the water management system. Slope will tend to increase when channels are straightened and decrease when overland flow is directed through storm sewers, street gutters, and diversions.

Time of Concentration Equations

The time of concentration for a catchment is the sum of the travel times of each flow segment:

Equation 1 - Time of Concentration Equation

$$t_c = \sum (t_{overland} + t_{shallow} + t_{concentrated})$$

Overland Flow

Overland flow or sheet flow is the shallow mass of runoff on a planar surface with a uniform depth across the sloping surface. This usually occurs at the headwater of streams over relatively short distances, rarely more than about 130 metres. The most accurate way to estimate the overland flow travel time is with a version of the kinematic wave equation, a derivative of Manning's equation, shown as:

Equation 2 - Kinematic Wave Equation

$$t_{ti} = \frac{0.438\, L^{0.6} n^{0.6}}{I^{0.4} S^{0.3}}$$

where t_{ti} = overland flow travel time (min)
L = overland flow length (m)
n = Manning's roughness coefficient
I = rainfall rate (meters/hr)
S = average slope of the overland area

Sediment Removal

1. After grading of the facility is completed and the SWM Pond liner (if applicable) has been installed, the Owner shall complete a topographic survey of the facility to determine the elevations prior to the facility being operational. The City requires that the survey work be completed in a dry condition. The Owner shall submit a plan to the City comparing the results of the topographic survey to the approved SWM Pond design. The results shall verify that the facility has been constructed in accordance with the approved design; otherwise the process may have to be repeated.

2. The forebay and main cell sediment levels shall be monitored until issuance of a Final Acceptance Certificate by the City. The Owner shall remove the sediments from the forebay on an annual basis, unless it has been demonstrated that the accumulated sediment volume is less than 25% of the forebay permanent pool volume. The volume of forebay sediments shall be estimated using at least 5 uniformly distributed measurements of sediment depth taken within the forebay. The Owner shall remove the sediments from the main cell when the accumulated sediment volume is greater than 25% of the main cell permanent pool volume. The volume of main cell sediments shall be estimated using at least 5 measurements of sediment depth along a mid section along the length of the facility. A secchi disk shall be used to estimate levels in a wet condition if the water level is too deep for a sediment rod to reach.

3. Prior to issuance of a Final Acceptance Certificate by the City, the Owner shall determine the sediment quality by taking samples of the sediment from both the forebay and main cell and submit them to an accredited lab; the results of these lab tests will indicate the disposal method and shall be submitted to the City. The Owner shall drain the facility and remove all sediments from the forebay and main cell in accordance with the *Environmental Protection Act* and MOE guidelines as determined by the test results. The Owner shall complete a second topographic survey after all the sediment has been removed. This topographic survey shall be submitted to the City, along with a comparative analysis to the survey taken after substantial completion and the approved SWM Pond design. The results shall verify that all sediments have been removed from the facility; otherwise the process may have to be repeated.

Water Quality Performance Monitoring

4. Water quality samplers shall be installed at the inlet and outlet of the SWM Pond to characterize the facility’s removal efficiency for TSS. Flow-weighted water samples from the samplers at the inlet and outlet of the facility shall be collected after significant rainfall events and submitted to an accredited laboratory to test for TSS.

5. Water samples shall be taken for the period from substantial completion to the date on which a Final Acceptance Certificate is issued by the City. If it is found that the TSS removal efficiency is not meeting the SWM Pond's design objectives as per the MOE Certificate of Approval then the City may require the Owner to undertake remedial works to the SWM Pond to ensure the facility is operating as designed, to the satisfaction of the City.

Water Quantity Performance Monitoring

6. A metric staff gauge shall be installed adjacent to the storm sewer inlet headwall so that the zero reading is set at the permanent pool elevation. The outlet structure shall be inspected on a monthly basis to ensure that perforated riser inlets are not blocked due to sediments or debris. The monthly inspection shall be undertaken in dry weather conditions, at least 120 hours after any rainfall event, as that is the expected drawdown time for the extended detention storage for the majority of SWM Ponds in Pickering. The monthly reports shall include a time-stamped picture of the staff gauge and a reading to determine any fluctuations in the permanent pool elevation.

7. Flow measurement equipment shall be installed at all inlets and outlets in addition to a water level sensor for the SWM Pond. Measurements from the monitoring equipment shall be made at 5 minute intervals. The water level sensor shall be referenced to a geodetic benchmark.

8. A tipping-bucket rain gauge shall be installed in a suitable location in the SWM Pond block (refer to guidance from meteorological organizations) which records rainfall data at 5 minute intervals. The rain gauge will need to be calibrated every spring during the monitoring period.

9. Data from the rain gauge shall be reviewed in conjunction with rainfall data from TRCA Rain Gauge 130 (if any issues use rainfall data from TRCA Rain Gauge 84 or 106) for 8 significant events. The resulting data shall be analyzed to assess the following in comparison to the SWM Pond approved engineering design and the MOE Certificate of Approval: permanent pool or normal water level; verification of the stage-discharge curve; fluctuation in water levels in response to rainfall events; and facility drain down time for a range of rainfall event sizes.

10. If it is found that the SWM Pond is not meeting the design objectives stated above in (9) as per the MOE Certificate of Approval then the Owner shall undertake remedial works, to the satisfaction of the City.

9.3 Bioswale

1. The Owner shall confirm the area connected to the Bioswale for the year in question, as it will change from year-to-year as the subdivision builds out and it may affect the quantity of runoff entering the system.

2. Flow measurement equipment shall be installed at the inlet and outlet of the bioswale. The monitoring equipment shall be installed immediately after substantial completion of the Bioswale facility.

3. Data from the rain gauge shall be reviewed in conjunction with rainfall data from TRCA Rain Gauge 130 (if there are any issues use rainfall data from TRCA Rain Gauge 84 or 106) for 20 rainfall events, including 8 significant events, which represent erosive flows to ensure that these erosive flows are not occuring at a greater frequency than under existing conditions. The rainfall and flow measurements shall be processed in a graphical format to display the fluctuation over time.

4. If it is found that the Bioswale is not meeting the design objectives stated in (3) above, as per the MOE Certificate of Approval, then the Owner shall undertake remedial works, to the satisfaction of the City.

9.4 Infiltration Trench

1. The Owner shall confirm the area connected to the Infiltration Trench for the year in question, as it will change from year-to-year as the subdivision builds out and it may affect the quantity of runoff entering the system.

2. The intent of the monitoring program is to determine the performance of the Infiltration Trench through completing a mass balance on the flow into the trench with the flow out of the trench measured at the overflow into the storm sewer system. The difference between these two measurements represents the volume of water that has infiltrated. Furthermore, the water level in the Infiltration Trench is being monitored to ensure that it drains within 72 hours and that the entire length of trench is being used for infiltration.

3. Flow measurement equipment shall be installed at the first manhole upstream of the Infiltration Trench to measure the inflow in addition to flow measurement equipment to measure the overflow into the storm sewer system. A series of piezometers may be installed along the length of the infiltration trench to monitor the water level and the infiltration rate and drawn down time of the facility. The elevation of piezometers shall be referenced to a geodetic benchmark. The monitoring equipment shall be installed immediately after substantial completion of the facility.

City of Pickering AES Storm Hyetographs
50-yr Return Period

IDF Data: Toronto, Bloor St.
AES Distribution: Toronto

1-Hour AES Storm

Time (hr)	Precip. (mm/hr)
0	0.00
5	6.17
10	18.50
15	49.34
20	92.52
25	172.70
30	92.52
35	74.02
40	49.34
45	30.84
50	18.50
55	6.17
60	6.17
Depth (mm)	**51.4**

12-Hour AES Storm

Time (hr)	Precip. (mm/hr)
0	0.00
15	0.79
30	0.79
45	0.79
60	0.79
75	0.79
90	0.79
105	0.79
120	0.79
135	4.74
150	4.74
165	4.74
180	4.74
195	13.43
210	13.43
225	13.43
240	13.43
255	36.34
270	36.34
285	36.34
300	36.34
315	10.27
330	10.27
345	10.27
360	10.27
375	5.53
390	5.53
405	5.53
420	5.53
435	3.16
450	3.16
465	3.16
480	3.16
495	1.58
510	1.58
525	1.58
540	1.58
555	0.79
570	0.79
585	0.79
600	0.79
615	0.79
630	0.79
645	0.79
660	0.79
675	0.79
690	0.79
705	0.79
720	0.79
Depth (mm)	**79.0**

City of Pickering AES Storm Hyetographs
100-yr Return Period

IDF Data: Toronto, Bloor St.
AES Distribution: Toronto

1-Hour AES Storm

Time (hr)	Precip. (mm/hr)
0	0.00
5	6.82
10	20.45
15	54.53
20	102.24
25	190.85
30	102.24
35	81.79
40	54.53
45	34.08
50	20.45
55	6.82
60	6.82
Depth (mm)	**56.8**

12-Hour AES Storm

Time (hr)	Precip. (mm/hr)
0	0.00
15	0.86
30	0.86
45	0.86
60	0.86
75	0.86
90	0.86
105	0.86
120	0.86
135	5.19
150	5.19
165	5.19
180	5.19
195	14.71
210	14.71
225	14.71
240	14.71
255	39.79
270	39.79
285	39.79
300	39.79
315	11.24
330	11.24
345	11.24
360	11.24
375	6.06
390	6.06
405	6.06
420	6.06
435	3.46
450	3.46
465	3.46
480	3.46
495	1.73
510	1.73
525	1.73
540	1.73
555	0.86
570	0.86
585	0.86
600	0.86
615	0.86
630	0.86
645	0.86
660	0.86
675	0.86
690	0.86
705	0.86
720	0.86
Depth (mm)	**86.5**

Hurricane Hazel
Rainfall Hyetograph

Time (min)	Intensity (mm/hr)
0	0
60	6
120	4
180	6
240	13
300	17
360	13
420	23
480	13
540	13
600	53
660	38
720	13

Note: To be used with AMC III conditions

HURRICANE HAZEL RAINFALL DEPTHS

	Depth (mm)	Depth (Inches)	Percent of 12 Hour
First 36 hours	73	2.90	-
37th hour	6	.25	3
38th hour	4	.17	2
39th hour	6	.25	3
40th hour	13	.50	6
41st hour	17	.66	8
42nd hour	13	.50	6
43rd hour	23	.91	11
44th hour	13	.50	6
45th hour	13	.50	6
46th hour	53	2.08	25
47th hour	38	1.49	18
48th hour	13	.50	6
	285	11.21	100

NOTE: For drainage areas 25 km^2 or less

HURRICANE HAZEL - AREAL REDUCTION

Drainage Area (km^2)	Percentage
0 to 25	100.0
26 to 45	99.2
46 to 65	98.2
66 to 90	97.1
91 to 115	96.3
116 to 140	95.4
141 to 165	94.8
166 to 195	94.2
196 to 220	93.5
221 to 245	92.7
246 to 270	92.0
271 to 450	89.4
451 to 575	86.7
576 to 700	84.0
701 to 850	82.4
851 to 1000	80.8
1001 to 1200	79.3
1201 to 1500	76.6
1501 to 1700	74.4
1701 to 2000	73.3
2001 to 2200	71.7
2201 to 2500	70.2
2501 to 2700	69.0
2701 to 4500	64.4
4501 to 6000	61.4
6001 to 7000	58.9
7001 to 8000	57.4

Source: Technical Guidelines for Flood Plain Management in Ontario, Working Paper C, Rainfall Analysis, Report to MNR, Dillon Consulting, August 1985

CN Value Conversion Table (AMC I, II, and III)

AMC II	AMC I	AMC III	AMC II	AMC I	AMC III
100	100	100	60	40	78
99	97	100	59	39	77
98	94	99	58	38	76
97	91	99	57	37	75
96	89	99	56	36	75
95	87	98	55	35	74
94	85	98	54	34	73
93	83	98	53	33	72
92	81	97	52	32	71
91	80	97	51	31	70
90	78	96	50	31	70
89	76	96	49	30	69
88	75	95	48	29	68
87	73	95	47	28	67
86	72	94	46	27	66
85	70	94	45	26	65
84	68	93	44	25	64
83	67	93	43	25	63
82	66	92	42	24	62
81	64	92	41	23	61
80	63	91	40	22	60
79	62	91	39	21	59
78	60	90	38	21	58
77	59	89	37	20	57
76	58	89	36	19	56
75	57	88	35	18	55
74	55	88	34	18	54
73	54	87	33	17	53
72	53	86	32	16	52
71	52	86	31	16	51
70	51	85	30	15	50
69	50	84			
68	48	84	25	12	43
67	47	83	20	9	37
66	46	82	15	6	30
65	45	82	10	4	22
64	44	81	5	2	13
63	43	80	0	0	0
62	42	79			
61	41	78			

Source: Mishra, Surendra and Vijay P. Singh (2003). Soil Conservation Service Curve Number (SCS-CN) Methodology. Norwell, MA: Kluwer Acedemic Publishers, p103.