PGO
PROFESSIONAL GEOSCIENTISTS ONTARIO

Under Our Feet and on the Horizon:

A two-decade review of erosion hazard assessment in Ontario

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Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Thursday, October 21st, 2021

Outline

Background

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

Under Our Feet

- Guideline Document Reviews
- Select Definitions and Topics for Discussion

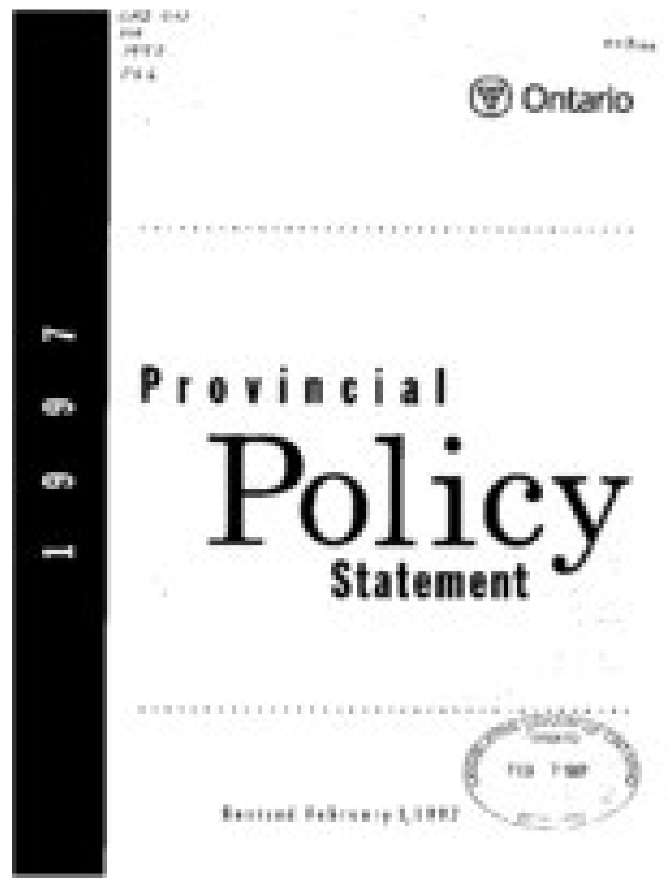
On the Horizon

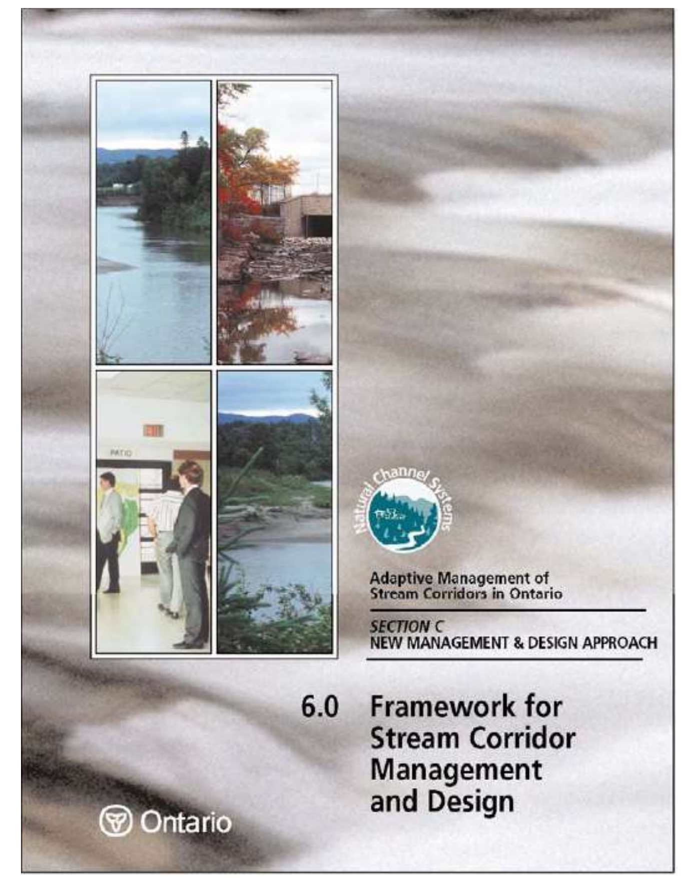
- Recommendations and Next Steps

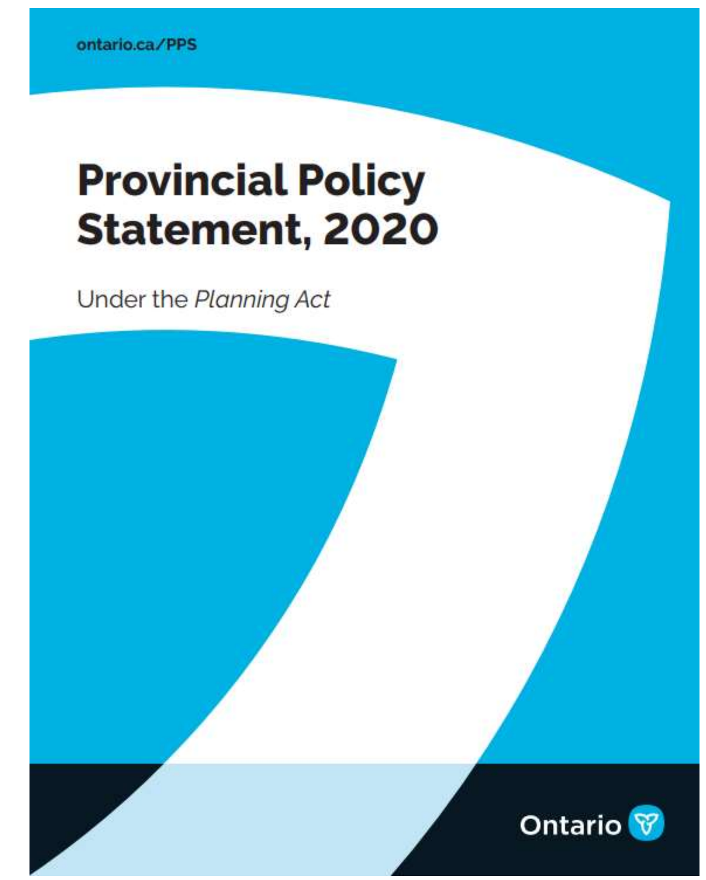
Background

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







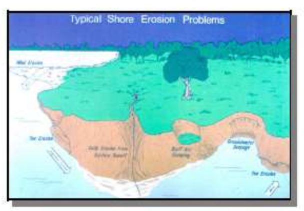
Which Guidelines?

PGO

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

PART 1

THE GREAT LAKES - ST. LAWRENCE RIVER SYSTEM: PHYSICAL FEATURES AND PROCESSES



PART 2

RECOMMENDED SHORELINE CLASSIFICATION SCHEME TO DETERMINE SHORELINE REACHES

PART 3

FLOODING HAZARD

PART 4

EROSION HAZARD

PART 5

DYNAMIC BEACH HAZARD

PART 6

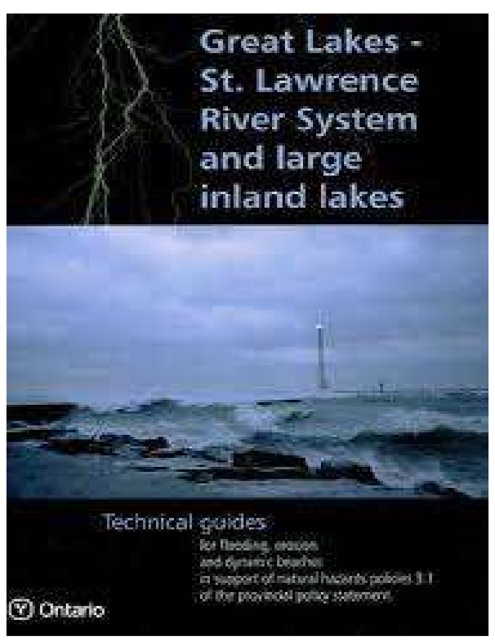
MAPPING AND STAKING HAZARDOUS LANDS

PART 7

ADDRESSING THE HAZARDS

PART 8

ENVIRONMENTALLY SOUND HAZARD MANAGEMENT WITHIN THE HAZARDOUS LANDS



1996

HAZARDOUS SITES

TECHNICAL GUIDE

Ministry of Natural Resources

Version 1.0

December 1996

Hazardous Sites

PROVINCE OF ONTARIO

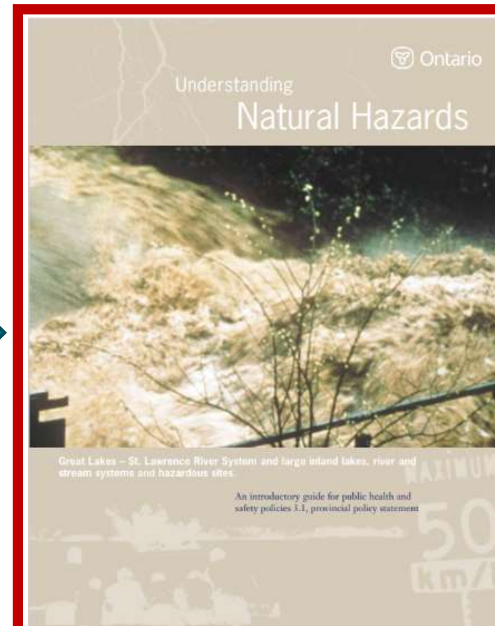
MINISTRY OF NATURAL RESOURCES

TECHNICAL GUIDE FOR LARGE INLAND LAKES

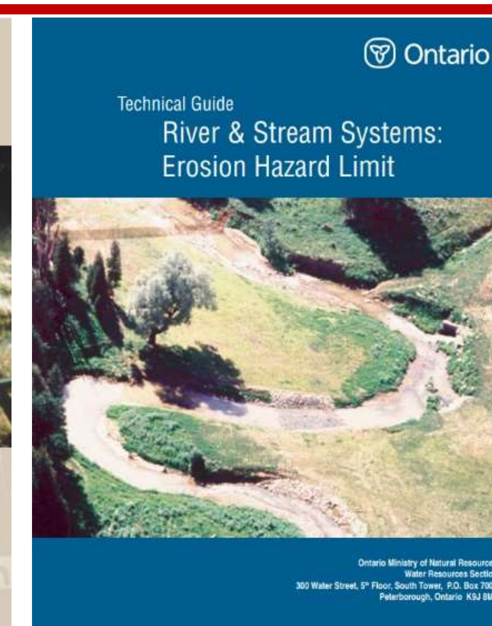
1996

Large Inland Lakes

2001



2002



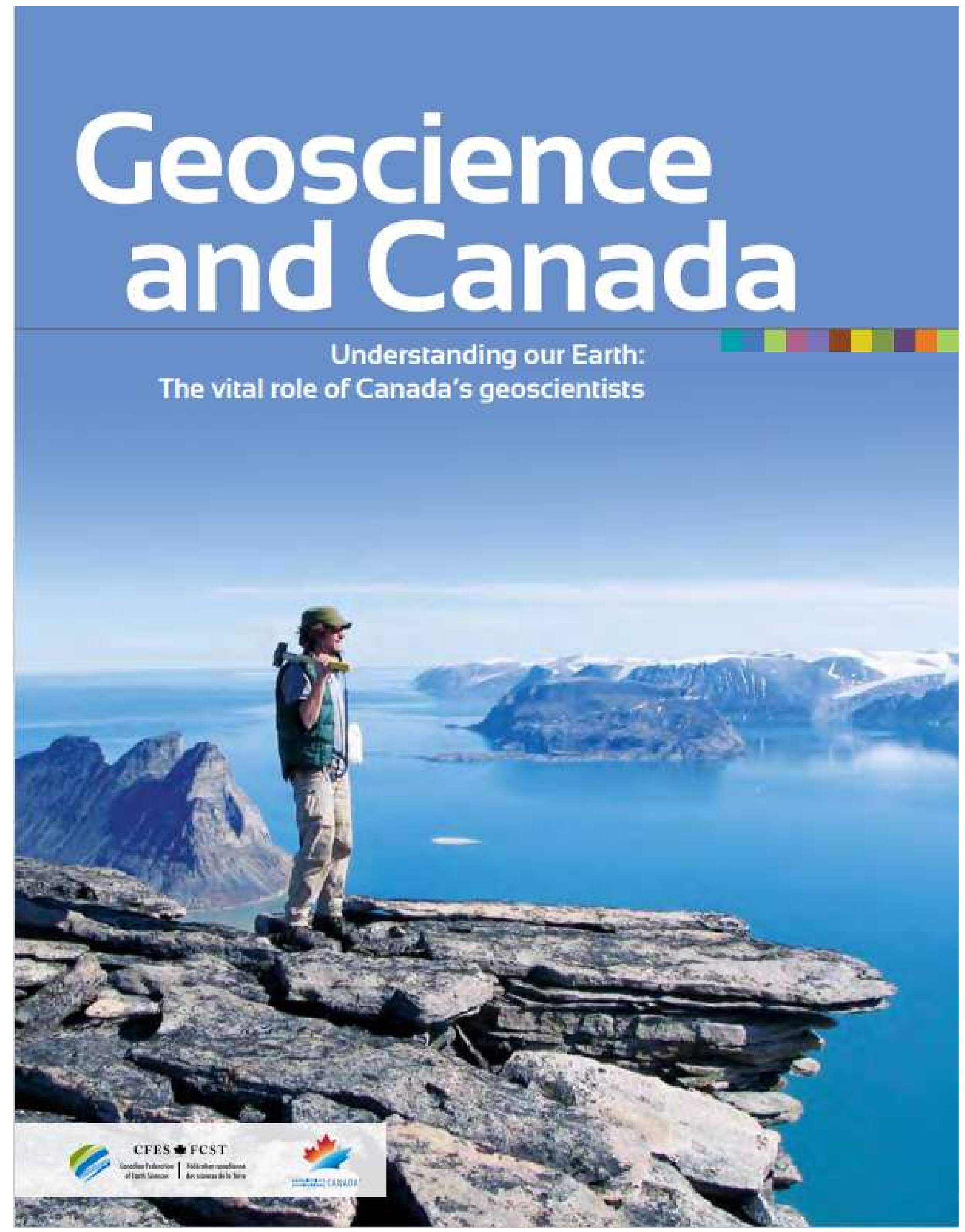
2002

Guideline Document Review for Erosion Assessment

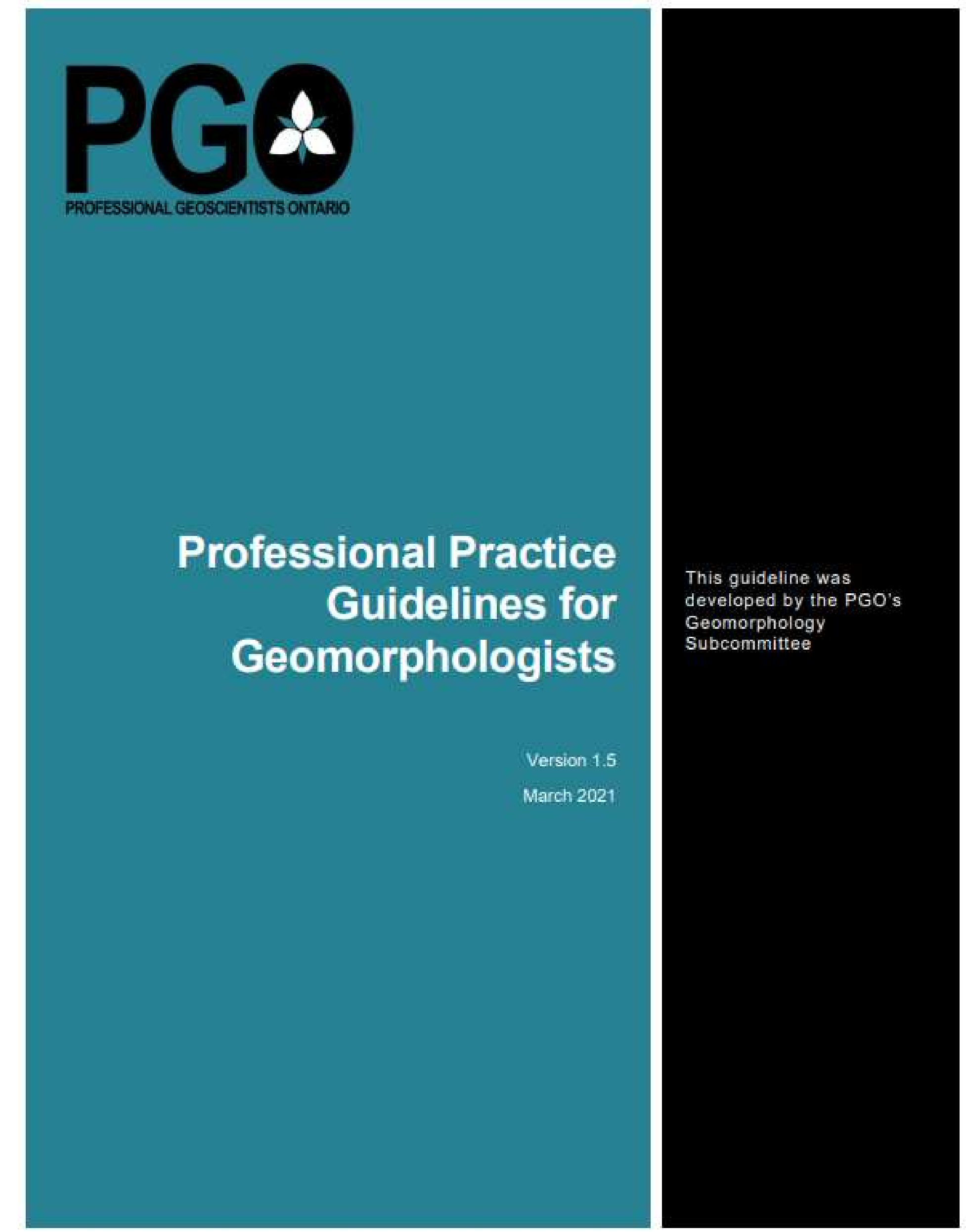
Why Professional Geoscientists Ontario, PGO?

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



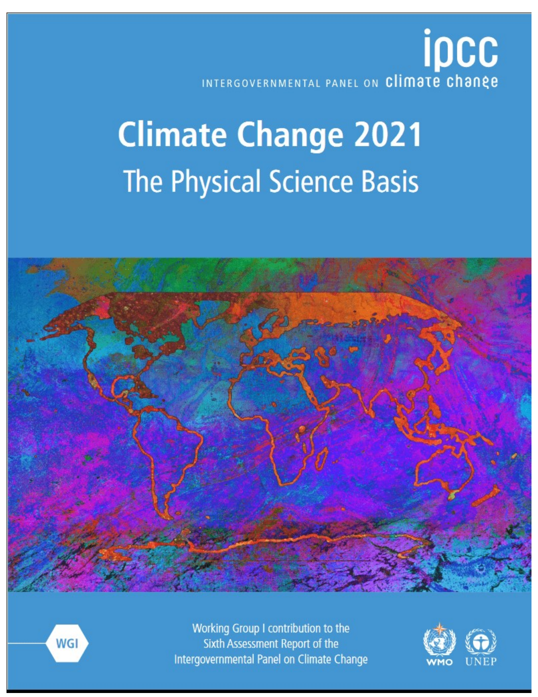
Geohazards, Engineering, and Infrastructure
https://geoscientistscanada.ca/publications.php



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)]

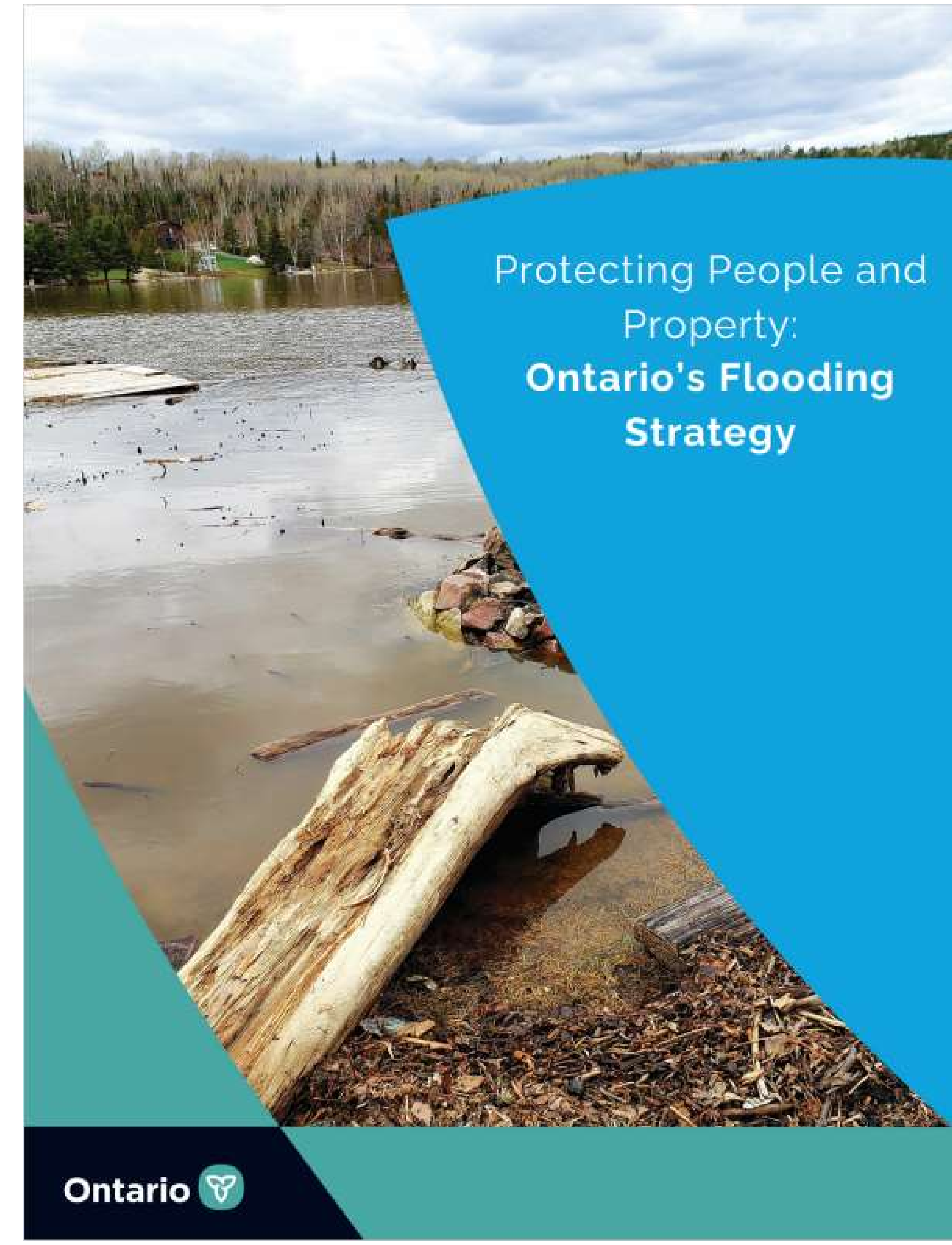
Ontario's Special Advisor on Flooding Report to Government

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]

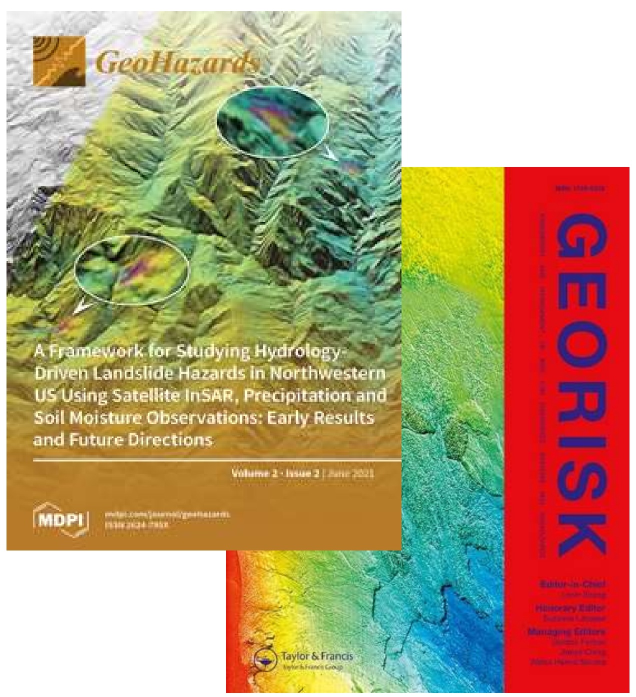


[Ontario 2020 Flooding Strategy]

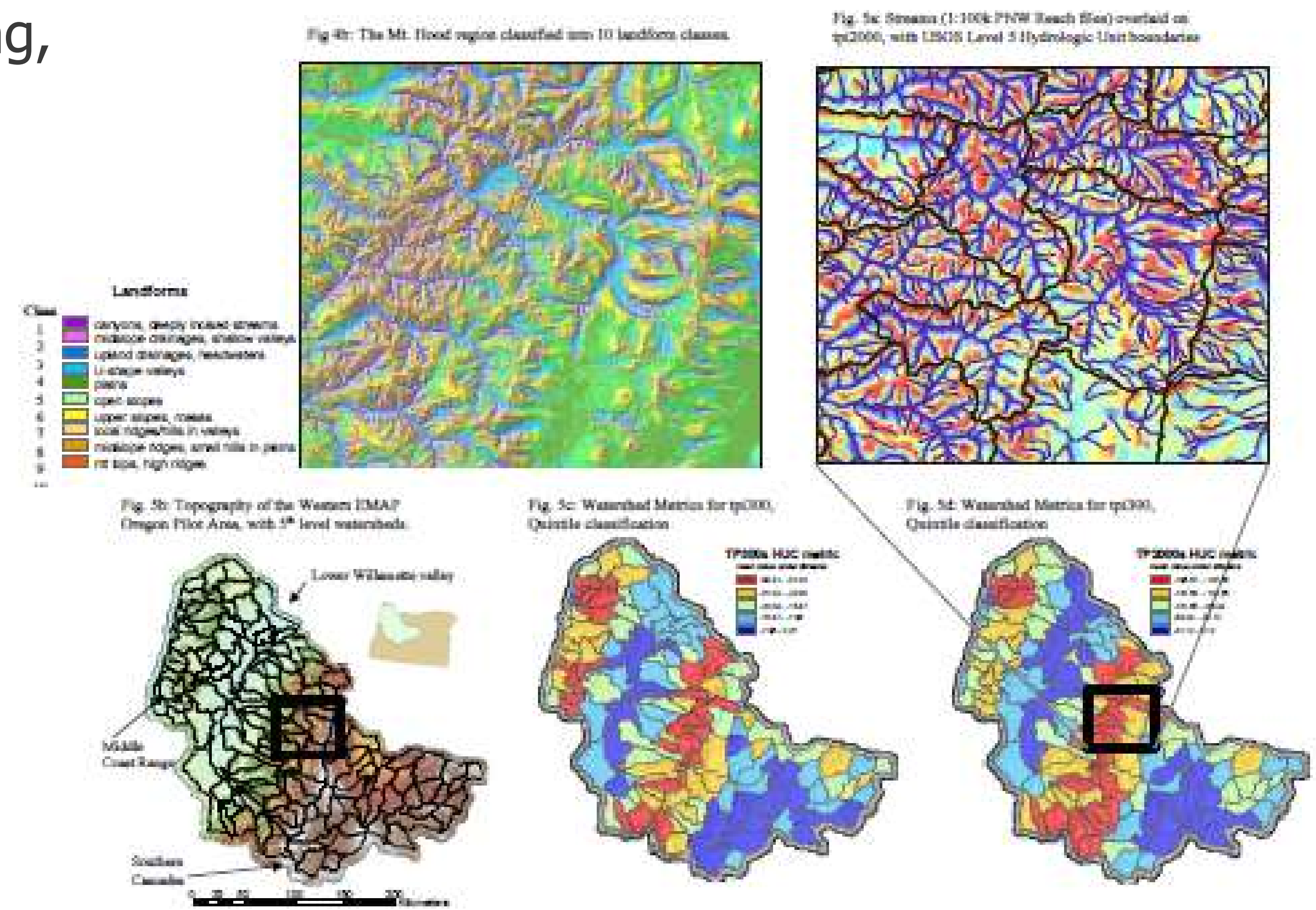
Why Now?

Better leverage scientific and technological advancements since 1990s

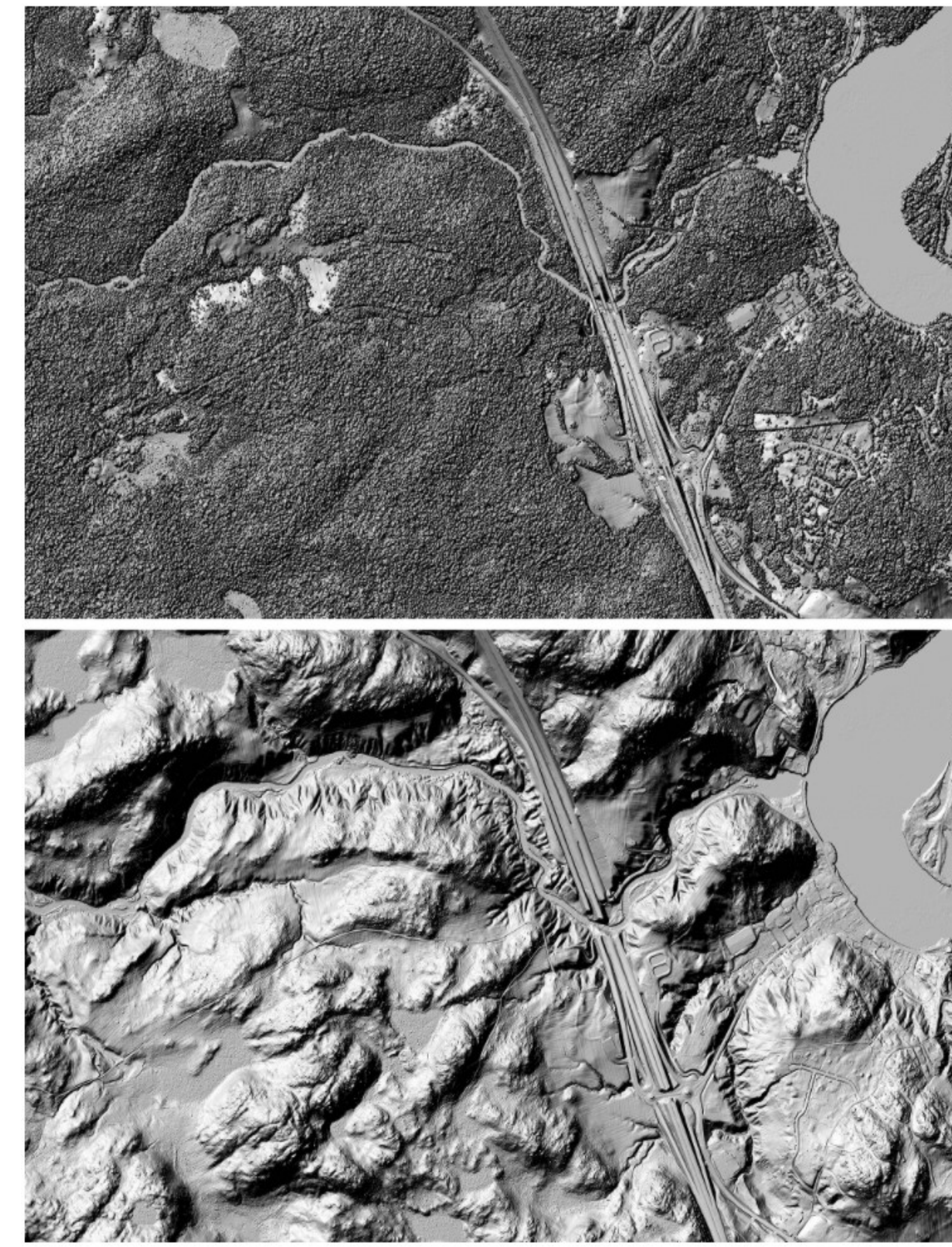
- Geographic information systems (GIS), remote sensing and LiDAR
- Advanced computing, 3D modelling, visualizations, geostatistics



Geohazard Journals



Advanced GIS Applications (e.g., Weiss, 2001)
http://www.jennessent.com/downloads/tpi-poster-tnc_18x22.pdf



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

Guideline Document Reviews

Erosion Hazard Assessment

Understanding Natural Hazards (2001)

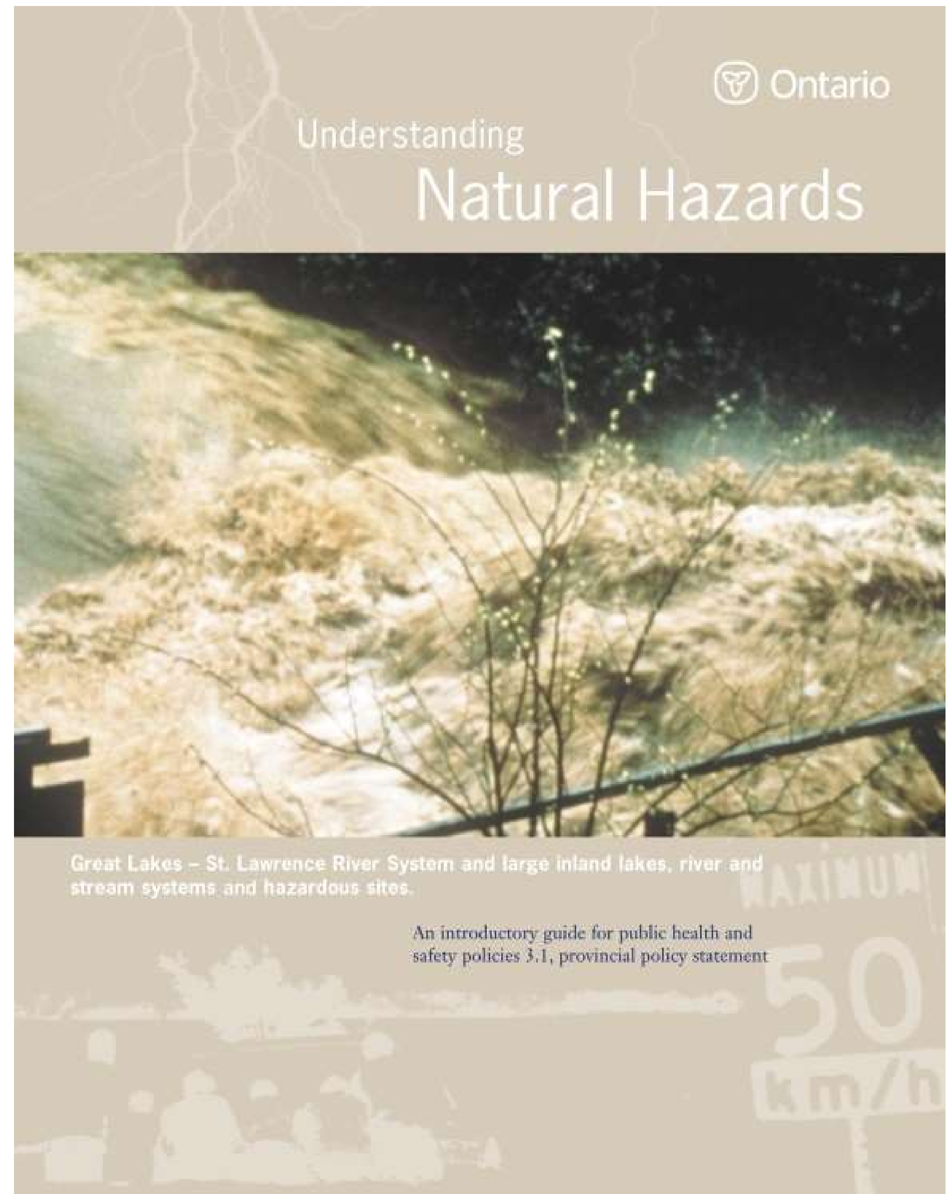
- Great Lakes – St Lawrence River System and Large Inland Lakes
- River and Stream Systems
- Hazardous Sites

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

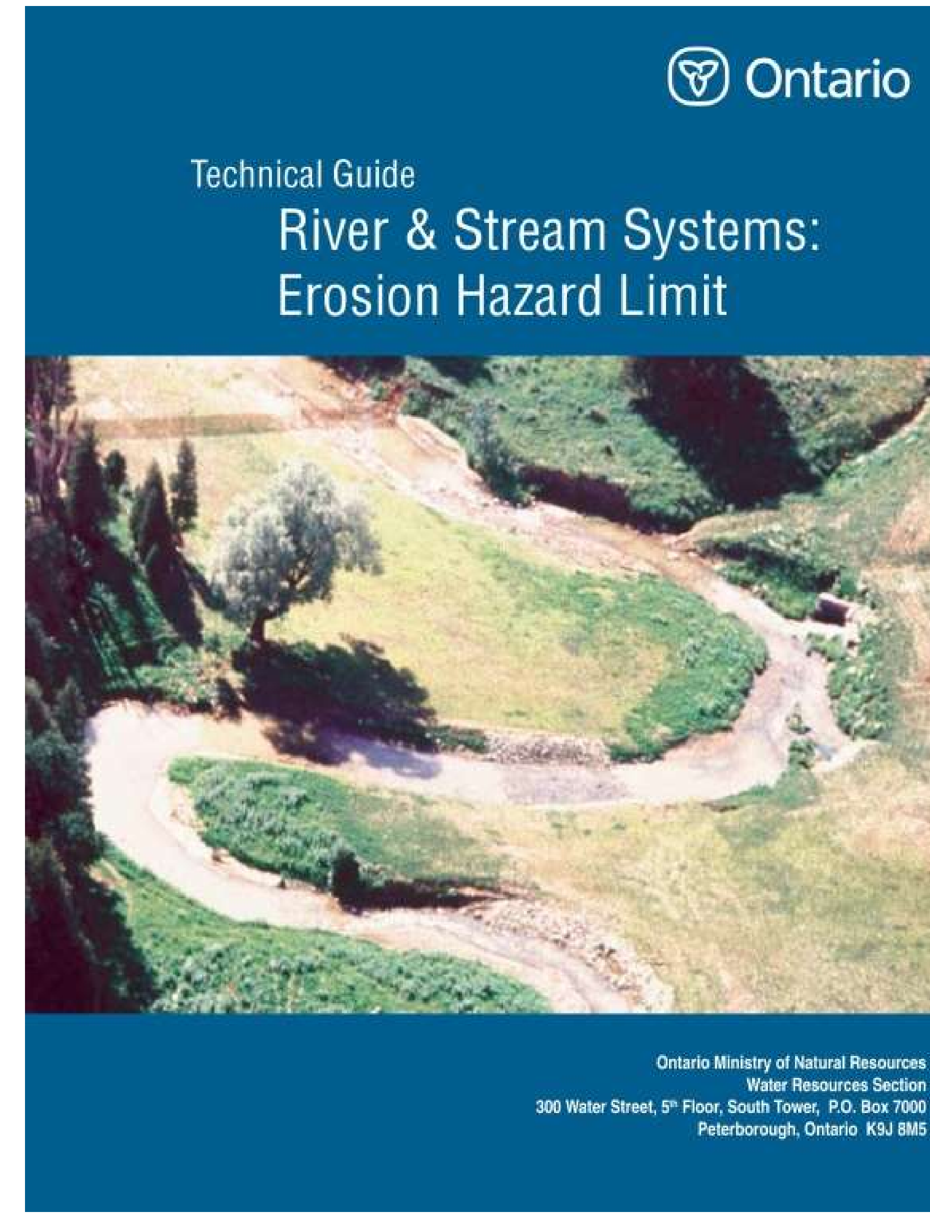
- Erosion Processes
- Application of Provincial Policy
- Site Investigations and Studies

Updates Recommended to Address:

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



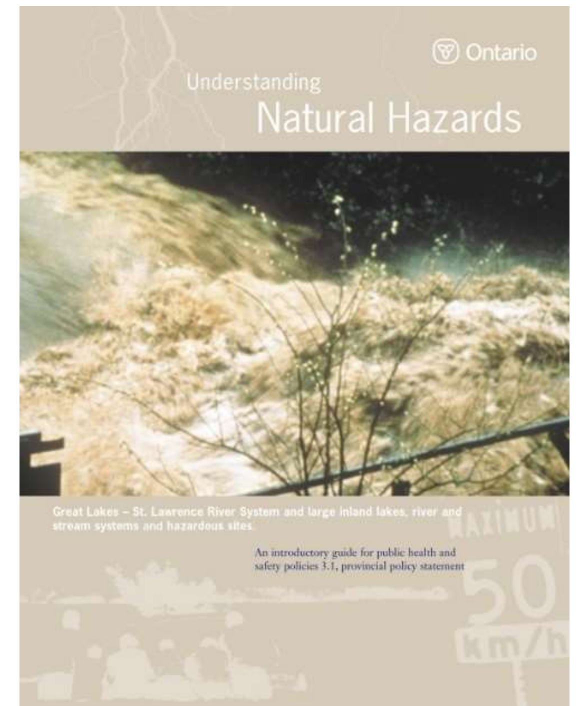
2001

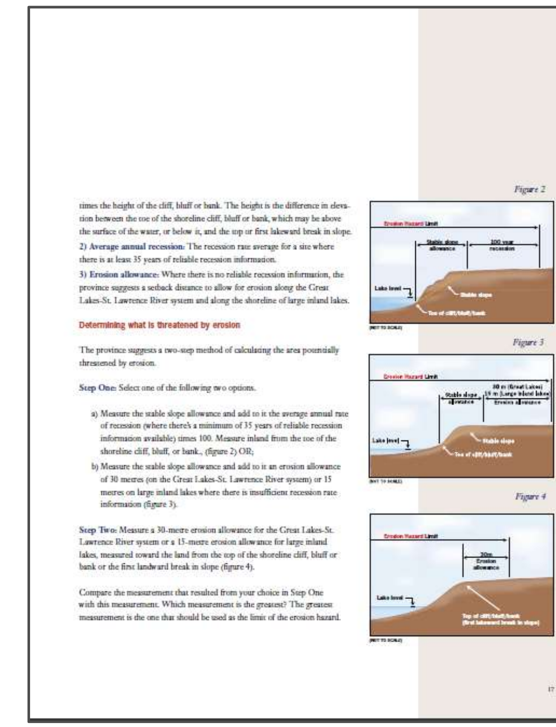


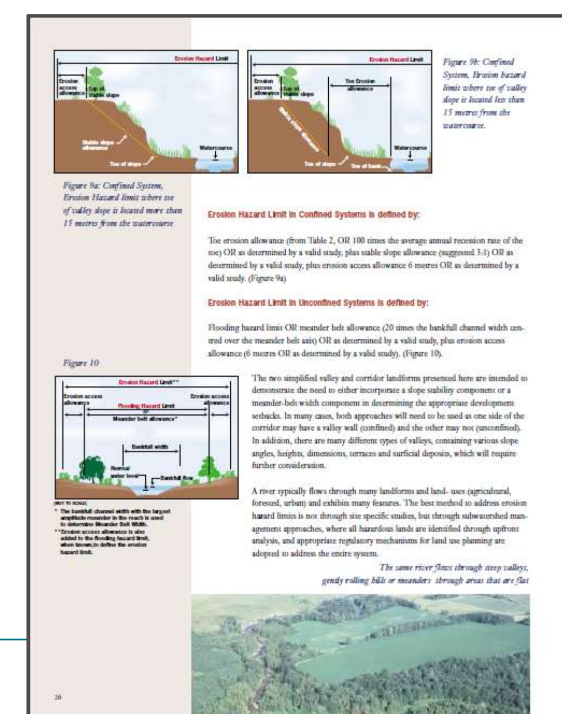
2002

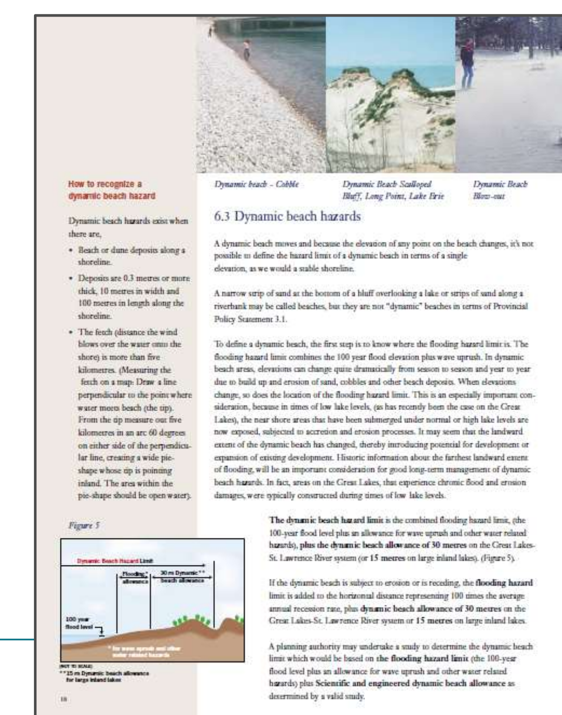
Understanding Natural Hazards (2001)

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



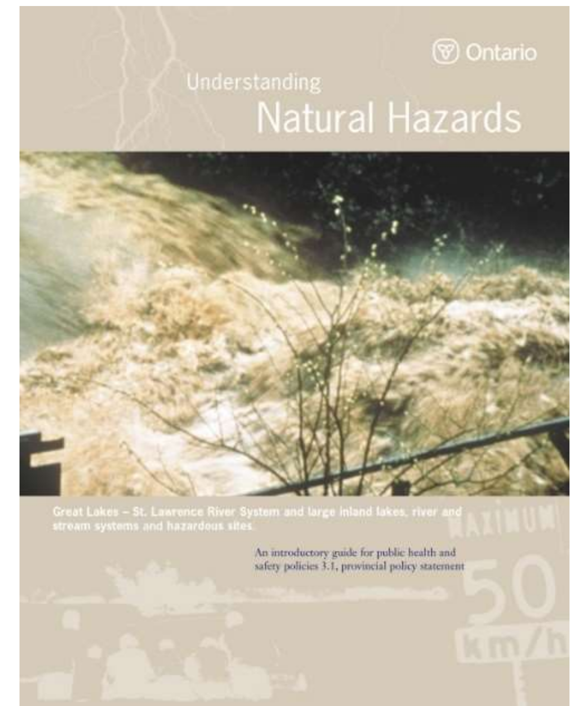


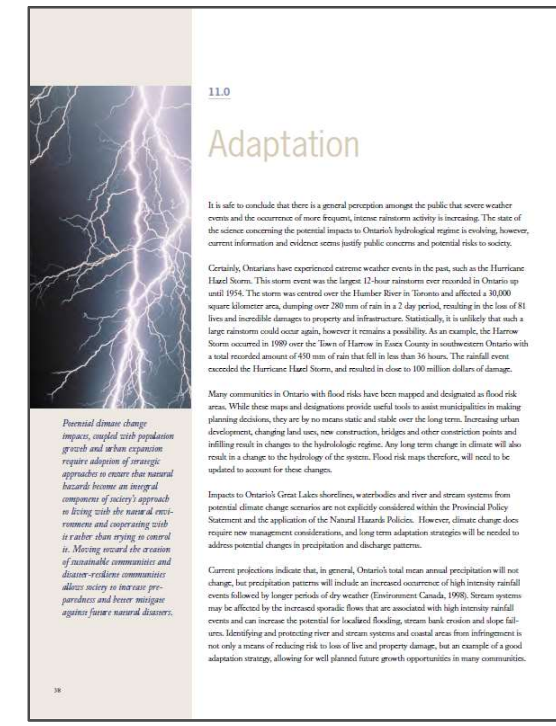


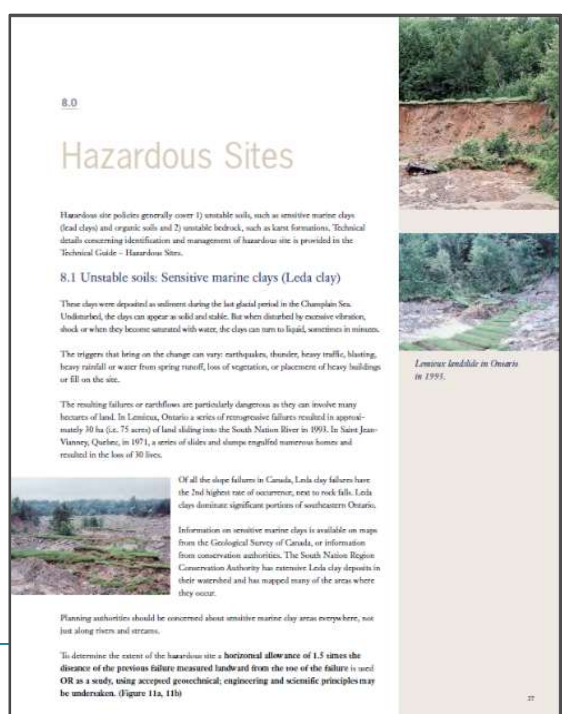


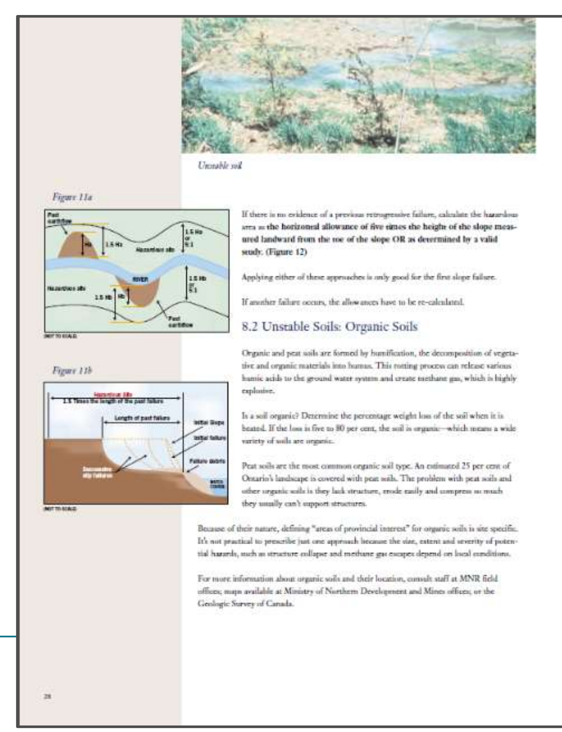
Understanding Natural Hazards (2001)

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


Ontario
Understanding
Natural Hazards
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


11.0
Adaptation


8.0
Hazardous Sites
8.1 Unstable soils: Sensitive marine clays (Leda clay)


8.2 Unstable Soils: Organic Soils

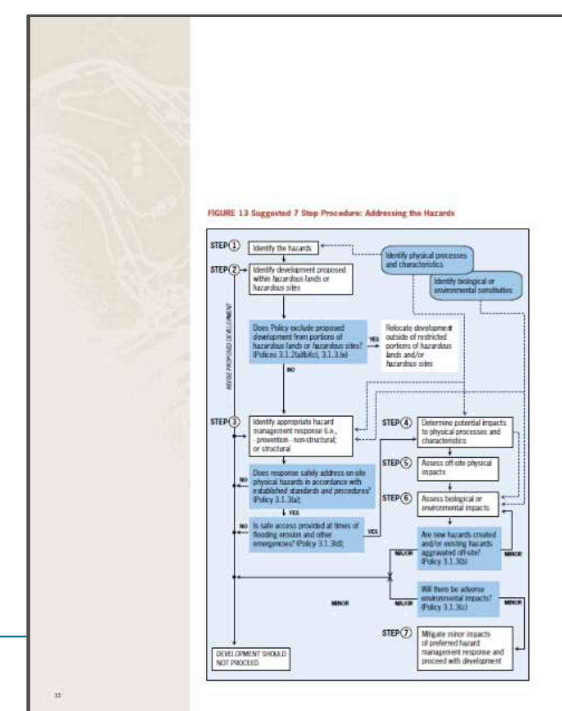
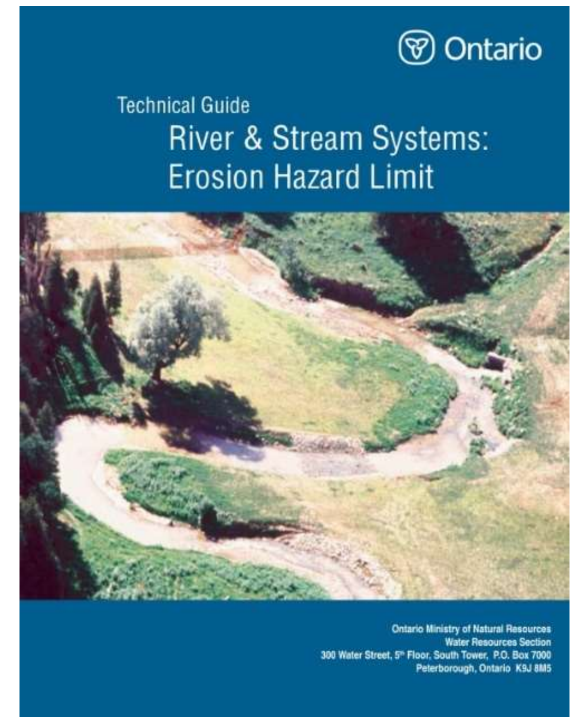


FIGURE 13 Suggested 7 Step Procedure: Addressing the Hazards


12.0
Implementation

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


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

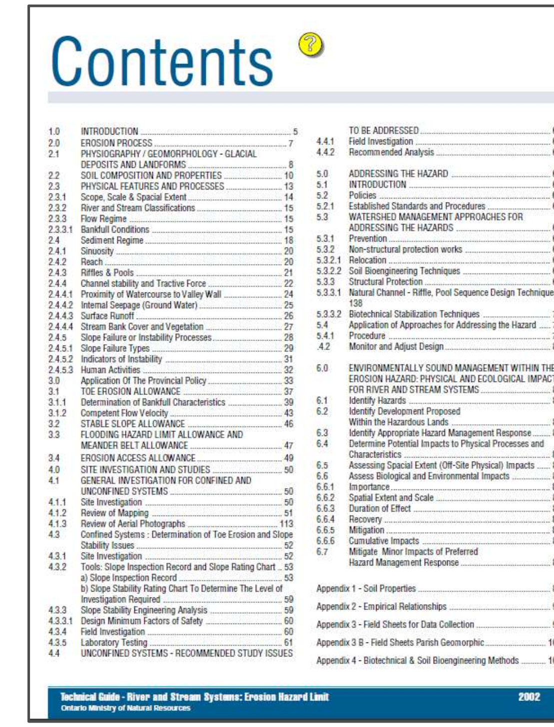

Contents


Figure 11 - Confined system
Figure 12 - Confined system
Figure 13 - Confined system
Figure 14 - Unconfined system
Figure 15 - Unconfined system

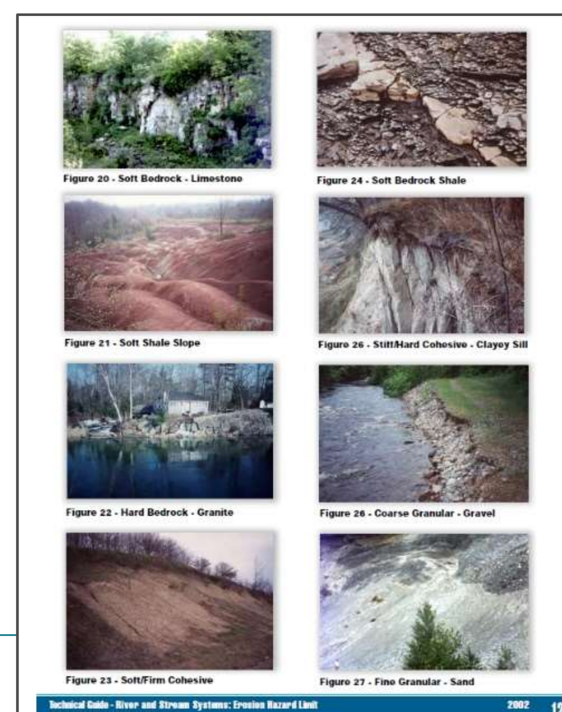
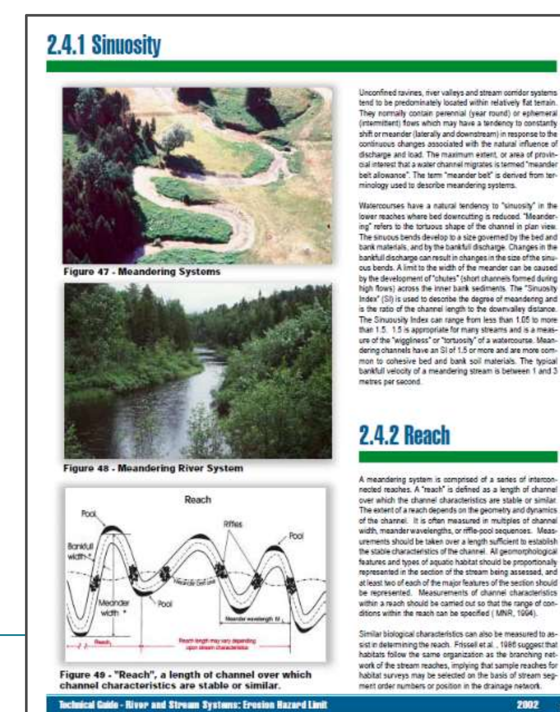


Figure 20 - Soft Bedrock - Limestone
Figure 21 - Soft Shale Slope
Figure 22 - Hard Bedrock - Granite
Figure 23 - Soft/Firm Cohesive
Figure 24 - Soft Bedrock Shale
Figure 26 - Coarse Granular - Gravel
Figure 27 - Fine Granular - Sand


2.4.1 Sinuosity
Figure 47 - Meandering Systems
Figure 48 - Meandering River System
2.4.2 Reach
Figure 49 - "Reach", a length of channel over which channel characteristics are stable or similar.

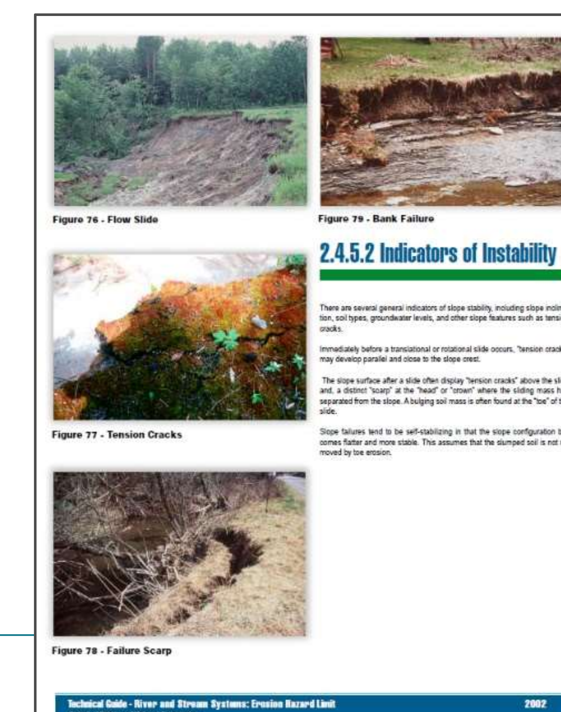
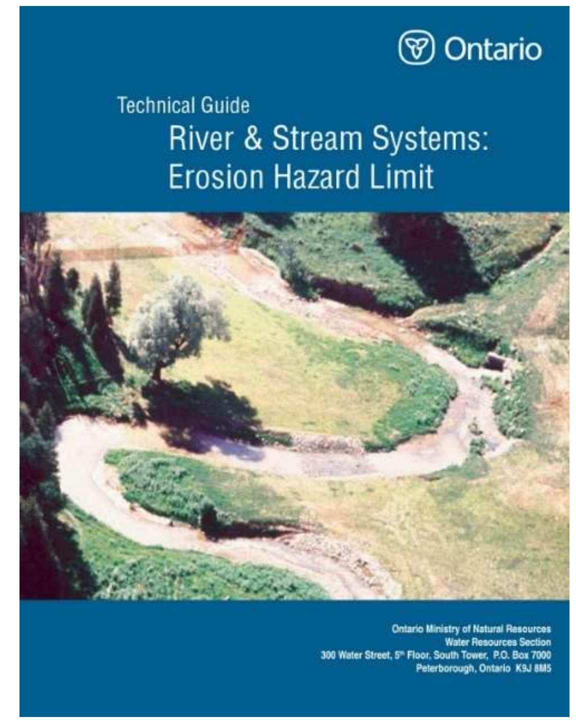


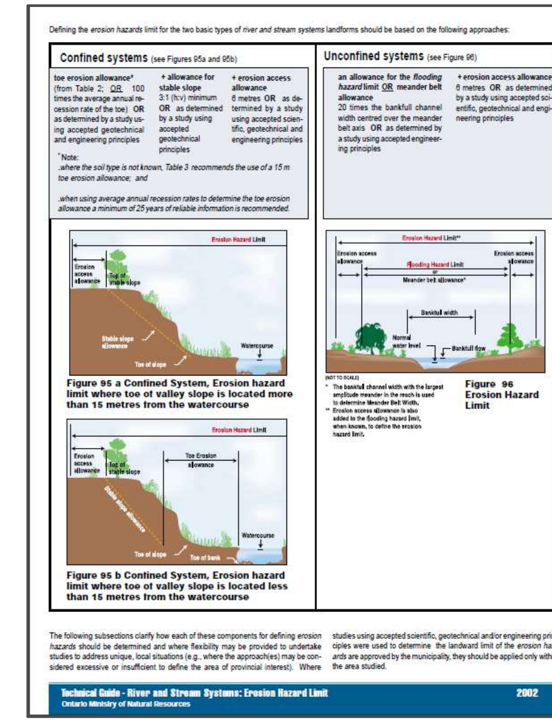
Figure 76 - Flow Slide
Figure 79 - Bank Failure
2.4.5.2 Indicators of Instability
Figure 77 - Tension Cracks
Figure 78 - Failure Scarp

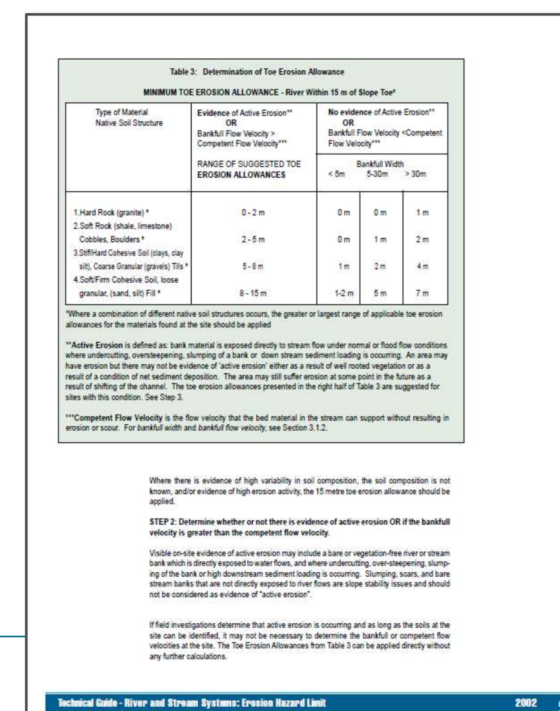
River & Streams Systems: Erosion Hazard Limit (2002)

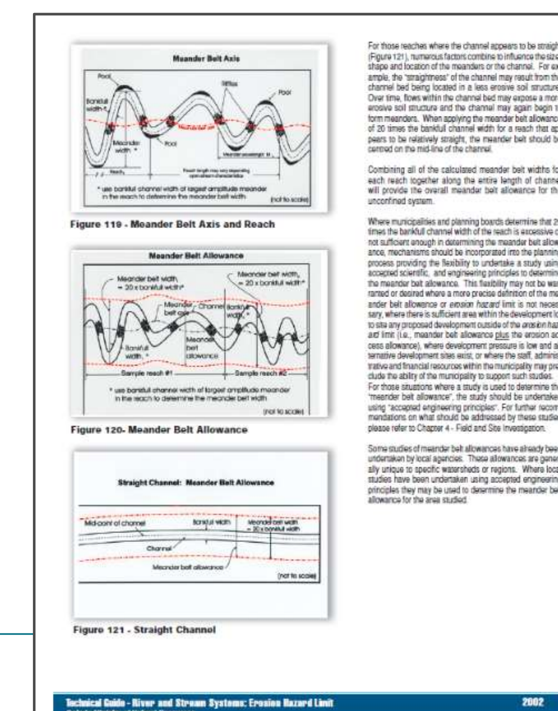
Section Title	Issues

3.0 Application of the Provincial Policy	Application of erosion hazards for specific systems at reach-scale, with reference to jurisdictions outside of Ontario (e.g., Quebec, various US states, scientific literature):
	• **Unconfined meander belts**
	• **Confined systems**, combined with geotechnical stable slope hazards, and complex partially confined systems
	• Headwater drainage features (HDF), generic standards for low-risk features
	• Existing erosion control structures (new and old)
	• Update **toe erosion allowance guidelines** (15 m and Table 3), scaled to channel size
	• Standardized definition and application of **erosion access allowance**
	• Erosion thresholds (competent flow velocity), advancements in theory and applications
	• Improved definitions of geomorphological terms / concepts:
	    ○ **Reach scale**
	    ○ Active erosion
	    ○ Bankfull and Top of bank
	• Update standards for field data collection and for use of geospatial data sources (e.g., LiDAR)





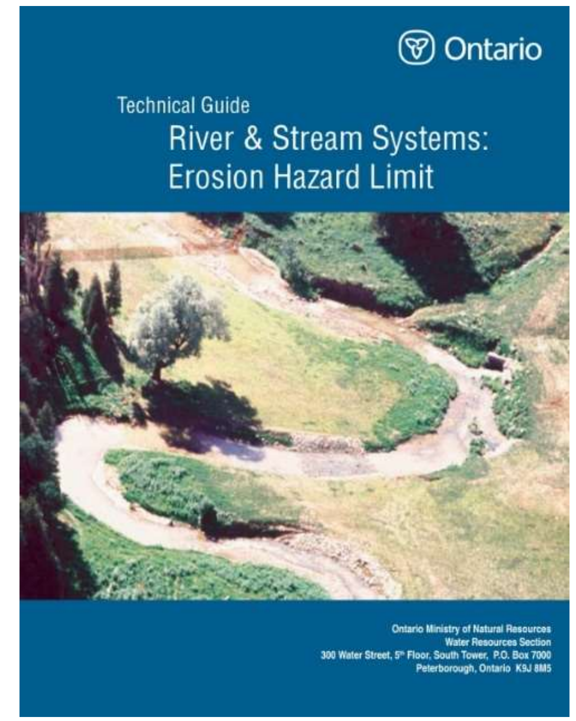


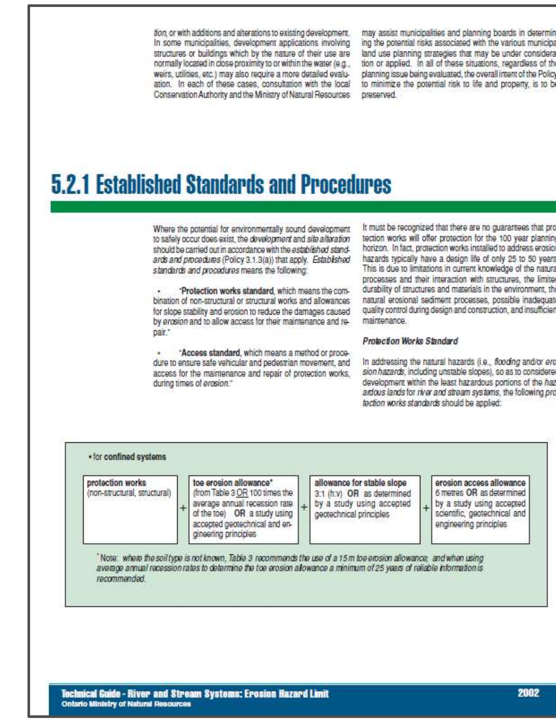


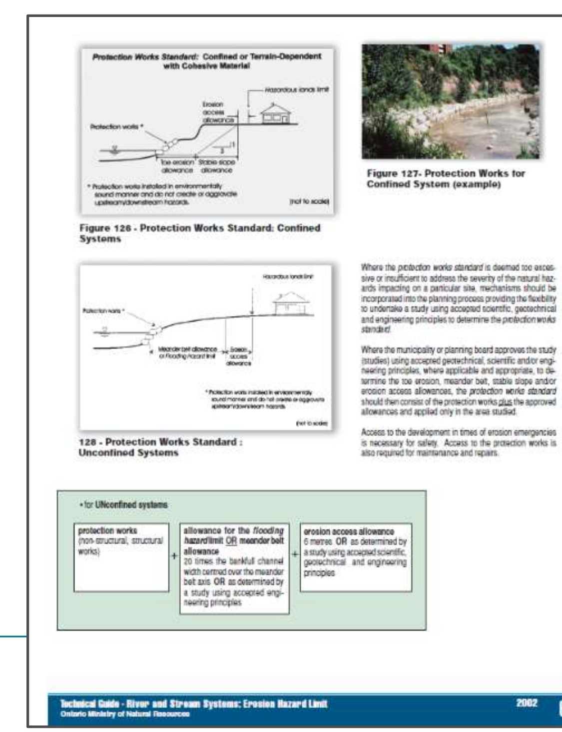
Technical Guide

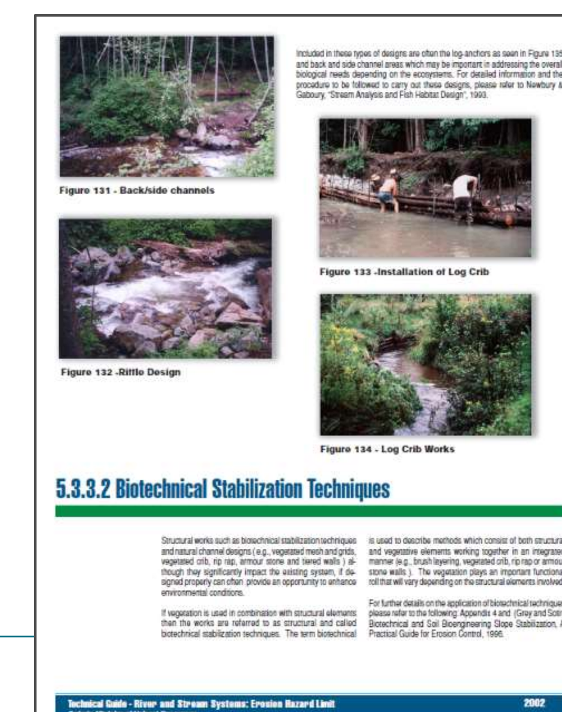
River & Streams Systems: Erosion Hazard Limit (2002)

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





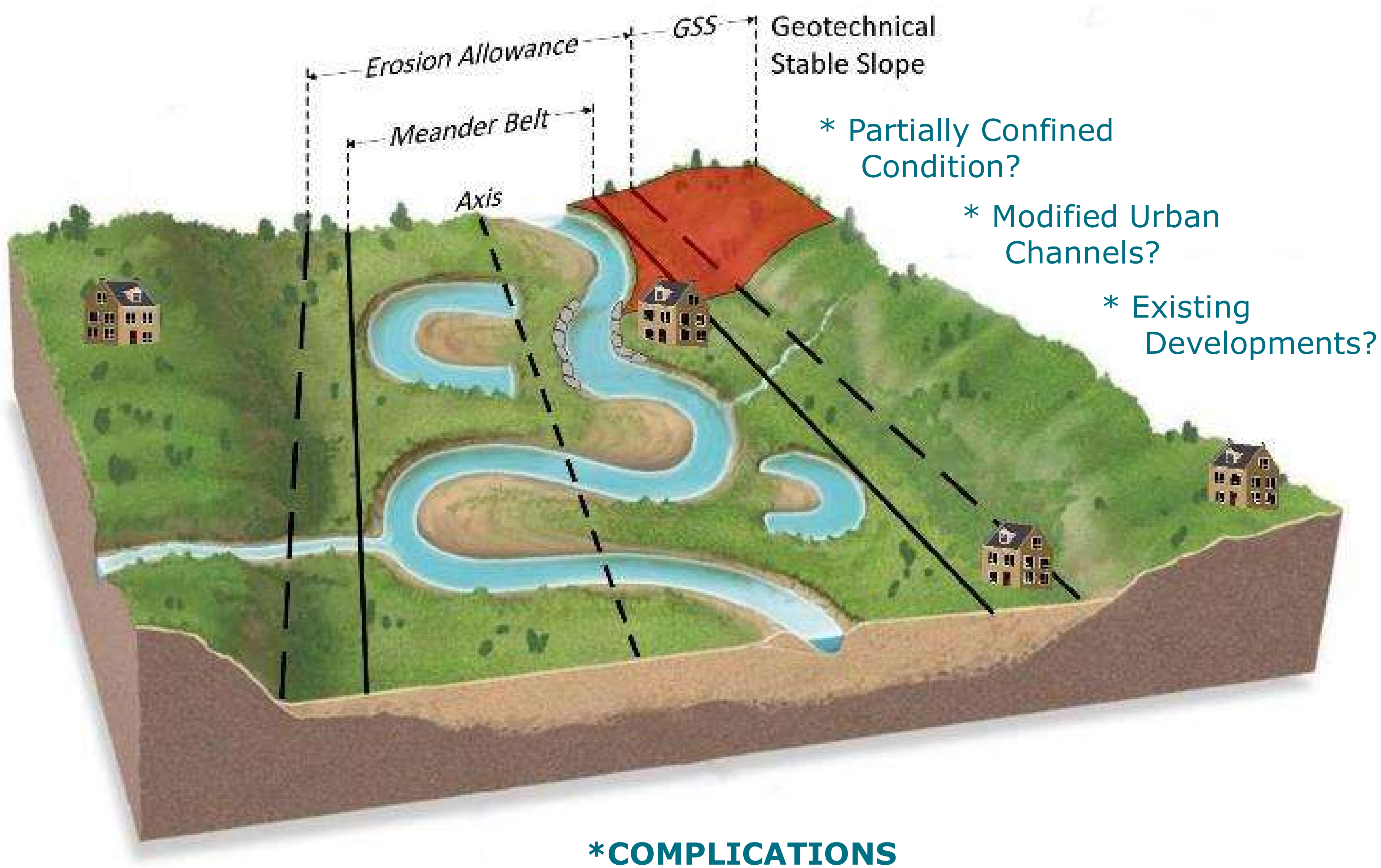




Erosion Hazard Assessment

Select Definitions and Topics for Discussion

- Simple Ideas, Tough Challenges



*COMPLICATIONS

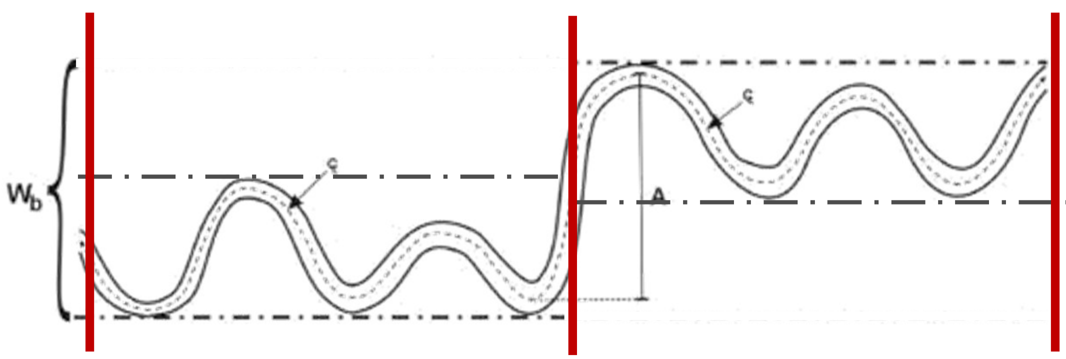
Definitions and Concepts

1. Stream reaches
2. Meander belts for unconfined reaches
3. 100-year erosion allowance
4. Confined systems
5. Erosion access allowance
6. Erosion control measures

Stream Reaches

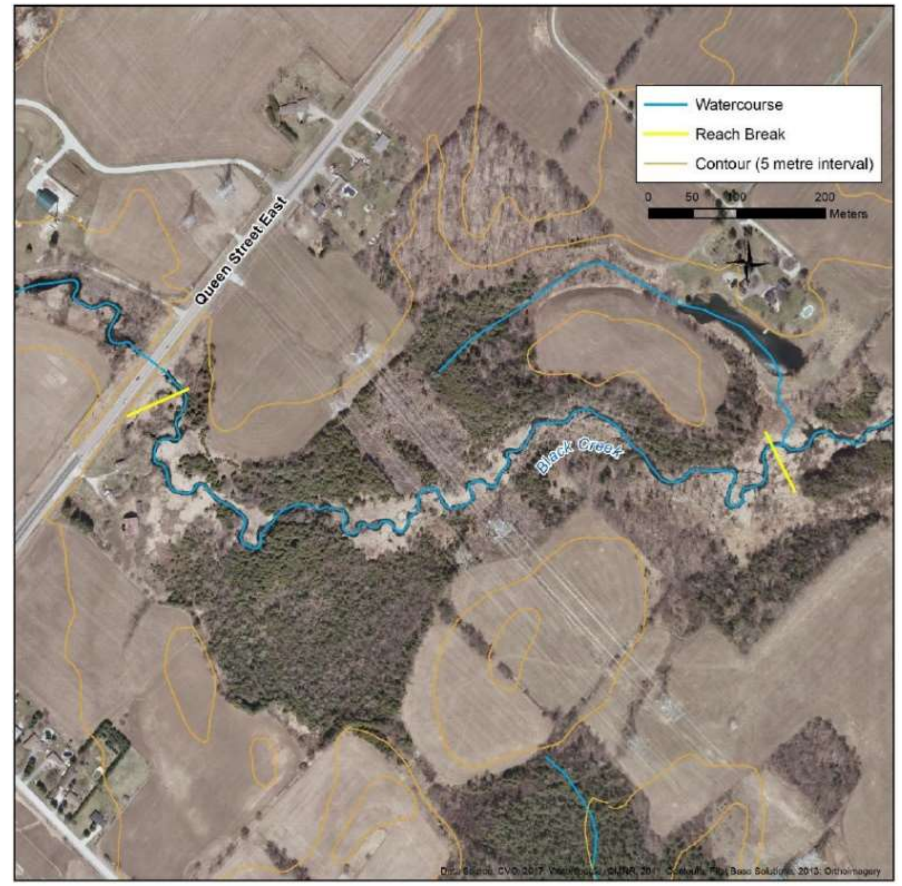
Reaches are lengths of channel that display similarity with respect to valley/floodplain setting, channel form, and function. The controlling influences of channel form and function should be nearly constant within the reach.

TRCA (2004) Belt Width Delineation Procedures



Challenge:

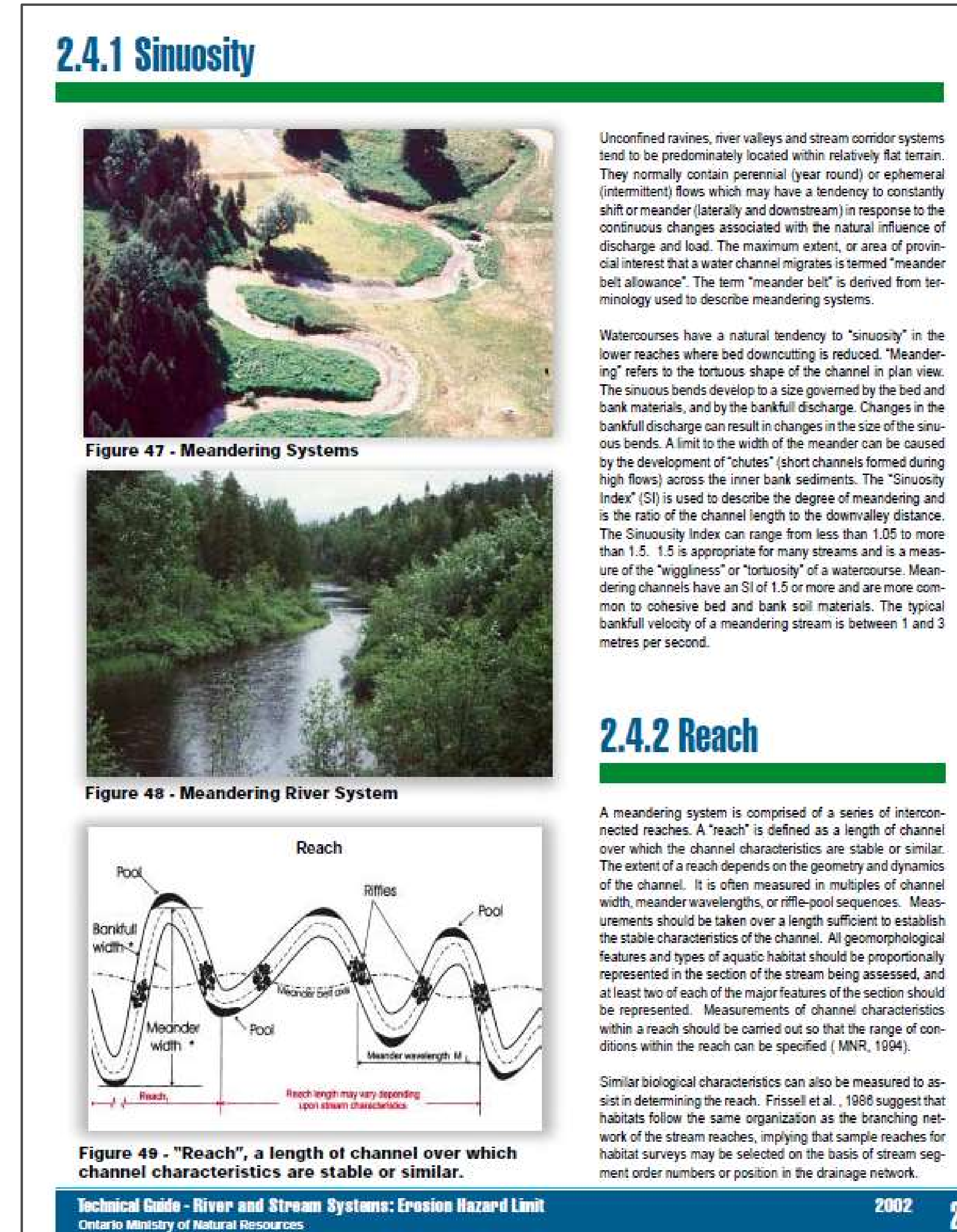
Where reach breaks are identified, and the length of reaches, can significantly change the meander belt width.



Howett (2017)

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

Figure 47 - Meandering Systems

Figure 48 - Meandering River System

Unconfined ravines, river valleys and stream corridor systems 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 terminology 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 "Sinuosity 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 channels have an SI 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

Figure 49 - "Reach", a length of channel over which channel characteristics are stable or similar.

A meandering system is comprised of a series of interconnected 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 characteristics 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 assist 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.

Technical Guide - River and Stream Systems: Erosion Hazard Limit
Ontario Ministry of Natural Resources 2002 20

Meander Belts for Unconfined Reaches

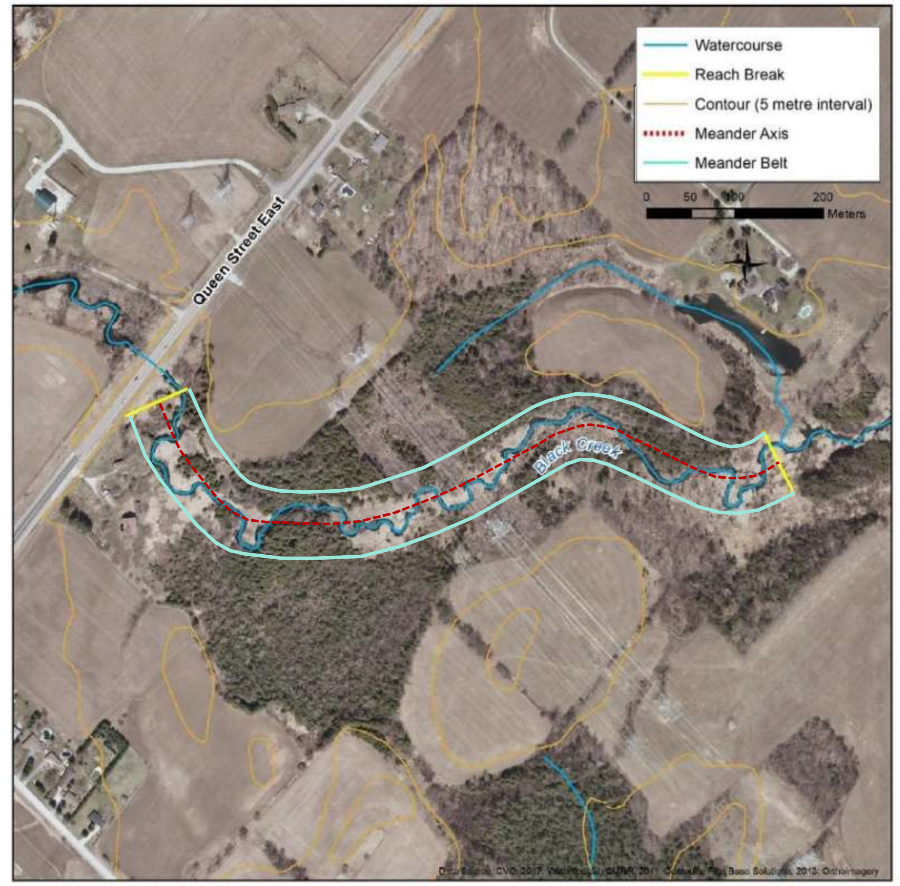
The term **meander belt allowance**, for the purposes of defining the "area of provincial interest", is essentially the maximum extent that a water channel migrates. MNR (2002) Erosion Hazard Limit

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.

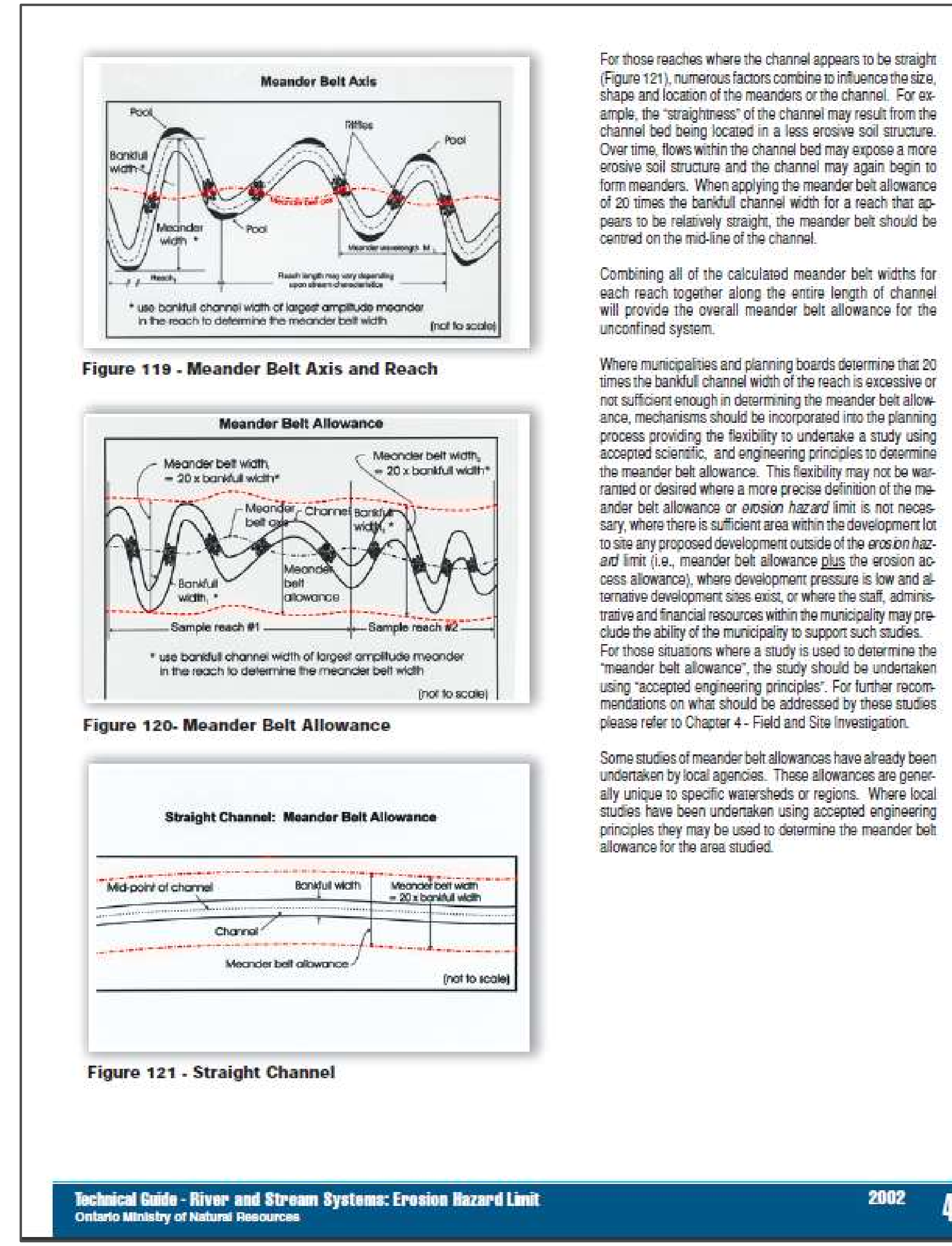


Modified from Howett (2017)

Different Approaches from Other Jurisdictions:

Washington State (2003), Channel Migration Zones

Quebec (Bill 67, 2020) Mobility Zones



Meander Belt Axis

Figure 119 - Meander Belt Axis and Reach

Meander Belt Allowance

Figure 120- Meander Belt Allowance

Straight Channel: Meander Belt Allowance

Figure 121 - Straight Channel

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 expose a more erosive soil structure and the channel may again begin to form meanders. When applying the meander belt allowance of 20 times the bankfull channel width for a reach that appears to be relatively straight, the meander belt 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 meander 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 *erosion hazard* 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, administrative 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.

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100-Year Erosion Allowance

Confine Reaches

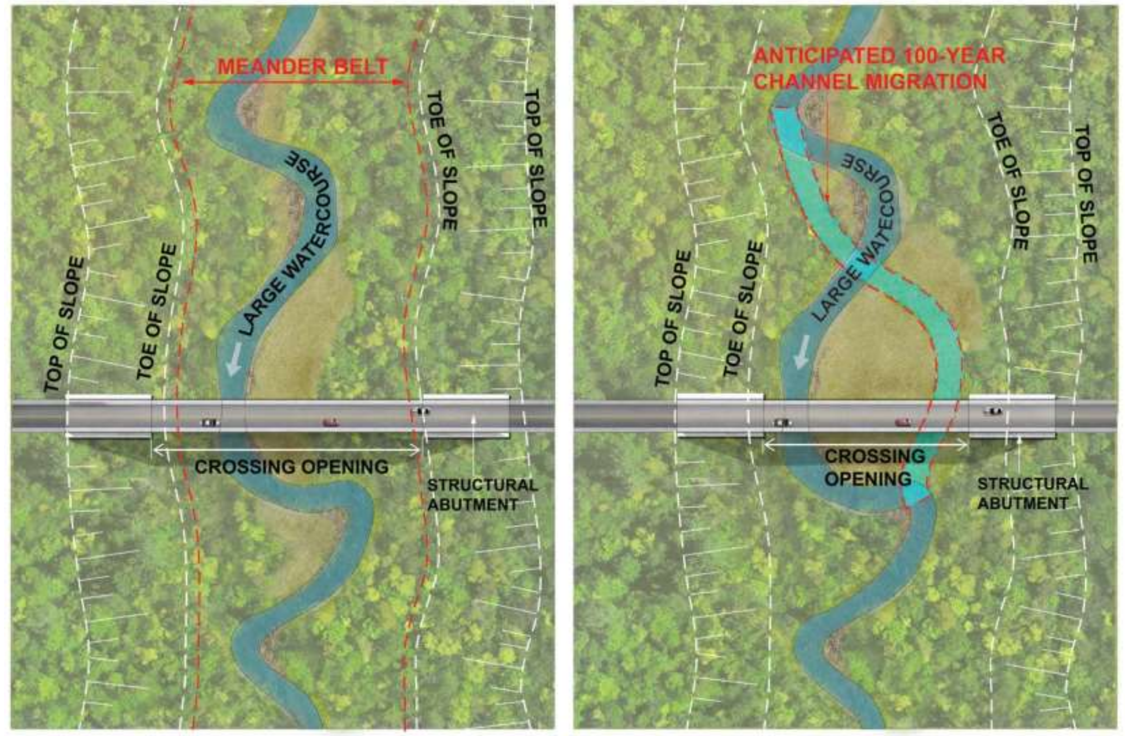
- 100-year toe erosion allowance in confined reaches (MNR, 2002; Table 3)

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

Table 3: Determination of Toe Erosion Allowance

MINIMUM TOE EROSION ALLOWANCE - River Within 15 m of Slope Toe*

Type of Material Native Soil Structure	**Evidence** of Active Erosion** OR Bankfull Flow Velocity > Competent Flow Velocity*** RANGE OF SUGGESTED TOE **EROSION ALLOWANCES**	**No evidence** of Active Erosion** OR Bankfull Flow Velocity <Competent Flow Velocity*** Bankfull Width < 5m	 5-30m	 > 30m
1.Hard Rock (granite) *	0 - 2 m	0 m	0 m	1 m
2.Soft Rock (shale, limestone) Cobbles, Boulders *	2 - 5 m	0 m	1 m	2 m
3.Stiff/Hard Cohesive Soil (clays, clay silt), Coarse Granular (gravels) Tills *	5 - 8 m	1 m	2 m	4 m
4.Soft/Firm Cohesive Soil, loose granular, (sand, silt) Fill *	8 - 15 m	1-2 m	5 m	7 m

*Where a combination of different native soil structures occurs, the greater or largest range of applicable toe erosion 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 conditions 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.

*****Competent Flow Velocity** is the flow velocity that the bed material in the stream can support without resulting in erosion 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 not known, and/or evidence of high erosion activity, the 15 metre toe erosion allowance should be applied.

STEP 2: Determine whether or not there is evidence of active erosion OR if the bankfull 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

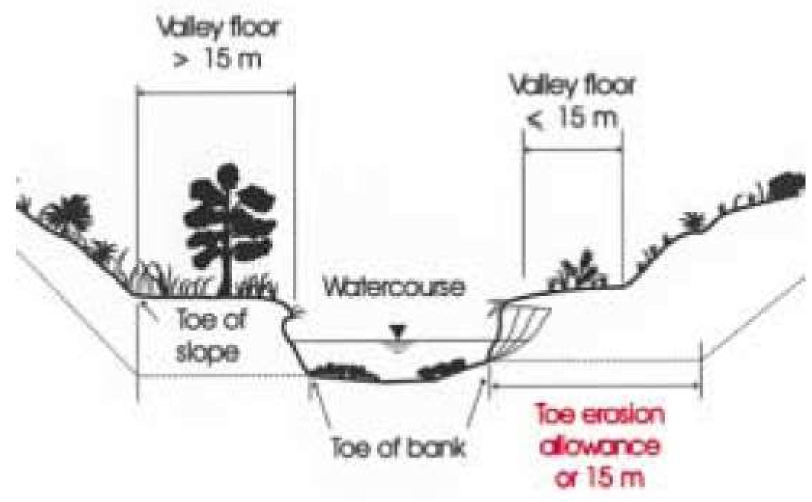
The confined river valley or stream system is one in which the physical presence of a valley corridor containing a river or stream channel is **visibly detectable** from the surrounding landscape...

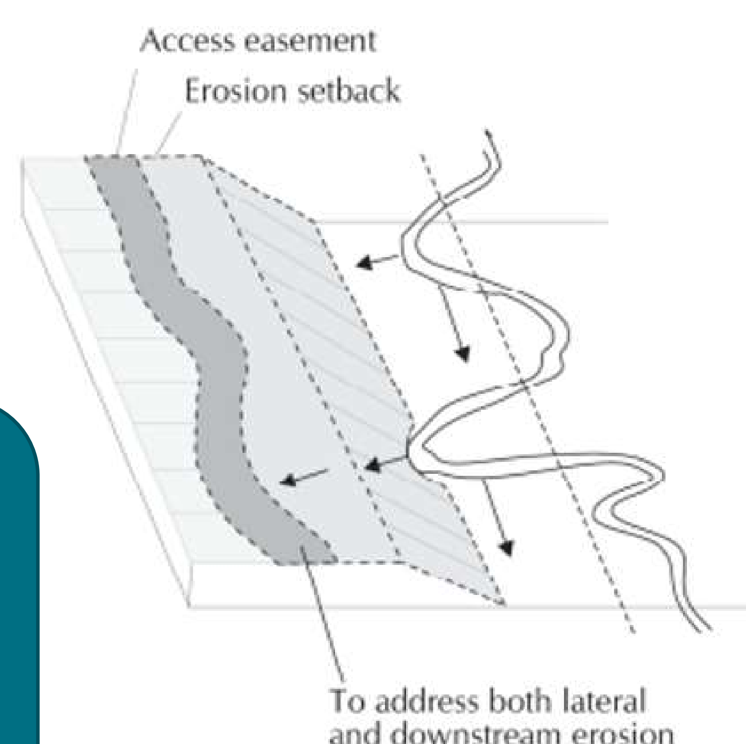
The location of the river or stream channel may be located at the base or toe of the valley slope, in close proximity to the valley slope toe (**less than 15 m**) or removed from the valley slope toe (15 m or more).

MNR (2002) Erosion Hazard Limit

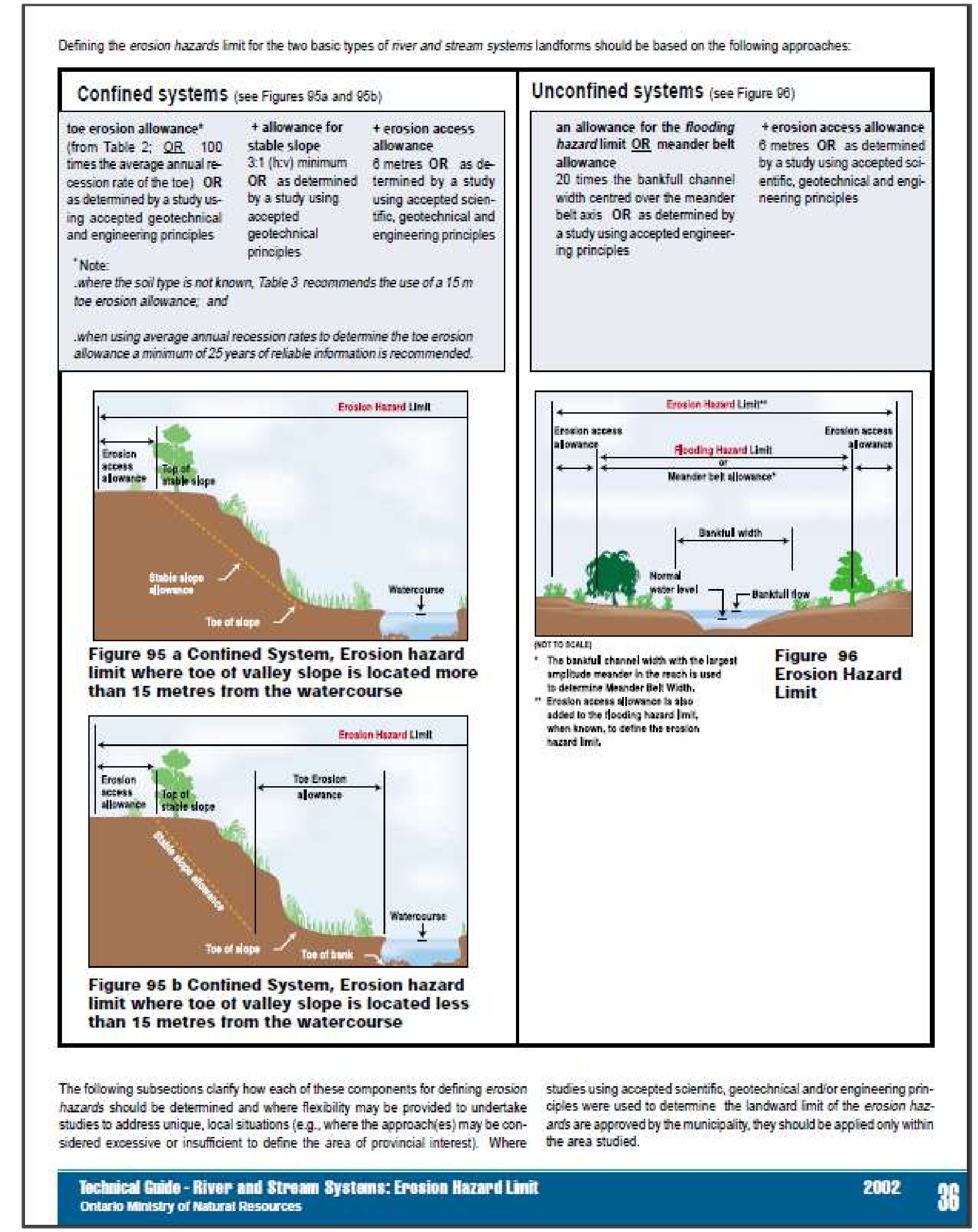
Challenges:

- 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





CVC (2015)



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

Confined systems (see Figures 95a and 95b)

toe erosion allowance* (from Table 2; OR 100 times the average annual recession rate of the toe) OR as determined by a study using accepted geotechnical and engineering principles

+ allowance for stable slope 3:1 (h:v) minimum OR as determined by a study using accepted geotechnical principles

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

*Note:
.where the soil type is not known, Table 3 recommends the use of a 15 m toe erosion allowance; and
.when using average annual recession rates to determine the toe erosion allowance a minimum of 25 years of reliable information is recommended.

Unconfined systems (see Figure 96)

an allowance for the *flooding hazard* limit OR meander belt allowance 20 times the bankfull channel width centred over the meander belt axis OR as determined by a study using accepted engineering principles

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

Figure 95 a Confined System, Erosion hazard limit where toe of valley slope is located more than 15 metres from the watercourse

Figure 95 b Confined System, Erosion hazard limit where toe of valley slope is located less than 15 metres from the watercourse

(NOT TO SCALE)

* The bankful channel width with the largest amplitude meander in the reach is used to determine Meander Belt Width.

** Erosion access allowance is also added to the flooding hazard limit, when known, to define the erosion hazard limit.

Figure 96 Erosion Hazard Limit

The following subsections clarify how each of these components for defining *erosion hazards* should be determined and where flexibility may be provided to undertake studies to address unique, local situations (e.g., where the approach(es) may be considered excessive or insufficient to define the area of provincial interest). Where studies using accepted scientific, geotechnical and/or engineering principles were used to determine the landward limit of the *erosion hazards* are approved by the municipality, they should be applied only within the area studied.

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Erosion Access Allowance and Erosion Control Measures

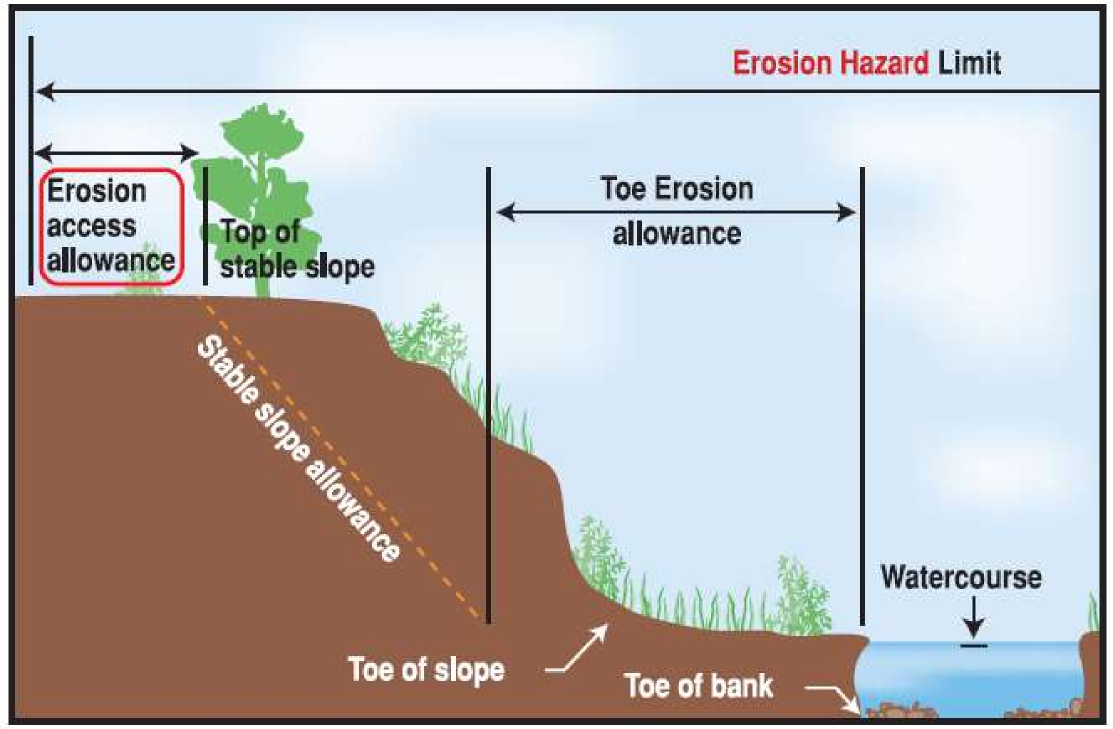
Erosion Access Allowance

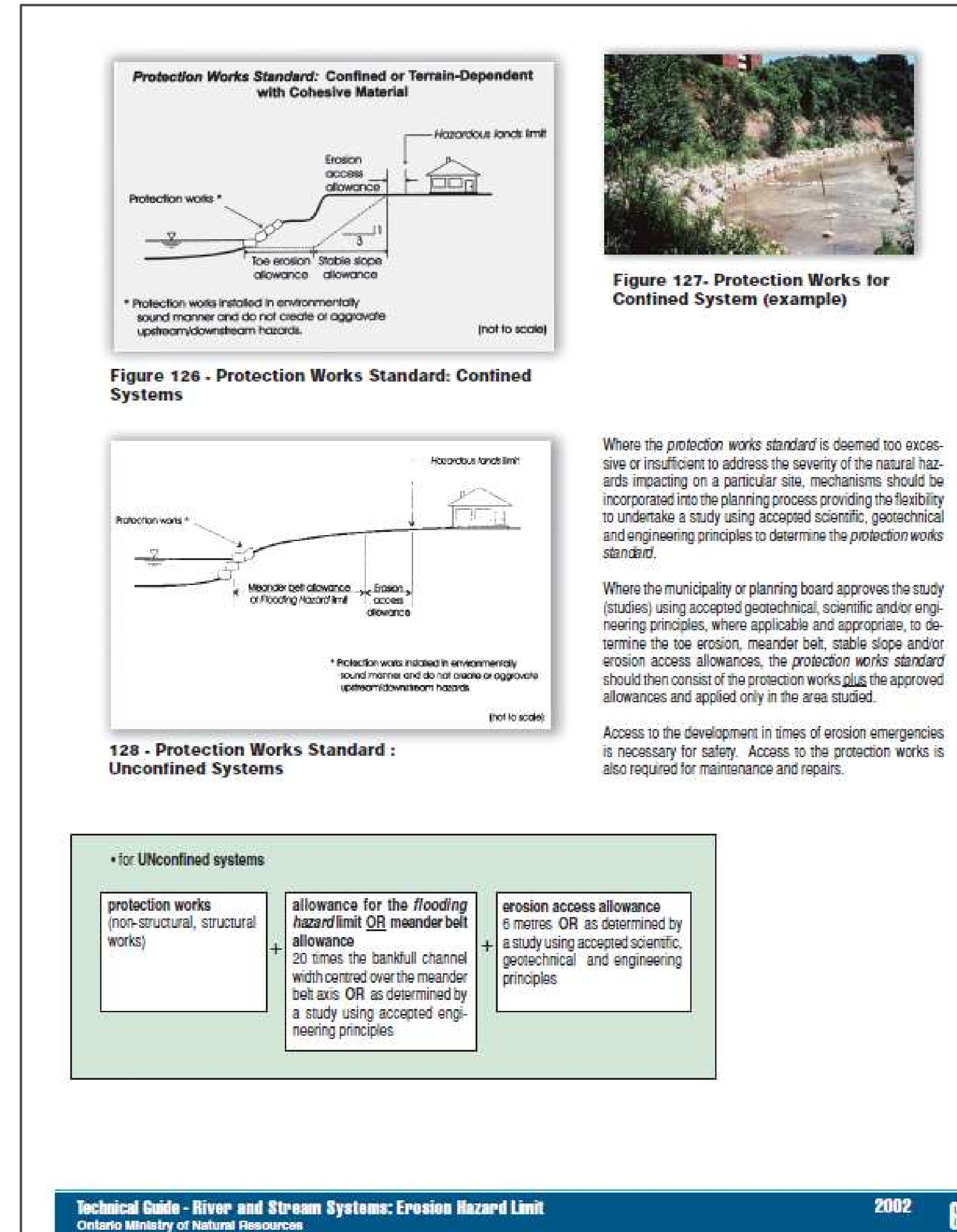
- Emergency access
- Construction access
- Factor of safety

MNR (2002) Erosion Hazard Limit

Erosion Control Measures

- Erosion hazard credit?
- Life-cycle costs





Protection Works Standard: Confined or Terrain-Dependent with Cohesive Material

Figure 126 - Protection Works Standard: Confined Systems

Figure 127- Protection Works for Confined System (example)

128 - Protection Works Standard : Unconfined Systems

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.

• for UNconfined systems

protection works (non-structural, structural works)	+	**allowance for the *flooding hazard* limit OR meander belt allowance** 20 times the bankfull channel width centred over the meander belt axis OR as determined by a study using accepted engineering principles	+	**erosion access allowance** 6 metres OR as determined by a study using accepted scientific, geotechnical and engineering principles

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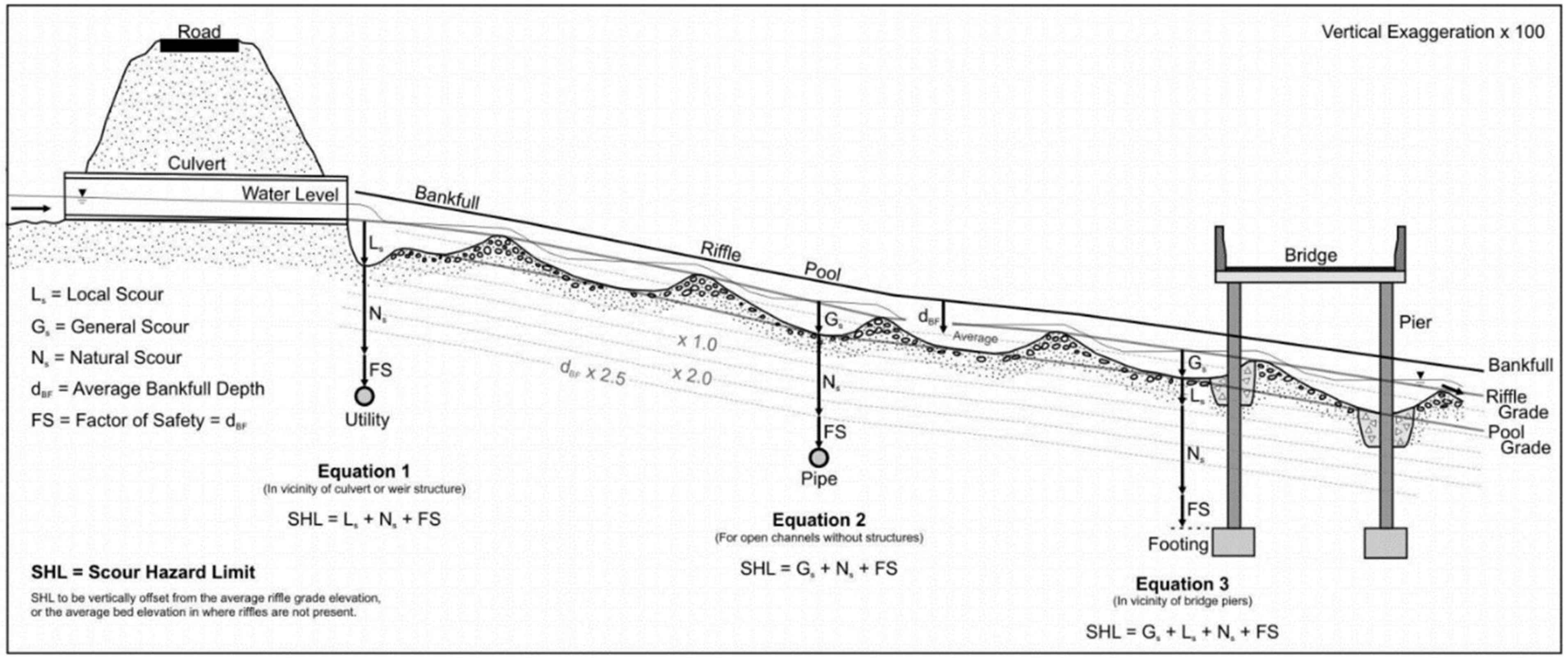
Challenges:

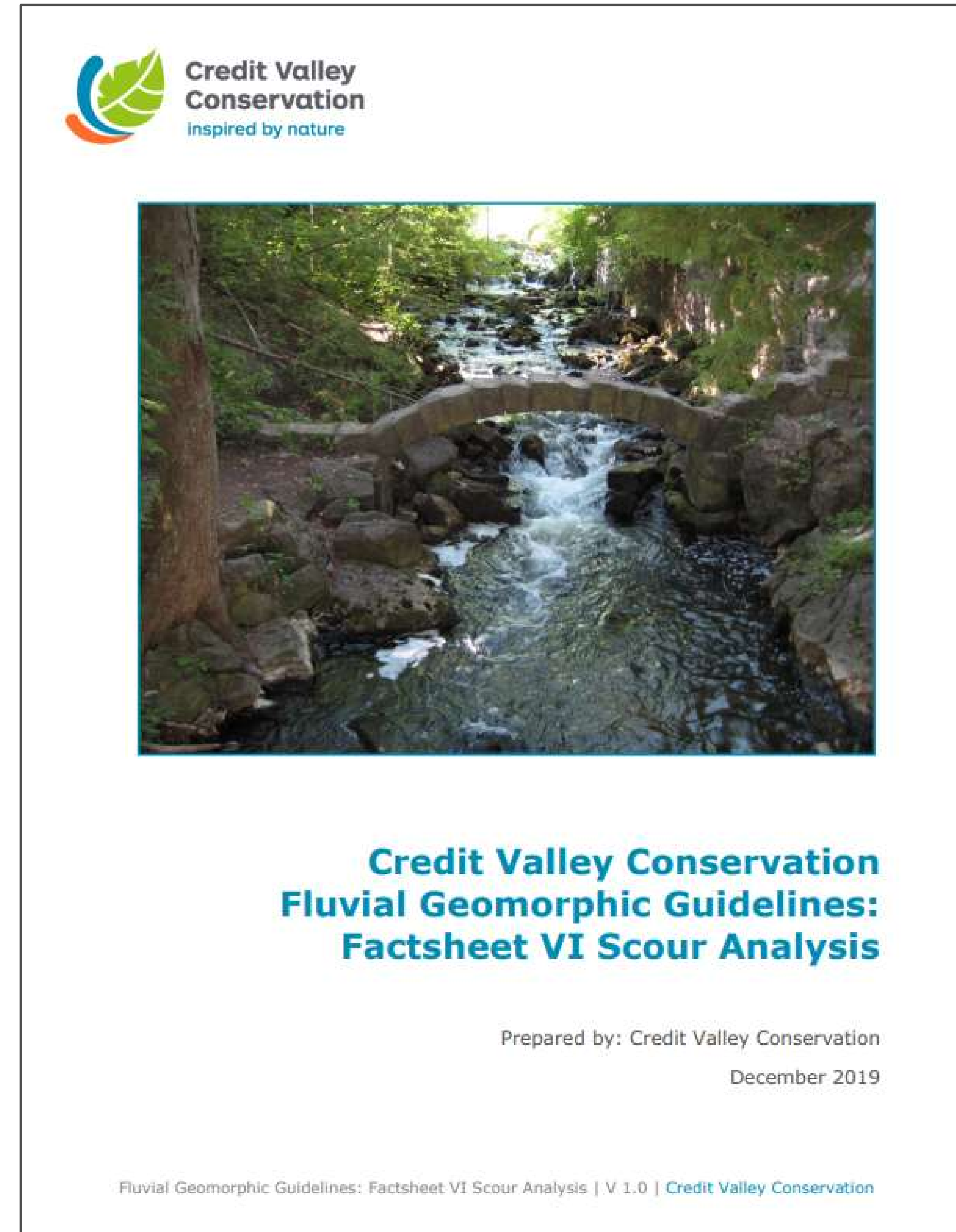
- Erosion access allowance is not as consistent as it could be in definition, size, and application across the province;
- Life-cycle costs are discussed, but insufficient guidance for implementation, so rarely well assessed in specific terms; and
- How to deal with erosion hazard credit for erosion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

Scour Hazard Analysis

CVC (2019) Scour Hazard Guidelines



Type	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



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

Recommendations and Next STEPs

Recommendations:

Update the guidelines to address:

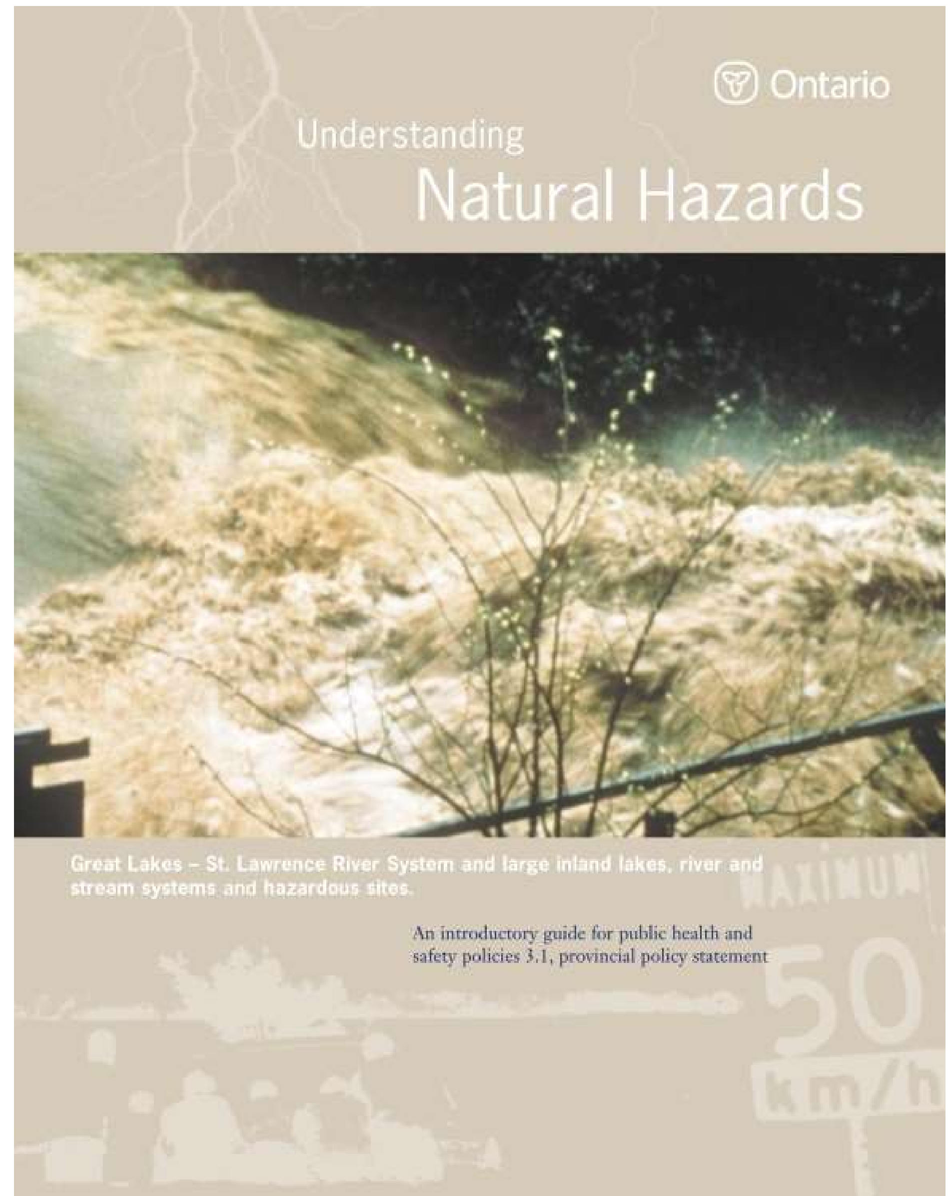
1. Specific Technical Issues
2. General Scientific Advancement
3. Guiding Principles for Policy Application

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



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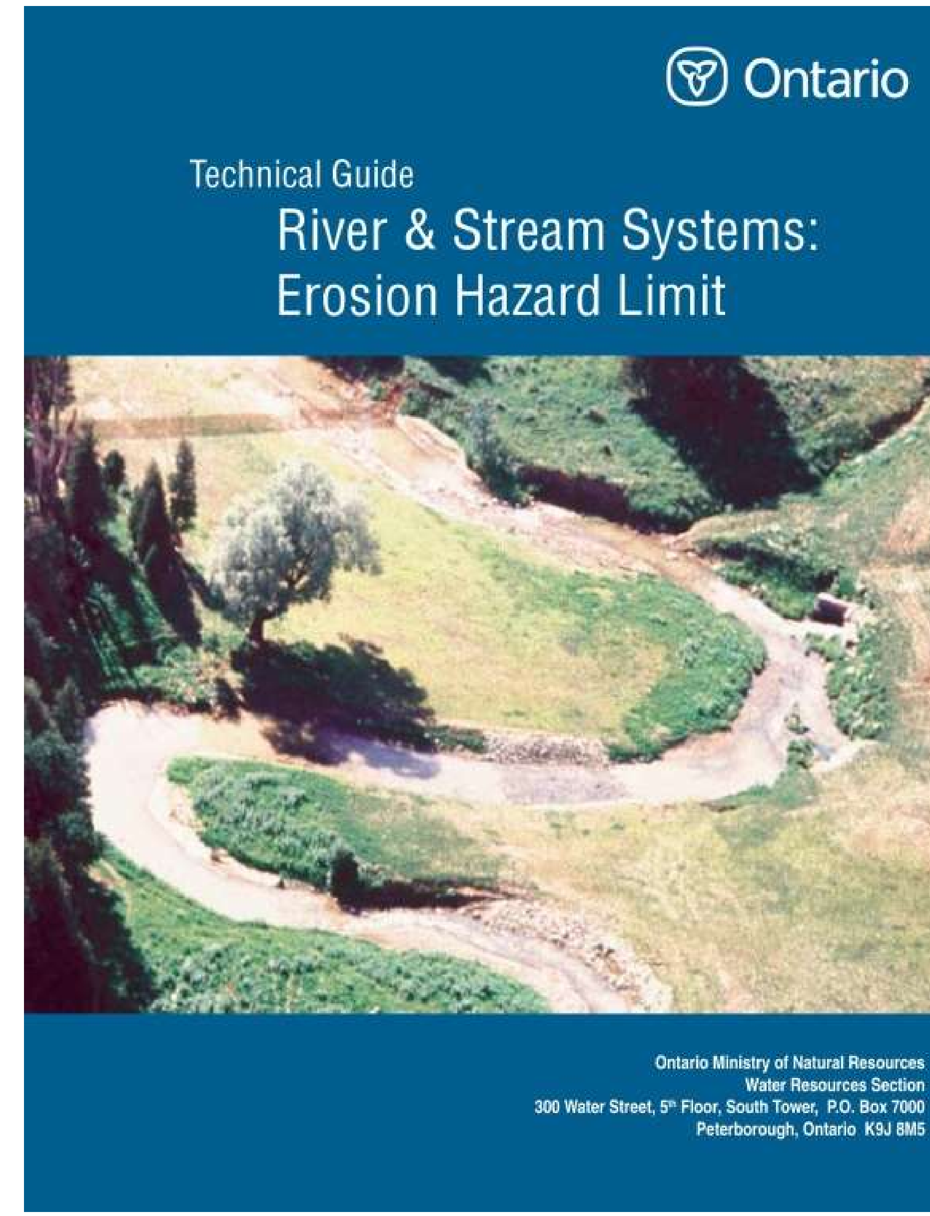

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Thank You!

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Under Our Feet and on the Horizon:

A two-decade review of erosion hazard assessment in Ontario

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

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Thursday, October 21st, 2021