LAND & BUILDING EXPERTS
Professional Engineers Ontario
Certificate of Authorization # 100205934
570 Alden Road unit #6 Markham ON L3R 8N5 (647) 340 8649

Proposed medical marijuana production facility.
998266 Mulmur-Tosorontio Townline, Mulmur, ON

Stormwater management brief

PREDEVELOPMENT CONDITION:

Existing Grass area	= 0.7690 ha
Total site area	= 0.7690 ha
Runoff coefficient (C)	= 0.35 (NVCA guideline Table 10.6)

$C_{2yr} = C_{5yr} = C_{10yr} = C = 0.35$
$C_{25yr} = 1.1*C = 1.1*0.35 = 0.39$
$C_{50yr} = 1.2*C = 1.2*0.35 = 0.42$
$C_{100yr} = 1.25*C = 1.25*0.35 = 0.44$

2 year predevelopment flow rate	= 0.002778*0.35*55.34mm/hr*0.7690ha = 0.041 m^3/s
5 year predevelopment flow rate	= 0.002778*0.35*73.0mm/hr*0.7690ha = 0.055 m^3/s
10 year predevelopment flow rate	= 0.002778*0.35*84.6mm/hr*0.7690ha = 0.063 m^3/s
25 year predevelopment flow rate	= 0.002778*0.39*99.4mm/hr*0.7690ha = 0.083 m^3/s
50 year predevelopment flow rate	= 0.002778*0.42*110.4mm/hr*0.7690ha = 0.099 m^3/s
100 year predevelopment flow rate	= 0.002778*0.44*121.23mm/hr*0.7690ha = 0.114 m^3/s

POST-DEVELOPMENT CONDITION:

Controlled area	
Proposed Building area	= 0.1635 ha
Proposed Impermeable area	= 0.0073 ha
Proposed Gravel area	= 0.2302 ha
Proposed/Existing Grass area	= 0.3090 ha

Composite runoff coefficient (NVCA guideline Table 10.5)
= {(0.1635+0.0073)x0.95+0.2302x0.6+0.3090x0.35}/0.710
= **0.58**

$C_{2yr} = C_{5yr} = C_{10yr} = C = 0.58$
$C_{25yr} = 1.1*C = 1.1*0.58 = 0.64$
$C_{50yr} = 1.2*C = 1.2*0.58 = 0.70$
$C_{100yr} = 1.25*C = 1.25*0.58 = 0.72$

Uncontrolled area	
Proposed/Existing Grass area	= 0.059 ha
Runoff coefficient (C)	= 0.35
Total site area	= 0.7690 ha

QUANTITY CONTROL

UNCONTROLLED AREA 100YR PEAK FLOW RATE

2 year post-development flow rate	= 0.002778*0.35*55.34mm/hr*0.059ha = 0.003 m^3/s
5 year post-development flow rate	= 0.002778*0.35*73.0mm/hr*0.059ha = 0.004 m^3/s
10 year post-development flow rate	= 0.002778*0.35*84.6mm/hr*0.059ha = 0.005 m^3/s
25 year post-development flow rate	= 0.002778*0.39*99.4mm/hr*0.059ha = 0.006 m^3/s
50 year post-development flow rate	= 0.002778*0.42*110.4mm/hr*0.059ha = 0.008 m^3/s
100 year post-development flow rate	= 0.002778*0.44*121.23mm/hr*0.059ha = 0.009 m^3/s

CONTROLLED AREA 100YR PEAK FLOW RATE WITH ENHANCED GRASS SWALE

Enhanced grass swale provides 40% runoff reduction.
(LID SWM planning and design guideline, Appendix1)

2 year post-development flow rate	= 0.002778*0.58*55.34mm/hr*0.710ha*0.6 = 0.038 m^3/s
5 year post-development flow rate	= 0.002778*0.58*73.0mm/hr*0.710ha*0.6 = 0.050 m^3/s
10 year post-development flow rate	= 0.002778*0.58*84.6mm/hr*0.710ha*0.6 = 0.058 m^3/s
25 year post-development flow rate	= 0.002778*0.64*99.4mm/hr*0.710ha*0.6 = 0.075 m^3/s
50 year post-development flow rate	= 0.002778*0.70*110.4mm/hr*0.710ha*0.6 = 0.091 m^3/s
100 year post-development flow rate	= 0.002778*0.72*121.23mm/hr*0.710ha*0.6 = 0.103 m^3/s

Total 100 year post-development flow rate = 0.009 m^3/s + 0.103 m^3/s
= 0.112 m^3/s
Allowable (100 year predevelopment flow rate) = 0.114 m^3/s

	2 year	5 year	10 year	25 year	50 year	100 year
Post-development flow rate	0.041 m^3/s	0.054 m^3/s	0.063 m^3/s	0.081 m^3/s	0.099 m^3/s	0.112 m^3/s
Allowable	0.041 m^3/s	0.055 m^3/s	0.063 m^3/s	0.083 m^3/s	0.099 m^3/s	0.114 m^3/s

CONCLUSION AND RECOMMENDATION

The preceding sections and the detailed design analysis appended herewith indicate that the proposed stormwater management system meets with NVCA requirements.

Total 100 year post-development flow rate = 0.112 m^3/s

Allowable (100 year predevelopment flow rate) = 0.114 m^3/s

Existing drainage patterns on adjacent properties shall not be altered and stormwater runoff from the subject development shall not be directed to drain onto adjacent properties.

It is therefore, recommended that this report be adopted for detailed design if the NVCA finds the analysis noted herein, acceptable.

Edgar Labuac, P.Eng
May 20, 2021

APPENDICES

APPENDIX 1

LID SWM PLANNING AND DESIGN GUIDELINE

Table 4.8.2 Volumetric runoff reduction achieved by enhanced grass swales

LID Practice	Location	% Runoff Reduction	Reference
Grass Swale	Virginia	0%	Schueler (1983)
Grass Swale	Various	40%	Strecker *et al.*(2004)
Grass Swale	California	27 to 41%	Barrett *et al.* (2004)
Runoff Reduction Estimate[1]		**20% on HSG A or B soils; 10% on HSG C or D soils**	

Notes:
1. This estimate is provided only for the purpose of initial screening of LID practices suitable for achieving stormwater management objectives and targets. Performance of individual facilities will vary depending on site specific contexts and facility design parameters and should be estimated as part of the design process and submitted with other documentation for review by the approval authority.

Water Quality – Pollutant Removal Capacity

Research has shown the pollutant mass removal rates of grass swales are variable, depending on influent pollutant concentrations (Bäckström *et al.*, 2006), but generally moderate for most pollutants (Barrett *et al.*, 1998; Deletic and Fletcher, 2006). Median pollutant mass removal rates of swales from available performance studies are 76% for total suspended solids, 55% for total phosphorus, and 50% for total nitrogen (Deletic and Fletcher, 2006). Significant reductions in total zinc and copper event mean concentrations have been observed in performance studies with a median value of 60%, but results have varied widely (Barrett, 2008). Site specific factors such as slope, soil type, infiltration rate, swale length and vegetative cover also affect pollutant mass removal rates. In general, the dominant pollutant removal mechanism operating in grass swales is infiltration, rather than filtration, because pollutants trapped on the surface of the swale by vegetation or check dams are not permanently bound (Bäckström *et al.*, 2006). Designers should maximize the degree of infiltration achieved within a grass swale by incorporating check dams and ensuring the native soils have infiltration rates of 15 mm/hr or greater or specifying that the soils be tilled and amended with compost prior to planting.

Several of the factors that can significantly increase or decrease the pollutant removal capacity of grass channels are provided in Table 4.8.3.

Table 4.8.3 Factors that influence the pollutant removal capacity of grass swales

Factors that Reduce Removal Rates	Factors that Enhance Removal Rates
Longitudinal slope > 1%	Longitudinal slope < 1%
Measured soil infiltration rate < 15 mm/hr	Measured soil infiltration rate is 15 mm/hr or greater
Flow velocity within channel > 0.5 m/s during a 4 hour, 25 mm Chicago storm event	Flow velocity within channel is 0.5 m/s or less during a 4 hour, 25 mm Chicago storm event
No pretreatment	Pretreatment with vegetated filter strips, gravel diaphragms and/or sedimentation forebays
Side slopes steeper than 3:1 (H:V)	Side slopes 3:1 (H:V) or less

4.8.2 Design Template

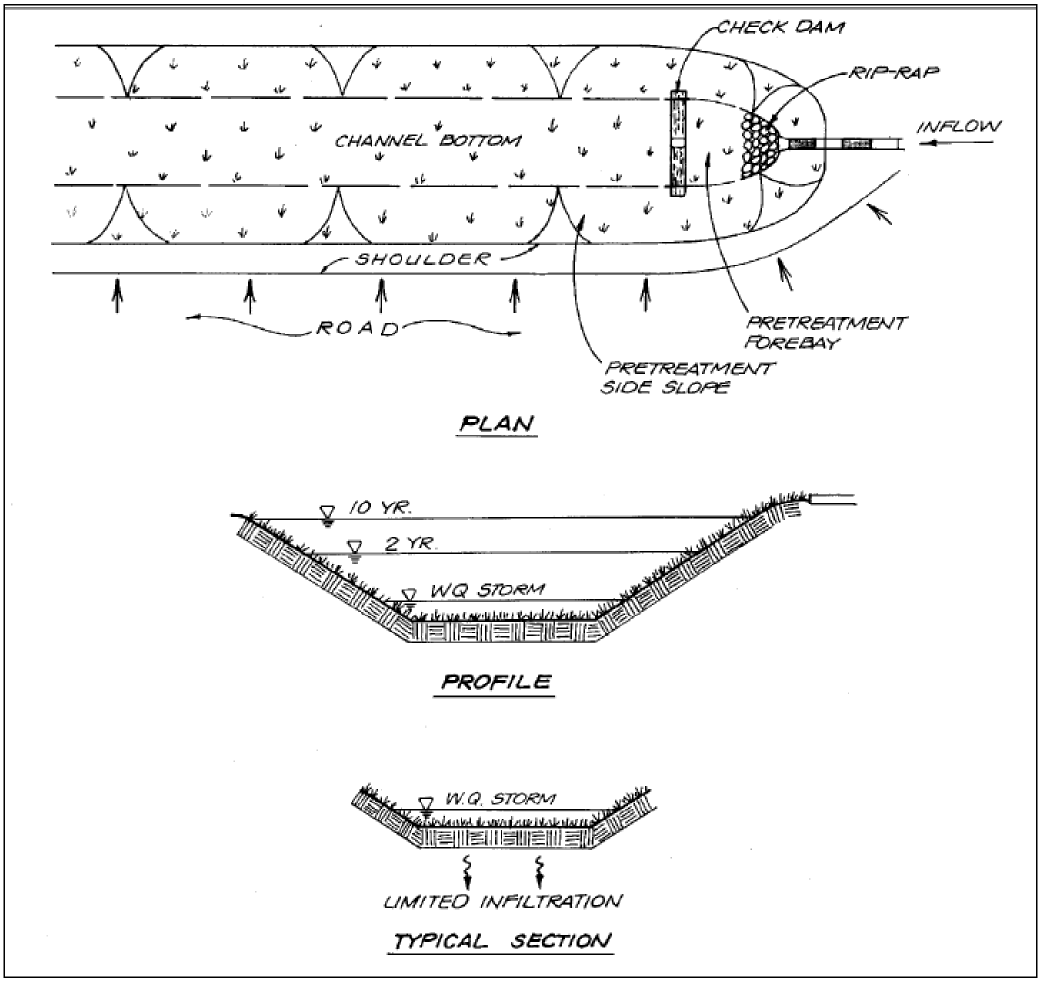
Applications

Enhanced grass swales are well suited for conveying and treating runoff from highways and other roads because they are a linear practice and easily incorporated into road rights-of-way. They are also a suitable practice for managing runoff from parking lots, roofs and pervious surfaces, such as yards, parks and landscaped areas. Grass swales can be used as snow storage areas.

Grass swales can also provide pretreatment for other stormwater best management practices, such as bioretention areas, soakaways and perforated pipe systems or be designed in series with other practices as part of a treatment train approach. They are often impractical in densely developed urban areas because they consume a large amount of space. Where development density and topograph permit, grass swales can be used in place of conventional curb and gutter and storm drain systems.

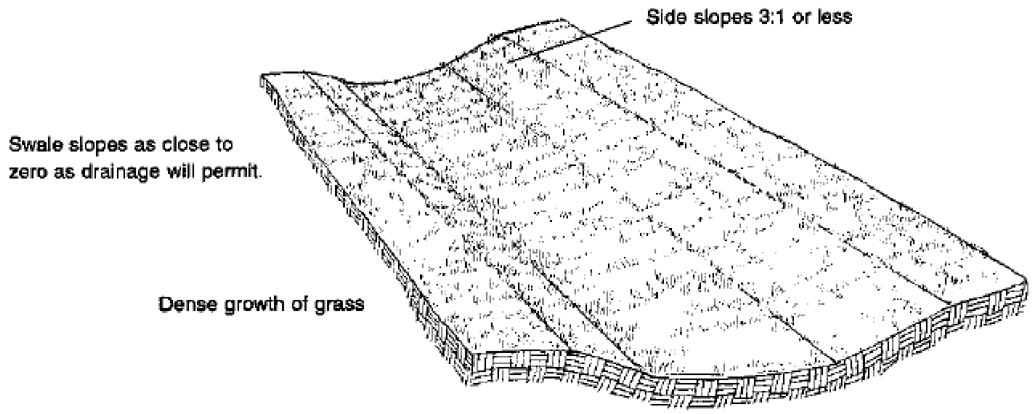
Typical Details

Figure 4.8.3 Plan, profile, and section views of a grass swale



Source: ARC, 2001

Figure 4.8.4 Plan view of a grass swale



Source: ARC, 2001

Design Guidance

Geometry and Site Layout

Design guidance regarding the geometry and layout of grass swales is provided below.

- *Shape:* Grass swales should be designed with a trapezoidal or parabolic cross section. Trapezoidal swales will generally evolve into parabolic swales over time, so the initial trapezoidal cross section design should be checked for capacity and conveyance assuming it is a parabolic cross section. Swale length between culverts should be 5 metres or greater.

- *Bottom Width:* Grass swales should be designed with a bottom width between 0.75 and 3.0 metres. The design width should allow for shallow flows and adequate water quality treatment, while preventing flows from concentrating and creating gullies.

- *Longitudinal Slope:* Slopes should be between 0.5% and 4%. Check dams should be incorporated on slopes greater than 3% (PDEP, 2006).

- *Length*: When used to convey and treat road runoff, the length simply parallels the road, and therefore should be equal to, or greater than the contributing roadway length.

- *Flow Depth:* The maximum flow depth should correspond to two-thirds the height of the vegetation. Vegetation in some grass swales may reach heights of 150 millimetres; therefore a maximum flow depth of 100 millimetres is recommended during a 4 hour, 25 mm Chicago storm event.

- *Side Slopes:* The side slopes should be as flat as possible to aid in providing pretreatment for lateral incoming flows and to maximize the swale filtering surface. Steeper side slopes are likely to have erosion gullying from incoming lateral flows. A maximum slope of 2.5:1 (H:V) is recommended and a 4:1 slope is preferred where space permits.

Pretreatment
A pea gravel diaphragm located along the top of each bank can be used to provide pretreatment of any stormwater runoff that may be entering the swale laterally along its length. Vegetated filter strips or mild side slopes (3:1) also provide pretreatment for any lateral sheet flow entering the swale. Sedimentation forebays at inlets to the swale are also a pretreatment option.

Conveyance and Overflow
Grass swales must be designed for a maximum velocity of 0.5 m/s or less for the 4 hour 25 mm Chicago storm. The swale should also convey the locally required design storm (usually the 10 year storm) at non-erosive velocities.

Soil Amendments
If soils along the location of the swale are highly compacted, or of such low fertility that vegetation cannot become established, they should be tilled to a depth of 300 mm and amended with compost to achieve an organic content of 8 to 15% by weight or 30 to 40% by volume.

Landscaping
Designers should choose grasses that can withstand both wet and dry periods as well as relatively high velocity flows within the swale. For applications along roads and parking lots, where snow will be plowed and stored, non woody and salt tolerant species should be chosen. Taller and denser grasses are preferable, though the species of grass is less important than percent coverage (Barrett *et al.*, 2004). Appendix B provides further guidance regarding suitable species and planting.

Other Design Resources
Section 4.9.8 of the OMOE *Stormwater Management Planning and Design Manual* (2003) provides further guidance regarding design and modelling performance of enhanced grass swales. Several other stormwater manuals that provide useful design guidance for grass swales include:

Minnesota Stormwater Manual
http://www.pca.state.mn.us/water/stormwater/stormwater-manual.html

Virginia Stormwater Management Handbook
http://www.dcr.virginia.gov/soil_&_water/stormwat.shtml

Georgia Stormwater Management Manual
http://www.georgiastormwater.com/

APPENDIX 2

NVCA GUIDELINE
RUNOFF COEEFICIENT
TABLE

10.5 Runoff Coefficients

Table 10.5: Runoff coefficient (Rational C) for urban catchments

Land Use		Runoff Coefficient Min	Max
Pavement	asphalt or concrete brick	0.8 0.7	0.95 0.85
Gravel roads and shoulders		0.4	0.6
Roofs		0.7	0.95
Business*	downtown neighbourhood light heavy	0.7 0.5 0.5 0.6	0.95 0.7 0.8 0.9
Residential*	single family urban multiple, detached multiple, attached suburban	0.3 0.4 0.6 0.25	0.5 0.6 0.75 0.4
Industrial*	light heavy	0.5 0.6	0.8 0.9
Apartments*		0.5	0.7
Parks, cemeteries*		0.1	0.25
Playgrounds (unpaved)*		0.2	0.35
Railroad yards*		0.2	0.35
Unimproved areas*		0.1	0.3
Lawns	sandy soil		
	flat, to 2% average, 2 to 7% steep, over 7%	0.05 0.1 0.15	0.1 0.15 0.2
	clayey soil		
	flat, to 2% average, 2 to 7% steep, over 7%	0.13 0.18 0.25	0.17 0.22 0.35

Ref: Design Chart 1.07, Ontario Ministry of Transportation, "MTO Drainage Management Manual," MTO. (1997)

Notes:

- *Only to be used during preliminary design calculations.
- As per MTO Manual, increase coefficients for the 1:25-year storm by 1.1, the 1:50-year design storm by 1.2 and the 1:100-year design storm by 1.25 (to a maximum value of 1.0).
- Proposed gravel parking and storage areas must be modeled as asphalt.
- Minimum values should be used for catchments with slopes less than 2% and maximum values used for catchments with slopes greater than 7%. For all catchments with slopes between 2 and 7% a weighted average should be used to determine the appropriate value.

Table 10.6: Runoff coefficient (Rational C) for rural catchments

Land Use & Topography	Soil Texture		
	Open Sand Loam (A-AB)	**Loam or Silt Loam (B-BC)**	**Clay Loam or Clay (C-CD-D)**
Cultivated			
Flat 0- 5% Slopes	0.22	0.35	0.55
Rolling 5 - 10% Slopes	0.3	0.45	0.6
Hilly 10 - 30% Slopes	0.4	0.65	0.7
Pasture/Meadows			
Flat 0- 5% Slopes	0.1	0.28	0.4
Rolling 5 - 10% Slopes	0.15	0.35	0.45
Hilly 10 - 30% Slopes	0.22	0.4	0.55
Woodland or Cutover			
Flat 0- 5% Slopes	0.08	0.25	0.35
Rolling 5 - 10% Slopes	0.12	0.3	0.42
Hilly 10 - 30% Slopes	0.18	0.35	0.52
Bare Rock	Coverage		
	30%	50%	70%
Flat 0- 5% Slopes	0.4	0.55	0.75
Rolling 5 - 10% Slopes	0.5	0.65	0.8
Hilly 10 - 30% Slopes	0.55	0.7	0.85
Lakes and Wetlands	0.05		

Ref: Design Chart 1.07, Ontario Ministry of Transportation, "MTO Drainage Management Manual," MTO. (1997)

10.6 Time of Concentration

Hydrograph time of concentration should be calculated as per the MTO manual and should be based on the Airport Method for catchments with a runoff coefficient less than 0.40 or the Bransby-Williams Equation for catchments with a runoff coefficient greater than 0.40 (based on the weighted catchment C).

The Upland method may be more appropriate for certain topography and the NVCA will allow for the use of this method in place of the MTO specified method; however, the use of the Upland method will require justification to be provided by the consultant as to its usage. Please note that sketches identifying Upland travel paths and land use must be included with the submission if this method is used.

Time to peak should be calculated as $t_p = 0.67\ t_c$, where t_c is time of concentration.

The number of linear reservoirs for the NASHYD command shall equal 3 unless calibration results indicate otherwise.