

Rural Beaches Program
Sharon Creek Water Quality Study
1992 PROGRESS REPORT

Prepared For:

The Ministry of the Environment

Produced By:

The Lower Thames Valley Conservation Authority

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1992 PROGRESS REPORT

Prepared For:
Provincial Rural Beaches Planning and Advisory Committee
The Ministry of the Environment

Produced By:
Kevin S. Cincurak
Water Resources Technician

LOWER THAMES VALLEY CONSERVATION AUTHORITY
February 1993

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DISCLAIMER

This report has been reviewed by the rural beaches steering committee and approved for publication.

The material presented in this report, both quantitative and qualitative, does not necessarily reflect the position, policies and/or the management priorities of the lower Thames Valley Conservation Authority, and any of the individual agencies involved and/or named herein.

Interpretation of the findings contained within this report should be examined in the context of other reports produced within the comprehensive framework of the rural beaches program.

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The Lower Thames Valley Conservation Authority Rural Beaches Steering Committee provided consultation and direction throughout this phase of the program. Their guidance throughout this program was greatly appreciated. The committee membership consisted of:

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BACKGROUND

Numerous beach closings in 1983 and 1984 drew public and government attention to the severity of water quality problems. In 1985, the Ontario Ministry of the Environment's (MOE) Water Resources Branch formulated the Provincial Rural Beaches Strategy Program.

Rural Beaches Studies (CURB Development)

With financial and technical assistance from the MOE, local Conservation Authorities carry out Rural Beaches studies to identify the relative impact of pollution sources, their pathways to beaches, and to develop a *Clean Up Rural Beaches (CURB) Plan* specific to the watershed upstream of each beach. The CURB Plan develops remedial strategy options and respective cost estimates for each beach through field inspections, farmer consultations, water quality monitoring and basic mathematical modeling techniques.

CURB PROGRAM

The Clean Up Rural Beaches Program is a \$57 million program, effective from September 1, 1991 to September 31, 2001.

It is the culmination of the Provincial Rural Beaches Strategy, initiated in 1985 in response to numerous rural beach closings in 1983 and 1984. Local Conservation Authorities carry out studies to identify the relative impact of pollution sources on downstream swimming beaches. A Clean Up Rural Beaches (CURB) Plan is developed as a guide to restore and maintain acceptable water quality in watersheds with rural beaches.

Participating Conservation Authorities apply the CURB Plan recommendations by using the CURB Program guidance and incentives for environmental protection measures and alternate management practices that improve rural water quality.

The CURB Program complements the Ontario Ministry of Agriculture and Food's (OMAF) Land Stewardship II Program (LS II). The LS II program provides financial assistance to address agricultural soil and water conservation problems in Ontario. The CURB Program is targeted at specific agricultural and rural residential sites in rural watersheds with rural downstream swimming beaches.

The program has six major aspects:

1. Conservation Authorities, with a completed CURB Plan for specific areas, are eligible to participate in a local five year CURB Program.
2. Emphasis is on local surface water quality improvement through improved rural land management practices.
3. Extension, education and technology transfer.
4. Grants to:
 - Farmers who build structures and adopt practices as part of their Water Quality Improvement Plan,
 - Rural residents who repair or rebuild a private sewage system as part of their Water Quality Improvement Plan.
5. Funds to Conservation Authorities for program delivery, conservation promotion, on-farm demonstrations, evaluation, and water quality monitoring.
6. Local CURB committees receive and review Water Quality Improvement Plans and project proposals for funding. They are locally represented by the Conservation Authority, Ontario Ministry of the Environment, Ontario Ministry of Agriculture and Food, Health Office, and the Ontario Soil and Crop Improvement Association.

Taken from: CURB Program, Guidelines for Project Eligibility and Funding, Ontario Ministry of the Environment, 06 May 1992.

L.T.V.C.A. BEACH STUDIES

Of the more than 100 beach closures each summer in Ontario, it is estimated that one quarter are rural beaches. The principle causes of rural beach postings are:

- faulty private sewage systems,
- agricultural runoff from manure storage and farm yards,
- poor manure handling practices,
- livestock access to watercourses, and
- inadequate milk house washwater disposal.

The proposal for this Authority to undertake the program was prepared by HSP Inc. and presented to the MOE in February 1992. During the spring, the LTVCA received financial support from the Ministry of the Environment (MOE) to undertake a beach study as part of the provincial Rural Beaches Program. The purpose of this study is to identify the sources of pollution which may contaminate the swimming area at the Sharon Creek Conservation Area in Delaware Township. Other beaches under preliminary investigation include Orford Township Park and Port Glasgow in Aldborough Township.

This phase of the program involved intense water sampling of Sharon Creek and its tributaries, which are located upstream of the swimming beach at the Conservation Area. The samples were analyzed for various chemical and bacterial concentrations. In addition, a comprehensive livestock operation assessment and household septic system survey was completed. This information will form the basis for a Clean Up Rural Beaches (CURB) plan, which will identify priority management areas within the study area.

Recent consultations with the MOE have led to a pending expansion of the study areas within the Authority's boundary. The additional areas likely to be examined will be the lands along Lake Erie in Kent County (*i.e.* Eriean, Erie Beach, and/or Rondeau Bay).

1.0 INTRODUCTION

1.1 BACKGROUND

To establish a list of considered study areas, the entire 3275 square kilometres of the Lower Thames Valley Conservation Authority's watershed was examined using the National Topographic Survey maps, Ontario Ministry of Natural Resources Base Maps, and individual township drainage maps. In addition, reports on land use, agricultural practices, outdoor recreational sites, and the 1980 and 1986 agriculture census were consulted. Finally, windshield surveys were done to confirm findings.

A list of criteria were utilized to discriminate between possible study areas. The watershed was scrutinized for a site that was a public swimming beach, had substantial upstream livestock operations, had a minimal influence by urban centres, and was able to be effectively investigated and managed in a one year study period.

Fourteen possible beach sites were considered (see Figure 1.1):

- Holiday Harbour, Wheatley
- Camper's Cove, Wheatley
- Wheatley Provincial Park
- Thamesgrove Conservation Area, Chatham
- C.M. Wilson Conservation Area, Harwich Township
- Big Bend Conservation Area, Aldborough Township
- Rondeau Provincial Park, Harwich Township
- Kent County Park, Howard Township
- Wildwood Beach, Howard Township
- Duttona Beach, Dunwich Township

These ten sites were not chosen for various reasons: size of study area being too large to effectively investigate in one year, minimal upstream livestock operations, urban pollution influence too great for the Rural Beaches Program, streams not directly affecting the beach, or no public swimming.

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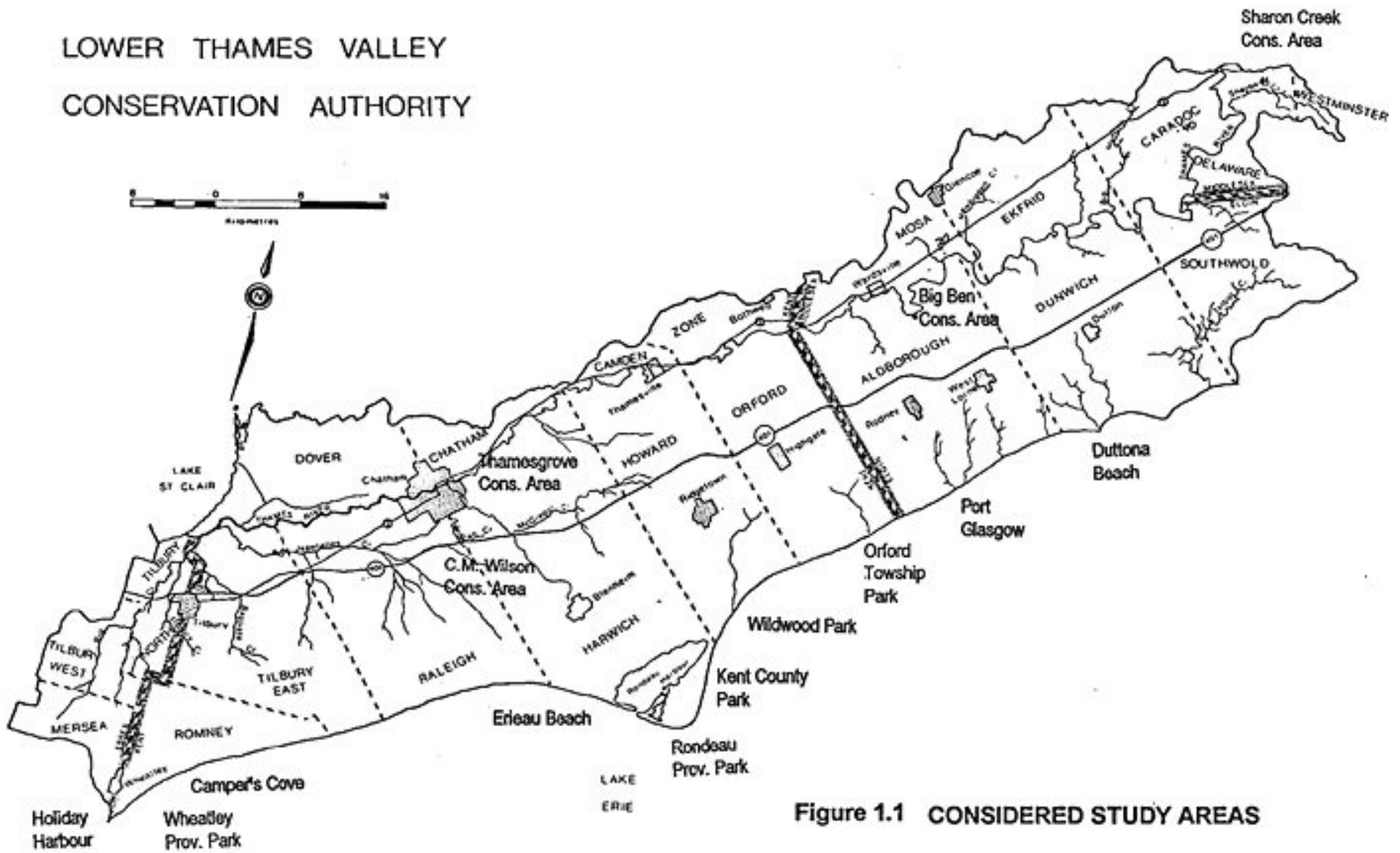


Figure 1.1 CONSIDERED STUDY AREAS

The remaining four beaches considered were:

- Rondeau Harbour, Erieau
- Orford Township Park, Clearville
- Port Glasgow, Aldborough Township
- Sharon Creek Conservation Area, Delaware and Westminster Townships

1.2 PROJECT GOALS AND OBJECTIVES

In order to maintain the recreational use of the beach at the Sharon Creek Conservation Area and gain the interest and involvement of the area landowners, the first year of the Lower Thames Valley Conservation Authority's Rural Beaches Program endeavored to achieve the following objectives:

- Upon the selection of the most suitable beach within the LTVCA boundary, conduct water quality monitoring of the beach and the contributing watershed. The purpose of the sampling regime is to locate the areas of both high faecal bacteria and high chemical nutrient concentrations within the study area.
- Produce a private landowner and rural residence questionnaire in order to inventory rural land use activities which could be contributing bacterial pollution to the selected beach and watershed.
- From the above information, identify and rank livestock operations as to their potential to cause faecal bacterial contamination of the selected beach and watershed.
- Establish a database to maintain a list of landowners who participated in the livestock operation assessment survey and to document the water quality problems related to bacterial sources within the watershed. This base of data will aid future monitoring of the watershed and implementation of remedial measures.

2.0 WATERSHED INFORMATION

2.1 SIZE AND LOCATION

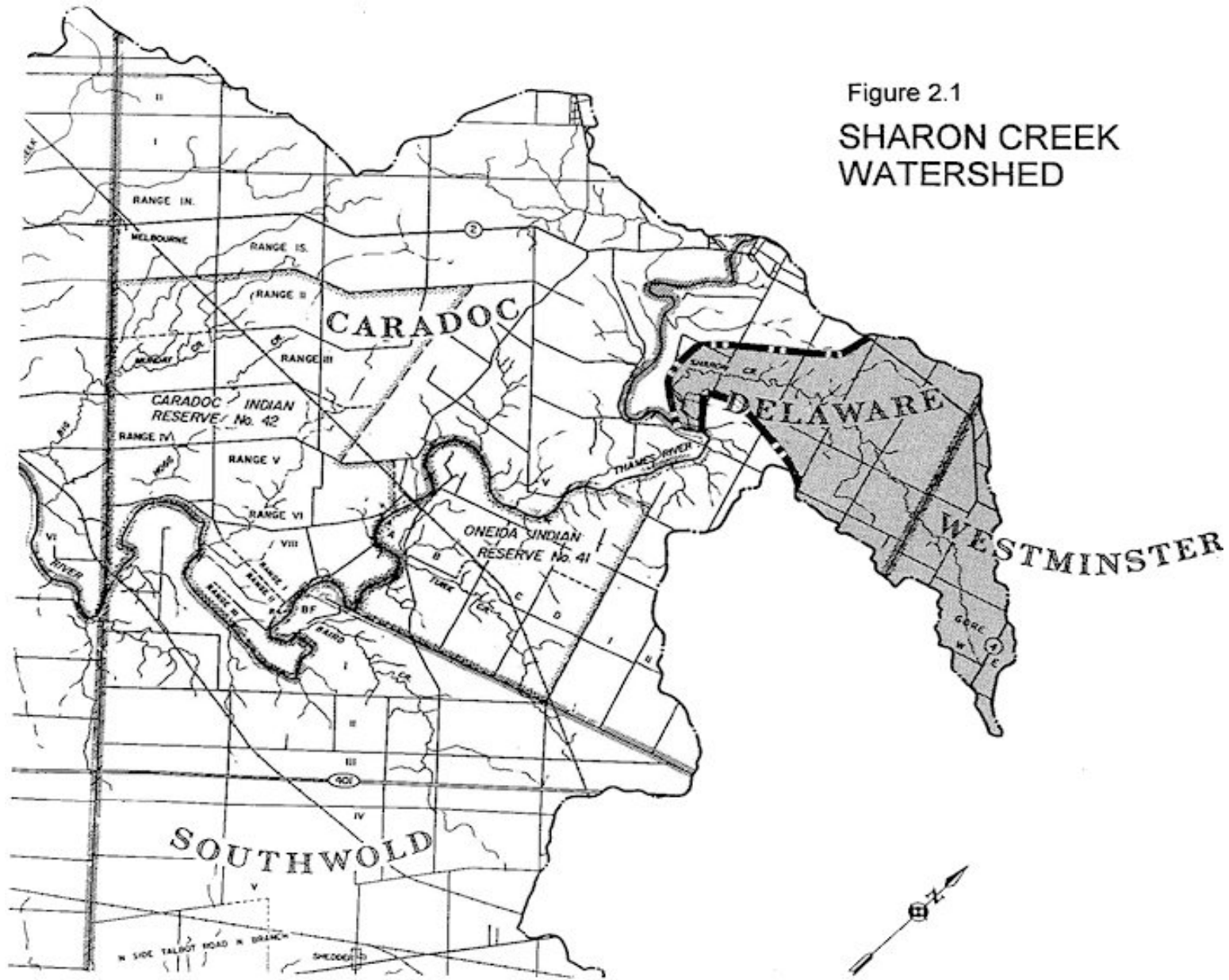
The focus of the 1992 Rural Water Quality Study is the Sharon Creek watershed. This watershed is located in Delaware Township and the Town of Westminster (formerly Westminster Township), in Middlesex County (see Figure 2.1). Currently the Town of Westminster no longer exists, having been annexed by the City of London. The watershed now lies within the City of London and the associated buffer zone. The size of the watershed is 29.52 square kilometres. Several tributaries and drains flow into the Sharon Creek which empties into Springer Lake, which was created by a dam. The lake drains into the Thames River through the control structure of the dam.

Two other watersheds were monitored for indications of elevated bacterial and chemical nutrient levels. These were Clear Creek in Orford Township, Kent County and Sixteen Mile Creek in Aldborough Township, Elgin County (see Figure 2.2). Table 2.1 below summarizes the watercourses, beaches and watershed areas.

TABLE 2.1: CURB PROGRAM BEACHES

Watercourse	Beach(s) Affected	Watershed Area (Square Kilometres)
Clear Creek	Orford Township Park (Lake Erie)	39.57
Sharon Creek	Sharon Creek Conservation Area (Springer Lake)	29.52
Sixteen Mile Creek	Port Glasgow Municipal Park (Lake Erie)	19.54

Figure 2.1
SHARON CREEK
WATERSHED



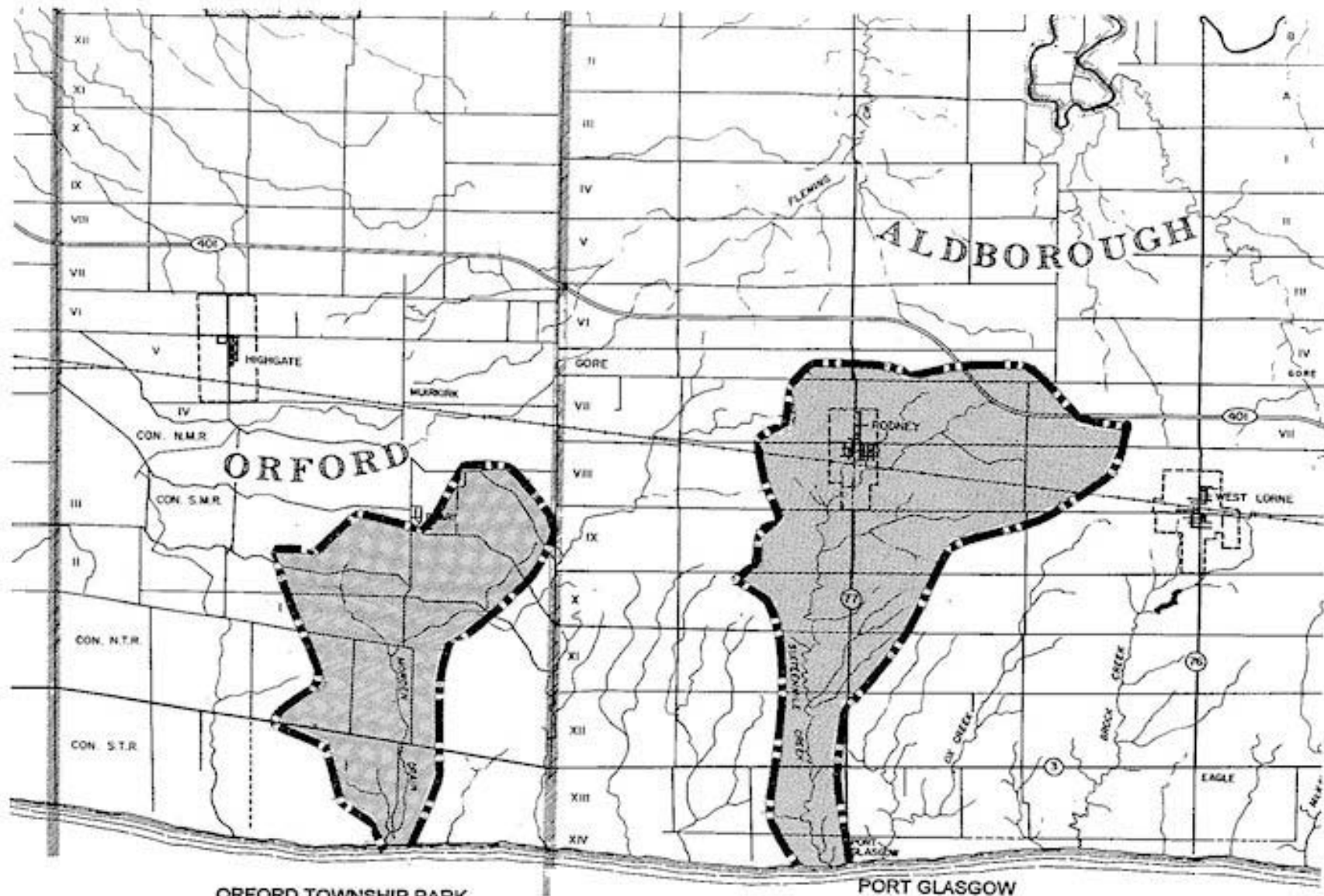


Figure 2.2

ORFORD TOWNSHIP PARK
(Clear Creek and Morden Drain)

PORT GLASGOW
(Sixteen Mile Creek)

L A K E
E R I E

Sharon Creek Conservation Area

The Lower Thames Valley Conservation Authority acquired the Sharon Creek Conservation Area in 1966 in connection with the construction of the Sharon Creek Dam and Reservoir. It comprises 48.5 hectares (115 acres) of which 35.6 hectares (83 acres) is water and 12.9 hectares (32 acres) is land. The Sharon Creek Conservation Area is located 11 kilometres southwest of London, off Highway 2 in Delaware Township, Middlesex County, lots 9 and 10, concessions 1 and 2. The reservoir and dam were constructed circa 1969 as a water retention feature to aid in flood reduction within the Sharon Creek watershed. The grand opening of the Sharon Creek Dam and Reservoir was June 11, 1969. The reservoir, named Springer Lake, the focal point of the park, contains about 25 million imperial gallons. It has reasonably good water quality for swimming and sport fishing. The supporting land area has a generally rolling topography with steep slopes bordering much of the reservoir. About 20 percent of the land is wooded with the remainder in grass. Much of the area is in service as a day-use area.

The Conservation Authority's goal for this property is to provide a regional level of outdoor recreational activities compatible with the water management objectives for the property. Development is of low intensity with the major expenditures being a drinking water supply, parking area, and eventually, pit toilets and a picnic shelter. Major activities on the site include picnicking, swimming, fishing, group camping, and nature trail use area.

Sport fishing is a popular use of the Conservation Area. Ministry of Natural Resources district records indicate the following fish species to be present in the reservoir: large and smallmouth bass, northern pike, crappies, pumpkinseed, bullhead, sucker and shad. These fish supply recreational fishing opportunities in the summer and winter to local fishermen. Notwithstanding, concern has recently been expressed by a few individuals over the quality of the fish caught in the reservoir, although no serious problems exist. This does, however, provide additional justification for the implementation program when the CURB Plan is completed.

2.2 PHYSIOGRAPHY / TOPOGRAPHY

The gray shale bedrock underlying the watershed is part of the Hamilton formation which is common to most of southern Ontario. Formed in mid-Devonian times and subsequently covered by glacial lakes, the only traces of this rock may be uncovered some 80 to 85 metres below surface soils. The Wisconsin Glacial period and ensuing post-glacial Lake Whittlesey are the main agents responsible for masking the bedrock of the region. These events produced a plain of lacustrine deposits with flat to gently undulating relief which has become known as the Caradoc Sand Plain. The most exaggerated relief of the sand plain is produced by the stream and river systems which have cut deeply incised valleys into this once featureless, yet easily erodible terrain. With the exception of the Thames Valley which was once a spillway for Wisconsin glaciers, regional valley systems of the region are characterized by steep valley walls and narrow flood plains.

2.3 SOILS / DRAINAGE

Surficial deposits of the watershed are lacustrine clays overlain by compacted clayey silts and sands at variable depths. Upland soils are characterized by highly permeable Berrien Sand Loams, underlain by impermeable clays. Drainage of these soils operates both laterally and vertically over the area. Water moving vertically through the permeable sands, upon reaching the impermeable clays moves horizontally. Drainage of the upland areas are hampered by the underlying clays. As such, the watershed is extensively artificially drained.

2.4 CLIMATE

The thirty year average climatic readings compiled by the Atmospheric Environment Service of Canada found the average maximum day time temperatures for July, the warmest month, to be 26.4°C (79.6°F), and the coldest temperatures in January to be about -9.8°C (14.2°F). Mean total precipitation for the region was found to be 924.5 millimetres. Located near a major snowbelt, snow can be expected an average of 66 days per year. Rain can be expected on a fairly even basis throughout the remainder of the year.

2.5 SHARON HEIGHTS GOLF ESTATES

During the summer and autumn months of 1988 and 1989, a study of the water quality of the Sharon pond was initiated by a land developer. The objective was to determine the quality of the water in the pond for future use as a recreation facility. The facility being considered was the development of a 28 lot estate residential subdivision and a 27 hole championship golf course. The lands affected by this development comprise approximately 28 hectares (69 acres) of proposed residential use and 117 hectares (288 acres) of ponds and proposed golf course use. The land in question is bounded by Sharon Road to the south, Highway 402 to the north, Middlesex County Road 15 to the west and Concession Road III to the east (see Figures 2.3 and 2.4).

A series of water samples were collected at various locations in and around the pond itself. As the results of these initial tests were analyzed, it was decided to expand the water sampling to include all the upstream waterways that terminate into the pond. In the following year, 1989, water testing was again carried out. The water samples were analyzed by a firm in London, Ontario for total phosphorus, ammonia, turbidity and total coliforms. The results of this testing were similar to those obtained by this beach study. However, the methodology of the consulting firm was questionable, and the results are not being considered in any case for the Sharon Creek Rural Beach Study.

The Sharon Heights Golf Estates was deemed incompatible with the current land use (agriculture) and was opposed by the area landowners. To make matters more difficult, the Sharon Pond Water Quality Assessment, commissioned by the developer, was rather accusational, containing specific allegations that the area farmers were indeed the cause of the pollution in the pond. The confrontation between the developer and the area residents increased until it ultimately concluded at an Ontario Municipal Board Hearing. The judgment was for the landowners and the development was halted.

Today, the entire Sharon Creek study area is within the City of London's new boundary or within the City's buffer zone. As such, no development is allowed in the area unless hard services are supplied. This means the residents will no longer have to worry about developments such as the golf estates from impacting the region, unless municipal water and sewage is provided in the future.

Figure 2.3
 TOWNSHIP OF DELAWARE
 ZONING MAP SCHEDULE "A"

ZONES LEGEND

AGRICULTURE	AG
OPEN SPACE	OS
INSTITUTIONAL	IN
SINGLE FAMILY RESIDENTIAL	R1
INDUSTRIAL	M1
INDUSTRIAL EXTRACTION	M2

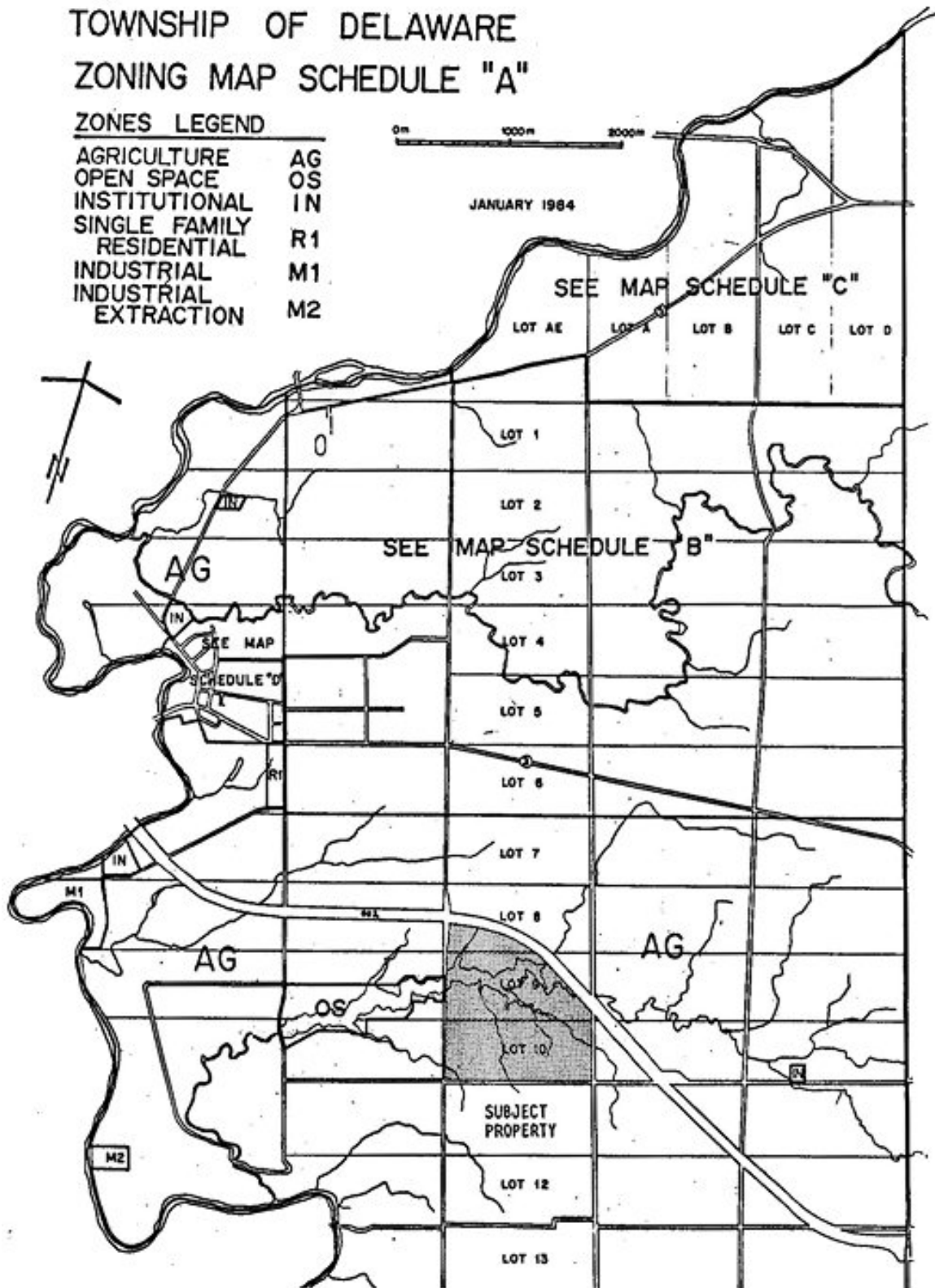
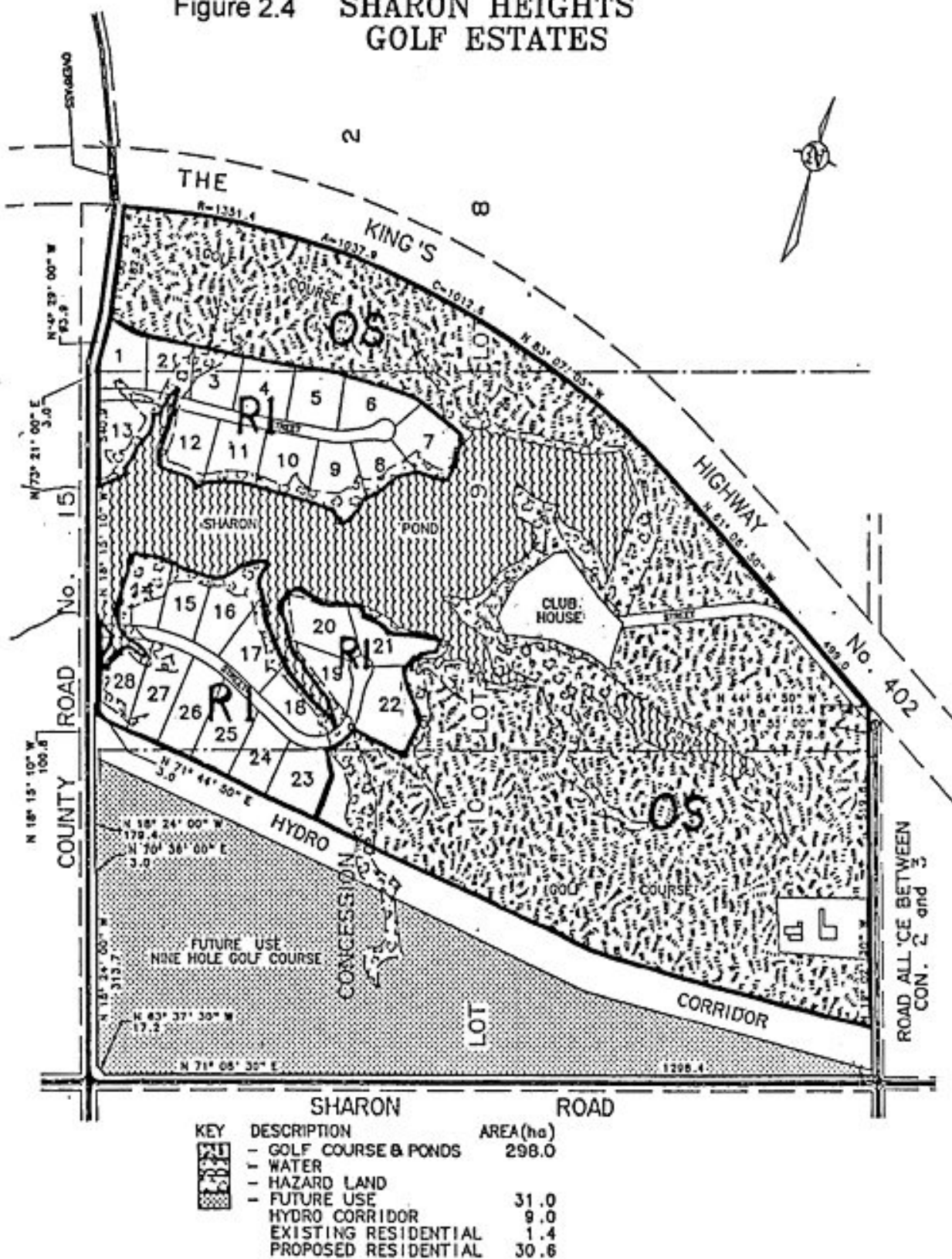


Figure 2.4 SHARON HEIGHTS GOLF ESTATES



3.0 WATER QUALITY METHODOLOGY

3.1 OBJECTIVES

The water quality monitoring aspect of the Rural Beaches Water Quality Study was designed to address several questions. The water sampling program attempted to identify what types specific contaminants are entering Springer Lake at the Conservation Area and what concentrations of contaminants are present throughout the watershed. It was also considered important to identify areas of the watershed where the Ministry of the Environment's guidelines for surface water quality were exceeded.

The water quality categories analyzed included bacterial pollution indicators and chemical parameters. The following specific parameters were analyzed:

TABLE 3.1: BACTERIAL AND CHEMICAL PARAMETERS ANALYZED

Bacterial Indicators	Chemical Parameters
Faecal Coliform	Free Ammonia
<i>Escherichia</i> Coliform	Total Kjeldahl Nitrogen (TKN)
Faecal Streptococci	Nitrite
<i>Pseudomonas aeruginosa</i>	Nitrate
	Total Phosphorus
	Dissolved Phosphorus
	pH
	Chloride
	Conductivity
	Suspended Solids

3.2 BACTERIAL INDICATORS

Historically, there has always been a need to protect the quality of water to be used by humans. However, it was not until the end of the 19th century when the microbial causes of many of the diseases that followed an anal-oral route of transmission had been established and the health hazards associated with water contaminated by faeces was confirmed beyond doubt. A major thrust of research was directed at the recognition of faecal contamination.

As the analytical technology developed, faecal contamination was evaluated by the laboratory analysis for inorganic material and included measurements of chloride, free and albuminoid ammonia, nitrate and nitrite, solids and oxygen consumption. By the turn of the century, information on the presence and levels of microorganisms in water had accumulated. At that time it was quickly recognized that the bacterial determinations were much more sensitive than the chemical measurements and significant effort was directed toward the detection and enumeration of microorganisms from faeces (Prescott and Winslow, 1904).

Nonetheless, the isolation, identification and enumeration of specific pathogens was still difficult. The low number of pathogenic microorganisms relative to the natural microbial populations and the wide variety of pathogens that may be present are severe limitations to the usefulness of procedures for the enumeration of pathogens. As a result, microbiologists suggested looking for the presence of faecal contamination rather than rely on the isolation of pathogens (Olivieri, 1979).

Therefore, the indicator bacteria selected for analysis included faecal coliform, *Escherichia* coliform, faecal streptococci and *Pseudomonas aeruginosa*. The main purpose of faecal streptococci, faecal coliform and *Escherichia* coliform is to try to establish the source of pollution. The presence of *Pseudomonas aeruginosa* indicates the relationship between man and sewage.

Faecal Coliform

Faecal coliform is indicative of the faeces of warm-blooded animals, and is a sub-group of the coliform group. The faecal coliform determination alone does not distinguish between human and animal faecal contamination, however, when measured against other indicators, it can be determined whether the faeces has a human or animal origin. The Ontario Ministry of the Environment has set a guideline limit of 100 organisms per 100 millilitres of sample for bathing purposes. At concentrations above this level eye and skin irritations may occur. If ingested, intestinal difficulties such as cramps and diarrhea may arise.

Escherichia Coliform

Escherichia coliform is the primary indicator of the presence of faecal contamination of water. Once released into the environment, this bacteria can grow only in faeces. This particular bacteria is the most reliable indicator for potable water. The Public Health Units uses the presence of this bacteria to determine whether a beach is to be posted as closed for public bathing. The Ontario Ministry of the Environment has set a recreational guideline limit of 100 organisms per 100 millilitres of sample.

Faecal Streptococci

The faecal streptococcus group has been used to assess the quality of streams and lakes. Although present in large numbers in faeces, they are considerably less numerous than the coliform group in human faeces and thus are a less sensitive indicator. When referenced with faecal coliforms, one is able to distinguish between an animal and a human source. If the faecal coliform count of a sample is four times greater than the faecal streptococci count, the source is assumed to be human. But if the faecal streptococci is 0.7 times greater than the faecal coliform count, the contamination is assumed to be of an animal origin. There is currently no Ministry of the Environment recreational guideline limit for faecal streptococci levels in water.

Pseudomonas Aeruginosa

Pseudomonas aeruginosa is a pathogen noted for its resistance to antibiotics and its association with eye and ear infections. This microorganism can be found in faeces and appears to be associated with human rather than animal faeces. The Ontario Ministry of the Environment has set a recreational guideline limit of only 4 organisms per 100 millilitres of sample. As this limit suggests, there is little tolerance for this pathogen.

TABLE 3.2: Ontario Ministry Of The Environment Recreational Guidelines For Bacterial Indicators

BACTERIA	M.O.E. GUIDELINE (per 100 ml)
Faecal coliform	100
<i>Escherichia</i> coliform	100
Faecal streptococcus	-
<i>Pseudomonas aeruginosa</i>	4

3.3 NUTRIENT / CHEMICAL PARAMETERS

In addition to the usefulness of bacterial indicators of pollution, there are various chemical parameters that provide significant information about water quality. Following is a description of these parameters, their effects and the Ministry of the Environment recreational guidelines.

Free Ammonia

Ammonia is a product of nitrogen which has been converted by bacteria and blue-green algae. Ammonia can enter the surrounding waters through decomposition of organic nitrogen, soil erosion, precipitation, soil leaching and industrial discharges. Sources of ammonia are vegetable or animal waste, treated sewage, fossil rocks, agricultural legumes, commercial fertilizers and industrial operations that use ammonia and ammonia salts.

Total Kjeldahl Nitrogen (TKN)

Total Kjeldahl Nitrogen (TKN) is an organic form of nitrogen which is composed of a combination of organic nitrogen and ammonia. The concentration of TKN is a good indicator of a productive stream and is a necessary ingredient for plant life. However, this nutrient contributes to eutrophication when in excessive amounts. Sources of TKN include manure, sewage and normal biological activities. The Ministry of the Environment recreational guideline for TKN is 0.5 milligrams per litre.

Nitrite

Nitrite is a chemical form of nitrogen that occurs as an intermediate form between ammonia and nitrate. Sources of nitrites include industrial and municipal sewage plants, agricultural uses of forage crops and feeds. High concentrations of nitrites indicate organic pollution through active biological processes. The Ministry of the Environment recreational guideline for nitrite should not exceed 1.0 milligram per litre.

Nitrate

Nitrate is the final stage in the formation of nitrogen, which is the product of nitrification. Sources of this chemical are igneous rocks, municipal and domestic discharges, and fertilizers. High concentrations will promote plant and algae growth (eutrophication). Ingestion of large amounts can cause illness in infants. The Ministry of the Environment recreational guideline for nitrate should not exceed 10.0 milligrams per litre.

Total Phosphorus

Total phosphorus occurs in numerous organic and inorganic forms as a dissolved and particulate constituent in the water. Phosphorus may result from the decomposition of organic matter, domestic sewage (including household cleansers), industrial discharges, milkhouse waste and agricultural drainage from fertilized lands. Although necessary for healthy aquatic plant growth, excessive amounts of phosphorus usually result in heavy eutrophication. Eutrophication will deplete the oxygen supply within the water and result in an overgrowth of aquatic vegetation and algae, reducing the aesthetic value of a beach and/or watercourse. The Ministry of the Environment recreational guideline for total phosphorus is 0.03 milligrams per litre.

Dissolved Phosphorus

Dissolved phosphorus is another measure of the amount of phosphorus present in the water. This particular phosphorus has been dissolved and is therefore readily available to plants. As a result, this form of phosphorus facilitates and hastens the process of eutrophication. This form of phosphorus has no specified Ministry of the Environment guideline.

pH

pH is a symbol representing the negative logarithm of the hydrogen ion concentration in the water. It is a measure of the acidity or alkalinity of a solution. pH is measured on a scale between 0 and 14. A reading of 7 on the scale indicates the solution is neutral. Acid solutions have a pH of less than 7 and alkaline (basic) solutions have a pH of greater than 7. Low pH water is corrosive and can cause skin and eye irritations. Nuisance growths of mineral in crustaceans are another result of acidic water. As with acidic water, high alkalinity can cause skin and eye irritations. The guideline for healthy pH in water is designated to be within the 6.5 to 8.5 range on the pH scale.

Chloride

Chlorides are found in all natural waters, and indicate the amount of salt present. Sources of chloride are variable, including minerals, domestic sewage, municipal drains (from road salting), industrial wastes and agricultural practices. High concentrations of chloride increase the corrosiveness of water and can render it useless for agriculture, municipal and industrial uses. Biologically, excessive chloride is harmful to the ionic balance of aquatic organisms such as fish. The recreational guideline for chloride is 250 milligrams per litre.

Conductivity

Conductivity is a measure of the presence of dissolved ions in the water such as chloride, sulphates and calcium. It is a numerical expression of the ability of the water to conduct an electrical current. This parameter serves as a valid water quality indicator, for the higher the conductivity becomes, the more polluted the water.

Suspended Solids (Turbidity)

The turbidity is an optical measurement which indicates the clarity of the water. Turbidity is dependent on the amount of suspended materials present in the water such as silt, clay organic material, plankton and microscopic organisms. High turbidity levels affect the penetration of light which in turn disrupts the biological communities. High levels also render the water undesirable for industrial and domestic supplies, as well as recreational purposes.

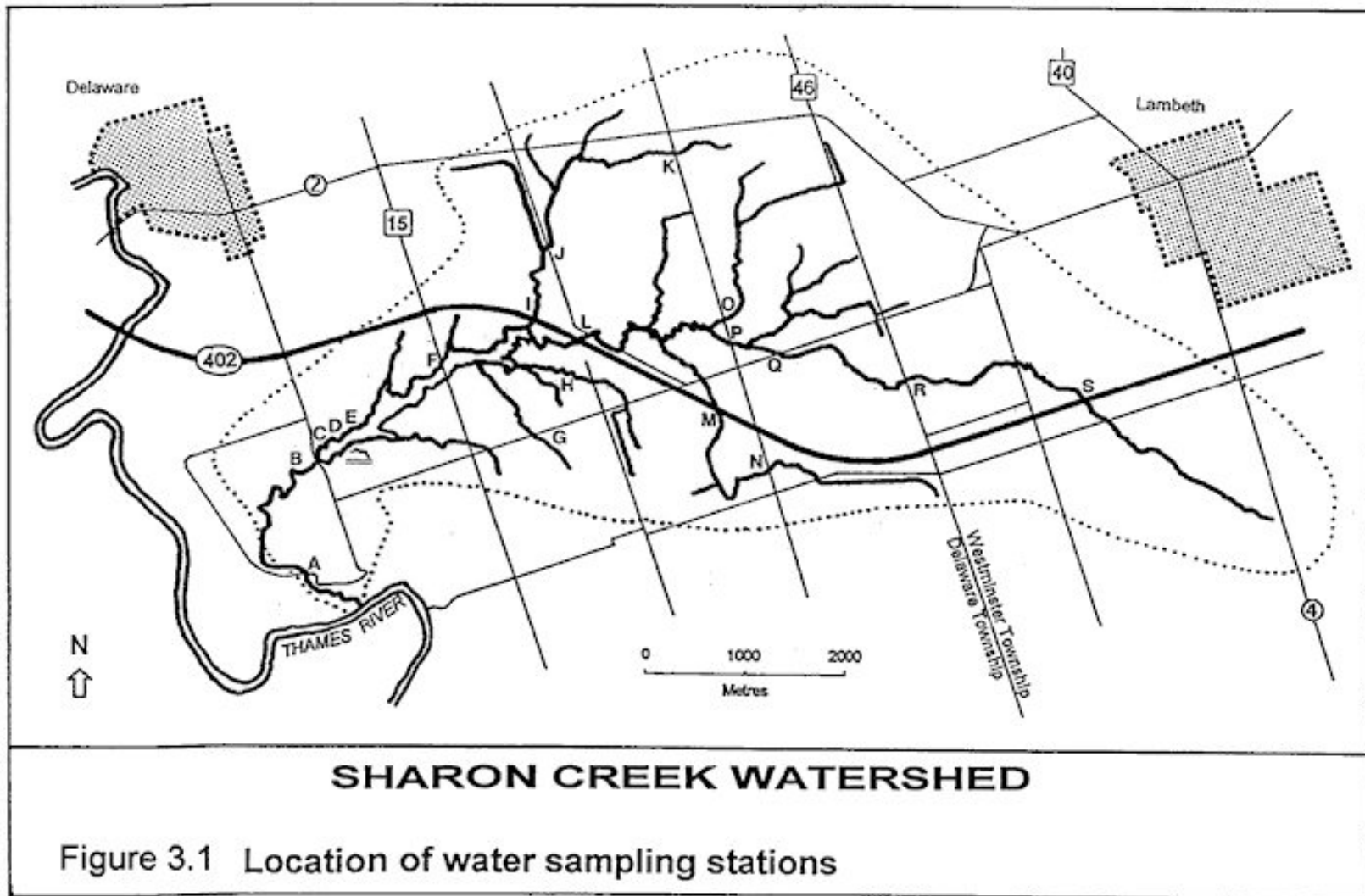
3.4 SAMPLING METHODOLOGY

Bacterial bottles and pet jars were used to obtain water samples for bacterial and chemical analysis respectively. The bacte samples were kept shielded from the sun and placed on ice to prevent further growth of bacteria. All samples were delivered to the Ministry of the Environment's Southwest Regional Laboratory on the same day the specimens were taken.

At the Sharon Creek watershed, an attempt was made to isolate individual or a single group of farms in order to determine specific pollution sources. Nineteen samples (see Figure 3.1) were taken at this watershed which is perhaps a bit much for such a small area (29.52 square kilometres). Nonetheless, such an abundance of samples in one concentrated area can serve several very useful purposes:

- Individual farms are able to be monitored and visual problems can be compared and reviewed against the results of the water sampling. For example, water samples that are taken upstream and downstream of a farm with cattle access.
- This water sampling arrangement facilitates the monitoring of improvements in water quality once remedial measures are in place.
- Mathematical modeling is in effect, not required. In a small watershed which is comprehensively sampled there are very few unknowns and therefore, very few assumptions to make within the CURB models.
- If modeling is completed in conjunction with a plethora of sampling sites, the effectiveness and validity of the model can be checked. This will be useful for refining the models to make it more accurate and legitimate.

In addition to the Sharon Creek watershed, water sampling was carried out at the Clear Creek in Orford Township, Kent County and Sixteen Mile Creek in Aldborough Township, Elgin County. These creeks were not as comprehensively sampled as Sharon Creek. These two sites exhibited the potential to pollute beach areas and were considered preliminary study areas for possible future CURB application. Samples were taken here solely to see whether any bacterial or chemical contamination was present. Results are discussed in the next chapter.



4.0 LIVESTOCK OPERATION ASSESSMENT

4.1 QUESTIONNAIRE

In addition to water quality analysis, a livestock operation assessment of the farms within the Sharon Creek watershed was conducted. The questionnaire used was similar to the one being utilized by other Conservation Authorities in their respective Rural Beaches Program. The questionnaire was designed to evaluate the agricultural practices which have the potential to degrade water quality. The essence of the survey was manure management, livestock access, milkhouse waste disposal and septic system conditions. Information gathered from these questionnaires assisted in determining the unknowns in the CURB algorithm models. Additionally, the information collected reduced the number of assumptions that the models made. The questionnaire can be viewed in Appendix 4.

There are nine major livestock operations (dairy, cattle, swine and turkeys) and eleven that are minor (fewer than one dozen livestock). Livestock owners were contacted within the watershed by letter, told of the ongoing water quality study, and asked to participate in the survey. This was followed up by a telephone call to see if the farmer did indeed wish to participate and if so, to set up arrangements for a meeting.

4.2 CURB MODEL

In order to quantify all potential pollution sources, a model approach has been used by various Conservation Authorities. The original CURB model has been adapted from the Pollution from Livestock Operation Predictor (PLOP). This model was produced in 1988 under contract to the Ontario Ministry of the Environment by the consulting firm Ecologistics Limited. The PLOP model is based on an American model for site specific pollution predictions. PLOP requires considerable detailed information which is not feasible to collect within the Ontario Rural Beaches Program. Further, PLOP addressed only barnyard pollution, solid manure stack runoff, stream access and milkhouse waste pollution. The Beaches studies examined all season manure spreading and rural septic system impacts.

It was easy to become entangled with the algorithms used by the PLOP Model. Simplification was crucial to the understanding and application of the model. The Maitland Valley Conservation Authority's version of the PLOP model was initially used in this beach study, but was further simplified until a model resembling the one used by the Upper Thames River Conservation Authority was obtained. Hayman et al (1992) are developing a BEAM model which is notably uncomplicated and understandable, as it is based on data which has been collected over the years by the Authorities participating in the Rural Beaches Program. It relies on a growing database of specific faecal coliform and phosphorus concentrations, rather than attempting to calculate individual fluid concentrations.

It is important to note that the models are used to calculate potential pollution for an entire watershed or sub-watershed. This involves the use of assumptions and therefore, the information obtained cannot be considered accurate for site specific evaluations. When averaged over the entire watershed however, you get a reasonably legitimate representation of the relative impact of each source of pollution at a downstream beach.

In the Sharon Creek watershed, the model was applied to calculate the impact of each type of pollution at Springer Lake (the Conservation Area). However, since each farm was surveyed, the impacts could be visually observed. For example, one could observe manure stacks with no containment, or see cattle that have access to a tributary or drain. Furthermore, the watershed was thoroughly water sampled, hence visual observations of pollution occurrences could be verified by the laboratory. This, perhaps unique situation will allow an evaluation of the modeling technique. Conceivably, the model can be refined to more accurately predict the relative impact of various pollution sources.

Following is a description of the algorithms used to determine potential pollution sources. The mathematical model is stated, accompanied by an explanation of the figures and assumptions used in the formulae. Subsequent to the models, the algorithms are applied to the information gained from the livestock operation assessment. The names of the landowners have been replaced by a number identifier, as all information collected was considered confidential.

CURB MODEL (ALGORITHMS)

Milkhouse Waste Algorithm

The milkhouse waste algorithm estimates the total annual faecal coliform delivered to the watercourse as a result of mismanaged milkhouse waste water.

$$\text{LOAD} = \text{Concentration} \times \text{Volume per cow per day} \times \text{Number of cows} \\ \times \text{Discharge days} \times \text{Percent delivery}$$

The following assumptions were made in order to calculate the milkhouse waste load:

- The concentration of faecal coliform in the waste water entering the milkhouse drain was assumed to be 2000 per litre.
- A volume of 13 litres of waste water per cow per day was assumed where survey information was not available (Fuller and Foran, 1989).
- The number of cows was taken from the Livestock Operation Assessment Questionnaire.
- 365 discharge days were assumed.
- The delivery of waste water to the tile system was assumed to be 50,000 percent (or 500 for calculation purposes). This figure accounts for growth of the bacteria in the tiles (UTRCA, 1989).

Livestock Access Algorithm

This algorithm estimates the total faecal coliform load from livestock having access to a stream.

$$\text{LOAD} = \text{Concentration per defecation} \times \text{EAU} \times \text{Probability of defecation} \\ \times \text{Number of days in pasture} \times \text{Number of access events per day} \\ \times \text{Number of animals}$$

The following assumptions were made in order to calculate the livestock access load:

- The concentration per defecation was assumed to be 8.9×10^8 Faecal Coliforms for a 454 Kilogram (1000 pound) steer.
- The Equivalent Animal Units (EAU) are listed in Appendix 1.
- The probability of an animal defecating in a stream was assumed to be 0.18 (Demal, 1982).
- It was assumed that the number of access events were 2.5 per day (Demal, 1982).

Feedlot / Barnyard Runoff Algorithm

The feedlot / barnyard runoff algorithm was used to calculate the total annual Faecal Coliform load delivered to streams from feedlot and barnyard areas within 150 metres of a watercourse. The volume of runoff was also calculated based on the yard size (Ha) and the annual depth of precipitation (mm).

LOAD = Concentration x Storage area (Ha) x Rainfall (Ha-mm) x Delivery to the watercourse

The following assumptions were made in order to calculate the feedlot / barnyard runoff load:

- A concentration of 5.0×10^9 faecal coliform per hectare per millimetre was assumed for the stack runoff (UTRCA, 1989).
- Storage area was determined from the questionnaire.
- A delivery of 70 percent was used if the feedlot / barnyard was within 150 metres of the watercourse and the runoff flowed toward the stream.
- The volume of runoff was calculated as follows:

Runoff Volume = Barnyard area x Annual precipitation x 0.60

- The total normal annual precipitation for the Sharon Creek area is 909 mm.
- The runoff from the yard area was assumed to be 60 percent of the annual precipitation (Coote and Hore, 1978).

Manure Stack Runoff Algorithm

This algorithm estimates the total annual faecal coliform load originating from solid manure stacks with no runoff containment that were within 150 metres of a watercourse,

$$\text{LOAD} = \text{Concentration} \times \text{Storage area (Ha)} \\ \times \text{Runoff volume} \\ \times \text{Delivery to watercourse}$$

The following assumptions were made in order to calculate the manure stack runoff load:

- A concentration of 5.0×10^9 faecal coliform per hectare per millimetre was assumed for feedlot runoff (UTRCA, 1989),
- Storage area was determined from the questionnaire.
- A delivery of 70 percent was used if the manure stack was within 150 metres of the watercourse and the runoff flowed toward the stream.
- The volume of runoff was calculated as follows:

$$\text{Runoff Volume} = \text{Manure storage area} \times \text{Annual precipitation} \times 0.60$$

- The total normal annual precipitation for the Sharon Creek area is 909 mm.
- The runoff from the yard area was assumed to be 60 percent of the annual precipitation (Coote and Hore, 1978),

Winter Manure Spreading Algorithm

This algorithm estimates the total annual faecal coliform load delivered to the watercourse from the manure spread during the winter season.

$$\text{LOAD} = \text{Number of bacteria winter spread} \times \text{Percent spread in winter} \\ \times \text{Delivery to the watercourse} \\ \times \text{Stack decay rate} \times \text{Field decay rate}$$

The following assumptions were made in order to calculate the winter manure spread load:

- The number of faecal coliform bacteria winter spread is calculated as follows:

$$\text{Number of Bacteria} = \text{Volume of manure per animal per day} \times \text{Concentration} \\ \times \text{Number of animals} \times \text{Number of days in a year} \times \\ \text{Percent of manure produced in winter}$$

WHERE:

- The volume of manure per animal per day in m³/day can be found in the Appendix 3.
- The concentrations of faecal coliform bacteria per defecation can be found in the Appendix 2, These figures have been adjusted to faecal coliforms per cubic metre.
- It was assumed if an operation spreads manure in the winter season that 25 percent of the annual manure produced was spread.
- It was assumed that 75 percent of the manure produced in the winter months was spread in the winter.
- It was assumed that 10 percent of the manure that was winter spread, within the critical distance of 150 metres alongside a stream, was delivered to the watercourse (Robinson and Draper, 1978).
- It was assumed that the stack decay rate was 0.01 (Hayman, 1993).
- It was assumed that the field decay rate was 0.034 (Hayman, 1993).

Spring, Summer and Fall Manure Spreading Algorithm

This algorithm estimates the total annual faecal coliform load delivered to the watercourse from the manure spread during the spring, summer and fall periods.

$$\text{LOAD} = \text{Number of bacteria spread in the spring, summer and fall} \\ \times \text{Delivery to the watercourse} \\ \times \text{Stack decay rate} \times \text{Field decay rate}$$

The following assumptions were made in order to calculate the spring, summer and fall manure spread load:

- The number of faecal coliform bacteria produced is calculated as follows:

$$\text{Number of Bacteria} = (\text{Volume of manure per animal per day} \times \\ \text{Concentration} \times \text{Number of animals} \times 365 \text{ days}) - \\ \text{Number of bacteria winter spread} - \text{Access load}$$

WHERE:

- The volume of manure per animal per day can be found in Appendix 3.
 - The concentrations of faecal coliform bacteria per cubic metre can be found in Appendix 2.
 - The number of bacteria spread in winter was previously calculated.
 - The number of bacteria delivered to watercourses from cattle access was previously calculated.
- It was assumed that 10 percent of the manure that was winter spread, within the critical distance of 150 metres alongside a stream, was delivered to the watercourse (Robinson and Draper, 1978).
 - It was assumed that the stack decay rate was 0.001 (Hayman, 1993).
 - It was assumed that the field decay rate was 0.034 (Hayman, 1993).

Septic System Failure Algorithm

The septic system algorithm estimates the total faecal coliform load to a watercourse as a consequence of faulty household septic systems.

LOAD =	Concentration x Number of homes x 365 days x Volume of water used per house x Percent failure rate x Delivery to the watercourse
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The following assumptions were made in order to calculate the private sewage system load:

- A concentration of 1.0×10^7 faecal coliform per litre of effluent at the tile outlet was assumed (MVCA, 1989),
- A volume of 450 litres per day was assumed (Hayman, 1993).
- The number of homes were counted from topographic and aerial photographs.
- The percentage of potential faulty septic systems with inadequate domestic waste disposal was estimated to be 30 percent,
- The delivery rate to the watercourse was assumed to be 50 percent.

4.3 MODELING RESULTS

MILKHOUSE WASTE ALGORITHM: Sharon Creek 1992 - 1993

$$LOAD = \text{Concentration} \times \text{Volume per cow per day} \times \text{Number of cows} \times \text{Discharge Days} \times \text{Percent delivery}$$

Concentration: 2000 per litre

Volume per cow per day: Survey or 13 litres per day

Number of cows: Survey

Discharge days: 365

Percent delivery: 50,000%

FARM	ANIMALS	No. Of Animals	Vol. Of Water Per Cow	Milkhouse Waste Load
1	Beef yearlings	100		
2	Dairy young	150		0
	Milking herd	110	6	2.41E+11
3	Beef feeders	50		
4	Turkeys	50000		
5	Dairy young	50		0
	Milking herd	50	8.2	1.50E+11
				0
6	Horses	7		
7	Dairy young	35		0
	Milking herd	68	8	1.99E+11
	Beef feeders	70		0
8	Beef feeders	50		
9	Horses	7		
10	Milking herd	50	13	2.37E+11
11	Beef feeders	500		
12	Beef cows	11		
13	Beef cows	9		
	Beef calves	8		
14	Beef feeders	13		
	Swine feeders	4		

Farm	Animals	No. Of Animals	Vol. Of Water Per Cow	Milkhouse Waste Load
15	Beef cows	40		
16	Beef cows	6		
	Beef calves	7		
	Beef yearlings	1		
17	Dairy young	50		0
	Milking herd	50	13.1	2.39E+11
18	Farrowing			
	Farrow - finish			
	Sows	800		
ANNUAL FAECAL COLIFORM LOADING			WATERSHED:	1.07E+12
			PER SITE:	2.13E+11

LIVESTOCK ACCESS ALGORITHM: Sharon Creek 1992 - 1993

LOAD = Concentration per defecation x EAU x Probability of defecation x Number of days in pasture x Number of access events per day x Number of animals

Concentration: 8.90E+8 Faecal Coliforms per defecation
EAU: Equivalent Animal Units: From Appendix 1
Probability of defecation: 0.18 (Demal, 1982)
Number of days in pasture: Survey or 180
No. of access events per day: 2.5 (Demal, 1982)
Number of animals: Survey

FARM	Animals	No. Of Animals	No. Of Days In Pasture	Eau	Livestock Access Load
1	Beef yearlings	100	240	0.71	
2	Dairy young	150		0.71	0
	Milking herd	110	184	1.62	1.31E+13
3	Beef feeders	50	180	0.71	
4	Turkeys	50000		0.03	
5	Dairy young	50		0.71	
	Milking herd	50	180	1.62	
6	Horses	7	360	0.013	1.31E+10
7	Dairy young	35		0.71	0
	Milking herd	68	180	1.62	7.94E+12
	Beef feeders	70	180	0.71	3.58E+12
8	Beef feeders	50	180	1.02	
9	Horses	7	365	0.013	1.33E+10
10	Milking herd	50	180		
11	Beef feeders	500	-	0.1	
12	Beef cows	11	180	1.02	
13	Beef cows	9	153	1.02	
	Beef calves	8	153	0.71	

FARM	ANIMALS	No. Of Animals	No. Of Days In Pasture	Eau	Livestock Access Load
14	Beef cows	40		0.71	
15	Beef feeders	13	100	0.71	3.70E+11
	Swine feeders	4	100		0
16	Beef cows	6	180	1.02	4.41E+11
	Beef calves	7	180	0.71	3.58E+11
	Beef yearlings	1	180	0.71	5.12E+10
17	Dairy young	50	180	0.71	
	Milking herd	50	180	1.62	
18	Farrowing	200			
	Farrow - finish	200			
	Sows	800			
	Horses	6	365	0.013	1.14E+10
ANNUAL FAECAL COLIFORM LOADING				WATERSHED:	2.59E+13
				PER SITE:	3.70E+12

FEEDLOT / BARNYARD RUNOFF ALGORITHM: Sharon Creek 1992 - 1993

LOAD = Concentration x Storage area (Ha) x Rainfall (Ha-mm Delivery to watercourse)

Concentration: 5.0E+9 Faecal Coliforms per hectare per millimetre

Storage area: From survey (in hectares)

Rainfall: 545 mm (60 Percent of 909 mm per annum)

Del to watercourse: 70 percent

FARM	Animals	No. Of Animals	Feedlot Area (Ha)	Feedlot Runoff Load
1	Beef yearlings	100	0.063345422	
2	Dairy young	150	0.8262441	1.74E+09
	Milking herd	110	0.8262441	
3	Beef feeders	50		
4	Turkeys	50000		
5	Dairy young	50	0.3672196	
	Milking herd	50	0.3672196	
6	Horses	7		
7	Dairy young	35	0.033416984	7.02E+07
	Milking herd	68	0.033416984	
	Beef feeders	70	0.033416984	
8	Beef feeders	50		
9	Horses	7		
10	Milking herd	50		
11	Beef feeders	500	0.63672196	7.71E+07
12	Beef cows	11	0.001101659	
13	Beef cows	9		
	Beef calves	8		
14	Beef feeders	13	0.016524882	3.47E+07
	Swine feeders	4	0.016524882	

FARM	Animals	No. Of Animals	Feedlot Area (ha)	Feedlot Runoff Load
15	Beef cows	40		
16	Beef cows	6		
	Beef calves	7		
	Beef yearlings	1		
17	Dairy young	50	0.032131715	6.75E+07
	Milking herd	50	0.032131715	
18	Farrowing	200		
	Farrow - finish	200		
	Sows	800		
	Horses	6		
ANNUAL FAECAL COLIFORM LOADING			WATERSHED:	1.98E+09
			PER SITE:	3.97E+08

MANURE STORAGE RUNOFF ALGORITHM: Sharon Creek 1992 - 1993

LOAD = Concentration x Storage area (Ha) x Rainfall (Ha-mm) x Delivery to watercourse

Concentration: 5.0E+9 Faecal Coliforms per hectare per millimetre

Storage area: From survey (in hectares)

Rainfall: 545 mm (909 mm per annum)

Del to watercourse: 70 percent

FARM	Animals	No. Of Animals	Manure Storage Area (Ha)	Manure Runoff Load
1	Beef yearlings	100	0.011016595	
2	Dairy young	150	0.037180985	7.81E+07
	Milking herd	110	0.037180985	
3	Beef feeders	50		
4	Turkeys	50000		
5	Dairy young	50	0.024787323	5.21E+07
	Milking herd	50	0.024787323	
6	Horses	7		
7	Dairy young	35	0.022033176	4.63E+07
	Milking herd	68	0.022033176	
	Beef feeders	70	0.022033176	
8	Beef feeders	50		
9	Horses	7	0.006885368	1.45E+07
10	Milking herd	50		
11	Beef feeders	500	0.1468874	3.08E+08
12	Beef cows	11		
13	Beef cows	9		
	Beef calves	8		
14	Beef feeders	13	0.003672196	7.71E+06
	Swine feeders	4	0.003672196	

FARM	Animals	No. Of Animals	Manure Storage Area (Ha)	Manure Runoff Load
15	Beef cows	40		
16	Beef cows	6		
	Beef calves	7		
	Beef yearlings	1		
17	Dairy young	50	0.068853675	1.45E+08
	Milking herd	50	0.068853675	
18	Farrowing	200		
	Farrow - finish	200		
	Sows	800		
	Horses	6		
ANNUAL FAECAL COLIFORM LOADING			WATERSHED:	6.52E+08
			PER SITE:	9.31E+07

WINTER SPREADING MANURE ALGORITHM: Sharon Creek 1992 - 1993

LOAD = Number of bacteria x Percent spread in winter x Delivery to watercourse x Stack and Field decay rate

Number of bacteria: Vol. of manure per animal per day x Concentration x No. of animals x No. of days in a year x Percent of manure produced in winter (25%).

Vol. of manure/day: Appendix 3 (cubic metres per day)

Concentration: Appendix 2 (Faecal coliforms per cubic metre)

Manure winter spread: 75 percent of manure produced in winter

Delivery to water: 10 percent (within the critical distance)

Stack decay rate: 0.01

Field decay rate: 0.034

FARM	ANIMALS	No. Of Animals	Vol of Manure Per Day	Conc'n Per Defecation	No. of Winter Bacteria	Winter Spread Load
1	Beef yearlings	100	0.0227	5.00E+11	1.04E+14	
2	Dairy young	150	0.0227	5.00E+11	1.55E+14	6.34E+08
	Milking herd	110	0.0581	5.00E+11	2.92E+14	1.19E+09
3	Beef feeders	50	0.034	5.00E+11	7.76E+13	3.16E+08
4	Turkeys	50000	0.0003	9.90E+13	1.36E+17	
5	Dairy young	50	0.0227	5.00E+11	5.18E+13	2.11E+08
	Milking herd	50	0.0616	5.00E+11	1.41E+14	5.73E+08
6	Horses	7	0.0566	8.70E+10	3.15E+12	
7	Dairy young	35	0.0227	5.00E+11	3.62E+13	1.48E+08
	Milking herd	68	0.0616	5.00E+11	1.91E+14	7.80E+08
	Beef feeders	70	0.034	5.00E+11	1.09E+14	4.43E+08
8	Beef feeders	50	0.034	5.00E+11	7.76E+13	3.16E+08
9	Horses	7	0.0566	8.70E+10	3.15E+12	
10	Milking herd	50	0.0616	5.00E+11	1.41E+14	5.73E+08
11	Beef feeders	500	0.034	5.00E+11	7.76E+14	3.16E+09
12	Beef cows	11	0.034	5.00E+11	1.71E+13	6.96E+07
13	Beef cows	9	0.034	5.00E+11	1.40E+13	5.70E+07
	Beef calves	8	0.017	5.00E+11	6.21E+12	2.53E+07

FARM	ANIMALS	No. Of Animals	Vol of Manure Per Day	Conc'n Per Defecation	No. of Winter Bacteria	Winter Spread Load
14	Beef feeders	13	0.34	5.00E+11	2.02E+14	8.23E+08
	Swine feeders	4	0.0071	1.00E+13	2.59E+13	1.06E+08
15	Beef caws	40	0.034	5.00E+11	6.21E+13	2.53E+08
16	Beef caws	6	0.034	5.00E+11	9.31E+12	3.80E+07
	Beef calves	7	0.017	5.00E+11	5.43E+12	2.22E+07
	Beef yearlings	1	0.0227	5.00E+11	1.04E+12	4.23E+06
17	Dairy young	50	0.0227	5.00E+11	5.18E+13	2.11E+08
	Milking herd	50	0.0616	5.00E+11	1.41E+14	5.73E+08
18	Farrowing	200	0.0023	1.00E+13	4.20E+14	1.71E+09
	Farrow - finish	200	0.0071	1.00E+13	1.30E+15	5.29E+09
	Sows	800	0.17	1.00E+13	1.24E+17	5.06E+11
	Horses	6	0.0566	8.70E+10	2.70E+12	1.10E+07
ANNUAL FAECAL COLIFORM LOADING				WATERSHED:	5.24E+11	
				PER SITE:	3.74E+10	

SPRING, SUMMER AND FALL MANURE SPREADING ALGORITHM:

Sharon Creek 1992 - 1993

LOAD = Number of bacteria x Delivery to watercourse x Stack decay rate x Field decay rate

Number of bacteria: (Vol. of manure per animal per day x Concentration x No. of animals x No. of days in year) - Winter spreading load - Access load

Vol. of manure/day: Appendix 3 (cubic metres per day)

Concentration: Appendix 2 (Faecal coliforms per cubic metre)

Delivery to water: 10 percent (within the critical distance)

Stack decay rate: 0.01

Field decay rate: 0.034

FARM	ANIMALS	No. of Animals	Vol of Manure Per Day	Conc'n Per Defecation	No. of Bacteria	Summer Spread Load
1	Beef yearlings	100	0.0227	5.00E+11	4.14E+14	
2	Dairy young	150	0.0227	5.00E+11	6.21E+14	3.38E+09
	Milking herd	110	0.0581	5.00E+11	1.15E+15	6.27E+09
3	Beef feeders	50	0.034	5.00E+11	3.10E+14	1.69E+09
4	Turkeys	50000	0.0003	9.90E+13	5.42E+17	
5	Dairy young	50	0.0227	5.00E+11	2.07E+14	1.13E+09
	Milking herd	50	0.0616	5.00E+11	5.62E+14	3.06E+09
6	Horses	7	0.0566	8.70E+10	1.26E+13	6.84E+07
7	Dairy young	35	0.0227	5.00E+11	1.45E+14	7.89E+08
	Milking herd	68	0.0616	5.00E+11	7.57E+14	4.12E+09
	Beef feeders	70	0.034	5.00E+11	4.31E+14	2.34E+09
8	Beef feeders	50	0.034	5.00E+11	3.10E+14	1.69E+09
9	Horses	7	0.0566	8.70E+10	1.26E+13	
10	Milking herd	50	0.0616	5.00E+11	5.62E+14	3.06E+09
11	Beef feeders	500	0.034	5.00E+11	3.10E+15	1.69E+10
12	Beef cows	11	0.034	5.00E+11	6.83E+13	3.71E+08

FARM	ANIMALS	No. Of Animals	Vol of Manure Per Day	Conc'n Per Defecation	No. Of Bacteria	Summer Spread Load
13	Beef cows	9	0.034	5.00E+11	5.58E+13	3.04E+08
	Beef calls	8	0.017	5.00E+11	2.48E+13	1.35E+08
14	Beef feeders	13	0.34	5.00E+11	8.06E+14	4.39E+09
	Swine feeders	4	0.0071	1.00E+13	1.04E+14	5.64E+08
15	Beef cows	40	0.034	5.00E+11	2.48E+14	1.35E+09
16	Beef cows	6	0.034	5.00E+11	3.68E+13	2.00E+08
	Beef calves	7	0.017	5.00E+11	2.14E+13	1.16E+08
	Beef yearlings	1	0.0227	5.00E+11	4.09E+12	2.23E+07
17	Dairy young	50	0.0227	5.00E+11	2.07E+14	1.13E+09
	Milking herd	50	0.0616	5.00E+11	5.62E+14	3.06E+09
18	Farrowing	200	0.0023	1.00E+13	1.68E+15	9.13E+09
	Farrow - finish	200	0.0071	1.00E+13	5.18E+15	2.82E+10
	Sows	800	0.17	1.00E+13	4.96E+17	2.70E+12
	Horses	6	0.0566	8.70E+10	1.08E+13	5.86E+07
ANNUAL FAECAL COLIFORM LOADING					WATERSHED:	2.79E+12
					PER SITE:	1.86E+11

SEPTIC SYSTEM FAILURE ALGORITHM: Sharon Creek 1992 -1993

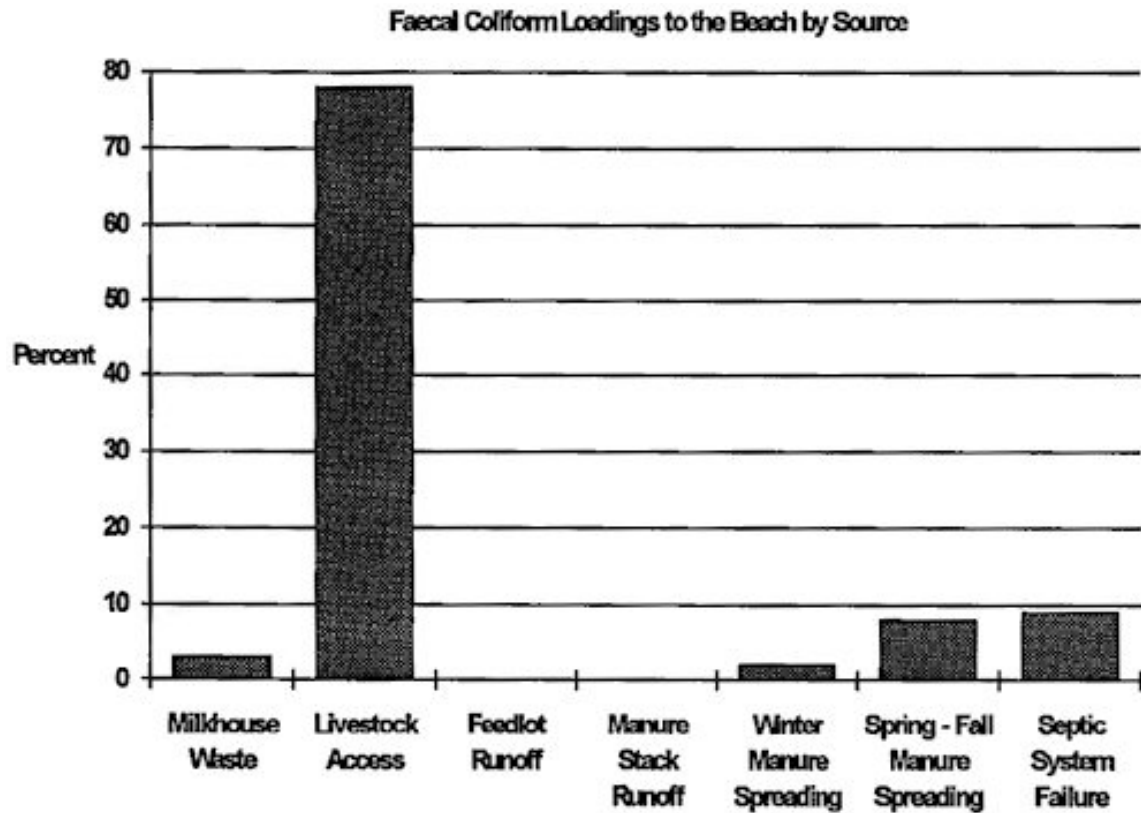
LOAD = Concentration x Number of homes x 365 days x Volume of water per house x Percent failure rate x Delivery to the watercourse.

Concentration: 1.0E+7 Faecal coliform per litre of effluent
Volume of water per household: 450 Litres per day
Percent failure rate: 30 Percent
Percent delivery: 50 Percent

CONCESSION	Number Of Homes	Septic System Load
D	6	1.48E+12
I	10	2.46E+12
II	11	2,71E+12
III	39	9.61E+12
IV	38	9.36E+12
GORE	38	9.36E+12
1W	27	6.65E+12
IE	12	2.96E+12
ANNUAL FAECAL COLIFORM LOADING	WATERSHED:	2.96E+12
	PER SITE:	1.63E+10

TABLE 4.1: Annual Faecal Coliform Loadings In The Sharon Creek Watershed

SOURCE	Total Faecal Coliforms	Percent Of Watershed
Milkhouse Waste	1.07E+12	3%
Livestock Access	2.59E+13	78%
Feedlot/Barnyard Runoff	1.98E+09	0%
Manure Stack Runoff	6.52E+08	0%
Winter Manure Spreading	5.24E+11	2%
Spring, Summer and Fall Spreading	2.79E+12	8%
Septic System Failure	2.96E+12	9%
TOTAL:	3.32E +13	100.00%



5.0 RESULTS / OBSERVATIONS

5.1 WATER QUALITY MONITORING

Sharon Creek

The Sharon Creek, as well as the drains and tributaries, were sampled on a weekly basis from June 1992 until the end of September 1992. Observations were made of the stream with respect to:

- visual water quality (colour, clarity),
- presence of odours indicating manure or gray water,
- appearance of fish and amphibian populations in and about the streams,
- growth of aquatic vegetation indicating nutrient loading,
- erosion concerns, such as unstable banks, and
- flow observations, whether low or high.

Generally speaking, although the swimming beach at the Conservation Area has never experienced a closure, and the water quality is on average relatively good, the upstream tributaries and drains do suffer from degraded water quality. Much of this degradation, to both water quality and the physical condition of the stream and banks, can be seen as the result of specific adjacent land use activities. Land use practices that affect water quality include the cropping of the land, barnyard runoff, rural septic systems and livestock operations which allow watercourse access for watering purposes.

On a positive note, several of the tributaries contained small fish populations. Nonetheless, there were considerable areas of algae growth, caused by increased levels of nitrogen and phosphorus in the water. Vegetation types consisted of algae, pondweed and duckweed. Concentrated in-stream vegetation was found along the municipal drainage ditches. Watercourses flowing alongside the Highway 402 contained litter deposited from passing traffic.

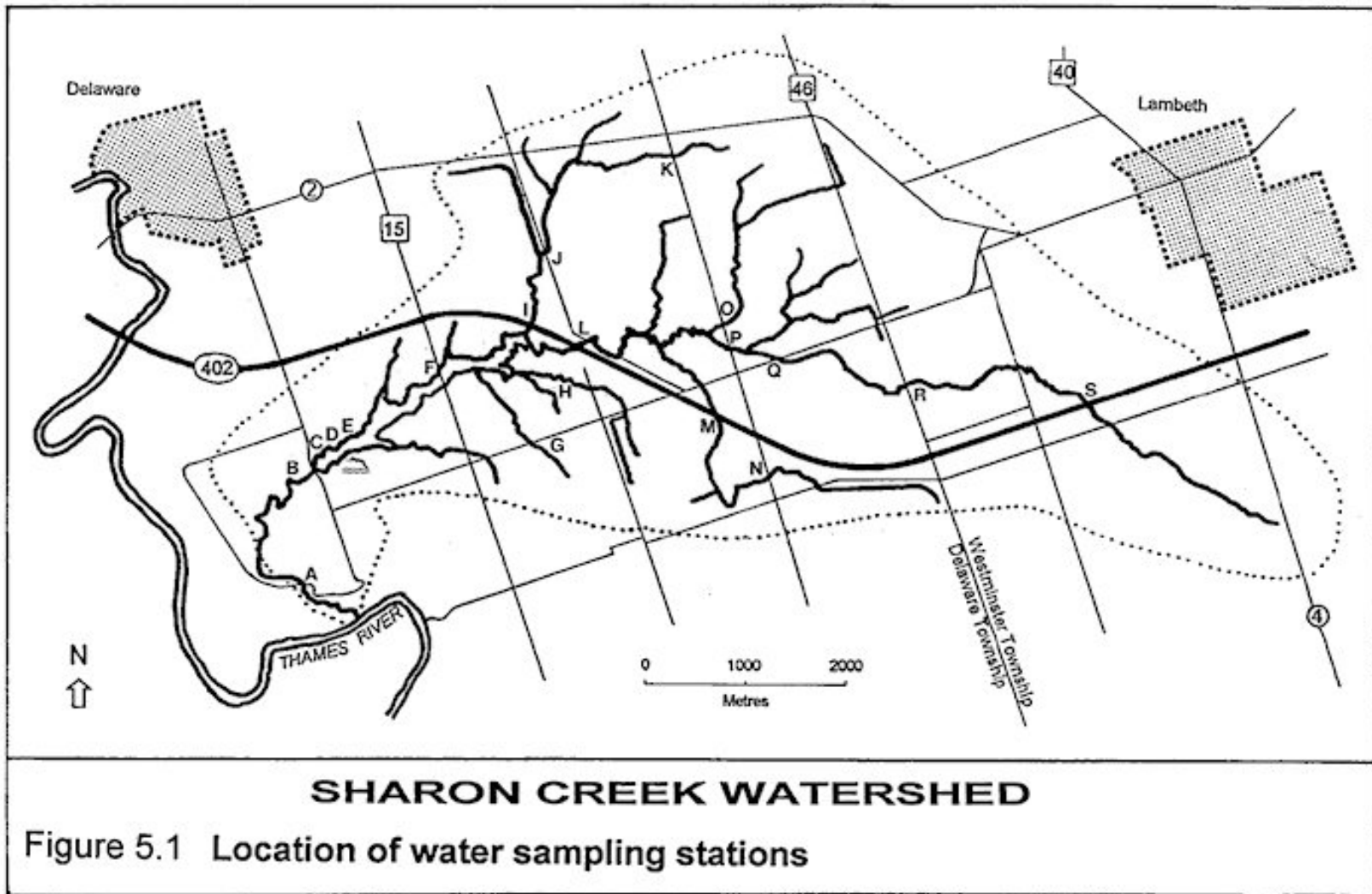
Appendix 5 contains the results from the bacterial indicators and chemical parameters that were analyzed from the various sampling stations. The following map (Figure 5.1) illustrates the location of the sampling stations. The data in the appendix has been classified into low (base) and high flow events, in order to observe the effect of stream flow on the magnitude of bacteria and chemical nutrient concentrations.

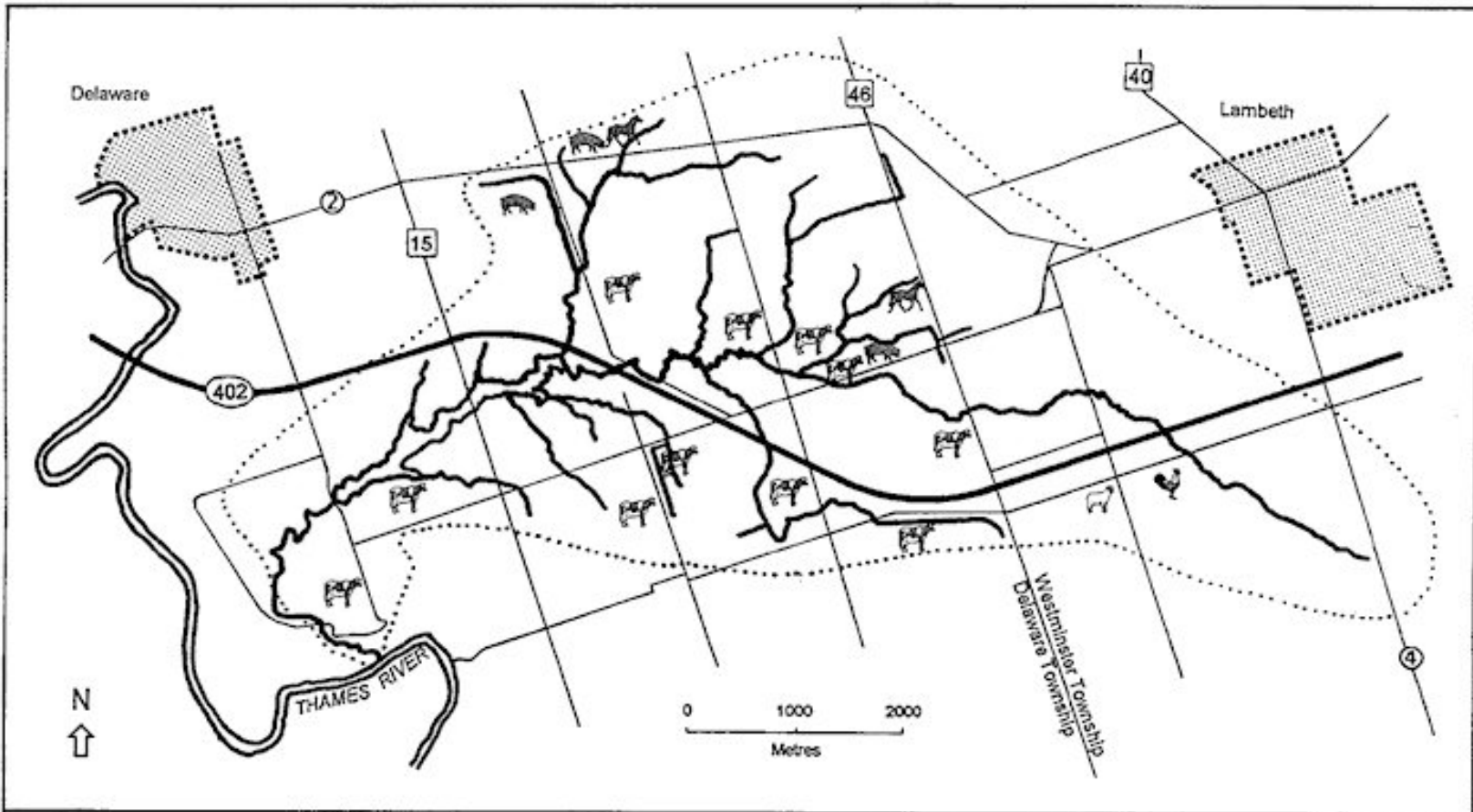
Figure 5.2 depicts the location of the principal livestock operations within the Sharon Creek watershed. Table 5.1 summarizes the bacterial indicator data in terms of high and low (base) flows. The flow of the streams were observed during the water sampling procedures. In addition, these estimates were confirmed with precipitation data from the London Weather office. Table 5.2 is a monthly precipitation summary for the months that water sampling occurred. The actual days of sampling are highlighted.

Figures 5.3 and 5.4 graphically illustrate the concentrations of faecal and *Escherichia coliform* bacteria during low and high flows. The concentrations have been segregated into ranges:

- High: greater than 1000 bacteria per 100 millilitre sample,
- Mid: 100 to 1000 bacteria per 100 millilitre sample, and
- Low: less than 100 bacteria per 100 millilitre sample.

These figures (5.3 and 5.4) assist in visually identifying priority areas along the watercourses. When these figures are compared with Figure 5.2, the location of the farming operations, one is able to determine which farms may be contributing bacterial contamination.

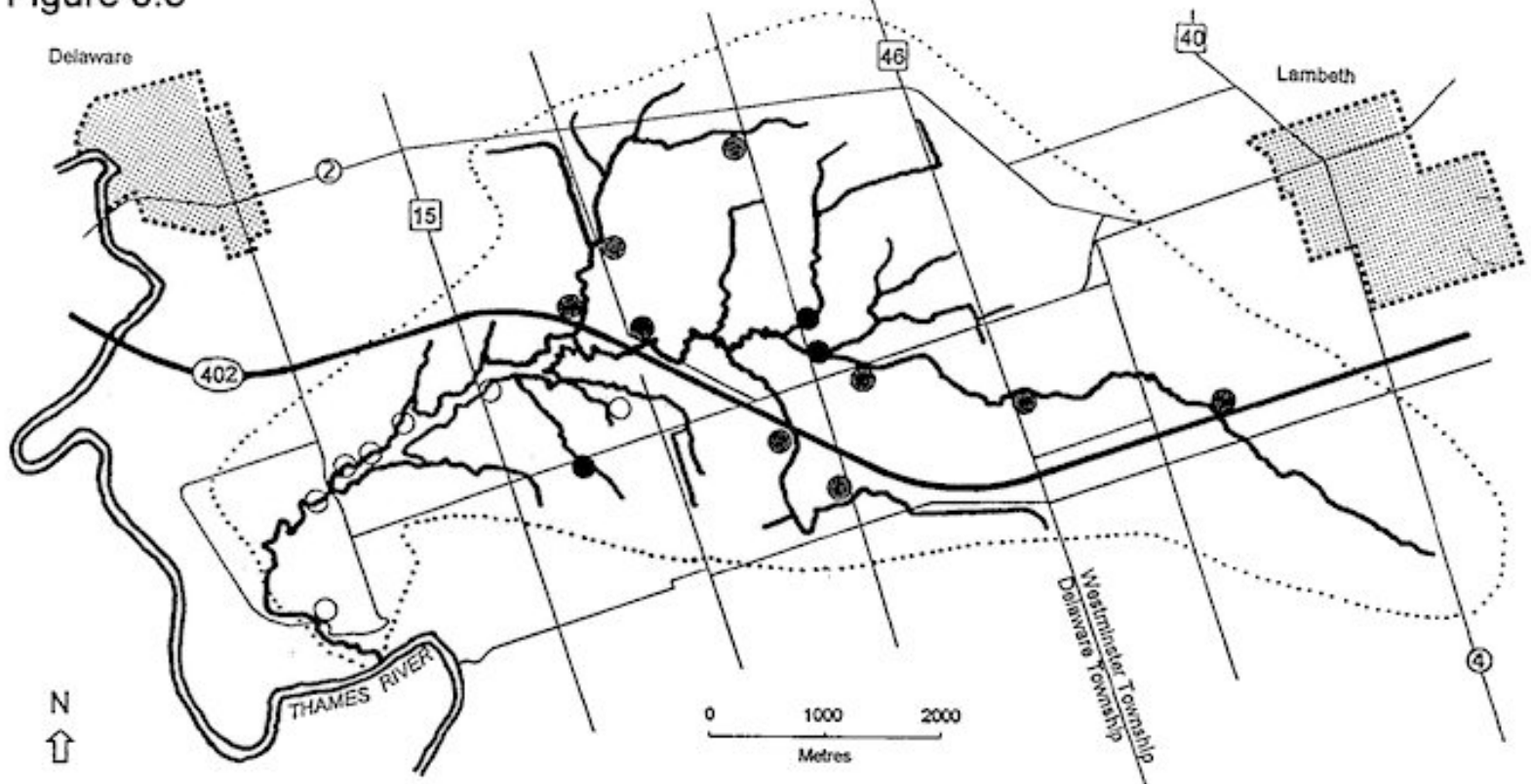




SHARON CREEK WATERSHED

Figure 5.2 Location of Significant Livestock Operations

Figure 5.3

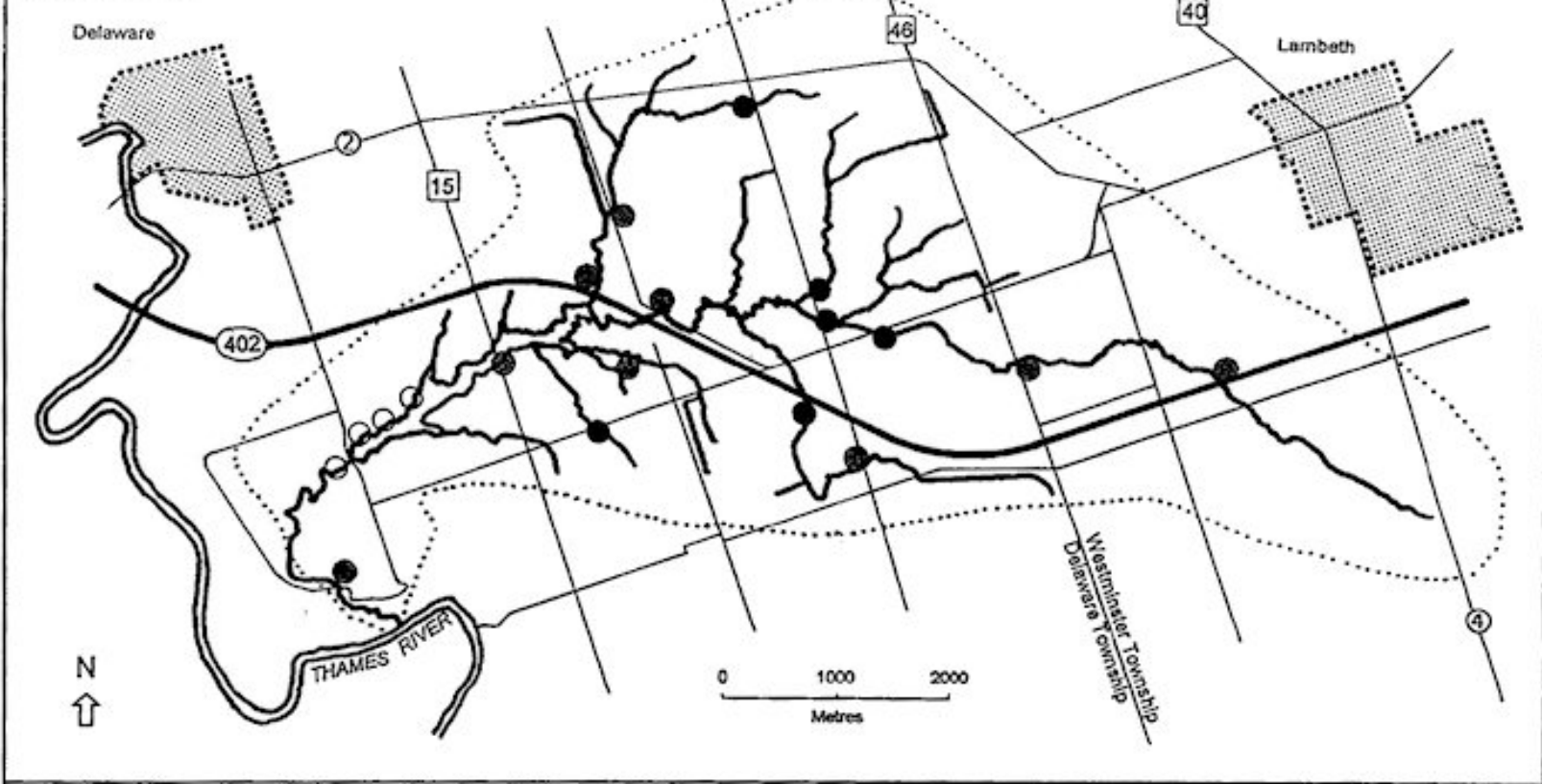


SHARON CREEK WATERSHED
Concentrations of Faecal and *Escherichia* Coliform
During Low (Base) Flow: June to September 1992

Concentrations of bacteria per 100 ml

- High (> 1000)
- Mid (100 - 1000)
- Low (< 100)

Figure 5.4



SHARON CREEK WATERSHED
Concentrations of Faecal and *Escherichia Coliform*
During High Flow Events: June to September 1992

Concentrations of bacteria per 100 ml

- High (> 1000)
- Mid (100 - 1000)
- Low (< 100)

Table 5.1: Bacterial Indicator Summary (Low And High Flow)

Site	Flow	No. of Samples Taken	Faecal Coliform		<i>Escherichia Coliform</i>		Faecal Streptococci		<i>Pseudomonas Aeruginosa</i>	
			No. over Guideline	Geometric Mean	No. over Guideline	Geometric Mean	No. over* Guideline	Geometric Mean	No. over Guideline	Geometric Mean
A	Low	9	3	106	2	89	-	164	1	5
	High	7	4	145	4	119	-	268	2	7
B	Low	4	1	18	1	37	-	59	0	4
	High	4	1	57	1	46	-	56	0	4
C	Low	7	0	6	0	6	-	9	0	4
	High	4	1	28	1	28	-	11	0	4
D	Low	6	0	9	0	11	-	10	0	4
	High	7	4	68	3	52	-	43	1	7
E	Low	7	0	10	0	7	-	8	0	4
	High	4	1	29	1	29	-	65	1	5
F	Low	6	4	76	4	70	-	30	4	5
	High	7	6	698	6	511	-	511	5	17
G	Low	6	6	1126	6	915	-	407	5	42
	High	7	7	2288	7	1420	-	1996	7	185
H	Low	6	2	38	2	34	-	88	1	4
	High	4	3	241	3	241	-	691	3	9
I	Low	9	9	354	9	268	-	380	3	4
	High	7	7	862	7	773	-	1220	5	10
J	Low	4	4	664	4	345	-	417	1	4
	High	4	4	735	4	735	-	2443	4	20

Site	Flow	No. of Samples Taken	Faecal Coliform		<i>Escherichia Coliform</i>		Faecal Streptococci		<i>Pseudomonas Aeruginosa</i>	
			No. over Guideline	Geometric Mean	No. over Guideline	Geometric Mean	No. over * Guideline	Geometric Mean	No. over Guideline	Geometric Mean
K	Low	4	3	222	3	163	-	219	1	4
	High	4	4	2507	4	2398	-	527	1	7
L	Low	9	9	460	9	397	-	281	3	6
	High	7	7	1049	7	820	-	801	6	16
M	Low	9	8	214	9	220	-	267	3	5
	High	7	6	1131	6	1028	-	4443	2	9
N	Low	4	4	899	4	200	-	484	1	9
	High	4	4	573	4	437	-	1364	1	5
O	Low	9	8	5306	8	4450	-	1868	2	5
	High	7	7	1932	7	1515	-	2672	5	17
P	Low	9	9	1043	9	636	-	354	1	4
	High	7	7	2236	7	2152	-	2147	3	14
Q	Low	4	4	842	4	420	-	943	1	4
	High	4	4	2280	4	2059	-	1573	2	5
R	Low	6	6	395	6	420	-	128	2	5
	High	7	7	1054	7	842	-	1077	5	9
S	Low	7	7	619	7	520	-	358	0	4
	High	4	4	406	4	400	-	361	1	5

* There is currently no Ministry of the Environment recreational guideline for faecal streptococcus.

**TABLE 5.2 Monthly Precipitation Summary
London Weather Office
Environment Canada**

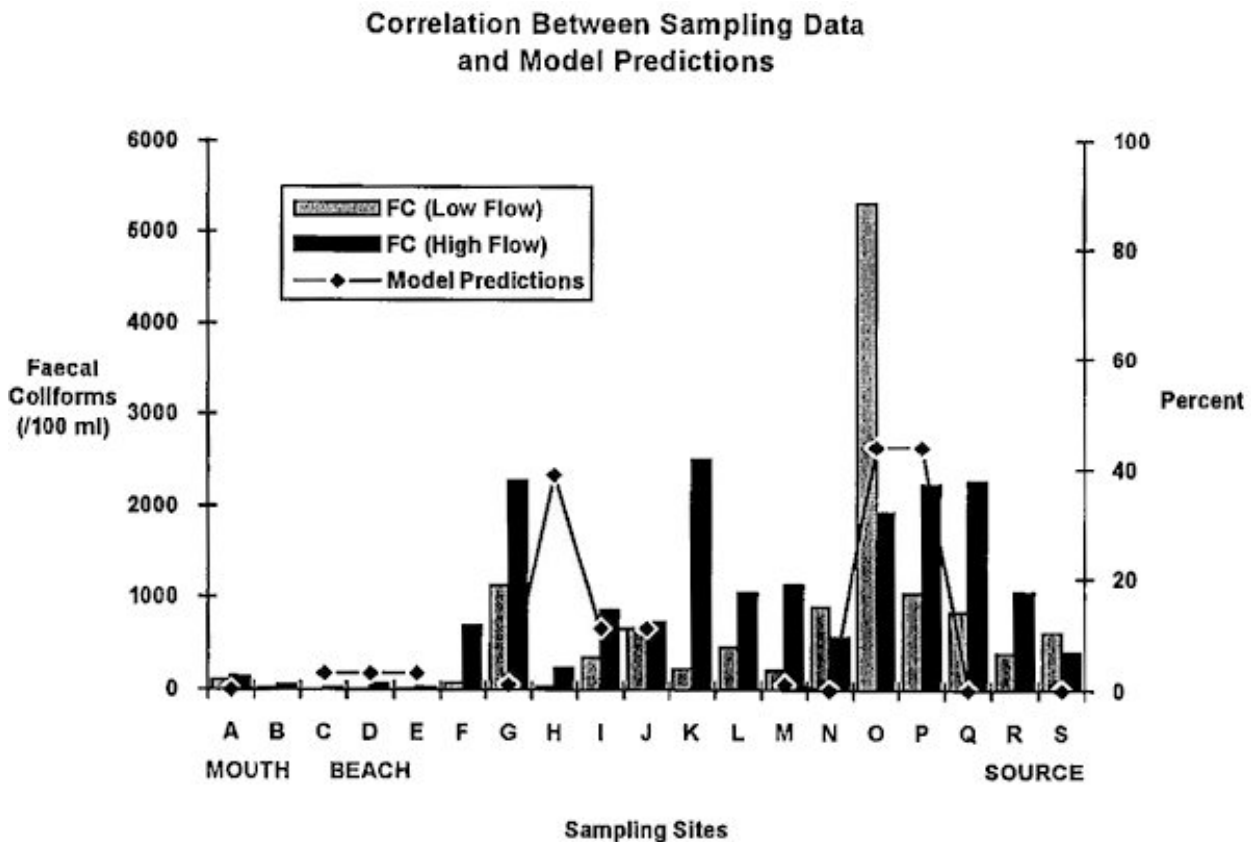
Date	PRECIPITATION			
	June mm	July mm	August mm	September mm
1		1		
2		1.2	2.8	9.8
3				13.8
4	5.2	1.0	0.6	
5	3.4	2.2		0.6
6				17.9
7	12.0		1.0	3.0
8		49.4	11.4	3.8
9				25.3
10		6.6		7.4
11				
12		10.6	1.6	
13		7.0	7.2	
14		15.8		
15		1.0	0.4	
16		2.0	17.6	0.6
17	17.8	44.2		0.4
18	8.4	2.2	10.0	31.8
19	1.4			
20	0.4			
21	0.2			15.8
22		9.4		16.2
23	1.0	7.6		
24	1.0		2.8	
25	0.6			
26	14.4	14.8	1.2	1.8
27			23.6	0.8
28			58.0	0.2
29		1.2		
30		6.6		1.0
31		21.8	0.2	
TOTAL	65.8	204.6	138.4	150.2
NORMAL	73.6	72.4	80.3	78.6



Indicates a water sampling day.

The graph illustrated below outlines the relationship between the data obtained from the water sampling stations and the predictions of faecal coliform pollution from the CURB model. The water sampling data has been segregated into high and low (base) flow. The model results from each aspect of the model (milkhouse waste, livestock access, etc.) were totalled for each farm assessed, and the corresponding value is expressed as a percentage of the total faecal coliform loading for all the farms surveyed, As each farm would impact one or more specific water sampling sites, the model information was plotted on the graph at the site(s) which that particular farm would affect.

This exercise attempts to establish whether a correlation exists between the water sampling data and the accuracy and integrity of the modelling process. As can be seen in the graph, there is a correlation, especially notable where there are peaks in faecal coliform loading. Where gaps exist in the model line or where the model does not conform to the sampling information, is likely due to incomplete modelling or the presence of faulty private sewage systems, which was modelled on a watershed basis, rather than individual farms, and therefore not included in this application.



Clear Creek and Sixteen Mile Creek

As previously stated, these creeks were sampled throughout the summer in three locations each. The objective was to determine if any bacterial or chemical contamination was present in the waters. These two areas have very few livestock operations, so the question of the existence of any pollution had to be addressed. The complete results from the sampling program can be found in Appendix 5.

No additional investigation was done here other than the water sampling. However, as the data demonstrates, bacterial contamination is indeed a problem. It is anticipated that these watersheds will undergo a further more comprehensive examination during the upcoming season (1993 - 1994).

5.2 LIVESTOCK OPERATION ASSESSMENT

As a component of the Rural Beaches Study, a livestock operation assessment was conducted. This consisted of a questionnaire which attempted gather information about: crops and land drainage, size of livestock operation, manure management, livestock watering, and the household sewage system.

Following are a summary of the findings of the survey:

- main livestock operations in the Sharon Creek watershed include cattle, dairy, horses, and turkeys
- this watershed contains one of the largest swine operations in Middlesex County
- the average dairy operation maintains about 60 cows
- the average beef operation maintains herds of 35 cattle
- most of the farms with solid manure storage have no runoff containment
- 70 percent of the farms which pasture livestock allow access to a watercourse
- all of the houses have a septic tank and tile bed arrangement (Class 4) except one which has a lagoon/cesspool (Class 3) system
- 90 percent of those surveyed pump their septic tanks on average every 2.5 years
- none of the respondents have ever had problems with animals being sick after drinking out the stream
- 80 percent have not updated or changed any of their farm/farming practices within the past five years
- approximately half of those surveyed are interested in or are considering changing or improving either manure storage, milkhouse wastewater disposal, livestock watering methods or the household septic system
- slightly more than half of the respondents were aware of the CURB Program, most heard about it through word of mouth
- most of the landowners expect nothing from the program, although a few are interested in making use of the grants to update and improve their farm and farming practices

6.0 CONCLUSIONS / RECOMMENDATIONS

The outcome of the qualitative and quantitative assessment of the Sharon Creek watershed is the assessment that bacterial and chemical contamination is indeed present. The concentrated pollution appears to be confined to the upstream tributaries and drains, however, the swimming beach at Springer Lake (the Conservation Area) does exhibit minor bacterial pollution. This ultimately flows into the Thames River, which already displays significant pollution problems upstream of the mouth of Sharon Creek.

Evidence of stream contamination comes from the assessment of the various information gathered during the study. Visual observations have indicated livestock access and farms with no manure runoff containment. Water sampling information has revealed areas where septic systems are failing, over spreading is occurring and livestock access is permitted. The landowner survey has supplied knowledge of faulty septic system hookups and improper milkhouse waste disposal.

Erosion is another difficulty that must be addressed in this program. In some areas with steep banks, erosion is prevalent. It is caused by natural means, row-cropping up to the edge of the bank and by livestock access to the water. This situation leads to sedimentation of the stream, increasing the turbidity, making the stream less aesthetically pleasing and possibly leading to the death of aquatic vegetation, fish and amphibians.

Clear Creek in Orford Township, Kent County and Sixteen Mile Creek in Aldborough Township, Elgin County exhibited significant bacterial contamination. These two watersheds warrant a further, more concentrated examination. These investigations are planned for the 1993 summer season, pending approval by the Ministry of the Environment.

At this juncture, a further intensive investigation of the quantitative inputs of pollutants is required. Once that data is acquired, relationships between land use and particular pollutants can be determined. Following this, cost-effective remedial action can be designed and implemented.

RECOMMENDATIONS

The following recommendations are proposed for the 1993 - 1994 season:

- Continue to monitor the water quality at the Sharon Creek watershed through weekly water sampling. The water sampling period from April to September 1992 proved to be extraordinarily wet with 700.8 mm of precipitation compared to the normal 453.0 mm. It will be worthwhile to contrast results from a particularly wet season to one where the seasonal precipitation is considered normal.
- Continue the watershed water quality monitoring of the Clear Creek and Sixteen Mile Creek in order to identify the sources of bacterial and nutrient contamination. The local landowners will be contacted to complete a questionnaire.
- Complete a full study of the Rondeau Bay area including water quality monitoring, contact with the local landowners, and mathematical modeling of the data gathered to determine sources of pollution. There is considerable interest in the Rondeau Harbour region by many private and public agencies.
- Obtain streamflow data from Sharon Creek, Clear Creek, Sixteen Mile Creek and the creeks and drains flowing into Rondeau Harbour in order to measure travel times of bacteria to determine the loading to the swimming beaches.
- Complete the development of a Clean Up Rural Beaches Plan for the Sharon Creek, Sixteen Mile Creek, Clear Creek and the Rondeau Bay area which will define the sources of bacteria and nutrient pollution and their impacts, identify a remedial action plan to reduce these sources and a cost-benefit evaluation of the remedial measures.
- Upon completion of the C.U.R.B. Plan, provide information and assistance to landowners on the implementation of improved animal and private septic waste management practice.
- Heavy soils exist in these areas which provide special opportunities for site demonstrations of innovative septic system and manure runoff storage designs.

7.0 REFERENCES

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8.0 APPENDICES

APPENDIX 1: Equivalent Animal Units (EAU)

ANIMAL TYPE	WEIGHT (Kg)	EAU P	EAU FC
Beef Cow	455	1.04	1.02
Slaughter Steer	455	1.00	1.00
Yearling Beef (Feeder)	365	0.78	0.71
Beef Calf	180	0.53	0.48
Dairy Cow		1.50	1.62
Young Dairy / Heifer	318	0.75	0.71
Dairy Calf	136	0.46	0.36
Sow / Boar		0.60	
Feeder Pig	22-90	0.40	
Sheep	45	0.17	0.02
Turkey	4.5	0.03	0.03
Chicken / Duck	1.8	0.02	
Horse	455	1.20	0.013

(Ecologistics, 1988)

P = Phosphorus

FC = Faecal Coliform

APPENDIX 2: Average Faecal Coliform Densities In Animal Faeces

ANIMAL TYPE	FAECAL COLIFORMS (Per Gram)	FAECAL COLIFORMS (Per m ³)
Cattle	5.0 x 10 ⁵	5.0 x 10 ¹¹
Swine	1.0 x 10 ⁷	1.0 x 10 ¹³
Chickens	9.9 x 10 ⁷	9.9 x 10 ¹³
Sheep	1.6 x 10 ⁷	1.6 x 10 ¹³
Horses	8.7 x 10 ⁴	8.7 x 10 ¹⁰

Provided by M. Young, Ministry of the Environment, Toronto.

APPENDIX 3: Manure Production Per Day By Animal Type

ANIMAL TYPE	FAECAL COLIFORMS (m ³ per day)
Beef or Dairy	
6 - 15 months	0.0170
15 - 24 months	0.0227
Beef cows (550 Kilograms)	0.0340
Dairy cows - free stall	0.0581
- tie stall	0.0616
Swine	
Weaners	0.0023
Feeders	0.0071
Sows and litter	0.1700
Chicken - broilers	0.0001
Turkeys - broilers	0.0003
- breeders and toms	0.0007
Sheep	0.0042
Horses	0.0566

APPENDIX 4

LIVESTOCK OPERATION ASSESSMENT QUESTIONNAIRE

Lower Thames Valley Conservation Authority

INFORMATION

Name: _____ Date: _____

Address: _____ Phone: _____

Township: _____ Lot(s): _____ Conc(s): _____

CROPS AND LAND DRAINAGE

<u>CROPS</u>	<u># of ACRES</u>	<u>ACRES TILED</u>	<u>RANDOM%</u>	<u>SYSTEMATIC (%)</u>
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

Total Farm Acres: _____

SIZE OF LIVESTOCK OPERATION

<u>LIVESTOCK</u>		<u>ANNUAL TOTAL</u>		
Dairy:	_____	young	_____	milking herd
Beef:	_____	cow	_____	calf _____ feeder
Swine:	_____	farrowing	_____	feeder _____ farrow to finish
Chicken:	_____	broiler	_____	laying _____ breeder
Turkey:	_____			
Horses:	_____			
Sheep:	_____		Other:	_____

MANURE AND MANURE MANAGEMENT

SOLID MANURE

Manure storage: _____ Inside _____ Outside

Type of Pad: _____ Concrete _____ Earthen _____ Covered

Pad dimensions: _____ Walls: _____ Yes _____ No

Type of runoff containment: _____ Pond _____ Tank

Dimensions: _____ Capacity: _____

Distance to Watercourse: _____

LIQUID MANURE

Type of tank: _____ Inground _____ Above-ground _____ Covered

Dimensions of tank: _____ Capacity: _____

Earthen pit/Lagoon Dimensions: _____ Capacity: _____

Distance watercourse: _____

MANURE APPLICATION

Type of spreader: _____ Liquid tanker _____ Injection
 _____ Irrigation _____ Box _____ Other

Type of soil: _____ Sand _____ Clay _____ Loam

Do you test the soil: ___ No ___ Yes How Often: _____

Do you test the manure: ___ No ___ Yes How Often: _____

Spreading Method	What Season	Application Rate	Acres Receiving Application	Incorporating Time
Solid:	_____	_____	_____	_____
Liquid:	_____	_____	_____	_____
Injection:	_____	_____	_____	_____
Irrigation:	_____	_____	_____	_____

LIVESTOCK WATERING

Animals in Pasture

<u>Waterway Access</u>	<u>Dairy</u>	Beef	<u>Pigs</u>	<u>Sheep</u>	<u>Horses</u>	Other
No. of Animals:	_____	_____	_____	_____	_____	_____
Unlimited:	_____	_____	_____	_____	_____	_____
Limited:	_____	_____	_____	_____	_____	_____
Restricted:	_____	_____	_____	_____	_____	_____
Days Per Year:	_____	_____	_____	_____	_____	_____
Time Per Day:	_____	_____	_____	_____	_____	_____
Access Length:	_____	_____	_____	_____	_____	_____

Describe the limited access (i.e. ramps, bridges, pumps, etc)

FEEDLOT / CEMENT YARD

Dimensions/Size: _____

Roofed portion dimensions: _____ Paved portion: _____

Eavestroughing: _____ Yes _____ No

Retaining walls: _____ Yes _____ No

Type of runoff containment: _____ Pond _____ Tank

Dimensions: _____ Capacity: _____

The distance to watercourse, catchbasin, nearest tile: _____

No. of Livestock in feedlot: _____ Dairy _____ Beef _____ Swine

_____ Poultry _____ Horses _____ Sheep

Other _____

Number of months used: _____ Hours per day: _____

Cleaning Frequency: _____ (Per Year)

DAIRY

Type of system used: _____ Pipeline _____ Parlour _____ Other

Method of waste containment: _____ Septic tank _____ Holding tank

_____ Tile drain _____ Lagoon

_____ Trench _____ Other

Volume of washwater/milking: _____(Gals/day)

GENERAL QUESTIONS

Have there been problems with animals being sick after drinking out of drain/stream?

Yes ____ No ____

Have you ever had any problems with your manure storage, milkhouse washwater disposal, septic system or livestock watering method(s)? Yes ____ No ____

Describe: _____

Would you be interested in or are you considering changing/improving any of the above systems? Yes ____ No ____

Describe: _____

Have you updated or changed any of your farm/farming practices within the past 5 years?

Yes ____ No ____

Describe: _____

Were you aware of the CURB Program? Yes ____ No ____

How did you find out about CURB? _____

What are your expectations? _____

HOUSEHOLD SEWAGE SYSTEM

Date: _____ Owner: _____

Address: _____

Lot: _____ Concession: _____ Township: _____

Person Interviewed: _____ Relationship to Owner: _____

Previous Owner: _____ Original Owner: _____

Household: Age of House: _____ How Long Living There: _____

No. of People: _____ Number of Bedrooms: _____

Type of Sewage Disposal System: _____ Septic Tank and Tile Bed
_____ Holding Tank
_____ Other

Type of Water Supply: _____ Municipal
_____ Drilled Well
_____ Dug Well Depth: _____

Description of System:

Size of Tank: _____ Concrete _____ Steel _____ Plastic

Size/Length of Tile Field: _____ Soil Type: _____

Age of the System: _____ Installer: _____

System Inspected by the Health Unit: _____ Yes _____ No _____ Unknown

Distance to Field Tiles or Water Courses: _____

Any System Failures: _____

Tank Pumped Out: _____ Yes _____ No How Often: _____

Waste Entering System: _____ Toilets _____ Dishwasher _____ Sinks
_____ Laundry _____ Shower/Bathtub _____ Jacuzzi

Sump Pump Drains To: _____

Other Washroom Facilities (i.e. in barn): _____

Grants:

If a substantial grant were available, would you upgrade the present system if it were undersized or faulty? _____ Yes _____ No

What would you consider to be a fair government grant for septic system upgrading?

_____ 0% cost is the responsibility of the owner
_____ 25% of cost _____ 50% of cost _____ 75% of cost

Site A: Mouth of Sharon Creek (at Thames River), Delaware Township

Low Flow

DATE	Temp. °C	F. Coli /100ml	E. Coli /100ml	F. Strep /100 ml	Pseudo. /100 ml	Free Ammonia	TKN	NO ₂	NO ₃	Tot. P	Diss. P	pH	Cl ⁻	Cond.	Susp. (mg/L)
Jun 16/92	13	180	100	130	<4	0.203	1.05	0.14	4.9	0.038	0.008	7.91	44.9	605	8.3
Jun 23/92	12	130	70	250	<4	0.248	1.03	0.09	5.6	0.043	0.002	7.92	43.8	604	9.5
Jun 30/92	15	36	36	216	<4	0.137	1.02	0.24	4.2	0.052	0.020	7.84	45.1	612	14.2
Jul 07/92	13	90	90	130	<4	0.304	1.07	0.17	3.7	0.077	0.018	7.84	44.5	603	16.8
Aug 04/92	18	90	90	120	<4	0.161	0.98	0.46	5.9	0.054	0.007	7.81	43.8	565	18.3
Aug 11/92	18	70	70	240	<4	0.139	1.01	0.26	5.4	0.068 exhausted		7.93	42.6	578	24.1
Aug 25/92	18	740	490	460	<4	0.214	0.97	0.52	4.9	0.061	0.041	7.78	43.7	600	13.2
Sep 15/92	18	80	80	100	12	0.151	1.11	0.15	3.6	0.245	0.174	7.79	23.6	517	23.9
Sep 29/92	15	60	60	70	<4	0.090	1.05	0.11	3.0	0.230	0.139	8.00	23.2	467	23.8
MIN:	12	36	36	70	4	0.090	0.97	0.09	3.0	0.036	0.002	7.76	23.2	467	8.3
MAX:	18	740	490	460	12	0.304	1.11	0.52	5.9	0.245	0.174	8.00	45.1	612	24.1
MEAN:	15	106	89	164	5	0.173	1.03	0.20	4.5	0.076	0.021	7.87	38.3	570	15.8
High Flow															
Jul 14/92	16	210	210	630	<4	0.084	1.05	0.01	4.6	0.075	0.057	7.85	43.2	601	32.3
Jul 21/92	18	50	50	220	<4	0.006	1.15	0.19	5.2	0.059	0.007	7.99	47.2	550	23.0
Jul 28/92	20	70	40	80	<4	0.133	1.04	0.32	6.2	0.053	0.008	7.93	42.2	541	17.1
Aug 18/92	20	60	60	150	<4	0.066	1.10	0.19	6.7	0.056	0.007	insuff.	41.9	insuff.	22.2
Sep 01/92	17	210	210	380	<4	0.600	1.90	0.15	3.9	0.155	0.052	7.81	37.9	554	39.3
Sep 08/92	21	450	230	330	48	0.220	1.23	0.18	4.2	0.131	0.050	7.88	34.6	525	30.9
Sep 22/92	19	330	280	480	20	0.011	1.28	0.12	2.6	0.250	0.147	7.88	22.1	437	46.4
MIN:	16	50	40	80	4	0.006	1.04	0.01	2.6	0.053	0.007	7.81	22.1	437	17.1
MAX:	21	450	280	630	48	0.600	1.90	0.32	6.7	0.250	0.147	7.99	47.2	601	46.4
MEAN:	19	145	119	268	7	0.068	1.22	0.12	4.6	0.094	0.026	7.89	37.5	532	28.7

Site B: Springer Lake Dam Outlet, Delaware Township

Low Flow

DATE	Temp. °C	F. Coli /100ml	E. Coli /100ml	F. Strep /100 ml	Pseudo. /100 ml	Free Ammonia	TKN	NO ₂	NO ₃	Tot. P	Diss. P	pH	Cl ⁻	Cond.	Susp. (mg/L)
Jul 07/92	12	4	90	130	<4	0.304	1.07	0.17	3.7	0.077	0.018	7.84	44.5	603	16.8
Aug 04/92	19	16	12	8	<4	0.724	1.78	0.19	4.5	0.049	0.004	7.84	44.6	551	8.1
Aug 11/92	17	8	8	40	<4	1.000	2.10	0.07	2.9	0.044	0.002	7.92	44.1	571	5.0
Aug 25/92	22	228	228	292	<4	1.400	1.00	0.17	1.8	0.090	0.048	7.74	45.6	593	10.2
MIN:	12	4	8	8	4	0.304	1.00	0.07	1.8	0.044	0.002	7.74	44.1	551	5.0
MAX:	22	228	228	292	4	1.400	2.10	0.19	4.5	0.090	0.048	7.92	45.6	603	16.8
MEAN:	17	18	37	59	4	0.745	1.41	0.14	3.1	0.062	0.009	7.83	44.7	579	9.1
High Flow															
Jul 14/92	13	210	210	630	<4	0.500	2.66	0.88	2.2	0.070	0.001	7.76	46.1	610	15.7
Jul 21/92	18	10	10	10	<4	0.469	1.68	0.09	3.8	0.051	0.006	7.87	46.2	539	11.0
Jul 28/92	20	16	16	16	4	0.389	1.46	0.26	5.6	0.048	0.015	8.10	42.6	526	7.4
Aug 18/92	20	80	32	100	<4	0.333	1.58	0.17	6.1	0.056	0.004	8.06	43.4	539	5.0
MIN:	13	16	16	10	4	0.333	1.46	0.09	2.2	0.048	0.001	7.76	42.6	526	5.0
MAX:	20	210	210	630	4	0.500	2.66	0.88	6.1	0.070	0.015	8.10	46.2	610	15.7
MEAN:	17	57	46	56	4	0.417	1.79	0.24	4.1	0.056	0.004	7.95	44.5	553	8.9

Site C: Springer Lake (west beach), Delaware Township

Low Flow

DATE	Temp. °C	F. Coli /100ml	E. Coli /100ml	F. Strep /100 ml	Pseudo. /100 ml	Free Ammonia	TKN	NO ₂	NO ₃	Tot. P	Diss. P	pH	Cl ⁻	Cond.	Susp. (mg/L)
Jun 16/92	23	10	10	8	<4	0.101	0.93	0.08	6.4	0.031	0.006	8.42	44.6	532	14.1
Jun 23/92	20	10	10	10	<4	0.088	1.29	0.09	6.9	0.104	0.007	8.44	45.1	531	86.6
Jun 30/92	23	4	4	4	<4	0.086	1.05	0.09	5.9	0.033	0.019	8.29	45.5	512	16.8
Jul 07/92	24	4	4	12	<4	0.067	0.90	0.09	5.6	0.020	0.001	8.42	46.8	522	5.0
Aug 04/92	22	8	8	12	<4	0.161	0.98	0.46	5.9	0.054	0.007	7.81	43.8	565	18.3
Aug 11/92	24	4	4	8	<4	0.066	1.01	0.15	7.2	0.037	0.001	8.63	42.3	526	5.0
Aug 25/92	24	4	4	12	<4	0.009	0.98	0.21	5.8	0.034	0.009	8.57	43.6	476	6.2
MIN:	20	4	4	4	4	0.009	0.90	0.08	5.6	0.020	0.001	7.81	42.3	476	5.0
MAX:	24	10	10	12	4	0.161	1.29	0.46	7.2	0.104	0.019	8.63	46.8	565	86.6
MEAN:	23	6	6	9	4	0.065	1.01	0.14	6.2	0.039	0.005	8.36	44.5	523	12.9

High Flow

Jul 14/92	24	100	100	20	<4	0.063	0.86	0.08	5.1	0.024	0.001	8.48	43.7	518	5.0
Jul 21/92	23	10	10	10	<4	0.281	1.08	0.13	5.6	0.045	0.011	8.42	48.7	490	12.6
Jul 28/92	23	16	16	4	<4	0.097	1.02	0.28	6.7	0.043	0.008	8.45	41.4	504	6.3
Aug 18/92	22	40	40	16	<4	0.103	1.06	0.19	6.9	0.042	0.007	8.24	43.2	530	5.0
MIN:	22	10	10	4	4	0.063	0.86	0.08	5.1	0.024	0.001	8.24	41.4	490	5.0
MAX:	24	100	100	20	4	0.281	1.08	0.28	6.9	0.045	0.011	8.48	48.7	530	12.6
MEAN:	23	28	28	11	4	0.115	1.00	0.15	6.0	0.037	0.005	8.40	44.2	510	6.7

Site D: Springer Lake (main beach area), Delaware Township

Low Flow

DATE	Temp. °C	F. Coli /100ml	E. Coli /100ml	F. Strep /100 ml	Pseudo. /100 ml	Free Ammonia	TKN	NO ₂	NO ₃	Tot. P	Diss. P	pH	Cl ⁻	Cond.	Susp. (mg/L)
Jul 07/92	25	10	10	10	<4	0.071	1.07	0.08	5.4	0.031	0.016	8.40	45.8	515	12.9
Aug 04/92	22	4	4	36	<4	0.067	1.03	0.28	7.2	0.034	0.001	8.30	43.3	520	5.0
Aug 11/92	24	4	4	8	<4	0.056	0.97	0.15	7.2	0.036	0.001	8.62	41.2	525	5.0
Aug 25/92	25	4	4	8	<4	0.056	0.98	0.26	5.8	0.038	0.011	8.56	43.5	476	11.7
Sep 15/92	22	20	80	10	<4	0.070	1.26	0.10	2.6	0.180	0.102	8.25	23.9	425	12.3
Sep 29/92	17	40	28	4	4	0.258	1.04	0.09	2.3	0.240	0.155	7.87	21.9	446	12.4
MIN:	17	4	4	4	4	0.056	0.97	0.08	2.3	0.031	0.001	7.87	21.9	425	5.0
MAX:	25	40	80	36	4	0.258	1.26	0.28	7.2	0.240	0.155	8.62	45.8	525	12.9
MEAN:	22	9	11	10	4	0.080	1.05	0.14	4.6	0.063	0.012	8.33	35.1	483	9.1

High Flow

Jul 14/92	24	100	100	10	<4	0.042	0.89	0.08	5.3	0.026	0.001	8.49	44.3	519	5.0
Jul 21/92	23	10	10	10	<4	0.123	0.97	0.13	5.7	0.032	0.007	8.41	48.6	495	9.9
Jul 28/92	23	20	10	10	<4	0.088	0.93	0.29	6.8	0.039	0.009	8.42	42.1	504	6.6
Aug 18/92	22	32	32	28	<4	0.104	1.04	0.19	6.8	0.048	0.007	8.22	43.4	526	20.5
Sep 01/92	20	200	50	90	4	0.138	1.23	0.15	4.8	0.090	0.029	7.84	36.0	483	11.8
Sep 08/92	22	250	320	680	100	0.146	1.26	0.14	3.9	0.134	0.060	7.75	33.6	479	16.4
Sep 22P92	20	200	200	150	12	0.091	1.19	0.10	2.3	0.198	0.147	7.78	22.1	419	11.5
MIN:	20	10	10	10	4	0.042	0.89	0.08	2.3	0.026	0.001	7.75	22.1	419	5.0
MAX:	24	250	320	680	100	0.146	1.26	0.29	6.8	0.198	0.147	7.49	48.6	523	20.5
MEAN:	22	68	52	43	7	0.098	1.06	0.14	4.8	0.062	0.014	8.12	37.5	488	10.6

Site E Springer Lake (east end of Conservation Area), Delaware Township Low Flow

DATE	Temp. °C	F. Coli /100ml	E. Coli /100ml	F. Strep /100 ml	Pseudo. /100 ml	Free Ammonia	TKN	NO ₂	NO ₃	Tot. P	Diss. P	pH	Cl ⁻	Cond.	Susp. (mg/L)	
Jun 16/92	23	10	10	4	<4	0.085	1.00	0.08	6.5	0.026	0.005	8.42	44.9	534	8.5	
Jun 23/92	20	50	10	10	<4	0.064	0.96	0.08	6.7	0.030	0.001	8.40	442	533	14.4	
Jun 30/92	23	8	8	4	<4	exhausted	1.06	0.09	6.1	0.033	exhausted	8.30	exhausted	518	17.9	
Jul 07/92	25	10	10	10	<4	0.087	0.92	0.08	5.4	0.022	0.001	8.41	45.8	522	9.3	
Aug 04/92	22	10	10	10	<4	0.070	1.04	0.28	7.2	0.035	0.001	8.30	43.3	522	5.0	
Aug 11/92	24	4	4	4	<4	0.056	0.97	0.15	7.2	0.036	0.001	8.63	42.2	522	5.0	
Aug 25/92	24	8	4	32	<4	0.045	1.05	0.21	5.7	0.049	0.006	8.56	43.3	454	8.1	
MIN:	20	4	4	4	4	0.045	0.92	0.08	5.4	0.022	0.001	8.30	42.2	454	5.0	
MAX:	25	50	10	32	4	0.087	1.06	0.28	7.2	0.049	0.006	8.63	45.8	534	17.9	
MEAN:	23	10	7	8	4	0.066	1.00	0.12	6.4	0.032	0.002	8.43	43.9	514	8.8	
High Flow																
Jul 14/92	24	100	100	10	<4	0.046	0.81	0.08	5.2	0.024	0.001	8.51	45.7	518	5.0	
Jul 21/92	23	4	4	100	<10	0.189	1.12	0.12	5.4	0.042	0.008	8.41	48.6	488	9.4	
Jul 28/92	23	40	40	170	<4	0.071	1.14	0.26	7.0	0.041	0.008	8.05	42.8	504	7.6	
Aug 18/92	22	44	44	108	<4	0.100	1.13	0.19	6.8	0.067	0.009	8.18	43.5	534	13.6	
MIN:	22	4	4	10	4	0.046	0.81	0.08	5.2	0.024	0.001	8.05	42.8	488	5.0	
MAX:	24	100	100	170	10	0.189	1.14	0.26	7.0	0.067	0.009	8.51	48.6	534	13.6	
MEAN:	23	29	29	65	5	0.089	1.04	0.15	6.0	0.041	0.005	8.29	45.1	511	8.3	

Site F: Sharon Creek Reservoir at County Road 15. Delaware Township

Low Row

DATE	Temp. °C	F. Coli /100ml	E. Coli /100ml	F. Strep /100 ml	Pseudo. /100 ml	Free Ammonia	TKN	NO ₂	NO ₃	Tot. P	Diss. P	pH	Cl ⁻	Cond.	Susp. (mg/L)	
Jul 07/92	24	10	10	10	<4	0.092	1.17	0.09	2.8	0.075	0.021	8.24	50.8	562	18.6	
Aug 04/92	22	100	100	20	<4	0.087	1.38	0.23	8.1	0.071	0.004	8.22	43.4	548	13.1	
Aug 11/92	26	240	150	10	<4	0.093	1.40	0.16	7.0	0.094	0.018	8.30	45.2	562	17.7	
Aug 25/92	24	10	10	110	<4	0.077	1.16	0.17	4.6	0.065	0.012	8.38	39.9	482	9.8	
Sep 15/92	22	180	180	60	12	0.074	1.16	0.06	2.5	0.278	0.196	7.91	20.5	460	23.2	
Sep 29/92	16	440	420	60	4	0.116	1.52	0.08	2.9	0.256	0.125	8.06	24.8	523	31.3	
MIN:	16	10	10	10	4	0.074	1.16	0.06	2.5	0.065	0.004	7.91	20.5	460	9.8	
MAX:	26	440	420	110	12	0.116	1.52	0.23	8.1	0.278	0.196	8.38	50.8	562	31.3	
MEAN:	22	76	70	30	5	0.069	1.29	0.12	4.2	0.115	0.028	8.18	35.6	521	17.7	
High Flow																
Jul 14/92	24	100	100	100	<4	0.017	1.26	0.20	3.0	0.095	0.004	8.14	53.0	555	21.2	
Jul 21/92	24	52	52	100	<10	0.586	2.30	0.22	12.5	0.135	0.070	8.43	46.1	593	18.7	
Jul 28/92	22	1000	760	660	8	0.047	1.38	0.28	9.1	0.098	0.014	8.51	38.1	526	19.2	
Aug 18/92	20	9000	9000	9100	64	0.086	1.54	0.14	5.4	0.248	0.122	7.95	36.2	509	28.4	
Sep 01/92	22	330	330	70	<4	0.109	1.40	0.10	4.7	0.194	0.115	7.88	30.4	502	16.8	
Sep 08/92	22	860	660	490	36	0.108	1.60	0.09	2.9	0.384	0.240	7.74	24.2	487	28.7	
Sep 22/92	18	6100	4400	4400	124	0.050	5.60	0.07	2.6	0.455	0.200	7.67	19.3	427	68.1	
MIN:	18	52	52	70	4	0.017	1.26	0.07	2.6	0.095	0.004	7.67	19.3	427	16.8	
MAX:	24	9000	9000	9100	124	0.586	5.60	0.28	12.5	0.455	0.240	8.51	53.0	593	68.1	
MEAN:	22	698	511	511	17	0.081	1.86	0.14	4.9	0.195	0.060	8.04	33.6	512	25.5	

Site G: Sharon Road (tile outlet) between County Road 15 and Concession III, Delaware Township

Low Flow

DATE	Temp. °C	F. Coli /100ml	E. Coli /100ml	F. Strep /100 ml	Pseudo. /100 ml	Free Ammonia	TKN	NO ₂	NO ₃	Tot. P	Diss. P	pH	Cl ⁻	Cond.	Susp. (mg/L)
Jul 07/92	16	1000	1000	770	600	0.378	1.52	0.45	4.8	0.415	0.140	7.86	142	1830	89.1
Aug 04/92	16	10,500	10,500	410	152	0.021	0.56	0.08	14.0	0.064	0.048	7.58	24.6	739	5.0
Aug 11/92	17	1000	1000	860	4	0.023	0.62	0.01	9.5	0.091	0.039	7.92	29.8	795	5.0
Aug 25/92	16	820	820	540	64	0.078	0.52	0.07	3.1	0.067	0.056	7.41	18.5	728	5.0
Sep 15/92	17	210	170	80	<4	0.038	0.64	0.01	2.7	0.103	0.089	7.61	14.6	660	5.0
Sep 29/92	15	lab acc.	400	388	60	0.010	0.47	0.01	0.9	0.078	0.069	8.30	18.6	721	5.0
MIN:	15	210	170	80	4	0.010	0.47	0.01	0.9	0.064	0.039	7.41	14.2	660	5.0
MAX:	17	10,500	10,500	860	600	0.378	1.52	0.45	14.0	0.415	0.140	8.30	29.8	1830	89.1
MEAN:	16	1126	915	407	42	0.042	0.66	0.04	4.1	0.104	0.067	7.77	19.3	848	8.1

High Flow

Jul 14/92	17	400	100	1500	392	0.014	0.93	0.02	10.2	0.099	0.030	7.79	33.4	717	26.2
Jul 21/92	17	2100	1800	1100	600	0.029	0.88	0.05	7.2	0.098	0.061	7.65	34.5	758	17.9
Jul 28/92	13	1000	1000	320	96	0.023	0.59	0.14	16.4	0.064	0.046	7.96	22.8	698	2.7
Aug 18/92	17	8600	5400	1170	344	0.018	0.65	0.03	7.6	0.093	0.072	7.76	17.7	641	5.0
Sep 01/92	15	1000	1000	960	600	0.004	0.60	0.03	3.4	0.082	0.058	7.78	13.2	667	9.5
Sep 08/92	18	35,000	12,000	25,000	160	0.255	1.95	0.19	2.0	0.680	0.370	7.35	11.7	425	12.1
Sep 22/92	17	1300	1000	8500	10	0.159	2.20	0.16	0.9	0.605	0.310	7.29	8.5	307	126.0
MIN:	13	400	100	320	10	0.004	0.59	0.02	0.9	0.064	0.030	7.29	8.5	307	2.7
MAX:	18	35,000	12,000	25,000	600	0.255	2.20	0.19	16.4	0.680	0.370	7.96	34.5	758	126.0
MEAN:	16	2288	1420	1996	185	0.031	0.97	0.06	4.8	0.153	0.088	7.65	18.0	576	13.7

Site H: Howlett Drain pond off Concession III, Delaware Township

Low Flow

DATE	Temp. °C	F. Coli /100ml	E. Coli /100ml	F. Strep /100 ml	Pseudo. /100 ml	Free Ammonia	TKN	NO ₂	NO ₃	Tot. P	Diss. P	pH	Cl ⁻	Cond.	Susp. (mg/L)
Jun 23/92	20	100	100	180	<4	0.085	3.20	0.02	0.9	0.600	0.267	9.20	34.8	376	23.3
Jun 30/92	24	12	12	216	<4	0.406	3.10	0.02	0.1	0.620	0.420	8.85	34.3	390	17.2
Jul 07/92	21	10	10	240	<4	0.058	2.80	0.01	0.1	0.580	0.358	10.02	35.6	380	36.2
Aug 04/92	23	400	200	100	4	0.828	3.76	0.03	0.1	0.920	0.580	7.94	39.1	462	25.7
Aug 11/92	27	60	60	50	<4	0.262	3.46	0.05	0.1	0.790	0.370	8.73	39.6	461	31.0
Aug 25/92	27	10	10	10	<4	0.063	3.08	0.01	0.1	0.720	0.610	9.22	36.6	426	21.7
MIN:	20	10	10	10	4	0.058	2.80	0.01	0.1	0.580	0.267	7.94	34.3	376	17.2
MAX:	27	400	200	240	4	0.828	3.76	0.05	0.9	0.920	0.610	10.02	39.6	462	36.2
MEAN:	24	38	34	88	4	0.174	3.22	0.02	0.1	0.695	0.417	8.97	36.6	414	25.1

High Flow

Jul 14/92	26	100	100	500	<10	0.022	3.10	0.01	0.1	0.750	0.390	9.30	37.4	395	50.3
Jul 21/92	25	10	10	1000	<10 exhausted		3.20	0.02	0.5	0.136	0.440	9.06	40.4	398	41.1
Jul 28/92	25	340	340	240	<4	0.509	3.90	0.05	1.1	0.840	0.520	8.64	36.3	446	41.6
Aug 18/92	23	10,000	10,000	1900	16	0.139	3.28	0.06	0.2	0.990	0.500	8.70	37.2	446	38.8
MIN:	23	10	10	240	4	0.022	3.10	0.01	0.1	0.136	0.390	8.64	36.3	395	38.8
MAX:	26	10,000	10,000	1900	16	0.509	3.90	0.06	0.5	0.990	0.520	9.30	40.4	446	50.3
MEAN:	25	241	241	641	9	0.116	3.36	0.03	0.3	0.540	0.460	8.92	37.8	421	42.7

Site I: Highway 402 between County Road 15 and Concession III, Delaware Township

Low Flow

DATE	Temp. °C	F. Coli /100ml	E. Coli /100ml	F. Strep /100 ml	Pseudo. /100 ml	Free Ammonia	TKN	NO ₂	NO ₃	Tot. P	Diss. P	pH	Cl ⁻	Cond.	Susp. (mg/L)
Jun 16/92	21	820	700	600	<4	0.002	0.75	0.08	8.7	0.116	0.069	8.28	82.6	954	3.5
Jun 23/92	15	370	350	510	<4	0.017	0.65	0.05	12.8	0.092	0.065	8.24	83.2	1006	10.2
Jun 30/92	18	150	120	300	<4	0.031	0.68	0.06	6.4	0.097	0.069	8.18	67.8	881	4.7
Jul 07/92	18	320	320	440	<4	0.097	0.84	0.05	1.6	0.123	0.033	8.10	76.2	966	9.2
Aug 04/92	17	470	420	530	4	0.040	0.67	0.27	16.1	0.180	0.142	8.12	76.8	1020	5.0
Aug 11/92	18	1000	330	320	4	0.020	0.64	0.09	15.9	0.120	0.013	8.25	81.1	1042	5.0
Aug 25/92	18	216	156	490	4	0.009	0.67	0.18	16.0	0.131	0.103	8.14	68.2	1037	5.0
Sep 15/92	17	280	220	410	<4	0.046	0.77	0.12	14.3	0.179	0.171	8.07	54.7	981	5.0
Sep 29/92	12	210	160	120	<4	0.051	0.70	0.09	13.1	0.102	0.092	8.16	58.3	968	5.0
MIN:	12	150	120	120	4	0.002	0.64	0.05	1.6	0.092	0.013	8.07	54.7	881	3.5
MAX:	21	1000	700	600	4	0.097	0.84	0.27	16.1	0.180	0.171	8.28	83.2	1042	10.2
MEAN:	17	354	268	380	4	0.023	0.71	0.09	9.9	0.123	0.092	8.17	71.4	983	5.5

High Flow

Jul 14/92	20	1000	1000	1500	16	0.033	0.20	0.20	14.5	0.290	0.238	8.10	88.7	1053	7.8
Jul 21/92	16	660	600	990	4	0.009	0.62	0.30	17.7	0.122	0.092	7.99	85.0	1067	5.0
Jul 28/92	17	400	400	600	16	0.045	0.71	0.05	20.0	0.154	0.080	8.15	68.0	1020	6.9
Aug 18/92	17	1000	1000	1500	8	0.063	0.78	0.08	13.9	0.290	0.260	8.06	56.5	927	5.0
Sep 01/92	17	380	290	770	<4	0.046	0.65	0.14	16.2	0.210	0.168	8.13	68.4	1022	5.0
Sep 08/92	18	430	330	1500	<4	0.229	1.16	0.15	11.8	0.440	0.380	7.98	63.5	936	10.5
Sep 22/92	17	8200	7200	2600	64	0.006	1.96	0.07	4.8	0.690	0.400	7.63	30.7	603	101.0
MIN:	16	380	290	600	6	0.106	0.62	0.05	4.8	0.122	0.080	7.63	30.7	603	7.8
MAX:	20	8200	7200	2600	64	0.229	1.96	0.30	20.0	0.690	0.400	8.15	88.7	1067	101.0
MEAN:	17	862	773	1220	10	0.034	0.88	0.12	13.1	0.269	0.197	8.00	62.8	932	9.5

Site J: Concession III North between Highways 2 and 402, Delaware Township

Low Flow

DATE	Temp. °C	F. Coli /100ml	E. Coli /100ml	F. Strep /100 ml	Pseudo. /100 ml	Free Ammonia	TKN	NO ₂	NO ₃	Tot. P	Diss. P	pH	Cl ⁻	Cond.	Susp. (mg/L)
Jul 07/92	23	1000	320	1100	<4	0.279	1.46	0.15	8.3	0.235	0.074	8.18	100.0	1005	71.0
Aug 04/92	17	670	340	610	<4	0.034	0.62	0.16	11.5	0.079	0.051	7.91	89.6	993	5.0
Aug 11/92	19	1000	520	610	4	0.042	0.50	0.07	9.9	0.056	0.005	8.05	94.4	1013	5.0
Aug 25/92	18	290	250	740	<4	0.034	0.58	0.17	10.4	0.067	0.055	7.92	78.5	991	5.0
MIN:	17	290	250	110	4	0.034	0.50	0.07	8.3	0.056	0.055	7.91	78.5	991	5.0
MAX:	23	1000	520	740	4	0.279	1.46	0.17	11.5	0.235	0.074	8.18	100.0	1013	71.0
MEAN:	19	664	345	417	4	0.061	0.72	0.13	10.0	0.091	0.032	8.01	90.3	1000	9.7

High Flow

Jul 14/92	21	1000	1000	1500	104	0.181	1.29	0.42	7.8	0.111	0.013	8.20	114.0	1018	12.4
Jul 21/92	17	730	730	1200	12	0.013	0.69	0.09	15.6	0.073	0.055	7.92	85.8	998	5.0
Jul 28/92	19	400	400	600	16	0.027	0.59	0.18	14.0	0.081	0.038	7.99	76.2	988	5.2
Aug 18/92	17	1000	1000	33,000	8	0.052	0.69	0.05	10.0	0.125	0.098	7.77	61.4	920	5.0
MIN:	17	400	400	600	8	0.013	0.59	0.05	7.8	0.073	0.013	7.77	61.4	920	5.0
MAX:	21	1000	1000	33,000	104	0.181	1.29	0.42	15.6	0.125	0.098	8.20	114.0	1018	12.4
MEAN:	18	735	735	2443	20	0.043	0.78	0.14	11.4	0.095	0.040	7.97	82.3	980	6.3

Site K: Concession IV North by Highway 2. Delaware Township

Low Flow

DATE	Temp. °C	F. Coli /100ml	E. Coli /100ml	F. Strep /100 ml	Pseudo. /100 ml	Free Ammonia	TKN	NO ₂	NO ₃	Tot. P	Diss. P	pH	Cl ⁻	Cond.	Susp. (mg/L)
Jul 07/92	17	40	40	930	4	0.076	0.60	0.07	14.7	0.230	0.201	8.41	36.1	728	4.6
Aug 04/92	17	520	300	120	<4	jar fail.	jar fail.	jar fail.	jar fail.	jar fail.	jar fail.	jar fail.	jar fail.	jar fail.	jar fail.
Aug 11/92	17	480	280	110	<4	0.012	0.46	0.01	9.8	0.058	0.018	7.55	122.0	1054	5.0
Aug 25/92	17	244	208	188	<4	0.027	0.41	0.12	8.9	0.061	0.060	7.59	134.0	1087	5.0
MIN:	17	40	40	110	4	0.012	0.41	0.01	8.9	0.058	0.018	7.55	36.1	728	4.6
MAX:	17	520	300	930	4	0.076	0.60	0.12	14.7	0.230	0.201	8.41	134.0	1087	5.0
MEAN:	17	222	163	219	4	0.029	0.48	0.04	10.9	0.093	0.060	7.84	83.9	941	4.9

High Flow

Jul 14/92	16	240,000	240,000	13,500	40	0.189	2.26	0.51	12.7	0.440	0.326	7.75	143.0	1154	6.4
Jul 21/92	17	490	410	110	<4	0.005	0.43	0.07	14.9	0.034	0.039	7.67	107.1	999	5.0
Jul 28/92	17	336	336	108	<4	0.035	0.36	0.13	13.9	0.054	0.024	7.60	93.1	988	2.5
Aug 18/92	17	000	1000	480	<4	0.013	0.43	0.03	10.2	0.030	0.013	7.59	72.9	947	5.0
MIN:	16	336	336	108	4	0.005	0.36	0.03	10.2	0.030	0.013	7.59	72.9	947	2.5
MAX:	17	240,000	240,000	13,500	40	0.189	2.26	0.51	14.9	0.440	0.326	7.75	143.0	1154	6.4
MEAN:	17	2507	2398	527	7	0.026	0.62	0.11	12.8	0.070	0.045	7.65	101.0	1019	4.5

Site L: Concession III North by Highway 402. Delaware Township

Low Flow

DATE	Temp. °C	F. Coli /100ml	E. Coli /100ml	F. Strep /100 ml	Pseudo. /100 ml	Free Ammonia	TKN	NO ₂	NO ₃	Tot. P	Diss. P	pH	Cl ⁻	Cond.	Susp. (mg/L)
Jun 16/92	21	440	440	520	<4	0.144	1.41	0.02	0.1	0.152	0.018	7.94	62.0	673	50.2
Jun 23/92	17	500	500	290	<4	0.033	1.01	0.02	1.6	0.065	0.011	7.93	79.2	730	6.4
Jun 30/92	23	180	160	220	<4	0.116	1.15	0.01	0.1	0.135	0.027	7.81	60.3	655	52.7
Jul 07/92	20	680	660	210	<4	0.100	1.68	0.01	0.1	0.205	0.082	8.06	64.9	663	51.1
Aug 04/92	20	460	330	240	<4	0.008	0.91	0.19	10.2	0.077	0.021	8.12	52.4	803	15.4
Aug 11/92	23	920	470	120	16	0.036	0.84	0.06	7.0	0.077	0.014	8.17	54.0	799	5.0
Aug 25/92	23	310	260	260	4	0.050	0.74	0.11	4.5	0.046	0.029	8.02	48.2	739	13.8
Sep 15/92	20	1000	1000	1500	24	0.257	1.50	0.03	1.7	0.380	0.182	7.77	32.3	765	13.7
Sep 29/92	13	260	260	140	<4	0.030	0.64	0.05	3.7	0.098	0.072	8.18	35.6	750	5.0
MIN:	13	180	160	120	4	0.008	0.64	0.01	0.1	0.046	0.011	7.77	32.3	655	5.0
MAX:	23	1000	1000	1500	24	0.257	1.68	0.19	10.2	0.380	0.182	8.18	79.2	803	52.7
MEAN:	20	460	397	281	6	0.057	1.05	0.03	1.1	0.112	0.033	8.00	52.3	729	15.9

High Flow

Jul 14/92	23	260	240	600	<4	0.078	1.41	0.23	2.1	1.240	0.011	8.12	78.7	762	15.7
Jul 21/92	19	2000	500	500	16	0.012	0.89	0.25	17.6	0.122	0.044	7.98	45.5	805	20.2
Jul 28/92	19	830	690	1500	32	0.009	0.82	0.24	13.7	0.107	0.043	8.15	39.3	793	18.8
Aug 18/92	17	1000	1000	1500	12	0.036	0.91	0.07	9.4	0.117	0.055	8.03	37.9	788	15.5
Sep 01/92	17	210	210	150	4	0.046	0.92	0.06	6.4	0.150	0.107	8.09	34.7	748	15.9
Sep 08/92	20	440	410	410	4	0.137	3.38	0.57	4.0	0.280	0.187	7.98	29.9	698	35.7
Sep 22/92	18	35,000	35,000	5100	600	0.064	2.20	0.08	2.1	0.710	0.390	7.68	18.6	452	161.0
MIN:	17	210	210	150	4	0.009	0.82	0.06	2.1	0.101	0.011	7.68	18.6	452	15.5
MAX:	23	35,000	35,000	5100	600	0.137	3.38	0.57	17.6	1.240	1.390	8.15	78.7	805	161.0
MEAN:	19	1049	820	801	16	0.038	1.30	0.16	5.9	0.247	0.071	8.00	37.4	709	26.2

Site M: Highway 402 between Concession III and Sharon Road, Delaware Township

Low Flow

DATE	Temp. °C	F. Coli /100ml	E. Coli /100ml	F. Strep /100 ml	Pseudo. /100 ml	Free Ammonia	TKN	NO ₂	NO ₃	Tot. P	Diss. P	pH	Cl ⁻	Cond.	Susp. (mg/L)
Jun 16/92	24	650	570	4400	<4	0.048	1.37	0.11	1.4	0.101	0.006	8.69	41.2	548	51.8
Jun 23/92	17	220	150	130	<4	0.060	1.16	0.25	8.4	0.111	0.051	8.19	81.6	860	9.8
Jun 30/92	22	50	160	120	<4	0.439	2.24	0.02	0.1	0.266	0.133	8.91	57.9	595	61.2
Jul 07/92	23	100	100	60	<4	0.484	5.05	0.01	0.1	1.320	0.350	8.38	64.7	649	368.0
Aug 04/92	21	460	390	570	8	0.007	1.12	0.49	6.2	0.450	0.380	8.18	63.3	827	5.0
Aug 11/92	25	240	230	1360	4	0.033	1.37	0.11	2.6	0.380	0.210	8.46	91.8	910	5.0
Aug 25/92	22	330	330	330	<4	0.020	1.10	0.10	1.9	0.260	0.011	8.27	53.0	807	5.5
Sep 15/92	22	280	250	30	12	0.211	1.24	0.25	2.1	0.430	0.390	7.94	23.6	639	17.4
Sep 29/92	12	130	120	216	<4	0.069	0.95	0.12	2.5	0.285	0.212	8.24	27.7	684	13.3
MIN:	12	50	100	30	4	0.007	0.95	0.01	0.1	0.101	0.006	7.94	23.6	548	5.0
MAX:	25	650	570	4400	12	0.484	5.05	0.49	8.4	1.320	0.390	8.91	91.8	910	368.0
MEAN:	20	214	220	267	5	0.070	1.49	0.10	1.4	0.303	0.100	8.36	51.5	714	19.3
High Flow															
Jul 14/92	22	7100	7100	13500	12D	0.101	2.05	0.13	1.1	0.425	0.306	8.08	230.0	1247	16.5
Jul 21/92	19	600	600	1700	<10	0.005	1.43	0.61	14.5	0.450	0.258	7.88	44.3	809	17.4
Jul 28/92	23	530	530	800	<4	0.116	1.83	<0.1	10.0	0.212	0.116	8.01	44.2	816	12.4
Aug 18/92	19	1000	1000	1500	<4	0.061	1.42	0.13	6.2	0.215	0.177	8.00	42.8	741	8.6
Sep 01/92	16	680	610	1020	<4	0.007	1.38	0.11	4.7	0.415	0.031	8.03	30.2	689	9.0
Sep 08/92	21	70	40	38000	present	0.417	2.70	0.12	1.5	0.675	0.420	7.62	32.9	528	81.7
Sep 22/92	17	22000	22000	32000	present	0.113	2.35	0.09	1.6	0.715	0.470	7.56	18.8	418	95.3
MIN:	16	70	40	800	4	0.005	1.38	0.09	1.1	0.212	0.031	7.56	18.8	418	8.6
MAX:	23	22000	22000	38000	120	0.417	2.70	0.61	14.5	0.715	0.470	8.08	230.0	1247	95.3
MEAN:	19	1131	1028	4443	9	0.053	1.82	0.14	3.8	0.404	0.193	7.88	44.8	712	21.5

Site N: Concession IV South, Delaware Township

Low Flow

DATE	Temp. °C	F. Coli /100ml	E. Coli /100ml	F. Strep /100 ml	Pseudo. /100 ml	Free Ammonia	TKN	NO ₂	NO ₃	Tot. P	Diss. P	pH	Cl ⁻	Cond.	Susp. (mg/L)
Jul 07/92	25	160,000	160,000	1000	<100	5.700	96.60	0.23	0.1	8.200	1.760	7.32	334.0	2790	2375.0
Aug 04/92	20	120	110	360	<4	0.008	1.15	0.15	8.8	0.096	0.061	8.23	69.3	877	5.0
Aug 11/92	22	170	170	250	<4	0.041	1.14	0.03	9.6	0.093	0.068	8.21	87.6	926	5.0
Aug 25/92	21	200	200	610	<4	0.026	0.95	0.12	10.2	0.103	0.030	7.96	68.6	943	12.5
MIN:	20	120	110	250	4	0.008	0.95	0.03	0.1	0.103	0.030	7.32	68.6	877	5.0
MAX:	25	160,000	160,000	1000	100	5.700	96.60	0.23	10.2	8.200	1.760	8.23	334.0	2790	2375.0
MEAN:	22	899	200	484	9	0.083	3.31	0.11	3.05	0.295	0.122	7.92	108.6	1209	29.4
High Flow															
Jul 14/92	23	800	700	8600	10	0.025	1.36	0.02	0.8	0.121	0.047	8.06	263.0	1297	10.1
Jul 21/92	18	450	290	400	<4	0.048	1.48	0.15	14.4	0.155	0.118	7.88	48.9	838	5.0
Jul 28/92	20	300	180	670	<4	0.010	1.20	0.22	113	0.126	0.084	8.09	47.3	819	10.4
Aug 18/92	18	1000	1000	1500	<4	0.030	1.25	0.04	9.5	0.143	0.108	8.00	54.5	848	5.0
MIN:	18	300	180	400	4	0.010	1.20	0.02	0.8	0.121	0.047	7.88	47.3	819	5.0
MAX:	23	1000	1000	8600	10	0.048	1.48	0.22	14.4	0.155	0.118	8.09	263.0	1297	10.4
MEAN:	20	573	437	1364	5	0.024	1.32	0.07	5.9	0.136	0.084	8.01	75.9	932	7.2

Site O: Concession IV North, Delaware Township

Low Flow

DATE	Temp. °C	F. Coli/100ml	E. Coli/100ml	F. Strep /100 ml	Pseudo. /100 ml	Free Ammonia	TKN	NO ₂	NO ₃	Tot. P	Diss. P	pH	Cl ⁻	Cond.	Susp. (mg/L)
Jun 16/92	20	133,000	133,000	8800	present	190.000	217.00	0.07	0.1	1.450	0.060	8.19	135.0	1640	404.0
Jun 23/92	22	43,000	35,000	1300	<10	0.011	2.40	0.01	1.3	0.134	0.051	7.46	40.2	760	unsuit.
Jun 30/92	29	240,000	240,000	22,000	<4	0.853	6.60	0.03	0.1	1.280	0.410	7.61	57.1	1093	180.0
Jul 07/92	31	290,000	180,000	29,000	<10	5.900	13.50	0.02	0.1	1.420	0.333	7.51	74.4	1210	365.0
Aug 04/92	21	260	180	530	<4	0.091	0.86	0.35	14.1	0.121	0.087	8.16	51.2	852	5.0
Aug 11/92	22	460	270	920	<4	0.026	0.72	0.25	9.4	0.115	0.036	8.12	45.7	826	5.0
Aug 25/92	22	1000	1000	1000	<4	0.057	0.76	0.18	5.7	0.076	0.056	8.03	41.0	780	12.4
Sep 15/92	20	1000	1000	650	<4	0.095	0.67	0.09	7.6	0.070	0.055	8.07	39.7	840	5.0
Sep 29/92	12	70	70	120	<4	0.058	0.65	0.15	5.6	0.089	0.050	8.21	48.1	818	5.0
MIN:	12	70	70	120	4	0.011	0.65	0.01	0.1	0.070	0.036	7.46	39.7	760	5.0
MAX	31	290,000	240,000	29,000	10	190.000	217.00	0.35	14.1	1.450	0.410	8.21	135.0	1640	404.0
MEAN:	21	5306	4450	1868	5	0.271	2.77	0.08	1.5	0.237	0.084	7.92	54.5	949	28.0
High Flow															
Jul 14/92	23	2200	1800	5200	30	0.614	2.55	0.93	6.5	0.450	0.287	8.02	56.6	758	21.5
Jul 21/92	18	860	520	890	20	0.054	1.14	0.40	18.1	0.165	0.120	7.96	37.9	812	5.0
Jul 28/92	20	1000	1000	1420	8	0.069	0.80	0.05	19.0	0.090	0.052	8.11	34.7	811	7.3
Aug 18/92	18	900	900	1500	<4	0.029	0.65	0.07	13.0	0.108	0.070	8.03	39.4	852	5.0
Sep 01/92	19	1100	500	880	<4	0.036	0.66	0.09	11.0	0.083	0.049	8.07	39.6	848	5.0
Sep 08/92	19	13,100	10,600	5100	28	0.045	0.79	0.10	9.5	0.107	0.084	7.82	37.4	844	5.0
Sep 22/92	18	4100	4100	22,000	176	0.039	1.40	0.05	4.2	0.760	0.660	7.66	26.4	573	47.4
MIN:	18	860	500	880	4	0.029	0.65	0.05	4.2	0.083	0.049	7.66	26.4	573	5.0
MAX	23	13,100	10,600	22,000	176	0.614	2.55	0.93	19.0	0.760	0.660	8.11	56.6	852	47.4
MEAN:	19	1932	1515	2672	17	0.064	1.01	0.13	10.4	0.174	0.119	7.95	38.0	779	9.0

Site P: Concession IV North by Sharon Road, Delaware Township

Low Flow

Jun 16/92	22	900	700	520	<4	0.152	1.08	0.02	0.3	0.088	0.009	7.98	36.5	576	30.1
Jun 23/92	17	1000	1000	760	<4	0.046	0.90	0.04	1.9	0.052	0.001	8.02	58.2	634	11.5
Jun 30/92	23	2700	1700	350	<4	0.161	1.14	0.03	1.6	0.089	0.025	7.81	45.4	607	32.4
Jul 97/92	23	4800	4600	730	<4	0.174	1.10	0.02	1.2	0.099	0.085	7.93	36.9	579	41.3
Aug 04/92	20	520	300	260	<4	0.012	0.70	0.14	9.1	0.062	0.001	8.07	58.8	806	21.8
Aug 11/92	23	1200	1100	280	<4	0.011	0.84	0.05	4.4	0.062	0.006	8.21	60.0	764	31.3
Aug 25/92	23	650	560	310	<4	0.027	0.62	0.10	2.3	0.075	0.015	8.08	55.8	769	25.0
Sep 15/92	20	1000	80	200	<10	0.178	0.91	0.11	2.5	0.259	0.163	8.07	34.2	729	5.0
Sep 29/92	12	310	210	190	<4	0.134	0.76	0.05	2.6	0.107	0.064	8.22	38.7	742	5.0
MIN:	12	310	800	19	4	0.011	0.62	0.02	0.3	0.052	0.001	7.81	34.2	576	5.0
MAX	23	4800	4600	760	10	0.178	1.14	0.14	9.1	0.259	0.163	8.22	60.0	806	31.3
MEAN:	20	1043	636	354	4	0.063	0.88	0.05	2.1	0.088	0.014	8.04	46.0	684	16.0

High Flow

Jul 14/92	24	6100	6100	2800	<4	0.039	1.04	0.15	3.9	0.115	0.108	8.20	62.3	698	54.6
Jul 21/92	20	2600	2600	900	<4	0.013	0.82	0.16	17.7	0.120	0.018	8.12	53.2	802	46.2
Jul 28/92	20	640	540	980	48	0.017	0.80	0.20	13.4	0.082	0.045	8.23	45.7	806	9.8
Aug 18/92	19	1000	1000	1500	28	0.036	0.74	0.07	8.4	0.087	0.047	8.08	432	806	5.0
Sep 01/92	19	210	210	240	<4	0.049	0.82	0.06	5.6	0.136	0.101	8.12	36.7	729	10.1
Sep 08/92	19	5700	5400	9100	present	0.251	2.30	0.35	2.9	0.705	0.420	7.64	24.0	576	215.0
Sep 22/92	18	23,000	22,000	26,000	88	0.147	1.95	0.08	1.7	0.625	0.360	7.50	17.1	457	124.0
MIN:	18	210	210	240	4	0.013	0.74	0.06	1.7	0.082	0.018	7.50	17.1	457	5.0
MAX	24	23,000	22,000	26,000	88	0.251	2.30	0.35	17.7	0.705	0.420	8.23	62.3	806	215.0
MEAN:	20	2236	2152	2147	14	0.048	1.09	0.13	5.8	0.179	0.094	7.98	37.2	684	31.9

Site Q: Sharon Road between Concession IV and Township Line, Delaware Township

Low Flow

DATE	Temp. °C	F. Coli /100ml	E. Coli /100ml	F. Strep /100 ml	Pseudo. /100 ml	Free Ammonia	TKN	NO ₂	NO ₃	Tot. P	Diss. P	pH	Cl ⁻	Cond.	Susp. (mg/L)
Jul 07/92	22	1500	500	3300	<4	0.191	1.80	0.01	0.1	0.250	0.059	7.82	73.8	637	94.0
Aug 04/92	20	760	310	500	<4	0.015	0.74	0.23	8.1	0.084	0.037	8.16	58.6	801	5.0
Aug 11/92	25	550	500	480	4	0.010	0.81	0.07	3.4	0.059	0.006	8.25	64.5	745	7.10
Aug 25/92	23	800	400	1000	<4	0.028	0.77	0.10	2.6	0.042	0.020	8.12	57.9	710	12.7
MIN:	20	550	310	480	4	0.010	0.74	0.01	0.1	0.042	0.006	7.82	57.9	637	5.0
MAX:	25	1500	500	3300	4	0.191	1.80	0.24	8.1	0.250	0.059	8.25	73.8	801	94.0
MEAN:	22	842	420	943	4	0.030	0.95	0.06	1.6	0.085	0.023	8.09	63.4	721	14.3

High Flow

Jul 14/92	24	6300	5400	6300	4	0.041	1.49	0.16	3.6	0.134	0.027	8.14	61.8	660	15.0
Jul 21/92	19	1000	1000	800	<4	0.012	0.85	0.18	18.3	0.103	0.012	8.06	48.0	814	13.6
Jul 28/92	19	670	640	810	<4	0.010	0.85	0.23	13.5	0.122	0.083	8.22	44.5	796	10.8
Aug 18/92	18	6400	5200	1500	12	0.063	0.96	0.11	8.4	0.132	0.096	8.05	46.6	793	5.0
MIN:	18	670	640	800	4	0.010	0.85	0.11	3.6	0.103	0.012	8.05	44.5	660	5.0
MAX:	24	6400	5400	6300	12	0.063	1.49	0.23	18.3	0.134	0.096	8.22	61.8	814	15.0
MEAN:	20	2280	2059	1573	5	0.024	1.01	0.16	9.3	0.122	0.040	8.12	49.8	763	10.2

Site R: Delaware-Westminster Township Line (Westdel Road), Westminster Township

Low Flow

DATE	Temp. °C	F. Coli /100ml	E. Coli /100ml	F. Strep /100 ml	Pseudo. /100 ml	Free Ammonia	TKN	NO ₂	NO ₃	Tot. P	Diss. P	pH	Cl ⁻	Cond.	Susp. (mg/L)
Jul 07/92	20	140	140	10	4	0.238	1.13	0.02	0.1	0.095	0.050	7.83	65.0	577	27.7
Aug 04/92	20	190	130	100	<4	0.013	0.66	0.15	8.5	0.032	0.005	8.11	59.3	806	5.0
Aug 11/92	24	360	180	240	<4	0.018	0.74	0.08	4.6	0.041	0.011	8.09	68.3	777	5.0
Aug 25/92	21	560	540	390	<4	0.022	0.72	0.15	2.8	0.046	0.026	7.96	64.1	785	10.8
Sep 15/92	20	1600	1600	270	<4	0.034	0.76	0.02	3.1	0.079	0.060	7.96	32.3	694	5.0
Sep 29/92	11	440	420	170	16	0.016	0.63	0.01	3.1	0.036	0.018	8.13	35.9	757	5.0
MIN:	11	140	130	10	4	0.013	0.63	0.01	0.1	0.032	0.005	7.83	32.3	577	5.0
MAX:	24	1600	1600	390	16	0.238	1.13	0.15	8.5	0.095	0.060	8.13	68.3	806	27.7
MEAN:	19	395	420	126	5	0.030	0.76	0.04	2.2	0.050	0.021	8.01	51.9	728	7.6

High Flow

Jul 14/92	22	790	510	790	4	0.020	0.98	0.14	5.8	0.360	0.004	8.23	693	757	4.6
Jul 21/92	19	420	330	340	<4	0.016	0.63	0.12	17.7	0.055	0.034	8.03	53.8	813	5.0
Jul 28/92	20	480	480	340	<4	0.007	0.67	0.19	13.6	0.053	0.017	8.11	45.5	806	7.1
Aug 18/92	18	570	570	520	4	0.021	0.75	0.04	8.7	0.057	0.043	8.01	47.7	802	5.0
Sep 01/92	18	550	340	350	4	0.020	0.82	0.05	5.5	0.086	0.058	8.04	33.8	679	12.6
Sep 08/92	20	5900	5200	11,600	92	0.127	1.65	0.12	2.6	0.505	0.290	7.58	22.3	516	87.7
Sep 22/92	18	4900	3700	8700	44	0.060	1.40	0.07	4.8	0.395	0.210	7.62	16.0	439	69.7
MIN:	18	420	330	340	4	0.007	0.63	0.04	2.6	0.053	0.004	7.58	16.0	439	4.6
MAX:	22	5900	5200	11,600	92	0.127	1.65	0.19	17.7	0.505	0.290	8.23	69.3	813	87.7
MEAN:	19	1054	842	1077	9	0.026	0.93	0.09	7.0	0.139	0.045	7.94	37.1	671	13.0

Site S: Highway 402 culvert by Westminster Drive, Westminster Township

Low Flow

DATE	Temp. °C	F. Coli /100ml	E. Coli /100ml	F. Strep /100 ml	Pseudo. /100 ml	Free Ammonia	TKN	NO ₂	NO ₃	Tot. P	Diss. P	pH	Cl ⁻	Cond.	Susp. (mg/L)
Jun 16/92	21	5000	4700	1100	<4	0.050	1.04	0.01	0.1	0.126	0.013	7.96	51.8	651	50.2
Jun 23/92	18	550	440	270	<4	0.012	1.98	0.01	2.0	0.144	0.001	8.06	69.4	743	30.6
Jun 30/92	22	660	480	900	<4	0.030	1.24	0.01	0.4	0.142	0.026	8.03	58.0	727	81.7
Jul 07/92	19	210	120	60	<4	0.275	1.60	0.02	0.1	0.161	0.060	7.85	67.3	750	51.2
Aug 04/92	20	260	260	100	<4	0.020	0.65	0.10	7.3	0.043	0.011	7.96	77.4	888	5.0
Aug 11/92	21	1000	1000	1000	<4	0.012	0.83	0.02	5.6	0.065	0.001	8.00	92.9	918	13.9
Aug 25/92	21	350	330	470	<4	0.019	0.76	0.07	2.6	0.053	0.016	7.81	106.0	954	15.6
MIN:	18	210	120	60	4	0.012	0.65	0.01	0.1	0.043	0.001	7.81	51.8	651	5.0
MAX:	22	5000	4700	1100	4	0.250	1.98	0.10	7.3	0.161	0.060	8.06	106.0	954	81.7
MEAN:	20	619	520	358	4	0.030	1.08	0.02	1.0	0.093	0.009	7.95	72.7	797	25.5

High Flow

Jul 14/92	22	1000	2100	1500	12	0.023	0.89	0.05	6.9	0.134	0.058	7.97	86.7	860	13.0
Jul 21/92	18	320	240	520	<4	0.010	0.56	0.08	15.2	0.049	0.039	7.83	63.7	847	5.0
Jul 28/92	20	170	170	310	<4	0.015	0.58	0.16	11.8	0.058	0.021	7.96	60.8	836	5.9
Aug 18/92	18	500	300	70	<4	0.027	0.66	0.02	8.4	0.061	0.017	7.89	66.6	880	9.8
MIN:	18	170	170	70	4	0.010	0.58	0.02	6.9	0.049	0.017	7.83	60.8	836	5.0
MAX:	22	1000	2100	1500	12	0.027	0.89	0.16	15.2	0.134	0.058	7.97	86.7	880	13.0
MEAN:	19	406	400	361	5	0.017	0.69	0.06	10.1	0.069	0.030	7.91	68.8	856	7.8

Site T: Mouth of Clear Creek at Lake Erie (park), Orford Township

Low Flow

DATE	Temp. °C	F. Coli /100ml	E. Coli /100ml	F. Strep /100 ml	Pseudo. /100 ml	Free Ammonia	TKN	NO ₂	NO ₃	Tot. P	Diss. P	pH	Cl ⁻	Cond.	Susp. (mg/L)
Jul 07/92	20	460	350	1000	<4	0.185	1.09	0.16	8.5	0.056	0.038	8.10	37.0	618	28.4
Aug 04/92	20	530	530	190	4	0.013	0.78	0.09	3.0	0.047	0.002	8.07	28.9	551	18.8
Aug 11/92	20	12,400	5300	16,500	560	0.053	1.95	0.12	4.9	0.385	0.092	7.92	33.1	481	106.0
Aug 25/92	23	100	100	200	<10	0.067	0.40	0.06	0.6	0.048	0.077	8.23	16.7	322	39.0
Sep 15/92	18	500	300	200	4	0.310	1.10	0.07	4.8	0.100	0.083	8.19	15.9	588	5.0
Sep 29/92	13	200	150	130	<4	0.028	0.74	0.02	4.1	0.056	0.031	8.24	22.5	643	14.1
MIN:	13	100	100	130	4	0.013	0.40	0.02	0.6	0.047	0.002	7.92	15.9	322	5.0
MAX:	23	12,400	5300	16,500	560	0.310	1.95	0.16	8.5	0.385	0.092	8.24	37.0	643	106.0
MEAN:	19	558	405	504	11	0.065	0.90	0.07	3.4	0.081	0.033	8.12	24.4	521	22.9

High Flow

Jul 14/92	21	2100	2100	12,300	60	1.000	2.34	1.45	3.5	0.200	0.051	7.99	35.0	617	66.4
Jul 21/92	15	2800	2100	5700	30	0.030	2.05	0.32	14.9	0.155	0.093	7.88	29.6	588	72.3
Jul 28/92	21	160	160	180	<4	0.008	1.18	0.17	7.7	0.086	0.020	8.18	28.9	609	52.1
Aug 18/92	17	1600	900	1800	20	0.033	1.18	0.05	7.2	0.128	0.066	8.05	18.8	574	31.5
Sep 01/92		330	160	1300	4	0.019	1.04	0.05	5.0	0.094	0.054	8.15	13.8	507	20.6
Sep 08/92	20	2200	1800	9600	124	0.107	1.50	0.12	4.1	0.275	0.158	7.98	15.6	487	83.7
Sep 23/92	15	700	700	1500	4	0.024	1.44	0.07	4.3	0.186	0.081	8.11	21.4	556	38.7
MIN:	15	160	160	180	4	0.008	1.04	0.05	3.5	0.086	0.020	7.88	13.8	487	20.6
MAX:	21	2800	2100	12,300	124	1.000	2.34	1.45	14.9	0.275	0.158	8.18	35.0	617	83.7
MEAN:	18	962	746	2374	16	0.045	1.47	0.15	5.9	0.149	0.064	8.05	22.1	561	47.2

Site U: Concession I (west of (travel pit), Orford Township

Low Flow

DATE	Temp. °C	F. Coli /100ml	E. Coli /100ml	F. Strep /100 ml	Pseudo. /100 ml	Free Ammonia	TKN	NO ₂	NO ₃	Tot. P	Diss. P	pH	Cl ⁻	Cond.	Susp. (mg/L)
Jul 07/92	16	310	210	4100	<4	0.098	0.95	0.06	7.1	0.056	0.031	8.12	38.5	664	15.1
Aug 04/92	18	2000	1800	4500	16	0.007	1.12	0.21	6.0	0.160	0.001	8.16	38.2	657	39.6
Aug 11/92	19	980	460	1280	16	0.018	1.02	0.03	6.7	0.077	0.017	8.31	21.3	637	19.1
Aug 25/92	20	800	800	1500	<4	0.019	0.85	0.06	6.5	0.048	0.026	8.22	30.4	674	12.9
MIN:	16	310	210	1280	4	0.007	0.85	0.03	6.0	0.048	0.001	8.12	21.3	637	12.9
MAX:	20	2000	1800	4500	16	0.098	1.12	0.21	7.1	0.160	0.031	8.31	38.5	674	39.6
MEAN:	18	835	611	2440	8	0.022	0.98	0.07	6.6	0.076	0.011	8.20	31.2	658	19.6

High Flow

Jul 14/92	20	1500	2100	9000	12	0.105	1.36	0.30	7.6	0.168	0.076	8.20	37.1	664	36.6
Jul 21/92	17	1000	1000	1400	<4	0.004	0.93	0.09	12.0	0.067	0.013	8.14	29.6	703	14.6
Jul 28/92	16	520	420	630	<4	0.010	0.90	0.14	9.2	0.055	0.008	8.30	33.4	670	9.6
Aug 18/92	16	1000	700	2100	<4	0.036	1.23	0.07	6.8	0.103	0.055	8.14	16.6	593	22.3
MIN:	16	520	420	630	5	0.004	0.90	0.07	6.8	0.055	0.008	8.14	16.6	593	9.6
MAX:	20	1500	2100	9000	12	0.105	1.36	0.30	12.0	0.168	0.076	8.30	37.1	703	36.6
MEAN:	17	940	886	2021	5	0.020	1.09	0.13	8.7	0.89	0.026	8.19	27.9	656	18.4

Site V: Kent County Road 21 (north of Concession I), Orford Township

Low Flow

DATE	Temp. °C	F. Coli /100ml	E. Coli /100ml	F. Strep /100 ml	Pseudo. /100 ml	Free Ammonia	TKN	NO ₂	NO ₃	Tot. P	Diss. P	pH	Cl ⁻	Cond.	Susp. (mg/L)
Jul 07/92	17	270	270	2100	8	0.105	1.01	0.09	4.8	0.071	0.032	7.78	34.8	556	31.5
Aug 04/92	17	5100	5100	9200	100	0.012	1.40	0.20	7.5	0.245	0.100	7.79	32.7	502	71.8
Aug 11/92	19	1000	410	1500	<4	0.130	1.20	0.26	9.4	0.162	0.080	7.92	27.8	672	51.0
Aug 25/92	20	5400	5300	4300	<4	5.000	perished	0.46	1.0	0.360	0.148	7.68	35.0	791	22.2
MIN:	17	270	270	1500	4	0.012	1.01	0.09	1.0	0.071	0.032	7.68	27.8	502	22.2
MAX:	20	5400	5300	9200	100	5.000	1.40	0.46	9.4	0.360	0.148	7.92	35.0	791	71.8
MEAN:	18	1651	1315	3341	11	0.169	1.19	0.22	4.3	0.178	0.078	7.79	32.4	621	40.0

High Flow

Jul 14/92	20	12,000	6000	17,000	<4	0.115	2.00	0.50	17.4	0.270	0.115	7.82	38.5	621	64.5
Jul 21/92	13	2100	2000	1700	<10	0.008	1.64	0.32	16.2	0.170	0.101	7.73	29.5	658	30.1
Jul 28/92	18	720	720	630	<4	0.541	1.85	0.55	9.6	0.216	0.110	7.88	30.3	692	41.2
Aug 18/92	15	-	-	-	<4	0.080	1.02	0.13	8.7	0.103	0.054	7.82	18.3	587	22.1
MIN:	13	720	720	630	4	0.008	1.02	0.13	8.7	0.103	0.054	7.73	18.3	587	22.1
MAX:	20	12,000	6000	17,000	10	0.541	2.00	0.5	17.4	0.270	0.115	7.88	38.5	692	64.5
MEAN:	16	2628	720	2631	5	0.079	1.58	0.33	12.4	0.179	0.091	7.81	28.2	638	36.5

Site W: Mouth of Sixteen Mile Creek (Port Glasgow), Aldborough Township

Low Flow

DATE	Temp. °C	F. Coli /100ml	E. Coli /100ml	F. Strep /100 ml	Pseudo. /100 ml	Free Ammonia	TKN	NO ₂	NO ₃	Tot. P	Diss. P	pH	Cl ⁻	Cond.	Susp. (mg/L)
Jul 07/92	20	2000	1100	1500	<4	0.105	0.85	0.08	3.1	0.071	0.029	8.13	39.2	563	33.8
Aug 04/92	20	440	440	890	<4	0.010	0.78	0.12	3.4	0.078	0.013	8.12	42.2	603	47.4
Aug 11/92	20	940	790	790	4	0.010	0.82	0.02	5.1	0.080	0.016	8.14	35.4	612	44.1
Aug 25/92	20	1400	700	600	<4	0.051	0.70	0.04	3.9	0.042	0.004	8.09	40.4	626	21.1
Sep 15/92	18	700	200	700	<4	0.013	0.75	0.01	4.9	0.058	0.026	8.06	32.4	611	34.3
Sep 29/92	13	360	330	50	<4	0.010	0.69	0.02	4.7	0.069	0.015	8.19	34.6	625	13.9
MIN:	13	360	200	50	4	0.010	0.69	0.01	3.1	0.042	0.004	8.06	32.4	563	13.9
MAX:	20	2000	1100	1500	4	0.105	0.85	0.12	5.1	0.080	0.029	8.19	42.2	626	47.4
MEAN:	18	814	510	530	4	0.020	0.76	0.03	4.1	0.065	0.015	8.12	37.2	606	29.9

High Flow

Jul 14/92	20	4500	3900	20,000	488	0.095	1.45	0.17	6.4	0.205	0.063	8.05	42.6	563	86.4
Jul 21/92	18	500	400	1900	8	0.006	0.86	0.08	7.3	0.096	0.022	7.92	36.2	603	59.3
Jul 28/92	20	380	380	390	<4	0.040	0.74	0.14	4.6	0.069	0.027	8.19	39.8	624	35.5
Aug 18/92	17	900	900	1160	8	0.030	0.74	0.03	6.9	0.069	0.018	8.03	30.5	609	38.2
Sep 01/92	-	1200	600	660	<4	0.011	0.84	0.04	5.8	0.058	0.014	8.08	32.4	615	32.7
Sep 08/92	19	1300	1300	1500	<4	0.031	1.02	0.07	5.9	0.084	0.032	7.95	27.9	588	44.9
Sep 23/92	15	370	350	690	8	0.036	0.67	0.09	3.5	0.051	0.010	7.64	80.8	946	19.0
MIN:	15	370	350	390	4	0.006	0.67	0.03	3.5	0.051	0.010	7.64	27.9	563	19.0
MAX:	20	4500	3900	20,000	488	0.095	1.45	0.17	7.3	0.205	0.063	8.19	80.8	946	86.4
MEAN:	18	891	759	1422	11	0.026	0.87	0.08	5.6	0.081	0.023	7.96	39.0	640	41.0

Site X: Concession II (southwest of Rodney), Aldborough Township

Low Flow

DATE	Temp. °C	F. Coli /100ml	E. Coli /100ml	F. Strep /100 ml	Pseudo. /100 ml	Free Ammonia	TKN	NO ₂	NO ₃	Tot. P	Diss. P	pH	Cl ⁻	Cond.	Susp. (mg/L)
Jul 07/92	16	1000	620	430	4	0.060	0.64	0.11	3.2	0.068	0.025	8.28	43.8	636	9.5
Aug 04/92	17	620	480	550	4	0.012	0.64	0.11	3.0	0.049	0.019	8.28	52.3	677	5.0
Aug 11/92	19	740	620	920	12	0.008	0.73	0.03	5.0	0.041	0.014	8.14	44.6	666	13.7
Aug 25/92	19	1100	600	1100	<4	0.016	0.56	0.06	3.3	0.037	0.031	8.12	55.3	699	8.6
MIN:	16	620	480	430	4	0.008	0.56	0.03	3.0	0.037	0.014	6.12	43.8	636	5.0
MAX:	19	1100	620	1100	12	0.060	0.73	0.11	5.0	0.068	0.031	6.28	55.3	699	13.7
MEAN:	18	843	577	699	5	0.017	0.64	0.07	3.5	0.047	0.021	8.20	48.8	669	8.6

High Flow

Jul 14/92	19	910	890	1500	96	0.032	0.83	0.09	7.0	0.078	0.016	8.08	42.6	674	27.3
Jul 21/92	17	640	400	880	44	0.002	0.73	0.07	6.4	0.043	0.011	7.97	47.1	651	12.3
Jul 28/92	17	840	680	730	16	0.021	0.64	0.15	3.9	0.038	0.014	8.30	51.7	680	9.2
Aug 18/92	17	930	930	800	4	0.021	0.82	0.03	6.0	0.039	0.014	7.96	37.2	630	12.0
MIN:	17	640	400	730	4	0.002	0.64	0.03	3.9	0.038	0.011	7.96	37.2	630	9.2
MAX:	19	930	930	1500	96	0.032	0.83	0.15	7.0	0.078	0.016	8.30	51.7	680	27.3
MEAN:	17	821	689	937	23	0.013	0.75	0.07	5.7	0.047	0.014	8.08	44.3	658	13.9

Site Y: Aldborough County Road 3 (south of Rodney), Aldborough Township

Low Flow

DATE	Temp. °C	F. Coli /100ml	E. Coli /100ml	F. Strep /100 ml	Pseudo. /100 ml	Free Ammonia	TKN	NO ₂	NO ₃	Tot. P	Diss. P	pH	Cl ⁻	Cond.	Susp. (mg/L)
Jul 07/92	12	460	350	1500	<4	0.073	0.68	0.06	4.7	0.041	0.004	8.19	23.9	520	30.7
Aug 04/92	17	350	270	540	<4	0.008	0.62	0.21	4.8	0.045	0.001	8.19	27.4	536	31.3
Aug 11/92	19	350	310	520	<4	0.067	0.68	0.26	5.6	0.029	0.001	8.05	26.3	536	11.0
Aug 25/92	18	440	440	510	<4	0.055	0.60	0.22	5.0	0.023	0.021	8.10	26.8	553	12.2
MIN:	12	350	270	510	4	0.008	0.60	0.06	4.7	0.023	0.001	8.05	23.9	520	11.0
MAX:	19	460	440	1500	4	0.073	0.68	0.26	5.6	0.045	0.021	8.19	27.4	553	31.3
MEAN:	16	397	337	681	4	0.038	0.64	0.16	5.0	0.033	0.003	8.13	26.1	536	18.9

High Flow

Jul 14/92	19	870	660	1500	<4	0.036	0.75	0.09	7.6	0.060	0.036	8.02	25.0	547	29.7
Jul 21/92	17	950	400	710	<4	0.008	0.78	0.08	7.1	0.032	0.007	7.89	25.8	541	17.1
Jul 28/92	17	670	670	480	<4	0.042	0.69	0.18	5.2	0.034	0.013	8.18	24.8	540	14.9
Aug 18/92	17	330	330	540	<4	0.065	0.72	0.04	6.7	0.031	0.004	7.95	26.8	554	13.0
MIN:	17	330	330	480	4	0.008	0.69	0.04	5.2	0.031	0.004	7.89	24.8	540	13.0
MAX:	19	950	670	1500	4	0.065	0.78	0.18	7.6	0.060	0.036	8.18	26.8	554	29.7
MEAN:	17	654	492	725	4	0.030	0.73	0.08	6.6	0.038	0.011	8.01	25.6	545	17.7

Site Z: Drainage Ditch off Westdel Road, Delaware Township

Low Flow

DATE	Temp. °C	F. Coli /100ml	E. Coli /100ml	F. Strep /100 ml	Pseudo. /100 ml	Free Ammonia	TKN	NO ₂	NO ₃	Tot. P	Diss. P	pH	Cl ⁻	Cond.	Susp. (mg/L)
Sep 29/92	13	40	40	210	<4	0.014	0.21	0.01	1.3	0.006	0.006	8.15	39.8	759	5.0

High Flow

Sep 22/92	17	1100	900	10,400	4	0.032	0.82	0.03	2.1	0.090	0.038	7.96	26.8	647	15.9
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