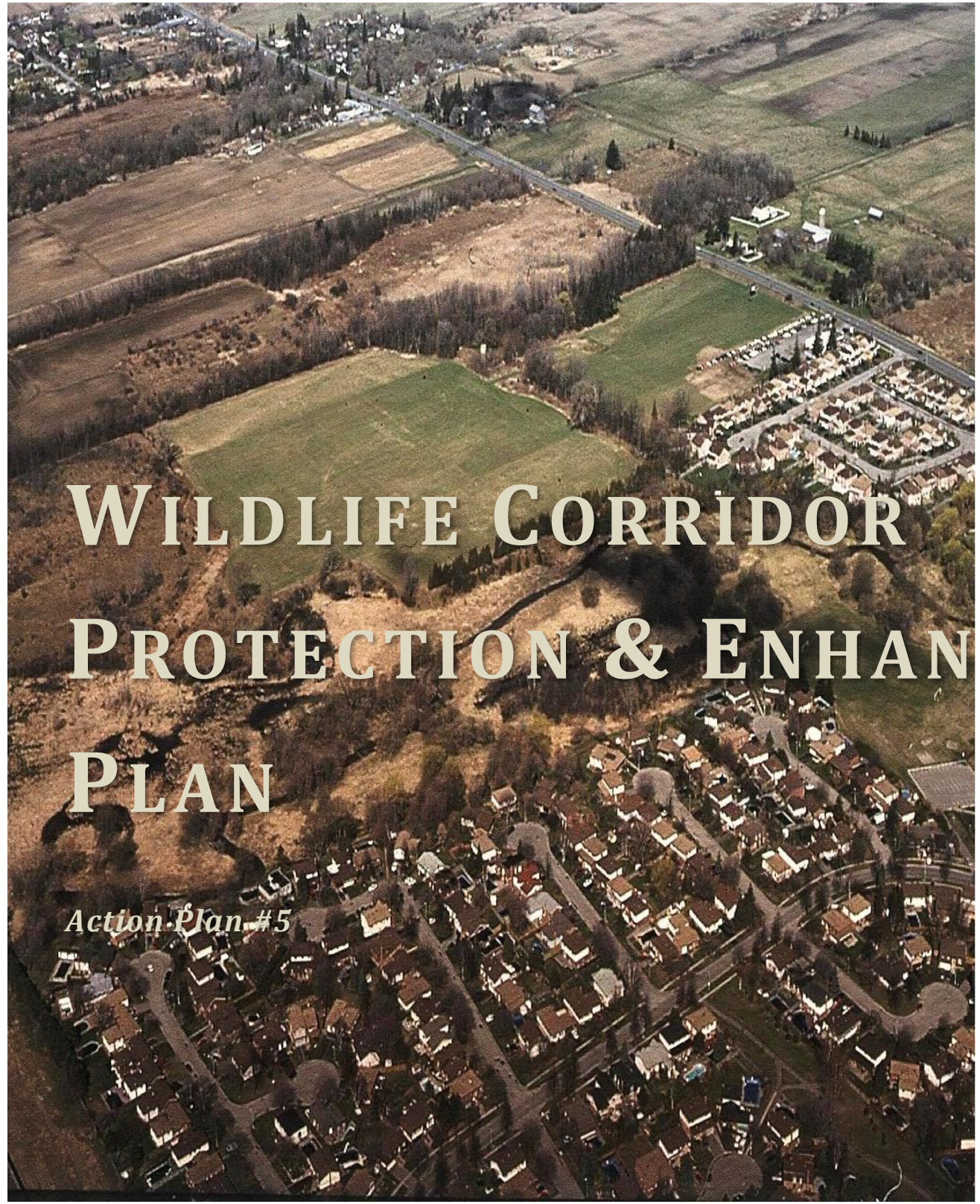

Wildlife Corridor Protection & Enhancement Plan

Action Plan #5

March 2015

Central Lake Ontario Conservation

Cover Photo Credits (clockwise from left): Lou Wise, I. Maciver, CLOCA, G. Ernest

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EXECUTIVE SUMMARY

Connectivity is a key concept in the maintenance of healthy ecological systems: for terrestrial wildlife, this means maintaining and creating direct linkages between important habitat areas. CLOCA has incorporated this principle into its watershed plans through the development of a Natural Heritage System (NHS) that includes a connected system of core habitats and corridors called the Wildlife Habitat Network (WHN).

Although there are numerous large, high quality wildlife habitats throughout the jurisdiction, many of them are isolated from each other as a result of gaps in natural cover and the presence of transportation infrastructure. This plan takes a closer look at the WHN in the jurisdiction and identifies gaps in the corridor system that require restoration (re-vegetation) and evaluates potential wildlife passage opportunities, in particular for mammals, reptiles and amphibians, across the road and rail networks.

A series of maps have been produced for this Plan that:

1. Identify the locations within the wildlife corridor system where gaps in vegetation exist;
2. Highlight 41 priority areas in the jurisdiction for targeted restoration; and,
3. Identify all of the breaks in the WHN that occur as a result of transportation infrastructure and assign each a 'wildlife potential permeability' score.

It is intended that Regional and Municipal planning and works staff, consultants, and landowners will use these maps to enhance landuse planning decision-making, assist with anticipating potential impacts to wildlife and incorporating wildlife movement needs into infrastructure improvement projects, and undertake strategic restoration or stewardship activities. The plan also includes several recommendations to assist decision-makers, landowners and land managers in protecting and restoring wildlife corridors and removing barriers to movement, including:

- Encouraging Durham Region and its Municipalities to adopt the NHS into their Official Plans;
- Encouraging planning authorities to incorporate the maps provided in this document into their planning processes to avoid removing or fragmenting existing natural heritage features;
- Incorporating wildlife mitigation measures, e.g., oversized culverts, into projects where traversing the WHN cannot be avoided;

- Encouraging land owners and managers to adopt best management practices, e.g., reduced mowing, within or adjacent to the WHN;
- Encouraging private landowners with WHN features on their lands to undertake stewardship activities to restore connectivity;
- Developing a communications strategy to assist planning authorities and works departments to utilize the maps provided in this plan, recognize potential wildlife improvement opportunities as they arise, e.g., planned culvert replacements, and involve CLOCA staff at an early stage; and,
- Tracking improvements in connectivity within the WHN to record and report on successes over time.

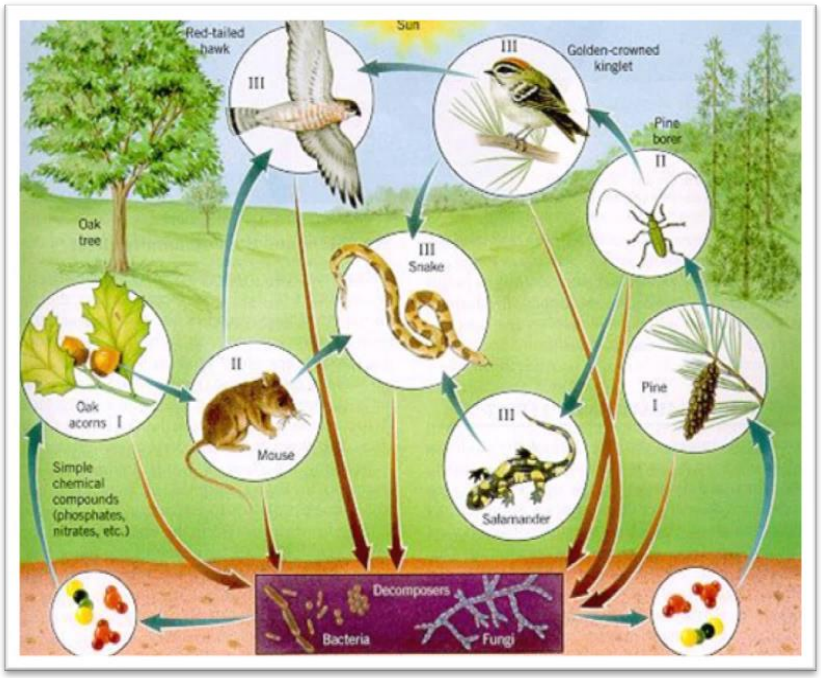

G. Ernest

Central Lake Ontario Conservation

1. INTRODUCTION

Ecological systems are complex: the relationships between the components, e.g., water, vegetation, climate, and wildlife, have evolved over very long periods of time, and are not always known or well-understood. We tend to value ecosystem components in terms of how they benefit human populations, e.g., preserve wetlands to prevent flooding or reduce impacts to human settlements, but we often overlook or undervalue the role that these components play in maintaining the balance of the overall ecosystem.

Wildlife, which are a key ecological component, are important for a number of reasons, not the least of which being that they service almost every level of the food chain, from eating dead animals to insects to small mammals to larger game. Population levels of all species are balanced in part by the lifecycles of other species, and this balance can be disturbed when a species or group of species are removed from the system. In some cases, it is easy to see the predator-prey relationships, e.g., foxes and rabbits, but in other cases, the impact of one species on another is not as clear, or there are multiple relationships that make identifying impacts difficult.



Sample of a terrestrial ecosystem (courtesy of worldslife-nisha.blogspot.com)

Wildlife activities also impact other ecosystem components like vegetation. Many trees and plants rely on animals to transport pollen or consume seeds and disperse them over a broader landscape, which in turn benefits the ecosystem in other ways. This type of relationship has local as well as provincial implications, as some wildlife can travel over large distances. In fact, ecosystem relationships can span over continents and even globally, so it is also important to note that in protecting local resources, we are maintaining more than just local ecosystems.

Everything is connected, so it is essential that we do our part to ensure that our local ecosystems, and the biodiversity of those systems, are protected and restored if needed. One way for people to support local biodiversity is to enable wildlife to fulfill their lifecycle needs without impeding their chances of success by restoring habitat connections that have been lost as a result of human activities and reducing the fragmenting effects/hazards of transportation infrastructure.

Wildlife are rarely confined to just one habitat, and often require more than one habitat type to complete their lifecycle or survive. These needs drive them to move or migrate to new habitats, but for many species the ability to relocate is hindered by the presence of roads, rail lines, or lack of cover between their current habitat and the one they need to get to. In some cases, these barriers prove to be fatal, either because an animal avoids/cannot cross the barrier and does not survive, or because it is hit by a car on the road or caught in the open by a predator. In either case, barriers to wildlife movement need to be addressed and minimized if the integrity of the local ecosystem is to be maintained.

1.1 Purpose of the Wildlife Corridors Protection and Enhancement Plan

Movement is a necessity for wildlife, and as such, a series of corridors connecting the key wildlife habitat areas within the CLOCA

Why Do Wildlife Move?

Reproduction

- Many amphibians move to seasonal or permanent water bodies to mate and lay eggs, but live and hibernate in upland habitats.
- Birds move in search of the right nesting sites.
- If there are not enough mates in one habitat, wildlife will move in search of one.

Resources

- All wildlife will move in search of food, water, and adequate shelter.

Competition

- Some wildlife actively defend their territories, so if there are more individuals in a habitat than there are territories, wildlife will be forced to move.

Predation

- All wildlife wishes to avoid being eaten, and as such, wildlife need to be able to escape from predators or areas of high predation.

Habitat Degradation

- Drought, flooding, fire, climate change, and human interference are all factors that can lead to habitat degradation (long-term or short-term). If habitat can no longer support wildlife needs, they must relocate to more suitable habitats.

Migration

- Wildlife that are unable to survive in colder climates have adopted large-scale migration patterns to overcome these seasonal changes.

jurisdiction have been identified (See Section 2); however, in order to function as they are intended, many of these corridors require improvement. It is these areas of improvement that this report will identify.

Two main wildlife movement issues currently exist within the jurisdiction: corridor fragmentation and infrastructure barriers. This plan will highlight those corridor areas that require habitat improvement, either through active plantings or through passive naturalization, and will identify all of the instances in which a road or railway prevents or impedes wildlife movement. This information can then be used by landowners, municipal planners, provincial agencies, parks departments, stewardship agencies, and CLOCA staff to make strategic restoration decisions as opportunities for corridor improvements arise.

It is not intended that the corridor improvements contained within this plan be implemented within a set time-frame, but rather, this plan is a guiding tool that can assist Watershed stakeholders in identifying areas where improvements are needed and to provide them with recommendations and best management practices to mitigate, enhance and restore movement corridors.

1.2 Context of this Plan and Watershed Planning

The goal of watershed planning is to provide a framework to protect, restore and enhance a healthy and resilient watershed. A Watershed Plan examines the environment and human activities within a watershed area and assesses the relationships between these activities to determine how the ecosystems of the watershed should be managed to ensure that they retain their ecological integrity and health in a sustainable manner. In 2012 and 2013, Watershed Plans for CLOCA's 4 large watersheds were completed: the recommendations that were made in these Plans will, when implemented, work to achieve specific watershed goals and targets. In order to achieve these goals, CLOCA has provided a suite of tools in the Watershed Plans, including 24 Action Plans, to direct and support the implementation of the Watershed Plan recommendations.

CLOCA Action Plans

The 24 Action Plans described in the Watershed Plans work to achieve and attain specific health objectives, contributing to the fundamental goal of a healthy and resilient watershed. All of the Action Plans address watershed concerns, issues, or actions that were identified during the development of the Watershed Plans. Some of the Action Plans will address large-scale issues, i.e., throughout the CLOCA jurisdiction, while

other Action Plans will focus on issues in particular watersheds, subwatersheds or within defined areas. CLOCA is taking the lead on preparing the Action Plans, some of which will compliment, support and/or inform Regional and/or Municipal programs, and these Plans will provide greater detail for achieving specific watershed goals and targets and will provide the framework and implementation planning necessary to complete future on-the-ground monitoring, research, restoration and rehabilitation work.

Action Plan #5 – the *Wildlife Corridor Protection and Enhancement Plan* – evaluates wildlife movement opportunities and constraints at a watershed scale, and was developed under the following direction from the Watershed Plan:

> *Wildlife corridors are mapped as part of the Natural Heritage System. Work is currently underway to: document the existing conditions in the watershed; conduct a corridor assessment and barriers to movement analysis; identify corridor enhancement, culvert improvement and stewardship opportunities; and develop key implementation tasks and priorities.*

While the driver for the development of this Action Plan is the Watershed Plans, policy support for this Plan also exists within Provincial Plans such as the ORMCP, Greenbelt Plan, and the 2014 Provincial Policy Statement, as well as Regional and Municipal Official Plans (OPs).

Section 2.3.2 of the Durham Region OP encourages the "development of a connected and functional natural system comprised of the Greenlands System[1] and additional linkages and corridors, [consisting of natural areas and features in order to provide for the migration of flora and fauna (section 10.3.2a)], substantiated by appropriate study, as identified in area municipal official plans". The actions described in this

[1] The Greenlands System includes areas with the highest concentration of sensitive and/or significant natural features and functions. These areas are to be managed as a connected and integrated natural heritage system recognizing the functional inter-relationships between them. The main features of the Greenlands System, particularly the Oak Ridges Moraine, valley systems, and the Waterfonts, shall be protected… further, linking the waterfronts with the Oak Ridges Moraine through the connecting valley systems shall the a primary objective of the continuous Greenlands System, as is linking the valley systems themselves. (Section 10.3.2)

policy are effectively met through the Natural Heritage System developed by CLOCA for the watershed plans and the Wildlife Habitat Network defined in this Action Plan.

Further support can be found in the municipal OPs; for example, section 4.4.6 of the Clarington OP states that "in order to ensure corridor functions are maintained, and where possible improved or restored, every application for development or site alteration shall identify planning, design and construction practices that ensure that no buildings or other site alterations impede the movement of plants and animals among natural heritage features…". The recommendations and mapping tools included in this Action Plan will assist planners in achieving this policy directive by identifying the need for wildlife movement opportunities in advance of projects commencing, thereby ensuring that corridor functions are maintained, improved, or restored within the Wildlife Habitat Network in each watershed.

Additional uses of this Plan will include informing other Action Plans, such as *Action Plan #1: Natural Heritage System Restoration Plan* to address issues relating to wildlife movement to support the achievement of a healthy and resilient watershed and will inform *Action Plan #10: Stewardship and Education Priorities and Plan*.

Planning Context

Currently, CLOCA provides planning advice, as defined within a Memorandum of Understanding (MOU), to its partner municipalities. This MOU recognizes CLOCA's expertise in the areas of watershed management and natural heritage/hazard planning, and identifies CLOCA as the advisory agency for these matters. CLOCA not only reviews studies that assess impacts on watershed resources and provides comments on planning applications relating to the identification, function and significance of natural heritage and hydrological features and systems, advice is also provided to support the implementation of the Authority's resource management plans including Watershed Plans and Action Plans. Management of water-related natural hazards and the protection of natural heritage features and water resources are also achieved by the Authority through Ontario Regulation 42/06. CLOCA's role with respect to the Environmental Assessment Act is to review and provide comments for any class and individual environmental assessments that occur within its jurisdiction, bringing local environmental and watershed knowledge into the review and assessment process.

CLOCA's involvement in both the local land use and EA review processes ensures that regard for the integrity of the NHS can be maintained throughout the planning process, and the information and recommendations contained within this Action Plan can be applied.

2. IDENTIFYING AND EVALUATING WILDLIFE CORRIDORS

As part of the watershed planning process, CLOCA developed a Natural Heritage System (NHS) for its jurisdiction. It is comprised of a connected system of natural heritage features and functions, as well as targeted restoration areas, which will maintain and improve the ecological integrity of each of CLOCA's four large watersheds over time. An important component of that ecological integrity is ensuring that wildlife have the ability to move between habitats. To reflect that importance, a Wildlife Habitat Network (WHN) was developed within the NHS that includes wildlife habitat areas as well as movement corridors. This network is shown in Figure 1. The following sections present a discussion about wildlife corridors, their health, maintaining continuity, and opportunities to protect, restore and enhance them.

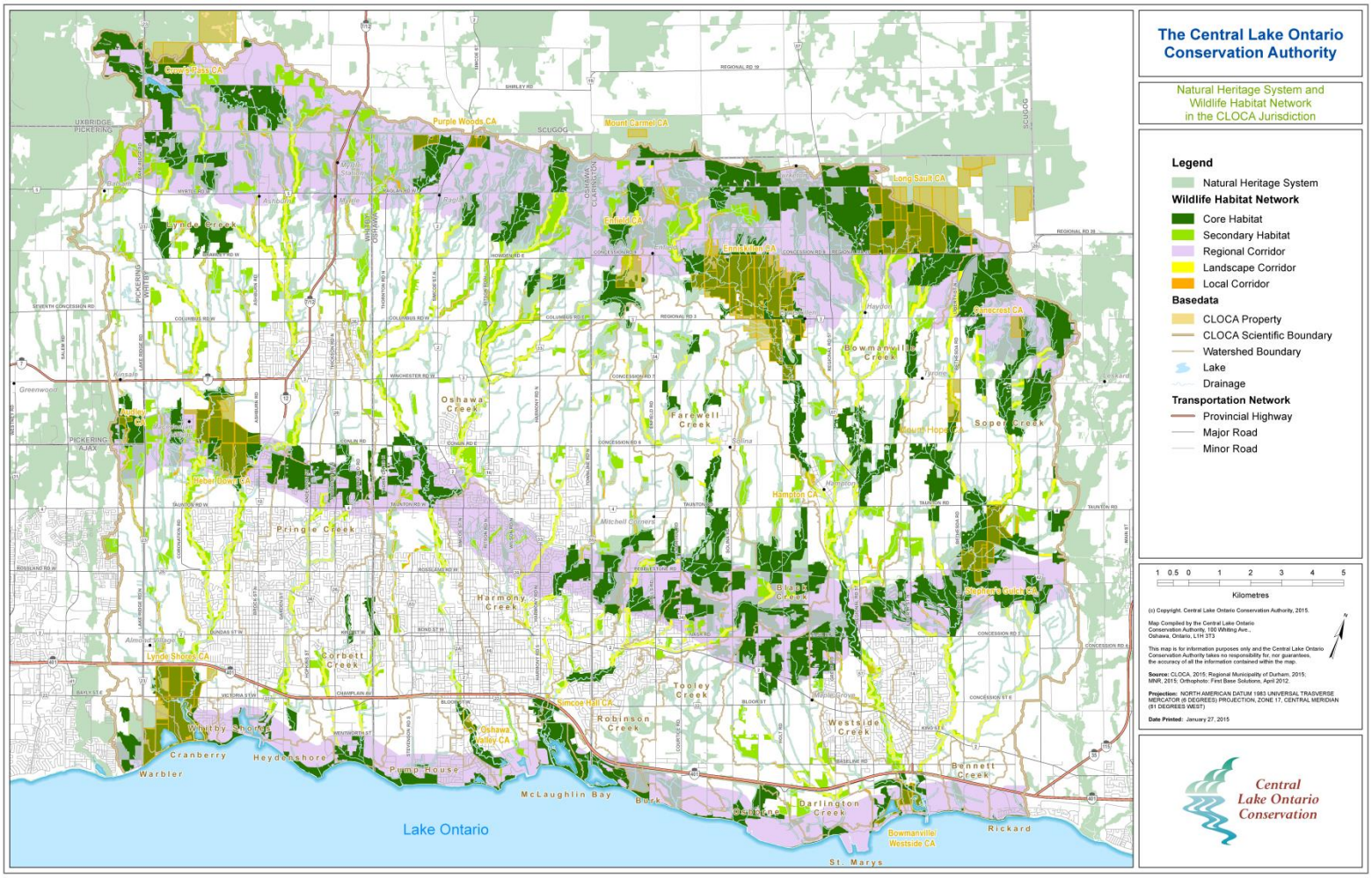
2.1 Characteristics of Healthy Wildlife Corridors

There is no simple definition of what a healthy corridor looks like: it is a subjective assessment that changes with each species considered. Furthermore, the need for corridors in a NHS is a function of urban sprawl and habitat fragmentation, not necessarily one driven by the needs of wildlife. As such, it is generally impossible to provide a generic description of a healthy corridor; however, some high level principles can be applied: a corridor should be continuous; a corridor should be robust (not too narrow); and a corridor should be naturally vegetated.

These principles can be further refined by scale: categorizing corridors into large, medium, and small-scale pathways enables those corridors with similar functions to be grouped and allows more specific restoration recommendations to be made. In the CLOCA jurisdiction, wildlife corridors have been designated as either regional, landscape, or local, and guidelines for maintaining the health of each corridor type are provided in Section 2.2.

While it is useful to identify those characteristics that make a corridor 'healthy', it is also useful to identify those characteristics that make a corridor 'unhealthy'. Generally, these are conditions that cause corridors to be fragmented, e.g., bisected by a road; narrowed, e.g., encroachment from urban development; or have reduced natural cover, e.g., mowing to creek edges. A more detailed discussion of disturbances that degrade wildlife corridors is presented in Section 2.3.

FIGURE 1: COMPONENTS OF THE WILDLIFE HABITAT NETWORK WITHIN THE CLOCA NATURAL HERITAGE SYSTEM



2.2 Types of Wildlife Corridors

The primary function of CLOCA's wildlife corridors is to facilitate wildlife movement through the maintenance of pathways between habitat areas. During the delineation of these pathways, no emphasis was placed on the type of habitat present within the corridors and no specific wildlife needs were attributed to them. They have been divided, based on scale, into 3 categories – regional, landscape and local – and the vast majority of them coincide with existing stream corridors as a result of existing urban development.

Regional corridors: The major movement pathways within a region. They tend to span multiple watersheds and facilitate movement across the larger landscape. In the CLOCA jurisdiction, regional corridors run from east to west, and are generally defined by the Lake Ontario Shoreline, the Lake Iroquois Beach, and the Oak Ridges Moraine.

Landscape corridors: The major movement pathways within a watershed. They connect core habitat patches to one another and often traverse the length of the watershed.

Local corridors: The minor movement pathways that help to connect secondary habitat patches in the watershed to core habitat areas or to landscape corridors. They generally function at a sub-watershed scale.

Both Environment Canada and the Ministry of Natural Resources and Forestry (MNRF) provide some general guidance on how robust a wildlife corridor should be to maintain its function. Environment Canada's 2004 and 2013 publications *How Much Habitat Is Enough?* suggest that "corridors designed to facilitate species movement should be a minimum of 50 metres to 100 metres in width". This guideline is based, in part, on a literature review that concluded that 50 m corridors were suitable for common generalist species, and that corridor widths of between 75 m and 175 m could support breeding birds. The MNRF's "Natural Heritage Reference Manual" (2010) recommends that corridors less than 16 km in length be 300 m wide. It does not differentiate between classes of corridor.

CLOCA has adopted corridor guidelines for its watersheds that have consideration for the recommendations provided by both Environment Canada and the MNRF, but recognize that there is a lack of species-specific information for the corridors in the jurisdiction, as well as a limited capacity for many of the urban corridors to be maintained or restored to widths as great as 300 m. CLOCA's guidelines are as follows:

- Regional corridor widths have not been strictly prescribed, as continuous cover throughout these regions is not generally attainable; however,
  - CLOCA recommends that a 1 km stretch of brushy or forested habitat be maintained along the Lake Ontario shoreline to positively affect migrant songbirds as well as facilitate wildlife movement.
  - CLOCA recommends that Municipalities maintain as much natural cover as possible within the Lake Iroquois Beach and Oak Ridges Moraine physiographic regions, and work towards establishing direct connections between east-west habitat patches as opportunities arise.
- Landscape corridors should be maintained or restored to no less than 100 m in width.
- Local corridors should be maintained or restored to no less than 60 m in width.

It should be noted that the corridor widths prescribed above are minimum recommendations and do not prevent individuals or agencies from preserving or restoring more robust corridors. A detailed rationale for the above corridor widths is provided in Appendix A.

2.3 Wildlife Corridor Disturbances

Corridor function can be impacted by a number of factors, although not all wildlife are affected by the same factors. The main disturbances to corridor function in the CLOCA jurisdiction are outlined below.

Lack of Natural Cover (Corridor Gaps)

For some species, lack of natural cover impedes movement. On a small scale, cover between habitat patches provides protection from predators and moderates environmental factors, such as wind or sun. On a larger scale, cover between habitat patches may act as temporary habitat, enabling species to move longer distances between core habitats thereby improving genetic diversity and allowing for the recolonization of habitats following local extinction events.

Instances within the watersheds where corridor cover is not continuous occurs frequently and is the result of numerous causes, including the presence of hydro corridors or pipelines, mowed or cleared areas for recreational/businesses/private use, urban development, and agricultural

activities. Where movement corridors are reduced or cut off as a result of human activities, sensitive wildlife may be unable to pass, and consequently may not survive. Less sensitive wildlife may attempt to cross such gaps, but this increases their risk of death from exposure to predators, including domestic cats, which are estimated to kill between 100 and 350 million birds per year (Blancher, 2013).

Transportation Infrastructure (Corridor Barriers)

Roads and railways also impede corridor function, most notably through direct mortality of wildlife from cars as they attempt to cross roads. The relative impact of road mortality is not the same for all species, however.

- Mammals are mobile, and most of the species in the CLOCA jurisdiction will readily cross roads, which makes them susceptible to being hit by cars. Consequently, roads can have a negative impact on their populations over time. The impact to such species may not be apparent when considering a single stretch of road, but the cumulative impacts of all the roads in a watershed, region, or province may be significant. Furthermore, wide-ranging mammals may be disproportionately affected by roads in that they encounter and cross them more frequently.
- Birds are highly mobile, and though one might assume that they would be less affected by road mortality as a result of being able to fly across roads, they are actually highly vulnerable to collisions with cars. This is particularly true for birds that forage, roost, or nest near roads, and in specific locations such as around watercourses and houses (Kociolek et al, 2011). Cars are estimated to kill 13,810,906 birds per year, which translates into 3,462 dead birds/100 km of road (Bishop and Brogan, 2013). Also concerning is the fact that vehicle collisions remove many healthy and mature breeding birds from populations, resulting in roadside habitats being population 'sinks' for some species (Bishop and Brogan, 2013).
- Amphibians in the CLOCA jurisdiction readily cross roads, particularly on warm, rainy nights when visibility is poor for drivers. Furthermore, their small size makes them almost impossible for drivers to see and avoid, especially at high


Spring Peeper

speeds, so amphibians have almost no chance of successfully crossing roads with high traffic volume. The impact of roads on amphibians is most apparent in locations where a road separates breeding ponds from upland habitat, and in those areas, road mortality of amphibians may result in the loss of one or more species over time.

- Reptiles face the same risk of being hit on roads as CLOCA's other vertebrate species, but are generally considered to be the most acutely impacted by road mortality.

Snapping turtle – I. Maciver

  - Turtles are especially vulnerable to being hit by cars for 3 reasons: they are slow-moving; their innate response to threat, like that of an approaching vehicle, is to retreat into their shells (or bite in the case of Snapping turtles), which is ineffective against cars; and, the females of the species readily use soft shoulders along roadsides as nesting habitat, so the risk of vehicle collisions is high. The last point is particularly true for roads that bisect wetlands, and for turtles is it perhaps the most devastating factor because the general result of continuously losing females in a population is local extinction over time - an impact that may not be apparent for several decades, as male turtles may persist in a wetland.


Monarch Butterflies - I. Maciver

- Snakes are at increased risk of being killed on roads because, in addition to crossing them in search of habitat or resources, they often perceive the warm pavement as a place to bask, resulting in accidental (and often intended) mortality from vehicles.

- Insects are most certainly subject to collisions with vehicles, but the impacts on particular species or on populations is not well understood.

Roads negatively impact wildlife in other ways too. Roads fragment habitats, which makes otherwise suitable habitats unsuitable to species that require large tracts of land. Furthermore, the fragmentation of large habitats, particularly forest, reduces the potential for those habitats to contain forest interior, which has negative implications for many breeding birds as it exposes them to increased predation from native mammals and domestic cats (Blancher, 2013).

Roads also contribute chemical contaminants to the environment, such as petroleum products and road salt, and assist in the spread of invasive plants: these factors can lead to the degradation of roadside habitats. Additionally, roads generate air, light, and noise pollution, which can impact adjacent habitats as far 1 km from the road, making roadside habitats completely un-inhabitable for some wildlife (Reijnen and Foppen, 2006). For song birds, it has been documented that traffic noise reduces breeding bird densities in habitats adjacent to roads (Reijnen and Foppen, 2006).

Some wildlife are known to avoid roads altogether. While this behaviour prevents them from being hit by cars, it can still lead to local extinction over time as a result of resource depravation, inbreeding (which can lead to increased disease or physiological problems), or lack of re-population following catastrophic events.

The impact of trains hitting wildlife is likely smaller due to the relative infrequency of train traffic in the CLOCA jurisdiction, though this has not been studied locally, and the issue of avoidance or inability to cross may still be valid for some species.

2.4 Identifying Movement Corridors and the Barriers Within Them (Methodology)

The identification of regional, landscape, and local corridors was done at the watershed scale, using the corridor definitions outlined in Section 2.2 as guidelines for categorization, and mapped using CLOCA's Ecological Land Classification (ELC) layer as a base. This exercise was undertaken as part of the development of the Watershed Management Plans, and a detailed methodology for this process is contained within those plans.

In order to provide recommendations about how to improve the Wildlife Habitat Network in the CLOCA jurisdiction, a secondary mapping exercise was undertaken as part of the Action Plan process to determine where gaps and barriers might exist. ***Corridor Gaps***, i.e., areas within the corridors lacking natural cover, were identified by generating an 'ideal' corridor layer in ArcView and comparing this to the existing corridor layer; this 'ideal' layer was developed using the creek layer, since the majority of corridors follow creeks in the watersheds. The creeks were

1. Map existing vegetation within corridors.

2. Buffer the creek layer to determine the recommended width of landscape and local corridors and refine if needed.

3. Overlay the 'ideal' corridor layer and the existing vegetation layers to show desired corridor width and highlight corridor gaps.

buffered by 50 m on either side for landscape corridors, and 30 m on either side for local corridors: in instances where there were no existing creeks between two habitat areas, the corridors were drawn in by hand. The 'ideal' regional corridor layer was produced using a 1 km buffer of the Lake Ontario Shoreline, and modified versions of the Lake Iroquois Beach and Oak Ridges Moraine physiographic layers. These 'ideal' layers, when displayed beneath the existing corridor layer for each watershed, highlight those areas within each corridor that are lacking in natural cover. The contrast between them makes the areas to target for restoration readily identifiable.

Corridor Barriers, i.e., transportation infrastructure, throughout the WHN were identified using the road and rail network layers provided by Durham Region and the Province of Ontario. The extent to which these breaks might already be permeable to all or some wildlife was not known, so to better understand the existing movement opportunities across the road network, a project was undertaken to evaluate the wildlife passage opportunities at every location where the WHN was bisected by a road or rail line. More specifically, the project aimed to evaluate the effectiveness of existing culverts and bridges in the jurisdiction as wildlife passages across roads and rail lines since the majority of the corridors in the WHN coincide with creeks. At each site, data such as culvert opening height, road width, traffic volume and presence of continuous exposed bank or terrain in the culvert was collected (see Appendix B for a sample data sheet), and the Openness Ratio (OR), which is the cross-sectional area of a structure divided by the length of the structure, was calculated for each culvert/bridge. The OR values, in combination with several other factors, were then used to assign wildlife permeability potential scores to each barrier. These scores ranged from Excellent to Very Poor. In some cases, the barrier locations were inaccessible, either permanently or due to construction activities, and these were given a score of Unknown.

TABLE 1: CLOCA DECISION MATRIX FOR EVALUATING WILDLIFE MOVEMENT POTENTIAL ACROSS ROADS[2]

CRITERIA	VALUE
• Culvert height ≥ 3.0 m • OR ≥ 0.6 m • Terrain is present along entire length of culvert/bridge	**EXCELLENT** *(suitable for all wildlife)*
• Culvert height ≥ 1.0 m • OR ≥ 0.25 • Terrain is present along entire length of culvert/bridge	**VERY GOOD** *(suitable for small mammals and reptiles)*
• Culvert height ≥ 1.0 m • OR ≥ 0.1 • Terrain is present along entire length of culvert/bridge	**MODERATE** *(suitable for small mammals only)*
• Culvert height ≥ 0.5 m • OR ≥ 0.25 • Terrain may or may not be present	**MODERATE** *(suitable for reptiles and amphibians only)*
• Any breaks in the habitat network that do not meet the above 4 criteria, but where the barrier is a gravel road with a traffic volume < 3 cars/5 min	**MODERATE** *(low risk of mortality from cars)*
• Any breaks in the habitat network where a culvert exists, but does not meet the criteria in first 5 categories	**POOR** *(not suitable for most wildlife)*
• Any breaks in the habitat network that do not meet the criteria in any of the categories listed above and where there is no culvert	**VERY POOR** *(mobile wildlife at highest risk of being hit on road)*
• Break location inaccessible	**UNKNOWN**

The matrix used to evaluate them is shown in Table 1. It was developed using the wildlife passage guidelines from the Highway 407 East EA Watercourse Crossing Reports (2008) as a reference. A copy of these guidelines has been included in Appendix C.

The corridor barrier evaluations, as well as the corridor gap analyses for each watershed, can be found in the corresponding watershed sections of this report.

[2] It should be noted that the road permeability scores that are derived from the decision matrix in Table 1 favour mammals, reptiles and amphibians. Aerial species, such as birds and insects, are not likely to use culverts or bridges as passages across roads, so it is important to recognize that the barrier evaluations presented in each of the watershed discussions is related to the existing potential for non-aerial species to pass across the transportation infrastructure network and does not necessarily reflect the impacts of those barriers on birds or insects.

3. IMPROVING WILDLIFE CORRIDORS

The goal of this action plan is to improve wildlife movement throughout the CLOCA jurisdiction. Eliminating gaps by restoring natural cover in the corridors, and removing barriers by improving the effectiveness of wildlife passages beneath roads will result in higher quality wildlife habitat in all of the watersheds and will lessen the overall impacts of urban development. Protecting, restoring and enhancing wildlife corridors does not only serve to improve wildlife habitat and biodiversity though, it also supports many of CLOCA's other watershed health targets, such as increasing natural cover, reducing impervious surfaces, enhancing water quality, increasing surface water flow retention, and protecting fish and aquatic habitat. As such, implementing the recommendations of this Action Plan should not be viewed as being solely beneficial to wildlife.

Achieving the goals of this Plan is possible, but the timeframe for success will be long, as restoration activities and barrier removals will generally occur opportunistically. In this Plan, specific restoration actions, such as prescribing the type of cover within each corridor, e.g., forest, or recommending active planting over passive naturalization, have generally not been included, as these types of actions should be tailored to each site; however, one over-arching restoration principle that should be applied to every site is that corridors should be continuously and naturally vegetated. Maintaining gaps in cover through activities such as mowing between trees is not encouraged, nor is planting a site with non-native species. Where vegetation management is necessary, the use of Best Management Practices is recommended.

One exception to the above vegetation removal prohibition would be for the establishment and maintenance of recreation trails, which many municipalities have created within their valley systems. It should be noted that trails can result in wildlife mortality from bike traffic, and increased human activity may negatively impact some of the more sensitive species (Barrueto, et al., 2014); however, a balance must be struck between the need for local recreation and nature exposure with the needs of wildlife, so maintained trails are not discouraged where the two uses are compatible. Some effort to determine the compatibility of these uses should be made prior to establishing trails however, and communication with CLOCA is recommended to assist with this.

The following subsections provide some additional information for maintaining and improving wildlife corridors in the CLOCA jurisdiction.

3.1 Corridor Protection, Restoration, and Removal of Barriers

Protecting and restoring the wildlife corridors in the watersheds to their 'ideal' state will require the use of several approaches to be successful. Ensuring that there is adequate vegetative cover within the corridors will involve landowners at all levels, and mitigating the impact of transportation infrastructure on wildlife movement will require the engagement of all levels of government.

Protecting Natural Cover

Preserving the existing wildlife corridors in the jurisdiction is the most effective means of maintaining the WHN, and this must be done in cooperation with partner municipalities as well as landowners. By adopting the NHS into municipal official plans, and using the NHS maps as planning tools, municipalities can ensure that the WHN is not lost to development. In addition, municipal bylaws can be revised and/or established to ensure that activities on private lands, such as tree cutting, do not compromise the integrity of the existing WHN.

The following recommendations have been adapted from the "Recommended Municipality Implementation Policies" contained in CLOCA's 4 Watershed Plans and will assist decision-makers, landowners and land managers in protecting natural cover within the wildlife corridor system:

- Adopt official plan policies that support connectivity and continuity of wildlife corridors including landscape corridors.
- Incorporate the CLOCA NHS into official plan schedules and adopt policies that protect the NHS.
- Identify the Oak Ridges Moraine, Lake Iroquois Beach and the Lake Ontario Shoreline as regional wildlife corridors in official plans, as they support east-west movement across the jurisdiction and provide important connections with north-south movement corridors.
- Implement measures that maintain and/or restore a continuous corridor function between the Regional Landscape whenever possible.
- Recognize the Lake Ontario Shoreline as an important regional wildlife movement corridor in official plans and adopt policies promoting the use of design criteria, plantings, and building materials to limit development impact on wildlife movement for all new development within 1 km of the Lake Ontario Shoreline.
- Promote the protection of the NHS on private lands, and continue to work proactively with developers to set aside appropriately-sized wildlife corridors in new developments, dedicating these lands to the municipality or an appropriate public agency.

- Develop and distribute a brochure to landowners with properties adjacent to landscape and local corridors explaining the importance of wildlife corridors and providing advice on maintaining and enhancing them.

CLOCA will promote the protection of natural cover within the WHN by adopting and implementing its resource management plans and by continuing to incorporate it as a principle in its permitting and plan review processes.

Restoring Natural Cover

Returning those corridors that are narrower than prescribed in the Watershed Plans to their recommended widths, or re-vegetating sections of corridors that are non-existent or severely fragmented, will require the involvement of anyone that owns affected lands. This includes municipalities, private industry, and local citizens. Where corridors run through municipal lands, such as parks, mowing practices should be reviewed to determine if the corridor widths can be enhanced and gaps restored, either passively or actively. Where corridors run through private property and restoration opportunities exist, landowners should be approached to see if there is interest in undertaking stewardship activities; either passive or active. An education campaign in key areas to encourage landowners to maintain healthy buffers around creeks and natural areas, and discourage mowing to creek edges, may be an effective technique for improving many of the urban corridors. In both cases, resources must be made available to landowners to assist them in undertaking stewardship activities.

The following recommendations have been made to assist landowners and land managers in restoring natural cover within the wildlife corridor system:

- Private land stewardship restoration projects should be promoted and, whenever possible, funding should be secured and guidance provided to assist landowners in undertaking corridor restoration projects.
- Landowners in key areas of each watershed should be contacted to promote corridor restoration projects on private lands. Refer to the watershed sections of this report for a list of key restoration sites.
- Municipal and Regional mowing practices should be reviewed to determine where corridors can be enhanced within public spaces via natural regeneration.

Removing Barriers

As the primary owners of roads in the jurisdiction, municipal, regional, and provincial governments play a crucial role in removing barriers to wildlife movement. Decreasing the impact of transportation on wildlife can only be achieved through a multi-faceted approach that begins with incorporating wildlife into transportation planning and ends with the enhancement of existing roads to include wildlife passage structures.

1. *GOOD PLANNING*

The most powerful way to minimize the impact of development and infrastructure on wildlife is through good planning. Ideally, the first consideration in any development proposal, particularly the construction of a new road, should be how it will impact the NHS and what can be done to avoid it. By building around the NHS from the outset – a feat that can be accomplished by including NHS mapping in all levels of planning – system functionality will be automatically preserved and restoration works will not be required after-the-fact.

In the CLOCA jurisdiction, where the Province has forecasted a population of almost 1 million people by 2031, urbanization – and the foundations upon which growth relies, e.g., roads, services, utilities, expansion and improvement to existing infrastructure – is a fact of life. In such a developing landscape, finding balance between competing interests is most effectively accomplished through the land use planning process and/or the Environmental Assessment (EA) process, whereby information and data is collected and analyzed, background and recommendation reports are prepared, and members of the public, review agencies and stakeholders are consulted. In this regard, CLOCA is an excellent resource.

In order to ensure that good planning practices occur, CLOCA recommends that:

- A training program be established whereby Municipal and Regional works departments are introduced to the mapping products in this Action Plan, taught to recognize when opportunities to enhance or create wildlife passage might coincide with planned projects, such as culvert replacements, and encouraged to communicate these opportunities to CLOCA in a timely manner so that CLOCA staff collect data and/or offer advice.

CLOCA will assist its Regional, Municipal, and Provincial partners in this responsibility by identifying wildlife movement barriers and promoting their removal/mitigation through the Authority's permitting and plan review processes.

2. *Pre-Development Monitoring & Mitigation of New Roads*

Should it be determined through the planning process, after exploring all of the opportunities available to avoid encroaching into or fragmenting the NHS, that impacting the system cannot be avoided, then development, in particular road crossings within the Wildlife Habitat Network, should be sited where the corridor is already narrow, or where the existing cover within a corridor is lowest, or at a location where the impacts of the development will be minimized. This is consistent with the "Recommended Municipal Implementation Policies" outlined in the Watershed Plans, which state:

> *Encourage municipal partners to avoid wildlife corridors when re-aligning and/or establishing transportation corridors. When every reasonable effort has been taken or explored to avoid wildlife corridors and impact is still a likely outcome, then implementation of appropriate mitigation techniques and methods is recommended.*
>
> *That municipalities address removal of barriers to wildlife movement when planning for and undertaking infrastructure upgrades, improvements, or repairs and that if appropriate wildlife corridor passages cannot be fully achieved, that appropriate mitigation methods be implemented.*

In addition, specific data will need to be collected as part of the EA and/or planning process (either during the preparation of secondary plans or at the subdivision/site scale) to better understand the impacts that the proposed development will have on the local wildlife populations and assist with implementing appropriate mitigation measures. The establishment of a 3-season monitoring program (minimum) is recommended to enable the proper assessment of habitat conditions, and identify which species will need to be accommodated in the mitigation plan.

Mitigation measures for wildlife could include, but are not limited to:

- Installing oversized box culverts (or bridges wherever possible) that include dry banks along creek edges for wildlife to use and installing fencing or incorporating funneling techniques, such as rip-rap embankments, to help direct wildlife to passages;
- Installing wildlife signage at sensitive road locations and removing gravel shoulders adjacent to wetlands;
- Providing healthy buffers between developed spaces and naturally vegetated corridors;
- Fencing backyards; and,

- Actively restoring adjacent corridors that have gaps or are discontinuous.

3. *Enhancement of Existing Roads*

It is not realistic to expect that existing roads should be removed from the transportation network to improve wildlife movement through the WHN, so mitigating their barrier effects is the only reasonable solution. Because most of the corridors in the WHN follow existing creek corridors, culverts are often already in place beneath the roads to accommodate water; consequently, there is the potential to replace poor-functioning culverts with larger versions that provide increased light penetration and maintain continuous dry banks to accommodate terrestrial wildlife movement through them. In addition, adding fencing along road edges within the corridor will assist in keeping wildlife from crossing roads at the surface and encourage use of the culverts under roads instead.

For roads that are adjacent to wetlands, signage to warn drivers to watch for nesting turtles may be an effective means of reducing road mortality, and lowering speed limits in these areas, even temporarily during the peak nesting season, will improve the chances of survival for wildlife in these areas (Farmer and Brooks, 2012)

3.2 Cooperation with Area Municipalities and Utility/Infrastructure Providers

Some activities, such as trail and park maintenance or hydro corridor maintenance, will not trigger any of the development application processes in which CLOCA participates, and in these instances it is incumbent upon municipal partners and private industry to recognize when their proposed activities will negatively impact the NHS. Where such activities are occurring within Conservation Areas, cooperation with private industry already exists, for example, Hydro One plans hydro corridor maintenance outside of wildlife nesting timing windows and manages vegetation to include wildlife habitat. These relationships can easily extend to similar areas throughout the watersheds, and the figures produced for this Action Plan are one tool that agencies and municipalities can use to anticipate where a conflict may occur and initiate a dialogue with CLOCA to discuss potential solutions. Similarly, developers and consultants can use the maps in this Plan to determine where pre-development monitoring for wildlife might be required and to notify CLOCA regarding future construction/development.

In the case of municipal capital works projects or utility/infrastructure work, where there may be the potential to improve corridor function, e.g., by upgrading a culvert to include terrestrial wildlife passage, recognition of the opportunity by municipal staff (via the mapping in this report)

and advanced communication to CLOCA of such projects will enable Authority staff to make informed recommendations, will result in timing and financial efficiencies, and will help to achieve the goal of improved wildlife corridors in the NHS.

3.3 Best Management Practices and Land Stewardship

All of the large valleys in the jurisdiction have been identified as wildlife corridors, and many of these are owned by Municipalities and are protected from development; however, public use within these lands is often not restricted, and many people have homes that back onto wildlife corridors, so every user plays a part in ensuring that their activities do not impair the quality of the habitat within the valleylands for wildlife. Activities that all users can do to help maintain corridor quality include:

- Practicing pooping & scooping with pets to maintain good water quality;
- Keeping pets on a leash to avoid disturbing wildlife;
- Not littering and picking up garbage;
- Staying on established trails to prevent soil compaction and erosion;
- Not dumping yard waste or compost in natural areas;
- Being aware of invasive garden plants and avoiding introducing them to natural areas;
- Avoiding using pesticides or herbicides near natural areas; and,
- Adopting the "take only pictures and leave only footprints" philosophy when using valleylands.

Developing good user-stewardship practices will ensure that the existing wildlife corridors, and indeed all of the wildlife habitats, will be maintained as high quality habitats for the long term.

Where existing corridors are narrower than the prescribed width or are discontinuous, more active stewardship may be required. In these cases, enhancing wildlife corridors can be as simple as not mowing to creek edges and leaving areas to naturalize on their own, or can be as involved as actively planting corridor gaps. CLOCA can provide guidance to landowners wishing to improve wildlife corridors or habitat on private property.

3.4 Evaluation, Monitoring and 5-Year Reviews

The study of wildlife corridors and the impact of roads on wildlife (road ecology) are developing fields, with new information being discovered and published on an ongoing basis. Not only is more research being conducted on species movement, but the performance of installed wildlife passages is currently being monitored and assessed by various agencies, and the lessons learned from past experiences are being applied to new projects, resulting in continual improvements to their efficacy. Information, as it is released, is collected by CLOCA and applied to the plan review process in order to provide meaningful comments for planning applications, policy documents and EAs.

CLOCA also endeavours to assist its municipal partners to track the health of the wildlife networks in their watersheds over time by collecting information on upgrades and improvements to existing barriers, identifying newly created passages, and tracking restoration works that enhance movement corridors: findings which will be included in the 5-year review and update of the Watershed Plans. Through these updates, the overall successes and failures of implementing the Action Plans can be assessed, and if needed, the recommendations can be re-visited.

In order to ensure that effective monitoring and updating occurs, CLOCA recommends that:

- A database be created to keep track of restoration activities that take place within the Wildlife Habitat Network, as well as to track the removal or mitigation of barriers to wildlife in the jurisdiction; and,
- The following long-term goals be established:
  - Endeavour to have all wildlife passages within the landscape corridor system at Very Good or better; and,
  - Endeavour to have all wildlife passages within the local corridor system at Moderate or better.

A future refinement of the recommendations in this Plan could be done if a Hotspot Mapping Analysis was conducted for the CLOCA jurisdiction. In this process, a computer analysis of the habitats adjacent to road crossings would be undertaken to determine potential mortality hotspots in the jurisdiction. Field surveys could then be done at sites that are identified as dangerous for amphibians and reptiles to quantify the danger and a list of priority sites for barrier removal could be generated.

4. WATERSHED FINDINGS AND RECOMMENDATIONS - LYNDE CREEK

Lynde Creek and its tributaries drain an area of approximately 130 km^2. The watershed is located entirely within the Regional Municipality of Durham and traverses through five local municipalities: the Township of Uxbridge, Township of Scugog, City of Pickering, Town of Ajax, and the Town of Whitby (Figure 2). Lynde Creek's headwaters originate in the Oak Ridges Moraine (ORM) and the creek outlets into Lake Ontario through the Provincially Significant Lynde Creek Marsh. The Lake Iroquois Beach crosses in an east-west direction through the centre of the watershed.

To the south of the Oak Ridges Moraine, the landscape is dominated by farmland. The urban area of the Town of Whitby occupies most of the south portion of the watershed, with the Lynde Shores Conservation Area forming the dominant open space on the Lake Ontario waterfront. The Village of Brooklin is located within the central portion of the watershed, and has seen tremendous growth in the last 15 years. Heber Down Conservation Area also lies within the middle of the watershed.

The NHS for the watershed, as shown in Figure 2, projects almost 40% natural cover for the watershed.

4.1 Analysis and Findings

Corridor Gaps

Figure 3, which shows the Wildlife Habitat Network in contrast to gaps in cover (red), demonstrates that the corridors within the Lynde Creek watershed vary in quality. Many of the landscape corridors (yellow) are in good shape, meaning that while they do narrow in parts, there is generally continuous natural cover. Some obvious fragmentation does exist, however. The local corridors (orange) are more fragmented and discontinuous overall.

Regional corridors, which are shown in a light purple colour, are not in continuous natural cover. Due to development and agricultural activities that have occurred along the Lake Ontario Shoreline, and within the Lake Iroquois Beach and Oak Ridges Moraine physiographic regions, it is unlikely that continuous natural cover can be achieved. As such, a series of larger habitat patches, along with several direct habitat connections, must be protected and enhanced to enable the majority of wildlife to move through these east-west corridors. Opportunities to create direct

connections, i.e., continuous/naturally-vegetated corridors, should be a consideration within the Regional Corridors. Development proposals within and/or adjacent to a regional corridor should identify restoration/preservation areas which would facilitate future connectivity or eliminate gaps in corridors.

Table 2 identifies some key areas in the Lynde Creek Watershed where corridor restoration activities, if undertaken, would greatly improve overall connectivity in the watershed and where private land stewardship should be encouraged. These areas are circled in Figure 3 as well.

TABLE 2: PRIORITY RESTORATION AREAS IN THE LYNDE CREEK WATERSHED

WILDLIFE HABITAT	NEAREST INTERSECTION	RECOMMENDED ACTION
Landscape Corridor	SW of Lyndebrook and Country Lane	Private land stewardship
Landscape Corridor	NE of Taunton and Cochrane (Cullen Gardens)	Active plantings along creek edge
Landscape Corridor	W & E of Brock St, N of Vipond	Private land stewardship/ education to reduce mowing
Landscape Corridor	SE of Lakeridge and Brawley	Private land stewardship
Landscape Corridor	SE of Lakeridge and Myrtle	Private land stewardship
Landscape Corridor	Myrtle Rd, west to Ashburn (Royal Ashburn Golf Club)	Private land stewardship

FIGURE 2: LYNDE CREEK WATERSHED AND NATURAL HERITAGE SYSTEM

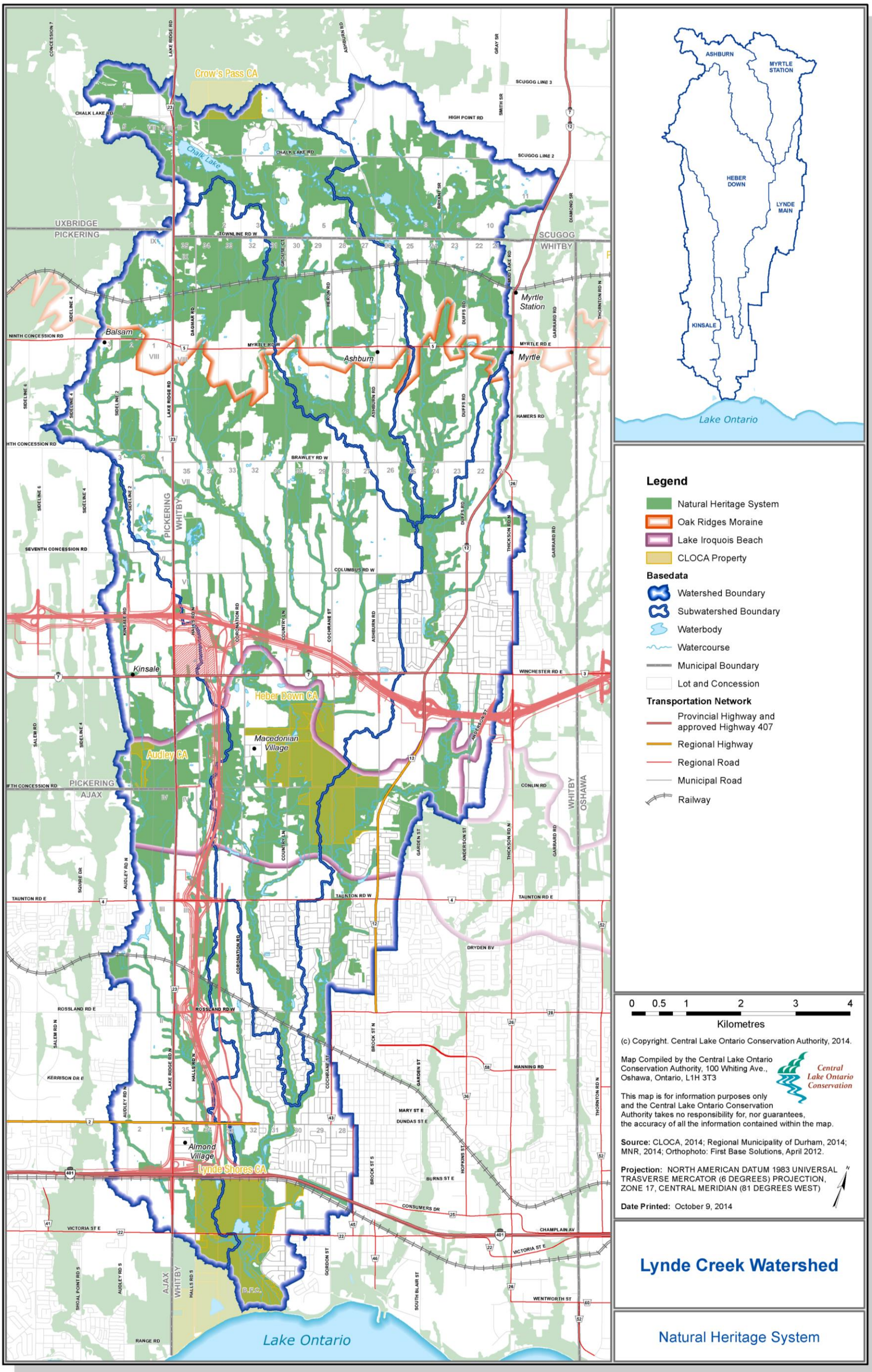
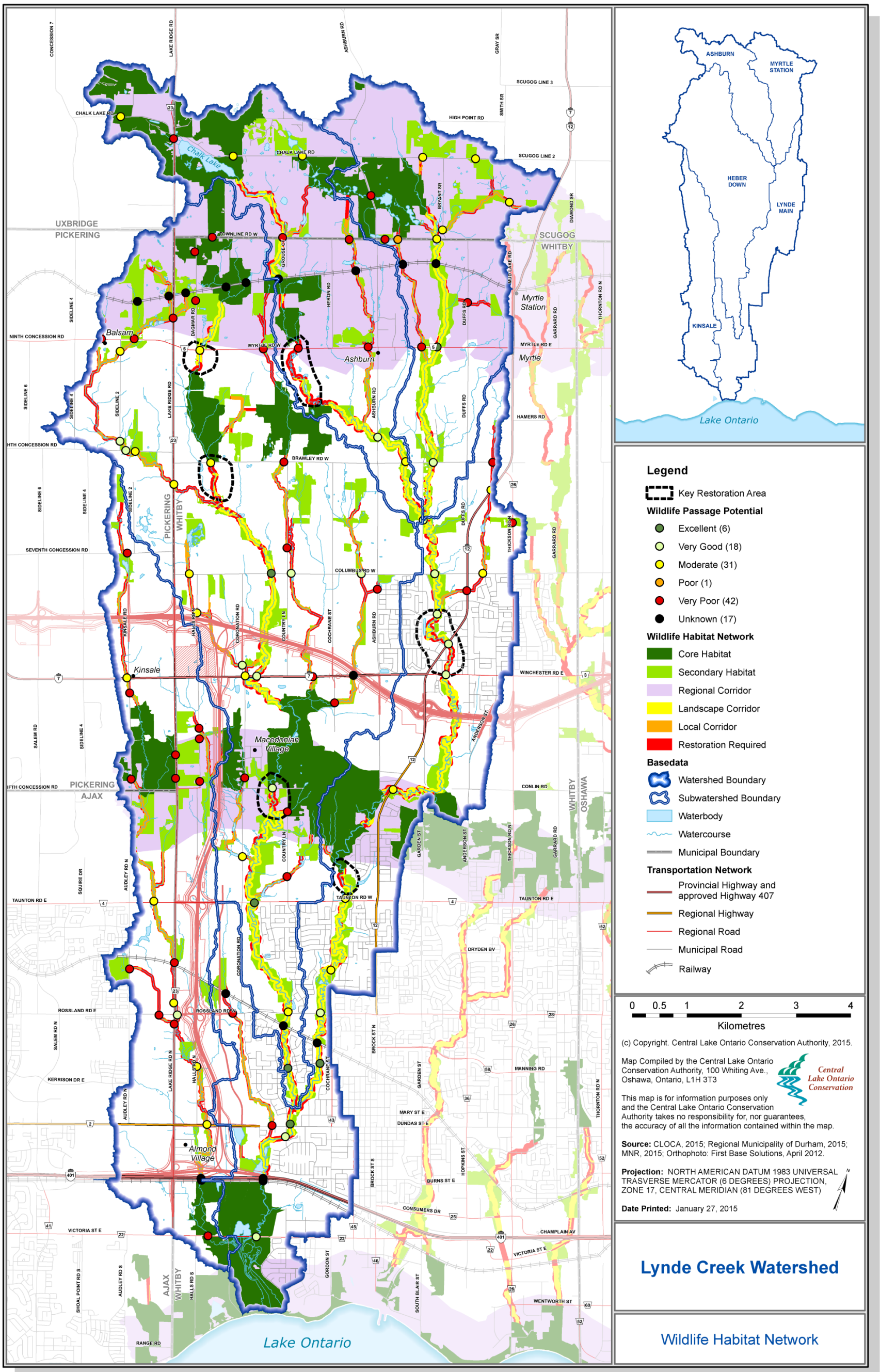


FIGURE 3: LYNDE CREEK CORRIDOR GAP ASSESSMENT & BARRIER ANALYSIS RESULTS



Corridor Barriers

Table 3 presents a summary of the road crossing evaluations in the Lynde Creek watershed. In total, 115 breaks were identified within the Wildlife Habitat Network in the Lynde Creek watershed: 12% were within a core or secondary habitat; 30% were within a landscape corridor; 52% were within a local corridor, which is a reflection of the higher number of local corridors in the watershed; and 5% were within a regional corridor. Of these breaks, 38% were deemed Poor or Very Poor, 27% scored Moderate, and 21% scored as either Very Good or Excellent (Figure 3) for their potential to support the movement of wildlife (mammals, reptiles and amphibians).

Core and Secondary Habitat Areas

Within the core habitats, twelve breaks were identified. None scored Excellent for enabling wildlife passage, due largely to the fact that few creeks, and therefore few bridges and culverts, exist for wildlife to use as passages across the roads. One break, at Victoria Street, did score Very Good, and several came out as Moderate because the roads were rural in nature and were deemed 'low risk' for road mortality. The rest were Very Poor or Unknown.

Within the secondary habitat areas, only 2 barriers to connectivity were identified, both as a result of the rail network. These were evaluated as 'Unknown', as the culverts were inaccessible at the time of the surveys.

Landscape Corridors

Within the Wildlife Habitat Network, landscape corridors returned the highest number of potentially 'Excellent' wildlife crossings. This is because the landscape system contains all of the large valley systems in the watershed, and the roads constructed across these valleys generally include span bridges, which have high Openness Ratios and which often contain continuous terrestrial habitat underneath.

Approximately 1/3 of the breaks scored Very Good, also the highest number in any of the habitat network categories, and another third were evaluated as Moderate. In total, 77% of the crossings within landscape corridors were ranked as Excellent to Moderate for their potential to accommodate wildlife passage.

The remaining passages, about 23%, were deemed to be Very Poor or of Unknown quality.

Local Corridors

None of the bridges or culverts in the local corridor system were evaluated as Excellent, and only 10% were deemed Very Good. In contrast to the landscape corridor system, there are very few large valleys within the local corridors, so bridges and large culverts are rare.

28% of the breaks were ranked as Moderate, either as suitable for reptiles only, small mammals only, or as areas with a low risk of mortality. The remaining breaks were mostly valued as Poor (2%), Very Poor (48%), or Unknown (12%).

Regional Corridors

The presence of existing culvert crossings within regional corridors is low because most of the creeks in the watershed run from north to south; consequently, all of the breaks in the regional corridors ranked as Very Poor.

TABLE 3: WILDLIFE POTENTIAL PERMEABILITY SCORE SUMMARY FOR THE LYNDE CREEK WATERSHED

HABITAT NETWORK CATEGORY	WILDLIFE PERMEABILITY SCORE																	
	EXCELLENT	%	VERY GOOD (small mammals and reptiles)	%	MODERATE (low risk)	%	MODERATE (reptiles only)	%	MODERATE (small mammals only)	%	POOR	%	VERY POOR	%	UN-KNOWN	%	GRAND TOTAL	%
Core			1	8	4	33							5	42	2	17	**12**	10
Secondary Habitat															2	100	**2**	2
Landscape Corridor	6	17	11	31			10	29					2	6	6	17	**35**	30
Local Corridor			6	10	5	8	7	12	5	8	1	2	29	48	7	12	**60**	52
Regional Corridor													6	100			**6**	5
TOTAL	**6**	5	**18**	16	**9**	8	**17**	15	**5**	4	**1**	1	**42**	37	**17**	15	**115**	

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5. WATERSHED FINDINGS AND RECOMMENDATIONS - OSHAWA CREEK

The Oshawa Creek Watershed, which includes the Montgomery Creek and Goodman Creek subwatersheds, drains an area of approximately 120 km^2. The watershed is located entirely within the Regional Municipality of Durham and the majority of it is within the boundaries of the City of Oshawa; small areas of the Watershed are also within the jurisdictions of the Town of Whitby (west) Township of Scugog (north) and the Municipality of Clarington (east) (Figure 4). Oshawa Creek's headwaters originate in the ORM and the creek outlets into Lake Ontario through the Provincially Significant Oshawa Creek Marsh and the Oshawa Harbour. The Lake Iroquois Beach crosses in an east-west direction through the centre of the watershed.

To the south of the Oak Ridges Moraine, the landscape is mostly agricultural, though urban growth has been happening quickly in the lands previously owned by Windfield Farms. South of Winchester Rd, the Oshawa Creek watershed is almost exclusively urban, with the Oshawa Creek Valleylands and a few forested wetlands in the Lake Iroquois Beach representing the only natural areas in this section of the Watershed.

The NHS for the watershed, as shown in Figure 4, projects just over 38% natural cover for the watershed.

5.1 ANALYSIS AND FINDINGS

Corridor Gaps

Figure 5 shows the Wildlife Habitat Network in contrast to gaps in cover (red). The landscape corridors in the watershed (yellow) are largely intact, but there are several sections where the corridors are very narrow or are severely fragmented. In particular, the main Oshawa Creek valley, south of Rossland Rd, is less than the recommended width of 100 m for a large section through the downtown core, and this section of the corridor is important as it is the only landscape level connection between the Lake Iroquois Beach and the Lake Ontario Shoreline. Most of the local corridors in the watershed (orange) are poorly vegetated and fragmented.

There are few direct east-west connections within the Lake Ontario Shoreline and Oak Ridges Moraine Regional Corridors; the Lake Iroquois Beach Regional Corridor connections are somewhat better. As is the general rule in the CLOCA jurisdiction, well-vegetated east-west

connections are not as common, as the tributaries tend to run in a north-south direction. As a result, few culverts/bridges are present that can accommodate wildlife passage across roads within the regional corridors.

Table 4 identifies some key areas in the Oshawa Creek Watershed where corridor restoration activities, if undertaken, would greatly improve overall connectivity in the watershed and where private land stewardship should be encouraged. These areas are also highlighted in Figure 5.

TABLE 4: PRIORITY RESTORATION AREAS IN THE OSHAWA CREEK WATERSHED

WILDLIFE HABITAT	NEAREST INTERSECTION	RECOMMENDED ACTION
Landscape Corridor	Oshawa Creek Valley west of Simcoe St., between Olive Ave and Rossland Rd	Active plantings along creek edge on municipal lands and private land stewardship
Landscape Corridor	Ritson Rd south of Winchester	Private land stewardship
Landscape Corridor	Northeast of Winchester and Thornton	Private land stewardship
Landscape Corridor	Simcoe St between Columbus and Howden	Private land stewardship
Landscape Corridor	North of Columbus Rd between Grandview and Townline	Private land stewardship

FIGURE 4: OSHAWA CREEK WATERSHED AND NATURAL HERITAGE SYSTEM

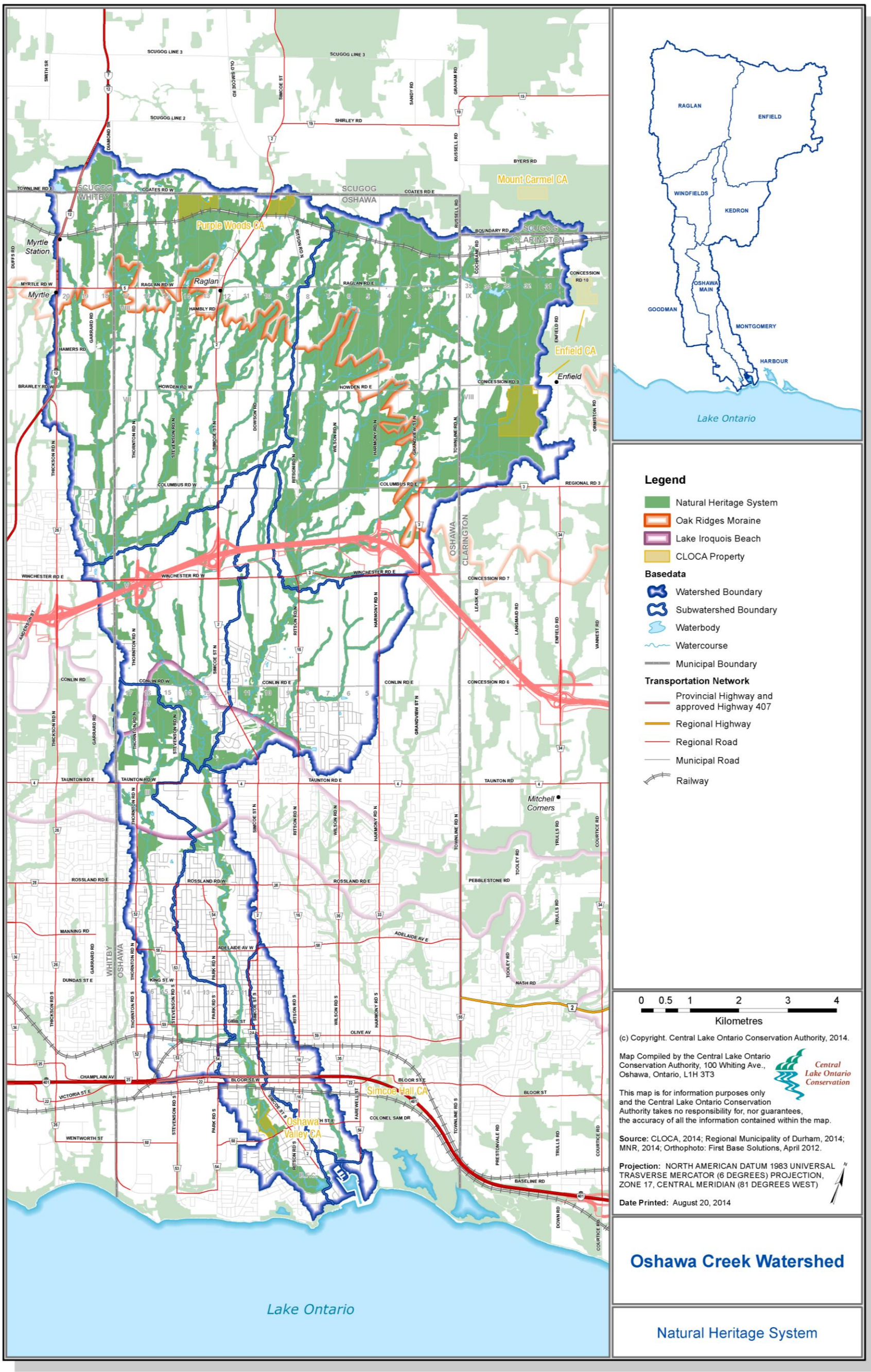

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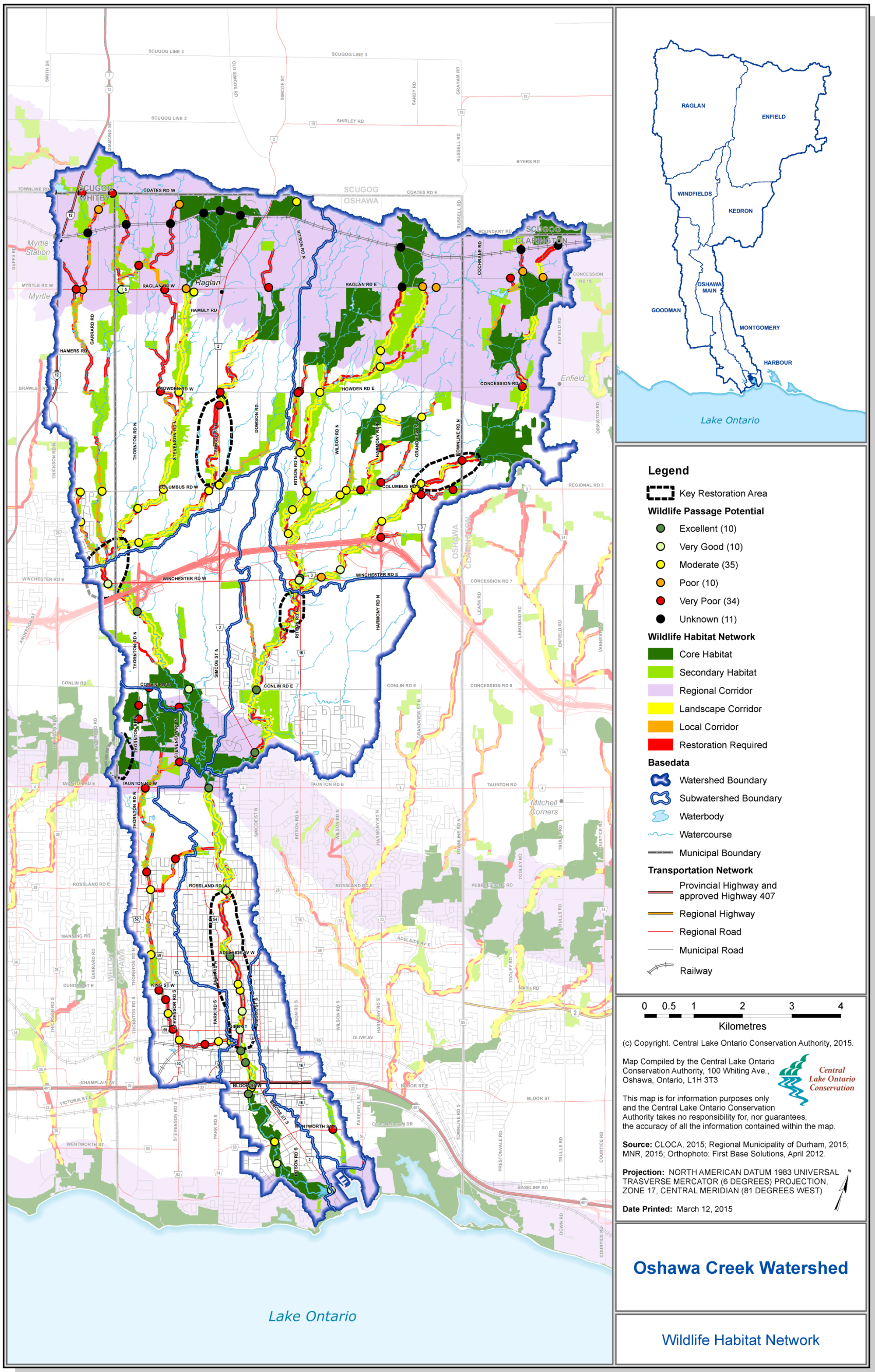
FIGURE 5: OSHAWA CREEK CORRIDOR GAP ASSESSMENT & BARRIER ANALYSIS RESULTS



Corridor Barriers

Table 5 presents the road crossing evaluation scores for the Oshawa Creek watershed. In total, 110 breaks in the WHN were identified: 15% were within a core or secondary habitat; 45% were within a landscape corridor; and 38% were within a local corridor. None were identified within the regional corridor system. Of these breaks, 31% were deemed Very Poor, 10% were Poor, 33% scored Moderate, 9% were Very Good, and 9% scored as Excellent for their potential to support wildlife (mammals, reptiles and amphibians) movement (Figure 5). The remaining 10% were categorized as 'Unknown', as the locations of the breaks were not accessible during the surveys.

Core and Secondary Habitat Areas

Within the core habitats, 16 breaks were identified. None scored Excellent for their potential to act as wildlife passage, due largely to the fact that there are fewer creeks, and therefore fewer bridges and culverts, that exist for wildlife to use as passages across the roads within core habitat areas. Three crossings received a score of Very Good: two within the Oshawa Creek Valleylands at the south end of the watershed and one in the centre of the watershed at Conlin Rd. Two crossings were classified as Moderate: one was identified as a 'low risk' site for mortality due to the rural nature of the road and the other was deemed appropriate for reptiles and aquatic wildlife, but not for terrestrial animals. The remaining 6 crossings were either Poor or Very Poor, and 5 crossings were labelled as Unknown.

Within secondary habitats, 3 breaks were identified, and all of these scored as Very Poor for passing wildlife.

Landscape Corridors

Within the WHN, landscape corridors were the only habitat category to return any Excellent wildlife crossings: this is because, like in the other watersheds in the CLOCA jurisdiction, the landscape corridors contain the large valley systems in the watershed, and the roads constructed across these valleys generally include span bridges, which have high Openness Ratios and which often contain continuous terrestrial habitat underneath. As a result, they tend to score more highly than at other locations. In the Oshawa Creek watershed, 20% of the breaks in the landscape corridor systems were evaluated as potentially 'Excellent' wildlife crossings.

12% of the breaks scored Very Good, 43% were evaluated as Moderate, and 24% were Poor, Very Poor, or Unknown for wildlife passage.

Local Corridors

None of the bridges or culverts in the local corridor system were evaluated as Excellent, and only 1 was given a rating of Very Good. In contrast to the landscape corridor system, there are very few large valleys within the local corridors, so bridges and large culverts are rarer.

12 of the breaks were ranked as Moderate (29%), either as potentially suitable for reptiles only, small mammals only, or as areas with a low risk of mortality. The remaining breaks were valued as Poor (12%), Very Poor (45%), or Unknown (12%).

Regional Corridors

No breaks in the Regional Corridor Network were identified in the Oshawa Creek Watershed.

TABLE 5: WILDLIFE POTENTIAL PERMEABILITY SCORE SUMMARY FOR THE OSHAWA CREEK WATERSHED

HABITAT NETWORK CATEGORY	WILDLIFE PERMEABILITY SCORE																	
	EXCELLENT	%	VERY GOOD (small mammals and reptiles)	%	MODERATE (low risk)	%	MODERATE (reptiles only)	%	MODERATE (small mammals only)	%	POOR	%	VERY POOR	%	UN-KNOWN	%	GRAND TOTAL	%
Core			3	19	1	6	1	6			1	6	5	31	4	31	**16**	15
Secondary Habitat													3	100			**3**	3
Landscape Corridor	10	20	6	12	3	6	17	35	1	2	4	8	7	14	1	2	**49**	45
Local Corridor			1	2	1	2	7	17	4	10	5	12	19	45	5	12	**42**	38
TOTAL	**10**	9	**10**	9	**5**	5	**25**	23	**5**	5	**10**	9	**34**	31	**11**	10	**110**	

6. WATERSHED FINDINGS AND RECOMMENDATIONS - BLACK/HARMONY/ FAREWELL CREEK

The Black/Harmony/Farewell Creek watershed is situated entirely within the Regional Municipality of Durham, and lies within the boundaries of the City of Oshawa and the Municipality of Clarington (Figure 6). It covers an area of approximately 108 km^2 and is divided into 3 primary subwatersheds: Black Creek, Harmony Creek and Farewell Creek.

The watershed drains southerly toward Lake Ontario from its headwaters, which originate in the south slope till plain of the Oak Ridges Moraine. Through the centre of the Watershed, the Lake Iroquois Beach runs east-west, and contains much of the natural cover in the Watershed. Along the Lake Ontario Shoreline, the tributaries drain into Lake Ontario just west of the Provincially Significant Oshawa Second Marsh Coastal Wetland, which represents the largest area of natural cover in the south end of the Watershed.

The NHS for the watershed, as shown in Figure 6, projects a natural cover of approximately 34% for the watershed.

6.1 ANALYSIS AND FINDINGS

Corridor Gaps

Figure 7, which shows the Wildlife Habitat Network in contrast to gaps in cover (red), shows that many of the landscape corridors in the watershed (yellow) are robust and continuously vegetated for much of their length. Local corridors (orange) are generally more fragmented and less continuous, which is the trend that has been observed in other watersheds.

The Black/Harmony/Farewell Creek Watershed is the most vegetated of all of CLOCA's watersheds across the Lake Iroquois Beach Regional Corridor, shown in light purple, and some narrow direct connections do exist. These should certainly be enhanced to make them wider and more functional for wildlife movement, and creating direct connections, i.e., continuous/naturally-vegetated corridors, should be encouraged within the Regional Corridor Network. Development proposals within and/or adjacent to a regional corridor should identify preservation/restoration areas that would enhance connectivity or eliminate gaps in corridors.

The ORM Regional Corridor does not feature significantly in this watershed, as the watershed boundaries just bisect the southern limit of the ORM boundary. Along the waterfront, however, there is a sizeable natural area within the Lake Ontario Shoreline Regional Corridor that contributes substantially to the functionality of east-west wildlife movement in this watershed.

Table 6 identifies some key areas in the Black/Harmony/Farewell Creek Watershed where corridor restoration activities, if undertaken, would greatly improve overall connectivity in the watershed and where private land stewardship should be encouraged. These areas are also circled in Figure 7.

TABLE 6: PRIORITY RESTORATION AREAS IN THE BLACK/HARMONY/FAREWELL CREEK WATERSHED

WILDLIFE HABITAT	NEAREST INTERSECTION	RECOMMENDED ACTION
Landscape Corridor	Bloor St just east of Harmony Rd	Private land stewardship
Landscape Corridor	Courtice Rd at Nash Rd	Private land stewardship
Landscape Corridor	Washington Rd between Taunton Rd and Concession Rd 6	Private land stewardship
Landscape Corridor	Two corridors north of Concession Rd 6, between Vannest Rd and Werry Rd	Private land stewardship
Landscape Corridor	Langmaid, south of Regional Road 3	Private land stewardship
Landscape Corridor	Townline Rd north of Conlin Rd	Private land stewardship
Regional Corridor	Several habitat gaps throughout the Lake Iroquois Beach	Private land stewardship

FIGURE 6: BLACK/HARMONY/FAREWELL CREEK WATERSHED AND NATURAL HERITAGE SYSTEM

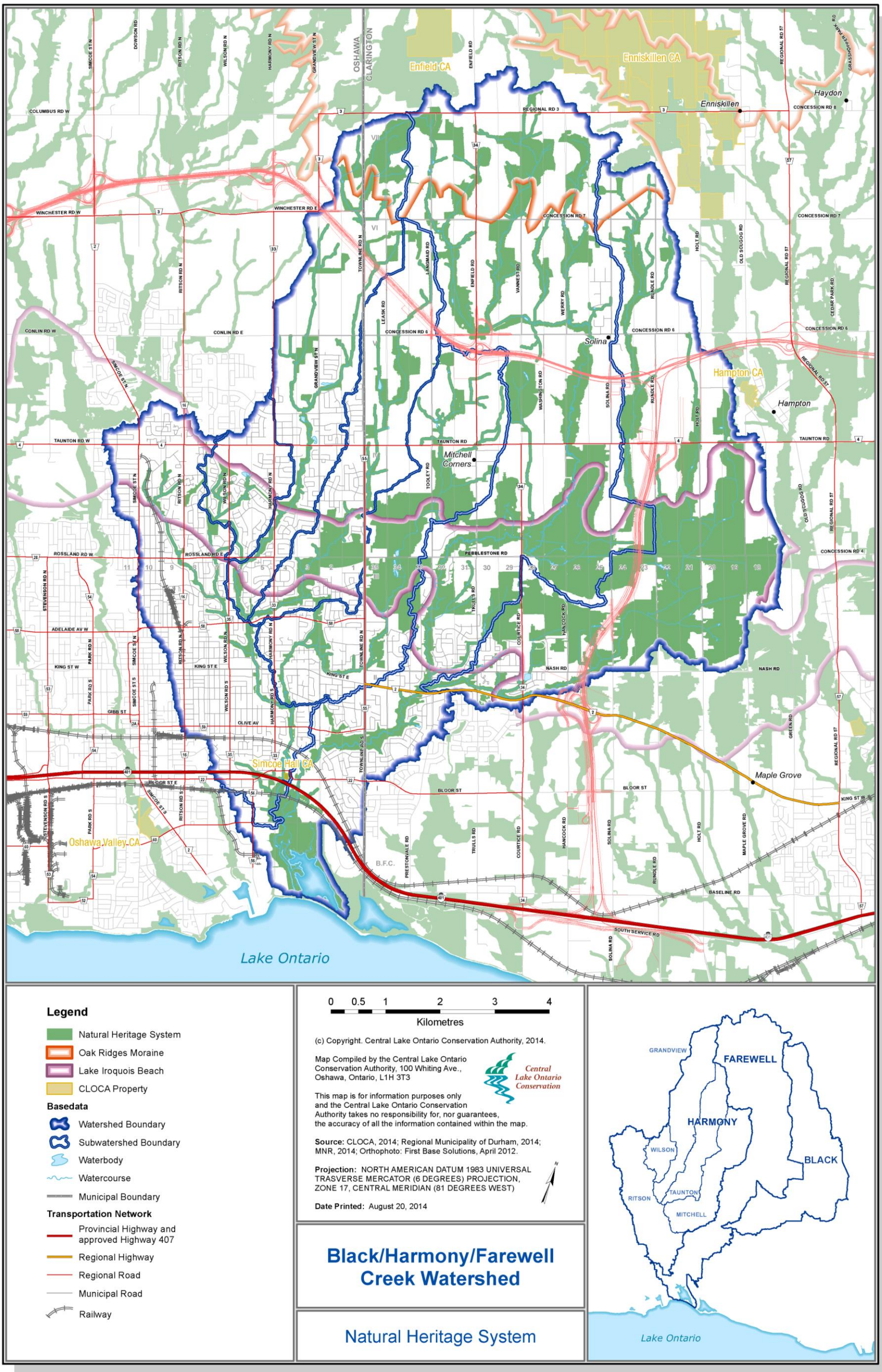


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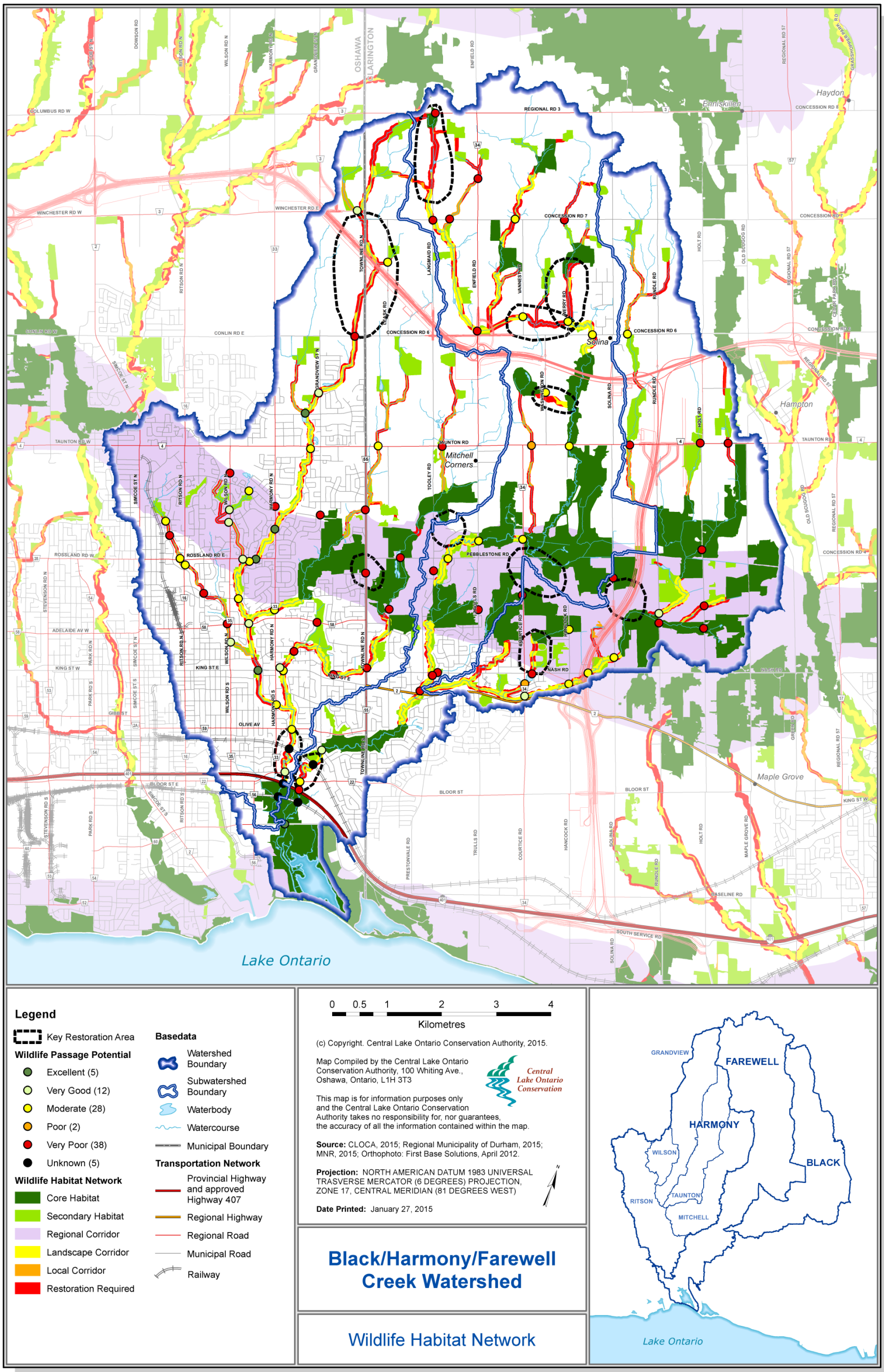
FIGURE 7: BLACK/HARMONY/FAREWELL CORRIDOR GAP ASSESSMENT & BARRIER ANALYSIS RESULTS



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Corridor Barriers

Table 7 contains a summary of the scores for wildlife movement potential across the transportation network from the Black/Harmony/Farewell Creek watershed. In total, 90 breaks were identified within the Wildlife Habitat Network: 16% were within a core habitat; 52% were within a landscape corridor; 27% were within a local corridor; and 6% were within a regional corridor. Of these breaks, 44% were deemed Poor or Very Poor, 31% scored Moderate, and 19% scored as either Very Good or Excellent for supporting wildlife movement (Figure 7). 6% could not be surveyed due to property inaccessibility, and were thus scored as Unknown.

Core and Secondary Habitat Areas

Within the core habitats, 14 breaks were identified, only one of which scored Excellent or Very Good for its potential to enable passage of mammals, reptiles and amphibians. This break occurs at the south end of the watershed at Colonel Sam Dr. As has been observed in other watersheds, breaks in core habitats do not always coincide with stream crossings; consequently, a culvert may not be available for wildlife to use. Two crossings came out as Moderate and the rest were Very Poor or Unknown.

No breaks in the secondary habitats within the watershed were identified.

Landscape Corridors

Within the Wildlife Habitat Network, landscape corridors returned the highest number of potentially 'Excellent' wildlife crossings (4). Just like in the Lynde and Oshawa Creek watersheds, this is because the landscape corridor network contains all of the large valley systems in the watershed, and the roads constructed across these valleys generally include span bridges, which have high Openness Ratios and which often contain continuous terrestrial habitat underneath.

15% of the breaks scored Very Good and almost half were evaluated as Moderate. In total, 66% of the crossings within landscape corridors were ranked as Excellent to Moderate for their potential to act as wildlife passages.

The remaining passages, about a third, were deemed to be Poor or Very Poor. 6% were listed as Unknown.

Local Corridors

None of the bridges or culverts in the local corridor system were evaluated as Excellent, but approximately 21% were deemed Very Good. In contrast to the landscape corridor network, there are very few large valleys within the local corridor system, so bridges and large culverts are not as common and the scores tend to be lower as a result.

A quarter of the breaks were ranked as Moderate, either as suitable for reptiles only or for small mammals, and the remaining breaks were mostly valued as Very Poor (50%) and Poor (4%).

Regional Corridors

Five breaks were identified in the Regional Corridor Network, and all of these were classified as Very Poor. Similar to the breaks in the core habitats, the regional corridors do not tend to follow tributaries, and as such, there is generally no culvert present to act as wildlife passage, resulting in very low scores.

TABLE 7: WILDLIFE POTENTIAL PERMEABILITY SCORE SUMMARY FOR THE BLACK/HARMONY/FAREWELL CREEK WATERSHED

HABITAT NETWORK CATEGORY	WILDLIFE PERMEABILITY SCORE																	
	EXCELLENT	%	VERY GOOD (small mammals and reptiles)	%	MODERATE (low risk)	%	MODERATE (reptiles only)	%	MODERATE (small mammals only)	%	POOR	%	VERY POOR	%	UN-KNOWN	%	GRAND TOTAL	%
Core	1	7			1	7	1	7					9	64	2	14	**14**	16
Landscape Corridor	4	9	7	15	2	4	17	36	1	2	1	2	12	26	3	6	**47**	52
Local Corridor			5	21			5	21	1	4	1	4	12	50			**24**	27
Regional Corridor													5	100			**5**	6
TOTAL	**5**	6	**12**	13	**3**	3	**23**	26	**2**	2	**2**	2	**38**	42	5	6	**90**	

7. WATERSHED FINDINGS AND RECOMMENDATIONS – BOWMANVILLE/SOPER CREEK

The Bowmanville/Soper Creek Watershed is situated entirely within the Regional Municipality of Durham and covers an area of approximately 170 km^2. It is entirely within the jurisdiction of the Municipality of Clarington, with the exception of a very small section at the north end which is located in the Township of Scugog (Figure 8).

Its tributaries, which are divided into two main subwatersheds – Bowmanville Creek and Soper Creek – drain south towards Lake Ontario from their headwaters in the Oak Ridges Moraine and outlet into Lake Ontario through the Provincially Significant Bowmanville Creek Marsh. The Lake Iroquois Beach crosses the watershed in an east-west direction just south of the centre of the watershed.

The Bowmanville/Soper Creek Watershed is largely agricultural south of the Oak Ridges Moraine, but there are a significant number of natural areas within the north half of the watershed. The urban area of the Town of Bowmanville occupies most of the southwest portion of the watershed, and the Bowmanville/Westside Conservation Area is the dominant open space on the Lake Ontario waterfront.

The NHS for the watershed, as shown in Figure 8, projects 52% natural cover for the watershed.

7.1 ANALYSIS AND FINDINGS

Corridor Gaps

The corridors in the Bowmanville/Soper Creek Watershed are the most robust and continuous of any of the watersheds in the CLOCA jurisdiction. The landscape (yellow) and local (orange) corridors, shown in contrast to gaps in cover (red) in Figure 9, demonstrate this. Compared with the other watersheds, the Wildlife Habitat Network in the Bowmanville/Soper Creek watershed consists mostly of core habitat areas and landscape corridors, and relatively few local corridors. This is partly due to the large valley systems in this watershed, but also reflects the high quality of the habitats. Some gaps do exist, however.

Regional corridors (light purple), are not in continuous natural cover, and are unlikely ever to be so, but as a result of the large core habitats within the ORM and Lake Iroquois Beach Regional Corridors, it is possible to preserve and restore strong connections across the watershed. Along the waterfront, the Bowmanville/Westside C.A. is a good stopover point for wildlife travelling east-west within the Lake Ontario Shoreline Regional Corridor. Protecting existing connections and creating new direct connections should be a priority, and development proposals within and/or adjacent to a regional corridor should identify preservation/restoration areas that would improve future connectivity or eliminate corridor gaps.

Table 8 identifies some key areas in the Bowmanville/Soper Creek Watershed where corridor restoration activities, if undertaken, would greatly improve overall connectivity in the watershed and where private land stewardship should be encouraged. These areas are circled in Figure 9 as well.

TABLE 8: PRIORITY RESTORATION AREAS IN THE BOWMANVILLE/SOPER CREEK WATERSHED

WILDLIFE HABITAT	NEAREST INTERSECTION	RECOMMENDED ACTION
Landscape Corridor	Concession St between Providence Rd and Darlington-Clarke Townline	Private land stewardship
Landscape Corridor	Concession Rd 3 (north and south) between Bragg Rd and Darlington-Clarke Townline	Private land stewardship
Landscape Corridor	Darlington-Clarke Townline south of Taunton Rd	Private land stewardship
Landscape Corridor	Mearns Rd north of Concession Rd 4	Private land stewardship
Landscape Corridor	Regional Road 57 south of Concession Rd 6	Private land stewardship
Landscape Corridor	North of Concession Rd 7 and east of Liberty St	Private land stewardship
Landscape Corridor	Acres Rd north of Concession Rd 6	Private land stewardship
Landscape Corridor	Middle Rd north of Concession Rd 8	Private land stewardship

FIGURE 8: BOWMANVILLE/SOPER CREEK WATERSHED AND NATURAL HERITAGE SYSTEM

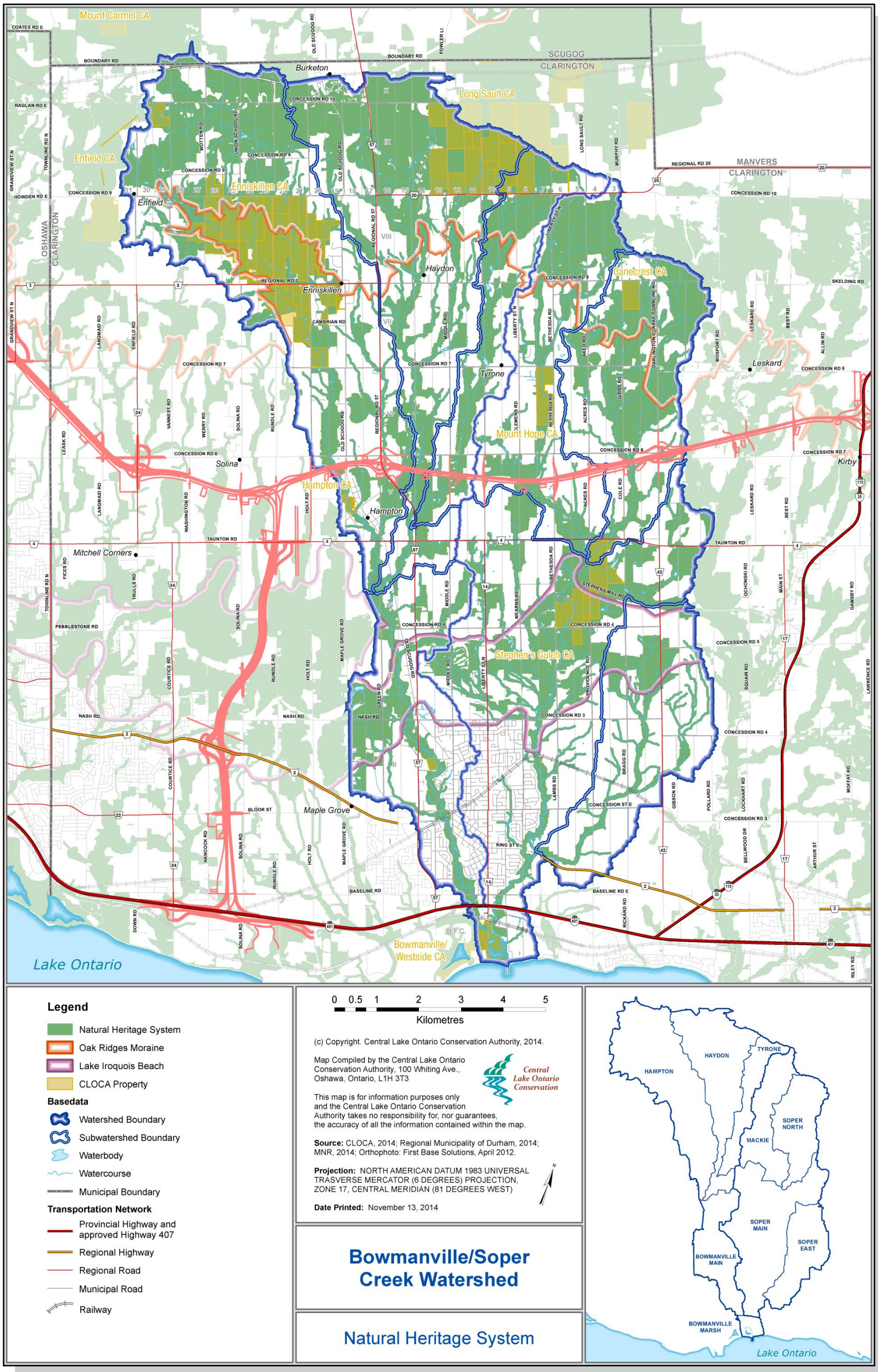

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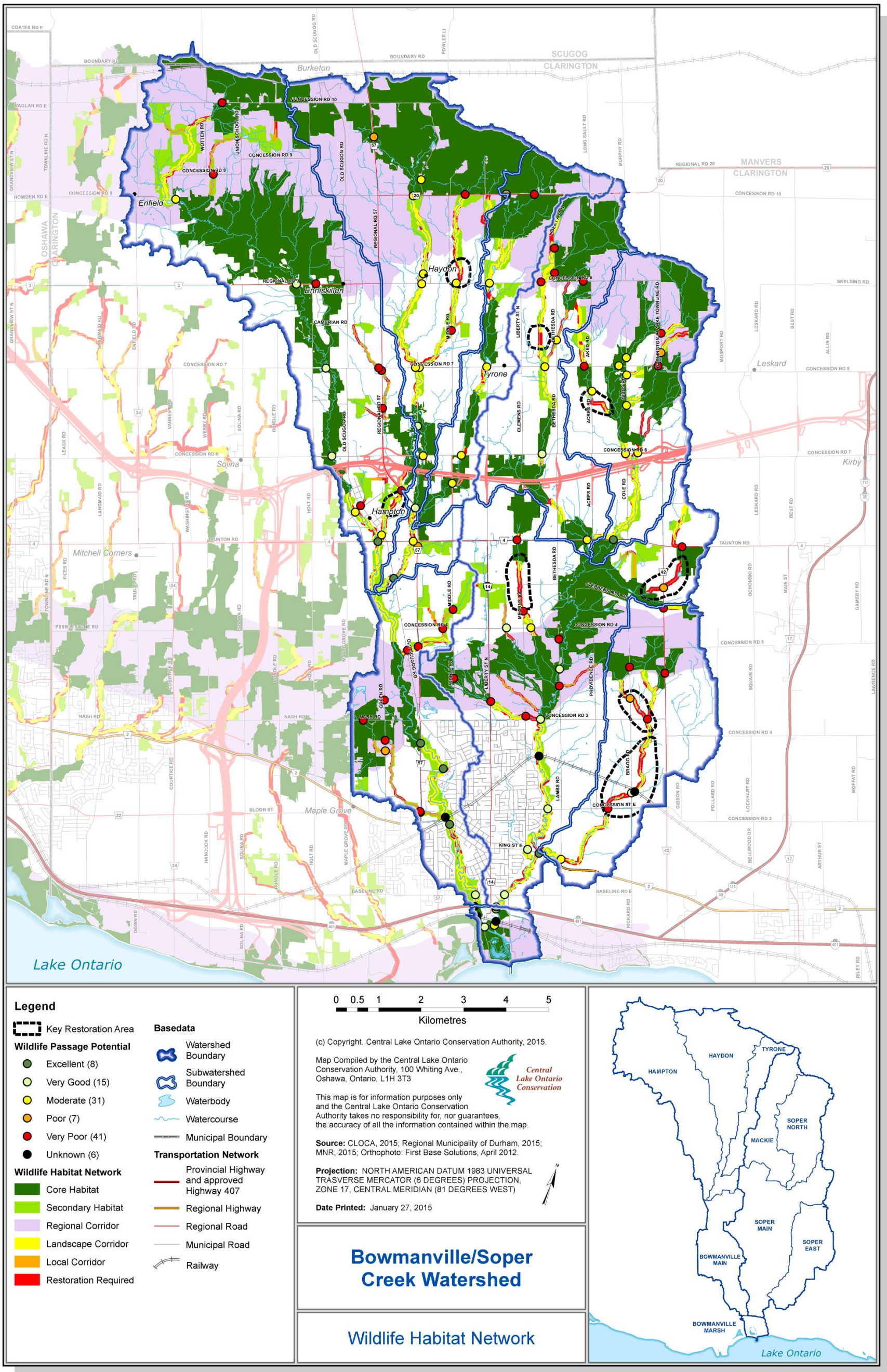
FIGURE 9: BOWMANVILLE/SOPER CREEK CORRIDOR GAP ASSESSMENT & BARRIER ANALYSIS RESULTS



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Corridor Barriers

Table 9 contains a summary of the existing wildlife passage potential in the Bowmanville/Soper Creek watershed. In total, 108 breaks were identified within the Wildlife Habitat Network in the watershed: 24% were within a core or secondary habitat and 62% were within a landscape corridor, which reflects the higher number of these WHN categories in the watershed; 13% were within a local corridor; and 1% was within the regional corridor system. Half of these breaks were evaluated as Poor, Very Poor, or Unknown, followed by 31% in the Moderate category. The remaining 21% scored as either Very Good or Excellent for supporting wildlife (mammals, reptiles and amphibians) movement.

Core and Secondary Habitat Areas

Within the core habitats, 25 breaks were identified. None scored Excellent for their potential to enable wildlife passage, but a quarter of them did score as Very Good, and several came out as Moderate. Just under half of the breaks were evaluated at Poor or Very Poor, and the remaining 8% were listed as Unknown.

One break was identified within the secondary habitat category, and it was evaluated as having Very Poor potential for wildlife passage.

Landscape Corridors

Within the WHN, landscape corridors were the only habitat category to earn scores of Excellent for their potential to pass wildlife. This is a result of the large valleys within the landscape network and the span bridges that have been constructed across them. 12% of the breaks were deemed Excellent, and another 12% were given scores of Very Good. 34% of the culverts/bridges received scores of Moderate, though none of these were considered suitable to accommodate small mammals. The remainder of the culverts within the landscape corridor network, approximately 41%, scored Poor, Very Poor, or Unknown.

Local Corridors

Compared to the other watersheds in the CLOCA jurisdiction, there are relatively few habitat areas identified as local corridors, and where they did exists, they tend to follow tributaries with shallow valleys, so the culverts present within the network are generally small. The highest score received was Very Good (1 break), and the rest were evaluated as Moderate (1 break), Poor (1 break) or Very Poor (11 breaks).

Regional Corridors

Only one break was identified within the Regional Corridor Network, in the Lake Iroquois Beach corridor, and it was given a score of Very Poor for its potential to act as wildlife passage.

TABLE 9: WILDLIFE POTENTIAL PERMEABILITY SCORE SUMMARY FOR THE BOWMANVILLE/SOPER CREEK WATERSHED

HABITAT NETWORK CATEGORY	WILDLIFE PERMEABILITY SCORE																	
	EXCELLENT	%	VERY GOOD (small mammals and reptiles)	%	MODERATE (low risk)	%	MODERATE (reptiles only)	%	MODERATE (small mammals only)	%	POOR	%	VERY POOR	%	UN-KNOWN	%	GRAND TOTAL	%
Core			6	24	1	4	6	24			1	4	9	36	2	8	**25**	23
Secondary Habitat													1	100			**1**	1
Landscape Corridor	8	12	8	12	2	3	21	31			5	7	19	28	4	6	**67**	62
Local Corridor			1	7			1	7			1	7	11	79			**14**	13
Regional Corridor													1	100			**1**	1
TOTAL	**8**	7	**15**	14	**3**	3	**28**	26			**7**	6	**41**	38	6	6	**108**	

8. WATERSHED FINDINGS AND RECOMMENDATIONS – SMALL WATERSHEDS

The Small Watersheds include all of the watersheds along the Lake Ontario Shoreline whose headwaters do not originate in the Oak Ridges Moraine. From west to east, they are:

- Warbler
- Cranberry*
- Whitby Shores*
- Pringle Creek
- Heydenshore*
- Corbett Creek
- Pumphouse*
- McLaughlin Bay*
- Robinson Creek
- Burk*
- Tooley Creek
- Osborne Creek*
- Darlington Creek
- St. Mary's*
- Westside Creek
- Bennett Creek*
- Rickard*

In total, these watersheds drain approximately 112 km^2, and span the entire CLOCA jurisdiction. All of them are located within the Regional Municipality of Durham, and together they are within the boundaries of the Towns of Ajax and Whitby, the City of Oshawa, and the Municipality of Clarington (Figures 10 and 11).

All of the watersheds drain into Lake Ontario and include portions of the Lake Ontario Shoreline Regional Corridor (those watersheds listed above with an asterisk are entirely or almost entirely located within this regional corridor). Only three of the small watersheds have headwaters in the Lake Iroquois Beach physiographic region – Pringle Creek, Tooley Creek, and Darlington Creek – and they are therefore the only watersheds in this group that contain sections of the Lake Iroquois Beach Regional Corridor.

Along the waterfront, land uses vary from natural areas to industrial to residential: in the larger watersheds, urban land cover is much higher; in some of the smallest watersheds, the land use is entirely natural and agricultural. The NHS for the small watersheds is displayed in Figures 10 and 11, and the projected natural cover (%) for each watershed is listed in Table 10. The amount of natural cover in each of these watersheds varies, from as much as 87% in the Cranberry watershed to as little as 7% in the Rickard Creek watershed. Together, they average 25% natural cover.

It should be noted that the Watershed Plan for the Small Watersheds has not yet been developed. Furthermore, the NHS for the Robinson and Tooley Creek Watersheds was undertaken by the Municipality of Clarington and not CLOCA, and as such, are discussed separately in this report.

TABLE 10: NATURAL COVER, AS PROJECTED BY THE NHS, FOR EACH OF THE SMALL WATERSHEDS

WATERSHED	SIZE (HA)	% NATURAL COVER (NHS)
Warbler	255	55
Cranberry	158	87
Whitby Shores	22	18
Pringle Creek	3102	19
Heydenshore	167	20
Corbett Creek	1485	15
Pumphouse	622	14
McLaughlin Bay	211	59
Robinson Creek	593	30
Burk	35	34
Tooley Creek	1157	29
Osborne	437	30
Darlington Creek	1782	34
St. Mary's	73	16
Westside Creek	538	21
Bennett Creek	321	18
Rickard Creek	224	7
TOTAL ACROSS CLOCA JURISDICTION	**11,182**	**25 (AVERAGE)**

8.1 Analysis and Findings

Corridor Gaps – Small Watersheds

Figures 12 and 13 show the Wildlife Habitat Network for all of the small watersheds except the Robinson and Tooley Creek Watersheds; they are discussed below. There is also no WHN displayed in the Bennett and Rickard Creek watersheds as a result of there being too little habitat to classify (Figure 13).

For those small watersheds with a WHN, Figures 12 and 13 display the landscape corridors (yellow) and local corridors (orange) in contrast to gaps in cover (red). Because the watersheds are generally small, compared to the large watersheds in the CLOCA jurisdiction, most of the corridors were classified as landscape corridors, and only a few corridors were classified as local. This is largely due to a lack of natural cover outside of the main creeks in the watersheds for which local corridors would be needed as habitat connectors. Corridors were not identified in every watershed; those that included corridors are the Pringle Creek, Corbett Creek, Darlington Creek, and Westside Creek watersheds. The corridors in these watersheds are generally continuous.

As has been already mentioned, all of the regional corridors (light purple) are not present in every small watershed. The Lake Iroquois Beach Regional Corridor in the Pringle Creek and Darlington Creek watersheds is well-vegetated and some direct connections between core habitat areas exist. In the Tooley Creek watershed there is a good habitat patch in the Lake Iroquois Beach Regional Corridor as well, which effectively connects the Darlington Creek watershed with the Black Creek watershed to the west.

Natural cover along the shoreline is not continuous but some good-sized natural habitats exist along the waterfront, which provide east-west movement opportunities for many wildlife: efforts to create direct connections between shoreline habitats and/or increase the overall natural cover within the Lake Ontario Shoreline Regional Corridor is a priority.

Table 11 identifies some key areas in the Small Watersheds where corridor restoration activities, if undertaken, would greatly improve overall connectivity in the watershed and where private land stewardship should be encouraged. For those watersheds that are entirely or almost entirely located within the Lake Ontario Shoreline Regional Corridor, achieving as much natural cover as possible is recommended. These areas are highlighted in Figures 12 and 13 as well.

TABLE 11: PRIORITY RESTORATION AREAS IN THE SMALL WATERSHEDS

WATERSHED	WILDLIFE HABITAT	NEAREST INTERSECTION	RECOMMENDED ACTION
Pringle Creek	Core Habitat	Throughout the Iroquois Beach Corridor	Private land stewardship
Corbett Creek	Landscape Corridor	Thickson Rd between Highway 401 and Victoria Rd	Active plantings along creek edge
Corbett Creek	Landscape Corridor	East and west of Thickson Rd between Highway 401 and Dundas St	Active plantings along creek edge and private lands stewardship
Pumphouse	Regional Corridor	Valley Dr west of Stevenson Rd	Private land stewardship
Darlington Creek	Landscape Corridor	Between Lake Ontario and rail line	Private land stewardship
Darlington Creek	Landscape Corridor	Maple Grove Rd between the Iroquois Beach and rail line	Private land stewardship
Darlington Creek	Landscape Corridor	Holt Rd/Rundle Rd between Highway 401 and the Iroquois Beach	Private land stewardship

Corridor Gaps – Robinson and Tooley Creek Watersheds

Because the NHS for the Robinson and Tooley Creek watersheds was completed by an external agency, the methodology used was not the same as that used by CLOCA for its other watersheds, and habitat components were not categorized into core habitats and corridors, as in the Wildlife Habitat Networks for the rest of the jurisdiction. Gaps in the NHS can be discussed, but the recommendations for restoration will be less specific, as CLOCA's guidelines for restoring landscape vs. local corridors, for example, are different, and these cannot be differentiated in the Robinson and Tooley Creek watersheds. Similarly, the gap analysis of overlaying an 'ideal' corridor layer with an existing vegetation layer is not possible, so Figure 13 does not include the same red 'gaps' as is shown for the other watersheds.

FIGURE 10: SMALL WATERSHEDS (WEST) AND NATURAL HERITAGE SYSTEM

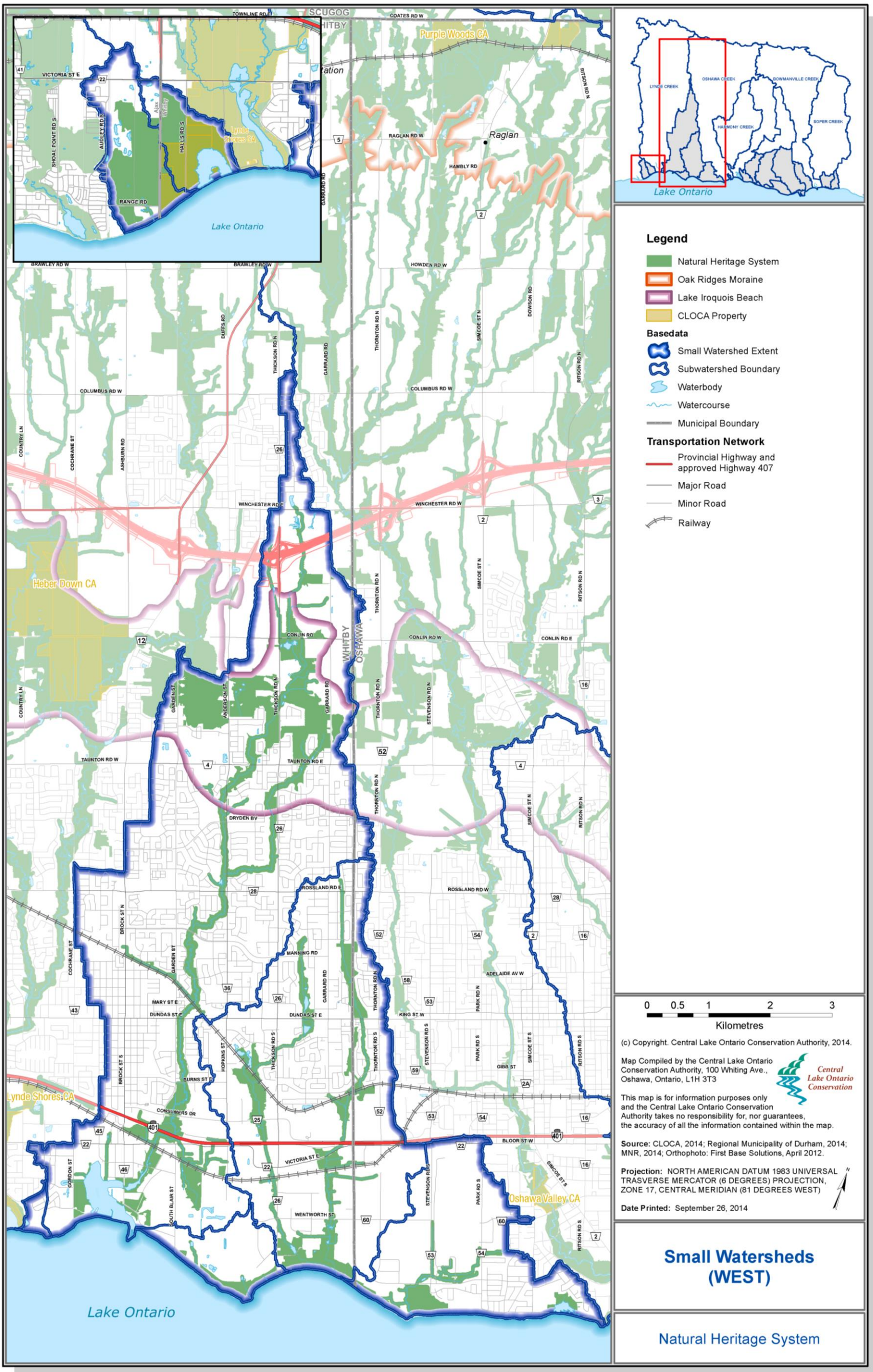

FIGURE 11: SMALL WATERSHEDS (EAST) AND NATURAL HERITAGE SYSTEM

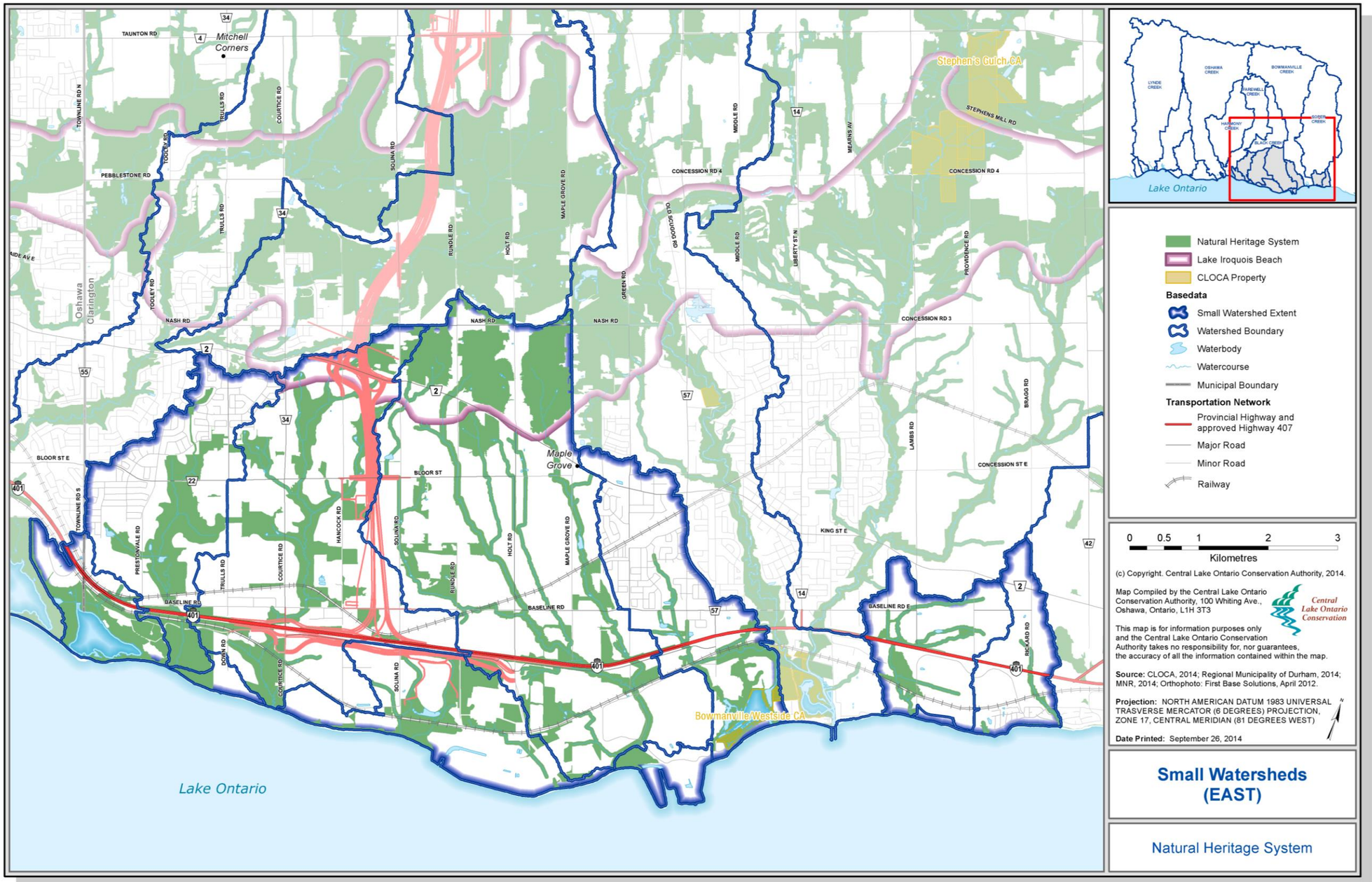

FIGURE 12: SMALL WATERSHEDS CORRIDOR GAP ASSESSMENT & BARRIER ANALYSIS RESULTS (WEST)

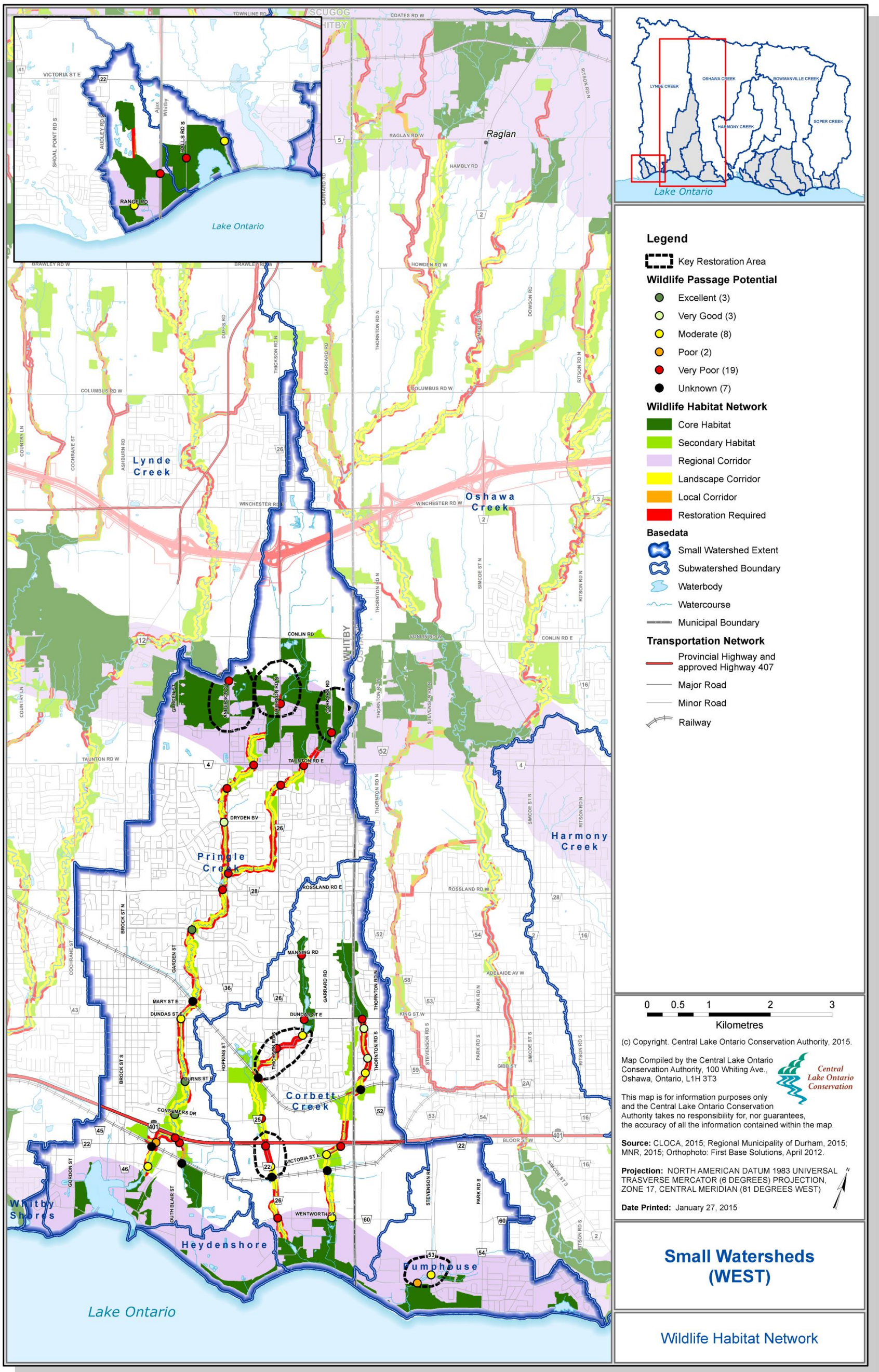

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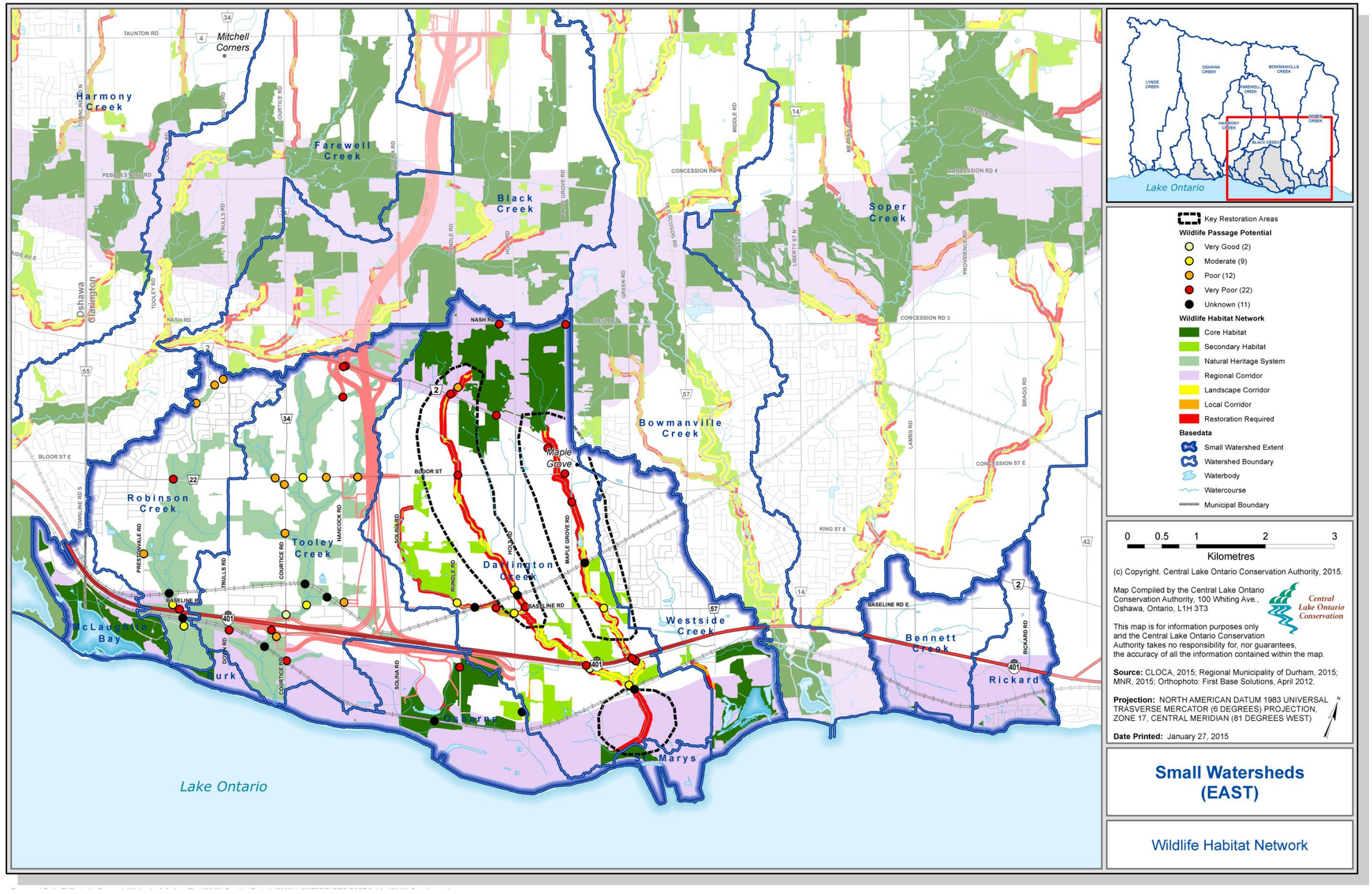
FIGURE 13: SMALL WATERSHEDS CORRIDOR GAP ASSESSMENT & BARRIER ANALYSIS RESULTS (EAST)



Corridor Barriers

Figures 12 and 13 show the evaluated breaks in the Wildlife Habitat Network within the small watersheds. In total, 73 breaks were identified in 7 of the 15 watersheds (excluding Robinson – Tooley Creek Watersheds): 19% were within a core or secondary habitat; 71% were within a landscape corridor; 7% were within a local corridor; and 3% were within a regional corridor. Of these breaks, 50% were deemed Very Poor, 3% scored Poor, 19% scored Moderate, and 9% scored as either Very Good or Excellent for potentially supporting wildlife movement (Table 12). The remaining 18% were listed as Unknown.

Core and Secondary Habitat Areas

Within the core habitats, 13 breaks were identified. The highest scores received by any of the breaks in the core habitat network were Moderate (2), and these were assigned based on the rural nature of the roads and the relatively low risk of mortality for wildlife. The majority of the remaining breaks (10) were classified as Very Poor, and the last break, in the Osborne Creek watershed, was labelled as Unknown as it could not be surveyed. A single break in the secondary habitat network in this watershed was also classified as Unknown due to inaccessibility.

Landscape Corridors

52 of the identified breaks in the WHN were within landscape corridors. None of these were given scores of Excellent, but there were 4 breaks that scored Very Good: these were in the Corbett, Darlington, and Pringle Creek watersheds, and they tended to be located in the south parts of the watersheds where the valley systems are largest. 10 breaks were evaluated as Moderate, and the remaining 35 were categorized as Poor, Very Poor or Unknown.

Local Corridors

Only the Pringle and Darlington Creek watersheds had any local corridors with transportation infrastructure breaks in the WHN. Two of the breaks were considered Moderate for their potential to act as wildlife passage, and the other 3 scored Very Poor or Unknown.

Regional Corridors

Two breaks, one Moderate and one Poor, were identified in the Lake Ontario Shoreline Regional Corridor system in the Pumphouse Watershed.

TABLE 12: WILDLIFE POTENTIAL PERMEABILITY SCORE SUMMARY FOR THE SMALL WATERSHEDS

WATERSHED	WILDLIFE PERMEABILITY SCORE																	
HABITAT NETWORK CATEGORY	EXCELLENT	%	VERY GOOD (sm. mammals and reptiles)	%	MODERATE (low risk)	%	MODERATE (reptiles only)	%	MODERATE (small mammals only)	%	POOR	%	VERY POOR	%	UNKNOWN	%	GRAND TOTAL	%
Warbler					1	50							1	50			**2**	
Core					1	50							1	50			2	100
Corbett Creek			2	11			3	16	2	11			8	42	4	21	**19**	
Core													2	100			2	11
Landscape Corridor			2	12			3	18	2	12			6	35	4	2	17	89
Cranberry Creek					1	50							1	50			**2**	
Core					1	50							1	50			2	100
Darlington Creek			1	4	1	4	3	13	1	4	1	4	13	54	4	17	**24**	
Core													3	100			3	13
Landscape Corridor			1	6			2	12	1	6	1	6	9	53	3	18	17	71
Local Corridor					1	25	1	25					1	25	1	25	4	17
Osborne Creek													1	33	2	67	**3**	
Core													1	50	1	50	2	67
Secondary Habitat															1	100	1	33
Pringle Creek	3	14	1	5			1	5	1	5	1	5	11	52	3	14	**21**	
Core													2	100			2	10
Landscape Corridor	3	17	1	6			1	6	1	6	1	6	9	50	2	11	18	86
Local Corridor															1	100	1	5
Pumphouse							1	50					1	50			**2**	100
Regional Corridor							1	50					1	50			2	100
Robinson-Tooley Creeks			1	3			4	14			11	38	8	28	5	17	**29**	
n/a			1	3			4	14			11	38	8	28	5	17	29	100
GRAND TOTAL	**3**	3	**5**	5	**3**	3	**12**	12	**4**	4	**13**	13	**44**	43	**18**	18	**102**	

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Corridor Barriers – Robinson and Tooley Creek Watersheds

Although the Natural Heritage Systems for the Robinson and Tooley Creek watersheds was not undertaken by CLOCA, barriers to wildlife movement in the watersheds was included in this analysis. In total, 29 breaks were identified. Of the breaks, 1 was evaluated as potentially Very Good for wildlife passage, 4 were given scores of Moderate, 11 were deemed Poor for wildlife movement, 8 were evaluated at Very Poor, and the remaining 5 were classified as Unknown as the breaks were not accessible for evaluation.


G. Ernest

9. DISCUSSION

Wildlife movement across the landscape is an important component of ecological health: CLOCA's Natural Heritage System, as developed for the watershed management plans, embodies this concept, and the categorization of a Wildlife Habitat Network within the NHS focuses the ability of landowners and managers to protect and restore those aspects of the system that are significant to terrestrial wildlife.

It is clear from the maps provided in this report that there is much to be proud of, as there are numerous large and high quality wildlife habitats throughout the jurisdiction; however, the maps also reinforce that there are some areas within the WHN where work is needed if the system is to function well into the future. Specifically, there are many corridors that have large gaps in natural cover, and the transportation system, which regularly bisects the WHN, fragments habitat within the jurisdiction and makes some areas of the watershed inaccessible to less mobile or more sensitive species.

9.1 Corridor Gaps

Overall, this Action Plan identifies a total of 41 locations as priority areas for corridor restoration. Generally, the largest watersheds (Lynde Creek, Oshawa Creek, Black/Harmony/Farewell Creek, and Bowmanville/Soper Creek) contain the most robust, naturally-vegetated corridors, particularly in the lower sections of the watersheds. These 'healthy' corridors often coincide with large valley systems that have been left intact as they were historically difficult to clear and develop; consequently, they tend to be free of gaps in cover.

The most significant loss of continuity in the WHN occurs from east to west across the watersheds within the Regional Corridor System, where few, if any, creek connections exist. In particular, significant gaps in cover exist where wetlands in the Lake Iroquois Beach have been removed in favour of residential development and agriculture, and along the Lake Ontario Shoreline.

9.2 Corridor Barriers

This Plan also identifies a total of 525 breaks in the Wildlife Habitat Network as a result of transportation infrastructure, and evaluates the wildlife permeability potential of the culverts, if present, at each location (Table 13).

18% of the culverts in the jurisdiction scored as potentially Excellent or Very Good for wildlife passage, meaning that mammals of all sizes, reptiles, and amphibians could pass through the structures. These culverts were generally located in those watersheds with the largest valley systems, as these valleys have traditionally been spanned by bridges and tend to include continuous banks beneath them. 27% of the culverts in the jurisdiction scored as Moderate for their potential to act as wildlife passages, and the remaining 55% were deemed to be Poor, Very Poor, or of Unknown quality.

TABLE 13: SUMMARY OF WILDLIFE POTENTIAL PERMEABILITY SCORES BY WATERSHED

WILDLIFE PERMEABILITY SCORE	WATERSHED					TOTAL
	LYNDE CREEK	OSHAWA CREEK	BLACK/HARMONY/FAREWELL CREEK	BOWMANVILLE/SOPER CREEK	SMALL WATERSHEDS	
Excellent	6	10	5	8	3	32
Very Good	18	10	12	15	5	60
Moderate	31	35	28	31	19	144
Poor	1	10	2	7	13	33
Very Poor	42	34	38	41	44	199
Unknown	17	11	5	6	18	57
TOTAL	115	110	90	108	102	**525**

9.3 IMPLEMENTING THE PLAN

The long-term goal of this plan is two-fold:

1. To restore the landscape and local corridor systems in the jurisdiction by re-vegetating the corridor gaps, starting with the largest; and
2. To improve wildlife passage across the transportation network as follows:
    a. culverts in the landscape corridor system will all have wildlife potential permeability scores of Very Good or better, and
    b. culverts in the local corridors system will all have wildlife potential permeability scores of Moderate or better.

Across the jurisdiction currently, 27% of the breaks in the landscape corridor system have passages that scored Very Good or better, and 35% of the breaks in the local corridor system have passages that scored Moderate or better (Table 14). To achieve the goals set above, a total of 277 culvert upgrades will be required across all of the watersheds.

As has been stated previously, the timeframe for the implementation of this plan is long, and any upgrades will be undertaken opportunistically. In this way, the goal of a barrier-free WHN is achievable within the time and budgetary constraints of CLOCA's Provincial, Regional, and Municipal partners.

TABLE 14: DISTRIBUTION OF SUITABLE PASSAGES BY JURISDICTION AND BY WATERSHED

WATERSHED	LANDSCAPE CORRIDORS					LOCAL CORRIDORS				
	# breaks ≥ very good	Total # breaks (all scores)	# breaks ≥ very good / total # breaks per watershed	# breaks ≥ very good / total # breaks ≥ very good	# breaks ≥ very good / total # breaks for jurisdiction	# breaks ≥ moderate	Total # breaks (all scores)	# breaks ≥ moderate / total # breaks per watershed	# breaks ≥ moderate / total # breaks ≥ moderate	# breaks ≥ moderate / total # breaks for jurisdiction
LYNDE CREEK	17	35	49%	25%	7%	23	59	39%	45%	16%
OSHAWA CREEK	16	49	33%	24%	6%	13	43	30%	25%	9%
BLACK / HARMONY / FAREWELL CREEKS	11	47	23%	16%	4%	11	24	46%	22%	8%
BOWMANVILLE / SOPER CREEKS	16	67	24%	24%	6%	2	14	14%	4%	1%
SMALL WATERSHEDS	7	52	13%	11%	3%	2	5	40%	4%	1%
TOTALS	**67**	**250**		**100%**	**27%**	**51**	**145**		**100**	**35%**

Table 14 also includes some interesting comparisons of the landscape and local corridor systems between the watersheds. For example, column 5 suggests that the distribution of breaks scoring very good or better within the landscape corridor system is pretty even between the

watersheds, particularly between the Lynde, Oshawa, and Bowmanville/Soper Creek watersheds. This likely reflects the similar size and shape of these 3 watersheds, and the fact that they each contain deep valley systems.

By contrast, the relative distribution of breaks scoring Moderate or better across the jurisdiction in the local corridor system is not as even, with the Lynde Creek watershed containing almost half of them (column 10). This suggests that in terms of meeting the target of having all passages in the local corridor system score Moderate or better for wildlife passage potential, the Lynde Creek watershed is further ahead than the other watersheds. However, this statistic is somewhat misleading because the Lynde Creek watershed has a significantly higher number of local corridor breaks as a result of its WHN having a higher number of local corridors, which is actually a reflection of increased habitat fragmentation and reduced overall connectivity – a generally negative trait – so the relative distribution of scores is perhaps not the most accurate way of comparing connectivity between the watersheds.

An alternative way of assessing the relative 'successes' of each watershed, in terms of how close they are to achieving the corridor barrier targets, is to look at the proportion of breaks that meet the targets in each watershed and compare this to the total number of breaks in the same watershed (columns 4 and 9). In this context, the Lynde Creek watershed is still doing well compared to the other watersheds, as almost half of its landscape corridor breaks score Excellent or Very Good, versus the Black/Harmony/Farewell and Bowmanville/Soper Creek watersheds where only a quarter of the breaks in their landscape corridor systems scored Very Good or Better. In terms of overall success in achieving the target of having all breaks in the local corridor system score Moderate or better, the Black/Harmony/Farewell Creek and Small watersheds are closest to meeting the goal, having 46% and 40% of the breaks already scoring as Moderate, Very Good or Excellent respectively.

Recommendations that have been made in this plan to help achieve these goals include:

- Encouraging Durham Region and it's Municipalities to adopt the NHS into their Official Plans to protect it from development;
- Preventing further fragmentation of the WHN by encouraging planning authorities to incorporate the maps provided in this document into their planning processes to avoid removing existing natural heritage features;
- Incorporating wildlife mitigation measures, e.g., oversized culverts, into projects where traversing the WHN cannot be avoided;
- Adopting best management practices, e.g., reduced mowing, in areas within or adjacent to the WHN;
- Encouraging private landowners with WHN features on their lands to undertake stewardship activities to restore connectivity;

- Developing a communications strategy whereby local planning agencies and works departments can use the maps provided in this plan to recognize potential wildlife improvement opportunities in upcoming projects, e.g., planned culvert replacements, and involve CLOCA staff at an early stage; and,
- Tracking improvements in connectivity within the WHN to record and report on success over time.

10. GLOSSARY

Agricultural Uses: The growing of crops, including nursery and horticultural crops; raising livestock; raising of other animals for food, fur or fibre, including poultry and fish; aquaculture; apiaries; agro-forestry; maple syrup production; and associated on-farm buildings and structures, including accommodation for full-time farm labour when the size and nature of the operation requires additional employment. (adapted from Provincial Policy Statement, 2005)

Best Management Practices (BMPs): Methods, facilities and structures which are designed to protect or improve the environment and natural features and functions from the effects of development or interference.

Biodiversity: the variability among living organisms from all sources, including inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems.

Buffers: An area or band of permanent vegetation, preferably consisting of native species, located adjacent to a natural heritage feature, surface water feature, HVRA and/or the Natural Heritage System, and usually bordering lands that are subject to development or site alteration and creating a physical separation that will discourage encroachment. The purpose of the buffer is to protect the feature and its function(s) by mitigating the impacts of the proposed land use and allowing an area for edge phenomena to continue. A buffer may also provide an area for a recreational trail. The vegetation within a buffer can be managed (e.g., trimmed, cut, thinned, but not cultivated) providing that the integrity of the buffer and the feature/function it is protecting is not negatively impacted

Connectivity: The degree to which key natural heritage features or key hydrologic features are connected to one another by links such as plant and animal movement corridors, hydrologic and nutrient cycling, genetic transfer, and energy flow through food webs.

Core Habitat: The primary habitat areas within the watersheds. Generally, they are the highest quality habitats as determined by factors such as size, shape, matrix influence, significant species, etc. See watershed management plans for methodology**.**

Ecological Function: The natural processes, products or services that living and non-living environments provide or perform within or between species, ecosystems and landscapes. These may include biological, physical and socio-economic interactions.

Ecological Integrity: Means the condition of ecosystems in which,

a) the structure, composition and function of the ecosystems are unimpaired by stresses from human activity,

b) natural ecological processes are intact and self-sustaining,

c) the ecosystems evolve naturally, and

d) includes hydrological integrity.

Ecosystem: Systems of plants, animals and micro-organisms together with non-living components of their environment, related ecological processes and humans.

Endangered Species (federal): A wildlife species that is facing imminent extirpation or extinction, listed in Schedule 1 of the Species at Risk Act as updated and amended from time to time, by order in council.

Endangered Species (provincial): A species that is classified by COSSARO (Committee on the Status of Species at Risk) as "endangered species" living in the wild in Ontario but is facing imminent extinction or extirpation.

Enhance: To improve, augment, intensify or increase in quality, value, or functionality.

Fragmentation: Loss of natural cover, often linear, within habitat areas or corridors, e.g., road crossing through a corridor. In large habitat patches, fragmentation results in loss of forest interior.

Infrastructure: Means physical structures (facilities or corridors) that form the foundation for development or resource use and may include: sewage and water systems, sewage treatment systems, waste management systems, electric power generation and transmission including renewable energy systems, communications/telecommunications, transit and transportation corridors and facilities, oil and gas pipelines and associated facilities, but does not include "community infrastructure" or trails.

Invasive Species: Species of plants, animals, and micro-organisms introduced by human action outside their natural past or present distribution whose introduction or spread threatens the environment, economy, or society.

Mitigate: To prevent, modify, or alleviate impacts (negative) on the natural environment. Mitigation also includes any action intended to enhance beneficial effects.

Natural Heritage Features: Features and areas including all wetlands, significant woodlands, significant valleylands, aquatic habitat, fish habitat, watercourses and bodies of water, significant habitat of endangered and threatened species, significant wildlife habitat, and significant areas of natural and scientific interest, which are important for their environmental and social values as a legacy of the natural landscapes of an area; part of an ecologically functional corridor or linkage between natural areas; or, any other features or areas that are considered ecologically important in terms of contributing to the quality and diversity of an identifiable geographic area or natural heritage system.

Natural Heritage System: A healthy connected system comprising existing natural heritage features and areas, corridors, and those areas identified for natural cover regeneration which improve connections and habitat patches necessary to achieve and maintain minimum targets of ecological integrity.

Restore: The re-establishment or rehabilitation of a former or degraded system or feature with the goal of returning natural functions and characteristics that have been partially or completely lost or damaged.

Secondary Habitat: Habitat areas in the watersheds that are not as high quality as the core habitat areas, but are still important refuges for wildlife within the Wildlife Habitat Network.

Special Concern Species: A species that is classified by COSSARO (Committee on the Status of Species at Risk) as a "special concern species" if it lives in the wild in Ontario, is not endangered or threatened, but may become threatened or endangered.

Threatened Species: A species that is classified by COSSARO (Committee on the Status of Species at Risk) as "threatened species" living in the wild in Ontario which is not endangered but is likely to become endangered.

Valley or Valleyland: Land that has depressional features associated with a river or stream, whether or not it contains a watercourse.

Watershed: An area that is drained by a river and its tributaries.

Wetland: Means land that:

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

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

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

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

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

Wildlife habitat: Areas where plants, animals and other organisms live, and find adequate amounts of food, water, shelter and space needed to sustain their populations. Specific wildlife habitats of concern may include areas where species concentrate at a vulnerable point in their annual or life cycle; and areas which are important to migratory or non-migratory species.

Wildlife Habitat Network (WHN): A layer within the Natural Heritage System that identifies core habitats, secondary habitats, and wildlife corridors in the CLOCA watersheds.

Woodlands: Treed areas that provide environmental and economic benefits to both the private landowner and the general public, such as wildlife habitat, erosion prevention, hydrological and nutrient cycling, provision of clean air and the long-term storage of carbon. Woodlands include treed areas, woodlots or forested areas and vary in their level of significance at the local, regional and provincial levels.

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APPENDICES

APPENDIX A: RATIONALE FOR ADOPTING SPECIFIC CORRIDOR WIDTHS FOR THE CLOCA JURISDICTION

Feature	Description	Recommended Size	Rationale	References
Local Corridor	Connects core areas or other natural areas within a subwatershed.	Creek valleys and some upland connections: 60 m wide (minimum)	• E.C. guidelines recommend minimum 50-100 m widths to support movement. • ORM technical paper 4 recommends min 60 m width on the ORM (or half the width of area separating features (max 240 m). • Fisheries recommends 30 m buffer on streams (most corridors follow watercourses). • NHRM does not differentiate between corridor types but cites Noss (1992) which suggests that the width of corridors shorter than 16 km should be three times measurable edge effects, or 300 m wide. • **Recommend 60 m corridor width to be consistent with fisheries, and accommodate movement of generalist species.**	E.C.(2004) (pg 40) ORM T.P. 4 (pg 5) OMNR (2nd ed., pg 29)
Landscape Corridor	Connects core areas across multiple subwatersheds or across the watershed.	Larger creek valleys and some upland connections: 100 m wide (minimum)	• E.C. guidelines recommend minimum 50-100 m widths to support movement. • E.C. guidelines also recommend 75-175 m to support breeding birds. • Wider corridors are more effective. • NHRM does not differentiate between corridor types but cites Noss (1992) which suggests that the width of corridors shorter than 16 km should be three times measurable edge effects, or 300 m wide. • **Recommend 100 m width to support generalist movement as well as breeding birds.** • **Bigger size acknowledges the importance of landscape corridors in connecting the shoreline with the ORM and Iroquois Beach Regional Corridors.**	E.C.(2004) (pg 40) OMNR (2nd ed., pg 29)

Feature	Description	Recommended Size	Rationale	References
Regional Corridor	Connects core habitats across watersheds.	Lake Ontario (1 km wide).	• OMNR recommends corridor width of up to 5 km from Lake Ontario shoreline. • NCC recommends 1 km corridor width from shoreline. • **Recommend 1 km corridor width for Lake Ontario to be consistent with OMNR and NCC recommendations.**	Significant Wildlife Habitat Decision support system (index #25). Agard (1993) (pg. 9) E.C.(2004) (pg 40) ORM T.P. 4 (pg 5) OMNR (2nd ed., pg 29)
		Iroquois Shoreline (300 m connections between habitat patches preferred. Min 100 m is acceptable when 300 m cannot be achieved).	• No published information specific to Iroquois Shoreline. • E.C. guidelines recommend minimum 50-100 m widths to support movement. • E.C. guidelines also recommend 75-175 m to support breeding birds. • Wider corridors are more effective. • NHRM does not differentiate between corridor types but cites Noss (1992) which suggests that the width of corridors shorter than 16 km should be three times measurable edge effects, or 300 m wide. • **Recommend 300 m corridor width for Lake Iroquois Shoreline to recognize importance of regional movement. This corridor is defined by a physiographic region therefore it is preferred that as much of the shoreline as possible be in natural cover/habitat (consistent with goals of g.w. recharge protection and fisheries). Where pinch points in cover occur, 100 m width is acceptable (consistent with landscape corridor widths).**	
		Oak Ridges Moraine (as large as possible but legal width defined in ORMCP T.P 4).	• ORM technical paper 4 recommends min 60 m width on the ORM (or half the width of area separating features (max 240 m). • **At provincial scale ORM is a corridor, therefore goal should be to keep as much of ORM as possible in natural cover. At watershed scale, ORMCP guidelines in T.P 4 should be followed.**	

APPENDIX B: SAMPLE DATA SHEET FOR BARRIER INVENTORY AND ANALYSIS

BACKGROUND		
Evaluator:	J. Scott	
Date:	11/17/11	
Time:	11:12 am	
Watershed:	Lynde Creek	
Location:	Zone 17	
	661878 m E	4863733 m N

INFRASTRUCTURE					
Watercourse?	Yes				
Culvert/Bridge?	Yes - Bridge	Height (h):	4 m	Width (w):	26.5 m
Road Width (l):	22.5 m	Lanes:	4	Sidewalk?	No
		Paved/Gravel?	Paved	Shoulder?	Curb
		Speed:	80 km/h	No. cars/5 min	86
Openness Ratio (h x w / l):		*4.71*			

WILDLIFE		
Adjacent Habitat:	Cattail marsh surrounded by deciduous forest to the north. Meadow with some cedar trees on the edges to the south.	
Terrestrial Passage?	Yes	Present on both sides of watercourse. Cobble, gravel, and sand.
Evidence of Use?	Yes	Tracks in sand.
Evidence of Roadkill?	Yes	2 raccoons and 1 bird (Northern Flicker).

PHOTOS	
52:	Animal tracks under the bridge.
53:	Bridge, taken from south side.

APPENDIX C: EXCERPT FROM APPENDIX D OF THE 407 EAST EA AND PRELIMINARY DESIGN REPORT (WILDLIFE AND DESIGNATED FEATURES)

…

Wildlife species vary in their tolerance or adaptability to moving through culvers/structures under roadways. Although some species may readily move through culverts (e.g. raccoons, skunks), others, particularly reptiles, show a greater reluctance. Factors including temperature/moisture differentials and reduced ambient light leading to a "tunnel effect" within the culverts likely influence the use of culverts by wildlife.

The inclusion of natural substrates and debris within an ecopassage can reduce the temperature and moisture differentials within a culvert. This is especially important for reptiles for thermoregulatory purposes and for amphibians where the risk of desiccation is a threat.

Substrate type and size can further influence wildlife usage of culverts. The use of sharp rock is not conducive to wildlife movement as it can be difficult to manoeuvre across, particularly for reptiles and ungulates. Therefore, too encourage wildlife movement, the surface layer of substrates should consist of fine material, creating a solid, stable platform and covering any underlying rock.

Wildlife species are more likely to enter a culvert if they can see the light at the other end. Increasing the span of the culvert increases the amount of light that enters the culvert, thereby reducing the tunnel effect. Openness Ratio (OR), which is the cross-sectional area of a structure (square metres) divided by the distance wildlife must travel through (or under – metres), is a measure of the tunnel effect of a structure that may influence use by various wildlife species.

Many small to mid-size wildlife species will use structures with an OR ranging from 0.03 to 0.05. This includes species that are nocturnal and/or utilize tunnels or other confined spaces in their life history. Such use has been more rigorously confirmed at the Bayview Avenue extension in York Region where remote camera detection systems installed by Ecoplans (2006/2007) in pipe culverts (1 m – 1.2 m diameter) confirmed passage by a surprising diversity of species (Deer Mouse, Meadow Vole, shrew, Eastern Cottontail, Striped Skunk, Raccoon, Short-tailed Weasel, American Toad, Leopard Frog, mole salamander, Eastern Garter Snake). Use of native or comparable substrates within the structure appears to be important in facilitating use by wildlife.

Where habitat conditions are more conducive to movements by a greater diversity of small to mid-size species, as well as common reptile and amphibian species, we have generally recommended an OR of 0.1 to increase potential use. This is a consideration where suitable habitat is present on both sides of the highway, where movements of some animals are already likely or established and where long term retention of habitat beyond the ROW is expected. Increasing the OR of an existing culvert would be anticipated to encourage use by a greater variety of species. Again, native or comparable substrates should be provided in the structure, both to reduce the thermal gradient and to provide a natural surface for movement.

For turtles, field-verified information on desired OR is still generally limited. However, based on field observations, discussions with other researchers and input from the Toronto Zoo March 2007 "Roads and Ecopassages" symposium, an OR of at least 0.25 is suggested. If SAR reptiles are also a target, this minimum OR is also applicable, particularly when considering thermal requirements (trying to avoid too large a temperature differential between inside and outside the structure). Providing native or comparable substrates as well as other cover elements (for shelter, predator protection) is also considered important in the culvert design.

For ungulates (deer), a minimum clearance height of 3 m is recommended. For valley systems, the 3 m clearance should be achieved in the overbank areas. A minimum OR of 0.6 to 1.0 is also provided as a recommendation for encouraging deer use.

Funnel fencing or other appropriate funneling techniques (i.e. rock/rip-rap embankments) on either side of culverts (and within the median), to help funnel animal movement, and recommending design measures relevant for the target species or groups of species will be addressed as the preliminary design progresses with final recommendations provided once all crossings, profile, and grading information is available.