Indices calculated for the second long-term station 501150005 (West Credit at 8th Line Gauge Station) had values in the expected range for an unimpaired site, with exceptions in a few years to suggest possible impairment. Taxa and EPT richness and percent EPT were each within the 'possibly impaired' range on two occasions, while percent Oligochaeta and HBI were each within the 'possibly impaired' range on three occasions. In two of the sample years, there were no mayfly taxa encountered. Stonefly taxa were rarely present in the sample, with no occurrences since 2003. Some of the EPT taxa identified in the sample were from relatively sensitive genera such as the caddisfly *Glossosoma* and the mayfly *Isonychia*.

Station 15-04-01 (West Credit downstream 10th Line, upstream Winston Churchill Blvd) had indices that were generally within the range expected for an unimpaired site. Shannon Diversity was fairly low in the 2007 sample, likely due in part to the extremely high numbers of one taxa, the mayfly *Tricorythodes*. Because Shannon Diversity takes into consideration evenness of the taxa in a sample, the dominance of one taxon will skew the index to a lower value. The dominance of this taxon also contributed significantly to the percent EPT value of 82% in 2007. Other mayflies present at this site included the facultative taxa *Caenis* and *Baetis*. There were very few records of stonefly taxa, although caddisfly taxa were present in relatively high numbers and from a variety of taxa. The average HBI for the two years of sampling at this site was quite low (4.03) suggesting relatively good water quality.

Results from station 15-08-02 (West Credit upstream 10th Line) showed index values indicative of an unimpaired site, except for percent Chironomid, which was slightly high at 14%. EPT taxa were diverse and present in high numbers, composing 42% of the sample. A number of sensitive EPT taxa were present in the sample including the mayfly *Isonychi*a, the caddisfly *Rhyacophila*, and the stonefly *Agnetina*. The sample was dominated by Coleopterans (beetles), particularly from the family Elmidae.

Indices calculated from station 15-08-03 (East branch downstream 10th Line) were within the expected range for an unimpaired site, with the exception of percent Chironomid (average of 27% for both samples). Mayfly taxa were mainly from the genus Tricorythodes, a relatively sensitive group. There was a good diversity of Caddisfly taxa in both years of sampling with individuals from ten separate families. One observation that would suggest possible impairment at the site is the high proportion of lunged snails in 2008. Lunged snails are considered tolerant of low dissolved oxygen conditions.

Table 2.5.4 suggests that the indices calculated from the sample at station 15-08-05 (South tributary downstream Main St., Erin Village) are for the most part within the range expected for an unimpaired site, with two exceptions including percent Chironomid and percent Isopoda (17%). The latter observation is particularly indicative of possible impairment as Isopoda have been known to tolerate high levels of organic enrichment. Another indication that the site may have some degree of impairment is the presence of the tolerant mayfly (i.e., *Baetis*) and caddisfly (i.e., Hydropsychidae) taxa.

Station 15-08-06 (West Credit at Woollen Mills, Erin Village) had a lower number of EPT taxa and percent EPT compared to most sites, although ranges were still indicative of an unimpaired site. Mayfly taxa present in the sample are fairly sensitive and included the genera *Isonychia* and *Tricorythodes*. Four caddisfly taxa were encountered and included some sensitive forms. There were no stonefly taxa in the sample. HBI and Shannon Diversity indices both indicated unimpaired conditions.

Indices calculated from station 15-16-01 (West Credit upstream 8th Line and Orangeville St., Hillsburgh) indicated both unimpaired and possibly impaired conditions. Those indices that indicated possibly impaired conditions included percent Chironomid, Shannon Diversity and HBI. Both taxa and EPT richness were fairly high. The calculated percent EPT was lower than most sites, although still within the expected range for an unimpaired site. Mayfly and caddisfly taxa were dominated by tolerant forms, including Baetidae (a mayfly family) and Hydropsychidae (a caddisfly family). One observation that is suggestive of possible impairment at the site is the dominance of lunged snails (*Physa* sp), which composed 61% of the sample. This occurrence suggests that the site may experience low dissolved oxygen concentrations.

Station 15-17-01 (West Credit upstream County Rd 22, downstream Hillsburgh) appears to support a relatively healthy benthic community, as indicated by the metrics calculated for this site (**Table 2.5.4**). The number of EPT taxa at this site is fairly high (19 taxa encountered in 2008), and the presence of stoneflies from two separate families is suggestive of relatively good conditions. While both the number of EPT taxa and the percent EPT are relatively high, many of the EPT taxa are tolerant ones, including Baetids and Hydropsychids. The site may be experiencing some impact due to higher temperatures from the upstream dam.

The benthic community at station 15-17-03 (West Credit downstream Hwy 25, Hillsburgh) had a very high percent EPT (63%), attributed mainly to the dominance of mayfly taxa in the sample (57% of the sample). Most mayflies are from the genus *Baetis*, however, making up 53% of the entire sample. Caddisflies were less abundant, however more taxa were represented (8 taxa). Stoneflies were also present in the sample, albeit in low numbers. There are likely some natural habitat limitations at this site, as the substrate is dominated by sand, therefore reducing the likelihood that certain taxa (i.e., those that favour coarser substrate) would be present.

Station 15-20-02 (Binkham Trib upstream 15th Sideroad) had indices that were generally suggestive of unimpaired conditions. Percent EPT was fairly high, at 29%, and while there were some fairly sensitive EPT taxa (e.g., *Isonychia*, *Stenonema vicarium*) in low numbers, there was a high proportion of the generalist mayfly *Caenis*. Habitat conditions may affect the benthic community at this site to some degree as the riparian community adjacent to the majority of the sampled reach is dominated by grasses, with trees present only in the upstream section.

2.5.4 Benthic Macroinvertebrates Characterization

Sampling of the benthic macroinvertebrate community in the Erin SSMP study area has revealed the following:

- Nearly 300 benthic invertebrate taxa have been identified since the start of CVC's long term monitoring;
- Metrics including taxa richness, EPT taxa richness, percent EPT, percent Oligochaeta, percent Isopoda, Shannon Diversity, and Hilsenhoff Biotic Index were generally within the expected range for unimpaired sites with some exceptions;
- Percent Chironomidae was relatively high in all samples; and
- Some stations may be somewhat impacted due to impoundments and/or agricultural activities.

2.5.5 Next Steps

Results from the Phase 1 benthic macroinvertebrate component will be used in the subsequent Phase 2 (Impact Assessment) to aid in identifying potential impacts as a result of future land use changes (i.e., water pollution control plant). Scenarios developed through the Impact Assessment will be ranked according to sensitive areas.

2.6 AQUATICS

2.6.1 Introduction

The objective of this study component is to identify and characterize the fish communities throughout the study area that provide integrative environmental indicators of the health of their respective subcatchments. The sensitivity of the fishery needs to be understood, including habitat requirements, in order to prevent any degradation as stipulated by the Department of Fisheries (DFO) Federal Fisheries Act and supported by the Ontario Ministry of Natural Resources (OMNR) and Credit Valley Conservation (CVC) policy.

Fisheries management is a shared responsibility by all agencies and stakeholders as outlined in the Credit River Fisheries Management Plan (CRFMP) (OMNR and CVC 2002). CVC's role includes a formal agreement with DFO to review all water related applications for direct or indirect Harmful Alteration, Disruption, or Destruction (HADD) of fish habitats. CVC values and utilizes fish communities as indicators of watershed management.

Specifically, hydrological linkages associated with land use change (e.g., agriculture, urbanization, and aggregate extraction), infrastructure/servicing (water and wastewater) or other stresses on fish also need to be documented in order to predict potential impacts based on future scenarios and planning applications. This Settlement and Servicing Master Plan (SSMP) will focus on water and wastewater disposal needs of the Town of Erin. Likewise mitigation and restoration of fish habitat can be better implemented at the landscape and stream reach levels with such an integrated study. Fish community monitoring will confirm any long term trends in the health of the West Credit River in this study area.

2.6.2 Fisheries Characterization

2.6.2.1 Recreational and Commercial Fisheries

These aspects of the fishery are regulated by OMNR and DFO for social and economic benefits. CVC has just completed an evaluation of the Credit River Fishery that further details recreational and economic values important for future management decisions (Hanna and CVC 2007 Draft). Licensed sport fishing along the West Credit River has been documented in creel surveys with very low angling pressure (upstream of Hillsburgh, Stanley Park ponds, and around 10th Line downstream of Erin Village). Angling pressure increases as the river approaches the Forks of the Credit (up to 30 anglers/hour on opening weekend of trout season). Within the Town of Caledon much of the trout fishery is regulated under Special Regulations that have created a highly valued catch and release fishery. Within the Town of Erin a catch and possession limit of 5 trout exists. This may create added harvesting pressures within Erin. Lower limits are under review by the OMNR for brook trout throughout Southern Ontario.

The West Credit River within the Town of Erin is licensed for commercial baitfish collection that is also permitted for licensed anglers.

Two commercial fish farm operations that raise trout for stocking and food sales exist within the study area. These farms are dependent on groundwater sources to ponds and/or artificial races and tanks.

It should be noted that CVC and the CRFMP place the greatest value on fisheries as integrative environmental indicators of watershed health. As an integral part of a greater Natural Heritage System they also indicate and contribute to a larger range of Ecological Goods and Services well beyond direct recreational and economic benefits.

2.6.2.2 Fish Collection Records

Fish collection records have been compiled for the study area since the 1980’s, with updates throughout the 1990’s mostly related to the West Credit Subwatershed Study. Additional sampling has since been made as part of the West Credit Appreciation, Rehabilitation and Enhancement (WeCARE) program and the Integrated Watershed Monitoring Program (IWMP).

All these records are useful in determining the distribution of the 25 fish species reported. Section 1.0 in the Aquatics Appendix lists all species found in the study area and their corresponding stations. The locations of historic Fish Collection Records are illustrated in **Figure 2.6.1**. **Figure 2.6.2** shows the 11 fish biomass sampling sites conducted as part of the Credit River Watershed Integrated Watershed Monitoring Program (IWMP).

Each fish species has a different set of habitat requirements based on life stages and behavioural traits (e.g., feeding strategies, cover, water quality and temperature, swimming adaptations, etc) that reflect the conditions and health of the waters sampled. Detailed information on each species as it relates to preferred habitat conditions are available from literature sources and have been conveniently summarized as tolerant (1), moderately tolerant (2), and sensitive (3) in Table 1.0 in the Aquatics Appendix. All streams are colour coded in **Figure 2.6.1** according to their community classification.

There is an unconfirmed report in the 1998 West Credit Subwatershed Study of a redside dace record to be designated under the new Endangered Species Act of Ontario. A more recent confirmation placed redside dace habitat nearer to the Forks of the Credit and outside this study area. For management constraints and opportunities a Recovery Plan for this species will be approved shortly. In 2009 Atlantic salmon were sampled downstream of Erin Village as a result of stocking as part of the Atlantic Salmon Restoration Program for this Endangered Species.

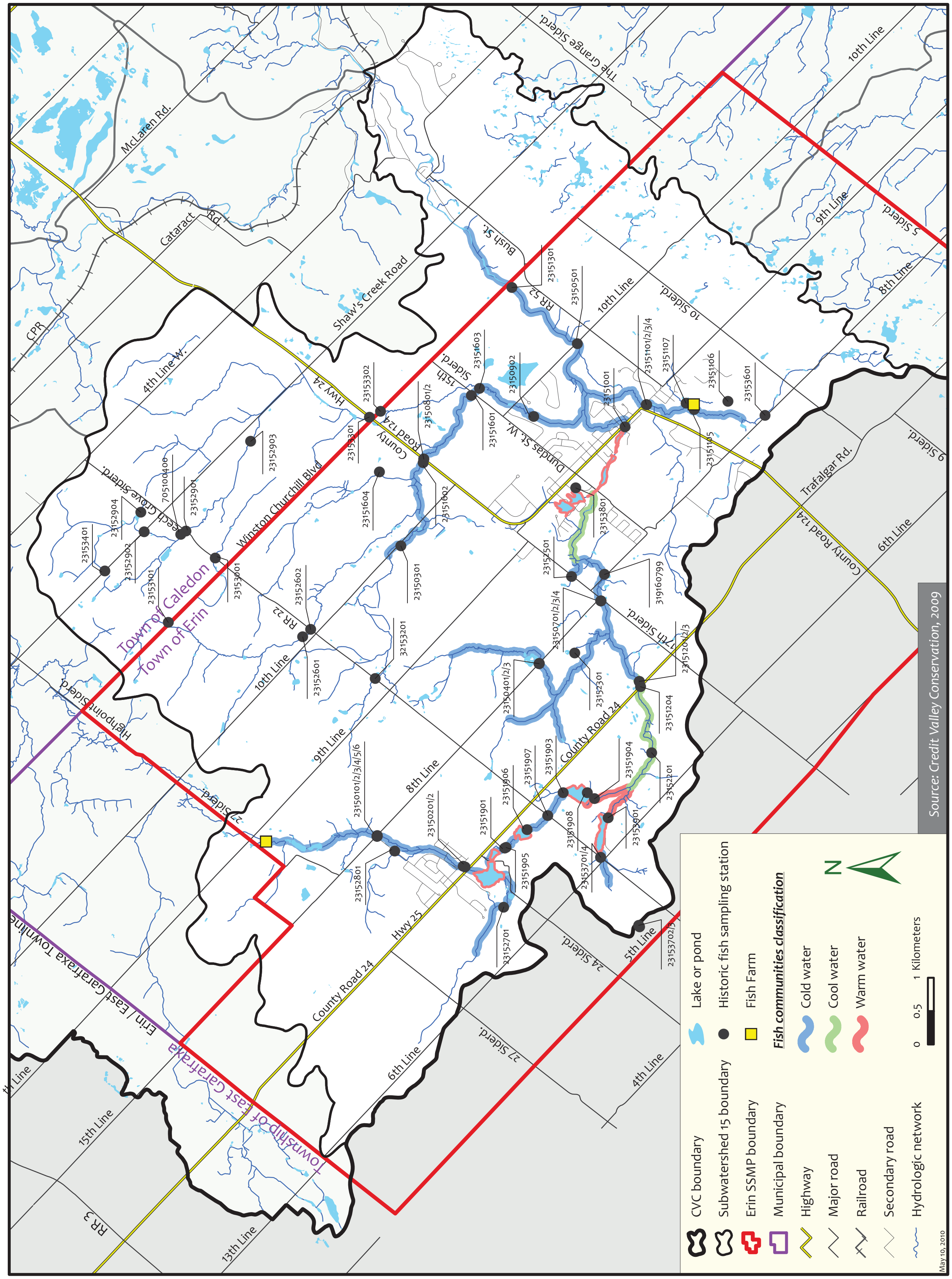
2.6.2.3 Fish Community Classification

Based on fish species presence and their sensitivities, stream reaches can be classified into the following categories consistent with the Credit River Fisheries Management Plan (CRFMP) (OMNR and CVC 2002). It should be noted that although these communities are predominantly classified according to preferred thermal regimes as the names implies, other habitat factors also play an important role. These other factors may be correlated with temperature including dissolved oxygen, nutrient status, turbidity, and siltation. Riparian conditions, stream size, and channel structure are usually independent of temperature. Anthropogenic impacts may at times completely alter the fish community classification (i.e., dams and urbanization).

Resident Coldwater
In the West Credit River these communities contain self-reproducing populations of resident brook trout. This species relies on significant groundwater contributions to incubate over-wintering eggs and to maintain summer temperatures, preferably not exceeding 20 ˚C for extended periods.

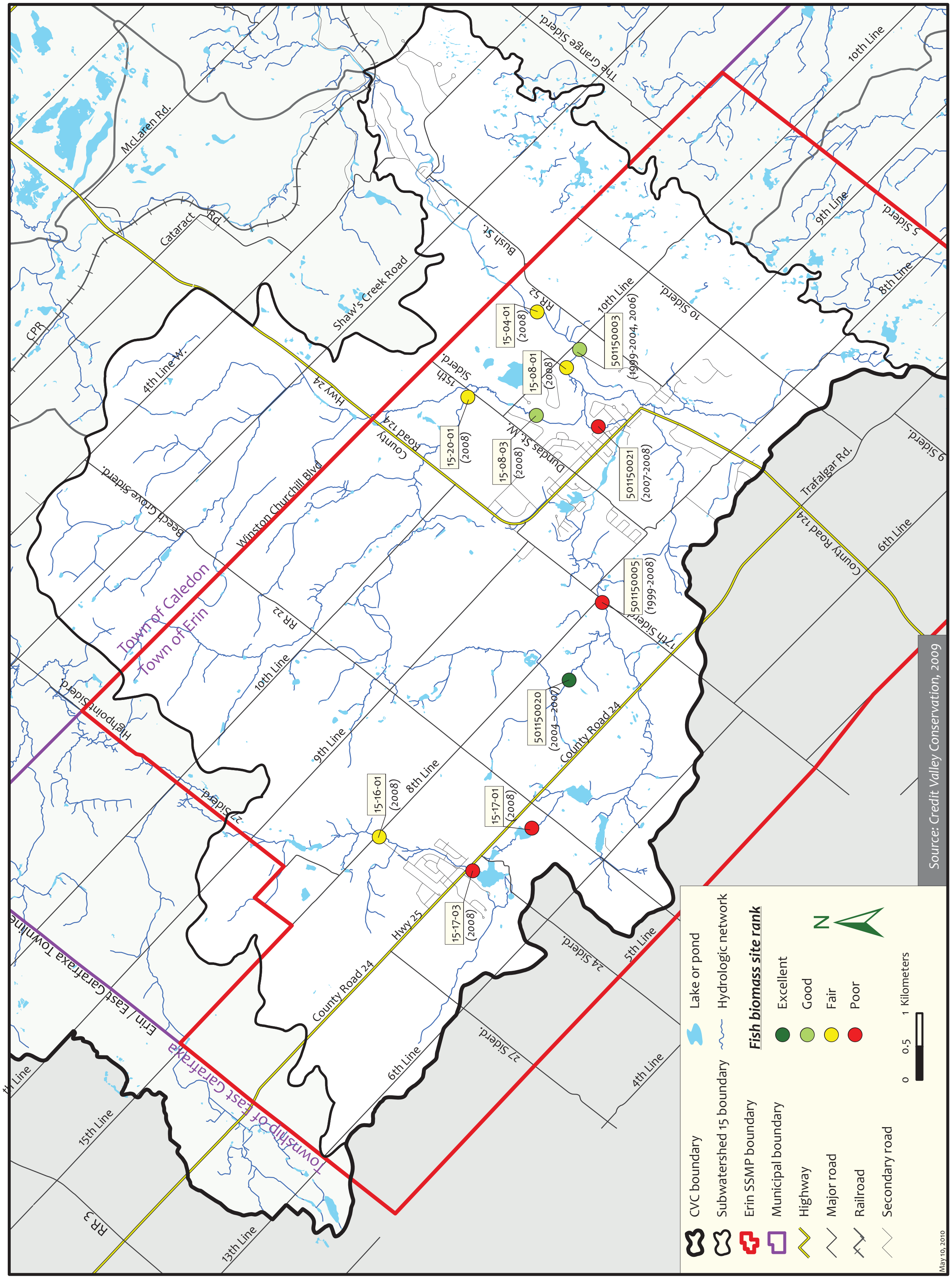
In a few circumstances mottled sculpin have also been recorded and are likewise considered a coldwater indicator species. Given that these are the only known and isolated locations above the Niagara Escarpment within the Credit, their origin and significance remain unknown.

Figure 2.6.1 Historic Fish Collection Record Stations



Source: Credit Valley Conservation, 2009

Figure 2.6.2 Fish Biomass Sampling Sites



Cool Water
Species including northern redbelly dace and central mudminnow, although tolerant of warm temperatures are more often associated with riverine wetlands or groundwater discharge wetlands. These species are commonly found in coldwater reaches as well.

Small Warmwater
This community is usually made up of species that are not habitat “specialists” and are adaptable to a variety of environmental conditions. Although found in other communities they will dominate small warmer water tributaries, ponds, intermittent tributaries, and seasonal wetlands.

Large Warmwater
This classification is applied to larger riverine, lacustrine, and wetland habitats and is characterized by the presence of predators, such as bass or pike, often in association with sunfish, rock bass, or perch. Bullhead catfish and white sucker may provide added benthic diversity. Within the Credit River watershed only the lower reaches connected to Lake Ontario and the 2 largest impoundments, Fairy Lake in Acton and Island Lake in Orangeville, are managed for these communities. Elsewhere, including this study area, such communities are often associated with smaller online ponds and dams where sustained management is not preferred.

Figure 2.6.1 conservatively extrapolates fish community classifications from sampled sites to illustrate the existing fish communities of the West Credit River subwatershed. This can be considered a local refinement to that in the CRFMP that had more generally mapped the entire watershed as coldwater. Present mapping of updated data now identifies reaches associated with online ponds and wetlands not suitable for brook trout. The greatest thermal impacts are represented by warmwater designations within and downstream of larger impoundments. Other reaches are designated cool water (with northern redbelly dace and central mudminnows as indicators that are also common to coldwater reaches), including the wetland reach upstream of County Road 24 and the reach upstream of Stanley Park ponds. Many of the smallest tributaries and headwaters remain unsampled, inaccessible, and not classified. They could be cold, cool water, or intermittent warmwater in nature.

Physiographic mapping suggests those potential or historical fish communities are based on hydrogeology. The CRFMP, again, from a watershed perspective designated the West Credit River subwatershed as coldwater, except for some of the eastern tributaries outside the SSMP study area that tend to be intermittent in nature. The mapping from the Hydrogeology Section 2.1 provides an explanation for groundwater recharge and discharge areas related to bedrock, water table elevations, and soils. The most underutilized trout reach within this study area is downstream of the Olesovsky Pond. Refer to **Figure 2.6.6** for the location of this pond. The physiography of the study area reveals a pocket of till centered around County Road 24 (Highway 25) crossing. This area is known to be a broad valley wetland, fine sediments (C6 channel type[3]), and warmer

[3] Refer to **Figure 2.4.4** Rosgen Classification System for the definition of a C6 channel.

temperatures that discourage trout. The West Credit Subwatershed Study noted that such wetland reaches although sustained by groundwater may be naturally warmed or evapotranspirated as they move across the wide flat valley floors before entering the river channel (CVC 1998[a]).

2.6.2.4 Fish Productivity and Community Health

Quantitative information on fish abundance can provide data that can be analysed with other study components such as geomorphology and water quality and show long term trends over time. Fish data collected under a scientific protocol developed by the Ministry of Natural Resources is used in this study area. These 11 fish biomass stations are located on **Figure 2.6.2**. These stations provide good baseline data for long term studies.

At these locations electrofishing equipment was used over a measurable area of habitat with fish species recorded by total weight or biomass in order to estimate biological productivity in terms of grams of fish per square metre in total and for each species. Fish biomass summary results per species collected annually since 1999 are presented in Section 2.0 in the Aquatics Appendix for each biomass site.

All results have been analysed as an Index of Stream Health in *A Methodology for Assessing the Biological Integrity of Fish Communities in the Credit River Watershed* (Morris and CVC 1999). The average IBI scores tabulated for the sites in the West Credit Subwatershed Study area ranked from poor to good in terms of fish community health in the Credit River watershed (see below).

Although the majority of these sites have only recently been established there are 3 sites representing the upper, middle, and lower reaches of the main channel that were established having 4 to 10 years of data suitable for a regression analysis to detect trends over time. The following regression equations for IBI scores (n / Y = mX + b / R^2 and ± SD) have been calculated where Y is the average IBI score over the number of years (n) sampled. R^2 represents the strength or accuracy of the trend in time with values approaching 1 being the most predictable. The Standard Deviation (SD) best represents the amount of “scatter” in the data. M is the slope indicating whether the trend over time represents degradation in health (indicated by a negative value) or improvement (positive value). Stations remaining relatively stable in health will exhibit a value nearer to zero (positive or negative). The biomass stations and their IBI scores are summarized below along with a graphic presentation for those having a regression trend calculated.

West Credit River downstream of 8th Line, Hillsburgh (Station ID No. 15-16-01)
This site can be considered as the uppermost reach sampled on the main branch upstream of Hillsburgh. It is rated as fair for the one sample done in 2008. Brook trout do dominate the catch here.

West Credit River at Hillsburgh Public Library (Station ID No. 15-17-03)
This site represents the upper reaches of the West Credit River just downstream of the built up area in Hillsburgh and upstream of the local impoundment and dam. Health is rated poor based on one sample in 2008. Although trout were present only 9 fish in total were caught.

West Credit River at Elizabeth St. (Station ID No. 15-17-01)
This site represents the upper main branch downstream of Hillsburgh and between two online impoundments. It also ranked poor but is closer to a fair ranking indicating some improved conditions than the site upstream in Hillsburgh. It was sampled once in 2008. Brook trout are present but rock bass likely originating from the ponds dominate the biomass here.

Tributary of West Credit River upstream of Rail Trail / 8th Line (Station ID No. 501150020)
This site is a tributary entering the main branch between the Villages of Hillsburgh and Erin. Based on 4 years of data there appears to be an increase in health from good to excellent in the last 2 years (**Figure 2.6.3**). The overall average indicates excellent health and is dominated by brook trout. This site is no longer sampled due to lack of permission from landowners.

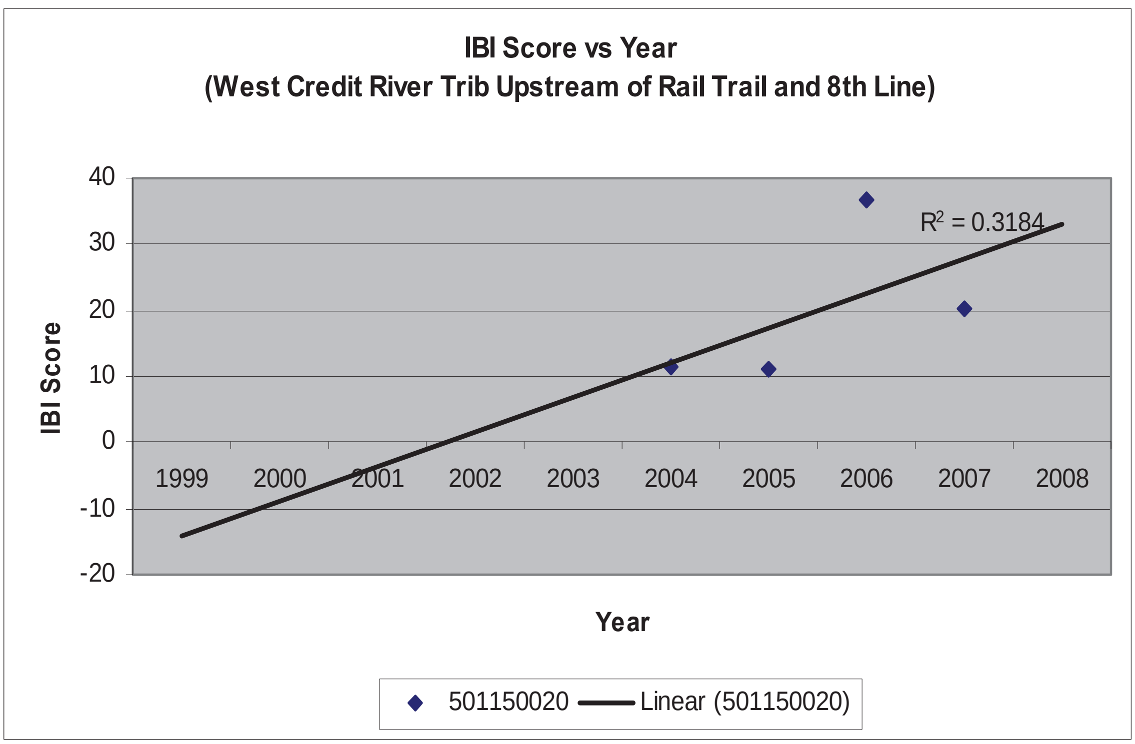


Figure 2.6.3 IBI Scores from 2004 to 2007 at Station 501150020, West Credit Tributary upstream of the Rail Trail / 8th Line

West Credit River at 8th Line Gauge Station (Station ID No. 50150005)
This site is the last upper main branch site upstream of Erin Village and indicates poor overall health on average with a statistically significant decline (R^2 = 0.56) from 1999 to 2008 (**Figure 2.6.4**). There appears to be a bit of recovery in the last 3 years but ratings remain poor. Brook trout and longnose dace mostly influence the scores. The upstream watershed includes Hillsburgh and a number of large online ponds and some gravel extraction areas. Construction and unknown spikes in flow rates should be further investigated and may be related to water taking and discharge issues. The site is shallow and wide with a side channel indicative of erosion but cover and riparian vegetation seem good.

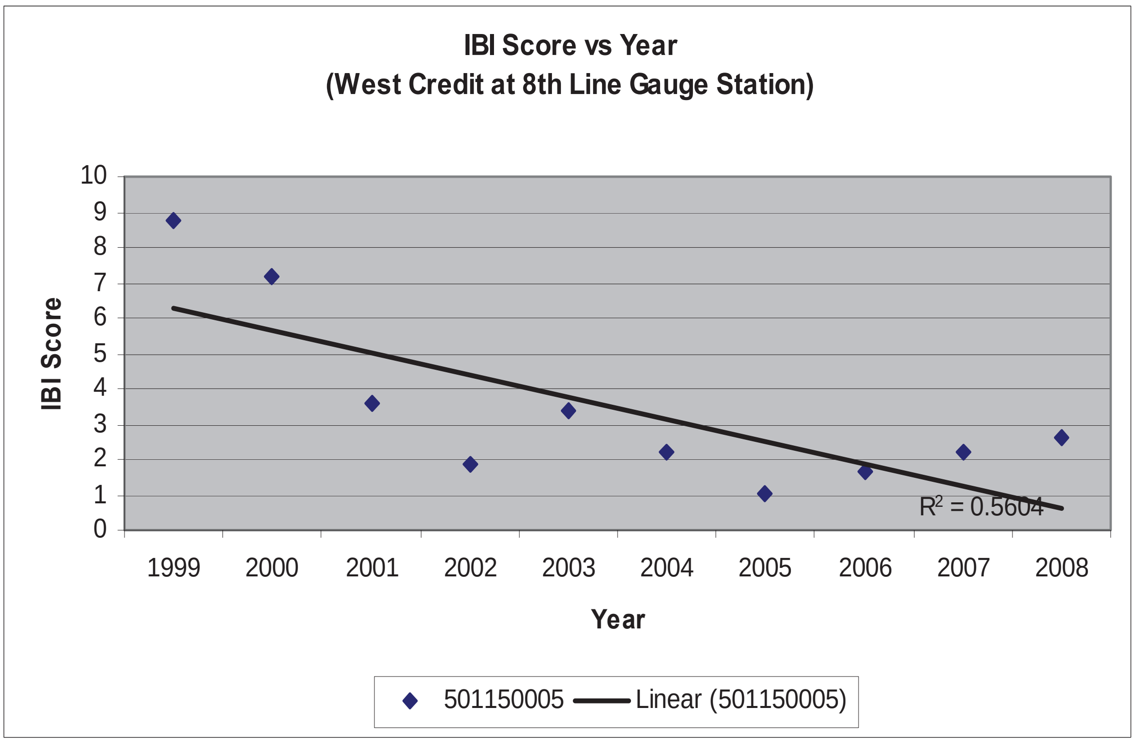


Figure 2.6.4 IBI Scores from 1999 to 2008 at Station 50150005, West Credit River at 8th Line Gauge Station

West Credit River at Woollen Mills (Station ID No. 501150021)
This station is located on the main branch downstream of 2 impoundments and the core of Erin Village and has been sampled in 2007 with a fair rating that fell in 2008 to poor. Brook trout are represented by single individuals in both years indicating limitations likely related to urban land use and dams upstream.

East Branch of the West Credit River upstream 15th Sideroad, East of 10th Line (Station ID No. 15-20-01)
This tributary was sampled in 2008 and ranked in fair health. It appears to be representative of a rural area dominated more by low gradients and few brook trout. Only

one brook trout was sampled here but spawning surveys indicate more exist further upstream.

East Branch of the West Credit River, south of Credit River Rd. (Station ID No. 15-08-03)
This is the same tributary as above and is in good health for the one sample taken in 2008. It enters the main river upstream of 10th Line. Although brook trout are the most dominant species they still represent a small portion of this diverse community totalling 16 species.

West Credit River west of 10th Line, north of Bush St. (Station ID No. 15-08-01)
This site best represents recovery conditions downstream of Erin Village with a fair health rating sampled in 2008. It will now replace the site originally set up upstream of the second crossing of 10th Line (Station ID No. 501150003 - below). Brook trout dominate this site.

West Credit River upstream of 10th Line, downstream of Erin (Station ID No. 501150003)
Overall this site is rated in good health over the 7 years sampled. There appears to be a slight trend of increasing health but it is not statistically significant (**Figure 2.6.5**). The last sample in 2006 was rated excellent health but continued access to the site has been denied by the landowner. A replacement site north of Bush St. (above) and downstream towards Winston Churchill Blvd. has been selected but neither has been sampled over sufficient years to suggest any overall trends. This site is downstream of Erin Village and experiences some angling pressure on brook trout that are responsible for overall community health. It is likely that groundwater upwelling in the area is able to moderate the negative impacts of Erin Village and its two online impoundments.

West Credit River downstream of 10th Line, upstream of Winston Churchill Blvd. (Station ID No. 15-04-01)
This site is the lower most reach of the main branch in the study area. The sample taken in 2008 rates the health of the fishery as fair with brook trout dominating the site.

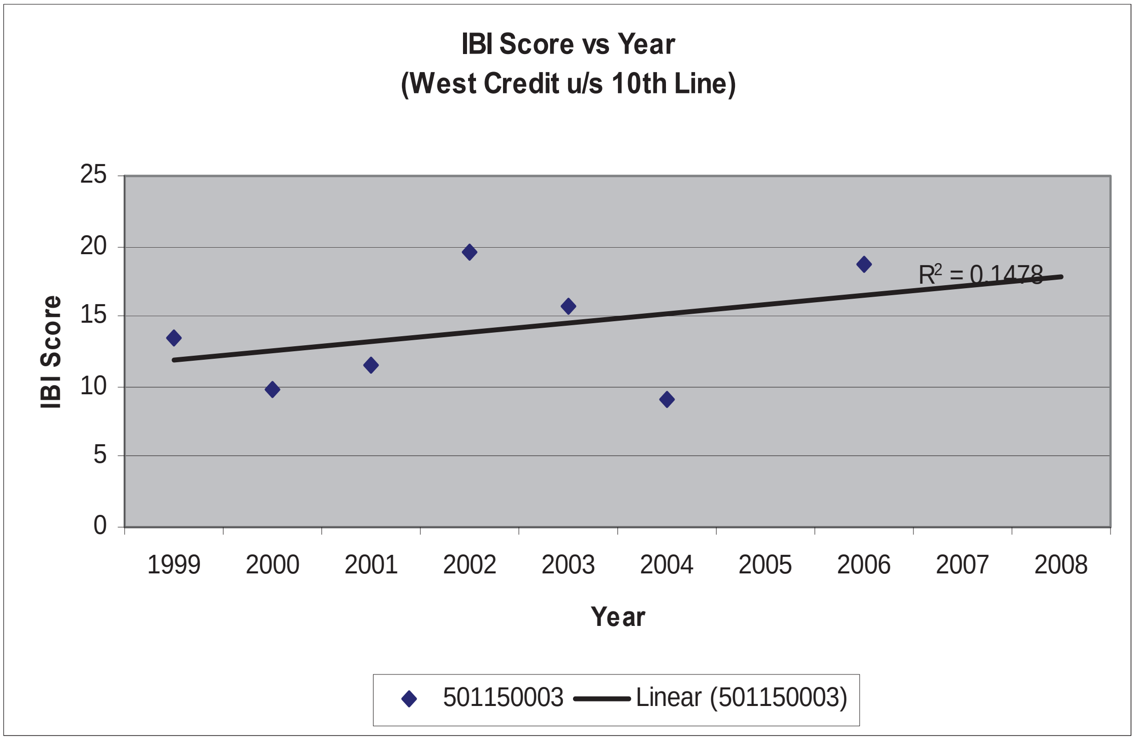


Figure 2.6.5 IBI Scores from 1999 to 2006 at Station 50150003, West Credit River upstream of 10th Line

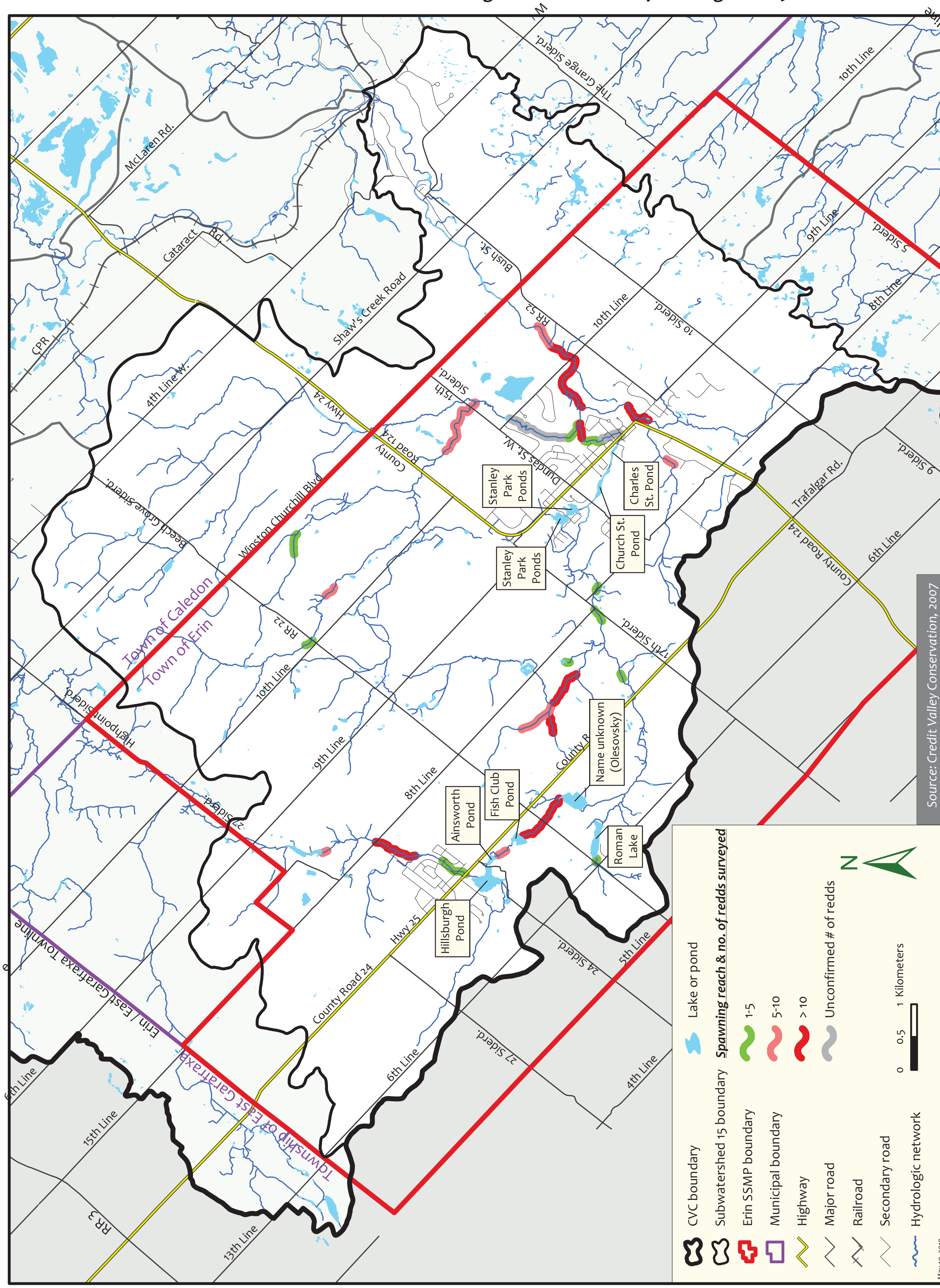
2.6.2.5 Spawning Surveys

Spawning nests or "redds" have been investigated in this study area since the late 1980's as they represent critical habitats that often are the single limiting factor to fish production for specialized species such as brook trout. Brook trout are known to specifically seek out and detect groundwater upwelling areas for winter long egg incubation. The same areas also offer coldwater refuge during heat waves and drought conditions.

Figure 2.6.6 summarizes spawning redds surveyed in the West Credit River subwatershed study area. The most productive spawning reach is on the main channel at the downstream end of the study area. This length of river extends unimpeded by dams for 6.5 km downstream to Belfountain and as such many trout throughout these lower reaches could migrate up into the study area. A self-sustaining population can not exist between barriers without "critical" spawning habitat conditions provided by strong upwelling groundwater.

The next longest isolated reach (5.2 km) on the main channel is upstream of the Church St. and Charles St. Dams to the confluence below Roman Lake and the Olesovsky Pond. Unlike the Erin to Belfountain reach that is all coldwater habitat, trout have only been sampled over about 2.2 km in the reach upstream of the Erin Village. Furthermore no spawning area has been located along this main channel reach. The only accessible

Figure 2.6.6 Fish Spawning Survey and Fish Barriers



spawning area is provided around the confluence of tributaries along the rail trail (between County Road 24 and 8^{th} Line north of 17^{th} Sideroad).

Next, the isolated reach in and upstream of the Village of Hillsburgh is 2.8 km in length with scattered observations of spawning, including just downstream of the headwater impoundments (also known to support stocked trout). The shortest and most isolated reaches with spawning are between Fish Club Dam and Olesovsky Pond (0.8 km), Ainsworth to Fish Club dams (0.3 km), and upstream of Roman Lake (0.4 km).

From a subwatershed perspective the best brook trout populations and spawning areas are downstream of Erin Village.

Areas identified by hydrogeologists as discharge zones should be further surveyed as potential spawning areas. This is particularly important for small tributary reaches isolated by online dams.

2.6.2.6 Fish Habitat

Fish species and abundance are determined by a variety of habitat factors. Observations and ongoing hydrological, geomorphological, and water quality surveys best describe fish habitat conditions. Physical habitat is described by valley confinement and gradient, and determines width/depth and pool/riffle ratios, and meander geometry. Other habitat features are represented by riparian conditions, woody cover, aquatic plants, and substrate composition. The water quality components most related to fish include nutrients, suspended solids, temperature, dissolved oxygen, and toxins. Natural and physical barriers directly affect the distribution of fish species.

Hydrology and Hydrogeology describes the water cycle of the study area. Overall channel capacity and discharge rates ultimately determine available habitat space. This is most limiting at low flow in the summer that is released from storage and groundwater sources. Groundwater sources are particularly important for cold temperatures required by brook trout and upwelling zones for winter long incubation of eggs. Hydrogeology mapping provides the best correlation with brook trout communities in the study area.

Water quantity concerns for fish life may be related to groundwater withdrawals during low flow conditions while uncontrolled runoff typical of older urban areas without stormwater management practices is a concern during storm and high flow conditions. In contrast, dammed impoundments along the river store and slow water and act as sediment traps.

Stream gradient and valley confinement are typically moderate to low in the study area compared to a more defined valley and steep gradient of the lower reaches of the West Credit River. On moderate slopes there is a predictable meander alternating with deeper runs and pools and shallow turbulent riffles. Past surveys and literature suggest a ratio of 40% pool – 60% riffle provides ideal fish habitat in river systems. There are some reaches of the West Credit River that meander more widely over a broader floodplain or wetland. The most significant channel reach of this type is from the confluence below Roman Lake and the Olesovsky Pond downstream to County Road 24. The channels are known for their riparian wetlands, stable undercut banks, and finer sediments. The adjacent wetland communities can be the most diverse and productive habitats overall even though trout productivity may be lower. Fish communities here are likely limited more by oxygen rather than temperature. Flooding and beaver ponds are also more common in this area. Wetlands could contribute either cold or warmwater (but stable) baseflows depending on the groundwater discharge route and travel time.

Online impoundments further reduce valley gradients and create more monotypical type wetlands of poorer quality.

Substrates provide important fish habitats. The interstitial spaces amongst gravel riffles also provide habitat for macroinvertebrates utilized as food. Some fish species live and feed within these interstitial spaces. Of great importance are those areas used to deposit and incubate eggs that are free of siltation, which can smother fish eggs. Brook trout have been observed to spawn on finer sediments in locations where groundwater upwellings are particularly strong. There are sufficient gravel reaches within the study area to support brook trout populations.

A lack of gravel riffles has been observed in lower gradient reaches of the study area. These areas are dominated with sand, silt, or organics that likely limit trout production. It should be realized that in some cases this is a natural limitation and whether preventative or rehabilitative actions are even warranted. Wetland reaches with finer substrates are more easily colonized and stabilized with plants providing habitat for many minnow species.

Manmade dams and poor agricultural practices are known to negatively impact sediment regimes.

Woody cover is an essential component within the stream system for increasing flood roughness and fish cover, reducing overall erosion especially along outside bends. Wood also provides a preferable surface to rock for many invertebrates. Log jams in high gradient streams may also provide dynamic functions related to grade control and sediment storage, yet are rough enough to permit fish passage. Many riparian animals such as mink also use log jams for cover and denning.

Woody cover surveyed along the West Credit River estimated less than 3% surface area. In a few areas [e.g., downstream of County Road 24 (Highway 25)] levels approached 6% which can sometimes be considered high and create issues for some landowners. In this reach, however, there is a recovery of better brook trout conditions and a healthy forest swamp in the valley. A few areas lack woody cover associated with rural landscaping and agriculture. The channelization and maintenance of infrastructure also affects the accumulation and distribution of woody cover.

Riparian vegetation provides important functions related to fish habitat including shade for temperature regulation, overhanging and instream cover, bank stability and erosion protection, water quality improvement through sediment trapping and nutrient uptake, and as buffer from adjacent land uses. It should be noted that there is an expectation of less canopy cover naturally in streams crossing large marsh areas. Past assessments of the West Credit River noted good connected riparian zones, although buffers have been impacted adjacent to urban areas and some farmlands. Historical and restoration potential should be investigated as they are often integral habitats for fish and wildlife connected along stream corridors. Further assessments are included in the Natural Heritage Section, Section 2.3, of this report.

Aquatic plants can benefit fish communities by providing cover and food. Within stream habitats many fish species are adapted to wetland vegetation and the depressed oxygen supplies that occur at times due to plant respiration and decomposition. These species include stickleback, mudminnow, redbelly dace, and creek chub that can be abundant in the study area.

In excess, however, plant growth may result in low oxygen supplies during night-time respiration that affects all aquatic life and water quality in general. Additional growth from further nutrient enrichment (septics, wastewater, urban, golf course, and farm runoff) may reduce fish and amphibian production. The dominance by algae rather than higher plant forms is more indicative of overly stressed aquatic ecosystems. Given their shorter nutrient cycling abilities there evolves a positive feedback loop and is known as the process of eutrophication. Algae growth observed in most online ponds indicate they are acting as nutrient sinks and possibly over-enriching downstream reaches. Phosphorus and dissolved oxygen water quality measures may confirm this as an issue.

Water quality can also be affected by runoff carrying sediments and chemical toxins from farmlands and urban areas. Given that agriculture is not of an intense nature and that many good buffers exist in the study area it is urban runoff that is of particular concern especially in older urban areas that do not have effective stormwater management techniques.

The *WeCARE (West Credit Appreciation, Rehabilitation and Enhancement Project). 2004 Watershed Information Summary and Project Recommendations* report, also known as WeCARE, (CVC et al. 2004) documented maximum water temperatures of 30 ˚C and 28 ˚C below Dundas St. and Charles St. in the Village of Erin. The next highest temperature was below the Hillsburgh impoundment (Fish Club dam) and at County Rd. 24 (old Highway 25) below the wetland reach. In the West Credit Subwatershed Study the maximum water temperature of 25 ˚C was recorded at the County Road 24 crossing. Overall from a subwatershed scale the reach between Hillsburgh to just downstream of Erin Village is the most thermally stressed reach of the West Credit River. There is a quick recovery of temperatures and brook trout populations near 10th Line as groundwater baseflows improve along with a confluence of other tributaries.

Instream barriers mostly in the form of dams with impoundments alter stream habitats significantly for fish and further shift the community towards more wetland and lake adapted species. Impoundments act as nutrient traps and further depress oxygen levels. Impounded waters typically warm up and thus, trout are excluded for a distance downstream. As sediment traps, impoundments only pass suspended fine sediments. The loss of the coarser bedloads gives added power to water downstream of the dam leading to channel erosion. Often the greatest impact is the isolation of populations from spawning or refuge areas and the long term exchange of genetic material with other populations until stresses lead to their extirpation.

The West Credit Subwatershed Study (CVC 2001[a]) identified a total of 270 on and off-line ponds. A more recent Dam and Online Pond survey by CVC inventoried seven major dams or impoundments on the main branch of the West Credit River from Hillsburgh to the Village of Erin that have been named on **Figure 2.6.6**. The most significant barriers from a subwatershed perspective begin at the Stanley Park ponds and continue upstream with two more dams and impoundments in Hillsburgh. Roman Lake also has a dam on a tributary but is presently being assessed for mitigation opportunities with the landowner. The fish farm in the Village of Erin isolates a very small stream reach upstream but may have thermal and water quality impacts downstream.

There about another 30 online ponds along tributaries within the study area. Many of these may be smaller, but when located at the more sensitive headwaters and natural springs have a different set of impacts in a cumulative manner. Many online ponds are located on former spawning habitats and thermal refugia and isolate relatively short reaches.

The protection and restored connectivity of isolated stream populations of all native species are a priority in the Credit River Fisheries Management Plan (OMNR and CVC 2002) and become more urgent with climate change or threats from spills (often associated with storm and wastewater effluent). Mitigation and restorations techniques that are promoted include fish ladders, by-pass channels, or dam removal.

WeCARE and the Clean Up Rural Beaches (CURB) program recommended that restoration opportunities should focus on dam mitigation (e.g., bottom draw outlets), by-passes, or removal. There are fewer opportunities related to riparian plantings that are normally a “best bet” restoration technique. This relates to the existing healthy and contiguous riparian corridor and recent planting efforts.

Beaver activity and dams are common throughout the West Credit River and are a natural part of the ecosystem, by regenerating wetlands and providing fish habitat with built-in mitigation processes. In fact brook trout and minnows, such as redbelly dace, and beaver are often synonymous having evolved together. Beaver dams are hydraulically rough aiding fish migration along with side channels at certain flood stages. Their porous nature also allows for the seepage of colder bottom waters. They are generally small and relatively short lived.

2.6.3 Fisheries Characterization

The fisheries of the study area are ideally used as integrative indicators of watershed characteristics and health. Indicator species are used to classify fish communities as warm, cool, or coldwater. The study area is managed for its potential for brook trout, a coldwater species.

- The reach above the Erin Village is influenced by wetlands and online ponds resulting in cool or warmwater communities. Brook trout access could be restored by addressing dam barriers in the Villages of Erin and Hillsburgh.
- Brook trout are directly dependent on groundwater resources and can be impacted by warmer temperatures (maximum temperature values recorded up and downstream of Erin Village), nutrient enrichment (leading to increasing algae), and reduced oxygen associated with online impoundments that affect water quality. Urban runoff is likely the next greatest limitation to brook trout.
- Fish community health (IBI) is variable throughout smaller tributaries. More conclusive data is available on the main branch upstream of Erin Village and downstream of Erin Village. Upstream of Erin Village fish health was found as poor and declining with some recovery indicated in the last 3 years, while downstream of Erin Village fish health is good with stable or increasing health. It appears the recovery of brook trout populations downstream of Erin Village can be attributed to greater groundwater contributions.
- From a subwatershed perspective the best brook trout spawning areas are also downstream of Erin Village. This is the longest reach of river uninterrupted by dams/barriers. The next longest reach is upstream of Erin Village but without access to adjacent spawning areas restoration potential may not be realized. The Stanley Park dams represent the most significant barriers at a subwatershed scale. Mitigation, by-pass, or removal would improve the resiliency of this population and improve the assimilative capacity of the river.

2.6.4 Next Steps

The review of fish collection records provides adequate information to classify fish communities along the main branch and major tributaries. A number of very small tributaries and headwater features are not classified given these are unlikely to be affected by servicing plans. If any of these sites are identified as being potentially impacted, site level assessments can be completed at that time. Sites for spawning surveys could once again survey the main reach upstream of Erin Village but also in consultation with groundwater information.

With respect to riparian zones, historical and restoration potential should be investigated as riparian zones are often integral habitats for fish and wildlife connected along stream corridors.

Some ponds represent data gaps due to either landowner access and/or inability to electrofish safely. Ponds most likely to be potentially influenced by servicing options (e.g., ponds located in Erin Village at Church St. and Charles St., refer to **Figure 2.6.6**) can be sampled for biomass using a hoop net method and analysed in a similar way to the stream based IBI. Data was collected in 2008 for the lower Stanley Park pond and the Hillsburgh online pond (refer to Section 3.0 in the Aquatics Appendix) but the sampling protocol for non-riverine ponds, lakes, and wetlands and an IBI analysis is still under development such that comparative conclusions on abundance and health cannot be made at this time. The species present (bass, perch, sunfish, and catfish) in these habitats are indicative of large warmwater communities. Some of these lacustrine species can have negative impacts on native stream species in adjoining reaches.

Biomass surveys will continue on an annual basis through CVC's Integrated Watershed Monitoring Program; through recommendations agreed upon as part of the Subwatershed Study; and through any monitoring required by MOE relating to Waste Pollution Control Plant (WPCP) discharge approvals.

A more detailed impact analysis of land use change and proposed WPCP options will more specifically address fisheries of the study area in Phase 2 and 3 of this study. Areas identified by hydrogeologists as discharge zones should be further surveyed as potential spawning areas. This is particularly important for small tributary reaches isolated by online dams.

2.7 WATER AND SEDIMENT CHEMISTRY

2.7.1 Introduction

For the purposes of Erin SSMP Study, water quality will be defined as the chemical, microbiological, and physical condition of water and sediment. This section will provide an introduction to indicators of water quality; including a summary of long-term water and sediment quality conditions at the provincial water quality monitoring network station (PWQMN) and shorter term SSMP stations will be presented. This will include spatial and temporal comparison with maps and graphs in conjunction with appropriate guidelines.

There are a number of existing programs and studies that have addressed the water quality of the West Credit River and its tributaries within the Erin SSMP study area. Available background information includes the annual reports from the Clean Up Rural Beaches (CURB) program (CVC and Soucek 1994; CVC and Soucek 1995); the *WeCARE (West Credit Appreciation, Rehabilitation and Enhancement Project), 2004 Watershed Information Summary and Project Recommendations* report (CVC et al. 2004); the *Phase 1 Characterization* report, *Draft Phase 1 Addendum* report, *Draft Phase 2 Impact Assessment* report from the West Credit Subwatershed Study (CVC 1998[a]; CVC 2001[a]; CVC 2001[b]); and the Long-term Provincial Water Quality Monitoring Data. The above information is summarized in the *Erin SSMP Data Gap Analysis Report* (CVC et al. 2008), and were used to build understanding of water quality and determine where additional monitoring was required.

Parameters of Concern

Through the work on the *Water Quality Strategy Phase 1 Report* (CVC et al. 2003), Parameters of Concern (POCs) have been identified on a watershed scale for the Credit River. These parameters had to be associated with the major watershed-scale issues and relevant to defining cumulative and long-term impacts. The watershed POCs were used as indicators for characterization of the study area. In addition, a number of other parameters were identified as potential POCs, based on results of the previous SSMP studies that have occurred in the Credit Valley Watershed (Town of Caledon et al. 2008). **Table 2.7.1** presents the parameters that were chosen for further analysis in this report, the current relevant guideline and the corresponding reference.

Table 2.7.1 Parameters of Concern

<table>
<tr><th>Category</th><th>Parameters of Concern</th><th colspan="2">Objective</th><th>Objective Reference</th></tr>
<tr><td rowspan="4">Nutrients</td><td>Total Phosphorus</td><td colspan="2">0.03 mg/L</td><td>PWQO (MOE 1999[a])</td></tr>
<tr><td>Nitrate Nitrogen</td><td colspan="2">2.93 mg/L</td><td>CCME (2003)</td></tr>
<tr><td>Ammonia-Nitrogen un-ionized</td><td colspan="2">20 µg/L</td><td>PWQO (MOE 1999[a])</td></tr>
<tr><td>Total Kjeldahl Nitrogen</td><td colspan="2">N/A</td><td>N/A</td></tr>
<tr><td>Oxygen Related</td><td>Biochemical Oxygen Demand (BOD)
Dissolved Oxygen Demand (DO)</td><td colspan="2">DO > 5 mg/L</td><td>PWQO (MOE 1999[a])</td></tr>
<tr><td rowspan="4">Metals</td><td>Aluminum</td><td colspan="2">75 µg/L</td><td>PWQO (MOE 1999[a])</td></tr>
<tr><td>Copper</td><td colspan="2">5 µg/L</td><td>PWQO (MOE 1999[a])</td></tr>
<tr><td>Iron</td><td colspan="2">300 µg/L</td><td>PWQO (MOE 1999[a])</td></tr>
<tr><td>Zinc</td><td colspan="2">20 µg/L</td><td>PWQO (MOE 1999[a])</td></tr>
<tr><td rowspan="3">Physical</td><td rowspan="2">Water Temperature</td><td>Absolute Maximum Summer Water Temperature</td><td>26 °C (coldwater)
28 °C (mixed water)
30 °C (warmwater)</td><td>CRFMP (OMNR and CVC 2002)</td></tr>
<tr><td>Daily Maximum Summer Average Water Temperature</td><td>20 °C (coldwater)
23 °C (mixed water)
26 °C (warm water)</td><td>CRFMP (OMNR and CVC 2002)</td></tr>
<tr><td>Total Suspended Solids</td><td colspan="2">25 mg/L</td><td>CCME (1999)</td></tr>
<tr><td>Other</td><td>Chlorides</td><td colspan="2">250 mg/L</td><td>CEPA (1999)</td></tr>
<tr><td>Microbiological</td><td>Escherichia coli</td><td colspan="2">100 CFU/100 mL</td><td>PWQO (MOE 1999[a])</td></tr>
</table>

These results were compared against the Provincial Water Quality Objectives (MOE 1999[a]), Canadian Environmental Quality Guidelines (CCME 1999), and CVC's criteria for water temperature for the protection of aquatic biota. Except for water temperature, these guidelines are all based on long-term conditions and chronic toxicity values. Typically, the results of surface water quality measurements are highly variable and therefore many measurements are needed before background conditions can be determined. Therefore, the purpose of the statistical analyses is to look at composite sets of data to determine background water quality conditions to compare to the long-term exposures guidelines.

2.7.2 Methodology and Data Analysis

2.7.2.1 Sampling Methodology

Five different assessments were conducted for the water chemistry analysis in the Erin SSMP study:

1. Long-term water quality data assessment
2. Local 2007 and 2008 field water quality data assessment
3. Local 2008 sediment chemistry data assessment
4. Diurnal 2008 water quality data assessment
5. Water temperature logger deployment and assessment

The large data set from the one long-term Ministry of Environment (MOE) Provincial Water Quality Monitoring Network (PWQMN) station in the study area is located on the West Credit River at Winston Churchill Blvd (**Figure 2.7.1**). The PWQMN station on the West Credit River, is sampled on a monthly basis on a randomly chosen day near the end of each month. The parameters chosen for analyses were those identified in **Table 2.7.1**.

The long term PWQMN station on the West Credit River is located at the lower portion of the study area, which created a significant spatial gap in the remaining study area, as identified in the *Erin SSMP Data Gap Analysis Report* (CVC et al. 2008). Therefore additional water quality data were collected across the study area during the 2007 and 2008 field season to provide an estimation of water quality conditions throughout the study area. Eleven additional stations were sampled on a monthly basis from September 2007 to September 2008 for the full suite of parameters. **Figure 2.7.1** shows the locations of the water and sediment chemistry sampling and **Table 2.7.2** gives a description of the type of monitoring at each station.

Sediment chemistry monitoring was conducted in the 2008 field season at all 11 water chemistry sites. This analysis allows a deeper look into the historical chemical compounds employed, their mobility, and ability to bioaccumulate in the subwatershed.

Figure 2.7.1 Water Quality, Temperature, and Sediment Chemistry Sampling Stations

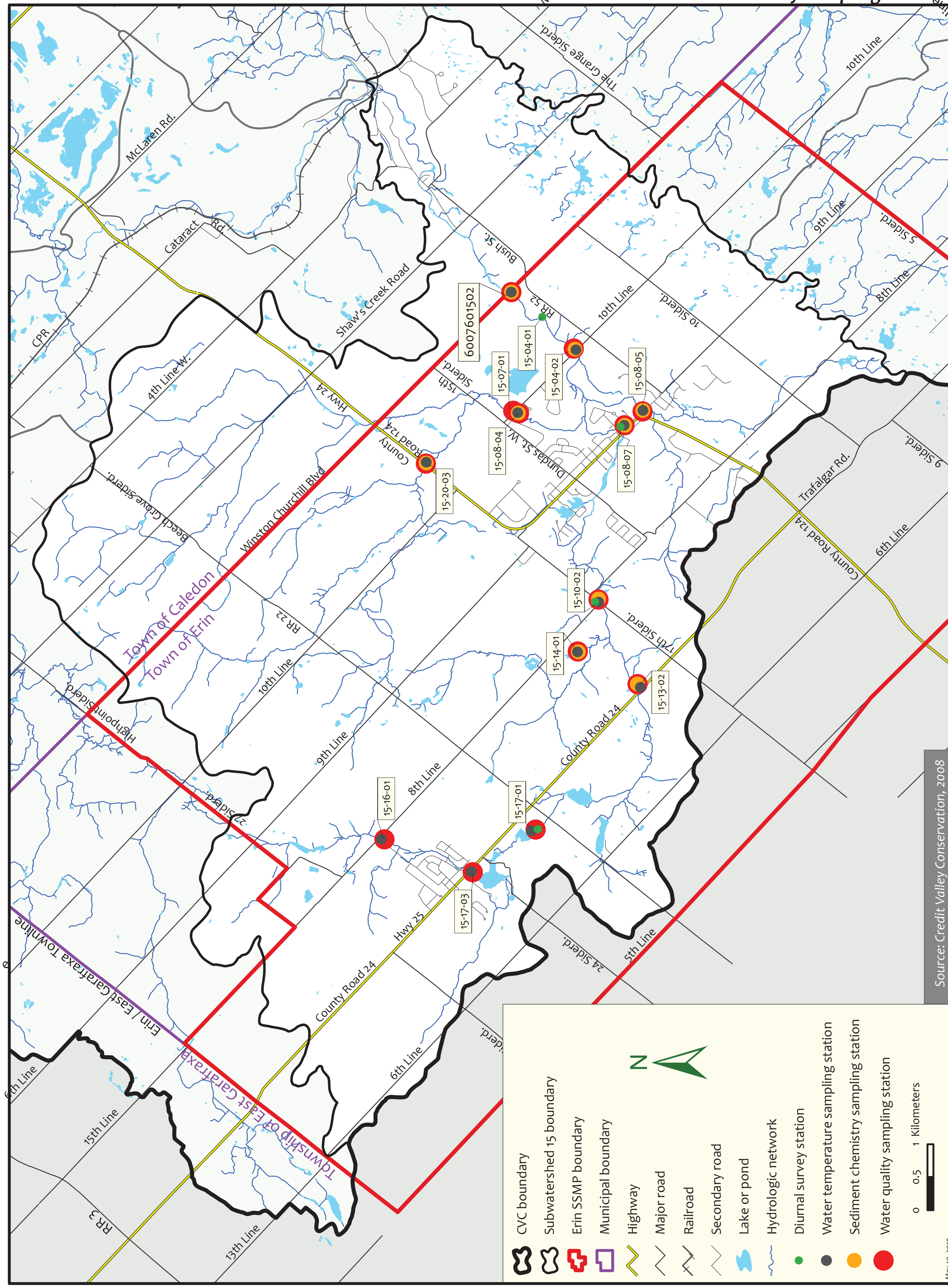


Table 2.7.2 Stations and Measured Parameters

Station ID	Description	Purpose of Site	Sampling Program	Length of Record	Diurnal Dissolved Oxygen Survey	Sediment Sampling	Continuous Water Temperature
15-16-01	West Credit upstream Hillsburgh, downstream 8th Line	Characterization upstream end of study area	Erin SSMP	1997-1998		√	√
15-17-03	West Credit downstream Hwy 25, Hillsburgh	Characterization downstream end of Hillsburgh	Erin SSMP	1997-1998		√	√
15-17-01	West Credit downstream Head Pond (also known as Hillsburgh Dam), Hillsburgh	Characterization downstream of online ponds	Erin SSMP	1997-1998	√	√	√
15-13-02	West Credit downstream County Rd 24	Characterization of downstream end of Hillsburgh branch	Erin SSMP	1997-1998		√	√
15-14-01*	West Credit Trib. at Caledon Rail Trail u/s 8th Line	Characterization of Central Branch	Erin SSMP	1997-1998		√	√
15-10-02	West Credit at 8th Line Gauge Station	Long-term monitoring station	Erin SSMP	1997-1998	√	√	√
15-08-07	West Credit downstream Main St., Erin Village	Characterization downstream of online ponds	Erin SSMP	1997-1998	√	√	√
15-08-05*	South Trib. downstream Main St., Erin Village	Characterization of South Branch	Erin SSMP	1997-1998		√	√
15-20-03*	East Branch downstream Wellington Rd 124	Characterization of Binkham Tributaries	Erin SSMP	1997-1998		√	√
15-08-04*	East Branch downstream 10th Line / North of West Credit River	Characterization of West Branch in Erin	Erin SSMP	1997-1998		√	√
15-04-02	West Credit downstream 10th Line	Downstream end of study area	Erin SSMP	1997-1998	√ (Station ID: 15-04-01)	√	√
06007601502	West Credit at Winston Churchill Blvd.	Long-term monitoring station	CVC -PWQMN	1996-1998			√

Note:
** These stations are located on tributaries of the West Credit River.*

2.7.2.2 Data Analysis

The large data sets from the long-term Ministry of Environment (MOE) Provincial Water Quality Monitoring Network (PWQMN) station, West Credit River at Winston Churchill Blvd., allowed for the evaluation of selected parameters for annual statistics, seasonal means, trend analysis, and guideline exceedance frequencies. Monitoring began in 1975 at the West Credit River at Winston Churchill Blvd station. Most parameters were sampled for the entire time period, however accurate *E. coli,* metals, and nitrate data are not available until after 1996. Therefore the long term analysis focused on the time period of 1996-2008. Parameters of Concern that were identified for further analysis and listed in **Table 2.7.1** underwent the following analyses:

- Time Series Graphing;
- Means and geometric means (for *E. coli*);
- Five percentiles (10th, 25th, 50th, 75th, and 90th);
- Percent violation of the standard guideline;
- Seasonal means for selected parameters; and
- Trend analysis for selected parameters.

A statistical analysis computer program, WQstat Plus™ (Intelligent Decision Technologies Inc, Co., US) was used for computation of water quality statistic and time trend analysis. Typically, environmental information, including water quality data do not follow a normal distribution and therefore require non-parametric statistical tests. To determine if water quality was improving, degrading, or stable non-parametric trend analyses were done using Sen's Slope test. The trend value provides information on both the direction and magnitude of the trend. A 90% confidence level was utilized for the trend analysis.

The Canadian Council for Ministers of the environment (CCME) adopted a water quality index (WQI) to help communicate complex water quality information to the public and provide a broad overview of environmental performance (CCME 2001). The CCME water quality index was used on the short term data set to give an overall rating of the general or ambient water quality and comparison between stations.

Local 2007 and 2008 field water quality data assessment included time series graphing and summary statistical analysis (means and geometric means, maximum and minimum and percentile analysis). Box and whisker plots were used to present the data graphically. Box and whisker plots can illustrate the distribution and statistics of a dataset. The box-whisker plot in **Figure 2.7.2** is an example to illustrate the 25th and 75th percentiles of the dataset, called the lower and upper quartiles, and the median (the 50th percentile). The whiskers represent the range of the data set to the 90th and 10th percentile (Peltier Technical Services). All stations listed from left to right within the box-whisker plots begin at the headwaters and move downstream.

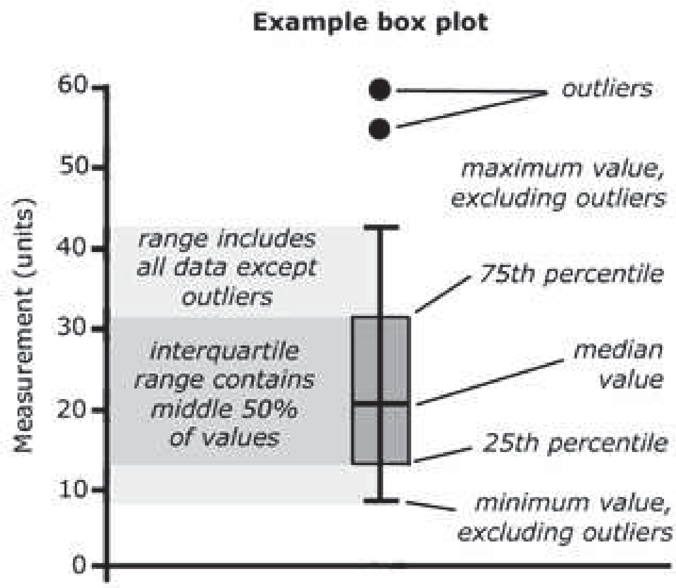


Figure 2.7.2 Box and Whisker Plot Illustrating the 10th, 25th, 50th (median), 75th, and 90th Percentiles and Outliers of the Data Set

2.7.3 Results and Discussion

Water quality measurements represent only a brief snapshot of the water quality conditions at the time of sampling. However, over a longer time period of sampling, general trends and patterns can emerge from the data sets. Averaged or summarized data can be compared against typical values and guidelines, such as those from the Canadian Council of Minister of the Environment (CCME 1999) and Provincial Water Quality Objectives (PWQOs) (MOE 1999[a]). CCME guidelines and PWQOs have been specifically developed based on long-term threshold water quality conditions. Therefore, median values for each parameter should not exceed their respective guidelines or objectives. Occasional samples that exceed the objectives or guidelines are not problematic as long as levels are not high enough to be acutely toxic. Under MOE's Policy 2 statement, the MOE will not permit any further degradation of the water quality by a parameter that presently exceeds its PWQO (MOE 1999[a]). For those parameters that are below their PWQO, some minimal degree of degradation may be accepted; however, degradation beyond the PWQO is not acceptable. This approach is outlined in Policy 1 (MOE 1999[a]). Typically, a 75th percentile value is used for comparison against the PWQO as it represents a conservative, 'worse than average' condition of the water body. The complete dataset for all measured parameters is presented in the Water Quality and Sediment Chemistry Appendix**.**

2.7.3.1 Nutrient Related Parameters

For most freshwater aquatic systems, **total phosphorus** is used for assessing the degree of nutrient enrichment as it is often the limiting macronutrient for the growth of aquatic plants. Sources of phosphorus to the watershed include both point sources (stormwater discharge) and non-point sources (atmospheric deposition, fertilizer application, livestock waste, urban runoff, failing septic systems, and natural sources). In excessive amounts, phosphorus can increase aquatic plant growth to biomass levels that causes significant diurnal fluctuations in dissolved oxygen from photosynthesis and respiration processes. Dissolved oxygen levels below the PWQO of 5 mg/l for coldwater streams, will stress fish communities.

Analysis of total phosphorus long-term data for the West Credit River at Winston Churchill Blvd. indicates that this reach of the West Credit River is not a Policy 2 watercourse with respect to Total Phosphorus. At this station the overall 75th percentile and monthly 75th percentile concentrations fell below the PWQO set by MOE (**Figure 2.7.3**) and the percent violation of the PWQO is 4%. Trend analysis demonstrates a slight decrease in phosphorus concentrations during period 1996-2008.

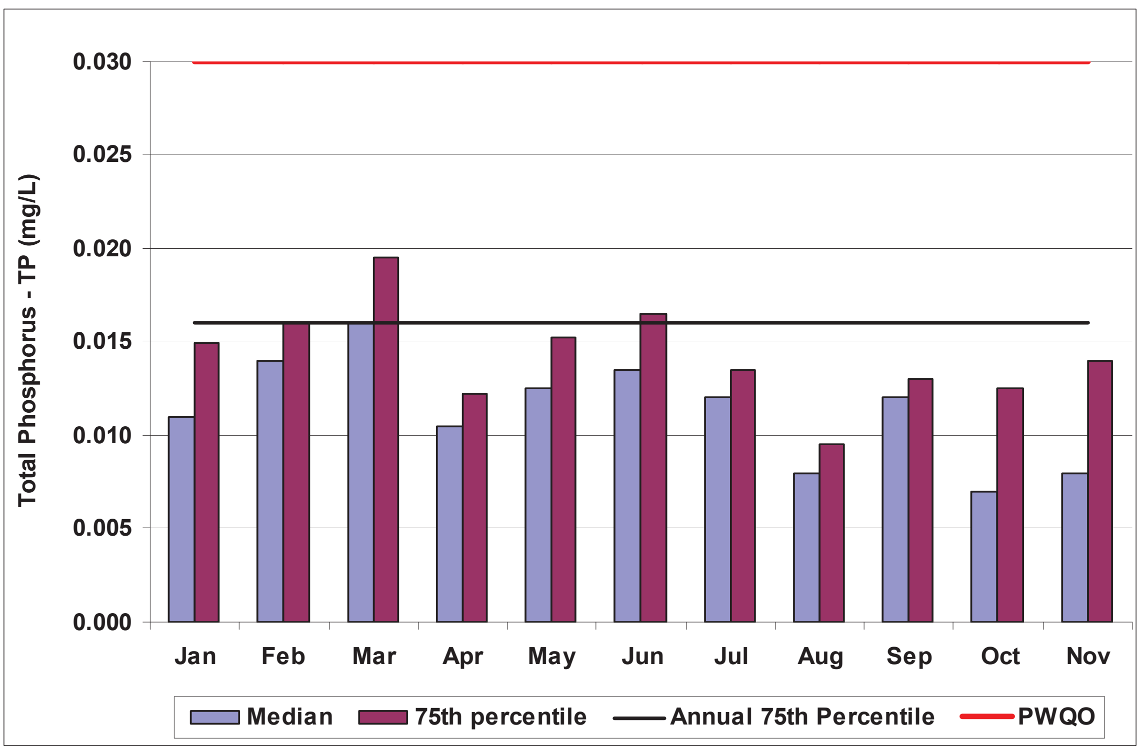


Figure 2.7.3 Summary Statistics of Total Phosphorus Concentrations for the West Credit River at Winston Churchill Blvd. from 1996-2008

Total phosphorus data collected through the SSMP fieldwork in 2007-2008 revealed that the phosphorus levels are generally below the PWQO on the smaller tributaries and on the West Credit River although some exceedances were measured. The summary analysis found that higher levels are present in stations located near the urban centers of

Hillsburgh and Erin stations indicating that phosphorus contributions are likely coming from urban storm water runoff (**Figure 2.7.4**).

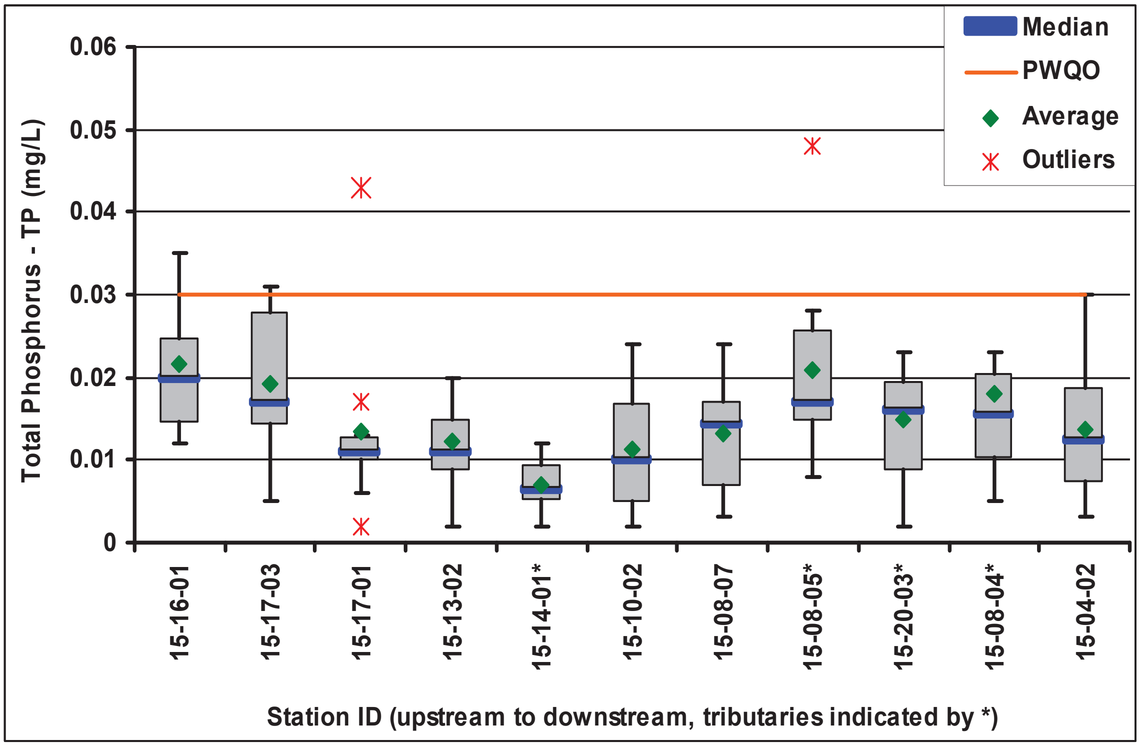


Figure 2.7.4 Box Plot of Total Phosphorus Concentrations for the SSMP Study Stations from 2007-2008 (PWQO = 0.03 mg/L)
Note: Extreme outlier for station 15-20-03 removed from graph for Sept 26 2007 TP = 0.510 mg/L)

Nitrate-Nitrogen is typically a groundwater quality concern and commonly arises from surficial spreading of fertilizers or from septic systems. Nitrates in surface watercourses can also originate from Water Pollution Control Plant (WPCP) discharges, runoff from both rural and urban land uses, as well as precipitation. Nitrate is a dissolved nitrogen species that acts as a nutrient to stimulate aquatic plant growth and may be toxic to aquatic biota at elevated levels. Excessive aquatic plant growth can lead to an unhealthy dissolved oxygen regime, since nighttime DO levels will be reduced by plant respiration. Because nitrate is soluble and does not absorb to soil particles, it is highly mobile in groundwater and can be a concern where groundwater discharges into creeks, especially in fish spawning locations. Recently, the CCME approved a Canadian Water Quality Guideline (CWQG) for nitrate-nitrogen of 2.93 mg/L for the protection of aquatic biota in freshwater systems (CCME 2003). The Ontario Drinking Water Objective for nitrate (as nitrogen) is 10 mg/L.

The long-term nitrate data from the PWQMN station at the West Credit River and Winston Churchill Blvd. station indicates that the mean and 75th percentile are below the criteria of 2.93 mg/L nitrate-nitrogen (NO_3-N). The percentage of samples which exceed the CWQG is approximately 4%, which is the same as the total phosphorus exceedance results. Although, statistical trend analysis portrayed a significant increasing trend in nitrate-nitrogen over the period of 1996-2009 (**Figure 2.7.5**).

The seasonal analysis of the long term PWQMN dataset showed elevated nitrate levels approaching the CWQG during the winter months of January and February. This may be a result of the absence of aquatic plants and bacteria that can convert the nutrient into a food source.

The nitrate-nitrogen data collected through the fieldwork in 2007-2008 revealed that the nitrate levels are elevated at many locations through the study area. The boxplot in **Figure 2.7.6** illustrates a similar trend as phosphorus with elevated concentrations in Hillsburgh where the median concentrations are consistently above the CCME guideline. Station 15-14-01 is located in a rural catchment and elevated results are likely due to agricultural practices.

The un-ionized fraction of **total ammonia (NH_3)** is considered one of the indicator parameters, as it has been shown to be toxic to aquatic life. The PWQO of 20 ug/l is based on the un-ionized ammonia fraction, which is related to the field water temperature and pH. The concentration of un-ionized ammonia increases with pH and water temperature increases. The value of un-ionized ammonia was calculated using the Emerson equation based on total ammonia, field water temperature, and field pH data.

The long-term un-ionized ammonia data from the PWQMN station, West Credit River at Winston Churchill Blvd., indicated that the mean and 75th percentile were well below the criteria of 20 ug/L and no samples exceeded this guideline (**Figure 2.7.7**). Seasonal distributions illustrate higher concentrations in the summer months from May to August. Trend analysis shows a significantly decreasing concentration over the study period at a 90% confidence level.

Results indicate that levels of un-ionized ammonia (NH_3) for the period of observation were also below the objective for un-ionized ammonia (**Figures 2.7.8**) for the full dataset at the eleven stations in the Erin SSMP study area. Ammonia concentrations were not recorded above the PWQO during the study period. Also, a seasonal trend was not evident in the short term un-ionized ammonia concentrations. Refer to the Water Quality and Sediment Chemistry Appendix for the full dataset.

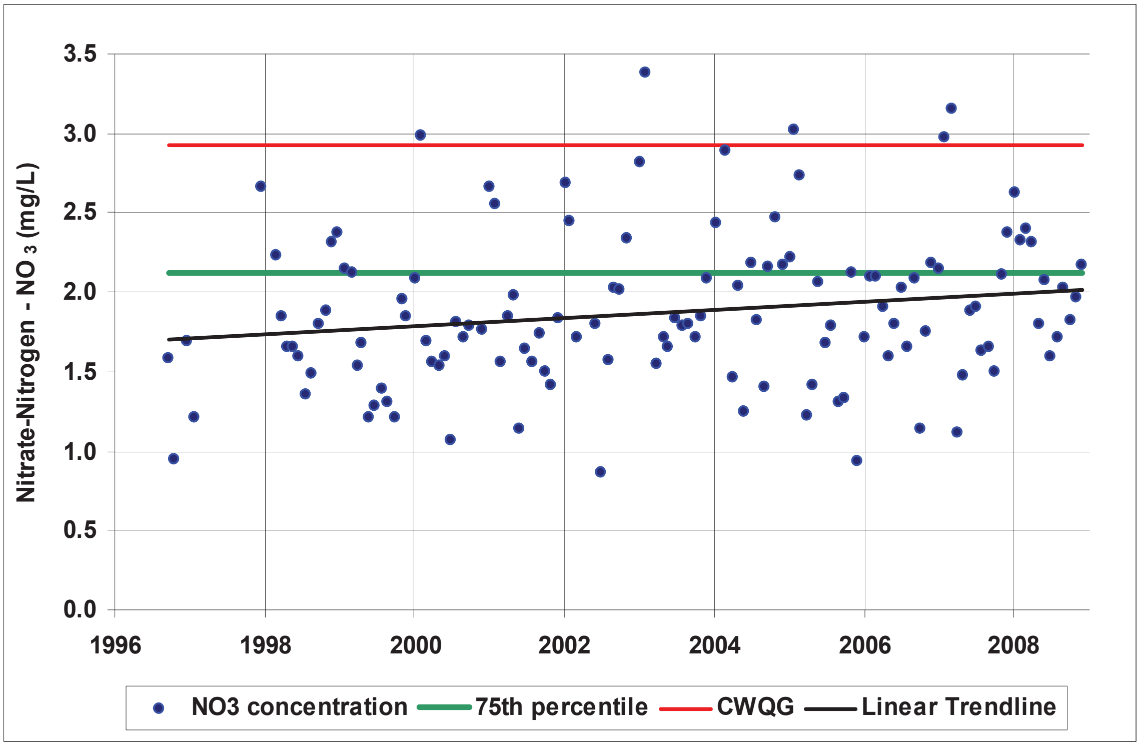


Figure 2.7.5 Nitrate-nitrogen Concentrations for the West Credit River at Winston Churchill Blvd. from 1996-2009 (CWQG = 2.93 mg/L)

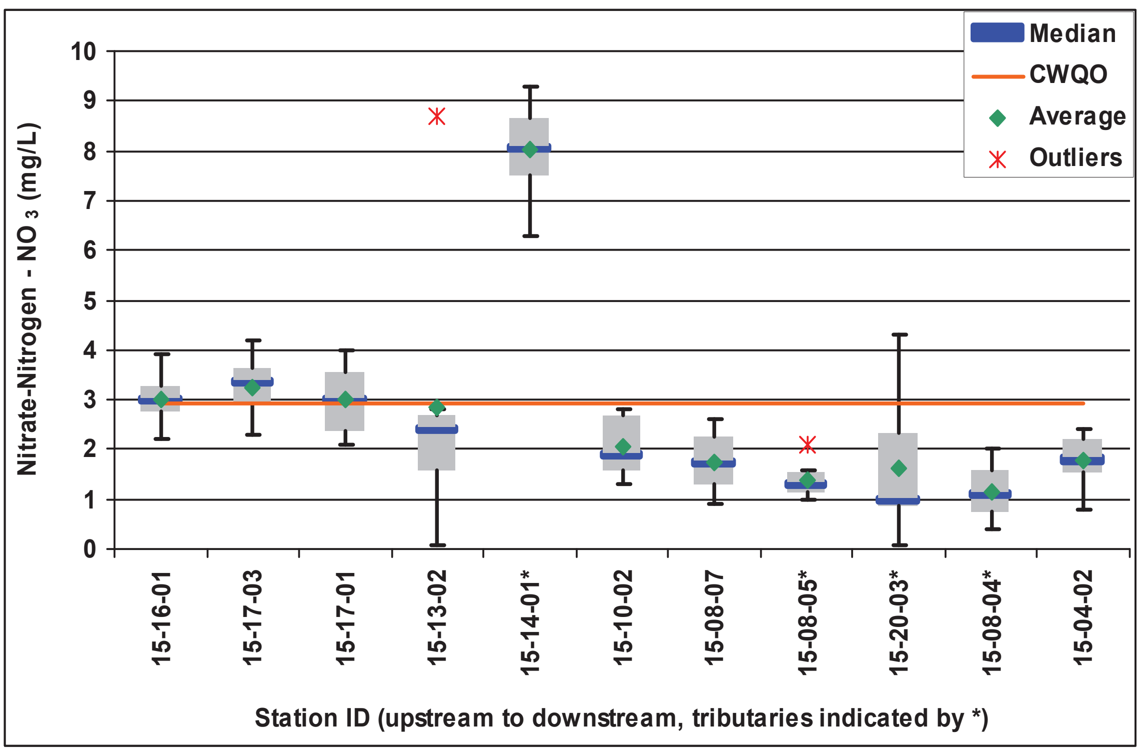


Figure 2.7.6 Box Plot of Nitrate-nitrogen Concentrations for the SSMP Study Stations from 2007-2008 (CWQG = 2.93 mg/L)

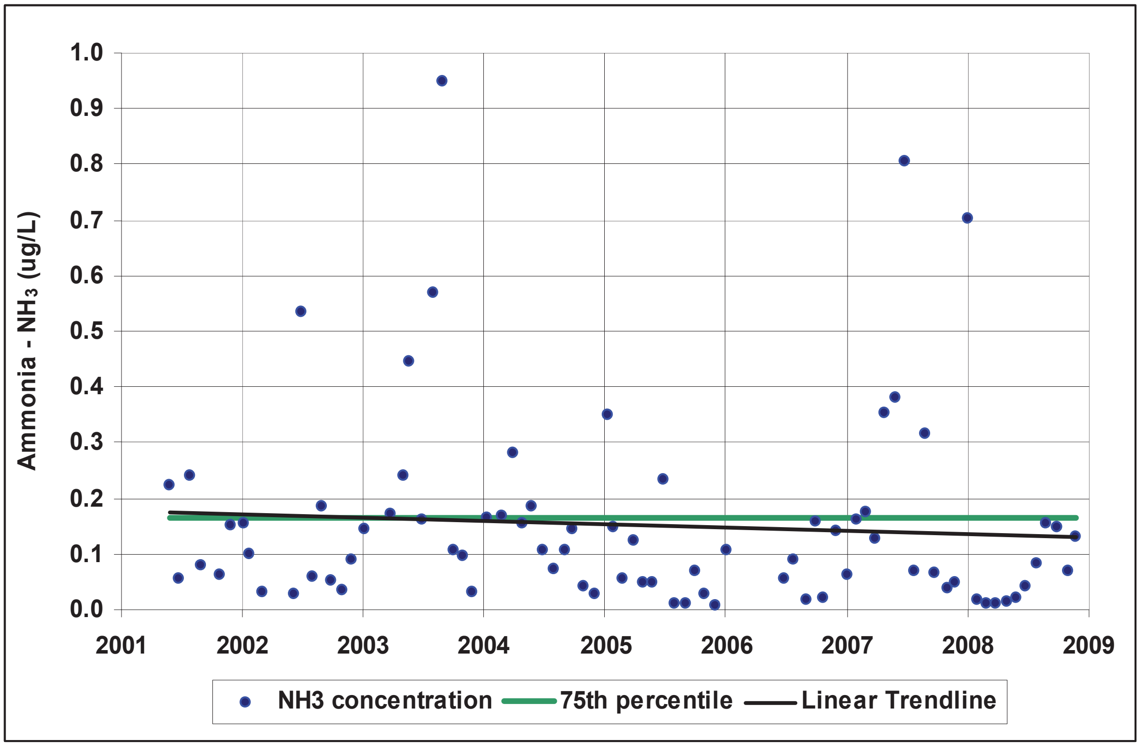


Figure 2.7.7 Un-ionized Ammonia Concentrations for the West Credit River at Winston Churchill Blvd. from 2001-2009 (PWQO = 20 ug/L)

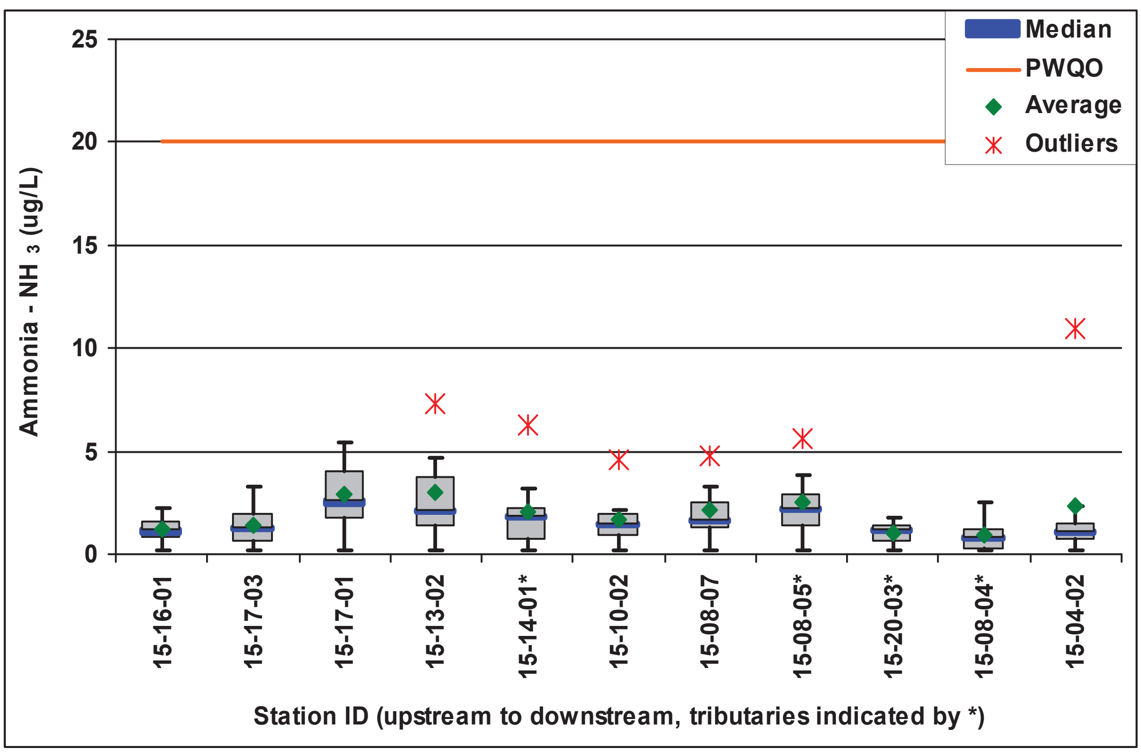


Figure 2.7.8 Box Plot of Un-ionized Ammonia (NH_3) concentrations for the SSMP Study Stations from 2007-2008 (PWQO = 20 ug/L)

Total Kjeldahl Nitrogen (TKN) is the sum of organic nitrogen, ammonia (NH_3), and ammonium (NH_4^+). TKN concentrations give information of the full nitrogen cycle but do not have an associated guideline or objective. **Figure 2.7.9** depicts a historical time series of TKN concentrations in the West Credit River at Winston Churchill Blvd. TKN concentrations vary from 0.18 – 0.74 mg/L with no seasonal differences evident. Trend analysis indicates that there is not a significant trend in the data.

Total Kjeldahl Nitrogen data collected through the SSMP fieldwork in 2007-2008 revealed no distinct differences between TKN concentrations at the eleven stations distributed throughout the study area (**Figure 2.7.10**).

2.7.3.2 Oxygen Related Parameters

A healthy dissolved oxygen regime is critical for fisheries and other aquatic biota. The PWQO for dissolved oxygen is 5 to 6 mg/L for coldwater fisheries and 4 to 5 mg/L for warmwater fisheries, within the temperature range of 10 ^oC to 25 ^oC. As opposed to most parameters, the standard for dissolved oxygen is a minimum, and therefore observed values should be above the PWQO. Oxygen levels are a function of many variables including:

- oxygen demanding parameters including carbonaceous, nitrogenous, and benthic sediment oxygen demand (increased oxygen demand will decrease dissolved oxygen);
- water temperature and decreases in atmospheric pressure (increased water temperatures and decreased pressure will decrease the amount of oxygen the water can hold);
- re-aeration (increased re-aeration will increase dissolved oxygen when levels are below saturation and will decrease levels when above saturation); and
- plant photosynthesis and respiration processes (photosynthesis processes produce oxygen while respiration processes consume oxygen).

Diurnal Monitoring
Although dissolved oxygen (DO) is measured during the water chemistry sampling events, these measurements are almost always taken during daylight hours and do not capture the period of lowest dissolved oxygen. Night time measurements of DO are important because if significant aquatic plant growth is present, DO levels can drop below healthy levels for fish just before dawn. During the day, aquatic plants use the sun's energy to photosynthesize, a process that produces oxygen, and therefore increases the dissolved oxygen levels for fish. However, aquatic plants respire continuously, a process that consumes dissolved oxygen in the water. Therefore at night, plant respiration can cause a depletion of dissolved oxygen, which can stress or even kill fish. Water temperature, re-aeration rates, and the amount of oxygen demanding material in the water can also affect the dissolved oxygen levels. Sediment oxygen demand, carbonaceous biological oxygen demand, and nitrogenous oxygen demand can remove dissolved

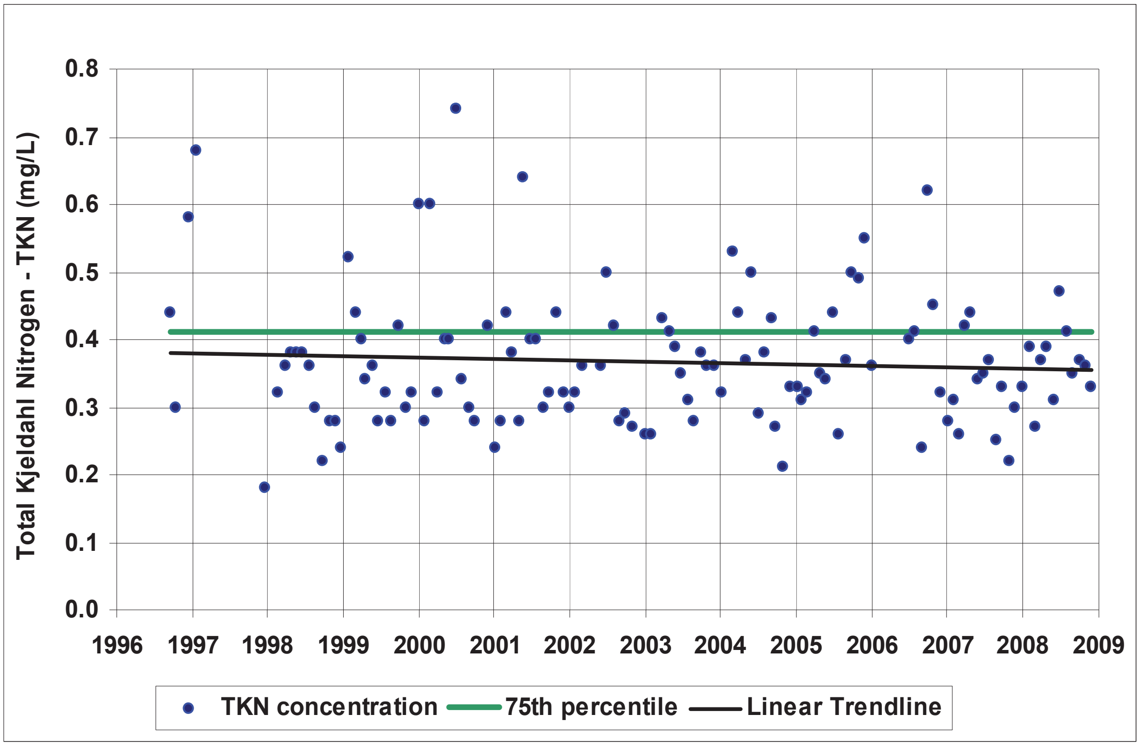


Figure 2.7.9 TKN Concentrations for the West Credit River at Winston Churchill Blvd. from 1996-2009

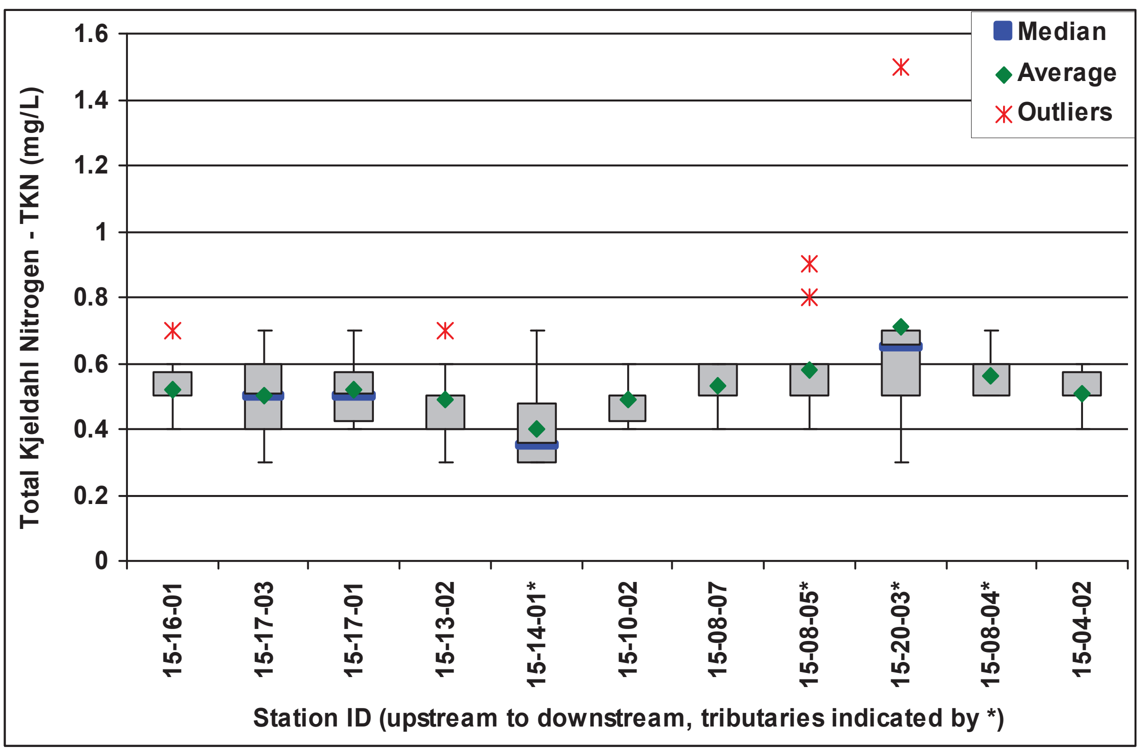


Figure 2.7.10 TKN Concentrations for the SSMP Study Stations from 2007-2008

oxygen in the water column. Warmer water holds less oxygen than colder water and also increases fish metabolism, which thereby increases the amount of oxygen needed by the fish. Higher re-aeration rates in turbulent, high gradient, fast moving water can reduce the impact on dissolved oxygen from aquatic plants and oxygen demanding materials. Because of the number of variables that can impact DO levels, diurnal surveys for dissolved oxygen are needed to measure both daytime and night-time dissolved oxygen levels.

Two sets of diurnal monitoring tests for dissolved oxygen, pH, conductivity, and water temperature were completed at 4 stations across the study area, one in late June, and one in late August. **Figure 2.7.11** illustrates DO concentrations over the five days of Hydrolab deployment in June 2008. All concentrations surpassed the minimum DO objective of 5 mg/L. The large variation seen in the West Credit River downstream of the Head Pond (also known as the Hillsburgh Dam) station in Hillsburgh (15-17-01) illustrates the influence of plant growth and respiration in the upstream pond in conjunction with re-aeration from the waterfall. Some mechanical difficulty was experienced with the Hydrolab probe at the 8th Line Gauge Station (15-10-02) which resulted in a shortened DO measurement period.

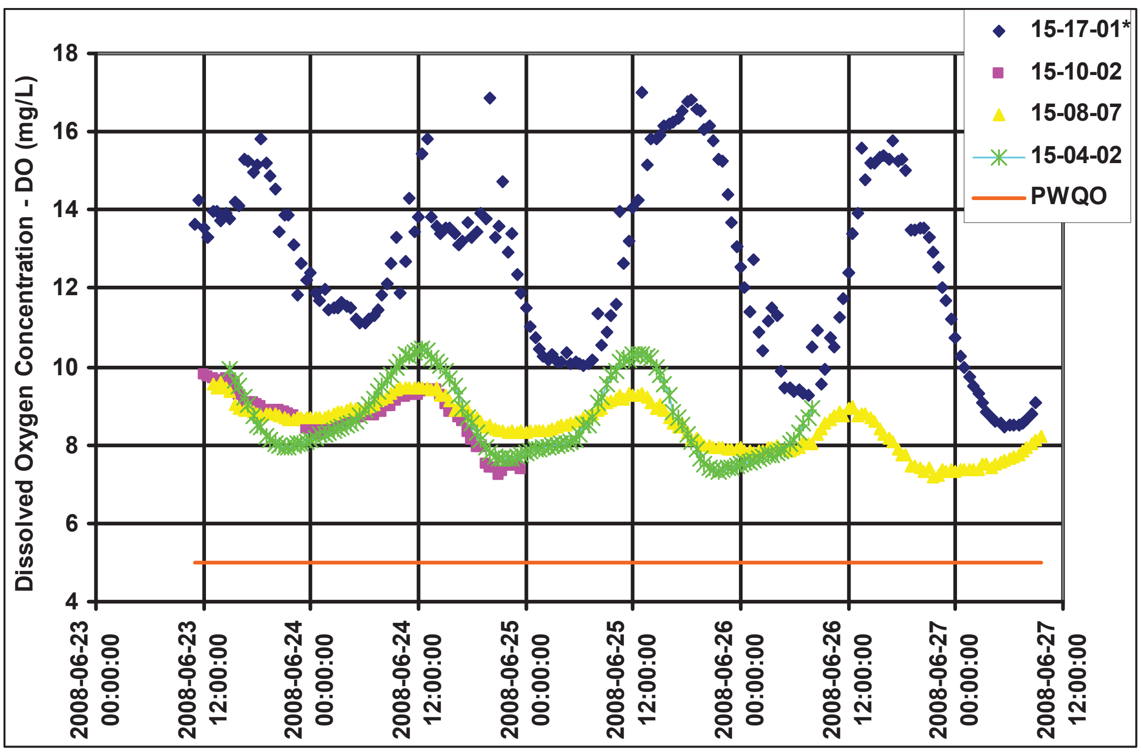


Figure 2.7.11 Diurnal Survey Dissolved Oxygen Results for West Credit River Stations in June 2008

The second diurnal sampling event was conducted in late August 2008, during a period of low flow conditions and warmer water temperatures. **Figure 2.7.12** illustrates the DO profile showing similar trends to June, with concentrations well above levels considered to be harmful to aquatic life. Station 15-17-01 is located downstream of the Head Pond (also known as the Hillsburgh Dam) in Hillsburgh and the large variations in DO found at this station are an artifact of the aquatic macrophyte growth within the pond upstream. These macrophytes produce dissolved oxygen during the day through photosynthesis and consume oxygen during the night through respiration. The air and water temperatures were below normal in the summer of 2008 which likely had a positive influence on dissolved oxygen concentration as the water has the capacity to hold more oxygen in colder water temperatures.

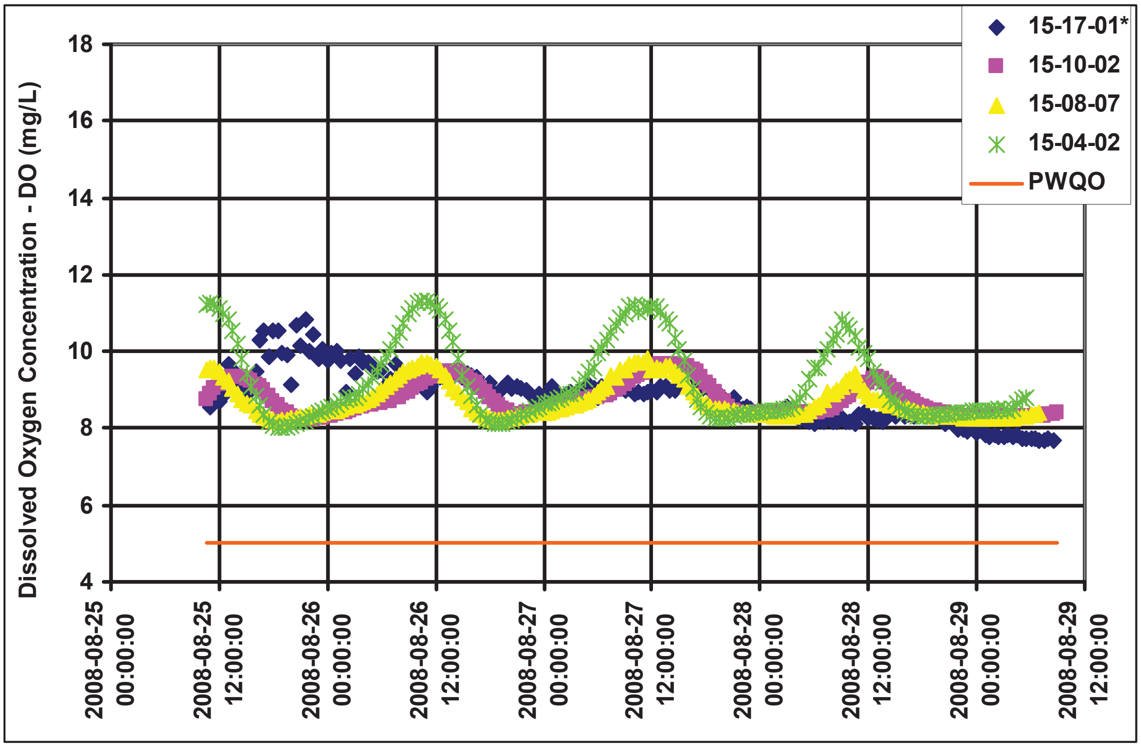


Figure 2.7.12 Diurnal Survey Dissolved Oxygen Results for West Credit River Stations in August 2008

Biochemical Oxygen Demand (BOD) is a measure of the amount of oxidizable organic substances in a water sample that can lower dissolved oxygen (DO). The standard oxidation (or incubation) test period for BOD is 5 days at 20 °C (BOD_5). This test determines how organic matter affects the concentration of dissolved oxygen (DO) in a stream or lake and is integral to water-quality management. PWQO or CCME standards for BOD_5 are not available at present time.

Figure 2.7.13 depicts the long term time series of BOD_5 concentration in the West Credit River at Winston Churchill Blvd. There were no major variations in seasonal / monthly 75^{th} percentile values. However, fall and winter appeared to have slightly higher BOD concentrations (refer to the Water Quality and Sediment Chemistry Appendix). BOD_5 data collected through the SSMP fieldwork in 2007-2008 measured no values above the detection limit of 2 mg/L. This is supported by the low levels of algal and aquatic macrophytes biomass observed in the study area.

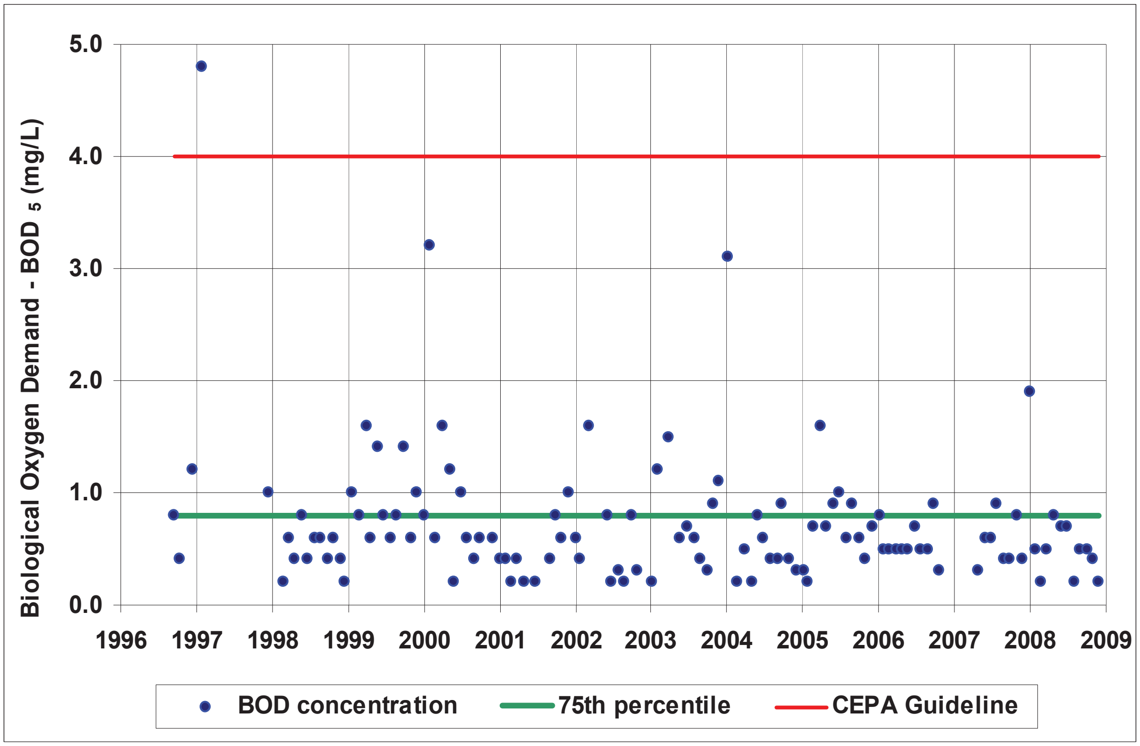


Figure 2.7.13 BOD$_5$ Concentrations for the West Credit River at Winston Churchill Blvd. from 1996-2008

2.7.3.3 Physical Parameters

Total Suspended Solids (TSS)

The type and concentration of suspended matter controls the turbidity and transparency of water. Suspended matter includes silt, clay, fine particles of organic and inorganic matter, soluble organic compounds, and microscopic organisms. Total Suspended Solids (TSS) are defined as un-dissolved particles that vary in size from approximately 10 nm to 0.1 mm in diameter, containing both biotic and abiotic components. Anthropogenic activities such as forest harvesting, road building, construction, dredging, and gravel pit operations can cause marked changes in the physical, chemical, and biological characteristics of the watercourses nearby, and areas downstream. Other major sources of anthropogenic sediment loading in streams include agricultural runoff, industrial, and municipal wastewater discharge. Urban runoff contributes dust and dirt collected on impervious surfaces. Also the increased rate of runoff from urban areas due to the impervious surfaces, and the efficient collection system of roadside curbs, gutters, catch basins, and sewers can increase channel erosion in natural stream banks and add to the TSS in streams during runoff events.

Currently, there is no PWQO for suspended solids but it is recognized that high levels can clog critical spawning areas for fish, increase sediment oxygen demand which can deplete DO levels, and result in poor water clarity for aquatic life and recreational uses. The Canadian Water Quality Guideline (CWQG) for suspended solids suggests that during clear flow conditions suspended solids levels should not increase from anthropogenic activities to over 25 mg/l of background levels for a 24 hr period and 5 mg/l for a period of longer-term exposure (24 hr to 30 d).

Suspended solids measurements are spot measurements similar to water temperature and can vary widely from wet to dry conditions (**Figure 2.7.14**). The data suggests that the West Credit River at Winston Churchill Blvd. station may occasionally receive large sediment loads through erosion, agricultural runoff, and stormwater flows but overall has a low suspended sediment loading as the 75th percentile is 3.6 mg/L, below the chronic toxicity CWQG. The seasonal distribution of the data demonstrated a slight increase in concentrations in the later winter and spring indicating that higher loading is likely associated with spring melt and runoff. Also, trend analysis did not demonstrate a significant trend in the long term TSS data.

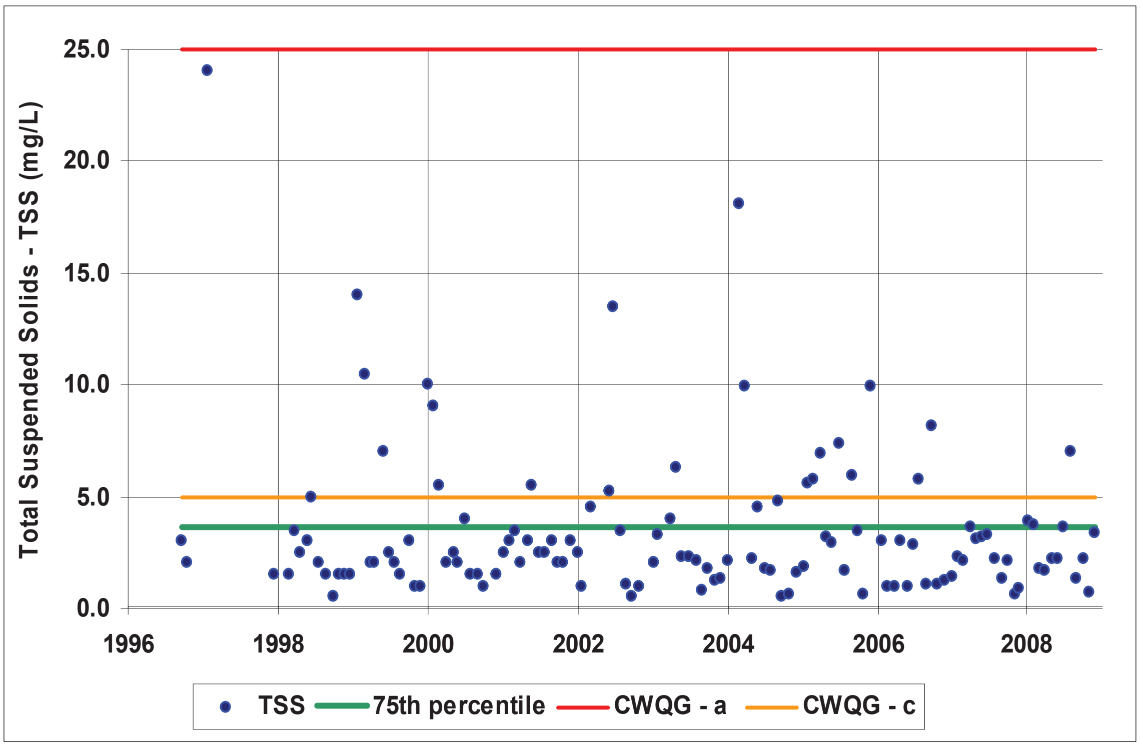


Figure 2.7.14 TSS Concentrations for the West Credit River at Winston Churchill Blvd. from 1996-2008
Note: CWQG-a = 25 mg/L for a 24 hr period, while CWQG-c = 5.0 mg/L for a 24 hr to 30 d period.

Total suspended solids data collected through the SSMP fieldwork in 2007-2008 revealed that most of the TSS values were recorded below detection limits. Isolated elevated samples were found in the late winter and spring and likely associated with spring runoff. The complete data set can be found in the Water Quality and Sediment Chemistry Appendix.

Chlorides
Sources of chlorides (Cl^-) include loadings from septic system effluent, road salting for ice in the winter (NaCl), use of a dust suppressant ($CaCl_2$) on dirt roads in the summer, and water softeners. Because chloride has a high solubility and is a conservative parameter, it can readily move through groundwater systems and into surface waters through runoff or groundwater discharges (Bowen and Hinton 1998). Chloride does not have a freshwater guideline for the protection of aquatic biota, however the current aesthetic drinking water quality objective for chloride is 250 mg/l (MOE 2001[b]) which is within the range of the lowest concentrations observed to be harmful to aquatic biota (Environment Canada and Health Canada 2001).

Figure 2.7.15 depicts the statistical characteristics and historical time series of chloride concentration in the West Credit River at the Winston Churchill Blvd. station. The chloride concentrations measured well below the CVC Objective (250 mg/L) and had a long term annual 75th percentile at 43 mg/L with no recorded exceedances of the objective. The time series graph demonstrates a slight seasonal distribution to chloride concentrations indicating influences from road salting contributions. Trend analyses did not find a significant trend in chloride levels during the study period.

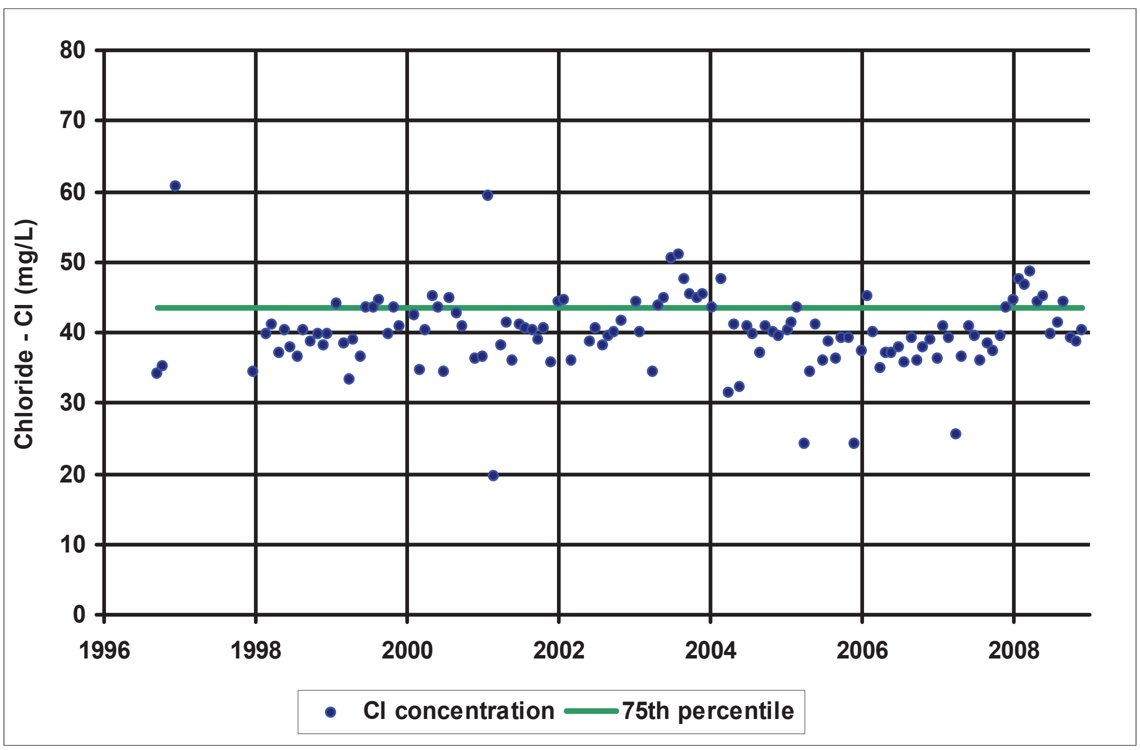


Figure 2.7.15 Chloride Concentrations for the West Credit River at Winston Churchill Blvd. from 1996-2008 (Lowest Observed Effect Concentration = 252 mg/L)

Chloride concentrations taken for the SSMP study indicate similar levels of chloride when compared to the long term results (**Figure 2.7.16**). All chloride concentrations were well below guideline levels. Slightly elevated concentrations are found in the smaller urban tributaries with less ability to dilute road salting impacts as compared to the West Credit River main branch.

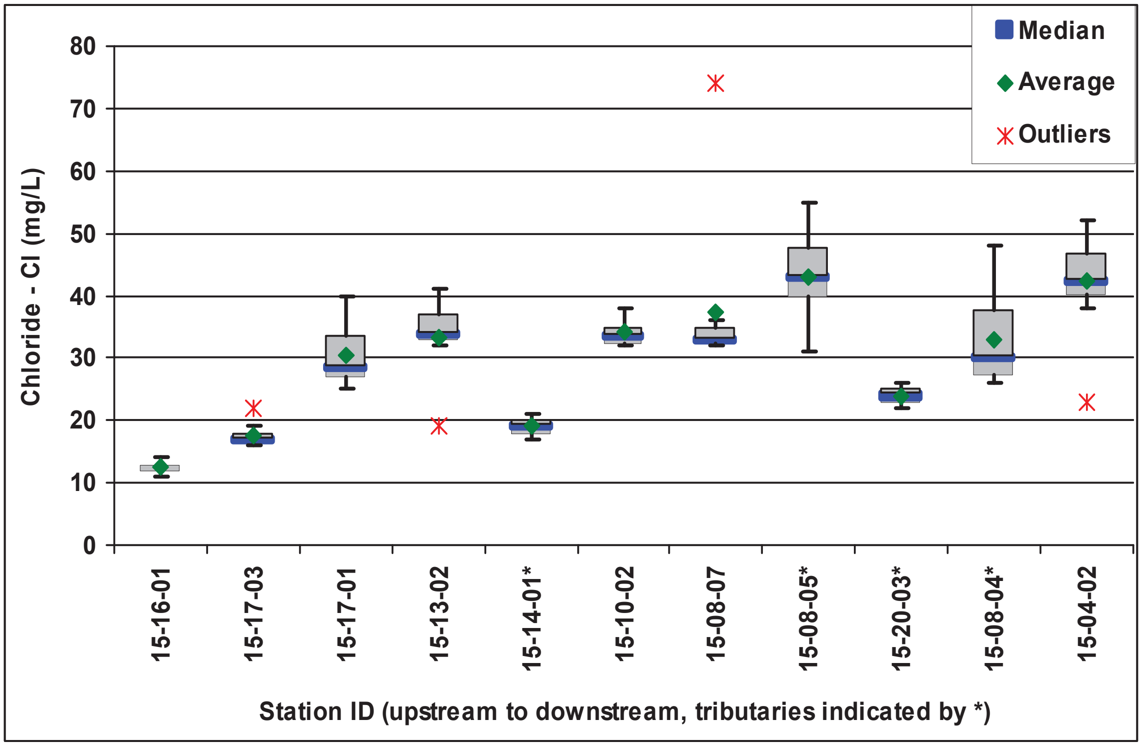


Figure 2.7.16 Chloride Concentrations for the SSMP Study Stations from 2007-2008 (Environment Canada's no effect concentration = 252 mg/L)

2.7.3.4 Metals

Most metals can be found naturally in soils and in the watercourses that discharge from these soils. Elevated levels of specific metals in watercourses and in soils can occur from naturally higher levels in geologic formations and from human activities, which can effectively concentrate metals directly and indirectly through urban, agricultural, and aggregate land uses, as shown in **Table 2.7.3**.

The metals aluminum, copper, iron, and zinc have been identified in the *Water Quality Strategy Phase 1 Report* (CVC et al. 2003) as the metal parameters of concern. Elevated total metal levels may occur from urban runoff and are usually attached to suspended solids. Also, geological groundwater sources can increase iron concentrations in surface water. **Aluminum** is associated with clay particles which form part of suspended solids. As the samples were not filtered before analysis, it is supposed that many of the high concentrations that violated the PWQO were due to clay particles in the sample. **Copper** is an acutely toxic metal to most forms of aquatic life at relatively low concentration. The PWQO for unfiltered total copper is 5 ug/L. The present potential anthropogenic sources of copper in the Erin SSMP study area include industrial and urban runoff (such as stormwater runoff, septic effluent). **Iron** is a naturally presented metal in groundwater and also occurs in urban runoff. Iron has a PWQO of 300 ug/L for the protection of aquatic life. **Zinc** is an acutely and chronically toxic metal to aquatic organisms, particularly for fish. The PWQO for unfiltered total zinc is 20 ug/L. The present potential anthropogenic sources of zinc in the Erin SSMP study area include industrial and urban runoff, and agriculture (fertilizers and pesticides).

The summary statistics of total metal concentrations for the 1996-2008 data set are shown in the **Table 2.7.4**. The 75th percentile values of all of the metal parameters were less than their respective PWQO for the PWQMN station, West Credit River at Winston Churchill Blvd. The percent of violation occurrence ranges from 0% to 4%, indicating relative low contributions from urban, agricultural, and aggregate sources.

Table 2.7.3 Examples of Metal Contributions to Watercourses from Natural Causes and Human Activities

	Natural	**Aggregate**	**Urban**	**Agricultural**
Direct	NA	NA	Discharge of wastewater or stormwater with elevated metals (i.e., from industrial inputs); Landfills	Application of metals, such as calcium, potassium, magnesium, sodium or other minerals/trace metals for crop nutrients or soil amendments
Indirect	Naturally high deposits of metals can increase soil, groundwater, and surface water concentrations of the given metal	Exposure of geologic formations to oxygen, which can release metals that would other-wise be 'locked' into the rock	Increased flows eroding bed and bank soils with naturally high metal content	Where cover crops are not used, erosion of clay soils with naturally high metal content

Table 2.7.4 Summary Statistics of Metals Parameters of Concern for the West Credit River at Winston Churchill Blvd

	Aluminum (ug/L)	**Copper (ug/L)**	**Iron (ug/L)**	**Zinc (ug/L)**
Time Period	1996-2008	1996-2008	1996-2008	1996-2008
Guideline	75	5	300	20
No. of Samples	127	127	127	127
Average	22.2	0.6	51.4	1.8
50th Percentile	15.9	0.5	38.8	1.6
75th Percentile	23.4	0.72	59.4	2.1
Exceedance (%)	3.9	0.0	0.8	0.0

Trend analysis did not demonstrate any consistent pattern between the metal species. Aluminum demonstrated a significant downward trend while copper exhibited a significant upward trend both at 95% level of confidence. Iron and zinc did not express significant trends over the period of 1996-2008 at the 95% or 90% confidence level.

2.7.3.5 Microbiological Parameters - Escherichia Coli

Although bacteria levels are typically more of a concern for the health of humans than fisheries, high bacteria levels can be indicative of an impaired watercourse. Livestock, wildlife, pets, and septic systems are the main sources of bacteria in the SSMP study area. Levels of ***Escherichia Coli*** (*E. coli)* are used as a surrogate indicator for the presence of pathogenic bacteria and nitrogenous waste that impair human uses of the water. The PWQO for *E. coli* is set for the safety of recreational uses, such as swimming and other water sports, and is therefore not necessarily an appropriate objective for fisheries health. However, since the previously mentioned sources of elevated bacteria levels can also contribute excessive nutrients and oxygen demanding materials, *E. coli* can still be considered a secondary indicator for fisheries health. In addition, the PWQO is meant to be compared to the geometric mean of five samples taken simultaneously. Geometric means (or geomeans) are used to measure 'average' bacteria values since this bacterial growth occurs at a logarithmic scale. For this analysis, long-term geometric mean results are compared to the PWQO for comparison of bacterial levels between stations. In general, the geometric mean value for *E. coli* at the Winston Churchill Blvd. station is below the PWQO of 100 counts/100 mL. However 27% of samples that exceeded the PWQO are assumed to have been associated with precipitation and urban runoff (**Figure 2.7.17**). Trend analysis does not indicate a significant trend over the study period. This is mostl likely due to the large range and variation in results.

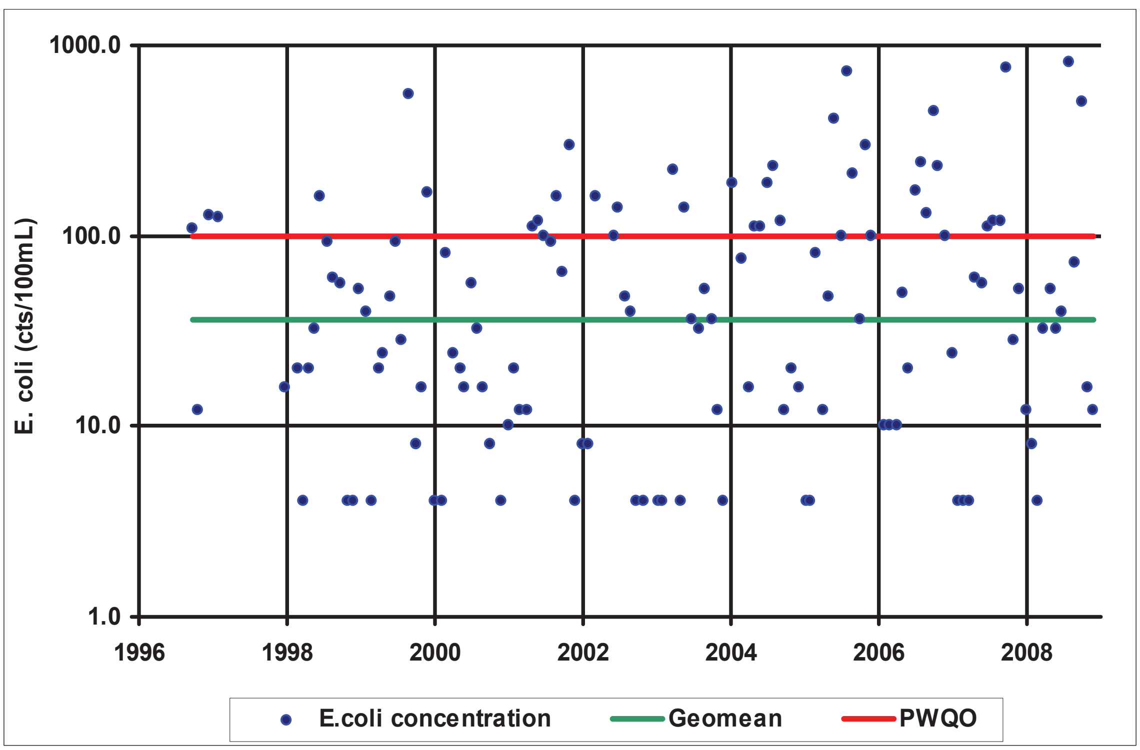


Figure 2.7.17 *E. coli* Concentrations (logarithmic scale) for the West Credit River at Winston Churchill Blvd. from 1996-2008 (PWQO = 100 cts/100mL)

There is a strong seasonal distribution to the bacteria results as higher temperatures in the summer months present ideal conditions for bacterial growth. **Figure 2.7.18** portrays the elevated bacteria concentrations found in the summer months at the West Credit River at Winston Churchill Blvd. station with exceedances to the PWQO occurring in June, July and September. It could be associated with increased biological activity from such sources as waterfowl, domestic animals, and livestock occurring in and around watercourses.

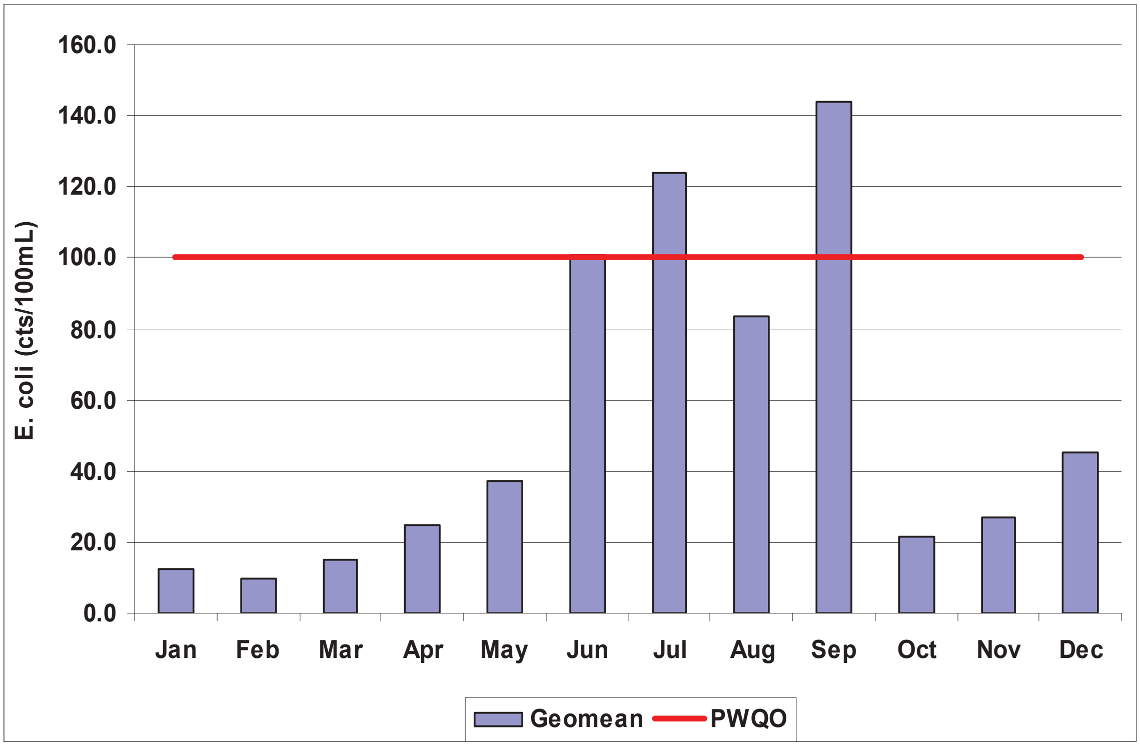


Figure 2.7.18 Monthly Geomean Values of *E. coli* Concentrations for the West Credit River at Winston Churchill Blvd. from 1996-2008 (PWQO = 100 cts/100 mL)

E. coli data collected through the SSMP fieldwork in 2007-2008 revealed slight differences between concentrations at the eleven stations distributed throughout the study area (**Figure 2.7.19**). Elevated concentrations were found in the urban Villages of Erin and Hillsburgh which is possibly associated with urban runoff, pet and wildlife feces, and effluent from septic systems. The relative rural station, East Branch downstream Wellington Rd 124 (15-20-03), recorded the highest concentrations in the study area. Specific sources are not able to be isolated in this study but waterfowl, septic effluent, and agricultural fertilizing practices are possible sources of bacterial contamination.

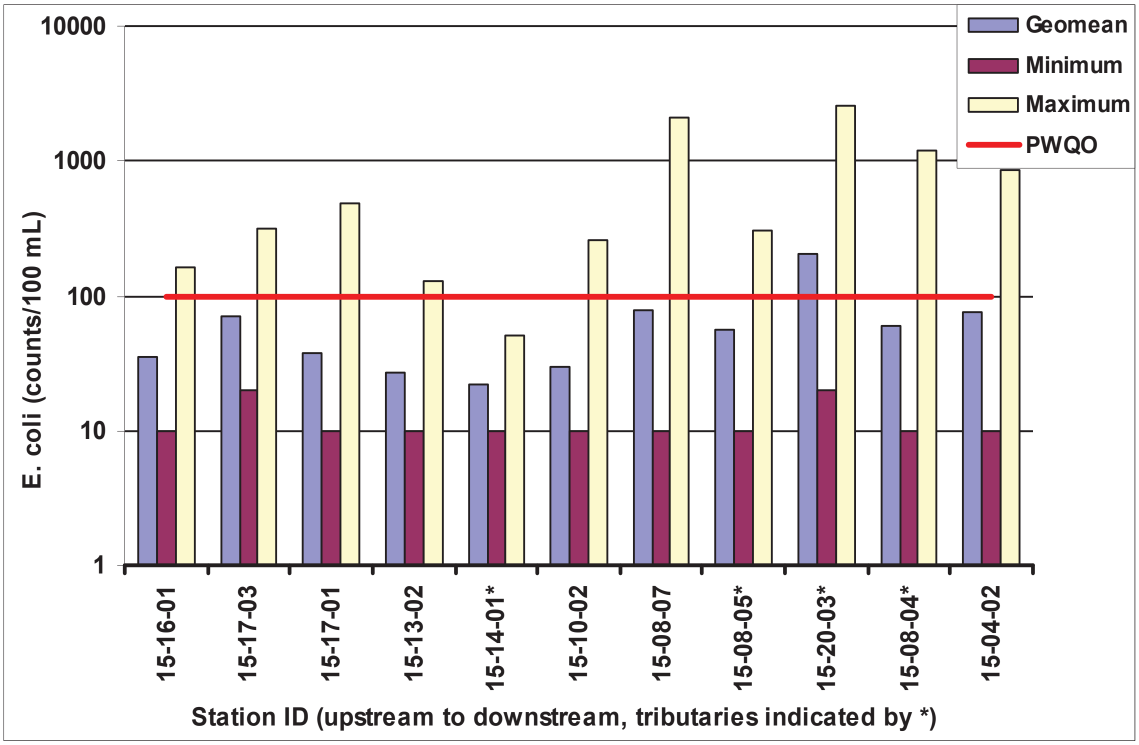


Figure 2.7.19 *E.coli* Concentrations on Logarithmic Scale for the SSMP Study Stations from 2007-2008 (PWQO = 100 cts/100 ml)

2.7.3.6 Summary of Short Term Results

Water Quality Index

A water quality index provides a convenient method of mathematically summarizing complex arrays of multivariate water quality data into simple water quality descriptors that facilitates easy communication of the water's status to general audiences.

While numerous water quality indexing systems are in use throughout Canada and the United States, none provide the power and versatility seen in the Canadian Council of Ministers of the Environment, Water Quality Index (CCME WQI). The CCME WQI is based on 3 analytical factors that compare water quality data with their associated provincial or federal objectives or guidelines for each parameter:

1. The number of variables whose objectives are not met (Scope – F_1);
2. The frequency with which the objectives are not met (Frequency – F_2); and
3. The amount by which the objectives are not met (Amplitude – F_3).

During the development of the CVC Water Quality Strategy a list of chemical and physical "Parameters of Concern" were identified. Those parameters provide the most relevant information pertaining to surface water quality changes relative to land use practices throughout the watershed. Since some of the identified parameters do not have provincial or federal "Objectives" they are not included in the index calculations (**Table**

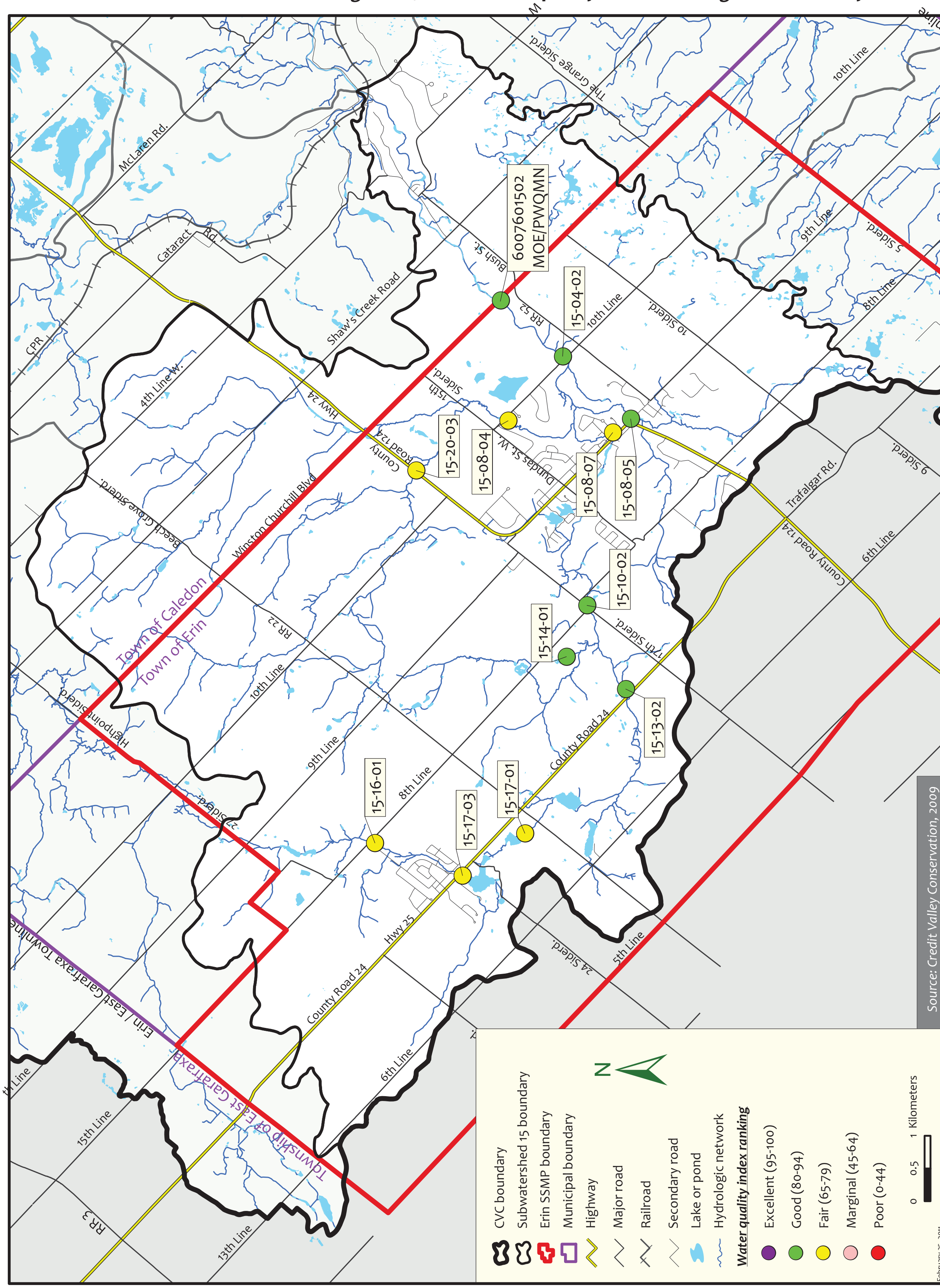
2.7.1). Parameters included in the water quality index include: total phosphorus, nitrate-nitrogen, TKN, un-ionized ammonia, zinc, copper, chloride, TSS, and *E.coli*. Indexing at least 6 parameters per site is recommended by CCME. The WQI analysis is based on a two year record of data collected from fall of 2007 to fall of 2008.

Results

The WQI generates a score between 0 and 100, whereby a score of zero indicates poor water quality and 100 indicates ideal water quality. Results from the analysis of the WQI rank the eleven stations in the study area from Good to Fair (**Figure 2.7.20**). The average WQI for all stations were calculated to be 79.3.

Overall, the water quality in the upper portion of the study area is fair in terms of impact to the health of aquatic biota. Elevated levels of bacteria, total phosphorus, and nitrate-nitrogen resulted in the lowered rankings. In the mid-portions of the study area the water quality ranking improved as downstream stations with significant groundwater discharge adds higher flows, which increases the streams ability to assimilate contaminants. In the Village centers of Hillsburgh and Erin, the influence of roads, septic systems, and urban land use with higher population density is apparent because median concentrations of total phosphorus, bacteria, and nitrate are higher than in rural areas. The western Binkham tributary (150804) and the East Branch of the West Credit River (152003) ranked fair due to elevated levels of bacteria and total phosphorus associated with wet events.

Figure 2.7.20 Water Quality Index Ranking at SSMP Study Stations



2.7.4 Water Temperature

Water temperature is one of the most critical water quality parameters for the health of fisheries and can determine what species of fish can survive and thrive in a watercourse. Higher water temperatures are also associated with lower dissolved oxygen concentrations. Routine sampling that occurs during normal working hours typically misses the critical period when the water is likely to be at its warmest (between 4 pm and 6 pm).

Continuous monitoring of water temperature took place in the 2008 field season at 12 monitoring sites throughout the West Credit River subwatershed. Water temperatures were recorded every half-hour using HOBO Water Temp Pro Version 2 loggers. As temperatures are typically at their highest from June through September, the analysis of data is based on recorded temperature during this time frame.

All West Credit River sites are managed as coldwater fisheries habitat according to the Credit River Fisheries Management Plan (OMNR and CVC 2002). Not all tributaries in the study area have been classified, although those that have been are also managed as coldwater fisheries habitat. More recent data and current mapping show areas associated with online ponds that may affect the thermal regime of particular reaches (CVC et al. 2008). This data suggests that reaches upstream (and slightly downstream) of County Road 24 and upstream of 9th Line in Erin Village show characteristics of cool water and warmwater fish community zones (CVC et al. 2008). Two targets are recommended for water temperature in coldwater habitat: the average daily summer maximum (20 °C), and the overall summer maximum temperature (26 °C). The average daily summer maximum and the overall summer maximum temperatures, as well as, the percent exceedances over the 26 °C overall target is presented in **Table 2.7.5**.

The West Credit River downstream of the head pond; West Credit River downstream of 9th Line in Erin Village; and West Credit River downstream of County Road 24 exceeded both the overall target temperature of 26 °C and the average daily maximum target temperature of 20 °C (**Figure 2.7.21**). The West Credit River downstream of the 9th Line station in Erin Village had the greatest proportion of exceedances beyond the overall target temperature of 26 °C. All other monitoring locations exhibit temperature regimes that are consistent with coldwater fisheries habitat. It should be noted that 2008 was a particularly wet and cool summer, which could possibly have affected marginal sites. The tributary downstream of 10th Line, north of the West Credit River, approached both target temperatures with an average daily max of 19.2 °C and a seasonal max of 25.6 °C. It is possible that during a warmer summer, this site would have exceeded the recommended guidelines. Most other sites were well below the target temperatures, with 4 sites not exceeding an average daily max of 16.9 °C. The West Credit River upstream of Winston Churchill Blvd. is the location furthest downstream and it did not exceed 21.7 °C. The ability of this and other sites to maintain low water temperatures during the summer months suggest substantial groundwater input into these channels.

Several anthropogenic factors may play a key role in affecting water temperature within the study area. In particular, the presence of numerous online ponds in the Villages of Erin and Hillsburgh are likely to have the greatest affect on downstream water temperatures. **Figure 2.6.6** illustrates the series of ponds upstream of 9th Line (Church St. pond, Charles St. pond, and Stanely Park ponds) which would contribute to the large number of exceedances recorded immediately downstream of 9th Line. The station located on the West Credit River downstream of the head pond in Hillsburgh (15-17-01) is another monitoring location directly downstream of a pond and it also exceeded both target temperatures. Recent fisheries data suggests that the West Credit River location downstream of County Road 24 (15-13-02) is located within cool water fisheries habitat, which would suggest the results for that location may be considered acceptable (CVC at al. 2008). Other factors influencing water temperature within the SSMP study area may include: the presence of dams, wetlands, increased impervious surfaces, and reduced riparian cover in urban areas.

Table 2.7.5 Average Daily Maximum Temperature, Overall Summer Maximum Temperature, and Percent Exceedances over 26 °C in 2008

Station ID	Site Name	Average Daily Max (Target: 20 ºC)	Seasonal Max (Target: 26 ºC)	Percent Exceedance over 26 ºC
15-16-01	West Credit upstream Hillsburgh, downstream 8th Line	16.0	19.1	0.00%
15-17-03	West Credit downstream Hwy 25, Hillsburgh	16.1	19.6	0.00%
15-17-01	West Credit downstream head pond	21.2	26.8	0.31%
15-13-02	West Credit downstream County Rd 24	18.3	22.8	0.00%
15-14-01*	West Credit Trib at Caledon Rail Trail, upstream 8th Line	19.4	24.6	0.00%
15-10-02	West Credit at 8th Line Gauge	16.9	21.7	0.00%
15-08-07	West Credit downstream Main St., Erin Village	22.0	28.3	2.24%
15-08-05*	South Trib downstream Main St., Erin Village	19.2	25.6	0.00%
15-20-03*	East Branch downstream Wellington Rd 124	18.5	23.8	0.00%
15-08-04*	East Branch downstream 10th Line / North of West Credit River	21.0	26.5	0.24%
15-04-02	West Credit downstream 10th Line	16.7	20.4	0.00%
06007601502	West Credit at Winston Churchill Blvd.	17.8	21.7	0.00%

Note:
Grey shaded cells indicate a violation over the target temperatures for managed coldwater fisheries habitat.

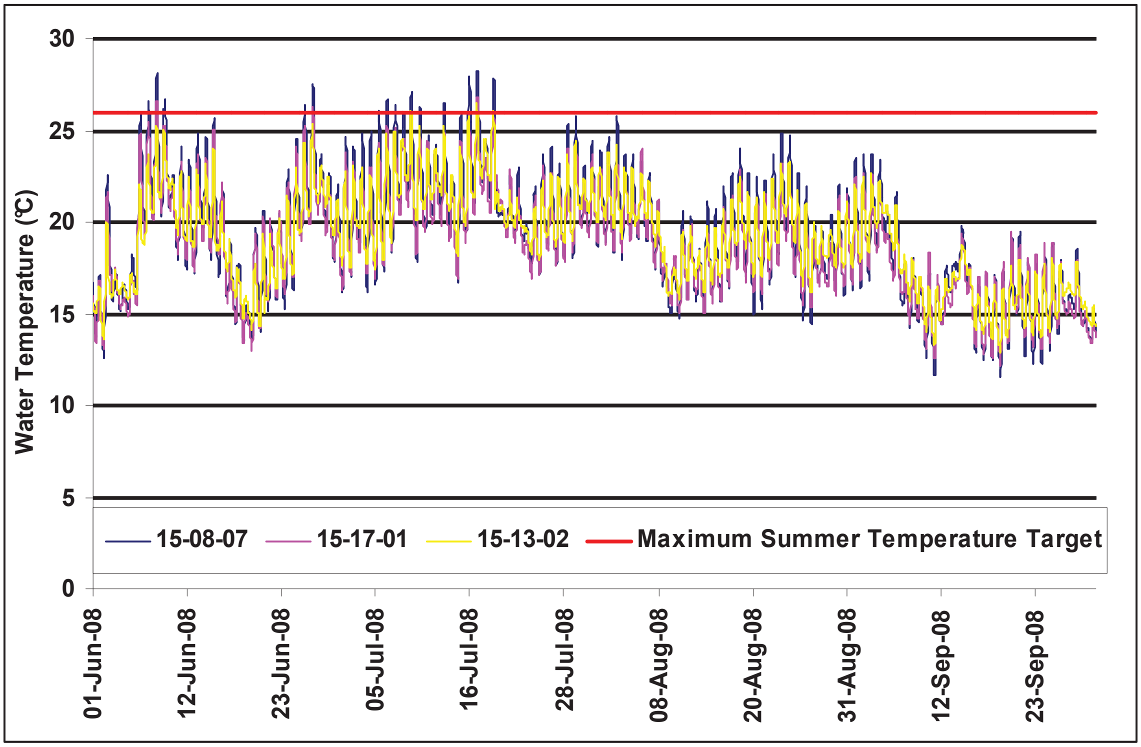


Figure 2.7.21 Water Temperatures at the West Credit River Stations with Water Temperatures Exceeding Guidelines, Summer 2008

2.7.5 Sediment Chemistry

Sediment chemistry monitoring was conducted in the 2008 field season at eleven sites in conjunction with the water chemistry and water temperature stations (**Table 2.7.2**). Sediment chemistry analysis allows a deeper look into the historical chemical compounds utilization, their mobility and ability to bioaccumulate. Bioaccumulation occurs in the sediments which are consumed by benthic macroinvertebrates. These benthic invertebrates are then consumed by larger predators such as fish that are then consumed by carnivorous animals and humans. Bioaccumulation occurs with metals, polychlorinated biphenyls (PCBs), phenanthrene (PAHs), and organo-chlorides (OC), all of which were analyzed for within this study. The complete dataset for all sediment parameters is presented in the Water Quality and Sediment Chemistry Appendix. These results are compared against the 4 standards described below:

- **Federal Probable Effect Level (PEL)** - level above which adverse effects are expected to occur frequently (CCME 1999);
- **Federal Threshold Effect Level (TEL)** – concentration below which adverse biological effects are expected to occur rarely (CCME 1999);
- **Provincial Severe Effect Level (SEL)** – level in sediments that could potentially eliminate most of the benthic organisms (MOE 1993); and

- **Provincial Lowest Effect Level (LEL)** – level at which actually eco-toxic effects become apparent. It is derived using field based data on the co-occurrence of sediment concentrations and benthic species (MOE 1993).

PCBs were commonly used as ballast in electrical equipment such as transformers and capacitors due to their chemical stability. Although the use of PCBs has been severely restricted in North America over the last two decades, the main sources to aquatic environments continue to be leaks, spills, municipal and industrial effluents, runoff from contaminated soils, leachates from unsecured landfills, and atmosphere deposition (WHO 1992). Like many other organochlorine compounds, PCBs are persistent, bioaccumulative and toxic. Once released into the environment PCBs tend to change composition and bind to sediments. The majority of PCBs that are introduced into the aquatic environment are eventually incorporated into bed sediments (Baker et al. 1985). Therefore, sediment represents an important exposure route for aquatic biota to PCBs. They are the cause of the majority of the fish consumption advisories in each of the Great Lakes and are considered a priority pollutant by many authorities. Total PCB were analyzed at all 11 stations in the Erin SSMP study area but were not detected above laboratory detection limits at any of the stations.

Polycyclic aromatic hydrocarbons are produced during the incomplete combustion of organic substances, most commonly the combustion of fossil fuels. As an indicator of human industrial activities, PAH contamination is relatively widespread throughout the Great Lake Basin. This study included an analysis of 16 different PAH chemicals listed in **Table 2.7.6**. Several stations recorded repeated exceedances for PAH chemical including stations located within and downstream of Erin Village. Exact sources of the PAHs are difficult to determine as they persist and accumulate in the sediment over long time periods.

The study also tested for a broad range of organochlorines including DDT and metabolites, and other common pesticides (dieldrin, chlordane, endosulfate, lindane, and mirex). These chemicals were all utilized for their pesticide properties, ranging from a broad spectrum pesticide to specific target receptors. Concentrations of organochlorine pesticides were found to be below laboratory reportable detection limits for all stations.

Total metal concentrations for a suite of commonly analyzed metals were analyzed in the sediment samples. Elevated total metal levels may be from domestic and/or industrial wastewater, landfill leachate, erosional processes, and both rural and urban runoff. Iron and aluminum are typically found in clay soils and can be present in other geologic formations. Leaching minerals from rock and both the natural and anthropogenic erosion of clay soils can increase aluminum and iron concentrations in the local watercourse. Elevated levels of cadmium, copper, manganese, and zinc were detected and exceeded either guideline of the Lowest / Probable Effect Levels (LEL or PEL).

Table 2.7.6 Polycyclic Aromatic Hydrocarbons (PAHs) Occurrence in Sediments (2008)

Parameter	Total Detected Number	Federal Guidelines				Provincial Guidelines		Percent of Violat-ion	Max Observed Concent-ration (ug/g)	Location of Exceeda-nces
		TEL (ug/g)	Excee-dance Number	PEL (ug/g)	Excee-dance Number	LEL (ug/g)	Excee-dance Number			
Acenaphthe-ne	0	0.00671	NA*	0.0889	NA		NA	NA	NA	NA
Acenaphthy-lene	0	0.00587	NA*	0.128	0		NA	NA	NA	NA
Anthracene	0	0.0469	NA	0.245	0	0.22	NA	NA	NA	NA
Benzo(a)ant-hracene	2	0.0317	2*	0.385	0	0.32	0	NA*	0.04	151401, 150402
Benzo(a)pyr-ene	5	0.0319	5*	0.782	0	0.37	0	NA*	0.05	151401, 150807, 150804, 150402
Benzo(g,h,i) perylene	0		NA		NA	0.17	0*	NA*	NA	NA
Benzo(k) fluoranthene	0		NA		NA	0.24	0	0	NA	NA
Chrysene	2	0.0571	0*	0.862	0	0.34	0	NA*	0.05	150402
Dibenz(a,h) anthracene	0	0.00622	NA*	0.135	NA	0.06	NA	NA	NA	NA
Fluoranthene	6	0.111	2	2.355	0	0.75	0	18.2	0.12	150807, 150402
Fluorene	0	0.0212	0*	0.144	0	0.19	0	NA*	NA	NA
Indeno (1,2,3-cd) pyrene	0		NA		NA	0.2	0*	NA*	NA	NA
Naphthalene	0	0.0346	NA*	0.391	NA		NA	NA*	NA	NA
Phenanthre-ne	2	0.0419	2*	0.515	0	0.56	0	NA*	0.05	150807, 150402
Pyrene	6	0.053	4*	0.875	0	0.49	0	NA*	0.09	150807
Total	23									

Note:
** Indicates that Guidelines are below the Laboratory Reportable Detection Limit.*

Inorganic species such as Total Organic Carbon, Total Ammonia-N, and Total Kjeldahl Nitrogen (TKN) were also analyzed for sediment quality in this study. TKN concentrations exceeded Severe Effect Level guidelines at 9 sites in the study area with the West Credit River station upstream of Hillsburgh and downstream of 8th Line (15-16-01) measuring more than twice the limit. Specific sources of the organic nitrogen would have to investigate further in the septic impact study.

2.7.6 Water and Sediment Chemistry Characterization

Overall, the water quality in the SSMP study area is good in terms of supporting healthy aquatic biota. In general, the tributaries that flow into the West Credit River are fair. These smaller tributaries have a lower population density and fewer roads and it would be expected that this area would be subject to lower loads of stormwater runoff but they also have less flow of assimilate contaminant inputs. In the Village centers of Hillsburgh and Erin, the influence of roads, septic systems, and urban land use with higher population density is apparent with median concentrations of the total phosphorus, bacteria, and nitrate higher than in rural areas. The following points summarize the water and sediment chemistry results of this section:

1. The long-term monitoring data indicates that the West Credit River is not considered a Policy 2 watercourse with respect to **total phosphorus**, as concentrations were determined to be below the PWQO set by MOE. Although certain SSMP study sites showed elevated levels during wet events indicating urban stormwater sources.

2. Seasonal distribution analysis for **nitrate-nitrogen** for the PWQMN long term data demonstrated elevated nitrate levels which approached CCME guideline during the winter months of January and February. This may be a result of the seasonal absence of aquatic plants and bacteria that can utilize the nutrient as a food source.

   Nitrate-nitrogen data from the 2007-2008 field season revealed that the nitrate levels are elevated in the vicinity of Hillsburgh. A specific study would need to be conducted to determine and isolate possible sources. Station 15-14-01 (West Credit Trib. at Caledon Rail Trail upstream of 8th Line) is located in a rural catchment and has a median concentration more than twice the guideline, which is likely due to agricultural practices.

3. The **dissolved oxygen regime** is relatively healthy in the West Credit River study area. There were no measured exceedances of the dissolved oxygen guideline. The greatest daily fluctuations were noticed at station 15-17-01, below the head pond in Hillsburgh, as the dissolved oxygen regime at this location is heavily influenced by the upstream pond's plant growth and respiration and reparation from the upstream waterfall.

4. Several anthropogenic factors may play a key role in affecting **water temperature** within the study area. In particular, the presence of numerous online ponds in the Villages of Erin and Hillsburgh are likely to have the greatest affect on downstream water temperatures. There are a series of ponds upstream of 9th Line (Church St. pond, Charles St. pond and Stanley Park ponds) which would contribute to the large number of exceedances recorded immediately downstream of 9th Line. Station 15-17-01, the West Credit River downstream of the head pond in Hillsburgh, is another monitoring location directly downstream of a pond and it also exceeded both target temperatures. The coolest water temperatures occurred in the upper portion of the subwatershed and in the groundwater fed tributaries.

5. Median **chloride** levels were below concentrations thought to be deleterious to aquatic life and no exceedance of the objective was recorded in the long-term data. Chloride concentrations taken for the SSMP study indicate similar levels of chloride when compared to the long term results as all stations recorded levels

well below guideline levels. Slightly elevated concentrations are found in the smaller urban tributaries with less ability to dilute road salting impacts when compared to the West Credit River main branch.

6. Bacterial levels from the long term data set indicate that just over a quarter of ***E. coli*** concentrations exceeded guidelines for recreational uses, which are most likely associated with rain events. Possible sources of the elevated levels include upstream agricultural sources, urban runoff, and from human sources (septic impacts). There is a strong seasonal distribution to the bacteria results with high concentrations associated with higher temperatures in the summer months which present ideal conditions for bacterial growth. The short term data set demonstrated elevated concentrations in the vicinity of the urban Villages of Erin and Hillsburgh. The higher concentrations were usually associated with rain events where stormwater runoff is possibly associated with urban runoff, pet and wildlife feces, and effluent from septic systems.
7. **Suspended solids** concentrations at the longer term West Credit River station at Winston Churchill Blvd. exhibited values below levels thought to be deleterious to aquatic life with occasional spikes. Suspended solids concentrations were highly variable at the short term stations over the study period. There was not sufficient information to accurately characterize suspended solids levels at the short term stations.
8. Pollution from **metals** is not considered to be a significant concern for most of the study area as a very low number of violations were observed for metals as compared to their respective PWQOs. Copper may be of particular concern under future conditions since it can be highly toxic to aquatic biota and was found to be at levels close to its PWQO and is demonstrating a significant increasing trend.
9. **Sediment chemistry** results generally indicated a healthy aquatic environment with minimal point source impacts. There was no indication of heavy metals or PCB accumulation in the study area. PAHs were found at multiple sites and exceeded guidelines for multiple species at stations located within and downstream of Erin Village. Exact sources of the PAHs are difficult to determine as they persist and accumulate in the sediment over long time periods.
10. The results of the **Water Quality Index** summarized the short term Erin SSMP stations measured in 2007-2008. Water quality was ranked from fair to good across the study area.

2.7.7 Next Steps

Now that the background and existing conditions data has been gathered and reviewed, the next step is to complete the impact assessment. The steps required to fulfill this task are as follows:

- use population numbers, effluent criteria, 7Q20, and background water quality data (i.e., 75th percentile) to conduct mass balance calculations for the West Credit River;

- if required, use the Dissolved Oxygen/Plant Growth Model to predict the impacts of effluent and other contaminants in municipal wastewater on the West Credit River;
- analyze surface water quality data in conjunction with Septic Impact Study information to isolate possible sources of contamination; and
- consider modelling the pond impacts on water temperature.

2.8 SEPTIC SYSTEM IMPACT ASSESSMENT

2.8.1 Introduction

The Town of Erin relies almost exclusively on private septic systems. A septic system is a small waste water treatment system designed to treat water from single homes or buildings. These systems were originally designed for houses widely separated from their nearest neighbour or where there are too few people to warrant a communal wastewater treatment system. Approximately 25% of Canadians are served by septic systems (Chambers et al. 2001). Concerns have been raised in the past by CVC (see Section 2.7) regarding the potential impact of septic system effluent discharging to the West Credit River through groundwater and/or surface water pathways.

There are a number of known contaminants and potential contaminants generated from waste water effluent passing through septic systems. It is difficult to assess the water quality impact from septic systems in a setting such as the Town of Erin, given the difficulty in isolating septic system impacts from other broader sources of contamination such as agriculture and urbanization. This is due to the proximity and overlapping nature of a number of contaminant sources and the complexity of the local groundwater flow system, as previously discussed in Section 2.1.

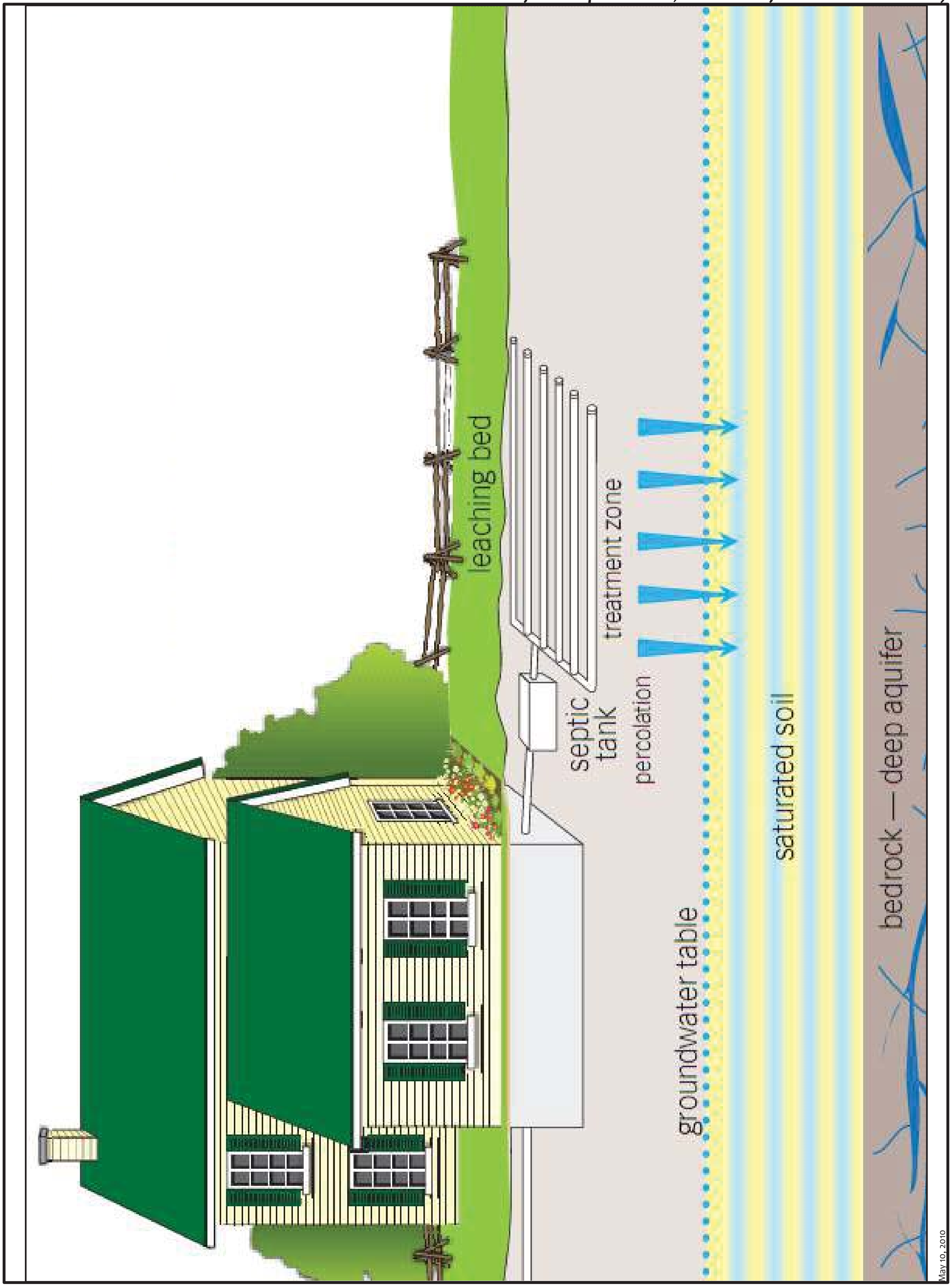
This section provides an overview of septic systems and water quality issues associated with septic systems and attempts to assess the potential impact of septic system effluent on the West Credit River, in the context of the Erin SSMP.

2.8.2 Overview of Septic Systems and Potential Septic System Impacts on Water Quality

2.8.2.1 Septic Systems

A typical septic system in Ontario consists of a holding tank connected to a series of pipes located in trenches (**Figure 2.8.1a**). In Ontario this is known as a Class IV leaching bed system under the Ontario Building Code. The piping area, where the septic effluent is dispersed, is typically called a field bed or septic drain field. The sizing of the holding tank and field bed is based on the local geologic properties under the field bed and how much water will be used for a specific household or building, using criteria such as the number of bedrooms, bathrooms etc., or the number of employees at business. There are

Figure 2.8.1a Schematic View of a Septic System (Adapted from Septic Smart, Province of Ontario Publication)



very specific design criteria for septic systems, which are regulated under the Ontario Building Code.

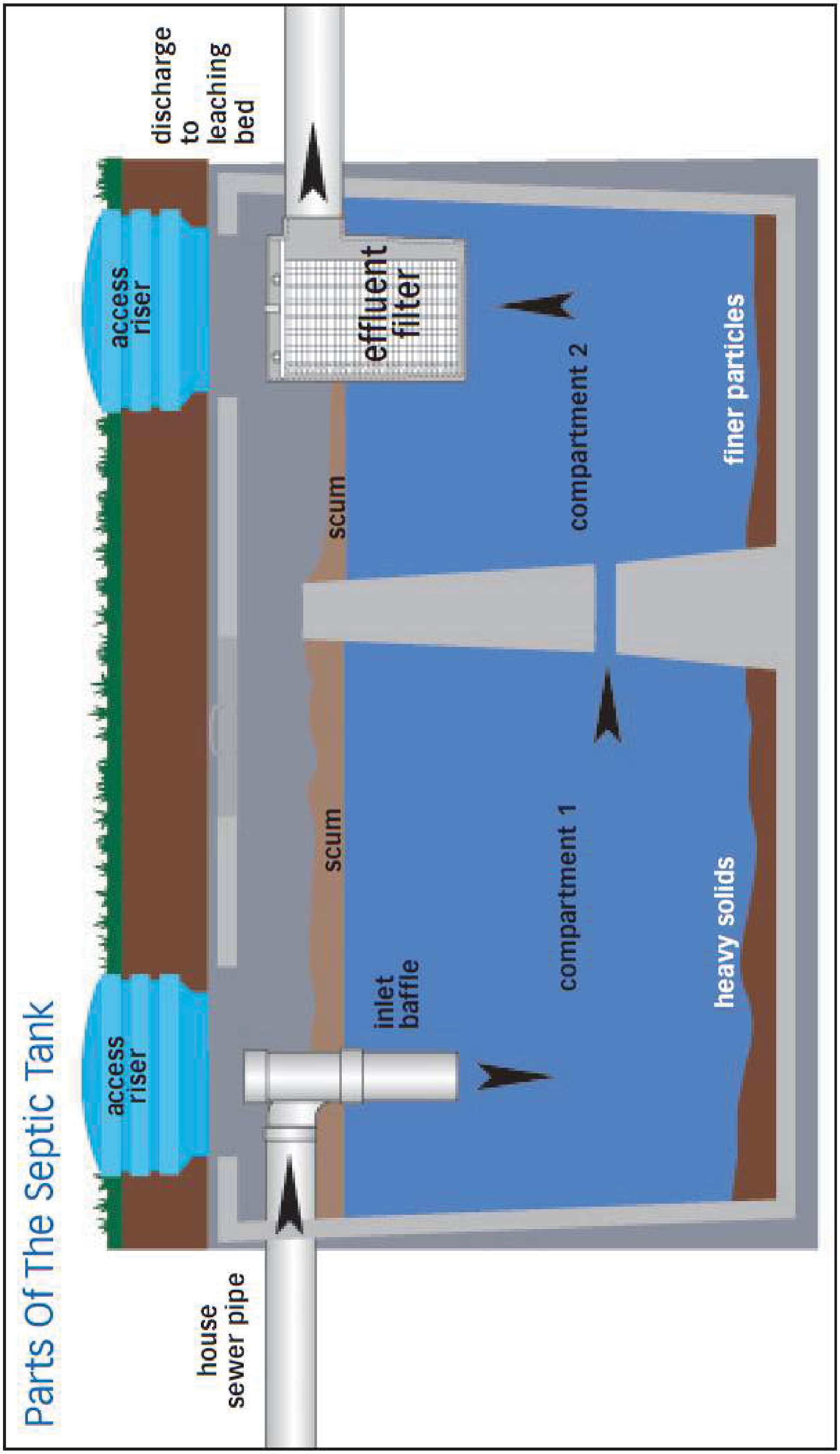
Wastewater flows from various plumbing fixtures in a household to a single pipe that discharges to the holding tank. Heavier solids and sludge collect on the bottom of the tank (**Figure 2.8.1b**) while grease and other light material float on top to create a scum layer on top of the water (USEPA 2002). These layers remain in the tank and are eventually broken down by micro-organisms in a properly functioning tank. The wastewater or septic effluent is eventually "clarified" and flows, typically by gravity drainage to the drainage tile or field bed. The effluent is evenly dispersed through these perforated drainage pipes (**Figure 2.8.1a**).

A "biomat" forms at the bottom of the percolation trenches in a properly functioning field bed. It is made up of living anaerobic organisms, which feed on organic matter in the septic effluent. As the biomat matures, it thickens and slows the migration of the septic effluent through it. As the effluent passes through a properly functioning biomat pathogenic organisms and viruses are removed.

After treatment and percolation of wastewater through the biomat, the wastewater migrates downward through the unsaturated zone until reaching the water table. Further chemical and biological processes occur in the unsaturated zone. The treated wastewater will mix with the groundwater at the water table and create a "plume" of impacted groundwater. This water will migrate with the general groundwater flow system. The amount of mixing and dilution will depend on site-specific groundwater flow conditions (e.g. hydraulic gradients, local recharge conditions). **Figure 2.8.2a** shows a schematic of a contaminant plume migrating with the groundwater flow system towards a local stream. **Figure 2.8.2b** shows a schematic of a series of septic system plumes recharging the groundwater and migrating along the groundwater flow system towards a local stream. If there are a sufficient number of septic systems in a small area there may be mixing of these plumes, resulting in less potential for dilution of the septic plumes within the groundwater system.

The degree to which nutrients and other constituents are retained in a septic field bed area will depend on a number of factors including, but not limited to: underlying soil characteristics such as adsorption capacity, permeability of the soils, natural drainage conditions, and the age of the field bed (Chambers et al. 2001). Nitrate, phosphorus, and pathogens are present in significant concentrations in most septic system wastewater. Some metals, organic compounds, and other contaminants are also present in lower levels depending on what is in the wastewater entering the septic tank. Most contaminants can be removed to substantially lower concentrations in a properly functioning septic system. Effluent quality is discussed in more detail in the next section.

Figure 2.8.1b Schematic of how a Septic Tank Functions (Adapted from Septic Smart, Province of Ontario Publication)



May 10, 2010

Figure 2.8.2a Schematic Migration of a Septic Plume in Groundwater (Adapted from Alley et al, 1999)

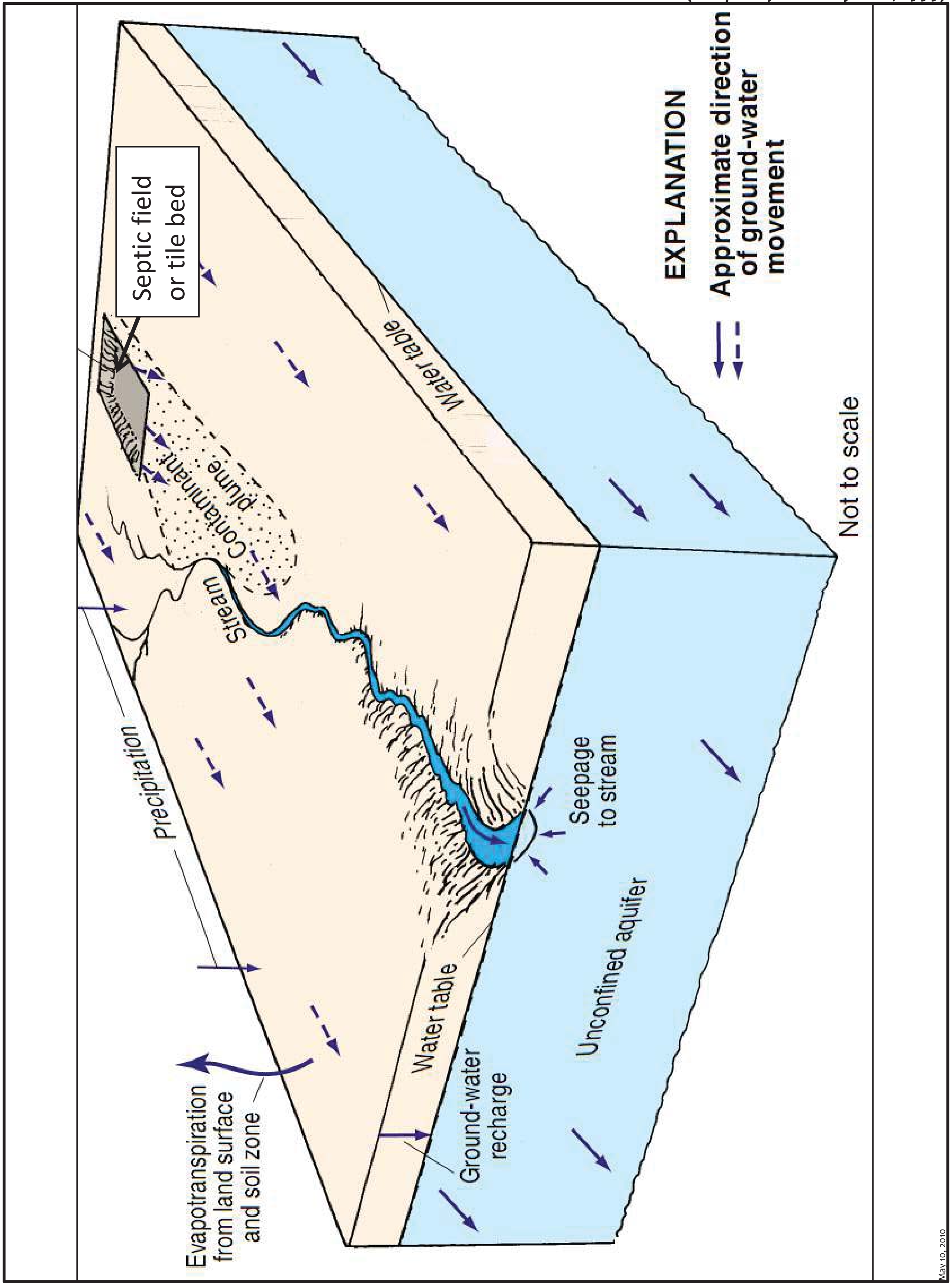
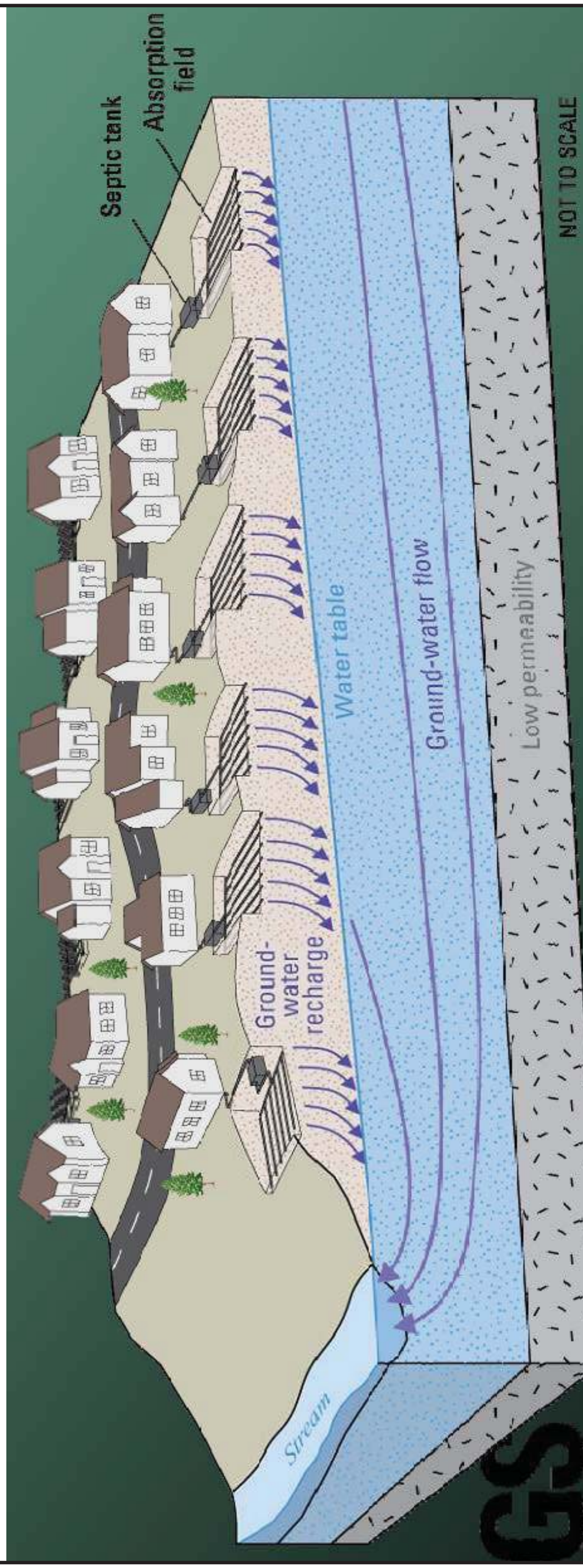


Figure 2.8.2b Schematic Migration of Multiple Septic Plumes in Groundwater (Adapted from USGS, 2008)



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2.8.2.2 Septic Effluent and Impacts on Water Quality

As indicated in the previous section, a number of contaminants are generated in the wastewater stream going into a septic system. Contaminants of varying concentrations are discharged to the environment after treatment within the septic system. **Table 2.8.1**, from "Onsite Wastewater Treatment Systems Manual" (USEPA 2002), shows a general list of pollutants generated from wastewater in septic systems and the reason for concern for each contaminant. The most prevalent contaminants of concern, with respect to groundwater contamination and potential loading to surface water, are nutrients (nitrogen and phosphorus), pathogens, and dissolved inorganic constituents, such as chloride and sodium. Heavy metals and organic compounds may also be a concern, depending on the concentrations present within site-specific septic effluent.

Table 2.8.1 Typical Wastewater Pollutants of Concern (from USEPA 2002)

Pollutant	Reason for concern
Total suspended solids (TSS) and turbidity (NTU)	In surface waters, suspended solids can result in the development of sludge deposits that smother benthic macroinvertebrates and fish eggs and can contribute to benthic enrichment, toxicity, and sediment oxygen demand. Excessive turbidity (colloidal solids that interfere with light penetration) can block sunlight, harm aquatic life (e.g., by blocking sunlight needed by plants), and lower the ability of aquatic plants to increase dissolved oxygen in the water column. In drinking water, turbidity is aesthetically displeasing and interferes with disinfection.
Biodegradable organics (BOD)	Biological stabilization of organics in the water column can deplete dissolved oxygen in surface waters, creating anoxic conditions harmful to aquatic life. Oxygen-reducing conditions can also result in taste and odor problems in drinking water.
Pathogens	Parasites, bacteria, and viruses can cause communicable diseases through direct/indirect body contact or ingestion of contaminated water or shellfish. A particular threat occurs when partially treated sewage pools on ground surfaces or migrates to recreational waters. Transport distances of some pathogens (e.g., viruses and bacteria) in ground water or surface waters can be significant.
Nitrogen	Nitrogen is an aquatic plant nutrient that can contribute to eutrophication and dissolved oxygen loss in surface waters, especially in lakes, estuaries, and coastal embayments. Algae and aquatic weeds can contribute trihalomethane (THM) precursors to the water column that may generate carcinogenic THMs in chlorinated drinking water. Excessive nitrate-nitrogen in drinking water can cause methemoglobinemia in infants and pregnancy complications for women. Livestock can also suffer health impacts from drinking water high in nitrogen.
Phosphorus	Phosphorus is an aquatic plant nutrient that can contribute to eutrophication of inland and coastal surface waters and reduction of dissolved oxygen.
Toxic organics	Toxic organic compounds present in household chemicals and cleaning agents can interfere with certain biological processes in alternative OWTSs. They can be persistent in ground water and contaminate downgradient sources of drinking water. They can also cause damage to surface water ecosystems and human health through ingestion of contaminated aquatic organisms (e.g., fish, shellfish).
Heavy metals	Heavy metals like lead and mercury in drinking water can cause human health problems. In the aquatic ecosystem, they can also be toxic to aquatic life and accumulate in fish and shellfish that might be consumed by humans.
Dissolved inorganics	Chloride and sulfide can cause taste and odor problems in drinking water. Boron, sodium, chlorides, sulfate, and other solutes may limit treated wastewater reuse options (e.g., irrigation). Sodium and to a lesser extent potassium can be deleterious to soil structure and SWIS performance.

Source: Adapted in part from Tchobanoglous and Burton, 1991.

Table 2.8.2 shows a range of concentrations and mass loading of various constituents in typical wastewater effluent from residential dwellings, as presented in the USEPA (2002) document, "Onsite Wastewater Treatment Systems Manual". **Table 2.8.3** shows minimum, maximum, and average concentrations of selected water quality parameters in septic tank effluent as reported by Senior and Cinotto (2007), in a US Geological Survey report on the effect of on-site wastewater disposal on the quality of groundwater and baseflow in a watershed in south-eastern Pennsylvania.

Table 2.8.2 Mass Loading and Concentrations in Typical Wastewater Effluent (from USEPA 2002)

Constituent	Mass loading (grams/person/day)	Concentration[b] (mg/L)
Total solids (TS)	115–200	500–880
Volatile solids	65–85	280–375
Total suspended solids (TSS)	35–75	155–330
Volatile suspended solids	25–60	110–265
5-day biochemical oxygen demand (BOD_5)	35–65	155–286
Chemical oxygen demand (COD)	115–150	500–660
Total nitrogen (TN)	6–17	26–75
Ammonia (NH_4)	1–3	4–13
Nitrites and nitrates (NO_2-N; NO_3-N)	<1	<1
Total phosphorus (TP)[c]	1–2	6–12
Fats, oils, and grease	12–18	70–105
Volatile organic compounds (VOC)	0.02–0.07	0.1–0.3
Surfactants	2–4	9–18
Total coliforms (TC)[d]	–	10^8–10^{10}
Fecal coliforms (FC)[d]	–	10^6–10^8

[a] For typical residential dwellings equipped with standard water-using fixtures and appliances.
[b] Milligrams per liter; assumed water use of 60 gallons/person/day (227 liters/person/day).
[c] The detergent industry has lowered the TP concentrations since early literature studies; therefore, Sedlak (1991) was used for TP data.
[d] Concentrations presented in Most Probable Number of organisms per 100 milliliters.

Source: Adapted from Bauer et al., 1979; Bennett and Linstedt, 1975; Laak, 1975, 1986; Sedlak, 1991; Tchobanoglous and Burton, 1991.

Table 2.8.3 Minimum, Maximum, and Average Concentrations of Selected Water Quality Parameters in Septic Tank Effluent, as reported by Senior and Cinotto, USGS Open File Report, 2007-1253.

Constituent or property	Minimum	Maximum	Average	Sources
Nitrate (mg/L as N)	0.1	1	0.1	3,4
Ammonia (mg/L as N)	40	100	70	2
Organic N (mg/L as N)	5	25	15	2
Phosphate (mg/L as P)	--	--	15	1
Chloride (mg/L)	37	200	53	1,2,4
Iron (mg/L)	0	20	2.6	1
pH (pH units)	6.5	7.5	6.9	1,3
Alkalinity	--	--	186	3
Calcium (mg/L)[1]	2	8	5	5
Magnesium (mg/L)[1]	0	2	1.5	5
Sodium (mg/L)[1]	25	50	38	4, 5
Potassium (mg/L)[1]	12	40	26	4, 5
Sulfate (mg/L)[1]	0	36	--	4
Boron (μg/L)	55	13,248	[2]400	6, 7, 8

[1]Constituent concentration adjusted for background concentrations in source water (upgradient ground water).

[2]Median of three studies (for 8 septic systems in Minnesota, median was 616 μg/L; for spray effluent in Chester County site, median was less than 200 μg/L; for raw sewage, adjusted for background, in Israel, median was about 400 μg/L).

[Sources; 1 = Canter and Knox (1985); 2 = Walker and others (1973); 3 = Andreoli and others (1979); 4 = Robertson and others (1991); 5 = Roberston and Blowes (1995); 6 = Minnesota Pollution Control Agency (1999); 7 = Schreffler and others (2005); 8 = Vengosh and others (1994); mg/L milligrams per liter; μg/L, micrograms per liter; N, nitrogen; P, phosphorus; --, not reported]

Tables 2.8.4 and **2.8.5** show examples of site-specific effluent quality and water quality in the unsaturated zone (i.e., the soil zone above the water table) and at the water table, directly under a septic bed. **Table 2.8.4** shows the concentrations of various water quality parameters in a septic tank effluent and the soil water quality in the unsaturated soils at depths of 0.6 m and 1.2 m below the septic bed. The following is noted:

- Total nitrogen, primarily ammonia, is quickly converted into nitrate within the shallow soils under the septic leaching bed.
- There is substantial reduction in total phosphorus, even at 0.6 m below the septic bed.
- There is almost a complete reduction of fecal bacteria within 0.6 m below the septic bed.
- Most total organic carbon (TOC) is removed before reaching a depth of 0.6 m below the septic bed.
- Dilution of chloride concentration is already occurring at 0.6 m below the leaching bed.

Table 2.8.4 Septic Tank Effluent and Underlying Soil Water Quality – Case Study (from USEPA 2002)

Parameter (units)	Statistics	Septic tank effluent quality	Soil water quality [b] at 0.6 meter	Soil water Quality[b] at 1.2 meters
BOD	Mean	93.5	<1	<1
(mg/L)	Range	46–156	<1	<1
	# samples	11	6	6
TOC	Mean	47.4	7.8	8.0
(mg/L)	Range	31–68	3.7–17.0	3.1–25.0
	# samples	11	34	33
TKN	Mean	44.2	0.77	0.77
(mg/L)	Range	19–53	0.40–1.40	0.25–2.10
	# samples	11	35	33
NO_3-N	Mean	0.04	21.6	13.0
(mg/L)	Range	0.01–0.16	1.7–39.0	2.0–29.0
	# samples	11	35	32
TP	Mean	8.6	0.40	0.18
(mg/L)	Range	7.2–17.0	0.01–3.8	0.02–1.80
	# samples	11	35	33
TDS	Mean	497	448	355
(mg/L)	Range	354–610	184–620	200–592
	# samples	11	34	32
Cl	Mean	70	41	29
(mg/L)	Range	37–110	9–65	9–49
	# samples	11	34	31
F. Coli	Mean	4.57	nd [c]	nd
(log # per	Range	3.6–5.4	<1	<1
100 mL)	# samples	11	24	21
F. strep.	Mean	3.60	nd	nd
(log # per	Range	1.9–5.3	<1	<1
100 mL)	# samples	11	23	20

[a] The soil matrix consisted of a fine sand; the wastewater loading rate was 3.1 cm per day over 9 months. TOC = total organic carbon; TKN = total Kjeldahl nitrogen; TDS = total dissolved solids; Cl = chlorides;
F. coli = fecal coliforms; F. strep = fecal streptococci.
[b] Soil water quality measured in pan lysimeters at unsaturated soil depths of 2 feet (0.6 meter) and 4 feet (1.2 meters).
[c] nd = none detected.

Source: Adapted from Anderson et al., 1994.

Table 2.8.5 Septic Tank Effluent, Background Groundwater Quality and Septic Plume Water Quality – Case Study, Cambridge, Ontario (Adapted from Wilhelm 1992)

Constituent	Tap Water (N=1)	Septic-Tank Effluent (N=6)	Water Table Samples[a] (N=8)	Background (N=7)
Sodium	15.6[b]	89.7 (15.6)[c]	91.0 (12.5)	4.4 (1.2)
Potassium	1.9	11.7 (1.9)	10.8 (2.1)	1.3 (0.9)
Calcium	40.0	41.1 (3.2)	92.5 (25.4)	106.6 (25.2)
Magnesium	13.0	14.0 (0.9)	15.1 (5.0)	15.7 (2.1)
DOC	3.0	38.1[d] (29.1)	3.2 (1.4)	2.7 (1.4)
Ammon. N	0.15	32.[e] (5.1)	0.09 (0.06)	<0.05 --
Nitrate N	<0.05	1.3[d] (1.5)	26.7 (9.3)	28.1 (7.1)
Sulphate S	4.7	6.8 (7.1)	20.4 (7.1)	15.4 (5.9)
Phosphate P	0.01	8.9 (3.0)	5.6 (1.5)	<0.01 --
Chloride	2.3	40.0 (15.3)	26.9 (3.4)	20.0 (7.8)
Alkalinity (as $CaCO_3$)	170.	374. (35.0)	279.7 (32.1)	168.4 (40.4)
pH	7.3	7.2	7.1	7.4
DIC[f]	46	102	79	44
$CaCO_3$ (log SI)[f]	-0.40	-0.23	-0.12	0.06

[a]"Water table" samples collected from sampling points in the top 0.5 m of the saturated zone directly below the absorption field.
[b]All concentrations except pH and $CaCO_3$ SI in mg/l.
[c]Standard deviation.
[d]N=4.
[e]N=5.
[f]DIC and $CaCO_3$ SI calculated by PHREEQE.

Table 2.8.5 shows an example of the water quality of septic tank effluent and the water quality at the water table directly under a septic bed, as well as background water quality (i.e., water quality in the shallow groundwater upgradient of the septic tank). The site is located within a predominantly agricultural area near Cambridge, Ontario and has been well-studied for many years (e.g., Robertson and Cherry 1992; Robertson 1995; and Robertson et al. 1998). The following is highlighted from the investigations:

- Ammonia is rapidly converted to nitrate by the time the effluent reached the water table. It is noted that the background nitrate is actually higher than the under the septic bed, reflecting the impact of agricultural activities on the shallow groundwater, upgradient of the groundwater impacted by the septic effluent.
- Chloride concentrations decline somewhat at the water table, indicating some minor dilution from the mixing with the shallow groundwater.
- Sodium concentrations are elevated in the septic effluent and remain elevated at the water table. The high sodium concentrations reflect the use of a water softener. It is noted in the research studies that sodium was one of the key parameters used to assess the migration of the "plume" of septic effluent-impacted groundwater.
- There is a substantial decrease in Dissolved Organic Carbon (DOC) from the septic effluent by the time the effluent reaches the water table.
- Phosphate concentration also decreases slightly by the time the septic effluent reaches the water table.

Once the septic effluent reaches the water table it moves and mixes with the groundwater, forming a contaminant "plume" of effluent-impacted groundwater, as previously shown in **Figures 2.8.2a** and **2.8.2b**. The mobility and attenuation of contaminants within the plume are influenced by various physical, chemical, and biological factors.

Physical factors affecting the movement or attenuation of contaminants in the subsurface include, but are not limited to the following:

- Permeability or hydraulic conductivity – The hydraulic conductivity of the underlying geologic material controls the rate of groundwater movement. The rate of vertical movement of water through the unsaturated soils above the water table is important in attenuating various contaminants, through chemical and biological processes.
- Filtration – Particle size plays an important role in the removal of suspended solids, including bacteria, from septic effluent.
- Mineral composition – The mineral composition, especially of fine-grained particles, and their mineral coating affects both chemical and biological process that occur with the interaction between the septic effluent and the geologic material through which the effluent is moving.

Chemical factors and processes that affect the migration or attenuation of contaminants include, but are not limited to the following:

- Adsorption – Adsorption is a factor in the removal of phosphates, ammonium, organic compounds, bacteria, and viruses. The physical factor of having clay size particles plays an important role in adsorption as does the mineral coating on the clay particles (e.g., iron, aluminum, and hydrous oxides). Adsorption retards the movement of the contaminant.
- Precipitation – Precipitation is the separation of an insoluble product when two solutions are mixed together (e.g., septic effluent and groundwater). Phosphate will precipitate out of the plume depending on the chemical composition of the groundwater and the pH of the soil.

Biological factors and processes that affect the migration of contaminants include, but are not limited to the following:

- Aerobic and anaerobic conditions in the soil zone above the water table (i.e., the unsaturated or vadose zone) – Microbial decomposition of organic matter occurs rapidly in the aerobic zones (zones with oxygen) where micro-organisms in the soil use oxygen to decompose organic matter. Anaerobic zones (zones without oxygen) also form underneath septic beds resulting in a growth in methanogenic bacteria.
- Nitrification and denitrification – The nitrogen content within the septic effluent in the holding tank is typically 70-90% ammonium and 10-30% organic nitrogen. Ammonium is quickly converted to nitrate as the effluent moves through the unsaturated zone through a process of nitrification, which requires oxygen. Denitrification occurs when there is a lack of oxygen and the presence of denitrifying bacteria and a readily available carbon source. Denitrification often occurs where the nitrate rich effluent moves through organic rich soils such as when groundwater discharges to wetlands.

Properly functioning septic systems and soil zones beneath the septic field beds will effectively treat or remove most chemical constituents from septic effluent. Maintaining sufficient depth of unsaturated soil depth beneath the septic bed is crucial for effective treatment processes. Typically, almost all fecal coliform bacteria are removed (>99.99%), almost all organic chemicals such as solvents and pesticides (>99%), and most phosphorus (typically 85-95%) are removed, however only about 10-20% of nitrogen is removed (EPA 2002) making nitrate one of the key parameters of concern.

Much of the scientific research has been conducted on the migration and behaviour of the migration of various chemical constituents from individual septic systems (e.g., Wilhelm 1991; Robertson et al. 1998; Harman et al. 1996; Robertson and Blowes 1995; Godfrey et al. 2007).

The extent of a contaminant plume from a septic system will depend on the physical and chemical factors previously discussed. Detailed investigations on individual septic plumes' plume lengths typically vary from 25 m up to 150 m, and usually not much wider than the septic tile bed (e.g., Minnesota Pollution Control Agency 1999; Harman et al. 1996; Robertson 1995; Robertson and Cherry 1992). The extent of the plume is primarily dependent on the velocity of the groundwater and the age of the septic system, although the migration of specific contaminants within the effluent plume will also be dependent on chemical and biological attenuation mechanisms.

Based on the background studies, the focus of the current study is primarily related to nutrient loading (nitrate and phosphorus) from septic systems, and other potential sources, to the surface water regime within the West Credit River subwatershed, in particular downgradient of Erin Village and to a lesser extent downgradient of Hillsburgh. The current study is a broad-based study, to investigate the potential larger-scale contaminant loading from the major urban areas serviced by septic systems, rather than assessment of individual septic systems.

2.8.3 Historical Water Quality Concerns

Historically, potential water quality concerns have been raised with respect to the potential impacts of septic systems on water quality in the West Credit River subwatershed. Many of these concerns have been previously discussed in the *Erin SSMP Data Gap Analysis Report* (CVC et al. 2008). The following is a summary of findings and comments or concerns, from previous reports/studies, as related to potential water quality impacts associated with septic systems in the urban areas of the Town of Erin. The summary provides the context for the approach to the assessment of the potential water quality impacts from septic systems. The summary is divided into two sections, surface water quality and groundwater quality as the potential impacts, and pathways for impacts are different.

2.8.3.1 Surface Water Quality

Much of the historical focus of water quality concerns with respect to septic system impact has been related to the potential impact on surface water quality, as most data collected is from surface water. A detailed discussion of surface water quality was presented in Section 2.7. The following summarizes the comments or conclusions from previous studies specifically related to surface water quality and potential impacts from septic systems or other activities (e.g., agriculture or urbanization) that could generate similar water quality impacts as septic systems.

- <u>Clean Up Rural Beaches Study (CURB study) 1993 and 1995 (CVC and </u>Soucek, <u>M. 1994; CVC and Soucek, M 1995)</u>: The focus of the CURB study was to develop a water quality base for the West Credit River and its tributaries to help locate bacteria pollution sources within the subwatershed and also serve as background information for future studies. Little information on general inorganic water quality was collected as part of this study. Relevant conclusions, related to potential impacts from septic systems, included the following:
    - Under dry weather conditions *E. coli* concentrations exceeded MOE guidelines for recreational water quality at 5 of the 18 sampling stations.
    - Three of these stations were within or immediately downgradient of Erin Village. The two sampling stations within the Erin Village were apparently

downgradient of an area shown to have malfunctioning septic systems resulting in "breakouts" (i.e., surface discharge of septic effluent) as well as a local hydraulic connection of shallow groundwater to storm sewer discharge.

- One of the other stations that exceeded MOE guidelines was in Hillsburgh; however the potential source of contamination was inconclusive, possibly attributed to cattle access, septic systems, agriculture, or urban runoff.
- The only other sampling station with high *E. coli* was in a rural tributary impacted by agricultural activities. Portions of the subwatershed, draining areas that are primarily agricultural also showed *E. coli* impacts, primarily in wet weather.
- Sampling stations on the main branch of the West Credit River, both downgradient of Erin Village and within Hillsburgh, showed the presence of *Pseudomonas aeruginosa*, possibly indicating sewage impacts of human origin.
- Bacterial beach contamination at Ballinafad was interpreted to originate from upstream agricultural and urban sources. Urban sources of bacteria could be from both faulty septic systems and urban runoff.

- *West Credit River Assimilative Capacity Report* (Triton Engineering Services 1995): including the Supplementary Report by Triton (December 1995). The assimilative capacity study was performed as part of an assessment of options to resolve the issue of private sewage disposal in the Village of Erin. One of the options that was considered was a communal sewage treatment system with direct discharge to the West Credit River. An assimilative capacity study of the West Credit River was conducted to assess the viability of this option. The following is noted with respect to the study:
  - A winter sampling program was conducted in 1995 to supplement the summer data collected as part of the CURB studies. Nitrate-nitrogen (NO_3-N) collected in the winter did show consistently higher concentrations than during the summer.
  - Surface water quality data were evaluated for data from 1976-1994 at the PWQM station, downstream of Erin Village. It was interpreted that historical data indicated impacts from increased urbanization based on the increase in chloride concentrations, from about 15 mg/L to over 30 mg/L. There was no apparent trend in nitrogen species over time, however it was also concluded there was insufficient data to fully evaluate nitrate (NO_3-N) trends.
  - Phosphorus concentrations remained relatively constant over the 18 years of data collection, for the 75th percentile concentration.

- *West Credit Subwatershed Study, Phase 1 Characterization* report (CVC et al. 1998[a]) and *Draft Phase 1 Addendum* report (CVC et al. 2001[a]): A number of data sets, collected for the West Credit Subwatershed Study, have been previously described in Section 2.7. Findings or comments related to septic system impacts included the following conclusions from the 2001 Addendum:
  - *Nitrates are high in the upper main branch of the subwatershed and some of the tributaries. There is also a significant increase in nitrates downstream*

of Erin, which cannot be accounted for by inputs from tributaries or biological transformation of nitrite and ammonia. It appears that the groundwater discharging into the watercourse in this area has an elevated concentration of nitrate. Two plausible sources of nitrates in groundwater are septic systems and farming activities but since much of the upstream land use is urban, septics seem the most probable source of nitrates. Mass balance calculations indicate that groundwater concentrations may range from 2.5 to 5 mg/l, with values possibly as high as 10 mg/l. This is a concern from both a fisheries perspective in the groundwater upwellings and from a drinking water perspective for residents downstream of Erin.

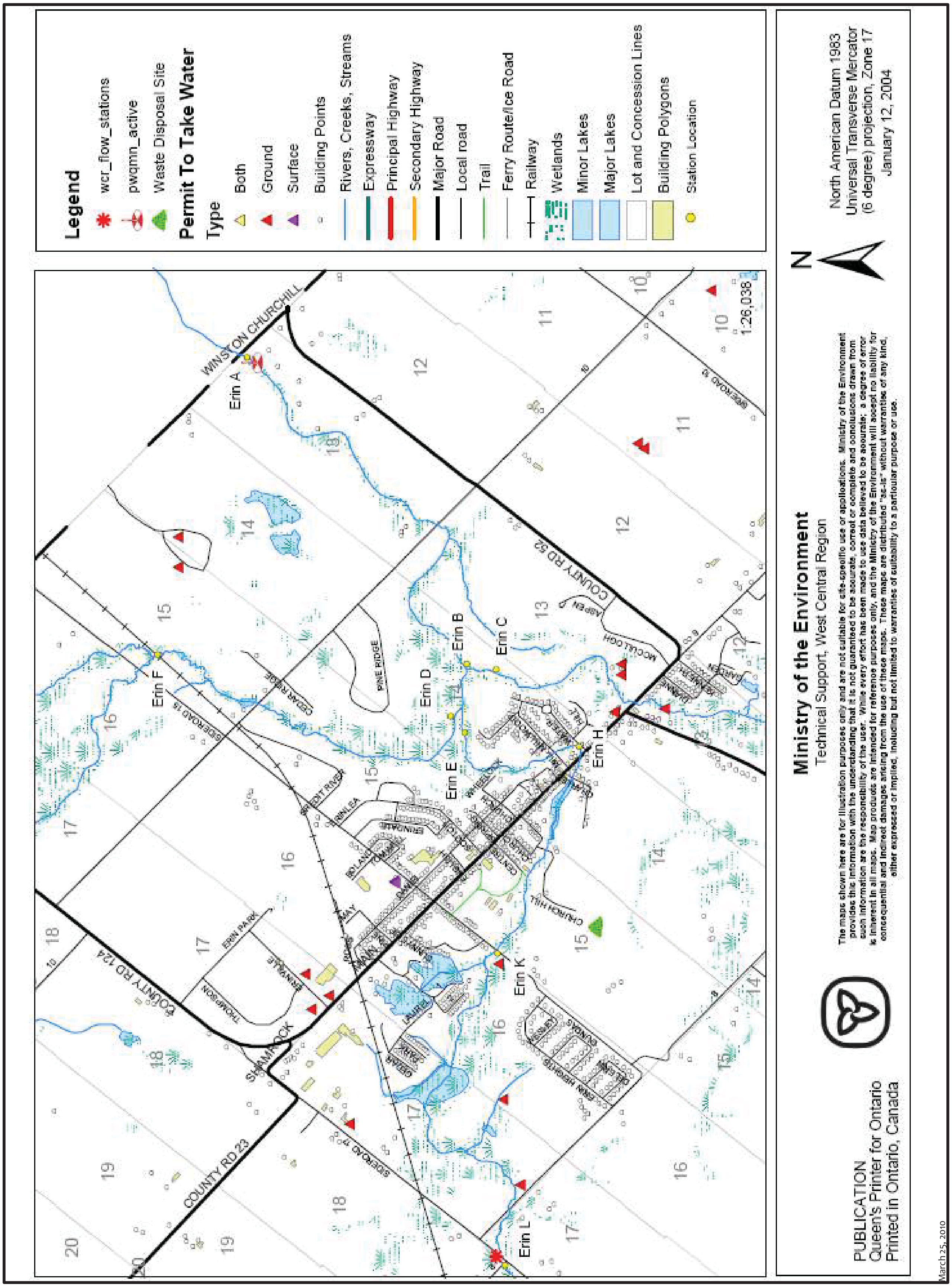
- *Nitrite levels have never been measured above the CCME guideline and violations of the un-ionized ammonia PWQO (based on chronic exposure) are rare. Long-term nitrite and toxic ammonia (un-ionized) levels are a magnitude lower than the CCME guideline and PWQO, respectively, for aquatic health and therefore do not appear to be problematic for the West Credit River.*
- *Long-term conductivity and chloride data for the West Credit River show that these two parameters have been consistently increasing since 1975. Another trend observed within the subwatershed is an increase in chlorides and conductivity downstream of Erin, through the same location where nitrate increases were observed. As in the case of the nitrates, tributary inputs and chemical and biological transformation could not account for the observed increase in chlorides.*

- Draft Town of Erin Septic Investigation 2005 (MOE et al. 2005): The study was completed by the Surface Water Unit of the Technical Support Section of the MOE at the request of CVC. The MOE were requested to evaluate the water chemistry in the West Credit River in the Town of Erin, as part of an assessment of strategies for treating sewage generated in the Town of Erin. CVC had previously indicated that studies on the West Credit River subwatershed identified the reach downstream of the Town of Erin as being of worse water quality than reaches upstream of the Town, as discussed above. There were concerns that septic system effluent could be responsible for this water quality degradation. The following is noted from the report by MOE:
  - Page 14 – Phosphorus: "*Surprisingly, total phosphorus exceeded the PWQO at only a single station, C, during June and August 2005. These results suggest that the water quality is generally good and based on phosphorus in the water column alone, the concentrations should not impair any use that could be made of this section of the West Credit River*." (see **Figure 2.8.3** for sampling station locations)
  - Page 15 – Phosphorus: "*From a spatial perspective, the stations influenced by agricultural areas were typically highest in total phosphorus. Furthermore, a positive relationship between total phosphorus and total suspended solids suggests that sediment load in the water column was a key factor driving the phosphorus concentration.*"
  - Page 16 – Nitrogen species, un-ionized ammonia: "*Un-ionized ammonia levels were well below the PWQO of 20 μg/L at all stations, on all dates";*

"Generally un-ionized ammonia concentrations in the water column were highest in the summer months (June, August), reflecting the contribution from agricultural activities"; and, "*Increasing un-ionized ammonia at the stations in and around the Town of Erin (stations, E, H, K), and in the background station (station L), suggest contributions from the adjacent lands, while the source of ammonia in the Town would likely be septic systems conveying poorly treated sewage to the West Credit. It should be noted that while these trends were observed, the magnitude of impact on the river seems to be very low*".

- Page 16 – Nitrogen species, nitrate-nitrogen: "*Nitrate nitrogen concentrations were below the CWQG value of 2.9 mg/L in this section of the West Credit River*"; "*Typically the stations associated with agricultural runoff had the highest concentrations of the stations sampled*"; and, "*In January, April and November, the concentration of nitrate in the West Credit River was fairly consistent among the stations, with stations E, H, K and L typically higher than the remainder of stations considered in this study. E, K and H were located within the Town of Erin and likely are influenced by contributions from septic systems. Station L was positioned upstream of the Town of Erin. In June and August, the highest concentrations were found at stations C (agricultural) and D (septics immediate to the station, but drains agricultural upstream) and at station A which reflects cumulative contributions from the Town of Erin and areas upstream*".
- Page 20 – *E. coli*: *E. coli* analysis was conducted however it was indicated that values can be highly variable. Several comments were presented however, related to septic systems: "*While variability was observed in the E. coli counts in the West Credit River, and relationships with immediate land use/sewage treatment strategies appeared in these data, the actual counts were typical of those found in surface water associated with failing individual septic systems (10^3 to 10^6; Edge and Schaefer 2006).*"
- Page 24 – "*Urban contributions can be treated as point-source and thus mitigative measures can be taken to further minimize these loadings to the West Credit. Although the results of this study do indicate that septic systems are a contributor of nutrients to the west branch of the Credit River, the relative impact on the receiver was low in 2005.*"
- Page 24 – "*One recommendation is to investigate the state of septic systems in the older portion of the Town of Erin, because the water quality downstream of these areas was typically higher in nitrate and phosphorus.*"

Figure 2.8.3 MOE Septic Investigation Station Locations



- Section 2.7 Water and Sediment Chemistry, of this *Erin SSMP Existing Environmental Conditions Report*: The following is noted with respect to surface water quality comments as related to potential impacts from septic systems:
  - Nutrient Related Parameters – Phosphorus. Phosphorus levels are generally below the PWQO. The summary analysis found that higher levels of phosphorus were present in stations located near the urban centres of Hillsburgh and Erin Village indicating that the contributions were likely coming from urban storm water runoff. The highest levels of phosphorus on the main branch of the Credit River are upstream and downstream of Hillsburgh, at the most upstream end of the West Credit River.
  - Nutrient Related Parameters – Nitrate-Nitrogen. As previously discussed nitrate-nitrogen can originate from a variety of sources, including septic systems, agriculture and urban environments. Because nitrate is soluble and does not absorb to soil particles, it is highly mobile in groundwater and can be a concern where groundwater discharges into creeks, especially in fish spawning locations. Long-term nitrate data from the PWQMN station, located downstream of Erin Village (MOE Location A in **Figure 2.8.3**), indicated that the mean and 75^{th} percentile concentrations were below the CWQG of 2.93 mg/L. Nitrate concentrations showed a similar trend as phosphorus with the most elevated concentrations occurring upstream and downstream of Hillsburgh.
  - Nutrient Related Parameters – Ammonia. Long-term un-ionized ammonia trends at the PWQMN station indicated that the mean and 75^{th} percentile concentrations were well below the PWQO criteria and there was a decreasing concentration over the 8-year study period (2000-2008).

2.8.3.2 Groundwater Quality

As previously discussed in Section 2.1, there have been historical issues with groundwater quality in some areas in Erin, where there is limited protection of the bedrock aquifer system from surface sources of contamination. Much of the aquifer system from which municipal water supplies are obtained appears to be well protected and shows no impact from septic systems. The following is noted from previous investigations and ongoing water quality monitoring of existing municipal wells as well as groundwater contribution to surface water, as they relate to potential impacts from septic systems:

- Hydrogeological Assessment for Erin Sewage Works (Terraqua 1995): This study was conducted as part of the West Credit River Assimilative Capacity Study by Triton Engineering Limited (1995). The study concluded the following:
  - The primary water supply aquifer system (bedrock aquifer of the Amabel Formation) appears to be generally well-protected, showing little evidence of water quality problems related to septic effluent.
  - The shallow overburden and bedrock aquifer in the eastern part of Erin Village is not considered viable for water supply use due to the limited protection from surface sources of contamination and the large number of

septic systems in the area. (As noted in Section 2.1, several former municipal water supply wells were abandoned due to water quality problems).

- The storm sewer system in the Erin Heights subdivision, located in the western portion of Erin Village, appears to intercept shallow groundwater and cause short-circuiting of sewage effluent to the local surface water regime, ultimately discharging to the West Credit River within Erin Village.
- The majority of septic systems within and around Erin Village appear to currently function well (hydraulically), but likely result in degradation of shallow groundwater quality. Attenuative mechanisms with the shallow aquifer appear to improve water quality prior to discharge to the West Credit River.

- Town of Erin Groundwater Management Study (Blackport Hydrogeology Inc. 2005): From results of routine water quality analysis on the currently operating municipal wells for Erin and Hillsburgh it was concluded that there was no apparent influence from surface sources of contamination for Erin Wells E7 and E8, related to septic effluent or fertilizer application. Water quality at Well H2 in Hillsburgh showed the possibility of minor impacts from road salting but no indication of impacts from septic system effluent. This was previously discussed in more detail in Section 2.1, and the well locations are shown in **Figure 2.1.15**.

  An assessment of potential contaminant loading from septic systems and agriculture was performed, as part of the Town of Erin Groundwater Management Study, using a groundwater flow model. As part of the impact assessment, nitrate loading from septic systems in the Village of Erin was examined. Simulations were conducted to assess nitrate loading to the groundwater system from existing septic systems, selecting various defined "points" throughout Erin Village to simulate changes in nitrate concentration over time at these locations. Simulated concentrations achieved a maximum of 6 mg/L nitrate (NO_3-N) in the western portion of the Erin Village but were typically 2-4 mg/L in other areas within Erin Village. Concentration of nitrate in the groundwater discharging to the surface water was not assessed.

- *Draft Town of Erin Septic Investigation 2005* (MOE et al. 2005): There was limited discussion related to groundwater quality as the study was completed by the Surface Water Unit of the Technical Support Section of the MOE. As discussed in the previous section, the MOE was requested to evaluate the water chemistry in the West Credit River in the Town of Erin. One comment is noted however, with respect to groundwater, as taken directly from the report:
  - Page 23 - "*These results certainly demonstrate the influence of agricultural land use on water quality in the West Branch of the Credit River. Urban areas also consistently contributed phosphorus and nitrogen to the river, however, the contributions were more obvious when groundwater contributions to the river were proportionately higher (i.e., during the dry portion of the summer and the winter months)*". It is noted that no flow data was collected as part of the MOE study so there was no ability to assess the relative contribution from surface water and groundwater or variations in

mass loading of phosphorus and nitrogen to the West Credit River between the various sampling dates. This type of assessment is discussed in more detail in Section 2.8.7, as part of the current investigation.

2.8.4 Approach to Septic Impact Assessment

Previous sections in this report have indicated that nitrate is the major concern with respect to potential water quality impacts from septic systems, on surface water quality. Bacteria are also a concern but are not the focus of the current investigation. The current investigation is examining the broader water quality issues related to the overall contribution of septic effluent to the surface and groundwater systems. The background hydrogeology section (Section 2.1) indicated that there were not any major water quality issues with the current municipal wells, which are located in the bedrock aquifer system. There have been historical issues, primarily elevated nitrate concentrations, with several former municipal wells located in the eastern part of the Erin Village, where there is limited natural protection of the bedrock aquifer.

Previous investigations have not been able to determine the exact source of nitrate in the surface water or groundwater. Historical water quality data shows some localized areas where there are elevated concentrations of nitrate as wells as sodium and chloride, indicating impacts from urbanization. Conclusions from previous investigations have also indicated that agriculture is also a potential source of some of the nitrate impacts to the surface water system. Some of these sources of nitrate can be organic (septic effluent, manure) or inorganic (mineral fertilizer). There has been considerable research conducted using nitrogen isotopes to determine the source of nitrate in groundwater and surface water.

The use of stable isotopes ratios of carbon, nitrogen, and sulphur can be used to identify sources of nitrogen in streams and groundwater (e.g., Cravotta 1997; and Bohlke 2002). There is a distinct difference between organic and inorganic nitrogen. Unfortunately many studies have shown there are various chemical transformations that affect isotopic fractionation that can control the composition of nitrogen compounds. Also, when multiple sources of nitrate are present it is difficult to estimate the relative amount of each source contributing to the total nitrogen loading. In the case of Erin Village, there will be multiple sources both organic and inorganic, as a result of agricultural loading (organic and inorganic), septic loading (organic), and urban loading (organic and inorganic). It is possible that stable isotopes may be useful in certain situations in Erin Village, and this is discussed in Section 2.8.9, Next Steps, based on some of the findings of the present assessment.

Various trace level constituents have also been used to investigate septic system effluent and potential impacts on groundwater and surface water. These include volatile organic compounds, trace level pharmaceutical compounds and caffeine (e.g., Godfrey et al. 2007; Buerge et al. 2003; and Seiler et al. 1999). Caffeine and human pharmaceuticals in groundwater with elevated nitrate will provide a clear indication that domestic wastewater is a source of at least some of the nitrate. Many of these studies involved looking at effluent from sewage treatment plants or in site specific septic systems. Many of these constituents are found at extremely low concentrations within individual septic plumes ranging from the low ppb range to low ppt.

A number of these compounds, such as caffeine, are not conservative and will breakdown, be adsorbed etc. as they migrate through the groundwater system. As a result, it is difficult and costly to try to assess the impact of septic systems across a broader area, such as downstream of Erin Village, especially if the physical system is complex. Detailed sampling for these trace constituents could provide this answer, however this would require a major monitoring and sampling program. It is possible that a very specific program may aid in the assessment of septic system impacts to the West Credit River, and this is discussed in Section 2.8.9, Next Steps, based on some of the findings of the present assessment.

Other approaches have been investigated, such as the use of trace metals, salts, and various ratios of chemical constituents (e.g., Hyer 2006 – USGS paper SIR2006-5317 "A Multiple-Tracer Approach for Identifying Sewage Sources to an Urban Stream System"; and Senior and Cinotto 2007). Examples include boron (from laundry detergent) and chloride/bromide ratio. Some of these were examined, where sufficient data existed to determine whether the information provided any additional interpretation.

The main approach to the assessment was to review existing data, primarily in the context of sources of nitrate loading to the West Credit River, as well as other water quality impacts, through reviewing historical trends and "snapshots" of water quality data. The primary method of assessment was to look at variations in mass loadings of nitrate, and where possible chloride, sodium, phosphorus, and TKN. Additional data was collected as part of this assessment, as a better understanding of the data gaps developed during the background review of the data. The following sections present a summary of the septic impact assessments and overall findings of the current study.

2.8.5 Historical Surface Water Quality Trends in the Context of Septic System and Urban Impacts

Historical surface water quality data was further examined in this study to assess the impact of urbanization on the water quality of the West Credit River. Since an increase in septic systems in Erin Village and Hillsburgh is the result of increased urbanization, looking at the impact of urbanization on water quality will aid in the determining impacts from septic system discharge on surface water quality and the potential source areas of water contributing to the West Credit River. The impact of urbanization on groundwater quality was discussed in detail in Section 2.1. The focus of this section is to assess trends in surface water quality in urban areas from either direct surface runoff or groundwater discharge to the surface water.

To aid in assessing the potential impacts of septic systems on the surface water system general water quality impacts of urbanization on groundwater and surface water needs to be examined. Primary impacts would include increases in sodium and chloride loading from road salt activities as well as septic effluent and potential loadings of nitrogen and phosphorus from both septic systems and urbanization. Since chloride is a conservative species (i.e., it does not breakdown or attenuate), trends in chloride concentration will be more representative of trends associated with impacts from urbanization. Section 2.7 discussed some of the current trends in surface water quality in the West Credit River. This section examines trends in specific water quality data over a longer-term with the focus of the assessment being the Village of Erin and the area downstream of Erin. As discussed in Section 2.1, there is local recharge to the groundwater system in Erin, at least during certain times of the year. Some of this recharge water discharges locally to the West Credit River immediately downstream of Erin Village.

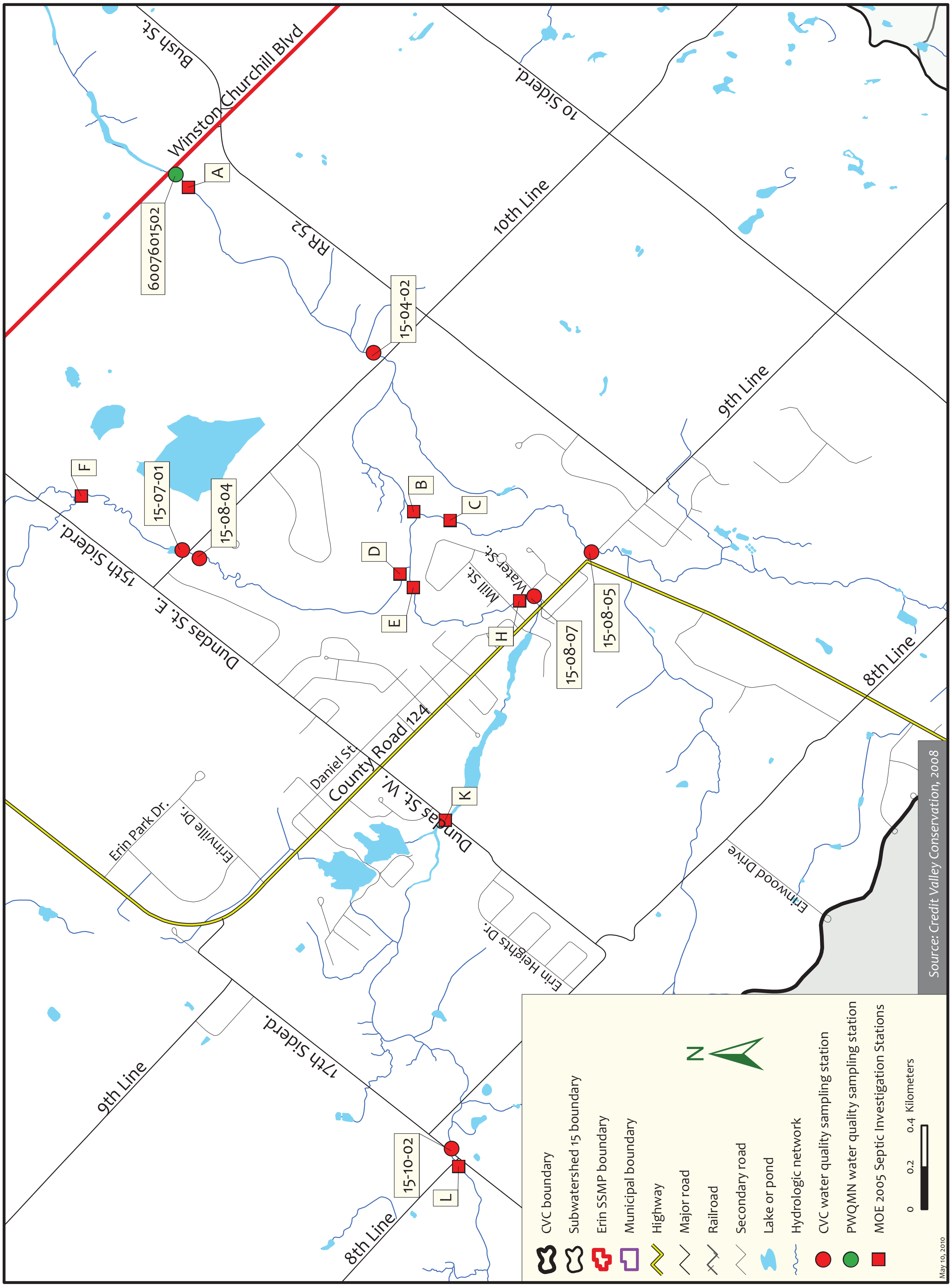
Long-term water quality data is available downstream of Erin Village at PWQMN station 6007601502. For reference purposes, **Figure 2.8.4** shows the location of local sampling and monitoring stations in the vicinity of Erin Village. Much of the discussion in this section is related to water quality and relative mass loading at the PWQMN station. This station captures the water quality from the upper portion of the subwatershed, including tributaries that enter the main branch of the West Credit River downgradient of Erin Village. Additional data was assessed from station 15-10-02, which is also the provincial flow monitoring station, upgradient of Erin Village. Simple mass loading estimates were made using water quality data from the PWQMN station and the flow gauge at station 15-10-02. It is recognized that flow will be higher at the water PWQMN station, however the assessment conducted was related to looking at general long-term trends relative to the broader variations in mass loading. A "multiplier" could be used to provide a more representative mass loading, however the same general trends would be present. More accurate mass loading assessments have been conducted using "snapshots" of flow and water quality, where both sets of data were obtained, from a number of sampling stations throughout the subwatershed and these are presented in Section 2.8.7.

2.8.5.1 Chloride Trends

Figure 2.8.5 shows historical chloride concentrations at the PWQMN station, from 1976 to 2008, a longer monitoring period then was presented in Section 2.7. **Figures 2.8.6** and **2.8.7** show long-term trends for summer and winter chloride concentrations, respectively. **Figures 2.8.8**, **2.8.9**, and **2.8.10** show relative long-term mass loadings of chloride for all data, summer loading only and winter loading only, respectively. The following is highlighted with respect to chloride concentrations and loading in the West Credit River:

- The results show a good statistical linear correlation, with respect to a long-term increase in chloride concentrations, showing a three fold increase from about 15 mg/L to 45 mg/L during the 30+ years of monitoring. It is noted in Section 2.7 that there was little increase in chloride concentration, using only data from 1996 to 2008. It could be interpreted that the chloride concentration increase may be levelling off, which may be a reflection of slow population growth during that time.

Figure 2.8.4 Sampling Stations in the Vicinity of the Village of Erin



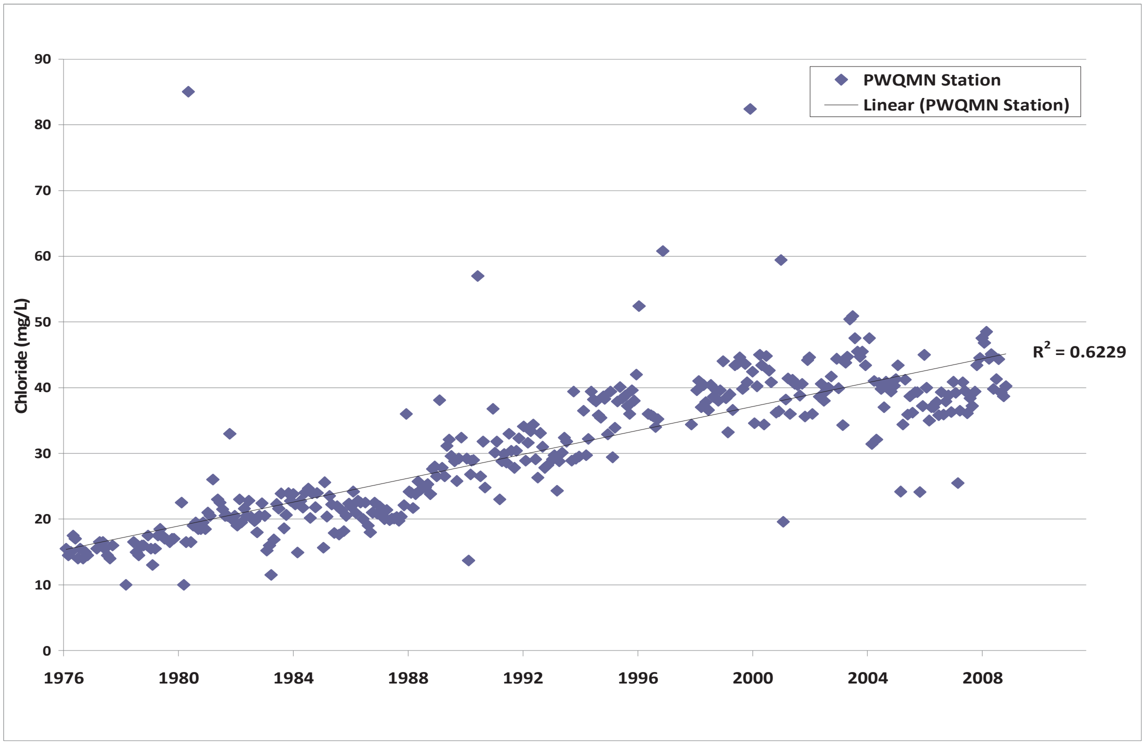


Figure 2.8.5 Historical Chloride Concentrations at the PWQMN Station from 1976 to 2008

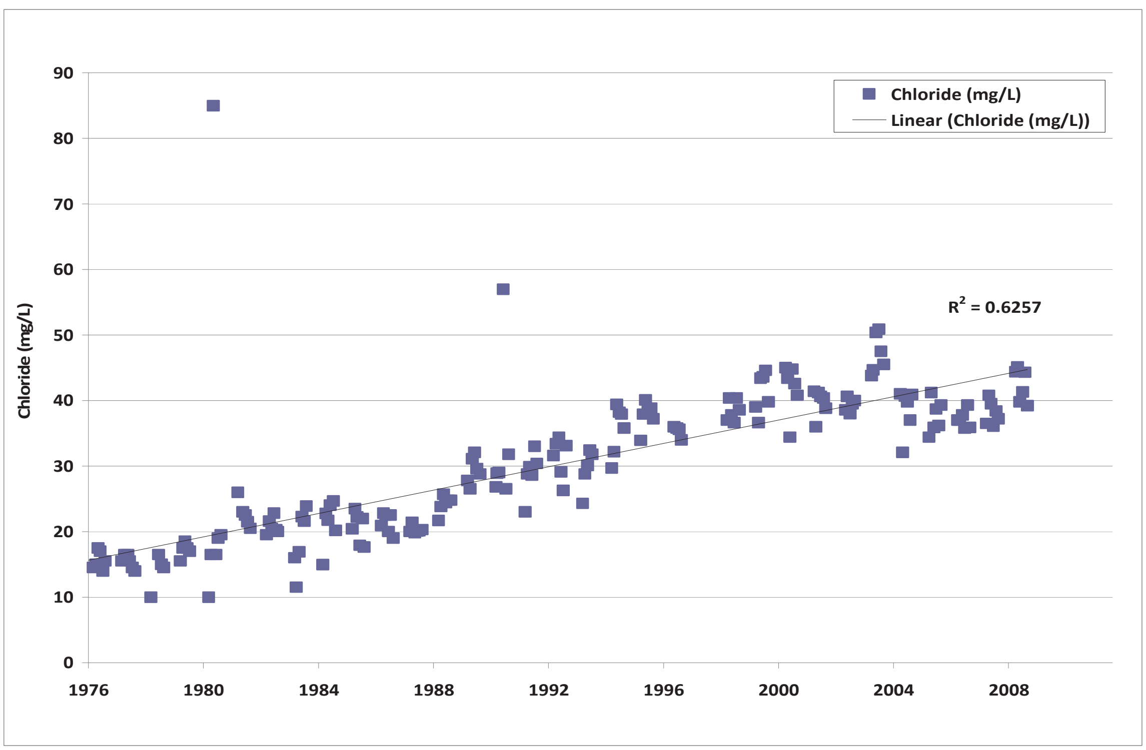


Figure 2.8.6 Long-term Trends for Summer Chloride Concentrations at the PWQMN Station from 1976 to 2008

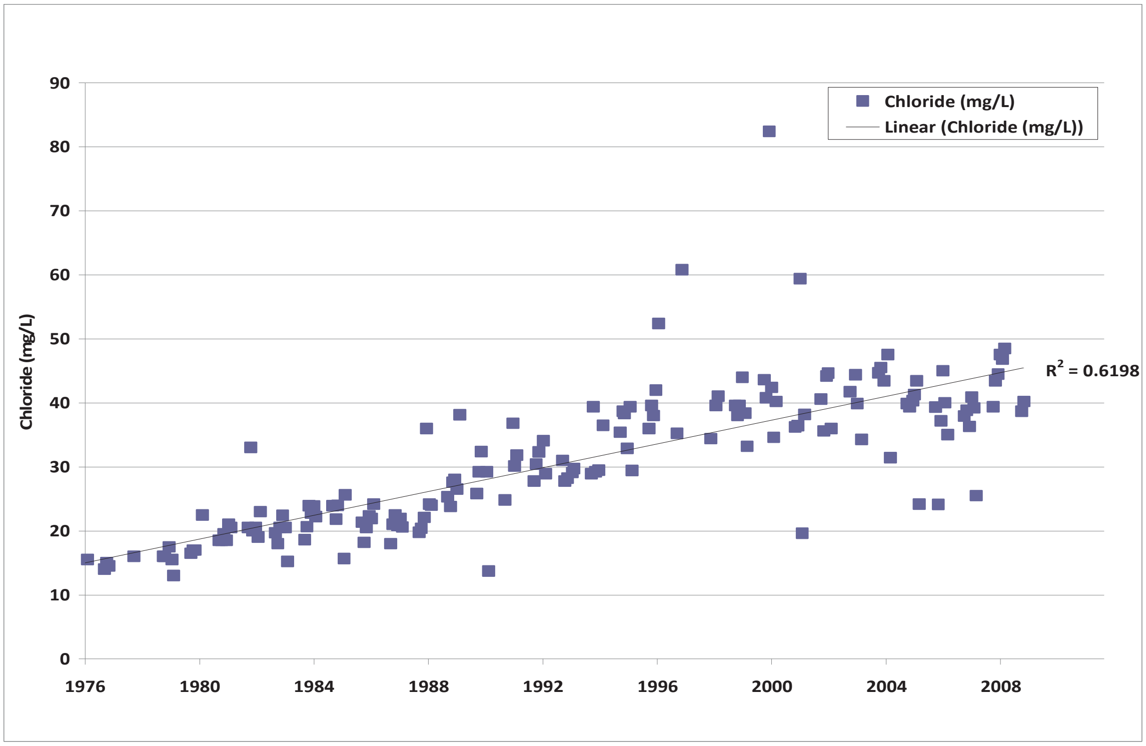


Figure 2.8.7 Long-term Trends for Winter Chloride Concentrations at the PWQMN Station from 1976 to 2008

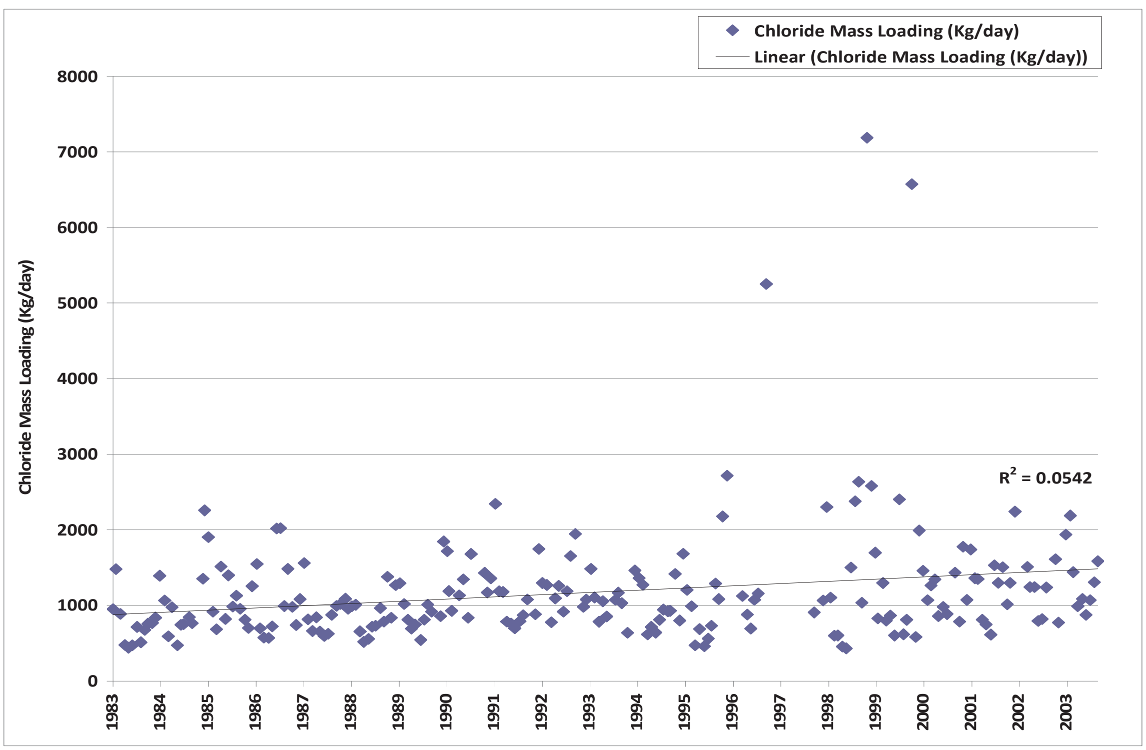


Figure 2.8.8 Long-term Trends for Mass Loadings of Chloride for the Entire Data Set at the PWQMN Station from 1983 to 2003

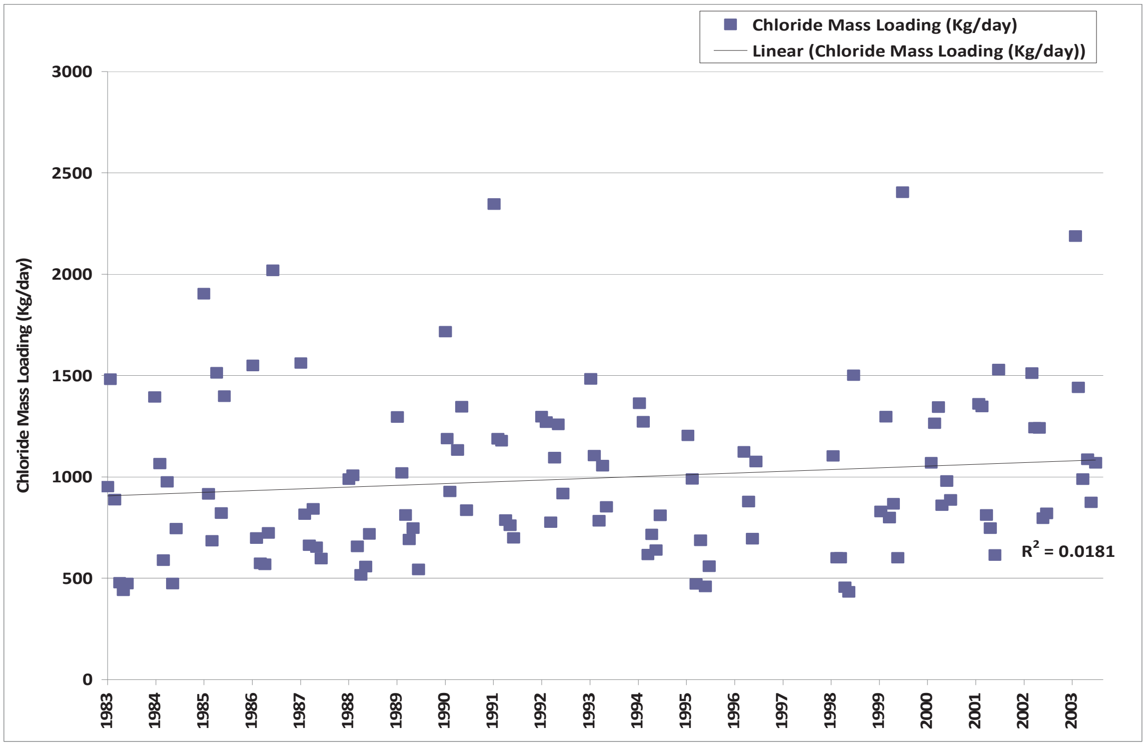


Figure 2.8.9 Long-term Trends for Summer Mass Loadings of Chloride at the PWQMN Station from 1983 to 2003

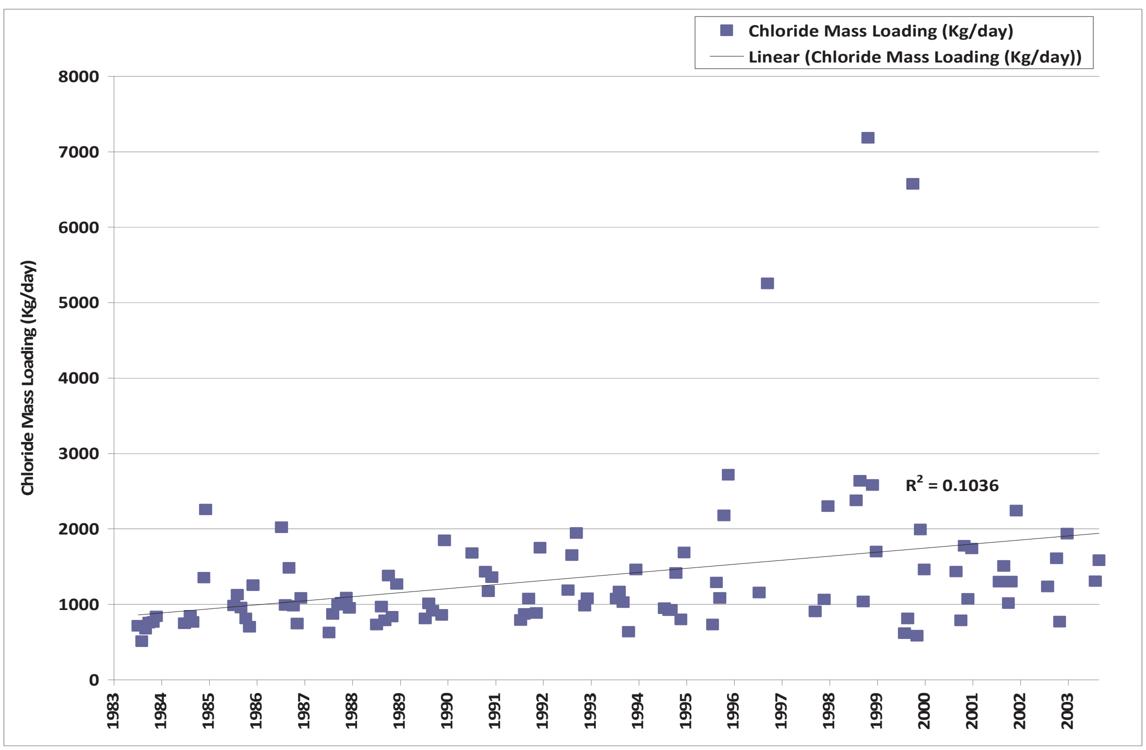


Figure 2.8.10 Long-term Trends for Winter Mass Loadings of Chloride at the PWQMN Station from 1983 to 2003

- Trends in summer and winter chloride concentrations were basically the same, showing almost identical and strong statistical linear correlations (approximately $R^2 = 0.62$) and a similar increase in concentration over time, from 15 mg/L to 45 mg/L.
- Total mass loading indicates a steady increase in chloride loading over the 20-year period, from 1983 to 2003, which both flow and water quality data were collected (**Figure 2.8.8**). Statistically however there is only a weak linear correlation ($R^2 = 0.054$) with respect to a trend showing a long-term increase in chloride loading. The low linear correlation is likely due to the high variation in flow rates, and the resulting variation in mass loading, for specific sampling dates. There is an even lower statistical correlation ($R^2 = 0.018$) for summer loading rates (**Figure 2.8.9**), again likely reflecting variable flow rates (i.e., wet and dry flows). There is a more distinct linear increase in the winter loading rates (**Figure 2.8.10**). There is likely a better correlation with chloride concentrations from winter runoff when road salt is present. Specific mass balance assessment were examined for more recent data, and presented in Section 2.8.7.
- Although it is a weak statistical correlation, the relative chloride mass loading assessment does show about a 70% increase over the 20 year period, using all data collected during that time. Relative summer mass loadings showed only about a 20% increase during that time while the relative winter mass loading showed about a 120% increase during the same time, indicating the majority of the loading is from winter road salting. The increase in summer loadings would also indicate that there has likely been an increase in chloride loading to the groundwater over this time, as reflected in summer baseflow.

Historical population levels for Erin, both the former Erin Township and the Village of Erin (**Table 2.8.6**) were typically collected every 10 years. The population increase for the Town of Erin (including the former Township and Village, prior to amalgamation) was about 34% from 1981 to 2001, much lower than the relative increase in chloride loading (about 70%) during a similar time. It is noted however that the increase in the Village of Erin population was only about 20% during that time. Summer chloride loadings increased about 20%, which could be reflective of a general increase in chloride concentrations in the groundwater as a result of urbanization and loading from septic systems as previously system as discussed in Section 2.1.

Table 2.8.6 Historical population levels for Erin, both the former Erin Township and the Village of Erin

	1901	**1911**	**1921**	**1931**	**1941**	**1951**	**1961**	**1971**	**1981**	**1991**	**2001**
Erin Township	3,587	3,147	2,797	2,822	2,605	2,635	3,272	4,354	*5,943*	7,561	8,270
Erin Village	511	511	479	451	499	650	1,005	1,446	*2,313*	2,489	2,782
Total Population	**4,098**	**3,658**	**3,276**	**3,273**	**3,104**	**3,285**	**4,277**	**5,800**	**8,256**	**10,050**	**11,052**
Change in Total Population between every 10 Years	0	-440	-382	-3	-169	181	992	1523	2456	1794	1002

Information obtained from Sally Stall in the Town of Erin Planning Department, 5685 Wellington Rd. 24, R.R#2, Hillsburgh, ON, (pers. comm.)

Overall, increases in historical chloride concentrations and loading appear to reflect the increase in urbanization within the subwatershed. It is noted that the PWQMN station reflects water quality contributions from the entire area upstream of the station. A detailed assessment of water quality data collected upstream and downstream of Erin Village is presented in Section 2.8.5.3, to examine the potential impacts of the Erin urban area on the water quality of the West Credit River.

2.8.5.2 Nitrate Trends

Figures 2.8.11 to **2.8.13** show historical nitrate (as NO_3-N) concentrations at the PWQMN station, downstream of Erin Village. **Figures 2.8.14** to **2.8.16** show the historical relative mass loadings of nitrate (as NO_3-N) at the PWQMN station. The following is highlighted with respect to historical nitrate concentrations and loading trends.

- There is only a weak statistical linear correlation (R^2 = 0.11) in nitrate concentration from 1976 to 2008 (**Figure 2.8.11**) with about a 35% increase in concentration, from 1.4 to 1.9 mg/L, during that time. A slightly better statistical linear correlation (R^2 = 0.2) is found in looking at historical nitrate concentration during summer months (**Figure 2.8.12**). The summer months also showed a similar 35% increase in nitrate concentration, from 1.25 to 1.7 mg/L. Winter nitrate concentrations (**Figure 2.8.13**) show the poorest statistical linear correlation (R^2 = 0.075), and shows a slightly smaller increase in concentration over time, about 30%, increasing from 1.7 to 2.2 mg/L. Nitrate concentrations are higher in the winter as there is limited uptake by plants so more total nitrogen is remains in the water.
- The population increase in the Town of Erin from 1971-2006 was about 2.6 times the 1971 level while the Village of Erin population increase was about 2 times the 1971 level. The relative increase in nitrate concentration was much lower (30-35%), indicating no apparent correlation to the population increase. It could mean that much of the nitrate from the septic effluent, entering the groundwater system, has not reached the West Credit River yet or the nitrate is attenuated before reaching the river.
- The relative mass loading of nitrate was estimated from available flow and water quality data over a 10 year period, from 1994 to 2003. The relative mass loading shows no linear statistical correlation (R^2 = 0.0003) or trend (**Figure 2.8.14**), either increasing or decreasing, during that time.
- Summer mass nitrate loading (**Figure 2.8.15**) shows a poor linear statistical correlation (R^2 = 0.056), but does indicate an apparent increase of about 30% over the 10 year time, similar to the increase in concentration. Mass loadings were highly variable, again likely reflecting wet and dry flow periods as well as variations in nutrient uptake by plants.
- Winter mass nitrate loadings (**Figure 2.8.16**) also showed no apparent linear correlation (R^2 = 0.0009) and no apparent increase in loading during the time period assessed. Relative mass loading of nitrate was more than double during

the winter months compared to the summer months, likely reflecting the limited uptake of nitrogen during the winter months.

In summary, given the various sources of nitrate and various factors that can affect nitrate concentration and the potential variable sources areas of groundwater discharge to the West Credit River, downstream of Erin Village, it is difficult to establish the potential impact of septic systems on nitrate concentration and loading in the West Credit River on the basis of water quality data only, from the PWQMN station. It is noted again that the data is a reflection of entire upstream portion of the subwatershed and not just the urban areas. The increase in nitrate concentration and loading over time does not compare to the increase in urbanization, and is less than the increase in chloride concentration and relative mass loading over time. A more detailed comparison of historical nitrate concentrations upstream and downstream of Erin Village is presented in the next section, to further examine the potential impacts of the urban area on water quality in the West Credit River.

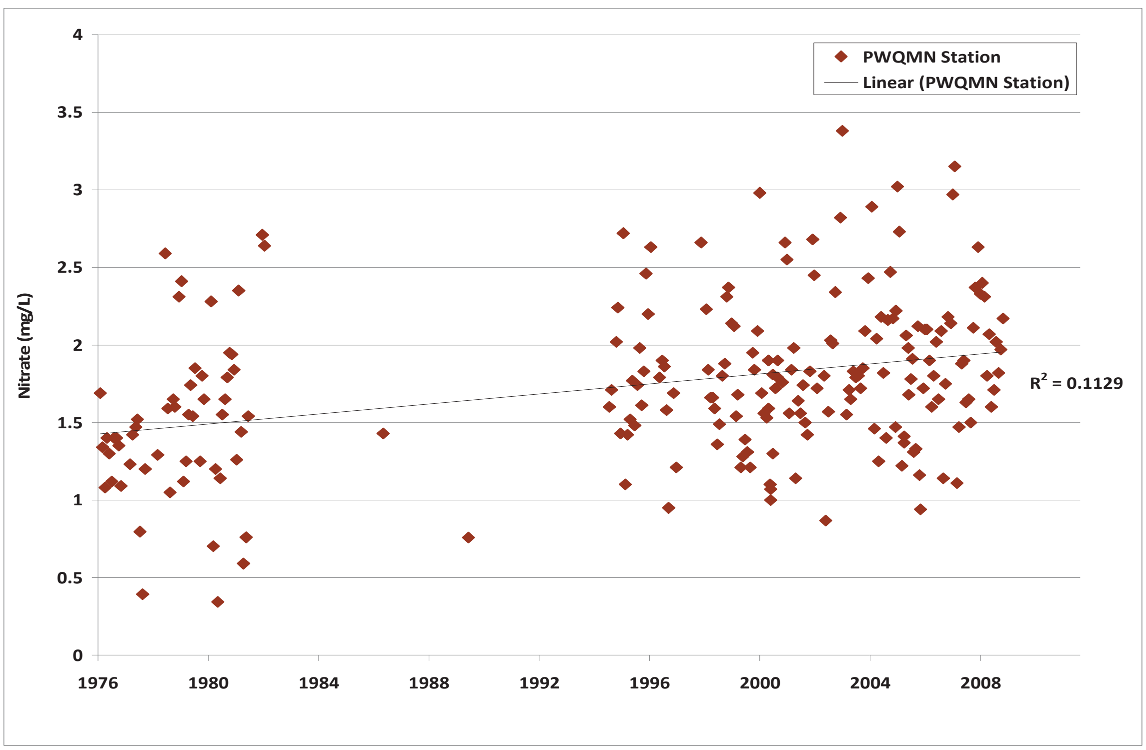


Figure 2.8.11 Historical Nitrate (as NO_3-N) Concentrations at the PWQMN Station from 1976 to 2008

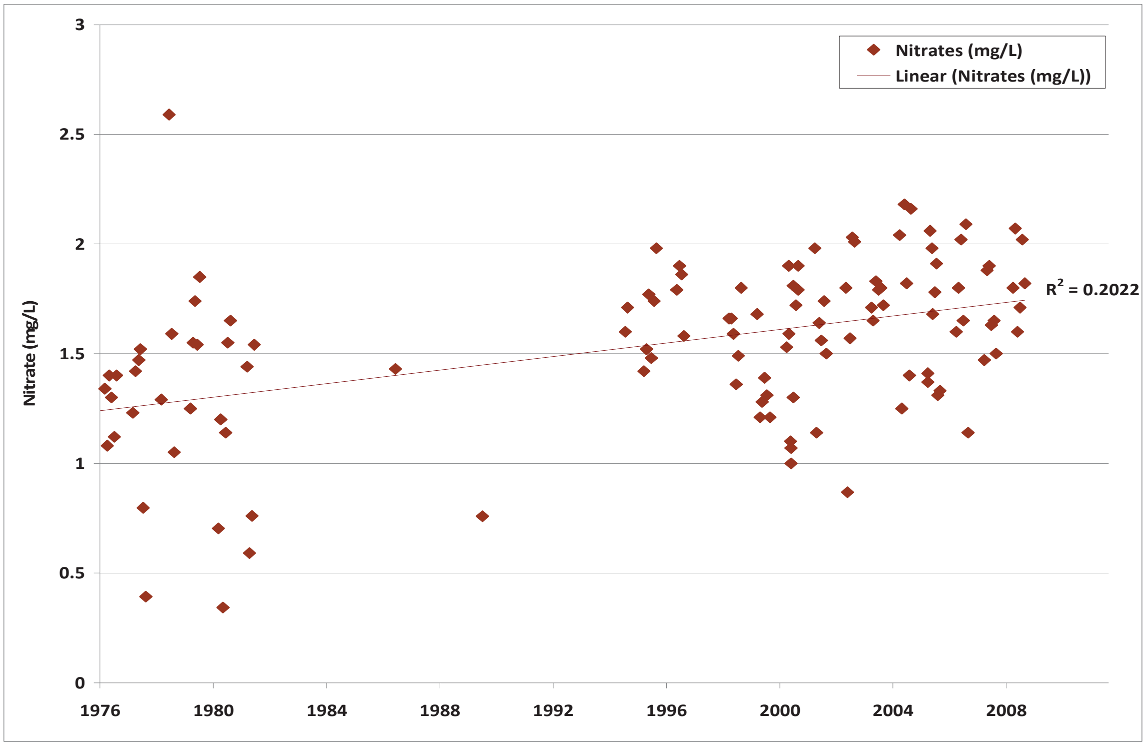


Figure 2.8.12 Long-term Trends for Summer Nitrate (as NO_3-N) Concentrations at the PWQMN Station from 1976 to 2008

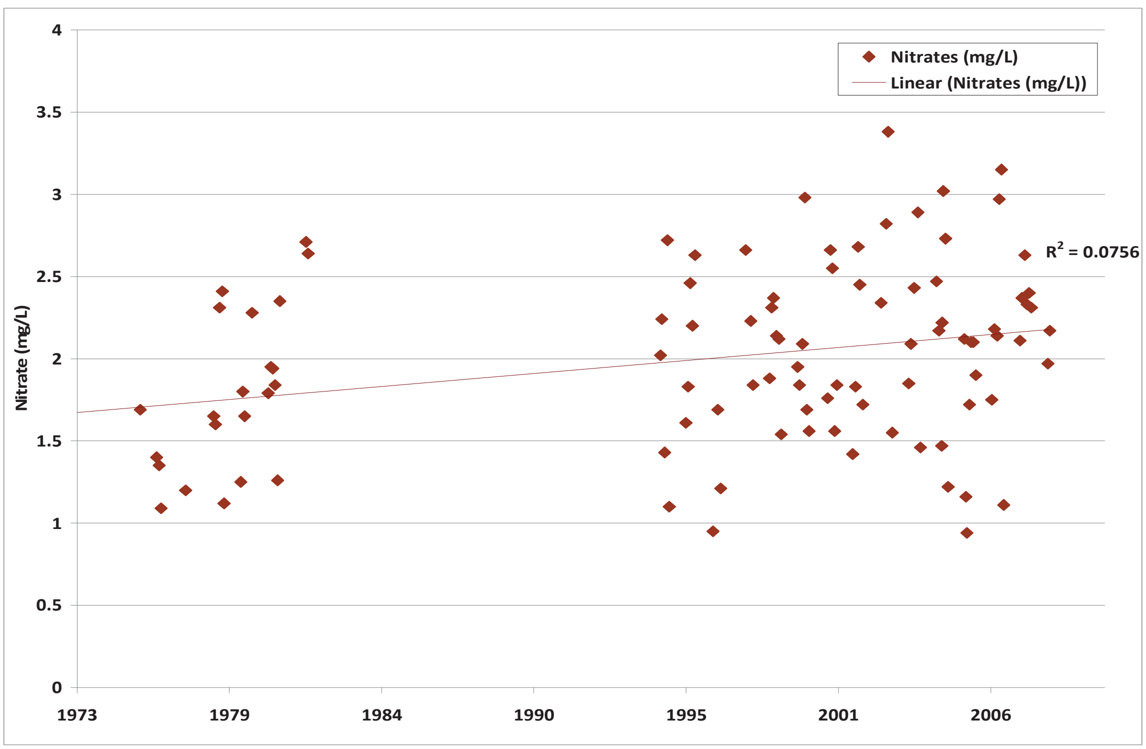


Figure 2.8.13 Long-term Trends for Winter Nitrate (as NO_3-N) Concentrations at the PWQMN Station from 1976 to 2008

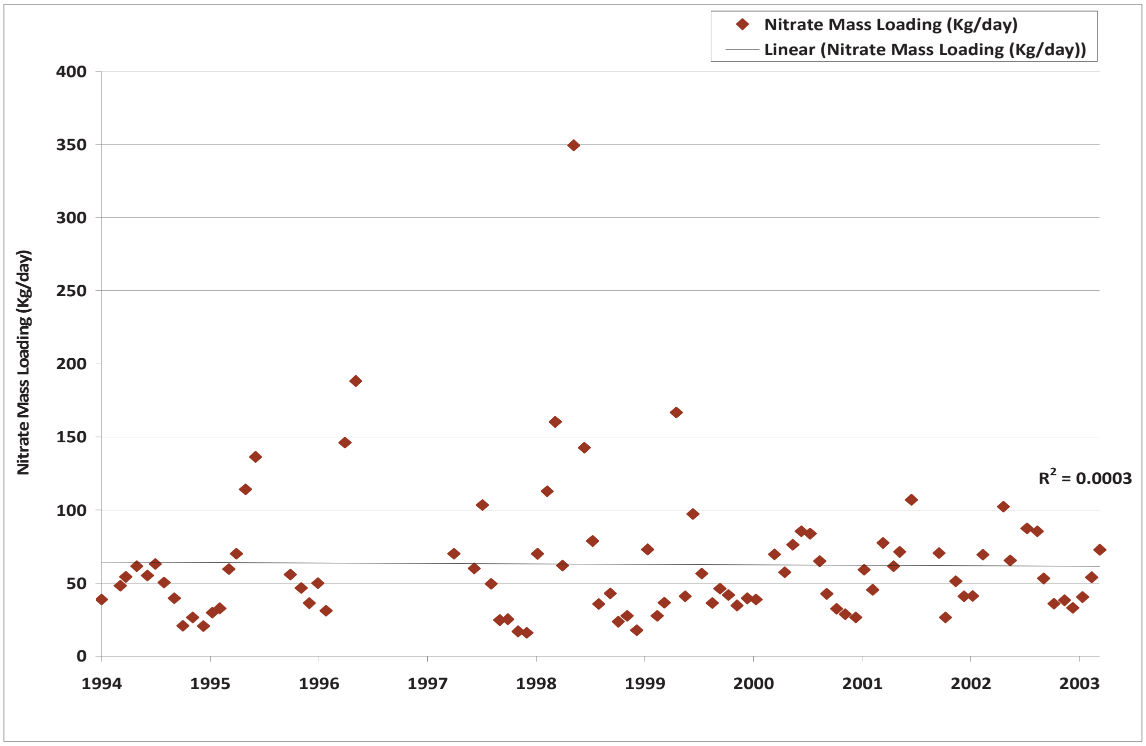


Figure 2.8.14 Long-term Trends for Mass Loadings of Nitrate (as NO_3-N) for the Entire Data Set at the PWQMN Station from 1994 to 2003

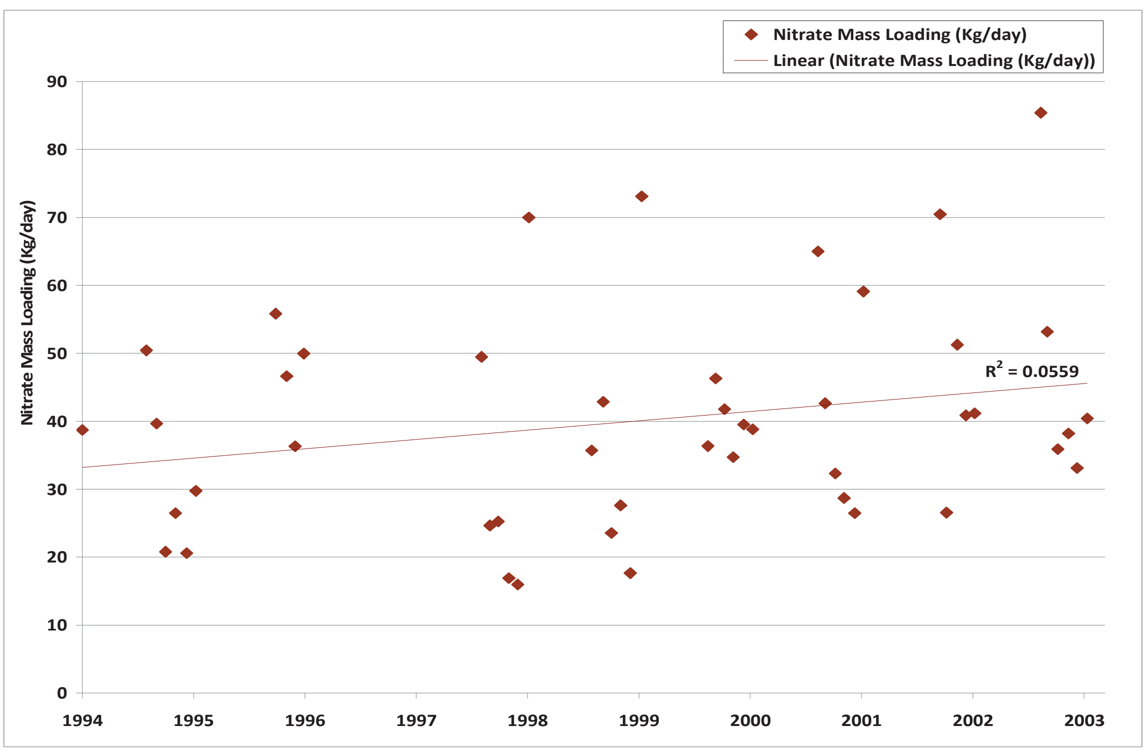


Figure 2.8.15 Long-term Trends for Summer Mass Loadings of Nitrate (as NO_3-N) at the PWQMN Station from 1994 to 2003

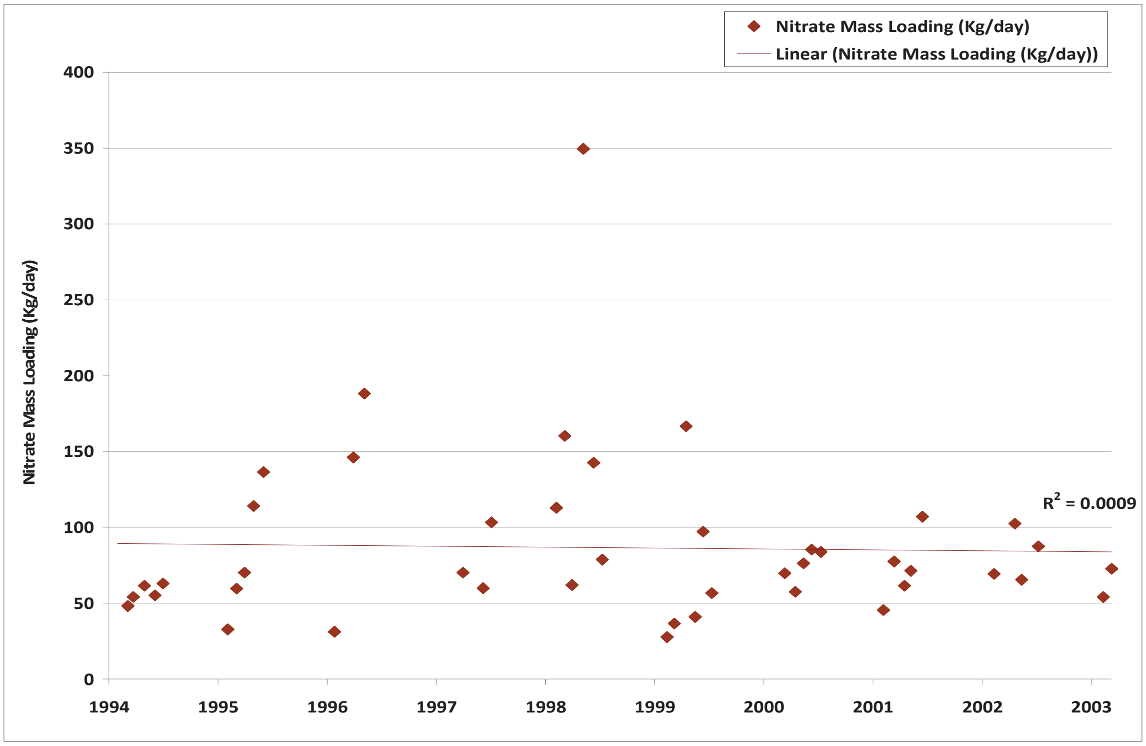


Figure 2.8.16 Long-term Trends for Winter Mass Loadings of Nitrate (as NO_3-N) at the PWQMN Station from 1994 to 2003

2.8.5.3 Comparison of Upstream and Downstream Chloride and Nitrate Concentrations

Historical water quality data exists for the monitoring station immediately upstream of Erin Village; however it is much less frequent than the data collected at the PWQMN station. **Figures 2.8.17** to **2.8.19** show a comparison of chloride concentrations between station 15-10-02, upstream of Erin Village, and the PWQMN station downstream of Erin Village (see **Figure 2.8.4** for locations). **Figures 2.8.20 to 2.8.22** show a comparison of nitrate concentrations between the two same stations. It is recognized that there will be variables that will affect concentration of chloride and nitrate in the surface water, such as different source areas and volumes of groundwater inputs downstream of Erin Village and the timing of sample collection (e.g. wet weather or dry weather), however a comparison of historical data from the two sampling stations do show some general trends. The following findings are highlighted.

- **Figure 2.8.17** shows a comparison of historical chloride concentrations between the two stations, upstream and downstream of Erin Village. There is a high statistical linear correlation for chloride concentrations at both stations, with both stations showing a similar increase in concentration over time. The chloride concentration is on average about 7.5 mg/L to 10 mg/L higher downstream of Erin Village compared to upstream. The increase in chloride concentration downstream of Erin Village appears to be at a slightly faster rate than the increase upstream of Erin Village.

- A comparison of summer chloride concentrations shows the same trends as the overall chloride concentrations, both upstream and downstream of Erin Village (**Figure 2.8.18**). There has been no long-term collection of winter water quality data at station 15-10-02, however recent winter chloride data (**Figure 2.9.19**) shows a similar range of concentration as the summer data, with chloride concentrations about 10 mg/L lower, upstream of Erin Village.
- A comparison of historical nitrate concentration at both water quality stations (**Figure 2.8.20**) appears to show an apparent strong linear correlation and a substantial increase in nitrate concentration over time, upstream of Erin Village. The results are misleading however; as all of the early historical data are from summer sampling events while the more recent data is a combination of both summer and winter data. As previously discussed there is a greater difference in nitrate concentration between summer and winter sampling periods then the increase in nitrate concentration over the last 30 years of monitoring. A comparison of summer nitrate data only (**Figure 2.8.21**) shows a moderate linear statistical correlation for both water quality stations, showing a slight increase in concentration over time. There appears to be a greater rate of increase in nitrate concentration over time upstream of Erin Village compared to downstream. Nitrate concentrations increased from about 1.5 mg/L to 1.75 mg/L downstream of Erin Village, between 1992 and 2008, while the nitrate concentration upstream of Erin Village increased from about 1.2 mg/L to 1.7 mg/L during the same time.
- There was insufficient data to assess long-term trends in winter nitrate concentrations upgradient of Erin Village (**Figure 2.8.22**), however the most recent data shows little difference in nitrate concentration upstream and downstream of Erin Village.

In summary, based on the existing historical water quality data, upstream and downstream of Erin Village, chloride concentrations increase through the Erin Village, and the rate of increase appears to be similar to upstream of the Village. Based on chloride data only, there is insufficient information to determine whether the impact from urbanization in Erin Village is greater than the general land use impact upstream of Erin Village, however it appears that there is a substantial increase in chloride contribution to the West Credit River from Erin Village. The existing water quality data for nitrate does show a small increase in concentration over time both upstream and downstream of Erin Village. Using this data only, there is insufficient information to determine if there is a greater impact on nitrate contributions to the West Credit River from septic systems, relative to nitrate contributions from other sources in the upper portion of the subwatershed.

The impact of urbanization is examined in more detail in Section 2.8.7, through the collection and analyses of additional data upstream and downstream of Erin Village, including tributaries downstream of the Village.

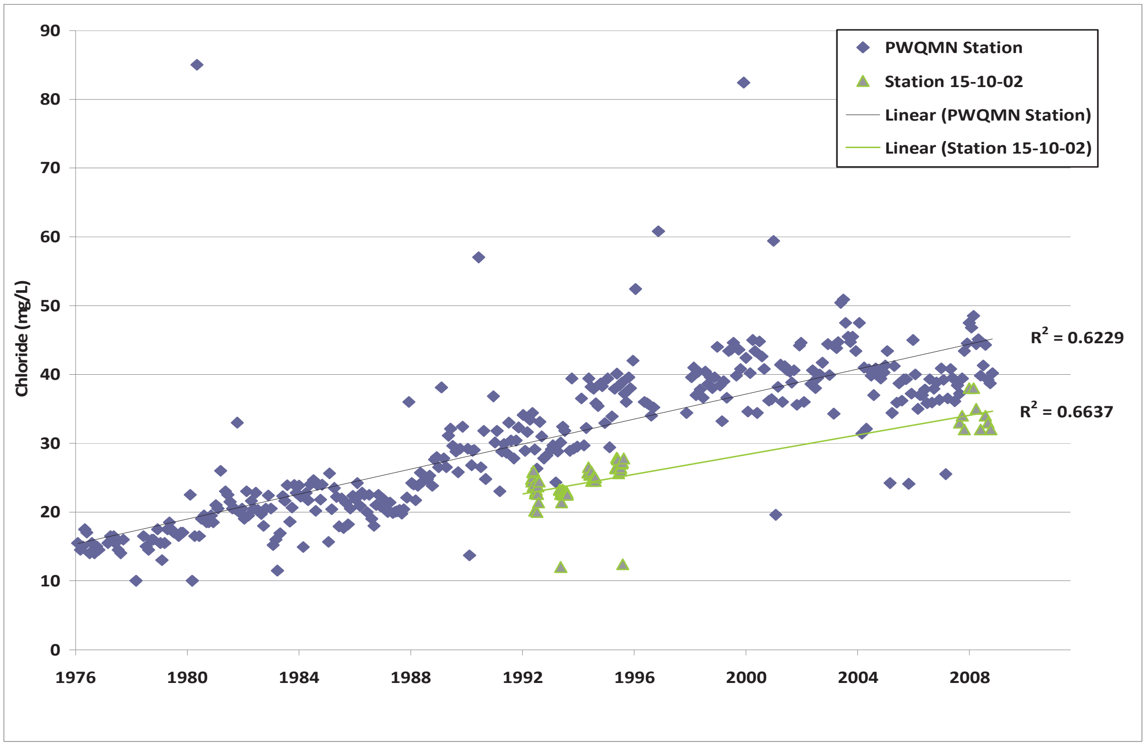


Figure 2.8.17 Comparison of Chloride Concentrations between Station 15-10-02 and the PWQMN Station for the Entire Data Set from 1976 to 2008

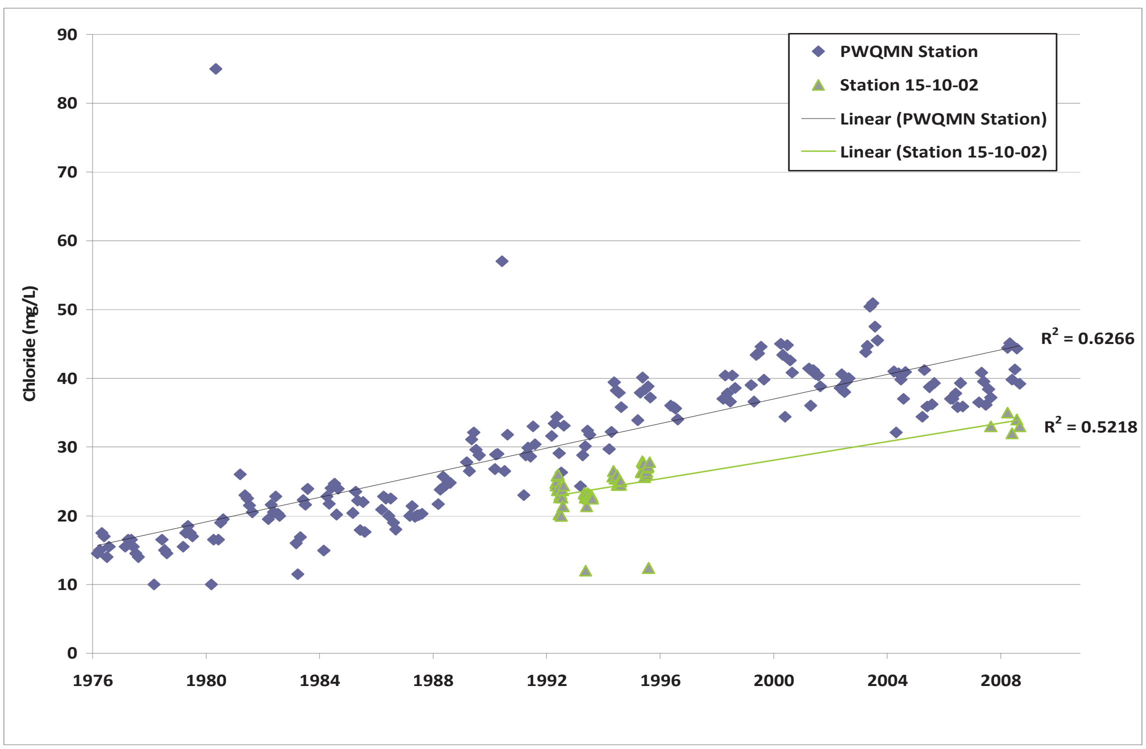


Figure 2.8.18 Comparison of Summer Chloride Concentrations between Station 15-10-02 and the PWQMN Station from 1976 to 2008

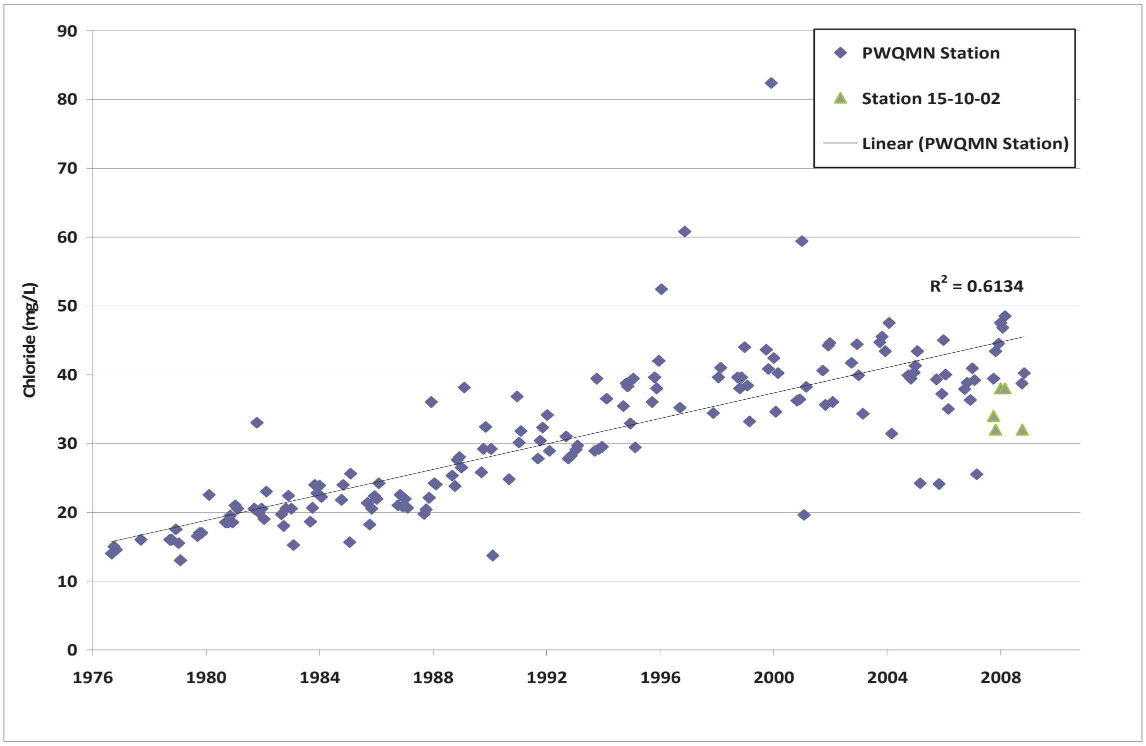
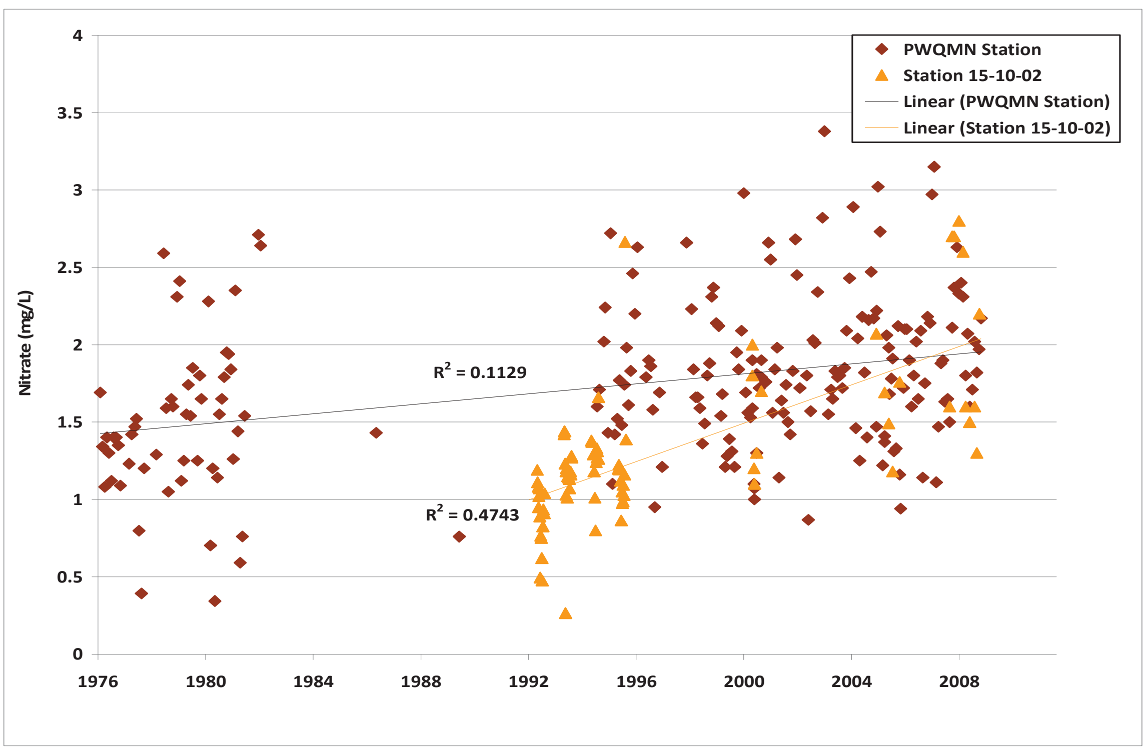


Figure 2.8.19 Comparison of Winter Chloride Concentrations between Station 15-10-02 and the PWQMN Station from 1976 to 2008



Figures 2.8.20 Comparison of Nitrate (as NO_3-N) Concentrations between Station 15-10-02 and the PWQMN Station for the Entire Data Set from 1976 to 2008

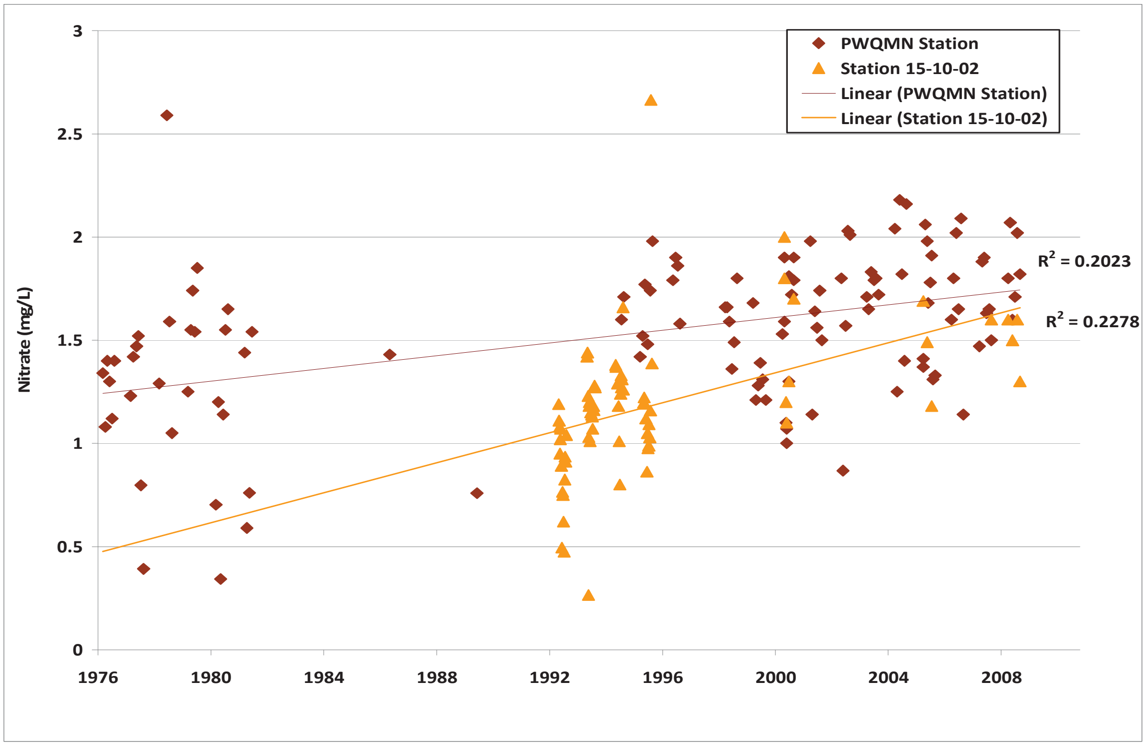


Figure 2.8.21 Comparison of Summer Nitrate (as NO_3-N) Concentrations between Station 15-10-02 and the PWQMN Station from 1976 to 2008

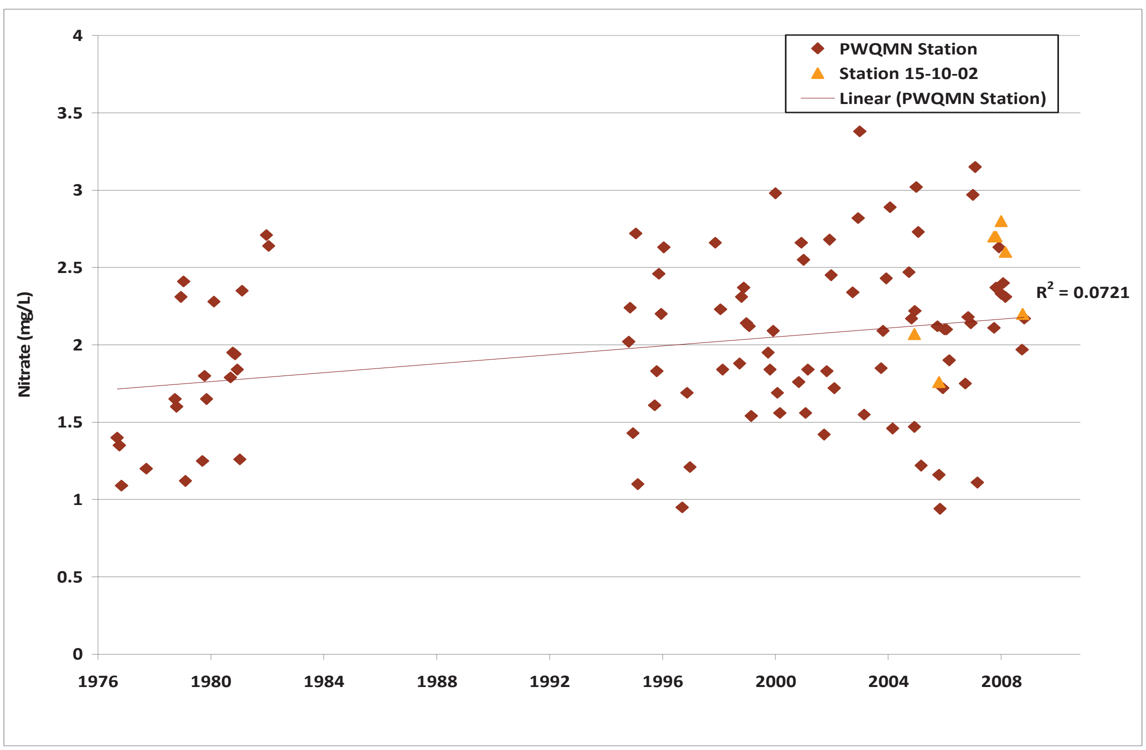


Figure 2.8.22 Comparison of Winter Nitrate (as NO_3-N) Concentrations between Station 15-10-02 and the PWQMN Station from 1976 to 2008

2.8.6 Simple Water/Mass Balance Assessment

Prior to conducting a more detailed assessment of water quality, flows, and mass loadings of various water quality parameters, the potential impact of nitrate loading from septic systems was examined using a simple water and mass balance assessment for Erin. There are several ways to perform a simple assessment of the potential impact of septic system effluent on the West Credit River. As indicated in Sections 2.8.2 and 2.8.3, nitrate loading and the subsequent addition to the concentration of nitrate in the surface water is the main concern with respect to the water quality impact from septic effluent. The following is a simple water balance assessment to determine the potential worst case loading of nitrate to the West Credit River, from septic systems in Erin Village. The worst case assessment is based on the following conservative assumptions:

- all water taking from the municipal water system is discharged into septic systems in Erin Village;
- all effluent from septic systems stays within the shallow groundwater and is discharged directly to the main branch of the West Credit River, just downstream of Erin Village;
- there is no additional dilution or mixing with the groundwater from outside of Erin Village;
- no loss of nitrogen occurs in the septic tank;
- no denitrification occurs in the groundwater zone or within the riparian zone prior to discharge to the West Credit River; and,
- there is no uptake of nitrogen, from septic effluent, by plants, during the growing season.

Two approaches were taken to estimate the mass loading of nitrate to the West Credit River, using the following information:

- Number of households in Erin Village = 1030 (2006 population estimate, County of Wellington)
- Population of Erin Village = 3020 (2006 population estimate County of Wellington)
- Average number of people per household = 2.93
- Average nitrate loading 12 gm/person/day from Chambers et al. (2001) = 35.16 gm/day/household (12 gm x 2.93 persons)
- MOE estimate of nitrate loading per septic system 40 mg/L x 1000 L/day (MOE design loading)
- Average daily water taking on an annual basis in 2008 = 900,000 L/day. This equates to 874 L/day per household if all of the water was household use (e.g., no lawn watering, industrial use).

- Using the MOE estimate, nitrate loading is 40 mg/L x 874 L/day = 34.96 gm/day/household.

The two loading estimates compare favourably at approximately 35 gm/household/day. Based on these loading estimates, daily loadings from the 1030 households would generate **36 kg/day** of nitrate. Using the worst case assumptions of no loss of nitrate through any process, as noted above, this would result in 36 kg/day mass loading to the West Credit, assuming and instantaneous continuous discharge to the West Credit River (i.e., the travel time to the West Credit River is instant and all of the effluent discharges locally to the West Credit River).

A worst case assessment can be made for the potential increase in nitrate concentration to the West Credit River using a simple dilution approach as follows:

- 36 kg/day nitrate loading from 900,000 L/day municipal pumping to septic systems, based on 40 mg/L nitrate loading
- 900,000 L/day is and average of 10.4 L/sec
- 40 mg/L x 10.4 L/sec = 416 mg/sec of nitrate entering the West Credit River
- Streamflow rates from the flow gauge upstream of Erin Village (station 15-10-02) are used to "mix" with Erin-generated groundwater discharging to the main branch of the West Credit River to assess the dilution factor. This is a conservative value for dilution as there is typically an increase in flow downstream of Erin Village and further dilution through mixing with water from several tributaries immediately downstream of Erin Village.
- **Figure 2.2.2** shows various means, as an average daily streamflow in m^3/sec.

Table 2.8.7 shows the theoretical nitrate concentration increase to the West Credit River under different streamflow rates. Three streamflow rates were used in the assessment: the annual mean daily flow, mean lowest flow month, and the mean lowest quartile for the lowest flow month. Based on these flows the theoretical increase in "worst case" nitrate concentration in the West Credit River ranges from an annual average of 0.85 mg/L to and increase of 1.59 mg/L for the mean lowest quartile for the lowest flow month. These theoretical increases are significantly higher than the nitrate concentrations discussed in the previous section, where increases of 0.3 mg/L or less were estimated, between upstream and downstream of Erin Village.

As indicated above, many conservative assumptions were used to look at theoretical increases in nitrate concentration to the West Credit River from septic systems in Erin Village. It is difficult to determine the increased nitrate loading from septic systems to the West Credit River, however it appears that the loading is much less than the conservative theoretical calculations. Additional more detailed work was conducted, using existing and new data from "snapshots" of local flow rates and water quality upstream and downstream of Erin Village, to attempt to estimate nitrate loading to the West Credit River. Some additional work was also conducted in Hillsburgh to examine the potential impacts of septic systems on the West Credit River. The results and analyses are presented in the next section.

Table 2.8.7 Theoretical Nitrate Concentrations to the West Credit River under Different Streamflow Rates

Streamflow Parameter (from streamflow data 1983-2008)	Average Daily Streamflow Rate (L/sec)	Theoretical Increase in Nitrate Concentration in the West Credit River (mg/L)
Annual Mean Daily Flow Rate	480 L/sec	0.85
Mean lowest Flow Month (August)	326 L/sec	1.24
Mean Lowest Quartile for the Lowest Flow Month (August)	252 L/sec	1.59

2.8.7 Mass Balance and Mass Loading Assessments

Considerable water quality data has been collected throughout the West Credit River subwatershed over the last 15 years, both along the main branch of the West Credit River and in many of its local tributaries. In some cases, flow data was obtained at the same time as water quality data but this was typically not the case. For example, the MOE septic investigation (MOE et al. 2005) did not obtain any flow data as part of the assessment, as previously discussed in Section 2.8.3, so it is difficult to interpret variations in nitrate concentrations between sampling stations. Another problem with assessing mass loadings to the West Credit River is that long term water quality data has been collected at the Provincial Water Quality Monitoring Network station on Winston Churchill Blvd., downstream of Erin Village, while flow monitoring has been conducted at station 15-10-02, located upstream of Erin Village. This was previously discussed in Section 2.8.5, related to a preliminary assessment of long-term trends in mass loading of chloride and nitrate. This section provides a more detailed assessment of mass loadings, with the focus on the potential impact from urbanization, including septic systems.

Historical flow and water quality data, as well as recent data collected as part of the SSMP study, were used to look at water balance and mass balance to attempt to assess potential impacts on the water quality of the West Credit River, from the Town of Erin urban areas (Erin Village and Hillsburgh). The focus of the assessment was Erin Village as there is more data available for Erin and there were more historical concerns related to Erin, although there was some assessment completed for Hillsburgh.

One of the ways the data was analyzed was to compare flow rates upstream and downstream of Erin Village, including flow from local tributaries entering the main branch of the West Credit River downstream of Erin Village. If there was a reasonable match between the sum of flows entering and leaving Erin Village, then it was assumed that the flow data could be used for a mass balance assessment.

As discussed in Section 2.7 and 2.8.4, nitrate is not a conservative species and can undergo various processes that can result in a loss of nitrate through denitrification and/or uptake by plant species during the growing season. As a result, it is difficult to independently assess the accuracy of the flow data through mass loading comparisons using nitrate data. Instead, chloride was used for a mass balance assessment as it is a conservative species. If the mass balance comparison for chloride was similar to the flow balance this would provide an increased level of confidence in validity of the flow data and flow balance. Chloride was also chosen as it is typically used as an indicator of impact from urban activities, primarily from road salting but also from septic systems, so chloride could aid in verifying nitrate contribution from urban impacts.

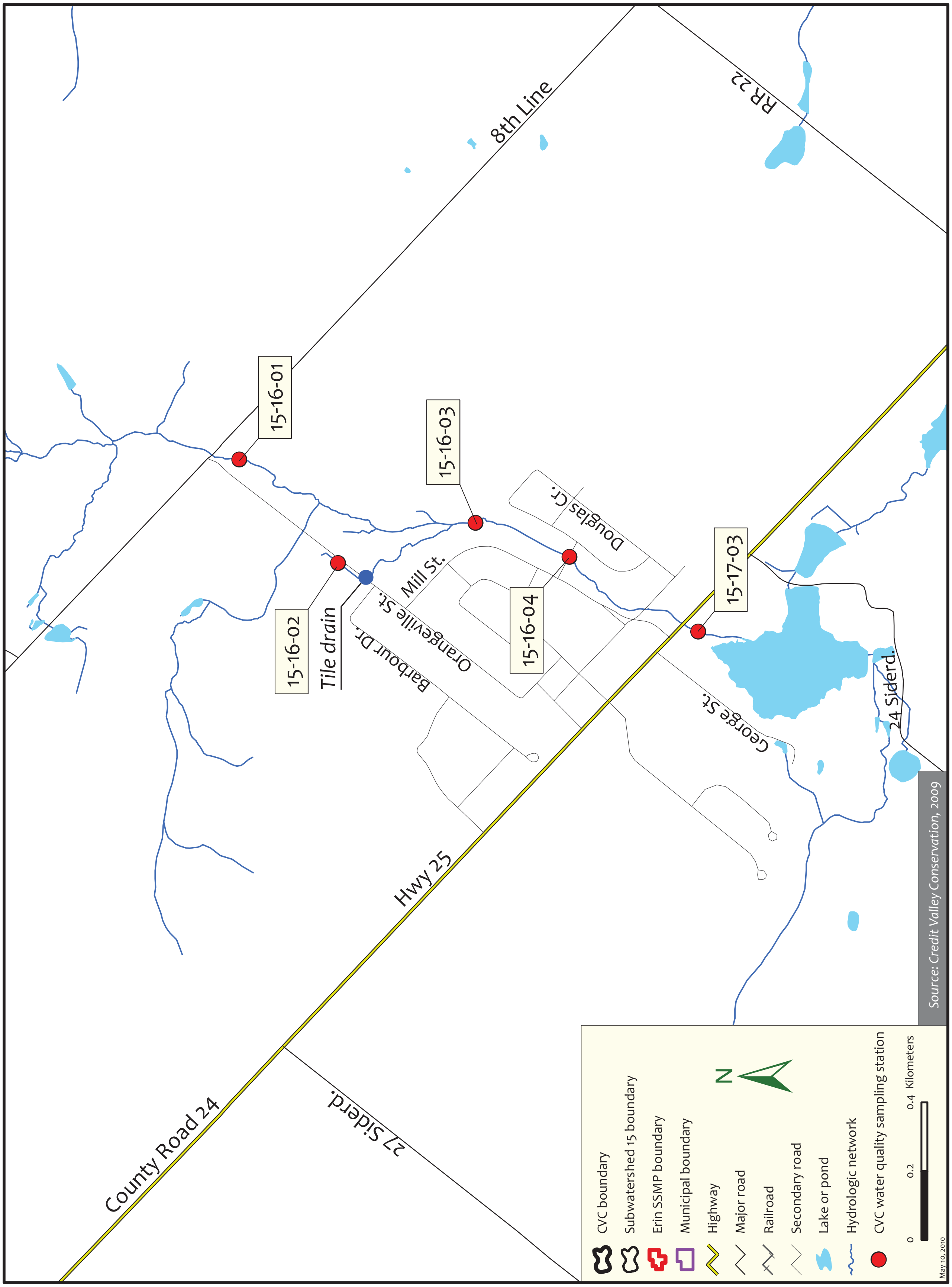
A large variation between the flow balance and mass balance could be the result of inaccurate flow measurement or the result of different source areas of groundwater inputs and outputs between the stations, where flows are being measured. This is discussed in more detail as part of the discussions for specific data sets.

The focus of the flow and mass loading assessment was the area around the Village of Erin. **Figure 2.8.4** shows the various monitoring stations in the vicinity of Erin Village used in the assessment. The locations were selected based on the data available and the potential for data from these locations to provide a reasonable water balance and mass balance. The primary locations used are located: a) upstream of Erin Village (station 15-10-02 for the SSMP study); b) in the central portion of Erin Village (station 15-08-07); c) downstream of Erin Village on the main branch of the West Credit River (station 15-04-02); d) on the northern tributary, prior to it flowing into the area downstream of the Erin urban area (station 15-08-04); and, e) on the southern tributary, prior to it flowing past the main portion of Erin Village (station 15-08-05). It is noted that the locations do not completely represent the contribution of flow and mass loading from Erin. Station 15-08-05 is downstream from several subdivisions in the southern portion of Erin Village and will represent a mix of urban and agricultural use upstream. The portion of the southern tributary between station 15-08-05 and the West Credit River, as well as the portion of the West Credit River downstream of the confluence, will likely have flow and contributions from both urban and agricultural sources.

As part of the more recent investigations, both flow and water quality data were collected from four additional stations downstream of Erin Village, previously identified in the *Draft Town of Erin Septic Investigation 2005* report by MOE et al. (2005) (**Figure 2.8.4**). The locations are near the confluence of the main branch of the West Credit River and the two tributaries converging near each other, downstream of Erin Village (stations B, C, D, and E). The rationale for the locations of the data collection and further analysis is discussed in the following subsections for each of the data sets analyzed.

As well, additional data was collected from the Hillsburgh area, to assess potential impacts from septic systems and urban land use along the section of the West Credit River that flows through Hillsburgh. **Figure 2.8.23** shows the location of sampling stations used in the vicinity of Hillsburgh. Stations 15-17-03 and 15-16-01 are located

Figure 2.8.23 Sampling Stations in the Vicinity of Hillsburgh



downstream and upstream of the core area of Hillsburgh, respectively. Additional stations were chosen for the current study to provide more detail on local flows (including local groundwater contributions or losses) and surface water quality trends in the core area of Hillsburgh. As discussed in Section 2.1, it was previously determined that there were significant changes in flow rates between the downgradient and upgradient stations, due to the presence of a large volume tile drain contributing to the upstream area and the fact that this reach of the West Credit River is a “losing stream” through Hillsburgh. As a result, less emphasis was placed on assessing the impacts of septic systems on the West Credit River given that the local groundwater contributes little, if any, to this reach of the West Credit River, although it may provide a substantial contribution further downstream of this reach. Sufficient data was collected for this study to determine if this interpretation is correct.

Data from the following data sets were analyzed with respect to mass balances and mass loadings:

- CVC 2000 flow and water quality data;
- CVC 2000 flow and water quality data, using manual and gauge flows from station 15-10-02;
- September 26, 2007 flow and water quality data;
- October 15, 2008 flow and water quality data;
- September 4, 2009 flow and water quality data; and
- September 18, 2009 flow and water quality data.

2.8.7.1 Flow and Water Quality Data – 2000

As part of the mass balance assessment, data previously collected by CVC in 2000 were re-examined. The 2000 data set is the only extensive historical data set where surface water flows and water quality data were collected for most of the CVC monitoring stations. Chloride concentrations were not obtained however, as the focus was on nutrient loading and physical water quality parameters. **Table 2.8.8** summarizes the flow data, collected by CVC on five separate occasions in the summer of 2000, and the total mass loading of nitrate, phosphorus, and TKN for five stations in the vicinity of Erin Village (see **Figure 2.8.4** for locations).

Table 2.8.8 Flow Assessments and Mass Loading Assessments from the Summer of 2000 for Stations in the Vicinity of the Village of Erin, using Flow Data collected by CVC

Column	1	2	3	4	5	6	7	8	9	10
Flow Assessment	**Date of Data Collection**	**Station 15-10-02**	**Station 15-08-05**	**Station 15-08-04**	**Station 15-08-07**	**Station 15-04-02**	**Total Combined Flow at 15-10-02, 15-08-05, 15-08-04**	**Station 15-04-02 flow compared to Stations 15-10-02, 15-08-05, 15-08-04**	**Total Combined Flow at 15-08-05, 15-08-04, 15-08-07**	**Station 15-04-02 flow compared to 15-08-05, 15-08-04, 15-08-07**
Flow (m^3/sec)	30-May-00	0.302	0.055	0.157	0.423	1.018	0.515	198%	0.635	160%
Flow (m^3/sec)	28-Jun-00	0.452	0.088	0.390	0.743	1.250	0.931	134%	1.222	102%
Flow (m^3/sec)	26-Jul-00	0.120	0.057	0.054	0.331	0.554	0.231	240%	0.441	126%
Flow (m^3/sec)	30-Aug-00	0.197	0.050	0.053	0.277	0.436	0.299	146%	0.379	115%
Flow (m^3/sec)	28-Sep-00	0.141	0.048	N/A	0.263	0.320	N/A	N/A	N/A	N/A
Mass Loading Assessment	**Date of Data Collection**	**Station 15-10-02**	**Station 15-08-05**	**Station 15-08-04**	**Station 15-08-07**	**Station 15-04-02**	**Total Mass Loading at 15-10-02 + 15-08-05 + 15-08-04**	**Mass Loading - Station 15-04-02 compared to Stations 15-10-02, 15-08-05, 15-08-04**	**Total Mass Loading at 15-08-05, 15-08-04, 15-08-07**	**Mass Loading - Station 15-04-02 compared to 15-08-05, 15-08-04, 15-08-07**
Mass Loading Nitrate (kg/day)	30-May-00	52.19	N/A	10.88	N/A	N/A	63.07	N/A	10.88	N/A
	28-Jun-00	42.96	6.88	10.11	51.37	129.55	59.95	216%	68.36	190%
	26-Jul-00	13.48	7.89	1.85	25.71	76.65	23.22	330%	35.44	216%
	30-Aug-00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	28-Sep-00	20.71	6.59	N/A	22.71	49.70	N/A	N/A	N/A	N/A
Mass Loading Phosphorus (kg/day)	30-May-00	1.04	0.38	0.54	2.19	7.04	1.97	357%	3.12	226%
	28-Jun-00	9.76	0.61	2.70	5.14	11.88	13.07	91%	8.45	141%
	26-Jul-00	0.31	0.20	0.14	N/A	1.44	0.65	222%	N/A	N/A
	30-Aug-00	0.85	0.21	0.18	1.20	1.51	1.25	121%	1.59	95%
	28-Sep-00	0.61	0.21	N/A	0.91	1.10	N/A	N/A	N/A	N/A

Column	1	2	3	4	5	6		7	8		9	10
Mass Loading Assessment	**Date of Data Collection**	**Station 15-10-02**	**Station 15-08-05**	**Station 15-08-04**	**Station 15-08-07**	**Station 15-04-02**		**Total Mass Loading at 15-10-02 + 15-08-05 + 15-08-04**	**Mass Loading - Station 15-04-02 compared to Stations 15-10-02, 15-08-05, 15-08-04**		**Total Mass Loading at 15-08-05, 15-08-04, 15-08-07**	**Mass Loading - Station 15-04-02 compared to 15-08-05, 15-08-04, 15-08-07**
Mass Loading TKN (kg/day)	30-May-00	10.44	2.86	6.80	18.27	61.56		20.10	306%		27.93	220%
	28-Jun-00	78.11	22.16	117.97	160.55	399.46		218.23	183%		300.67	133%
	26-Jul-00	7.26	3.45	3.24	17.14	23.95		13.94	172%		23.83	101%
	30-Aug-00	15.32	4.72	4.99	26.33	33.88		25.03	135%		36.04	94%
	28-Sep-00	4.87	2.06	N/A	9.09	11.04		N/A	N/A		N/A	N/A

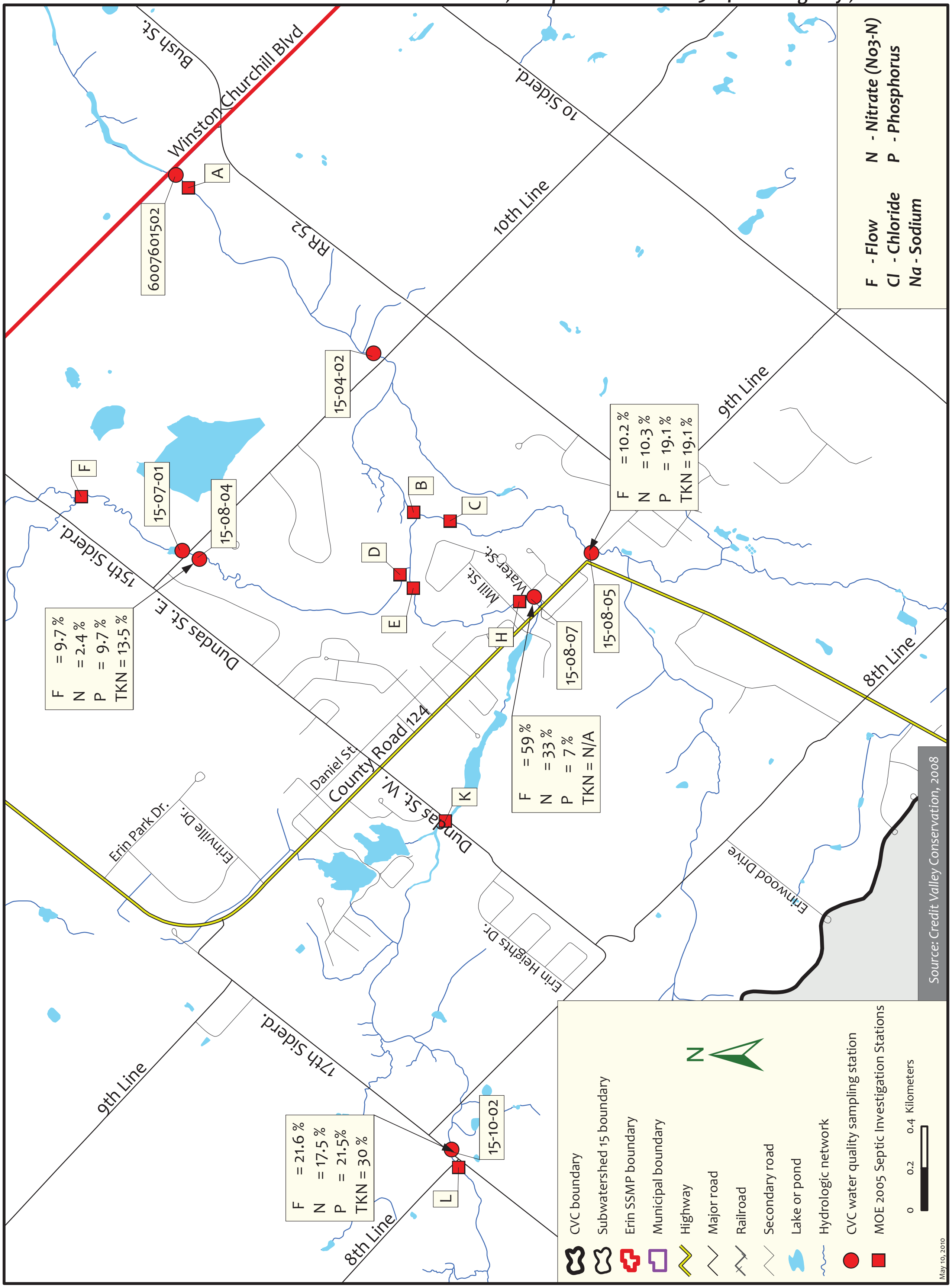
Note:

N/A = Not Available

The mass balance calculations were based on flow and water quality values obtained at each station. In the first portion of the table (Columns 1-6) total flows and mass loadings are presented for each station for the five data collection dates (note that some data are missing for specific dates so a complete analysis could not be done). In the second portion of the table (Columns 7-8) a comparison was made of flows and mass loading of each of the parameters, between the downstream station, station 15-04-02, and the sum of the upstream stations, stations 15-10-02, 15-08-05, and 15-08-04. The third portion of the table (Columns 9-10) shows a comparison of flows and mass loadings between downstream station 15-04-02 and the sum of the upstream stations 15-08-07, 15-08-05 and 15-08-04. The first mass loading comparison uses the monitoring station on the West Credit River upstream of Erin Village (station 15-10-02) while the second mass loading comparison uses the monitoring station on the West Credit River in the centre of Erin Village (station 15-08-07). The different West Credit River stations were used in the analyses to see if there was much variation in the assessment, as historical monitoring has shown a wide variation in flows between these two stations for different sampling events. The following is highlighted for the 2000 data set:

- A comparison of flows, between station 15-04-02 (downstream of Erin Village) and the total combined "upstream" flows from stations 15-10-02, 15-08-05, and 15-08-04, shows an apparent substantial increase in contribution to overall surface flow, for the main branch of the West Credit River and the downstream tributaries, within the Town of Erin. Increases in flow through Erin Village ranged from 34% to 140%, with the greatest percentage increase occurring during periods of lower flows at station 15-10-02. The results appear to show a substantial increase in baseflow through the Town of Erin from either groundwater discharge or contributions through sources such as flowing storm drains. There may be errors associated with the flow data, as will be discussed later.
- A comparison of flow values between station 15-04-02 (downstream of Erin Village) and combined upstream flows from stations 15-08-07 (in central Erin), 15-08-05 and 15-08-04 show a much closer comparison, ranging from a 2% to 60% increase at station 15-04-02, compared to the combined flow from the three upstream stations. This would indicate that there is less additional flow entering the West Credit River in the downstream portion of Erin Village (either from groundwater or stormwater discharge), compared to upstream of station 15-08-07 in the central portion of Erin.
- **Table 2.8.8** shows the percentage increase in flow and the percentage increase in mass loadings between station 15-04-02 and stations 15-10-02, 15-08-05, and 15-08-04 (Column 8). The assessment indicates a substantial increase in mass loading of nitrate between the downstream station and the combined upstream stations (i.e., the area covering most of Erin Village). **Figure 2.8.24** shows an example of the percentage of flow/mass loading at individual stations, as compared to the downstream station (station 15-04-02) using the July 2000 data to better illustrate the findings. This figure illustrates that flow at the upstream stations (15-10-02, 15-08-05, and 15-08-04) accounts for 41.5% of the flow at the downstream station (15-04-02) but the mass loading only accounts for 30.2% of

Figure 2.8.24 Percentage of Flow/Mass Loading at Individual Stations, Compared to Station 15-04-02 Using July , 2000 Data



the nitrate, indicating a higher loading of nitrate in the additional surface water flow gained through Erin Village, relative to the average mass loading from the portion of the subwatershed upstream of Erin Village.

- A comparison of the percentage increase in phosphorus mass loading typically showed a lower mass loading at station 15-04-02, relative to the percentage increase in flow, with the exception of the May 30, 2000 monitoring data. A similar pattern was noted for TKN, although the June 28, 2000 monitoring event showed a slight increase in mass loading compared to what would have been expected based on flow data and mass loading from upstream stations. This would indicate that there appears to be little difference in the average contribution of phosphorus and TKN between the Erin Village area and the average contribution from the upstream portion of the subwatershed. Variations in mass loadings are more likely related to timing of sampling events relative to rainfall events and surface runoff.

- **Table 2.8.8** also shows a comparison of flow/mass balance using station 15-08-07 in central Erin (Columns 9-10), instead of station 15-10-02, for the contribution from the West Credit River to downstream of Erin. Flow rates at this central station were substantially higher than flow rates measured at the upstream station. The flow data showed a much closer water balance for most monitoring events, between the downstream station and the combined upstream stations (Column 10), using the flows obtained from station 15-08-07. With the exception of the May 2000 monitoring event, all flows were within 26% of each other, between station 15-04-02 and the combined upstream flows (stations 15-08-07, 15-08-05, and 15-08-04) and were actually within 2% for two of the monitoring events. This would imply that there is not much additional flow contribution to the West Credit River along the East Branch in Erin Village and immediately downstream of Erin Village.

- Although the total flows, upstream and downstream of the eastern portion of Erin Village, were shown to closer in volume using station 15-08-07 there was a substantial increase in the mass of nitrate at station 15-04-02, relative to the percentage increase in total flow. **Figure 2.8.24** shows that the combined upstream flow for stations 15-08-07, 15-08-05, and 15-08-04 accounts for 78.9% of the flow at station 15-04-02 but only 45.7% of the mass of nitrate at the downstream station. This would indicate a significantly greater contribution of nitrate from the eastern portion of Erin Village compared to the average contribution from the upstream portion of the subwatershed.

- As part of this analysis, the flow data was examined in more detail, with respect to the accuracy of “spot” flow measurements at each monitoring station. Based on a review of flow data collected during other monitoring events, the percentage difference in flow between station 15-10-02 and station 15-04-02 was much greater for a number of the monitoring events in 2000. Flow data obtained for the 2000 monitoring program for station 15-10-02 was compared to flow data electronically obtained from the automated flow gauge at station 15-10-02. **Table 2.8.9** provides a summary of the flow and mass loading assessment for the 2000 data set using flows obtained from the flow gauge (02HB020) at station 15-10-02

Table 2.8.9 Flow Assessments and Mass Loading Assessments from the Summer of 2000 for Stations in the Vicinity of the Village of Erin, using Flow Data Electronically obtained by the Water Survey Canada Gauge (02HB020)

Column	1	2	3	4	5	6		7	8
Flow Assessment	**Date of Collection**	**Station 15-10-02**	**Station 15-08-05**	**Station 15-08-04**	**Station 15-08-07**	**Station 15-04-02**		**Total Combined Flow at 15-10-02, 15-08-05, 15-08-04**	**Station 15-04-02 flow compared to Stations 15-10-02, 15-08-05, 15-08-04**
flow (m^3/sec)	30-May-00	0.337	0.055	0.157	0.423	1.018		0.550	185%
flow (m^3/sec)	28-Jun-00	0.452	0.088	0.390	0.743	1.250		0.931	134%
flow (m^3/sec)	26-Jul-00	0.222	0.057	0.054	0.331	0.554		0.333	167%
flow (m^3/sec)	30-Aug-00	0.266	0.050	0.053	0.277	0.436		0.368	118%
flow (m^3/sec)	28-Sep-00	0.251	0.048	N/A	0.263	0.320		N/A	N/A
Mass Loading Assessment	**Date of Collection**	**Station 15-10-02**	**Station 15-08-05**	**Station 15-08-04**	**Station 15-08-07**	**Station 15-04-02**		**Total Mass Loading at 15-10-02 + 15-08-05 + 15-08-04**	**Mass Loading - Station 15-04-02 compared to Stations 15-10-02, 15-08-05, 15-08-04**
Mass Loading Nitrate (kg/day)	30-May-00	58.23	N/A	10.88	N/A	N/A		N/A	N/A
	28-Jun-00	42.96	6.88	10.11	51.37	129.55		59.95	216%
	26-Jul-00	24.94	7.89	1.85	25.71	76.65		34.67	221%
	30-Aug-00	N/A	N/A	N/A	N/A	N/A		N/A	N/A
	28-Sep-00	36.87	6.59	N/A	22.71	49.70		43.45	114%
Mass Loading Phosphorus (kg/day)	30-May-00	1.16	0.38	0.54	2.19	7.04		2.09	337%
	28-Jun-00	9.76	0.61	2.70	5.14	11.88		13.07	91%
	26-Jul-00	0.58	0.20	0.14	N/A	1.44		0.91	158%
	30-Aug-00	1.15	0.21	0.18	1.20	1.51		1.55	97%
	28-Sep-00	1.08	0.21	N/A	0.91	1.10		N/A	N/A
Mass Loading TKN (kg/day)	30-May-00	83.28	2.86	6.80	18.27	61.56		92.94	66%
	28-Jun-00	78.11	22.16	117.97	160.55	399.46		218.23	183%
	26-Jul-00	13.43	3.45	3.24	17.14	23.95		20.11	119%
	30-Aug-00	20.68	4.72	4.99	26.33	33.88		30.40	111%
	28-Sep-00	8.67	2.06	N/A	9.09	11.04		N/A	N/A

Note:
N/A = Not Available

for each of the sampling event days. Flows were available for four of the monitoring dates in 2000. Automated flow rates were found to be higher than the manual flows obtained during the monitoring event, ranging from 18% to 85% higher. There was still an increase in flow through Erin Village (Column 8 in Table 2.8.9) with a greater increase in nitrate mass loading relative to the percentage increase in flow (Column 8 in Table 2.8.9), although much less than using the manual flow data, as compared to the upstream portion of the subwatershed.

2.8.7.2 Flow and Water Quality Data – September 26, 2007

Flow and water quality data were collected for the four monitoring stations upstream and downstream of Erin Village. Data was collected during a period of lower flow and dry weather to better assess the contribution from groundwater baseflow to the West Credit River and its tributaries, in the vicinity of Erin Village. **Table 2.8.10** shows the flows and the mass loading estimates for chloride, nitrate, TKN, and phosphorus. It also shows a percentage comparison of upstream and downstream flows and mass loadings. **Figure 2.8.25** shows a comparison of flow and mass loading at individual upstream stations relative to station 15-04-02 downstream of Erin Village. The following is highlighted from the findings:

- The water balance shows that there appears to be only a slight gain in flow, through Erin Village showing about a 9% increase relative to the combined upstream flows.
- There is a decrease in the mass of chloride downstream of Erin Village, relative to upstream. The upstream areas contribute about 91% of the flow to downstream but contribute about 32% more chloride than can be accounted at the downstream station (**Figure 2.8.25**). Since chloride is a conservative species, the decrease in mass could represent sampling error or it could mean that there is a “mixed” source of water contributing to the downstream station. There could be a “loss” of an urban source of groundwater recharge (discharging farther downstream) and a gain in a non-urban source of water through groundwater discharge into the area upstream of station 15-04-02, providing an overall water balance but not a mass balance due to the different sources areas of water.
- There is a much greater loss of nitrate mass through Erin Village, with the mass of nitrate at the downstream station only 55% of the mass from the three upstream stations, compared to 75% for chloride mass. This would indicate that even if there is a percentage of flow that is from a different source area there is a substantial decrease in nitrate mass contribution downstream of Erin Village compared to the average mass loading in the upper portion of the subwatershed upstream of Erin Village. The most likely explanation is that denitrification is occurring in the riparian area downstream of Erin Village but upstream of station 15-04-02. This is investigated in more detail in later monitoring.
- Mass loading estimates for TKN and phosphorus show that there is an increase in both parameters downstream of Erin Village, relative to upstream contributions, although they are not high. **Figure 2.8.25** shows that there is an 18.2% increase

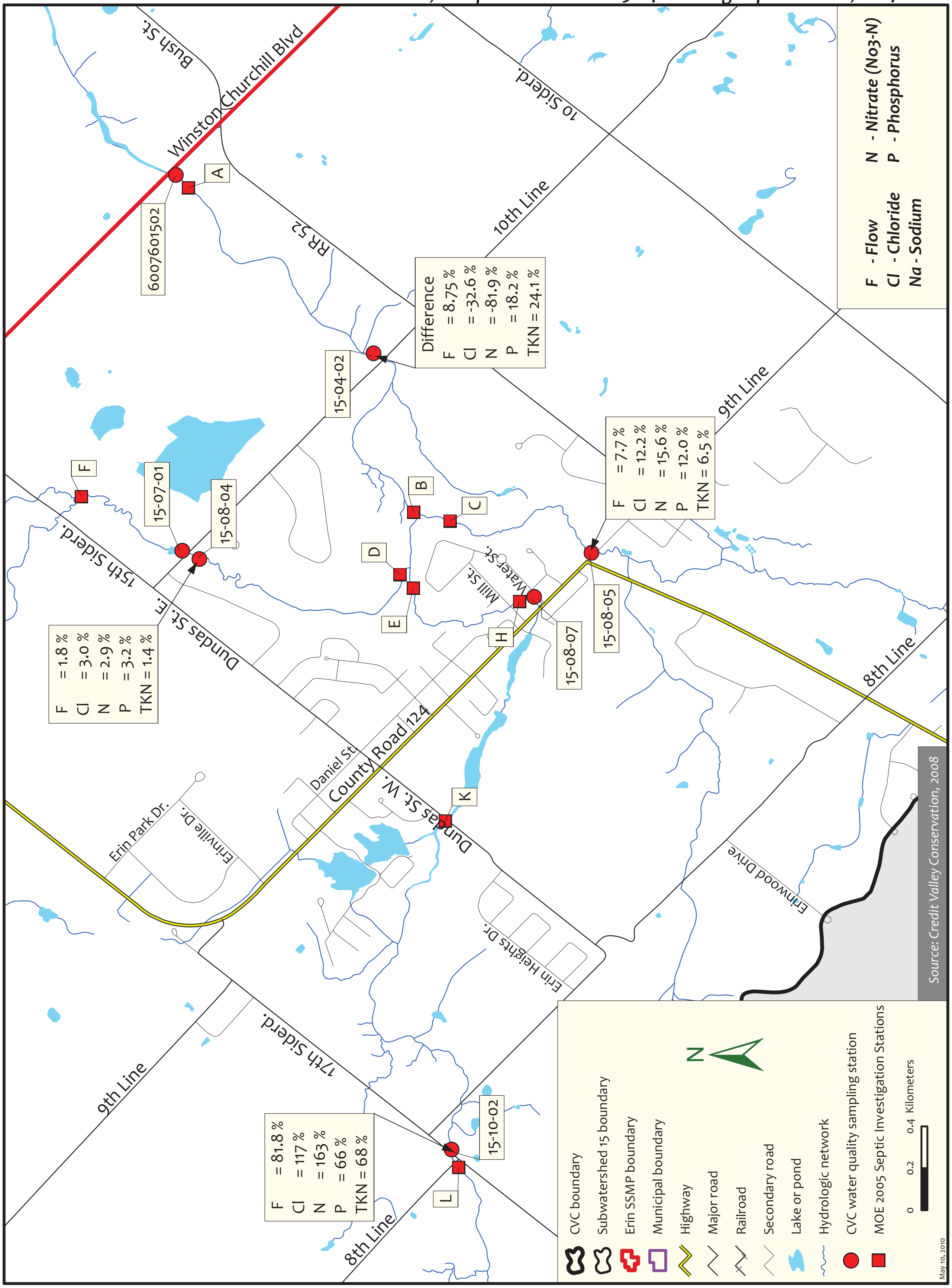
Table 2.8.10 Flow and Mass Loading Estimates for Chloride, Nitrate, TKN and Phosphorus at the CVC Stations in the Vicinity of Erin Village for September 26, 2007

	Station	Flow Data (m^3/sec)	Chloride (mg/L)	Nitrate (mg/L)	TKN (mg/L)	Total Phosphorus (mg/L)	Mass Loading Chloride (kg/day)	Mass Loading Nitrate (kg/day)	Mass Loading TKN (kg/day)	Mass Loading Phosphorus (kg/day)	Ratio Cl/N	Ratio N/P
26-Sep-2007	Station 15-10-02	0.2884	33	1.6	0.5	0.024	822.29	39.87	12.46	0.60	20.63	66.67
	Station 15-08-05	0.0275	36	1.6	0.5	0.048	85.54	3.80	1.19	0.11	22.50	33.33
	Station 15-08-04	0.0063	39	1.3	0.5	0.053	21.23	0.71	0.27	0.03	30.00	24.53
	Station 15-04-02	0.3525	23	0.8	0.6	0.030	700.49	24.36	18.27	0.91	28.75	26.67
Percent Comparison	* 15-04-02/(15-10-02 + 15-08-05 + 15-08-04)	109%					75%	55%	131%	123%		

Note:

** The percentage is the percentage of flow or mass at Station 15-04-02 as compared to the combined sum of flow or mass at Station 15-10-02, Station 15-08-05, and Station 15-08-04.*

Figure 2.8.25 Percentage of Flow/Mass Loading at Individual Stations, Compared to Station 15-04-02 Using September 26, 2007 Data



in phosphorus and 24.1% increase in TKN downstream of Erin Village, as compared to less than 9% increase in flow. Given the lower mass of chlorides and nitrate downstream of Erin it is likely that the increase is attributed to surface runoff or storm sewer contributions from the urban area.

2.8.7.3 Flow and Water Quality Data – October 15, 2008

Flow and water quality data were collected at the four MOE stations downgradient of Erin Village and at station 15-10-02 (MOE station L) upgradient of Erin Village (**Figure 2.8.4**). The MOE locations downgradient of Erin were selected to look more closely at the water balance and mass balance near the confluence of the main branch and tributaries of the West Credit River. As discussed in Section 2.8.3, flow data was not collected at the MOE stations as part of the MOE assessment. Given the proximity of the stations there is little opportunity for a substantial addition to flow volumes between stations so these monitoring locations would provide a good "check" on the accuracy of the flow measurements and balance. Results of the analysis and assessment are presented in **Table 2.8.11**. The following is highlighted from the findings:

- There is a good correlation between flows and mass loading at the MOE stations downgradient of Erin. There was a measured 10% increase in flow between MOE B and MOE C, E and D. This could indicate a minor increase in flow or just be measurement error. With the exception of TKN, the mass loading showed an increase of only 2-14% as compared to the 10% increase in flow. The results would indicate that the flow and mass balances are reasonably accurate, although they are only a "snapshot" of conditions for the specific monitoring event.
- Flow data from the West Credit River upstream of Erin (MOE L) and immediately downstream of the core area of Erin (MOE E) shows an increase in flow of about 12% in the West Credit River reach through Erin Village. There is an increase in chloride loading of about 33% indicating a substantially higher loading of chloride in Erin, compared to the average loading in the portion of the subwatershed upstream of Erin. The mass increase of sodium was similar at about 37%.
- It is noted however that there is a good correlation between flow and mass loading for sodium and chloride between the downstream monitoring station, MOE B, and the combined upstream stations, MOE L and tributary stations MOE D and MOE C. There is an 18% increase in flow and a 22% and 19% increase in chloride and sodium respectively. This would indicate that there is not a substantial difference in chloride and sodium loading through Erin, relative to the overall loading in the subwatershed upstream of Erin. Given the findings in the previous bullet, it would appear that there is potentially a mixing of groundwater from different source areas downstream of Erin (i.e., the some of the water from upstream of Erin is "lost" through Erin and additional groundwater is gained). A more complete data set was collected to assess this, and is discussed in the next section.
- The ratio of chloride to sodium is generally indicative of impacts from road salt, which has a typical chloride/sodium ratio of about 1.55. Chloride/sodium ratios

Table 2.8.11 Flow and Mass Loading Estimates for Chloride, Nitrate, TKN, Phosphorus, and Sodium at the MOE Stations in the Vicinity of Erin Village for October 15, 2008

	MOE Station	Flow Data (m^3/sec)	Chloride (mg/L)	Nitrate (mg/L)	TKN (mg/L)	Total Phosp-horus (mg/L)	Sodium (mg/L)	Mass Loading Chloride (kg/day)	Mass Loading Nitrate (kg/day)	Mass Loading TKN (kg/day)	Mass Loading Phosphorus (kg/day)	Mass Loading Sodium (kg/day)	Ratio Cl/N	Ratio N/P	Ratio Cl/Na
15-Oct-2008	**MOE L**	0.3644	33	N/A	0.5	N/A	18	1039	N/A	15.7	N/A	567	N/A	N/A	1.83
	MOE E	0.4089	39	1.8	0.4	0.013	22	1378	63.59	14.13	0.46	777	21.7	138	1.77
	MOE D	0.1414	58	1.6	0.5	0.012	35	709	19.55	6.11	0.15	428	36.3	133	1.66
	MOE C	0.1077	45	1.7	0.4	0.014	29	419	15.82	3.72	0.13	270	26.5	121	1.55
	MOE B	0.726	42	1.8	0.5	0.012	24	2635	112.91	31.36	0.75	1505	23.3	150	1.75
Perce-ntage	***B/(C+E+D)**	110%						105%	114%	131%	102%	102%			
	****B/(C+L+D)**	118%						122%		123%		119%			

Note:

N/A = Not available

** The percentage is the percentage of flow or mass at Station Erin B as compared to the combined sum of flow or mass for Stations MOE C, MOE E and MOE D.*

***The percentage is the percentage of flow or mass at Station Erin B as compared to the combined sum of flow or mass for Stations Erin C, Erin L and Erin D.*

ranged from 1.55 to 1.83. It is noted that the tributaries had the lowest ratios and also had the higher chloride and sodium concentrations, compared to the main branch of the West Credit River, indicating less dilution from non-urban impacted water.

- There is a much greater mass loading of nitrate to the West Credit River during this monitoring event as compared to the September 26, 2007 monitoring event, discussed in the previous section. Although not the same downstream locations, flow and mass loading between monitoring events for station 15-04-02 and MOE B were compared. There was an increase in flow by 105% between the September 26, 2007 monitoring event and the October 14, 2008 monitoring event. However, there was also a 363% increase in nitrate loading, with the mass loading increasing from about 24 kg/day to 113 kg/day, much greater than the can be accounted for with the percentage flow increase. The increase in mass loading is likely due to limited uptake of nitrate by plants during the October monitoring event.

2.8.7.4 Flow and Water Quality Data – September 4, 2009

A more complete set of flow and water quality data was collected in and around the villages of Erin and Hillsburgh to attempt to increase the understanding of surface water and groundwater contributions to the West Credit River through these areas. Data was collected at MOE stations downstream of Erin Village (i.e., MOE B, C, D, and E) and at CVC monitoring stations "upstream" of much of the urban area of Erin Village (i.e., stations 15-10-02, 15-08-05, and 15-08-04). A more complete set of flows and water quality was also obtained in Hillsburgh, as previous flow data indicated that this portion of the West Credit River is likely a losing stream. **Table 2.8.12** provides a summary of water quality data and mass loading for chloride, nitrate, sodium and phosphorus. To aid in the discussion for Erin Village, **Figure 2.8.26** shows a comparison of the percentage of flow and mass loading between the CVC sampling stations. **Figure 2.8.27** shows a comparison of flow and mass loading in the reaches between the CVC stations and the MOE stations. **Figure 2.8.28** presents a comparison of flow and mass loading between the stations in Hillsburgh. The following is highlighted from the findings:

- Combined total flows for the MOE stations downstream of Erin Village compare reasonably well with flow at MOE B. MOE B flow was estimated to be 86% of the flow at MOE C, MOE D, and MOE E (**Table 2.8.12**). This could mean there is some loss in flow between stations or it is measurement error as discussed in the previous section. A comparison of mass loading differences for chloride, sodium and phosphorus at the MOE stations show a very good correlation to the flow data. A comparison of combined mass loading from MOE C, MOE D, and MOE E to the mass loading at MOE B shows 83%, 89%, and 87% for chloride, sodium and phosphorus, respectively, essentially the same as the flow percentage (86%). The percentage of nitrate loading was slightly lower, at 74%, which may reflect some uptake of nitrate in the riparian zone, very locally.
- Combined flow from the upstream CVC stations (15-10-02, 15-08-05, and 15-08-04) was 97% of the total flow at MOE B (**Table 2.8.12**). Flow recorded at station

Table 2.8.12 Summary of Water Quality Data and Mass Loading for Chloride, Nitrate, Sodium, and Phosphorus for Stations in the Vicinity of Hillsburgh and Erin Village on September 4, 2009

	Station	Flow Data (m^3/sec)	Chlor-ide (mg/L)	Nitrate (mg/L)	Sodium (mg/L)	Total Phosp-horus (mg/L)	Mass Loading Chloride (kg/day)	Mass Loading Nitrate (kg/day)	Mass Loading Sodium (kg/day)	Mass Loading Phospho-rus (kg/day)	Ratio Cl/Na	Ratio Cl/N	Ratio N/P
04-Sep-2009	Station 15-10-02	0.399	29	1.7	14.9	0.011	999	59	513	0.38	1.95	17.1	155
	Station 15-08-07	0.353	30	1.2	15.3	0.013	915	37	467	0.40	1.96	25.0	92
	MOE E	0.396	36	1.5	17.9	0.010	1231	51	612	0.34	2.01	24.0	150
	Station 15-08-05	0.073	39	1.2	22.3	0.030	245	8	140	0.19	1.75	32.5	40
	MOE C	0.089	43	1.9	26.9	0.026	331	15	207	0.20	1.60	22.6	73
	Station 15-08-04	0.072	26	1.1	11.6	0.017	162	7	72	0.11	2.24	23.6	65
	MOE D	0.124	57	1.8	33.9	0.008	612	19	364	0.09	1.68	31.7	225
	MOE B	0.525	40	1.4	23.3	0.012	1814	64	1057	0.54	1.72	28.6	117
	Station 15-16-01	0.143	11	2.7	4.2	0.016	136	33	52	0.20	2.62	4.1	169
	Station 15-16-02	0.047	19	4.3	9.5	0.002	77	17	39	0.01	2.00	4.4	2150
	Station 15-16-03	0.242	16	3	6.4	0.016	334	63	134	0.33	2.50	5.3	188
	Station 15-16-04	0.165	16	2.9	6.4	0.018	227	41	91	0.26	2.50	5.5	161
	Station 15-17-03	0.139	16	3.3	6.3	0.019	191	39	75	0.23	2.54	4.8	174
Perce-ntage	* B/(C+D+E)	86%					83%	74%	89%	87%			
	* B/(15-10-02 + 15-08-05 + 15-08-04	97%					129%	87%	146%	81%			
	* 15-16-04/15-16-03	68%					68%	66%	68%	77%			
	* 15-17-03/15-16-03	57%					57%	63%	56%	68%			

Note:

** Percentage is a percentage comparison of total flow or mass at the listed stations.*

Figure 2.8.26 Percentage of Flow/Mass Loading at Individual Stations, Compared to Station MOE-B Using September 4, 2009 Data

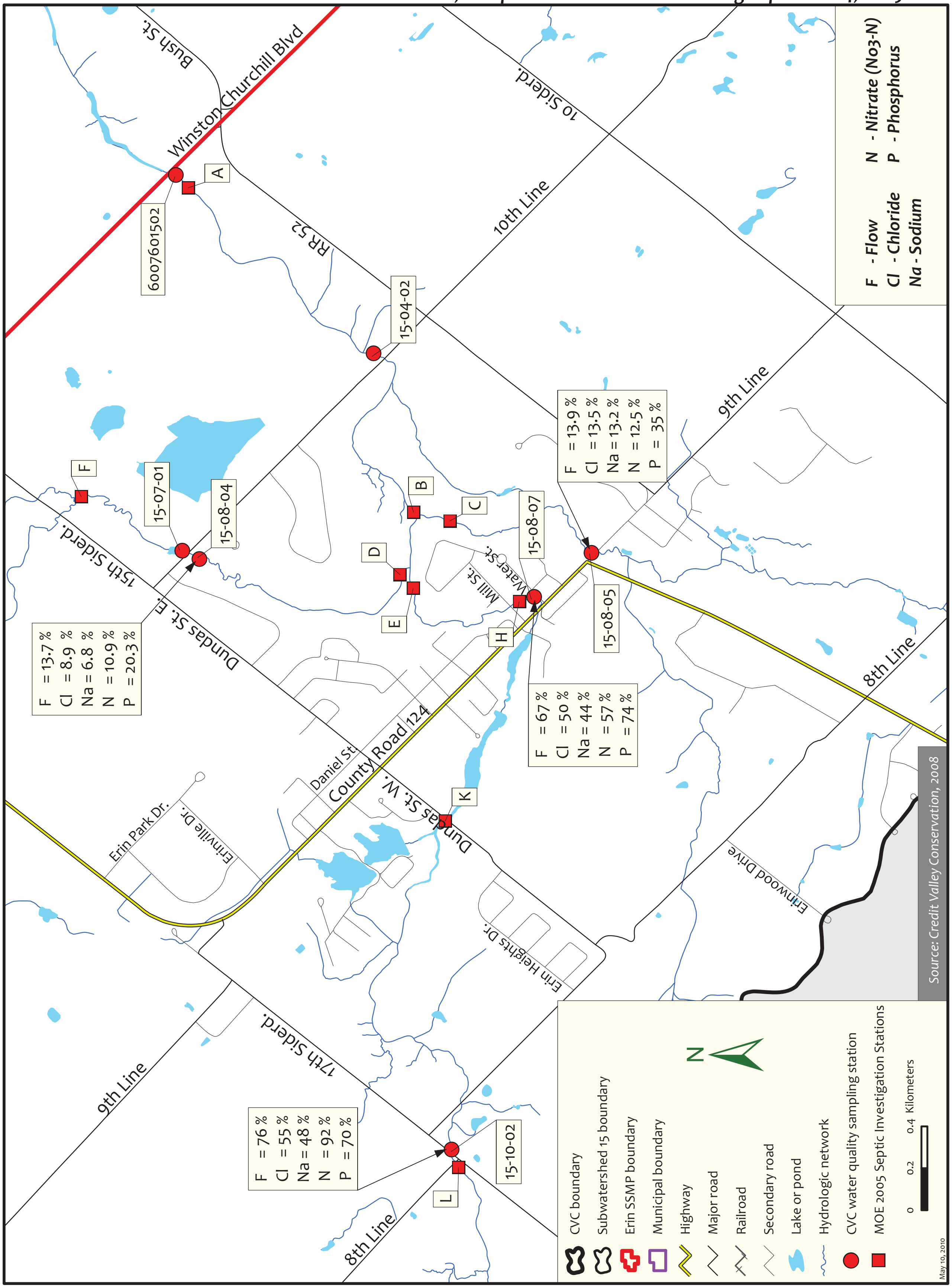


Figure 2.8.27 Comparison of Flow/Mass Loading Between Stations Using September 4, 2009 Data

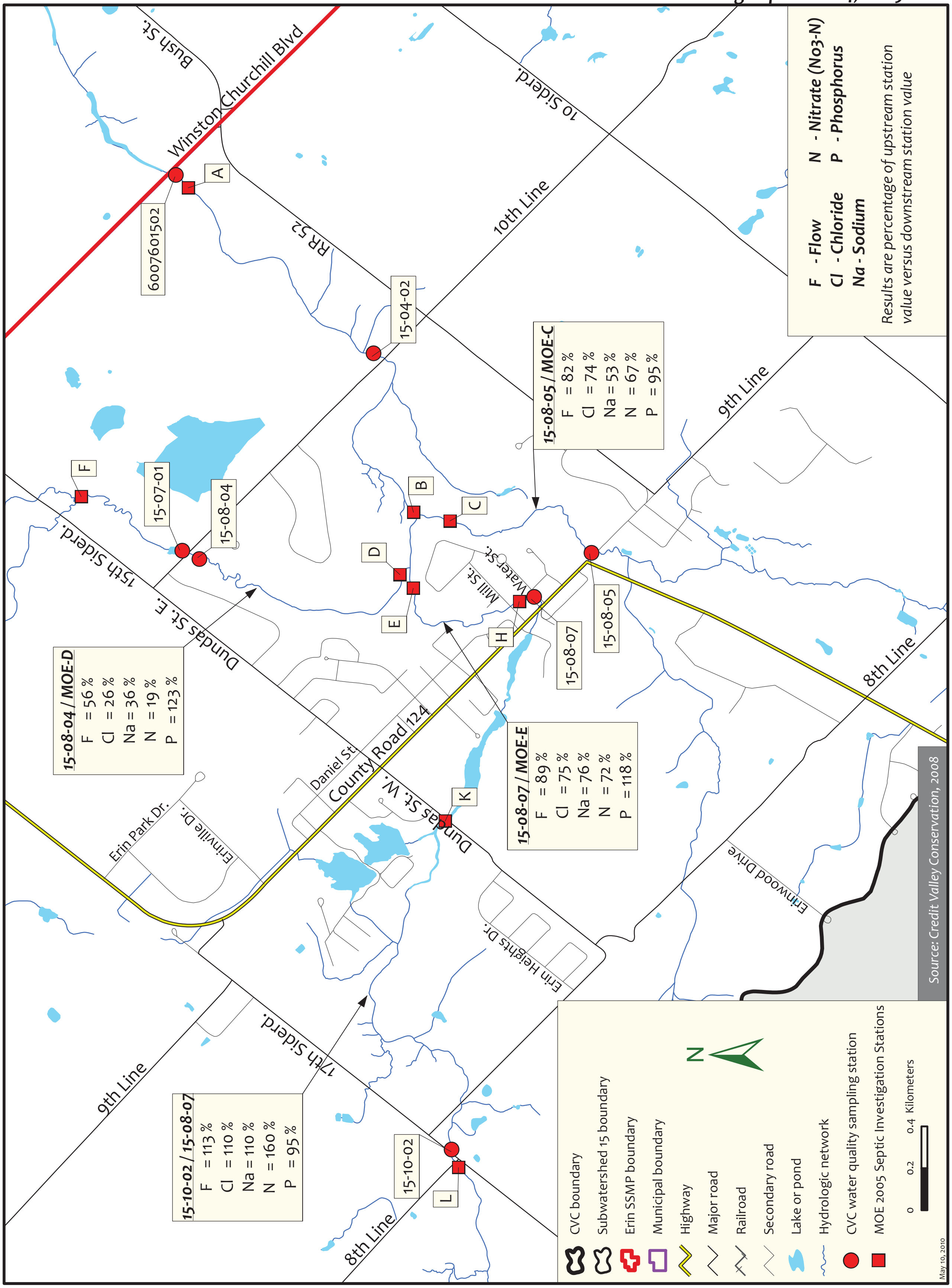
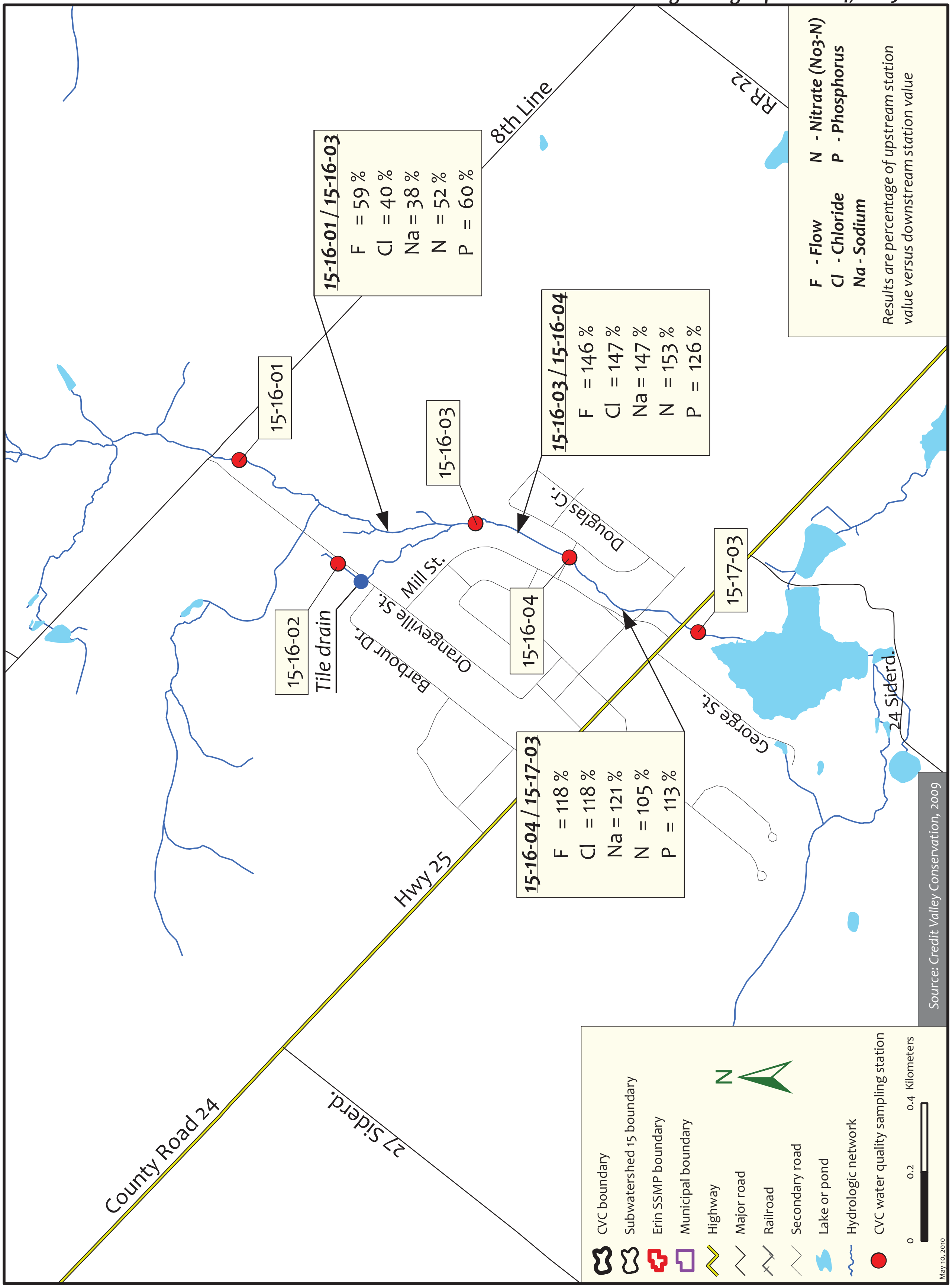


Figure 2.8.28 Comparison of Flow/Mass Loading Between Stations in Hillsburgh Using September 4, 2009 Data



E was the essentially the same as flow measured at station 15-10-02, indicating no gain in flow to the West Credit River, through the Erin Village reach. It is noted however that based on the measured flows, there is a loss of flow between station 15-10-02 (upstream of Erin) and station 15-08-07 (in the core area of Erin) and an apparent gain in flow between station 15-08-07 and MOE E.

- A comparison of mass loading differences between MOE B and the total mass loading for stations 15-10-02, 15-08-05, and 15-08-04 (i.e., the area that encompasses much of the area of Erin Village) shows a large increase in sodium and chloride loading, relative to upstream of Erin. Although there was not a measured overall increase in flow through Erin there was a 29% increase in chloride mass loading and a 45% increase in sodium mass loading through Erin. This would indicate that there are areas in Erin where there are losses of surface flows and areas where there are increases groundwater discharge, with more elevated sodium and chloride. This appears to correlate with the gain and loss in flow discussed in the previous bullet.
- **Figure 2.8.26** shows the relative contribution of flow and mass loading for each CVC station compared to MOE B, downstream of Erin Village. The results show that MOE L upstream of Erin contributes 76% of the flow to MOE B but only 55% and 48% of chloride and sodium loadings, respectively. However, the results show a 92% contribution of nitrate loading, relative to MOE B. At station 15-08-07, in the central portion of Erin, flows and mass loadings have all decreased, with the exception of phosphorus.
- A comparison of nitrate and phosphorus mass loading differences show that there is a slight decrease in mass loadings through Erin Village from station 15-10-02 to MOE E. The decrease in nitrate loading could be a reflection of nutrient uptake in the riparian zone.
- **Figure 2.8.27** shows a comparison of flow and mass loading between stations on the West Credit River and the north and south tributaries, downstream of Erin Village, to assess the loading from specific surface water reaches in Erin. Of note is:
    - The upper reach of the West Credit River (between 15-10-02 and 15-08-07) shows similar percentage contributions for flow, chloride, and sodium but a much higher contribution for nitrate upstream of the reach. Phosphorus loading is lower upstream. The reach also shows a loss in flow.
    - The downstream reach of the West Credit River within Erin Village (between 15-08-07 and MOE E), shows a gain in flow and a lower percentage contribution of chloride, sodium, and nitrate relative to flow, which would indicate higher chloride, sodium, and nitrate contributions within this reach, relative to the average upstream contribution. The exception to this is phosphorus, showing more than 100% contribution from upstream.
    - There are increased contributions of chloride, sodium, and nitrate along the reach of the northern tributary (between 15-08-04 and MOE D), compared to upstream contributions. The reach upstream of 15-08-04 contributes 56% of the flow to MOE D but only 26% of the chloride loading, 36% of the

sodium loading, and 19% of the nitrate loading. The upstream reach contributes more than 100% of the phosphorus loading to the downstream reach. This would indicate a substantially greater contribution of chloride, sodium, and nitrate locally, compared to the upstream portion of the tributary.

- There are also increased contributions of chloride, sodium, and nitrate along the reach of the southern tributary (between 15-08-05 and MOE C), compared to upstream, although there is a smaller increase in total flow and mass loading compared to the northern reach. Again, phosphorus contributions are higher in the upstream reach, compared to the reach in Erin Village.

- Flow data obtained from the Hillsburgh area show that the West Credit River is a losing stream flowing through Hillsburgh. This was discussed in previously in Section 2.1. **Table 2.8.12** shows that flows were essentially the same for stations 15-16-01, upstream of Hillsburgh and station 15-17-03, downstream of the core area of Hillsburgh, with the downstream flow measured at 97% of the upstream flow measured. Based on historical assessments of groundwater flow, additional stations were monitored in Hillsburgh as previously shown in **Figure 2.8.23**. Downstream flow (station 15-17-03) is about 57% of the upstream flow (station 15-16-03).

- The percentage difference in mass loadings for chloride, sodium, and nitrate are essentially the same as the percentage difference flow between each of the monitoring stations within Hillsburgh. **Figure 2.8.28** shows a comparison of flow and mass loading for reaches in Hillsburgh. The results show that there is a decrease in loading through Hillsburgh, which generally matches the percentage decrease in flow (from 15-16-03 to 15-16-04; and from 15-16-04 to 15-17-03). The reach upstream of Hillsburgh (from 15-16-01 to 15-16-03) shows a higher percentage upstream flow relative to the percentage contribution of mass loading of chloride, sodium, and nitrate. This reach has a major contribution from tile drainage and also is parallel to a major road, all adding to increased mass loading within this reach.

- A comparison of mass loadings for this monitoring event shows the variation between nitrate and chloride loadings moving downstream along the main Branch of the West Credit River. Nitrate and chloride loadings (per day) for the reach entering Hillsburgh were 63 kg and 334 kg respectively (station 15-16-03), while loadings for the reach leaving the core area of Hillsburgh were 39 Kg and 191 Kg respectively (station 15-17-03). Nitrate and chloride loadings for the reach entering Erin Village were 59 kg and 999 kg respectively (station 15-10-02), while loadings for the reach leaving Erin Village were 64 kg and 1814 kg respectively (MOE B).

2.8.7.5 Flow and Water Quality Data – September 18, 2009

Flow and water quality data were collected at the MOE monitoring stations in the vicinity of Erin Village. As well, a stream-bed piezometer was installed adjacent to each of the four downstream MOE monitoring locations (MOE B, C, D and E). Water quality samples were collected from the piezometers to compare the groundwater quality with the surface water quality at each of these locations. Water levels were also obtained to assess the vertical gradients at each location (i.e., determine recharge/discharge conditions). **Table 2.8.13** shows the flow data and water quality data used for the mass loading assessment. **Figure 2.8.29** shows a comparison of flow and mass loading between the MOE stations used for this monitoring event. The following is highlighted from the findings:

- The combined flows upstream of MOE B (MOE E, C, and D) compare favourably to the flow at MOE B. Flow at MOE B was about 93% of the combined upstream flow. As previously indicated that could mean a slight loss in flow or measurement error. It is noted however, water levels measured at piezometer locations MOE D, B, and C showed a downward gradient, indicating potential recharge conditions. It is also noted that there is considerable beaver activity in the area of MOE C and B resulting in surface water ponding and changes to surface water elevations. Modifications to the surface water will have an impact on the local vertical gradients which will impact groundwater recharge/discharge conditions.
- Using flow data from upstream of Erin Village (MOE L) instead of MOE E, on the main branch of the West Credit River, shows a slight decrease in flow through Erin, with the measured flow at MOE B only 88% of the combined upstream flow (MOE L, C, and D).
- Mass loading estimates show that nitrate, TKN, and phosphorus are all greater at MOE B relative to contributions from upstream monitoring stations (MOE E, C, and D). This would indicate an increased mass loading between these stations and MOE B (i.e., throughout Erin Village).
- Mass loading estimates, using upstream station 15-10-02 (MOE L) instead of MOE E on the main branch of the West Credit River, shows that nitrate and TKN contributions are lower at MOE B relative to contributions upstream of the monitoring stations. This would indicate there is a loss of nitrate and TKN along the main branch of the West Credit River between the two sampling stations on the main branch.
- **Figure 2.8.29** shows a comparison of flow and mass loading between stations. The variations along the main branch of the West Credit River show the complexity of assessing the impact of Erin Village on water quality. A comparison of the upstream station (MOE L) to the downstream station (MOE E) shows that the upstream flow is 8% higher than the downstream flow, but has a mass loading more than 60% higher than downstream for nitrate, TKN, and phosphorus, indicating a substantial loss in mass in this reach through Erin Village.

Table 2.8.13 Summary of Water Quality Data and Mass Loading for Chloride, Nitrate, TKN, and Phosphorus for Stations in Erin Village on September 18, 2009

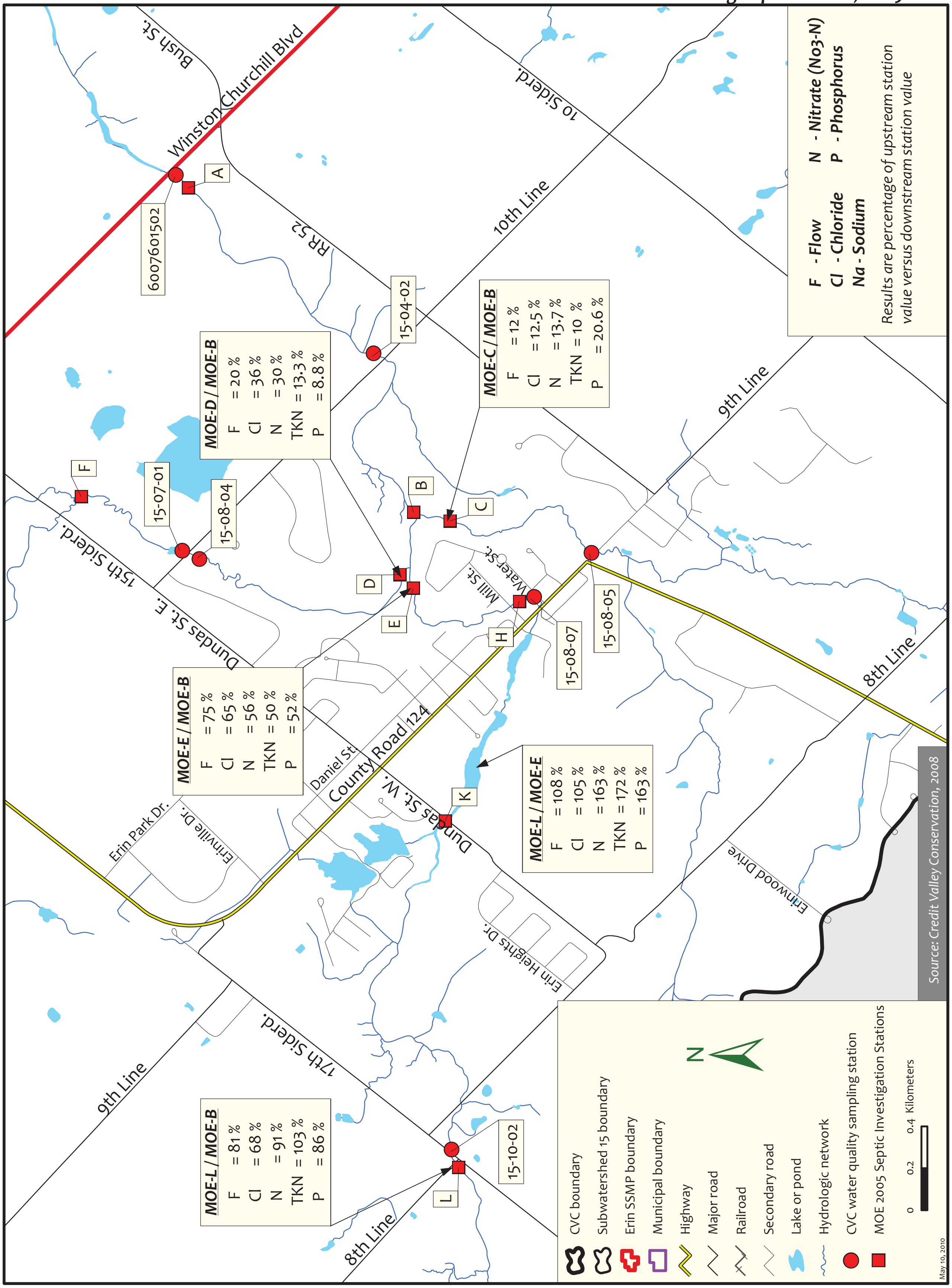
	Station	Flow Data (m^3/sec)	Chlo-ride (mg/L)	Nitrate (mg/L)	TKN (mg/L)	Total Phosph-orus (mg/L)	Dissolved Phosph-orus (mg/L)	Mass Loading Chloride (kg/day)	Mass Loading Nitrate (kg/day)	Mass Loading TKN (kg/day)	Mass Loading Phosphorus (kg/day)	Ratio Cl/N	Ratio N/P
18-Sep-2009	**Station 15-10-02 (MOE L)**	0.3778	32	1.8	0.8	0.018		1045	58.8	26.11	0.59	17.78	100.00
	MOE E	0.35	33	1.2	0.5	0.012		998	36.3	15.12	0.36	27.50	100.00
	MOE D	0.0928	70	2.4	0.4	0.007		561	19.2	3.21	0.06	29.17	342.86
	MOE C	0.0565	39	1.8	0.5	0.028		190	8.8	2.44	0.14	21.67	64.29
	MOE B	0.4643	38	1.6	0.6	0.017		1524	64.2	24.07	0.68	23.75	94.12
	MOE E - piezometer	NA	56	1.1	7	5.5	ND						
	MOE D - piezometer	NA	49	ND	17	23	ND						
	MOE C - piezometer	NA	51	ND	11	12	ND						
	MOE B - piezometer	NA	43	ND	3	2.5	0.17						
Percen-tage	*** B/(C+E+D)**	93%						87%	100%	116%	123%		
	*** B/(L+D+C)**	88%						85%	74%	76%	87%		

Note:
NA = Not Applicable
ND = Not Detected

The highlighted cells indicate that the analyses are from unfiltered samples.

** The percentage is the percentage of flow or mass at MOE B as compared to the sum of the listed stations.*

Figure 2.8.29 Comparison of Flow/Mass Loading Between MOE Stations Using September 18, 2009 Data



- **Figure 2.8.29** also shows the variation in flow and mass loading between the two tributaries downstream of Erin Village. The south tributary (MOE C) was only 12% of the flow at MOE-B and had similar percentages of mass loadings as the flow percentage, with the exception of phosphorus which had a much higher contribution from upstream. In contrast, the northern tributary (MOE D) provided 20% of the flow at MOE B but also provided 36% of the chloride mass loading and 30% of the nitrate loading, indicating a significant source contribution to the water quality impacts on the West Credit River, along this reach. The percentages of TKN and phosphorus loadings however, were much lower than the flow percentage.
- Water quality data was collected from stream-bed piezometers installed in the shallow groundwater zone at each of the four downgradient MOE stations to compare to the water quality at the adjacent MOE surface water stations. At the time the water quality data was collected three of the four locations showed a downward gradient indicating recharge conditions. MOE E showed a slight upward gradient, indicating groundwater discharge conditions. MOE E and MOE C showed higher chloride concentrations in the groundwater than the surface water. MOE D showed a much higher chloride concentration in the surface water compared to the groundwater. It is interpreted that elevated chloride in the surface water along the northern reach is likely from groundwater discharge immediately upstream of MOE D as discussed in the previous section.
- There was only one groundwater location that that had detectable nitrate, at the MOE E piezometer. It also had the highest chloride concentration and was the only location showing groundwater discharge conditions. The nitrate concentration was 1.1 mg/L, which was lower than any of the surface water nitrate concentrations. It is interpreted that there is considerable denitrification occurring or uptake by plants throughout the riparian area downstream of Erin Village.
- Dissolved phosphorus was non-detectable at three of the groundwater locations but was found a 0.17 mg/L at MOE B piezometer, an order of magnitude higher than the surface water concentration at this location. It is noted that analyses were also conducted on unfiltered groundwater samples, which often have a high turbidity from suspended sediment when sampling piezometers installed in locations with organic material and some fine-grained sediments. Results for unfiltered samples show high phosphorus, ranging from 2.5-23 mg/L in these samples, indicating the extent of phosphorus present in some of the fine-grained sediment or organic material.

2.8.7.6 Summary of Findings from Mass Balance/Loading Assessments

The following summarizes the findings and interpretations of the mass balance and loading assessments for the specific monitoring events discussed in the previous sections. It is recognized that there is variability in the results as all of the events are “snapshots” over time. There appear to be some general findings based on the assessment of all of the information and these are highlighted below.

Hillsburgh

The West Credit River is a losing stream through the main core area of Hillsburgh. Historically, data has been collected at stations 15-16-01, upstream of Hillsburgh near the 8th Line, and at station 15-17-03, downstream of Hillsburgh near Highway 25. Flows were similar at these locations and there was a slight increase in mass loading moving downstream. Flow leaving Hillsburgh was only about 57% of the flow in the West Credit River entering Hillsburgh. Percentage mass contributions of sodium and chloride were both about 57% while both nitrate and phosphorus were slightly higher indicating a small potential contribution to mass loading in Hillsburgh, likely from stormwater.

Main Branch of the West Credit River in Erin Village

Results of monitoring events at stations along the main branch of the West Credit River show variable flows and mass loadings. Some flow data show consistent gains in flow through Erin Village while other sets, especially during lower flow periods show local losses and gains to flow along the main branch. For some events there is a loss of chloride and sodium and for other events there is a gain in chloride and sodium. This would indicate that there are different source areas contributing directly to the West Credit River at different times. It would also indicate there are areas where surface water is lost to the groundwater system under certain conditions, likely during low flow. Analysis of the data collected for the current study shows a decrease in nitrate contribution along the main branch of the West Credit River as mass loading of nitrate was lower downstream (above the confluence of the tributaries) compared to upstream. This data were collected during the growing season however and may reflect uptake of nitrate in the riparian zone along the West Credit River.

It is noted that for the one major sampling event (September 4, 2009) conducted for this study the mass loading of nitrate was almost unchanged from just upstream of Hillsburgh (63 kg/day at station 15-16-03) to downstream of Erin Village (64 kg/day at MOE B). Chloride mass loading increased from 334 kg/day to 1814 kg/day between the same stations, factor of 5.4 times increase while flow only increased by a factor of 2.2.

Phosphorus and TKN are highly variable and appear to reflect loadings primarily surface runoff and suspended solids associated with surface flows.

Northern Tributary Reach in Erin Village

The northern tributary flows into the main branch of the West Credit River downstream of Erin Village contributes on the order of 20% of the flow to the West Credit River at this location but contributes a much greater percentage mass loading of chloride, sodium, and nitrate, relative to the flow contribution. It also appears to contribute a lower percentage of phosphorus mass loading relative to the flow contribution.

The reach of the northern tributary upstream of station 15-08-04 typically contributes a much smaller percentage of mass loading of chloride and nitrate relative to the percentage contribution of flow within the tributary.

Flow increases by almost 50% in the reach of the northern tributary that flows through Erin Village. Much of this increase is interpreted to be from local groundwater discharge or stormwater contribution from the urban area of Erin. It is interpreted that there is substantial loading of chloride, sodium, and nitrate to this reach as a result of urban activities, including septic systems. The relative contribution is much greater than the average contribution to the main branch of the West Credit River upstream of the confluence with the northern branch, at least during certain times of the year. There is no winter data available to assess mass loadings in the winter.

Southern Tributary Reach in Erin Village

The southern tributary flows into the main branch of the West Credit River downstream of Erin Village and the confluence with the northern tributary. The reach of the southern tributary that was assessed and considered primarily urban, with some agricultural contribution, was downstream of station 15-08-05. It is recognized that there is some urban area upstream of this station. One of the urban areas has only recently been developed and was previously agricultural with historically high nitrate loadings. There is also an aquaculture operation upstream of this station, so there is a mix of land use contributing to the loadings at station 15-08-05.

Upstream flows at station 15-08-05 were typically on the order of 10% of the flow in the main Branch of the West Credit River, downstream of Erin (MOE B). Results showed variable mass loadings from upstream but nitrate loadings were typically similar to the percentage contribution of flow, with the exception of one very low flow event, where nitrate contribution was higher upstream. Phosphorus contributions from upstream of station 15-08-05 were consistently higher than the percentage contribution of flow to the West Credit River.

Contribution from the entire southern tributary to the West Credit River appears to show similar overall mass loadings relative to the upstream area of the West Credit River, with a similar percentage of flow contribution relative to percentage mass contribution for chloride and nitrate, but again much higher for phosphorus.

Data from upstream (15-08-05) and downstream (MOE C) of the primarily urban reach on the southern tributary showed that there was a substantially greater percentage mass loading of chloride, sodium, and nitrate relative to the percentage increase in flow for this reach, again showing a substantial impact from urban activities on this reach of the tributary, at least during the summer months.

2.8.8 Summary of Septic System Impact Assessment

General Impacts of Septic Systems

- A number of contaminants are generated in the wastewater stream going into a septic system. The most prevalent contaminants of concern, with respect to groundwater contamination and potential loading to surface water, are nutrients (nitrogen and phosphorus), pathogens, and dissolved inorganic constituents such as chloride and sodium. Heavy metals and organic compounds may also be a concern, depending on the concentrations present within site-specific septic effluent.
- Most contaminants can be removed to substantially lower concentrations in a properly functioning septic system.
- Properly functioning septic systems and soil zones beneath the septic field beds will effectively treat or remove most chemical constituents from septic effluent. Typically, almost all fecal coliform bacteria are removed (>99.99%), almost all organic chemicals such as solvents and pesticides (>99%) and most phosphorus (typically 85-95%), however only about 10-20% of nitrogen is removed (EPA 2002). Total nitrogen, primarily ammonia, is quickly converted into nitrate within the shallow soils under the septic leaching bed making nitrate one of the key parameters of concern.

Summary of Interpretation of Septic System Impacts in the Town of Erin

- The existing municipal wells show no apparent impact from septic systems and appear to be well protected. Some historical locations of abandoned municipal wells in the eastern portion of Erin Village did appear to show water quality impacts from septic systems. These wells were located in areas with little natural protection of the aquifer.
- Historical water quality data downgradient of Hillsburgh, along Highway 25, shows elevated levels of nitrate and chloride (still meeting Ontario Drinking Water Objectives) in the shallow and deep groundwater zones indicating urban impacts and potential impacts from septic systems.
- Historical water quality data show only a slight increase in nitrate concentration over time at the Provincial Water Quality Monitoring Network (PWQMN) station, downstream of Erin Village. Nitrate concentration increased from about 1.5 to 1.75 mg/L downstream of Erin Village, from 1992 to 2008, while the nitrate concentrations increased from about 1.2 to 1.7 mg/L upstream of Erin Village during the same time.
- Multiple potential sources of nitrate make it difficult to determine if the increase in nitrate concentrations is from septic systems only based on general water quality trends at the PWQMN station. It is difficult to determine the source of nitrate so other indicators of urban impacts need to be used to aid in determining if the source of nitrate is from septic systems.

- Chloride is a useful indicator of urban impacts. Chloride concentrations and mass loading to the West Credit River have increased considerably during the last 20-30 years of monitoring, at a much faster rate than nitrate.
- Chloride is a conservative species whereas nitrate concentration and mass loading can be affected by denitrification and uptake by plants during the growing season. This will impact nitrate concentrations and mass loading. Long-term data indicate that there is a greater difference in nitrate concentration between summer and winter data than then the increase in nitrate concentration for data collected during the summer over the 20-30 years of data collection
- A snapshot of mass loading of nitrate, chloride, and phosphorus from upstream of Hillsburgh to downstream of Erin Village, for a 2009 monitoring event, shows little increase in nitrate mass loading. Nitrate mass loadings were 63 kg/day upstream of Hillsburgh, 59 kg/day upstream of Erin Village, and 64 kg/day downstream of Erin Village. Phosphorus mass loadings were 0.33 kg/day, 0.38 kg/day, and 0.54 kg/day for the same locations. In contrast chloride mass loadings were 334 kg/day, 999 kg/day, and 1814 kg/day for the same locations. It is obvious that chloride loadings reflect the impact of urbanization. Phosphorus may reflect some impact from urbanization, but not likely from septic systems. Nitrate mass loadings do not reflect any greater impact from above Hillsburgh to below Erin Village. It is interpreted that there is considerable uptake of nitrate and/or denitrification throughout the length of the riparian system on the West Credit River. A sampling event at the same locations in the winter may provide more representative results with respect to nitrate loading to the West Credit River.
- Data collected for the present study does show that there are relatively higher impacts from urban activity, including septic systems, on reaches of both tributaries downstream of Erin Village immediately adjacent to the urban area. There is typically a much higher percentage of mass loading of nitrate and chloride, relative to the percentage increase in flow, compared to the main branch of the West Credit River. The highest nitrate and chloride concentrations are found in the reach along the northern tributary.
- Phosphorus concentrations and mass loadings are high and appear to reflect contributions from surface runoff loadings rather than septic systems. There has been no apparent historical increase in concentration over time, in the upper portion of the West Credit River. Monitoring stations in areas upstream of Erin Village, on the main branch and the two tributaries, typically show a higher percentage of phosphorus mass loadings relative to the percentage contribution of flow to the area downstream of Erin Village.
- Limited data collected from the shallow groundwater system downgradient of Erin Village shows very little nitrate present in the groundwater zone, with three of four shallow piezometers showing no detectable nitrate. The nitrate concentration in the other piezometer was less than the surface water concentration of nitrate at all four stations. This would indicate little impact

from groundwater with respect to nitrate loading in the riparian zone downstream of Erin Village. It is noted however that, there was generally a downward gradient (recharge to the groundwater system) in this area during the monitoring event. No data was collected in the winter to determine the potential for nitrate loading during periods of higher water levels and no use of nitrate by plants during the non-growing season.

2.8.9 Next Steps

Data collected to date to assess the potential impacts from septic systems and urban land use in general, on water quality in the West Credit River subwatershed have not been conducted in any detail during the winter months. Nitrate concentrations are known to be much higher in the winter time, likely due to less uptake by plants and less denitrification in the riparian zone, especially downstream of Erin Village. Collection of flows and water quality data in the winter, at the monitoring stations around Erin Village would aid in assessing nitrate loading and changes to concentration, downstream of Erin Village.

Additional data could be collected at site-specific locations to potentially determine the source of nitrate with a greater degree of confidence. This could include isotope analyses as well as trace contaminants such as caffeine. Potential areas include immediately upstream of Hillsburgh, downstream of the core area of Hillsburgh (in private wells along Highway 25) and downstream of Erin Village, along the two tributaries.

Additional flow data should be collected from the monitoring stations around Erin Village as it is important to understand the variations in local flow within and downstream of Erin Village under different flow conditions. Based on the existing data there are times when there some reaches are gaining streams and some are losing streams. The timing and location of these variations will potentially influence any decisions on future inputs to the West Credit River as part of any servicing option.

Data collected from the present study indicate that the reach of the West Credit River through the core area of Hillsburgh is a losing stream. The general groundwater flow system is to the south-southeast away from the core area and away from the municipal wells. Historical groundwater quality data indicate the potential impact from septic systems downgradient of the core area of Hillsburgh, along Highway 25, showing elevated nitrate and chloride in this area. This should be investigated in more detail, given the number of private water supplies located in this area.

The assessment of the groundwater analysis (septic system impact) must be combined with the other component studies to determine the overall sensitivity of the environmental features, functions, and linkages within the Town of Erin. This analysis will form the basis for the assessment of potential impacts and opportunities for future land use changes and servicing.

2.9 SUMMARY OF ENVIRONMENTAL COMPONENTS

The following summary will provide an overview of the environmentally significant features, functions, and linkages throughout the Erin SSMP study area. The environmental disciplines discussed in Section 2.0 are integrated below to illustrate how each component is essential in order for the entire system to function in a sustainable manner.

The physiographic features of the West Credit River subwatershed include the pervious soils which dominate among wetland and depressional storage features associated with the hummocky terrain. These features are a major influence on the groundwater recharge and discharge throughout the study area. The subwatershed contains three main recharge areas, the Orangeville Moraine, the outwash gravels, and the Paris Moraine which have a high infiltration capacity. This allows the majority of the mean annual precipitation to infiltrate into the groundwater aquifers, such as the main bedrock aquifer system that is found throughout the entire study area. The high recharge rates are also important for providing significant baseflow to the West Credit River through groundwater discharge. As a result, baseflows at the Erin Branch Water Survey of Canada gauge station (02HB020) are higher compared to other headwater areas in the Credit River watershed.

The physiographic features of the study area also benefit the geomorphic conditions of the West Credit River and its tributaries. During storm events the permeable soils and hummocky topography facilitate water percolation into the ground, reducing runoff to the streams and reducing the erosive capacity of peak flows. This contributes to the geomorphic conditions observed in many of the channel reaches which are considered to be stable or moderately stable with little erosion and infrequent flooding. Peak flows are further subdued as a result of the numerous online ponds, which provide temporary storage but also interfere with the sediment transport process. Therefore, aggradational channel conditions are common upstream of these ponds, and sediment starved conditions are common downstream of these ponds. The most sensitive stream channels to increased flows are those where current and historic signs of stress (erosion) are apparent. These are typically stream channels where land use (e.g., urbanization) impinges upon the floodplain, such as along the West Credit River in Hillsburgh. Planform adjustment is also common throughout the subwatershed especially as these previously straightened channels seek to regain a meandering form.

The stability of the stream channels is also a reflection of the largely intact vegetated riparian zone, where many of the wetland complexes, woodlands, and natural areas are found along the floodplain of the West Credit River and its tributaries. The riparian zones and wetland communities are very dependent on the hydrologic regime for their functions and are the most sensitive to changes in that regime. The other sensitive terrestrial components include the 125 large natural areas throughout the subwatershed and three regionally rare fen communities which provide habitat for provincially and regionally rare flora and fauna species. There are six Environmentally Sensitive Areas, one Provincially Significant Life Science Areas of Natural and Scientific Interest (ANSI), and two Regionally Significant Life Science ANSIs. These areas are considered significant for providing substantial hydrological function to the West Credit River, such as headwater protection, groundwater recharge/discharge areas, and supporting large wetland complexes such as the five Provincially Significant Wetlands in the subwatershed. These wetland complexes also contribute significant hydrological function to the subwatershed such as flood attenuation, water quality improvement, groundwater recharge and discharge, and contributions to baseflow.

There are significant groundwater discharges contributing to baseflow in the West Credit River and thus the quality of the groundwater is important as it strongly influences stream health. Generally the groundwater quality is good with some indication of impacts from surface sources. The piezometers installed into the shallow groundwater system downstream of Erin Village in September of 2009 showed very little nitrate present in the groundwater zone, with three of four shallow piezometers showing no detectable nitrate. It is noted however that, there was generally a downward gradient (recharge to the groundwater system) in this area during the monitoring event. In contrast, there is historical evidence of shallow groundwater contamination from urban and septic system sources of chlorides and/or nitrates, specifically in areas where there is a higher aquifer vulnerability to contamination such as in the eastern and southern portion of Erin Village and in the southern portion of Hillsburgh. The deep groundwater zone in Erin and Hillsburgh also shows evidence of impact from surface sources with elevated chloride, however elevated nitrate levels were found only in Hillsburgh. Despite these pockets of groundwater contamination, the source of municipal drinking water for the Erin and Hillsburgh Villages (the bedrock aquifer), appears to be reasonably well-protected by natural geologic conditions providing good water quality to the current wells (Wells E7, E8, H2, H3) and showing no apparent impacts from septic systems.

However, the impacts from urban and septic system sources mentioned above are evident in the streams. Reaches of both tributaries downstream of Erin Village immediately adjacent to the urban area are showing relatively higher impacts than the main branch of the West Credit River. There is typically a much higher percentage of mass loading of nitrate and chloride, relative to the percentage increase in flow, with the highest nitrate and chloride concentrations found in the reach along the northern tributary. Of the nitrate, chloride, and phosphorus mass loading analysis on the main West Credit River from upstream of Hillsburgh to downstream of Erin Village only chloride loadings obviously reflected the impact from urbanization. The increase in phosphorus mass loadings appeared to reflect contributions from surface runoff loadings rather than septic systems. The minor increase in nitrate is interpreted to be due to the considerable uptake of nitrate and/or denitrification occurring in the stream riparian corridors.

The surface water quality in the upper portion of the study area is fair in terms of impact to the health of aquatic biota. This lower ranking is the result of elevated levels of bacteria, total phosphorus, and nitrate-nitrogen. In addition, the West Credit River through Hillsburgh is a losing stream, thus reducing its assimilative capacity. In the mid-portions of the study area the water quality ranking improves as downstream stations with significant groundwater discharge contribute to higher flows, which increase the streams ability to assimilate contaminant inputs. In the Villages of Hillsburgh and Erin, the influence of roads, septic systems, and urban land use with higher population density is apparent because median concentrations of total phosphorus, bacteria, and nitrate are higher than in rural areas. Downstream of the Village of Erin, at 10th Line, the water quality improves once again as a result of significant groundwater discharge into the West Credit River. This indicates that throughout this subwatershed the quantity of groundwater discharges contribute significantly to improving the surface water quality.

The surface water quality is a reflection of the aquatic biota found throughout the subwatershed, in combination with but not limited to other factors such as peak and baseflows. Benthic invertebrate abundance and diversity were found to decrease as mean particle mobility increased. Therefore the stable or moderately stable channel reaches throughout the subwatershed, as mentioned previously, benefit the benthic communities which were found to be generally healthy. The few impacted benthic sites found are a result of impoundments and/or agricultural activities but their impacts reach beyond benthics, also influencing the fisheries.

The West Credit River subwatershed is managed for its potential for brook trout habitat, a coldwater heritage species. The reach upstream of Erin Village is influenced by wetlands and online ponds, and water temperature results indicate warmer water in these areas. Thus fish health was found as poor and declining with some recovery indicated in the last three years. Fish health was also found as poor within the Village of Erin, likely a result of urban runoff contributing to the warm water temperature and fair water quality found here. Downstream of the Village of Erin fish health is good with stable or increasing health, likely attributed to increased groundwater contributions here. This is also the most productive brook trout spawning area as this is the longest reach in the subwatershed uninterrupted by dams/barriers. The Stanley Park dams represent the most significant barriers at a subwatershed scale. Mitigation, by-pass, or removal of these dams would improve the resiliency of this brook trout population and improve the assimilative capacity of the river.

In conclusion, the Erin SSMP study area appears to be relatively healthy and productive, despite some signs of impacts from septic systems, urbanization, and agriculture. During the process of determining community planning and municipal servicing alternatives it is important to keep in mind that watershed ecosystem health depends on maintaining the form and functions of key natural attributes and functions. The overall sensitivities of the features, functions, and linkages within the Erin SSMP study area need to be determined in order to assess the potential impacts from future land use changes and servicing. Details of the next steps to determine the overall sensitivities and to complete the impact analysis for each discipline can be found at the end of their sections.

3.0 NEXT STEPS

The information from this Environmental Component-Existing Conditions Report will be integrated with the Town of Erin's *Erin SSMP Phase 1 Background Issues Report* to describe the existing environmental conditions and identify limitations and sensitivities (Triton Engineering Services Limited 2008). The preparation of the *Erin SSMP Phase 1 Background Issues Report* will integrate all four of the components (Community Design, Form and Function Component; Community Planning Component; Environmental Component; and Water and Wastewater Servicing, Transportation and Stormwater Management Component) and will provide the information required to formalize a problem/opportunity statement. Where data gaps are identified in Phase 1, the development and completion of a supplementary work program to fill critical data gaps will be required prior to undertaking Phase 2 activities (Triton Engineering Services Limited 2008).

During Phase 2, the Phase 1 results will be used to identify and evaluate various community planning and servicing alternatives in concert with environmental considerations and opportunities for public input. The alternatives will then be evaluated, and the preferred planning and servicing concepts will be selected and incorporated into the SSMP Report for the study area. After community review of the plans, the recommended plans will be presented to Erin's Council for adoption, with the Servicing Component also being taken to Council for approval. Any related amendments to the Official Plan and other relevant planning documents, will also be brought forward for approval at that time.

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APPENDIX A:
Glossary and Acronyms

Phase 1 -
Environmental Component -
Existing Conditions Report

For The

Erin Servicing and Settlement Master Plan

Prepared for:

County of Wellington
Town of Erin

Prepared by:

Credit Valley Conservation

May 2011

GLOSSARY AND ACRONYMS APPENDIX

7Q20 - The lowest mean flow for 7 consecutive days that has a 20 yr recurrence interval period, or a 1 in 20 chance of occurring in any one year.

Abiotic - Not relating to living things.

Adjustment - A stream condition where the stream channel is considered unstable. The channel morphology is not within the consensual range of variance and evidence of instability is wide spread. The RGA Form Stability Index Value for a stream in Adjustment is > 0.4.

Aggradation - To fill and raise the level of (the bed of a stream) by deposition of sediment.

Alluvial channel - Is a river channel cut in sediment deposited by flowing water; it is self-forming, in that its form reflects the load and discharge of the river rather than the constraints of a bedrock.

Alluvium - Sediment deposited by flowing water, as in a riverbed, flood plain, or delta. Also called *alluvion.*

amsl - Above mean sea level

Anura - An order of the class Amphibia comprising the frogs and toads.

ANSIs - Areas of Natural and Scientific Interest - Areas of land and water containing natural landscapes or features that have been identified by the Ontario Ministry of Natural Resources as having life (ecologic) science or earth (geologic) science values related to protection, scientific study, or education (Provincial Policy Statement, 2005). These areas are recognized and protected under the Ontario's Planning Act, Provincial Policy Statement, Oak Ridges Moraine Conservation Plan, Niagara Escarpment Plan, Greenbelt Plan, Growth Plan, and municipal official plans.

Aquatic – Growing, or living in, or frequenting water.

Aquifer - A saturated permeable geologic unit that can transmit significant quantities of water under ordinary hydraulic gradients.

Artesian - Groundwater that is confined in an aquifer, but which may overflow on to the land surface via artificial boreholes or, sometimes, natural springs, because of the high hydraulic head that may be developed in a confined aquifer.

Attenuation (Flow) - Flow that is lessened or weakened, or the severity reduced.

Bank Stability - The ability of a stream bank to resist change.

Base Flow - The water that flows into a stream through the subsurface (often seen as the flow during a dry period in the summer).

Bedrock - The solid rock underlying unconsolidated surface material.

Bedrock Geology - The science of the solid rock underlying unconsolidated surface material. It includes magma petrology, sedimentary petrology, sedimentology, metamorphic petrology, structure geology, and related disciplines such as ore deposits and paleontology.

Benthic Invertebrates - Organisms without an internal skeletal structure that live on or in a body of water, e.g., water insects.

mbgs – Meters below ground surface

Bioaccumulation - The accumulation of a substance, such as a toxic chemical, in various tissues of a living organism

Biodiversity - See Biological Diversity.

Biogeomorphology - The science relating biota with geomorphic forms and processes.

Biological Diversity - The variability among organisms and the ecological complexes of which they are a part.

Biological Oxygen Demand – BOD – A measure of the oxygen consumed during the biochemical oxidation of organic oxidants, and organic nitrogenous matter.

Biomass - The amount of living matter, usually measured per unit area or volume of habitat.

Biotic - Relating to or caused by living beings.

BMP - Beneficial Management Practices

BOD – See Biological Oxygen Demand.

Carbonaceous Biological Oxygen Demand - $cBOD_5$ - Is the amount of oxygen required to biologically transform organic material to simpler end products.

$cBOD_5$ - See Carbonaceous Biological Oxygen Demand.

CDWQG – Canadian Drinking Water Quality Guidelines - Developed by the Federal-Provincial-Territorial Committee on Drinking Water.

Channel – A feature that conveys water; a ditch or channel excavated for the flow of water. River, creek, run, branch, anabranch, and tributary are some of the terms used to describe natural channels, which may be single or braided. Canal, aqueduct, and floodway are some of the terms used to describe artificial (man-made) channels.

Chemical Oxygen Demand – COD - Measures the amount of oxygen consumed during the chemical oxidization of both organic and inert oxidants.

Climate - The average weather conditions of a place or region throughout the seasons.

COD – See Chemical Oxygen Demand.

Communal Sewage Disposal System – CSDS - A Plant where, through physical-chemical and biological processes, organic matter, bacteria, viruses and solids are removed from residential, commercial and industrial wastewaters before they are discharged in rivers, lakes and seas.

Conductivity - A water quality parameter that measures the flow of electrons through the water.

Contiguous - Having contact with, or touching along a boundary or point.

COSEWIC - Committee on the Status of Endangered Wildlife in Canada

Creek - A small stream of water which serves as the natural drainage course for a drainage basin; a flowing rivulet or stream of water normally smaller than a river and larger than a brook. The term is often relative according to size and locality.

Crepuscular - Becoming active at twilight or before sunrise, as do bats and certain insects and birds.

CRFMP - Credit River Fisheries Management Plan - Is a resource document that provides background information about the historic and current fish community and aquatic conditions within the watershed. The plan is used to set management directions for the fish community, fish habitat, and human use of the resource.

CRWMS - Credit River Water Management Strategy - Is a plan of action that is designed to ensure that we have “abundant, clean and safe water” in the Credit River watershed, now and into the future.

CRWMSU - Credit River Watershed Management Strategy Update – Is the updated version of the CRWMS, which was finalized in 2007.

CSDS – See Communal Sewage Disposal System.

CURB - Clean Up Rural Beaches Program

CWQG - Canadian Water Quality Guideline - Are a set of acceptable levels derived by Environment Canada for substances or conditions that affect water quality such as toxic chemicals, temperature and acidity. These are designed to protect all plants and animals that live in our lakes, rivers, and oceans and to protect sensitive crop species that may be exposed to toxic substances such as pesticides in irrigation water.

D_{50} - Median diameter of particle.

D_{84} - Representative of the channel bed roughness, it is the diameter for which 84% of sediment is finer.

Denitrification – is an anaerobic bacterial process where nitrates are reduced to release N_2 gas as the end product: NO_3 -> NO_2 -> N_2O -> N_2

DFO - Department Of Fisheries and Oceans

Discharge Area - An area where water leaves the saturated zone across the water table surface.

Dissolved Oxygen – DO - The concentration of oxygen dissolved in water, expressed in mg/l or as percent saturation.

DO – See Dissolved Oxygen.

Drainage Density - Length of watercourse per unit drainage area.

Ecological - Relating to the totality or pattern relations between organisms and their environment.

Ecological Land Classification – ELC - Seeks to address all the dimensions of ecosystems and as such incorporates the interactions among landforms, soil, water, climate, fauna and human activities. In other words, this approach classifies natural environments based on a limited number of ecological factors, none of which is predominant.

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

ELC – See Ecological Land Classification.

Elevation - The height of a portion of the earth’s surface in relation to its surroundings.

Entrain - To draw in and transport through water.

Environmentally Significant Areas – ESA - Areas of land and water containing natural landscapes which contain or support natural forms, features, or attributes deemed to be significant or essential, using a set of approved criteria, in the context of the watershed or municipality which have been designated by conservation authorities, and incorporated into conservation authorities' policies and municipal official plans (Town of Caledon, 2004).

Ephemeral stream - Streams which flow only in direct response to precipitation and whose channel is at all times above the water table.

EPT - Ephemeroptera, Plecoptera, Trichoptera – Categories of benthic invertebrates.

Erosion - The wearing away of the land by the action of water, wind or glacial ice.

ESA – See Environmentally Significant Areas.

Eutrophication - a process where water bodies receive excess nutrients that stimulate excessive plant growth.

Evapotranspiration - Discharge of water from the earth's surface to the atmosphere by evaporation from lakes, streams, and soil surfaces, and by transpiration from plants.

Exotic – A species that has been introduced from another geographic region to an area outside its natural range.

FDRP - Federal/Provincial Flood Damage Reduction Program Study

Floodplain - A plain bordering a river, which has been formed from deposits of sediment carried down the river. When a river rises and overflows its banks, the water spreads over the floodplain.

Flow Regime - The pattern of how water levels change in a stream.

Flow Stability - Determined by measuring the ratio of surface discharge to groundwater discharge on an annual basis.

Fluvial - Relating to a stream or river.

FRI - Forest Resource Inventory Mapping

GAWSER - Guelph All-Weather Simulation Events Runoff

GBP – See Greenbelt Plan.

Geology - The science of the composition, structure and history of the earth. It thus includes the study of the materials of which the earth is made, the forces which act upon these materials and the resulting structures.

Geomorphology - The scientific study of landforms and the processes responsible for landform evolution.

GGH – Greater Golden Horseshoe – Includes the cities of Toronto, Hamilton, Kawartha Lakes, Guelph, Peterborough, Barrie, Orillia, and Brantford, the regional municipalities of Halton, Peel, York, Durham, Waterloo and Niagara and the counties of Haldimand, Brant, Wellington, Dufferin, Simcoe, Northumberland and Peterborough.

GIS - Geographic Information System

Glaciation - The covering of an area or the action on that area, by an ice sheet or by glaciers.

Grading – see High Grading.

Gradient - The rate of regular or graded ascent or descent.

Granular - Having a texture composed of small particles.

Greenbelt Plan – GBP - Created through the *Greenbelt Act, 2005* is enforced by the Ministry of Municipal Affairs and Housing. This plan protects about 1.8 million acres of environmentally sensitive and agricultural land in the Golden Horseshoe from urban development and sprawl.

Groundwater - Water occurring below the earth's surfaces that lies in the area of total saturation. Groundwater can exist in bedrock, overburden, and underground spaces.

Groundwater Table - Groundwater table is the level at which the ground water pressure is equal to atmospheric pressure. It may be conveniently visualized as the 'surface' of the groundwater in a given area where the aquifer is unconfined (i.e., at atmospheric pressure).

GUDI - Groundwater Under Direct Influence of surface water. GUDI refers to groundwater sources (wells, springs, infiltration galleries, etc.) where microbial pathogens are able to travel from nearby surface water to the groundwater source. A GUDI well means that there is a hydraulic connection that allows rapid recharge between the groundwater source and surface water.

Habitat - The environment of an organism; the place where it is usually found.

HADD - Harmful alterations, disruption or destruction - Section 35(1) of the Fisheries Act, which states that "no person shall carry on any work or undertaking that results in the harmful alteration, disruption or destruction of fish habitat"

HBI – See Hilsenhoff's Biotic Index.

High Grading - Refers to the poor forestry practice of harvesting of the best individual trees in a woodlot. The best trees being those that are the most vigorous and healthy.

Often leads to a genetically inferior woodlot with low economic potential for forest products

Hilsenhoff's Biotic Index – HBI - A benthic invertebrate index used as an indicator of impairment, and increased nutrients.

Hydrogeology - consists of a package of closely related sciences, such as geology, groundwater hydrology and hydraulics, surface water hydrology, meteorology, water chemistry, dedicated to the study of the part of the water cycle under the ground surface.

Hydrology - The science of waters of the earth, their occurrence, distribution, and circulation; their physical and chemical properties; and their reaction with the environment, including living beings.

Hydromodification - consists of changes to the stormwater runoff characteristics of an area caused by changes in land use.

Hydroperiods - The pattern of water-level fluctuations in a wetland

Hydrophytic vegetation - is plant-life that thrives in wet conditions

IBI – See Index of Biotic Integrity.

igpm – Imperial gallons per minute

Index of Biotic Integrity – IBI - Is a tool (index) which we use to determine the overall health and integrity of the fish and benthic community (biotic) in a given river.

Infiltration – Water entering the pores of the earth's surface.

Intermittent Stream or Seasonal Stream – Streams which flow only at certain times of the year when it receives water from springs, rainfall, or from surface sources such as melting snow.

Intrinsic Susceptibility Index – ISI - Is a calculated value that estimates the susceptibility of a given groundwater aquifer to surficial contamination at a given point.

Invasive Species – Species that intrude or encroach on the native species in the area

Invertebrates – Animals lacking a spinal column.

ISI – See Intrinsic Susceptibility Index.

Isohyetal map – A map with isohyetal lines, which are lines that join points of equal precipitation on a map.

IWMP - Integrated Watershed Monitoring Program – An intensive, long-term monitoring program implemented by CVC which measures key environmental indicators.

Lacustrine - Of or relating to lakes. Living or growing in or along the edges of lakes.

Lake Ontario LaMP - Lake Ontario Lakewide Management Plan

Lepidopterans - Butterflies and moths

Littoral - The topmost zone near the shore of a lake or pond is the littoral zone, often containing aquatic vegetation.

Local Discharge - Discharge to a watercourse that originates nearby. The water moves through the upper layers of the groundwater system.

LOD - Large Organic (woody) Debris

Lowflow - The flows that exist a stream channel in dry conditions.

Macroinvertebrates - Animals lacking a spinal column that are visible with the unaided eye.

Macrophytes - A macroscopic plant.

Mbgs – Meters below ground surface

Meandering - A curve in the course of a river, which over time, moves from side to side.

Meltwater Channel - A subglacial meltwater channel formed beneath an ice mass, like ice sheets and valley glaciers, roughly parallel to the main ice direction. Meltwater channels can have different sizes, ranging from very small channels of a meter deep and wide to big valleys which can be up to a kilometer wide. The sediments deposited by the meltwater channel are composed of well sorted gravel and sand in an elongated form.

MNR - Ministry of Natural Resources

MOE - Ministry of the Environment

MOEE - Ministry of Environment and Energy

Moraine - The debris or rock fragments deposited by a glacier.

Morphology - The study of form or structure.

MSC - Environment Canada's Meteorological Service of Canada

N/A - Not Applicable

Native Species - An animal or plant that occurs naturally in a particular region, state, ecosystem, and habitat without direct or indirect human actions.

NEP – See Niagara Escarpment Plan.

NHIC – Natural Heritage Inventory Centre – Acquires, maintains, updates, and makes available data on the province's rare species, vegetation communities, and natural areas. The NHIC is part of the Ontario OMNR Fish and Wildlife Branch. The NHIC contributes to OMNR's role in protecting the genetic, species and ecosystem diversity of Ontario.

Niagara Escarpment Plan – NEP - Created through the *Niagara Escarpment Planning and Development Act, 1990*. The NEP serves as a framework of objectives and policies to strike a balance between development and preservation of this important resource.

Nitrification – The conversion of ammonium (NH4+) or organic nitrogen into nitrate (NO3) by oxidizing the nitrite by nitrobacteria. NH_4^+ -> N_20 -> NO_2 -> NO_3

Nitrogenous oxygen demand – NOD - is a quantitative measure of the amount of dissolved oxygen required for the biological oxidation of nitrogenous material, for example, nitrogen in ammonia, and organic nitrogen in waste water.

NOD – See Nitrogenous oxygen demand.

Nutrient - Something that nourishes and promotes growth. It is possible to have too many nutrients in an ecosystem, which can result in an unhealthy imbalance or overgrowth of certain species.

ODWS - Ontario Drinking Water Quality Standards – standards for drinking water quality in Ontario, prescribed in O. Reg. 169/03 under the *Safe Drinking Water Act, 2002*.

OMNR - Ontario Ministry of Natural Resources

OP - Official Plans

Odonates - Dragonflies and damselflies

Organic Matter - Of, relating to, or derived from, living organisms.

Orthophotography - Aerial photographs of the earths surface that more precisely show the features of the landscape, including those that might be important for agriculture such as slope or size of gullies, because they are corrected for distortion caused by tilt, curvature, and ground relief.

Ortho-rectified aerial photography – A satellite or aerial photographic image of the earth's surface that has been digitally corrected to ensure ground features are depicted in their correct geographic location.

Percentile - Is the value of a variable below which a certain percent of observations fall. So the 20th percentile is the value (or score) below which 20 percent of the observations may be found.

Perennial Streams - Streams which flow continuously.

Permeability - The quality of having pores or openings that allow liquids to pass through.

PESA - Potentially Environmentally Significant Areas designated using a set of criteria developed by CVC, incorporated into CVC policies, and if adopted by the municipalities they are recognized by the Provincial Policy Statement.

Physiography – also named physical geography, is the study and description of all natural phenomena on the ground surface in geographic ways. It is closely related to such disciplines as geomorphology, hydrology, climatology, and geology.

Planform - The shape or form of an object (eg. A river), as seen from above, as in a plan view.

Planimetric (form) Adjustment – Changes to the horizontal position of features (without regard to elevation) within a watercourse. For example, a change in stream width. The planimetric view of various stream patterns may be qualitatively described as straight, meandering, or braided forms; and quantitatively defined through measurements of meander wavelength, radius of curvature, and belt width.

Planform Adjustment or **Planform Development** – See Planimetric Adjustment.

POC - Parameters of Concern – Indicators of water quality for the Credit River watershed identified through the Water Quality Strategy Phase I Report (CVC, 2003)

PPS - Provincial Policy Statement - Is issued under the authority of Section 3 of the *Planning Act.* It provides direction on matters of provincial interest related to land use planning and development, and promotes the provincial "policy-led" planning system.

Precipitation - The deposits of water in either liquid or solid form which reach the earth from the atmosphere. It includes rain, sleet, snow and hail.

Productivity - Rate of production, especially of food or solar energy by producer organisms.

PSW – Provincially Significant Wetlands - Lands inventoried and assessed by certified professionals using the Ontario Wetland Evaluation System to calculate a score based on the wetland's biology, hydrology, uniqueness, and social values. Wetlands are designated to be provincially significant by the Ontario Ministry of Natural Resources based on the score calculated through the evaluation. Provincially Significant Wetlands are protected from development and site alteration by the Ontario's Planning Act, Provincial Policy Statement, Oak Ridges Moraine Conservation Plan, Niagara Escarpment Plan, Greenbelt Plan, Growth Plan, Conservation Authorities Act, and municipal official plans.

PTTW - Permit to Take Water – A permit required when the total volume of water obtained from either a surface or groundwater source exceeds 50,000 L/day.

PWQMN - Provincial Water Quality Monitoring Network – Is a network of partnerships including MOE, conservation authorities, municipalities and Ontario Parks, who collect surface water quality information from rivers and streams across Ontario.

PWQO - Provincial Water Quality Objective - Are numerical and narrative criteria which serve as chemical and physical indicators representing a satisfactory level for surface waters (i.e. lakes and rivers) and ground water of the Province. The PWQO are set at a level of water quality which is protective of all forms of aquatic life and all aspects of the aquatic life cycles during indefinite exposure to the water. The Objectives for protection of recreational water uses are based on public health and aesthetic considerations.

Rapid Geomorphic Assessment – RGA - Is a type of channel assessment technique developed by MOE to assess reaches in urban channels. RGA's involve recording evidence of channel instability. The instability features for each category are tallied and used to calculate a reach stability index, which corresponds to a stability classification

Reach - A stream segment with relatively repetitious and homogenous sequence of physical processes and habitat types (e.g., homogenous slope, discharge, habitat, channel type and riparian features.). Thus **reach break** is the upper and lower limits of a reach that delineates it from adjoining reaches. The reach break symbol is placed at the upstream limit of a reach.

Recharge Area - An area where water enters saturated zone at the water table surface.

Reconnaissance – Inspection/exploration conducted to gain information

Regime – A stream condition where the stream channel is considered stable knowing that streams continually adjust to maintain equilibrium with its environment. Evidence of instability is isolated or associated with normal river meander propagation processes.
The RGA Form Stability Index Value for a stream in Regime is > 0.2.

Regional Discharge - Water that has traveled deep beneath the ground through the saturated zone and resurfaces at the water table.

Return period - Is the mean number of such time units necessary to obtain a value equal to or greater than a certain value one time. For example, with a one-year interval between observations, a return period of 100 years means that, on the average, an event of this magnitude, or greater, is not expected to occur more often than once in 100 years.

RGA – See Rapid Geomorphic Assessment.

Riffle:Pool System - A riverine (flowing) system that alternates cycles of shallow water (riffle) and deeper water (pool).

Riparian - Relating to or located on the bank of a watercourse, wetland, or body of water.

River - A natural stream of water of considerable volume, generally larger than a creek. Throughout this report River refers to the Credit River, or the West Credit River.

SARO - Species at Risk in Ontario

Scale - A graduated series or scheme of rank or order.

Seasonal Stream – See Intermittent Stream.

Sediment - Material deposited by water, wind or glaciers.

Sediment Oxygen Demand – SOD - The rate of oxygen consumption exerted by the bottom sediment on the overlying water.

Sinuosity – Represents the ratio of channel length per unit length of valley. As such, it represents the degree to which a channel meanders. The lower the sinuosity value the straighter the watercourse or the less meandering the watercourse.

SOD – See Sediment Oxygen Demand.

Spawn - To produce or deposit eggs during the reproductive process, especially by aquatic animals).

SS – See Suspended Solids.

SSMP - Settlement and Servicing Master Plan

Stream - A general term for a body of flowing water; natural water course containing water at least part of the year.

Stream Order - The designation by a integer series (1, 2, 3, …) of the relative position of stream segments in the network of a drainage basin.

Substrate - The base or surface on which an organism lives.

Subwatershed - A region or area bounded peripherally by a water parting and draining ultimately to a tributary of a larger watercourse or body of water.

Surficial Geology - Deals with the study and description of the forms on the outer layer of the earth.

Suspended Solids – SS - Small solid particles which remain in suspension in water.

SWM - Storm Water Management – the management of storm water run-off, often using water retention facilities to provide controlled release of water into receiving streams.

TDS – See Total Dissolved Solids.

Terrestrial - Living on or growing on land.

Thalweg - the path of maximum depth along the stream.

Thermal Regime - The characteristic behaviour and pattern of temperature.

Till - A tough unstratified clay loaded with stones originating from finely ground rock particles that were deposited by glacial activity.

TKN – See Total Kejdahl Nitrogen.

Topography - The description or representation of the ground surface shape and existing related natural and artificial features of an area. The result is usually presented in a topographic map.

TOT - Time of travel - The time for groundwater to travel from a potential source of contamination to the well head.

Total Dissolved Solids – TDS - Comprise inorganic salts and small amounts of organic matter that are dissolved in water.

Total Kejdahl Nitrogen – TKN - Reduced forms of nitrogen such as organic nitrogen, ammonia nitrogen, ammonium nitrogen.

Total Phosphorus – TP - The sum of all phosphorus forms.

TP – See Total Phosphorus.

Transition/stress - A stream condition where the stream channel is considered moderately stable. The channel morphology is within the consensual range of variance for streams of similar hydrographic characteristics but the evidence of instability is frequent. The RGA Form Stability Index Value for a stream in transition or stress: 0.21< Stability Index >0.4.

Tributary - (1) A stream which joins another stream or body of water. (2) A stream or other body of water, surface or underground, which contributes its water to another normally larger stream or body of water.

USDA - US Department of Agriculture.

Valley - A long, narrow depression on the earth's surface, usually with a fairly regular downward slope. A river or stream usually flows through it.

Watercourse - A depression formed by water moving over the surface of the earth; any natural or artificial channel through which water flows; a lake, river, creek, stream, wash, arroyo, channel or other topographic feature on or over which waters flow at least periodically. Watercourses include specifically designated areas in which substantial flood damage may occur.

Water Cycle - The continuous movement of water from the oceans to the atmosphere (by evaporation), from the atmosphere to the land by condensation and precipitation, and from the land back to the sea (via stream flow).

Water Quality Indicator – A biological entity that provides information on the condition of water through it's life cycle patterns. Water quality can also be determined through non living sources, like chemical sampling.

Watershed - A region or area bounded peripherally by a water parting and draining ultimately to a particular watercourse or body of water.

Weathering - The disintegration of the earth's crust by exposure to the atmosphere, most importantly, rain. Other elements such as temperature, biological action and gravity also play important roles.

WeCARE - West Credit Appreciation, Rehabilitation and Enhnacement (WeCARE) program

Wetland - Lands that are seasonally or permanently covered by shallow water, as well as lands where the water table is close to or at the surface. In either case, the presence of abundant water has caused the formation of hydric soils (formed under flooding or saturation) and has favoured the dominance of either hydrophytic (water-loving) plants or water tolerant plants. The four major types of wetland are swamps, marsh, fen, and bog (in order of abundance in the Credit River Watershed). Periodically soaked or wet lands being used for agriculture purposes which no longer exhibit wetland characteristics are not to be considered wetlands for the purpose of this definition (Provincial Policy Statement, 2005).

WHPA - Wellhead Protection Area - Protection of all or part of the area surrounding a well from which the well's ground water is drawn.

Winnowing - To separate or get rid of (an undesirable part); eliminate.

WPCP – Waste Pollution Control Plant - The site where raw wastewater is processed before it is discharged back to the environment.

APPENDIX B:
Hydrology and Hydraulics

Phase 1 -
Environmental Component -
Existing Conditions Report

For The

Erin Servicing and Settlement Master Plan

Prepared for:

County of Wellington
Town of Erin

Prepared by:

Credit Valley Conservation

May 2011

HYDROLOGY AND HYDRAULICS APPENDIX

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1.0 Low Flow Frequency Analysis

The objectives of the low flow analyses are to determine the minimum flow rates for various durations and return periods. The low flow analyses determines streamflow rates that can be expected to occur on average once every 1.005 through 500 years. A separate low flow frequency analysis was carried out for each duration of 7, 15, and 30 days. The minimum streamflow rates for the various return periods are best determined using data recorded over long periods (50 to 100 years) from the basin where the predicted runoff rates are required. Less accurate results would be expected for shorter periods of record or flow rates recorded on adjacent basins.

The analyses involved first the determination of a series of annual minimum mean daily flow rates for durations of 7, 15, and 30 consecutive days (moving or rolling average) and then performed a frequency analysis with each data series. A spreadsheet was used to abstract the minimum 7, 15, and 30 day flow values that occur within each calendar year of the recorded data. The values are then averaged to generate an annual minimum mean daily flow rate for each duration. The minimum values must occur over a consecutive period of time. For example, each non leap year of recorded data will contain 358 seven (7) day mean daily flow rates. The minimum seven (7) day mean daily flow rates for each year will than be used in the frequency analysis, which results with the low flow indices such as the 7Q2, 7Q10, or 7Q20. For example the 7Q20 flow can be interpreted as the 7-day low flow with a 20-year return period, using mean daily discharge data.

The frequency analysis was carried out with the aid of the Low Flow Frequency Analysis Package (LFA) computer program maintained and distributed by the Water Resources Branch of the Inland Waters Directorate of Environment Canada. The input data for the LFA program consists of a series of annual minimum data. The output includes the following:

- The ranked input and cumulative probabilities;
- Population statistics; and
- Estimates of the minimum annual mean daily flow rates for the selected return periods.

Each annual series of minimum runoff rates are ranked in ascending order. The following equation was used to assign a cumulative probability of occurrence as described by Cunnane plotting position:

$$\text{Probability of Occurrence} = (m - 0.4) / (N + 0.2) \qquad (1)$$

Where m = series rank of the value in ascending order
N = sample size

The LFA program fits the annual minimum data series to a Gumbel III distribution and determines values for return periods ranging from 1.005 to 500 years. The Gumbel III distribution has been considered to be acceptable for drought analysis by the Water

Resources Branch although numerous distributions are available with which to determine the return period values.

The return period flow rates are values that occur on average over a long period of record such as 200 to 300 years. As an example a 60 day flow rate of 0.171 m^3/s has a return period on average of 100 years. There is a one (1) percent chance that the minimum 60 day flow rate will be less than 0.171 m^3/s in any one year. The risk that the 60 day flow rate will be less than 0.171 m^3/s in a given period, say 20 years can be estimated using the following equation:

$$RISK = 1 - (1 - 1/RP)^{EP} \qquad (2)$$

Where RP = return period, years
EP = period of interest, years

The following table describes the risk of exceedance for periods of interest and return periods of design:

Table 1.0 Risk of exceedance for periods of interest and return periods of design

Return Period (years)	R I S K (%) Period of Interest (years)				
2	**5**	**10**	**20**	**50**	**100**
5	67	89	98	99.9	99.9
10	41	65	88	99.5	99.9
20	19	34	56	87	98
50	10	18	33	64	87
100	4.9	9.6	18	40	63

As an example there is an 18 % risk that the minimum 60 day low flow rate with a return period of 100 years will be less than 0.171 m^3/s in any 20 year period.

The results of the low flow frequency analysis for the Erin Branch Gauge are illustrated in **Table 1.1**.

Table 1.1 Low flow frequency analysis (durations of 7, 15, and 30 days) for the station, West Credit River at Erin Branch above Erin (period of record 1983 to 2008)

Return Period (years)	Avg. Min. 7 Day Flow Rate (m^3/s)	Avg. Min. 15 Day Flow Rate (m^3/s)	Avg. Min. 30 Day Flow Rate (m^3/s)
1.005	0.366	0.390	0.452
1.01	0.352	0.375	0.430
1.11	0.294	0.307	0.339
1.25	0.268	0.279	0.303
2	0.216	0.226	0.242
5	0.165	0.178	0.192
10	0.140	0.156	0.173
20	0.120	0.140	0.160
50	0.100	0.125	0.149
100	0.088	0.117	0.144
200	0.079	0.111	0.140
500	0.069	0.105	0.137

Flows at one site where results of a frequency analysis are available can be transposed to another site using:

$$QY = QX\ (AY/AX)^{n} \qquad (3)$$

where QY is the flow (in m/s) at site Y with drainage area AY (km^2) and QX and AX are the corresponding quantities at site X and n is an exponent [taken as n = 0.842, from Moin and Shaw (1985)].

Moin and Shaw (1985) developed regional flow estimates based on regression analyses of observed index floods (i.e., 2-year) for the whole province. For their Region 4, which contains the West Credit River subwatershed, the index flood is computed as:

$$Q2 = 0.71 * (\text{Drainage Area})^{0.842} \qquad (4)$$

Where Q2 is the index flood (in m^3/s) and the drainage area is in km^2.

For each monitoring station the low flow frequency values were determined for each duration series 7-day, 15-day and 30-day and return periods 1.005 to 500 years by transposing the values from the Erin Branch gauge station using equation 3. The results are presented in **Tables 1.2 to 1.5**.

Table 1.2 Low flow frequency analysis at Beech Grove Sideroad

Return Period (years)	Avg. Min. 7 Day Flow Rate (m^3/s)	Avg. Min. 15 Day Flow Rate (m^3/s)	Avg. Min. 30 Day Flow Rate (m^3/s)
1.005	0.213	0.227	0.263
1.01	0.205	0.218	0.250
1.11	0.171	0.179	0.197
1.25	0.156	0.162	0.176
2	0.126	0.132	0.141
5	0.096	0.104	0.112
10	0.082	0.091	0.101
20	0.070	0.082	0.093
50	0.058	0.073	0.087
100	0.051	0.068	0.084
200	0.046	0.065	0.082
500	0.040	0.061	0.080

Table 1.3 Low flow frequency analysis at 17th Sideroad

Return Period (years)	Avg. Min. 7 Day Flow Rate (m^3/s)	Avg. Min. 15 Day Flow Rate (m^3/s)	Avg. Min. 30 Day Flow Rate (m^3/s)
1.005	0.214	0.228	0.264
1.01	0.206	0.219	0.251
1.11	0.172	0.179	0.198
1.25	0.157	0.163	0.177
2	0.126	0.132	0.141
5	0.096	0.104	0.112
10	0.082	0.091	0.101
20	0.070	0.082	0.094
50	0.058	0.073	0.087
100	0.051	0.068	0.084
200	0.046	0.065	0.082
500	0.040	0.061	0.080

Table 1.4 Low flow frequency analysis downstream of 10th Line

Return Period (years)	Avg. Min. 7 Day Flow Rate (m^3/s)	Avg. Min. 15 Day Flow Rate (m^3/s)	Avg. Min. 30 Day Flow Rate (m^3/s)
1.005	0.431	0.460	0.533
1.01	0.415	0.442	0.507
1.11	0.347	0.362	0.400
1.25	0.316	0.329	0.357
2	0.255	0.266	0.285
5	0.195	0.210	0.226
10	0.165	0.184	0.204
20	0.141	0.165	0.189
50	0.118	0.147	0.176
100	0.104	0.138	0.170
200	0.093	0.131	0.165
500	0.081	0.124	0.161

Table 1.5 Low flow frequency analysis at Winston Churchill Blvd.

Return Period (years)	Avg. Min. 7 Day Flow Rate (m^3/s)	Avg. Min. 15 Day Flow Rate (m^3/s)	Avg. Min. 30 Day Flow Rate (m^3/s)
1.005	0.902	0.961	1.114
1.01	0.867	0.924	1.059
1.11	0.724	0.756	0.835
1.25	0.660	0.687	0.746
2	0.532	0.557	0.596
5	0.406	0.439	0.473
10	0.345	0.384	0.426
20	0.296	0.345	0.394
50	0.246	0.308	0.367
100	0.217	0.288	0.355
200	0.195	0.273	0.345
500	0.170	0.259	0.338

2.0 Flood Flow Frequency Analysis

The object of the flood flow frequency analysis is to determine the maximum annual instantaneous peak flow rates that will occur on average at various return periods. Runoff from a subwatershed is a natural process, which is subject to large daily and monthly fluctuations, which cannot be predicted to occur at any specific time. However, using past occurrences of runoff rates, it is possible to predict on average when a specific runoff rate will occur. The analysis determined streamflow rates that can be expected to occur on average once every 2 through 100 years. The various return period streamflow rates should be viewed with caution. Predicted values of peak streamflow rates tend to decrease for return periods greater than twice the number of years of recorded data.

The analyses involved first the determination of a series of annual maximum instantaneous flow rates for each year and then performed a frequency analysis of the flow rates. The frequency analysis was carried out with the aid of the CFA88 (Consolidated Frequency Analysis Package) computer program that is maintained and distributed by the Water Resources Branch of the Inland Waters Directorate of Environment Canada.

The input data for the CFA88 program consists of a series of annual maximum data that is described by the year and month of occurrence and the annual maximum peak streamflow rate. In addition, the program requires the Water Survey of Canada gauge number, the drainage area in km^2, and the number of data points and whether historic information is being used.

The output includes the following:

- The ranked input series of annual maximum flood flows with high and low outliers and empirical probabilities;
- Estimates of population statistics and distribution parameters;
- Streamflow rates for various return periods; and
- Plots of the frequency curves and a display of non-parametric data.

The program allows the user to conduct the following:

- Enter, modify (add, delete or change) and save data sets for future use;
- Perform non-parametric tests for homogeneity, trend, independence and randomness;
- Perform tests for low and high outliers; and
- Determines T year events for the straight forward case, samples with historic information, and samples with low outliers, samples with zero values. In addition any data sets can be combined.

The following probability distributions can be computed:

- Generalized extreme value;
- Three parameter lognormal;
- Log Pearson Type III; and
- Wakeby.

The Cunnane plotting position that follows is used to plot the data on probability paper:

$$\text{Probability of Occurrence} = (m - 0.4) / (N + 0.2) \tag{5}$$

Where m = series rank of the value in ascending order
N = sample size

The CFA88 program determines return period values for the four (4) frequency distributions mentioned above. The CFA88 computer program does not select a frequency distribution and the resultant return period annual maximum peak flow rates. The user must determine which frequency distribution best fits the data. Typically, a distribution is selected by reviewing the distribution statistics with the statistics of the data values and by comparing how closely the data plots with distributions. The computer program prints out the data values and plots the four distributions and ranked data values. The results of the flood frequency analysis for each distribution are tabulated in **Table 2.0**.

Table 2.0 Flood flow frequency analysis (instantaneous peak flow rates) for the station, West Credit River at Erin Branch above Erin (period of record 1983 to 2008)

Return Period	Exceedance Probability (m^3/s)	Generalized Extreme Value (m^3/s)	3 Parameter Log Normal Distribution (m^3/s)	Log Pearson Type III Distribution (m^3/s)	Wakeby Distribution (m^3/s)
1.003	0.997	1.16	**1.67**	1.59	1.64
1.050	0.952	1.88	**2.09**	2.09	1.90
1.250	0.800	2.59	**2.63**	2.66	2.54
2.000	0.500	3.53	**3.47**	3.49	3.51
5.000	0.200	4.82	**4.78**	4.73	4.91
10.000	0.100	5.68	**5.73**	5.61	5.80
20.000	0.050	6.52	**6.70**	6.51	6.57
50.000	0.020	7.61	**8.04**	7.74	7.42
100.000	0.010	8.43	**9.11**	8.73	7.97
200.000	0.005	9.26	**10.20**	9.78	8.44
500.000	0.002	10.4	**11.80**	11.30	8.96

In the case of the Erin Branch Above Erin gauge, experience has shown that the 3-Parameter Log Normal Frequency Distribution best fits the data. Using equation number 3 the peak flow values for the Erin Branch station based on the 3-Parameter Log Normal Distribution were than transposed to each monitoring location. The results are tabulated in **Table 2.1**.

Table 2.1 Flood flow frequency regime (instantaneous peak flow rates) at each monitoring location within the West Credit River subwatershed

Location	QBF (m^3/s)	Q2 (m^3/s)	Q5 (m^3/s)	Q10 (m^3/s)	Q20 (m^3/s)	Q50 (m^3/s)	Q100 (m^3/s)
Beech Grove Sideroad	1.62	2.02	2.78	3.34	3.90	4.68	5.30
Stream Gauge	**2.78**	**3.47**	**4.78**	**5.73**	**6.70**	**8.04**	**9.11**
17th Sideroad	1.62	2.03	2.79	3.35	3.92	4.70	5.3
D/S of 10th Line	3.27	4.09	5.63	6.75	7.90	9.48	10.7
Winston Churchill	6.84	8.55	11.8	14.1	16.5	19.8	22.4

The values QBF represent the bankfull flows. The bankfull flows were determined using the Annables' model (1995). The bankfull flows were estimated by multiplying the 2-year flood flow by 0.8 (ratio between bankfull flow and 2-year flood flow established by Annable for Ontario streams (1995).

3.0 References

Annable, W.K. 1995. Morphological relations of rural water courses in southeastern Ontario for use in natural channel design. Guelph, Ontario, Canada, University of Guelph, School of Engineering, Masters Thesis, 389 p.

Moin, S. M. A. and Shaw, M. A. 1985. Regional flood frequency analysis for Ontario streams (three volumes). Canada/Ontario Flood Damage Reduction Program, Environment Canada and Ontario Ministry of Natural Resources.

APPENDIX C:
Natural Heritage

Phase 1 -
Environmental Component -
Existing Conditions Report

For The

Erin Servicing and Settlement Master Plan

Prepared for:

County of Wellington
Town of Erin

Prepared by:

Credit Valley Conservation

May 2011

NATURAL HERITAGE APPENDIX

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1.0 Ecological Land Classification Community Types and Existing Land Use

Table 1.0 Ecological Land Classification Community Types (Lee et al. 1998)

Community	Description
Terrestrial	**Water table rarely or briefly above the substrate surface, saturation period not long enough to promote organic or hydric substrates; non-hydrophytic plant species making up more than 50 percent of total species composition.**
Deciduous Forest	A terrestrial vegetation community where deciduous trees comprise >75% of the canopy cover.
Coniferous Forest	A terrestrial vegetation community where coniferous trees comprise >75% of the canopy cover.
Mixed Forest	A terrestrial vegetation community containing a mixed composition of coniferous and deciduous tree species, between 25% and 75%.
Plantation	A treed community in which the majority of the trees have been planted. Like the forest communities, plantations can be coniferous (PLC), deciduous (PLD) or mixed (PLM). Nurseries and orchards are not considered plantations, rather these are agricultural communities.
Cultural	**Vegetation communities that originate from, or are maintained by anthropogenic influences and culturally based disturbances. They often contain a large proportion of non-native species.**
Cultural Meadow	Open terrestrial communities characterized by grasses or forbs; usually originating from cultural disturbances such as mowing, burning, or grazing. These communities may be maintained through infrequent or low-intensity disturbances.
Cultural Savannah	A terrestrial vegetation community that originates from, or is maintained by anthropogenic influences and culturally based disturbances. Cultural savannah communities are similar to Cultural Meadow communities, except that CUS habitats will also contain 11 to 35% cover by tree species.
Cultural Thicket	A terrestrial vegetation community that originates from, or is maintained by anthropogenic influences and culturally based disturbances. Cultural thickets are characterized by <10% tree cover and >25% shrub cover. (*Note: a shrub is defined as a perennial plant usually with a woody stem, shorter than a tree, often with a multi-stemmed base; included small trailing woody species).
Cultural Woodland	Treed area where historical land use practices have severely affected the resulting substrate and vegetation. Tree cover is between 35 and 60%. Vegetation is stratified with scattered trees and is dominated by graminoids and forbs.
Wetland	**An area of land that is saturated with water long enough to promote hydric soils or aquatic processes as indicated by poorly drained soils, hydrophytic vegetation and various kinds of biological activity that are adapted to wet environments. This includes shallow waters generally <2 m deep.**
Coniferous Swamp	Wetland areas where the tree cover is >25% and the coniferous composition is >75%.
Mixed Swamp	Wetland areas where the tree cover is > 25%, where neither the coniferous nor the deciduous composition of the community is <25%.
Deciduous Swamp	Wetland areas where the tree cover is > 25%, and the deciduous composition is >75%.

Community	Description
Thicket Swamp	Wetland areas where the tree cover is <10%, and the shrub species cover is >25%.
Meadow Marsh	Areas at the wetland-terrestrial interface, which are seasonally inundated with water and usually dominated by grasses or forbs.
Shallow Marsh	Vegetation communities with a water table that rarely drops below the substrate surface and vegetation composed primarily of broad-leaved or narrow-leaved emergent species.
Bog	A wetland community whose water source is confined to precipitation with no connection to groundwater, and very low in nutrients. They are acidic and often dominated by heath shrubs and *Sphagnum* mosses and may include open-growing, stunted trees.
Fen	A wetland community with a peat substrate and nutrient-rich waters. They are primarily vegetated by shrubs and graminoids.
Shallow Aquatic	Aquatic communities in which the permanent water is generally <2m deep and in which there is a vegetation cover of >25% composed mainly of submerged or floating-leaved species.

Table 1.1 Existing Land Use Communities (Non-ELC Community Types)

Land Use	Description
Active Aggregate	Resource extraction pits or quarries that are currently being excavated. They are identified by pits, extraction machinery, an unvegetated landscape & piles of extracted materials. They may or may not contain open water. Note: Peat and top soil removal are also forms of extraction and are considered as a part of this category.
Inactive Aggregate	Resource extraction pits or quarries that are no longer under active excavation. These areas have often revegetated to and may appear as grasslands or shrub-covered depressions. Abandoned pits may also appear as ponds or lakes.
Intensive Agriculture (IAG)	Cultivated fields producing crops in varying degrees (e.g. corn and wheat). This includes specialty agriculture, which consists of orchards, market gardens, Christmas tree plantations, and nurseries.
Non-intensive Agriculture (NAG)	Fields dominated with herbaceous vegetation and grasses with an understory of similar materials in various states of decay. Pasture and grazing areas are considered NAG habitats if weedy hay and/or pasture cover more than 50 percent of the area. These areas are associated with extensive or unconfined grazing of livestock. There should be minimal evidence of recent cultivation.
Rural Development	Rural development areas include lands that are between 0.5 and 2.0 ha in size, which contain residential, commercial or other buildings not directly associated with a farming operation, and manicured open space (e.g. estate residential or service station). These lands are heavily impacted and still under intensive use. Based upon canopy cover these areas will often appear as Cultural Savannah or Cultural Woodland; however, the presence of buildings and manicured lands identify the area as Rural Development.
Urban Development	The U/R (Urban/Rural) designation relates to the lands and structures associated with residential, commercial, and industrial development. This includes structures, lawns, landfills, and roads. It does not include barns, which are dealt with under the Agricultural classifications, but does include the farm house. Urban related uses include continuous ribbon development. They are interpreted from air photos by number of rooftops, and groupings of 5 or more residential units equaling 2 or more hectares (i.e. the presence of pavement, buildings and structures). Single rural residential lots are not included as Urban Area unless part of a group of 5 or more units (OMAF, 1982).
Manicured Open Space	Areas that are often associated with Urban and Rural Development, in which vegetation communities are dominated by gardens, parklands, and lawn areas. For example, cemeteries, golf courses, urban parks, ski hills, and residential/industrial open space with a minimum size of 2 hectares.
Wet Meadow (WM)	Lands that are periodically "soaked" or "wet", and are currently being used for agricultural purposes (i.e. grazing). These lands, by definition under the Ontario Wetland Evaluation System, are not considered to be wetlands. Note: Wet Meadows are being mapped as part of the Natural Heritage Project to recognize their ecological function, such as groundwater recharge areas and wildlife habitat, and to identify areas of potential restoration in cooperation with the landowners.

Table 1.2 Aquatic Systems Descriptions

Classification	Definition	Interpretation
Natural Waterways		
Watercourse	A watercourse is constituted when there is sufficient continuous flow of water to form and maintain a defined channel (with bed and banks) of a permanent, yet dynamic nature.	Watercourses are interpreted from spring aerial photography by the presence of a defined channel observed to contain water.
Intermittent and/or Ephemeral Watercourse	An intermittent or ephemeral watercourse is constituted when there is sufficient periodic flow of water to form and maintain a defined channel (with bed and banks) of a permanent, yet dynamic nature. These watercourses often convey seasonal flows, and will generally flow with most rainfall events.	Intermittent watercourses are interpreted from spring aerial photography by the presence of a defined channel observed not to contained water.
Watercourse Not Visible	Watercourse Not Visible refers to watercourses or intermittent watercourses where the exact location of the channel cannot be determined through air photo interpretation because they pass under the canopy of forests, swamps or other heavily vegetated areas.	The location of these watercourses can be estimated from aerial photography based on topographic features or changes in vegetation patterns.
Wetland Flow	Wetland flow is formed when a watercourse dissipates as it enters a wetland. The water in these wetlands, flow through poorly defined channels, multiple braided channels, or outside a defined channel.	Wetland flow is interpreted from spring aerial photography by the presence of poorly defined channels, multiple braided channels or as water moving across the surface as a sheet. Identify only major channels when mapping multiple braided channels. When mapping sheet flows, map the most direct route following topography between the point where the watercourse enters the wetland and where it exits the wetland. Do not map isolated wetland flows.
Swales	Swales are natural drainage courses without defined channels that contain intermittent or seasonally flowing water. These swales will generally only flow during large rainfall events or the snowmelt.	Swales are interpreted from spring aerial photography by the presence of a linear depression observed to, or shows evidence of, containing water. Swales will require field investigations to ensure that they are not watercourses or intermittent watercourses. Do not map isolated swales.

Classification	Definition	Interpretation
Modified Waterways		
Engineered Watercourse	Engineered Watercourses are any watercourses that have hardened banks and/or beds, including concrete lining, gabion baskets, armour stone or riprap. These watercourses have usually also been straightened or smoothed.	Engineered Watercourses are interpreted from spring aerial photography by the presence of a defined channel observed to have hardened banks and/or beds that may or may not contain water.
Agricultural or Municipal Drain	Agricultural Drains are straightened and/or widened watercourses or constructed drainage courses to drain wetlands and wet rural or agricultural land.	These drains are interpreted from spring aerial photography by the presence of a defined channel that appears to be constructed or altered that may or may not contain water. Rural drains appear as straightened watercourses on agricultural or rural lands in aerial photography. Agricultural Drains do not have hardened banks and/or beds.
Roadside Ditch	Roadside Ditches are generally straight, constructed watercourses created adjacent to roads to deal with their runoff related to rainfall and meltwater. Roadside Ditches are considered to be part of the watercourse system if it receives flow from, and/or discharges flow to, a watercourse.	Roadside Ditches are interpreted from spring aerial photography by the presence of a defined channel adjacent to roads that appears to be constructed and may or may not contain water. Do not map isolated roadside ditches.
Lakes and Ponds		
Lakes	A Lake is an extensive body of water lying in a depression that is 2 ha. in size or greater. A lake can be completely enclosed by land or can have either or both an in-flowing or out-flowing stream. A lake can also be created by interrupting the normal flow of a watercourse with a dam.	Lakes are interpreted from spring aerial photography by the presence of a body of water lying in a depression that is 2 ha. in size or greater. Size is determined using a dot grid or Geographic Information Systems.
Pond	A Pond is an area of still water between 0.5 and 2 ha. in size lying in a natural or man-made depression. They can be completely enclosed by land or can have either or both an in-flowing or out-flowing stream. A pond can also be created by interrupting the normal flow of a watercourse with a dam.	Ponds are interpreted from spring aerial photography by the presence of a body of water lying in a depression that is between 0.5 and 2 ha. in size. Size is determined using a dot grid or Geographic Information Systems.

Classification	Definition	Interpretation
Lakes and Ponds		
On-line Ponds (less than 0.5 hectares)	Ponds are areas of still water lying in a natural or man-made depression. They can be completely enclosed by land or can have either or both an in-flowing or out-flowing stream. A pond can also be created by interrupting the normal flow of a watercourse with a dam.	These ponds are mapped as point data since the pond boundaries are too small to be accurately mapped at a 1:10,000 scale. The size of the symbol does not relate to the size of the pond.

Table 1.3 Modified ELC Vegetation Community List

Legend

	Code from 1998 ELC absent from TRCA list
	Harold's new code, no TRCA equivalent
	CVC Urban Codes

Harold has combined TRCA codes FOD9-A and FOD9-B

VEGETATION COMMUNITIES - FIELD REFERENCE LIST 2009
ELC codes are from TRCA (2007), Harold Lee (new, 2008), "CVC" codes are to be used by CVC in 2008 and on

TRCA Code	Harold Code	CVC Code	Vegetation Type (* indicates present as inclusion and/or complex only)	Notes (most species are listed here using their 7-letter ELC code)
			Beach / Bar	
BBO		**BBO**	**Open Beach / Bar**	
BBO1		**BBO1**	**Mineral Open Beach / Bar Ecosite**	coastal, no CAKEDEN or CHAPOLY
BBO1-1		BBO1-1	Sea Rocket Sand Open Beach Type	coastal
BBO1-2		BBO1-2	Wormwood Gravel Open Beach type	coastal
BBO1-3		BBO1-3	Reed-canary Grass Mineral Open Beach Type	usually riparian; cover >10-25%
BBO1-A		BBO1-A	Riparian Sand / Gravel Bar Type	generally bare, disturbed hydrology
		BBO2	**Bedrock Open Beach / Bar Ecosite**	
BBO2-1		BBO2-1	Shrubby Cinquefoil Carbonate Open Bedrock Beach Type	
BBO2-A		BBO2-A	Rubble Open Shoreline / Beach Type	anthropogenic debris or boulders
BBS		**BBS**	**Shrub Beach / Bar**	
BBS1		**BBS1**	**Mineral Shrub Beach / Bar Ecosite**	
BBS1-1		BBS1-1	Red Cedar - Common Juniper Shingle Shrub Beach Type	
BBS1-2		BBS1-2	Willow Gravel Shrub Beach Type	usually riparian; cover >10-25%
BBS1-A	**SHSM1-2**	BBS1-A	Red Osier Dogwood Shrub Beach Type	usually sheltered coastal
	SHSM1	**SHSM1**	**Mineral Shrub Shoreline Ecosite**	SHSM1-1 and SHSM1-3 belong to SHSM1 Mineral Shrub Shoreline Ecosite. Vegetation is a patchy or continuous cover of shrubs; understory consists mainly of the species found in Open Mineral Bedrock shorelines. The substrate is unconsolidated mineral substrates; dominant materials <2 mm diameter ; e.g. sands, loams, silts, and clays.
	SHSM1-1	SHSM1-1	Alder Mineral Shrub Shoreline Type	
	SHSM1-3	SHSM1-3	Willow Mineral Shrub Shoreline Type	
BBS2		**BBS2**	**Bedrock Shrub Beach / Bar Ecosite**	
	SHSR2-1	SHSR2-1	Bedrock Shrub Shoreline Type	
BBT		**BBT**	**Treed Beach / Bar**	
BBT1		**BBT1**	**Mineral Treed Beach / Bar Ecosite**	coastal or riparian
	SHTM1-1	SHTM1-1	Cottonwood Mineral Treed Shoreline Type	
BBT2		**BBT2**	**Bedrock Treed Beach / Bar Ecosite**	
			Sand Dune	
SDO		**SDO**	**Open Sand Dune**	
SDO1		**SDO1**	**Open Sand Dune Ecosite**	
SDO1-1		SDO1-1	Little Bluestem - Switchgrass - Beachgrass Open Dune Type	
SDO1-2		SDO1-2	Little Bluestem - Long-leaved Reed Grass - Great Lakes Wheatgrass Open Dune Type	
SDO1-A		SDO1-A	Sand Dropseed - Flat-stemmed Bluegrass Open Dune Type	

	SBOD1	**SBOD1**	**Open Sand Dune Ecosite**	Vegetation is dominated by graminoid species; cover varies from barren scattered to more continuous cover. Substrate is active rolling sand hills formed by shoreline and aeolian processes; restricted to the near-shore areas of the Great Lakes in 6E and 7E. Stability of substrate most variable in open areas; little to no accumulation of organic materials; low nutrient availability. Substrate is subjected to drought and temperature extremes.
	SBOD1-3	SBOD1-3	Beach Grass - Wormwood Open Graminoid Sand Dune Type	
SDS		**SDS**	**Shrub Sand Dune**	
SDS1		**SDS1**	Sand Shrub Dune Ecosite	
SDS1-1		SDS1-1	Sand Cherry Shrub Sand Dune Type	
SDS1-2		SDS1-2	Hop-tree Shrub Sand Dune Type	
SDS1-3		SDS1-3	Juniper Shrub Sand Dune Type	
SDS1-A	**SBSD1-3**	SDS1-A	Willow Shrub Sand Dune Type	check also BBS1-2, CUT1-G
SDS1-B	**SBSD1-4**	SDS1-B	Dogwood Shrub Sand Dune Type	
SDT		**SDT**	**Treed Sand Dune**	
SDT1		**SDT1**	**Treed Sand Dune Ecosite**	
SDT1-1		SDT1-1	Cottonwood Treed Sand Dune	
SDT1-2		SDT1-2	Balsam Poplar Treed Sand Dune	
SDT1-3		SDT1-3	Red Cedar Treed Sand Dune Type	
			Alvar	
ALO		**ALO**	**Open Alvar**	
ALO1		**ALO1**	**Open Alvar Ecosite**	
ALO1-1		ALO1-1	Dry Lichen - Moss Open Alvar Pavement Type	
ALO1-2		ALO1-2	Dry Annual Open Alvar Pavement Type	
ALO1-3		ALO1-3	Dry - Fresh Little Bluestem Open Alvar Meadow Type	
ALO1-4		ALO1-4	Dry - Fresh Poverty Grass Open Alvar Meadow Type	
ALO1-5		ALO1-5	Fresh - Moist Tufted Hairgrass Open Alvar Meadow Type	
ALS		**ALS**	**Shrub Alvar**	
ALS1		**ALS1**	**Shrub Alvar Ecosite**	
ALS1-1		ALS1-1	Common Juniper Shrub Alvar Type	
ALS1-2		ALS1-2	Creeping Juniper-Shrubby Cinquefoil Dwarf Shrub Alvar Type	
ALS1-3		ALS1-3	Scrub Conifer - Dwarf Lake Iris Shrub Alvar Type	
ALT	**ALO**	**ALT**	**Treed Alvar**	
ALT1		**ALT1**	**Treed Alvar Ecosite**	
ALT1-1		ALT1-1	Chinquapin Oak - Nodding Onion Treed Alvar Type	
ALT1-2		ALT1-2	Shagbark Hickory - Prickly Ash Treed Alvar Type	
ALT1-3		ALT1-3	White Cedar - Jack Pine Treed Alvar Type	
ALT1-4		ALT1-4	Jack Pine - White Cedar - White Spruce Treed Alvar Type	
ALT1-5		ALT1-5	Red Cedar - Early Buttercup Treed Alvar Type	

	RBTA1	**RBTA1**	**Treed Alvar Rock Barren Ecosite**	Vegetation: patch to semi-open treed communities; understory plant cover patchy to continuous. Sedimentary rock, with high calcareous content; level, unfractured limestone bedrock; patchy mosaic of bare rock pavement and shallow substrates over bedrock; substrate depth <15cm: treed alvars tend to reflect greater accumulations of soil within the cracks and pockets of the bedrock surfaces, seasonal alternation between inundation and drought; shade effects may dampen temperature and moisture extremes.
	RBTA1-6	RBTA1-6	Bur Oak Treed Alvar Type	
			Rock Barren	
RBO		**RBO**	**Open Rock Barren**	
RBO1		**RBO1**	**Carbonate Open Rock Barren Ecosite**	
RBO1-1		RBO1-1	Dry Carbonate Open Rock Barren Type	
	RBOB1-2	RBOB1-2	Calcareous Open Rock Barren Meadow Type	
RBO2		**RBO2**	**Basic Open Rock Barren Ecosite**	
RBO2-1		RBO2-1	Dry Basic Open Rock Barren Type	
RBO3		**RBO3**	**Acidic Open Rock Barren Ecosite**	
RBO3-1		RBO3-1	Dry Acidic Open Rock Barren Type	
	RBOB2-2	RBOB2-2	Non-Calcareous Open Rock Barren Meadow Type	
RBS		**RBS**	**Shrub Rock Barren**	
RBS1		**RBS1**	**Carbonate Shrub Rock Barren Ecosite**	
RBS1-1		RBS1-1	Common Juniper Carbonate Shrub Rock Barren Type	
RBS1-2		RBS1-2	Round-leaved Dogwood Carbonate Shrub Rock Barren Type	
RBS2		**RBS2**	**Basic Shrub Rock Barren Ecosite**	
RBS2-1		RBS2-1	Chokecherry Basic Shrub Rock Barren Type	
RBS2-2		RBS2-2	Common Juniper Basic Shrub Rock Barren Type	
RBS3		**RBS3**	**Acidic Shrub Rock Barren Ecosite**	
RBS3-1		RBS3-1	Blueberry Acidic Shrub Rock Barren Type	
RBS3-2		RBS3-2	Common Juniper Acidic Shrub Rock Barren Type	
RBT		**RBT**	**Treed Rock Barren**	
RBT1		**RBT1**	**Carbonate Treed Rock Barren Ecosite**	
RBT1-1		RBT1-1	Red Cedar Carbonate Treed Rock Barren Type	
RBT1-2		RBT1-2	Hackberry Carbonate Treed Rock Barren Type	
RBT1-3		RBT1-3	Oak Carbonate Treed Rock Barren Type	
RBT2		**RBT2**	**Basic Treed Rock Barren Ecosite**	
RBT2-1		RBT2-1	Oak - Red Maple - Pine Basic Treed Rock Barren Type	
RBT2-2		RBT2-2	Red Cedar Basic Treed Rock Barren Type	
RBT2-3		RBT2-3	Jack Pine Basic Treed Rock Barren Type	
RBT3		**RBT3**	**Acidic Treed Rock Barren Ecosite**	

RBT3-1		RBT3-1	Pitch Pine Acidic Treed Rock Barren Type	
RBT3-2		RBT3-2	Jack Pine Acidic Treed Rock Barren Type	
			Sand Barren	
CBO1		**CBO1**	**Open Clay Barren Ecosite**	exposed soil, not steep, SOLNEMO, grasses
CBS1		**CBS1**	**Shrub Clay Barren Ecosite**	stunted PRUVIG, JUP_SPP, etc.
SBO		**SBO**	**Open Sand Barren**	
SBO1		**SBO1**	**Open Sand Barren Ecosite**	
SBO1-1		SBO1-1	Dry Bracken Fern Sand Barren Type	
SBO1-2		SBO1-2	Dry Hay Sedge Sand Barren Type	CARSICC
SBO1-3		SBO1-3	Dry Slender Wheat-grass Sand Barren Type	
SBO1-A		SBO1-A	Dry Dropseed Sand Barren Type	
SBO1-B		SBO1-B	Dry-Fresh Flat-stemmed Bluegrass - Forb Sand Barren Type	
SBO1-C		SBO1-C	Hard Fescue Sand Barren Type	
	SBOB1-7	SBOB1-7	Tall Wormwood Open Sand Barren Type	
	SBOB1-8	SBOB1-8	Poverty Oat Grass Open Sand Barren Type	
SBO2		**SBO2**	**Anthropogenic Sand / Gravel Barren Ecosite**	ground rubble, asphalt, brick fragments
SBS		**SBS**	**Shrub Sand Barren**	
SBS1		**SBS1**	**Shrub Sand Barren Ecosite**	
	SBSB1-1	SBSB1-1	Sweet-Fern Lowshrub Barren Type	
	SBSB1-2	SBSB1-2	Sweet-Fern - New Jersey Tea Sand Barren Type	
SBT		**SBT**	**Treed Sand Barren**	
SBT1		**SBT1**	**Treed Sand Barren Ecosite**	
			Crevice and Cave	
CCR		**CCR**	**Crevice**	
CCR1		**CCR1**	**Carbonate Crevice Ecosite**	
CCR1-1		**CCR1-1**	**Moist Liverwort - Moss - Fern Carbonate Crevice Type**	
CCR2		**CCR2**	**Acidic Crevice Ecosite**	
CCA		**CCA**	**Cave**	
CCA1		**CCA1**	**Carbonate Cave Ecosite**	
CCA2		**CCA2**	**Acidic Cave Ecosite**	
			Bluff	
BLO		**BLO**	**Open Bluff**	
BLO1		**BLO1**	**Mineral Open Bluff Ecosite**	use for all non-shrub/treed bluffs
BLO1-1		BLO1-1	Open Clay Bluff Type	
BLS		**BLS**	**Shrub Bluff**	
BLS1		**BLS1**	**Mineral Shrub Bluff Ecosite**	
BLS1-A	**BLSM1-1/BLSM1-2**	BLS1-A	Sumac - Willow Shrub Bluff Type	
BLS1-B	**BLSM1-3**	BLS1-B	Serviceberry - Buffaloberry Shrub Bluff Type	
BLS1-C	**BLSM1-4**	BLS1-C	Exotic Shrub Bluff Type	exotics >50% canopy: ELAUMBE, etc.
	BLSM1-5	BISM1-5	Raspberry Low Shrub Bluff Type	
BLT		**BLT**	**Treed Bluff**	

BLT1		**BLT1**	**Mineral Treed Bluff Ecosite**	
BLT1-A	**BLTM1-1**	BLT1-A	White Cedar Treed Bluff Type	coniferous or mixed composition
BLT1-B	**BLTM1-3**	BLT1-B	Deciduous Treed Bluff Type	deciduous composition
BLT1-C	**BLTM1-4**	BLT1-C	Exotic Treed Bluff Type	exotics >50% canopy: ALNGLUT, ROBPSEU, etc.
	BLTM1-2	BLTM1-2	Manitoba Maple Treed Bluff Type	
			Talus	
TAO		**TAO**	**Open Talus**	
TAO1		**TAO1**	**Carbonate Open Talus Ecosite**	
TAO1-1		TAO1-1	Dry - Fresh Calcareous Open Talus Type	
TAO1-2		TAO1-2	Fresh - Moist Calcareous Open Talus Type	
TAO2		**TAO2**	**Acidic Shrub Talus Ecosite**	
TAS		**TAS**	**Shrub Talus**	
TAS1		**TAS1**	**Carbonate Treed Talus Ecosite**	
TAS1-1		TAS1-1	Round-leaved Dogwood Carbonate Shrub Talus Type	
TAS1-2		TAS1-2	Mountain Maple Carbonate Shrub Talus Type	
TAT		**TAT**	**Treed Talus**	
TAT1		**TAT1**	**Carbonate Treed Talus Ecosite**	
TAT1-1		TAT1-1	Dry- Fresh Chinquapin Oak Carbonate Treed Talus Type	
TAT1-2		TAT1-2	Dry - Fresh White Cedar Carbonate Treed Talus Type	
TAT1-3		TAT1-3	Dry - Fresh White Birch Carbonate Treed Talus Type	
TAT1-4		TAT1-4	Fresh - Moist Sugar Maple Carbonate Treed Talus Type	
TAT1-5		TAT1-5	Fresh - Moist Basswood - White Ash Carbonate Treed Talus Type	
TAT1-6		TAT1-6	Fresh - Moist Hemlock - Sugar maple Carbonate Treed Talus Type	
			Cliff	
CLO		**CLO**	**Open Cliff**	
CLO1		CLO1	**Carbonate Open Cliff Ecosite**	
CLO1-1		CLO1-1	Cliffbrake - Lichen Carbonate Open Cliff Type	
CLO1-2		CLO1-2	Bulblet Fern - Herb Robert Carbonate Open Cliff Type	
CLO1-3		CLO1-3	Canada Bluegrass Carbonate Open Cliff Type	
CLO1-4		CLO1-4	Moist Open Carbonate Cliff Seepage Type	
CLO1-5		CLO1-5	Open Carbonate Cliff Rim Type	
CLS		**CLS**	**Shrub Cliff**	
CLS1		**CLS1**	**Carbonate Shrub Cliff Ecosite**	consolidated rock only
CLS1-1		CLS1-1	Common Juniper Carbonate Cliff Type	
CLS1-2		CLS1-2	Round-leaved Dogwood Carbonate Cliff Type	
CLS2		**CLS2**	**Acidic Shrub Cliff Ecosite**	
CLT		**CLT**	**Treed Cliff**	
CLT1		**CLT1**	**Carbonate Treed Cliff Ecosite**	

CLT1-1		CLT1-1	White Cedar Treed Calcareous Cliff Type	
CLT1-2		CLT1-2	Sugar Maple - Ironwood - White Ash Treed Carbonate Cliff Type	consolidated rock only
CLT1-3		CLT1-3	White Birch - Aspen Treed Carbonate Cliff Type	
			Tallgrass Prairie, Savannah and Woodland	
TPO		**TPO**	**Open Tallgrass Prairie**	
TPO1		**TPO1**	**Dry Tallgrass Prairie Ecosite**	
TPO1-1		TPO1-1	Dry Tallgrass Prairie Type	
TPO2		**TPO2**	**Fresh-Moist Tallgrass Prairie Ecosite**	
TPO2-1		TPO2-1	Fresh-Moist Tallgrass Prairie Type	
TPS		**TPS**	**Tallgrass Savannah**	
TPS1		**TPS1**	**Dry Tallgrass Savannah Ecosite**	
TPS1-1		TPS1-1	Dry Black Oak Tallgrass Savannah Type	
TPS1-2		TPS1-2	Dry Black Oak - Pine Tallgrass Savannah Type	
TPS2		TPS2	Fresh-Moist Tallgrass Savannah Ecosite	
TPS2-1		TPS2-1	Fresh-Moist Pink Oak - Bur Oak Tallgrass Savannah Type	
TPW		**TPW**	**Tallgrass Woodland**	
TPW1		**TPW1**	**Dry Tallgrass Woodland Ecosite**	
TPW1-1		TPW1-1	Dry Black Oak - White Oak Tallgrass Woodland Type	
TPW1-2		TPW1-2	Dry Bur Oak - Shagbark Hickory Tallgrass Woodland Type	
	WODM2-1	WODM2-1	Dry White Birch - Trembling Aspen Deciduous Tallgrass Woodland Type	
	WODM3-2	WODM3-2	Dry Black Oak Tallgrass Woodland Type	
	WODM3-3	WODM3-3	Dry White Oak Tallgrass Woodland Type	
	WODM4-1	WODM4-1	Hawthorn / Apple Deciduous Tallgrass Woodland Type	
	WODM4-2	WODM4-2	White Ash Deciduous Tallgrass Woodland Type	
	WODM4-3	WODM4-3	Sugar maple Deciduous Tallgrass Woodland Type	
	WODM4-4	WODM4-4	Dry - Fresh Black Walnut Deciduous Tallgrass Woodland Type	
TPW2		**TPW2**	**Fresh - Moist Tallgrass Woodland Ecosite**	
TPW2-1		TPW2-1	Fresh - Moist Black Oak - White Oak Tallgrass Woodland Type	
TPW2-2		TPW2-2	Fresh - Moist Pin Oak Tallgrass Woodland Type	
TPW2-A		TPW2-A	Fresh - Moist Cottonwood Tallgrass Woodland Type	coastal variant
	WODM5-1	WODM5-1	Fresh - Moist Poplar Deciduous Woodland Type	
	WODM5-2	WODM5-2	Fresh - Moist Elm Deciduous Woodland Type	
	WODM5-3	WODM5-3	Fresh - Moist Manitoba Maple Deciduous Woodland Type	
	WODM5-4	WODM5-4	Fresh - Moist Hawthorn / Apple Deciduous Woodland Type	

			Forest	
FOC		**FOC**	**Coniferous Forest**	
FOC1		**FOC1**	**Dry-Fresh Pine Coniferous Forest Ecosite**	
FOC1-1		FOC1-1	Dry Jack Pine Coniferous Forest Type	
FOC1-2		FOC1-2	Dry-Fresh White Pine - Red Pine Coniferous Forest Type	PINSTRO (almost never PINRESI), not planted
FOC1-A		FOC1-A	Dry-Fresh Scots Pine Coniferous Forest Type	not planted, more mature than CUT1-A3
FOC2		**FOC2**	**Dry-Fresh Cedar Coniferous Forest Ecosite**	
FOC2-1		FOC2-1	Dry-Fresh Red Cedar Coniferous Forest Type	
FOC2-2		FOC2-2	Dry-Fresh White Cedar Coniferous Forest Type	
FOC3		**FOC3**	**Fresh-Moist Hemlock Coniferous Forest Ecosite**	
FOC3-1		FOC3-1	Fresh-Moist Hemlock Coniferous Forest Type	
FOC3-A	**FOCM3-2**	FOC3-A	Fresh-Moist Hemlock - White Pine Coniferous Forest Type	
FOC4		**FOC4**	**Fresh-Moist White Cedar Coniferous Forest Ecosite**	
FOC4-1		FOC4-1	Fresh-Moist White Cedar Coniferous Forest Type	
FOC4-2		FOC4-2	Fresh-Moist White Cedar - Hemlock Coniferous Forest Type	
FOC4-3		FOC4-3	Fresh-Moist White Cedar - Balsam Fir Coniferous Forest Type	
FOC4-A	**FOCM4-4**	FOC4-A	Fresh-Moist White Cedar - White Pine Coniferous Forest Type	
	FOCM6	**FOCM6**	**Naturalized Coniferous Plantation**	Communities succeeding to Hardwood types. Species are present in canopy and regenerating in understory. Hardwood may be dominant with conifers or dominant.
	FOCM6-1	FOCM6-1	Dry - Fresh White Pine Naturalized Coniferous Plantation Type	
	FOCM6-2	FOCM6-2	Dry - Fresh Red Pine Naturalized Coniferous Plantation Type	
	FOCM6-3	FOCM6-3	Dry - Fresh Scotch Pine Naturalized Coniferous Plantation Type	
FOM		**FOM**	**Mixed Forest**	If the site is a regenerating plantation please refer to FOCM6
FOM1		**FOM1**	**Dry Oak - Pine Mixed Forest Ecosite**	
FOM1-1		FOM1-1	Dry Pitch Pine - Oak Mixed Forest Type	
FOM1-2		FOM1-2	Dry Chinquapin Oak - Pine Mixed Forest Type	
FOM2		**FOM2**	**Dry-Fresh White Pine - Maple - Oak Mixed Forest Ecosite**	
FOM2-1		FOM2-1	Dry-Fresh White Pine - Oak Mixed Forest Type	
FOM2-2		FOM2-2	Dry-Fresh White Pine - Sugar Maple Mixed Forest Type	
FOM2-A	**FOMM2-3**	FOM2-A	Dry-Fresh White Pine - Hardwood Mixed Forest Type	PINSTRO with PRUSERO, FRAAMER, ULMAMER, etc.
	FOMM2-4	FOMM2-4	Dry-Fresh White Pine - Early Successional Mixed Forest Type	PINSTRO with BETPAPY, POPTREM, ACERUBR, PRUSERO
FOM3		**FOM3**	**Dry-Fresh Hardwood - Hemlock Mixed Forest Ecosite**	
FOM3-1		FOM3-1	Dry-Fresh Hardwood Hemlock Mixed Forest Type	
FOM3-2		FOM3-2	Dry-Fresh Sugar Maple - Hemlock Mixed Forest Type	
FOM3-A		FOM3-A	Dry-Fresh Hemlock - Manitoba Maple Mixed Forest Type	probably indicates decline of TSUCANA

	FOMM3-3	FOMM3-3	Dry-Fresh Hemlock - White Pine Mixed Forest Type	TSUCANA with PINSTRO, hard maple (ACESASA or ACESANI), ACERUBR, BETPAPY, and FAGGRAN associates
FOM4		**FOM4**	**Dry-Fresh White Cedar Mixed Forest Ecosite**	
FOM4-1		FOM4-1	Dry-Fresh White Cedar - White Birch Mixed Forest Type	
FOM4-2		FOM4-2	Dry-Fresh White Cedar - Poplar Mixed Forest Type	
FOM4-A	**FOMM4-3**	FOM4-A	Dry-Fresh White Cedar - Hardwood Mixed Forest Type	THUOCCI with FRAAMER, QUERUBR, ULMAMER
FOM5		**FOM5**	**Dry-Fresh White Birch - Poplar - Conifer Mixed Forest Ecosite**	if THUOCCI dominant, see FOM4
FOM5-1		FOM5-1	Dry-Fresh White Birch Mixed Forest Type	BETPAPY with TSUCANA, PINSTRO, PIC_SPP, ABIBALS
FOM5-2		FOM5-2	Dry-Fresh Poplar Mixed Forest Type	POP_SPP with TSUCANA, PINSTRO, PIC_SPP, ABIBALS
FOM6		**FOM6**	**Fresh-Moist Hemlock Mixed Forest Ecosite**	
FOM6-1		FOM6-1	Fresh-Moist Sugar Maple - Hemlock Mixed Forest Type	
FOM6-2		FOM6-2	Fresh-Moist Hemlock - Hardwood Mixed Forest Type	
FOM7		**FOM7**	**Fresh-Moist White Cedar - Hardwood Mixed Forest Ecosite**	
FOM7-1		FOM7-1	Fresh-Moist White Cedar - Sugar Maple Mixed Forest Type	
FOM7-2		FOM7-2	Fresh-Moist White Cedar - Hardwood Mixed Forest Type	
FOM8		**FOM8**	**Fresh-Moist Poplar - Paper Birch Mixed Forest Ecosite**	THUOCCI low or absent; if dominant see FOM7
FOM8-1		FOM8-1	Fresh-Moist Poplar Mixed Forest Type	POPTREM/POPBALS with PINSTRO, TSUCANA, ABIBALS, PICMARI
FOM8-2		FOM8-2	Fresh-Moist White Birch Mixed Forest Type	BETPAPY with PINSTRO, TSUCANA, ABIBALS, PICGLAU, PICMARI
FOM8-A		FOM8-A	Fresh-Moist Poplar - White Birch Coastal Mixed Forest Type	derives from planting under POPDEDE, BETPAPY
FOM8-B		FOM8-B	Fresh-Moist Ash Mixed Forest Type	FRAPENN/FRAAMER with PINSTRO, PINSYLV, ABIBALS, TSUCANA, PICGLAU, PICMAR
FOMA		**FOMA**	**Fresh-Moist White Pine Mixed Forest Ecosite**	
FOMA-A	**FOMM9-1**	FOMA-A	Fresh-Moist White Pine - Sugar Maple Mixed Forest Type	
FOMA-B		FOMA-B	Fresh-Moist White Pine - Hawthorn Mixed Forest Type	TRCA found at Boyd North property
	FOMM9-2	FOMM9-2	Fresh-Moist White Pine - Hardwood Mixed Forest Type	
	FOMM10	**FOMM10**	**Fresh-Moist Spruce/Fir-Hardwood Mixed Forest Ecosite**	
	FOMM10-1	FOMM10-1	Fresh-Moist Balsam Fir- Hardwood Mixed Forest Type	
	FOMM10-2	FOMM10-2	Fresh-Moist White Spruce - Hardwood Mixed Forest Type	
FOD		**FOD**	**Deciduous Forest**	
FOD1		**FOD1**	**Dry-Fresh Oak Deciduous Forest Ecosite**	
FOD1-1		FOD1-1	Dry-Fresh Red Oak Deciduous Forest Type	
FOD1-2		FOD1-2	Dry-Fresh White Oak Deciduous Forest Type	
FOD1-3		FOD1-3	Dry-Fresh Black Oak Deciduous Forest Type	
FOD1-4		FOD1-4	Dry-Fresh Mixed Oak Deciduous Forest Type	2+ spp of Quercus, no single dominant
	FODR1-1	FODR1-1	Dry - Fresh Sugar Maple - Hardwood Calcareous Shallow Deciduous Forest Type	May be present on the Niagara Escarpment. Shallow soils <30cm.

FOD2		**FOD2**	**Dry-Fresh Oak - Maple - Hickory - Deciduous Forest Ecosite**	
FOD2-1		FOD2-1	Dry-Fresh Oak - Red Maple Deciduous Forest Type	
FOD2-2		FOD2-2	Dry-Fresh Oak - Hickory Deciduous Forest Type	
FOD2-3		FOD2-3	Dry-Fresh Hickory Deciduous Forest	
FOD2-4		FOD2-4	Dry-Fresh Oak - Hardwood Deciduous Forest Type	
	FODR2-1	FODR2-1	Dry - Fresh Oak - Hardwood Non-Calcareous Shallow Deciduous Forest Type	Soils <30cm
FOD3		**FOD3**	**Dry-Fresh Poplar - Paper Birch Deciduous Forest Ecosite**	
FOD3-1		FOD3-1	Dry-Fresh Poplar Deciduous Forest Type	
FOD3-2		FOD3-2	Dry-Fresh White Birch Deciduous Forest Type	
FOD4		**FOD4**	**Dry-Fresh Deciduous Forest Ecosite**	
FOD4-1		FOD4-1	Dry-Fresh Beech Deciduous Forest Type	
FOD4-2		FOD4-2	Dry-Fresh White Ash Deciduous Forest Type	
FOD4-3		FOD4-3	Dry - Fresh Hackberry Deciduous Forest Type	
FOD4-A	**FODM4-4**	FOD4-A	Dry-Fresh Ironwood Deciduous Forest Type	
FOD4-B	**FODM4-5**	FOD4-B	Dry-Fresh Manitoba Maple Deciduous Forest Type	
FOD4-C	**FODM4-11**	FOD4-C	Dry-Fresh Black Locust Deciduous Forest Type	ROBPSEU always from plantings
FOD4-D	**FODM4-6**	FOD4-D	Dry-Fresh Norway Maple Deciduous Forest Type	
FOD4-E	**FODM4-12**	FOD4-E	Dry-Fresh Exotic Deciduous Forest Type	ULMPUMI, AILALTI, MOR_SP, CRA_SP, etc
FOD4-F	**FODM4-8**	FOD4-F	Dry-Fresh Black Cherry Deciduous Forest Type	
FOD4-G	**FODM4-9**	FOD4-G	Dry-Fresh Basswood Deciduous Forest Type	
FOD4-H	**FODM4-10**	FOD4-H	Dry-Fresh Hawthorn - Apple Deciduous Forest Type	
FOD4-I	**FODM4-7**	FOD4-I	Dry-Fresh Red Maple Deciduous Forest Type	
FOD4-J		FOD4-J	Dry-Fresh Pin Cherry Deciduous Forest Type	
FOD5		**FOD5**	**Dry-Fresh Sugar Maple Deciduous Forest Ecosite**	
FOD5-1		FOD5-1	Dry-Fresh Sugar Maple Deciduous Forest Type	
FOD5-2		FOD5-2	Dry-Fresh Sugar Maple - Beech Deciduous Forest Type	
FOD5-3		FOD5-3	Dry-Fresh Sugar Maple - Oak Deciduous Forest Type	
FOD5-4		FOD5-4	Dry-Fresh Sugar Maple - Ironwood Deciduous Forest Type	
FOD5-5		FOD5-5	Dry-Fresh Sugar Maple - Hickory Deciduous Forest Type	
FOD5-6		FOD5-6	Dry-Fresh Sugar Maple - Basswood Deciduous Forest Type	
FOD5-7		FOD5-7	Dry-Fresh Sugar Maple - Black Cherry Deciduous Forest Type	
FOD5-8		FOD5-8	Dry-Fresh Sugar Maple - White Ash Deciduous Forest Type	
FOD5-9		FOD5-9	Dry-Fresh Sugar Maple - Red Maple Deciduous Forest Type	
FOD5-10		FOD5-10	Dry-Fresh Sugar Maple - White Birch - Poplar Deciduous Forest Type	
FOD5-A		FOD5-A	Dry-Fresh Sugar Maple - Hawthorn Deciduous Forest Type	
FOD5-B		FOD5-B	Dry-Fresh Sugar Maple - Norway Maple Deciduous Forest Type	

	FODM5-11	FODM5-11	Dry - Fresh Sugar Maple - Hardwood Deciduous Forest Type	
FOD6		**FOD6**	**Fresh-Moist Sugar Maple Deciduous Forest Ecosite**	
FOD6-1		FOD6-1	Fresh-Moist Sugar Maple - Lowland Ash Deciduous Forest Type	
FOD6-2		FOD6-2	Fresh-Moist Sugar Maple - Black Maple Deciduous Forest Type	both ACESASA & ACESANI - see also FOD7-5
FOD6-3		FOD6-3	Fresh-Moist Sugar Maple - Yellow Birch Deciduous Forest Type	
FOD6-4		FOD6-4	Fresh-Moist Sugar Maple - White Elm Deciduous Forest Type	
FOD6-5		FOD6-5	Fresh-Moist Sugar Maple - Hardwood Deciduous Forest Type	if oak is dominant, see FOD9-1
FOD7		**FOD7**	**Fresh-Moist Lowland Deciduous Forest Ecosite**	
FOD7-1		FOD7-1	Fresh-Moist White Elm Lowland Deciduous Forest Type	
FOD7-2		FOD7-2	Fresh-Moist Ash Lowland Deciduous Forest Type	
FOD7-3		FOD7-3	Fresh-Moist Willow Lowland Deciduous Forest Type	exotic SAL_SP or SALAMYG
FOD7-4		FOD7-4	Fresh-Moist Black Walnut Lowland Deciduous Forest Type	
FOD7-5		FOD7-5	Fresh-Moist Black Maple Lowland Deciduous Forest Type	ACESANI>ACESASA; usually floodplains
FOD7-A	**FODM7-7**	FOD7-A	Fresh-Moist Manitoba Maple Lowland Deciduous Forest Type	
FOD7-B	**FODM7-8**	FOD7-B	Fresh-Moist Norway Maple Lowland Deciduous Forest Type	
FOD7-C	**FODM7-9**	FOD7-C	Fresh-Moist Exotic Lowland Deciduous Forest Type	mature RHA__SP; ALNGLUT, ULMPUMI, etc.
FOD7-D		FOD7-D	Fresh-Moist Red Maple Lowland Deciduous Forest Type	
FOD7-E		FOD7-E	Fresh-Moist Hawthorn - Apple Lowland Deciduous Forest Type	native CRA__SP>MAL__SP, CRAMONO
FOD7-F		FOD7-F	Fresh-Moist Basswood Lowland Deciduous Forest Type	
	FODM7-6	FODM7-6	Fresh-Moist Black Ash - Hardwood Lowland Deciduous Forest Type	
FOD8		**FOD8**	**Fresh-Moist Poplar - Sassafras Deciduous Forest Ecosite**	
FOD8-1		FOD8-1	Fresh-Moist Poplar Deciduous Forest	
FOD8-2		FOD8-2	Fresh - Moist Sassafras Deciduous Forest Type	
FOD8-A		FOD8-A	Fresh-Moist Cottonwood Coastal Deciduous Forest	on fill & old beach ridges
FOD8-B		FOD8-B	Fresh-Moist Paper Birch Deciduous Forest	
	FODM8-3	FODM8-3	Fresh-Moist Cottonwood Deciduous Forest	
FOD9		**FOD9**	**Fresh-Moist Oak - Maple - Hickory Deciduous Forest Ecosite**	
FOD9-1		FOD9-1	Fresh-Moist Oak - Sugar Maple Deciduous Forest Type	Oak with ACESASA or ACESANI; also FOD6-5
FOD9-2		FOD9-2	Fresh-Moist Oak - Maple Deciduous Forest Type	Oak with ACESACC, ACERUBR, ACEXFRE, ACENEGU
FOD9-3		FOD9-3	Fresh-Moist Bur Oak Deciduous Forest Type	QUEMACR alone or with FRAPENN, ULMAMER
FOD9-4		FOD9-4	Fresh-Moist Shagbark Hickory Deciduous Forest Type	
FOD9-5		FOD9-5	Fresh-Moist Bitternut Hickory Deciduous Forest Type	
FOD9-A	**FODM9-6**	FOD9-A	Fresh-Moist Oak - Beech Deciduous Forest Type	
FOD9-B	**FODM9-6**	FOD9-B	Fresh-Moist Oak - Birch Deciduous Forest Type	QUERUBR with BETPAPY, BETALLE

	FODM10	**FODM10**	**Fresh-Moist Carolinian Deciduous Forest Ecosite**	
	FODM10-1	FODM10-1	Fresh-Moist Sugar Maple - Beech Carolinian Deciduous Forest Type	hard maple (ACESASA/ACESANI) and FAGGRAN with LIRTULI, SASALBI, GAYBACC
	FODM10-2	FODM10-2	Fresh-Moist Oak Carolinian Deciduous Forest Type	QUERUBR, QUEALBA, QUEMACR, TILAMER with LIRTULI, SASALBI, GAYBACC
			Cultural	
CUP		**CUP**	**Plantation**	
CUP1		**CUP1**	**Deciduous Plantation Ecosite**	
CUP1-1		CUP1-1	Sugar Maple Deciduous Plantation Type	
CUP1-2		CUP1-2	Basswood Deciduous Plantation Type	
CUP1-3		CUP1-3	Black Walnut Deciduous Plantation Type	
CUP1-4		CUP1-4	Hybrid Poplar Deciduous Plantation Type	
CUP1-5		CUP1-5	Silver Maple Deciduous Plantation Type	
CUP1-6		CUP1-6	Red Maple Deciduous Plantation Type Type	
CUP1-7		CUP1-7	Green Ash Deciduous Plantation Type	
CUP1-7A		CUP1-7A	White Ash Deciduous Plantation Type	
CUP1-8		CUP1-8	Red Oak Deciduous Plantation Type	
CUP1-9		CUP1-9	Sassafras Deciduous Plantation Type	
CUP1-10		CUP1-10	Tulip Tree Deciduous Plantation Type	
CUP1-A		CUP1-A	Restoration Deciduous Plantation Type	3+ spp native trees & shrubs
CUP1-B		CUP1-B	Willow Deciduous Plantation Type	
CUP1-C		CUP1-C	Black Locust Deciduous Plantation Type	formerly designated FOD4-C
CUP1-D		CUP1-D	Horticultural Deciduous Plantation Type	ACEPLAT, ULMPUMI, TILCORD, etc.
CUP1-E		CUP1-E	White Birch Deciduous Plantation Type	
CUP1-F		CUP1-F	Siberian Elm Deciduous Plantation Type	
CUP1-G		CUP1-G	Apple Deciduous Plantation Type	abandoned orchard
CUP2		**CUP2**	**Mixed Plantation Ecosite**	
CUP2-1		CUP2-1	Black Walnut - White Pine Mixed Plantation Type	
CUP2-1A		CUP2-1A	Black Walnut - Conifer Mixed Plantation Type	
CUP2-A		CUP2-A	Restoration Mixed Plantation Type	3+ spp native trees & shrubs
CUP2-B		CUP2-B	Black Locust - Conifer Mixed Plantation Type	
CUP2-C		CUP2-C	Norway Maple - Conifer Mixed Plantation Type	outcome easy to predict
CUP2-D		CUP2-D	Apple - Conifer Mixed Plantation Type	old orchard with conifers planted
CUP2-E		CUP2-E	Silver Maple - Conifer Mixed Plantation Type	
CUP2-F		CUP2-F	Hybrid Poplar - Conifer Mixed Plantation Type	
CUP2-G		CUP2-G	Ash - Conifer Mixed Plantation Type	
CUP2-H		CUP2-H	Horticultural Mixed Plantation Type	decid & conif ornamentals
CUP2-I		CUP2-I	Red Oak - Conifer Mixed Plantation Type	QUERUBR with native or exotic conifers
CUP3		**CUP3**	**Coniferous Plantation Ecosite**	
CUP3-1		CUP3-1	Red Pine Coniferous Plantation	
CUP3-2		CUP3-2	White Pine Coniferous Plantation	

CUP3-3		CUP3-3	Scots Pine Coniferous Plantation	
CUP3-4		CUP3-4	Jack Pine Coniferous Plantation	
CUP3-5		CUP3-5	Tamarack- European Larch Coniferous Plantation Type	
CUP3-6		CUP3-6	European Larch Coniferous Plantation Type	
CUP3-7		CUP3-7	Japanese Larch - European Larch Coniferous Plantation Type	
CUP3-8		CUP3-8	White Spruce - European Larch Coniferous Plantation Type	
CUP3-8A		CUP3-8A	White Spruce - Tamarack Coniferous Plantation Type	
CUP3-9		CUP3-9	Norway Spruce - European Larch Coniferous Plantation Type	
CUP3-10		CUP3-10	Red Spruce - European Larch Coniferous Plantation Type	
CUP3-11		CUP3-11	Black Spruce - European Larch Coniferous Plantation Type	
CUP3-A		CUP3-A	Restoration Coniferous Plantation Type	3+ native conif. ONLY (decid shrub OK)
CUP3-B		CUP3-B	Austrian Pine Coniferous Plantation Type	1970s ornamental plantings
CUP3-C		CUP3-C	White Spruce Coniferous Plantation Type	
CUP3-D		CUP3-D	Black Spruce Coniferous Plantation	
CUP3-E		CUP3-E	Norway Spruce Coniferous Plantation Type	
CUP3-F		CUP3-F	Tamarack Coniferous Plantation Type	
CUP3-G		CUP3-G	White Cedar Coniferous Plantation Type	
CUP3-H		CUP3-H	Mixed Conifer Coniferous Plantation Type	blend native & exotic or all exotic conifers
CUP3-I		CUP3-I	Douglas Fir Coniferous Plantation Type	
CUP3-J		CUP3-J	Colorado Spruce Coniferous Plantation Type	
CUM		**CUM**	**Meadow**	
CUM1		**CUM1**	**Mineral Cultural Meadow Ecosite**	
CUM1-1		CUM1-1	Dry - Moist Old Field Meadow Type	
CUM1-A		CUM1-A	Native Forb Old Field Meadow Type	
CUM1-B		CUM1-B	Exotic Cool-Season Grass Old Field Meadow Type	
CUM1-C		CUM1-C	Exotic Forb Old Field Meadow	
CUM2		**CUM2**	**Bedrock Cultural Meadow Ecosite**	
CUT		**CUT**	**Cultural Thicket**	
CUT1		**CUT1**	**Mineral Cultural Thicket Ecosite**	tree cover<25% and shrubs >25%
CUT1-1		CUT1-1	Sumac Cultural Thicket Type	
CUT1-2		CUT1-2	Serviceberry Cultural Thicket Type	
CUT1-3		CUT1-3	Chokecherry Cultural Thicket Type	
CUT1-4		CUT1-4	Gray Dogwood Cultural Thicket Type	
CUT1-5		CUT1-5	Raspberry Cultural Thicket Type	
CUT1-6		CUT1-6	Poison Ivy Cultural Thicket Type	
CUT1-A	**THMM1-1**	CUT1-A	Native Sapling Cultural ThicketType	subdivided into three types below
CUT1-A1	**THDM4-1**	CUT1-A1	Native Deciduous Sapling Cultural Thicket Type	tree saplings & shrubs, natives >50%
CUT1-A2		CUT1-A2	Native Mixed Sapling Cultural Thicket Type	tree saplings & shrubs, natives >50%
CUT1-A3	**THCM1-2**	CUT1-A3	Coniferous Sapling Cultural Thicket Type	PINSTRO, PINSYLV, THUOCCI
CUT1-B	**THDM2-6**	CUT1-B	Buckthorn Cultural Thicket Type	more-or-less pure stands
CUT1-C		CUT1-C	Exotic Cultural Thicket Type	LONXBEL, SYRVULG, ROSMULT, ELAUMBE, etc.

CUT1-D	**THDM2-5**	CUT1-D	Round-leaved Dogwood Cultural Thicket Type	
CUT1-E		CUT1-E	Red Osier Dogwood Cultural Thicket Type	CORSTOL in upland; no wetland spp.
CUT1-F		CUT1-F	Silky Dogwood Cultural Thicket Type	upland CORAMOM
CUT1-G		CUT1-G	Willow Cultural Thicket Type	upland eliminate SWT2-2, BBS1-2, SDS1-A
	THDM1-1	THDM1-1	New Jersey Tea Lowshrub Tallgrass Thicket Type	
	THDM2-7	THDM2-7	Prickly Ash Deciduous Shrub Thicket Type	
	THDM2-10	THDM2-10	Apple Deciduous Shrub Thicket Type	
	THDM2-11	THDM2-11	Hawthorn Deciduous Shrub Thicket Type	
CUT2		CUT2	Bedrock Cultural Thicket Ecosite	
CUT2-1		CUT2-1	Common Juniper Cultural Alvar Thicket Type	
CUS		**CUS**	**Cultural Savannah**	
CUS1		**CUS1**	**Mineral Cultural Savannah Ecosite**	tree cover 25-35%
CUS1-1		CUS1-1	Hawthorn Cultural Savannah Type	history of cattle grazing. Native hawthorn.
CUS1-2		CUS1-2	White Cedar - Green Ash Cultural Savannah Type	
CUS1-3		CUS1-3	Dry Red Oak Cultural Savannah Type	
CUS1-2A		CUS1-2A	White Cedar Cultural Savannah Type	often on floodplains. THUOCCI and decid.
CUS1-A		CUS1-A	Native Cultural Savannah Type	subdivided into other types
CUS1-A1		CUS1-A1	Native Deciduous Cultural Savannah Type	open-grown natives (not QUE__SP or CRA__SP)
CUS1-A2	**SVCM1-2**	CUS1-A2	White Pine Cultural Savannah Type	PINSTRO with or without deciduous trees
CUS1-B		CUS1-B	Exotic Cultural Savannah Type	check also CUP1-D
CUS1-3A	**SVDM3-2**	CUS1-3A	White Oak Cultural Savannah Type	tallgrass prairie grasses absent
CUS1-3B	**SVDM3-3**	CUS1-3B	Bur Oak Cultural Savannah Type	often relatively moist
	SVDM3-5	SVDM3-5	White Birch / Poplar Deciduous Savannah Type	
	SVDM4-1	SVDM4-1	Fresh - Moist Willow Deciduous Savannah Type	
	SVMM2-1	SVMM2-1	Dry - Fresh Hawthorn - White Cedar Mixed Savannah Type	
CUS2		**CUS2**	**Bedrock Cultural Savannah Ecosite**	
CUS2-A		**CUS2-A**	**Rubble Cultural Savannah**	anthropogenic rock or concrete dumps
	SVDM3-2	SVDM3-2	Dry - Fresh White Oak Deciduous Savanna Type	
	SVDM3-3	SVDM3-3	Dry - Fresh Bur Oak Deciduous Savanna Type	
	SVDM3-5	SVDM3-5	White Birch / Poplar Deciduous Savanna Type	
	SVDM4-1	SVDM4-1	Fresh - Moist Willow Deciduous Savanna Type	
CUW		**CUW**	**Cultural Woodland**	
CUW1		**CUW1**	Mineral Cultural Woodland Ecosite	tree cover 35-60%
CUW1-1		CUW1-1	Red Cedar Cultural Woodland	JUNVIRG with or without deciduous trees
CUW1-2		CUW1-2	Dry Red Oak Cultural Woodland Type	
CUW1-A		CUW1-A	Native Cultural Woodland	subdivided into three types below
CUW1-A1	**WOCM1-2**	CUW1-A1	White Cedar Cultural Woodland	THUOCCI with or without deciduous trees
CUW1-A2	**WOCM1-3**	CUW1-A2	White Pine Cultural Woodland	PINSTRO with or without deciduous trees
CUW1-A3		CUW1-A3	Native Deciduous Cultural Woodland	native trees>50%; not QUE__SP or CRA__SP
CUW1-B		CUW1-B	Exotic Cultural Woodland	check also CUP1-D
CUW1-C		CUW1-C	White Oak Cultural Woodland	tallgrass prairie grasses absent
CUW1-D		CUW1-D	Hawthorn Cultural Woodland	history of cattle grazing. Native hawthorn.

CUW2		**CUW2**	**Bedrock Cultural Woodland Ecosite**	
CUW2-1		CUW2-1	Red Cedar Cultural Alvar Woodland Type	
CUW2-2		CUW2-2	Hawthorn Cultural Alvar Woodland Type	
CUW2-A		CUW2-A	Rubble Cultural Woodland	anthropogenic rock or concrete dumps
CUH		**CUH**	**Hedgerow**	
CUH1		**CUH1**	**Hedgerow Ecosite**	<20m wide; ag/urban/CUM1 both sides
CUH1-A		CUH1-A	Treed Hedgerow Type	tree cover >25%. Planted rows =CUP
CUH1-B	**THDM3-2**	CUH1-B	Native Shrub - Sapling Hedgerow Type	shrub cover>25%
CUH1-C	**THDM3-1**	CUH1-C	Buckthorn Hedgerow Type	tree/shrub of which 70%+ is RHACATH
CUH1-D		CUH1-D	Exotic Shrub Hedgerow Type	ROSMULT, etc. See also CUT1-C
			Swamp	
SWC		**SWC**	**Coniferous Swamp**	
SWC1		**SWC1**	**White Cedar Mineral Coniferous Swamp Ecosite**	
	SWCR1-1	SWCR1-1	White Cedar Calcareous Rock/Bedrock Coniferous Swamp Type	
SWC1-1		SWC1-1	White Cedar Mineral Coniferous Swamp Type	
SWC1-2		SWC1-2	White Cedar - Conifer Mineral Coniferous Swamp Type	THUOCCI with PINSTRO, TSUCANA, ABIBALS, PIC_SPP, LARLARI
SWC2		**SWC2**	**White Pine - Hemlock Mineral Coniferous Swamp Ecosite**	
SWC2-1		SWC2-1	White Pine Mineral Coniferous Swamp Type	
SWC2-2		SWC2-2	Hemlock Mineral Coniferous Swamp Type	
SWC3		**SWC3**	**White Cedar Organic Coniferous Swamp Ecosite**	
SWC3-1		SWC3-1	White Cedar Organic Coniferous Swamp Type	
SWC3-2		SWC3-2	White Cedar - Conifer Organic Coniferous Swamp Type	
SWC4		**SWC4**	**Tamarack - Spruce - Fir Organic Coniferous Swamp Ecosite**	see also FET1-1. THUOCCI minor/absent
SWC4-1		SWC4-1	Tamarack - Black Spruce Organic Coniferous Swamp Type	PICMARI. For PICGLAU, see SWC4-A
SWC4-2		SWC4-2	Tamarack Organic Coniferous Swamp Type	
SWC4-3		SWC4-3	Black Spruce Organic Coniferous Swamp Type	
SWC4-A	**SWCO2-4**	SWC4-A	Tamarack - Balsam Fir - Spruce Organic Coniferous Swamp Type	ABIBALS with LARLARI, PICMARI, PINSTRO, THUOCCI in variable mixtures
SWCA		**SWCA**	**Hemlock Organic Coniferous Swamp Ecosite**	If THUOCCI>25%, see SWC3
SWCA-A	**SWCO3-1**	SWCA-A	Hemlock Organic Coniferous Swamp Type	If THUOCCI>25%, see SWC3-2
SWM		**SWM**	**Mixed Swamp**	
SWM1		**SWM1**	**White Cedar Mineral Mixed Swamp Ecosite**	
	SWMR1-1	SWMR1-1	White Cedar - Hardwood Calcareous Rock/Bedrock Mixed Swamp Type	
SWM1-1		SWM1-1	White Cedar - Hardwood Mineral Mixed Swamp Type	
SWM2		**SWM2**	**Maple Mineral Mixed Swamp Ecosite**	if THUOCCI dominant, see SWM1
SWM2-1		SWM2-1	Red Maple - Conifer Mineral Mixed Swamp Type	ACERUBR with other conifers than THUOCCI
SWM2-2		SWM2-2	Swamp Maple - Conifer Mineral Mixed Swamp Type	ACEXFRE with other conifers

		SWM3	**Birch - Poplar Mineral Mixed Swamp Ecosite**	
		SWM3-1	Birch - Conifer Mineral Mixed Swamp Type	
		SWM3-2	Poplar - Conifer Mineral Mixed Swamp Type	
SWMA		**SWMA**	**Ash Mineral Mixed Swamp Ecosite**	
SWMA-A	**SWMM4-1**	SWMA-A	Red/Green Ash - Hemlock Mineral Mixed Swamp Type	
	SWMM4-2	SWMM4-2	Black Ash - Conifer Mineral Mixed Swamp Type	
	SWMM5	**SWMM5**	**Conifer-Hardwood Mineral Mixed Swamp Ecosite**	
	SWMM5-1	SWMM5-1	Balsam Fir - Hardwood Mineral Mixed Swamp Type	
	SWMM5-2	SWMM5-2	Tamarack - Hardwood Mineral Mixed Swamp Type	
SWM4		**SWM4**	**White Cedar Organic Mixed Swamp Ecosite**	
SWM4-1		SWM4-1	White Cedar - Hardwood Organic Mixed Swamp Type	if BETPAPY present see SWMO3-3
SWM5		**SWM5**	**Maple Organic Mixed Swamp Ecosite**	if THUOCCI dominant, see SWM4
SWM5-1		SWM5-1	Red Maple - Conifer Organic Mixed Swamp Type	
SWM5-2		SWM5-2	Swamp Maple - Conifer Organic Mixed Swamp Type	
SWM6		**SWM6**	**Birch - Poplar Organic Mixed Swamp Ecosite**	if THUOCCI dominant, see SWM4
SWM6-1		SWM6-1	Birch - Conifer Organic Mixed Swamp Type	
SWM6-2		SWM6-2	Poplar - Conifer Organic Mixed Swamp Type	
	SWMO3-3	SWMO3-3	White Birch - Conifer Organic Mixed Swamp Type	BETPAPY with ABIBALS or THUOCCI
	SWM04	**SWM04**	**Conifer - Hardwood Organic Mixed Swamp Ecosite**	
	SWM04-1	SWM04-1	Balsam Fir - Hardwood Organic Mixed Swamp Type	
	SWM04-2	SWM04-2	Hemlock- Hardwood Organic Mixed Swamp Type	
SWD		**SWD**	**Deciduous Swamp**	
SWD1		**SWD1**	**Oak Mineral Deciduous Swamp Ecosite**	
SWD1-1		SWD1-1	Swamp White Oak Mineral Deciduous Swamp Type	
SWD1-2		SWD1-2	Bur Oak Mineral Deciduous Swamp Type	
SWD1-3		SWD1-3	Pin Oak Mineral Deciduous Swamp Type	
SWD1-4		SWD1-4	Shumard's Oak Mineral Deciduous Swamp Type	
SWD2		**SWD2**	**Ash Mineral Deciduous Swamp Ecosite**	
SWD2-1		SWD2-1	Black Ash Mineral Deciduous Swamp Type	
SWD2-2		SWD2-2	Green Ash Mineral Deciduous Swamp Type	
SWD2-A		SWD2-A	White Ash Mineral Deciduous Swamp Type	Atypical, often disturbed
SWD3		**SWD3**	**Maple Mineral Deciduous Swamp Ecosite**	
SWD3-1		SWD3-1	Red Maple Mineral Deciduous Swamp Type	
SWD3-2		SWD3-2	Silver Maple Mineral Deciduous Swamp Type	
SWD3-3		SWD3-3	Swamp Maple Mineral Deciduous Swamp Type	Freeman's maple, Acer x freemanii
SWD3-4		SWD3-4	Manitoba Maple Mineral Deciduous Swamp Type	
SWD4		**SWD4**	**Mineral Deciduous Swamp Ecosite**	
SWD4-1		SWD4-1	Willow Mineral Deciduous Swamp Type	native or exotic Salix
SWD4-2		SWD4-2	White Elm Mineral Deciduous Swamp Type	
SWD4-3		SWD4-3	White Birch - Poplar Mineral Deciduous Swamp Type	

SWD4-4		SWD4-4	Yellow Birch Mineral Deciduous Swamp Type	
	SWDM4-5	SWDM4-5	Poplar Mineral Deciduous Swamp Type	
SWD4-A	**SWDM4-6**	SWD4-A	White Birch - Cottonwood Coastal Mineral Deciduous Swamp Type	ground layer: EQUXNEL, JUNBALT, etc.(Harold removed coastal affiliation)
SWD4-b		SWD4-B	European Alder Mineral Deciduous Swamp Type	ALNGLUT or ALNININA
SWD5		**SWD5**	**Ash Organic Deciduous Swamp Ecosite**	
SWD5-1		SWD5-1	Black Ash Organic Deciduous Swamp Type	
	SWD01-2	SWD01-2	Green Ash Organic Deciduous Swamp Type	
SWD6		**SWD6**	**Maple Organic Deciduous Swamp Ecosite**	
SWD6-1		SWD6-1	Red Maple Organic Deciduous Swamp Type	
SWD6-2		SWD6-2	Silver Maple Organic Deciduous Swamp Type	
SWD6-3		SWD6-3	Swamp Maple Organic Deciduous Swamp Type	
SWD6-A		SWD6-A	Upland Hardwood Organic Deciduous Swamp Type	ACESASA, etc. Atypical, well-aerated organic
SWD7		**SWD7**	**Birch - Poplar Organic Deciduous Swamp Ecosite**	
SWD7-1		SWD7-1	White Birch - Poplar Organic Deciduous Swamp Type	
SWD7-2		SWD7-2	Yellow Birch Organic Deciduous Swamp Type	
SWD7-A		SWD7-A	Willow Organic Deciduous Swamp Type	native or exotic Salix
	SWDO3-3	SWDO3-3	Trembling Aspen Organic Deciduous Swamp Type	
	SWDO3-4	SWDO3-4	White Elm Organic Deciduous Swamp Type	
SWT		**SWT**	**Thicket Swamp**	
SWT1		**SWT1**	**Bedrock Thicket Swamp Ecosite**	
SWT2		**SWT2**	**Mineral Thicket Swamp Ecosite**	
SWT2-1		SWT2-1	Alder Mineral Thicket Swamp Type	
SWT2-2		SWT2-2	Willow Mineral Thicket Swamp Type	check also BBS1-2, CUT1-G
SWT2-3		SWT2-3	Mountain Maple Mineral Thicket Swamp Type	
SWT2-4		SWT2-4	Buttonbush Mineral Thicket Swamp Type	
SWT2-5		SWT2-5	Red-osier Mineral Thicket Swamp Type	
SWT2-6		SWT2-6	Meadowsweet Mineral Thicket Swamp Type	
SWT2-7		SWT2-7	Ninebark Mineral Thicket Swamp Type	
SWT2-8		SWT2-8	Silky Dogwood Mineral Thicket Swamp Type	
SWT2-9		SWT2-9	Gray Dogwood Mineral Thicket Swamp Type	
SWT2-10		SWT2-10	Nannyberry Mineral Thicket Swamp Type	
SWT2-11		SWT2-11	Southern Arrow-wood Mineral Thicket Swamp Type	
SWT2-12		SWT2-12	Paw-paw Mineral Thicket Swamp Type	
SWT2-A	**SWTM5-8**	SWT2-A	Exotic Mineral Thicket Swamp Type	exotics>50% e.g. ROSMULT
SWT2-B	**SWTM5-6**	SWT2-B	Winterberry Mineral Thicket Swamp Type	
SWT3		**SWT3**	**Organic Thicket Swamp Ecosite**	
SWT3-1		SWT3-1	Alder Organic Thicket Swamp Type	
SWT3-2		SWT3-2	Willow Organic Thicket Swamp Type	
SWT3-3		SWT3-3	Mountain Maple Organic Thicket Swamp	
SWT3-4		SWT3-4	Buttonbush Organic Thicket Swamp Type	
SWT3-5		SWT3-5	Red-osier Organic Thicket Swamp Type	

SWT3-6		SWT3-6	Sweet Gale Organic Thicket Swamp Type	
SWT3-7		SWT3-7	Winterberry Organic Thicket Swamp Type	
SWT3-8		SWT3-8	Mountain Holly Organic Thicket Swamp Type	
SWT3-9		SWT3-9	Fen Birch Organic Thicket Swamp Type	
SWT3-10		SWT3-10	Gray Dogwood Organic Thicket Swampt Type	
SWT3-11		SWT3-11	Spicebush Organic Thicket Swamp Type	
SWT3-12		SWT3-12	Nannyberry Organic Thicket Swamp Type	
SWT3-13		SWT3-13	Poison Sumac Organic Thicket Swamp Type	
SWT3-14		SWT3-14	Huckleberry Organic Thicket Swamp Type	
SWT3-A	**SWTO5-10**	SWT3-A	Meadowsweet Organic Thicket Swamp Type	
SWT3-B	**SWTO4-3**	SWT3-B	Silky Dogwood Organic Thicket Swamp Type	
SWT3-C		SWT3-C	Exotic Organic Thicket Swamp Type	RHACATH, RHAALNI, ROSMULT, etc.
			Fen	
FEO		**FEO**	**Open Fen**	
FEO1		**FEO1**	**Open Fen Ecosite**	organic soil; Carex, brown moss>Sphagnum
FEO1-1		FEO1-1	Twig-rush Open Fen Type	
FEO1-2		FEO1-2	Slender Sedge Open Fen Type	CARLASI
FEO1-3		FEO1-3	Low Sedge - Clubrush Open Fen Type	
FEO1-4		FEO1-4	Bog Buckbean - Sedge Open Fen Type	
FEO1-5		FEO1-5	Beaked Sedge Open Fen Type	CARUTRI
	FEOG1-5	FEOG1-5	Water Sedge Open Fen Type	CARAQUA
	FEOG1-6	FEOG1-6	Narrow Reed Grass Open Fen Type	CALSTIN
	FEOG1-7	FEOG1-7	Porcupine Sedge Open Fen Type	CARHYST
	FEOG1-8	FEOG1-8	Schweinitz's Sedge Open Fen Type	CARSCHW
	FEOG1-9	FEOG1-9	Inland sedge Open Fen Type	CARINTE
	FEOG1-10	FEOG1-10	Water Horsetail Open Fen Type	EQUFLUV
FES		**FES**	**Shrub Fen**	
FES1		**FES1**	**Shrub Fen Ecosite**	organic soil; Carex, brown moss>Sphagnum
FES1-1		FES1-1	Sweet Gale Shrub Fen Type	
FES1-2		FES1-2	Fen Birch Shrub Fen Type	BETPUMI
FES1-3		FES1-3	Shrubby Cinquefoil Shrub Fen Type	
FES1-4		FES1-4	Leatherleaf - Forb Shrub Fen Type	see also BOS2-1
FES1-5		FES1-5	Velvet-leaf Blueberry Shrub Fen Type	
FES1-6		FES1-6	Mountain Holly Shrub Fen Type	
FES1-7		FES1-7	Chokeberry Shrub Fen Type	
FES1-8		FES1-8	Highbush Blueberry - Leatherleaf - Chokeberry Shrub Fen Type	see also BOS2-2
FES1-9		FES1-9	Low White Cedar Shrub Fen Type	
	FESD1-9	FESD1-9	Water Willow Shrub Fen Type	
	FESM1-1	FESM1-1	Mixed Shrub Fen Type	
FET		**FET**	**Treed Fen**	
FET1		**FET1**	**Treed Fen Ecosite**	organic soil; Carex, brown moss>Sphagnum

FET1-1		FET1-1	Tamarack Treed Fen	see also BOT2-1
FET1-2		FET1-2	Tamarack - White Cedar Treed Fen	
	FETM1-1	FETM1-1	Tamarack-Hardwood Mixed Fen Type	
			Bog	
BOO		**BOO**	**Open Bog**	
BOO1		**BOO1**	**Open Bog Ecosite**	Sphagnum in ground layer
		BOO1-1	Few-seeded Sedge Open Bog Type	
BOO1-2		BOO1-2	Cotton-grass Open Bog Type	probably not in our jurisdiction
BOOG2		**BOOG2**	**Open Kettle Bog Ecosite**	
	BOOG2-1	BOOG2-1	Three-way Sedge Open Kettle Bog Type	DULARUN
	BOOG2-2	BOOG2-2	Slender Sedge Open Kettle Bog Type	CARLASI
BOS		**BOS**	**Shrub Bog**	
BOS1		**BOS1**	**Shrub Bog Ecosite**	
BOS1-1		BOS1-1	Leatherleaf Shrub Bog Type	
BOS2		**BOS2**	**Shrub Kettle Bog Ecosite**	Sphagnum in ground layer
BOS2-1		BOS2-1	Leatherleaf Shrub Kettle Bog Type	see also FES1-4
BOS2-2		BOS2-2	Highbush Blueberry Shrub Kettle Bog Type	see also FES1-8
	BOSD2-2	BOSD2-2	Winterberry Shrub Kettle Bog Type	
BOT		**BOT**	**Treed Bog**	
BOT1		**BOT1**	**Treed Bog Ecosite**	
BOT1-1		BOT1-1	Black Spruce Treed Bog Type	
BOT2		**BOT2**	**Treed Kettle Bog Ecosite**	Sphagnum in ground layer
BOT2-1		BOT2-1	Tamarack - Leatherleaf Treed Kettle Bog Type	see also FET1-1
BOT2-1A		BOT2-1A	White Pine - Red Maple - Birch - Leatherleaf Treed Kettle Bog Type	LARLARI absent; scattered other trees
			Marsh	
MAM		**MAM**	**Meadow Marsh**	
MAM1		**MAM1**	**Bedrock Meadow Marsh Ecosite**	
MAM 1-1		MAM 1-1	Reed-canary Grass Bedrock Meadow Marsh Type	
MAM1-2		MAM1-2	Red-top Bedrock Meadow Marsh Type	
MAM1-3		MAM1-3	Forb Bedrock Meadow Marsh Type	
MAM1-4		MAM1-4	Horsetail Bedrock Meadow Marsh Type	
MAM2		**MAM2**	**Mineral Meadow Marsh Ecosite**	
MAM2-1		MAM2-1	Bluejoint Mineral Meadow Marsh Type	Canada Blue-joint with Rice Cut grass, Spotted Joe-Pye Weed, Purple-stemmed Aster, Panicled Aster, Reed Canary grass
MAM2-2		MAM2-2	Reed Canary Grass Mineral Meadow Marsh Type	
MAM2-3		MAM2-3	Red-top Mineral Meadow Marsh Type	Agrostis gigantea
MAM2-4		MAM2-4	Fowl Manna Grass Mineral Meadow Marsh Type	
MAM2-5		MAM2-5	Narrow-leaved Sedge Mineral Meadow Marsh Type	leaf width <5 mm e.g. CARSTRI

MAM2-6		MAM2-6	Broad-leaved Sedge Mineral Meadow Marsh Type	leaf width > 5 mm e.g. CARLACU
MAM2-7		MAM2-7	Horsetail Mineral Meadow Marsh Type	non-coastal; also denser cover than MAM5-1
MAM2-8		MAM2-8	Prairie Slough Grass Graminoid Mineral Meadow Marsh Type	
MAM2-9		MAM2-9	Jewelweed Mineral Meadow Marsh Type	Spotted jewelweed, pale jewelweed, with sensitive fern, purple-stemmed aster, rice-cut grass, panicled aster, reed canary grass, wood nettle, stinging nettle.
MAM2-10		MAM2-10	Forb Mineral Meadow Marsh Type	forbs other than IMPCAPE or LYTSALI
MAM2-A	**MAMM1-12**	MAM2-A	Common Reed Mineral Meadow Marsh Type	
MAM2-B	**MAMM2-5**	MAM2-B	Purple Loosestrife Mineral Meadow Marsh Type	
MAM2-C	**MAMM1-13**	MAM2-C	Rush Graminoid Mineral Meadow Marsh Type	JUN_SPP; denser cover than MAM5-1
MAM2-D	**MAMM1-14**	MAM2-D	Rice Cut-grass Graminoid Mineral Meadow Marsh Type	
MAM2-E	**MAMM1-15**	MAM2-E	Bulrush Graminoid Mineral Meadow Marsh Type	
MAM2-F		MAM2-F	Miscanthus Mineral Meadow Marsh Type	
MAM2-G		MAM2-G	Cool-season Grass Mineral Meadow Marsh Type	ALOEQU, ELYREPE, needs strong soil evidence
	MAMM1-2	MAMM1-2	Cattail Graminoid Mineral Meadow Marsh Type	
	MAMM1-6	MAMM1-6	Tall Manna Grass Graminoid Mineral Meadow Marsh Type	GLYGRAND
	MAMM1-7	MAMM1-7	Fowl Meadow Grass Graminoid Mineral Meadow Marsh Type	POAPALU
	MAMM1-8	MAMM1-8	Creeping Bent Grass Graminoid Mineral Meadow Marsh Type	Agrostis stolonifera
	MAMM2-2	MAMM2-2	Panicled Aster Mineral Meadow Marsh Type	ASTLANC with ASTPUNI, EUPMACU, PHAARUN, AGRGIGA
	MAMM2-3	MAMM2-3	Purple-stemmed Aster Mineral Meadow Marsh Type	ASTPUNI
	MAMM2-6	MAMM2-6	Joe Pye Weed Forb Mineral Meadow Marsh Type	
	MAMM2-7	MAMM2-7	Ostrich Fern Forb Mineral Meadow Marsh Type	
	MAMM3-1	MAMM3-1	Mixed Mineral Meadow Marsh Type	When you can't pick a dominant and vegetation is a mix of many species.
MAM3		**MAM3**	**Organic Meadow Marsh Ecosite**	
MAM3-1		MAM3-1	Bluejoint Organic Meadow Marsh Type	
MAM3-2		MAM3-2	Reed-canary Grass Organic Meadow Marsh Type	may result from siltation of kettles
MAM3-3		MAM3-3	Rice Cut-grass Organic Meadow Marsh Type	
MAM3-4		MAM3-4	Fowl Manna Grass Organic Meadow Marsh	
MAM3-5		MAM3-5	Narrow-leaved Sedge Organic Meadow Marsh	leaf width <5 mm e.g. CARSTRI
MAM3-6		MAM3-6	Broad-leaved Sedge Organic Meadow Marsh	leaf width > 5 mm e.g. CARLACU
MAM3-7		MAM3-7	Prairie Slough Grass Organic Meadow Marsh Type	
MAM3-8		MAM3-8	Jewelweed Organic Meadow Marsh	
MAM3-9		MAM3-9	Mixed Forb Organic Meadow Marsh	
	MAMO1-2	MAMO1-2	Cattail Graminoid Organic Meadow Marsh Type	
	MAMO2-2	MAMO2-2	Joe Pye Weed Forb Organic Meadow Marsh Type	
MAM4		**MAM4**	**Great Lakes Coastal Fen Meadow Marsh Ecosite**	Lake Ontario coastline ONLY
MAM4-1		MAM4-1	Graminoid Coastal Meadow Marsh Type	
MAM4-2		MAM4-2	Shrubby Cinquefoil Coastal Meadow Marsh Type	
MAM4-A	MAMM4-3	MAM4-A	Nelson's Scouring Rush - Baltic Rush Coastal Fen Type	EQUXNEL>other EQU_SPP, CALCANA, JUNBALT

	MAMM4-4	MAMM4-4	Twig-rush Coastal Meadow Marsh Type	
MAM5		**MAM5**	**Mineral Fen Meadow Marsh Ecosite**	mineral soil, non-coastal; seepage
MAM5-1		MAM5-1	Mineral Fen Meadow Marsh Type	+ thin cover, see also MAM2-7, MAM2-C
MAM5-2		MAM5-2	Tallgrass Mineral fen Meadow Marsh Type	
MAM6		**MAM6**	**Tallgrass Meadow Marsh Ecosite**	coastal in our jurisdiction
MAM6-1		MAM6-1	Bluejoint - Prairie Slough Grass Tallgrass Meadow Marsh Type	
MAM6-A	MAMM6-2	MAM6-A	Bluejoint - Switchgrass Tallgrass Meadow Marsh Type	probably only on Toronto Island
MAS		**MAS**	**Shallow Marsh**	
MAS1	**MASR1**	**MAS1**	**Graminoid Bedrock Shallow Marsh Ecosite**	
	MASR1-1	MASR1-1	Graminoid Bedrock Shallow Marsh Ecosite	
	MASR2-1	MASR2-1	Forb Bedrock Shallow Marsh Ecosite	
MAS2		**MAS2**	**Mineral Shallow Marsh Ecosite**	
MAS2-1		MAS2-1	Cattail Mineral Shallow Marsh Type	
MAS2-1A		MAS2-1A	Broad-leaved Cattail Mineral Shallow Marsh Type	TYPLATI
MAS2-1B		MAS2-1B	Narrow-Leaved Cattail Mineral Shallow Marsh Type	TYPANGU or TYPXGLA
MAS2-2		MAS2-2	Bulrush Mineral Shallow Marsh Type	for SCIPUNG see MAS2-6; other SCI__SP
MAS2-3		MAS2-3	Narrow-leaved Sedge Mineral Shallow Marsh Type	leaf width <5 mm e.g. CARSTRI
MAS2-4		MAS2-4	Broad-leaved Sedge Mineral Shallow Marsh Type	leaf width > 5 mm e.g. CARLACU
MAS2-5		MAS2-5	Wild Rice Mineral Shallow Marsh Type	
MAS2-6		MAS2-6	Three-square Mineral Shallow Marsh Type	SCIPUNG
MAS2-7		MAS2-7	Bur-reed Mineral Shallow Marsh Type	
MAS2-8		MAS2-8	Rice Cut-grass Mineral Shallow Marsh Type	
MAS2-9		MAS2-9	Forb Mineral Shallow Marsh Type	forbs other than ACOAMER, LYTSALI
MAS2-A	**MASM1-12**	MAS2-A	Common Reed Mineral Shallow Marsh Type	
MAS2-B	**MASM2-4**	MAS2-B	Purple Loosestrife Mineral Shallow Marsh Type	
MAS2-C	**MASM1-13**	MAS2-C	Horsetail Mineral Shallow Marsh Type	
MAS2-D	**MASM1-14**	MAS2-D	Reed Canary Grass Mineral Shallow Marsh Type	
MAS2-E	**MASM1-15**	MAS2-E	Giant Manna Grass Mineral Shallow Marsh Type	GLYMAXI ONLY (an exotic). See MAS2-G
MAS2-F	**MASM1-16**	MAS2-F	Sweet Flag Mineral Shallow Marsh Type	
MAS2-G	**MASM1-17**	MAS2-G	Manna Grass Mineral Shallow Marsh Type	native GLY_SPP ONLY
	MASM1-4	MASM1-4	Narrow-leaved Sedge Mineral Shallow Marsh Type	
	MASM2-2	MASM2-2	Beggar-ticks Mineral Shallow Marsh Type	
	MASM2-3	MASM2-3	Arrow-head Mineral Shallow Marsh Type	
	MASM1-9	MASM1-9	Canada Blue-joint Graminoid Mineral Shallow Marsh Type	
	MASM1-11	MASM1-11	Spike Rush Mineral Shallow Marsh Type	
MAS3		**MAS3**	**Organic Shallow Marsh Ecosite**	
MAS3-1		MAS3-1	Cattail Organic Shallow Marsh Type	
MAS3-1A		MAS3-1A	Broad-leaved Cattail Organic Shallow Marsh	TYPLATI
MAS3-1B		MAS3-1B	Narrow-leaved Cattail Organic Shallow Marsh Type	TYPANGU or TYPXGLA
MAS3-2		MAS3-2	Bulrush Organic Shallow Marsh Type	
MAS3-3		MAS3-3	Narrow-leaved Sedge Organic Shallow Marsh Type	leaf width <5 mm e.g. CARSTRI

MAS3-4		MAS3-4	Broad-leaved Sedge Organic Shallow Marsh Type	leaf width > 5 mm e.g. CARLACU
MAS3-5		MAS3-5	Wild Rice Organic Shallow Marsh Type	
MAS3-6		MAS3-6	Spike Rush Organic Shallow Marsh Type	
MAS3-7		MAS3-7	Bur-reed Organic Shallow Marsh Type	
MAS3-8		MAS3-8	Rice Cut-grass Organic Shallow Marsh Type	
MAS3-9		MAS3-9	Rush Grass Organic Shallow Marsh Type	
MAS3-10		MAS3-10	Forb Organic Shallow Marsh Type	forbs other than CALPALS, DECVERT, LYTSALI
MAS3-11		MAS3-11	Calla Lily Organic Shallow Marsh Type	
MAS3-12		MAS3-12	Water Willow Organic Shallow Marsh Type	
MAS3-A	**MASO2-8**	MAS3-A	Purple Loosestrife Organic Shallow Marsh Type	
MAS3-B	**MASO1-14**	MAS3-B	Horsetail Organic Shallow Marsh Type	usually EQUFLUV
MAS3-C	**MASO1-12**	MAS3-C	Manna Grass Organic Shallow Marsh Type	usually GLYSEPT, GLYBORE
	MASO1-4	MASO1-4	Reed Canary Grass Organic Shallow Marsh Type	
	MASO1-3	MASO1-3	Canada Blue-joint Graminoid Organic Shallow Marsh Type	
	MASO1-13	MASO1-13	Foxtail Organic Shallow Marsh Type	
	MASO2-4	MASO2-4	Beggar-ticks Organic Shallow Marsh Type	
	MASO2-5	MASO2-5	Water Parsnip Organic Shallow Marsh Type	
	MASO2-6	MASO2-6	Smartweed Organic Shallow Marsh Type	
	MASO2-7	MASO2-7	Arrow-head Organic Shallow Marsh Type	
			Aquatic	
OAO		**OAO**	**Open Aquatic**	
OAO1		**OAO1**	**Open Aquatic Ecosite (deep or riverine)**	natural system, deep or moving water
OAO1-T		OAO1-T	Turbid Open Aquatic Type	disturbed system, sediment and/or nutrient
SAS		**SAS**	**Submerged Shallow Aquatic**	
SAS1		**SAS1**	**Submerged Shallow Aquatic Ecosite**	submerged >(10)25%; floating <25%
SAS1-1		SAS1-1	Pondweed Submerged Shallow Aquatic Type	spp. with no floating leaves
SAS1-2		SAS1-2	Waterweed Submerged Shallow Aquatic Type	
SAS1-3		SAS1-3	Stonewort Submerged Shallow Aquatic Type	
SAS1-4		SAS1-4	Water Milfoil Submerged Shallow Aquatic Type	
SAS1-5		SAS1-5	Wild Celery Submerged Shallow Aquatic Type	
SAS1-6		SAS1-6	Water Marigold Submerged Shallow Aquatic Type	
SAS1-7		SAS1-7	Water Stargrass Submerged Shallow Aquatic Type	
SAS1-A	**SAS_1-8**	SAS1-A	Coon-tail Submerged Shallow Aquatic Type	
SAS1-B	**SAS_1-9**	SAS1-B	Bushy Naiad Submerged Shallow Aquatic Type	
SAM		**SAM**	**Mixed Shallow Aquatic**	
SAM1		SAM1	Mixed Shallow Aquatic Ecosite	
SAM1-1		SAM1-1	Pickerel-weed Mixed Shallow Aquatic Type	
SAM1-2		SAM1-2	Duckweed Mixed Shallow Aquatic Type	LEMMINO, LEMTRIS, SPIPOLY, WOL_SPP
SAM1-3		SAM1-3	Watercress Mixed Shallow Aquatic Type	
SAM1-4		SAM1-4	Pondweed Mixed Shallow Aquatic Type	spp. with floating leaves
SAM1-5		SAM1-5	Bur-reed Mixed Shallow Aquatic Type	
SAM1-6		SAM1-6	Bladderwort Mixed Shallow Aquatic Type	

SAM1-7		SAM1-7	Water Milfoil Mixed Shallow Aquatic Type	
SAM1-A	**SAM_1-8**	SAM1-A	Water Lily - Bullhead Lily Mixed Shallow Aquatic Type	
SAM1-B		SAM1-B	Floating-heart Mixed Shallow Aquatic Type	NYMPELT (exotic) with submerged spp.
SAM1-C		SAM1-C	Crowfoot Floating-leaved Shallow Aquatic Type	RANFLAB, RANSCEL, RANAQUA
SAF		**SAF**	**Floating-leaved Shallow Aquatic**	
SAF1		**SAF1**	**Floating-leaved Shallow Aquatic Ecosite**	floating >25%; submerged <25%
SAF1-1		SAF1-1	Water Lily - Bullhead Lily Floating-leaved Shallow Aquatic Type	
SAF1-2		SAF1-2	American Lotus Floating-leaved Shallow Aquatic Type	
SAF1-3		SAF1-3	Duckweed Floating-leaved Shallow Aquatic Type	
	SAF_1-4	SAF_1-4	Pondweed Floating-leaved Shallow Aquatic Type	
SAF1-A		SAF1-A	Liverwort Floating-leaved Shallow Aquatic Type	RICCFLU, RICCNAT
			CVC Urban	
		TP	**Transportation**	
		TPH	Highway	
		TPR	Regional Road	
		TPC	Collector	
		TPX	Railways	
		TPA	Airport	
		UR	**Urban Residential**	
		URL	Low Density Residential	
		URM	Medium Density Residential	
		URH	High Density Residential	
		URR	High Rise Residential	
		URX	Mixed Residential	
		URE	Residential Estate	
		CI	**Commercial / Industrial / Institutional**	
		CII	Educational / Institutional	
		CIC	Commercial / Industrial	
		MO	**Manicured Open Space**	
		MOC	Commercial / Industrial Open Space	
		MOI	Educational / Institutional Open Space	
		MOR	Recreational Open Space	
		MOP	Residential (Private) Open Space	
		MOO	Other Open Space	

2.0 Species within the Erin SSMP Study area

Table 2.0 Significant flora recorded within the Erin SSMP study area

Species	Common Name	Species At Risk[1]	S-Rank[2]	CVC/Peel Rarity[3]	GTA Status[4]	Wellington County Significance[5]	Observation Source[6]
Acorus americanus	American Sweetflag		S4	R/L	rare		2
Agrostis scabra	Ticklegrass		S5	R	rare		1
Alopecurus aequalis	Short-awn Foxtail		S4S5	L	rare to uncommon		2
Andromeda polifolia ssp. *glaucophylla*	Bog Rosemary		S5	R/L	rare	rare	1, 2
Anemone americana	Round-lobed Hepatica		S5	R/L	rare		2
Aralia racemosa ssp. *racemosa*	Spikenard		S5	L	uncommon		1, 2
Aronia melanocarpa	Black Chokeberry		S5	R/L	rare		1, 2
Bidens tripartita	Three-Lobe Beggar-ticks		S5	L	rare to common		1, 2
Botrychium dissectum	Cutleaf Grape-fern		S5	R/L	prov, rare	rare	1, 2
Botrychium rugulosum	Rugulose Grape-fern		**S2**		prov, rare	rare	6
Brachyelytrum erectum	Bearded Shorthusk		S4S5	R/L	rare		1
Bromus ciliatus	Fringed Brome		S5		rare to uncommon		1, 2
Calla palustris	Water Arum		S5		rare to uncommon		1, 2
Callitriche palustris	Vernal Water-starwort		S5	R/L	rare		1
Campanula aparinoides	Marsh Bellflower		S5	R/L	rare		1, 2, 4
Cardamine pensylvanica	Pennsylvania Bitter-cress		S5		rare to uncommon		1
Carex albursina	White Bear Sedge		S5	L	rare to uncommon		1
Carex aquatilis	Water Sedge		S5	R/L	rare		1, 2
Carex brunnescens ssp. *brunnescens*	Brownish Sedge		S5	R/L	rare		1
Carex careyana	Carey's Sedge		**S2**		prov, rare	rare	6
Carex castanea	Chestnut-colored Sedge		S5	R/L	rare	rare	2
Carex cephaloidea	Thinleaf Sedge		S5	R/L	rare to uncommon		2
Carex chordorrhiza	Creeping Sedge		S5	R/L	rare	rare	1, 2

Species	Common Name	Species At Risk[1]	S-Rank[2]	CVC/Peel Rarity[3]	GTA Status[4]	Wellington County Significance[5]	Observation Source[6]
Carex comosa	Bristly Sedge		S5	L	rare to uncommon		1, 2
Carex cryptolepis	Northeastern Sedge		S4	R/L	rare	rare	2
Carex eburnea	Ebony Sedge		S5	L	rare to uncommon		1, 2
Carex echinata ssp. *echinata*	Little Prickly Sedge subspecies		S5	R/L	rare	rare	1
Carex flava	Yellow Sedge		S5	L	rare to uncommon		1, 2
Carex formosa	Handsome Sedge		S4	new to the watershed	rare	rare	1
Carex hirtifolia	Pubescent Sedge		S5	L	rare to uncommon		1
Carex hitchcockiana	Hitchcock's Sedge		S5	L	rare to uncommon		1
Carex laevivaginata	Smooth-sheath Sedge		S4	R/L	rare to uncommon		1
Carex lasiocarpa	Slender Sedge		S5	R/L	rare		1, 2
Carex laxiculmis	Spreading Sedge		S4	R/L	rare	rare	1
Carex laxiflora	Loose-flowered Sedge		S5	L	rare to uncommon		1
Carex leptalea ssp. *leptalea*	Bristly-stalk Sedge subspecies		S5		rare to uncommon		1, 2
Carex leptonervia	Finely-nerved Sedge		S4	L	rare to common	rare	1
Carex limosa	Mud Sedge		S5	R/L	rare		1, 2
Carex lurida	Sallow Sedge		S5	R/L	rare		2
Carex magellanica ssp. *Irrigua*	Boreal Bog Sedge		S5	R/L	rare		1, 2
Carex pellita	Woolly Sedge		S5	R/L	rare		2
Carex prairea	Prairie Sedge		S5	R/L	rare		1
Carex projecta	Necklace Sedge		S5	L	rare to common		1
Carex scabrata	Rough Sedge		S5	L	rare to uncommon		1, 2
Carex scoparia	Pointed Broom Sedge		S5	R/L	rare		1, 2
Carex sprengelii	Longbeak Sedge		S5	R/L	rare		1, 2
Carex trisperma var. *trisperma*	Three-seed Sedge subspecies		S5	R/L	rare		1, 2
Carex tuckermanii	Tuckerman Sedge		S4	L	rare to uncommon		1, 2
Carex vesicaria	Inflated Sedge		S5	R/L	rare		2
Carex woodii	Pretty Sedge		S4	R/L	rare	rare	1

Species	Common Name	Species At Risk[1]	S-Rank[2]	CVC/Peel Rarity[3]	GTA Status[4]	Wellington County Significance[5]	Observation Source[6]
Ceratophyllum demersum	Common Hornwort		S5	R/L	rare to uncommon		2
Chamaedaphne calyculata	Leatherleaf		S5	R/L	rare		1, 2
Chrysosplenium americanum	American Golden-saxifrage		S5	R/L	rare to uncommon	rare	1
Cinna latifolia	Slender Wood Reedgrass		S5	L	rare to uncommon		1, 2
Cirsium muticum	Swamp Thistle		S5	R/L	rare		2
Cornus amomum ssp. *obliqua*	Silky Dogwood		S5	L	rare to uncommon		2
Cornus canadensis	Bunchberry		S5		rare to uncommon		1, 2
Cypripedium calceolus	Yellow Lady's-slipper		SNA	L	rare to uncommon		1, 2
Cypripedium reginae	Showy Lady's-slipper		S4	R/L	rare		1, 2
Cystopteris tenuis	Upland Brittle Bladder Fern		S5		rare to uncommon		1
Dalibarda repens	Robin Runaway		S4S5	R/L	rare	rare	1
Deparia acrostichoides	Silvery Spleenwort		S4	L	rare to uncommon		2
Dicentra canadensis	Squirrel-corn		S5		rare to uncommon		1, 2
Diphasiastrum digitatum	Fan Clubmoss		S5		rare to uncommon		1
Diplazium pycnocarpon	Glade Fern		S4	R/L	extripated to rare	rare	1
Dirca palustris	Eastern Leatherwood		S4?	L	rare to uncommon		2
Doellingeria umbellata var. *umbellata*	Flat-top White Aster		S5	L	rare to uncommon		2
Drosera rotundifolia	Roundleaf Sundew		S5	R/L	rare		1, 2
Dryopteris clintoniana	Clinton Woodfern		S4	L	rare to uncommon	rare	1
Dulichium arundinaceum	Three-way Sedge		S5	R/L	rare		1, 2
Eleocharis intermedia	Matted Spike-rush		S4	R/L	rare	rare	2
Eleocharis smallii	Creeping Spike-rush		S5	L	rare to uncommon		1, 2
Elodea canadensis	Canada Waterweed		S5	L	rare to uncommon		1
Epilobium coloratum	Purple-leaf Willow-herb		S5	R/L	rare		1, 2
Epilobium leptophyllum	Linear-leaved Willow-herb		S5	L	rare to uncommon		1, 2
Equisetum fluviatile	Water Horsetail		S5	L	rare to common		1, 2
Equisetum palustre	Marsh Horsetail		S5	R/L	rare	rare	2

Species	Common Name	Species At Risk[1]	S-Rank[2]	CVC/Peel Rarity[3]	GTA Status[4]	Wellington County Signifi-cance[5]	Observation Source[6]
Equisetum pratense	Meadow Horsetail		S5	R/L	rare	rare	2
Equisetum scirpoides	Dwarf Scouring Rush		S5	L	rare to uncommon		1, 2
Equisetum sylvaticum	Woodland Horsetail		S5	R	rare	rare	2
Equisetum variegatum var. *variegatum*	Variegated Scouring Rush		S5	L	rare to uncommon	rare	2
Eriophorum vaginatum ssp. *spissum*	Dense Cotton-grass		S5	R/L	rare		1
Eriophorum virginicum	Tawny Cotton-grass		S5	R/L	rare		1, 2
Eriophorum viridi-carinatum	Thinleaf Cottonsedge		S5	R/L	rare		1
Galium boreale	Northern Bedstraw		S5	R/L	rare		4
Galium tinctorium	Stiff Marsh Bedstraw		S5	R/L	rare		1, 2
Galium trifidum ssp. *trifidum*	Small Bedstraw		S5	L	rare to uncommon		1, 2
Gaultheria hispidula	Creeping Snowberry		S5	R/L	rare		1, 2
Gaylussacia baccata	Black Huckleberry		S4	R/L	rare		1, 2
Geum laciniatum	Rough Avens		S4		rare to common	rare	2
Geum rivale	Purple Avens		S5	R/L	rare to uncommon		1, 2
Glyceria borealis	Small Floating Manna-grass		S5	R/L	rare to uncommon	rare	1, 2
Glyceria septentrionalis	Floating Manna-grass		S4	R/L	rare		1
Hydrocotyle americana	American Marshpennywort		S5		rare to uncommon		1, 2
Hydrophyllum canadense	Blunt-leaf Waterleaf		S4	R/L	rare to uncommon	rare	1, 2
Hypericum ascyron	Great St. John's-wort		**S3?**	R/L	rare	rare	2
Hypericum punctatum	Spotted St. John's-wort		S5	R/L	rare		1
Impatiens pallida	Pale Touch-me-not		S5	L	rare to uncommon	rare	2
Juglans cinerea	Butternut	**END**	**S3?**	END	common	rare	1, 2, 5
Juncus alpinoarticulatus	Richardson Rush		S5	R/L	rare		1
Juncus brevicaudatus	Narrow-panicled Rush		S5	R/L	rare		1, 2
Kalmia polifolia	Bog Laurel		S5	R/L	rare	rare	1, 2
Ledum groenlandicum	Common Labrador Tea		S5	R/L	rare		1, 2
Lemna trisulca	Star Duckweed		S5	L	rare to uncommon		1, 2

Species	Common Name	Species At Risk[1]	S-Rank[2]	CVC/Peel Rarity[3]	GTA Status[4]	Wellington County Signifi-cance[5]	Observation Source[6]
Linnaea borealis ssp. *longiflora*	Twinflower		S5	L	rare to uncommon		1, 2
Liparis loeselii	Loesel's Twayblade		S4S5	L	rare to uncommon		1, 2
Lobelia kalmii	Kalm's Lobelia		S5	R/L	rare	rare	1, 2
Lonicera hirsuta	Hairy Honeysuckle		S5	R/L	rare		2
Lonicera oblongifolia	Swamp Fly-honeysuckle		S4S5	R/L	rare		2
Ludwigia palustris	Marsh Seedbox		S5	R/L	rare		2
Lycopodium dendroideum	Treelike Clubmoss		S5		rare to uncommon		1, 2
Lycopodium obscurum	Tree Clubmoss		S4	R/L	rare		2
Lysimachia thyrsiflora	Water Loosestrife		S5	L	rare to common		1, 2
Maianthemum trifolium	Three-leaf Solomon's-seal		S5	L	rare to uncommon		1, 2
Malaxis monophyllos ssp. *brachypoda*	White Adder's-mouth		S4	R/L	rare		2
Medeola virginiana	Indian Cucumber-root		S5	L	rare to uncommon		1, 2
Menispermum canadense	Canada Moonseed		S4	L	rare	rare	2
Menyanthes trifoliata	Bog Buckbean		S5	R/L	rare	rare	1, 2
Milium effusum	American Milletgrass		S4S5	R/L	rare to uncommon		2
Monotropa hypopithys	American Pinesap		S4	R/L	rare		1, 2
Muhlenbergia sylvatica	Woodland Muhly		**S2**	P/R/L	prov, rare	rare	2
Myriophyllum sibiricum	Common Water-milfoil		S5	R/L	rare		2
Myriophyllum verticillatum	Whorled Water-milfoil		S5	R/L	rare		2
Nemopanthus mucronatus	Mountain Holly		S5	R/L	rare		1, 2
Nuphar variegata	Yellow Cow-lily		S5	L	rare to uncommon		1, 2
Nymphaea odorata	American Water-lily		S5	L	rare to uncommon		1, 2
Orthilia secunda	One-side Wintergreen		S5	R/L	rare		1
Osmunda claytoniana	Interrupted Fern		S5	R/L	rare	rare	2
Osmunda regalis var. *spectabilis*	Royal Fern		S5	L	rare to uncommon		1, 2
Oxalis acetosella ssp. *montana*	Mountain Woodsorrel		S5	R/L	rare		1, 2
Packera aurea	Golden Ragwort		S5	R/L	rare		1, 2

Species	Common Name	Species At Risk[1]	S-Rank[2]	CVC/Peel Rarity[3]	GTA Status[4]	Wellington County Signifi-cance[5]	Observation Source[6]
Phegopteris connectilis	Northern Beech Fern		S5	R/L	rare		1, 2
Phlox divaricata	Wild Blue Phlox		S4	R/L	rare		1, 2
Picea glauca	White Spruce		S5	L	common		1, 2
Picea mariana	Black Spruce		S5	R/L	rare		1, 2
Pilea fontana	Springs Clearweed		S4	R/L	rare		1
Platanthera hyperborea var. *hyperborea*	Northern Green Orchid		SU		rare to uncommon		1, 2, 3
Platanthera obtusata	Small Northern Bog-orchid		S5	R/L	rare	rare	2
Pogonia ophioglossoides	Rose Pogonia		S4S5	R/L	rare	rare	1
Polygala paucifolia	Gay-wing Milkwort		S5		rare to uncommon	rare	2
Polygonum hydropiperoides	Mild Water-pepper		S5	R/L	rare		2
Polygonum pensylvanicum	Pennsylvania Smartweed		S5	R/L	rare		2
Potamogeton foliosus	Leafy Pondweed		S5	R/L	rare		1
Potamogeton pusillus var. *pusillus*	Slender Pondweed		SU	R/L	extripated to rare		1
Potamogeton zosteriformis	Flatstem Pondweed		S5	R/L	rare		1
Potentilla palustris	Marsh Cinquefoil		S5	L	rare to uncommon		1, 2
Pyrola asarifolia	Pink Wintergreen		S5		rare to uncommon		1, 2
Pyrola chlorantha	Greenish-flowered Wintergreen		S4S5	R/L	extripated to rare		2
Ranunculus pensylvanicus	Bristly Crowfoot		S5	R/L	rare		2
Rhamnus alnifolia	Alderleaf Buckthorn		S5	L	rare to uncommon		1, 2
Rhynchospora alba	White Beakrush		S5	R/L	rare		1
Ribes hirtellum	Smooth Gooseberry		S5	R/L	rare	rare	1
Rumex orbiculatus	Water Dock		S4S5	L	rare to uncommon		1
Sagittaria cuneata	Arum-leaved Arrowhead		S4?	R/L	rare	rare	1
Salix amygdaloides	Peach-leaved Willow		S5	L	rare to common		2
Salix lucida	Shining Willow		S5	L	rare to common		1, 2
Salix pedicellaris	Bog Willow		S5	R/L	rare		1
Sarracenia purpurea	Northern Pitcher-plant		S5	R/L	rare		1, 2

Species	Common Name	Species At Risk[1]	S-Rank[2]	CVC/Peel Rarity[3]	GTA Status[4]	Wellington County Signifi-cance[5]	Observation Source[6]
Scheuchzeria palustris	Pod Grass		S4S5	R/L	extripated to rare	rare	1, 2
Scutellaria parvula var. *parvula*	Small Skullcap		S4	R/L	extirpated		4
Selaginella eclipes	Hidden Spike-moss		S4	R/L	extirpated to rare		1
Sisyrinchium montanum	Strict Blue-eyed-grass		S5	L	rare to common		2
Solidago uliginosa	Bog Goldenrod		S5	R/L	rare		1, 2
Sparganium emersum	Greenfruit Bur-reed		S5	L	rare to common		1, 2
Sparganium eurycarpum	Large Bur-reed		S5	L	rare to uncommon		2
Sparganium natans	Small Bur-reed		S5	new to the watershed	rare		1
Spiranthes romanzoffiana	Hooded Ladies'-tresses		S5	new to the watershed	rare	rare	1
Spirodela polyrrhiza	Greater Duckweed		S5		rare to uncommon		1, 2
Thelypteris noveboracensis	New York Fern		S4S5	R/L	rare		2
Triadenum fraseri	Marsh St. John's-wort		S5	L	rare to uncommon		1, 2
Triglochin palustre	Marsh Bog Arrow-grass		S5	R/L	rare	rare	2
Triosteum aurantiacum	Coffee Tinker's-weed		S5	R/L	rare		1, 2
Ulmus thomasii	Rock Elm		S4?	R/L	rare		2
Utricularia intermedia	Flatleaf Bladderwort		S5	R/L	extripated to rare		1
Utricularia minor	Lesser Bladderwort		S5	R/L	rare	rare	1
Utricularia vulgaris	Greater Bladderwort		S5	L	rare to uncommon		1, 2
Vaccinium macrocarpon	Large Cranberry		S4S5	R/L	extripated to rare		1, 2
Vaccinium myrtilloides	Velvetleaf Blueberry		S5	R/L	rare		1, 2
Vaccinium oxycoccos	Small Cranberry		S5	R/L	extripated to rare		1, 2
Veronica americana	American Speedwell		S5		rare to uncommon		2, 4
Viburnum cassinoides	Northern Wild-raisin		S5	R/L	rare		1
Viola cucullata	Marsh Blue Violet		S5	L	rare to common		1
Viola macloskeyi ssp. *pallens*	Smooth White Violet		S5	R/L	rare to uncommon		1, 2
Viola renifolia	Kidney-leaf White Violet		S5	L	rare to uncommon		1, 2
Viola selkirkii	Selkirk's Violet		S5	R/L	rare to uncommon		1

Legend

[1] Species at Risk, ranked federally (COSEWIC or SARA) or provincially (OMNR). END = Endangered, a species facing imminent extirpation or extinction.

[2] S-Ranks (S1-S5). Provincial (or Subnational) ranks used by the Natural Heritage Information Centre to set protection priorities for rare species and natural communities. Ontario Natural Heritage Information Centre Home Page: http://nhic.mnr.gov.on.ca/nhic_old.cfm

- **S1 =** Critically Imperiled – Critically imperiled in the nation or state/province because of extreme rarity (often 5 or fewer occurrences) or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the state/province.
- **S2 =** Imperiled – Imperiled in the nation or state/province because of rarity due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation from the nation or state/province.
- **S3 =** Vulnerable – Vulnerable in the nation or state/province due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation.
- **S4 =** Apparently Secure – Uncommon but not rare; some cause for long-term concern due to declines or other factors.
- **S5 =** Secure – Common, widespread, and abundant in the nation or state/province.
- **SxSy =** Species whose status may be Sx or Sy. Insufficient data exists to provide a definitive assessment.
- **SNA =** Not Applicable —A conservation status rank is not applicable because the species is not a suitable target for conservation activities.
- **SU =** Unrankable—Currently unrankable due to lack of information or due to substantially conflicting information about status or trends. Breeding migrant (not a permanent or year-round resident)
- **B =** Breeding migrant (not a permanent or year-round resident)

[3] CVC/Peel Rarity. R = Regionally Rare, L= Locally Rare. Source: *The Vascular Plant Flora of the Region of Peel and the Credit River Watershed. Prepared for Credit Valley Conservation, The Regional Municipality of Peel and Toronto and Region Conservation Authority* (Kaiser 2001).

[4] Greater Toronto Area significance/rarity. Source: *Distribution and Status of the Vascular Plants of the Greater Toronto Area* (OMNR, Aurora District. August 2000. Draft). Status included in this table are generalized across 5 municipalities (Halton, Peel, Toronto, York and Durham), 2 site districts (6E7 & 7E4) and for the GTA.

[5] Significant species for Wellington County. Source: Guelph Natural Heritage Strategy. Phase 2: Terrestrial Inventory and Natural Heritage System. Volume 2: Technical Appendices (Dougan 2009)

[6] Observation source. 1 = Charles Cecile, 2 = CVC field staff, 3 = Bob Curry, 4 = Bill McIllveen, 5 = Jim Proudfoot, 6 = NHIC record

Table 2.1 Mammal species recorded within 2 km of the Erin SSMP study

Scientific Name	Common Name	Conservation Status				Observer[2]	Observation Date
		National		Provincial			
		SARA	COSEWIC	SARO	S_Rank[1]		
Canis latrans	Coyote				S5	1, 2, 3	2000, 2003, 2005, 2008, 2009
Castor canadensis	Beaver				S5	1, 2	2003, 2004, 2005, 2008, 2009
Erethizon dorsatum	Porcupine				S5	1	2000, 2004, 2008
Marmota monax	Woodchuck				S5	2	2008, 2009
Mephitis mephitis	Striped skunk				S5	2	2009
Mustela vison	American mink				S4	1	2000
Odocoileus virginianus	White-tailed deer				S5	1, 2	1997, 1999, 2000, 2001, 2003, 2004, 2005, 2008, 2009
Ondatra zibethicus	Muskrat				S5	1, 2	2004, 2008, 2009
Procyon lotor	Northern raccoon				S5	1, 2	1997, 2000, 2001, 2003, 2004, 2005, 2008, 2009
Sciurus carolinensis	Eastern gray squirrel				S5	1	1999, 2000, 2001, 2004, 2008
Sylvilagus floridanus	Eastern cottontail				S5	1, 2	2008, 2009
Tamias striatus	Eastern chipmunk				S5	1, 2	1997, 2000, 2004, 2008, 2009
Tamiasciurus hudsonicus	Red squirrel				S5	1, 2	2000, 2001, 2005, 2004, 2008, 2009

Legend

1 **S-Ranks.** See Legend in Table 2.0.

2 **Observers**: 1 = Bob Curry, 2 = CVC Field Staff

Table 2.2 Bird species recorded within 2 km of the Erin SSMP study

Scientific Name	Common Name	Conservation Status				Area Sensitive Species[5]	Observer[6]	Observation Date
		National		Provincial				
		SARA[1]	COSEWIC[2]	SARO[3]	S_Rank[4]			
Accipiter cooperii	Cooper's Hawk				S4B	X	1	2009
Accipiter gentilis	Northern Goshawk				S4	X	1	2009
Accipiter striatus	Sharp-shinned Hawk				S5	X	1	2008
Actitis macularia	Spotted Sandpiper				S5B		1	2009
Agelaius phoeniceus	Red-winged Blackbird				S5B		1, 2	1997, 2000, 2003, 2004, 2008, 2009
Aix sponsa	Wood Duck				S5B		1, 2	2008, 2009
Anas platyrhynchos	Mallard				S5B		1, 2	2000, 2001, 2003, 2008, 2009
Archilochus colubris	Ruby-throated Hummingbird				S5B		1, 2	2000, 2008, 2009
Ardea herodias	Great Blue Heron				S5B		1, 2	2003, 2008, 2009
Bombycilla cedrorum	Cedar Waxwing				S5B		1, 2	1997, 1999, 2000, 2003, 2004, 2005, 2006, 2008, 2009
Bonasa umbellus	Ruffed Grouse				S5		1,2	2000, 2003, 2005, 2008, 2009
Bubo virginianus	Great Horned Owl				S5		1	2009
Buteo jamaicensis	Red-tailed Hawk				S5B		1, 2	2003, 2004, 2008, 2009
Buteo lineatus	Red-shouldered Hawk	SC			S4B	X	2	2008
Buteo platypterus	Broad-winged Hawk				S5B	X	1	2009
Butorides virescens	Green Heron				S4B		1, 2	2003, 2004, 2009
Cardinalis cardinalis	Northern Cardinal				S5		1, 2	2001, 2004, 2005, 2008, 2009
Carduelis pinus	Pine Siskin				S4B		1	2009
Carduelis tristis	American Goldfinch				S5B		1, 2	1997, 1999, 2000, 2001, 2003, 2004, 2005, 2008, 2009
Carpodacus mexicanus	House Finch				SNA		1	2009
Carpodacus purpureus	Purple Finch				S4B		1	2009
Cathartes aura	Turkey Vulture				S5B		1, 2	2003, 2008, 2009

Scientific Name	Common Name	Conservation Status				Area Sensitive Species[5]	Observer[6]	Observation Date
		National		Provincial				
		SARA[1]	COSEWIC[2]	SARO[3]	S_Rank[4]			
Catharus fuscescens	Veery				S4B	X	1, 2	2000, 2001, 2004, 2005, 2008, 2009
Certhia americana	Brown Creeper				S5B	X	1	2008, 2009
Ceryle alcyon	Belted Kingfisher				S4B		1, 2	1997, 2000, 2008, 2009
Chaetura pelagica	Chimney Swift	**THR**	**THR**	**THR**	S4B		1	2009
Charadrius vociferus	Killdeer				S5B,S5N		1, 2	2003, 2009
Circus cyaneus	Northern Harrier				S4B	X	2	2004
Coccyzus erythropthalmus	Black-billed Cuckoo				S5B		1	2009
Colaptes auratus	Northern Flicker				S4B		1, 2	1997, 1999, 2000, 2003, 2004, 2008, 2009
Contopus virens	Eastern Wood-pewee				S4B		1, 2	1997, 2000, 2001, 2003, 2004, 2008, 2009
Corvus brachyrhynchos	American Crow				S5B		1, 2	1997, 2000, 2001, 2004, 2005, 2006, 2008, 2009
Corvus corax	Common Raven				S5		1	2009
Cyanocitta cristata	Blue Jay				S5		1, 2	1997, 2000, 2001, 2003, 2004, 2005, 2006, 2008, 2009
Cygnus buccinator	Trumpeter Swan				**S2S3**		1	2009
Dendroica caerulescens	Black-throated Blue Warbler				S5B	X	1	2009
Dendroica coronata	Yellow-rumped Warbler				S5B		1	1997, 2008, 2009
Dendroica fusca	Blackburnian Warbler				S5B	X	1	2009
Dendroica magnolia	Magnolia Warbler				S5B	X	1, 2	1997, 2005, 2008, 2009
Dendroica pensylvanica	Chestnut-sided Warbler				S5B		1, 2	2000, 2001, 2004, 2008, 2009
Dendroica petechia	Yellow Warbler				S5B		1, 2	1997, 2000, 2001, 2008, 2009
Dendroica pinus	Pine Warbler				S5B	X	1	2008, 2009
Dendroica virens	Black-throated Green Warbler				S5B	X	1, 2	1997, 2000, 2001, 2008, 2009
Dolichonyx oryzivorus	Bobolink				S4B	X	1	2008, 2009
Dryocopus pileatus	Pileated Woodpecker				S5	X	1, 2	1999, 2000, 2001, 2003, 2004, 2005, 2006, 2008, 2009

Scientific Name	Common Name	Conservation Status				Area Sensitive Species[5]	Observer[6]	Observation Date
		National		Provincial				
		SARA[1]	COSEWIC[2]	SARO[3]	S_Rank[4]			
Dumetella carolinensis	Gray Catbird				S5B		1, 2	1999, 2000, 2004, 2008, 2009
Empidonax alnorum	Alder Flycatcher				S5B		1, 2	2008, 2009
Empidonax minimus	Least Flycatcher				S4B	X	1	2009
Empidonax traillii	Willow Flycatcher				S5B		2	1997
Eremophila alpestris	Horned Lark				S5B		1	2009
Falco sparverius	American Kestrel				S5B		1	2009
Fulica americana	American Coot				S4B	X	1	2009
Geothlypis trichas	Common Yellowthroat				S5B		1, 2	1999, 2000, 2001, 2003, 2004, 2005, 2008, 2009
Hirundo rustica	Barn Swallow				S5B		1, 2	2003, 2004, 2008, 2009
Hylocichla mustelina	Wood Thrush				S4B		1, 2	1997, 2000, 2001, 2004, 2008, 2009
Icterus galbula	Baltimore Oriole				S4B		1, 2	1997, 2008, 2009
Larus delawarensis	Ring-billed Gull				S5B,S4N		2	2008
Melanerpes carolinus	Red-bellied Woodpecker				S4		1	2009
Meleagris gallopavo	Wild Turkey				S5		1, 2	2004, 2008, 2009
Melospiza georgiana	Swamp Sparrow				S5B		1, 2	2000, 2001, 2005, 2008, 2009
Melospiza lincolnii	Lincoln's Sparrow				S5B		1, 2	2003, 2009
Melospiza melodia	Song Sparrow				S5B		1, 2	2000, 2003, 2004, 2005, 2008, 2009
Mniotilta varia	Black-and-white Warbler				S5B	X	1, 2	1997, 2000, 2008, 2009
Molothrus ater	Brown-headed Cowbird				S4B		1, 2	2000, 2008, 2009
Myiarchus crinitus	Great Crested Flycatcher				S4B		1, 2	2000, 2001, 2008, 2009
Oporornis agilis	Connecticut Warbler				S4B		2	2001
Oporornis philadelphia	Mourning Warbler				S4B		1	2008, 2009
Pandion haliaetus	Osprey				S5B		1	2009
Passer domesticus	House Sparrow				SNA		1	2009

Scientific Name	Common Name	Conservation Status				Area Sensitive Species[5]	Observer[6]	Observation Date
		National		Provincial				
		SARA[1]	COSEWIC[2]	SARO[3]	S_Rank[4]			
Passerculus sandwichensis	Savannah Sparrow				S4B	X	1	2008, 2009
Passerina cyanea	Indigo Bunting				S4B		1, 2	2004, 2005, 2008, 2009
Petrochelidon pyrrhonota	Cliff Swallow				S4B		1	2009
Pheucticus ludovicianus	Rose-breasted Grosbeak				S4B		1, 2	1997, 2004, 2009
Picoides pubescens	Downy Woodpecker				S5		1, 2	1997, 2000, 2001, 2004, 2008, 2009
Picoides villosus	Hairy Woodpecker				S5	X	1, 2	2003, 2004, 2008, 2009
Pipilo erythrophthalmus	Eastern Towhee				S4B		1	2009
Pipilo erythrophthalmus	Eastern Towhee				S4B		1	2009
Piranga olivacea	Scarlet Tanager				S4B	X	1	2009
Poecile atricapillus	Black-capped Chickadee				S5		1, 2	1997, 1999, 2000, 2001, 2003, 2004, 2005, 2006, 2008, 2009
Pooecetes gramineus	Vesper Sparrow				S4B		1	2009
Quiscalus quiscula	Common Grackle				S5B		1, 2	2000, 2004, 2008, 2009
Rallus limicola	Virginia Rail				S5B		1	2009
Regulus satrapa	Golden-crowned Kinglet				S5B		1	2009
Riparia riparia	Bank Swallow				S4B		1	2009
Sayornis phoebe	Eastern Phoebe				S5B		1	2009
Scolopax minor	American Woodcock				S4B		1, 2	2000, 2004, 2008, 2009
Seiurus aurocapilla	Ovenbird				S4B	X	1, 2	1997, 2000, 2001, 2008, 2009
Seiurus noveboracensis	Northern Waterthrush				S5B		1, 2	2001, 2008, 2009
Setophaga ruticilla	American Redstart				S5B	X	1, 2	2004, 2005, 2008, 2009
Sialia sialis	Eastern Bluebird				S5B		1	2009
Sitta canadensis	Red-breasted Nuthatch				S5	X	1, 2	2000, 2005, 2008, 2009
Sitta carolinensis	White-breasted Nuthatch				S5		1, 2	1997, 2000, 2001, 2003, 2005, 2006, 2008, 2009
Sphyrapicus varius	Yellow-bellied Sapsucker				S5B	X	1, 2	2000, 2005, 2008, 2009

Scientific Name	Common Name	Conservation Status				Area Sensitive Species[5]	Observer[6]	Observation Date
		National		Provincial				
		SARA[1]	COSEWIC[2]	SARO[3]	S_Rank[4]			
Spizella pallida	Clay-colored Sparrow				S4B		1	2008
Spizella passerina	Chipping Sparrow				S5B		1, 2	2003, 2008, 2009
Spizella pusilla	Field Sparrow				S4B		1, 2	2000, 2008, 2009
Stelgidopteryx serripennis	Northern Rough-winged Swallow				S4B		1	2009
Sturnella magna	Eastern Meadowlark				S5B	X	1	2008, 2009
Sturnus vulgaris	European Starling				SNA		1, 2	1997, 2008, 2009
Tachycineta bicolor	Tree Swallow				S4B		1, 2	2000, 2001, 2004, 2008, 2009
Toxostoma rufum	Brown Thrasher				S4B		1	2009
Troglodytes aedon	House Wren				S5B		1, 2	2005, 2008, 2009
Troglodytes troglodytes	Winter Wren				S5B	X	1	2008, 2009
Turdus migratorius	American Robin				S5B		1, 2	1997, 2000, 2001, 2003, 2004, 2005, 2006, 2008, 2009
Tyrannus tyrannus	Eastern Kingbird				S5B		1, 2	2003, 2008, 2009
Vermivora pinus	Blue-winged Warbler				S4B		1, 2	2001, 2009
Vermivora ruficapilla	Nashville Warbler				S5B		1, 2	2005, 2008, 2009
Vireo flavifrons	Yellow-throated Vireo				S4B	X	1	2009
Vireo gilvus	Warbling Vireo				S5B		1	2009
Vireo olivaceus	Red-eyed Vireo				S5B		1, 2	1997, 2000, 2001, 2003, 2004, 2008, 2009
Vireo solitarius	Blue-headed Vireo				S5B	X	1	2009
Wilsonia canadensis	Canada Warbler		**THR**	**SC**	S4B	X	1	2009
Wilsonia citrina	Hooded Warbler	**THR**	**THR**	**SC**	**S3B**	X	1	2009
Zenaida macroura	Mourning Dove				S5		1, 2	1999, 2001, 2004, 2008, 2009
Zonotrichia albicollis	White-throated Sparrow				S5B		1, 2	1999, 2000, 2005, 2008, 2009

Legend

1 **SARA (Species at Risk Act). 2009.** List of species at risk in Canada: http://www.sararegistry.gc.ca/sar/index/default_e.cfm

2 **COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2008.** Web site: http://www.cosewic.gc.ca/eng/sct1/searchform_e.cfm

National Conservation Status Categories

END = Endangered - A wildlife species facing imminent extirpation or extinction.
THR = Threatened - A wildlife species that is likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction.
SC = Special Concern - A wildlife species that may become threatened or endangered because of a combination of biological characteristics and identified threats.
NAR = Not At Risk - A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.

3 **SARO (Species at Risk in Ontario). 2009.** Species at Risk in Ontario (SARO) List. Updated September 11, 2009. http://www.mnr.gov.on.ca/en/Business/Species/2ColumnSubPage/276722.html

END = Endangered – A species facing imminent extinction or extirpation in Ontario which is a candidate for regulation under Ontario's ESA.
THR = Threatened – A species that is at risk of becoming endangered in Ontario if limiting factors are not reversed.
SC = Special Concern – A species with characteristics that make it sensitive to human activities or natural events.

4 **S-Ranks.** See Legend in Table 2.0.

5 **OMNR (Ontario Ministry of Natural Resources). 2000.** Significant Wildlife Habitat Technical Guide. 151p. Appendix G: Wildlife Habitat Matrices and Habitat Descriptions for Rare Vascular Plants. (Includes complete list of area sensitive species). http://www.mnr.gov.on.ca/MNR/pubs/pubmenu.htm

6 **Observers**: 1 = Bob Curry, 2 = CVC Field Staff

2.1 NAI Breeding Bird Inventory Methodology

(text from bird consultant contract)

DELIVERABLES

1) **Data Collection – Field Work**

Methodology

- For each natural area a comprehensive list of breeding bird species will be assembled, based on field observations in the 20xx season. Presence of bird species will be recorded as well as evidence of breeding activity.
- The bird inventories will be conducted following the methodology used for the 2008 Bird Inventory work, which follows the Toronto and Region Conservation Authority protocol for breeding bird surveys, adapted from the Breeding Bird Atlas. Tape playback may be used if desired but is not a required part of the protocol. Additionally, only CVC Species of Conservation Concern, Levels 1 and 2 (lists provided by CVC) need be mapped, except for Level 3 species in urban-influenced areas. For all other species a checklist should be kept that corresponds to each natural area.
- A separate list will be kept for each natural area visited.
- CVC Species of Conservation Concern, Levels 1 and 2 will be mapped as per CVC SoCC Mapping Protocol (attached), directly on the provided ortho-photo or by recording GPS coordinates of species occurrences. In urban-influenced areas (indicated by CVC) Level 3 Species of Conservation Concern will also be mapped in addition to Level 1 and 2 species.
- Ortho-photo mapping for each area (at 1:5000 scale) will be provided by the NAI. The specific details as to how each natural area will be covered are left to the discretion of the consultant. The intention is that, as close as possible, all of the bird species living in the natural area are detected. Work will be conducted efficiently in order to maximize coverage of NAI areas overall.
- Incidental reports on other fauna and rare plants (mapped) are also welcomed.

Survey Dates and Times

- 2 visits per identified Natural Area
    - the first to occur between late May and mid-June
    - the second to occur between mid-June and mid-July
    - with at least six days between visits at any site

- All bird surveys must be completed during the early morning hours (anytime between one half hour before sunrise and five hours after sunrise)
- Ideally, weather conditions should be clear and calm; wind speed should not exceed 15 km/h; nor should counts be conducted in continuous rain.
- Specific site-visit schedule is at discretion of consultant (due to specific weather requirements of surveys)
- The NAI Coordinator will be kept appraised of when the consultant is moving on to a new natural area in order to ensure that landowners who wish to be notified of details of visit dates, may be contacted.

Locations

- Surveys must only be completed at the designated sites. It is acknowledged that landowner permissions will play a large part in completing all natural areas and flexibility between site selection and survey targets will be considered as the season progresses, between CVC and the consultant. Only properties for which permission for access has been granted will be visited. In cases where a natural area extends to an adjoining property where there is no access permission, visual observations may be made and species recorded, as long as trespass does not occur.

A preliminary list of sites/properties to be visited (with confirmed permission for access) is attached. Additional sites/properties may be added or substituted as permission for access is obtained, and field time (and project budget) permits.

Table 2.3 List of herpetofauna (amphibians and reptiles) recorded within the Erin SSMP study area

Scientific Name	Common Name	Conservation Status				Observer[2]
		National		Provincial		
		SARA	COSEWIC	SARO	S-Rank[1]	
Amphibians						
Bufo americanus	American Toad				S5	1 , 2, 3
Hyla versicolor	Gray Treefrog				S5	1, 2, 3
Pseudacris crucifer	Spring Peeper				S5	1, 2, 3
Pseudacris triseriata triseriata[3]	Western Chorus Frog		THR		S4	3
Rana catesbeiana	American Bullfrog				S4	1, 3
Rana clamitans	Green Frog				S5	1, 2 ,3
Rana pipiens	Northern Leopard Frog		NAR	NAR	S5	1, 2, 3
Rana sylvatica	Wood Frog				S5	1, 2, 3
Plethodon cinereus	Eastern Red-backed Salamander				S5	1, 2
Reptiles						
Storeria occipitomaculata	Northern Red-bellied Snake				S5	2
Thamnophis sirtalis	Eastern Gartersnake				S5	1, 2
Chrysemys picta	Midland Painted Turtle				S5	2
Chelydra serpentina	Eastern Snapping Turtle		SC	SC	S3	1, 2

Legend

[1] S-Ranks (S1-S5). See Legend in Table 4.

[2] Observers: 1 = CVC field staff, 2 = Bob Curry, 3 = Rob Milne and Lorne Bennett

[3] This (sub)species has been split into two distinct populations

Table 2.4 List of odonates (dragonflies and damselflies) recorded within the Erin SSMP study area

Scientific Name	Common Name	Conservation Status	
		Provincial	Regional
		S-Rank[1]	Significant in Wellington County[2]
Amphiagrion saucium	Eastern Red Damsel	S4	X
Anax junius	Common Green Darner	S5	
Argia fumipennis violacea	Violet Dancer	S5	
Arigomphus furcifer	Lilypad Clubtail	S3	X
Calopteryx aequabilis	River Jewelwing	S5	
Calopteryx maculata	Ebony Jewelwing	S5	
Celithemis elisa	Calico Pennant	S5	
Coenagrion resolutum	Taiga bluet	S5	X
Cordulegaster diastatops	Delta-spotted Spiketail	S4	X
Cordulia shurtleffii	American Emerald	S5	X
Dorocordulia libera	Racket-tailed Emerald	S5	X
Enallagma boreale	Boreal Bluet	S5	
Enallagma civile	Familiar Bluet	S5	
Enallagma cyathigerum (Synonym *E. annexum*)	Northern Bluet	**S3**	X
Enallagma ebrium	Marsh Bluet	S5	
Enallagma exsulans	Stream Bluet	S5	
Epitheca cynosura	Common Baskettail	S5	
Epitheca spinigera	Spiny Baskettail	S5	
Gomphus exilis	Lancet Clubtail	S5	
Gomphus graslinellus	Pronghorn clubtail	S3	X
Gomphus lividus	Ashy Clubtail	S4	X
Gomphus spicatus	Dusky Clubtail	S5	X
Ischnura posita	Fragile Forktail	S4	
Ischnura verticalis	Eastern Forktail	S5	
Ladona (Libellula) julia	Chalk-fronted Corporal	S5	X
Lestes dryas	Emerald Spreadwing	S5	
Lestes rectangularis	Slender Spreadwing	S5	
Lestes unguiculatus	Lyre-tipped Spreadwing	S5	
Leucorrhinia frigida	Frosted Whiteface	S5	X
Leucorrhinia hudsonica	Hudsonian Whiteface	S5	X
Leucorrhinia intacta	Dot-tailed Whiteface	S5	
Leucorrhinia proxima	Red-waisted Whiteface	S5	X
Libellula luctuosa	Widow Skimmer	S5	
Libellula pulchella	Twelve-spotted Skimmer	S5	

Libellula quadrimaculata	Four-spotted Skimmer	S5	
Nehalennia irene	Sedge Sprite	S5	
Pachydiplax longipennis	Blue Dasher	S5	
Plathemis lydia	Common Whitetail	S5	
Somatochlora williamsoni	Williamson's Emerald	S4	X
Sympetrum obtrusum	White-faced Meadowhawk	S5	
Sympetrum rubicundulum	Ruby Meadowhawk	S5	

Legend
[1] S-Ranks (S1-S5). See Legend in Table 2.0.
[2] Significant in Wellington County. Determined by Colin Jones, Project Zoologist at NHIC and provincial expert on Ontario odonata. See Dougan and Associates (2009) for methods used to assess significance.

Table 2.5 List of lepidoptera (butterflies and moths) recorded within the Erin SSMP study area

Scientific Name	Common Name	Conservation Status[1]			
		National		Provincial	
		COSEWIC	SARA	OMNR	S-Rank
Ancyloxypha numitor	Least Skipper				S5
Carterocephalus palaemon	Arctic Skipper				S5
Celastrina argiolus	Spring Azure				S5
Celastrina neglecta	Summer Azure				S5
Cercyonis pegala	Common Wood-Nymph				S5
Coenonympha tullia	Common Ringlet				S5
Colias philodice	Clouded Sulphur				S5
Danaus plexippus	Monarch	SC	SC	SC	S2N,S4B
Enodia anthedon	Northern Pearly-Eye				S5
Epargyreus clarus	Silver-spotted Skipper				S4
Euphyes vestris	Dun Skipper				S5
Everes comyntas	Eastern Tailed Blue				S5
Glaucopsyche lygdamus	Silvery Blue				S5
Limenitis archippus	Viceroy				S5
Limenitis arthemis arthemis	Banded Purple				S5
Limenitis arthemis astyanax	Red-spotted Purple				S5
Lycaena hyllus	Bronze Copper				S5
Lycaena phlaeas	American Copper				S5
Megisto cymela	Little Wood-Satyr				S5
Nymphalis antiopa	Mourning Cloak				S5
Papilio canadensis	Canadian Tiger Swallowtail				S5
Papilio polyxenes	Black Swallowtail				S5
Pholisora catullus	Common Sootywing				S3
Phyciodes pascoensis	Northern Crescent				S5

Phyciodes tharos	Pearl Crescent				S4
Pieris oleracea	Mustard White				S4
Pieris rapae	Cabbage White				SNA
Poanes hobomok	Hobomok Skipper				S5
Polites mystic	Long Dash Skipper				S5
Polygonia comma	Eastern Comma				S5
Polygonia interrogationis	Question Mark				S5
Satyrodes appalachia	Appalachian Brown				S4
Satyrodes eurydice	Eyed Brown				S5
Speyeria cybele	Great Spangled Fritillary				S5
Thymelicus lineola	European Skipper				SNA
Vanessa atalanta	Red Admiral				S5
Vanessa virginiensis	American Painted Lady				S5

Legend
[1] National and Provincial Conservation Status. See Legend in Table 2.2.

3.0 Analysis of Natural Area Significance

What follows is a brief summary of the criteria that have been used to evaluate the relative importance or significance of individual mapped natural area patches, or blocks of patches at a landscape or subwatershed scale and the resulting findings.

As recommended by the Province (OMNR 1997), the majority of this analysis relies on the "Minimum Standards" evaluation method or as Smith and Theberge (1987) referred to as the "Disjunctive Method". This method ranks candidate sites based on whether they meet a minimum standard for at least one criterion, regardless of whether they meet minimum standards for any of the other criteria. This approach is considered more ecologically and mathematically valid than other approaches (such as weighting and ranking) when comparing measures at different scales and/or of different ecological criteria (OMNR 1997). In our approach, we rank each isolated patch or cluster of patches, as appropriate, based on each of the individual measures. "Special Features" (such as old forest) are also considered when evaluating the natural areas.

In order to facilitate the integration of this analysis of the terrestrial communities with the various component studies for the characterization of the subwatershed, a summary map was developed to identify the overall significance of the natural areas (Figure 2.3.9 in the *Environmental Component – Existing Conditions Report*).

I. Community Diversity or Complexity

Community diversity or complexity refers to the number of different communities within a given area or patch. The biodiversity of a particular community or patch is critical to its long-term stability. The identification of a set of sites which maximize diversity is an essential prerequisite for conservation evaluation (Margules et al. 1988).

Procedures:
All terrestrial and wetland communities or “natural areas” 0.5 hectares and larger were mapped as polygons, whether partially or entirely contained within the subwatershed. “Natural area” boundaries (i.e. polygon clusters or isolated polygons) were identified based on breaks between patches (i.e. land use or roadways).

An index can be used as a means of measuring proportional change or dispersion from the maximum possible diversity for a set of observations (i.e. communities mapped) distributed among a given set of categories (i.e. total number of different community types found). The data that has been collected cannot be considered a random sample. In fact, the data can be said to represent the entire population (i.e. all communities at this scale were mapped). On this basis the diversity index measure developed by Brillouin (1962) was used as set out in Zar (1984).

Based on the results of these calculations, the data set was divided among 4 classes, with Class 1 having the highest diversity and Class 4 having the lowest diversity. Refer to **Figure 3.0.1** in this Appendix.

II. Relative Community Size

It is generally accepted that plant and animal diversity increases as the size of an area increases (Riley and Mohr 1994, OMNR 1997). It is important, however, to evaluate the size of a community within the context of the percentage cover, or frequency of occurrence, of that community within a study area. This is due in part to the fact that the viability of some wildlife is dependent not only upon the characteristics of the habitat in which they reside, but also upon the characteristics of the landscape in which the habitat occurs (OMNR 1999). Based on the example for woodlands recommended by the province (OMNR 1999) we utilized the following categories in determining potential significance of individual natural community polygons (excluding Cultural Communities and Plantations):

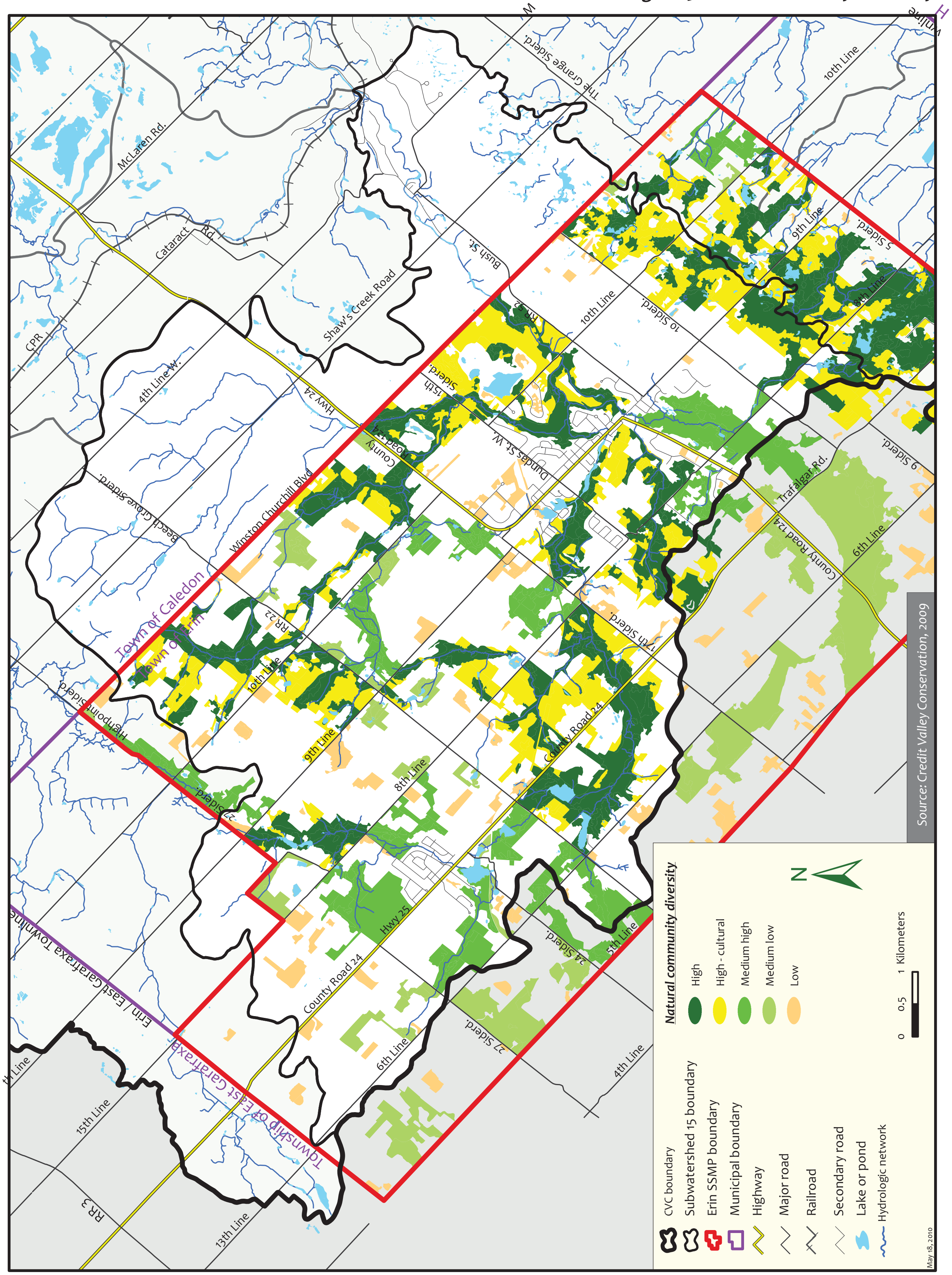
Procedures:

A. Where the community cover-type is less than 5% of the natural communities mapped, community polygons 2 ha or larger should be considered significant (or Class 1).

B. Where the community cover-type is between 5 to 15% of the natural communities mapped, community polygons 4 ha or larger should be considered significant (or Class 1).

C. Where the community cover-type is between 15 to 30% of the natural communities mapped, community polygons 40 ha or larger should be considered significant (or Class 1).

Figure 3.0.1 Community Diversity



Where the percentage cover of a community type is greater than 30%, the size of individual polygons become less significant based on this measure (**Figure 3.0.2** in this Appendix).

It should be recognized that not all community types will be identified through this classification system because of the 2 ha minimum size requirement. Communities that are less than 5% of the total subwatershed area will be identified on the "Special Feature" map as a rare community (**Figure 2.3.7** in the *Environmental Component – Existing Conditions Report*).

III. Interior Habitat or Core Area

Interior habitats are generally free from the often-negative effects found in edge habitats such as increased predation, competition, pollution, and wind. The literature suggests that on average, edge effects are felt at least 100 metres into a forest patch (Riley and Mohr 1994). Some species require a 200-metre buffer from the edge of the patch (also referred to as deep core) (Environment Canada 2004). Interior habitat is critical to the survival of many species, particularly "forest-interior" birds (OMNR 1997). Parasitism and predation have been found to decline as the distance towards the forest interior increases (Riley and Mohr 1994).

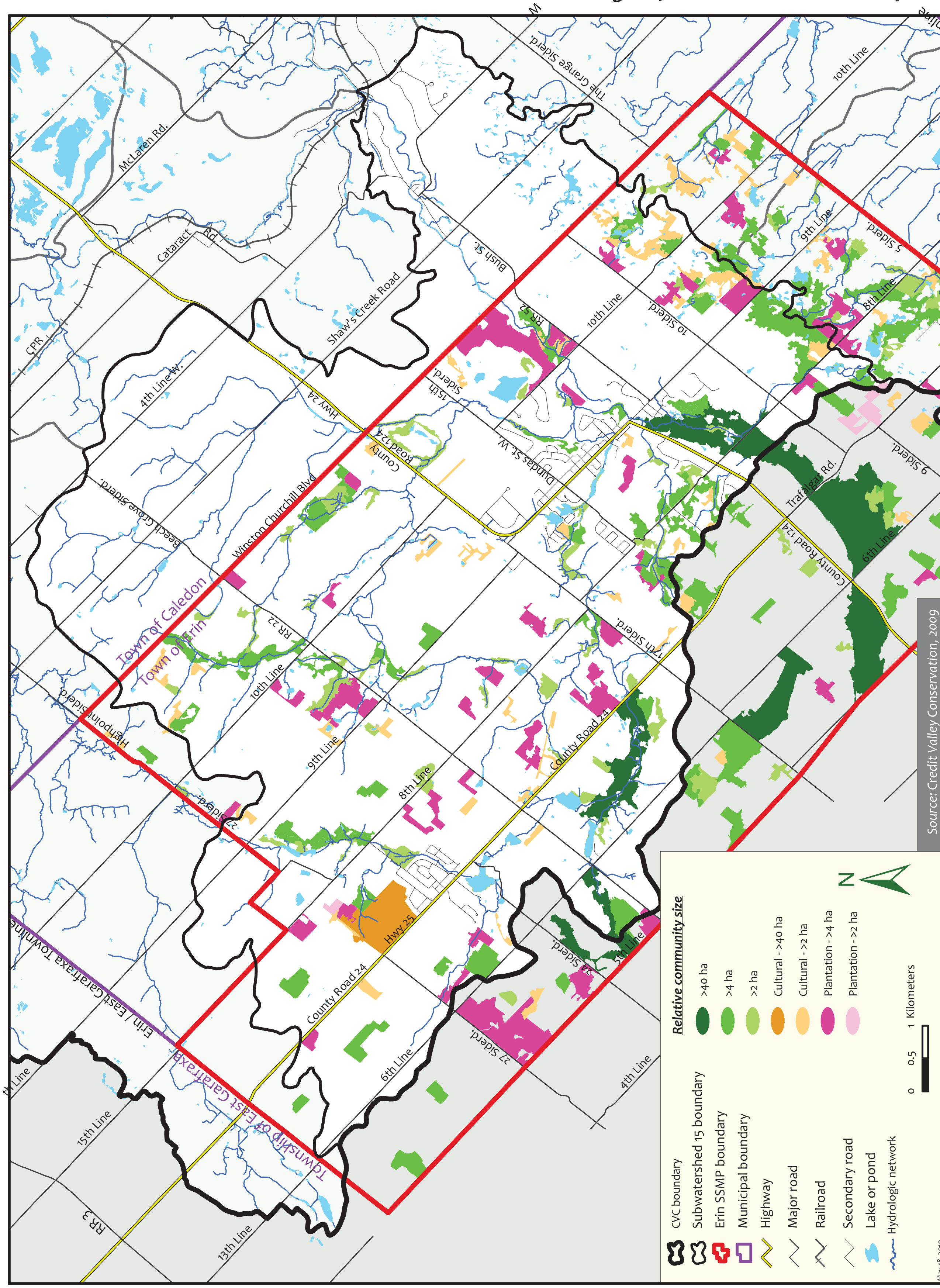
Procedures:
Polygon clusters (i.e. patches) and isolated polygons or patches of Forest, Plantation and/or Swamp (i.e. treed wetland) Communities were used for the analysis. Of these communities, those that were completely or partially within the subwatershed were included. A 100-metre buffer from the edge of the clusters and isolated polygons was created to identify interior core area. A second and similar procedure was used based on a 200-metre buffer to identify deep core area.

Environment Canada (2004) has suggested guidelines for the amount of upland forest core area in a subwatershed: 10% or greater for core areas and 5% or greater for deep core areas. It should be noted that the core area calculations for the subwatershed included areas that were not upland forest and therefore there would actually be less if measured against this higher standard. No minimum size was required in order for an area to be identified as core or deep core, however, core that was greater than 4 hectares was specifically noted. Refer to Figure 2.3.8 in the Environmental Component – Existing Conditions Report.

IV. Special Features

There are certain features or areas with certain designations that necessitate recognition and protection. Some of these sites are protected through Provincial Policy (e.g. Provincially Significant Wetlands), or Conservation Authority Policy (e.g. Environmentally Significant Areas), or are simply recognized locally as representing particular functions or values that warrant efforts for protection (e.g. rare communities).

Figure 3.0.2 Relative Community Size



The following communities or areas have been selected as representing special features within the study area. They are all automatically included as significant communities. A brief description of these areas was provided within the main text of the study.

The following Special Features were included:

- Provincially Significant Life Science ANSI's
- Provincially Significant Wetlands
- Species at Risk
- Environmentally Significant Areas
- Rare Communities within the Subwatershed
- Rare Communities at a Provincial Level
- Communities that contain 3 or more locally rare flora and/or fauna
- Communities that contain trees greater than 125 years of age

3.1 Determination of Natural Area Priorities

The Natural Area Significance Map (Figure 2.3.9 in the *Environmental Component – Existing Conditions Report*) consists of an overlay of the results of the analysis for Community Diversity, Core Habitat and Relative Community Size and Special Features.

High Priority Areas – These are the most significant natural areas carrying out essential roles in maintaining the health of the subwatershed. The High Priority Areas have been defined as:

- Communities or patches containing a Special Feature
- Natural Communities identified to be significant based on Relative Community Size
- Communities that are core, or contribute to core (i.e. the 100 m of "Forested Area" around the core area or 200 m of "Forested Area" around deep core),[1] except where the core area is entirely within a plantation[2]
- Forest and Wetland Communities (i.e. not Plantation or Cultural Communities) within patches that are Class 1 for Diversity.[3]

Explanatory Notes:

[1] Impacts within core areas are minimized or buffered by the adjacent natural area. In addition, disturbances outside the core area and the calculated buffer area (that was required to create that core area) can ultimately affect the core functions. Therefore, by maintaining a natural area around the core area, the role of the buffer is recognized. In addition, forest interior species that use core area for breeding may use the balance of the community (beyond the calculated buffer) for other life processes. On this basis, the entire community is classified as High Priority.

[2] Plantations can provide important core area; however, many plantations are managed as a monoculture and are grown as a source of wood. In some instances, they have been recently planted and therefore are of young age and may not actually contain any core-type habitat area. Therefore, core area that consists entirely in plantation is classified as Medium Priority.

[3] Although plantations and cultural communities add to the diversity of a patch, it must be recognized that these communities are anthropogenic and can potentially be utilized for agricultural purposes or for a source of wood. However, these areas do provide wildlife habitat, buffers to more natural areas and diversity to the natural patch; therefore, they are classified Medium Priority.

Medium Priority Areas – are also significant, however, additional analysis is required to determine their overall role within the subwatershed. The Medium Priority Areas are:

- Forest and wetland communities that connect High Priority communities[4]
- Core areas that are entirely plantation
- Forest or Wetland Communities that are connected to a community that contributes to core area (i.e. connected to the buffer)[5]
- Cultural communities and plantations that were part of a patch that was rated as Class 1 for Diversity
- Cultural communities and plantations that were identified to be significant based on Relative Community Size
- Forest or wetland communities that are connected to a Class 1 Community based on its relative size and frequency
- Communities that are ranked as moderate for Diversity

Explanatory Notes:
[4] Forests and wetlands that connect, or link, to High Priority Areas will increase diversity and maintain the integrity of the area; as well as providing a corridor for wildlife movement between the communities.

[5] Forest communities that are within patches that contain core areas provide an additional level of support to the core habitat functions, as well as increasing diversity of the patch. In addition, there forest interior birds or other wildlife may use communities for part of their life cycle.

Low Priority Areas – based upon our analysis, have a lower functional role, but this does not mean that they are not important. In fact, in order to meet the targets for a healthy subwatershed, protection of these areas should be encouraged and additional natural areas created. The Low Priority Areas are:

- The remaining communities that were not classified as Special Feature or determined to be High or Medium Priority.

4.0 References

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APPENDIX D:
Stream Geomorphology

Phase 1 -
Environmental Component -
Existing Conditions Report

For The

Erin Servicing and Settlement Master Plan

Prepared for:

County of Wellington
Town of Erin

Prepared by:

Aquafor Beech Limited and
Credit Valley Conservation

May 2011

STREAM GEOMORPHOLOGY APPENDIX

Table Of Contents

List of Tables

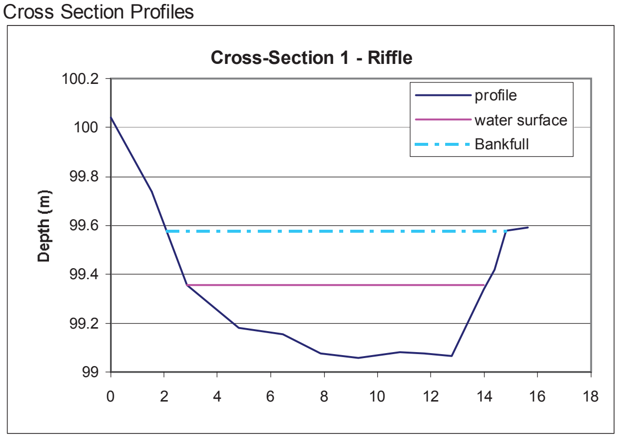
1.0 Biogeomorphic Reach Summaries

WATERCOURSE		West Credit River	Aquafor Ref No:	64809
Reach:	15-001	Field Site 15-04-01		
Date of Survey:		August 20, 2007		
Location of Field Site:		Main branch of West Credit River upstream of Winston Churchill Boulevard crossing.		
Surrounding landuse and/or cover:		Dense wooded wetland area Geologic deposit - alluvium		
Channel Characteristics:		Moderate to low sinuosity with coarse substrate in matrix of fine sediemnt. Well connected to floodplain with dense rooting structures tight to bank		
Length Surveyed		138.9 m		

Site Photos


CROSS-SECTIONS	Min.	Max.	Avg.
Key Parameters			
Width at Floodplain (m)	4.2	12.7	7.4
Depth at Floodplain (m)	0.5	99.6	66.6
Channel area (m2)	0.5	6.4	2.3
Bankfull Width (m)	7.4	12.7	11.3
Bankfull depth (m)	0.5	0.8	0.6
Width/Depth ratio (m/m)	16.8	31.6	25.5
Area (m2)	3.2	6.0	5.1
BF hydraulic radius	0.4	0.5	0.4
Wetted Width (m)	7.1	11.1	9.6
Water Depth (m)	0.2	0.3	0.3
wetted perimeter	7.8	11.2	10.0

Cross Section Profiles



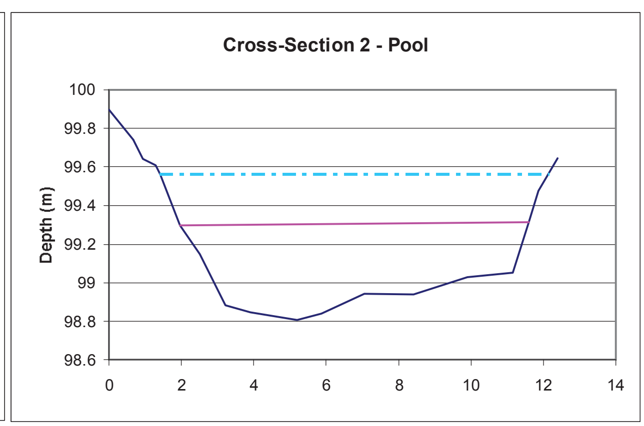


Figure D3.5.2_15-04-01.xls

BANKS

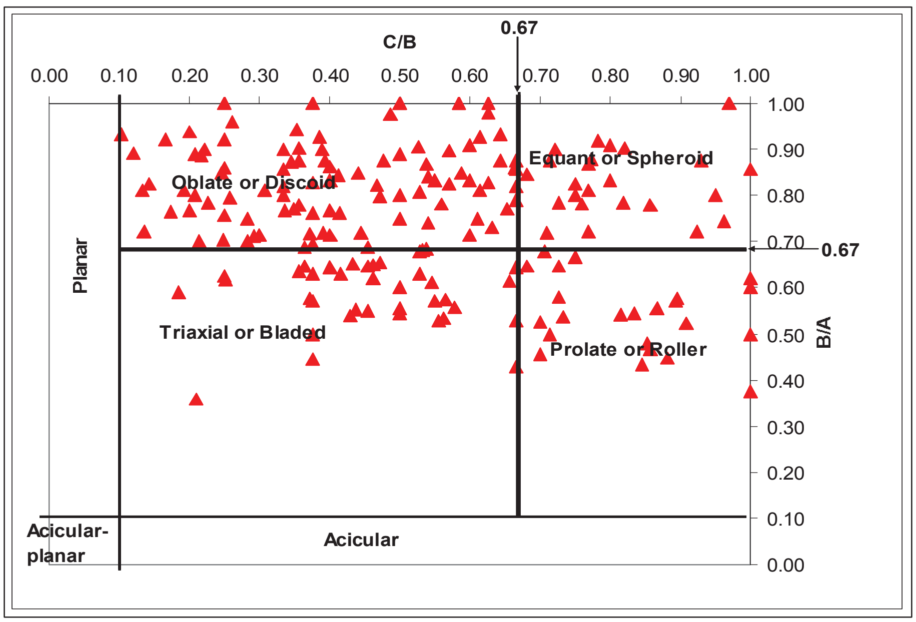
Physical Dimensions	Min.	Max.	Avg.
Left Bank Height (m)	0.5	0.7	0.6
Right Bank Height (m)	0.4	0.6	0.5
Angle (degrees)	5.0	63.1	25.5

Vegetation type	Trees (cedars)
Rooting depth (cm)	Trees rooted 1.0 metres; grasses 0.5m
Rooting Density	Cedars - moderate; grasses - dense

BED MATERIALS

Riffle Substrate (all sizes in mm)

Location	**A**	**B**	**C**	**(All Data)**
D90	160	155	150	160
D84	140	136	140	140
D75	120	116	110	120
D65	110	100	90	105
D50	100	42	65	80
D35	85	20	55	60
D25	80	16	45	32
D16	60	13	20	20
D10	30	11	17	15



Shape (All Data)

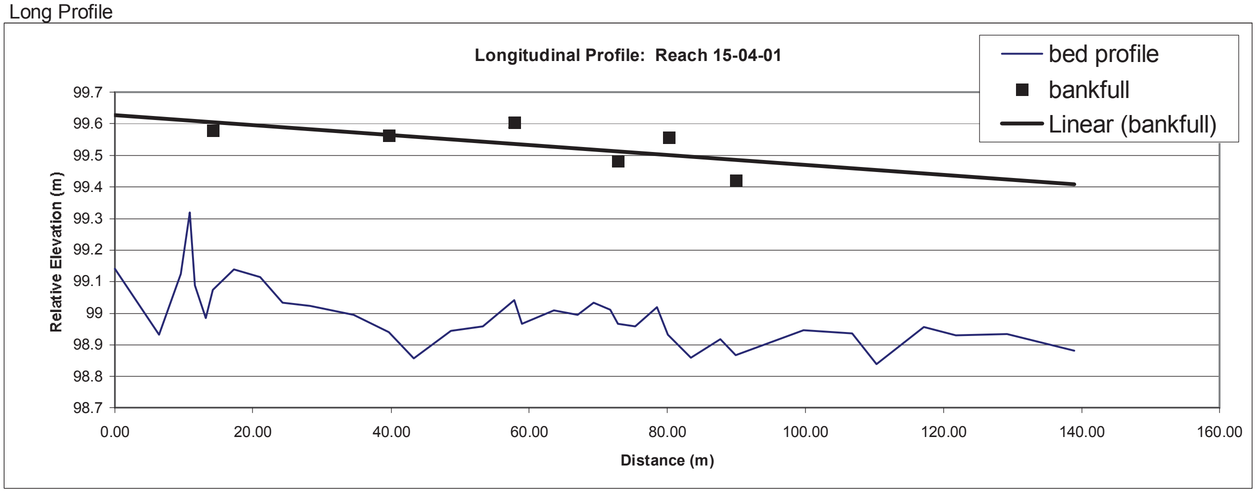
Flatness	
min	9
max	440
avg	87
Roundness	
min	1
max	10
avg	3
Sphericity	
min	0
max	1
avg	1
General Shape	
	Discoid
Volume	
min	59559
max	27489
avg	36652

SUBSTRATUM DATA

			Grain size in mm	
Location	**Sample** (Left to Right Bank)	**D84**	**D50**	**D16**
Riffle 1	A	14	6.6	0.65
Riffle 1	B	13	5.3	0.5
Riffle 1	C	19	1.5	0.26
Riffle 2	A	15	13.75	0.63
Riffle 2	B	14.75	14	0.81
Riffle 2	C	14.5	9.2	0.43
Riffle 3	A	10	1.5	0.31
Riffle 3	B	20	5	0.3
Riffle 3	C	20	0.72	0.24

Figure D3.5.2_15-04-01.xls

Long Profile



Notes: Large fluctuations in profile caused by accumulations of large woody debris

Physical Parameters

Riffle Grade	0.6	%	Avg. Riffle Spacing	35.2	m
Inter - Pool Grade	n/a	%	Avg. Riffle Length	16.3	m
Bankfull grade	0.2	%			

HYDRAULIC FLOW PARAMETERS AND THRESHOLD DETERMINATION

Bankfull Boundary Shear stress	7.1	N/m2
Bankfull Discharge	3.4	m3s-1
Bankfull Velocity	0.7	m/s
Bankfull Stream Power	53.9	W/m
Bankfull Unit Stream Power	4.8	W/m2

Figure D3.5.2_15-08-03.xls

WATERCOURSE		West Credit River Tributary	Aquafor Ref No:	64809
Reach:	15-003	Field Site 15-08-03		

Date of Survey: August 20, 2007
Location of Field Site: Downstream of 10th Line Crossing near Dundas St East and 10th Line intersection

Surrounding landuse and/or cover: Dense cedar / poplar wooded wetland area approximately 200m in width. Housing developments beyond wooded area. Geologic deposit glaciofluvial outwash.

Channel Characteristics: Moderate sinuosity with cobble bed in fine sediment matrix. Dense herbaceous banks. Channel slightly entrenched.

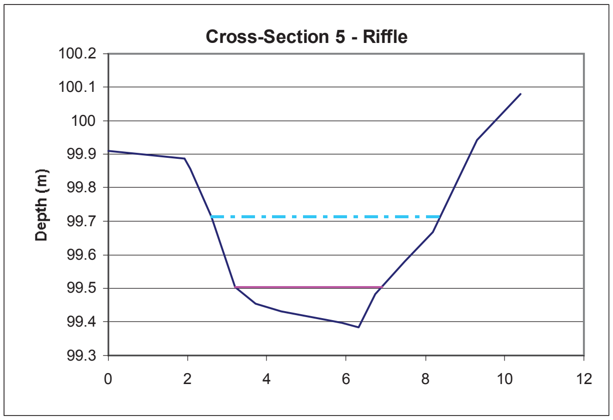
Length Surveyed 121.6 m

Site Photos

CROSS-SECTIONS

Key Parameters	Min.	Max.	Avg.
Width at Floodplain (m)	2.4	9.3	4.4
Depth at Floodplain (m)	0.4	99.9	66.8
Channel area (m2)	0.5	2.8	1.2
Bankfull Width (m)	4.5	8.2	6.6
Bankfull depth (m)	1.2	2.3	1.8
Width/Depth ratio (m/m)	16.5	35.1	24.5
Area (m2)	4.5	8.2	6.6
BF hydraulic radius	0.1	0.3	0.2
Wetted Width (m)	3.1	5.6	4.3
Water Depth (m)	0.1	0.2	0.1
Wetted Perimeter	3.3	5.9	4.5

Cross Section Profiles



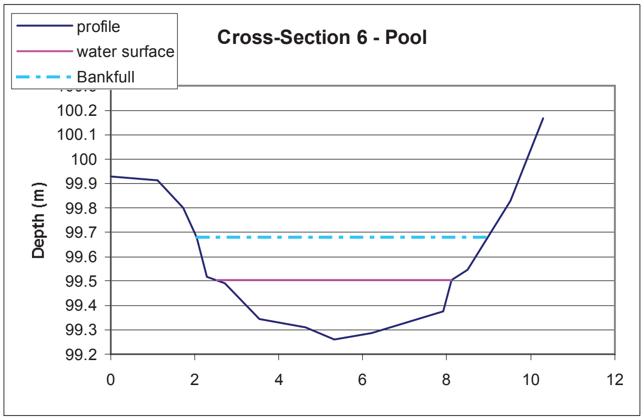


Figure D3.5.2_15-08-03.xls

Figure D3.5.2_15-08-03.xls

BANKS

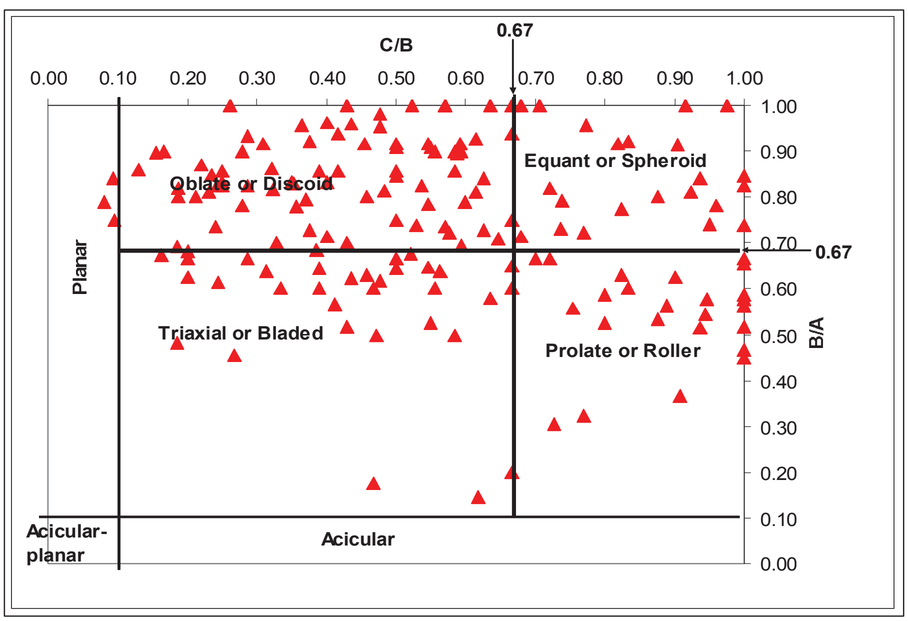
Physical Dimensions	Min.	Max.	Avg.
Left Bank Height (m)	0.3	0.7	0.4
Right Bank Height (m)	0.2	0.6	0.4
Angle (degrees)	6.6	55.9	22.0

Vegetation type	Trees (cedars)
Rooting depth (cm)	Trees rooted 1.0 metres; grasses 0.5m
Rooting Density	Cedars - moderate; grasses - dense

BED MATERIALS

Riffle Substrate (all sizes in mm)

Location	**A**	**B**	**C**	**D**	**E**	**(All Data)**
D90	155	260	150	140	190	170
D84	140	210	130	135	180	155
D75	125	160	115	130	170	140
D65	120	140	105	115	170	120
D50	115	120	90	100	140	105
D35	100	110	80	75	120	85
D25	65	90	70	70	100	75
D16	25	27	53	60	90	60
D10	21	25	40	60	70	53



Shape (All Data)

Flatness	
min	20
max	483
avg	112
Roundness	
min	1
max	14
avg	3
Sphericity	
min	0
max	1
avg	1
General Shape	Oblate or Discoid
Volume	
min	167879
max	198968
avg	130900

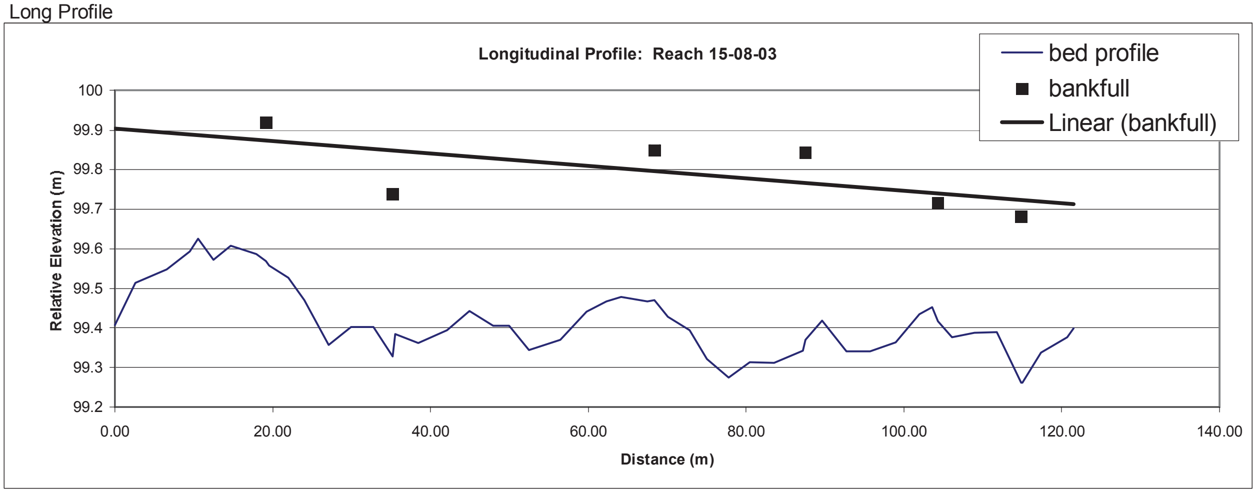
SUBSTRATUM DATA

Location	**Sample** (Left to Right Bank)	**Grain size in mm** D84	D50	D16
Riffle 1	A	21	13.5	0.6
Riffle 1	B			
Riffle 1	C	7.3	1.1	0.315
Pool 1	A	1.2	0.43	0.175
Pool 1	B	5.4	0.77	0.31
Pool 1	C	9	0.72	0.3
Riffle 2	A	16	1.1	0.21
Riffle 2	B	14.5	3.5	0.22
Riffle 2	C	14.5	2.2	0.31

Figure D3.5.2_15-08-03.xls

Figure D3.5.2_15-08-03.xls

Long Profile



Physical Parameters

Riffle Grade	1.3 %	Avg. Riffle Spacing	31.0 m
Inter - Pool Grade	0.1 %	Avg. Riffle Length	12.4 m
Bankfull grade	0.4 %		

HYDRAULIC FLOW PARAMETERS AND THRESHOLD DETERMINATION

Bankfull Boundary Shear stress	4.4 N/m2
Bankfull Discharge	0.9 m3s-1
Bankfull Velocity	0.5 m/s
Bankfull Stream Power	13.6 W/m
Bankfull Unit Stream Power	2.1 W/m2

Figure D3.5.2_15-13-01.xls

WATERCOURSE	West Credit River	Aquafor Ref No:	64809
Field Site: 15-13-01			
Reach: 15-045			
Date of Survey:	August 27, 2007		
Location of Field Site:	Upstream of 8th Line and 17th Sideroad Intersection		

Surrounding landuse and/or cover: Dense wooded riparian (cedar) setting in wetland area. Geologic Deposit - Bog deposit.

Channel Characteristics: Moderate sinuosity with pool riffle development. Banks well vegetated with exposed root structures. Large woody debris is very abundant, consisting of trees (cedar) that have fallen into the channel.

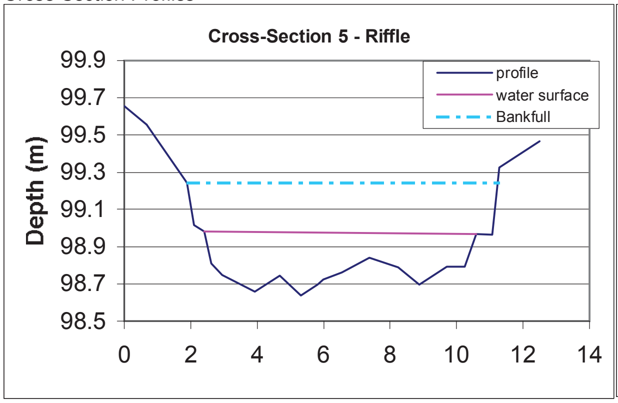
Length Surveyed 104.5 m

Site Photos

CROSS-SECTIONS

Key Parameters	Min.	Max.	Avg.
Width at Floodplain (m)	6.3	9.2	7.7
Depth at Floodplain (m)	0.7	99.6	66.6
Channel area (m2)	0.7	4.5	2.1
Bankfull Width (m)	8.0	14.2	9.6
Bankfull depth (m)	0.5	1.1	0.7
Width/Depth ratio (m/m)	12.6	37.6	20.5
Area (m2)	4.3	5.4	4.6
BF hydraulic radius	0.4	0.6	0.5
Wetted Width (m)	5.9	14.2	8.6
Water Depth (m)	0.2	0.4	0.3
Wetted Perimeter	6.2	10.2	8.3

Cross Section Profiles



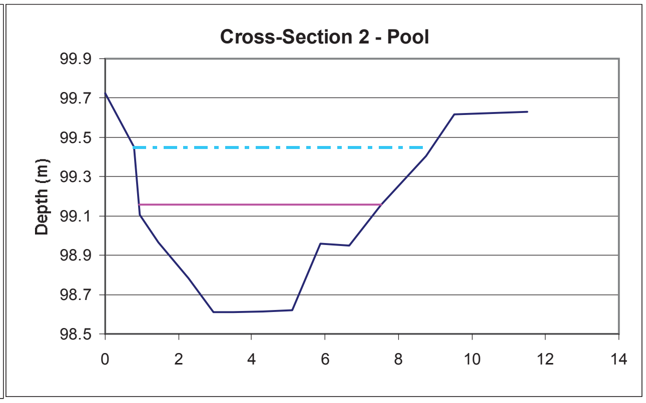


Figure D3.5.2_15-13-01.xls

Figure D3.5.2_15-13-01.xls

BANKS

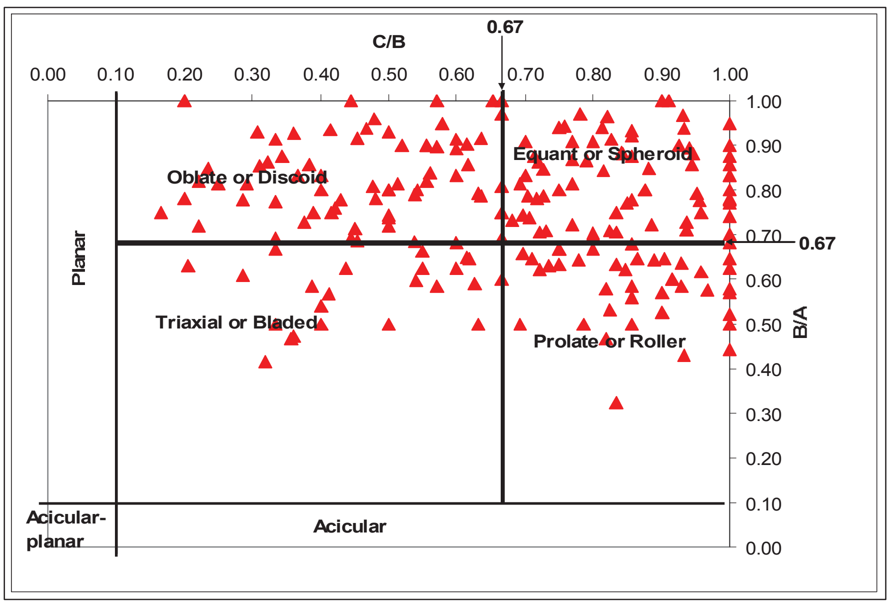
Physical Dimensions	Min.	Max.	Avg.
Left Bank Height (m)	0.4	0.8	0.6
Right Bank Height (m)	0.5	1.0	0.7
Angle (degrees)	13.1	85.6	38.5

Vegetation type: Trees (cedars) and mixed poplars - brush and grass in open areas
Rooting depth (cm)
Rooting Density: Cedars - moderate; grasses and brush - dense

BED MATERIALS

Riffle Substrate (all sizes in mm)

Location	**A**	**XS3**	**XS1**	**D**	**E**	**(All Data)**
D90	48	200	290	410	160	260
D84	45	160	260	350	140	210
D75	42	130	180	330	120	160
D65	40	110	160	310	100	125
D50	39	90	95	280	90	90
D35	33	68	40	240	70	60
D25	30	55	25	230	60	45
D16	22	40	20	230	45	35
D10	20	37	20	210	33	30



Shape (All Data)

Flatness
min 16
max 590
avg 123

Roundness
min 1
max 7
avg 2

Sphericity
min 0
max 1
avg 1

General Shape
discoid, spheroid

Volume (mm)
min 397411
max 1017876
avg 265072

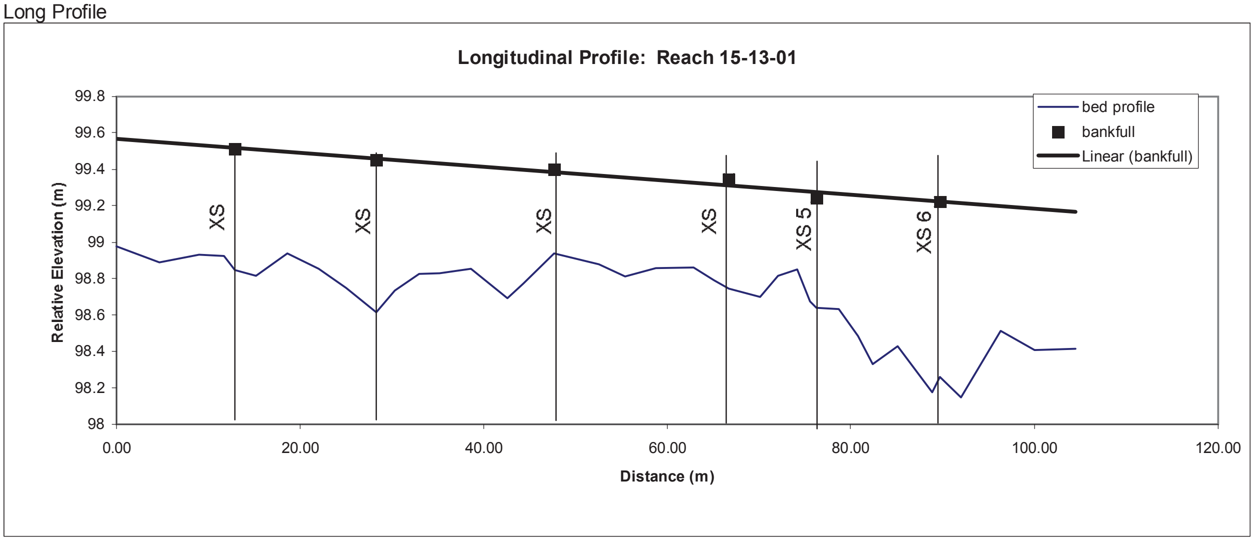
SUBSTRATUM DATA

Location	**Sample** (Left to Right Bank)	**D84**	**Grain size in mm** **D50**	**D16**
Riffle 1	A	0.88	0.76	0.21
Riffle 1	B	14	4	0.19
Riffle 1	C	0.89	1.45	0.22
Riffle 2	A	14	1.1	0.15
Riffle 2	B	14	3.2	0.4
Riffle 2	C	14	1.1	0.38
Riffle 3	A	7.3	1.2	0.3
Riffle 3	B	9	0.99	0.15
Riffle 3	C	13.5	1.8	0.25

Figure D3.5.2_15-13-01.xls

Figure D3.5.2_15-13-01.xls

Long Profile



Physical Parameters

Riffle Grade	6.9 %	Avg. Riffle Spacing	31.3 m
Inter - Pool Grade	0.3 %	Avg. Riffle Length	8.3 m
Bankfull grade	0.3 %		

HYDRAULIC FLOW PARAMETERS AND THRESHOLD DETERMINATION

Bankfull Boundary Shear stress	27.5	N/m2
Bankfull Discharge	4.9	m3s-1
Bankfull Velocity	1.1	m/s
Bankfull Stream Power	270.3	W/m
Bankfull Unit Stream Power	28.2	W/m2

Figure D3.5.2_15-13-01.xls

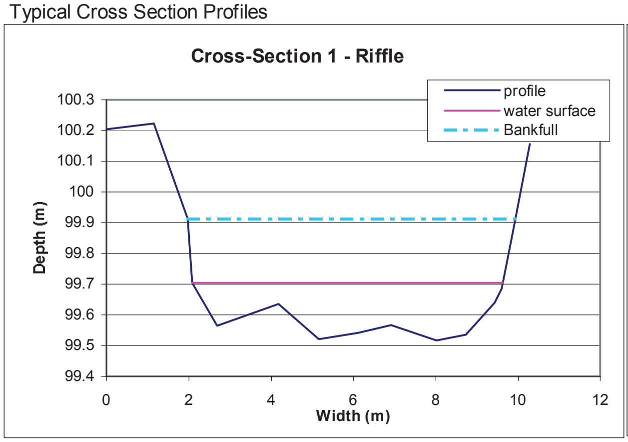
Figure D3.5.2_15-17-01.xls

WATERCOURSE	West Credit River	Aquafor Ref No:	64809
Field Site: 15-17-01			
Reach 15-052			
Date of Survey:	August 21, 2007		
Location of Field Site:	West Credit River downstream of Town of Hillsburgh and Fish Club Dam		
Surrounding landuse and/or cover:	Dense wooded wetland area over 350 m wide with agricultural pastures beyond riparian area Geologic deposit - alluvium		
Channel Characteristics:	Low sinuosity with coarse substrate in matrix of fine sediemnt. Well connected to floodplain with large accumulations of woody debris in channel		
Length Surveyed	104.7 m		

Site Photos .

CROSS-SECTIONS	Min.	Max.	Avg.
Key Parameters			
Width at Floodplain (m)	2.6	9.0	4.9
Depth at Floodplain (m)	0.6	99.9	66.8
Channel area (m2)	0.4	4.7	1.8
Bankfull Width (m)	5.7	8.0	6.8
Bankfull depth (m)	0.4	0.7	0.5
Width/Depth ratio (m/m)	13.4	24.3	19.4
Area (m2)	2.1	2.6	2.4
BF hydraulic radius	0.3	0.4	0.3
Wetted Width (m)	3.7	7.5	5.7
Water Depth (m)	0.1	0.9	0.3
Wetted Perimeter	0.0	7.8	5.0

Typical Cross Section Profiles



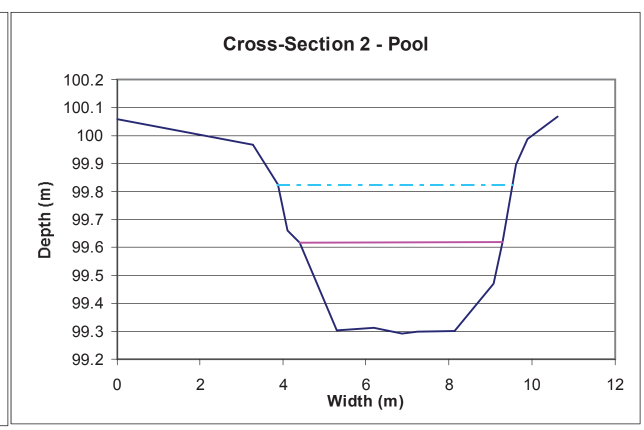


Figure D3.5.2_15-17-01.xls

Figure D3.5.2_15-17-01.xls

BANKS

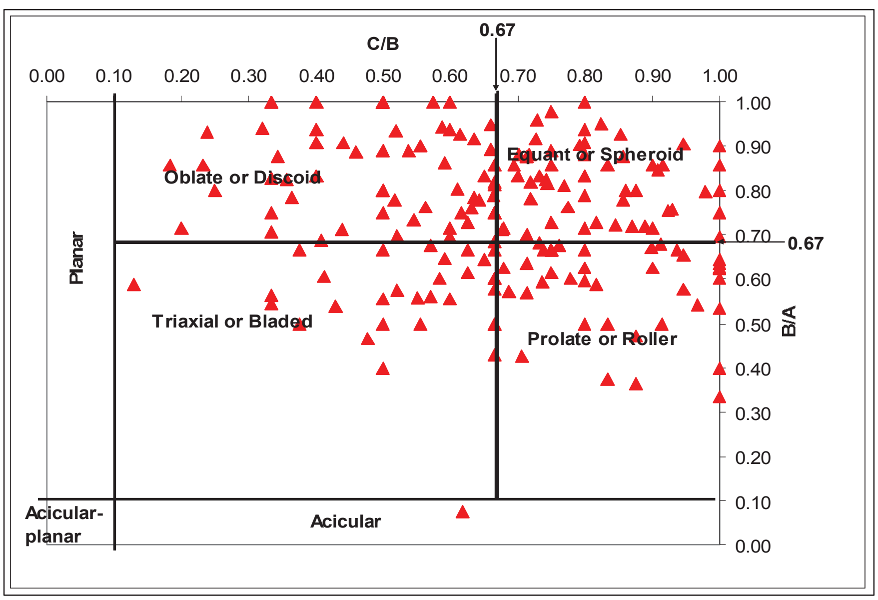
Physical Dimensions	Min.	Max.	Avg.
Left Bank Height (m)	0.2	0.6	0.5
Right Bank Height (m)	0.3	0.5	0.4
Angle (degrees)	8.4	83.1	34.8

Vegetation type	Trees (cedars)
Rooting depth (cm)	Trees rooted 1.0 metres; grasses 0.5m
Rooting Density	Cedars - moderate; grasses - dense

BED MATERIALS

Riffle Substrate (all sizes in mm)

Location	**A**	**B**	**C**	**D**	**(All Data)**
D90	120	80	210	115	140
D84	105	60	210	100	110
D75	94	55	200	85	90
D65	69	50	200	70	65
D50	47	40	170	57	50
D35	25	30	150	45	40
D25	23	25	150	35	30
D16	16	15	140	30	24
D10	12	15	140	25	17



Shape (All Data)

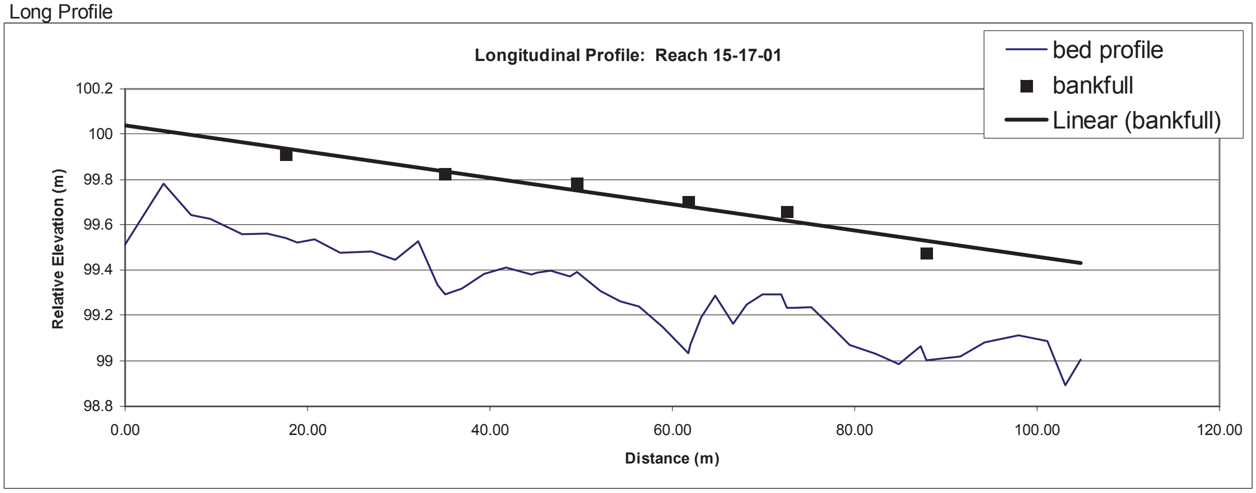
Flatness		
	min	7
	max	285
	avg	68
Roundness		
	min	1
	max	12
	avg	2
Sphericity		
	min	0
	max	1
	avg	1
General Shape		
		Discoid or Spheroid
Volume		
	min	800844
	max	1878672
	avg	1737301

SUBSTRATUM DATA

Location	**Sample** (Left to Right Bank)	**D84**	**Grain size in mm** **D50**	**D16**
Riffle 1	A	20	6.5	0.44
Riffle 1	B	13	5	0.84
Riffle 1	C	20	8.5	0.55
Riffle 2	A	14	7	0.61
Riffle 2	B	20	12	0.9
Riffle 2	C	14	5.8	0.42
Riffle 3	A	20	4.15	0.3
Riffle 3	B	19.9	7	0.55
Riffle 3	C	20.1	14	0.73

Figure D3.5.2_15-17-01.xls

Long Profile



Physical Parameters

Riffle Grade	0.8	%	Avg. Riffle Spacing	30.3	m
Bankfull grade	0.6	%	Avg. Riffle Length	17.8	m

HYDRAULIC FLOW PARAMETERS AND THRESHOLD DETERMINATION

Bankfull Boundary Shear stress	22.6	N/m2
Bankfull Discharge	2.5	m3s-1
Bankfull Velocity	1.0	m/s
Bankfull Stream Power	157.8	W/m
Bankfull Unit Stream Power	23.3	W/m2

Figure D3.5.2_15-20-02.xls

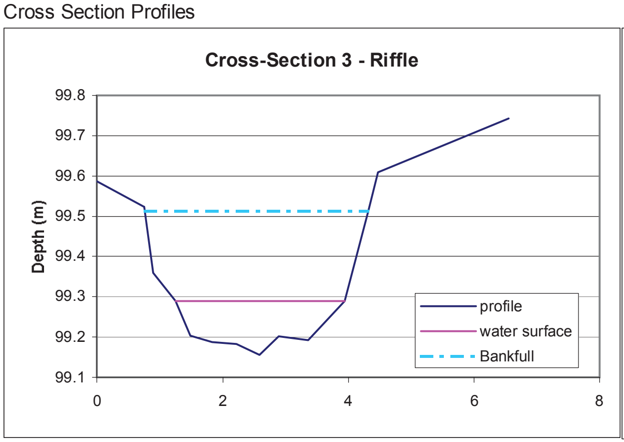
WATERCOURSE	West Credit River Tributary	Aquafor Ref No:	64809
Field Site: 15-20-02			
Reach: 15-065			
Date of Survey:	August 21, 2007		
Location of Field Site:	Downstream extent of Binkham tributaries, North of 15th Sideroad and East of 10th Line		
Surrounding landuse and/or cover:	Dense wooded wetland area, agricultural fields beyond wooded areas. Geologic deposit glaciofluvial outwash and alluvium		
Channel Characteristics:	Moderate to low sinuosity with coarse substrate. Dense herbaceous banks. Long run and short pool.		
Length Surveyed	107.3 m		

Site Photos

CROSS-SECTIONS

Key Parameters	Min.	Max.	Avg.
Width at Floodplain (m)	1.0	8.3	3.4
Depth at Floodplain (m)	0.3	99.6	66.5
Channel area (m2)	0.4	1.5	0.8
Bankfull Width (m)	3.6	8.3	5.5
Bankfull depth (m)	0.3	0.4	0.4
Width/Depth ratio (m/m)	13.3	42.6	22.7
Area (m2)	1.0	1.6	1.3
BF hydraulic radius	0.2	0.3	0.2
Wetted Width (m)	2.7	6.7	3.9
Water Depth (m)	0.1	0.2	0.1
Wetted Perimeter	2.7	6.9	4.6

Cross Section Profiles



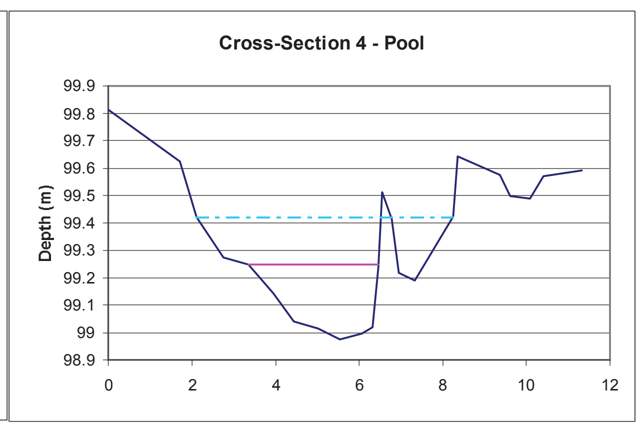


Figure D3.5.2_15-20-02.xls

BANKS

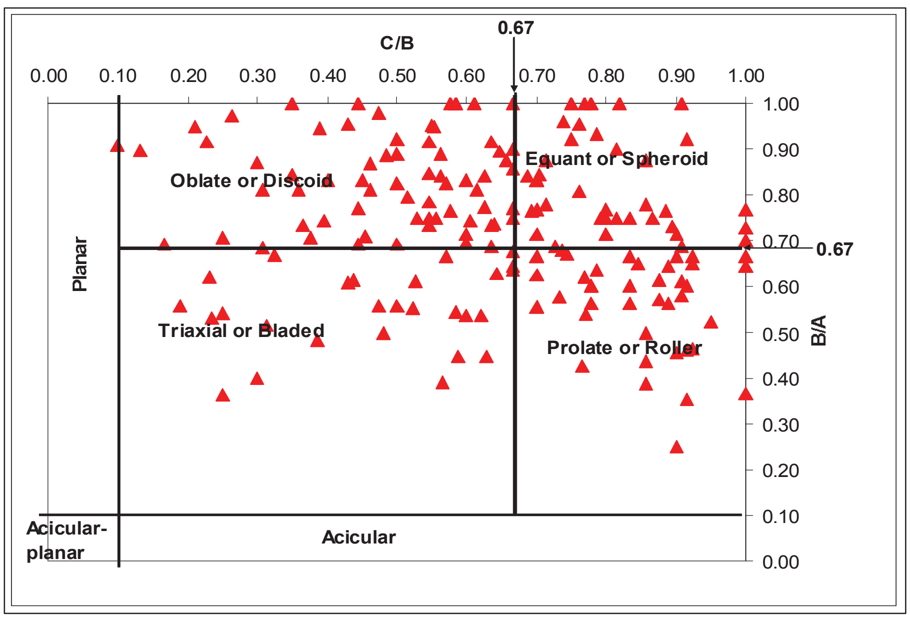
Physical Dimensions	Min.	Max.	Avg.
Left Bank Height (m)	0.2	0.6	0.4
Right Bank Height (m)	0.2	0.5	0.4
Angle (degrees)	5.0	70.9	25.6

Vegetation type	Trees (cedars)
Rooting depth (cm)	Trees rooted 1.0 metres; grasses 0.5m
Rooting Density	Cedars - moderate; grasses - dense

BED MATERIALS

Riffle Substrate (all sizes in mm)

Location	**A**	**B**	**C**	**D**	**(All Data)**
D90	380	130	135	95	190
D84	320	130	130	80	140
D75	290	120	130	75	130
D65	250	105	120	70	105
D50	175	95	110	60	85
D35	110	80	85	55	70
D25	90	65	60	50	60
D16	70	45	50	35	45
D10	70	55	60	40	50



Shape (All Data)

Flatness		
	min	16
	max	527
	avg	110
Roundness		
	min	1
	max	11
	avg	2
Sphericity		
	min	0
	max	1
	avg	1
General Shape		
		Discoid, Spheroid
Volume		
	min	549648
	max	659734
	avg	1272345

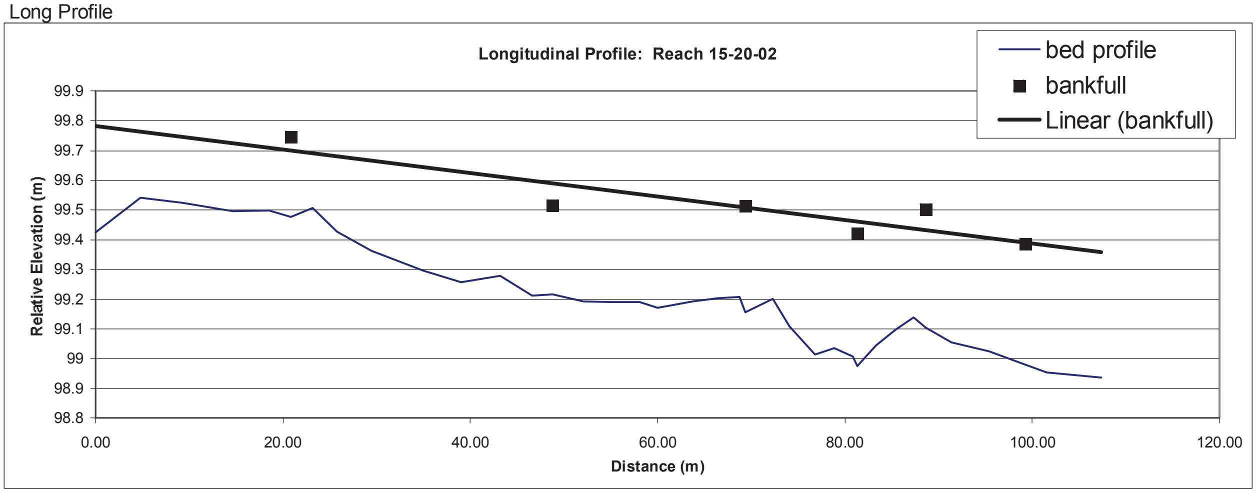
SUBSTRATUM DATA

			Grain size in mm	
Location	**Sample** (Left to Right Bank)	**D84**	**D50**	**D16**
Riffle 1	A	13.5	1.7	0.32
Riffle 1	B	13.5	2.5	0.34
Riffle 1	C	8	1.1	0.4
Riffle 2	A	3.15	0.75	0.25
Riffle 2	B	8.9	3.15	0.31
Riffle 2	C	13	4.6	0.36
Riffle 3	A	15	0.64	0.04
Riffle 3	B	14	2.7	0.35
Riffle 3	C	20	5	0.26
Pool 2'	A	0.8	0.25	0.1
Pool 2'	B			
Pool 2'	C	12	2.6	0.31

Figure D3.5.2_15-20-02.xls

Figure D3.5.2_15-20-02.xls

Long Profile



Notes:

Physical Parameters

Riffle Grade	0.8 %	Avg. Riffle Spacing	27.5 m
Bankfull grade	0.4 %	Avg. Riffle Length	20.2 m

HYDRAULIC FLOW PARAMETERS AND THRESHOLD DETERMINATION

Bankfull Boundary Shear stress	21.1	N/m2
Bankfull Discharge	1.0	m3s-1
Bankfull Velocity	0.7	m/s
Bankfull Stream Power	54.6	W/m
Bankfull Unit Stream Power	10.0	W/m2

Figure D3.5.2_15-20-02.xls

2.0 Site Photos by Catchment

Erin SSMP Photo Pages - Main Branch of West Credit River

Downstream extent of study area (Reach 15-001)

Channel through dense wooded riparian lot (Reach 15-045A)

Large organic debris jam impeding flow (Reach 15-045A)

Hard lined banks and manicured grass (Reach 15-038)

Minor bank erosion along private property (Reach 15-038)

Backwater / wetland conditions upstream of Hall's Dam (Reach 15-038B)

Reach 15-054B

Reach 15-054B

Reach 15-055

Reach 15-053

Reach 15-054

Reach 15-054A

Erin SSMP Photo Pages - Winston Churchill Boulevard Tributaries

Wetland / backwater conditions upstream of Highway 24 (Reach 15-087B)

Meandering / braided channel through agricultural pasture (Reach 15-093)

Meandering pattern forming within roadside ditch (Reach 15-104)

Alluvial channel through scrubland (Reach 15-109)

Cedar wetland area near confluence with Binkham Tributaries (Reach 15-087)

Minor bank erosion at downstream extent of straightened channel (Reach 15-093)

Erin SSMP Photo Pages - Binkham Tributaries


Reach 15-065


Reach 15-065


Reach 15-064


Reach 15-087


Reach 15-077


Reach 15-078

Erin SSMP Photo Pages - Subwatersheds 10, 11, 12

Meandering pattern forming within roadside ditch (Reach 12-169)

Vegetation dominated, braided channel (Reach 11-142)

Cedar / poplar /birch wetland conditions (Reach 10-159)

Reach 11-113

Reach 11-125

Reach 12-191

Erin SSMP Photo Pages - Subwatershed 17

Reach 17-049H

Reach 17-049J

Roadside ditch with backwater conditions (Reach not labeled)

Reach 17-049J

Reach 17-049F

Reach 17-0459H

3.0 Biogeomorphic Assessment

3.1 Data Collection in Erin SSMP Study Area

During the course of the Erin SSMP study, field data were intended to be collected by various disciplines including benthic invertebrate sampling and geomorphology. Field site locations that were considered to be mutually appropriate given the overall goals of the Erin SSMP study were identified. Data collection was undertaken concurrently by both study disciplines at the 5 field site locations shown in **Figure 2.4.3** within the *Environmental Component - Existing Conditions Report*. An opportunity was thus provided to examine biogeomorphic relations at the field sites.

Details pertaining to the benthic field data collection program are provided in Section 2.5 of the *Environmental Component - Existing Conditions Report*. The geomorphic data collection program consisted of the following:

- A detailed topographic survey of channel planform, profile and cross-sections;
- Pebble counts at each riffle cross-section, along the same transect line as benthic invertebrate sampling;
- Substratum sediment sample collection – at each of the 5 field sites, 3 sediment samples at the three riffle transects coinciding with benthic data collection sites A, B and C (i.e., from left to right across channel, facing upstream) were collected below the surface or substrate layer on the channel bed. (A total of 9 samples were taken at each field site). These samples were submitted for laboratory grain size analysis;
- Bank characterization – slopes, material characterization, soil consistency etc.; and
- Photographic inventory of field site.

In total 3 riffles and 3 pools were included in each geomorphic field site. This constituted one additional pool than was included in the benthic field sampling program. Once collected, the data were processed to quantify pebble count grain size distributions and Hydraulic parameters of both the low-flow and bankfull flow channels. Where the bankfull flow elevation was considered to be lower than the top of the bank, then hydraulic parameters associated with the entire channel (i.e., greater than bankfull) were also calculated. Field site data used in this analyses are summarized in **Table 2.4.5** within the *Environmental Component - Existing Conditions Report*. Further detail including typical cross-section and profile, are provided in Section 1.0 of this Appendix.

3. 2 Results

Building on work previously completed by Aquafor Beech (e.g., West Credit Subwatershed Study (2001)), the intent of the biogeomorphic analyses was to link measurable channel parameters to benthic invertebrate diversity or abundance. Four categories of analyses were defined and are described as follows:

1) Bed materials – The Bed material mobility

2) Low-flow channel parameters
3) Bankfull/Dominant discharge channel parameters

The following definitions are used as they pertain to the benthic invertebrate data:

Abundance: number or % of Ephemeroptera, Plecoptera, and Trichoptera (EPT)
Diversity: number of taxa (at each site, number of distinct taxa were recorded and used to define the diversity, ie. a larger number of taxa, greater diversity. Only presence or absence of the taxa is considered, not their abundance.)

3.2.1 Bed Materials – Substrate and Substratum

In this suite of analyses, the D16, D50 and D84 (called Dx for x% of the cumulative frequency curve) of the substrate and substratum grain size distributions were examined in relation to benthic abundance and diversity. In addition, ratios of the different grain sizes of substrate samples were used in the analyses (i.e., D84:D50, D50:D16, D84:D16). The analyses were repeated using the substratum data. Further analyses were undertaken by examining grain size ratios of substrate:substratum data (e.g., D84substrate:D84substratum, etc.). Since substrate and substratum data were only collected at riffles, all results pertain to riffles.

Substrate by site

- Site 15-13-01 has the largest substrate (d16, d50, d84)
- Site 15-17-01 has the finest substrate (d16, d50, d84)
- Site 15-20-02 has the largest range in substrate (d50, d84) and site 15-04-01 (d16)

Substratum by site

- Site 15-17-01 has the largest substratum (d16, d50, d84), then 15-04-01 **15-17-01 approx 100m d/s of Fish Club Dam
- Lot of scatter amongst the finer particles by site.
- Site 15-17-01 has the largest range in substratum (d16), site 15-04-01 (d50), site 15-08-03 (d84)

<u>Best Relationships (all data)</u>

Total Number of Taxa vs Substrate

- R^2 - d16 – 0.50; d50 – 0.40; d84 – 0.36
- General Trend – as substrate increases in size ➔ total taxa decreases
- Site 15-13-01 has the least number of taxa and the largest substrate

Percent Chironomid Individuals vs Substrate

- R^2 - d16 – 0.16; d50 – 0.17; d84 – 0.17
- R^2 (without 15-13-01) - d16 – 0.41; d50 – 0.36; d84 – 0.33
- General Trend – as substrate increases in size ➔ percentage of chironomid individuals increases
- Site 15-04-01 has the highest percentage of chironomid individuals

Total Number of Individuals vs Substratum

- R^2 - d16 – 0.12; d50 – 0.12; d84 – 0.06
- General Trend – as substrate increases in size ➔ total number of individuals increases

<u>General Relationships (all data)</u>
(R^2 = d16, d50, d84)

As substrate increases ➔

Total Number of Individuals decreases (R^2 = 0.15, 0.09, 0.09)
Percent EPT Individuals remains constant
Percent Chironomid Individuals increases (R^2 = 0.16, 0.17, 0.17)
Total Number of Taxa decreases (R^2 = 0.50, 0.40, 0.36)
Percent EPT Taxa decreases (R^2 = 0.05, 0.02, 0.02)
Percent Chironomid Taxa remains constant

As substratum increases ➔

Total Number of Individuals increases (R^2 = 0.12, 0.12, 0.06)
Percent EPT Individuals increases (R^2 = 0.03, 0.04, 0.02)
Percent Chironomid Individuals remains constant
Total Number of Taxa increases (R^2 = 0.05, 0.04, 0.04)
Percent EPT Taxa increases (R^2 = 0.01, 0.12, 0.10)
Percent Chironomid Taxa increases (d16 : R^2 = 0.01), decreases (d50 : R^2 = 0.007, d84 : R^2 = 0.03)

Table 3.2.1 Summary of R^2 values obtained through linear or power models between substrate and substratum parameters and benthic abundance or diversity.

	Substrate			**Substratum**		
	d16	*d50*	*d84*	*d16*	*d50*	*d84*
Total Number Individuals	0.15	0.09	0.09	0.12	0.12	0.06
Percent EPT Individuals	0.0006	0.001	0.001	0.03	0.04	0.02
Percent Chironomid Individuals	0.16	0.17	0.17	0.007	0.002	0.005
Total Number of Taxa	**0.5**	**0.4**	**0.36**	0.05	0.04	0.04
Percent EPT Taxa	0.05	0.02	0.02	0.01	0.12	0.1
Percent Chironomid Taxa	1.20E-06	0.007	0.002	0.01	0.007	0.03

In summary, while the statistical strength of the relations were typically, poor, the data revealed an overall positive correlation with increasing size of substratum and benthic indicators.

Section 4.0 of this Appendix contains all graphs of Benthic Indicators vs Substrate and Substratum.

3.2.2 Bed Material Mobility

The potential for a given flow to move the bed material of a stream is determined, in part, by the size and shape of the particles that comprise it.

To assess the relationship between particle mobility and benthic invertebrate diversity/abundance, an index of particle mobility was defined as follows:

Particle mobility = $\frac{Equivalent\ Diameter}{3\ x\ Flatness}$ where

Equivalent diameter = the diameter of a sphere of equivalent volume to the particle; and

Flatness =

$$\frac{Length\ of\ the\ particle's\ first\ major\ axis\ +\ Length\ of\ the\ particle's\ second\ major\ axis}{2\ x\ length\ of\ the\ particle's\ minor\ axis}$$

Where substrate samples yielded sufficient particles of bed material, the particle mobility of individual substrate particles was calculated. Particle mobility data was available for most riffle cross-sections; representative cross-sections from each field site location (e.g., 8th Line) were chosen to assess the relationship between particle mobility and benthic invertebrate diversity/abundance. Nine cross-sections were selected for analysis (**Table 3.2.2)**. Refer to **Figure 2.4.3** within the *Environmental Component - Existing Conditions Report* for the location of each site.

Table 3.2.2 Representative cross-sections selected to assess the relationship between particle mobility and benthic invertebrate diversity/abundance.

Field Site Number	Field Site Location	Reference Number
15-13-01	8th Line	1
15-13-01	8th Line	2
15-08-03	10th Line	3
15-08-03	10th Line	4
15-08-03	10th Line	5
15-20-02	15th Sideroad	6
15-07-01	County Road 22	7
15-04-01	Winston Churchill Boulevard	8
15-04-01	Winston Churchill Boulevard	9

The individual substrate particles of each cross-section were divided into three approximately equal groups (A, B or C) based on their location of collection from within the stream. Facing upstream, these groups are defined as A = left third of channel, B = middle third of channel and C = right third of channel.

For each cross-section, the mean, range and standard deviation of particle mobility were calculated for each collection site (i.e., A, B or C). The same summary statistics were also calculated for the overall cross-section by pooling the data for collection sites A, B and C.

For each cross-section, three measures of benthic invertebrate abundance (**Table 3.2.3**) and three measures of benthic invertebrate diversity (**Table 3.2.4**) were calculated for each collection site (i.e. A, B or C). These same six measures were also calculated for the overall cross-section by pooling the data for collection sites A, B and C.

Table 3.2.3 Measures of benthic invertebrate abundance

Measure	Definition
Total number of individuals	Total number of all benthic invertebrate individuals found during sampling
Proportion of EPT individuals	Proportion of the total number of benthic invertebrate individuals found during sampling that are members of the Orders Ephemeroptera, Plecoptera or Trichoptera
Proportion of Chironomid individuals	Proportion of the total number of benthic invertebrate individuals found during sampling that are members of the Family Chironomidae

Table 3.2.4 Measures of benthic invertebrate diversity

Measure	Definition
Total number of taxa	Total number of benthic invertebrate taxa of which one or more individuals was found during sampling
Proportion of EPT taxa	Proportion of the total number of benthic invertebrate taxa found during sampling that are elements of the Orders Ephemeroptera, Plecoptera or Trichoptera
Proportion of Chironomid taxa	Proportion of the total number of benthic invertebrate taxa found during sampling that are elements of the Family Chironomidae

To assess the relationship between particle mobility and benthic invertebrate abundance/diversity, the six measures (**Tables 3.2.3** and **3.2.4**) were plotted against the mean and standard deviation of particle mobility for each collection site (i.e., A, B or C) and for the overall cross-section.

Results

Section 5.0 of this Appendix contains all graphs of Benthic Indicators versus Mobility and Location.

Particle mobility at the nine representative cross-sections was reviewed to assess the influence of field site location and collection site. This assessment revealed the following:

- Within the representative cross-sections, the mean, range and standard deviation of particle mobility does not vary consistently between collection sites (A, B or C) along the cross-sections.
- The mean particle mobility of seven of the nine representative cross-sections is similar. However, the mean particle mobility of Cross-sections 12 and 20 are approximately three and four times greater than the others, respectively.
- The range and standard deviation of particle mobility of seven of the nine representative cross-sections are generally similar. The range and standard deviation of particle mobility are highest at Collection Site B of Cross-section 4 and Collection Sites B and C of Cross-section 20.

Benthic invertebrate abundance at the nine representative cross-sections was reviewed to assess the influence of field site location and collection site. This assessment revealed the following:

- The total number of individuals, proportion of EPT individuals and proportion of Chironomid individuals do not vary consistently between collection sites (A, B or C).
- Cross-section 16 has the highest overall abundance of benthic invertebrates (2463 individuals) while Cross-section 20 has the lowest (560 individuals). The overall

abundance of benthic invertebrates of the remaining cross-sections varies from 1022 to 1672 individuals.

- The overall proportion of EPT individuals varies from 11.0% to 43.2% between the nine cross-sections.
- Cross-sections 16 and 25 have the highest overall proportion of Chironomid individuals (>78%). The overall proportion of Chironomid individuals varies from 31.4% to 43.9% at the remaining cross-sections.
- At most cross-sections, the overall proportion of EPT individuals and the overall proportion of Chironomid individuals are inversely proportional. However, in cross-section 20 the values are similar (43.2 % versus 42.7 %).

Benthic invertebrate diversity at the nine representative cross-sections was also reviewed to assess the influence of field site location and collection site. This assessment revealed the following:

- The total number of taxa, proportion of EPT taxa and proportion of Chironomid taxa do not vary consistently between collection sites (A, B or C).
- Cross-sections 3 and 4 have the highest overall diversity (75 taxa each) while cross-section 20 has the lowest (30). The overall diversity of the remaining sections is similar (56-62 taxa).
- The overall proportion of EPT taxa varies from 20.0% to 33.9% between the nine cross-sections.
- The overall proportion of Chironomid taxa varies from 29.3% to 44.1% between the nine cross-sections.
- At most cross-sections, the overall proportion of EPT taxa and the overall proportion of Chironomid taxa are inversely proportional. However, in Cross-section 1 both values are relatively low, while in Cross-section 25 both values are relatively high.

Finally, benthic invertebrate abundance and diversity at the nine representative cross-sections was reviewed to assess the influence of particle mobility (**Table 3.2.5**). This assessment revealed the following:

- Benthic invertebrate abundance (total number of individuals) and diversity (total number of taxa) are strongly correlated with mean particle mobility (r^2=0.29 and r^2=0.37, respectively). Both benthic invertebrate abundance and diversity decrease as mean particle mobility increases. However, this relationship does not hold for EPT or Chironomid taxa.
- The proportion of EPT individuals is strongly (r^2=0.30) and positively correlated with mean particle mobility. However, there is no correlation (r^2=0.02) between the proportion of EPT taxa and mean particle mobility.
- The proportion of Chironomid individuals and the proportion of Chironomid taxa vary little with mean particle mobility.
- Benthic invertebrate abundance (total number of individuals) and diversity (total number of taxa) are correlated with the standard deviation of particle mobility (r^2=0.16 and r^2=0.29, respectively). In general, both benthic invertebrate abundance

and diversity decrease as the standard deviation of particle mobility increases. However, this relationship does not hold for EPT or Chironomid taxa.

- The proportion of EPT individuals is weakly (r^2=0.05) but positively correlated with the standard deviation of particle mobility. The proportion of EPT taxa not correlated with the standard deviation of particle mobility.
- The proportion of Chironomid individuals and taxa are both weakly but positively correlated with the standard deviation of particle mobility (r^2=0.03 and r^2=0.07, respectively).

In summary, these results indicate the following:

- With some exceptions, particle mobility is generally similar between field site locations and within cross-sections.
- The abundance and diversity of benthic invertebrates varies between field site locations and cross-sections.
- In general, both benthic invertebrate abundance and diversity decrease as mean particle mobility increases. However, the proportion of EPT individuals (but not the proportion of EPT taxa) increases with mean particle mobility. This suggests that, relative to other benthic invertebrate taxa, certain EPT taxa can tolerate (or actually favour) environments of greater particle mobility. In contrast, Chironomids do not appear to respond to particle mobility.

Table 3.2.5 Relationships between measures of benthic invertebrate abundance/diversity and particle mobility. R^2 values > 0.10 are shaded in grey.

Benthic Invertebrate Measure	**R^2 Value**	
	Mean Particle Mobility	**Standard Deviation of Particle Mobility**
Total number of individuals	0.29	0.16
Proportion of EPT individuals	0.30	0.05
Proportion of Chironomid individuals	0.04	0.03
Total number of taxa	0.37	0.29
Proportion of EPT taxa	0.02	0.04
Proportion of Chironomid taxa	0.02	0.07

3.2.3 Low-Flow Channel Parameters

Recognizing that water depth and characteristics of flow are important invertebrate habitat parameters, analyses were undertaken to examine the relation between measurable low-flow parameters and benthic diversity or abundance. The three specific parameters analyzed included:

- Water depth;
- Width:depth ratio of wetted channel; and
- Wetted perimeter.

The data were evaluated by riffles and/or pools per site and as a combined data set for all five field sites. Results revealed the following:

- Linear models were often better than exponential or power models;
- Relations were stronger for the combined data set (all site data) than for riffle only data (for all sites); and
- For most sites, R^2 values were considered to be weak or moderately weak.

Spatial variability in site characteristics will affect the diversity and abundance of species. Findings revealed the following:

- 8th line – had the lowest number of taxa and EPT in comparison to all other field sites;
- All sites showed distinction between number of EPT in riffle and pools; greater number in riffles than pools;
- In general, the number of taxa was typically greater in riffles than pools;
- 22nd sideroad and 8th line – most marked distinction in number of taxa between riffle and pool; and
- Statistical strength of relations explored with low flow parameters (combined pool and riffle data) were strongest for 22nd Sideroad and weakest for 8th line.

<u>Low Flow Parameters</u>

Width:Depth Ratios

- For all field sites, the relation between # of Taxa or # of EPT and width:depth ratio was positive (i.e., # of Taxa and # of EPT increased with increasing ratio)
- The strength of the relations varied by field site
  - Highest strengths (R^2 in brackets):
    - # of Taxa vs W:D ratio: 22nd Side Rd (0.67), 10th line (0.39)
    - # of EPT vs W:D ratio: 22nd Side Rd (0.64), WCB (0.53), 10th line (0.76),
  - Lowest strengths:
    - # of Taxa vs W:D ratio: 15th S.R. (0.15): WCB (0.32), 8th line (0.004)
    - # of EPT vs W:D ratio: 15th S.R. (0.21): 8th line (0.05)

- When all data were combined
  - # of Taxa vs W:D ratio: R^2 = 0.05
  - # of EPT vs W:D ratio: R^2 = 0.14
- When 15th SR and 8th line data were removed from the combined data set:
  - # of Taxa vs W:D ratio: R^2 = 0.44
  - # of EPT vs W:D ratio: R^2 = 0.46

Average Water Depth

- For all field sites, the relation between # of Taxa or # of EPT and average water depth was negative (i.e., # of Taxa and # of EPT decreased with increasing water depth)
  - The strength of the relations varied by field site
    - Highest strengths (R^2 in brackets):
      - # of Taxa vs avg water depth: 22 S.R. (0.66), 15 S.R. (0.67)
      - # of EPT vs avg water depth: 22 S.R. (0.52), 15 S.R. (0.64), 10th Line (0.63)
    - Lowest strengths:
      - # of Taxa vs avg water depth: WCB (0.27), 10th line (0.23), 8th line (0.18)
      - # of EPT vs avg water depth: WCB (0.33), 8th line (0.32)
  - When all data were combined
    - # of Taxa vs avg water depth: R^2 = 0.33
    - # of EPT vs avg water depth: R^2 = 0.28
  - When WCB and 8th line data were removed from the combined data set:
    - # of Taxa vs avg water depth: R^2 = 0.42
    - # of EPT vs avg water depth: R^2 = 0.18

Wetted Perimeter

- For all field sites, the relation between # of Taxa or # of EPT and wetted perimeter positive with the exception of 15th Sideroad (where both relations were negative)
  - The strength of the relations varied by field site and were typically weak
    - Highest strengths (R^2 in brackets):
      - # of Taxa vs wetted perimeter: 22 S.R. (0.58)
      - # of EPT vs wetted perimeter: 22 S.R. (0.58), WCB (0.42)
    - Lowest strengths:
      - # of Taxa vs wetted perimeter: 15th S.R. (0.07), WCB (0.14), 10th line (0.01), 8th line (0.13)
      - # of EPT vs wetted perimeter: 15th S.R. (0.02), 10th line (0.004), 8th line (0.26)
  - When all data were combined
    - # of Taxa vs wetted perimeter: R^2 = 0.06
    - # of EPT vs wetted perimeter: R^2 = 0.19
  - When 15th SR and 10th line data were removed from the combined data set:
    - # of Taxa vs wetted perimeter: R^2 = 0.002
    - # of EPT vs wetted perimeter: R^2 = 0.001

Riffle Samples

The analyses described above, were repeated using only the riffle samples, under the assumption that, for most invertebrates, riffle environments would determine abundance and diversity of species.

In general,

- there was some spatial diversity between samples A, B and C (i.e., from left to right across the channel) in each riffle.
  - The R^2 values of the relations were not consistently better or worse than the combined pool/riffle data sets for each of the 3 parameters evaluated for each field site.
    - Riffle relations always weaker than combined data set: 22nd S.R.
    - Riffle relations always better than combined data set: 8th line
  - When the data for all sites was combined, the R^2 values were higher than for the

Width:Depth ratio

- All relations between # of taxa or EPT and width:depth ratio for riffles were positive, with the exception of 15 S.R. # of taxa, which was negative
- The strength of relations varied by field site and were weaker than in the combined pool/riffle data sets
  - Highest strengths (R^2 in brackets):
    - # of Taxa vs W:D ratio: 10th line (0.44), WCB (0.37)
    - # of EPT vs W:D ratio: 10th line (0.41), WCB (0.60)
  - Lowest strengths:
    - # of Taxa vs W:D ratio: 22nd S.R. (0.01), 15th S.R. (0.31), 8th line (0.30)
    - # of EPT vs W:D ratio: 22nd S.R. (0.33), 15th S.R. (0.00), 8th line (0.36)
- When all data were combined, the relations were higher than individual sites
    - # of Taxa vs W:D ratio: $R^2 = 0.44$
    - # of EPT vs W:D ratio: $R^2 = 0.46$

Average Water Depth

- For all field sites, the relation between # of Taxa or # of EPT and average water depth was negative (i.e., # of Taxa and # of EPT decreased with increasing water depth) with the exception of 10th line # of taxa data, where the relation was positive.
  - The strength of the relations varied by field site
    - Highest strengths (R^2 in brackets):
      - # of Taxa vs avg water depth: 8th line (0.43)
      - # of EPT vs avg water depth: 15th S.R. (0.43), WCB (0.37), 8th line (0.52)
    - Lowest strengths:
      - # of Taxa vs avg water depth: 22nd S.R. (0.06), WCB (0.29), 10th line (0.03), 15th S.R. (0.13
      - # of EPT vs avg water depth: 22nd S.R. (0.19),), 10th line (0.00)

- When all data were combined
  - # of Taxa vs avg water depth: $R^2 = 0.43$
  - # of EPT vs avg water depth: $R^2 = 0.35$
- When 10th line data were removed from the combined data set:
  - # of Taxa vs avg water depth: $R^2 = 0.36$
  - # of EPT vs avg water depth: $R^2 = 0.21$

Wetted Perimeter

- For all field sites, the relation between # of Taxa or # of EPT and wetted perimeter were positive with the exception of 15th Sideroad (where both relations were negative)
  - The strength of the relations varied by field site and were typically weak
    - o Highest strengths (R^2 in brackets):
      - # of Taxa vs wetted perimeter: 8th line (0.47), 15th S.R. (0.48)
      - # of EPT vs wetted perimeter: 8th line (0.57), 22nd S.R. (0.43
    - o Lowest strengths:
      - # of Taxa vs wetted perimeter: 22nd S.R. (0.00), WCB (0.03), 10th line (0.04)
      - # of EPT vs wetted perimeter: 15th S.R. (0.04), WCB (0.14), 10th line (0.00
  - When all data were combined
    - # of Taxa vs wetted perimeter: $R^2 = 0.14$
    - # of EPT vs wetted perimeter: $R^2 = 0.08$

<u>Low Flow Summary</u>

Section 6.0 of this Appendix contains all graphs of Benthic Indicators versus Low Flow.

Results of the analyses suggest that low-flow characteristics do influence the abundance and diversity of benthic invertebrate species within the channel within the Erin SSMP study area. Of the parameters evaluated, the width:depth ratio and average water depth correlations were stronger than the wetted perimeter data.

Table 3.2.6 Summary of R^2 values obtained through linear or power models between low flow channel parameters and benthic abundance or diversity.

		Width:Depth		Avg Water Depth		Wetted Perimeter	
		All data	**Riffles**	**All data**	**Riffles**	**All data**	**Riffles**
22nd S.R	Taxa	**0.67**	0.01	**0.66**	0.06	**0.58**	0.00
	EPT	**0.64**	0.33	0.52	0.19	**0.58**	0.43
15th S.R.	Taxa	0.15	0.31	**0.67**	0.13	0.07	0.48
	EPT	0.21	0.00	**0.64**	0.43	0.02	0.04
WCB	Taxa	0.32	0.37	0.27	0.29	0.14	0.03
	EPT	0.53	**0.60**	0.33	0.37	0.42	0.14
10th line	Taxa	0.39	**0.44**	0.23	0.03	0.01	0.04
	EPT	**0.76**	**0.41**	**0.63**	0.00	0.00	0.00
8th line	Taxa	0.00	0.30	0.18	**0.43**	0.13	**0.47**
	EPT	0.05	0.36	0.32	**0.52**	0.26	**0.57**
All sites combined	Taxa	0.05	0.44	0.33	0.43	0.06	0.14
	EPT	0.14	0.46	0.28	0.35	0.19	0.08
	Taxa	0.44		0.42	0.36	0.00	
	EPT	0.46		0.18	0.21	0.00	
		Remove 15th SR and 8th line data		Remove WCB and 8th line data	Remove 10th line data	Remove 15th and 10th line data	

3.2.4 Bankfull Channel Parameters

Hydraulic conditions that occur during the bankfull or dominant discharge flow events are those that determine channel form and are responsible for the highest volume of sediment transport during the hydrologic regime. As such, relations between bankfull channel parameters and benthic invertebrate abundance and diversity were examined. The four specific parameters that were analyzed included:

- Width:depth ratio
- Bankfull perimeter
- Average bankfull depth
- Bankfull stream power

The data were evaluated by riffles and/or pools per site and as a combined data set for all five field sites. Both linear and power regression models were examined to determine which yielded the strongest relations. Results revealed the following:

- Linear models were often better than exponential or power models
- Relations were stronger for the average bankfull depth (all site data combined) than for any other parameter
- For most sites, R^2 values were considered to be weak or moderately weak

Spatial variability in site characteristics will affect the diversity and abundance of species. Findings revealed the following:

- Riffle only data – 8th line had strongest relations for average depth and width:depth ratio
- All data combined – 22nd S.R. exhibited strongest relations for all but the stream power relation.

Width:Depth Ratio

- For all field sites, the relation between # of Taxa or # of EPT and width:depth ratio was positive (i.e., # of Taxa and # of EPT increased with increasing ratio) with the exception of 15th S.R. and 10th Line where both the Taxa and EPT.

The strength of the relations varied by field site

- Highest strengths (R^2 in brackets):
    - # of Taxa vs W:D ratio: 22nd Side Rd (0.74)
    - # of EPT vs W:D ratio: 22nd Side Rd (0.85)
- Lowest strengths:
    - # of Taxa vs W:D ratio: all sites except 22nd S.R. (< 0.30)
    - # of EPT vs W:D ratio: all sites except 22nd S.R. (< 0.30)

- When all data were combined
    - # of Taxa vs W:D ratio: $R^2 = 0.02$
    - # of EPT vs W:D ratio: $R^2 = 0.01$

Average Bankfull Depth

- For all field sites, the relation between # of Taxa or # of EPT and average bankfull depth was typically negative (i.e., # of Taxa and # of EPT decreased with increasing water depth). Exceptions included site 15th S.R where the relation was positive.
- The strength of the relations varied by field site
    - Highest strengths (R^2 in brackets):
        - # of Taxa vs avg water depth: 22nd S.R. (0.87)
        - # of EPT vs avg water depth: 22nd S.R. (0.77)
    - Lowest strengths:
        - # of Taxa vs avg water depth: all sites except 22nd S.R. (< 0.25)
        - # of EPT vs avg water depth: all sites except 22nd S.R. (< 0.20)
- When all data were combined
    - # of Taxa vs avg water depth: $R^2 = 0.21$
    - # of EPT vs avg water depth: $R^2 = 0.14$

Wetted Perimeter

- For all field sites, the relation between # of Taxa or # of EPT and wetted perimeter were positive with the exception of 15th Sideroad (where both relations were negative)
- The strength of the relations varied by field site and were typically weak
    - Highest strengths (R^2 in brackets):

        - # of Taxa vs wetted perimeter: 22^{nd} S.R. (0.48)
        - # of EPT vs wetted perimeter: 22^{nd} S.R. (0.68)
    - Lowest strengths:
        - # of Taxa vs wetted perimeter: : all sites except 22^{nd} S.R. (< 0.20)
        - # of EPT vs wetted perimeter: : all sites except 22^{nd} S.R. (< 0.25)
    - When all data were combined
        - # of Taxa vs wetted perimeter: $R^2 = 0.01$
        - # of EPT vs wetted perimeter: $R^2 = 0.00$

Stream Power

- For all field sites, the relation between # of Taxa or # of EPT and stream power were not consistently negative or positive amongst the field sites.
    - Relations were negative for: 22^{nd} S.R., 15^{th} S.R. EPT, 8^{th} line
    - Relations were positive for: 15^{th} S.R. taxa, WCB, 10^{th} line
- The strength of the relations varied by field site and were typically weak
    - Highest strengths (R^2 in brackets):
        - # of Taxa vs stream power: WCB (0.39)
        - # of EPT vs stream power: WCB (0.56)
    - Lowest strengths:
        - # of Taxa vs stream power: all sites except WCB (< 0.30)
        - # of EPT vs stream power: all sites except WCB (< 0.20)
    - When all data were combined
        - # of Taxa vs stream power: $R^2 = 0.22$
        - # of EPT vs stream power: $R^2 = 0.04$

Riffles

The analyses described above, were repeated using only the riffle samples, under the assumption that, for most invertebrates, riffle environments would determine abundance and diversity of species.

In general,

- there was some spatial diversity between samples A, B and C (i.e., from left to right across the channel) in each riffle.
- The R^2 values of the relations were not consistently better or worse than the combined pool/riffle data sets for each of the 3 parameters evaluated for each field site.
    - Riffle relations always weaker than combined data set: 22^{nd} S.R.
    - Riffle relations always better than combined data set: 15^{th} line, 8^{th} line
- When the data for all sites was combined, the R^2 values were higher for the riffle data than for the combined pool and riffle data set.

Width:Depth Ratio

- For all field sites, the relation between # of Taxa or # of EPT and width:depth ratio was positive (i.e., # of Taxa and # of EPT increased with increasing ratio) with the exception of 15^{th} S.R. and 10^{th} Line (EPT only).

The strength of the relations varied by field site

- Highest strengths (R^2 in brackets):
  - # of Taxa vs W:D ratio: 8th line (0.47), 15th S.R. (0.44)
  - # of EPT vs W:D ratio: 8th line (0.57), WCB (0.42), 22nd S.R. (0.36)
- Lowest strengths:
  - # of Taxa vs W:D ratio: 22nd S.R., WCB, 10th line (< 0.20)
  - # of EPT vs W:D ratio: 15th S.R. (0.02), 10th line (0.03)

- When all data were combined
  - # of Taxa vs W:D ratio: $R^2 = 0.02$
  - # of EPT vs W:D ratio: $R^2 = 0.00$

Average Bankfull Depth

- For all field sites, the relation between # of Taxa or # of EPT and average bankfull depth was typically negative (i.e., # of Taxa and # of EPT decreased with increasing bankfull depth). Exceptions included 22nd S.R. (EPT only), site 15th S.R (Taxa only) and 10th line where the relation was positive.
- The strength of the relations varied by field site
  - Highest strengths (R^2 in brackets):
    - # of Taxa vs avg bankfull depth: 8th line (0.52), 10th line (0.46)
    - # of EPT vs avg bankfull depth: 8th line (0.63), 10th line (0.64), WCB (0.45)
  - Lowest strengths:
    - # of Taxa vs avg bankfull depth: 22nd S.R. 15th line, WCB (< 0.30)
    - # of EPT vs avg bankfull depth: 22nd S.R., 15th line (< 0.10)
- When all data were combined
  - # of Taxa vs avg bankfull depth: $R^2 = 0.42$
  - # of EPT vs avg bankfull depth: $R^2 = 0.27$

Wetted Perimeter

- For all field sites, the relation between # of Taxa or # of EPT and wetted perimeter were positive with the exception of 15th Sideroad (where both relations were negative)
- The strength of the relations varied by field site and were typically weak
  - Highest strengths (R^2 in brackets):
    - # of Taxa vs wetted perimeter: 15th S.R. (0.51), 8th line (0.36)
    - # of EPT vs wetted perimeter: 8th line (0.43), 22nd S.R. (0.37)
  - Lowest strengths:
    - # of Taxa vs wetted perimeter: 22nd S.R., WCB, 10th line (< 0.11)
    - # of EPT vs wetted perimeter: 15th S.R. WCB, 10th line (<0.31)
  - When all data were combined
    - # of Taxa vs wetted perimeter: $R^2 = 0.02$
    - # of EPT vs wetted perimeter: $R^2 = 0.00$

Stream Power

Analyses for riffle only data were not completed for the stream power data.

Bankfull Summary

Section 7.0 of this Appendix contains all graphs of Benthic Indicators versus Bankfull Parameters.

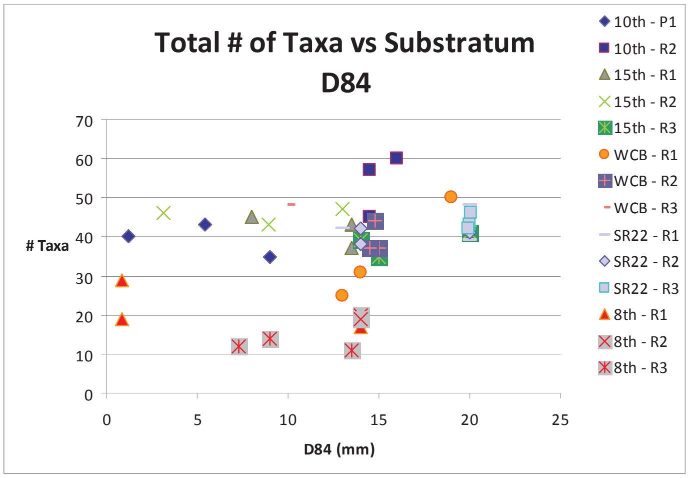
Results of the analyses suggest that bankfull channel characteristics, for most field sites, do not appear to have a strong relation to the abundance and diversity of benthic invertebrate species within the channels of the Erin SSMP study area. This may signify that low-flow channel characteristics, with respect to water depth, width:depth ratio and wetted perimeter are more important habitat parameters than the bankfull channel.

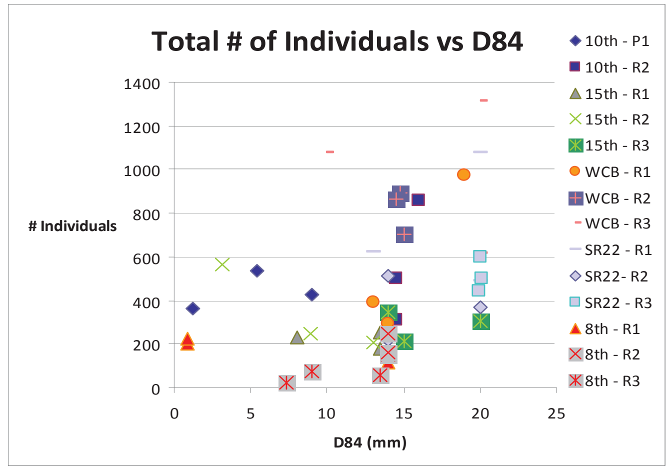
Table 3.2.7 Summary of R^2 values obtained through linear or power models

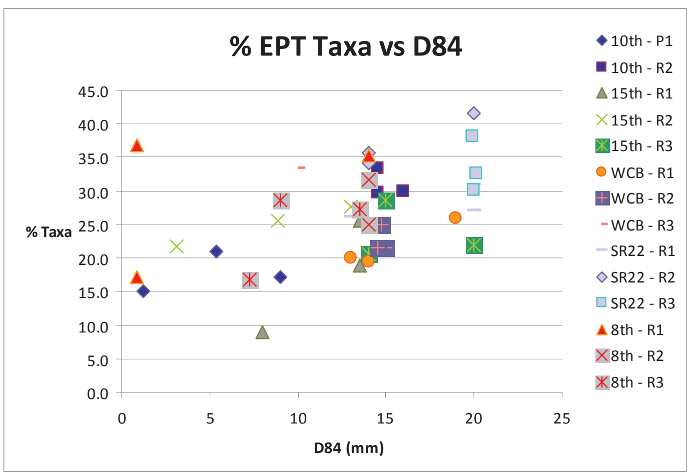
		Stream Power		Width:Depth		Avg BF Depth		Wetted Perimeter	
		All data	Riffles	All data	Riffles	All data	Riffles	All data	Riffles
22nd S.R	Taxa	0.28		0.74	0.01	0.87	0.24	0.48	0.00
	EPT	0.17		0.85	0.36	0.77	0.06	0.68	0.37
15th S.R.	Taxa	0.03		0.04	0.44	0.07	0.27	0.10	0.51
	EPT	0.00		0.00	0.02	0.02	0.01	0.03	0.07
WCB	Taxa	0.39		0.26	0.18	0.23	0.20	0.11	0.10
	EPT	0.56		0.27	0.42	0.20	0.45	0.17	0.07
10th line	Taxa	0.05		0.00	0.00	0.00	0.46	0.19	0.11
	EPT	0.15		0.06	0.03	0.03	0.64	0.25	0.31
8th line	Taxa	0.06		0.01	0.47	0.08	0.52	0.02	0.36
	EPT	0.03		0.07	0.57	0.20	0.63	0.06	0.43
All sites combined	Taxa	0.22		0.02	0.02	0.21	0.42	0.01	0.02
	EPT	0.04		0.01	0.00	0.14	0.27	0.00	0.00

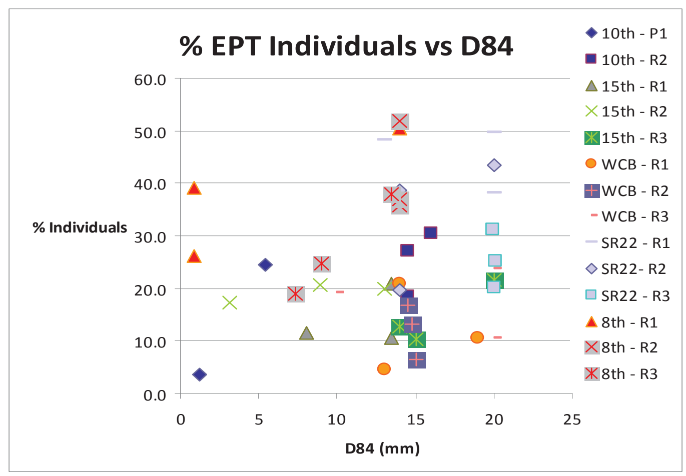
4.0 Benthic Indicators vs Substrate and Substratum

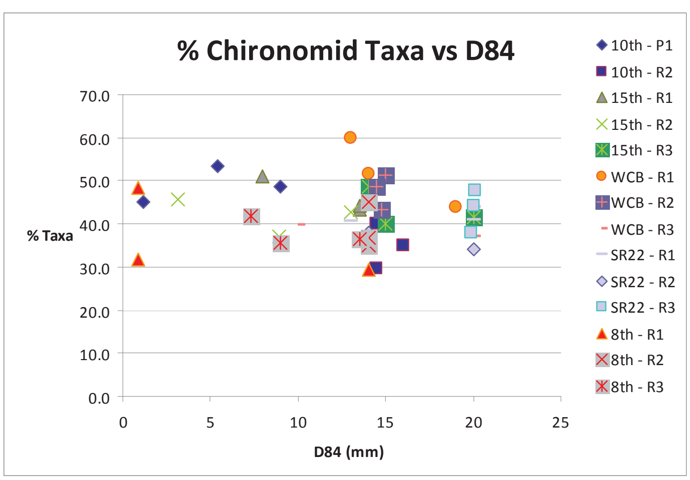
4.1 Benthic Indicators vs Substratum (D84)

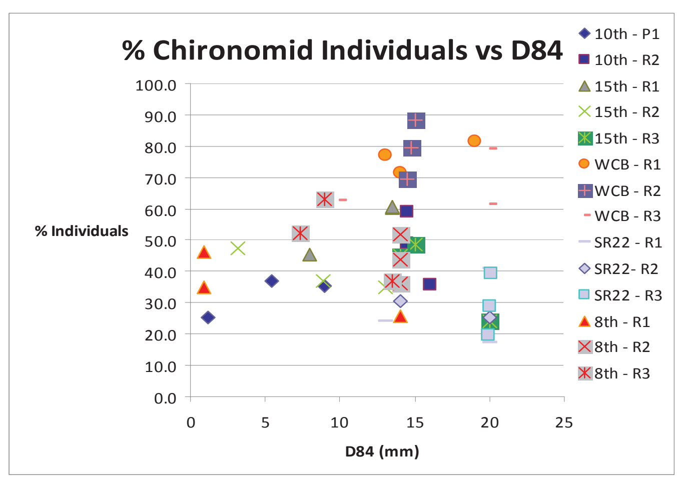




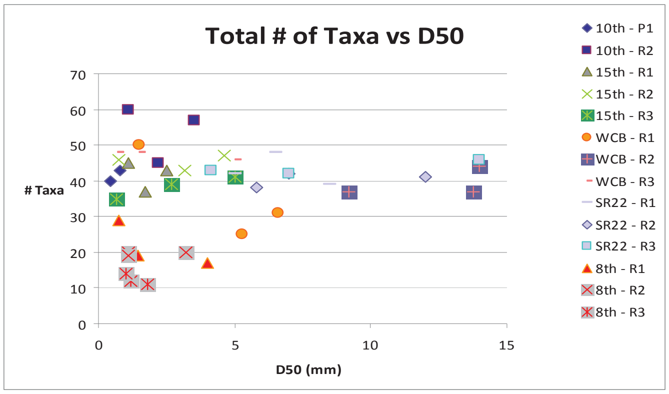


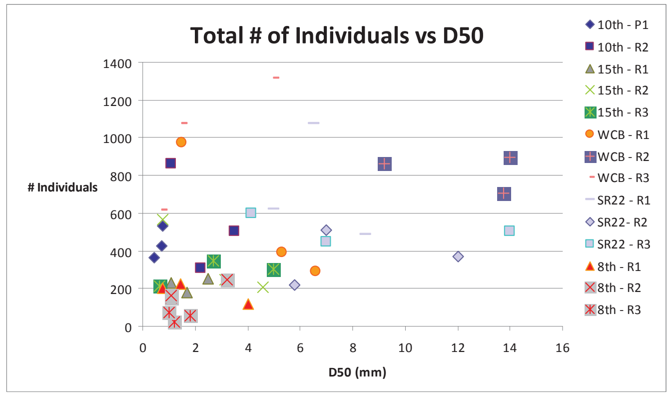


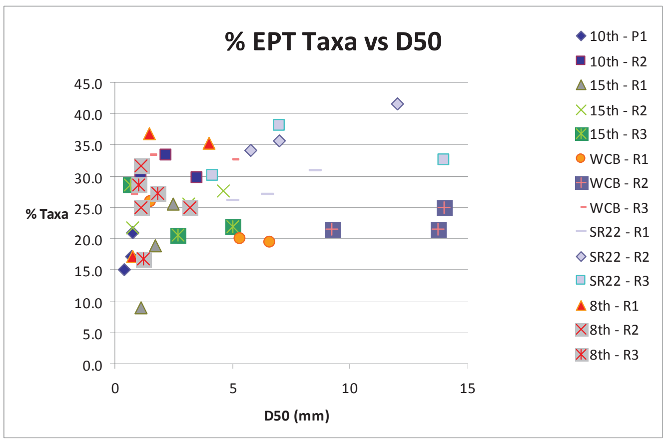


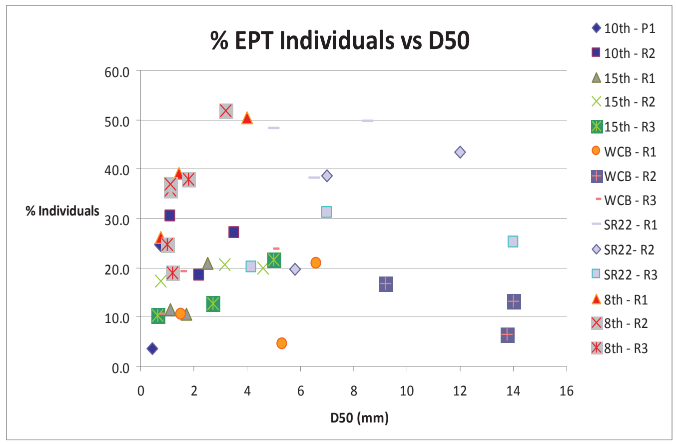


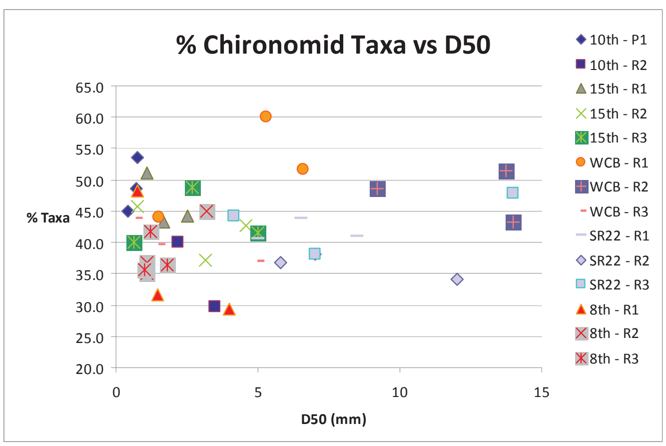
4.2 Benthic Indicators vs Substratum (D50)

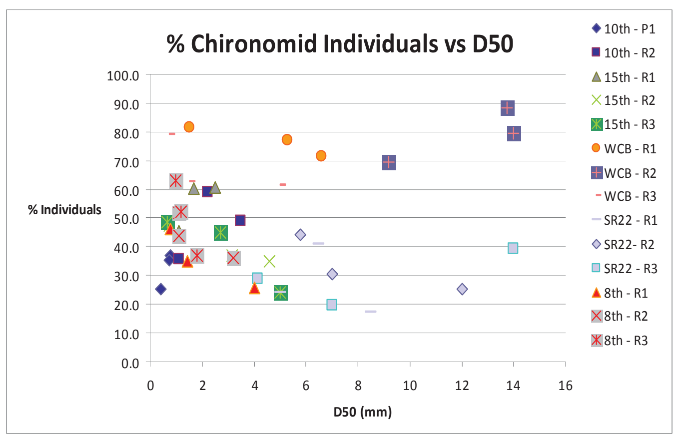




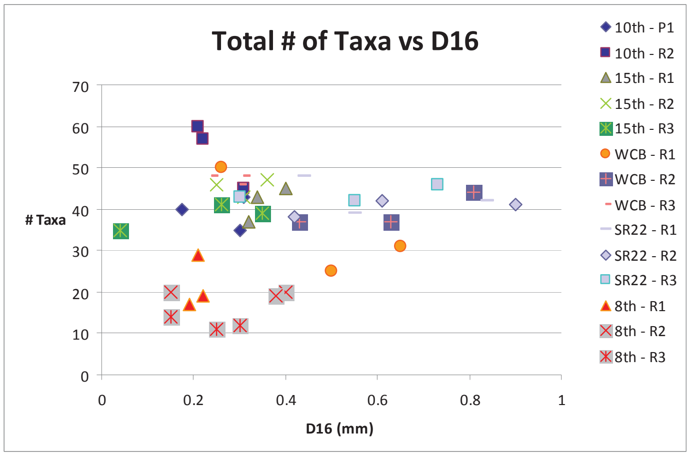


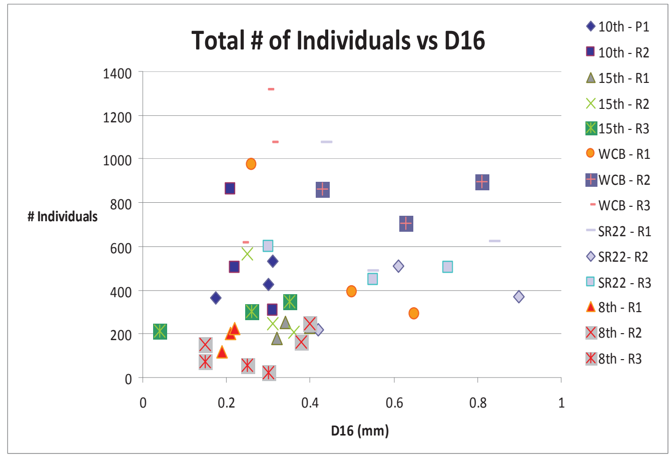


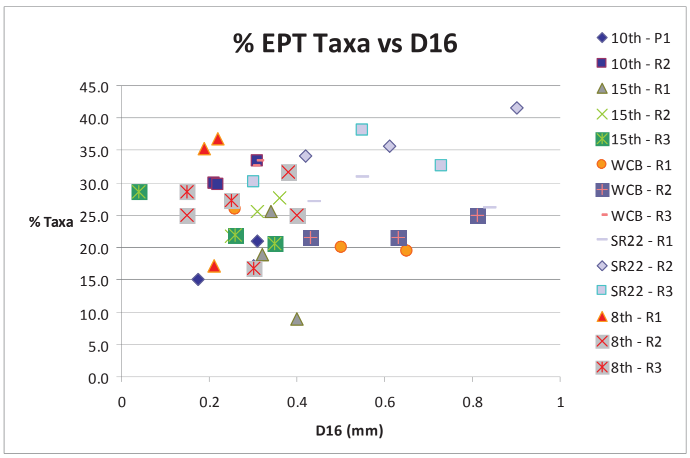


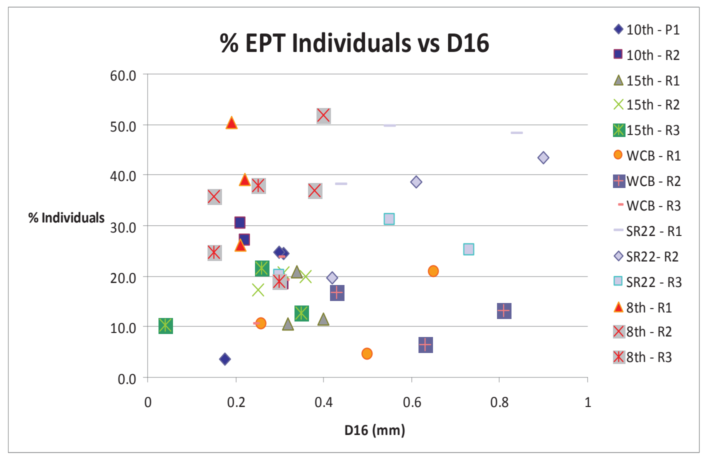


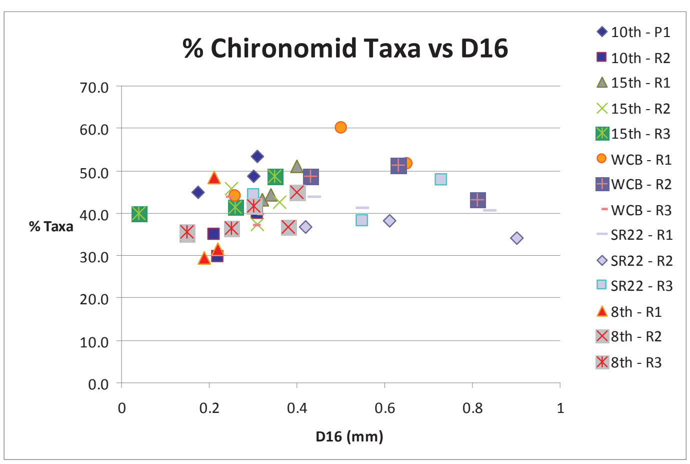
4.3 Benthic Indicators vs Substratum (D16)

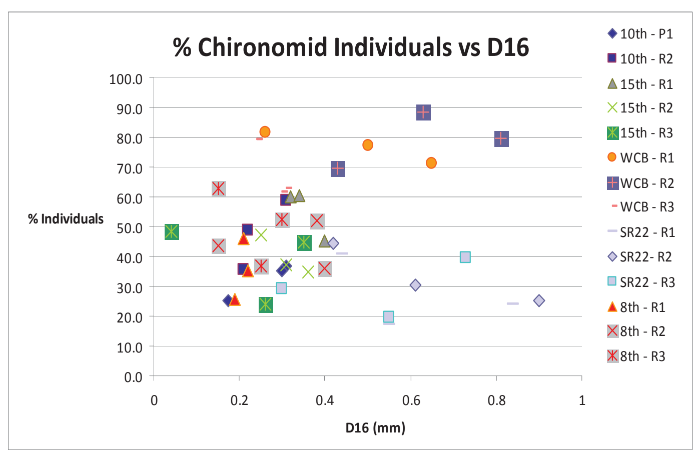




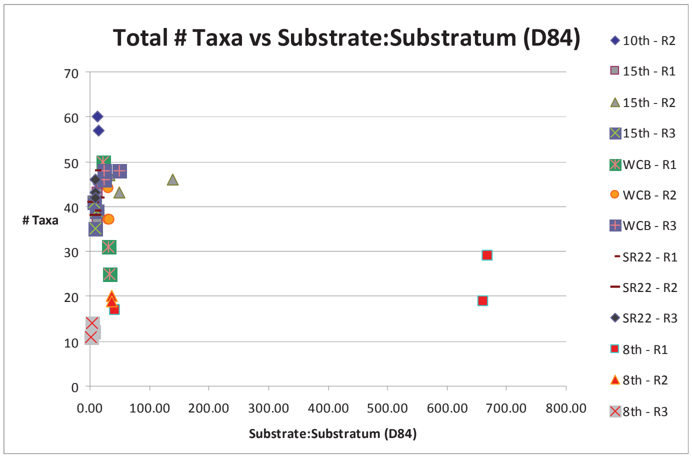


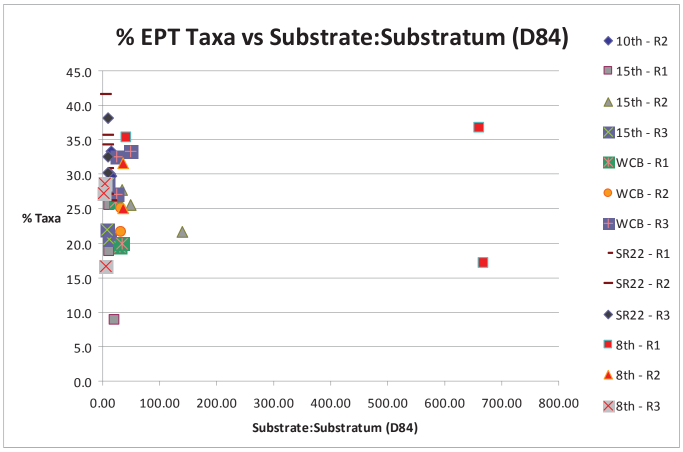


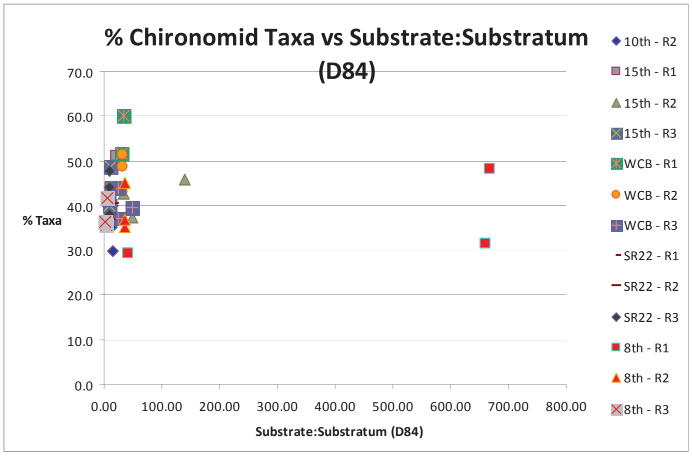


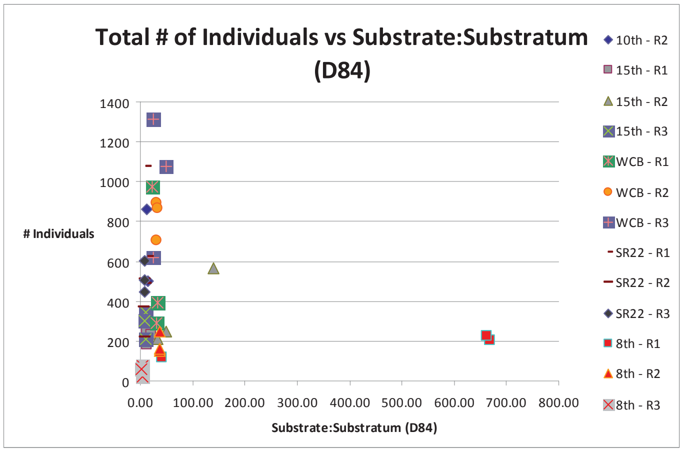


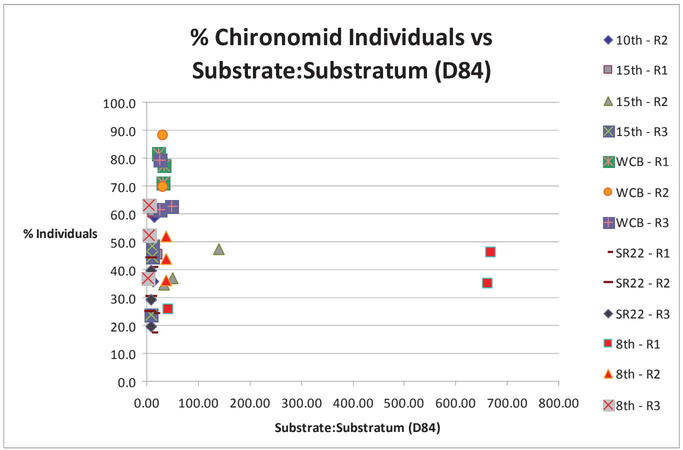
4.4 Benthic Indicators vs Substrate:Substratum (D84)

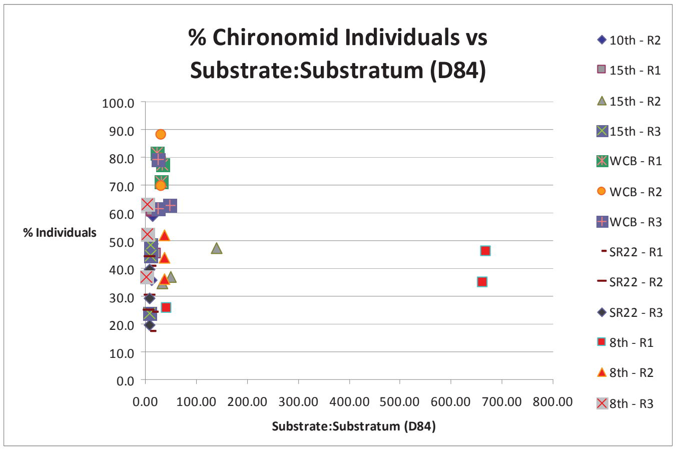




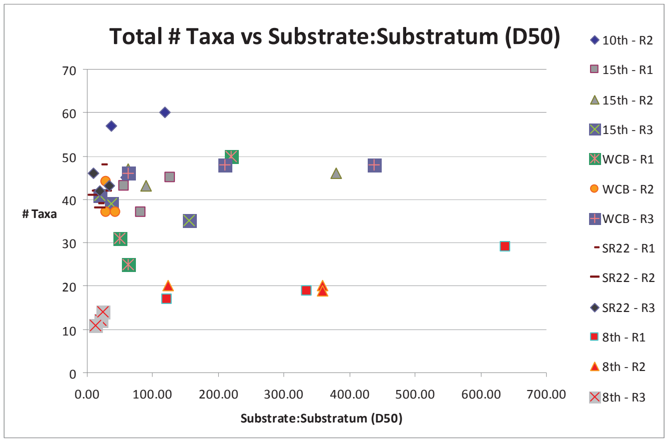


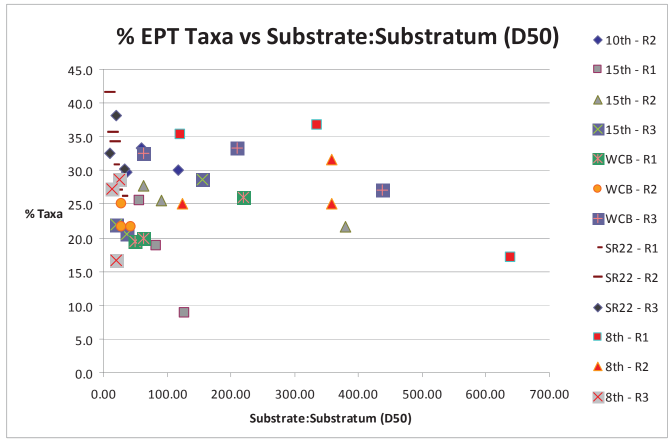


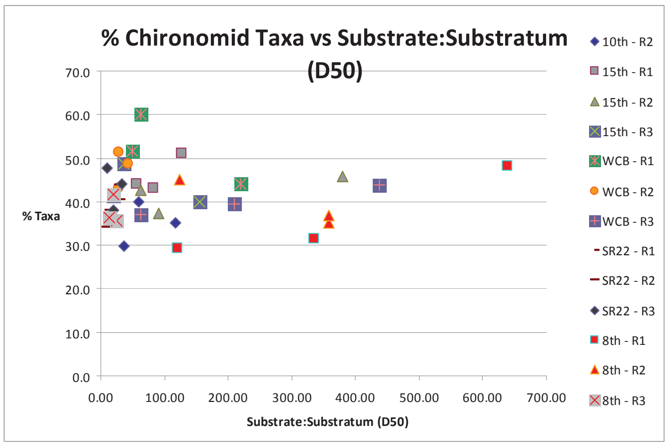


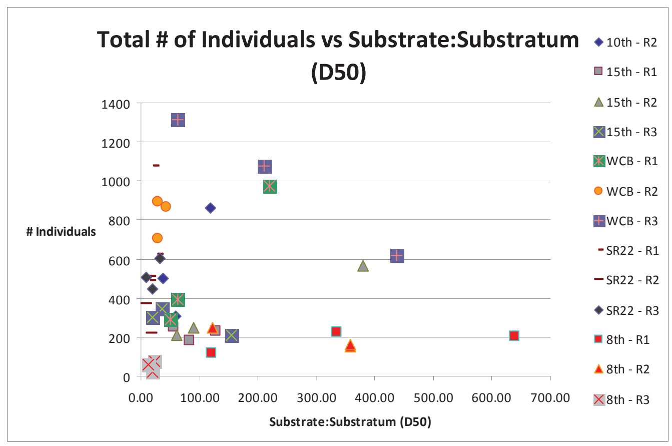


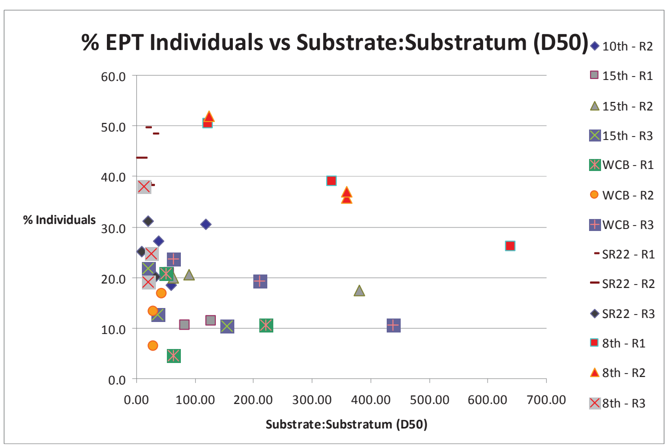
4.5 Benthic Indicators vs Substrate:Substratum (D50)

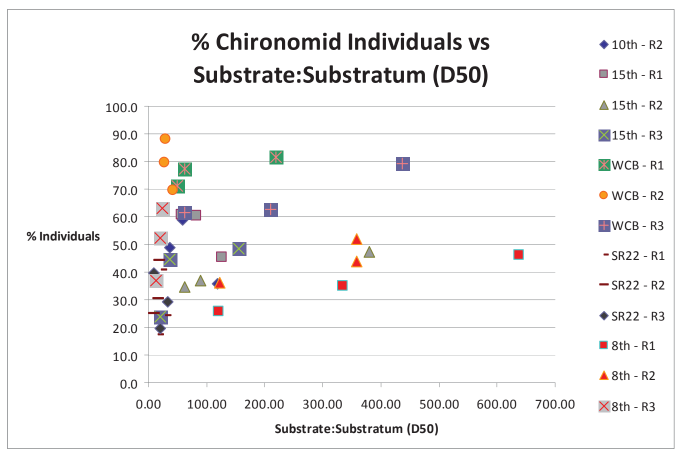




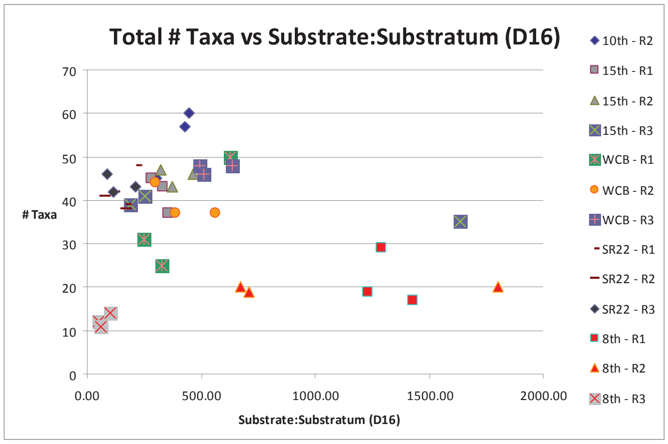


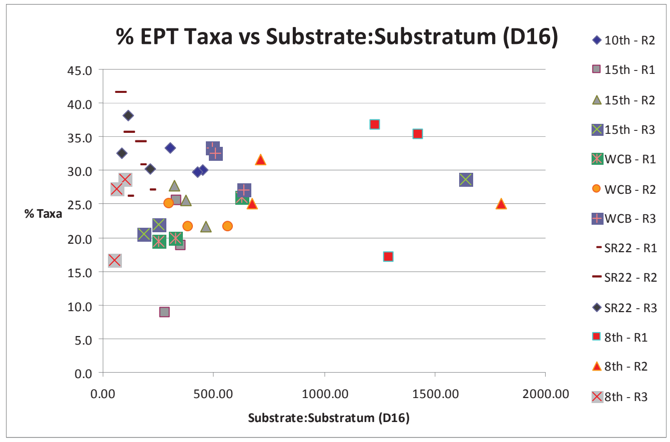


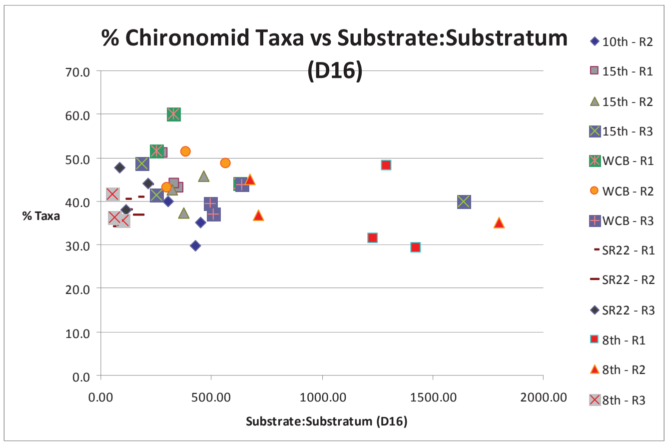


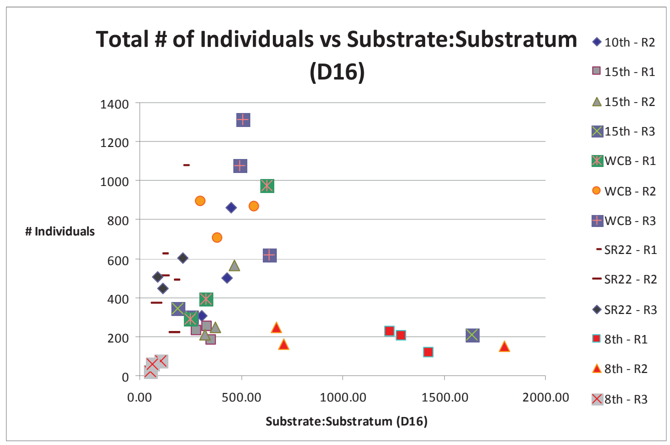


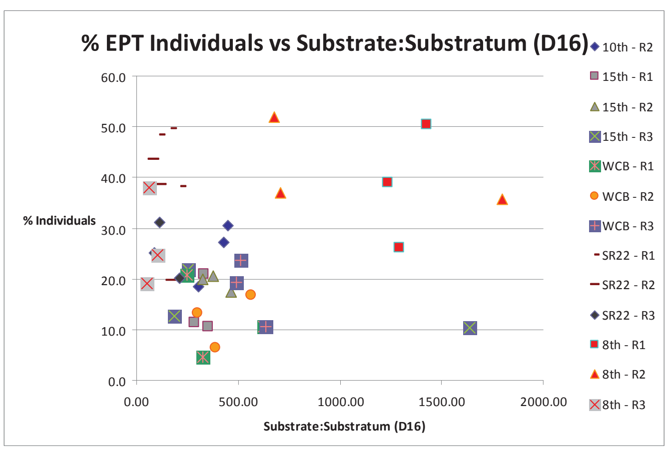
4.6 Benthic Indicators vs Substrate:Substratum (D16)

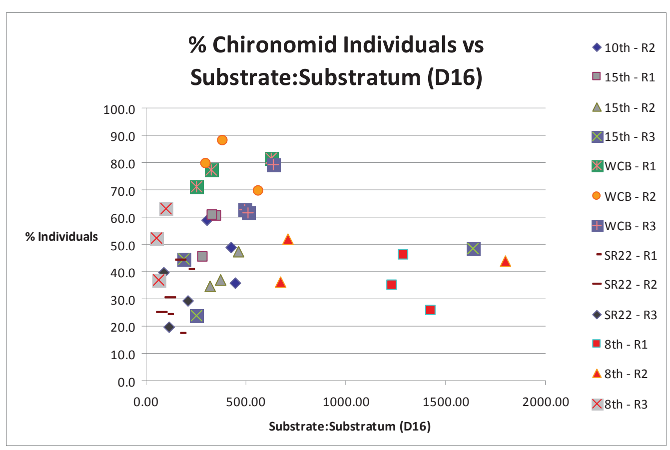






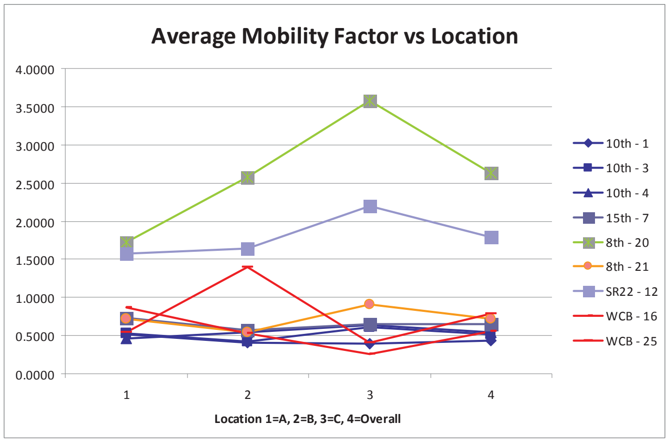


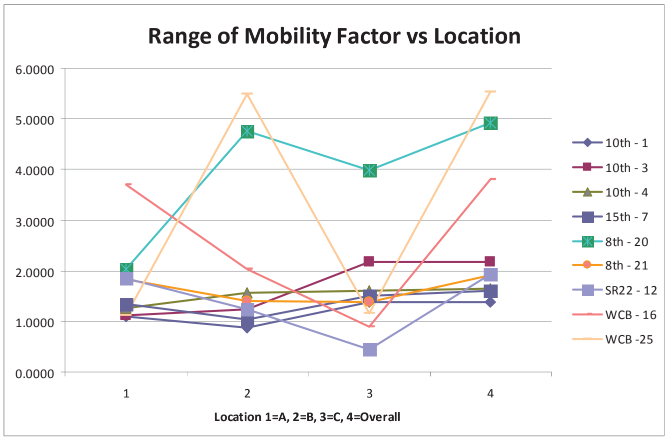


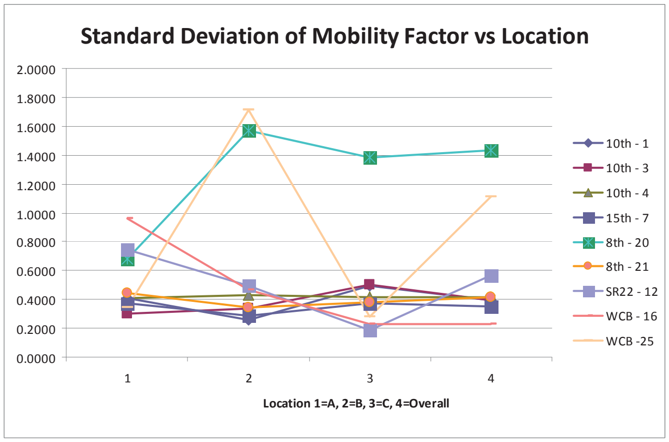


5.0 Benthic Indicators vs Mobility and Location

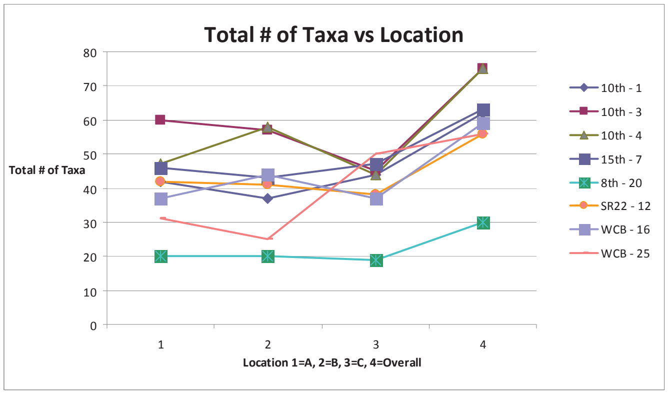
5.1 Mobility Analysis vs Location

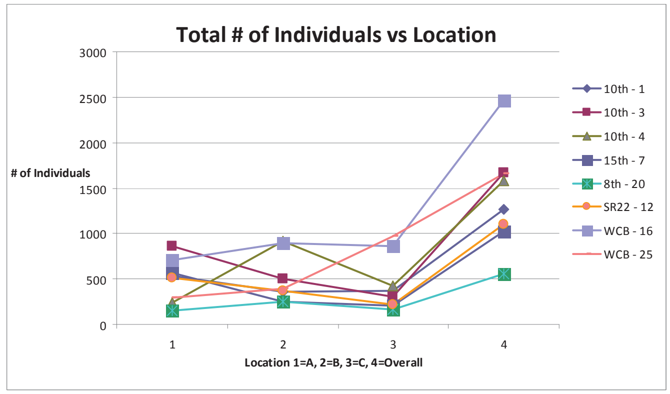


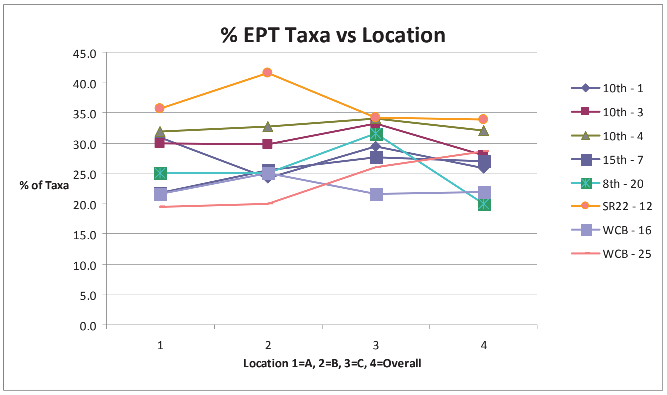


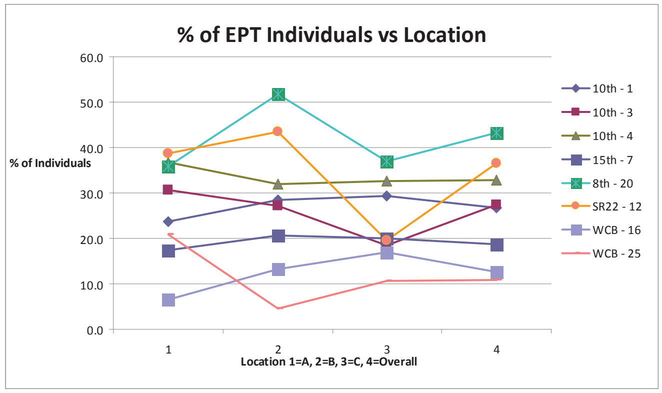


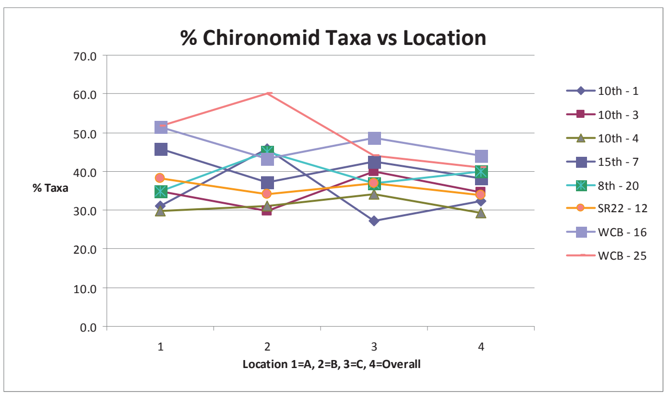
5.2 Benthic Indicators vs Location

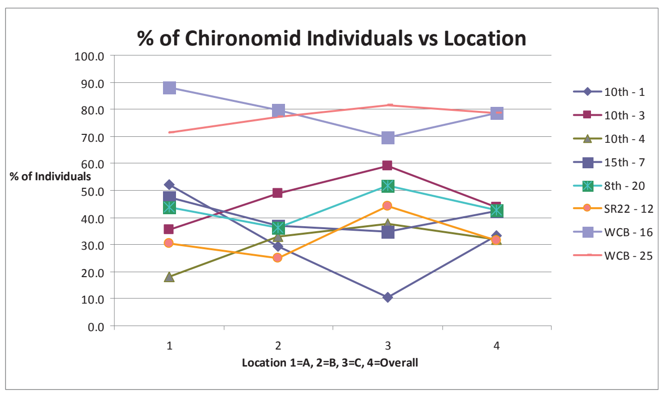




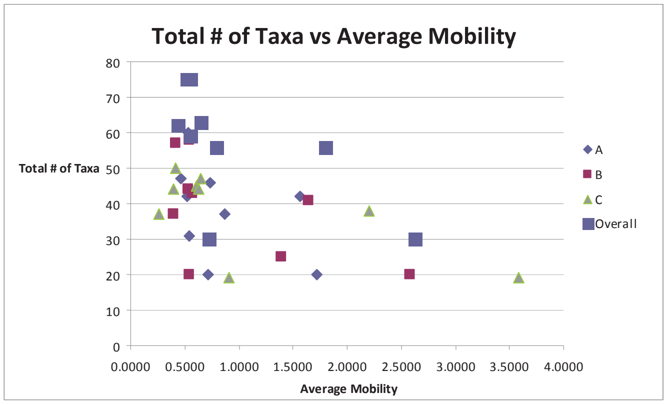


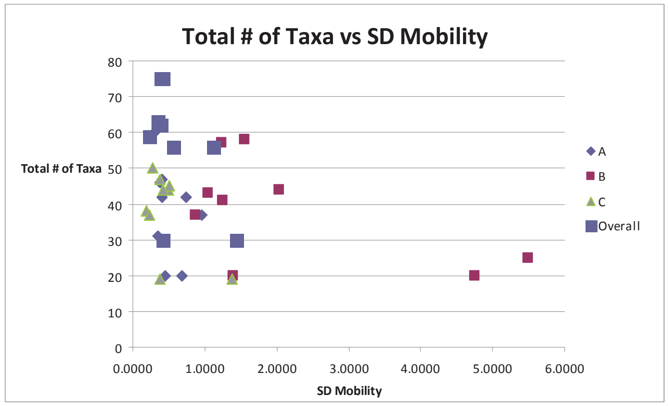


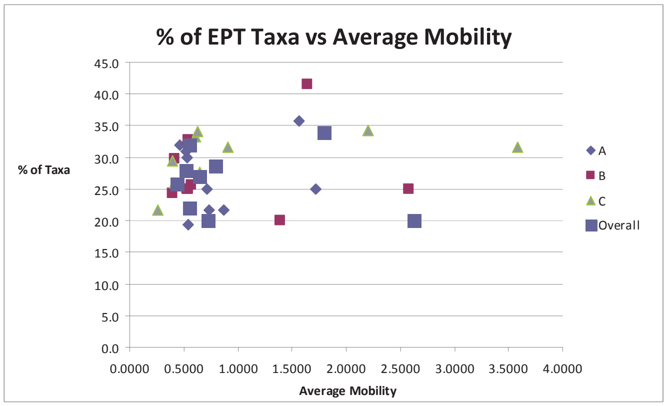


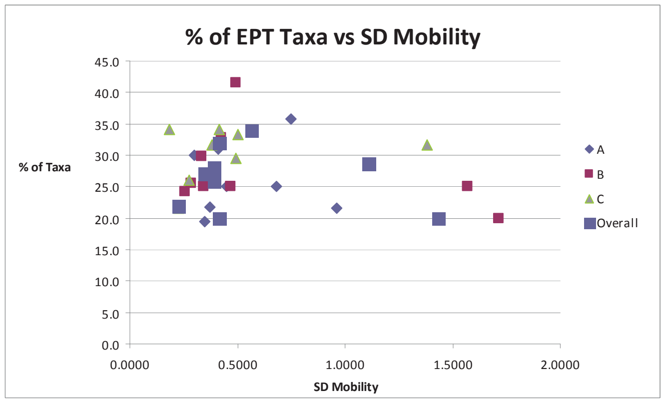


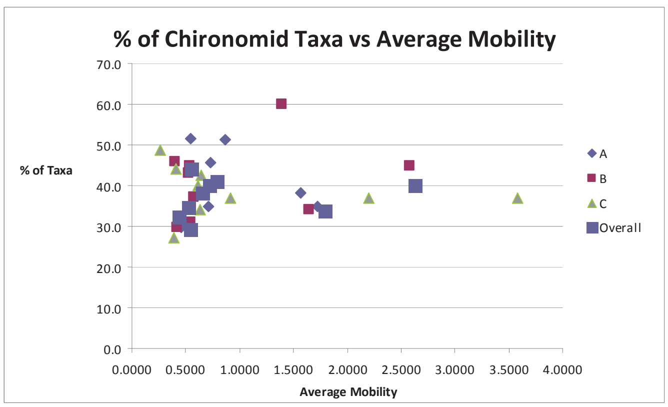
5.3 Benthic Indicators vs Mobility

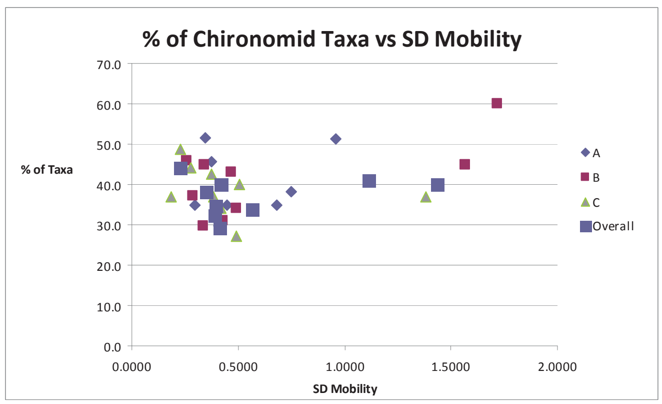




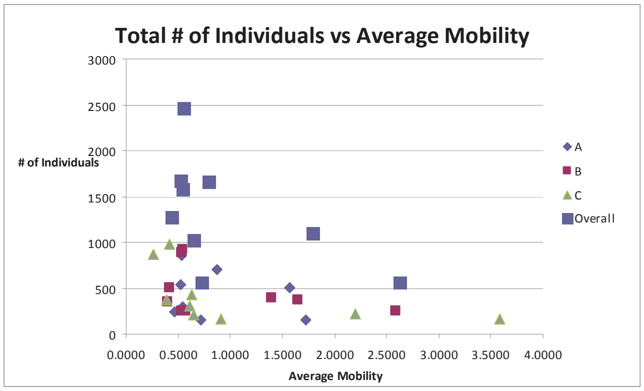


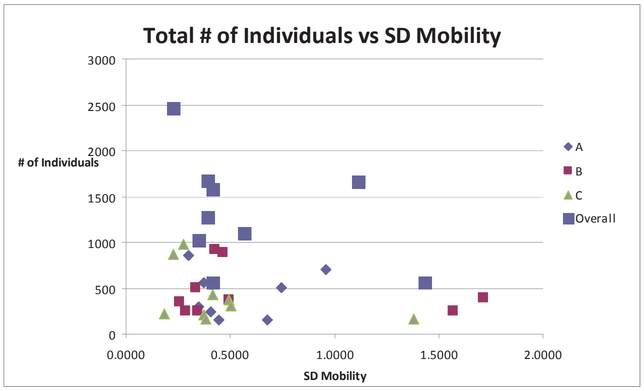


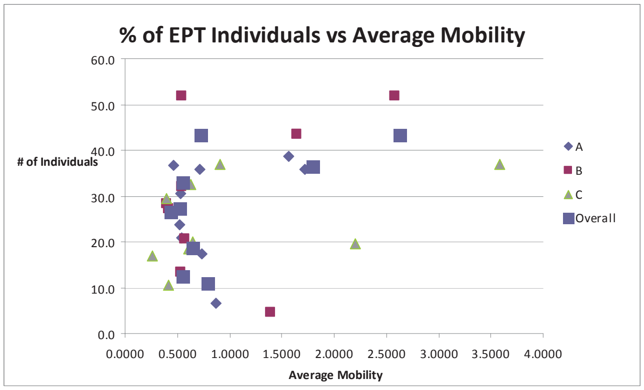


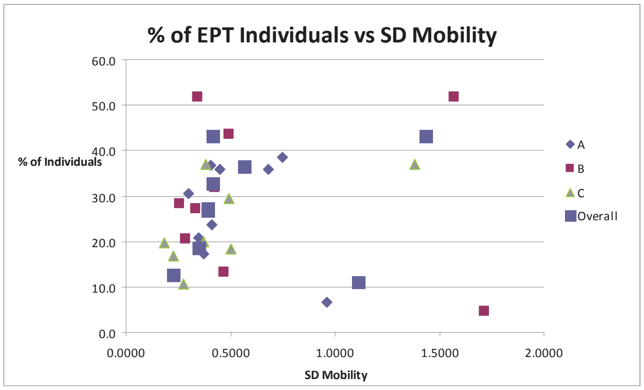


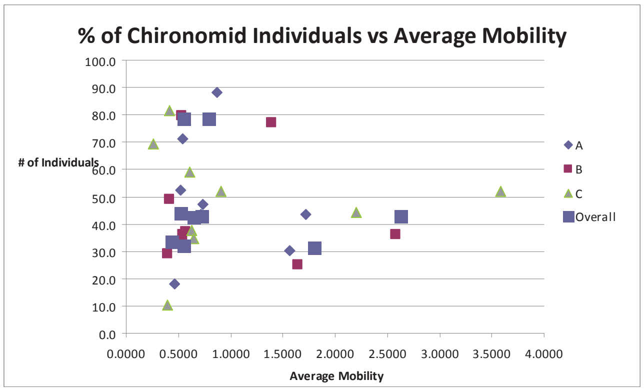
5.4 Benthic Indicators vs Mobility (Continued)

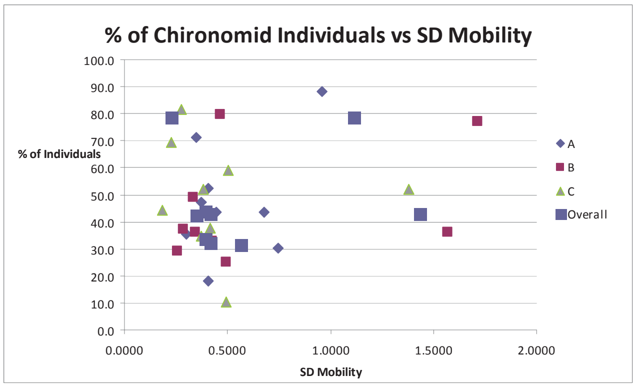






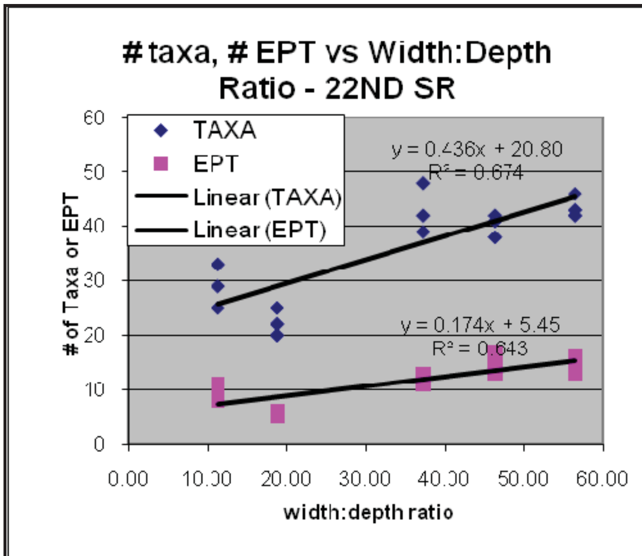


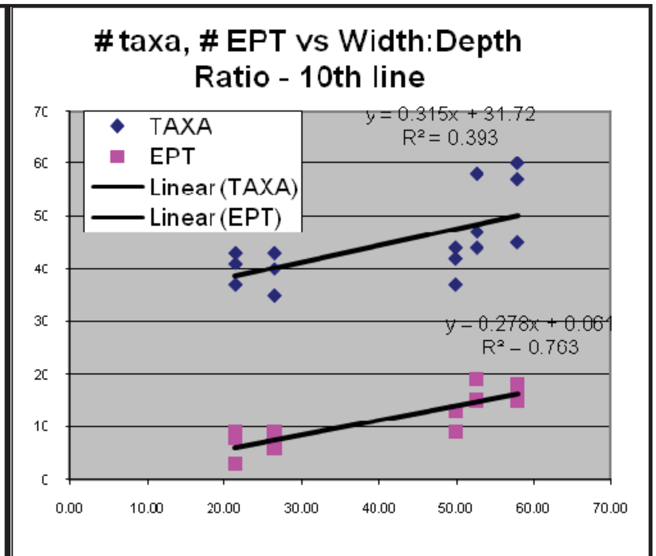


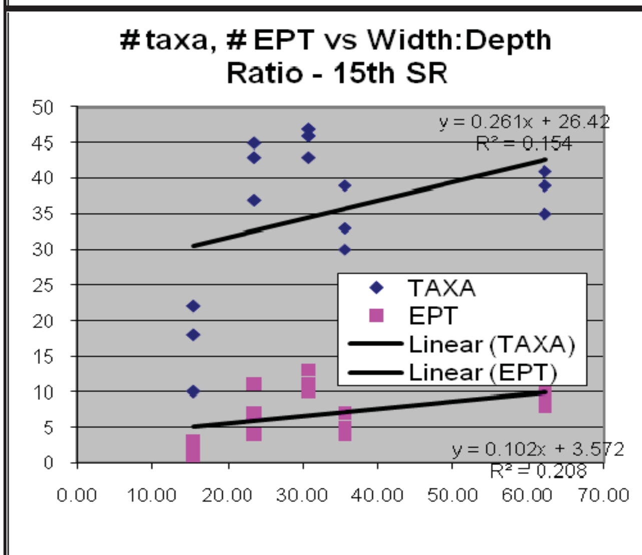


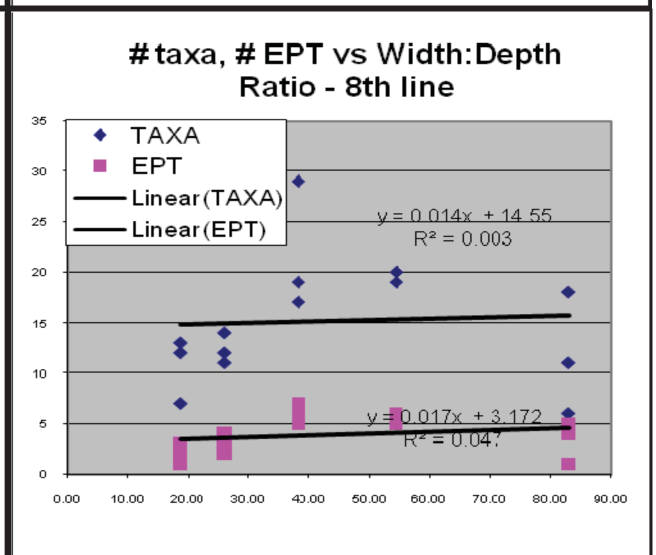
6.0 Benthic Indicators vs Low-Flow Parameters

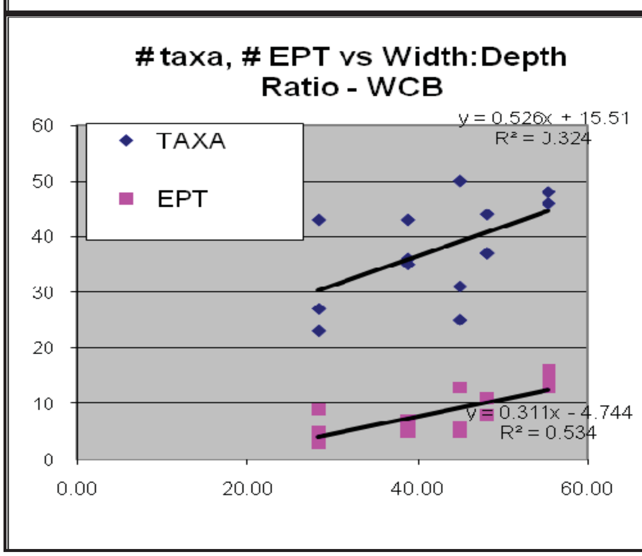
6.1 Number of Taxa or EPT versus Width:Depth Ratio of Riffles and Pools

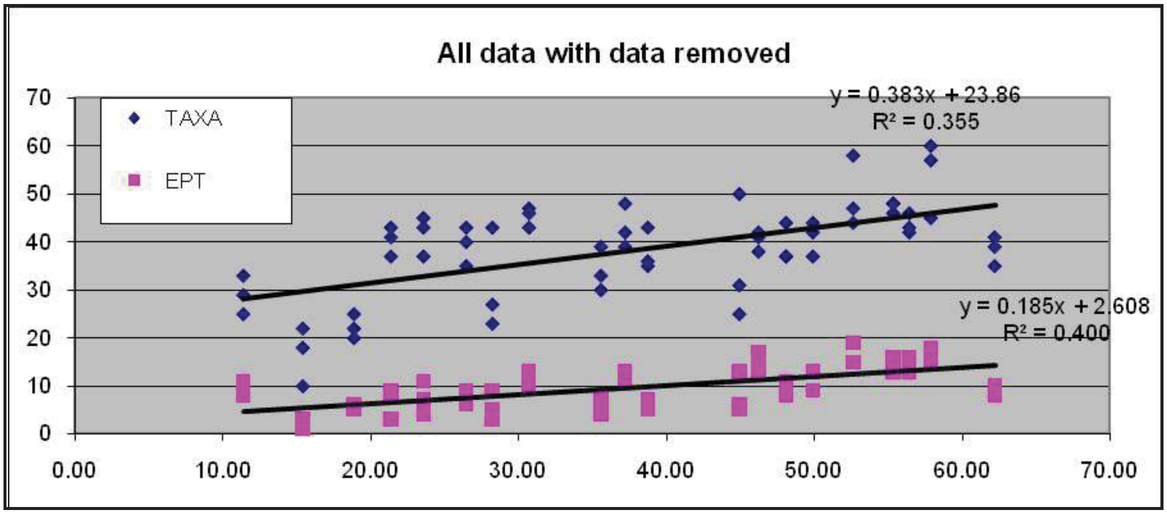




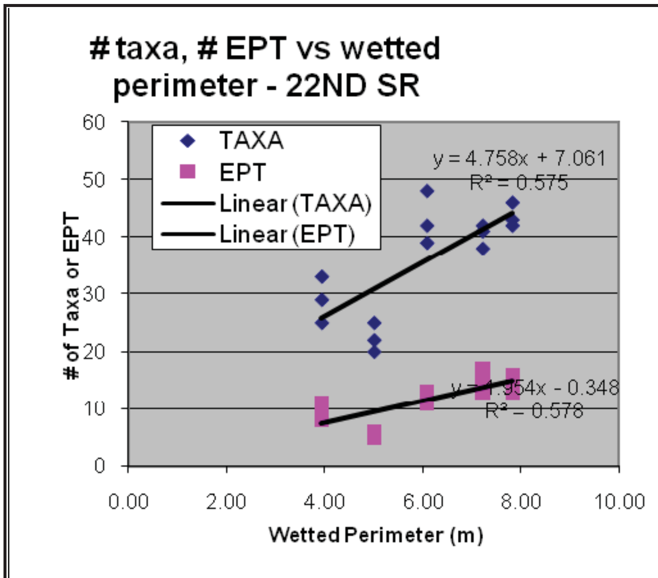


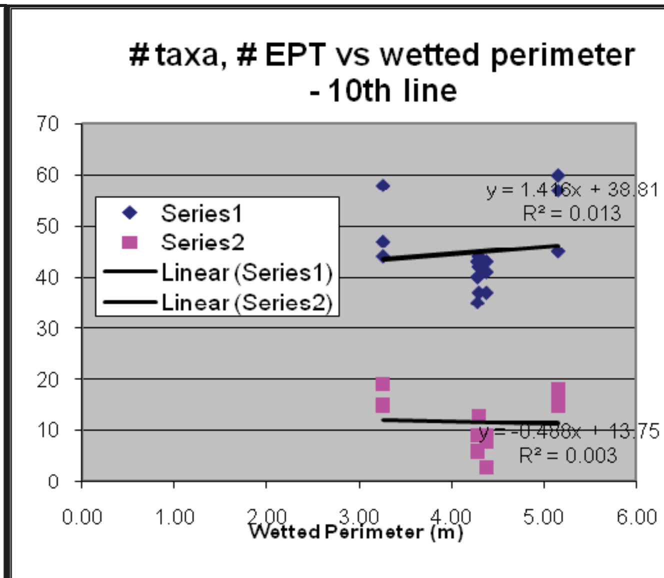


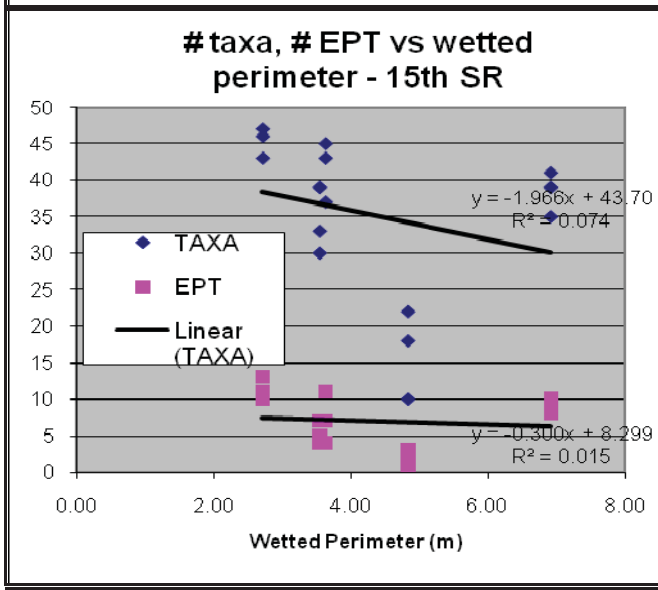


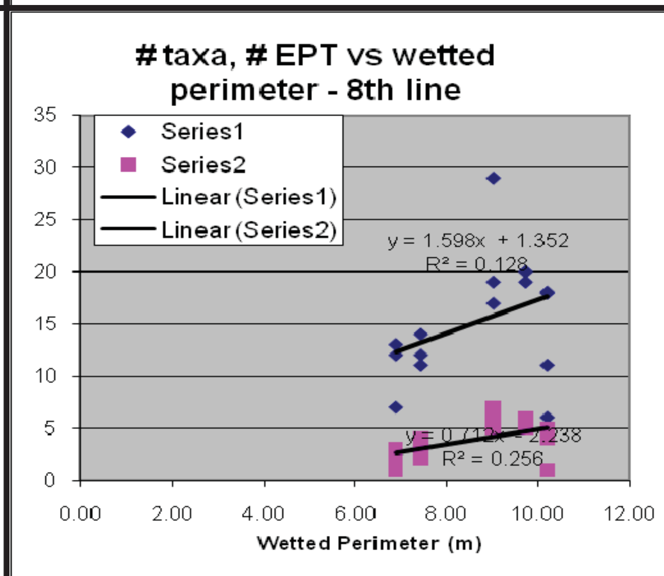

All data with data removed
TAXA
EPT
y = 0.383x + 23.86
R² = 0.355
y = 0.185x + 2.608
R² = 0.400
70
60
50
40
30
20
10
0
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00

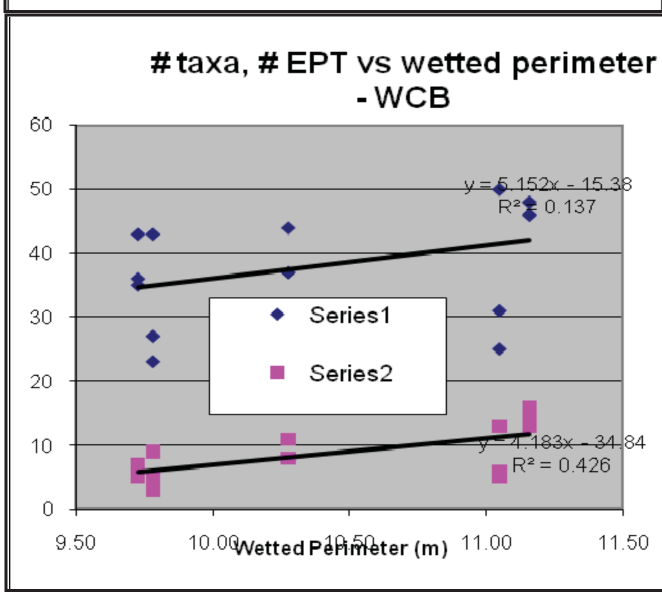
6.2 Number of Taxa or EPT versus Wetted Perimeter of Riffles and Pools

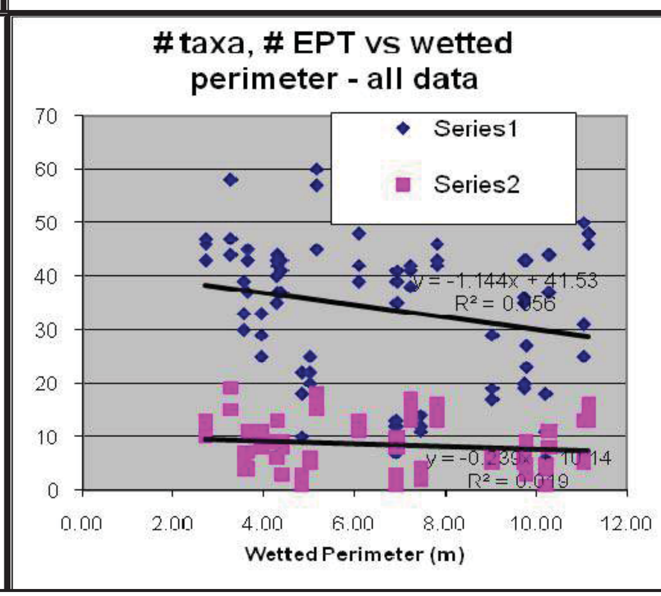


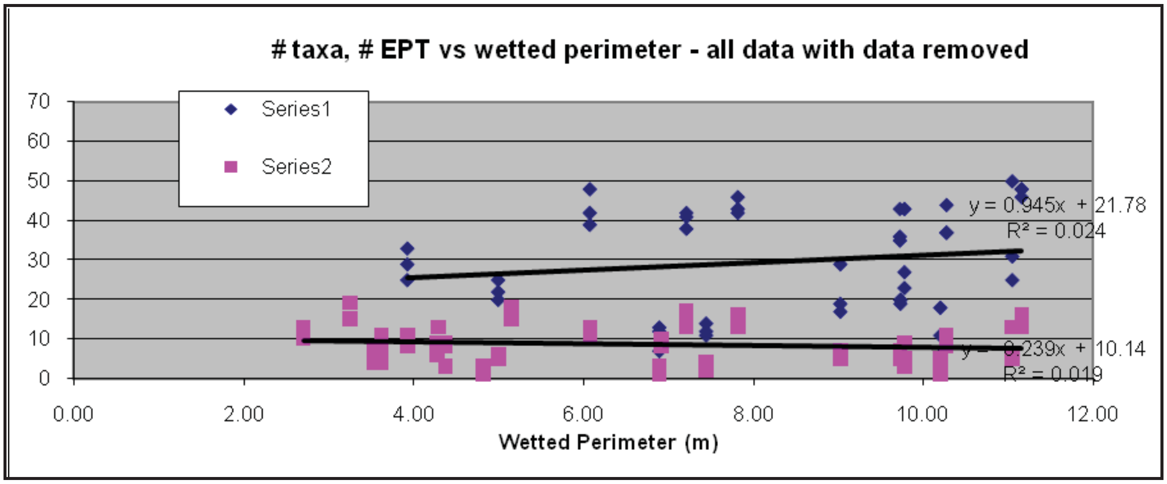






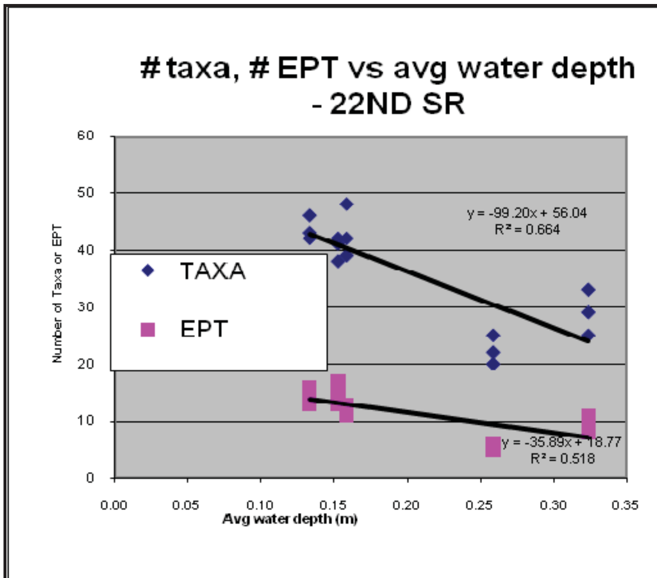


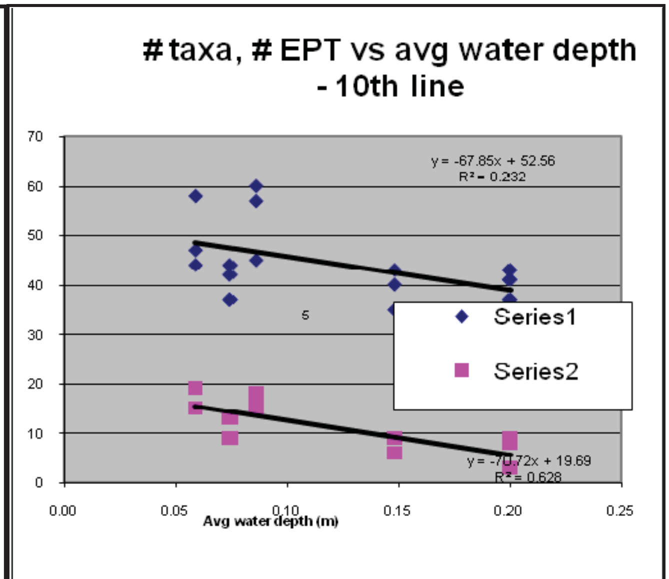


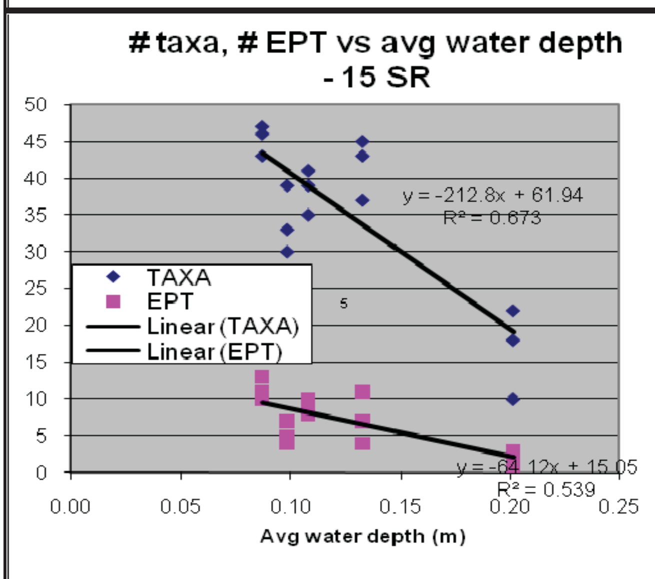


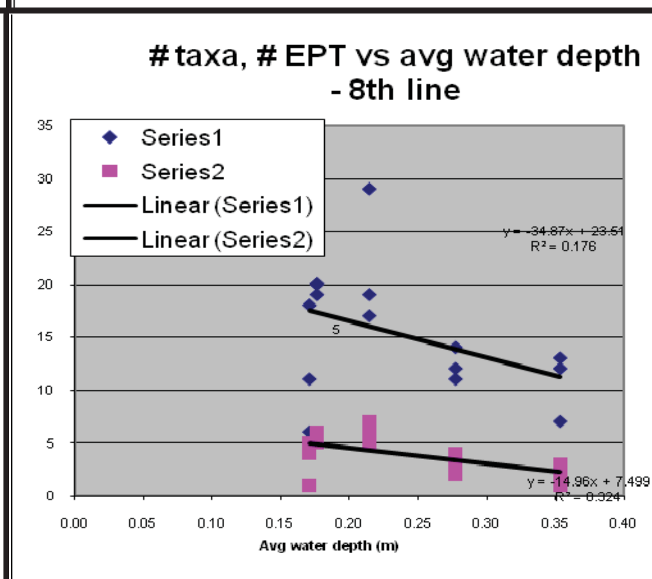
taxa, # EPT vs wetted perimeter - all data with data removed
Series1
Series2
y = 0.945x + 21.78
R² = 0.024
y = -0.239x + 10.14
R² = 0.019
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Wetted Perimeter (m)

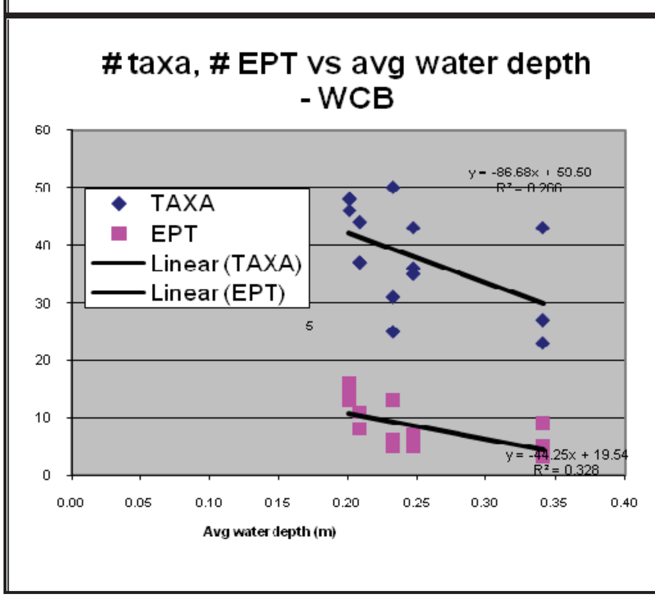
6.3 Number of Taxa or EPT versus Average Water Depth of Riffles and Pools

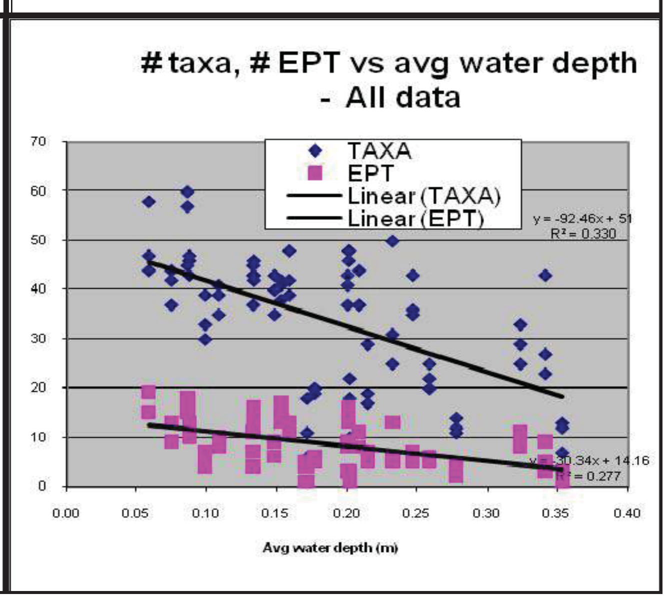




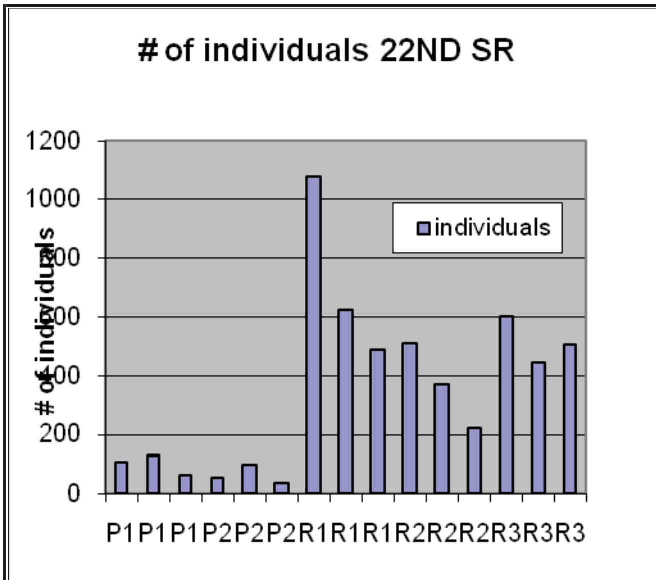


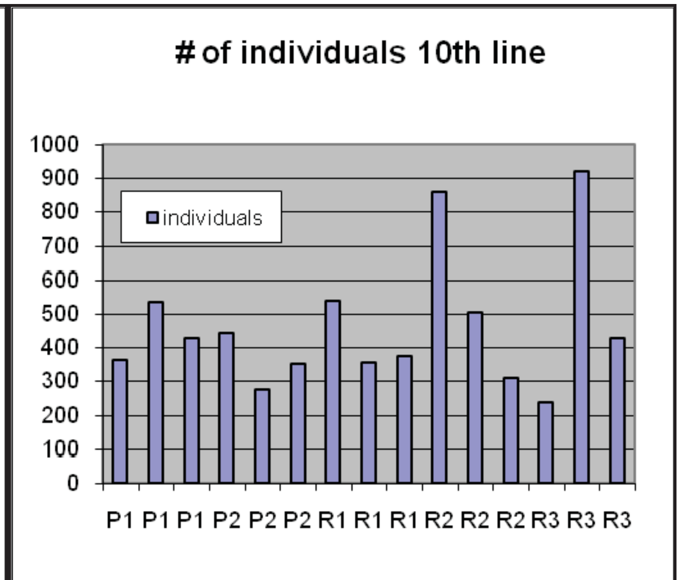


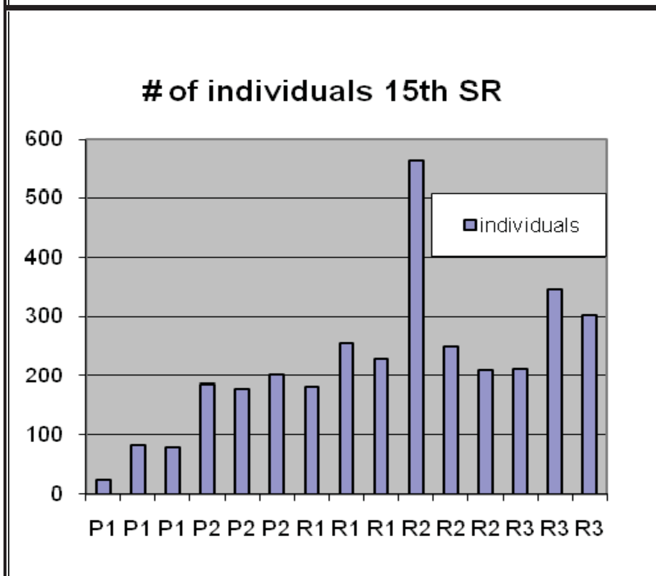


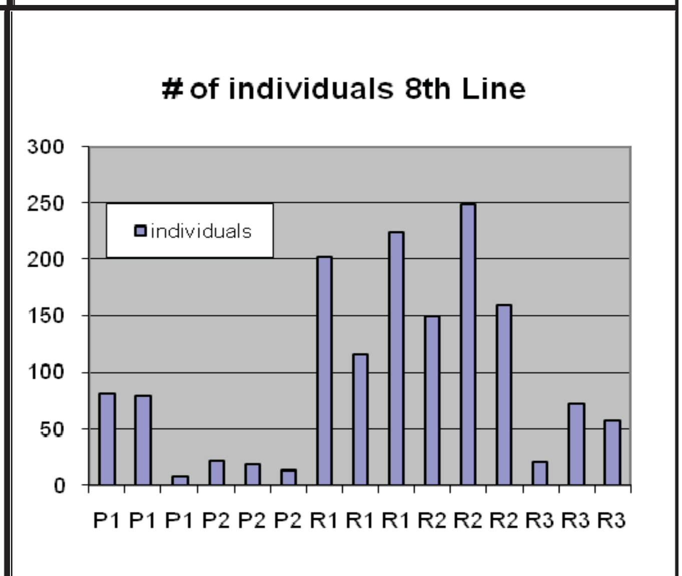


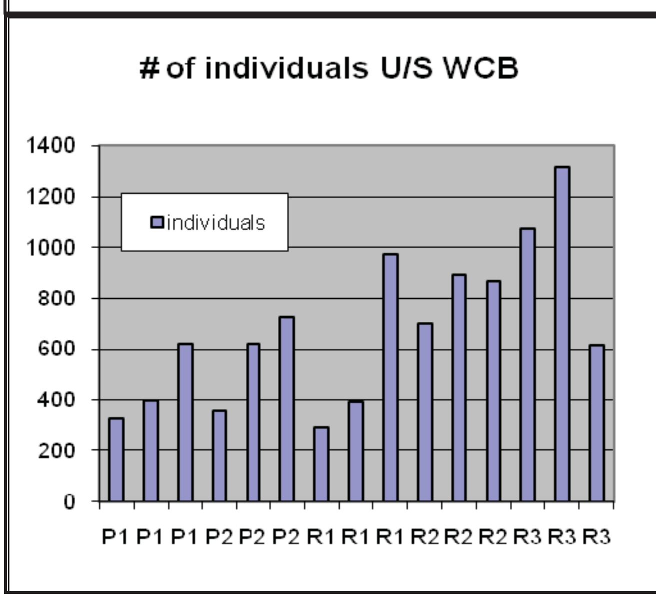
6.4 Number of Individuals found in Riffles and Pools

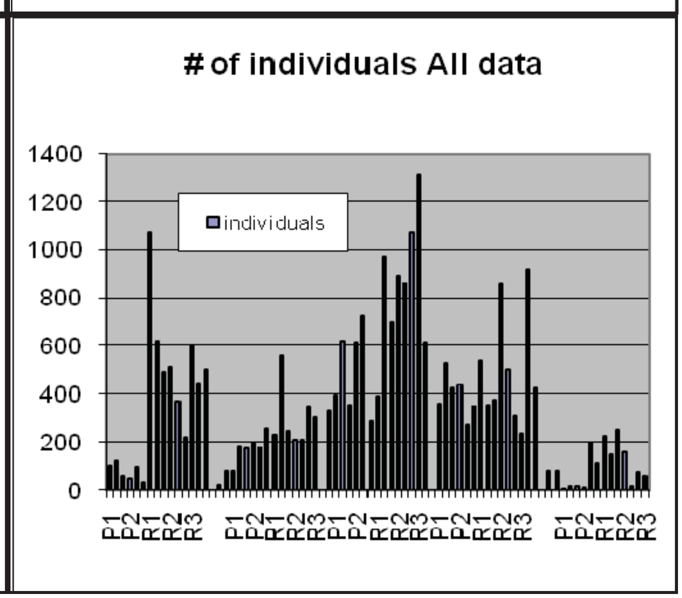


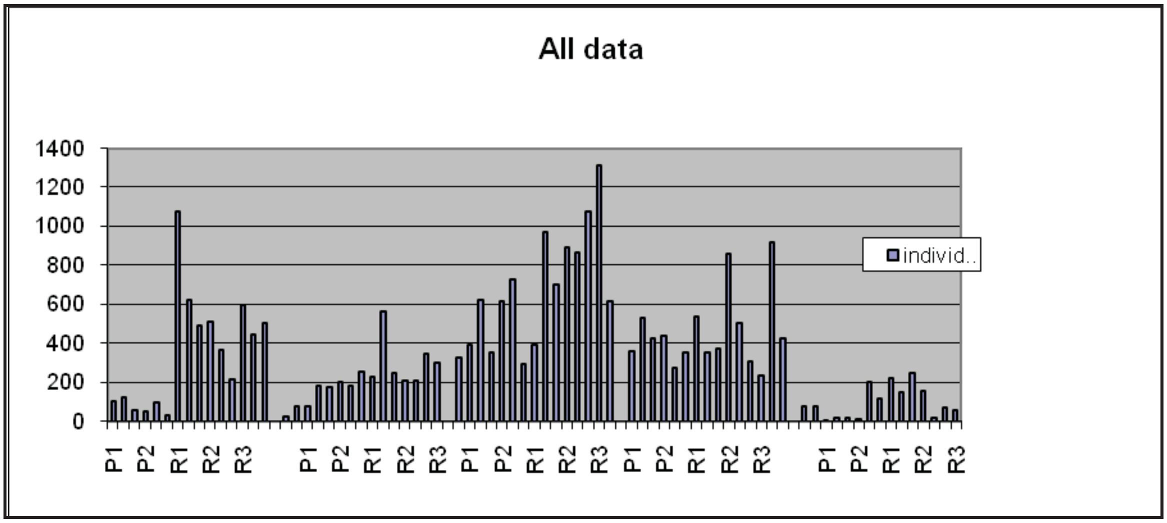






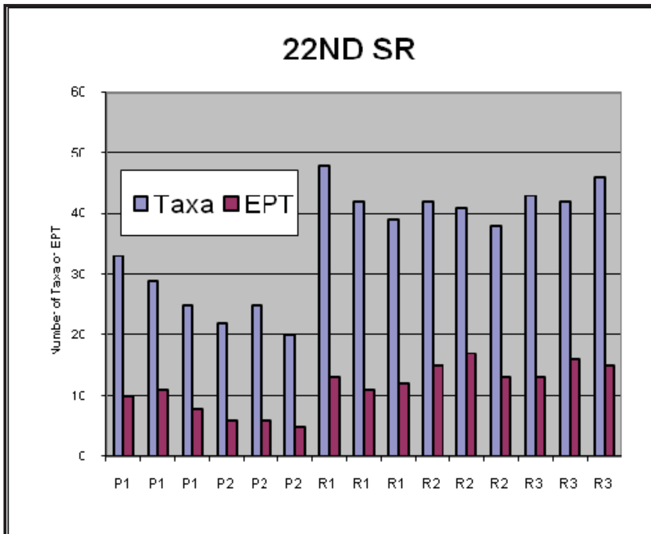


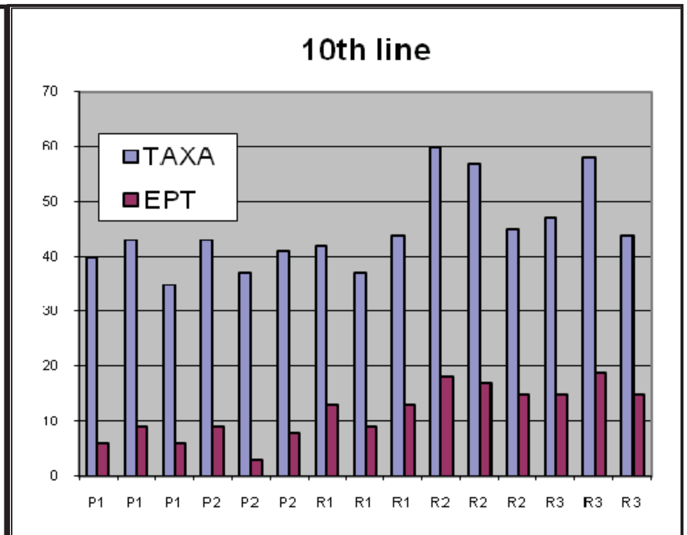


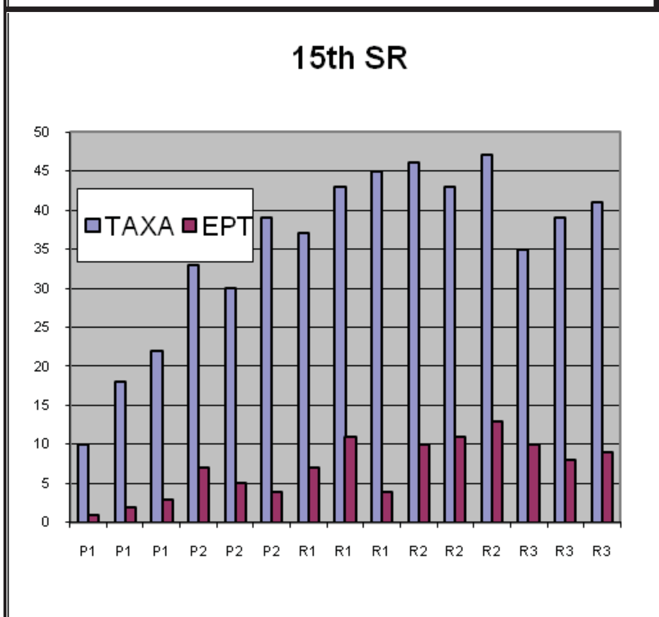


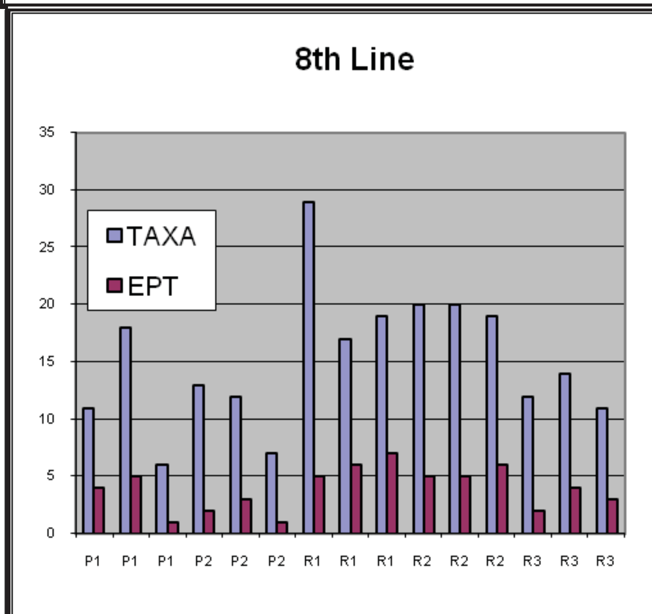
All data
1400
1200
1000
800
600
400
200
0
individ..
P1
P2
R1
R2
R3

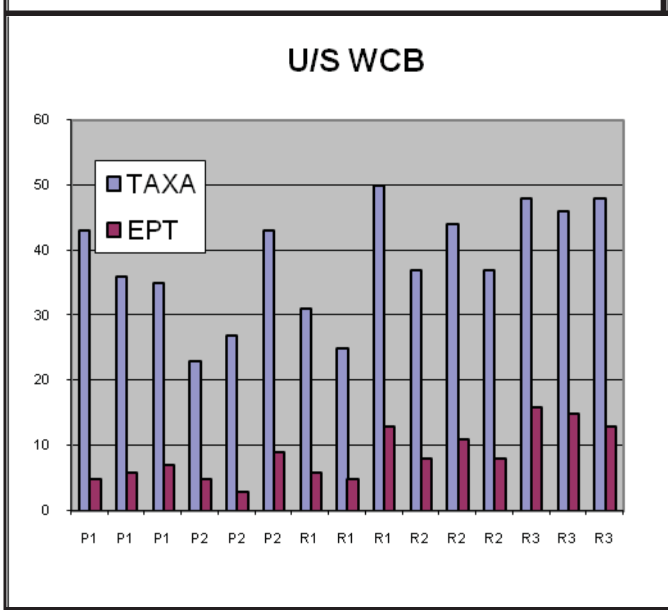
6.5 Number of Taxa or EPT found in Pools and Riffles

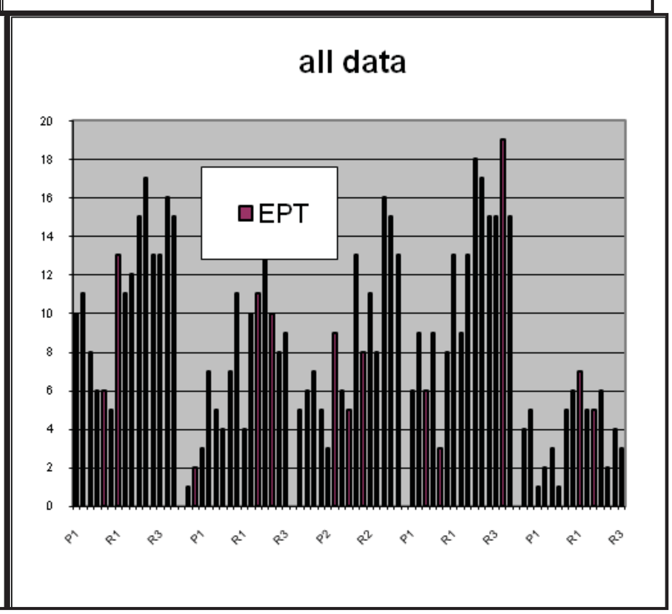


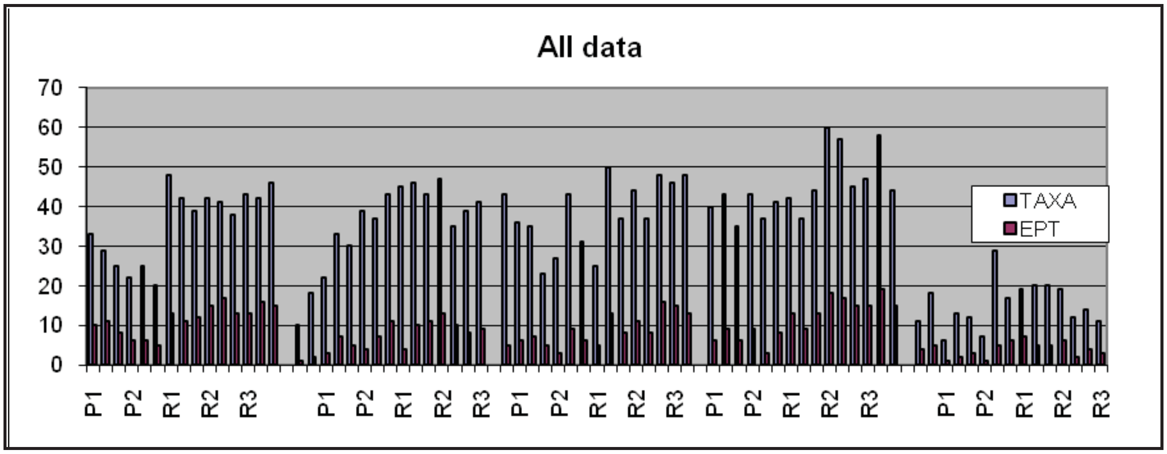






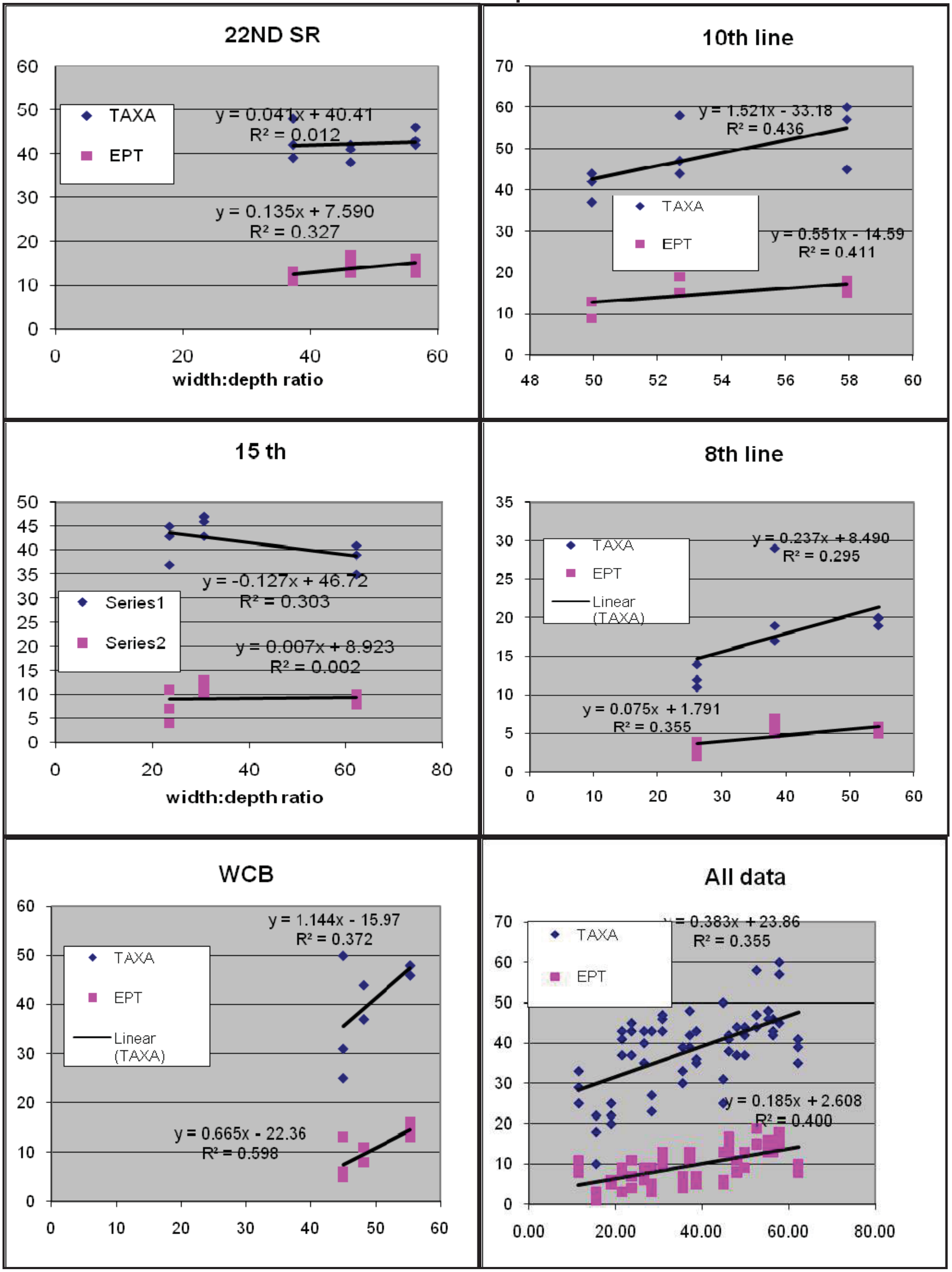




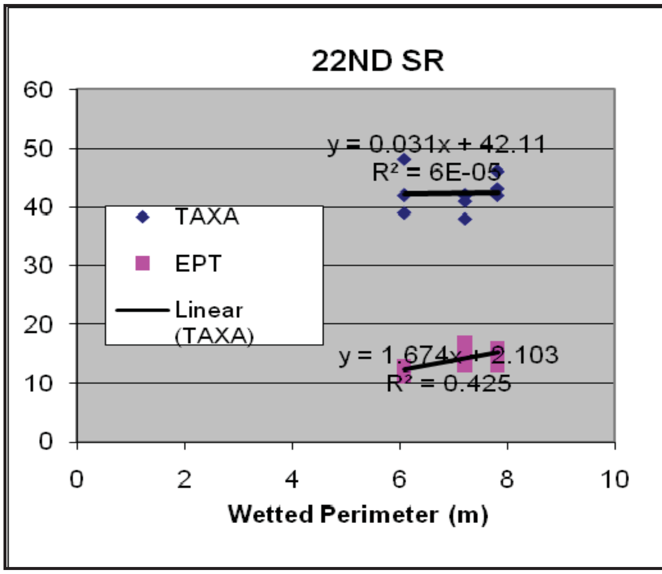


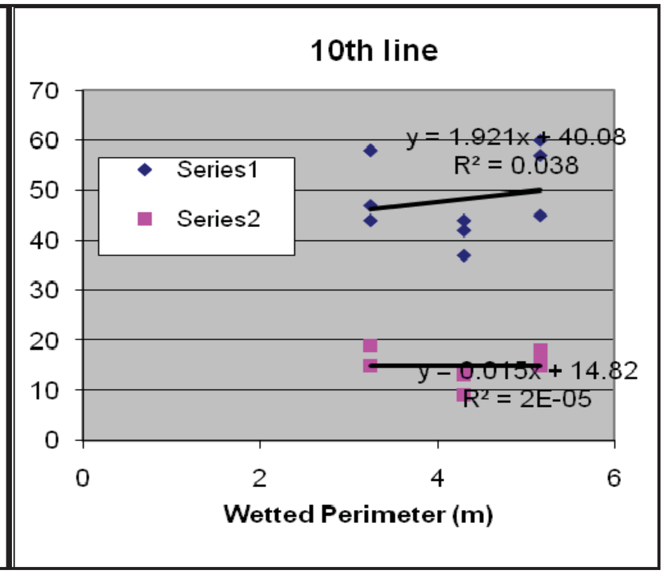
All data
70
60
50
40
30
20
10
0
TAXA
EPT
P1
P2
R1
R2
R3
P1
P2
R1
R2
R3
P1
P2
R1
R2
R3
P1
P2
R1
R2
R3
P1
P2
R1
R2
R3

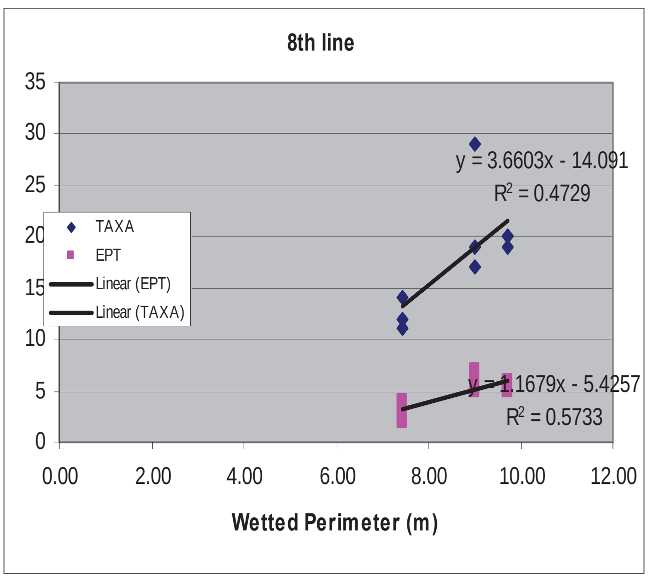
6.6 Number of Taxa or EPT versus Width:Depth Ratio of Riffles

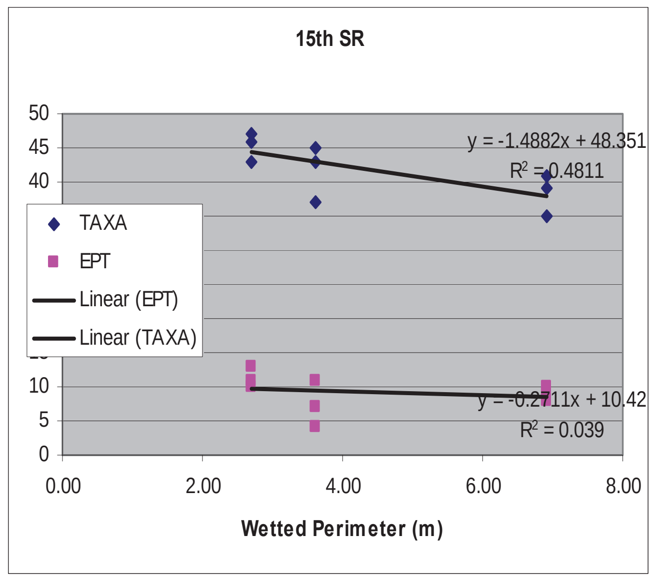


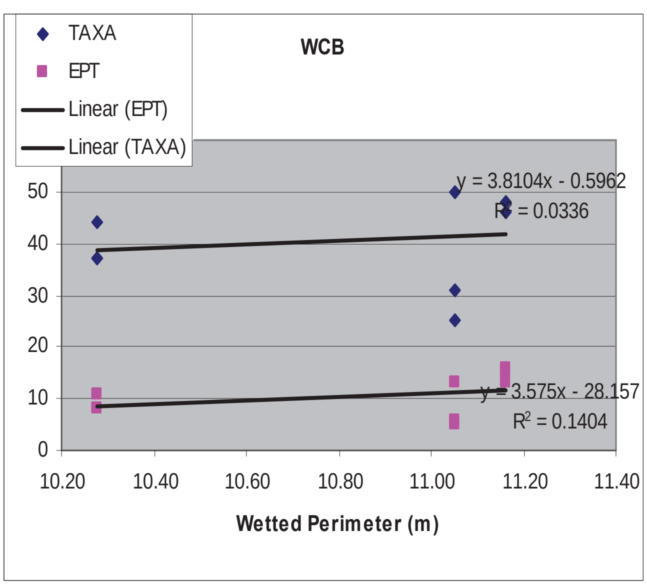
6.7 Number of Taxa or EPT versus Wetted Perimeter of Riffles

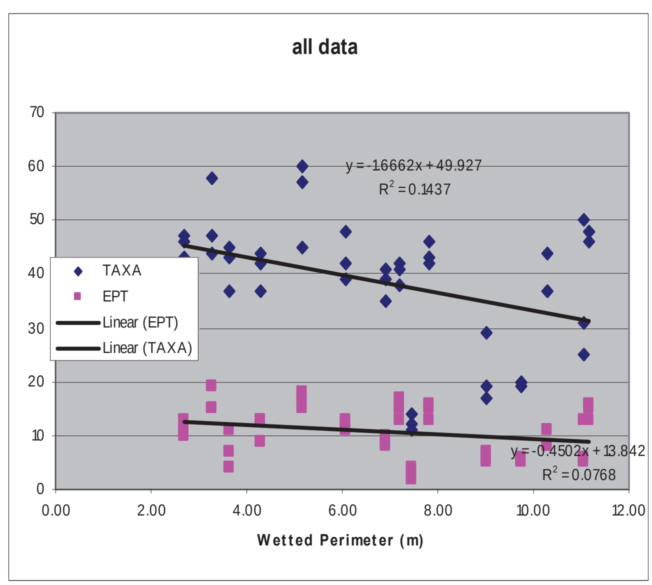




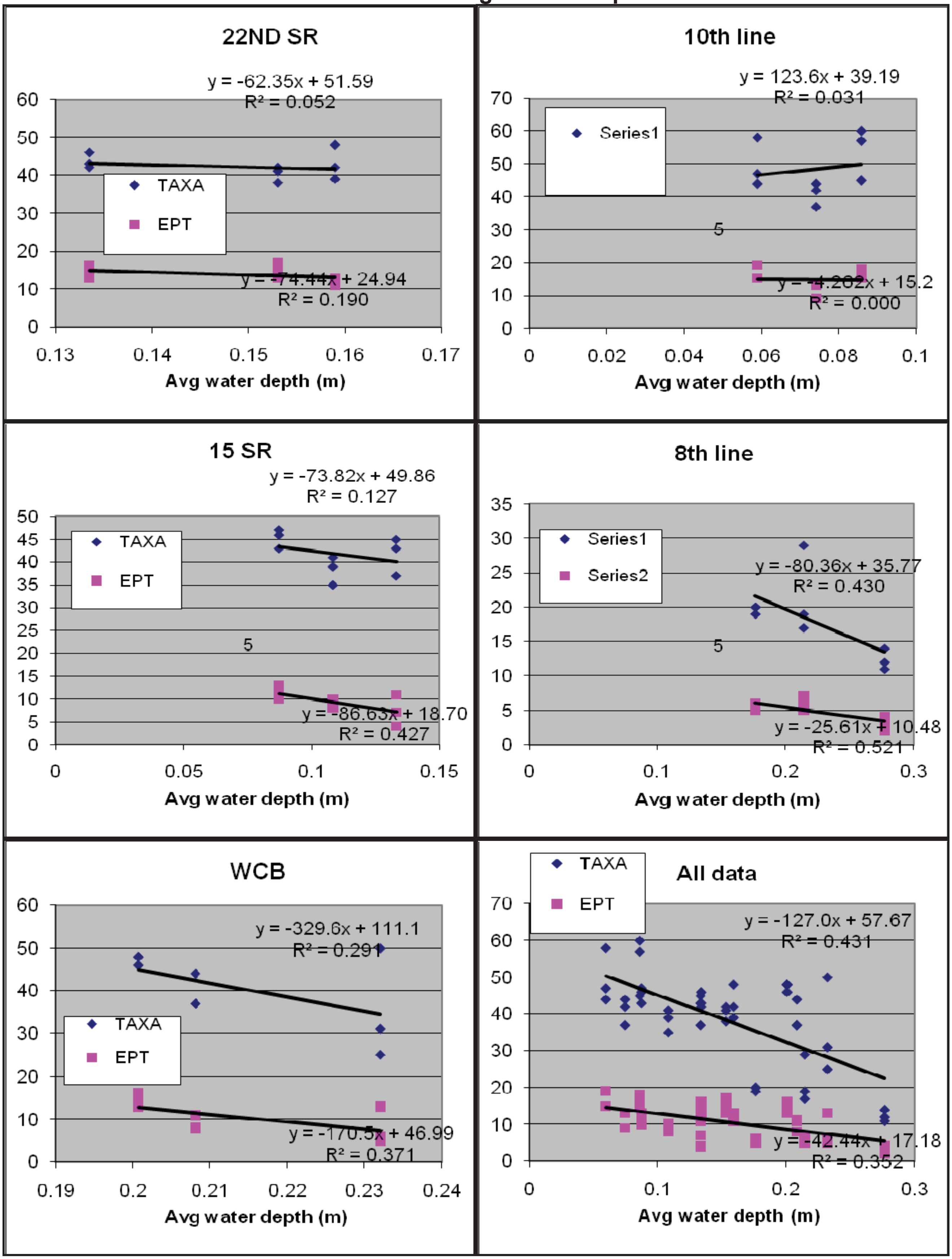




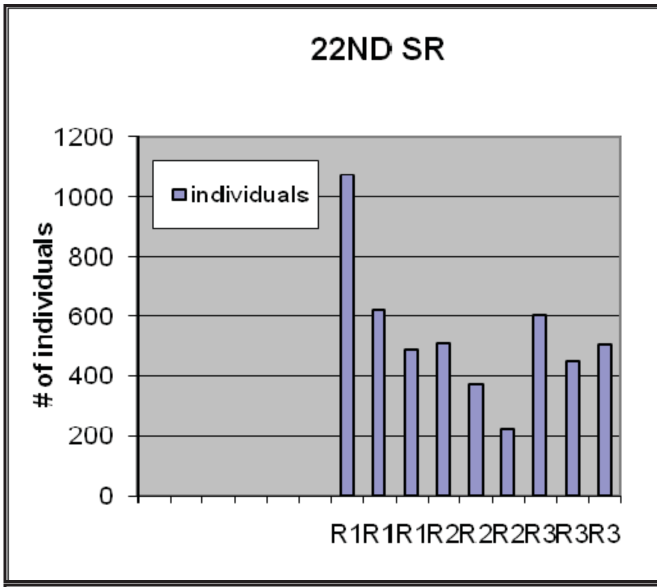


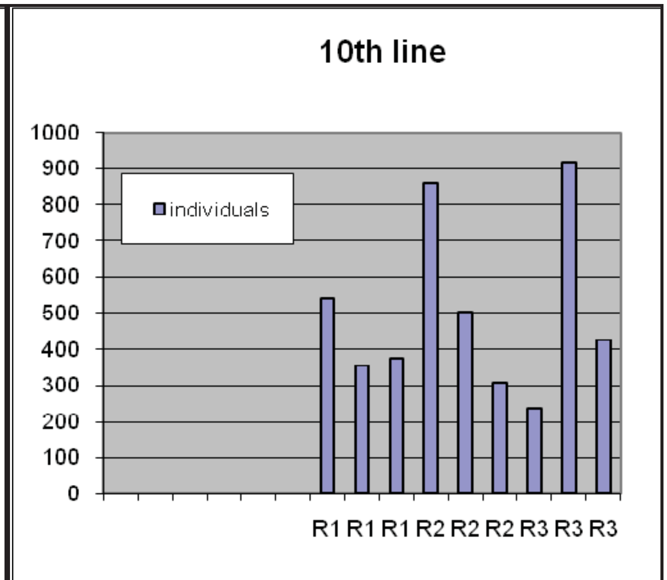


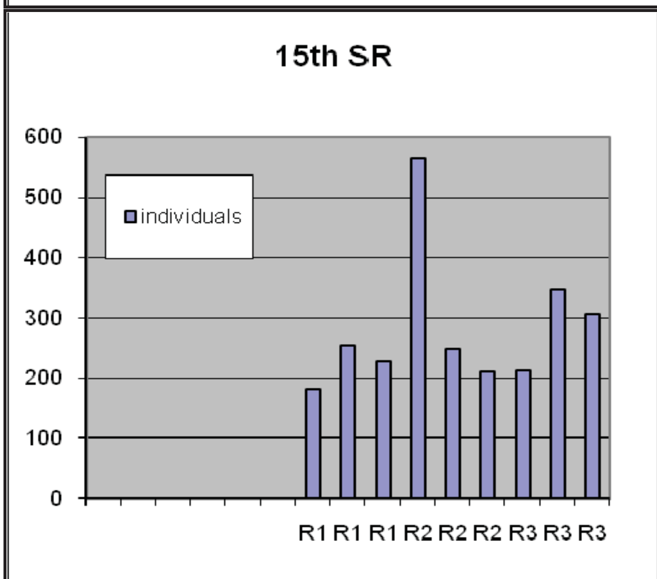
6.8 Number of Taxa or EPT versus Average Water Depth of Riffles

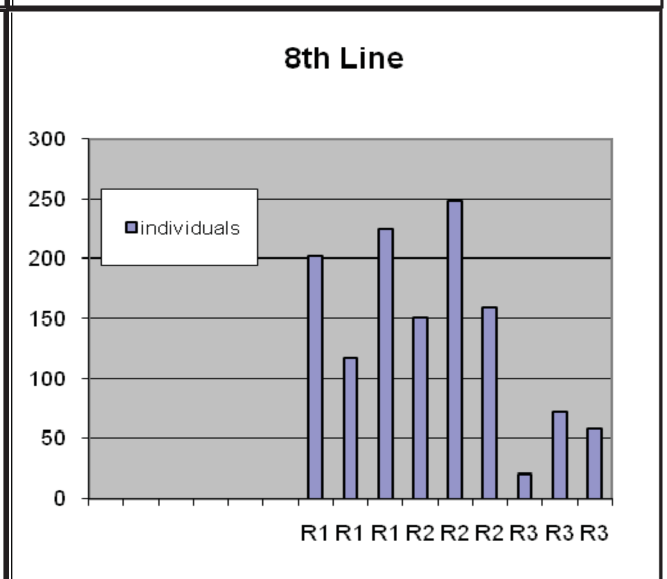


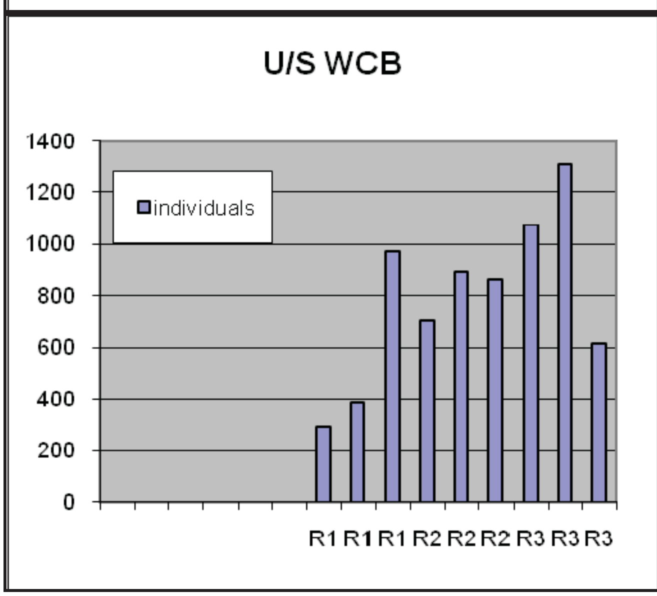
6.9 Number of Individuals found in Riffles

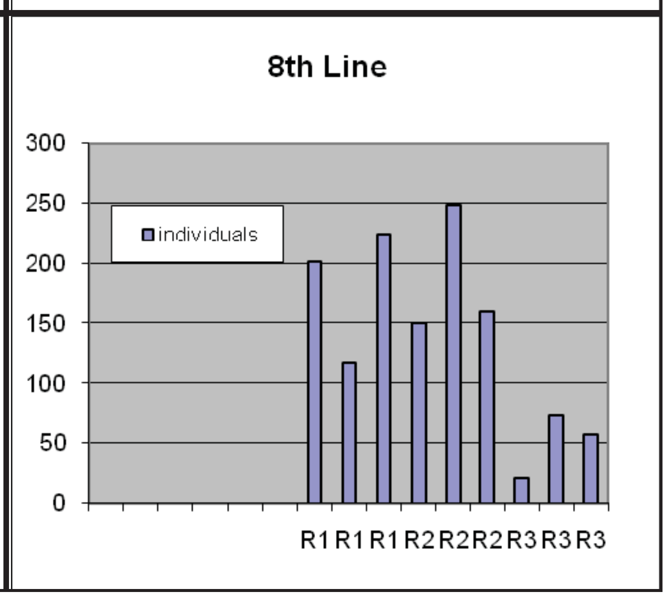


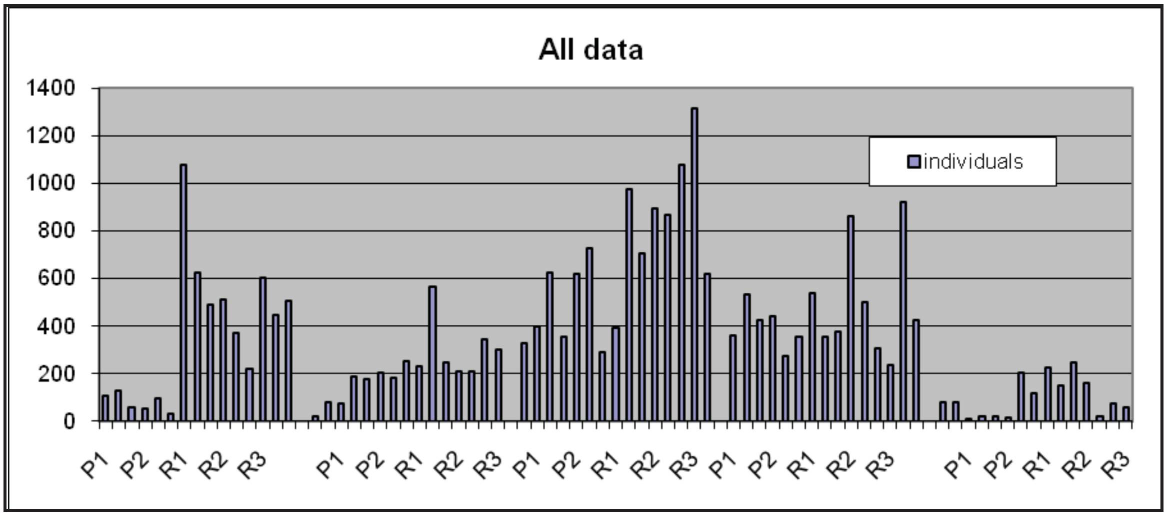




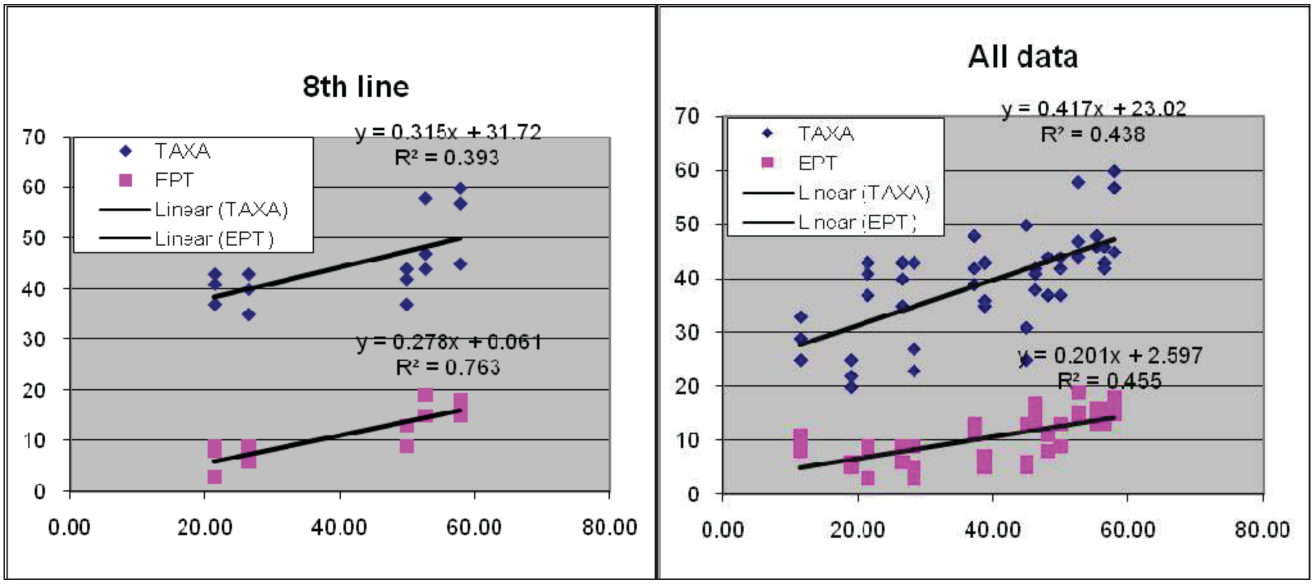






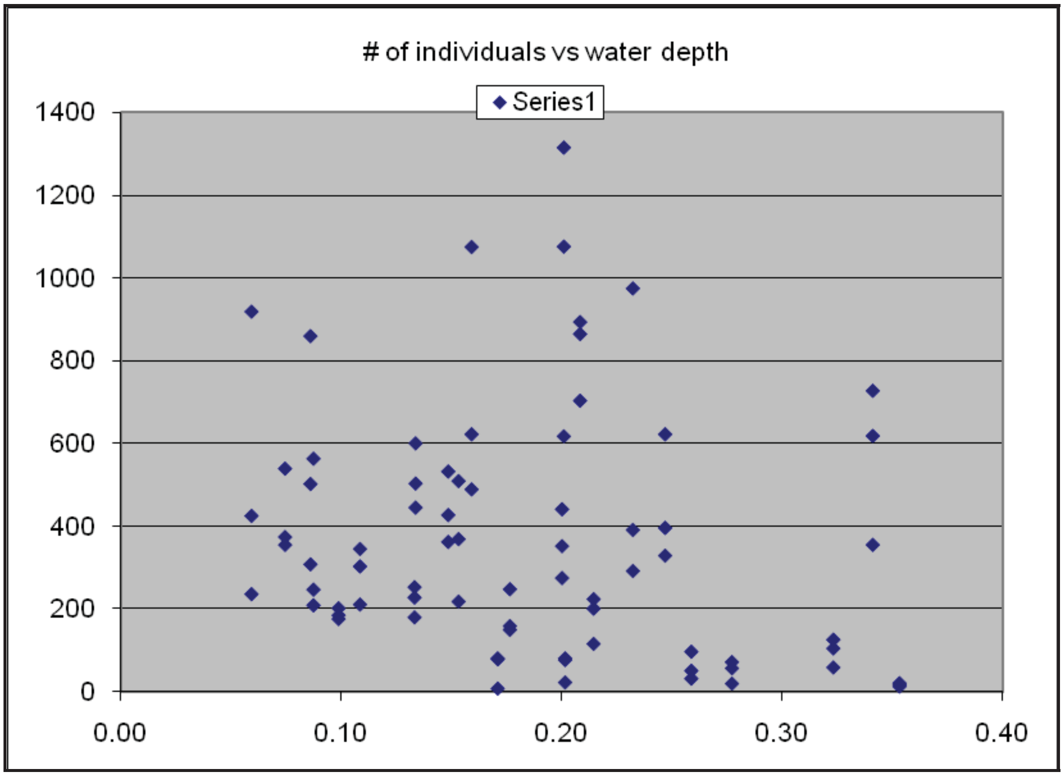

All data
1400
1200
1000
800
600
400
200
0
individuals
P1
P2
R1
R2
R3
P1
P2
R1
R2
R3
P1
P2
R1
R2
R3
P1
P2
R1
R2
R3
P1
P2
R1
R2
R3

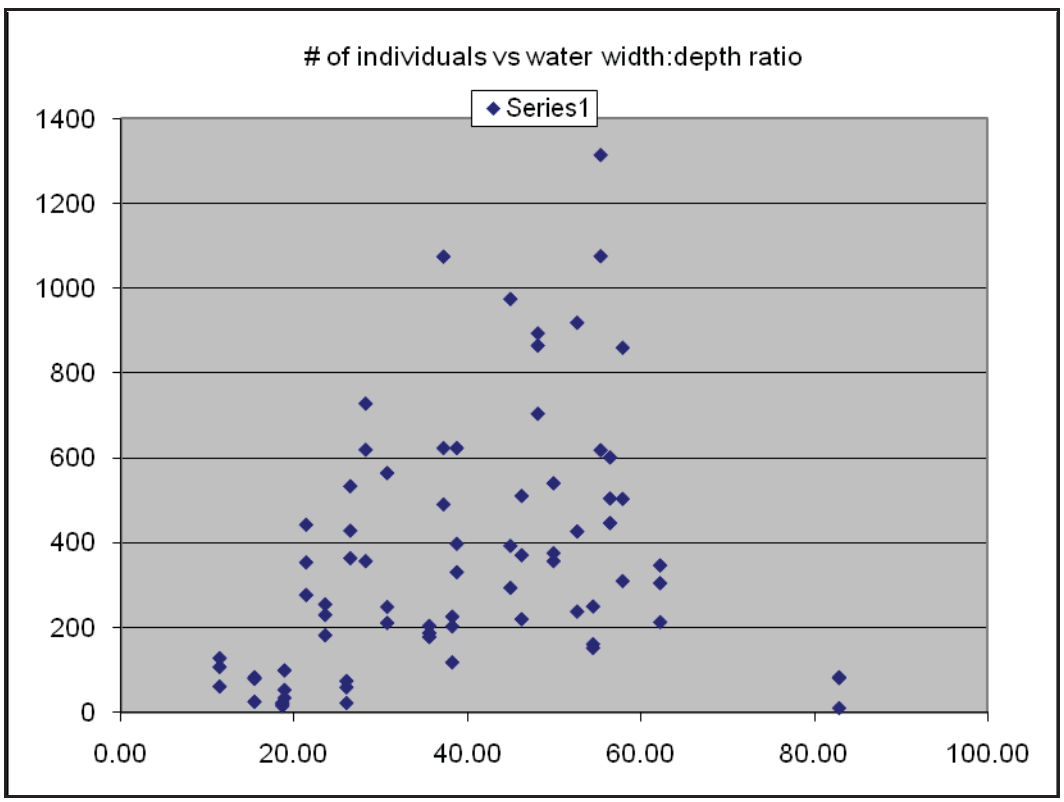
6.10 Number of Taxa or EPT versus Width:Depth Ratio

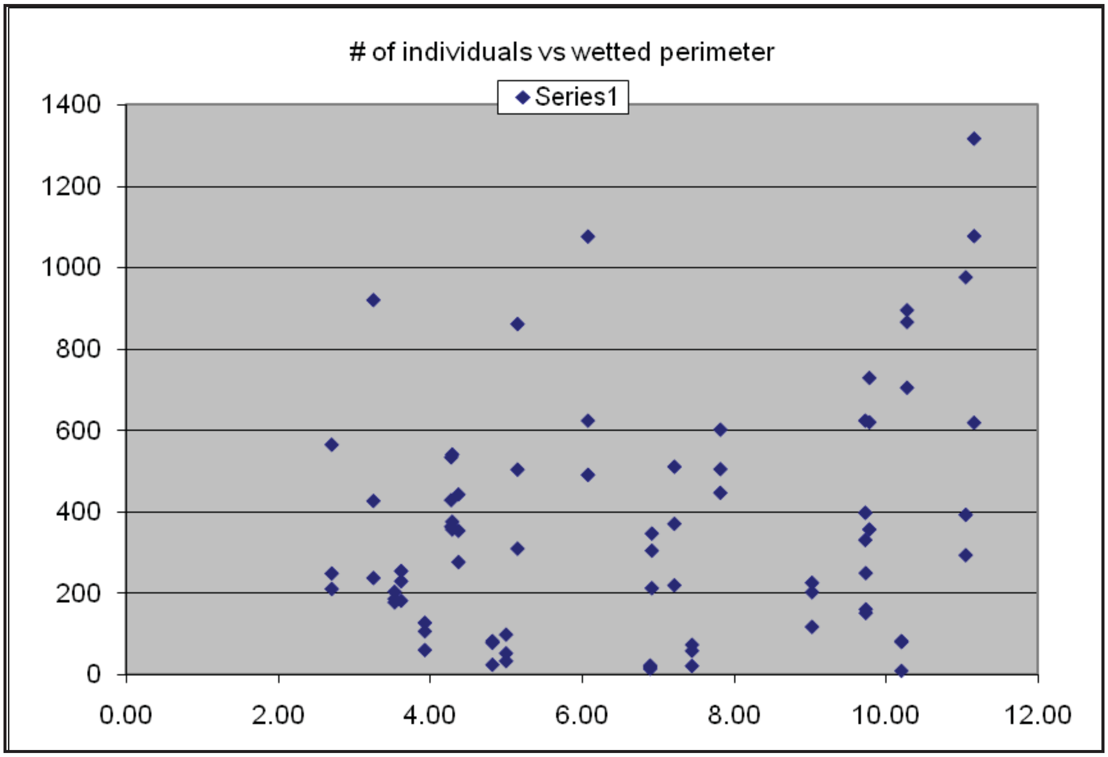


7.0 Benthic Indicators vs Bankfull Parameters

7.1 Number of Individual versus Water Depth; Width:Depth Ratio; and Wetted Perimeter

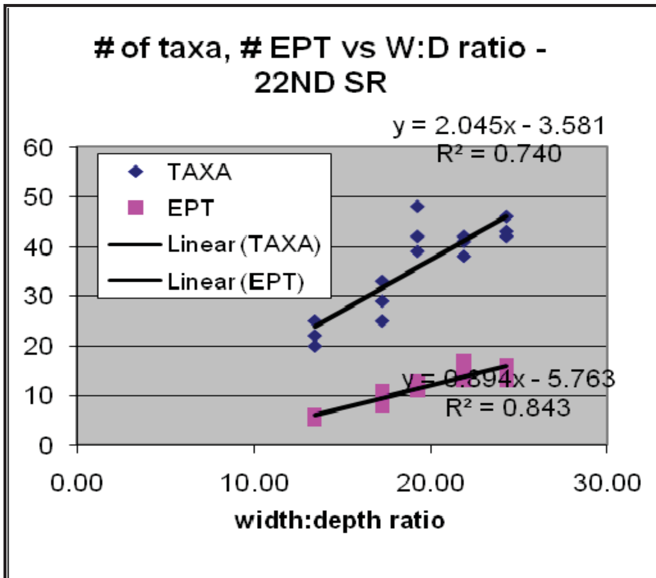


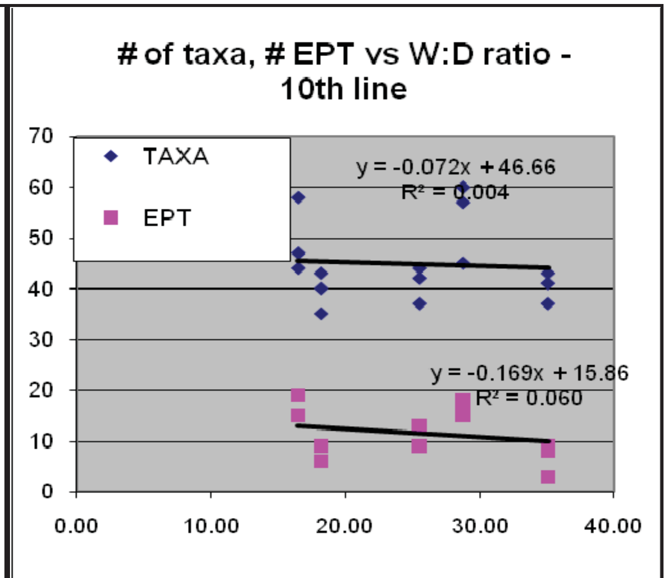


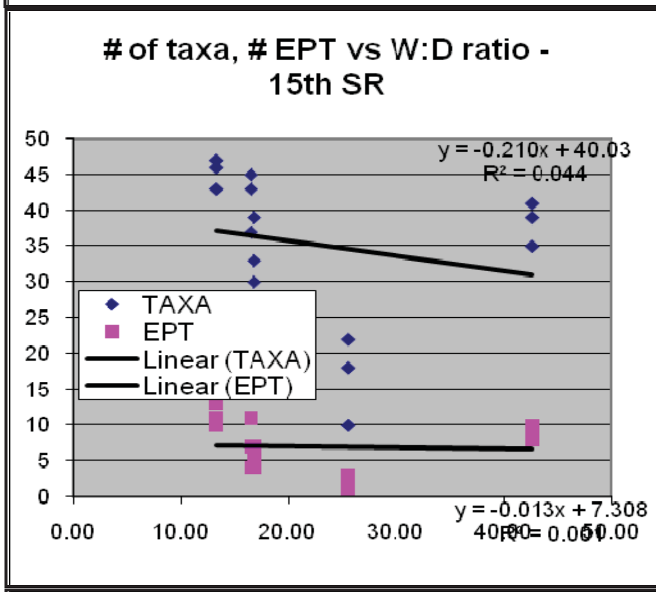


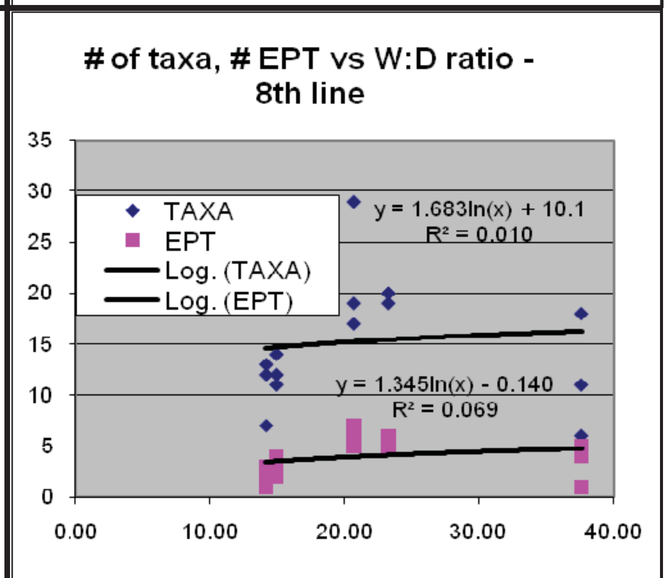
# of individuals vs wetted perimeter
Series1
1400
1200
1000
800
600
400
200
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00

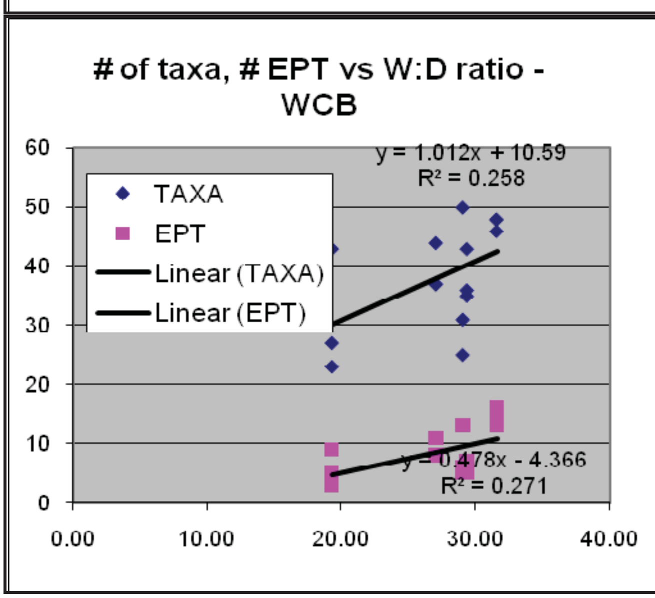
7.2 Number of Taxa and EPT versus Width:Depth Ratio

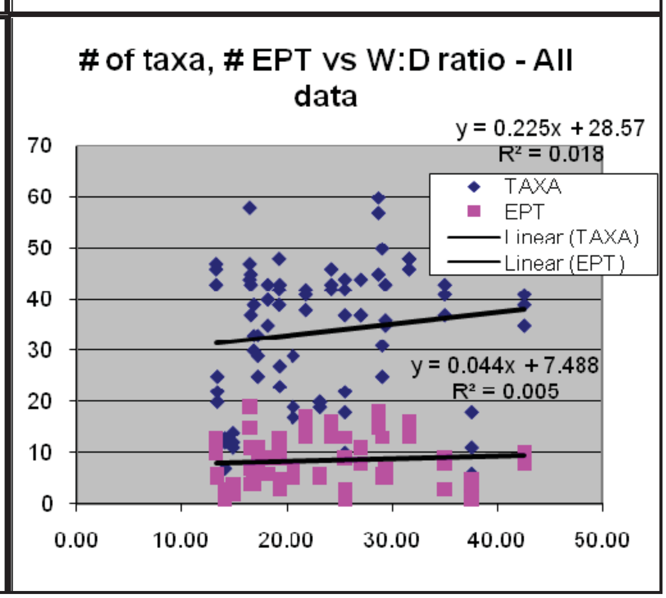


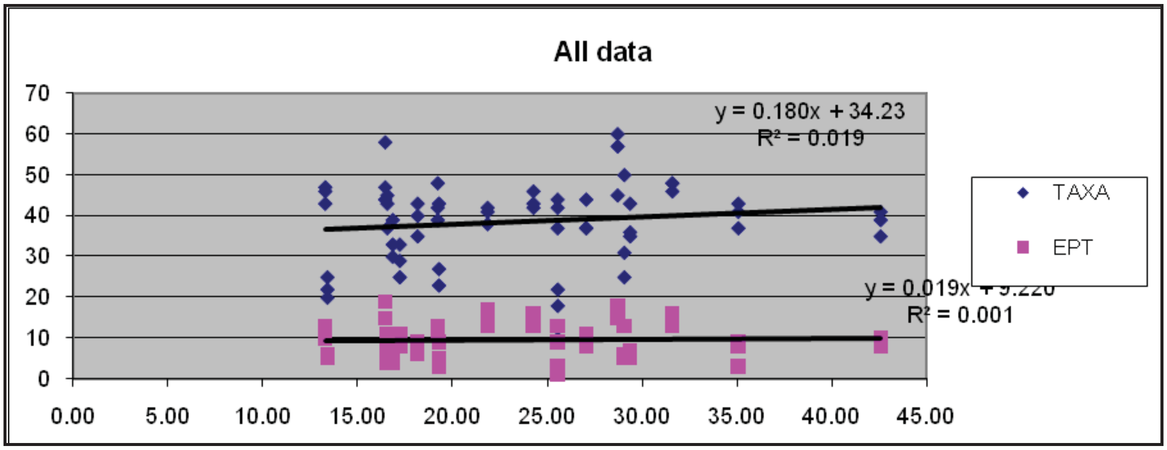




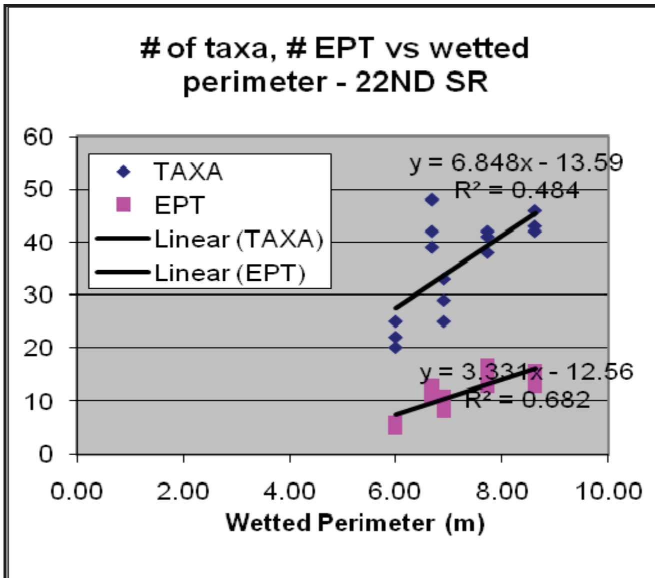


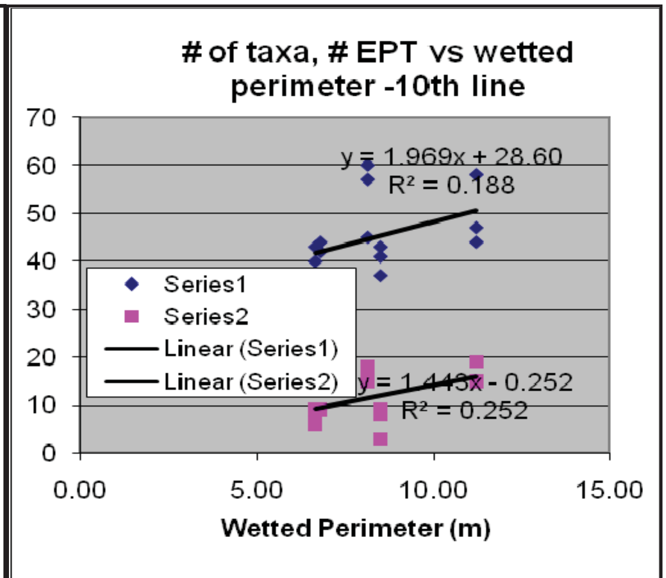


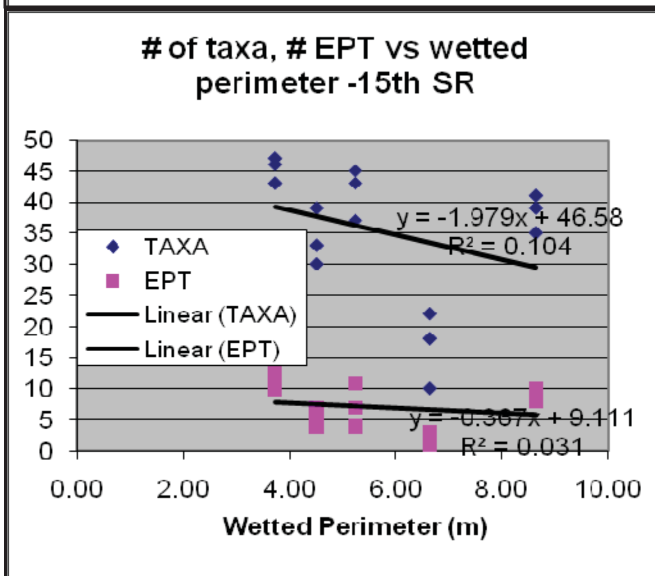


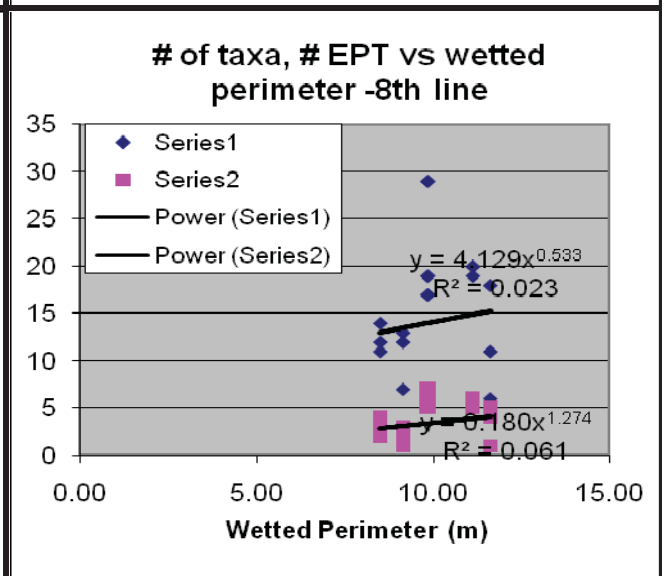

All data
y = 0.180x + 34.23
R² = 0.019
y = 0.019x + 9.220
R² = 0.001
TAXA
EPT
70
60
50
40
30
20
10
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00

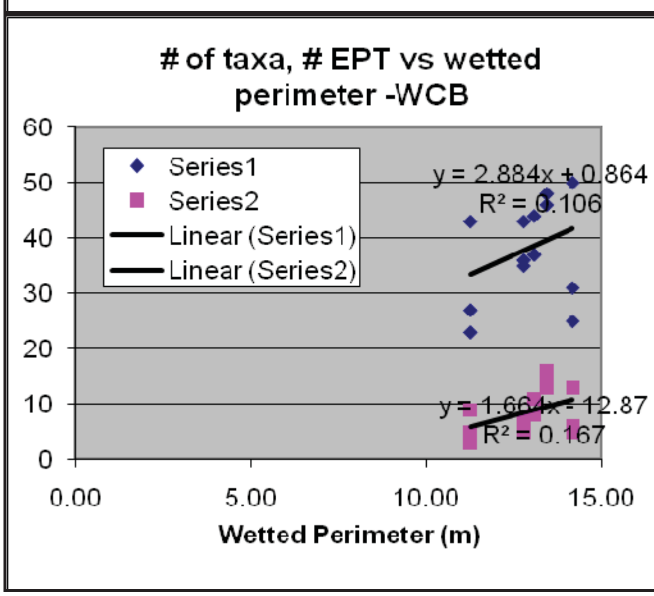
7.3 Number of Taxa and EPT versus Wetted Perimeter

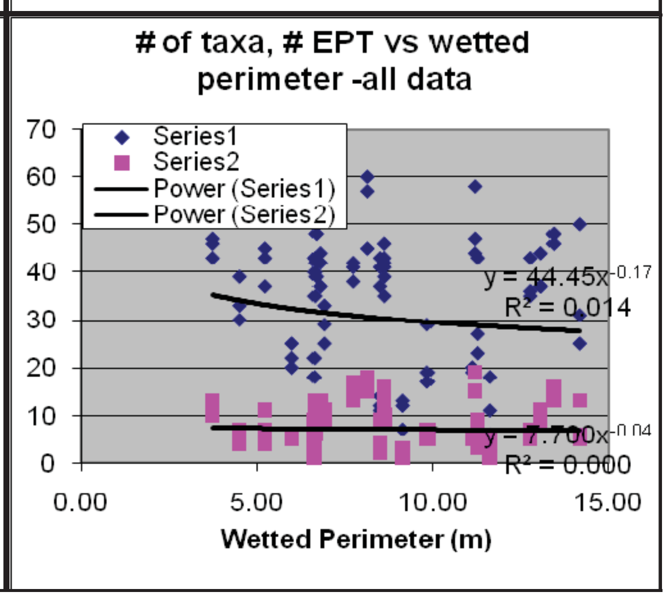




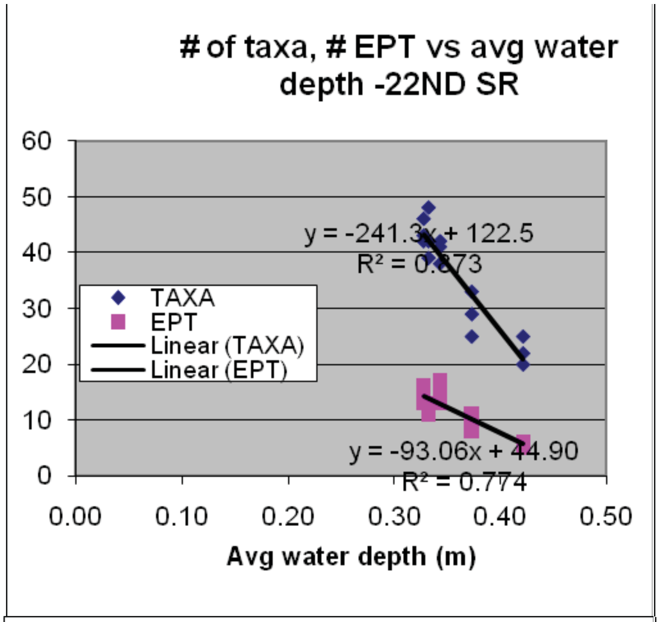


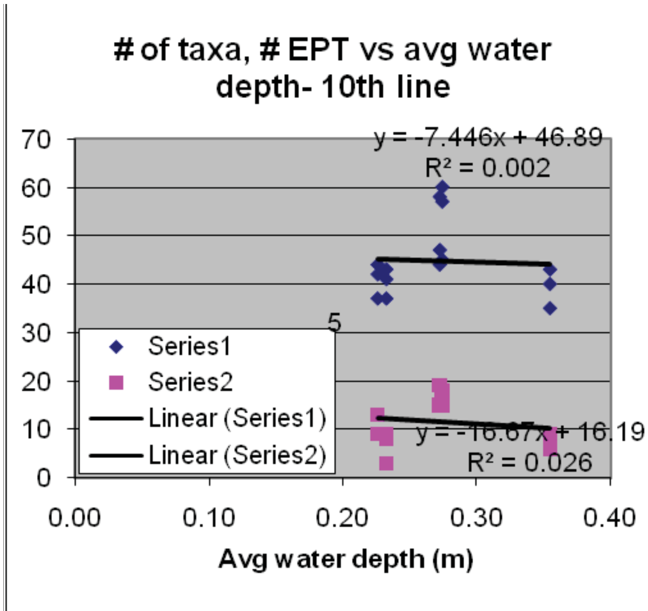


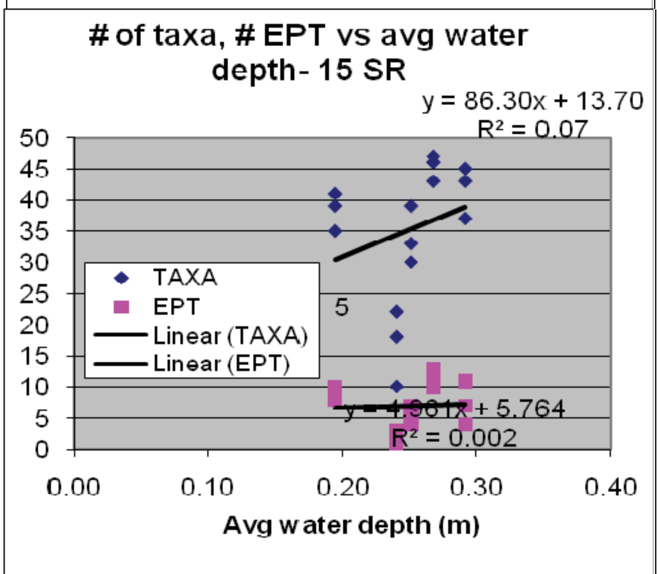


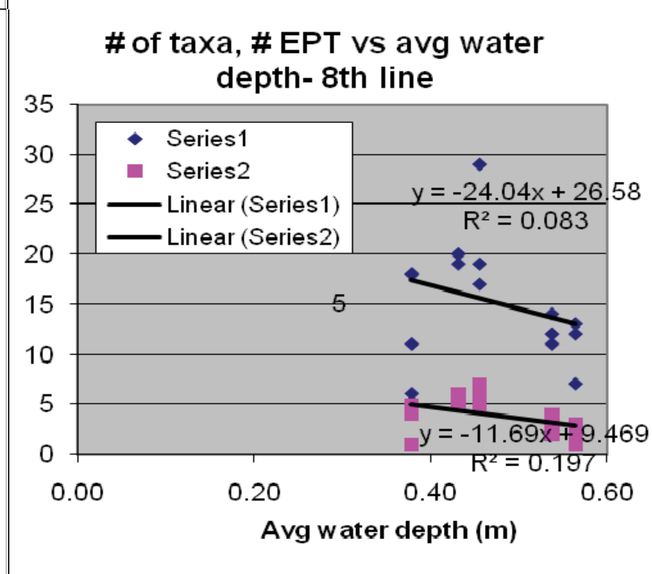


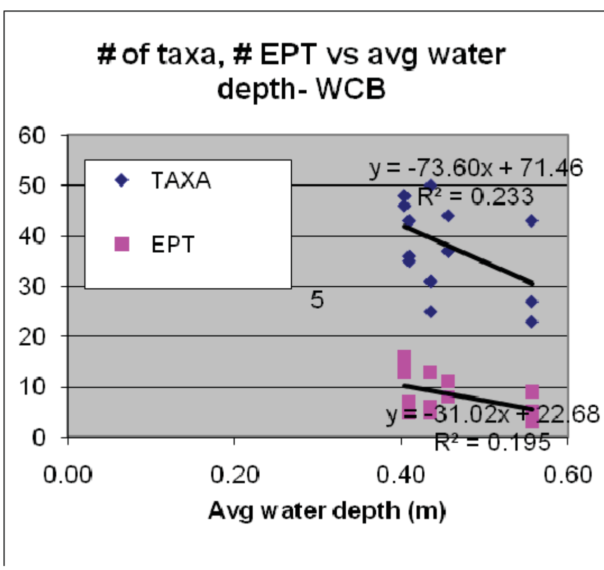
7.4 Number of Taxa and EPT versus Average Wetted Depth

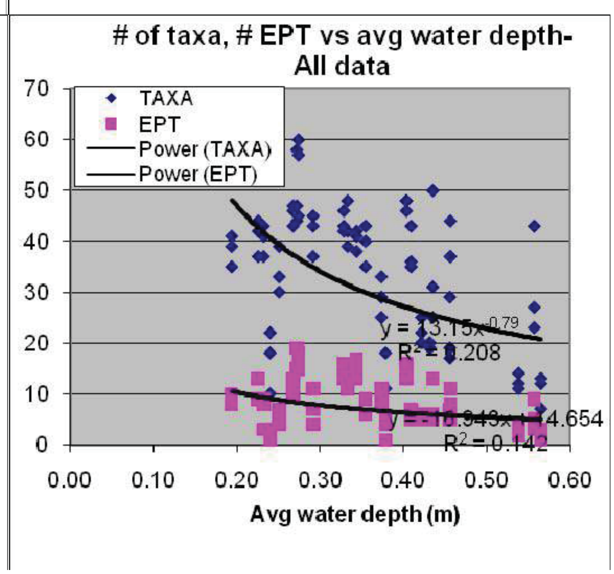




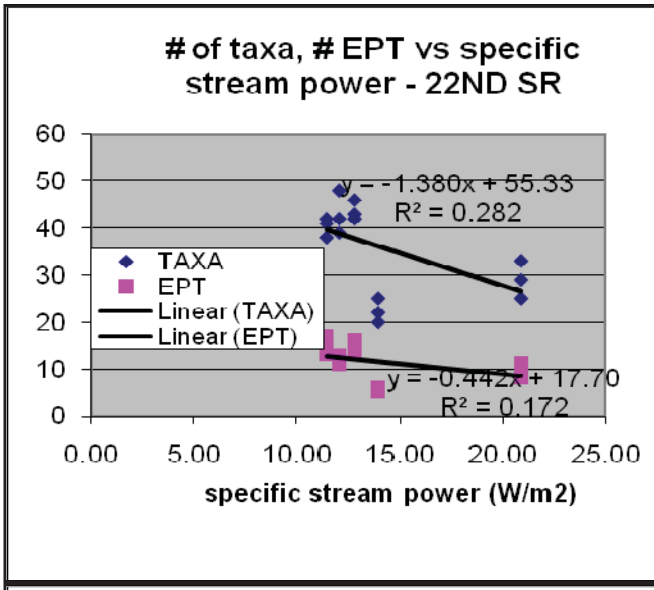


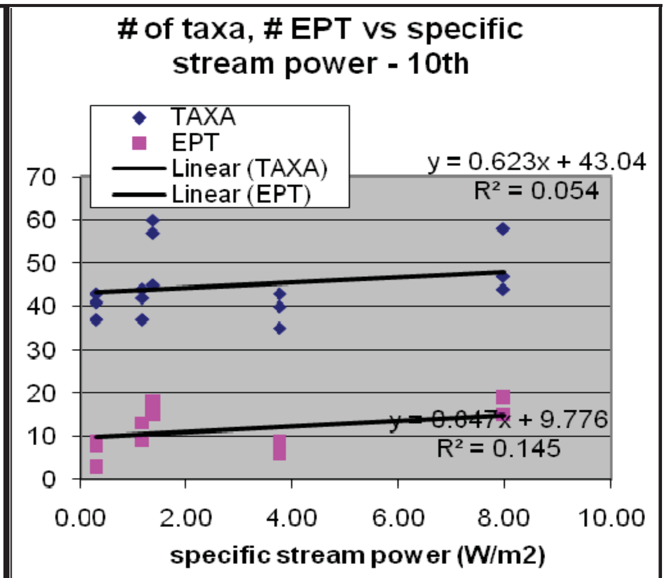


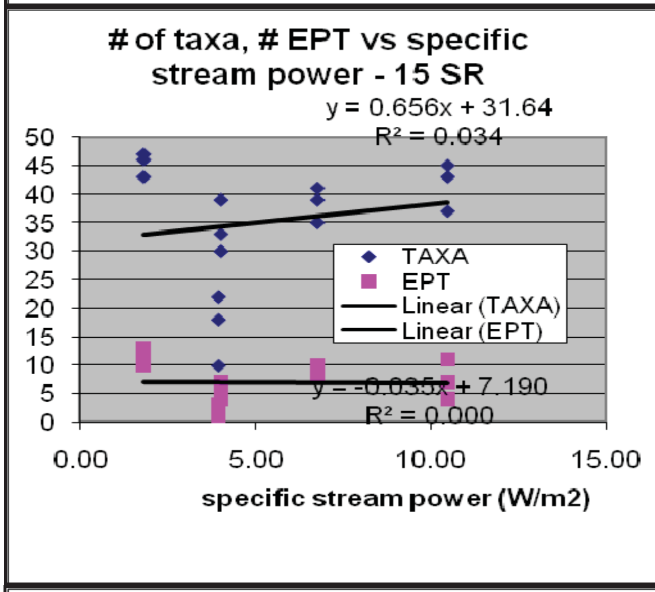


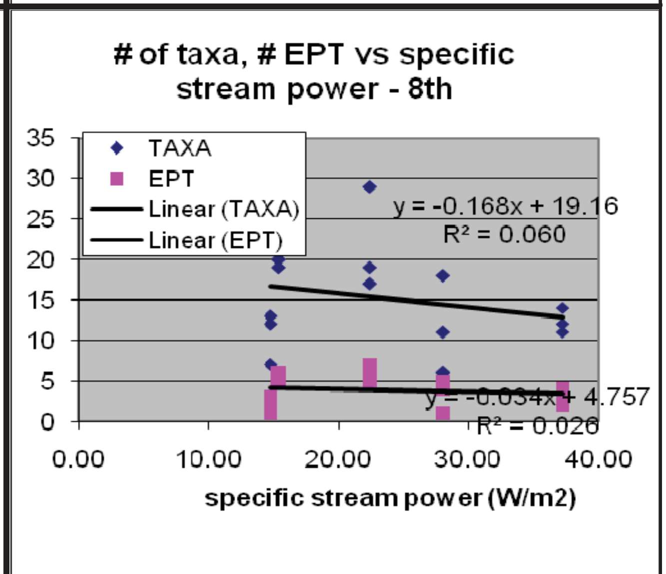


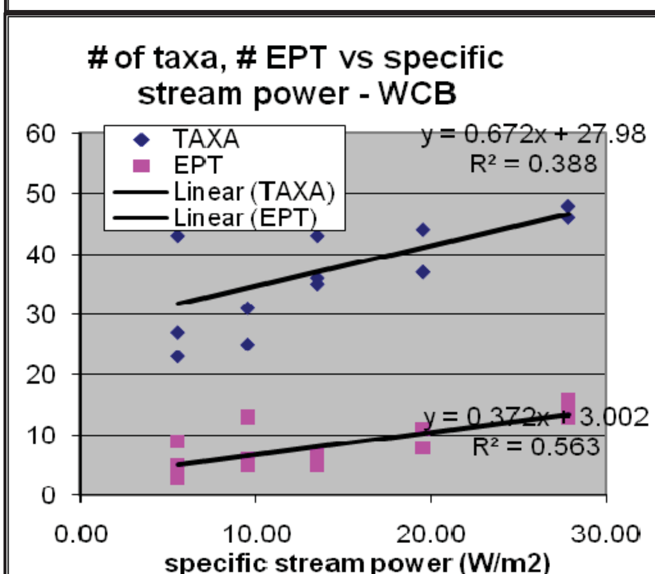
7.5 Number of Taxa and EPT versus Specific Stream Power

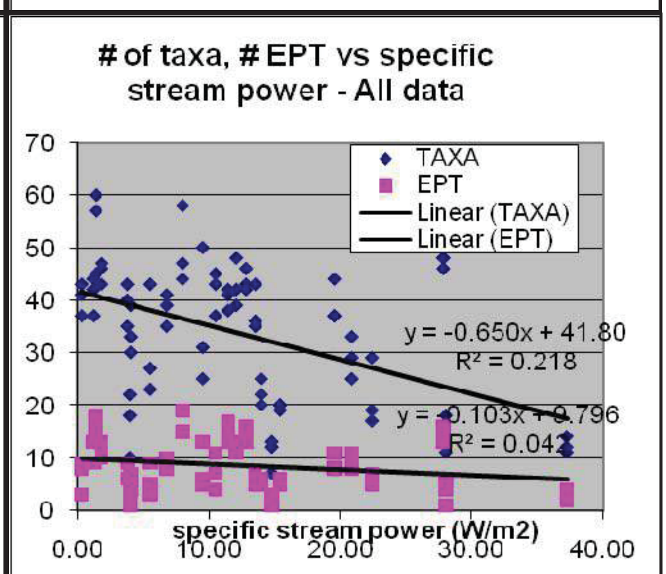




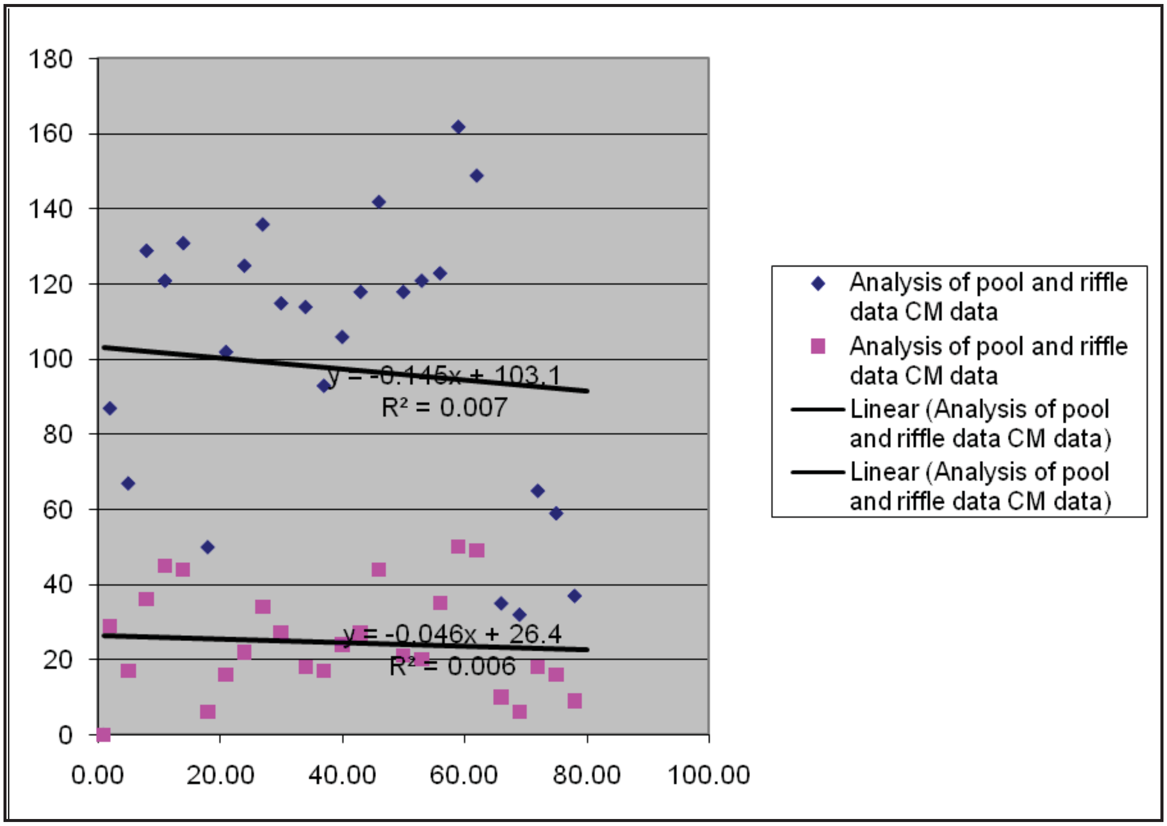




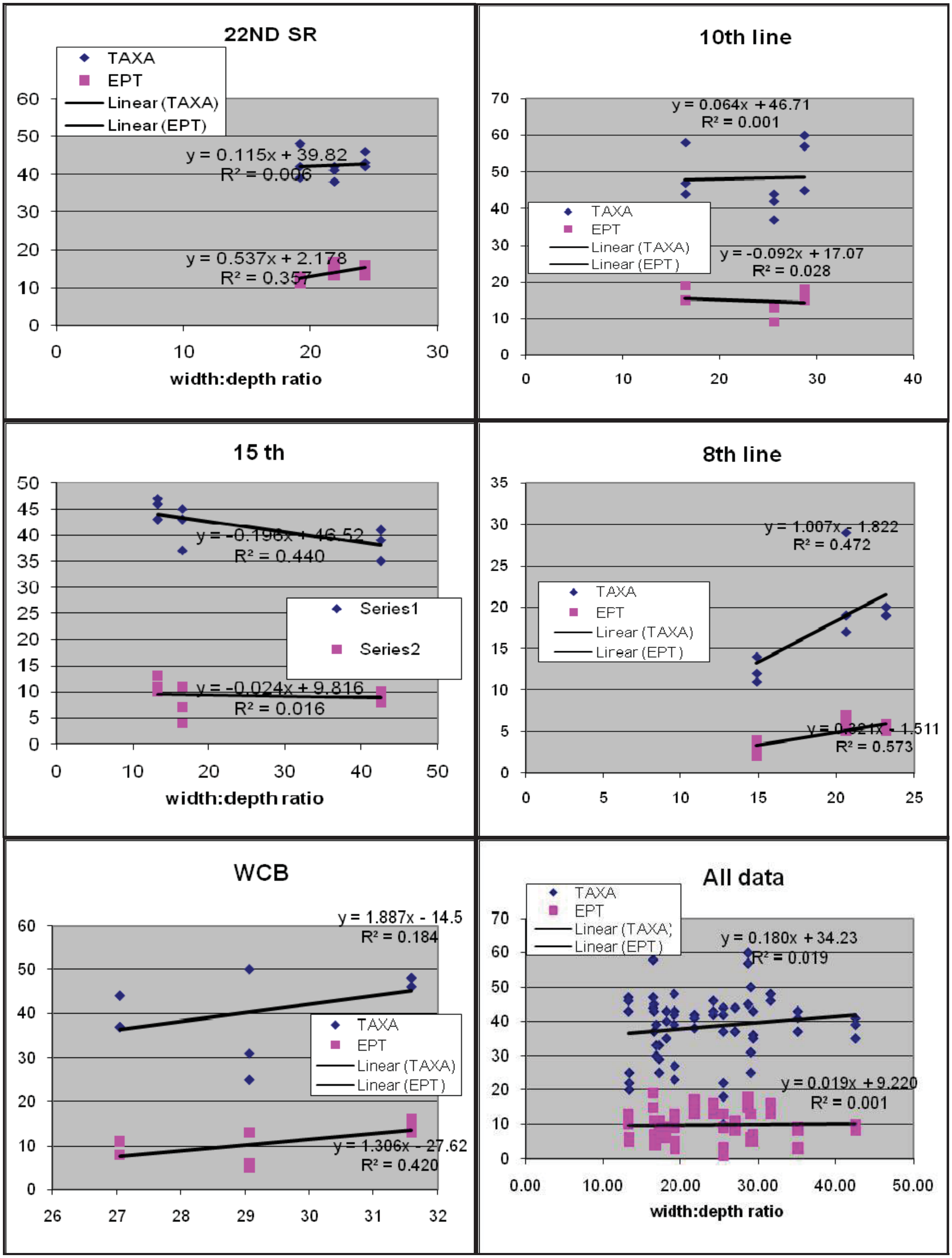




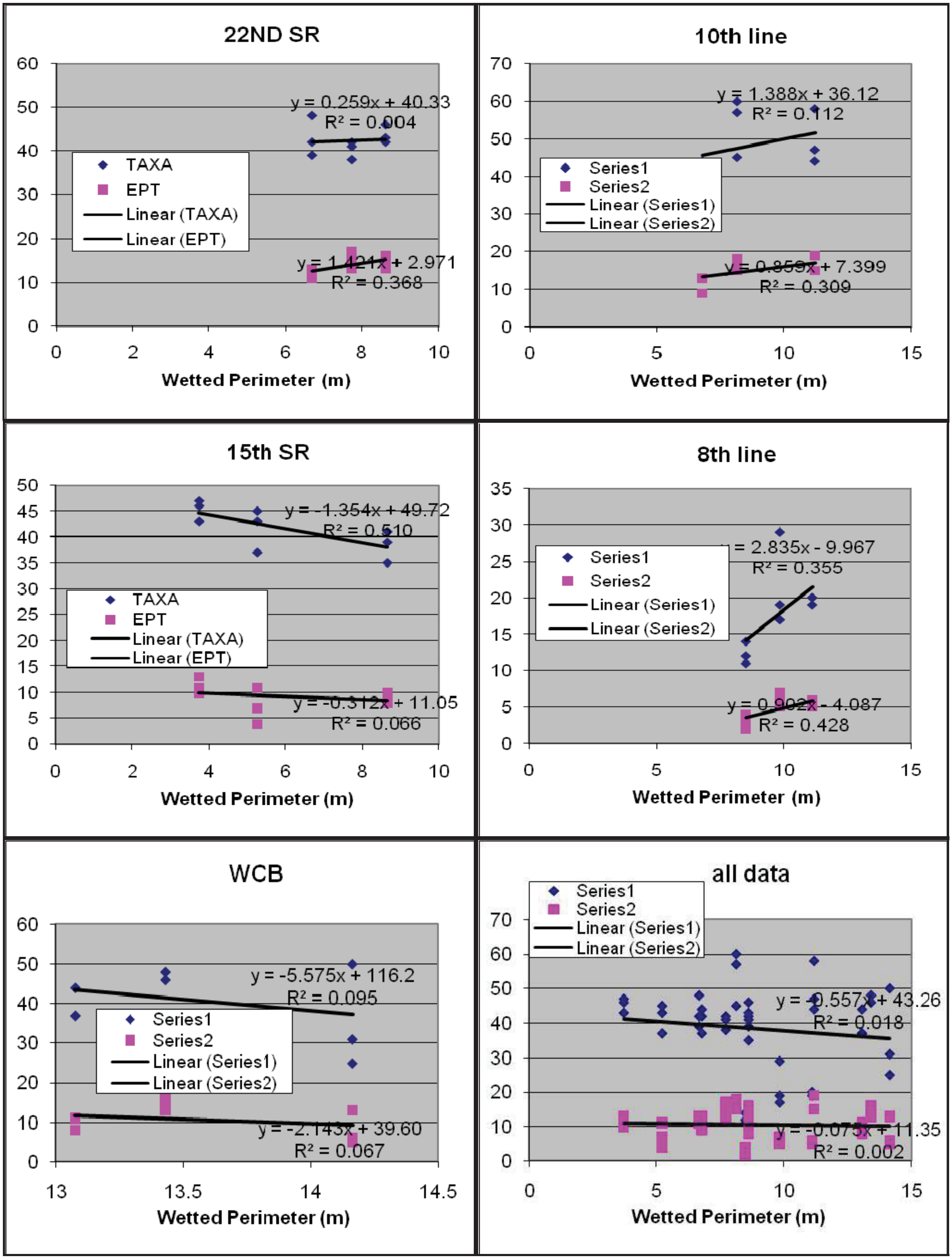
7.6 Number of Taxa and EPT versus Width:Depth Ratio



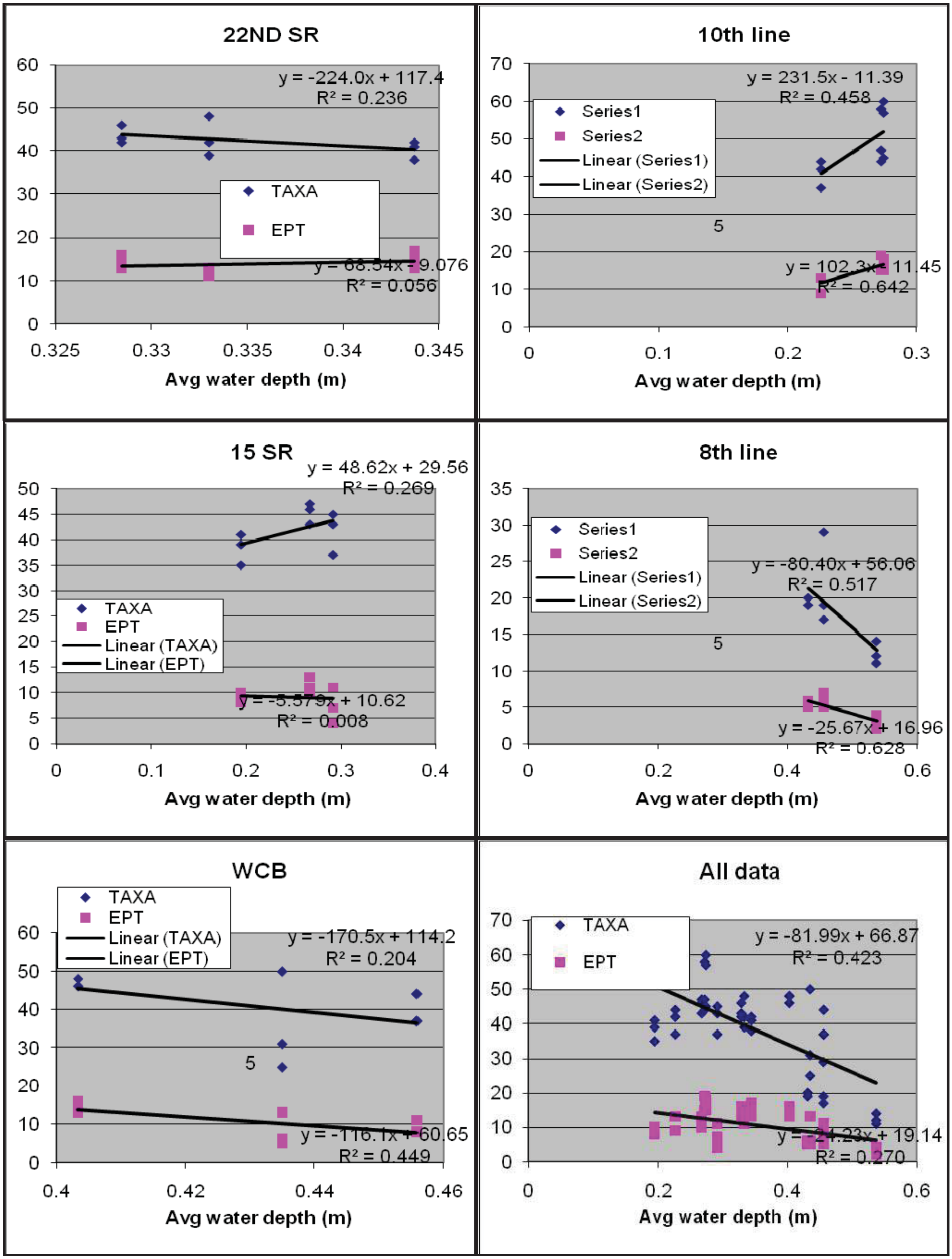
7.7 Number of Taxa and EPT versus Width:Depth Ratio of Riffles



7.8 Number of Taxa and EPT versus Wetted Perimeter of Riffles



7.9 Number of Taxa and EPT versus Average Water Depth of Riffles



APPENDIX E:
Aquatics

Phase 1 -
Environmental Component -
Existing Conditions Report

For The

Erin Servicing and Settlement Master Plan

Prepared for:

County of Wellington
Town of Erin

Prepared by:

Credit Valley Conservation

May 2011

AQUATICS APPENDIX

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1.0 Fish Collection Records

Fish collection records have been compiled for the study area since the 1980's, with updates throughout the 1990's mostly related to the West Credit Subwatershed Study. Additional sampling has since been made as part of the West Credit Appreciation, Rehabilitation and Enhancement (WeCARE) program.

Table 1.0 lists all species found in the study area and their corresponding stations. The locations of the 72 Fish Collection Records are illustrated in **Figure 2.6.1** within the *Environmental Component - Existing Conditions Report*. **Figure 2.6.2** of the *Environmental Component - Existing Conditions Report* indicates the fish biomass sampling sites conducted as part of the Credit River Watershed's Integrated Watershed Monitoring Program (IWMP).

Table 1.0 does not include the biomass stations, see pages 4 to 24 of this Appendix for this data.

Fish Collection Record Number Representation – eg. 23150102
23 – represents the Credit River Watershed
15 – represents the subwatershed, Subwatershed 15 is the West Credit Subwatershed
01 – represents the station number
02 – represents the sampling number

Table 1.0 Fish species present in the West Credit River Study Area

	Indicator Species					Number of Individual Fish Species																	
Habitat	Cd	Cd	Cl	Cl	Cl	Cd-Cl	Cd-Cl	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Sensitivity	3	3	2	2	2	3	3	1	3	3	1	1	1	1	1	3	1	1	1	1	1	1	1
Sampling Event No.	**Brook Trout**	**Mottled Sculpin**	**Pearl Dace**	**Central Mudminnow**	**Northern Redbelly Dace**	**Rainbow Trout**	**Brown Trout**	**White Sucker**	**Northern Hog Sucker**	**River Chub**	**Golden Shiner**	**Common Shiner**	**Bluntnose Minnow**	**Fathead Minnow**	**Blacknose Dace**	**Longnose Dace**	**Creek Chub**	**Brown Bullhead**	**Brook Stickleback**	**Rock Bass**	**Pumpkinseed**	**Largemouth Bass**	**Yellow Perch**
23150101	1				1			17							5		2						
23150102	1			2				87					1		35		21		2				
23150103	2				3			32							18		11		2				
23150104	4				1			15							56		11				1		
23150105	2						1	2								1							
23150106	1							4					5		9								
23150201	2			33			1	10					2		33	4	12		2				
23150202	21			1			3	2									2			1			
23150301	12	3	1					6							3		3						
23150401					1			2							9		7				2		
23150402				1	29									5	10		21		5				21
23150403				2											2		4						

	Indicator Species					Number of Individual Fish Species																	
Habitat	Cd	Cd	Cl	Cl	Cl	Cd-Cl	Cd-Cl	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Sensitivity	3	3	2	2	2	3	3	1	3	3	1	1	1	1	1	3	1	1	1	1	1	1	1
Sampling Event No.	**Brook Trout**	**Mottled Sculpin**	**Pearl Dace**	**Central Mudminnow**	**Northern Redbelly Dace**	**Rainbow Trout**	**Brown Trout**	**White Sucker**	**Northern Hog Sucker**	**River Chub**	**Golden Shiner**	**Common Shiner**	**Bluntnose Minnow**	**Fathead Minnow**	**Blacknose Dace**	**Longnose Dace**	**Creek Chub**	**Brown Bullhead**	**Brook Stickleback**	**Rock Bass**	**Pumpkinseed**	**Largemouth Bass**	**Yellow Perch**
23150501	10				1										1	3	1						2
23150701	2				2			7					4	1	13	1	9				3		
23150702		4		2	9			5							3		19		2				
23150703								15				1	2		1	2	14					1	
23150704	4				1			14							30	1	11				1		
23150801	16	20	19	2	3			9							7				6				
23150802	3	36	2	20	2			3							1		4		10				
23150902	7		3		2			13					1	1	27	4	10		2				
23151001								12				30				47	6	6			2	2	3
23151101	9	2				3		4															
23151102	10	1		1	2			5							13		6		1				
23151103	6		6		1	1		41							9		9						
23151104	2				1			6							1		10						
23151105	4														30		10		NA		NA		
23151106	16																						
23151107			10		4			7		1		1			6				1				
23151201	1			1	1			4							8		6						
23151202					3			3							10		5				2		
23151203	1				9			14					6		13						2		
23151204				4	1			NA				NA	3		5		7			1	2		
23151301	37		2	2										20	62			10	1		1		
23151601					8			18					22		106	2	73						
23151602			6	3	12			2			1			12				1					
23151603	14	25	4		3			15					6		40		30		10		8		
23151604															4		4		4				
23151901	45							18				65	61		28		14			7	2	14	
23151903	17							24					12		12		35			6	3	1	
23151904					1			30				3	10	3	12	1	35	2		12	5	7	1
23151905	32			3				6				2	17		14		3					7	
23151906	NA							NA			NA	NA	NA				NA				NA	NA	
23151907	20							8					20		20								
23151908													20								55	1	
23152201								3							3		2						
23152301	4																2						
23152501	1																1						
23152601	29				1			2									3						

	Indicator Species					Number of Individual Fish Species																	
Habitat	Cd	Cd	Cl	Cl	Cl	Cd-Cl	Cd-Cl	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Sensitivity	3	3	2	2	2	3	3	1	3	3	1	1	1	1	1	3	1	1	1	1	1	1	1
Sampling Event No.	**Brook Trout**	**Mottled Sculpin**	**Pearl Dace**	**Central Mudminnow**	**Northern Redbelly Dace**	**Rainbow Trout**	**Brown Trout**	**White Sucker**	**Northern Hog Sucker**	**River Chub**	**Golden Shiner**	**Common Shiner**	**Bluntnose Minnow**	**Fathead Minnow**	**Blacknose Dace**	**Longnose Dace**	**Creek Chub**	**Brown Bullhead**	**Brook Stickleback**	**Rock Bass**	**Pumpkinseed**	**Largemouth Bass**	**Yellow Perch**
23152602	33		12	1	8			5									5		3				
23152701	25	5		6				NA									2		4				
23152801	2																						
23152901				1															2				
23152902			2		7									1			3	1	2		2		
23152903			4	16	17				1				1		11		33		11		10		
23152904															50		15			10	25		
23153001																			2				
23153101																			5				
23153301			1	2	31													2	18		1		
23153302			1	16	50														100				
23153401														5									
23153601	1				1			6							2		4		8				
23153701	6	2		6													1		10				
23153702	18	1																					
23153703	5	1																					
23153704	12																						
23153801	No catch																						
23153901								4			2						7				28	5	
32153201														1									
319160799				1				20				6			16	31	80					1	
705100400					1			10					NA				NA				1		

Note:
N/A – Unknown
Cd – Cold water
Cl – Cool water
Cd-Cl – Cold/cool water
W – Warm water
1 – Tolerant
2 – Moderately Tolerant
3 - Sensitive

2.0 Biomass Density Summary by Station

Figure 2.6.2 within the main report illustrates the location of the fish biomass sampling sites conducted as part of the Credit River Watershed's Integrated Watershed Monitoring Program (IWMP).

West Credit downstream 8th Line

IWMP Station: 501150024
SSMP Station: 15-16-01

Species	Density (g/m^2)									
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Eastern Blacknose Dace *Rhinichthys atratulus*										0.339
Central Mudminnow *Umbra limi*										0.082
Brook Trout *Salvelinus fontinalis*										1.876

Biomass Density Summary by Station

West Credit at Hillsburgh Public Library

IWMP Station: 501150023
SSMP Station: 15-17-03

Species	Density (g/m^2)									
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
White Sucker *Catostomus commersonii*										0.207
Creek Chub *Semotilus atromaculatus*										0.088
Brown Trout *Salmo trutta*										0.713
Brook Trout *Salvelinus fontinalis*										0.238

Biomass Density Summary by Station

West Credit River at Elizabeth Street

IWMP Station: 501150025
SSMP Station: 15-17-01

Species	Density (g/m²)									
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Rock Bass *Ambloplites rupestris*										1.722
Brook Trout *Salvelinus fontinalis*										0.174
Brown Trout *Salmo trutta*										0.214
Pumpkinseed *Lepomis gibbosus*										0.040
Bluntnose Minnow *Pimephales notatus*										0.070
White Sucker *Catostomus commersonii*										0.002
Eastern Blacknose Dace *Rhinichthys atratulus*										0.073

Biomass Density Summary by Station

Tributary of West Credit River upstream Rail Trail and 8th Line

IWMP Station: 501150020

Species	Density (g/m²)									
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Brook Trout *Salvelinus fontinalis*						3.587	3.645	12.113	6.715	
Pumpkinseed *Lepomis gibbosus*						0.048			0.004	
Eastern Blacknose Dace *Rhinichthys atratulus*						0.675	0.101	0.299	0.241	

Biomass Density Summary by Station

West Credit River at 8th Line Gauge Station

IWMP Station: 501150005

Species	Density (g/m²)									
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Rock Bass *Ambloplites rupestris*							0.091			
Longnose Dace *Rhinichthys cataractae*	0.642	0.634	0.236	0.141	0.078	0.047	0.059	0.060	0.142	0.079
Brook Trout *Salvelinus fontinalis*		0.581	0.217		0.427	0.433		0.138	0.160	0.503
Central Mudminnow *Umbra limi*	0.015	0.023						0.009	0.009	
Spottail Shiner *Notropis hudsonius*			0.002							
Bluntnose Minnow *Pimephales notatus*			0.018	0.009	0.007				0.018	
Pumpkinseed *Lepomis gibbosus*						0.007				
Common Shiner *Luxilus cornutus*	0.154	0.108	0.254	0.171	0.101		0.007	0.050	0.042	0.018
Creek Chub *Semotilus atromaculatus*	1.763	1.908	1.094	0.581	0.816	0.451	0.280	0.668	1.076	0.631
Eastern Blacknose Dace *Rhinichthys atratulus*	0.193	0.215	0.132	0.091	0.220	0.230	0.251	0.123	0.184	0.132
Largemouth Bass *Micropterus salmoides*	0.002		0.011	0.008	0.011	0.003	0.025	0.011		
White Sucker *Catostomus commersonii*	4.691	1.302	0.686	0.577	0.722	0.076	0.103	0.213		0.092

Biomass Density Summary by Station

West Credit River at Woollen Mills Conservation Area

IWMP Station: 501150021

Species	Density (g/m^2)									
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Longnose Dace *Rhinichthys cataractae*									0.678	0.307
Rock Bass *Ambloplites rupestris*										0.032
Northern Redbelly Dace *Phoxinus eos*									0.008	
Pumpkinseed *Lepomis gibbosus*									0.129	
Pearl Dace *Margariscus margarita*									0.193	0.051
Rainbow Trout *Oncorhynchus mykiss*									0.174	
White Sucker *Catostomus commersonii*									0.107	0.361
Bluntnose Minnow *Pimephales notatus*									0.090	0.002
Brook Trout *Salvelinus fontinalis*									0.050	0.159
Brown Bullhead *Ameiurus nebulosus*									0.342	0.334
Common Shiner *Luxilus cornutus*									0.311	0.327
Creek Chub *Semotilus atromaculatus*									1.080	0.369
Eastern Blacknose Dace *Rhinichthys atratulus*									0.138	0.204
Fathead Minnow *Pimephales promelas*										0.016

Biomass Density Summary by Station

East Branch of the West Credit River upstream of 15th Sideroad, East of 10th Line

IWMP Station: 501150028
SSMP Station: 15-20-01

Species	Density (g/m²)									
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Pearl Dace *Margariscus margarita*										0.230
Northern Redbelly Dace *Phoxinus eos*										0.437
Brook Trout *Salvelinus fontinalis*										0.211
Mottled Sculpin *Cottus bairdii*										0.115
White Sucker *Catostomus commersonii*										0.073
Bluntnose Minnow *Pimephales notatus*										0.426
Brook Stickleback *Culaea inconstans*										0.004
Central Mudminnow *Umbra limi*										0.388
Common Shiner *Luxilus cornutus*										0.673
Creek Chub *Semotilus atromaculatus*										1.347
Eastern Blacknose Dace *Rhinichthys atratulus*										2.363
Fathead Minnow *Pimephales promelas*										0.060
Longnose Dace *Rhinichthys cataractae*										0.030
Brassy Minnow *Hybognathus hankinsoni*										0.305

Biomass Density Summary by Station

East Branch of the West Credit River, South of Credit River Road

IWMP Station: 501150026
SSMP Station: 15-08-03

Species	Density (g/m²)									
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Brook Trout *Salvelinus fontinalis*										1.567
Pumpkinseed *Lepomis gibbosus*										0.391
Pearl Dace *Margariscus margarita*										0.192
Northern Redbelly Dace *Phoxinus eos*										0.101
Mottled Sculpin *Cottus bairdii*										0.207
Longnose Dace *Rhinichthys cataractae*										0.101
Brook Stickleback *Culaea inconstans*										0.020
Stonecat *Noturus flavus*										0.231
White Sucker *Catostomus commersonii*										1.378
Largemouth Bass *Micropterus salmoides*										0.010
Bluntnose Minnow *Pimephales notatus*										0.121
Fathead Minnow *Pimephales promelas*										0.003
Central Mudminnow *Umbra limi*										0.414
Common Shiner *Luxilus cornutus*										0.456
Creek Chub *Semotilus atromaculatus*										1.544
Eastern Blacknose Dace *Rhinichthys atratulus*										0.671

Biomass Density Summary by Station

West Credit River West of 10th Line, North of Bush St

IWMP Station: 501150027
SSMP Station: 15-08-01

Species	Density (g/m²)									
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Central Mudminnow *Umbra limi*										0.036
Creek Chub *Semotilus atromaculatus*										0.018
Longnose Dace *Rhinichthys cataractae*										0.001
Brook Trout *Salvelinus fontinalis*										2.016
Atlantic Salmon *Salmo salar*										0.027
Eastern Blacknose Dace *Rhinichthys atratulus*										0.617

Biomass Density Summary by Station

West Credit River upstream 10th Line, downstream of Erin

IWMP Station: 501150003

Species	Density (g/m²)									
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
White Sucker *Catostomus commersonii*		1.632	1.286	2.085	0.650	0.795		2.244		
Pearl Dace *Margariscus margarita*				0.009	0.069	0.020				
Atlantic Salmon *Salmo salar*				0.095						
Brook Trout *Salvelinus fontinalis*	3.463	2.012	3.063	5.388	4.620	2.242		4.348		
Brown Bullhead *Ameiurus nebulosus*	0.197					0.128				
Central Mudminnow *Umbra limi*		0.005	0.031	0.011		0.020		0.011		
Common Shiner *Luxilus cornutus*	0.076									
Creek Chub *Semotilus atromaculatus*	0.357	0.144	0.048	0.273	0.402	0.030		0.536		
Eastern Blacknose Dace *Rhinichthys atratulus*	0.103	0.056	0.087	0.283	0.333	0.059		0.088		
Largemouth Bass *Micropterus salmoides*	0.106			0.003	0.011					
Longnose Dace *Rhinichthys cataractae*	0.445	0.610	0.314	0.145	0.127	0.111		0.435		
Pumpkinseed *Lepomis gibbosus*	0.052	0.080				0.937		0.082		
Rainbow Trout *Oncorhynchus mykiss*	0.254							0.474		
Yellow Perch *Perca flavescens*	0.118									

Biomass Density Summary by Station

West Credit River downstream 10th Line, upstream Winston Churchill Blvd

IWMP Station: 501150022
SSMP Station: 15-04-01

Species	Density (g/m²)									
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Eastern Blacknose Dace *Rhinichthys atratulus*										0.129
Central Mudminnow *Umbra limi*										0.028
Atlantic Salmon *Salmo salar*										0.019
Largemouth Bass *Micropterus salmoides*										0.003
Longnose Dace *Rhinichthys cataractae*										0.093
Brook Trout *Salvelinus fontinalis*										2.027

3.0 Fish Communities within Ponds Sampled

Data was collected in 2008 for the lower Stanley Park pond and the Hillsburgh online pond but the sampling protocol for non-riverine ponds, lakes, and wetlands and an IBI analysis is still under development such that comparative conclusions on abundance and health cannot be made at this time. The species present (see below) in these habitats are indicative of large warm water communities. Some of these lacustrine species can have negative impacts on native stream species in adjoining reaches. **Figure 2.6.6** within the *Environmental Component - Existing Conditions Report* illustrates the location of the ponds sampled.

Fish Species Present in Hillsburgh Pond (upstream of Station St):

Pumpkinseed
Lepomis gibbosus
Rock Bass
Ambloplites rupestris
Bluntnose Minnow
Pimephales notatus
Largemouth Bass
Micropterus salmoides

Fish Species Present in Stanley Park Ponds within the Village of Erin:

White Sucker
Catostomus commersonii
Yellow Perch
Perca flavescens
Pumpkinseed
Lepomis gibbosus
Rock Bass
Ambloplites rupestris

APPENDIX F:
Water Quality and Sediment Chemistry

Phase 1 –
Environmental Component –
Existing Conditions Report

For The

Erin Servicing and Settlement Master Plan

Prepared for:

County of Wellington
Town of Erin

Prepared by:

Credit Valley Conservation

May 2011

WATER QUALITY AND SEDIMENT CHEMISTRY APPENDIX

List of Tables

Table 1.0 Overall and monthly 75th percentile values (Geomean values for E. coli) of Parameters of Concern for the West Credit River at Winston Churchill Blvd #06007601502 (1996-2008)

Overall	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Total Phosphorus, mg/L (PWQO=0.03 mg/L)												
0.016	0.015	0.016	0.020	0.012	0.015	0.017	0.014	0.010	0.013	0.013	0.014	0.021
Nitrate Nitrogen, mg/L (PWQO=2.93 mg/L)												
2.12	2.68	2.89	1.86	1.85	1.82	1.85	1.79	1.91	1.81	2.12	2.18	2.52
Ammonia un-ionized, ug/L (2001-2008, PWQO=20 ug/L)												
0.165	0.165	0.162	0.169	0.159	0.204	0.309	0.232	0.126	0.217	0.145	0.064	0.133
Total Kjeldahl Nitrogen (TKN), mg/L												
0.410	0.360	0.463	0.425	0.385	0.405	0.448	0.405	0.325	0.425	0.420	0.345	0.410
Biochemical Oxygen Demand (BOD5), mg/L												
0.800	1.05	0.63	1.60	0.625	0.875	0.800	0.600	0.550	0.825	0.600	0.925	1.1
Escherichia coli (E. coli) Geomean concentrations, (PWQO=100 cts/100mL)												
36	12	10	15	25	37	101	124	84	144	21	27	45
Aluminum, ug/L (PWQO=75 ug/L)												
23	30	36	36	20	25	17	17	14	24	11	16	103
Copper, ug/L (PWQO=5 ug/L)												
0.720	0.888	0.903	0.707	0.539	0.873	0.521	0.676	0.766	0.634	0.594	0.512	0.990
Iron, ug/L (PWQO=300 ug/L)												
59	72	75	81	39.9	70	57	45	28	61	26.6	41	195
Zinc, ug/L (PWQO=20 ug/L)												
2.12	3.22	3.35	2.72	1.74	2.18	1.75	1.60	1.92	1.70	1.38	1.91	7.49
Total Suspended Solids (TSS), mg/L (CWQG=25 mg/L)												
3.6	3.9	5.8	5.1	3.0	4.8	5.1	3.0	2.3	3.0	1.4	2.3	13.8
Chloride, mg/L (PWQO=250 mg/L)												
43.4	44.9	43.4	38.9	41.1	44.0	40.8	42.5	43.5	40.2	40.4	42.1	50.2

Note: December percentiles are not representative / accurate, because of a few number (3) of December samples.

Table 2.0 Summary Statistics of Parameters of Concern for the West Credit River at Winston Churchill Blvd #06007601502 (1996-2008)

Parameter of Concern	Unit	# of Samples	Average	Minimum	Maximum	50th	10th	25th	75th	90th	% Violation
Total Phosphorus	mg/L	129	0.013	0.002	0.058	0.011	0.006	0.008	0.016	0.0222	3.9
Nitrate Nitrogen	mg/L	129	1.872	0.868	3.380	1.800	1.304	1.570	2.120	2.486	3.9
Ammonia un-ionized	ug/L	80	0.152	0.006	0.950	0.101	0.020	0.047	0.165	0.351	0.0
Total Kjeldahl Nitrogen	mg/L	124	0.366	0.18	0.74	0.355	0.27	0.3	0.410	0.497	NA
Biochemical Oxygen Demand	mg/L	121	0.712	0.200	4.800	0.600	0.200	0.400	0.800	1.200	NA
Escherichia coli	cts/100mL	128	36	4	820	38	4	12	110	213	27.3
Aluminum	ug/L	127	22.19	0.28	191.00	15.90	7.07	10.90	23.35	38.14	3.9
Copper	ug/L	127	0.573	0.016	2.000	0.500	0.175	0.361	0.720	0.929	0.0
Iron	ug/L	127	51.38	16.30	353.0	38.80	22.22	27.60	59.40	82.56	0.8
Zinc	ug/L	127	1.811	0.025	12.700	1.560	0.539	0.885	2.120	3.192	0.0
Total Suspended Solids	mg/L	128	3.549	0.500	26.000	2.250	1.000	1.500	3.600	7.000	0.8
Chloride	mg/L	129	41.6	19.6	209	39.8	34.92	37	43.4	45.18	0.0

Table 3.1 Raw Data for Nutrient and BOD Parameters of Concern West Credit River at Winston Churchill Blvd #06007601502 (1996-2008)

Sample Date	Total Phos-phorus (mg/L)	Nitrate (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Total Ammonia NH3+NH4 (mg/L)	Field Water Temp-erature	Field pH	NH3 (ug/L)	BOD5 (mg/L)
17-Sep-96	0.012	1.58	0.44					0.8
15-Oct-96	0.004	0.95	0.3					0.4
17-Dec-96	0.036	1.69	0.58					1.2
23-Jan-97	0.058	1.21	0.68					4.8
18-Dec-97	0.002	2.66	0.18					1
24-Feb-98	0.008	2.23	0.32					0.2
24-Mar-98	0.016	1.84	0.36					0.6
23-Apr-98	0.018	1.66	0.38					0.4
21-May-98	0.014	1.66	0.38					0.8
17-Jun-98	0.016	1.59	0.38					0.4
22-Jul-98	0.012	1.36	0.36					0.6
20-Aug-98	0.004	1.49	0.3					0.6
25-Sep-98	0.006	1.8	0.22					0.4
27-Oct-98	0.014	1.88	0.28					0.6
24-Nov-98	0.006	2.31	0.28					0.4
18-Dec-98	0.006	2.37	0.24					0.2
25-Jan-99	0.026	2.14	0.52					1
01-Mar-99	0.018	2.12	0.44					0.8
29-Mar-99	0.008	1.54	0.4					1.6
19-Apr-99	0.008	1.68	0.34					0.6
27-May-99	0.008	1.21	0.36					1.4
23-Jun-99	0.008	1.28	0.28					0.8
23-Jul-99	0.006	1.39	0.32					0.6
24-Aug-99	0.006	1.31	0.28					0.8
30-Sep-99	0.016	1.21	0.42					1.4
01-Nov-99	0.004	1.95	0.3					0.6
25-Nov-99	0.022	1.84	0.32					1
04-Jan-00	0.044	2.09	0.6					0.8
03-Feb-00	0.016	2.98	0.28					3.2
29-Feb-00	0.032	1.69	0.6					0.6
30-Mar-00	0.006	1.56	0.32					1.6
04-May-00	0.008	1.53	0.4					1.2
30-May-00	0.008	1.59	0.4					0.2
28-Jun-00	0.02	1.07	0.74					1
26-Jul-00	0.01	1.81	0.34					0.6
30-Aug-00	0.008	1.72	0.3					0.4
28-Sep-00	0.004	1.79	0.28					0.6
29-Nov-00	0.012	1.76	0.42					0.6
03-Jan-01	0.006	2.66	0.24					0.4
30-Jan-01	0.008	2.55	0.28					0.4
27-Feb-01	0.014	1.56	0.44					0.2
29-Mar-01	0.008	1.84	0.38					0.4
30-Apr-01	0.008	1.98	0.28					0.2

Continued

Table 3.1 Raw Data for Nutrient and BOD Parameters of Concern West Credit River at Winston Churchill Blvd #06007601502 (1996-2008)

Sample Date	Total Phosp horus (mg/L)	Nitrate (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Total Ammonia NH3+NH4 (mg/L)	Field Water temper ature	Field pH	NH3 (ug/L)	BOD5 (mg/L)
24-May-01	0.022	1.14	0.64	0.008	13.4	8.08	0.223	NA
26-Jun-01	0.008	1.64	0.4	0.002	17.1	7.96	0.056	0.2
25-Jul-01	0.014	1.56	0.4	0.008	18.1	7.96	0.241	
29-Aug-01	0.008	1.74	0.3	0.002	15.4	8.16	0.077	0.4
26-Sep-01	0.012	1.5	0.32	NA	NA	NA	NA	0.8
25-Oct-01	0.018	1.42	0.44	0.004	9.6	7.95	0.062	0.6
29-Nov-01	0.016	1.83	0.32	0.014	3.4	8	0.149	1
03-Jan-02	0.016	2.68	0.3	0.012	0.9	8.17	0.154	0.6
24-Jan-02	0.014	2.45	0.32	0.008	1.7	8.12	0.098	0.4
04-Mar-02	0.016	1.72	0.36	0.002	3.9	8.13	0.030	1.6
05-Jun-02	0.012	1.8	0.36	0.002	12.6	7.8	0.028	0.8
26-Jun-02	0.028	0.868	0.5	0.009	20.2	8.2	0.533	0.2
31-Jul-02	0.018	1.57	0.42	0.002	20.2	7.88	0.059	0.3
28-Aug-02	0.01	2.03	0.28	0.006	16.8	8.01	0.184	0.2
26-Sep-02	0.009	2.01	0.29	0.002	14.4	8	0.050	0.8
30-Oct-02	0.008	2.34	0.27	0.002	4.5	8.15	0.033	0.3
07-Jan-03	0.007	2.82	0.26	0.007	1.3	8.16	0.091	0.2
30-Jan-03	0.012	3.38	0.26	0.007	6	8.2	0.145	1.2
27-Mar-03	0.018	1.55	0.43	0.042	3	7.59	0.170	1.5
01-May-03	0.016	1.71	0.41	0.012	9.3	8.07	0.240	NA
22-May-03	0.017	1.65	0.39	0.016	11	8.16	0.446	0.6
26-Jun-03	0.013	1.83	0.35	0.002	21	8.32	0.162	0.7
31-Jul-03	0.01	1.79	0.31	0.011	17.3	8.23	0.568	0.6
28-Aug-03	0.006	1.8	0.28	0.02	14.6	8.28	0.950	0.4
30-Sep-03	0.013	1.72	0.38	0.004	8.6	8.22	0.106	0.3
30-Oct-03	0.007	1.85	0.36	0.003	7	8.36	0.096	0.9
27-Nov-03	0.007	2.09	0.36	0.002	3.2	8.16	0.030	1.1
08-Jan-04	0.008	2.43	0.32	0.009	6.1	8.14	0.164	3.1
25-Feb-04	0.037	2.89	0.53	0.013	0.4	8.19	0.167	0.2
30-Mar-04	0.029	1.46	0.44	0.022	5.1	8.02	0.282	0.5
28-Apr-04	0.011	2.04	0.37	0.01	5.7	8.08	0.154	0.2
26-May-04	0.015	1.25	0.5	0.009	12.9	7.96	0.185	0.8
29-Jun-04	0.014	2.18	0.29	0.003	13.8	8.17	0.105	0.6
28-Jul-04	0.01	1.82	0.38	0.002	15.5	8.13	0.073	0.4
31-Aug-04	0.021	1.4	0.43	0.003	15.3	8.12	0.105	0.4
23-Sep-04	0.008	2.16	0.27	0.004	13.7	8.18	0.143	0.9
27-Oct-04	0.006	2.47	0.21	0.002	9.1	8.09	0.041	0.4
30-Nov-04	0.008	2.17	0.33	0.002	2.7	8.11	0.026	0.3
10-Jan-05	0.007	2.22	0.33	0.012	1.6	8.51	0.350	0.3
27-Jan-05	0.015	3.02	0.31	0.031	0.3	7.76	0.148	0.2
24-Feb-05	0.015	2.73	0.32	0.006	0.1	8.04	0.053	0.7
31-Mar-05	0.025	1.22	0.41	0.022	1.7	7.78	0.124	1.6
28-Apr-05	0.016	1.41	0.35	0.004	6.1	7.97	0.050	0.7

Continued

Table 3.1 Raw Data for Nutrient and BOD Parameters of Concern West Credit River at Winston Churchill Blvd #06007601502 (1996-2008)

Sample Date	Total Phosphorus (mg/L)	Nitrate (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Total Ammonia NH3+NH4 (mg/L)	Field Water temperature	Field pH	NH3 (ug/L)	BOD5 (mg/L)
26-May-05	0.014	2.06	0.34	0.002	13.7	7.99	0.047	0.9
29-Jun-05	0.018	1.68	0.44	0.002	20.2	8.52	0.232	1
28-Jul-05	0.01	1.78	0.26	0.002	15.6	7.31	0.011	0.6
31-Aug-05	0.026	1.31	0.37	0.002	17.6	7.18	0.010	0.9
29-Sep-05	0.013	1.33	0.5	0.01	12.7	7.48	0.068	0.6
27-Oct-05	0.016	2.12	0.49	0.002	6.4	7.99	0.027	0.4
30-Nov-05	0.024	0.94	0.55	0.002	2.6	7.45	0.006	0.7
05-Jan-06	0.013	1.72	0.36	0.02	1.6	7.76	0.106	0.8
26-Jan-06	0.015	2.1	NA	NA	NA	NA	NA	0.5
22-Feb-06	0.009	2.1	NA	NA	NA	NA	NA	0.5
30-Mar-06	0.004	1.9	NA	NA	NA	NA	NA	0.5
27-Apr-06	0.002	1.6	NA	NA	NA	NA	NA	0.5
25-May-06	0.006	1.8	NA	NA	NA	NA	NA	0.5
29-Jun-06	0.016	2.02	0.4	0.004	16.3	7.68	0.056	0.7
27-Jul-06	0.013	1.65	0.41	0.011	19.2	7.34	0.088	0.5
31-Aug-06	0.006	2.09	0.24	0.002	14	7.57	0.018	0.5
28-Sep-06	0.023	1.14	0.62	0.013	12.2	7.75	0.157	0.9
25-Oct-06	0.007	1.75	0.45	0.002	5.8	7.88	0.020	0.3
28-Nov-06	0.006	2.18	0.32	0.016	6.9	7.79	0.140	NA
04-Jan-07	0.006	2.14	0.28	0.005	2.7	8.09	0.062	NA
31-Jan-07	0.009	2.97	0.31	0.024	0.8	7.89	0.161	NA
28-Feb-07	0.008	3.15	0.26	0.021	2.0	7.94	0.174	NA
28-Mar-07	0.024	1.11	0.42	0.018	3.0	7.83	0.126	NA
25-Apr-07	0.011	1.47	0.44	0.022	9.1	7.98	0.353	0.3
30-May-07	0.011	1.88	0.34	0.013	15.5	8.03	0.379	0.6
26-Jun-07	0.012	1.90	0.35	0.02	18.4	8.08	0.803	0.6
25-Jul-07	0.012	1.63	0.37	0.002	16.6	8.07	0.069	0.9
29-Aug-07	0.009	1.65	0.25	0.007	18.2	8.14	0.316	0.4
26-Sep-07	0.011	1.50	0.33	0.002	16.9	8.04	0.066	0.4
31-Oct-07	0.005	2.11	0.22	0.002	8.5	8.06	0.037	0.8
26-Nov-07	0.005	2.37	0.3	0.005	3.1	7.96	0.048	0.4
03-Jan-08	0.010	2.63	0.33	0.012	0.1	8.88	0.703	1.9
31-Jan-08	0.008	2.33	0.39	0.005	0.7	7.59	0.017	0.5
27-Feb-08	0.004	2.40	0.27	0.002	0.7	7.79	0.011	0.2
26-Mar-08	0.007	2.31	0.37	0.002	2.1	7.7	0.010	0.5
29-Apr-08	0.010	1.80	0.39	0.003	7.6	7.43	0.012	0.8
28-May-08	0.007	2.07	0.31	0.002	10.8	7.76	0.022	0.7
25-Jun-08	0.012	1.60	0.47	0.002	15.2	7.88	0.041	0.7
30-Jul-08	0.019	1.71	0.41	0.01	16.5	7.44	0.082	0.2
27-Aug-08	0.003	2.02	0.35	0.01	13.4	7.82	0.155	0.5
30-Sep-08	0.012	1.82	0.37	0.013	12.6	7.71	0.148	0.5
29-Oct-08	0.004	1.97	0.36	0.01	4.4	7.76	0.067	0.4
26-Nov-08	0.011	2.17	0.33	0.011	2.5	8.08	0.131	0.2

Table 3.2 Raw Data for Metals, Chlorides TSS and E. coli Parameters of Concern West Credit River at Winston Churchill Blvd #06007601502 (1996-2008)

Sample Date	Aluminum (ug/L)	Copper (ug/L)	Iron (ug/L)	Zinc (ug/L)	TSS (mg/L)	Chloride Dissolved	E. coli (cts/100mL)
17-Sep-96	30.2	0.279	71.6	1.41	3	34	108
15-Oct-96	NA	NA	NA	NA	2	35.2	12
17-Dec-96	191	1.48	353	12.7	26	60.8	128
23-Jan-97	148	1.79	291	5.96	24	209	124
18-Dec-97	15.5	0.5	29.2	1.42	1.5	34.4	16
24-Feb-98	19.2	0.0279	42	1.81	1.5	39.6	20
24-Mar-98	28.2	0.558	59	3.4	3.5	41	4
23-Apr-98	18.9	0.423	44.9	1.7	2.5	37	20
21-May-98	19.7	0.526	56.2	1.31	3	40.4	32
17-Jun-98	17.4	0.5	42	1.54	5	37.8	160
22-Jul-98	15.9	0.5	30.4	0.956	2	36.6	92
20-Aug-98	13.3	0.5	27.2	1.23	1.5	40.4	60
25-Sep-98	11	0.474	26.7	0.441	0.5	38.6	56
27-Oct-98	14.9	0.594	16.3	0.378	1.5	39.6	4
24-Nov-98	10.5	0.5	20.2	0.523	1.5	38	4
18-Dec-98	12.6	0.5	37	2.28	1.5	39.6	NA
25-Jan-99	41.1	0.0478	96	3.33	14	44	52
01-Mar-99	124	0.759	238	8.48	10.5	38.4	40
29-Mar-99	17.2	0.439	43.3	1.35	2	33.2	4
19-Apr-99	14.7	0.5	36.7	1.85	2	39	20
27-May-99	19.9	0.332	65.9	2.4	7	36.6	24
23-Jun-99	14.9	0.302	41.7	1.03	2.5	43.4	48
23-Jul-99	10.8	0.5	22.1	4.34	2	43.6	92
24-Aug-99	8.68	0.162	23.8	0.948	1.5	44.6	28
30-Sep-99	22.8	0.582	58.9	2.34	3	39.8	556
01-Nov-99	9.92	0.117	20.4	0.624	1	43.6	8
25-Nov-99	12.6	0.212	22.3	0.635	1	40.8	16
04-Jan-00	80.5	0.291	137	4.09	10	82.4	168
03-Feb-00	32.4	0.529	59.8	2.35	9	42.4	4
29-Feb-00	45.9	0.696	77	3.89	5.5	34.6	4
30-Mar-00	9.54	0.537	23.5	1.72	2	40.2	80
04-May-00	21.6	0.482	39.2	1.05	2.5	45	24
30-May-00	16.1	0.523	38.8	0.733	2	43.4	20
28-Jun-00	17.5	0.584	66.9	1.66	4	34.4	16
26-Jul-00	16.8	0.376	30	0.623	1.5	44.8	56
30-Aug-00	3.58	0.17	22.3	0.544	1.5	42.6	32
28-Sep-00	11.3	0.313	24.8	0.531	1	40.8	16
29-Nov-00	11.1	0.303	32	1.2	1.5	36.2	8
03-Jan-01	20.5	0.37	30.4	1.58	2.5	36.4	4
30-Jan-01	17.3	1.88	29.4	2.65	3	59.4	10
27-Feb-01	25.4	2	51.5	3.35	3.5	19.6	20
29-Mar-01	12.7	0.5	32.4	1.74	2	38.2	12
30-Apr-01	11.8	0.316	32.4	1.63	3	41.4	12
24-May-01	24.4	0.509	69.6	2.1	5.5	36	110
26-Jun-01	7.61	0.138	39.9	0.855	2.5	41.2	120
25-Jul-01	8.76	0.189	25	0.83	2.5	40.6	100

Continued

Table 3.2 Raw Data for Metals, Chlorides TSS and E. coli Parameters of ConcernWest Credit River at Winston Churchill Blvd #06007601502 (1996-2008)

Sample Date	Aluminum (ug/L)	Copper (ug/L)	Iron (ug/L)	Zinc (ug/L)	TSS (mg/L)	Chloride Dissolved	E. coli (cts/100mL
29-Aug-01	9.86	0.418	17.8	0.21	3	40.4	92
26-Sep-01	15.1	0.372	37.3	0.948	2	38.8	160
25-Oct-01	14.1	0.498	35.4	1.38	2	40.6	64
29-Nov-01	24.5	0.523	54.1	1.82	3	35.6	300
03-Jan-02	18.1	0.436	30.8	1.46	2.5	44.2	4
24-Jan-02	15.2	0.422	25	1.29	1	44.6	8
04-Mar-02	NA	NA	NA	NA	4.5	36	8
05-Jun-02	22.6	0.455	58	1.48	5.2	38.6	160
26-Jun-02	16.9	0.0358	54.4	1.12	13.5	40.6	100
31-Jul-02	17.5	0.335	52.8	1.11	3.5	38	140
28-Aug-02	8.03	0.106	19.3	0.354	1.1	39.5	48
26-Sep-02	8.47	0.567	22.5	0.99	0.5	40	40
30-Oct-02	9.58	0.568	17.2	1.13	1	41.7	4
07-Jan-03	13.8	0.178	31.9	1.31	2	44.4	4
30-Jan-03	17.8	0.317	37.8	1.88	3.3	39.9	4
27-Mar-03	27.9	0.727	66	2.46	4	34.3	4
01-May-03	60.2	0.873	90.2	2.99	6.3	43.8	220
22-May-03	7.79	0.628	28.9	0.774	2.3	44.7	4
26-Jun-03	15.4	0.351	37.8	1.29	2.3	50.4	140
31-Jul-03	17	0.427	36.4	0.905	2.1	50.9	36
28-Aug-03	14.5	0.735	19.5	0.818	0.8	47.5	32
30-Sep-03	21.6	0.289	42.9	1.69	1.8	45.5	52
30-Oct-03	9.66	0.5	21.2	1.6	1.2	44.7	36
27-Nov-03	10.6	0.74	23.9	2.61	1.3	45.5	12
08-Jan-04	22.2	0.915	30.4	2.39	2.1	43.4	4
25-Feb-04	60.4	0.903	112	5.09	18.1	47.5	190
30-Mar-04	75.2	0.499	84.6	2.14	9.9	31.4	76
28-Apr-04	12.5	0.5	28	1.56	2.2	41	16
26-May-04	32.8	0.328	70.8	3.1	4.5	32.1	110
29-Jun-04	15.5	0.136	30.9	4.45	1.8	40.7	110
28-Jul-04	13.8	0.619	37	2.44	1.7	39.8	190
31-Aug-04	35.4	0.669	71.2	1.83	4.8	37	230
23-Sep-04	18.1	0.789	28.7	0.317	0.5	40.9	120
27-Oct-04	11.4	0.17	26	0.78	0.6	39.9	12
30-Nov-04	16.9	0.5	25.2	1.41	1.6	39.4	20
10-Jan-05	22	0.532	42.4	2.9	1.9	40.3	16
27-Jan-05	41	0.713	78.2	2	5.6	41.3	4
24-Feb-05	36.3	0.634	66.7	2.83	5.8	43.4	4
31-Mar-05	40.9	0.402	82.2	2.98	6.9	24.2	80
28-Apr-05	21.4	0.393	40.9	1.65	3.2	34.4	12
26-May-05	25.6	0.874	54.5	0.965	2.9	41.2	48
29-Jun-05	34.7	0.635	83.1	2.16	7.4	35.9	410
28-Jul-05	9.68	1.44	33.9	1.19	1.7	38.7	100
31-Aug-05	35.7	0.787	84.6	2.3	5.9	36.2	720
29-Sep-05	29.1	1.37	69.1	1.74	3.5	39.3	210
27-Oct-05	4.58	1.01	21.5	0.376	0.6	39.3	36
30-Nov-05	50	0.698	115	2.72	9.9	24.1	300
05-Jan-06	31.3	0.52	67.6	3.93	NA	37.2	100

Continued

Table 3.2 Raw Data for Metals, Chlorides TSS and E. coli Parameters of Concern West Credit River at Winston Churchill Blvd #06007601502 (1996-2008)

Sample Date	Aluminum (ug/L)	Copper (ug/L)	Iron (ug/L)	Zinc (ug/L)	TSS (mg/L)	Chloride Dissolved	E. coli (cts/100mL
26-Jan-06	16	1	74	6	3	45	10
22-Feb-06	17	1	75	2	1	40	10
30-Mar-06	13	0.5	30	2	1	35	10
27-Apr-06	23	0.5	30	2	3	37	50
25-May-06	21	0.5	71	2	1	37	20
29-Jun-06	9.58	0.49	46.1	2	2.8	37.8	170
27-Jul-06	6.27	0.951	50	2	5.8	35.8	240
31-Aug-06	1.33	0.805	20	2	1.1	39.3	130
28-Sep-06	33.2	1.28	131	1.59	8.2	35.9	450
25-Oct-06	1.00	0.512	26.6	2	1.1	37.9	230
28-Nov-06	1.00	0.322	25.0	2	1.2	38.8	100
04-Jan-07	2.00	0.124	26.2	0.061	1.4	36.30	24
31-Jan-07	1.00	0.213	25.3	0.273	2.3	40.90	4
28-Feb-07	15.8	0.086	30.1	0.611	2.1	39.20	4
28-Mar-07	30.1	0.891	80.6	2.190	3.6	25.50	4
25-Apr-07	5.49	0.656	38.1	0.025	3.1	36.50	60
30-May-07	18.9	0.887	55.7	0.984	3.2	40.80	56
26-Jun-07	13.6	0.387	48.1	0.673	3.3	39.50	110
25-Jul-07	14.0	0.584	40.7	0.806	2.2	36.10	120
29-Aug-07	11.6	0.744	28.8	0.186	1.3	38.40	120
26-Sep-07	14.2	0.016	51.9	0.894	2.1	37.20	760
31-Oct-07	9.55	0.617	33.5	0.628	0.6	39.40	28
26-Nov-07	2.54	0.5	23.5	1.100	0.9	43.40	52
03-Jan-08	23.70	0.908	45.6	1.590	3.9	44.50	12
31-Jan-08	26.60	0.826	60.4	1.960	3.7	47.50	8
27-Feb-08	8.50	0.544	23.9	0.945	1.8	46.80	4
26-Mar-08	6.05	0.687	29.8	0.875	1.7	48.50	32
29-Apr-08	8.36	0.742	39.6	0.682	2.2	44.40	52
28-May-08	11.50	1.060	39.3	0.807	2.2	45.10	32
25-Jun-08	13.30	1.440	56.1	0.232	3.6	39.80	40
30-Jul-08	48.40	0.732	102.0	0.739	7.0	41.30	820
27-Aug-08	3.82	0.910	19.6	2	1.3	44.30	72
30-Sep-08	20.40	0.499	55.6	1.870	2.2	39.20	500
29-Oct-08	2.27	0.277	19.8	0.578	0.7	38.70	16
26-Nov-08	14.90	0.225	49.7	1.260	3.4	40.20	12

Note: Blue highlighted values are Detectable Limit values which have been used instead of negative values.

Table 4.1 Summary Statistics of Total Phosphorus concentration (mg/L) for the Erin SSMP stations (2007-2008)

Station Name	Station ID	# of Samples	Average	Minimum	Maximum	50th	10th	25th	75th	90th
West Credit u/s Hillsburgh, d/s 8th Line	151601	10	0.022	0.012	0.035	**0.020**	0.014	0.015	**0.025**	0.035
West Credit d/s Hwy 25, Hillsburgh	151703	10	0.019	0.005	0.031	**0.017**	0.010	0.015	**0.028**	0.030
West Credit d/s Head Pond, Hillsburgh	151701	10	0.014	0.002	0.043	**0.011**	0.006	0.010	**0.013**	0.020
West Credit d/s County Rd 24	151302	9	0.012	0.005	0.020	**0.011**	0.007	0.009	**0.015**	0.018
West Credit Trib at Caledon Rail Trail u/s 8th Line	151401	10	0.007	0.002	0.012	**0.007**	0.005	0.005	**0.009**	0.010
West Credit at 8th Line Gauge	151002	10	0.011	0.002	0.024	**0.010**	0.003	0.005	**0.017**	0.020
West Credit d/s Main St, Erin	150807	10	0.013	0.003	0.024	**0.015**	0.006	0.007	**0.017**	0.022
South Trib. d/s Main St., Erin	150805*	10	0.021	0.008	0.048	**0.017**	0.012	0.015	**0.026**	0.030
East Trib. d/s 17th Sideroad (Wellington Rd 124)	152003*	8	0.077	0.008	0.510	**0.018**	0.009	0.009	**0.021**	0.169
East Trib. d/s 10th Line/North West Credit R.	150804*	10	0.018	0.005	0.053	**0.016**	0.006	0.010	**0.021**	0.026
West Credit d/s 10th Line	150402	10	0.014	0.003	0.030	**0.013**	0.007	0.008	**0.019**	0.021

Table 4.2 Summary Statistics of Nitrate-Nitrogen concentration (mg/L) for the Erin SSMP stations (2007-2008)

Station Name	Station ID	# of Samples	Average	Minimum	Maximum	50th	10th	25th	75th	90th
West Credit u/s Hillsburgh, d/s 8th Line	151601	10.0	3.0	2.2	3.9	**3.0**	2.5	2.8	**3.3**	3.5
West Credit d/s Hwy 25, Hillsburgh	151703	10.0	3.2	2.3	4.2	**3.4**	2.4	2.9	**3.6**	3.8
West Credit d/s Head Pond, Hillsburgh	151701	10.0	3.0	2.1	4.0	**3.0**	2.2	2.4	**3.6**	3.6
West Credit d/s County Rd 24	151302	9.0	2.9	1.4	8.7	**2.4**	1.6	1.6	**2.7**	4.0
West Credit Trib at Caledon Rail Trail u/s 8th Line	151401	10.0	8.0	6.3	9.3	**8.1**	7.4	7.5	**8.7**	8.9
West Credit at 8th Line Gauge	151002	10.0	2.1	1.3	2.8	**1.9**	1.5	1.6	**2.7**	2.7
West Credit d/s Main St, Erin	150807	10.0	1.7	0.9	2.6	**1.8**	1.1	1.3	**2.3**	2.3
South Trib. d/s Main St., Erin	150805*	10.0	1.4	1.0	2.1	**1.3**	1.1	1.2	**1.5**	1.7
East Trib. d/s 17th Sideroad (Wellington Rd 124)	152003*	8.0	1.6	0.1	4.3	**1.0**	0.6	0.9	**2.4**	3.0
East Trib. d/s 10th Line/North West Credit R.	150804*	10.0	1.2	0.4	2.0	**1.1**	0.5	0.8	**1.6**	1.9
West Credit d/s 10th Line	150402	10.0	1.8	0.8	2.4	**1.8**	1.3	1.6	**2.2**	2.3

Table 4.3 Summary Statistics of Organic Nitrogen concentration (mg/L) for the Erin SSMP stations (2007-2008)

Station Name	Station ID	# of Samples	Average	Minimum	Maximum	50th	10th	25th	75th	90th
West Credit u/s Hillsburgh, d/s 8th Line	151601	10	0.52	0.40	0.70	**0.50**	0.40	0.50	**0.57**	0.61
West Credit d/s Hwy 25, Hillsburgh	151703	10	0.50	0.30	0.70	**0.50**	0.39	0.40	**0.60**	0.61
West Credit d/s Head Pond, Hillsburgh	151701	10	0.52	0.40	0.70	**0.50**	0.40	0.42	**0.57**	0.70
West Credit d/s County Rd 24	151302	9	0.49	0.40	0.70	**0.50**	0.40	0.40	**0.50**	0.62
West Credit Trib at Caledon Rail Trail u/s 8th Line	151401	10	0.40	0.30	0.70	**0.35**	0.30	0.30	**0.47**	0.52
West Credit at 8th Line Gauge	151002	10	0.49	0.40	0.60	**0.50**	0.40	0.42	**0.50**	0.60
West Credit d/s Main St, Erin	150807	10	0.53	0.40	0.60	**0.50**	0.49	0.50	**0.60**	0.60
South Trib. d/s Main St., Erin	150805*	10	0.58	0.40	0.90	**0.50**	0.49	0.50	**0.60**	0.81
East Trib. d/s 17th Sideroad (Wellington Rd 124)	152003*	8	0.71	0.50	1.50	**0.65**	0.50	0.50	**0.70**	0.94
East Trib. d/s 10th Line/North West Credit R.	150804*	10	0.56	0.50	0.70	**0.50**	0.50	0.50	**0.60**	0.70
West Credit d/s 10th Line	150402	10	0.51	0.40	0.60	**0.50**	0.40	0.50	**0.57**	0.60

Table 4.4 Summary Statistics of Total Kjeldahl Nitrogen concentration (mg/L) for the Erin SSMP stations (2007-2008)

Station Name	Station ID	# of Samples	Average	Minimum	Maximum	50th	10th	25th	75th	90th
West Credit u/s Hillsburgh, d/s 8th Line	151601	10	0.52	0.40	0.70	**0.50**	0.40	0.50	**0.58**	0.61
West Credit d/s Hwy 25, Hillsburgh	151703	10	0.50	0.30	0.70	**0.50**	0.39	0.40	**0.60**	0.61
West Credit d/s Head Pond, Hillsburgh	151701	10	0.52	0.40	0.70	**0.50**	0.40	0.43	**0.58**	0.70
West Credit d/s County Rd 24	151302	9	0.49	0.40	0.70	**0.50**	0.40	0.40	**0.50**	0.62
West Credit Trib at Caledon Rail Trail u/s 8th Line	151401	10	0.40	0.30	0.70	**0.35**	0.30	0.30	**0.48**	0.52
West Credit at 8th Line Gauge	151002	10	0.49	0.40	0.60	**0.50**	0.40	0.43	**0.50**	0.60
West Credit d/s Main St, Erin	150807	10	0.53	0.40	0.60	**0.50**	0.49	0.50	**0.60**	0.60
South Trib. d/s Main St., Erin	150805*	10	0.58	0.40	0.90	**0.50**	0.49	0.50	**0.60**	0.81
East Trib. d/s 17th Sideroad (Wellington Rd 124)	152003*	8	0.71	0.50	1.50	**0.65**	0.50	0.50	**0.70**	0.94
East Trib. d/s 10th Line/North West Credit R.	150804*	10	0.56	0.50	0.70	**0.50**	0.50	0.50	**0.60**	0.70
West Credit d/s 10th Line	150402	10	0.51	0.40	0.60	**0.50**	0.40	0.50	**0.58**	0.60

Table 4.5 Summary Statistics of Ammonia un-ionized (NH_3) concentration (ug/L) for the Erin SSMP stations (2007-2008)

Station Name	Station ID	# of Samples	Average	Minimum	Maximum	50th	10th	25th	75th	90th
West Credit u/s Hillsburgh, d/s 8th Line	151601	8	1.20	0.33	2.29	**1.13**	0.39	0.80	**1.60**	1.99
West Credit d/s Hwy 25, Hillsburgh	151703	8	1.43	0.41	3.27	**1.26**	0.53	0.63	**1.96**	2.44
West Credit d/s Head Pond, Hillsburgh	151701	8	2.86	0.59	5.40	**2.52**	1.23	1.75	**4.01**	4.92
West Credit d/s County Rd 24	151302	7	2.98	1.11	7.34	**2.11**	1.16	1.43	**3.73**	5.76
West Credit Trib at Caledon Rail Trail u/s 8th Line	151401	9	2.05	0.25	6.28	**1.77**	0.51	0.85	**1.88**	3.84
West Credit at 8th Line Gauge	151002	8	1.71	0.41	4.59	**1.49**	0.51	0.90	**2.00**	2.88
West Credit d/s Main St, Erin	150807	8	2.11	0.57	4.79	**1.67**	1.06	1.30	**2.57**	3.76
South Trib. d/s Main St., Erin	150805*	8	2.53	1.02	5.60	**2.18**	1.31	1.43	**2.87**	4.39
East Trib. d/s 17th Sideroad (Wellington Rd 124)	152003*	7	1.06	0.45	1.76	**1.19**	0.47	0.64	**1.37**	1.54
East Trib. d/s 10th Line/North West Credit R.	150804*	8	0.95	0.16	2.56	**0.81**	0.21	**0.25**	**1.22**	1.98
West Credit d/s 10th Line	150402	8	2.31	0.34	10.95	**1.07**	0.56	0.78	**1.48**	4.93

Table 4.6 Summary Statistics of Biochemical Oxygen Demand concentration (mg/L) for the Erin SSMP stations (2007-2008)

Station Name	Station ID	# of Samples	Average	Minimum	Maximum	50th	10th	25th	75th	90th
West Credit u/s Hillsburgh, d/s 8th Line	151601	10	2	2	2	2	2	**2**	**2**	2
West Credit d/s Hwy 25, Hillsburgh	151703	10	2	2	2	2	2	**2**	**2**	2
West Credit d/s Head Pond, Hillsburgh	151701	10	2	2	2	2	2	**2**	**2**	2
West Credit d/s County Rd 24	151302	9	2	2	2	2	2	**2**	**2**	2
West Credit Trib at Caledon Rail Trail u/s 8th Line	151401	10	2	2	2	2	2	**2**	**2**	2
West Credit at 8th Line Gauge	151002	10	2	2	2	2	2	**2**	**2**	2
West Credit d/s Main St, Erin	150807	10	2	2	2	2	2	**2**	**2**	2
South Trib. d/s Main St., Erin	150805*	10	2	2	2	2	2	**2**	**2**	2
East Trib. d/s 17th Sideroad (Wellington Rd 124)	152003*	8	2	2	2	2	2	**2**	**2**	2
East Trib. d/s 10th Line/North West Credit R.	150804*	10	2	2	2	2	2	**2**	**2**	2
West Credit d/s 10th Line	150402	10	2	2	2	2	2	**2**	**2**	2

Table 4.7 Summary Statistics of Escherichia coli concentration (cts/100mL) for the Erin SSMP stations (2007-2008)

Station Name	Station ID	# of Samples	Geomean	Minimum	Maximum	50th	10th	25th	75th	90th
West Credit u/s Hillsburgh, d/s 8th Line	151601	10	35	10	160	**35**	10	13	**98**	151
West Credit d/s Hwy 25, Hillsburgh	151703	10	71	20	320	**70**	29	35	**133**	176
West Credit d/s Head Pond, Hillsburgh	151701	10	38	10	490	**25**	10	13	**70**	247
West Credit d/s County Rd 24	151302	9	27	10	130	**30**	10	10	**50**	122
West Credit Trib at Caledon Rail Trail u/s 8th Line	151401	10	22	10	50	**25**	10	10	**40**	50
West Credit at 8th Line Gauge	151002	10	30	10	260	**20**	10	10	**60**	233
West Credit d/s Main St, Erin	150807	10	78	10	2100	**45**	10	13	**393**	1038
South Trib. d/s Main St., Erin	150805*	10	56	10	300	**85**	10	20	**118**	282
East Trib. d/s 17th Sideroad (Wellington Rd 124)	152003*	8	206	20	2600	**195**	69	113	**358**	1109
East Trib. d/s 10th Line/North West Credit R.	150804*	10	59	10	1200	**40**	10	23	**70**	930
West Credit d/s 10th Line	150402	10	75	10	840	**55**	19	33	**160**	453

Table 4.8 Summary Statistics of Aluminum concentration (ug/L) for the Erin SSMP stations (2007-2008)

Station Name	Station ID	# of Samples	Average	Minimum	Maximum	50th	10th	25th	75th	90th
West Credit u/s Hillsburgh, d/s 8th Line	151601	9	58	19	110	**62**	24	31	**80**	93
West Credit d/s Hwy 25, Hillsburgh	151703	9	69	27	140	**41**	29	34	**100**	116
West Credit d/s Head Pond, Hillsburgh	151701	9	51	14	290	**19**	15	16	**30**	88
West Credit d/s County Rd 24	151302	8	15	8	21	**15**	9	13	**18**	20
West Credit Trib at Caledon Rail Trail u/s 8th Line	151401	9	19	8	36	**15**	10	10	**27**	30
West Credit at 8th Line Gauge	151002	9	19	7	28	**19**	9	13	**26**	28
West Credit d/s Main St, Erin	150807	9	40	11	95	**37**	14	18	**53**	66
South Trib. d/s Main St., Erin	150805*	9	27	12	59	**20**	14	16	**27**	54
East Trib. d/s 17th Sideroad (Wellington Rd 124)	152003*	7	27	11	45	**29**	14	17	**36**	41
East Trib. d/s 10th Line/North West Credit R.	150804*	9	30	8	57	**25**	15	17	**37**	51
West Credit d/s 10th Line	150402	9	20	8	40	**18**	8	11	**26**	31

Table 4.9 Summary Statistics of Copper concentration (ug/L) for the Erin SSMP stations (2007-2008)

Station Name	Station ID	# of Samples	Average	Minimum	Maximum	50th	10th	25th	75th	90th
West Credit u/s Hillsburgh, d/s 8th Line	151601	9	1	1	1	**1**	1	1	**1**	1
West Credit d/s Hwy 25, Hillsburgh	151703	9	1	1	1	**1**	1	1	**1**	1
West Credit d/s Head Pond, Hillsburgh	151701	9	1	1	2	**1**	1	1	**1**	1
West Credit d/s County Rd 24	151302	8	1	1	2	**1**	1	1	**1**	1
West Credit Trib at Caledon Rail Trail u/s 8th Line	151401	9	1	1	2	**1**	1	1	**1**	1
West Credit at 8th Line Gauge	151002	9	1	1	1	**1**	1	1	**1**	1
West Credit d/s Main St, Erin	150807	9	1	1	2	**1**	1	1	**1**	1
South Trib. d/s Main St., Erin	150805*	9	1	1	2	**1**	1	1	**1**	1
East Trib. d/s 17th Sideroad (Wellington Rd 124)	152003*	7	1	1	1	**1**	1	1	**1**	1
East Trib. d/s 10th Line/North West Credit R.	150804*	9	1	1	1	**1**	1	1	**1**	1
West Credit d/s 10th Line	150402	9	1	1	1	**1**	1	1	**1**	1

Table 4.10 Summary Statistics of Iron concentration (ug/L) for the Erin SSMP stations (2007-2008)

Station Name	Station ID	# of Samples	Average	Minimum	Maximum	50th	10th	25th	75th	90th
West Credit u/s Hillsburgh, d/s 8th Line	151601	9	156	100	240	**160**	100	100	**200**	208
West Credit d/s Hwy 25, Hillsburgh	151703	9	160	100	300	**100**	100	100	**200**	252
West Credit d/s Head Pond, Hillsburgh	151701	9	126	100	330	**100**	100	100	**100**	146
West Credit d/s County Rd 24	151302	8	100	100	100	**100**	100	100	**100**	100
West Credit Trib at Caledon Rail Trail u/s 8th Line	151401	9	100	100	100	**100**	100	100	**100**	100
West Credit at 8th Line Gauge	151002	9	100	100	100	**100**	100	100	**100**	100
West Credit d/s Main St, Erin	150807	9	117	100	200	**100**	100	100	**100**	160
South Trib. d/s Main St., Erin	150805*	9	100	100	100	**100**	100	100	**100**	100
East Trib. d/s 17th Sideroad (Wellington Rd 124)	152003*	7	114	100	200	**100**	100	100	**100**	140
East Trib. d/s 10th Line/North West Credit R.	150804*	9	100	100	100	**100**	100	100	**100**	100
West Credit d/s 10th Line	150402	9	100	100	100	**100**	100	100	**100**	100

Table 4.11 Summary Statistics of Zinc concentration (ug/L) for the Erin SSMP stations (2007-2008)

Station Name	Station ID	# of Samples	Average	Minimum	Maximum	50th	10th	25th	75th	90th
West Credit u/s Hillsburgh, d/s 8th Line	151601	9	6	5	9	**5**	5	5	**7**	7
West Credit d/s Hwy 25, Hillsburgh	151703	9	7	5	12	**6**	5	5	**8**	10
West Credit d/s Head Pond, Hillsburgh	151701	9	5	5	8	**5**	5	5	**5**	6
West Credit d/s County Rd 24	151302	8	5	5	6	**5**	5	5	**5**	5
West Credit Trib at Caledon Rail Trail u/s 8th Line	151401	9	5	5	6	**5**	5	5	**5**	5
West Credit at 8th Line Gauge	151002	9	5	5	5	**5**	5	5	**5**	5
West Credit d/s Main St, Erin	150807	9	5	5	6	**5**	5	5	**5**	5
South Trib. d/s Main St., Erin	150805*	9	8	5	15	**8**	5	5	**8**	12
East Trib. d/s 17th Sideroad (Wellington Rd 124)	152003*	7	5	5	5	**5**	5	5	**5**	5
East Trib. d/s 10th Line/North West Credit R.	150804*	9	5	5	7	**5**	5	5	**5**	5
West Credit d/s 10th Line	150402	9	5	5	5	**5**	5	5	**5**	5

Table 4.12 Summary Statistics of Total Suspended Solids (TSS) concentration (mg/L) for the Erin SSMP stations (2007-2008)

Station Name	Station ID	# of Samples	Average	Minimum	Maximum	50th	10th	25th	75th	90th
West Credit u/s Hillsburgh, d/s 8th Line	151601	10	11	10	14	**10**	10	10	**10**	11
West Credit d/s Hwy 25, Hillsburgh	151703	10	11	10	14	**10**	10	10	**10**	13
West Credit d/s Head Pond, Hillsburgh	151701	10	14	10	46	**10**	10	10	**10**	14
West Credit d/s County Rd 24	151302	9	10	10	10	**10**	10	10	**10**	10
West Credit Trib at Caledon Rail Trail u/s 8th Line	151401	10	10	10	10	**10**	10	10	**10**	10
West Credit at 8th Line Gauge	151002	10	10	10	10	**10**	10	10	**10**	10
West Credit d/s Main St, Erin	150807	10	10	10	10	**10**	10	10	**10**	10
South Trib. d/s Main St., Erin	150805*	10	10	10	10	**10**	10	10	**10**	10
East Trib. d/s 17th Sideroad (Wellington Rd 124)	152003*	8	10	10	10	**10**	10	10	**10**	10
East Trib. d/s 10th Line/North West Credit R.	150804*	10	10	10	10	**10**	10	10	**10**	10
West Credit d/s 10th Line	150402	10	10	10	10	**10**	10	10	**10**	10

Table 4.13 Summary Statistics of Chloride concentration (mg/L) for the Erin SSMP stations (2007-2008)

Station Name	Station ID	# of Samples	Average	Minimum	Maximum	50th	10th	25th	75th	90th
West Credit u/s Hillsburgh, d/s 8th Line	151601	10	13	11	14	**13**	12	12	**13**	13
West Credit d/s Hwy 25, Hillsburgh	151703	10	18	16	22	**17**	16	16	**18**	19
West Credit d/s Head Pond, Hillsburgh	151701	10	30	25	40	**29**	27	27	**34**	36
West Credit d/s County Rd 24	151302	9	33	19	41	**34**	29	33	**37**	38
West Credit Trib at Caledon Rail Trail u/s 8th Line	151401	10	19	17	21	**19**	18	18	**20**	20
West Credit at 8th Line Gauge	151002	10	34	32	38	**34**	32	32	**35**	38
West Credit d/s Main St, Erin	150807	10	37	32	74	**33**	32	32	**35**	40
South Trib. d/s Main St., Erin	150805*	10	43	31	55	**43**	36	40	**48**	49
East Trib. d/s 17th Sideroad (Wellington Rd 124)	152003*	8	24	22	26	**24**	23	23	**25**	25
East Trib. d/s 10th Line/North West Credit R.	150804*	10	33	26	48	**30**	26	27	**38**	41
West Credit d/s 10th Line	150402	10	42	23	52	**43**	37	40	**47**	51

Table 5.1 **Total Phosphorus concentration (mg/L) for the Erin SSMP stations (Raw Data, 2007-2008)**

Sample Date	West Credit u/s Hillsburgh, d/s 8th Line (151601)	West Credit d/s Hwy 25, Hillsburgh (151703)	West Credit d/s Head Pond, Hillsburgh (151701)	West Credit d/s County Rd 24 (151302)	West Credit Trib at Caledon Rail Trail, u/s 8th Line (151401)	West Credit at 8th Line Gauge (151002)	West Credit d/s Main St., Erin (150807)	South Trib. d/s Main St., Erin (150805*)	East Trib. d/s 17th Sideroad (Wellington Rd 124) (152003*)	East Trib. d/s 10th Line/North West Credit R. (150804*)	West Credit d/s 10th Line (150402)
26-Sep-07	0.024	0.016	0.012	0.018	0.01	0.024	0.022	0.048		0.053	0.03
31-Oct-07	0.014	0.011	0.006	0.008	0.005	0.003	0.006	0.019	0.009	0.011	0.007
26-Nov-07	0.022	0.014	0.011	0.005	0.006	0.004	0.007	0.015	0.008	0.006	0.009
31-Jan-08	0.014	0.005	0.002		0.002	0.002	0.003	0.008		0.005	0.003
26-Mar-08	0.035	0.021	0.043	0.01	0.007	0.009	0.015	0.012		0.013	0.014
29-Apr-08	0.025	0.031	0.01	0.009	0.006	0.008	0.007	0.015	0.009	0.01	0.007
25-Jun-08	0.018	0.03	0.01	0.011	0.005	0.013	0.017	0.022	0.019	0.018	0.011
27-Aug-08	0.012	0.016	0.013	0.015	0.012	0.011	0.017	0.028	0.023	0.023	0.015
30-Sep-08	0.035	0.03	0.017	0.02	0.01	0.018	0.024	0.027	0.02	0.021	0.02
05-Nov-08	0.017	0.018	0.011	0.014	0.007	0.02	0.014	0.015	0.016	0.019	0.02

Table 5.2 **Nitrate-Nitrogen concentration (mg/L) for the Erin SSMP stations (Raw Data, 2007-2008)**

Sample Date	West Credit u/s Hillsburgh, d/s 8th Line (151601)	West Credit d/s Hwy 25, Hillsburgh (151703)	West Credit d/s Head Pond, Hillsburgh (151701)	West Credit d/s County Rd 24 (151302)	West Credit Trib at Caledon Rail Trail, u/s 8th Line (151401)	West Credit at 8th Line Gauge (151002)	West Credit d/s Main St., Erin (150807)	South Trib. d/s Main St., Erin (150805*)	East Trib. d/s 17th Sideroad (Wellington Rd 124) (152003*)	East Trib. d/s 10th Line/North West Credit R. (150804*)	West Credit d/s 10th Line (150402)
26-Sep-07	2.5	2.4	2.1	8.7	8.7	1.6	1.1	1.6	0.1	1.3	0.8
31-Oct-07	3.9	4.2	3.6	2.7	9.3	2.7	2.1	2.1	4.3	2	2.4
26-Nov-07	3.3	3.8	3.5	2.7	8.8	2.7	2.3	1.3	2.3	1.9	2.3
31-Jan-08	3.4	3.7	4		8.5	2.8	2.6	1.3		1.2	2.3
26-Mar-08	3.2	3.4	3.6	2.8	7.6	2.6	2.3	1.3		1	2
29-Apr-08	2.9	3	2.7	1.8	7.8	1.6	1.3	1.3	0.8	0.5	1.5
25-Jun-08	2.7	2.9	2.2	1.4	6.3	1.5	0.9	1	1	0.4	1.3
27-Aug-08	2.9	3.3	2.3	1.6	7.5	1.6	1.3	1.6	2.5	1.7	1.8
30-Sep-08	2.2	2.3	2.6	1.6	7.5	1.3	1.5	1.1	0.9	0.9	1.7
05-Nov-08	3.1	3.4	3.3	2.4	8.3	2.2	2	1.1	1	0.7	1.8

Table 5.3 Organic Nitrogen concentration (mg/L) for the Erin SSMP stations (Raw Data, 2007-2008)

Sample Date	West Credit u/s Hillsburgh, d/s 8th Line (151601)	West Credit d/s Hwy 25, Hillsburgh (151703)	West Credit d/s Head Pond, Hillsburgh (151701)	West Credit d/s County Rd 24 (151302)	West Credit Trib at Caledon Rail Trail, u/s 8th Line (151401)	West Credit at 8th Line Gauge (151002)	West Credit d/s Main St., Erin (150807)	South Trib. d/s Main St., Erin (150805*)	East Trib. d/s 17th Sideroad (Wellington Rd 124) (152003*)	East Trib. d/s 10th Line/North West Credit R. (150804*)	West Credit d/s 10th Line (150402)
26-Sep-07	0.50	0.60	0.50	0.40	0.40	0.50	0.60	0.50	1.50	0.50	0.60
31-Oct-07	0.40	0.30	0.40	0.40	0.30	0.40	0.50	0.50	0.50	0.50	0.50
26-Nov-07	0.50	0.40	0.40	0.40	0.30	0.40	0.50	0.50		0.50	0.40
31-Jan-08	0.50	0.40	0.40		0.40	0.50	0.50	0.60		0.60	0.60
26-Mar-08	0.50	0.40	0.70	0.40	0.30	0.40	0.40	0.40	0.60	0.50	0.50
29-Apr-08	0.60	0.60	0.60	0.50	0.50	0.60	0.60	0.80	0.50	0.50	0.50
25-Jun-08	0.70	0.60	0.50	0.60	0.50	0.60	0.60	0.60	0.70	0.70	0.50
27-Aug-08	0.60	0.70	0.70	0.70	0.70	0.50	0.60	0.90	0.70	0.70	0.60
30-Sep-08	0.50	0.60	0.50	0.50	0.30	0.50	0.50	0.50	0.70	0.50	0.50
05-Nov-08	0.40	0.40	0.50	0.50	0.30	0.50	0.50	0.50	0.50	0.60	0.40

Table 5.4 Total Kjeldahl Nitrogen (TKN) concentration (mg/L) for the Erin SSMP stations (Raw Data, 2007-2008)

Sample Date	West Credit u/s Hillsburgh, d/s 8th Line (151601)	West Credit d/s Hwy 25, Hillsburgh (151703)	West Credit d/s Head Pond, Hillsburgh (151701)	West Credit d/s County Rd 24 (151302)	West Credit Trib at Caledon Rail Trail, u/s 8th Line (151401)	West Credit at 8th Line Gauge (151002)	West Credit d/s Main St., Erin (150807)	South Trib. d/s Main St., Erin (150805*)	East Trib. d/s 17th Sideroad (Wellington Rd 124) (152003*)	East Trib. d/s 10th Line/North West Credit R. (150804*)	West Credit d/s 10th Line (150402)
26-Sep-07	0.5	0.6	0.5	0.4	0.4	0.5	0.6	0.5	1.5	0.5	0.6
31-Oct-07	0.4	0.3	0.4	0.4	0.3	0.4	0.5	0.5	0.5	0.5	0.5
26-Nov-07	0.5	0.4	0.4	0.4	0.3	0.4	0.5	0.5	0.6	0.5	0.4
31-Jan-08	0.5	0.4	0.4		0.4	0.5	0.5	0.6		0.6	0.6
26-Mar-08	0.5	0.4	0.7	0.4	0.3	0.4	0.4	0.4		0.5	0.5
29-Apr-08	0.6	0.6	0.6	0.5	0.5	0.6	0.6	0.8	0.5	0.5	0.5
25-Jun-08	0.7	0.6	0.5	0.6	0.5	0.6	0.6	0.6	0.7	0.7	0.5
27-Aug-08	0.6	0.7	0.7	0.7	0.7	0.5	0.6	0.9	0.7	0.7	0.6
30-Sep-08	0.5	0.6	0.5	0.5	0.3	0.5	0.5	0.5	0.7	0.5	0.5
05-Nov-08	0.4	0.4	0.5	0.5	0.3	0.5	0.5	0.5	0.5	0.6	0.4

Table 5.5 Ammonia un-ionized (NH3) concentration (ug/L) for the Erin SSMP stations (Raw Data, 2007-2008)

Sample Date	West Credit u/s Hillsburgh , d/s 8th Line (151601)	West Credit d/s Hwy 25, Hillsburg h (151703)	West Credit d/s Head Pond, Hillsburg h (151701)	West Credit d/s County Rd 24 (151302)	West Credit Trib at Caledon Rail Trail, u/s 8th Line (151401)	West Credit at 8th Line Gauge (151002)	West Credit d/s Main St., Erin (150807)	South Trib. d/s Main St., Erin (150805*)	East Trib. d/s 17th Sideroad (Wellingto n Rd 124) (152003*)	East Trib. d/s 10th Line/Nort h West Credit R. (150804*)	West Credit d/s 10th Line (150402)
26-Sep-07	1.23	1.92	5.40	4.71	6.28	4.59	4.79	3.88	1.39	2.56	10.95
31-Oct-07	0.93	1.41	2.04	1.11	1.88	1.46	2.31	2.53	1.76	1.05	1.19
26-Nov-07											
31-Jan-08	1.86	1.11	1.50		1.88	1.01	1.27	1.02		0.23	1.12
26-Mar-08											
29-Apr-08	2.29	3.27	4.71	2.11	1.77	1.96	1.37	1.44	1.35	0.77	2.36
25-Jun-08	1.03	2.08	0.59	1.19	0.57	0.56	0.57	1.43	1.19	0.84	0.65
27-Aug-08	1.51	0.59	3.78	1.67	0.85	0.41	1.96	2.27	0.80	0.25	0.34
30-Sep-08	0.33	0.65	3.01	7.34	3.23	1.52	3.32	5.60	0.45	1.73	1.03
05-Nov-08	0.42	0.41	1.84	2.75	0.25	2.15	1.31	2.08	0.48	0.16	0.82

Table 5.6 Biochemical Oxygen Demand (BOD) concentration (mg/L) for the Erin SSMP stations (Raw Data, 2007-2008)

Sample Date	West Credit u/s Hillsburgh, d/s 8th Line (151601)	West Credit d/s Hwy 25, Hillsburgh (151703)	West Credit d/s Head Pond, Hillsburgh (151701)	West Credit d/s County Rd 24 (151302)	West Credit Trib at Caledon Rail Trail, u/s 8th Line (151401)	West Credit at 8th Line Gauge (151002)	West Credit d/s Main St., Erin (150807)	South Trib. d/s Main St., Erin (150805*)	East Trib. d/s 17th Sideroad (Wellington Rd 124) (152003*)	East Trib. d/s 10th Line/North West Credit R. (150804*)	West Credit d/s 10th Line (150402)
26-Sep-07	2	2	2	2	2	2	2	2	2	2	2
31-Oct-07	2	2	2	2	2	2	2	2	2	2	2
26-Nov-07	2	2	2	2	2	2	2	2	2	2	2
31-Jan-08	2	2	2		2	2	2	2		2	2
26-Mar-08	2	2	2	2	2	2	2	2		2	2
29-Apr-08	2	2	2	2	2	2	2	2	2	2	2
25-Jun-08	2	2	2	2	2	2	2	2	2	2	2
27-Aug-08	2	2	2	2	2	2	2	2	2	2	2
30-Sep-08	2	2	2	2	2	2	2	2	2	2	2
05-Nov-08	2	2	2	2	2	2	2	2	2	2	2

Table 5.7 Escherichia coli (E. coli) concentration (cts/100mL) for the Erin SSMP stations (Raw Data, 2007-2008)

Sample Date	West Credit u/s Hillsburgh, d/s 8th Line (151601)	West Credit d/s Hwy 25, Hillsburgh (151703)	West Credit d/s Head Pond, Hillsburgh (151701)	West Credit d/s County Rd 24 (151302)	West Credit Trib at Caledon Rail Trail, u/s 8th Line (151401)	West Credit at 8th Line Gauge (151002)	West Credit d/s Main St., Erin (150807)	South Trib. d/s Main St., Erin (150805*)	East Trib. d/s 17th Sideroad (Wellington Rd 124) (152003*)	East Trib. d/s 10th Line/North West Credit R. (150804*)	West Credit d/s 10th Line (150402)
26-Sep-07	160	160	490	130	50	260	2100	280	2600	900	410
31-Oct-07	10	70	20	10	50	10	40	20	200	10	50
26-Nov-07	20	20	20	10	10	20	10	20	90	40	40
31-Jan-08	10	30	30		30	10	10	10		40	20
26-Mar-08	50	30	70	10	40	10	20	60		10	30
29-Apr-08	20	70	10	50	10	30	10	120	20	30	60
25-Jun-08	60	110	10	30	40	10	250	110	320	70	170
27-Aug-08	110	140	70	30	10	70	440	110	190	70	130
30-Sep-08	150	320	220	120	20	230	920	300	470	1200	840
05-Nov-08	10	50	10	10	10	20	50	10	120	20	10

Table 5.8 Aluminum concentration (ug/L) for the Erin SSMP stations (Raw Data, 2007-2008)

Sample Date	West Credit u/s Hillsburgh, d/s 8th Line (151601)	West Credit d/s Hwy 25, Hillsburgh (151703)	West Credit d/s Head Pond, Hillsburgh (151701)	West Credit d/s County Rd 24 (151302)	West Credit Trib at Caledon Rail Trail, u/s 8th Line (151401)	West Credit at 8th Line Gauge (151002)	West Credit d/s Main St., Erin (150807)	South Trib. d/s Main St., Erin (150805*)	East Trib. d/s 17th Sideroad (Wellington Rd 124) (152003*)	East Trib. d/s 10th Line/North West Credit R. (150804*)	West Credit d/s 10th Line (150402)
31-Oct-07	25	29	16	10	11	7	23	20	29	24	8
26-Nov-07	110	110	38	19	8	28	11	16	18	17	17
31-Jan-08	89	27	30		15	19	53	53		34	40
26-Mar-08	80	40	290	15	10	13	95	14		8	11
29-Apr-08	78	140	25	21	36	28	15	16	16	17	18
25-Jun-08	31	100	16	17	27	20	47	27	38	49	26
27-Aug-08	31	41	14	15	29	17	37	23	34	57	19
30-Sep-08	62	98	15	14	26	26	59	59	45	37	29
05-Nov-08	19	34	19	8	10	9	18	12	11	25	8

Table 5.9 Copper concentration (ug/L) for the Erin SSMP stations (Raw Data, 2007-2008)

Sample Date	West Credit u/s Hillsburgh, d/s 8th Line (151601)	West Credit d/s Hwy 25, Hillsburgh (151703)	West Credit d/s Head Pond, Hillsburgh (151701)	West Credit d/s County Rd 24 (151302)	West Credit Trib at Caledon Rail Trail, u/s 8th Line (151401)	West Credit at 8th Line Gauge (151002)	West Credit d/s Main St., Erin (150807)	South Trib. d/s Main St., Erin (150805*)	East Trib. d/s 17th Sideroad (Wellington Rd 124) (152003*)	East Trib. d/s 10th Line/North West Credit R. (150804*)	West Credit d/s 10th Line (150402)
31-Oct-07	1	1	1	2	1	1	1	1	1	1	1
26-Nov-07	1	1	1	1	1	1	1	1	1	1	1
31-Jan-08	1	1	1		1	1	1	1		1	1
26-Mar-08	1	1	1	1	2	1	2	1		1	1
29-Apr-08	1	1	1	1	1	1	1	1	1	1	1
25-Jun-08	1	1	1	1	1	1	1	1	1	1	1
27-Aug-08	1	1	2	1	1	1	1	1	1	1	1
30-Sep-08	1	1	1	1	1	1	1	2	1	1	1
05-Nov-08	1	1	1	1	1	1	1	1	1	1	1

Table 5.10 Iron concentration (ug/L) for the Erin SSMP stations (Raw Data, 2007-2008)

Sample Date	West Credit u/s Hillsburgh, d/s 8th Line (151601)	West Credit d/s Hwy 25, Hillsburgh (151703)	West Credit d/s Head Pond, Hillsburgh (151701)	West Credit d/s County Rd 24 (151302)	West Credit Trib at Caledon Rail Trail, u/s 8th Line (151401)	West Credit at 8th Line Gauge (151002)	West Credit d/s Main St., Erin (150807)	South Trib. d/s Main St., Erin (150805*)	East Trib. d/s 17th Sideroad (Wellington Rd 124) (152003*)	East Trib. d/s 10th Line/North West Credit R. (150804*)	West Credit d/s 10th Line (150402)
31-Oct-07	100	100	100	100	100	100	100	100	100	100	100
26-Nov-07	240	240	100	100	100	100	100	100	100	100	100
31-Jan-08	160	100	100		100	100	100	100		100	100
26-Mar-08	200	100	330	100	100	100	150	100		100	100
29-Apr-08	200	300	100	100	100	100	100	100	100	100	100
25-Jun-08	100	200	100	100	100	100	100	100	100	100	100
27-Aug-08	100	100	100	100	100	100	100	100	100	100	100
30-Sep-08	200	200	100	100	100	100	200	100	200	100	100
05-Nov-08	100	100	100	100	100	100	100	100	100	100	100

Table 5.11 Zinc concentration (ug/L) for the Erin SSMP stations (Raw Data, 2007-2008)

Sample Date	West Credit u/s Hillsburgh, d/s 8th Line (151601)	West Credit d/s Hwy 25, Hillsburgh (151703)	West Credit d/s Head Pond, Hillsburgh (151701)	West Credit d/s County Rd 24 (151302)	West Credit Trib at Caledon Rail Trail, u/s 8th Line (151401)	West Credit at 8th Line Gauge (151002)	West Credit d/s Main St., Erin (150807)	South Trib. d/s Main St., Erin (150805*)	East Trib. d/s 17th Sideroad (Wellington Rd 124) (152003*)	East Trib. d/s 10th Line/North West Credit R. (150804*)	West Credit d/s 10th Line (150402)
31-Oct-07	5	12	5	5	5	5	6	8	5	5	5
26-Nov-07	6	6	5	6	5	5	5	5	5	5	5
31-Jan-08	9	5	5		5	5	5	5		7	5
26-Mar-08	7	5	8	5	6	5	5	5		5	5
29-Apr-08	7	10	5	5	5	5	5	8	5	5	5
25-Jun-08	5	6	5	5	5	5	5	5	5	5	5
27-Aug-08	5	5	5	5	5	5	5	8	5	5	5
30-Sep-08	5	8	5	5	5	5	5	15	5	5	5
05-Nov-08	5	5	5	5	5	5	5	11	5	5	5

Table 5.12 Total Suspended Solids (TSS) concentration (mg/L) for the Erin SSMP stations (Raw Data, 2007-2008)

Sample Date	West Credit u/s Hillsburgh, d/s 8th Line (151601)	West Credit d/s Hwy 25, Hillsburgh (151703)	West Credit d/s Head Pond, Hillsburgh (151701)	West Credit d/s County Rd 24 (151302)	West Credit Trib at Caledon Rail Trail, u/s 8th Line (151401)	West Credit at 8th Line Gauge (151002)	West Credit d/s Main St., Erin (150807)	South Trib. d/s Main St., Erin (150805*)	East Trib. d/s 17th Sideroad (Wellington Rd 124) (152003*)	East Trib. d/s 10th Line/North West Credit R. (150804*)	West Credit d/s 10th Line (150402)
26-Sep-07	10	10	10	10	10	10	10	10	10	10	10
31-Oct-07	10	10	10	10	10	10	10	10	10	10	10
26-Nov-07	14	10	10	10	10	10	10	10	10	10	10
31-Jan-08	11	10	10		10	10	10	10		10	10
26-Mar-08	10	10	46	10	10	10	10	10		10	10
29-Apr-08	10	14	10	10	10	10	10	10	10	10	10
25-Jun-08	10	13	10	10	10	10	10	10	10	10	10
27-Aug-08	10	10	10	10	10	10	10	10	10	10	10
30-Sep-08	10	10	10	10	10	10	10	10	10	10	10
05-Nov-08	10	10	10	10	10	10	10	10	10	10	10

Table 5.13 Chloride concentration (mg/L) for the Erin SSMP stations (Raw Data, 2007-2008)

Sample Date	West Credit u/s Hillsburgh, d/s 8th Line (151601)	West Credit d/s Hwy 25, Hillsburgh (151703)	West Credit d/s Head Pond, Hillsburgh (151701)	West Credit d/s County Rd 24 (151302)	West Credit Trib at Caledon Rail Trail, u/s 8th Line (151401)	West Credit at 8th Line Gauge (151002)	West Credit d/s Main St., Erin (150807)	South Trib. d/s Main St., Erin (150805*)	East Trib. d/s 17th Sideroad (Wellington Rd 124) (152003*)	East Trib. d/s 10th Line/North West Credit R. (150804*)	West Credit d/s 10th Line (150402)
26-Sep-07	13	17	27	19	19	33	32	36	22	39	23
31-Oct-07	13	17	27	34	20	34	33	31	25	26	42
26-Nov-07	12	16	25	32	19	32	32	48	26	30	41
31-Jan-08	13	17	40		20	38	36	48		48	51
26-Mar-08	13	22	35	41	21	38	74	55		40	52
29-Apr-08	13	18	34	37	18	35	35	45	23	34	46
25-Jun-08	11	16	27	33	17	32	32	41	23	26	40
27-Aug-08	12	17	32	37	18	34	33	40	23	27	47
30-Sep-08	14	19	30	34	20	33	34	47	25	30	43
05-Nov-08	12	16	27	33	18	32	33	40	25	28	38

Notes:

1. *Yellow shaded blocks were found as No Detection. The Reportable Detection Limit value (RDL) was inserted.*
2. *Blue shaded blocks indicate that the Hydrolab malfunctioned, and the calculation could not be determined.*
3. *Green highlighted blocks indicate that the site was frozen, and the sample wasn't taken.*

Table 6.0 Summary Statistics of the West Credit River Water Temperature (Erin SSMP stations) for summer 2008

Site Name	Site ID	Average Daily Max (Target: 20ºC)	Seasonal Max (Target: 26ºC)	% Exceedance over 26ºC
West Credit u/s Hillsburgh, d/s 8th Line	151601	16	19.1	0.0%
West Credit d/s Hwy 25, Hillsburgh	151703	16.1	19.6	0.0%
West Credit d/s Head Pond, Hillsburgh	151701	21.2	26.8	0.3%
West Credit d/s County Rd 24	151302	21	26.5	0.2%
West Credit Trib at Caledon Rail Trail u/s 8th Line	151401*	18.5	23.8	0.0%
West Credit at 8th Line Gauge	151002	19.4	24.6	0.0%
West Credit d/s Main St, Erin	150807	22	28.3	2.2%
South Trib. d/s Main St., Erin	150805*	16.7	20.4	0.0%
East Trib. d/s 17th Sideroad (Wellington Rd 124)	152003*	16.9	21.7	0.0%
East Trib. d/s 10th Line/North West Credit R.	150804*	19.2	25.6	0.0%
West Credit d/s 10th Line	150402	18.3	22.8	0.0%
West Credit at Winston Churchill Blvd.	501150002	17.8	21.7	0.0%

*Note: Water Temperature **Raw Data** (°C) for the Erin SSMP stations is available in the Excel format (season 2008).*

Table 7.0 Calculated values of CCME Water Quality Index (WQI) for the Erin SSMP stations (2007-2008)

Station Name	Station ID	WQI	Rank
West Credit u/s Hillsburgh, d/s 8th Line	151601	73.8	Fair
West Credit d/s Hwy 25, Hillsburgh	151703	73.0	Fair
West Credit d/s Head Pond, Hillsburgh	151701	73.2	Fair
West Credit d/s County Rd 24	151302	83.1	Good
West Credit Trib at Caledon Rail Trail u/s 8th Line	151401*	83.3	Good
West Credit at 8th Line Gauge	151002	91.3	Good
West Credit d/s Main St, Erin	150807	79.1	Fair
South Trib. d/s Main St., Erin	150805*	82.3	Good
East Trib. d/s 17th Sideroad (Wellington Rd 124)	152003*	67.1	Fair
East Trib. d/s 10th Line/North West Credit R.	150804*	78.8	Fair
West Credit d/s 10th Line	150402	87.8	Good
Average value		**79.3**	

Table 8.0 Hydrolab deployment raw data for the Erin SSMP stations (June 23-27, 2008): Station Nos. 15-17-01 and 15-10-02

Site name	West Credit d/s Head Pond, Hillsburgh					West Credit at 8th Line Gauge				
Site ID	15-17-01					15-10-02				
date / time	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)
2008-06-23 11:00:00	17.76	473	8.35	146.3	13.64					
2008-06-23 11:30:00	18.29	467	8.4	154.6	14.26					
2008-06-23 12:00:00	18.71	442	8.42	148	13.53	17.15	471	7.5	103.7	9.79
2008-06-23 12:30:00	19.16	419	8.45	147	13.32	17.45	473	7.55	103.7	9.73
2008-06-23 13:00:00	19.61	439	8.46	155.3	13.95	17.81	467	7.59	103.9	9.68
2008-06-23 13:30:00	19.81	410	8.45	155.9	13.95	18.15	468	7.62	104.5	9.66
2008-06-23 14:00:00	20	416	8.43	154.1	13.73	18.47	470	7.64	104.3	9.58
2008-06-23 14:30:00	20.25	438	8.45	156.8	13.91	18.8	471	7.67	106.2	9.7
2008-06-23 15:00:00	20.48	445	8.46	156.2	13.79	19.17	473	7.68	106.5	9.65
2008-06-23 15:30:00	20.37	412	8.47	160.7	14.22	19.25	477	7.67	104.9	9.49
2008-06-23 16:00:00	20.08	445	8.44	158.7	14.12	19.02	463	7.66	101.8	9.25
2008-06-23 16:30:00	19.85	439	8.43	171.1	15.29	18.61	459	7.59	98.8	9.05
2008-06-23 17:00:00	19.89	451	8.42	170.7	15.24	18.49	467	7.55	98.8	9.08
2008-06-23 17:30:00	19.92	445	8.42	167.7	14.97	18.62	469	7.54	98.9	9.06
2008-06-23 18:00:00	19.99	443	8.4	169.9	15.14	18.56	472	7.53	98.6	9.05
2008-06-23 18:30:00	19.9	431	8.39	177	15.8	18.23	476	7.51	97.3	8.98
2008-06-23 19:00:00	19.75	456	8.37	170	15.22	18.04	477	7.5	95.9	8.89
2008-06-23 19:30:00	19.57	420	8.35	165.5	14.88	17.89	477	7.5	94.7	8.81
2008-06-23 20:00:00	19.34	427	8.34	161	14.53	17.79	473	7.5	95.1	8.87
2008-06-23 20:30:00	19.13	447	8.33	148.3	13.45	17.63	474	7.49	95.1	8.89
2008-06-23 21:00:00	18.94	443	8.31	152.6	13.89	17.43	475	7.48	94	8.82
2008-06-23 21:30:00	18.8	442	8.28	151.9	13.87	17.27	476	7.47	93.3	8.79
2008-06-23 22:00:00	18.63	415	8.25	142.9	13.09	17.16	477	7.46	92.5	8.73
2008-06-23 22:30:00	18.39	410	8.2	128.4	11.82	17.07	477	7.45	91.4	8.64
2008-06-23 23:00:00	18.17	418	8.15	136.9	12.66	16.95	476	7.44	90.9	8.62
2008-06-23 23:30:00	17.97	467	8.12	131.7	12.22	16.89	476	7.43	88.8	8.43
2008-06-24 00:00:00	17.77	472	8.11	132.9	12.39	16.78	474	7.43	88.4	8.42
2008-06-24 00:30:00	17.59	450	8.09	127	11.89	16.59	474	7.42	87.4	8.35
2008-06-24 01:00:00	17.4	442	8.06	124.5	11.7	16.46	462	7.42	86.5	8.29
2008-06-24 01:30:00	17.22	449	8.03	127	11.97	16.36	449	7.42	87.5	8.4
2008-06-24 02:00:00	17.04	451	8.01	121.2	11.47	16.29	374	7.4	87.9	8.45
2008-06-24 02:30:00	16.86	452	7.98	120.9	11.49	16.21	374	7.41	88.8	8.56
2008-06-24 03:00:00	16.72	474	7.96	120.9	11.52	16.19	373	7.4	88.8	8.56
2008-06-24 03:30:00	16.53	467	7.94	121.5	11.63	16.17	373	7.43	89.3	8.61
2008-06-24 04:00:00	16.42	475	7.93	120.3	11.54	16.17	373	7.39	90.6	8.74
2008-06-24 04:30:00	16.29	476	7.93	119.7	11.51	16.18	372	7.43	90.7	8.74
2008-06-24 05:00:00	16.19	478	7.93	116.1	11.19	16.2	369	7.39	90.8	8.75
2008-06-24 05:30:00	16.08	480	7.92	115.2	11.12	16.19	369	7.4	90.1	8.69
2008-06-24 06:00:00	16	488	7.93	114.7	11.1	16.16	369	7.37	90.8	8.76
2008-06-24 06:30:00	15.93	489	7.93	115.8	11.21	16.18	370	7.4	91.1	8.78
2008-06-24 07:00:00	15.9	486	7.94	116.5	11.3	16.22	368	7.39	91	8.76
2008-06-24 07:30:00	15.86	484	7.97	118.1	11.45	16.23	367	7.41	91.6	8.82
2008-06-24 08:00:00	15.85	482	8	122	11.84	16.3	366	7.37	91.8	8.83
2008-06-24 08:30:00	15.93	485	8.06	125.1	12.12	16.37	439	7.38	93.8	9
2008-06-24 09:00:00	16.1	473	8.15	130.8	12.62	16.53	365	7.4	93.9	8.99
2008-06-24 09:30:00	16.31	479	8.26	138.3	13.3	16.67	364	7.41	95.5	9.11

Continued

Table 8.0 Hydrolab deployment raw data for the Erin SSMP stations (June 23-27, 2008): Station Nos. 15-17-01 and 15-10-02

Site name	West Credit d/s Head Pond, Hillsburgh					West Credit at 8th Line Gauge				
Site ID	15-17-01					15-10-02				
date / time	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)
2008-06-24 10:00:00	16.68	464	8.36	124.7	11.89	16.82	364	7.42	96.8	9.21
2008-06-24 10:30:00	17.18	462	8.41	134.6	12.7	17.05	364	7.4	97.7	9.24
2008-06-24 11:00:00	17.64	462	8.46	153.1	14.31	17.35	364	7.41	98.8	9.29
2008-06-24 11:30:00	18.17	459	8.49	145.3	13.44	17.65	364	7.42	99.1	9.26
2008-06-24 12:00:00	18.75	450	8.51	151	13.8	17.97	364	7.43	99.6	9.25
2008-06-24 12:30:00	19.29	439	8.53	170.7	15.43	18.38	364	7.43	101.8	9.37
2008-06-24 13:00:00	19.83	422	8.52	177.1	15.84	18.75	364	7.41	102.8	9.4
2008-06-24 13:30:00	20.22	444	8.49	155.8	13.82	19.17	364	7.39	103.7	9.4
2008-06-24 14:00:00	20.71	445	8.49	154.8	13.61	19.55	363	7.39	104.9	9.43
2008-06-24 14:30:00	21.15	423	8.48	153.7	13.39	19.97	364	7.37	103.7	9.25
2008-06-24 15:00:00	21.59	441	8.47	156.6	13.53	20.21	364	7.33	101.6	9.02
2008-06-24 15:30:00	21.73	403	8.45	157.1	13.53	20.51	366	7.31	100.3	8.85
2008-06-24 16:00:00	21.88	424	8.43	155.8	13.38	20.79	366	7.28	100.6	8.83
2008-06-24 16:30:00	21.97	435	8.42	152.7	13.09	20.96	365	7.26	99.3	8.68
2008-06-24 17:00:00	22.07	419	8.42	154.5	13.22	21.01	366	7.24	98.4	8.59
2008-06-24 17:30:00	21.97	402	8.41	159.4	13.67	21.07	366	7.22	95.5	8.33
2008-06-24 18:00:00	21.92	428	8.39	155.1	13.31	21.03	365	7.2	92.9	8.11
2008-06-24 18:30:00	21.85	415	8.41	156.6	13.46	20.87	365	7.2	90.3	7.92
2008-06-24 19:00:00	21.72	419	8.4	161.3	13.9	20.71	365	7.2	90.4	7.95
2008-06-24 19:30:00	21.48	394	8.4	159.1	13.78	20.57	364	7.19	85.2	7.51
2008-06-24 20:00:00	21.29	412	8.36	193.8	16.84	20.39	362	7.19	83.8	7.41
2008-06-24 20:30:00	21.03	435	8.35	152.3	13.3	20.14	363	7.19	83.6	7.44
2008-06-24 21:00:00	20.71	435	8.33	154.7	13.59	19.91	362	7.19	81.2	7.25
2008-06-24 21:30:00	20.39	399	8.29	166.3	14.71	19.69	363	7.19	81.6	7.32
2008-06-24 22:00:00	20.06	459	8.25	145.4	12.94	19.44	363	7.19	82.7	7.45
2008-06-24 22:30:00	19.77	446	8.21	149.8	13.41	19.22	362	7.18	82.4	7.46
2008-06-24 23:00:00	19.49	457	8.16	137	12.33	19	362	7.18	82.1	7.47
2008-06-24 23:30:00	19.23	431	8.13	131.3	11.88	18.8	362	7.18	81	7.39
2008-06-25 00:00:00	19.02	467	8.1	126.6	11.5	18.57	360	7.18	75.7	6.95
2008-06-25 00:30:00	18.81	462	8.05	120.9	11.03	18.37	360	7.17	75.3	6.94
2008-06-25 01:00:00	18.59	466	8.01	117	10.72	18.19	359	7.17	75.3	6.96
2008-06-25 01:30:00	18.38	441	7.99	113.5	10.45	18.01	358	7.17	71.8	6.66
2008-06-25 02:00:00	18.19	460	7.96	111	10.26	17.81	361	7.16	75	6.99
2008-06-25 02:30:00	18.01	479	7.96	109.5	10.16	17.67	360	7.16	75.1	7.01
2008-06-25 03:00:00	17.84	472	7.95	111	10.33	17.54	360	7.15	74.4	6.97
2008-06-25 03:30:00	17.67	488	7.94	108.3	10.12	17.4	359	7.15	74.5	7.00
2008-06-25 04:00:00	17.52	488	7.93	108.3	10.14	17.28	359	7.14	73.9	6.97
2008-06-25 04:30:00	17.37	487	7.93	110	10.34	17.16	359	7.14	73.8	6.97
2008-06-25 05:00:00	17.23	488	7.93	106.8	10.07	17.06	360	7.14	73.4	6.95
2008-06-25 05:30:00	17.1	490	7.93	106.9	10.11	16.96	359	7.13	72.8	6.91
2008-06-25 06:00:00	16.99	489	7.93	106.4	10.08	16.9	359	7.13	72.1	6.85
2008-06-25 06:30:00	16.92	491	7.93	105.9	10.04	16.81	359	7.12	71.6	6.81
2008-06-25 07:00:00	16.86	491	7.94	106.1	10.08	16.74	359	7.12	71.9	6.85
2008-06-25 07:30:00	16.8	490	7.96	106.7	10.15					
2008-06-25 08:00:00	16.78	490	7.99	119.3	11.35					

Continued

Table 8.0 Hydrolab deployment raw data for the Erin SSMP stations (June 23-27, 2008): Station Nos. 15-17-01 and 15-10-02

Site name	West Credit d/s Head Pond, Hillsburgh					West Credit at 8th Line Gauge				
Site ID	15-17-01					15-10-02				
date / time	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)
2008-06-25 08:30:00	16.86	491	8.05	111	10.54					
2008-06-25 09:00:00	17.04	491	8.12	115.2	10.9					
2008-06-25 09:30:00	17.35	487	8.21	120.1	11.29					
2008-06-25 10:00:00	17.77	482	8.28	124.2	11.57					
2008-06-25 10:30:00	18.28	479	8.34	151.4	13.97					
2008-06-25 11:00:00	18.84	477	8.38	138.6	12.64					
2008-06-25 11:30:00	19.44	471	8.42	146.5	13.2					
2008-06-25 12:00:00	20.08	465	8.42	157.9	14.05					
2008-06-25 12:30:00	20.76	453	8.42	162.2	14.24					
2008-06-25 13:00:00	21.37	414	8.42	196.1	17.02					
2008-06-25 13:30:00	21.93	380	8.42	176.3	15.14					
2008-06-25 14:00:00	22.42	379	8.42	186	15.81					
2008-06-25 14:30:00	22.84	390	8.42	187.9	15.84					
2008-06-25 15:00:00	23.25	410	8.41	190.1	15.91					
2008-06-25 15:30:00	23.49	299	8.41	193.9	16.16					
2008-06-25 16:00:00	23.7	366	8.4	195	16.18					
2008-06-25 16:30:00	23.85	387	8.4	196.5	16.26					
2008-06-25 17:00:00	23.97	390	8.39	198	16.35					
2008-06-25 17:30:00	23.87	398	8.39	199.6	16.51					
2008-06-25 18:00:00	23.72	388	8.39	200	16.75					
2008-06-25 18:30:00	23.56	405	8.38	200	16.82					
2008-06-25 19:00:00	23.28	403	8.36	198	16.56					
2008-06-25 19:30:00	22.94	339	8.35	196.3	16.53					
2008-06-25 20:00:00	22.59	361	8.31	189.4	16.05					
2008-06-25 20:30:00	22.13	414	8.31	188.6	16.13					
2008-06-25 21:00:00	21.75	378	8.27	183.2	15.77					
2008-06-25 21:30:00	21.43	362	8.22	176.4	15.29					
2008-06-25 22:00:00	21.12	396	8.19	174.8	15.24					
2008-06-25 22:30:00	20.86	406	8.12	164.5	14.41					
2008-06-25 23:00:00	20.64	374	8.06	155.5	13.69					
2008-06-25 23:30:00	20.43	397	8.02	147.7	13.06					
2008-06-26 00:00:00	20.29	382	7.99	141.4	12.53					
2008-06-26 00:30:00	20.18	424	7.96	135.3	12.01					
2008-06-26 01:00:00	20.05	455	7.93	128.2	11.41					
2008-06-26 01:30:00	19.87	447	7.92	142.4	12.72					
2008-06-26 02:00:00	19.69	453	7.9	121.2	10.86					
2008-06-26 02:30:00	19.56	449	7.89	115.7	10.4					
2008-06-26 03:00:00	19.47	440	7.87	123.9	11.16					
2008-06-26 03:30:00	19.4	439	7.85	127.8	11.52					
2008-06-26 04:00:00	19.34	458	7.88	125.3	11.31					
2008-06-26 04:30:00	19.27	457	7.85	109.5	9.9					
2008-06-26 05:00:00	19.17	443	7.85	104.4	9.46					
2008-06-26 05:30:00	19.08	461	7.86	104.2	9.46					
2008-06-26 06:00:00	19	459	7.88	102.9	9.35					
2008-06-26 06:30:00	18.94	426	7.86	103.4	9.41					
2008-06-26 07:00:00	18.9	459	7.85	102.3	9.32					

Continued

Table 8.0 Hydrolab deployment raw data for the Erin SSMP stations (June 23-27, 2008): Station Nos. 15-17-01 and 15-10-02

Site name	West Credit d/s Head Pond, Hillsburgh					West Credit at 8th Line Gauge				
Site ID	15-17-01					15-10-02				
date / time	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)
2008-06-26 07:30:00	18.86	450	7.86	101.8	9.28					
2008-06-26 08:00:00	18.86	451	7.88	115.3	10.51					
2008-06-26 08:30:00	18.85	468	7.9	119.9	10.94					
2008-06-26 09:00:00	18.88	464	7.92	104.7	9.54					
2008-06-26 09:30:00	19.01	460	7.99	109.3	9.93					
2008-06-26 10:00:00	19.2	451	8.06	118.4	10.72					
2008-06-26 10:30:00	19.54	446	8.16	117	10.52					
2008-06-26 11:00:00	19.99	468	8.23	126.2	11.25					
2008-06-26 11:30:00	20.43	454	8.25	132.8	11.74					
2008-06-26 12:00:00	20.87	436	8.27	141.5	12.4					
2008-06-26 12:30:00	21.33	367	8.32	154.5	13.41					
2008-06-26 13:00:00	21.66	412	8.33	161.2	13.91					
2008-06-26 13:30:00	22.2	391	8.33	182.6	15.59					
2008-06-26 14:00:00	22.83	339	8.36	175.1	14.78					
2008-06-26 14:30:00	23.43	333	8.36	182	15.18					
2008-06-26 15:00:00	24.05	384	8.35	184.4	15.2					
2008-06-26 15:30:00	24.58	309	8.34	188.1	15.35					
2008-06-26 16:00:00	24.84	347	8.3	189.3	15.38					
2008-06-26 16:30:00	25.05	294	8.31	188.8	15.28					
2008-06-26 17:00:00	25.07	255	8.32	195.1	15.79					
2008-06-26 17:30:00	25.13	298	8.32	188.9	15.27					
2008-06-26 18:00:00	25.01	331	8.3	188.8	15.29					
2008-06-26 18:30:00	24.9	330	8.27	185.2	15.03					
2008-06-26 19:00:00	24.68	348	8.27	165.3	13.47					
2008-06-26 19:30:00	24.44	302	8.27	164.5	13.47					
2008-06-26 20:00:00	24.07	340	8.26	164.1	13.52					
2008-06-26 20:30:00	23.67	313	8.24	163.1	13.54					
2008-06-26 21:00:00	23.29	308	8.22	159	13.3					
2008-06-26 21:30:00	22.92	321	8.19	153.6	12.94					
2008-06-26 22:00:00	22.58	302	8.14	147.9	12.54					
2008-06-26 22:30:00	22.28	456	8.08	140.9	12.01					
2008-06-26 23:00:00	21.99	449	8.03	136.2	11.68					
2008-06-26 23:30:00	21.74	444	7.98	130.3	11.22					
2008-06-27 00:00:00	21.51	432	7.95	124.1	10.74					
2008-06-27 00:30:00	21.32	416	7.91	118.4	10.28					
2008-06-27 01:00:00	21.17	435	7.87	114.6	9.98					
2008-06-27 01:30:00	21.04	402	7.86	111.5	9.74					
2008-06-27 02:00:00	20.9	443	7.84	108.4	9.49					
2008-06-27 02:30:00	20.73	451	7.82	105.8	9.3					
2008-06-27 03:00:00	20.58	429	7.79	103.1	9.09					
2008-06-27 03:30:00	20.41	419	7.77	100.2	8.86					
2008-06-27 04:00:00	20.26	479	7.77	98.3	8.72					
2008-06-27 04:30:00	20.08	467	7.77	96.7	8.6					
2008-06-27 05:00:00	19.96	460	7.77	95.8	8.54					
2008-06-27 05:30:00	19.88	447	7.75	94.9	8.48					
2008-06-27 06:00:00	19.81	437	7.74	94.9	8.49					

Continued

Table 8.0 Hydrolab deployment raw data for the Erin SSMP stations (June 23-27, 2008): Station Nos. 15-17-01 and 15-10-02

Site name	West Credit d/s Head Pond, Hillsburgh					West Credit at 8th Line Gauge				
Site ID	15-17-01					15-10-02				
date / time	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)
2008-06-27 06:30:00	19.76	429	7.75	94.8	8.49					
2008-06-27 07:00:00	19.76	424	7.76	95.1	8.51					
2008-06-27 07:30:00	19.75	397	7.79	95.3	8.54					
2008-06-27 08:00:00	19.73	376	7.81	96.4	8.64					
2008-06-27 08:30:00	19.71	353	7.84	98.2	8.8					
2008-06-27 09:00:00	19.78	340	7.9	101.5	9.08					

Note: Hydrolab lost power on June 25, 7:30 AM at the site "West Credit at 8th Line Gauge".

Table 8.1 Hydrolab deployment raw data for the Erin SSMP stations (June 23-27, 2008): Station Nos. 15-08-07 and 15-04-02

Site name	West Credit d/s Main St., Erin					West Credit d/s 10th Line				
Site ID	15-08-07					15-04-02				
date / time	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)
2008-06-23 13:00:00	19.45	494	8.16	106.3	9.6					
2008-06-23 13:30:00	19.69	493	8.19	105.3	9.4					
2008-06-23 14:00:00	20.02	493	8.23	107.6	9.6					
2008-06-23 14:30:00	20.28	493	8.25	106.8	9.5					
2008-06-23 15:00:00	20.41	493	8.26	105.7	9.3	16.8	555	8.29	107.1	10.18
2008-06-23 15:30:00	20.44	497	8.24	102	9.0	16.81	550	8.29	102.9	9.78
2008-06-23 16:00:00	20.35	485	8.26	101.1	8.9	16.79	548	8.27	99.5	9.46
2008-06-23 16:30:00	20.08	468	8.25	100	8.9	16.56	524	8.23	95	9.08
2008-06-23 17:00:00	19.92	448	8.25	100.6	9.0	16.74	524	8.23	95.5	9.09
2008-06-23 17:30:00	19.45	392	8.24	97.9	8.8	16.63	512	8.18	91.8	8.76
2008-06-23 18:00:00	19.5	430	8.21	97.6	8.8	16.78	486	8.13	89.3	8.5
2008-06-23 18:30:00	19.51	448	8.19	97.4	8.8	16.56	443	8.08	86	8.22
2008-06-23 19:00:00	19.32	451	8.16	97.4	8.8	16.38	451	8.06	85.2	8.17
2008-06-23 19:30:00	19.17	452	8.12	97.3	8.8	16.4	470	8.06	85.5	8.2
2008-06-23 20:00:00	19.03	456	8.09	96.7	8.8	16.37	474	8.06	85.6	8.22
2008-06-23 20:30:00	18.9	463	8.06	96.1	8.8	16.29	480	8.06	85.3	8.2
2008-06-23 21:00:00	18.7	465	8.03	95.4	8.7	16.24	497	8.06	85.4	8.22
2008-06-23 21:30:00	18.46	464	8	94.3	8.7	16.18	506	8.07	85.1	8.19
2008-06-23 22:00:00	18.2	463	7.96	93.8	8.7	16.08	510	8.06	84.7	8.17
2008-06-23 22:30:00	17.95	464	7.93	93.6	8.7	15.95	514	8.05	84.2	8.15
2008-06-23 23:00:00	17.72	467	7.91	93.2	8.7	15.82	516	8.05	84.4	8.19
2008-06-23 23:30:00	17.5	469	7.9	92.6	8.7	15.68	520	8.05	84.1	8.19
2008-06-24 00:00:00	17.29	471	7.88	92.4	8.7	15.52	521	8.04	84.2	8.23
2008-06-24 00:30:00	17.08	474	7.88	92.2	8.7	15.35	521	8.03	84.2	8.26
2008-06-24 01:00:00	16.88	479	7.87	91.6	8.7	15.17	523	8.03	84.4	8.31
2008-06-24 01:30:00	16.68	479	7.86	91.3	8.7	15	525	8.03	84.4	8.34
2008-06-24 02:00:00	16.5	482	7.86	91.2	8.7	14.83	527	8.03	84.5	8.38
2008-06-24 02:30:00	16.32	483	7.86	91.7	8.8	14.66	529	8.03	84.4	8.39
2008-06-24 03:00:00	16.17	485	7.86	91.5	8.8	14.52	530	8.03	84.6	8.45
2008-06-24 03:30:00	16.04	487	7.85	91.5	8.8	14.41	533	8.03	85	8.5
2008-06-24 04:00:00	15.92	488	7.86	91.9	8.9	14.3	535	8.03	85	8.52
2008-06-24 04:30:00	15.8	490	7.86	91.8	8.9	14.19	537	8.03	84.9	8.54
2008-06-24 05:00:00	15.68	490	7.86	91.8	8.9	14.07	538	8.03	85.1	8.57
2008-06-24 05:30:00	15.55	491	7.86	91.2	8.9	13.96	539	8.03	85.3	8.62
2008-06-24 06:00:00	15.45	492	7.86	91.5	9.0	13.85	541	8.03	85.3	8.63
2008-06-24 06:30:00	15.36	492	7.86	91.6	9.0	13.75	542	8.04	85.7	8.7
2008-06-24 07:00:00	15.29	493	7.87	92.2	9.1	13.68	543	8.04	86.3	8.77
2008-06-24 07:30:00	15.25	493	7.85	92.8	9.1	13.64	544	8.05	87.1	8.86
2008-06-24 08:00:00	15.24	494	7.88	93.4	9.2	13.64	545	8.06	88.3	8.98
2008-06-24 08:30:00	15.31	493	7.9	94.2	9.2	13.67	546	8.07	89.4	9.09
2008-06-24 09:00:00	15.45	493	7.91	95.3	9.3	13.71	547	8.09	90.8	9.23
2008-06-24 09:30:00	15.74	494	7.95	96.9	9.4	13.82	547	8.1	92.5	9.37
2008-06-24 10:00:00	16.1	493	7.97	97.8	9.4	13.99	547	8.12	94.3	9.52
2008-06-24 10:30:00	16.55	493	8	98.8	9.4	14.25	548	8.14	96.9	9.73
2008-06-24 11:00:00	17.11	493	8.04	100.2	9.5	14.51	548	8.16	98.8	9.86

Continued

Table 8.1 Hydrolab deployment raw data for the Erin SSMP stations (June 23-27, 2008): Station Nos. 15-08-07 and 15-04-02

Site name	West Credit d/s Main St., Erin					West Credit d/s 10th Line				
Site ID	15-08-07					15-04-02				
date / time	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)
2008-06-24 11:30:00	17.67	493	8.07	101.4	9.5	14.81	549	8.18	100.7	9.98
2008-06-24 12:00:00	18.32	492	8.11	102.8	9.5	15.17	549	8.2	102.9	10.13
2008-06-24 12:30:00	18.93	491	8.14	104.2	9.5	15.58	549	8.22	104.6	10.21
2008-06-24 13:00:00	19.45	491	8.17	104.8	9.4	15.86	549	8.23	105.1	10.19
2008-06-24 13:30:00	20.07	491	8.2	105.6	9.4	16.3	550	8.25	106.7	10.25
2008-06-24 14:00:00	20.71	490	8.23	107.4	9.4	16.77	549	8.27	108.3	10.3
2008-06-24 14:30:00	21.2	490	8.25	106.6	9.3	17.11	549	8.28	108.3	10.23
2008-06-24 15:00:00	21.69	489	8.27	107.5	9.3	17.46	550	8.29	108.7	10.2
2008-06-24 15:30:00	22.12	489	8.27	106.7	9.1	17.75	550	8.29	108.3	10.09
2008-06-24 16:00:00	22.39	488	8.26	104.4	8.9	18.03	550	8.3	107.5	9.96
2008-06-24 16:30:00	22.66	488	8.29	106.1	9.0	18.29	550	8.31	107.5	9.91
2008-06-24 17:00:00	22.77	488	8.29	105.4	8.9	18.3	551	8.29	104.8	9.66
2008-06-24 17:30:00	22.84	487	8.29	105.4	8.9	18.38	551	8.29	103.2	9.49
2008-06-24 18:00:00	22.8	487	8.28	103.5	8.7	18.4	552	8.27	100.3	9.23
2008-06-24 18:30:00	22.72	487	8.28	103	8.7	18.4	552	8.26	98	9.02
2008-06-24 19:00:00	22.58	487	8.26	101.3	8.6	18.37	552	8.24	95.2	8.76
2008-06-24 19:30:00	22.38	487	8.24	99.6	8.5	18.32	553	8.22	92.6	8.53
2008-06-24 20:00:00	22.14	487	8.22	99.5	8.5	18.3	553	8.21	91.9	8.47
2008-06-24 20:30:00	21.87	487	8.2	97.8	8.4	18.15	553	8.18	89.1	8.24
2008-06-24 21:00:00	21.55	488	8.17	96.9	8.4	17.99	553	8.16	87.6	8.12
2008-06-24 21:30:00	21.21	488	8.14	96	8.4	17.83	554	8.14	86.2	8.02
2008-06-24 22:00:00	20.88	489	8.11	95.3	8.3	17.64	554	8.12	85.3	7.97
2008-06-24 22:30:00	20.55	489	8.07	94.7	8.4	17.45	554	8.11	84.7	7.95
2008-06-24 23:00:00	20.22	490	8.05	93.9	8.3	17.25	555	8.11	84.4	7.95
2008-06-24 23:30:00	19.91	491	8.02	93.6	8.4	17.03	555	8.1	84.3	7.98
2008-06-25 00:00:00	19.61	491	7.99	92.8	8.3	16.8	555	8.09	84.4	8.02
2008-06-25 00:30:00	19.33	491	7.98	92.5	8.4	16.57	556	8.08	84.3	8.05
2008-06-25 01:00:00	19.05	492	7.96	92.1	8.4	16.34	556	8.08	84.3	8.09
2008-06-25 01:30:00	18.77	492	7.94	91.6	8.4	16.11	557	8.07	84.5	8.15
2008-06-25 02:00:00	18.5	492	7.93	91.3	8.4	15.88	557	8.07	84.6	8.2
2008-06-25 02:30:00	18.24	492	7.92	90.6	8.4	15.66	557	8.06	84.7	8.25
2008-06-25 03:00:00	17.98	492	7.91	90.9	8.4	15.44	558	8.06	84.8	8.29
2008-06-25 03:30:00	17.74	492	7.9	90.7	8.5	15.25	558	8.05	84.9	8.34
2008-06-25 04:00:00	17.5	492	7.89	90.6	8.5	15.05	558	8.05	84.7	8.36
2008-06-25 04:30:00	17.28	492	7.88	90.4	8.5	14.86	559	8.05	85	8.42
2008-06-25 05:00:00	17.06	492	7.88	90.4	8.6	14.69	559	8.05	85.1	8.47
2008-06-25 05:30:00	16.87	492	7.87	90.4	8.6	14.52	559	8.05	85.1	8.5
2008-06-25 06:00:00	16.69	492	7.87	90.2	8.6	14.37	559	8.05	85.4	8.56
2008-06-25 06:30:00	16.56	492	7.87	90.8	8.7	14.25	559	8.05	85.9	8.62
2008-06-25 07:00:00	16.44	492	7.88	91.1	8.7	14.14	559	8.06	86.9	8.74
2008-06-25 07:30:00	16.35	492	7.88	91.8	8.8	14.07	560	8.07	88	8.87
2008-06-25 08:00:00	16.28	491	7.89	92.5	8.9	14.05	560	8.08	89.6	9.03
2008-06-25 08:30:00	16.29	491	7.9	93.1	9.0	14.07	559	8.09	90.9	9.16
2008-06-25 09:00:00	16.38	491	7.92	94.6	9.1	14.16	559	8.11	92.8	9.34
2008-06-25 09:30:00	16.58	490	7.94	95.7	9.1	14.31	560	8.13	94.7	9.49

Continued

Table 8.1 Hydrolab deployment raw data for the Erin SSMP stations (June 23-27, 2008): Station Nos. 15-08-07 and 15-04-02

Site name	West Credit d/s Main St., Erin					West Credit d/s 10th Line				
Site ID	15-08-07					15-04-02				
date / time	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)
2008-06-25 10:00:00	16.91	490	7.97	96.6	9.2	14.53	558	8.15	96.6	9.64
2008-06-25 10:30:00	17.35	489	8	98.5	9.3	14.8	560	8.17	98.8	9.8
2008-06-25 11:00:00	17.9	488	8.03	98.6	9.2	15.15	559	8.19	101.3	9.97
2008-06-25 11:30:00	18.55	488	8.07	101.5	9.3	15.56	559	8.21	103.9	10.14
2008-06-25 12:00:00	19.21	488	8.1	102.4	9.3	15.99	559	8.23	106.4	10.29
2008-06-25 12:30:00	19.86	487	8.13	103.6	9.3	16.24	559	8.25	106.8	10.27
2008-06-25 13:00:00	20.47	486	8.16	105.6	9.3	16.65	558	8.27	108.7	10.36
2008-06-25 13:30:00	21.18	486	8.19	106.1	9.2	17.12	559	8.28	110.3	10.42
2008-06-25 14:00:00	21.73	485	8.22	105.3	9.1	17.51	561	8.3	111.6	10.45
2008-06-25 14:30:00	22.27	485	8.24	105.1	9.0	17.93	560	8.31	111.9	10.39
2008-06-25 15:00:00	22.73	484	8.25	106.8	9.0	18.17	561	8.31	110.6	10.22
2008-06-25 15:30:00	23.1	483	8.27	105.9	8.9	18.47	561	8.32	110.4	10.14
2008-06-25 16:00:00	23.47	483	8.28	104.7	8.7	18.74	562	8.32	109.8	10.03
2008-06-25 16:30:00	23.84	483	8.29	103.6	8.6	18.99	557	8.32	109	9.9
2008-06-25 17:00:00	24.12	482	8.29	102.8	8.5	19.08	558	8.32	106.7	9.68
2008-06-25 17:30:00	24.37	481	8.29	104.4	8.6	19.17	558	8.31	105	9.51
2008-06-25 18:00:00	24.47	481	8.29	101.9	8.3	19.24	558	8.3	102.6	9.28
2008-06-25 18:30:00	24.5	480	8.28	99.5	8.1	19.16	558	8.27	98.6	8.93
2008-06-25 19:00:00	24.43	480	8.27	100.2	8.2	19.05	559	8.26	95.7	8.69
2008-06-25 19:30:00	24.26	481	8.26	98.5	8.1	19.03	560	8.24	94.4	8.57
2008-06-25 20:00:00	23.98	481	8.24	97	8.0	18.93	560	8.22	91.7	8.34
2008-06-25 20:30:00	23.67	481	8.21	96.2	8.0	18.8	561	8.2	89.1	8.13
2008-06-25 21:00:00	23.33	481	8.18	95.3	8.0	18.68	561	8.17	86.9	7.94
2008-06-25 21:30:00	22.97	482	8.16	94.3	7.9	18.58	561	8.15	85	7.79
2008-06-25 22:00:00	22.61	483	8.12	93.7	7.9	18.48	562	8.13	83.9	7.7
2008-06-25 22:30:00	22.25	484	8.09	92.6	7.9	18.38	562	8.12	83.4	7.67
2008-06-25 23:00:00	21.92	484	8.05	92	7.9	18.29	562	8.1	83	7.65
2008-06-25 23:30:00	21.62	485	8.02	91.3	7.9	18.15	563	8.09	82.9	7.66
2008-06-26 00:00:00	21.35	486	8	91.3	7.9	18	563	8.09	82.6	7.66
2008-06-26 00:30:00	21.11	487	7.97	90	7.9	17.84	563	8.08	82.9	7.72
2008-06-26 01:00:00	20.88	487	7.95	89.7	7.9	17.64	564	8.07	83.2	7.77
2008-06-26 01:30:00	20.67	488	7.93	89	7.8	17.45	564	8.07	82.9	7.78
2008-06-26 02:00:00	20.47	488	7.92	88.7	7.8	17.25	564	8.06	83.1	7.83
2008-06-26 02:30:00	20.31	488	7.91	88.8	7.9	17.08	565	8.06	83.3	7.88
2008-06-26 03:00:00	20.16	488	7.9	89.2	7.9	16.93	565	8.05	83.2	7.89
2008-06-26 03:30:00	20.02	489	7.88	89	7.9	16.8	566	8.05	83.4	7.93
2008-06-26 04:00:00	19.89	489	7.87	89.3	8.0	16.69	566	8.04	83.5	7.96
2008-06-26 04:30:00	19.76	489	7.86	88.4	7.9	16.56	566	8.04	83.5	7.98
2008-06-26 05:00:00	19.63	489	7.86	88.2	7.9	16.45	567	8.04	83.5	8
2008-06-26 05:30:00	19.51	489	7.85	87.3	7.9	16.36	567	8.03	83.6	8.02
2008-06-26 06:00:00	19.4	489	7.84	87.7	7.9	16.27	568	8.03	83.6	8.04
2008-06-26 06:30:00	19.29	489	7.83	87.9	7.9	16.18	568	8.02	83.8	8.07
2008-06-26 07:00:00	19.18	489	7.83	89.2	8.1	16.13	568	8.03	84.3	8.13
2008-06-26 07:30:00	19.11	489	7.84	88.8	8.1	16.11	568	8.04	85.9	8.29
2008-06-26 08:00:00	19.06	489	7.84	88.7	8.1	16.11	568	8.06	88.1	8.5

Continued

Table 8.1 Hydrolab deployment raw data for the Erin SSMP stations (June 23-27, 2008): Station Nos. 15-08-07 and 15-04-02

Site name	West Credit d/s Main St., Erin					West Credit d/s 10th Line				
Site ID	15-08-07					15-04-02				
date / time	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)
2008-06-26 08:30:00	19.02	489	7.84	90.9	8.3	16.09	571	8.07	88.2	8.51
2008-06-26 09:00:00	19.04	488	7.85	92.9	8.4	16.11	573	8.09	90.3	8.71
2008-06-26 09:30:00	19.12	488	7.86	94.2	8.5	16.23	569	8.12	94.2	9.06
2008-06-26 10:00:00	19.29	488	7.87	95.5	8.6	16.39	567	8.15	96.3	9.24
2008-06-26 10:30:00	19.58	487	7.89	97.4	8.8	16.63	566	8.18	100.1	9.55
2008-06-26 11:00:00	19.91	487	7.92	99	8.8	16.88	566	8.21	103.3	9.81
2008-06-26 11:30:00	20.26	486	7.94	98.5	8.7	17.08	565	8.24	104.8	9.9
2008-06-26 12:00:00	20.73	485	7.98	101.8	8.9	17.42	565	8.26	108	10.13
2008-06-26 12:30:00	21.33	484	8.03	103.6	9.0	17.77	565	8.29	109.8	10.23
2008-06-26 13:00:00	21.8	483	8.06	101.8	8.8	17.88	565	8.29	109.3	10.16
2008-06-26 13:30:00	22.49	482	8.08	103.8	8.8	18.45	566	8.31	112.4	10.32
2008-06-26 14:00:00	23.1	481	8.1	104.5	8.8	18.95	568	8.32	113.5	10.32
2008-06-26 14:30:00	23.73	481	8.11	105.2	8.7	19.34	566	8.34	114.3	10.31
2008-06-26 15:00:00	24.35	480	8.14	104.9	8.6	19.76	560	8.35	114.8	10.27
2008-06-26 15:30:00	24.92	480	8.13	104	8.4	20.14	557	8.36	114.9	10.2
2008-06-26 16:00:00	25.39	479	8.15	102.8	8.3	20.35	557	8.35	112.7	9.97
2008-06-26 16:30:00	25.78	478	8.14	102.3	8.2	20.45	558	8.35	110.9	9.79
2008-06-26 17:00:00	26.05	478	8.13	101.6	8.1	20.54	558	8.34	108.4	9.55
2008-06-26 17:30:00	26.23	477	8.15	99.7	7.9	20.59	557	8.32	105.1	9.25
2008-06-26 18:00:00	26.34	477	8.17	98.1	7.8	20.51	558	8.29	100.4	8.85
2008-06-26 18:30:00	26.34	477	8.17	97.9	7.7	20.5	558	8.28	98.7	8.7
2008-06-26 19:00:00	26.3	477	8.17	94.6	7.5	20.48	559	8.26	96.4	8.5
2008-06-26 19:30:00	26.16	477	8.13	94.2	7.5	20.43	562	8.24	93.6	8.27
2008-06-26 20:00:00	25.93	477	8.12	93	7.4	20.35	563	8.22	91.4	8.08
2008-06-26 20:30:00	25.6	478	8.1	91.6	7.3	20.27	563	8.2	89.1	7.89
2008-06-26 21:00:00	25.27	478	8.09	91.9	7.4	20.12	565	8.17	86.4	7.67
2008-06-26 21:30:00	24.89	478	8.07	88.7	7.2	19.96	565	8.14	84.3	7.51
2008-06-26 22:00:00	24.53	479	8.04	88.7	7.3	19.83	566	8.12	83	7.41
2008-06-26 22:30:00	24.19	480	8.02	89.4	7.4	19.66	566	8.1	82.1	7.36
2008-06-26 23:00:00	23.83	480	7.99	88.6	7.3	19.5	567	8.09	81.6	7.34
2008-06-26 23:30:00	23.48	481	7.97	88.4	7.4	19.33	567	8.08	81.5	7.36
2008-06-27 00:00:00	23.15	482	7.94	87.6	7.3	19.14	566	8.07	81.6	7.4
2008-06-27 00:30:00	22.87	482	7.92	87.4	7.4	18.96	567	8.06	81.7	7.43
2008-06-27 01:00:00	22.59	483	7.89	86.9	7.4	18.79	567	8.05	81.7	7.46
2008-06-27 01:30:00	22.37	483	7.88	86.5	7.4	18.6	567	8.05	81.8	7.5
2008-06-27 02:00:00	22.14	484	7.86	86.4	7.4	18.42	568	8.05	82	7.54
2008-06-27 02:30:00	21.93	485	7.85	85.6	7.4	18.22	567	8.04	82.1	7.58
2008-06-27 03:00:00	21.74	485	7.83	86.9	7.5	18.02	567	8.04	82.2	7.61
2008-06-27 03:30:00	21.53	487	7.82	86.7	7.5	17.82	567	8.04	82.2	7.65
2008-06-27 04:00:00	21.35	487	7.81	85.6	7.4	17.63	568	8.04	82.4	7.7
2008-06-27 04:30:00	21.16	487	7.8	86	7.5	17.45	568	8.03	82.4	7.73
2008-06-27 05:00:00	20.97	487	7.79	86.5	7.6	17.28	568	8.03	82.6	7.77
2008-06-27 05:30:00	20.8	486	7.79	86.7	7.6	17.16	568	8.03	82.7	7.8
2008-06-27 06:00:00	20.63	487	7.79	86.8	7.6	17.05	569	8.03	82.8	7.83
2008-06-27 06:30:00	20.48	486	7.79	87	7.7	16.96	569	8.03	83.3	7.89

Continued

Table 8.1 Hydrolab deployment raw data for the Erin SSMP stations (June 23-27, 2008): Station Nos. 15-08-07 and 15-04-02

Site name	West Credit d/s Main St., Erin					West Credit d/s 10th Line				
Site ID	15-08-07					15-04-02				
date / time	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)
2008-06-27 07:00:00	20.35	487	7.79	87.5	7.7	16.91	569	8.03	84.5	8.02
2008-06-27 07:30:00	20.25	487	7.8	88.5	7.8	16.86	570	8.03	85.5	8.12
2008-06-27 08:00:00	20.17	487	7.8	89.5	7.9	16.84	569	8.05	87.8	8.34
2008-06-27 08:30:00	20.15	486	7.81	90.3	8.0	16.88	569	8.08	89.9	8.54
2008-06-27 09:00:00	20.17	486	7.83	91.8	8.2	16.94	569	8.1	91.9	8.71
2008-06-27 09:30:00	20.25	486	7.83	93	8.2	17.02	569	8.12	94.3	8.92

Table 8.2 Hydrolab deployment raw data for the Erin SSMP stations (August 25-29, 2008): Station Nos. 15-17-01 and 15-10-02

Site name	West Credit d/s Head Pond, Hillsburgh					West Credit at 8th Line Gauge				
Site ID	15-17-01					15-10-02				
date / time	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)
2008-08-25 10:30						17.45	532	8.07	93.5	8.77
2008-08-26 11:00						17.53	531	8.09	95.2	8.91
2008-08-25 11:30	17.24	490	7.66	90.7	8.55	17.64	530	8.11	96.9	9.05
2008-08-25 12:00	17.41	491	7.68	93.7	8.8	17.83	530	8.13	98.4	9.15
2008-08-25 12:30	17.58	492	7.69	93.2	8.72	18.07	529	8.15	99.8	9.24
2008-08-25 13:00	17.84	492	7.72	95	8.84	18.38	528	8.17	100.7	9.27
2008-08-25 13:30	18.14	493	7.72	104.7	9.68	18.67	528	8.18	102	9.33
2008-08-25 14:00	18.52	493	7.73	103.5	9.5	18.91	528	8.19	102.5	9.33
2008-08-25 14:30	18.9	494	7.74	100.5	9.15	19.17	527	8.2	102.9	9.32
2008-08-25 15:00	19.26	493	7.75	99.8	9.03	19.45	527	8.21	103.1	9.29
2008-08-25 15:30	19.64	492	7.76	99.1	8.89	19.69	527	8.21	102.8	9.22
2008-08-25 16:00	19.96	492	7.78	103.9	9.26	19.79	526	8.21	102.3	9.15
2008-08-25 16:30	20.2	491	7.79	106.7	9.47	19.73	524	8.21	101.6	9.1
2008-08-25 17:00	20.38	490	7.79	116.3	10.29	19.45	522	8.19	100	9.01
2008-08-25 17:30	20.47	489	7.79	119.2	10.52	19.36	531	8.17	98.2	8.86
2008-08-25 18:00	20.49	489	7.78	111.5	9.84	19.44	535	8.15	96.5	8.69
2008-08-25 18:30	20.42	488	7.77	119.1	10.52	19.45	536	8.14	95.4	8.59
2008-08-25 19:00	20.28	487	7.77	119	10.55	19.39	536	8.13	94.1	8.48
2008-08-25 19:30	20.06	487	7.76	111.7	9.94	19.25	536	8.13	92.8	8.39
2008-08-25 20:00	19.81	487	7.77	111	9.93	19.09	536	8.12	91.5	8.3
2008-08-25 20:30	19.55	486	7.77	101.6	9.14	18.91	536	8.11	90.8	8.26
2008-08-25 21:00	19.24	486	7.75	118	10.67	18.68	536	8.09	89.7	8.2
2008-08-25 21:30	18.93	486	7.74	111.4	10.14	18.42	536	8.08	89.2	8.2
2008-08-25 22:00	18.64	486	7.74	118.2	10.82	18.13	535	8.08	88.7	8.2
2008-08-25 22:30	18.36	486	7.76	108.8	10.02	17.86	535	8.07	88.4	8.22
2008-08-25 23:00	18.08	486	7.76	112.5	10.42	17.6	535	8.06	88.3	8.25
2008-08-25 23:30	17.81	487	7.76	105.2	9.8	17.36	535	8.05	88.1	8.28
2008-08-26 0:00	17.58	488	7.76	107.6	10.07	17.13	535	8.04	87.9	8.3
2008-08-26 0:30	17.39	489	7.76	103.9	9.76	16.93	534	8.03	87.9	8.33
2008-08-26 1:00	17.22	489	7.75	105.8	9.97	16.75	533	8.03	87.9	8.36
2008-08-26 1:30	17.06	490	7.76	105.9	10.02	16.56	532	8.02	87.9	8.4
2008-08-26 2:00	16.9	491	7.76	103.1	9.78	16.39	532	8.02	87.9	8.43
2008-08-26 2:30	16.77	492	7.76	93.8	8.93	16.22	532	8.02	87.9	8.46
2008-08-26 3:00	16.62	492	7.76	102.9	9.82	16.08	531	8.01	88	8.5
2008-08-26 3:30	16.48	492	7.75	98.5	9.43	15.91	531	8.01	88.1	8.53
2008-08-26 4:00	16.32	493	7.75	102.4	9.84	15.77	531	8.02	88.1	8.56
2008-08-26 4:30	16.18	493	7.74	100.6	9.7	15.64	531	8.01	88.2	8.59
2008-08-26 5:00	16.04	492	7.75	100.4	9.71	15.52	531	8.01	88.1	8.61
2008-08-26 5:30	15.9	493	7.75	99.2	9.62	15.4	531	8.01	88.4	8.66
2008-08-26 6:00	15.77	493	7.75	97.4	9.47	15.28	531	8.02	88.3	8.67
2008-08-26 6:30	15.65	493	7.75	97.8	9.53	15.16	531	8.01	88.4	8.7
2008-08-26 7:00	15.51	493	7.75	93.6	9.15	15.05	531	8.02	88.4	8.72
2008-08-26 7:30	15.42	492	7.74	94.6	9.26	14.96	532	8.01	88.8	8.78
2008-08-26 8:00	15.35	492	7.74	98.4	9.65	14.9	532	8.02	89.1	8.82
2008-08-26 8:30	15.29	492	7.74	95.4	9.37	14.9	532	8.02	89.8	8.89

Continued

Table 8.2 Hydrolab deployment raw data for the Erin SSMP stations (August 25-29, 2008): Station Nos. 15-17-01 and 15-10-02

Site name	West Credit d/s Head Pond, Hillsburgh					West Credit at 8th Line Gauge				
Site ID	15-17-01					15-10-02				
date / time	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)
2008-08-26 9:00	15.31	492	7.75	95.6	9.38	14.96	533	8.03	90.5	8.95
2008-08-26 9:30	15.44	492	7.75	96.1	9.41	15.09	533	8.04	91.8	9.05
2008-08-26 10:00	15.66	492	7.75	93.9	9.15	15.24	533	8.05	93	9.14
2008-08-26 10:30	15.94	491	7.74	96.6	9.36	15.44	533	8.06	94.1	9.2
2008-08-26 11:00	16.25	492	7.74	96.4	9.28	15.67	533	8.07	95.4	9.28
2008-08-26 11:30	16.59	492	7.74	93.6	8.94	15.92	532	8.09	96.5	9.35
2008-08-26 12:00	16.98	492	7.74	95.9	9.09	16.22	532	8.1	97.6	9.4
2008-08-26 12:30	17.37	492	7.74	100.5	9.44	16.57	531	8.11	98.7	9.43
2008-08-26 13:00	17.79	492	7.75	99.9	9.31	16.93	531	8.12	99.7	9.46
2008-08-26 13:30	18.16	492	7.76	100.5	9.29	17.32	530	8.13	100.7	9.47
2008-08-26 14:00	18.53	493	7.76	100.8	9.25	17.72	530	8.14	101.5	9.46
2008-08-26 14:30	18.85	492	7.78	103.6	9.45	18.11	530	8.15	102.1	9.45
2008-08-26 15:00	19.18	492	7.77	104.9	9.5	18.48	530	8.16	102.2	9.38
2008-08-26 15:30	19.5	492	7.77	103.8	9.34	18.83	531	8.16	102.3	9.33
2008-08-26 16:00	19.78	491	7.77	105.4	9.43	19.1	531	8.16	102	9.25
2008-08-26 16:30	20.09	491	7.78	105.7	9.4	19.3	531	8.16	101.5	9.16
2008-08-26 17:00	20.29	491	7.78	105.3	9.33	19.45	531	8.16	100.3	9.04
2008-08-26 17:30	20.39	491	7.76	103.3	9.13	19.51	531	8.16	99.3	8.93
2008-08-26 18:00	20.41	491	7.75	101.5	8.97	19.53	531	8.15	98.1	8.82
2008-08-26 18:30	20.37	491	7.76	103.5	9.16	19.45	531	8.14	96.7	8.7
2008-08-26 19:00	20.26	491	7.76	100.5	8.91	19.31	532	8.13	95.4	8.61
2008-08-26 19:30	20.11	491	7.77	100.6	8.94	19.1	532	8.12	94	8.52
2008-08-26 20:00	19.91	491	7.78	101	9.02	18.85	532	8.1	92.6	8.44
2008-08-26 20:30	19.62	490	7.79	102.4	9.19	18.56	532	8.09	91.4	8.38
2008-08-26 21:00	19.28	491	7.77	100.1	9.05	18.23	532	8.08	90.5	8.36
2008-08-26 21:30	18.93	491	7.75	99.6	9.07	17.84	531	8.07	90	8.37
2008-08-26 22:00	18.58	491	7.75	98.4	9.02	17.52	531	8.06	89.5	8.39
2008-08-26 22:30	18.24	491	7.74	97.5	9	17.25	531	8.05	89.2	8.4
2008-08-26 23:00	17.93	492	7.73	95.9	8.91	17	532	8.04	88.8	8.41
2008-08-26 23:30	17.64	492	7.72	93.6	8.75	16.78	533	8.03	88.6	8.42
2008-08-27 0:00	17.41	493	7.73	94.7	8.89	16.58	533	8.02	88.3	8.44
2008-08-27 0:30	17.19	493	7.73	92.8	8.76	16.38	533	8.02	88.4	8.48
2008-08-27 1:00	16.98	494	7.73	93.8	8.89	16.2	533	8.02	88.3	8.5
2008-08-27 1:30	16.8	493	7.74	95.7	9.1	16.02	533	8.01	88.2	8.53
2008-08-27 2:00	16.62	494	7.74	93.3	8.91	15.84	532	8.01	88.4	8.58
2008-08-27 2:30	16.46	494	7.75	91.2	8.73	15.67	532	8.01	88.5	8.61
2008-08-27 3:00	16.3	494	7.74	92.5	8.89	15.51	531	8.01	88.4	8.64
2008-08-27 3:30	16.15	494	7.76	92.5	8.92	15.36	531	8.01	88.6	8.68
2008-08-27 4:00	16	494	7.75	92	8.9	15.2	531	8.01	88.5	8.71
2008-08-27 4:30	15.86	494	7.74	92.9	9.01	15.07	531	8	88.6	8.74
2008-08-27 5:00	15.72	494	7.75	93.4	9.08	14.95	531	8.01	88.5	8.76
2008-08-27 5:30	15.59	493	7.75	93.5	9.12	14.83	531	8	88.6	8.79
2008-08-27 6:00	15.48	494	7.75	92.3	9.03	14.72	531	8.01	88.6	8.81
2008-08-27 6:30	15.36	493	7.75	89.6	8.78	14.62	531	8	88.6	8.83
2008-08-27 7:00	15.27	493	7.75	92.6	9.09	14.52	531	8	88.7	8.85

Continued

Table 8.2 Hydrolab deployment raw data for the Erin SSMP stations (August 25-29, 2008): Station Nos. 15-17-01 and 15-10-02

Site name	West Credit d/s Head Pond, Hillsburgh					West Credit at 8th Line Gauge				
Site ID	15-17-01					15-10-02				
date / time	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)
2008-08-27 7:30	15.2	493	7.75	92.1	9.06	14.45	531	8	89	8.89
2008-08-27 8:00	15.17	492	7.75	93.5	9.2	14.44	531	8.01	89.9	8.99
2008-08-27 8:30	15.18	492	7.75	91.9	9.05	14.47	531	8.01	90.5	9.04
2008-08-27 9:00	15.22	492	7.75	92.4	9.08	14.55	531	8.02	91.5	9.13
2008-08-27 9:30	15.36	492	7.76	91.5	8.97	14.71	531	8.03	93	9.25
2008-08-27 10:00	15.54	492	7.76	92.3	9.02	14.92	531	8.04	94.2	9.32
2008-08-27 10:30	15.74	493	7.77	91.2	8.87	15.16	531	8.06	95.4	9.39
2008-08-27 11:00	16.02	492	7.77	92.2	8.92	15.38	532	8.07	96.3	9.43
2008-08-27 11:30	16.34	493	7.77	92.5	8.89	15.65	531	8.09	97.5	9.5
2008-08-27 12:00	16.64	492	7.77	93.5	8.92	15.99	530	8.1	98.9	9.56
2008-08-27 12:30	16.9	493	7.78	94.7	8.99	16.25	529	8.12	100.1	9.63
2008-08-27 13:00	17.2	493	7.79	94.7	8.93	16.51	529	8.13	100.9	9.65
2008-08-27 13:30	17.49	492	7.79	97	9.09	16.76	529	8.15	101.8	9.68
2008-08-27 14:00	17.8	492	7.8	97.5	9.08	17.02	529	8.16	102.1	9.66
2008-08-27 14:30	18.12	492	7.81	97	8.97	17.37	529	8.17	103	9.68
2008-08-27 15:00	18.34	491	7.82	97.5	8.98	17.61	530	8.18	102.9	9.62
2008-08-27 15:30	18.59	491	7.83	99.8	9.15	17.92	529	8.19	103.8	9.64
2008-08-27 16:00	18.84	490	7.82	99.5	9.07	18.18	529	8.2	104	9.61
2008-08-27 16:30	19.02	490	7.82	100.3	9.11	18.42	529	8.21	103.6	9.52
2008-08-27 17:00	19.16	490	7.82	100.9	9.14	18.61	529	8.21	103.4	9.47
2008-08-27 17:30	19.23	490	7.82	98.4	8.9	18.69	529	8.21	102.2	9.34
2008-08-27 18:00	19.26	490	7.82	99.7	9.01	18.7	529	8.2	100.7	9.2
2008-08-27 18:30	19.27	490	7.83	100.4	9.08	18.64	529	8.19	99.2	9.08
2008-08-27 19:00	19.2	489	7.82	99	8.97	18.57	529	8.18	97.5	8.94
2008-08-27 19:30	19.09	490	7.84	97.5	8.85	18.5	529	8.17	95.9	8.81
2008-08-27 20:00	18.96	490	7.82	97.8	8.9	18.4	529	8.15	94.3	8.68
2008-08-27 20:30	18.76	490	7.82	95.7	8.74	18.27	530	8.13	92.7	8.55
2008-08-27 21:00	18.52	490	7.81	94.3	8.66	18.1	530	8.11	91.4	8.46
2008-08-27 21:30	18.29	491	7.8	95.3	8.79	17.91	531	8.1	90.5	8.41
2008-08-27 22:00	18.06	491	7.79	92.5	8.57	17.73	531	8.08	89.7	8.37
2008-08-27 22:30	17.85	491	7.78	91.5	8.51	17.53	531	8.07	89.4	8.37
2008-08-27 23:00	17.67	492	7.77	91.6	8.55	17.29	531	8.05	89.1	8.38
2008-08-27 23:30	17.51	493	7.76	90.6	8.49	17.09	531	8.04	88.8	8.39
2008-08-28 0:00	17.38	493	7.74	89.6	8.42	16.95	531	8.03	88.5	8.39
2008-08-28 0:30	17.26	493	7.73	88.5	8.33	16.86	533	8.02	88.3	8.38
2008-08-28 1:00	17.17	493	7.72	89	8.4	16.8	535	8.01	88.1	8.38
2008-08-28 1:30	17.09	493	7.72	89	8.42	16.76	535	8.01	88	8.37
2008-08-28 2:00	17.01	493	7.72	88.9	8.42	16.72	535	8	88.1	8.39
2008-08-28 2:30	16.95	494	7.71	89.2	8.46	16.67	534	7.99	88.1	8.4
2008-08-28 3:00	16.88	494	7.72	89.7	8.52	16.64	534	7.99	88	8.4
2008-08-28 3:30	16.81	494	7.71	89.9	8.55	16.63	534	7.98	88.1	8.41
2008-08-28 4:00	16.74	494	7.71	88.2	8.4	16.61	534	7.98	88	8.4
2008-08-28 4:30	16.68	495	7.7	87.8	8.37	16.59	534	7.98	88	8.41
2008-08-28 5:00	16.62	494	7.7	86	8.21	16.58	534	7.98	88.1	8.42
2008-08-28 5:30	16.56	494	7.7	86	8.22	16.56	534	7.98	88.1	8.42

Continued

Table 8.2 Hydrolab deployment raw data for the Erin SSMP stations (August 25-29, 2008): Station Nos. 15-17-01 and 15-10-02

Site name	West Credit d/s Head Pond, Hillsburgh					West Credit at 8th Line Gauge				
Site ID	15-17-01					15-10-02				
date / time	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)
2008-08-28 6:00	16.5	495	7.7	85.4	8.17	16.55	534	7.97	88.1	8.42
2008-08-28 6:30	16.45	495	7.71	84.5	8.1	16.52	534	7.97	88	8.41
2008-08-28 7:00	16.38	494	7.7	86	8.25	16.48	533	7.97	88.2	8.44
2008-08-28 7:30	16.31	494	7.69	85.2	8.19	16.44	533	7.97	88.3	8.46
2008-08-28 8:00	16.29	495	7.69	86.8	8.34	16.42	533	7.97	88.9	8.52
2008-08-28 8:30	16.29	495	7.68	84.8	8.15	16.46	533	7.98	89.9	8.61
2008-08-28 9:00	16.33	495	7.68	84.8	8.15	16.56	533	7.99	90.9	8.68
2008-08-28 9:30	16.38	494	7.68	86.2	8.28	16.66	533	8	92.1	8.78
2008-08-28 10:00	16.49	494	7.68	85.4	8.18	16.78	533	8.01	93	8.84
2008-08-28 10:30	16.69	494	7.69	85.5	8.15	16.96	533	8.02	94.7	8.97
2008-08-28 11:00	16.95	494	7.69	85.8	8.13	17.2	533	8.04	95.8	9.04
2008-08-28 11:30	17.27	494	7.7	88.5	8.34	17.4	533	8.05	97.3	9.14
2008-08-28 12:00	17.67	495	7.7	89.9	8.39	17.65	533	8.06	98.5	9.2
2008-08-28 12:30	18.09	495	7.71	89.4	8.28	17.86	533	8.08	100	9.3
2008-08-28 13:00	18.44	495	7.72	90	8.27	18.04	532	8.1	100.7	9.33
2008-08-28 13:30	18.7	495	7.72	89.8	8.21	18.11	532	8.11	100.2	9.27
2008-08-28 14:00	18.83	494	7.73	89.5	8.17	18.11	532	8.12	99.2	9.18
2008-08-28 14:30	18.84	493	7.73	92.3	8.42	18.18	532	8.12	98.1	9.07
2008-08-28 15:00	18.8	493	7.75	91.8	8.38	18.23	533	8.12	97.3	8.98
2008-08-28 15:30	18.69	493	7.75	91.1	8.33	18.31	533	8.13	96.6	8.9
2008-08-28 16:00	18.53	492	7.75	91.5	8.4	18.33	533	8.13	95.8	8.82
2008-08-28 16:30	18.36	492	7.74	90.3	8.31	18.3	533	8.13	95.1	8.76
2008-08-28 17:00	18.18	491	7.74	90.4	8.36	18.2	534	8.12	94.2	8.7
2008-08-28 17:30	18	491	7.75	89.6	8.32	18.08	534	8.11	93.1	8.62
2008-08-28 18:00	17.85	491	7.76	89.9	8.36	17.95	535	8.1	92.1	8.55
2008-08-28 18:30	17.72	490	7.76	90	8.39	17.83	535	8.09	91.3	8.5
2008-08-28 19:00	17.6	490	7.75	89.1	8.33	17.69	536	8.08	90.7	8.47
2008-08-28 19:30	17.49	490	7.74	88.8	8.33	17.57	536	8.07	90.4	8.46
2008-08-28 20:00	17.39	491	7.73	89.2	8.38	17.46	536	8.06	89.8	8.42
2008-08-28 20:30	17.29	492	7.72	87.5	8.24	17.37	536	8.05	89.3	8.39
2008-08-28 21:00	17.2	493	7.7	86.1	8.13	17.28	535	8.04	88.8	8.36
2008-08-28 21:30	17.11	493	7.69	87.4	8.26	17.2	535	8.03	88.4	8.34
2008-08-28 22:00	17.03	494	7.69	85.1	8.05	17.15	535	8.03	88.2	8.32
2008-08-28 22:30	16.96	494	7.68	84.2	7.99	17.1	535	8.02	88.1	8.32
2008-08-28 23:00	16.88	494	7.67	84.1	7.98	17.06	535	8.01	88	8.32
2008-08-28 23:30	16.82	494	7.67	83.3	7.92	17.03	535	8.01	87.9	8.31
2008-08-29 0:00	16.77	494	7.67	84	8	17.01	536	8.01	87.9	8.32
2008-08-29 0:30	16.72	494	7.68	82.8	7.89	16.98	536	8	87.9	8.33
2008-08-29 1:00	16.68	494	7.68	83.5	7.96	16.96	536	8	87.9	8.33
2008-08-29 1:30	16.64	494	7.68	82.2	7.84	16.95	536	8	87.9	8.33
2008-08-29 2:00	16.59	494	7.69	81.3	7.77	16.93	536	8	87.9	8.34
2008-08-29 2:30	16.55	494	7.68	82.1	7.84	16.94	536	7.99	87.8	8.33
2008-08-29 3:00	16.52	495	7.68	81.2	7.76	16.94	537	7.99	87.8	8.32
2008-08-29 3:30	16.48	494	7.69	81.5	7.8	16.95	536	7.99	87.8	8.32
2008-08-29 4:00	16.45	494	7.68	81.8	7.84	16.95	536	7.98	87.8	8.32

Continued

Table 8.2 Hydrolab deployment raw data for the Erin SSMP stations (August 25-29, 2008): Station Nos. 15-17-01 and 15-10-02

Site name	West Credit d/s Head Pond, Hillsburgh					West Credit at 8th Line Gauge				
Site ID	15-17-01					15-10-02				
date / time	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)
2008-08-29 4:30	16.42	495	7.69	81.3	7.8	16.96	536	7.98	87.7	8.31
2008-08-29 5:00	16.39	494	7.69	81.4	7.81	16.97	536	7.97	87.7	8.31
2008-08-29 5:30	16.37	494	7.69	80.8	7.75	16.97	537	7.97	87.7	8.31
2008-08-29 6:00	16.35	494	7.69	80.3	7.71	16.97	537	7.96	87.8	8.31
2008-08-29 6:30	16.33	495	7.69	80.6	7.74	16.98	538	7.96	87.5	8.29
2008-08-29 7:00	16.31	494	7.69	80.6	7.74	16.98	538	7.95	87.6	8.29
2008-08-29 7:30	16.3	495	7.69	80.1	7.7	16.98	539	7.95	87.7	8.3
2008-08-29 8:00	16.29	495	7.69	80	7.69	16.99	540	7.95	88	8.34
2008-08-29 8:30	16.3	495	7.69	80.2	7.71	17.01	540	7.95	88.5	8.38
2008-08-29 9:00	16.32	494	7.69	79.8	7.67	17.04	540	7.96	89.2	8.43

Table 8.3 Hydrolab deployment raw data for the Erin SSMP stations (August 25-29, 2008): Station Nos. 15-08-07 and 15-04-02

Site name	West Credit d/s Main St., Erin					West Credit d/s 10th Line				
Site ID	15-08-07					15-04-02				
date / time	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)
2008-08-25 12:30	18.05	535	8.13	102.6	9.51					
2008-08-25 13:00	18.57	534	8.16	104.4	9.57					
2008-08-25 13:30	19.15	534	8.19	105.4	9.55					
2008-08-25 14:00	19.79	534	8.22	105.9	9.47	16.0	613	8.28	116.2	11.23
2008-08-25 14:30	20.4	534	8.24	105.7	9.34	16.31	614	8.3	117.4	11.28
2008-08-25 15:00	20.98	533	8.26	105.8	9.24	16.55	614	8.31	117.5	11.22
2008-08-25 15:30	21.48	533	8.27	104.7	9.06	16.7	614	8.32	116.6	11.11
2008-08-25 16:00	21.9	533	8.28	103.8	8.91	16.81	614	8.32	115.6	10.98
2008-08-25 16:30	22.26	532	8.29	102.8	8.76	16.9	613	8.32	114	10.81
2008-08-25 17:00	22.51	531	8.3	101.9	8.64	16.92	613	8.3	111.3	10.55
2008-08-25 17:30	22.61	531	8.29	101.7	8.61	16.88	613	8.28	107.6	10.21
2008-08-25 18:00	22.61	531	8.29	99.9	8.45	16.81	613	8.25	103.5	9.83
2008-08-25 18:30	22.59	531	8.29	98.7	8.36	16.74	615	8.21	98.9	9.41
2008-08-25 19:00	22.46	531	8.28	97.7	8.3	16.69	617	8.18	95.7	9.11
2008-08-25 19:30	22.23	531	8.27	96.6	8.24	16.62	618	8.14	92.7	8.84
2008-08-25 20:00	21.91	531	8.26	95.8	8.22	16.53	619	8.11	90	8.6
2008-08-25 20:30	21.51	531	8.24	94.6	8.18	16.4	619	8.07	87	8.34
2008-08-25 21:00	21.06	532	8.22	94.1	8.2	16.27	618	8.04	84.8	8.15
2008-08-25 21:30	20.58	532	8.19	93.3	8.22	16.16	617	8.02	83.8	8.08
2008-08-25 22:00	20.12	532	8.18	92.7	8.24	16.05	615	8.01	83	8.02
2008-08-25 22:30	19.64	533	8.15	92.1	8.26	15.92	614	8	82.7	8.01
2008-08-25 23:00	19.21	533	8.13	91.8	8.31	15.79	613	7.99	82.6	8.03
2008-08-25 23:30	18.81	533	8.11	91.2	8.32	15.64	612	7.99	82.8	8.06
2008-08-26 0:00	18.44	533	8.09	90.8	8.35	15.46	611	7.99	82.8	8.1
2008-08-26 0:30	18.1	533	8.07	90.4	8.36	15.27	610	7.99	83	8.15
2008-08-26 1:00	17.75	533	8.05	89.9	8.38	15.04	610	7.98	83.1	8.19
2008-08-26 1:30	17.43	534	8.04	89.8	8.42	14.81	610	7.98	83.2	8.25
2008-08-26 2:00	17.15	535	8.02	89.6	8.45	14.56	610	7.98	83.4	8.32
2008-08-26 2:30	16.89	536	8	89.2	8.46	14.31	610	7.98	83.7	8.39
2008-08-26 3:00	16.65	537	7.99	88.9	8.48	14.07	610	7.97	83.7	8.44
2008-08-26 3:30	16.42	538	7.98	88.9	8.52	13.82	610	7.97	83.8	8.49
2008-08-26 4:00	16.22	538	7.97	88.9	8.56	13.59	610	7.96	84.1	8.57
2008-08-26 4:30	16.03	539	7.96	88.8	8.58	13.35	610	7.96	84.2	8.62
2008-08-26 5:00	15.82	539	7.96	88.6	8.6	13.14	611	7.96	84.4	8.68
2008-08-26 5:30	15.63	539	7.95	88.7	8.65	12.92	612	7.95	84.4	8.73
2008-08-26 6:00	15.44	539	7.95	88.8	8.69	12.73	613	7.95	84.6	8.78
2008-08-26 6:30	15.24	539	7.94	88.9	8.73	12.55	614	7.95	84.6	8.82
2008-08-26 7:00	15.06	539	7.94	89.1	8.79	12.39	614	7.95	84.8	8.88
2008-08-26 7:30	14.87	539	7.94	89.6	8.88	12.24	614	7.96	86	9.02
2008-08-26 8:00	14.74	539	7.95	90.3	8.97	12.13	615	7.97	86.7	9.13
2008-08-26 8:30	14.65	538	7.96	91.3	9.09	12.08	615	7.98	88.4	9.31
2008-08-26 9:00	14.61	538	7.97	92	9.17	12.1	615	8	90	9.48
2008-08-26 9:30	14.64	538	7.98	93.2	9.28	12.17	614	8.01	91.9	9.66
2008-08-26 10:00	14.74	537	8	94.3	9.36	12.31	614	8.04	94.2	9.88
2008-08-26 10:30	14.96	536	8.02	95.6	9.45	12.48	614	8.06	96.5	10.07

Continued

Table 8.3 Hydrolab deployment raw data for the Erin SSMP stations (August 25-29, 2008): Station Nos. 15-08-07 and 15-04-02

Site name	West Credit d/s Main St., Erin					West Credit d/s 10th Line				
Site ID	15-08-07					15-04-02				
date / time	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)
2008-08-26 11:00	15.32	536	8.04	96.9	9.51	12.73	614	8.09	99.2	10.3
2008-08-26 11:30	15.77	536	8.07	98.3	9.55	13.04	613	8.12	101.9	10.51
2008-08-26 12:00	16.32	535	8.1	100.2	9.63	13.43	613	8.15	105.1	10.74
2008-08-26 12:30	16.99	535	8.13	102.6	9.71	13.85	612	8.19	108.3	10.96
2008-08-26 13:00	17.68	534	8.16	104	9.71	14.26	612	8.21	111	11.14
2008-08-26 13:30	18.32	534	8.19	105.1	9.69	14.67	612	8.24	113.1	11.25
2008-08-26 14:00	18.95	533	8.21	105.6	9.6	15.03	611	8.26	114.5	11.3
2008-08-26 14:30	19.54	533	8.22	105.7	9.5	15.36	610	8.28	115.6	11.33
2008-08-26 15:00	20.07	533	8.23	105.4	9.37	15.66	610	8.29	115.9	11.29
2008-08-26 15:30	20.53	532	8.24	104.7	9.22	15.9	608	8.3	115.4	11.17
2008-08-26 16:00	20.96	533	8.25	103.4	9.04	16.1	606	8.3	114.6	11.06
2008-08-26 16:30	21.32	532	8.26	102.8	8.92	16.24	605	8.29	112.6	10.83
2008-08-26 17:00	21.58	532	8.26	102	8.81	16.32	605	8.28	110	10.56
2008-08-26 17:30	21.76	532	8.27	101.1	8.7	16.35	604	8.26	106.6	10.23
2008-08-26 18:00	21.85	532	8.26	99.2	8.52	16.34	605	8.23	102.3	9.81
2008-08-26 18:30	21.86	532	8.26	98.2	8.43	16.31	606	8.19	97.7	9.39
2008-08-26 19:00	21.77	532	8.25	97.2	8.37	16.29	607	8.16	94.5	9.08
2008-08-26 19:30	21.58	533	8.25	96.2	8.3	16.24	608	8.13	91.9	8.84
2008-08-26 20:00	21.29	533	8.24	95.2	8.27	16.16	609	8.1	89.3	8.6
2008-08-26 20:30	20.93	533	8.22	94.1	8.23	16.03	610	8.07	86.7	8.38
2008-08-26 21:00	20.52	533	8.2	93.1	8.21	15.91	611	8.04	84.9	8.23
2008-08-26 21:30	20.07	534	8.18	92.6	8.23	15.76	612	8.02	84.1	8.17
2008-08-26 22:00	19.63	534	8.16	91.9	8.24	15.64	613	8.01	83.5	8.13
2008-08-26 22:30	19.19	535	8.14	91.4	8.27	15.49	613	8	83	8.11
2008-08-26 23:00	18.77	535	8.12	90.9	8.3	15.33	613	7.99	82.9	8.13
2008-08-26 23:30	18.37	535	8.1	90.3	8.31	15.16	613	7.99	83	8.17
2008-08-27 0:00	18.01	536	8.08	90	8.34	14.96	613	7.99	83.1	8.21
2008-08-27 0:30	17.67	536	8.06	89.6	8.36	14.74	613	7.98	83.3	8.27
2008-08-27 1:00	17.37	536	8.04	89.3	8.39	14.51	613	7.98	83.6	8.34
2008-08-27 1:30	17.09	537	8.03	88.9	8.4	14.28	614	7.98	83.6	8.38
2008-08-27 2:00	16.82	537	8.02	88.6	8.42	14.04	614	7.97	83.8	8.45
2008-08-27 2:30	16.59	537	8	88.2	8.42	13.81	614	7.97	84	8.51
2008-08-27 3:00	16.37	538	7.99	88.4	8.48	13.58	614	7.97	84.1	8.56
2008-08-27 3:30	16.18	537	7.98	88.3	8.5	13.36	614	7.96	84.3	8.63
2008-08-27 4:00	15.98	537	7.97	87.9	8.51	13.15	614	7.96	84.3	8.67
2008-08-27 4:30	15.8	538	7.96	87.9	8.53	12.95	614	7.96	84.3	8.71
2008-08-27 5:00	15.59	537	7.96	88.2	8.6	12.75	614	7.95	84.4	8.76
2008-08-27 5:30	15.41	537	7.95	88	8.62	12.58	615	7.95	84.7	8.82
2008-08-27 6:00	15.21	537	7.95	88.2	8.67	12.41	615	7.95	84.9	8.87
2008-08-27 6:30	15.02	536	7.94	88.1	8.7	12.26	615	7.95	84.7	8.89
2008-08-27 7:00	14.83	536	7.94	88.1	8.74	12.13	615	7.95	85.2	8.96
2008-08-27 7:30	14.66	536	7.94	89	8.86	12.05	614	7.96	86.5	9.12
2008-08-27 8:00	14.53	536	7.95	89.7	8.95	12.01	614	7.97	88	9.29
2008-08-27 8:30	14.44	536	7.96	90.5	9.05	12	614	7.99	89.5	9.45
2008-08-27 9:00	14.41	536	7.97	91.1	9.11	12.03	614	8	90.8	9.58

Continued

Table 8.3 Hydrolab deployment raw data for the Erin SSMP stations (August 25-29, 2008): Station Nos. 15-08-07 and 15-04-02

Site name	West Credit d/s Main St., Erin					West Credit d/s 10th Line				
Site ID	15-08-07					15-04-02				
date / time	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)
2008-08-27 9:30	14.48	536	7.99	93.6	9.36	12.2	613	8.04	94.7	9.95
2008-08-27 10:00	14.55	536	8	93.5	9.33	12.33	613	8.06	96.2	10.08
2008-08-27 10:30	14.74	535	8.02	95.7	9.5	12.54	613	8.09	99	10.32
2008-08-27 11:00	15.06	535	8.04	96.5	9.52	12.76	612	8.11	101.1	10.49
2008-08-27 11:30	15.44	535	8.07	98.6	9.65	13.08	612	8.14	103.7	10.68
2008-08-27 12:00	15.94	534	8.1	100.6	9.74	13.45	611	8.17	106.7	10.9
2008-08-27 12:30	16.4	534	8.12	101.2	9.7	13.69	611	8.2	108.3	11
2008-08-27 13:00	16.86	534	8.15	102.5	9.74	13.91	610	8.22	110.2	11.15
2008-08-27 13:30	17.27	533	8.18	104	9.79	14.1	610	8.25	111.5	11.23
2008-08-27 14:00	17.57	533	8.18	102	9.54	14.14	609	8.24	109.7	11.04
2008-08-27 14:30	17.93	532	8.21	103.2	9.59	14.31	609	8.26	111.2	11.15
2008-08-27 15:00	18.2	531	8.23	103.3	9.54	14.48	608	8.27	111.4	11.13
2008-08-27 15:30	18.5	530	8.25	105	9.64	14.71	607	8.28	112.3	11.16
2008-08-27 16:00	18.75	530	8.27	105.3	9.62	14.96	607	8.29	113.2	11.19
2008-08-27 16:30	18.99	529	8.27	104.2	9.47	15.12	607	8.29	112	11.03
2008-08-27 17:00	19.23	529	8.28	103.5	9.36	15.21	607	8.29	110.4	10.85
2008-08-27 17:30	19.44	529	8.29	102.9	9.27	15.39	606	8.29	109.6	10.73
2008-08-27 18:00	19.59	528	8.29	101.3	9.1	15.43	607	8.27	105.7	10.34
2008-08-27 18:30	19.7	528	8.29	99.9	8.95	15.46	608	8.24	102.6	10.04
2008-08-27 19:00	19.73	528	8.29	98.9	8.85	15.47	608	8.22	99.8	9.76
2008-08-27 19:30	19.7	529	8.28	97.3	8.72	15.45	608	8.18	96.1	9.4
2008-08-27 20:00	19.6	529	8.27	96.1	8.63	15.38	609	8.14	92.2	9.03
2008-08-27 20:30	19.43	529	8.26	94.9	8.55	15.31	610	8.1	89.2	8.75
2008-08-27 21:00	19.23	529	8.25	94.2	8.52	15.24	610	8.07	87.2	8.57
2008-08-27 21:30	19	530	8.23	93.6	8.51	15.17	611	8.05	85.5	8.41
2008-08-27 22:00	18.75	530	8.21	93	8.5	15.11	611	8.02	84.5	8.32
2008-08-27 22:30	18.51	531	8.19	92.2	8.47	15.06	611	8.01	83.8	8.26
2008-08-27 23:00	18.28	532	8.17	91.6	8.45	15	612	8	83.8	8.28
2008-08-27 23:30	18.09	533	8.14	90.9	8.42	14.92	612	7.99	83.6	8.27
2008-08-28 0:00	17.9	534	8.12	90.5	8.41	14.83	612	7.99	83.5	8.28
2008-08-28 0:30	17.74	535	8.11	90.3	8.42	14.74	612	7.98	83.7	8.31
2008-08-28 1:00	17.61	535	8.09	89.6	8.37	14.64	612	7.98	83.8	8.34
2008-08-28 1:30	17.49	536	8.07	89.3	8.37	14.54	613	7.98	83.8	8.36
2008-08-28 2:00	17.38	536	8.05	89.1	8.37	14.45	613	7.98	83.8	8.37
2008-08-28 2:30	17.3	537	8.04	88.6	8.34	14.36	613	7.97	83.9	8.4
2008-08-28 3:00	17.22	537	8.03	88.6	8.35	14.28	613	7.97	83.9	8.42
2008-08-28 3:30	17.15	538	8.02	88.3	8.33	14.2	614	7.96	83.9	8.43
2008-08-28 4:00	17.08	538	8	88.1	8.33	14.12	614	7.96	84.1	8.46
2008-08-28 4:30	17.01	538	7.99	88.1	8.34	14.06	614	7.96	83.8	8.45
2008-08-28 5:00	16.95	538	7.98	88	8.34	14	615	7.96	84	8.48
2008-08-28 5:30	16.88	538	7.97	87.7	8.33	13.95	615	7.95	84	8.48
2008-08-28 6:00	16.81	538	7.97	87.9	8.35	13.91	615	7.95	84	8.49
2008-08-28 6:30	16.74	538	7.96	87.8	8.35	13.86	614	7.95	84	8.51
2008-08-28 7:00	16.65	538	7.96	87.7	8.37	13.79	614	7.95	84.1	8.53
2008-08-28 7:30	16.58	537	7.96	88.5	8.46	13.75	615	7.95	85.3	8.66

Continued

Table 8.3 Hydrolab deployment raw data for the Erin SSMP stations (August 25-29, 2008): Station Nos. 15-08-07 and 15-04-02

Site name	West Credit d/s Main St., Erin					West Credit d/s 10th Line				
Site ID	15-08-07					15-04-02				
date / time	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)
2008-08-28 8:00	16.51	537	7.96	89.2	8.53	13.76	615	7.97	87	8.82
2008-08-28 8:30	16.46	537	7.96	89.7	8.59	13.76	615	7.98	88.3	8.96
2008-08-28 9:00	16.46	537	7.97	91.4	8.76	13.82	614	8	91.8	9.3
2008-08-28 9:30	16.55	537	7.99	93.5	8.94	13.96	614	8.03	94.7	9.57
2008-08-28 10:00	16.61	537	7.99	93.3	8.91	14.04	614	8.04	94.9	9.57
2008-08-28 10:30	16.76	537	8.01	94.2	8.97	14.16	614	8.07	98.2	9.88
2008-08-28 11:00	17.03	537	8.03	95.9	9.07	14.36	613	8.11	100.6	10.07
2008-08-28 11:30	17.41	537	8.06	98.2	9.22	14.56	613	8.13	103.3	10.3
2008-08-28 12:00	17.83	537	8.09	99.7	9.27	14.83	612	8.16	105.4	10.45
2008-08-28 12:30	18.37	536	8.12	102.4	9.43	15.24	611	8.2	110.2	10.83
2008-08-28 13:00	18.77	536	8.13	100.1	9.13	15.34	611	8.21	109	10.68
2008-08-28 13:30	19.13	536	8.14	99	8.97	15.36	611	8.22	108.1	10.59
2008-08-28 14:00	19.36	536	8.15	98.2	8.86	15.35	611	8.22	106	10.39
2008-08-28 14:30	19.5	536	8.16	97.3	8.75	15.28	611	8.2	102.7	10.08
2008-08-28 15:00	19.6	535	8.18	97.4	8.74	15.26	611	8.19	101.2	9.94
2008-08-28 15:30	19.62	535	8.19	97.7	8.77	15.29	612	8.18	99.8	9.8
2008-08-28 16:00	19.55	534	8.19	96.3	8.66	15.3	612	8.15	96.8	9.49
2008-08-28 16:30	19.44	534	8.19	95.3	8.58	15.29	612	8.13	94.6	9.28
2008-08-28 17:00	19.3	534	8.19	95.3	8.61	15.3	612	8.13	93.7	9.19
2008-08-28 17:30	19.13	534	8.19	94.2	8.54	15.32	612	8.11	91.8	9
2008-08-28 18:00	18.98	534	8.18	93.5	8.5	15.32	613	8.08	89.2	8.75
2008-08-28 18:30	18.82	534	8.17	93.1	8.49	15.31	612	8.07	88.5	8.68
2008-08-28 19:00	18.66	534	8.16	92.7	8.48	15.32	612	8.06	87.3	8.57
2008-08-28 19:30	18.5	536	8.15	91.7	8.42	15.29	612	8.04	86.1	8.45
2008-08-28 20:00	18.34	535	8.13	91.3	8.41	15.25	612	8.03	85.4	8.39
2008-08-28 20:30	18.17	536	8.12	90.7	8.38	15.19	612	8.02	84.8	8.34
2008-08-28 21:00	18.02	536	8.1	90.4	8.38	15.13	612	8.01	84.6	8.33
2008-08-28 21:30	17.87	536	8.09	89.6	8.33	15.05	612	8	84.2	8.31
2008-08-28 22:00	17.74	537	8.07	89.6	8.35	14.98	612	8	84	8.3
2008-08-28 22:30	17.63	537	8.06	89	8.32	14.92	612	8	84.2	8.33
2008-08-28 23:00	17.53	538	8.05	89	8.33	14.85	612	8	84.1	8.34
2008-08-28 23:30	17.45	538	8.03	88.6	8.31	14.78	612	7.99	84.1	8.35
2008-08-29 0:00	17.38	539	8.03	88.5	8.31	14.71	613	7.99	84.1	8.36
2008-08-29 0:30	17.33	539	8.02	88	8.28	14.64	613	7.99	84.1	8.38
2008-08-29 1:00	17.28	540	8.01	88.1	8.29	14.57	613	7.98	84.4	8.41
2008-08-29 1:30	17.24	540	8	87.9	8.28	14.51	614	7.98	84.4	8.43
2008-08-29 2:00	17.2	540	7.99	87.8	8.28	14.45	614	7.98	84.2	8.42
2008-08-29 2:30	17.16	541	7.99	87.5	8.26	14.4	614	7.97	84.3	8.43
2008-08-29 3:00	17.13	541	7.98	87.5	8.26	14.35	614	7.97	84.5	8.46
2008-08-29 3:30	17.08	541	7.97	87.6	8.28	14.3	615	7.97	84.4	8.46
2008-08-29 4:00	17.04	542	7.97	87.5	8.27	14.27	615	7.96	84.3	8.46
2008-08-29 4:30	17	542	7.96	87.5	8.28	14.23	615	7.96	84.4	8.47
2008-08-29 5:00	16.96	542	7.96	87.1	8.26	14.21	615	7.95	84.4	8.48
2008-08-29 5:30	16.92	543	7.95	87.5	8.3	14.19	615	7.95	84.4	8.48

Continued

Table 8.3 Hydrolab deployment raw data for the Erin SSMP stations (August 25-29, 2008): Station Nos. 15-08-07 and 15-04-02

Site name	West Credit d/s Main St., Erin					West Credit d/s 10th Line				
Site ID	15-08-07					15-04-02				
date / time	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)	Temp (°C)	SpCond (µS/cm)	pH	DO (%)	DO (mg/L)
2008-08-29 6:00	16.89	543	7.95	87.1	8.27	14.18	616	7.95	84.4	8.49
2008-08-29 6:30	16.86	543	7.95	87.5	8.3	14.16	616	7.94	84.4	8.49
2008-08-29 7:00	16.84	543	7.94	87.3	8.29	14.14	616	7.93	84.3	8.48
2008-08-29 7:30	16.82	543	7.94	87.6	8.32	14.11	616	7.93	84.6	8.52
2008-08-29 8:00	16.82	542	7.94	88	8.37	14.11	617	7.94	85.8	8.64
2008-08-29 8:30	16.83	542	7.94	88.2	8.38	14.12	617	7.95	87.1	8.77
2008-08-29 9:00	16.84	542	7.94	88.4	8.4	14.12	617	7.95	87.2	8.78

Table 9.0 Inorganics Occurrence in Sediments for the Erin SSMP stations (October 2008)

Parameter	Total detected number	Provincial Guidelines					Max observed concentration (ug/g)	Location
		LEL, ug/g	Exceedance Number	SEL, ug/g	Exceedance Number	Percent of violation		
Total Ammonia-N	0	100	0	100	0	0	NA	All Stations
Total Kjeldahl Nitrogen	11	550	2	4800	9	100	10500	West Credit u/s Hillsburgh 8th Line

Notes:
1. *SEL = Severe Effect Level*
2. *NA = Not Applicable*
3. *For Ammonia established just level of effect in Provincial Guidelines: Table 3 of "Guidelines for the protection and management of aquatic sediment quality in Ontario";*
4. *Percent of violation: indicates the total number of samples with level of contamination which exceeds Lowest Effect Level (LEL).*

Table 9.1 Occurrence of Exceedance the Federal / Provincial / Standards for Metals in Sediments for the Erin SSMP stations (October 2008)

Metals	Total detected number	Federal Guidelines				Provincial Guidelines				% of violation	Max observed concentration (ug/g)	Location (Station ID)
		TEL, ug/g	Excee-dance Number	PEL, ug/g	Excee-dance Number	LEL, ug/g	Exceedance Number	SEL, ug/g	Exceedance Number			
Arsenic (As)	11	**5.9**	0	**17**	0	**6**	0	**33**	0	0	5	151701, 152003*
Cadmium (Cd)	11	**0.6**	6	**3.5**	0	**0.6**	6	**10**	0	54.5	1.4	150805*
Chromium (Cr)	11	**37.3**	0	**90**	0	**26**	0	**110**	0	0	14	151601
Cobalt (Co)	11		NA		NA	**50**	0	**50**	0	0	4.1	150804*, 152003*
Copper (Cu)	11	**35.7**	0	**197**	0	**16**	9	**110**	0	81.8	28	150807
Lead (Pb)	11	**35**	0	**91.3**	0	**31**	1	**250**	0	9.1	32	150805*
Manganese (Mn)	11		NA		NA	**460**	5	**1100**	3	72.7	1500	150804*
Mercury (Hg)	8	**0.17**	0	**0.486**	0	**0.2**	0	**2**	0	0	0.09	150807, 152003*
Nickel (Ni)	11		NA		NA	**16**	0	**75**	0	0	7.6	151601
Silver (Ag)	2		NA		NA	**0.5**	0	**0.5**	0	0	0.3	152003*
Zinc (Zn)	11	**123**	8	**315**	0	**120**	8	**820**	0	72.7	300	150805*

Notes:

1. *For Cobalt and Silver established just one level of effect: Table 3 of "Guidelines for the protection and management of aquatic sediment quality in Ontario"*
2. *Percent of violation: indicates the total number of samples with level of contamination which exceeds minimum of Lowest / Probable Effect Levels (LEL or PEL).*

Table 9.2 Polycyclic Aromatic Hydrocarbons (PAHs) Occurrence in Sediments for the Erin SSMP stations (October 2008)

Parameter	Total detected number	Federal Guidelines				Provincial Guidelines		Percent of violation	Max observed concentration (ug/g)	Location of Exceedance
		TEL, ug/g	Excee-dance Number	PEL, ug/g	Excee-dance Number	LEL, ug/g	Excee-dance Number			
Acenaphthene	0	0.00671	NA*	0.0889	NA		NA	NA	NA	NA
Acenaphthylene	0	0.00587	NA*	0.128	0		NA	NA	NA	NA
Anthracene	0	0.0469	NA	0.245	0	0.22	NA	NA	NA	NA
Benzo(a)anthracene	2	0.0317	2*	0.385	0	0.32	0	NA*	0.04	151401, 150402
Benzo(a)pyrene	5	0.0319	5*	0.782	0	0.37	0	NA*	0.05	151401, 150807, 150804, 150402
Benzo(g,h,i)perylene	0		NA		NA	0.17	0*	NA*	NA	NA
Benzo(k)fluoranthene	0		NA		NA	0.24	0	0	NA	NA
Chrysene	2	0.0571	0*	0.862	0	0.34	0	NA*	0.05	150402
Dibenz(a,h)anthracene	0	0.00622	NA*	0.135	NA	0.06	NA	NA	NA	NA
Fluoranthene	6	0.111	2	2.355	0	0.75	0	18.2	0.12	150807, 150402
Fluorene	0	0.0212	0*	0.144	0	0.19	0	NA*	NA	NA
Indeno(1,2,3-cd)pyrene	0		NA		NA	0.2	0*	NA*	NA	NA
Naphthalene	0	0.0346	NA*	0.391	NA		NA	NA*	NA	NA
Phenanthrene	2	0.0419	2*	0.515	0	0.56	0	NA*	0.05	150807, 150402
Pyrene	6	0.053	4*	0.875	0	0.49	0	NA*	0.09	150807

Notes:

1. Acenaphthene, Acenaphthylene, Dibenz(a,h)anthracene: Reported Detection Limit (RDL) >Threshold Effect Level (TEL) for each of 11 samples
2. Benzo(a)anthracene: for 6 samples RDL>TEL
3. Benzo(a)pyrene: for 7samples RDL>TEL
4. Benzo(g,h,i)perylene: for 5 samples RDL>LEL
5. Chrysene: for 8 samples RDL>TEL
6. Fluorene: for 7samples RDL>TEL

7. Indeno (1,2,3-cd)pyrene: for 5 samples RDL>=LEL
8. Naphthalene: for 6 samples RDL>TEL
9. Phenanthrene: for 2 samples RDL>TEL
10. Pyrene: for 1 sample RDL>TEL

Table 9.3 Polychlorinated Biphenyls (PCBs) Occurrence in Sediments for the Erin SSMP stations (October 2008)

Parameter	Total detected number	Federal Guidelines		Provincial Guidelines	
		TEL, ug/g	Exceedance Number	LEL, ug/g	Exceedance Number
Total PCB	0	0.0341	0	0.07	0

Notes:
1. *Concentrations of Organochlorine Pesticides in all samples are below Reported Detection Limit (RDL) for particular sample*
2. *Aldrin: RDL>Lowest Effect Level (LEL) for each sample*
3. *a-BHC and b-BHC: RDL>=LEL for each sample*
4. *Guidelines are available for Chlordaine (no a- or g-) and used for a-Chlordane: RDL> Threshold Effect Level (TEL) for each sample*
5. *Remaining Pesticides, excepting Hexachlorobenzene: RDL>= TEL or LEL*

APPENDIX G:
Flow Measurement and Surface Water Quality Data

Phase 1 -
Environmental Component -
Existing Conditions Report

For The

Erin Servicing and Settlement Master Plan

Prepared for:

County of Wellington
Town of Erin

Prepared by:

Blackport Hydrogeology Inc.

May 2011

Flow Measurement and Water Quality Appendix

List of Tables

Table 1.0 Flow Measurement Data Summary

SITE FLOW SUMMARY

	Date:	23-Jul-07	6-Sep-07	14-Oct-08	15-Oct-08	5-Nov-08	4-Sep-09	18-Sep-09
TA REF	CVC REF	Flow (L/s)	Flow (L/s)	Flow (L/s)	Flow (L/s)	Flow (L/s)	Flow (L/s)	Flow (L/s)
BELFOUNTAIN # 4		755.4	645.2	n/a	n/a	n/a	n/a	n/a
#21		759.8	n/a	n/a	n/a	963.0	n/a	n/a
# 5		no flow	dry	n/a	n/a	n/a	n/a	n/a
#6		no flow	no flow	n/a	n/a	n/a	n/a	n/a
#10	Station 9	286.3	218.2	369.7	n/a	467.9	353.1	n/a
#9	Station 8	49.0	27.5	91.4	n/a	100.9	72.7	n/a
#8		500.6	352.5	n/a	n/a	845.2	n/a	n/a
#7 pond discharge		28.6	6.3	n/a	n/a	118.6	72.2	n/a
#20		20.9	12.0	n/a	n/a	n/a	n/a	n/a
#19		no flow	dry	n/a	n/a	n/a	n/a	n/a
#13	Gauge Station 12	293.4	288.4	364.4	n/a	509.7	398.8	377.8
#14		13.8	3.8	n/a	n/a	n/a	n/a	n/a
#15	Station 16	99.9	91.6	111.3	n/a	121.0	142.6	n/a
#16	Station 15	124.4	139.7	163.9	n/a	162.8	138.5	n/a
#17	Station 14	263.6	188.8	278.0	n/a	253.1	n/a	n/a
#18		114.7	241.5	n/a	n/a	410.5	n/a	n/a
#22		6.9	9.9	n/a	n/a	85.7	n/a	n/a
#23		5.8	5.5	n/a	n/a	10.5	n/a	n/a
H1		n/a	n/a	n/a	n/a	n/a	47.0	n/a
H3		n/a	n/a	n/a	n/a	n/a	241.9	n/a
H4		n/a	n/a	n/a	n/a	n/a	164.5	n/a
MOE Erin B		n/a	n/a	n/a	726.5	838.2	525.0	464.3
MOE Erin C		n/a	n/a	n/a	107.7	101.9	89.2	56.5
MOE Erin D		n/a	n/a	n/a	141.4	185.8	124.3	92.8
MOE Erin E		n/a	n/a	n/a	408.9	536.2	395.7	350.0

Table 1.1 Flow Measurement Data: July 23, 2007

Site:	BELFOUNTAIN # 4				23-Jul-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0	0.22					
0.5	0.41	0.31			0.027163	27.1625	
1	0.37	0			0.030225	30.225	
2	0.38	0.35			0.065625	65.625	
3	0.41	0.32			0.132325	132.325	
4	0.38	0.4			0.1422	142.2	
5	0.4	0.24			0.1248	124.8	
6	0.44	0.41			0.1365	136.5	
6.5	0.39	0.3			0.073663	73.6625	total
7	0	0.17			0.022913	22.9125	755.4125

Site:	#21				23-Jul-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.18	0.31					
1	0.27	0.36			0.075375	75.375	
2	0.3	0.38			0.10545	105.45	
3	0.3	0.3			0.102	102	
4	0.29	0.29			0.087025	87.025	
5	0.31	0.33			0.093	93	
6	0.28	0.28			0.089975	89.975	
7	0.31	0.31			0.087025	87.025	
8	0.17	0.32			0.0756	75.6	total
9.1	0.14	0.2			0.04433	44.33	759.78

Site:	# 5				23-Jul-07	
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)
0	0	0	0	very still water, no flow	unable to measure	

Site:	#6					
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)
0	0	0	0	very still water, no flow	unable to measure	

Site:	#10				23-Jul-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.42	0.07					
0.5	0.49	0.17			0.0273	27.3	
1	0.57	0.18			0.046375	46.375	
1.5	0.57	0.25			0.061275	61.275	
2	0.57	0.14			0.055575	55.575	
2.5	0.55	0.2			0.0476	47.6	total
3	0.55	0.15			0.048125	48.125	286.25

Site:	#9				23-Jul-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.16	0					
0.3	0.2	0.12			0.00324	3.24	
0.6	0.21	0.19			0.009533	9.5325	
0.9	0.24	0.29			0.0162	16.2	
1.1	0.25	0.27			0.01372	13.72	total
1.3	0.17	0.03		edge of active flow	0.0063	6.3	48.9925

Site:	#8				23-Jul-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.2	0.02					
0.8	0.26	0.13			0.0138	13.8	
1.8	0.32	0.19			0.0464	46.4	
2.8	0.41	0.2			0.071175	71.175	
3.8	0.46	0.19			0.084825	84.825	
4.8	0.48	0.28			0.11045	110.45	
5.8	0.48	0.03	0.26		0.0912	91.2	
6.8	0.46	0.01	0.15		0.052875	52.875	
7.8	0.45	0.02			0.0273	27.3	total
8.6	0.2	0			0.0026	2.6	500.625

Site:	#7 pond discharge				23-Jul-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.07	0.01		estimate v			
0.5	0.15	0.17			0.00495	4.95	
1	0.13	0.18			0.01225	12.25	
1.5	0.1	0.12			0.008625	8.625	
2	0.065	0.01		estimate v	0.002681	2.68125	total
2.2	0.05	0.01		estimate v	0.000115	0.115	28.62125

Site	#20				23-Jul-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.16	0.01					
0.4	0.17	0.01			0.00066	0.66	
0.8	0.17	0.34			0.0119	11.9	
1.1	0.14	0.01			0.008138	8.1375	total
1.3	0.06	0.01			0.0002	0.2	20.8975

Site:	#19					
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)
0.45	0.15			to shallow to measure		

Site:	#13				23-Jul-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0.3	0.15	0.13					
1	0.17	0.26			0.02184	21.84	
2	0.19	0.41			0.0603	60.3	
3	0.18	0.46			0.080475	80.475	
4	0.14	0.37			0.0664	66.4	
5	0.12	0.31			0.0442	44.2	
5.6	0.095	0.21			0.01677	16.77	total
6.2	0	0.03			0.00342	3.42	293.405

Site	#14			pond discharge nearby	23-Jul-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.08	0.05					
0.2	0.08	0.34			0.00312	3.12	
0.4	0.09	0.37			0.006035	6.035	
0.57	0.07	0.21			0.003944	3.944	total
0.64	0.02	0.21		est v	0.000662	0.6615	13.7605

Site:	#15				23-Jul-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.16	0.08					
0.5	0.27	0.23			0.016663	16.6625	
1	0.23	0.22			0.028125	28.125	
1.5	0.22	0.22			0.02475	24.75	
2	0.18	0.22			0.022	22	total
2.25	0.17	0.16		edge of active flow	0.008313	8.3125	99.85

Site:	#16				23-Jul-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.21	0.15					
0.5	0.25	0.08	0.31		0.0207	20.7	
1	0.23	0.27			0.0264	26.4	
1.5	0.21	0.15			0.0231	23.1	
2	0.18	0.22			0.018038	18.0375	
2.5	0.26	0.23			0.02475	24.75	total
3	0.12	0.01		edge of active flow	0.0114	11.4	124.3875

Site;	#17				23-Jul-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.3	0.12					
0.5	0.33	0.35			0.037013	37.0125	
1	0.44	0.4	0.34		0.069942	69.94167	
1.5	0.4	0.46	0.4		0.084	84	
2	0.31	0.12			0.057983	57.98333	total
2.5	0.14	0.14			0.014625	14.625	263.5625

Site:	#18	culvert #1	north	two culverts	23-Jul-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0	0.18					
0.4	0.19	0.26			0.00836	8.36	
1	0.3	0.1			0.02646	26.46	
1.5	0.29	0.21			0.022863	22.8625	
2	0.2	0.21			0.025725	25.725	
2.5	0.16	0.21		edge of flow (weeds)	0.0189	18.9	subtotal
							102.3075
		culvert #2	south				
0	0	0.02					
0.3	0.165	0.18			0.002475	2.475	
0.4	0.2	0.15			0.003011	3.01125	
0.5	0.24	0.14			0.00319	3.19	
0.6	0.25	0.06			0.00245	2.45	
0.7	0.25	0.04		edge of flow (weeds)	0.00125	1.25	subtotal
							12.37625
						total	114.6838

Site:	#22	box culvert with 1929 at D/S edge			23-Jul-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.11	0.01					
0.2	0.12	0.02			0.000345	0.345	
0.4	0.16	0.07			0.00126	1.26	
0.6	0.16	0.05			0.00192	1.92	
0.8	0.17	0.04			0.001485	1.485	
1	0.12	0.03			0.001015	1.015	
1.2	0.05	0.04			0.000595	0.595	total
1.5	0.05	0			0.0003	0.3	6.92

Site:	#23	box culvert with 1928 at D/S edge			23-Jul-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.03	0					
0.2	0.085	0.16			0.00092	0.92	
0.4	0.085	0.17			0.002805	2.805	total
0.6	0.06	0.11			0.00203	2.03	5.755

Table 1.2 Flow Measurement Data: September 6, 2007

Site:	BELFOUNTAIN # 4				06-Sep-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0	0.08	0				
0.5	0.34	0.25	0.22		0.0116875	11.6875	
1	0.37	0.38	0.17		0.0452625	45.2625	
2	0.35	0.21	0.22		0.0882	88.2	
3	0.36	0.26	0.2		0.0789875	78.9875	
4	0.23	0.39	0.28		0.0833375	83.3375	
5	0.36	0.47	0.46		0.118	118	
6	0.34	0.41	0.25		0.139125	139.125	
6.5	0.4	0.42	0.22		0.060125	60.125	total
7	0	0.18	0		0.0205	20.5	645.225

Site:	# 5				06-Sep-07	
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)
0	0	0	0	dry		

Site:	#6				06-Aug-07	
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)
0	0	0	0	very still water, no flow	unable to measure	

Site:	#10				06-Sep-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.42	0.1	0.11				
0.5	0.48	0.2	0.13		0.030375	30.375	
1	0.49	0.2	0.16		0.0418313	41.83125	
1.5	0.49	0.21	0.12		0.0422625	42.2625	
2	0.49	0.2	0.13		0.040425	40.425	
2.5	0.39	0.2	0.17		0.0385	38.5	total
3	0.32	0.12	0.07		0.02485	24.85	218.2438

Site:	#9				06-Sep-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.16	0		weeds to edge			
0.25	0.17	0.03			0.0006188	0.61875	
0.5	0.17	0.11			0.002975	2.975	
0.75	0.17	0.17			0.00595	5.95	
1	0.21	0.25			0.009975	9.975	
1.25	0.21	0.03		edge of active flow	0.00735	7.35	total
1.5	0.15	0		weeds to edge	0.000675	0.675	27.54375

Site:	#8				06-Sep-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.075	0.05					
1	0.22	0.08	0.06		0.0093417	9.341667	
2	0.34	0.14	0.11		0.0273	27.3	
3	0.42	0.16	0.13		0.0513	51.3	
4	0.51	0.16	0.13		0.067425	67.425	
5	0.5	0.19	0.18		0.083325	83.325	
6	0.48	0.13	0.06		0.0686	68.6	
7	0.5	0.06	0.03		0.0343	34.3	
7.8	0.46	0.01	0.01		0.01056	10.56	total
8	0	0			0.0003067	0.306667	352.4583

Site:	#7 pond discharge				06-Sep-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.06	0		weeds to .20			
0.5	0.09	0.06			0.001125	1.125	
1	0.11	0.08			0.0035	3.5	total
1.5	0.06	0		edge of stream	0.0017	1.7	6.325

Site	#20				06-Sep-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.05	0.07					
0.5	0.15	0.06			0.00325	3.25	
1	0.15	0.1			0.006	6	total
1.5	0.07	0		weeds 1.10 to 1.5	0.00275	2.75	12

Site:	#19				06-Sep-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0			dry			dry

Site:	#13				06-Sep-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
1.3	0.03	0.04					
2	0.09	0.06			0.0021	2.1	
2.5	0.1	0.31			0.0087875	8.7875	
3	0.12	0.26			0.015675	15.675	
3.5	0.14	0.49			0.024375	24.375	
4	0.15	0.43			0.03335	33.35	
4.5	0.17	0.54			0.0388	38.8	
5	0.17	0.45			0.042075	42.075	
5.5	0.15	0.51			0.0384	38.4	
6	0.15	0.47			0.03675	36.75	
6.5	0.17	0.36			0.0332	33.2	total
7	0.12	0.05			0.0148625	14.8625	288.375

Site	#14			pond discharge nearby	06-Sep-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0.2	0.01	0					
0.5	0.04	0.01			0.0000375	0.0375	
0.8	0.08	0.09			0.0009	0.9	
1.1	0.05	0.16		edge of water	0.0024375	2.4375	
1.3	0	0			0.0004	0.4	total
1.8	0	0		culvert edge to edge 1.80 M	0	0	3.775

Site:	#15				06-Sep-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.165	0					
0.5	0.28	0.06			0.0033375	3.3375	
1	0.3	0.27			0.023925	23.925	
1.5	0.24	0.23			0.03375	33.75	
2	0.23	0.18			0.0240875	24.0875	total
2.5	0.06	0		weeds 2.20 to 2.50	0.006525	6.525	91.625

Site:	#16				06-Sep-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.05	0.01					
0.5	0.15	0.02			0.00075	0.75	
1	0.26	0.23			0.0128125	12.8125	
1.5	0.33	0.28			0.0376125	37.6125	
2	0.28	0.21			0.0373625	37.3625	
2.5	0.23	0.25			0.029325	29.325	
3	0.14	0.14			0.0180375	18.0375	total
3.4	0.13	0		edge of active flow	0.00378	3.78	139.68

Site;	#17				06-Sep-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.08	0.05					
0.5	0.3	0.22	0.19		0.0145667	14.56667	
1	0.3	0.33	0.19		0.034875	34.875	
1.5	0.39	0.41	0.29		0.0526125	52.6125	
2	0.35	0.31	0.25		0.058275	58.275	
2.5	0.1	0.14			0.02625	26.25	total
2.7	0.09	0.09			0.002185	2.185	188.7642

Site:	#18	culvert #1	north	two culverts	06-Sep-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.2	0.06					
0.5	0.25	0.62	0.57		0.046875	46.875	
1	0.26	0.48	0.44		0.0672563	67.25625	
1.5	0.22	0.57	0.32		0.0543	54.3	
2	0.16	0.39			0.0405333	40.53333	
2.3	0.13	0.13			0.01131	11.31	subtotal
							220.2746
		culvert #2	south				
0	0.12	0		weeds to 1.5			
0.2	0.2	0.07			0.00112	1.12	
0.4	0.22	0.32			0.00819	8.19	
0.6	0.21	0.12			0.00946	9.46	
0.8	0.2	0			0.00246	2.46	
1.1	0.1	0			0	0	
1.2	0.04	0		edge of flow (weeds)	0	0	subtotal
							21.23
						total	241.5046

Site:	#22	box culvert with 1929 at D/S edge			06-Sep-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.01	0					
0.2	0.04	0			0	0	
0.4	0.11	0			0	0	
0.6	0.14	0.07			0.000875	0.875	
0.8	0.13	0.1			0.002295	2.295	
1	0.1	0.12			0.00253	2.53	
1.2	0.09	0.11			0.002185	2.185	total
1.5	0.06	0.07			0.002025	2.025	9.91

Site:	#23	box culvert with 1928 at D/S edge			06-Sep-07		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0	0					
0.5	0.01	0		edge of water	0	0	
0.75	0.02	0		to shallow to measure	0	0	
1	0.04	0.06			0.000225	0.225	
1.25	0.04	0.11			0.00085	0.85	
1.5	0.05	0.12			0.0012938	1.29375	
1.75	0.05	0.16			0.00175	1.75	
2	0.03	0.07			0.00115	1.15	total
2.25	0.02	0		edge of water	0.0002188	0.21875	5.4875

Table 1.3 Flow Measurement Data: October 14, 2008

Site:	#10	CVC Station 9			14-Oct-08		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.66	0.17	0.13				
0.5	0.63	0.24	0.15		0.0556313	55.63125	
1	0.64	0.27	0.22		0.06985	69.85	
1.5	0.62	0.25	0.21		0.0748125	74.8125	
2	0.57	0.26	0.2		0.068425	68.425	
2.5	0.48	0.22	0.17		0.0557813	55.78125	total
3.04	0.45	0.18	0.15		0.045198	45.198	369.698

Site:	#9	CVC Station 8			14-Oct-08		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.12	0.11					
0.5	0.27	0.24			0.0170625	17.0625	
1	0.28	0.33			0.0391875	39.1875	
1.5	0.25	0.14			0.0311375	31.1375	
1.7	0.24	0.01			0.003675	3.675	total
2.1	0.11	0			0.00035	0.35	91.4125

Site:	#13	CVC Gauge Station 12			14-Oct-08		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.04	0.12					
0.5	0.12	0.23			0.007	7	
1	0.17	0.25			0.0174	17.4	
1.5	0.165	0.32			0.0238688	23.86875	
2	0.205	0.32			0.0296	29.6	
2.5	0.21	0.34			0.0342375	34.2375	
3	0.235	0.36			0.0389375	38.9375	
3.5	0.23	0.32			0.039525	39.525	
4	0.24	0.29			0.0358375	35.8375	
4.5	0.24	0.28			0.0342	34.2	
5	0.25	0.3			0.035525	35.525	
5.5	0.26	0.23			0.0337875	33.7875	
6	0.25	0.14			0.0235875	23.5875	total
6.45	0.19	0.08			0.01089	10.89	364.3963

Site:	#15	CVC Station 16			14-Oct-08		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.135	0.11					
0.5	0.135	0.14			0.0084375	8.4375	
1	0.145	0.15			0.01015	10.15	
1.5	0.16	0.19			0.0129625	12.9625	
2	0.175	0.3			0.0205188	20.51875	
2.5	0.18	0.32			0.0275125	27.5125	
2.85	0.2	0.33			0.0216125	21.6125	total
3.1	0.07	0.27			0.010125	10.125	111.3188

Site:	#16	CVC Station 15			14-Oct-08		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.08	0.09					
0.4	0.21	0.1			0.00551	5.51	
1	0.26	0.2			0.02115	21.15	
1.5	0.29	0.24			0.03025	30.25	
2	0.31	0.33			0.04275	42.75	
2.5	0.26	0.29			0.044175	44.175	
3	0.19	0.05			0.019125	19.125	total
3.2	0.11	0.01		estimate	0.0009	0.9	163.86

Site;	#17	CVC Station 14			14-Oct-08		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.19	0.39					
0.5	0.2	0.71			0.053625	53.625	
1	0.2	0.72			0.0715	71.5	
1.5	0.2	0.65			0.0685	68.5	
2	0.2	0.42			0.0535	53.5	
2.5	0.2	0.11			0.0265	26.5	total
2.73	0.18	0.09			0.00437	4.37	277.995

Site:	Erin B	MOE location			15-Oct-08		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.08		0				
1	0.35		0.07		0.007525	7.525	
2	0.4	0.29	0.24		0.075	75	
3	0.38	0.54	0.23		0.12675	126.75	
4	0.36	0.73	0.47		0.182225	182.225	
5	0.35	0.42	0.33		0.1730625	173.0625	
5.99	0.23	0.39	0.26		0.100485	100.485	
6	0.11		0.26		0.0005157	0.515667	
7	0.11		0.2		0.0253	25.3	
7.7	0.23		0.06		0.01547	15.47	
8	0.18		0.15		0.0064575	6.4575	total
9	0.04		0.1		0.01375	13.75	726.5407

Site:	Erin C	MOE location			15-Oct-08		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.11		0.01				
0.5	0.215		0.11		0.004875	4.875	
1	0.28		0.14		0.0154688	15.46875	
1.5	0.18		0.19		0.018975	18.975	
2	0.25		0.16		0.0188125	18.8125	
2.5	0.12		0.15		0.0143375	14.3375	
3	0.15		0.14		0.0097875	9.7875	
3.5	0.15		0.19		0.012375	12.375	
4	0.125		0.12		0.0106563	10.65625	total
4.6	0		0.01		0.0024375	2.4375	107.725

Site:	Erin D	MOE location			15-Oct-08		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.04		0.01				
0.5	0.125		0.12		0.0026813	2.68125	
1	0.175		0.13		0.009375	9.375	
1.5	0.25		0.08		0.0111563	11.15625	
2	0.26		0.15		0.0146625	14.6625	
2.5	0.22		0.19		0.0204	20.4	
3	0.195		0.13		0.0166	16.6	
3.5	0.16		0.15		0.012425	12.425	
4	0.09		0.16		0.0096875	9.6875	
4.5	0.09		0.18		0.00765	7.65	
5	0.09		0.15		0.007425	7.425	
5.5	0.17		0.15		0.00975	9.75	
6	0.17		0.17		0.0136	13.6	total
6.4	0.06		0.09		0.00598	5.98	141.3925

Site:	Erin E	MOE location			15-Oct-08		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0		0.01				
0.5	0.14		0.07		0.0014	1.4	
1	0.31		0.13		0.01125	11.25	
1.5	0.34	0.14	0.14		0.0222083	22.20833	
2	0.47	0.19	0.18		0.0329063	32.90625	
2.5	0.49	0.26	0.26		0.0534	53.4	
3	0.37	0.28	0.19		0.0532125	53.2125	
3.5	0.36	0.34	0.27		0.049275	49.275	
4	0.36	0.23	0.2		0.0468	46.8	
4.5	0.4	0.35	0.31		0.051775	51.775	
5	0.32		0.23		0.0534	53.4	
5.5	0.28		0.13		0.027	27	total
6	0.08		0.01		0.0063	6.3	408.9271

Table 1.4 Flow Measurement Data: November 8, 2008

Site:	#21				8-Nov-08		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.3	0.41					
0.5	0.3	0.41			0.0615	61.5	
1	0.35	0.44			0.0690625	69.0625	
1.5	0.37	0.43			0.0783	78.3	
2	0.38	0.43			0.080625	80.625	
2.5	0.4	0.36			0.077025	77.025	
3	0.4	0.33			0.069	69	
3.5	0.33	0.35			0.06205	62.05	
4	0.35	0.32			0.05695	56.95	
4.5	0.35	0.27			0.051625	51.625	
5	0.4	0.27			0.050625	50.625	
5.5	0.35	0.18			0.0421875	42.1875	
6	0.3	0.35			0.0430625	43.0625	
6.5	0.39	0.2			0.0474375	47.4375	
7	0.37	0.26			0.0437	43.7	
7.5	0.23	0.22			0.036	36	
8	0.24	0.28			0.029375	29.375	
8.5	0.23	0.23			0.0299625	29.9625	total
9.1	0.24	0.26			0.034545	34.545	963.0325

Site:	#10	CVC Station 9			8-Nov-08		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.69	0.22	0.22				
0.5	0.69	0.31	0.25		0.08625	86.25	
1	0.65	0.32	0.26		0.095475	95.475	
1.5	0.63	0.34	0.23		0.092	92	
2	0.62	0.28	0.2		0.0820313	82.03125	
2.5	0.5	0.24	0.19		0.0637	63.7	total
3.04	0.47	0.15	0.16		0.0484515	48.4515	467.9078

Site:	#9	CVC Station 8			8-Nov-08		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.1	0					
0.5	0.2	0.06			0.00225	2.25	
1	0.31	0.35			0.0261375	26.1375	
1.5	0.31	0.26			0.047275	47.275	
2	0.16	0.15			0.0240875	24.0875	total
2.15	0.05	0			0.0011813	1.18125	100.9313

Site:	#8				8-Nov-08		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.11	0					
0.5	0.36	0			0	0	
1	0.49	0			0	0	
1.5	0.59	0.1	0.08		0.0162	16.2	
2	0.56	0.18	0.14		0.0359375	35.9375	
2.5	0.57	0.18	0.15		0.0459063	45.90625	
3	0.57	0.18	0.15		0.047025	47.025	
3.5	0.57	0.28	0.25		0.061275	61.275	
4	0.58	0.3	0.29		0.0805	80.5	
4.5	0.56	0.33	0.22		0.081225	81.225	
5	0.55	0.3	0.29		0.0790875	79.0875	
5.5	0.51	0.29	0.24		0.0742	74.2	
6	0.5	0.28	0.27		0.068175	68.175	
6.5	0.47	0.27	0.23		0.0636563	63.65625	
7	0.44	0.27	0.22		0.0563063	56.30625	
7.5	0.38	0.26	0.24		0.0507375	50.7375	
8	0.32	0.22			0.042	42	
8.5	0.2	0.19			0.02665	26.65	total
9.1	0.15	0.12			0.016275	16.275	845.1563

Site:	#7 pond discharge				8-Nov-08		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.46	0.07					
0.5	0.47	0.06			0.0151125	15.1125	
1	0.46	0.07			0.0151125	15.1125	
1.5	0.47	0.07			0.016275	16.275	
2	0.49	0.06			0.0156	15.6	
2.5	0.49	0.07			0.015925	15.925	
3	0.47	0.06			0.0156	15.6	
3.5	0.49	0.04			0.012	12	
4	0.52	0.02			0.007575	7.575	
4.5	0.53	0.01			0.0039375	3.9375	
5	0.64	0			0.0014625	1.4625	total
5.6	0.61	0			0	0	118.6

Site:	#13	CVC Gauge Station 12			8-Nov-08		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.19	0.11					
0.5	0.28	0.12			0.0135125	13.5125	
1	0.28	0.26			0.0266	26.6	
1.5	0.27	0.33			0.0405625	40.5625	
2	0.28	0.32			0.0446875	44.6875	
2.5	0.28	0.34			0.0462	46.2	
3	0.28	0.38			0.0504	50.4	
3.5	0.28	0.41			0.0553	55.3	
4	0.25	0.42			0.0549875	54.9875	
4.5	0.25	0.37			0.049375	49.375	
5	0.23	0.33			0.042	42	
5.5	0.21	0.31			0.0352	35.2	
6	0.24	0.29			0.03375	33.75	
6.5	0.1	0.1			0.016575	16.575	total
6.7	0	0			0.0005	0.5	509.65

Site:	#15	CVC Station 16				8-Nov-08		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)		Comment	Q (m3/s)	Q (L/s)	
0	0.15	0.37						
0.5	0.22	0.32				0.0319125	31.9125	
1	0.18	0.26				0.029	29	
1.5	0.17	0.19				0.0196875	19.6875	
2	0.16	0.21				0.0165	16.5	
2.5	0.15	0.18				0.0151125	15.1125	total
3	0.12	0.08				0.008775	8.775	120.9875

Site:	#16	CVC Station 15				8-Nov-08		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)		Comment	Q (m3/s)	Q (L/s)	
0	0.1	0.06						
0.5	0.2	0.2				0.00975	9.75	
1	0.2	0.37				0.0285	28.5	
1.5	0.23	0.32				0.0370875	37.0875	
2	0.23	0.34				0.03795	37.95	
2.5	0.21	0.25				0.03245	32.45	total
3	0.14	0.14				0.0170625	17.0625	162.8

Site;	#17	CVC Station 14				8-Nov-08		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)		Comment	Q (m3/s)	Q (L/s)	
0	0.18	0.06						
0.5	0.2	0.15				0.009975	9.975	
1	0.19	0.61				0.03705	37.05	
1.5	0.2	0.63				0.06045	60.45	
2	0.19	0.74				0.0667875	66.7875	
2.5	0.19	0.51				0.059375	59.375	total
2.75	0.19	0.31				0.019475	19.475	253.1125

Site:	#18	culvert #1	north			8-Nov-08		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)		Comment	Q (m3/s)	Q (L/s)	
0	0.09	0.28						
0.3	0.3	0.32				0.01755	17.55	
0.6	0.31	0.24				0.02562	25.62	
								43.17
		culvert #2	south					
0	0.21	0.24						
0.5	0.28	0.44				0.04165	41.65	
1	0.35	0.46		0.42		0.0693	69.3	
1.5	0.39	0.43		0.38		0.0781625	78.1625	
2	0.36	0.42		0.32		0.0726563	72.65625	
2.5	0.35	0.4		0.33		0.0652313	65.23125	
3	0.2	0.15				0.0403333	40.33333	subtotal
								367.3333
							total	410.5033

Site:	#22	box culvert with 1929 at D/S edge			8-Nov-08		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.23	0.24					
0.5	0.27	0.25			0.030625	30.625	
1	0.29	0.21			0.0322	32.2	total
1.56	0.22	0.11			0.022848	22.848	85.673

Site:	#23	box culvert with 1928 at D/S edge					
W	D	Vu	Vl				
0	0.02	0.14					
0.4	0.06	0.23			0.00296	2.96	
0.8	0.05	0.2			0.00473	4.73	total
1.2	0.04	0.11			0.00279	2.79	10.48

Site:	Erin B	MOE location			8-Nov-08		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.25	0.04	0.08				
0.5	0.19	0.02			0.0051333	5.133333	
1	0.3	0.11	0.08		0.008575	8.575	
1.5	0.4	0.19	0.2		0.025375	25.375	
2	0.36	0.54	0.45		0.06555	65.55	
2.5	0.34	0.47	0.56		0.088375	88.375	
3	0.32	0.67	0.67		0.0977625	97.7625	
3.5	0.25	0.78			0.1007	100.7	
4	0.24	0.75			0.0937125	93.7125	
4.5	0.29	0.66	0.6		0.088775	88.775	
5	0.31	0.43	0.31		0.075	75	
5.5	0.38	0.54	0.45		0.0746063	74.60625	
6	0.38	0.23	0.15		0.065075	65.075	
6.5	0.4	0.13	0.1		0.0297375	29.7375	
7	0.33	0.04			0.016425	16.425	total
7.6	0.23	0			0.00336	3.36	838.1621

Site:	Erin C	MOE location			8-Nov-08		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.13		0.01				
0.5	0.22		0.11		0.00525	5.25	
1	0.23		0.22		0.0185625	18.5625	
1.5	0.23		0.18		0.023	23	
2	0.24		0.16		0.019975	19.975	
2.5	0.11		0.14		0.013125	13.125	
3	0.18		0.05		0.0068875	6.8875	
3.5	0.15		0.11		0.0066	6.6	
4	0.1		0.11		0.006875	6.875	total
4.6	0		0		0.00165	1.65	101.925

Site:	Erin D	MOE location			8-Nov-08		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.17		0.11				
0.5	0.22		0.17		0.01365	13.65	
1	0.16		0.17		0.01615	16.15	
1.5	0.13		0.12		0.0105125	10.5125	
2	0.14		0.12		0.0081	8.1	
2.5	0.18		0.12		0.0096	9.6	
3	0.25		0.19		0.0166625	16.6625	
3.5	0.25		0.11		0.01875	18.75	
4	0.3		0.15		0.017875	17.875	
4.5	0.31		0.18		0.0251625	25.1625	
5	0.27		0.1		0.0203	20.3	
5.5	0.19		0.18		0.0161	16.1	
6	0.17		0.08		0.0117	11.7	total
6.3	0.04		0		0.00126	1.26	185.8225

Site:	Erin E	MOE location			8-Nov-08		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.24	0.11	0.11				
0.5	0.36	0.2	0.13		0.020625	20.625	
1	0.4	0.38	0.28		0.047025	47.025	
1.5	0.35	0.25	0.26		0.0548438	54.84375	
2	0.35	0.36	0.25		0.049	49	
2.5	0.36	0.28	0.25		0.0505875	50.5875	
3	0.33	0.23			0.0437	43.7	
3.5	0.51	0.26	0.24		0.0511	51.1	
4	0.47	0.21	0.16		0.0532875	53.2875	
4.5	0.34	0.34	0.2		0.0460688	46.06875	
5	0.32	0.32			0.0473	47.3	
5.5	0.31	0.31			0.0496125	49.6125	
6	0.1	0.1			0.0210125	21.0125	total
6.8	0	0			0.002	2	536.1625

Table 1.5 Flow Measurement Data: September 4, 2009

TA13					04-Sep-09		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.1	0.08					
0.5	0.22	0.22				12	
1	0.24	0.31				30.475	
1.5	0.21	0.37				38.25	
2	0.21	0.41				40.95	
2.5	0.18	0.33				36.075	
3	0.2	0.48				38.475	
3.5	0.21	0.47				48.6875	
4	0.18	0.43				43.875	
4.5	0.17	0.42				37.1875	
5	0.13	0.38				30	
5.5	0.13	0.31				22.425	
6	0.09	0.28				16.225	total
6.5	0.03	0				4.2	398.825

TA7					04-Sep-09		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.14	0.41					
0.5	0.15	0.35				27.55	
1	0.17	0.3				26	
1.5	0.12	0.12				15.225	total
1.8	0.09	0.1				3.465	72.24

TA9					04-Sep-09		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.13	0.08					
0.5	0.2	0.09				7.0125	
1	0.25	0.36				25.3125	
1.5	0.21	0.21				32.775	total
2	0.08	0				7.6125	72.7125

TA10					04-Sep-09		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.56	0.08	0.2				
0.5	0.5	0.22	0.31			53.6625	
1	0.5	0.2	0.27			62.5	
1.5	0.58	0.2	0.25			62.1	
2	0.47	0.24	0.28			63.65625	
2.5	0.48	0.23	0.29			61.75	total
3	0.38	0.2	0.2			49.45	353.1188

Erin E					04-Sep-09		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.09	0.01					
0.5	0.25	0.09				4.25	
1	0.32	0.28				26.3625	
1.5	0.38	0.38				57.75	
2	0.35	0.2				52.925	
2.5	0.31	0.33				43.725	
3	0.38	0.28				52.6125	
3.5	0.48	0.31				63.425	
4	0.32	0.17				48	
4.5	0.31	0.19				28.35	
5	0.17	0.09				16.8	total
5.4	0	0				1.53	395.73

Erin D					04-Sep-09		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0	0.17					
0.5	0.13	0.12				4.7125	
1	0.19	0.35				18.8	
1.5	0.13	0.29				25.6	
2	0.2	0.21				20.625	
2.5	0.15	0.28				21.4375	
3	0.18	0.2				19.8	
3.5	0.12	0.11				11.625	total
4	0	0				1.65	124.25

Erin C					04-Sep-09		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0	0					
0.5	0.07	0.15				1.3125	
1	0.1	0.25				8.5	
1.5	0.14	0.19				13.2	
2	0.19	0.14				13.6125	
2.5	0.16	0.21				15.3125	
3	0.15	0.31				20.15	
3.5	0.14	0.11				15.225	total
4	0	0				1.925	89.2375

Erin B					04-Sep-09		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.24	0	0				
1	0.32	0.1	0.12			15.4	
2	0.38	0.03	0.11			31.5	
3	0.44	0.27	0.37			79.95	
4	0.37	0.28	0.4			133.65	
5	0.4	0.2	0.32			115.5	
6	0.31	0.31				98.21667	total
6.9	0.24	0.1				50.7375	524.9542

H1					04-Sep-09		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.01	2.02					
0.155	0.14	2.02				23.4825	total
0.31	0.01	2.02				23.4825	46.965

TA15					04-Sep-09		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.24	0.24					
0.5	0.27	0.3				34.425	
1	0.22	0.27				34.9125	
1.5	0.21	0.27				29.025	
2	0.16	0.23				23.125	
2.5	0.17	0.13				14.85	total
2.8	0.18	0.11				6.3	142.6375

H4					04-Sep-09		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.12	0.08					
0.5	0.32	0.19				14.85	
1	0.33	0.36				44.6875	
1.5	0.35	0.34				59.5	
2	0.26	0.18				39.65	total
2.5	0	0				5.85	164.5375

H3					04-Sep-09		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.06	0.32					
0.5	0.19	0.51				25.9375	
1	0.16	0.49				43.75	
1.5	0.21	0.5				45.7875	
2	0.24	0.56				59.625	
2.5	0.27	0.39				60.5625	total
2.7	0.04	0.01				6.2	241.8625

TA16					04-Sep-09		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.09	0.04					
0.5	0.2	0.2				8.7	
1	0.26	0.3				28.75	
1.5	0.35	0.19				37.3625	
2	0.26	0.14				25.1625	
2.5	0.29	0.25				26.8125	total
3	0.07	0.01				11.7	138.4875

Table 1.6 Flow Measurement Data: September 18, 2009

TA13					18-Sep-09		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.125	0.04					
0.5	0.21	0.27				12.98125	
1	0.19	0.37				32	
1.5	0.21	0.39				38	
2	0.18	0.43				39.975	
2.5	0.19	0.41				38.85	
3	0.19	0.47				41.8	
3.5	0.19	0.46				44.175	
4	0.17	0.41				39.15	
4.5	0.14	0.42				32.1625	
5	0.12	0.35				25.025	
5.5	0.115	0.3				19.09375	
6	0.07	0.24				12.4875	total
6.35	0.03	0				2.1	377.8

Erin E					18-Sep-09		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.05	0					
0.5	0.25	0.04				1.5	
1	0.32	0.24				19.95	
1.5	0.35	0.3				45.225	
2	0.31	0.32				51.15	
2.5	0.28	0.34				48.675	
3	0.3	0.21				39.875	
3.5	0.43	0.22				39.2375	
4	0.35	0.23				43.875	
4.5	0.23	0.19				30.45	
5	0.21	0.19				20.9	total
5.6	0	0.1				9.135	349.9725

Erin D					18-Sep-09		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0	0.07					
0.5	0.12	0.31				5.7	
1	0.14	0.23				17.55	
1.5	0.185	0.24				19.09375	
2	0.16	0.15				16.81875	
2.5	0.12	0.18				11.55	
3	0.12	0.19				11.1	
3.5	0.09	0.18				9.7125	total
3.8	0	0.01				1.2825	92.8075

Erin C					18-Sep-09		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0	0					
0.5	0.08	0.1				1	
1	0.1	0.11				4.725	
1.5	0.12	0.12				6.325	
2	0.13	0.13				7.8125	
2.5	0.13	0.17				9.75	
3	0.14	0.13				10.125	
3.5	0.205	0.09				9.4875	total
4	0.16	0.07				7.3	56.525

Erin B					18-Sep-09		
Width (m)	Depth (m)	V_u (m/s)	V_l (m/s)	Comment	Q (m3/s)	Q (L/s)	
0	0.48	0.01	0.01				
1	0.54	0.08	0.03			16.575	
2	0.55	0.19	0.15			61.3125	
3	0.55	0.22	0.19			103.125	
4	0.58	0.18	0.13			101.7	
5	0.41	0.21	0.2			89.1	
6	0.39	0.15				74.66667	total
6.5	0.36	0.04				17.8125	464.2917

Table 2.0 Surface Water Quality CVC Stations: October 14, 2008

Maxxam Job #: A8C0153
Report Date: 2008/10/23

Credit Valley Conservation
Client Project #: Erin SSMP 2008
Project name:
Sampler Initials:

RESULTS OF ANALYSES OF WATER

Maxxam ID		AT9452		AT9453	AT9453	AT9454	AT9454	AT9455	AT9455	AT9456	AT9456	AT9457	AT9458	AT9458
Sampling Date		2008-10-14 11:30		2008-10-14 12:15		2008-10-14 13:15		2008-10-14 13:50		2008-10-14 14:45		2008-10-14 16:00	2008-10-14 11:20	
COC Number		98124-01		98124-01	98124-01	98124-01	98124-01	98124-01	98124-01	98124-01	98124-01	98124-01	98124-01	98124-01
	Units	**STATION 16**	**RDL**	**STATION 15**	**STATION 15 Lab-Dup**	**GAUGE STATION 12**	**GAUGE STATION 12 Lab-Dup**	**STATION 9**	**STATION 9 Lab-Dup**	**BHI 9**	**BHI 9 Lab-Dup**	**STATION 14**	**STATION 160**	**STATION 160 Lab-Dup**
Calculated Parameters														
Hardness (CaCO3)	mg/L	270	1	280		270		270		300		280	270	
Inorganics														
Total Carbonaceous BOD	mg/L	ND	2	2		ND		ND		2		2	ND	
Conductivity	umho/cm	499	2	530		555		561		647		571	501	
Total Dissolved Solids	mg/L	310	10	326		365		370		425		380	315	320
Dissolved Inorganic Carbon (C)	mg/L	51	1	52	52	53		53		61		52	51	
Total Kjeldahl Nitrogen (TKN)	mg/L	0.8	0.2	0.4		0.5		0.5		0.5		0.4	0.8	
Dissolved Organic Carbon	mg/L	1.7	0.1	2.2		2.8		3.4	3.5	4.3		1.9	1.6	
Orthophosphate (P)	mg/L	ND	0.01	ND		ND	ND	ND		ND	ND	ND	ND	
pH	pH	8.1		8.1		8.2		8.2		8.1		8.2	8.1	
Total Phosphorus	mg/L	0.026	0.002	0.024		0.013		0.013		0.019		0.013	0.028	
Total Suspended Solids	mg/L	ND	10	ND		ND		ND		ND		ND	ND	
Dissolved Sulphate (SO4)	mg/L	23	1	24		21	21	22		18	18	24	24	
Alkalinity (Total as CaCO3)	mg/L	221	1	227		223		231		265		229	224	
Dissolved Chloride (Cl)	mg/L	12	1	18		33	34	34		42	44	32	12	
Nitrite (N)	mg/L	ND	0.01	ND		ND		ND		0.02	0.02	0.03	0.01	
Nitrate (N)	mg/L	3.4	0.1	2.1		ND		1.5		1.2	1.2	3.1	2.8	
Nitrate + Nitrite	mg/L	3.4	0.1	2.1		ND		1.5		1.2	1.2	3.1	2.9	

ND = Not detected
RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
QC Batch = Quality Control Batch

Maxxam Job #: A8C0153
Report Date: 2008/10/23

Credit Valley Conservation
Client Project #: Erin SSMP 2008
Project name:
Sampler Initials:

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

Maxxam ID		AT9452	AT9453	AT9454	AT9455	AT9456	AT9457	AT9457	AT9458	
Sampling Date		2008-10-14 11:30	2008-10-14 12:15	2008-10-14 13:15	2008-10-14 13:50	2008-10-14 14:45	2008-10-14 16:00	2008-10-14 16:00	2008-10-14 11:20	
COC Number		98124-01	98124-01	98124-01	98124-01	98124-01	98124-01	98124-01	98124-01	
	Units	**STATION 16**	**STATION 15**	**GAUGE STATION 12**	**STATION 9**	**BHI 9**	**STATION 14**	**STATION 14 Lab-Dup**	**STATION 160**	**RDL**
Metals										
Total Aluminum (Al)	mg/L	0.055	0.083	0.009	0.022	0.016	0.017	0.017	0.068	0.005
Total Antimony (Sb)	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	0.0005
Total Arsenic (As)	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	0.001
Total Barium (Ba)	mg/L	0.039	0.043	0.041	0.039	0.058	0.049	0.050	0.041	0.005
Total Beryllium (Be)	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	0.0005
Total Bismuth (Bi)	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	0.001
Total Boron (B)	mg/L	0.09	0.05	0.04	0.04	0.03	0.01	ND	0.02	0.01
Total Cadmium (Cd)	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	0.0001
Total Calcium (Ca)	mg/L	72	76	77	76	87	81	79	76	0.2
Total Chromium (Cr)	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	0.005
Total Cobalt (Co)	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	0.0005
Total Copper (Cu)	mg/L	0.002	0.002	0.002	ND	0.001	ND	ND	ND	0.001
Total Iron (Fe)	mg/L	0.1	0.1	ND	ND	ND	ND	ND	0.1	0.1
Total Lead (Pb)	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	0.0005
Total Lithium (Li)	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	0.005
Total Magnesium (Mg)	mg/L	22	22	23	22	23	23	24	23	0.05
Total Manganese (Mn)	mg/L	0.025	0.021	0.008	0.026	0.023	0.011	0.011	0.024	0.002
Total Molybdenum (Mo)	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	0.001
Total Nickel (Ni)	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	0.001
Total Phosphorus (P)	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	0.1
Total Potassium (K)	mg/L	1.2	1.4	1.5	1.6	1.6	1.6	1.6	1.2	0.2
Total Selenium (Se)	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	0.002
Total Silicon (Si)	mg/L	5.1	5.3	4.4	4.2	4.6	4.7	4.7	5.4	0.05
Total Silver (Ag)	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	0.0001
Total Sodium (Na)	mg/L	4.6	7.4	18	18	27	17	17	4.8	0.1
Total Strontium (Sr)	mg/L	0.11	0.12	0.15	0.15	0.16	0.13	0.13	0.12	0.001
Total Thallium (Tl)	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	0.00005
Total Tin (Sn)	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	0.001
Total Titanium (Ti)	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	0.005
Total Tungsten (W)	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	0.001
Total Uranium (U)	mg/L	0.0004	0.0004	0.0004	0.0004	0.0003	0.0004	0.0005	0.0004	0.0001
Total Vanadium (V)	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	0.001
Total Zinc (Zn)	mg/L	0.006	0.007	ND	ND	0.007	ND	ND	0.006	0.005

ND = Not detected
RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
QC Batch = Quality Control Batch

Maxxam Job #: A8C0153
Report Date: 2008/10/23

Credit Valley Conservation
Client Project #: Erin SSMP 2008
Project name:
Sampler Initials:

MICROBIOLOGY (WATER)

Maxxam ID		AT9452	AT9452	AT9453	AT9454	AT9455	AT9456	AT9457	AT9458	
Sampling Date		2008-10-14 11:30	2008-10-14 11:30	2008-10-14 12:15	2008-10-14 13:15	2008-10-14 13:50	2008-10-14 14:45	2008-10-14 16:00	2008-10-14 11:20	
COC Number		98124-01	98124-01	98124-01	98124-01	98124-01	98124-01	98124-01	98124-01	
	Units	**STATION 16**	**STATION 16 Lab-Dup**	**STATION 15**	**GAUGE STATION 12**	**STATION 9**	**BHI 9**	**STATION 14**	**STATION 160**	**RDL**
Microbiological										
Fecal streptococcus	CFU/100mL	10	10	160	10	70	20	30	40	10
Escherichia coli	CFU/100mL	50	40	60	10	70	<10	<10	20	10

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
QC Batch = Quality Control Batch

Results relate only to the items tested.

Table 3.0 Surface Water Quality Erin B-E Stations: October 15, 2008

Credit Valley Conservation
Maxxam Job #: A8C0964 — Client Project #: Erin SSMP 2008
Report Date: 2008/10/23 — Project name:
Sampler Initials:

RESULTS OF ANALYSES OF WATER

Maxxam ID		AU3334	AU3334	AU3335	AU3336	AU3337	
Sampling Date		2008-10-15 16:00	2008-10-15 16:00	2008-10-15 15:00	2008-10-15 13:40	2008-10-15 12:15	
COC Number		98124-02	98124-02	98124-02	98124-02	98124-02	
	Units	**ERIN B**	**ERIN B Lab-Dup**	**ERIN C**	**ERIN D**	**ERIN E**	**RDL**
Calculated Parameters							
Hardness (CaCO3)	mg/L	290		310	320	280	1
Inorganics							
Total Carbonaceous BOD	mg/L	ND		ND	ND	ND	2
Conductivity	umho/cm	629		669	718	588	2
Total Dissolved Solids	mg/L	412		440	475	386	10
Dissolved Inorganic Carbon (C)	mg/L	57		61	63	53	1
Total Kjeldahl Nitrogen (TKN)	mg/L	0.5	0.4	0.4	0.5	0.4	0.1
Dissolved Organic Carbon	mg/L	3.1		3.1	4.4	2.7	0.1
Orthophosphate (P)	mg/L	ND		ND	ND	ND	0.01
pH	pH	8.2		8.2	8.3	8.3	
Total Phosphorus	mg/L	0.012		0.014	0.012	0.013	0.002
Total Suspended Solids	mg/L	ND		ND	ND	ND	10
Dissolved Sulphate (SO4)	mg/L	21		19	18	22	1
Alkalinity (Total as CaCO3)	mg/L	249		268	281	235	1
Dissolved Chloride (Cl)	mg/L	42		45	58	39	1
Nitrite (N)	mg/L	ND	ND	ND	ND	ND	0.01
Nitrate (N)	mg/L	1.8	1.8	1.7	1.6	1.8	0.1
Nitrate + Nitrite	mg/L	1.8	1.8	1.7	1.6	1.8	0.1

ND = Not detected
RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
QC Batch = Quality Control Batch

Maxxam Job #: A8C0964
Report Date: 2008/10/23

Credit Valley Conservation
Client Project #: Erin SSMP 2008
Project name:
Sampler Initials:

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

Maxxam ID		AU3334	AU3334	AU3335	AU3336	AU3337	
Sampling Date		2008-10-15 16:00	2008-10-15 16:00	2008-10-15 15:00	2008-10-15 13:40	2008-10-15 12:15	
COC Number		98124-02	98124-02	98124-02	98124-02	98124-02	
	Units	**ERIN B**	**ERIN B Lab-Dup**	**ERIN C**	**ERIN D**	**ERIN E**	**RDL**
Metals							
Total Aluminum (Al)	mg/L	0.013	0.011	0.014	0.010	0.011	0.005
Total Antimony (Sb)	mg/L	ND	ND	ND	ND	ND	0.0005
Total Arsenic (As)	mg/L	ND	ND	ND	ND	ND	0.001
Total Barium (Ba)	mg/L	0.046	0.050	0.065	0.038	0.044	0.005
Total Beryllium (Be)	mg/L	ND	ND	ND	ND	ND	0.0005
Total Bismuth (Bi)	mg/L	ND	ND	ND	ND	ND	0.001
Total Boron (B)	mg/L	0.03	0.03	0.02	0.06	0.02	0.01
Total Cadmium (Cd)	mg/L	ND	ND	ND	ND	ND	0.0001
Total Calcium (Ca)	mg/L	78	80	86	85	79	0.2
Total Chromium (Cr)	mg/L	ND	ND	ND	ND	ND	0.005
Total Cobalt (Co)	mg/L	ND	ND	ND	ND	ND	0.0005
Total Copper (Cu)	mg/L	0.002	0.001	0.001	0.002	ND	0.001
Total Iron (Fe)	mg/L	ND	ND	ND	ND	ND	0.1
Total Lead (Pb)	mg/L	ND	ND	ND	ND	ND	0.0005
Total Lithium (Li)	mg/L	ND	ND	ND	ND	ND	0.005
Total Magnesium (Mg)	mg/L	21	22	22	24	23	0.05
Total Manganese (Mn)	mg/L	0.010	0.010	0.012	0.004	0.013	0.002
Total Molybdenum (Mo)	mg/L	ND	ND	ND	ND	ND	0.001
Total Nickel (Ni)	mg/L	ND	ND	ND	ND	ND	0.001
Total Phosphorus (P)	mg/L	ND	ND	ND	ND	ND	0.1
Total Potassium (K)	mg/L	1.6	1.6	1.6	1.8	1.6	0.2
Total Selenium (Se)	mg/L	ND	ND	ND	ND	ND	0.002
Total Silicon (Si)	mg/L	3.9	4.2	4.4	4.1	4.2	0.05
Total Silver (Ag)	mg/L	ND	ND	ND	ND	ND	0.0001
Total Sodium (Na)	mg/L	24	25	29	35	22	0.1
Total Strontium (Sr)	mg/L	0.15	0.16	0.16	0.17	0.16	0.001
Total Thallium (Tl)	mg/L	ND	ND	ND	ND	ND	0.00005
Total Tin (Sn)	mg/L	ND	ND	ND	ND	ND	0.001
Total Titanium (Ti)	mg/L	ND	ND	ND	ND	ND	0.005
Total Tungsten (W)	mg/L	ND	ND	ND	ND	ND	0.001
Total Uranium (U)	mg/L	0.0004	0.0004	0.0003	0.0004	0.0004	0.0001
Total Vanadium (V)	mg/L	ND	ND	ND	ND	ND	0.001
Total Zinc (Zn)	mg/L	ND	ND	ND	ND	ND	0.005

ND = Not detected
RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate

Maxxam Job #: A8C0964
Report Date: 2008/10/23

Credit Valley Conservation
Client Project #: Erin SSMP 2008
Project name:
Sampler Initials:

MICROBIOLOGY (WATER)

Maxxam ID		AU3334	AU3334	AU3335	AU3336	AU3337		
Sampling Date		2008-10-15 16:00	2008-10-15 16:00	2008-10-15 15:00	2008-10-15 13:40	2008-10-15 12:15		
COC Number		98124-02	98124-02	98124-02	98124-02	98124-02		
	Units	**ERIN B**	**ERIN B Lab-Dup**	**ERIN C**	**ERIN D**	**ERIN E**	**RDL**	**QC Batch**
Microbiological								
Fecal streptococcus	CFU/100mL	100		60	<10	80	1	1645645
Escherichia coli	CFU/100mL	30	20	10	80	60	10	1645644

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
QC Batch = Quality Control Batch

Results relate only to the items tested.

Table 4.0 Surface Water Quality: September 4, 2009

Maxxam Job #: A9B6881
Report Date: 2009/09/15

Groundwater Science
Client Project #: ERIN
Project name:
Sampler Initials:

RESULTS OF ANALYSES OF WATER

Maxxam ID		DP8344	DP8345	DP8346	DP8347	DP8348	DP8349	DP8350	DP8351	DP8352	DP8353	DP8354	DP8355	DP8356	DP8357	DP8398	
Sampling Date		2009-09-04	2009-09-04	2009-09-04	2009-09-04	2009-09-04	2009-09-04	2009-09-04	2009-09-04	2009-09-04	2009-09-04		2009-09-04	2009-09-04	2009-09-04		
COC Number		162160-0	162160-0	162160-0	162160-0	162160-0	162160-0	162160-0	162160-0	162160-0	162160-0	162160-0	162160-0	162160-0	162160-0	16216001	
	Units	**TA13**	**TA7**	**TA9**	**TA10**	**ERIN E**	**ERIN D-1**	**ERIN D-2**	**ERIN C**	**ERIN B**	**H1**	**H4**	**TA15**	**H3**	**TA16**	**TA 16B**	**RDL**
Calculated Parameters																	
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	201	264	267	209	212	271	268	261	232	236	221	216	219	217	219	1
Bicarbonate (HCO3)	mg/L	330	433	438	342	347	444	439	428	380	387	362	355	360	356	360	0.05
Carb. Alkalinity (calc. as CaCO3)	mg/L	4	5	3	3	3	4	5	4	5	2	4	4	4	4	4	1
Hardness (CaCO3)	mg/L	230	290	290	240	240	300	300	280	260	280	260	250	260	260	260	1
Langelier Index (@ 20C)	N/A	1.01	1.24	1.05	0.875	0.931	1.15	1.22	1.16	1.15	0.808	1.04	1.01	1.02	1.06	1.03	
Langelier Index (@ 4C)	N/A	0.759	0.988	0.797	0.626	0.682	0.903	0.969	0.909	0.905	0.559	0.791	0.765	0.773	0.813	0.779	
Saturation pH (@ 20C)	N/A	7.31	7.11	7.09	7.29	7.28	7.09	7.09	7.10	7.20	7.15	7.22	7.24	7.22	7.23	7.22	
Saturation pH (@ 4C)	N/A	7.56	7.35	7.34	7.54	7.53	7.34	7.34	7.35	7.45	7.40	7.47	7.49	7.46	7.47	7.47	
Inorganics																	
Total Ammonia-N	mg/L	ND	ND	0.07	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.05
Total Chemical Oxygen Demand (COD)	mg/L	15	19	12	11	11	8	8	11	7	ND	5	14	5	11	9	4
Conductivity	umho/cm	510	581	636	519	541	709	706	655	589	570	516	485	514	510	511	1
Dissolved Inorganic Carbon (C)	mg/L	46	60	60	48	48	61	61	60	52	53	49	49	50	49	49	1
Total Kjeldahl Nitrogen (TKN)	mg/L	0.4	0.5	0.5	0.4	0.4	0.3	0.4	0.4	0.4	0.1	0.5	0.4	0.4	0.5	0.4	0.1
Dissolved Organic Carbon	mg/L	2.8	6.5	3.0	4.2	3.1	3.8	3.8	2.6	3.6	1.3	2.3	2.2	2.0	2.1	2.0	0.2
Total Organic Carbon (TOC)	mg/L	3.3	6.8	3.7	3.9	3.5	4.2	4.3	3.1	3.6	0.7	2.6	2.5	2.4	2.4	2.5	0.2
Orthophosphate (P)	mg/L	ND	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.01
pH	pH	8.3	8.3	8.1	8.2	8.2	8.2	8.3	8.3	8.4	8.0	8.3	8.3	8.2	8.3	8.2	
Total Phosphorus	mg/L	0.011	0.017	0.030	0.013	0.010	0.008	0.008	0.026	0.012	0.002	0.018	0.016	0.016	0.019	0.018	0.002
Total Suspended Solids	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	10
Dissolved Sulphate (SO4)	mg/L	19	17	19	21	21	20	20	19	21	25	23	23	23	23	23	1
Turbidity	NTU	2.2	2.4	1.9	2.5	1.6	1.1	1.0	2.3	1.4	0.1	2.5	1.9	2.3	3.3	3.2	0.1
Alkalinity (Total as CaCO3)	mg/L	205	270	270	211	215	275	273	266	237	238	225	220	223	221	223	1
Dissolved Chloride (Cl)	mg/L	29	26	39	30	36	57	57	43	40	19	16	11	16	16	16	1
Nitrite (N)	mg/L	ND	ND	0.04	ND	ND	ND	ND	0.02	ND	ND	0.01	0.02	0.01	0.01	0.01	0.01
Nitrate (N)	mg/L	1.7	1.1	1.2	1.2	1.5	1.8	1.8	1.9	1.4	4.3	2.9	2.7	3.0	3.6	3.0	0.1

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Sample DP8347-: Total Organic Carbon < Dissolved Organic Carbon: Both values fall within acceptable RPD limits for duplicates and are likely equivalent.
Sample DP8353-: Total Organic Carbon < Dissolved Organic Carbon: Both values fall within acceptable RPD limits for duplicates and are likely equivalent.
Results relate only to the items tested.

Maxxam Job #: A9B6881
Report Date: 2009/09/15

Groundwater Science
Client Project #: ERIN
Project name:
Sampler Initials:

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

Maxxam ID		DP8344	DP8345	DP8346	DP8347	DP8348	DP8349	DP8350	DP8351	DP8352	DP8353	DP8354	DP8355	DP8356	DP8357	DP8398	
Sampling Date		2009-09-04	2009-09-04	2009-09-04	2009-09-04	2009-09-04	2009-09-04	2009-09-04	2009-09-04	2009-09-04	2009-09-04		2009-09-04	2009-09-04	2009-09-04		
COC Number		162160-0	162160-0	162160-0	162160-0	162160-0	162160-0	162160-0	162160-0	162160-0	162160-0	162160-0	162160-0	162160-0	162160-0	16216001	
	Units	**TA13**	**TA7**	**TA9**	**TA10**	**ERIN E**	**ERIN D-1**	**ERIN D-2**	**ERIN C**	**ERIN B**	**H1**	**H4**	**TA15**	**H3**	**TA16**	**TA 16B**	**RDL**
Metals																	
Dissolved Calcium (Ca)	mg/L	61.5	78.0	81.7	63.6	63.8	82.9	82.6	82.0	71.1	79.0	70.7	68.2	71.5	70.4	71.3	0.05
Dissolved Magnesium (Mg)	mg/L	19.4	23.3	19.8	19.5	18.9	21.8	21.8	19.3	19.7	19.0	19.5	19.6	19.7	19.4	19.6	0.05
Dissolved Potassium (K)	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
Dissolved Sodium (Na)	mg/L	14.9	11.6	22.3	15.3	17.9	33.9	33.9	26.9	23.3	9.5	6.4	4.2	6.4	6.3	6.3	0.5
Total Aluminum (Al)	ug/L	34	41	18	22	11	ND	5	18	13	ND	59	48	66	81	63	5
Total Antimony (Sb)	ug/L	ND	ND	1.1	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.5
Total Arsenic (As)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
Total Barium (Ba)	ug/L	39	26	60	38	40	38	38	65	43	48	40	40	41	42	42	5
Total Beryllium (Be)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.5
Total Boron (B)	ug/L	ND	ND	ND	15	16	55	57	ND	24	ND	ND	ND	ND	ND	ND	10
Total Cadmium (Cd)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.1
Total Calcium (Ca)	ug/L	64000	76000	83000	61000	62000	80000	81000	81000	68000	79000	69000	71000	70000	71000	72000	200
Total Chromium (Cr)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5
Total Cobalt (Co)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.5
Total Copper (Cu)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
Total Iron (Fe)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	100
Total Lead (Pb)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.5
Total Magnesium (Mg)	ug/L	21000	23000	21000	19000	19000	22000	22000	20000	20000	20000	20000	21000	20000	20000	21000	50
Total Manganese (Mn)	ug/L	23	32	37	34	20	4	4	20	14	ND	12	14	14	13	12	2
Total Molybdenum (Mo)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
Total Nickel (Ni)	ug/L	ND	ND	ND	1	74	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
Total Potassium (K)	ug/L	1100	1200	1300	1000	1000	1500	1500	1400	1200	780	860	980	870	880	900	200
Total Selenium (Se)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2
Total Silicon (Si)	ug/L	3700	4100	4100	3300	3300	3800	3800	4000	3400	5200	4600	4900	4700	4700	4800	50
Total Silver (Ag)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.1
Total Sodium (Na)	ug/L	16000	11000	22000	14000	17000	32000	32000	26000	22000	9400	6000	4400	6100	6300	6200	100
Total Strontium (Sr)	ug/L	120	140	140	120	120	150	160	140	130	110	100	110	110	110	110	1
Total Thallium (Tl)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.05
Total Titanium (Ti)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5
Total Uranium (U)	ug/L	0.4	0.5	0.3	0.4	0.4	0.4	0.4	0.2	0.3	0.4	0.4	0.4	0.4	0.5	0.4	0.1
Total Vanadium (V)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
Total Zinc (Zn)	ug/L	ND	ND	7	ND	ND	ND	11	ND	ND	13	ND	ND	8	5	8	5

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Table 4.1 Surface Water Quality: September 18, 2009

Sampler Initials:

RESULTS OF ANALYSES OF WATER

Maxxam ID		DT9320	DT9321		DT9322		DT9323		DT9324		DT9325		DT9326		DT9327		DT9328	
Sampling Date		2009-09-18	2009-09-18		2009-09-18		2009-09-18		2009-09-18		2009-09-18		2009-09-18		2009-09-18		2009-09-18	
COC Number		163071-0	163071-0		163071-0		163071-0		163071-0		163071-0		163071-0		163071-0		163071-0	
	Units	**TA 13**	**ERIN D**	**RDL**	**ERIN D PIEZO**	**RDL**	**ERIN E**	**RDL**	**ERIN E-PIEZO**	**RDL**	**ERIN C**	**RDL**	**ERIN C-PIEZO**	**RDL**	**SAMPLE 1**	**RDL**	**SAMPLE 2**	**RDL**
Calculated Parameters																		
Anion Sum	me/L			N/A	7.36	N/A		N/A	7.42	N/A		N/A	7.64	N/A		N/A	6.34	N/A
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	192	276	1	285	1	202	1	264	1	269	1	281	1	226	1	254	1
Calculated TDS	mg/L	270	418	1	387	1	278	1	391	1	363	1	396	1	316	1	323	1
Carb. Alkalinity (calc. as CaCO3)	mg/L	3	4	1	2	1	3	1	2	1	4	1	1	1	4	1	ND	1
Cation Sum	me/L			N/A	7.42	N/A		N/A	7.28	N/A		N/A	7.13	N/A		N/A	5.68	N/A
Hardness (CaCO3)	mg/L	200	280	1	310	1	210	1	280	1	270	1	290	1	230	1	240	1
Ion Balance (% Difference)	%			N/A	0.400	N/A		N/A	0.970	N/A		N/A	3.45	N/A		N/A	5.49	N/A
Langelier Index (@ 20C)	N/A	0.818	1.09		0.788		0.832		0.672		1.12		0.659		0.955		0.154	
Langelier Index (@ 4C)	N/A	0.568	0.843		0.539		0.583		0.424		0.872		0.410		0.706		-0.0950	
Saturation pH (@ 20C)	N/A	7.41	7.12		7.06		7.37		7.13		7.11		7.08		7.27		7.19	
Saturation pH (@ 4C)	N/A	7.66	7.36		7.31		7.62		7.38		7.36		7.32		7.52		7.44	
Inorganics																		
Total Ammonia-N	mg/L	ND	ND	0.05	0.53	0.05	ND	0.05	0.09	0.05	ND	0.05	0.82	0.05	ND	0.05	0.88	0.05
Conductivity	umho/cm	496	768	1	684	1	511	1	697	1	651	1	712	1	582	1	592	1
Dissolved Inorganic Carbon (C)	mg/L	42	62	1	65	1	45	1	60	1	60	1	62	1	51	1	54	1
Total Kjeldahl Nitrogen (TKN)	mg/L	0.8	0.4	0.1	17	2	0.5	0.1	7	1	0.5	0.1	11	2	0.6	0.1	3	1
Dissolved Organic Carbon	mg/L	2.5	2.3	0.2	4.4	0.2	2.8	0.2	1.6	0.2	1.9	0.2	4.9	0.2	2.5	0.2	4.3	0.2
Total Organic Carbon (TOC)	mg/L	2.8	2.3	0.2			2.9	0.2			2.1	0.2			2.8	0.2		
Orthophosphate (P)	mg/L	ND	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01
pH	pH	8.2	8.2		7.8		8.2		7.8		8.2		7.7		8.2		7.3	
Total Phosphorus	mg/L	0.018	0.007	0.002	23	0.2	0.012	0.002	5.5	0.2	0.028	0.002	12	0.2	0.017	0.002	2.5	0.2
Total Suspended Solids	mg/L	10	ND	10	30000	10	ND	10	2400	10	ND	10	25000	10	ND	10	4600	10
Dissolved Sulphate (SO4)	mg/L	22	24	1	11	1	22	1	22	1	20	1	27	1	22	1	1	1
Turbidity	NTU	4.1	0.3	0.1			1.1	0.1			2.0	0.1			1.2	0.1		
Alkalinity (Total as CaCO3)	mg/L	195	280	1	287	1	205	1	266	1	273	1	282	1	230	1	255	1
Dissolved Chloride (Cl)	mg/L	32	70	1	49	1	33	1	56	1	39	1	51	1	38	1	43	1
Nitrite (N)	mg/L	ND	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01
Nitrate (N)	mg/L	1.8	2.4	0.1	ND	0.1	1.2	0.1	1.1	0.1	1.8	0.1	ND	0.1	1.6	0.1	ND	0.1
Nitrate + Nitrite	mg/L				ND	0.1			1.1	0.1			ND	0.1			ND	0.1

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

GENERAL COMMENTS

Sample DT9321-: Total Organic Carbon < Dissolved Organic Carbon: Both values fall within acceptable RPD limits for duplicates and are likely equivalent.
Sample DT9320, Lab Filtered Metals Analysis by ICP: Test repeated.
Sample DT9320, Total Metals Analysis by ICPMS: Test repeated.
Results relate only to the items tested.

Groundwater Science
Client Project #: ERIN
Project name:
Sampler Initials:

Maxxam Job #: A9C4655
Report Date: 2009/10/01

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

Maxxam ID		DT9320		DT9321	DT9322	DT9323	DT9324	DT9325	DT9326	DT9327	DT9328	
Sampling Date		2009-09-18		2009-09-18	2009-09-18	2009-09-18	2009-09-18	2009-09-18	2009-09-18	2009-09-18	2009-09-18	
COC Number		163071-0		163071-0	163071-0	163071-0	163071-0	163071-0	163071-0	163071-0	163071-0	
	Units	**TA 13**	**QC Batch**	**ERIN D**	**ERIN D PIEZO**	**ERIN E**	**ERIN E-PIEZO**	**ERIN C**	**ERIN C-PIEZO**	**SAMPLE 1**	**SAMPLE 2**	**RDL**
Metals												
Dissolved Calcium (Ca)	mg/L	51.4	1951696	77.2		53.7		78.0		62.3		0.05
Dissolved Magnesium (Mg)	mg/L	18.5	1951696	20.4		18.6		18.8		18.9		0.05
Dissolved Potassium (K)	mg/L	ND	1956236	2		1		2		1		1
Dissolved Sodium (Na)	mg/L	13.7	1951696	38.6		14.3		24.9		20.7		0.5
Dissolved Aluminum (Al)	ug/L				ND		ND		5		6	5
Total Aluminum (Al)	ug/L	74	1950695	11		17		41		25		5
Dissolved Antimony (Sb)	ug/L				ND		0.6		1.8		ND	0.5
Total Antimony (Sb)	ug/L	ND	1950695	ND		ND		ND		ND		0.5
Dissolved Arsenic (As)	ug/L				2		ND		6		1	1
Total Arsenic (As)	ug/L	ND	1950695	ND		ND		ND		ND		1
Dissolved Barium (Ba)	ug/L				70		37		150		81	5
Total Barium (Ba)	ug/L	31	1950695	45		32		66		44		5
Dissolved Beryllium (Be)	ug/L				ND		ND		ND		ND	0.5
Total Beryllium (Be)	ug/L	ND	1950695	ND		ND		ND		ND		0.5
Dissolved Boron (B)	ug/L				43		50		17		25	10
Total Boron (B)	ug/L	13	1950695	100		23		18		34		10
Dissolved Cadmium (Cd)	ug/L				ND		ND		ND		ND	0.1
Total Cadmium (Cd)	ug/L	ND	1950695	ND		0.1		ND		ND		0.1
Dissolved Calcium (Ca)	ug/L				84000		78000		83000		67000	200
Total Calcium (Ca)	ug/L	54000	1950695	83000		54000		82000		67000		200
Dissolved Chromium (Cr)	ug/L				ND		ND		ND		ND	5
Total Chromium (Cr)	ug/L	ND	1950695	ND		ND		ND		ND		5
Dissolved Cobalt (Co)	ug/L				ND		ND		ND		ND	0.5
Total Cobalt (Co)	ug/L	ND	1950695	ND		ND		ND		ND		0.5
Dissolved Copper (Cu)	ug/L				ND		2		ND		1	1
Total Copper (Cu)	ug/L	1	1950695	ND		ND		ND		ND		1
Dissolved Iron (Fe)	ug/L				1500		ND		450		2100	100
Total Iron (Fe)	ug/L	170	1950695	ND		ND		ND		ND		100
Dissolved Lead (Pb)	ug/L				ND		ND		ND		ND	0.5
Total Lead (Pb)	ug/L	ND	1950695	ND		ND		ND		ND		0.5
Dissolved Magnesium (Mg)	ug/L				23000		22000		21000		16000	50
Total Magnesium (Mg)	ug/L	20000	1950695	22000		19000		20000		21000		50
Dissolved Manganese (Mn)	ug/L				790		23		270		2100	2
Total Manganese (Mn)	ug/L	39	1950695	4		16		23		17		2
Dissolved Molybdenum (Mo)	ug/L				ND		ND		2		ND	1
Total Molybdenum (Mo)	ug/L	ND	1950695	1		ND		ND		ND		1
Dissolved Nickel (Ni)	ug/L				ND		ND		1		ND	1
Total Nickel (Ni)	ug/L	ND	1950695	ND		ND		ND		ND		1
Dissolved Phosphorus (P)	ug/L				ND		ND		ND		170	100
Dissolved Potassium (K)	ug/L				1900		1600		1700		1200	200
Total Potassium (K)	ug/L	1100	1956006	1600		1000		1500		1200		200
Dissolved Selenium (Se)	ug/L				ND		ND		ND		ND	2
Total Selenium (Se)	ug/L	ND	1950695	ND		ND		ND		ND		2
Dissolved Silicon (Si)	ug/L				7200		5700		7000		7900	50
Total Silicon (Si)	ug/L	3700	1950695	3700		3400		3900		3700		50
Dissolved Silver (Ag)	ug/L				ND		ND		ND		ND	0.1
Total Silver (Ag)	ug/L	ND	1950695	ND		ND		ND		ND		0.1
Dissolved Sodium (Na)	ug/L				27000		36000		26000		19000	100
Total Sodium (Na)	ug/L	15000	1950695	43000		15000		26000		23000		100
Dissolved Strontium (Sr)	ug/L				170		170		150		130	1
Total Strontium (Sr)	ug/L	110	1950695	170		120		140		130		1
Dissolved Thallium (Tl)	ug/L				ND		ND		ND		ND	0.05
Total Thallium (Tl)	ug/L	ND	1950695	ND		0.07		ND		ND		0.05
Dissolved Titanium (Ti)	ug/L				ND		ND		ND		ND	5
Total Titanium (Ti)	ug/L	ND	1950695	ND		ND		ND		ND		5
Dissolved Uranium (U)	ug/L				ND		0.2		0.2		ND	0.1
Total Uranium (U)	ug/L	0.2	1950695	0.2		0.3		ND		ND		0.1
Dissolved Vanadium (V)	ug/L				ND		ND		5		ND	1
Total Vanadium (V)	ug/L	ND	1950695	ND		ND		ND		ND		1
Dissolved Zinc (Zn)	ug/L				560		290		1500		15000	5
Total Zinc (Zn)	ug/L	5	1950695	ND		ND		6		ND		5

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch