An Evaluation of Roadside Ditches

And Other Related Stormwater Management Practices

Addendum - Revised Cost Analysis and Selection Tool

Original Report Published April 1997

February, 2000

THE TORONTO AND REGION CONSERVATION AUTHORITY

Ministry of the Environment
Ontario

Lake Simcoe Region Conservation Authority

Environment Canada / Environnement Canada
GREAT LAKES 2000 CLEANUP FUND

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J.F. Sabourin and Associates Inc.
Water Resources and Environmental Consultants

In cooperation with: City of Ottawa, City of Toronto, Town of Richmond Hill, Rideau Valley Conservation Authority, Totten Sims Hubicki Associates, and Donald G. Weatherbe Associates Inc.

"Evaluation of Roadside Ditches and Other Related Stormwater Management Practices"

- Addendum -

Revised Cost Analysis and Selection Tool
February, 2000

FINAL REPORT

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The Toronto and Region Conservation Authority

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The Great Lakes 2000 Cleanup Fund is a component of the Federal Government's Great Lakes 2000 program. The Cleanup Fund provides resources to demonstrate and implement technologies and techniques to assist in the remediation of Areas of Concern and other priority areas in the Great Lakes. The report that follows was sponsored by the Great Lakes 2000 Cleanup Fund and addresses stormwater management issues in the Toronto and Region Area of Concern in Toronto, Ontario. Although the report was subject to technical review, it does not necessarily reflect the views of the Cleanup Fund or Environment Canada.

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Table of Contents

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Preface

This addendum updates chapters 10 (Economic Considerations) and 12 (Alternative Drainage System Selection Tool) of the final report from *An Evaluation of Roadside Ditches and Other Related Stormwater Management Practices* (J.F. Sabourin and Associates Inc., 1997). In the updated chapters, the road drainage system Selection Tool has been enhanced in the following areas:

- revised cost tables, allowing for a comparison of present values using dicount rates and life cycles;
- the addition of standardized objective setting tables;
- update and completion of stormwater management performance tables; and
- clearer documentation for the tool's use.

One significant enhancement is the transformation of the tool from a paper copy to a digital spreadsheet format, for on-screen use. It is expected that this latter improvement will make the tool much easier to use, and will thereby enhance its adoption by designers.

Revisions to the Selection Tool have been made in response to recommendations from a demonstration study (Totten Sims Hubicki and Associates and Donald G. Weatherbe and Associates, 1999). That study, commissioned by the TRCA, tested the Selection Tool in the design of four urban road reconstruction projects, located in the City of Toronto, Town of Richmond Hill, and City of Ottawa. Other partners in the study included: the City of Ottawa, City of Toronto, Town of Richmond Hill, Environment Canada's Great Lakes 2000 Cleanup Fund (GL2000CUF), the Ministry of the Environment (MOE), the Rideau Valley Conservation Authority, Lake Simcoe Region Conservation Authority, and Ryerson University.

The information and tools provided in the original report and this addendum are intended to assist designers and reviewers in determining the appropriate road drainage system for a given location. Results of the study again underscore the fact that no single road drainage system is suitable for all cases. The project partners hope that this information will promote further consideration and testing of alternative technologies.

NOTE: *As of January 1, 1998, the Metropolitan Toronto and Region Conservation Authority (MTRCA) changed its name to Toronto and Region Conservation Authority (TRCA).*

10.0 Economic Considerations

The purpose of this section is to provide the necessary information to allow comparative cost analyses to be undertaken in the comparison of alternative drainage systems. However, the economic comparison should only be undertaken after the elimination of alternatives that are incompatible with site characteristics and development objectives.

The sources of information used to prepare this section include: City of Ajax, City of Oshawa, City of Etobicoke, York Region, Town of Richmond Hill, City of Nepean, City of Kanata, City of Vanier, City of Gatineau, Markborough Properties Inc., Sorbara Group (Vaughan), the MOEE Stormwater Management Practices Planning and Design Manual, the book "Techniques Alternatives en Assainissement Pluvial" by Azzout et al., and personal communications with several municipal engineers. Details of the collected information is provided in Appendix F.

It is noted that the information presented in this section represents an average of collected data and that capital and maintenance costs can vary from one municipality to another. In particular, maintenance costs can vary greatly with the frequency of the activities and should be adjusted based on individual needs. The digital spreadsheet copy of the selection tool provides this flexibility.

To simplify the cost comparison between various alternatives, Table 10.1 provides Capital, Maintenance and Total Present Value Costs for the construction and maintenance of various road drainage system components.

The Amortized Capital Costs (ACC) for the individual components were first computed with the following equation based on the provided construction or replacement cost, the annual discount rate and the life expectancy (longevity) of each component.

$$Amortized\ Capital\ Cost\ (ACC) = \frac{(CR \times i\%)}{1 - (1 + i\%)^{-L}} \qquad \mathbf{(10.1)}$$

Where
- CR= the construction or replacement cost
- i%= the annual discount rate
- L= the life expectancy (longevity) of the component

As an example, the construction or replacement cost of a manhole which is installed within the structure of a street was estimated at \$3,300. With an annual discount rate of 7% and a life expectancy of 40 years, the ACC of the manhole can be computed as \$247.53 using equation (1) as follows;

$$\frac{(\$3{,}300 \times 7\%)}{1 - (1 + 7\%)^{-40}} = \$247.53 \qquad \text{Example application of equation (10.1)}$$

Next, the present value of the capital and annual repair costs for each drainage component are calculated with the following equation based on the calculated amortized capital cost (equation 1), the annual discount rate, the selected life cycle and the estimated annual repair costs.

$$Present\ Value\ of\ (Capital + Annual\ Repairs) = TACC \times \frac{1 - (1 + i\%)^{-LC}}{i\%} \qquad \mathbf{(10.2)}$$

Where	TACC	=	Total of the Amortized Capital and the Annual Repair Costs
	i%	=	the annual discount rate
	LC	=	the Life Cycle being considered

As an example, the present value of a manhole installed within the structure of a street was computed at $3,691.04 based on annual discount rate of 7%, a life cycle of 80 years and an estimated annual repair cost of $12 per manhole. This can be computed by applying equation (2) as follows;

$$(\$247.53 + \$12.00) \times \frac{1 - (1 + 7\%)^{-80}}{7\%} = \$3{,}691.04 \qquad \text{Example application of equation (10.2)}$$

Similarly, the Present Value of the Amortized Annual Maintenance Activities (costs related to typical maintenance activities are provided in Table 10.2 and discussed below) can also be computed with the use of equation (2). The TOTAL Present Value Cost presented in Table 10.1 is thus the sum of the Present Value of the Capital and Repair Costs plus the Present Value of the Annual Maintenance Costs.

Various maintenance activities and related costs, which can be associated to various drainage components, are provided in Table 10.2. These unit maintenance costs refer mainly to cleaning activities. As with the capital costs, the provided unit maintenance costs represent average values obtained from several sources and should be verified against local cost information. It should also be noted that the provided maintenance costs are based on volume. For example, catch basin cleaning was estimated at $5/ea on the basis that a contractor would be required to clean several catch basins within the same work order.

The Amortized Annual Maintenance Costs of the various maintenance activities of Table 10.2 can be established based on the Average Unit Maintenance Cost and the proposed frequency. As such if the frequency of the maintenance activity is set to one or more times per year then the Amortized Annual Maintenance Cost is equal to the Average Unit Maintenance Cost multiplied by the frequency. For example, the Average Unit Maintenance Cost for street flushing was estimated at $0.10 / m. If street flushing is undertaken twice a year then the associated Amortized Annual Maintenance Cost is $0.20 (2 x $0.10).

However, if the frequency of the maintenance activity is less than once per year then the associated Amortized Annual Maintenance Cost (AMC) can be computed with the help of equation (1), but modified in order to not double count certain maintenance activities when the drainage component is actually replaced. The modified equation is as follows;

$$Amortized\ Annual\ Maintenance\ Cost\ (AAMC) = \frac{\left(\frac{AMUC}{(1 + i\%)^{(1/FREQ)}} \times i\%\right)}{1 - (1 + i\%)^{-(LONG \times (\frac{LONG}{(1/FREQ)} - 1)^{-1})}} \qquad \textbf{(10.3)}$$

Where	AMUC	=	the Average Maintenance Unit Cost
	i%	=	the annual discount rate
	FREQ	=	the Frequency of maintenance activity (0.2 = once in 5 years)
	LONG	=	the Longevity of the associated drainage component

A simple example as to why the modified equation (3) is needed, is with Item # 5 (Ditch regrading and cleaning) which is scheduled to occur every 10 years. However, since the longevity of the ditch is set to 20 years (Table 10.1) a ditch would in fact be cleaned only every 20 years. Using a 10 year cycle in the original equation (1) would double count the costs associated with the ditch regrading and cleaning.

For each drainage system component and the selected maintenance activities, the individual AMC of the Average Unit Maintenance Costs are summed up and transferred to the appropriate column in Table 10.1. The Present Value of the total AMC are then computed and added to the Present Value of the Capital and Repair Costs to give the TOTAL Present Value COST associated with each drainage system component.

It is noted that because of the potentially large variability from one area to another, the cost of land and losses in tax revenues were not included in the overall cost of end of pipe facilities.

With the digital Excel spreadsheet copy of the cost tables, the user can enter, modify and adjust the following parameters;

i) construction or replacement costs
ii) life expectancy (longevity)
iii) discount rate
iv) lifecyle
v) up to four maintenance activities associated with each component
vi) average costs associated with each maintenance activity
vii) frequency of maintenance activities

The use of the Excel spreadsheet will provide the flexibility to designers and engineers to easily evaluate and compare the total Present Value of various potential alternative drainage systems.

10.1 Example Cost Comparison

As an example, Table 10.3 compares the cost for four typical drainage systems where System #1 is a conventional curb and gutter system with concrete pipes and an end of pipe facility for quality and erosion control; System #2 is similar to System # 1 but an Oil and Grit Separator unit is used to provide some quality control; System #3 is a conventional ditch system with an end of pipe facility for quality and erosion control; and System #4 is a grass swale system with perforated pipes and infiltration trenches capable of retaining and infiltrating the runoff of a 25 mm storm. It is assumed that the various designs will provide at least a 1:5 yr level of service with quality and erosion control based on a 25 mm storm. The type of development used in the example consists of a 10 ha area with 40% imperviousness, 20 m ROW, and 20 x 40 m lots.

Based on the costs provided in Table 10.1 and Table 10.2 and the design assumptions presented in Table 10.3, it is found that the least costly alternative is the conventional ditch system with an end of pipe facility for erosion control. The second least expensive system is the grass swale with perforated pipe system and exfiltration trenches capable of retaining and exfiltrating the runoff of a 25 mm storm.

When compared to the conventional curb and gutter system the total present value costs of the conventional ditch system and grass swale with perforated pipe system represent 60% and 74% of the present value costs associated with the conventional curb and gutter system. The conventional curb and gutter system with an Oil and Grit Separator is approximately 3% more expensive.

The Excel Spreadsheet of Tables 10.1 and 10.2 provide the means to conduct quick cost comparisons for various other alternative drainage systems.

However, in view of the potential variability in unit cost between municipalities, it is strongly recommended that further assessment of cost be conducted through site specific case examples.

Table 10.1: Capital, Annualized and Total Present Value Costs

(assumes that rock excavation is not required)

Discounted Rate = 7% Life cycle (yrs): 80

Road Drainage System Components		Capital costs – Construction / Replacement: Construction or replacement cost	Longevity (yrs)	Amortized capital cost	Annual repair costs	Present Value capital and repair costs	Maintenance activities and related cost: Activity (refer to Table 10.2 for descriptions)			Total Annual maintenance cost	Present Value annual maint. cost	TOTAL PRESENT VALUE COST
Road Surfaces[+]	with curbs	$311.00 /m	40	$23.33 /m	n/a	$331.77 /m	1	2		$0.55 /m	$7.82	$339.59 /m
(with curbs, w = 8.5 m)	with ditches or swales (w/o subdrains)	$346.00 /m	20	$32.66 /m	n/a	$464.49 /m	1	3		$0.60 /m	$8.53	$473.02 /m
(others, w = 7.5 m + shldr)	with ditches or swales (w/ subdrains)	$346.00 /m	40	$25.95 /m	n/a	$369.11 /m	1	3		$0.60 /m	$8.53	$377.64 /m
Subdrains 100mm diam		$20.00 /m	40	$1.50 /m	n/a	$21.34 /m	n/a			$0.00 /m	$0.00	$21.34 /m
Curbs (one side only)		$45.00 /m	20	$4.25 /m	$0.27 /m	$64.25 /m	n/a			$0.00 /m	$0.00	$64.25 /m
Cubs and gutter (one side only)		$60.00 /m	20	$5.66 /m	$0.27 /m	$84.39 /m	n/a			$0.00 /m	$0.00	$84.39 /m
Manholes	installed on street	$3,300.00 /ea	40	$247.53 /ea	$12.00 /ea	$3,691.04 /ea	8a			$5.00 /ea	$71.11	$3,762.15 /ea
	installled off traffic areas	$3,300.00 /ea	80	$232.03 /ea	$3.00 /ea	$3,342.67 /ea	8b			$2.36 /ea	$33.55	$3,376.22 /ea
Regular Catch Basins	installed on street	$1,400.00 /ea	40	$105.01 /ea	$12.00 /ea	$1,664.16 /ea	8a			$5.00 /ea	$71.11	$1,735.27 /ea
	installed off traffic areas	$1,400.00 /ea	80	$98.44 /ea	$3.00 /ea	$1,442.67 /ea	8b			$2.36 /ea	$33.55	$1,476.22 /ea
Corrugated steel catch basins with 12" grate		$550.00 /ea	40	$41.26 /ea	n/a	$586.73 /ea	8b			$2.30 /ea	$32.75	$619.48 /ea
Storm sewers	(typ. 450mm)	$480.00 /m	40	$36.00 /m	$0.27 /m	$515.89 /m	n/a			$0.00 /m	$0.00	$515.89 /m
Multiple pipe exfiltration system		$1,000.00 /m	40	$75.01 /m	$0.14 /m	$1,058.77 /m	15b			$0.31 /m	$4.43	$1,073.20 /m
Ditches	(one side of road)	$45.00 /m	20	$4.25 /m	n/a	$60.41 /m	5			$0.29 /m	$4.09	$64.51 /m
Grass swales	(one side of road)	$36.00 /m	20	$3.40 /m	n/a	$48.33 /m	4			$0.30 /m	$4.27	$52.60 /m
Roadside topsoil and grass	(one side of road)	$36.00 /m	20	$3.40 /m	n/a	$48.33 /m	n/a			$0.00 /m	$0.00	$48.33 /m
Culverts	(typ. 450mm)	$700.00 /ea	20	$66.08 /ea	$3.80 /ea	$993.76 /ea	7			$5.00 /ea	$71.11	$1,064.87 /ea
Check dams		$300.00 /ea	10	$42.71 /ea	n/a	$607.47 /ea	??			$0.00 /ea	$0.00	$607.47 /ea
Perforated pipes (including granular	no pre-treatment	$175.00 /m	40	$13.13 /m	$0.14 /m	$188.68 /m	15b			$0.31 /m	$4.43	$193.10 /m
material and geotextile)	with pre-treatment	$175.00 /m	40	$13.13 /m	$0.14 /m	$188.68 /m	15d			$0.06 /m	$0.90	$189.58 /m
House sump pumps		$200.00 /ea	10	$28.48 /ea	n/a	$404.98 /ea	n/a			$0.00 /ea	$0.00	$404.98 /ea
Outfall and Erosion control		$10,000.00 /ea	20	$943.93 /ea	n/a	$13,424.57 /ea	10a (if at end of curb & gutter)			$500.00 /ea	$7,111.00	$7,111.00 /ea
							10b (if at end of ditch or swale)			$134.50 /ea	$1,912.82	$1,912.82 /ea
							10c (if system retains 25mm runoff)			$68.74 /ea	$977.57	$977.57 /ea
Dry ponds	40% imperviousness	$20,000.00 /10 ha	40	$150.02 /1 ha *$1.50 /m*	n/a	$2,133.56 /1 ha *$21.34 /m*	12	13		$336.28 /1 ha *$3.36 /m*	$4,782.51	$6,916.07 /1 ha* *$69.16 /m*
Wet ponds	40% imperviousness	$30,000.00 /10 ha	40	$225.03 /1 ha *$2.25 /m*	n/a	$3,200.34 /1 ha *$32.00 /m*	11	13		$396.28 /1 ha *$3.96 /m*	$5,635.83	$8,836.17 /1 ha* *$88.36 /m*
Artificial wetlands	40% imperviousness	$35,000.00 /10 ha	40	$262.53 /1 ha *$2.63 /m*	n/a	$3,733.73 /1 ha *$37.34 /m*	11	13		$396.28 /1 ha *$3.96 /m*	$5,635.83	$9,369.56 /1 ha* *$93.70 /m*
Infiltration Basin	40% imperviousness	$25,000.00 /10 ha	40	$187.52 /1 ha *$1.88 /m*	n/a	$2,666.95 /1 ha *$26.67 /m*	12	13	14	$400.75 /1 ha *$4.01 /m*	$5,699.48	$8,366.43 /1 ha* *$83.66 /m*
Water quality inlets: Oil and grit separators**	40% imperviousness	$5,520.00 /1 ha *($13,800 /ha imp)*	40	$414.05 /1 ha *$4.14 /m*	$4.80 /1 ha *($12/unit/ha imp)*	$5,956.89 /1 ha *$59.57 /m*	9			$500.00 /1 ha *$5.00 /m*	$7,111.00	$13,067.90 /1 ha *$130.68 /m*
Infiltration trenches	40% imperviousness	$20,000.00 /1 ha	10	$2,847.55 /1 ha *$28.48 /m*	n/a	$40,497.87 /1 ha *$404.98 /m*	16			$277.50 /m²	$3,946.61	$44,444.48 /1 ha
Exfiltration wells	40% imperviousness	$62,500.00 /1 ha	10	$8,898.59 /1 ha *$88.99 /m*	n/a	$126,555.85 /1 ha *$1,265.56 /m*	17			$3,100.00 /1 ha	$44,088.22	$170,644.07 /1 ha

Notes:

Conversions from (ha) to (m) are based on the assumption of a typical street ROW of 20 m and 40 m deep lots

*) Total amortized cost does not include land value and potential losses in tax revenues

**) Costing information provided by *Stormceptor*

+) Does not include the cost of the curbs or subdrains.

Costs are in 1996 dollars and represent averages. Actual costs may vary between municipalities

Amortized capital cost is at the given discounted rate (7%) over the longevity period

Present Value calculation all done over the given life cycle (80 years) at the shown discounted rate.

- Annual costs for activities done less than once per year have been determined by a two step calculation
  1. Present value at the discounted rate is determined over the maintenance period
  2. Amortized cost are then calculated over the maintenance period at discount rate of 7%
  3. For activities which are done only once in the lifetime of the device, the cost is amortized over the entire life = 2X the maintenance period

Table 10.2: Maintenance Activities and Associated Costs

Item	Maintenance Activity			Average Cost per unit	Frequency per year
1	Street Flushing		(both sides)	$0.10 /m	2
2	Street sweeping (only for roads with curbs)		(both sides)	$0.07 /m	5
3	Shoulder and edge treatment		(both sides)	$0.20 /m	2
4	Grass cutting and repairs			$0.30 /m	1
5	Ditch regrading and cleaning		(both sides)	$6.00 /m	0.1
6	Swale regrading, sod and topsoil			/m	
7	Culvert thawing and winter drainage		($500 per 100 units)	$5.00 /ea	1
8a	Catch basin cleaning	installed on street		$5.00 /ea	1
8b		installed off street (w/ pre-treatment)		$5.00 /ea	0.5
9	Oil and grit separator cleaning ($250) + disposal ($250) actual cost depends on the number of units being cleaned out at a given time.			$500.00 /ea	1
10a	Outfall maintenance	from conventional C&G system		$500.00 /ea	1
10b		from ditch or grass swale system		$500.00 /ea	0.33
10c		if system retains 25mm rainfall		$500.00 /ea	0.2
11	Wet pond maintenance	grass cutting, litter pickup, weed control, re-planting		$390.00 /1 ha drainage area	1
12	Dry pond maintenance	grass cutting, litter pickup, weed control, re-planting		$330.00 /1 ha drainage area	1
13	Sediment removal from end of pipe facilities including disposal	40 % imperviousness (Annual Loading = 0.925m³/ha)		$323.75 /1 ha	0.05
14	Infiltration basin maintenance	tiling and re-vegitation		$140.00 /1 ha drainage area	0.5
15a	Pervious pipe maintenance	no pre-treatment	flushing	$1.00 /m	0.2
15b			radial washing	$2.00 /m	0.2
15c	Pervious pipe maintenance	with pre-treatment	flushing	$1.00 /m	0.07
15d			radial washing	$2.00 /m	0.07
16	Infiltration trench maintenance (1.5 m deep, control runoff from 25mm runoff @ 40% imp)			$277.50 /1 ha	1
17	Exfiltration wells (assume 3.2 exfiltration wells per hectare for 40% imperviousness)			$3,100.00 /1 ha	1
18	**User Defined Maintenance Activity**				
19	**User Defined Maintenance Activity**				
20	**User Defined Maintenance Activity**				

Notes:
- Conversions from (ha) to (m) are based on the assumption of a typical street ROW of 20 m and 40 m deep lots.
- Costs are in 1996 dollars and represent averages of collected information.
- Actual unit costs may vary between municipalities.
- Frequency of maintenance activities should also be adjusted accordingly.

Table 10.3: Cost comparison between four typical systems
(New system)

System objectives: Designed to provide at least a 1:5 yr level of service with quality and erosion control based on a 25 mm storm. Use 7% annual discount rate and 80 year lifecycle.

Development: 10 ha area at 40% imperviousness, with a 1000 m x 8.5 m roadway and a 20 m ROW with 20 x 40 m lots.

System components	TOTAL Present Value COSTS , ( ) represents number of units			
	System #1 Conventional curb and gutter system with concrete pipes and an end of pipe facility for quality and erosion control.	**System #2** Like System #1 but with Oil & Grit Separator units for source control and an end of pipe facility for additional quality and erosion control.	**System #3** Conventional ditch system with an end of pipe facility for quality and erosion control. Road has no subdrains.	**System #4** Grass swale system with perforated pipe system and infiltration trenches capable of retaining and infiltrating the runoff of a 25 mm storm.
Roads	$339,590.80	$339,590.80	$473,023.22[1]	$377,639.22
Subdrains	$42,671.22	$42,671.22	0	0
Curbs and gutter	$168,774.69	$168,774.69	0	0
Manholes	(10 on street) $37,621.49	(9 on street) $33,859.34	0	(5 on street, 5 off street) $35,691.84
Catch basins	(32 regular) $55,528.53	(32 regular) $55,528.53	0	(100 corrugated steel off road) $61,947.82
Sewers	(1000 m) $515,894.52	(1000 m) $515,894.52	0	(2000 m, perforated with pre-treatment) $379,152.96
Ditches	0	0	(2000 m) $129,010.13	0
Swales or roadside grass	(2000 m) $96,656.88	(2000 m) $96,656.88	0	(2000 m) $108,190.09
Culverts	0	0	(100) $106,487.33	0
Sump pumps	0	0	(100) $40,497.87	(100) $40,497.87
Outfall and end of pipe erosion control	$7,111.00	$7,111.00	$1,912.82	$977.57
End of pipe facility (wet pond)	$88,434.10 + land + losses in tax revenues	$70,747.28[2] + land + losses in tax revenues	$70,747.28[3] + land + losses in tax revenues	0
Oil & Grit Separator[4]	0	(5 units) $65,339.48	0	0
Total present value cost (per 10 ha of drainage area or 1000 m of roadway)	**$1,352,283.24***	**$1,396,173.75***	**$821,678.66***	**$1,001,097.36**

Notes: *) Cost for land required by end of pipe facility or losses in tax revenues are not included due to large variability.
1) Cost of road can be reduced by $95,384 if subdrains can be installed. For subdrains add $42,671.
2) Assumes Oil & Grit Separators are 50% efficient and therefore includes a 50% credit on cost for sediment removal from end of pipe facility.
3) Cost assumes that ditches are 50% efficient at removing sediments. If properly constructed, ditched roads may not require an end of pipe facility in which case the cost can be reduced by ($70,747.28 + land + losses in tax revenues).
4) Prices reflect the use of Stormceptor units for which the cost information was available from the manufacturer.
General) Total annual costs are based on "average" total costs and individual costs may vary between municipalities.

12.0 Alternative Drainage System Selection Tool

Design guidelines for the construction of alternative drainage systems can be found in various literature. Their potential advantages and disadvantages with respect to stormwater management functions are also well documented. However, it is often the selection of the most appropriate alternative(s) which can become complicated and may require a detailed assessment. Unfortunately, such assessments are most often conducted on a qualitative basis with a lack of objectivity and can, consequently, lead to arguable results.

To improve the assessment for the potential use of various alternative drainage techniques it is necessary to know and consider as many quantifiable aspects as possible. Such aspects should be easily obtainable.

In order to properly assess the potential use of various alternative drainage systems, the following aspects should be considered:

i) Compatibility with physical site characteristics.
ii) Compatibility with planning objectives (or existing development in the case of a retrofit situation) and ease of integration.
iii) Ability to meet stormwater management objectives.
iv) Economics.
v) Public acceptance / Safety.

In this section of the report, a systematic procedure to help determine which types of alternative drainage systems (see Table 12.1 for list of features and description) could be used within a specific project is developed and presented. In its initial steps, the procedure uses the process of elimination to identify which drainage features are compatible with the physical site characteristics and/or with the type of development. Based on the potential use of various drainage features, conceptual drainage systems can then be evaluated in terms of their ability to meet stormwater management objectives, costs (capital and maintenance, refer to Section 10), and public expectations.

The procedure which makes use of various tables can be used for new developments or retrofit situations. The step by step approach which is described in the following sections can be visualized by the flowchart presented in Figure 12.1.

The use of the Tables which are presented in this section have been programmed into a user interactive Excel Spreadsheet application which also includes the costing information presented in Section 10. The User's guide for the Excel Spreadsheet program is provided in Appendix H with a sample application. Additional "real life" applications of the Selection Tool are presented in a separate document entitled "Demonstration of a Conveyance System Selection Tool in Urban Road Projects" by Totten Sims Hubicki Associates and Donald G. Weatherbe Associates.

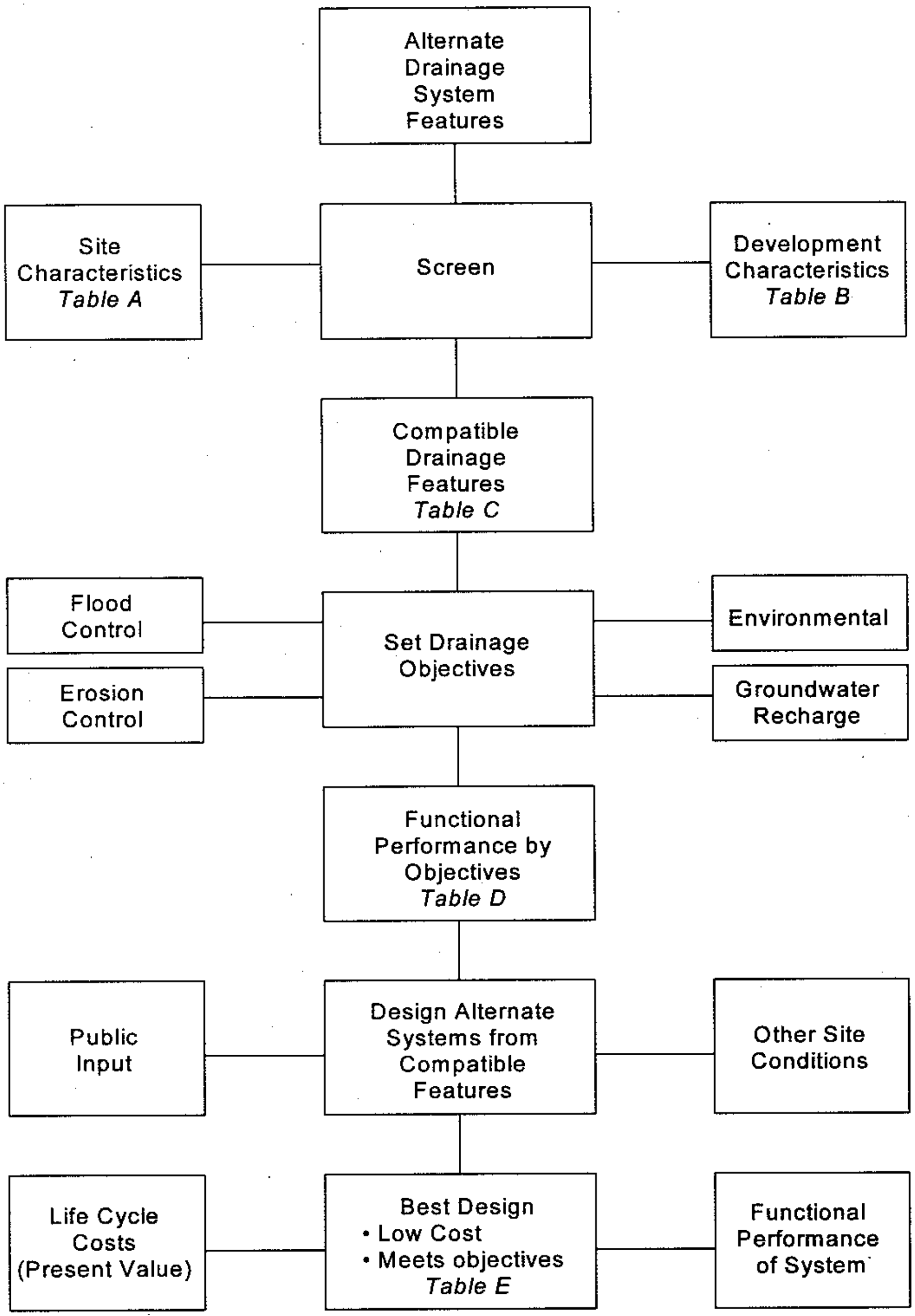

Figure 12.1: Steps in Application of Selection Tool

(see Table 12.2 for a list and description of various alternative drainage features)

Table 12.1: Description of Drainage Features

	Drainage Features and Description
1	**Street curbs** A raised concrete, asphalt or stone edging along the side of a road to form part of a gutter. Figures 1.1a and 1.1b show typical cross-sections of standard curbs while Figure 1.4 shows a typical road section with curbs. By themselves, street curbs can provide some on-site flood control but little environmental benefits. Curbs can sometimes be viewed as more socially acceptable and found to provide a sense of security. No site or development characteristics were found to prevent the use of street curbs.
2	**Roads with one-sided cross slopes** A road built without a centre crown so that the runoff is directed to one side of the street only. This allows for fewer catchbasins or the need to only have one drainage ditch/swale. Except for some economical benefits, one-sided cross slope streets provide no valuable SWM benefits. In some areas, where snow accumulation is a factor, one-sided cross slope streets may be discouraged to prevent snowmelt from freezing across the road surface.
3	**Porous pavement with storage structure** A pavement structure which by design and construction allows some surface runoff to flow through and stored in a clear stone granular base. The stored water can then be released slowly to another drainage feature such as storm sewers through sub-base drains. A typical section of a porous pavement structure is shown in Figure 1.2. When designed properly, such structures could provide some erosion and water quality control benefits. However, the use of porous pavements should be discouraged where the ground surface can freeze for extended periods and should be prohibited in areas where surface sediments are abundant (eg. where local soils are highly susceptible to erosion or in industrial areas).
4	**Porous pavement with exfiltration system** Similar to Feature #3 but in this case the water which is retained within the porous pavement structure is released (exfiltrated) slowly to the surrounding soils. When designed properly, such structures could retain and exfiltrate sufficient runoff to provide groundwater recharge, erosion and quality control benefits. However, exfiltrating water to the surrounding soils should only be considered if the underlaying soils are compatible with the presence of water, and if the groundwater quality is not at risk, and when the subsurface infiltration rates are at least 2.5 mm/hr, and when the depth of groundwater or bedrock is at least 1.5 m from the surface. Furthermore, the use of porous pavements should be prohibited in areas where surface sediments are abundant (eg. where local soils are highly susceptible to erosion or in industrial areas) or where toxic chemicals are transported or stored (eg. gas stations). Finally special care may be required where below ground franchise utilities are found or where surface slopes exceed 5%.
5	**Storm sewers with foundation drain connections** This is the typical storm sewer system normally found in conventional urban developments. The storm sewer must be installed at a sufficient depth (usually more than 2 m) in order to allow a gravity connection from the nearby building foundation drains. Consequently, such systems also require sufficiently deep outlets. While storms sewers can be designed to provide adequate on-site flood control and possibly off-site flood control (if the major system is retained on the street and catchbasins are equipped with inlet control devices), they cannot, by themselves, provide any groundwater recharge, erosion control or water quality control benefits. Storms sewers can, however, provide some thermal impact reduction.
6	**Shallow storm sewers with sump pumps** This system is simular to the one described under Feature #5 except that the depth of the storm sewer is mainly governed by frost protection requirements since water collected by foundation drains is removed by sump pumps. While storms sewers with sump pumps can be designed to provide adequate on-site flood control and possibly off-site flood control if the major system is retained on the street and catchbasins are equipped with inlet control devices, they cannot, by themselves, provide much SWM benefits. If the sump pumps discharge to a grass surface area, some groundwater recharge may be achieved. Furthermore, storms sewers can also provide some thermal impact reduction.
7	**Roadside ditches with culverts** This is the typical roadway drainage system usually found in low density urban areas and rural areas. Figure 1.9 shows a typical cross-section of a roadside ditch drainage system. The depth of a ditch can usually vary between 0.6 m to 1.5 m, however, in order to maintain a sufficient culvert cover, ditches should be at least 1.0 m deep. The perviousness of roadside ditches can provide some groundwater recharge benefits while the less than smooth surface of a ditch can reduce flow velocities and provide some erosion control benefits. The vegetative cover along ditches can provide adequate sediment removal and some nutrient uptake and thermal impact reduction. In addition, the storage volume of some ditches can further provide on-site and off-site flood control. However, the use of roadside ditches with culverts should be implemented with additional considerations where the surface slopes are less than 1% or more than 5%. Available space (i.e. within the road right-of-way and between private driveways) can also represent an important limitation for the use of roadside ditches with culverts. As such, a single ditch requires at least 2.5 m within the ROW and should at least have 5.0 m in length between driveways. Other factors which may affect the use of ditches are; i) climate, ii) type of soils, iii) type of development, and iv) location of sidewalks.

	Drainage Features and Description
8	**Shallow ditches or swales (no culverts)** Unlike roadside ditches with culverts (Feature #7), shallow ditches or swales are normally only a few centimetres deep (10 to 25 cm) and the vegetative surface of a swale is continuous with the landscaping of the adjoining lot. A typical cross-section of a grass swale is shown in Figure 1.12 while a true life picture can be seen in the Factsheet of Section 14. Like the typical roadside ditch, shallow ditches or swales can provide some groundwater recharge, erosion control, sediment removal, nutrient uptake, bacteria die-off and oil and grease removal benefits. However, unlike typical ditches and because of the lack of culverts, grass swales cannot provide, by themselves, adequate on-site and off-site flood control. Factors which may affect the use of shallow ditches or swales include; i) surface infiltration rates to prevent excessive surface ponding, ii) surface slopes, iii) type of soil, iv) available space within the road right-of-way, and v) location of sidewalks.
9	**Shallow perforated pipe exfiltration system** Usually consists of a shallow perforated pipe system installed within a granular trench of clear stone surrounded by a filter cloth. Surface stormwater can be directed to such a system by means of catchbasins and/or from the ground surface by infiltration. Once in the pipe, water can exfiltrate (out of the pipe) to the surrounding granular trench and soils. If the pipe is continuous then any excess water can be conveyed to a downstream outlet (eg. standard storm sewer or ditch). Shallow perforated pipes are usually installed next to the roadway underneath shallow ditches or grass swales. An example of such a system is shown in Figure 1.12. When properly designed and constructed, shallow perforated pipe exfiltration systems can provide a wide range of SWM. benefits including; groundwater recharge, erosion and quality control, thermal reduction, and flood control. However, such systems should not be considered where local soils are incompatible with the presence of water or where the groundwater quality is at risk. Similarly, such systems should not be considered where the sub-surface infiltration rates (hydraulic conductivity) are less than 2.5 mm/hr or if the groundwater levels (or bedrock) are less than 1.5 m from the bottom of the granular trench. Additionaly, special considerations may be required if the following site and development characteristics exist; i) shallow outlet, ii) surface slopes greater than 5%, iii) surface soils suspectible to erosion, iv) industrial land use or high imperviousness, v) limited space within the road right-of-way, vi) sidewalks next to road, vii) trees within the road right-of-way, and viii) presence of below ground franchise utilities.
10	**Deep perforated pipe exfiltration system** Similar to the shallow perforated pipe exfiltration system except for the fact that the perforated pipe is installed at lower depths. However, because the pipes are deep, surface runoff must be directed to the system with the use of catchbasins. Once in the pipe, water can exfiltrate (out of the pipe) to the surrounding granular trench and soils. If the pipe is continuous then any excess water can be conveyed to a downstream outlet (eg. standard storm sewer). Deep perforated pipes have been installed under the roadway as standard storm sewers. An example of a drainage system incorporating a deep perforated pipe was constructed in the City of Etobicoke is shown in Figure 1.5. When properly designed and constructed, deep perforated pipe exfiltration systems can provide a wide range of SWM. benefits including; groundwater recharge, erosion and quality control, thermal reduction, and flood control. However, the use of such systems should not be considered where local soils are incompatible with the presence of water or where the groundwater quality is at risk (unless adequate pre-treatment is provided). Similarly, such systems should not be considered where the sub-surface infiltration rates (hydraulic conductivity) are less than 2.5 mm/hr or if the groundwater levels (or bedrock) are less than 1.5 m from the bottom of the granular trench. Additionally, special considerations may be required if the following site and development characteristics exist; i) shallow outlet, ii) surface slopes greater than 5%, iii) surface soils susceptible to erosion, and iv) industrial land use or high imperviousness.
11	**Deep perforated pipe filtration system** Unlike the shallow and deep perforated pipe exfiltration systems, the deep perforated pipe filtration system can be used where the soils are impervious or with low infiltration rates. The system requires at least two perforated pipes; one deeper than the other. Typically, the surface runoff captured by a catchbasin would be directed to the shallower perforated pipe from which water could exfiltrate to a filtrating sand layer below which another perforated pipe would re-collect the exfiltrated water. A drainage system incorporating a deep perforated pipe filtration system was installed in the City of Etobicoke (see Figure 1.6). When properly designed and constructed, deep perforated pipe filtration systems can provide some groundwater recharge (limited), erosion and water quality control, and thermal reduction. When constructed in combination with standard storm sewers as shown in Figure 1.6, this drainage system can also provide some flood control benefits. However, the use of such systems are not applicable where a sufficient deep outlet is not available and furthermore, the system may require special attention where the local groundwater levels are high.
12	**Raised culverts** Raised culverts would normally be used with roadside ditches (feature #7) except that the culverts are installed in such a way that their inverts are slightly higher than the ditch bottom elevation. Depending on the difference in elevation between the culvert invert and ditch bottom, and the width and slope of the ditch, raised culverts can create conditions which provided some the erosion, quality and groundwater recharge control benefits. Figure 1.10 shows a typical roadside ditch with raised culvert. The application of raised culverts should not be considered to increase surface infiltration when the local soils are incompatible with the presence of water or when the groundwater quality is at risk. Similarly, the use of raised culverts should not be considered if the surface infiltration rates are too low (eg. less than 13 mm/hr) as this may create excessive periods of surface ponding. Other considerations for the use of raised culverts are similar to the ones for the Roadside ditches with culverts (Feature # 7).

	Drainage Features and Description
13	**Dipped driveways** As the name implies, the concept with dipped driveways is that rather than having to install culverts, the driveways are dipped to allow their overtopping during major runoff events. By having the driveways slightly higher than the bottom of the ditch/swale will provide some opportunity for storage and water infiltration. The benefits and limitations of using dipped driveways in shallow ditches/swale are similar to the ones of using raised culverts. However, dipped driveways will not provide much in terms of flood control.
14	**Check dams** Check dams would normally be used with roadside ditches (Feature #7) with a similar objective as using raised culverts except that check dams can be constructed anywhere along the ditch to increase local water retention and infiltration. Depending on the height of a check dam, the width and slope of the ditch along which it is constructed, check dams provide some the erosion, quality and groundwater recharge control benefits. Figure 1.3 shows a typical log check dam while Figure 1.11 shows a typical roadside ditch with a check dam. The limitations of using check dams are similar to those of using raised culverts (Feature #12) and dipped driveways (Feature #13).
15	**Oil and Grit separators** Oil and Grit separators (O&Gs) are devices which cannot be used by themselves to create a drainage system. Usually their use is combined with the use of conventional storm sewers such as depicted in Figure 1.7. O&Gs are large manhole structures consisting of separate chambers (usually 3) through which stormwater travels in order to remove coarse sediments (grit), oils and other floatable pollutants. The only real site constraint in using O&Gs is with the depth of the drainage outlet which has to be sufficiently deep to accommodate the device's physical requirements. In terms of SWM benefits, O&Gs can provide some quality control (sediments, phosphorus, oil and grease). In fact O&Gs are one of few SWM features that can effectively remove (retain) oil and grease from stormwater.
16	**Greenbelts and backyard swales** Greenbelts and backyard swales are typically shallow vegetated channels that provide a means to convey and infiltrate storm water runoff. Examples of backyard swales are sometimes found along the back property line residential developments where split drainage is allowed. Sometimes, rear lot catchbasins and /or perforated pipes are also used in combination with such swales to enhance backyard drainage. As shown in Figure 1.8, deep swales within greenbelts can also be used in combination with conventional storm sewers. When properly constructed, greenbelts and backyard swales can provide significant groundwater recharge, erosion and quality control benefits as well as some thermal reduction and on-site flood control. However, in order to prevent nuisance ponding, the use of greenbelts or backyard swales should probably not be considered if surface infiltration rates are less than 13 mm/hr. Furthermore, additional limitations may be imposed if the local groundwater quality is at risk, surface slopes, and erodibility of surface soils.
17	**Horizontal infiltration / exfiltration trenches** Horizontal infiltration / exfiltration trenches are stone filled trenches in which surface runoff can infiltrate and then exfiltrate to the surrounding soils. Filter fabrics are commonly placed around all sides of the trench to prevent clogging of the stone voids. When properly constructed, horizontal infiltration / exfiltration trenches can provide significant groundwater recharge, erosion and water quality control benefits as well as thermal impact reduction. However, the application of such drainage features are not recommended in areas where the soils are incompatible with the presence of water or where the sub-surface infiltration rates are less than 2.5 mm/hr or where the depth of the groundwater table (or bedrock) is within 1.0 m from the expected bottom of the trench. Other aspects to consider include; i) quality of water to be infiltrated, ii) surface slopes, iii) surrounding landuse, iv) space constraints, v) location of trees, and vi) presence of nearby below ground franchise utilities.
18	**Vertical exfiltration wells and perforated catchbasins** Exfiltration wells and perforated catchbasins consist of semi-deep narrow vertical stone filled trenches from which surface runoff can exfiltrate to the surrounding soils. Filter fabrics are commonly placed around all sides of the trench to prevent clogging of the stone voids. When properly constructed and maintained, vertical exfiltration wells and perforated catchbasins can provide significant groundwater recharge, erosion and water quality control benefits as well as thermal impact reduction. As with the horizontal infiltration / exfiltration trenches, the application of such drainage features are not recommended in areas where the soils are incompatible with the presence of water or where the sub-surface infiltration rates are less than 2.5 mm/hr or where the depth of the groundwater table (or bedrock) is within 1.0 m from the expected bottom of the well. Other aspects to consider before making use of vertical exfiltration wells and perforated catchbasins include; i) quality of water to be infiltrated, ii) surface slopes, iii) surrounding landuse, iv) location of trees, and v) presence of nearby below ground franchise utilities.
19	**Infiltration basins** Infiltration basins are a type of end-of-pipe SWM facilities which can usually be considered for drainage areas of at least 5.0 ha. When properly constructed they can provide adequate groundwater recharge, erosion and water quality control benefits, and thermal impact reduction. Site and development characteristics which may prevent the use of wet ponds include; i) incompatibility of soils with water, ii) groundwater quality at risk, iii) low surface infiltration rates (eg. less than 60 mm/hr), iv) depth of groundwater table (or bedrock), v) erodibility of surface soils, vi) expected of inflowing water quality, and lack of available space.

	Drainage Features and Description
20	**Wet ponds (extended detention)** Wet ponds are a type of end-of-pipe SWM facilities which can be considered for drainage areas of at least 5.0 ha. When properly constructed they can provide adequate erosion and water quality control benefits, and possibly some off-site flood control. Site and development characteristics which may prevent the use of wet ponds include; i) inability to maintain a permanent pool of water, ii) depth of outlet, and iii) lack of available space.
21	**Dry ponds** Dry ponds are a type of end-of-pipe SWM facilities which can be considered for drainage areas of at least 5.0 ha. When properly constructed they can provide adequate erosion and water quality control benefits, and possibly some off-site flood control. Site and development characteristics which may prevent the use of wet ponds include; i) depth of outlet, ii) expected quality of inflowing stormwater, and iv) lack of available space.
22	**Artificial wetlands** Artificial wetlands are a type of end-of-pipe SWM facilities which can be considered for drainage areas of at least 5.0 ha. When properly constructed they can provide some erosion and water quality control benefits, and possibly some off-site flood control. Site and development characteristics which may prevent the use of artificial wetlands include; i) inability to maintain a permanent pool of water, ii) reduced effectiveness during winters, iii) expected quality of inflowing stormwater, and iv) lack of available space.

12.1 Selection of Drainage Features Based on Site Characteristics (Table A)

Most physical characteristics of a given site are unlikely to change even after its development. Therefore, such characteristics can be used to quickly identify and eliminate incompatible drainage features. Important site characteristics which should be considered include the following:

Incompatibility of soils with water: Some soils are incompatible or react to the presence of water. For example, soils with a high gypsum content should not be considered for use with concentrated infiltration measures because such soils are susceptible to dissolution and could represent a risk for cave-ins. In other cases, the soil composition may have a tendency to swell when wet and shrink when dry. Such changes in volume may create problems to surrounding structures. The assessment of such characteristics requires the expertise of a qualified soil engineer, geologist or hydrogeologist.

The use of infiltration BMPs is not recommended when an incompatibility of soils with water has been established.

Groundwater quality at risk: This may be a concern when the project is located within or near an area where groundwater is a source of potable water or baseflow to a nearby stream with sensitive aquatic habitat. Safe distances or buffer zones will depend on various factors such as existing groundwater quality, soil types, presence of open-jointed rocks, location of aquifers, and speed of groundwater flow. To quantify the risk associated with the potential contamination of groundwater requires discussions with local authorities and the expertise of a qualified hydrogeologist.

The use of infiltration BMPs is not recommended when a risk associated with groundwater contamination as been established.

Soil types and infiltration rates: The types of soils and their corresponding capacities for infiltration are of prime concern for all types of alternative drainage systems which incorporate an infiltration function. Reasons for this concern are to prevent the potential for nuisance ponding of stormwater and to ensure that any storage volume provided by the drainage feature can be regained before the next rainfall event. In general surface infiltration rates should be in the order of 13 mm/hr as to prevent lengthy accumulation of standing water; and similarly subsurface infiltration rates should be at least 2.5 mm/hr so that storage volumes may be replenished in time for the next possible storm. However, for surface infiltration basins it is often recommended that the soil infiltration rates be at least 60 mm/hr. Standard infiltration or percolation tests can be conducted to identify the soils' infiltration capacities.

Table 12.2 provides typical textbook values of hydraulic conductivities for various USDA Soil-Texture Classes.

Table 12.2: Average Hydraulic Conductivities for Various Soil-textures

USDA Soil-Texture Class	**Hydraulic Conductivity, K**	
	in/hr	**mm/hr**
Sand	4.74	120.4
Loamy Sand	1.18	30.0
Sandy Loam	0.43	10.9
Loam	0.13	3.3
Silt Loam	0.26	6.6
Sandy Clay Loam	0.06	1.5
Clay Loam	0.04	1.0
Silty Clay Loam	0.04	1.0
Sandy Clay	0.02	0.5
Silty Clay	0.02	0.5
Clay	0.01	0.3

Source: Design and Construction of Urban Stormwater Management Systems, ASCE Manuals and Reports of Engineering Practice No. 77, WEF Manual of Practice FD-20

Depth of groundwater table or bedrock: The depth of bedrock or the highest seasonal groundwater level is an important consideration for the following reasons; i) the vertical space which can be available for underground storage may be limited, and ii) a high groundwater table can easily be contaminated by chronic or accidental pollution if filtration through soils is not adequately provided. In general, the seasonally high groundwater level or bedrock should be at least 1 m below any drainage feature which uses infiltration. Standard geotechnical site investigations can provide this information.

Source of continuous flow: For the use of wet detention ponds or wetlands it may be necessary to maintain a given water level for the livelihood of an ecosystem. In this case a source of a continuous flow would have to be available.

Depth of drainage outlet: The depth of the anticipated drainage outlet, whether to an existing man made structure (eg. ditches, storm sewers) or to a natural feature can be a significant physical constraint in selecting potential stormwater conveyance systems. For example, if a shallow municipal drain is the only possible outlet to a proposed rural subdivision, then the use of deep storm sewers with water quality inlets could not be an option. A simple site visit or the review of existing topographic maps or municipal drawings can easily provide this information.

Surface slopes: Ground surface slopes can also represent physical constraints for some types of conveyance systems and infiltration measures. It is important to note however that the average slope of the site is not necessarily the determining factor unless it is relatively flat (ie. less than 1%). Where the average slopes are in the order of 5% and over, it is more important to try to consider the slope of the ultimate drainage infrastructure. Information on surface slopes can be obtained from topographic maps, areal photos and/or site investigations.

Climate: The climate is not always considered a factor in selecting potential alternative drainage system components. However, the climate should be given some special consideration in areas where snow and freezing temperatures are expected. For example, the construction of a single cross slope street may be acceptable in south Florida where the freezing or snowmelt running across the road surface is not a concern.

Highly Erodible soils: Areas where surface vegetation is sparse or which are in proximity of construction or farming activities can represent conditions which may not be compatible with infiltration techniques if adequate erosion and sediment controls cannot be provided. Under such conditions the use of effective pre-treatment measures must be incorporated to prevent the premature clogging of infiltration surfaces.

Size of drainage area: The size of the total drainage area is only a constraint if it is smaller than approximately 5 ha. For such areas the use of large end of pipe facilities is not practical. On the other hand it is noted that, in some cases, large drainage areas could be serviced only in part by some types of drainage features. For example, roadside ditches or swales have limited hydraulic capacities and as such their use could be restricted to upstream reaches. The extent of this constraint will depend on the layout of the development and, as demonstrated in the Section 4, on the physical characteristics of the conveyance system.

12.2 Selection of Drainage Features Based on Development Characteristics (Table B)

Constraints imposed by development features can be rigid if the site is already developed and the assessment is for a retrofit system. On the other hand if the site is being considered for development then the potential constraints can become flexible if the assessment is made in the early planning stages. In either case, development characteristics which may become constraints to the potential use of alternative drainage systems include the following:

Type of landuse: The type of landuse may limit the use of certain alternative drainage measures. For example, in industrial areas where the transportation or storage of dangerous chemicals is likely, the use of any infiltration techniques would not be acceptable unless sufficient pre-treatment components are incorporated in their designs. It should also be noted that commercial areas with gas stations represent a similar risk. In general, residential types of developments are the most compatible with any type of alternative drainage systems.

ROW planning: The main ROW planning issues which may interfere with the use of certain types of alternative drainage features include: i) available space (which can be defined as the ROW width less the road surface width and less the total width of sidewalks), ii) presence and location of sidewalks, iii) planting of trees within the road boulevard, and iv) the presence and location of underground utilities. Issues related to ROW planning were discussed in Section 9.

Lot planning: Features at the lot level which may further reduce the potential use of alternative drainage features include: i) lot widths or more precisely the spacing between entrances, ii) imperviousness, iii) type of lot drainage (ie. back to front or split), iv) presence of reverse slope driveways. Issues related to ROW planning were discussed in Section 9.

12.3 Selection of Drainage Features Based on Ability to Meet SWM Objectives (Table D)

SWM requirements can vary from site to site based on local and downstream conditions. In general SWM objectives can be determined by general guidelines, local authorities or based on the results of an overall watershed/subwatershed plan. The most important SWM objectives which may have to be considered include the following:

Groundwater recharge: Groundwater recharge may be important for the maintenance of baseflows in streams and rivers as well as to replenish the source of drinking water for those who depend on wells. As a general rule and in order to meet this requirement, the runoff of a 5 to 10 mm storm (see Section 5.3) should be retained and infiltrated, unless local studies specify an alternative recharge target. Special attention must be taken when both groundwater recharge and the risk of contamination are important.

Erosion control: Erosion control may or may not be a requirement and depends on the conditions of the receiving water body. However, if erosion control is an issue it can be provided, in general, by controlling the runoff of a 25 mm storm (See section 5.2). (NOTE: a higher level of control may be required depending on site specific studies). The control can be provided through the combination of retention and infiltration.

Quality control: Quality control requirements can differ from location to location and will vary based on the type of receiving water body (eg. lake or river), its size, its potential use, and the type of fish habitat which may or could exist. In general stormwater quality control objectives may be achieved by the removal of; i) suspended sediments, ii) nutrients such as phosphorous, iii) bacteria and iv) oil and grease. Refer to Section 5.1 for additional information and guidelines.

Thermal impact reduction: Thermal impacts can be an important consideration for receiving water bodies with cold water stream ecosystems. In such cases, the effects from stormwater are predominant when surface runoff is conveyed or retained at ground level and exposed to warm air and sunlight for some time. Refer to Section 5.1.1.7 for additional information and guidelines.

Flood control and level of service: Flood control could be a requirement within the site and/or off site. That is, the operation of the drainage system should not inundate surrounding properties and should not convey stormwater in such a way as to increase the potential of downstream flooding. In new developments such controls can usually be achieved while in retrofit situations it may be difficult. The level of service can be defined as the capacity of the system in relation to a design event (ie. 1 in 5 yrs). Another element to consider is whether or not a major system outlet is present or if can be incorporated within the development. Although this latter element can greatly depend on the final grading and configuration of the site, it should nonetheless be considered in the derivation of alternatives. Refer to Section 5 for additional information and limitations of alternative stormwater conveyance systems.

12.4 The Selection Tool

As described at the beginning of this section, the main purpose of the Selection Tool is to: i) help determine which types of alternative drainage features could be used within a specific site, and ii) help compare potential conceptual drainage systems. This can be achieved through the use of the detailed tables described in this section.

Tables A and B present the elements described in Sections 12.1 and 12.2 respectively. That is, Table A can be used to eliminate specific drainage features which are incompatible with the local site characteristics while Table B can be used to eliminate options which are incompatible with existing or potential development characteristics. Table C can be used to summarize the results obtained from the use of Tables A and B, and to identify which drainage features could be incorporated in a conceptual system.

Table CD was recently added to the Tool and derived from the work done by D.G. Weatherbe and Associates and Totten Sims Hubicki. The table can be used to summarise the stormwater management objectives and target performance for the drainage system being considered. The table can also be used to assign variable priorities to the various SWM objectives which are to be met.

Table D is used as a reference and compares the potential SWM functions (benefits) of the various alternative drainage features.

Finally, Table E can be used to describe and evaluate possible conceptual drainage systems. The evaluation can be based on potential SWM performance, specific design objectives (eg. foundation drain connections), and costs. It is noted that conceptual drainage systems must be established from the designer's experience and knowhow.

The following sections describe how to use the various tables. An example application follows in Section 12.5.

12.4.1 How to use Table A - site characteristics

Based on a preliminary assessment of site conditions, the designer checks (✓) all of the applicable site conditions which are listed in the table. Any (✗) which appears below a checked site characteristic eliminates the potential use of the alternative drainage feature on that line. For any (O) which appears below a checked characteristic the designer must refer to the numbered comment for Table A to determine if there is a valid concern.

The alternatives which are not eliminated receive a score of '1' in the appropriate column of Table C while alternatives for which an unresolved (O) remains is given a score of '0.5'.

12.4.2 How to use Table B - development characteristics

Based on the known or anticipated development characteristics of the site, the designer checks (✓) all of the applicable characteristics which are listed in the table. Any (✗) which appears below a checked characteristic eliminates the potential use of the alternative drainage feature on that line. For any (O) which appears below a checked characteristic the designer must refer to the corresponding numbered comment for Table B and determine if there is a valid concern.

The alternatives which are not eliminated receive a score of '1' in the appropriate column of Table C while alternatives for which an unresolved (O) remains is given a score of '0.5'.

12.4.3 How to use Table C - identification of compatible features

Table C is used to summarize the results obtained from Tables A and B, and to identify which drainage features could be used within a given study area. The score of any alternative drainage feature is obtained by multiplying the results from Tables A and B.

Since the results from Tables A and B can only be '0', '0.5' or '1' it then follows that any feature which was found to be incompatible (ie. value of '0') with either the site or development characteristics will be eliminated and as such could not be used within the study area. Features which end up with a final score of '1' are fully compatible with both site characteristics and development characteristics.

Features with a final score of '0.5' or '0.25' are potentially incompatible with either or both site characteristics and development characteristics. A review of the notes for Tables A and B should help determine if such features should be considered or not.

12.4.4 How to use Table D - comparison of SWM functions

Table D was prepared for reference purposes only and provides an indication of how well a particular drainage feature can respond to a particular SWM objective. SWM objectives were divided into 5 groups; i) groundwater recharge, ii) erosion control, iii) quality control, iv) flood control, and v) thermal reduction. The water quality control objective was further divided into 4 subgroups; i) sediment removal, ii) nutrient removal, iii) bacterial die-off, and iv) oil and grease removal.

The numbers provided in Table D are referred to as "Stormwater Management Function Potential (SWM-FP) values". SWM-FP values can vary from '0' to '1'. A value of '0' indicates that the corresponding drainage feature provides no valuable benefit (0%) towards the respective SWM target objective. By comparison, a SWM-FP value of '1' (100%) would indicate that the corresponding drainage feature could, if designed and constructed properly, achieve 100% of the targeted SWM objective.

Examples for SWM-FP values could be: i) a simple curb & gutter (no pipes) does not, as a drainage feature, provide any benefits for groundwater recharge and is therefore given a corresponding SWM-FP value of '0', ii) roadside ditches and swales (if properly constructed and well vegetated) could remove up to 80% of sediments and therefore are given a corresponding SWM-FP values of '0.8' , and iii) an oil and grit separator (if properly sized and maintained) can remove, on average, approximately 60% of sediments and therefore was given SWM-FP values of 0.60.

The SWM-FP values provided in Table D are further used in the comparison of conceptual drainage systems (see Section 12.4.5). Note, however, that SWM-FP values are intended to assist in relatively comparing alternative drainage systems and, until further monitored data is available, should not be expected to estimate actual performance.

It is further noted that SWM-FP values can be modified or updated as new information on the SWM function effectiveness of the various drainage features becomes available. Furthermore, the values currently presented in Table D are based on the assumption that each drainage feature is optimally designed to service the entire area. Consequently, in the final comparison (Section 12.4.5), SWM-FP values should be reduced for drainage features which will only be used for certain parts of the site.

12.4.5 How to use Table E - comparison of conceptual drainage systems

Based on the results obtained in Table C (identification of site and development compatible drainage features) it may be possible, based on design experience, to conceive various alternative drainage systems which may include some or all of the potential drainage features. To further compare each alternative it is necessary to evaluate the cost of each system and how well it can meet the objectives of the project. As can be anticipated, some drainage features may only address some specific objectives and therefore the evaluation must consider the system as a whole and not simply its individual components.

Once a conceptual drainage system is defined it can be further evaluated with the use of Table E. (Examples of alternative drainage systems and drainage features are discussed in Sections 1 and 11). This is done by first listing the system's individual components in the first column of Table E and entering the system's objectives in the columns under the heading of "Drainage System Objectives and Compliance". System objectives may include SWM objectives as well as other specific requirements which may have been requested by the public (eg. elimination of sump pumps and direct connection to storm sewers). For each drainage feature and based on Table D, SWM-FP values are then selected and entered in the corresponding columns of Table E (the Excel Spreadsheet does this automatically). SWM-FP values for features which will only be used in parts of the system could be adjusted based on drainage area accordingly. The total cost for each feature can also be calculated and entered in the last column.

To identify whether or not the proposed drainage system could meet the SWM objectives the Selection Tool Excel Spreadsheet offers two methods to evaluate the overall SWM-FP of the system.

With the first method, a simple sum of SWM-FP values could be used to provide a comparative evaluation of the system's potential performance.

The second method is somewhat more sophisticated as it accounts for the fact that the effective performance of SWM features which work in series can not be evaluated by the simple sum of individual performances but rather by their product summation. This can be applied with the multi-efficiency model presented in a paper by J.Li et al in which the cumulative performance of groundwater recharge, TSS, TP and Bacteria removal functions of a series of SWM features can be evaluated with the use of equation (12.1).

$$\text{Overall SWM-FP} = \left[1 - \prod_{i}^{n} (1-\eta)\right] \times 100\% \tag{12.1}$$

Where	i	=	is the i^{th} feature being considered
	n	=	is the total number of features with the system
	Π	=	is the product summation of (1-η)
	η	=	the runoff volume reduction or the sediment reduction efficiency of a specific feature

With either method, the resulting score of the overall SWM-FP for each system objectives will indicate if the system could meet the individual requirements. In general, a score of '1' or more would indicate that the system could meet the objective. Anything less than '1' would indicate a potential deficiency and the need to re-evaluate the system.

If more than one alternative drainage system is being considered, then the overall effectiveness of each system and their costs can be used in the final selection.

Table A: Selection of alternative drainage features based on site characteristics

FEATURE	TABLE A	TABLE B	Drainage Features	Site Characteristics															
				Soils are incompatible with the presence of water	Ground water quality is at risk	Soil Infiltration Rates			Depth of groundwater or bedrock (m)		No source of continuous flow	Depth of drainage outlet (m)			Surface Slopes (%)		Climate is vulnerable to cold and snowy winters	Surface soils are highly susceptible to erosion	Drainage area is less than 5.0 ha or space is limited
						Surface inf. < 13 mm/hr	Surface inf. < 60 mm/hr	Sub-surf. inf. < 2.5 mm/hr	< 1.5	1.5 - 4.0		< 1.0	1.0 - 2.0	> 2.0	< 1.0	> 5.0			
E	A	B		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
1	1	1	Street curbs																
2	1	1	Roads with one-sided cross slopes														O_8		
3	1	1	Porous pavement with storage structure														O_8	X	
4	1	1	Porous pavement with exfiltration system	X	X			X	X							O_6	O_{14}	X	
5	1	1	Storm sewers with foundation drain connections									X	X						
6	1	1	Shallow storm sewers with sump pumps									X	O_{17}						
7	1	1	Roadside ditches with culverts									O_4	O_3		O_5	O_6	O_7	O_{10}	
8	1	1	Shallow ditches or swales (no culverts)			O_{18}										O_6		O_{10}	
9	1	1	Shallow perforated pipe exfiltration system	X	X			X	X	O_1		O_{15}	O_{15}			O_6		O_{10}	
10	1	1	Deep perforated pipe exfiltration system	X	O_{16}			X	X	O_1		O_{15}	O_{15}			O_6		O_{10}	
11	1	1	Deep perforated pipe filtration system						X	O_1		X	X						
12	1	1	Raised culverts	O_{11}	X	X						X	O_4			O_6	O_8	O_{10}	
13	1	1	Dipped driveways	O_{11}	X	X										O_6	O_8		
14	1	1	Check dams	O_{11}	X	X										O_6	O_8	O_{10}	
15	1	1	Oil and Grit separators									X	X						
16	1	1	Greenbelts and backyard swales		O_{12}										O_5	O_6		O_{10}	
17	1	1	Horizontal infiltration / exfiltration trenches	X	O_{16}			X	X	O_1						O_6		O_{10}	
18	1	1	Vertical exfiltration wells and perforated catchbasins	X	O_{16}			X	X	X								O_{10}	
19	1	1	Infiltration basins	X	O_{16}	X	X		X	X		X	O_{20}				O_9	O_{10}	X
20	1	1	Wet ponds								O_2	X	O_{20}					O_{10}	X
21	1	1	Dry Ponds		O_{13}							O_{19}	O_{20}					O_{10}	X
22	1	1	Artificial wetlands								O_2						O_9		X
23	1	1	**User Defined Feature (ex: Lot level ctls)**																
24	1	1	**User Defined Feature (ex: Major System)**																
25	1	1	**User Defined Feature**																

Blank - Compatible alternative, gives a score of '1' in Table C

X - Not compatible, gives a score of '0' in Table C

O - May or may not be compatible, gives a score of '0.5' in Table C (see notes for Table A)

Table A Notes

To be used to further evaluate the compatibility of drainage features with site characteristics.

Note #	Check Caution	Override Caution	Notes for Table A
1		☐	Not recommended when the distance between the bottom of the infiltration structure and the groundwater table (or bedrock) is less than 1.0 m.
2		☐	Not recommended if a minimum permanent pool cannot be maintained.
3		☐	Not recommended for situations where water table is less than depth of ditch or where the infiltration rate of surface soils is less than 13 mm/hr.
4		☐	Not recommended if in order to maintain the proper culvert cover, the level of entrances or driveways have to be raised in such a way as to negatively affect the comfort of driving.
5		☐	Should only be considered if surface infiltration rates are greater than 13 mm/hr in order to prevent nuisance surface ponding.
6		☐	The average surface slope should not be the determining factor but rather the slope of the expected structure. For example, even if the average surface slope is above 5%, roads and ditches may be constructed at a less accentuated cross slope. In the case of ditches and swales, such high slopes may easily create conditions for erosion due to high flow velocities. In the case of raised culverts or check dams these would have to be high and frequent to have any positive influence. In the case of infiltration trenches the use of vertical flow barriers may be required to maximize the use of storage.
7		☐	Not recommended if ditch is too shallow (< 0.60 m) and poorly drained (slope < 1% or surface infiltration < 13 mm/hr) or if culverts are too small (< 450 mm). The first condition is prone to culvert heaving and the second to ice or snow clogging.
8		☐	Not recommended if located in areas where ground surface can freeze for extended periods.
9		☐	Not recommended if pollutant removal effectiveness is also required during the winter season.
10		☐	The presence of highly erodible soils or high contents of suspended solids in surface runoff require that pretreatment measures be used to ensure the longevity of any infiltration technique and/or to minimize maintenance requirements.
11		☐	Not recommended if designed amounts of infiltrated runoff exceeds natural conditions.
12		☐	Not recommended if contaminated runoff is expected. Only use in backyards.
13		☐	Not recommended unless bottom of facility is impermeable.
14		☐	Not recommended unless roadbase is free draining and not affected by frost.
15		☐	Not recommended if system is to be connected to an outlet which is shallower than the perforated pipe system.
16		☐	Not recommended unless sufficient pre-treatment can be provided (eg. with oil and grit separators).
17		☐	Not recommended unless sufficient depth cover can be provided for frost protection.
18		☐	Not recommended unless used jointly with another feature that allows proper drainage.
19		☐	Not recommended unless used for major system storage only.
20		☐	May not be feasible is used jointly with conventional storm sewers with foundation drain connections.

Table B: Selection of alternative drainage features based on development characteristics

FEATURE	TABLE A	TABLE B	Drainage Features	Development characteristics: Type of landuse: Residential	Commercial	Industrial	ROW planning: [ROW width] - [Road surface Width] - [Sidewalk Width] (m) < 2.5	2.5 - 5.0	Sidewalks next to road	Trees within ROW	Below ground franchise utilities	Lot Planning: Spacing between entrances < 5.0 m	Imperviousness > 75%	Back to front drainage	Reverse slope driveways
				☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
1	1	1	Street curbs												
2	1	1	Roads with one-sided cross slopes		X	X									
3	1	1	Porous pavement with storage structure			X									
4	1	1	Porous pavement with exfiltration system		O_1	X					O_8				
5	1	1	Storm sewers with foundation drain connections												
6	1	1	Shallow storm sewers with sump pumps												X
7	1	1	Roadside ditches with culverts		O_2		X	O_5	O_{11}			X	O_9		X
8	1	1	Shallow ditches or swales (no culverts)				O_5		O_{11}						
9	1	1	Shallow perforated pipe exfiltration system			O_3	O_5		O_{11}	O_7	O_8		O_9		
10	1	1	Deep perforated pipe exfiltration system			O_3									
11	1	1	Deep perforated pipe filtration system												
12	1	1	Raised culverts			O_3	X		O_{11}			X	O_9		X
13	1	1	Dipped driveways			X			O_{11}						X
14	1	1	Check dams			O_3	X		O_{11}			X	O_9		X
15	1	1	Oil and Grit separators												
16	1	1	Greenbelts and backyard swales			O_3			O_6				O_9	O_{10}	
17	1	1	Horizontal infiltration / exfiltration trenches			O_3	O_4		O_6	O_7	O_8		O_9		
18	1	1	Vertical exfiltration wells and perforated catchbasins			O_3				O_7	O_8				
19	1	1	Infiltration basins			O_3									
20	1	1	Wet ponds			O_{12}									
21	1	1	Dry Ponds												
22	1	1	Artificial wetlands			O_{12}									
23	1	1	**User Defined Feature (ex: Lot level ctls)**												
24	1	1	**User Defined Feature (ex: Major System)**												
25	1	1	**User Defined Feature**												

Blank - Compatible alternative, gives a score of '1' in Table C

X - Not compatible, gives a score of '0' in Table C

O - May or may not be compatible, gives a score of '0.5' in Table C (see notes for Table B)

Table B Notes

To be used to further evaluate the compatibility of drainage features with development characteristics.

Note #	Check Caution	Override Caution	Notes for Table B
1		☐	Not recommended if area includes gas stations or other types of activities where toxic chemicals are transported or stored.
2		☐	May not be aesthetically pleasing in highly developed areas.
3		☐	Any infiltration techniques used within an industrial area should be done with extreme care. Gas stations and storage areas for toxic chemicals should not be considered if such techniques are anticipated. Not recommended for use in roadside ditches or swales with extremely permeable soils.
4		☐	Not recommended if sufficient available space is not available to also include buffer strips or adequate pretreatment.
5		☐	Can only be installed on one side of the street.
6		☐	Difficult to incorporate within ROW. Could only be used as lot level control.
7		☐	Not recommended unless special techniques such as the use of copper mesh installed around the infiltration structure in order to prevent damage from tree roots. The appropriate selection of trees or adequate distances between planting and infiltration structures may also reduce this potential problem.
8		☐	Not recommended if the presence of underground utilities interferes with the use of underground infiltration structures. Proper planning and discussions with the local utilities may address this problem. However, in the case of a retrofit situation, the use of infiltration techniques within the ROW may be more difficult.
9		☐	Not recommended if the the availability of contiguous open space is very limited.
10		☐	Backyard swales cannot be used.
11		☐	Cannot be used if two sidewalks are constructed. If only one sidewalk is constructed then could be used on side without sidewalk.
12		☐	Not recommended unless it is demonstrated that bioaccumulation of pollutants will not create adverse environmental effects.

Table C: Identification of compatible drainage features
(use to compile results from Tables A and B, optional)

Feature	Drainage system features	Compatibility checks (refer to Tables A and B)		
		(A) Site characteristics	(B) Development characteristics	Overall Score (A) x (B)
1	Street curbs	1	1	1
2	Roads with one-sided cross slopes	1	1	1
3	Porous pavement with storage structure	1	1	1
4	Porous pavement with exfiltration system	1	1	1
5	Storm sewers with foundation drain connections	1	1	1
6	Shallow storm sewers with sump pumps	1	1	1
7	Roadside ditches with culverts	1	1	1
8	Shallow ditches or swales (no culverts)	1	1	1
9	Shallow perforated pipe exfiltration system	1	1	1
10	Deep perforated pipe exfiltration system	1	1	1
11	Deep perforated pipe filtration system	1	1	1
12	Raised culverts	1	1	1
13	Dipped driveways	1	1	1
14	Check dams	1	1	1
15	Oil and Grit separators	1	1	1
16	Greenbelts and backyard swales	1	1	1
17	Horizontal infiltration trenches	1	1	1
18	Vertical exfiltration wells and perforated catchbasins	1	1	1
19	Infiltration basins	1	1	1
20	Wet ponds	1	1	1
21	Dry Ponds	1	1	1
22	Artificial wetlands	1	1	1
23	**User Defined Feature (ex: Lot level ctls)**	1	1	1
24	**User Defined Feature (ex: Major System)**	1	1	1
25	**User Defined Feature**	1	1	1

Notes on Overall Score values

Score	Suggestion
1	This drainage feature is potentially compatible with both site and development characteristics
0.5	This drainage feature may be compatible, however a cautionary note was generated for Table A or Table B -- See Table A Notes and Table B Notes
0.25	This drainage feature may be compatible, however a cautionary note exists for both Table A and Table B -- See Table A Notes and Table B Notes
0	This drainage feature is potentially not compatible with both site and development characteristics

Table CD: Stormwater Management Objectives

Function	Objective Narrative Target	Target (10) Performance	Importance to Project (11)	
			Text	Weight
Groundwater recharge (1) (Infiltration of runoff from a 10 mm storm)	**Infiltrate or reduce flows**	**100%**	High	3
Erosion control (Control or infiltration of runoff from a 25 mm strom)	**Rate of runoff control for downstream erosion control**	**100%**	High	3
Suspended solids (2)	**Reduce load**	**100%**	High	3
Phosphorus removal	**Reduce load**	**100%**	High	3
Bacteria uptake (3)	**Reduce load**	**100%**	High	3
Oil and grease (4)	**Control**	**100%**	High	3
Thermal reduction (5)	**Control**	**100%**	High	3
Flood control (on-site) (6)	**Minor system performance to design storm**	**100%**	High	3
Flood control (off-site) (7)	**Rate of runoff control for downstream flood control**	**100%**	N/A	0
Major system (8)	**Major system to be considered in design**	**100%**	High	3
Source Controls (9)	**Source controls to be considered in design**	**100%**	N/A	0

Notes:
1) Intiltrate or reduce annual flow volumes.
2) Use 50 to 80% depending on use in the receiving water.
3) Reduce numbers in discharge.
4) Percent flow through measure.
5) Percent flow through measure.
6) Always assumed as basis for design of all elements.
7) Control of 25 mm storm assumed to control both erosion flooding. Target is percent control for system.
8) Only if needed to be added at additional cost - set weight as 1.
9) Only if performance and cost know - set weight as 1.
10) Numbers shown are for illustration purposes. The user must set targets for each analysis based on subwatershed uses.
11) Importance and and weights (see Config sheet to modify).

Table D: Comparison of SWM Function Potentials

FEATURE	TABLEC	SCEN. 1	SCEN. 2	SCEN. 3	Drainage Features	SWM Function Potentials: Ground water recharge (5 (Infiltration of runoff from a to 10 mm storm)	Erosion control (Control or infiltration of runoff from a 25 mm storm)	Quality control: Suspended Solids (1	Quality control: Phosphorus Removal (1	Quality control: Bacteria die-off	Quality control: Oil and grease (2	Thermal reduction	Flood control: On-site	Flood control: Off-site	Major System (3	Social Values (3
1	1	☐	☐	☐	Street curbs	0	0	0	0	0	0	0	1	0		
2	1	☐	☐	☐	Roads with one-sided cross slopes	0	0	0	0	0	0	0	0	0		
3	1	☐	☐	☐	Porous pavement with storage structure	0	0.5	0.8	0.53	0	0	0	0	0		
4	1	☐	☐	☐	Porous pavement with exfiltration system	0.95	1	0.9	0.86	0.76	0	1	0	0		
5	1	☐	☐	☐	Storm sewers with foundation drain connections	0	0	0	0	0	0	1	1	1 (*		
6	1	☐	☐	☐	Shallow storm sewers with sump pumps	0.1 (-	0	0.08	0.08	0.08	0	1	1	1 (*		
7	1	☐	☐	☐	Roadside ditches with culverts	0.4	0.25	0.86	0.68	0.32	0	0.25	1	1 (:		
8	1	☐	☐	☐	Shallow ditches or swales (no culverts)	0.8	0.5	0.93	0.83	0.64	0	0	0	0		
9	1	☐	☐	☐	Shallow perforated pipe exfiltration system	0.95	1	0.95	0.89	0.76	0	1	1	1 (*		
10	1	☐	☐	☐	Deep perforated pipe exfiltration system	0.95	1	0.81	0.79	0.76	0	1	1	1 (*		
11	1	☐	☐	☐	Deep perforated pipe filtration system	0.1	0.5	0.45	0.33	0.08	0	1	1	1 (*		
12	1	☐	☐	☐	Raised culverts	0.1	0.05	0.36	0.26	0.08	0	0	1	1 (:		
13	1	☐	☐	☐	Dipped driveways	0.1	0.05	0.22	0.17	0.08	0	0	0	0		
14	1	☐	☐	☐	Check dams	0.15	0.1	0.38	0.3	0.12	0	0	0	0		
15	1	☐	☐	☐	Oil and Grit separators	0	0	0.6	0.4	0	1	0	0	0		
16	1	☐	☐	☐	Greenbelts and backyard swales	0.8	0.5	0.86	0.78	0.64	0	0.5	0.5	0		
17	1	☐	☐	☐	Horizontal infiltration trenches	0.8	1	0.86	0.78	0.64	0	1	0	0		
18	1	☐	☐	☐	Vertical exfiltration wells and perforated catchbasins	0.8	1	0.86	0.78	0.64	0	1	0	0		
19	1	☐	☐	☐	Infiltration basins	0.8	0.5	0.82	0.76	0.64	0	0.5	0	0		
20	1	☐	☐	☐	Wet ponds	0	1	0.75	0.5	0.75	1 (+	0	0	1		
21	1	☐	☐	☐	Dry Ponds	0	1	0.5	0.33	0.7	0	0	0	1		
22	1	☐	☐	☐	Artificial wetlands	0	0.75	0.4	0.4	0.5	0	0	0	1		
23	1	☐	☐	☐	**User Defined Feature (ex: Lot level ctls)**											
24	1	☐	☐	☐	**User Defined Feature (ex: Major System)**											
25	1	☐	☐	☐	**User Defined Feature**											

Notes: +) If equipped with appropriate booms.

-) Only if pumps discharge to backyards or onto a grass area.

*) Only if system has inlet control devices and storage on street is permitted.

:) Only if ditches / swales are deep enough to provide adequate storage.

1) Values shown are combined efficiency of removal from infiltration and other processes such as sedimentation.

2) While most devices will remove some oil and grease, only those with specific design features for this have been given values.

3) Values for "Major System" and "Social" benefits must be entered by user.

4) Values for "User Defined Features" must be entered by user if applied.

5) Groundwater recharge values shown in relation to infiltration of 10 mm storms or less, which represents approximately 80% of annual volume. Total performance for measures with infiltration has been adjusted to reflect annual performance due to infiltration.

Table E: Comparison of conceptual drainage systems - Scenario 1
(working table)

Total drainage area (ha): **10**

Total Percentage of Impervious Area: **40.0%**

Cost of this system: $0.00 (from "Cost Comparisons" table)

Description of potential alternative drainage system: ______________________

Selected Drainage Features	Area (1 serviced by feature (ha)	Drainage System Objectives and Compliance (refer to Table D)									
☐ Use multi-efficiency model **System Efficiency**	→										
Target Performance (from Table CD)	→										
System Compliance	→										
Objectives Priority Weighting (from Table CD)	→										
Weighted Compliance as per SWM Priorities	→										

Total Feature Benefit Index	0.00	The sum of each Drainage Feature Benefit Index
Average System Compliance	0.00	The average of each objective's System Compliance
Overall Score	0.00	The sum of Weighted Compliance as per SWM Priorities

NOTES: 1) Areas associated to any feature must be less than or equal to the Total Drainage area.
2) The System Compliance must be recalculated when the areas associated to Drainage Feature are modified. To do this, "click" twice on the "Use multi-efficiency model" CheckBox next.

APPENDIX H

USER GUIDE

Drainage System Selection Tool
Microsoft Excel Version

"Evaluation of Roadside Ditches and other Stormwater Management Practices"

Prepared for:

The Toronto and Region Conservation Authority

Prepared by:

J.F. Sabourin and Associates Inc.
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February 2000

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Table of Contents

General Information

Specific Details of Each Worksheet

ANNEX A: Sample Print-outs from Drainage System Selection Tool

Introduction

This is an electronic version of the selection tool developed as part of the study, "Evaluation of Roadside Ditches and other related Stormwater Management Practices" (1997, J.F. Sabourin and Associates Inc.)

Using the flexibility of a spreadsheet and the power of the Visual Basic programming language, "Report-Ready" analysis and recommendations can be made with the click of a few buttons.

The electronic version of the tool was developed for Microsoft Excel, and has been optimized for version 7. A spreadsheet was chosen as the tool naturally lent itself to this type of application because of it's tabular layout. Microsoft Excel was chosen as it is capable of sustaining VBA modules and can link form objects such as check boxes and buttons to Visual Basic programming code.

Methodology

- The selection tool allows for an efficient identification of drainage system features which are compatible with site and development characteristics.
- The user simply checks a series of boxes, and clicks a few buttons to conceptualize and cost various potential drainage systems.
- A complete set of capital and related maintenance costs are provided in tables, which are used to evaluate the total "Present Value" of potential alternatives.
- A complete set of performance tables is included to identify the environmental and social benefits of one system over another.
- An intuitive "build" algorithm is used to approximate the quantities of the various elements required to build the system (how many meters of pipes are required, how many catchbasins need to be installed etc.)

Results

- The tool can identify whether or not a drainage feature is compatible with the site and development characteristics.
- The tool can be used to calculate the quantities of materials needed to build a proposed drainage system based on drainage area and imperviousness.
- The use of this tool can speed up the evaluation of various drainage system design proposals.
- The tool can quickly and accurately produce a cost/benefit comparison of one system over another.

System Requirements

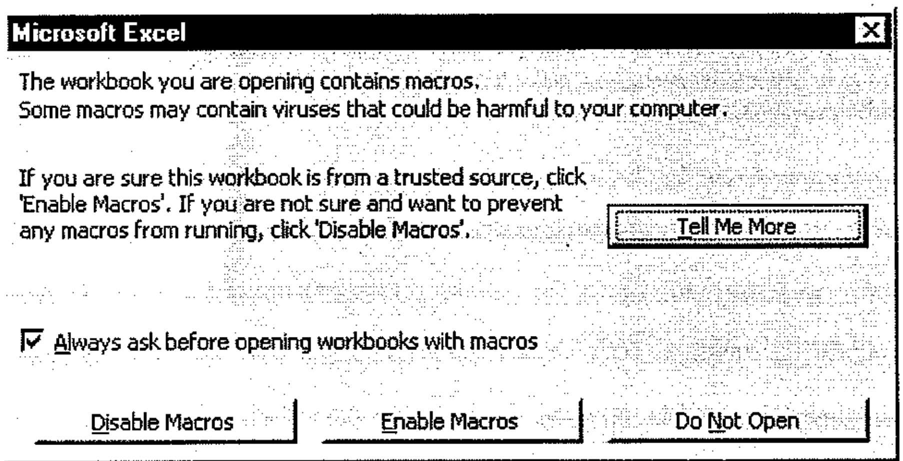
- Microsoft Excel, (version 7 or better) for Windows 95/98/NT
- Minimum screen resolution: 800 x 600 x 256 colours
- Recommended screen resolution: 1024 x 768 x 256 colours or better

Viewing Each Page

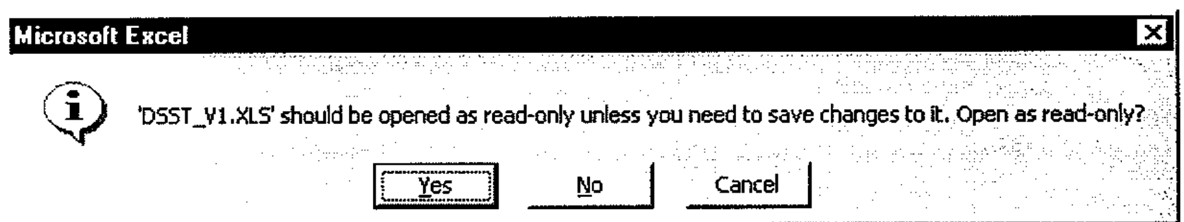
Each table has been designed so that the hard copy print-out covers the majority of a standard 8-1/2" x 11" page leaving adequate room for margins, headers and footers. To view each table properly, it is suggested that full-screen mode be employed and that all toolbars are turned off. This is accomplished by selecting "Full-Screen" from the "View" menu, and deselecting the toolbars listed under "Toolbars", also on the "View" menu.

Start Up

To start the tool, open the file, "DSST_V1.XLS" (Drainage System Selection Tool, Version 1), with Microsoft Excel (version 7 or better). This file contains VBA modules that are encoded as Macros. The latest version of Excel may produce a warning screen such as the one below. In order for the tool to run you need to Enable Macros. The macros contained within this tool are not malicious in nature, nor do they contain viruses.



It is suggested that you open the file as read-only. This way, any changes made to the file will have to be saved with a new filename. This ensures that the original values contained within the selection tool will remain intact.



Note:

Although other spreadsheet programs such as Quattro Pro or Lotus 1-2-3 may be able to open an Excel workbook, these programs do not have the ability to properly open and process the VBA code contained within the macros. This code is required for the tool to work. Microsoft provides a free viewer for Excel files; however, the viewer is not capable of executing VBA code contained within macros. The tool will not operate properly if opened in the viewer.

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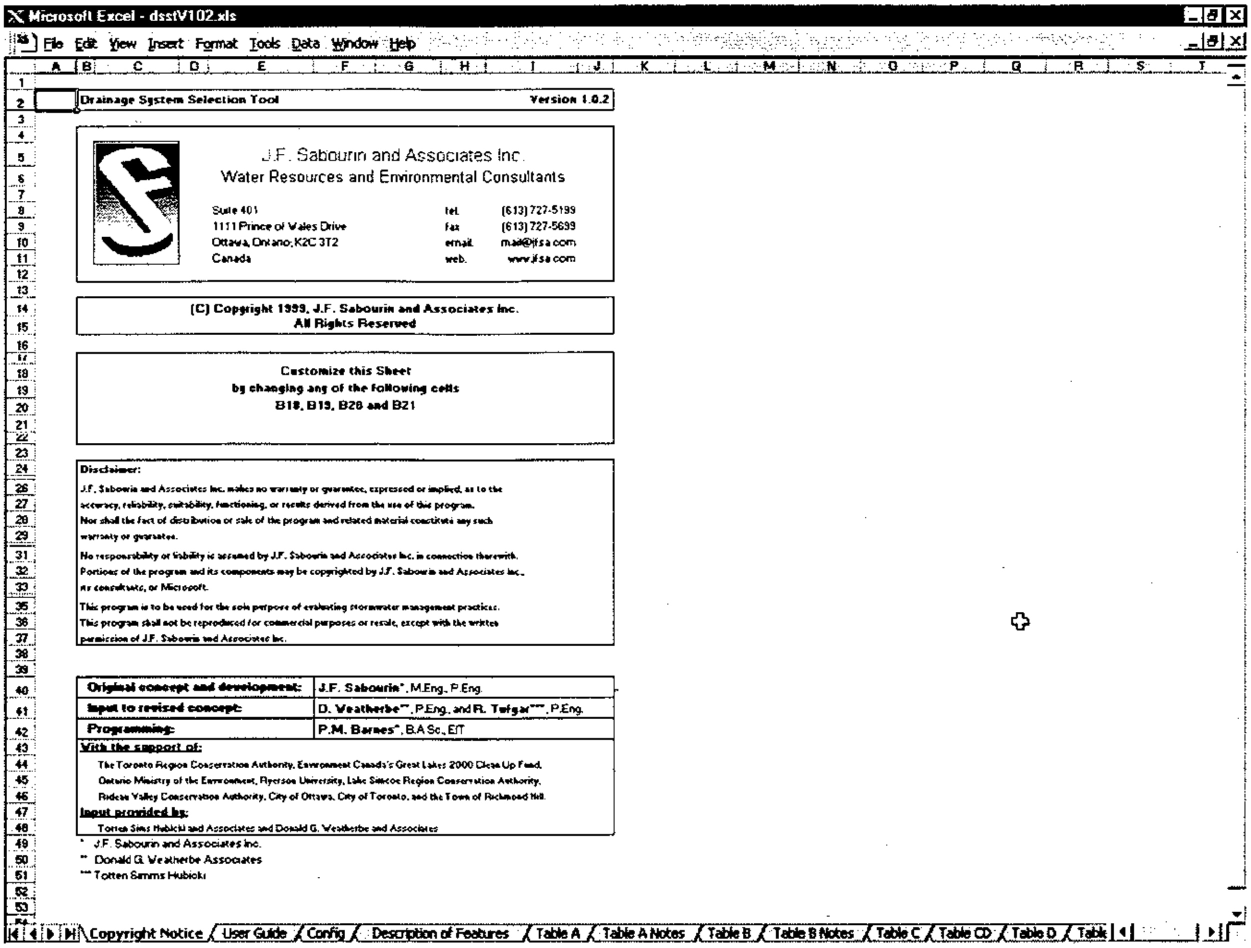
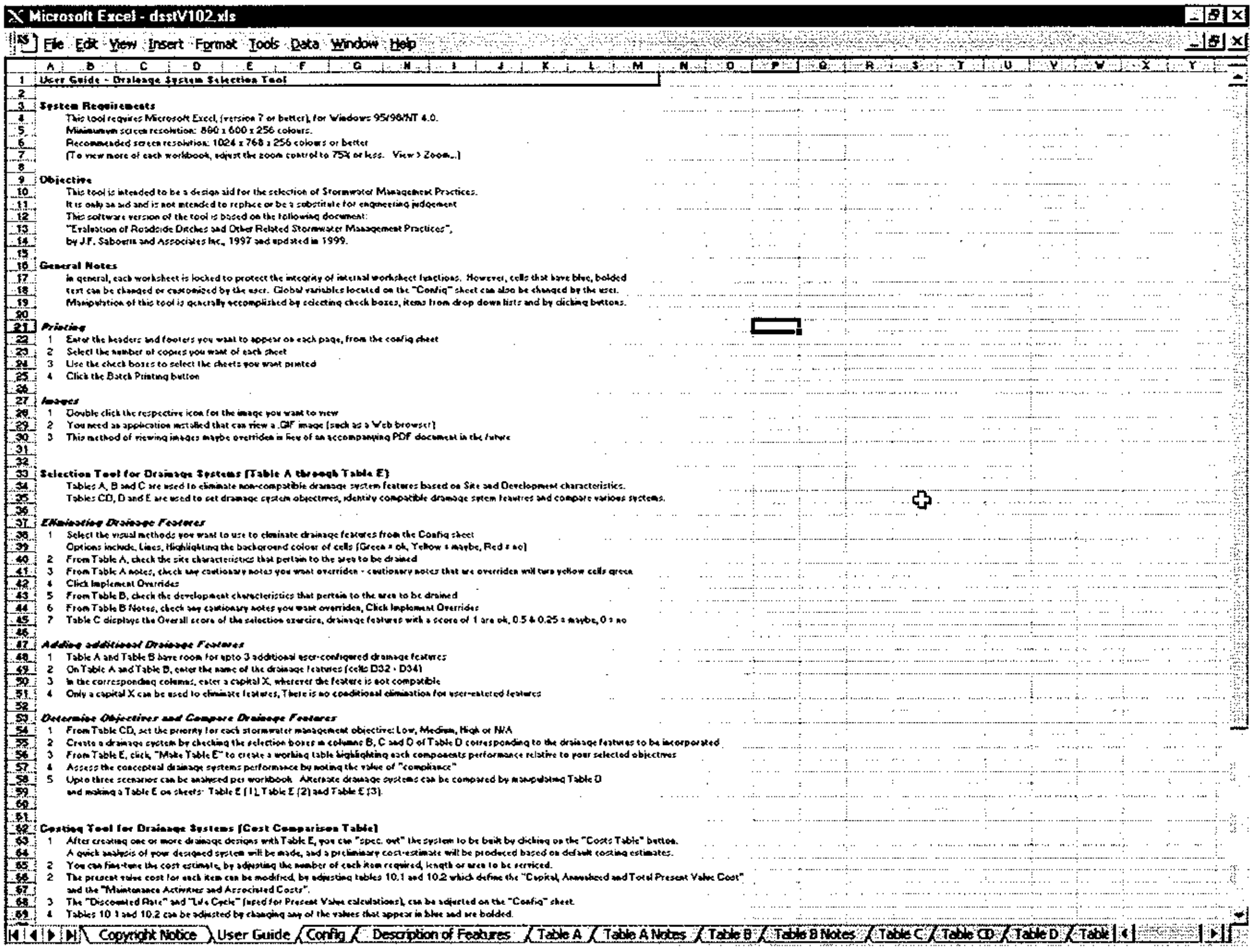


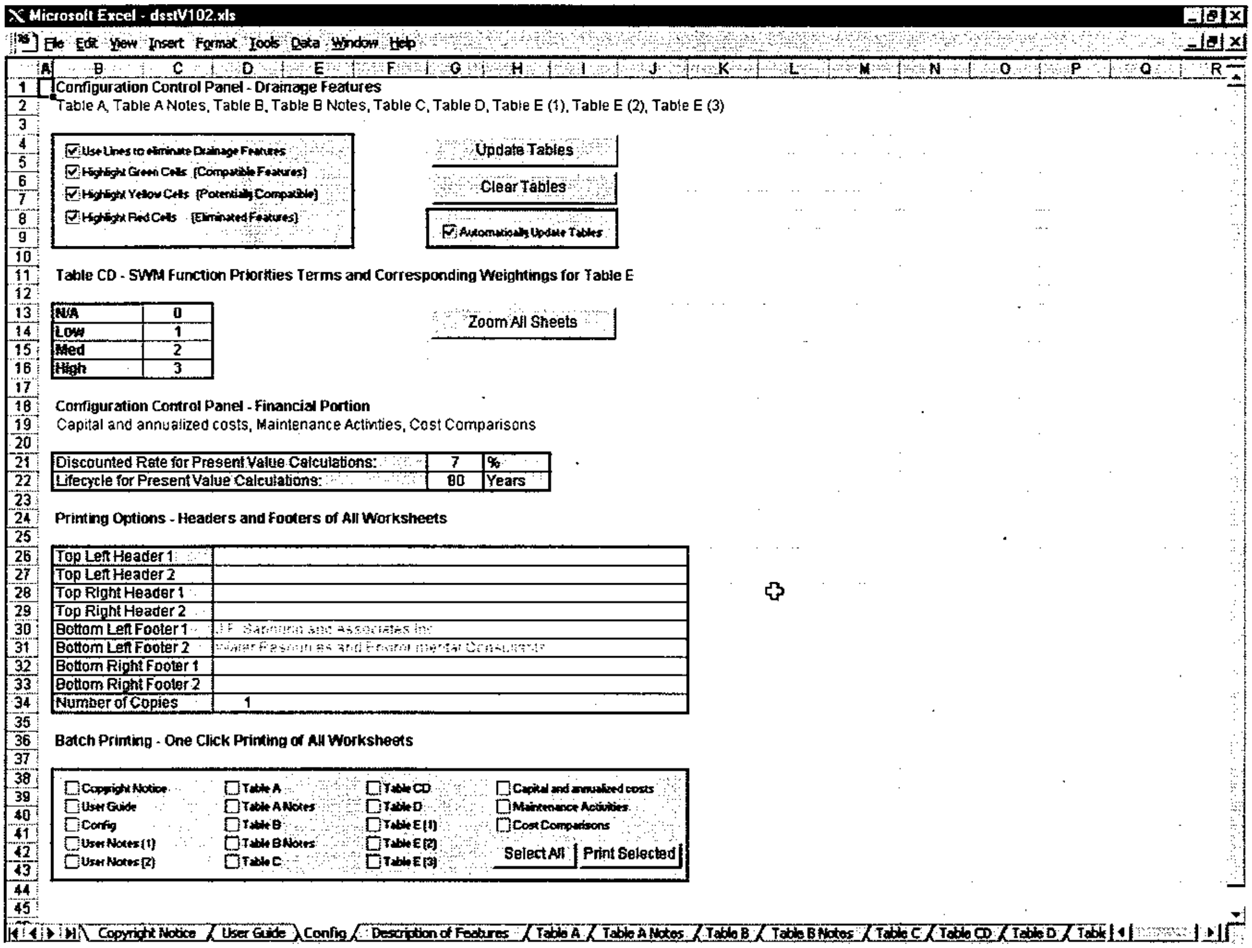
This page is used as a "Splash Screen", and is the first worksheet the user sees when opening up the workbook. It gives credit to the authors, and provides a general disclaimer on the tool's use. Changing cells "B18" to "B21" can customize this page. It is recommended that this customized page be used as a front page, or first page, of a report in which this tool is used.

User Guide



Additional user-help is available on this sheet.

Config



This page is the most critical page of the tool as it is used to set up certain default values, and controls how the tool operates.

The first series of check boxes in the top left corner are used to control how compatible and non-compatible drainage features are highlighted. Background colours can be turned on and off, so can lines that strike out non-compatible features. Some experimenting with this may be necessary to optimize outputs for screen and printer.

Update Tables

This button is used when Automatic Updates is turned off. It recalculates each table, and changes the background colours as necessary.

Clear Tables

This button is used to remove any of the user input from Tables A through E and from the Cost Comparisons table.

[ ] Automatically Update Tables

This check box toggles the worksheet's auto-update mode. Working with this feature turned off, can speed up data-entry; however, the user should always use the **Update Tables** feature before making drainage system selections and printing output.

Zoom All Sheets

This button will cycle through each worksheet and select an appropriate Zoom factor so that the entire sheet will fit on the screen. This is useful as each table is quite large, and not all monitors are the same. For data input and detailed viewing, you may have to zoom in, and use the scroll bars to navigate each page.

SWM FUNCTION PRIORITIES

You can set the numeric weighting associated with the text value of each SWM Function Priority. These values are used in TABLE CD and TABLE E.

Discounted Rate

You can enter in a discounted rate in cell "G21". This value will be used for present value and payment functions in the "Capital and Annualized Costs" table.

Lifecycle

The lifecycle that is used for the financial calculations in the "Capital and Annualized Costs" table can be configured in cell "G22".

Batch Printing

Printing of the entire workbook can be automated through the batch printing utility at the bottom of the "CONFIG" page. Select which pages you want to print, and enter in the header and footer information you wish to appear.

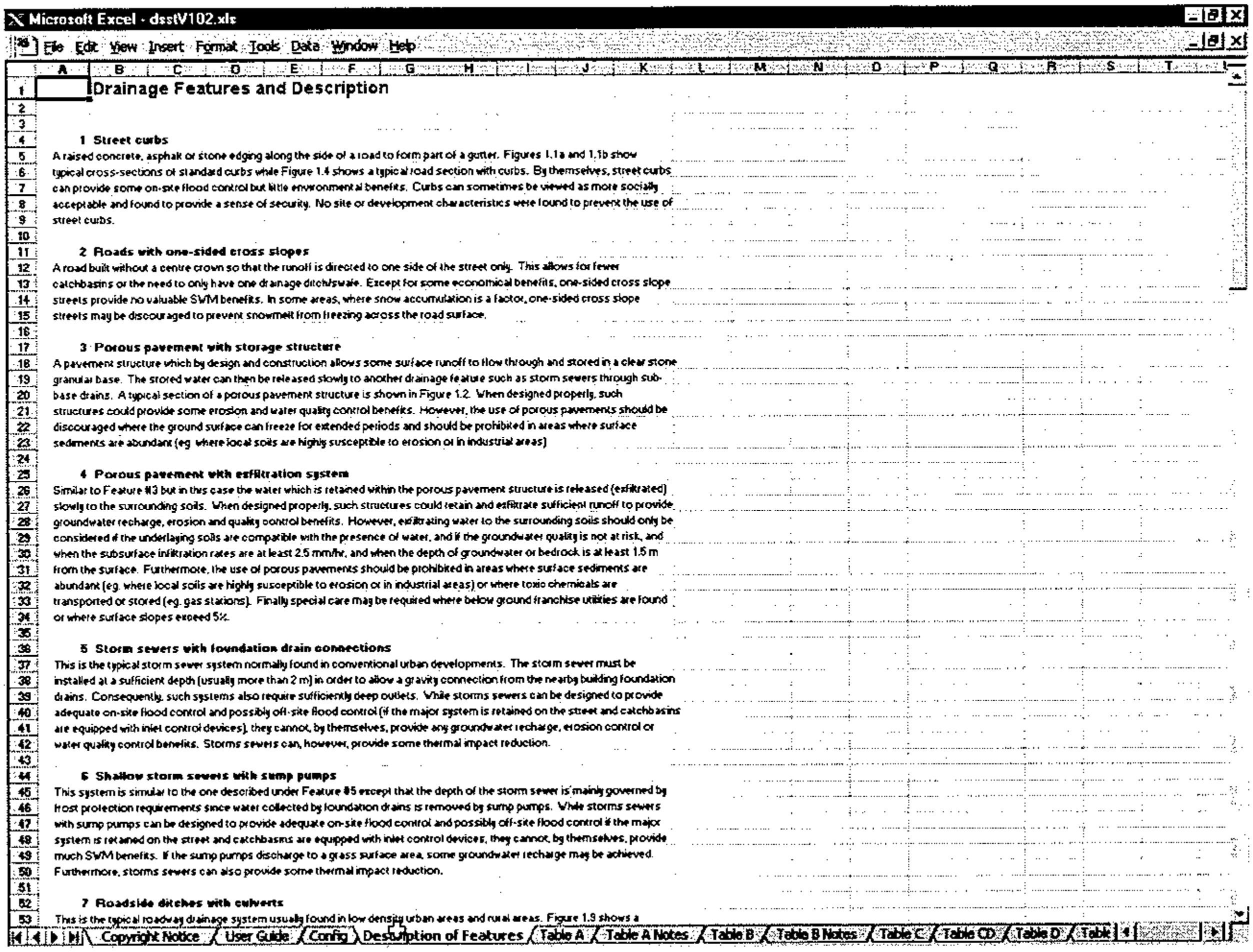
Select All

This button selects all of the worksheets in the workbook to be printed.

Print Selected

This button prints all of the worksheets that have been selected.

Drainage Features and Description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Drainage Features and Description

1 Street curbs

A raised concrete, asphalt or stone edging along the side of a road to form part of a gutter. Figures 1.1a and 1.1b show typical cross-sections of standard curbs while Figure 1.4 shows a typical road section with curbs. By themselves, street curbs can provide some on-site flood control but little environmental benefits. Curbs can sometimes be viewed as more socially acceptable and found to provide a sense of security. No site or development characteristics were found to prevent the use of street curbs.

2 Roads with one-sided cross slopes

A road built without a centre crown so that the runoff is directed to one side of the street only. This allows for fewer catchbasins or the need to only have one drainage ditch/swale. Except for some economical benefits, one-sided cross slope streets provide no valuable SWM benefits. In some areas, where snow accumulation is a factor, one-sided cross slope streets may be discouraged to prevent snowmelt from freezing across the road surface.

3 Porous pavement with storage structure

A pavement structure which by design and construction allows some surface runoff to flow through and stored in a clear stone granular base. The stored water can then be released slowly to another drainage feature such as storm sewers through sub-base drains. A typical section of a porous pavement structure is shown in Figure 1.2. When designed properly, such structures could provide some erosion and water quality control benefits. However, the use of porous pavements should be discouraged where the ground surface can freeze for extended periods and should be prohibited in areas where surface sediments are abundant (eg. where local soils are highly susceptible to erosion or in industrial areas)

4 Porous pavement with exfiltration system

Similar to Feature #3 but in this case the water which is retained within the porous pavement structure is released (exfiltrated) slowly to the surrounding soils. When designed properly, such structures could retain and exfiltrate sufficient runoff to provide groundwater recharge, erosion and quality control benefits. However, exfiltrating water to the surrounding soils should only be considered if the underlaying soils are compatible with the presence of water, and if the groundwater quality is not at risk, and when the subsurface infiltration rates are at least 2.5 mm/hr, and when the depth of groundwater or bedrock is at least 1.5 m from the surface. Furthermore, the use of porous pavements should be prohibited in areas where surface sediments are abundant (eg. where local soils are highly susceptible to erosion or in industrial areas) or where toxic chemicals are transported or stored (eg. gas stations). Finally special care may be required where below ground franchise utilities are found or where surface slopes exceed 5%.

5 Storm sewers with foundation drain connections

This is the typical storm sewer system normally found in conventional urban developments. The storm sewer must be installed at a sufficient depth (usually more than 2 m) in order to allow a gravity connection from the nearby building foundation drains. Consequently, such systems also require sufficiently deep outlets. While storms sewers can be designed to provide adequate on-site flood control and possibly off-site flood control (if the major system is retained on the street and catchbasins are equipped with inlet control devices), they cannot, by themselves, provide any groundwater recharge, erosion control or water quality control benefits. Storms sewers can, however, provide some thermal impact reduction.

6 Shallow storm sewers with sump pumps

This system is simular to the one described under Feature #5 except that the depth of the storm sewer is mainly governed by frost protection requirements since water collected by foundation drains is removed by sump pumps. While storms sewers with sump pumps can be designed to provide adequate on-site flood control and possibly off-site flood control if the major system is retained on the street and catchbasins are equipped with inlet control devices, they cannot, by themselves, provide much SWM benefits. If the sump pumps discharge to a grass surface area, some groundwater recharge may be achieved. Furthermore, storms sewers can also provide some thermal impact reduction.

7 Roadside ditches with culverts

This is the typical roadway drainage system usually found in low density urban areas and rural areas. Figure 1.9 shows a

Copyright Notice / User Guide / Config / Description of Features / Table A / Table A Notes / Table B / Table B Notes / Table C / Table CD / Table D / Table

This sheet provides you with a complete description of the alternative drainage features considered by the Selection Tool.

Table A

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Table A: Selection of alternative drainage features based on site characteristics [Update Table A]

FEATURE	TABLE A	TABLE B	Drainage Features	Soils are incompatible with the presence of water	Ground water quality is at risk	Soil Infiltration Rates [Select From Table]: Surface inf. < 13 mm/hr	Soil Infiltration Rates: Surface inf. < 60 mm/hr	Soil Infiltration Rates: Sub-surf. inf. < 2.5 mm/hr	Depth of groundwater or bedrock (m): < 1.5	Depth of groundwater or bedrock (m): 1.5 - 4.0	No source of continuous flow	Depth of drainage outlet (m): < 1.0	Depth of drainage outlet (m): 1.0 - 2.0	Depth of drainage outlet (m): > 2.0	Surface Slopes (%): < 1.0	Surface Slopes (%): > 5.0	Climate is vulnerable to cold and snowy winters	Surface soils are highly susceptible to erosion	Drainage area is less than 5.0 ha or space is limited
				☐	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐
1	1	1	Street curbs																
2	0.5	1	Roads with one-sided cross-slopes														O_{8}		
3	0.5	1	Porous pavement with storage structure														O_{8}	X	
4	0	1	Porous pavement with exfiltration system	X	X			X	X							O_{6}	O_{14}	X	
5	1	1	Storm sewers with foundation drain connections									X	X						
6	1	1	Shallow storm sewers with sump pumps									X	O_{17}						
7	1	1	Roadside ditches with culverts									O_{4}	O_{3}		O_{5}	O_{6}	O_{7}	O_{10}	
8	1	1	Shallow ditches or swales (no culverts)			O_{18}										O_{6}		O_{10}	
9	0	1	Shallow perforated pipe exfiltration system	X	X			X	X	O_{1}		O_{15}	O_{15}			O_{6}		O_{10}	
10	0	1	Deep perforated pipe exfiltration system	X	O_{16}			X	X	O_{1}		O_{15}	O_{15}			O_{6}		O_{10}	
11	1	1	Deep perforated pipe filtration system						X	O_{1}		X	X						
12	0.5	1	Raised culverts	O_{11}	X	X						X	O_{4}			O_{6}	O_{8}	O_{10}	
13	0.5	1	Dipped driveways	O_{11}	X	X										O_{6}	O_{8}		
14	0.5	1	Check dams	O_{11}	X	X										O_{6}	O_{8}	O_{10}	
15	1	1	Oil and Grit separators									X	X						
16	1	1	Greenbelts and backyard swales		O_{12}										O_{5}	O_{6}		O_{10}	
17	0	1	[illegible]	X	O_{16}			X	X	O_{1}						O_{6}		O_{10}	
18	0	1	Vertical exfiltration wells and perforated catchbasins	X	O_{16}			X	X	X								O_{10}	
19	1	1	Infiltration basins	X	O_{16}	X	X		X	X		X	O_{20}				O_{9}	O_{10}	X
20	1	1	Wet ponds								O_{2}	X	O_{20}					O_{10}	X
21	1	1	Dry Ponds		O_{13}							O_{19}	O_{20}					O_{10}	X
22	1	1	Artificial wetlands								O_{2}						O_{9}		X
23	1	1	**User Defined Feature (ex: Lot level ctls)**																
24	1	1	**User Defined Feature (ex: Major System)**																
25	1	1	**User Defined Feature**																

Blank - Compatible alternative, gives a score of '1' in Table C

X - Not compatible, gives a score of '0' in Table C

O - May or may not be compatible, gives a score of '0.5' in Table C (see notes for Table A)

The following notes were overriden by the user: 7, 9.

Copyright Notice / User Guide / Config / Description of Features / Table A / Table A Notes / Table B / Table B Notes / Table C / Table CD / Table D / Tab

This table is used to determine which features are compatible and which are not based on site characteristics. Not all drainage features are compatible with all site characteristics. Features that are not compatible are eliminated here.

Using the check boxes in Row 9, select the characteristics that match your site. If a feature has an "X" in the column relating to a specific site characteristic, it is not compatible, and that feature is highlighted (Red background, with solid line through it), this eliminates the drainage feature. If a feature has an "O" in the column relating to a specific site characteristic, it is potentially not compatible, and is highlighted as conditional (Yellow background, with dashed line through it). A table of notes is associated with each conditional "O", "TABLE A NOTES". You can "reinstate" a drainage feature by overriding the associated note in "TABLE A NOTES". Any notes that are overridden will be listed at the bottom of "TABLE A."

User defined drainage features can be added in rows 23, 24 and 25. "X's" can be placed in the site characteristics column where appropriate. Conditional "O's" may not be used for user-defined drainage features.

Select From Table

A pop-up menu has been included with "TABLE A" to help determine the soil infiltration rate. This table lists common soil-types and values of hydraulic conductivity. Choosing a soil type from this pop-up menu will select the appropriate surface infiltration rate of the site.

Update Table A

Clicking this button updates "TABLE A". This is only necessary if "Automatically Update Tables" is not checked on the "CONFIG" sheet.

Table A Notes

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Table A Notes

To be used to further evaluate the compatibility of drainage features with site characteristics.

Note #	Check Caution	Override Caution	Notes for Table A
1		☐	Not recommended when the distance between the bottom of the infiltration structure and the groundwater table (or bedrock) is less than 1.0 m.
2		☐	Not recommended if a minimum permanent pool cannot be maintained.
3		☐	Not recommended for situations where water table is less than depth of ditch or where the infiltration rate of surface soils is less than 13 mm/hr
4		☐	Not recommended if in order to maintain the proper culvert cover, the level of entrances or driveways have to be raised in such a way as to negatively affect the comfort of driving.
5		☐	Should only be considered if surface infiltration rates are greater than 13 mm/hr in order to prevent nuisance surface ponding.
6		☐	The average surface slope should not be the determining factor but rather the slope of the expected structure. For example, even if the average surface slope is above 5%, roads and ditches may be constructed at a less accentuated cross slope. In the case of ditches and swales, such high slopes may easily create conditions for erosion due to high flow velocities. In the case of raised culverts or check dams these would have to be high and frequent to have any positive influence. In the case of infiltration trenches the use of vertical flow barriers may be required to maximize the use of storage.
7	X	☑	Not recommended if ditch is too shallow (< 0.60 m) and poorly drained (slope < 1% or surface infiltration < 13 mm/hr) or if culverts are too small (< 450 mm). The first condition is prone to culvert heaving and the second to ice or snow clogging.
8	X	☐	Not recommended if located in areas where ground surface can freeze for extended periods.
9	X	☑	Not recommended if pollutant removal effectiveness is also required during the winter season.
10		☐	The presence of highly erodible soils or high contents of suspended solids in surface runoff require that pretreatment measures be used to ensure the longevity of any infiltration technique and/or to minimize maintenance requirements.
11		☐	Not recommended if designed amounts of infiltrated runoff exceeds natural conditions.
12		☐	Not recommended if contaminated runoff is expected. Only use in backyards.
13		☐	Not recommended unless bottom of facility is impermeable.
14		☐	Not recommended unless roadbase is free draining and not affected by frost.
15		☐	Not recommended if system is to be connected to an outlet which is shallower than the perforated pipe system.
16		☐	Not recommended unless sufficient pre-treatment can be provided (eg. with oil and grit separators).
17		☐	Not recommended unless sufficient depth cover can be provided for frost protection.
18		☐	Not recommended unless used jointly with another feature that allows proper drainage.
19		☐	Not recommended unless used for major system storage only.
20		☐	May not be feasible is used jointly with conventional storm sewers with foundation drain connections

De-select all Overrides | Implement Overrides

Copyright Notice / User Guide / Config / Description of Features / Table A / Table A Notes / Table B / Table B Notes / Table C / Table CD / Table D / Table

This table is used to override the conditional "O's" on "TABLE A". Each "O" on "TABLE A" has a note attached to it as a sub-script. These notes are listed in "TABLE A NOTES". An explanation, recommendation or guideline is listed beside each note.

A red "X" will appear in the column marked, "CHECK CAUTION" if a conditional elimination exists on "TABLE A". If the note beside the caution number does not apply, or is not relevant, a conditional elimination can be "reinstated" by checking the corresponding box in the "OVERIDE CAUTION" column.

Each cautionary note that is overridden on this sheet will be printed at the bottom of "TABLE A".

De-select all Overrides

Clicking this button is a fast way to remove all of the selected overrides. Any check marks in the "OVERRIDE CAUTION" column will be removed.

Implement Overrides

Clicking this button updates "TABLE A" with the new overrides. This is only necessary if "Automatically Update Tables" is not checked on the "CONFIG" sheet.

Table B

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Table B: Selection of alternative drainage features based on development characteristics (Update Table B)

FEATURE	TABLE A	TABLE B	Drainage Features	Development characteristics – Type of landuse: Residential	Commercial	Industrial	ROW planning – [ROW width] - [Road surface Width] - [Sidewalk Width] (m): < 2.5	2.5 - 5.0	Sidewalks next to road	Trees within ROW	Below ground franchise utilities	Lot Planning – Spacing between entrances < 5.0 m	Imperviousness > 75%	Back to front drainage	Reverse slope driveways
				☑	☐	☐	☐	☐	☐	☑	☑	☐	☐	☐	☐
1	1	1	Street curbs												
2	0.5	1	Roads with one-sided cross slopes		X	X									
3	0.5	1	Porous pavement with storage structure			X									
4	0	1	Porous pavement with exfiltration system		O_1	X					O_8				
5	1	1	Storm sewers with foundation drain connections												
6	1	1	Shallow storm sewers with sump pumps												X
7	1	1	Roadside ditches with culverts		O_2		X	O_5	O_{11}			X	O_9		X
8	1	1	Shallow ditches or swales (no culverts)				O_5		O_{11}						
9	0	1	Shallow perforated pipe exfiltration system			O_3	O_5		O_{11}	O_7	O_8		O_9		
10	0	1	Deep perforated pipe exfiltration system			O_3									
11	1	1	Deep perforated pipe filtration system												
12	0.5	1	Raised culverts			O_3	X		O_{11}			X	O_9		X
13	0.5	1	Dipped driveways			X			O_{11}						X
14	0.5	1	Check dams			O_3	X		O_{11}			X	O_9		X
15	1	1	Oil and Grit separators												
16	1	1	Greenbelts and backyard swales			O_3			O_6				O_9	O_{10}	
17	0	1	Horizontal infiltration / exfiltration trenches			O_3	O_4		O_6	O_7	O_8		O_9		
18	0	1	Vertical exfiltration wells and perforated catchbasins			O_3				O_7	O_8				
19	1	1	Infiltration basins			O_3									
20	1	1	Wet ponds			O_{12}									
21	1	1	Dry Ponds												
22	1	1	Artificial wetlands			O_{12}									
23	1	1	**User Defined Feature (ex: Lot level ctls)**												
24	1	1	**User Defined Feature (ex: Major System)**												
25	1	1	**User Defined Feature**												

Blank - Compatible alternative, gives a score of '1' in Table C

X - Not compatible, gives a score of '0' in Table C

O - May or may not be compatible, gives a score of '0.5' in Table C (see notes for Table B)

The following notes were overriden by the user: 7, 8.

Copyright Notice / User Guide / Config / Description of Features / Table A / Table A Notes / Table B / Table B Notes / Table C / Table CD / Table D / Table

This table is used to determine which features are compatible and which are not based on the development characteristics. Not all drainage features are compatible with all development characteristics. Features that are not compatible can be eliminated here.

This table follows the same principles as "TABLE A"

Table B Notes

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Table B Notes

To be used to further evaluate the compatibility of drainage features with development characteristics.

Note #	Check Caution	Override Caution	Notes for Table B
1		☐	Not recommended if area includes gas stations or other types of activities where toxic chemicals are transported or stored.
2		☐	May not be aesthetically pleasing in highly developed areas.
3		☐	Any infiltration techniques used within an industrial area should be done with extreme care. Gas stations and storage areas for toxic chemicals should not be considered if such techniques are anticipated. Not recommended for use in roadside ditches or swales with extremely permeable soils.
4		☐	Not recommended if sufficient available space is not available to also include buffer strips or adequate pretreatment
5		☐	Can only be installed on one side of the street.
6		☐	Difficult to incorporate within ROW. Could only be used as lot level control.
7	X	☑	Not recommended unless special techniques such as the use of copper mesh installed around the infiltration structure in order to prevent damage from tree roots. The appropriate selection of trees or adequate distances between planting and infiltration structures may also reduce this potential problem.
8	X	☑	Not recommended if the presence of underground utilities interferes with the use of underground infiltration structures. Proper planning and discussions with the local utilities may address this problem. However, in the case of a retrofit situation, the use of infiltration techniques within the ROW may be more difficult.
9		☐	Not recommended if the the availability of contiguous open space is very limited.
10		☐	Backyard swales cannot be used.
11		☐	Cannot be used if two sidewalks are constructed. If only one sidewalk is constructed then could be used on side without sidewalk.
12		☐	Not recommended unless it is demonstrated that bioaccumulation of pollutants will not create adverse environmental effects.

[De-select all Overrides] [Implement Overrides]

Copyright Notice / User Guide / Config / Description of Features / Table A / Table A Notes / Table B / Table B Notes / Table C / Table CD / Table D / Table

This table is used to override the conditional "O's" on "TABLE B".

This table follows the same principles as "TABLE A NOTES"

Table C

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Table C: Identification of compatible drainage features
(use to compile results from Tables A and B, optional)

Update Table C

Feature	Drainage system features	Compatibility checks (refer to Tables A and B) (A) Site characteristics	(B) Development characteristics	Overall Score (A)x(B)
1	Street curbs	1	1	1
~~2~~	~~Roads with one-sided cross-slopes~~	~~0.5~~	~~1~~	~~0.5~~
~~3~~	~~Porous pavement with storage structure~~	~~0.5~~	~~1~~	~~0.5~~
~~4~~	~~Porous pavement with exfiltration system~~	~~0~~	~~1~~	~~0~~
5	Storm sewers with foundation drain connections	1	1	1
6	Shallow storm sewers with sump pumps	1	1	1
7	Roadside ditches with culverts	1	1	1
8	Shallow ditches or swales (no culverts)	1	1	1
~~9~~	~~Shallow perforated pipe exfiltration system~~	~~0~~	~~1~~	~~0~~
~~10~~	~~Deep perforated pipe exfiltration system~~	~~0~~	~~1~~	~~0~~
11	Deep perforated pipe filtration system	1	1	1
~~12~~	~~Raised culverts~~	~~0.5~~	~~1~~	~~0.5~~
~~13~~	~~Dipped driveways~~	~~0.5~~	~~1~~	~~0.5~~
~~14~~	~~Check dams~~	~~0.5~~	~~1~~	~~0.5~~
15	Oil and Grit separators	1	1	1
16	Greenbelts and backyard swales	1	1	1
~~17~~	~~Horizontal infiltration trenches~~	~~0~~	~~1~~	~~0~~
~~18~~	~~Vertical exfiltration wells and perforated catchbasins~~	~~0~~	~~1~~	~~0~~
19	Infiltration basins	1	1	1
20	Wet ponds	1	1	1
21	Dry Ponds	1	1	1
22	Artificial wetlands	1	1	1
23	**User Defined Feature (ex: Lot level ctls)**	1	1	1
24	**User Defined Feature (ex: Major System)**	1	1	1
25	**User Defined Feature**	1	1	1

Notes on Overall Score values

Score	Suggestion
1	This drainage feature is potentially compatible with both site and development characteristics
0.5	This drainage feature may be compatible, however a cautionary note was generated for Table A or Table B -- See Table A Notes and Table B Notes
0.25	This drainage feature may be compatible, however a cautionary note exists for both Table A and Table B -- See Table A Notes and Table B Notes
0	This drainage feature is potentially not compatible with both site and development characteristics

Copyright Notice / User Guide / Config / Description of Features / Table A / Table A Notes / Table B / Table B Notes / Table C / Table CD / Table D / Table

This table is used to identify which drainage features are compatible based on the site and development characteristics identified on "TABLE A" and "TABLE B".

A score of 1 is given to each drainage feature on "TABLE A" and "TABLE B" that is compatible with the site and development characteristics. A score of 0.5 is given for each feature which has been conditionally eliminated and not reinstated by overriding the cautionary notes on either "TABLE A NOTES" or "TABLE B NOTES"

An overall score is computed for each drainage feature by multiplying the score from "TABLE A" with the "TABLE B" score. Drainage features that are suitable based on both site and development characteristics will be given an overall score of 1, and will be highlighted in green. Drainage features that are not suitable will have a total score of 0.5 or less, and will appear highlighted in yellow with a dashed line (where a conditional caution exists), or highlighted in red with a solid line (where no conditional cautions exist).

Update Table C

Clicking this button will re-compute the overall score of each drainage feature based on user input from "TABLE A", "TABLE A NOTES", "TABLE B" and "TABLE B NOTES". This is only necessary, if "Automatically Update Tables" is not checked on the "CONFIG" sheet.

Table CD

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Table CD: Stormwater Management Objectives

Function	Objective Narrative Target	Target (10) Performance	Importance to Project (11) Text	Importance to Project (11) Weight
Groundwater recharge (1) (Infiltration of runoff from a 10 mm storm)	Infiltrate or reduce flows	100%	Med	2
Erosion control (Control or infiltration of runoff from a 25 mm stro	Rate of runoff control for downstream erosion control	100%	High	3
Suspended solids (2)	Reduce load	100%	Med	2
Phosphorus removal	Reduce load	100%	Med	2
Bacteria uptake (3)	Reduce load	100%	Low	1
Oil and grease (4)	Control	100%	Med	2
Thermal reduction (5)	Control	100%	Low	1
Flood control (on-site) (6)	Minor system performance to design storm	100%	Med	2
Flood control (off-site) (7)	Rate of runoff control for downstream flood control	100%	N/A	0
Major system (8)	Major system to be considered in design	100%	High	3
Source Controls (9)	Source controls to be considered in design	100%	High	3

Reset Weights

Notes:
1) Infiltrate or reduce annual flow volumes.
2) Use 50 to 80% depending on use in the receiving water.
3) Reduce numbers in discharge.
4) Percent flow through measure.
5) Percent flow through measure.
6) Always assumed as basis for design of all elements.
7) Control of 25 mm storm assumed to control both erosion flooding. Target is percent control for system.
8) Only if needed to be added at additional cost - set weight as 1.
9) Only if performance and cost know - set weight as 1.
10) Numbers shown are for illustration purposes. The user must set targets for each analysis based on subwatershed uses.
11) Importance and and weights (see Config sheet to modify)

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This table is used to identify the "Stormwater management objectives", and apply weightings and target performances for selected stormwater management functions. For each function, the user can enter a narrative target that identifies the objective (in column B); a target performance percentage (in Column C) and a weighting value (in Column D).

Objective Narrative Target

Words the user wants to describe the overall goal for the SWM function. Examples may include: "Reduce Load", "Strictly Control", "Maximize", "Minimize" etc.

Target Performance

This is a percentage value representing the goal for the SWM function. It will be used to compute a value for "SYSTEM COMPLIANCE" on "TABLE E".

Importance to Project

This is a drop-down box, with text values: "N/A", "Low", "Med", or "High". A corresponding numeric value, "Weight" is linked to this selection box. The weighting will be used to compute a value for "Weighted Compliance as per SWM Priorities" on "TABLE E". The numeric weighting for each value in the drop-down boxes can be set on the "CONFIG" sheet.

Reset Weights

Clicking this button resets all of the drop-down boxes to "N/A" and sets the weight to the corresponding value for "N/A" as set on the "CONFIG" sheet.

Table D

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Table D: Comparison of SWM Function Potentials [Clear] [Update Table D]

Row	FEATURE	TABLE C	SCEN. 1	SCEN. 2	SCEN. 3	Drainage Features	Ground water recharge (5 (Infiltration of runoff from a 10 mm storm)	Erosion control (Control or infiltration of runoff from a 25 mm storm)	Quality control: Suspended Solids (1	Quality control: Phosphorus Removal (1	Quality control: Bacteria die-off	Quality control: Oil and grease (2	Thermal reduction	Flood control: On-site	Flood control: Off-site	Major System (3	Social Values (3
9	1	1	☑	☐	☐	Street curbs	0	0	0	0	0	0	0	1	0		
10	2	0.5	☐	☐	☐	~~[illegible]~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~		
11	3	0.5	☐	☐	☐	~~[illegible]~~	~~0~~	~~0.5~~	~~0.8~~	~~0.53~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~		
12	4	0	☐	☐	☐	~~[illegible]~~	~~0.95~~	~~1~~	~~0.8~~	~~0.96~~	~~0.76~~	~~0~~	~~1~~	~~0~~	~~0~~		
13	5	1	☑	☐	☐	Storm sewers with foundation drain connections	0	0	0	0	0	0	1	1	1		
14	6	1	☐	☐	☐	Shallow storm sewers with sump pumps	0.1	0	0.08	0.08	0.08	0	1	1	1		
15	7	1	☐	☑	☐	Roadside ditches with culverts	0.4	0.25	0.86	0.68	0.32	0	0.25	1	1		
16	8	1	☐	☐	☑	Shallow ditches or swales (no culverts)	0.8	0.5	0.93	0.83	0.64	0	0	0	0		
17	9	0	☐	☐	☐	~~[illegible]~~	~~0.95~~	~~1~~	~~0.95~~	~~0.90~~	~~0.76~~	~~0~~	~~1~~	~~1~~	~~1~~		
18	10	0	☐	☐	☐	~~[illegible]~~	~~0.95~~	~~1~~	~~0.81~~	~~0.73~~	~~0.75~~	~~0~~	~~1~~	~~1~~	~~1~~		
19	11	1	☑	☐	☐	Deep perforated pipe filtration system	0.1	0.5	0.45	0.33	0.08	0	1	1	1		
20	12	0.5	☐	☐	☐	~~[illegible]~~	~~0.1~~	~~0.05~~	~~0.36~~	~~0.26~~	~~0.08~~	~~0~~	~~0~~	~~1~~	~~1~~		
21	13	0.5	☐	☐	☐	~~[illegible]~~	~~0.1~~	~~0.05~~	~~0.22~~	~~0.17~~	~~0.08~~	~~0~~	~~0~~	~~0~~	~~0~~		
22	14	0.5	☐	☐	☐	~~[illegible]~~	~~0.15~~	~~0.1~~	~~0.38~~	~~0.3~~	~~0.12~~	~~0~~	~~0~~	~~0~~	~~0~~		
23	15	1	☑	☐	☐	Oil and Grit separators	0	0	0.6	0.4	0	1	0	0	0		
24	16	1	☐	☐	☑	Greenbelts and backyard swales	0.8	0.5	0.86	0.78	0.64	0	0.5	0.5	0		
25	17	0	☐	☐	☐	~~[illegible]~~	~~0.8~~	~~1~~	~~0.86~~	~~0.78~~	~~0.64~~	~~0~~	~~1~~	~~0~~	~~0~~		
26	18	0	☐	☐	☐	~~[illegible]~~	~~0.8~~	~~1~~	~~0.86~~	~~0.78~~	~~0.64~~	~~0~~	~~1~~	~~0~~	~~0~~		
27	19	1	☐	☐	☐	Infiltration basins	0.8	0.5	0.82	0.76	0.64	0	0.5	0	0		
28	20	1	☐	☐	☐	Wet ponds	0	1	0.75	0.5	0.75	1	0	0	1		
29	21	1	☐	☑	☐	Dry Ponds	0	1	0.5	0.33	0.7	0	0	0	1		
30	22	1	☑	☐	☐	Artificial wetlands	0	0.75	0.4	0.4	0.5	0	0	0	1		
31	23	1	☐	☐	☐	User Defined Feature (ex: Lot level ctls)											
32	24	1	☐	☐	☐	User Defined Feature (ex: Major System)											
33	25	1	☐	☐	☐	User Defined Feature											

Notes:
+) If equipped with appropriate booms.
-) Only if pumps discharge to backyards or onto a grass area
*) Only if system has inlet control devices and storage on street is permitted
) Only if ditches / swales are deep enough to provide adequate storage.
1) Values shown are combined efficiency of removal from infiltration and other processes such as sedimentation.
2) While most devices will remove some oil and grease, only those with specific design features for this have been given values
3) Values for "Major System" and "Social" benefits must be entered by user
4) Values for "User Defined Features" must be entered by user if applied
5) Groundwater recharge values shown in relation to infiltration of 10 mm storms or less, which represents approximately 80% of annual volume
Total performance for measures with infiltration has been adjusted to reflect annual performance due to infiltration.

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The purpose of this table is two fold. It is first used to associate a numeric value to each drainage feature's SWM function potential. Secondly, it is used to select which drainage features will be used to design a conceptual drainage system for comparison purposes.

SWM Function Potential

A numeric value between 0 and 1 and is used to identify the effectiveness of each drainage feature with respect to a given stormwater management function (Ground water recharge, flood control, thermal reduction etc..). 0 is used for non-effectiveness and 1 is used for complete effectiveness. The SWM function potential is used to compute the "System Efficiency" on "TABLE E". Rows 23, 24 and 25 can be used to enter values for user-defined drainage features.

Conceptual Drainage System Design

Columns C, D and E, are used to identify three user-defined drainage system scenarios. Clicking the check boxes corresponding to the drainage features to be included in the design creates a drainage system scenario. The scenario may contain multiple drainage features. The selected drainage features, the SWM function potentials and the SWM objectives as identified on "TABLE CD" will be used to create "TABLE E".

Update Table D

Clicking this button will re-compute the overall score of each drainage feature based on user input from "TABLE A", "TABLE A NOTES", "TABLE B" and "TABLE B NOTES". The overall score from "TABLE C" will be placed in column "B", and the corresponding background color for the drainage feature's compatibility will be updated. This is only necessary, if "Automatically Update Tables" is not checked on the "CONFIG" sheet.

Table E

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Table E: Comparison of conceptual drainage systems - Scenario 1
(working table)

[Make Table E] [Clear Table E] [Costs Table]

Total drainage area (ha):	10	Cost of this system: $2,554,311.51 (from "Cost Comparisons" table)
Total Percentage of Impervious Area:	40.0%	

Description of potential alternative drainage system:

	Selected Drainage Features	Area (ha) serviced by feature (ha)	Drainage System Objectives and Compliance (refer to Table D)										Feature Benefit Index
			Ground water	Erosion control	Suspended solids	Phosphorus removal	Bacteria up-take	Oil and grease	Thermal reduction	Flood control	Major system	Social values	
1	Street curbs	10	0	0	0	0	0	0	0	1	0	0	1
5	Storm sewers with foundation drain connections	10	0	0	0	0	0	0	1	1	0	0	2
11	Deep perforated pipe filtration system	10	0.1	0.5	0.45	0.33	0.08	0	1	1	0	0	3.46
15	Oil and Grit separators	10	0	0	0.6	0.4	0	1	0	0	0	0	2
22	Artificial wetlands	10	0	0.75	0.4	0.4	0.5	0	0	0	0	0	2.05
☑ Use multi-efficiency model	System Efficiency	→	0.10	0.88	0.87	0.76	0.54	1.00	1.00	1.00	0.00	0.00	6.14
	Target Performance (from Table CD)	→	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	
	System Compliance	→	0.10	0.88	0.87	0.76	0.54	1.00	1.00	1.00	0.00	0.00	0.61
	Objectives Priority Weighting (from Table CD)	→	2	3	2	2	1	2	1	2	3	3	
	Weighted Compliance as per SWM Priorities	→	0.20	2.63	1.74	1.52	0.54	2.00	1.00	2.00	0.00	0.00	11.62

Total Feature Benefit Index	6.14	The sum of each Drainage Feature Benefit Index
Average System Compliance	0.61	The average of each objective's System Compliance
Overall Score	11.62	The sum of Weighted Compliance as per SWM Priorities

NOTES: 1) Areas associated to any feature must be less than or equal to the Total Drainage area
2) The System Compliance must be recalculated when the areas associated to Drainage Feature are modified.
To do this, "click" twice on the "Use multi-efficiency model" CheckBox

Table C / Table CD / Table D / Table E (1) / Table E (2) / Table E (3) / Capital and annualized costs / Maintenance Activities / Cost Comparisons / User

This table is used to list the selected drainage features of a conceptual system, as selected from "TABLE D". The components of the conceptualized drainage system are analyzed and a series of comparative indices are computed based on SWM function objectives and potentials.

There are three copies of "TABLE E", one for each scenario as selected by the user on "TABLE D". To automate "TABLE E", click the button at the top right, **[Make Table E].**

The total drainage area and percentage of impervious area are entered in cells "C4" and "C5" respectively. The area is used to compute a pro-weighted value of compliance in columns "D" through "M" (see **[MAKE TABLE E]**). The area and imperviousness are also used to compute the "Cost of System" (see **[COSTS TABLE]**)

Make Table E

Clicking this button fills columns "A" and "B", with the drainage features selected for the scenario in "TABLE D". Rows 10 and 11 of columns "D" through "M", will contain the headings of any SWM Function from "TABLE CD", which was given a text rating other than "N/A", for "Importance to Project".
The remaining rows in columns "D" through "M" will contain the numeric value (0 to 1) of the SWM function potential for the corresponding drainage feature listed in Column "B".

Values in columns "D" through "M" will be pro-weighted based on the ratio of "Area Serviced By Feature" (entered by the user in column "C"), and "Total Drainage Area" (entered by the user in cell "C4").

Feature Benefit Index

This value is reported in column "N" and is calculated as the sum of each pro-weighted value listed in columns "D" through "M". This value can be used to comparatively assess the effectiveness of each drainage feature with respect to all of the system objectives.

System Efficiency

The system efficiency is a comparative measure of the proposed drainage system's effectiveness with respect to each SWM function objective.

*Use Multi-Efficiency Model **not** selected*

This value is the sum of each pro-weighted value reported for the various drainage system objectives.

Use Multi-Efficiency Model selected

This value uses the product summation as follows:

$$N_e = \left[1 - \prod_{i}^{n} (1 - n_e) \right] * 100\%$$

Where: N_e = the overall Efficiency
n_e = individual efficiency of a particular item

System Compliance

This value is a measure of the system efficiency with respect to the user's target performance objectives as specified on "TABLE CD", and reported on row 32.

System Compliance = System Efficiency / Target Performance.

Weighted Compliance as per SWM Priorities

This value is a measure of the system's compliance with respect to the user's objective priorities as specified on "TABLE CD", and reported on row 34.

Weighted Compliance = System Compliance x Objectives Priority Weighting

Total Feature Benefit Index

This is the sum of each individual "Feature Benefit Index". This value can be used for comparing the effectiveness of one proposed system (or scenario) with another.

Average System Compliance

This is the average value of "System Compliance". This value can be used for comparing the effectiveness of one proposed system (or scenario) with another.

Overall Score

This is the sum of each "Weighted Compliance as per SWM Priorities". This value can be used for comparing the effectiveness of one proposed system (or scenario) with another.

Clear Table E

Clicking this button removes all of the data from "TABLE E".

( ) Use Multi-Efficiency Model

Checking this box changes the calculation method for "System Efficiency" (see **System Efficiency**).

Costs Table

Clicking this button invokes a costing sub-routine that approximates the cost of the proposed drainage system by computing the quantities of materials needed to construct the system. The quantities are placed in the appropriate column of the "COST COMPARISONS" table. A present value item cost is computed based on the "Cost Per Unit" and a total present value cost is computed as the sum of each item cost. (See **"Costs Comparisons", "Capital and Annualized Costs" and "Maintenance Activities"**).

The value of "Total Cost (Present Value)" is placed in cell "G4" and labeled, "Cost of this System". This value can be used to compare the cost-benefit of each proposed scenario.

Note: This cost is an approximation only. For a detailed breakdown of how this feature works, see the text for the "COST COMPARISONS" table.

Maintenance Activities

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Table 10.2: Maintenance Activities and Associated Costs

Item	Maintenance Activity			Average Cost per unit	Frequency per year
1	Street Flushing		(both sides)	$0.10 /m	2
2	Street sweeping (only for roads with curbs)		(both sides)	$0.07 /m	5
3	Shoulder and edge treatment		(both sides)	$0.20 /m	2
4	Grass cutting and repairs			$0.30 /m	1
5	Ditch regrading and cleaning		(both sides)	$6.00 /m	0.1
6	Swale regrading, sod and topsoil			/m	
7	Culvert thawing and winter drainage		($500 per 100 units)	$5.00 /ea	1
8a	Catch basin cleaning	installed on street		$5.00 /ea	1
8b		installed off street (w/ pre-treatment)		$5.00 /ea	0.5
9	Oil and grit separator cleaning ($250) + disposal ($250) actual cost depends on the number of units being cleaned out at a given time			$500.00 /ea	1
10a	Outfall maintenance	from conventional C&G system		$500.00 /ea	1
10b		from ditch or grass swale system		$500.00 /ea	0.33
10c		if system retains 25mm rainfall		$500.00 /ea	0.2
11	Wet pond maintenance	grass cutting, litter pickup, weed control, re-planting		$390.00 /1 ha drainage area	1
12	Dry pond maintenance	grass cutting, litter pickup, weed control, re-planting		$330.00 /1 ha drainage area	1
13	Sediment removal from end of pipe facilities including disposal	40 % imperviousness (Annual Loading = 0.925m³/ha)		$323.75 /1 ha	0.05
14	Infiltration basin maintenance	tiling and re-vegitation		$140.00 /1 ha drainage area	0.5
15a	Pervious pipe maintenance	no pre-treatment	flushing	$1.00 /m	0.2
15b			radial washing	$2.00 /m	0.2
15c	Pervious pipe maintenance	with pre-treatment	flushing	$1.00 /m	0.07
15d			radial washing	$2.00 /m	0.07
16	Infiltration trench maintenance (1.5 m deep, control runoff from 25mm runoff @ 40% imp)			$277.50 /1 ha	1
17	Exfiltration wells (assume 3.2 exfiltration wells per hectare for 40% imperviousness)			$3,100.00 /1 ha	1
18	**User Defined Maintenance Activity**				
19	**User Defined Maintenance Activity**				
20	**User Defined Maintenance Activity**				

Notes:
- Conversions from (ha) to (m) are based on the assumption of a typical street ROW of 20 m and 40 m deep lots
- Costs are in 1996 dollars and represent averages of collected information.
- Actual unit costs may vary between municipalities.
- Frequency of maintenance activities should also be adjusted accordingly.

Table C / Table CD / Table D / Table E (1) / Table E (2) / Table E (3) / Capital and annualized costs / Maintenance Activities / Cost Comparisons / User N

This table is used to define the frequency and cost per unit of various maintenance activities. This table is referenced by the "CAPTIAL AND ANNUALIZED COSTS" table to compute a "Total Present Value Cost" for each drainage feature.

Common maintenance activities are listed as Items 1 through 17. Default values for "Average Cost Per Unit" and "Frequency Per Year" have been entered based on, "Evaluation of Roadside Ditches and other Stormwater management Practices" (J.F. Sabourin and Associates Inc., 1997). The user is free to change the values in these columns to better match the costs and practices in their area.

Items 18, 19 and 20 are left blank for three additional user-defined maintenance activities.

Note on Frequency per Year values: If a maintenance activity is performed less than once per year, such as once every 5 years, a value of 1/5 or 0.2 is used as the frequency.

Capital and Annualized Costs

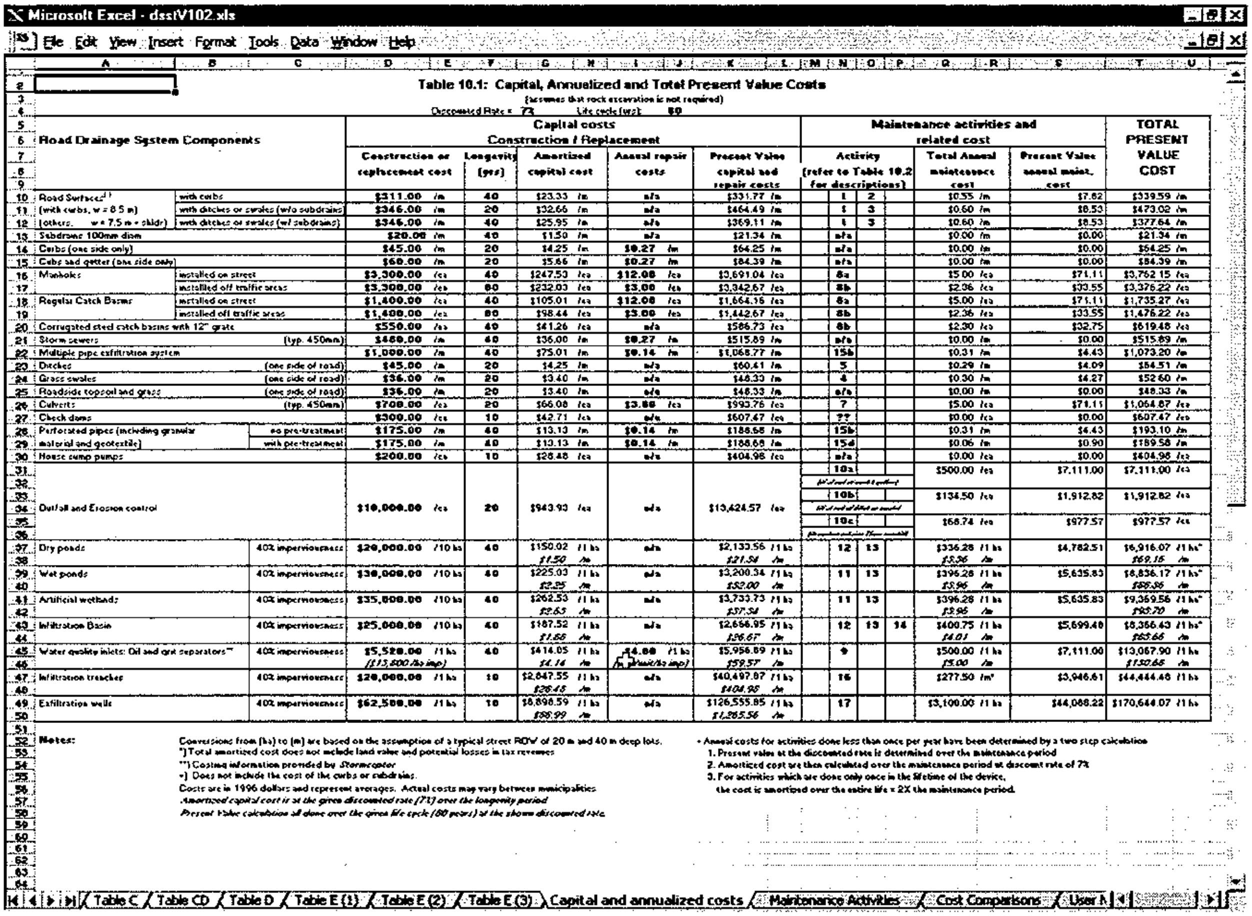

Table 10.1: Capital, Annualized and Total Present Value Costs

(assumes that rock excavation is not required)

Discounted Rate = 7% Life cycle (yrs): 80

Road Drainage System Components		Capital costs Construction / Replacement: Construction or replacement cost	Longevity (yrs)	Amortized capital cost	Annual repair costs	Present Value capital and repair costs	Maintenance activities and related cost: Activity (refer to Table 10.2 for descriptions)	Total Annual maintenance cost	Present Value annual maint. cost	TOTAL PRESENT VALUE COST
Road Surfaces[+]	with curbs	$311.00 /m	40	$23.33 /m	n/a	$331.77 /m	1, 2	$0.55 /m	$7.82	$339.59 /m
(with curbs, w = 8.5 m)	with ditches or swales (w/o subdrains)	$346.00 /m	20	$32.66 /m	n/a	$464.49 /m	1, 3	$0.60 /m	$8.53	$473.02 /m
(others, w = 7.5 m + shldr)	with ditches or swales (w/ subdrains)	$346.00 /m	40	$25.95 /m	n/a	$369.11 /m	1, 3	$0.60 /m	$8.53	$377.64 /m
Subdrains 100mm diam		$20.00 /m	40	$1.50 /m	n/a	$21.34 /m	n/a	$0.00 /m	$0.00	$21.34 /m
Curbs (one side only)		$45.00 /m	20	$4.25 /m	$0.27 /m	$64.25 /m	n/a	$0.00 /m	$0.00	$64.25 /m
Curbs and gutter (one side only)		$60.00 /m	20	$5.66 /m	$0.27 /m	$84.39 /m	n/a	$0.00 /m	$0.00	$84.39 /m
Manholes	installed on street	$3,300.00 /ea	40	$247.53 /ea	$12.08 /ea	$3,691.04 /ea	8a	$5.00 /ea	$71.11	$3,762.15 /ea
	installed off traffic areas	$3,300.00 /ea	80	$232.03 /ea	$3.00 /ea	$3,342.67 /ea	8b	$2.36 /ea	$33.55	$3,376.22 /ea
Regular Catch Basins	installed on street	$1,400.00 /ea	40	$105.01 /ea	$12.08 /ea	$1,664.16 /ea	8a	$5.00 /ea	$71.11	$1,735.27 /ea
	installed off traffic areas	$1,400.00 /ea	80	$98.44 /ea	$3.00 /ea	$1,442.67 /ea	8b	$2.36 /ea	$33.55	$1,476.22 /ea
Corrugated steel catch basins with 12" grate		$550.00 /ea	40	$41.26 /ea	n/a	$586.73 /ea	8b	$2.30 /ea	$32.75	$619.48 /ea
Storm sewers	(typ. 450mm)	$480.00 /m	40	$36.00 /m	$0.27 /m	$515.89 /m	n/a	$0.00 /m	$0.00	$515.89 /m
Multiple pipe exfiltration system		$1,000.00 /m	40	$75.01 /m	$0.14 /m	$1,068.77 /m	15b	$0.31 /m	$4.43	$1,073.20 /m
Ditches	(one side of road)	$45.00 /m	20	$4.25 /m	n/a	$60.41 /m	5	$0.29 /m	$4.09	$64.51 /m
Grass swales	(one side of road)	$36.00 /m	20	$3.40 /m	n/a	$48.33 /m	4	$0.30 /m	$4.27	$52.60 /m
Roadside topsoil and grass	(one side of road)	$36.00 /m	20	$3.40 /m	n/a	$48.33 /m	n/a	$0.00 /m	$0.00	$48.33 /m
Culverts	(typ. 450mm)	$700.00 /ea	20	$66.08 /ea	$3.00 /ea	$993.76 /ea	7	$5.00 /ea	$71.11	$1,064.87 /ea
Check dams		$300.00 /ea	10	$42.71 /ea	n/a	$607.47 /ea	??	$0.00 /ea	$0.00	$607.47 /ea
Perforated pipes (including granular material and geotextile)	no pre-treatment	$175.00 /m	40	$13.13 /m	$0.14 /m	$186.68 /m	15b	$0.31 /m	$4.43	$193.10 /m
	with pre-treatment	$175.00 /m	40	$13.13 /m	$0.14 /m	$186.68 /m	15d	$0.06 /m	$0.90	$189.58 /m
House sump pumps		$200.00 /ea	10	$28.48 /ea	n/a	$404.98 /ea	n/a	$0.00 /ea	$0.00	$404.98 /ea
Outfall and Erosion control		$10,000.00 /ea	20	$943.93 /ea	n/a	$13,424.57 /ea	10a	$500.00 /ea	$7,111.00	$7,111.00 /ea
							10b	$134.50 /ea	$1,912.82	$1,912.82 /ea
							10c	$68.74 /ea	$977.57	$977.57 /ea
Dry ponds	40% imperviousness	$20,000.00 /10 ha	40	$150.02 /1 ha *$1.50 /m*	n/a	$2,133.56 /1 ha *$21.34 /m*	12, 13	$336.28 /1 ha *$3.36 /m*	$4,782.51	$6,916.07 /1 ha* *$69.16 /m*
Wet ponds	40% imperviousness	$30,000.00 /10 ha	40	$225.03 /1 ha *$2.25 /m*	n/a	$3,200.34 /1 ha *$32.00 /m*	11, 13	$396.28 /1 ha *$3.96 /m*	$5,635.83	$8,836.17 /1 ha* *$88.36 /m*
Artificial wetlands	40% imperviousness	$35,000.00 /10 ha	40	$262.53 /1 ha *$2.63 /m*	n/a	$3,733.73 /1 ha *$37.34 /m*	11, 13	$396.28 /1 ha *$3.96 /m*	$5,635.83	$9,369.56 /1 ha* *$93.70 /m*
Infiltration Basin	40% imperviousness	$25,000.00 /10 ha	40	$187.52 /1 ha *$1.88 /m*	n/a	$2,666.95 /1 ha *$26.67 /m*	12, 13, 14	$400.75 /1 ha *$4.01 /m*	$5,699.48	$8,366.43 /1 ha* *$83.66 /m*
Water quality inlets: Oil and grit separators**	40% imperviousness	$5,520.00 /1 ha *($13,800 /ha imp)*	40	$414.05 /1 ha *$4.14 /m*	$4.00 /1 ha *(/unit/ha imp)*	$5,956.89 /1 ha *$59.57 /m*	9	$500.00 /1 ha *$5.00 /m*	$7,111.00	$13,067.90 /1 ha *$130.68 /m*
Infiltration trenches	40% imperviousness	$20,000.00 /1 ha	10	$2,847.55 /1 ha *$28.48 /m*	n/a	$40,497.87 /1 ha *$404.98 /m*	16	$277.50 /m*	$3,946.61	$44,444.48 /1 ha
Exfiltration wells	40% imperviousness	$62,500.00 /1 ha	10	$8,898.59 /1 ha *$88.99 /m*	n/a	$126,555.85 /1 ha *$1,265.56 /m*	17	$3,100.00 /1 ha	$44,068.22	$170,644.07 /1 ha

Notes:

Conversions from (ha) to (m) are based on the assumption of a typical street ROW of 20 m and 40 m deep lots.
*) Total amortized cost does not include land value and potential losses in tax revenues
**) Costing information provided by *Stormceptor*
+) Does not include the cost of the curbs or subdrains.
Costs are in 1996 dollars and represent averages. Actual costs may vary between municipalities
Amortized capital cost is at the given discounted rate (7%) over the longevity period
Present Value calculation all done over the given life cycle (80 years) at the shown discounted rate.

• Annual costs for activities done less than once per year have been determined by a two step calculation
1. Present value at the discounted rate is determined over the maintenance period
2. Amortized cost are then calculated over the maintenance period at discount rate of 7%
3. For activities which are done only once in the lifetime of the device, the cost is amortized over the entire life = 2X the maintenance period.

This table is used to compute a "Total Present Value Cost" for each road drainage system component. This cost is then transferred to the "COST COMPARISONS" table, for costing comparisons of various drainage system scenarios. The "Total Present Value Cost", takes into account, the construction and replacement cost, the longevity of the component, the annual repair cost, and the total maintenance cost. Present value computations are made using a specified Discounted Rate and Lifecycle (these values are entered on the "CONFIG" sheet).

Default values are provided for each field based on "Evaluation of Roadside Ditches and other Stormwater management Practices" (J.F. Sabourin and Associates Inc., 1997); however, any value that appears in blue, bolded text can be changed by the user.

Note: This table uses the Excel functions, **PV** and **PMT**, for "Present Value" and "Payment" calculations.

Construction or replacement cost

The cost per unit to construct or replace the drainage system component.

Longevity

The number of years the drainage system component is expected to last before being replaced.

Amortized Capital Cost

The construction or replacement cost of the drainage system component amortized over the longevity at the user specified discounted rate.

*Amortized Capital Cost = - **PMT(Discounted Rate, Longevity, Construction or replacement cost)***

Annual Repair Costs
The value in dollars per unit expected for annual repairs to the drainage system component.

Present Value capital and repair costs
The present value of amortized capital costs plus annual repair costs for the drainage system component.

*Present Value capital and repair costs = - **PV**(Discounted Rate, Lifecycle, Amortized Capital Cost +Annual Repair Costs)*

Activity
The maintenance activities associated with the drainage system component. Four columns, "M", "N", "O" and "P" can be used to identify four different maintenance activities from the "MAINTENANCE ACTIVITIES" table.

Total Annual Maintenance Cost
For Each Maintenance Activity Identified in columns "M", "N", "O" and "P", an individual maintenance cost must first be calculated.

Frequency = Maintenance Frequency from "MAINTENANCE ACTIVITIES" sheet.
Avg. Maint. Cost = Average cost per unit from "MAINTENANCE ACTIVITIES" sheet.

If Frequency >= once per year then
Maintenance Cost = Avg. Maintenance Cost x Frequency

Otherwise,
*Present Value = - **PV** (Discounted Rate, Integer value of (1 / Frequency), 0, Avg. Maint. cost)*
*Maint. Cost = -**PMT** (Discounted Rate, (Longevity / (Longevity x Frequency - 1)), Present Value)*

Total Annual Maintenance Cost = sum of the Maintenance Costs for each activity identified in columns "M", "N", "O" and "P".

Present Value Annual Maintenance Cost
The present value of the annual maintenance costs taking into account the Discounted Rate and the Lifecylce.

*Present Value annual maint. cost = -**PV**(Discounted Rate, Lifecycle, Total Annual Maintenance Cost)*

Total Present Value Cost
The total present value cost of the item taking into account the capital costs, repair costs and maintenance costs.

Total Present Value Cost = Present Value Capital and Repair Costs + Present Value Annual Maint. Cost.

Cost Comparisons

Microsoft Excel - dsstV102.xls

Cost Comparison Table

System Components		Cost Per Unit		Scenario 1 Required	Units	Item Cost	Scenario 2 Required	Units	Item Cost	Scenario 3 Required	Units	Item Cost	Scenario 4 Required	Units	Item Cost
Road Surfaces[1]	with curbs	$339.59	/m	1000	/m	$339,590.80		/m			/m			/m	
(with curbs, w = 8.5 m)	with ditches or swales (w/o subdrains)	$473.02	/m		/m			/m			/m			/m	
(others, w = 7.5 m + shldr)	with ditches or swales (w/ subdrains)	$377.64	/m		/m		1000	/m	$377,639.22	1000	/m	$377,639.22		/m	
Subdrains 100mm diam		$21.34	/m	2000	/m	$42,671.22	2000	/m	$42,671.22	2000	/m	$42,671.22		/m	
Street Curbs (one side only)		$64.25	/m		/m			/m			/m			/m	
Street Curbs and gutter (one side only)		$84.39	/m	2000	/m	$168,774.69		/m			/m			/m	
Manholes	installed on street	$3,762.15	/ea	10	/ea	$37,621.49		/ea			/ea			/ea	
	installed off traffic areas	$3,376.22	/ea		/ea			/ea			/ea			/ea	
Regular Catch Basins	installed on street	$1,735.27	/ea	32	/ea	$55,528.53		/ea			/ea			/ea	
	installed off traffic areas	$1,476.22	/ea	-	/ea			/ea			/ea			/ea	
Corrugated steel catch basins with 12" grate		$619.48	/ea		/ea			/ea			/ea			/ea	
Storm sewers	(typ. 450mm)	$515.89	/m	1000	/m	$515,894.52		/m			/m			/m	
Multiple pipe exfiltration system		$1,073.20	/m	1000	/m	$1,073,198.77		/m			/m			/m	
Ditches	(one side of road)	$64.51	/m		/m		2000	/m	$129,010.13		/m			/m	
Grass swales	(one side of road)	$52.60	/m		/m			/m		2000	/m	$105,190.09		/m	
Roadside topsoil and grass	(one side of road)	$48.33	/m	2000	/m	$96,656.68	2000	/m	$96,656.68	2000	/m	$96,656.66		/m	
Culverts	(typ. 450mm)	$1,064.87	/ea		/ea		100	/ea	$106,487.33		/ea			/ea	
Check dams		$607.47	/ea		/ea			/ea			/ea			/ea	
Perforated pipes (including granular	no pre-treatment	$193.10	/m		/m			/m			/m			/m	
material and geotextile)	with pre-treatment	$189.58	/m		/m			/m			/m			/m	
House sump pumps		$404.98	/ea		/ea		100	/ea	$40,497.87	100	/ea	$40,497.87		/ea	
Outfall and Erosion control	Curb and Gutter	$7,111.00	/ea		/ea			/ea			/ea			/ea	
	Ditch and Swale	$1,912.82	/ea		/ea			/ea			/ea			/ea	
	If system retains 25mm runoff	$977.57	/ea		/ea			/ea			/ea			/ea	
Dry ponds	40% imperviousness**	$6,916.07	/1 ha*		/1 ha*		10	/1 ha*	$69,160.73		/1 ha*			/1 ha*	
		$69.16	/m		/m			/m			/m			/m	
Wet ponds	40% imperviousness**	$8,836.17	/1 ha*		/1 ha*			/1 ha*			/1 ha*			/1 ha*	
		$88.36	/m		/m			/m			/m			/m	
Artificial wetlands	40% imperviousness**	$9,369.56	/1 ha*	10	/1 ha*	$93,695.64		/1 ha*			/1 ha*			/1 ha*	
		$93.70	/m		/m			/m			/m			/m	
Infiltration Basin	40% imperviousness**	$8,366.43	/1 ha*		/1 ha*			/1 ha*			/1 ha*			/1 ha*	
		$83.66	/m		/m			/m			/m			/m	
Water quality inlets: Oil and grit separators	40% imperviousness**	$13,067.90	/1 ha	10	/1 ha	$130,678.96		/1 ha			/1 ha			/1 ha	
		$130.68	/m		/m			/m			/m			/m	
Infiltration trenches	40% imperviousness**	$44,444.48	/1 ha		/1 ha			/1 ha			/1 ha			/1 ha	
Exfiltration wells	40% imperviousness**	$170,644.07	/1 ha		/1 ha			/1 ha			/1 ha			/1 ha	
TOTAL COST (Present Value)						**$2,554,311.51**			**$862,123.38**			**$662,655.27**			**$0.00**
DRAINAGE SYSTEM OVERALL SCORE (FROM TABLE E)						**11.62**			**10.20**			**10.45**			**N/A**
COST / OVERALL SCORE						**$219,846.75**			**$83,886.99**			**$63,436.27**			**N/A**

Notes: Total costs are based on "average" of collected information. Actual costs may vary between municipalities
*) Cost does not include land value and potential losses in tax revenues
**) Cost are approximated linearly for imperviousness ratios other than 40%.
All costs are presented as present value of all capital, operation and maintenance activities undertaken over 50 years using a discount rate of 7%

Table C / Table CD / Table D / Table E (1) / Table E (2) / Table E (3) / Capital and annualized costs / Maintenance Activities / Cost Comparisons / User...

This table is used to compare the costs of each drainage system scenario, as built using "TABLE D" and "TABLE E". The "Cost per Unit", for each drainage system component has been transferred from the "CAPITAL AND ANNUALIZED COSTS" table. A total present value cost is computed by multiplying each unit cost by the number of units required per drainage system component, and summing up the values for each scenario.

This table is automatically filled in by clicking [COSTS TABLE] from "TABLE E". Alternatively, you can manually enter in a "Shopping List" of items required for a conceptual drainage system.

A description of the scenario, as entered by the user (Cell "C7" on "TABLE E"), is placed atop each column. If the description is longer than 28 characters, it is truncated followed by "...".

The following procedure is applied to determine the required quantities of the system components, when the [COSTS TABLE] button is clicked from "TABLE E"...

Road Surfaces with curbs

If any of the following drainage features are selected: Street curbs, Roads with one-sided cross slopes, Porous pavement with storage structure, Porous pavement with exfiltration system, Storm sewers with foundation drain connections, Shallow storm sewers with sump pumps, Deep perforated pipe filtration system.

Road Surfaces with curbs = Area (ha) x 100 m of road per hectare

Road Surfaces with swales (Sub-drains are assumed)

If any of the following drainage features are selected: Roadside ditches with culverts, Shallow ditches or swales (no culverts), Shallow perforated pipe exfiltration system.

Road Surfaces with swales = Area (ha) x 100 m of road per hectare

Subdrains

Subdrains are assumed for all Road Surfaces. Subdrains are required for each side of the road.

Subdrains = Length of Road Surfaces (m) x 2 lengths of subdrain per length of road

Street Curbs

If Street curbs are selected as a drainage feature, street curbs are assumed for each side of the road.

Street Curbs = Length of Road Surfaces with curbs (m) x 2 street curbs per road length

If Storm sewers with foundation drains are selected, then street curbs with gutters are then assumed to be included.

Street Curbs with Gutters = Length of Road Surfaces with curbs (m) x 2 curbs and gutters per road length

Manholes installed on street and off traffic areas

If any of the following drainage features are selected: Storm sewers with foundation drain connections, Deep perforated pipe exfiltration system or Deep perforated pipe filtration system, then all of the manholes are installed on the street.

Manholes installed on street = Length of Road Surfaces (m) / 100 m per Man Hole installation
Manholes installed off traffic areas = 0

If a shallow perforated pipe exfiltration system is selected then, half of the manholes are installed on the street and half are installed off the street.

Manholes installed on street = Length of Road Surfaces (m) / 100 m per Man Hole installation / 2
Manholes installed off traffic areas = Length of Road Surfaces (m) / 100 m per Man Hole / 2

Regular Catch Basins installed on street or off traffic areas

If any of the following drainage features are selected: Storm sewers with foundation drain connections, Shallow storm sewers with sump pumps, Deep perforated pipe exfiltration system, Deep perforated pipe filtration system. If Street curbs have been selected, the catch basins are installed on street, otherwise they are installed off traffic areas.

Regular Catch Basins = Area (ha) x 3.2 Catch Basins per hectare

If Roads with one-sided cross slopes have been selected, only have the number of catch basins are required.

Regular Catch Basins = Area (ha) x 3.2 Catch Basins per hectare / 2

Corrugated steel catch basins

If shallow perforated pipe exfiltration system is selected, one corrugated steel catch basin is installed per lot.

Corrugated steel catch basins = Area (ha) x 10 Lots per hectare x 1 CB per lot

Storm sewers
If Storm sewers with foundation drain connections are selected.

Storm sewers = Length of Road Surfaces (m)

Multiple pipe exfiltration system
If Deep perforated pipe exfiltration system or Deep perforated pipe filtration system are selected.

Multiple pipe exfiltration system = Length of Road Surfaces (m)

Ditches
If Roadside ditches with culverts are selected.

Ditches = Length of Road Surfaces (m) x 2 ditches per length of road

Grass Swales
If Shallow ditches or swales (no culverts) or Shallow perforated pipe exfiltration system are selected.

Grass Swales = Length of Road Surfaces (m) x 2 swales per length of road

If Greenbelts and backyard swales are selected, an additional length of swale is required equivalent to the lot frontage (which is approximated as the length of road surfaces).

Additional Length of Swale for Greenbelts/backyard swales = Length of Road Surfaces (m)

Roadside topsoil and grass
This is generally required for all drainage systems, except for roadside ditches with culverts. For the latter system, it is assumed that the existing roadside topsoil and grass will be used.

Roadside topsoil and grass = Length of Road Surfaces (m) x 2 sides of road

Culverts
Culverts are required for Roadside ditches with culverts. One culvert per lot is assumed.

Culverts = Area (ha) x 10 Lots per hectare x 1 Culvert per lot

Check Dams
If Check dams are selected, one check dam per lot is assumed.

Check dams = Area (ha) x 10 Lots per hectare x 1 Check dam per lot

Perforated Pipes (including granular material and geotextile (with or without pre-treatment)
If Shallow perforated pipe exfiltration system is selected then perforated pipes are required.

If Oil and grit separators or grass swales are selected:

Perforated Pipes with pretreatment = Length of Road Surfaces (m) x 2 pipes per road length

Otherwise:

Perforated Pipes without pretreatment = Length of Road Surfaces (m) x 2 pipes per road length

House sump pumps

If any of: Shallow storm sewers with sump pumps, Roadside ditches with culverts, Shallow ditches or swales (no culverts) or Shallow perforated pipe exfiltration system are selected, one sump pump per lot is required.

House sump pumps = Area (ha) x 10 Lots per hectare x 1 Sump pump per lot

Dry Ponds, Wet Ponds, Artificial Wetlands, Infiltration Basins, Oil and Grit Separators and Exfiltration Wells

If any of the following: Dry Ponds, Wet Ponds, Artificial Wetlands, Infiltration Basins, Oil and Grit Separators and Exfiltration Wells are selected, a calculation is made to determine an equivalent contributing area at 40% imperviousness to the respective facility. This calculation is necessary as the unit costing is done based on an assumed imperviousness of 40%.

Equivalent Area @ 40% Imperviousness = Contributing area to the facility (ha) x Imperviousness (As given in "TABLE E") / Costing Imperviousness (40 %).

Infiltration Trenches

If Porous pavement with storage structure, Porous pavement with exfiltration system or Horizontal infiltration trenches are selected, then an equivalent contributing area at 40% imperviousness is required. (The same reasoning and procedure is followed as above).

Equivalent Area @ 40% Imperviousness = Contributing area to the facility (ha) x Imperviousness (As given on "TABLE E") / Costing Imperviousness (40 %).

ANNEX A

Sample Print-outs from Drainage System Selection Tool

Annex A: Sample Print-outs from Drainage System Selection Tool

For demonstration purposes, a fictitious example was created. The site and development characteristics are as follows:

Site Characteristics

- Sub-surface infiltration rate = 2 mm/hr.
- The site is located in Ottawa (climate is vulnerable to cold and snowy winters).

Notes

- The surface infiltration rate is 70 mm/hr (this will be used to override caution note 7 on Table A Notes).
- The ground surface can freeze for extended periods of time (therefore caution note 8 cannot be overridden).
- Pollutant removal is not necessary during the winter season (this will override caution note 9).

Development Characteristics

- Land use will be residential.
- There are some trees are within the ROW (Right of Way).
- Franchise utilities (cablevision, phone and gas) are located below ground.
- Lot entrances are spaced less than 5 m.

Notes

- Caution will be taken to prevent damage to tree roots (this will override caution 7 on Table B Notes).
- Utilities will be placed in a safe location outside of any underground infiltration structures (overrides note 8).

Stormwater Management Objectives

The target performance will be 100% for all functions, except groundwater recharge will be 80%. The following functions are considered to be high priority: Erosion control and social values. The following functions are considered to be of medium priority: Groundwater recharge, Suspended solids removal, Phosphorus removal, Oil and grease removal and on-site flood control. Thermal reduction and bacteria uptake are of low importance.

Social Values

Social values will vary from community to community. A survey done in the fictitious community where this new drainage system is to be installed has revealed the values and opinions with respect to some drainage system features. The results are shown in column "Q" of "Table D".

Design Concepts

Three designs are to be considered:

1. Conventional curb and gutter system with storm sewers and additional SWM controls such as: deep perforated pipe filtration system, oil and grease separators, and artificial wetlands.
2. Typical roadside ditch system with a dry pond.
3. Shallow ditches, swales and greenbelts/backyard swales.

Drainage System Selection Tool	Version 1.0.2

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Drainage System Selction Tool
Example Output
- Fictitious Scenario for Example Purposes Only -
Prepared by: Phil Barnes, J.F. Sabourin and Associates Inc.

Original concept and development:	**J.F. Sabourin***, M.Eng., P.Eng.
Input to revised concept:	**D. Weatherbe****, P.Eng., and **R. Tufgar*****, P.Eng.
Programming:	**P.M. Barnes***, B.A.Sc., EIT

With the support of:

The Toronto Region Conservation Authority, Environment Canada's Great Lakes 2000 Clean Up Fund, Ontario Ministry of the Environment, Ryerson University, Lake Simcoe Region Conservation Authority, Rideau Valley Conservation Authority, City of Ottawa, City of Toronto, and the Town of Richmond Hill.

Input provided by:

Totten Sims Hubicki and Associates and Donald G. Weatherbe and Associates.

* J.F. Sabourin and Associates Inc.
** Donald G. Weatherbe Associates
*** Totten Simms Hubicki

User Guide - Drainage System Selection Tool

System Requirements

This tool requires Microsoft Excel, (version 7 or better), for Windows 95/98/NT 4.0.
Minimumum screen resolution: 800 x 600 x 256 colours.
Recommended screen resolution: 1024 x 768 x 256 colours or better.
(To view more of each workbook, adjust the zoom control to 75% or less. View > Zoom...)

Objective

This tool is intended to be a design aid for the selection of Stormwater Management Practices.
It is only an aid and is not intended to replace or be a substitute for engineering judgement.
This software version of the tool is based on the following document:
"Evaluation of Roadside Ditches and Other Related Stormwater Management Practices",
by J.F. Sabourin and Associates Inc., 1997 and updated in 1999.

General Notes

In general, each worksheet is locked to protect the integrity of internal worksheet functions. However, cells that have blue, bolded text can be changed or customized by the user. Global variables located on the "Config" sheet can also be changed by the user. Manipulation of this tool is generally accomplished by selecting check boxes, items from drop down lists and by clicking buttons.

Printing

1 Enter the headers and footers you want to appear on each page, from the config sheet
2 Select the number of copies you want of each sheet
3 Use the check boxes to select the sheets you want printed
4 Click the Batch Printing button

Images

1 Double click the respective icon for the image you want to view
2 You need an application installed that can view a .GIF image (such as a Web browser)
3 This method of viewing images maybe overriden in lieu of an accompanying PDF document in the future

Selection Tool for Drainage Systems (Table A through Table E)

Tables A, B and C are used to eliminate non-compatible drainage system features based on Site and Development characteristics.
Tables CD, D and E are used to set drainage system objectives, identify compatible drainage sytem feautres and compare various systems.

Eliminating Drainage Features

1 Select the visual methods you want to use to eliminate drainage features from the Config sheet

Options include, Lines, Highlighting the background colour of cells (Green = ok, Yellow = maybe, Red = no)

2 From Table A, check the site characteristics that pertain to the area to be drained
3 From Table A notes, check any cautionary notes you want overriden - cautionary notes that are overriden will turn yellow cells green
4 Click Implement Overrides
5 From Table B, check the development characteristics that pertain to the area to be drained
6 From Table B Notes, check any cautionary notes you want overriden, Click Implement Overrides
7 Table C displays the Overall score of the selection exercise, drainage features with a score of 1 are ok, 0.5 & 0.25 = maybe, 0 = no

Adding additional Drainage Features

1 Table A and Table B have room for upto 3 additional user-configured drainage features
2 On Table A and Table B, enter the name of the drainage features (cells D32 - D34)
3 In the corresponding columns, enter a capital X, wherever the feature is not compatible
4 Only a capital X can be used to eliminate features, There is no conditional elimination for user-entered features

Determine Objectives and Compare Drainage Features

1 From Table CD, set the priority for each stormwater management objective: Low, Medium, High or N/A
2 Create a drainage system by checking the selection boxes in columns B, C and D of Table D corresponding to the drainage features to be incorporat
3 From Table E, click, "Make Table E" to create a working table highlighting each components performance relative to your selected objectives
4 Assess the conceptual drainage systems performance by noting the value of "compliance"
5 Upto three scenarios can be analysed per workbook. Alternate drainage systems can be compared by manipulating Table D and making a Table E on sheets: Table E (1), Table E (2) and Table E (3).

Costing Tool for Drainage Systems (Cost Comparison Table)

1 After creating one or more drainage designs with Table E, you can "spec. out" the system to be built by clicking on the "Costs Table" button. A quick analysis of your designed system will be made, and a preliminary cost-estimate will be produced based on default costing estimates.
2 You can fine-tune the cost estimate, by adjusting the number of each item required, length or area to be serviced.
2 The present value cost for each item can be modified, by adjusting tables 10.1 and 10.2 which define the "Capital, Annualized and Total Present Valu and the "Maintenance Activities and Associated Costs".
3 The "Discounted Rate" and "Life Cycle" (used for Present Value calculations), can be adjusted on the "Config" sheet.
4 Tables 10.1 and 10.2 can be adjusted by changing any of the values that appear in blue and are bolded.

Configuration Control Panel - Drainage Features
Table A, Table A Notes, Table B, Table B Notes, Table C, Table D, Table E (1), Table E (2), Table E (3)

- ☑ Use Lines to eliminate Drainage Features
- ☑ Highlight Green Cells (Compatible Features)
- ☑ Highlight Yellow Cells (Potentially Compatible)
- ☑ Highlight Red Cells (Eliminated Features)

Update Tables

Clear Tables

☑ Automatically Update Tables

Table CD - SWM Function Priorities Terms and Corresponding Weightings for Table E

N/A	0
Low	1
Med	2
High	3

Zoom All Sheets

Configuration Control Panel - Financial Portion
Capital and annualized costs, Maintenance Activities, Cost Comparisons

Discounted Rate for Present Value Calculations:	7	%
Lifecycle for Present Value Calculations:	80	Years

Printing Options - Headers and Footers of All Worksheets

Top Left Header 1	**Drainage System Selection Tool**
Top Left Header 2	
Top Right Header 1	**User Guide**
Top Right Header 2	**Example Output**
Bottom Left Footer 1	J.F. Sabourin and Associates Inc.
Bottom Left Footer 2	Water Resources and Environmental Consultants
Bottom Right Footer 1	**Ref.: # 9800220**
Bottom Right Footer 2	**Annex A**
Number of Copies	1

Batch Printing - One Click Printing of All Worksheets

☑ Copyright Notice	☑ Table A	☑ Table CD	☑ Capital and annualized costs
☑ User Guide	☑ Table A Notes	☑ Table D	☑ Maintenance Activities
☑ Config	☑ Table B	☑ Table E (1)	☑ Cost Comparisons
☑ User Notes (1)	☑ Table B Notes	☑ Table E (2)	Select All / Print Selected
☑ User Notes (2)	☑ Table C	☑ Table E (3)	

Table A: Selection of alternative drainage features based on site characteristics

FEATURE	TABLE A	TABLE B	Drainage Features	Site Characteristics: Soils are incompatible with the presence of water	Ground water quality is at risk	Soil Infiltration Rates: Surface inf. < 13 mm/hr	Surface inf. < 60 mm/hr	Sub-surf. inf. < 2.5 mm/hr	Depth of groundwater or bedrock (m): < 1.5	1.5 - 4.0	No source of continuous flow	Depth of drainage outlet (m): < 1.0	1.0 - 2.0	> 2.0	Surface Slopes (%): < 1.0	> 5.0	Climate is vulnerable to cold and snowy winters	Surface soils are highly susceptible to erosion	Drainage area is less than 5.0 ha or space is limited
				☐	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐
1	1	1	Street curbs																
2	0.5	1	~~Roads with one-sided cross slopes~~														O_8		
3	0.5	1	~~Porous pavement with storage structure~~														O_8	X	
4	0	1	~~Porous pavement with exfiltration system~~	X	X			X	X							O_6	O_{14}	X	
5	1	1	Storm sewers with foundation drain connections									X	X						
6	1	1	Shallow storm sewers with sump pumps									X	O_{17}						
7	1	1	Roadside ditches with culverts									O_4	O_3		O_5	O_6	O_7	O_{10}	
8	1	1	Shallow ditches or swales (no culverts)			O_{18}										O_6		O_{10}	
9	0	1	~~Shallow perforated pipe exfiltration system~~	X	X			X	X	O_1		O_{15}	O_{15}			O_6		O_{10}	
10	0	1	~~Deep perforated pipe exfiltration system~~	X	O_{16}			X	X	O_1		O_{15}	O_{15}			O_6		O_{10}	
11	1	1	Deep perforated pipe filtration system						X	O_1		X	X						
12	0.5	1	~~Raised culverts~~	O_{11}	X	X						X	O_4			O_6	O_8	O_{10}	
13	0.5	1	~~Dipped driveways~~	O_{11}	X	X										O_6	O_8		
14	0.5	1	~~Check dams~~	O_{11}	X	X										O_6	O_8	O_{10}	
15	1	1	Oil and Grit separators									X	X						
16	1	1	Greenbelts and backyard swales		O_{12}										O_5	O_6		O_{10}	
17	0	1	~~Horizontal infiltration / exfiltration trenches~~	X	O_{16}			X	X	O_1						O_6		O_{10}	
18	0	1	~~Vertical exfiltration wells and perforated catchbasins~~	X	O_{16}			X	X	X								O_{10}	
19	1	1	Infiltration basins	X	O_{16}	X	X		X	X		X	O_{20}				O_9	O_{10}	X
20	1	1	Wet ponds								O_2	X	O_{20}					O_{10}	X
21	1	1	Dry Ponds		O_{13}							O_{19}	O_{20}					O_{10}	X
22	1	1	Artificial wetlands								O_2						O_9		X
23	1	1	**User Defined Feature (ex: Lot level ctls)**																
24	1	1	**User Defined Feature (ex: Major System)**																
25	1	1	**User Defined Feature**																

Blank - Compatible alternative, gives a score of '1' in Table C

X - Not compatible, gives a score of '0' in Table C

O - May or may not be compatible, gives a score of '0.5' in Table C (see notes for Table A)

The following notes were overriden by the user: 7, 9.

Table A Notes

To be used to further evaluate the compatibility of drainage features with site characteristics.

Note #	Check Caution	Override Caution	Notes for Table A
1		☐	Not recommended when the distance between the bottom of the infiltration structure and the groundwater table (or bedrock) is less than 1.0 m.
2		☐	Not recommended if a minimum permanent pool cannot be maintained.
3		☐	Not recommended for situations where water table is less than depth of ditch or where the infiltration rate of surface soils is less than 13 mm/hr.
4		☐	Not recommended if in order to maintain the proper culvert cover, the level of entrances or driveways have to be raised in such a way as to negatively affect the comfort of driving.
5		☐	Should only be considered if surface infiltration rates are greater than 13 mm/hr in order to prevent nuisance surface ponding.
6		☐	The average surface slope should not be the determining factor but rather the slope of the expected structure. For example, even if the average surface slope is above 5%, roads and ditches may be constructed at a less accentuated cross slope. In the case of ditches and swales, such high slopes may easily create conditions for erosion due to high flow velocities. In the case of raised culverts or check dams these would have to be high and frequent to have any positive influence. In the case of infiltration trenches the use of vertical flow barriers may be required to maximize the use of storage.
7	X	☑	Not recommended if ditch is too shallow (< 0.60 m) and poorly drained (slope < 1% or surface infiltration < 13 mm/hr) or if culverts are too small (< 450 mm). The first condition is prone to culvert heaving and the second to ice or snow clogging.
8	X	☐	Not recommended if located in areas where ground surface can freeze for extended periods.
9	X	☑	Not recommended if pollutant removal effectiveness is also required during the winter season.
10		☐	The presence of highly erodible soils or high contents of suspended solids in surface runoff require that pretreatment measures be used to ensure the longevity of any infiltration technique and/or to minimize maintenance requirements.
11		☐	Not recommended if designed amounts of infiltrated runoff exceeds natural conditions.
12		☐	Not recommended if contaminated runoff is expected. Only use in backyards.
13		☐	Not recommended unless bottom of facility is impermeable.
14		☐	Not recommended unless roadbase is free draining and not affected by frost.
15		☐	Not recommended if system is to be connected to an outlet which is shallower than the perforated pipe system.
16		☐	Not recommended unless sufficient pre-treatment can be provided (eg. with oil and grit separators).
17		☐	Not recommended unless sufficient depth cover can be provided for frost protection.
18		☐	Not recommended unless used jointly with another feature that allows proper drainage.
19		☐	Not recommended unless used for major system storage only.
20		☐	May not be feasible is used jointly with conventional storm sewers with foundation drain connections.

Table B: Selection of alternative drainage features based on development characteristics

FEATURE	TABLE A	TABLE B	Drainage Features	Development characteristics: Type of landuse: Residential	Commercial	Industrial	ROW planning: [ROW width] - [Road surface Width] - [Sidewalk Width] (m) < 2.5	2.5 - 5.0	Sidewalks next to road	Trees within ROW	Below ground franchise utilities	Lot Planning: Spacing between entrances < 5.0 m	Imperviousness > 75%	Back to front drainage	Reverse slope driveways
				☑	☐	☐	☐	☐	☐	☑	☑	☐	☐	☐	☐
1	1	1	Street curbs												
2	0.5	1	Roads with one-sided cross slopes		X	X									
3	0.5	1	Porous pavement with storage structure			X									
4	0	1	Porous pavement with exfiltration system		O_1	X					O_8				
5	1	1	Storm sewers with foundation drain connections												
6	1	1	Shallow storm sewers with sump pumps												X
7	1	1	Roadside ditches with culverts		O_2		X	O_5	O_{11}			X	O_9		X
8	1	1	Shallow ditches or swales (no culverts)				O_5		O_{11}						
9	0	1	Shallow perforated pipe exfiltration system			O_3	O_5		O_{11}	O_7	O_8		O_9		
10	0	1	Deep perforated pipe exfiltration system			O_3									
11	1	1	Deep perforated pipe filtration system												
12	0.5	1	Raised culverts			O_3	X		O_{11}			X	O_9		X
13	0.5	1	Dipped driveways			X			O_{11}						X
14	0.5	1	Check dams			O_3	X		O_{11}			X	O_9		X
15	1	1	Oil and Grit separators												
16	1	1	Greenbelts and backyard swales			O_3			O_6				O_9	O_{10}	
17	0	1	Horizontal infiltration / exfiltration trenches			O_3	O_4		O_6	O_7	O_8		O_9		
18	0	1	Vertical exfiltration wells and perforated catchbasins			O_3				O_7	O_8				
19	1	1	Infiltration basins			O_3									
20	1	1	Wet ponds			O_{12}									
21	1	1	Dry Ponds												
22	1	1	Artificial wetlands			O_{12}									
23	1	1	**User Defined Feature (ex: Lot level ctls)**												
24	1	1	**User Defined Feature (ex: Major System)**												
25	1	1	**User Defined Feature**												

Blank - Compatible alternative, gives a score of '1' in Table C

X - Not compatible, gives a score of '0' in Table C

O - May or may not be compatible, gives a score of '0.5' in Table C (see notes for Table B)

The following notes were overriden by the user: 7, 8.

Table B Notes

To be used to further evaluate the compatibility of drainage features with development characteristics.

Note #	Check Caution	Override Caution	Notes for Table B
1		☐	Not recommended if area includes gas stations or other types of activities where toxic chemicals are transported or stored.
2		☐	May not be aesthetically pleasing in highly developed areas.
3		☐	Any infiltration techniques used within an industrial area should be done with extreme care. Gas stations and storage areas for toxic chemicals should not be considered if such techniques are anticipated. Not recommended for use in roadside ditches or swales with extremely permeable soils.
4		☐	Not recommended if sufficient available space is not available to also include buffer strips or adequate pretreatment.
5		☐	Can only be installed on one side of the street.
6		☐	Difficult to incorporate within ROW. Could only be used as lot level control.
7	X	☑	Not recommended unless special techniques such as the use of copper mesh installed around the infiltration structure in order to prevent damage from tree roots. The appropriate selection of trees or adequate distances between planting and infiltration structures may also reduce this potential problem.
8	X	☑	Not recommended if the presence of underground utilities interferes with the use of underground infiltration structures. Proper planning and discussions with the local utilities may address this problem. However, in the case of a retrofit situation, the use of infiltration techniques within the ROW may be more difficult.
9		☐	Not recommended if the the availability of contiguous open space is very limited.
10		☐	Backyard swales cannot be used.
11		☐	Cannot be used if two sidewalks are constructed. If only one sidewalk is constructed then could be used on side without sidewalk.
12		☐	Not recommended unless it is demonstrated that bioaccumulation of pollutants will not create adverse environmental effects.

Table C: Identification of compatible drainage features
(use to compile results from Tables A and B, optional)

Feature	Drainage system features	Compatibility checks (refer to Tables A and B)		
		(A) Site characteristics	(B) Development characteristics	Overall Score (A) x (B)
1	Street curbs	1	1	1
~~2~~	~~Roads with one-sided cross slopes~~	~~0.5~~	~~1~~	~~0.5~~
~~3~~	~~Porous pavement with storage structure~~	~~0.5~~	~~1~~	~~0.5~~
~~4~~	~~Porous pavement with exfiltration system~~	~~0~~	~~1~~	~~0~~
5	Storm sewers with foundation drain connections	1	1	1
6	Shallow storm sewers with sump pumps	1	1	1
7	Roadside ditches with culverts	1	1	1
8	Shallow ditches or swales (no culverts)	1	1	1
~~9~~	~~Shallow perforated pipe exfiltration system~~	~~0~~	~~1~~	~~0~~
~~10~~	~~Deep perforated pipe exfiltration system~~	~~0~~	~~1~~	~~0~~
11	Deep perforated pipe filtration system	1	1	1
~~12~~	~~Raised culverts~~	~~0.5~~	~~1~~	~~0.5~~
~~13~~	~~Dipped driveways~~	~~0.5~~	~~1~~	~~0.5~~
~~14~~	~~Check dams~~	~~0.5~~	~~1~~	~~0.5~~
15	Oil and Grit separators	1	1	1
16	Greenbelts and backyard swales	1	1	1
~~17~~	~~Horizontal infiltration trenches~~	~~0~~	~~1~~	~~0~~
~~18~~	~~Vertical exfiltration wells and perforated catchbasins~~	~~0~~	~~1~~	~~0~~
19	Infiltration basins	1	1	1
20	Wet ponds	1	1	1
21	Dry Ponds	1	1	1
22	Artificial wetlands	1	1	1
23	**User Defined Feature (ex: Lot level ctls)**	1	1	1
24	**User Defined Feature (ex: Major System)**	1	1	1
25	**User Defined Feature**	1	1	1

Notes on Overall Score values

Score	Suggestion
1	This drainage feature is potentially compatible with both site and development characteristics
0.5	This drainage feature may be compatible, however a cautionary note was generated for Table A or Table B -- See Table A Notes and Table B Notes
0.25	This drainage feature may be compatible, however a cautionary note exists for both Table A and Table B -- See Table A Notes and Table B Notes
0	This drainage feature is potentially not compatible with both site and development characteristics

Table CD: Stormwater Management Objectives

Function	Objective Narrative Target	Target (10) Performance	Importance to Project (11) Text	Importance to Project (11) Weight
Groundwater recharge (1) (Infiltration of runoff from a 10 mm storm)	**Infiltrate or reduce flows**	**100%**	Med	2
Erosion control (Control or infiltration of runoff from a 25 mm strom)	**Rate of runoff control for downstream erosion control**	**100%**	High	3
Suspended solids (2)	**Reduce load**	**100%**	Med	2
Phosphorus removal	**Reduce load**	**100%**	Med	2
Bacteria uptake (3)	**Reduce load**	**100%**	Low	1
Oil and grease (4)	**Control**	**100%**	Med	2
Thermal reduction (5)	**Control**	**100%**	Low	1
Flood control (on-site) (6)	**Minor system performance to design storm**	**100%**	Med	2
Flood control (off-site) (7)	**Rate of runoff control for downstream flood control**	**100%**	N/A	0
Major system (8)	**Major system to be considered in design**	**100%**	High	3
Source Controls (9)	**Source controls to be considered in design**	**100%**	High	3

Notes:
1) Intiltrate or reduce annual flow volumes.
2) Use 50 to 80% depending on use in the receiving water.
3) Reduce numbers in discharge.
4) Percent flow through measure.
5) Percent flow through measure.
6) Always assumed as basis for design of all elements.
7) Control of 25 mm storm assumed to control both erosion flooding. Target is percent control for system.
8) Only if needed to be added at additional cost - set weight as 1.
9) Only if performance and cost know - set weight as 1.
10) Numbers shown are for illustration purposes. The user must set targets for each analysis based on subwatershed uses.
11) Importance and and weights (see Config sheet to modify).

Table D: Comparison of SWM Function Potentials

FEATUR	TABLEC	SCEN. 1	SCEN. 2	SCEN. 3	Drainage Features	SWM Function Potentials: Ground water recharge (5 (Infiltration of runoff from a to 10 mm storm)	Erosion control (Control or infiltration of runoff from a 25 mm storm)	Quality control: Suspended Solids (1	Quality control: Phosphorus Removal (1	Quality control: Bacteria die-off	Quality control: Oil and grease (2	Thermal reduction	Flood control: On-site	Flood control: Off-site	Major System (3	Social Values (3
1	1	☑	☐	☐	Street curbs	0	0	0	0	0	0	0	1	0		1
2	0.5	☐	☐	☐	~~Roads with one-sided cross slopes~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~		
3	0.5	☐	☐	☐	~~Porous pavement with storage structure~~	~~0~~	~~0.5~~	~~0.8~~	~~0.53~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~		
4	0	☐	☐	☐	~~Porous pavement with exfiltration system~~	~~0.95~~	~~1~~	~~0.9~~	~~0.86~~	~~0.76~~	~~0~~	~~1~~	~~0~~	~~0~~		
5	1	☑	☐	☐	Storm sewers with foundation drain connections	0	0	0	0	0	0	1	1	1 (*		
6	1	☐	☐	☐	Shallow storm sewers with sump pumps	0.1 (-	0	0.08	0.08	0.08	0	1	1	1 (*		
7	1	☐	☑	☐	Roadside ditches with culverts	0.4	0.25	0.86	0.68	0.32	0	0.25	1	1 (:		0.5
8	1	☐	☐	☑	Shallow ditches or swales (no culverts)	0.8	0.5	0.93	0.83	0.64	0	0	0	0		1
9	0	☐	☐	☐	~~Shallow perforated pipe exfiltration system~~	~~0.95~~	~~1~~	~~0.95~~	~~0.89~~	~~0.76~~	~~0~~	~~1~~	~~1~~	~~1 (*~~		
10	0	☐	☐	☐	~~Deep perforated pipe exfiltration system~~	~~0.95~~	~~1~~	~~0.81~~	~~0.79~~	~~0.76~~	~~0~~	~~1~~	~~1~~	~~1 (*~~		
11	1	☑	☐	☐	Deep perforated pipe filtration system	0.1	0.5	0.45	0.33	0.08	0	1	1	1 (*		
12	0.5	☐	☐	☐	~~Raised culverts~~	~~0.1~~	~~0.05~~	~~0.36~~	~~0.26~~	~~0.08~~	~~0~~	~~0~~	~~1~~	~~1 (:~~		
13	0.5	☐	☐	☐	~~Dipped driveways~~	~~0.1~~	~~0.05~~	~~0.22~~	~~0.17~~	~~0.08~~	~~0~~	~~0~~	~~0~~	~~0~~		
14	0.5	☐	☐	☐	~~Check dams~~	~~0.15~~	~~0.1~~	~~0.38~~	~~0.3~~	~~0.12~~	~~0~~	~~0~~	~~0~~	~~0~~		
15	1	☑	☐	☐	Oil and Grit separators	0	0	0.6	0.4	0	1	0	0	0		0.5
16	1	☐	☐	☑	Greenbelts and backyard swales	0.8	0.5	0.86	0.78	0.64	0	0.5	0.5	0		0.5
17	0	☐	☐	☐	~~Horizontal infiltration trenches~~	~~0.8~~	~~1~~	~~0.86~~	~~0.76~~	~~0.64~~	~~0~~	~~1~~	~~0~~	~~0~~		
18	0	☐	☐	☐	~~Vertical exfiltration wells and perforated catchbasins~~	~~0.8~~	~~1~~	~~0.86~~	~~0.76~~	~~0.64~~	~~0~~	~~1~~	~~0~~	~~0~~		
19	1	☐	☐	☐	Infiltration basins	0.8	0.5	0.82	0.76	0.64	0	0.5	0	0		
20	1	☐	☐	☐	Wet ponds	0	1	0.75	0.5	0.75	1 (+	0	0	1		1
21	1	☐	☑	☐	Dry Ponds	0	1	0.5	0.33	0.7	0	0	0	1		1
22	1	☑	☐	☐	Artificial wetlands	0	0.75	0.4	0.4	0.5	0	0	0	1		1
23	1	☐	☐	☐	**User Defined Feature (ex: Lot level ctls)**											
24	1	☐	☐	☐	**User Defined Feature (ex: Major System)**											
25	1	☐	☐	☐	**User Defined Feature**											

Notes: +) If equipped with appropriate booms.

-) Only if pumps discharge to backyards or onto a grass area.

*) Only if system has inlet control devices and storage on street is permitted.

:) Only if ditches / swales are deep enough to provide adequate storage.

1) Values shown are combined efficiency of removal from infiltration and other processes such as sedimentation.

2) While most devices will remove some oil and grease, only those with specific design features for this have been given values.

3) Values for "Major System" and "Social" benefits must be entered by user.

4) Values for "User Defined Features" must be entered by user if applied.

5) Groundwater recharge values shown in relation to infiltration of 10 mm storms or less, which represents approximately 80% of annual volume. Total performance for measures with infiltration has been adjusted to reflect annual performance due to infiltration.

Table E: Comparison of conceptual drainage systems - Scenario 1
(working table)

Total drainage area (ha): **10**
Total Percentage of Impervious Area: **40.0%**

Cost of this system: $2,554,311.51 (from "Cost Comparisons" table)

NOTE: To clear the Costs Table, first
clear Table E and Click on Costs Table

Description of potential alternative drainage system:

	Selected Drainage Features	Area (1 serviced by feature (ha)	Drainage System Objectives and Compliance (refer to Table D) Ground water	Erosion control	Suspended solids	Phosphorus removal	Bacteria up-take	Oil and grease	Thermal reduction	Flood control	Major system	Social values	Feature Benefit Index
1	Street curbs	**10**	0	0	0	0	0	0	0	1	0	1	2
5	Storm sewers with foundation drain connections	**10**	0	0	0	0	0	0	1	1	0	0	2
11	Deep perforated pipe filtration system	**10**	0.1	0.5	0.45	0.33	0.08	0	1	1	0	0	3.46
15	Oil and Grit separators	**10**	0	0	0.6	0.4	0	1	0	0	0	0.5	2.5
22	Artificial wetlands	**10**	0	0.75	0.4	0.4	0.5	0	0	0	0	1	3.05
	☑ Use multi-efficiency model **System Efficiency**	→	**0.10**	**0.88**	**0.87**	**0.76**	**0.54**	**1.00**	**1.00**	**1.00**	**0.00**	**1.00**	**7.14**
	Target Performance (from Table CD)	→	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	
	System Compliance	→	**0.10**	**0.88**	**0.87**	**0.76**	**0.54**	**1.00**	**1.00**	**1.00**	**0.00**	**1.00**	**0.71**
	Objectives Priority Weighting (from Table CD)	→	**2**	**3**	**2**	**2**	**1**	**2**	**1**	**2**	**3**	**3**	
	Weighted Compliance as per SWM Priorities	→	**0.20**	**2.63**	**1.74**	**1.52**	**0.54**	**2.00**	**1.00**	**2.00**	**0.00**	**3.00**	**14.62**

Total Feature Benefit Index	**7.14**	The sum of each Drainage Feature Benefit Index
Average System Compliance	**0.71**	The average of each objective's System Compliance
Overall Score	**14.62**	The sum of Weighted Compliance as per SWM Priorities

NOTES: 1) Areas associated to any feature must be less than or equal to the Total Drainage area.
2) The System Compliance must be recalculated when the areas associated to Drainage Feature are modified.
To do this, "click" twice on the "Use multi-efficiency model" CheckBox next.

Table E: Comparison of conceptual drainage systems - Scenario 2
(working table)

Total drainage area (ha):	**10**	Cost of this system:	$862,123.38 (from "Cost Comparisons" table)
Total Percentage of Impervious Area:	**40.0%**		

NOTE: To clear the Costs Table, first clear Table E and Click on Costs Table

Description of potential alternative drainage system: ____________________

	Selected Drainage Features	Area serviced by feature (ha)	Drainage System Objectives and Compliance (refer to Table D)										Feature Benefit Index
			Ground water	Erosion control	Suspended solids	Phosphorus removal	Bacteria up-take	Oil and grease	Thermal reduction	Flood control	Major system	Social values	
7	Roadside ditches with culverts	**10**	0.4	0.25	0.86	0.68	0.32	0	0.25	1	0	0.5	4.26
21	Dry Ponds	**10**	0	1	0.5	0.33	0.7	0	0	0	0	1	3.53
☑ Use multi-efficiency model	**System Efficiency**	→	**0.40**	**1.00**	**0.93**	**0.79**	**0.80**	**0.00**	**0.25**	**1.00**	**0.00**	**1.00**	**6.16**
	Target Performance (from Table CD)	→	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	
	System Compliance	→	**0.40**	**1.00**	**0.93**	**0.79**	**0.80**	**0.00**	**0.25**	**1.00**	**0.00**	**1.00**	**0.62**
	Objectives Priority Weighting (from Table CD)	→	**2**	**3**	**2**	**2**	**1**	**2**	**1**	**2**	**3**	**3**	
	Weighted Compliance as per SWM Priorities	→	**0.80**	**3.00**	**1.86**	**1.57**	**0.80**	**0.00**	**0.25**	**2.00**	**0.00**	**3.00**	**13.28**

Total Feature Benefit Index	**6.16**	The sum of each Drainage Feature Benefit Index
Average System Compliance	**0.62**	The average of each objective's System Compliance
Overall Score	**13.28**	The sum of Weighted Compliance as per SWM Priorities

NOTES: 1) Areas associated to any feature must be less than or equal to the Total Drainage area.
2) The System Compliance must be recalculated when the areas associated to Drainage Feature are modified.
To do this, "click" twice on the "Use multi-efficiency model" CheckBox next.

Table E: Comparison of conceptual drainage systems - Scenario 3
(working table)

Total drainage area (ha): **10**
Total Percentage of Impervious Area: **40.0%**

Cost of this system $662,655.27 (from "Cost Comparisons" table)

Description of potential alternative drainage system:

NOTE: To clear the Costs Table, first
clear Table E and Click on Costs Table

	Selected Drainage Features	Area serviced by feature (ha)	Ground water	Erosion control	Suspended solids	Phosphorus removal	Bacteria up-take	Oil and grease	Thermal reduction	Flood control	Major system	Social values	Feature Benefit Index
			Drainage System Objectives and Compliance (refer to Table D)										
8	Shallow ditches or swales (no culverts)	10	0.8	0.5	0.93	0.83	0.64	0	0	0	0	1	4.7
16	Greenbelts and backyard swales	10	0.8	0.5	0.86	0.78	0.64	0	0.5	0.5	0	0.5	5.08
☑ Use multi-efficiency model	**System Efficiency**	⟶	**0.96**	**0.75**	**0.99**	**0.96**	**0.87**	**0.00**	**0.50**	**0.50**	**0.00**	**1.00**	**6.53**
	Target Performance (from Table CD)	⟶	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	
	System Compliance	⟶	**0.96**	**0.75**	**0.99**	**0.96**	**0.87**	**0.00**	**0.50**	**0.50**	**0.00**	**1.00**	**0.65**
	Objectives Priority Weighting (from Table CD)	⟶	**2**	**3**	**2**	**2**	**1**	**2**	**1**	**2**	**3**	**3**	
	Weighted Compliance as per SWM Priorities	⟶	**1.92**	**2.25**	**1.98**	**1.93**	**0.87**	**0.00**	**0.50**	**1.00**	**0.00**	**3.00**	**13.45**

Total Feature Benefit Index	**6.53**	The sum of each Drainage Feature Benefit Index
Average System Compliance	**0.65**	The average of each objective's System Compliance
Overall Score	**13.45**	The sum of Weighted Compliance as per SWM Priorities

NOTES: 1) Areas associated to any feature must be less than or equal to the Total Drainage area.
2) The System Compliance must be recalculated when the areas associated to Drainage Feature are modified.
To do this, "click" twice on the "Use multi-efficiency model" CheckBox next.

Table 10.1: Capital, Annualized and Total Present Value Costs

(assumes that rock excavation is not required)

Discounted Rate = 7%   Life cycle (yrs): 80

Road Drainage System Components		Capital costs Construction / Replacement: Construction or replacement cost	Longevity (yrs)	Amortized capital cost	Annual repair costs	Present Value capital and repair costs	Maintenance activities and related cost: Activity (refer to Table 10.2 for descriptions)			Total Annual maintenance cost	Present Value annual maint. cost	TOTAL PRESENT VALUE COST
Road Surfaces[+] (with curbs, w = 8.5 m) (others, w = 7.5 m + shldr)	with curbs	$311.00 /m	40	$23.33 /m	n/a	$331.77 /m	1	2		$0.55 /m	$7.82	$339.59 /m
	with ditches or swales (w/o subdrains)	$346.00 /m	20	$32.66 /m	n/a	$464.49 /m	1	3		$0.60 /m	$8.53	$473.02 /m
	with ditches or swales (w/ subdrains)	$346.00 /m	40	$25.95 /m	n/a	$369.11 /m	1	3		$0.60 /m	$8.53	$377.64 /m
Subdrains 100mm diam		$20.00 /m	40	$1.50 /m	n/a	$21.34 /m	n/a			$0.00 /m	$0.00	$21.34 /m
Curbs (one side only)		$45.00 /m	20	$4.25 /m	$0.27 /m	$64.25 /m	n/a			$0.00 /m	$0.00	$64.25 /m
Cubs and gutter (one side only)		$60.00 /m	20	$5.66 /m	$0.27 /m	$84.39 /m	n/a			$0.00 /m	$0.00	$84.39 /m
Manholes	installed on street	$3,300.00 /ea	40	$247.53 /ea	$12.00 /ea	$3,691.04 /ea	8a			$5.00 /ea	$71.11	$3,762.15 /ea
	installled off traffic areas	$3,300.00 /ea	80	$232.03 /ea	$3.00 /ea	$3,342.67 /ea	8b			$2.36 /ea	$33.55	$3,376.22 /ea
Regular Catch Basins	installed on street	$1,400.00 /ea	40	$105.01 /ea	$12.00 /ea	$1,664.16 /ea	8a			$5.00 /ea	$71.11	$1,735.27 /ea
	installed off traffic areas	$1,400.00 /ea	80	$98.44 /ea	$3.00 /ea	$1,442.67 /ea	8b			$2.36 /ea	$33.55	$1,476.22 /ea
Corrugated steel catch basins with 12" grate		$550.00 /ea	40	$41.26 /ea	n/a	$586.73 /ea	8b			$2.30 /ea	$32.75	$619.48 /ea
Storm sewers	(typ. 450mm)	$480.00 /m	40	$36.00 /m	$0.27 /m	$515.89 /m	n/a			$0.00 /m	$0.00	$515.89 /m
Multiple pipe exfiltration system		$1,000.00 /m	40	$75.01 /m	$0.14 /m	$1,068.77 /m	15b			$0.31 /m	$4.43	$1,073.20 /m
Ditches	(one side of road)	$45.00 /m	20	$4.25 /m	n/a	$60.41 /m	5			$0.29 /m	$4.09	$64.51 /m
Grass swales	(one side of road)	$36.00 /m	20	$3.40 /m	n/a	$48.33 /m	4			$0.30 /m	$4.27	$52.60 /m
Roadside topsoil and grass	(one side of road)	$36.00 /m	20	$3.40 /m	n/a	$48.33 /m	n/a			$0.00 /m	$0.00	$48.33 /m
Culverts	(typ. 450mm)	$700.00 /ea	20	$66.08 /ea	$3.80 /ea	$993.76 /ea	7			$5.00 /ea	$71.11	$1,064.87 /ea
Check dams		$300.00 /ea	10	$42.71 /ea	n/a	$607.47 /ea	??			$0.00 /ea	$0.00	$607.47 /ea
Perforated pipes (including granular material and geotextile)	no pre-treatment	$175.00 /m	40	$13.13 /m	$0.14 /m	$188.68 /m	15b			$0.31 /m	$4.43	$193.10 /m
	with pre-treatment	$175.00 /m	40	$13.13 /m	$0.14 /m	$188.68 /m	15d			$0.06 /m	$0.90	$189.58 /m
House sump pumps		$200.00 /ea	10	$28.48 /ea	n/a	$404.98 /ea	n/a			$0.00 /ea	$0.00	$404.98 /ea
Outfall and Erosion control		$10,000.00 /ea	20	$943.93 /ea	n/a	$13,424.57 /ea	10a (if at end of curb & gutter)			$500.00 /ea	$7,111.00	$7,111.00 /ea
							10b (if at end of ditch or swale)			$134.50 /ea	$1,912.82	$1,912.82 /ea
							10c (if system retains 25mm runoff)			$68.74 /ea	$977.57	$977.57 /ea
Dry ponds	40% imperviousness	$20,000.00 /10 ha	40	$150.02 /1 ha *$1.50 /m*	n/a	$2,133.56 /1 ha *$21.34 /m*	12	13		$336.28 /1 ha *$3.36 /m*	$4,782.51	$6,916.07 /1 ha* *$69.16 /m*
Wet ponds	40% imperviousness	$30,000.00 /10 ha	40	$225.03 /1 ha *$2.25 /m*	n/a	$3,200.34 /1 ha *$32.00 /m*	11	13		$396.28 /1 ha *$3.96 /m*	$5,635.83	$8,836.17 /1 ha* *$88.36 /m*
Artificial wetlands	40% imperviousness	$35,000.00 /10 ha	40	$262.53 /1 ha *$2.63 /m*	n/a	$3,733.73 /1 ha *$37.34 /m*	11	13		$396.28 /1 ha *$3.96 /m*	$5,635.83	$9,369.56 /1 ha* *$93.70 /m*
Infiltration Basin	40% imperviousness	$25,000.00 /10 ha	40	$187.52 /1 ha *$1.88 /m*	n/a	$2,666.95 /1 ha *$26.67 /m*	12	13	14	$400.75 /1 ha *$4.01 /m*	$5,699.48	$8,366.43 /1 ha* *$83.66 /m*
Water quality inlets: Oil and grit separators**	40% imperviousness	$5,520.00 /1 ha *($13,800 /ha imp)*	40	$414.05 /1 ha *$4.14 /m*	$4.80 /1 ha *($12/unit/ha imp)*	$5,956.89 /1 ha *$59.57 /m*	9			$500.00 /1 ha *$5.00 /m*	$7,111.00	$13,067.90 /1 ha *$130.68 /m*
Infiltration trenches	40% imperviousness	$20,000.00 /1 ha	10	$2,847.55 /1 ha *$28.48 /m*	n/a	$40,497.87 /1 ha *$404.98 /m*	16			$277.50 /m³	$3,946.61	$44,444.48 /1 ha
Exfiltration wells	40% imperviousness	$62,500.00 /1 ha	10	$8,898.59 /1 ha *$88.99 /m*	n/a	$126,555.85 /1 ha *$1,265.56 /m*	17			$3,100.00 /1 ha	$44,088.22	$170,644.07 /1 ha

Notes:

Conversions from (ha) to (m) are based on the assumption of a typical street ROW of 20 m and 40 m deep lots.
*) Total amortized cost does not include land value and potential losses in tax revenues
**) Costing information provided by *Stormceptor*
+) Does not include the cost of the curbs or subdrains.
Costs are in 1996 dollars and represent averages. Actual costs may vary between municipalities
Amortized capital cost is at the given discounted rate (7%) over the longevity period

- Annual costs for activities done less than once per year have been determined by a two step calculation
  1. Present value at the discounted rate is determined over the maintenance period
  2. Amortized cost are then calculated over the maintenance period at discount rate of 7%
  3. For activities which are done only once in the lifetime of the device, the cost is amortized over the entire life = 2X the maintenance period.

Table 10.2: Maintenance Activities and Associated Costs

Item	Maintenance Activity				Average Cost per unit	Frequency per year
1	Street Flushing			(both sides)	$0.10 /m	2
2	Street sweeping (only for roads with curbs)			(both sides)	$0.07 /m	5
3	Shoulder and edge treatment			(both sides)	$0.20 /m	2
4	Grass cutting and repairs				$0.30 /m	1
5	Ditch regrading and cleaning			(both sides)	$6.00 /m	0.1
6	Swale regrading, sod and topsoil				/m	
7	Culvert thawing and winter drainage			($500 per 100 units)	$5.00 /ea	1
8a	Catch basin cleaning	installed on street			$5.00 /ea	1
8b		installed off street (w/ pre-treatment)			$5.00 /ea	0.5
9	Oil and grit separator cleaning ($250) + disposal ($250) actual cost depends on the number of units being cleaned out at a given time.				$500.00 /ea	1
10a	Outfall maintenance	from conventional C&G system			$500.00 /ea	1
10b		from ditch or grass swale system			$500.00 /ea	0.33
10c		if system retains 25mm rainfall			$500.00 /ea	0.2
11	Wet pond maintenance	grass cutting, litter pickup, weed control, re-planting			$390.00 /1 ha drainage area	1
12	Dry pond maintenance	grass cutting, litter pickup, weed control, re-planting			$330.00 /1 ha drainage area	1
13	Sediment removal from end of pipe facilities including disposal	40 % imperviousness (Annual Loading = 0.925m³/ha)			$323.75 /1 ha	0.05
14	Infiltration basin maintenance	tiling and re-vegitation			$140.00 /1 ha drainage area	0.5
15a	Pervious pipe maintenance	no pre-treatment	flushing		$1.00 /m	0.2
15b			radial washing		$2.00 /m	0.2
15c	Pervious pipe maintenance	with pre-treatment	flushing		$1.00 /m	0.07
15d			radial washing		$2.00 /m	0.07
16	Infiltration trench maintenance (1.5 m deep, control runoff from 25mm runoff @ 40% imp)				$277.50 /1 ha	1
17	Exfiltration wells (assume 3.2 exfiltration wells per hectare for 40% imperviousness)				$3,100.00 /1 ha	1
18	**User Defined Maintenance Activity**					
19	**User Defined Maintenance Activity**					
20	**User Defined Maintenance Activity**					

Notes:
- Conversions from (ha) to (m) are based on the assumption of a typical street ROW of 20 m and 40 m deep lots.
- Costs are in 1996 dollars and represent averages of collected information.
- Actual unit costs may vary between municipalities.
- Frequency of maintenance activities should also be adjusted accordingly.

Cost Comparison Table

System Components		Cost Per Unit		Scenario 1 Required	Units	Item Cost	Scenario 2 Required	Units	Item Cost	Scenario 3 Required	Units	Item Cost	Scenario 4 Required	Units	Item Cost
Road Surfaces[*]	with curbs	$339.59	/m	1000	/m	$339,590.80		/m			/m			/m	
(with curbs, w = 8.5 m)	with ditches or swales (w/o subdrains)	$473.02	/m		/m			/m			/m			/m	
(others, w = 7.5 m + shldr)	with ditches or swales (w/ subdrains)	$377.64	/m		/m		1000	/m	$377,639.22	1000	/m	$377,639.22		/m	
Subdrains 100mm diam		$21.34	/m	2000	/m	$42,671.22	2000	/m	$42,671.22	2000	/m	$42,671.22		/m	
Street Curbs (one side only)		$64.25	/m		/m			/m			/m			/m	
Street Curbs and gutter (one side only)		$84.39	/m	2000	/m	$168,774.69		/m			/m			/m	
Manholes	installed on street	$3,762.15	/ea	10	/ea	$37,621.49		/ea			/ea			/ea	
	installed off traffic areas	$3,376.22	/ea		/ea			/ea			/ea			/ea	
Regular Catch Basins	installed on street	$1,735.27	/ea	32	/ea	$55,528.53		/ea			/ea			/ea	
	installed off traffic areas	$1,476.22	/ea		/ea			/ea			/ea			/ea	
Corrugated steel catch basins with 12" grate		$619.48	/ea		/ea			/ea			/ea			/ea	
Storm sewers	(typ. 450mm)	$515.89	/m	1000	/m	$515,894.52		/m			/m			/m	
Multiple pipe exfiltration system		$1,073.20	/m	1000	/m	$1,073,198.77		/m			/m			/m	
Ditches	(one side of road)	$64.51	/m		/m		2000	/m	$129,010.13		/m			/m	
Grass swales	(one side of road)	$52.60	/m		/m			/m		2000	/m	$105,190.09		/m	
Roadside topsoil and grass	(one side of road)	$48.33	/m	2000	/m	$96,656.88	2000	/m	$96,656.88	2000	/m	$96,656.88		/m	
Culverts	(typ. 450mm)	$1,064.87	/ea		/ea		100	/ea	$106,487.33		/ea			/ea	
Check dams		$607.47	/ea		/ea			/ea			/ea			/ea	
Perforated pipes (including granular	no pre-treatment	$193.10	/m		/m			/m			/m			/m	
material and geotextile)	with pre-treatment	$189.58	/m		/m			/m			/m			/m	
House sump pumps		$404.98	/ea		/ea		100	/ea	$40,497.87	100	/ea	$40,497.87		/ea	
Outfall and Erosion control	Curb and Gutter	$7,111.00	/ea		/ea			/ea			/ea			/ea	
	Ditch and Swale	$1,912.82	/ea		/ea			/ea			/ea			/ea	
	If system retains 25mm runoff	$977.57	/ea		/ea			/ea			/ea			/ea	
Dry ponds	40% imperviousness**	$6,916.07	/1 ha*		/1 ha*		10	/1 ha*	$69,160.73		/1 ha*			/1 ha*	
		$69.16	/m		/m			/m			/m			/m	
Wet ponds	40% imperviousness**	$8,836.17	/1 ha*		/1 ha*			/1 ha*			/1 ha*			/1 ha*	
		$88.36	/m		/m			/m			/m			/m	
Artificial wetlands	40% imperviousness**	$9,369.56	/1 ha*	10	/1 ha*	$93,695.64		/1 ha*			/1 ha*			/1 ha*	
		$93.70	/m		/m			/m			/m			/m	
Infiltration Basin	40% imperviousness**	$8,366.43	/1 ha*		/1 ha*			/1 ha*			/1 ha*			/1 ha*	
		$83.66	/m		/m			/m			/m			/m	
Water quality inlets: Oil and grit separators	40% imperviousness**	$13,067.90	/1 ha	10	/1 ha	$130,678.96		/1 ha			/1 ha			/1 ha	
		$130.68	/m		/m			/m			/m			/m	
Infiltration trenches	40% imperviousness**	$44,444.48	/1 ha		/1 ha			/1 ha			/1 ha			/1 ha	
Exfiltration wells	40% imperviousness**	$170,644.07	/1 ha		/1 ha			/1 ha			/1 ha			/1 ha	
TOTAL COST (Present Value)						$2,554,311.51			$862,123.38			$662,655.27			$0.00
DRAINAGE SYSTEM OVERALL SCORE (FROM TABLE E)						14.62			13.28			13.45			N/A
COST / OVERALL SCORE						$174,730.24			$64,932.62			$49,282.71			N/A

Notes:

Total costs are based on "average" of collected information. Actual costs may vary between municipalities
*) Cost does not include land value and potential losses in tax revenues
**) Cost are approximated linearly for imperviousness ratios other than 40%.
All costs are presented as present value of all capital, operation and maintenance activities undertaken over 80 years using a discount rate of 7%