FACTSHEET

Sizing Grassed Waterways

This fact sheet presents sizing methods for grassed waterways that effectively manage water flow and limit erosion problems. Technical information concerning waterway location, the selection of an appropriate drainage system for the waterways and construction phases and maintenance are presented in the fact sheet entitled Grassed Waterways and Interception Channels.

This fact sheet presents simplified sizing methods. If the drainage basin of the planned waterway exceeds 20 ha in surface area, a specialist should be consulted.

Photos 1 (2004) and 2 (2006): Effectiveness of a waterway in limiting gully formation
Source: Mikael Guillou, MAPAQ

Steps involved in sizing a waterway are the following:

Step 1: Acquiring land data

Before visiting the field, existing documentation on the plot to be studied should be obtained: a high-resolution aerial photograph, a contour or subsurface drainage plan.

During the visit, ditch networks and land surfaces that will be drained by the proposed waterway should be examined for signs of erosion. The most vulnerable areas are the lower parts of the plots, hills and sites crossed by water flow.

Identify the optimal location for the waterway, conduct topographical surveys to determine longitudinal slopes and note characteristics of the drainage basin, such as:

- soil types,
- average slope of the drainage basin,
- slopes of the terrain in the area to be developed,
- size of the drainage basin,
- type of vegetation cover,
- distance travelled by the water,
- location of erosion and sedimentation areas.

Step 2: Calculating peak flow for the drainage basin

To evaluate the peak flow that will be used to size a waterway, a 10-year rainfall should be used for an installation on an agricultural plot and a 25-year rainfall should be used if waterway overflow could cause major material damage (e.g., to a building or road).

For more information, consult the fact sheet entitled **Evaluation of Peak Flows for Small Agricultural Drainage Basins in Quebec**.

Step 3: Choosing maximum water flow velocity in the waterway

This step entails estimating the maximum allowable velocity of the water in the waterway. In order to limit the risks of bed erosion, this flow velocity must not be exceeded.

The velocity depends on the future density of the vegetation cover that will be established in the waterway and on the erodibility of the soil. To be safe, a velocity consistent with more sparse or scattered vegetation is preferable, even if degradable mulch is used during construction. It should be kept in mind that the quality of the vegetation cover varies over time.

Table 1. Choosing the maximum allowable velocity

	Erosion resistant soil (m/s)	Soil that is not very erosion resistant (m/s)
Bare ground or waterway covered with crop residue	0.7	0.5
Scattered vegetation cover	0.9	0.6
Moderately established vegetation	1.2 to 1.5	0.9 to 1.0
Very well established vegetation (*)	1.8 to 2.0	1.2 to 1.5
(*) Vegetation can be easily damaged by machinery, herbicide drift, etc. Using this type of vegetation cover could result in erosion problems within the waterway.		

Velocities of 0.6 to 0.9 m/s are the safest

If the anticipated velocity exceeds the maximum allowable limits indicated in the above table, the central part of the waterway must be riprapped or sills must be built.

A waterway can be covered simply by seeding it. However, if the seeding is conducted in the fall, or if the drainage basin is sizeable, an erosion-control net or sod must be added to immediately reinforce the centre of the waterway.

Step 4: Waterway dimensions

A parabolic shape is generally preferable. This shape effectively reduces water velocity by spreading runoff over a wider vegetation cover and limits the risk of gully formation.

The width and depth of a waterway are calculated on the basis of peak flow, the longitudinal slope of the waterway and the maximum flow velocity according to soil and cover type.

The width and depth must be determined for each homogenous part of the waterway. If there are any significant changes in the longitudinal slope or size of the area being drained, the dimensions of the waterway must be reevaluated (for example, downstream from the mouth of an interception channel).

• Evaluating waterway width

The roughness of vegetation protects the soil and slows runoff, but its upward growth also obstructs the waterway. Therefore, the type and height of vegetation have a direct impact on the velocity and depth of water flow.

The width and depth data in the graph below are calculated for vegetation of a minimum height of 0.10 m (retardance D) and a maximum height of 0.15 to 0.30 m (retardance C).

In the evaluation of the dimensions of a waterway, these two values are important in terms of ensuring that the resulting installation will resist high flow velocities where vegetation is short and contain water flow even when vegetation is tall.

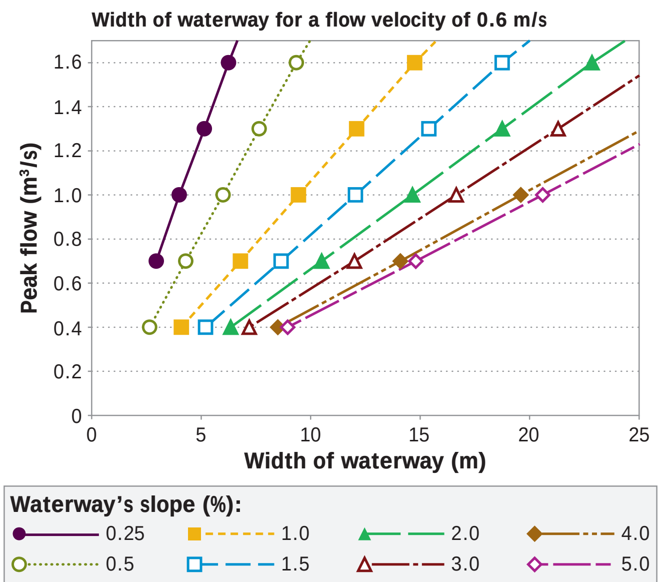

Figure 2. Width of waterway for a flow velocity of 0.6 m/s
Sources: NRCS 1984, MAPAQ 1990

For a velocity of 0.9 m/s, divide the width obtained in the graph of figure 2 above by 2.1.

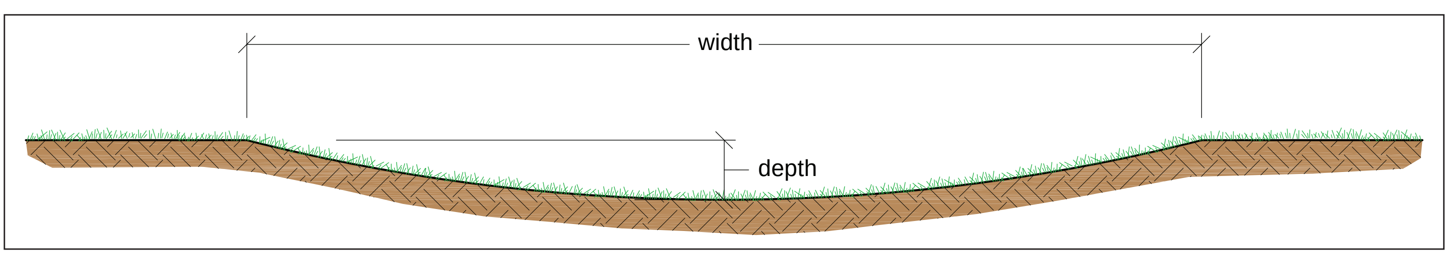

Figure 1: Shape of a parabolic waterway
Source: Brochu Y et coll. 1992, drawing adapted by Luc Lemieux, MAPAQ

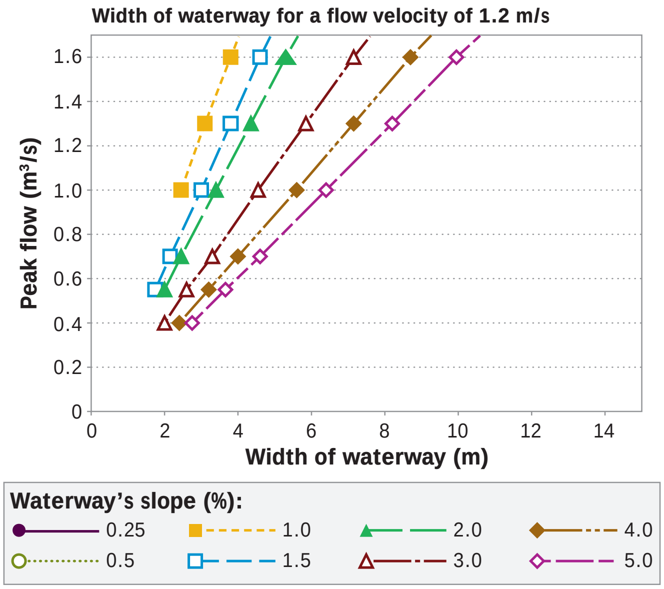

Figure 3: Width of waterway for a flow velocity of 1.2 m/s
Sources: NRCS 1984, MAPAQ 1990

For a velocity of 1.5 m/s, divide the width obtained in the graph of figure 3 above by 1.6.

• Evaluating waterway depth

The only parameters to consider in determining the optimal depth of a waterway are flow velocity and longitudinal slope of the waterway. Peak flow has little impact on the depth of a waterway, but does affect the width.

Table 2. Waterway depth (in metres)

Maximum flow velocity	Longitudinal waterway slope (%)							
	0.25	0.5	1.0	1.5	2.0	3.0	4.0	5.0
0.6 m/s	0.7	0.5	0.35	0.30				
0.9 m/s	0.9	0.6	0.45	0.35	0.30			
1.2 m/s			0.55	0.45	0.35	0.30		
1.5 m/s			0.65	0.55	0.45	0.35	0.30	
Sources: NRCS 1984, MAPAQ 1990								

- For a high peak flow and a waterway with a steep slope, the result is a wide, shallow canal.
- For a moderate peak flow and a waterway with a gentle slope, the result is a narrow, deep canal. In this case, manoeuvring of machinery and maintenance must also be taken into consideration to adjust bank slopes (see Step 5).

Step 5: Adapting the waterway dimensions

- To limit the risks of overflow, the waterway should be made 0.10 m deeper than required. The width of the waterway must also be increased accordingly.
- To facilitate mowing of the vegetation, bank slopes must be a maximum of 1:4 (horizontal:vertical). For example, a 6-m-wide waterway will have a maximum depth of 0.75 m.
- If a waterway is perpendicular to the direction of cultivation, farm machinery must be able to cross it anywhere along its length. Bank slopes must be less than or equal to 1:10. Because of this constraint, the designer may increase the calculated width of the waterway, but maintain the recommended depth.
- If a waterway must be crossed by farm machinery at a specific location, a culvert or rock chute can be used to create the crossing. The slope of the chute banks must not exceed 1:8 to 1:10, but can be less than or equal to 1:4 elsewhere.
- If the quantity of eroded soil in the drainage basin is significant, the depth and width of the waterway can be increased to improve its sediment trapping capability. The same is true if significant snow accumulations are expected in the waterway (snowdrifts).

Table 3. Examples of width/depth combinations that correspond to bank slopes of 1:10

Depth (m)	0.30	0.40	0.50	0.60	0.70
Width (m)	6.0	8.0	10.0	12.0	14.0

Sizing an interception channel

Calculations are not generally used for this type of installation. This type of canal is 0.30 to 0.40 m deep and 6 to 8 m wide. Because interception channels are generally perpendicular to the direction of cultivation, bank slopes must be less than or equal to 1:10 to be easily crossed by machinery. The longitudinal slope of a channel follows the general slope of the land, and the central part should be grassed to ensure better load-bearing capacity and prevent rutting.

References

Brochu, Yvon and Jacques Desjardins. 1992. **Voie d'eau engazonnée. Feuillet technique – génie rural**, Agdex 751. Conseil des productions végétales du Québec (CPVQ), Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec.

Atlantic Committee on Agricultural Engineering. 1992. **Integrated Erosion Control on Potato Land in Atlantic Canada**. Agdex 573.

Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec. 1990. **Normes de conception et d'exécution pour les travaux de conservation et gestion du sol et de l'eau**. Internal publication.

New Brunswick Department of Agriculture and Aquaculture. 2003. **Grassed Waterways**. Technical fact sheet. http://www.gnb.ca/0173/30/0173300006-e.asp

Ontario Ministry of Agriculture and Food. 1982. **Grassed Waterways**. Technical fact sheet, Agdex 573.

Ontario Ministry of Agriculture and Food. 1999. **Use of Earthen Berms For Erosion Control**. Agdex 751. http://www.omafra.gov.on.ca/english/engineer/facts/99-047.htm

NRCS 1984. Engineering Field Handbook. Cpt. 7, **Grassed Waterways**. http://directives.sc.egov.usda.gov/media/pdf/H_210_650_7.pdf

Schwab, G.O, D.D. Fangmeier, W.J. Elliot and R.K. Frevert. 1993. **Soil land Water Conservation Engineering**, 4th edition. John Wiley & Sons, United States of America.

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