A Clean Up Rural Beaches Plan (CURB)
FOR THE BIG OTTER CREEK

Prepared for:

Provincial Rural Beaches Planning and Advisory Committee
Ontario Ministry of the Environment

by:
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LONG POINT REGION
CONSERVATION AUTHORITY

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RURAL BEACHES IMPACT STUDY

SUMMARY

The CURB (Clean Up Rural Beaches) Plan is a report which outlines the specific remedial projects required to improve water quality at the Lake Erie Beaches of Port Burwell and Sandhills Park Regions. In recent years, water pollution from rural and urban land management practices has led to water quality impairment at beach areas resulting in beach closures.

Recent water quality analyses in the Big Otter Creek watershed have shown that high phosphorous concentrations and fecal coliform bacterial counts periodically exist throughout the watershed. During the summers of 1991 and 1992, the beaches of Port Burwell and the Sandhills Region were closed by the Elgin-St. Thomas County Board of Health due to elevated fecal coliform levels. Evidently, the major causes of these beach closures can be attributed to point and non-point sources of pollutants resulting from land-use activities along the Big Otter Creek watercourse and from the shoreward dispersion of pollutants by lakeshore drift.

The CURB plan is a result of a five month study which began in April 1992 in cooperation with the Ontario Ministry of the Environment. It is based on air surveys, farm interviews and questionnaires, water quality data, stream surveys, and field assessments. The CURB plan incorporates a simple quantitative model of all sources of bacterial pollution which is believed to impact the beach areas.

The result of the CURB study is a remedial action plan designed to reduce the impact of agricultural practices on water quality of the Big Otter Creek. The remedial action plan provides a framework for long term upgrading and protection of recreational water quality.

DISCLAIMER

The material presented in this report, both quantitative and qualitative, does not necessarily reflect the policies or the management priorities of the Long Point Region Conservation Authority. 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 Impact Study.

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1.0 Introduction

The closures of many of Ontario's recreational beaches have become a common occurrence throughout the summer months within the last few years. Beach closures have become a widespread concern, for not only do they deny citizens of recreational opportunity, but they result in estimated millions of dollars of lost revenue to many resort communities. in response to the ever growing number of beach closures in Southern Ontario, the Ontario Ministry of Environment (MOE) began working with Conservation Authorities in 1985 to identify sources of water pollution and take action to improve water quality at rural beaches. This became known as the Rural Beaches Strategy Program.

In April 1992, the Long Point Region Conservation Authority (LPRCA) and the MOE began an investigative study under the Rural Beaches Program to determine the factors contributing to declining water quality of the beaches of Port Burwell and the Sandhills park region. The objective of the first five months of study was to address the sources of water contamination in the Big Otter Creek watershed and to research a long term solution to these problems.

Water contamination has been a constant and recurring problem in the Big Otter Creek. Many parts of the watershed are susceptible to bacterial contamination due to a variety of land use practices. Faulty septic systems, milkhouse wastes, liquid manure spreading, and uncontrolled livestock access to the creek are a few of the rural water quality impacts that have been reported by area residents. in some of the communities along the watercourse, water quality impairments resulting from a combination of septic system failure, improper greywater waste handling facilities, sewage lagoon discharge, and urban runoff have also been observed.

The beaches of Port Burwell and Sandhills Park were tested by the Aylmer Ministry of Natural Resources, the Elgin County Board of Health and the Haldimand-Norfolk Region Board of Health. During the summer season, these beaches regularly exceeded the recommended guidelines from the board of health for risk-free swimming. As a result, beach closures have occurred during the peak of the swimming season.

The Big Otter Creek Clean Up Rural Beaches (CURB) Program is an environmental program aimed at prevention of beach closures through water pollution control initiatives. Although beach closures during the summer months are a sign of deteriorating water quality in the environment, there are also many indirect ramifications: The substantial revenue losses which impact the local economy (which thrive heavily on tourism as major source of income) along with the continued loss of public recreation are among the undesired effects.

This report presents the Clean Up Rural Beaches Plan, which summarizes the culmination of the five month study and provides a framework for the implementation of remedial measures designed to achieve study objectives.

2.0 Background Summary

The Big Otter Creek watershed extends north from the village of Port Burwell for a distance of 42 km and covers an area of approximately 508 square kilometres (Department of Lands and Forests, 1962). its main tributary is the Little Otter Creek, which joins the stream at approximately 9.7 km north of Lake Erie. The watershed encompasses parts of the Township of Norfolk, Oxford Brant, and Elgin counties. The main towns and villages along the watershed are Tillsonburg, Norwich, Otterville, Vienna and Port Burwell (Figure 1).

In general, two different soil types predominate along the Big Otter Creek watershed. Along its northern portions is an area of heavy clay loam soils characteristic of a till plain. in contrast, sandy loam is prevalent along its southern portions and is characteristic of the Norfolk Sand Plain found throughout the Long Point Region. The northern boundary extends from the moraine north and west of Norwich, where the elevation drops from 320 m to approximately 175 m at the rivermouth in Lake Erie. The river valley itself appears fairly flat along its northern portion, but in its southern portion the topography becomes deeply incised in the near level sand plain.

A significant relationship exists between the river and the soil materials through which it flows. Most of the permanent flow originates in the sand lands (Department of Lands and Forests, 1962). However, the tributaries situated along the heavier clay areas in the north-west portion of the watershed and immediately upstream of Vienna have a tendency to dry up to standing pools during the dry periods of the summer.

2.1 Agricultural Land Use

The headwater portions of the Big Otter Creek watershed are favourably suited for dairy and beef farming due to the heavier nature of the soils (clay loam) and the irregular topography found in this region. The extensive network of spillways and drainage channels from glacial meltwater associated with the St. Thomas, Norwich and the Tillsonburg moraine formed wide valleys which often contained poorly drained gravelly soils. in these areas, the land is often forested or used as pasture (Dept. of Lands and Forests, 1962). Field observations indicate that a few intensive dairy operations of approximately 150 cattle exist, with most consisting of family run operations of approximately 35-50 head (LPRCA, 1979).

In well drained areas, corn is grown mainly as a cash crop and livestock feed (LPRCA, 1979). Until recently, some farms along these headwater areas have diversified to include other forms of livestock farming, such as swine, sheep, and elk.

The Tillsonburg area is situated at the midpoint of the watershed between the headwaters and the rivermouth at Port Burwell. In this region, the agricultural base is primarily tobacco in rotation with grains. The cultivation of flue-cured tobacco coincides with the occurrence of the sandy soils typical of the Norfolk sand plain. in tobacco growing areas, the sands are generally well drained and are usually low in inherent fertility. Their low moisture holding capacity often results in widespread irrigational demands occurring in the hot summer months.

In the lower portions of the watershed, tobacco farming was also practiced, but the sands may be imperfectly drained and generally more suitable as unimproved forest of scrub. There are heavier soils found in the vicinity of Bayham, where a clay plain extends along both sides of the river. Soybeans, commercial orchards, and corn were often produced in these heavier soils. The deep valleys along the downstream areas are often unsuitable for agricultural land use, so that agricultural activity along the lower portion of the watershed was not very intensive.

3.0 The Clean Up Rural Beaches (CURB) Model

The number of fecal coliform bacteria loads delivered to the watercourse were calculated from a number of specific sources. Potential agricultural and urban sources were quantified according to their relative contributions to the watercourse. These sources include milkhouse washwater wastes, livestock access, manure spreading, household septic system failures, feedlot and barnyard runoff, manure spills, urban non-point runoff, and municipal waste discharges.

3.1.0 Source Assessment Methodology

The strategy for determining specific problem areas within the watershed consisted of collecting site specific farm data for entry into the CURB model, in-stream chemical analysis, and land use surveys. Stream chemistry data was used to support the predictions made by the CURB model. During a two day period from May 6 to 7, 1992, an aerial flight was taken over the entire Big Otter Cr. and its tributaries to locate specific problem sites. This flight confirmed additional evidence which could not be seen from ground truthing surveys. This additional time-saving measure aided greatly in sampling design and were used to assess the pollution potential for each property.

3.1.1 Land Use Survey and Landowner Questionnaire

Descriptive data on land use was obtained through windshield and ground-truthing surveys. Windshield surveys were conducted by driving along rural roads and taking a visual inventory of each farm adjacent to the creek. The type of farm operation, the size, and the estimated number of livestock was recorded. Ground-truthing surveys were achieved by creating a mailing list of riparian landowners through tax assessment records. Subsequently, the majority of landowners along the Big Otter Cr., Spittler Cr. and Stony Cr. were contacted and personally interviewed. A questionnaire designed to evaluate components of on site farm livestock management, wastewater treatments, and manure spreading practices was administered by Rural Beaches staff. Stream surveys were taken in conjunction with the on site interviews to detect any potential sources of pollution.

3.1.2 Stream Discharge Monitoring

Stream discharge data was utilized from Environment Canada records (inland Waters Directorate, Ottawa, 1990). Stream discharge data from the months of April to September in Big Otter Cr. station no. 02GC010 (Tillsonburg, Ont) was averaged over a 30-year period and entered in LPRCA's HEC-2 Model. However, the HEC-2 model was only applicable for the region from Tillsonburg and downstream towards Port Burwell, so that the time of travel for bacterial loads was estimated from the Tillsonburg area.

3.1.3 Water Quality Monitoring

Water samples were collected from a total of 25 locations (Figure 2) in the Big Otter Cr. and taken to the MOE's Rexdale Laboratory for chemical and microbiological analysis. Sampling began from May 20 1992 and ended July 28, 1992. In sites where water quality problems were suspected, additional water sampling stations were established to confirm the extent of water quality impairments at those locations. Subsequently, an analysis of drainage tile effluent and stormwater inputs was included and compared with background surface water quality data.

Figure 1: The Big Otter Creek Watershed Study Area. Small dots (●) denote farm sites, and stars (★) indicate major towns and villages that were surveyed in this study.

4.0 CURB Model Calculations

In 1988, a computer model was developed by Ecologistics Limited under a contract with the Ontario Ministry of the Environment (MOE). This model, known as the Pollution from Livestock Operations Predictor (PLOP), served as the basic model used by the early participants of the MOE and Conservation Authorities' Rural Beaches Strategy Program.

However, the PLOP model had a number of limitations: Originally, it was designed to model phosphorous loadings. Changes had to be made to make it workable at a watershed scale and to incorporate fecal coliform loadings and other pollution sources (Quinlan, 1992). Another major difficulty with the PLOP model was that it was insensitive to local environmental conditions. Thus, a lot of information was needed to be included in the model to ensure that it was site specific. Literature sources have indicated that bacterial survival was greatly influenced by the ambient climatic conditions (Palmateer, 1988; Khaleel *et al.*, 1980; Baxter-Potter, 1988). Accordingly, several Conservation Authorities have altered the existing PLOP model to reflect local conditions (Bos, 1988).

For the Big Otter Cr. watershed, the Long Point Region Conservation Authority has decided to utilize the model used by the St. Clair Region Conservation Authority (SCRCA) since it incorporates the latest experiments in manure spreading and subsurface loading (P. Mar, pers. comm.). The SCRCA CURB model has been one of the most recent studies that have been done in 1992 and contains up-to-date revisions from earlier versions of the CURB model. Although there are differences in the conditions found in the St. Clair region when compared to the conditions found in the Big Otter Cr., a few changes to the model calculations were necessary to account for these differences.

Figure 2: Water Quality Sampling Sites in the Big Otter Creek CURB Study Area (May-July, 1992).

4.1. Algorithm Calculations

There are a number of algorithms developed to determine the relative contributions of bacterial fecal coliform loads on a farm-by-farm basis. Recent studies made by the Conservation Authorities of Ontario, the Ontario Ministry of the Environment, and the Ontario Ministry of Agriculture and Food have led to the development of each algorithm based on a series of assumptions in combination with the actual experimental data.

4.1.1 Milkhouse Waste Algorithm

This formula gives an estimate of the number of fecal coliform bacteria delivered to the watercourse each year through the discharge of untreated milkhouse washwater. Each dairy farm where no treatment system exists is a potential contributor of this waste. Landowner contact surveys reveal properties where this form of contamination may exist.

MHW LOAD = CONCENTRATION X VOLUME / COW / DAY X NUMBER OF COWS X LOAD DAYS X GROWTH

1) The concentration of fecal coliform bacteria per day in milkhouse washwater entering a drain was assumed to be 2000 FC/L. This figure was based on the studies conducted by the UTRCA (1989).

2) The volume of washwater used was assumed to be 11 litres per cow each day (SCRCA, 1992).

3) The number of cows in the dairy farms of the watershed was taken from survey data. in case of farms not visited, it was assumed that the average number of milking cows from the herd was approximately 35 cows, based on survey averages.

4) The number of load days (discharge days) for a year-round operation was 365 days.

5) Growth of bacteria in the tile drain was found to be 50,000 % based on studies by the UTRCA (1989). The milk substrates enhance conditions for bacterial growth, so that the load increased by 50,000 % by the time it reaches the end of the tile drain.

4.1.2. Livestock Access Load Algorithm

This formula calculates an estimate of the number of fecal coliform bacteria delivered to the watercourse from livestock defecating directly into the stream.

LIVESTOCK ACCESS = FECAL CONC./DEFECATION X EAU X PROB. X EVENTS/DAY X NO. OF ANIMALS X # OF DAYS

1) A fecal coliform concentration of 8.9 E+8 was assumed for each 454 kg steer (1000 lb) (MVCA, 1989; SCRCA, 1992).

2) EAU is the Equivalent Animal Units developed to calculate standardized amounts of manure production based on the size of the animal. These EAU's are found on Appendix A.

3) A probability factor of 0.18 was assumed for each animal defecating in the watercourse during an access event (Demal, 1982)

4) it was assumed that animals enter a watercourse approximately 2.5 times per day on average (Demal, 1982).

5) The number of animals with access was taken from survey data. in farms where a survey was not possible, field counts were made to estimate herd size.

6) The number of days of access was assumed to be 183 days from May 1 to November 1 when cows are normally pastured.

4.1.3 Feedlot and Exercise Yard Runoff Algorithm

This formula gives an estimate of the number of fecal coliform bacteria delivered to the watercourse as a result of runoff from feedlots and exercise yards. In places where the possibility of runoff was noted due to its proximity to the watercourse, an estimate of overland load was calculated. In 10 % of the remaining feedlots in the watershed, bacterial contribution through underground tiles laid around or near barnyards was assumed to occur (SCRCA, 1990).

a) FEEDLOT OVERLAND LOAD = CONC. X VOL X DELIVERY POTENTIAL

or

b) FEEDLOT TILE LOAD = CONC. X VOL X DELIVERY POTENTIAL X (% OF FARMS)

1) Recent studies by the Ausable Bayfield Conservation Authority in 1989 have revealed that the concentration of fecal coliform bacteria in one cubic meter of runoff has an average of 7.5 E+8.

2) Volume of water per cubic meter was calculated using the following formula:

Volume = yard area x annual precipitation x % runoff

where yard area in square meters was taken from survey data or visual estimate; where annual precipitation for the Elgin/Oxford County was on average, 812 mm (Environment Canada, 1986); and assuming that 60 % of rainfall results in runoff while the rest is absorbed of evaporated (MVCA, 1989; SCRCA, 1992).

3) The delivery potential of this bacteria to the nearby stream is assumed to be 80 %. It is assumed that the remaining 20 % is absorbed in the ground through infiltration (MVCA, 1989; SCRCA, 1992).

4.1.4 Manure Stack Runoff Algorithm

This formula estimates the total annual fecal coliform load originating from solid manure stacks with no runoff containment situated within a proximity of 150 meters from the watercourse. All manure stacks in this zone was assumed to contribute bacterial, pollution from overland runoff, while 10 % of all the remaining farms was expected to contribute through subsurface tiles (SCRCA, 1992). The manure stack runoff formula estimates loading regardless of stack shape or size, since these contribute little to the actual bacterial counts measured from rainwater landing on the pad.

OVERLAND MANURE STACK = CONC. X VOLUME X DELIVERY POTENTIAL
RUNOFF

SUBSURFACE MANURE STACK = CONC. X VOL. X DEL. POTENTIAL
(OVERLAND FLOW) % FARMS

1) A concentration of 7.5 E+8 fecal coliforms per cubic meter was assumed in the formula for manure stack runoff based on the findings by ABCA (1989).

2) The volume of water (m^2) that flows through a feedlot was calculated by multiplying the area of yard (m^2) by the annual precipitation (m) and by the percentage runoff that occurs. From studies by Coote and Hore (1978), it was assumed that 60 % of the precipitation that lands in the manure stack results in surface runoff.

3) A delivery potential of 80 % was assigned if the manure stack was located within 150 m of an open watercourse, and where runoff flowed toward the watercourse (MVCA, 1989).

4.1.5. Manure Spreading Algorithm

This algorithm consists of a series of formulae which calculate the fecal coliform load that occurs from manure overspreading. Three separate formulae were used to calculate individual contributions from overland runoff from solid manure, overland runoff from liquid manure, and subsurface tile contamination from liquid manure (SCRCA, 1992).

Since bacterial die-off rates are highly variable depending on the time of the year, separate calculations were made for the loading that occurs from Fall and Winter spreading and the Spring and Summer spreading. This method allows for separate bacterial die-off rates to be factored into each equation.

4.1.5.1 Overland Loading from Liquid Manure Spreading

This formula gives an estimate of the fecal coliform bacterial load that occurs by surface runoff from liquid manure spreading. The formula incorporates the latest findings made by ABCA in 1991 on the average fecal coliform concentrations of liquid manure spread on the field.

LIQUID MANURE SPREADING = VOL X % SPREAD/SEASON X FIELD CONC. X FIELD DIE-OFF RATE X CRITICAL ZONE X DELIVERY POTENTIAL

1) The volume of liquid manure produced per year was calculated by multiplying the number of livestock (producing liquid manure) by their average daily manure production (Appendix B). The product is then multiplied by the number of days the animals are kept confined. Approximately 75 % or 100 % of this manure is kept in storage before actually being spread depending on the survey results.

2) The percentage of liquid manure which is spread per season was calculated from the total liquid manure produced per year. if survey data was unavailable, it was assumed that half was spread in the spring and summer and the other half was spread in the fall and winter (SCRCA, 1992).

3) The fecal coliform concentration per cubic meter of manure spread on the field were taken from work done by ABCA.

4) Dieoff rates on the field which occurs between the time of spreading and the time of precipitation was calculated as:

$$\text{Field dieoff rate} = 10^{-kt}$$

where k is the bacterial decay rate constant (-0.066) (Ecologistics Ltd., 1988) and t is the time (days) between significant rainfall events (15 days).

5) The critical zone, where this form of contamination is likely to occur covers approximately 35 % of the upper Big Otter Cr. watershed. Assuming that manure is spread evenly in this part of the watershed, 35 % would land in the critical zone and would have the potential to runoff.

6) The delivery potential was assumed to be 1 % (SCRCA, 1992). This assumption is based on a 1 % delivery to the watercourse via surface runoff from the critical zone.

4.1.5.2 Overland Loading from Solid Manure Spreading

This formula gives an estimate of the fecal coliform load delivered to the watercourse as a result of surface runoff from the spreading of solid manure.

OVERLAND LOAD OF SOLID MANURE = NO. OF FECAL COL. SPREAD X STORAGE DIE-OFF-RATE X FIELD DIE-OFF RATE X CRITICAL ZONE X DELIVERY POTENTIAL

1) The number of fecal coliforms spread was calculated by multiplying the number of livestock by their average daily manure production. The product is then multiplied by the number of days that the livestock are kept in confinement. This gives an answer of how much solid manure are produced. The manure stored for spreading is calculated based on survey results. The number of fecal coliforms per square meter for specific livestock (Appendix C) is multiplied to this figure to give total fecal coliform production. Since only a portion is spread per season, % spread is calculated from survey data or assumed to be 50 % (SCRCA, 1992) if data was unavailable.

2) Storage die-off rate was assumed to be two orders of magnitude (Thelin and Gifford, 1983).

3) The formula for dieoff 10^{-kt} was used as in 4.1.5.1

4) The critical zone where land is located within 150 m of an open watercourse covers approximately 35 % of the Upper Big Otter Cr. watershed. Assuming that manure is spread evenly along the watercourse, this assumes that 35 % of the manure would land in the critical zone and have the potential to runoff.

5) The delivery potential was assumed to be 1 %. This is based from the assumption that if all the manure that falls in the critical zone, 1% would runoff into the nearby watercourse (from SCRCA, 1992).

4.1.5.3 Subsurface Loading from Liquid Manure Spreading

This formula utilizes the results of a two year study done by ABCA on the subsurface tile contamination resulting from liquid manure spreading. This algorithm was developed by C. Quinlan, SCRCA to depict tile contaminant loading occurring under these conditions.

LIQUID MANURE TILE RUNOFF = VOL. X % SPREAD / SEASON X CONC. (FIELD) X DEL. POTENTIAL

1) The volume of liquid manure was calculated by multiplying the number of livestock (producing liquid manure) by their daily manure production. The product is then multiplied by the number of days that the animals are kept in confinement. Since not all of the manure produced is stored for spreading, survey results were used to calculate how much is stored according to the type of manure storage which is available.

2) The percentage of the total manure available in storage is calculated according to the amount spread in each season. This percentage was taken from survey results. if data was unavailable, it was assumed that 50 % of the manure stored was spread in the fall, while the other 50 % was spread in the spring.

3) The fecal coliform concentrations that exist per volume of manure spread were extrapolated from data collected by ABCA in 1991.

4) Contaminant delivery from the field to the tile drains was assumed to be 0.5 % on average, based on studies collected by ABCA in 1990 and 1991. This delivery was based on the first 24 hours after spreading.

4.1.6 Pasture Land Runoff Algorithm

This formula estimates the number of fecal coliforms delivered to the watercourse from the grazed pasture lands during runoff events (SCRCA, 1992).

PASTURE LAND RUNOFF LOAD = AREA X PRECIP X % RUNOFF X CONC. X CRITICAL ZONE

1) The area of pastureland in square meters was calculated from survey results.

2) A precipitation value of 812 mm was used for the Big Otter Cr. watershed (Environment Canada, 1986).

3) It was assumed that 40 % of the precipitation resulted in runoff from a pasture field. The remaining 60 % is assumed to be absorbed in the environment.

4) The average fecal coliform concentration per volume of pastureland runoff was extrapolated from research made by Crane *et al.* (1983). Although this information was taken from American studies, it was the only data available (SCRCA, 1992).

5) It was assumed that pastureland situated within a critical zone would contribute bacteria from overland runoff. Accordingly, if pastureland was evenly distributed throughout the watercourse, 35 % of the total pastureland would be in the critical zone where bacterial loading of this type would occur.

4.1.7. Septic System Failure Algorithm

This formula estimates the total annual fecal coliform loading that occurs as a consequence of faulty household septic systems.

Faulty septic systems are common throughout Ontario, and in clay soils, the failure rates are usually fairly high.

SEPTIC SYSTEM FAILURES = CONC. X VOL / HOME / DAY X NO. OF DAYS X NO. OF HOMES X % FAILURE RATE X DELIVERY POTENTIAL

1) A concentration of 1.0 E+7 fecal coliform per litre was assumed at the tile outlet (MVCA, 1989).

2) The total consumption of 137 litres/person/day was assumed for household wastewater consumption (UTRCA, 1988). in the watershed, the average number of persons/household is 3 (Norwich and Bayham Municipal Township Offices, pers comm.). The current population in rural communities was found through municipal records.

3) Permanent septic systems are assumed to be functioning for 365 days a year.

4) The current number of homes in the Big Otter Cr watershed was taken from municipal township records and was also counted through 1:50,000 topographical maps.

5) A failure rate for septic systems was assumed to 40 % for the village of Burgessville (Oxford County Health Unit, pers. comm.), 30 % for the town of Otterville (Oxford County Health Unit, pers. comm.), and 40 % for the village of Vienna (Elgin-St. Thomas Health Unit, pers. comm.). All of these villages and towns are situated on clay type soils, where these failure rates are not unusual. in the rural farmsteads, the septic system failure rate was assumed to be 10 %, since many of these are on sandy soils and are located far from the watercourse.

6) it was assumed that 50 % of the total water consumption was reaching the tile outlet and the watercourse. in other words, it was assumed that the septic systems treated at least half of the wastewater volume.

4.1.8. Urban Non-Point Source Algorithm

This formula estimates the bacterial fecal coliform contribution delivered from urban and storm-sewer runoff from towns and villages which are believed to impact the watercourse.

URBAN RUNOFF LOAD = FECAL COLIFORM CONC. / HECTARE X AREA (ha)

1) The average concentration of fecal coliforms in urban runoff coming from low density centres (Less than 50 people/hectare) was found to be approximately 3.1 E+10 fecal coliforms per hectare (Marsalek, 1978).

2) The areas of urban runoff in Burgessville, Norwich, Otterville, Tillsonburg, Vienna, and Port Burwell was estimated by a digital planimeter from a 1:50000 topographical map.

4.1.9. Sewage Treatment Plant Algorithm

This formula estimates the contribution from sewage treatment plant facilities (STP) located on villages and towns which are large enough to accommodate these systems. Accordingly, information on the operation of sewage treatment facilities on the Big Otter Cr. watershed was obtained from the operators of the Ministry of the Environment Water Pollution Control Plants in the Town of Tillsonburg and the Village of Norwich. Port Burwell's sewage treatment plant is located in the mouth of the Big Otter Cr. The plant is operating at a 30 % capacity (W. Winegarden, pers comm.), so that effluent which is discharged into the river is assumed to be very low.

SEWAGE TREATMENT LOAD = MEAN FECAL COL CONC. X VOL. OF DISCHARGE

1) For the Tillsonburg Water Pollution Control Plant, operational records showed that effluent was discharged continuously throughout the year (R. Andrews, pers comm.). in this calculation, it was assumed that summer fecal coliform concentrations reflect the highest levels and are significant with respect to the water quality of the beaches (ie. winter counts are negligible). To calculate the mean fecal coliform concentration, effluent samples from April to September 1992 were examined. A value of 98 FC/100 ml was used represent average loading conditions.

2) For the Norwich Sewage treatment plant, operational records revealed that sewage was kept in sewage lagoons. These lagoons were subsequently discharged in early spring soon after the ice had melted, and again in the fall just before freeze-up occurred. No data on fecal coliform loads was available from the effluent released from these lagoons (MOE, pers comm.). Discharge readings were obtained and a value of 64 FC/100 ml (from SCRCA, 1992) was assumed to estimate the average fecal coliform levels in these lagoons.

4.2.0 Manure Spills Algorithm

This formula accounts for the total annual fecal coliform load to the Big Otter Cr. watershed as a result of manure spills. information on the occurrences of manure spills was obtained from the Ministry of the Environment Abatement Section at the London district office.

On average, it is assumed that London district office has received approximately 2 occurrences of manure spillage in a given year on the Big Otter Cr. watershed (D. Beretta, pers comm.). These spills are often associated with the tile contamination from the spreading of liquid swine manure.

MANURE SPILL LOAD = VOL/SPILL X FECAL COL. CONC. X SPILLS/YEAR

1) The actual volumes of each spill was not known. in SCRCA 's CURB Model, it was assumed that an average spill would deliver 22,750 litres or 5,000 gallons of manure to the watercourse. This is equivalent to an amount held by two liquid tankers of manure. This amount only incorporates the actual contamination caused by spillage, which does not take into account the results from tile contamination from manure spreading.

2) Samples collected by the SCRCA from liquid manure storages and fields immediately after application of liquid swine manure showed a geometric mean concentration of 290,000 fecal coliforms per litre (SCRCA, 1992).

3) According to the SCRCA, spills from equipment failure and discharge account for approximately 10 % of the reported spills. Since there are approximately 2 spills reported each year, so that the load was multiplied by a factor of 2.

4) This algorithm likely underestimates the manure spill contribution in the upper Big Otter Cr. watershed. Manure spills are often unreported, and there has been several unconfirmed accounts of manure discharges occurring at night in this region as reported by local residents.

5.0 Bacterial Loading to the Big Otter Cr. Watershed and Beaches of Port Burwell

This section is grouped into two parts: Agricultural loadings to the Big Otter Cr. and its tributaries, and a summary of all loadings and its significance to the target areas of the Port Burwell Beaches. Since CURB is a program designed to provide remedial funding for agriculturally related sources of pollution, it is felt that all agricultural problems should be viewed individually to determine which agricultural practice is likely to be the most contributing in terms of bacterial load to the watercourse.

On the other hand, when viewing the entire model with respect to the bacterial levels at the beaches of Port Burwell, agricultural problems may not be the main cause of the water quality impairments. Agricultural contaminant loadings in the Big Otter Cr. watershed are generally more concentrated in the upstream clay areas north of Tillsonburg. Because of its proximity to the target beach area, these problems may not rank highly in significance when compared to a contaminant problem originating within a few miles from the beach area.

5.0.1. Continuous and Event Related Pollutants

The sources of bacterial pollutants in the Big Otter Cr. watershed can be categorized as either continuous or event related discharges. Continuous discharges are those sources which contribute bacteria to the watercourse continuously regardless of weather conditions. Continuous discharges may occur on a daily basis, or depending on the frequency that these activities take place. Sources of continuous loads include milkhouse washwater wastes, livestock access to streams, liquid manure tile contamination, manure spills, septic system discharges or household wastes, and effluent from urban sewage treatment plants.

In the case of event or pulse related contaminant loading, the pollutant load occurs only during specific precipitation events. During periodic rainfall events, runoff from manure stacks, feedlots, and urban areas are contributing, as well as overland flow from manure spread in fields.

5.1 The Bacterial Transport Model

When deducing the impacts of individual bacterial inputs to the target beach area, a bacterial transport model is used which consists of decay function :

$$N_t = N_o \times 10^{-kt}$$

Where N_t = the number of bacteria delivered to the beach per season
N_o = the initial number of bacteria delivered to the stream per season (algorithms).
k = bacterial decay rate
t = baseflow or event travel time to the target area in days

These parameters of bacterial travel time, decay rates and their relevance to the equation are explained in the following manner :

5.1.1. Bacterial Travel Time

Bacterial travel time is defined as the time that it takes for bacteria to travel from its source to its destination in the beach area. The travel time for bacteria is directly related to streamflow velocity and varies during high flow and low flow events. Accordingly, continuous discharges would be present in the stream during baseflow conditions, while event related discharges are present during high flow conditions. Therefore, differences in travel time and hence bacterial die-off would occur during high and low-flow conditions.

In order to estimate bacterial travel time, the following assumptions were made: First, it was determined that livestock based agricultural practices were centred on the town of Otterville. Otterville was located at approximately the midpoint between Tillsonburg and the headwater areas of Holbrook. Assuming that all sources were evenly distributed throughout the watershed, travel times to the beach area were estimated from this midpoint using the LPRCA's HEC-2 model streamflow forecasting system. Secondly, separate travel times for bacterial sources from Tillsonburg and Vienna were calculated based on the HEC-2 model. Finally, high and low flow travel times were calculated from monthly mean discharge records at the Provincial Water Quality Monitoring Network (PWQN) station #02GC010 at Tillsonburg. Maximum discharge values were used to represent high flow, and minimum discharge values were used to represent low flow in LPRCA's HEC-2 model.

5.1.2. Bacterial Decay Rates

Bacterial decay rates for the Big Otter Cr. was estimated at various times of the year. A number of bacterial die-off studies were undertaken by the Conservation Authorities of Ontario (MTRCA, UTRCA, ABCA, LSRCA) and the MOE and showed variable results. it was shown that decay rates varied with stream conditions such as dissolved organic carbon, temperature, pH, turbidity and nutrient levels. Based on these studies, two decay rates were chosen : a high flow decay rate of 0.26 logs/day and a low flow decay rate of 0.35 logs/day. A high flow decay rate of 0.26 logs per day was assumed to reflect conditions found in the Big Otter Cr. from by comparing its water chemistry to those studies where this type of decay rate was often found. Similarly, a low flow decay rate of 0.35 logs/day corresponds to values obtained under similar conditions.

5.1.3 Timing of High Flow and Low Flow Events

For the purposes of beach closure prevention in Port Burwell, the bacterial transport model used in this study is based on a 180 day loading period from April to September in a given year. This period is the time in which bacterial survival is highest due to warming conditions. it is these bacteria that are of fundamental importance, since it is often assumed that the majority of bacteria were unable to survive the overwintering period to be of significance to summer beach closures (D. Hayman, pers. comm.).

The timing of rainfall events for the purposes of the LPRCA CURB model is once every 14 days (SCRCA, 1992). Because of the paucity of available data, and yearly variations in weather patterns, this figure was used to simulate loading conditions occurring in a typical year. Assuming that high flow occurs during the time of rainfall and a day after, rainfall events would occur 13 times out of the 180 day period. Thus, it is assumed that the Big Otter Cr. would be in high flow for 26 days, while the remainder would be in baseflow condition.

6.0 CURB Model Predictions

Overall, the LPRCA's CURB model was divided into four parts.
These are :

a) Agricultural loads to the Big Otter watershed (main branch)

b) Agricultural loads to the tributaries (Spittler Cr., Branch Cr. and Stony Cr.).

c) Annual bacterial loads to the Big Otter Cr. from all sources.

d) Pollutant loading model for the Lake Erie beaches of Port Burwell.

6.0.1. Agricultural Pollutant Loading

On an annual basis, the agricultural sources of bacterial pollution on the main branch of the upper Big Otter Cr. watershed is shown in Figure 3. The relative contribution of livestock access constitutes approximately 74 % of the input, followed by rural septic system failures (13.6 %) and milkhouse washwater wastes (6.1 %). Event-related farm practices such as pastureland runoff, manure spreading and barnyard runoff contribute less than 5 % of the bacterial loading that occurs in the main branch (Figure 3a).

In the tributaries of Spittler Cr., Branch Cr. and Stony Cr., the relative contribution of livestock access is greater and is predicted to have 90 % of the agricultural bacterial load. The remainder of the problems consists of rural septic systems (3.6 %), milkhouse wastes (2.5%), pastureland runoff (1.9 %), manure spreading (1.8 %) and barnyard runoff (0.4 %) (Figure 3b).

6.0.2 Annual Bacterial Loads to the Big Otter Cr. Watershed

From all sources, urban septic systems (49 %), livestock access to streams (32 %), and urban non-point source runoff (14 %) contribute the greatest extent of the fecal coliform contamination throughout the Big Otter Cr. (Figure 4). There is evidence of urban septic system failure in Burgessville, Otterville, and Vienna as reflected by routine water quality testing by LPRCA CURB staff in the summer of 1992. The extent of these problems are unknown, but it isn't surprising that faulty urban septic systems are a much greater problem than agricultural sources. Rural towns situated in clay areas are often unsuitable for septic tank systems. in the Village of Vienna, water tests by the MOE conducted from the storm sewer system revealed fecal coliform bacterial counts ranging from 2500 FC/100 ml to 670,000 FC/ml. Corresponding counts from *Pseudomonas aeruginosa* showed counts of 24/100 ml to 460/100 ml respectively. Since *P. aeruginosa* is known to be a direct indicator of human fecal wastes, it is apparent that effluents entering the stream from the sewer system are septic.

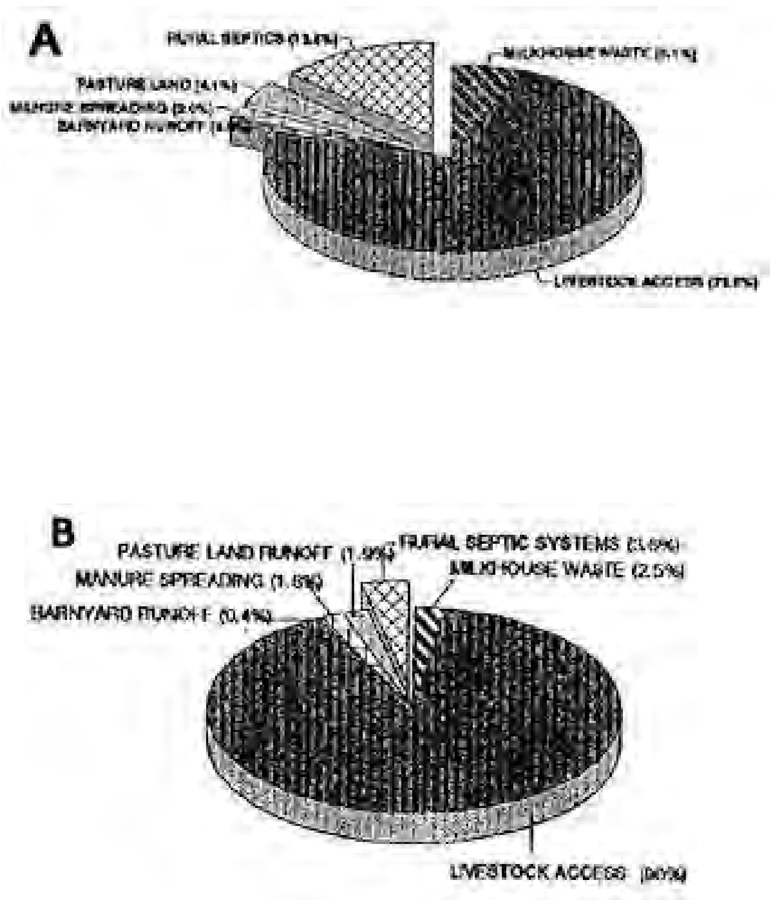

Figure 3: Relative contributions of agricultural non-point bacterial loading in the Big Otter Creek and tributaries as shown in (a) main branch of the Big Otter Creek; and (b) tributaries in Spittler, Branch, and Stony Creek.

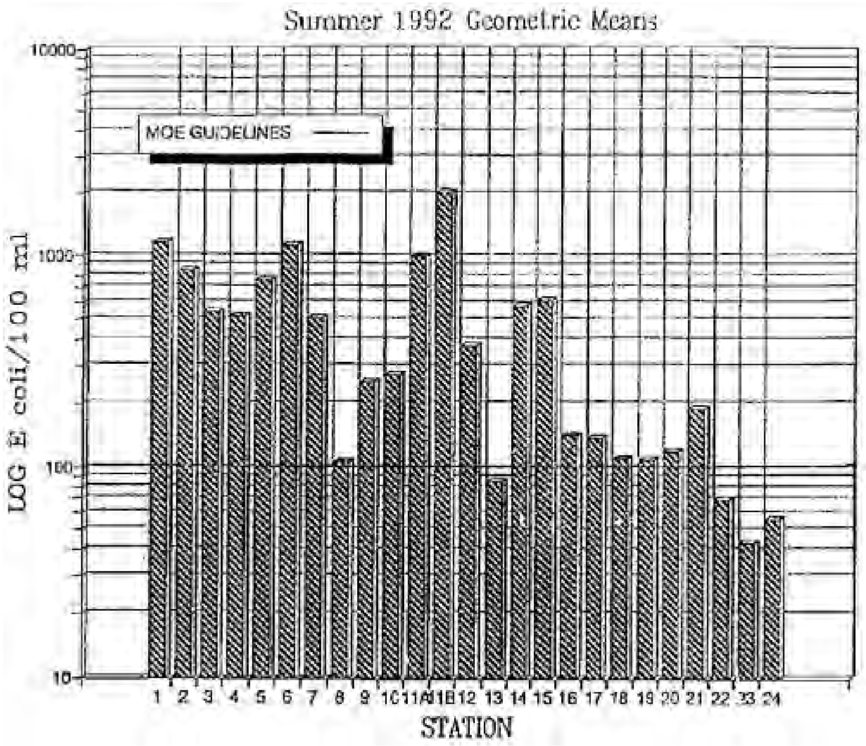

Figure 4a: Spatial geometric mean *E. coli* counts at stations in the Big Otter Creek Watershed. Samples (n=5) were taken from May 20 to July 28, 1992.

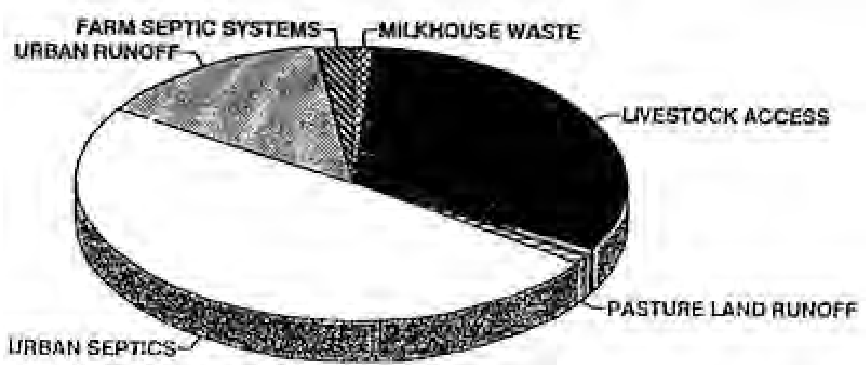

Figure 4b: Relative annual contributions of bacterial pollutant loads in the Big Otter Creek from all sources.

6.0.3 The Pollutant Loading Model for the Lake Erie Beaches of the Port Burwell Region

Figure 5 shows the pollutant loading model from the Big Otter Cr. watershed. From this perspective, the pollutant model illustrates the significance of pollutant loads ranked, with respect to their potential to deliver bacteria to the beach. Therefore, when differences with travel time are incorporated in the model, the prediction shows that the downstream septic systems in Vienna contributes approximately 66 % of the bacterial loading to the beaches because of its closeness to the beach site. Uncontrolled livestock access accounts for approximately 18 % of the bacterial loading and is the biggest agricultural contributor. The other contributors are upstream septic systems (9.5 %) and urban runoff from the town of Tillsonburg (3 %). The fact that other agricultural sources contribute less than 5 % of the bacterial loading to the beaches can be explained by their location with respect to the beach area. The majority of livestock based agriculture was confined to the headwater regions and tributaries where there was little baseflow during the summer months. Thus, agricultural operations would be expected to contribute mainly during precipitation events, which enable bacteria to reach the beach in a relatively short time.

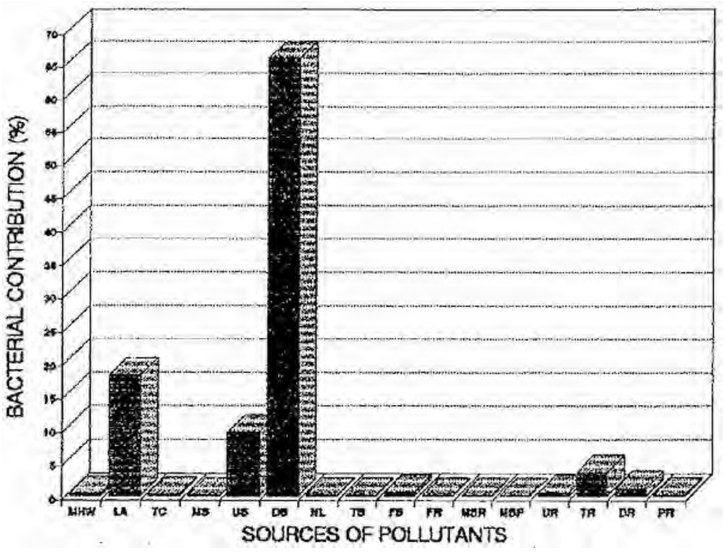

Figure 5a: Pollutant -source loading predictions for the Lake Erie beaches of Port Burwell from Big Otter Creek sources.

(MHW-milkhouse waste, LA-livestock access, TC-tile contamination, MS-manure spills US-upstream septics, downstream septics, NL-Norwich lagoon, TS-Tillsonburg treatment plant, FS-farm septics, FR-feedlot runoff, MR-manure stack runoff, UR-upstream urban runoff, TR-Tillsonburg urban runoff, DR-downstream runoff, PR-pasture runoff)

Bacterial Transport Model

Beach Loading Model	Time Frame April-Sept 183 Days	Time Of Travel Days (HEC-2)		Die-off Rate Logs/day	Total Summer Beach Load		Total Load By Freq. Of Events		Beach Load
CONTINUOUS SOURCES		STORM	BASEFLOW		STORM	BASEFLOW			
Milkhouse wastes	1.64E+12	2.2	4.15	0.35	2.78E+11	5.78E+10	3.89E+10	4.97E+10	8.85E+10
Livestock access	9.26E+13	2.2	4.15	0.35	1.57E+13	3.27E+12	2.2E+12	2.81E+12	5.01E+12
Tile contamination	7.23E+11	2.2	4.15	0.35	1.23E+11	2.55E+10	1.72E+10	2.18E+10	3.91E+10
Manure spills	1.32E+09	2.2	4.15	0.35	2.24E+09	48548897	31371855	40032051	71403706
Septic system discharges									
upstream	4.88E+13	2.2	4.15	0.35	8.29E+12	1.72+12	1.18E+12	1.48E+12	2.84E+12
downstream	2.15E+13	0.125	0.21	0.35	1.84E+13	1.81E+13	2.72+12	1.58E+13	1.83E+13
Sewage Treatment plant									
Norwich	1.16E+11	2.2	4.15	0.35	1.98E+10	4.11E+09	2.77E+09	3.53E+09	8.3E+03
Tillsonburg	7.22E+10	1.1	2	0.35	2.97E+10	1.44E+10	4.16E+09	1.24E+10	1.65E+10
Farm septics	2.85E+12	2.2	4.15	0.35	4.84E+11	1E+11	6.77E+10	8.84E+10	1.54E+11
EVENT RELATED SOURCES									
Feedlot runoff	1.64E+11	2.2		0.26	4.4E+10		8.17E+09		8.17E+09
Manure stack runoff	7.15E+10	2.2		0.26	1.92E+10		2.88E+09		2.88E+09
Manure spreading runoff	2.58E+11	2.2		0.26	6.87E+10		9.62E+09		8.62E+09
Urban stormwater runoff									
upstream	4.13E+12	2.2		0.26	1.11E+12		1.55E+11		1.55E+11
Tillsonburg	1.36E+13	1.1		0.26	7.02E+12		9.83E+11		9.83E+11
downstream	2.32E+12	0.125		0.26	2.16E+12		3.02E+11		3.02E+11
Pastureland runoff	1.22E+12	2.2		0.26	3.27E+11		4.58E+10		4.58E+10

Figure 5b: CURB bacterial transport model for the Big Otter Creek.

7.0 Costs of Reducing Bacterial Inputs

The abatement strategies and funding allocations of the CURB grant plan are aimed towards the most cost-effective improvements to water quality. The CURB program is an environmental program and by its nature, it is not equitable to everyone. The program attempts to help the environment by reducing sources of water pollution, ultimately decreasing bacterial levels at local swimming beaches through the use of funding incentives available to landowners.

To find the most cost effective solutions, the research phase of the CURB program utilized mathematical modelling techniques and water quality testing to isolate the nature of the pollutant sources, to estimate pollutant loads, and to establish a ranking of sources in terms of their degree of impact. Thus, when a large number of pollutant sources have been identified, decisions for funding allocation is prioritized according to those which have the most potential for pollution.

7.1 Implementation Strategies

There are three basic alternatives which may be used to address the problem sources of the Big Otter Creek watershed :

a) The first strategy is to promote improvement to the existing water quality of the Port Burwell beach by reducing impacts from the Big Otter Creek. According to this strategy, ranking of bacterial sources would be based on their potential to impact the beach. The advantage of this strategy is its benefit to the regional economy of the Port Burwell region through increased tourism and recreational opportunities from the enhancement of swimming opportunities at local beach areas.

b) The second strategy is to target the widespread reduction of all agricultural sources of bacterial contamination throughout the entire watershed. Although the goal of the CURB program is targeted toward improvement of beach water, other sources of pollution occurring in regions far from the beach may be low in priority and would not receive any benefit from the program. By shifting to the watershed-based approach, all significant sources are weighted equally and would qualify for funding.

   Despite the impact of agricultural wastes on upstream water quality of the Big Otter Creek, little remedial work could be done if funding eligibility was based on the distance of the pollution source to the Port Burwell beach. By implementing a watershed based-strategy, CURB funding could be used to accomplish a greater overall reduction of bacterial input at a local level, allowing a greater share to be accessible to rural landowners in upstream areas. Funding 'eligibility would then be based on the propensity of the individual farm to pollute, which could benefit a greater portion of the agricultural community. This strategy would encourage prudent land stewardship and result in improved water quality through reduced agricultural input, fisheries habitat restoration, and stream rehabilitation.

c) Do nothing - This approach will be taken if projects undertaken are not high on the overall priority list with regards to the state of present water quality, or the promotion of better land stewardship practices through public awareness.

7.1.1 Implementation Strategy # 1.

The ranking of bacterial inputs to the Port Burwell beach from Big Otter Creek sources as predicted by the CURB model (6.0.3) is shown as follows:

Sources	Contributions
Vienna	66.0 %
Livestock access	18.0%
Upstream town and village septic systems	9.5%
Tillsonburg non-point runoff	3.0%
Other Agricultural contributors	3.5%

Potential Solutions:

Source #1 Vienna Septic Problems

The CURB model predictions suggest that mitigation of septic problems in the village of Vienna is the first priority in reducing bacterial input to the Port Burwell beaches. In 1992, the Village had population of 434 residents. Surface water quality tests (Figure 4) have shown that bacteria levels have a tendency to decrease in the Norfolk Sand Plain region, which may be explained by higher bacterial die-off in sandy soils, dilution from groundwater input through the sand aquifer, or the scarcity of livestock agricultural operations in sand regions. However, it is apparent that an increase in the level of bacterial indicators occurs downstream of the Village of Vienna. In the majority of water samples tested downstream and at specific tile outlets at the village, analytical results suggested that the range and magnitude of bacterial counts likely originated from human sewage.

At certain weather and wind current conditions, bacterial pollution from Vienna's tile outlets could pose a risk to swimmers at Port Burwell. Presumably, the Village's close proximity to the target beach would lead to high probability of pathogen survival because of the short travel time to the stream mouth. It is assumed that during rainfall events, bacterial travel time would be faster due to higher flows.

Although there is a high probability of pathogen survival at the streammouth, contamination to the beach would likely be minimized by the presence of breakwalls. These breakwalls are found along either side of the streammouth and act as barriers by preventing direct mixing of contaminated water in beach areas situated east and west of the stream mouth. The probable mechanism for bacterial transport involves adsorption of bacteria to fine silt and clay sediments, which are deposited as a plume. In order to reach the beach, sediments must first be displaced offshore to the end of the barriers and then moved shoreward by wind currents and wave activity. This may explain why the geometric mean levels of bacteria taken at the beach sites to the east and west of Port Burwell during the summer tended to be fairly low.

The abatement section of the Southwestern Region Ministry of the Environment is considering the feasibility of a sewage treatment plant for waste water in Vienna. Since this project represents a major capital expenditure, it could be regarded as a last resort measure if a more economical means of treatment could be met within the scope of the CURB Program.

Sewage Treatment Options

Prior to the commencement of any work, an environmental assessment study would be required to identify the options available for the village. it would include options for providing additional waste water treatment capacity for future population expansion, alternative strategies for achieving secondary effluent quality, and an evaluation of pumping requirements.

Due to site specific factors, there are limited options for sewage treatment in the Vienna. One of the main reasons is that the Village is on a floodplain, which makes it difficult to construct any type of permanent structure to house a water treatment unit. The main core of the Village consists of commercial and residential buildings and is situated entirely within regional floodline limits. Along either side of the flood plain, an increase in elevation occurs to the east and west bank, and along the roadway leading south to Port Burwell. The predominance of clay soils in the vicinity and the lack of adequate lot sizes in majority of the properties have made septic systems prone to failure. The exact source of septic failure, evidenced by sewage seepage, blowouts or illegal hookups to storm drains, are often very difficult to detect. in an attempt to assess the overall condition of septic systems in the Village, the MOE handed out surveys to residents to increase the homeowners' level of understanding regarding septic maintenance and failures, and to obtain permission to dye test some of the suspected problem areas. Dye testing began in the summer and in the fall of 1992 to determine the number and approximate locations of faulty septic systems.

As an interim solution, an idea which has been suggested by Mr. Wayne Winegarden, a public health inspector for the Elgin-St. Thomas Board of Health, may involve the temporary installation of a holding tank at a vacant lot near the worst areas. According to Mr. Winegarden, the main problem area may be located on a section of Front St between Oak St. and Main St.(Figure 6). This area is presumably the oldest section of the village, and as the settlement grew, many of the buildings are still known to have inadequate lots for a proper septic disposal system, in the proposed plan, the existing road allowance on either side of the street could be utilized for the installation of a manifold collection system. if the major problem area was indeed confined to these locations, a system involving a collection of waste water from failing septic tanks (via a small diameter gravity sewer system) leading to a covered, in-ground holding tank near the effluent discharge could be utilized to prevent further contamination from reaching the Big Otter Creek. Assuming that solids remained in the existing septic tanks and cannot clog sewer mains, operation and maintenance costs could be minimized.

One of the major advantages of a sewage collecting system is that it can be hooked up directly to a waste water treatment facility when future need becomes greater. The anticipated cost of this system is the capital cost of installation and diversion of septic hookups from storm sewer system, the instalment of a holding tank, and the pumping (operational) costs of this holding tank (Note: No cost estimates are available at this point).

As an alternative, other existing septic systems with adequate lot sizes for a proper tile bed may receive finding for repairs through a conditional basis. in some sites, the Elgin-St. Thomas Health Unit has already approved septic system upgrades on a basis of non-conforming status. These approvals are aimed at making the best of an existing situation, which clarifies the need to fix a failing system immediately.

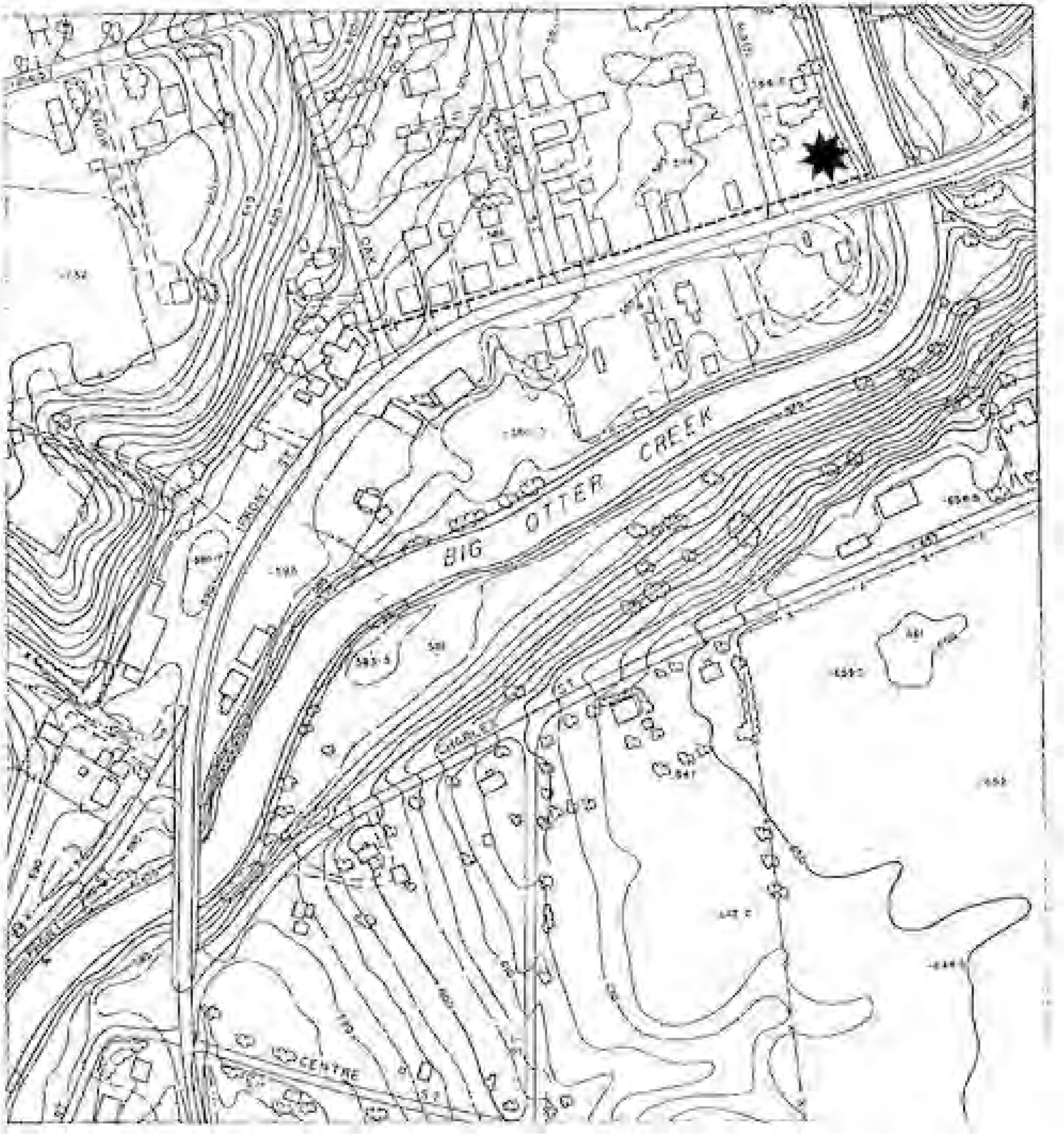

Figure 6: A section of Vienna adjacent to the Big Otter Creek showing the location of possible problem area. Possible solution may involve the use of a collection system (- - - -) and a temporary sewage collecting tank (★).

If Vienna residents wish to correct septic systems on an individual basis the estimated unit cost of repairing faulty septic systems is approximately $4000.00/ per system. When applied to a population of 434 at a septic system failure rate of 40 %, the total estimated cost is as follows:

 # HOMES X FAILURE RATE X $4000.00/HOME = $231,146.67

Composting Toilets (Demonstration Project)

As a further alternative, composting toilets may be introduced as a form of decentralized waste treatment for the village. Decentralizing the sewage treatment process eliminates the need for large quantities of water and energy to transport wastes. Currently, the composting toilet system is utilized in parts of Sweden and the United States as an alternative waste management strategy.

By implementing a waterless toilet system, daily waste water production is reduced by about 45 % or approximately 30 gallons per person/per day (Ecology House, unpublished data). Studies indicate that the adoption of composting toilets could not only generate significant benefits on the subject of water conservation, but could result in savings of sewage bills, energy, and the infrastructure required to collect sewage from homes (Wynia *et al.*, 1990).

The CURB Program could provide an incentive for landowners to introduce the concept of composting toilets to the village as a funded demonstration project. Such a project would provide an opportunity to test the efficacy of composting toilets in a rural area, and would become an educational vehicle for participants and the broader public through media coverage. The cost is comparatively cheaper than a septic system, with the estimated cost of a composting toilet unit at approximately $1200.00 to $1500.00 per unit. The composting toilet is manufactured in Ontario and is available from Sun-Mar Corporation, Burlington. The incentive to change to this type of system could encourage a greater sense of responsibility for waste among rural residents and is in-line with the changes in social attitudes which are manifested in the form of recycling cans, bottles and paper. The estimated costs of installing composting toilets for each home is calculated as follows:

 # HOMES X FAILURE RATE X $1500.00/HOME = $86,800.00

Other Existing Alternatives (Non-CURB)

These forms of treatment are non-eligible for CURB assistance but are included in the CURB plan to show the range of available options:

(a) Package Sewage Treatment Plants - These systems are widely used in Ontario and provide waste water treatment primarily through an extended aeration process to serve a small number of housing units which cannot be served by municipal sewers due to isolation, economic reasons or phasing of development (PLUARG, 1977). The effluent is of high quality and is suitable for discharge providing that the assimilation capacity of the Big Otter Creek is sufficient. The advantage of this system is its flexibility to local conditions. The disadvantage of this system is its cost: The capital cost required for a package plant typically range from $250,000.00 to $500,000.00. However, this figure is expected to increase to approximately $1,000,000.00 when installation costs such as sanitary sewer system hook-up are added (C. Demeyre P.Eng. pers comm.).

b) Pumping sewage from Vienna to the Village of Port Burwell - this option is conditional upon an agreement that the town of Port Burwell is willing to accept sewage from the village. As of November 1992, the existing sewage treatment plant in Port Burwell is operating at a 30 - 50 % efficiency and can accommodate the sewage load from Vienna (W. Winegarden, pers comm.). The capital cost estimates are expected to be approximately $800,000.00 because of a need for a forced main required to pump the sewage uphill to Port Burwell (C. Demeyre P.Eng, pers comm). A pumping chamber may also have to be installed to handle excessive solids.

c) Biological treatment of waste water - These systems involve the cultivation or maintenance of microorganisms which consume or convert the contaminants in waste water. The most common examples are activated sludge, Rotating Biological Contactors (RBCs), Trickling Filters, Waste Stabilization Ponds, Land Treatment, and Proprietary Technologies. A high quality effluent is produced, along with residue or sludge coming from the treatment process. in Ontario, the activated sludge process is the most commonly used secondary treatment of municipal waste water because of its proven track record, its capability to provide the required effluent quality, and its suitability for small plants. Aside from the major drawback associated with its cost, the constraints posed by the local climate/temperature conditions, land requirements, compatibility with the surrounding land, and the concern for ground water contamination may favour the use of activated sludge as a last resort alternative (No costs are available at this point until all other alternatives have been explored).

Source # 2 Livestock Access

CURB model predictions suggest that uncontrolled livestock access to the watercourse is among one of the main agricultural impacts affecting the Big Otter Creek and the beaches. Since cattle pasturing adjacent to watercourses has been a tradition in many parts of the watershed, it remains as one of the hardest practices to break. To many farmers, the restriction of cattle from watercourses does not appear to provide a great advantage because improvements in production and herd health are not often associated with poor water quality (Ryan, 1989). in addition, it is often considered as inconvenient and costly. Many parts of the Big Otter Creek can be difficult to fence because of the meandering nature of the stream, and the difficulty in repairing damaged fences during flood conditions. Fencing streams often requires increased labour because of the necessity for extra maintenance and clearing vegetation in and around fence rows. in spite of these concerns, the removal of livestock from a watercourse can have an immediate effect on water quality, and has the greatest potential for cooperation between resource agencies and user groups. Benefits to fisheries can also be very significant (Ryan, 1989).

The areas which could be enhanced by controlled livestock access are shown in Figure 7. in parts of Spittler, Stony and the Big Otter Creek headwaters, the need for livestock restriction to streams should become a priority over all other agricultural applications wherever dairy operations are involved. Many parts of the tributaries have potential to support a warm water fishery and could recover from increased stream bank stabilization, reduced siltation and lower fecal coliform bacterial levels. Nevertheless, total exclusion of livestock is not always feasible nor cost effective in intermittent streams, small drains, or where the stream exhibits extensive meandering.

Figure 7: Proposed Remedial Plan for bacterial reduction in the Big Otter Creek Watershed (Legend: ▦ - controlled livestock access sites; -▬ sewage treatment sites).

The estimated cost of fencing watercourses is approximately $0.80/ft. for a 3 strand high tensile electric type of fencing to a more expensive page wire at a price of $2.00/ft. The cost of a cattle fencing project may be highly variable depending upon the nature of the project (ie. whether the project involves fencing both sides of the creek, installing a water pump or a culvert crossing). The cost installation of a culvert crossing is estimated to be in the range of $3,000.00 to $5,000.00 (T. Briggs, UTRCA, pers comm.). In addition, a value of $1000.00 is added for the estimated cost of backfill, erosion protection and the cost of providing an alternate watering system.

In the watershed, the total length of streambank which requires fencing has been calculated from a 1:50000 topographical map. The total length of fencing required for 100 % exclusion of all livestock from the watercourse was estimated as follows :

Location	Length of Fencing Required m	 (ft.)
Big Otter Creek		
upstream section (5 sites)	3,500	11,482.94
downstream section (1 site)	100	328.00
Spittler Creek (12 sites)	8,900	29,199.47
Stony Creek (3 sites)	1,750	5,741.47
Total	14,250	46,751.98

Assuming that each site would require the fencing of both sides of the watercourse, the total cost for page wire fencing at $2.00/ft is estimated to be (46,751.98 ft x 2 sides x $ 2.00/ft) $187,007.92. The cost of providing an alternate watering device for all sites is an additional (21 sites x $1,000.00/per site) $21,000.00. Thus, the total cost of eligible projects that would be used to mitigate livestock access problems in the watershed is $208,007.92.

Source # 3 Upstream town and village septic systems

The CURB model predicted that bacterial input from upstream towns and villages was among the third highest source of pollution to Port Burwell Beaches. As in Vienna, the rural Village of Burgessville and the Town of Otterville both contribute significant amounts of bacteria through faulty septic systems. In Burgessville, the CURB model assumes that septic system failures are 40%, whereas in Otterville, the failure rates are assumed to be 30 %. The estimated costs for reducing these inputs are calculated as follows:

 # HOMES X FAILURE RATE x $4000.00/PER HOME

For the village of Burgessville, the cost for septic system improvement is approximately (120 x 0.40 x $4000.00) $192,000.00. For the town of Otterville, the cost is approximately (280 x 0.30 x $4000.00) $336,000.00.

Source # 4 Tillsonburg non-point source runoff

Urban non-point sources of bacteria from the town of Tillsonburg and other towns originate mainly from storm-sewer runoff. Urban and suburban development typically result in large, impervious areas that shed water during rainstorms. Although a water treatment facility exists in Tillsonburg, high bacterial counts have been detected in 1992 water samples of storm water drains to Lake Lisgar. The apparent causes of these bacterial sources are not yet fully understood.

Presently, the remedial action needed to correct urban runoff are not applicable to the CURB funding program. However, the implementation of the "Lake Lisgar Rehabilitation Plan", which will be funded through an alternative funding plan, will have a positive effect on clean-up efforts in Lake Lisgar through reduction of bacterial inputs, heightened public awareness, and shoreline stabilization.

Source #5 Other agricultural contributions

Collectively, other agricultural contributors such as farm septic systems, manure spreading practices, milkhouse waste water runoff and manure spills account for a small percentage of the bacterial input at the Port Burwell beaches. As mentioned earlier, these agricultural contributions were situated in upstream tributaries of the watershed and constitute a local impact on headwaters. Nevertheless, of all local impacts in these areas, the most apparent source of animal wastes which has been reported by area residents comes from the handling of liquid swine manure.

Manure wastes in confined swine operations are often handled in a liquid form because of the difficulties involved in managing solid manure systems, the added labour, and the cost of bedding. Liquid manure is considered an environmental hazard not only because of its toxicity, but its potential to contaminate watercourses. Liquid manure spreading under saturated soil conditions has been known to contaminate field tiles in a matter of a few minutes (ABCA, 1991). Manure spills from tank overflows and spreading equipment have also been known to pollute the upper tributaries of the Big Otter Creek and Stony Creek and resulted in fish kills.

Landowner interviews during the summer of 1992 revealed that there are two main causes of liquid manure pollution in the watershed: First, the farmer simply does not have enough containment space to eliminate the need for untimely spreading, or to contain precipitation. Secondly, the farmer either irrigates on wet soils, and in insufficient land space, and overspreads on sloping ground resulting in tile and overland flow contamination. Still, in other cases, some dairy operations have also reported a need for manure storages and milkhouse waste water treatment. Notwithstanding, these contributions were not significant compared to the problems resulting from handling of swine manure. The estimated costs for the construction of liquid manure storages in Ontario (1991) were listed as follows:

Concrete Circular Manure Storage Pit

Type	Size	Cost Estimate
	W D	
Open	60' X 12'	$22,000.00 - $25,000.00
	50' X 12'	$17,000.00 - $18,000.00

(Note: the cost of a safety fence at approx. $42.00/m would also be added to the cost of an open circular manure pit.)

	W D	Cost Estimate
Covered	60' X 12'	$30,000.00 - $32,000.00
	50' X 10'	$28,500.00

Square/Rectangular Concrete Inground Liquid Manure Storage

Type	Size L W D	Cost Estimate
Under Barn	200' X 12' X 9'	$25,000.00
	24' X 60' X 8'	$26,000.00
Open	50' X 50' X 8'	$20,000.00
Covered	50' X 48' X 9'	$30,000.00 - $35,000.00

(Source : UTRCA; MVCA; ABCA, 1991)

Assuming that the average cost/per farm is equivalent to the construction of a 60' X 12' concrete circular manure storage at approximately $20,000.00 each unit, then the average cost of eliminating sources of input from manure handling are estimated to be:

Location	Estimated Cost
Big Otter Creek	
3 potential headwaters sites*	$ 60,000.00
Stony Creek	
3 potential sites*	$ 60,000.00

Total Cost	$120,000.00

* - based on field survey results

7.1.2 Summary:

implementation Strategy #1 is an approach which is based on the rank of individual sources of bacteria with respect to their impact on the Lake Erie Beaches of Port Burwell. The implementation costs of remedial projects that relate to this strategy are listed as follows:

Source #1	Estimated Capital Cost
Septic System option	$ 231,146.67
Composting Toilet option	$ 86,800.00
Package Plant option	$1,000,000.00
Pipe Sewage to Port Burwell option	$ 800,000.00
Source #2	
Livestock fencing	$ 208,007.92
Source #3	
Burgessville septic systems	$ 192,000.00
Otterville septic systems	$ 336,000.00
Source #4	
Tillsonburg non-point sources	N/A
Case #5	
Manure Storages	$ 120,000.00

7.1.3 Cost Effectiveness

A cost effectiveness ratio was used to determine the relationship between the capital costs of implementing various alternatives and the associated reduction in fecal coliform loads contributed by each source. This ratio was evaluated by dividing fecal coliform load from the estimated cost of implementing each remedial measure:

Remedial Measure	Fecal coliform Load (X 10^{10})	Estimated Cost ($)	Cost/$ to remove 10 billion fecal coliform
Case 1	1829.37		
Septic System		231,146.67	126.35
Composting toilets		86,800.00	47.48
Package Plant		1,000,000.00	546.64
Piped Sewage		800,000.00	37.31
Case 2	501.06		
Livestock Fencing & watering devices		208,007.92	415.14
Case 3	264.22		
Upstream septics		528,000.00	1,998.33
Case 4	98.32		
Tillsonburg runoff		N/A	N/A
Case 5	10.71		
Manure storages (inc. milkhouse waste diversion)		120,000.00	11,204.48

Conclusions:

1) From the standpoint of cost effectiveness of various remedial options, the analysis shows that the installation of composting toilets or the repair of existing septic systems are among the most viable alternatives to the abatement of sewage problems in the village of Vienna. The equivalent number of bacteria that could be reduced/per dollar spent increases dramatically when package plants and piped sewage systems are considered.

2) In the case of agricultural remedial measures, access control by livestock restriction from watercourses appear to be the most cost effective structural improvement that could be used on dairy/beef operations. in terms of bacterial load reduced per dollar spent, more bacteria could be reduced through livestock access restriction, compared to the construction of manure storages and milkhouse waste disposal systems. Furthermore, the installation of proper manure storages does not guarantee that untimely spreading of manure, the probability of spillage, and the risk of tile contamination are reduced.

3) Septic system repairs for the town of Otterville and in the village of Burgessville are more cost effective compared to manure storage projects in area farms. However, since these villages are situated upstream, their cost effectiveness ranking is not as high as septic system improvements that are closer to the Port Burwell beach areas.

7.2 Implementation Strategy #2 (Watershed based)

The relative contribution of bacterial inputs to the Big Otter Creek watershed from all sources as ranked by the CURB model (6.0.2) was as follows:

Sources	Contributions
Urban septic systems	49 %
Livestock access	32 %
Urban non-point source runoff	14 %
Farm septic systems	2 %
Milkhouse wastes	1 %
Other agricultural contributors	< 2 %

Possible Solutions

Source #1 Urban Septic Problems

Since it was predicted that all urban septic system failures are contributing approximately 49 % of the bacterial pollution regardless of their location, the estimated cost of repairing these problems are as follows:

Vienna	$231,146.67
Otterville	$336,000.00
Burgessville	$192,000.00
	$759,146.00

Source #2 Livestock access

The fencing of both sides of the watercourse and providing an alternative watering source are predicted to eliminate 32% of the bacterial load that occurs locally throughout the Big Otter Creek watershed. The estimated cost of implementation, using page wire fencing, is approximately $208,007.92.

Source #3 Urban non point sources

Non-point sources originating from storm water runoff, residential lawns, highways and urban streets, construction sites and streambank disturbances are predicted to contribute as much as 14% of the total watershed bacterial load. Projects that could minimize this impact include the installation of retention basins and buffer strips along areas susceptible to runoff. Although these projects are not eligible for funding under the CURB Program, some could be funded under a different government program (such as Permanent Cover II).

Source #4 Farm septic systems, milkhouse wastes and other agricultural contributors

The combined inputs of all farm septic systems, manure storages, feedlot runoff and milkhouse disposal systems contribute approximately 5 % of the bacterial load to the watershed. Although these occurrences are few and appear to be low in priority, their impacts are detrimental to the state of the local streams. Projects which should be considered are prevention of liquid manure contamination, and prevention of milkhouse waste entry in municipal drains and streams. As in Implementation strategy #1, the cost of fixing these projects are approximately $120,000.00.

7.2.1. Cost Effectiveness

A cost effectiveness ratio was used to determine the relationship between the capital costs of implementing various alternatives and the associated reduction in fecal coliform loads contributed by each source to the watershed. This ratio was evaluated by dividing the number of fecal coliform loads from the estimated cost of implementing each remedial measure:

Remedial Measure	Fecal coliform Load (X 10^{10})	Estimated cost ($)	$ to remove 10 billion fecal col.
Case 1	14251.43		
Urban Septic System (repair)		$ 759,146.00	$ 53.25
Case 2	9259.46		
Livestock Fencing & watering devices		$ 208,007.92	$ 22.46
Case 3	4059.45		
Urban non point sources		N/A	N/A
Case 4	1155.02		
Farm septic systems (8 homes)		$ 32,000.00	$ 55.40
Manure storages (inc. milkhouse waste diversion)		$ 120,000.00	$207.81

Conclusion:

1) The implementation of strategy #2 consists of the various remedial alternatives that could be accomplished in terms of bacterial load reduction to the watershed. On a cost per dollar basis, the restriction of livestock from the stream is the most cost effective way of achieving reduction. The next cost effective solution is the repair of all faulty septic systems. Finally, it was found that the construction of manure storages is the least cost effective option available.

8.0 Summary and Recommendations

1) Cost effective analysis of remedial measures from either Implementation Strategy #1 or Implementation Strategy #2 suggest that <u>livestock restriction from watercourses</u> and the <u>repair of faulty</u> urban septic <u>systems</u> are consistently the most beneficial projects that could achieve the greatest improvement to the state of the bacterial water quality of the Big Otter Creek watershed.

2) From the standpoint of protecting the Lake Erie beaches of Port Burwell or Implementation Strategy # 1, the repair of faulty septic systems, or the adoption of composting toilets in the Village of Vienna was the most cost-effective remedial measures which will cause an anticipated reduction in bacterial levels at the beaches. In upstream regions, the repair of faulty septic systems becomes increasingly less cost effective.

3) In general, it is more cost effective to implement strategy #2 than strategy # 1. Money spent in the implementation of remedial efforts is much more effective in improving <u>local water quality,</u> but not as effective in terms of improving the existing water quality of the Port Burwell beaches. Thus, project funding should be based on the potential of the individual property to pollute, regardless of its distance to the Port Burwell beach.

4) While it may be necessary for the local CURB advisory committee to decide which implementation strategy should be chosen, the best remedial solution likely involves a combination of strategies #1 and #2. For example, the village of Vienna's septic system problems may be cost-effectively solved by the subsidized installation of composting toilets for (in the case of sewage treatment plant) through a separate funding program from the provincial government. In both of these cases, available CURB funding allocations are not used up and will still be available for landowners wishing to apply for assistance.

5) The Long Point Region Conservation Authority should undertake a general education and extension program to promote local awareness on site specific topics that are unique to the Big Otter Creek watershed. These activities include presentations to interested groups, information days, media releases and the production of information factsheets for local distribution. The Elgin and the Oxford County Health Units should coordinate efforts with CURB staff to increase awareness on the proper functioning and maintenance of septic systems. Similarly, OMAF and OSCIA should coordinate efforts with CURB staff to draw greater attention to and to encourage the restriction of livestock access to streams as an effective means of protecting water quality.

6) In promoting public awareness, greater emphasis should be placed on the widespread benefits that could be gained from alternative land management practices that are not necessarily beach related. For instance, proper manure and septic system management may aid in the prevention of nitrate contamination of ground water which is of greater relevance to the Norfolk Sand Plains Region. Similarly, fisheries habitat can be made more productive through livestock access restriction and erosion protection. This aspect is of greater regional significance in some of the headwaters tributaries of the watershed.

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Appendix A

Equivalent Animal Units

Animal type	Approximate Weight (kg)	EAU Fecal coliforms
Beef Cow	----	1.04
Slaughter Steer	455	1.00
Yearling Beef	365	0.71
Beef Calf	180	0.48
Dairy Cow	---	1.62
Heifer	318	0.71
Dairy calf	136	0.36
Sow/Boar	--	----
Feeder Pig	22-90	----
Sheep	45	0.02
Turkeys	4.5	----
Chickens	1.8	----
Horses	455	0.013

(Ecologistics Ltd, 1988)

Appendix B

Average Daily Manure Production Per Animal Type

Animal Type	Daily Production (per cu. m)
Beef or Dairy	
Calf	0.0170
Juvenile	0.0227
Beef Cow	0.0340
Dairy Cow (free stall)	0.0581
Dairy Cow (tie stall)	0.0616
Swine	
Weaners	0.0023
Feeders	0.0071
Sows & Litter	0.1700
Poultry	
Chickens and Broilers	0.0001
Turkeys (broilers)	0.0003
Turkeys (breeders and toms)	0.0007
Sheep	0.0042
Horses	0.0566

(Source: OMAF Factsheet #400/721)

Appendix C

Average Fecal Coliform Densities in Animal Feces

Animal Type	Fecal coliforms (per gram)	Fecal coliforms (per m^2)
Cattle	5.0 x 10	5.0 x 10
Swine	$1.0\text{x } 10^{7}$	$1.0\text{x } 10^{11}$
Chickens	$9.9\text{x } 10^{7}$	$9.9\text{x } 10^{13}$
Sheep	$1.6\text{x } 10^{7}$	$1.6\text{x } 10^{13}$
Horses	$8.7 \text{ x } 10^{4}$	$8.7 \text{ x } 10^{10}$

(M. Young, MOE Toronto)