UPPER THAMES RIVER CONSERVATION AUTHORITY

Reference Manual

DETERMINATION OF REGULATION LIMITS

FINAL TERMS OF REFERENCE

MARCH 2006

UPPER THAMES RIVER CONSERVATION AUTHORITY

Contents

Figures

Tables

1.0 Introduction

The Upper Thames River Conservation Authority (UTRCA) is currently developing new Regulation Limits for the riverine, and wetland systems in the UTRCA watershed, based on the new Generic Regulation made under Section 28 (1) of the Conservation Authorities Act. These limits will be used to map all hazard areas within the watershed, and will ultimately form the basis for Regulation for Development, Interference with Wetlands, and Alterations to Shorelines and Watercourses (Ontario Regulation 97/04).

2.0 General Objectives

The Upper Thames River Conservation Authority has established objectives which will form the basis of the decision making process associated with regulation implementation. These objectives include, but are not necessarily limited to, an Authority program designed to:

- prevent loss of life,
- minimize property damage and social disruption,
- reduce public and private expenditure for emergency operation, evacuation and restoration,
- minimize the hazards and unnecessary development of riverine floodplains and flood and erosion susceptible shoreline areas which in future years may require expensive protection measures,
- regulate works and development which, singularly or collectively, may reduce riverine channel capacities to pass flood flows resulting in increased flood levels, and creating potential danger to upstream and downstream landowners,
- control filling and / or draining of natural storage areas such as wetlands,
- encourage the conservation of land through the control of construction and placement of fill on existing or potentially unstable valley slopes or shoreline bluffs,
- reduce soil erosion and sedimentation from development activity,
- control pollution or other degradation of existing and potential groundwater aquifer(s) and aquifer recharge areas, created by fill activities, and,
- control water pollution, sedimentation, and potential nuisances due to floating objects and debris.

3.0 Study Area

The study area (Figure 1) is comprised of the area within the Upper Thames River Conservation Authority's jurisdiction. The Watershed boundary is shown below. The UTRCA plans to approach non-member municipalities, currently included within our watershed boundary, to become members and included to our area of jurisdiction.

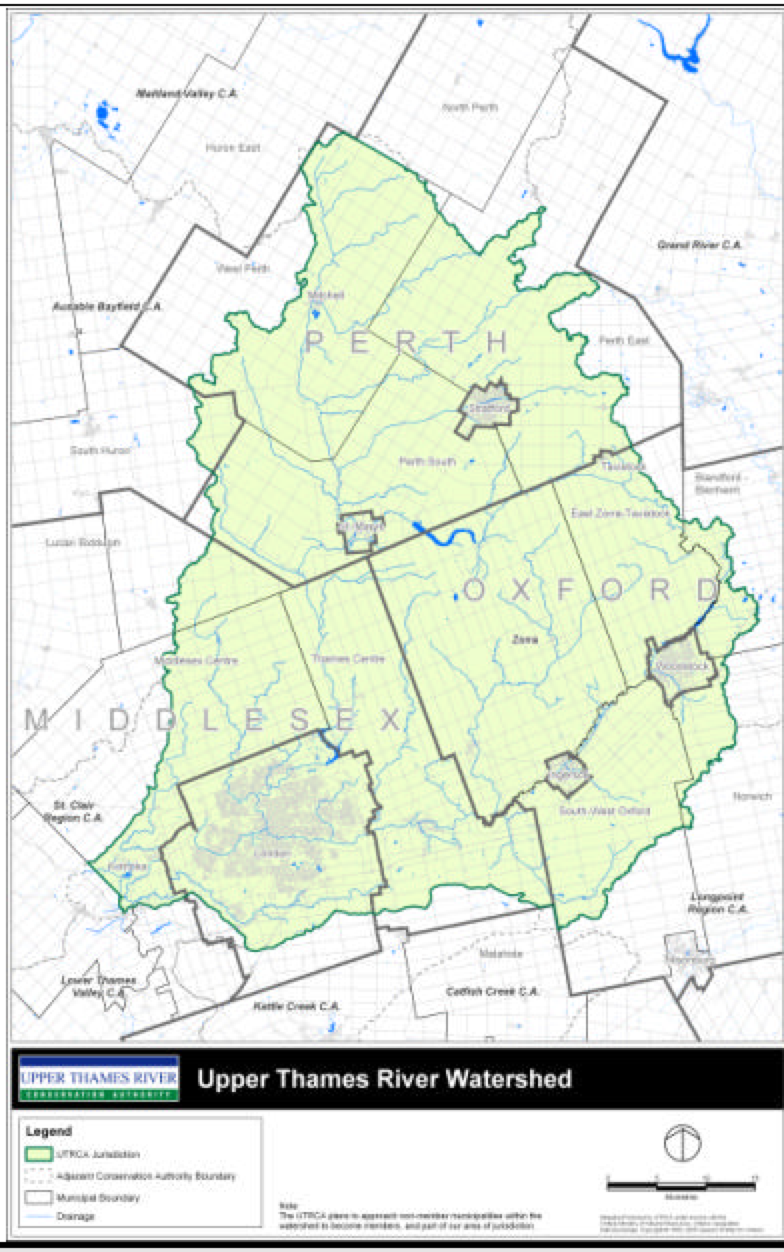


Figure 1: Study Area

4.0 Riverine Hazards

Riverine Hazard Limits address the potential hazards resulting from the proximity of development to a river, creek, or stream. The hazards addressed include flooding and erosion.

The following sections outline the methods that have been implemented to set the boundaries within which development is potentially susceptible to hazards.

4.1 RIVERINE FLOODING HAZARD LIMIT

The *Riverine Flooding Hazard Limit*, is generally based on observations of 1937 Upper Thames River Watershed flooding which is designated as the Regulatory Flood. The UTRCA received approval from the Minister of Natural Resources, in a letter dated February 21, 1989, to change from the Hurricane Hazel Storm to the Observed flood event based on the 1937 flood. Flood lines for the Regulatory Storm are calculated using precipitation data from Observed 1937 Flood event, which is based on a storm that statistically occurs once every two hundred and fifty years. Table 1 displays the watersheds within the Upper Thames River watershed, and the standards for their respective flood lines. Flood lines from the various floodplain mapping sources have been digitized for use in determining the Riverine Flooding Hazard Limit where engineered studies have been completed within the UTRCA watershed.

Table 1: Flood line Source	
Upper Thames River Conservation Authority	**1987. Technical Report to Support Use of the 1937 Flood as the Historical Event for Floodplain Management Purposes in the UTRCA.**
Cumming Cockburn Limited	**1990. Boughdale Dyke Study.**
Cumming Cockburn Limited	**1991. Ingersoll Floodway Study.**
Kotzamanis Graumann Smith Macmillin Inc.	**2000. Red River Basin. Stage-Damage Curves Update and Preparation of Flood Damage Maps Final Report.**
Marshall Macklin Monagham	**1983. Background Report to the Glengowan Environmental Assessment. Report No. 9 Hydrological and Flood Damage Study.**
Marshall Macklin Monagham	**1983. Flood Damage Reduction Study Town of St. Marys.**
Ontario Department of Planning and Development	**1952. Upper Thames Valley Conservation Report.**
Paragon Engineering Limited	**1986. Development of Flood Depth Damage-Curves for Residential Homes in Ontario.**
Upper Thames River Conservation Authority	**1983. Town of Mitchell Flood line Study.**
Upper Thames River Conservation Authority	**1985. Hydraulic Computer Model for the City of London (HEC-2 Update 1985).**
Upper Thames River Conservation Authority	**1986. Calculated Water Surface Elevations for Floodplain Management within the City of London.**
Upper Thames River Conservation Authority	**1987. Regional and 1:100 Year Flood lines on the North Thames River in St. Marys and Trout Creek from St. Marys to Wildwood Dam.**
Upper Thames River Conservation Authority	**1998. Damage Assessment Management Program. North Thames River and Whirl Creek in Mitchell.**

US Army Corps of Engineers	**1996. Engineering and Design. Risk Based Analysis for Flood Damage Reduction Studies. EM1110-2-1619.**
US Army Corps of Engineers	**1998. HEC-FDA: Flood Damage Reduction Analysis User's Manual.**

4.1.1 FLOOD LINE ESTIMATION

Approximated floodplains have been based on the best available information including field investigations, available mapping and aerial photography in a manner consistent with Section 3 of the *Guidelines for Developing Schedules of Regulated Areas, Conservation Ontario (August 2003).*

The following procedure was adopted for preparing estimated floodplain maps for the rivers and reaches where engineering studies have been completed; where the drainage area is greater that 1000 hectares; and where 1:10000 OBM is the best available information. Areas less than this will use a variety of techniques, depending on which is appropriate for each specific location, including depth/width/area/flow relationships, backwater calculations at culverts, apparent valley where evident. The methods used for estimating flood plain extents in areas less than 1000 ha will be described in detail later in this document.

A Digital Elevation Model (DEM) grid was first prepared from 1:10,000 Ontario Base Mapping (OBM) with 5 m contour intervals. 0.5 meter contour elevations were interpolated from the OBM data for better resolution in generating flood lines. We are aware that creating a DEM from the OBM with only 5 m contours and then trying to interpolate 0.5 contours may not be very accurate. Because of the base map scale and absence of surveyed cross sections at river and stream crossings, we acknowledge that these floodplains do not have the same level of precision. Approximated floodplains have been based on the best available information including field investigations, available mapping and aerial photography in a manner consistent with Section 3 of the *Guidelines for Developing Schedules of Regulated Areas, Conservation Ontario (August 2003).* We have consulted with adjacent Conservation Authorities who are endeavouring to estimate flood lines, where base mapping is only available at a 1:10000 scale. This approach is consistent with the Grand River Conservation Authority (GRCA), and Ausable Bayfield Conservation Authority (ABCA). In areas where better mapping exits (ie 1:2000, with 1 m contours) the better base information was used, and a finer DEM created. The preparation of the HEC-RAS model which is exported from the HEC GeoRAS extension requires the following steps:

1. Digitize stream centreline and left and right bank locations estimated from digital orthoimagery, and from 0.5 m interpolated contours as an added guide.
2. Digitize stream flow path centrelines for left and right overbanks and for main channel
3. Add cross section cut lines at appropriate locations to accurately cover entire width of regulatory flood plain, drawn from left to right, looking downstream. This is an iterative process as the first time through the location of the regulatory flood plain is unknown, and some cross sections will need to be extended, and new ones may be required to better describe the terrain.
4. Pre-process HEC GeoRAS data to create output file for importing to HEC-RAS . This process creates the basic model used by HEC-RAS , including setting up cross sections, downstream reach lengths, right and left bank stations and geo-referencing the model schematic.

Once the data has been successfully imported into HEC-RAS , flow data, Manning's roughness and bridge data is added using HEC-RAS . For this project, the study team decided to add flow change locations at each confluence along the stream being analyzed, with a contributing drainage area greater than 125 ha. At each of these junctions drainage area was calculated and using either regional analysis or transposed statistics, a flow was calculated and a flow change location created in the HEC-RAS model. Manning's n values are held constant for this project, using 0.03 for the channel and 0.05 for the overbanks. These values are typical of values used in engineered models in the watershed and, in the case of the overbank value, somewhat conservative. These estimates have been adapted to local watershed conditions considering climate, physiography, stream morphology and land use.

I) *BRIDGE MODELLING*

As this exercise is meant to estimate flood lines, and the results are not considered to be as accurate as the Engineered Models in the watershed, bridges are not explicitly modelled. Rather, as a substitute for bridge modelling, each road crossing is modelled using the blocked obstruction feature available in HEC-RAS . This is intended to give a better prediction of the effects of a constriction on the river than no obstruction at all. This technique will increase backwater behind a bridge or culvert opening, but will not model weir flow overtop of a road. Due to the number of crossings in the watershed, it would not be possible within the time and budget constraints of this project to fully model bridges. As mapping is produced, we will evaluate the appropriateness of the floodplains generated, and will adjust if required. It is also worth noting that the drainage areas are all quite large for the areas we are using this technique (for drainage areas greater than 1000 hectares). It has been our experience that in our watershed there are very few, if any, small culverts with large embankments.

Where possible, the opening widths for the blocked obstructions were estimated from a combination of orthoimagery, and also by correlating actual measured bridge openings on Waubuno creek with drainage area for an estimate. This correlation was calculated to be:

Width = 0.18(DA) + 5.755

Where Width = bridge width in m, and DA= drainage area in km^2. For example this would predict approximately a 7.5 m wide bridge opening for a crossing with a drainage area of 10 km^2 which is a reasonable estimate.

The tops of the obstructions were set to be above the level of the estimated regulatory flood. This produces conservative results as it does allow for weir flow over the road crossing. In cases where this produces unreasonable flood lines, field checks can be made, and the road top surveyed if required. Also the spot elevation data is useful for some bridges as there is often one created for bridge crossings on the OBM. In these cases the waterlevel over the bridge can be set to 0.5 to 1 m above the road elevation. The Figure below illustrates the concept of using blocked obstructions to approximate bridge openings.

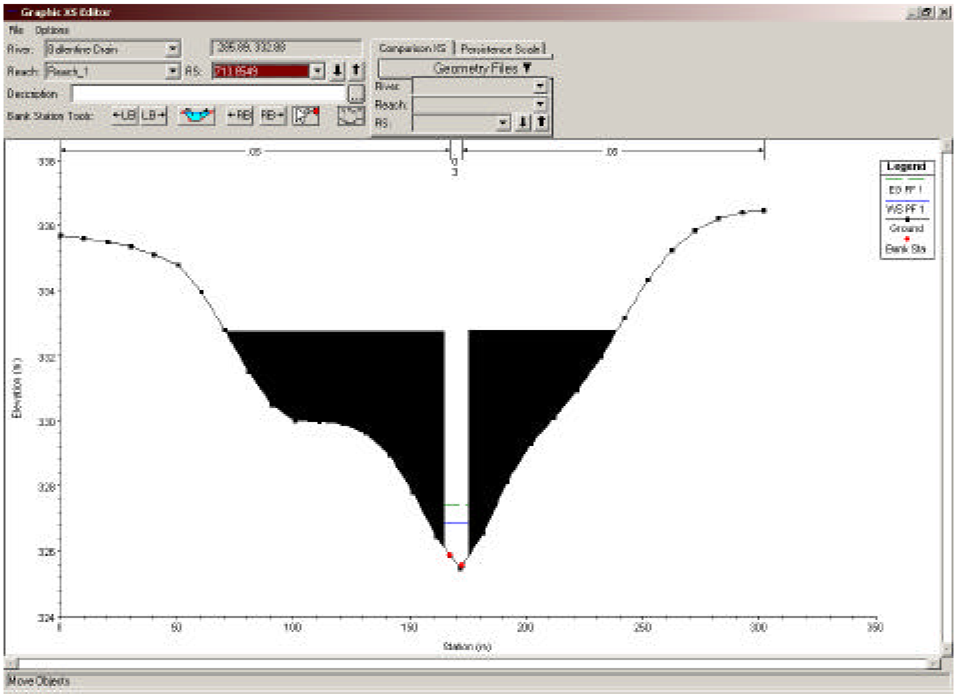


Figure 2: Approximating Bridge Openings

II) *CREATION OF FLOOD LINES*

Once flood lines elevations are calculated using HEC-RAS , the results are exported back to HEC GeoRAS, which essentially calculates the surface of intersection between the water surface profile created by HEC-RAS , and the DEM, which represents the flood line. These lines end up quite blocky, as they can only be as detailed as the DEM they are created from, which is 10 m resolution. There is a smoothing algorithm within ArcMap which will be applied to the lines to remove the blocky structure, keeping in mind they will ultimately be drawn on a 1:10000 scale which does not show much detail.

The flood line is determined through a hydrologic simulation of the specified storm centered over the watershed in question, and a hydraulic model that analyses the effect of conveying the storm runoff over the landscape. Figure 3 displays the application of the modelling in delineating the flood line.

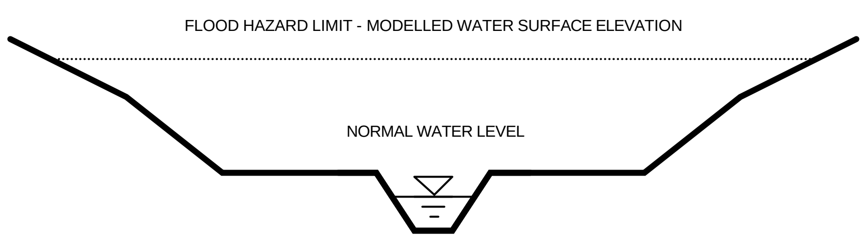


Figure 3a: Watercourse Cross-Section with Flood line

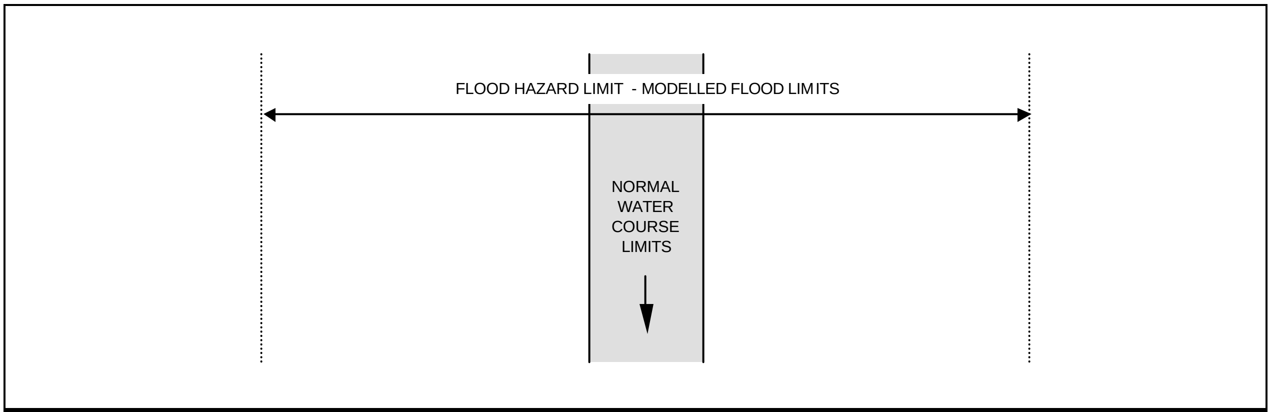


Figure 3b: Plan View of Watercourse with Flood line

III) *FLOOD LINES IN UPSTREAM CATCHMENTS*

Flood lines in portions of the watershed with drainage areas smaller than 1000 ha are estimated using Allowances. In these areas, there is insufficient mapping detail available (1:10000 OBM, 5 m contours only) to do any more rigorous analysis for drains this small. In order to estimate reasonable floodplain width values to use for these areas, an analysis of the floodplain top widths created in the estimated models, as well as for two models of engineered floodplains which have rural upstream drainage (Kelly and Stanton Drains), were examined, and an attempt made to correlate these values to drainage area, and to slope. No useful relationship could be derived from this analysis, and so drainage area and flood plain top widths alone were analyzed. This also proved inconclusive. In the Upper Thames watershed there is no concrete relationship between Floodplain width and Drainage Area.

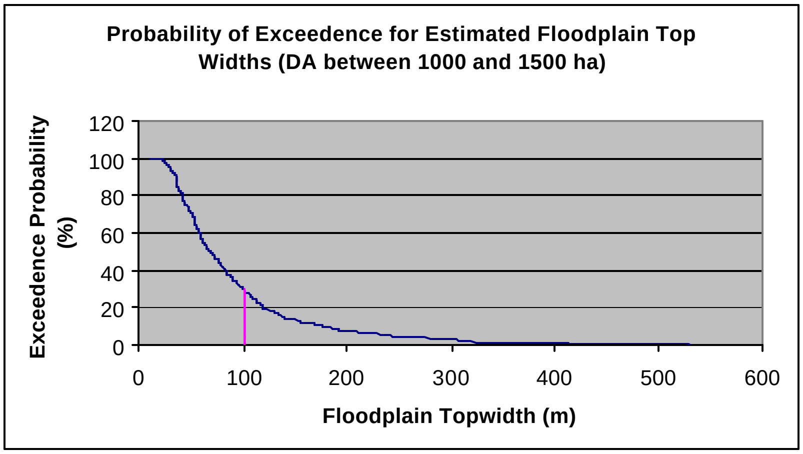
Table 2: Flood line in Upstream Catchments Buffer Widths[1]

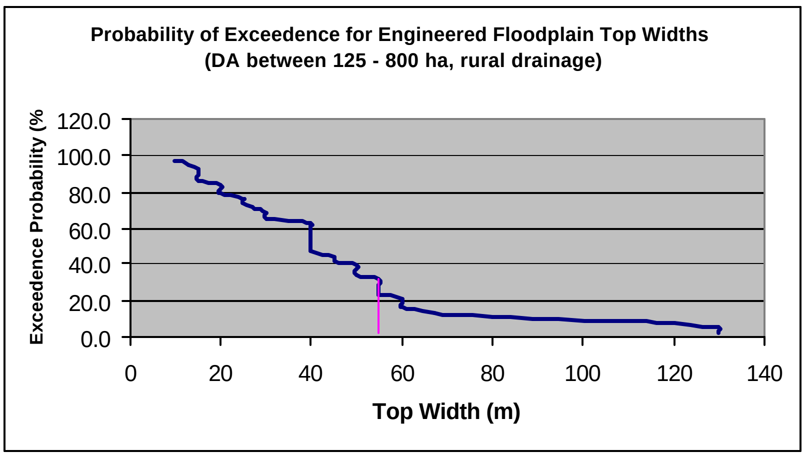
Upstream Drainage Area	Flood line Allowance width (measured from waters edge)
1000 – 500 ha	45 m
500 – 125 ha	25 m
< 125 ha	15 m

[1] Identified tiled drains were buffered by 1m to ease identification on mapping schedules.

DEM derived watercourses based on accumulated drainage areas in urban areas that were interpreted as being "municipality piped" were removed.

To further justify these allowances, a probability of exceedence analysis was also carried out, and the graphs below show the results:





Assuming a 5 m top width[2] of the stream for 1000 to 500 ha drainage area, a 45 m allowance corresponds to approximately a 100 m flood plain top width, which in turn has about a 30% probability of exceedence, meaning that 70% of the flood plains in this range of drainage area would be safely within this allowance.

Similarly, for drainage areas less than 500 ha, and assuming a 2.5 m stream width[3], this corresponds to about a 55 m flood plain top width. From the figure above this also corresponds to a 30% probability of exceedence.

For areas where the flood plain is wider, this should be evident by the allowance crossing contour lines, and will be manually adjusted as required; these areas will usually be in backwater areas behind small culverts and bridges.

For completeness, also included are distribution plots of measured flood plain top widths for both the estimated flood plains, and for the few engineered floodplains occurring in rural drainage basins in the two

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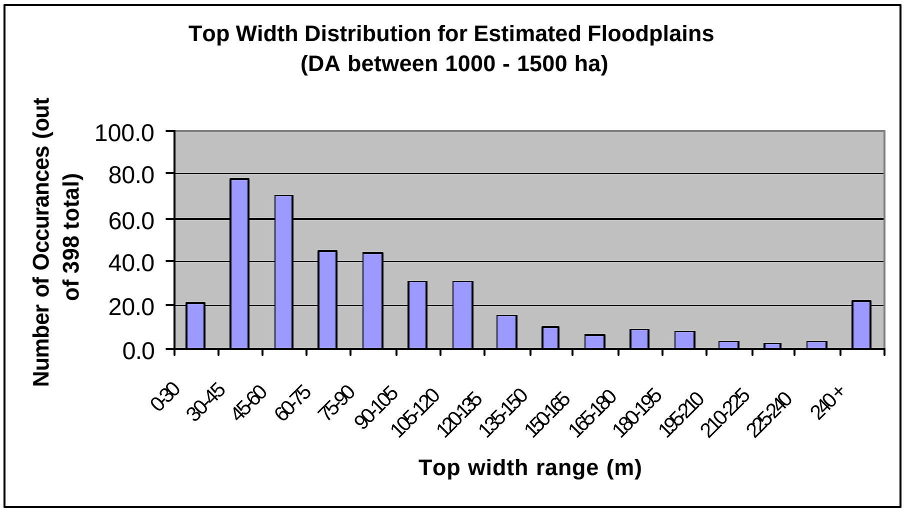
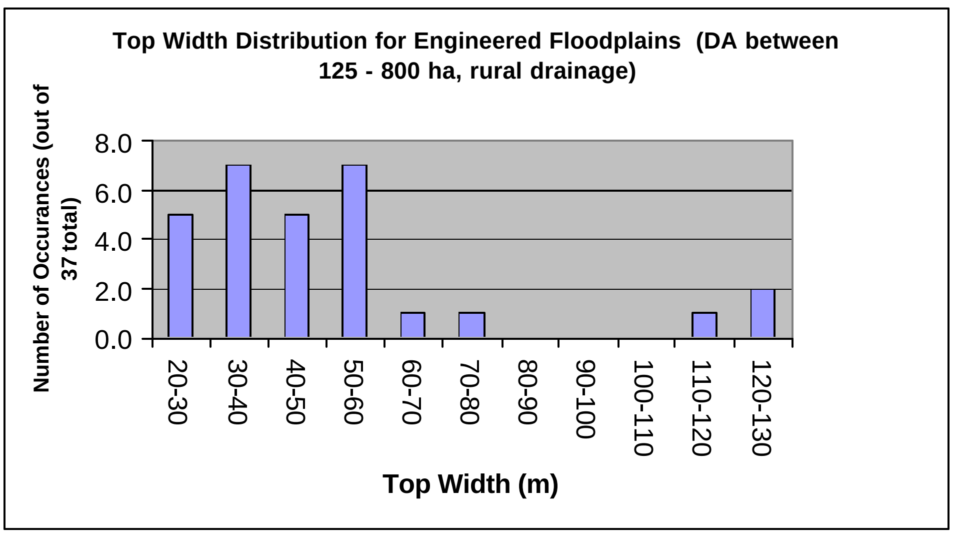
[2] Taken from analysis done by UTRCA of stream width vs. stream order, and assuming a stream order of 3.

[3] Taken from analysis done by UTRCA of stream width vs stream order, and assuming a stream order of 2.

figures below. This illustrates the distribution of the top widths for both analyses considered. We should also note that the UTRCA has been in communication with the Grand River Conservation Authority and the Ausable Bayfield Conservation Authority, and similar methodologies are being employed by these organizations in areas where mapping detail and time constraints are insufficient to do a more thorough analysis. The areas under these CA jurisdictions are very similar to the Upper Thames Basin in terms of both hydrology and geology.





4.2 RIVERINE EROSION HAZARD LIMIT - APPARENT SYSTEMS

The Erosion Hazard Limit for a riverine system consists of the valley Top of Slope and where necessary, the Toe Erosion Allowance, and the Stable Slope Allowance for an Apparent riverine system. An Apparent system is identified by a clearly visible valley (notable break in slope) shown on 1:10000 OBM's, Aerial Photos and 1:2000 mapping where it was available.

The following table details the number and scales of maps used to delineate the Erosion Hazard Limits for riverine systems.

Table 3: Base Mapping used for Riverine Erosion Hazard Limits

MUNICIPALITY	SCALE OF BASE MAPS	REVISION DATE	NO. OF MAP SHEETS
City of London	1:2,000 Ontario Base Maps	1988	21(1:10000 OBM)
Remainder of Watershed	1:10,000 Ontario Base Maps	1992	83
TOTAL			94

In addition, the existing fill line mapping currently in use by the UTRCA was used as a reference for areas where features are not fully evident.

The 2000 georeferenced ortho photography (digital air photos – UTRCA Watershed, 2000) has been used to check watercourse location and limits.

4.2.1 Valley Top of Slope – Apparent Riverine Systems

The Valley Top of Slope is the break in slope point between the valley side slope and the tableland, and should be discernable from the contour line information and aerial photo interpretation.

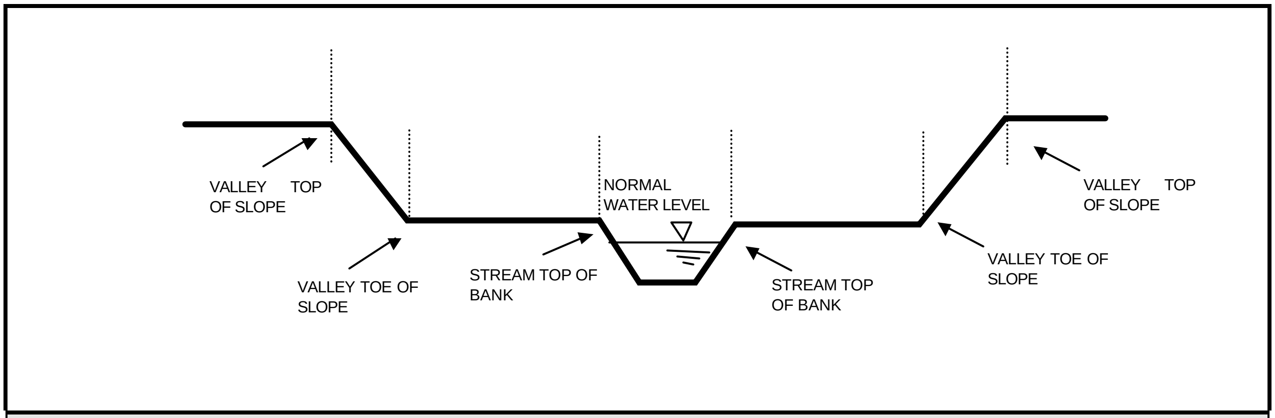


Figure 4: Apparent Riverine System Identifying Valley Top of Slope and Valley Toe of Slope

4.2.2 Stream Erosion – Apparent Riverine Systems

Stream bank erosion is an important cause of valley slope instability and is ultimately responsible for the presence of a valley. Stream erosion directly at the toe of a valley slope can steepen and undercut the slope, leading to the eventual failure of the bank. The *Toe Erosion Allowance* has been implemented to buffer development from the hazardous effects of toe erosion, and also to buffer the natural river processes from the influences of development. This allowance is based on a minimum distance of 15 metres between the edge of a river system, and the toe of its confining valley wall. Figure 5 shows the application of the Toe Erosion Allowance.

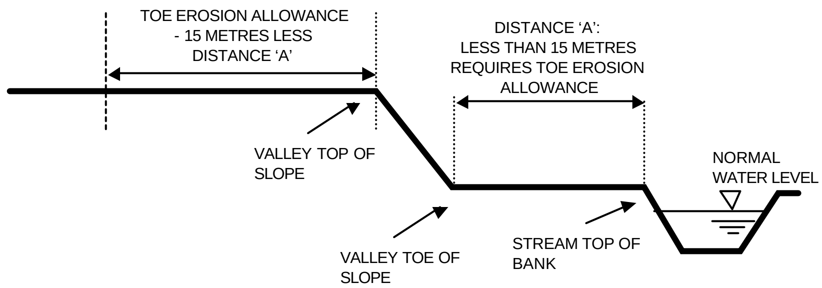


Figure 5a: Watercourse Cross-Section with Toe Erosion Allowance

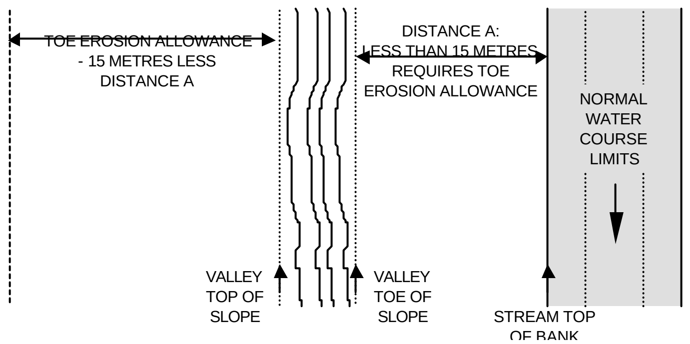


Figure 5b: Plan View of Watercourse with Toe Erosion Allowance

4.2.3 Slope Stability – Apparent Riverine Systems

Slopes are also naturally subject to movement and failure. The *Stable Slope Allowance* has been implemented to buffer development from the hazards of slope instability, and also to prevent the influence of development on the rate of slope movement. This allowance is based on an assumed stable slope gradient of 3 horizontal units to 1 vertical unit (3:1). For slopes at steeper gradients, the allowance is equal to the distance between the actual valley top of slope and the point at which a slope at a 3:1 gradient, rising from the same toe position, would intersect the ground surface. Figure 6 shows the application of the Stable Slope Allowance.

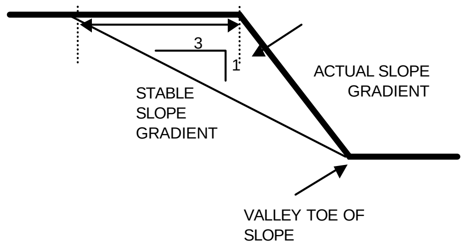


Figure 6: Stable Slope Allowance

4.3 RIVERINE EROSION HAZARD LIMIT - NOT APPARENT SYSTEMS

The Erosion Hazard Limit for Not Apparent systems consists of the meander belt allowance. Not Apparent systems occur where a watercourse is not contained within a clearly visible valley section.

4.3.1 Meander Belt – Not Apparent Systems

In Not Apparent systems, the watercourse is contained within a visible valley, and the flow of water is free to shift across the shallower land. Although toe erosion and slope stability are deemed potential hazards, consideration for the meandering tendencies of the system must be provided. The *Meander Belt Allowance* provides a limit to development within the areas where the river system is likely to shift. This allowance is based on twenty (20) times the bankfull channel width, where the bankfull channel width is measured at the widest riffle section of the reach. A riffle is a section of shallow rapids where the water surface is broken by small waves. The meander belt is centred over a meander belt axis that connects the riffle sections of the stream.

The meander belt has been delineated for each not apparent and partially-apparent watercourse with drainage areas less than 125ha which is not classified as a drain. Drains are subject to regular maintenance and cleanout activities to reduce the effects of the meander belt, therefore have not been included for study at this time. Not apparent systems have been determined on the basis of the best available topographic mapping.

For each selected study reach:

- The meander belt allowance has been delineated on the regulation mapping, centred on the defined meander belt axis. An automated GIS approach to defining the meander axis was deemed to be the most efficient method. The methodology was tested in an area that was characteristic of meandering and straight reaches, and compared to a manual approach. After comparison, adjustments were made to produce an output that would be acceptable in most situations.
- The alignment of the meander belt axis has been defined using a combination of the best available topographic mapping and aerial photography;
- The contributing catchment area has been quantified at each stream confluence and road crossing;
- Given the contributing catchment area, an initial estimate of bankfull width has been made using Ontario River Geometry Relationships presented on Figure 106 of the document entitled *Technical Guide for River & Stream Systems: Erosion Hazard Limit* (Ministry of Natural Resources, 2002);
- The reasonableness of the initial bankfull width estimate has been assessed using field measurements of stream width at 605 sites in the Upper Thames River Watershed; and

- A meander belt width has been estimated as 20 times the bankfull channel width.

The following explains the GIS steps taken to create the meander belt layer:

1. ArcGIS was used to create a minimum bounding polygon for each candidate reach
2. The Straight Line Medial Axis of the minimum bounding polygon was derived (the centreline of this polygon approximates the meander axis)
3. Drainage areas were derived from the flow accumulation grid at road crossings (the flow accumulation grid is a raster that stores accumulated upstream drainage areas in each 100m2 cell)
4. Drainage areas were converted to a corresponding bankfull width (as described in Ontario River Geometry Relationships Fig 106, *Technical Guide for River & Stream Systems: Erosion Hazard Limit*)
5. Buffers were created using the formula Bankfull Width * 10 (the GIS applies this distance to both sides of the axis to represent 20 times bankfull channel width)
6. Where on-line ponds are located in Not Apparent systems, the meander belt width is increased by the width of the open water in the pond.

Figure 7 shows a typical application of the Meander Belt Allowance.

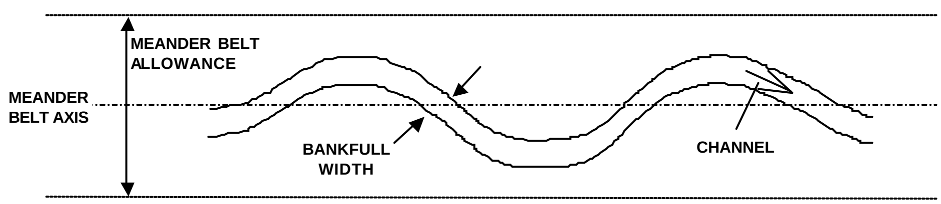


Figure 7: Erosion Hazard Limit (for a Not Apparent system)

4.4 RIVERINE HAZARD LIMIT

The Erosion Hazard Limit (developed for either an Apparent or Not Apparent system) and the Flood Hazard Limit are applied in combination to every riverine system in the watershed. The greatest extent of these two limits is the Riverine Hazard Limit.

5.0 Shoreline Hazards

The coast or shoreline refers to the furthest landward limit bordering a large body of water. For the Upper Thames River watershed, no shoreline is present.

6.0 Wetlands and Wetland Complexes

6.1 WETLANDS

Wetlands play an important role in the hydrology of watersheds, and therefore are also important features in floodplain management. From a natural hazard perspective, wetlands retain surface water and may release stored water to streams over periods of time. The attenuation of drainage in wetlands is a function that will influence the shaping of stormwater flow and flooding.

Because of the role of wetlands in floodplain management, the intent of mapping and regulating these features is to prevent effects to natural flood conditions through the loss of wetlands. It should be noted that compliance with this regulation does not exempt applicants from having regard for local by-laws, Municipal and County Official Plans, or the Provincial Policy Statements.

6.1.1 Wetland Mapping

Wetland mapping consists of evaluated and unevaluated wetlands, derived from a combination of information sources.

For the evaluated wetland component, boundaries from OMNR Land Information Subscription (LIDS) dataset are utilized. The age of wetland boundaries within this dataset is varied, ranging from mid 1980's through to present. The evaluated wetlands from OMNR are "open files", meaning that boundaries can be adjusted based on new information from time to time.

The unevaluated wetland component is derived from SOLRIS mapping. The methodology used to map unevaluated wetlands was derived from the SOLRIS Training Manual, specifically Section 9, SOLRIS Evaluated Wetland Editing, prepared by Inventory Monitoring and Assessment Section Science and Information Branch and Provincial Geomatics Services Centre Natural Resources Management Branch and Southern Science and Information Section Science and Information Resources Branch, June 15, 2004. SOLRIS mapping was compiled from 2000 georeferenced ortho photography (digital air photos). GIS software is used view layers identified as "wetlandunit" and "Waterpoly" from the overall SOLRIS mapping. Additional GIS information which included soil type, forest type, and drainage were analyzed with the digital aerial photography and boundaries were digitized on screen at a scale of 1:3000. This mapping was completed in 2005 by trained staff. No wetland with an area of less than 0.5 ha is included as part of the regulation mapping, except in special circumstances (i.e. <0.5 ha wetland in close proximity to larger wetland feature).

Where detailed wetland information was available (e.g. Ecological Land Classification) the following ELC Community Class Codes (which meet wetland criteria) were extracted, and included as wetland hazards:

SW (swamp) - MA (marsh) - BO (bog) - FE (fen) - SA (shallow water) - OA (open water)

The MNR evaluated wetland boundaries, UTRCA wetland boundaries, and ELC information were then overlain. In order to reconcile differences between OMNR and UTRCA data, polygons were reviewed in conjunction with recent (2000 digital imagery) air photos. A trained photo-interpreter would decide which line work was more accurate and accept the more precise of the lines. The layers would then be merged to form the Regulated Wetlands.

6.1.2 Wetland Complexes

For the purpose of the regulation, wetland complex boundaries are not used. Wetlands will be protected from indirect impacts through the establishment of an "other area" around all wetlands as described in section 7.2.

7.0 Allowances, Other Areas, and Regulation Limits

7.1 ALLOWANCES

The Generic Regulation describes the use of an allowance that may be applied to all riverine and shoreline Hazard Limits. The allowance is for the purpose of maintaining sufficient access for emergencies, maintenance, and construction activities. This allowance is analogous to a factor of safety, providing protection against unforeseen conditions that may adversely affect the land adjacent to a natural hazard area. A 15 metre allowance is applied to the Hazard Limit.

7.2 OTHER AREAS

Wetlands can be affected by development where the development is outside of the wetland boundary but within the adjacent lands. These lands are known as *Areas of Interference*. The width of an Area of Interference could be different for each application, and requires site by site assessment. Provincially Significant Wetlands are afforded a 120 metre setback through the Planning Act process.

For consistency, and to ensure wetland protection, UTRCA has considered the Area of Interference to include all land within 120 metres of all provincially significant wetlands and all wetlands larger than 2 hectares in size. This Area of Interference may be too extensive for small wetlands (less than 2 hectares) that are not provincially significant. These small wetlands will have an area of interference of 30 metres. The Areas of Interference will be included in the UTRCA regulation under Section 2(1)(d), as an "Other Area". This will allow UTRCA to review each application for development on land adjacent to wetlands through the permit process.

7.3 REGULATION LIMITS

The Regulation Limit is mapped as the greatest extent of the:

- Riverine Hazard Limit, and
- a 15 metre Allowance, and
- wetland boundary, and
- areas of interference (30 or 120 metres) adjacent to all wetlands.

The greatest extent of all features identified above is the Regulation Limit provided on the UTRCA Regulation Limit mapping.

8.0 Definitions

The following definitions are intended to provide a clearer understanding of the basis by which these terms of reference have been written. All definitions have been obtained through accepted sources, as outlined in Section 8.0 – References.

Accepted engineering principles:

The current coastal, geotechnical, and hydraulic engineering principles, methods, and procedures that would be judged by a peer group of qualified engineers (by virtue of their training and experience) as being reasonable for the scale and type of project being considered, the sensitivity of the location, and the potential threats to life and property.

Access (ingress/egress):

Standards and procedures currently applied in engineering practice associated with providing safe passage for vehicles and people to and from a shoreline or river-side property during an emergency situation as a result of flooding, other water related hazards, the failure of floodproofing and/or protection works, and/or erosion that have been reviewed and approved by the Conservation Authority and/or the Ministry of Natural Resources.

ArcGIS:

Popular GIS software by ESRI. ArcGIS Desktop GIS software products are used to Compile, author, analyze, map, and publish geographic information and knowledge.

Bankfull discharge:

The formative flow of water that characterizes the morphology of a fluvial channel. In a single channel stream, "bankfull" is the discharge, which just fills the channel without flowing onto the floodplain.

Apparent System:

A riverine system where the physical presence of a valley corridor containing the system is visibly discernible. Also "well-defined system".

DEM-Digital Elevation Model:

The representation of continuous elevation values over a topographic surface by a regular array of z-values, referenced to a common datum. DEMs are typically used to represent terrain relief.

Development:

Development means:

a) The construction, reconstruction, erection, or placing of a building or structure of any kind;
b) Any change to a building or structure that would have the effect of altering the use or potential use of the building or structure, increasing the size of the building or structure, or increasing the number of dwelling units in the building or structure;
c) Site grading; or
d) The temporary or permanent placing, dumping or removal of any material, originating on the site or elsewhere.

Drainage area:

For a point, the area that contributes runoff to that point.

Fetch:

The overwater length across which the wind blows.

Fill:

Any material used or capable of being used to raise, lower, or in any way affect the contours of the ground, whether on a permanent or temporary basis, and whether it originated on the site or elsewhere.

Hazardous land:

Hazardous land means land that could be unsafe for development because of naturally occurring processes associated with flooding, erosion, dynamic beaches, or unstable soil or bedrock .

HEC-RAS

Hydrologic Engineering Centers River Analysis System (HEC-RAS) is software developed by the U.S. Army Corps of Engineers to perform hydraulic analysis for steady and unsteady flow conditions.

HEC GeoRAS

Software developed by the U.S. Army Corps of Engineers for pre and post-processing geospatial data for use with HEC-RAS.

Protection works:

Refers to structural or not-structural works, which are intended to appropriately address damages caused by flooding, erosion, and / or other water related hazards.

Slope crest:

The highest point on a slope at which the gradient becomes shallow enough to be used for access. Also “top of slope”.

Slope toe:

The lowest point on a slope, where the surface gradient changes from relatively shallow to relatively steep.

Not Apparent system:

A river or stream system where there is no discernible valley slope or bank that can be detected from the surrounding landscape. Also “Ill-defined system”.

Watercourse:

Watercourse means an identifiable depression in the ground in which a flow of water regularly or continuously occurs.

Wetland:

Wetland means land that

a) is seasonally or permanently covered by shallow water, or has a water table close to or at its surface;

b) directly contributes to the hydrological function of a watershed through connection with a surface watercourse;

c) has hydric soils, the formation of which has been caused by the presence of abundant water; and,

d) has vegetation dominated by hydrophytic plants or water tolerant plants, the dominance of which has been favoured by the presence of abundant water.

But does not include periodically soaked or wet land that is used for agricultural purposes and no longer exhibits a wetland characteristic referred to in clause c) or d)

9.0 References

1. ***Conservation Authorities Act*** (Revised Statutes of Ontario, 1990, Chapter C.27, as amended, Queens Printer March 29, 1999).

2. Lee, H., W. Bakowsky, P. Uhlig, S. McMurray, J. Riley, J. Bowles, M. Puddister; ***Reference Manual for Land Classification in Southern Ontario***; Ontario Ministry of Natural Resources Science and Technology Transfer Unit; 1997.

3. Ontario Ministry of Natural Resources; ***Natural Hazards Training Manual, Provincial Policy Statement, Public Health and Safety Policies 3.1, Version 1.0***; 1997.

4. Inventory Monitoring and Assessment Section Science; Information Branch, Provincial Geomatics Services Centre Natural Resources Management Branch; and Southern Science and Information Section Science and Information Resources Branch; ***SOLRIS Evaluated Wetland Edition Version 3.1***; June 15, 2004.

5. Upper Thames River Conservation Authority, ***City of London Slope Stability Study***, 1996.

6. Upper Thames River Conservation Authority, ***Slope Stability Mapping Project for the Township of Middlesex Centre***, 2001.

7. Upper Thames River Conservation Authority, ***Slope Stability Mapping Project for the Township of Thames Centre***, 2002.

Appendix A: Determination of Regulation Limits

Regulation Limits are the result of several components, each of which addresses a specific hazard. These include riverine flooding hazard limits, riverine erosion hazard limits, shoreline flooding limits, shoreline erosion limits, wetlands limits, allowances, and "other areas". Each of these components are identified and defined individually. The final Regulation Limit for each system is taken as the greater of the applicable hazard limits. The following identifies the steps taken by UTRCA staff to develop the regulation mapping:

1) Riverine Systems

a. Identify the valley Top-of-Slope with a GREEN line. The Top-of-Slope is the break in slope point between the valley side slope and the tableland, and should be discernable from the contour line information. In agricultural area, the limit of tree line or fence lines is also indicators of the Top-of-Slope. Where a Top-of-Slope can be discerned (Not Apparent valley) proceed to step e).

b. Identify the valley Toe-of-Slope with an ORANGE line. The Toe-of-Slope is the break in slope point between the valley floor and the valley side slope, and should be discernable from the contour line information.

c. Identify portions of steep valley slope. A greater contour density can identify steep slopes. At these sites, calculate the slope from the Valley Toe-of-Slope to the Valley Top-of-Slope by measuring the horizontal distance, and calculating the difference between the Valley Toe-of-Slope elevation and the Valley Top-of-Slope elevation. If the ratio of horizontal distance: elevation difference is more steep than 3:1, multiply the elevation difference by 3, and identify a Stable Slope Allowance at this distance from the valley Toe-of-Slope with a RED line.

d. Identify portions of the valley system where the creek bank is close to the valley side slope (wherever the creek bank and the valley Toe-of-Slope are within 15 metres or less). At these sites, identify a Toe Erosion Allowance with a BLUE line, as the difference between 15 metres and the actual distance between the creek bank and the valley Toe-of-Slope. Apply this allowance beyond the valley Top-of-Bank. If a Stable Slope Allowance has already been calculated at the site, apply the Toe Erosion Allowance beyond the Stable Slope Allowance.

e. Where a valley Top-of-Slope is not evident, the valley is considered Not Apparent, and a Meander Belt is applied in place of the features identified in steps a) through d). The meander belt is drawn as a PURPLE line. Calculate the meander belt width as 20 times the width of the bank full channel. Where the channel width can be measured or is known, assume a minimum width of 1.5 metres. Although the meander belt should be centered on the meander axis, estimation can be made by setting the meander belt as an offset from the watercourse layer.

f. Select the Riverine Erosion Hazard Limit as the outer most line of all the combined features identified in items a) through e).

g. Add the Riverine Flood line Hazard Limit. This line has been developed from the floodplain mapping sources listed in Table 1 of this report. The flood line is coloured RED.

h. Select the Riverine Hazard Limit as the outer most line of the Erosion and Flood line Hazard Limits.

2) Allowance of 15 metres to Hazard Limits

a. Apply an Allowance of 15 metres outward from the combined Hazard Limits. This is the portion of the Regulation Limit for Riverine and Shoreline Systems.

3) Wetland Systems

a. Add the wetland layers from Ministry of Natural Resources digital wetland layers and from UTRCA SOLRIS mapping queries. Map the Wetland Limit as the greater extent of the two data sources. (ie: eliminate wetlands less than 0.5 hectares in size).

b. Apply an "Area of Interference" of 120 metres beyond the Wetland Limit of provincially significant wetlands and all other wetlands greater than 2 Ha.

c. Apply an "Area of Interference" of 30 metres beyond the Wetland Limit of all not-provincially significant wetlands that are less than 2 Ha.

4) Regulation Limit

Combine the Regulation Limit for Riverine and Shoreline Systems and the "Other Area "Limit. The outer most limit of these features is the UTRCA Regulation Limit. The Regulation Limit is the greatest extent of:

- Riverine Hazard Limit, and
- A 15 metre Allowance on all Riverine Hazards, and
- Wetland boundary, and
- "Areas of Interference" within 120 or 30 metres of all wetlands

5) Base Mapping.

The UTRCA Regulation Limit is shown on year 2000, georeferenced ortho photography. The mapping will be published at a scale of 1:10,000, and will include the Regulation Limit Line, roadway and watercourse labels, and a full legend. The mapping will be provided on individual sheets no larger than 2'x3'.