Pollution from Septic Systems: Assessing the Implementation of Ontario *EPA* Regulation 358 and the Clean Up Rural Beaches (CURB) Program

By

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ABSRACT

Septic systems contribute the largest volumetric source of effluent discharged into the groundwater supply. As a result, faulty or improperly sited systems have been recognized as a significant cause of water contamination. Previous research has focused on the performance of the system rather than the implementation of septic system policies.

Traditionally, regulatory controls have been enforced to control the installation of new septic systems and cost-sharing programs implemented to alleviate pollution from existing systems. The implementation of the Ontario *EPA* Regulation 358 and the Clean Up Rural Beaches (CURB) programs was assessed for effectiveness in controlling water pollution from septic systems. Three townships in Middlesex County were selected as the case study area: Biddulph, London and West Nissouri. Data were acquired from permits, applications, interviews with relevant government officials, and information used to create a series of GIS maps. The programs were evaluated based on the criteria of equity, efficiency, level of risk, performance, and consistency.

Results indicate the need for regulatory controls as the primary means of ensuring the proper installation and repair of septic systems, and the need for cost-sharing incentives to remediate contamination from existing systems. Both programs functioned efficiently, provided an equitable process, addressed the high level of risk, and were implemented in a consistent manner. However, the performance was inadequate in terms of controlling pollution from septic systems. Results revealed that there is a need for on-going monitoring and landowner education as well as an improved method for determining site suitability.

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1. INTRODUCTION

1.1 The Problem in Brief

While septic systems comprise the largest volumetric source of effluent discharged into Ontario's groundwater supply (Robertson *et al.*, 1991), the risk that poorly sited, improperly designed, and aging systems pose a considerable threat to the groundwater and human health has only recently been noticed (Hanson and Jacobs, 1989). Close to three million people in Ontario get their drinking water from groundwater supplies (MOEE, 1992). This translates into more than 500,000 wells in the province, a large proportion of which are located in rural areas, with approximately 20,000 new wells added each year (MOEE, 1992). Due to septic tank malfunction, the same population that depends on this resource contributes to its contamination. This thesis assesses the effectiveness of two Ontario government programs that address pollution from septic systems.

1.2 Pollution from Septic Systems: Types and Risks

Diffuse pollution has been defined as the cumulative impacts resulting from numerous small pollutant inputs over a broad geographic area (Chesters and Schierow, 1985; UTRCA, 1989). As water flows over land and through the ground, pollutants from septic systems can be transported and deposited as diffuse sources of contamination in the surface and groundwater supply (US EPA, 1996). The U.S. Environmental Protection Agency (US EPA, 1996) identified agriculture, forestry, grazing, septic systems, recreational boating, and urban runoff as examples of diffuse pollution sources. In Ontario, four main causes of diffuse pollution were identified: unrestricted livestock access to watercourses, improper handling of milkhouse wastewater, inadequate manure management practices, and improper or faulty domestic septic systems (UTRCA, 1991).

A recent study of 1,300 private water wells was carried out by the Ontario Ministry of the Environment (MOE) between October 1991 and March 1992, (formerly referred to as the Ministry of the Environment and Energy) (MOEE, 1992). Results of the survey showed that 37% of the wells were contaminated at concentrations above provincial drinking water objectives. Thirty-one percent exceeded the acceptable limit of coliform bacteria, 20% had excessive amounts of fecal coliform bacteria and more than 13% exceeded the maximum allowable concentration of nitrate. A follow-up study completed later in 1992 showed a slightly higher percentage of contamination. Unsuitable location, improper construction and poor maintenance of septic systems were identified as the leading causes of well contamination.

Diffuse pollution from malfunctioning or improperly sited septic systems poses an immediate threat to water quality and human health. In 1984, the U.S. Environmental Protection Agency reported that diffuse source pollution was one of the leading causes of surface water quality problems throughout the nation (Thomas, 1985). Pollutants such as nutrients and pathogenic bacteria were among the most prevalent substances that harm surface and groundwater (Chesters and Schierow, 1985). It has become increasingly necessary for the government to control these diffuse sources of pollution in order to improve water quality (Kramer *et al.*, 1984).

Groundwater can become contaminated when effluent from septic systems mixes with shallow groundwater, or effluent is drained directly into the groundwater supply. In the first case, septic effluent mixes with water before pollutants can be removed by the soil. This often occurs in areas that are prone to shallow groundwater tables (Hanson and Jacobs, 1989). The consequences of contamination are compounded as pathogens in the waste pollute drinking water in areas where a shallow well is located nearby. The second opportunity for potential groundwater contamination occurs where the leaching bed systems are located in highly permeable soils (Hanson *et al.*, 1989). In these conditions, effluent drains too quickly through the soil and may enter directly into the groundwater supply beneath the leaching bed.

Diffuse or non-point source pollution control is an important focus of resource and environmental management agencies in Ontario. The nature and impacts of pollutants necessitate effective action. Table 1.1 lists the more common chemical constituents found in septic wastewater effluent.

Table 1.1: Selected chemical constituents contained in septic effluent

CHEMICAL	MEAN CONCENTRATION
Suspended Solids	75 mg/L
Biological Oxygen Demand (BOD_5)	140 mg/L
Chemical Oxygen Demand (COD)	300 mg/L
Total Nitrogen	40 mg - N/L
Ammonia Nitrogen	31 mg - N/L
Nitrate Nitrogen	0.4 mg - N/L
Total Phosphorus	15 mg/L

(Adapted from Hanson and Jacobs, 1989)

Nitrates (NO_3^-) and phosphates (PO_4^{2-}) are the primary inorganic compounds that contribute to groundwater contamination from septic systems (Harman *et al.*, 1996).

Research has shown that elevated levels of nitrates have carcinogenic, teratogenic, and mutagenic effects on humans and have been linked to blue baby syndrome, stomach cancer, infant cyanosis and methaemoglobinaemia, a serious blood condition (Simpson, 1992; Harman *et al.*, 1996; Reddy and Dunn, 1984). Phosphates can stimulate plant and algae growth leading to lake eutrophication in estuarine environments. Similarly, a number of bacterial constituents found in septic effluent including fecal coliform and fecal streptococci cause health concerns. For instance, a number of infections and diseases have been attributed to the bacteria in human feces transported by septic waste (Perkins, 1984). Conditions such as meningitis, poliomyelitis, hepatitis, diarrhea and upper respiratory illness are included among the more commonly associated diseases. Common diffuse source pollutants also cause beach closures, destroyed habitat, unsafe drinking water, and numerous other environmental and health problems in both the U.S. and Canada (US EPA, 1996; UTRCA, 1991). These outcomes highlight the need for effective control of pollution from septic systems.

1.3 Diffuse Source Pollution Control: General Approaches and Practice in Ontario

In response, governments have initiated two general strategies to address the problem: voluntary and cost-sharing controls, and regulatory programs.

1.3.1 Voluntary and Cost-Sharing Controls

The first method of diffuse pollution control includes landowners voluntarily requesting technical assistance, information, and education from government agencies. Studies in Maryland found that farmers generally believe that water quality maintenance is someone else's problem and do not realize the extent of the problem (Lichtenberg and Lessley, 1992). There is no tangible method of ensuring participation in the various voluntary programs. In Ontario, the Upper Thames River Conservation Authority (UTRCA) targeted voluntary efforts in areas of the watershed identified as the most severe in terms of water quality and erosion (UTRCA, 1983). In this case, opportunities to improve local water quality were made available to landowners without regulatory enforcement. However, the benefits of a program must exceed the costs of implementation in order to be adopted by the landowner. Despite these efforts, a recent study in Wisconsin found that no substantial improvements to water quality were attained through voluntary efforts (Wolf, 1995). Low levels of participation created a weak link between program implementation and improved water quality.

Cost-sharing arrangements encourage farmers to improve rural land and water management practices as a form of remedial action (UTRCA, 1991). Grants are made available by an implementing agency to pay a percentage of the landowner's costs of adopting specific practices. Cost-sharing has been the dominant type of agricultural pollution control strategy in Canada and elsewhere (Wilcox, 1992). However, it has been determined that the adoption of better management practices is often directly related to the grant rate (Tice and Epplin, 1984), and that remedial initiatives can be inequitable as they tend to favor larger farming operations (Boggess *et al.*, 1979). This approach can also become costly for governments to implement. Ideally, grant money should be targeted to focus on highly sensitive or problem regions (Tice and Epplin, 1984).

In Ontario, one of the most serious problems

> is that cost shared grants are not necessarily directed at the most severe instances of agriculturally-caused water pollution. Rather, funds are divided among the various county agricultural associations in rough proportion to their annual production (Castle, 1993, pg.220).

Despite its weaknesses, this type of initiative has proven somewhat effective in reducing pollution (Kramer *et al.*, 1984). Cost-sharing provides economic incentives to landowners, which entice them to utilize new technologies (Tice and Epplin, 1984). Benefits to overall water quality can occur on a large scale if conservation measures are adopted by a majority of the landowners.

Agricultural activities have frequently been the target of cost-sharing programs. In the 1970s, the International Joint Commission (IJC) appointed a Pollution from Land Use and Agricultural Research Group (PLUARG) to study diffuse sources of pollution affecting the Great Lakes Basin ecosystem (IJC, 1978). PLUARG identified agriculture as a major source of Ontario's ground and surface water pollution. Programs including the Ontario Soil Conservation and Environmental Protection Assistance Program (OSCEPAP), and the Soil and Water Environmental Enhancement Program (SWEEP) have targeted agricultural activities such as waste management and soil erosion but did not consider septic systems as a potential source of pollution.

In 1986, the Ontario Ministry of Agriculture and Food (OMAF), now the OMAFRA (Ontario Ministry of Agriculture, Food, and Rural Affairs), revised its first environmental initiative for agriculture (OSCEPAP) to create the Ontario Soil Conservation & Environmental Protection Assistance Program II (OSCEPAP II) (OMAF, 1987). The former program was revised in order to provide capital grants for soil conservation practices. OSCEPAP II focused on existing soil erosion problems, manure storage facilities, milkhouse wastewater disposal systems, and pesticide handling facilities on Ontario farms. As the number of livestock operations in Southern Ontario increased, there was growing need for improved waste and operations management. Unlike purely voluntary programs, this cost-sharing program provided grants to eligible farmers to supplement the costs of engineering fees, permits, labor, repairs and materials used during approved projects. OSCEPAP II was one of the first programs to specify minimum distance requirements between sources of surface water and agricultural facilities. Engineering design standards had to be met before a project could be approved for funding. This four-year program targeted the most severe land management activities and specified the type of projects that were approved for grants (OMAF, 1987). At this time, septic system projects were not considered for cost-sharing assistance.

In 1991, the Clean Up Rural Beaches Program (CURB) identified septic systems as another significant source of diffuse pollution (UTRCA, 1992). CURB shifted emphasis on soil conservation towards the improvement of water quality at rural beaches. Like OSCEPAP II, CURB targeted its financial efforts to the most severely polluted areas. Due to an unprecedented number of beach closings in Ontario, the MOE Water Resources Branch devised a Provincial Rural Beaches Strategy program. This initiative included members of the MOE, OMAF, and the Ministry of Natural Resources (MNR). Local conservation authorities were provided with financial and technical assistance from the MOE in order to identify the relative impact of pollution sources, locate their pathways to beaches, and to develop a CURB plan specific to the upstream watershed. Essentially, this plan was intended to lead towards the restoration and long-term maintenance of water quality at certain provincial rural beaches. Four areas that contribute diffuse sources of pollution into Ontario's rural beaches were targeted: livestock access restrictions, manure storage facilities, milkhouse washwater disposal, and private sewage systems (MOEE, 1994). CURB was the first program to provide cost-sharing to rural residents whose activities impacted the water quality at downstream beaches.

Prior to the introduction of the CURB program, diffuse pollution controls focused primarily on the environmental and health effects of the problem. CURB addressed reducing pollution through improving management and land-use practices, which may cumulatively have detrimental effects on surface water quality. The CURB program was also the first to recognize that non-farm rural land use activities, namely the use of domestic septic systems, contributed to the pollution potential. Rural landowners now received grants to improve inadequate septic systems on their property. The government anticipated that CURB grants would control diffuse pollution more effectively than efforts taken in the past. Assessing this cost-sharing program will be a significant focus of the thesis.

1.3.2 Regulatory Controls

In the context of pollution control, regulatory programs describe codes of conduct or performance which are intended to prevent or minimize contamination from occurring (Wilcox, 1992). In Ontario, landowners must comply with the requirements of regulations including the *Environmental Protection Act*, the *Ontario Water Resources Act*, the *Drainage Act*, the *Planning Act* and relevant municipal zoning by-laws.

Landowners who do not comply with the mandated regulations face sanctions or penalties.

Diffuse pollution is commonly regulated through the enforcement of quotas and mandatory requirement of permits. Although regulatory approaches can effectively prevent diffuse source pollution, they may result in a decrease of net farm income, by forcing landowners to employ costly mitigative measures. In this way, regulations can interfere with farm decision making (Kramer *et al.*, 1984). Often landowners that can afford to pay the penalty may choose not to comply. Since the sources of diffuse pollution are difficult to determine, costs of regulations are often borne by the taxpayers rather than the polluter. Consequently, there has been resistance to preventative regulatory enforcement by the rural population and the politically influential agricultural sector (Wolf, 1995).

Traditionally, the provincial government has been responsible for the preservation of natural resources and plays the leading role in the protection of Ontario's ground and surface water. A number of policies and guidelines pertain to the protection of ground and surface water. For example, Ontario's "Blue Book" describes a set of objectives for water quality, which govern the management of ground and surface water. This booklet identifies criteria for determining acceptable levels of contamination and lists the Ontario drinking water objectives. According to the "Blue Book", septic systems are considered a regulated source of contamination and the "degradation of groundwater supplies will be controlled to protect existing and potential reasonable uses of water on adjacent properties" (MOEEb, 1994, pg. 54).

The MOE has legislative authority for water management under two statutes, the *Ontario Water Resources Act* (*OWRA*), and the *Environmental Protection Act* (*EPA*) (MOEEb, 1994). Of relevance to this research are the sections of these statutes that provide MOE with the authority to implement water quality policies. To this end, MOE has developed regulations related to the construction, alteration or enlargement of private sewage disposal systems as regulated under Part VIII, Section 64 of the Ontario *EPA*. It states that:

> No person shall construct, install, establish, enlarge, extend or alter,
> a) any building or structure in connection with which a sewage system will be used if the use of the building or structure so constructed, installed, established, enlarged, extended or altered will or is likely to affect the operation or effectiveness of the sewage system; or
> b) any sewage system, unless a certificate of approval for the construction, installation, establishment, enlargement, extension or alteration of the sewage system has been issued by the Director (*EPA*,1992, pg. 5).

The Ontario *EPA* provides protection of the natural environment through Ontario Regulation 358, which is the primary means of controlling diffuse sources of pollution from domestic septic systems. This regulation defines a universal set of standards and guidelines for all domestic septic systems. Therefore, the discharge of contaminants to the water supply is prohibited except where permitted by a Certificate of Approval (MOEEb, 1994). Under Regulation 358, a Certificate of Approval must be obtained before a building permit is issued for the construction of any establishment. In most of the province, the MOE delegated authority to the local health unit, which is responsible for reviewing applications and issuing the Certificate of Approval. In Middlesex County, applications are directed to the Upper Thames River Conservation Authority (UTRCA) which acts on behalf of the MOE.

A few amendments have been proposed to Regulation 358 since it was last updated in 1992. For example, a proposal was submitted in 1997 to incorporate new technologies such as peat filter systems, artificial media filter systems, and gravelless trench technology into the regulation (MOEE, 1997). This was intended to benefit areas where it is currently difficult to develop while maintaining the quality of public health and the environment. Further amendments under Bill 152, the *Services Improvement Act*, that would shift the responsibility for regulating domestic septic systems to the *Building Code Act* were proposed in August of 1997 (MOEE, 1997). Currently, the Ontario Building Code outlines recommended septic system design flows based on the number of fixture units. Since landowners are required to apply for a Certificate of Approval and a building permit for all new development, Bill 152 will provide a 'one window service' by consolidating applications for septic systems into the *Building Code Act* (MOEE, 1997). This initiative is an attempt by government to download responsibility to and simplify approval and enforcement activities of municipalities in order to create cost savings for the province. Bill 152 was passed in the spring of 1998. There was uncertainty as to whether additional amendments would be made to Regulation 358 once this consolidation occurred (Gregson, 1997). According to UTRCA officials currently in charge of the septic tank permitting, their use of discretion will be restricted under the new arrangement. Decisions will be based strictly on the compliance with the regulation. According to the MOE (1997), once this consolidation of responsibilities occurs, environmental standards will be maintained through provincial rules for the installation and operation of septic systems as well as requiring certification of all installers and inspectors. An evaluation of Regulation 358 and the implications of Bill 152 will be completed as part of this thesis.

1.4 Research Trends

Over the past decade, septic tank related research has primarily examined the environmental effects of domestic systems and groundwater contamination (Olivieri *et al.*, 1981; Hanson *et al.*, 1986; Hanson and Jacobs, 1989; Simpson, 1992; Baker *et al.*, 1993; Packer and Ferguson, 1995). Since septic systems are located beneath the earth's surface, there is a high potential for groundwater contamination from inadequately maintained and poorly sited systems (Hanson *et al.*, 1986). Risks to public health have grown as the rural population has expanded, and the reliance on private water supply and septic systems has increased. Contaminated surface water also poses an immediate threat to human health.

Previous research that has examined the impacts of septic systems on water quality has focused on assessing the performance of the system and did not adequately consider the process and outcomes of policy implementation. Performance-based research emphasized the impacts of malfunctioning septic systems on water quality as determined through the collection of field data, whereas implementation research examines the underlying policies for controlling pollution from septic systems in addition to assessing performance-based measures. According to Hanson *et al.* (1989, pg.97) "private sewage systems are a safe, reliable means of wastewater disposal when properly sited, installed, maintained and operated". Unfortunately these conditions are often not achieved. A study in Wisconsin concluded that private sewage disposal systems contributed the most to groundwater pollution in total volume of wastewater that is discharged directly into the soil (Hanson *et al.*, 1989). According to this study, fewer than half of the existing systems met the current standards and many exceeded the recommended design life.

In the UTRCA watershed, the Clean Up Rural Beaches (CURB) Program initiated in 1991 was the first to identify septic systems as a significant contributor to contamination of reservoir water quality (UTRCA, 1992). Improvements to rural septic systems were identified as a cost-effective means for reducing bacteria and phosphorus levels in the Fanshawe Lake reservoir. Site inspections were carried out to determine the distance pollutants travel from the system to various sources of surface water. Grants were allocated to assist landowners in repairing septic systems that were significantly contributing to the contamination of beaches downstream. According to an environmental accounting model, septic system improvements decreased bacterial inputs to public beaches by approximately 8% after the third year of the program's implementation (UTRCA, 1994).

Previous performance-based research does not provide the full range of implications of malfunctioning septic systems on the ground and surface water. These studies have utilized field-oriented research methods in order to determine the levels of contaminants in well water supplies (Reddy and Dunn, 1984; Harmen *et al.*, 1996; Perkins, 1984; Yates, 1985). Very little research has taken an implementation-based approach to assess the implications of septic tank policy on water quality (Hanson and Jacobs, 1989; Simpson, 1992). In addition, studies which have evaluated the effects of septic tank effluent on water quality have not used map-based data as an integral aspect of the analysis (Baker *et al.*, 1993; Rifai *et al.*, 1993). This thesis addresses these research needs.

1.5 Research Objectives and Organization

The objective of this research is to assess the implementation of two septic system control programs in Ontario. The first program, Clean Up Rural Beaches (CURB), was a cost-sharing initiative created to provide funding to rural landowners whose septic system demonstrated a direct impact on local surface water quality. The second program that will be examined is the Ontario *EPA* Regulation 358, which controls the installation of new septic systems. The implementation of the two programs will be evaluated separately based on the criteria of equity, efficiency, level of risk, and performance. They will also be evaluated jointly in terms of the consistency between two regulatory programs targeting the same population. Information collected from *EPA* permits and CURB applications, interviews with government officials, and a series of digital maps will provide the primary source of data in evaluating the programs.

Specific objectives are to:

1. Review relevant literature in order to understand the different types of septic systems and how they function to treat wastewater. Examine the implications of septic effluent on water quality as determined by previous studies. Establish the need to conduct implementation-based research (Chapter 2).
2. Describe data collection methods and the framework for analysis (Chapter 3).

3. Evaluate the implementation of the CURB program and the *EPA* Regulation 358 according to the criteria of efficiency, equity, level of risk, performance, and consistency. Discuss the results of this analysis (Chapter 4).
4. Explain the practical and academic implications of Regulation 358 and CURB, and identify future research opportunities (Chapter 5).

2. REVIEW OF LITERATURE

A review of relevant literature was conducted in order to understand how septic systems function to treat domestic waste, the different types of systems, and the limitations of the natural environment for treating wastewater. Also, previous research that examined the implications of septic effluents on water quality was reviewed.

2.1 Septic System Function

Private septic systems are onsite wastewater treatment units that collect, treat and dispose of wastewater generated by homes (NSFC, 1995). The wastewater originating from dwellings is comprised of bathroom waste, liquid kitchen waste and laundry waste (MOE, 1990). In the Province of Ontario, over 2.5 million people are serviced by one million private sewage systems (MOEE, 1992). The National Small Flows Clearinghouse (NSFC, 1995) claims that effectively designed and maintained septic systems can be expected to function properly for up to twenty years.

A septic system is comprised of two main parts that work together to treat household waste: the septic tank and the leaching bed. The septic tank serves as a collection outlet where gravity separates the wastewater into three distinct layers (ONHWP). The size of the tank is determined by the flow requirements of the household. The densest wastewater materials settle in the bottom of the tank and form a layer of sludge that remains until pumped out. The lightest materials rise to the top of the tank and form a layer of scum composed of oils and grease. The layer of scum also remains in the tank where natural bacteria anaerobically break down a portion of the waste. A remnant of the scum remains to be pumped out with the sludge layer. As a result of this separation between the sludge and scum layers, the middle layer of liquid is partially clarified. This liquid wastewater then flows through an outlet in the tank into the distribution system of pipes. These pipes carry the wastewater from the tank to the leaching bed for further treatment.

The second part of the septic system, the leaching bed, is comprised of a series of perforated pipes that lie in trenches filled with filtering materials such as gravel or course sand. The maximum length of any single trench in a leaching bed is 30 metres (MOEE, 1990). As the water passes through the pipes out into the filtering material, the soil beneath the bed acts as an additional biological filter. Water percolates through the soil while toxins, bacteria, viruses, and pollutants are removed (NSFC, 1995). In this way, septic effluent is prevented from ponding on the surface and entering the ground and surface water supply (Hanson and Jacobs, 1989).

There are four primary mechanisms by which pollutants can be separated out of the wastewater in the leaching bed (Hanson *et al.*, 1986).

1. The first is the process of *filtration*. Wastewater constituents are physically strained in the pores of fine textured soil such as medium sands allowing clarified water to pass through.
2. Pollutants can also be removed from wastewater by means of *absorption*. Weak attractions between electrically charged chemical constituents and the soil surface cause pollutants to adhere to the soil.
3. The third mechanism, *ion exchange* can take place whereby ions in the wastewater are reversibly interchanged with ions in the soil without changing the physical structure of the soil.
4. Pollutants can also be removed from septic effluent through *biological processes*. Complex organic matter is broken down into simple compounds by plants and microorganisms to remove nutrients such as nitrogen and phosphorus.

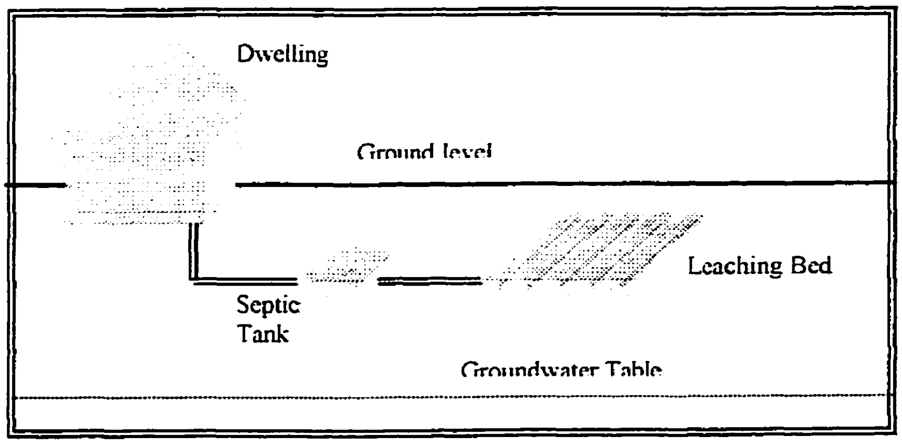
The process used to treat septic effluent is dependent on the type of system installed and the nature of the soil environment.

2.2 Types of Septic Systems

Four main types of septic systems are used throughout North America to treat domestic wastewater: conventional, raised leaching beds, filter beds and holding tanks. Conventional septic systems are installed where the physical environment is capable of effective wastewater treatment. However, if site evaluations reveal difficult or unsuitable characteristics, two common alternative systems can be installed - the raised leaching bed system or the filter bed system. Finally, a holding tank can be used as a last resort in those areas where leaching beds cannot be installed.

The *conventional septic system* is the most common method of treating domestic waste in Ontario (Figure 2.1).

Figure 2.1: Conventional septic system



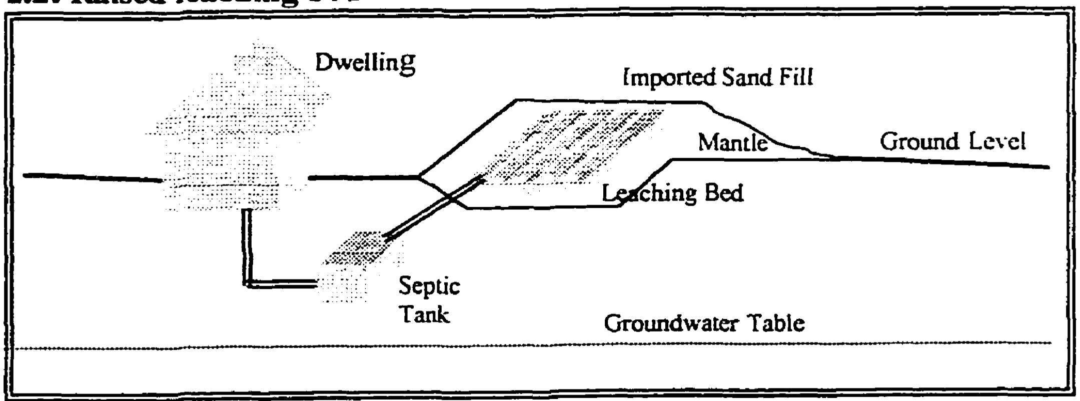
(Adapted from MOE, 1990)

This system pretreats waste in a septic tank where the solids, liquids, and scum are separated. Conventional systems are suitable in areas where the natural soils beneath the leaching bed are capable of filtration. Sites which are level or slightly sloped, well drained and remote from water wells or surface water are also ideal locations for conventional septic systems (MOE, 1990). On these sites, the pipes in the leaching bed are laid in stone filled trenches below the ground (ONHWP).

Ontario *EPA* regulations state that the bottom of the leaching bed must be at least 0.5 meters above the high groundwater table and a minimum of 0.9 meters above the highest elevation of bedrock. The *EPA* guidelines also recommends that the leaching bed area be free of trees and bushes to promote an well-aired bed and prevent damage from roots (MOE, 1990).

The second most common type of septic system, *raised leaching beds*, are appropriate in areas where natural soils are not suitable filters or the groundwater table is too high. Raised beds require the use of imported sand fill to create a leaching bed above the ground. In this case, sandy silt soils are brought into the site where the leaching pipes are laid in stone filled trenches (Figure 2.2).

Figure 2.2: Raised leaching bed

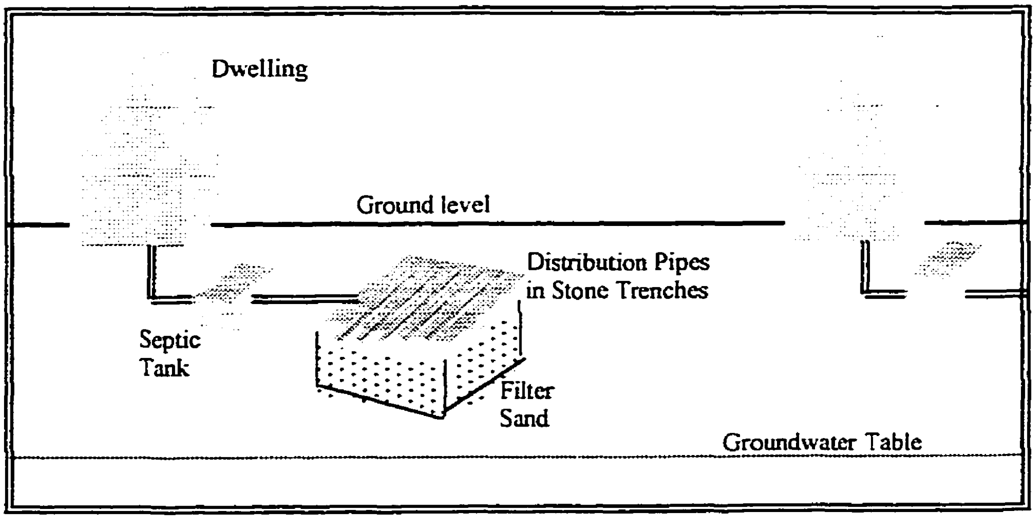


(Adapted from MOE, 1990)

Soil material and topsoil are used to cover the system, which creates a mound on the surface of the ground. Since the tank is located beneath the ground, the liquid waste must be pumped up from the tank into the leaching bed. In addition, soil is placed "downstream" from the bed to create a mantle area of extra filtration. The Ontario MOE (1990) suggested raised leaching beds should be installed when less than 0.9 meters of soil is available between the bottom of the leaching bed and the bedrock, where there is a minimum of 0.5 meters clearance above the high groundwater table or when the natural soils consist of fine silt or clay.

A third type of system, the *filter bed* is used when a smaller bed area is required or on sites where a conventional leaching bed system is not possible. This is often the case on smaller lots, which do not have the area to meet minimum distance requirements of a conventional system. With a filter bed system, the pipes are not placed in a leaching bed but are set in a continuous layer of stone above a layer of filter sand (Figure 2.3).

Figure 2.3: Filter bed

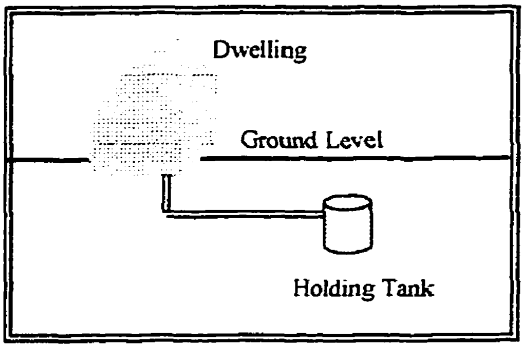


(Adapted from MOE, 1990)

In order to create a filter bed, the entire area must be excavated to install a network of distribution pipes that are laid closer together. This type of system is used in areas that are flat and consist of natural soils that are fine to coarse sand. The same clearances as the conventional system are required above the rock and groundwater table. Since less sewage treatment area is required, the application of sewage to be treated by the soil is concentrated over a smaller area. For this reason, the Ontario MOE stipulates a smaller daily sewage flow into a filter bed.

The *holding tank* is a fourth type of sewage disposal system, primarily installed where it is physically impossible to locate a septic tank (Figure 2.4).

Figure 2.4: Holding tank



(Adapted from MOE, 1990)

Holding tanks are watertight, underground storage tanks, which hold the sewage waste until it is pumped out and hauled away. The benefit of the holding tank is that they can be installed virtually anywhere since there is no contact between the sewage and the land. However, the tank must be pumped out regularly in order to prevent overflow of untreated effluent into the soil environment. Since this type of system is most often installed in areas with a high groundwater table, leakages of septic effluent from holding tanks cause immediate and severe impacts to groundwater (Hanson *et al.*, 1986). Also, once the tank has been pumped, proper disposal of the effluent must take place. For this reason, holding tanks are not readily approved as a method of domestic sewage treatment.

2.3 Limitations of the Natural Environment

The nature of the soil environment affects what type of septic system can be installed and work effectively (Hanson *et al.*, 1986). Four characteristics of the physical environment are important to ensure proper treatment of wastewater effluent and are critical in determining site suitability of conventional septic systems: soil permeability, depth to the bedrock, groundwater depth and the proximity to surface water. The characteristics will also dictate the type of alternative system that is appropriate in those areas that are not fitting for conventional systems.

2.3.1 Soil Permeability

The permeability of soil refers to its ability transmit water (Perkins, 1989). The amount, size, continuity of the pores and the moisture content of the soil determine permeability (B.C. MOE, 1984). The soil below the leaching bed must be able to absorb particles and retain the effluent long enough to remove harmful constituents. Thus, the texture of soils determines its ability to move and cleanse the wastewater (Perkins, 1989). Coarse textured soils such as sand and gravel have relatively few very large pores resulting in rapid movement of effluent. This causes ineffective cleansing of the wastewater because the effluent is not retained in the soil for an adequate period of time. At the other extreme, very finely textured soils such as clay retain effluent too long causing the soil to become saturated. To remove nutrients and microbes from the wastewater, the soil must be continually unsaturated in order to promote an aerobic environment necessary for chemical reactions (Hanson *et al.*, 1986). Medium textured soils such as loam have many small pores that cause the effluent to move slowly, allowing for more treatment. Thus, the fine textured sandy loam soils are optimal for effective effluent treatment. The permeability of the soil is measured in terms of its percolation rate.

2.3.1.1 Percolation Rate

Permeability for septic system regulations is determined by the percolation test which measures the rate of change in water levels surveyed in a hole dug at the site (B.C. MOE, 1984). Percolation rates (T) with units of minutes per centimeter (min/cm) provides a guide for determining the capacity of the soil for handling effluent. This ultimately governs the size of the leaching bed required for adequate wastewater treatment (MOE, 1990). Essentially, the percolation rate will be high for very fine textured soils indicating slow movement of water through the soil. Lower rates will be measured for coarse textured soils since the water moves rapidly through the soil. Conventional leaching beds can be adapted to reflect the percolative capacity of the soils (Hanson *et al.*, 1986). For soils with a low permeability, the leaching bed area can be increased to spread the effluent over a larger area and increase the time for the effluent to enter the soil. Raised leaching beds can also be used to overcome limitations posed by inadequate percolation rates. In these situations, an absorption field is raised above the surface of the ground and effluent is partially treated through the sand fill before it is able to reach the natural soils. Therefore, the permeability of the soil can be lower when a raised leaching bed system is installed (Hanson *et al.*, 1986).

According to the Ontario MOE guidelines, conventional and filter septic systems require a percolation rate greater than T = 50 min/cm. Raised leaching beds must contain an imported fill mound with a percolation rate of T = 15 min/cm. Unfortunately, variations in the percolation rate measured for specific sites are not uncommon. The level of soil saturation prior to measurement may affect the percolation rate obtained (B.C. MOE, 1984). Table 2.1 outlines typical percolation rates determined for various soil types.

Table 2.1: Percolation rates for various soil types

Soil Type	Percolation Rate T = min/cm
Sand	0
Loamy Sand	25
Sandy Loam	50
Loam	76
Silt Loam	102
Silty Clay Loam	127 – 152
Silty Clay	152 – 191
Clay	279

(Adapted from Perkins, 1989)

Soils consisting of sandy loam provide the optimal percolation rate in accordance with Ontario MOE guidelines.

2.3.2 Depth to the Bedrock

The depth of the bedrock refers to the thickness of the overburden between the surface and the bedrock. Bedrock depth is a critical factor for siting septic systems because it determines the amount of material available for effluent treatment. Once wastewater moves through the leaching bed and out into the soil environment, adequate treatment must occur before the water reaches the bedrock. Groundwater contamination can occur if water that has not been fully clarified flows along the bedrock and into the groundwater supply. Contamination of the groundwater can also occur if effluent flows through crevices in the bedrock. A study completed in Wisconsin found that a minimum of approximately one meter of unsaturated soil between the bottom of the bed and the high groundwater table is necessary to remove harmful constituents through filtration (Hanson *et al.*, 1986). In areas where the bedrock has crevices, overburden should be no less than approximately two meters above the rock. This will prevent polluted water from being transmitted directly to the groundwater through the cracks.

The Ontario MOE regulations specify that a minimum of 0.9 meters of soil be present between the bottom of the leaching bed and the underlying bedrock. Since most systems are located between 0.6 – 0.9 meters below ground a minimum of approximately two meters of soil between the surface and the bedrock will ensure proper treatment of sewage with conventional systems. In areas where the bedrock is too shallow, raised leaching bed systems may be installed to overcome the limitations of a conventional septic system.

2.3.3 Depth to the Groundwater Table

Like the depth to the bedrock, the depth to the groundwater table refers to the thickness of the soil between the surface of the ground and the highest point to which the water table rises. Groundwater occurs in two layers beneath the surface. Wastewater effluent first seeps through an *unsaturated zone*, where liquid water, vapor and air partially fill the soil's pores. It is in this zone that the wastewater is clarified. In order to maintain an aerobic environment necessary to effectively remove microorganisms and bacteria from septic effluent, the soil must be continually unsaturated. Thus, the wastewater must be fully treated in the unsaturated zone before reaching the groundwater table. The *saturated zone* is located further down in the soil at the point where all of the pores in the soil are filled with water. This occurs as the water reaches an impermeable layer of rock and becomes trapped. The top of the saturated zone is referred to as the water table. An inadequate depth of the soil above the water table will result in untreated effluent entering directly into the groundwater supply. In areas with a high groundwater level, or a groundwater table that is close to the surface, untreated effluent can to rise to the soil's surface and pond on the ground or back up unto the house.

Ontario MOE regulations enforce a minimum of 0.5 meters between the bottom of the leaching bed and the high water table. Typically, septic systems are located between 0.6 – 0.9 meters below the surface. Thus, the groundwater table should be approximately two meters deep in order to prevent untreated effluent from entering directly into the groundwater supply. It is not uncommon for domestic water wells to be used in areas serviced by septic systems. Olivieri *et al.* (1981) maintained that in these areas the minimum distance between the bottom of the bed and the water table should be at least 9 – 12 meters deep and 3 – 6 meters deep in alluvium soils. Since groundwater is the primary source of drinking water and recharge for lakes and rivers, it is critical that untreated effluent does not reach the groundwater supply.

2.3.4 Surface Water

Surface water pollution from private septic systems occurs in the form of runoff and indirectly from groundwater recharge (Chesters and Schierow, 1985; Viraraghavan, 1982). Hanson *et al.* (1986) have outlined eight factors that influence the extent that septic systems affect surface water:

1. the volume of water in the lake,
2. the concentration (density) of systems around the lake,
3. the number of failing systems,
4. the soil permeability,
5. the source of water feeding the water body,
6. the lake's turn over rate,
7. the ability of the lake to assimilate pollutants, and
8. the existing pollution level in the lake.

Thus, a high-risk water body is one that has a low volume of water, low turn-over rate and is fed by groundwater or another water body that is being directly contaminated by a septic system. The potential for surface water contamination is compounded if there are many failing systems located around the lake, or if a system is draining directly into a watercourse without treatment of the effluent. In an effort to protect surface water, the Ontario MOE mandates minimum distances between the location of a septic system and sources of surface water. There must be at least 15 meters between the leaching bed or tank and any source of surface water including lakes, rivers and streams.

2.4 Previous Research on Septic Systems

Previous research has focused on the performance of septic systems by assessing the implications of malfunctioning systems and the impacts of wastewater effluents on water quality. The studies evaluating septic systems have been divided into three types; performance-based, map-based often with the use of Geographic Information Systems (GIS), and implementation-based research.

2.4.1 Performance - Based Research

Research over the past decade that examined the impacts of private septic systems has focused on the performance of the system as an indicator of pollution potential (Reddy and Dunn, 1984; Harman *et al.*, 1996; Perkins, 1984; Yates, 1985; Poel, 1991; Lawton and Ormseth, 1993; Packer and Ferguson, 1995). For the purpose of this research, the performance-based studies have been divided into two sections: (1) studies that have assessed the implications of septic effluent on water quality, and (2) the density of septic systems.

2.4.1.1 Water Quality Studies

Nitrate and phosphates are the primary inorganic compounds contained in septic effluent that contaminate the ground and surface water supplies. (Harman *et al.*, 1996; Simpson, 1992; Reddy and Dunn, 1984). A number of studies have measured the levels of these constituents detected in well water, and used computer simulations and mathematical models to assess the performance of septic systems.

In order to evaluate the effects of septic effluents on the quality of groundwater, the levels of nitrate, chloride and phosphorus were studied for a series of observation wells in North Carolina (Reddy and Dunn, 1984). The authors concluded that high levels of nitrate were found in groundwater adjacent to septic system disposal fields. The concentration of nitrate was correlated with the depth of the water well and the distance of the well from the septic system. Thus, the concentration of nitrate decreased as the depth of the well increased. For this reason, the authors suggested that dilution into the groundwater was the only feasible process to lower nitrate levels. It was established that a larger leaching bed area was required to adequately dilute nitrates. In addition, high levels of phosphorus were attributed to household detergents disposed via the septic system. These detergents are surfactants that cause increased mobility of pollutants throughout the soil. Thus, the depth of the bedrock and underlying water table are important factors in siting septic systems. Also, the minimum safe distances from watercourses recommended by government regulations may be inadequate to prevent contamination from surfactants.

A study completed in Ontario measured the presence of solutes such as nitrates, chlorides and phosphorus in well water samples near septic system impacted groundwater (Robertson *et al.*, 1991). The authors determined the mobility of contaminants in groundwater plumes and the geochemical processes that foster or hinder contamination of the groundwater supply. Computer models showed that plumes located in unconfined sand aquifers exceeded the length expected to adequately protect well water quality based on the minimum permissible distance-to-well regulations. It follows that the Ontario

MOE regulation stipulating a minimum distance of 15 meters between the septic system and a well may be inadequate to protect drinking water.

Harman *et al.* (1996) recently conducted a study that focused on the groundwater impacts of an older system (44 years) in order to understand the long-term attenuation capacity of the soil. The study was carried out in Langton, a small community in southwestern Ontario, where well water and sediment core samples were analyzed for the presence of nitrates and phosphorus. It was shown that over time, the attenuation capacity of the soil became consumed allowing contaminants to advance in the ground and surface water supply at a potentially significant rate. According to the Ontario MOE (1990), septic systems are expected to function properly for twenty years as long as they are maintained properly. Therefore, in order to maintain the attenuation capacity of soils, it is important to have septic tanks pumped regularly and to replace aging systems.

The CURB program identified septic systems as a significant source of water pollution in the UTRCA watershed. Since CURB was initiated, a number of studies more thoroughly examined the contamination from private septic systems. A survey in Oxford County, Ontario, conducted between 1989 and 1990 identified the prevalence of faulty septic systems throughout the area (Poel, 1991). Over 25% of the residences serviced by domestic septic systems had improperly functioning greywater disposal methods (*i.e.* dish and laundry wastewater). In addition, 62% of the systems examined were older than 40 years of age and 35% of groundwater samples from rural homes contained fecal or total coliform levels in excess of the government recommended guidelines. Forty-one percent of homeowners questioned reported that their system had been inspected in the past. However, outdated or incomplete records at the Health Unit only had record of an inspection for 19% of the systems. It became evident that stringent enforcement was required to prevent unacceptable septic system installation (Poel, 1991). The author concluded that further research linking the type of soil and the depth of the water table to sites of potential contamination would be beneficial in understanding the extent of the problem.

In 1993, a questionnaire-based survey was conducted of cottages located around Fanshawe and Wildwood Lakes in the UTRCA watershed to determine if malfunctioning septic systems were the cause of contamination from fecal bacteria (Lawton and Ormseth, 1993). This was not the case, as it was shown that over 90% of the cottages had properly functioning systems. This may be due to the fact that the systems did not reach full capacity during the seasonal use of the cottages. Approximately 4% of the cottage owners questioned did not have a septic system to treat domestic waste. It was being deposited directly into the lake. Also, approximately 5% of the cottages exhibited problems with greywater disposal. Only 41% of the cottages had their septic tanks pumped at least once since gaining ownership of the cottage. According to the authors, many cottage owners believed that it was not necessary to have a septic tank pumped out despite that the Ontario MOE recommends a pumping rate of every three to four years. Although cottage septic systems did not appear to be a significant source of pollution, it became apparent during this study that a majority of the landowners were not familiar with proper maintenance requirements. However, during the course of that study, two of the cottage owners had been approved for a CURB grant. This could suggest that landowners were becoming increasingly aware of the pollution potential from septic systems with the initiation of CURB.

2.4.1.2 Density Studies

In terms of influencing regional groundwater contamination, septic tank density is the most influential parameter (Perkins, 1984; Yates, 1985). In areas with a low density of systems, the regulations for distance setbacks, minimum percolation rates, and leaching bed restrictions are adequate. However, in areas with a high density of septic systems, the potential for groundwater contamination increases as the soil's purification capacity becomes weakened (Yates, 1985). In order to ensure that groundwater does not become contaminated, Olivieri *et al.* (1981) suggested a density of one house unit (dwelling with 3.8 persons) per 0.6 hectares.

Perkins (1984) compared typical residential lot sizes and the impact on groundwater contamination determined in a number of studies conducted across the United States. Mathematical models that incorporated local characteristics were examined to determine theoretical lot sizes. For example, in Colorado where housing densities were greater than one dwelling per 0.4 hectares, nitrate nitrogen contamination at levels exceeding 10 mg/l was measured (Ford *et al.*, 1980 in Perkins, 1984). Similarly, a study in Minnesota correlated rural population density with well water pollution and estimated a contamination rate of approximately 30% in areas with a density of 0.15 hectares per person (Woodward *et al.*, 1961 in Perkins, 1984). The minimum lot sizes determined by groundwater protection regulations in the United States ranged from 0.2 – 0.4 hectares. Using predictive mathematical modeling to simulate regional physical and land development conditions, Perkins (1984) calculated that the minimum lot size for a residential area should be no less than 0.3 – 0.4 hectares. The author concluded that lot sizes used in subdivisions were generally determined by engineering standards and environmental impacts were often not considered. Minimum lot sizes must be regulated as an essential component of the permitting process (Yates, 1985).

The cumulative effects resulting from a high density of septic systems have prompted the Ontario government to consider alternative methods of wastewater treatment in rural areas not serviced by a municipal system. One alternative is communal septic systems, which are larger facilities shared among a number of residences in high density, small lot developments. When located in a subdivision setting, these communal facilities are expected to result in a higher degree of environmental protection than individual septic systems (MOEb, 1994).

A survey of Oxford County, Ontario revealed that a large concentration of septic systems in a small area should be replaced with a series of communal septic systems to prevent groundwater contamination (Packer and Ferguson, 1995). In this study of commercial and residential establishments in the small rural community of Thamesford, it was observed that a large proportion of the landowners did not have the available lot space required by MOE regulations to replace failing systems. Furthermore, several property owners had installed or made repairs to their systems without obtaining the required government approvals. In addition, vehicular traffic over the weeping bed, old systems, infrequent pumping and direct disposals of greywater were very prevalent. In this community, the improper care and maintenance of septic systems contributed to groundwater contamination. The authors also analyzed water quality data for the presence of bacteria associated with septic waste including *Escherichia coli*, *Pseudomonas aeruginosa*, and *Enterococci*. Levels for all three bacterial counts exceeded provincial guidelines. It was recommended that a municipal sanitary sewer or a series of communal septic systems be installed in Thamesford as a feasible alternative to the inadequate sewage disposal methods currently taking place.

In summary, this performance-based research has utilized computer and mathematical modeling and field-oriented studies to quantify the level of contamination from faulty septic systems. Models that incorporate local characteristics can provide useful information in predicting groundwater contamination (Yates, 1985). However, they may not provide a complete picture of the complex nature of site specific conditions and cumulative impacts of septic systems.

2.4.2 Map (GIS) - Based Research

Assessment of soil and the physical site conditions are critical steps in evaluating the suitability for septic system installation (Connors, 1980). Although individual site inspections are necessary, data displayed in map form can provide a useful tool for regulatory agencies when areas of groundwater sensitivity are delineated (Rifai *et al.*, 1993). Digital data generated by a GIS can be applied to research, planning, and resource management in order to enhance decision making. Maps in digital form are advantageous because data are easily transferable between agencies, changes in the physical or land-use patterns can be made easily, and decision makers are able to present data spatially (Rifai *et al.*, 1993). Despite these benefits, very little has been done in Ontario to utilize GIS technology to its full capacity for the purpose of protecting ground and surface water quality.

The Ontario MOE has compiled a series of maps entitled *Susceptibility to Groundwater Contamination*, which identify areas throughout the province that are more susceptible to groundwater contamination. Four factors were considered when the maps were created (Fleming, 1992):

1. permeability of surface material,
2. groundwater movement,
3. presence of shallow aquifers, and
4. use of the groundwater.

This data source would have been more effective for agencies involved in the regulation of septic systems had maps been created for the entire province and in digital format. However, due to restricted financial and personnel resources, the feasibility of producing maps of this kind is limited.

Research completed in New York utilized aerial photographs and surficial geologic maps to determine septic tank suitability (Connors, 1980). Although digital data were not used at this time, the authors identified the value of map-based information in the siting of septic systems. Six factors affecting the location of a septic system were considered:

1. type of soil material,
2. grain size distribution,
3. permeability,
4. depth to bedrock and water table,
5. slope,
6. hazard of ponding and flooding.

Using these criteria, a map of the study area was divided into three groupings identifying slight, moderate or severe restrictions for septic tank systems. Laboratory soil testing corroborated the results on the map. It was concluded that maps showing the suitability for septic tank installation provide a useful source of information to local planners. They also required relatively less time than compiling detailed soils reports or laboratory testing.

In 1986, an extensive report outlined the impacts of private septic systems on Wisconsin's critical resources (Hanson *et al.*, 1986). Using GIS software, digital maps were created to determine the amount of land available for septic system use and the location of these lands. However, septic systems are situated on small individual plots of land, therefore mapping data at a statewide level provided only generalizations of the site-specific conditions. Five criteria that create limitations for septic system installation in the prevention of groundwater contamination were used in the assessment:

1. depth to the bedrock,
2. depth to the groundwater,
3. soil permeability,
4. location of major water bodies, and
5. areas of peat.

A composite map was created based on these criteria which identified areas of Wisconsin that were suitable for septic tank development. A soil analysis was conducted at specific sites in order to verify the accuracy of the statewide data. The maps were effective in locating broad areas of the state suitable for conventional septic systems, assessing the implications of future policies for siting alternative types of systems, and examining the diverse nature of the natural conditions.

More recently, the US EPA has utilized GIS technology to delineate Wellhead Protection Areas (WHPA) in implementing state and local government groundwater protection strategies and protecting well water supplies from contamination (Baker *et al.*, 1993; Rifai *et al.*, 1993). Seepage from septic systems was classified as a major cause of groundwater contamination resulting in well closures. Polluted drinking water supplies prompted the government to develop more effective methods of groundwater protection. Therefore, GIS maps were produced to identify areas that contributed water to public wells. These WHPAs were defined in the U.S. *Safe Water Drinking Act* as:

> The surface and subsurface areas surrounding a water well or well field, supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water well or well field. (Rifai *et al.*, 1993, pg. 480)

Criteria based on the physical characteristics of the area and the availability of financial and personnel resources were used to delineate WHPAs in digital map form. The GIS technology was used to produce a sensitivity map that incorporated several parameters affecting well water quality. The same data were also used to calculate information such as hydraulic gradients, transmissivity, capture zones and other analytical data. The use of digital mapping has proven to be a valuable management tool in the conservation of well water supplies and in assisting agencies with meeting water protection strategies (Baker *et al.*, 1993). Although WHPAs did not focus directly on the siting of septic systems, it was a significant advancement for resource managers and regulatory agencies.

2.5 The Need for Implementation - Based Research

This thesis takes an implementation-based approach in evaluating two policies that control ground and surface water contamination from septic systems. Rather than conducting field research or applying mathematical models, implementation research examines the policies which control pollution from septic systems. A number of general frameworks for evaluating resource policies in this manner have been proposed. Sabatier and Mazmanian (1981) identified that the crucial role of implementation analysis was the identification of factors that affect the *tractability* of the problem, the *non-statutory structure* of the process, and the *statutory objectives*. Kreutzwiser and Slaats (1994) suggested that policy evaluation research should consider the criteria of *efficiency, effectiveness, accountability, efficacy* and *implementation*. Thomas and Palfrey (1996) have established a more extensive set of criteria with the addition of *equity, acceptability, accessibility, appropriateness, ethical considerations, responsiveness*, and *choice*. An alternative set of criteria was used to conduct an institutional analysis of nitrate pollution policy in England (Watson *et al*., 1996). The authors evaluated the policy based on seven criteria, which were divided into two sections: (1) the procedural values of *co-ordination, participation, mix of strategies*, and *adaptive capacity*; and (2) a group of substantive values including *equity, efficiency* and *effectiveness*.

Previous studies of septic systems have not considered these policy implementation criteria when evaluating the impacts on water quality. Instead, the focus remained on performance-based measurements such as the levels of contaminants detected in well water. However, a few studies have assessed the implications of septic tank policy on water quality (Hanson and Jacobs, 1989; Simpson, 1992).

In Wisconsin, implementation-based research examined the impacts of private sewage systems on planning and policy (Hanson and Jacobs, 1989). Data from permits, questionnaires distributed to septic system users, and interviews with county officials provided information about the accomplishments of septic system policy. By analyzing these data, the authors determined that septic system use promoted a highly dispersed rural development. This created problems when using the current septic system policy in dealing with land-use and environmental impacts. These difficulties arose because the policy did not consider broad-scale settlement, landscape, or planning impacts but rather acted as a health policy designed to remove harmful constituents from effluent. Soil, slope, and water table information were the primary criteria considered for the delineation of areas unsuitable for development and septic system approval. However, with the development of alternative septic tank technology, rural development trends have changed. The authors concluded that the impacts of most land settlement trends could not be mitigated with septic tank policy alone, and suggested that elements of land-use planning comprise an important aspect of the regulation.

Further research completed in the Region of Waterloo, Ontario took an implementation-based approach to assess the land-use planning implications of septic systems (Simpson, 1992). This involved a case study that examined current institutional arrangements to create improved strategies for groundwater protection. The author proposed that groundwater protection zones (GPZ) be delineated as a form of land-use control to restrict development in areas where groundwater resources may become contaminated. According to the GPZ strategy, a region could be classified into recharge areas according to the potential for groundwater contamination. Simpson (1992) noted the current approach to groundwater protection was based primarily on minimum setback distances from land uses that affected water quality. Since not all groundwater is vulnerable to contamination, the GPZ strategy took into account the dynamics of groundwater flow in determining site suitability. For example, the well setback distances in current septic tank policy required a minimum lot size of one hectare. However, a groundwater plume contaminated with nitrates often exceeded this boundary. Therefore, present regulations were not effective in the prevention of contamination, whereas the

GPZ strategy considered the overall groundwater resource of the region as a more effective means to protecting groundwater. Simpson (1992, pg.114) concluded,

> the existing legal and institutional arrangements in the province of Ontario are not adequate to protect groundwater quality from contamination from small scale and widespread sources such as septic systems.

The groundwater protection zone approach to policy implementation provided an ecological perspective to ensure that the groundwater in an entire region was considered rather than focusing on the water lying beneath the property boundaries of an individual septic system.

These two studies have taken an implementation-based approach to evaluate policies for controlling pollution from septic tanks. However, a narrow range of criteria were examined resulting in conclusions on the performance of the policy rather than the effectiveness of the implementation process in preventing pollution from septic systems.

2.6 Summary

Relatively little research has taken a policy implementation approach to examine the impacts of septic systems on ground and surface water quality. The few studies, which have assessed policy implementation, did not consider a complete range of criteria including equity, efficiency, and the level of risk in their evaluation. This type of analysis should consider the policy instruments and processes, implementing organizations, and the stakeholders when evaluating a policy (Hansenfeld and Brock, 1991). Furthermore, implementation research examines the accomplishments of an agency in implementing the policy and the overall achievement of the policy goals

(O'Toole, 1989). Therefore, these studies examine how a policy meets its objectives and provide information to policy makers on how to improve management strategies (VanMeter and VanHorn, 1975).

A wide range of criteria for evaluating the implementation of policy has been proposed. The formulation of an evaluative framework and the selection of evaluative criteria are dependent on the objectives of the programs. Therefore, there is no single correct set of evaluative criteria. A policy such as the Ontario *EPA* regulation 358 is one that is intended to regulate the proper installation and maintenance of septic systems. It was expected that the policy would assist in controlling the amount of diffuse pollution from septic systems entering the ground and surface water supply. CURB was a cost-sharing approach aimed at reducing the effects of existing malfunctioning septic systems. The CURB program was intended to improve the water quality in local reservoirs and ultimately reduce the number beach closures. Effective implementation of these two programs should be linked to some measurable outcomes in the form of changes in society, economy, or the environment. The framework and criteria for evaluating these two programs will be developed further in chapter three.

3. METHODOLOGY

The methodology required important decisions concerning the selection of a case study, data collection, and development of a framework for analysis. Each is considered below.

3.1 The Case Study

This evaluation of the Ontario *EPA* Regulation 358 and CURB programs utilized a case study approach. On one hand, case study research is advantageous because it allows for the sensitive research of specific instances that may show historical and causal processes. This enables the researcher to answer the 'how' and 'why' questions (Stoecker, 1991). Other supporters of the case study emphasized its ability to discover complex sets of decisions and recount the effects of those decisions over time (Orum *et al.*, 1991). Also, the observations and concepts of case study research are grounded in a natural setting rather than based purely on theory. Yin (1992) identified that the strengths of the case study as an evaluative tool lie in its ability to capture processes and outcomes in a causal method. This can ultimately provide useful feedback to officials. On the other hand, case study research is often criticized for lacking objectivity and difficulty in providing generalizations (Stoecker, 1991). In addition, this approach often relies on retrospect or post-program evaluations since no accurate measure of independent variables or control groups are possible. These shortcomings may compromise the reliability of the research when used as the primary means of analysis.

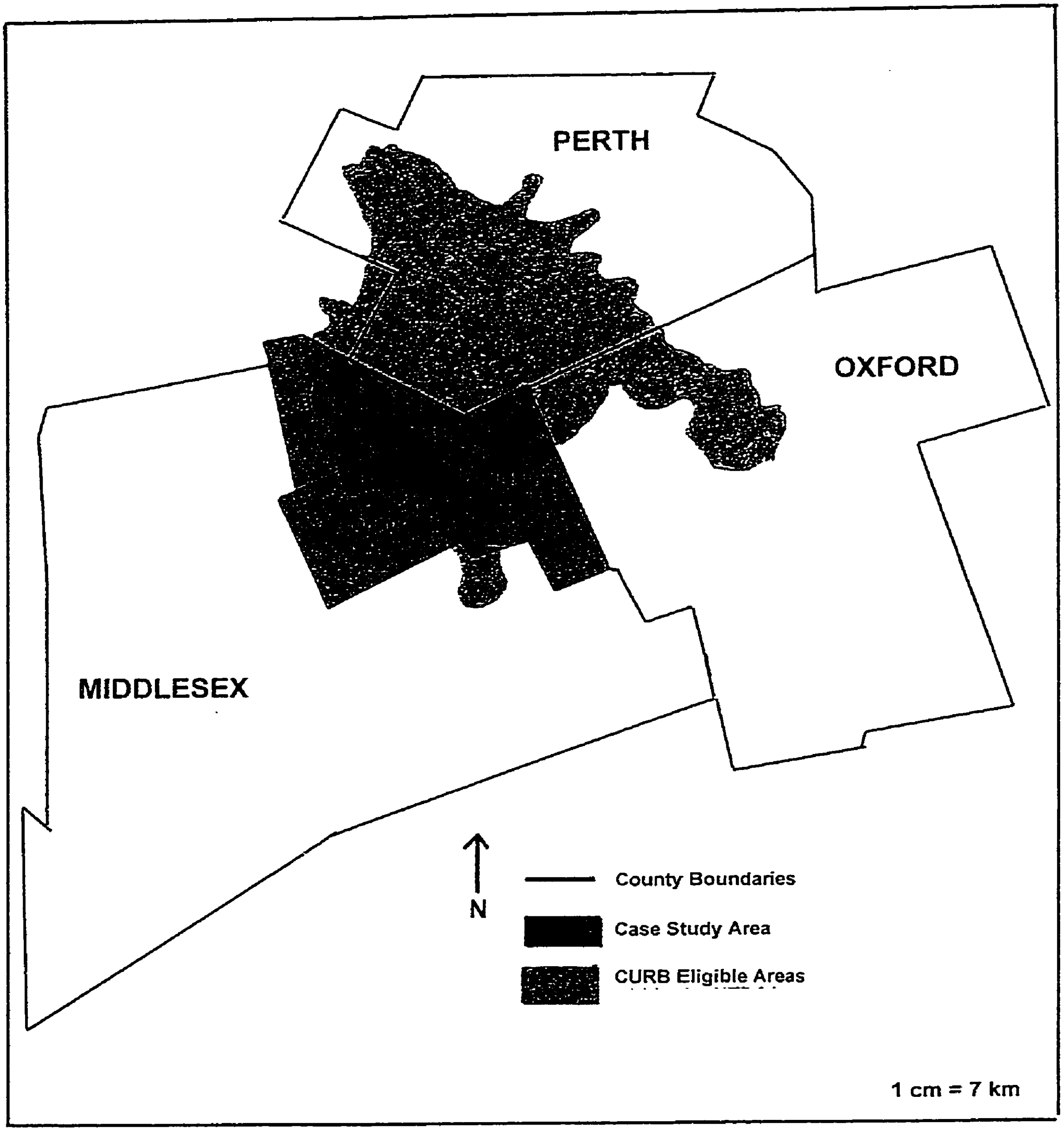
Very little research has evaluated the implementation of policies for controlling pollution from private septic systems. As noted in chapter two, research on septic systems has involved ground and surface water monitoring, computer simulations, and mathematical modeling to assess the biophysical impacts. Unlike previous studies, this thesis used a case study to examine the implementation of two programs for controlling water pollution from septic systems.

3.1.1 Case Study Area

Three townships in Middlesex County, Biddulph, London, and West Nissouri, were selected for detailed study (Figure 3.1). These townships are located within the northeastern most section of Middlesex County and participated in the CURB program. Since these three townships are located in the southern most tip of the CURB eligible area and lie within the Fanshawe Lake reservoir, the activities undertaken upstream had a direct impact on the surface and groundwater quality throughout Middlesex County. CURB targeted these areas because they significantly contributed to the contamination of downstream beaches. When the government's financial resources are scarce, policies that target certain areas ensure that remedial measures and assistance are directed to priority areas (Dickinson *et al.*, 1990). Targeting critical areas also ensures that the greatest improvement can be made in areas for the least investment (Maas *et al.*, 1985).

The Fanshawe Reservoir had experienced recurring beach closures due to blue-green algae blooms and elevated fecal coliform levels since the early 1980s (UTRCA, 1991). The UTRCA (1991) identified that 50% of the bacteria in Fanshawe Lake was attributed to rural sources, mainly unacceptable septic systems.

Figure 3.1 Case Study Area



The selection of Biddulph, London, and West Nissouri townships serve to illustrate the implementation of both the Ontario *EPA* Regulation 358 and CURB programs. In this way, questions related to "how" and "why" these programs were or were not effective in controlling pollution from septic systems can be answered.

The townships are predominantly rural with close to one hundred percent of the total population classified as rural (Table 3.1). According to Census Canada (1996), rural is defined as a built-up area with a ceiling of 1000 people or a density of 400 people per square kilometer.

Table 3.1: Rural population as a percent of total population

	1976		1981		1986		1991	
	Total	**Rural (%)**	**Total**	**Rural (%)**	**Total**	**Rural (%)**	**Total**	**Rural (%)**
Biddulph	2204	(100)	2260	(100)	2247	(100)	2196	(100)
London	5923	(86.6)	5738	(88.5)	5841	(100)	5877	(100)
West Nissouri	3372	(100)	3343	(100)	3282	(88.5)	3538	(88)

(Census Canada)

Regulation 358 was not applicable to a small portion of the population that lives in communities such as Lucan and Ilderton serviced by municipal wastewater treatment systems. However, a majority of the landowners were serviced by private sewage systems to dispose and treat domestic wastewater including a significant population in small rural communities. The rise in exurban growth has resulted in substantial subdivision development throughout the case study area. The impacts of these small lot developments will be examined in this thesis. All of these landowners must comply with the Ontario *EPA* Regulation 358 when installing or making improvements to their septic system. Between 1992 and 1996, the UTRCA received 343 applications from landowners in Biddulph, London, and West Nissouri townships for septic system Certificates of Approval. During this same time period, 136 landowners in Middlesex County received funding from the CURB program to repair existing malfunctioning septic systems. This time period was selected for two reasons. First, the CURB program was implemented in the fall of 1991 and was terminated in 1995 therefore, all projects that received CURB funding were considered. Second, the UTRCA was delegated as the agency responsible for implementing Regulation 358 in the fall of 1992, therefore all applications submitted in the case study area were processed by the same agency. By examining all applications for the period of 1992 to 1996, an accurate representation of Regulation 358 and the simultaneous implementation of CURB were achieved. Septic systems proved to be a significant source contributing to water contamination in these three townships. Therefore, the high proportion of septic system use and number of applications submitted for CURB funding in the case study area provided an adequate representation of the programs.

Minor limitations arose in the selection of the case study area. For instance, agricultural activities, which are predominant throughout Middlesex County, can also contribute to water pollution. According to Census Canada, approximately 75% of the County had been used for farm related land use activities over the past 20 years (Table 3.2). The large numbers of livestock present in Middlesex County identify the significance of these farming operations in terms of contributing to diffuse pollution.

Table 3.2: Agricultural profile of Middlesex County

	1976	1981	1986	1991	1996
# of Farms	3548	3520	3244	3162	2987
% of Area in Farms	77%	76%	75%	75%	77%
# of Cattle	NA	134791	106221	86145	85718
# of Pigs	NA	261916	261238	266307	225856
# of Chickens	NA	1909080	1821580	1585521	1458569

(Census Canada)

Over the past 50 years, agriculture has become industrialized in Canada and other developed countries (Bowler, 1992). This resulted in fewer but larger farms that relied on machinery, fertilizers and other chemicals. According to Bowler (1992), one consequence of agricultural industrialization is the destruction of the rural environment. In addition, over-use of fertilizers and other agrichemicals, and leakages from wastewater storage areas can contribute to the pollution of watercourses. This type of chemical application was apparent in Middlesex County where 68% of the farms reported use of fertilizer, manure, herbicides, insecticides, and fungicides in 1991 (Census Canada, 1991). During the same year in Biddulph, London and West Nissouri townships, 77% of the farms reported use of these chemicals. In these three townships, agricultural industrialization has occurred resulting in fewer farms operating with a larger number of livestock (Table 3.3). According to Troughton (1995), Ontario has experienced the growth of large-scale housed livestock operations, which has resulted in problems dealing with the tremendous accumulation of waste.

Table 3.3 Agricultural profile of Biddulph, London, and West Nissouri Townships

	1976	1981	1986	1991	1996
Number of Farms	925	NA	867	813	758
Area in Farms (ha)	121037	NA	NA	NA	63914
# of Cattle	45211	NA	30010	23637	NA
# of Pigs	39284	NA	58271	53561	NA
# of Chickens	167661	NA	531220	566054	NA

(Census Canada)

Land use activities associated with livestock operations have been identified as sources of water pollution. For example, in addition to malfunctioning septic systems, the CURB program identified unrestricted livestock access to watercourses, improper handling of milkhouse wastewater, and inadequate manure management practices as significant sources of diffuse pollution in Middlesex County (MOEEa, 1994). Due to the economic pressures of agricultural production, the stewardship ethics once practiced by farmers were often lacking in order to remain economically efficient (Troughton, 1995). As a result, there was a greater threat to water contamination and degradation of the rural environment as a whole.

The causes of water contamination in rural areas are extensive making it impossible to identify a case study area impacted solely by septic systems. Although septic systems represented a potentially significant source of ground and surface water pollution in the case study area, there is little doubt that agricultural activities could also contribute significant amounts. For this reason, efforts at reducing sources of diffuse pollution into rural water supplies are complex. However, in Biddulph, London, and West Nissouri Townships, malfunctioning septic systems have been identified as one significant source of water pollution (UTRCA, 1991). The Ontario *EPA* Regulation 358 and CURB programs represent two important mechanisms for addressing this problem. Effective implementation of these two programs will be evaluated in the following chapter.

3.2 Data Collection

In order to accurately evaluate the Ontario *EPA* Regulation 358 and the CURB programs, four primary sources of data were collected over the course of this research: (1) applications for *EPA* permits and Certificates of Approval, (2) CURB applications, (3) questionnaires and interviews with government officials, and (4) GIS maps indicating sections of the case study area unsuitable for conventional septic system use.

3.2.1 Applications for EPA Permits and Certificate of Approval

The first source of data was contained on the applications for the Ontario *EPA* Use Permits and Certificate of Approval, and pertained to the installations of new and replacement domestic septic systems. All applications submitted to the UTRCA in Biddulph, London and West Nissouri Townships for the period of 1992 to 1996 were collected. A total of 343 applications were submitted during this time period. Copies of the application, Certificate of Approval, and Use Permit are contained in Appendix 1. These forms provided information about the physical characteristics of the septic system, the location and conditions of the property, and the type and size of dwelling (Table 3.4). These forms also provided insight as to the rate of approvals and any conditions that had to be met before an application was approved.

Table 3.4: Information collected from *EPA* applications and Certificate of Approvals.

1. Type of Septic System	• Conventional, Raised, Filter bed, Holding tank
2. Purpose for Applying	• Construct, Enlarge, Alter
3. Type of Applicant	• Single family home, Institutional, Commercial
4. Dates	• To issue a C of A, To issue a Use Permit
5. Capacity of the System	• Size of tank (l) based on number of bedrooms
6. Soil Percolation Rate	• T = min/cm based on number of bedrooms
7. Lot Size	• Availability of space (ha)
8. Conditions	• Imported fill, Distance setbacks, etc.

For more complex applications such as those associated with a new development, a professional engineer must submit a Soils Report that provided further details about the physical conditions of the property and recommendations for the type of system that should be installed. The UTRCA provides a list to landowners of professional engineering consultants who are familiar with the standards of the *EPA* Regulation 358. For this reason, all of the reports contained the same coverage of information and were uniformly of high quality. There were 78 Soils Reports completed during the study period. These were reviewed as part of the research process and information about percolation rates, description of the site, the type of system proposed, and conditions for approvals were collected.

3.2.2 CURB Applications

The second primary data source for this thesis was information from applications submitted for CURB grants to repair or replace faulty septic systems in Middlesex

County. Upon the termination of the CURB program in 1995, the applications and documents from all participating conservation authorities were stored at the MOE office in Toronto, Ontario. During the course of this research, information from the Water Quality Improvement Plan (WQIP), Section A pertaining to septic systems was collected from files at the MOE office. A copy of the WQIP is contained in Appendix 2.

In order to portray an accurate representation of the CURB program, all of the applications for septic system projects in the UTRCA watershed were considered, including the few projects completed in Biddulph, London, and West Nissouri Townships. A total of 136 applications were submitted for septic system projects in the UTRCA watershed. The landowner and a CURB Facilitator completed the applications. Therefore, the data should have provided an accurate description of the conditions on the property. For this research, data including the characteristics of the septic system, as well as the causes, degree and pathways of surface water contamination were collected from the documents (Table 3.5).

Table 3.5: Information collected from CURB applications

1. Source of Pollution	• Surface effluent, Subsurface effluent, Greywater
2. Cause of Pollution	• Ponding, Direct connection to watercourse, drain etc.
3. Tank Pumping Rates	• < 1 year, 1-2 years, 2-4 years, > 4 years
4. Age of System	• 0-20 years, 21-50 years, > 50 years
5. Impact on Water Quality	• Limited, Moderate, Severe
6. Distance Separations	• To leaching bed, To municipal drain, To watercourse, To beach
7. Dates	• To obtain local approval, To obtain provincial approval
8. Type of Project	• New tank, New leaching bed, New system
9. Cost of Project	• < $1000, $ 1000-2000, $ 2000-3000, $ 3000-4000, > $ 4000

3.2.3 Questionnaires

The third source of data was questionnaires and interviews directed to officials involved in the execution of the *EPA* and CURB programs. Since their focus was not the same, a separate questionnaire was designed for each program. Copies of both questionnaires are contained in Appendix 3. Questionnaires were sent to the officials at the UTRCA who were responsible for the implementation of the Ontario *EPA* permitting process for domestic septic systems. Although four officials agreed to complete the questionnaires, only two were returned. Two officials involved with the CURB program completed a different questionnaire. Respondents included an official from the MOE and from the UTRCA. The official from the UTRCA was not directly involved in the implementation of the *EPA* permitting program.

The purpose of the questionnaires was to gain a better understanding of both programs in terms of the staff / agency commitment and the perceptions of the public managers about the overall performance of the program. Also, the questionnaires gave insight into the experience and knowledge of officials directly involved in the implementation of the programs. Throughout the research, ongoing communication with officials at the UTRCA and the MOE also provided clarification and understanding about the programs.

3.2.4 Mapping of Physical Characteristics

A series of maps was generated in order to identify areas where the physical environment could limit the use of a **conventional septic system**. As discussed earlier in chapter 2, when siting a domestic septic system there are three main factors that affect groundwater contamination: (1) the soil permeability, (2) the depth of the bedrock, and (3) the depth to the groundwater table. Each factor was used to construct a different map layer.

The regulatory process does not involve the use of digital maps during the approval of septic systems. Instead, the Ontario *EPA* required that site specific tests of the percolation rate and soil type be carried out prior to the issuance of a Use Permit. However, maps can provide a valuable source of data in determining those areas of a region unsuitable for siting a conventional septic system. Ideally, maps at a large scale (*i.e.* 1:5,000) that portrayed the characteristics on individual lots would provide greater detail of the conditions, but these are not currently available. Nevertheless, maps produced at a county-level scale (*i.e.* 1:50,000) can provide general determinations of where limitations in the physical environment exist for the placement of conventional systems. For this thesis, a series of digital maps was produced at a township level for Biddulph, London, and West Nissouri.

3.2.4.1 Soil Permeability

The first map layer that was produced in this thesis showed the soil permeability. Data were taken from the Soil Survey Report #56, Sheet 3 of the Ontario Eastern Townships map series entitled *Soils of Middlesex County*. Agriculture Canada published this map in 1991 at a scale of 1:50,000. The original map was organized into the various soil types located throughout the county. For example, a different class was assigned according to the texture of the soil material (*i.e.* clay, silt, sand) and corresponding drainage properties (*i.e.* well, moderate, poor).

Since conventional septic systems rely on the soil beneath the leaching bed to treat effluent, the type of soil plays a critical role in the removal of harmful constituents. Therefore, for the purpose of this thesis, when the original map was digitized the data were further simplified into three categories of soils according to the degree of permeability and texture (Table 3.6). The resulting map identified areas that can cause limited, moderate and severe impacts on water quality when siting a conventional septic system.

Table 3.6: Soil permeability categories

Soil Type	Permeability & Texture	Impact on Water Quality
Sand and gravel	High permeability Coarse texture	Moderate
Silty Loam	Medium permeability Medium texture	Limited
Clay	Low permeability Fine texture	Severe

(Adapted from Hanson *et al.*, 1986)

The categories were determined based on a study completed by Hanson *et al.* (1986) in Wisconsin, who created a similar set of digital maps. For example, all the classes of soil on the original Agriculture Canada map that were composed of sands and gravel were grouped into the first category. This high permeability / coarse textured soil does not retain effluent long enough for adequate treatment. According to Hanson *et al.* (1986), siting a conventional septic system in these areas could pose a moderate degree of impact on water quality. The second category used in this study combined all classes from the original map that consisted of silty loam soils. These soils represent medium permeability and texture and provide optimal treatment of effluent. It is expected that a limited impact on water quality would occur in these areas. Finally, classes on the original map consisting of clay were grouped into the third category for this research. These areas are characteristic of low permeability / fine textured soils and retain wastewater too long in the soil creating a saturated environment, unable to properly treat effluent. Septic systems located within these areas could pose a severe impact on water quality (Hanson *et al.*, 1986).

3.2.4.2 Depth of the Bedrock

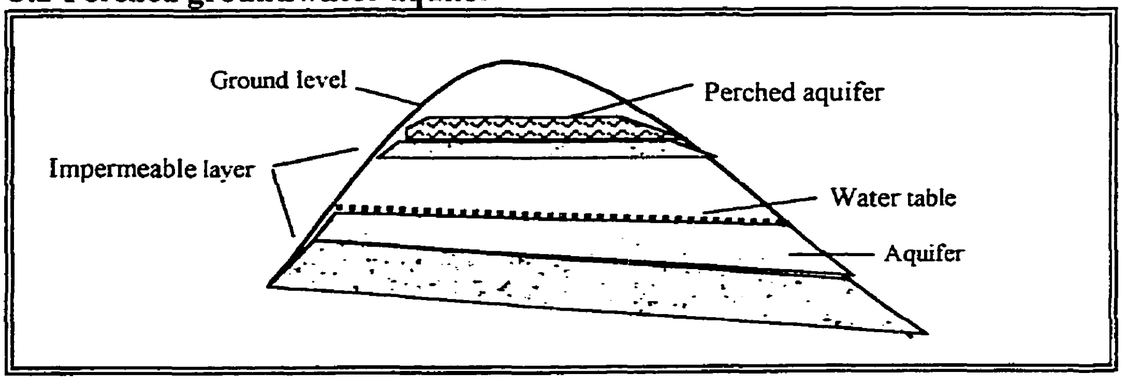
The second map layer produced for this thesis showed the depth of the bedrock beneath the surface of the ground. As noted earlier, the distance between the bottom of the leaching bed in a conventional septic system and the bedrock must be deep enough to provide adequate treatment of effluent. Data for this layer was obtained from the *Drift Thickness Series* map #2359 (MNR, 1980), which had a scale of 1:50,000.

Just as in the soil permeability map, when the depth of the bedrock map was digitized to create the second map layer for this thesis, it was organized into four varying depths of the bedrock. The categories were established based on the Ontario MOE guidelines for construction of a conventional septic system and ranged from limited to severe impact on water quality: (a) > 50 meters deep, (b) 15 – 50 meters, (c) 2 – 15 meters, and (d) < 2 meters deep. According to the Ontario MOE, in areas where a conventional septic system is to be installed, there should be at least two meters of soil between the surface of the ground and the bedrock (MOE, 1992).

3.2.4.3 Depth of the Groundwater

The third map layer produced for this thesis showed the depth to the groundwater table. In areas where the groundwater table is high (*i.e.* less than 2 meters below the surface), the potential for groundwater contamination from septic effluent is significant (Hanson *et al.*, 1986). Therefore, this map layer was critical in determining regions of the study area suitable for the installation of conventional septic systems. The information for this map layer was obtained from the Ontario MOE *Water Well Construction Record* database. The water well construction data consisted of a table containing 7723 records indicating the observed depth to the static groundwater level. This table was organized according to the UTM Easting and Northing, and the corresponding depth of the water table in meters. Well drillers, following the completion of digging water wells, reported these data. Therefore, the reliability of the information depended greatly on the attention applied during the collection of the data. As a result, the presence of a perched aquifer could have produced misleading values for the true depth to the groundwater. These perched groundwater bodies develop above a bed of an impermeable layer of rock or soil (Dunne and Leopold, 1978) (Figure 3.2).

Figure 3.2 Perched groundwater aquifer



(Adapted from Dunne and Leopold, 1978)

Unlike the previous two data sets, which provided information about the entire study area, the groundwater depth was given for specific well construction locations. There were two possible opportunities for error that could have occurred during the collection of the well log. The first error may have resulted from annual or inter-annual variations that could have created inaccuracies in the measurement of depth to the static groundwater level. Also, it was not uncommon for static groundwater levels to vary slightly with the depth of the well in areas of groundwater recharge or discharge (Piggott, 1998).

For this thesis, the depth to the groundwater map layer was organized into three categories ranging from limited to severe impact on groundwater: (a) > 50 meters, (b) between 5.1 and 50 meters, and (c) < 5 meters. The MOE regulation stipulates a minimum of two metres above the high water table. However, considering the reliability of the information used to create this map layer, areas with less than five metres of overburden were considered severely limiting the use of conventional septic systems. Negative values were measured in cases where the groundwater rises above the surface of the ground. Similar categories were verified by Hanson *et al.* (1986) in determining the impacts of septic systems in Wisconsin. According to Ontario MOE guidelines for siting a conventional septic system, the groundwater table must be at least two meters below the surface of the ground (MOE, 1992).

3.2.5 Production of Map Layers

A base map for each of these three factors was created for the study area in Middlesex County (Figures 4.2, 4.3 and 4.4). Since the distance from a septic system to a watercourse is an important factor in the protection of water quality, the locations of surface water sources were also plotted on the maps (NTS sheet 40 P/3, *Lucan Ontario* 1:50,000). Maps in digital form did not exist for the area, therefore information was extracted from the three relevant hardcopy maps (Ontario Eastern Townships, *Soils of Middlesex County* 1:50,000; Ontario Geologic Survey, *Drift Thickness Series* 1:50,000; NTS sheet 40 P/3, *Lucan Ontario* 1:50,000). The information was scanned into the computer using the Adobe Photoshop software program. This involved tracing the pertinent information from the hardcopy maps by hand. In order to ensure that the information was traced accurately, the same outline was used to align the perimeter of the study area. For this reason, the perimeter may not fall along the exact position of the township boundary. Rather, a county road and concession were used as the boundary of the case study area. In the case of the groundwater table data, information was converted from table format (Ontario MOE, *Water Well Construction Records*) into a digital map with the GIS software Map•Factory.

Prior to being scanned, the information from the original maps was organized into categories according to the degree of impact on water quality. These categories were established based on criteria outlined in the Ontario MOE regulations for siting a conventional septic system. Once the maps had been digitized, each layer was adjusted in order to align all three of the map layers. Next, the maps were imported into a drawing program, Claris Draw, in order to assign a relevant color scheme.

The final step was to import all of the map layers into the GIS program Map•Factory to create a map which illustrated the combined limitations of soil permeability, depth of the bedrock, and the groundwater depth on the siting of conventional septic systems. By implementing simple computational operations, this composite map was created. The resulting map highlighted the areas in the study area that were susceptible to groundwater contamination since the siting of a conventional septic system would present severe impacts on the water quality (Figure 4.5). This map was utilized to evaluate the performance of the Ontario *EPA* Regulation 358.

Any area that was situated on land that was not capable of supporting the effective operation of a conventional septic system based on any combination of soil permeability, depth to bedrock and depth to groundwater was classified as "severely limiting". The intent was to identify where these severely limiting areas were generally located and to review both *EPA* and CURB applications. In the absence of a supporting Soils Report, conventional septic systems should not be located in these areas. This targeted approach provides for insights concerning the performance of the *EPA* and CURB programs. Consistency of decision outcomes within the program and the intent between the programs can be assessed.

3.3 Evaluative Framework

The purpose of this thesis was to evaluate two policies for controlling pollution from domestic septic systems. Policy evaluations can be completed to determine the adequacy of resource programs and what factors account for their success or failure. Valuable insights into the success of resource policies can effectively be made with evaluation methodologies (Kreutzwiser and Slaats, 1994). According to Thomas and Palfrey (1996), the approach taken during a research-based evaluation can be classified as an academic inquiry. This approach is most likely to result in an independent evaluation in which the data collection and analysis must be reliable in order to meet the review of academic peers. Evaluations carried out by academics often provide generalized truths rather than the specifics of a more systematic review (Thomas and Palfrey, 1996). This thesis can be considered an academic evaluation of the Ontario *EPA* Regulation 358 and the CURB program, and will also provide useful information for government officials in formulating future programs. The evaluative criteria selected to analyze the programs are described in Table 3.7.

Table 3.7: Evaluative criteria measures and data sources for policy analysis

CRITERIA	*EPA* REGULATION 358 MEASURES	CURB MEASURES	DATA SOURCE
Efficiency	1. Number of days to process applications 2. Accuracy / reliability of information on the application 3. Accessibility of the program to the public	1. Number of days to process applications 2. Accuracy / reliability of information on the application 3. Accessibility of the program to the public	1. Applications and permits 2. Questionnaires and interviews
Equity	1. Decision according to type of applicant 2. Decision according to type of system 3. Decision according to type of project	1. Decision according to project costs 2. Decision according to purpose for applying 3. Decision according to type of project	1. Applications
Level of Risk	1. Working capacity of the system 2. Lot size 3. Percolation rates	1. Pumping rates 2. Age of System 3. Distance separations 4. Severity of impact on water quality	1. Applications
Performance	1. Locational Suitability	1. Achievement of Objectives	1. GIS Maps 2. Questionnaires and interviews
Consistency	1. Consistent Objectives 2. Cross Compliance		1. Questionnaires and interviews 2. Government documents

The two programs were first evaluated as separate policies based on the criteria of efficiency, equity, level of risk and, performance. Since both of the programs focused on pollution from septic systems, an additional criterion of consistency was used to evaluate the combined efforts of the simultaneous implementation of the programs.

3.3.1 Efficiency

The first criterion used in this thesis to evaluate the programs was *efficiency*. Measures of efficiency often involve the ratio of benefits to costs (Thomas and Palfrey, 1996). However, a benefit-cost analysis is difficult to quantify since these are often in the form of intangible variables. Efficiency has been utilized as an evaluative criterion in previous resource management research. For example, Shrubsole and Wilcox (1996) and Shrubsole *et al.*, (1995) measured the efficiency of government programs in Ontario for controlling agricultural pollution and floodplain management respectively. In addition. Watson *et al.*, (1996) measured the efficiency of nitrate pollution control measures in England.

In this research, three measures were used to indicate efficiency: (1) time spent to process an application, (2) accuracy or reliability of the information used during the approval of an application, and (3) the accessibility of the program to the public. Efficient implementation required that an application was processed within a reasonable time frame, that the information contained on the application was clear and precise, and that the target population was aware of and utilized the program.

There were three sources of data used to measure efficiency. The first involved information taken from the applications and permits regarding the length of time to complete the process of approval. Second, interviews with relevant officials involved in the implementation of the program provided insight into the staff commitment to the program and the support of the public. The third source of data was the information taken from relevant MOE and UTRCA documents that showed the responsibilities of the provincial and local governments as well as the landowner.

3.3.2 Equity

The second criterion evaluated in this thesis was *equity*. This is based on the premise that people with comparable needs are treated equally in due process (Thomas and Palfrey, 1996). In previous evaluations of resource policies, equity was commonly indicated by the uniform implementation of a program among various groups (Shrubsole and Wilcox, 1996). Previous research has examined the equity of land use regulations (Kreutzwiser and Slaats, 1994; Shrubsole *et al.*, 1995) and pollution controls (Shrubsole and Wilcox, 1996; Watson *et al.*, 1996).

Equity of the Ontario *EPA* and CURB programs was assessed in this thesis based on approval rates among the type of applicant, type of system, and purpose for the application. The conditions that must be met by the landowner before approval of the application were also assessed as a measure of equity. Consistency among the types of conditions placed on individual applicants ensured that the process was fair and did not entertain elements of favoritism.

The data for determining the equity of the program were derived from applications, permits, and comments from agency officials. A chi squared test was used to determine if there was a significant difference between the approval rates ($\alpha = 0.01$).

This test indicated statistical significance or different treatment among the various groups of applicants.

3.3.3 Level of Risk

The third criterion examined in this thesis was the *level of risk*. Over 23% of the population, almost three million people, in Ontario rely on groundwater as their primary source of fresh water (MacRitchie *et al.*, 1994). Programs that attempt to decrease the pollution potential from septic systems should target the areas and activities that most severely affect water quality. The level of risk represents an important criterion for evaluation in issues involving resource management. For example, Shrubsole *et al.* (1995) measured the level of risk involved during land use development in floodways.

In this thesis, each program was assessed based on variables that indicated the level of risk during the approval process (Table 3.1). For the Ontario *EPA* program, the working capacity of the system, the lot size, and percolation rates were used as indicators of the level of risk. Pumping rates, the age of the system, distance separations, and the severity of impact on water quality portrayed the level of risk of the CURB program.

All of the information used to indicate the level of risk was taken directly from the applications. Different measures of analysis between the Ontario *EPA* and CURB were used because of the inherent differences in the focus of the programs. However, a clear indication of the level of risk was established.

3.3.4 Performance

The fourth criterion for evaluation of the Ontario *EPA* Regulation 358 and CURB was the *performance* or effectiveness of the programs. Essentially, an evaluation of this nature assesses the accomplishments of the program in controlling certain land use activities. This criterion aided in answering the questions, "Were the programs successful in achieving the stated objectives?" and ultimately, "Were the programs necessary?" Previous research that evaluated resource policies has considered performance. For example, the effectiveness of England's nitrate pollution controls in protecting aquatic environments has been examined (Watson *et al.*, 1996). Measures of performance were also used to assess the impact of land use regulations on the development of hazard shorelines (Kreutzwiser and Slaats, 1996).

The need for the two programs could have been established through examining the number of beach closures and levels of bacterial contaminants in local reservoirs. However, information for beach closures at Fanshawe Lake was not accessible over the entire study period. A beach curtain, which isolated the swimming area at Fanshawe Conservation Area from the rest of the lake, was installed in the summer of 1988. This has allowed ongoing recreational use of the beach since that time. According to one UTRCA official, beach closures would not have given a clear indication of the contamination of Fanshawe Lake since water quality samples were taken only within the swimming area. As a result, bacterial count data were also not available for Fanshawe Lake. It is also important to recognize that beach closure and bacterial count data were influenced by a number of diffuse pollution sources other than septic systems. Septic system malfunctions alone did not account for the levels of bacteria detected in the ground and surface water throughout the watershed. As described in Section 3.1.1 there was also a potential for significant agricultural pollution sources. Therefore, it would have been difficult to establish a cause and effect relationship between the impacts of septic effluent and bacterial counts.

For this thesis, digital map data were used to give an indication of the performance of the *EPA* program. Map data were generated to identify areas that may exhibit a potential for water contamination. This type of suitability mapping provides a valuable tool for agencies in locating areas that cannot support conventional septic systems and areas highly sensitive to groundwater contamination. In this way, a regional assessment of the area can be made prior to the site-specific tests. Ultimately the performance of the programs was determined through examining the extent of septic tank use in areas identified on the maps as susceptible to groundwater contamination. Performance of CURB was determined by assessing the effectiveness of the program in meeting its objectives.

3.3.5 Consistency

The final criterion used to evaluate the accomplishments of the policy process was consistency. An institutional analysis of nitrate pollution controls in England examined consistency by measuring the level of co-ordination between agencies with shared or overlapping responsibilities (Watson *et al.*, 1996). In addition, research completed on the utility of land use regulations for shoreline development in Ontario considered consistency in their evaluation (Kreutzwiser and Slaats, 1996). In this case, the clarity of program goals and the comprehensiveness of the regulation were selected as evaluative criteria.

The Ontario *EPA* and CURB programs involved efforts from multiple levels of government. In order to be effective, these programs which targeted the same population and land use activity should have goals and objectives that were consistent. In addition, the responsibilities between the two agencies should not overlap. Any element of inconsistency could have counteracted the efforts of one or both programs in meeting its purpose. Through examining the objectives outlined for each of the programs as well as input from relevant officials, the consistency of the programs was determined.

4. ANALYSIS

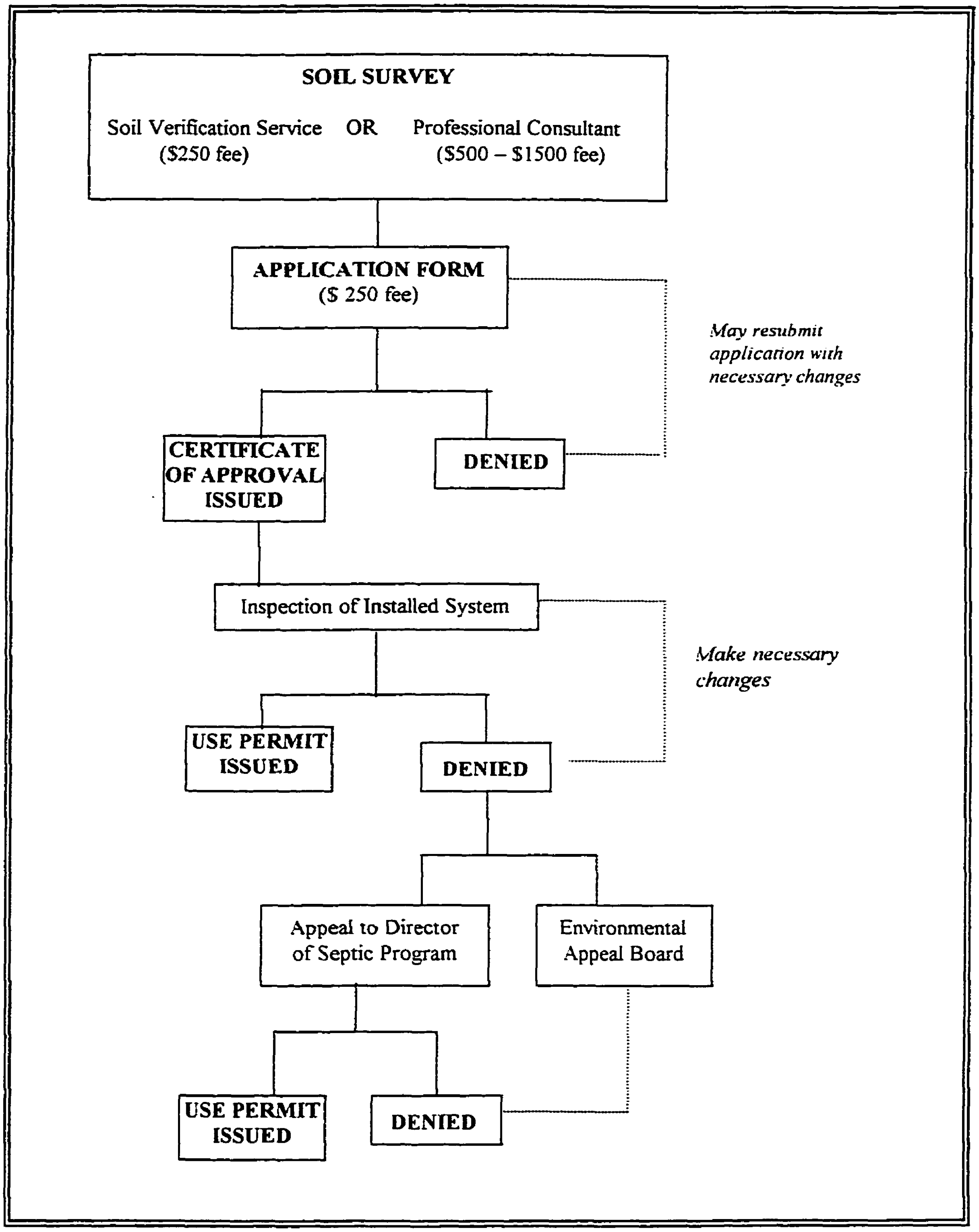
Two programs that control the pollution from septic systems were evaluated in this thesis. First, Regulation 358 under Section 64 of the *EPA* governs the installation, maintenance and use of domestic septic systems was evaluated. Second, the CURB program provided financial assistance to landowners that had to replace or repair faulty septic systems.

In this chapter, the *EPA* and CURB policy processes are described in order to provide a context for the evaluation. The programs were evaluated separately based on the criteria of efficiency, equity, level of risk and performance (Table 3.1). They were also evaluated for consistency in the efforts of government in dealing with the pollution from septic systems. This chapter describes these programs and evaluates their effectiveness.

4.1 Ontario EPA Regulation 358 Certificate of Approval Process

In Ontario, section 64 of the *EPA* regulates the construction, alteration and enlargement of private sewage disposal systems. This regulation requires a landowner to obtain two permits: (1) a Certificate of Approval prior to any related building construction; and (2) a Use Permit before the system may be used to treat domestic waste. In Middlesex County, applications are directed by the Upper Thames River Conservation Authority (UTRCA), which acts on behalf of the Ontario MOE. The process of applying for and obtaining a Certificate of Approval and the Use Permit is illustrated in Figure 4.1 and described below.

Figure 4.1: Flowchart of the *EPA* Regulation 358 permit process



4.1.1 Soil Survey

The first step in applying for a Certificate of Approval requires the applicant to provide a soil survey report indicating the soil and water conditions on their property. The soil survey provides information to determine if a site is suitable for supporting a conventional septic system. This report must contain the following information:

1. A site plan including an outline of the sewage disposal envelope,
2. location of contingency space equal to the area of the disposal field,
3. a soil analysis,
4. the percolation rate (T = min/cm),
5. the elevation of the high groundwater table.

Each landowner installing a new septic system has the option of determining the soil type, percolation rate, and high groundwater elevation themselves, or hiring an engineering consultant to carry out the appropriate tests. The UTRCA provides a Soils Verification Service to reduce the costs of hiring an engineering consultant (professional fee ranges from $500 - $1500). In this case, the landowner performs the necessary soil tests and a staff member from the UTRCA visits the site to confirm the results. A fee of $250 is charged for this option. The UTRCA provides an information package containing specific guidelines for measuring each of the parameters to landowners using the Soils Verification Service. This service is provided only when the property owners intend to construct a conventional septic system on a single lot. The site must be characterized by consistent soils as indicated by the sample taken from the site and the expected percolation rate must not be less than one min/cm or exceed 50 min/cm. If these soil conditions are not met or when multi-lot development is planned, an engineering consultant familiar with the program must be hired to complete the soil report. During the study period, the 78 soil reports that were submitted by professional engineers were reviewed.

Certain conditions apply to those applications where a percolation rate exceeding 50 min/cm is measured or a raised leaching bed is recommended. In these cases, the septic system must be designed and inspected by a professional engineer to ensure the requirements of Ontario Regulation 358 are met. For example, when a raised leaching bed system is recommended, percolation tests must be completed for the fill material as well as a final percolation test once the system has been installed on the site. This step ensures that the required percolation rate between five and 10 min/cm is measured. If the percolation rates are unacceptable, the fill material must be removed and replaced prior to a Certificate of Approval being issued.

In cases where the applicant wishes to repair or replace an existing system, a full soil report is not required. Instead, the applicant must provide a one-metre deep test pit near the system so a government inspector can examine the soil conditions on the property. According to UTRCA officials, if the soil conditions are not appropriate, a permit will not be issued.

4.1.2 Application Form

Once the soil report has been completed, an application form must be submitted to the UTRCA. This application has six sections requiring information on: (1) the property location, (2) existing and proposed structures, (3) environmental features, (4) distances including building setbacks, lot size, building dimensions, and proximity of structures and environmental features, (5) a site plan, and (6) an estimate of the number of fixture units. A Certificate of Approval should not be issued until all of the information required is received by the UTRCA.

Once the application is received by the UTRCA, the Director of the Private Sewage Disposal Program will assess the application and an Inspector will visit the proposed site. If the information on the application and soil assessment is adequate, a Certificate of Approval is issued to the landowner and they may **install** the septic system.

4.1.3 Inspection of Installed System

Before using the system, the Ontario *EPA* requires inspection of the system in order to ensure compliance with Regulation 358. According to the regulation, the installed system must not be back-filled until authorized by the Inspector. After the system has been inspected and approved, a Use Permit is issued. In addition to the requirements of the Certificate of Approval, the landowner will also be provided with a list of standard provisions for the operation and maintenance of all sewage systems:

1. The sewage system or any part thereof shall not emit, discharge or deposit sewage or effluent onto the surface of the ground.
2. Sewage or effluent shall not emit, discharge, seep, leak or otherwise escape from the sewage system, or any part thereof into a piped water supply, well water supply, a watercourse, groundwater or surface water.
3. Sewage or effluent shall not emit, discharge, seep, leak or otherwise escape from the sewage system or any part thereof other than from a place or part of the sewage system where the system is designed or intended to discharge sewage or effluent.
4. Insects and animal life shall be prevented from gaining access to sewage contained in the sewage system.
5. No sewage system or any part thereof shall emit, discharge, deposit or allow the emission, discharge or deposit or micro-organisms of intestinal origin into the natural environment in such a manner as may be a hazard to health.

6. No gas shall emit, discharge, or otherwise escape from the sewage system into any building or structure except in the manner which the sewage system was designed or intended to emit or discharge gas.
7. No connection to the sewage system from non-sewage wastewater sources shall be made.
8. The operator of the sewage system shall keep it maintained at all time so that its construction remains in accordance with the certificate of approval and any order made under the Act (MOE, 1990).

These provisions are not monitored by a government agency. Instead, the landowner is responsible for proper care and maintenance of their system once a Use Permit has been issued. For this reason, the UTRCA provides a booklet of suggestions to landowners for ongoing care and maintenance of their septic system.

4.1.4 Issuance of a Use Permit

A Certificate of Approval allows for the installation of a septic system but the Use Permit must be issued before the system may be used to dispose and treat domestic sewage. Operation of a system without a Use Permit contravenes the Ontario *EPA* and is a violation of the regulation. In cases where a landowner failed to obtain the required permits or violated the approval process, fines can be levied by the UTRCA. According to UTRCA officials, the property owner is ordered to obtain the necessary permits and possibly uncover the system and make any required changes. The permit fee is doubled when this type of non-compliance occurs.

Special conditions apply when a raised leaching bed system has been installed. In this case, an engineering consultant provides a certificate to the UTRCA indicating that the system has been installed properly and conforms to Ontario Regulation 358. The entire area must be covered in grass sod prior to the issuance of a Use Permit. Thus, installation and operation of a new septic system requires both a Certificate of Approval and a Use Permit.

4.1.5 Appeal Process

When a landowner has been denied a permit, they may re-apply with the correct information and design requirements that meet the *EPA* standards: appeal to the Director of the program who can use discretionary powers to grant a permit: or they may appeal to the Environmental Appeal Board (EAB). According to the UTRCA officials, an appeal almost always decides in favor of the Director. UTRCA officials indicated that on average only one or two applications are refused per year primarily due to inadequate soil conditions and very few appeals are made to the Director or the EAB. In fact, very few applications are actually denied since the landowner is usually willing to make the required amendments in order to meet *EPA* standards.

4.2 Ontario *EPA* Regulation 358: Description of the Case Study Area

The Certificate of Approval process has been implemented in Middlesex County since 1974. From the onset of the program and up until 1992, the London Middlesex Health Unit was responsible for implementing the program. Between April 1992 and October 1992, the Ontario MOE London Branch carried out the responsibilities for the program. Since that time, the Upper Thames River Conservation Authority (UTRCA) was delegated as the implementing agency and presently carries out the approval of private septic systems. This transfer occurred because the Health Unit no longer had adequate financial support to implement the program. Therefore, according to an

UTRCA official, because the MOE were responsible for the legislation, they took over the program for a brief period until the UTRCA volunteered to become the implementing agency.

Since the UTRCA has implemented the Ontario *EPA* Certificate of Approval program, approximately 2000 applications have been submitted. During the same time period, Biddulph, London, and West Nissouri Townships have contributed 83, 167 and 93 applications respectively (Table 4.1). In this thesis, applications submitted by landowners in these three townships will be used to evaluate the program.

Table 4.1 Regulation 358: applications submitted and approval rates in study area between 1992 and 1996

	Biddulph		London		West Nissouri		TOTAL	
	#	(%)	#	(%)	#	(%)	#	(%)
Applications Submitted	83		167		93		343	
Approved / Permit Issued	64	(77)	125	(75)	81	(87)	270	(79)
Approved / No Permit Issued	10	(12)	42	(25)	12	(13)	64	(19)
Not Approved	9	(11)	0	(0)	0	(0)	9	(3)

(Septic Permits: UTRCA, 1992-1996)

Of the applications submitted, over 79% were approved and issued a Use Permit to install, replace or repair a domestic septic system. Less than 20% were approved but not issued a Use Permit. According to UTRCA officials, often a Use Permit was not issued due to conditions that had yet to be met, expiration of the application, or in the case of more recent applicants, the application may still be in the process of approval.

Table 4.2 *EPA* Approvals, conditions, and denials by applicant, system and project types for Biddulph, London, and West Nissouri Townships

	Applications		Total Approved*		Conditional Approval		Denied Permit	
	N	(%)	N	(%)	N	(%)	N	(%)
Type of Applicant								
Residential	302	(88.0)	245	(81.1)	94	(31.1)	57	(18.9)
Commercial	23	(7.0)	17	(73.9)	6	(26.1)	6	(26.1)
Institutional	11	(3.0)	8	(72.7)	2	(18.2)	3	(27.3)
Other	7	(2.0)	5	(71.4)	2	(28.6)	2	(28.6)
Type of System								
Raised Bed	103	(30.0)	75	(71.8)	52	(50.0)	28	(27.2)
Conventional	65	(19.0)	62	(95.3)	16	(24.6)	3	(4.6)
Filter Bed	26	(8.0)	25	(96.2)	4	(15.4)	1	(3.8)
Holding Tank	15	(4.0)	11	(73.3)	7	(46.7)	4	(26.7)
Trench	12	(3.0)	10	(83.3)	4	(33.3)	2	(16.7)
Unknown	122	(35.6)	92	(75.4)	21	(17.2)	30	(24.6)
Type of Project								
Construct	221	(64.4)	170	(76.9)	74	(33.5)	51	(22.6)
Alter	60	(17.5)	54	(90.0)	13	(21.7)	6	(10.0)
Install	60	(17.5)	50	(83.3)	15	(25.0)	10	(16.7)
Enlarge	2	(0.5)	1	(50.0)	2	(100)	1	(50.0)
TOTAL	**343**		**275**	**(80.4)**	**104**	**(30.0)**	**68**	**(19.8)**

* Total Approved includes Conditional Approvals

(Septic Permits: UTRCA, 1992-1996)

A majority of the applications were submitted by landowners that occupied a single-family dwelling (Table 4.2). Only a small number of commercial establishments have requested a permit since the UTRCA has administered the program. This trend reflects, in part, the fact that most commercial establishments were located within small communities that were serviced by municipal sewage systems.

Raised leaching bed septic systems, followed by conventional systems were the most common type of system indicated on the applications (Table 4.2). In all cases, the type of system employed should be strongly influenced by the nature of the soil environment in which the system is to be installed. The conditions of the natural environment in Biddulph, London, and West Nissouri townships will be examined further in this thesis.

In all three townships, the most common reason for submitting an application was to construct a new septic system. A number of applications were also submitted to approve the installation or alterations of an existing system. The increasing rural population in this area, specifically rural non-farm residential development, can explain this trend (Table 3.2). Therefore, a high number of applications requesting approval for new systems could have been indicative of the new development. Very few applications were actually not approved. In fact, between 1992 and 1996 only nine applications (3%) were denied a Certificate of Approval.

4.3 Evaluation of the Ontario *EPA* Regulation 358

The Ontario Regulation 358 permitting program for domestic septic systems was evaluated as a major part of this thesis. Applications that were submitted in three townships between 1992 and 1996 represented the implementation of the program in the UTRCA watershed of Middlesex County. During this time period, the UTRCA was responsible for the implementation of the program. The program was evaluated based on the criteria of: (1) equity, (2) efficiency, (3) the level of risk, and (4) performance. Later in this thesis, the Ontario *EPA* and CURB programs will be further evaluated as the combined efforts of government in controlling the pollution from septic systems.

4.3.1 Equity

Indicators of equity commonly reflect the uniformity of implementation among groups. Three measurements were used to determine the equity of the *EPA* program: (1) approval rates among applicant types, (2) decisions according to the type of system, and (3) approval rates based on the type of project (Table 4.2). The nature of conditions attached to an approval also provided a measurement of equity.

4.3.1.1 Applicant Type

An equitable program can refer to the equal treatment of all applications, regardless of the type. The types of applications were noted from the permit records as residential (single family), commercial, institutional, and other. It was expected that requests for septic systems in residential dwellings would comprise the greatest proportion of applications submitted to the UTRCA. In fact, 88% of the applications were submitted by residential landowners. The increase in new development throughout these townships also accounted for the higher proportion of residential applicants. On the other hand, village communities such as Lucan and Ilderton that are located in Biddulph and London Townships respectively had a substantial commercial and institutional economic base. These communities were often serviced by municipal wastewater treatment systems and were not subject to the requirements of Section 64 of the Ontario *EPA* program. As a result, only 7% and 2% of the applications were submitted by commercial and institutional landowners respectively (Table 4.2). Nevertheless, the rate of approval was relatively consistent among the groups with 81% of the residential applications approved and approximately 73% of the commercial and institutional applications approved.

Very few applications were denied. According to UTRCA officials, applications submitted for systems used in anything other than residential were more closely checked. This occurs because often commercial or institutional developments require a more complex system to treat larger quantities of waste. In these cases, a professional engineer completed the soil report, which ensured that the information was accurate. It was more common that an applicant would have to meet certain conditions before their application was approved, rather than denied a permit altogether. The total number of applications that were approved conditionally is presented in Table 4.2. Commonly imposed conditions included importing sand fill material, distance setback requirements and the installation of a pump or meter. Results indicated that from a total of 302 residential applications, 31% were approved conditionally. From a total of 23 commercial applications, 26% received conditional approval. A chi square analysis ($\alpha = 0.01$) proved that there was a significant difference between the conditional approvals based on applicant type. This result was expected considering that residential applications comprised the largest proportion of the total applications. In addition, the soil report for residential applications was often completed by the landowner whereas professional engineers usually completed the report for commercial and institutional applications. Therefore, there was a greater likelihood that the commercial and institutional properties would meet all mandated requirements prior to submitting their application.

4.3.1.2 Type of System

The second measure of equity considered the type of septic system. The type of system installed depended primarily on the nature of the soil environment at each individual site. Adequacy of the locational suitability between differing systems will be pursued further in this thesis when the performance of the programs is evaluated. Alternative types of systems allowed for wastewater treatment in soils that may not be conducive to a conventional septic system. However, once a landowner received a Use Permit, the approval rates should be equitable among the various types of systems. The approval rates for the type of system and the nature of conditional approvals are outlined in Table 4.2.

The use of conventional systems appears to be low (19%). However, a large number of the landowners did not indicate the type of system on their application (36%). According to UTRCA officials, it was assumed that when a type of system was not identified on an application, a conventional system would be employed. Conventional systems are designed to operate effectively on sites that do not require modifications to the soil environment. As a result, applications for conventional septic systems tend to be less complex than alternative types of systems. Therefore, the number of conventional systems increased to 187 or 55% of the total applications. The second most commonly used system was the raised leaching bed (30%) followed by filter beds (8%).

Holding tanks were one of the least commonly approved systems (4%). The approvals of holding tanks are to be limited to areas where the physical environment makes a septic system infeasible (Section 2.2). Of the applications submitted for a holding tank, 87% were from commercial or institutional establishments such as a church, office buildings, a restaurant, and a fire hall. These buildings were located in the small rural communities throughout the townships and often the lot was not large enough to contain a septic system, in which case a holding tank was the only alternative. To ensure protection of the groundwater, holding tanks were approved with the condition that a meter and warning device were installed, and that a licensed hauler was contracted to pump the tank at regular intervals.

According to a chi square analysis, there was no statistically significant difference ($\alpha = 0.01$) between approval rates for the type of system used. However, the chi square statistic showed that there was a significant difference between the conditional approvals placed on the type of system. Out of a total of 103 applications for a raised bed system, approximately 50% were approved conditionally. Similarly, 47% of the applications for a holding tank were approved conditionally and only 25% of the conventional systems had conditional approvals. These conditions reflected the complexity of the system required to adapt to the nature of the soil environment. For instance, UTRCA officials clarified that the high percentage of conditions place on applications for raised bed systems could be accounted by the certainty that imported sand fill was required before the application was approved. Also, applicants wishing to install a holding tank were often approved on the condition that the old tank was properly disposed. Very few conventional systems required conditions attached to the approvals since the soil environment permitted the use of the technology with relatively few modifications to the property.

During the study period, only nine (3%) of the applicants were denied a permit. For example, in August 1996, a permit application was submitted to install a holding tank by a commercial establishment. A letter of refusal was sent to the landowner, which explained that holding tanks were restricted due to their costly operating expense and unreliability for dealing with sewage. As a result, a permit was denied and the landowner had the option to comply with this outcome or make an appeal to the Environmental Appeal Board. In this case, an appeal was not made. In another case, an application was submitted to extend a septic system in a single family home that had recently changed landowners who had a larger family. The permit was denied until the system had time to adjust to the increased flow characteristics of the new users. Once the system had adapted to these changes, the landowner was able to apply for a permit to make the extension.

In terms of the type of system, the program appears to be equitable in the treatment of applications. Since the nature of the soil environment influences the type of system installed, it was expected that a greater number of conventional septic systems were issued a permit. Although a statistically significant difference was found between the conditions for approval, the degree of complexity experienced when installing alternative types of systems required that additional standards be met.

4.3.1.3 Type of Project

Approval rates among project types also reflect an element of equity. Three main types of projects were undertaken: (1) the construction of a new septic system in a location where there was not a system previously; (2) the alteration of an existing system; or (3) the installation of a new system in the location where an older system existed. Since the number of applications to enlarge an existing system were very small (2 applications), this type of project was not considered in the evaluation. According to the data collected, 64% of the applications were submitted to construct a new system and 18% of the applications involved the alteration and, the installation of a septic system respectively. Of the 221 applications to construct a new system, 77% were approved, 90% of the 60 applications to alter an existing system were approved and, of the 60 applications to install a new system, 83% were approved. This can be explained by the new development that had taken place throughout the three townships over the past five years, a large proportion occurring in the past year. In these cases, a new system had to be installed, which explained the majority of the applications submitted to construct a new system.

Results of a chi square statistic ($\alpha = 0.01$) indicated that there was a significant difference in approval rates among the type of project. The difference in approval rates could be explained by one of two reasons. First, a number of the applications to construct a new system had been submitted in 1996 and were still pending approval when the data for this research were collected. Second, the construction of a new system involved a greater deal of complexity since the residence was often being built simultaneously. Therefore, it could have taken a longer period of time before an application was approved. Since UTRCA officials indicated that very few projects are denied, it is anticipated that most of the applications submitted to construct a new system would be approved once all conditions had been met.

Statistical testing also showed that there was a significant difference between the conditions for approval among the types of projects (Table 4.2). Of the 221 applications to construct a new system, 35% were approved conditionally. A conditional approval was also placed on 22% of the 60 applications to alter an existing system and 25% of the 60 applications to install a new system. It was expected that a greater proportion of the projects to construct a new system would receive a conditional approval. This was due to the fact that construction projects comprised the largest number of total applications as well as the higher degree of complexity involved during these projects.

4.3.2 Efficiency

The efficiency of the Ontario *EPA* Regulation 358 was evaluated based on: (1) the number of days to process an application, (2) the reliability of the information on the applications, and (3) the public's awareness of the program.

4.3.2.1 Number of Days to Process an Application

The number of days required to process applications is an important indicator of efficiency (Table 4.3).

Table 4.3: Length of time to process an Ontario *EPA* septic application

	# of Applications		
Time	**To Issue a C of A***	**To Issue a Use Permit**	**TOTAL TIME**
< 7 Days	171	44	9
8 – 21 Days	91	35	30
22 – 90 Days	42	74	80
91 - 180 Days	12	64	82
> 181 Days	18	53	69
Average	**36 Days**	**106 Days**	**143 Days**

* Certificate of Approval

(Septic Permits: UTRCA, 1992-1996)

In the case of Regulation 358, there were two levels of approval before the application process was completed. First, a Certificate of Approval must have been issued in order to install or repair the system. Second, a Use Permit must have been issued before the system could be used to treat domestic waste. The entire process was carried out by the UTRCA.

The average length of time to review applications and issue a Certificate of Approval (C of A) was roughly one month (36 days). This is similar to other permitting programs implemented in southwestern Ontario (Shrubsole and Wilcox, 1996; Shrubsole *et al.*, 1995). Variability among the permits reflected various levels of policy and technical complexity. For example, differences between the length of time required for an approval can reflect the abilities of the landowners to provide the necessary information, and to complete the construction of the building and the septic system. Variations could also occur in the ability of the UTRCA to inspect the system promptly. The average length of time required to issue a Use Permit once the C of A had been issued was approximately 3.5 months (106 days). Finally, the average length of time taken to complete the entire process was five months (143 days). Over 51% of the applicants were issued a C of A within one week of submission and 91% were issued a C of A in less than three months. Approximately 57% of the applicants received a Use Permit within three months of obtaining their C of A. Close to 74% of the landowners completed the application process within six months of submitting their application.

4.3.2.2 Reliability of Information

The second measure of efficiency involved the reliability of the information on the applications and soil report. In order that site suitability for septic systems was properly assessed, the information on the applications must be accurate. In addition, a program can operate efficiently only when the information assessed during the approval is exact.

It was the responsibility of the landowner to provide the necessary information on the applications regarding the size of dwelling and intended use of the system. Their signature was required to ensure the information was correct. In other words, the government relied on the landowner to provide honest and accurate information. If information was missing or incomplete, an employee from the UTRCA contacted the landowner directly. At this point, the landowner had one of two options: (1) provide the missing information so the approval process may be continued; or (2) fail to provide the information in which case the application would be refused and withdrawn from the approval process.

Information on the soil report must have been accurate as well. This report was the primary means of determining the type of system that could be installed to work effectively. For all new developments, a soil report must have been completed and included with the application. The report could have either be completed by the landowner and the results verified by an UTRCA employee or, a professional engineer familiar with the program was hired to perform the required tests and provide a formal report to the agency. In each case, to ensure validity, a trained professional verified the information. The time required to process the permits reflects, in part, the extent of these inspections.

Ongoing monitoring would have ensured that systems were properly maintained and operated. Landowners were provided with a "Care and Maintenance" brochure with their permit however, the UTRCA often relied on complaints from neighbours or the landowners to report a system failure. According to the Director of the program, all complaints received are investigated. However, due to limited finances and staffing by the implementing agency, once the system had been installed, it was difficult to monitor its performance and ensure compliance with the guidelines. One UTRCA inspector indicated that it was possible to "stumble across" conditions that presented a potential problem with a system while performing other job responsibilities. When this occurred, the malfunction was investigated and remedial measures ordered. Officials indicated that this situation might only take place two or three time per year. However, in Oxford County groundwater contamination resulted from large proportions of landowners improperly maintaining their septic system (Packer and Ferguson, 1995).

4.3.2.3 Public Awareness

The final measure of efficiency involved the level of support and public awareness of the program. In order that programs operate in the most efficient manner, the target population must be familiar with the application process. Since the Ontario *EPA* permit program is a mandatory regulation, landowners were legally obligated to comply. Nevertheless, according to UTRCA officials systems have been installed or repaired without the required permits. A similar situation occurred in Oxford County

(Packer and Ferguson, 1995). Unfortunately, it was virtually impossible to determine the extent of this type of non-compliance unless neighbours filed complaints. Despite this fact, one UTRCA official perceived that, public support for the program was generally high and the only resistance arose in terms of the fees (application fee $250 and soils verification service $250 or consultant fees $500 - $1500) required to process the application.

To increase public awareness, the provincial government provided a number of pamphlets and educational booklets on how to properly maintain and operate a septic system that were readily available to the public. However, septic systems were generally not sufficiently maintained in Middlesex County. As one inspector pointed out "homeowners can never be trusted to effectively maintain their system... out of sight, out of mind". It was made clear that often landowners did not appreciate the potential for environmental contamination until after their system had failed and effluent rose to the surface of their property or, backed up into their home. This issue will be addressed further in this thesis during the evaluation of the CURB program.

Although the time taken to process applications is efficient and the information on the applications is accurate and verified by professionals, the lack of on-going monitoring introduces an element of inefficiency. One UTRCA official stated that their office did not have the time or people power to provide a monitoring service to the 10,000 septic systems operating in Middlesex County. Officials also made it clear that homeowners can never be trusted to effectively maintain their system. Therefore, it is clear that future efforts at improving the efficiency of septic tank policy should involve the implementation of a long-term monitoring program.

4.3.3 Level of Risk

The final criterion used to evaluate the implementation of the Ontario *EPA* program was the level of risk. Landowner compliance with *EPA* regulations for: (1) the minimum capacity of the system, (2) soil percolation rates, and (3) lot size demonstrated the level of risk according to present provincial policies for preventing water contamination.

4.3.3.1 Capacity of the System

Both the Ontario Regulation 358 and the U.S. Manual of Septic Tank Practice provided recommended septic tank capacities based on the number of bedrooms in a dwelling (Table 4.4). Capacities based on the number of bedrooms assume that an increase in the number of bedrooms reflects an increase in the number of people and therefore an increase in the quantity of water used. For a septic system to adequately handle the wastewater loads, regardless of the type of system, these capacities should not be exceeded. The capacities that have been determined by the two regulations are comparable for the size of the dwelling. The level of risk for water contamination is increased when systems operate below the minimum recommended tank capacity.

Table 4.4: Septic tank capacities in litres based on the number of bedrooms

# OF BEDROOMS	Ontario *EPA* Tank Capacity	U.S. Manual Tank Capacity
1-2	2700 l	2839 l
3	3600 l	3785 l
4	4500 l	4542 l
5	4500 l	5678 l

(MOEE, 1990 and Perkins, 1989)

Table 4.5 shows the capacities of the septic systems as recorded on the applications by landowners.

Table 4.5: The number of applications and septic tank capacities as indicated by the number of bedrooms

	Working Capacity of System (Litres)								
	< 2700		**3600**		**4500**		**>4500**		
Number of Bedrooms	**#**	**(%)**	**#**	**(%)**	**#**	**(%)**	**#**	**(%)**	**TOTAL**
2 or less	15	(50)	13	(43)	0	(0)	2	(7)	30
3	5	(3)	114	(61)	65	(35)	4	(2)	188
4 - 5	3	(4)	0	(0)	50	(69)	19	(26)	72
More than 5							3	(100)	3

(Septic Permits: UTRCA, 1992-1996)

The gray shaded area marks the minimum requirement based on the number of bedrooms in a residential dwelling as required by the Ontario *EPA*.

Out of a total of 30 applications submitted by landowners that occupied a two-bedroom dwelling, 100% met the minimum tank capacity. Moreover, 50% (15) of the applicants exceeded the minimum requirement with the installation of a tank capable of handling a greater amount of wastewater. In the case of three bedroom homes, only 3% of the 188 applicants did not meet the required capacity of 3600 litres. Similarly, approximately 4% of the landowners with four or five bedroom homes failed to meet a required minimum tank capacity of 4500 litres. All three of the applications for homes with more than five bedrooms had septic tank capacities that met the Ontario *EPA* requirements. Overall, 97% out of a total of 293 applicants, for which information regarding the number of bedrooms and the capacity of the septic tank were available, met the minimum *EPA* requirement. Fifty applications did not have information about the capacity of the system or the number of bedrooms. This can be explained by the applications submitted by a commercial or institutional establishment that did not have bedrooms or when a holding tank was installed. In these cases, the recommended capacity is determined on a site-specific basis.

4.3.3.2 Soil Percolation Rates

The level of risk was also assessed based on the percolation rate of the soil. Adequate treatment of septic effluent is determined by the rate at which wastewater percolates through the soil. Table 4.6 shows the required percolation rate (T = min/cm) according to the number of bedrooms and the length of the distribution pipe (m) for residential dwellings. The shaded areas mark the minimum percolation rate recommended by the Ontario *EPA*.

The data in the table represent only those applications on which the percolation rate, number of bedrooms, and the length of the distribution pipe were recorded by the landowner. Consequently, less than half (40%) of the 343 applications submitted between 1992 and 1996 contained information on all three parameters. Three possible situations accounted for the missing information: (1) applications submitted by a commercial or institutional establishment that did not have a bedroom, (2) applications for holding tanks, and (3) applicants who were making repairs or replacing a system that had previously been approved.

Table 4.6: Soil percolation rates (T) for residential dwellings according to the length of the distribution pipe and the number of bedrooms

	Length of Distribution Pipe (Metres)					
Two Bedrooms or less	**40**	**40**	**70**	**100**	**130**	**>130**
T = 1 - 4.9min	1					
T = 5.1 - 9.9min					1	
T = 10.0 - 14.9min				1		
T = 15 - 19.9min				1	4	
T = 20 - 24.9min					1	
T > 25min			3			1
Three Bedrooms	**40**	**60**	**100**	**140**	**180**	**8T**
T = 1 - 4.9min	1	5	2		1	1
T = 5.1 - 9.9min		3	3	1	1	1
T = 10.0 - 14.9min		1	8	4		
T = 15 - 19.9min		1		4		
T = 20 - 24.9min					3	
T > 25min	5	18	9	3	7	
Four Bedrooms	**40**	**80**	**130**	**180**	**230**	**10T**
T = 1 - 4.9min	2					
T = 5.1 - 9.9min	1	1				
T = 10.0 - 14.9min			1	1		
T = 15 - 19.9min				1	3	
T = 20 - 24.9min					3	
T > 25min	8	10	6	1		
Five or More	**45**	**92**	**150**	**207**	**265**	**11.5T**
T = 1 - 4.9min						
T = 5.1 - 9.9min		1	1			
T = 10.0 - 14.9min						
T = 15 - 19.9min						
T = 20 - 24.9min						
T > 25min	1		1			

(Septic Permits: UTRCA, 1992-1996)

Out of a total of 13 applications for two bedroom dwellings, 3% (3) did not meet the minimum requirement. Of even great risk, from the 82 applications for three bedroom homes, 54% (44) failed to meet the Ontario *EPA* minimum. Similarly, out of a total of 38 applications submitted by landowners that occupied a four bedroom dwelling, 68% (26) fell short of the regulation. Since only four applications contained information on all of the parameters required to determine the percolation rate for those dwellings with five or more bedrooms, it was not considered representative of the population.

In total, 54% of the applicants did not meet the minimum required percolation rate based on the length of the distribution pipe and the number of bedrooms. This may suggest a high level of risk for water contamination. However, when the percolation rate measured on an individual site did not meet the minimum requirement, alternative types of septic systems were considered. Therefore, although it appears that a majority of the applicants failed to meet the Ontario *EPA* standard, officials at the UTRCA maintained that in these cases a non- conventional septic system was installed. The permit data supports this view; when the percolation rate exceeded 50 min/cm, a raised leaching bed was installed.

4.3.3.3 Lot Sizes

Septic tank density is an important parameter in terms of pollution potential. In areas where high densities of septic systems are present, the level of risk for groundwater contamination is increased as the soil's purification capacity becomes weakened. Lot sizes provide a measure of the density of septic systems. Since lot sizes used in subdivisions are normally determined by engineering standards, environmental impacts are often not considered. Generally recognized minimum lot sizes for the placement of domestic septic systems is 0.19ha (Perkins, 1984; Yates, 1985). However, one study has shown contamination of nitrate on lots of 0.1 to 0.2ha that were characterized by well-drained soils (Miller in Perkins, 1984). In addition, a study completed in Wisconsin showed that the typical lot size of 1ha is not large enough to contain plumes contaminated with nitrate in areas with adequate soil conditions (Hanson *et al.*, 1986).

Table 4.7 shows lot sizes as recorded by the landowner on the applications. In the UTRCA, 22% of the applicants indicated that their lot was less than 0.19ha ($\frac{1}{2}$ acre). In Biddulph, London, and West Nissouri townships 18%, 19%, and 29% of the lots were less than the

0.19ha standard respectively.

Table 4.7: Lot sizes in case study area

	Lot Size									
	< 0.19 Ha		0.19 - 1 Ha		1.1 - 5 Ha		5.1 - 25 Ha		> 25 Ha	
	#	(%)	#	(%)	#	(%)	#	(%)	#	(%)
Biddulph	7	(18)	11	(29)	5	(13)	5	(13)	10	(26)
London	13	(19)	28	(42)	3	(4)	10	(15)	13	(19)
W.Nissouri	14	(29)	17	(35)	9	(19)	3	(6)	5	(10)

(Septic Permits: UTRCA, 1992-1996)

Overall, approximately 60% of the applications were from landowners whose lot was less than one hectare in size. In Biddulph township, 47% of the lots were less than one hectare, 61% of the lots were less than one hectare in London township, and 65% of the lots in West Nissouri township were less than one hectare in size. These high proportions of small lots were most often in rural communities located throughout the county such as Granton, Thorndale, Arva and Birr. These communities had experienced a high level of subdivision growth over the past few years. This new-sprung development often required the installation of new septic systems due to the fact that municipal sewerage was not available.

Since subdivision lots are smaller than typical rural plots, this explained the majority of applications with lots less than one hectare in size. Nevertheless, previous research concludes that lots less than one hectare provide inadequate protection against water contamination (Yates, 1985). As a result of this widespread problem, in August of 1997 the Ontario government developed a Provincial Water Protection Fund to assist municipalities improve their water and sewage systems (MOE, 1998). As a part of this initiative, Biddulph Township was to receive close to $855,000 to construct a communal sewage collection and treatment system to serve residents currently on malfunctioning private septic systems in the town of Granton. The use of communal septic systems has been recommended for use on smaller lots characteristic of subdivision developments because they tend to have fewer malfunctions, a longer life expectancy, easier operation and maintenance, and ultimately better protection of the environment (MOEb, 1994).

The assessments of the level of risk to the water supply have been measured. According to the analysis, the capacity of the septic system was met by 97% of the applicants resulting in adequate prevention of effluent ponding on the surface or reaching the ground water supply. Although it appeared that a large proportion of the applicants did not meet the recommended percolation rates, in these cases an alternative type of septic system was installed. However, the greatest level of risk occurred because of the high percentage (60%) of applicants installing a septic system on lots that were less than one hectare in size. The government as a part of the Provincial Water Protection Fund has addressed the risk associated with these small lots, which are usually located in rural subdivisions. Future programs that implement alternative wastewater treatment technologies in areas characterized by small lots will further ensure that the level of risk to the water supply is minimized.

4.3.4 Performance

The performance of the Ontario *EPA* Regulation 358 was evaluated as the appropriateness of septic system approvals using a GIS (Map•Factory) and the three map layers described below. As discussed in Section 2.3, four factors are important for siting a conventional septic system: (1) soil permeability, (2) bedrock depth, (3) the depth of the groundwater table, and (4) the proximity to surface water. These biophysical factors indicate areas that are generally suitable and unsuitable for the operation of a conventional septic system.

4.3.4.1 Soil Permeability

The soil characteristics in Biddulph, London and West Nissouri Townships are illustrated in Figure 4.2. In Section 2.3.1 unacceptable parameters were described as very coarse, highly permeable soils or very fine textured, and low permeable soils. These conditions present inadequate treatment of wastewater effluent. The map of the case study area shows that a majority of these townships are dominated by medium permeability and textured silt soils. Consequently, based on soil permeability alone, a large portion of Middlesex County is able to rely on the use of conventional septic systems to treat domestic wastewater.

Figure 4.2: Soil Characteristics of Biddulph, London, & West Nissouri Townships
(source: Soils of Middlesex County 1:50,000, Ag. Can. 1991)

Some deposits of highly permeable sands and gravel are interspersed throughout the area, a large proportion occurring in southern West Nissouri Township. These coarse textured soils may pose a moderate threat to water quality if septic systems malfunction. The small sections of clay soils can lead to more severe groundwater contamination. Conventional septic systems cannot be located in these low permeable, fine textured soils. In the study area (Figure 4.2), soils with low permeability are located in the southeastern section of Biddulph Township and in the southwestern section of London Township.

4.3.4.2 Depth of Bedrock

As was discussed earlier in Section 2.3.2, shallow depth to bedrock conditions may require the use of alternative types of septic systems. For instance, conventional systems cannot be located where there is less than two metres of soil above the bedrock. In these areas there is an inadequate amount of soil for proper treatment of the effluent. The depth of the bedrock is illustrated on the map in Figure 4.3. A large proportion of the western section of the study area is dominated by bedrock that is covered by at least 50 metres of overburden. This depth permits the effective use of conventional septic systems. The eastern portion of the study area consists of bedrock, which is between 15 and 50 metres below the surface of the ground. These areas can also adequately support conventional systems with moderate limitations. For example, moderate limitations may exist where the bedrock has fractures through which wastewater could reach the groundwater supply. For this reason, it is important that the soil characteristics are adequate to ensure proper treatment of effluent before it reaches the bedrock.

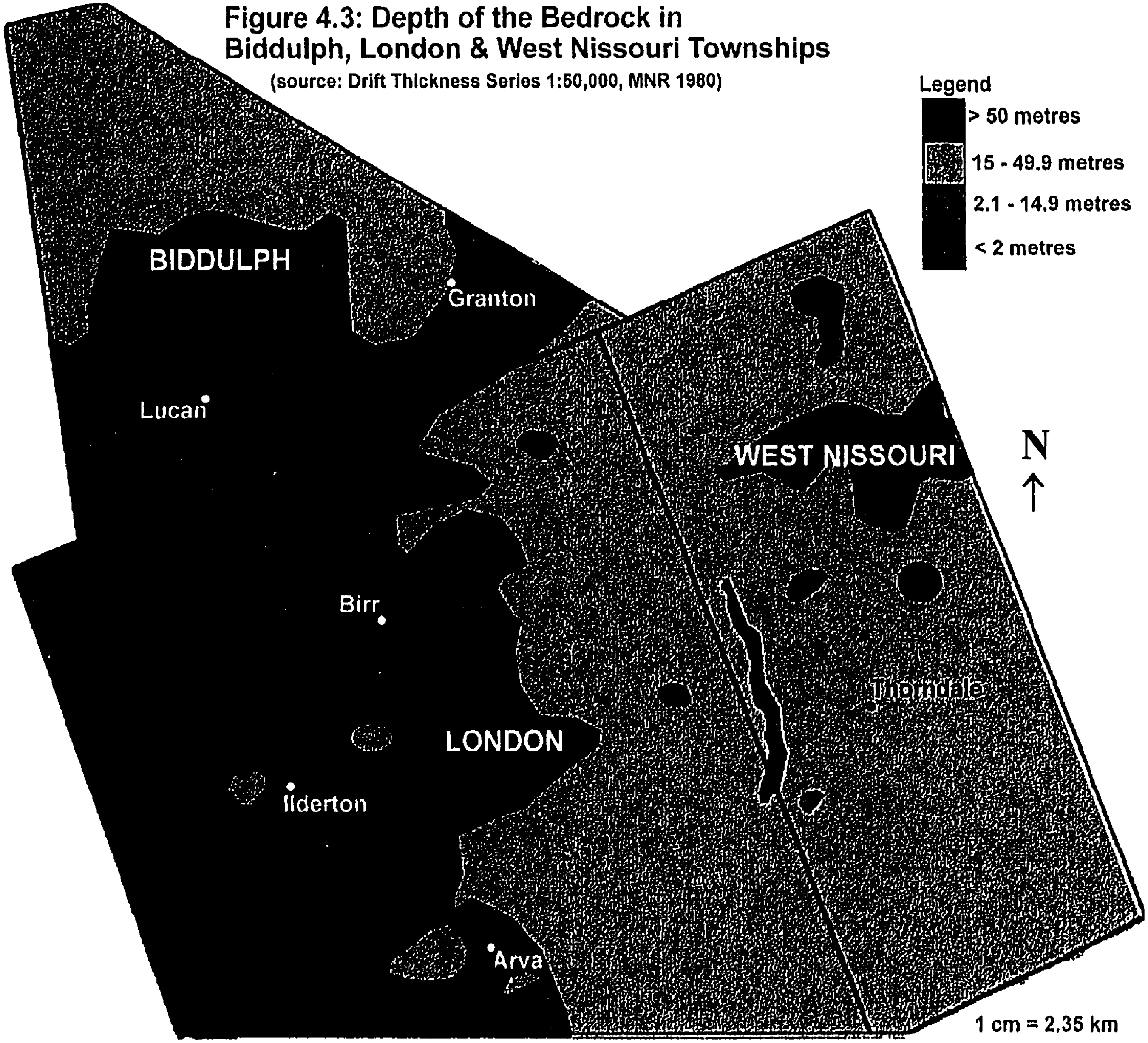


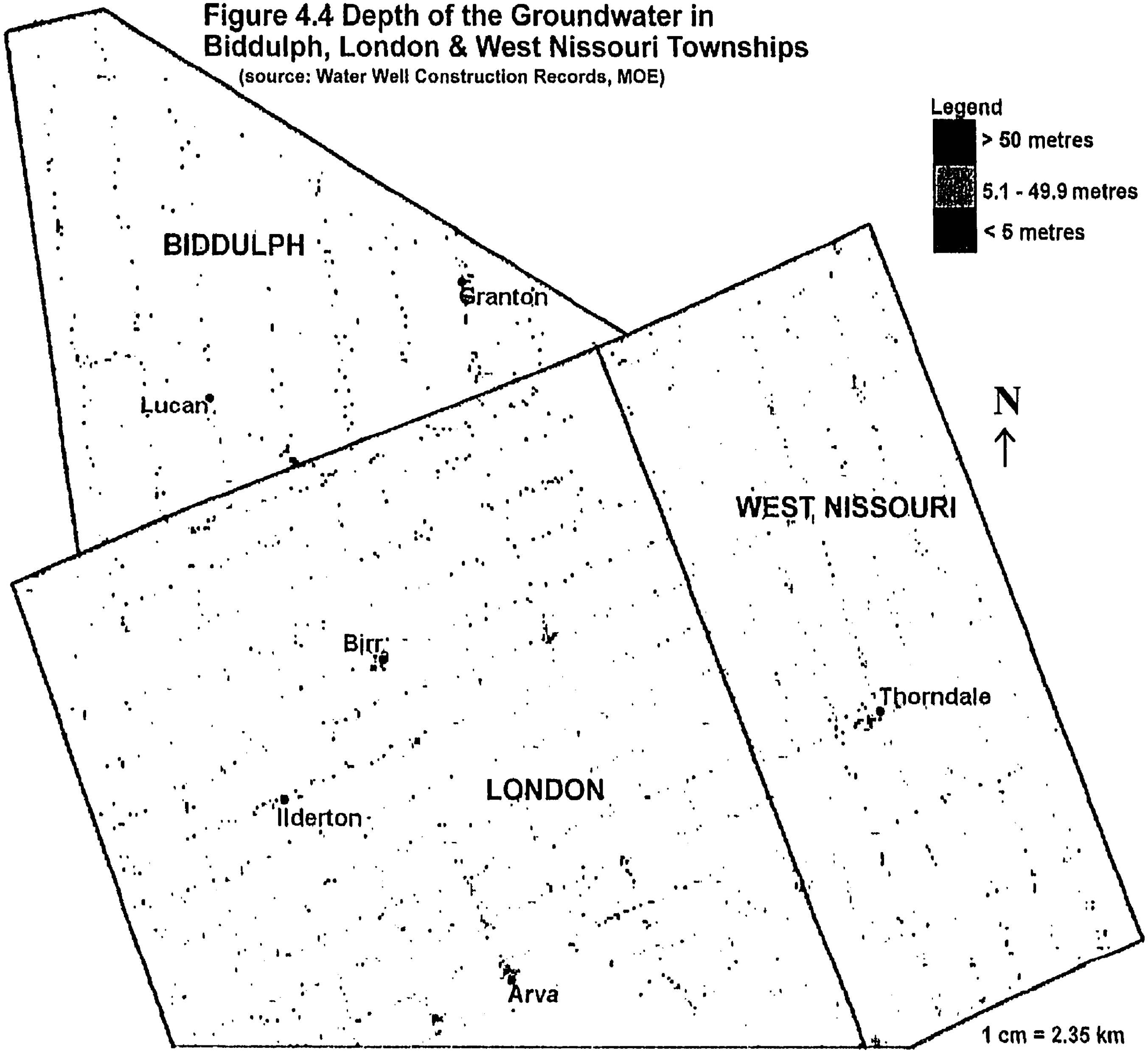
Figure 4.3: Depth of the Bedrock in Biddulph, London & West Nissouri Townships
(source: Drift Thickness Series 1:50,000, MNR 1980)

Within the study area, shallow depth to bedrock occurs along a narrow ridge, which straddles London and West Nissouri Townships. This section along the Thames River is characterized by less than two metres of overburden between the surface and the bedrock. Due to the potential for severe impacts on water quality, conventional septic systems should not be approved in this area.

4.3.4.3 Groundwater Depth

Areas with shallow depth to the groundwater require alternative types of septic systems. As described in Section 2.3.3, wastewater must be fully treated in the unsaturated zone before reaching the water table. In cases where there is inadequate depth of soil between the surface and the groundwater (less than two metres), untreated effluent may enter directly into the groundwater supply. Since the groundwater data are collected through the Ontario Well Log, a regional groundwater map has not been published for the study area. However, based on the Well Log data in Figure 4.4, which is represented by a single dot for each groundwater depth measurement, the study area is comprised of two general regions. The first are those areas in which the groundwater is located more than 50 metres below the surface. Most of Biddulph Township and a small section of northern London Township lie within this section. The second main area comprises almost all of London and West Nissouri Townships and outlines groundwater occurring between 5.1 and 50 metres deep. Both of these areas can adequately support conventional septic system technology based on the requirements of the Ontario *EPA*.

Figure 4.4 Depth of the Groundwater in Biddulph, London & West Nissouri Townships
(source: Water Well Construction Records, MOE)

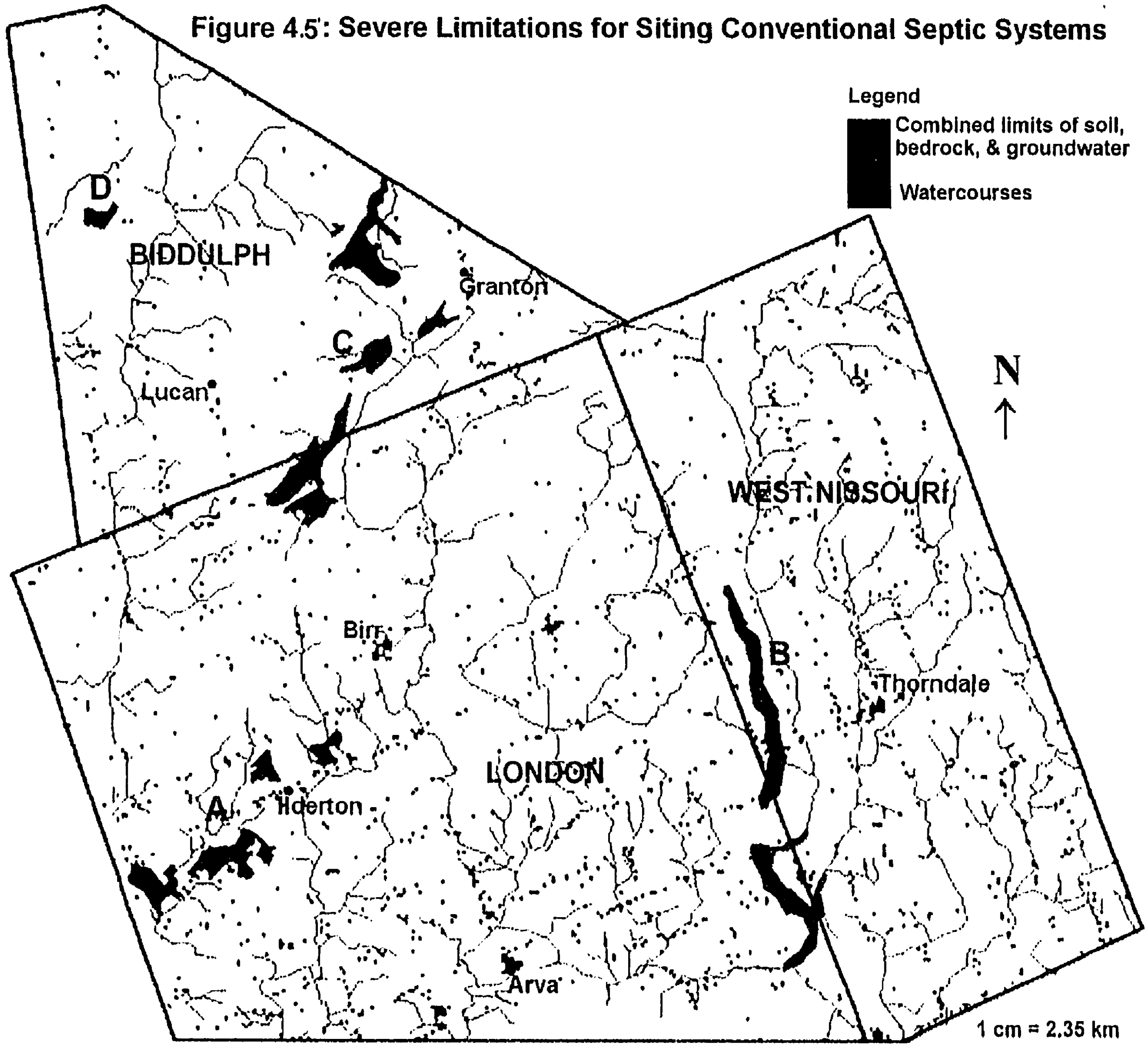


However, there are small sections scattered throughout the area that appear to present severe limitations for conventional septic system use. In these regions, the groundwater is able to reach the surface of the ground or is located less than six metres below the surface. While these areas are scattered across the study area, they are located primarily in the central and southeastern part of London Township, the southern part of West Nissouri Township, and the southeastern section of Biddulph Township. The scattered points on the map are likely the results of a perched groundwater table (refer to Section 3.2.4.3). On these sites, there could be a high potential for water contamination if a conventional system were located in close proximity to the water well. In this case, untreated effluent may reach the drinking water supply. Since the map provides a generalization of the groundwater conditions, these points would require site-specific testing to determine the adequacy of locating a septic system.

4.3.5 Site Suitability Map Analysis

The performance of Regulation 358 was evaluated using site suitability maps to assess the nature of approvals in areas identified as severely limiting conventional septic system use. The combined consequences of soil, bedrock, and groundwater limitations are represented in Figure 4.5. The surface watercourses have also been plotted on this composite map. These watercourses were taken from the NTS Sheet 40 P/3 *Lucan, Ontario,* at a scale of 1:50,000 (Department of Energy Mines and Resources, 1994). Although this map contained streams up to the fifth stream order (Horton, 1945), lower order intermittent and ephemeral streams are the result of seasonal events such as spring runoff.

Figure 4.5': Severe Limitations for Siting Conventional Septic Systems



To produce this map, the three maps in Figures 4.2, 4.3, and 4.4, along with a fourth map consisting of the watercourses were created as layers in a GIS (Map•Factory). This composite map (Figure 4.5) shows locations in the study area least suitable for conventional septic system use. There are four general locations (labeled A, B, C, and D on Figure 4.5) where the siting of a conventional septic system is inappropriate and applications for their use should be denied a permit. However, alternative types of septic systems may be approved in these areas. The nature of septic tank approvals in these four locations will be examined to indicate the performance of the program (Table 4.8).

Table 4.8: Approvals in areas identified as severely limiting conventional septic use

Severely Limited Area (Figure 4.7)	Number of Applications Submitted	Use Permit Not Issued		Alternative System Approved		Conventional System Approved	
		#	(%)	#	(%)	#	(%)
A	8	4	(50)	1	(13)	3	(38)
B	9	3	(33)	4	(44)	2	(22)
C	26	8	(31)	2	(8)	16	(62)
D	5	0	(0)	2	(40)	4	(60)
Total	**48**	**15**	**(31)**	**9**	**(19)**	**25**	**(52)**

(Septic Permits, UTRCA 1992-1996)

Smaller sections of severely limited conditions were also detected in communities such as Arva, Thorndale, and Birr. In these communities, determining the lot and concession data and the corresponding Use Permit would require maps of a more detailed scale. Therefore, site-specific testing of the conditions is necessary for identifying local variations in these areas. Nevertheless, the utility of the site suitability map generated for this thesis is in its ability to provide an adequate representation of the general conditions.

Location A presents severe limits on conventional septic system use primarily due to low soil permeability in the western section of London Township near the community of Ilderton. The impacts on water quality could be compounded in cases where systems are located in close proximity to Medway Creek and its tributaries flowing throughout this area. During the study period, eight applications for single family homes were submitted in this area, four of these were not approved (Table 4.8). In these instances, approval was denied for reasons including the presence of a high water table or expiration of the permit. One applicant was approved to construct a raised leaching bed due to groundwater detected at 1.5m below the surface. Therefore, five applications submitted in this area received the appropriate action. However, three applications to operate a conventional septic system were granted a Use Permit. All three of these applicants were single family homes.

Location B is located between London and West Nissouri Townships. The potential for surface water contamination in this area could be even greater as it lies along the banks of the Thames River. In this area, out of the nine applications submitted, three were denied (of the denied applications two were for a conventional system) and four were approved to operate alternative types of systems. In this area, filter beds were recommended as the appropriate technology in overcoming the limitations of the natural environment specifically, the shallow depth of the bedrock. Nevertheless, two of the applications were approved to use a conventional system. It is interesting to note that although the presence of a seasonal high water table was recorded on one of the applications submitted by the landowner a conventional system was approved.

The third area of severely limiting conditions is the largest (C), occupying a substantial portion of eastern Biddulph Township. These limitations are primarily due to the presence of a high groundwater level and low soil permeability. Twenty-six applications were submitted during the study period and 31% (8) were not approved. Reasons for denial included the detection of high water levels, adverse affects on neighboring properties, and the expiration of the application. Only 8% (2) of the applications were for the use of alternative types of systems. These two landowners proposed a raised leaching bed. In this area, 62% (16) of the applications were approved to operate a conventional system. Approximately three-quarters of these applications were submitted to repair or replace the existing system. This meant that a conventional system had previously been approved and alternative technologies were not recommended when the system required alterations. The CURB program was targeted at repairing malfunctioning septic systems. This area (C, Figure 4.5) was located within the geographic boundaries designated by CURB. However, these landowners did not apply to receive funding despite the fact that their systems were located in an area that was deemed severely limiting.

Area D, characterized by severely limiting soil conditions, is also located in the northwestern corner of Biddulph Township. Two of the five applications were approved for an alternative system. Raised leaching beds were recommended to overcome the limitations of clay soils in the area. Nevertheless, three applications were approved for a conventional system.

Despite the presence of inadequate soils, shallow depth to the bedrock and groundwater, and/or the proximity to surface watercourses, over half (52%) of the applications from these four areas were granted a Use Permit to operate conventional septic systems. The appropriate measures for applications that were submitted in these areas should have been to deny the permit or to approve the use of alternative technologies. However, only 31% and 19% of the applicants received this type of action respectively.

Approval of septic systems was based on site assessments of the physical conditions on the property. According to UTRCA officials, the soil characteristics and depth, prevalence of bedrock, the maximum groundwater elevation, and setbacks to watercourses were all considered with equal importance in determining the acceptability of an application. Yet, analysis of the maps and permit data shows that conventional systems have been approved in areas deemed severely limiting.

Since the maps provided a generalization of the natural characteristics, site specific testing may have been adequate to permit the use of conventional systems. For example, approval of a conventional system was granted due to the presence of silt loam soils on a property in location A. Silty loam soils were also present on a majority of the other sites approved for a conventional septic system in section C. As stated earlier, this type of soil provides adequate permeability and texture for treating septic effluent. Soil characteristics represent an important criterion when determining site suitability. Officials at the UTRCA have indicated that the site assessment criteria established by the *EPA* were adequate but in cases where heavy clay soils are present, the system design and testing becomes more difficult.

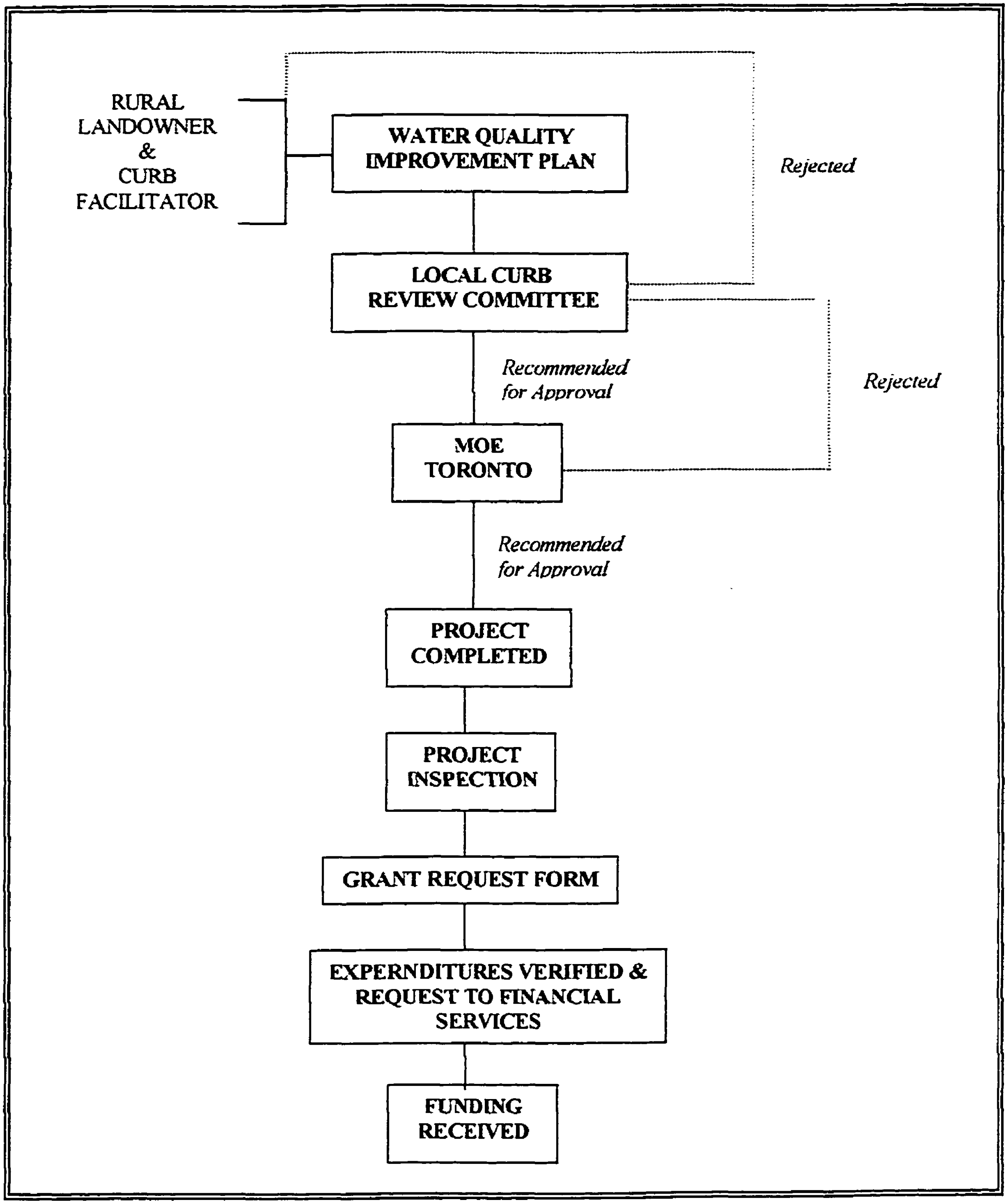
As evident in this map analysis, approval of the appropriate technology occurred approximately half of the time. Performance of this level will not adequately protect water quality from the contamination of malfunctioning septic systems. In general, officials at the UTRCA perceived that the performance of the program required improvement. For example, one official expressed the view that soil assessment methods were often complex and at best the results tended to be guesses. This situation was often overcome when a professional engineering consultant completed the Soils Report, which provided a detailed account of the site-specific conditions. However, because of the fees required to hire a consultant, it was more common for the landowner to utilize the Soil Verification Service (Section 4.1.1). In this case, the performance was often compromised, as the landowner was required to carry out site suitability tests. Officials at the UTRCA expressed the opinion that grant programs such as CURB were required to improve the installation of adequate systems.

4.4 CURB Program Grant Application Process

The primary method of controlling the installation and alterations of domestic septic systems in Ontario is through the regulatory process set out by the *EPA*. However, cost-sharing initiatives have also been taken to improve the pollution potential from existing domestic septic systems. These programs provided financial incentives to landowners who were willing to reduce the potential for contamination by improving their system. Most often, in an attempt to ensure maximized efficiency, cost-sharing efforts were directed to areas identified as the most severe in terms of environmental quality.

In the case of the UTRCA watershed, three beaches that had experienced recurring closures were targeted by CURB as regions of significant surface water contamination: the Fanshawe, Pittock and Wildwood reservoirs (Figure 3.1). In this thesis, townships were examined because of the contamination attributed to septic system failures within the Fanshawe Lake watershed. Beach closures due to elevated indicator bacteria levels, fecal coliform counts, and blue-green algae levels presented primary concern for public health and aesthetic reasons. CURB plans developed for these reservoirs provided evidence that significant changes in current rural land management practices were necessary to improve downstream conditions (UTRCA, 1991). The process of applying for a CURB grant is discussed below and outlined in the flowchart (Figure 4.6).

Figure 4.6: Flowchart of applying for and receiving CURB funding



(Adapted from MOEEa, 1994)

4.4.1 Determination of Eligibility

If a landowner wished to apply for a grant under the CURB program, they must first contact their local conservation authority to determine if the property was located in a CURB target watershed (MOEEa, 1994). Not all locations within a region were eligible for a CURB grant. The program attempted to target areas of highest concern and gave priority to the landowners within this area. Once locational eligibility was approved, a number of subsequent requirements had to be met before the application process began. This generally involved a site visit by a local CURB facilitator. There was no cost to the landowner for the services of the CURB facilitator or the application process. The facilitator provided the landowner with all relevant literature and the required documentation.

4.4.2 Water Quality Improvement Plan and Application

The second stage of the application process involved completion of a Water Quality Improvement Plan (WQIP). This plan was required to describe the specific practices and structures on the property that contributed to surface water quality impairment (MOEEa, 1994). The WQIP usually documented the farm resources, current practices and structures, sources and pathways of water contamination, and environmental impacts. When completed, it was sent to the local conservation authority, which provided a subsequent application to be filled out for the specific activity of concern. CURB identified four specific activities eligible for grants: Section A - Septic Systems, Section B- Livestock Access, Section C- Milkhouse / Parlour Washwater, and

Section D- Manure Storage / Barnyard Runoff. Section A pertaining to septic systems was evaluated as a major part of this thesis.

Grants approved by the CURB program were limited to improving existing water quality impairment problems. Therefore, new operations, new buildings, additions to homes, or building expansions to increase capacity were not eligible under this program (MOEE, 1994). These types of projects would be administered through the previously discussed *EPA* process.

4.4.3 Approval Process

All CURB applications were reviewed by the conservation authority which recommended an approval to the Ontario MOE (formerly the Ministry of Environment and Energy) in Toronto. The approval of projects was based on the CURB plan developed for the watershed. Therefore, projects may have been denied if they did not correspond with the objectives of the CURB plan. An accepted project must have emphasized the need for remedial measures to reduce or eliminate contamination of the surface water, or assist in facilitating the improved management practices that had the potential to reduce or eliminate contamination (MOEEa, 1994). The MOE made the final project approval and sent notification to the landowner indicating that the project may be implemented as part of the WQIP. Funds were allocated on a priority basis for each of the watersheds. Therefore, the projects with the greatest potential improvement to local water quality were to be considered first (MOEEa, 1994). As a result, the local CURB committee may restrict the number of grants available to meet local priorities and budgets. In the study area the committee included members from the agricultural community, OMAFRA, MOE, Oxford County Board of Health, UTRCA, and the Ontario Soil and Crop Improvement Association. In the case where the local budget was exceeded for a particular year, a project could be carried over into the proceeding year's budget with written approval from the MOE.

Two possible situations exist in which the application could be rejected and either discarded or appealed by the landowner. The local CURB review committee, which was led by the conservation authority, may reject the initial WQIP or it may be rejected by the MOE after being recommended by the local CURB review committee. According to an official from the MOE, very few applications were denied funding. However, if a project failed to meet the guidelines for project eligibility and funding, a grant should not have been issued.

4.4.4 Project Implementation

Once a landowner received an approval notification from the MOE, they could implement the project. However, any applicant who proceeded with the project prior to receiving acceptance from the local CURB committee or approval from the MOE could not be guaranteed financial assistance once the project was fully completed (MOEE, 1994). A project must have been fully completed and inspected by a CURB facilitator before any grant funds were allocated. In addition, the project had to be concluded within the specified completion date indicated on the application in order to receive a grant payment. The local CURB Review Committee could approve extensions.

4.4.5 Grant Request Form

Following the final project inspection, the landowner submitted a Grant Request Form and was required to provide all invoices and receipts for work completed, supplies purchased, fees paid, and all other proofs of payment related to the project. A list of eligible costs is outlined in Appendix 4. The MOE verified the project expenditures and submitted a request to the Financial Services, which then mailed a cheque to the local conservation authority. The landowner was notified that their grant had arrived and could obtain it from the local CURB facilitator.

4.5 CURB Program: Description of Case Study Area

In September of 1991, the Ontario MOE announced the commencement of the CURB program intended to operate for ten years. The purpose of this initiative was to provide grant assistance to improve rural land management practices in order to reduce bacterial contamination at local beaches (MOE, 1996). A landowner was able to apply for a grant from the CURB program's implementation agency in order to assist with the costs of repairing a structure, improving existing structures, or replacement of deteriorating and inadequate structures. Grant approval was subject to screening and certain eligibility criteria must have been met before a landowner received the funds.

CURB focused primarily on the enhancement of local surface water quality throughout Southern Ontario. Twenty-eight conservation authorities participated over the four-and-a-half years to complete 3,650 water quality improvement projects. Of these projects, 1,824 were improvements to private sewage systems (MOEE, 1996). The septic system projects implemented in UTRCA watershed were reviewed in this thesis.

The CURB plan outlined remedial strategy actions and estimated the cost of these actions for each individual beach through field inspections, consultations with farmers, monitoring water quality, and mathematical modeling techniques. In an attempt to improve water quality, the plan included recommendations for measures to be taken at specific beaches, and cumulatively at a broader provincial scale. CURB provided financial incentives to rural landowners within a targeted area for the installation of cost-effective environmental measures that may improve reservoir water quality at the local level.

In 1994, over half (54%) of the applications funded through CURB were septic system projects, comprising nearly $95,000 of the total grant allocation for that year. In fact, since the program began in 1991, 55% of the total approved applications were septic tank projects consisting of over $200,000 in grant money allocated. In the UTRCA watershed 140 projects were completed before the program was terminated (UTRCA, 1994) (Table 4.9).

Table 4.9: Number of septic system projects completed and not completed in the UTRCA watershed

	FISCAL YEAR				TOTAL
	1992/93	1993/94	1994/95	1995/96	
Number of Projects Completed	54	48	38	41	140
Number of Projects Not Completed	4	4	5	NA	13

(UTRCA, 1994)

In the 1993 CURB progress report (UTRCA, 1993), upgrading faulty household septic systems was identified as a cost-effective method of reducing bacteria and phosphorus inputs to the reservoirs. However, due to lack of funding availability resulting from the government spending reductions set out in the Treasurer's Ontario Economic Statement to the House (November 29,1995), the program was discontinued in 1995, six years earlier than intended. According to this same report, at the end of 1995, 13 projects had not been completed (Table 4.9).

The level of activity for septic system projects completed with CURB funding remained consistent over the course of the program. This suggests a clear need for the program. As a result of the earlier than anticipated termination, CURB may have been viewed as inadequately meeting its overall objectives for improved water quality. An MOE official agreed, stating that because of the early termination CURB did achieve a significant reduction in bacterial contamination at rural beaches.

CURB has been unique, as it was the first program to recognize non-farm land uses, specifically septic systems, as potential sources of diffuse source pollution. Since the restoration and installation of new systems were costly, CURB provided grants to landowners requiring repairs or replacement of malfunctioning septic tank and leaching bed systems. For the first time in Ontario, non-farm landowners were eligible for a program to decrease the potential of diffuse source pollution from contaminating the surface and groundwater. Given the recent increase in rural residential development in Ontario, this was a necessary initiative.

A grant rate of 50% of the total project costs, and a grant ceiling of $2,000 was established by the MOE for septic system projects approved under CURB. Since the average cost of replacing a septic system was $4000, the ceiling should have covered half of the expenses to the landowner. Certain eligible items were specified for all landowners requesting a CURB grant (MOEEa, 1994). Qualified applicants involved those whose septic systems:

a) had demonstrated to be discharging sewage or effluent to the surface of the ground with evidence of direct impact on water quality; or
b) were improperly connected to a surface or sub-surface drainage system (*i.e.* municipal drain, storm drainage pipe, field tile, etc.) and demonstrated a surface water quality problem (MOEEa, 1994, pg. 15).

In addition, all septic system project applicants were required to provide a copy of the local Health Unit or conservation authority application for a Certificate of Approval (C of A) as well as the receipt indicating payment of the fee.

The MOE clearly indicated that the CURB program was not intended to be available to all rural residents (MOEEa, 1994). The program focused on improving the water quality at Fanshawe, Wildwood, and Pittock beaches. Thus, in order to achieve the maximum environmental improvement for the money invested, grants were only available to landowners within a designated area whose operations or practices demonstrated a negative impact on the local surface water quality. A number of ineligible projects were outlined by the CURB program which could not receive grant funding. For example, projects involving private sewage system upgrades or replacement which did not indicate evidence of failure, applications for household expansions, and the addition of dishwashers, bathrooms, or other devices which may increase wastewater volume were not eligible for grant assistance.

The installation of septic systems for new development, which were also not eligible for CURB funding, tended to be easier to monitor since a C of A was mandatory before a building permit was issued. However, repairs and alterations to existing systems were often more difficult to enforce since landowners may have put up with inadequate systems to avoid a financial strain. Therefore, CURB provided an incentive to landowners that required repairs to their existing system that may not have otherwise done so. According to an official at the MOE, the $2000 grant was sufficient to get landowners to remedy the problem with their septic system immediately.

In the UTRCA watershed, 140 private sewage system projects were completed (Table 4.10).

Table 4.10: CURB septic system projects

LOCATION	NUMBER OF SEPTIC SYSTEM PROJECTS
UTRCA Watershed	140
Middlesex County	10
Total CURB Area	1824

(UTRCA, 1994)

Since this was the first time non-farm land uses were eligible for grant assistance, the number of inquiries made by landowners to improve faulty septic systems was higher than anticipated. In 1994, almost 40% of the inquiries made to the UTRCA about the CURB program were for septic system improvements (UTRCA, 1994).

Over 75% of the septic projects completed in the UTRCA watershed involved the installation of a new tank and leaching bed system (Table 4.11). Since CURB grants covered 50% of the project costs up to $2000, it was more cost effective for the landowner to replace both parts of the septic system. Only a small portion of the applicants replaced just the tank (4%), or just the leaching bed (20%). This may reflect in part, the fact that the tank and tile systems were approximately the same age, or the age of the system was unknown.

Table 4.11. Number and percent of CURB applications in UTRCA among the type of project, the purpose for applying, and the cost of a project

	Number of Applications	Pecent %
Type of Project		
New tank and Tile Bed	104	(75)
New Tank	6	(40)
New Tile Bed	28	(20)
Purpose for Applying		
Ponding on Surface	28	(21)
Leaking / Backed Up	17	(13)
Drainage to Ditch	16	(12)
Direct Tile Connection	15	(11)
Capacity of System	14	(10)
Greywater not Connected	12	(9)
Cost of Project		
< $1000	1	(1)
$1000 - $2000	4	(3)
$2000 - $3000	13	(10)
$3000 - $4000	37	(27)
> $4000	80	(59)

(CURB Septic System Applications, Middlesex County)

According to information on the CURB applications, approximately 59% of the septic systems had been in operation for over twenty years. Since these systems were being utilized beyond their life expectancy, they could pose a considerable threat to water quality. The average age of the septic tanks was 31 years and almost 45% of the tanks were older than 30 years. In addition, 37% of the leaching beds were older than 30 years. However, 58 of the applicants (44%) were unsure of the age of their leaching bed. If well maintained, septic systems are expected to function properly for approximately 20 - 30 years. Nevertheless, it was evident from the CURB applications that large proportions of the septic systems in the UTRCA watershed were operating beyond their life expectancy.

The primary reasons for upgrading the systems was due to effluent ponding on the surface (21%), a leaking or backed up system (13%), a system that was draining to a ditch or municipal drain (12%), or the system was directly connected to the leaching bed (11%) (Table 4.11). All of these reasons presented a significant potential for surface water contamination.

During the application process, a CURB facilitator determined the degree of impact each system had on the local surface water quality and the nearest beach. This was done by examining the extent of the septic system failure and proximity of the lot to a source of water or beach. In the UTRCA watershed, 73% of the applicants were causing a severe impact on the local surface water quality and 26% were severely impacting the beach. Twenty-six percent of the applicants were identified as creating a severe impact on both the local surface water quality and the local beach.

The CURB facilitator also estimated the approximate distance septic pollutants must travel to reach the leaching bed, municipal drain, or a watercourse. The Ontario *EPA* has established minimum setback distances in order to prevent water contamination from occurring (Table 4.12). The standards set by the Ontario EPA are similar to those for the U.S.

Table 4.12: Minimum septic tank distance separations in meters for Ontario and the U.S.

	ONTARIO *EPA*		U.S. MANUAL	
	Septic Tank	**Distribution Pipes**	**Septic Tank**	**Distribution Pipes**
Building or Structure	1.5 m	5 m	1.5 m	3 m
Well	15 m	15 m	15 m	30 m
Property Boundary	3 m	3 m	N/A	N/A
Watercourse	15 m	15 m	15 m	30 m
Spring	15 m	30 m	N/A	N/A

(MOEE, 1990; Perkins, 1989)

It was determined that 26% of the systems were directly connected to a source of surface water, which meant that septic effluent was being discharged without treatment. Fifteen percent of the systems were located such that septic pollutants had less than ten metres travel distance from the leaching bed, municipal drain or a watercourse and 37% of the systems were less than 50 metres away. It was evident from the 140 applications submitted in the UTRCA that these standards were often not met.

4.6 Evaluation of the CURB Program

4.6.1 Equity

The CURB guidelines stated explicitly that the program was targeted at specific agricultural and rural residential sites within a defined geographic area. Therefore, those residents located within the CURB target area whose land management practices demonstrated impairment to the local surface water were eligible for funding. Although this was a targeted approach, equitable implementation should be apparent. Equity of the

CURB program was measured by assessing uniform performance among: (1) the type of project completed, (2) the purpose for applying, and (3) the cost of the project (Table 4.11).

4.6.1.1 Type of Project

Only projects that involved the repair or replacement of existing malfunctioning septic tank and leaching bed systems were eligible for funding. A landowner had one of three project options: (1) to replace the septic tank; (2) to replace the leaching bed; or (3) to replace both components of the septic system. Of the applications submitted in the UTRCA, 75% were to replace both the tank and leaching bed. With grant programs such as CURB, it was often in the best interest of the applicant to maximize the allowable amount of financial assistance. According to the high proportion of applications to replace both components (Table 4.11), it was evident that a majority of the landowners took advantage of the opportunity to upgrade their entire septic system while a funding program was available. In this case, it was also in the best interest of the implementing agency and ultimately the environment. This is because most often, the septic tank and leaching bed both exceeded the recommended operating life and both required replacement to function at an optimal level. The age of the septic system will be discussed further in the analysis of the level of risk.

4.6.1.2 Purpose for Applying

Since CURB was a remedial program aimed at existing surface water quality contamination and not a preventative measure, new operations, new buildings, additions to homes and expansions to existing buildings were ineligible for grant assistance. The applicant was required to identify the specific cause of surface water quality impairment from their property. Given that the applicant had demonstrated surface water contamination, an equitable program should require that uniform implementation occurred among the various causes of pollution. The most common reason (21%) for applying for a CURB grant was that septic effluent was ponding on the surface of the ground (Table 4.11). Thirteen percent of the applicants identified that their system was leaking or backing up into their homes and, 12% suggested that their system was draining directly into a ditch or municipal drain. All of the events represent a serious potential for surface water contamination.

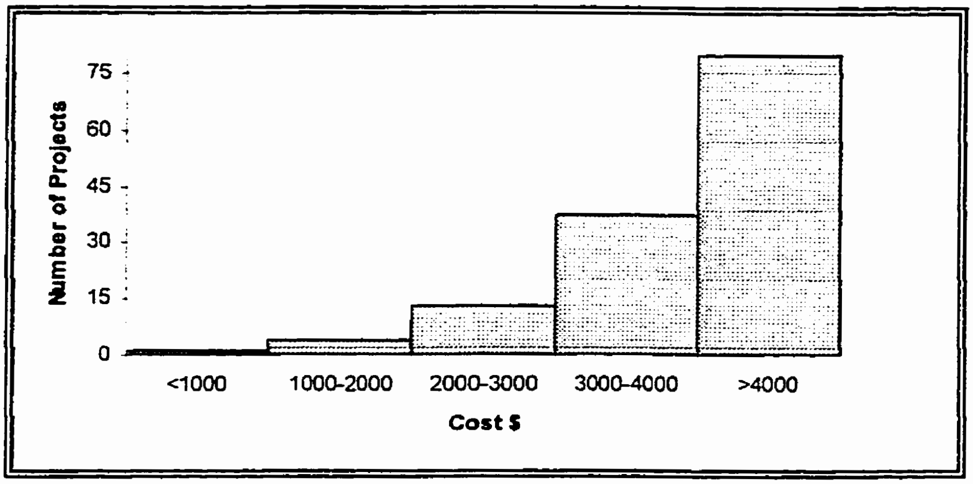
Chi square analysis (α=0.01) revealed that there was no significant difference between the purposes for applying in terms of the percentage of applications accepted. However, 10% of the applications were submitted by landowners that identified the CURB grant would be used to fund an increase in the capacity of their system. This contradicts the CURB guidelines which state that "new operations, new buildings, additions to homes, or building expansions" (MOEE, 1995 pg. 9) were not eligible for grant funding. Therefore, approval of this type of project violated the eligibility requirements. In response to these findings, an official at the MOE believed that approval was likely appropriate because the tank or leaching bed was initially sized too small for the flow needs of the household and caused the system to fail. The minimum capacity of the system should have been enforced by the *EPA* Regulation 358. In these cases, increasing the capacity of the system solved the problem and would not reflect an addition to the home. Furthermore, an official at the UTRCA clarified that if a septic system was found to be impacting surface water at the same time a new system was to be installed to allow for an addition to the home, a grant was given on a pro-rated basis. In other words, grants were given according to the size and cost of the septic system required to correct the surface water quality problem based on the existing house size and not the expanded size of the home.

Without further explanation, the level of discretion exhibited by the CURB officials for approving projects did not appear to comply with the guidelines for eligibility. However, when questioned about the validity of project approvals, officials were able to justify these special considerations. For future programs, clarification of the eligibility criteria would have addressed this misunderstanding.

4.6.1.3 Cost of Project

Acceptable septic system projects were qualified to obtain assistance, which covered 50% of the total costs of the project up to a grant ceiling of $2000. An indicator of equity concerned the uniform allocation of funding among projects of various amounts. The expenditure by a landowner was directly related to the nature of the project undertaken. Approximately 60% of the projects incurred expenses over $4000 (Figure 4.7), maximizing the grant ceiling.

Figure 4.7: Cost of CURB septic system projects: Middlesex County



(CURB Septic System Applications, Middlesex County)

According to the application data, the average cost of a project was calculated at $3867. This was expected, as a majority of the projects were to replace both the septic tank and the leaching bed. This further demonstrated that most landowners took advantage of the opportunity to repair their entire septic system with a financial reimbursement of 50%.

4.6.2 Efficiency

Again, the three measures used to evaluate the efficiency of the CURB program were: (1) the number of days to process an application; (2) the reliability of the information on the applications; and (3) the public's awareness of the program.

4.6.2.1 Number of Days to Process an Application

Table 4.13 illustrates the number of days required to process a CURB application. The process involved two approvals. First, the local CURB review committee at the

UTRCA had to recommend approval of the Water Quality Improvement Plan to the MOE in Toronto. The second approval occurred once the MOE received the WQIP and sent written notification to the landowner indicating that they were eligible for funding.

Table 4.13: Length of time to process a CURB septic system application by the number and percent of applications

Time	UTRCA to Recommend Approval		MOE to Notify Applicant*		Total Time to Process Application*	
	#	(%)	#	(%)	#	(%)
< 7 Days	24	(19)	8	(21)	0	(0)
8 – 21 Days	42	(34)	30	(77)	10	(26)
22 – 90 Days	48	(39)	1	(2)	25	(64)
91 – 180 Days	3	(2)	0	(0)	3	(8)
> 180 Days	7	(6)	0	(0)	1	(2)
Average	**47 Days**		**15 Days**		**53 Days**	

* MOE approval date missing from 97 applications
(CURB Septic System Applications, Middlesex County)

The average length of time taken by the UTRCA to make a recommendation for approval to the MOE was approximately six weeks (47 days). The average time taken by the MOE to notify the applicant of their approval for funding was about two weeks (15 days). Finally, the average length of time that was required to process an application was almost two months (53 days).

In total, 53% of the applicants were recommended for approval by the UTRCA in less than one month and 92% were sent to the MOE with a recommendation for approval in less than three months. Almost 100% of the applicants were notified by mail that they had been approved for CURB funding within three weeks of sending the WQIP to the MOE. Ninety percent of the landowners completed the approval process within three weeks of submitting their application to the local CURB review committee. Some variations occurred between the applications due in part to the differences in the ability of the landowner to provide all the relevant information or the complexity of the project.

4.6.2.2 Reliability of Information

Efficiency of the CURB program was also measured by assessing the reliability of the information provided on the applications. Eligibility for funding was based on the severity of impact on the local surface water quality as expressed in the WQIP. According to the CURB guidelines,

> it is the responsibility of the applicant to ensure that the practices and structures undertaken are suitable to the applicant's operation and technically and structurally adequate (MOEE, 1995, pg. 11).

The applicant had to ensure that the information on the applications was complete and correct and met all local, provincial and federal laws and regulations such as obtaining a Certificate of Approval, Use Permit or a building permit. The MOE would not issue the grant unless proof of these permits was provided. A CURB facilitator would conduct a site visit to evaluate the potential sources, pathways and magnitude of the water quality impairment indicated on the WQIP. This ensured that the grant was used to repair septic systems that were contributing to water quality contamination.

In addition, the CURB guidelines state that applicants were required to "sign an agreement that promises to maintain and use the new structures in accordance with their WQIP for a period of not less than five years" (MOEE, 1995, pg. 11). However, an official from the MOE involved in the implementation of the CURB program stated that since the program was terminated early, he was not aware that a 5-year agreement protocol had been established. In fact, the only monitoring that was carried out occurred immediately after the project was completed. At this time, the CURB facilitator made a final inspection to ensure that the project indicated on the WQIP was indeed complete and that all the required documentation had been submitted. No further follow-up was to be conducted.

In summary, the CURB program was efficient in ensuring that the information on the application and WQIP was accurate and that the funds were being spent appropriately on an approved project. This was achieved through on-going inspections and verifications by both the local conservation authority and the MOE. However, with no follow-up intended, it was the responsibility of the landowner to ensure proper care and maintenance of the system. Efficient programs should incorporate long-term monitoring of projects to ensure adequate protection of water quality.

4.6.2.3 Pubic Awareness

A third measure was utilized to determine the efficiency of the CURB program. Since CURB was a cost-sharing program aimed at landowners in a specific target area, efficient implementation would require that this population was aware of the program. It was the responsibility of the provincial government to produce information outlining the details of the program. The UTRCA was responsible for ensuring that this information was made available to eligible applicants. The number of inquiries made about the program and the number of projects completed indicates the level of public interest in the program as a whole.

Since the commencement of CURB in 1991, 615 inquiries were made by landowners, 526 of these were in eligible areas. According to the CURB 1994 annual report (UTRCA, 1994), 379 projects of all types had been submitted for approval. Of these, 295 were approved for grant funding and 160 projects were completed. For septic system projects, 153 applications were submitted and 140 completed. In 1995, research was completed to determine the adequacy of the communication strategies employed to promote the CURB program (Joynt and Wood, 1995). Of those responding, 53% had heard of CURB through the newspaper and 41% of the respondents were not aware that opportunities for water quality conservation were available. However, 90% of the respondents did not feel that there was a water quality problem on their property.

According to officials at the MOE and the UTRCA, prior to the implementation of CURB "out of sight, out of mind" reflected the attitude of most landowners toward their septic systems. For this reason, a large portion of the CURB program was devoted to increasing public awareness of the need for proper construction and maintenance. This was achieved by distributing brochures and booklets on septic system care as well as field days and demonstrations conducted by the local conservation authorities. As a result, officials noticed a marked increase in the public's understanding of their septic systems and the impacts caused by faulty systems.

4.6.3 Level of Risk

The level of risk for the CURB program was ascertained by considering: (1) the pumping rates, (2) age of the septic system, (3) distance separations, and (4) the severity of impact on the local water quality (Table 4.14 and Table 4.15).

Table 4.14: Septic tank pumping rates, age of the tank, and age of the tile bed

	Number of Applications	Percent (%)
Tank Pumping Rates		
< 1 year	1	(1)
1-2 years	20	(17)
3-4 years	85	(74)
> 4 years	9	(8)
Age of Tank		
0-20 years	40	(41)
21-50 years	49	(51)
>50 years	8	(8)
Age of Tile Bed		
0-20 years	33	(44)
21-50 years	38	(51)
>50 years	4	(5)

(CURB Septic System Applications, Middlesex County)

4.6.3.1 Tank Pumping Rates

The Ontario *EPA* recommends that a licensed hauler pump septic tanks out every three to four years to ensure proper working conditions. If a system was pumped more often, it was a clear indication that the capacity of the system may be too small to contain the sewage flow activities of the building. Conversely, if a tank was pumped less often, sludge or scum could be carried over into the leaching bed resulting in soil clogging, system failure and ultimately, improper treatment of the sewage. According to the CURB applications, 74% of the landowners had their system pumped at the recommended time of every three to four years (Table 4.14). However, 18% of the applications indicated that the system was pumped out every two years or less and 8% of the systems were pumped out more than every four years.

According to MOE officials, it was anticipated that through the efforts of CURB these landowners would have become aware of the importance of proper septic system maintenance and in the future have their tanks pumped out at the recommended intervals. However, throughout this research it became clear that very few landowners properly maintain their system despite the efforts of government. In the future, a program that required mandatory septic tank pumping every three years would further decrease the level of risk to water quality. In this way, on a regular basis licensed haulers would monitor the systems.

4.6.3.2 Age of the System

If properly maintained and operated, septic systems are expected to function adequately for approximately 20 years. Over half of the septic tanks (41%) and the tile beds (44%) were less than twenty years old. However, 51% of the systems (both tank and tile beds) were between 21 – 50 years old. In addition, 8% of the tanks, and 5% of the tile beds were older than 50 years.

The large number of systems under the twenty-year life span could be explained by the increase in new residential development throughout the townships that required a new system be installed at the time of construction. The replacement or repair of these systems, although not exceeding their life expectancy, could reflect the misuse by residents. Officials from the UTRCA agreed, commenting that landowners could never be trusted to effectively maintain their systems. In addition, a CURB official stated that often septic systems were misused by former urban residents who moved to rural areas and did not understand proper care and maintenance. This further emphasizes the need for effective education of landowners.

The average age of the septic system was 31 years. The townships in the CURB target area of the UTRCA watershed also had a population of predominately older rural residential dwellings and farming operations. Since many of the homes were older than 20 years, it was expected that the septic system would be also. It was more likely that an older system would be repaired or enlarged rather than completely replaced, which also explains the majority of the systems over the age of 21 years.

4.6.3.3 Distance Separations

The Ontario *EPA* outlines a series of locational clearance minimums from which the septic tank and distribution pipes must be located. Engineering requirements must be met to ensure a property is compatible with the environmental conditions necessary to support a conventional septic system. The United States has similar policies described in the U.S. Manual of Septic Tank Practice (Perkins, 1989). These distances have been calculated in order to prevent pollution from contaminating the nearby water supplies (Table 4.11).

The distance septic effluent traveled before reaching an outlet for potential water contamination was recorded on the application (Table 4.15). The gray shaded area marks the minimum requirement as recommended by the Ontario *EPA*. Applicants could have indicated more than one location to which effluent flows from their faulty septic system, thus causing a greater level of risk to water contamination.

Table 4.15: The distance and location to which effluent travels from a faulty septic system

	Location To Which Septic Effluent Travels							
	Tile Bed		**Municipal Drain**		**Water Source**		**Beach**	
	#	(%)	#	(%)	#	(%)	#	(%)
Distance								
Direct Connection	26	(49)	4	(8)	1	(7)	2	(67)
1 <= 15 m	15	(28)	5	(10)	0	(0)	0	(0)
> 15 <= 50m	9	(17)	7	(14)	1	(7)	0	(0)
> 50 m	3	(6)	35	(69)	12	(86)	1	(33)

(CURB Septic System Applications, Middlesex County)

These four distances selected by CURB presented a more severe impact on water quality if contaminated by septic effluent, relative to a system that was backing up into a home or ponding on the surface of the ground. In addition, the distance effluent must travel also affected the level of impact on water quality. The farther effluent traveled, the more likely that it will become diluted prior to reaching a water source.

Out of a total of 136 applications, 61%, 63%, 88%, and 98% did not indicate effluent reaching the leaching (tile) bed, municipal drain, a water source, or a beach respectively. There were two possible reasons for this. First, an applicant may have failed to fill in the required information. This outcome was unlikely since it was the responsibility of the CURB Facilitator not the landowner, to make an assessment and fill in the appropriate section of the application. Second, effluent did not travel to any of the four locations, but instead was causing other concerns such as leakage or backing up into the home.

Of an immediate concern to surface water quality, 27% of the applicants revealed that effluent was directly connected to one of the four sites. According to the applications, 17% of the septic systems had effluent that traveled between one and 15 meters before reaching a source of surface water. The Ontario *EPA* regulation stipulated that there be a minimum of 15 meters between the system and a water source. In addition to causing a threat to water quality, these septic systems failed to meet the minimum distance requirements. Distances greater than 50 meters were considered less severe in terms of pollution potential. In Middlesex County, 42% of the applications were submitted by landowners whose septic effluent had greater than 50 meters traveling distance before reaching the leaching (tile) bed, municipal drain, water source or a beach. CURB targeted septic systems that demonstrated an immediate hazard to water quality. Therefore, a majority of the approved projects should have been a high-priority for remedial measures.

The level of risk associated with the distance between a malfunctioning septic system and a source of water can be significant in terms of the potential for contamination. Since CURB was established to remedy existing structures that demonstrated water quality impairment, a large proportion of the approved projects should have been for those systems, which pose the greatest risk to water quality. Therefore, CURB adequately addressed the level of risk from septic systems polluting nearby sources of surface water.

4.6.3.4 Severity of Impact

The focus of the CURB program was to target septic systems that posed the greatest impact on the local surface water quality and the quality of the water at local beaches. A CURB Facilitator assessed the severity of impact and the landowners whose systems demonstrated the most severe impact were to be given priority in receiving grant funding (Table 4.16).

Table 4.16: Number and percent of applications that demonstrated an impact from septic system malfunction on the local surface water quality and the local beach

	Impact on Local Surface Water							
	Limited		Moderate		Severe		TOTAL	
	#	(%)	#	(%)	#	(%)	#	(%)
Impact on Local Beach								
Limited	2	(3)	6	(8)	16	(22)	24	(33)
Moderate	1	(1)	10	(14)	18	(25)	29	(40)
Severe	0	(0)	1	(1)	19	(26)	20	(27)
TOTAL	3	(4)	17	(23)	53	(73)	73	

(CURB Septic System Applications, Middlesex County)

Three percent of the applications suggested a limited impact on both the surface water and the beach. This was expected since applicants whose systems did not pose an immediate threat to water quality were unlikely to receive funding.

Out of a total of 73 applicants, 73% identified that their system had a severe impact on the local water quality. In addition, 27% of the applications were recognized as creating a severe impact on the local beach. Results indicated that 26% of the landowners whom received CURB funding demonstrated a severe impact on the local water quality as well as on the local beach. Thus, CURB funding was most often allocated to landowners whom demonstrated that their septic system was severely impacting surface water quality.

4.6.4 Performance

During this research, no applications were received for areas A – D on the map (Figure 4.5) produced for this analysis. Therefore, the performance of CURB was determined with the use of questionnaires from officials involved in the program, and relevant government documents. Respondents were asked to consider the performance of CURB relative to its ability to achieve stated objectives.

The main objective of CURB was to control surface water pollution from rural sources. According to an official from the MOE, CURB was unsuccessful in meeting this objective. Since it was terminated five-and-a-half years earlier than intended, the early termination detracted from its adequacy. As a result, elevated bacterial levels in the rural watercourses may persist. Nevertheless, a total of 1,824 septic system projects were completed for all of the participating conservation authorities during the duration of the program, as well as numerous efforts to educate the public on proper septic tank care and maintenance. In addition, the performance of CURB was demonstrated by improved water quality in some streams and by the opening of several beaches. For example, bacterial levels remained lower than the closure guidelines of 100 bacteria per 100ml of water at Fanshawe and Wildwood Beaches (UTRCA, 1994). A more thorough analysis of the bacterial count data would have given a good indication of the performance of the program. However, as discussed in Section 3.3.4, these data were not readily available and would not have provided an adequate representation of the conditions in the study area.

Upon termination of the program, the interest by applicants to repair their septic systems was high (Table 4.9). For this reason, it can be presumed that if government funding had not been terminated, it is likely that CURB would have been successful in reducing the surface water contamination attributed to faulty septic systems.

A significant aspect of CURB also involved efforts to increase knowledge of pollution impacts from private septic system failures. CURB funded education and demonstration projects in an attempt to change the attitudes of many rural landowners about the importance of good water quality and the extent of rural diffuse pollution. According to officials, the performance of CURB was highly successful in raising public awareness of the need for proper care and maintenance of their septic system. In fact, this official felt that a program of ongoing public education was essential. Officials from the UTRCA also held this opinion, stating that the cost-sharing incentives of CURB have enhanced the performance of implementing Regulation 358. The combined efforts of CURB and Regulation 358 will be assessed further in the evaluation of consistency

4.7 The Efforts of Regulation 358 and CURB in Controlling Pollution from Septic Systems

In this section, the *EPA* Regulation 358 and CURB programs are examined with respect to their level of consistency. Both the CURB program and the *EPA* Regulation 358 targeted the same population. In order to be effective, (1) their objectives should be consistent, and (2) there had to be a high level of cross compliance between the agencies with overlapping responsibilities.

4.7.1 Consistency of Program Objectives

The objectives of the CURB program had to be consistent with Regulation 358 which is a mandated legislation under the Ontario *EPA*. The UTRCA is responsible for approving private sewage disposal systems in compliance with the legislative requirements. According to the UTRCA (1998), the objective of the Private Sewage Disposal Program, which implements Regulation 358, is:

> To protect ground and surface water quality and public health by delivering private sewage disposal services and, to reduce the risk to human health by reducing the contamination of groundwater and surface water from private sewage systems. (UTRCA, 1998, pg. 3)

The objectives of the septic system portion of the CURB program were similar:

> To ensure the safe, healthful and environmentally responsible treatment and disposal of domestic sewage and thereby protect local surface water resources. (MOEE, 1994, pg. 15)

Both programs identified the need to protect human health as well as the quality of water as a whole. The objectives are consistent.

Section 3.1.1 described that in rural areas diffuse source pollution can originate from a number of sources and affect both surface and groundwater quality. Most research tends to focus on a single resource rather than the combined impacts on both surface and groundwater (Table 4.17).

Table 4.17: Impacts from septic systems identified in selected previous research efforts

AUTHOR	Surface Water	Groundwater
Hanson and Jacobs, 1989	X	X
Hanson *et al.*, 1986	X	X
Chesters and Schierow, 1985	X	
Lawton and Ormseth, 1993	X	
Viraraghavan, 1982	X	
Baker *et al.*, 1993		X
Connors, 1980		X
Fleming, 1992		X
Harman *et al.*, 1996		X
MOEE, 1992		X
Olivieri *et al.*, 1981		X
Packer and Ferguson, 1995		X
Perkins, 1984		X
Poel, 1991		X
Reddy and Dunn, 1984		X
Rifai *et al.*, 1993		X
Robertson *et al.*, 1991		X
Simpson, 1992		X
Yates, 1985		X

The Ontario *EPA* recognized that contamination from septic systems pose a threat to both ground and surface water resources. The CURB program did not address groundwater resources but only emphasized the improvement of local surface water quality. In fact, eligible projects must have demonstrated a surface water quality problem in order to receive funding approval (MOEE, 1994).

According to officials involved with the CURB program, the focus on surface water contamination was justified. This conclusion came from studies that surveyed landowners within the targeted areas and found high proportions of substandard septic systems contributing to bacterial loads in local streams (UTRCA, 1991). The extent of surface water pollution was compounded by landowners that connected sewage waste and greywater to a pipe, which was directly discharged into a surface watercourse. Since CURB had a limited amount of funding, it was necessary to focus on these priority sources. Therefore, septic systems may be a large contributor to groundwater pollution (Table 4.17), but it was clear that in the UTRCA watershed, the contribution to surface water contamination was significant.

The focus on surface water can also be explained by considering the CURB program as a whole. Septic system repairs comprised only a portion of the projects funded under CURB. The other land use activities targeted by CURB (livestock access to streams, improper milkhouse washwater facilities, and inadequate manure storage) were also significant sources of surface water contamination (UTRCA, 1991). As a result, the evidence of contamination at local rural beaches necessitated the CURB program's focus on surface water quality improvement.

4.7.2 Cross Compliance

Programs that involve responsibilities from different levels of government should not contradict one another. For this reason, the provincial government intended the septic system portion of the CURB program to operate simultaneously with the *EPA* permitting process. Before a CURB grant was issued, a landowner was responsible for obtaining the required permits and compliance with the regulations mandated by the *EPA*. Thus, CURB provided a means for financial assistance to landowners that, under the *EPA*, were obligated to repair or replace their faulty septic system. This meant that in addition to obtaining approval for a grant from the CURB Committee at the local conservation authority and from the provincial government at the MOE, approval for a Certificate of Approval had to be granted under Regulation 358. This element of cross compliance ensured that the programs were implemented effectively.

To guarantee that CURB was consistent with the requirements of Regulation 358, the Guidelines (MOEEa, 1994) stated that all funded septic system projects had to be constructed in accordance with Regulation 358. In addition, a copy of the application for the Certificate of Approval along with a receipt showing payment was required prior to the allocation of funds. This type of consistency promoted more efficient implementation of both programs in terms of the length of time required processing an application (Section 4.3.1.1 and 4.6.1.1).

Since CURB projects required *EPA* approvals, officials in charge of implementing Regulation 358 had to be aware of the necessity of the CURB program. Officials at the UTRCA watershed were supportive of provincial government funding remediation efforts. In fact, the Director of the Private Sewage Disposal Program stated that "if grants to the owner or provincial funding to the agencies were re-instated, then [the UTRCA] would see an improvement in the cooperation with residents to obtain permits and install adequate systems" (Palin, 1997). An Inspector from the same office agreed, insisting that new construction can pay for itself but repairs and replacements need funding for the common good. This is because it is difficult for new development to avoid obtaining the required approvals and permits but landowners often consider repairing their system without a permit. Therefore, officials at the local level identified the need for cost-sharing programs such as CURB to effectively address pollution from existing septic systems.

4.8 Summary

The *EPA* Regulation 358 and CURB programs have been evaluated based on the criteria of *equity, efficiency, level of risk, performance*, and *consistency*. The key findings and their implications for controlling the pollution from septic systems will be discussed below.

Results of this analysis suggest that Regulation 358 has been somewhat successful in achieving its goals, however some areas requiring improvement were discovered. In terms of ***equity***, the program tended to be dominated by applications submitted by residential landowners (88%) constructing a new system (64%). This was due to the fact that the area is predominately rural residential that had recently experienced growth of new development. There was no statistical difference between the type of system approved. However, there was a difference between the conditional approvals. In this case, alternative systems received a conditional approval more often (49%) than conventional types (25%). Analysis has shown that the program is equitable considering the degree of complexity involved in approving alternative systems.

Based on the number of days to process applications, the ***efficiency*** of the program was more than adequate. Potential areas for improving efficient implementation included increasing public awareness of proper septic system care and maintenance, and performing on-going monitoring. The CURB program addressed the issue of increasing public awareness through its education efforts, for that reason enhanced the efficiency of Regulation 358. Nevertheless, the lack of funding and agency staffing prohibited long-term monitoring.

The *EPA* program appeared to address a moderate ***level of risk***. For instance, 97% of the applicants met the minimum required tank capacity but percolation rate minimums were not met by 54% of the applicants. In these cases, alternative systems were approved. The highest level of risk occurred because 60% of the lots were less than one hectare in size. To prevent groundwater contamination, these small lots characteristic of new development, may require the installation of communal septic systems or the implementation of government assistance programs.

The largest area for improvement involved the ***performance*** of the program. For example, 52% of the *EPA* applications were granted a Use Permit for a conventional septic system in areas that were identified as severely limiting their use. This was often the result of inadequate soil assessments and the difficulty experienced with testing techniques carried out in more complex soil environments.

The CURB program was not successful in meeting its overall objective primarily due to its early termination. However, the program was equitable, implemented efficiently, and addressed the high level of risk from malfunctioning septic systems. In terms of ***equity***, it was expected that a majority of the applicants would replace their entire system (75%) incurring expenses over $4000 (60%) in order to maximize the grant ceiling. The program was highly ***efficient***, approving almost all applications within three months of submission (92%) and ensured reliable information with the assistance of CURB facilitators who completed the application and carried out on-going inspections. More efficient implementation would have required long-term monitoring. CURB adequately addressed the high ***level of risk*** demonstrated by funding repairs for 51% of the systems older than the 20-year life expectancy, 27% of the systems that were directly connected to a water source, and 73% of the systems that were severely impacting the local water quality.

In terms of ***performance***, CURB failed to meet its objective because it was terminated six years earlier than anticipated. A detailed biochemical analysis of the bacterial contaminates measured in the watershed would have been a desirable indicator of performance. These data were not available. However, CURB was highly successful in raising public awareness and increasing landowner knowledge.

The final criterion evaluated was ***consistency***. This analysis showed that the objectives of the two programs were very consistent and there was a high degree of cross-compliance

5. CONCLUSIONS

The practical and academic implications that were drawn from the analysis and the need for further research about future septic system policy are discussed in this chapter.

5.1 Implications

This research revealed (1) the practical implications of the specific operations of Regulation 358 and the CURB program, and (2) the academic implications of the need for this type of research.

5.1.1 Practical Implications

1. *The continued need for regulation:* Regulation is a necessity for septic tank pollution control. The *EPA* program was efficient, equitable, and somewhat successful in protecting public health and the environment. Since landowners are generally unaware of the extent of septic system malfunctions, alternative methods of pollution control may be inadequate. A system of long-term monitoring is required to ensure that compliance with *EPA* standards is not compromised. To this end, there is also a need for adequate sanctions. The current penalties (*i.e.* double permit fee) for operating septic systems that have not been approved, or operating a faulty septic system, may not be sufficient. UTRCA officials have expressed a need to conduct on-going monitoring of approved systems but they do not have the personnel available. Therefore, if not for limited government budgets, monitoring on a regular basis would mitigate this problem.

2. *An on-going need for public education:* Most landowners are perceived to have an "out of sight, out of mind" attitude towards their septic system. A large number of landowners are not aware of the extent of septic system malfunctions until effluent ponds in the backyard or backs up into their home. Officials believed that landowners can never be trusted to properly maintain or operate their system. To operate effectively, programs that control the pollution from septic systems require that landowners are educated about their system and utilize it appropriately. This issue brings to light the implications of providing cost-sharing incentives to landowners that were improperly utilizing their system. Almost 50% of the CURB projects were to repair faulty systems. These systems likely malfunctioned as the result of inadequate care and a lack of strict maintenance. A grant program to repair or modernize faulty systems may not be necessary if the public is appropriately educated. Since there is no way of ensuring that landowners use their system properly once it is installed, a program of on-going education and raising public awareness may be more cost-effective than the provision of grants.

3. *Consequences of new development*: There has been an increase in new development occurring in small rural communities throughout the study area. This type of development is characteristic of a high density of small lots, often less than one hectare in size. In terms of influencing regional groundwater contamination, septic tank density is the most influential parameter (Perkins, 1984; Yates, 1985). The Ontario government has initiated programs that consider alternative methods of wastewater treatment in these areas (MOE, 1998). However, to ensure protection of

the groundwater supply, there should be a mandatory requirement for the installation of communal systems in new rural subdivision developments not serviced by municipal facilities. There are also implications of the fact that most of the landowners living in these new rural developments were former urban residents who have moved to the country. Often these residents fail to understand the treatment capacity limits of a septic system, and the importance of proper maintenance. The mandatory installation of communal systems in new subdivisions would address this problem in the future. However, there is an immediate need for the implementation of on-going public education about septic system operation and maintenance, and increased awareness of the extent and impacts of malfunctioning systems. This could be achieved by providing the current "Care and Maintenance" brochure during the home ownership process and by regulating periodic pumping and inspections of the system by a licensed hauler.

4. *The utility of GIS maps:* In terms of overall performance, Regulation 358 and CURB both had shortcomings. The *EPA* program approved conventional systems in areas deemed severely limiting their use. The CURB program did not specifically target efforts to these high priority areas. Rather, CURB targeted malfunctioning systems within a specific watershed that had experienced recurring beach closures. Currently, digital maps are not being utilized as a part of the approval process. Instead, soil surveys were conducted by the landowner and verified by a government official. Site suitability maps may assist in enhancing the efficiency of the *EPA* program by providing a more reliable data set and reducing the reliance on landowners to report

the precise conditions of their property. Ideally, these maps would have to be at a scale (1:5,000) that illustrated the conditions on individual lots rather than the general conditions of the entire region. However, more general maps (scale 1:50,000) would also be useful to future cost-sharing programs such as CURB. These programs could utilize maps to direct remedial measures in areas with a high potential for water contamination.

5. *Integration into the Building Code:* On April 6, 1998, Bill 152 the *Services Improvement Act* transferred Regulation 358 from the *EPA* to the *Building Code Act*. This integration has significant implications for the approval of septic systems. For example, the Ministry of Municipal Affairs and Housing (MMAH) has been named the provincial body responsible for training and certifying inspectors but, at present they have no experience with septic system function or approval (Palin, 1999). As a result, Building Inspectors now in charge of enforcing septic system regulations have a mere five-day MMAH training course. Under the previous *EPA* Regulation, a majority of the conservation authorities had close to 30 years of experience in the design, enforcement, and approval of septic systems. According to an UTRCA official, these employees are rapidly becoming unemployed. At the UTRCA, four municipalities representing over 50% of their workload have opted to have the approval of septic systems enforced by Municipal Building Officials, primarily because provincial funding was terminated and the cost of permits increased. This integration has serious implications for the environment. To illustrate, the *EPA* prohibited the installation of septic systems in areas prone to flooding or in wetlands.

However, the installation is prohibited under Building Code on the condition that the flooding does not affect the operation or construction of the septic system (Palin, 1999). Consequently, septic systems approvals are granted in flood plains and in provincially significant wetlands. The primary objective of the Building Code is to promote the construction of new development; it does not protect the environment or public health. If Regulation 358 is to remain in the Building Code changes may be required to improve the protection of the environment. The extent of these changes may not be fully realized until the two programs have been completely amalgamated and the program has been implemented for a sufficient period of time.

6. *Integrating water quality and quantity*: Both programs have addressed the importance of protecting the quality of surface and groundwater supplies. Septic systems also present important concerns for the quantity of water consumed. For example, the consumption of water by the average household in Ontario consists of 20% dishes and laundry, 30% shower and bath, and 45% for toilet usage (Cook, 1994). The wastewater from all of these uses enters directly into the septic system. Consequently, there is a significant potential for implementing household water conservation measures. In August of 1991, the provincial government initiated a program for reducing municipal water use (Sharrat *et al.*, 1994). Under this program, the Ministry of Housing amended the *Plumbing Code* by decreasing the allowable flow rates of faucets, showerheads, and toilets. The installation of these conservation fixtures is now enforced in all permitted renovations and new construction. Since these water efficient fixtures are no longer more expensive that the standard fixtures,

it is expected that this initiative will significantly reduce water consumption in all new developments. However, cost-sharing programs may be required to entice residents to replace their existing fixtures with the more efficient models. The CURB applications revealed that only 35% of the landowners had installed water conservation devices. There is clearly a need for increased public awareness on the importance of adopting water conservation measures.

5.1.2 Academic Implications

1. *The need for implementation-based research:* Past research on septic systems has usually considered the performance of the system as the primary focus. This was achieved through measuring water quality parameters and examining the density of lots to assess the implications of malfunctioning systems and the impacts of wastewater effluents. This type of performance-based approach to research could have provided the biophysical monitoring data lacking from this study. However, very little is known about the implementation of septic system policy and its effectiveness in controlling pollution. This research has taken an implementation-based approach to determine the effectiveness of the *EPA* Regulation 358 and CURB programs in meeting their objectives for protecting water quality and human health. The resulting analysis will provide a useful tool for government agencies in formulating more effective resource policies in the future.

2. *The use of GIS maps:* An analysis of the efficiency, equity, level of risk, and consistency continues to provide an adequate framework for evaluating resource

policies. This research demonstrated the utility of GIS maps as an alternative measure of program performance at a regional level. These maps provided a useful method of identifying the site suitability for locating conventional septic systems, and highlighting areas that severely limit their use. Nevertheless, improvements could be made that would enable a more precise evaluation. For instance, a scale of 1:50,000 illustrated the general conditions across an entire region. Although it is important to understand the environmental factors as a whole, septic systems rely on site-specific conditions to function adequately. Therefore, maps that provide data on the detailed conditions at individual lots (1:5,000) would be more valuable to approval agencies. Maps of this scale would enable a more rigorous evaluation of the programs because the location of septic systems could be plotted on each property. Also, mapping additional parameters such as slope, flooding potential, surface drainage, and topography would render a superior resource in determining septic system site suitability, and virtually eliminate the need for field testing. Since maps of this type and scale do not currently exist, the time, expense, and complexity involved in creating them would be extensive. This would explain why approval agencies continue to rely on field testing as the primary means of determining site suitability.

5.2 Future Research Needs

The research presented in this thesis has provided a thorough evaluation of the implementation of two policies for controlling the pollution from septic systems. However, there are a number of issues requiring further investigation, which could be addressed by future research. First, the lack of public awareness of septic systems was clearly identified throughout this research. Future studies should examine public perceptions by conducting formal interviews with landowners. This type of work would provide a valuable resource for approval agencies in formulating effective landowner education initiatives.

Second, future studies should address the linkage between water quality and quantity related to septic system use. Research presented in this thesis has addressed the significant potential for water contamination from malfunctioning septic systems. However, there are possibilities for implementing water conservation measures, which have not been fully examined.

A third area for potential research is to examine the implications of the new development in rural areas. Small rural communities are experiencing subdivision growth, which presents serious concerns for protecting water quality. This research highlighted the problem with septic systems installed on small lots, which are characteristics of this type of development. Alternative wastewater technologies have been proposed and implemented in some rural subdivisions but the performance of these systems has not been evaluated.

Finally, future research must address the current integration of septic system approvals into the Building Code. Building Inspectors are now responsible for approving and regulating septic systems. For this reason, an official from the UTRCA anticipates that the environment will be sacrificed for the sake of development. Utilizing GIS maps could assist in evaluating the effectiveness of this new program. Site suitability maps showing the location of septic systems approved under the new regulation would provide a clear indication of the program's performance.

APPENDICES

Ministry of Environment and Energy
Ontario

Application Form And Certificate Of Approval For A Class 2 – 6 Sewage System

Do not complete shaded areas
Application No.
Fee Receipt No.
Date Received:

Personal information contained on this form is collected under the authority of the Environmental Protection Act, Part VIII. It is used to facilitate the issuance of a Certificate of Approval as prescribed in Section 77 of the Act. Questions should be directed to the Ministry's District Office in your area.

1. Name and mailing address (number, street, city, town, etc.) of owner

Tel. no. ( ) –
Alternate Tel. no. ( ) –

2. Name and address (number, street, city, town, etc.) of installer

Tel. no. ( ) –

3. Propose to ________ a Class ______ sewage system to serve ________
(construct, install, alter, extend, enlarge) (facility: e.g. single family dwelling, motel, etc.)

4. Property location	Region/County/District	Ward, Township, Town	Lot No.	Conc. No.	Sub Lot No.	Plan No.	Area of lot (m²)

5. State number of: Bedrooms/motel units | People | Flush toilets | Urinals | Washbasins | Showers & bathtubs
Total fixture units | Assessment Roll No.

6. Water supply
☐ Proposed or ☐ Existing
☐ Dug or bored well ☐ Drilled well ☐ Municipal ☐ Other

7. Attach completed sketch on Page 2. List other attachments.

8. Relationship to severance (if applicable)
☐ Lot approval pending
☐ Lot approved, under Severance Application No. ________

9. Directions to lot (Highway No., secondary roads, signs to follow, etc.)

10. I certify that the above information is complete and correct and that, if approved, the work will conform with Provincial requirements for sewage systems and local Municipal By–laws.

Name and address of agent (if agent is completing this form) – number, street, city, town, etc.
Tel no. ( ) –
Signature of owner or agent (if agent is completing this form)
Date

11. Inspector's Report

Inspection time and date
________ ☐ A.M. ☐ P.M. ________, 19

Weather | Representing owner | Leaching bed design criteria: Depth to rock ___ m. Design H.W.T. ___ m.

Requirements | Length of distribution pipe ___ metres | Working capacity of septic/holding tank ___ litres

Sub–surface conditions encountered
Rock & G.W.T. | Depth (m) | Soil type
0
0.25
0.50
0.75
1.00
1.25
1.50

☐ Conditions of approval and reasons (e.g. fill, grading, drainage improvements, design sewage flows)
or
☐ Reasons where proposal not acceptable (add additional pages, if required)

APPENDIX 1b. Certificate of Approval

Ministry of Environment and Energy
Ontario

APPLICATION NUMBER

12. LOT DIAGRAM AND SEWAGE SYSTEM PLAN: Draw to scale indicating north point and showing:
    (a) Location of sewage system components (eg. tanks, leaching bed). Locate and show horizontal distances from system to adjacent existing or proposed buildings, water supplies (including neighbours), existing on-site sewage systems, driveways, property lines, lakes, rivers, water courses, swimming pools.
    (b) Lot dimensions, topographic features (e.g. swamps, steep slopes) near system.
    (c) If any part of proposal conforms to specific standard drawing, give reference number(s).

A Certificate of Approval for this application is refused for the reasons given in Section 11 Page 1

Inspected and Recommended by	Refused Director	Date

CERTIFICATE OF APPROVAL

Application approved and this Certificate of Approval under Section 77 of the Environmental Protection Act is hereby issued for the proposal outlined on Pages 1 and 2 of the application and its attachments as amended by the requirements and conditions of Section 11 provided that the sewage system shall be completed and a Use Permit issued within 12 months of the issue hereof or such extended period as the Director on application allows. DO NOT OPERATE THE SYSTEM UNTIL A USE PERMIT IS ISSUED.

Inspected and Recommended by	Issued Director	Date

Under Section 139 of the Environmental Protection Act, an applicant may appeal a decision by writing to the Director and to the Environmental Appeal Board, 112 St. Clair Avenue West, Suite 502, Toronto, Ontario, M4V 1N3 within 15 days of receipt of the decision.

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OFFICE COPY

APPENDIX 1c. Use Permit

Ministry of Environment & Energy
Ontario

USE PERMIT
FOR CLASS 4, 5, 6 SEWAGE SYSTEMS

APPLICATION NO.

INSPECTION DETAILS	TIME DATE	WEATHER
REPRESENTING:	THE OWNER	THE INSTALLER

1. Work authorized by the Certificate of Approval has been satisfactorily completed and includes:

a) Septic tank/holding tank of working capacity of ________ Litres constructed of steel ☐ concrete ☐ fibreglass ☐ on site ☐ or prefabricated ☐ to serve ______ (no. of bedrooms or units).

MAKE AND MODEL, IF PREFABRICATED TANK

b) Leaching bed of total ________ metres of ____ mm(millimetres) diameter distribution pipe of ________________ ________________ (type and product description e.g. manufacturer(s) and material of which pipe is made) laid in _____ runs and fed by ________________ (gravity, siphon, pump).

c) Proprietary Aerobic System: (Manufacturer) ________________ (Model) ________________

d) Other details ________________

2. Location

a) System components installed as shown on application supporting Certificate of Approval ☐

b) If located other than in (a) use space below for sketch and dimensions from permanent points of reference sufficient to facilitate future location of tank and leaching bed including orientation of pipe runs.

3. The following work remains to be completed:—

☐ Backfill System and Complete
☐ Finish Grading to Shed Run-off and Divert Water Around Leaching Bed
☐ Stabilize All Sloped Surfaces
☐ Other . . . .

USE PERMIT

Under Section 78 of the Environmental Protection Act, and subject to the provisions of the Act and Regulations a Permit is hereby issued to (Owner) ________________ for the use and operation of the Class ______ sewage system constructed/installed/enlarged/extended/altered persuant to the Certificate of Approval issued under the above application number in accordance with the application and Certificate of Approval with any changes indicated above and located on Lot ________ Concession ________ Ward/Township/Municipality ________________ Region/District/County ________________ Plan No.________ Sub-Lot No. ________________

INSPECTED AND RECOMMENDED BY	PERMIT ISSUED BY	DATE ISSUED
	DIRECTOR	

Note: Section 76(a) of the Act provides that no change can be made to any building(s) or structure(s) in connection with which this sewage system is used, if the operation or effectiveness of the sewage system will or is likely to be affected by the change, unless a new Certificate of Approval is obtained.
Section 139 of the Act provides that an applicant for a permit may appeal a decision to refuse to issue a permit. Written notice of appeal must be forwarded to the Director (who refused to issue the permit) and to the Environmental Appeal Board, 112 St. Clair Avenue West, Suite 502, Toronto, Ontario M4V 1N3 within 15 days of receipt of a permit.

WARNING: UNDER NO CIRCUMSTANCES SHOULD A HOMEOWNER ENTER A SEPTIC TANK. NOXIOUS GASES WHICH ARE HEAVIER THAN AIR REMAIN IN THE TANK AFTER THE TOP IS REMOVED, AND HAVE CAUSED DEATH BOTH TO THE ORIGINAL VICTIM AND TO THOSE WHO ATTEMPT TO RESCUE HIM FROM THE TANK.

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OWNER

APPENDIX 2. Water Quality Improvement Plan

FOR OFFICE USE ONLY 1995/96 | 23 | 00 | 03 | | |

Water Quality Improvement Plan — Septic System Section A

Applicant Name: ______________________ Telephone ( ) ______________

Mailing Address: ______________ Town: ______________ Postal Code: ______________

Project Location

County ______________ Lot: ______________

Township: ______________ Concession ______________

Note: Obtain an application form for a Certificate of Approval from your local Part VIII Inspector. The septic system must be approved to qualify for grant assistance.

I Existing System

The existing waste handling system includes the following: Septic Tank Yes ☐ No ☐

Tile Bed Yes ☐ No ☐

Other (specify) ______________________

Don't Know ☐ Number of people in the home ______________ Number of bedrooms ______________

Septic Tank: Age of septic tank ______________ Size of septic tank (gal.) ______________

Type of septic tank Metal ☐ Concrete ☐ Unknown ☐

One compartment ☐ Two compartment ☐

Tile Bed: Age of tile bed ______________ Number of lines ______________ Length of each line ______________

Distance from edge of tile bed to drainage tile ______________ to open drain/stream ______________

What surface water pollution is your present septic system causing? ______________________

____

II Water Inputs

Which types of household waste water enter the present septic system?

	number	**enter septic tank (yes/no)**
showers		
laundry		
toilets		
sinks		
dishwashers		
other		

(specify) ______________________

If no, to where does the wastewater drain? ______________________

Note: **ALL sources of household wastewater must be connected to the septic system**

(see reverse)

III Proposal

Reasons for upgrading/replacing the current septic system ____________________

	(yes/no)	Estimated Cost
- Replace septic tank and tile bed	______	______
- Replace septic tank only	______	______
- Replace tile bed only	______	______
- Add plumbing connections for transfer of waste water to septic tank	______	______
- Laundry pump for transfer of waste water to septic tank	______	______
- Soil test holes dug (one hour backhoe time maximum)	______	
- Soil inspection (engineer's report)	______	______
- Other project items	______	______
Fee for Certificate of Approval		______
Total estimated cost of Project		______
Estimated Project Completion Date		______

How will you reduce water use in your home in order to prolong the life of the septic system? ____________________

How often do you plan to have the septic tank pumped? ______

IV Approvals

The following documents will be obtained for the septic system project:

1. **Certificate of Approval** (to be obtained prior to the initiation of any sewage system project) yes ☐ no ☐

2. **Use Permit** (to be obtained following the completion of the project). yes ☐ no ☐

Note: Maintain copies of these documents along with proof of payment for other eligible costs. Both must be submitted to receive final grant payment.

To the best of my knowledge, the information related to the private sewage system and its operation, contained in this form, is true and accurate. I will use the above facilities for the proper disposal of household sewage only. Further, I will properly maintain these facilities after construction is completed.

Name of Applicant (please print) ____________________

Signature of Applicant ____________________

Date ____________________

Approved

CURB Committee Chairperson ____________________ Date ________

Ministry of Environment and Energy ____________________ Date ________

Pursuant to Section 42(b) of the Freedom of Information and Protection of Privacy Act,

I ____________________ (print name)

authorize the Ontario Ministry of Environment and Energy to obtain information concerning funding received from any Federal or Provincial Program for the project described herein.

Signature ____________________ Date ____________________

Site Inspection Report

Do Not Complete This Section - For Staff Use Only.

Septic Tank Description: ____________________

____

Weeping Bed Description: ____________________

____

Pollution Sources:	1. ____________________	Modes of travel: surface / subsurface
	2. ____________________	Modes of travel: surface / subsurface
	3. ____________________	Modes of travel: surface / subsurface

Distance of pollutant travel from source(s) to:

1. Field tile/Tile: ________ Dry / Flowing
2. Municipal Drain/Ditch: ________ Dry / Stagnant / Slow flow / Fast flow
3. Stream/River/Lake: ________ Dry / Stagnant / Flowing
4. Beach: ________

Evidence of water quality impairment: ____________________

____

____

Qualitative impact of this site on the:

1. local water quality:	limited ☐	moderate ☐	severe ☐
2. rural beach:	limited ☐	moderate ☐	severe ☐

CURB staff: ____________________ Date: ____________________

APPENDIX 3a: *EPA* Regulation 358 Questionnaire

A. Permit Process
1a. Concerning the application, are some sections considered more important that others?
Explain.

1b. How does your agency deal with incomplete applications?
(Are applicants required to provide the missing information, do they have to resubmit a new application? If incomplete applications are accepted, how does this effect the efficiency of the program?)

2. How is the accuracy of the information on the application ensured?

3. What sanctions are imposed for non-compliance or failure to obtain a permit? Comment on the adequacy of these sanctions?

4. Are certain types of applications considered or treated differently than others?
(Is the permit process different for applications from developers or commercial establishments, or residents in certain areas? i.e. time required, reliability of information)

5. How does your agency follow-up or monitor the performance of a septic system once it has been installed?
(What measures are taken to ensure effective installation and operation of an approved septic system?)

6. Typically, why would an application be refused or not approved? How often does this occur?

7a. What recourse or appeal process does an individual who has been denied a permit have?
(What are the options for an individual who has been denied a permit?)

7b. If one exists, how effective is the appeal process?

7c. If none exists, is there a need for an appeal process?

B. Evaluation

1a. How many staff are involved in the permit process?

1b. What percent of time does each member of the program devote? (hrs/week)
(Is there an adequate number of staff involved in the program? If not, how is the process limited by the lack in staff?)

2. How important is this program relative to your agency's other responsibilities?
(What level of priority do the staff members place on the program?)

3. Comment on the strengths and weaknesses of the program.
(Is the current permitting system an adequate means of controlling the installation of septic systems?
What areas of the process need to be improved, what areas work well?)

4a. What criteria are used in determining the acceptability of an application?
(Biophysical, soils, bedrock, water table, distance to watercourses or other criteria that are most important when siting a private septic system?

4b. Is this criterion adequate to properly siting a septic system?

5a. Are the design and installation standards implemented effectively?
(Are the minimum clearances and setbacks set out by the EPA implemented?)

5b. Are the standards of the program adequate to meet current environmental goals and objectives?
If no, what would you change?
(Are these adequate for preventing groundwater pollution?)

6. How well does this program address the issue of cumulative environmental effects?
(Are the effects from other systems and from other sources (agricultural runoff) considered?)

7. What could be done to improve the current policies for regulating the installation of private septic systems?
(Are grant programs like CURB needed? Should the objectives of the program be changed?
Are changes required in the administrative agency? Should more money be allocated to the implementing agency?)

8. How will the recent amendments proposed in Bill 57 affect the permit process?
(What will be the impact of incorporating septic system regulations into the building code?)

C. Public Support
1a. What the level of public support / cooperation for the EPA program is demonstrated to you by the landowners? Developers?
(Very high, High, Neutral, low, Very low.)

1b. What factors contribute or detract from public support?
(Do landowners generally have a basic knowledge of their septic systems in terms of where it is located, age, how it works, care and maintenance etc.? Are certain aspects of the process disliked by the landowner?)

2a. In Middlesex County, generally are septic systems effectively maintained?

2b. Do you think the public is aware of the potential contamination from their septic system?

APPENDIX 3b: CURB Questionnaire

1. Typically, why would an application be refused or not approved for funding?

2. How often were applications not approved for funding? Approximately how many applications were denied funding?

3. What were the most important criteria in determining the acceptability of an application for funding?

4. How important was the Septic System portion of the CURB program relative to the other three areas of concern?

5. Was the CURB program an effective means of controlling surface water pollution?

6. Comment on the strengths and weaknesses of the program

7. Were beach closures the main reason that CURB was created? Do septic system malfunctions directly cause beach closures?

8. In the CURB guidelines it was stated that a 5-year agreement is made by the landowner to maintain the project completed with CURB funding. How is this commitment ensured?

9. The CURB guidelines indicated that projects involving the expansion of a septic system were not eligible for funding yet, a number of applicants received funding who stated clearly on their application that they were increasing the capacity of their system. Please explain.

10. CURB was established with the objective of reducing surface water contamination. However, previous research has shown that septic systems are the largest contributor of ground water pollution. What prompted the government to include septic system projects in a program aimed at surface water?

11. What was the level of support / cooperation demonstrated to you by the landowners?

12. Do you think the public is aware of the potential contamination from their septic system?

13. Do you think that the required improvements to septic systems would have been made without the financial assistance from CURB?

14. Do you think the CURB program was successful in meeting its objectives?

15. What are the implications of terminating the CURB program earlier than originally anticipated?

16. CURB was the first to provide funding to non-farm rural landowners. Are similar programs necessary in the future?

APPENDIX 4: CURB Eligibility Criteria

A grant to implement all or parts of a Water Quality Improvement Plan may be paid to an individual applicant

a) who is a resident of Ontario;
b) who is a registered owner of the property who completes an approved CURB Water Quality Improvement Plan.

1. Under this program, a person is deemed to be the owner of the land if:

    a) the person is the registered owner of the land and resides in the Province of Ontario for a minimum of 180 days per year; or
    b) the person leases the land for farming from the registered owner and has signed a lease that is satisfactory to the Director of the Science and Technology Branch; or
    c) the person is an Indian under the Indian Act (Canada) and who is lawfully in possession of land on a reserve under the Act for which a Water Quality Improvement Plan has been prepared.

2. A partnership or corporation, controlled by Ontario residents, is considered to be one applicant and must meet all of the above conditions and must complete a special section of the project proposal form.

3. The following costs are eligible for grant assistance:

    a) Required permits
    b) Purchased material and supplies
    c) Professional fees
    d) Fees for design, construction and supervision
    e) Repairs to existing structures.

The labour and machinery use of the applicant, family dependents and the applicant's business are not eligible.
(MOEE, 1994)

Bibliography

Agriculture Canada (1991) Soils of Middlesex County, Sheet 3 Ontario Eastern Townships Soils Survey Report #56 Middlesex County.

Baker, C.P., Bradley, M.D. and Bobiak, M.K. (1993) "Wellhead Area Delineation: Linking Flow Model with GIS". *Journal of Water Resources and Planning Management.* 119(2). 275-287

B.C. Ministry of the Environment (B.C. MOE) (1984) "Soil Constraints for Septic Tank Effluent Absorption". Surveys and Resource Mapping Branch, Kelowna. February 1984.

Boggess, W., McGrann, J., Boehlje, M. and Heady, E. (1979) "Farm level inputs of alternative soil loss control policies". *Journal of Soil and Water Conservation.* 34(4). 177-183

Bowler, I.R. (ed.) (1992) *The Geography of Agriculture in Developed Market Economies*. Longman Scientific & Technical, New York.

Castle, G. (1993) "Agricultural waste management in Ontario, Wisconsin and British Columbia". *Canadian Water Resources Journal.* 18(3). 217-227

Chesters, G. and Schierow, L. (1985) "A primer on nonpoint pollution." *Journal of Soil and Water Conservation.* 40(1). 9-13

Connors, S.D. (1980) "Application of Aerial Photographs and Surficial Geologic Maps to the Suitability of Land for Septic Tank Systems". *Bulletin of the Association of Engineering Geologists.* XVII(3). 153-162

Department of Energy, Mines and Resources Canada. (1994) "Lucan, Ontario 1:50,000." National Topographic Series (40 P/3).

Dickinson, W.T., Rudra, R.P., and Wall, G.J. (1990) "Targeting Remedial Measures to Control Nonpoint Source Pollution". *Water Resources Bulletin.* 26(3). 499-507

Environmental Protection Agency (EPA) (1992) *Regulation 358 Sewage Systems.*

Fleming, R.J. (1992) *Rural Well Water Survey Huron County 1991*. Ontario Ministry of Agriculture and Food, July 1992.

Gregson, W. (1997) MOE Approvals Branch, Assistant Director. Personal Communication.

Hanson, M.E., Jacobs, H.M., Ham, E.D., Leonard, K.L., Simmons, K.J. (1986) *The Impact of Private Sewage Systems on Wisconsin's Critical Resources.* Center for Land Information Studies, Institute for Environmental Studies and Department of Urban and Regional Planning, University of Wisconsin-Madison.

Hanson, M.E. and Jacobs, H.M. (1989) "Private Sewage System Impacts in Wisconsin Implications for Planning Policy". *American Planning Association Journal.* 169-181

Hansonfeld, Y. and Brock, T. (1991) "Implementation of Social Policy Revisited". *Administration and Society.* 22(4). 451-479

Harman, J., Robertson, W.D., Cherry, J.A., and Zanini, L. (1996) "Impacts on a Sand Aquifer from and Old Septic System: Nitrate and Phosphate". *Groundwater.* 34(6). 1105-1114

Horton, R.E. (1945) "Erosional development of streams and their drainage basins". *Bulletin of the Geological Society of America* (56). 275-230

International Joint Commission (IJC) (1978) *Environmental Management Strategy for the Great Lakes System,* Windsor, Ontario.

Kramer, R., McSweeney, W., Kerns, W. and Stavros, R. (1984) "An evaluation of alternative policies for controlling agricultural nonpoint source pollution". *Water Resources Bulletin.* 20(6). 841-846

Kreutzwiser, R.D. and Slaats, M.J. (1994) "The utility of evaluation research to land use regulations: the case of shoreline development". *Applied Geography.* (14) 169-181

Lawton, C. and Ormseth, J. (1993) *Septic System Survey of UTRCA Cottage Properties* Upper Thames River Conservation Authority, Water Quality Report.

Lichtenberg, E. and Lessley, B.V. (1992) "Water quality, cost-sharing, and technical assistance: Perceptions of Maryland farmers". *Journal of Soil and Water Conservation.* 47(3). 260-264

Maas, R.P, Smolen, M.D., and Dressing, S.A. (1985) "Selecting Critical Areas for Nonpoint-Source Pollution Control". *Journal of Soil and Water Conservation.* 40(1). 68-71

MacRitchie, S.M., Pupp, C., Grove, G., Howard, K.W.F., and Lapcevic, P. (1994) *Groundwater in Ontario: Hydrogeology, Quality Concerns, Management.* National Hydrology Institute, Environment Canada.

Ministry of the Environment (MOE) (1990) *Septic Tank Systems.*

_______a. (1994) *Funding Programs for Agriculture and The Environment 1983-1994.*

_______b. (1994) *An introduction to communal sewage systems.*

_______. (1997) "Responsibility for Sewage Systems: Environmental Protection Act Part VIII". *In Brief.* August 1997.

_______a. (1998) "Changes to Ontario's Regulation of Septic Systems and Hauled Sewage". *In Brief.* June 1998.

_______b. (1998) "Municipalities to receive $104,650,527 for water and sewage system improvements". *Media Backgrounder.* June 2, 1998.

Ministry of the Environment and Energy (MOEE) (1992) *Status Report on Ontario's Air, Water, and Waste.*

_______a. (1994) *CURB Program Guidelines for Project Eligibility and Funding.* Science and Technology Branch. Toronto, May 1994.

_______b. (1994) *Water Management Policies, Guidelines, Provincial Water Quality Objectives of the Ministry of Environment and Energy*, July 1994.

_______(1995) *CURB Program Guidelines for Project Eligibility and Funding.* May 15, 1995.

_______ (1996) *CURB – Clean Up Rural Beaches Program 1991 – 1996.* April 1996.

_______ (1997) *Notice for Proposal for a Regulation: Amendments to Regulation 358 Sewage Systems.*

Ministry of Natural Resources (MNR) (1980) *Drift Thickness Series Lucan Area Map # 2359.* Ontario Geologic Survey.

National Small Flows Clearinghouse (NSFC). (1995) *Pipeline.* University of West Virginia, 6(3).

Olivieri, A.W., Roche, R.J. and Johnston, G.L. (1981) "Guidelines for Control of Septic Tank Systems". *Journal of the Environmental Engineering Design.* (107). 1025 -1033

Ontario Ministry of Agriculture and Food (OMAF) (1987) *OSCEPAP II Control Soil Erosion. Sustain Crop Productivity. Protect Water Resources.*

Ontario New Home Warranty Program (ONHWP). *A Builders Guide to Septic Systems.*

Orum, A.M., Feagin, J.R., and Sjoberg, G. (1991) *A Case for the Case Study.* University of North Carolina Press, Chapel Hill.

O'Toole, L.J. (1989) "Alternative Mechanisms for Multiorganizational Implementation: The Case of Wastewater Management". *Administration and Society.* 21(3). 313-339

Packer, C. and Ferguson, D. (1995) *Thamesford Core Area Sanitary Survey 1995.* Oxford County Board of Health.

Palin, Rob (1997-1999) Director, Private Sewage Disposal Program, UTRCA. Personal Communication.

Perkins, R.J. (1984) "Septic Tanks, Lot Size and Pollution of Water Table Aquifers". *Journal of Environmental Health.* 46(6). 298-304

Perkins, R.J. (1989) *On Site Wastewater Disposal.* Lewis Publishers, Michigan.

Piggott, A. (1998) National Water Research Institute. Personal Communication

Poel, K. (1991) *Contamination from Private Septic Systems 1989 and 1990 Survey Results.* UTRCA.

Reddy, M.R. and Dunn, S.J. (1984) "Effects of Domestic Effluents on Groundwater Quality: A Case Study". *The Science of the Total Environment.* (40). 115-124

Rifai, H.S., Hendricks, L.A., Kilborn, K. and Bedient, P.B. (1993) "A Geographic Information System (GIS) User Interface for Delineating Wellhead Protection Areas". *Groundwater.* 31(3). 480-488

Robertson, W.D., Cherry, J.A., and Sudicky, E.A. (1991) "Ground-Water Contamination from Two Small Septic Systems on Sand Aquifers". *Groundwater.* 29(1). 82-92

Sabatier, P.A. and Mazmanian, D.A. (1981) "The Implementation of Public Policy: A Framework for Analysis". in *Effective Policy Implementation,* Lexington Books. Toronto, Ontario.

Shrubsole, D., and Wilcox, I. (1996). "Assessing a Regulatory Approach to Controlling Agricultural Pollution: The Experience of Ellice Township, Ontario, Canada". *Applied Geography.* 16(2). 123-136

Shrubsole, D., Hammond, V.J. and Green, M. (1995) "Floodplain Management in London, Ontario, Canada: Assessing Implementation of Section 28 of the Conservation Authorities Act". *Environmental Management.* 19(5). 703-717.

Simpson, H.C. (1992) *Assessing the Impact on Groundwater and Land Use Planning Implications of Septic Systems on Sandy Aquifers.* University of Waterloo, Unpublished Masters Thesis.

Stoecker, R. (1991) "Evaluating and Rethinking the Case Study". *Sociological Review.* 39(1).

Thomas, L.M. (1985) "Management of nonpoint-source pollution: What priority?" *Journal of Soil and Water Conservation.* 40(1). 8

Thomas, P. and Palfrey, C. (1996) "Evaluation: Stakeholder-focused Criteria". *Social Policy and Administration.* 30(2). 125-142

Tice, T.F. and Epplin, F.M. (1984) "Cost-sharing to promote use of conservation tillage". *Journal of Soil and Water Conservation.* 39(6). 395-397

Troughton, M.J. (1995) "Agriculture and Rural Resources". In Mitchell, B. (ed.) *Resource and Environmental Management in Canada: Addressing Conflict and Uncertainty*, Oxford University Press, Toronto. 151-182

U.S. Environmental Protection Agency (U.S. EPA) (1996) *Nonpoint Source Pollution: The Nation's Largest Water Quality Problem.* Nonpoint Source Control Branch, Washington.

Upper Thames River Conservation Authority (UTRCA) (1983) *Annual Report.*

________ (1989) *Annual Report.*

________ (1991) *Clean Up Rural Beaches (CURB) Plan for the Fanshawe, Pittock and Wildwood Reservoirs.*

________(1992) Clean Up Rural Beaches (CURB) 1992 Progress Report.

________(1994) Clean Up Rural Beaches (CURB) Program 1994 Annual Report.

________ (1999) *Programs and Services*, http://thamesriver.org/HomePage/Programs. Jan 20. 1999.

VanMeter, D.S. and VanHorn, C.E. (1975) "The Policy Implementation Process: A Conceptual Framework". *Administration and Society.* 6(4). 445-488

Viraraghavan, T. (1982) "Effects of Septic Tank Systems on Environmental Quality". *Journal of Environmental Management.* (15). 63-70

Watson, N., Mitchell, B. and Mulamoottil, G. (1996) "Integrated Resource Management: Institutional Arrangements Regarding Nitrate Pollution in England". *Journal of Environmental Planning and Management.* 39(1). 45-64

Wilcox, I (1992) *Environmental Regulation: Agricultural Pollution Control.* University of Western Ontario. Unpublished Masters Thesis.

Wolf, A.T. (1995) "Rural nonpoint source pollution control in Wisconsin: the Limits of a voluntary program". *Water Resources Bulletin.* (31)6. 1009-1022

Yates, M.V. (1985) "Septic Tank Density and Ground-Water Contamination". *Groundwater.* 23(5). 586-591

Yin, R.K. (1992) "The Case Study Method as a Tool for Doing Evaluations". *Current Sociology.* 40(1).