2.0 STUDY AREA DESCRIPTION AND EXISTING CONDITIONS

2.1 General

As noted in Section 1.1 there are two general study areas that have been defined for this study. The first area (Figure 1.3) relates to the area of the City that is serviced by separate storm sewers (the Water / Wastewater Master Plan addressed areas serviced by combined sewer systems). This area was considered when addressing issues relating to existing storm sewer capacity or the potential impacts of land use change on sewer capacity.

The second area (Figure 1.4) includes the entire City of Hamilton (urban and rural areas). Within the City there are 15 watersheds, and associated tributaries and creeks, as well as several receiving bodies of water including Cootes Paradise, Hamilton Harbour and the Welland River. This area was considered when assessing existing environmental conditions or impacts on the environment associated with existing or proposed land uses.

This chapter will initially summarize existing environmental conditions for the entire City of Hamilton (Section 2.2). It should be noted that for the purpose of this report, existing environmental conditions were based on a review of existing documents.

Section 2.4 summarizes the existing conditions for the storm sewer system.

2.2 Natural Environment

2.2.1 Natural Heritage

The following information was taken primarily from the report “Hamilton Natural Areas Inventory 2003”.

The City of Hamilton is located in the transition zone between two major forest regions: the Eastern Deciduous Forest (Carolinian Zone) and the Great Lakes – St. Lawrence Forest. In addition, the area boasts an exceptionally diverse physical landscape dominated by three features: the western Lake Ontario Shoreline and Hamilton Harbour Embayment; the Niagara Escarpment cuesta, running parallel to the shoreline, but some 2 km inland; and, the Dundas Valley, a major partially buried bedrock gorge in the shoreline and Escarpment. The physical landscape also creates some diverse microclimate conditions, particularly between the Escarpment and the Lake shoreline. Consequently, the floral and faunal assemblage is diverse and includes many species that are near the northern or southern limits of their geographic range (Heagy, 1995). Aquatic, wetland and terrestrial ecological systems are represented within the City of Hamilton as follows:

- Aquatic environments, including the Lake Ontario shoreline zone, the Hamilton Harbour – Cootes Paradise embayment, numerous small watercourses draining into the Harbour, Lake Ontario, the Grand River and the Niagara River, four inland reservoirs, and some natural and artificial ponds.
- Wetland environments are generally much more prevalent here than in other parts of Southwestern Ontario, particularly in Flamborough, where extensive areas of relatively undisturbed lowland forest are present on poorly drained, shallow, rocky soils. These forests include broadleaf swamps, mixed swamps, and cedar swamps. Other wetland environments include riparian marshes and swamps, small slough forest remnants, shoreline marshes and a few kettle bogs.
Throughout most of Hamilton, the terrestrial environment is dominated by agricultural and urban land use. The Dundas Valley and Niagara Escarpment corridors represent the largest remaining natural terrestrial habitats in the Hamilton area. Smaller, more disturbed upland areas with woodlots, plantations and old field habitats are widespread.

The natural areas of Hamilton encompass diverse natural features and serve important ecological and hydrological functions. Natural areas include both undeveloped lands (woodlots, wetlands, wildlife reserves, Escarpment lands and ravines) and previously disturbed lands that are reverting to a more natural state either spontaneously or deliberately. The present distribution of natural areas has been determined largely by geographic factors. Although no part of the area can be considered pristine, several relatively undisturbed greenspace areas remain. The largest natural areas are associated with either the Niagara Escarpment or the extensive bedrock plain found above the Escarpment in Flamborough.

Based on the Natural Areas Inventory study, a total of 107 sites were assessed, leading to the identification of 103 Environmentally Significant Areas (ESA’s). Table 2.1 provides a summary of natural heritage features within the City.

### Table 2.1: Summary of Natural Areas by Special Status Designation

<table>
<thead>
<tr>
<th>Area type</th>
<th>Number of Areas</th>
<th>Total Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth Science ANSI’s*</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Life Science ANSI’s</td>
<td>13</td>
<td>5,438</td>
</tr>
<tr>
<td>Candidate Earth Science ANSI’s*</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>International Biological Program Areas*</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>ESA’s (including candidate ESA’s)</td>
<td>103</td>
<td>20,924</td>
</tr>
<tr>
<td>Provincially Significant Wetlands</td>
<td>25</td>
<td>7,546</td>
</tr>
</tbody>
</table>

* Area not available

The distribution of these features is shown in Figure 2.1. There is considerable overlap among the 3 key special status areas, and as a result, the total natural area within the City with protection status is less than the sum of the individual categories. Table 2.2 provides a summary by watershed, of the area covered by designated natural features within the City.
### Table 2.2: Distribution of Natural Areas by Watershed

<table>
<thead>
<tr>
<th>Watershed</th>
<th>Receiving Waterbody</th>
<th>Natural Areas (ha)</th>
<th>Watershed Area (ha)</th>
<th>Percent Natural Area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Big Creek</td>
<td>Grand River</td>
<td>1165</td>
<td>12473</td>
<td>9.3</td>
</tr>
<tr>
<td>Borer's Creek</td>
<td>Hamilton Harbour</td>
<td>350</td>
<td>2092</td>
<td>16.7</td>
</tr>
<tr>
<td>Bronte Creek</td>
<td>Lake Ontario</td>
<td>3247</td>
<td>8901</td>
<td>36.5</td>
</tr>
<tr>
<td>Central Business</td>
<td>Hamilton Harbour</td>
<td>110</td>
<td>3132</td>
<td>3.5</td>
</tr>
<tr>
<td>Chedoke Creek</td>
<td>Hamilton Harbour</td>
<td>224</td>
<td>2658</td>
<td>8.4</td>
</tr>
<tr>
<td>Community of Stoney Creek</td>
<td>Lake Ontario</td>
<td>442</td>
<td>3491</td>
<td>12.7</td>
</tr>
<tr>
<td>Watercourses</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fairchild Creek</td>
<td>Grand River</td>
<td>4172</td>
<td>17421</td>
<td>23.9</td>
</tr>
<tr>
<td>Forty Mile Creek</td>
<td>Lake Ontario</td>
<td>140</td>
<td>1986</td>
<td>7.0</td>
</tr>
<tr>
<td>Grindstone Creek</td>
<td>Hamilton Harbour</td>
<td>2274</td>
<td>7088</td>
<td>32.1</td>
</tr>
<tr>
<td>Red Hill Creek</td>
<td>Hamilton Harbour</td>
<td>905</td>
<td>6912</td>
<td>13.1</td>
</tr>
<tr>
<td>Spencer Creek</td>
<td>Hamilton Harbour</td>
<td>5868</td>
<td>36249</td>
<td>16.2</td>
</tr>
<tr>
<td>Stoney Creek</td>
<td>Lake Ontario</td>
<td>510</td>
<td>3079</td>
<td>16.6</td>
</tr>
<tr>
<td>Sulphur Creek</td>
<td>Hamilton Harbour</td>
<td>1796</td>
<td>4128</td>
<td>43.5</td>
</tr>
<tr>
<td>Twenty Mile Creek</td>
<td>Lake Ontario</td>
<td>362</td>
<td>10985</td>
<td>3.3</td>
</tr>
<tr>
<td>Welland River</td>
<td>Niagara River</td>
<td>743</td>
<td>10534</td>
<td>7.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>22308</strong>*</td>
<td><strong>131131</strong>*</td>
<td><strong>17.0</strong>*</td>
</tr>
</tbody>
</table>

* Numbers rounded

The largest blocks of designated features occur within the Niagara Escarpment Area and in association with several large Provincially Significant Wetlands (PSWs) occurring in the headwaters of Fairchild, Bronte, Spencer and Grindstone Creeks. A list of Provincially Significant Wetlands is provided in Table 2.3 and is shown on Figure 2.1. The Hayesland Alvar, an ESA with an area of 550 ha located in close proximity to the Hayesland – Christie Wetland complex is also shown.
With over 7,500 ha of PSW’s (mostly in the northern part of its jurisdiction), the City has a much greater representation of wetlands than the rest of southwestern Ontario. Remaining undesigned natural features are primarily limited to woodlots in the rural parts of the watersheds.

Despite having a significant number of designated natural features for an area of this size, there are a number of threats to these areas as follows:

- Aggregate extraction, particularly in the northern part of the City: this encroaches on and potentially destroys a number of wetland features and also affects local water tables and even results in localized surface water diversions that impact wetland hydrology.
- Agricultural land uses: primarily encroachment on natural features and also installation of tile drainage/diversion of surface flows that change the water balance of these natural features.
- Ownership: many of these features remain in private ownership and are at risk from disturbance/destruction by landowners.
- Urban land uses: similar to agriculture, impacts relate to encroachment and changes to local water balance, drainage.
- Fragmentation: as urban areas gradually replace agriculture, many opportunities to maintain linkages between natural features are lost, in many cases leaving only the watercourses as the primary wildlife corridors. Upland corridors are scarce in the watersheds, primarily limited to the

### Table 2.3: List of Provincially Significant Wetlands (1998)

<table>
<thead>
<tr>
<th>Area Name</th>
<th>Size (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 Mile Creek- Wetland</td>
<td>30.8</td>
</tr>
<tr>
<td>Binbrook Conservation Area - Wetland</td>
<td>90.9</td>
</tr>
<tr>
<td>Carlisle Wetland Complex</td>
<td>15.0</td>
</tr>
<tr>
<td>Cootes Paradise- Wetland</td>
<td>121.7</td>
</tr>
<tr>
<td>Copetown Bog - Wetland</td>
<td>12.0</td>
</tr>
<tr>
<td>Dunmark Lake-Curans Swamp</td>
<td>39.2</td>
</tr>
<tr>
<td>Fairchild Creek Headwaters Complex</td>
<td>249.0</td>
</tr>
<tr>
<td>Flamborough Centre Complex</td>
<td>205.3</td>
</tr>
<tr>
<td>Fletcher Creek Swamp - Crieff Bog</td>
<td>525.5</td>
</tr>
<tr>
<td>Harrisburg East Swamp</td>
<td>45.4</td>
</tr>
<tr>
<td>Hayesland-Christie Wetland Complex</td>
<td>1473.09</td>
</tr>
<tr>
<td>Lake Medad Valley Swamp-Wetland</td>
<td>212.9</td>
</tr>
<tr>
<td>Logies Creek Wetland Complex</td>
<td>108.51</td>
</tr>
<tr>
<td>Lower Mountsberg Creek Complex- Wetland</td>
<td>299.2</td>
</tr>
<tr>
<td>North Carlisle Swamp</td>
<td>11.0</td>
</tr>
<tr>
<td>North Progreston Swamp</td>
<td>61.3</td>
</tr>
<tr>
<td>North Seneca Swamp - Wetland</td>
<td>10.0</td>
</tr>
<tr>
<td>Sheffield-Rockton Wetland Complex</td>
<td>735.2</td>
</tr>
<tr>
<td>Sinclairville Meander Basin Swamp - Wetland</td>
<td>37.1</td>
</tr>
<tr>
<td>Tiffany Creek Headwaters Wetland Complex</td>
<td>30.08</td>
</tr>
<tr>
<td>Troy Swamp</td>
<td>55.0</td>
</tr>
<tr>
<td>Valen's Reservoir And Swamp - Wetland</td>
<td>259.5</td>
</tr>
<tr>
<td>Van Wagner's Marsh</td>
<td>13.3</td>
</tr>
<tr>
<td>Vinemount Swamp</td>
<td>95.3</td>
</tr>
<tr>
<td>Welland River Area 5- Wetland</td>
<td>49.28</td>
</tr>
</tbody>
</table>
Niagara Escarpment Planning Area. In particular there are few linkages between features in the headwaters of the watercourses that are outside the drainage of the Hamilton Harbour – Cootes Paradise drainage area. Watercourses for the primary linkages between headwater areas and the natural heritage systems exist downstream in Bronte, Fairchild, Big, Twenty Mile, Forty Mile Creeks and the Welland River.

### 2.2.2 Aquatic Resources

The amount of fisheries information available for watercourses within the City is variable, with most information available on watercourses in the northern part of the City and the central part (draining to Cootes Paradise and Hamilton Harbour). Information is generally sparse for Fairchild and Big Creeks (GRCA); the Welland River, Twenty Mile and Forty Mile Creeks (NPCA); and watercourses within the community of Stoney Creek.

Of equal importance as the streams in supporting fish communities, are the principal receiving waterbodies, including Cootes Paradise, Hamilton Harbour, Lake Ontario, the Grand River and the Niagara River. Both the Niagara River and Hamilton Harbour/Cootes Paradise are Great Lakes Areas of Concern identified by the International Joint Commission. In both cases, Remedial Action Plans have been developed to address aquatic environmental problems associated with these areas, and implementation of the plans is ongoing. Both Fairchild and Big Creek are actively managed as part of the Grand River Fisheries Management Plan (Zones 2 and 3 respectively).

There are several reservoirs within the City including Christie and Valens Reservoirs (Spencer Creek), Mountsberg (Bronte Creek), Lake Medad (Grindstone Creek) and Binbrook/Lake Niapenco (Welland River).

The distribution of aquatic communities is provided in Figure 2.2.

**Grand River Drainage: Fairchild Creek, Big Creek**

The headwaters of Fairchild Creek contain numerous wetland features, however these appear to function locally to attenuate runoff providing limited local baseflow to Fairchild Creek. The main branch of the creek within the City is considered to be a warmwater stream supporting a tolerant/diverse warmwater fish community. Many of the headwater tributaries are intermittent. Further downstream, Fairchild Creek is part of the Middle Grand Management Zone and is considered to provide an important refuge for coldwater species such as rainbow trout.

The headwaters of Big Creek within the City are characterized by numerous small drainage features that are predominantly intermittent. Big Creek is part of the Lower Grand Management Zone, which is managed for warmwater and coolwater sportfish including large and small mouth bass and walleye.

Agricultural land uses represent the primary stressors on the aquatic communities of Big and Fairchild Creeks. Key limitations include:

- Lack of baseflow
- Erosion and sedimentation of stream channels
- Lack of riparian habitat
- Water quality impacts, primarily nutrient and bacteria enrichment
Lake Ontario South Shore/Niagara River Drainage: Forty Mile Creek, Twenty Mile Creek, Welland River

Forty Mile Creek is represented by several small headwater drainage features near the eastern boundary of the City. These watercourses are intermittent and have been altered to some degree as municipal drains. Further downstream, Forty Mile Creek supports a tolerant/diverse warmwater fish community. Key habitat limitations include:

- Lack of baseflow
- Alteration and sedimentation of stream channels
- Lack of riparian habitat
- Water quality impacts, primarily nutrient and bacteria enrichment

Twenty Mile Creek consists of two major branches and numerous intermittent headwater drainage features. The main branches are low gradient, meandering channels in ill-defined valley features. Based on historic and current fisheries inventories, the fish community of Twenty Mile Creek has changed very little in the past 30 years and is characteristically a tolerant/diverse warmwater fish community. The creek also has some unique species such as grass pickerel, that is currently being evaluated as a potential COSEWIC species. Impacts to the creek are primarily related to agricultural land uses, however there are some urban impacts related to the international airport and associated commercial development. Key habitat limitations that have been identified in the Twenty Mile Creek Watershed Plan (NPCA 2004) include:

- Lack of baseflow
- Alteration and sedimentation of stream channels
- Lack of riparian habitat
- Water quality impacts, primarily nutrient and bacteria enrichment

The Welland River headwaters, including the Binbrook/Lake Niapenco Reservoir are located within the City limits. The physiographic characteristics of the Welland River are similar to the upper Twenty Mile Creek and land use is also similar since the airport and associated commercial lands straddle the watershed boundary between Twenty Mile and Welland River. The Welland River also supports a diverse warmwater fish community, primarily as a result of the reservoir, which creates additional habitat diversity for warmwater species that prefer lacustrine habitats, including the basses, northern pike, grass pickerel, yellow perch and crappie. There is little information on the water quality/fish community of the reservoir, or on its potential effect on the downstream reaches of the river and the Niagara River. In addition, the reservoir is sensitive to sediment generation and transport from the upper watershed. Key habitat limitations include:

- Lack of baseflow
- Alteration and sedimentation of stream channels
- Lack of riparian habitat
- Water quality impacts, primarily nutrient and bacteria enrichment
Hamilton South Shore Drainage: Stoney Creek, Community of Stoney Creek Watercourses

The Community of Stoney Creek Watercourses are a number of small drainage features that drain part of the former municipality of Stoney Creek, north of the Escarpment. These features generally support a tolerant warmwater fish community with stream flows that are dominated by storm runoff.

Stoney Creek itself is a small Lake Ontario tributary that is essentially divided into 2 river segments by the Niagara Escarpment where it flows through the Devil’s Punchbowl. The watercourse on the Escarpment is intermittent in nature and supports a very tolerant warmwater fish community. Downstream of the Escarpment, the watercourse is strongly influenced by Lake Ontario fish species as well as the fish community of a large pond in Confederation Park. The fish community is typically a tolerant/diverse warmwater fish community and includes a number of sensitive minnow species such as rosyface shiner and brassy minnow. Salmonids, including rainbow trout migrate into the watercourse on a seasonal basis. Key limitations to fish habitat include:

- Stormwater inputs from industrial/commercial development (water quality and quantity)
- Lack of baseflow (above the Escarpment)
- Lack of riparian vegetation
- Poor instream habitats
- Channelization

Hamilton Harbour – Cootes Paradise Drainage: Chedoke, Red Hill, Sulphur, Spencer, Grindstone and Borer’s Creeks

All of these watercourses are characterized by having their headwaters on top of the Escarpment and their lower reaches flowing across glacial Lake Iroquois shore deposits before discharging into Cootes Paradise/Hamilton Harbour.

Chedoke Creek discharges into a long narrow southerly extension of Cootes Paradise adjacent to the Chedoke Parkway, with it headwaters in the vicinity of the Chedoke Golf and Ski Club and the Iroquoia Heights Conservation Area. The majority of the creek flows through parkland, including the Royal Botanical Gardens. The upper Chedoke Creek supports a very tolerant fish community and the lower Chedoke Creek supports a diverse warmwater fish community because of its proximity to Cootes Paradise.

Red Hill Creek flows for a significant portion of its length below the Escarpment and discharges into Hamilton Harbour via Windemere Basin. It flows over the Escarpment at Albion Falls and flows through the Kings Forest Park and Golf Course. Below the Escarpment, Red Hill Creek supports a tolerant warmwater fish community and has been heavily impacted by industrial land use around the harbour. A major restoration project, that includes fish habitat enhancements, is underway as part of the construction of the Red Hill Valley Parkway project. Upstream of the Escarpment (south of Lincoln Alexander Parkway), the creek supports also supports a tolerant warmwater fish community. Key habitat limitations include:

- Stormwater inputs from industrial/commercial development (water quality and quantity)
- Lack of baseflow (above the Escarpment)
- Lack of riparian vegetation (near the Harbour and upstream of the Escarpment)
- Poor instream habitats
• Channelization

Sulphur Creek is actually a tributary of Spencer Creek, joining Spencer Creek just upstream of its point of discharge to Cootes Paradise. Ancaster Creek and Tiffany Creek are major tributaries of Sulphur Creek. Tiffany, Ancaster and Sulphur Creeks have headwaters upstream of the Escarpment. Historically the upper reaches of Sulphur Creek was considered to be coldwater streams, however, currently conditions would be considered marginal to support brook trout. There are some rainbow trout in the headwaters of Sulphur Creek. The lower watercourse is also considered to provide coolwater habitat as a result of groundwater discharges that occur as the creek traverses the Escarpment. A major portion of the lower watershed is located in the Dundas Valley Conservation Area. These watercourse support a tolerant/diverse warmwater fish community downstream of the Escarpment, and in the case of Sulphur Creek in the headwaters as well, including some cool/coldwater species such as American brook lamprey and rainbow trout. The upper Ancaster and Tiffany Creeks support a tolerant warmwater fish community. There are numerous fish barriers on the upper part of Sulphur Creek. Key habitat limitations are primarily related to the portions of the watercourses upstream of the Escarpment and include:

• Lack of baseflow
• Urban construction impacts
• Alteration and sedimentation of stream channels
• Lack of riparian habitat

Spencer Creek is one of the larger watershed within the City and drains into Cootes Paradise via the Desjardins Canal, downstream of the West Pond. The majority of the watershed, particularly upstream of the Spencer Falls (where the creek falls over the Escarpment), is rural. The upper watershed also contains one of the few remaining coldwater streams within the City. A watershed plan was developed for Spencer Creek, including Sulphur and Ancaster Creeks (HCA, 1998). The watercourse is largely urban from the village of Greensville, downstream of the Christie reservoir. Headwater tributaries include Westover, Upper Spencer and Flamborough Creeks, all of which historically or currently support a coldwater fish community, including brook trout and mottled sculpin. These tributaries also historically or current support redside dace. The presence of the Valens and Christie Reservoirs have had a moderating effect on stream temperatures and also have resulted in an increase in abundance of warmwater fish species included yellow perch, northern pike and bass/sunfish species. The impact of the Christie Reservoir has resulted in Spencer Creek being classified as a warmwater stream downstream of this point. The main watercourses upstream of Christie Reservoir are considered to represent a coldwater fish community and a diverse warmwater fish community. Downstream of the reservoir, a diverse warmwater fish community exists. Most of the small tributaries above the Escarpment are either intermittent in nature, supporting a very tolerant warmwater fish community, or are dominated by cedar/tamarack swamp/wetland features and support a limited fish community including species such as redbelly dace, central mudminnow and a variety of minnow species. This wetland dominated headwater areas are limited in their ability to support fish, because they are wetland features rather than well defined watercourses. Key habitat limitations upstream of Christie Reservoir include:

• Lack of riparian habitat
• Runoff from agricultural lands
• Aggregate extraction impacting wetland features
• Nutrient enrichment from rural land uses
Key habitat limitations downstream of Christie Reservoir include:

- Lack of riparian habitat
- Erosion and sedimentation
- Stormwater discharges

Grindstone Creek discharges into Hamilton Harbour near the outlet of Cootes Paradise, after flowing through the Royal Botanical Gardens. There are several headwater tributaries of Grindstone Creek that are considered coldwater streams (the Millgrove Tributary and the Medad Tributary), although they no longer support brook trout. The main Grindstone Creek upstream of the Escarpment supports a tolerant/diverse warmwater fish community and most remaining tributaries upstream of the Escarpment are intermittent. Downstream of the Escarpment, groundwater discharge creates a cool/coldwater environment in the main creek, which is considered to support tolerant coldwater (rainbow trout) and diverse warm water fish communities. The other tributaries to the creek downstream of the Escarpment are considered intermittent. Key habitat limitations occur upstream of the Escarpment and include:

- Lack of baseflow (above the Escarpment)
- Lack of riparian habitat
- Storm drainage impact from urban areas
- Nutrient enrichment from agricultural land uses

Many tributaries of Borer’s Creek are intermittent upstream of the Escarpment, however the main stream supports a tolerant warmwater fish community that also includes northern pike and largemouth bass. Significant portions of the creek have been channelized as a result of urbanization. Downstream of the Escarpment (at Borer’s Falls), to its mouth in Cootes Paradise, the stream is largely in public ownership. It is considered to support a tolerant/diverse warmwater fish community and also has a migratory run of rainbow trout. Key habitat limitations include:

- Channelization in urban areas
- Lack of riparian habitat
- Lack of base flow
- Sedimentation and nutrient enrichment from agricultural land uses

**Lake Ontario North Shore Drainage: Bronte Creek**

A portion of the headwaters of Bronte Creek occur near the northern limit of the City. This includes part of Mountsberg Creek, including Mountsberg Reservoir and the East/Northeast Tributary of Bronte Creek. Bronte Creek is considered to be a coldwater stream in its lower reaches and discharges to the north shore of Lake Ontario in Oakville. Historically both the East Tributary and Mountsberg Creek were coldwater streams supporting brook trout, however brook trout are now only present in the East tributary. Both of these tributaries are also considered to support redside dace. Mountsberg Creek is considered to support a diverse warmwater fish community, although may still support remnant populations of Brook and Brown Trout. Key habitat limitations include:

- Lack of riparian habitat
- Lack of base flow (East Tributary)
- Thermal effects from Mountsberg Reservoir
2.2.3 Water Quality

Nutrients, bacteria, metals, suspended sediments and other contaminants can enter rivers and streams from a variety of sources, including:

- Excessive application of fertilizers and pesticides on rural and urban lands;
- Road runoff carrying contaminants from road maintenance, vehicle emissions;
- Contaminants in sediments eroded from urban and rural areas;
- Bacteria from domestic pets and livestock wastes;
- Improper storage and handling of chemicals in industrial/commercial/residential areas that enter storm sewers; and
- Sanitary sewage sources incorrectly connected to storm sewers.

Once in rivers and streams, these contaminants can cause degraded water quality leading to algae blooms, fish kills, beach closures, increased stress and even mortality to fish and wildlife, and poor aesthetics. Several water quality parameters that are indicators of water quality and general stream health were selected to compare the current conditions of Hamilton area streams. The following parameters were selected:

- Total Phosphorus: a nutrient that is usually in short supply in streams. High levels of Phosphorus (above Provincial Standards) can cause algae blooms, nuisance aquatic weed growths and reduce oxygen levels necessary to support fish;
- Total Suspended Solids: a measure of the amount of very fine sediment in water. Nutrients, bacteria and metals can be transported by suspended sediment from the land to streams, contributing to water quality degradation. High suspended sediment levels can also smother fish spawning grounds and impair fish respiration leading to mortality;
- E.coli Bacteria: a bacteria known to be associated with human and animal wastes that may indicate the presence of other, more harmful bacteria that can affect human health. The presence of high levels of E.coli result in swimming beach closures; and
- Copper: a metal that can cause stress and mortality to aquatic plants, fish and wildlife. It is one of several trace metals, including zinc and lead, that are often elevated in streams in urban and rural areas.

Table 2.4 summarizes the type of data which is available together with the period for which the data was collected. Water quality data is generally lacking for the other watercourses, although there is anecdotal data available for a number of locations as a result of specific water quality programs such as the Rural Beaches program, various municipal sewer outfall studies and aquatic habitat studies. In addition, there have been a number of benthic invertebrate community studies which were used to provide a relative water quality ranking of watersheds.
Table 2.4 – Summary of Available Water Quantity and Quality Data

<table>
<thead>
<tr>
<th>Tributary Name</th>
<th>Location</th>
<th>Flow</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spencer Creek</td>
<td>Westover</td>
<td>1989 to 2003</td>
<td>Phosphorus, Bacteria, Metals, TSS Concentrations</td>
</tr>
<tr>
<td>Spencer Creek</td>
<td>Main St.</td>
<td>-</td>
<td>1989 to 1995</td>
</tr>
<tr>
<td>Spencer Creek</td>
<td>Dundas</td>
<td>1989 to 2003</td>
<td>2002 to 2003</td>
</tr>
<tr>
<td>Grindstone Creek</td>
<td>Unsworth</td>
<td>1989 to 2003</td>
<td>-</td>
</tr>
<tr>
<td>Grindstone Creek</td>
<td>Hidden Valley Rd.</td>
<td>-</td>
<td>1997 to 2001</td>
</tr>
<tr>
<td>Grindstone Creek</td>
<td>Mill St. S.</td>
<td>-</td>
<td>1989 to 1997</td>
</tr>
</tbody>
</table>

Figure 2.3 and Table 2.5 compare average concentrations of these parameters at monitoring stations in Hamilton area streams to provincial standards. These data generally show that streams exhibit moderately degraded water quality conditions.

Urban streams: Red Hill and to a lesser extent Stoney Creek have water quality stations the represent urban conditions. Total Phosphorus and E. coli consistently exceed PWQO’s, while TSS and total copper generally exceed PWQO’s, only during precipitation/runoff events. These conditions would also be expected in Chedoke Creek, the Community of Stoney Creek watercourses, and the urban parts of Spencer and Grindstone Creeks.

Rural streams: Spencer, Grindstone, Bronte and Twenty Mile Creeks and the Welland River exhibit water quality conditions typical of streams dominated by agricultural land uses. Generally Total Copper and E. coli concentrations are within PWQO’s, while TSS and Total Phosphorus concentrations exceed PWQO’s, particularly during precipitation/runoff events.

While instream water quality conditions are important in terms of impacts on stream fish communities and habitats, the annual loading of these parameters, particularly TSS and Total Phosphorus, from these streams into Cootes Paradise and Hamilton Harbour is also significant, because these contaminants contribute to eutrophication of the wetland and harbour. Likewise, annual loadings from the other watersheds to receiving bodies such as Lake Ontario, the Grand River, and the Niagara River contribute to enrichment/contamination of these waterbodies. Figure 2.4 shows estimated annual loadings for the 4 parameters of concern at the mouths or City limits for each of the watersheds in the study area, under existing conditions, based on the watershed water quality model (see Section 5.3). In general, the results can be summarized as follows:

- Total Phosphorus: the more rural watersheds (Spencer, Fairchild, Big, Welland, Twenty Mile, Bronte and Grindstone) contribute the greatest phosphorus loadings, followed by Red Hill Creek.
- Total Suspended Sediment: results show similar trend to the total phosphorus results.
• E.coli: Spencer Creek and Red Hill Creek have the highest loadings, followed by the NPCA and GRCA watersheds, suggesting that both urban and rural sources of bacteria contribute significantly to annual loadings.

• Total Copper: Results generally reflect the urban contribution of each watershed to total copper loadings, with Red Hill, Spencer, Sulphur and Chedoke watershed contributing the greatest loading.
Table 2.5 - Dry and Wet Weather Concentrations for Watersheds within the City of Hamilton Area

<table>
<thead>
<tr>
<th>Reference Site No.</th>
<th>Creek Location</th>
<th>1 Station ID</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>Provincial Water Quality Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>9000800502</td>
<td>9000902402</td>
<td>900100502</td>
<td>9000800802</td>
<td>F1,M1,H1302,H1602</td>
<td>6002400602</td>
<td>16018409302</td>
<td>11000100902</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reference Site No.</td>
<td>900008000502</td>
<td>90000902402</td>
<td>9000100502</td>
<td>900008000802</td>
<td>F1,M1,H1302,H1602</td>
<td>6002400602</td>
<td>16018409302</td>
<td>11000100902</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Average Concentration</td>
<td>TP / dry</td>
<td>0.052 (26)*</td>
<td>0.072 (66)</td>
<td>0.064 (13)</td>
<td>0.046 (2)</td>
<td>0.035 (11)</td>
<td>0.2286 (10)</td>
<td>0.1029 (24)</td>
<td>0.1734 (8)</td>
</tr>
<tr>
<td></td>
<td>(mg/L) (no. of samples)</td>
<td>TP / wet</td>
<td>0.156 (24)</td>
<td>0.160 (46)</td>
<td>0.113 (3)</td>
<td>0.070 (4)</td>
<td>0.38 (8)</td>
<td>0.3283 (28)</td>
<td>0.1674 (15)</td>
<td>0.1582 (6)</td>
</tr>
<tr>
<td></td>
<td>Average Concentration</td>
<td>Cu / dry</td>
<td>0.0024 (26)</td>
<td>0.0030 (65)</td>
<td>0.0032 (13)</td>
<td>0.003 (2)</td>
<td>0.002 (9)</td>
<td>0.0044 (27)</td>
<td>0.002 (24)</td>
<td>0.0028 (8)</td>
</tr>
<tr>
<td></td>
<td>(mg/L) (no. of samples)</td>
<td>Cu / wet</td>
<td>0.0042 (25)</td>
<td>0.0110 (42)</td>
<td>0.0063 (3)</td>
<td>0.0062 (5)</td>
<td>0.0023 (7)</td>
<td>0.0054 (11)</td>
<td>0.0032 (15)</td>
<td>0.0033 (6)</td>
</tr>
<tr>
<td></td>
<td>Average Concentration</td>
<td>DO / dry</td>
<td>8.4318 (20)</td>
<td>9.9465 (43)</td>
<td>8.4608 (12)</td>
<td>13.37 (1)</td>
<td>10.00 (18)</td>
<td>8.4269 (26)</td>
<td>8.3512 (25)</td>
<td>5.56 (9)</td>
</tr>
<tr>
<td></td>
<td>(mg/L) (no. of samples)</td>
<td>DO / wet</td>
<td>10.8168 (22)</td>
<td>10.1147 (17)</td>
<td>9.4500 (20)</td>
<td>11.0920 (5)</td>
<td>8.41 (8)</td>
<td>8.5833 (12)</td>
<td>9.3773 (14)</td>
<td>10.6 (3)</td>
</tr>
<tr>
<td></td>
<td>Average Concentration</td>
<td>TSS / dry</td>
<td>20.8925 (26)</td>
<td>7.2278 (27)</td>
<td>5.8615 (13)</td>
<td>6.750 (2)</td>
<td>7.00 (10)</td>
<td>25.8296 (27)</td>
<td>41.276 (14)</td>
<td>88.9 (8)</td>
</tr>
<tr>
<td></td>
<td>(mg/L) (no. of samples)</td>
<td>TSS / wet</td>
<td>86.4320 (25)</td>
<td>15.3375 (16)</td>
<td>36.2333 (3)</td>
<td>9.54 (5)</td>
<td>9.61 (7)</td>
<td>72.8 (11)</td>
<td>78.3067 (25)</td>
<td>71.5 (6)</td>
</tr>
<tr>
<td></td>
<td>Average Concentration</td>
<td>E.coli / dry</td>
<td>1152 (20)</td>
<td>3007 (10)</td>
<td>4832 (10)</td>
<td>4880 (2)</td>
<td>86 (8)</td>
<td>1196 (14)</td>
<td>N/A</td>
<td>252 (8)</td>
</tr>
<tr>
<td></td>
<td>(counts) (no. of samples)</td>
<td>E.coli / wet</td>
<td>3064 (20)</td>
<td>916 (7)</td>
<td>4863 (3)</td>
<td>5402 (5)</td>
<td>425 (4)</td>
<td>1126 (7)</td>
<td>N/A</td>
<td>514 (5)</td>
</tr>
</tbody>
</table>

(Further details in Appendix D) * Number in brackets represents number of samples
In addition to water chemistry results, that provide an indication of water quality conditions in each watercourse, collections of benthic invertebrates (stream dwelling organisms including aquatic insects, worms, crayfish, clams and snails) can be used to provide an indication of the water quality conditions in a stream. A stream quality index, BIOMAP, can be calculated by tallying up the numbers, diversity and sensitivity of each benthic invertebrate species collected at stream locations, to give a water quality score. This score generally characterizes the degree of nutrient enrichment of the stream but can also indicate the effects of other contaminants such as trace metals, pesticides or organochloride compounds that may be toxic to aquatic life. The resulting scores are grouped into the following categories:

- Unimpaired
- Moderately Impaired
- Impaired
- Severely Impaired

BIOMAP data was sampled and compiled by each conservation authority over the past several years.

Table 2.6 provides a summary by watershed of the BIOMAP results, where data exists:

<table>
<thead>
<tr>
<th>Watercourse</th>
<th>Downstream of Escarpment</th>
<th>Upstream of Escarpment</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 Mile Creek</td>
<td>Impaired</td>
<td></td>
</tr>
<tr>
<td>Welland River</td>
<td>Impaired</td>
<td></td>
</tr>
<tr>
<td>40 Mile Creek*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stoney Creek*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community of Stoney Creek Watercourses*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red Hill Creek</td>
<td>Impaired</td>
<td>Impaired</td>
</tr>
<tr>
<td>Chedoke Creek*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulphur Creek</td>
<td>Unimpaired</td>
<td>Impaired</td>
</tr>
<tr>
<td>Ancaster Creek</td>
<td>Impaired</td>
<td>Impaired</td>
</tr>
<tr>
<td>Tiffany Creek</td>
<td>Unimpaired</td>
<td>Impaired</td>
</tr>
<tr>
<td>West Spencer/Westover Creek</td>
<td></td>
<td>Impaired</td>
</tr>
<tr>
<td>Flamborough Creek</td>
<td>Unimpaired</td>
<td></td>
</tr>
<tr>
<td>Mid Spencer Creek</td>
<td></td>
<td>Impaired</td>
</tr>
<tr>
<td>Lower Spencer Creek</td>
<td>Unimpaired</td>
<td></td>
</tr>
<tr>
<td>Borer’s Creek</td>
<td>Unimpaired</td>
<td>Impaired</td>
</tr>
<tr>
<td>Grindstone Creek</td>
<td>Moderately impaired</td>
<td>Impaired</td>
</tr>
<tr>
<td>Mountsberg Creek</td>
<td></td>
<td>Impaired</td>
</tr>
<tr>
<td>East/Northwest Tributary Creek</td>
<td></td>
<td>Unimpaired</td>
</tr>
</tbody>
</table>

* No data available

BIOMAP results generally agree with water quality (chemistry) results, indicating impaired/enriched conditions in both urban areas and agricultural areas. Unimpaired conditions still exist in some watersheds, however these areas are limited to the headwaters of Spencer Creek and a number of locations on creeks immediately downstream of the Escarpment, where significant inputs of groundwater occur, i.e. Sulphur, Tiffany, Lower Spencer and Borer’s Creeks. In addition to the groundwater inputs, these stream locations are well buffered from urban/rural land uses by extensive
areas of parkland or open spaces. The BIOMAP sampling locations were selected based on each conservation authorities priorities and are sampled on a routine basis.

2.2.4 Surface Drainage and Hydrology

There are numerous watersheds within the City of Hamilton that flow as far away as the Niagara River and Lake Erie. Major watersheds include:

- Lake Ontario: Bronte Creek, Forty Mile Creek, Stoney Creek, Twenty Mile Creek, Community of Stoney Creek Watercourses
- Hamilton Harbour: Borer’s Creek, Chedoke Creek, Grindstone Creek, Red Hill Creek, Sulphur Creek, Spencer Creek
- Niagara River: Welland River
- Lake Erie: Fairchild Creek, Big Creek

In addition, there are many smaller watercourses that drain into Hamilton Harbour, Cootes Paradise and Lake Ontario (Community of Stoney Creek). Streams are nature’s infrastructure, just as roads move vehicles and sewer systems move wastewater from one place to another, streams move water and their associated sediment, nutrient and contaminant load from their headwaters (on the Escarpment) to their mouths at the harbour or lake.

The hydrologic cycle describes how water moves. Precipitation reaching the ground is either taken up by plants (evapotranspiration), soaks into the ground (infiltration) entering the groundwater system or runs over the land surface to enter a creek (runoff). Stream flow is a combination of runoff and baseflow. Baseflow is groundwater that discharges into the stream. Land use change changes the proportions of runoff and baseflow entering streams. Urbanization often increases runoff and reduces baseflow in streams resulting in increased flooding and erosion and reduced baseflow. Streams with baseflows representing a large proportion of total flow often support coldwater fish communities, while streams with lower baseflows often support warmwater fish communities.

Floodline mapping has been completed by the Conservation Authorities for many of the City’s streams. Floodplain mapping identifies areas subject to flooding where development is prohibited. In some areas, historic development within the floodplain has occurred.

Stream flow gauges within the City are illustrated in Figure 2.5. Information from these gauges provides an overview of stream flows which can be linked to land use. For example, Figure 2.6 shows an annual hydrograph for Spencer Creek, a mostly rural watershed and Red Hill Creek, a mostly urban watershed. Comparison of the graphs show that runoff from rural areas is generally less flashy (precipitation events enter the stream more gradually showing an inverted “V” shape) than urban areas (precipitation events enter the stream quickly showing a “pulse” or “spike” of flow). Base flow in rural streams is also generally more consistent than in urban streams, as more water is able to infiltrate into the ground in a rural stream, since paved surfaces prevent infiltration and promote rapid runoff. On an annual basis, the amount of base flow in rural streams often is greater than 20% of the total annual streamflow, while in urban streams it is often less than 20%. The relative amount of base flow and runoff or event flow in a watercourse is significant for a number of reasons:

- Surface runoff generally transports more contaminants from land surfaces to streams than base flow, meaning a greater loading of pollutants to the stream
- Base flow is generally cooler than surface runoff, meaning that coldwater fish have a better chance to survive in streams with greater baseflows
- A larger proportion of surface runoff typically results in greater potential for stream flows to cause erosion, meaning that the stream may become wider and shallower and create erosion hazards to nearby properties and structures.

As one of the larger urban centres in southern Ontario, the surface drainage within the City of Hamilton is unique in that its jurisdiction straddles two significant landforms: the Niagara Escarpment, that defines an earlier lake shoreline; and the drainage divide between two Great Lakes – Lake Ontario and Lake Erie. Thus, not only are there 15 watersheds, with a total drainage area of over 131,000 ha, located within the City, but each has a significant portion of its headwaters within the City. As a result, Hamilton has a preponderance of headwater streams, which are often the watercourses that are most sensitive to land use impacts. Under current land use conditions, the majority of these headwater streams are located in the rural portions of the City. While the City is predominately rural – 61% of total land use, land use within each watershed varies considerably:

<table>
<thead>
<tr>
<th>Watershed</th>
<th>Urban (%)</th>
<th>Rural (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Big Creek</td>
<td>3.5%</td>
<td>96.5%</td>
</tr>
<tr>
<td>Borer’s Creek</td>
<td>13.4%</td>
<td>86.6%</td>
</tr>
<tr>
<td>Bronte Creek</td>
<td>0.0%</td>
<td>100.0%</td>
</tr>
<tr>
<td>Central Business</td>
<td>99.8%</td>
<td>0.2%</td>
</tr>
<tr>
<td>Chedoke Creek</td>
<td>99.4%</td>
<td>0.6%</td>
</tr>
<tr>
<td>Community of Stoney Creek Watercourses</td>
<td>56.8%</td>
<td>43.2%</td>
</tr>
<tr>
<td>Fairchild Creek</td>
<td>0.0%</td>
<td>100.0%</td>
</tr>
<tr>
<td>Forty Mile Creek</td>
<td>0.0%</td>
<td>100.0%</td>
</tr>
<tr>
<td>Grindstone Creek</td>
<td>5.3%</td>
<td>94.7%</td>
</tr>
<tr>
<td>Red Hill Creek</td>
<td>80.6%</td>
<td>19.4%</td>
</tr>
<tr>
<td>Spencer Creek</td>
<td>5.1%</td>
<td>94.9%</td>
</tr>
<tr>
<td>Stoney Creek</td>
<td>27.4%</td>
<td>72.6%</td>
</tr>
<tr>
<td>Sulphur Creek</td>
<td>46.2%</td>
<td>53.8%</td>
</tr>
<tr>
<td>Twenty Mile Creek</td>
<td>4.6%</td>
<td>95.4%</td>
</tr>
<tr>
<td>Welland River</td>
<td>4.1%</td>
<td>95.9%</td>
</tr>
</tbody>
</table>

Floodplain mapping has been completed for most of the watersheds. Most flooding upstream of the Escarpment does not create hazardous conditions and is primarily associated with the large wetland features in the northern part of the City, as well as the well defined valley systems along Fairchild, Big and Twenty Mile Creeks and the Welland River. On the other hand, where watercourses cross the Escarpment and the historic lake deposits below the Escarpment, flooding and erosion hazards exist. This area also includes the majority of the urban lands in the City. There are ongoing erosion and flooding concerns (including some areas with basement flooding issues) in the following watercourses, downstream of the Escarpment: Borer’s, Sulphur, Ancaster, Red Hill and Chedoke Creeks. There are also localized flooding problems in Stoney Creek and the Community of Stoney Creek Watercourses. Localized flooding and erosion problems also occur in some of the rural settlement areas, and both the Welland River and Twenty Mile Creek have flood damage centres located downstream of the City of Hamilton.
There are several reservoirs that serve a flood control function within the City including Christie and Valens Reservoirs (Spencer Creek), Mountsberg (Bronte Creek), Lake Medad (Grindstone Creek) and Binbrook/Lake Niapenco (Welland River).

The City updated their Development Charges in 2006 that included estimated costs for stormwater management facilities and erosion control works, updated from the 2004 study. Approximately $43 million was identified for erosion control works associated with new development, however only a portion of this total was considered recoverable through Development Charges. In total, 53 sites were identified for erosion control works in the following areas:

- Waterdown
- Ancaster
- Hamilton Mountain
- Mount Hope
- Upper Stoney Creek
- Binbrook
- Lower Stoney Creek

This work did not address existing erosion problems within the urban area.

![Annual Hydrograph (1989)](image)

**Figure 2.6: Annual hydrographs from a rural (Spencer Creek) versus an urban (Red Hill Creek) stream**

### 2.2.5 Geology, Physiography and Soils

Material for this section was taken primarily from the report “Hamilton Groundwater Resource Characterization and Wellhead Protection Partnership Study” (SNC Lavalin, 2004).
Physiography

Portions of the following physiographic regions, as described by Chapman and Putnam (1984), occur within the study area:

- Niagara Escarpment,
- Iroquois Plain,
- Flamborough Plain,
- Horseshoe Moraines, and
- Norfolk Sand Plain.

The Niagara Escarpment extends through the study area in a westerly direction from Stoney Creek in the southeast end of Hamilton to a point west of Dundas from where it then runs east-northeast to Waterdown. It is a bedrock Escarpment characterized by steep cliffs on the eastern side and gently sloping terrain to the west. Extending back from the Escarpment, the surficial deposits overlying the dolostone bedrock are generally thin to non-existent. The configuration of the Escarpment is greatly influenced by the Dundas Valley, within which the old City of Hamilton is located. It is of pre-glacial origin and extends inland for about 13 kilometers from the western edge of Lake Ontario. It contains a major buried valley and creates a re-entrant feature within the Escarpment. There are no large streams within the valley, however, there are a number of smaller streams that have dissected the drift and nearby Red Hill Creek occupies another pre-glacier valley. From the Dundas valley northward, the crest of the Escarpment increases in elevation, and is cut by numerous creeks, including Bronte Creek. A broad band of red shale is exposed beneath the dolostone and the long lower slopes for the Escarpment are highly eroded.

Between the foot of the Escarpment and Lake Ontario is the Iroquois Plain that resulted from the inundation of the area by glacial Lake Iroquois. The Iroquois Plain consists of lacustrine deposits and lake-bottom sediments that have been smoothed by wave action and which extend around the western end of Lake Ontario through the study area. The width of the plain is about 3 kilometres in the study area, and it is cut by a number of creeks, with lagoons or marshes near their outlet to the lake.

The Flamborough Plain is a small area of shallow drift overlying the dolostone rocks that outcrop at the top of the Niagara Escarpment, and is bounded to the northwest by the Galt Moraine. A few drumlins are scattered over this plain and swamps are plentiful. The underlying dolostone is exposed in places, particularly near the edge of the Escarpment on its eastern border. The little overburden that is present is either bouldery glacial till or sand and gravel. The Beverley Swamp and other small swamp features provide flow to Spencer and Bronte Creeks. The dolostone bedrock of the Flamborough Plain is a major aquifer supplying the Carlisle and Frelton municipal wellfields.

The Haldimand Clay Plain occupies the area from the Niagara Escarpment to Lake Erie in the south portion of the study area. A glacial lake covered this area and, as a result, at some locations stratified clay overlies clay till and there are also intermixed layers of till and stratified clay. The overburden thickness increases southward from the Niagara Escarpment. The Horseshoe Moraines constitute a long system of moraines that skirts the west edge of the study area. The deposits are mixed till, kame, and sand and gravel terrace deposits. Some of the moraine is very hilly with significant local relief.

Between the Horseshoe Moraines and the Haldimand Clay Plain there are glaciolacustrine sand deposits which make up the Norfolk Sand Plain and overly the upper reaches of the Dundas Valley. The bedrock within the centre of the Dundas Valley is believed to be about 105 m below sea level and the valley has
been traced southwestward into the Branford area (Karrow and Sprague, 1975) where it connects to the Grand River valley. Karrow (1987) suggests the valley was cut by an earlier form of the Grand River and then deepened by glacial action.

Geology

The Quarternary Geology of the study area closely parallels the Physiography. The lacustrine deposits of the Iroquois Plain are found along the Lake Ontario shoreline, and extend from Hamilton towards Burlington. Sand and gravel bars also occur and there are alluvial fan gravels at the outlet of the Dundas Valley. Halton till mantles the Escarpment north of Burlington and through Dundas, over the Dundas Valley, and extending along the south shore of Lake Ontario through Stoney Creek and Grimsby. Areas of Queenston Shale are exposed along the slopes of the Escarpment where gullies have cut through the Halton Till, and fairly extensively along the south shore of the Lake. Above the Escarpment, from the City’s eastern boundary to west of Lynden, there are deposits of lacustrine sand. Through Flamborough, the bedrock surface is covered by a thin veneer of sand or is exposed at the surface. Further north, deposits from the Wentworth Till, a stoney sandy silt till, occur along with northwest to southeast trending drumlins and deposits of the Galt Moraine along the northwest boundary of the study area. Glacio lacustrine gin grained sediments (silt and clay) occur in much of the southern portion of the study area, encompassing most of Glenbrook, the southern portion of Ancaster, and extending along the western City boundary.

Paleozoic Geology

The oldest bedrock in the study area includes the Georgian Bay formation (which does not outcrop in the study area but lies beneath the Queenston Formation) and the Queenston formation that outcrops extensively between the base of the Escarpment and the Lake Ontario shoreline. It is also exposed as reddish brown mudstones and shales at the Escarpment base with a thickness of about 140 m. The remaining bedrock units are of Silurian age and are exposed along the face of the Niagara Escarpment and outcrop or subcrop up to 70 km west of the Escarpment.

The Silurian bedrock shows considerable variation throughout the study area, thus making it difficult to represent the study area in one cross section. The deepest Silurian group is the Cataract Group (about 15 m thick in the study area) that includes sandstones, dolostones, as well as shales. Reddish-brown sandstones and shales of the Grimsby formation represent the most recent Silurian deposits, near the base of the Escarpment. The Clinton Group overlies the Cataract Group in the central part of the study area and have a combined thickness of about 30 m, consisting of a succession of sandstones, shales, dolostones and limestones most of which pinch out to the west and north (for example they are only about 9 m thick where they underlie former Flamborough Township). The Clinton Group is overlain by the Lockport and Amabel Formations, the shallowest of the bedrock features that form the cliffs of the Escarpment. The Lockport Formation is about 30 m thick gives way laterally to the Amabel Formation around Waterdown. The Eramosa formation (Lockport Formation unit) overlays much of the Lockport and Amabel bedrock in the study area. The Amabel Formation is a reef-rich formation exceeding 30 m in thickness. The Guelph Formation outcrops extensively in the Flamborough Township area and reaches a thickness of 10 – 15 m. In the southern portion of the study area, and in Haldimand County, petroleum gas reserves are found in some of the bedrock formations. These reserves occur in the lower Silurian layers including the Thorold, Grimsby and Whirlpool Formations (Cataract layers).

There is one location that has been officially recognized as a provincially significant area of natural and scientific interest (ANSI) because of the existence of clearly defined karst landforms and features. It is
the Eramosa Karst and is located in the former City of Stoney Creek, roughly bounded by Highland, Rymal and Upper Mount Albion Roads and Second Road West. It has examples of 16 different karst features and is owned by HCA. In the Waterdown area, karst features have also been identified and it can be expected that karst features may exist wherever carbonate deposits are found, however these are often obscured by overlying quaternary deposits and not easily observed. Karst topography likely plays a role in the movement of groundwater in the aquifers supplying Carlisle, Freelton and Greensville municipal wells.

The soils in the City to a large extent reflect the surficial geology. The most striking features are the extensive areas in the former township of Flamborough, with very shallow soils or exposed bedrock. The soils in this area which includes much of Fairchild, Bronte, Spencer have limited capability for agriculture and are sandy and nutrient poor. Overburden thickness is much greater in much of the remainder of the rural parts of the City with much heavier loamy – clayey till soils. This is the case for parts of Big Creek as well as the watersheds draining the southern part of the City.

2.2.6 Hydrogeology

The overburden aquifers in the study area consist of granular deposits within the shallow overburden and those present in the thicker deposits found within or on the flanks of bedrock valleys, such as the Dundas Valley.

The Bedrock aquifers are found primarily in the dolostones of the Guelph and Amabel/Lockport Formations, occurring above the Niagara Escarpment and supply municipal wells at Freelton, Carlisle and Greensville. This aquifer, referred to as the Guelph-Lockport Aquifer or in the area north of Hamilton, as the Guelph-Amabel Aquifer, is considered to be one of the major aquifers in Ontario. In the Niagara Peninsula, this aquifer has a maximum thickness of over 60 m, but in the vicinity of Carlisle and Freelton municipal wellfields, where the Guelph formation is absent, the aquifer thickness is significantly less, about 13 – 27 m. The Salina formation, which overlies the Guelph Formation in western parts of the study area, is not exploited as a source of municipal water supply within the City of Hamilton, however it does serve as the source of water for many private wells and can be considered as a regional aquifer, however water quality problems occasionally arise.

The shales of the Cataract Group that underlie the Dolostones form a regional aquitard beneath the area, as is apparent from the springs which occur along the face of the Niagara Escarpment at the contact beween the water-bearing dolostones and the underlying shales. While the Guelph-Amabel/Guelph-Lockport Aquifer extends beneath much of the City and is used as a source of water throughout the area, it is only in the Dundas Valley, where it has been developed as a source of municipal water supply. Limestones and dolostones, while typically having low permeability, frequently have a high secondary permeability due to the presence of solution channels the develop along faults, fractures and bedding planes. The aquifers in Freelton, Carlisle and Greensville are developed on these characteristics.

The complex nature of the surficial and bedrock geology as well as the complexity of the aquifer systems results in some variable effects on groundwater discharge streams. In areas where there is Karst topography, there are “losing” streams, streams that recharge the groundwater through the stream bed. Such areas occur in the middle and upper reaches of Spencer Creek, in Twenty Mile Creek and possibly in parts of Bronte Creek. In many areas above (upstream) of the Escarpment, it appears that there is limited local groundwater supplies to support stream base flows and as a result, many headwater drainage features in all of the watersheds are intermittent. Instead, recharge occurring on and above the Escarpment tends to supply deeper aquifer systems and often discharges to watercourses as they descend.
over the Escarpment. This phenomenon is sufficiently pronounced, that in the case of some streams, such as Grindstone, Borer’s, Ancaster and Sulphur Creeks, there is a marked reduction in stream temperature, in some cases sufficient to result in cool/cold water stream status.

While there are numerous wetlands, particularly in the northern part of the City, the function of these wetlands in recharging groundwater supplies appears limited to recharging the deep aquifer system. These wetlands do also serve a significant water storage function and as such contributed to stream base flow in Spencer, Bronte and Fairchild Creeks.

The groundwater system behaves similarly within the headwaters of Big Creek, Welland River, Twenty and Forty Mile Creeks, in that the majority of headwater streams are intermittent and bedrock outcrops in these systems occur much further downstream outside of the City limits.

2.3 Socio-Economic Environment

2.3.1 Social Environment

Hamilton has a long history of human settlement and development. Due to the combination of favorable climate conditions and productive soils, Hamilton includes some of the best agricultural lands in Canada, including specialty croplands used for growing tender fruits. The area continues to support an important agricultural industry.

Due to its strategic geographic location at the apex of the Ontario’s Golden Horseshoe, much of the area’s landscape has been strongly influenced by human settlements and land use activity. Non-agricultural development in the area was initially concentrated in small clusters wherever streams could provide a source of hydraulic power. Following the construction of shipping canals in the 1800’s, urban centers began to develop around the Harbour facilities at Hamilton and Dundas. Industrial, commercial and residential developments subsequently spread out along the system of railways that radiated out from the head of the lake.

The City of Hamilton spans 110,000 hectares along the Niagara Escarpment and south western shores of Lake Ontario. It is home to approximately 510,000 people and millions of annual visitors. Hamilton’s geography is distinctive, with the Escarpment (the Mountain) acting as a dividing line between the waterfront / core area and other parts of the City.

Hamilton has a diversity of neighbourhoods. The core area along with parts of Dundas, Flamborough, Ancaster and Stoney Creek has well established, mature neighbourhoods defined by older homes, mature trees and heritage properties. The core area is also where much of Hamilton’s higher density neighbourhoods are located. Suburban parts of former Hamilton, Flamborough, Ancaster and Stoney Creek have modern residential and commercial development. Glenbrook typifies the more rural parts of the City that blend old with new homes.

The south and east shores of the Harbour have been filled over time and developed for industrial and commercial activities (primarily the iron and steel industries), marine terminals, railway and highway construction, institutional uses and recreational uses. Twenty-five percent of the area of the original bay has been filled, eliminating 65 percent of the wetlands, protected inlets and shallow areas.
The eastern shore is comprised of the highway, the Desjardins canal, institutional lands, as well as commercial activities that prevent significant general public access. However, increasing public access in the south eastern end is one of the tasks of the Hamilton Harbour RAP.

The north shore of the Harbour in the Aldershot district of the City of Burlington consists largely of private homes, a private golf course, two cemeteries and public park.

The western shore is shared between railway land and the Hamilton Waterfront Trail, a public walking trail.

The western end of the south shore includes Bayfront Park and Pier 4 Park, both with public beaches.

Urban land uses within the City of Hamilton comprise approximately 15 percent of the total land area. Of the remaining 85 percent, approximately 61 percent of the lands are classified as rural. Proposed development, which includes the development of vacant lands within the existing Official Plan and lands outside the existing urban boundary, will increase the percentage of urban lands from 15 percent to 21 percent.

2.4 Municipal Infrastructure

2.4.1 Stormwater Infrastructure

Prior to amalgamation, each of the former municipalities managed their own storm drainage system, and set its own storm drainage policies and guidelines. Local differences related to physical setting or past development resulted in differences between the policies and guidelines of the former municipalities. The City of Hamilton Storm Drainage Policy (2004) provides a historical perspective as to how each former municipality designed and managed their storm drainage system. Further information with respect to storm drainage system criteria and policy is provided in section 5.2.3 of this report.

The stormwater infrastructure that was considered in this study includes the storm trunk sewers for areas serviced by separate storm sewer system together with the existing (as of 2004) stormwater management facilities. Figure 2.7 illustrates the study area, approximate location of the stormwater management facilities and general extent of the storm sewer infrastructure that was included as part of this study. Chapter 5 provides further details.

2.5 Summary of Environmental Conditions

Physiography and Groundwater

Portions of the following physiographic regions, as described by Chapman and Putnam (1984), occur within the study area:

- Niagara Escarpment,
- Iroquois Plain,
- Flamborough Plain,
- Horseshoe Moraines, and
- Norfolk Sand Plain.
STORMWATER MASTER PLAN STRATEGY
Existing Storm Sewer and Stormwater Management Pond Locations

DATE: 18 April 2007
Together with their proximity to Lake Ontario, Hamilton Harbour and Cootes Paradise, these features create a complex mosaic of geology and topography, unique in southern Ontario. Overburden is thin to non-existent in the northern part of the City, however richer loamy and silty clay soils persist to south and east. Below the Escarpment, which is mostly urban, are the glacial lake deposits and prehistoric shore features of Lake Iroquois. The Niagara Escarpment, which runs through the centre of the City’s jurisdiction around the harbour, is the most prominent topographic feature and creates radically different environmental conditions between the landscapes at its base versus those above it. There are also numerous karst features scattered along the Escarpment, most notably in Twenty Mile and Spencer Creeks. Significant recharge areas exist in the northern part of the City above the Escarpment and also in scattered areas along the landward side of the Escarpment to the south and east. The headwaters of Big and Fairchild Creeks also have some extensive recharge areas.

The Bedrock aquifers are found primarily in the dolostones of the Guelph and Amabel/Lockport Formations, occurring above the Niagara Escarpment and supply municipal wells at Freelton, Carlisle and Greensville. This aquifer, referred to as the Guelph-Lockport Aquifer or in the area north of Hamilton, as the Guelph-Amabel Aquifer, is considered to be one of the major aquifers in Ontario. Shallow groundwater supplies are generally poor, and the majority of the watercourses above the Escarpment are intermittent in nature, except where wetlands provide a source of stream flow by storing surface runoff. This is the case with Fairchild, Grindstone, Spencer and Bronte Creeks. As the creeks fall over the Escarpment there is significant groundwater discharge, to the extent that some streams that are warmwater streams above the Escarpment become coldwater streams below it, for example, Ancaster, Sulphur, Borer’s and Grindstone Creeks.

While there are numerous wetlands, particularly in the northern part of the City, the function of these wetlands in recharging groundwater supplies appears limited to recharging the deep aquifer system. These wetlands do also serve a significant water storage function and as such contributed to stream base flow in Spencer, Bronte and Fairchild Creeks.

The groundwater system behaves similarly within the headwaters of Big Creek, Welland River, Twenty and Forty Mile Creeks, in that the majority of headwater streams are intermittent and bedrock outcrops in these systems occur much further downstream outside of the City limits.

**Surface Drainage and Hydrology**

As one of the larger urban centres in southern Ontario, the surface drainage within the City of Hamilton is unique in that its jurisdiction straddles two significant landforms: the Niagara Escarpment, that defines an earlier lake shoreline; and the drainage divide between two Great Lakes – Lake Ontario and Lake Erie. Thus not only are there 15 watersheds, with a total drainage area of over 131,000 ha, located within the City, but each has a significant portion of its headwaters within the City. As a result, Hamilton has a preponderance of headwater streams, which are often the watercourses that are most sensitive to land use impacts. Under current land use conditions, the majority of these headwater streams are located in the rural portions of the City. While the City is predominately rural – 61% of total land use, land use within each watershed varies considerably:
Floodplain mapping has been completed for most of the watersheds. Most flooding upstream of the Escarpment does not create hazardous conditions and is primarily associated with the large wetland features in the northern part of the City, as well as the well defined valley systems along Fairchild, Big, Twenty Mile Creeks and the Welland River. On the other hand, where watercourses cross the Escarpment and the historic lake deposits below the Escarpment, flooding and erosion hazards exist. This area also includes the majority of the urban lands in the City. There are ongoing erosion and flooding concerns (including some areas with basement flooding issues) in the following watercourses, downstream of the Escarpment: Borer’s, Sulphur, Ancaster, Red Hill and Chedoke Creeks. There are also localized flooding problems in Stoney Creek and the Community of Stoney Creek Watercourses. Localized flooding and erosion problems also occur in some of the rural settlement areas, and both the Welland River and Twenty Mile Creek have flood damage centres located downstream of the City of Hamilton.

The City updated their Development Charges in 2006 that included estimated costs for stormwater management facilities and erosion control works, updated from the 2004 study. Approximately $43 million was identified for erosion control works associated with new development, however only a portion of this total was considered recoverable through Development Charges.

There are several reservoirs that serve a flood control function within the City including Christie and Valens Reservoirs (Spencer Creek), Mountsberg (Bronte Creek), Lake Medad (Grindstone Creek) and Binbrook/Lake Niapenco (Welland River).

**Water Quality**

Contaminants from urban and rural land uses are delivered to watercourses through surface runoff and in suspended sediments. Once in rivers and streams, these contaminants can cause degraded water quality leading to algae blooms, fish kills, beach closures, increased stress and even mortality to fish and wildlife and poor aesthetics. Several water quality parameters that are indicators of water quality and general stream health were selected to compare the current conditions of Hamilton area streams. The following parameters were selected:
• Total Phosphorus: a nutrient that is usually in short supply in streams. High levels of Phosphorus (above Provincial Standards) can cause algae blooms, nuisance aquatic weed growths and reduce oxygen levels necessary to support fish;
• Total Suspended Solids: a measure of the amount of very fine sediment in water. Nutrients, bacteria and metals can be transported by suspended sediment from the land to streams, contributing to water quality degradation. High suspended sediment levels can also smother fish spawning grounds and impair fish respiration leading to mortality;
• E.coli Bacteria: a bacteria known to be associated with human and animal wastes that may indicate the presence of other, more harmful bacteria that can affect human health. The presence of high levels of E.coli result in swimming beach closures; and
• Copper: a metal that can cause stress and mortality to aquatic plants, fish and wildlife. It is one of several trace metals, including zinc and lead, that are often elevated in streams in urban and rural areas.

A comparison of average concentrations of these parameters at monitoring stations in Hamilton area streams was made to provincial standards. These data generally show that streams exhibit moderately degraded water quality conditions.

**Urban streams:** Red Hill and to a lesser extent Stoney Creek have water quality stations the represent urban conditions. Total Phosphorus and E. coli consistently exceed PWQO’s, while TSS and Total Copper generally exceed PWQO’s, only during precipitation/runoff events. These conditions would also be expected in Chedoke Creek, the Community of Stoney Creek watercourses, and the urban parts of Spencer and Grindstone Creeks.

**Rural streams:** Spencer, Grindstone, Bronte and Twenty Mile Creeks and the Welland River exhibit water quality conditions typical of streams dominated by agricultural land uses. Generally Total Copper and E. coli concentrations are within PWQO’s, while TSS and Total Phosphorus concentrations exceed PWQO’s, particularly during precipitation/runoff events.

While instream water quality conditions are important in terms of impacts on stream fish communities and habitats, the annual loading of these parameters, particularly TSS and Total Phosphorus, from these streams into Cootes Paradise and Hamilton Harbour is also significant, because these contaminants contribute to eutrophication of the wetland and harbour. Likewise, annual loadings from the other watersheds to receiving bodies such as Lake Ontario, the Grand River, and the Niagara River contribute to enrichment/contamination of these waterbodies.

Sources of these poor water quality conditions can be linked to the following:

• Excessive application of fertilizers and pesticides on rural and urban lands;
• Road runoff carrying contaminants from road maintenance, vehicle emissions;
• Contaminants in sediments eroded from urban and rural areas
• Bacteria from domestic pets and livestock wastes;
• Improper storage and handling of chemicals in industrial/commercial/residential areas that enter storm sewers
• Sanitary sewage sources incorrectly connected to storm sewers.
Aquatic Resources

The general character of the aquatic communities in the 15 watersheds within the City is strongly influenced by physiography and land use. Many of the watercourses upstream of the Escarpment are intermittent streams, except in the northern part of the City where numerous wetland features serve and important water storage function and provide a source of baseflow. As the watercourses flow over the Escarpment, they receive groundwater discharge and a number of streams shift in thermal regime from warmwater to coldwater as a result. Agriculture is the dominant land use in the headwaters of the streams with urban uses dominating below the Escarpment. While some watercourses are predominantly urban (e.g. Chedoke and Red Hill) and others rural (e.g. Spencer, Big, Fairchild, Welland), others are mixed use and are impacted by both land uses.

The Welland River headwaters, including the Binbrook/Lake Niapenco Reservoir are located within the City limits. The characteristics of the Welland River are similar to the upper Twenty Mile Creek and land use is also similar since the airport and associated commercial lands straddle the watershed boundary between Twenty Mile and Welland River. The Welland River also supports a diverse warmwater fish community, primarily as a result of the reservoir, which creates additional habitat diversity for warmwater species that prefer lacustrine habitats, including the basses, northern pike, grass pickerel, yellow perch and crappie. The headwaters of Fairchild Creek contain numerous wetland features; however these appear to function locally to attenuate runoff providing limited local baseflow to Fairchild Creek. The main branch of the creek within the City is considered to be a warmwater stream supporting a tolerant/diverse warmwater fish community. Many of the headwater tributaries are intermittent. The headwaters of Big Creek within the City are characterized by numerous small drainage features that are predominantly intermittent. Big Creek is part of the Lower Grand Management Zone, which is managed for warmwater and coolwater sportfish including large/small mouth bass and walleye. The upper Spencer and Bronte watersheds contain one of the few remaining coldwater streams within the City. The presence of the Valens and Christie Reservoirs have had a moderating effect on stream temperatures and also have resulted in an increase in abundance of warmwater fish species including yellow perch, northern pike and bass/sunfish species. Grindstone and Borer’s Creeks are also considered warmwater streams although there are some historic coldwater streams in upper Grindstone Creek.

Agricultural land uses represent the primary stressors on the aquatic communities these watercourses. Key limitations include:

- Lack of baseflow
- Erosion and sedimentation of stream channels
- Lack of riparian habitat
- Water quality impacts, primarily nutrient and bacteria enrichment

The upper Chedoke Creek supports a very tolerant fish community and the lower Chedoke Creek supports a diverse warmwater fish community because of its proximity to Cootes Paradise. Below the Escarpment, Red Hill Creek supports a tolerant warmwater fish community and has been heavily impacted by industrial land use around the harbour. Upstream of the Escarpment, the creek supports also supports a tolerant warmwater fish community. These watercourses support a tolerant/diverse warmwater fish community downstream of the Escarpment, and in the case of Sulphur Creek in the headwaters as well, including some cool/coldwater species such as American brook lamprey and rainbow trout. The upper Ancaster and Tiffany Creeks support a tolerant warmwater fish community.
The fish community is typically a tolerant/diverse warmwater fish community and includes a number of sensitive minnow species such as rosyface shiner and brassy minnow. Salmonids, including rainbow trout migrate into the watercourse on a seasonal basis. Key limitations to fish habitat in these watercourses include:

- Stormwater inputs from industrial/commercial development (water quality and quantity)
- Lack of baseflow (above the Escarpment)
- Lack of riparian vegetation
- Poor instream habitats
- Channelization

**Terrestrial Resources**

The City of Hamilton is located in the transition zone between two major forest regions: the Eastern Deciduous Forest (Carolinian Zone) and the Great Lakes – St. Lawrence Forest. In addition, the area boasts an exceptionally diverse physical landscape dominated by three features: the western Lake Ontario Shoreline and Hamilton Harbour Embayment; the Niagara Escarpment cuesta, running parallel to the shoreline, but some 2 km inland; and, the Dundas Valley, a major partially buried bedrock gorge in the shoreline and Escarpment.

The present distribution of natural areas has been determined largely by geographic factors. Although no part of the area can be considered pristine, several relatively undisturbed greenspace areas remain. The largest natural areas are associated with either the Niagara Escarpment or the extensive bedrock plain, found above the Escarpment in Flamborough. Based on the Natural Areas Inventory study, a total of 107 sites were assessed, leading to the identification of 103 Environmentally Significant Areas (ESA’s) and 25 Provincially Significant Wetlands. Together these areas represent over 17% of the City’s area. The largest blocks of designated features occur within the Niagara Escarpment Area and in association with several large Provincially significant wetlands occurring in the headwaters of Fairchild, Bronte, Spencer and Grindstone Creeks.

Despite having a significant number of designated natural features for an area of this size, there are a number of threats to these areas as follows:

- Aggregate extraction, particularly in the northern part of the City: this encroaches on and potentially destroys a number of wetland features and also affects local water tables and even results in localized surface water diversions that impact wetland hydrology
- Agricultural land uses: primarily encroachment on features and also installation of tile drainage/diversion of surface flows that change the water balance of these features
- Ownership: many of these features remain in private ownership and are at risk from disturbance/destruction by landowners
- Urban land uses: similar to agriculture, impacts relate to encroachment and changes to local water balance, drainage
- Fragmentation: as urban areas gradually replace agriculture, many opportunities to maintain linkages between natural features are lost, in many cases leaving only the watercourses as the primary wildlife corridors. Upland corridors are scarce in the watersheds, primarily limited to the Niagara Escarpment Planning Area. In particular there are few linkages between features in the headwaters of the watercourses outside the drainage of Hamilton Harbour – Cootes Paradise to natural heritage systems that existing downstream in Bronte, Fairchild, Big, Twenty Mile, Forty Mile Creeks and the Welland River