment = 0.050 hours
Time on left represents time for first value in each row.

Time (hours)	Flow (ft³/s)	Flow (ft³/s)	Flow (ft³/s)	Flow (ft³/s)	Flow (ft³/s)
30.100	0.33	0.32	0.32	0.31	0.31
30.350	0.31	0.30	0.30	0.29	0.29
30.600	0.28	0.28	0.27	0.27	0.27
30.850	0.26	0.26	0.25	0.25	0.25
31.100	0.24	0.24	0.23	0.23	0.23
31.350	0.22	0.22	0.22	0.21	0.21
31.600	0.21	0.20	0.20	0.20	0.19
31.850	0.19	0.19	0.19	0.18	0.18
32.100	0.18	0.17	0.17	0.17	0.17
32.350	0.16	0.16	0.16	0.16	0.15
32.600	0.15	0.15	0.15	0.15	0.14
32.850	0.14	0.14	0.14	0.13	0.13
33.100	0.13	0.13	0.13	0.12	0.12
33.350	0.12	0.12	0.12	0.12	0.11
33.600	0.11	0.11	0.11	0.11	0.11
33.850	0.10	0.10	0.10	0.10	0.10
34.100	0.10	0.09	0.09	0.09	0.09
34.350	0.09	0.09	0.09	0.08	0.08
34.600	0.08	0.08	0.08	0.08	0.08
34.850	0.08	0.07	0.07	0.07	0.07
35.100	0.07	0.07	0.07	0.07	0.07
35.350	0.07	0.06	0.06	0.06	0.06
35.600	0.06	0.06	0.06	0.06	0.06
35.850	0.06	0.05	0.05	0.05	0.05
36.100	0.05	0.05	0.05	0.05	0.05
36.350	0.05	0.05	0.05	0.05	0.04
36.600	0.04	0.04	0.04	0.04	0.04
36.850	0.04	0.04	0.04	0.04	0.04
37.100	0.04	0.04	0.04	0.04	0.04
37.350	0.04	0.03	0.03	0.03	0.03
37.600	0.03	0.03	0.03	0.03	0.03
37.850	0.03	0.03	0.03	0.03	0.03
38.100	0.03	0.03	0.03	0.03	0.03
38.350	0.03	0.03	0.02	0.02	0.02
38.600	0.02	0.02	0.02	0.02	0.02
38.850	0.02	0.02	0.02	0.02	0.02
39.100	0.02	0.02	0.02	0.02	0.02
39.350	0.02	0.02	0.02	0.02	0.02
39.600	0.02	0.02	0.02	0.02	0.02
39.850	0.02	0.02	0.02	0.02	0.02
40.100	0.02	0.01	0.01	0.01	0.01
40.350	0.01	0.01	0.01	0.01	0.01
40.600	0.01	0.01	0.01	0.01	0.01
40.850	0.01	0.01	0.01	0.01	0.01

Subsection: Diverted Hydrograph
Label: NORTH-OUT

Return Event: 0 years
Storm Event: TypeII 24hr (0.9 in)

HYDROGRAPH ORDINATES (ft³/s)
Output Time Increment = 0.050 hours
Time on left represents time for first value in each row.

Time (hours)	Flow (ft³/s)	Flow (ft³/s)	Flow (ft³/s)	Flow (ft³/s)	Flow (ft³/s)
41.100	0.01	0.01	0.01	0.01	0.01
41.350	0.01	0.01	0.01	0.01	0.01
41.600	0.01	0.01	0.01	0.01	0.01
41.850	0.01	0.01	0.01	0.01	0.01
42.100	0.01	0.01	0.01	0.01	0.01
42.350	0.01	0.01	0.01	0.01	0.01
42.600	0.01	0.01	0.01	0.01	0.01
42.850	0.01	0.01	0.01	0.01	0.01
43.100	0.01	0.01	0.01	0.01	0.01
43.350	0.01	0.01	0.01	0.01	0.01
43.600	0.01	0.01	0.00	0.00	0.00
43.850	0.00	0.00	0.00	0.00	0.00
44.100	0.00	0.00	0.00	0.00	0.00
44.350	0.00	0.00	0.00	0.00	0.00
44.600	0.00	0.00	0.00	0.00	0.00
44.850	0.00	0.00	0.00	0.00	0.00
45.100	0.00	0.00	0.00	0.00	0.00
45.350	0.00	0.00	0.00	0.00	0.00
45.600	0.00	0.00	0.00	0.00	0.00
45.850	0.00	0.00	0.00	0.00	0.00
46.100	0.00	0.00	0.00	0.00	0.00
46.350	0.00	0.00	0.00	0.00	0.00
46.600	0.00	0.00	0.00	0.00	0.00
46.850	0.00	0.00	0.00	0.00	0.00
47.100	0.00	0.00	0.00	0.00	0.00
47.350	0.00	0.00	0.00	0.00	0.00
47.600	0.00	0.00	0.00	0.00	0.00
47.850	0.00	0.00	0.00	0.00	0.00
48.100	0.00	0.00	0.00	0.00	0.00
48.350	0.00	0.00	0.00	0.00	0.00
48.600	0.00	0.00	0.00	0.00	(N/A)