Natural Heritage Restoration Prioritization Model

A METHODOLOGY

WATERSHED PLANNING & NATURAL HERITAGE

JUNE 2019

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Introduction

CLOCA has a large jurisdiction consisting of over 639 km^2, with a variety of significant natural areas and features. Presently, many of CLOCA's 4 major and 18 minor watersheds are not meeting the minimum targets for watershed health as a result of significant existing and future development pressures, invasive species, climate change and a historical legacy of impacts. In addition, with limited financial and staff resources to undertake restoration, CLOCA needs to be strategic about where to invest in restoration to ensure we receive the greatest ecological return. The Natural Heritage Restoration Prioritization model helps us overcome this financial and ecological challenge. The model uses the existing conditions of the landscape to determine what areas would benefit most from restoration, which is an important and often overlooked component to restoration success (Wickham, et al, 2017). The model will satisfy the first step of the *Conservation and Restoration Planning Framework* (CLOCA, 2019) and will help guide the decision-making process for determining where to implement restoration on the landscape. It identifies priority areas for restoration, using a standardized, repeatable approach from which projects can be developed that will lead to the critical enhancement of ecosystem function of natural features within the CLOCA jurisdiction. The model combines CLOCA's Watershed Action Plan methodologies and ecological datasets into one cohesive product and summarizes the results at the 30 hectare (ha) catchment scale. Prioritization of catchments for restoration was based on the principle of growing the areas in CLOCA's jurisdiction that have high ecological quality. In doing so, an emphasis has been placed on expanding overall habitat, improving habitat connectivity and protecting CLOCA's headwaters.

This model will enable CLOCA to approach restoration proactively, targeting areas that would benefit most from restoration. It is recognized that restoration is often opportunistic and this model will identify locations based on a holistic ecological approach; but it is not meant to restrict where restoration can occur if opportunities arise, nor will it identify specific restoration projects at the site level. It is one tool in the tool box that can be utilized by CLOCA, municipal partners and its various non-profit partners involved in restoration. It is important to supplement the natural heritage restoration prioritization model with expert judgement, sound program planning and project management to allow for successful restoration outcomes.

The document below identifies the methodology for developing the Natural Heritage Restoration Prioritization model for the Black, Bowmanville and Soper creek watersheds. It is intended to be a living document that will be updated as necessary to reflect new implementation strategies, latest datasets and new information as acquired. The methodology was first tested on the Black, Bowmanville and Soper Creek watersheds before being extended to cover CLOCA's full jurisdiction.

Methodology

The Natural Heritage Restoration Prioritization model has been developed in three phases and the detailed methodology is provided below. The first phase utilizes several of CLOCA's existing watershed action plan methodologies, data sets, and GIS layers to create a map of existing conditions. The second phase prioritizes catchments from the existing conditions dataset to identify priority catchments to focus restoration efforts. The third and final phase is the development of an online mapping tool that combines the existing conditions and priority catchments to enable the user to review the priority catchments and assess catchment-scale conditions. If the user needs to go beyond the priority

catchments, the existing conditions data can be refined to address a user's specific objectives and queries.

Phase I: Existing Conditions

Each watershed in CLOCA's jurisdiction was broken down into 30 ha catchments. This allows for catchments to be aggregated up to a coarser resolution, while also providing manageable sized areas to allow for appropriate assessment and engagement opportunities (Wickham, et al, 2017; TRCA, 2015). To determine the existing conditions for each catchment, three categories were created to describe the natural systems: Natural Cover; Natural Heritage Connectivity, and Aquatic conditions. Each category was then assigned with multiple metrics that represent a measurable attribute reflective of the ecological condition (Table 1). Metrics were scored as a percentage between 0-100, where data was available and averaged within catchments. The final existing conditions provides a combined score out of 100 for each 30 ha catchment. Higher scoring catchments are considered least impaired, while lower scoring catchments are considered most impaired.

CLOCA has robust datasets that have been used to characterize existing conditions. Spatial data is available for wetland and terrestrial cover in the form of aerial photography and Ecological Land Classification (ELC) mapping (Lee, et al, 1998); CLOCA's ELC layer was last updated using 2017 aerial orthophotography. In addition to this, three watershed action plans have been developed that identify potential restoration opportunities spatially across the jurisdiction. These action plans are the Wildlife Corridor Protection & Enhancement Plan (CLOCA, 2015), In-stream Barrier Action Plan (CLOCA, 2017), and the Riparian Corridors Restoration Plan (CLOCA, 2017). To prevent any duplication of effort, the same methodologies and datasets that were used to develop the action plans and identify restoration opportunities have been used as metrics for their associated natural system category. In addition to this, CLOCA used existing aquatic monitoring data to support the metrics for the aquatic conditions category.

Natural System Category	Metric	Measure
Natural Cover	Terrestrial cover	Percent cover of specified community types
	Wetland cover	Percent cover of specified community types
Natural Heritage Connectivity	Wildlife Habitat Corridor (WHC)	Percent of vegetated WHC that exists within the total WHC
	Riparian Corridor	Percent of stream length with adequate riparian corridor
Aquatic Conditions	Golden Horseshoe Fish Index	Multi-metric tool characterizing stream health based on fish community composition
	Barriers	Quantitative scoring of known barriers obstructing or limiting aquatic connectivity and stream hydrology and function
	In-stream temperature	Percent of time a stream reach was considered cold water

Table 1: Natural System categories and associated metrics

Natural Cover

Natural cover refers to natural features on the landscape, including forest, wetland, successional and beach bluff communities as defined by Ecological Land Classification (Lee, et al., 1998) and is represented as a score out of 100. Natural cover has been separated into two metrics; terrestrial cover and wetland cover. The calculations completed for each metric are mutually exclusive to reduce any overlap, therefore the sum of terrestrial and wetland cover is the total natural cover per catchment.

Terrestrial Cover

CLOCA's ELC data for forest and successional habitat types was used to calculate the percent cover for each 30 ha catchment. Community types used include forests (coniferous, deciduous and mixed) and cultural communities (plantation, meadow, thicket, savannah and woodland).

Wetland Cover

Wetland cover uses CLOCA's ELC data for wetland community types. Wetland communities included in this metric include: fens (open, shrub and treed), bogs (open, shrub and treed), marsh (meadow and shallow), shallow aquatic (submerged, mixed and floating), swamps (coniferous, mixed, deciduous and thicket) and open water aquatic. Similar to terrestrial cover, this metric is calculated as percent cover for each 30 ha catchment.

Natural Heritage Connectivity

Natural heritage connectivity includes both riparian and wildlife habitat corridors. Both metrics play important functions on the landscape. Wildlife habitat corridors are a necessity for wildlife, as they often require more than one habitat type to complete their life cycle. Riparian corridors play a significant role in improving and maintaining water quality, water temperature, fish habitat and diversity; they also provide connectivity across the landscape. These metrics are scored individually as a percentage out of 100 for each 30 ha catchment and are combined into the final catchment score.

Riparian Corridor

Adequate riparian corridor is defined as 30 m of vegetation extending perpendicular from each side of a watercourse. This metric uses the methodology identified in CLOCA's Riparian Corridors Restoration Plan (2017). Areas with 30 m riparian vegetation on both sides of the stream were mapped and calculated. The percent of adequate riparian corridor was calculated as a function of the total stream length for each 30 ha catchment. Figure 1 shows a catchment with adequate riparian along 33% of the stream length (shown in red); the riparian corridor score for this catchment is 33%.

Figure 1: Riparian Calculation Example

Wildlife Habitat Corridor

This metric uses the methodology defined in CLOCA's Wildlife Corridor Protection & Enhancement Plan (2015) which identifies a series of corridors connecting key wildlife habitat areas within CLOCA's jurisdiction. This series of corridors includes existing and potential corridors (potential corridors are areas that require restoration) and together they are the wildlife habitat corridor (WHC) used in this model. Local corridors are defined as minor pathways within watersheds connecting secondary habitats to the overall Wildlife Habitat Network with a recommended width of 60 m. Landscape corridors are major pathways within watersheds connecting core habitat areas, with a recommended width of 100 m. Regional corridors are major pathways between watersheds and have not been included in this metric.

Catchment score is based on the percent of existing wildlife habitat corridor within the total wildlife habitat corridor of each catchment. Figure 2 below provides an example of the WHC calculation; this catchment scored 29% for WHC because that is the existing (vegetated) wildlife corridor present (shown in orange), leaving approximately 71% available for restoration. Some catchments may not have WHC identified within it, and as a result receive a "null" value and this criteria is not calculated in the final score.

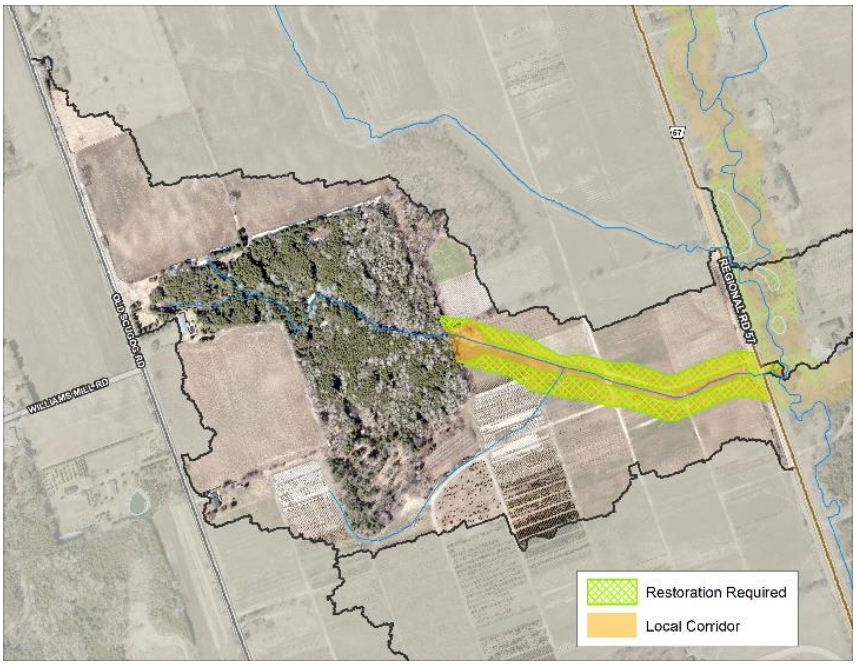

Figure 2: Wildlife Habitat Corridor Calculation Example

Aquatic Conditions

Three metrics are used to represent aquatic conditions; Golden Horseshoe Fish Index, Barriers, and In-stream temperature. These metrics are scored individually for each 30 ha catchment and are combined into the final catchment score.

Golden Horseshoe Fish Index

CLOCA has been collecting fisheries data for over twenty years across the jurisdiction. Due to limitations around landowner access, habitat conditions (e.g. non-wadable sections) and availability (e.g. intermittent streams) the fisheries data does not cover all 30 ha catchments.

For this reason, only catchments with fisheries data points were scored. Catchments lacking data resulted in “null” value, and this criteria was not averaged in the final existing conditions score.

Catchment scores use the Golden Horseshoe Fish Index (GHFI) to determine stream condition based on the fish community composition. Catchments with multiple data points or years of data were averaged.

Barriers

The In-stream Barrier Action Plan (2017) identified 72 known barriers. This was not an exhaustive list as access to some barriers is restricted or limited and evaluation of all culverts across the jurisdiction assessing fish passage has not been completed. Within this action plan five categories were looked at to determine the priority score for each barrier, four were quantitative and one was qualitative.

The four quantitative categories are: quality of biotic life; extent of barrier; quantity of habitat; and quality of habitat. The qualitative category questions whether there are other considerations for removal (e.g. invasive species or sensitive species (e.g. Brook Trout) partition). The in-stream barrier action plan ranks highest scoring barriers as priority for removal. The scoring has been reversed to suit the needs and methodology of this model. Barriers that are a priority for removal score lower, thus bringing down the total score of the catchment.

Similar to fish scores, data was not available for all 30 ha catchments. For this reason, any catchment lacking data resulted in “null” values and this criteria was not tallied in the final prioritization score. Most 30 ha catchments do not have more than one barrier; however, in the rare case of multiple barriers the barrier with the highest score (maximum) represented the score for the catchment.

In-stream temperature

Thermal data from CLOCA’s in-stream temperature loggers was used to determine the percent of time a stream reach was considered cold water (19°C and below) during summer months (July and August). Temperature data from each logger was used to characterize the reach upstream of that point to the next logger or to the end of the stream length. In cases where there were multiple reaches with different temperatures in a catchment, the average temperature was taken relative to stream length.

Final Score: Existing Conditions

Once all the calculations were run for each metric, the scores were averaged per catchment. Higher scoring catchments are considered the least impaired, while lower scoring catchments are more impaired. The map below shows the total score for existing conditions.

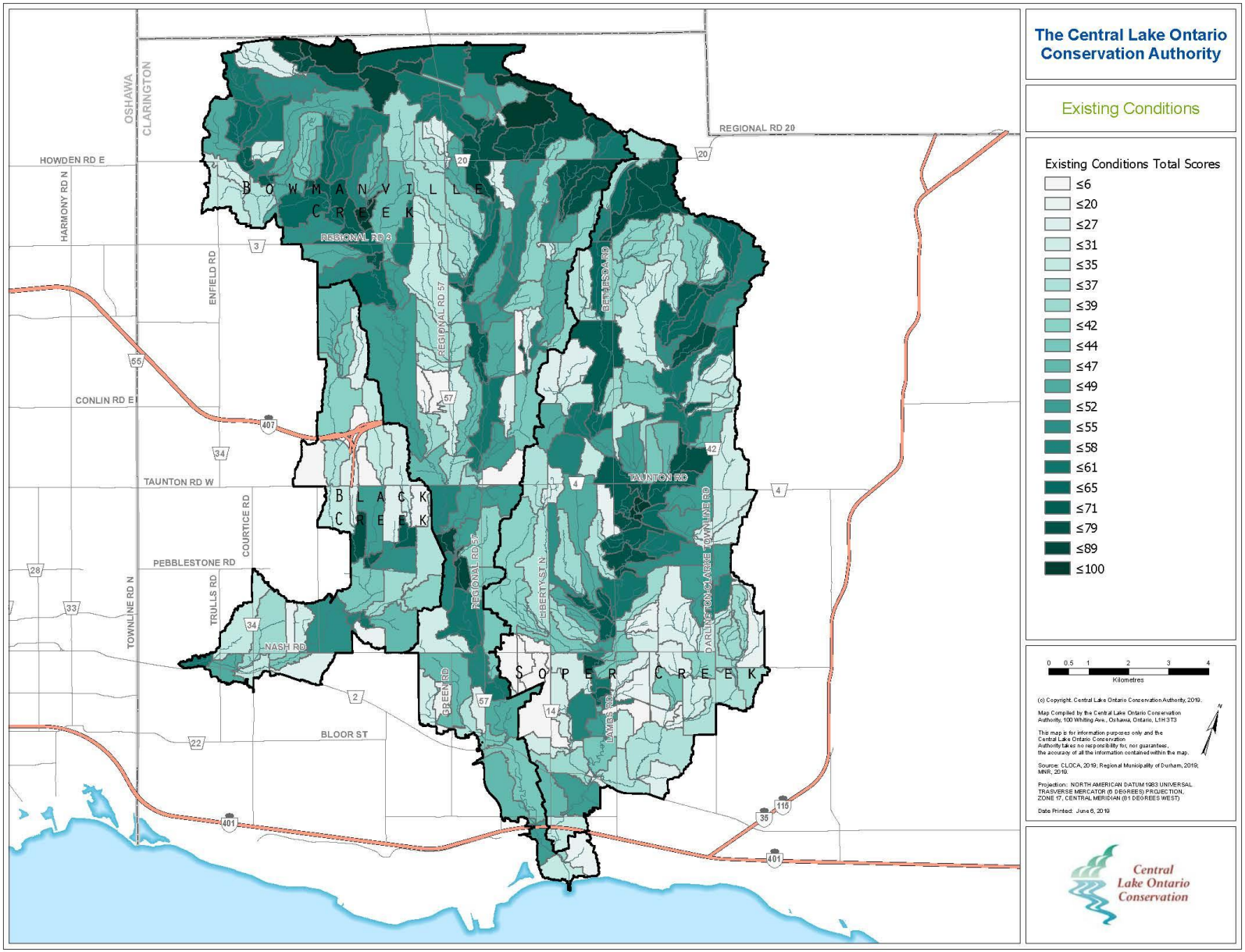

Figure 3: Total Score for Existing Conditions at a 30 ha catchment scale for the Bowmanville, Soper and Black creek watersheds

Phase II: Prioritizing Catchments

The Natural Heritage Restoration Prioritization model focuses on the ecological components of the catchments. CLOCA's prioritization rationale aims to increase size, cover and connectivity of natural features within its jurisdiction while also aiming to reduce the impacts of threats and stressors placed on these features. This approach will be applied on a spatial scale, targeting catchments adjacent to least impaired catchments for restoration. Taking this approach will help to enhance the quality of these catchments, supporting significant habitat areas and biodiversity.

To identify CLOCA's priority catchments, TRCA's Integrated Restoration Prioritization (2015) ecological potential metric was adapted for CLOCA's watersheds. This metric was created using CLOCA's value surface model (VSM) and average natural cover calculations. The VSM is a raster layer that scores each 10mx10m grid cell based on 15 criteria (CLOCA, 2010). The VSM was used to quantify the ecological value (TRCA, 2015) at the catchment scale and represents the protection and restoration values of the entire landscape (CLOCA, 2010). A high VSM score represents a higher quality area, a lower VSM represents a lower quality area.

above average Ecological Potential [VSM Score]	+	below average Natural Cover	=	Ecological Potential

Ecological potential identifies catchments that have above average ecological value (VSM), and below average natural cover. This was calculated by comparing catchment averages to watershed averages. Therefore, if a catchments VSM score was greater than the watershed VSM score, and the catchment natural cover was below the watershed natural cover average, the catchment is said to have ecological potential, Figure 4 (TRCA, 2015). For example, an area with high ecological value, but low natural cover would be seen as an area with ecological potential and would benefit from restoration since it already has a solid ecological foundation that can be improved upon by increasing natural cover.

To rank CLOCA's priority catchments, each catchment with ecological potential was given a score based on the average existing conditions score of all catchments adjacent to it. Therefore, CLOCA catchments with highest priority are those with ecological potential adjacent to catchments that are least impaired. These priority catchments have been displayed below, represented in three categories: high priority, medium priority and low priority (Figure 5).

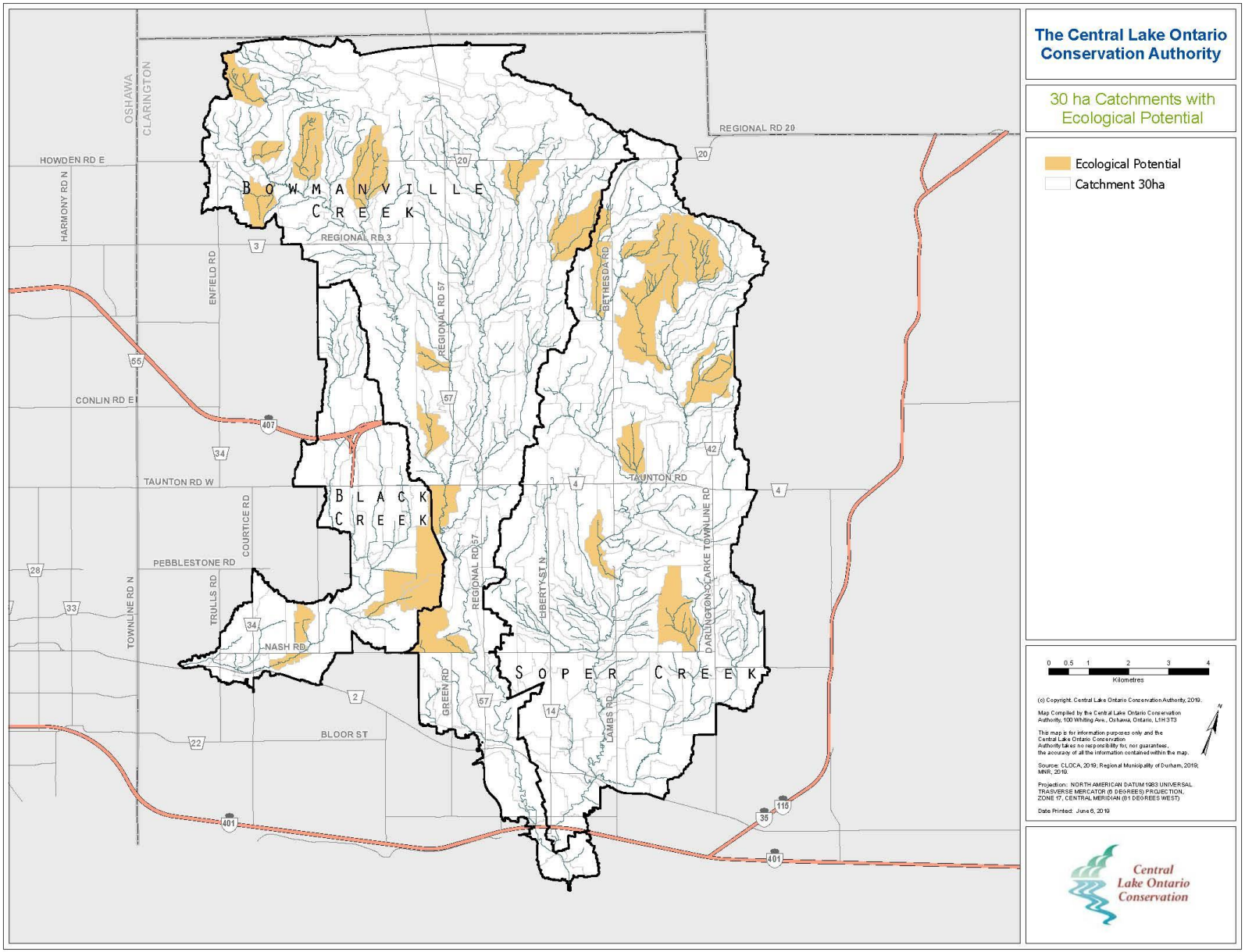

Figure 4: 30 ha catchments with ecological potential for the Bowmanville, Soper and Black creek watersheds

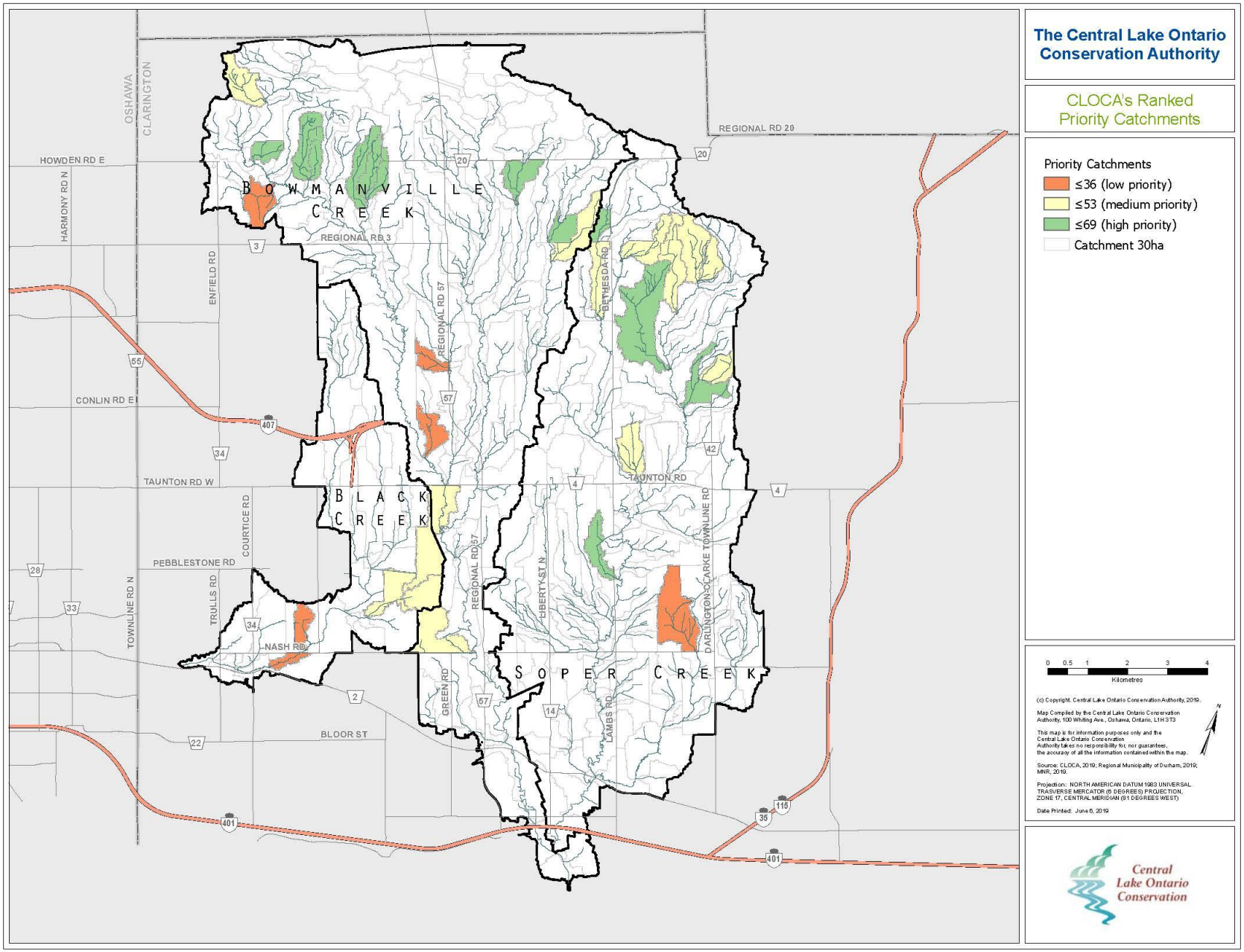

Figure 5: CLOCA's ranked priority catchments for the Bowmanville, Soper and Black creek watersheds

Phase III: Restoration Prioritization Web Application

The last component of the Natural Heritage Restoration Prioritization model takes all existing data, priority catchments and additional data layers and puts them into one web-based product that can be used to help guide restoration initiatives.

This product is a web-based application where users can apply queries, add and remove layers and mark up maps to assist in the restoration planning phase. The application has been developed for the Bowmanville, Soper and Black creek watershed pilot project. Upon completion of the full model, the application will be created for the entire CLOCA jurisdiction.

Layers included in the initial web-based application include:

- Priority Catchments
- Existing Conditions - Total Score
    - Terrestrial Cover
    - Wetland Cover
    - Riparian corridors
    - Wildlife Habitat Corridor
    - Golden Horseshoe Fish Index
    - Barriers
    - In-stream Temperature
- Base data for metrics
    - Wildlife Habitat Corridor mapping
    - Wildlife passage point data
    - Barrier point data
- NHS Targeted layer
- Percent Imperviousness
- Landownership data
    - CA land holdings
    - Public Lands (excluding CA lands)
    - Private lands

Assumptions & Limitations

Through the development of this model, it was identified that there are some basic assumptions made and inherent limitations. These assumptions and limitations are stated below and accepted as part of the development process. The level of risk these assumptions and limitations represented were deemed acceptable, as the associated data was important enough to be included as part of this model.

Natural Cover

The natural cover category has two metrics to represent it, wetlands and terrestrial habitats. Due to anthropogenic influences, their quantity and distribution across the landscape continues to decline. In addition, not all vegetation communities are equally represented across the landscape as a result of the variations in natural geology and hydrology within the CLOCA jurisdiction. As such these two metrics have a lower average score and standard deviation compared to metrics within the other natural

systems categories. Due to these variations in quantity and distribution, expertise from technical staff will be required to identify what restoration should occur within each priority catchment.

Ecological Potential

CLOCA's focus for determining existing conditions and prioritizing catchments has been driven predominantly by ecological factors (natural systems categories). The VSM used to calculate ecological potential relies on CLOCA's GIS and spatial data, it also takes into account certain socio/political attributes. These attributes include proximity to a provincially significant wetland (PSW), areas of natural and scientific interest (ANSI), environmentally sensitive area (ESAs), Generic Regulation areas, CLOCA owned conservation lands, Oak Ridges Moraine (ORM) and Greenbelt designated lands. While these attributes are not negative, it was determined that CLOCA's focus should be on identifying all the biologically significant elements first, with as little socio/political influence as possible. Despite this, it was decided to use the VSM in its entirety instead of removing socio-political components. Ecological potential is the only criteria that includes socio/political attributes, and the influence on the overall results of the model are low.

Null Values

The model has assigned null values to specific metrics where data does not exist in some catchments. Nulls do not equate to poor data sets or metric choices but occur as a result of a few circumstances. Due to the smaller catchment area (30 ha) being used for this modeling exercise there is not always data collected for certain metrics within some catchments which may result in nulls. Monitoring and data collection efforts are distributed across the CLOCA jurisdiction based on value and resources, which means that data is not collected for every part of the watershed. This provides CLOCA the opportunity to enhance our datasets in areas where data for certain metrics are lacking. In addition, nulls may also be assigned to a certain catchment because the feature does not exist or was not identified in that catchment through other planning exercises. An example of this is the Wildlife Habitat Corridor (WHC) (identified in part through desktop exercises) and in-stream barriers (limited access to private property may limit the identification of all barriers). While the Natural Heritage Restoration Prioritization Model may not identify any opportunities for WHC or in-stream barrier restoration in a particular catchment based on the available data, technical expertise will be used to identify other potential restoration opportunities that can be pursued within the catchment and adjacent catchments.

Case Studies

Case study 1

The catchment highlighted below (Figure 6) scored as high priority for restoration. Looking at the individual scores, this catchment would benefit from increasing adequate riparian. In addition to this, the catchment would benefit from additional terrestrial cover. Although terrestrial cover sits at 37%, it is predominantly cultural thicket with a small portion of cultural woodland and deciduous forest.

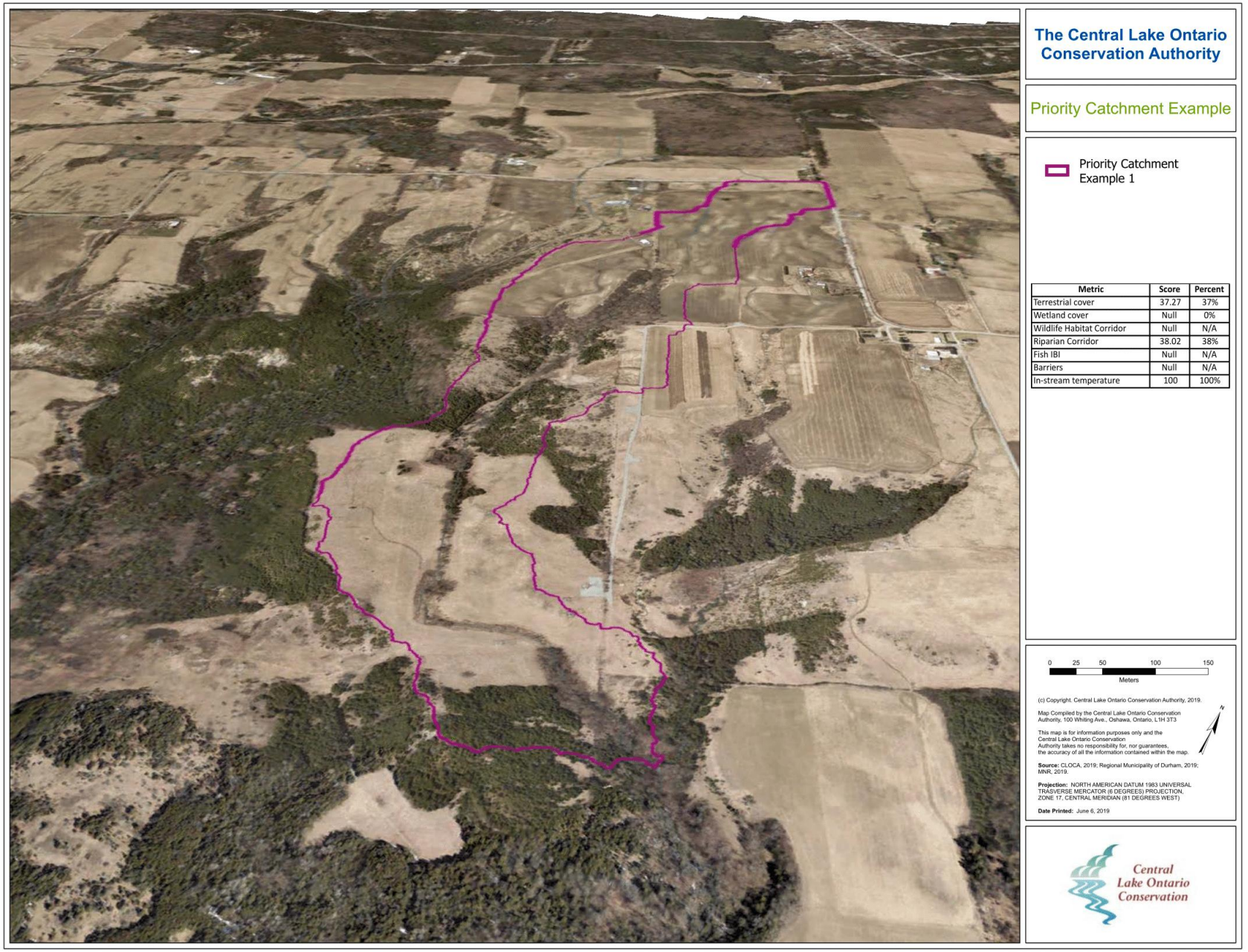

Figure 6: Case Study 1 - High Priority Catchment

Case study 2

The catchment shown in Figure 7 was also identified as a high priority for restoration. This catchment would benefit from increased riparian to help cool stream temperatures; additional assessment of the site would be required to determine potential mitigation of the online pond. There may also be opportunity to increase wetland cover and terrestrial cover, enhancing the shape and size of the terrestrial features.

Case study 3

The catchment shown in Figure 8 was identified as a lower priority for restoration, however is still considered a priority. This catchment would benefit from improving wildlife habitat connectivity and adequate riparian corridors. Through these measures terrestrial cover would also increase. Additional reconnaissance to assess the cause of lower stream temperature scores would provide insight on how to mitigate the potential negative affects on aquatic conditions.

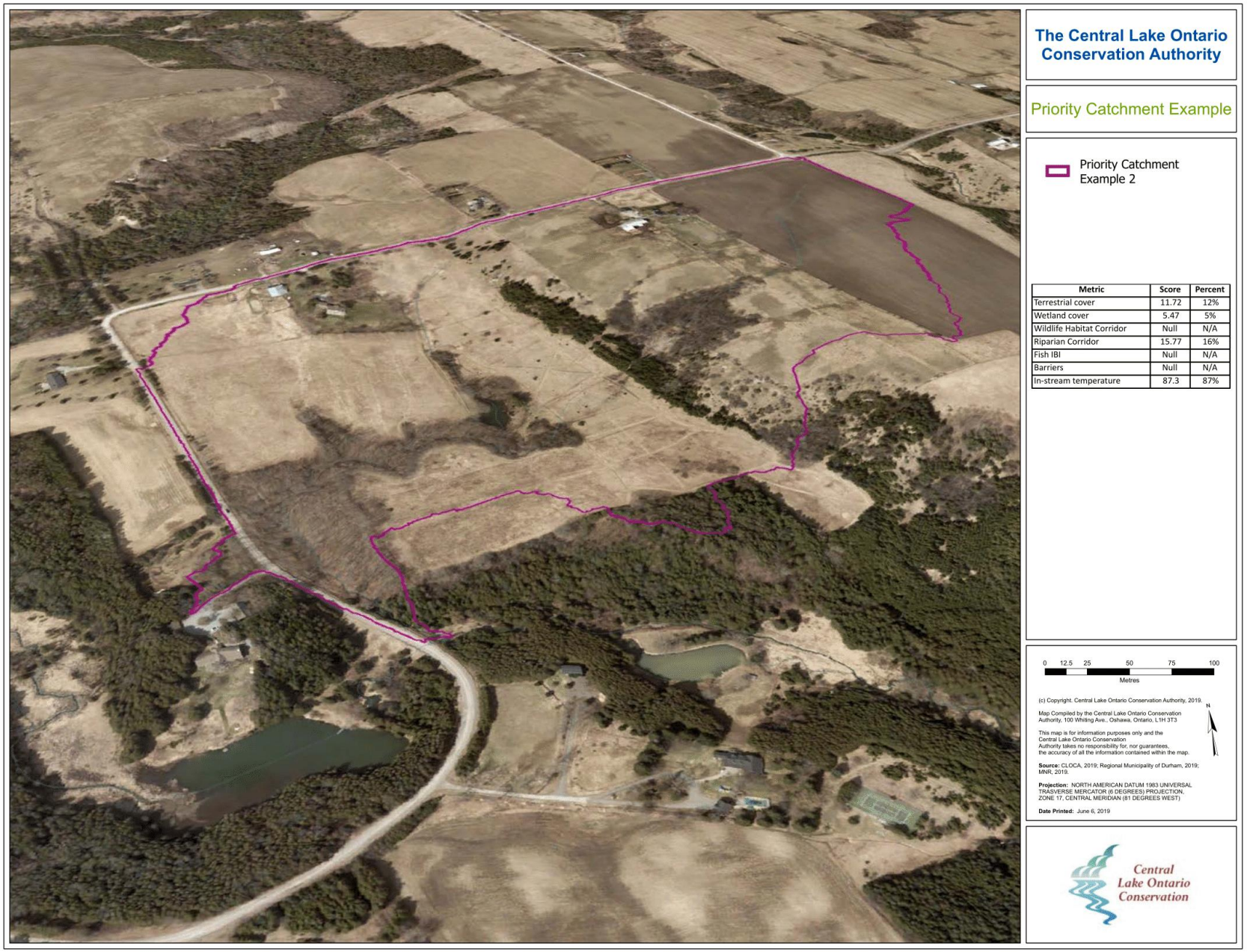

Figure 7: Case Study 2 - High Priority Catchment

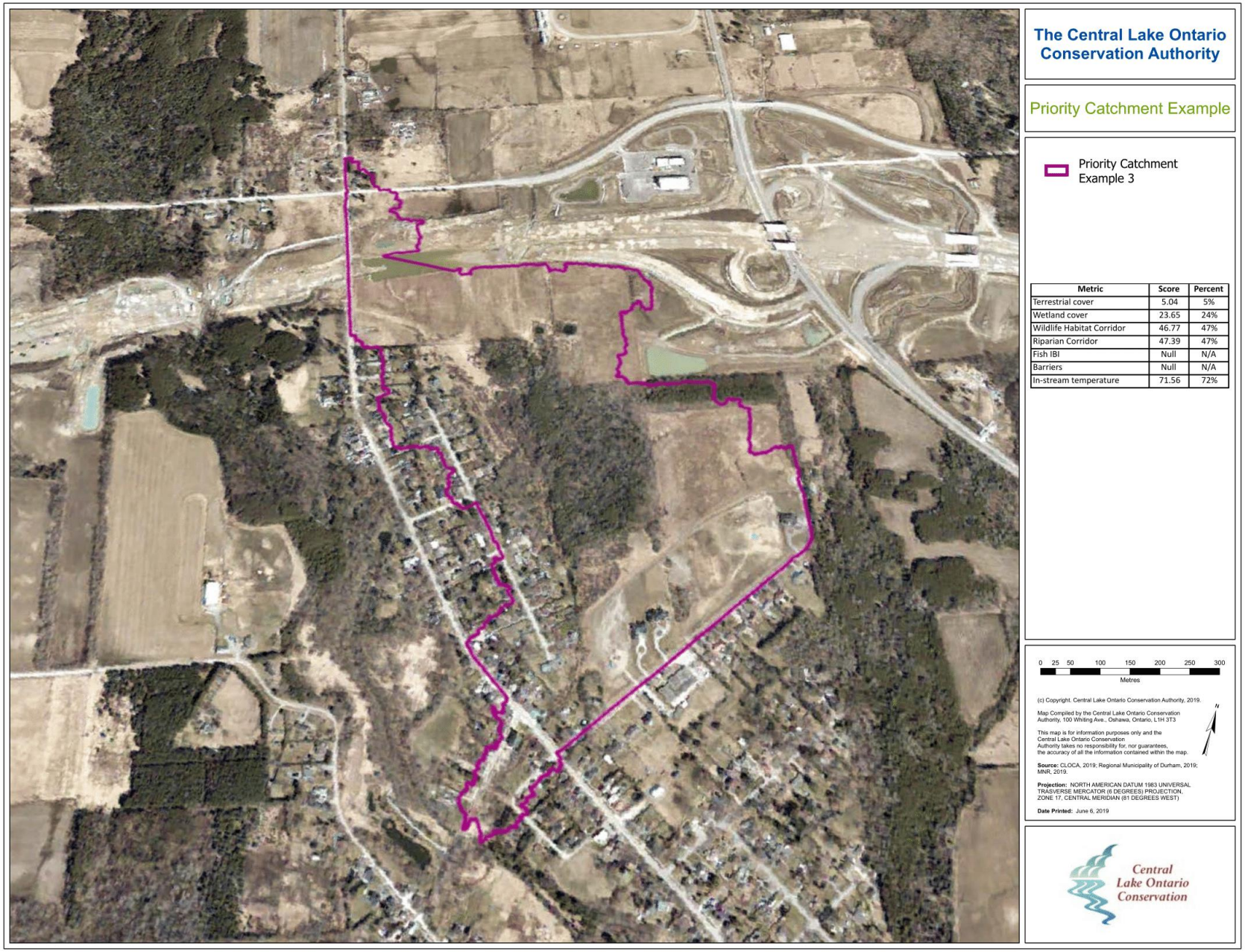

Figure 8: Case Study 3 - Low Priority Catchment

Next Steps & Recommendations

This model and document are a living project and will need to be updated on a regular basis to ensure restoration decisions are made on the most up to date science available. As such, the following recommendations are suggested to be reviewed on an on-going basis:

- Run the model for the entire CLOCA jurisdiction (September 2019)
- Continuously review and grow the model to capture additional data layers as they emerge
- Review additional platforms to enhance the functionality of the web application
- Update the model to reflect the latest information, keeping existing conditions updated (at least on a five year rotational basis)
- Add CLOCA's Restoration Tracking database as an additional layer once completed
- Consult with other CLOCA Departments for potential expansion and adaptation of the model to incorporate other forms of restoration (eg. Green Infrastructure)
- Consult with municipalities to promote knowledge of model

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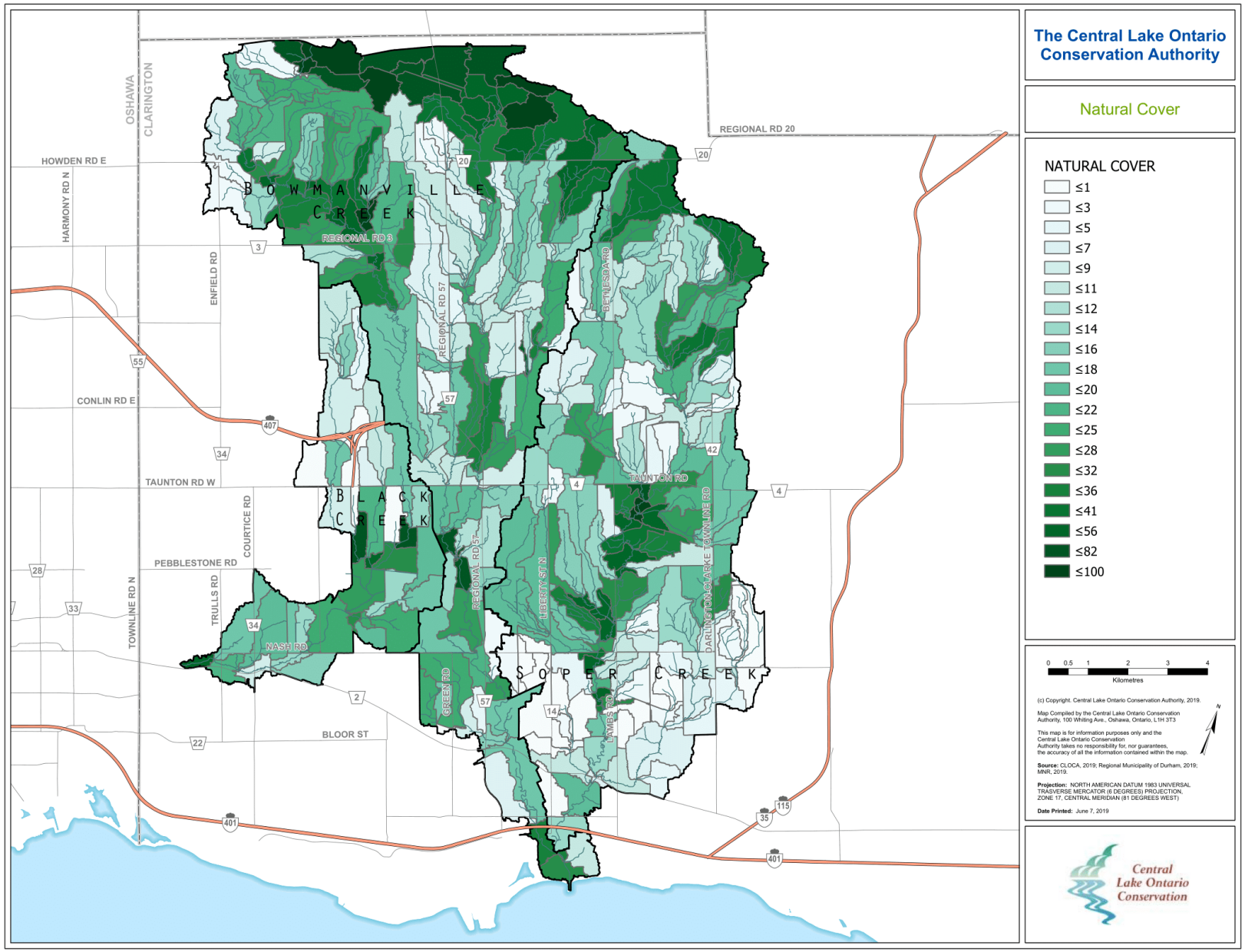
Appendix 1: Summary of data processing for metrics

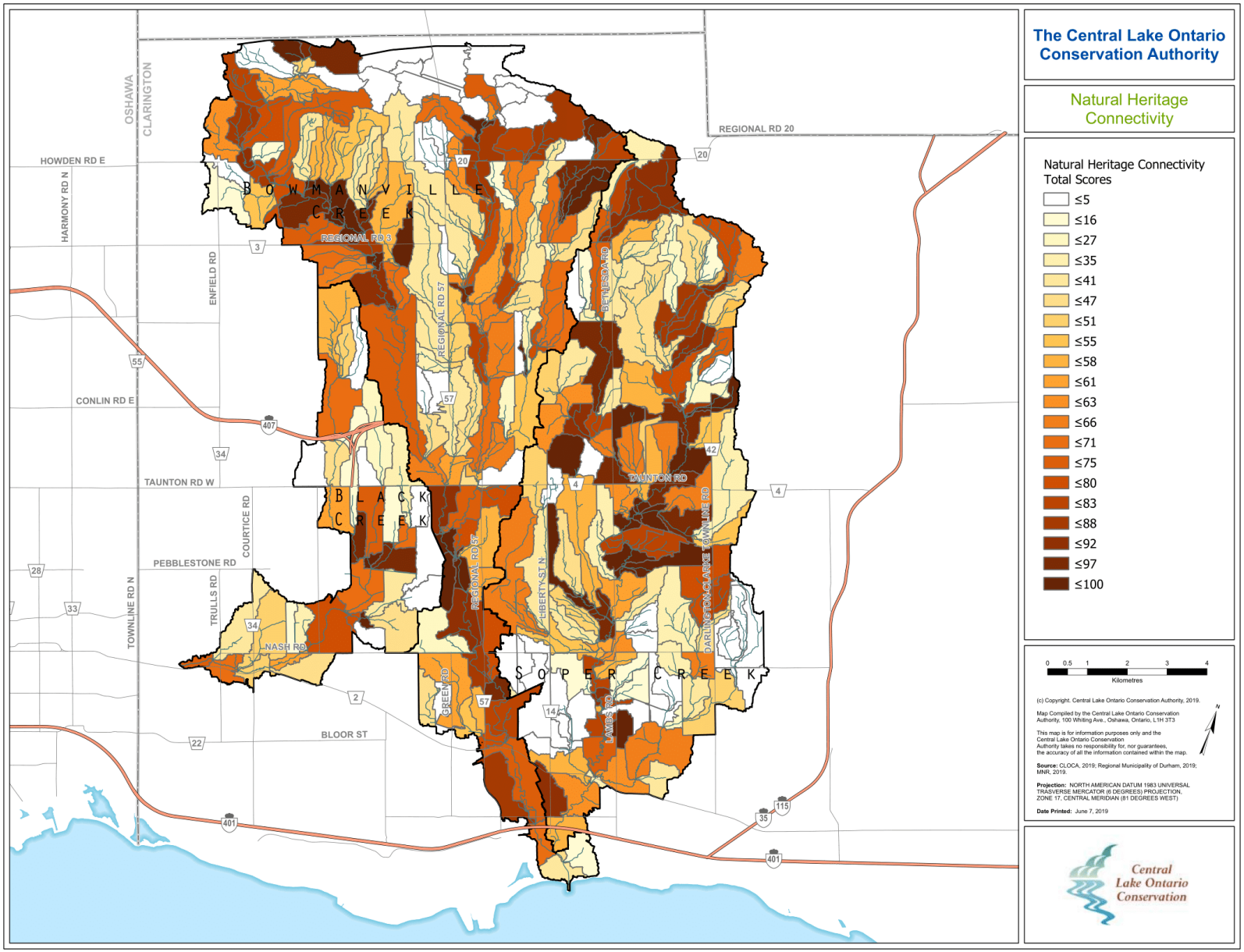
Natural System Category	Data name	Description	Data Analysis	Year
Natural Cover	Wetland Cover	ELC data querried for only wetlands (FEO, FES, FET, BOO, BOS, BOT, MAM, MAS, OAO, SAS, SAM, SAF, SWT, SWC, SWD, SWM) - data should be mutually exclusive, riparian zone removed from wetland and forest/successional, etc.	% cover for 30ha catchments	2017
	Terrestrial Cover	ELC data querried for only forest and successional habitat (FOC, FOD, FOM, CUP, CUM, CUT, CUS, CUW) - data should be mutually exclusive, riparian zone removed from wetland and forest/successional, etc.	% cover for 30ha catchments	2017
Natural Heritage Connectivity	Riparian Cover	ELC data querried for only riparian cover (following action plan methodology) - data should be mutually exclusive, riparian zone removed from wetland and forest/successional, etc.	% cover for 30ha catchments	2017
	Wildlife Habitat Corridor (WHC)	Wildlife Habitat Corridor portion of the Wildlife Habitat Network	-use only landscape corridor & local corridor Calculate: -existing WHN -Total WHN (to be restored and existing) Final Output: -% existing WHN of Total WHN	2015
Aquatic Conditions	Golden Horseshoe Fish Index	Multi-metric tool characterizing stream health based on fish community composition	GHFI score per catchment -if multiple data points, average scores per catchment	1998 to 2018
	Barriers	Quantitative scoring of known barriers obstructing or limiting aquatic connectivity and stream hydrology and function	In-stream barrier scores, reversed (eg. An original score of 80% is now 20%)	2017
	In-stream temperature	Percent of time a stream reach was considered cold water	percent of time a stream reach was considered cold water (19°C and below) for July & August	2005 to 2016
Score for each catchment			Average of all scores	

Prioritizing			
Ecological Potential	use Landscape Analysis Model/VSM to calculate average scores for watershed and catchment areas	Calculate: -Mean VSM for watershed -Mean VSM for 30ha catchment -Natural cover %cover for watershed -Natural cover %cover for 30ha catchment -Natural Cover =Wetland+Riparian+Terrestrial Final Output: -if catchment vsm < watershed vsm =0; if catchment vsm > watershed vsm AND catchment Natural Cover < watershed Natural cover=1; otherwise 0 If score =1, transparent crosshatch layer	2019
Priority Catchment	Catchments with ecological potential, scored based on the average existing conditions score of all catchments adjacent to it	-use only catchments with ecological potential -select all catchments adjacent to catchment with ecological potential Calculate: -average the total existing conditions score for all catchments selected (excluding the target catchment) -this average score is the priority catchment score for the target catchment	2019

Appendix 2: Natural Cover



Appendix 3: Natural Heritage Connectivity



Appendix 4: Aquatic Conditions