Attachment 2:
WRS Summary Report 2022

Toronto and Region Conservation Authority

TRCA Water Resource System: A Summary Report

Prepared By:
Watershed Planning and Ecosystem Science
Development and Engineering Services
August, 2022

Acknowledgements

Special thanks to TRCA's partner municipalities and research partners for their support in developing this work.

Region of Peel
City of Toronto
York Region
Durham Region
University of Toronto
Mitacs Inc

This report was completed with input and analysis by the Ecosystem and Climate Science group at the Toronto and Region Conservation Authority (TRCA). Advice and input were provided by Mason Marchildon from the Oak Ridges Moraine Groundwater Program (ORMGP) for Ecologically Significant Groundwater Recharge Areas (ESGRAs) and Seepage Areas and Springs. Also, thanks to the Geographic Information System team for their contributions, specifically Victoria Trinidad and Colleen Gibson, who contributed to the refinement of the wetland and inland lakes and their littoral zones layers. Lastly, thanks for feedback and advice provided from the Science and Research Working Group at TRCA.

Report Prepared by

Jonathan Ruppert, Senior Research Scientist, Ecosystem and Climate Science

Project Team Contributors

Andrew Chin, Research Analyst, Ecosystem and Climate Science
David Lawrie, Research Scientist, Ecosystem and Climate Science
Jason Tam, Manager, Business Intelligence and Data Analytics
Laura DelGiudice, Associate Director, Watershed Planning and Ecosystem Science
Namrata Shrestha, Senior Manager, Watershed Planning and Reporting
Steven Ling, Technologist, Business Intelligence and Data Analytics

Summary

The development of Water Resource System (WRS) data layers for Toronto and Region Conservation Authority (TRCA) provides robust decision support tools and information to guide various TRCA and municipal initiatives, including watershed planning, restoration planning, land use, and infrastructure planning. Notably, the development and update of the WRS within TRCA's jurisdiction is intended to assist municipal partners with achieving provincial policy conformity that requires them to identify the WRS through watershed planning. Components of the WRS are critical to the overall function and health of watersheds. Broadly, the total amount and protection afforded to Key Hydrologic Features (KHFs) and Key Hydrologic Areas (KHAs) within a watershed is related to water quality, water quantity, aquatic ecosystem health, terrestrial ecosystem health, erosion, hydrogeology, and flooding. WRS components defined in the *Growth Plan* (2020) include:

Key Hydrologic Areas (KHAs)

- Significant Groundwater Recharge Areas (SGRAs);
- Highly Vulnerable Aquifers (HVAs);
- Significant Surface Water Contribution Areas (SSWCAs);
- Ecologically Significant Groundwater Recharge Areas (ESGRAs);

Key Hydrologic Features (KHFs)

- Permanent streams;
- Intermittent streams;
- Inland lakes and their littoral zones;
- Seepage areas and springs;
- Wetlands.

In 2019 a review was conducted by the Ecosystem and Climate Science team to assess the various data layers that are used for mapping the WRS within the TRCA jurisdiction. This identified that many KHF and KHA data layers had several issues that contributed to a higher level of mapping uncertainty, including a high level of error associated with the spatial location of the current features/areas as well as with errors associated with their configuration, size, and shape of features/areas. Further, the review revealed other issues, including that existing data layers were somewhat outdated (>5 years), were produced for cartographic purposes only, had many versions that varied in scope and mapping, or did not include features/areas that had been identified in more recent policy updates.

This report summarizes TRCA's systematic approach, methods, and resulting data that helps to delineate TRCA's WRS. This addresses a large share of the previously highlighted issues associated with

existing data layers and provides an increased level of accuracy from previous versions. This document provides details around several WRS features and areas, including: (1) Ecologically Significant Groundwater Recharge Areas (ESGRAs), (2) Seepage areas and springs, (3) inland lakes and littoral zones, (4) wetlands, (5) intermittent/permanent streams, and (6) Significant Surface Water Contribution Areas (SSWCAs). Notably, outside of refinements and overlapping between WRS layers, there are only two layers that map new areas for the WRS, including ESGRAs and Seepage areas and Springs. Other components, including both Highly Vulnerable Aquifers (HVAs) and Significant Groundwater Recharge Areas (SGRAs) are also part of the WRS, but are developed to satisfy requirements of the *Source Protection Plan* for the Credit Valley, Toronto and Region and Central Lake Ontario region (CTC-SPC 2015) under the *Clean Water Act* (2006). Thus, there is already a process in place for HVAs and SGRAs, which is detailed in other referenced materials.

Altogether, the WRS has an aerial footprint of 66.3% for the TRCA jurisdiction, where most KHAs and KHFs are found in the urbanized (32.0%), followed by greenbelt (29.4%), and whitebelt (4.9%) lands. However, most of this footprint was related to Source Water Protection layers, where HVAs (43.3%) and SGRAs (29.1%) represent the largest aerial footprints for the jurisdiction. When considering newly developed layers (ESGRA and Seepage areas and Spring) the aerial footprint of new mapped areas for the WRS only equates to 2.5% (~6,100 Ha) of the TRCA jurisdiction. After HVAs (43.3%) and SGRAs (29.1%), the footprint of KHAs and KHFs (from largest to smallest) includes ESGRAs (13.6%), seepage areas and springs (10.5%), SSWCAs (9.3%), wetlands (4.6%), and inland lakes and their littoral zones (0.4%). Lastly, classification of watercourses found that permanent (46.2%) and intermittent (21.2%) streams make up most of the watercourses in the TRCA, however, there remains a large portion of unknown watercourses (i.e., data deficient; 32.6%).

Overall, this project has produced scientifically robust mapping products, where the methods outlined in this document detail how the amount of uncertainty is reduced as much as possible. Notably, KHFs and KHAs may be subject to development, such as within the whitebelt, and require watershed planning exercises. To that end, these data products will be useful for TRCA and its partners in the many land use and infrastructure planning processes they undertake, such as watershed planning, restoration planning, settlement area boundary expansions, and achieving provincial policy conformity through municipal comprehensive reviews. Specifically, these data products can be used by municipalities to identify the WRS to provide for the long-term protection of key hydrologic features, key hydrologic areas, and their functions, as required by provincial policies. Similar to Natural Heritage System (NHS) planning, municipalities should adopt consistent policies for the protection of the WRS. This should include, at a minimum, protection policies for key hydrologic features and appropriate mitigation policies for key hydrologic areas through Official Plans.

Table of Contents

INTRODUCTION

Broadly, the Water Resource System (WRS) as defined and/or referred to in various Ontario provincial policies (*Provincial Policy Statement* (PPS; 2020), *Growth Plan* (2020), *Greenbelt Plan* (2017), and *Oak Ridges Moraine Conservation Plan* (ORMCP; 2017) comprises of both Key Hydrological Features (KHFs) and Key Hydrological Areas (KHAs). Specifically, the WRS as defined in the *Growth Plan* (2020) is considered to include, "*ground water features* and areas and *surface water features* (including shoreline areas), and *hydrologic functions*, which provide the water resources necessary to sustain healthy aquatic and terrestrial ecosystems and human water consumption." The components of the WRS, are:

Key Hydrologic Areas (KHAs)

- Significant Groundwater Recharge Areas (SGRAs);
- Highly Vulnerable Aquifers (HVAs);
- Significant Surface Water Contribution Areas (SSWCAs);
- Ecologically Significant Groundwater Recharge Areas (ESGRAs);

Key Hydrologic Features (KHFs)

- Permanent streams;
- Intermittent streams;
- Inland lakes and their littoral zones;
- Seepage areas and springs;
- Wetlands.

As water is essential for our survival and the health of the natural environment that it supports. This concept is recognized in many of TRCA's strategic priorities, but is central to the strategic priority of, "Manage our regional water resources for current and future generations" (TRCA 2018). Here, desirable outcomes within this priority include:

- Natural aquatic ecosystem functions within the nine watersheds are protected and enhanced using the best available tools and data to target investments for the best results;
- Adaptive measures to address climate change are integrated into infrastructure projects to ensure their durability and resilience;
- Toronto Region waterways are suitable for swimming, fishing, and recreational activities;
- Source water quality and quantity is maintained or improved;

- Known flood and erosion risks, as part of the TRCA Erosion and Hazard Mitigation Strategy which, if funded, can mitigate known risks in the jurisdiction, are being addressed by TRCA and stakeholders on a priority basis.

To meet these desirable outcomes, it requires a robust understanding of the WRS, where KHFs and KHAs are components of a watershed that are required to maintain or improve key processes and functions, such as the resulting biodiversity that the WRS supports. From a holistic perspective, the water resource system can encompass hydrological, infrastructure, ecological, and human processes that involve water (Brown et al. 2015). Notably this includes biogeophysical processes (the hydrologic cycle and ecosystem function) and human activities/uses (construction, operation, removal of infrastructure, water consumption) (Brown et al. 2015). At a basic level, this means identifying KHFs and KHAs that support these processes so they can be considered for mitigation, compensation, protection, or restoration in management or planning decisions.

Given the importance of the WRS, there have been many policy documents that outline KHFs and KHAs, which as a result feature in many planning development processes. The development of WRS data layers for TRCA provides robust decision support tools and information to guide various TRCA and municipal initiatives, including watershed planning, restoration planning, land use and infrastructure planning. Notably, the development and update of the WRS within TRCA's jurisdiction is intended to assist municipal partners with achieving provincial policy conformity that requires them to identify the WRS for its long-term protection. This can be achieved through incorporating the WRS in municipal comprehensive reviews, settlement area boundary expansions, Official Plans, natural heritage system planning, among other strategic planning development exercises.

Identified Needs & Process

Ecosystem and Climate Science alongside *Watershed Planning and Reporting* with the support of the *Business Intelligence and Data Analytics* team have consistently met the WRS data needs for external and internal uses with the best available data. However, like any data product, best management practice, guideline, or tool, it requires a regular evaluation to ensure that needs are met, and that the product remains the best science-based evidence available.

This project undertook an evaluation process to identify needs externally and internally alongside an assessment of the feasibility and needs for the creation and update of various WRS components (Figure 1 and Table 1). Initial scoping identified that separate processes exist for the creation and update of Highly Vulnerable Aquifers (HVAs) and Significant Groundwater Recharge Areas (SGRAs). Both HVAs and SGRAs were developed for the TRCA jurisdiction to satisfy requirements of the *Source Protection Plan* for the Credit Valley, Toronto and Region and Central Lake Ontario region (CTC-SPC 2015) under the *Clean Water Act* (2006).

For the remaining components, we found that half of the WRS components, no data layers existed as of the start of 2020 and out of those that existed, 2 of 3 existing layers had many identified issues requiring an update to improve accuracy and provide the best data available (see wetlands and inland lakes sections below for further details; Table 1). Firstly, both the 'wetland' and 'inland lakes and their littoral zones' layers were subject to jurisdiction wide Quality Assurance and Quality Control (QA/QC) analysis using the best and newest data available to provide the most up to date products. For wetlands, this meant refining several available layers into one single data product. Secondly, the remaining three layers that did not exist as of the beginning of 2020 required an individual project-based approach for each layer to first conceive of a methodology to implement the creation of data layers with strong consideration given to feasibility (Figure 1). This consisted of using the best available knowledge and/or data to delineate seepage areas and springs, intermittent and permanent stream classifications, and Significant Surface Water Contribution Areas (SSWCAs; Table 1). Altogether the work completed in this program addresses the largest gaps in knowledge by providing data products that can be used by internal and external partners for various land use and infrastructure planning processes.

Table 1. A list of key hydrologic features and areas that were subject to this evaluation and development project. Listed are the six layers, a status of their availability at the end of 2019, whether they map new areas in the jurisdiction, lead and partner groups involved. **NB:** WPES – Watershed Planning & Ecosystem Science; ORMGP – Oak Ridges Modelling Groundwater Program; BIDA - Business Intelligence & Data Analytics.

WRS Component	2019 Availability	New Areas Mapped	Lead	Partner
Seepages areas and Springs	N	Y	WPES	ORMGP
Wetlands	Y	N	WPES	BIDA
Inland lakes and their littoral zones	Y	N	WPES	BIDA
Permanent and Intermittent Streams	N	N	WPES	-
ESGRAs	Y	Y	WPES	BIDA/ORMGP
SSWCAs	N	N	WPES	-
HVAs*	Y	N	-	-
SGRAs*	Y	N	-	-

*Separate processes exist for the development of this layer (see CTC-SPC 2015).

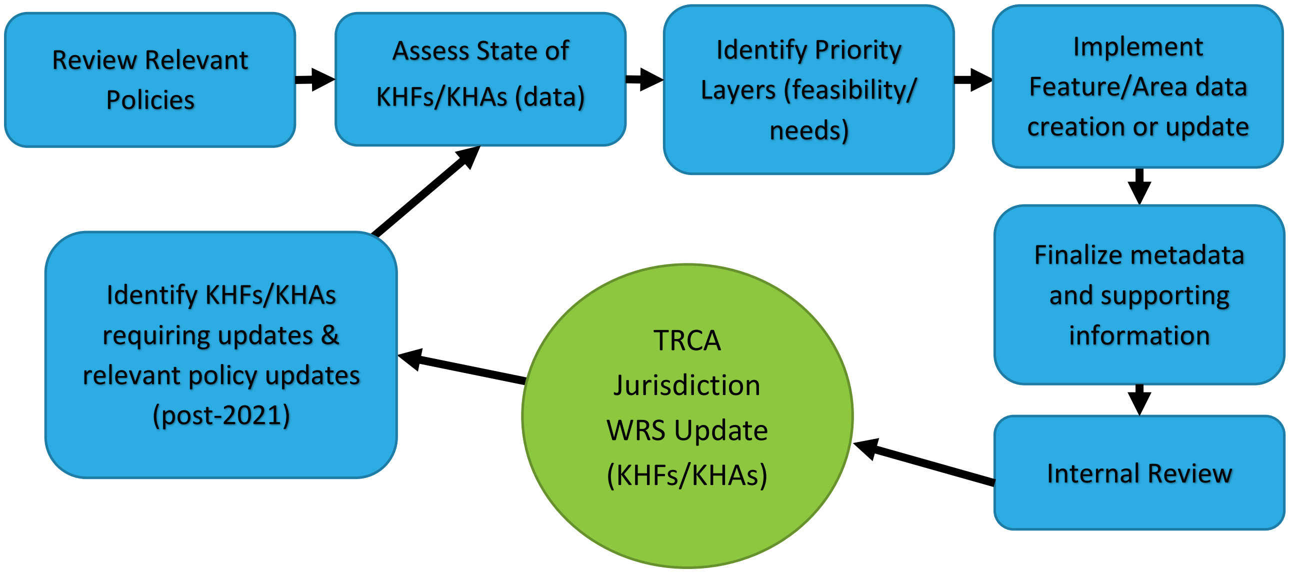

Figure 1. The process undertaken for the development and update of Key Hydrologic Features (KHFs) and Key Hydrologic Areas (KHAs).

Potential Uses of Data Layers

As is the case with any mapping product, there is a level of uncertainty with KHF and KHA data layers due to sampling, model, and data errors that may exist in the process of delineating features or areas. The data presented here should be viewed as the best available scientific knowledge applied to produce these mapping products. However, the project team has focused on minimizing error to the best possible ability in the development of the product. Notably, when possible, field data was used in the creation, update, and implementation of creating these data products (as there is greater certainty with field collected data) to ensure that uncertainty is reduced as much as possible. Regardless, as is the case with any data layer, on the ground validation is strongly recommended at the site level and should be considered to validate the presence, scale, size, and shape of KHFs and KHAs presented in this document. Ultimately, TRCA is confident that these data layers can be used by municipal partners to identify the WRS as required by provincial policies and allow for appropriate policies to ensure the protection of KHFs and KHAs.

METHODS & ANALYSIS

Below we provide the definition, data, methods, and analysis involved in the creation of KHFs and KHAs for the TRCA jurisdiction. Proceeding this we provide a brief overview of the features and areas for the jurisdiction to provide some context for the data products (see Jurisdiction Overview & Mapping). This includes data layers included in Table 1, which includes: seepage areas and springs, wetlands, inland lakes and their littoral zones, intermittent/permanent streams, ESGRAs, and SSWCAs. Although HVAs and SGRAs are not a key focus of the work presented in this document we include references to methods and analysis as well as provide a jurisdiction overview for them as they are also components of the WRS. Lastly, the implications and future considerations are provided to give some context as to what the mapping products might mean for the previously mentioned planning development processes.

Seepage Areas & Springs

A seepage area and/or spring is considered a location of the emergence of groundwater, generally occurring when the water table is at the surface. Prior to 2020 TRCA did not have a comprehensive seepage areas and springs layer for the jurisdiction that met this definition. Here the seepage areas and springs layer was developed by the Ecosystem and Climate Science (ECS) team at TRCA in collaboration with the Oak Ridges Moraine Groundwater Program (ORMGP) team. The ECS team devised a methodology that best approximates this key hydrologic feature (seepage areas and springs), which is developed using two sub-parts:

1. A linear layer describing the watercourses where groundwater discharge in the stream is predicted to be stronger than the regional average stream discharge (i.e., describing strongly discharging streams);

2. A polygon layer describing areas with strong potential for groundwater discharge at surface (i.e., water seeping out of the ground, at least during part of the year). This layer is also refined to eliminate areas of extensive urban land cover, where subsurface and surface infrastructure interferes with discharge processes.

Specifically, the discharging watercourse layer was a product of the output from a steady-state solution of the TRCA Expanded Groundwater Flow Model (TEGWFM; ORMGP 2018). For the second component, the potential discharge area is a product produced by Oak Ridges Moraine Groundwater Group (ORMGP) in 2020. This layer identifies areas where the water table potentially exceeds ground surface elevation produced by interpolating shallow water level measurements. Both these layers were combined and refined to remove areas with land cover classes defined as urban areas (this includes airport, commercial, high density residential, industrial, institutional, landfill, medium density residential, mixed commercial entertainment, railway, and road land uses).

Post-processing of the resulting layer was required as there were many small features within the watercourse and elsewhere that likely do not represent a significantly sized feature that would contribute a large amount of discharge within a given watershed (i.e., features that were < 1 hectare in size). Further, many small seepage areas were identified within urban recreational areas (e.g., urban parks, greenspaces) and along the shoreline of Lake Ontario. The reality with these small urban features is that these are not “seepage areas and springs”, as groundwater does not tend to reach the land surface as it is likely to be intercepted, diverted, and drained by urban infrastructure. Below are the criteria used to filter the final layer (Table 2). In total, approximately 7.8% of the layer was removed using these criteria.

Table 2. Criteria, action, representative area, and percentage applied during post-processing to produce the final layer of seepage area and springs.

Criteria		Action	Area (ha)	Aera of Percentage
1	Does not touch 30-m watercourse buffer; less than 1 ha	Remove	363.6	1.3%
2	Overlaps 500-m buffer along shoreline; less than 5ha	Remove	80.1	0.3%
3	Does not touch 30-m watercourse buffer; greater than 1 ha, falls within recreational	Remove	385.1	1.4%
4	Does not touch 30-m watercourse buffer; greater than 1 ha, does not fall within recreational	Keep	1,159.2	4.1%
5	Overlaps 30-m watercourse buffer; falls within natural cover	Keep	17,774.9	62.4%
6	Overlaps 30-m watercourse buffer; does not fall within recreational	Keep	7,363.9	25.8%
7	Overlaps 30-m watercourse buffer; falls within recreational	Remove	1,367.0	4.8%

Wetlands

As per the *Provincial Policy Statement* (2020), a wetland is defined as "lands that are seasonally or permanently covered by shallow water, as well as lands where the water table is close to or at the surface. In either case the presence of abundant water has caused the formation of hydric soils and has favoured the dominance of either hydrophytic plants or water tolerant plants. The four major types of wetlands are swamps, marshes, bogs and fens." Wetlands support many sensitive species and can contribute to mitigating erosion and flooding but can also present a natural hazard to surrounding development.

Prior to 2020 there were several different variations of wetland layers available across the jurisdiction including wetlands as classified in and TRCA's ortho-photo interpreted natural cover data, field collected Ecological Land Classification (ELC) data, Ontario Ministry of Natural Resources and Forestry (OMNRF) wetland data, supplemented by other available data from various sources such as from field verifications for planning purposes and recently restored wetlands. Each of these data layers were targeted for specific purpose and had different level of accuracies and spatial coverage. The layer developed here consolidates these layers and refines it to reflect the latest information from the field and orthophoto interpretation (described below). The TRCA's consolidated wetland layer was developed by the TRCA Business Intelligence and Data Analytics (BIDA) group and was updated in collaboration with ECS in 2020. A subsequent QA/QC process was completed using the latest orthophotography imagery from 2019.

The undertaking to develop this layer included three key data layers as follows:

1. **Natural cover layer** - from 2017 orthophoto interpretation. This layer is made according to TRCA internal technical standard '2017 Land use Natural Cover Class Definitions'.
2. **TRCA ELC wetland layer** - extracted from Ecological Land Classification data. The data is collected on an annual basis from 1996 to 2019 in various locations by biologists according to Ecological Land Classification System.
3. **OMNRF wetlands** - evaluated using the Ontario Wetland Evaluation System (OWES). The data collection date varies from 2000 to 2020.

The QA/QC process consisted of a visual verification of whether the TRCA's natural cover and the field collected wetland polygons match the 2019 Southern Central Ontario Orthophotography (SCOOP) image (OMNRF 2019). Both the field collected ELC wetland and OMNRF wetland layers were updated for regulation limit criteria in 2019 and 2020, which included detailed field verified comments from TRCA staff and other stakeholders, where field visits and further discussion were conducted. This information was documented in the TRCA's data update commenting tool developed by BIDA, which was thoroughly used in this wetland update for QA/QC. Any additional wetland polygons that were included from TRCA's natural cover data were also verified using orthophoto, existing data in the commenting tool, and additional discussion with TRCA staff, if there was any uncertainty in terms of its classification, boundary, or existence. All the updated data layers were consolidated into one wetland layer in GIS, which was followed by the rigorous QA/QC process using the workflow outlined in Figure 2, which essentially focused on final visual checking to assess whether the updated wetland polygons matched the 2019 SCOOP image. This essentially resulted in the following key steps:

- Remove clearly developed/graded/paved areas from wetlands; keep the remaining portions unless there is a compelling reason or clear visual evidence to the contrary.
- In some cases, if the GIS inspector is unsure whether the wetland polygon or portion of it still exist or not, further confirmation is need. The commenting tool can be used to collect advise from other professional staff to verify.
- Since ELC wetland and MNRF wetland was checked for updating regulation limit criteria layer (wetland AOI) in 2019 and 2020, the corresponding historical action layer can be used as a reference to perform QA/QC.
- Also, an accuracy assessment to ensure data quality check will be implemented to ensure there is no duplicate polygon and to establish an accuracy standard for the final data layer. 5% of the wetland data will be selected to perform quality check.

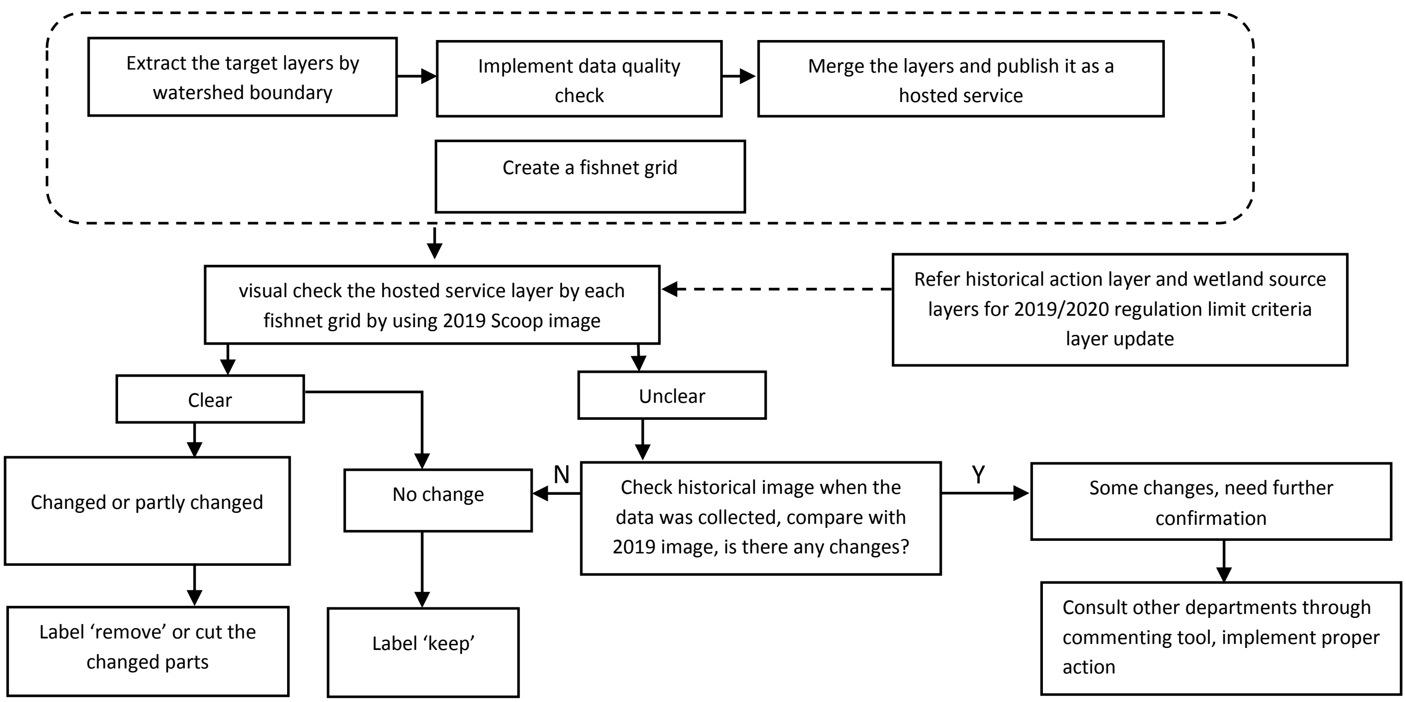

Figure 2. Overall workflow for wetland refinement process that was completed for 32,352 features across the TRCA jurisdiction.

Altogether the 32,352 wetland records were assessed across the whole jurisdiction. Wetlands included in the 2019 and 2020 regulation limit update (only includes wetlands larger than 0.5 ha) were also applied on the final layer such that 113 wetlands are added, 951 wetlands are removed. The only outstanding feature is one wetland record in ELC data that was uncertain due to watercourse realignment. This record has been submitted to Policy Planning group to identify and will be verified with the 2021 regulation limit update. Lastly, the accuracy assessment was completed using a subset of 1,598 wetland records using the 2019 orthophotography data, which indicated that 105 records had some inaccuracies, which has since been corrected. This suggests that the overall accuracy of the updated wetland layer is 93.4%, which is relatively high for this type of data at the regional scale. For site level applications it is recommended that further verification is conducted using a more targeted field surveys, as appropriate.

Inland lakes and their littoral zones

Inland lakes and their littoral zones are defined as permanent standing bodies of water, usually freshwater, larger than a pool or pond or a body of water filling a depression in the earth's surface (Greenbelt Plan 2017). The inland lakes and littoral zones layer available was developed by the TRCA Business Intelligence and Data Analytics (BIDA) group about 10 years ago and was largely intended for cartographic purposes. As satellite imagery was the only data used to delineate features, all waterbody types are included in this layer, which includes:

- **Lakes** - naturally occurring, but may have portions of the shoreline which are artificial;
- **Natural ponds** - generally smaller than a 'lake', often no name, includes beaver ponds;
- **Estuary** - found exclusively along Lake Ontario shoreline upstream from river mouth to first riffle or approximately 77m ASL, yet confined to 'backwater' areas of coastal marshes;
- **Stormwater Management Ponds** (SWMPs)[1] - only those with water should be delineated (no 'dry' ponds to be included);
- **Artificial** - golf course pond, farm pond, reservoir, gravel, or quarry pit, man-made on-line pond;
- **Aggregate** – associated with provincial pits and quarries mapping and feature may be subject to an active aggregate licence. Site level assessments should be completed to validate.
- **Unknown** - includes temporary SWMP or any water body in an actively developing area, any other water body that does not fit in to the other classes.

For the refinement of the inland lakes and littoral zones layer, further screening to address a few issues with accuracy of mapping and overlap with wetland features were completed. The following steps were taken to refine the inland lakes and littoral zones layer:

1. A waterbody was removed if layer overlapped with refined wetland layer when it was 2/3 or more covered by wetland;
2. Field verified data took precedence for delineating the outline of a particular feature;
3. Orthophotography verification was completed to determine if the feature is still on the landscape via most recent data from 2019 (remove/edit if it is not still on the landscape or changed in shape);
4. Identify stormwater infrastructure where possible, using existing data and orthophotography, so it can be separated from non-stormwater features (where possible).

In total 3,887 waterbody features were checked, where 1,433 were removed and 125 added given the criteria above. The resulting refined layer has 2,329 inland lakes and their littoral zones where 649 have been identified as stormwater infrastructure. For the purposes of this report, we report numbers that exclude SWMPs where they have been identified.[1]

[1] Stormwater Management Ponds (SWMPs) are not considered to be an inland lake, but due to a combination of data limitations and methodology we cannot identify all SWMPs. Where possible they have been identified and can be removed from this layer.

Permanent & Intermittent Streams

Permanent streams and watercourses are classified based on having a continual flow within an average climate year. In contrast, intermittent streams flow during wetter seasons, but are dry at certain predictable times during an average climate year. Altogether, both types of features contribute to the overall function and flow of water in the watershed (Stanfield 2017). Here the permanent and intermittent streams layer was developed by the ECS team at TRCA in 2020.

To develop this layer many different sources of data were used, which differed by watershed (please see details in Appendix A). The base layer for this work was the TRCA watercourse layer (except for Carruthers Creek – which uses a finer resolution layer consistent with the recent watershed plan). Here the watercourse layer is matched with data that provides information about the permanency of flow within a particular reach of the system. The data used to infer permanency of flow within reaches includes:

- Headwater Drainage Features Survey Data
- Baseflow Data
- TRCA Instream Temperature Data
- TRCA Instream Barrier Survey Data
- RWMP Fisheries and Temperature Data
- TRCA Historical Fisheries Data
- Orthophotography Interpreted 2017 and 2018 Imagery
- Valley and Stream Crossings Survey Data

For each of these data sources, the coverage of each data source through space and time differs throughout the jurisdiction, meaning that some watersheds and areas may be missing some data sets or have data from different points in time (see Appendix A for watershed-based details). Where possible, the TRCA regulated watercourse was classified as permanent or intermittent. Where there is clear data deficiency for a particular reach they have been classified as unknown. Where on the ground surveys have been completed, formal survey data was used to assess watercourse permanency and there is likely higher certainty with these classifications (this applies to Carruthers and Etobicoke Creeks). It must be noted that most watersheds (7 in total) have not had a formal survey dedicated to defining watercourse permanency and all the remaining watercourses have been defined using the best available data listed above. There are plans moving forward to conduct formal surveys alongside watershed plans and as data becomes available this can be used to update classifications here.

Ecologically Significant Groundwater Recharge Areas (ESGRAs)

An Ecologically Significant Groundwater Recharge Area (ESGRA) can be defined as an area of land that is responsible for replenishing groundwater systems that directly support sensitive areas like coldwater streams and wetlands (Greenbelt Plan, 2017). The protection of groundwater-dependent ecologically sensitive areas depends, in part, on understanding where on the landscape the groundwater comes from and taking steps to ensure the recharge function of these areas is protected (Figure 3). ESGRAs are identified using regional-scale modelling to predict where groundwater recharge at a given location will emerge or "discharge" within ecologically sensitive areas.

The ESGRA layer was developed in 2019 for entire jurisdiction by the Ecosystem and Climate Science team at TRCA in collaboration with the Oak Ridges Moraine Groundwater Program (ORMGP). An ecologically sensitive system that ESGRAs support includes fens (type of rare wetland that depends on groundwater inputs), groundwater dependent cold water fish species, and groundwater dependent plant species. Relevant to this data layer, ESGRAs are defined under the *Growth Plan for the Greater Golden Horseshoe* (2020) and the *Greenbelt Plan* (2017). The term also has policy associations in TRCA's *Stormwater Management Criteria* (2012). Mapping of ESGRAs can be used to inform decisions around municipal growth through the land use and infrastructure planning processes. Extensive documentation has been developed for the ESGRA layer and is found in TRCA (2019) and is available upon request.

The ability to establish hydrogeological connections between areas of land and groundwater-supported ecosystems has been enhanced by significant improvements in understanding of regional-scale hydrogeology. As part of Source Water Protection (SWP), water budget models were developed for many watersheds in southern Ontario in the mid-2000s. These water budget models provided the knowledge and the modelling framework necessary for a more detailed assessment of groundwater-dependent ecosystems. In 2012, Lake Simcoe Region Conservation Authority (LSRCA) completed ESGRA modelling and mapping for the western Lake Simcoe drainage basin; LSRCA subsequently completed mapping for most of the remainder of the drainage basin over 2013-2015. Central Lake Ontario Conservation Authority (CLOCA) completed ESGRA modelling and mapping for their entire jurisdiction in 2014.

Building on these precedents, TRCA contracted the Oak Ridges Moraine Groundwater Program (ORMGP) to complete reverse particle tracking for the watersheds of TRCA jurisdiction using existing SWP numerical models following the methodology used by LSRCA and CLOCA. Using the model outputs, TRCA staff developed a methodology for mapping ESGRAs that maximizes the protection of groundwater-dependent ecosystems while minimizing the area of the watershed that is covered by ESGRAs. The details of this methodology are outlined TRCA (2019). This updated mapping supersedes the version of the map appearing in the 2012 *Stormwater Management Criteria* and uses a methodology that is consistent with neighbouring conservation authorities.

Briefly, the (reverse) particle tracking analysis reveals the connectivity between groundwater recharge and discharge areas throughout the TRCA jurisdiction(Marchildon et al. 2016). Pairing particle tracks from the expanded groundwater model (Marchildon et al., 2016) with data from Highly Dependent Groundwater Ecosystems (HDGEs; fish, flora, and fens) allowed us to determine where ESGRAs are likely to found on the landscape. Details of this approach can be found in TRCA (2019) and plain language memos that accompanied the work (Taylor et al. In Review). The methodology presented here was the result of a multidisciplinary collaboration between TRCA staff and representatives from Credit Valley Conservation and the Oak Ridges Moraine Groundwater Program, altogether providing varied skillsets and experience including: hydrogeologists, ecologists, and geomatics and policy specialists.

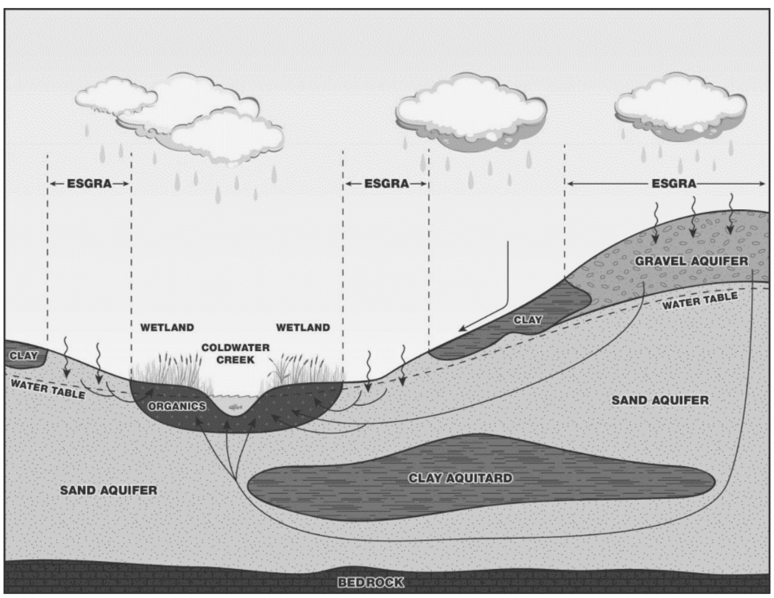

Figure 3. Conceptual drawing of Ecologically Significant Groundwater Recharge Areas in a landscape context.

Significant Surface Water Contribution Areas (SSWCAs)

An SSWCA is defined in the *Growth Plan for the Greater Golden Horseshoe* (2020) as, "Areas, generally associated with headwater catchments, that contribute to baseflow volumes which are significant to the overall surface water flow volumes within a watershed." Municipalities have sought further clarity from the province (Ministry of Environment, Conservation and Parks), herein the definition of SSWCAs is focused on contribution to baseflow volumes that are significant to surface water flow volumes, which is more specific than simply delineating headwaters. This does not include headwaters into SSWCAs, because SSWCAs only protect groundwater contribution in some headwater areas. See also previous TRCA memos on ESGRAs, other KHFs, and technical methodologies for SGRAs, HVGRAs and HVAs under the Credit Valley – Toronto Region – Central Lake Ontario (CTC) Source Protection Area (CTC-SPC 2015).

Based on discussion with municipal staff the following methodology was offered for delineating SSWCAs, "SSWCAs are those areas which are both SGRAs and ESGRAs; the methodologies used to delineate SGRAs and ESGRAs should be used to identify SSWCAs." Under this definition, SSWCAs would therefore comprise the areas of overlap between ESGRAs and SGRAs (or in the case of SGRAs, unclipped layers based on Technical Rule 45, e.g. High Volume Groundwater Recharge Areas; HVGRAs). HVGRAs were identified for the Source Protection Program based on the volume of recharge that occurs, not where water resources contributing to recharge expresses itself in streams. Conversely, ESGRAs are identified as the most likely site of groundwater recharge for the receiving feature that they support (streams and wetlands), but not based on the volume of water that they contribute. Those overlap areas then, are areas that provide a large volume of groundwater recharge, and where that recharge has been found through groundwater modelling to support sensitive areas like coldwater streams and wetlands. In other words, the "significant" component of the SSWCA term would be covered through volume contributions identified by HVGRAs, and the "surface water contribution areas" component of the SSWCA term would be covered by recharge-discharge connections to sensitive receiving features, as identified by ESGRAs. An important virtue of this methodology is that it would not expand the total size of the WRS very much, as there would be a high overlap with other WRS components; however, there may be a distinct policy implication.

Highly Vulnerable Aquifers (HVAs)

The HVA layer was developed to satisfy requirements of the *Source Protection Plan* for the Credit Valley, Toronto and Region and Central Lake Ontario region (CTC-SPC 2015) under the *Clean Water Act* (2006). Here aquifers are defined as water-bearing permeable rock, fractures within rocks, or loose materials (such as gravel, sand, or silt). Vulnerability of aquifers is considered to be related to the depth to aquifer, soil type and thickness to provide an indication of the potential protection provided by materials above the aquifer (CTC-SPC 2015). Details of the methodology used to develop this layer can be found in CTC-SPC (2015).

Significant Groundwater Recharge Areas (SGRAs)

The SGRA layer was developed to satisfy requirements of the Source Protection Plan for the Credit Valley, Toronto and Region and Central Lake Ontario region (CTC-SPC 2015) under the *Clean Water Act* (2006). Groundwater recharge occurs when rain/snow seeps down into an aquifer and generally this is associated with particular soil types (e.g., loose sand/gravel). SGRAs are delineated using a water budget modelling process, where the high potential recharge areas are delineated by the method outlined in full in CTC-SPC (2015). Details of the methodology used to develop this layer can be found in CTC-SPC (2015).

MAPPING & JURISDICTION OVERVIEW

Considering KHFs and KHAs that have an aerial footprint, the amount of area they represent within the jurisdiction varies overall, within planning zones (greenbelt, whitebelt and urban), and across the watersheds found within the TRCA jurisdiction. Altogether the WRS is found to have an aerial footprint of 66.3% (164,655 ha) in the TRCA jurisdiction (note this excludes permanent and intermittent watercourses which are linear features; Figure 4). Without source protection layers (HVAs and SGRAs; which are not part of this update) this area reduces to 25.7% (63,852 ha; Figure 4). If we consider the layers with new spatial footprints (ESGRAs and Seepage Areas and Springs) the area reduces further to 23.3% (57,761 ha). Lastly, considering overlap with pre-existing and refined layers the new spatial area added to the WRS has an aerial footprint of 2.5% (6,091 ha; Figure 4). Altogether, while the spatial footprint of all WRS layers is sizeable (66.3%), most of this aerial coverage is related to Source Water Protection areas and when considering new layers, only 2.5% is a new addition to the WRS.

Within the three broad planning zones/areas in the TRCA jurisdiction (greenbelt, whitebelt and urban), the overall WRS (considering all layers with 66.3% coverage) has a coverage of 29.4% in the greenbelt, 4.9% in the whitebelt, and 32.0% within urbanized areas (Table 3 and Figure 4). Notably, when only considering the new additions to the WRS (representing only 6,091 hectares or 2.5% of the jurisdiction), the breakdown follows a similar pattern (1.6% greenbelt, 0.2% whitebelt, and 0.7% urban; Table 3). Specifically, most features and areas have higher numbers and aerial footprints within the greenbelt, where seepage areas and springs, wetlands, inland lakes and littoral zones, ESGRAs, SSWCAs, SGRAs are all found to have >50% of their areas in designated greenbelt areas (Figure 4; Figures 5-12; Table 4). In contrast, HVAs have the largest portion (~50%) within urbanized areas (Table 4). Lastly, while whitebelt areas generally have lower aerial footprints of WRS features and areas, there is still 12,091 hectares of WRS in the whitebelt (out of a possible 19,092 ha hectares or 63.3%) that are present (Table 4).

Altogether KHFs with an aerial footprint include seepage areas and springs (10.5%), wetlands (4.5%), and inland lakes and their littoral zones (0.4%; Table 5; Figures 5-7). The only new layer is seepage areas and springs, while the wetland and inland lake layers have simply been refined and updated. For KHAs, the HVAs (43.3%) and SGRAs (29.1%) represent the largest aerial footprints for the jurisdiction (Table 5; Figure 10,11). As mentioned these layers were developed to satisfy requirements of the Source Protection Plan for the Credit Valley, Toronto and Region and Central Lake Ontario region (CTC-SPC 2015) under the *Clean Water Act* (2006). For the remaining KHAs, ESGRAs (13.9%) and SSWCAs (9.3%), as SSWCAs largely overlap with SGRAs and ESGRAs, the SSWCA aerial footprint is mostly not unique (Table 5; Figure 8,9).

Across the watersheds there is a notable pattern where eastern watersheds (e.g., Carruthers, Duffins, Rouge) tend to have higher amounts of KHFs and KHAs compared to central and western watersheds in the jurisdictions (Table 5). One exception to this is the Humber River watershed which has the highest numbers of KHFs and KHAs compared to other watersheds within the central and western portions of the jurisdiction (Table 5). While this is likely related to the amount of impervious surface and historical development practices throughout the jurisdiction, it should be noted that impervious cover does not necessarily preclude all KHFs and KHAs, though it can play a direct role in disrupting natural discharge and recharge processes which these layers represent.

The final KHF, permanent and intermittent streams, are a classification of regulated watercourse, where we find that there is about 1,777 kilometers of permanent streams within the TRCA jurisdiction, representing the largest share of watercourses (46.2%; Table 6; Figure 12). In general, the watersheds that are more developed tend to have higher amounts of permanent watercourse, including Etobicoke (54.6%), Mimico (85.3%), Don (68.4%), Highland (88.7%) and Carruthers (50.5%). Intermittent streams represent approximately 817 kilometers of watercourse within he TRCA jurisdiction (21.2%; Table 6). In general, the smaller watersheds in the jurisdiction that still have subwatershed with lower impervious cover, tend to have the highest amount of intermittent streams, including Carruthers (49.4%), Petticoat (49.9%) and Etobicoke (31.7%; Table 6). Lastly, there are roughly one third of watercourses (1,252 kms; 32.6%) that remain unknown (Table 6). The highest amounts of unknown watercourses are associated with the largest watersheds, Humber River (38.0%) and Duffins Creek (50.2%; Table 6).

Table 3. Summary of water resource system features and areas as percentages of aerial footprints within the jurisdiction for each land use zone (greenbelt, whitebelt, and urban).

WRS Layers	Greenbelt	Whitebelt	Urban
All WRS	73,168 (29.4%)	12,091 (4.9%)	79,396 (32.0%)
WRS without HVA + SGRA	37,772 (15.2%)	5,574 (2.2%)	20,506 (8.3%)
ESGRA + Seeps	33,862 (13.6%)	5,137 (2.1%)	18,762 (7.6%)
New WRS Additions	3,910 (1.6%)	437 (0.2%)	1,743 (0.7%)

Table 4. Summary of water resource system features and areas as total hectares and percentage within each land use zone (greenbelt, whitebelt, and urban).

Feature/Area	Greenbelt	Whitebelt	Urban
Seepage Areas and Springs	17150 (65.5%)	1486 (5.7%)	7563 (28.9%)
Wetlands	7751 (70.0%)	700 (6.3%)	2617 (23.6%)
Inland Lakes and Littoral Zones	626.5 (67.1%)	28.4 (3.0%)	279.2 (29.9%)
ESGRA	18721 (54.1%)	3846 (11.1%)	12044 (34.8%)
SSWCA	15732 (68.2%)	2155 (9.3%)	5183 (22.5%)
HVA	39945 (37.1%)	4891 (4.5%)	62711 (58.3%)
SGRA	54844 (75.9%)	6866 (9.5%)	10536 (14.6%)

Table 5. Summary of water resource system features and areas as total hectares and percentage within each spatial area (watershed and the jurisdiction total).

Feature/Area	Etobicoke	Mimico	Humber	Don	Highland	Rouge	Petticoat	Frenchman's Bay	Duffins	Carruthers	Waterfront	Jurisdiction
Seepage areas and Springs	903.2 (4.3%)	235.1 (3.1%)	11095.8 (12.2%)	2250.4 (6.3%)	540.0 (5.1%)	4978.3 (14.8%)	294.6 (12.2%)	125.5 (4.6%)	4793.6 (17.0%)	720.0 (18.1%)	266.5 (2.3%)	26202.9 (10.5%)
Wetlands	508.6 (2.4%)	55.5 (0.7%)	5004.9 (5.5%)	322.9 (0.9%)	78.7 (0.7%)	1935.9 (5.8%)	266.1 (11.0%)	271.3 (10.0%)	2359.0 (8.4%)	367.0 (9.2%)	237.5 (2.0%)	11407.5 (4.6%)
Inland Lakes and Littoral Zones	49.2 (0.2%)	33.8 (0.4%)	480.0 (0.5%)	33.6 (0.1%)	0.8 (0.0%)	172.1 (0.5%)	0.6 (0.1%)	0.4 (0.4%)	149.0 (0.5%)	11.5 (0.3%)	3.3 (4.3%)	934.3 (0.4%)
ESGRA	2765.7 (13.0%)	758.3 (10.0%)	14468.0 (15.9%)	1714.5 (4.8%)	193.3 (1.8%)	5595.3 (16.7%)	403.8 (16.7%)	256.8 (9.5%)	7743.9 (27.4%)	687.2 (17.3%)	39.8 (0.3%)	34626.6 (13.9%)
SSWCA	95.2 (0.4%)	132.0 (1.7%)	11446.7 (12.6%)	1060.2 (3.0%)	68.4 (0.6%)	4373.3 (13.0%)	144.1 (6.0%)	46.0 (1.7%)	5517.1 (19.6%)	173.4 (4.4%)	13.3 (0.1%)	23069.6 (9.3%)
HVA	5441.4 (25.6%)	2005.8 (26.6%	38094.0 (41.9%)	16813.7 (47.1%)	5115.8 (48.3%)	13876.9 (41.4%)	924.8 (38.3%)	1179.0 (43.7%)	13683.3 (48.5%)	1767.6 (44.5%)	8698.9 (73.8%)	107601.0 (43.3%)
SGRA	121.9 (0.6%)	0.0 (0.0%)	42461.8 46.7%)	1036.6 (2.9%)	0.0 (0.0%)	13054.5 (38.9%)	509.4 (21.1%)	75.3 (2.8%)	14483.8 (51.3%)	502.2 (12.6%)	0.0 (0.0%)	72245.5 (29.1%)

Table 6. Summary of total and percentage of permanent, intermittent, and unknown stream classes in each watershed, and jurisdiction total and percentage of the jurisdiction. Frenchman's Bay and Waterfront are excluded due to the absence of data.

Watercourse Type	Etobicoke	Mimico	Humber	Don	Highland	Rouge	Petticoat	Duffins	Carruthers	Jurisdiction
Permanent	143.5 (54.6%)	55.0 (85.3%)	727.0 (38.2%)	200.3 (68.4%)	69.4 (88.7%)	289.2 (56.7%)	9.5 (18.0%)	240.1 (40.3%)	43.1 (50.5%)	1777.2 (46.2%)
Intermittent	83.3 (31.7%)	3.5 (5.5%)	453.4 (23.8%)	43.0 (14.7%)	3.5 (4.4%)	105.0 (20.6%)	26.4 (49.9%)	56.6 (9.5%)	42.1 (49.4%)	816.8 (21.2%)
Unknown	36.2 (13.8%)	5.9 (9.1%)	723.0 (38.0%)	49.7 (17.0%)	5.4 (6.9%)	115.5 (22.7%)	17.0 (32.1%)	299.4 (50.2%)	0.1 (0.1%)	1252.3 (32.6%)

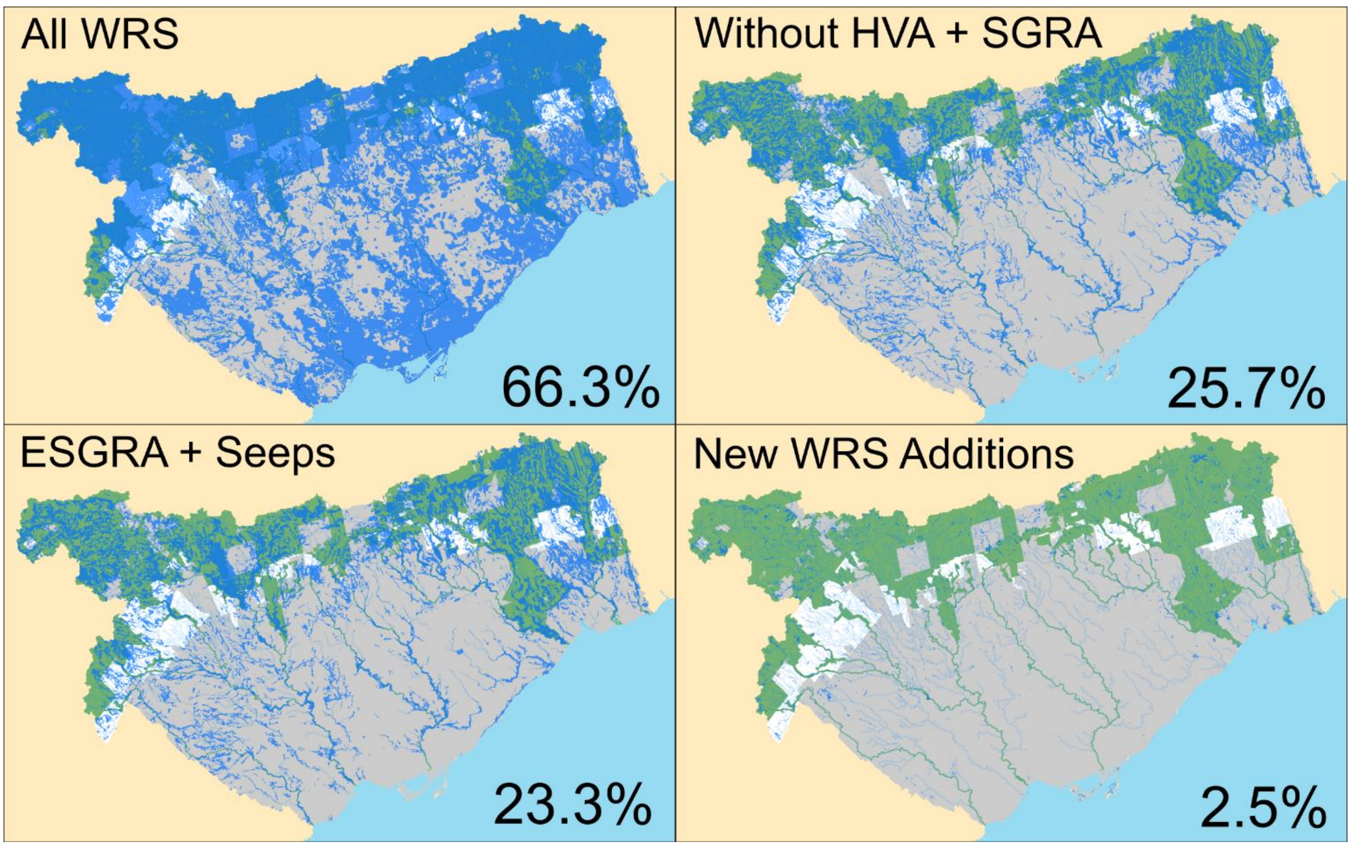

Figure 4. Maps show the WRS aerial footprint (A) with Source Protection layers (SGRAs and HVAs), (B) without Source Protection layers (SGRAs and HVAs), (C) layers that are new and have unique footprints (Seepage areas and Springs and ESGRAs), and (D) uniquely new areas included in the WRS. These overlayed on the Greenbelt, whitebelt, and urbanized portions of the TRCA jurisdiction. Percentages represent the total aerial footprint of combinations.

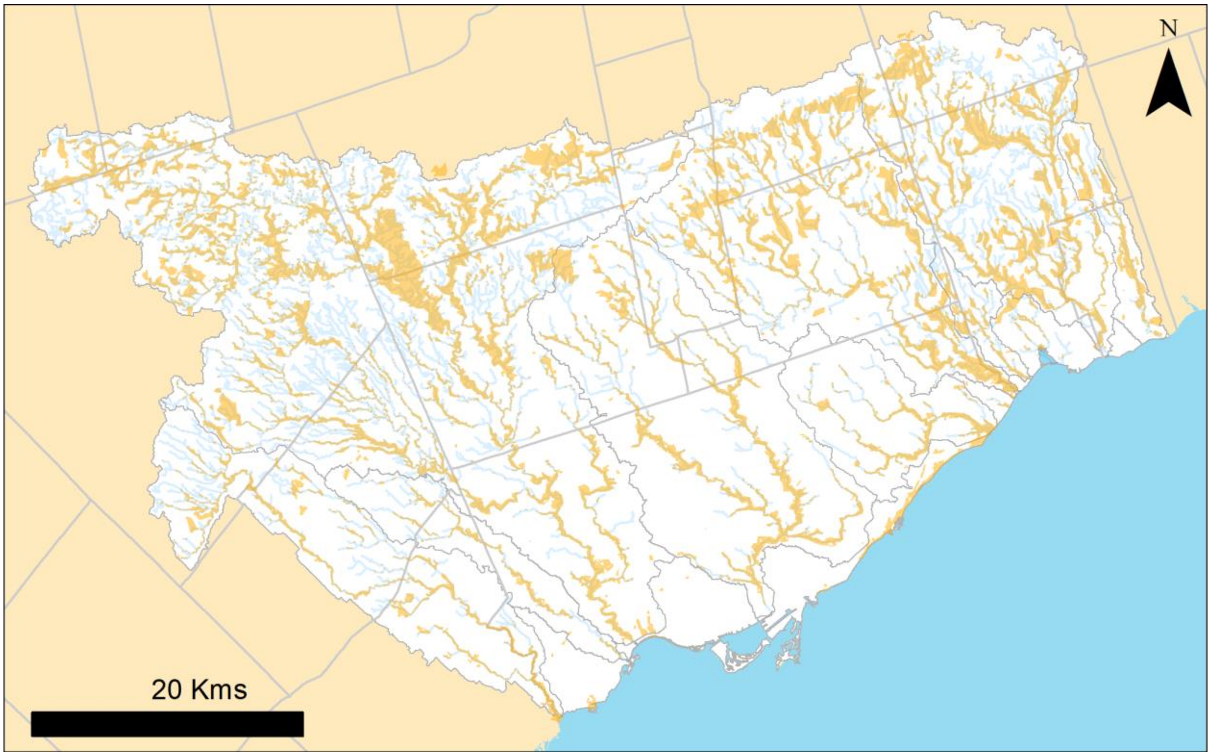

Figure 5. Shown are the seepage areas and springs in the TRCA jurisdiction (orange polygons and polylines). Features have been enlarged slightly to better identify features at this scale.

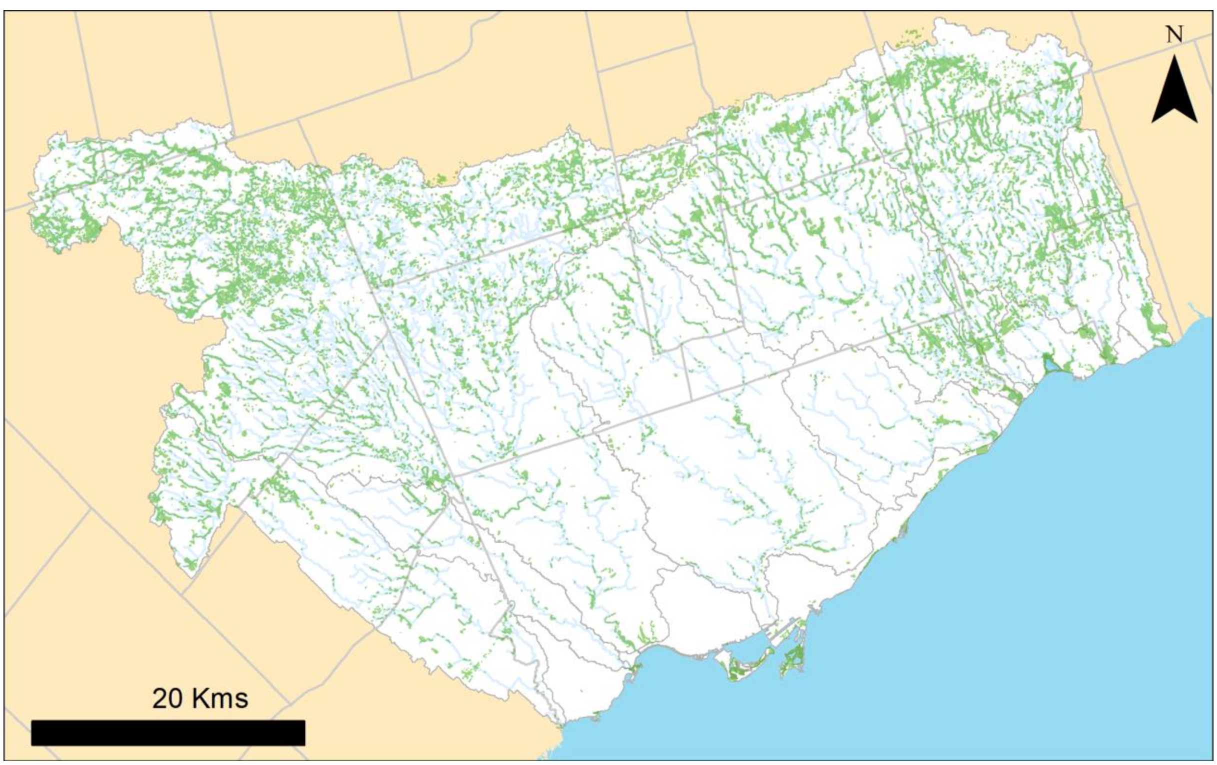

Figure 6. Shown is the refined wetland layer in the TRCA jurisdiction (green polygons). Features have been enlarged slightly to better identify features at this scale.

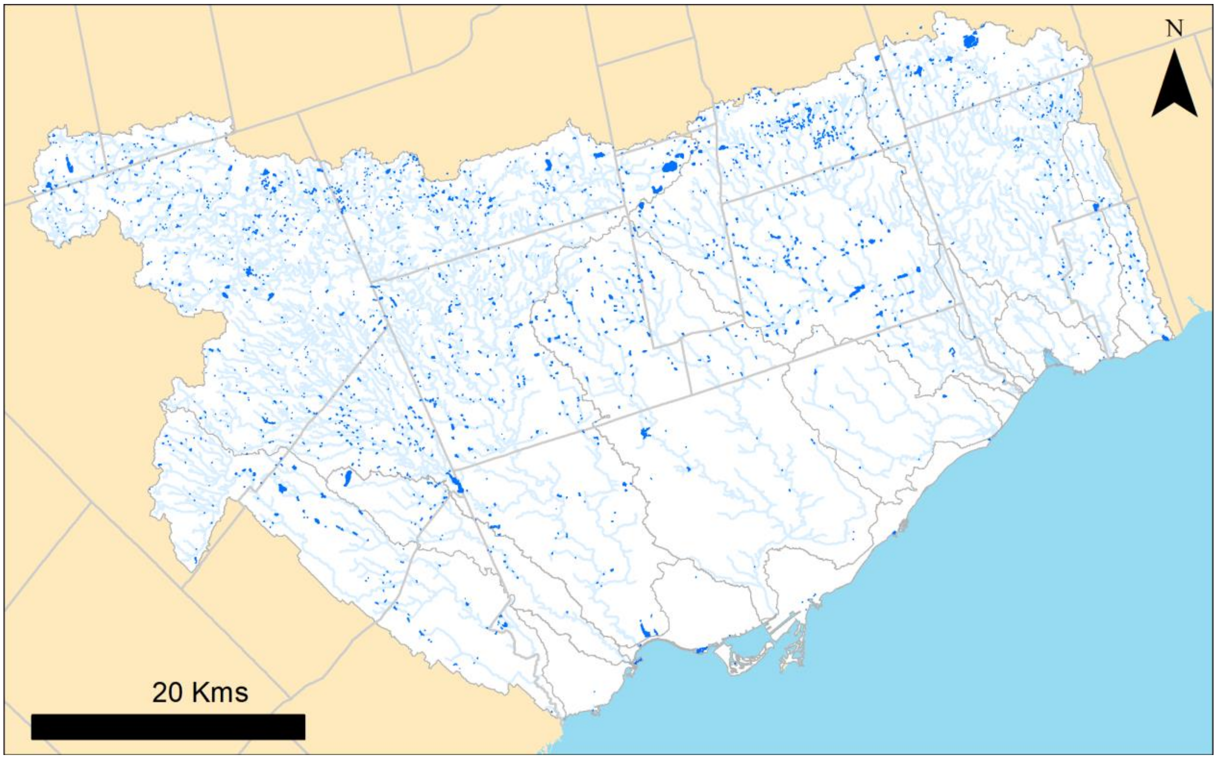

Figure 7. Shown is the refined inland lake and littoral zones layer in the TRCA jurisdiction (dark blue polygons). Features have been enlarged slightly to better identify features at this scale.

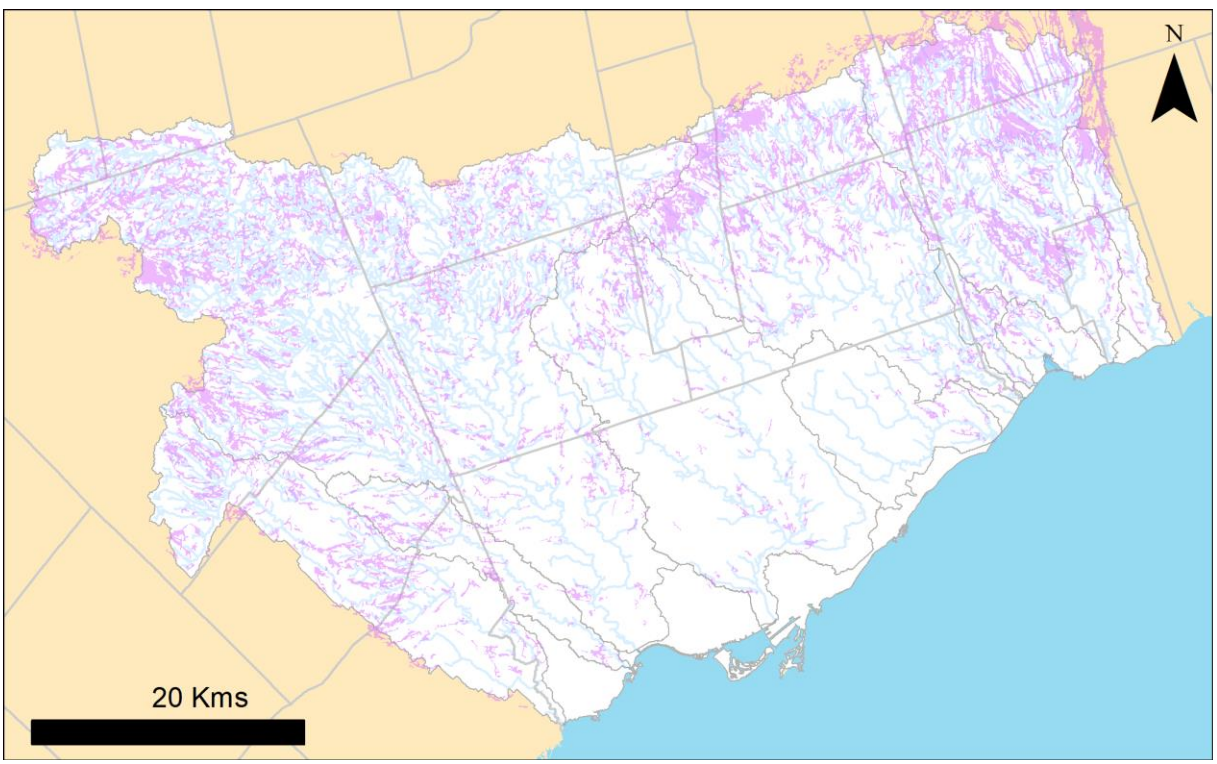

Figure 8. Shown is the Ecologically Significant Groundwater Recharge Areas (ESGRAs) layer in the TRCA jurisdiction (purple polygons).

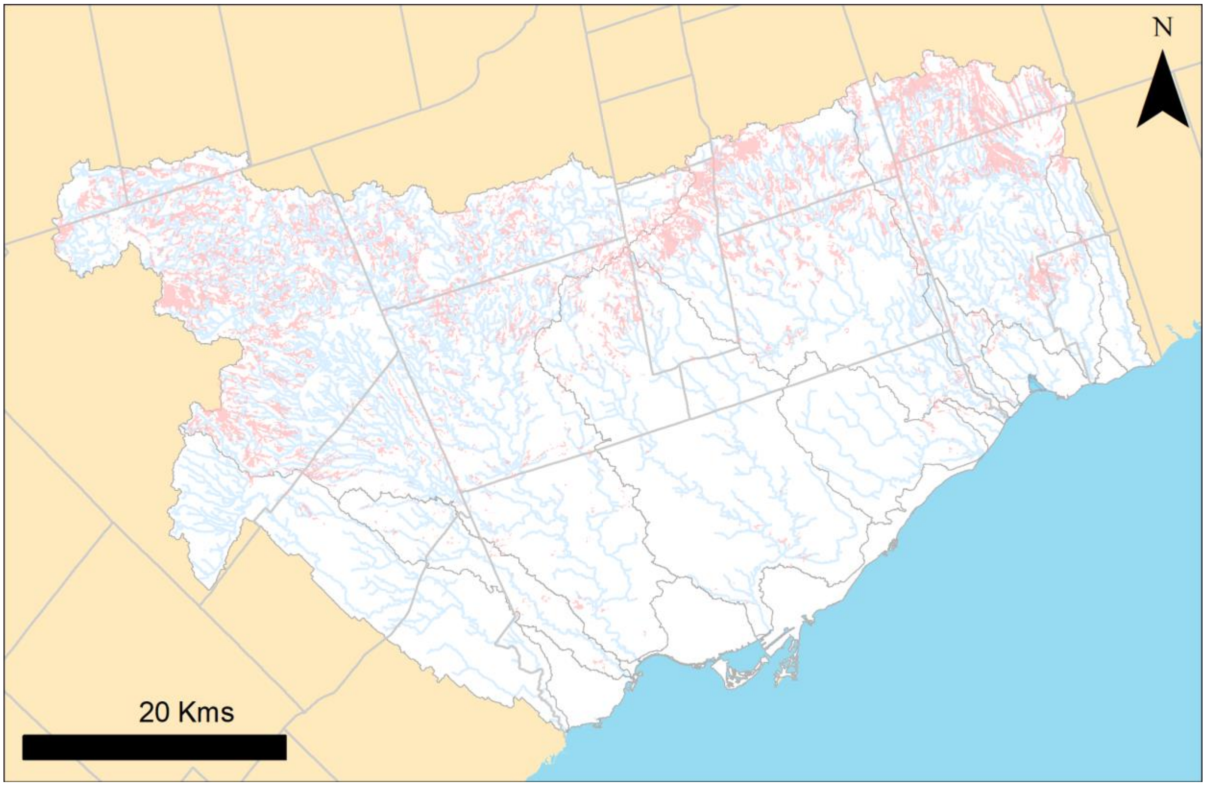

Figure 9. Shown is the Significant Surface Water Contribution Areas (SSWCAs) layer in the TRCA jurisdiction (pink polygons).

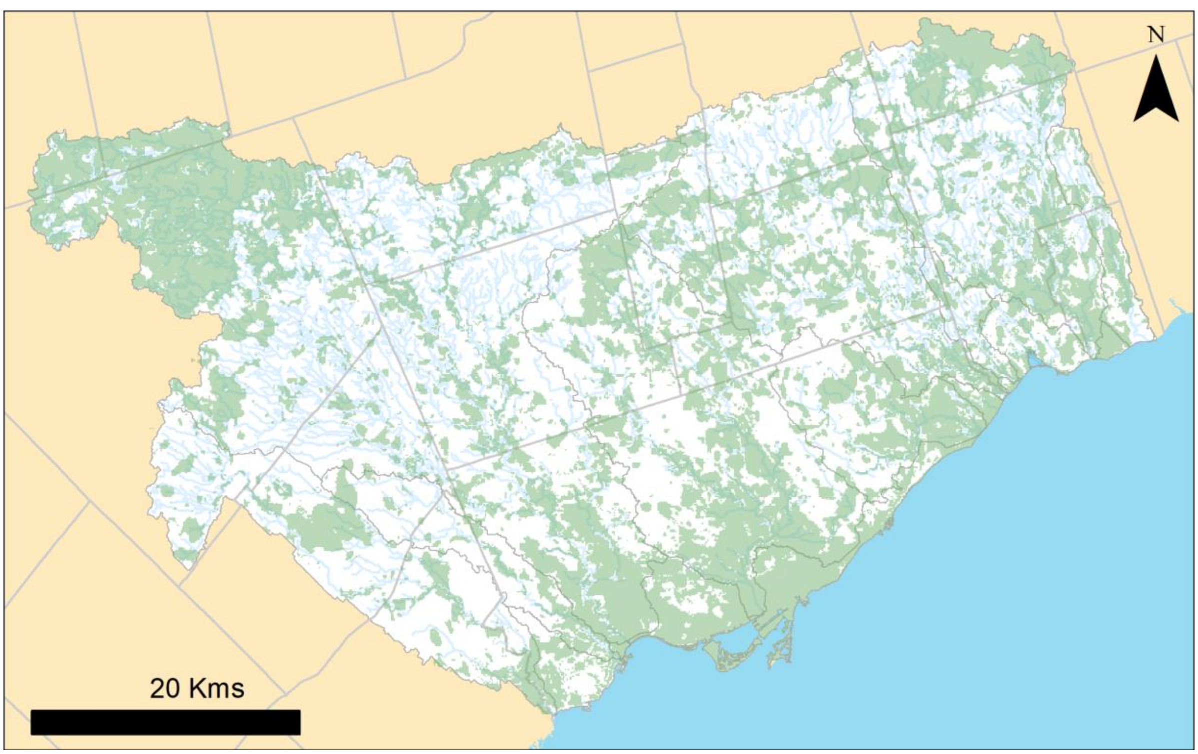

Figure 10. Shown is the Source Water Protection layer, Highly Vulnerable Aquifers (HVAs), in the TRCA jurisdiction (green polygons).

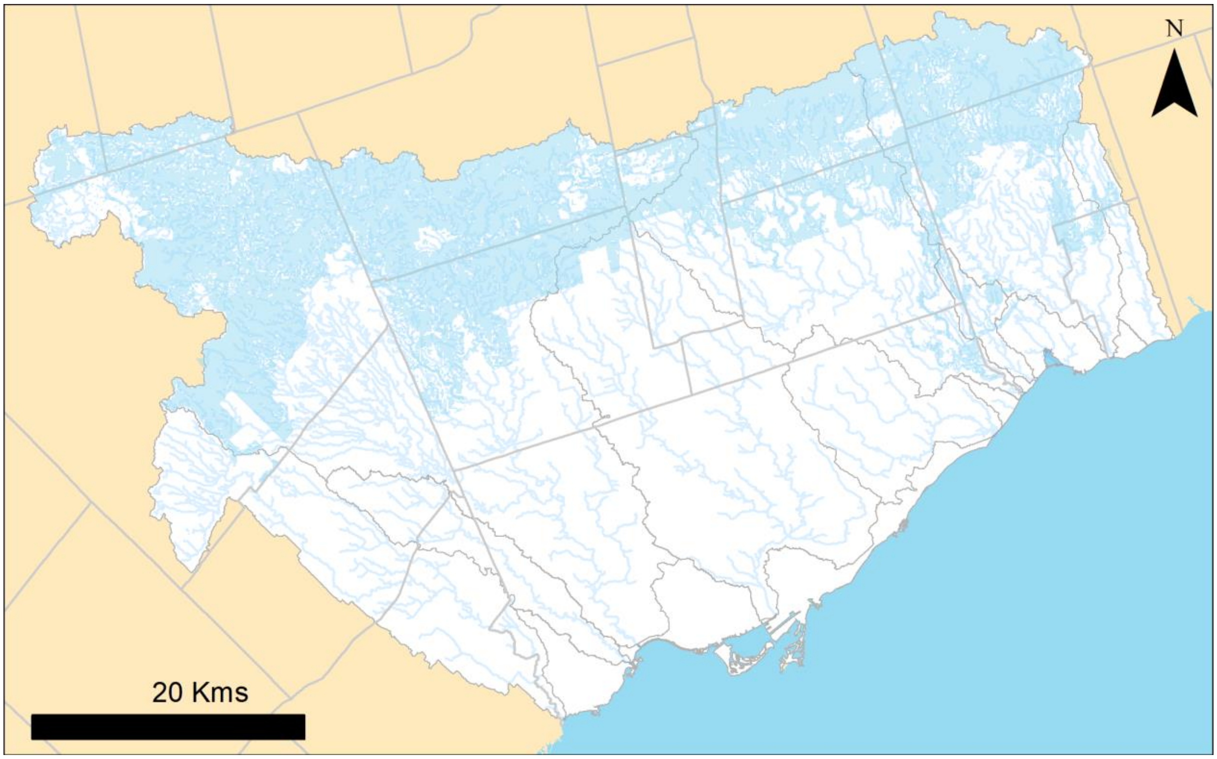

Figure 11. Shown is the Source Water Protection layer, Significant Groundwater Recharge Areas (SGRAs) in the TRCA jurisdiction (light blue polygons).

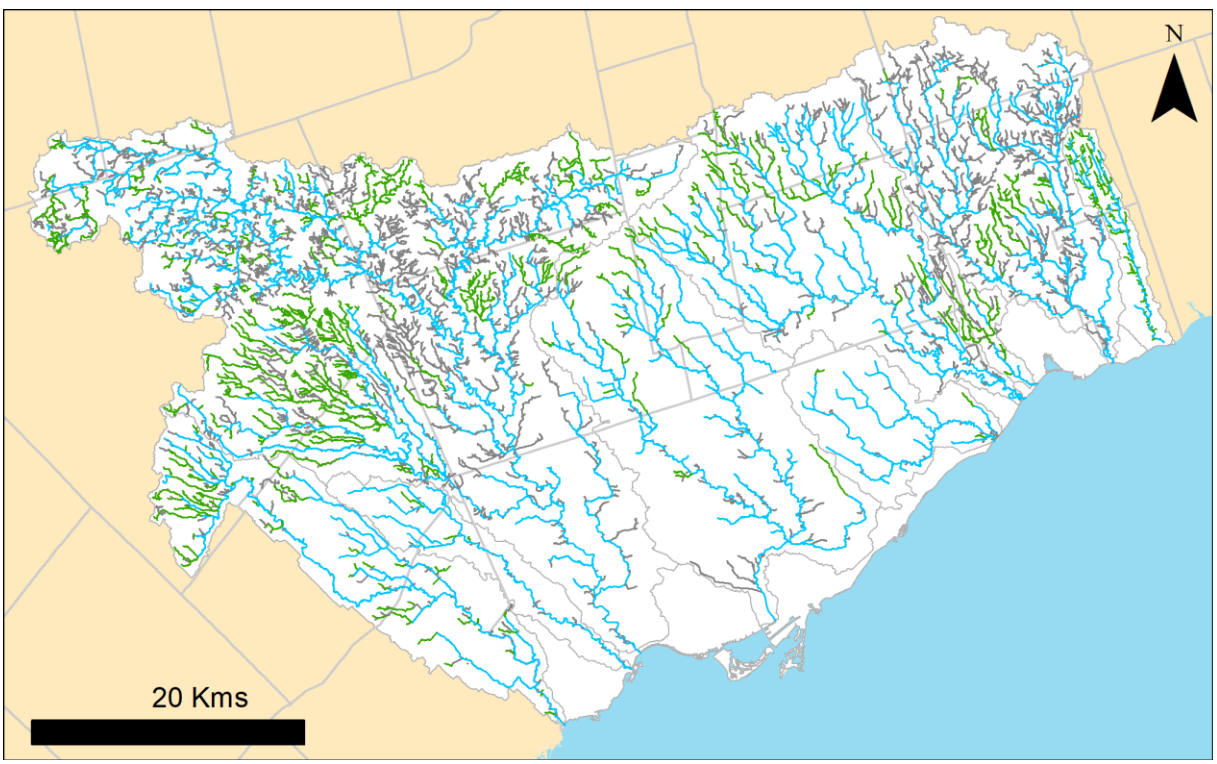

Figure 12. Shown is the permanent (blue) and intermittent (green) watercourse layer in the TRCA jurisdiction. Also shown are the unknown watercourses (data deficient; dark grey).

IMPLICATIONS

Reviewing the mapping of KHFs and KHAs reveals that most WRS components are either found within protected greenbelt (29.4%) or the urbanized (32.0%) areas of the TRCA jurisdiction. This implies that these components are afforded protection through the *Greenbelt Plan* (2017) or have been subject to development activities that have already occurred or were initiated at the time of this report. The remaining portion of the jurisdiction that may be subject to development, the whitebelt, represents a total of 19,092 hectares within the TRCA jurisdiction (4.9% of the jurisdiction), yet only contains 7.3% of WRS components (or 12,091 hectares). As outlined in Figure 4 and Table 3 only 437 hectares are new additions with the mapping completed as part of this work.

Under the *Growth Plan* (2020), municipalities are required to undertake watershed planning to inform the protection of water resources and decisions around planning for growth. Both the *Growth Plan* (2020) and the *Greenbelt Plan* (2017) require municipalities to identify and protect the features, areas, and functions of the Water Resource System, of which ESGRAs are one type of area. Relevant to this is the presence and aerial footprint of WRS within the whitebelt of the TRCA jurisdiction. It should be noted that the presence of a KHF and KHA is not prohibitive to potential development but presents opportunities for the mitigation and protection of the WRS components. These data layers are intended to be a tool to help aid decision makers, specifically partners through best management practices, decision support tools, and information to guide various TRCA and municipal initiatives, including watershed planning, restoration planning, land use and infrastructure planning.

One example is through the implementation and guidance provided in TRCA's *Stormwater Management Criteria* (2012). Within the *Stormwater Management Criteria*, section 6.2.1 outlines criteria for development and infrastructure applications within three types of significant groundwater recharge area, one of which is ESGRAs. Further detail on geographic applicability and study requirements are outlined in appendices D and E of the *Stormwater Management Criteria*. However, the development and update of the WRS within TRCA's jurisdiction is mainly intended to assist municipal partners with achieving provincial policy conformity that requires them to identify the WRS for its long-term protection. This can be achieved through incorporating the WRS in municipal comprehensive reviews, settlement area boundary expansions, Official Plans, natural heritage system planning, among other strategic planning development exercises.

Lastly, within urban areas, identified KHFs and KHAs represent an opportunity for enhancement of biogeophysical processes that support the WRS. For instance, restoring or enhancing groundwater recharge through the implementation of Low Impact Design (LID) within urban settings can benefit ESGRAs and SGRAs alongside development and may help to either mitigate the impact or enhance the function of KHFs and KHAs alongside developed lands.

FUTURE CONSIDERATIONS

There is a continual need to evaluate and update KHFs and KHAs on both a short-term and long-term schedule to ensure the latest products are available for TRCA and its partners given on the ground monitoring and surveys that are completed every year. As regulated wetlands and watercourse layers are updated annually these will need to be adjusted to complement the revisions. On the longer term, there is a need to ensure the best science available has been used to produce the most accurate data product for use by TRCA and its partners. Notably, as new data becomes available or new models are produced this will help to inform the mapping of KHFs and KHAs.

Mapping of the KHFs and KHAs has identified the need to invest more time and effort to not only understand stream permanency (close to one third of watercourses are unknown), but by extension there is an identified need to map as many Headwater Drainage Features (HDFs) as possible, especially in areas that may be subject to near future development. Here we mapped permanency using best available data, which provides some evidence and certainty of stream permanency (which is why we used it). One solution is to address this through the cycle of watershed plans using modified field approaches, however, this will likely take well over 10 years to fully complete, meaning there may be some feature losses before this can be completed. Other planning processes can play a role in this regard, where subwatershed plans, master environmental servicing plans, among others can help to fill these gaps. Regardless, addressing this ongoing gap will be beneficial to TRCA and its partners moving forward.

Altogether the mapping products produced here represent the best available knowledge and employ scientifically sound methodology. As with any method there is a degree of error that should be considered and at the site level on the ground validation is strongly recommended. The research and science team at TRCA is best positioned to ensure that both short- and long-term needs for mapping the WRS are met in partnership with other internal TRCA groups. The project here and the future work cycle of evaluation, maintenance, and QA/QC will be led through ECS with support of partner groups such as WPR, BIDA, and others.

REFERENCES

Brown, C. M., J. R. Lund, X. Cai, P. M. Reed, E. A. Zagona, A. Ostfeld, J. Hall, G. W. Characklis, W. Yu, and L. Brekke. 2015. The future of water resources systems analysis: Toward a scientific framework for sustainable water management. Water Resources Research **51**:6110-6124.

CTC-SPC. 2015. Approved updated assessment report: Toronto and Region Source Protection Area. CTC Source Protection Committee. Chapter 4. 65 p. https://ctcswp.ca/app/uploads/2018/06/TRSPA_5_Chapter-4_Assessing-Vulnerability-of-Drinking-Water-Sources.pdf.

Marchildon, M., P. J. Thompson, S. Cuddy, E. J. Wexler, K. Howson, and J. D. C. Kassenaar. 2016. A methodology for identifying ecologically significant groundwater recharge areas. Canadian Water Resources Journal **41**:515-527.

OMNRF. 2019. Land Information Ontario (LIO), Ontario Ministry of Natural Resources. South Central Ontario Orthophotography Project (SCOOP) [digital resource: grid]. Land Information Ontario (LIO), Ontario Ministry of Natural Resources. https://geohub.lio.gov.on.ca/datasets/e339b6a196b34c348a3534bb5a58f7d8.

Ontario. 2017a. Greenbelt Plan. Ministry of Municipal Affairs. Ontario, Canada. 98 pages. https://files.ontario.ca/greenbelt-plan-2017-en.pdf.

Ontario. 2017b. Oak Ridges Moraine Conservation Plan. Ministry of Municipal Affairs. Ontario, Canada. 88 pages. https://files.ontario.ca/oak-ridges-moraine-conservation-plan-2017.pdf.

Ontario. 2020a. A Place to Grow: Growth Plan for the Greater Golden Horseshoe. Office Consolodation 2020. Ministry of Municipal Affairs and Housing. Ontario, Canada. 114 pages. https://files.ontario.ca/mmah-place-to-grow-office-consolidation-en-2020-08-28.pdf.

Ontario. 2020b. Provincial Policy Statement, 2020: Under the Planning Act. Ministry of Municipal Affairs and Housing. Ontario, Canada. 57 pages. https://files.ontario.ca/mmah-provincial-policy-statement-2020-accessible-final-en-2020-02-14.pdf.

ORMGP. 2018. Ecologically-Signicant Groundwater Recharge Areas. Oak Ridges Moraine Groundwater Program. Vaughan, ON. 12 p.

Stanfield, L. 2017. Ontario Stream Assessment Protocol. Ontario Ministry of Natural Resources, Peteborough, Ontario.

Taylor, N., M. Marchildon, J. L. W. Ruppert, and D. MaCloed. In Review. Protecting groundwater-dependent ecosystems through a refined approach to mapping connected recharge areas.

TRCA. 2012. Stormwater Managment Criteria. Version 1.0. Toronto, ON. https://trca.ca/conservation/stormwater-management/understand/swm-criteria-2012/download. Accessed June 4, 2021.

TRCA. 2018. Five year update to building The Living City: 2013-2022 Strategic Plan. Toronto and Region Conservation Authority (TRCA). Vaughan, Ontario. 22 pages.

APPENDIX A – PERMANENT AND INTERMITTENT STREAM CLASSIFICATION

To develop this layer many different sources of data were used, which differed by watershed. The base layer for this work was the TRCA watercourse layer (except for Carruthers Creek – which uses a finer resolution layer consistent with the recent watershed plan). Here the watercourse layer is matched with data that provides information about the permanency of flow within a particular reach of the system. Data used to infer permanency of flow within reaches used many different data sources, including:

- Baseflow Data
- Headwater Drainage Features Survey Data
- TRCA Instream Temperature Data
- TRCA Instream Barrier Survey Data
- RWMP Fisheries and Temperature Data
- TRCA Historical Fisheries Data
- Air photo Interpreted 2017 and 2018 Imagery
- Valley and Stream Crossings Survey Data

Details related to each watershed and the relevant data sources used can be found below for all TRCA watersheds. Where formal surveys have been completed to assess watercourse permanency there is likely higher certainty with classifications (Carruthers and Etobicoke Creeks). It must be noted that the remaining watersheds have not a had a formal survey dedicated to defining watercourse permanency, and all watercourses that have been defined using the best available data.

Carruthers Creek

Data Sources

1. Carruthers Creek Headwaters Survey Protocol Data 2015
2. Carruthers Instream Barrier Survey Data and Imagery 2016
3. Instream Temperature Data and Related Field Notes 2012
4. Arc Hydro Lines (5 ha drainage) and LiDAR imagery 2015

Mapping Methodology

Permanent Watercourses were those that were identified in the field during the 2017 HDF surveys following the TRCA HDF protocol. For the watercourses not surveyed during the 2017 HDF field surveys, other data was used to augment the understanding of instream water conditions during mid to late summer. In this case the presence of flowing or connected water in the channel during the mid to late summer timeframe was used to define a permanent watercourse. All other information that indicated that there was a dry watercourse was then used to identify intermittent watercourses. Finally, the ArcHydro lines developed for the 2017 HDF surveys were used as an overlay on the LiDAR

Hillshade layer to identify intermittent watercourses where no other field surveys had been undertaken. Where the Archydro lines aligned with a visible drainage feature on the LiDAR Hillshade layer, those features where then classified as intermittent watercourses.

Etobicoke Creek

Data Sources

1. Baseflow Data 2001-2019
2. Headwater Drainage Features Survey 2020
3. TRCA Instream Temperature Data 2005 and 2020
4. TRCA Instream Barrier Survey Data 2006-2008
5. RWMP Fisheries and Temperature 2001-2019
6. TRCA Historical Fisheries Data
7. Air photo Interpreted 2017 and 2018 Imagery

Mapping Methodology

Permanent and Intermittent watercourses were specifically surveyed in the Etobicoke Headwaters subwatershed in 2020. However, those headwater drainage features that were surveyed were only those that occurred at road and watercourse crossings. There are many unsurveyed watercourses that occur between road crossings for which there is no data. For watercourses in the southern portion of the watershed multiple data sources were used in the classification process. Watercourses were mapped as permanent watercourses where point data existed that had evidence or confirmed the presence of water during the summer low flow period. This data includes photographic evidence, field measurements and/or field notes. Watercourses where measurements or evidence indicated no presence of water were mapped as intermittent. Where no data existed for a watercourse, the watercourse was mapped as having its permanency as being Unknown with no available (NA) data. In some cases, professional judgement was used based on Air photo imagery to look for transition areas between intermittent and permanent watercourse to make line breaks using changes in vegetation communities.

It must be noted that only the headwaters subwatershed had a formal survey dedicated to defining watercourse permanency and all other watercourses were that their condition defined by the best available data, such as baseflow or instream barrier surveys.

*Photo reference in the data field refers to actual photo data from barrier inventories as well as field measurement data.

Duffins Creek

Data Sources

1. Baseflow Data 2001-2019
2. 2006 Instream Temperature Data and Related Notes
3. Existing Fisheries Data Historical and TRCA 2003-2020
4. MNRF Instream Barrier Data 2008 2009
5. Air photo Interpreted 2018 Imagery

Mapping Methodology

Watercourses were mapped as permanent watercourses where point data existed that had evidence or confirmed the presence of water during the summer low flow period. This data includes photographic evidence, field measurements and/or field notes. Watercourses where measurements or evidence indicated no presence of water were mapped as intermittent. Where no data existed for a watercourse, the watercourse was mapped as having its permanency as being Unknown with no available (NA) data. In some cases, professional judgement was used based on Air photo imagery to look for transition areas between intermittent and permanent watercourse to make line breaks using changes in vegetation communities.

*Photo reference in the data field refers to actual photo data from barrier inventories.

Petticoat Creek

Data Sources

1. TRCA Baseflow Data 2001-2019
2. RWMP Fisheries and Temperature Data 2001-2019
3. TRCA Historical Fisheries Data
4. Air photo Interpreted 2017 and 2018 Imagery

Mapping Methodology

Watercourses were mapped as permanent watercourses where point data existed that had evidence or confirmed the presence of water during the summer low flow period. This data includes photographic evidence, field measurements and/or field notes. Watercourses where measurements or evidence indicated no presence of water were mapped as intermittent. Where no data existed for a watercourse then the watercourse was mapped as having its permanency as being Unknown with no available (NA) data. In some cases, professional judgement was used based on Air photo imagery to look for transition areas between intermittent and permanent watercourse to make line breaks using changes in vegetation communities.

*Photo reference in the data field refers to actual photo data from barrier inventories.

Rouge River

Data Sources

1. Baseflow Data 2001-2019
2. TRCA Instream Barrier Survey Data 2006
3. TRCA Instream Temperature Data 2005
4. RWMP Fisheries and Temperature 2001-2019
5. TRCA Historical Fisheries Data
6. Air photo Interpreted 2017 and 2018 Imagery

Mapping Methodology

Watercourses were mapped as permanent watercourses where point data existed that had evidence or confirmed the presence of water during the summer low flow period. This data includes photographic evidence, field measurements and/or field notes. Watercourses where measurements or evidence indicated no presence of water were mapped as intermittent. Where no data existed for a watercourse then the watercourse was mapped as having its permanency as being Unknown with no available (NA) data. In some cases, professional judgement was used based on Air photo imagery to look for transition areas between intermittent and permanent watercourse to make line breaks using changes in vegetation communities.

*Photo reference in the data field refers to actual photo data from barrier inventories.

Highland Creek

Data Sources

1. Baseflow Data 2001-2019
2. TRCA Instream Barrier Survey Data 2004
3. RWMP Fisheries and Temperature 2001-2019
4. TRCA Historical Fisheries Data
5. Air photo Interpreted 2017 Imagery

Mapping Methodology

Watercourses were mapped as permanent watercourses where point data existed that had evidence or confirmed the presence of water during the summer low flow period. This data includes photographic evidence, field measurements and/or field notes. Watercourses where measurements or evidence indicated no presence of water were mapped as intermittent. Where no data existed for a watercourse, the watercourse was mapped as having its permanency as being Unknown with no available (NA) data. In some cases, professional judgement was used based on Air photo imagery to look for transition areas between intermittent and permanent watercourse to make line breaks using changes in vegetation communities.

*Photo reference in the data field refers to actual photo data from barrier inventories.

Don River

Data Sources

1. Baseflow Data 2001-2019
2. TRCA Instream East Don Barrier Survey Data 2006
3. TRCA Instream Temperature Data 2005
4. RWMP Fisheries and Temperature 2001-2019
5. TRCA Historical Fisheries Data
6. Air photo Interpreted 2017 and 2018 Imagery

Mapping Methodology

Watercourses were mapped as permanent watercourses where point data existed that had evidence or confirmed the presence of water during the summer low flow period. This data includes photographic evidence, field measurements and/or field notes. Watercourses where measurements or evidence indicated no presence of water were mapped as intermittent. Where no data existed for a watercourse, the watercourse was mapped as having its permanency as being Unknown with no available (NA) data. In some cases, professional judgement was used based on Air photo imagery to look for transition areas between intermittent and permanent watercourse to make line breaks using changes in vegetation communities.

*Photo reference in the data field refers to actual photo data from barrier inventories.

Humber River

Data Sources

1. Baseflow Data 2001-2019
2. Valley and Stream Crossings Survey 2017
3. TRCA Instream Temperature Data 2007-2008
4. RWMP Fisheries and Temperature 2001-2019
5. TRCA Historical Fisheries Data
6. Air photo Interpreted 2017 and 2018 Imagery

Mapping Methodology

Watercourses were mapped as permanent watercourses where point data existed that had evidence or confirmed the presence of water during the summer low flow period. This data includes photographic evidence, field measurements and/or field notes. Watercourses where measurements or evidence indicated no presence of water were mapped as intermittent. Where no data existed for a watercourse, the watercourse was mapped as having its permanency as being Unknown with no available (NA) data. In some cases, professional judgement was used based on Air photo imagery to look for transition areas between intermittent and permanent watercourse to make line breaks using changes in vegetation communities. *Photo reference in the data field refers to actual photo data.

Mimico Creek

Data Sources

1. Baseflow Data 2001-2019
2. TRCA Instream Barrier Survey Data 2009
3. RWMP Fisheries and Temperature 2001-2019
4. TRCA Historical Fisheries Data
5. Air photo Interpreted 2017 and 2018 Imagery

Mapping Methodology

Watercourses were mapped as permanent watercourses where point data existed that had evidence or confirmed the presence of water during the summer low flow period. This data includes photographic evidence, field measurements and/or field notes. Watercourses where measurements or evidence indicated no presence of water were mapped as intermittent. Where no data existed for a watercourse then the watercourse was mapped as having its permanency as being Unknown with no available (NA) data. In some cases, professional judgement was used based on Air photo imagery to look for transition areas between intermittent and permanent watercourse to make line breaks using changes in vegetation communities.

*Photo reference in the data field refers to actual photo data from barrier inventories.

Peel SABE Area (Etobicoke, Humber)

Data Sources

1. 2007 and 2008 Instream Temperature Data and Related Notes
2. 2017 VSC Culvert Survey Data and Imagery
3. TRCA Baseflow Data 2000-2017
4. Existing Fisheries Data
5. Interpreted

Mapping Methodology

Because there was no actual HDF survey conducted for the SABE area of Peel Region there has been no specific data collected that targets the question around the permanent or intermittent nature of the watercourses within the study area boundary. As such, data needed to be drawn from other sources, and in some cases due to the nature of the data, it required interpretation or expert judgement to be applied to help define the WRS. Many of the data points that help to define the understanding of watercourse permanency are based in many cases by a single point in time measurement and is sometimes at a coarser scale of resolution than would be ideal for this exercise. In many cases there is evidence to define that a watercourse is a permanently flowing watercourse, however there are instances, particularly in the West Humber where the starting point of this permanently flowing condition may need further field refinement.

For this study area the presence of flowing or connected water in the channel during the mid to late summer timeframe was used to define a permanent watercourse. All other information that indicated that there was a dry watercourse was then used to identify intermittent watercourses. In some cases, there is a permanent watercourse upstream and an intermittent watercourse downstream. This condition could be due to groundwater recharge and discharge conditions, or from human induced landscape functional changes, such as groundwater or surface water pumping. In some locations further field investigation is warranted to help to better refine the understanding of watercourse permanency.

In a few watercourses it was noted in the data file that the data source was interpreted. In these cases, there is a transition zone between two data points where there was evidence to identify an intermittent watercourse upstream, and a permanent watercourse downstream. In these cases, classification was determined based on air photo interpretation, informed largely by the vegetation condition surrounding the watercourse.

APPENDIX B – SUGGESTED COLOUR PALETTE FOR MAPPING THE WRS

Table 1C. The colour palette used in this report and recent watershed plans for key hydrologic features and areas.

Feature/Area	Polyline/ Outline Thickness	Colour	Hex Code	RGB
Seepage Areas and Springs	0.5		#FFD580	255 213 128
Wetlands	0.5		#9CD480	156 212 128
Inland Lakes and their Littoral Zones	0.5		#0070FF	000 112 255
Streams - Permanent	0.7		#00C5FF	000 197 255
Streams - Intermittent	0.7		#38A800	056 168 000
Streams - Unknown	0.7		#828282	130 130 130
ESGRAs	0.5		#EFB9FF	239 185 255
SSWCAs	0.5		#FFCDCE	255 206 206
HVAs	0		#B9D9B9	185 217 185
SGRAs	0		#CBEDF9	203 237 249

www.trca.ca

Toronto and Region Conservation Authority