6 Constraints

This section identifies and describes the ecological constraints associated with the Erbsville South Study area which have the potential to be impacted by future development.

Terrestrial ecological features and functions that have been identified in association with the Erbsville South Study area include:

Provincial Policy Constraints:
1. Habitat of Endangered and Threatened Species
2. Significant Wetlands
3. Significant Wildlife Habitat

Watershed / Regional / Municipal Constraints:
4. Species of Conservation Concern (watershed, regional, local)
5. Environmentally Sensitive Policy Area (ESPA)
6. Environmentally Sensitive Landscape (ESL)
7. Core Environmental Features in the Regional Greenlands Network
8. Ecological Linkages
9. Supporting Natural Features

The following sections discuss each constraint identified including information on recommended buffers and development setbacks. These Ecological constraints are presented on Figures 6.1, 6.3, 6.4 and consolidated on Figure 6.5.

6.1 Provincial Policy Constraints:

6.1.1 Habitat of Endangered & Threatened Species

Habitat of Endangered and Threatened Species was identified in the Erbsville South study area in association with the following species: Barn Swallow, and Blanding's Turtle.

Barn Swallow
In 2013, one pair of Barn Swallows was found nesting under the eaves of the gazebo next to the pond (polygon 18). No Category 1 General Habitat (*i.e.* the nest; OMNR, 2013d) will be impacted as the nesting structure will not be removed. However, should it be necessary to remove the gazebo in the future, lost Barn Swallow breeding habitat, will need to be compensated in accordance with provincial regulations. Furthermore, no Category 2 General Habitat (*i.e.* the area within 5 m of the nest) will be impacted as the gazebo is well inside the 30 m wetland buffer associated with the pond. However, future development will decrease the amount of foraging habitat for this species. Category 3 General Habitat is largely consistent with foraging habitat between 5 m and 200 m of the nest (see Figure 6.1) and includes open areas that provide good sources of flying insects, such as waterbodies, pastures with livestock, and woodland edges (OMNR, 2013d). Based on this definition, the amount of suitable foraging habitat (within the 200 m radius) was determined and compared to the post development scenario. Based on a maximum of 12.57 ha, the total amount of suitable foraging habitat was calculated to be 7.87 ha before development and 5.3 ha after development. This was based on 30 m wetland and stream buffers as well as the revised regulatory floodline for the culvert replacement at Erbsville Road and Wideman Creek. This amounts to a 32.7% loss of suitable habitat (shown in red on Figure 6.2; white areas are unsuitable habitat). According to Ministry of Natural Resources and Forestry, amounts less than 50% are generally not considered significant (Buck, pers. com., 2015).

The same sets of calculations were made for the active nest reported at 521 Forest Gate Crescent, on the east side of Erbsville Road. Using the same constraints and buffer widths, 16.5% of the 5.52 ha of available foraging habitat would be potentially lost according to the post development scenario (shown in red on Figure 6.2). As such, the proposed development should not significantly impact its future nesting at this location.

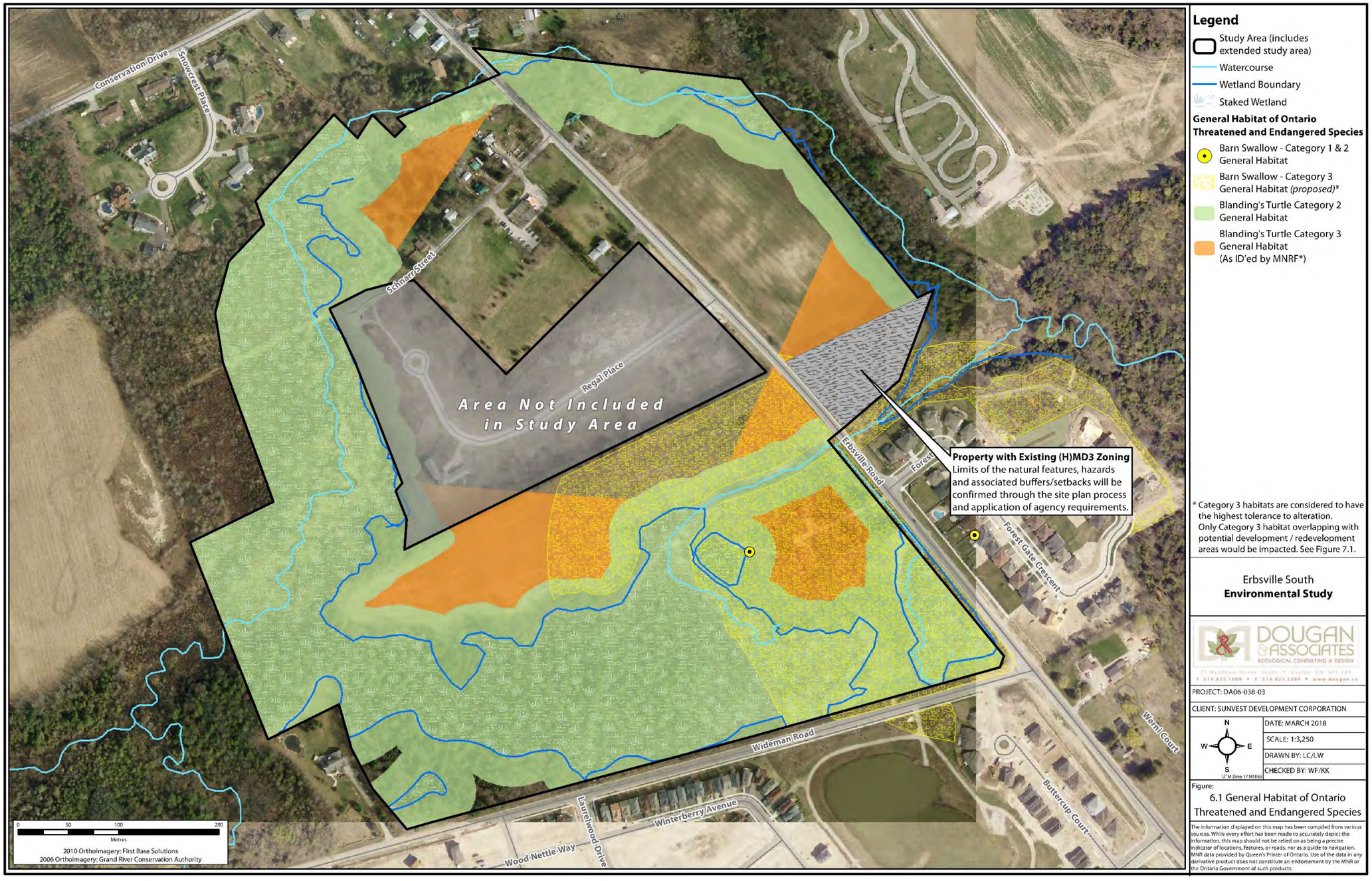

Figure 6-1 General Habitat of Ontario Threatened and Endangered Species

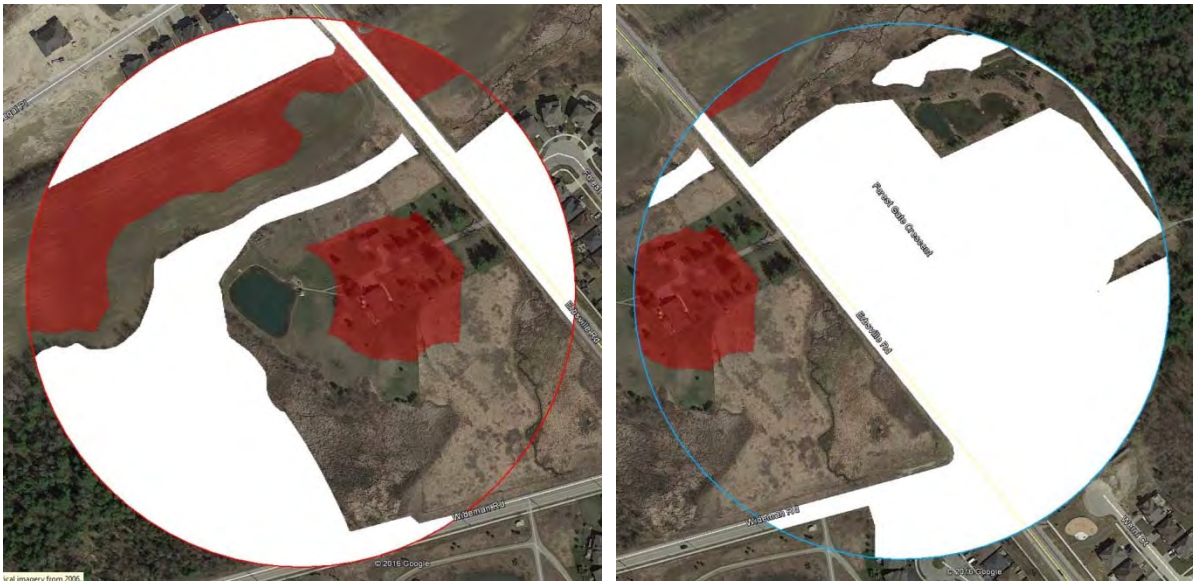

Figure 6-2 Estimated Loss of Potential Barn Swallow Category 3 General Habitat for Two Reported Nest Sites

Blanding's Turtle

Blanding's Turtle is designated Threatened in Ontario (OMNRF, 2016) and ranked S3 (NHIC, 2016). On June 1, 2015, Graham Buck (OMNRF Management Biologist, Guelph District) advised that, due to there being two records of this species within two (2) kilometres of the site, the entire Erbsville South Study Area (terrestrial and wetland) is considered 'General Habitat' of Blanding's Turtle by the Ministry. Later, as part of their review of an earlier draft of this report, MNRF specifically indicated that polygons 14 and 15 (*i.e*. the wetland at the northwest corner of Wideman Road and Erbsville Road) represents protected habitat for Blanding's Turtle under the ESA and that an 'Overall Benefit Permit' under the Endangered Species Act (ESA) maybe required if this wetland will be impacted by future improvements to Erbsville Road. Based on this information and the possibility that as yet undetected Blanding's Turtles could be present within the study area, efforts to search for their presence were reinitiated. Five additional basking turtle surveys were scheduled for 2016, to go with the 9 basking turtle surveys already conducted in 2013 and 2014. The two original basking turtle survey sites were resurveyed in 2016, along with 3 additional locations, a small pond located in the back yard of the lot in the southwest corner of the Regal Place subdivision, as well the stormwater management pond north of Forest Gate Crescent and the larger stormwater management pond at the southwest corner of Wideman Road and Erbsville Road, both adjacent to the study area. In addition to the basking turtle surveys, two additional nest searches were also planned.

Up until 2016, no Blanding's Turtles had been documented from the study area. However, on May 22, 2016, a Blanding's Turtle was photographed by a local resident, crossing the laneway that runs across Laurel Creek, west of Schnarr Street. It isn't clear if the turtle was simply using the creek and wetland as a seasonal movement corridor, or if it was starting to look for a place to nest (the date seemed a little bit early) but regardless, it represented the first documented sighting of a Blanding's Turtle within the Erbsville South study area. At about the same time, the Ministry of Natural Resources and Forestry issued new "Blanding's Turtle Nest and Nesting Survey Guidelines" (OMNRF, 2016b). Based on the May 2016 observation and new survey requirements, the survey program planned for 2016 was expanded to be consistent with the new guidelines. In addition to the five basking turtle surveys, six "nest" and six "nesting" surveys were planned.

Results of 2016 basking surveys yielded no Blanding's Turtle observations. Similarly, no turtles were observed actively nesting, nor were any successful nests or raided nests found during any of the visits. However, this result wasn't surprising given the relatively low abundance of turtles present and how well turtles mask their nests once complete. Nevertheless, a possible turtle nest scrape by was noted near the very western end of polygon 20 on June 20th 2016, the agricultural field. Also, a Blanding's Turtle was incidentally observed on June 10th 2016 by Dougan & Associates staff, basking in the pond at 665 Erbsville Road (polygon 18). In summary,

the results of the survey effort have confirmed the fact that the limited wetland habitats within the study area are being utilized by a very low number, or possibly a single individual Blanding's Turtle.

To better understand which habitats within the study area are being used by Blanding's Turtles, an assessment of Category 2 and Category 3 Blanding's Turtle General Habitat was undertaken. No Category 1 General Habitat is known to be present within the study area. According to the General Habitat Description for the Blanding's Turtle (OMNR, 2103e):

- Category 1 is the nest/overwintering sites and the area within 30 m
- Category 2 is all suitable wetlands/ waterbodies within 500 m of each other extending up to 2 km from an occurrence, plus a 30 m buffer (Figure 6.1), and
- Category 3 is the area 30 – 250 m around suitable wetlands/ waterbodies identified in Category 2, within 2 km of an occurrence.

With respect to Category 3 habitat, the General Habitat Description also states: "*Blanding's Turtles depend on these areas as movement corridors between wetlands, which are essential for carrying out life processes associated with Category 1 and 2 habitats*."

Based on this understanding, all lands situated between nearby wetland patches were considered as potential Category 3 habitat. One important assumption was made when conducting the assessment. Where watercourses join one wetland patch to another, it was assumed that the most likely path a Blanding's Turtle would take between the two was along the watercourse itself. That is, it didn't seem reasonable to assume a turtle would exit the watercourse and travel overland parallel with the watercourse and then re-enter at some later point. This was also the assumption when the watercourse was not always the shortest route between two potentially suitable wetland habitats. Nevertheless, all areas of land were scrutinized and where overland routes made more sense they were included. As a rule, developed areas such as subdivisions and roadways were also excluded as suitable habitat.

Finally, the assessment considered the results of the 2016 turtle nest and nesting activity surveys, conducted as per the recently issued (May 2016) guidelines from the Ministry. That is, adjacent lands, including the agricultural fields, which might function as turtle nesting habitat, were considered. However, since no evidence of nesting activity could be confirmed, they were mostly excluded.

The interpretation of Category 3 Blanding's Turtle General Habitat is depicted on Figure 6.1. The Ministry of Natural Resources and Forestry (MNRF), has recently conducted its own assessment of Category 2 and 3 Blanding's Turtle General Habitat. Although similar to Figure 6.1, the Category 2 and 3 General Habitat was more extensive in coverage (see Appendix 2.12). Taking MNRF's interpretation into consideration, a revised assessment is presented on Figure 6.1. Aside from using more recent, field staked and agency approved wetland mapping, site-specific to the study area, and excluding unsuitable habitat such as Erbsville Road, it incorporates MNRF's conservative interpretation with respect to the outer extent of the Category 3 habitat. It should be noted that by applying 30 m buffers to the full length of Wideman creek, as well as the unnamed watercourse draining into Wideman Creek from the south, it results in an additional 0.93 ha of Category 2 habitat that will be protected, as compared to MNRF's interpretation.

The future replacement of the culvert under Erbsville Road, through which Wideman Creek passes, also has the potential to negatively impact the species, especially when individuals may be making seasonal movements between wetlands. For this reason, it is recommended that construction activities take place when Blanding's Turtles tend to be inactive (*i.e*. generally between October 1st and April 1st). However, given the fact that this period also overlaps with timing restrictions related to Brown Trout spawning and development of their eggs and fry, we recommend that construction works be limited to the period between July 1st and August 31st. This is after their critical nesting period but before they are likely to start moving to overwintering sites. However, since it's possible that breeding birds may still be nesting during the late summer period, screening surveys should be conducted by a qualified bird expert immediately prior to construction activities being initiated, to ensure no nesting birds are disturbed and the Migratory Birds Convention Act is not contravened.

An information Gathering Form (IGF) will be completed and submitted to the MNRF for review, for any development proposed within the study area. The purpose of the IGF will be to provide the MNRF with the necessary information to inform whether or not the proposed development will likely impact species at risk (e.g., Blanding's Turtles) or their habitats, and whether an authorization under the Endangered Species Act may be required.

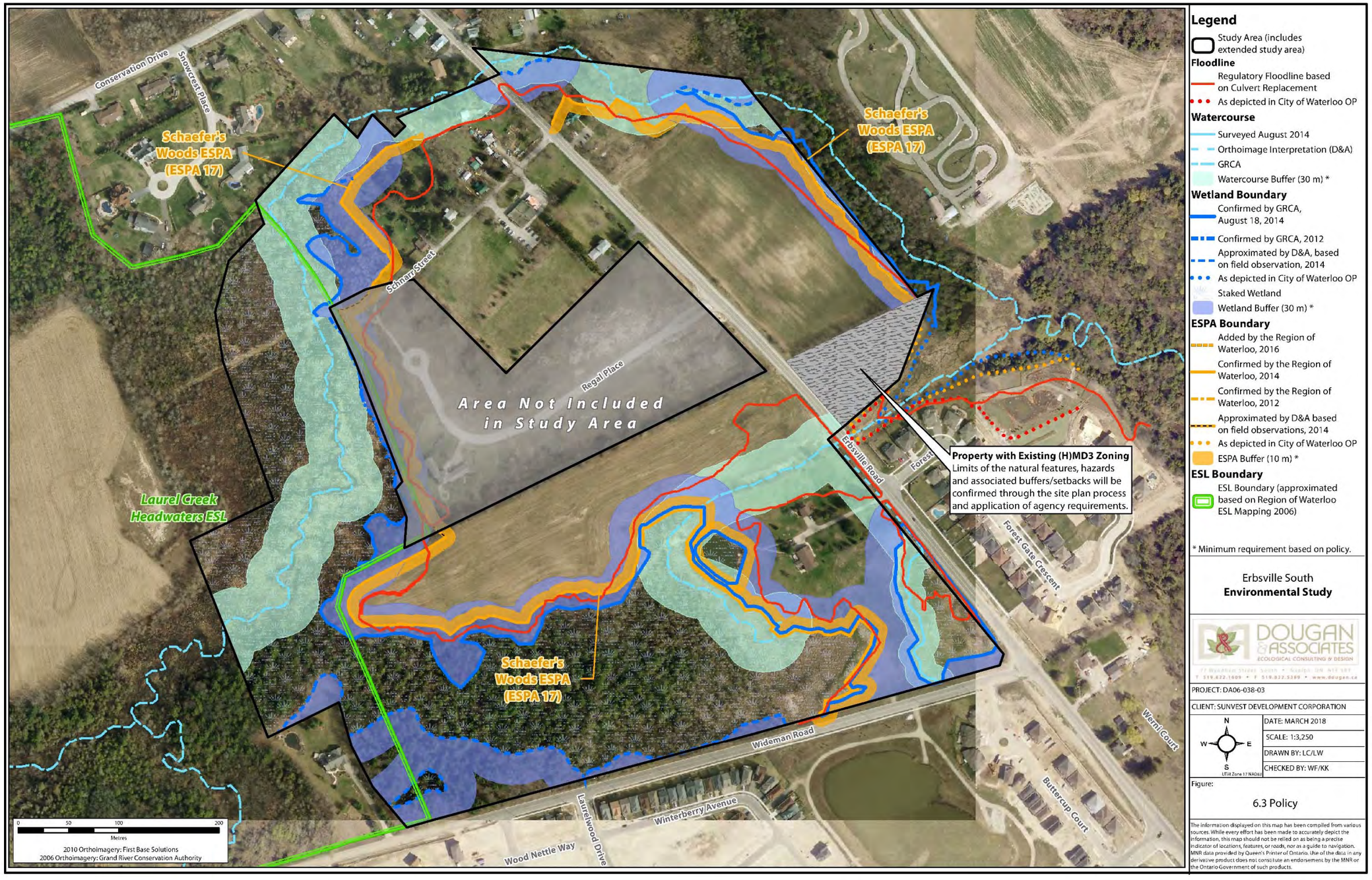

Figure 6-3 Ecological Constraints - Policy

6.1.2 Significant Wetlands

Section 2.1.4 of the PPS (OMMAH, 2014) states that development and site alteration in significant wetlands is not permitted. This applies to the Sunfish Lake - Laurel Creek Provincially Significant Wetland (PSW) Complex, which encompasses 811 ha of swamp and marsh in total, including the wetlands within and bordering the Erbsville South study area. GRCA indicated that a minimum 30 m development setback, consistent with the North Waterloo Scoped Subwatershed Study and Laurel Creek Watershed Study, will be required to protect the PSW from negative impacts, and that increased buffer widths should be implemented where warranted, or where they reflect recommendations outlined in current literature. For example, with respect to significant wildlife functions, buffer widths need to be commensurate with the movement patterns of the various taxa using these areas, particularly amphibians (which can radiate large distances away from wetland areas to forage) and turtles (which move considerable distances over land to find suitable nesting areas).

To address these comments and overall sufficiency of a 30 m buffer (see Figure 6.3), the diversity of wildlife species present within the wetlands and their sensitivities to human development was reviewed, as were the linkage opportunities provided by the wetland buffers, stream buffers and regional floodlines. Based on our assessment, only 4 of the 14 area-sensitive wildlife species documented (OMNR, 2000) are primarily associated with wetland habitats. This included: American Bullfrog (*Lithobates catesbeianus)*, Northern Map Turtle (*Graptemys geographica*), American Bittern (*Botaurus lentiginosus*), and Bald Eagle (*Haliaeetus leucocephalus*).

"American Bullfrogs are a highly aquatic species and are associated with wetlands containing a high invertebrate abundance" (Dodd, 2013). They inhabit permanent bodies of water, including lakes, sloughs, marshes, impoundments, river and creek backwaters, and small farm and ornamental ponds (Dodd, 2013; Harding, 1997), such as the pond behind the home at the southwest corner of the Regal Place subdivision, where an individual was recorded. Furthermore, during the non-breeding season, they inhabit shorelines of wetlands of varying sizes, and movements also tend to be around wetlands and watercourses (Dodd, 2013). For these reasons, the proposed 30 m wetland buffers should provide the species with sufficient terrestrial habitat.

A hatchling Northern Map Turtle was documented from the laneway just north of the Regal Place subdivision in May 2012. Although successful nesting likely occurred somewhere nearby, no potential nest site was found. Nevertheless, opportunities for future nesting will persist as the northernmost lots in the Regal Place development do not extend all the way north to the laneway. More specifically, approximately 950 m^2 of undeveloped land owned by the City (excluding the laneway itself) will remain north of the lots, between Laurel Creek and the YMCA Early Years Centre. Furthermore, given the large amounts of wetland habitats within the Erbsville South study area, the proposed 30 m wetland boundaries should provide sufficient opportunities for future nesting (at least an additional 16,900 m^2), so long as these edge habitats don't become permanently overgrown by vegetation.

An American Bittern was observed by a local resident on May 15, 2013 in the wetland south of the laneway, at the west end of Schnarr Street. Based on the date it is possible this individual was a migrant. However, since egg laying in Ontario can begin in early May (Peck and James, 1983), it is also possible it was a local resident. American Bitterns normally inhabit freshwater marshes in Ontario but they can also nest in swamps and bogs, and even upland areas seeded to non-native grasses and legumes, such as smooth brome, witch grass and alfalfa (Timmermans, 2007; Sandilands, 2005). They can nest in all sizes of wetlands (0.1 – 1,000 ha or larger) but are more abundant in larger ones (Sandilands, 2005). Approximately 1.3 ha of open marsh habitat is present along the margins of Laurel Creek west of the Regal Place development. Although considered to be on the small size, it is possible conditions may be suitable for nesting. Sandilands (2005) suggests that it is susceptible to human disturbance, dogs and livestock. Lowther *et al*. (2009) also lists recreational boating and incidental hunting as concerns. Fortunately, given the wet conditions and limited access, especially post development, human disturbance in the wetland is not expected to be a concern. Furthermore, the wetland edge is bordered by a strip of trees and shrubs of varying width within the 30 m buffer, providing a visual barrier to human disturbance.

Local residents reported Bald Eagle from the Erbsville South study area in 2012 and January 2015. Specific dates and locations were not provided, or what the birds were doing. Nevertheless, the Erbsville South study area lands likely provide little foraging habitat for the species. Laurel Creek is small in size as are the few ponds,

which are also situated close to existing homes. It seems most likely that the individuals observed were likely frequenting other, more attractive foraging areas, such as the Laurel Creek Reservoir, which is little more than 1 km away to the east. Since it is unlikely that Bald Eagles forage in the study area, the size of the wetland buffers should not be a concern.

As mentioned above, frogs can move considerable distance away from wetlands to forage. Similarly, turtles may make significant seasonal movements over land to access suitable nesting or overwintering sites. The life history requirements of these and other taxa were considered, including linkage opportunities, in context to the natural heritage features present within the study area and their associated buffers (including 30 m watercourse buffers, 10 m ESPA buffers, and the areas contained the regulatory floodline). The abundance of the natural heritage features protected by these various designations is shown in Figure 6.1, Ecological Constraints. Once the associated buffers and environmental constraints are applied, significant amounts of additional habitat end up receiving protection. It even effectively joins the wetland fragment at the northwest corner of Wideman Road and Erbsville Road with the rest of the PSW to the west. Additional field surveys were carried out in 2016 to detect turtle nesting activity. Although numerous visits were made in accordance with new MNRF protocols, including searching adjacent agricultural fields, no nesting activity was detected in any areas beyond the 30 m buffer limit. Overall permeability in the study area and local landscape was also considered robust. Applying wider wetland buffers would do little to further enhance local connectivity.

Finally, while development and site alteration is not permitted in PSWs, the PPS permits development of essential infrastructure within PSWs when alternatives have been assessed under the Environmental Assessment Act. The Region's planned future widening of Erbsville Road will affect the integrity and functions of wetland polygons 14 and 15, which MNRF recently confirmed are part of the PSW. As previously discussed in this report, there has been discussion with MNRF staff regarding the history, current status and future of the wetland that would be affected. Appendix 6.1 includes further discussion on this issue including an alternative scenario that would remove the wetlands that will be impacted, and enhance the balance of the PSW for an overall benefit to the local ecosystems in the long term. The City of Waterloo, Region of Waterloo and GRCA have agreed that further discussion at this time is premature but should be considered during the Environmental Assessment process required for the widening of Erbsville Road.

6.1.3 Significant Wildlife Habitat

A Significant Wildlife Habitat assessment (SWH) was carried out based on the 34 visits made to the study area between April 2013 and December 2014. Using the Significant Wildlife Habitat Technical Guide (SWHTG) as the primary guide for the assessment (OMNR, 2000), and supplemented by the *SWH Ecoregion 6E Criterion Schedule* (OMNR, 2012), 18 SWH criteria (out of more than 50 potential SWH criteria reviewed) were considered to merit consideration as candidate Significant Wildlife Habitat. The 18 SWH criteria are listed below.

1. Deer winter congregation area
2. Turtle wintering areas
3. Snake hibernaculum
4. Bullfrog concentration areas
5. Habitat for area-sensitive species
6. Marsh bird breeding habitat
7. Shrub/early successional bird breeding habitat
8. Forests providing a high diversity of habitats
9. Amphibian woodland breeding ponds
10. Turtle nesting habitat
11. Seeps and springs
12. Terrestrial crayfish
13. Species identified as "Special Concern" in Ontario based on lists of *Special Concern, Threatened, Endangered, Extirpated or Extinct Species of Ontario* that are periodically updated by OMNR.
14. Species that are listed as rare (S1–S3) or historical in Ontario based on records kept by the Natural Heritage Information Centre in Peterborough.
15. Species whose populations appear to be experiencing substantial declines in Ontario.
16. Species that have a high percentage of their global population in Ontario and are rare or uncommon in the planning area

17. Species that are rare within the planning area, even though they may not be provincially rare[2]
18. Animal Movement Corridors

There are currently no SWH criteria thresholds for the Regional Municipality of Waterloo (SWH designation is a municipal responsibility); this list shows potential SWH only based on data from this site, using status lists that are likely out-dated at the local scale. Potential SWH is strongly associated with the PSW and ESPA limits, as shown in this Environmental Study (see Figure 6.4). For a detailed assessment of each criterion, please refer to Appendix 2.9.

The majority of identified SWH categories are located within the protected PSW, ESPA and/or ESL. Potential exceptions are snake hibernacula, turtle nesting habitat, and certain locally-significant plants. These are discussed below. Animal movement corridors will be enhanced through the replacement of the Wideman Creek culvert and riparian corridor enhancement.

6.2 Watershed / Regional / Municipal Constraints

6.2.1 Species of Conservation Concern

Vegetation Species of Conservation Concern:

Seven (7) species of local significance were recorded including: three graminoids, Rough Sedge, Canada Rush and Wirestem Muhly; two low shrubs, Virginia Creeper and Bristly Sarsaparilla; one deciduous tree, Black Walnut; and one coniferous tree, White Spruce. These species are either not of indigenous origin (planted), or are already protected within the ESPA and/or PSW. Ongoing discussions with MNRF and GRCA will include the possibility of wetland restoration and enhancement in the areas where some of these species are located. If a wetland restoration strategy goes forward it should consider protection and/or salvage of any vegetation species of conservation concern located in areas to be impacted.

Wildlife Species of Conservation Concern:

Adult newts are permanent residents of Polygon 18 (see Figure 3.3), which has PSW and ESPA designation. Impacts to this pond at any time of year could be detrimental to breeding populations. Furthermore, linkages with the natural features to the west (wetlands and forests) are required to maintain a population of Red-spotted Newts within the study area. Terrestrial subadults migrate overland into forest habitat before returning to breed in the pond several years later (Petranka, 1998). Protection and enhancement of the buffer around Polygon 18 is recommended to maintain its suitability for Red-spotted Newts and increase its suitability for other herpetofauna (Spotted Salamander, Midland Painted Turtle, Snapping Turtle, and Blandings Turtle). If a wetland restoration strategy goes forward it should consider protection and/or salvage of any wildlife species of conservation concern located in areas to be impacted.

Turtle nesting has been observed in the study area in opportunistic settings such as gravel piles, a sand box, and roadside verges. More permanent nesting sites can be created in feature buffers which allow a west to south-west exposure, using gravel piles or areas set into graded sideslopes. Roadkill is a significant hazard for herpetofauna in particular; road surfaces offer suitable basking habitat for snakes, and both turtles and amphibians are relatively slow moving, which increases their time spent on the road surface. Better protection of wildlife against road mortality can be achieved with informational signage, traffic calming, and a strategically placed wildlife-friendly underpass (a structure installed underneath a roadway, with drift fencing or curbs which guide wildlife into the crossing structure).

Eastern Gartersnake is a common, widespread and cosmopolitan species of snake (Rowell, 2012). It is not listed as a Species-at-Risk federally (COSEWIC, 2015; COSEWIC, 2016) or provincially (OMNRF, 2016), nor is it considered to be a regionally (Plourde *et al*., 1989) or locally significant species (RMW, 1985a). This species is a generalist and capable of thriving in a variety of habitat types and therefore is likely capable of persisting within

[2] The Significant Wildlife Habitat Ecoregion 6E Criterion Schedule (OMNR, January, 2015) does not include this subcategory, and the findings should be viewed with caution. Many of the 'locally rare bird species observed also occurred outside the study area boundary.

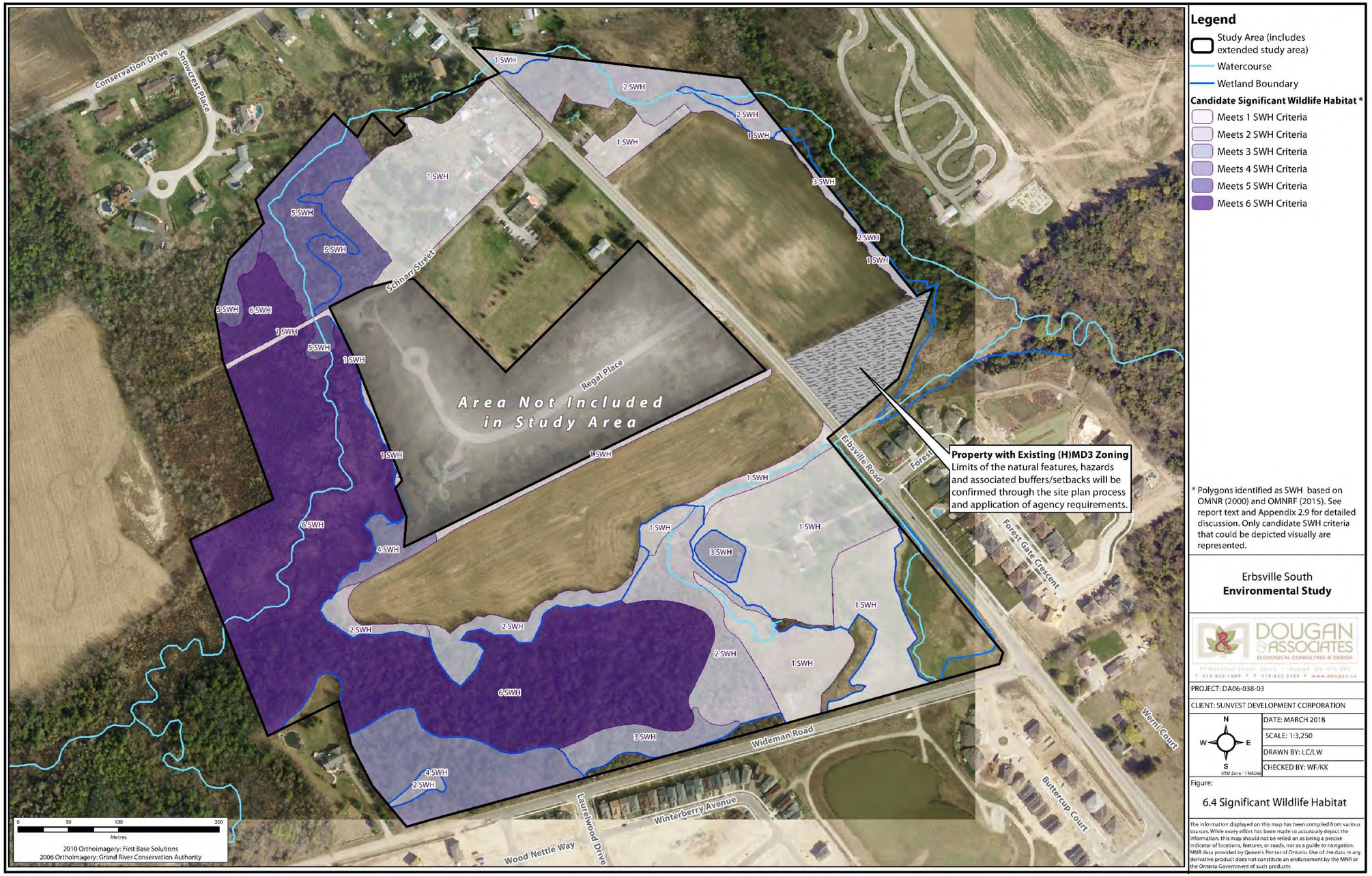

Figure 6-4 Significant Wildlife Habitat

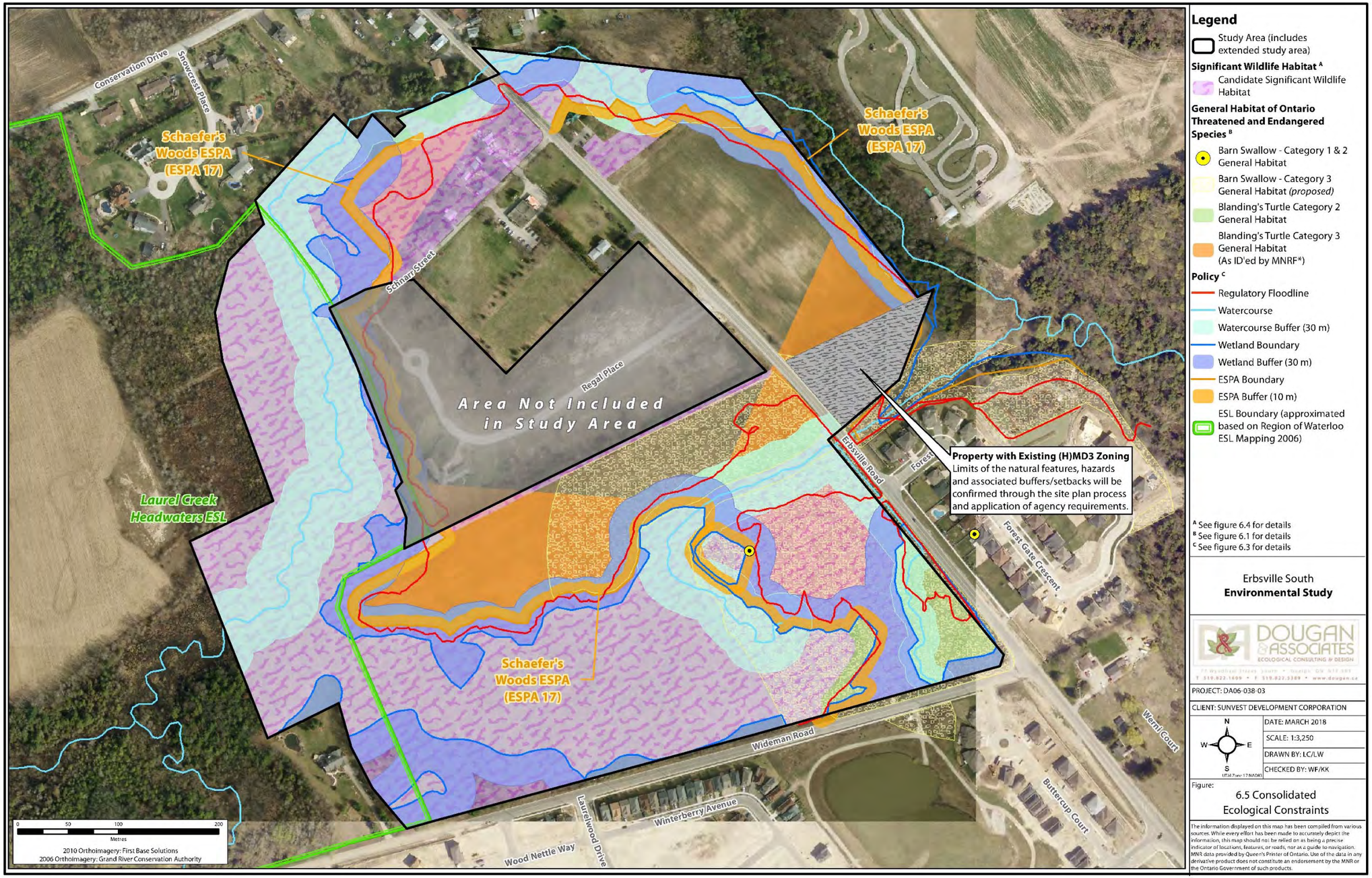

Figure 6-5 Consolidated Ecological Constraints

the study area in the long term if core natural habitat features are properly protected. Similarly, Eastern Milksnake is a generalist of mixed habitat cover (Rowell, 2012). To help protect local populations, potential snake hibernacula, such as building footings and foundations, should be surveyed during the appropriate time of year, prior to grading or land clearing within the study area. If any overwintering sites are identified, opportunities to move snakes to suitable habitat nearby should be investigated, as well as measures to prevent the snakes from returning before works begin. Snake relocation requires an MNRF wildlife handling permit. If snake hibernacula will be impacted, new hibernacula can be created in buffers and enhancement areas using salvaged small boulders and log sections, embedded in a pit up to 2 m deep, designed to avoid inundation or flooding.

6.2.2 Environmentally Sensitive Policy Areas (ESPA)

Schaefer's Woods (ESPA 17)
This diverse complex of upland and lowland forest forms an important segment of the Laurel Creek corridor, and contains the confluence of Laurel and Monastery Creeks (RMW, No Date (a)). This natural feature is 103.8 ha located north of Wideman Road. The upland forest is predominantly Sugar Maple-Beech, and contains many sizable specimens in addition to a fine hemlock stand. The swamp communities associated with the creeks are of very high quality. Especially noteworthy is a very fine Tamarack swamp and large Hemlock-Cedar, Balsam Fir and Yellow Birch wetland forest. In addition, a significant Silver Maple swamp is also present. The area has long been recognized as an outstanding field site for research by both local universities.

Laurel Creek Forest (ESPA 80)
This feature is a combination of swamp and upland forest associated with Laurel Creek and is located between Schaefer's Woods and the Laurel Creek Reservoir, acting as an important natural corridor [RWM, No Date (b)]. Laurel Creek is considered a cool water stream where sections have been rehabilitated to improve fish habitat. The Laurel Creek Nature Centre is located in the eastern portion of this ESPA. Most of the ESPA is contained within the Laurel Creek Class 1 Wetland Complex.

6.2.3 Environmentally Sensitive Landscape (ESL)

The Erbsville South study area is adjacent to the Laurel Creek Headwaters ESL. The extended study area along the west side is designated ESL. The primary study area is within the urban boundary and does not include any lands designated as ESL. ESL boundaries are based on City/Region mapping and not subject to further refinement during field study.

The Laurel Creek Headwaters ESL is an approximately 2,075 ha area of land spanning the northwest corner of the City of Waterloo and portions of the Townships of Wellesley, Wilmot and Woolwich. Environmentally Sensitive Landscapes are landscape-scale environmental features designated by the Region of Waterloo as part of their official plan. This ESL links important landforms and habitats on the Waterloo Moraine. The Waterloo Moraine is a significant groundwater recharge area and also provides groundwater discharge to wetlands and some of the watercourses within this ESL (RMW, 2005).

Three kettle lakes are considered key features of this ESL (RMW, 2005), however none of these are present within the Ersbville South study area. This area is characterized by its rolling topography and contains upland and lowland forest, extensive swamp and marsh wetland complexes. The majority of the wetlands in this ESL are designated as Provincially Significant (RMW, 2005). The ESL contains seven ESPAs including the Schaefer's Woods ESPA (RMW, 2005), which is associated with the Erbsville South study area. Beaver Creek, Monastery Creek and headwater reaches of Laurel Creek are located within the ESL.

6.2.4 Core Features in the Regional Greenlands Network

The Regional Greenlands Network designated in the ROP includes *Core Environmental Features* among other natural heritage features and the linkages among these features. *Core Environmental Features* are defined by the ROP as features that are "the most significant elements of the regional landscape in terms of maintaining, protecting and enhancing biodiversity and important ecological functions" (Section 7.C.1). As provided for in Section 7.A.6 of the ROP, interpretations of the boundaries of Core Environmental Features to support development applications "will be achieved through the completion of Environmental Impact Statements".

6.2.5 Ecological Linkages

As discussed in the ROP, ecological linkages contribute to the overall ecological integrity of the Greenlands Network and are to be identified and accounted for in the design of new development. Linkages are to be maintained, enhanced or wherever feasible, restored among environmental features.

Ecological linkages include terrestrial and aquatic habitat corridors that facilitate movement of wildlife across the landscape between natural features. With regard to the Erbsville South study area, potentially useful linkages run in an east-west direction, connecting the relatively large intact natural features to the east and west of the study area. Erbsville Road, running in a north-south direction, is a busy roadway and the primary barrier to wildlife movement in this landscape; it is planned to be widened in the future. Linkages that facilitate safe wildlife movement from east to west crossing Erbsville Road are key to minimizing road kill and reinforcing the ecological integrity of the Regional Greenlands Network.

Three existing features with the potential to function as ecological linkages have been identified including:

1. Wideman Creek corridor and Hedgerow
2. Hedgerow that straddles the boundary between the Regal Place development and the Erbsville South Study area ('the Regal Place hedgerow')
3. Laurel Creek corridor north of Schnarr Street.

Wideman Creek Corridor and Hedgerow

The Wideman Creek corridor and hedgerow includes a corridor of riparian vegetation along Wideman Creek. The size, location and ecological character of this corridor make it the highest quality linkage feature within the Erbsville South study area. Erbsville Road currently represents a barrier to wildlife movements, and as a regional arterial road, could cause significant road kills without appropriate mitigation.

The value of this corridor as a terrestrial ecological linkage was previously identified in the Final Subwatershed Management Plan 309/313 (SWS). The SWS noted that the 30m buffer applied to the watercourse will strengthen the linkage function of this natural corridor. The SWS provided enhancement recommendations related to the corridor including upgrading the culvert to Regional Storm capacity, designing the new culvert to provide opportunities for wildlife movement, native species plantings within the 30m buffer from the creek, maintaining marsh areas and incorporating them into the buffer, streambank revegetation or armouring with local stone to prevent scour, and stormwater management techniques to maintain or reduce existing peak flows.

As discussed in Section 4.1, the existing culvert is a partially buried elliptical steel pipe. The proposed culvert would be an open bottom structure, which will enable movement of small to medium size vertebrates.

The culvert proposed for retrofitting and the surrounding lands were examined from a terrestrial ecology perspective on Feb 9, 2012. The lands surrounding the culvert include a small amount of Mineral Meadow Marsh (MAM2) and Cultural Meadow (CUM1-1) along the channel edge. There is a steep embankment up to the road, which should be retained to discourage wildlife from crossing the road.

Although terrestrial benches are desirable on each side of the creek, at least one terrestrial bench for movement of terrestrial wildlife is recommended. Each bench should be 0.5 to 1 m wide and substrates need to be stable enough that they will not blow out during storm events. The terrestrial bench needs to be placed above bankfull level so that it will remain accessible and not become flooded under routine flows. Larger substrate materials (300 – 500 mm diameter) intermixed with fines can be used to form a stable bench. Use of the culvert is expected to include small to medium-sized mammals, amphibians, and reptiles. Larger wildlife species such as White-tailed Deer may use the culvert if clearance permits and adequate fencing is installed to exclude them from the road right of way on both sides of the road. Signage can be used to help to advise drivers of potential deer crossing activity.

The possibility of creating one culvert for aquatic movement and a second culvert for terrestrial movement was explored, however it was determined that a single crossing is preferable because the watercourse itself is the key feature that directs wildlife movement. Additionally, secondary culverts would be more costly and labour intensive, requiring more extensive grading and fencing within the adjoining road corridor.

Regal Place Hedgerow

The Regal Place hedgerow provides a local east-west corridor connecting the larger natural features in the landscape, however there is redundancy as this hedgerow is located only about 80 m north of the Wideman Creek crossing. The value of the Regal Place hedgerow as an ecological linkage was discussed with City and Region staff during site walks for the Regal Place EIS. At that time it was determined that the Wideman Creek corridor has the greater value and opportunities to function as a linkage for the Erbsville South landscape, but that the Regal Place hedgerow would be retained as a linkage feature until the Wideman Creek corridor could be enhanced. The Regal Place hedgerow was to be kept under temporary conservation easement and subsequently released from the easement once the Wideman Creek corridor enhancement is established. For the north side of this hedgerow a 15 m building setback from the property line was applied.

Laurel Creek Corridor North of Schnarr Street

The Laurel Creek corridor north of Schnarr Street, at the north edge of the study area is another local linkage where two natural features abut Erbsville Road, creating an east-west opportunity for movement. However, there are limited opportunities for enhancements for safe wildlife movement across Erbsville Road at this location, especially given the planned road widening. Although not in the scope of the current study, future replacement of the creek culvert in Erbsville would represent an opportunity.

6.2.6 Supporting Natural Features

According to the City of Waterloo's Official Plan, Supporting Natural Features are components of the City's Natural System. Section 8.2.5 of the Official Plan states that Supporting Natural Features "are those natural features not meeting the criteria for provincial or regional significance… but which are locally significant" (City of Waterloo, 2012). Although Schedule A4 (see Figure 2.3) shows the wetland at the corner of Wideman Road and Erbsville Road is designated as a Supporting Natural Feature, it has since been complexed with the adjacent PSW by MNRF and therefore is now considered a Core Environmental Feature. However, all watercourses within the study area, including the outlet tributary that flows along the edge of this wetland, are considered Supporting Natural Features under the City's policy.

The form and ecological function of Supporting Natural Features are to be maintained, enhanced, or where feasible restored. Supporting Natural Features are subject to different policies depending on their categorization into "A" features and "B" features. Based on the criteria provided all of the watercourses within the study area are considered "A" features. The Official Plan describes various restrictions on land use within Supporting "A" and "B" Natural Features and provides guidance on buffers. Section 8.2.5(7) recommends a 30 m buffer be applied to perennial watercourses under the Supporting "A" Natural Features category as shown on Figures 6.3 and 6.5.

6.3 Buffers

Besides protecting environmental features and functions, buffers add an additional constraint to development limits. The Grand River Conservation Authority, the City of Waterloo, and the Region of Waterloo have provided guidance regarding setbacks/buffer standards to protect features and functions as outlined in Table 6.1 below.

Table 6.1 Agency Recommended Development Setbacks for Terrestrial Ecological Constraints

<table>
<tr><th>Feature/ Function</th><th>Buffer Width/ Protected Habitat</th><th colspan="5">Discussion</th></tr>
<tr><td rowspan="3">Habitat of Endangered and Threatened Species</td><td rowspan="3">Species-specific</td><td colspan="5">Varies depending on the species, the General Habitat Category, and site-specific context. To be confirmed by MNRF.</td></tr>
<tr><td rowspan="2">Species</td><td colspan="3">General Habitat Category</td><td rowspan="2">Comments</td></tr>
<tr><td>1</td><td>2</td><td>3</td></tr>
<tr><td>Blanding's Turtle</td><td>Nest/ overwintering sites and the</td><td>All suitable wetlands/ waterbodies within 500 m of each other extending up to 2 km</td><td>Area 30 – 250 m around suitable wetlands/ waterbodies identified in Category</td><td>Tolerance to alteration of general habitat</td></tr>
</table>

			area within 30 m.	from an occurrence, + 30 m buffer.	2, within 2 km of an occurrence.	increases from Category 1 to 3.
		Barn Swallow	Nest	The area within 5 m of the nest.	The area from 5 m to 200 m of the nest.	
Provincially Significant Wetlands (PSW)	30 m	Discussions with GRCA indicate that a 30 m buffer from the PSW will be required and that it should be commensurate with the life history requirements of the various taxa present. Grading or special uses (*e.g.*, stormwater management facilities) may be permitted within the buffer, subject to GRCA approval. City of Waterloo Official Plan policy also provides guidance with respect to buffers of Core Natural Features (including PSW's), stating that buffers are to remain in a primarily natural state or be restored (if already disturbed). This policy allows for some low impact uses and stormwater management facilities within buffers (see City of Waterloo Official Plan Policy 8.2.4(9) for full detail).				
Environmentally Sensitive Policy Area (ESPA)	10 m / 15 m	Region of Waterloo policy requires 10 m setback from driplines. City of Waterloo policy also indicates a minimum 10 m buffer.				
Environmentally Sensitive Landscape (ESL)	None	Urban development is not permitted within ESL; Core features require a minimum 10 m buffer, to be assessed in an EIS.				
Significant Wildlife Habitat	Site-specific	To be determined at site plan stage. Most categories of SWH are within protected ecological features.				
Core Environmental Features in the Regional Greenlands Network	Site-specific	Core features require a minimum 10 m buffer from driplines, to be assessed in an EIS.				
Ecological Linkages	Site-specific	Ecological linkages are protected as part of the Regional Greenlands Network. Floodplain designations and setbacks from Wideman Creek will enhance the size of the corridor; buffers for hedgerows will be determined through site-specific EIS.				
Supporting Natural Features	Locally Significant Wetlands: 15 m Intermittent watercourse: 15 m from each side of watercourse measured from bankfull channel	Refer to City of Waterloo OP Section 8.2.5.				

Buffers will help protect and maintain most significant wildlife habitat functions in protected sensitive areas. The implementation of buffers and creation of new habitats can result in a net gain in overall natural vegetation cover as compared to existing conditions.

Based on current policy guidance and findings from the field studies undertaken for the Erbsville South Environmental Study, the following minimum development setbacks are recommended and are illustrated on Figures 6.1, 6.3, 6.4, and 6.5:

- PSW wetland: 30 metres
- ESPA: 10 metres
- Watercourses: 30 metres
- Woodlands: 10 metres

Finalized buffer widths should be established at the development stage through an Environmental Impact Study, when information on proposed adjacent land uses and lot layouts are known.

6.4 Natural Hazard Constraints

Natural Hazard areas also provide a significant constraint to future development. Within the Erbsville South Study Area flooding hazards are a significant constraint. The floodplains of Laurel Creek and Wideman Creek and its tributary are considered a One Zone Area. Policies under the Provincial Policy Statement, Grand River Conservation Authority, the City of Waterloo and the Regional Municipality of Waterloo state that development and site alteration shall not be permitted within One Zone Policy Areas. Figure 4.1 illustrates the limits of the flood plains, as defined by the Regulatory Floodline, for Laurel Creek and Wideman Creek. The revised Regulatory Floodline for Wideman Creek, based on improvements to the Erbsville Road culvert discussed in Section 4.1, is also shown on Figures 6.3 and 6.5.

7 Stormwater Management

7.1 Stormwater Management Criteria

The stormwater management criteria for future development areas within the Study Area have been set through previous studies including the Laurel Creek Watershed Study, the subsequent Subwatershed Plans #313 and #309 Study, and additional review and verification throughout this Environmental Study process. The Study Area is located within subwatershed #309, and the stormwater management requirements include:

- Stormwater management facilities are required to provide water quantity (peak flow) control for the 2, 5, 25, and 100 year storms. The targets to control post-development flows to pre-development levels are provided in Table B4.3 of the SWP;
- Extended detention control for erosion control is required for runoff volume in excess of the existing 100 year runoff volume as outlined in Table D1.3, Page D-27 of the Subwatershed Management Plan and are to be released over a 48 hour period;
- Stormwater management facilities are required to provide an enhanced level of water quality control for all flows not infiltrated across the site. The level of treatment must meet water quality targets established in the SWP and MOE (2003) for Enhanced Protection Level;
- Thermal impacts on Laurel Creek and Wideman Tributary must be avoided or mitigated where necessary;
- Low Impact Development (LID) measures should be considered on a site-specific basis to provide on-site stormwater management enhancements;
- Maintaining the infiltration capacity and seepage characteristics of the site is a requirement of the SWP and the recommendations of the Hydrogeological Investigation. The proposed development is required to provide both infiltration to depth and maintain seepage toward wetland areas. At-source infiltration measures will be provided to promote infiltration of clean and treated runoff to maintain existing infiltration rates as close to existing levels as possible;
- Grading and servicing design must ensure that there are no adverse impacts on groundwater and on the adjacent significant natural features; and
- All development must remain outside of the established buffers in accordance with City of Waterloo Official Plan Policy 8.2.4(9). Portions of stormwater management facilities such as pond outfalls will only be permitted where *"… the Core Natural Feature can be enhanced, no other alternative location is feasible, low impact development measures are implemented to the extent feasible outside the buffer, root zones are not impacted, and the facility replicates or complements an existing function of the buffer lands."*

Based on the development constraints identified in Section 6.0 there are five potential development or redevelopment parcels within the Study Area (Areas 101 to 105) identified on Figure 7.1, and discussed in further detail below. Note that Figure 7.1 also identifies the approximate sanitary sewer inverts and locations, based on the as-constructed trunk sanitary sewer on Erbsville Road.

7.2 External Areas

The current stormwater outflow from the Laurel Creek Village Subdivision pond to the south of Wideman Road currently drains through a small wetland area to a the western roadside ditch along Erbsville Road. Assuming this configuration remains there should be no impact to the stormwater management design for any developing areas. However, if the existing driveway culvert servicing Area 102 requires replacement, hydraulic calculations must confirm that it has the capacity to convey the 100 year peak flow from the Laurel Creek Village Subdivision stormwater management pond, and from all other adjacent drainage areas.

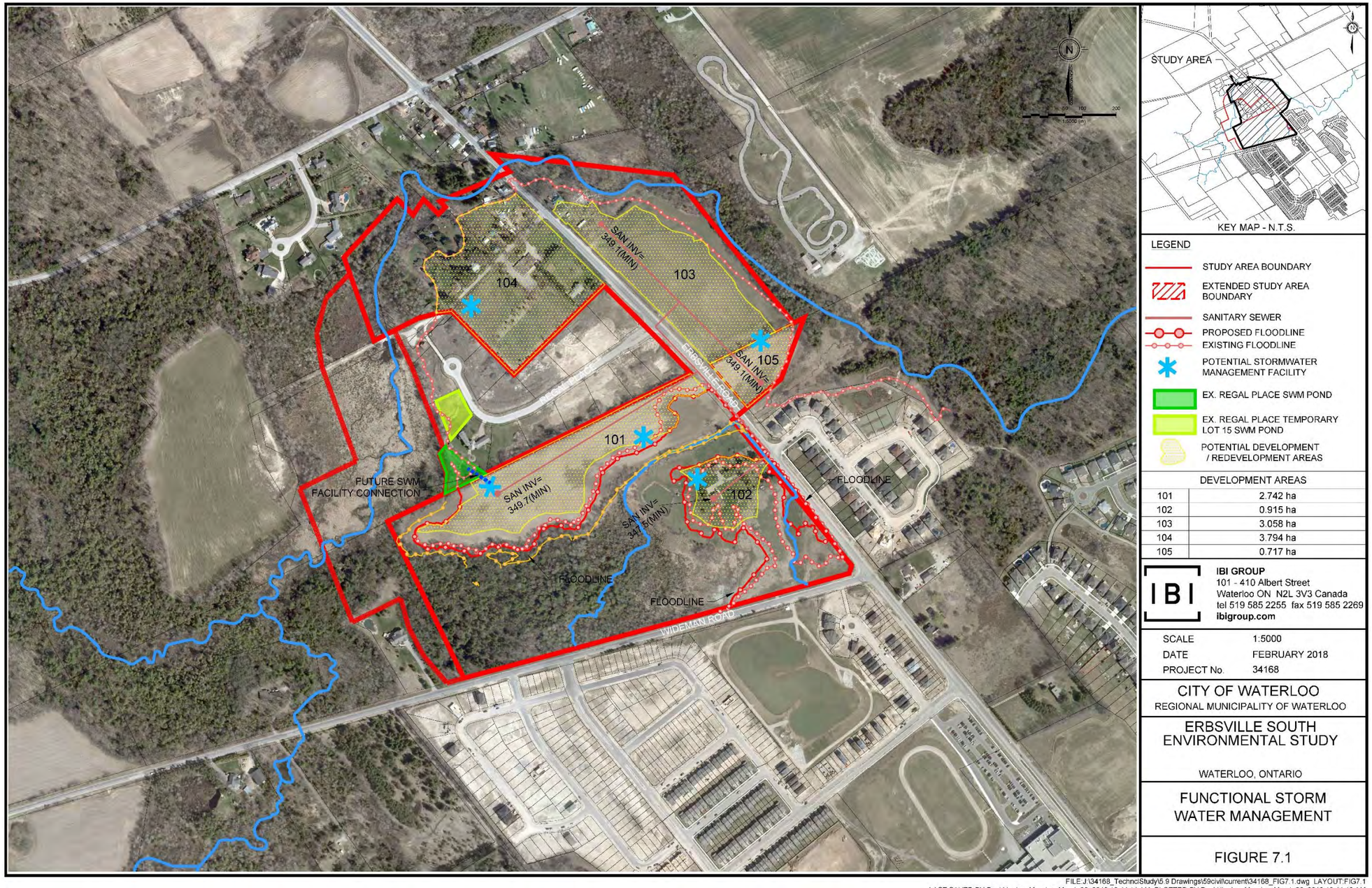

Figure 7-1 Functional Stormwater Management

7.3 Stormwater Quantity and Erosion Control

The proposed conditions hydrologic modelling should be completed using the SWMHYMO computer model (or approved equivalent) to determine storage requirements for a range of events including the 25mm, and 2, 5, 25, and 100 year storms for each development parcel. The required quantity criterion will be to control post-development conditions peak flows to pre-development conditions levels as defined in the SWP. The outlet locations and storage area configurations are discussed below for each potential development area. The SWP provides the peak flow and erosion control targets, and additional modelling should be completed once development concepts and functional grading designs have been prepared, to confirm the erosion thresholds developed in the Fluvial Geomorphology component of this Study (see Section 3.3).

7.4 Stormwater Quality Control

An Enhanced Protection Level for stormwater quality control is required, including modelling and retention times for the 25mm storm, as is extended detention for erosion control as per the SWP. Preliminary plans for stormwater management facilities, including ponds will be prepared at the development application stage. The stormwater management designs should utilize Low Impact Development (LID) measures that avoid thermal impacts of storm runoff. Based on the relatively small drainage areas for the developing parcels (< 5 ha), stormwater management for quality control will likely comprise of a treatment-train approach since the areas are too small to support constructed wetlands (as per MOE 2003). The designs are expected to include oil/grit separators, vegetated swales, infiltration swales, and vegetated spreader swales to provide treatment of runoff. Thermal impacts can be mitigated using infiltration methods, SWM ponds configuration, and planting strategies.

7.5 Water Balance and Infiltration

The native soils throughout the Study Area are typically sandy with a low to moderate silty component resulting in a relatively low to moderate permeability, with an estimated annual infiltration rate of 110 mm/year, with relatively shallow groundwater levels. Post-development site infiltration should be designed to attempt to match pre-development rates within the Study Area through methods such as at-source infiltration from rooftops connected to infiltration galleries, where feasible. Under post-development conditions, runoff contributions from the Study Area to adjacent wetlands and other catchments should also match pre-development rates.

As noted in the Hydrogeological Investigation (Section 5.4), the pre-development infiltration rate is relatively low, and wetland areas are supported in part by surface water runoff. Measures to maintain runoff volumes and direct it towards wetland areas will be important to maintain the function of the wetlands. Depression-focused infiltration within the wetland areas should be maintained by maintaining runoff rates to the wetlands.

Water balance calculations should be completed based on the recommendations of the Hydrogeological Investigation to ensure that the hydrologic balance and hydrogeological regimes sustaining natural areas and watercourses are maintained. An analysis of wetland hydroperiod (depth, duration, and extent of flooding) and lag times between storm events and peak discharge rates should be undertaken when preliminary design concepts and outlet locations are available. The water balance calculation methodology utilized for developments in Waterloo (Westside Lands, Laurel Creek Village, White Tail Crossing, etc.) and other developments throughout Southwestern Ontario should be adopted for this study. This is generally a spreadsheet calculations based on the methodology in Section 3.2 of the *Stormwater Management Planning and Design Manual* (MOE, 2003), which can be augmented by hydrologic modelling to provide additional hydrograph timing information.

Recommendations and preliminary designs for infiltration methods and infrastructure should also be provided. At-source infiltration of precipitation from rooftops (or other impervious areas), is dependent on the native soil types, and specific design components (infiltration trenches, infiltration swales) and should be investigated on a site-by-site basis during the development stage. Site grading must consider shallow groundwater elevations as well as subsurface soil types to avoid the potential of localized groundwater mounding from at-source infiltration that could impact footings and foundations.

7.6 Development Areas

Figure 7.1 indicates the locations of the five potential development areas within the Study Area. The proposed stormwater management for each is described as follows:

Area 101

This 2.742 ha area includes agricultural fields that drain toward Wideman Tributary to the south under existing conditions. A smaller area drains west toward Laurel Creek. Two SWM ponds are proposed for this area and are shown on Figure 7.1. The first pond is proposed to be located at the southeast part of the property, and should provide stormwater quantity control and erosion control for the majority of the area. The pond should outlet to the buffer area along the southern portion of this parcel, with flows then discharging to Wideman Creek. The design will include the consideration of maintaining surface drainage to adjacent wetlands as part of the site water balance calculations, and will incorporate features that provide mitigation of thermal impacts of runoff.

A second pond should be located at the western end of this parcel, and should provide stormwater quantity control and erosion control for lands draining west toward Laurel Creek. This pond is proposed to be connected to the existing Regal Place development SWM pond to the north of Area 101. The connection would include the construction of a pipe through the existing hedgerow (Polygon 44). Alternative methods to install the pipe to minimize impacts to trees (i.e., trenchless methods vs. open cut) will be explored at the development application stage.

In order to provide the storage requirements to meet the SWP targets, a temporary secondary SWM pond was constructed on lot 15 on the Regal Place development to service that development. Although that pond was designed to meet the required specifications and criteria, it is considered to be temporary until a permanent SWM pond on the west part of Area 101 can be constructed. Once a concept plan has been developed, the configuration of the west pond and its connection with the existing Regal Place pond can be confirmed. The approximate connection location is shown on Figure 7.1.

The existing Regal Place main stormwater management pond and the proposed pond at the west part of Area 101 would function as one connected hydraulic unit, with the existing Regal Place main pond outlet toward Laurel Creek providing flow control. Stormwater quality control should include a treatment-train approach, including oil/grit separators and swales. The area draining to the common Regal Place and Area 101 pond will be in part treated by the exiting configuration, as well as by new SWM facilities constructed as part of the Area 101 development. The existing Regal Place main pond was designed as a wetland (prior to MOE 1994/2003 standards). An OGS unit was added in the recent re-design for Regal Place, which provides stormwater quality treatment for the Regal Place subdivision. It is likely that future development within Area 101 draining toward the west will also include an OGS unit, and additional polishing in the proposed Area 101 pond cell.

Area 102

This 0.915 ha area includes an existing residential building and lawn and landscaped areas. The area drains in a north direction, and outlets to Wideman Creek. Given the relatively small area of this parcel, it will likely be developed as a Site Plan or Draft Plan of Condominium. Stormwater management should therefore be provided on-site (rooftop storage, surface storage, oil/grit separators, etc.), and should be required to meet all the SWP targets outlined above. If a pond is proposed for stormwater quantity and erosion control, it could potentially be located as shown on Figure 7.1 at the northwest part of this area.

Area 103 and Area 105

Area 103 is a 3.058 ha area that includes agricultural fields that drain toward Laurel Creek to the east under existing conditions. Area 105 is an approximately 0.717 ha triangular shaped parcel located immediately south of Area 103 east of Erbsville Road (See Figure 7.1). At the owner's request Area 105 was not included in any of the field surveys undertaken for the Erbsville South Environmental Study as it has already gone through extensive review and evaluation of environmental constraints and received planning approvals. However this parcel remains undeveloped as conditions of draft approval state that this parcel must be developed in conjunction with the development of Area 103, including roadways, sewer and water connections, and

stormwater management. Consequently the stormwater management strategy outlined for Area 103 must also apply to this parcel.

One SWM pond is recommended for the two areas and should be located at the southeast corner of Area 103 and/or within Area 105 as shown on Figure 7.1. It should provide stormwater quantity control and erosion control for the majority of the area. The pond should outlet to the buffer area in the southeast of the property, with flows then discharging to Laurel Creek. In this regard, thermal mitigation methods will be required. Stormwater quality control should include a treatment-train approach, including oil/grit separators and swales.

Area 104

This 3.794 ha area includes existing residential lots, a former public school site now a day care facility, and wooded areas that drain northwest toward Laurel Creek. At this time there is no indication that this area or any part of it will be redeveloped in the near future. Consequently no SWM ponds have been proposed for this area. Never the less in the event that a redevelopment concept is prepared, stormwater management will be required to meet all the SWP targets outlined above. A conceptual location of a stormwater management facility is shown on Figure 7.1, based on the lowest topographic location within the area. The pond would continue to drain Area 104 toward Laurel Creek.

7.7 Monitoring

The SWP indicates that a Maintenance, Monitoring and Response (MMR) program is required for the during-development period. The developer is responsible for maintenance monitoring and response activities until the end of the guarantee period. The City of Waterloo also provides guidelines in the City of Waterloo Development Monitoring Protocol Document and Section 6.0 of the Development Engineering Manual. The general components of the monitoring are described below, and specific monitoring locations and parameters will be identified as each Area proceeds to the development application stage. The conceptual locations of the stormwater management facilities are shown on Figure 7.1.

Pre-Development Monitoring

Pre-Development Monitoring for stormwater management features will include surface water monitoring, and will integrate the results of the on-going groundwater monitoring and ecological monitoring. The surface water monitoring should be located within the receiver watercourse, where the future stormwater management facilities are intended to outlet to. Results of this monitoring are submitted to the City once per year at the end of the monitoring season. The intent of the Pre-Development monitoring is to establish and maintain a baseline of data to which future During-Development and Post-Construction Monitoring data can be compared to and analyzed.

During-Development and Post-Construction Monitoring

The Guarantee Period Monitoring component (During-Construction Monitoring and Post-Construction Monitoring) of the MMR Program would begin when the first stage of construction commences and will continue until the end of the guarantee period when the City assumes the road works and stormwater management facilities. This monitoring will consist of the inspections of the specific stormwater management facilities. The Pre-Development Monitoring will continue until the end of the guarantee period for the development.

Water quality testing for total suspended solids, temperature, dissolved oxygen, and chloride will be conducted on effluent from the pond. The Laurel Creek Watershed Study requires event-mean concentration with flow 162proportional sampling, and monitoring reports will be submitted to the City once per year at the end of the monitoring season. Event-mean sampling will be conducted during the Post-Construction period only. The target concentration from the stormwater management pond is 25 mg/L. The event mean concentration of total suspended solids will be measured with flow proportional sampling while the other parameters will have a single sample taken at the inlet and outlet.

It is important to provide a response program if the targets for the stormwater management are not being met on a consistent basis. The initial response to the identification of any problem (by inspections, monitoring, etc.) will be to conduct a detailed investigation of the problem area immediately to determine the source of the problem. Once the source has been discovered, a brief report should be submitted to the City outlining the problem, the

methodology and results of the detailed investigation and the proposed method of resolving the problem. The City can then approve the proposed solution or suggest that another alternative be evaluated.

Table 7.1 provides an overview of the inspection and monitoring requirements for typical stormwater management infrastructure:

Table 7.1 Monitoring Summary

Facility	Task	During Construction		Post Construction	
		Frequency	Comments	Frequency	Comments
Stormwater Management Ponds	Regular Inspection	After storm events (about 4/yr)	General inspection of facility, single samples as required	Once per year	General inspection of facility, event-mean samples
Oil/Grit Separator Units	Sediment Depth Oil Accumulation	Twice/year	Measure and clean as needed	Once/year	Measure and clean as needed
Infiltration Galleries	Regular Inspection	Twice/year	Measure after storm and again 3 days later	Once/year	Measure after storm and again 3 days later
	Valve Operation	Once/year	Open valve in spring, close in fall	Once/year	Open valve in spring, close in fall
Lot Level Soakaway Pits	Regular Inspection all lots	Twice/year	Measure after storm and again 3 days later	Once/year	Measure after storm and again 3 days later

Maintenance is critical for all stormwater management facilities to ensure continued operation and efficiency. The maintenance requirements for the stormwater management facilities are based on information provided in MOE 2003 and the SWP. Maintenance requirements are expected to include the following components:

- Regular inspections as noted in Table 7.1;
- Sediment removal;
- Replanting of dead or dying vegetation; and
- Repair of eroded areas and infrastructure (slopes, pipes, outlets, headwalls, etc.).

8 Impact Assessment and Mitigation Measures

8.1 Impact Assessment and Response

This section discusses the type of impacts that could reasonably be expected to occur and the recommended measures to be taken in order to avoid, mitigate and/or compensate for these impacts. Table 8.1 lists various future development activities and their potential direct and indirect impacts that could occur to the natural features within the study area. Prevention, minimization and mitigation measures are summarized for each potential impact identified, pre, during and post development.

Specific details of proposed vegetation clearing, grading, servicing, building construction and human occupation will be determined on a site-specific basis during future development planning. Table 8.1 was prepared based on a number of assumptions:

- It was assumed that vegetation clearing, grading, servicing and building construction would be concentrated in cultural/anthropogenic features, agricultural fields and field edges, and possibly cultural woodlands and hedgerows.
- The human occupation section assumes residential development, however the impacts and impact response measures can be apply to other types of development as well
- Widening of Erbsville Road by the Region to a 30.5 m ROW requires additional property on west side of Erbsville Road. The road will likely be designed with an urban cross-section including storm drainage that will discharge to Wideman Creek. The future road widening as defined by the Official Plan for the Regional Municipality of Waterloo, will be taken by the Region either as a condition of or pre-requisite to any future Planning Act application. The widening would extend along the entire frontage of Erbsville Road. Water mains and sanitary sewers to support future development have already been installed.
- There will be a new roadway entrance into property across from Forest Gate Crescent.
- Wideman Creek Culvert Replacement (per SWP recommendations) is planned to convey Regional Storm flows. Culvert design includes an open bottom with dimensions supporting passage for small to medium-sized wildlife.

8.2 Buffer Identification, Analysis and Management

As discussed in Section 6.3, buffers will help protect and maintain most significant wildlife habitat functions in protected sensitive areas. The implementation of buffers and creation of new habitats can result in a net gain in overall natural vegetation cover as compared to existing conditions.

Based on current policy guidance and findings from the field studies undertaken for the Erbsville South Environmental Study, the following minimum development setbacks are recommended and are illustrated on Figures 6.3 and 6.5:

- PSW wetland: 30 metres
- ESPA: 10 metres
- Watercourses: 30 metres
- Woodlands: 10 metres

Depending on the presence of site-specific features and/or functions, their sensitivity, and the type of proposed development planned, buffers widths should be reviewed and refined during site specific EISs.

In order to help ensure buffers function at optimal levels and meet their objectives of protecting Core Natural Features and where feasible, enhancing or restoring Core Natural Features and their ecological functions, the following buffer management measures are recommended:

Table 8.1 Impact Assessment & Response

Impact Type	Description of Potential Impacts	Proposed Impact Response Measures	
		Prevention	**Mitigation**
Culvert Retrofit	The Wideman Creek culvert crossing Erbsville Road will be replaced with a larger open bottom culvert including terrestrial benches and other design features to provide a safe wildlife crossing. Once constructed it is anticipated that the environmental impact of the culvert retrofit will be positive, however negative impacts may occur during construction. Direct Impacts: o Temporary disturbance to wildlife o Temporary vulnerability to soil erosion in the area of the culvert resulting in potential for siltation to adjacent creek o Potential for increase in road kills Indirect Impacts: o Altered hydrology of natural features upstream of culvert resulting from the altered floodline. IBI has modelled the existing and future Regional Floodlines. The Regional storm floodplain on the Wideman property south of Regal Place will be more confined due to the culvert retrofit. Impacts of this altered floodline to natural features will be negligible, and likely undetectable. Changes under more frequent storm events may impact natural features and functions in the immediate vicinity of the watercourse.	Pre-Construction: o Culvert should be designed to direct wildlife usage (i.e., terrestrial benches, curb walls. directional plantings, drift fencing). This should result in a reduction in road kills. o Prepare Environmental Management Plan to summarize protective measures and actions during construction, and guidelines for incidents and emergencies related to natural environment. o Construction timing should avoid sensitive seasonal windows for wildlife. However, given overlapping timing restrictions for Brown Trout, Blanding's Turtle and breeding birds, it is recommended that clearing and construction activities be restricted to July 1 – August 31. While this window avoids the turtle nesting period and the fall Brown Trout spawning/egg and fry development period, potential conflicts with nesting birds are still possible. Therefore, to ensure no nesting birds are disturbed (*i.e*. compliance with the Migratory Birds Convention Act), screening surveys should be conducted by a qualified bird expert immediately prior to construction activities being initiated. o Prepare erosion and sediment control plan During Construction: o Place interim barriers and signage to reduce wildlife mortality o Monitor and maintain erosion and sediment control measures. o Reduce wildlife disturbance by minimizing periods of heavy equipment operation. o Install fencing around the mouth of the creek underpass to prevent wildlife species (including turtle species) from gaining access to Erbsville Road. The fencing should be consistent with OMNR's 2013 Best Practices Technical Note "Reptile and Amphibian Exclusion Fencing", and extend north to the development limit (where additional wildlife exclusion fencing will be installed), and south all the way to Wideman Road. Post Construction: o Remove erosion control fences once construction is complete and all soils are vegetated and stable. o Install permanent road signage warning drivers of potential wildlife presence o Monitor groundwater and floodplain impacts	Pre-Construction: o Implement sediment and erosion control measures prior to construction o Educate supervisors and workers on key natural environmental protection practices, following Environmental Management Plan. During Construction: o Monitor and maintain sediment and erosion control measures throughout construction o Maintain records of monitoring, maintenance and incidents Post Construction: o In conformity with the Final Subwatershed Management Plan (Planning Initiatives Ltd., 1996), enhancement plantings of native vegetation should be installed within the 30 m watercourse buffer following construction of the new culvert.
Vegetation Clearing	Vegetation clearing may include removal of existing trees, successional growth or meadow cover. Direct Impacts: o Potential damage to protected natural features o Removal of specific wildlife habitat (i.e., active bird nests, tree cavities) o Disruption of wildlife habitat supporting seasonal use (i.e., foraging, nesting and migratory habitat) o Micro-climate alteration (i.e., edge tree removal may create exposure of vegetation unaccustomed to greater light and wind exposure, causing in decline, mortality and species composition within the protected feature) Indirect Impacts: o Reduction in local native species abundance and diversity o Decreased evapotranspiration and carbon sequestration o Soil erosion resulting in potential for siltation to adjacent creek and PSW o Clearing in or near wetlands may alter local hydrologic functioning over time	Pre-Construction: o Plan erosion and sediment control plan for susceptible areas including slopes, wetlands and watercourses. o Plan protective measures at limits of setbacks/buffers to feature boundaries o Complete site-specific arborist assessment for trees proposed for removal or preservation o Plan clearing operations to avoid sensitive seasonal timing windows for wildlife (i.e., migratory bird nesting and turtle nesting periods: restrict clearing activities to between August 1 and April 30) to avoid conflict with Migratory Birds Convention Act. Conduct screening surveys to ensure that nests are not present if timing requires construction during nesting period. o .Review development plans and modify if required to ensure hydrologic functions of wetlands and watercourses are not impacted by vegetation removal. o In the potential development area north of Schnarr Street (see Figure 7-1), as many trees should be protected within the development envelope as possible to reduce potential impacts on candidate Significant Wildlife Habitat (i.e. breeding birds whose populations appear to be experiencing substantial declines in Ontario). During Construction: o Avoid removal of natural vegetation along edges of wooded features and vegetation providing wildlife habitat. o Monitor and maintain erosion and sediment control plan measures. o Maintain setbacks/buffers to feature boundaries	Pre-Construction: o Implement protective fencing and other measures o Prepare edge management plans where feature edge disturbance will occur to ensure that the new "edge" contains vegetation species which are adaptive to new micro-climate changes o Identify woody materials to be salvaged for use in habitat enhancement works, or to be transplanted. Identify areas for storage or 'healing-in' o Install artificial nesting structures for Species at Risk (i.e., Barn Swallow nest structure within 1 km of removed nesting site and within 200 metres of appropriate foraging habitat, and ensure all other conditions contained in Section 23.5 of Ontario Regulation 242/08, issued under the Endangered Species Act (2007), are followed.) o Conduct nesting bird surveys and implement buffers or other avoidance measures if clearing must occur between April 30 and Sept 1. o Restore and enhance wildlife habitat to compensate for loss (i.e., create turtle nesting areas within buffers) Post Construction: o Tree and shrub plantings to compensate for tree removal; edge reinforcement where the integrity of the woodland edge has been disturbed or compromised o Compensation plantings and habitat creation to offset impacts to existing habitats or species diversity

Impact Type	Description of Potential Impacts	Proposed Impact Response Measures	
		Prevention	**Mitigation**
		Post Construction: o Maintain and monitor erosion and sediment works until construction is completed and disturbed areas are re-vegetated.	
Grading and Drainage Alteration	Grading plans will be prepared on a site-specific basis. Grading will primarily occur within developable areas, and may extend within buffers subject to agency approvals. Direct Impacts: o Temporary increase in susceptibility to erosion o Temporary disturbance to wildlife and interference with habitat functions (if conducted during key seasonal windows). o Alteration of landform complexity and drainage patterns/hydrologic functioning. Indirect Impacts: o Grading in close proximity to treed features or individual trees may cause hydrologic alteration that result in tree decline o Increased erosion could cause sediment runoff into wetlands and watercourses.	Pre-Construction: o Prepare erosion and sediment control plan for susceptible areas including slopes, wetlands and watercourses. o Plan protective measures at limits of setbacks/buffers to feature boundaries void grading within the drip line of trees that are to be retained. Tree protection fencing meeting City standards to be installed prior to grading. o Time grading activities to avoid sensitive periods of habitat use (breeding, nesting, seasonal migration) by amphibians, turtles and birds. o Identify site-specific water balance strategies. Maintain/match contribution of existing surface drainage catchment areas. Careful review (and alteration if necessary) of development plans to ensure hydrologic functions of wetlands and watercourses are not impacted by vegetation removal and grading works. o Plan and design Low Impact Development (LID) strategies to reduce alteration of water quality or quantity interactions between development sites and wetlands (i.e., bioswales). o Wet weather plan for emergency measures During Construction: o Maintain and monitor protective measures at setbacks/buffers to feature boundaries o Control access, storage and movement of equipment away from sensitive areas. o Provide interim seeding of exposed areas Post Construction: o Provide contract requirements for removal of sediment control fences within 12 months after completion of servicing.	Pre-Construction: o Implement erosion and sediment control plan in susceptible areas including slopes, adjacent to wetlands and watercourses. During Construction: o Monitor and maintain sediment and erosion control measures throughout construction o Maintain supplies for prompt cleanup and repair for spills and other events which may occur Post Construction: o Reinstate vegetative cover promptly in compliance with GRCA and City timing requirements. o Implement Low Impact Development (LID) strategies to reduce alteration of water quality or quantity interactions between development sites and wetlands (i.e., bioswales). o Remove erosion control measures once soil construction is completed and adjoining slopes are stabilized.
Servicing	Service installation (roads, water supply, sewers, stormwater management facilities, natural gas and hydro) will be necessary to support future development. Direct Impacts: o Vegetation clearing and tree removals o Temporary or permanent increase in runoff and potential erosion o Temporary or permanent disturbances to wildlife and interference with habitat functions (especially if installation occurs during key seasonal windows). Indirect Impacts: o Increase in erosion risk could impact nearby wetlands and watercourses o Installation of infrastructure in close proximity to treed features or individual trees may cause alterations (i.e., microclimate) that result in tree decline o Increased vehicular traffic may result in increased roadkill of wildlife o Bedding for buried services may intercept groundwater and divert or modify flows	Pre-Construction: o Develop and implement erosion and sediment control plan. Install approved sediment and erosion control measures in susceptible areas to reduce erosion impacts to slopes and prevent sediment from entering wetlands and watercourses. o Mark setbacks/buffers to feature boundaries and install protective fencing and other measures. o Complete site-specific arborist assessment for trees proposed for removal prior to installation of servicing o Time servicing activities to avoid sensitive periods of habitat use and re-establish temporarily-removed vegetation as soon as possible. o Design underground services to minimize impacts on groundwater flows. During Construction: o Avoid grading alterations within the drip line of trees that are to be retained. Tree protection fencing should be installed at tree drip lines prior to service installations to ensure contractors are aware of setbacks. o Control access and movement of equipment. o Maintain protective fencing and other measures along natural feature setback limits. Post Construction: o Provide contract requirements for removal of sediment control fences within 12 months after completion of servicing.	Pre-Construction: o Design planting plans to re-vegetate cleared areas using adaptive native species During Construction: o Implement Low Impact Development (LID) strategies to reduce alteration of water quality or quantity interactions between development sites and wetlands (i.e., bioswales). Post Construction: o Implement planting plan to re-vegetate cleared areas o Provide low impact lighting of streets and public space in conformity with Regional standards. o Remove erosion control fences and measures once servicing is completed, grades restored, and adjoining slopes are stabilized.
Building Construction	Direct Impacts: o Potential for contaminated runoff (i.e., industrial and automotive chemicals) to enter adjacent natural areas and negatively impact vegetation and wildlife	Pre-Construction: o Control use of hazardous substances/ chemicals/ materials on construction sites by providing contractors with written notification of expectations regarding use and disposal of such items.	Pre-Construction: o Inspect and maintain temporary fencing at limit of development. During Construction:

Impact Type	Description of Potential Impacts	Proposed Impact Response Measures	
		Prevention	**Mitigation**
	o Potential for sediment related impacts to water quality in wetlands and watercourses. o Construction materials and waste often generate litter and trash entering natural habitats. o Storage and movement of equipment and materials may damage protected areas Indirect Impacts: o Increased level of human activity resulting in higher noise levels which may negatively affect wildlife behavior within adjoining natural features. o Sediment related impacts could lead to a reduction in overall species diversity o Habitat degradation and injuries to wildlife from construction waste	o Mark setbacks/buffers to feature boundaries o Install protective barriers (i.e. double silt-fencing layer with hay-bale layer in between) around particularly sensitive areas such as wetlands and watercourses. o Plan stabilization measures (including emergency preparedness). During Construction: o Maintain setbacks/buffers to feature boundaries o Avoid artificial lighting of construction sites o Implement and monitor erosion control measures to reduce sedimentation and erosion transport runoff o Control use of hazardous substances/ chemicals/ materials as per contractor agreement o Avoid use of heavy machinery during key wildlife seasonal timing windows (breeding birds) o Provide storage and disposal for construction waste and debris Post Construction: o Maintain vegetated buffers and naturalized cover o Inspect and remove construction waste and debris o Provide contract requirements for removal of sediment control fences within 12 months after completion of construction o Install fencing along the limit of development/rear lot lines to prevent wildlife species (including turtle species) from entering residential areas or roadways. The fencing should be consistent with OMNR's 2013 Best Practices Technical Note "Reptile and Amphibian Exclusion Fencing".	o Inspect and maintain temporary fencing at limit of development. o Collect and remove construction waste on a weekly basis during active construction. Inspect adjacent natural areas to ensure that wind-borne trash has not accumulated. Post Construction: o Conduct final cleanup of construction waste and debris. o Decommission and remove erosion control measures once construction is completed and adjoining slopes are stable.
Human Occupation	There will be increased human presence following construction. Direct Impacts: o Potential introduction of non-native and invasive plants o Increased noise and general disturbance to wildlife o Artificial lighting may negatively affect wildlife behaviour within adjoining natural features. o Encroachments into edges and interior of natural features (i.e., trail creations, lawn extensions, dumping, trespass). o Increased potential for contamination of wetlands and watercourses through dumping of household paints or chemicals, pesticides and fertilizers applied to lawns, and run-off from vehicle maintenance. Indirect Impacts: o Introductions of non-native invasive species can ultimately lead to a reduction in native species abundance and diversity o Off-leash pets causing predation of wildlife	Post Construction: o Educate residents: • to use native or non-invasive species in landscaping, • to discourage encroachments into vegetated buffers such as dumping of yard waste; lawn extensions into buffers or features, or creation of informal trails • to keep pets indoors or on leash, • to ensure pools are not drained into natural areas, • to ensure safe disposal of chemicals and contaminants at municipal disposal sites. o Restrict or carefully control human access into natural features o Initiate and/or encourage local stewardship efforts o Develop monitoring plan for vegetated buffers and naturalized cover to identify encroachments, invasive species.	Post Construction: o Implement monitoring and management plan for vegetated buffers and naturalized cover to identify and remediate encroachments, invasive species. o Provide and maintain a low impact, publicly accessible trail system in less sensitive areas outside of natural features. Install educational signage (i.e., stay on trails, pets on-leash only, respect flora and fauna, etc.).
Trails (pedestrian/ recreational)	A site-specific assessment of the potential impacts of trails on associated natural heritage features and functions should be carried out, along with a similar identification of potential prevention and/mitigation measures, to determine if trails can be accommodated within or adjacent to (*i.e*. within buffers) core natural heritage features. **Direct impacts** Positive o Strategically located and maintained trails within the core natural heritage features may reduce the likelihood that informal trails will develop in more sensitive locations. o Allowing local residents to more closely interact with these natural features may increase their awareness and stewardship participation. o Trails located behind rear lot lines (in buffers) may: • Prevent local residents from encroaching their lot uses into neighbouring natural heritage features • Prevent or reduce the dumping of yard waste	Pre-Construction o Avoid areas of high ecological sensitivity (e.g. wetlands, turtle nesting habitat, habitat of area-sensitive species) o Ensure that construction work takes place outside of sensitive wildlife breeding seasons • To help ensure compliance with the Migratory Birds Convention Act (1994), restrict construction activities from taking place during the breeding bird season (i.e. between May 1 and July 31). Consult with the City for additional guidance. o Ensure that creek crossings are wildlife friendly and do not disrupt local animal movements/corridor function. • Ensure terrestrial access is available for wildlife passage under normal, seasonal water levels. During Construction o If breeding bird nesting activity is noted during construction, ensure construction is suspended temporarily and a pre-approved response protocol is followed. Post Construction o Ensure trails are maintained in an environmentally sensitive manner and no potentially damaging chemicals are used/enter the wetlands.	Pre-Construction o Develop adaptive management plan to respond to potential negative impacts. During Construction o Encourage a local stewardship ethic with interpretive signage to educate local residents and other users to the special qualities and/or sensitive nature of the adjacent natural heritage features. Ensure City and GRCA involvement with respect to the number of signs, their location and content. o Discourage uncontrolled access to the remaining natural areas through the use of strategic buffer plantings, landscaping, and installation of natural or artificial barriers. o Implement enhanced plantings zones at creek crossings to mitigate the disturbance to wildlife associated with the trails. Post Construction o Maintain and replace interpretive signage as necessary.

Impact Type	Description of Potential Impacts	Proposed Impact Response Measures	
		Prevention	Mitigation
	• Help prevent the spread of invasive, exotic plant species from residential lots Negative o Loss of natural habitat in core areas and/or buffers to accommodate trail construction and maintenance o Reduced ability to buffer impacts, unless buffer width is adequate to accommodate o Increased risk of inappropriate access to sensitive natural habitats/species. o Potential for off-leash dogs to disturb natural heritage features and wildlife. **Indirect impacts** o Increased disturbance (noise and visual) from human activities extending into core natural heritage, resulting in a decrease in habitat quality. o Increased opportunities for invasive species to establish and spread through increased pedestrian/pet traffic.		o Implement local monitoring program in accordance with Watershed Study recommendations to document impacts and trigger implementation of adaptive management plan.

1. Review and consider the mitigation measures recommended in Chapter 15 of the North Waterloo Scoped Subwatershed Study (pg. 341) (see below).

   "9) ***Buffer Management.*** *The following buffer management measures are recommended, with confirmation and/or refinements at the plan of subdivision stage through a detailed EIS:*

   a. Buffer Restoration and Enhancement Plan: Should site alteration be permitted within the buffer area, the EIS shall also include an appropriate grading and buffer restoration or enhancement plans, to the satisfaction of the City and agencies.
   b. Permanent fencing. At the natural heritage feature – development interface i.e. at the greater limit of the outside of the transitional buffer or whatever allowable encroachment into this transitional buffer is justified through a site-specific EIS for pedestrian trails and/or a portion of a SWM facility, as shown on Figure 14.3 - Development Constraint Limits.
   c. Signage. Interpretive / natural areas signage at regular intervals along feature limits.
   d. Native species plantings and/or managed succession. To be considered within the buffer areas where no SWM facilities / trails are proposed; and in portions of SWM blocks (e.g., berms). Consider specific direction provided in Section 14.2 and of the NWSSS and R.O.P. policy 7.I.12, buffer plantings should be of locally appropriate indigenous species.
   e. Target habitat creation. General – mix of successional habitats (meadow, thicket) and denser thicket / screening plantings in areas. Specific habitat elements are discussed in Section 14.4.
   f. Trails
      i. Subject to a future EIS, may be permitted in outer portions of the buffer (i.e., the 'outside' 5 m zone) if warranted for technical reasons and do not reduce the integrity and functionality of the buffer
      ii. Delineated by permanent fencing (i.e., between the trail and the natural feature) or other approaches (e.g., robust native vegetation) as may be established through a future EIS
      iii. The 'lightshed' of proposed lighting (i.e. distribution and coverage) should be considered in relation to both pedestrian safety and impacts to natural areas with the objective of restricting ambient lighting and directing away from natural areas to the extent possible
   g. Stormwater Management (SWM) Facilities
      i. Located outside buffers wherever feasible, but may be permitted partially within buffers, pending future approved site-specific EIS.
      ii. Similar planting / buffer treatments as remainder of buffer (i.e. native species, successional habitats, visual screening elements).
      iii. Provides an opportunity to supplement and enhance the recommended NHS through native species plantings and additional semi-natural area creation.
      iv. May include recreational trail links, with preferred location in the 'outer' portion (i.e. further from the natural area) of the SWM block."
2. Installation of turtle nesting habitat nodes adjacent to polygon 18.
3. Vegetation enhancement between polygon 18 and the main wetland block to the west, to help ensure that the pond remains suitable for pond-breeding salamanders (*i.e*. Red-spotted newts and Spotted Salamanders), as well as other frogs and toads.
4. Installation of snake hibernacula at select locations within the 30 m wetland buffer taking into account proposed grading, groundwater levels, and existing vegetation.
5. Maintenance and incorporation of marsh habitats along Wideman Creek corridor in anticipation of future wetland losses expected following widening of Erbsville Road.
6. Ensure only SWM pond outfalls are allowed to encroach into buffers.
7. Follow the prevention and mitigation measures for trails proposed in Table 8.1 in this report.

Similar to the identification of appropriate buffer widths, final approved buffer management measure should be confirmed or refined at the detailed EIS stage.

8.3 Ecological Enhancements

The Region's Greenlands Network Implementation Guideline states that "a*n ecological enhancement increases or improves the ecological functioning of altered or degraded natural areas".* Ecological enhancement opportunities identified through this study include improvements to the Wideman Creek corridor to strengthen and support its function as an ecological linkage; and potential enhancement opportunities related to the small wetland at the intersection of Erbsville Road and Wideman Road.

As previously discussed, the Wideman Creek corridor will be enhanced through installation of a new culvert that will facilitate movement of terrestrial wildlife and aquatic species. This will decrease road kills and strengthen the connectivity of the Regional Greenlands Network. There is an excellent opportunity to improve the Wideman Creek corridor linkage functions by increasing the natural cover within the future regional floodplain and/or the 30m minimum watercourse buffer; this is currently primarily in active agricultural cover.

Ecological enhancements opportunities related to the wetland at the intersection of Erbsville Road and Wideman Road and the outlet tributary have been explored with MNRF, GRCA, Region of Waterloo and City of Waterloo and details have been included in Appendix 6.1. The agencies have agreed that further discussion at this time is premature but should be considered during the Environmental Assessment process required for the widening of Erbsville Road.

Other ecological enhancements can be determined on a site-specific basis during the development application stage. Such enhancements may include:

- 'smoothing' of buffers to produce more uniform edges;
- restoration plantings;
- invasive species management (such as Tall Reed Grass control, Common Buckthorn removal);
- addition of wildlife habitat enhancements such as turtle nesting areas, snake hibernacula, and bird perching logs.

The Region's Greenlands Network Implementation Guideline should be consulted for future decisions regarding ecological enhancements.

8.4 Future Management Recommendations

Table 8.1 summarizes the potential terrestrial impacts of future development, and recommends preventative actions and mitigation. This is intended to guide the preparation development applications, which will need to be assessed through scoped Environmental Impact Studies to ensure that key recommendations are achieved. The underlying themes for future management of the natural heritage system are the protection of the PSW and ESPA as defined in this study, the consolidation of linkage functions using the enhanced Wideman Creek culvert and naturalized floodplain, enhancement of disturbed features such as the constructed pond, and integration of buffers for these features. These initiatives will represent major improvements to landscape level ecological functions. The detailed design of the road crossing will require the inclusion of plantings, step-walls or fencing to guide wildlife movements under the roadway. An Environmental Management Plan should be prepared to guide the construction process with environmental protection standards.

The following are key matters to be addressed at the development application stage, and considered in scoped EIS:

- Updated field data collection if scoped EIS are prepared more than 3 years after the finalization of the Erbsville South Environmental Study;
- Protection of existing natural heritage features through the development process, including buffers and water balance integration;
- Avoidance and/or mitigation of potential impacts on candidate Significant Wildlife Habitat;
- Minimization of impacts of artificial light on the ESPA/PSW and Wideman Creek corridor;
- Removal of invasive plants and guidance on appropriate landscape material;

- Management of human uses after construction, including protective fencing, demarcation and planting of buffers and/or natural feature enhancements;
- Trails planned and implemented to the satisfaction of the Region, City and GRCA;
- Education materials such as signage and a brochure for new residents regarding best practices; and
- Stewardship options to manage all components of the natural heritage system, including core natural areas, buffer zones and ecological linkages.

8.5 Monitoring

As a result of recommendations from the *Laurel Creek Watershed Study* (1993), the City of Waterloo has developed a three part monitoring program to ensure management practices are protecting Core Environmental Features and their functions as well as the functions of Supporting Natural Features. The three steps include 1) System Monitoring; 2) During Development Monitoring; and 3) Post Development Monitoring. Ongoing System Monitoring occurs across the entire Laurel Creek Watershed and is undertaken by the City, other agencies such as the GRCA, or other groups such as a community group. Details of the System Monitoring Program for Subwatershed #309 in which the Erbsville South study area is located can be found in the *Final Subwatershed Management Plan 313/309* (1996).

During Development Monitoring is undertaken by development proponents. *The City of Waterloo Development Monitoring Protocol* (City of Waterloo, 1999) outlines three stages of monitoring: Pre-Development or Pre-Construction Monitoring; During Construction Monitoring; and Post Construction Monitoring.

As discussed in Section 7.7 the intent of Pre-Development Monitoring is to establish and maintain a baseline of data to which future During Construction and Post Construction Monitoring data can be compared to and analyzed. Pre-development monitoring must be initiated no less than two years prior to any site disturbance (vegetation removal, grading) for a future development. Once construction is initiated a During Construction monitoring program will commence and will continue until the development reaches 90% buildout. At that point Post Development Monitoring is initiated and will continue through a 2-year guarantee period to ensure watershed targets are being met and ecological health maintained. This stage of monitoring generally focuses on the effectiveness of stormwater management facilities and other mitigative measures that were implemented during construction of the development to determine where and when further measures may be required.

Following the City's Monitoring Protocol and using baseline data collected in this study and supplemented by new information from future EISs, specific monitoring programs should be developed for each development area within the study area. Based on site specific development plans, potential impacts should be identified based on Table 8.1, and mitigation measures identified. The monitoring plan should address the scope, duration and reporting of key indicator attributes and their condition over time.

Monitoring results may identify encroachments into the protected areas, changes to populations of key biota and levels of invasive species. Potential negative impacts should be addressed through prescribed actions. At the end of the 2-year guarantee period, recommendations for continued monitoring, mitigation and maintenance will be provided to the City of Waterloo and agencies for incorporation into the ongoing Systems Monitoring Program.

Key components for surface and groundwater monitoring and stormwater management monitoring for a During Development Monitoring program have been discussed in Sections 5.6 and 7.7 respectively and are repeated again here in Table 8.2 along with biological components. In addition Appendix 6.2 outlines a geomorphological monitoring program in the event any watercourse in the study area is rechanneled or rehabilitated.

Table 8.2. Monitoring Plan Components

MONITORING ELEMENT	COMPONENT	PARAMETER	FREQUENCY		
			PRE-CONSTRUCTION	DURING CONSTRUCTION	POST CONSTRUCTION
Groundwater (GW)	GW Table Depth	Manual measurements of groundwater table depths in all well installations and continuous groundwater level recording with data-loggers in selected well installations	Quarterly	Quarterly	Quarterly
	GW Chemistry	Sampling and analysis of chemical parameters Na, Cl, Br, NO_3, P, dissolved O_2 and pH; physical parameters T, TDS, TSS, turbidity and E.C.; and biological parameters E. coli	Bi-annual	Bi-annual	Bi-annual
	Wetland	Manual measurements of groundwater table depths in all mini-piezometers and continuous groundwater level recording with data-loggers in selected mini-piezometers	Quarterly	Quarterly	Quarterly
Surface Water (SW)	SW Levels	Manual measurements of surface water levels in all streambed mini-piezometers and continuous surface water level recording with data-loggers in selected streambed mini-piezometers, including data of Erbsville flow gauge from GRCA (No. 8785042)	Monthly (March to November), 1 rainfall event within 24 hours (flush), 3 dry weather events (low flow conditions)	Monthly (March to November), 1 rainfall event within 24 hours (flush), 3 dry weather events (low flow conditions)	Monthly (March to November), 1 rainfall event within 24 hours (flush), 3 dry weather events (low flow conditions)
	SW Chemistry	Sampling (upstream, in stream and downstream locations) and analysis of chemical parameters P, CL, dissolved O_2; physical parameter TSS	Monthly (March to November), 1 rainfall event within 24 hours (flush), 3 dry weather events (low flow conditions)	Monthly (March to November), 1 rainfall event within 24 hours (flush), 3 dry weather event (low flow conditions)	1 rainfall event within 24 hours (flush), and 1 dry weather event (low flow conditions) per season
	SW Flow Rate	Flow and baseflow rate measurements at selected locations within various stream reaches	Monthly (March to November), 1 rainfall event, 3 dry weather events	Monthly (March to November), 1 rainfall event 3 dry weather events	1 rainfall event and 1 dry weather event per season
Biological	Vegetation/Flora	Record diversity, abundance, Floristic Quality Index (FQI), Tree height and diameter. Installation and monitoring of permanent 10m x 10m control and treatment forest monitoring plots based on Ecological Monitoring and Assessment Network (Roberts-	Annual	Annual	Annual

MONITORING ELEMENT	COMPONENT	PARAMETER	FREQUENCY		
			PRE-CONSTRUCTION	DURING CONSTRUCTION	POST CONSTRUCTION
		Pichette and Gillespie, 1999). FQI calculations based on Oldham *et al*. (1995).			
	Disturbance	Mapping and characterization of encroachment into natural areas following build-out.	Annual	Annual	Annual
	Calling Amphibians	Develop Marsh Monitoring Program (MMP) to record diversity and abundance	Annual	Annual	Annual
	Breeding Birds	Record diversity and abundance with 10 min. point counts, conducted at least one week apart, following Ontario Breeding Bird Atlas (OBBA) weather guidelines.	Annual	Annual	Annual
	Aquatic Habitat	In addition to SW Chemistry, water temperature to be taken using temperature loggers between June 1 and October 31. Utilize City of Waterloo system monitoring for benthic invertebrates and fish communities.	Annual	Annual	Annual
Stormwater Management (SWM)	SWM Ponds	General Inspection, manual measurements of surface water levels in all stormwater management pond	N/A	Monthly (March to November) 1 rainfall event, 3 dry weather events	Monthly (March to November) 1 rainfall event, 3 dry weather events
		Sampling at inlet and outlet locations and analysis of chemical parameters P, Cl, dissolved O_2; physical parameter TSS	N/A	Monthly (March to November), 1 rainfall event, 3 dry weather events	1 rainfall event and 1 dry weather event per season
		Flow rate measurements at discharge locations of stormwater management ponds	N/A	Monthly (March to November), 1 rainfall event 3 dry weather events	1 rainfall event and 1 dry weather event per season
		Regular inspection of operation	N/A	After storm events (4/yr)	Annual
	Oil/Grit Separator Units	Measure sediment depth and oil accumulation and clean as needed	N/A	Bi-annual	Annual
	Infiltration Galleries	Regular inspection – measure after storm and again 3 days later	N/A	Bi-annual	Annual

MONITORING ELEMENT	COMPONENT	PARAMETER	FREQUENCY		
			PRE-CONSTRUCTION	DURING CONSTRUCTION	POST CONSTRUCTION
		Valve Operation – open valve in spring, close in fall	N/A	Annual	Annual
	Lot Level Soakaway Pits	Regular Inspection on all lots – measure after storm and again 3 days later	N/A	Bi-annual	Annual
	Erosion and Sediment Controls	Inspect all SE controls and correct/repair/replace where necessary	N/A	Bi-monthly	Monthly

9 Conclusions and Recommendations

9.1 Natural Heritage Conclusions and Recommendations

Terrestrial:
Terrestrial ecological features and functions that have been identified in association with the Erbsville South Study area include:

1. Habitat of Endangered and Threatened Species
2. Significant Wetlands
3. Significant Wildlife Habitat
4. Species of Conservation Concern (watershed, regional, local)
5. Environmentally Sensitive Policy Area (ESPA)
6. Environmentally Sensitive Landscape (ESL)
7. Core Environmental Features in the Regional Greenlands Network
8. Ecological Linkages
9. Supporting Natural Features

A summary of possible negative impacts that have been identified as summarized in Table 8.1, along with methods to prevent and/or mitigate negative impacts through actions pre-, during and post- development. Enhancement approaches are recommended. Measures and supplementary studies are recommended for future site specific scoped EIS. An Information Gathering Form (IGF) must be completed and submitted to MNRF for any development proposed within the study area.

Aquatic:
The results of the fish and fish habitat investigations undertaken during this study are generally consistent with those of previous studies. The physical habitat characterizations do not differ substantively from those previously documented. The water quality values implied by the benthic invertebrate community in Laurel Creek are consistent with those reported in the NWSSS, and indicate considerably better habitat conditions in the vicinity of Erbsville Road than were reported in the Laurel Creek Watershed Study.

The absence of coldwater species (trout or sculpin) in recent fish collections from Laurel Creek, together with the temperature data collected during this study, suggest that Laurel Creek, and possibly Wideman Creek, might more appropriately be considered a coolwater than a coldwater streams. However, the management options should assume that Laurel Creek and Wideman Creek are cold water systems in accordance with OMNRF and GRCA classification of these watercourses and therefore cold water temperature targets and thermal mitigation measures must be established. Regardless of how the watercourses are characterized, groundwater discharge is considered an important factor for maintaining the existing thermal regime which is suitable for coolwater fish species such as Iowa darter.

Fluvial Geomorphology:
Upstream of Erbsville Road Wideman Creek has developed a meandering channel and active floodplain within the confined former agricultural drain in the lower part of this reach, however in the upper portion it is still in transition. The Wideman Tributary is actively incising through its upper reach, which is the steepest reach surveyed in this study. The lower portion that was investigated is dominated by in-channel vegetation, silt and organic deposits associated with wetlands.

The erosion threshold analysis for Wideman Creek revealed that the critical discharge exceeded the estimated bankfull discharge, but would still be contained within the overall agricultural drain. The critical discharge for the Wideman Tributary was determined to be less than the bankfull discharge, verifying the field observations of channel instability. Further frequency analysis should be performed on both of these channels to determine the percent of time that these erosion thresholds are exceeded, which can give insight into the rate that these channels are adjusting.

9.2 Natural Hazards Conclusions and Recommendations

The Hamlet of Erbsville has been identified as a Flood Damage Centre as during a Regional Storm runoff will overtop Conservation Drive and Erbsville Road. In addition, under existing conditions during a Regional Storm spill between Wideman Creek and Laurel Creek can occur in part due to the limited capacity of the Wideman Creek culvert at Erbsville Road. Therefore as a management target regional storm peak flows and flood levels must be maintained or reduced wherever possible. To this end and following through with the recommendations of the Final Subwatershed Management Plan #313 and #309, preliminary designs have been undertaken to increase the size of the Wideman Creek culvert at Erbsville Road. The proposed open bottom culvert will have the capacity to convey the entire Regulatory storm peak flow under Erbsville Road, and reduce the Regulatory floodline elevations upstream of Erbsville Road to allow a portion of the Laurel Creek flows to spill toward Wideman Creek. The final engineering drawings of the culvert should include erosion protection features for the upstream and downstream interfaces with Wideman Creek, and should accommodate requirements for wildlife passage.

Regional Transportation staff have noted that, as of 2017, the culvert replacement is not in the Transportation Capital Plan (TCP) or identified in the Regional Development Charges (RDC) By-law. At this time, the TCP provides for widening and resurfacing Erbsville Road from Wideman Road to the Waterloo/Woolwich Boundary in 2024 (TCP Project no. 7422). If the larger culvert needs to be installed before 2024, the cost of installation would have to come from a source other than the Region based on the TCP and RDC as of 2017. Since the structure is owned, maintained and inspected by the Region, the City will have no role in funding the work. In the meantime, Regional staff will give consideration to including it in potential updates to the RDC and TCP in the coming years.

There are no steep slopes within the study area that cause erosion issues.

9.3 Hydrogeology Conclusions and Recommendations

The soil and groundwater conditions of the Study Area offer limited options for groundwater infiltration:

- The Study Area is underlain by a variety of soil types, consisting generally of Maryhill Tills interlayered with sand and silty sand deposits.
- The majority of the outcropping soils have a relatively low vertical hydraulic conductivity. Groundwater mounds on top of the Maryhill Till mapped within the Study Area, and the pre-development recharge rate of these till soils is low, approximately 50 mm/year or less.
- The existing pocket of granular and permeable soil around Schnarr Street is in an area with existing low density residential development, and with a potential water supply well for the Regional Municipality of Waterloo. This pocket of soil is an enhanced recharge area which supplies infiltration to the Shallow and Deep Overburden Aquifers.
- Infiltration under post-development conditions should be directed into near surface Shallow Overburden Aquifer(s), as the Deep Overburden Aquifer is a confined aquifer protected by aquitards, and because it of its use as a source for municipal water.
- The topographic low point around Wideman Creek could be an appropriate location for a SWM facility, preserving topographically higher lands which are better suited for development.
- Runoff water chemistry can generally be addressed by SWM ponds through treatment of runoff from the Study Area prior to discharge to Laurel Creek.

By ensuring the water balance is maintained and that the water chemistry of infiltrated water is not significantly degraded, the potential impacts to the Shallow Overburden Aquifer will be mitigated. It is noted that the change in the land use from primarily agricultural to residential use will likely improve the water chemistry of infiltrated water due to a reduction in fertilizer, insecticide, and pesticide use within the Study Area.

A combination of spatially distributed at-source and other infiltration measures may be applied where subsurface soils are adequately permeable and there is sufficient separation between groundwater and footing elevations. It is important to note that these areas are limited within the Study Area.

Maintaining the spatial distribution of pre-development infiltration rates on Maryhill Tills (where extended detention times may be required to achieve significant infiltration) and more granular deposits is recommended, with consideration of the chemistry of water being infiltrated in order to minimize detrimental impacts to users of the Shallow Groundwater Aquifer, and to wetlands and surface water features. Infiltration of clean water should be considered; otherwise, treatment of infiltrating water will likely be necessary to maintain groundwater quality.

Maintaining, but not enhancing, the pre-development high infiltration rates within the granular soil pocket at Schnarr Street is suggested.

During the design phase of the proposed development within the Study Area, grading and footing information should be compared to groundwater monitoring data to achieve separation between the seasonally high groundwater table elevation and house footings. Additionally, proposed mitigation measures to maintain the groundwater chemistry within the Study Area should be evaluated for their effectiveness.

The post-development water balance should endeavour to match the pre-development water balance, by maintaining spatial distribution of infiltration across the Study Area. In order to maintain the form and function of wetlands, the proposed residential development will need to maintain pre-development groundwater levels, and seasonal runoff volumes.

Post-development runoff from the Study Area should be collected in SWM ponds, and treated to meet MOECC "Enhanced Level" stormwater management standards prior to discharging to Laurel Creek or to Wideman Creek.

9.4 Stormwater Management Conclusions & Recommendations

The Study Area is located within subwatershed #309, and the stormwater management requirements include:

- Stormwater management facilities are required to provide water quantity (peak flow) control for the 2, 5, 25, and 100 year storms. The targets to control post-development flows to pre-development levels are provided in Table B4.3 of the SWP;
- Extended detention control for erosion control is required for runoff volume in excess of the existing 100 year runoff volume as outlined in Table D1.3, Page D-27 of the Subwatershed Management Plan and are to be released over a 48 hour period;
- Stormwater management facilities are required to provide an enhanced level of water quality control for all flows not infiltrated across the site. The level of treatment must meet water quality targets established in the SWP and MOE (2003) for Enhanced Protection Level. Low Impact Development (LID) measures need to be included that enable achievement of enhanced water quality;
- Thermal impacts on Laurel Creek and Wideman Tributary must be avoided or mitigated where necessary;
- Maintaining the infiltration capacity and seepage characteristics of the site is a requirement of the SWP and the recommendations of the Hydrogeological Investigation. The proposed development is required to provide both infiltration to depth and maintain seepage toward wetland areas. At-source infiltration measures will be provided to promote infiltration of clean and treated runoff to maintain existing infiltration rates as close to existing levels as possible;
- Grading and servicing design must ensure that there are no adverse impacts on groundwater and on the adjacent significant natural features; and
- All development must remain outside of the established buffers. Portions of stormwater management facilities, such as outfalls, will only be permitted in accordance with City of Waterloo Official Plan Policy 8.2.4(9).

Three future development sites (see Figure 7.1) were investigated including locations for future stormwater management facilities. It should be noted that the stormwater management strategy for Area 103 must include

Area 105. A fourth area includes the existing residential development and daycare centre along Schnarr Street. As there is no indication that this area or any portion of it is slated for redevelopment any time soon, the location of a stormwater management facility was not recommended at this time. However, any redevelopment in this area will be subject to the requirements noted above.

9.5 Environmental Management Plan

The purpose of the Erbsville South Environmental Study is to supplement existing environmental information that is contained in the *Laurel Creek Watershed Study* and the subsequent *Final Subwatershed Management Plan #313 and #309*. The ES identifies and categorizes natural features and functions within the study area, delineates areas to be protected and recommends development setbacks and mitigation measures necessary to maintain or improve the ecological sustainability within the study area.

Based on the findings and conclusions of this study, the following key recommendations form the Environmental Management Plan for the Erbsville South Study Area:

1. **Core Environmental Features** - Confirm the boundaries of all core natural areas within the Erbsville South study area so that they can be adequately protected before, during, and after the development process. This includes Provincially Significant Wetlands, Environmentally Sensitive Policy Areas, areas of Significant Wildlife Habitat, and their ecological linkages, as well as the immediately contiguous Laurel Creek Headwaters Environmentally Sensitive Landscape. During the Environmental Assessment process required for the widening of Erbsville Road it is recommended that alternative approaches be investigated for maintaining the long term protection of the functions associated with the small wetland feature located at the corner of Wideman and Erbsville Roads that was recently complexed by MNRF with the Sunfish Lake - Laurel Creek PSW.

2. **Watercourses** – Retain and protect all watercourses within the Erbsville South study area. During the Environmental Assessment process required for the widening of Erbsville Road it is recommended that alternative approaches be explored for the stormwater outflow tributary at Wideman Road including the current functions of this watercourse.

3. **Development Setbacks** – Based on current policy guidance and findings from the field studies undertaken for the Erbsville South Environmental Study, the following minimum development setbacks are recommended:

    - PSW wetland: 30 metres
    - ESPA: 10 metres
    - Watercourses: 30 metres
    - Woodlands: 10 metres

    Finalized buffer widths should be established and confirmed at the development application stage through an Environmental Impact Study, when information on proposed adjacent land uses and lot layouts are known.

4. **Corridors/Linkages** – Establish and enhance with natural plantings a minimum width of 30 metres along each side of Wideman Creek as a wildlife corridor and linkage between core areas. Prior to any development within the study area and/or in conjunction with the upgrading of Erbsville Road, the Wideman Creek culvert under Erbsville Road should be improved to convey the Regulatory storm peak flow and reduce the upstream Regulatory Floodline. The design should incorporate an open bottom culvert including terrestrial benches and other design features to provide a safe wildlife crossing.

5. **Hydrogeology** - The post-development water balance should endeavour to match the pre-development water balance, by maintaining spatial distribution of infiltration across the Study Area. In order to maintain the form and function of wetlands, the proposed residential development will need to maintain

pre-development groundwater levels, and seasonal runoff volumes. House footings must be separated from the seasonally high water table levels.

6. **Storm Water Management Strategy** – For all future development areas with in the study area the following criteria must be adhered to:

    - Stormwater management facilities are required to provide water quantity (peak flow) control for the 2, 5, 25, and 100 year storms;
    - Extended detention control for erosion control is required for runoff volume in excess of the existing 100 year runoff volume and are to be released over a 48 hour period;
    - Stormwater management facilities are required to provide an enhanced level of water quality control for all flows not infiltrated across the site utilizing Low Impact Development (LID) measures;
    - Thermal impacts on Laurel Creek and Wideman Tributary must be avoided or mitigated where necessary;
    - Infiltration of clean treated runoff to depth is to be provided and seepage toward wetland areas maintained as close to existing levels as possible; and
    - Grading and servicing design must ensure that there are no adverse impacts on groundwater and on the adjacent significant natural features.
    - A program of Systems and Post Development Monitoring should continue to be undertaken by public agencies and/or stewardship programs. In addition, a comprehensive Development Monitoring program should be undertaken by developers that includes three phases: 1) pre-development; 2) during construction; and 3) post development.

7. **Stewardship Initiatives** - The City of Waterloo, Regional Municipality of Waterloo and other agencies implement a Public Education Program that covers such topics as potential environmental impacts of public activities, groundwater protection strategies and terrestrial preservation techniques. It should be noted that the City of Waterloo has developed the “Naturally Your Waterloo” environmental stewardship brochure. Purchasing and providing copies to new home owners will be a condition of draft plan approval.

8. **Future Studies** – Submit Scoped Environmental Impact Studies with future development applications to verify or refine findings and recommendations presented in this report. An Information Gathering Form (IGF) must be completed and submitted to MNRF for any development proposed within the study area.

The Erbsville South Environmental Study meets the requirements of the Council-approved Terms of Reference and has been prepared in accordance with the Technical Work Plan approved by the City of Waterloo, the Regional Municipality of Waterloo, the Grand River Conservation Authority and the Ministry of Natural Resources and Forestry. This study is also consistent with the policies of these agencies with respect to completion of subwatershed studies. The Erbsville South Environmental Study provides an environmental management strategy that will guide the development of the Erbsville South Block Plan Study.

10 References

10.1 Policy Framework (IBI Group)

City of Waterloo & Grand River Conservation Authority*, Laurel Creek Watershed Study*, (1993)

City of Waterloo, *City of Waterloo Official Plan*, (December 2012)

Ecoplans, MHBC & Stantec, *North Waterloo Scoped Subwatershed Study,* (2013)

Grand River Conservation Authority, *Grand River Fisheries Management Plan*, (1998)

Grand River Conservation Authority, *Policies for the Administration of the Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulation, Ontario Regulation 150/06*, (January 2013)

Planning Initiatives Ltd. And Associates, *Final Subwatershed Management Plan, Subwatershed Plans #313 and #309, Laurel Creek Watershed, City of Waterloo*, (April 1996)

Province of Ontario, *Conservation Authorities Act*, (1998)

Province of Ontario, Ministry of Municipal Affairs and Housing, *2014 Provincial Policy Statement*, (April 2014)

Province of Ontario, *Ontario Regulation 97/04, Development, Interference with Wetlands and Alteration to Shorelines and Watercourses Regulation*

Province of Ontario, *Ontario Regulation 150/06, Grand River Conservation Authority: Regulation of Development, Interference with Wetlands and Alteration to Shorelines and Watercourses*, (February 2013)

Regional Municipality of Waterloo, *Regional Official Plan*, (December 2010)

10.2 Terrestrial Resources (Dougan & Associates)

AOU (American Ornithologists' Union). 1998. Check-list of North American Birds. 7th edition. American Ornithologists' Union, Washington, D.C. 829 pp.

Badzinski, D.S. 2007. Hooded Warbler. Pg. 524 – 525, *In*, M.D. Cadman, D.A. Sutherland, G.G. Beck, D. Lepage, and A.R. Couturier editors. Atlas of the Breeding Birds of Ontario, 2001 – 2005. Bird Studies Canada, Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, and Ontario Nature, Toronto. xxii + 706 pp.

Bavrlic, K. 2007. Red-bellied Woodpecker. Pg. 322 – 323, *In*, M.D. Cadman, D.A. Sutherland, G.G. Beck, D. Lepage, and A.R. Couturier editors. Atlas of the Breeding Birds of Ontario, 2001 – 2005. Bird Studies Canada, Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, and Ontario Nature, Toronto. xxii + 706 pp.

BSC (Bird Studies Canada). 2009. Marsh Monitoring Program Participant's Handbook for Surveying Amphibians. 2009 Edition. 13 pages. Published by Bird Studies Canada in cooperation with Environment Canada and the U.S. Environmental Protection Agency. February 2009.

Cadman, M.D., D.A. Sutherland, G.G. Beck, D. Lepage, and A.R. Couturier (eds.) 2007. Atlas of the Breeding Birds of Ontario, 2001 – 2005. Bird Studies Canada, Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, and Ontario Nature, Toronto. xxii + 706 pp.

Campbell, C.A. 1975. Ecology and reproduction of Red-shouldered hawks in Waterloo Region, southern Ontario. *Raptor Research* **9:** 12–17.

Chapman, L.J. and **D.F. Putnam. 1984**. The Physiography of Southern Ontario, 3rd Edition. Ontario Geological Survey, Special Volume 2.

Cheskey, E. 2014. Breeding Bird Monitoring Report for the City of Waterloo, 2014. December 2014. 35 pp.

Chesser, R.T., K.J. Burns, C. Cicero, J.L. Dunn, A.W. Kratter, I.J. Lovette, P.C. Rasmussen, J.V. Remsen, Jr., J.D. Rising, D.F. Stotz, and **K. Winker. 2016.** Fifty-seventh Supplement to the American Ornithologists' Union Check-list of North American Birds. *The Auk* **133:** 544 - 560.

City of Waterloo. 1999. City of Waterloo Development Monitoring Protocol. 15 pp.

City of Waterloo. 2012. Official Plan. Available at: City of Waterloo Official Plan (http://www.waterloo.ca/en/government/officialplan.asp)

City of Waterloo & GRCA (Grand River Conservation Authority). **1993.** Laurel Creek Watershed Study.

Cobb, Farnsworth & Lowe. 2005. Ferns of Northeastern and Central North America, Second Edition. Peterson

Conservation Authorities Act. R.S.O 1990. c. C. 27

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2008. COSEWIC assessment and status report on the Snapping Turtle *Chelydra serpentina* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 47 pp. (COSEWIC Assessment and Status Report (www.sararegistry.gc.ca/status/status_e.cfm)).

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2015. Canadian Wildlife Species at Risk. October 2015. Committee on the Status of Endangered Wildlife in Canada. Web site: http://www.cosewic.gc.ca/eng/sct0/rpt/rpt_csar_e.cfm [accessed 13 September 2016]

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2016. COSEWIC Wildlife Species Assessments (detailed version), April 2016. Available at: http://www.cosewic.gc.ca/rpts/201604/Detailed_species_assessments_e.pdf

COSSARO (Committee on the Status of Species at Risk in Ontario). 2012a. COSSARO Candidate Species at Risk Evaluation for Little Brown Myotis (*Myotis lucifugus*) [formerly Little Brown Bat], May 2012. Available at: COSSARO Candidate Species (http://files.ontario.ca/environment-and-energy/species-at-risk/stdprod_101774.pdf)

COSSARO (Committee on the Status of Species at Risk in Ontario). 2012b. COSSARO Candidate Species at Risk Evaluation for Northern Myotis (*Myotis septentrionalis*) [formerly Northern Long-eared Bat], May 2012. Available at: COSSARO Candidate Species (http://files.ontario.ca/environment-and-energy/species-at-risk/stdprod_101777.pdf)

Crolla, J. P. and J. D. Lafontaine.1996. COSEWIC Status Report on the Monarch Butterfly. 23 pp.

Curry. R. and the **Hamilton Naturalists' Club. 2006.** Birds of Hamilton and Surrounding Areas: including all or parts of Brant, Halton, Haldimand, Niagara, Norfolk, Peel, Waterloo and Wellington. Hamilton Naturalists' Club. 647 pp.

CWS (Canadian Wildlife Service). 2008. Forest Bird Monitoring Program: Site Set-up and Bird Survey Instructions (Spring 2008 Revised Edition). 6 p.

Dore, W.G. and J. McNeill. 1980. Grasses of Ontario. Biosystematics Research Institute, Research Branch, Agriculture Canada. Monograph 26. Minister of Supply and Services Canada. Hull, Quebec.

D&A (Dougan & Associates). 2008. Draft Wideman Road Environmental Impact Study.

D&A (Dougan & Associates). 2010. 2010 Forested Hills ESPA Salamander Inventory. Activa Holdings and Townline Estates. 26 pp.

D&A (Dougan & Associates). 2013. Scoped Environmental Impact Study for the Regal Place Subdivision (Registered Plan 58M--5), Community of Erbsville, City of Waterloo. 29pp + apps.

D&A (Dougan & Associates). 2014. Forested Hills ESPA: Herpetofaunal Characterization. Prepared for the City of Waterloo. 14 pp. + Figures and Appendices.

Dodd, C.K., Jr. 2013. Frogs of the United States and Canada. Johns Hopkins University Press, Baltimore. 2 Volumes, i-xxvii + 962 pp.

Drabick, D. 2003. Ontario Wetland Evaluation System Data Record for Sunfish Lake-Laurel Creek Wetland Complex.

Ecoplans, MHBC, and **Stantec. 2013.** North Waterloo Scoped Subwatershed Study. Vol. 1–3.

eFloras. 2008. Published on the Internet http://www.efloras.org [accessed 21 August 2014] Missouri Botanical Garden, St. Louis, MO & Harvard University Herbaria, Cambridge, MA.

Elbroch, M. 2003. Mammal Tracks & Sign – A Guide to North American Species. Stackpole Books. Mechanicsburg, Pennsylvania. 779 pp.

Environment Canada (EC). 1999. Invasive Plants of Natural Habitats in Canada. Available at: http://www.grandriver.ca/forestry/invasives.pdf

Environment Canada. 2014. Bird Conservation Strategy for Bird Conservation Region 13 in Ontario Region: Lower Great Lakes/St. Lawrence Plain – Abridged Version – July 2014. Available online at: https://www.ec.gc.ca/mbc-com/default.asp?lang=En&n=F43BE8A4-1

Francis, G.R. and C.A. Campbell. 1983. The Herpetofauna of Waterloo Region, Ontario. *Ontario Field Biologist* **37(2)**: 51–86.

Gleason, H.A. & A. Chronquist. 1991. Manual of vascular plants of northeastern United States and adjacent Canada. Second edition.

Government of Canada. 1994a. Migratory Birds Convention Act, Statutes of Canada (1994, c. 22). Retrieved from the Department of Justice Laws Website: Migratory Birds (http://laws-lois.justice.gc.ca/eng/acts/M-7.01/FullText.html)

Government of Canada. 1994b. Migratory Birds Regulations, Consolidated Regulations of Canada (1994, c. 1035). Retrieved from the Department of Justice Laws Website: Migratory Birds (http://laws-lois.justice.gc.ca/eng/regulations/C.R.C.,_c._1035/FullText.html)

Government of Canada. 2002. Species at Risk Act, Statutes of Canada (2002, c. 29). Retrieved from the Department of Justice Laws Website: Species at Risk Act (http://laws-lois.justice.gc.ca/eng/acts/S-15.3/index.html)

Government of Ontario. 1990. Planning Act, Revised Statutes of Ontario (1990, c. P.13). Retrieved from the Service Ontario e-Laws website: Planning Act (http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_90p13_e.htm)

Government of Ontario. 2007. Endangered Species Act, Statutes of Ontario (2007, c. 6). Retrieved from the Service Ontario e-Laws website: Endangered Species Act (http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_07e06_e.htm)

GRCA (Grand River Conservation Authority). 2005. Grand River Fisheries Management Plan. A Community-based Approach to Fisheries Management in the Grand River Watershed. Part A.

GRCA (Grand River Conservation Authority). 2009. Policies for the Administration of the Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulation. Ontario Regulation 150/06. 58 pp.

GRCA (Grand River Conservation Authority). 2013a. Conservation Authorities Act, Ontario Regulation 150/06. Grand River Conservation Authority: Regulation of Development, Interference with Wetlands and Alterations to Shorelines and Watercourses. Available at: http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_060150_e.htm

GRCA (Grand River Conservation Authority). 2013b. Policies for the Administration of the Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulation Ontario Regulation 150/06. Available at: GRCA Policy Planning Regulations (http://www.grandriver.ca/PolicyPlanningRegulations/GRCA_Policies.pdf)

GRCA (Grand River Conservation Authority). 2014a – Chapter 2.2 Invasive Exotics from the Grand River Watershed Forest Plan. Available at: GRCA - Invasive Exotics (http://www.grandriver.ca/forestry/forestPlan_Ch22_Invasive.pdf)

GRCA (Grand River Conservation Authority). 2014. Grand River Watershed Viewer. Access on: Dec. 23, 2014. Available at: GRCA Watershed Viewer (http://www.grandriver.ca/index/document.cfm?Sec=17&Sub1=80&Sub2=0)

Harding, J.M. 1997. Amphibians and Reptiles of the Great Lakes Region. University of Michigan Press. Ann Arbor, Michigan. 378pp.

Henson, B.L. and K.E. Brodribb. 2005. Great Lakes Conservation Blueprint for Terrestrial Biodiversity. Volume 2: Ecodistrict Summaries. 344 pp.

Hipp, A. 2008. Field Guide to Wisconsin Sedges. University of Wisconsin Arboretum. University of Wisconsin – Dept of Botany. 209pp + apps.

Howe, R.W., G.J. Niemi, S.J. Lewis, and D.A. Welsh. 1997. A standard method for monitoring songbird populations in the Great Lakes Region. *The Passenger Pigeon* 59(3): 189 – 194.

Lamond, W.G. 1994. The Reptiles and Amphibians of the Hamilton Area. An Historical Summary and the Results of the Hamilton Herpetofaunal Atlas. Hamilton Naturalists' Club. 174pp.

Lepage, D. 2007. Barn Swallow. Pp 398–399. *In* Cadman, M.D., D.A. Sutherland, G.G. Beck, D. Lepage, and A.R. Couturier (eds.). Atlas of the Breeding Birds of Ontario 2001-2005. Bird Studies Canada, Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, and Ontario Nature, Toronto, xxii + 706 pp.

Lee, H., W. Bakowsky, J. Riley, J. Bowles, M. Puddister, P. Uhlig, and S. McMurray. 1998. Ecological Land Classification for Southern Ontario: First Approximation and its Application. Ontario Ministry of Natural Resources, Southcentral Sciences Section, Science Development and Transfer Branch, SCSS Field Guide FG-02.

Lowther, Peter E., Alan F. Poole, James P. Gibbs, Scott M. Melvin and **F. A. Reid. (2009).** American Bittern (*Botaurus lentiginosus*), The Birds of North America (P.G. Rodewald, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America: https://birdsna.org/Species-Account/bna/species/amebit

DOI: 10.2173/bna.18

LVM, a division of EnGlobe Corp. 2014. Erbsville South Environmental Study, Erbsville Road and Wideman Road Waterloo, Ontario Hydrogeology Study FINAL.

MacCulloch, R.D. 2002. The R.O.M. field guide to the amphibians and reptiles of Ontario. Toronto, Ontario. 168p

McLaren, M. 2007. Eastern Wood-Pewee. Pp 340–341. *In* Cadman, M.D., D.A. Sutherland, G.G. Beck, D. Lepage, and A.R. Couturier (eds.). Atlas of the Breeding Birds of Ontario 2001-2005. Bird Studies Canada, Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, and Ontario Nature, Toronto, xxii + 706 pp.

Mitz & Associates Inc. 2010. Hydrogeological Study Report: Michael Property, Waterloo, Ontario.

Morris, M.M. J., B.L. Penak, R.E. Lemon, and **D.M. Bird. 1982.** Characteristics Red-shouldered Hawk, *Buteo lineatus*, nest sites in southwestern Québec. *Canadian Field-Naturalist* **96:** 139 – 142.

Naughton, D. 2012. The Natural History of Canadian Mammals. University of Toronto Press, Toronto. 824 pages.

NatureServe Explorer. 2016. National and Subnational Conservation Status Definitions web page. Available at: NatureServe Explorer 2016 (http://explorer.natureserve.org/nsranks.htm)

Newcomb, L. 1977. Newcomb's Wildflower Guide. 490 pp

NHIC (Natural Heritage Information Centre). 2011. NHIC List of Vascular Plants for Ontario. Acquired by request Feb 24, 2011.

NHIC (Natural Heritage Information Centre). 2013. Element occurrence data for provincially tracked species, plant communities and wildlife concentration areas. May 2013. Ontario Ministry of Natural Resources.

NHIC (Natural Heritage Information Centre). 2016. NHIC Species Lists. Available at: https://www.ontario.ca/page/get-natural-heritage-information

Norminton, L. 2013. Correspondence from Lorraine Norminton (District Planner, OMNR – Guelph District) to Robyn McMullen (Policy Planner, Growth Management, City of Waterloo) dated July 19, 2013, re: comments on Draft Technical Work Plan for the Erbsville South Environmental Study.

OABRT (Ontario American Badger Recovery Team). 2010. Recovery Strategy for the American Badger (*Taxidea taxus*) in Ontario. Ontario Recovery Strategy Series. Prepared for the Ontario Ministry of Natural Resources, Peterborough, Ontario. vi + 27 pp.

OBBA (Ontario Breeding Bird Atlas). 2014. Ontario Breeding Bird Atlas – Atlas Data Summary webpage. Ontario Bird Breeding Atlas (http://www.birdsontario.org/atlas/datasummaries.jsp?lang=en)

Oldham, M.J. 1999. Natural Heritage Resources of Ontario: Rare Vascular Plants. Third Edition. Natural Heritage Information Centre, Ontario Ministry of Natural Resources, Peterborough, Ontario. 53 pages. MNR - Rare Vascular Plants (http://www.mnr.gov.on.ca/MNR/nhic/species/rarevascular.pdf)

Oldham, M.J., W.D. Bakowsky, and **D.A. Sutherland. 1995.** Floristic Quality Assessment System for Southern Ontario. Natural Heritage Information Center, OMNR (Ontario Ministry of Natural Resources). Peterborough, Ontario. 69 pp.

Oldham, M.J., and **S.R. Brinker, S.R. 2009.** Rare Vascular Plants of Ontario. Fourth Edition. Natural Heritage Information Centre, Ontario Ministry of Natural Resources, Peterborough, Ontario. 188 pages. Available at: MNR - Rare Vascular Plants (http://publicdocs.mnr.gov.on.ca/View.asp?Document_ID=15769&Attachment_ID=33301)

Ontbirds, 2014. Ontbirds, the Ontario Field Ornithologists' electronic mailing listserv archives. Accessed September 22, 2014. Ontbirds, 2014 Electronic Mailing List (http://mailman.hwcn.org/pipermail/ontbirds/)

OMMAH (Ontario Ministry of Municipal Affairs & Housing). 2008. Land Use Planning, 1. The Planning Act. OMMAH - Planning Act (http://www.mah.gov.on.ca/Page1760.aspx)

OMMAH (Ontario Ministry of Municipal Affairs & Housing). 2014. Provincial Policy Statement. 50 pp. Available at: OMMAH - PPS (http://www.mah.gov.on.ca/AssetFactory.aspx?did=10463)

OMNR (Ontario Ministry of Natural Resources). 2000. Significant Wildlife Habitat Technical Guide. 139 pp. Available at: OMNR - Significant Wildlife Habitat Technology (http://www.mnr.gov.on.ca/stdprodconsume/groups/lr/@mnr/@fw/documents/document/mnr_e001285.pdf)

OMNR (Ontario Ministry of Natural Resources). 2007. Butternut Assessment Guidelines; Assessment of Butternut Tree Health for the Purposes of the *Endangered Species Act*. 11 pp + appendices.

OMNR (Ontario Ministry of Natural Resources). 2010. Natural Heritage Reference Manual. Available at: OMNR Natural Heritage Reference Manual (http://www.mnr.gov.on.ca/stdprodconsume/groups/lr/@mnr/@lueps/documents/document/289522.pdf)

OMNR (Ontario Ministry of Natural Resources). 2013a. Ontario Wetland Evaluation System, Southern Manual, 3rd Edition, Version 3.2. 293 pages.

OMNR (Ontario Ministry of Natural Resources). 2013b. Milksnake Survey Protocol - MNR Guelph District. Current as of June 2013. 2 pp.

OMNR (Ontario Ministry of Natural Resources). 2013c. Draft Occurrence Survey Protocol for Blanding's Turtle (*Emydoidea blandingii*) in Ontario. Ontario Ministry of Natural Resources, Species at Risk Branch. Peterborough, Ontario. ii + 17 pp.

OMNR (Ontario Ministry of Natural Resources). 2013d. General Habitat Description for the Barn Swallow (*Hirundo rustica*). Ministry of Natural Resources and Forestry. Available at: http://files.ontario.ca/environment-and-energy/species-at-risk/mnr_sar_ghd_brn_swllw_en.pdf

OMNRF (Ontario Ministry of Natural Resources and Forestry). 2013e. General Habitat Description for the Blanding's Turtle (*Emydoidea blandingii*). Ministry of Natural Resources and Forestry. Available at: https://files.ontario.ca/environment-and-energy/species-at-risk/mnr_sar_ghd_bln_trtl_en.pdf

OMNRF (Ontario Ministry of Natural Resources and Forestry). 2015. Significant Wildlife Habitat Criteria Schedules for Ecoregion 6E, January, 2015. 39 pp. Available at: https://www.ontario.ca/document/significant-wildlife-habitat-ecoregional-criteria-schedules-ecoregion-6e

OMNRF (Ontario Ministry of Natural Resources and Forestry). 2016a. Species at Risk in Ontario List. Available at: http://www.ontario.ca/laws/regulation/080230 or https://www.ontario.ca/environment-and-energy/species-risk-ontario-list [current as of 20, June 2016].

OMNRF (Ontario Ministry of Natural Resources and Forestry). 2016b. Blanding's Turtle Nest and Nesting Survey Guidelines; Ministry of Natural Resources and Forestry Guelph District; May 2016 – version 1.

ORAA (Ontario Reptile and Amphibian Atlas). 2013. Ontario Reptile and Amphibian Atlas. Available online at: ORAA (http://www.ontarionature.org/protect/species/herpetofaunal_atlas.php) (accessed November 25, 2013)

Peck, G.A., and R.D. James. 1983. Breeding Birds of Ontario, Nidiology and Distribution, Volume 1: Nonpasserines. Royal Ontario Museum, Toronto, Ontario. 321pp.

Peck, G.A., and R.D. James. 1987. Breeding Birds of Ontario, Nidiology and Distribution, Volume 2: Passerines. Royal Ontario Museum, Toronto, Ontario. 387pp.

Petranka, J.W. 1998. Salamanders of the United States and Canada. Smithsonian Institution Press. Washington, D.C. 587pp.

PIL and Associates (Planning Initiatives Ltd. And Associates). 1996. Final Subwatershed Management Plan: Subwatershed Plans # 313 and #302, Laurel Creek Watershed, City of Waterloo. 22pp.

Plourde, S.A., E.L. Szepesi, J.L. Riley, M.J. Oldham and C. Campbell. 1989. Distribution and Status of the Herpetofauna of Central Region, Ontario Ministry of Natural Resources. Parks and Recreational Areas Section, OMNR, Open File Ecological Report SR8903, Central Region, Richmond Hill, Ontario. 27pp.

Rezendes, P. 1999. Tracking and the Art of Seeing: How to Read Animal Tracks and Sign (2nd Edition). Firefly Books Ltd., Willowdale, Ontario. 336pp.

Riley, J.L. 1989. Distribution and Status of the Vascular Plants of Central Region. Ontario Ministry of Natural Resources. Richmond Hill. 110 pp.

RMW (Regional Municipality of Waterloo) (a). ESPA 17 Schaefer's Woods Technical Data Sheet (Unpublished).

RMW (Regional Municipality of Waterloo) (b). ESPA 80 Laurel Creek Forest Technical Data Sheet (Unpublished).

RMW (Regional Municipality of Waterloo). 1985a. Appendix 3: Reptiles and Amphibians in Environmentally Sensitive Policy Areas Technical Appendix. Approved by Council: 1986.

RMW (Regional Municipality of Waterloo). 1985b. Appendix 4: Mammals in Environmentally Sensitive Policy Areas Technical Appendix. Approved by Council: 1986.

RMW (Regional Municipality of Waterloo). 1996. Revisions to Waterloo Region's Significant Species List: Breeding Birds Component. Report to Planning and Culture Committee PC-96-021. Approved by Council: April 25, 1996.

RMW (Regional Municipality of Waterloo). 1999. Significant Species List. Native vascular plants component. PC-99-028.1 Appendix A.

RMW (Regional Municipality of Waterloo). 2003. Schaefer's Woods Environmentally Sensitive Policy Area 17. Draft document provided by Chris Gosselin. Revised January 2, 2003.

RMW (Regional Municipality of Waterloo). 2005. Laurel Creek Headwaters, Environmentally Sensitive Landscape 1. Draft for Discussion. Revised April 7, 2005. 5 pp.

RMW (Regional Municipality of Waterloo). 2010. Regional Official Plan. Approved, with modifications, by the Minister of Municipal Affairs and Housing on December 22, 2010 and under appeal before the Ontario Municipal Board (OMB) as of January 24, 2011.

RMW (Regional Municipality of Waterloo). 2012. Region of Waterloo Greenlands Network Implementation Guideline.

Roberts-Pichette, P. and L. Gillespie. 1999. Terrestrial Vegetation Biodiversity Monitoring Protocols, Ecological Monitoring and Assessment Network (EMAN) Coordinating Office, Vegetation Monitoring Protocols

Working Group of the Biodiversity Science Board of Canada, Ecological Monitoring and Assessment Network**:** 1 - 29.

Rowe, J.S. 1972. Forest Regions of Canada. Department of the Environment, Canadian Forestry Service. Publication Number 1300. 172 pp + map.

Rowell, J.C. 2012. The Snakes of Ontario – Natural History, Distribution, and Status. 411 pp.

Sandilands, 2005. Birds of Ontario. Habitat Requirements, Limiting Factors, and Status (Nonpasserines: Waterfowl through Cranes). UBC Press, Vancouver. 365 pp.

Sandilands, A. 2007. Bank Swallow. Pp 394–395. *In* Cadman, M.D., D.A. Sutherland, G.G. Beck, D. Lepage, and A.R. Couturier (eds.). Atlas of the Breeding Birds of Ontario 2001-2005. Bird Studies Canada, Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, and Ontario Nature, Toronto, xxii + 706 pp.

Sharp, M.J. and **C.A. Campbell. 1982.** Breeding ecology and status of Red-shouldered Hawks (*Buteo l. lineatus*) in Waterloo Region. *Ontario Field Biologist* **36**: 1 – 10.

Stantec. 2007. Simpson Lands Stage I Monitoring 2006.

Stantec. 2008. Simpson Lands Stage I Monitoring 2007.

Stantec. 2009. Simpson Lands Stage I Monitoring 2008.

Stantec. 2010. Simpson Lands Stage I Monitoring 2009.

Stantec. 2011. Simpson Lands Stage I Monitoring 2010.

Stantec. 2012. Simpson Lands Stage I Monitoring 2011 (Draft).

Steyermark, A.C., M.S. Finkler and R. J. Brooks. 2008. Biology of the Snapping Turtle (*Chelydra serpentina*). The Johns Hopkins University Press. Baltimore Maryland. 225 p.

Timmermans, S.T.A. 2007. American Bittern. Pp 154–155. *In* Cadman, M.D., D.A. Sutherland, G.G. Beck, D. Lepage, and A.R. Couturier (eds.). Atlas of the Breeding Birds of Ontario 2001-2005. Bird Studies Canada, Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, and Ontario Nature, Toronto, xxii + 706 pp.

Weseloh, C. 2007. Black Tern. Pg. 268 – 269, *In*, M.D. Cadman, D.A. Sutherland, G.G. Beck, D. Lepage, and A.R. Couturier editors. Atlas of the Breeding Birds of Ontario, 2001 – 2005. Bird Studies Canada, Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, and Ontario Nature, Toronto. xxii + 706 pp.

Woodliffe, P.A. 2007a. Least Bittern. Pg. 156 – 157, *In*, M.D. Cadman, D.A. Sutherland, G.G. Beck, D. Lepage, and A.R. Couturier editors. Atlas of the Breeding Birds of Ontario, 2001 – 2005. Bird Studies Canada, Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, and Ontario Nature, Toronto. xxii + 706 pp.

Woodliffe, P.A. 2007b. Red-headed Woodpecker. Pg. 320 – 321, *In*, M.D. Cadman, D.A. Sutherland, G.G. Beck, D. Lepage, and A.R. Couturier editors. Atlas of the Breeding Birds of Ontario, 2001 – 2005. Bird Studies Canada, Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, and Ontario Nature, Toronto. xxii + 706 pp.

10.3 Aquatic Resources (C. Portt and Associates)

Bode, R.W. 1988a. Quality assurance work plan for biological stream monitoring in New York State. Stream Biomonitoring Unit, Bureau of Monitoring and Assessment. Division of Water, NYS Department of Environmental Conservation. August, 1988.

Bode, R.W. 1988b. Methods for rapid biological assessment of streams. Stream Biomonitoring Unit, Bureau of Monitoring and Assessment. Division of Water, NYS Department of Environmental Conservation. February, 1988.

Chu, C., N.E. Jones, A.R. Piggott and J.M. Buttle. 2009. Evaluation of a simple method to classify the thermal characteristics of streams using a nomogram of daily maximum air and water temperatures. North American Journal of Fisheries Management 29:1605–1619.

Ecoplans and others, 2013. North Waterloo Scoped Subwatershed Study. 365 p. + Figures and Appendices.

Grand River Conservation Authority, 1992. Laurel Creek Watershed Study.

Hilsenoff, W.L., 1982. Using a biotic index to evaluate water quality in streams. Tech. Bull. Wisconsin Dept. Nat. Resour. 132. 22 pp.

Hilsenoff, W.L. 1987. An improved biotic index of organic stream pollution. Great Lakes Entomologist Vol. 20 (1): pp 31-39,

Hilsenhoff (1982, 1987) and Bode (1988a). The water quality implied by these indices is from Shannon and Weaver (1949; Shannon's diversity), Hilsenhoff (1987; HBI) and Bode (1988, Jones, C., K.M. Somers, B. Craig, and T.B. Reynoldson. 2007. Ontario benthos biomonitoring network: protocol manual. 109 pp.

Golder Associates, 2011. Regional Municipality of Waterloo Waterloo North water supply class environmental assessment hydrogeological and natural environment report. 95 pp.

Planning Initiatives Ltd. And Associates, 1996. Final Subwatershed Management Plan. Subwatershed Plans #313 and #309. Laurel Creek, City of Waterloo.

Shannon, C.E. and W. Weaver. 1949. The Mathematical Theory of Communication. Univ. Ill. Press, Urbana Ill.

Stanfield, L. (editor). 2013. Ontario Stream Assessment Protocol. Version 9.0. Fisheries Policy Section. Ontario Ministry of Natural Resources. Peterborough, Ontario. 505 pp.

10.4 Fluvial Geomorphology (JTB Environmental Systems Inc.)

Chang, H.H. (1988). "Fluvial Processes in River Engineering", John Wiley and Sons, New York.

Chow, V.T. (1959). "Open Channel Hydraulics", McGraw-Hill Book Company, Inc., New York.

Galli, J. (1999). "Rapid Stream Assessment Technique (RSAT) Field Methods", Metropolitan Washington Council of Governments, Washington, D.C.

Fischenich, C. (2001). "Stability Thresholds for Stream Restoration Materials", EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR-29), U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Julien, P.Y. (1995). Erosion and Sedimentation.

Kouwen, N.; Li, R.M.; and Simons, D.B., (1980). "A stability criteria for vegetated waterways", Proceedings, International Symposium on Urban Storm Runoff. University of Kentucky, Lexington, KY.

Norman, J.N. (1975). "Design of stable channels with flexible linings", Hydraulic Engineering Circular 15, U.S. Dept. of Transportation, Federal Highway Adm., Washington, DC.

Ontario Geological Survey (2010). "Surficial geology of southern Ontario", Ontario Geological Survey, Miscellaneous Release – Data 128 – Revised.

Ontario Ministry of Environment (2003). "Stormwater Management Planning and Design Manual", Queen's Printer for Ontario.

Parish Geomorphic (2011). "North West Waterloo Scoped Subwatershed Study Fluvial Geomorphology Assessment Final Report". City of Waterloo, Waterloo, Ontario.

Presant, E.W. and Wicklund, R.E. (1971). "The soils of Waterloo County", Research Branch, Canada Department of Agriculture.

University of Waterloo Weather Station (2014). "July 2014 Data Archives: GeoNOR Precipitation Gauge", Accessed December 19, 2014. University of Waterloo Weather (www.weather.uwaterloo.ca)

10.5 Natural Hazards & Stormwater Management (IBI Group)

IBI Group, *Final Stormwater Management Report, Sunvest Regal Place Subdivision, City of Waterloo*, (April, 2013)

Planning Initiatives Ltd. And Associates, *Final Subwatershed Management Plan, Subwatershed Plans #313 and #30, Laurel Creek Watershed, City of Waterloo*, (April 1996)

Province of Ontario, Ministry of the Environment, *Stormwater Management Planning and Design Manual*, (March 2003)

U.S. Army Corps of Engineers, *HEC-RAS Version 4.1.1*, (January 2010)

10.6 Hydrogeology (LVM, a division of EnGlobe Corp.)

Bajc, A.F. and Shirota, J. 2007. *Three-dimensional Mapping of Surficial Deposits in the Regional Municipality of Waterloo, Southwestern Ontario; report*. Ontario Geological Survey, Groundwater Resources Study 3, 42p.

CH2M HILL Engineering Ltd. 1991. Detailed Hydrogeological Investigation – Beechwood West, Neighbourhood Four, Waterloo. Final Report.

Chapman, L.J. and D.F. Putnam. 1984. The Physiography of Southern Ontario. 3rd ed. Ontario Geological Survey Special Volume 2, Ontario Ministry of Natural Resources, Ontario, Canada.

Blackport Hydrogeology Inc. 2012. Tier 3 Water Budget and Local Area Risk Assessment Waterloo North, William Street and Lancaster Well Fields Characterization Study. Final Report.

City of Waterloo. 2014. Official Plan.

City of Waterloo & Grand River Conservation Authority. 1993, Laurel Creek Watershed Study.

Credit Valley Conservation & Toronto and Region Conservation Authorities (CVC & TRCA). 2010. Low Impact Development Stormwater Management Planning and Design Guide.

Ecoplans Ltd. 2007. Road Salt Impact Assessment and Mitigation Study - Brookville Operations Centre 11302 Guelph Line, Milton, Ontario. Draft Report.

Ecoplans, **MHBC & Stantec**. 2013. North Waterloo – Scoped Subwatershed Study.

Freeze, R.A. and J.A. Cherry. 1979. *Groundwater*. Englewood Cliffs, New Jersey: Prentice-Hall. 614pp.

Golder. 2011. Waterloo North Water Supply Class Environmental Assessment - Hydrogeological and Natural Environment Report.

Grand River Conservation Authority. 2004. Laurel Creek Conservation Area Master Plan.

Karrow, P.F. 1993. *Quaternary Geology of the Stratford Area, Southern Ontario*; Ontario Geological Survey, Map 2559, 1:50,000.

Karrow, P.F. 1993. *Quaternary Geology of the Stratford – Conestogo Area*; Ontario Geological Survey Report 283.

Kaubisch, M. 1986. The Indirect Determination of Hydrogeological Parameters Illustrated by Dump Materials of Lignite Mines. Ph.D. Thesis, Technical University of Freiberg, Germany.

Lake Erie Region Source Protection Committee. 2012. *Grand River Protection Area, Approved Assessment Report.*

Lake Erie Region Source Protection Committee. 2015a. Grand River Source Protection Area, Updated Assessment Report.

Lake Erie Region Source Protection Committee. 2015b. Approved Source Protection Plan for the Grand River Source Protection Area within the Lake Erie Region Source Protection Region; November 26, 2015.

McCabe, G.J., and Markstrom, S.L. 2007. A monthly water-balance model driven by a graphical user interface: U.S. Geological Survey Open-File report 2007-1088.

Mitz & Associates Inc. Hydrogeological Study Report - Michael Property; Waterloo, Ontario.

MOEE. 1995. Hydrogeological Technical Information Requirements for Land Development Applications.

Naylor Engineering Associates. 2003. Wideman Road Sanitary Sewer – Wideman Road and Erbsville Road, Waterloo, Ontario. Internal Project Number 1704G10.

Naylor Engineering Associates. 2006. Simpson Lands Residential Subdivision – 720 Erbsville Road, Waterloo, Ontario. Internal Project Number 6454G1.

Parish Geomorphic. 2011. Northwest Waterloo – Scoped Subwatershed Study. Fluvial Geomorphological Assessment. 01-09-64/03 v2.

Puls, R.W. & Barcelona, M.J. 1989. Ground Water Sampling for Metals Analyses. Superfund Ground Water Issue. EPA/540/4-89/001.

Regional Municipality of Waterloo. 2011. Waterloo North Water Supply Class EA - Environmental Study Report (Final). Volume 2 of 2.

Regional Municipality of Waterloo. 2015. Regional Official Plan 2031.