

Under Our Feet and on the Horizon: A two-decade review of erosion hazard assessment in Ontario

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Thursday, October 21st, 2021



Outline

Background

- Which guidelines?
- Why PGO?
- Why now?

Under Our Feet

- Guideline Document Reviews
- Select Definitions and Topics for Discussion

On the Horizon

• Recommendations and Next Steps





Background

Published guidelines prepared by the Ontario Ministry of Natural Resources to assist the public and planning authorities, such as municipalities and conservation authorities, with an explanation of the Natural Hazards **Policies** (3.1) of the Provincial Policy Statement (PPS) of the 1990 Planning Act.

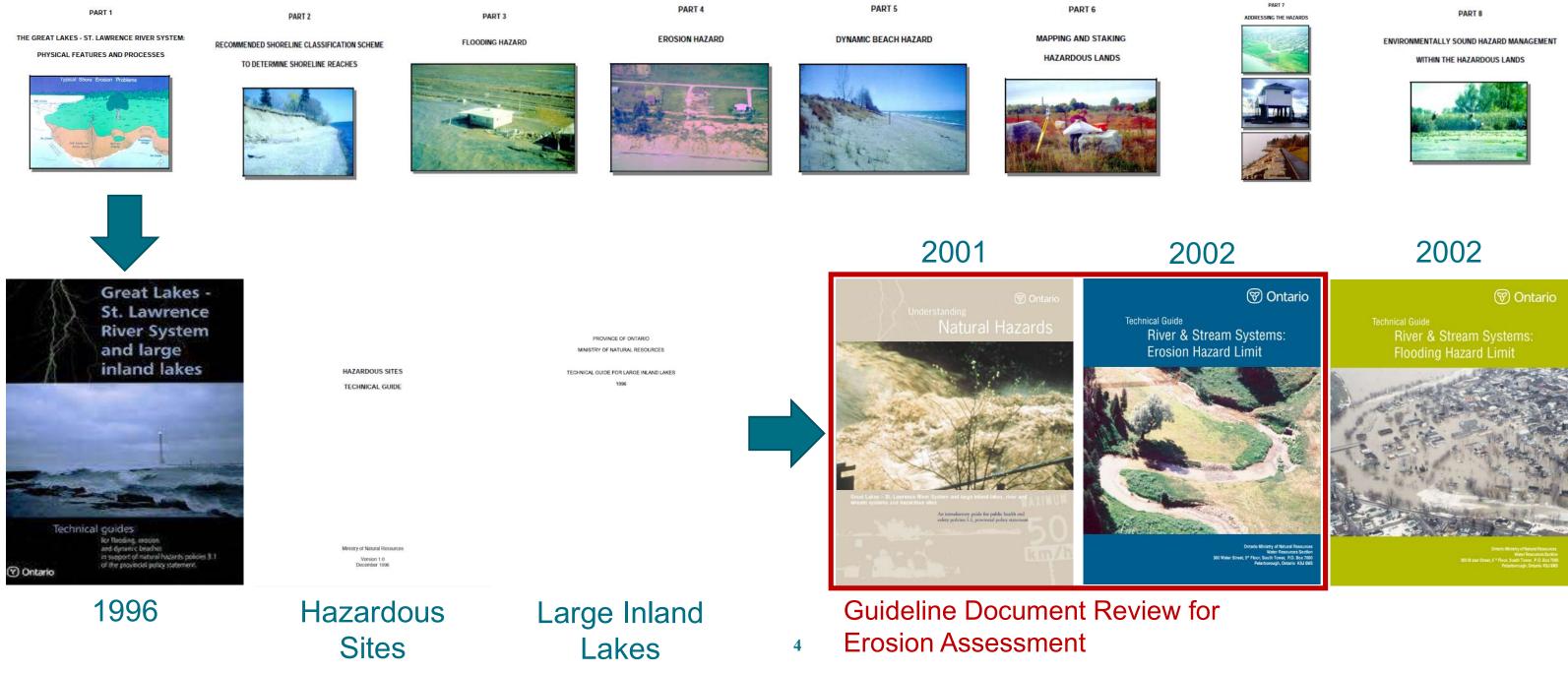
- References to natural hazards, flooding, and erosion referenced throughout the PPS
- 1996/1997 PPS updated in 2005, 2014, 2020
- Also referenced in 2002 Adaptive Management of Stream Corridors in Ontario publication





Which Guidelines?

1996 TECHNICAL GUIDE FOR GREAT LAKES – ST. LAWRENCE RIVER SHORELINES





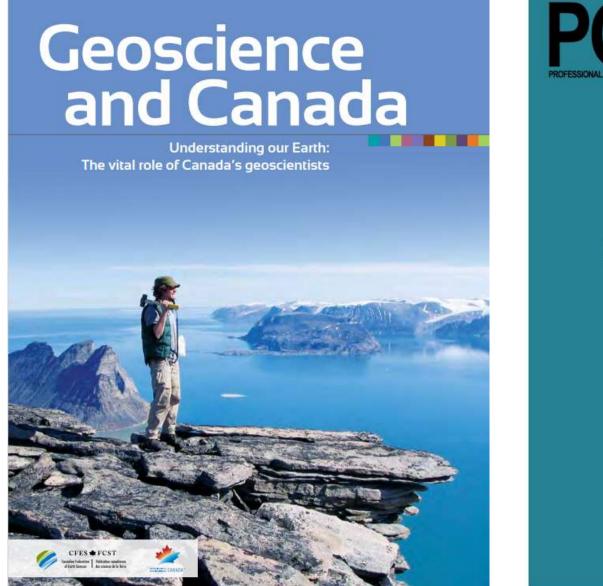




Why Professional Geoscientists Ontario, PGO?

Mandated through the Professional Geoscientists Act, 2000 (PGA) to serve and protect the public and natural environment by regulating the practice of professional geoscience in Ontario.

- Role of geoscientists in "geohazards"
- PGO is recognized stakeholder
- PGO registrants include many of experts in the field
- Professional Practice Guidelines for Geomorphologists relevant to geohazards and erosion hazard assessment



Geohazards, Engineering, and Infrastructure https://geoscientistscanada.ca/publications.php





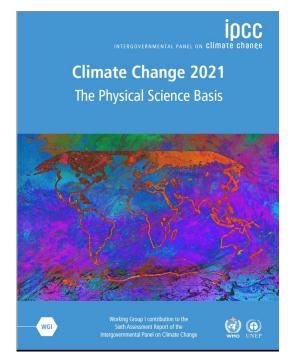
Professional Practice Guidelines for Geomorphologists

Version 1.5 March 2021 This guideline was developed by the PGO's

Geomorphology Subcommittee https://www.pgo.ca/about/professional-practice

Why Now?

- Existing guidelines have been in services for two decades
- Science, practice, and regulatory landscape have evolved
- Climate change has renewed public focus on flooding and erosion hazards



Sixth Assessment Report (ipcc.ch)

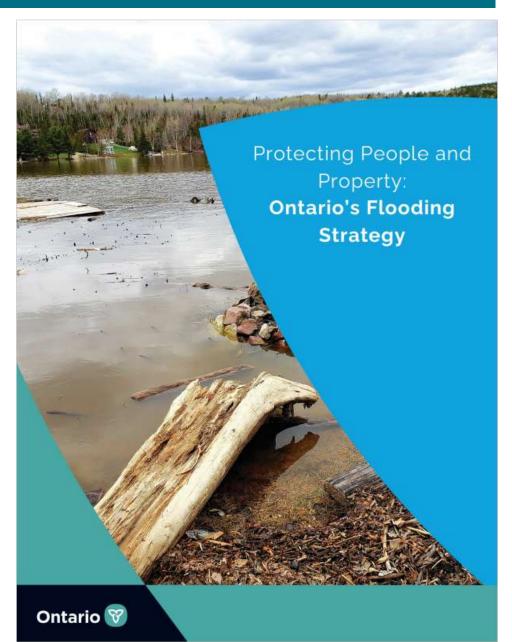
Ontario's Special Advisor on Flooding Report to Government

An Independent Review of the 2019 Flood Events in Ontario

A Report to the Hon. John Yakabuski, Minister of Natural Resources and Forestry

Douglas McNeil, P.Eng. McNeil Consulting Inc. – Winnipeg, Manitoba

An Independent Review of the 2019 Flood Events in Ontario



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Ontario 2020 Flooding Strategy

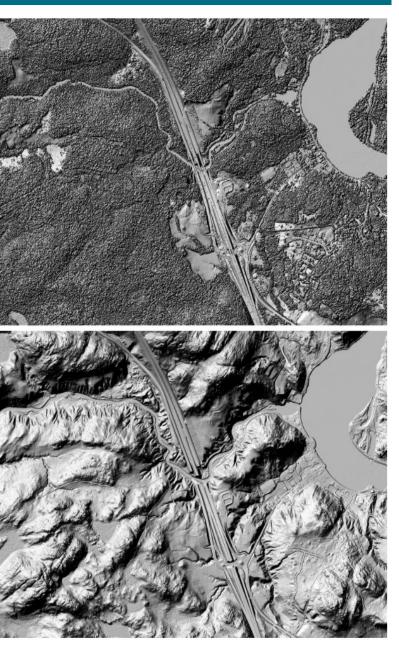
Why Now?

Better leverage scientific and technological advancements since 1990s

- Geographic information systems (GIS), remote sensing and LiDAR
- Advanced computing, Fig. So: Streams (J: 100k PNW Reach Hes) courtaid on Fig 4h: The Mt. House region classified unto 10 landform classes atth USOS Level 5 Hydrologic Unit houndarie 3D modelling, visualizations, geostatistics Fig. 5b; Topography of the Westers IMAP Fig. 5c: Watershad Metrics for tp0000, Fig. 52: Wasarshed Matrice for tpi303. Oregon Pilot Area, with 5th level restarsheds Designation of a second distance of **Opintile** dissification ନ 0 20 _ CO Advanced GIS Applications (e.g., Weiss, 2001) **Geohazard Journals** http://www.jennessent.com/downloads/tpi-poster-tnc 18x22.pdf

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LiDAR Digital Elevation Models https://www.nrcan.gc.ca/

Guideline Document Reviews

Erosion Hazard Assessment

Understanding Natural Hazards (2001)

- Great Lakes St Lawrence River System and Large Inland Lakes
- River and Stream Systems
- Hazardous Sites

Technical Guide River & Streams Systems: Erosion Hazard Limit (2002)

- Erosion Processes
- Application of Provincial Policy
- Site Investigations and Studies

Updates Recommended to Address:

- 1. Specific Technical Issues
- 2. General Scientific Advancement
- 3. Guiding Principles for Policy Application





Great Lakes – St. Lawrence River System and large inland lakes, river and stream systems and hazardous sites.

An introductory guide for public health and safety policies 3.1, provincial policy statement



2001



🕅 Ontario

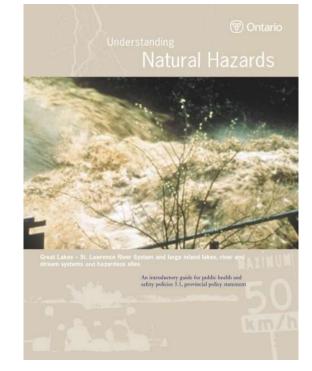
Technical Guide River & Stream Systems: Erosion Hazard Limit

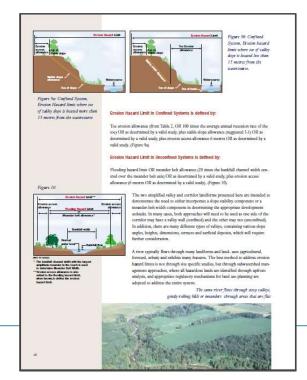


Ontario Ministry of Natural Resources Water Resources Section 300 Water Street, 5th Floor, South Tower, P.O. Box 7000 Peterborough, Ontario K9J 8M5

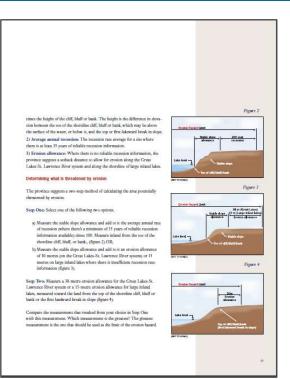
Understanding Natural Hazards (2001)

Section Title	Select Issues
1.0 Purpose of Publication	General update for current policy and science
2.0 What are Natural Hazards?	Benefits of floodplains in watershed management
3.0 Natural Hazards in Ontario	Climate change risks
4.0 Provincial Perspective	Life-cycle cost analyses of mitigation
5.0 Natural Hazard Policies, Section 3.1 of the PPSs	Define engineering, geotechnical, and scientific principles
6.0 Great Lakes – St Lawrence River System and Large Inland Lakes	 Update data, science and technology to provide clear evidence-based criteria for hazard setbacks Increase emphasis on climate change risk Major technical topics to address include: Dynamic beaches Seiche events
7.0 River and Stream Systems	 Update data, science and technology to provide clear evidence-based criteria for hazard setbacks Increase emphasis on climate change risk Major technical topics to address include: Definition of confined systems Meander belt concept Generic erosion hazard setbacks





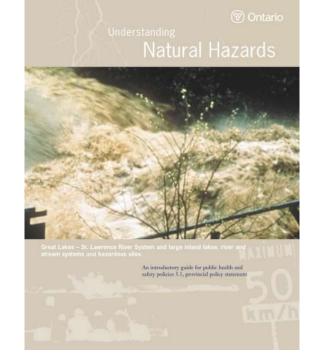


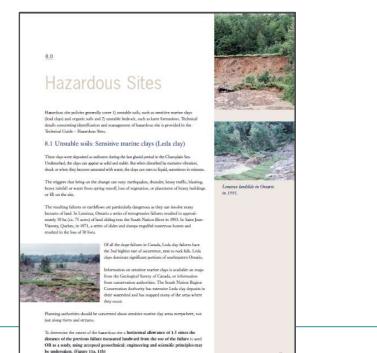


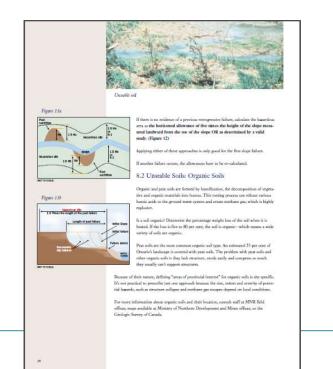


Understanding Natural Hazards (2001)

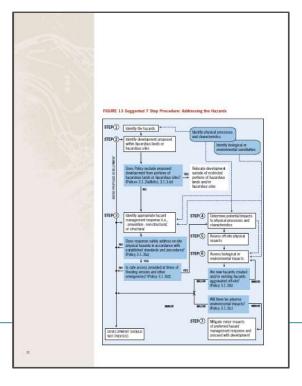
Section Title	Select Issues
8.0 Hazardous Sites	Unstable soils and bedrock, karst sinkhole hazards
9.0 Addressing the Hazards	Update with guiding principles
10.0 Ecosystem Based Planning and Management	Context of updated PPC, role of conservation authorities, and future adaptations to regulatory landscape
11.0 Adaptation	Update climate change risks
12.0 Implementation	Role of conservation authorities; Qualified Persons
13.0 Summary Statement	General update for current policy and science







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Adaptation

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Implementation

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Implementation of the Provinced Dollary Statement is advanced through the Makinyy of Manipul Millin, "Dev Wahning Hunging State". Conservation resolution is advect they each have been delegated sole consensating responsibility for the National Tatasaba Polisies. Department, The Millinger Olivard Tatasamo similarity for the National Tatasaba Polisies. Department, The Millinger Olivard Tatasamo similarity for the National Tatasaba Polisies. Department, The Millinger Olivard Tatasamo similarity of the State State State State and care intera work permit, approximate the Kontino of the work as well in the plane and specifications. If provident similarity that the FRIL Construction and Altrensian to Warrangy Regulations under the Construction clusterium in the Altrensian to Warrangy Regulation under the Construction clusterium in the State State State State State and Altrensian to Warrang Kangahan and Partmentane to Warrangy Regulations and the the Construction clusterium in the State Sta

Where information does not take concerning location of defined haurdows lands, planning authorities are advised in underwise studies in identify potential risks from named haurdos. Such studies are normally undervalent by accredited engineers in the consulting community, in accordance with pulsane previsided in the usis of natural haurds technical pulses.

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Technical Guide River & Streams Systems: Erosion Hazard Limit (2002)

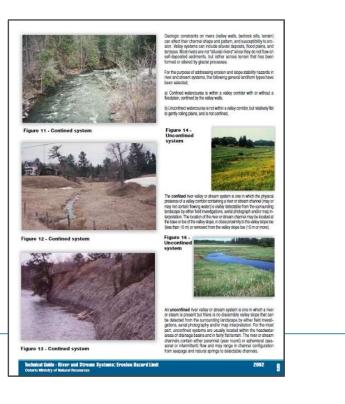
Section Title	Issues
1.0 Introduction	General update for current policy and science
2.0 Erosion Processes	 Update data, science and technology to provide clear evidence-based criteria for hazard setbacks. Increase emphasis on climate change risk. Major technical topics to address include: Definition of confined systems Vertical "scour" hazards (missing) Instream erosion and sediment transport Semi-alluvial systems (bedrock and till) Definitions of reaches, instability and other geomorphological terms



Technical Guide River & Stream Systems: Erosion Hazard Limit



Ontario Ministry of Natural Resources Water Resources Section 300 Water Street, 5" Floor, South Tower, P.O. Box 7000 Peterborough, Ontario KSJ 8M5





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Figure 77 - Tension Cracks



Figure 78 - Failure Scarp

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There are several general indicators of slope stability, including slope inclination, soil types, groundwater levels, and other slope features such as tension cracks.

mmediately before a translational or rotational slide occurs, "tension cracks" may develop parallel and close to the slope crest.

The slope surface after a slide often display "tension rancks" above the slide and, a distinct "scarp" at the "head" or "crown" where the sliding mass has separated from the slope. A bulging soli mass is often found at the "toe" of the slide.

Stope failures tend to be self-stabilizing in that the slope configuration becomes flatter and more stable. This assumes that the slumped soil is not removed by toe erosion.



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Section Title
3.0 Application of the Provincial Policy

🗑 Ontario

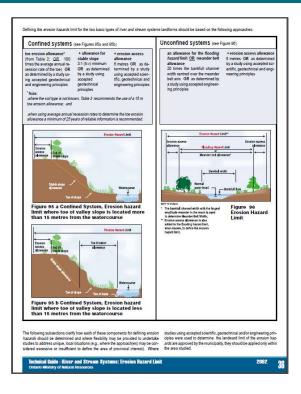
Technical Guide River & Stream Systems: Erosion Hazard Limit

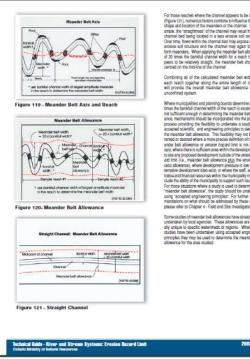


Ontario Ministry of Natural Resources Water Resources Section 300 Water Street, 5th Floor, South Tower, P.O. Box 7000 Peterborough, Ontario KSJ 8M3

	e 3: Determination of Toe Erosion A			
MINIMUM T	DE EROSION ALLOWANCE - River W		ilope Toe'	Erosion**
Native Soil Structure	OR Bankfull Flow Velocity > Competent Flow Velocity***	OR Bankfull Flow Velocity <competent Flow Velocity***</competent 		
	RANGE OF SUGGESTED TOE EROSION ALLOWANCES	< 5m	ankfull Wid 5-30m	h > 30m
1.Hard Rock (granite) * 2.Soft Rock (shale, limestone)	0 - 2 m	0 m	0 m	1 m
Cobbles, Boulders * 3.StiflHard Cohesive Soil (clays, clay	2 - 5 m	0 m	1 m	2 m
sit), Coarse Granular (gravels) Tills 4 Soft/Firm Cohesive Soil, loose	5-8 m	1=	2 m	4=
granular, (sand, silt) Fill *	8 - 15 m	1-2 m	5 m	7 m
owances for the materials found at Active Erosion is defined as: bank here undercuting, overskepening, we erosion but there may not be e- suit of a condition of net sediment- suit of shifting of the channel. The swith this condition. See Step 3. "Competent Flow Velocity is the	the soil structures cours, the greater or the site should be applied material is exposed directly to stream slumping of a bank or down stream se dence of active ension either as a re deposition. The area may still suffer er to be ension allowances presented in th flow velocity that the bed material in a flow velocity that the bed material in th	Now under nom diment loading sult of well root ision at some p e right half of Ti ie stream can s	nal or flood is occurring ed vegetati oint in the f able 3 are s	flow conditions . An area may on or as a uture as a uggested for
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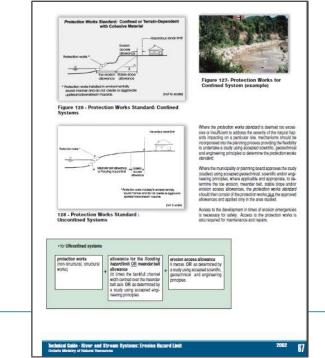
Section Title	Issues
4.0 Site Investigations and Studies	 Specific examples of data and technology to be address include: Topographic mapping, including digital elevation models, and LiDAR derived terrain models Aerial photography, including historical airphotos, and applications of orthorectification and photogrammetry. Subsurface data and databases, including boreholes and shallow geophysics. Geochronology methods (e.g., lead-210, radiocarbon dating)
5.0 Addressing the Hazard	 Guiding principles of policy application to encourage more sophisticated technological approaches, evidence-based statistical predictions including reporting uncertainties, professional judgment by qualified persons, and expectations for peer review processes. Standardize expectations for how to incorporate existing or new erosion control measures in erosion hazard assessments, or how not to. Update erosion control and stream restoration approaches.
6.0 Environmental Sound Management	Climate change risks

🐨 Ontario

Technical Guide River & Stream Systems: Erosion Hazard Limit



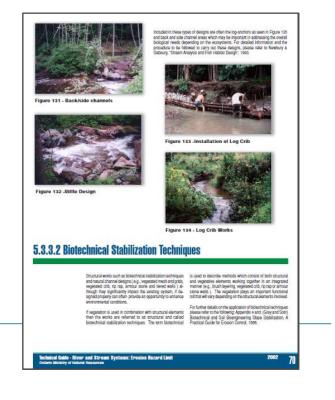
Ontario Ministry of Natural Hesources Water Resources Section 300 Water Street, 5th Floor, South Tower, P.O. Box 7000 Peterborough, Ontario KSJ 8M5



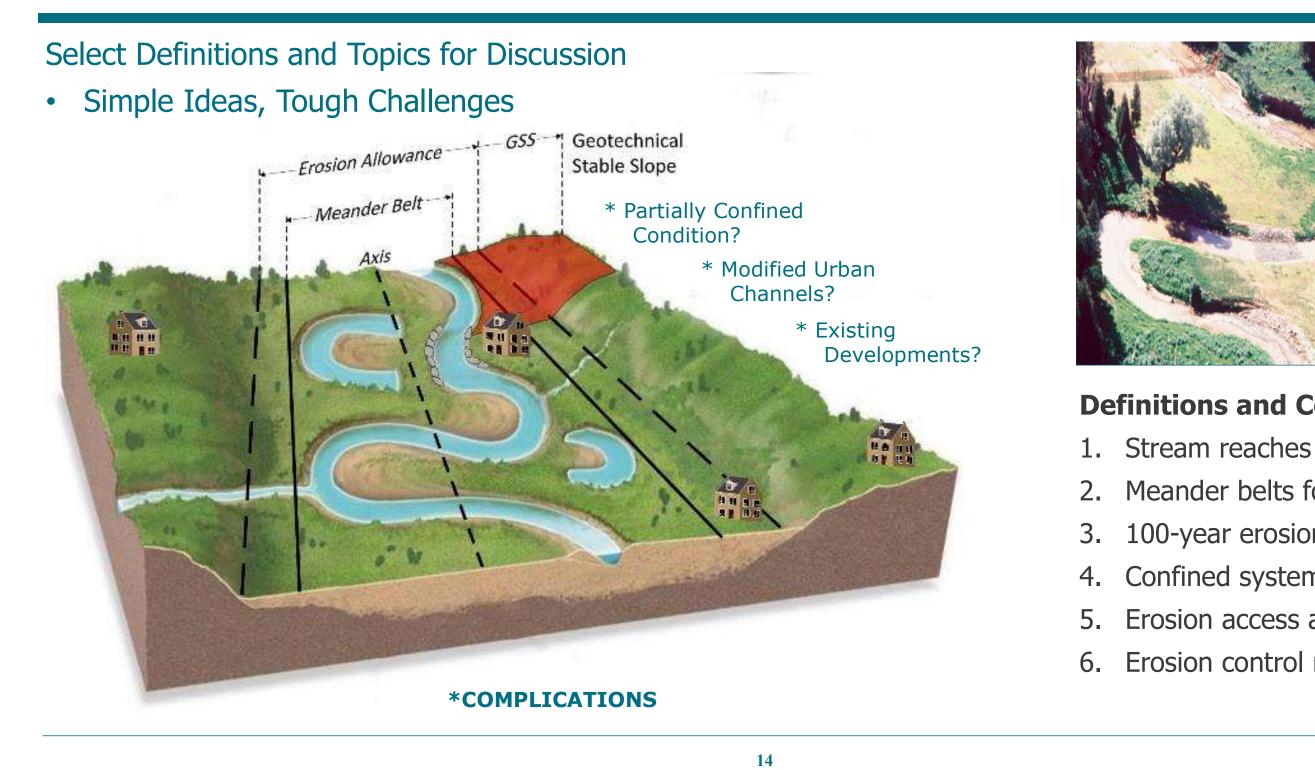
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Erosion Hazard Assessment







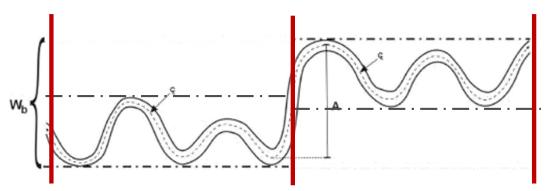
Definitions and Concepts

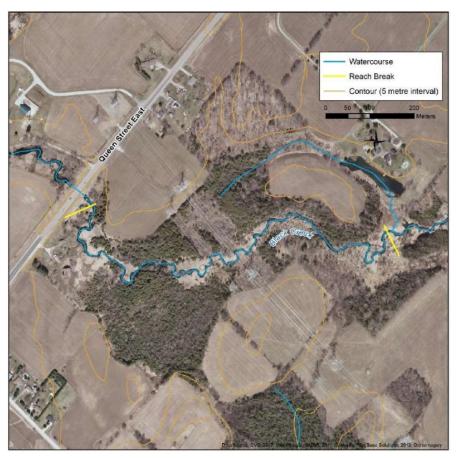
- Meander belts for unconfined reaches
- 100-year erosion allowance
- Confined systems
- Erosion access allowance
- **Erosion control measures**

Stream Reaches

Reaches are lengths of channel that display similarity with respect to valley/floodplain setting, channel form, and function. The controlling influences of channel form and function should be nearly constant within the reach.

TRCA (2004) Belt Width Delineation Procedures





Howett (2017)

Challenge:

Where reach breaks are identified, and the length of reaches, can significantly change the meander belt width.

A reach is defined as a length of channel over which the channel characteristics are stable or similar.

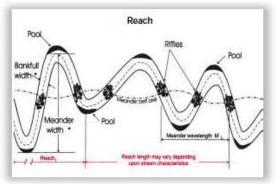
MNR (2002) Erosion Hazard Limit

2.4.1 Sinuosity





igure 48 - Meandering



channel characteristics are stable or similar Ontario Ministry of Natural Resource



River System

Figure 49 - "Reach", a length of channel over which

hnical Guide - River and Stream Systems: Erosion Hazard Limit

Unconfined ravines, river valleys and stream corridor system tend to be predominately located within relatively flat terrain. They normally contain perennial (year round) or ephemeral (intermittent) flows which may have a tendency to constantly shift or meander (laterally and downstream) in response to the continuous changes associated with the natural influence of discharge and load. The maximum extent, or area of provincial interest that a water channel migrates is termed "meander belt allowance". The term "meander belt" is derived from ter minology used to describe meandering systems.

Watercourses have a natural tendency to "sinuosity" in the lower reaches where bed downcutting is reduced. "Meandering" refers to the tortuous shape of the channel in plan view. The sinuous bends develop to a size governed by the bed and bank materials, and by the bankfull discharge. Changes in the bankfull discharge can result in changes in the size of the sinuous bends. A limit to the width of the meander can be caused by the development of "chutes" (short channels formed during high flows) across the inner bank sediments. The "Sinuositi Index" (SI) is used to describe the degree of meandering and is the ratio of the channel length to the downvalley distance. The Sinuousity Index can range from less than 1.05 to more than 1.5. 1.5 is appropriate for many streams and is a measure of the "wiggliness" or "tortuosity" of a watercourse. Meandering changels have an SL of 1.5 or more and are more common to cohesive bed and bank soil materials. The typical bankfull velocity of a meandering stream is between 1 and 3 metres per second.

2.4.2 Reach

A meandering system is comprised of a series of inte nected reaches. A "reach" is defined as a length of channel over which the channel characteristics are stable or similar. The extent of a reach depends on the geometry and dynamics of the channel. It is often measured in multiples of channel width, meander wavelengths, or riffle-pool sequences. Measurements should be taken over a length sufficient to establish the stable characteristics of the channel. All geomorphological features and types of aquatic habitat should be proportionally represented in the section of the stream being assessed, and at least two of each of the major features of the section should be represented. Measurements of channel characteristic within a reach should be carried out so that the range of conditions within the reach can be specified (MNR, 1994)

Similar biological characteristics can also be measured to as sist in determining the reach. Frissell et al., 1986 suggest that habitats follow the same organization as the branching network of the stream reaches, implying that sample reaches for habitat surveys may be selected on the basis of stream segment order numbers or position in the drainage network

Meander Belts for Unconfined Reaches

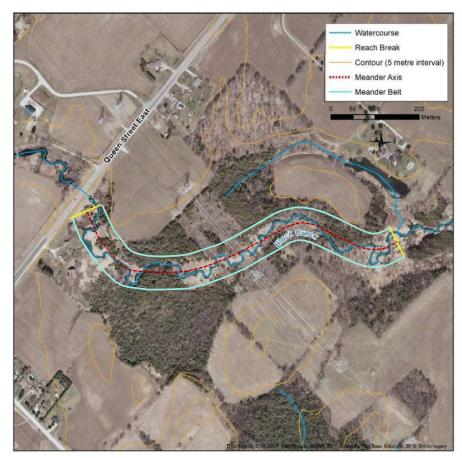
The term **meander belt allowance**, for the purposes of defining the "area of provincial interest", is essentially the maximum extent that a water channel migrates. MNR (2002) Erosion Hazard Limit

Because a watercourse is expected to move and change within the meander belt, anything situated within it could, at some time in the future, be subject to erosion by the channel. Thus, the meander belt as a tool for planning purposes is a valid approach for defining the area in which river processes occur and will likely occur in the future.

TRCA (2004) Belt Width Delineation Procedures

Challenges:

Simplified approach is relied on for complex erosion hazards or when forced on low risk reaches where concept is not appropriate.



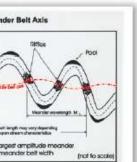
Modified from Howett (2017)

Different Approaches from Other Jurisdictions:

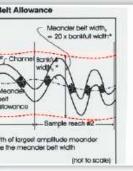
Washington State (2003), Channel Migration Zones Quebec (Bill 67, 2020) Mobility Zones

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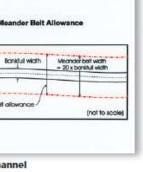












For those reaches where the channel appears to be straight (Figure 121), numerous factors combine to influence the size, shape and location of the meanders or the channel. For example, the "straightness" of the channel may result from the channel bed being located in a less erosive soil structure. Over time, flows within the channel bed may again begin to form meanders. When applying the meander bet allowance of 20 times the bankfull channel width for a reach that appears to be relatively straight, the meander bet should be centred on the mid-line of the channel.

Combining all of the calculated meander belt widths for each reach together along the entire length of channel will provide the overall meander belt allowance for the unconfined system.

Where municipalities and planning boards determine that 20 times the bankfull channel width of the reach is excessive or not sufficient enough in determining the meander belt allowance, mechanisms should be incorporated into the planning process providing the flexibility to undertake a study using accepted scientific, and engineering principles to determine the meander belt allowance. This flexibility may not be warranted or desired where a more precise definition of the me ander belt allowance or erosion hazard limit is not necessary, where there is sufficient area within the development lot. to site any proposed development outside of the eros ion hazand limit (i.e., meander belt allowance plus the erosion access allowance), where development pressure is low and alternative development sites exist, or where the staff, administ trative and financial resources within the municipality may preclude the ability of the municipality to support such studies. For those situations where a study is used to determine the "meander belt allowance", the study should be undertaken using "accepted engineering principles". For further recommendations on what should be addressed by these studies please refer to Chapter 4 - Field and Site Investigation.

Some studies of meander belt allowances have already been undertaken by local agencies. These allowances are generally unique to specific watersheds or regions. Where local studies have been undertaken using accepted engineering principles they may be used to determine the meander belt allowance for the area studied.

m Systems: Erosion Hazard Limit

100-Year Erosion Allowance

Confine Reaches

100-year toe erosion allowance in confined reaches (MNR, 2002; Table 3)

Unconfined Reaches

- 100-year erosion allowance is also used in TRCA (2004) belt width procedures for a factor of safety applied in addition to existing belt width
- Instead, MNR (2002) requires belt width plus erosion access allowance of 6 m

100-Year Erosion Limit

The term 100-year erosion hazard limit is also used to for detailed predictions of channel locations in 100 years based on bank erosion rates



TRCA (2015) Crossings Guideline for Valley and Stream Corridor

Challenges:

Confusion about 100-year erosion allowance terminology and definition; and

Overreliance on Table 3 with large ranges in erosion allowances and insufficient guidance for consistency

	Tabl
	of Material e Soil Structure
1.Hard Roc	k (granite) *
2.Soft Rock	(shale, limestone)
Cobbles, I	Boulders *
3.Stiff/Hard C	ohesive Soil (clays, clay
silt), Coars	e Granular (gravels) Tills
4.Soft/Firm	Cohesive Soil, loose
	sand, silt) Fill *

allowances for the materials found at the site should be applied Active Erosion is defined as: bank material is exposed directly to stream flow under normal or flood flow condition where undercutting, oversteepening, slumping of a bank or down stream sediment loading is occurring. An area may have erosion but there may not be evidence of 'active erosion' either as a result of well rooted vegetation or as a result of a condition of net sediment deposition. The area may still suffer erosion at some point in the future as a result of shifting of the channel. The toe erosion allowances presented in the right half of Table 3 are suggested for sites with this condition. See Step 3.

3: Determination of Toe Erosion Allowance

E EROSION ALLOWANCE - River Within 15 m of Slope Toe

	Evidence of Active Erosion** OR Bankfull Flow Velocity > Competent Flow Velocity***	No evidence of Active Erosion** OR Bankfull Flow Velocity <competent Flow Velocity***</competent 			
	RANGE OF SUGGESTED TOE EROSION ALLOWANCES	< 5m	ankfull Wic 5-30m	lth > 30m	
	0 - 2 m	0 m	0 m	1 m	
8	2 - 5 m	0 m	1 m	2 m	
/ 5 *	5 - 8 m	1 m	2 m	4 m	
	8 - 15 m	1-2 m	5 m	7 m	

tive soil structures occurs the greater or largest range of applicable toe erosis

'Competent Flow Velocity is the flow velocity that the bed material in the stream can support without result osion or scour. For bankfull width and bankfull flow velocity, see Section 3.1.2

> Where there is evidence of high variability in soil composition, the soil composition is no known, and/or evidence of high erosion activity, the 15 metre toe erosion allowance should be

STEP 2: Determine whether or not there is evidence of active erosion OR if the bankful velocity is greater than the competent flow velocity.

Visible on-site evidence of active erosion may include a bare or vegetation-free river or stream bank which is directly exposed to water flows, and where undercutting, over-steepening, slumping of the bank or high downstream sediment loading is occurring. Slumping, scars, and bare stream banks that are not directly exposed to river flows are slope stability issues and should not be considered as evidence of "active erosion"

If field investigations determine that active erosion is occurring and as long as the soils at the site can be identified, it may not be necessary to determine the bankfull or competent flow velocities at the site. The Toe Erosion Allowances from Table 3 can be applied directly without any further calculations

Confined Systems

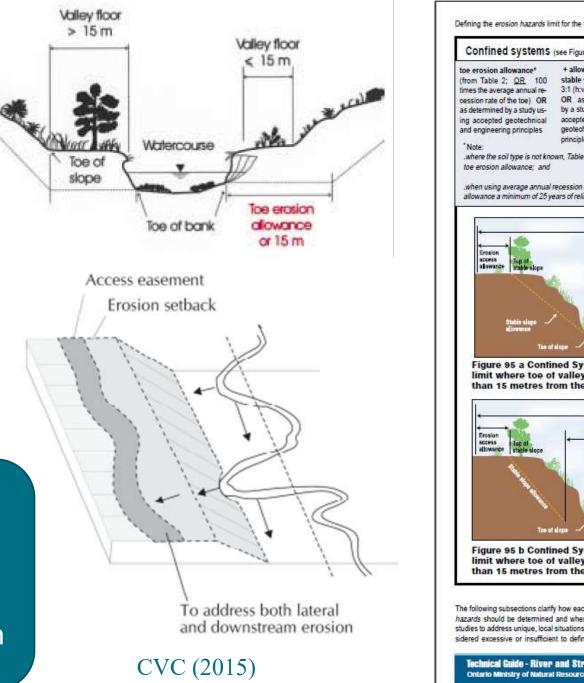
The confined river valley or stream system is one in which the physical presence of a valley corridor containing a river or stream channel is **visibly detectable** from the surrounding landscape...

The location of the river or stream channel may be located at the base or toe of the valley slope, in close proximity to the valley slope toe (less than 15 m) or removed from the valley slope toe (15 m or more).

MNR (2002) Erosion Hazard Limit

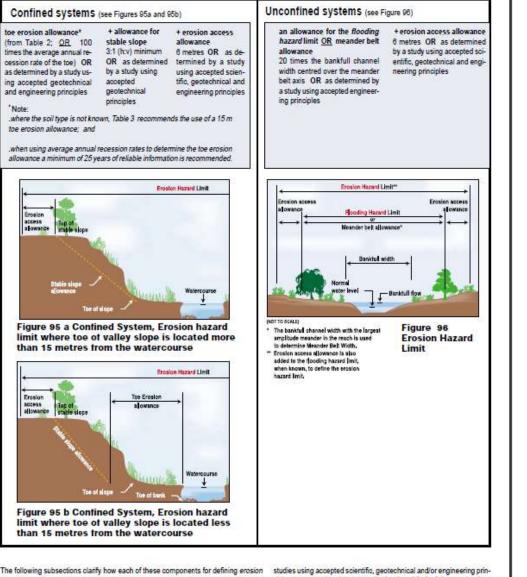
Challenges:

- 15-metre criterion not technical justified, needs to be scaled to channel size; and
- Insufficient guidance for consistency on how to integrate channel and slope erosion hazards in partially confined systems





Defining the erosion hazards limit for the two basic types of river and stream systems landforms should be based on the following approaches



sidered excessive or insufficient to define the area of provincial interest). Where the area studied

hazards should be determined and where flexibility may be provided to undertake ciples were used to determine the landward limit of the erosion hazstudies to address unique, local situations (e.g., where the approach/es) may be con-

Erosion Access Allowance and Erosion Control Measures

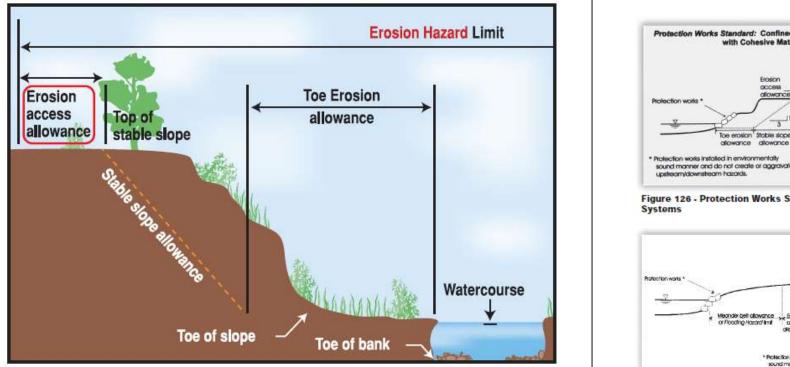
Erosion Access Allowance

- **Emergency access**
- Construction access
- Factor of safety

MNR (2002) Erosion Hazard Limit

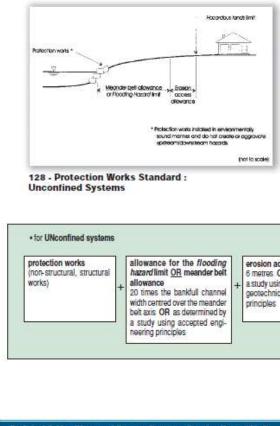
Erosion Control Measures

- Erosion hazard credit?
- Life-cycle costs



Challenges:

- Erosion access allowance is not as consistent as it could be in definition, size, and application across the province;
- Life-cycle costs are discussed, but insufficient guidance for implementation, so rarely well assessed in specific terms; and
- How to deal with erosion hazard credit for erosion control measures?





Protection Works Standard: Confined or Terrain-Dep

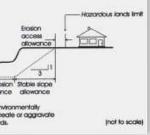


Figure 126 - Protection Works Standard: Confined



Figure 127, Protection Works for Contined System (example)

Where the protection works standard is deemed too excessive or insufficient to address the severity of the natural hazards impacting on a particular site, mechanisms should be incorporated into the planning process providing the flexibility to undertake a study using accepted scientific, geotechnical and engineering principles to determine the protection works standard.

Where the municipality or planning board approves the study (studies) using accepted geotechnical, scientific and/or engineering principles, where applicable and appropriate, to determine the toe erosion, meander belt, stable slope and/or erosion access allowances, the protection works standard should then consist of the protection works plus the approved allowances and applied only in the area studied.

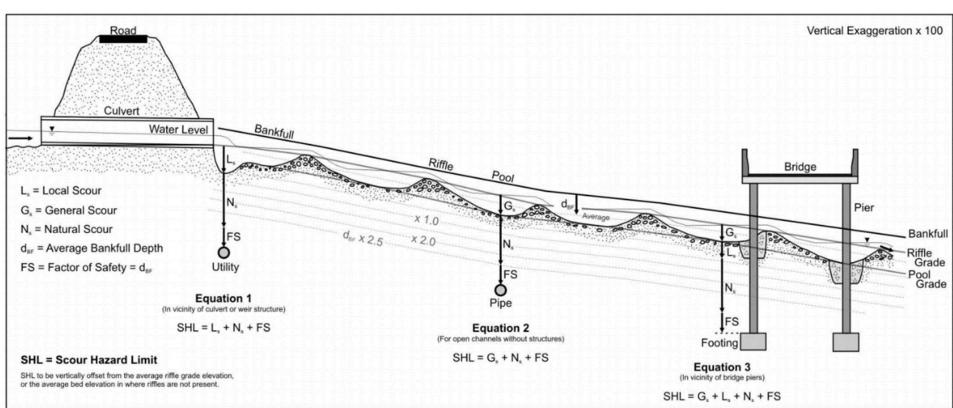
Access to the development in times of erosion emergencies is necessary for safety. Access to the protection works is also required for maintenance and repairs.

erosion access allowance 6 metres OR as determined by a study using accepted scientific. geotechnical and engineering

echnical Guide - River and Stream Systems: Erosion Hazard Limit

Scour Hazard Analysis

CVC (2019) Scour Hazard Guidelines



Туре	Definition	
Local Scour (Ls) Localized erosion of the streambed around in-stream structures and artificial obstructions to the flow.		
General Scour (Gs)	Lowering of the channel bed that generally affects all or most of the channel cross-section.	
Natural Scour (Ns)	Degradation or lowering of the average bed elevation at the reach- scale due to natural fluvial processes of erosion and sediment transport operating over the long-term and may include the effects of watershed land use change	-



Fluvial Geomorphic Guidelines: Factsheet VI Scour Analysis | V 1.0 | Credit Valley Conservation

https://cvc.ca/wp-content/uploads//2021/06/rpt_scourfactsheet_f_111219.pdf



Credit Valley Conservation Inspired by nature

Credit Valley Conservation Fluvial Geomorphic Guidelines: Factsheet VI Scour Analysis

Prepared by: Credit Valley Conservation December 2019

Recommendations and Next STEPs

Recommendations:

Update the guidelines to address:

- 1. Specific Technical Issues
- 2. General Scientific Advancement
- 3. Guiding Principles for Policy Application

PGO Geomorphology Subcommittee Next STEPs:

Continue to engage with the Ministry (NDMNRF) as stakeholder in geohazard policies and technical guidelines for erosion hazard assessments

Welcome consultation with municipal and conservation authority stakeholders

Email: geomorphology@pgo.ca





Great Lakes – St. Lawrence River System and large inland lakes, river and stream systems and hazardous sites. An introductory guide for public health and safety policies 3.1, provincial policy statement



2001



🕅 Ontario

Technical Guide River & Stream Systems: Erosion Hazard Limit

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PGX Thank You!

Under Our Feet and on the Horizon: A two-decade review of erosion hazard assessment in Ontario

Roger Phillips, Ph.D., P.Geo.



Thursday, October 21st, 2021

