LYNDE CREEK WATERSHED EXISTING CONDITIONS REPORT CHAPTER 13 – FLUVIAL GEOMORPHOLOGY

June 2008

Central Lake Ontario Conservation

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1.0 INTRODUCTION

Fluvial Geomorphology is the study of how waterways react and evolve to changes. The causes that trigger the changes within the creeks can be a result of natural or anthropogenic activity.

Stable stream systems are dynamic, with erosion, sediment transport and deposition all occurring. These processes cause a stream to "migrate", although the rate of movement may be quite gradual. In natural areas, this stream movement may cause erosion of stream banks and collapse of vegetation, but the impact of these processes are not harmful to the environment, and may even be of benefit to the fishery.

In urban areas, the natural movement of streams can become a concern. Stream movement and erosion may impact urban structures and services within the valley systems. Also, hydrological changes brought on by urban development (i.e., greater surface runoff, less infiltration and evapotranspiration) have the potential to exacerbate stream instability and rate of change.

'stable stream systems are dynamic, with erosion, sediment transport and deposition all occurring'

2.0 STUDY AREA AND SCOPE

The Lynde Creek watershed is situated entirely within the Regional Municipality of Durham and covers an area of approximately 130 km^2 (Figure 1). The watershed drains southerly towards Lake Ontario from its headwaters in the Oak Ridges Moraine. The Lynde Creek watershed is divided into 5 subwatersheds being Lynde Main, Heber Down, Kinsale, Ashburn, and Myrtle Station. This chapter focuses on the fluvial geomorphology found within the watershed and each subwatershed.

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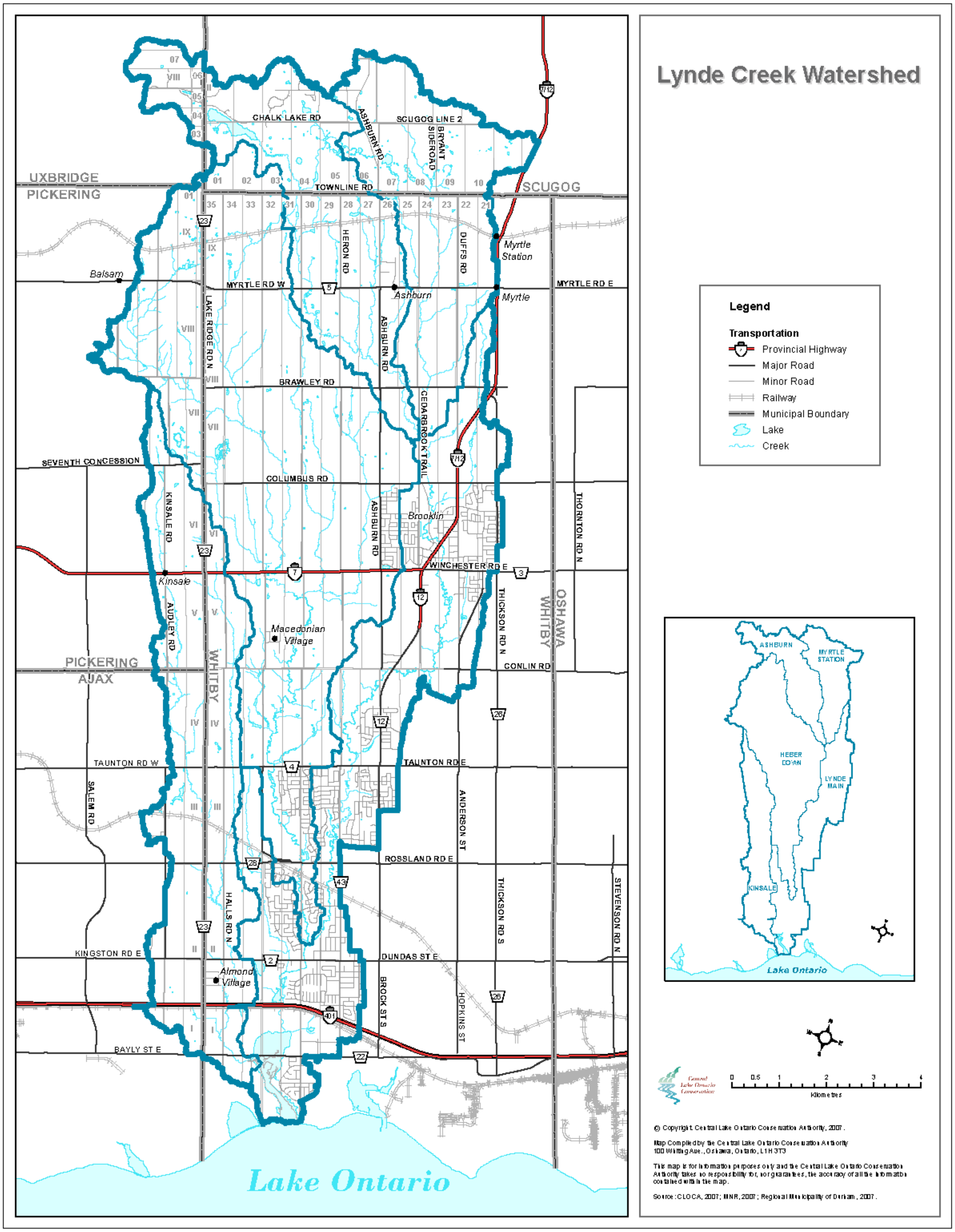


Figure 1: Lynde Creek watershed.

An assessment of the stream stability has been completed through the urban portion of the Lynde Creek watershed specifically where erosion is of particular concern. Prior studies of the Lynde Creek watershed have denoted reaches or areas of concern related to urbanization and erosion control.

Master Drainage Study, Lynde Creek
(G.M. Sernas and Associates Limited, 1988)
This study investigated erosion sites on Lynde Creek south of Taunton Road. Forty-four erosion sites were reported, with the greatest concentration in the East and West Tributary between Highway No. 2 and Taunton Road. The majority are within the open space system, and do not pose a risk to existing structures or services. Many of the sites reported in this study have been/are being addressed by the Town of Whitby in association with adjacent land development.

Brooklin Master Drainage Plan East Lynde Creek
(Cosburn Patterson Wardman Limited, 1992)
A field study was conducted for the East Lynde Creek, from Taunton Road to the northern study limits of the future Brooklin community. Seventeen erosion sites were identified with eight of these noted as requiring treatment, and the remaining requiring monitoring. The identified sites were noted as erosion scars caused by the watercourse coming into contact with the valley wall, causing slope instability. Ultimately, loss of tableland and/or structures would occur. Three of the sites noted have already been/are being treated by the Town of Whitby through "natural" channel realignment (Klingler sites), and soil bioengineering (Smith site).

'a field study was conducted for the East Lynde Creek, from Taunton Road to the northern study limits of the future Brooklin community. Seventeen erosion sites were identified with eight of these noted as requiring treatment, and the remaining requiring monitoring'

In addition to the 17 sites, this study noted numerous areas of eroding stream banks in floodplain areas, occurring predominantly on the meandering sections of the watercourse extending 2 km south of Winchester Road. However, the condition of the stream bank at these sites is considered typical of small southern Ontario watercourses where agricultural practices have significantly altered the naturally occurring floodplain vegetation and tree cover at the edge of the stream.

Lynde Creek Water Resource Management Strategy
(Gartner Lee, 1994)
The focus of the Water Resource Management Strategy of 1994 was to predict the impacts of future land use as it relates to erosion rates within the Lynde Creek Watershed and its tributaries. At that time it was believed that there would be minimal impact on the watershed due to development. Four stream reaches were identified as key areas of increased erosion potential, based on unmitigated future land development.

As described above, in ideal conditions the various reaches of the stream work together to supply, transport, and deposit sediment in a balanced system. Erosion is therefore a natural and essential part of stream evolution. This being said, it must also be recognized that in some situations the movement of streams will be hazardous to the public, either through damage to services and/or structures or creation of unsafe ground conditions. These situations tend to occur more in urban areas where the public has access to the valleys, and where structures exist within hazardous areas. In the urban areas of Lynde Creek, the stream has also experienced extensive alterations and a change in flow regime due to changing land use. These impacts also lead to increased rates of fluvial processes, and added concern for stream erosion. For these reasons the urban area is the focus of fluvial analysis. The following assessment has been provided to give a more holistic view of the stream and fluvial processes that may exist.

3.0 METHODOLOGY

Two assessments have been completed for each representative reach of the creek throughout the urban portion of the watershed, as shown in Figure 8. Representative reaches are sections of creek more than 300m in length with constant flow regime. These assessments include the Rapid Stream Assessment technique (Galli, 1996) and the Rapid Geomorphic Assessment (MOE, 1999). These assessments provide information on the existing condition of reaches of the stream, and evidence of fluvial processes that may be occurring through the reach. This in turn provides insight into best management approaches for dealing with erosion or stream restoration.

'representative reaches are sections of creek more than 300m in length with constant flow regime'

Rapid Geomorphic Assessment (RGA)
The Rapid Geomorphic Assessment provides a scoring system of stream stability, culminating in a Stability Index value. The assessment is based on evidence of stream form adjustment. It sorts reaches into categories of aggradation (deposition of sediment), degradation (erosion of the stream bed), channel widening, or movement of the meander pattern of the stream (plan form adjustment).

This assessment provides an overall value of stability, or Stability Index (SI), that can be used to classify the reach as "in regime" where SI<0.2, "stressed" where 0.2<SI<0.4, or "unstable" where SI>0.4. Furthermore, this assessment provides additional insight into the processes acting on the stream when stressed or unstable conditions exist

Rapid Stream Assessment (RSA)
The second assessment of stream stability is the RSA. This assessment is somewhat qualitative, although measurements of the bank full stream dimensions, entrenchment, and plan form assist with the qualitative portion of the assessment. The RSA provides an assessment of overall stream health, including instream habitat, water quality, riparian conditions and biological indicators. Each stream feature is assigned a numeric value and a corresponding health classification: excellent (40-50), good (30-39), fair (20-29), poor (0-19).

'the RSA provides an assessment of overall stream health, including instream habitat, water quality, riparian conditions and biological indicators'

While efforts have been made to accurately present the reported findings, manipulation of support data typically introduces a certain margin of error. As a result, tabular data may not always add to the expected total due to rounding and the number of significant digits reported is not intended to imply a certain level of accuracy.

4.0 FINDINGS

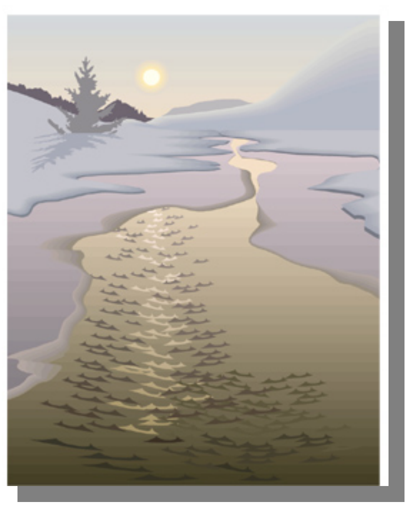
4.1 Lynde Creek Watershed

Figure 3 delineates the reaches where the field assessments where completed. The geomorphology of Lynde Creek is typical of moraine-fed streams draining to Lake Ontario. The Moraine itself is generally able to hold and infiltrate precipitation into groundwater, and does not produce sufficient surface water to cause the formation of streams. Additionally the hummocky topography that characterizes the Moraine promotes infiltration as numerous sinks trap surface water between mounds forcing it to percolate into the ground. The headwater streams therefore originate on the south shoulder of the Moraine where in many cases groundwater discharges to the ground surface. As these small streams flow through the Till Plain, the topography becomes much more uniform, with a significant north to south slope. The till soils are erodible, and over time steep gullies and valleys have been created.

In the Iroquois Beach, many small streams originate as a result of groundwater discharge and erodible soils from the Beach feature. South of the Beach, through the lacustrine plain, the soils are less erodible, the land flattens, and fewer small tributaries exist, with the main East and West Tributaries of Lynde Creek conveying the majority of the flow. The Lynde Creek valley through the lacustrine plain is typically steep sided with a broad, flat, floodplain. As a result, the valley is accessible, and the floodplain areas have been historically cleared of trees, and utilized for both crop and pasture land. This feature of the Lynde Creek is quite distinct from neighbouring watersheds such as the Oshawa Creek or Bowmanville/Soper Creek, where steep sided, narrow valleys made tree clearing impractical, and valleys remained forested.

'the geomorphology of Lynde Creek is typical of moraine-fed streams draining to Lake Ontario'

As the East and West Lynde Creek Tributaries meet, near the Highway 401 corridor, the creek changes from a confined valley with a pool/riffle type system to an unconfined low bed relief stream. These lower reaches meander through the coastal wetland of the Lynde Shores area.



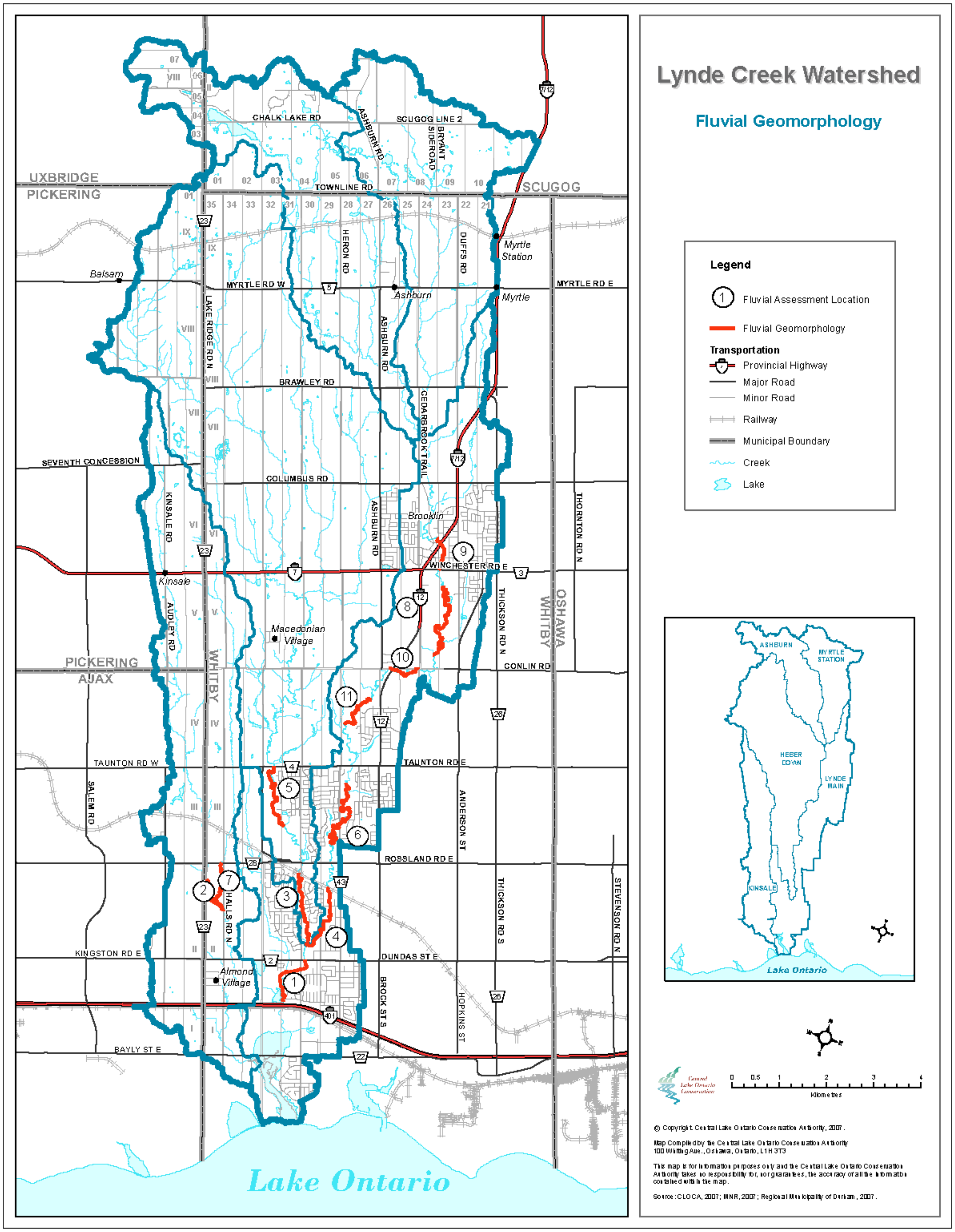


Figure 2: Location of fluvial geomorphic assessments in the Lynde Creek watershed.

4.2 Subwatershed Findings

4.2.1 Lynde Main Subwatershed

Table 1 and Table 2 detail the results of the classification and the score of the Rapid Geomorphic Assessment and the Rapid Stream Assessment technique respectively for the subwatershed. Figure 3 delineates the reaches where the field assessments where completed.

Table 1: Rapid Geomorphic Assessment of the Lynde Main subwatershed.

Reach	Evidence of Adjustment Due to				SI	Classification
	Aggradation	Degradation	Widening	Plan Form		
1	0.14	0.13	0.33	0.43	0.26	Stressed
4	0.00	0.00	0.44	0.29	0.18	In Regime
6	0.14	0.00	0.33	0.71	0.30	Stressed
8	0.14	0.00	0.30	0.43	0.22	Stressed
9	0.14	0.13	0.33	0.14	0.19	In Regime
10	0.00	0.00	0.50	0.14	0.16	In Regime
11	0.29	0.14	0.56	0.43	0.35	Stressed

Table 2: Rapid Stream Assessment of the Lynde Main subwatershed.

Reach	Channel Stability	Scour/ Deposition	Instream Habitat	Water Quality	Riparian Conditions	Biological Indicators	Score
1	7	6	5	4	3	3	28 (fair)
4	8	6	6	6	6	6	38 (good)
6	6	5	6	4	5	6	32 (good)
8	5	4	6	5	5	5	30(good)
9	6	5	4	6	4	4	29(fair)
10	5	5	5	6	4	5	30(good)
11	5	5	6	6	6	5	33(good)

'Reach 1 is the last reach of stream with a pool/riffle system, and leads to the low bed relief style reaches through the Lynde Shores wetland area'

Reach 1; Lynde Creek south of Highway No. 2

Reach 1 is the last reach of stream with a pool/riffle system, and leads to the low bed relief style reaches through the Lynde Shores wetland area. The stream gradient is low, and the flow rate was noted as "steady". The stream is well connected to a broad floodplain, and meanders through meadows and areas of sparse deciduous tree cover. Although there is very little evidence of channel hardening, the stream is impacted by bridge crossings and numerous shopping carts embedded in the stream.

This reach is "stressed" with evidence of channel widening and plan form adjustment, but does not pose a threat to structures or services because of the broad open space area adjacent to the stream. The combination of turbid water, lack of shrub and tree cover, and significant garbage/shopping carts resulted in a "Fair" classification.

Reach 4; East Lynde Creek at Bonacord Avenue
Although similar in size to the West Branch at Bonacord Avenue, the riparian zone of Reach 4 is quite different. Mature wooded areas cover this stream reach with a mixture of coniferous and deciduous trees. The stream moves rapidly through a substrate of cobble and boulders, and is not impacted by channel hardening or disturbances, other than the Bonacord Avenue bridge crossing. Other than some evidence of widening, the stream scored well in the RGA assessment and is rated as "in regime". Similarly, in the RSA assessment, this reach scored well in all categories, and fell just shy of an "excellent" score.

In a few locations, the stream flows against the valley slope, causing a large erosion scar at the south limit of Reach 4, and creating the potential for valley slope erosion in other locations. Currently, however, there are no structures in peril.

Reach 6; East Lynde Creek at Cochrane Street
Reach 6 is within a recently developed residential area. South of the Cochrane Street bridge, a combination of landscaping and natural regeneration are converting this old pasture land to thicket. The stream has been altered through soil bioengineering works including crib walls, fascines, and brush layering. These works have been in place for several years, and are not only providing channel stability, but also providing fish and wildlife habitat with extensive shrub growth overhanging the stream. This portion of the reach is a terrific example of creating a natural open space system through the land development process. An abundance of waterfowl was observed in this regeneration area, and a large beaver dam created a beaver pond midway between Cochrane Street and Rossland Road. The beaver dam obstructed the flow of water for a considerable distance upstream, and the stream flow was noted as steady but not rapid. Other than turbid water quality, the reach scored "good" on all RSA parameters.

'Reach 6 has been altered through soil bioengineering works including crib walls, fascines, and brush layering'

Upstream of Cochrane Street, the stream flows through a pasture (horses), where bank erosion is prevalent. Beyond this pasture the stream moves back into a forested valley reach with a mix of deciduous and coniferous tree species.

Although stable through the subdivision lands, the evidence of widening and plan form adjustment through the private pasture land results in a "stressed" score in the RGA.

Reach 8; East Lynde Creek south of Winchester Road
Situated immediately south of Brooklin, Reach 8 is benefiting from extensive valley restoration efforts of local community groups. The valley vegetation is a mixture of meadow and forest, with extensive plantings of young conifers throughout. Approximately 700 metres of trail system have also recently been constructed between Winchester Road and a downstream stormwater management facility. Although this reach is relatively stable, downstream of the stormwater facility, several instances of stream widening and plan form adjustment were observed. These occurrences caused the RGA assessment to score "stressed". It may be that the input of urban stormwater at this location has instigated geomorphologic changes to the stream below this point. The pond facility has an extended detention system for frequent rainfall/runoff events that should help mitigate these impacts, but may not be able to address the additional volume of surface runoff that is contributed from the urban areas.

The RSA evaluation scored the reach as "good" due to healthy riparian conditions and instream habitat.

Reach 9; Way Street to Winchester Road, Brooklin

Reach 9 of East Lynde Creek is within the community of Brooklin, and meanders through numerous back yards and private properties. Although some properties within the reach have manicured lawns extending to the creek bank, the reach benefits from mature deciduous trees and generally healthy riparian conditions. Multiple channel disturbances are present including weirs, storm sewer outfalls, and boulder armouring. This reach scored an "in regime" under the RGA assessment, and is generally free of significant erosion concerns. The RSA assessment scored only a "fair" due to influence of urban conditions and disturbances.

Reach 10; East Lynde Creek between Baldwin Street and Garden Street

Reach 10 meanders through the Lyndebrook Golf Course lands. Despite areas of manicured grass, the riparian zone generally consists of mixed deciduous and coniferous forest and thicket. The water moves rapidly over a streambed of boulders and clay. No evidence of streambed aggradation or degradation was observed, and the RGA assessment yielded an "in regime" score. There are however many signs of stream widening and riprap armouring on stream banks at several meanders. This reach scored "good" on all categories except channel stability, where eroded outer bends lowered the RSA score.

Reach 11; East Lynde Creek between Taunton Road and Brock Street

This reach extends through Cullen's Garden/Cullen Central Park and Sheridan Nursery lands. The riparian area is generally noted as "excellent", with mature cedar forest and dense shrub cover immediately adjacent to the stream. The stream is very sinuous with sharp (small radius) meanders. At numerous points within the reach, the creek has eroded into mature cedar trees, as evidenced by exposed roots and fallen trees. At one location, a collection of fallen trees has formed a dam, and cause a back up of water upstream. These erosion areas, basal scour on inside meander bends, and erosion through riffle sections indicate the tendency of the creek to widen. This reach is within the Iroquois Beach, and therefore the erodible, sandy soils and shallow groundwater movement within this reach may make it susceptible to erosion processes. The assessments yielded scores of "stressed" due to evidence of widening and "good" due to excellent riparian conditions.

'Reach 9 of East Lynde Creek is within the community of Brooklin, and meanders through numerous back yards and private properties'

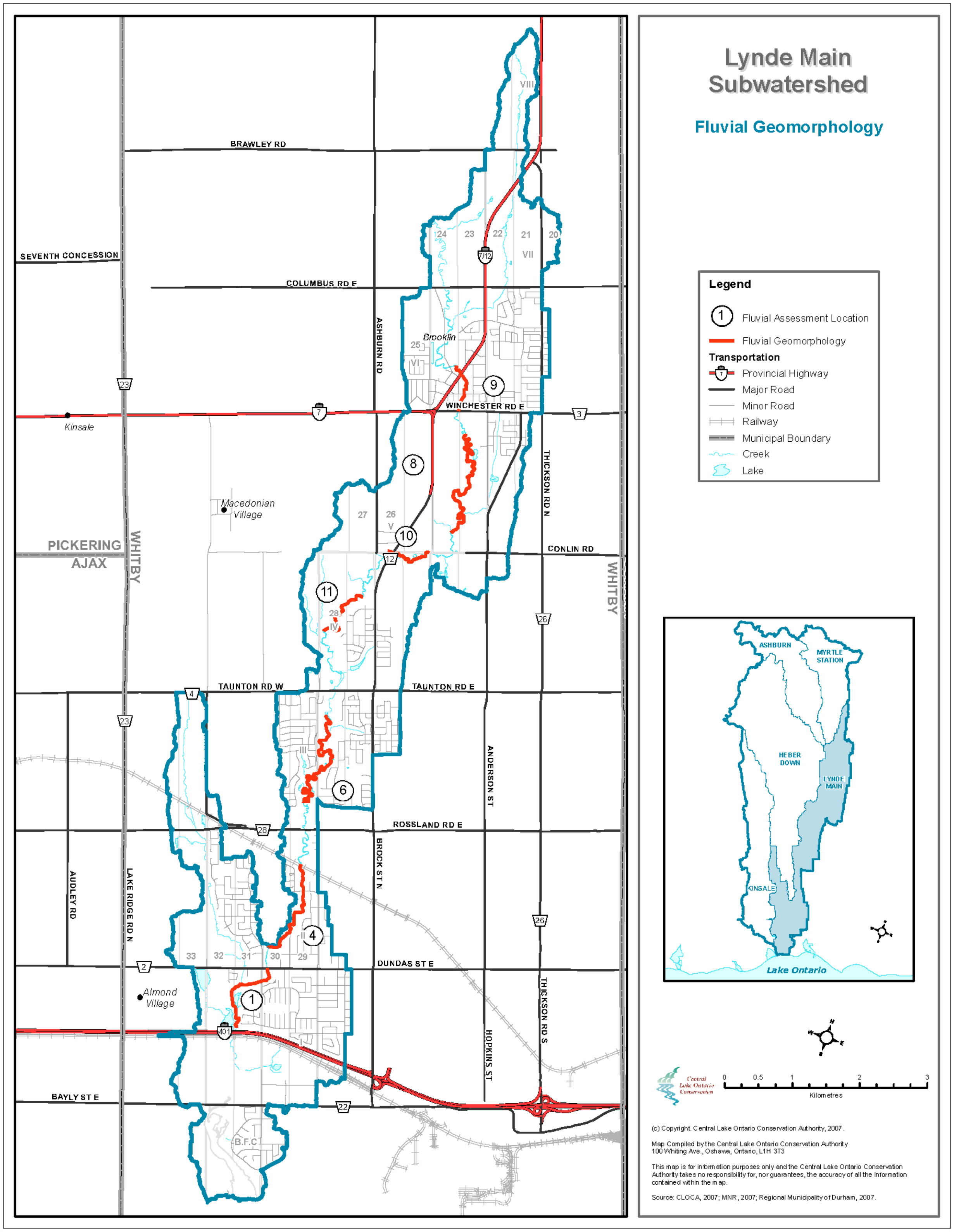


Figure 3: Location of fluvial geomorphic assessments in the Lynde Main subwatershed.

4.2.2 Heber Down Subwatershed

Table 3 and Table 4 detail the results of the classification and the score of the Rapid Geomorphic Assessment and the Rapid Stream Assessment technique respectively for the subwatershed. Figure 4 delineates the reaches where the field assessments where completed.

Table 3: Rapid Geomorphic Assessment of the Heber Down subwatershed.

Reach	Evidence of Adjustment Due to				SI	Classification
	Aggradation	Degradation	Widening	Plan Form		
3	0.43	0.20	0.40	0.43	0.37	Stressed
5	0.14	0.00	0.50	0.43	0.27	Stressed

Table 4: Rapid Stream Assessment of the Heber Down subwatershed.

Reach	Channel Stability	Scour/ Deposition	Instream Habitat	Water Quality	Riparian Conditions	Biological Indicators	Score
3	5	5	6	5	3	4	28 (fair)
5	5	4	5	6	2	4	26 (fair)

Reach 3; West Lynde Creek at Bonnacord Avenue

Reach 3 is a rapid flowing stream flowing through a broad open floodplain with meadow and sparse dogwood and deciduous tree cover. Lack of riparian cover and channel instability contributed to a "fair" condition rating in the RSA assessment. Although the creek is centred within the open space system, and does not pose a threat to adjacent residential neighbourhoods, there are channel-hardening sites including gabion baskets, armour stone, and rip rap stone. Approximately 200m downstream of Bonacord Avenue, the stream flows over a section of bedrock, which acts as a grade control structure to prevent stream bed erosion.

'Reach 5 is currently utilized for cattle pasture, although subdivision applications and construction work are active within the reach'

The RGA assessment rated this reach as "stressed", due to evidence of stream widening and plan form adjustment. This reach was noted as an area of many erosion sites (GM Sernas 1988), and a reach with erosion potential (Gartner Lee, 1993).

Reach 5; West Lynde Creek south of Taunton Road

Reach 5 is currently utilized for cattle pasture, although subdivision applications and construction work are active within the reach. The area is impacted by long-term agricultural activity, and is characterized by short grass and sparse cedar trees. Cattle were evident in the reach at the time of the site walk, and trampled stream bank areas were numerous. Active erosion is evident along outside bends due to the lack of deep-rooted vegetation on the stream banks.

Heber Down Subwatershed (Reach 5) *© Lou Wise*

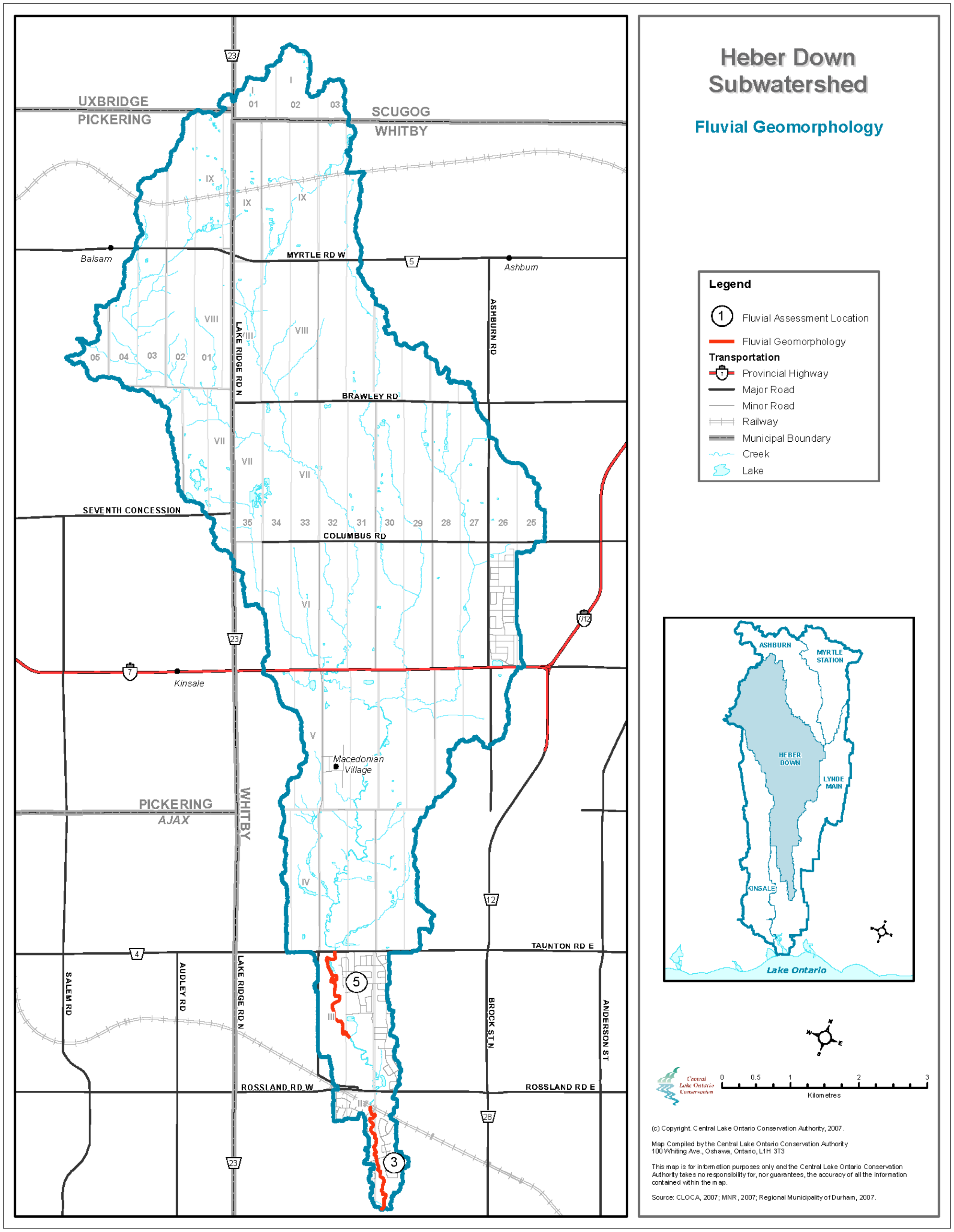


Figure 4: Location of fluvial geomorphic assessments in the Heber Down subwatershed.

4.2.3 Kinsale Subwatershed

Table 5 and Table 6 detail the results of the classification and the score of the Rapid Geomorphic Assessment and the Rapid Stream Assessment technique respectively for the subwatershed. Figure 5 delineates the reaches where the field assessments where completed.

Table 5: Rapid Geomorphic Assessment of the Kinsale subwatershed.

Reach	Evidence of Adjustment Due to				SI	Classification
	Aggradation	Degradation	Widening	Plan Form		
2	0.14	0.13	0.20	0.71	0.30	Stressed
7	0.00	0.13	0.40	0.14	0.17	In Regime

Table 6: Rapid Stream Assessment of the Kinsale subwatershed.

Reach	Channel Stability	Scour/ Deposition	Instream Habitat	Water Quality	Riparian Conditions	Biological Indicators	Score
2	4	4	4	6	2	4	24(fair)
7	5	6	6	5	4	4	30(good)

Reach 2; Lakeridge Tributary South of Rossland Road
This tributary of Lynde Creek originates near the upper limit of the Iroquois Beach, and in this reach, meanders through active dairy farms upstream and downstream of Rossland Road. Upstream of Rossland Road, the stream has been altered in the past, and a series of gabion weirs are providing grade control for the streambed. Cattle pasturing also influences the creek in this reach. The lack of riparian cover or deep-rooted vegetation appears to be a factor that is contributing to the creek's tendency to rapidly change plan form. Multiple abandoned oxbows and former stream alignments are evident in the portion of the reach immediately downstream of Rossland Road, and some channel hardening (concrete rubble) is evident in outside meander bends. This reach was scored as "stressed" by RGA, although evidence of planimetric form adjustment scored very high. The RSA scored "fair" with low scores for riparian conditions and channel stability.

'upstream of Rossland Road, the stream has been altered in the past, and a series of gabion weirs are providing grade control for the streambed'

Reach 7; Lynde Tributary south of Rossland Road
Reach 7 is adjacent to Reach 2 and is similar with respect to the contributing drainage area and channel capacity. Unlike Reach 2, this segment has the benefit of a healthy riparian zone. Immediately downstream of Rossland Road, the stream flows for a length of 125m through a mixed forest block, and then travels through regenerating thicket. A section of historical alteration occurs further downstream, where the stream appears to have been straightened along a distance of approximately 175m for the purpose of maximizing the adjacent cropland.

This reach scored "good" in the RSA assessment, primarily due to riparian cover. The RGA assessment scored this reach as "in regime", although extensive evidence of channel widening was observed. It appears that this reach has been impacted in the past through forest clearing, pasturing of livestock and physical alterations. Despite these impacts, the reach appears to have adjusted over time (as evidenced by abandoned oxbows) and is currently healthy from a geomorphic perspective.

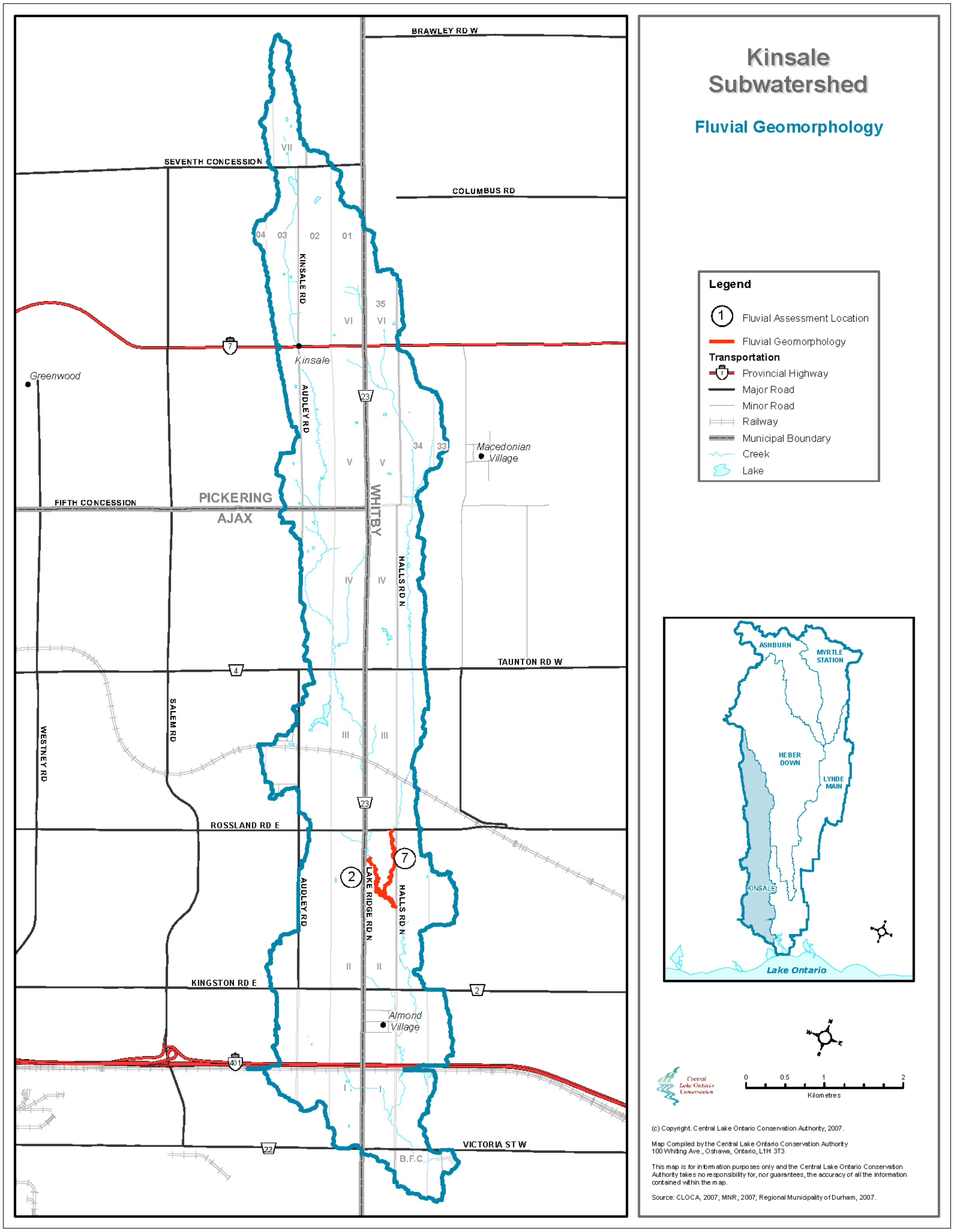


Figure 5: Location of fluvial geomorphic assessments in the Kinsale subwatershed.

4.2.4 Ashburn Subwatershed

There were no assessments undertaken in the Ashburn subwatershed.

Ashburn Subwatershed © Lou Wise

'there were no assessments undertaken in the Ashburn subwatershed'

4.2.5 Myrtle Station Subwatershed

As within the Ashburn subwatershed there were no assessments undertaken in the Myrtle Station subwatershed.

Myrtle Station Subwatershed © Lou Wise

'there were no assessments undertaken in the Myrtle Station subwatershed'

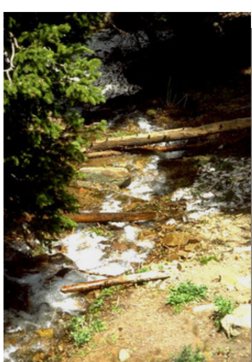
5.0 CONCLUSIONS

Rapid changes in plan form stability were recognized at reaches 2, 5, and 6 where livestock grazing and lack of riparian vegetation existed. These areas would benefit from restoration of a riparian zone either through private land stewardship exercises or through restoration associated with new urban development.

Comparing reach 3 against reach 4, it appears that riparian vegetation plays a significant role in channel stability. Despite hard armouring in reach 3, the stream continues to adjust. Hard armouring is sometimes required to protect structures, but should otherwise be discouraged because it has a tendency to translate energy past the armoured works and increase the rate of erosion of the next downstream sections. Hard armouring also requires maintenance and is prone to failure. If armouring is required, a bioengineering component should be included to provide some roughness (shrub vegetation reduces velocity of flowing water), and some long term soil stability (vegetation groundcover and root growth holds soil against erosion). Reach 6 is a successful example of restoration of the riparian zone. Old pasture land has been transformed into a healthy floodplain, and bioengineering works have restored unstable stream sections. This work was completed by the developer of the Williamsburg development lands.

'despite best efforts to manage stormwater with lot level, conveyance, and end of pipe treatments, urban development can still trigger stream instability'

Despite best efforts to manage stormwater with lot level, conveyance, and end of pipe treatments, urban development can still trigger stream instability. Reach 8 showed significant indications of stream instability downstream of the stormwater management pond south of the Brooklin community centre. Although stormwater ponds are designed to release stormwater at rates that are designed to be non-erosive to the stream, the increased stormwater volume and longer duration of runoff from the pond may still cause problems. Where multiple ponds are discharging from various developments, the problem cumulates. Efforts to use stormwater on site (rainwater harvesting), and infiltrating stormwater into the ground should be maximized to reduce this problem.



Golf courses can provide conditions for geomorphically stable streams, as indicated by the health of the stream in reach 10 through the Lyndebrook Golf Course. Stewardship efforts should be directed to attaining similar conditions on all golf courses.

Stream health in reach 9 was negatively affected by manicured yards associated with private residential lots extending to the creek bank. This is a reminder that severing/subdividing floodplain or valley land for residential development is not an environmentally sound practice. Valleys should be kept intact, and transferred to public ownership if the adjacent lands are to be developed.

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